5 Data content and structure

This data specification defines the following application schema:

– The Atmospheric Conditions and Meteorological Geographical Features application schema.

5.1 Application schemas – Overview

5.1.1 Application schemas included in the IRs

Articles 3, 4 and 5 of the Implementing Rules lay down the requirements for the content and structure of the data sets related to the INSPIRE Annex themes.

IR Requirement
Article 4
Types for the Exchange and Classification of Spatial Objects

1. For the exchange and classification of spatial objects from data sets meeting the conditions laid down in Article 4 of Directive 2007/2/EC, Member States shall use the spatial object types and associated data types, enumerations and code lists that are defined in Annexes II, III and IV for the themes the data sets relate to.

2. Spatial object types and data types shall comply with the definitions and constraints and include the attributes and association roles set out in the Annexes.

3. The enumerations and code lists used in attributes or association roles of spatial object types or data types shall comply with the definitions and include the values set out in Annex II. The enumeration and code list values are uniquely identified by language-neutral mnemonic codes for computers. The values may also include a language-specific name to be used for human interaction.

The types to be used for the exchange and classification of spatial objects from data sets related to the spatial data theme Atmospheric Conditions and Meteorological Geographical Features are defined in the following application schemas (see sections 5.3):

– The Atmospheric Conditions and Meteorological Geographical Features application schema (section 5.3).

The application schemas specify requirements on the properties of each spatial object including its multiplicity, domain of valid values, constraints, etc.

NOTE The application schemas presented in this section contain some additional information that is not included in the Implementing Rules, in particular multiplicities of attributes and association roles.

TG Requirement 1	Spatial object types and data types shall comply with the multiplicities defined for the attributes and association roles in this section.

An application schema may include references (e.g. in attributes or inheritance relationships) to common types or types defined in other spatial data themes. These types can be found in a sub-section called "Imported Types" at the end of each application schema section. The common types referred to from application schemas included in the IRs are addressed in Article 3.

IR Requirement
Article 3
Common Types

Types that are common to several of the themes listed in Annexes I, II and III to Directive 2007/2/EC shall conform to the definitions and constraints and include the attributes and association roles set out in Annex I.

NOTE Since the IRs contain the types for all INSPIRE spatial data themes in one document, Article 3 does not explicitly refer to types defined in other spatial data themes, but only to types defined in external data models.

Common types are described in detail in the Generic Conceptual Model [DS-D2.7], in the relevant international standards (e.g. of the ISO 19100 series) or in the documents on the common INSPIRE models [DS-D2.10.x]. For detailed descriptions of types defined in other spatial data themes, see the corresponding Data Specification TG document [DS-D2.8.x].

5.1.2 Additional recommended application schemas

There is no additional application schemas defined for the theme *Atmospheric Conditions and Meteorological Geographical Features*.

5.2 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].

5.2.1 Notation

5.2.1.1. Unified Modeling Language (UML)

The application schemas included in this section are specified in UML, version 2.1. The spatial object types, their properties and associated types are shown in UML class diagrams.

NOTE For an overview of the UML notation, see Annex D in [ISO 19103].

The use of a common conceptual schema language (i.e. UML) allows for an automated processing of application schemas and the encoding, querying and updating of data based on the application schema – across different themes and different levels of detail.

The following important rules related to class inheritance and abstract classes are included in the IRs.

IR Requirement
Article 5
Types

(…)

2. Types that are a sub-type of another type shall also include all this type's attributes and association roles.

3. Abstract types shall not be instantiated.

The use of UML conforms to ISO 19109 8.3 and ISO/TS 19103 with the exception that UML 2.1 instead of ISO/IEC 19501 is being used. The use of UML also conforms to ISO 19136 E.2.1.1.1-E.2.1.1.4.

NOTE ISO/TS 19103 and ISO 19109 specify a profile of UML to be used in conjunction with the ISO 19100 series. This includes in particular a list of stereotypes and basic types to be used in application schemas. ISO 19136 specifies a more restricted UML profile that allows for a direct encoding in XML Schema for data transfer purposes.

To model constraints on the spatial object types and their properties, in particular to express data/data set consistency rules, OCL (Object Constraint Language) is used as described in ISO/TS 19103, whenever possible. In addition, all constraints are described in the feature catalogue in English, too.

NOTE Since "void" is not a concept supported by OCL, OCL constraints cannot include expressions to test whether a value is a *void* value. Such constraints may only be expressed in natural language.

5.2.1.2. Stereotypes

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

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

Stereotype	Model element	Description
applicationSchema	Package	An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model.
leaf	Package	A package that is not an application schema and contains no packages.
featureType	Class	A spatial object type.
type	Class	A type that is not directly instantiable, but is used as an abstract collection of operation, attribute and relation signatures. This stereotype should usually not be used in INSPIRE application schemas as these are on a different conceptual level than classifiers with this stereotype.
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	An enumeration.
codeList	Class	A code list.
import	Dependency	The model elements of the supplier package are imported.
voidable	Attribute, association role	A voidable attribute or association role (see section 5.2.2).
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.

5.2.2 Voidable characteristics

The «voidable» stereotype is used to characterise those properties of a spatial object that may not be present in some spatial data sets, even though they may be present or applicable in the real world. This does *not* mean that it is optional to provide a value for those properties.

For all properties defined for a spatial object, a value has to be provided – either the corresponding value (if available in the data set maintained by the data provider) or the value of *void.* A *void* value shall imply that no corresponding value is contained in the source spatial data set maintained by the data provider or no corresponding value can be derived from existing values at reasonable costs.

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

The VoidReasonValue type is a code list, which includes the following pre-defined values:

- *Unpopulated*: The property 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 property receives this value for all spatial 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 only to those spatial objects where the property in question is not known.
- *Withheld*: The characteristic may exist, but is confidential and not divulged by the data provider.

NOTE It is possible 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, 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. In cases where the minimum multiplicity is 0, the absence of a value indicates that it is known that no value exists, whereas a value of void indicates that it is not known whether a value exists or not.

EXAMPLE If an address does not have a house number, the corresponding Address object should not have any value for the «voidable» attribute house number. If the house number is simply not known or not populated in the data set, the Address object should receive a value of *void* (with the corresponding void reason) for the house number attribute.

5.2.3 Enumerations

Enumerations are modelled as classes in the application schemas. Their values are modelled as attributes of the enumeration class using 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).

IR Requirement
Article 6
Code Lists and Enumerations

(…)

5) Attributes or association roles of spatial object types or data types that have an enumeration type may only take values from the lists specified for the enumeration type."

5.2.4 Code lists

Code lists are modelled as classes in the application schemas. Their values, however, are managed outside of the application schema.

5.2.4.1. Code list types

The IRs distinguish the following types of code lists.

IR Requirement
Article 6
Code Lists and Enumerations

1) Code lists shall be of one of the following types, as specified in the Annexes:
   a) code lists whose allowed values comprise only the values specified in this Regulation;
   b) code lists whose allowed values comprise the values specified in this Regulation and narrower values defined by data providers;
   c) code lists whose allowed values comprise the values specified in this Regulation and additional values at any level defined by data providers;
   d) code lists, whose allowed values comprise any values defined by data providers.

