Artificial Intelligence to Monitor our Seas

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AIMS

Artificial Intelligence to Monitor our Seas

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SHORT ABSTRACT FOR DISSEMINATION PURPOSES

Abstract

This Data Management Report serves as a document for the AIMS (Artificial Intelligence to Monitor our Seas) project, providing a comprehensive overview of the data management key elements. This report outlines the Research Data Management Plan (DMP), to be applied to all data generated during the project, in compliance with FAIR (Findable, Accessible, Interoperable, Reusable) principles, and following the philosophy of "as open as possible, as closed as necessary", considering restrictions about IP.

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LIST OF PARTNERS

Nº	Logo	Name	Short Name	City
1	Politecnico di Torino 1859	Politecnico di Torino	POLITO	Torino
2	ROMA TRE UNIVERSITÀ DEGLI STUDI	Universitá degli studi di Roma Tre	ROMA3	Roma
3	Italian National Research Council	Consiglio Nationale delle Ricerche	CNR	Firenze

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ABBREVIATIONS

Acronym	Description
AI	Artificial Intelligence
DMP	Data Management Plan
DMS	Data Management System
MDA	Marine Data Archive
MDDP	Marine Data Discovery Platform
NRT	Near Real Time
PI	Principal Investigator
WG	Wave Glider

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EXECUTIVE SUMMARY

This report serves as a short but comprehensive guide to the Data Management Plan for the Artificial Intelligence to Monitor our Seas (AIMS) project. It provides an essential overview of the key components and strategies outlined in the DMP, which are crucial for the effective management of both observational and model data within the project.

The Data Management Plan (DMP) details the the methodologies for organizing, documenting, storing, and sharing data collected through various observational instruments as well as generated via model simulations. Indeed, in the project, a combination of earth observation data (in-situ and remote sensing) and model simulations is needed to achieve its objectives. Additionally, the plan outlines how data will be produced and prepared for use by artificial intelligence (AI) algorithms, ensuring it meets the necessary quality and format standards. By emphasizing structured and accessible data management, the DMP aims to maximize the utility and reproducibility of the data collected.

Key components of the DMP include:

1. Data Acquisition: The project collects observational data through various instruments and platforms, including buoys, wave gliders, and remote sensing technologies. In addition, model data is generated using state-of-the-art numerical simulations, such as the SWAN (Simulating Waves Nearshore) and the WaveWatchIII (WW3) models. The DMP outlines procedures for ensuring the quality and reliability of both observational and model data.
2. Data Organization and Documentation: Observational and model data are organized and documented according to standardized protocols to facilitate easy retrieval and interpretation. Metadata, including information on data sources, processing methods, and quality control procedures, are recorded to provide essential context for understanding the data.
3. Data Storage and Access: The project employs secure data storage systems to protect both observational and model data. Access to the data is granted to project members and authorized users through controlled mechanisms, ensuring data security and privacy while fostering collaboration and data sharing.
4. Data Sharing and Publication: The project is committed to sharing its data with the broader scientific community to facilitate transparency

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and reproducibility. Observational and model data are disseminated through appropriate channels, including data repositories, publications, and online platforms, following relevant data sharing policies and standards.

5. Data Preservation:
    - Long-Term data archiving: procedures are established to maintain data integrity and accessibility;
    - Future availability: Efforts ensure that data remains available for future research, allowing for continued advancements in the field and enabling the ongoing training of AI models.

Overall, this DMP provides a structured framework for managing the project's data throughout its lifecycle, ensuring data integrity, accessibility, and collaborative potential, while also preparing the data for effective use by artificial intelligence algorithms.

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1. DATA MANAGEMENT PLAN

1.1 Introduction

The Data Management Plan (DMP) documents how data will be collected, organized, documented, stored, quality assured, protected, shared, and archived throughout its lifecycle. This plan provides detailed descriptions of the data, processes, decisions, roles, and responsibilities, and includes a long-term plan for data sharing and preservation to ensure they are accessible and reusable according to FAIR (Findable, Accessible, Interoperable, Reusable) principles.

