MELOA CATALOGUE AND GEOPORTAL: A MODERN APPROACH FOR OPEN ACCESS AND VISUALIZATION OF *IN SITU* DRIFTER DATA

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Abstract

The MELOA H2020 project proposes to develop a low-cost, easy-to-handle, wave resilient, multi-purpose, multi-sensor, extra light surface drifter for use in all water environments: The WAVY drifters. The data products generated by the MELOA project are openly accessible through standard-based Catalogue and Geoportal to promote the availability of the data to other communities such as GEOSS or Copernicus.

MELOA will provide an effective way to monitor surface currents and surface dynamic features and temperature at different levels. A complete Software Ecosystem is developed in MELOA to manage the transmission of data from the WAVY drifters, raw files collection, campaigns operation and data curation and consolidation of data products to make the data openly accessible through the Catalogue and Geoportal.

Driven by FAIR (findable, accessible, interoperable and re-usable) data principles and state-of-the-art data visualization technologies, the following components are described: 1) A Data Catalogue to make WAVYs data and metadata accessible in standard formats such as Comma-separated values (CSV), Observations & Measurements (O&M), Data Catalogue Vocabulary (DCAT); allowing interoperability

with other Earth Observation (EO) catalogues. 2) A Data Geoportal, exposing interoperable Web Services such as Open Geospatial Consortium's (OGC) Web Feature Service and OGC's Sensor Web Enablement (SWE) services and effective data visualization taking advantage of Vector Tiles technology.

Keywords: Open data, Interoperability, *in situ* measurements, GEOSS, Sensor Web Enablement, SensorThings API, Sensor Observation Service, Web Feature Service, Web Map Services, Vector Tiles

1. Introduction

The MELOA (Multi-purpose/Multi-sensor Extra Light Oceanography Apparatus) H2020 project purpose is to provide an effective way to monitor sea surface currents and surface dynamic features and temperature at different levels. To achieve this objective, MELOA is developing low-cost, easy-to-handle, wave resilient, multi-purpose, multi-sensor, extra light surface drifters for use in all water environments: The WAVY drifters.

The main attributes of the WAVYs are:

- Small sized, making the WAVY very easy-to-handle;
- Optimized buoyancy, reducing the WAVY vulnerability to direct wind effect;
- Minimized pendular motion, facilitating the WAVY position detection.

The WAVY family will range from small drifters suitable for beach and surf zone studies, to somewhat larger drifters tailored for coastal and long-term open ocean observations.

Table I. MELOA WAVY family and features

MAIN FEATURES	MAIN FEATURES
Basic	GNSS, GPRS, 1 thermistor (near sea-surface temperature)
Littoral	GNSS, adjustable ballast module, 2 thermistors (near sea-surface temperatures), satellite communications, IMU.
Ocean	GNSS, adjustable ballast module, 2 thermistors (near sea-surface temperatures), satellite communications (Argos), IMU, solar panels
Ocean-plus	GNSS, adjustable ballast module, 2 thermistors (near surface sea-temperatures), satellite communications (Argos), IMU, solar panels and wave energy harvesting
Ocean-atmo	Equatorial floating (wind exposure), GNSS, adjustable ballast module, 4 thermistors (near surface sea and air temperatures), atmospheric pressure, satellite communications (Argos), IMU, solar panels and wave energy harvesting

A complete Software Ecosystem is developed in MELOA to manage the transmission of data from the WAVY drifters (Argos, GPRS; Wi-Fi), raw files collection (WavyHub App), campaigns operation and data curation (WAVY Operation SW); and consolidation of data products (L1 Processor) to make the data accessible through the Catalogue and Geoportal and facilitate the development and sharing of applications and value added data products, such as wave parameters data products, WAVY recovery applications, etc.