   For the purposes of points (b), (c) and (d), in addition to the allowed values, data providers may use the values specified in the relevant INSPIRE Technical Guidance document available on the INSPIRE web site of the Joint Research Centre.

The type of code list is represented in the UML model through the tagged value *extensibility*, which can take the following values:

– *none*, representing code lists whose allowed values comprise only the values specified in the IRs (type a);
– *narrower*, representing code lists whose allowed values comprise the values specified in the IRs and narrower values defined by data providers (type b);
– *open*, representing code lists whose allowed values comprise the values specified in the IRs and additional values at any level defined by data providers (type c); and
– *any*, representing code lists, for which the IRs do not specify any allowed values, i.e. whose allowed values comprise any values defined by data providers (type d).

Recommendation 2 Additional values defined by data providers should not replace or redefine any value already specified in the IRs.

NOTE This data specification may specify recommended values for some of the code lists of type (b), (c) and (d) (see section 5.2.4.3). These recommended values are specified in a dedicated Annex.

In addition, code lists can be hierarchical, as explained in Article 6(2) of the IRs.

IR Requirement
Article 6
Code Lists and Enumerations

(…)

2) Code lists may be hierarchical. Values of hierarchical code lists may have a more generic parent value. Where the valid values of a hierarchical code list are specified in a table in this Regulation, the parent values are listed in the last column.

The type of code list and whether it is hierarchical or not is also indicated in the feature catalogues.

5.2.4.2. Obligations on data providers

IR Requirement
Article 6
Code Lists and Enumerations

(….)

3) Where, for an attribute whose type is a code list as referred to in points (b), (c) or (d) of paragraph 1, a data provider provides a value that is not specified in this Regulation, that value and its definition shall be made available in a register.

4) Attributes or association roles of spatial object types or data types whose type is a code list may only take values that are allowed according to the specification of the code list.

Article 6(4) obliges data providers to use only values that are allowed according to the specification of the code list. The "allowed values according to the specification of the code list" are the values explicitly defined in the IRs plus (in the case of code lists of type (b), (c) and (d)) additional values defined by data providers.

For attributes whose type is a code list of type (b), (c) or (d) data providers may use additional values that are not defined in the IRs. Article 6(3) requires that such additional values and their definition be made available in a register. This enables users of the data to look up the meaning of the additional values used in a data set, and also facilitates the re-use of additional values by other data providers (potentially across Member States).

NOTE Guidelines for setting up registers for additional values and how to register additional values in these registers is still an open discussion point between Member States and the Commission.

5.2.4.3. Recommended code list values

For code lists of type (b), (c) and (d), this data specification may propose additional values as a recommendation (in a dedicated Annex). These values will be included in the INSPIRE code list register. This will facilitate and encourage the usage of the recommended values by data providers since the obligation to make additional values defined by data providers available in a register (see section 5.2.4.2) is already met.

Recommendation 3 Where these Technical Guidelines recommend values for a code list in addition to those specified in the IRs, these values should be used.

NOTE For some code lists of type (d), no values may be specified in these Technical Guidelines. In these cases, any additional value defined by data providers may be used.

5.2.4.4. Governance

The following two types of code lists are distinguished in INSPIRE:

– *Code lists that are governed by INSPIRE (INSPIRE-governed code lists).* These code lists will be managed centrally in the INSPIRE code list register. Change requests to these code lists (e.g. to add, deprecate or supersede values) are processed and decided upon using the INSPIRE code list register's maintenance workflows.

  INSPIRE-governed code lists will be made available in the INSPIRE code list register at *http://inspire.ec.europa.eu/codelist/<CodeListName>*. They will be available in SKOS/RDF, XML and HTML. The maintenance will follow the procedures defined in ISO 19135. This means that the only allowed changes to a code list are the addition, deprecation or supersession of values, i.e. no value will ever be deleted, but only receive different statuses (valid, deprecated, superseded). Identifiers for values of INSPIRE-governed code lists are constructed using the pattern *http://inspire.ec.europa.eu/codelist/<CodeListName>*/<value>.

– *Code lists that are governed by an organisation outside of INSPIRE (externally governed code lists).* These code lists are managed by an organisation outside of INSPIRE, e.g. the World Meteorological Organization (WMO) or the World Health Organization (WHO). Change requests to these code lists follow the maintenance workflows defined by the maintaining organisations. Note that in some cases, no such workflows may be formally defined.

  Since the updates of externally governed code lists is outside the control of INSPIRE, the IRs and these Technical Guidelines reference a specific version for such code lists.

  The tables describing externally governed code lists in this section contain the following columns:

  – The *Governance* column describes the external organisation that is responsible for maintaining the code list.
  – The *Source* column specifies a citation for the authoritative source for the values of the code list. For code lists, whose values are mandated in the IRs, this citation should include the version of the code list used in INSPIRE. The version can be specified using a version number or the publication date. For code list values recommended in these Technical Guidelines, the citation may refer to the "latest available version".
  – In some cases, for INSPIRE only a subset of an externally governed code list is relevant. The subset is specified using the *Subset* column.
  – The *Availability* column specifies from where (e.g. URL) the values of the externally governed code list are available, and in which formats. Formats can include machine-readable (e.g. SKOS/RDF, XML) or human-readable (e.g. HTML, PDF) ones.

  Code list values are encoded using http URIs and labels. Rules for generating these URIs and labels are specified in a separate table.

Recommendation 4	The http URIs and labels used for encoding code list values should be taken from the INSPIRE code list registry for INSPIRE-governed code lists and generated according to the relevant rules specified for externally governed code lists.

NOTE Where practicable, the INSPIRE code list register could also provide http URIs and labels for externally governed code lists.

5.2.4.5. Vocabulary

For each code list, a tagged value called "vocabulary" is specified to define a URI identifying the values of the code list. For INSPIRE-governed code lists and externally governed code lists that do not have a persistent identifier, the URI is constructed following the pattern *http://inspire.ec.europa.eu/codelist/<UpperCamelCaseName>*.

If the value is missing or empty, this indicates an empty code list. If no sub-classes are defined for this empty code list, this means that any code list may be used that meets the given definition.

An empty code list may also be used as a super-class for a number of specific code lists whose values may be used to specify the attribute value. If the sub-classes specified in the model represent all valid extensions to the empty code list, the subtyping relationship is qualified with the standard UML constraint "{complete,disjoint}".

5.2.5 Identifier management

IR Requirement
Article 9
Identifier Management

1. The data type Identifier defined in Section 2.1 of Annex I shall be used as a type for the external object identifier of a spatial object.
2. The external object identifier for the unique identification of spatial objects shall not be changed during the life-cycle of a spatial object.

NOTE 1 An external object identifier is a unique object identifier which is published by the responsible body, which may be used by external applications to reference the spatial object. [DS-D2.5]

NOTE 2 Article 9(1) is implemented in each application schema by including the attribute *inspireId* of type Identifier.

