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Infrastructure for Spatial Information in Europe

D2.8.III.13-14 Data Specification on Atmospheric Conditions and Meteorological Geographical Features – Draft Guidelines

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Foreword
How to read the document?

This document describes the *"INSPIRE data specification on Atmospheric Conditions and Meteorological Geographical Features – Guidelines"* version 2.0 as developed by the Thematic Working Group (TWG) *Atmospheric conditions / Metereological geographical features* using both natural and a conceptual schema language. This version is now available for the public consultation. Based on the results of the consultation (received comments and the testing reports), the final version 3.0 will be prepared by the TWGs.

The data specification is based on a common template used for all data specifications and has been harmonised using the experience from the development of the Annex I data specifications.

This document provides guidelines for the implementation of the provisions laid down in the draft Implementing Rule for spatial data sets and services of the INSPIRE Directive.

This document includes two executive summaries that provide a quick overview of the INSPIRE data specification process in general, and the content of the data specification on *Atmospheric Conditions and Meteorological Geographical Features* in particular. We highly recommend that managers, decision makers, and all those new to the INSPIRE process and/or information modelling should read these executive summaries first.

The UML diagrams (in Chapter 5) offer a rapid way to see the main elements of the specifications and their relationships. The definition of the spatial object types, attributes, and relationships are included in the Feature Catalogue (also in Chapter 5). People having thematic expertise but not familiar with UML can fully understand the content of the data model focusing on the Feature Catalogue. Users might also find the Feature Catalogue especially useful to check if it contains the data necessary for the applications that they run. The technical details are expected to be of prime interest to those organisations that are/will be responsible for implementing INSPIRE within the field of *Atmospheric Conditions and Meteorological Geographical Features.*

The technical provisions and the underlying concepts are often illustrated by examples. Smaller examples are within the text of the specification, while longer explanatory examples and descriptions of selected use cases are attached in the annexes.

In order to distinguish the INSPIRE spatial data themes from the spatial object types, the INSPIRE spatial data themes are written in *italics.*

Interoperability of Spatial Data Sets and Services – General Executive Summary

The challenges regarding the lack of availability, quality, organisation, accessibility, and sharing of spatial information are common to a large number of policies and activities and are experienced across the various levels of public authority in Europe. In order to solve these problems it is necessary to take measures of coordination between the users and providers of spatial information. The Directive 2007/2/EC of the European Parliament and of the Council adopted on 14 March 2007 aims at establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment.

INSPIRE will be based on the infrastructures for spatial information that are created and maintained by the Member States. To support the establishment of a European infrastructure, Implementing Rules addressing the following components of the infrastructure are being specified: metadata, interoperability of spatial data themes (as described in Annexes I, II, III of the Directive) and spatial data services, network services and technologies, data and service sharing, and monitoring and reporting procedures.

INSPIRE does not require collection of new data. However, after the period specified in the Directive[1] Member States have to make their data available according to the Implementing Rules.

Interoperability in INSPIRE means the possibility to combine spatial data and services from different sources across the European Community in a consistent way without involving specific efforts of humans or machines. It is important to note that “interoperability” is understood as providing access to spatial data sets through network services, typically via Internet. Interoperability may be achieved by either changing (harmonising) and storing existing data sets or transforming them via services for publication in the INSPIRE infrastructure. It is expected that users will spend less time and efforts on understanding and integrating data when they build their applications based on data delivered within INSPIRE.

In order to benefit from the endeavours of international standardisation bodies and organisations established under international law their standards and technical means have been utilised and referenced, whenever possible.

To facilitate the implementation of INSPIRE, it is important that all stakeholders have the opportunity to participate in specification and development. For this reason, the Commission has put in place a consensus building process involving data users, and providers together with representatives of industry, research and government. These stakeholders, organised through Spatial Data Interest Communities (SDIC) and Legally Mandated Organisations (LMO)[2], have provided reference materials, participated in the user requirement and technical[3] surveys, proposed experts for the Data Specification Drafting Team[4] and Thematic Working Groups[5].

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[1] For all 34 Annex I,II and III data themes: within two years of the adoption of the corresponding Implementing Rules for newly collected and extensively restructured data and within 5 years for other data in electronic format still in use

[2] Number of SDICs and LMOs on 8/6/2011 was 461 and 249 respectively

[3] Surveys on unique identifiers and usage of the elements of the spatial and temporal schema,

[4] The Data Specification Drafting Team has been composed of experts from Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Switzerland, UK, and the European Environmental Agency

[5] The Thematic Working Groups of Annex II and III themes have been composed of experts from Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Norway, Poland, Romania, Slovakia, Spain, Sweden, Switzerland, Turkey, UK, the European Commission, and the European Environmental Agency

This open and participatory approach was successfully used during the development of the data specification on Annex I data themes as well as during the preparation of the Implementing Rule on Interoperability of Spatial Data Sets and Services[6] for Annex I spatial data themes.,

The development framework elaborated by the Data Specification Drafting Team aims at keeping the data specifications of the different themes coherent. It summarises the methodology to be used for the data specifications and provides a coherent set of requirements and recommendations to achieve interoperability. The pillars of the framework are four technical documents:

- The Definition of Annex Themes and Scope[7] describes in greater detail the spatial data themes defined in the Directive, and thus provides a sound starting point for the thematic aspects of the data specification development.

- The Generic Conceptual Model[8] defines the elements necessary for interoperability and data harmonisation including cross-theme issues. It specifies requirements and recommendations with regard to data specification elements of common use, like the spatial and temporal schema, unique identifier management, object referencing, a generic network model, some common code lists, etc. Those requirements of the Generic Conceptual Model that are directly implementable will be included in the Implementing Rule on Interoperability of Spatial Data Sets and Services.

- The Methodology for the Development of Data Specifications[9] defines a repeatable methodology. It describes how to arrive from user requirements to a data specification through a number of steps including use-case development, initial specification development and analysis of analogies and gaps for further specification refinement.

- The “Guidelines for the Encoding of Spatial Data”[10] defines how geographic information can be encoded to enable transfer processes between the systems of the data providers in the Member States. Even though it does not specify a mandatory encoding rule it sets GML (ISO 19136) as the default encoding for INSPIRE.

Based on these framework documents and following the successful development of the Annex I Data specifications (Technical Guidelines) and the Implementing Rules, the new Thematic Working Groups have created the INSPIRE data specification for each Annex II and III theme. These documents – at the version 2.0 – are now publicly available for INSPIRE stakeholders for consultation. The consultation phase covers expert review as well as feasibility and fitness-for-purpose testing of the data specifications.

The structure of the data specifications is based on the “ISO 19131 Geographic information - Data product specifications” standard. They include the technical documentation of the application schema, the spatial object types with their properties, and other specifics of the spatial data themes using natural language as well as a formal conceptual schema language[11].

A consolidated model repository, feature concept dictionary, and glossary are being maintained to support the consistent specification development and potential further reuse of specification elements. The consolidated model consists of the harmonised models of the relevant standards from the ISO

[6] Commission Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services, published in the Official Journal of the European Union on 8th of December 2010.
[7] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*
[8] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.5_v3.3.pdf*
[9] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*
[10] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.7_v3.2.pdf*
[11] UML – Unified Modelling Language

19100 series, the INSPIRE Generic Conceptual Model, and the application schemas[12] developed for each spatial data theme. The multilingual INSPIRE Feature Concept Dictionary contains the definition and description of the INSPIRE themes together with the definition of the spatial object types present in the specification. The INSPIRE Glossary defines all the terms (beyond the spatial object types) necessary for understanding the INSPIRE documentation including the terminology of other components (metadata, network services, data sharing, and monitoring).

By listing a number of requirements and making the necessary recommendations, the data specifications enable full system interoperability across the Member States, within the scope of the application areas targeted by the Directive. They will be published (version 3.0) as technical guidelines and will provide the basis for the content of the Amendment of the Implementing Rule on Interoperability of Spatial Data Sets and Services for data themes included in Annex II and III of the Directive. The Implementing Rule Amendment will be extracted from the data specifications keeping in mind short and medium term feasibility as well as cost-benefit considerations. The Implementing Rule will be legally binding for the Member States.

In addition to providing a basis for the interoperability of spatial data in INSPIRE, the data specification development framework and the thematic data specifications can be reused in other environments at local, regional, national and global level contributing to improvements in the coherence and interoperability of data in spatial data infrastructures.

[12] Conceptual models related to specific areas (e.g. INSPIRE themes)

Atmospheric Conditions and Meteorological Geographical Features – Executive Summary

The Thematic Working Group responsible for the specification development of Atmospheric Conditions and Meteorological Geographical Features was composed of ten experts coming from Austria, Finland, France, Italy, the Netherlands, Sweden, the United Kingdom and the European Commission.
The two themes are defined by the INSPIRE Directive as:

- Atmospheric conditions: physical conditions in the atmosphere. Includes spatial data based on measurements, on models or on a combination thereof and includes measurements locations;
- Meteorological geographical features: weather conditions and their measurements: precipitation, temperature, evapotranspiration, wind speed and direction.

It was noted from the start that these definitions leave many open questions regarding the scope of the two themes. In particular, there is no basis for a practical distinction between information on Atmospheric Conditions on the one hand and on Meteorological Features on the other. Noting that physical conditions in the atmosphere actually encompass weather conditions, the TWG decided that the most efficient way of covering the two themes was to address “Atmospheric Conditions” first, and to check later on that the resulting specifications cover “Meteorological Features” as well. Therefore, for the present version of data specifications documentation is provided under the theme “Atmospheric Conditions” only; no gap has been identified so far to address user requirements for spatial information on Meteorological Geographical Features.
Another element which was important to note from the start was that other work aiming at ensuring interoperability of meteorological information was under way in a MetOcean Domain Working Group of the OGC, and also in the worldwide context of the development of a new WMO Information System. It was necessary to ensure coherence between these developments and the present data specification.

<u>Use cases</u>
In order to identify priority areas for the specification of meteorological data, the TWG selected the following three high level use cases:

1. Use of meteorology in support of environmental emergency response
2. Flood forecasting
3. Climate assessment (with past or predicted data).

These cases were selected after reviewing a list of use cases considered for conceptual modelling by the OGC Met Ocean Domain Working Group. It was felt that they were all highly relevant to environmental protection, and that they would all require significant and possibly challenging cross boundary as well as cross theme cooperation.
A close examination of the stated User Requirements had been carried out as well.
Five detailed use cases have been developed, involving the use of both real time and non real time data.

The scope
According to the INSPIRE Directive the data relevant to the themes “Atmospheric Conditions” and “Meteorological Geographical Features” should provide sufficient information for the users to assess, at least, precipitation, temperature, evapotranspiration and wind at their location of interest. General information on physical conditions should also be made available, however, neither the Directive nor any of the subsequent documents give any operative guidance regarding the range that this information should cover: questions such as the inclusion of forecast data, the list of parameters, the spatial resolution of the data, are not addressed.
After reviewing in detail the available documents on these issues, the TWG considered that there was no a priori reason to exclude any type of meteorological information from the overall scope of the themes on Atmospheric Conditions and Meteorological Geographical Features. It could possibly be argued that real time and forecast data is not needed strictly speaking for protecting the environment but only for ensuring security. However, as the example of GMES is showing, there is no clear limit between these two fields of activity, and it is highly likely that they will eventually be combined into a common framework.
The critical question which arises is then the question of feasibility and affordability. While the work on data specification should indeed not exclude any data type, the implementing rules will have to provide

the necessary safeguards against unrealistic implementation requirements. For the initial implementation, the list of mandatory parameters to be made available should be limited to the basic meteorological parameters required for the reference use cases.

The model

The AC-MF conceptual schema specified in this document is organized into four leaf packages - AtmosphericCondition, AtmosphericConditionProcess, ObservableProperty, CSML v3 - with dependencies on packages from the INSPIRE Generic Conceptual Model. The general structure of the schema gives a central place to "Atmospheric Condition", i.e., an aggregation of one or more instances of OM_Observation (or its specialisations); examples of such aggregation could be:

- an entire result set (all parameters, all times, all levels) of a single model run,
- all observations collected from a single ground observation station within one collecting period (1 minute - 1 day),
- all observations collected from all available ground observation stations within one collecting period (last 3-6h),
- all possible weather information available for a given region over a given time period,
- all air traffic related meteorological information considering two given airports and the airspace between,
- any distinct data set containing meteorologically interesting data.

Description of the Atmospheric Condition spatial and temporal extent, the range within which this set of values of atmospheric parameters are available, is provided by the attribute extent:EX_Extent, the union of spatial and temporal extents of all observation members. The spatial and temporal extent of each observation member are provided by the observation's related spatial sampling feature and the OM_Observation attribute phenomenonTime respectively

The list of parameters to be included in an Atmospheric Condition instance is extracted from a "Property Code" code list, depending on the need of the application for which the data is produced.

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The Thematic Working Group Atmospheric conditions and Meteorological geographical features (TWG-AC-MF) included:
Bernard Strauss (TWG Facilitator), Spiros Ventouras (TWG Editor), Sheila Cryan, Esa Falkenroth, Frédéric Guillaud, Stefano Nativi, Erwin Petz, Ilkka Rinne, Raymond Sluiter, Bruce Wright, Alessandro Sarretta (European Commission contact point).

Other contributors to the INSPIRE data specifications are the Drafting Team Data Specifications, the JRC data specifications team and the INSPIRE stakeholders - Spatial Data Interested Communities (SDICs) or Legally Mandated Organisations (LMOs).

Contact information

Vanda Nunes de Lima
European Commission Joint Research Centre
Institute for Environment and Sustainability
Spatial Data Infrastructures Unit
TP262, Via Fermi 2749
I-21027 Ispra (VA)
ITALY
E-mail: vanda.lima@jrc.ec.europa.eu
Tel.: +39-0332-7865052
Fax: +39-0332-7866325
http://ies.jrc.ec.europa.eu/
http://ec.europa.eu/dgs/jrc/
http://inspire.jrc.ec.europa.eu/

Table of contents

1 Scope

This document specifies a harmonised data specification for the spatial data theme *Atmospheric Conditions and Meteorological Geographical Features* as defined in Annex III of the INSPIRE Directive.

This data specification provides the basis for the drafting of Implementing Rules according to Article 7 (1) of the INSPIRE Directive [Directive 2007/2/EC]. The entire data specification will be published as implementation guidelines accompanying these Implementing Rules.

2 Overview

2.1 Name

INSPIRE data specification for the theme Atmospheric Conditions and Meteorological Geographical Features.

2.2 Informal description

Definition:

Theme III-13, Atmospheric conditions:

Physical conditions in the atmosphere. Includes spatial data based on measurements, on models or on a combination thereof and includes measurements locations. [Directive 2007/2/EC]

Theme III-14, Meteorological geographical features:

Weather conditions and their measurements: precipitation, temperature, evapotranspiration, wind speed and direction. [Directive 2007/2/EC]

Description:

A very wide range of activities related to environmental protection require input information on meteorological conditions. Meteorological and related data (land /ocean surface conditions, etc.) held operation-ally within the European Meteorological Infrastructure (EMI, comprising the national meteorological ser-vices as well as the two European organisations ECMWF and EUMETSAT) include, among many other parameters:

- General parameters
  - Temperature
  - Humidity
  - Wind speed and direction
- Surface parameters
  - Pressure
  - Precipitation (amount and type)
  - Evaporation
  - Radiative fluxes (solar and infrared)
  - Snowdepth
- Other weather parameters
  - Cloud cover

This list is coherent with the requirements of the Use Cases indicated in Annex B. In addition, it should be noted that the overall data set operated by the EMI is actually much larger. Many parameters are of limited use outside purely meteorological applications. Others which could be useful for user applications have not be included, bearing in mind the potential difficulty with data volumes, because they do not emerge from the selected Use Cases. They could however be added at a later stage using the same specification framework.
The same recommendation arises for atmospheric data related to the chemical composition of the atmosphere, which has importance for the protection of both human health and the environment and for climate change.

Regarding the temporal aspect, there is a distinction between:

1. data whose validity is restricted to the specific time for which they have been computed or at which they have been observed, e.g. the temperature at a given time over a given location,
2. and data whose validity is not linked to a unique time or time interval, e.g., the mean annual temperature over a given location. Such data is often referred to as climate information.

The overall volume of category 1 data is huge.
It must be stressed that there is no fundamental difference between past and future meteorological information, at least as far as data specification is concerned. There is however one important aspect specific to forecast information, namely, the possible use of probabilistic forecasts, usually derived from ensemble forecasts.

Several types of time information are necessary to describe meteorological data, especially in the case of data resulting from a numerical simulation:

Usual denomination	Used in the present specification	O & M modelling	Explanation, comments...
	1-phenomenonTime	6.2.2.2 phenomenonTime TM_Object	Time domain of the data set Only meaningful for a collection of data
Availability time	2-resultTime	6.2.2.3 resultTime TM_Instant	The time when the result became available
		6.2.2.4 validTime TM_Period	The time period during which the result is intended to be used
Initial time	3-analysisTime	6.2.2.5 parameter TM_Instant	Time instant for the initial conditions of a numerical simulation, chosen toward the middle of the assimilation window where the model state is considered to be more realistic Only for information resulting from a numerical simulation process
Assimilation window	4-assimilationWindow	6.2.2.5 parameter TM_Period	Only for information resulting from a numerical simulation process
Cut-off time			Latest time of reception of input data for the production process (mainly for information resulting from a numerical simulation process)
Validity time Validity time window			For instantaneous parameters (temperature, precipitation rate, ...) For integrated parameters (precipitation amount, ...)

Regarding the respective scopes of the two themes AC and MF, it should be noted that physical conditions in the atmosphere actually encompass weather conditions. It could further be noted that in the French version of the Directive (and possibly others) the designations of themes 13 “Conditions atmosphériques: conditions physiques dans l’atmosphère etc.” and 14 “Caractéristiques géographiques météorologiques: conditions météorologiques et leur mesure etc.” are in actual fact equivalent, inasmuch as the word “météorologiques” does not imply any limitation to weather; the only specificity

of III-14 is given by the prescribed list of parameters, which is nothing but a subset of the list expected from III-13.
On that basis the TWG on Atmospheric Conditions and Meteorological Gegraphical Features decided that the most efficient way of covering the two themes was to address “Atmospheric Conditions” first, and to check later on that the resulting specifications do cover Meteorological Conditions as well. Therefore, for the present version of data specifications documentation is provided under the theme “Atmospheric Conditions” only; separate documentation for Meteorological Geographical Features will be added at a later stage if a specific requirement has emerged.

2.3 Normative References

[Directive 2007/2/EC] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)

[ISO 19107] EN ISO 19107:2005, Geographic Information – Spatial Schema

[ISO 19108] EN ISO 19108:2005, Geographic Information – Temporal Schema

[ISO 19108-c] ISO 19108:2002/Cor 1:2006, Geographic Information – Temporal Schema, Technical Corrigendum 1

[ISO 19109] ISO 19109:2006, Geographic Information — Rules for application schemas

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007)

[ISO 19113] EN ISO 19113:2005, Geographic Information – Quality principles

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003)

[ISO 19118] EN ISO 19118:2006, Geographic information – Encoding (ISO 19118:2005)

[ISO 19123] EN ISO 19123:2007, Geographic Information – Schema for coverage geometry and functions

[ISO 19135] EN ISO 19135:2007 Geographic information – Procedures for item registration (ISO 19135:2005)

[ISO 19138] ISO/TS 19138:2006, Geographic Information – Data quality measures

[ISO 19139] ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

[OGC 06-103r3] Implementation Specification for Geographic Information - Simple feature access – Part 1: Common Architecture v1.2.0

NOTE This is an updated version of "EN ISO 19125-1:2006, Geographic information – Simple feature access – Part 1: Common architecture". A revision of the EN ISO standard has been proposed.

[Regulation 1205/2008/EC] Regulation 1205/2008/EC implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata

[WMO 306] Manual on Codes WMO - No 306, Volumes I.1 and I.2, World Meteorological Organisation, ISBN 978-92-63-10306-2.

WMO Manual on the Global Observing System (WMO-No 544)

WMO Manual on the Global Data-processing and Forecasting System (WMO-No. 485)

WMO Manual on the WIS (subject to WMO Congress-XVI 2011 approval)

2.4 Terms and definitions

General terms and definitions helpful for understanding the INSPIRE data specification documents are defined in the INSPIRE Glossary[13].

Open issue 1: To be completed before version 3.0

2.5 Symbols and abbreviations

Open issue 2: To be completed before version 3.0

2.6 Notation of requirements and recommendations

To make it easier to identify the mandatory requirements and the recommendations for spatial data sets in the text, they are highlighted and numbered.

IR Requirement X	Requirements that are reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style.

DS Requirement X	Requirements that are not reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style.

Recommendation 1 Recommendations are shown using this style.

2.7 Conformance

DS Requirement 1	Any dataset claiming conformance with this INSPIRE data specification shall pass the requirements described in the abstract test suite presented in Annex A.

[13] The INSPIRE Glossary is available from http://inspire-registry.jrc.ec.europa.eu/registers/GLOSSARY

3 Specification scopes

This data specification does not distinguish different specification scopes, but just considers one general scope.

NOTE For more information on specification scopes, see [ISO 19131:2007], clause 8 and Annex D.

4 Identification information

NOTE Since the content of this chapter was redundant with the overview description (section 2) and executive summary, it has been decided that this chapter will be removed in v3.0.

5 Data content and structure

IR Requirement 1 Spatial data sets related to the theme *Atmospheric Conditions and Meteorological Geographical Features* shall be provided using the spatial object types and data types specified in the application schema(s) in this section.

IR Requirement 2 Each spatial object shall comply with all constraints specified for its spatial object type or data types used in values of its properties, respectively.

Recommendation 1 The reason for a void value should be provided where possible using a listed value from the VoidValueReason code list to indicate the reason for the missing value.

NOTE The application schema specifies requirements on the properties of each spatial object including its multiplicity, domain of valid values, constraints, etc. All properties have to be reported, if the relevant information is part of the data set. Most properties may be reported as "void", if the data set does not include relevant information. See the Generic Conceptual Model [INSPIRE DS-D2.5] for more details.

5.1 Basic notions

This section explains some of the basic notions used in the INSPIRE application schemas. These explanations are based on the GCM [DS-D2.5].

5.1.1 Stereotypes

In the application schemas in this sections several stereotypes are used that have been defined as part of a UML profile for use in INSPIRE [INSPIRE DS-D2.5]. These are explained in Table 1 below.

Table 1 – Stereotypes (adapted from [INSPIRE DS-D2.5])

Stereotype	Model element	Description
applicationSchema	Package	An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model.
featureType	Class	A spatial object type.
type	Class	A conceptual, abstract type that is not a spatial object type.
dataType	Class	A structured data type without identity.
union	Class	A structured data type without identity where exactly one of the properties of the type is present in any instance.
enumeration	Class	A fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list.
codeList	Class	A flexible enumeration that uses string values for expressing a list of potential values.
placeholder	Class	A placeholder class (see definition in section 5.1.2).
voidable	Attribute, association role	A voidable attribute or association role (see definition in section 5.1.3).
lifeCycleInfo	Attribute, association role	If in an application schema a property is considered to be part of the life-cycle information of a spatial object type, the property shall receive this stereotype.
version	Association role	If in an application schema an association role ends at a spatial object type, this stereotype denotes that the value of the property is meant to be a specific version of the spatial object, not the spatial object in general.

5.1.2 Placeholder and candidate types

Some of the INSPIRE Annex I data specifications (which were developed previously to the current Annex II+III data specifications) refer to types that thematically belong and were expected to be fully specified in Annex II or III spatial data themes. Two kinds of such types were distinguished:

– *Placeholder types* were created as placeholders for types (typically spatial object types) that were to be specified as part of a future spatial data theme, but which was already used as a value type of an attribute or association role in this data specification.

  Placeholder types received the stereotype «placeholder» and were placed in the application schema package of the future spatial data theme where they thematically belong. For each placeholder, a definition was specified based on the requirements of the Annex I theme. The Annex II+III TWGs were required to take into account these definitions in the specification work of the Annex II or III theme.

  If necessary, the attributes or association roles in the Annex I data specification(s) that have a placeholder as a value type shall be updated if necessary.

– *Candidate types* were types (typically spatial object types) for which already a preliminary specification was given in the Annex I data specification. Candidate types did not receive a specific stereotype and were placed in the application schema package of the future spatial data theme where they thematically belong. For each candidate type, a definition and attributes and association roles were specified based on the requirements of the Annex I theme. The Annex II+III TWGs were required to take into account these specifications in the specification work of the Annex II or III theme.

If the type could not be incorporated in the Annex II or III data specification according to its preliminary specification, it should be moved into the application schema of the Annex I theme where it had first been specified. In this case, the attributes or association roles in the Annex I data specification(s) that have the type as a value type shall be updated if necessary.

Open issue 3: For all Annex II+III themes for which placeholders and candidate types were specified in an Annex I data specification, it should be clearly indicated in the data specification, how the placeholder and candidate types were taken into account. If the proposed solution would require any changes to an Annex I data specification (and the corresponding section in the IR for interoperability of spatial data sets and services), this should also be clearly indicated.

A thorough investigation of the implications of the proposed changes of candidate types (in particular related to requirements of Annex I maintenance) will have to be performed for v3.0 of the data specifications.

5.1.3 Voidable characteristics

If a characteristic of a spatial object is not present in the spatial data set, but may be present or applicable in the real world, the property shall receive this stereotype.

If and only if a property receives this stereotype, the value of *void* may be used as a value of the property. A *void* value shall imply that no corresponding value is contained in the spatial data set maintained by the data provider or no corresponding value can be derived from existing values at reasonable costs, even though the characteristic may be present or applicable in the real world.

It is possible to qualify a value of void in the data with a reason using the VoidValueReason type. The VoidValueReason type is a code list, which includes the following pre-defined values:

- *Unpopulated*: The characteristic is not part of the dataset maintained by the data provider. However, the characteristic may exist in the real world. For example when the “elevation of the water body above the sea level” has not been included in a dataset containing lake spatial objects, then the reason for a void value of this property would be ‘Unpopulated’. The characteristic receives this value for all objects in the spatial data set.
- *Unknown*: The correct value for the specific spatial object is not known to, and not computable by the data provider. However, a correct value may exist. For example when the “elevation of the water body above the sea level” *of a certain lake* has not been measured, then the reason for a void value of this property would be ‘Unknown’. This value is applied on an object-by-object basis in a spatial data set.

NOTE It is expected that additional reasons will be identified in the future, in particular to support reasons / special values in coverage ranges.

The «voidable» stereotype does not give any information on whether or not a characteristic exists in the real world. This is expressed using the multiplicity:

- If a characteristic may or may not exist in the real world, its minimum cardinality shall be defined as 0. For example, an if an Address may or may not have a house number, the multiplicity of the corresponding property shall be 0..1.
- If at least one value for a certain characteristic exists in the real world, the minimum cardinality shall be defined as 1. For example, if an Administrative Unit always has at least one name, the multiplicity of the corresponding property shall be 1..*.

In both cases, the «voidable» stereotype can be applied. A value (the real value or void) only needs to be made available for properties that have a minimum cardinality of 1.

5.1.4 Code lists and Enumerations

5.1.4.1. Style

All code lists and enumerations use the following modelling style:
- No initial value, but only the attribute name part, is used.
- The attribute name conforms to the rules for attributes names, i.e. is a lowerCamelCase name. Exceptions are words that consist of all uppercase letters (acronyms).

5.1.4.2. Governance of code lists

Two types of code lists are defined in INSPIRE. These two types are distinguished using the tagged value “extendableByMS” in the UML data model:
- *Code lists that **may not** be extended by Member States.* For these code lists, the tagged value is set to “false”. They shall be managed centrally in the INSPIRE code list register, and only values from that register may be used in instance data.
- *Code lists that **may** be extended by Member States.* For these code lists, the tagged value is set to “true”.

5.2 Application schema AC-MF

5.2.1 Description

Identification of meteorological features
In meteorology there are few objects in the usual (vernacular) meaning of this term, and they are seldom of any significance to the users, which makes the identification of spatial objects not at all straightforward. Therefore the model is based entirely on what could be called an Eulerian approach, aimed at providing information at specific locations in space and time (past and future). In applications where a Lagrangian approach is appropriate, such as pollution emergencies with plume identification, the underlying information, e.g. concentration of pollutants, will still be exchanged as grids or other point values collection.