As data flows and structures evolve over time, driven by observational and scientific activities and needs, the DMP is a dynamic document. Its nature is to evolve by anticipating changes in the data framework, thus it is periodically and continuously reviewed and integrated.

This DMP is based on the Horizon 2020 FAIR Data Management Plan template and serves as the framework for all data acquired and managed by the project partners, from acquisition and processing to dissemination, along the entire data lifecycle, in order to maximize the data value chain.

A good DMP can include a Data Management System (DMS), a Marine Data Archive (MDA) and the Marine Data Discovery Platform (MDDP).

Data Management System (DMS): the DMS is an integrated set of components for collecting, storing, and processing data, as well as providing information, knowledge, and digital products. It encompasses various tools and processes, including database management systems, data integration tools, and analytics, to extract value from data. The DMS offers user services to classify, store, organize, document, share, publish, find, and reuse data in accordance with the FAIR principles. Its main platforms include:

Marine Data Archive (MDA): An online and secure system for managing data files and versions within specific contexts (e.g., projects, reports, analyses, monitoring campaigns). It serves as a personal or institutional archive, backup system, and repository for scientific products.

Marine Data Discovery Platform (MDDP): A service responsible for managing numerous marine data, databases, and information systems. It facilitates exploration of interesting data by providing access to metadata and unlocking the value of the data.

Within AIMS, data and metadata will be updated as soon as recorded (Near Real Time – NRT), at regular intervals and/or according to the specific

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needs/requirements of the Data producer in order to always guarantee the maximum efficiency of the system for data/metadata identification and retrieval. Where possible, data will be shared immediately after acquisition and/or production. For the other cases, a moratorium period by the Istitution's Data policy is planned.

1.2 Data collection and generation

The primary objective of project's data management is to ensure a consistent and valuable flow of marine data to stakeholders. This involves integrating information on data model, EO and in situ dataset. Additionally, CNR is committed to adhering to common principles for sharing observation data sets, making them available for use and redistribution across European marine infrastructures, including EuroGOOS ROOS, Copernicus Marine Service, SeaDataNet, EMODnet, Global Biodiversity Information Facility (GBIF), and ESFRI Research Infrastructure (RI).

CNR, together with the project partners, ensures that data is easily discoverable through the use of metadata, providing essential information for data identification. Data will be assigned with Digital Object Identifiers (DOIs), and metadata will be accessible via URLs.

To maintain data integrity and consistency, AIMS employs a naming convention that utilizes clear and descriptive names for files. These names include elements like date, location, and version number, adhering to a standardized format. Hyphens or underscores are used in place of spaces, and special characters are avoided to ensure compatibility across different platforms and systems.

Versioning of files follows a standardized date format (e.g. YYYYMMDD or YYYY-MM-DD) within the naming convention. This approach facilitates easy comparison and sorting of versions, reducing confusion when collaborating with other researchers or systems using different date formats.

Metadata creation follows a template incorporating the fifteen "core" metadata from the Dublin Core Metadata Initiative, supplemented by specific elements from the ISO 19115 standard. This comprehensive approach ensures that metadata meets standardization principles, enhancing data discovery and access.

Data acquired within the project is accessible through a computer platform that uniformly stores datasets, adhering to interoperability and access standards. An example of such cataloguing is provided by the Thematic Real-time Environmental Distributed Data Services (THREDDS), which allow

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free and regulated access under a Creative Commons Attribution license for visualization, download, and distribution services (WMS, WCS). Currently, data from the LaMMA Consortium's HF radar system are hosted in these servers.
For the specific purposes of AIMS, ZENODO has been chosen as best platform for sharing the AIMS dataset also outside of the field of metocean experts. Zenodo is an open-access repository developed under the European OpenAIRE program and operated by CERN. It supports the storage and dissemination of research outputs across all disciplines, providing a platform for sharing datasets, research software, reports, and other digital artifacts.