NOTE 3 Article 9(2) is ensured if the *namespace* and *localId* attributes of the Identifier remains the same for different versions of a spatial object; the *version* attribute can of course change.

5.2.6 Geometry representation

IR Requirement
Article 12
Other Requirements & Rules

1. The value domain of spatial properties defined in this Regulation shall be restricted to the Simple Feature spatial schema as defined in Herring, John R. (ed.), OpenGIS® Implementation Standard for Geographic information – Simple feature access – Part 1: Common architecture, version 1.2.1, Open Geospatial Consortium, 2011, unless specified otherwise for a specific spatial data theme or type.

NOTE 1 The specification restricts the spatial schema to 0-, 1-, 2-, and 2.5-dimensional geometries where all curve interpolations are linear and surface interpolations are performed by triangles.

NOTE 2 The topological relations of two spatial objects based on their specific geometry and topology properties can in principle be investigated by invoking the operations of the types defined in ISO 19107 (or the methods specified in EN ISO 19125-1).

5.2.7 Temporality representation

The application schema(s) use(s) the derived attributes "beginLifespanVersion" and "endLifespanVersion" to record the lifespan of a spatial object.

The attributes "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described by the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

IR Requirement
Article 10
Life-cycle of Spatial Objects

(…)

3. Where the attributes beginLifespanVersion and endLifespanVersion are used, the value of endLifespanVersion shall not be before the value of beginLifespanVersion.

NOTE The requirement expressed in the IR Requirement above will be included as constraints in the UML data models of all themes.

Recommendation 5 If life-cycle information is not maintained as part of the spatial data set, all spatial objects belonging to this data set should provide a void value with a reason of "unpopulated".

5.2.7.1. Validity of the real-world phenomena

The application schema(s) use(s) the attributes "validFrom" and "validTo" to record the validity of the real-world phenomenon represented by a spatial object.

The attributes "validFrom" specifies the date and time at which the real-world phenomenon became valid in the real world. The attribute "validTo" specifies the date and time at which the real-world phenomenon is no longer valid in the real world.

Specific application schemas may give examples what “being valid” means for a specific real-world phenomenon represented by a spatial object.

IR Requirement
Article 12
Other Requirements & Rules

(…)

3. Where the attributes validFrom and validTo are used, the value of validTo shall not be before the value of validFrom.

NOTE The requirement expressed in the IR Requirement above will be included as constraints in the UML data models of all themes.

5.2.8 Coverages

Coverage functions are used to describe characteristics of real-world phenomena that vary over space and/or time. Typical examples are temperature, elevation, precipitation, imagery. A coverage contains a set of such values, each associated with one of the elements in a spatial, temporal or spatio-temporal domain. Typical spatial domains are point sets (e.g. sensor locations), curve sets (e.g. isolines), grids (e.g. orthoimages, elevation models), etc.

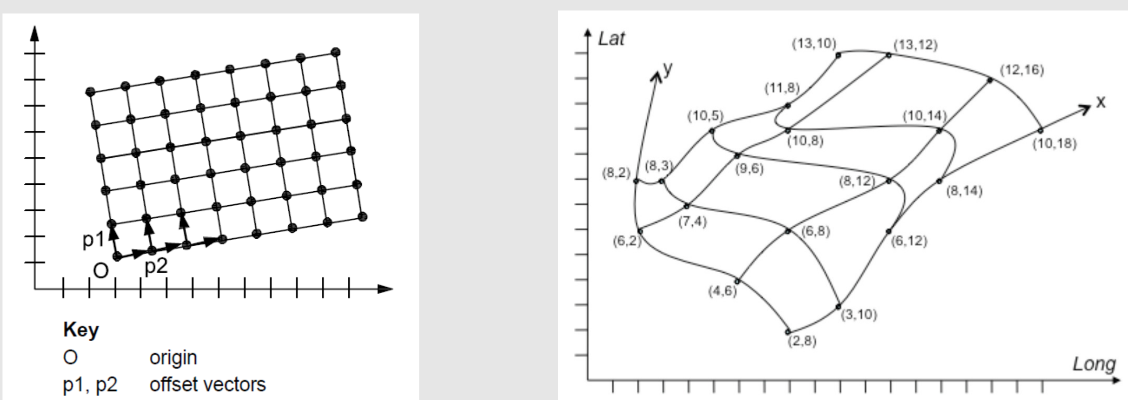
In INSPIRE application schemas, coverage functions are defined as properties of spatial object types where the type of the property value is a realisation of one of the types specified in ISO 19123.

To improve alignment with coverage standards on the implementation level (e.g. ISO 19136 and the OGC Web Coverage Service) and to improve the cross-theme harmonisation on the use of coverages in INSPIRE, an application schema for coverage types is included in the Generic Conceptual Model in 9.9.4. This application schema contains the following coverage types:

- *RectifiedGridCoverage*: coverage whose domain consists of a rectified grid – a grid for which there is an affine transformation between the grid coordinates and the coordinates of a coordinate reference system (see Figure 1, left).
- *ReferenceableGridCoverage*: coverage whose domain consists of a referenceable grid – a grid associated with a transformation that can be used to convert grid coordinate values to values of coordinates referenced to a coordinate reference system (see Figure 1, right).

In addition, some themes make reference to the types TimeValuePair and Timeseries defined in Taylor, Peter (ed.), *OGC® WaterML 2.0: Part 1 – Timeseries, v2.0.0,* Open Geospatial Consortium, 2012. These provide a representation of the time instant/value pairs, i.e. time series (see Figure 2).

Where possible, only these coverage types (or a subtype thereof) are used in INSPIRE application schemas.



(Source: ISO 19136:2007) (Source: GML 3.3.0)

Figure 1 – Examples of a rectified grid (left) and a referenceable grid (right)

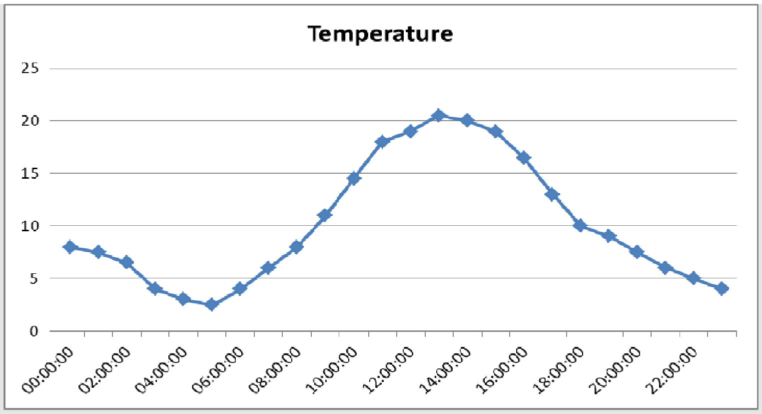


Figure 2 – Example of a time series

5.3 Application schema Atmospheric Conditions and Meteorological Geographical Features

5.3.1 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[1], 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.

5.3.1.1. Narrative description

The Atmospheric Conditions and Meteorological Geographical Features data specification is based on the Observation and Measurements (O&M) conceptual model, defined in ISO 19156:2011, using concepts – together with their associations - defined within INSPIRE Generic Conceptual Model.