5.2.1.1. Narrative description

The AC-MF conceptual schema specified in this document is organized into four leaf packages - AtmosphericCondition, AtmosphericConditionProcess, ObservableProperty, CSML v3 - with dependencies on packages from the INSPIRE Generic Conceptual Model and geographic information International Standards as shown in Figure 2. An overview of the AC-MF conceptual schema is shown in Figure 3.
In particular, the AC-MF conceptual schema is rooted on the common base conceptual model of Observation and Measurements (O&M) defined in ISO 19156:2011 which introduces the concept of observation: observation is an act that results in the estimation of the value of a feature property of a feature of interest using a designated procedure (Figure 3).
A specialised observation type, defined in O&M model, is the discrete coverage observation whose result is ‘coverage’, i.e. result values are explicitly associated with specific locations in space and time (Figure 7).
For applications where an exhaustive observation of environmental parameters is not possible – for example, there is no observation that can provide air temperature values of the whole atmosphere above London – so that spatial sampling strategies need to be involved, considerable flexibility regarding the target of an observation (the ‘feature of interest’) can be provided by the sampling coverage observation (a specialisation of discrete coverage observation). The feature of interest for a sampling coverage observation is a spatial sampling feature (a concept defined also in O&M model) which describes the applied sampling regime (Figure 7). The following figure illustrates the use of

concepts: sampling coverage observation, sampling feature and sampled feature in an example of time series measurements of air temperature (observed property) at a specific location (a point spatial sampling feature) of the atmosphere above Chilbolton Observatory, UK (sampled feature).

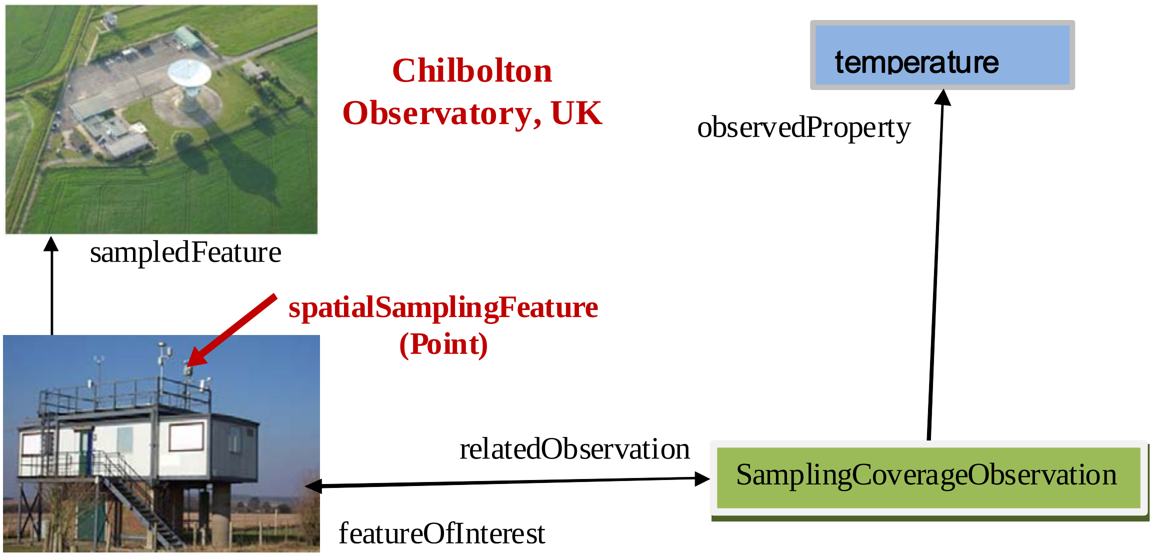


Figure 1: Example of time series measurements of air temperature showing the use of the concepts: sampling cover-age observation, sampling feature and sampled feature

Further, as shown in Figure 8, AC-MF model adopts the CSML observation types - specialisations of sampling coverage observation - each corresponding to a particular spatiotemporal sampling geometry and related coverage result [OGC pending document 11-021].

The general structure of the schema gives a central place to “Atmospheric Condition”, i.e., a set of values of a range of atmospheric parameters generated by its observation members (Figure 3), describing the state of the atmosphere over a defined spatiotemporal extent. An instance of Atmospheric Condition is an aggregation of one or more instances of OM_Observation (or its specialisations); examples could be:

- an entire result set (all parameters, all times, all levels) of a single model run
- all observations collected from a single ground observation station within one collecting period (1 minute - 1 day)
- all observations collected from all available ground observation stations within one collecting period (last 3-6h)
- all possible weather information available for a given region over a given time period
- all air traffic related meteorological information considering two given airports and the airspace between
- any distinct data set containing meteorologically interesting data.

Description of the Atmospheric Condition spatial and temporal extent, the range within which this set of values of atmospheric parameters are available, is provided by the attribute extent:EX_Extent, the union of spatial and temporal extents of all observation members. The spatial and temporal extent of each observation member are provided by the observation’s related spatial sampling feature and the OM_Observation attribute phenomenonTime respectively [ISO 19156:2011].
Information about the outcome of evaluating the result of each observation against a specified acceptable conformance quality level, e.g. pass or fail, if required, shall be provided by AtmosphericConditionDQ_Element (Figure 4).
The list of parameters to be included in an Atmospheric Condition instance shall be extracted from the “ObservablePropertyValue” code list, depending on the need of the application for which the data is produced. The segment of AC-MF model, included in the leaf package ObservableProperty, is depicted in Figure 6 and has been adapted from a relevant model presented in EGU 2011 [Lowe and

Cox, An extensible model for describing real world properties in observational contexts, EGU, Vienna, April 2011]. As shown in Figure 6, the observedProperty of an observation can be composite, i.e., consisting of two or more observed properties extracted from the ObservablePropertyValue code list. As an example, a run of a model (an observation) providing values of wind speed and direction could have a composite observedProperty of type CompositeObservableProperty (see 5.2.2.2.3), named windCharacteristics (see 5.2.2.2.1, the attribute label has the value windCharacteristics), consisting of the simple observable properties with basePhenomenon:windDirection and basePhenomenon:windSpeed from the ObservablePropertyValue code list (see 5.2.2.2.5). If the codelist ObservablePropertyValue is not sufficient to describe an observedProperty, e.g. daily maximum temperature, further detail shall be provided by the attribute SimpleObservableProperty.constraint – an example is given in 5.2.2.2.5. No attempt is made to standardize meteorological spatial features, as explained in 5.2.1.

The Directive states that atmospheric data can originate from measurements, models, or post-processed information combining measurement and model output. “AtmosphericConditionProcess”, see figure 4, shall provide information regarding the procedure used to generate the result for each observation member of AtmosphericCondition. This set of information consists of the following information pieces: identification, type and further documentation of the applied procedure; individual(s) and/or organisation(s) related to the procedure; names of parameters controlling the procedure’s output. Typical examples of using the processParameter attribute are: description of instrumentation settings for a specific measurement or measurement series; description of initial conditions in numerical computations e.g. simulations. The values of the parameters denoted by the processParameter attribute are stored in the OM_Observation.parameter attribute. Therefore, If processParameter is present, its value (a name)x shall appear also in OM_Observation.parameter. An example of using AtmosphericConditionProcess.processParameter and OM_Observation.parameter is given in 5.2.2.1.2.

Additional information for the observed values could be provided by the ISO 19115 class MD_Metadata (Figure 4).

5.2.1.2. Basic properties

The list of base ObservablePropertyValues is given in the table below. This does not represent the list of properties that must be published under INSPIRE, but an attempt to harmonise the use of property names in the Atmospheric Conditions context for this limited set of properties.

Observable Property Value	Units (SI)	Description	Notes	Use Cases
evaporationAmount	kg m^{-2}	Evaporation amount	Constraint provides time period; if absent, default period = 1 day	2.2
precipitationAmount	Kg m^{-2}	Precipitation amount	Constraint provides time period; if absent, default period = 1 day	2.1, 2.2, 3.2
precipitationRate	Kg m^{-2} s^{-1}	Precipitation rate		1, 2.1, 2.2, (3.1)
precipitationType	-	Precipitation type	Uses code table	1, (3.1)
pressureReducedToMSL	Pa	Pressure reduced to mean sea level		3.2
relativeHumidity	%	Relative humidity		1, (3.1) , 3.2
snowDepth	m	Lying snow depth		3.2
temperature	K	Air temperature	Default height = screen level	1, 2.2, (3.1) , 3.2
totalCloudCover	%	Total cloud cover		1, 3.2
windDirection	deg	Wind direction (from which wind is blowing)		1, 3.1, 3.2
windSpeed	m s^{-1}	Wind speed		1, 3.1, 3.2

Observable Property Value	Units (SI)	Description	Notes	Use Cases
windSpeedGust	$m\ s^{-1}$	Wind speed of maximum gust		3.1, 3.2

Open issue 4: Complex Observable Property Values (e.g. monthly mean daily maximum temperature) can be specified using the ObservablePropertyConstraint in the current model (a more sophisticated model for handling this is under development).

Notes:
1. All properties will use SI Units.
2. Use case numbers refer as follows:
   - 1 - Plume prediction in support of emergency response
   - 2.1 - Flash flood management
   - 2.2 - Flood forecasting short and medium range
   - 3.1 - Finding the most interesting locations for new wind farms
   - 3.2 - Climate impacts

5.2.1.3. UML Overview

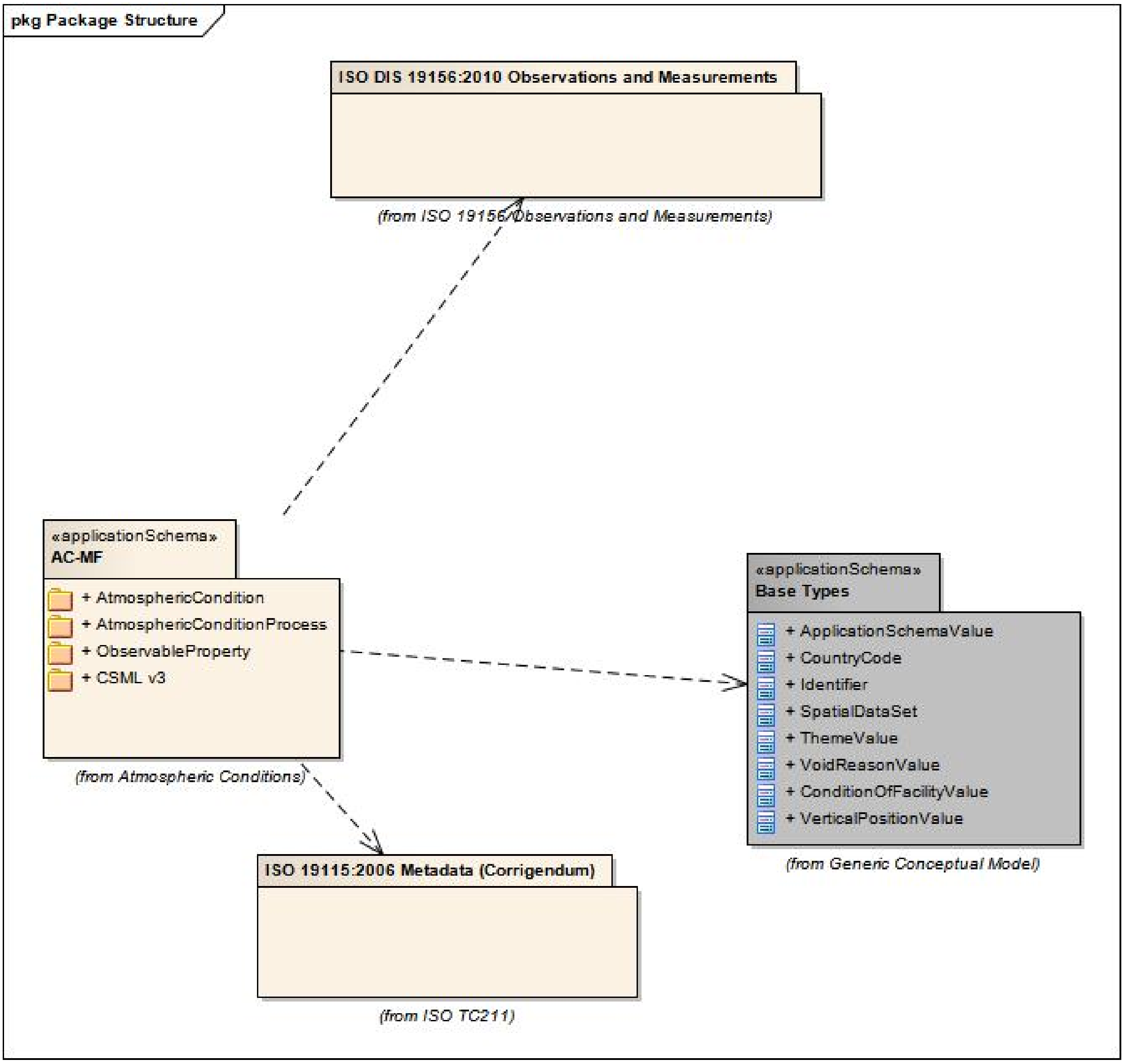


Figure 2 – package dependencies of AC-MF conceptual schema

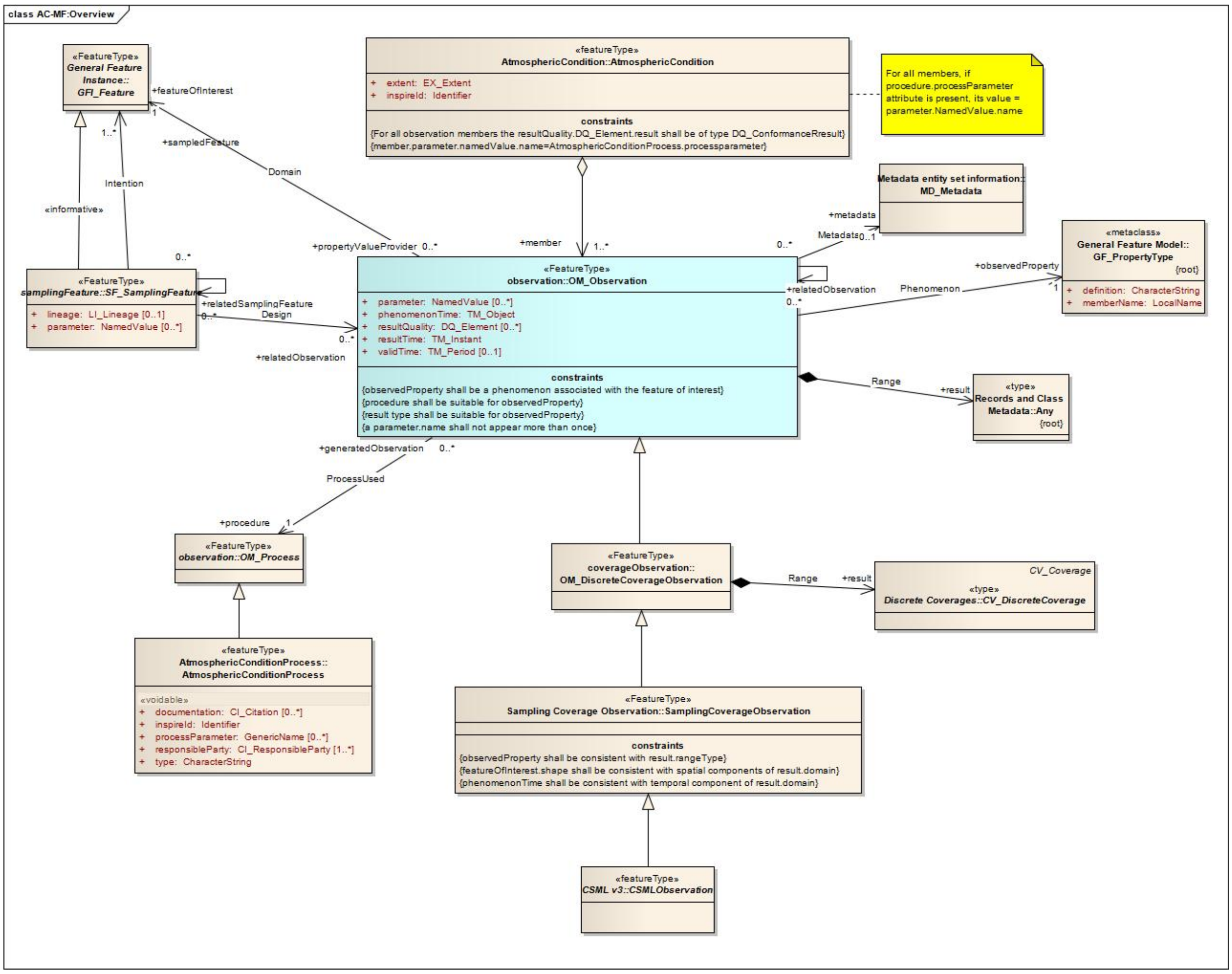


Figure 3: overview of the AC-MF conceptual model

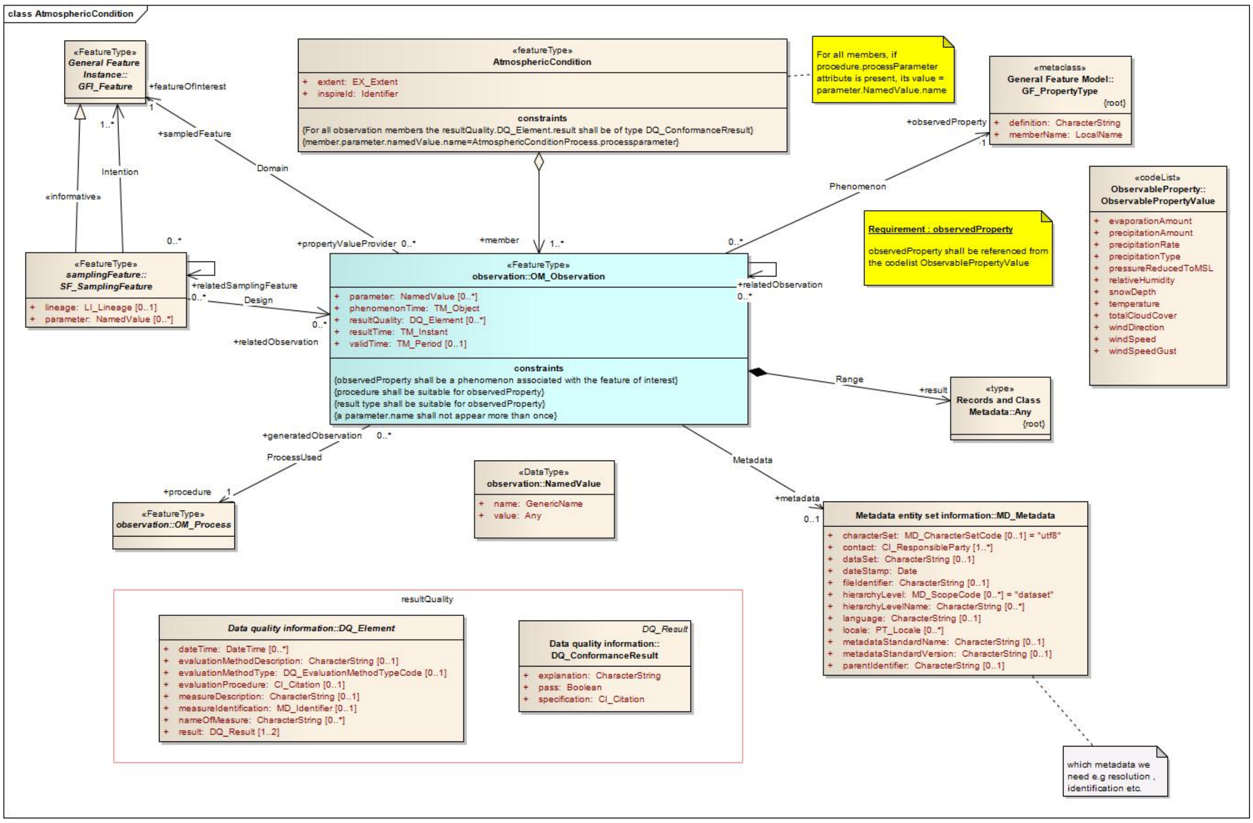


Figure 4: AtmosphericCondition model

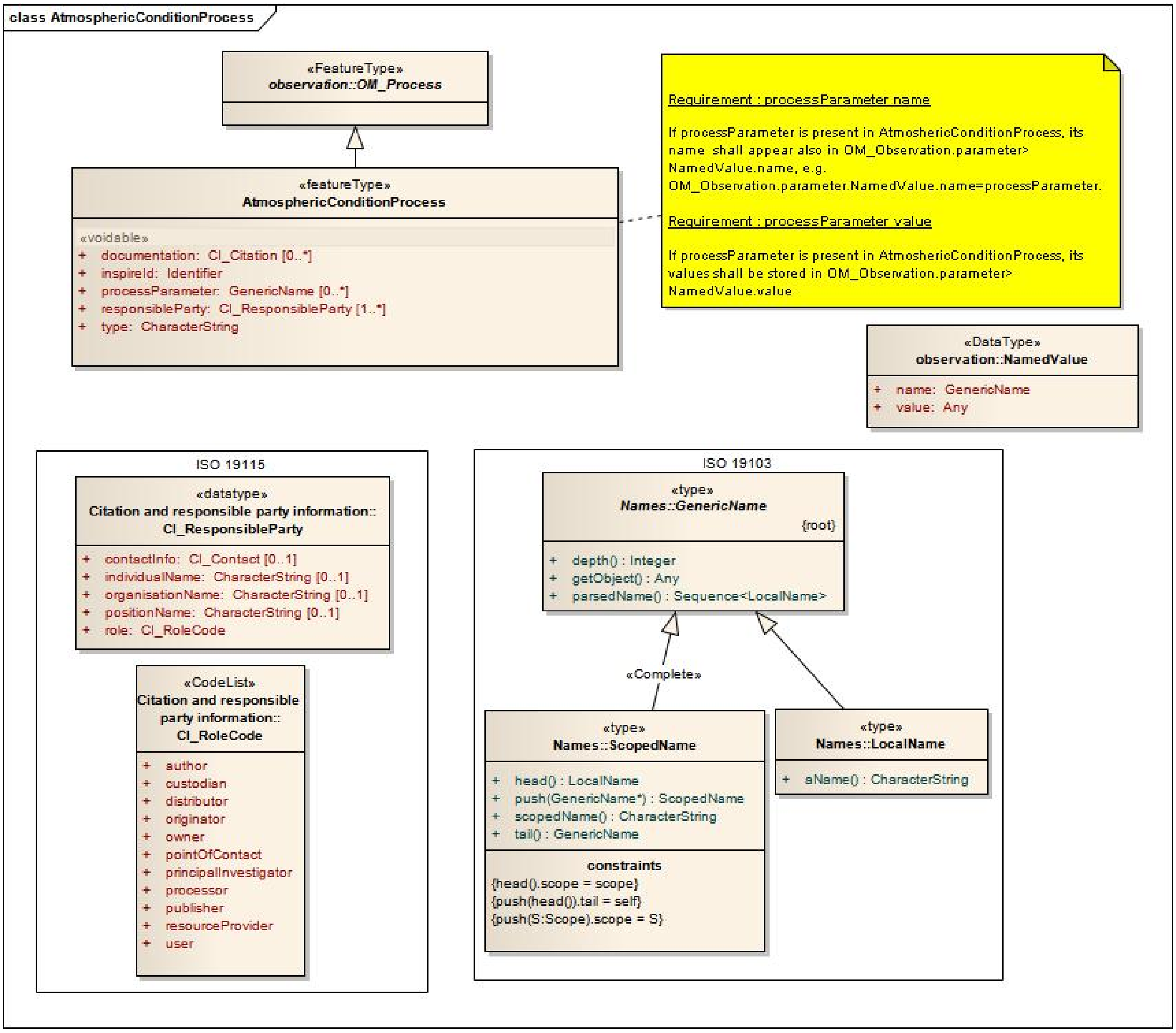


Figure 5: AtmosphericConditionProcess model

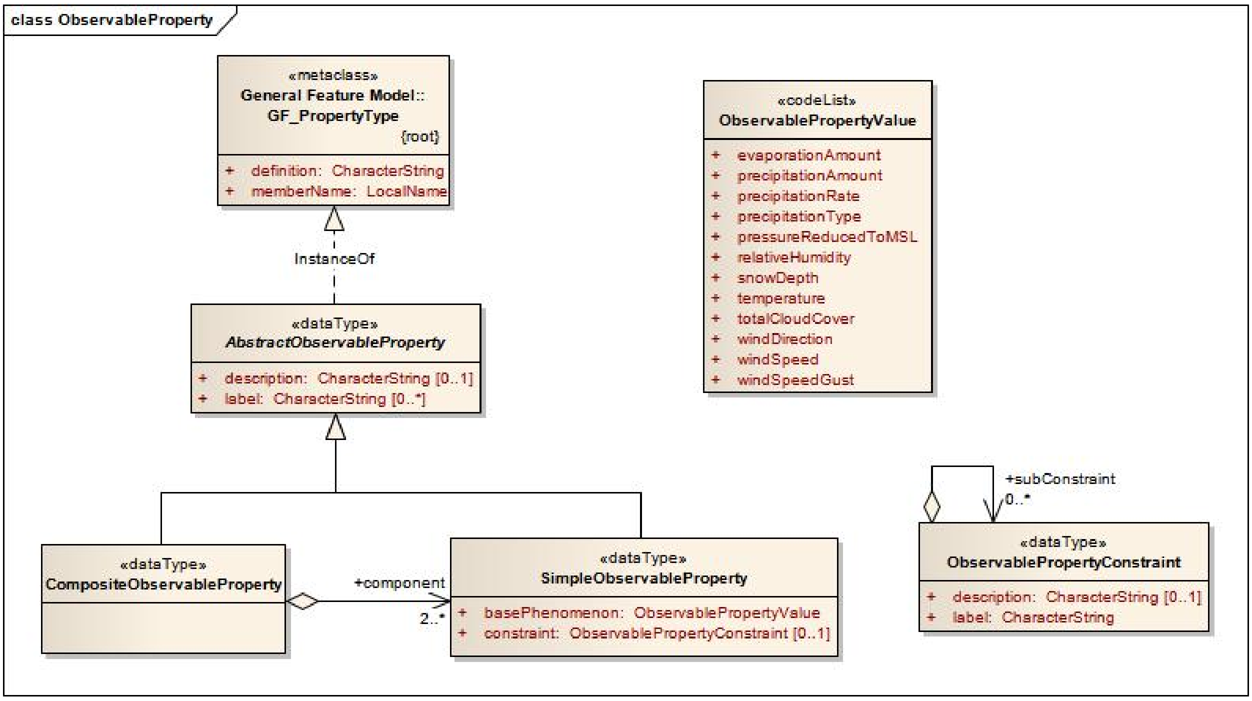


Figure 6: ObservableProperty model

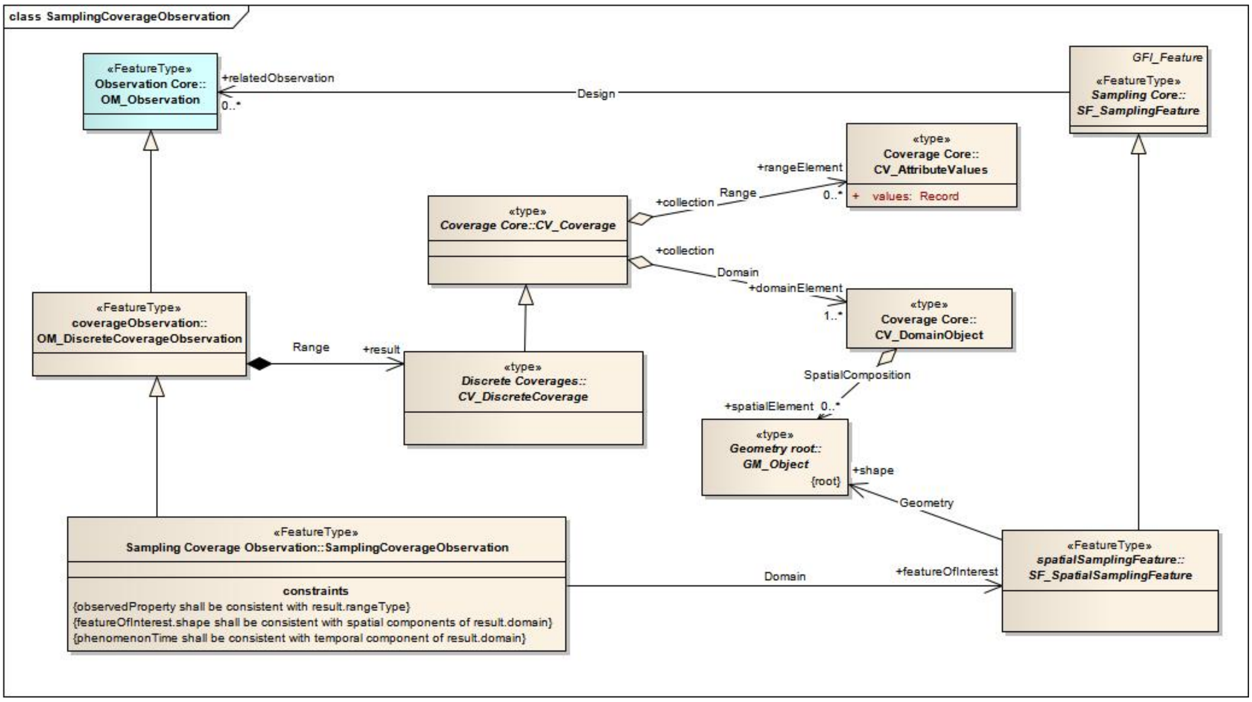
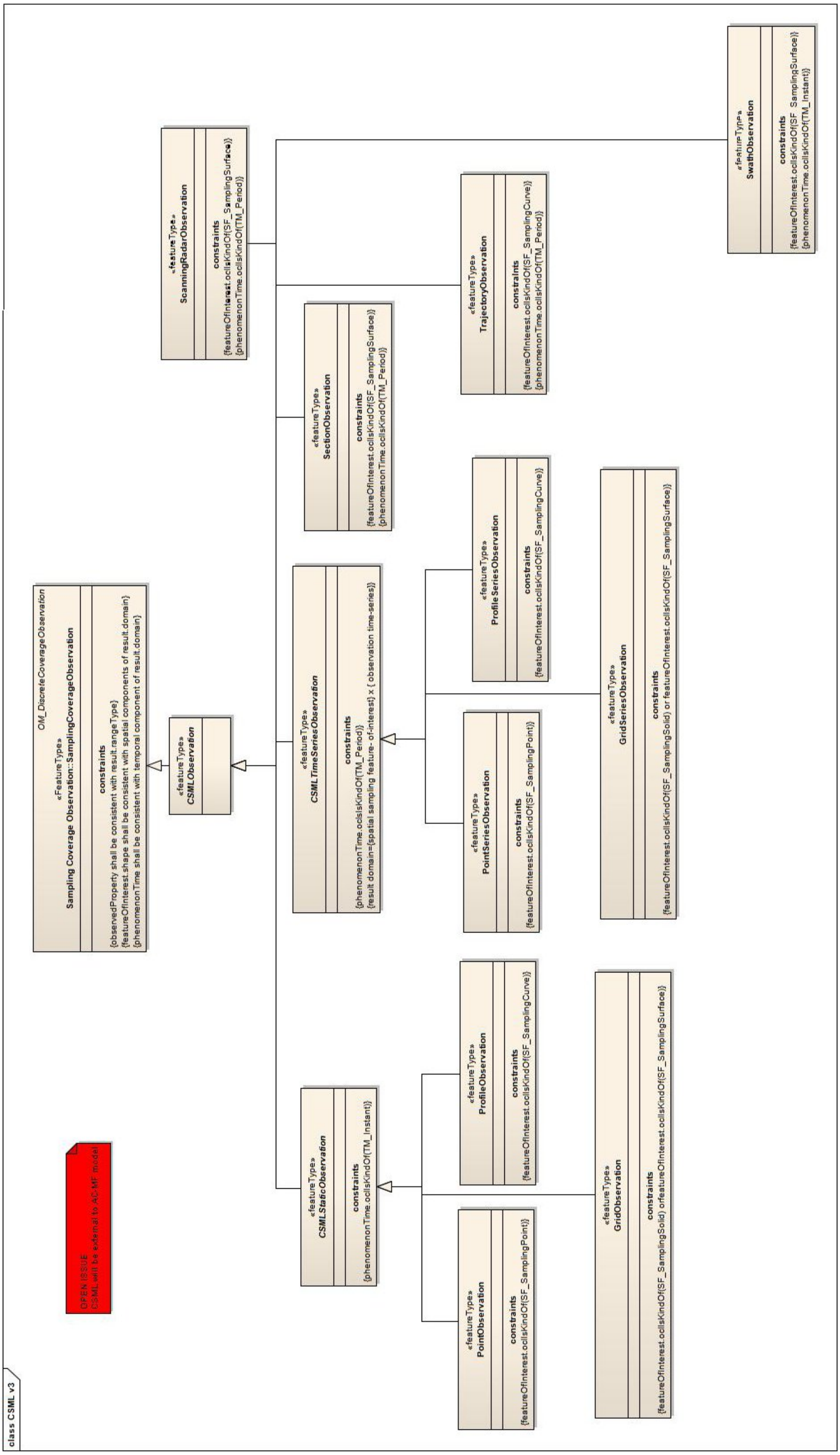