Its key features and policies include:

- DOI Assignment: Zenodo assigns Digital Object Identifiers (DOIs) to all deposited items, ensuring persistent and citable access.
- Content Scope: The repository accepts contributions from all research fields and supports all types of research artifacts, including data at any stage of the research lifecycle.
- Eligible Depositors: Any registered user with the appropriate rights to the content can deposit. Ownership rights remain unchanged, with no transfer to CERN.
- File Formats: Zenodo accepts all file formats, though preservation-friendly formats are encouraged. Each record can include up to 50GB of data, with higher quotas available upon request.
- Access Levels: Depositors can choose to make files open, closed, or under embargo. Closed access files are protected, and embargoed files become publicly available after the embargo period ends. Restricted files can be shared with others upon approval by the depositor.
- Licenses and Reuse: Users must specify a license for all publicly available files, guiding the terms of use and reuse. Metadata is licensed under CC0.
- Metadata: Metadata is stored in JSON format and exported in several standard formats such as MARCXML, Dublin Core, and DataCite Metadata Schema, facilitating interoperability and data sharing.
- Data Integrity and Preservation: Data is preserved in multiple replicas within CERN's data centres, primarily in Geneva, with backups in Budapest. Nightly backups and MD5 checksums ensure data integrity

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and authenticity. Zenodo aims to retain items for the lifetime of the repository, which aligns with CERN's long-term experimental program.

2. DATA TYPES AND FORMAT

The dataset within the AIMS project framework can be categorized into three main types:

1. **Raw data**: This category encompasses source or atomic data that has not been processed for presentation. While it may be unrecognizable without processing, raw data can still hold interpretative value depending on the context. Examples include raw environmental parameter data, sequence data, biological specimens, water samples, and core drilling samples.
2. **Processed data**: These data have undergone processing to transform raw data into usable information. Examples include calibrated and quality-controlled environmental data, data from non-standard chemical tracers, and data resulting from experiments or numerical simulations.
3. **Products**: These are intellectual outputs such as theoretical and physical models, data on biological communities and populations, interpreted and processed data, synthetic graphic representations, thematic maps, source code, software, and algorithms.

The data acquisition methods are categorized into four main types:

1. **Remote sensing data**: This includes data about the Earth's surface (in this case, the sea surface) or atmosphere collected without direct contact. Common examples are satellite data and High Frequency Radar data, which vary in spectral, spatial, and temporal resolutions.
2. **In situ data**: These are measurements or collections taken at specific known locations where instruments are deployed. Unlike remote sensing data, in situ data pose challenges due to the diversity of parameters, sampling techniques, processing methods, and sampling frequencies. This type includes data from the DWS buoys and Wave Glider before the processing phase.

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3. **Laboratory data**: This comprises data collected from experimental studies where measurements are manipulated by human intervention. Researchers manipulate variables to understand their effects on other variables. Laboratory data must adhere to good practice guidelines and EU legislation, documenting experimental procedures for valid conclusions. This type includes data from the DWS buoys and Wave Glider after the processing phase.
4. **Modeling outputs**: These are computational data generated by models that represent reality by simplifying its features and processes. Models are used to study processes that cannot be directly measured. All model outputs can be reproduced with information about the model type, setup, input data, and computing resources availability.

Below is a description of the main types of data and their formats that will be acquired during the project, along with the involvement of other partners for their respective data expertise.

2.1 Wave Glider

The Wave Glider (WG) is an autonomous surface vehicle that harnesses wave motion energy for propulsion and uses a series of solar panels to power its sensors and payloads. It is equipped with multiple sensors capable of detecting key marine weather parameters. Notably, the Datawell GPS-Wave Sensor can record wave height, period (both peak and mean), direction (peak), and wave spectrum. This sensor operates in the 0.2Hz-2Hz range and is typically configured to acquire data every 30 minutes.

The collected dataset can be easily exported in ASCII tabular format and subsequently converted into the standard ODV4 format (as specified by the SeaDataNet standard) after quality control. The ODV (Ocean Data View) data format, an ASCII format, is ideal for managing both profile and time series data related to trajectories, making it optimal for data from mobile platforms like the WG.