ISO 19156:2011 defines the concept of observation, an act that results in the estimation of the value of a feature property using a designated procedure, such as a sensor, instrument, algorithm or process chain. An observation is associated with a discrete time instant or period through which a number, term or other symbol is assigned to a phenomenon. The result of an observation is an estimate of the value of a property of some feature, so the details of the observation are metadata concerning the value of the feature property.

Concepts defined within ISO 19156 and are directly associated with the concept of observation are (see Figure 4):
Feature of interest: a real-world object whose properties are under observation, or is a feature intended to sample the real-world object.
Observed Property: a phenomenon associated with the feature-of-interest for which the observation result provides an estimate of its value.
Process: a process (procedure) used to generate the result. A process might be responsible for more than one observation. A description of the observation procedure provides or implies an indication of the reliability or quality of the observation result.

---

[1] Cf. http://en.wikipedia.org/wiki/Lagrangian_and_Eulerian_specification_of_the_flow_field

Observation results may have many data-types, including primitive types like category or measure, but also more complex types such as time, location and geometry.

The result-type may be used as a basis for defining specialized observation types. 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 (see Figure 5).

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 de-scribes the applied sampling regime (see Figure 5).
Spatial sampling feature is a specialisation of the generic concept sampling feature, an artefact of the observational strategy which has no significance function outside of its role in the observation process - it is established in order to make observations concerning some domain feature.

Spatial sampling features are useful when observations are made to estimate properties of a geospatial feature such as the atmosphere, in particular where the value of a property varies within the scope of the feature. Spatial sampling features can be specialised according to their shapes: point, curve, surface and solid spatial sampling features (see Figure 4).

The following Figure illustrates the use of concepts: sampling coverage observation, sampling feature and sam-pled 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).

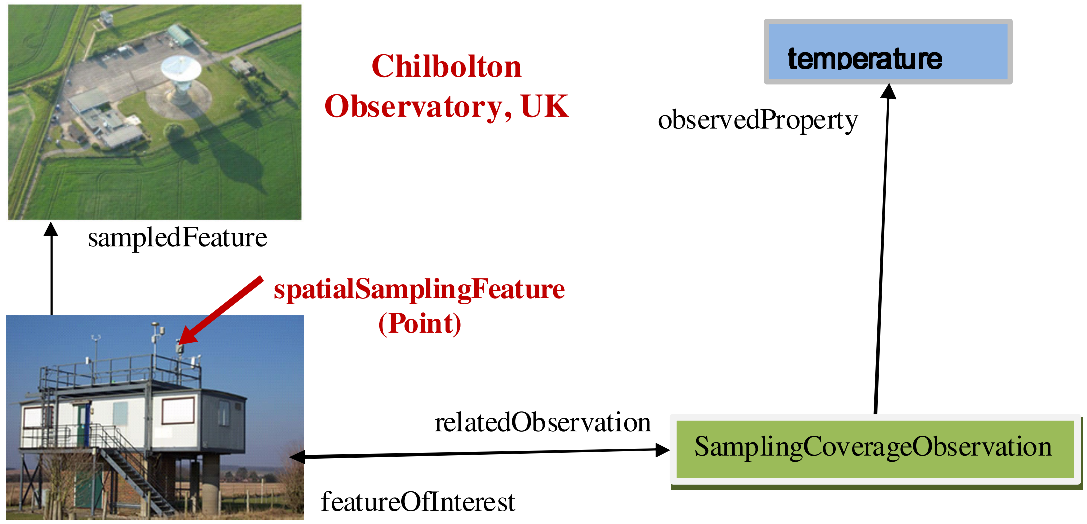


Figure 3: Example of time series measurements of air temperature showing the use of the concepts: sampling coverage observation, sampling feature and sampled feature

Use of this common model allows observation data (either from measurements, model runs or both) using different procedures to be combined unambiguously. Observation details are also important for data discovery and for data quality estimation.

INSPIRE Generic Conceptual Model

Specialised observations defined within INSPIRE Generic Conceptual Model describe elegantly a wide range of data regarding atmospheric conditions or meteorological phenomena. In particular, the specialised observations used in this data specification are (see Figure 8):

Point observation: an observation that represents a measurement or estimation of a property at a single point in time and space, e.g. a single temperature measurement at a fixed weather station.
Point Time Series Observation: an observation that represents a time-series of point measurements or estimations of a property at a fixed location in space, e.g. measurements made repeatedly by a fixed monitoring instrument.
Multi Point Observation: an Observation that represents a set of measurements or estimations all made at exactly the same time but at different locations, e.g. a distributed sensor network reporting the temperature at 10am. The result of this observation is a MultiPointCoverage.
Grid Observation: an observation representing a gridded field at a single time instant, e.g. output from a model, or rectified georeferenced satellite data. The result of a 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.
Grid Series Observation: an observation representing an evolving gridded field at a succession of time instants. A Grid Series Observation is a time series of gridded fields representing the same phenomenon (or phenomena) over a series of time instances. The result of a 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.
Profile Observation: an observation representing the estimates of a property along a vertical profile in space at a single time instant.
Trajectory Observation: an observation representing the estimates of a property along a meandering curve in time and space, e.g. a Pollutant concentration from a mobile air quality sensor.

IR Requirement
Annex IV, Section 13.3
Theme-specific Requirements

The observed property of an OM_Observation shall be identified by an identifier from the EU Air Quality Reference Component, the WMO GRIB Code & Flags Table 4.2, the Climate and Forecast Standard Names vocabularies or another appropriate vocabulary.

The **observed property** of an observation instance shall be extracted from the codelists CF Standard Names Value, WMO GRIB Table 4.2 Value and EU Air Quality Reference Component Value, depending on the need of the application for which the data is produced (see section 5.3.1.2). Following the application schema "Observable properties" of the INSPIRE Generic Conceptual Model the observed property of an observation can be composite, i.e., consisting of two or more observed properties extracted from the above mentioned code lists. Further detail required for the observed property, which are not given by the used code list e.g. daily maximum temperature, shall be provided by the classes Constraint and Statistical Measure (see Figure 6 and Figure 9).

The Directive states that atmospheric data can originate from measurements, models, or post-processed information combining measurement and model output. The "Process" of the INSPIRE Generic Conceptual Model, which specialises the abstract class OM_Process, shall pro-vide information regarding the procedure used to generate the result of an observation (see Figure 7). This set of information consists of the following information pieces: identification, type and further documentation of the applied procedure (online/offline); individual(s) and/or organisation(s) related to the procedure; names of parameters controlling the procedure's output. Typical examples of using the process-Parameter 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.

Spatial/Temporal extent, Quality and additional metadata of data
The spatial and temporal extents of an observation are provided by the observation's related spatial sampling feature and the OM_Observation attribute phenomenonTime respectively [ISO 19156:2011].

If description of the quality of the observation result is required, it shall be provided by the attribute resultQuality:DQ_Element of the generic class OM_Observation.

Additional information for the observed values could be provided by the ISO 19115 class MD_Metadata.

