Enabling access to spatio-temporal observation data through SOS and O&M

Workshop structure

Part 1. General overview of SOS & O&M (30 min.)
- Introduction 5 min.
- SOS and O&M in a nutshell (K. Schleidt) 5 min.
- INSPIRE technical guidance documents (S. Grellet, BRGM) - 10 min.
- An INSPIRed SOS implementation (S. Jirka, 52N Germany) 10 min.

Part 2. Flash presentations of SOS-based solutions (35 min.)
- AIT SOS (Kathi Schleidt, AT (server)) -
- Reference SOS and O&M projects (S. Jirka, C. Hollmann, 52N, Germany) - 5 min.
- SOS download services in the context of scientific workflows. Virtual Research Environment of LifeWatch Italy (P. Tagliolato, CNR-ISMAR/IREA Italy)
- RITMARE architecture (A. Sarretta, P. Tagliolato, CNR-ISMAR/IREA Italy)
- SOS deployments for geoscience data: water quantity/quality, borehole logs, geothermy (S. Grellet, M. Beaufils, BRGM)
- AirSensEUR – an INSPIRed sensor platform for air pollution monitoring (A. Kotsev, JRC)
- Advertising slide about other initiatives implementing EF/OM/SWE in Europe (ODIP2, EuroFleet2, OceanOfTomorrow, eLTER, EPOS, tests for French Water Information System and French MNHN-biodiv, ? EmodNet ?…) and outside (CSIRO, NOAA, USGS, NR-CAN, IOOS…)

Part 3. Way ahead (10 min.)
- IT open points (Kathi see D2.9 : out-of-band, FoI encoding, …): come to us in room xxx / bar yyy / restaurant zzz

Part 4. Open mic (15 min.)
Part 1. General overview of SOS & O&M
Context

● 10 years ago
  ○ Geospatial information was hardly (if at all) exchanged in a streamlined way

● Now
  ○ Extensive use of WMS/WFS/WCS/etc.

● It is time to do the same for observation datasets
  ○ Standards & tools are waiting for you

● Fasten your seatbelts & let’s go for a tour
Context

- Connected devices expected to reach 50 billion in 2020 (*Swan, 2012*)
- The number of devices connected to the Internet exceeded that of people in 2008
- **Revolution in environmental sciences** similar to the one generated by the use of satellite remote sensing in the 1970s (*Hart et. al. 2006*)
- Going beyond the Geospatial
  - limited number of features of interest
  - terabytes of temporal data
Context

- INSPIRE as Framework Directive is not only focused on the ‘spatial’
  - ex: Environmental Monitoring Facilities definition: “… includes observation and measurement of … by or on behalf of public authorities.
- Thus:
  - Necessity to provide observation data in Annex II and Annex III

=> Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in INSPIRE Annex II and III data specification development

- SOS is in the process of being adopted as an INSPIRE download service
O&M Data Models in INSPIRE

Themes integrating Observations

A. Geology
B. Oceanographic Geographical Features
C. Atmospheric Conditions
D. Environmental Monitoring Facilities
E. Soil
F. Species Distribution
G. Natural Risk Zones
Possible future extensions

a. Area management/restriction/regulation zones ...
b. Human Health and Safety
c. Land cover
d. Production and industrial facilities
e. Statistical units & Population distribution, demography
f. Utility and governmental services
g. Habitats & biotopes
OGC Sensor Web Enablement Suite (SWE) provides base data and service standards

- **Observations & Measurements (O&M):**
  - Base data model for provision of observational or measurement data
  - Integrated into several INSPIRE data models
- **Sensor Observation Service (SOS):**
  - OGC Webservice for provision of O&M data
  - Same structure as other OGC services
  - Tailored for access to O&M data with focus on time series
- **Sensor Model Language (SensorML):**
  - Description of measurement process
  - In INSPIRE use INSPIRE Process
To understand the data from an observation or measurement, we must know:

- What was measured (observedProperty)
- Where was it measured (featureOfInterest)
- How was it measured (procedure)
- When was it measured (phenomenonTime)
- Data quality information (resultQuality)

And of course, we need the result of the observation.
O&M - What is an observation?