Figure 7: Sampling Coverage Observation model



class CSML v3
OM_DiscreteCoverageObservation
«FeatureType»
Sampling Coverage Observation::SamplingCoverageObservation
constraints
{observedProperty shall be consistent with result.rangeType}
{featureOfInterest.shape shall be consistent with spatial components of result.domain}
{phenomenonTime shall be consistent with temporal component of result.domain}
«featureType»
CSMLObservation
«featureType»
ScanningRadarObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingSurface)}
{phenomenonTime.oclIsKindOf(TM_Period)}
«featureType»
SwathObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingSurface)}
{phenomenonTime.oclIsKindOf(TM_Instant)}
«featureType»
TrajectoryObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingCurve)}
{phenomenonTime.oclIsKindOf(TM_Period)}
«featureType»
SectionObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingSurface)}
{phenomenonTime.oclIsKindOf(TM_Period)}
«featureType»
CSMLTimeSeriesObservation
constraints
{phenomenonTime.oclIsKindOf(TM_Period)}
{result domain=(spatial sampling feature-of-interest) x (observation time-series)}
«featureType»
ProfileSeriesObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingCurve)}
«featureType»
PointSeriesObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingPoint)}
«featureType»
GridSeriesObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingSolid) or featureOfInterest.oclIsKindOf(SF_SamplingSurface)}
«featureType»
CSMLStaticObservation
constraints
{phenomenonTime.oclIsKindOf(TM_Instant)}
«featureType»
ProfileObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingCurve)}
«featureType»
PointObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingPoint)}
«featureType»
GridObservation
constraints
{featureOfInterest.oclIsKindOf(SF_SamplingSolid) orfeatureOfInterest.oclIsKindOf(SF_SamplingSurface)}
OPEN ISSUE
CSML will be external to AC-MF model

Figure 8: CSML observation types

5.2.1.4. Consistency between spatial data sets

Not relevant for AC-MF

5.2.1.5. Identifier management

Open issue 5: Is there a need to include to management of other identifiers (e.g. WMO station number, ICAO airport codes, etc)?

5.2.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue AC-MF
Scope	AC-MF
Version number	2.0
Version date	2011-06-21
Definition source	INSPIRE data specification AC-MF

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
AbstractObservableProperty	ObservableProperty	«dataType»	5.2.2.2.1
AtmosphericCondition	AtmosphericCondition	«featureType»	5.2.2.1.1
AtmosphericConditionProcess	AtmosphericConditionProcess	«featureType»	5.2.2.1.2
CSMLObservation	CSML v3	«featureType»	5.2.2.1.3
CSMLStaticObservation	CSML v3	«featureType»	5.2.2.1.4
CSMLTimeSeriesObservation	CSML v3	«featureType»	5.2.2.1.5
CompositeObservableProperty	ObservableProperty	«dataType»	5.2.2.2.2
GridObservation	CSML v3	«featureType»	5.2.2.1.6
GridSeriesObservation	CSML v3	«featureType»	5.2.2.1.7
ObservablePropertyConstraint	ObservableProperty	«dataType»	5.2.2.2.3
ObservablePropertyValue	ObservableProperty	«codeList»	5.2.2.3.1
PointObservation	CSML v3	«featureType»	5.2.2.1.8
PointSeriesObservation	CSML v3	«featureType»	5.2.2.1.9
ProfileObservation	CSML v3	«featureType»	5.2.2.1.10
ProfileSeriesObservation	CSML v3	«featureType»	5.2.2.1.11
ScanningRadarObservation	CSML v3	«featureType»	5.2.2.1.12
SectionObservation	CSML v3	«featureType»	5.2.2.1.13
SimpleObservableProperty	ObservableProperty	«dataType»	5.2.2.2.4
SwathObservation	CSML v3	«featureType»	5.2.2.1.14
TrajectoryObservation	CSML v3	«featureType»	5.2.2.1.15

5.2.2.1. Spatial object types

5.2.2.1.1. AtmosphericCondition

AtmosphericCondition

AtmosphericCondition	
Definition:	An identifiable set of estimated values, and their semantics, of a number of atmospheric phenomena.
Description:	A set of estimated values of a range of atmospheric phenomena, generated by Atmospheric Condition's observation members, describing the state of the atmosphere over a spatiotemporal extent. NOTE The estimated values are based on measurements, on models or on a combination. EXAMPLE Measured values of air temperature, pressure and relative humidity.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: extent	
Value type:	EX_Extent
Definition:	Information about the spatial and temporal extent of AtmosphericCondition.
Multiplicity:	1
Attribute: inspireId	
Value type:	Identifier
Definition:	External object identifier.
Multiplicity:	1
Association role: member	
Value type:	OM_Observation
Definition:	Member of Atmospheric Condition
Multiplicity:	1..*
Constraint: member.parameter.namedValue.name=AtmosphericConditionProcess.processparameter	
Natural language:	inv: member.forAll(o:OM_Observation | o.parameter.namedValue.name=o.procedure.processParameter.head())
Constraint: For all observation members the resultQuality.DQ_Element.result shall be of type DQ_ConformanceRresult	
Natural language:	inv: member.forAll(s:OM_Observation | s.resultQuality.dq_Element.result.oclIsTypeOf(DQ_ComformanceResult))

5.2.2.1.2. AtmosphericConditionProcess

AtmosphericConditionProcess	
Subtype of:	OM_Process
Definition:	Method, algorithm or instrument, or system of these, which may be used in making an observation.
Description:	SOURCE [ISO 19156:2011] NOTE 1 An instance of Atmospheric condition process might consist of more than one components in order to generate the observation result, e.g. component1: instrument , component2: numerical processing of primitive instrument output. NOTE 2 An instance of Atmospheric condition process might be responsible for more than one observation events e.g. a radiometer.
Status:	Proposed
Stereotypes:	«featureType»

AtmosphericConditionProcess

URI: null

Attribute: documentation

Value type: CI_Citation
Definition: Document(s) providing further information associated with the atmospheric condition process .
Multiplicity: 0..*
Stereotypes: «voidable»

Attribute: inspireId

Value type: Identifier
Definition: External object identifier by which an instance of atmospheric condition process is known.
Multiplicity: 1
Stereotypes: «voidable»

Attribute: processParameter

Value type: GenericName
Definition: Name or other identifier of a parameter controlling the application of the process and as a consequence its output.
Description: Typical examples of using processParameter are: description of instrumentation settings for a specific measurement or measurement series ; description of intial contidions in numerical computations e.g. simulations.

NOTE The values of a procesParameter are stored in OM_Observation.parameter>NamedValue.value as they are specific to the event of the observation and not to the applied process .

EXAMPLE 1 For information resulting from a numerical simulation process:
- the analysis time is represented by the OM_Observation attribute *parameter:NamedValue* with name= AnalysisTime (TM_Instant)
- the assimilation window is represented by the OM_Observation attribute *parameter:NamedValue* with name= AssimilationWindow (TM_Period).

EXAMPLE 2 Analysis time of a forecast

- Instance of AtmosphericConditionProcess

AtmosphericConditionProcess.processParameter:
http://inspire.jrc.ec.europa.eu/inspire/processParameterValue.html#AnalysisTime
Instance of OM_Observation
OM_OObservation.parameter>NamedValue.name:
http://inspire.jrc.ec.europa.eu/inspire/processParameterValue.html#AnalysisTime
OM_Observation.parameter>NamedValue.value:
00z-15/05/2011
Multiplicity: 0..*
Stereotypes: «voidable»

Attribute: responsibleParty

Value type: CI_ResponsibleParty
Definition: Individual or organisation related to atmospheric condition process.
Description: EXAMPLE For a numerical simulation a responsible party may be the NWP centre which conducted the simulation.

AtmosphericConditionProcess

Multiplicity:	1..*
Stereotypes:	«voidable»

Attribute: type

Value type:	CharacterString
Definition:	Type of process.
Description:	EXAMPLE raingauge, numerical model.
Multiplicity:	1
Stereotypes:	«voidable»

5.2.2.1.3. CSMLObservation

CSMLObservation (abstract)

Subtype of:	SamplingCoverageObservation
Definition:	A base abstract observation class to provide a common root for domain-specific met/ocean sampling coverage observations.
Description:	SOURCE [OGC pending document 11-021] NOTE CSMLObservation adds nothing to the semantics of the Sampling Coverage(ISO/DIS 19156) from which it derives.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

5.2.2.1.4. CSMLStaticObservation

CSMLStaticObservation (abstract)

Subtype of:	CSMLObservation
Definition:	A base absract observation class for sampling coverage observations which (may be considered to be) made at an instant in time.
Description:	SOURCE [OGC pending document 11-021]
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Constraint: phenomenonTime.oclIsKindOf(TM_Instant)

Natural language:	

5.2.2.1.5. CSMLTimeSeriesObservation

CSMLTimeSeriesObservation (abstract)

Subtype of:	CSMLObservation
Definition:	A base absract observation class for observations made repeatedly on a spatial sampling feature, generating a time-series result.
Description:	SOURCE [OGC pending document 11-021] NOTE Mathematically, the spatiotemporal domain of the coverage result is the direct product of the discrete spatial sampling locations and the time-series observation times.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Constraint: phenomenonTime.oclsIsKindOf(TM_Period)

CSMLTimeSeriesObservation (abstract)	
Natural language:	
Constraint: result domain={spatial sampling feature- of-interest} x { observation time-series}	
Natural language:	

5.2.2.1.6. GridObservation

GridObservation	
Subtype of:	CSMLStaticObservation
Definition:	A CSML static observsation representing a gridded field at a single time instant.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML grid observation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a two- or three-dimensional grid of points, all having the same time instant temporal component. EXAMPLE Midnight atmospheric surface pressure field analysed on a grid.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingSolid) orfeatureOfInterest.oclIsKindOf(SF_SamplingSurface)	
Natural language:	

5.2.2.1.7. GridSeriesObservation

GridSeriesObservation	
Subtype of:	CSMLTimeSeriesObservation
Definition:	A CSML time series observation representing an evolving gridded field at a succession of time instants.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML grid series observation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a series of two- or three-dimensional grids of points, each at a successive time instant. EXAMPLE Time-series of three-dimensional oceanic velocity field from a finite-difference general circulation model.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingSolid) or featureOfInterest.oclIsKindOf(SF_SamplingSurface)	
Natural language:	

5.2.2.1.8. PointObservation

PointObservation	
Subtype of:	CSMLStaticObservation

PointObservation	
Definition:	A CSML static observsation that represents a measurement of a property at a single point in time and space.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML point observation is a discrete coverage having a domain of a single point within a compound spatiotemporal CRS. EXAMPLE Single raingauge precipitation measurement.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingPoint)	
Natural language:	

5.2.2.1.9. PointSeriesObservation

PointSeriesObservation	
Subtype of:	CSMLTimeSeriesObservation
Definition:	A CSML time series observsation that represents a time-series of point measurements of a property at a fixed location in space.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML point series observation is a discrete coverage within a spatiotemporal CRS, with a series of domain elements at a fixed spatial point location but with temporal components corresponding to the series of sampling times. EXAMPLE Time-series of daily raingauge precipitation measurements.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingPoint)	
Natural language:	

5.2.2.1.10. ProfileObservation

ProfileObservation	
Subtype of:	CSMLStaticObservation
Definition:	A CSML static observsation that represents a single instantaneous 'profile' of a property along a vertical line in space.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML profile observation is a discrete coverage with respective domain elements having the same temporal component (the instantaneous sampling time) and spatial locations laid out along the sampling curve. EXAMPLE Expendable bathythermograph observation of seawater tempearature.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

ProfileObservation
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingCurve)
Natural language:

5.2.2.1.11. ProfileSeriesObservation

ProfileSeriesObservation	
Subtype of:	CSMLTimeSeriesObservation
Definition:	A CSML time series observsation representing a time-series of vertical profiles at a fixed horizontal location.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML profile series observation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of sets of points, or 'profiles', each profile aligned along the same vertical curve, and at a specific sampling time. The sampling times of successive profiles forms a time-series. EXAMPLE Radar wind profiler measurement
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingCurve)	
Natural language:	

5.2.2.1.12. ScanningRadarObservation

ScanningRadarObservation	
Subtype of:	CSMLObservation
Definition:	A CSML observsation measuring a set of backscatter profiles along a radar look direction rotating in azimuth at fixed elevation.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML scanning radar observation is a discrete gridded coverage within a compound spatiotemporal CRS, using the radar's azimuth-elevation axes as the spatial coordinate system. As well, successive columns of the grid have a temporal component increasing with the radar scan rotation. EXAMPLE Weather radar.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingSurface)	
Natural language:	
Constraint: phenomenonTime.oclIsKindOf(TM_Period)	
Natural language:	

5.2.2.1.13. SectionObservation

SectionObservation

SectionObservation	
Subtype of:	CSMLObservation
Definition:	A CSML observsation comprising a series of profiles topologically offset from a trajectory.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML section observation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a set of profiles (usually vertical) arranged along the trajectory path of a ship or aircraft (normally). EXAMPLE Vertical profiles of water current measurements taken by an acoustic doppler current profiler towed along a ship's track
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingSurface)	
Natural language:	
Constraint: phenomenonTime.oclIsKindOf(TM_Period)	
Natural language:	

5.2.2.1.14. SwathObservation

SwathObservation	
Subtype of:	CSMLObservation
Definition:	A CSML observsation providing a two-dimensional surface grid along a satellite ground path.
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML swath observation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a quadrilateral grid in the horizontal, but with a varying time along the central ground-path axis.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingSurface)	
Natural language:	
Constraint: phenomenonTime.oclIsKindOf(TM_Instant)	
Natural language:	

5.2.2.1.15. TrajectoryObservation

TrajectoryObservation	
Subtype of:	CSMLObservation
Definition:	A CSML observsation representing measurement of a property along a meandering curve in time and space.

TrajectoryObservation	
Description:	SOURCE [OGC pending document 11-021] NOTE The result of a CSML trajectory observation is a discrete coverage within a compound spatiotemporal CRS where the domain consists of a set of points associated with successive sampling times and located along the trajectory path. EXAMPLE Pollutant concentration from mobile air quality sensor.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: featureOfInterest.oclIsKindOf(SF_SamplingCurve)	
Natural language:	
Constraint: phenomenonTime.oclIsKindOf(TM_Period)	
Natural language:	

5.2.2.2. Data types

5.2.2.2.1. AbstractObservableProperty

AbstractObservableProperty (abstract)	
Definition:	Generalisation of more specific observable property classes: simple observable property, composite observable property.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: description	
Value type:	CharacterString
Definition:	Human readble description of AbstractObservableProperty.
Multiplicity:	0..1
Attribute: label	
Value type:	CharacterString
Definition:	Human readable name by which an instance of AbsractObservableProperty is known.
Description:	EXAMPLE label can be: rain rate or rainfall rate whereas basePhenomenon shall be :precipitationIntensity.
Multiplicity:	0..*
Association role:	
Value type:	GF_PropertyType
Multiplicity:	

5.2.2.2.2. CompositeObservableProperty

CompositeObservableProperty	
Subtype of:	AbstractObservableProperty
Definition:	Observable property consisting of two or more simple observable properties.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null

CompositeObservableProperty	
Association role: component	
Value type:	SimpleObservableProperty
Multiplicity:	2..*

5.2.2.2.3. ObservablePropertyConstraint

ObservablePropertyConstraint	
Definition:	Description of further detail for an instance of SimpleObservableProperty required when the description provided by the codelist PropertyCode is not sufficient.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: description	
Value type:	CharacterString
Definition:	Meaning added to an instance of SimpleObsrvableProperty by the value of attribute label.
Multiplicity:	0..1
Attribute: label	
Value type:	CharacterString
Definition:	Text added to the name of an instance of SimpleObservableProperty.
Multiplicity:	1
Association role: subConstraint	
Value type:	ObservablePropertyConstraint
Multiplicity:	0..*

5.2.2.2.4. SimpleObservableProperty

SimpleObservableProperty	
Subtype of:	AbstractObservableProperty
Definition:	Observable property which cannot split into components.
Description:	EXAMPLE temperature, total cloud cover, wind direction.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: basePhenomenon	
Value type:	ObservablePropertyValue
Definition:	Name of a simple observable property from a controlled vocabulary.
Description:	EXAMPLE snow depth, precipitation type etc.
Multiplicity:	1
Attribute: constraint	
Value type:	ObservablePropertyConstraint
Definition:	If present, it shall provide further detail required for an instance of the SimpleObservableProperty.

SimpleObservableProperty	
Description:	NOTE It is used when a description of an instance of SimpleObservableProperty from the codelist ObservablePropertyValue is not sufficient. EXAMPLE For an observation of time series of daily maximum temperature: • basePhenomenon>temperature • constraint>ObservablePropertyConstraint.label>Daily maximum • constraint>ObservablePropertyConstraint.description>Maximum temperature recorded for each day.
Multiplicity:	0..1

5.2.2.3. Code lists

5.2.2.3.1. ObservablePropertyValue

ObservablePropertyValue	
Definition:	Name of basePhenomenon.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	
Value: evaporationAmount	
Value: precipitationAmount	
Value: precipitationRate	
Value: precipitationType	
Value: pressureReducedToMSL	
Value: relativeHumidity	
Value: snowDepth	
Value: temperature	
Value: totalCloudCover	

ObservablePropertyValue
Value: windDirection
Value: windSpeed
Value: windSpeedGust

5.2.2.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.2.2.4.1. CI_Citation

CI_Citation	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19115:2006 Metadata (Corrigendum)::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.2. CI_ResponsibleParty

CI_ResponsibleParty	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19115:2006 Metadata (Corrigendum)::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.3. CharacterString

CharacterString	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Primitive::Text [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.4. EX_Extent

EX_Extent	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19115:2006 Metadata (Corrigendum)::Extent information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.5. GenericName

GenericName (abstract)	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Implementation::Names [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.6. Identifier

Identifier

Identifier	
Package:	INSPIRE Consolidated UML MOdel::Generic Conceptual Model::Base Types [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object.
Description:	NOTE1 External object identifiers are distinct from thematic object identifiers. NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.2.2.4.7. OM_Observation

OM_Observation	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO FDIS 19156:2011 Observations and Measurements::Observation schema::observation [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.8. OM_Process

OM_Process (abstract)	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO FDIS 19156:2011 Observations and Measurements::Observation schema::observation [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.2.2.4.9. SamplingCoverageObservation

SamplingCoverageObservation	
Package:	INSPIRE Consolidated UML MOdel::Foundation Schemas::ISO TC211::ISO 19156 Observations and Measurements::ISO FDIS 19156:2011 Observations and Measurements::Sampling Coverage Observation [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

6 Reference systems

6.1 Coordinate reference systems

6.1.1 Datum

IR Requirement 3 For the coordinate reference systems used for making available the INSPIRE spatial data sets, the datum shall be the datum of the European Terrestrial Reference System 1989 (ETRS89) in areas within its geographical scope, and the datum of the International Terrestrial Reference System (ITRS) or other geodetic coordinate reference systems compliant with ITRS in areas that are outside the geographical scope of ETRS89. Compliant with the ITRS means that the system definition is based on the definition of the ITRS and there is a well established and described relationship between both systems, according to EN ISO 19111.

6.1.2 Coordinate reference systems

IR Requirement 4 INSPIRE spatial data sets shall be made available using one of the three-dimensional, two-dimensional or compound coordinate reference systems specified in the list below.

Other coordinate reference systems than those listed below may only be used for regions outside of continental Europe. The geodetic codes and parameters for these coordinate reference systems shall be documented, and an identifier shall be created, according to EN ISO 19111 and ISO 19127.

1. Three-dimensional Coordinate Reference Systems
   – Three-dimensional Cartesian coordinates
   – Three-dimensional geodetic coordinates (latitude, longitude and ellipsoidal height), using the parameters of the GRS80 ellipsoid

2. Two-dimensional Coordinate Reference Systems
   – Two-dimensional geodetic coordinates, using the parameters of the GRS80 ellipsoid
   – Plane coordinates using the Lambert Azimuthal Equal Area projection and the parameters of the GRS80 ellipsoid
   – Plane coordinates using the Lambert Conformal Conic projection and the parameters of the GRS80 ellipsoid
   – Plane coordinates using the Transverse Mercator projection and the parameters of the GRS80 ellipsoid

3. Compound Coordinate Reference Systems
   – For the horizontal component of the compound coordinate reference system, one of the two-dimensional coordinate reference systems specified above shall be used
   – For the vertical component on land, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights within its geographical scope
   – Other vertical reference systems related to the Earth gravity field shall be used to express gravity-related heights in areas that are outside the geographical scope of EVRS. The geodetic codes and parameters for these vertical reference systems shall be documented and an identifier shall be created, according to EN ISO 19111 and ISO 19127
   – For the vertical component measuring the depth of the sea floor, where there is an appreciable tidal range, the Lowest Astronomical Tide shall be used as reference surface. In marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200 m, the depth of the sea floor shall be referenced to the Mean Sea Level
   – For the vertical component measuring depths above the sea floor in the free ocean, barometric pressure shall be used
   – For the vertical component in the free atmosphere, barometric pressure, converted to height using ISO 2533:1975 International Standard Atmosphere shall be used

6.1.3 Display

IR Requirement 5 For the display of the INSPIRE spatial data sets with the View Service specified in D003152/02 Draft Commission Regulation implementing Directive 2007/2/EC of the European Parliament and of the Council as regards Network Services, at least the two dimensional geodetic coordinate system shall be made available.

6.1.4 Identifiers for coordinate reference systems

IR Requirement 6 For referring to the non-compound coordinate reference systems listed in this Section, the identifiers listed below shall be used.

For referring to a compound coordinate reference system, an identifier composed of the identifier of the horizontal component, followed by a slash (/), followed by the identifier of the vertical component, shall be used.

- ETRS89-XYZ for Cartesian coordinates in ETRS89
- ETRS89-GRS80h for three-dimensional geodetic coordinates in ETRS89 on the GRS80 ellipsoid
- ETRS89-GRS80 for two-dimensional geodetic coordinates in ETRS89 on the GRS80
- EVRS for height in EVRS
- LAT for depth of the sea floor, where there is an appreciable tidal range
- MSL for depth of the sea floor, in marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200m
- ISA for pressure coordinate in the free atmosphere
- PFO for Pressure coordinate in the free ocean
- ETRS89-LAEA for ETRS89 coordinates projected into plane coordinates by the Lambert Azimuthal Equal Area projection
- ETRS89-LCC for ETRS89 coordinates projected into plane coordinates by the Lambert Conformal Conic projection
- ETRS89-TMzn for ETRS89 coordinates projected into plane coordinates by the Transverse Mercator projection

6.2 Temporal reference system

IR Requirement 7 The Gregorian Calendar shall be used for as a reference system for date values, and the Universal Time Coordinated (UTC) or the local time including the time zone as an offset from UTC shall be used as a reference system for time values.

6.3 Theme-specific requirements and recommendations on reference systems

Other horizontal and vertical coordinate reference systems than those listed above may only be used for data sets containing data with position outside the continental Europe. The geodetic codes and parameters for these coordinate reference systems shall be documented, and an identifier shall be created, according to EN ISO 19111 and ISO 19127. Note: WGS-84 has been proposed as a the primary reference for horizontal positioning within WMO [WMO ET-SAT-6].
The justifications for extending vertical coordinate reference systems are:

- Meteorological observed properties vary greatly close to the ground. Converted to heights using ISO 2533:1975 International Standard Atmosphere lack the precision for e.g. altitude of wind speed data near ground level. WMO code tables support altitude above ground.

- The original list of vertical coordinates reference systems refer to free atmosphere where the effect of the surface is neglible. However, many meteorological data sets contain data for altitudes where the effects of surface fluxes cannot be ignored. WMO code tables apply also to data that are below the free atmosphere.
- Some applications require data sets with vertical component expressed with hybrid-levels or pressure-levels rather than altitude/height. Without those, data ingestion becomes more complex for e.g. atmospheric transport models and other environmental models that operate directly on hybrid level data. Here, WMO code tables support hybrid level data.
- Plotting of meteorological charts often requires pressure-levels rather than converted altitudes. WMO code tables support all commonly used vertical discretization schemes.

Some data sets describe atmospheric phenomena, e.g. cloud cover, with no precise altitude information. WMO code tables handle this.

<u>Units</u>
Only units from the International System of Units (S.I.) are to be used for the delivery of atmospheric data, following the established practice within WMO.

IR Requirement 8	The International System of Units (S.I.) shall be used as the reference system for atmospheric information

7 Data quality

This chapter includes a description of data quality elements and sub-elements as well as the associated data quality measures (section 0). The selected data quality measures should be used to evaluate quality of data sets for a specific data quality element / sub-element. The evaluation can be performed at the level of spatial object, spatial object type, dataset or dataset series.

The results of the evaluation are then reported at the spatial object type or dataset level in metadata utilising the same data quality elements and measures (see chapter 8).

NOTE The selection of appropriate data quality measures represents the first step towards the harmonisation of documenting data quality.