5.3.1.2. Basic properties

Observable property external code lists
Chapter 5.3.3 Code lists provides detailed guidance on the requirements for the provision and maintenance of external code lists by a competent international organisation (the preferred solution), and these organisations have their own governance and version management processes, allowing the code lists to be extended in response to community needs.

The choice of external code list is within the scope of this data specification. It is acknowledged that no single existing external code list sufficiently meets all requirements for AC-MF, but that a number code lists collectively do cover the requirement. Whilst no absolute requirements are placed on the use of particular external code lists, strong recommendations are made.

Meteorological parameters are represented within the AC-MF model through the Observable Property model, which provides the ability to describe statistical properties and constraints. This model includes main three properties for which codelists are required:

- basePhenomenon (also used for constrainedProperty) (e.g. “air_temperature”)
- statisticalFunction (e.g. “maximum”)
- uom – units of measure (e.g. “K”)

Units of measure are managed in a standard way for all INSPIRE themes (using UCUM: *http://unitsofmeasure.org/*), and so are not considered further here.

Statistical function is provide as an INSPIRE-managed codelist as part of the O&M Complex Property model (StatisticalFunctionTypeValue), and so is not considered further here.

For basePhenomenon (and constrainedProperty), it is recommended that meteorological parameters are referenced either as:

- CF Standard Names from the NERC Vocabulary Server
- WMO GRIB parameters from Code Table 4.2 of the GRIB code tables

And that air quality parameters are referenced either as:

- EEA reference air quality components in the codelists on the Eionet Air Quality Portal
- CF Standard Names from the NERC Vocabulary Server

However, it should be noted that the terms for air quality are still under development.

Recommendation 6	basePhenomenon should refer to external code lists CF Standard Names, Code Table 4.2 of the WMO GRIB code tables or codelists on the Eionet Air Quality Portal.

5.3.1.3. UML Overview

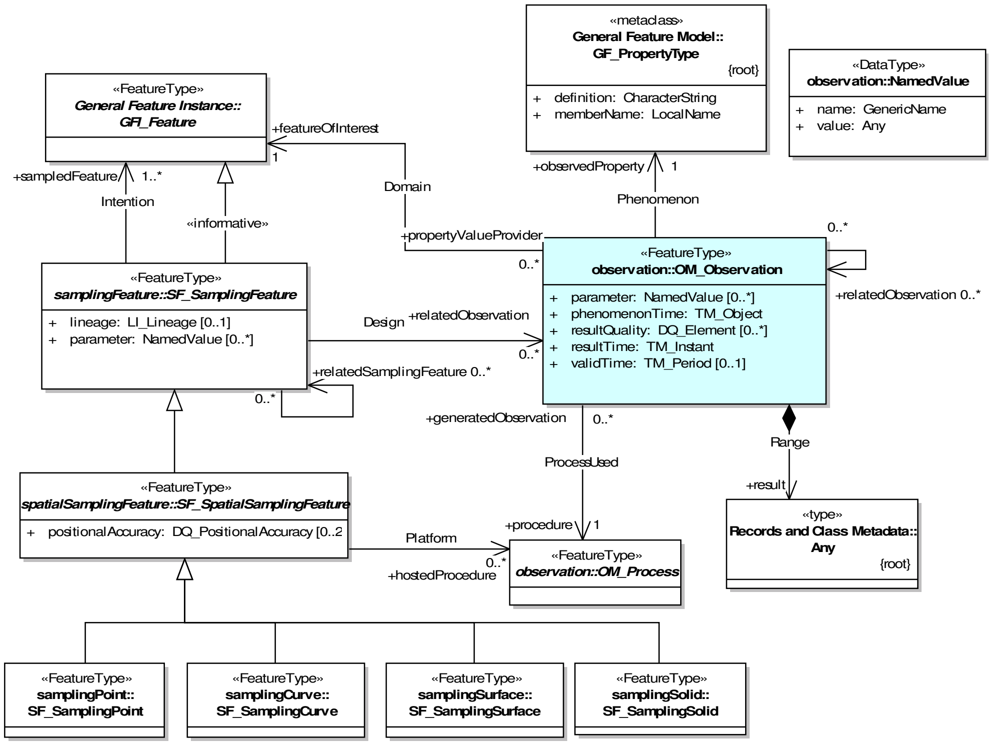


Figure 4: Overview of generic Observation concept together with the directly associated concepts FeatureOfInterest, observedProperty, procedure and sampling feature

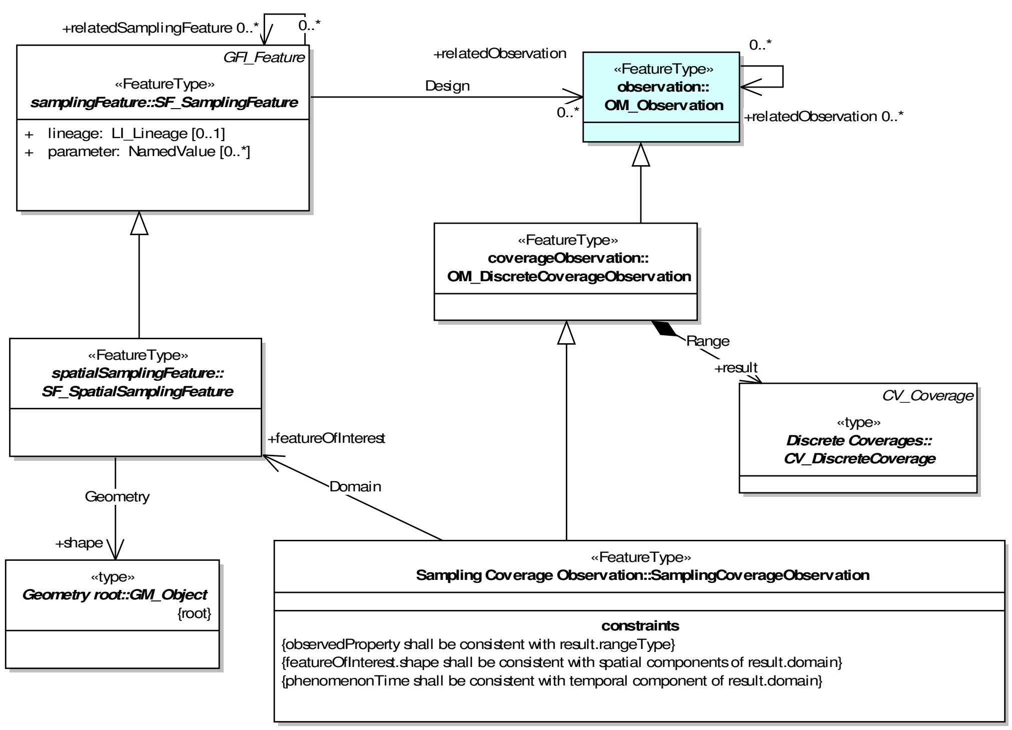


Figure 5: The specialised observations OM_DiscreteCoverageObservation and SamplingCoverageObservation of O&M model

