NOOS-Drift

CMEMS User Uptake tender 67-DEM4-L5

Specification of the simulation results package

Report of task T3.2

Authors: Knut-Frode Dagestad (MET Norway), Pierre Daniel (Météo-France), Sébastien Legrand (RBINS)

Task : T3.2
Document version: v2.0
Date: 2019/04/09

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List of the acronyms and abbreviations used

Co-Contractors acronyms:

RBINS	Royal Belgian Institute of Natural Sciences
MET Norway	Norwegian Meteorological Institute
Météo-France	French Meteorological Institute

Bonn Agreement	The Bonn Agreement is the mechanism by which the North Sea States, and the European Union (the Contracting Parties), work together to help each other in combating pollution in the North Sea Area from maritime disasters and chronic pollution from ships and offshore installations. The North Sea States are Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Sweden, and the United Kingdom of Great Britain and Northern Ireland.
CMEMS	Copernicus Marine Environment Monitoring Service
CCS	Central Communication System, the technical core of the NOOS-Drift service.
EuroGOOS	EuroGOOS is an international non-profit association of national governmental agencies, research organisations, and private companies, committed to European-scale operational oceanography within the context of the intergovernmental Global Ocean Observing System (GOOS). Founded in 1994, EuroGOOS has today 41 members from 19 European countries providing operational oceanographic services and carrying out marine research.
KPI	Key Performance Indicator
MSP	Drift Model Service Provider. This acronym represents all the operation drift forecast services connected to the central communication system.
NOOS	North West Shelf Operational Oceanographic System, one of the 5 ROOSes of EuroGOOS.
NWS	the European North West continental Shelf

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1 Introduction

1.1 About NOOS-Drift objectives

Drift models are multi-purpose tools that can forecast the drift trajectory of any objects, substances or resources that are drifting at the sea surface or in the water column. Typically activated several hundred to several thousands of times per year and per country, drift models are among the most valuable tools in the day to day management of the coastal and marine environment, marine resources and maritime safety. However, in order to better assess risk and impacts, the end-users benefiting from these drift services also often request to get accurate and reliable estimation of the uncertainty in the drift forecast.
To answer this difficult question, the members of the NOOS working group on drift have the ambition to develop and operate NOOS-Drift, a transnational multi-models ensemble system to assess and improve drift forecast accuracy in the European North West Continental Shelf Seas. Three members of this working group have taken the leadership to implement the system: **RBINS, MET Norway and Météo-France**.

NOOS-Drift implementation runs from the 15th of May 2018 until the 15th of November 2019.

NOOS-Drift ID Card

Service objectives:

1. To operate a transnational multi-models ensemble system that can produce drift forecast on demand.
2. To develop a set of quantified indicators on drift trajectory accuracy, estimated from the spread of the different drift models forecast connected to NOOS-Drift;
3. To discriminate which differences are due to different trajectory models and which are due to different forcing data;
4. To help identify possible outliers;
5. To improve the end-users trust in the drift model results and help guide them in their decision making process, *a real need expressed by users*

Service domain :
The whole ***European North West Shelf Seas***, with a focus on the territorial waters and exclusive economic zones of Belgium, France and Norway. NOOS members from Denmark, Germany, The Netherlands and Ireland have already expressed interest to join the system once developed and validated.

CMEMS area of benefits:

- Coastal and marine environment
- Marine resources
- Maritime safety

CMEMS products used by all the NOOS-Drift operators:

- northwestshelf-analysis-forecast-phys-004-001-b

NB: According to the NOOS-Drift operator, other CMEMS products are used either upstream to downscale and validate met-ocean forcing in coastal waters or directly as alternative met-ocean forcing in other areas.

NOOS-Drift service operation: from the end of the contract-onwards, if the present offer is awarded.

1.2 About this report

This report presents the **specification of the simulation results package**. This package aims at returning the results of a simulation performed by a model connected to the NOOS-Drift system to the NOOS-Drift central communication server. Once uploaded on the central server, the results from all the individual simulations will be jointly analysed by the multi-model ensemble system and the results of the individual simulations as well as of the multi-models ensemble analysis will be made downloadable to the end-users.

To keep the (individual) simulation results package as simple as possible, the NOOS-Drift consortium decided to exchange simulations results to the rawest possible information, preserving as much as possible the information available at the level of the Lagrangian particles.

To make these packages as portable and self-contained as possible, the simulations results will formatted as a netCDF-CF file; the meta information of the simulations being duplicated in the global attributes of the netCDF-CF file and, optionally, in an updated version of the simulation request JSON file (cf. report of Task 3.1).