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- Data quality information (\texttt{resultQuality})

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Note: \textbf{Bold parts} already provided with EF Facility
SOS in a nutshell

- OGC Standard; current version: 2.0
- Applicable when data on spatial features needs to be managed in an interoperable way
- Works for measurement (sensor) data, but also observational data
- Part of SWE suite
SOS in a nutshell

Core Operations:

- getCapabilities
- describeSensor
- getObservation

Further Operations:

- getObservationById
Sensor Web Enablement Suite

SPS: Sensor Planning Service
SES: Sensor Event Service
WNS: Web Notification Service
INSPIRE technical guidance documents

- The guidance document framework has been updated in between both conference
  - INSPIRE O&M & SWE guidelines document (D2.9) has been refined
  - SOS as an INSPIRE Download Service = new Technical Guidance document
  - Both documents are linked

- Member States consultation until Sept. 16th 2016
  - No blocker
  - OK to submit TGs to the MIG-P for endorsement after taking in account the provided comments (DK, NL, FR, SWE)
D2.9 : INSPIRE O&M & SWE guidelines document

- Restructured to differentiate explanatory text on O&M & SWE from guidance (should/shall) -> OGC modular specification structure
  - Recommendations / Requirements in core part and uniquely identified
  - Normative and Informative annexes

- 3 main parts
  - Decision Tree O&M Design patterns
  - O&M INSPIRE profile
  - Service Layer
D2.9 : Decision tree

Observation data

Observation-centric View

Coverage-centric View

The observation context is

Point Based

- SinglePoint
  - Single Acquisition InTime
  - pointObservation

- MultiplePoint
  - Multiple Acquisition InTime
  - multiPointObservation

- Distributed Network

- Grouped

Trajectory Based

- Vertical
  - profileObservation

- Moving
  - trajectoryObservation

Grid Based

- Single Acquisition InTime
  - gridObservation

- Multiple Acquisition InTime
  - gridSeriesObservation

Specimen Based

- Single Acquisition InTime
  - specimenObservation

- Multiple Acquisition InTime
  - specimenTimeSeriesObservation
An example of such case could be an air quality monitoring station providing ozone concentration measurements. The featureOfInterest represents the direct surrounds of the air intake (i.e. the air bubble surrounding the air intake). The location for the measurements is provided through this featureOfInterest. As this design pattern usually provides a time series (temporal coverage) result, the phenomenonTime and/or resultTime will often be provided together with the result values.

When the Observation represents a time-series of point measurements of a property at a fixed location in space the specialised observation ‘PointTimeSeriesObservation’ SHOULD be used.
D2.9 : Core Observation profile

- Requirement classes: mostly recommendations (only few requirements)
- OM_Observation: identifier, time (ISO 8601)
- observedProperty: communityVocabulary, SKOS
- featureOfInterest:
  - SF_SamplingFeature,
  - provision of sampledFeature: either domain feature or reference ontology entry
  - pattern for depth/elevation provision
- procedure
  - sensorType not instance (as in SOS hydro profile)
  - dedicated Process specialisation in Inspire (xsd)
D2.9 : Core Observation profile

- Link to monitoringFacility or monitoringNetwork generating the observation:
  - Pattern defined using om:parameter. With value pointing to URI of the facility/network

- Metadata
  - In case SOS GetObservation is ‘behind’ a URI, guidance to provide metadata to access the endpoint in gml:metaDataProperty.
D2.9 : Service Layer

- Link to INSPIRE SOS technical guidance document

- GetDataAvailability
  - from OGC SOS hydrology profile, enables to test ground for observation availability
  - enhanced during that exercise
  - now an alternative to providing INSPIRE EF ObservingCapability via a WFS

- Hierarchical offering capability
  - To allow to structure offerings thus have decent getCapabilities
D2.9 : Service Layer