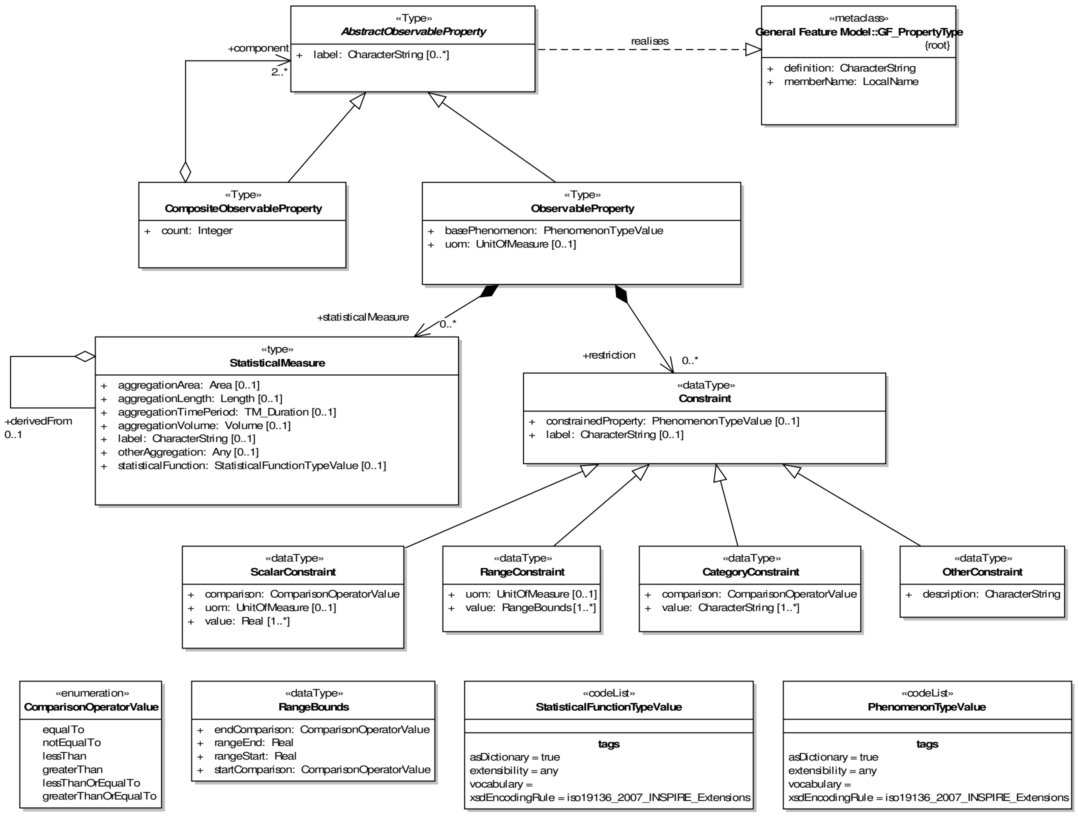


Figure 6: The Observable Property Model Process as defined within INSPIRE Generic Conceptual Model