In addition, for some of the data quality elements described in section 0, minimum data quality requirements or recommendations may be defined. These are described in the section 1.2.

Recommendation 1	If data quality information is required at spatial object level then it should be modelled in the data model as an attribute of a relevant spatial object type.

Meteorological measurements compliant with WMO regulations go through operational procedures:
(a) To ensure the best possible quality of the data which are used in the real-time operations;
(b) In non-real time, to protect and improve the quality and integrity of data destined for storage and retrieval;
(c) To provide the basis for feedback of information on errors and questionable data to the source of the data.

Minimum standards for quality control of data apply to all WMO operational centres (cf. Manual on the Global Data-processing and Forecasting System, WMO-No. 485).
They include quality control at various stages of processing. They apply to both real-time and non-real-time processing and lead to various records of quality-control actions.
Checking includes:

- Detection of missing data at centres
- Adherence to prescribed coding formats

- Internal consistency
- Time consistency
- Space consistency
- Physical and climatological limits

Records to be maintained include:

- Information to identify source of data such as station, aircraft, ship
- Type of deficiency (nonreceipt, incomplete or incorrect reports, etc.)
- Identification of deficient element (whole report, specific parameter, etc.)
- Frequency of occurrence of data deficiencies (according to station type and element)

In non real time, checking includes in addition:

- Review of recorded data in comparison with observations
- Inter-comparison of parameters and calculations
- Check of supplementary data
- Check of extreme values

Similarly, numerical model output go through thorough and systematic evaluation and quality assessment. Standard procedures have been developed for the production and exchange of verification results.

The question of the quality of meteorological data is closely related to its representativity. Depending on the way in which it is generated, the representativity of meteorological data can vary to a very large extent:

- in space:
  - o local representativity, ranging from a few m2 to a few km2 at most over very homogeneous terrain
  - o wider area representativity, over up to ~103 km2 or even more
- in time:
  - o so-called instantaneous data (i.e. a few seconds)
  - o average (or other statistical combinations) over periods of hours, days, months etc.

Local data come from in-situ measurements and are available only at the locations of observing sites; area representative data come mainly from

- numerical models, available everywhere
- and remote-sensing (satellite based or not).

7.1 Data quality elements and measures

No data quality elements for quantitative evaluation are defined for this theme.

7.2 Minimum data quality requirements and recommendations

No minimum data quality requirements are defined.

No minimum data quality recommendations are defined.

8 Dataset-level metadata

Metadata can be reported for each individual spatial object (spatial object-level metadata) or once for a complete dataset or dataset series (dataset-level metadata). Spatial object-level metadata is fully described in the application schema (section **5**). If data quality elements are used at spatial object level, the documentation shall refer to the appropriate definition in section 7. This section only specifies dataset-level metadata elements.

For some dataset-level metadata elements, in particular on data quality and maintenance, a more specific scope can be specified. This allows the definition of metadata at sub-dataset level, e.g. separately for each spatial object type. When using ISO 19115/19139 to encode the metadata, the following rules should be followed:

- The scope element (of type DQ_Scope) of the DQ_DataQuality subtype should be used to encode the scope.
- Only the following values should be used for the level element of DQ_Scope: Series, Dataset, featureType.
- If the level is featureType the levelDescription/MDScopeDescription/features element (of type Set< GF_FeatureType>) shall be used to list the feature type names.

NOTEThe value featureType is used to denote spatial object type.

Mandatory or conditional metadata elements are specified in Section 8.1. Optional metadata elements are specified in Section 8. The tables describing the metadata elements contain the following information:

- The first column provides a reference to a more detailed description.
- The second column specifies the name of the metadata element.
- The third column specifies the multiplicity.
- The fourth column specifies the condition, under which the given element becomes mandatory (only for Table 2 and Table 3).

8.1 Common metadata elements

IR Requirement 9 The metadata describing a spatial data set or a spatial data set series related to the theme **Atmospheric Conditions and Meteorological Geographical** Features shall comprise the metadata elements required by Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata) for spatial datasets and spatial dataset series (Table 2) as well as the metadata elements specified in Table 3.

Table 2 – Metadata for spatial datasets and spatial dataset series specified in Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata)

Metadata Regulation Section	Metadata element	Multiplicity	Condition
1.1	Resource title	1	
1.2	Resource abstract	1	
1.3	Resource type	1	

1.4	Resource locator	0..*	Mandatory if a URL is available to obtain more information on the resource, and/or access related services.
1.5	Unique resource identifier	1..*	
1.7	Resource language	0..*	Mandatory if the resource includes textual information.
2.1	Topic category	1..*	
3	Keyword	1..*	
4.1	Geographic bounding box	1..*	
5	Temporal reference	1..*	
6.1	Lineage	1	
6.2	Spatial resolution	0..*	Mandatory for data sets and data set series if an equivalent scale or a resolution distance can be specified.
7	Conformity	1..*	
8.1	Conditions for access and use	1..*	
8.2	Limitations on public access	1..*	
9	Responsible organisation	1..*	
10.1	Metadata point of contact	1..*	
10.2	Metadata date	1	
10.3	Metadata language	1	

Table 3 – Mandatory and conditional common metadata elements

INSPIRE Data Specification Atmospheric Conditions and Meteorological Geographical **Features Section**	**Metadata element**	**Multiplicity**	**Condition**
8.1.1	Coordinate Reference System	1	
8.1.2	Temporal Reference System	0..*	Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time.
8.1.3	Encoding	1..*	

8.1.4	Character Encoding	0..*	Mandatory, if an encoding is used that is not based on UTF-8.
8.1.5	Data Quality – Logical Consistency – Topological Consistency	0..*	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.

8.1.1 Coordinate Reference System

Metadata element name	Coordinate Reference System
Definition	Description of the coordinate reference system used in the dataset.
ISO 19115 number and name	13. referenceSystemInfo
ISO/TS 19139 path	referenceSystemInfo
INSPIRE obligation / condition	mandatory
INSPIRE multiplicity	1
Data type(and ISO 19115 no.)	189. MD_CRS
Domain	Either the referenceSystemIdentifier (RS_Identifier) or the projection (RS_Identifier), ellipsoid (RS_Identifier) and datum (RS_Identifier) properties shall be provided. NOTE More specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: ETRS_89 codeSpace: INSPIRE RS registry
Example XML encoding	<gmd:referenceSystemInfo> <gmd:MD_ReferenceSystem> <gmd:referenceSystemIdentifier> <gmd:RS_Identifier> <gmd:code> <gco:CharacterString>ETRS89 </gco:CharacterString> </gmd:code> <gmd:codeSpace> <gco:CharacterString>INSPIRE RS registry</gco:CharacterString> </gmd:codeSpace> </gmd:RS_Identifier> </gmd:referenceSystemIdentifier> </gmd:MD_ReferenceSystem> </gmd:referenceSystemInfo>
Comments	

8.1.2 Temporal Reference System

Metadata element name	Temporal Reference System
Definition	Description of the temporal reference systems used in the dataset.
ISO 19115 number and name	13. referenceSystemInfo
ISO/TS 19139 path	referenceSystemInfo

INSPIRE obligation / condition	Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time.
INSPIRE multiplicity	0..*
Data type(and ISO 19115 no.)	186. MD_ReferenceSystem
Domain	No specific type is defined in ISO 19115 for temporal reference systems. Thus, the generic MD_ReferenceSystem element and its reference SystemIdentifier (RS_Identifier) property shall be provided. NOTE More specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: GregorianCalendar codeSpace: INSPIRE RS registry
Example XML encoding	<gmd:referenceSystemInfo> <gmd:MD_ReferenceSystem> <gmd:referenceSystemIdentifier> <gmd:RS_Identifier> <gmd:code> <gco:CharacterString>GregorianCalendar</gco:CharacterString> </gmd:code> <gmd:codeSpace> <gco:CharacterString>INSPIRE RS registry</gco:CharacterString> </gmd:codeSpace> </gmd:RS_Identifier> </gmd:referenceSystemIdentifier> </gmd:MD_ReferenceSystem> </gmd:referenceSystemInfo>
Comments	

8.1.3 Encoding

Metadata element name	**Encoding**
Definition	Description of the computer language construct that specifies the representation of data objects in a record, file, message, storage device or transmission channel
ISO 19115 number and name	271. distributionFormat
ISO/TS 19139 path	distributionInfo/MD_Distribution/distributionFormat
INSPIRE obligation / condition	mandatory
INSPIRE multiplicity	1
Data type (and ISO 19115 no.)	284. MD_Format
Domain	See B.2.10.4. The property values (name, version, specification) specified in section 9 shall be used to document the default and alternative encodings.
Implementing instructions	

Example	name: **Atmospheric Conditions and Meteorological Geographical** Features GML application schema version: version **2.0**, GML, version 3.2.1 specification: D2.8.**III.13-14** Data Specification on **Atmospheric Conditions and Meteorological Geographical** Features – Draft Guidelines
Example XML encoding	<gmd:MD_Format> <gmd:name> <gco:CharacterString> **Atmospheric Conditions and Meteorological Geographical** Features GML application schema </gco:CharacterString> </gmd:name> <gmd:version> <gco:CharacterString>**2.0**, GML, version 3.2.1</gco:CharacterString> </gmd:version> <gmd:specification> <gco:CharacterString>D2.8.**III.13-14** Data Specification on **Atmospheric Conditions and Meteorological Geographical** Features – Draft Guidelines</gco:CharacterString> </gmd:specification> </gmd:MD_Format>
Comments	

8.1.4 Character Encoding

Metadata element name	**Character Encoding**
Definition	The character encoding used in the data set.
ISO 19115 number and name	
ISO/TS 19139 path	
INSPIRE obligation / condition	Mandatory, if an encoding is used that is not based on UTF-8.
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	
Domain	
Implementing instructions	
Example	-
Example XML encoding	<gmd:characterSet> <gmd:MD_CharacterSetCode codeListValue="8859part2" codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/ML_gmxCodelists.xml#CharacterSetCode">8859-2</gmd:MD_CharacterSetCode> </gmd:characterSet>
Comments	

8.1.5 Data Quality – Logical Consistency – Topological Consistency

Metadata element name	**Data Quality – Logical Consistency – Topological Consistency**
Definition	Correctness of the explicitly encoded topological characteristics of the dataset as described by the scope
ISO 19115 number and name	18. dataQualityInfo
ISO/TS 19139 path	dataQualityInfo

INSPIRE obligation / condition	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	115. DQ_TopologicalConsistency
Domain	Lines 100-107 from ISO 19115
Implementing instructions	This metadata should be filled, at least, with these elements: - valueUnit: UnitOfMeasure - value: Record
Example	
Example XML encoding	
Comments	See clauses on topological consistency in section 7 for detailed information. This metadata element is mandatory if connectivity is not assured for network centrelines in the dataset. In this case the *Connectivity tolerance* parameter – as described in section 7 – must be provided in order to ensure automatic and unambiguous creation of centreline topology in post-process.

8.2 Metadata elements for reporting data quality

Recommendation 2 For reporting the results of the data quality evaluation quantitatively, the data quality elements and measures defined in chapter 7 should be used.

The scope for reporting may be different from the scope for evaluating data quality (see section 7). If data quality is reported at the data set or spatial object type level, the results are usually derived or aggregated.

Metadata element name	**See chapter 7**
Definition	See chapter 7
ISO 19115 number and name	80. report
ISO/TS 19139 path	dataQualityInfo/*/report
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	Corresponding DQ_xxx element from ISO 19115, e.g. 109. DQ_CompletenessCommission
Domain	Lines 100-107 from ISO 19115 100. nameOfMeasure : CharacterString [0..*] 101. measureIdentification : MD_Identifier [0..1] 102. measureDescription : CharacterString [0..1] 103. evaluationMethodType : DQ_EvaluationMethodTypeCode [0..1] 104. evaluationMethodDescription : CharacterString [0..1] 105. evaluationProcedure : CI_Citation [0..1] 106. dateTime : DateTime [0..*] 107. result : DQ_Result [1..2]

Implementing instructions	**Recommendation 3** For each DQ result included in the metadata, at least the following properties should be provided: 100. nameOfMeasure NOTE This should be the name as defined in Chapter 7. 103. evaluationMethodType 104. evaluationMethodDescription NOTE If the reported data quality results are derived or aggregated (i.e. the scope levels for evaluation and reporting are different), the derivation or aggregation should also be specified using this property. 106. dateTime NOTE This should be data or range of dates on which the data quality measure was applied. 107. result NOTE This should be of type DQ_QuantitativeResult
Example	
Example XML encoding	
Comments	See Chapter 7 for detailed information on the individual data quality elements and measures to be used.

Open issue 6: In the ongoing revision of ISO 19115 and development of new ISO 19157 standard (Geographic Information – Data quality), a new element is introduced (DQ_DescriptiveResult). This element enables to describe and report qualitative results of the data quality evaluation and could be used instead of DQ_QuantitativeResult. Once the new (version of the) standards are approved, these guidelines will be revisited and be updated if necessary.

Open issue 7: For reporting compliance with minimum data quality requirements and recommendations specified in section 7, the INSPIRE conformity metadata element should be used.

However, since this issue is part of the larger discussion on the Abstract Test Suite and the definition of conformance classes for the data specification, detailed instructions on how to provide metadata on compliance with minimum data quality requirements and recommendations will only be provided for v3.0.

8.3 Theme-specific metadata elements

No mandatory theme-specific metadata elements are defined for this theme.

No optional theme-specific metadata elements are defined for this theme.

8.4 Guidelines on using metadata elements defined in Regulation 1205/2008/EC

8.4.1 Conformity

The *Conformity* metadata element defined in Regulation 1205/2008/EC allows to report the conformance with the Implementing Rule for interoperability of spatial data sets and services or another specification. The degree of conformity of the dataset can be *Conformant* (if the dataset is fully conformant with the cited specification), *Not Conformant* (if the dataset does not conform to the cited specification) or *Not evaluated* (if the conformance has not been evaluated).

Recommendation 4 The Conformity metadata element should be used to report conceptual consistency with this INSPIRE data specification. The value of Conformant should be used for the Degree element only if the dataset passes all the requirements described in the abstract test suite presented in Annex A. The Specification element should be given as follows:
- title: "INSPIRE Data Specification on <Theme Name> – Draft Guidelines"
- date:
    - dateType: publication
    - date: 2011-06-20

Open issue 8: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

This may also lead to an update of the recommendations on how to fill the conformity metadata element.

8.4.2 Lineage

Recommendation 5 Following the ISO 19113 Quality principles, if a data provider has a procedure for quality validation of their spatial data sets then the data quality elements listed in the Chapters 7 and 8 should be used. If not, the *Lineage* metadata element (defined in Regulation 1205/2008/EC) should be used to describe the overall quality of a spatial data set.

According to Regulation 1205/2008/EC, lineage "is a statement on process history and/or overall quality of the spatial data set. Where appropriate it may include a statement whether the data set has been validated or quality assured, whether it is the official version (if multiple versions exist), and whether it has legal validity. The value domain of this metadata element is free text".

The Metadata Technical Guidelines based on EN ISO 19115 and EN ISO 19119 specify that the statement sub-element of LI_Lineage (EN ISO 19115) should be used to implement the lineage metadata element.

Recommendation 6 To describe the transformation steps and related source data, it is recommended to use the following sub-elements of LI_Lineage:
- For the description of the transformation process of the local to the common INSPIRE data structures, the LI_ProcessStep sub-element should be used.
- For the description of the source data the LI_Source sub-element should be used.

NOTE 1 This recommendation is based on the conclusions of the INSPIRE Data Quality Working Group to avoid overloading of the overall lineage statement element with information on the transformation steps and related source data.

NOTE 2 In order to improve the interoperability, domain templates and instructions for filling these free text elements (descriptions) may be specified in an Annex of this data specification.

Open issue 9: The suggested use of the LI_Lineage sub-elements needs to be discussed as part of the maintenance of the INSPIRE metadata Technical Guidelines.

8.4.3 Temporal reference

According to Regulation 1205/2008/EC, at least one of the following temporal reference metadata elements shall be provided: temporal extent, date of publication, date of last revision, date of creation. If feasible, the date of the last revision of a spatial data set should be reported using the *Date of last revision* metadata element.

9 Delivery

9.1 Delivery medium

DS Requirement 2	Data conformant to this INSPIRE data specification shall be made available through an INSPIRE network service.

DS Requirement 3	All information that is required by a calling application to be able to retrieve the data through the used network service shall be made available in accordance with the requirements defined in the Implementing Rules on Network Services.

EXAMPLE 1 Through the Get Spatial Objects function, a download service can either download a pre-defined data set or pre-defined part of a data set (non-direct access download service), or give direct access to the spatial objects contained in the data set, and download selections of spatial objects based upon a query (direct access download service). To execute such a request, some of the following information might be required:

- the list of spatial object types and/or predefined data sets that are offered by the download service (to be provided through the Get Download Service Metadata operation),
- and the query capabilities section advertising the types of predicates that may be used to form a query expression (to be provided through the Get Download Service Metadata operation, where applicable),
- a description of spatial object types offered by a download service instance (to be proviced through the Describe Spatial Object Types operation).

EXAMPLE 2 Through the Transform function, a transformation service carries out data content transformations from native data forms to the INSPIRE-compliant form and vice versa. If this operation is directly called by an application to transform source data (e.g. obtained through a download service) that is not yet conformant with this data specification, the following parameters are required:
Input data (mandatory). The data set to be transformed.

- Source model (mandatory, if cannot be determined from the input data). The model in which the input data is provided.
- Target model (mandatory). The model in which the results are expected.
- Model mapping (mandatory, unless a default exists). Detailed description of how the transformation is to be carried out.

9.2 Encodings

As stated in the guidelines for the encoding of spatial data [INSPIRE D2.7 3.0], there is no best practice solution for integration of meteorological data within a spatial data infrastructure. The data volume of meteorological and atmospheric datasets makes it impracticable to use XML-based encodings only. Two efficient code forms have been developed for international exchange of meteorological data and are widely used within the meteorological community at large, namely, GRIB2 (mainly for gridded data) and BUFR. The use of these WMO standards is allowed as well as netCDF-CF and the default encoding rule based on GCM.

GRIB2 is a binary data format for exchange of processed meteorological data in the form of values typically located at an array of grid points. This format is used primarily to exchange numerical forecasts, hindcasts and analysis-data among national weather services and other users. The definition of grids, products and data representations in GRIB2 is handled through template numbers; if a new product, grid or type of data representation is needed, the new template(s) go through a formal process for WMO approval, as described in the WMO Manual on Codes [WMO 306].
In section 1, (identification section) the originating centre and sub-centre must be provided. Since this information is not present in the MF/AC model, the Common Code Table C-1 should be consulted. Several entities in the model for meteorological features and atmospheric conditions lack corresponding entry in the public GRIB2-templates. Specifically, the Inspire Id could be included in section two (local use section) in the GRIB message.
For a complete documentation on GRIB2, refer to the WMO Manual on Codes [WMO 306].

BUFR (Binary Universal Form for the Representation of meteorological data) is a binary encoding developed by WMO mainly for the exchange of non-gridded data, essentially measurements from observing stations. BUFR is a table-driven code form where the meaning of data elements is determined by referring to a set of tables that are kept and maintained separately from the message itself.
To be compatible with existing software, BUFR-messages should conform to the BUFR-templates defined by WMO. For instance, atmospheric conditions represented by SF_SamplingPoint could be coded with the template TM307080 developed for point-wise synoptic reports.
Many data elements in the WMO BUFR-templates have no corresponding attributes in the MF/AC-model. For those missing data elements, the recommendation is to include the data-elements in the BUFR-telegram, but mark the value of those data elements to missing (BUFR reserves the highest value of a data element domain as a missing value indicator where all bits in the bitstream are set to 1's).
The BUFR templates require identification of originating/generating centre, sub-centre and station (or site) name. If applicable, the information published in the WMO publication No. 9, Volume A, Observing Stations [WMO 9] should be used.

NetCDF (network Common Data Form) is a data model for array-oriented scientific data, a freely distributed collection of access libraries implementing support for that data model, and a machine-independent format. Together, the interfaces, libraries and format, support the creation, access and sharing of multi-dimensional scientific data. NetCDF-CF encoding format is netCDF conforming to the Climate and Forecast (CF) conventions which provide the necessary semantics to implement geospatial information interoperability. In fact, netCDF-CF entities can implement most of the ISO 19123 coverage geometries and related metadata (i.e. ISO 19115). NetCDF-CF data model and encodings are widely used and well supported by the international Earth Sciences Community (e.g. meteorology, climatology, and ocean Communities). Both netCDF version 3 and 4 can be used for the dataset encoding; while, CF version 1.5 or 1.6 are recommended. NetCDF has recently become an OGC standard [OGC 10-090], [OGC 10-092].

9.2.1 Default Encoding(s)

DS Requirement 4 Data conformant to the application schema(s) defined in section 5.2 shall be encoded using the encoding(s) specified in this section.

9.2.1.1. Default encoding for application schema <application schema name>

Name: <name of the application schema> GML Application Schema
Version: version <version of the GML Application Schema>, GML, version 3.2.1
Specification: D2.8.**III.13-14** Data Specification on **Atmospheric Conditions and Meteorological Geographical** Features – Draft Guidelines
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

Open issue 10: More detail on the default encoding, and in particular the combined use of GML and binary formats, will be provided in version 3

9.2.2 Alternative Encoding(s)

Recommendation 7 It is recommended that also the encodings specified in this section be provided for the relevant application schemas.

Open issue 11: More detail on alternative encodings, and in particular the combined use of GML and binary formats, will be provided in version 3

10 Data Capture

There is no specific guidance required with respect to data capture.

11 Portrayal

This clause defines the rules for layers and styles to be used for portrayal of the spatial object types defined for this theme.

In section 11.1, the *types* of layers are defined that are to be used for the portrayal of the spatial object types defined in this specification. A view service may offer several layers of the same type, one for each dataset that it offers on a specific topic.

Section 11.2 specifies the styles that shall be supported by INSPIRE view services for each of these layer types.

In section **Error! Reference source not found.**, further styles can be specified that represent examples of styles typically used in a thematic domain. It is recommended that also these styles should be supported by INSPIRE view services, where applicable.

Where XML fragments are used in these sections, the following namespace prefixes apply:

- sld="http://www.opengis.net/sld" (WMS/SLD 1.1)
- se="http://www.opengis.net/se" (SE 1.1)
- ogc="http://www.opengis.net/ogc" (FE 1.1)

IR Requirement 10	If an INSPIRE view services supports the portrayal of data related to the theme **Atmospheric Conditions and Meteorological Geographical** Features, it shall provide layers of the types specified in this section.

DS Requirement 5	If an INSPIRE view network service supports the portrayal of spatial data sets corresponding to the spatial data theme **Atmospheric Conditions and Meteorological Geographical** Features, it shall support the styles specified in section 11.2. If no user-defined style is specified in a portrayal request for a specific layer to an INSPIRE view service, the default style specified in section 11.2 for that layer shall be used.

Recommendation 8	In addition to the styles defined in section 11.2, it is recommended that, where applicable, INSPIRE view services also support the styles defined in section **Error! Reference source not found.**.

11.1 Layers to be provided by INSPIRE view services

Standardization of portrayal of coverage data with the Atmospheric Conditions and Meteorological Geographical Feature is challenging. The generic data model used for defining spatial objects for these themes is based on the Observations & Measurements standard (ISO 1956:2011). According to this model, all the (gridded) coverage data is modelled using structure based rather than semantically meaningful spatial object types: The spatial objects are Observation events containing estimates of some atmospherically meaningful properties, but these Observations for different properties are not modelled as different spatial objects. The results of these Observation events are typically modelled as discrete coverages.
The Technical Guidance for the implementation of INSPIRE View Services, version 3.0[14] contains the following requirement considering the Name property of the INSPIRE View Service:

> "**Implementation Requirement 39:** Name shall be mapped with the <wms:Name> element. The harmonised name of a layer shall comply with the Layer requirements of the [INS DS, Article 14][15]"

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14 http://inspire.jrc.ec.europa.eu/documents/Network_Services/TechnicalGuidance_ViewServices_v3.0.pdf

Because the coverage-valued spatial object types often do not directly reflect the contained estimated properties, like precipitation or wind speed, it's not useful from the end-user perspective to follow the harmonized layer naming convention of the Annex I and II consisting of a theme-specific prefix followed by the name of the spatial object type (like GN.GeographicalNames).

In the Data Model for AC-MF (see chapter 5 of this document) all the spatial objects are of type "AtmosphericCondition::AtmosphericCondition" or derived from "Observation Core::OM_Observation". If the harmonized naming convention mentioned above would be followed, all the layers would be either of type "AC.AtmosphericCondition", "AC.OM_Observation" or similar, with no indication of the actual data content provided by the layer.

IR Requirement 11 If an INSPIRE view service supports the portrayal of data related to the theme Atmospheric Conditions and Meteorological Geographical Features, and the portrayed data reflects one of the geophysical properties enlisted in the Observable Property Value code list (see Table in paragraph 5.2.1.2 Basic Properties), the Name property the WMS layer must be constructed by prefixing the Observable Property Value in lower camel case notation by string "AC". The prefix "AC" must not be used for layer names of the properties not defined in the aforementioned Observable Property Value code list.

Example:

```
<wms:WMS_Capabilities version="1.3.0"
xmlns:wms="http://www.opengis.net/wms>
    ...
  <wms:Capability>
    ...
    <wms:Layer>
      <wms:Name>AC.evaporationAmount</wms:Name>
      <wms:Title>Evaporation amount</wms:title>
    </wms:Layer>
    <wms:Layer>
      <!-- The "AC" prefix not used properties outside the
           Observable Property Value code list -->
      <wms:Name>uvIndex</wms:Name>
      <wms:Title>UV Index</wms:title>
    </wms:Layer>
  </wms:Capability>
</wms:WMS_Capabilities>
```

The layer names alone provide limited means for identifying the portrayed properties. The Basic properties defined in the ObservablePropertyValue code list only contains a very basic list of meteorological parameters, and it's expected that most INSPIRE View Services providing meteorological data will also provide other data visualization layers that the ones in this list. Also it should be noted that it's not required for an INSPIRE View Service supporting the portrayal of AC-MF data, to provide all, or even any, of the properties listed in the ObservablePropertyValue code list. Therefore it's important for the data providers to also give additional property identification for the provided layers, if possible. This information should be in both machine and human readable format and accessible online.

The Technical Guidance for the implementation of INSPIRE View Services chapter 4.2.3.3.4.5 defines "Unique Resource Identifier" of the resource used to create a layer using the Implementation Requirements 37 and 38:

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[15] Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services

"**Implementation Requirement 37** The [INS MD] Regulation defines a Unique Resource Identifier as a value uniquely identifying an object within a namespace. The code property shall be specified at a minimum, and a codeSpace (namespace) property may be provided."

"**Implementation Requirement 38** To be able to map the concept of a responsible body/codeSpace and local identifier/code to [ISO 19128]), AuthorityURL and Identifier elements shall be used. The authority name and explanatory URL shall be defined in a separate AuthorityURL element, which may be defined once and inherited by subsidiary layers. Identifiers themselves are not inherited."

Recommendation 9 It is recommended to use the WMS layer properties Identifier and AuthorityURL to provide detailed information about the physical properties visualized by the layer. More than one Identifier element may be used for alternative sources of property definitions.

Recommendation 10 A well know catalog for meteorological geophysical properties should be used for creating values for Identifier and AuthorityURL if possible. The catalog should provide information about the visualized meteorological properties in a format that is well known, and both human and machine readable. The precise definitions of those catalogs and formats are beyond the scope of this document.