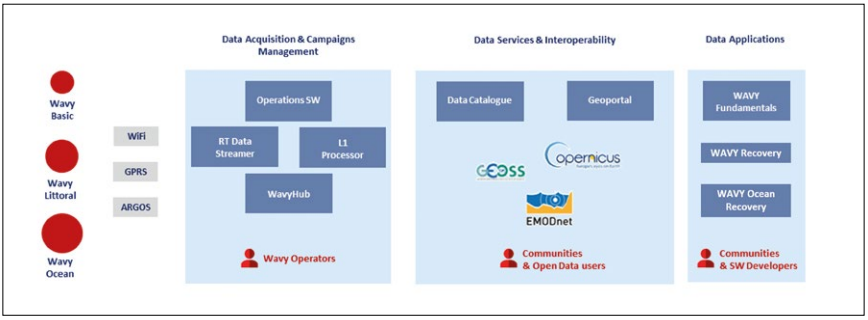

Fig. 1. MELOA SW Ecosystem.

Driven by FAIR data principles and state-of-the-art data visualization technologies, the following components are described in this article: 1) A Data Catalogue to make WAVYs data and metadata openly accessible in standard formats such as CSV, O&M, DCAT, GeoDCAT; allowing interoperability and connection with other EO catalogues. 2) A Data Geoportal and associated standard data services, exposing interoperable Web Services such as OGC WFS and OGC SOS/SensorThings and effective end-user data visualization taking advantage of Vector Tiles technology.

2. MELOA Catalogue

The MELOA Catalogue (http://catalogue.ec-meloa.eu/) solution is based on CKAN, a tool for making open data systems, by helping the management and publishing of data collections. It is used by national and local governments, research institutions, and other organizations who collect lots of data. Once the data is published, users can use its faceted search features to browse and find the data they need, and preview it using maps, graphs and tables - whether they are developers, journalists, researchers, NGOs.

It uses Apache Solr, a search server based on Lucene, that provides a distributed, multitenant capable full text search engine with a REST interface and schema free JSON documents. The main capabilities for MELOA are:

- Flexible Harvesting Engine that will allow catalogue lots of Data provided by the MELOA WAVYs;
- RESTful API to query and access metadata and geospatial Capabilities, geospatial features, covering data preview, search, and discovery;
- Intuitive Web Interface, with a set of important features to search and visualize geographic and non-geographic data products;
- Flexible Search Engine, rich search experience which allows for quick 'Google-style' keyword search as well as faceting by tags and browsing between related datasets.

The main purpose of the Catalogue is to enable search and discovery of the data and metadata from the observations of the WAVYs in order to enable federation and data sharing with other data catalogues and communities such as GEOSS or Copernicus. Currently, MELOA data is also available through the NextGEOOS Catalogue (https://catalogue.nextgeoss.eu/) which is harvesting the metadata directly from the MELOA Catalogue.

The data ingestion in the Catalogue is driven by the L1 processor, a piece of software that retrieves WAVY data from the WAVY Operations Software and also from Argos systems and transform the data into a higher-level product with variables available in scientific units. The latest and optimal standards and recommendations for publishing geolocated sensor open data like OGC O&M (SOS/SensorThings) data models have been taken into consideration in the definition of these products. L1 Processor has two interfaces with different APIs and formats: WAVY Operation Software (in CSV format for all types of WAVYs) and Argos server (in binary messages for WAVY ocean types). The L1 Processor then decodes the messages creating the corresponding product that is uploaded into the MELOA Catalogue, properly classified in terms of metadata. The L1 Processor is responsible also for harvesting CMEMS resources metadata on the MELOA Catalogue in order to make relevant CMEMS collections available for Catalogue users and integrations such as the Geoportal.

3. MELOA Geoportal

The MELOA Geoportal (https://geoportal.ec-meloa.eu) is an online, map based, data visualization tool for the public data stored in the WAVY's online Catalogue.

The main purpose of the MELOA Geoportal is to enable end-users the exploration and visualization of WAVYs data in an easy-to-use way, targeting diverse audiences: From marine scientists to citizens and general public. The usability and user experience have

been one of the main objectives to be addressed, bringing user experience research methods to the design process to provide a user-centered perspective during software development. Based on these premises, the following use cases were defined for the MELOA geoportal:

- To be able to search WAVY data from the metadata stored in the catalogue: campaign data, serial number, date, geographic region, WAVY model, etc;
- Dynamically display not only trajectory data, but also data from individual observations of scientific variables such as surface temperature;
- Display value-added products such as wave parameters or spatial aggregations of scientific variables, time series, etc;
- Being able to compare observation data with other data sources such as CMEMS (models, satellite observations, etc.) or WMS services.

