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# Temporal Extension metadata

*Draft*

*Version 0.1 (2006 September 16)*

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## Scope

This document discusses the usage of temporal ancillary information (metadata) in geo-information discovery, particularly in the GMES and environmental monitoring sectors. This is intended for the INSPIRE Metadata DT activity.

## Introduction

Like any information system, a geographic information system must deal with the problem of outdated data. One approach is to simply delete outdated data and constrain the system state to an eternal present. This is totally sound in certain application domains, where past data are totally useless (e.g. navigation systems), but in general, the possibility of accessing data related to previous system states must be supported, at least to a certain extent.

In fact, since geo-information is related to the Earth and the Earth is embedded in a spatio-temporal universe, it is arguable that neglecting the temporal connotation of geo-information could highly decrease the information usefulness and constitute an unacceptable simplification.

On the other side, denoting geo-information with temporal information is obviously cumbersome, and adds complexity to the already complex processes of production, maintenance and provisioning of geo-information.

Some critical issues related to temporal information are [1]:

1. Temporal knowledge may be relative, and either the relative times are more precisely known than absolute times or they cannot be described by a date (e.g. geological eras);
2. Some temporal reference systems can have a moving reference time, (e.g. weather forecasts are relative to the issue time, and current weather is “now”);
3. Temporal knowledge may be uncertain, that is, the exact relationship between two times may be not known precisely;
4. Temporal information may be ordinal, where the periods are in sequence and are named (e.g. spring, summer, autumn, winter) and the transitions may not have specific dates;
5. The granularity of temporal information may vary significantly (e.g. geological eras vs. the duration of a solar eclipse).

A careful design of temporal metadata model and implementation should trade off between the unpractical requirement of precisely referring data to time and the unreasonable assumption that time is of little importance for geo-information discovery.

Some examples of use-cases that rely on temporal information for data discovery in the GMES sector are given below. Some considerations on the implementation of temporal metadata follow.

## Use-cases

The use of temporal extension metadata to discover geospatial resources is recognized to be essential for the following use cases:

### 1. Defence and Security

- High Resolution Vector Data (i.e. MGPC): resource discovery is performed on the basis of several metadata including the temporal extension which must be referred to the date and time of “source material”. In fact, at least for “imagery source” it is advisable for such a material to be at most three years old. The same criterion is applied to the extracted features.
- Automatic creation of new digital and paper maps: in order to prepare a new map, procedure queries and extracts the recent obstacles (e.g. new electric pylons created by a energy supplier company) to be included in a new map version. This is possible by issuing a query, which includes a temporal extent, such as: “return all the obstacles created as of 2005 January 1”. In fact, there exists a national directive which obligates public and private entities to communicate the creation of new obstacles to Aeronautical Geotopographic Information Centre (CIGA) providing their creation date and time metadata.
- Notices to mariners and NOtice To AirMan (NOTAM): in order to issue notices to mariners and aviators, there must be issued queries, such as: return all the notices on the following *area* ..... from the *date&time* ..... to the *date&time* .....

### 2. Civil Protection

- Civil Protection disaster assessment – after a disaster, it is necessary to compare the previous situation with current one, to assess the severity of damages and plan the following phases of restoration/recovery. Thus temporal interval selections are mandatory.
- Fire detection – fire detection systems exploit a near real-time data input (at a resolution in the order of the minute or less), to compute the differences that may possibly indicate a fire event; past data may also be useful for calibrating the algorithms. Thus temporal interval selections are mandatory.