Example: WMS Capabilities document fragment pointing an external property definition

```
<wms:WMS_Capabilities version="1.3.0"
xmlns:wms="http://www.opengis.net/wms>
    ...
  <wms:Capability>
    ...
    <wms:Layer>
      <wms:Name>BasicWeatherData</wms:Name>
      <wms:Title>Basic Weather Data</wms:Title>
      <wms:AuthorityURL name="wmo_property">
        <OnlineResource xlink:type="simple"
xlink:href="http://www.wmo.int/def/atmosphericProperties.owl" />
      </wms:AuthorityURL>
      <wms:Layer>
        <wms:Name>AC.temperature</wms:Name>
        <wms:Title>Air temperature/wms:Title>
        <wms:Identifier authority="wmo_property">AirTemperature</wms:Identifier>
      </wms:Layer>
      <wms:Layer>
        <wms:Name>AC.pressureReducedToMSL</wms:Name>
        <wms:Title>Air pressure</wms:Title>
        <wms:Identifier authority="wmo_property">pressureMSL</wms:Identifier>
      </wms:Layer>
    </wms:Layer>
  </wms:Capability>
</wms:WMS_Capabilities>
```

Example: Air temperature description in Web Ontology Language (OWL)

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE rdf:RDF [
  <!ENTITY owl "http://www.w3.org/2002/07/owl#">
  <!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#">
  <!ENTITY temp "http://sweet.jpl.nasa.gov/2.2/quanTemperature.owl">
]>
```