To facilitate ODV4 encoding, SeaDataNet provides a free software tool called 'NEMO' (https://www.seadatanet.org/Software/NEMO). NEMO, an interactive tool written in JAVA, features a user-friendly graphical interface. It guides users through a process for importing data, filling in all required fields, and validating the entered data.

According to SeaDataNet conventions, ODV data should be accompanied by CDI (Common Data Index) metadata files. These files contain all metadata and detailed information, including external references (URL links, HTML, XML) necessary for the correct identification of the marine dataset. This information covers aspects such as acquisition station, geographical information, types of instruments, and data providers.

From the ODV files, 'CDI summary CSV files' records will be generated. These records will then be processed using another SeaDataNet tool called 'MIKADO' (https://www.seadatanet.org/Software/MIKADO) to create 'XML CDI' metadata files. MIKADO reads the summary CSV files and generates the required XML CDI files, ensuring that all metadata is properly structured and comprehensive.

2.2 DWS buoys

The DWS buoys, developed by LDL at the Scripps Institution of Oceanography (SIO), are designed to measure wave conditions, including directional spectra, and sea temperature. Data are acquired at different temporal resolutions and transmitted in real-time to the ground via an Iridium satellite link. Each DWS buoy measures orbital wave motion using a GPS (Global Positioning System) sensor and is capable of missions lasting one year, acquiring data at 6-hour intervals. Wave spectra can be recorded in hourly or half-hourly formats, within the frequency range of 0.03Hz to 0.5Hz (bandwidth of 1/256 Hz). The interval between measurements is programmable remotely.

Parameters calculated from spectral data—such as significant wave height (Hs), peak period (Tp), zero-crossing period (Tz), peak direction (Dp), and temperature—can be easily exported in ASCII tabular format. After quality control, this data can then be converted to the standard ODV4 format.

2.3 Numerical dataset

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The numerical datasets produced by the wave models are generated by both CNR and ROMA3. CNR, through the LaMMA Consortium, provides data from the WaveWatchIII (WW3) model, while ROMA3 offers data from the SWAN model. Conceptually, these models are very similar, as both describe the generation, propagation, and transformation of waves, though each has specific features.

Below is a description of the standards adopted for the data processed by WW3. However, following technical meetings between CNR and ROMA3, the data output format for both models will be similar.

The datasets produced by the WaveWatchIII (WW3) wave model are run by CNR in collaboration with the LaMMA Consortium. The model, is implemented in various versions at the LaMMA Consortium, both for operational forecast, meteomarine hindcast or climate projections. As for the numerical implementation, the model has been configured using both structured and unstructured grids. Numerical wave models in use simulate several processes including wave generation, transformation and propagation, producing two-dimensional datasets. The output is normally provided with a temporal resolution of 1 hour and a variable spatial resolution. In the unstructured wave model configuration operational at LaMMA, the model has a maximum resolution of approximately 500 meters along the North-Tyrrhenian and Ligurian coast. The WW3 model has been calibrated and validated using in-situ measurements from 14 buoys in the Ligurian Sea and the Tyrrhenian Sea. The quality of the simulations has been assessed using appropriate statistical indicators to quantify the deviation between observed and simulated data.

With this model, hindcast scenarios have been generated, available as historical series covering the period 1979-2020. Forecast scenarios are available in real-time.

The datasets are provided in NetCDF format and adhere to the international CF-1.6 convention. Currently, they are available in real-time only for graphical visualization through a website. These data have not undergone Quality Control procedures, although they are accompanied by complete metadata.

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In the absence of an internationally adopted standard for data model, it is proposed to adopt the quality control procedures provided by the two reference products in the European context (CMCC and MERCATOR), in addition to the standard CF-1.0 or higher convention for operational production.

The requested results may include time series of the most important wave parameters: significant wave height (Hs), peak period (Tp) or mean period (Tm), peak direction (Dp) or mean direction (Dm). Wave spectra can be produced by models and stored at any given frequence (hourly), normally using a logarithmic-type resolution for frequencies and a constant resolution for directions (normally 10°).