- Recommended service pattern (WFS / SOS)
  - 1°/ WFS: access Monitoring Facility/Network description
  - 2°/ SOS: getDataAvailability to test ground for observation available at the monitoring feature level => retrieve offeringID
  - 3°/ SOS: getObservation on a given offeringID
D2.9 : Identification of expected next steps

- List of current ‘worth following’ activities in the field of Sensor Web
  - OGC SWE DWG : SensorML2, SOS 2.0 update, SWE data arrays
  - OGC TimeSeriesML SWG
  - OGC O&M JSON encoding Discussion Paper
  - Out-of-band issues
  - OGC SensorThings API
  - RDA discussion on URIs for timeseries
Activity overview

● INSPIRE O&M & SWE maintenance group (MIWP-7a)
  ○ Real running services experience available (some presented today)
● Pre-existing O&M & SWE guidelines efforts consulted
  ○ New Zealand Environmental Observation Data Profile - Core, V1.0
  ○ EU Ambient Air Quality reporting DataModel
  ○ OGC Citizen science Observations & Measurements profile
  ○ Canada Common Observations and Measurements Profile
● Communication within OGC
  ○ OGC Washington TC : SWE DWG, Hydro DWG
  ○ OGC Hydro DWG Workshop Koblenz
  ○ OGC Dublin TC : SWE DWG to discuss into more details
  ○ D 2.9 document circulated to SWE and Hydro DWG to gather more detailed comments
Technical guidelines for SOS as an INSPIRE download service

- Extended capabilities for metadata
- Mapping Inspire terminology to SOS operations
  - Ex: INSPIRE dataset -> Offerings

- **DescribeSensor operation**
  - Behaviour linked back to D2.9 recommendations

- Observation identifier handling
  - getObservationById should reuse gml:identifier. Inspire ‘identifier’ is a dedicated type that is not gml:identifier
52°North SOS Implementation

● Idea
  ○ Provide implementation of proposed TG updates for SOS and O&M
    → Validate content of proposed TG updated during specification process
    → Re-usable by interested data providers

● INSPIRE SOS extension comprises
  ○ Enhanced INSPIRE functionality
    ■ Additional metadata
    ■ Multi-language and Multi-CRS support
  ○ Support of specialised observation types

● Implementation is available as open source software
  ○ [https://github.com/52North/SOS](https://github.com/52North/SOS)
  ○ [https://wiki.52north.org/SensorWeb/SensorObservationServiceIVDocumentation#INSPIRE_Download_Service_extension](https://wiki.52north.org/SensorWeb/SensorObservationServiceIVDocumentation#INSPIRE_Download_Service_extension)
52°North SOS Implementation

- Supported specialized observation types:

<table>
<thead>
<tr>
<th>Observation Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PointObservation</td>
<td>Latest measurement of an observed property at a location</td>
</tr>
<tr>
<td>PointTimeSeriesObservation</td>
<td>Time series of measurements of an observed property at a location</td>
</tr>
<tr>
<td>MultiPointObservation</td>
<td>Latest measurement of an observed property at the same time on multiple locations</td>
</tr>
<tr>
<td>ProfileObservation</td>
<td>Measurement of an observed property at different depths or heights</td>
</tr>
<tr>
<td>TrajectoryObservation</td>
<td>Mobile sensors and their measurement</td>
</tr>
</tbody>
</table>
52°North SOS Implementation

- Flexible Integration into existing IT infrastructures
- Can be connected to different database management systems
  - Oracle
  - PostgreSQL
  - MySQL
  - Microsoft SQL Server
- Object-relational mappings may be used for configuring the SOS to a specific database model (Hibernate)
- Different approaches for database integration are supported and used in operational environments
52°North SOS Implementation - Extensions

**FAQ e-Reporting**
- Air Quality Directive 2008/50/EC requires provision via INSPIRE
- INSPIRE EF and AM models have been extended accordingly
  - Reporting requirements added to data model
- AQD e-Reporting fulfills both INSPIRE and air quality requirements
- Other environmental reporting obligations to follow