```
<rdf:RDF xmlns:owl="&owl;" xmlns:rdfs="&rdfs;" xmlns:rdf="&rdf;">
  <owl:Ontology rdf:about="" owl:versionInfo="1.1">
     <owl:imports rdf:resource="&temp;"/>
  </owl:Ontology>
  ....
  <owl:Class rdf:about="#AirTemperature">
    <rdfs:subClassOf rdf:resource="&temp;#Temperature"/>
    <rdfs:comment xml:lang="en">A measured or predicted air temperature in
atmosphere.</rdfs:comment>
  </owl:Class>
  ...
</rdf:RDF>
```

11.1.1 Layers organisation

None.

11.2 Styles to be supported by INSPIRE view services

An even more difficult task that defining layer names, is to define a standard visualization styles for atmospheric coverage data. Well-know and widely used, even legally mandating meteorological data visualization styles have been defined the WMO and ICAO, but these are designed for specific usage contexts (weather forecasters and aviation), and may not be suitable for non-expert or cross-theme usage contexts.

Most meteorological properties are portrayed differently according to the intended usage: For example a ground temperature coverage could be visualized as a colour map, an isoline contour plot, or as numerical values at certain points on a map. Some of these styles are very difficult, if not impossible to define properly using the current versions of OGC Styled Layer Descriptor (SLD) and Symbology Encoding (SE) standards. One example of these are the isoline visualizations of gridded coverage data, which are typically used for atmospheric temperature and pressure visualizations.

For the reasons stated above no specific requirements or recommendations are given for styling of the meteorological coverage data as WMS layers. It is however recommended that existing de facto or de jure standards for coverage and feature meteorological data visualization should be used when the anticipated user community is expecting them: if the service is mainly intended for meteorological expert users, then the visualizations should follow the WMO meteorological data visualization standards as closely as possible. The compliancy with existing visualization standards should be indicated in the layer or service metadata.

11.2.1 Styles for the layer <layer name>

No relevant to AC-MF

Bibliography

[DS-D2.3] INSPIRE DS-D2.3, Definition of Annex Themes and Scope, v3.0, *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*

[DS-D2.5] INSPIRE DS-D2.5, Generic Conceptual Model, v3.3, *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/D2.5_v3_3.pdf*

[DS-D2.6] INSPIRE DS-D2.6, Methodology for the development of data specifications, v3.0, *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*

[DS-D2.7] INSPIRE DS-D2.7, Guidelines for the encoding of spatial data, v3.2, *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/D2.7_v3.2.pdf*

[D2.8.I.1] D2.8.I.1 INSPIRE Specification on Coordinate Reference Systems – Guidelines version 3.1

[ISO 19101] EN ISO 19101:2005 Geographic information – Reference model (ISO 19101:2002)

[ISO 19103] ISO/TS 19103:2005, Geographic information – Conceptual schema language

[ISO 19107] EN ISO 19107:2005, Geographic information – Spatial schema (ISO 19107:2003)

[ISO 19108] EN ISO 19108:2005 Geographic information - Temporal schema (ISO 19108:2002)

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007)

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003)

[ISO 19118] EN ISO 19118:2006, Geographic information – Encoding (ISO 19118:2005)

[ISO 19135] EN ISO 19135:2007 Geographic information – Procedures for item registration (ISO 19135:2005)

[ISO 19139] ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

[OGC 06-103r3] Implementation Specification for Geographic Information - Simple feature access – Part 1: Common Architecture v1.2.0

[WMO ET-SAT-6] EXPERT TEAM ON SATELLITE SYSTEMS SIXTH SESSION, ET-SAT-6/Doc. 16 (1)(25.III. 2011), World Meteorological Organisation.

Delete any of these references or add further references as applicable.

Annex A (normative)

Abstract Test Suite

Any dataset conforming to this INSPIRE data specification shall meet all requirements specified in this document.

Open issue 12: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

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Annex B
(informative)
Use Case Descriptions

1. Rationale for data content

According to the INSPIRE Directive the data relevant to the themes "Atmospheric Conditions" and "Meteorological Geographical Features" should provide sufficient information for the users to assess, at least, precipitation, temperature, evapotranspiration and wind at their location of interest. General information on physical conditions should also be made available, however, neither the Directive nor any of the subsequent documents give any applicable (operative?) guidance regarding the range (in space and time) that this information should cover. However, it does specify that the data can originate from measurements, from models, or from post-processed information combining measurement output and model output.
The questions arising about data content are related to:
- *Temporal range: should forecasts be included? If yes, out to what range? If not, should real time or near real time data be included? (it should be noted that the word "forecast" does not appear in the Directive)*
- *Temporal frequency: frequency of data? Frequency of updates?*
- *Horizontal resolution*
- *Vertical extent and resolution*
- *Range of parameters*

as well as to data formats:
- *Should point data and field data be included?*
- *Should imagery be included?*

To address these questions it was noted that:
- Community policy on the environment must aim at a high level of protection
- The stated aim of the Directive is to assist decision-making regarding policies and activities that may have a direct or indirect impact on the environment
- The Directive should apply to the use of spatial data by public authorities in the performance of their public tasks
- The Directive is implemented with a view to stimulating the development of added-value services by third parties

On these grounds there seems to be no a priori reason to exclude any type of meteorological information from the scope of the themes on Atmospheric Conditions and Meteorological Geographical Features. It could possibly be argued that real time and forecast data is not needed strictly speaking for protecting the environment but only for ensuring security. However, as the example of GMES is showing, there is no clear limit between these two fields of activity, and it is highly likely that they will eventually be combined into a common framework.
The critical question which arises is the question of feasibility and affordability. Considering the very large volumes of data potentially involved it is not possible within the prescribed timeframe of the implementation of the Directive that the required services could be provided for all meteorological data. Therefore, while the work on data specification should indeed not exclude any data type, the implementing rules will have to provide the necessary safeguards against unrealistic implementation requirements.
An important element to bear in mind regarding implementation is the worldwide development of the WMO Information System, a new generation system for the exchange of meteorological and related data and products, with built-in Discovery, Access and Retrieval facilities. The EMI takes an active part in this development

2. Selected use cases

In order to identify priority areas for the specification of meteorological data, the TWG selected the following three high level use cases:

1. Use of meteorology in support of environmental emergency response
2. Flood forecasting
3. Climate assessment (with past or predicted data).

These cases have been selected after reviewing a list of Use cases considered for conceptual modelling by the OGC Met Ocean Domain Working Group. It was felt that they were all highly relevant to environmental protection, and that they would all require significant and possibly challenging cross boundary as well as cross-theme cooperation. Detailed use cases have been developed under these three categories:

- Under 1:
    - Plume prediction in support of emergency response

The weather can have a major influence on the release of a pollutant into the atmosphere, from incidents such as large fires, chemical releases, biological incidents, nuclear releases and volcanic eruptions. The latest observations and sophisticated computer predictions can be used to provide plume predictions, ranging immediately after release (to allow safe approach to an incident) through to longer-range predictions of areas at risk, as well as information on local weather conditions. These services support the activities of emergency services and other government departments, as well as to the international community.

- Under 2:
    - Flash flood management

Intense and localized rain events are commonly observed in the Mediterranean area. Because of the short response time of the basins, these events lead to flash flood, likely to cause serious damages, especially over urban areas. That is why the need for systems able to help authorities in related crisis management is increasing. The meteorological data inputs for such systems are mainly rainfall observations and nowcasting, from radars, ground based sensors; input data from very high resolution non hydrostatic models is also becoming available.

- Short and medium range flood forecasting

Severe (transnational) fluvial floods frequently occur and have large impact on societies. To reduce the impacts of floods early warning systems have been setup simulating hydrological processes in river basins and providing flood information for stakeholders. Different meteorological datasets are input for the models: weather observations, deterministic forecasts and ensemble forecasts.

- Under 3:
    - Finding the most interesting locations for new wind farms

Wind power companies planning on building wind turbines need several estimated wind parameters like wind speed distribution, vertical wind profile, turbulence intensity, gustiness and maximum wind speed. for drafting early plans for the best places as well as the most suitable properties of the wind farms The parameters should be visualised in a way appropriate for quickly finding the most promising areas for production in the time frame 2015-2020.

- Climate impacts

Organisations are becoming more aware of their sensitivity to weather, and to climate change, particularly those concerned with water, agriculture, food production, ecosystems, biodiversity, utilities, transport, energy, health, economics, natural disasters and security. Past climate data (climatological observation records, gridded climatologies, and re-analyses) can be used to calculate the existing risks due to current weather and climate, before climate projections for various horizons are used to assess the likely change in the future. The main parameters of interest are temperature and precipitation, with ensembles helping to provide estimates of uncertainty.

Use Case 1 - Plume Prediction in Support of Emergency Response

Description

The weather can be the cause of an emergency and/or have a major influence on its impact. Thus, meteorological organisations (such as national meteorological services) can play a key role in providing expert advice on the interpretation and impact of the weather during an emergency, as well as assisting in the development and maintenance of risk registers, providing input into exercise and planning processes and attending incident command and control centres. Specialist forecasters can provide specialist meteorological information to deal with a variety of environmental incidents to the emergency services and other government departments, as well as to the international community and citizens.

Meteorological organisations can provide plume predictions during emergencies, with specialist forecasters interpreting data from the latest observations as well as from sophisticated computer models to deduce the local weather conditions and the areas at risk from the pollutant. Local variations in wind speed and direction are the main influencers on dispersion. Rain at the scene or downwind can also wash the pollutant out of the atmosphere leading to higher concentrations on the ground. The vertical temperature profile of the atmosphere also affects the stability of the air and this determines how high the plume is likely to rise, which subsequently affects the distance it might travel and its behaviour close to hills. This service covers a range of incident types which can result in the release of a potentially hazardous plume:

- Fire (e.g. fire at a chemical plant or oil refinery);
- Chemical Release (e.g. chemical spillage or a road traffic accident in which a hazardous substance has either escaped or ignited);
- Biological Incidents (e.g. foot & mouth, blue tongue)
- Nuclear Release (e.g. accident at nuclear power plant);
- Volcanic Eruption (i.e. prediction of ash plume).

Numerical atmospheric dispersion modelling environments can utilise a Lagrangian approach to determine the location of a plume: pollutants are represented by a large number of model 'particles' which are released into the modelled atmosphere at the source location. These particles are affected by the local wind speed, atmospheric turbulence, precipitation, and other processes. Each model 'particle' can have its own characteristics, represent different compounds, chemicals and real particulate sizes, and can be affected by temporal and spatial variations in the meteorology including turbulence and loss processes such as precipitation. Such models are able to simulate highly complex dispersion events, predicting the movement of a wide range of pollutants in the atmosphere.

Although these 'model particles' can be shown output directly, either as plots showing each particle at a given time (possibly with colouring used to show height) or as particle trajectories, they are usually accumulated into three-dimensional cells on a regular grid, to give concentration (potentially at different vertical levels and times). They may alternatively be shown in terms of standard deviation from the mid-plume value at a given radius from the release site, a so-called "Area at Risk Map" (usually with at least two threshold values); this is important for early predictions, where the details of release concentrations can be limited, and a prediction of an actual concentration could be misleading.

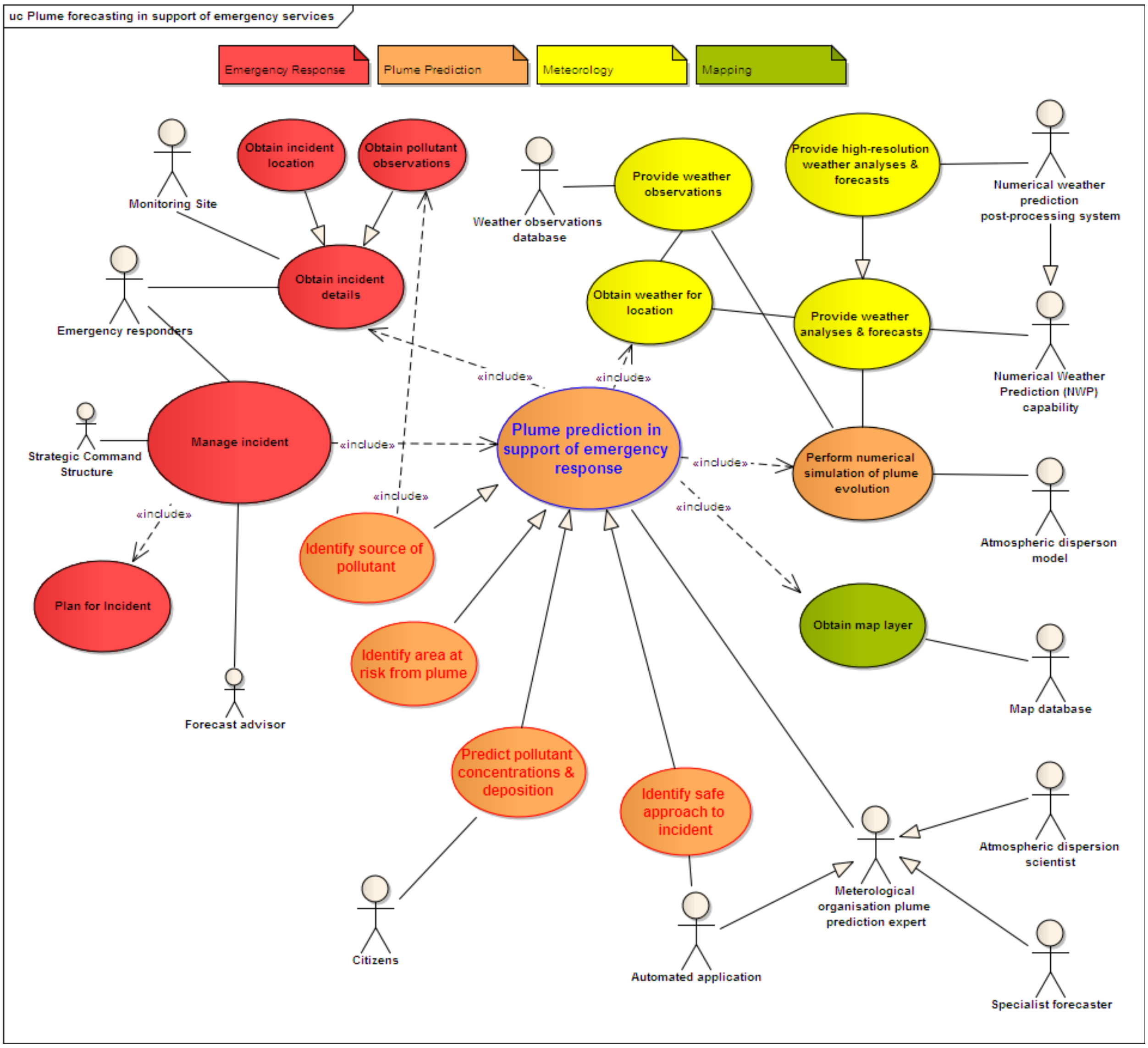
On notification of an incident, the specialist forecasters will run an atmospheric dispersion model, having input all information provided about the release, to predict the movement, deposition and dispersal of large plumes of material for periods of time ranging from hours to several days. The model produces a geographical display of the movement of the plume showing the area at risk. The response time for providing such information can vary from tens of minutes for small scale events to hours for a predictions running out to a week or more. The models can be re-run as more detail becomes available following an accident, providing more precise concentration and deposition values. However, in most incidents it is at least hours into an event before the composition of chemicals or substances involved is fully known.

Typically, the models are highly configurable, and for more involved situations or non-standard cases, the atmospheric dispersion research scientist will become involved in the process of running the model. Unlike NWP models, the output is not usually a 'complete set', but only those parameters, heights, times, etc that are of interest (and for efficiency, zero values are not output).

Typically, services provided range from an immediate prediction of the direction of the plume, to allow safe approach to an incident (e.g. a large fire), through to short-range predictions of areas of risk (e.g. from chemical release) and longer-range prediction of areas at risk (e.g. from volcanic ash) and the identification of the likely origin of particular pollutant (e.g. for a nuclear incident).

High Level Use Case

The Use Case diagram below shows all the use cases and actors considered. Use cases are colour-coded to indicate their focus, with blue writing used to show the 'super use case' for plume prediction and red writing used to show the four main more specific use cases, which are described in the following section; all other use cases are not explicitly detailed, but may appear as a step within the main use cases. Large actors are involved in the detailed use cases; small actors are included to provide a wider context, but are not involved directly in the detailed use cases.



Actors

- **Emergency Responder** – organisations heavily involved in managing incident; for example, emergency services, local authorities, health service bodies, health and safety agencies, transport and utility companies (although exactly which organisations will depend on the nature of the incident)

Monitoring Site – site measuring a particular pollutant

Strategic Command – a general class of actor used to describe the range of groups which may come together to carry out a strategic role in the management of an incident. This includes a range of levels (depending of the severity of the event):

- Operation command at incident site (police or fire officer)
- Tactical command within site of incident (usually senior police office)
- Strategic command and control centre remote from incident (chief police constable)
- Central government crisis response committee
- Scientific and technical advisory groups established to coordinate multi-agency specialist advice to central government

Citizens

Forecast advisors

Meteorological Organisation Plume Prediction Expert – a general class of actor used to describe the experts involved in providing plume prediction services:

Automated Application – used to quickly provide automated guidance

- **Specialist Forecaster** – provide routine operational guidance
- **Atmospheric Dispersion Scientist** – provide operational input in more specialist situations

Weather Observations Database – source of real-time weather observations

Numerical Weather Prediction (NWP) Capability – range of NWP models and post-processing, which provides automated weather forecasts at a range of scales, including:

- **NWP Post-Processing Systems** – applications employing down-scaling and rapid updates (nowcasts) to provide a high-resolution (kilometre-scale) weather forecasts

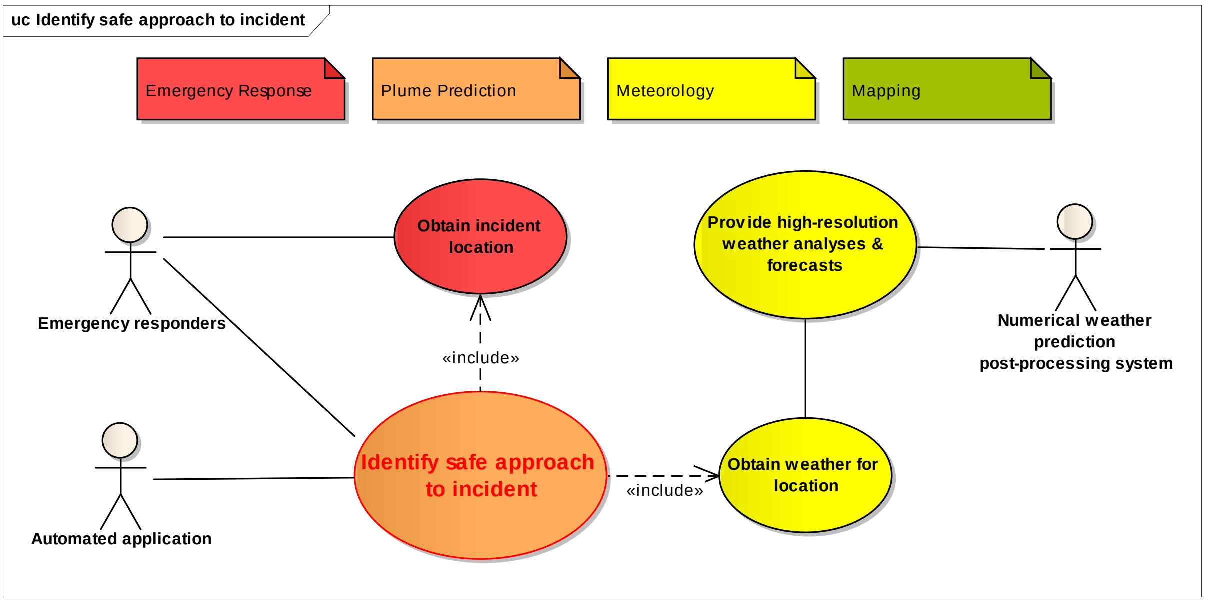
Atmospheric Dispersion Model – Lagrangian model used to determine the location of a plume

Map Database – Database of map overlays at wide range of scales.

Detailed Structured Description of Plume Prediction Use Cases

The plume prediction use cases are presented in more detail using a standard template in the following sections, with primary example (and other examples) indicated in brackets in the title.

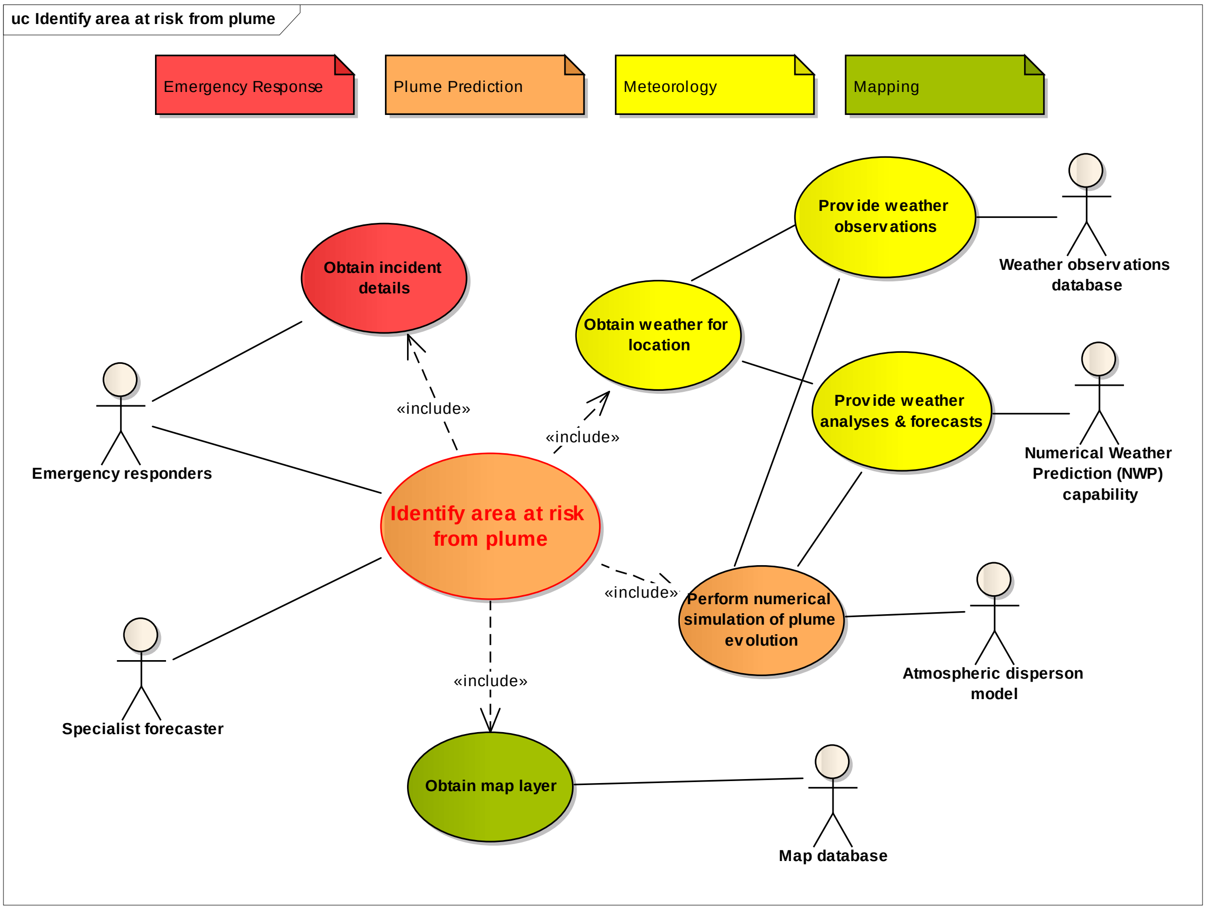
Use Case 1.1: Identify Safe Approach to Incident



Use Case 1.1	Identify safe approach to incident
Priority	High
Description	Provide Fire and Rescue Service (FRS) responders with the latest weather information to help them identify a safe approach when dealing with a major incident. Provides immediate access to forecast conditions, before a more detailed area at risk product is available. This is realised through the use of an automated application, with a web interface, available to all FRS incident command units, mobilising centres and the national coordination centre.
Pre-condition	An incident releasing a plume has occurred.
Flow of Events - Basic Path	
Step 1	***Emergency Responder***s provide the Incident Location via webpage
Step 2	***Automated Application*** automatically obtains **Current Weather** data by interpolating from the **High-Resolution Post-Processed Model Analysis/Forecast** provided by ***NWP Post-ProcessingCapability***
Step 3	***Automated Application*** automatically generates **Hazard Sector** visualisation, with supporting text, and a presentational form of **Current Weather** (table & graph) on the webpage
Step 4	***Emergency Responders*** review the **Hazard Sector** and **Current Weather** products on a Webpage
Post-condition	***Emergency Responders*** understand the safe approach directions to the incident.
Data Source: Incident Location	
Description	Location of incident as: • Place name or Postcode (e.g. EX1 3PB) • Country map grid reference (e.g. GB Ordnance Survey: SX500534) or grid coordinates (e.g. UK eastings, northings: 377400, 399500) • Latitude & Longitude
Data Provider	Fire and Rescue Service (FRS) responders
Geographic Scope	Point (or Polygon as proxy for point)
Thematic Scope	Addresses (AD), Coordinate Reference Systems (RS)
Scale, resolution	*Point* or *Polygon*
Delivery	Webpage entry
Documentation	None
Data Source: Current Weather	
Description	Point interpolation from high-resolution post-processed model analysis /

	forecast provided as: • Table (text) of Temperature, Humidity, Precipitation Type, Precipitation rate, Hazard Sector, wind speed Wind direction; • Graphs of Precipitation rate, Temperature and Humidity against time. Example shown in figure (b)
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Point
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*PointSeries* (hourly data for 6-hour window centred on current hour)
Delivery	Webpage
Documentation	For example, see: *http://www.metoffice.gov.uk/corporate/pws/emergency_response.pdf* (section 3.8 FireMet)
Supporting Data Source: High-Resolution Post-Processed Model Analysis/Forecast	
Description	High-resolution NWP model analyses and forecasts post-processed to produce gridded data accounting for local topographic effects.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area around specific point
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (km resolution; hourly, past times as analyses, forecasts out to 12 hours or more)
Delivery	Standard output in a standard meteorological (e.g. netCDF or GRIB) or bespoke format
Documentation	For example, see: *http://www.metoffice.gov.uk/research/areas/numerical-modelling/post-processing* *http://www.metoffice.gov.uk/science/creating/daysahead/nwp/um_config.html*
Data Source: Hazard Sector	
Description	Point interpolation from high-resolution post-processed model analysis provided as: • Visualisation of 'Hazard Sector', with wind speed and direction • Table with text information on Hazard Sector and wind (in range of formats) Example shown in figure (b)
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Point
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*Point; TimeInstant* (current hour)
Delivery	Webpage
Documentation	For example, see: *http://www.metoffice.gov.uk/corporate/pws/emergency_response.pdf* (section 3.8 FireMet)

Use Case 1.2: Identify area at risk from plume

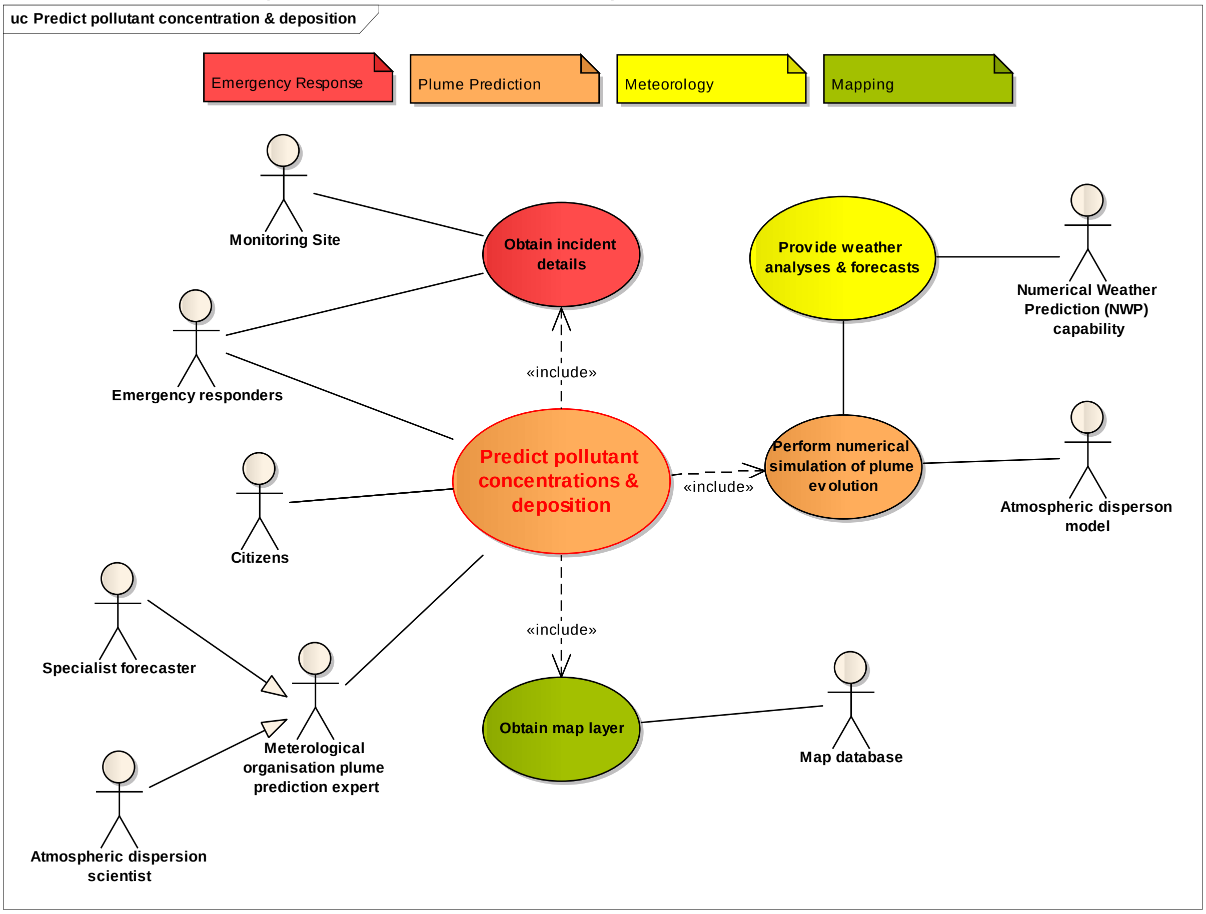


Use Case 1.2	**Identify areas at risk from plume**
Priority	High
Description	Identify the areas at risk from the plume and the local weather conditions for the next few hours in the form of a snapshot.
Pre-condition	An incident releasing a plume has occurred.
Flow of Events - Basic Path	
Step 1	***Emergency Responders*** provides **Incident Details** by phone, which are recorded.
Step 2	A ***Specialist Forecasters*** use the ***Incident Details*** to initialise the ***Atmospheric Dispersion Model.***
Step 3	***Atmospheric Dispersion Model*** runs to generate a **Forecast,** using either: **Model Analyses/Forecasts** generated by the ***Numerical Weather Prediction (NWP) Capability***; or: **Weather Observations** provided by ***Weather Observations Database***.
Step 4	***Atmospheric Dispersion Model*** generates an **Area At Risk Map** using a **Map Overlay** obtained from the **Map Database**.
Step 5	**EMARC** generates **Forecast of Relevant Meteorological Parameters**, using either the **Model Analyses/Forecasts** or **Weather Observations**.
Step 6	The ***Specialist Forecaster*** delivers **Area At Risk Map** and **Forecast of Relevant Meteorological Parameters** to the ***Emergency Responders*** by website, email or fax.
Post-condition	***Emergency responders*** have received and understood briefing material.
Data Source: Plume Incident Details	
Description	Details including: • Location of incident as:

	• Place name or Postcode (e.g. EX1 3PB); • Country map grid reference (e.g. GB Ordnance Survey: SX500534) or grid coordinates (e.g. UK eastings, northings: 377400, 399500); or: • Latitude & Longitude • Time of the event • Any additional information on the chemicals involved • Site characteristics (Urban, Rural, Coastal) • Nature of Release (Continuous , Instantaneous, Fire at site) • If available, details of the current weather at the site
Data Provider	Emergency Services
Geographic Scope	Point
Thematic Scope	Addresses (AD), Coordinate Reference Systems (RS), Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*Point; TimeInstant*
Delivery	Phone
Documentation	See for example: *http://www.metoffice.gov.uk/publicsector/CHEMET/*
Data Source: Atmospheric Dispersion Model Forecast	
Description	4-dimensional (3d space & time) predictions of pollutant concentration. The concentrations of the tracked parcels of air are mapped onto regular grid-boxes. Note that only the required data are output, resulting, resulting in limited sets of variables & levels, and 'sparse' grids (values only held where non-zero)
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area around specific point
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (spatial and temporal resolution depends on area of interest)
Delivery	Standard output as netCDF, GRIB or text, suitable for visualisation in a GIS environment.
Documentation	For example, see: *http://www.metoffice.gov.uk/environment/name.html*
Data Source: Model Analysis/Forecast	
Description	A range of NWP models provide automated weather forecasts as 4-dimensional (3d space & time) fields.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area around specific point
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (km resolution; hourly, past times as analyses, forecasts out to 12 hours or more)
Delivery	Standard output in a standard meteorological (e.g. netCDF or GRIB) or bespoke format
Documentation	For example, see: *http://www.metoffice.gov.uk/science/creating/daysahead/nwp/um_config.html*
Data Source: Weather Observations	
Description	Observations of the weather from a nearby observing site, in WMO BUFR format.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Point, but representative of local area of interest
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*Point* or *PointSeries*
Delivery	n/a
Documentation	None
Data Source: Map Overlay	
Description	High-resolution geographical map
Data Provider	Map provider

Geographic Scope	Area of interest
Thematic Scope	Cadastral Parcels (CP)
Scale, resolution	*Polygons* provided as raster image (at, e.g. 1:50,000)
Delivery	Website, email or fax (as part of ***Area at Risk Map*** product)
Documentation	None
Data Source: Area At Risk Map	
Description	Product generated by ***Atmospheric Dispersion Model*** showing the prediction of the plume extent, for two threshold values of standard deviation from the concentration at the centre of the plume for a given radial distance from the release site. This is visualised in combination with a **Map Overlay.** Example shown in figure (c)
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area of interest
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*Grid; TimePeriod* (representing area of interest; typically <6 hour validity period (but left to the forecaster's discretion), with updates as necessary before existing forecast expires)
Delivery	Website, email or fax
Documentation	For example, see: *http://www.metoffice.gov.uk/publicsector/CHEMET/*
Data Source: Forecast of Relevant Meteorological Parameters	
Description	Product generated ***Model Analyses/Forecasts*** covers: Surface wind direction (8-point compass degrees true) Wind speed at 10 metres above ground level (kilometres per hour.) Indication of the behaviour of the plume due to weather conditions while the chemical is assumed to have neutral buoyancy Total cloud cover (oktas), with height (in feet above ground level) of the lowest significant cloud layer (5 oktas or more) Temperature Relative humidity. Intensity & type of precipitation Depth of the mixing layer Mean wind in the mixing layer Estimate of the vertical stability of the atmosphere using the Pasquill Stability Index Any changes during the period are given remarks sections.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Point, but representative of local area of interest
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*Point* or *Polygon; TimePeriod* (representing area of interest; typically <6 hour validity period (but left to the forecaster's discretion), with updates as necessary before existing forecast expires)
Delivery	Website, email or fax
Documentation	For example, see: *http://www.metoffice.gov.uk/publicsector/CHEMET/*

Use Case 1.3: Predict pollutant concentrations & deposition

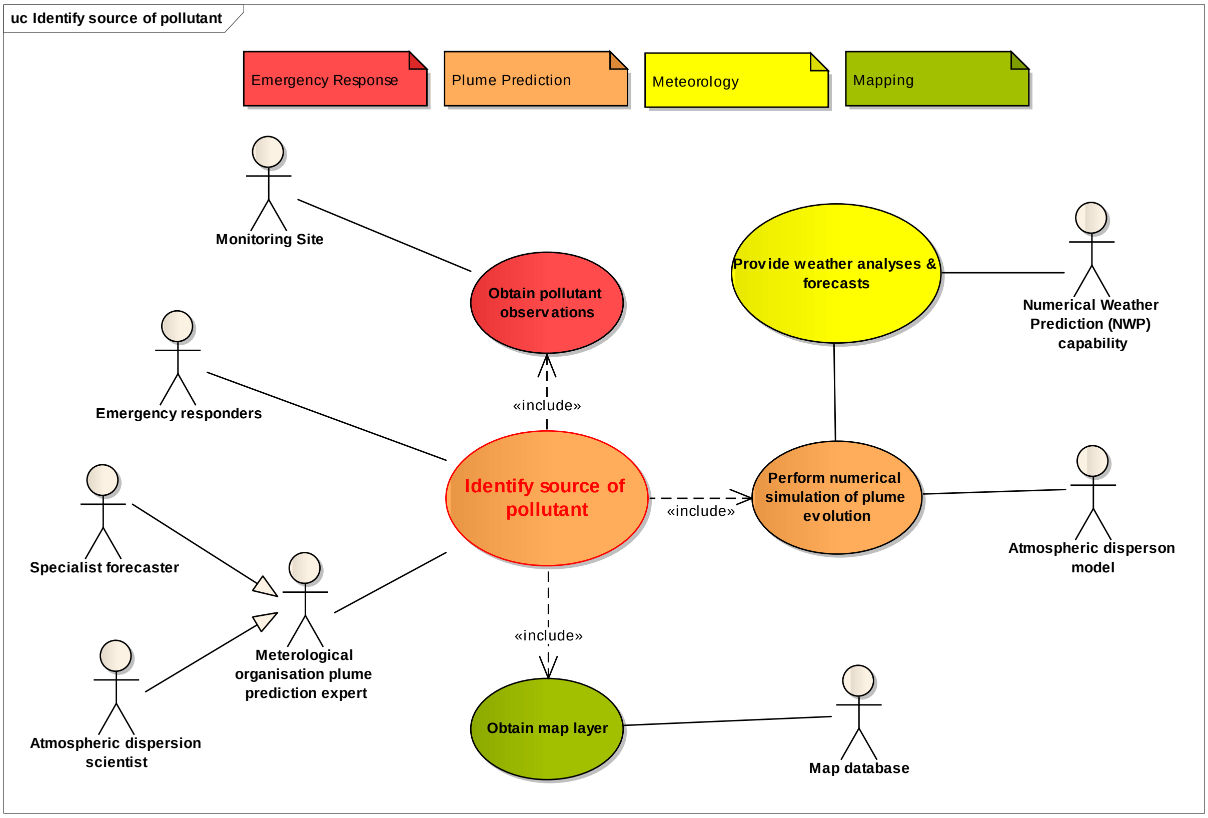


Use Case 1.3	Predict pollutant concentrations & deposition
Priority	High
Description	Provide predictions of the pollutant concentrations and deposition of the pollutant from the plume incident out from a few hours to a week ahead in the form of an animation (or series of snapshots). N.B. Only pollutant concentration product is described below, but similar products can be generated for deposition.
Pre-condition	Either incident is already being monitored, or large-scale incident is detected or notified (e.g. volcanic eruption).
Flow of Events - Basic Path	
Step 1	***Monitoring Site*** *(e.g. Volcanic Ash Advisory Centre)* (or possibly ***Emergency Responders***) provide **Incident Details**.
Step 2	A ***Specialist Forecaster*** uses the ***Incident Details*** to initialise the ***Atmospheric Dispersion Model*** (including specification of incident area, plume height, chemical species or particle size distribution, etc).
Step 3	***NAME*** runs to generate a ***NAME Forecast*** using from the **Model Analyses/Forecasts** provided from the ***Numerical Weather Prediction (NWP) Capability***.
Step 4	The ***Atmospheric Dispersion Model*** generates **Pollutant Concentrations Forecast** using a **Map Overlay** obtained from the **Map Database**
Step 5	The ***Specialist Forecaster*** delivers **Pollutant Concentrations Forecast** to the ***Emergency Responders*** (and possibly the ***Citizens***) by either WMO GTS, website, email or fax.
Post-condition	***Emergency responders*** (and ***General Public***) have received and understood briefing material.

Flow of Events - Alternative Path 1	
Replace Step 2	An ***Atmospheric Dispersion Scientist*** carries out more complex configuration and initialisation of ***Atmospheric Dispersion Model*** using the **Incident Details.**
Flow of Events - Alternative Path 2	
Additional Step 4a	The ***Specialist Forecaster*** draws simpler polygons around the **Pollutant Concentration Forecast** to generate a variant of this product.
Data Source: Plume Incident Details	
Description	Details including: • Location • Time of the event • As much information on the plume characteristics as possible
Data Provider	Monitoring Site, Volcanic Ash Advisory Centres (with initial identification by eye witnesses or volcanic eruption detection system)
Geographic Scope	Point, potentially anywhere on the globe