A fixed nomenclature can be defined according to the Copernicus Physical Parameter List (https://archimer.ifremer.fr/doc/00422/53381/) and the BODC VOCAB LIBRARY (http://vocab.nerc.ac.uk/collection/P09/current/) used by SeaDataNet.

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APPENDIX

Wave Glider output dataset (ASCII table)

Timestamp(UTC), Hs [m], Ta [s], Dp [°] , E [meters^2 / Hz], f [Hz], dir [°], spread [deg]
data: ..

Dataset of spectral quantities

Timestamp(UTC), f (Hz), dir (°), a1, b1, a2, b2
data: ..

DWS output dataset (ASCII table)

Platform-ID, Timestamp(UTC), GPS-Latitude(°), GPS-Longitude(°), SST(°C), SLP(mB), Battery(volts), Hs (m) , Tp (s), Ta (s), Dd (°), Drogue(Count), GPS-FixDelay, GPS-Param1, GPS-Param2, SBD-Transmit-Delay, SBD-Retries, Hull T (°C), Hull P (mb), Hull RH (%)
data: ..

Dataset of spectral quantities

Platform-ID, Timestamp(UTC), f(Hz), a0, dir (°), a1, b1, a2, b2.
data: ..

WW3 output dataset (NetCDF)

```
dimensions:
    node = 90189 ;
    time = UNLIMITED ; // (121 currently)
    element = 169597 ;
    noel = 3 ;
variables:
    float longitude(node) ;
        longitude:units = "degree_east" ;
        longitude:long_name = "longitude" ;
        longitude:standard_name = "longitude" ;
        longitude:valid_min = -180.f ;
        longitude:valid_max = 360.f ;
        longitude:axis = "X" ;
    float latitude(node) ;
        latitude:units = "degree_north" ;
        latitude:long_name = "latitude" ;
        latitude:standard_name = "latitude" ;
        latitude:valid_min = -90.f ;
        latitude:valid_max = 180.f ;
        latitude:axis = "Y" ;
    double time(time) ;
        time:long_name = "julian day (UT)" ;
        time:standard_name = "time" ;
        time:calendar = "standard" ;
        time:units = "days since 1990-01-01 00:00:00" ;
        time:conventions = "relative julian days with decimal part (as parts of the day )" ;
        time:axis = "T" ;
    int tri(element, noel) ;
    short MAPSTA(node) ;
        MAPSTA:long_name = "status map" ;
        MAPSTA:standard_name = "status map" ;
        MAPSTA:units = "1" ;
        MAPSTA:valid_min = -32 ;
        MAPSTA:valid_max = 32 ;
    short uwnd(time, node) ;
        uwnd:long_name = "eastward_wind" ;
        uwnd:standard_name = "eastward_wind" ;
        uwnd:globwave_name = "eastward_wind" ;
        uwnd:units = "m s-1" ;
        uwnd:_FillValue = -32767s ;
        uwnd:scale_factor = 0.1f ;
        uwnd:add_offset = 0.f ;
        uwnd:valid_min = -990 ;
        uwnd:valid_max = 990 ;
        uwnd:comment = "wind=sqrt(U10**2+V10**2)" ;
    short vwnd(time, node) ;
        vwnd:long_name = "northward_wind" ;
        vwnd:standard_name = "northward_wind" ;
        vwnd:globwave_name = "northward_wind" ;
        vwnd:units = "m s-1" ;
        vwnd:_FillValue = -32767s ;
```