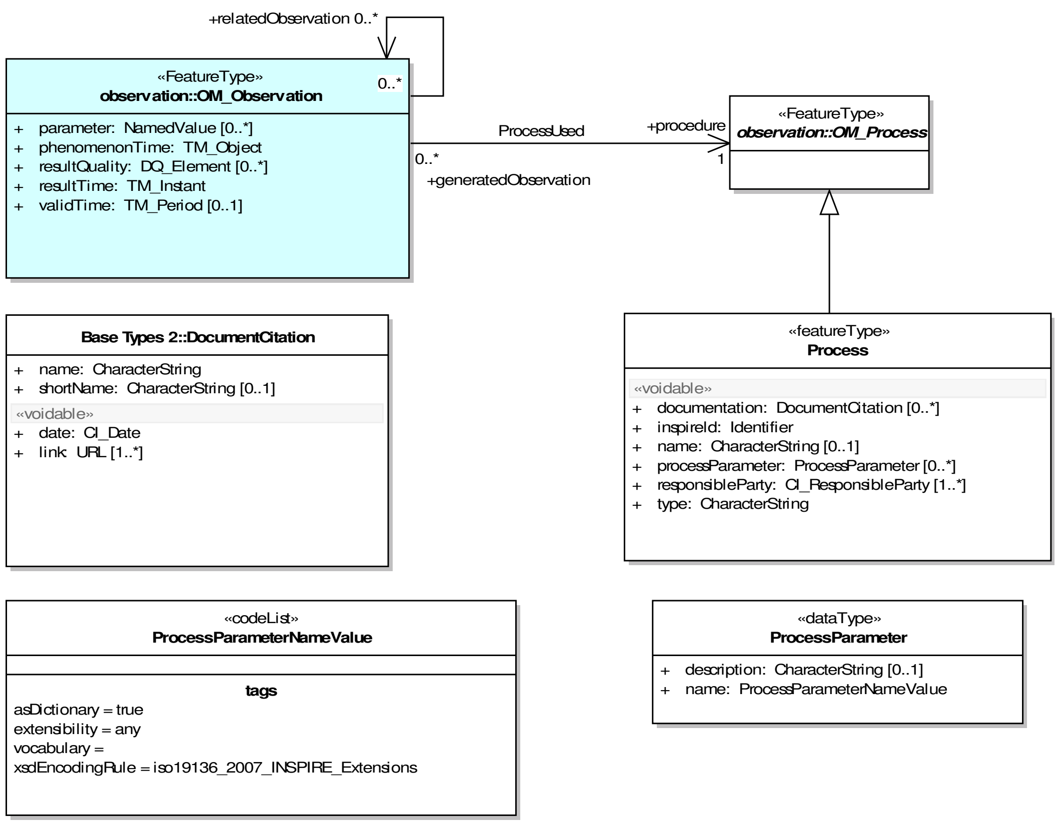


Figure 7: The INSPIRE Process as defined within INSPIRE Generic Conceptual Model

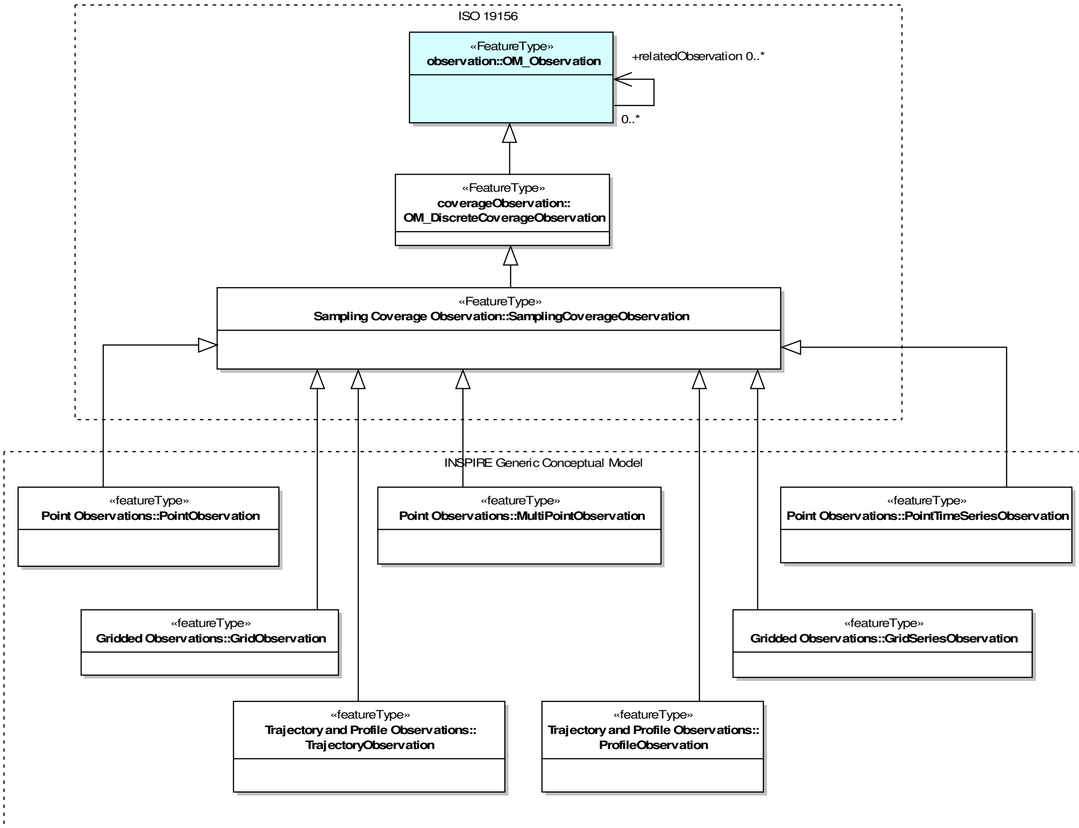


Figure 8: The Observation classes used to describe data within AC-MF data specification

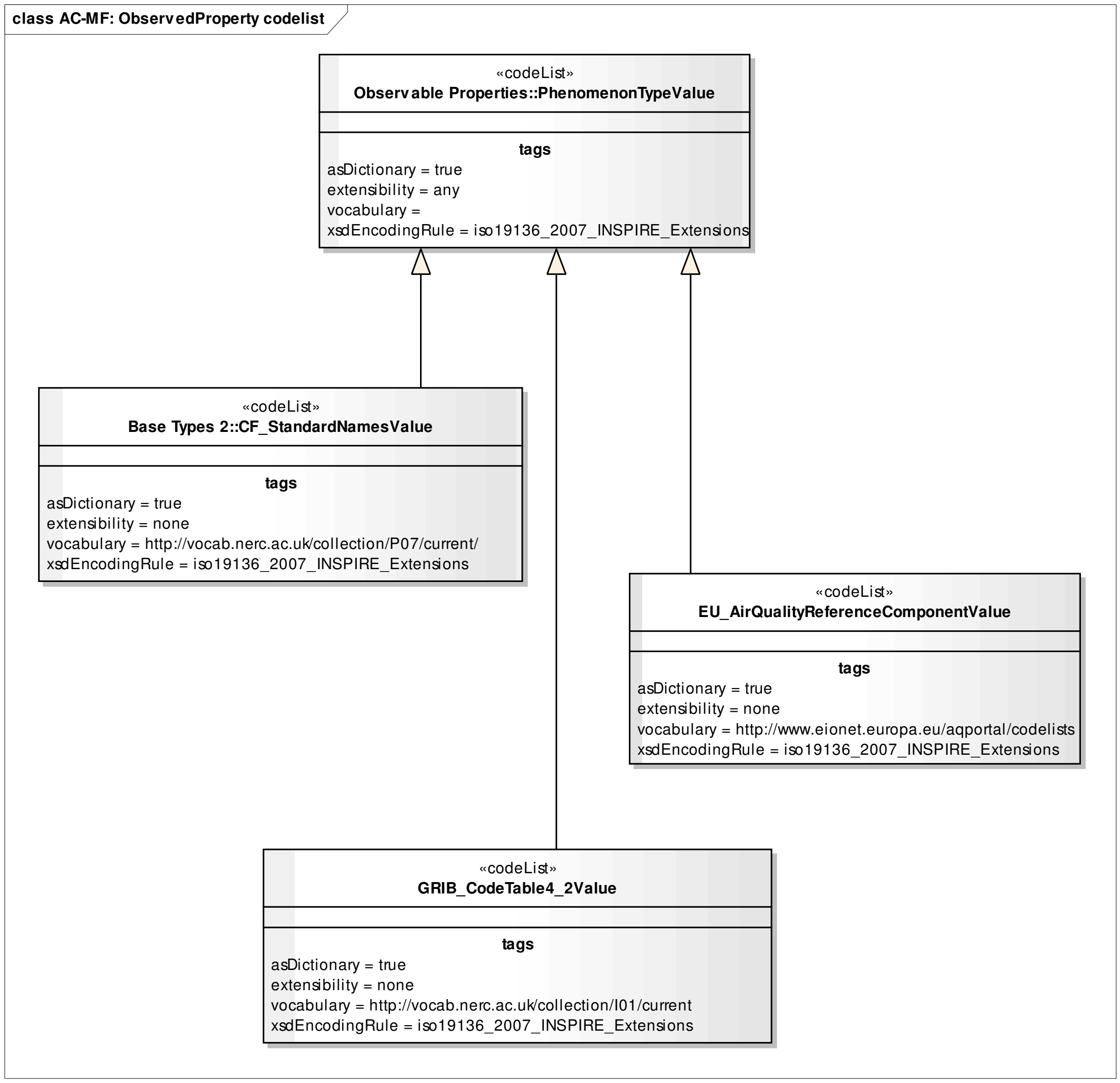


Figure 9: Code lists used for AC-MF data specification

5.3.1.4. Consistency between spatial data sets

Not relevant for AC-MF.

5.3.1.5. Identifier management

Three places were identified in the AC-MF data model where INSPIRE identifiers might be used, but in all three cases it is argued that there is no strong use case for such use, and therefore no requirements are made for such usage; the text below explores the three cases to explain this reasoning.

A) INSPIRE identifier for SpecialisedObservations

INSPIRE identifiers are intended to provide stable, unique references to the data, but SpecialisedObservations are not usually assigned such an identifier, but rather referred to by a combination of their geographic and temporal characteristics. Further, they are often transient (e.g. for real-time data) and may be groups and aggregated in many different ways. They are only usually references in a persistent way through the broader dataset to which they belong, which is described by the dataset-level metadata.

B) Geographic identifiers

Where relevant, geographic identifiers are related to features of interest and/or sampling features, such as observing stations, administrative units, and transport network. Geographic identifiers could be a WMO station identifier (i.e. “07481”), an ICAO identifier (i.e. “LFLL”), geographic names (i.e. “LYON ST EXUPERY”), or any other local identifiers (i.e. French INSEE number: “69299001”) provided there is a recognized authority (like the WMO, INSPIRE, etc) in charge of the identifier management. However, in all these cases, these identifiers are covered by other INSPIRE themes.