Thematic Scope	Coordinate Reference Systems (RS)
Scale, resolution	*Point*
Delivery	Phone
Documentation	*http://www.metoffice.gov.uk/aviation/vaac/eruption_detection.html*
Data Source: Atmospheric Dispersion Model Forecast	
Description	4-dimensional (3d space & time) predictions of pollutant concentration. The concentrations of the tracked parcels of air are mapped onto regular grid-boxes. Note that only the required data are output, resulting, resulting in limited sets of variables & levels, and 'sparse' grids (values only held where non-zero)
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area of interest, potentially anywhere on the globe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (spatial and temporal resolution depends on area of interest)
Delivery	Standard output as netCDF, GRIB or text, suitable for visualisation in a GIS environment.
Documentation	For example, see: *http://www.metoffice.gov.uk/environment/name.html*
Data Source: Model Analysis/Forecast	
Description	A range of NWP models provide automated weather forecasts as 4-dimensional (3d space & time) fields.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area of interest, potentially anywhere on the globe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (representing area of interest which may extend outside the UK, and time scales of interest out to 5 days or more)
Delivery	Standard output in a standard meteorological (e.g. netCDF or GRIB) or bespoke format
Documentation	For example, see: *http://www.metoffice.gov.uk/science/creating/daysahead/nwp/um_config.html*
Data Source: Map	
Description	Geographical map at appropriate scale
Data Provider	Map provider
Geographic Scope	Area of interest, potentially anywhere on the globe
Thematic Scope	Cadastral Parcels (CP)?
Scale, resolution	*Polygons* provided as raster image
Delivery	Website, email or fax (as part of ***Pollutant Concentrations Forecast*** product)
Documentation	None
Data Source: Pollutant Concentrations Forecast	
Description	Generated product from ***NAME Forecast*** shows sequence of charts

	showing the predicted evolution of the plume extent at different heights and different times for multiple thresholds. These are shown as raster, filled contour or polygons (which also may be colour-filled); the polygons are also produced as a text product. This is visualised in combination with an appropriate **Map Overlay.** Examples of the three forms shown in figure (a), (d) and (e) respectively.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area of interest, potentially anywhere on the globe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* or *PolygonSeries* (representing area of interest which may extend outside the UK, and time scales of interest out to 5 days or more)
Delivery	(WMO) Global Telecommunications System (GTS), website, email or fax
Documentation	For example, see: *http://www.metoffice.gov.uk/aviation/vaac/forecasting.html*

Use Case 1.4: Identify source of pollutant



Use Case 1.4	**Identify Source of Pollutant**
Priority	High
Description	Identify the likely area of origin in of a particular measured pollutant as area-based probability
Pre-condition	A particular pollutant has been detected at one or more monitoring sites.
Flow of Events - Basic Path	
Step 1	***Monitoring Site*** provides **Pollutant Observations** data.
Step 2	A ***Specialist Forecaster*** or the ***Atmospheric Dispersion Scientist*** uses the **Pollutant Observations** to initialise the ***Atmospheric Dispersion Model***.
Step 3	The ***Atmospheric Dispersion Model*** runs 'backwards' to generate a ***Forecast*** using from the **Model Analyses/Forecasts** provided from the ***Numerical Weather Prediction (NWP) Capability***.

Step 4	The ***Atmospheric Dispersion Model*** generates **Plume Origin Prediction** from **forecast** using a **Map Overlay** obtained from the **Map Database**.
Step 5	The ***Specialist Forecaster*** delivers ***Plume Origin Prediction*** to the ***Emergency Responders*** by either website, email or fax
Post-condition	***Emergency responders*** have received and understood briefing material.
Data Source: Polluant Observations	
Description	Measurement of a particular pollutant by a sensor at a particular site. Detection of the pollutant at multiple sites would usually be required.
Data Provider	Various monitoring organisations (depending on pollutant type)
Geographic Scope	Point
Thematic Scope	Environmental Monitoring Facilities (EF)
Scale, resolution	*PointSeries* (a number of points, with time period depending on what is available)
Delivery	Various
Documentation	None
Data Source: Atmospheric Dispersion Model Forecast	
Description	4-dimensional (3d space & time) predictions of pollutant concentration. The concentrations of the tracked parcels of air are mapped onto regular grid-boxes. Note that only the required data are output, resulting, resulting in limited sets of variables & levels, and 'sparse' grids (values only held where non-zero).
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area of interest
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (spatial and temporal resolution depends on area of interest)
Delivery	Standard output as netCDF, GRIB or text, suitable for visualisation in a GIS environment.
Documentation	For example, see: *http://www.metoffice.gov.uk/environment/name.html*
Data Source: Model Analysis/Forecast	
Description	A range of NWP models provide automated weather forecasts as 4-dimensional (3d space & time) fields.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area around specific point
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (km resolution; hourly, past times as analyses, forecasts out to 12 hours or more)
Delivery	Standard output in a standard meteorological (e.g. netCDF or GRIB) or bespoke format
Documentation	For example, see: *http://www.metoffice.gov.uk/science/creating/daysahead/nwp/um_config.html*
Data Source: Map	
Description	High-resolution geographical map
Data Provider	Map provider
Geographic Scope	Area of interest
Thematic Scope	Cadastral Parcels (CP)
Scale, resolution	*Polygons* provided as raster image (at, e.g. 1:50,000)
Delivery	Website, email or fax (as part of ***Area at Risk Map*** product)
Documentation	None
Data Source: Plume Origin Prediction	
Description	Generated product from the ***Atmospheric Dispersion Model Forecast***, shows the likelihood of a plume originating from within the area of the cell of a raster map, as a probability (most cells will have a zero probability). This is visualised in combination with an appropriate **Map Overlay.** Example shown in figure (f)
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Area of interest, potentially anywhere on the globe

Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	Variable, depending on area of interest
Delivery	Webpage, email or fax
Documentation	For example, see: *http://www.metoffice.gov.uk/corporate/pws/emergency_response.pdf* (section 3.6 Source Identification)

Use Case 2.1 - Flash flood management

High level Use Case

Intense and localized rain events are commonly observed, especially in the Mediterranean area. When occurring over short response time basins, these events lead to flash flood, likely to cause serious damages, especially over urban areas. That is why the need for systems able to assist authorities in related crisis management is critical.

The system can be broadly described in five steps:

1. **Acquisition of input data for the numerical model**
   Rainfall data from rain gauges and radars (for instance polarized X-Band radars), short term rainfall forecasts ("nowcasting"), discharge data.

2. **Calculate the flood extent and its short term evolution**
   Running a "rainfall-runoff" model over the area of interest

3. **Identify a flood risk scenario**
   On the basis of expected discharges, past flooding events and vulnerability.

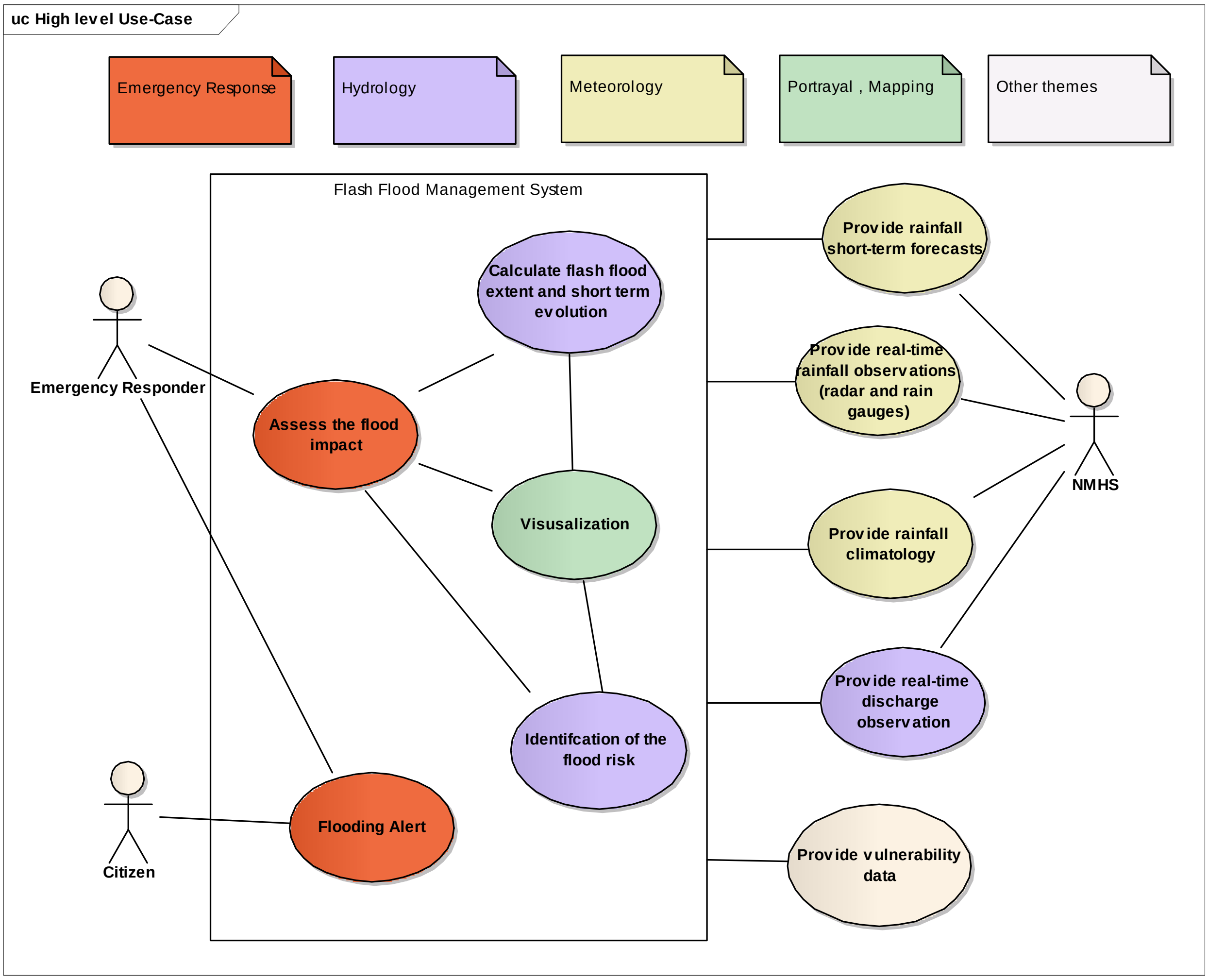
4. **Human assessment of the results**
   Real-time data, model output, risk map visualisation for human assessment of the risk of flooding and risk scenarios.

5. **Activation of the warning plan depending on the risk**

Actors

- **Emergency Responder**
  Organisations involved in managing the flood event (local authorities, civil protection authorities)
- **Citizens:**
  The target of flood warnings and safety plans when a flood risk has been identified and assessed by the emergency responder.
- **NMHS (National Meteorological & Hydrological Service)**
  NMHS provides :
  - Radar production environment from radar network infrastructure and reflectivity measurements, post processing etc. to consolidated rainfall estimations.
  - Surface observation environment from sensor networks, in-situ acquisition systems, hubs etc. to consolidated rainfall measures, including databases and archives (past data).
  - Numerical simulation environment: data assimilation, high resolution non hydrostatic model run on supercomputers, post-processing.
  - Databases, data access services and / or dissemination systems

High level UML Diagram



Hydrology is actually the core activity of this use-case, the meteorological sub-cases are intended to provide weather data (mainly rainfall data and very short-range forecasts). So, the overall use-case has been split in order to isolate sub-cases related to the INSPIRE themes "Atmospheric Conditions" and "Meteorological Geographical Features".

Detailed Structured Description of Flash flood management Use Cases

Use Case 2.1.1 - Calculate flash flood extent and its short term evolution

Use Case Description	
Name	Calculate flash flood extent and its short term evolution
Primary actor	Rainfall – Runoff model
Goal	Predict the flash-flood extent
System under consideration	Flash flood information system
Importance	High
Description	Hydrological models used to calculate flash-floods extents are usually rainfall-runoff models. The meteorological data input for such models is mainly radar

Use Case Description	
	rainfall data, calibrated with surface rain gauges measurements when available. Recently, high resolution non hydrostatic models are able to provide accurate short-term rainfall forecasts. Finally, real-time rainfall data is compared against rainfall and flow information climatology to identify a flood scenario.
Pre-condition	- Operational network of surface rain gauges - Operational network of radars (and post processing system to convert measured reflectivities into spatial rainfall data) - Operational nowcasting system to predict rainfall (fine mesh model or other method) - Rainfall and flow climatology in order to calibrate the Rainfall-Runoff model - Operational Rainfall-Runoff model
Post-condition	Flood extent and water velocity dataset
Flow of Events – Basic Path	
Step 1.	Collect rainfall data from surface gauges within the spatio-temporal domain of interest
Step 2	Collect rainfall radar data within the spatio-temporal domain of interest
Step 3	Calibrate spatial radar data with surface gauges measurements
Step 4	Collect short-term rainfall forecasts on the spatio–temporal domain of interest
Step 5	Collect rainfall and flow climatology on the domain of interest
Step 6	Run the Rainfall-Runoff model
Step 7	Make available the probable flood extent and its short term evolution
Data set: Surface rain gauge data	
Description	Rainfall time series from surface gauges within the spatio-temporal domain of interest. The dataset consist of rainfall measures on an irregularly distributed set of points (the location of the rain gauges)
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Limited area: ~100 km2
Thematic scope	Atmospheric Conditions (observed)
Scale, resolution	Typically 30 rain gauges over the area of interest
Delivery	Online (FTP, WFS, SOS) or routine dissemination
Documentation	Metadata
Data set: Radar data	
Description	Spatial rainfall radar data. Rainfall is computed from reflectivities measured by a network of radars covering the area of interest (for instance polarized X-Band radars). The dataset consist of rainfall measures on a regularly distributed set of grid points. When the dataset is an image, each pixel corresponds to a grid-point.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Limited area: ~100 km2
Thematic scope	Atmospheric Conditions (AC - observed)

Use Case Description	
Scale, resolution	1 km
Delivery	Online (FTP, WCS) or routine dissemination
Documentation	Metadata
Data set: Short term forecasts	
Description	Short-term rainfall forecast data calculated by a fine mesh non hydrostatic model. The dataset consist of rainfall forecasts values on a regularly distributed set of grid points.
Type	input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Limited area: ~100 km2
Thematic scope	Atmospheric Conditions (AC - nowcasting)
Scale, resolution	1 - 2 km
Delivery	Online (FTP, WCS), routine dissemination
Documentation	Metadata
Data set: Rainfall and flood climatology	
Description	Rainfall and flood reference climatology and derived products (for instance return period of observed / predicted rainfall data) For instance, the dataset will consists of return period values on a regularly distributed set of grid points.
Type	input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Limited area: ~100 km2
Thematic scope	Atmospheric Conditions (AC - climatology)
Scale, resolution	1km
Delivery	Online (FTP, WCS, WFS) or routine dissemination
Documentation	Metadada
Data set: Probable flood scenario	
Description	Product showing the total extent of the flood and its short term evolution
Type	Output
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Limited area: ~100 km2
Thematic scope	Natural Risk Zone
Scale, resolution	1km
Delivery	Online (FTP, WCS), routine dissemination
Documentation	Metadada

Mapping UC datasets to AC-MF model (Informative)

Dataset: Surface rain gauge data

AC-MF	Value
AtmosphericConditions	
extent	Spatio-temporal extent of the dataset covering the area of interest this dataset is an instance (temporal instance) of a serie that has been previously discovered through a catalogue service with the phenomenon and the spatial domain of interest of the system as input parameters
inspireId	Inspire identifier of the dataset [16]
member	CSML **PointObservation** collection or CSML **PointSeriesObservation** collection depending on the dataset (Common datasets on WMO GTS are PointObservation collection)
Case **PointObservation** AC member **:**	
PointObservation *inherit* *CSMLStaticObservation inherit* *CSMLSamplingCoverageObservation inherit* *OM_DiscreteCoverageObservation inherit* *OM_Observation*	
phenomenonTime	*2011-04-11T12:00:00Z*
resultTime	*2011-04-11T12:02:30Z*
observedProperty	SimpleObservableProperty
Result	CV_DiscretePointCoverage
procedure	AtmosphericConditionProcess
featureOfInterest (spatial sampling feature)	*Surface meteorological station network*
Case **PointSerieObservation** AC member :	
PointSeriesObservation *inherit* *CSMLTimeSeriesObservation inherit* *CSMLSamplingCoverageObservation inherit* *OM_DiscreteCoverageObservation inherit* *OM_Observation*	
phenomenonTime	*2011-04-11T12:00:00Z/2011-04-11T13:00:00Z*
resultTime	*2011-04-11T13:02:30Z*
observedProperty	SimpleObservableProperty

[16] Issue : Structure of Inspire identifiers for AC-MF datasets has to be defined and both compatible with WMO core metadata profile and Inspire conventions.

result	CVT_DiscreteTimeInstantCoverage
procedure	AtmosphericConditionProcess
featureOfInterest (spatial sampling feature)	*Surface meteorological station*
AtmosphericConditionProcess	
type documentation	*"InSituMeasurement"* **CI_Citation** (ISO 19115 metadata object)
SimpleObservableProperty	
basePhenomenon label	*PrecipitationAmount* *"5Mn Precipitation Accumulation"*[17]
CV_DiscretePointCoverage	
element	**CV_PointValuePair** collection [point[18], precipitation measure]*
CVT_DiscreteTimeInstantCoverage	
element	**CVT_TimeInstantValuePair** collection [timestamp, precipitation measure]*

Dataset: Radar data

AC-MF	Value
AtmosphericConditions	
extent	*Spatio-temporal extent of the dataset covering the area of interest* *this dataset is an instance (temporal instance) of a serie that has been previously discovered through a catalogue service with the phenomenon and the spatial domain of interest of the system as input parameters*
inspireId	*Inspire identifier of the dataset*
member	CSML **GridObservation** collection or CSML **GridSeriesObservation** *depending on the dataset (common datasets issued from DCPC are Grid radar data)*
Case **GridObservation** AC member	
GridObservation *inherit* *CSMLStaticObservation inherit* *CSMLSamplingCoverageObservation inherit* *OM_DiscreteCoverageObservation inherit* *OM_Observation*	
phenomenonTime	*2011-04-11T12:00:00Z*
resultTime	*2011-04-11T12:03:47Z*
observedProperty	SimpleObservableProperty

[17] Issue: How to handle the accumulation period? As a process / Observation parameter?

[18] point: often a geographic identifier in AC-MF datasets (typically WMO indicator , French INSEE number …)

result	**CV_DiscreteGridPointCoverage** (grid definition: 2d geodetic or projected)
procedure	AtmosphericConditionProcess
featureOfInterest (spatial sampling feature)	*The grid on which rainfall amounts are measured*
Case **GridSeriesObservation** AC member	
GridSeriesObservation *inherit* *CSMLTimeSeriesObservation inherit* *CSMLSamplingCoverageObservation inherit* *OM_DiscreteCoverageObservation inherit* *OM_Observation*	
phenomenonTime	2011-04-11T12:00:00Z/2011-04-11T13:00:00Z
resultTime	2011-04-11T13:05:47Z
observedProperty	**SimpleObservableProperty**
result	**CV_DiscreteGridPointCoverage** (grid definition : 2d geodetic or projected + 1d temporal)
procedure	**AtmosphericConditionProcess**
featureOfInterest (spatial sampling feature)	*The grid on which rainfall amounts are measured*
AtmosphericConditionProcess	
type	*"RemoteSensingMeasurement"*
documentation	**CI_Citation**
SimpleObservableProperty	
basePhenomenon	PrecipitationAmount
label	*"15Mn Precipitation Accumulation"*
CV_DiscreteGridPointCoverage	
element	**CV_GridPointValuePair** collection [2d grid point [x,y] , precipitation measure]*
CV_DiscreteGridPointCoverage	
element	**CV_GridPointValuePair** collection [3d grid point [x,y,t] , precipitation measure]*

Dataset: Short Term Forecast

AC-MF	**Value**
AtmosphericConditions	
extent	*Spatio-temporal extent of the dataset covering the area of interest* *this dataset is an instance (temporal instance) of a serie that has been previously discovered through a catalogue service with the phenomenon and the spatial domain of interest of the system as input parameters*
inspireId	*Inspire identifier of the dataset*
member	CSML **GridSeriesObservation**
GridSeriesObservation	
GridSeriesObservation *inherit* *CSMLTimeSeriesObservation inherit* *CSMLSamplingCoverageObservation inherit* *OM_DiscreteCoverageObservation inherit*	

OM_Observation	
phenomenonTime	*2011-04-11T13:00:00Z/2011-04-11T15:00:00Z*[19]
resultTime	*2011-04-11T13:14:57Z*[20]
parameter	NamedValue
observedProperty	SimpleObservableProperty
result	CV_DiscreteGridPointCoverage (grid definition : 2d geodetic or projected + 1d temporal
procedure	AtmosphericConditionProcess
featureOfInterest (spatial sampling feature)	*The grid on which rainfall amounts are simulated by the numerical model*
NamedValue	
name	*"analysisTime"*
value	*2011-04-11T13:00:00:00Z*[21]
SimpleObservableProperty	
basePhenomenon	*PrecipitationAmount*
label	*"15Mn Precipitation Accumulation »*
AtmosphericConditionProcess	
type	*"NumericalSimulation"*
documentation	**CI_Citation** (ISO 19115 metadata object)
processParameter	*"analysisTime"*
responsibleParty	**CI_ResponsibleParty** (ISO19115 metadata object)
CV_DiscreteGridPointCoverage	
element	CV_GridPointValuePair collection [3d grid point [x,y,t] , precipitation measure]*

Dataset: Radar data climatology (case return period of observed rainfall)

AC-MF	Value
AtmosphericConditions	
extent	Spatio-temporal extent of the dataset covering the area of interest
inspireId	Inspire identifier of the dataset
member	CSML **GridObservation**
GridObservation	
GridSeriesObservation *inherit* *CSMLTimeSeriesObservation inherit* *CSMLSamplingCoverageObservation inherit* *OM_DiscreteCoverageObservation inherit* *OM_Observation*	
phenomenonTime	*2011-04-11T12:00:00Z/2011-04-11T13:00:00Z*
resultTime	*2011-04-11T13:17:50Z*[22]

[19] Temporal extent of simulation result (2 hours here)
[20] The time at which simulation results are published
[21] Or model « run »

parameter	NamedValue
observedProperty	SimpleObservableProperty
result	CV_DiscreteGridPointCoverage (grid definition : 2d geodetic or projected)
procedure	AtmosphericConditionProcess
featureOfInterest (spatial sampling feature)	*The grid on which rainfall return periods are calculated*
NamedValue	
Name	*“referencePeriod“*
value	*1980-01-01T00:00:00:00Z/2010-01-01T00:00:00Z* [23]
SimpleObservableProperty	
basePhenomenon label	*Duration* *"Return period of 1 hour Precipitation Accumulation"*
AtmosphericConditionProcess	
type	*"Statistical"*
documentation	**CI_Citation** (ISO 19115 metadata object)
processParameter	*"referencePeriod "*
responsibleParty	**CI_ResponsibleParty** (ISO19115 metadata object)
CV_DiscreteGridPointCoverage	
element	**CV_GridPointValuePair** collection [grid point [x,y] , return period]*

[22] The time at which statistics are published
[23] Statistical period used for statistics (here 30 years)

Use Case 2.2 – Flood forecasting short and medium range

Background description

Severe (transnational) fluvial floods frequently occur and have large impact on societies. The European Environment Agency (EEA) estimated that the large flooding events that occurred in Europe between 1998 and 2002 caused 700 deaths, displacement of half a million people and 25 billion € insured economic losses.

To reduce the impacts of floods several early warning systems have been setup by hydrological and meteorological institutes, recently reinforced by the EU Floods Directive (EU 2007). These systems simulate hydrological processes in river basins from local to global scales and provide flood information for stakeholders. A variety of meteorological datasets (observations, model forecasts) and hydrological datasets are input for the models. The system described in this use case has two main objectives:

- To complement European Member States activities on flood preparedness and to achieve longer warning times.
- To provide the European Commission with an overview of ongoing and expected floods in Europe for improved international aid and crisis management in the case of large transnational flood events that might need intervention on an international level.

The system is set up for the whole of Europe on a 5-km grid. Twice daily it provides the national hydrological centres with medium-range ensemble flood forecasting information. In addition, when a high probability for flooding is forecast, the end users are alerted by e-mail and advised to monitor the development of the situation using the information system. Forecasts with lead times of 3 to 10 days are achieved through the incorporation of ensemble and deterministic forecasts.

High Level Use Case

The process can be broadly described as follows:

1: Ingestion of meteorological data
Observations.
Deterministic forecasts
Ensemble forecasts
Notification of event (non-meteorological)

2: Preprocessing of meteorological data for use in the flooding model:
Internal procedures (spatial interpolation of point data)
Pre-processing application for potential evapotranspiration

3: Running the flooding model
4: (Automatic) evaluation of results
5: Visualisation of results
Hydrographs
Threshold exceedance maps
Time series diagrams
Threshold exceendance tables
Risk/warning maps
6: In case of flooding event: notification of end users.

Actors

Operators

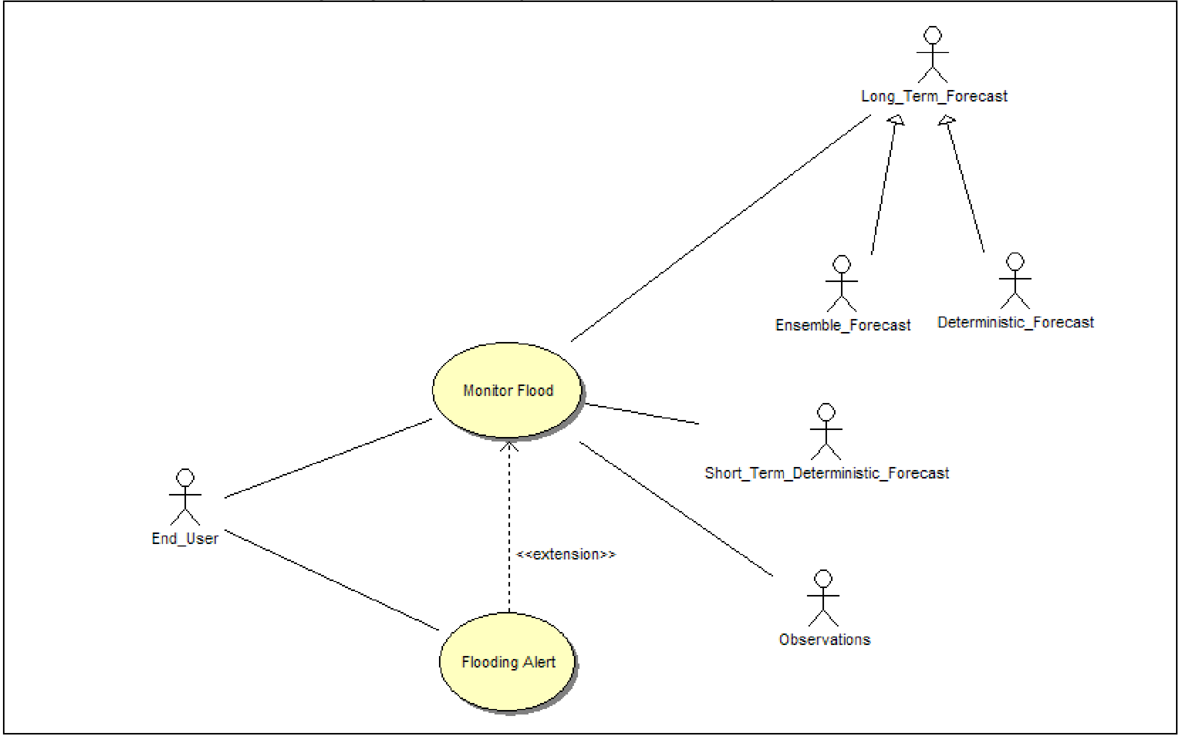
End users: experts from national hydrological and meteorological services

Data Requirements

The flooding model makes use of static data layers that should be available within INSPIRE at European scale, such as land use, soil type and texture, river network. The flooding model simulates canopy and surface processes, soil and groundwater system processes and flow in the river channel.

Detailed Structured Description of Flood forecasting short and medium range Use Case

Use case 2.2.1 - Monitoring ongoing and expected floods in Europe.



Use Case Description	
Name	Monitoring ongoing and expected floods in Europe.
Priority	High
Description	Monitoring ongoing and expected floods in Europe, provide monitoring information and alerts end users.
Pre-condition	System running operationally.
Flow of Events - Basic Path	
Step 1	Run flooding forecasts (twice daily). 1.1 Ingest meteorological data. 1.2 Pre-process meteorological data. 1.3 Run flooding model. 1.4 (Automatic) evaluation of results. 1.5 Visualisation of results.
Step 2	Provide results to end users. 2.1 Alert for flooding .

Post-condition	Results successfully delivered to end users.
Data Source: Short term Deterministic forecast	
Description	Temporal resolution: staggered, 1h (1-3 days), 3h (4-7 days). Spatial resolution: staggered, 7km (1-3 days), 40 km (1-3 days). Times provided: 12:00, 00:00. Input fields: 1 (P,T,E). Bias removal: none. Down-scaling: dynamic.
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Europe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Features (MF)
Scale, resolution	Temporal resolution: staggered, 1h (1-3 days), 3h (4-7 days). Spatial resolution: staggered, 7km (1-3 days), 40 km (1-3 days). Times provided: 12:00, 00:00.
Delivery	FTP
Documentation	
Data Source: Long term Deterministic forecast	
Description	Temporal resolution: staggered, 3h (1-3 days), 6h (4-10 days). Spatial resolution: +- 40 km Times provided: 12:00, 00:00. Input fields: 1 (P,T,E). Bias removal: none Down-scaling: none
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Europe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Features (MF)
Scale, resolution	Temporal resolution: staggered, 3h (1-3 days), 6h (4-10 days). Spatial resolution: +- 40 km (TL511L60). Times provided: 12:00, 00:00.
Delivery	FTP
Documentation	
Data Source: Ensemble forecast	
Description	Temporal resolution: 6h (1-10 days). Spatial resolution: +- 80 km (TL255L40) Times provided: 12:00, 00:00. Input fields: 50+1 (P,T,E). Bias removal: none. Down-scaling: none.
Data Provider	Meteorological organisation
Geographic Scope	Europe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Features (MF)
Scale, resolution	Temporal resolution: 6h (1-10 days). Spatial resolution: +- 80 km (TL255L40). Times provided: 12:00, 00:00.

Delivery	FTP
Documentation	
Data Source: Meteorological observations	
Description	Temporal resolution daily Spatial resolution: 50 km (gridded) Times provided: irregular: typically 23:00 Input fields: P,T,E_0, ES_0, ET_0. Bias removal: none Down-scaling: none
Data Provider	Meteorological organisation (e.g. national meteorological service)
Geographic Scope	Europe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Features (MF)
Scale, resolution	Temporal resolution daily Spatial resolution: 50 km (gridded) Times provided: irregular: typically 23:00
Delivery	FTP
Documentation	

References

EU. (2007). "Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (Text with EEA relevance)." Retrieved 13/07/2010, from *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32007L0060:EN:NOT*.

Use Case 3.1 - Finding the most interesting locations for new wind farms

High-level Use Case
This use case is mainly based on information provided by a pilot project. The steps described in the use case description are adapted to a near future scenario, where the necessary data sets are available from the EU member states using the INSPIRE SDI and the delivery methods specified by it. As of writing, the necessary input data sets are gathered from various, mostly off-line sources by the users.

The process for finding new wind farm locations is basically an iterative data mining and decision making task, an thus it is difficult to formulate it as a step-wise process. In the scenario selected for this use case the wind farm planning engineer does the following rough work steps:

1. Planner finds the most promising geographic areas from the target area using map visualizations of wind-related geophysical parameters. The existing wind farm locations act as verification data.
2. The initial set of candidate areas are reduced based on information about existing transfer networks, high-power electricity networks, land use and natural protection zones in the vicinity of the candidate areas. The existing infrastructure also helps in pin-pointing the best wind farms locations within the candidate areas.
3. The potential new wind farm locations and the optimal turbine heights are submitted to a detailed analysis within the company's planning process.

Actors

- The electricity companies and specialized wind power planning companies in Europe.
- Public sector organizations at national level providing statistical meteorological information about wind, temperature and humidity conditions from the ground level up to 200m above the ground.
- Public sector organizations at national and sub-national level providing information about the existing wind power facilities, transport networks, electricity networks, land use, and natural protection zones.

Detailed Structured Description of finding the most interesting locations for new wind farms use case.

Use case 3.1.1 - Find new promising locations for building wind power farms in Europe.

Use Case Description	
Name	Find new promising locations for building wind power farms in Europe.
Primary actor	Companies planning on building new wind power
Goal	Planners working for the company have found an initial set of the most promising new wind farm locations to be included in the detailed analysis.
System under consideration	Desktop GIS systems used for wind farm planning able to retrieve geospatial information from INSPIRE SDI data servers via Internet.
Importance	Medium
Description	Wind power engineers use sophisticated models for planning the new wind farms. To be able to decide the best potential locations for new wind farms, they need many kinds of information besides the actual measured and predicted wind conditions, like possibility of ice formation on the blades, proximity of electricity and transport networks, cost of land, building rights and whether there is an existing or planned natural protection area overlapping the planned location.
Pre-condition	The cost/benefit ratio for the planned wind turbines at certain wind conditions, the approximate cost of building new electricity transfer network, the approximate cost of building new roads to access the planned location for certain land type, existing

Use Case Description	
	wind farms locations with owner information. The planner has a GIS workstation able to display layers of a map information over Europe.
Post-condition	An identified set of locations worth a more detailed benefit/cost analysis based on more detailed information.
Flow of Events – Basic Path	
Step 1.	The planner asks the workstation to display the basic map layer over Europe.
Step 2.	The planner asks the workstation to display the existing locations for all the wind farms as well as known planned farms to be taken into use within the next 10 years.