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```
        vwnd:scale_factor = 0.1f ;
        vwnd:add_offset = 0.f ;
        vwnd:valid_min = -990 ;
        vwnd:valid_max = 990 ;
        vwnd:comment = "wind=sqrt(U10**2+V10**2)" ;
    short hs(time, node) ;
        hs:long_name = "significant height of wind and swell waves" ;
        hs:standard_name = "sea_surface_wave_significant_height" ;
        hs:globwave_name = "significant_wave_height" ;
        hs:units = "m" ;
        hs:_FillValue = -32767s ;
        hs:scale_factor = 0.002f ;
        hs:add_offset = 0.f ;
        hs:valid_min = 0 ;
        hs:valid_max = 32000 ;
    short t02(time, node) ;
        t02:long_name = "mean period T02" ;
        t02:standard_name = "sea_surface_wind_wave_mean_period_from_variance_spectral_density_second_frequency_moment" ;
        t02:globwave_name = "mean_period_t02" ;
        t02:units = "s" ;
        t02:_FillValue = -32767s ;
        t02:scale_factor = 0.01f ;
        t02:add_offset = 0.f ;
        t02:valid_min = 0 ;
        t02:valid_max = 5000 ;
    short t01(time, node) ;
        t01:long_name = "mean period T01" ;
        t01:standard_name = "sea_surface_wind_wave_mean_period_from_variance_spectral_density_first_frequency_moment" ;
        t01:globwave_name = "mean_period_t01" ;
        t01:units = "s" ;
        t01:_FillValue = -32767s ;
        t01:scale_factor = 0.01f ;
        t01:add_offset = 0.f ;
        t01:valid_min = 0 ;
        t01:valid_max = 5000 ;
    short fp(time, node) ;
        fp:long_name = "wave peak frequency" ;
        fp:standard_name = "sea_surface_wave_peak_frequency" ;
        fp:globwave_name = "dominant_wave_frequency" ;
        fp:units = "s-1" ;
        fp:_FillValue = -32767s ;
        fp:scale_factor = 0.001f ;
        fp:add_offset = 0.f ;
        fp:valid_min = 0 ;
        fp:valid_max = 10000 ;
    short dir(time, node) ;
        dir:long_name = "wave mean direction" ;
        dir:standard_name = "sea_surface_wave_from_direction" ;
        dir:globwave_name = "wave_from_direction" ;
        dir:units = "degree" ;
        dir:_FillValue = -32767s ;
        dir:scale_factor = 0.1f ;
        dir:add_offset = 0.f ;
        dir:valid_min = 0 ;
        dir:valid_max = 3600 ;
    short dp(time, node) ;
        dp:long_name = "peak direction" ;
        dp:standard_name = "sea_surface_wave_peak_direction" ;
        dp:globwave_name = "dominant_wave_direction" ;
        dp:units = "degree" ;
        dp:_FillValue = -32767s ;
        dp:scale_factor = 1.f ;
        dp:add_offset = 0.f ;
        dp:valid_min = 0 ;
        dp:valid_max = 360 ;
    short phs0(time, node) ;
        phs0:long_name = "wave significant height partition 0" ;
        phs0:standard_name = "sea_surface_wave_significant_height_partition_0" ;
        phs0:globwave_name = "significant_wave_height_partition_0" ;
        phs0:units = "m" ;
        phs0:_FillValue = -32767s ;
        phs0:scale_factor = 0.002f ;
        phs0:add_offset = 0.f ;
        phs0:valid_min = 0 ;
        phs0:valid_max = 32000 ;
        phs0:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short phs1(time, node) ;
        phs1:long_name = "wave significant height partition 1" ;
        phs1:standard_name = "sea_surface_wave_significant_height_partition_1" ;
        phs1:globwave_name = "significant_wave_height_partition_1" ;
        phs1:units = "m" ;
        phs1:_FillValue = -32767s ;
        phs1:scale_factor = 0.002f ;
        phs1:add_offset = 0.f ;
        phs1:valid_min = 0 ;
        phs1:valid_max = 32000 ;
        phs1:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short phs2(time, node) ;
        phs2:long_name = "wave significant height partition 2" ;
        phs2:standard_name = "sea_surface_wave_significant_height_partition_2" ;
        phs2:globwave_name = "significant_wave_height_partition_2" ;
        phs2:units = "m" ;
        phs2:_FillValue = -32767s ;
        phs2:scale_factor = 0.002f ;
```

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```
        phs2:add_offset = 0.f ;
        phs2:valid_min = 0 ;
        phs2:valid_max = 32000 ;
        phs2:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pdir0(time, node) ;
        pdir0:long_name = "wave mean direction partition 0" ;
        pdir0:standard_name = "sea_surface_wave_from_direction_partition_0" ;
        pdir0:globwave_name = "wave_from_direction_partition_0" ;
        pdir0:units = "degree" ;
        pdir0:_FillValue = -32767s ;
        pdir0:scale_factor = 0.1f ;
        pdir0:add_offset = 0.f ;
        pdir0:valid_min = 0 ;
        pdir0:valid_max = 3600 ;
        pdir0:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pdir1(time, node) ;
        pdir1:long_name = "wave mean direction partition 1" ;
        pdir1:standard_name = "sea_surface_wave_from_direction_partition_1" ;
        pdir1:globwave_name = "wave_from_direction_partition_1" ;
        pdir1:units = "degree" ;
        pdir1:_FillValue = -32767s ;
        pdir1:scale_factor = 0.1f ;
        pdir1:add_offset = 0.f ;
        pdir1:valid_min = 0 ;
        pdir1:valid_max = 3600 ;
        pdir1:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pdir2(time, node) ;
        pdir2:long_name = "wave mean direction partition 2" ;
        pdir2:standard_name = "sea_surface_wave_from_direction_partition_2" ;
        pdir2:globwave_name = "wave_from_direction_partition_2" ;
        pdir2:units = "degree" ;
        pdir2:_FillValue = -32767s ;
        pdir2:scale_factor = 0.1f ;
        pdir2:add_offset = 0.f ;
        pdir2:valid_min = 0 ;
        pdir2:valid_max = 3600 ;
        pdir2:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pdp0(time, node) ;
        pdp0:long_name = "peak direction partition 0" ;
        pdp0:standard_name = "sea_surface_wave_peak_from_direction_partition_0" ;
        pdp0:globwave_name = "dominant_wave_from_direction_partition_0" ;
        pdp0:units = "degree" ;
        pdp0:_FillValue = -32767s ;
        pdp0:scale_factor = 0.1f ;
        pdp0:add_offset = 0.f ;
        pdp0:valid_min = 0 ;
        pdp0:valid_max = 3600 ;
        pdp0:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pdp1(time, node) ;
        pdp1:long_name = "peak direction partition 1" ;
        pdp1:standard_name = "sea_surface_wave_peak_from_direction_partition_1" ;
        pdp1:globwave_name = "dominant_wave_from_direction_partition_1" ;
        pdp1:units = "degree" ;
        pdp1:_FillValue = -32767s ;
        pdp1:scale_factor = 0.1f ;
        pdp1:add_offset = 0.f ;
        pdp1:valid_min = 0 ;
        pdp1:valid_max = 3600 ;
        pdp1:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pdp2(time, node) ;
        pdp2:long_name = "peak direction partition 2" ;
        pdp2:standard_name = "sea_surface_wave_peak_from_direction_partition_2" ;
        pdp2:globwave_name = "dominant_wave_from_direction_partition_2" ;
        pdp2:units = "degree" ;
        pdp2:_FillValue = -32767s ;
        pdp2:scale_factor = 0.1f ;
        pdp2:add_offset = 0.f ;
        pdp2:valid_min = 0 ;
        pdp2:valid_max = 3600 ;
        pdp2:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pt01c0(time, node) ;
        pt01c0:long_name = "mean period T01 partition 0" ;
        pt01c0:standard_name = "sea_surface_wave_mean_period_t01_partition_0" ;
        pt01c0:globwave_name = "mean_wave_period_T01_partition_0" ;
        pt01c0:units = "s" ;
        pt01c0:_FillValue = -32767s ;
        pt01c0:scale_factor = 0.01f ;
        pt01c0:add_offset = 0.f ;
        pt01c0:valid_min = 0 ;
        pt01c0:valid_max = 10000 ;
        pt01c0:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pt01c1(time, node) ;
        pt01c1:long_name = "mean period T01 partition 1" ;
        pt01c1:standard_name = "sea_surface_wave_mean_period_t01_partition_1" ;
        pt01c1:globwave_name = "mean_wave_period_T01_partition_1" ;
        pt01c1:units = "s" ;
        pt01c1:_FillValue = -32767s ;
        pt01c1:scale_factor = 0.01f ;
        pt01c1:add_offset = 0.f ;
        pt01c1:valid_min = 0 ;
        pt01c1:valid_max = 10000 ;
        pt01c1:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pt01c2(time, node) ;
        pt01c2:long_name = "mean period T01 partition 2" ;
```