If a precise reference to a geographic identifier is required, this should be realised by a link to the relevant thematic data model. In most cases this would be specified in feature of interest and/or sampling features. However, a special example is the link to Environmental Monitoring Facilities to provide information on an observing site, which could be realised in one of two ways:

- If the SpecialisedObservation is of prime importance, the observing station can be referenced as a link to EF via Process;
- If the observing station is of prime importance, then this should be specified under the EF data model, with the SpecialisedObservations linked hasObservation association (see air quality use case example).

Where a precise reference to a geographic identifier is not essential, but adds useful reference information about the observation, it can be include as part of the free-text “name” property of the Process (see below).

C) Process identifier

Although Process has an INSPIRE identifier (which is voidable), there is no special requirement to provide this for AC-MF. Instead it is suggested that property “name” property is used to hold information on the process (and the observing site) that may be informative. For example for the long time series of observations at Aberporth, might be assigned the name “Climatological observation record for WMO station 03502 (Aberporth)”.

5.3.1.6. Geometry representation

Art. 12(1) of Regulation 1089/2010 restricts the value domain of spatial properties to the Simple Feature spatial schema as defined in the *OpenGIS® Implementation Standard for Geographic information – Simple feature access – Part 1: Common architecture, version 1.2.1*, unless specified otherwise for a specific spatial data theme or type.

5.3.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue AC-MF
Scope	AC-MF
Version number	0.1
Version date	2010-10-27
Definition source	INSPIRE data specification AC-MF

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
AtmosphericPhenomenonCoverage	AC-MF	«featureType»	5.2.2.1.1
AtmosphericPhenomenonName	AC-MF	«codeList»	5.2.2.2.1
DataSource	AC-MF	«codeList»	5.2.2.2.2
WeatherCondition	AC-MF	«featureType»	5.2.2.1.2

5.3.2.1. Spatial object types

5.3.2.1.1. AtmosphericPhenomenonCoverage

AtmosphericPhenomenonCoverage

AtmosphericPhenomenonCoverage	
Definition:	An identifiable spatial object that associates positions within the spatio-temporal extent of an atmospheric phenomenon (domain) to its assigned values (range).
Status:	Proposed
Stereotypes:	«featureType»
Attribute: dataSource	
Value type:	DataSource
Definition:	Makes known whether the data come from measurements, model or a combination.
Multiplicity:	1
Attribute: identifier	
Value type:	Identifier
Multiplicity:	1
Association role: relevantObservation	
Value type:	OM_Observation
Multiplicity:	
Stereotypes:	«voidable»

5.3.2.1.2. WeatherCondition

WeatherCondition	
Definition:	An identifiable set of estimated values of a number of atmospheric phenomena.
Description:	NOTE The estimated values are based on measurements, on models or on a combination. EXAMPLE Measured values of air temperature, air pressure and relative humidity.
Status:	Proposed
Stereotypes:	«featureType»
Attribute: extent	
Value type:	EX_Extent
Definition:	Information about the spatial and temporal extent of WeatherCondition.
Multiplicity:	1
Attribute: identifier	
Value type:	Identifier
Definition:	External object identifier of the spatial object.
Multiplicity:	1
Attribute: phenomenon	
Value type:	AtmosphericPhenomenonName
Definition:	Atmoshperic phenomena composing LocalWeatherCondition.
Multiplicity:	1..*
Association role: coverage	
Value type:	AtmosphericPhenomenonCoverage
Multiplicity:	1..*

5.3.2.2. Code lists

5.3.2.2.1. AtmosphericPhenomenonName

AtmosphericPhenomenonName	
Definition:	Defines different types of atmospheric phenomena.

AtmosphericPhenomenonName	
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May be extended by Member States.
Value: rainIntensity	
Definition:	
Value: temperature	
Definition:	

5.3.2.2.2. DataSource

DataSource	
Definition:	Define different types of originating processes.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May be extended by Member States.
Value: combination	
Definition:	
Value: measurements	
Definition:	
Value: model	
Definition:	

5.3.2.3. 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.

5.3.2.3.1. 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]

5.3.2.3.2. 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.

5.3.2.3.3. Identifier

Identifier	
Package:	INSPIRE Consolidated UML Model::Themes::Annex II::Orthoimagery::Orthoimagery [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.

5.3.2.3.4. OM_Observation

OM_Observation	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO DIS 19156:2010 Observations and Measurements::Observation Core [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

INSPIRE governed code lists are given in Annex C.

5.3.3 Externally governed code lists

The externally governed code lists included in this application schema are specified in the tables in this section.

5.3.3.1. Governance and authoritative source

Code list	Governance	Authoritative Source (incl. version[2] and relevant subset, where applicable)
CF_StandardNamesValue	CF Governance Committee and CF Standard Names Committe (representatives from multiple data centres)	British Oceanographic Data Centre
EU_AirQualityReferenceComponentValue	European Environment Agency	European Environment Agency
GRIB_CodeTable4_2Value	WMO InterProgramme Expert Team on data Codes &	World Meteorological Organisation

[2] If no version or publication date are specified, the "latest available version" shall be used.

	Representations (IPET-DRC)	
GRIB_CodeTable4_201Value	WMO InterProgramme Expert Team on data Codes & Representations (IPET-DRC)	World Meteorological Organisation

5.3.3.2. Availability

Code list	Availability	Format
CF_StandardNamesValue	*http://vocab.nerc.ac.uk/collection/P07/current/* *http://cf-pcmdi.llnl.gov/documents/cf-standard-names*	SKOS/RDF, XML, HTML
EU_AirQualityReferenceComponentValue	*http://www.eionet.europa.eu/aqportal/codelists*	SKOS/RDF, XML, HTML
GRIB_CodeTable4_2Value	*http://vocab.nerc.ac.uk/collection/I01/current* *http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/LatestVERSION.html*	SKOS/RDF, PDF, Zip of XML
GRIB_CodeTable4_201Value	*http://vocab.nerc.ac.uk/collection/I02/current* *http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/LatestVERSION.html*	SKOS/RDF, PDF, Zip of XML

5.3.3.3. Rules for code list values

Code list	Identifiers	Examples
CF_StandardNamesValue	n/a	*http://vocab.nerc.ac.uk/collection/P07/current/CFSN0413*
EU_AirQualityReferenceComponentValue		
GRIB_CodeTable4_2Value	n/a	*http://vocab.nerc.ac.uk/collection/I01/current/0.1.1*
GRIB_CodeTable4_201Value	n/a	*http://vocab.nerc.ac.uk/collection/I02/current/5*

Code list	Labels	Examples
CF_StandardNamesValue	The string contained in SKOS preflabel e.g <skos:prefLabel>relative_humidity</skos:prefLabel>	relative_humidity used for relative humidity
EU_AirQualityReferenceComponentValue		
GRIB_CodeTable4_2Value	The string contained in SKOS preflabel e.g <skos:prefLabel xml:lang="en">Snow depth</skos:prefLabel>	Snow depth used for snow depth
GRIB_CodeTable4_201Value	The string contained in SKOS preflabel e.g <skos:prefLabel>Snow</skos:pref	Snow

	Label>	

.