Step 3.	The planner asks the workstation to display set statistical wind parameters visualized as coloured map layers. The planner evaluates the values of these parameters at different possible vertical turbine heights (50m, 100m, 200m) and compares them with the optimal values from the specifications of the planned turbines by the company, and identifies the most suitable locations not already in wind farm use as well as the existing wind farms with most potential to build new turbines possibly at different heights than the existing ones. The work includes zooming the map back and forth to verify the findings on a higher resolution map (up to 1:20000). The interesting locations are marked on the map with annotations.
Step 4.	The planner asks the workstation to display the most accurate cartographic information about existing transport networks, primary electricity transfer networks, existing and planned natural protection areas, land type, land use planning, and approximate cost of land at the selected locations. The most expensive locations as well as those overlapping natural protection zones are excluded.
Step 5.	The planner sends the data set containing the potential wind farms locations to be used as input in the detailed investment analysis.
Flow of Events – Alternative Paths	
	NONE
Data set: Basic map data for Europe	
Description	Basic background maps covering Europe
Type	Input
Data provider	National mapping agencies across Europe
Geographic scope	Europe
Thematic scope	Coast lines, rivers, lakes, mountain areas, geographical names
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WMS)
Documentation	

Data set: Existing wind farms and public plans for new farms	
Description	Information about the locations and the ownership of the existing wind power farms and public plans for building new ones.
Type	Input
Data provider	National and sub-national level agencies responsible for energy planning.
Geographic scope	Europe
Thematic scope	Wind farms
Scale, resolution	1:20000
Delivery	Online (WFS)
Documentation	

Data set: Monthly statistical wind speed distribution	
Description	Colour maps visualisations for monthly average wind speeds for a typical month ranging from below 4 m/s to more than 13.5 m/s at 50, 100 and 200 meters above the ground. This gridded data is based on high resolution weather model re-analysis of the past weather observations for selected, statistically representative months.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Europe
Thematic scope	Atmospheric Conditions (AC), statistical wind speed coverage
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WMS or WCS)
Documentation	

Data set: Monthly maximum wind speed (over 50 years)	
Description	Colour maps visualisations for monthly maximum wind speeds ranging from below 4 m/s to more than 13.5 m/s at 50, 100 and 200 meters above the ground. This gridded data is based on high resolution weather model re-analysis of the past weather observations for selected, statistically representative months.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Europe
Thematic scope	Atmospheric Conditions (AC), statistical wind speed coverage
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WMS or WCS)
Documentation	

Data set: Monthly statistical strength of wind turbulence	
Description	Colour maps visualisations for monthly average wind turbulence at 50, 100 and 200 meters above the ground. This gridded data is based on high resolution weather model re-analysis of the past weather observations for selected, statistically representative months.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Europe
Thematic scope	Atmospheric Conditions (AC), statistical wind turbulence coverage
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WMS or WCS)
Documentation	

Data set: Monthly statistical wind gustiness	
Description	Colour maps visualisations for monthly average wind gustiness at 50, 100 and 200 meters above the ground. This gridded data is based on high resolution weather model re-analysis of the past weather observations for selected, statistically representative months.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Europe
Thematic scope	Atmospheric Conditions (AC), statistical wind gust coverage
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WMS or WCS)
Documentation	

Data set: Monthly statistical vertical wind profile	
Description	A set of statistical monthly wind speed and direction values at different heights ranging from the ground level to 200m above ground at each grid point.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Europe
Thematic scope	Atmospheric Conditions (AC), statistical wind speed and direction coverage
Scale, resolution	1:20000, 10m vertical resolution
Delivery	Online (WFS or WCS)
Documentation	

Data set: Number of months per year for significant blade ice formation probability	
Description	Statistical probability for significant ice formation on surfaces similar to wind turbine blades at different vertical heights (50, 100, 200m). Reported as the average number of months per year with these kind of conditions expected.
Type	Input
Data provider	Meteorological organisation (e.g. national meteorological service)
Geographic scope	Europe
Thematic scope	Atmospheric Conditions (AC), statistical wind speed, air temperature and humidity coverages
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WMS or WCS)
Documentation	

Data set: Existing High-voltage electricity transfer networks	
Description	High-voltage electricity transfer networks for connecting new power stations.
Type	Input
Data provider	National and sub-national level agencies responsible for energy planning.
Geographic scope	Europe
Thematic scope	Energy transfer networks
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WFS)
Documentation	

Data set: Existing transport networks	
Description	Road, rail and water networks able to support the construction and servicing of a wind farm.
Type	Input
Data provider	National mapping agencies across Europe
Geographic scope	Europe
Thematic scope	Transport networks
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WFS)
Documentation	

Data set: Land use, planning and building rights	
Description	Land use, plans for land use and building right information
Type	Input
Data provider	National and sub-national level agencies responsible for land use planning
Geographic scope	Europe
Thematic scope	Land use, area management/restriction/regulation zones & reporting units
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WFS)
Documentation	

Data set: Natural protection zones	
Description	Existing and planned natural protection zones where building of new wind turbines is not allowed.
Type	Input
Data provider	National environment agencies
Geographic scope	Europe
Thematic scope	Natural protection zones
Scale, resolution	1:500000 – 1:20000
Delivery	Online (WFS)
Documentation	

Use Case 3.2 - Climate Impacts

Description

The meteorological organisations (such as national meteorological services) have a history of providing advice on weather impacts to customers across many sectors, and the provision of climate impacts advice is a natural extension of these existing activities. Existing and potential customers and stakeholders, both in government and private sector, are now focusing significantly on climate impacts. Many sectors are becoming more aware of their weather sensitivity, and climate change means that we cannot assume that the statistics of weather derived from the historical record are applicable now and certainly not so in the future.

Some of the organisations or systems for which climate impact assessments are of particular relevance are:

- Water, Agriculture, Food production;
- Ecosystems, Biodiversity;
- Utilities, Transport, Energy;
- Health, Economics;
- Natural disasters, Security.

The requirements of the users of climate research have changed; rather than simply requiring evidence for the human contribution to climate change and scenarios of its potential future magnitude, an increasing number of stakeholders are beginning to require assessment of the likely impacts of climate change. In general, this is either to inform decisions on the level and nature of action to mitigate climate change, or to help plan for adaptation. In the latter case, this can be related to both long-term and short-term changes or variability in climate arising from either natural or anthropogenic causes.

Here, the term “Climate Impacts” refers to anything which is a consequence of climate change. Some customer requirements relate to improving resilience against change and variability on seasonal to decadal timescales – these can often be addressed with similar techniques to those used to assess the impacts of longer-term climate change. It is for this reason that we use the term “climate impacts” as opposed to “climate change impacts”. Indeed, impacts assessments are required over a very large range of time and space scales, from local impacts over timescales of seasons to the next few years, to global impacts several decades or more into the future. While there are some exceptions, in general the short-term, local assessments are required for adaptation while long-term, large-scale assessments are for informing mitigation.

Most direct impacts are on “natural” process (either physical processes such as river flows, or biological processes such as ecosystem changes) and these can then exert further impacts on humans and their economy and society. In some cases, climatic or meteorological processes can have impacts directly on humans, e.g.: rising temperatures leading to heat stress, or changes in storminess causing damage to infrastructure with further financial or economic consequences.

In the near term, products will be delivered through the application of existing climate models to existing impacts models or analysis methods. This bespoke climate and impacts model analysis for customers ensures that the data and techniques are being applied appropriate for the question from end to end. This could include new simulations with existing climate models as well as new analysis of the large number of existing climate model simulations. As well as involving the application of climate model output to offline impacts models or impacts-focussed climate metrics (e.g.: heat stress, growing season onset), we will also analyse climate model outputs which relate more directly to impacts, such as runoff and vegetation productivity.

In the longer term, global scale impacts assessments will be provided using both general circulation models (GCMs) and Integrated Assessment Models (IAMs), which will allow the simulation of crops, ecosystems, water resources, flooding, irrigation, glaciers, and chemistry impacts all interactively, thus facilitating internally-consistent impacts assessment including non-climatic drivers such as land use change and atmospheric chemistry.

In the approach described for this use case (which is used by the Met Office Hadley Centre Climate Impacts Analysis team), past climate data are used to 'baseline' the 'climate risk', before the predictions of the future climate are analysed to identify the future risk. The **Climate Impacts and Risk assessment Framework**, or CIRF (pronounced as "serf") [1], represents the standard process of doing a risk assessment for an organisation or system.

Step 1: Identify the needs, objectives and extent of the project, including the required outcomes and expectations
Step 2: Explore how available datasets can meet the key requirements
Step 3: Assess existing risks due to the current weather and climate
Step 4: Assess in detail how the key risks identified in step 3 are likely to change in the future
Step 5: Work with the customer to explore suitable adaptation options associated with the key risks
Step 6: Communicate clearly the project results and outcomes
Step 7: Review that the assessment has met the customer's requirements, and identify future steps to be taken.

Steps 2, 3 & 4 (in blue above) require the input of weather and climate information, both past data and future projections.

The main parameters of interest are:
Temperature
Precipitation

Although, there are a number of other parameters (e.g. wind, humidity, pressure), which may be useful for particular impact assessments, and the Global Climate Observing System (GCOS) has defined a much wider set of Essential Climate Variables (ECVs) [2].

Gridded datasets in the form of time series or long term averages (e.g. 10 year and 30 year) with extremes and probabilities of exceeding threshold (of interest to the particular organisation/system) are most useful, as they provide the coverage required, and allow matching of past and future data. However, past observations may be useful for particular locations and the assessment of specific incidents.

Baselining the current climate risk requires past climate data, in the form of:
Climatological observation records (e.g. Met Office Hadley Centre observations datasets [3])
Gridded climatologies,
e.g. for the UK UKCP09 5km x 5km grids:
- Daily datasets (1960 to 2006)
- Metrics of precipitation
- Monthly datasets (currently updated to the end of 2005)
- Annual datasets (1961 to 2000)
- Baseline average datasets (1961 to 1990)

e.g. for Europe the ENSEMBLES daily gridded observational dataset (E-OBS RT5; 0.22 to 0.50 degrees resolution) from the European Climate Assessment & Dataset (ECA&D) [8]:

- Cloud cover
- Wind direction
- Wind speed
- Wind gusts
- Relative humidity
- Sea level pressure
- Precipitation amount
- Snow depth
- Sunshine
- Mean temperature
- Minimum temperature
- Maximum temperature

Re-analyses, e.g.:

- ERA-Interim, ERA40 (ECMWF) [5]
- ACRE [6]

The future climate risk analysis requires **Climate projections** for various horizons out to 2100, including single and multi-model ensembles (with probabilities) and down-scaling using regional models. e.g.:

- **UKCP09** [4], which are based on the Met Office Hadley Centre climate model HadCM3, using perturbed physics ensembles, with:
  - Annual, seasonal and monthly climate averages.
  - Individual 25 km grid squares, and for pre-defined aggregated areas.
  - Seven 30 year time periods.
  - Three emissions scenarios.
  - Projections are based on change relative to a 1961–1990 baseline.

- **WCRP[24] CMIP3[25] multi-model dataset** [7], which provides climate projections[26] from a large number of groups in support of IPCC AR4[27].

(Seasonal and decadal forecasts are also useful tools to provide a full range of future predictions.)

The process identifies Risk Indicators (a measure of some quantity of interest to the customer, e.g. fire incidents per day), which are a function of the Hazard (e.g. fire) and the Vulnerability (e.g. population density). Note that Vulnerability here includes Exposure, which is sometimes treated separately.

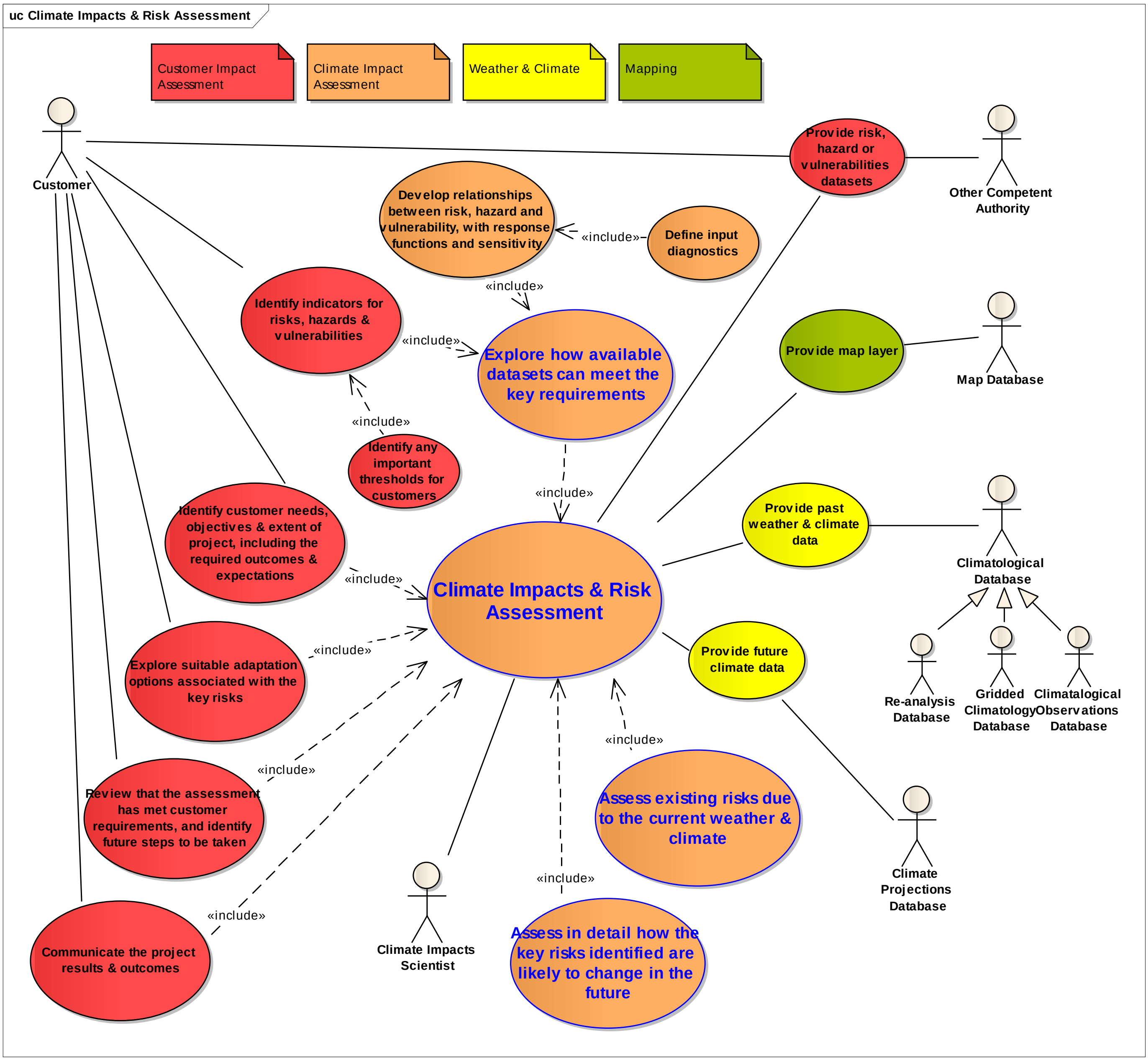
The Hazard can be related to the climate variables (e.g. for fire incidents, it may be related to the number of days with the temperatures above a certain threshold and the precipitation below a certain threshold). This relationship may be given by an existing model, or past data provided by the customer can be used to define the relationship.

Vulnerability data may also be provided by the customer or by another competent authority (e.g. social scientists).

The baseline and future risks are usually shown as a raster plot against and appropriate map overlay, with time series at a location being used to shown variability over time. Plots with 'error bars' and probability distribution functions may also be used to show the variability against a mean (either past or projected).

[24] World Climate Research Programme
[25] Phase 3 of the Coupled Model Intercomparison Project
[26] Projections against various emissions scenarios
[27] Fourth Assessment Report of the Intergovernmental Panel on Climate Change

High Level Use Case
The Use Case diagram below shows all the use cases and actors considered. Use cases are colour-coded to indicate their focus.



Actors

Climate Impacts Scientist – scientists involved in providing assessing climate impact and risk

Customer – general class of actor used to describe a wide range of customers

Other Competent Authority – some agency other than the customer qualified to provide information required for the impact and risk assessment

Climatological Database – set of past weather and climate data available

- **Climatological Observations Database** – time series of point weather and climate observations
- **Gridded Climatology Database** – gridded datasets derived from observations
- **Re-analysis Database** – gridded datasets derived using an NWP model data assimilation scheme to analyse the observations

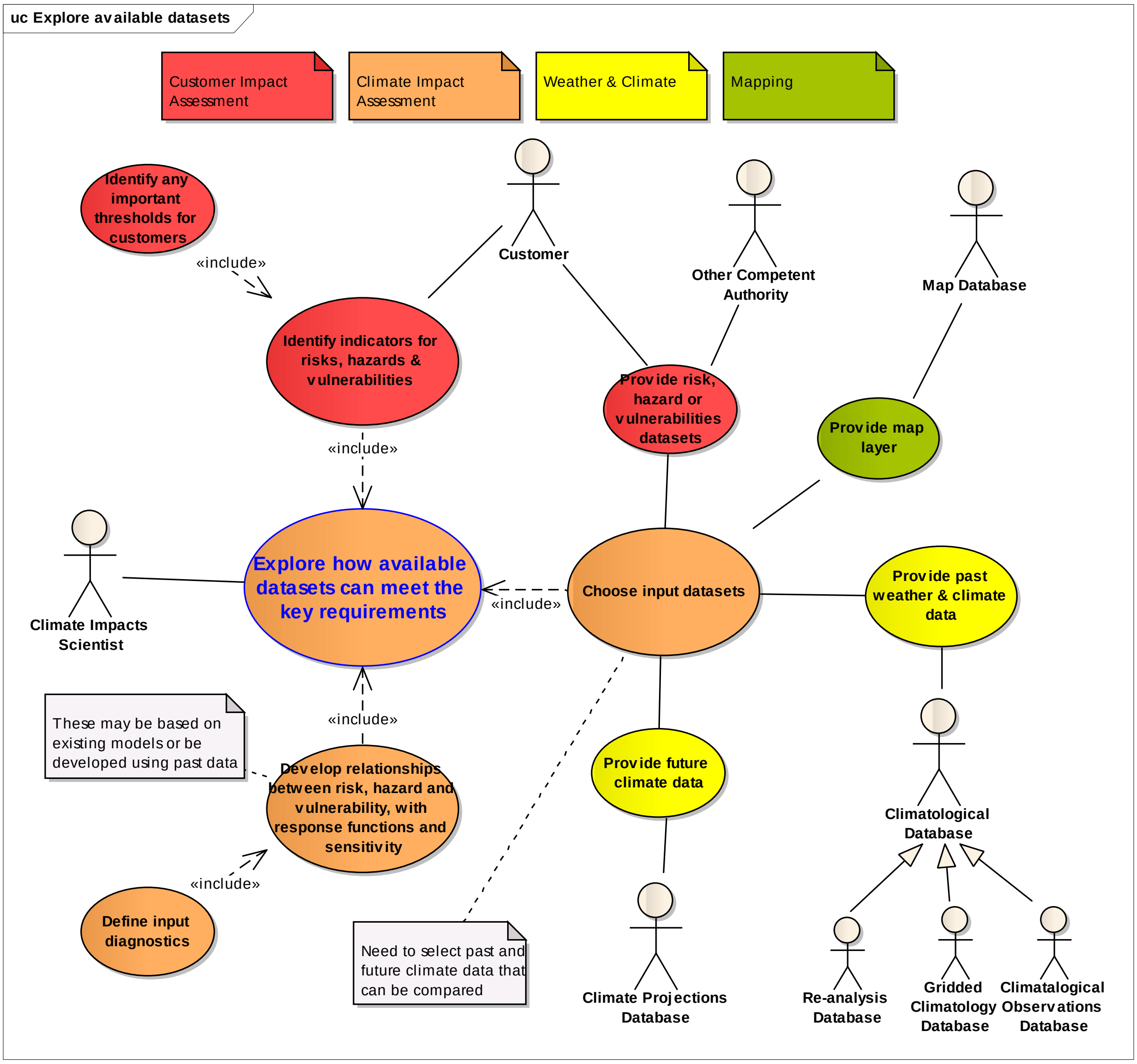
Climate Projections Database – set of future climate projections using difference scenarios (this includes single and multi-model ensembles)

Map Database – Database of map overlays at wide range of scales.

***Detailed Structured Description of Climate Prediction Impact Use Case*s**

The climate impact use cases are presented in more detail using the standard template in the following sections.

Use Case 3.2.1: Explore how available datasets can meet the key requirements

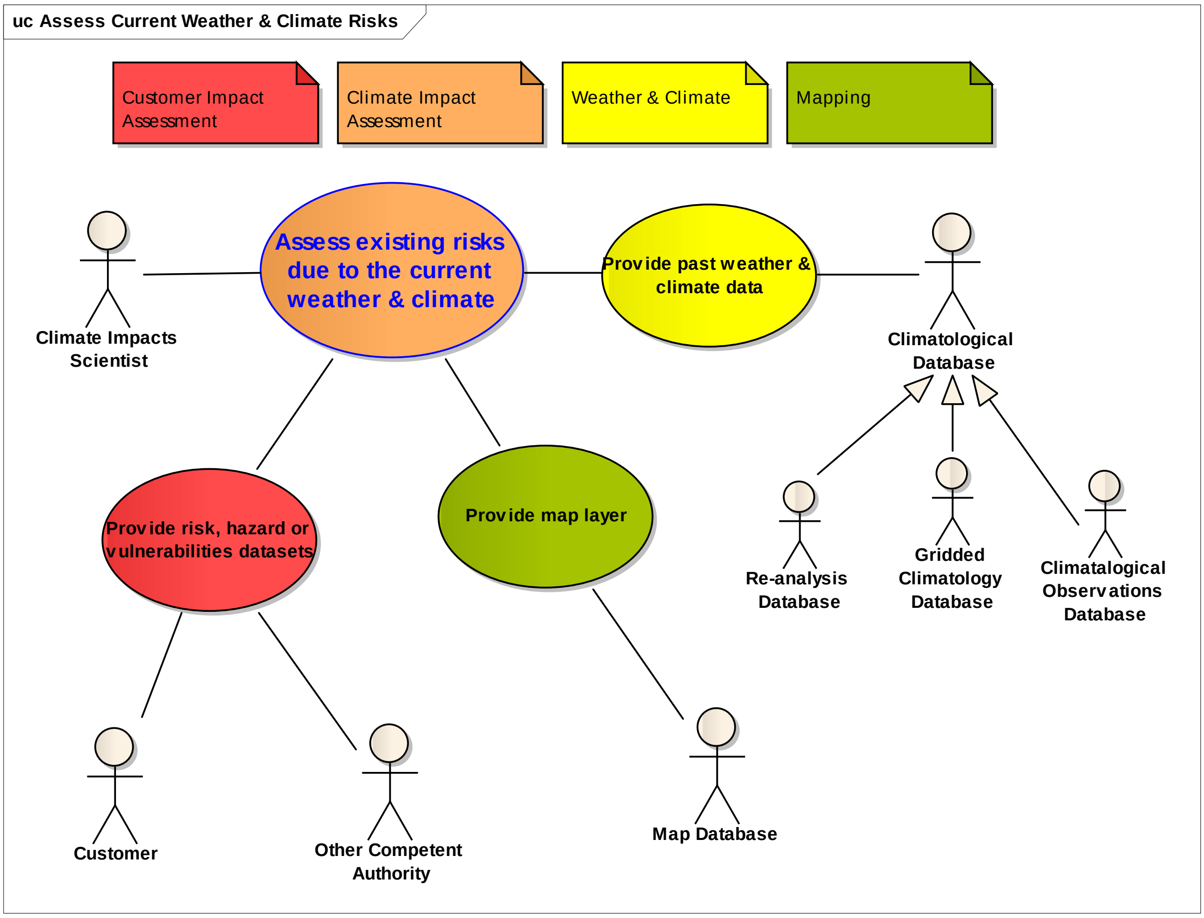


Use Case 3.2.1	Explore how available datasets can meet the key requirements
Priority	High
Description	Climate Impact Scientist works with the customer to decide on the set of past weather & climate, future climate and other data should be used to assess the climate impact and risk for a particular customer. They also develop the relationships between the risk, hazard and vulnerabilities, with assessment of the response function and the sensitivity, using existing models or past data.
Pre-condition	Customer needs, objectives & extent of project, including the required outcomes & expectations, for the climate impact and risk assessment have been identified.
Flow of Events - Basic Path	
Step 1	***Climate Impacts Scientist*** works with the ***Customer*** to identify the **Risks, Hazards and Vulnerabilities Indicators** of important to their area of concern.
Step 2	***Customer*** identifies and important threshold values.
Step 3	***Climate Impacts Scientist*** develops the relationship between the risk, hazard and vulnerabilities, including the response function and an assessment of the sensitivity.

Step 4	***Climate Impacts Scientist*** defines the input diagnostics required for the risk function (including the inputs to the hazard model)
Step 5	***Climate Impacts Scientist*** chooses the datasets to provide the input diagnostics for the risk function, and for the calibration of the hazard model, if required. This includes **Past Weather & Climate Data (Climatological Observations, Gridded Climatologies, Re-analyses)**, **Future Climate Projections** and **Risk, Hazard & Vulnerability Data**
Post-condition	Identified set of input climate and vulnerabilities datasets and a calibrated hazard model.
Flow of Events - Alternative Path	
Additional Step 6	If necessary, the ***Climate Impacts Scientist*** develops the hazard model relationship with the input diagnostics.
Data Source: Risk, Hazards & Vulnerabilities Indicators	
Description	Risk, hazard and vulnerabilities indicators of importance for the customer's area of concern, including any important threshold values.
Data Provider	Customer
Geographic Scope	n/a
Thematic Scope	n/a
Scale, resolution	n/a
Delivery	Consultation
Documentation	None – dependent on customer
Data Source: Risk, Hazards & Vulnerabilities Datasets	
Description	Various datasets characterising the risk, hazard and vulnerabilities of importance for the customers area of concern
Data Provider	Customer, Other Competent Authority
Geographic Scope	Area of interest (may be national, regional or global)
Thematic Scope	Various (depending on customer area of concern)
Scale, resolution	Various, but likely to include *PointSeries* and *GridSeries* (spatial and temporal resolution depends on area of interest)
Delivery	Various
Documentation	None
Data Source: Climatological Observations	
Description	Point weather and climate observations
Data Provider	Competent authorities in the weather and climate domain
Geographic Scope	Area of interest (potentially global)
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*PointSeries* (typically daily max, min, mean or accumulation, but could be over various periods)
Delivery	Typically space-delimited text files as download
Documentation	For example, see: *http://www.hadobs.org/*
Data Source: Gridded Climatologies for the Country of Interest	
Description	Grids of climate parameters interpolated from observations
Data Provider	Competent authorities in the weather and climate domain
Geographic Scope	Country of interest
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (various, but for example for the UK: 5km, daily, monthly, annual and 30 year means)
Delivery	Typically space-delimited text or netCDF files as download
Documentation	For example, see: *http://www.metoffice.gov.uk/climatechange/science/monitoring/ukcp09/index.html*
Data Source: Gridded Climatologies for Europe	
Description	ENSEMBLES daily gridded observational dataset (E-OBS)
Data Provider	European Climate Assessment & Dataset (ECA&D)
Geographic Scope	Europe
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (0.22 – 0.50 degrees, daily 1950 – present)

Delivery	netCDF
Documentation	For example, see: *http://eca.knmi.nl/download/ensembles/ensembles.php*
Data Source: Re-analyses	
Description	Grids derived using an NWP model data assimilation scheme to analyse the observations
Data Provider	Competent authorities in the weather and climate domain
Geographic Scope	Global
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (various spatial & temporal resolutions)
Delivery	Typically netCDF file download
Documentation	For example, see: *http://www.ecmwf.int/research/era/do/get/Reanalysis_ECMWF*
Data Source: Future Climate Projections	
Description	Set of gridded data of future climate projections using difference scenarios (this includes single and multi-model ensembles)
Data Provider	Competent authorities in the weather and climate domain
Geographic Scope	Global
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF)
Scale, resolution	*GridSeries* (various spatial & temporal resolutions)
Delivery	Typically netCDF file download
Documentation	For example, see: *http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php*
Data Source: Map	
Description	Geographical map at appropriate scale
Data Provider	Various
Geographic Scope	Area of interest, potentially anywhere on the globe
Thematic Scope	Cadastral Parcels (CP)
Scale, resolution	*Polygons* provided as raster image
Delivery	As part of visualisation of other data
Documentation	None

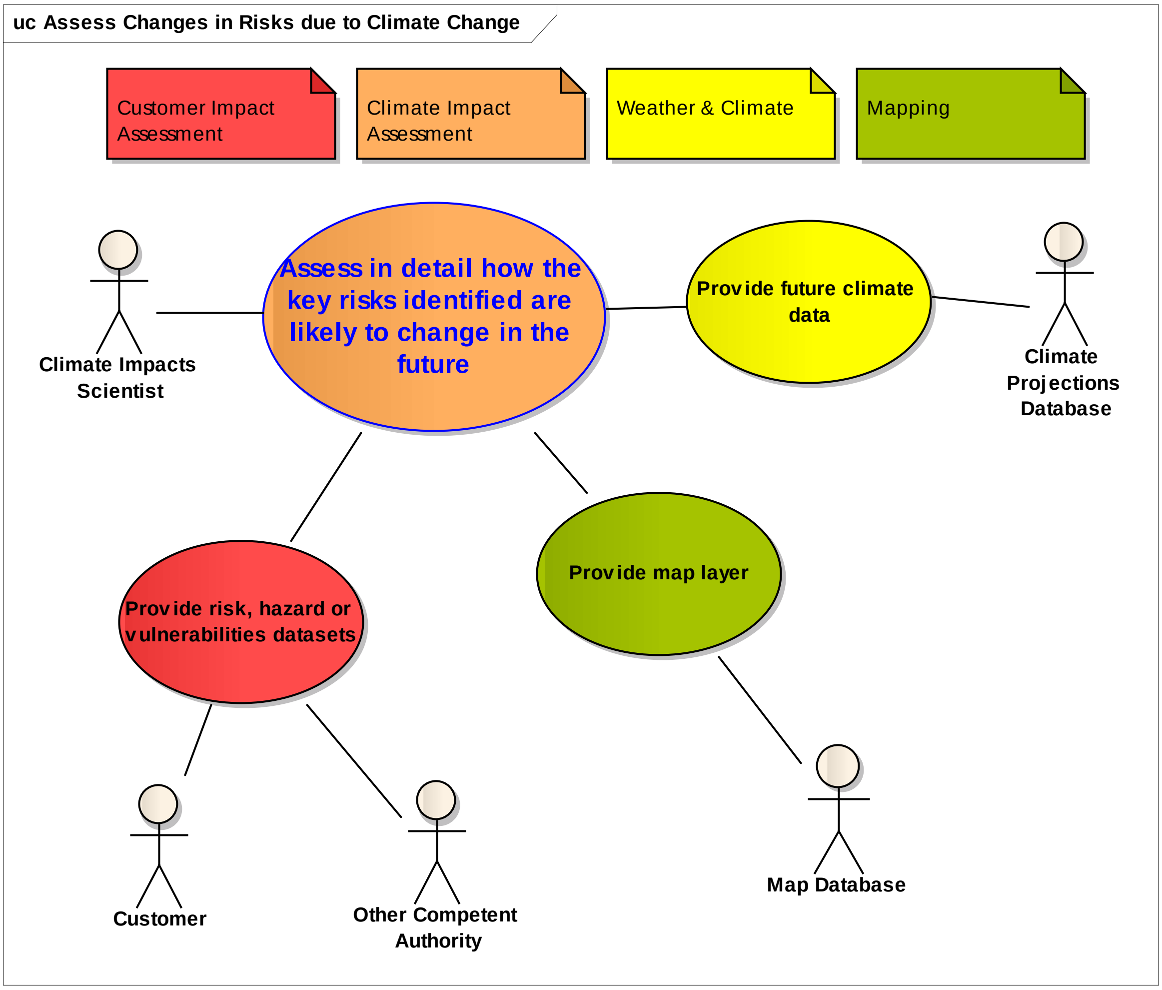
Use Case 3.2.2: Assess existing risks due to the current weather & climate



Use Case 3.2.2	**Assess existing risks due to the current weather & climate**
Priority	High
Description	Climate Impacts Scientist assesses the current customer expose to climate impacts and risks using past climate and weather data. They also calibrate/baseline the risk function relationship.
Pre-condition	Identified set of input climate and vulnerabilities datasets and a calibrated hazard model.
Flow of Events - Basic Path	
Step 1	***Climate Impacts Scientist*** uses the **Past Weather & Climate Data (Climatological Observations, Gridded Climatologies, Re-analyses)** and **Risk, Hazard & Vulnerability Data** within the risk function and hazard model relationships to assess the current exposure (and calibrate/baseline the relationships) to climate and weather.
Step 2	***Climate Impacts Scientist*** reviews the results using various **Visualisations of Risk Indicators**
Post-condition	Current (baseline) risk understood. Risk function calibrated.
Flow of Events - Alternative Path	
Additional Step 1a	If relevant the ***Climate Impacts Scientist*** may use Climatological **Observations** with the **Risk, Hazard & Vulnerability Data** to investigate specific events to gain further insight to the hazard model relationship with the input diagnostics.
Data Source: Climatological Observations (as per Use Case 3.2.1)	
Data Source: Gridded Climatologies (as per Use Case 3.2.1)	
Data Source: Re-analyses (as per Use Case 3.2.1)	
Data Source: Risk, Hazards & Vulnerabilities Data (as per Use Case 3.2.1)	
Data Source: Visualisations of Risk Indicators	

Description	Visualisation of risk indicators, as maps (usually filled gridboxes), time series (possibly with error/range bars) or probability distribution functions (PDFs).
Data Provider	Competent authorities in the weather and climate domain
Geographic Scope	Area of interest (may be national, regional or global)
Thematic Scope	Atmospheric Conditions (AC), Meteorological Geographic Features (MF) and various others (depending on customer area of concern)
Scale, resolution	*Grid, Point , PointSeries* (spatial and temporal resolution depends on area of interest)
Delivery	GIS tool, webpage or as part of a report
Documentation	None
Data Source: Map (as per Use Case 3.2.1)	

Use Case 3.2.3: Assess in detail how the key risks identified are likely to change in the future



Use Case 3.2.3	**Assess in detail how the key risks identified are likely to change in the future**
Priority	High
Description	Climate Impact Scientists assesses the future customer expose to climate impacts and risks using climate projections.
Pre-condition	Current (baseline) risk understood. Risk function calibrated.
Flow of Events - Basic Path	
Step 1	***Climate Impacts Scientist*** uses the **Future Climate Projections** and **Risk, Hazard & Vulnerability Data** within the risk function and hazard model relationships to assess the exposure to future changes in climate and weather.
Step 2	***Climate Impacts Scientist*** reviews the results using various **Visualisations of Risk Indicators**
Post-condition	Future risk understood.
Data Source: Future Climate Projection (as per Use Case 3.2.1)	
Data Source: Risk, Hazards & Vulnerabilities Data (as per Use Case 3.2.1)	
Data Source: Visualisations of Risk Indicators (as per Use Case 3.2.2)	
Data Source: Map (as per Use Case 3.2.1)	

References

[1] **Prepare: Understand your weather and climate related risks** (Climate Impacts and Risk assessment Framework (CIRF) Data Sheet): *http://www.metoffice.gov.uk/publicsector/cirf-datasheet.pdf*

[2] **Essential Climate Variables (ECV) Data Access Matrix** (GCOS): *http://gosic.org/ios/MATRICES/ECV/ecv-matrix.htm*

[3] **Met Office Hadley Centre observations datasets**: *http://www.hadobs.org/*

[4] **UK Climate Projections** (UKCP09): *http://ukclimateprojections.defra.gov.uk/content/view/868/531/*

[5] **Reanalysis at ECMWF** (ERA): *http://www.ecmwf.int/research/era/do/get/Reanalysis_ECMWF*

[6] **Atmospheric Circulation Reconstructions over the Earth** (ACRE): *http://www.met-acre.org/*

[7] **WCRP CMIP3 multi-model dataset** (IPCC AR4): *http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php*

[8] **European Climate Assessment and Dataset** (ECA&D): *http://eca.knmi.nl/*

Annex C
(informative)
Data Content

According to the INSPIRE Directive the data relevant to the themes "Atmospheric Conditions" and "Meteorological Geographical Features" should provide sufficient information for the users to assess, at least, precipitation, temperature, evapotranspiration and wind at their location of interest. General information on physical conditions should also be made available, however, neither the Directive nor any of the subsequent documents give any applicable (operative?) guidance regarding the range (in space and time) that this information should cover. However, it does specify that the data can originate from measurements, from models, or from post-processed information combining measurement output and model output.

The questions arising about data content are related to:

- *Temporal range: should forecasts be included? If yes, out to what range? If not, should real time or near real time data be included? (it should be noted that the word "forecast" does not appear in the Directive)*
- *Temporal frequency: frequency of data? Frequency of updates?*
- *Horizontal resolution*
- *Vertical extent and resolution*
- *Range of parameters*

as well as to data formats:

- *Should point data and field data be included?*
- *Should imagery be included?*

To address these questions it was noted that:

- Community policy on the environment must aim at a high level of protection
- The stated aim of the Directive is to assist decision-making regarding policies and activities that may have a direct or indirect impact on the environment
- The Directive should apply to the use of spatial data by public authorities in the performance of their public tasks
- The Directive is implemented with a view to stimulating the development of added-value services by third parties

On these grounds there seems to be no a priori reason to exclude any type of meteorological information from the scope of the themes on Atmospheric Conditions and Meteorological Geographical Features. It could possibly be argued that real time and forecast data is not needed strictly speaking for protecting the environment but only for ensuring security. However, as the example of GMES is showing, there is no clear limit between these two fields of activity, and it is highly likely that they will eventually be combined into a common framework.

The critical question which arises is the question of feasibility and affordability. Considering the very large volumes of data potentially involved it is not possible within the prescribed timeframe of the implementation of the Directive that the required services could be provided for all meteorological data. Therefore, while the work on data specification should indeed not exclude any data type, the implementing rules will have to provide the necessary safeguards against unrealistic implementation requirements.

An important element to bear in mind regarding implementation is the worldwide development of the WMO Information System, a new generation system for the exchange of meteorological and related data and products, with built-in Discovery, Access and Retrieval facilities. The EMI takes an active part in this development.

ObservablePropertyValue mapping to GRIB2 Descriptions & CF Standard Names

ObservablePropertyValue	GRIB 2 Code	Description	BUFR Code	Element name	CF Standard Name
evaporationAmount	1 6	Evaporation	0 13 033	Evaporation/evapotranspiration	water_evaporation_amount
precipitationAmount	1 52 (+ 4.10 1) (or 1 8)	Total precipitation rate + type of statistical processing = accumulation (or Total precipitation (depreciated))	0 13 011 or 0 13 060	Total precipitation/total water equivalent or Intensity of precipitation	precipitation_amount
precipitationRate	1 52 (or 1 7)	Total precipitation rate (or Precipitation rate (depreciated))	0 13 055	Intensity of precipitation	precipitation_flux
precipitationType	1 19	Precipitation type	0 20 021	Intensity of precipitation (Flag Table 0 20 021)	NONE
pressureReducedToMSL	3 1	Pressure reduced to MSL	0 10 051	Pressure reduced to mean sea level	air_pressure_at_sea_level
relativeHumidity	1 1	Relative humidity	0 13 003	Relative humidity	relative_humidity
snowDepth	1 11	Snow depth	0 13 013	Total snow depth	surface_snow_thickness
temperature	0 0	Temperature	0 12 001	Temperature/air temperature	air_temperature
totalCloudCover	6 1	Total cloud cover	0 20 010	Cloud cover (total)	cloud_area_fraction
windDirection	2 0	Wind direction (from which blowing)	0 11 001 or 0 11 011	Wind direction (degree true) or Wind direction at 10 m (degree true)	wind_from_direction
windSpeed	2 1	Wind speed	0 11 002 or 0 11 012	Wind speed or Wind speed at 10 m	wind_speed
windSpeedGust	2 22	Wind speed (gust)	0 11 041	Maximum wind gust speed	wind_speed_of_gust