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- Subsidence detection - land subsidence can occur naturally or through human activity (e.g. the withdrawal of groundwater through well pumping has resulted in subsidence in Venice, Italy). The phenomenon heavily affects both infrastructures and ecosystems. Its detection requires time series analysis at the year scale. Thus temporal interval selections are mandatory.
  - Data network temporal acquisition and coordinates
    - Seismic network data:  
time location is mandatory; we distinguish between two kinds of data: 1) historical data, characterised by the following time coordinates: day, month and year. 2) present data, characterised by the following time coordinates: seconds, minute, hour, day, month and year. Time location is provided in UTC. Routinely, each station acquires 60 samples per second; each sample is characterised by three components (two horizontals and one vertical).
    - Accelerometric network data:  
time location is mandatory; present data are characterised by the following time coordinates: seconds, minute, hour, day, month and year. Time location is provided in UTC. Routinely, each station acquires 128-256 samples per second; each sample is characterised by three components (two horizontals and one vertical). Timing type is GPS; accuracy is GPS 5 microsecond of UTC.
    - Hydrology network data:  
time location is mandatory; present data are characterised by the following time coordinates: minutes, hour, day, month and year. Time location is provided in UTC. Routinely, the network consists of 2500 stations and produces 5000-10000 samples per hour.
    - Meteo-radar network: time location is mandatory; present data are characterised by the following time coordinates: minutes, hour, day, month and year. Time location is provided in UTC. Routinely, the network will manage 40-80 maps per hour.
3. Environmental monitoring
- Climate change – the monitoring of phenomena such as the Greenhouse-effect, El Niño/La Niña and desertification requires time-series analysis of data stemming from different sources and at different scales. Thus temporal interval selections are important.
  - Enforcement of environmental regulation –human activity impact on the environment must be monitored for appropriate management and protection of environmental resources. Thus temporal interval selections are important.
  - Data network temporal acquisition and coordinates
    - ...EIONET...
4. Land Management



- Cadastral Data: the management of events associated to objects (i.e. land parcels or urban ones) and their ownership requires a mandatory temporal definition. Temporal coordinates are expressed as: day, month and year of the event. These coordinates allow to build information records by:
  - Ownerships: alienation or transfer of effective rights.
  - Parcels: effective variations in terms of: geometry, extension and revenue.In particular, the temporal coordinates presence, associated to parcel creation/variation/deletion, allows ownership description, which is the subject of cadastral map representation, at different epochs.

#### 5. General discovery queries

- A travel company wishes to search for the January snow climatology for the Alps, for inclusion in a brochure. The full temporal coverage might be the summary statistics of snowfall and snow cover for the period 1971 to 2000 taken over all Januaries. Here the discovery metadata is specific for area and for temporal extent. The classification of temporal extent is an ordinal referene system of named months.
- A hydrologist is looking for winter rainfall climatology in a catchment area. Here the ordinal classification of winter is more important than a specific geographical position, as the hydrologist will expect to generalize to the catchment from whichever specific locations comes up.
- A geologist may wish to find surface beds of Tertiary minerals across western Europe. Again the ordinal temoral classification is initially more important than location.
- A marine investigator requires weather information at a specific period for an accident at sea, the location being only approximately known.
- An archaeologist wishes to compare sites across a region which are known to be active in the same time period. The discovery is to find locations for a known period.
- Anyone who wants a weather forecast for 3 days hence. For a weather forecast, the sequence of weather is usually more important and may be more accurately forecast than the expected weather at a specific location and time.

### A general model

An holistic model for temporal extent metadata implementation must consider complex and different concepts, such as:

- ‘instantaneous’ observation temporal location; for example, measuring temperature at a specific instant in time;
- accumulated observations (or averages etc.) temporal location; for example, measuring a 3-hr average temperature; time interval is a property of measured phenomena and the event temporal location of observation occurs at the end of the time interval

- related observation temporal location; for example, the maximum temperature during a time interval. Time interval is a property of measured phenomena and the event temporal location of observation occurs at the end of the time interval;
- collection of observations, for example time series characterized by a collection period property which is the time interval bounding all discrete observations within the collection.
- Simulated datasets may be characterized by an assimilation period (the useful period to produce the analysis) and a usage period (the interval during which the results of the simulation should be used). Thus, we have a couple of temporal axes: a simulation time axis and a real time axis.
- Both absolute and relative temporal locations should be supported. Thus, date&time and ordinal reference systems are allowed. In fact, some times cannot be described by date and time, but have better defined relative positions; such as averages over many years but still classified by relative time of year; for examples: seasons (spring, summer, autumn, winter) and January monthly summary might be described as “all Januaries 1971-2000”. Figures 1 and 2 shows date&time intervals and ordinal ones, respectively.