**Hydrology**
- Support of SOS 2.0 Hydrology Profile
- WaterML 2.0 Support
52°North SOS Implementation - Client

Mobile Sensors (e.g. Ferry Boxes - sensors mounted on ferries)
52°North SOS Implementation - Client

Point time series observations (e.g. air quality measurements)
Part 2. Flash presentations of SOS-based solutions
AQD e-Reporting - Member States using 52°North SOS

- Common model based on O&M for reporting air quality data to the EEA
- Several member states are using the SOS
  - Belgium
  - Lithuania
  - Sweden
  - The Netherlands
  - United Kingdom
- Demo
  - http://sensorweb.demo.52north.org/client/#/diagram?timespan=2016-09-12T00%3A00%3A00%2B02%3A00%2F2016-09-18T23%3A59%3A59%2B02%3A00&ts=52nSensorweb__ts_6b4312a023c204544035387722ca8794%2C52nSensorweb__ts_619363f8d5a45c3b5c333ea898937d
Marine Sensors

Source: UPC/NeXOS
Austrian AQD SOS implementation

UWEDAT

Austrian Nat’l AQ DB
Austrian AQD SOS implementation

Austrian Nat’l AQ DB

AQD DB

GeoServer

WFS

ETL
Metadata

UWEDAT

Austrian Nat’l AQ DB
Austrian AQD SOS implementation

Data Handler provides interface to existing data source. Simple Interface can be implemented for different data sources.
Austrian AQD SOS implementation

Data Handler Class must be adapted in the following methods:

- Setter methods to parameterize data source connection
- Open & Close methods
- Filter methods to specify specific data point (~ ObservingCapabilities).
- getTimeSeries

TimeSeries class must be configured in accordance with data to be served
Austrian AQD SOS implementation

First approach
Problem: how to keep featureOfInterest and Process aligned between WFS and SOS
Austrian AQD SOS implementation

- AQD DB
- GeoServer
- ETL Metadata
- UWEDAT
- Austrian Nat'I AQ DB
- CORBA Interface Measurements
- Open UWEDAT
- WFS
- SOS
- Redirect for getFeatureOfInterest and describeSensor

DH
Austrian AQD SOS implementation

WFS:
http://luft.umweltbundesamt.at/inspire/wfs
   ?service=WFS&version=2.0.0&request=GetCapabilities

SOS:
http://luft.umweltbundesamt.at/inspire/sos
   ?service=SOS&version=2.0.0&request=getCapabilities
SOS deployments for geoscience data at BRGM

- Near-realtime groundwater level monitoring - system

- Observation Database O&M compliant by design. Easier to expose
- Temperature, salinity foreseen
SOS deployments for geoscience data at BRGM

- Near-realtime groundwater level monitoring - results
  - Our colleagues ask for more and more reuse

Raw observation exploration, validation

Raw observations not yet validated (in red) next to validated timeseries (forecast)
SOS deployments for geoscience data at BRGM

- Near-realtime groundwater level monitoring - results
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SOS deployments for geoscience data at BRGM

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QGIS GML Application Schema Toolbox - visualisation
SOS deployments for geoscience data at BRGM

- Near-realtime groundwater level monitoring - results
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QGIS GML Application Schema Toolbox - visualisation
SOS deployments for geoscience data at BRGM

- Geothermy platform monitoring
  - Same rationale: sensor -> raw observation DB
  - One BRGM campus building entirely monitored + one BRGM/ADEME test platform
SOS deployments for geoscience data at BRGM

- **Borehole logs**
  - Standardised way to expose geological logs
SOS deployments for geoscience data at BRGM

- **On-going**
  - Exposing validated groundwater level database
  - Groundwater quality -> samples (Specimens)

- **Main conclusion**
  - Domain colleagues are happy = we are on the right tracks
GET-IT: GeoEnabling Information Toolkit

Open source software suite developed inside the RITMARE (Italian Research for the Sea) project: www.ritmare.it.

The main goal is to enable non expert groups to serve geospatial and observational data (plus their metadata) in an interoperable way through autonomous nodes in the infrastructure for the collection, annotation, and deployment of data.

http://www.get-it.it
GET-IT: GeoEnabling Information Toolkit

Supporting researchers to insert observations.