The MELOA Geoportal is based on software components used for Spatial Data Infrastructures such as a spatial database (PostreSQL/PostGIS), a map server (Geoserver) and a cache layer (GeoWebCache). The Geoportal UI and frontend are built using state-of-the art technologies such as HTML5, CSS, Angular framework and JavaScript.

The Vector Tiles technology is introduced as a new layer of the SDI of the MELOA Geoportal, in order to provide effective data visualization, interactivity and dynamic capabilities. The efficient management and visualization of the number of measurements and datasets that may generated on each WAVYs campaign due to the high sampling rate has been also a key factor for choosing Vector Tiles technology in the view layer.

Vector Tiles enable dynamic map styling from large feature datasets because vector data are sent to the UI frontend directly (Agafonkin, 2019). On the other side, in order to take advantage of its capabilities, it requires a transformation process that needs to be well-designed for the specific use cases to be addressed. Vector Tiles are already a standard in dominant web map platforms such as Google, Esri, or Microsoft and evaluated by the Open Geospatial Consortium (Meek, 2019), but still has not been widely adopted in research or scientific geoportals where interoperability needs condition the use of more established technologies such as Web Map Services (WMS) or Web Map Tiled Services (WMTS).

The MELOA Geoportal stack for the Vector Tiles layer is based on Tippecanoe for the transformation of the datasets into Mapbox Vector Tile format (MVT) and Tileserver GL as a tile server. A cache layer based on Apache web server, mod_cache_socache module and Memcached is used to increase the rendering performance on the frontend side.

4. MELOA OGC Data Services

Besides of the User Interface frontend for data visualization, the Geoportal provides OGC Web Services for interoperability and integration in GIS programs: Web Map Service (WMS), Web Feature Service (WFS), Sensor Observation Service (SOS) and SensorThings API. Due to the characteristics of the features being managed, sensor observations, the main interfaces are SOS and SensorThings, but WMS and WFS are also offered in order to provide standard view and download services compliant with most Geospatial Information Systems (GIS) applications.

4.1 Web Map Services

A Web Map Service has been deployed as part of the MELOA SE to provide georeferenced maps of the relevant measurements grouped by campaign or WAVY identifiers. Styles are defined according to aggregated campaign/wavy data and available are available through the standard GetCapabilities request https://geoportal.ec-meloa.eu/geoserver/wms?REQUEST=GetCapabilities. This interface if offered for compatibility with GIS applications, but the MELOA Geoportal frontend uses Vector Tiles for better performance and interactivity.

4.2 Web Feature Services

A Web Feature Service is deployed to provide standard download services for the relevant measurements collected by the WAVYs, with support to time parameters and other capabilities supported by WFS. https://geoportal.ec-meloa.eu/geoserver/wfs?REQUEST=GetCapabilities. Through this interface user are able to integrate MELOA datasets in their GIS applications.

4.3 Sensor Observation Service

The lack of standardization and data harmonization across scientific domains and data infrastructures has been the driving force for the OGC to propose the Sensor Web Enablement framework (SWE) (Bröring, 2011). This framework is a set of standards that provides data models, encodings and common interfaces which aim to provide the building blocks for interoperable Sensor Web infrastructures. In this context, the concept of the Sensor Web refers to a set of Web accessible sensor networks and their collected sensor data/metadata that can be discovered and accessed using standard protocols and interfaces.

A Sensor Observation Service (SOS) has been deployed as a part of the MELOA SE (Bröring, 2012). SOS is a central piece of the SWE framework, providing a set of operations to manage sensor data and metadata. These operations include registration, injection, archival and access within a data/metadata repository. SOS uses the Observations and Measurements (O&M) data model to encode WAVY observations

and their contextual information, providing strong semantic relationships within all the elements involved in the sampling process.

Regarding sensor metadata, WAVY descriptions encoded using the Sensor Model Language (SensorML) are also available via the SOS. This standard provides unambiguous, semantically-robust and machine-actionable sensor descriptions, significantly enhancing data traceability.