2. Specification of the NOOS-Drift netCDF-CF file format

A netCDF file is made of dimensions, variables and attributes.

Dimensions are used to define the shape of data in netCDF. Dimensions for a netCDF dataset are defined when it is created, while the netCDF dataset is in define mode. A netCDF dimension has a name and a length. In a netCDF classic or 64-bit offset file, at most one dimension can have the unlimited length, which means variables using this dimension can grow along this dimension. In a netCDF-4 file multiple unlimited dimensions are supported.

Variables are used to store the bulk of the data in a netCDF dataset. A variable represents an array of values of the same type. A scalar value is treated as a 0-dimensional array. A variable has a name, a data type, and a shape described by its list of dimensions specified when the variable is created. A variable may also have associated attributes, which may be added, deleted or changed after the variable is created.

Coordinate variables - It is legal for a variable to have the same name as a dimension. Such variables have no special meaning to the netCDF library. However, by convention, a variable with the same name as a dimension typically defines a physical coordinate corresponding to that dimension.

NetCDF attributes are used to store data about the data (ancillary data or metadata), similar in many ways to the information stored in data dictionaries and schema in conventional database systems. Most attributes provide information about a specific variable. These are identified by the name (or ID) of that variable, together with the name of the attribute.

Some attributes provide information about the dataset as a whole and are called global attributes. These are identified by the attribute name together with a blank variable name (in CDL) or a special null "global variable" ID (in C or Fortran).

A netCDF-CF file is nothing else than a usual netCDF file for which the attributes respect the conventions for Climate and Forecast (CF) metadata: http://cfconventions.org/. The CF conventions are increasingly gaining acceptance and have been adopted by a number of projects and groups as a primary standard. The conventions define metadata that provide a definitive description of what the data in each variable represents, and the spatial and temporal properties of the data. This enables users of data from different sources to decide which quantities are comparable, and facilitates building applications with powerful extraction, regridding, and display capabilities.

The file format shall be "netCDF4 classic", adhering to the CF-conventions for trajectory data ("Discrete sampling Geometries"): http://cfconventions.org/Data/cf-conventions/cf-conventions-1.7/cf-conventions.html#_incomplete_multidimensional_array_representation

2.1 Dimensions of NOOS-Drift results netCDF-CF file

The two dimensions shall be defined:

- "**trajectory**" : number of trajectories/particles/elements
- "**time**" : number of times. This "time" dimension can be unlimited.

2.2 Variables of NOOS-Drift results netCDF-CF file

2.2.1 1D variable : time

A 1D variable with standard_name "time" of dimension ("time") shall define the discrete times. This shall have an attribute "units" which is e.g. "seconds since 1970-01-01 00:00:00"

Note that output are expected at least every round hour.

2.2.2 2D mandatory variables

The file shall have 2D arrays of dimension (trajectory, time) for the following variables, including an attribute "standard_name" with the same name:

- '**longitude**' (units "degrees_east")
- '**latitude**' (units "degrees_north")
- '**z**' (units: "m", "positive": "up") i.e. -10 for 10m depth below sea level. 'z' is optional, otherwise z=0 (ocean surface) is assumed.
- '**status**': an array of integers indicating the status of each particle. This array shall have an attribute "flag_values" indicating the integer values in use, and an attribute "flag_meanings" which can include:
    - 'active': the particle is active and drifting
    - 'stranded': the particle has hit land and has been deactivated
    - 'missing_data': the particle has moved outside of the coverage of the drift simulation (i.e. outside coverage of forcing data)

Example:

- int status(trajectory, time)
- status:flag_values = 0, 1, 2 ;
- status:flag_meanings = "active stranded missing_data" ;

In addition to the attribute “standard_name”, all the mandatory variables should have the CF standard attributes such as **“value_min”, “value_max”** (or equivalently **"valid_range"**) and **“_fill_value”.**

2.2.3 2D optional variables

In case of oil simulation, the file can have 2D arrays of dimension (trajectory, time) for the following variables, including an attribute “standard_name” with the same name:

- ‘**mass_oil**’: the mass of pure oil (in kg, not including water) of the given particle/element
- ‘**mass_evaporated**’: the mass of oil which has been evaporated from the given particle/element
- ‘**water_fraction**’: the mass fraction of the particle/element which is water, e.g. 0 for pure oil and 0.9 for emulsion with 90% water and 10% oil.

The sum of mass_oil+mass_evaporated+mass_dispersed shall be conserved and equal to the initial mass of the given particle.