Use cases in RITMARE:

- real-time observations from sensors
- manually recorded observations
SOS Client Interface
SOS Client Interface
## SOS: Observation types in GET-IT

| Point - Multiple Results | Physical (water temp, etc.)
| | Hydrodynamical (current direction/intensity, etc.)
| | Meteorological (rain, pressure, wind speed/direction, etc.)

| Specimen - Multiple times | Biological specimen (biomass, density, etc.)
| | Chemistry (pH, salinity, conductivity, etc.)
| | Geochemistry

| Point - Single Result | Species identification and distribution (VGI, biological observation, etc.)

http://skmi.irea.cnr.it
http://vesk.ve.ismar.cnr.it
http://vesk.ve.ismar.cnr.it
Point - Multiple Results

Physical (water temp, etc.)
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http://vesk.ve.ismar.cnr.it
Specimen - Multiple time

http://vesk.ve.ismar.cnr.it

Biological specimen (biomass, density, etc.)
Chemistry (pH, salinity, conductivity, etc.)
Geochemistry (}
Species identification and distribution (VGI, biological observation, etc.)
EDI is a metadata editor configurable for different schema profiles:

- INSPIRE ISO 19139,
- SensorML defined by SOS lightweight profile for Stationary In-Situ Sensors.
SOS download services in the context of scientific workflows. Virtual Research Environment of LifeWatch Italy

Scientific workflows for VLab

**Workflow**: series of activities necessary to complete a task -> an orchestrated sequence of data transmissions.

**Virtual Lab**: remotely accessible virtual environment offering interactive opportunities to collaborate with related web services.

Modular workflows as building blocks designed for easing use and re-use

Subworkflows – associated to web applications for advanced user interaction (e.g. selection of parameters based on descriptive statistics)

New workflows as recombination of the existing modules offered in the Virtual Lab
SOS download services in the context of scientific workflows. Virtual Research Environment of LifeWatch Italy


LTER Timeseries + SOS download services + LW SOS Client within workflow = Ecological Monitoring
AirSensEUR - open hardware/software ....
AirSensEUR High level objectives

• JRC & partners are working on the AirSensEUR project since 2015
• **Data management:** Digital Earth Unit (Sven Schade, Max Craglia, Alex Kotsev)
• **Data quality and calibration:** European Reference Laboratory for Air Pollution (Michel Gerboles, Laurent Spinelle)
• **Sensor creation:** Liberaintentio srl (Marco Signorini)
• **Objective:** Create an open software/hardware multi-sensor board to provide good quality of observation data, and meet the requirements of
  A) INSPIRE Directive
  B) AQ Directive
Architecture
Results

- 17+ million observations
- JRC Technical Report (Parts A, B, C, D)
- 3-D printable boxing
- Licensed under EUPL
- Reusable architecture
- CoP
Server

- 52°N
- Austrian AIT
- Geomatys
- IST-SOS
- Kisters
- + several ad-hoc solutions
Client

- QGIS Plugin
- Web Clients (52°N & IST)
- Kisters
- 52°N Lightweight for Mobile
- GET-IT web js clients (vis. & transactional)
Part 3. The way ahead for observation data in INSPIRE
Still much to do:

Codelists:

- Confusion due to wrong transposition from UML to IR, most codelists have values and are not extendable. INSPIRE codelist registry has been updated accordingly

Feature of Interest (FoI) Encoding:

- Often unclear what to use as FoI
- Common mistake is to use Station as FoI
Still much to do:

Result Encoding:

- Alignment with WaterML 2.0 - valid for other domains?
- Specialized Observations - valid for other domains?
- Out-of-Band encoding:
  - Still no agreement (see discussion in D2.9)
  - How to serve non-OGC results, i.e.:
    - NetCDF
    - Images
Still much to do:

No dedicated session, so will do impromptu meetings during the week

First meeting this evening! (Location TBD)
Part 4. Open mic
Providing INSPIRE measurement data

Thanks for your attention!
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