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```
        pt01c2:standard_name = "sea_surface_wave_mean_period_t01_partition_2" ;
        pt01c2:globwave_name = "mean_wave_period_T01_partition_2" ;
        pt01c2:units = "s" ;
        pt01c2:_FillValue = -32767s ;
        pt01c2:scale_factor = 0.01f ;
        pt01c2:add_offset = 0.f ;
        pt01c2:valid_min = 0 ;
        pt01c2:valid_max = 10000 ;
        pt01c2:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pt02c0(time, node) ;
        pt02c0:long_name = "mean period T02 partition 0" ;
        pt02c0:standard_name = "sea_surface_wave_mean_period_t02_partition_0" ;
        pt02c0:globwave_name = "mean_wave_period_T02_partition_0" ;
        pt02c0:units = "s" ;
        pt02c0:_FillValue = -32767s ;
        pt02c0:scale_factor = 0.01f ;
        pt02c0:add_offset = 0.f ;
        pt02c0:valid_min = 0 ;
        pt02c0:valid_max = 10000 ;
        pt02c0:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pt02c1(time, node) ;
        pt02c1:long_name = "mean period T02 partition 1" ;
        pt02c1:standard_name = "sea_surface_wave_mean_period_t02_partition_1" ;
        pt02c1:globwave_name = "mean_wave_period_T02_partition_1" ;
        pt02c1:units = "s" ;
        pt02c1:_FillValue = -32767s ;
        pt02c1:scale_factor = 0.01f ;
        pt02c1:add_offset = 0.f ;
        pt02c1:valid_min = 0 ;
        pt02c1:valid_max = 10000 ;
        pt02c1:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;
    short pt02c2(time, node) ;
        pt02c2:long_name = "mean period T02 partition 2" ;
        pt02c2:standard_name = "sea_surface_wave_mean_period_t02_partition_2" ;
        pt02c2:globwave_name = "mean_wave_period_T02_partition_2" ;
        pt02c2:units = "s" ;
        pt02c2:_FillValue = -32767s ;
        pt02c2:scale_factor = 0.01f ;
        pt02c2:add_offset = 0.f ;
        pt02c2:valid_min = 0 ;
        pt02c2:valid_max = 10000 ;
        pt02c2:comment = "Wind sea and swells defined using topographic partitions and spectral wave-age cut-off" ;