4.4 Sensor Things Service

The SensorThings API is also an OGC standard providing an open and unified framework to interconnect sensing devices, data, and applications over the Web (Liang, 2016). Like SOS, it is a standard specification under the OGC SWE standards suite. However, it has a strong focus on the Internet of Things (IoT) and uses an easy-to-use REST-like style. Although it has better performance and it is more user-friendly than SOS, its data model is less restrictive, resulting in weaker semantic relationships.

A SensorThings API has been deployed within the MELOA's, providing an easy, flexible and efficient way access WAVY data and metadata compliant with the O&M data model.

5. Conclusions and future work

The MELOA Catalogue and Geoportal are developed and described as a modern approach for data sharing and visualization of marine *in situ* drifter data, using open standards for data sharing, search and display, focusing on open data communities and efficient data visualization for diverse audiences.

MELOA *in situ* data are available in the NextGEOSS catalogue and further work is ongoing during the MELOA H2020 project in order to provide *in situ* data from relevant scientific variables (temperatures, wave parameters) to CMEMS and EMODNet. Calibration, annotations and quality check mechanisms are being researched and developed to ensure the quality of the data being delivered.

Using SWE services such as SOS and SensorThings data is discoverable and accessible through standardized interfaces widely used in the oceanography domain. Furthermore, these services provide a robust data/metadata model based on the O&M and SensorML standards, ensuring syntactic and semantic interoperability with other data infrastructures.

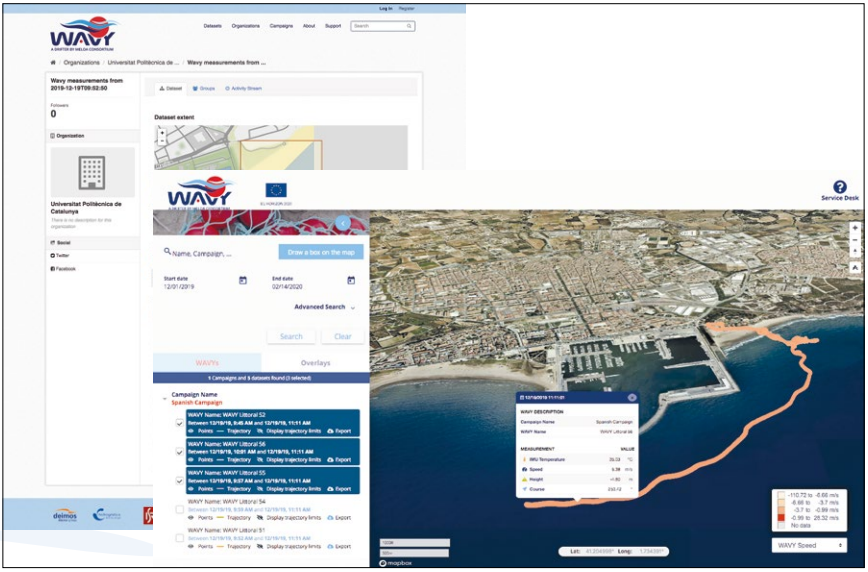

Fig. 2. MELOA Catalogue and Geoportal screenshots.

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References

Agafonkin, V., Firebaugh, J., Fischer E., Käfer K., Loyd C., MacWright T., Pavlenko A., Springmeyer D., Thompson B. Mapbox Vector Tile Specification (2014). github.com/mapbox/vector-tile-spec.

Meek S., Open Geospatial Consortium, OGC Vector Tiles Pilot: Summary Engineering Report (2019). docs.opengeospatial.org/per/18-086r1.html

Bröring, A., Echterhoff, J., Jirka, S., Simonis, I., Everding, T., Stasch, C., ... & Lemmens, R. (2011). New generation sensor web enablement. *Sensors*, 11(3), 2652-2699.

Bröring, A., Stasch, C., & Echterhoff, J. (2012). *OGC Sensor Observation Service Interface Standard*, Version 2.0.

Liang, S., Huang, C. Y., & Khalafbeigi, T. (2016). OGC SensorThings API Part 1: Sensing, Version 1.0. *OGC Standard*