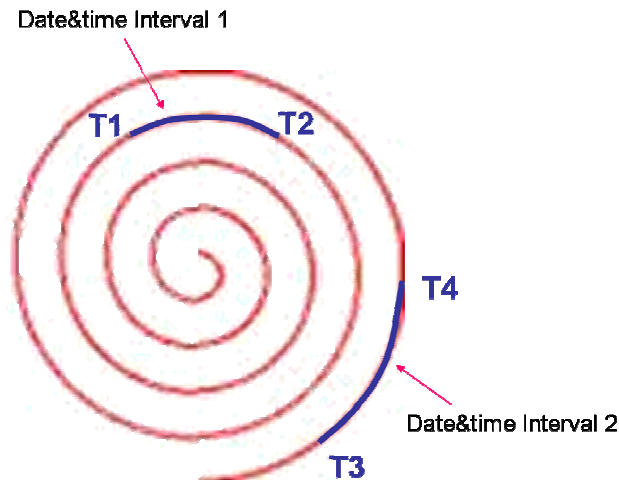


Fig. 1 Date&Time intervals

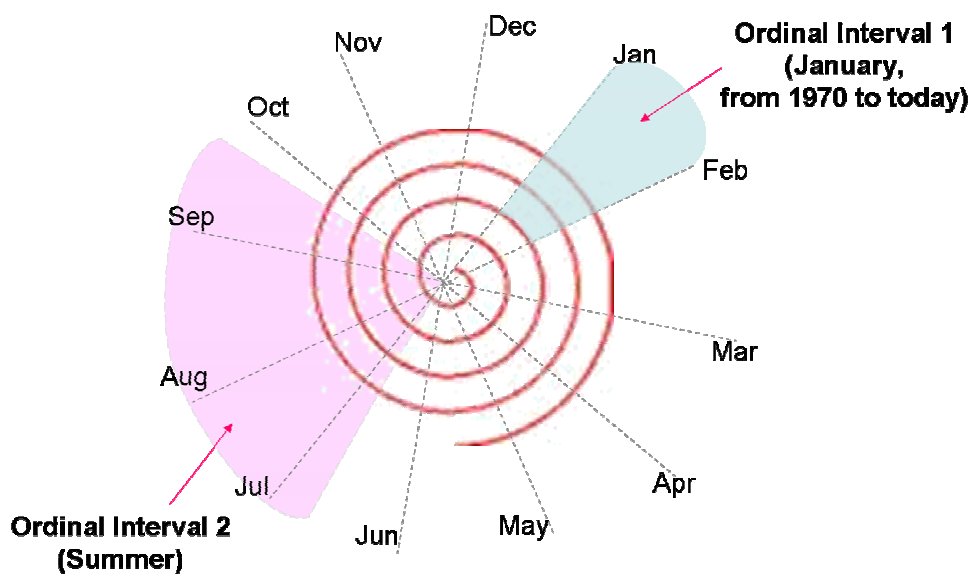


Fig. 2 Ordinal intervals

## Implementation solutions

Implementations can vary according to specific requirements and needs coming from provided services and application users and scope. Indeed, detailed temporal extent implementations are crucial for specific themes (e.g. regional weather and marine forecasts, severe weather warnings, geological disturbances monitoring, risks management, etc.).

As far as temporal extent metadata content and structures are concerned, ISO 19115 and 19108 seem to provide all the necessary primitives to implement them. For encoding, ISO 19139 and 19136 (GML) seem to provide the required encoding elements.

Several implementing models and related encodings are under development and experimentation for specific themes and information communities. They are useful to understand the complexity of the task, and as useful references. The authors are involved in a couple of these experimentations:

- "Explanation of times for observations and simulations Encoding in ISO 19115 / 19139 metadata", MetOffice document, April 2006.
- "Temporal extension metadata implementation model – ver 0.5", INTERO SDIC document, September 2006.