// global attributes:
        :_NCProperties = "version=1|netcdflibversion=4.6.1|hdf5libversion=1.10.3" ;
        :WAVEWATCH_III_version_number = "6.07" ;
        :WAVEWATCH_III_switches = "F90 NOGRB NC4 SHRD PR3 UQ FLX0 LN1 ST4 NL1 BT1 DB1 MLIM TR1 BS0 IC0 IS0 REF0 XX0 WNT1 WNX1 CRT1 CRX1 TRKNC O0
          O1 O2 O3 O4 O5 O6 O7 O11 O14" ;
        :SIN4\ namelist\ parameter\ BETAMAX = 1.55f ;
        :product_name = "ww3.ug.20240408T12Z.nc" ;
        :area = "MEDITERRANEAN" ;
        :latitude_resolution = "n/a" ;
        :longitude_resolution = "n/a" ;
        :southernmost_latitude = "30." ;
        :northernmost_latitude = "46." ;
        :westernmost_longitude = "-10." ;
        :easternmost_longitude = "36." ;
        :minimum_altitude = "-12000 m" ;
        :maximum_altitude = "9000 m" ;
        :altitude_resolution = "n/a" ;
        :start_date = "2024-04-08 12:00:00" ;
        :stop_date = "2024-04-08 12:00:00" ;
data: ..
```

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