Any other 2D variables could be also added in the results file to track for instance the downwind and crosswind leeway coefficient, the wind speed or the current speed at the Lagrangian particles location. However, these variables won’t be considered in the multi-model ensemble analysis tools in the framework of this project.

In addition to the attribute “standard_name”, all the mandatory variables should have the CF standard attributes such as “value_min”, “value_max” (or equivalently "valid_range") and “_fill_value”.

2.3 Global attributes of NOOS-Drift results netCDF-CF file

In addition to the standard global attributes defined by the netCDF-CF convention, a NOOS-Drift results file must have the following global attributes defined:

- **“model_name”**, the name of the drift model used in the simulation
  (Possible values : “undefined”, “opendrift”, “mothy”, “oserit”)
- **"wind_name"**, the name of the wind forcing used in the simulation
  (Possible values : “undefined”, “ecmwf”, “ukmo”, “arpege”, “arome”, “gfs”)
- **"current_name"**, the name of the ocean forcing used for the simulation
  (Possible values : “undefined”, “cmems_nws7”, “cmems_nws1.5”, “cmems_ibi”, “cmems_global”, “norkyst”, “optos”)

These attributes can be added by the simulation tool directly, but they can also be appended afterwards (ncatted).

2.4 Filename convention

In order to preserve the link with the NOOS-Drift simulation request package and to help the implementation at the central server side, the file should be named according this convention :

noosdrift**_requestId_modelName_oceanForcingName_windForcingName **.nc

The advantage of this convention is that a link with the request is always preserved. This will help the development at the central server side.

The non-exhaustive list of possible modelName is 'oserit', 'mothy', 'opendrift', ...

The non-exhaustive list of windForcingName could be 'ecmwf', 'ukmo', ...

The non-exhaustive list of possible oceanForcingName could be 'cmems_nws7', 'cmems_nws1.5', 'cmems_ibi', 'cmems_global', 'norkyst', 'optos', ... The first 4 names are related to CMEMS products. The number refers to the horizontal resolution in km.

3 Examples

The output of the ncdump of a NOOS-Drift results netCDF-CF file should looks like:

```
netcdf opendrift_sar_norway_rlw {
dimensions:
	trajectory = 1000 ;
	time = 49 ;
variables:
	int trajectory(trajectory) ;
		trajectory:cf_role = "trajectory_id" ;
		trajectory:units = "1" ;
	double time(time) ;
		time:units = "seconds since 1970-01-01 00:00:00" ;
		time:standard_name = "time" ;
		time:long_name = "time" ;
	int status(trajectory, time) ;
		status:coordinates = "lat lon time" ;
		status:valid_range = 0, 0 ;
		status:flag_values = 0 ;
		status:flag_meanings = "active" ;
	float lon(trajectory, time) ;
		lon:coordinates = "lat lon time" ;
		lon:units = "degrees_east" ;
		lon:standard_name = "longitude" ;
		lon:long_name = "longitude" ;
	float lat(trajectory, time) ;
		lat:coordinates = "lat lon time" ;
		lat:units = "degrees_north" ;
```

```
            lat:standard_name = "latitude" ;
            lat:long_name = "latitude" ;
      float z(trajectory, time) ;
            z:coordinates = "lat lon time" ;
            z:long_name = "vertical position" ;
            z:standard_name = "z" ;
            z:positive = "up" ;
            z:units = "m" ;
            z:axis = "Z" ;
// global attributes:
            :Conventions = "CF-1.6" ;
            :standard_name_vocabulary = "CF-1.6" ;
            :featureType = "trajectory" ;
            :history = "Created 2018-12-01 15:47:13.067412" ;
            :source = "Output from simulation with OpenDrift" ;
            :model_url = "https://github.com/OpenDrift/opendrift" ;
            :model_name = "opendrift"
            :wind_name = "ecmwf"
            :current_name = "norkyst"
}
```

4 Conclusion

This report presents the specifications of the NOOS-Drift simulation results file. This file has been designed as a standalone netCDF-CF file.

To make the NOOS-Drift simulation results package as portable and self-contained as possible, the netCDf-CF file can optionally be accompanied by an updated version of the simulation request JSON file (cf. report of Task 3.1). This JSON file contains all the metadata necessary to create a valid simulation.

Acknowledgment

NOOS-Drift is the User Uptake tender 67-DEM4-Lot5 of the Copernicus Marine Environment Monitoring Service (CMEMS).

This study is being conducted using E.U. Copernicus Marine Service Information.