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MERSEA IP

Marine EnviRonment and Security for
the European Area - Integrated Project

WP 5
"Integrated System Design and Assessment"

List of internal metrics for the MERSEA-GODAE Global Ocean: Specification for implementation

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Acronyms

ARGO	global array of profiling floats
CLIVAR	CLImate VARiability and predictability
ECMWF	European Center for Medium Range Weather Forecast
EOF	Empirical Orthogonal Functions
ESEOO	Establecimiento de un Sistema Español de Oceanografía Operacional
ESSC	Environmental Systems Science Centre
GLOSS	Global Sea Level Observing System
GODAE	Global Ocean Data Assimilation Experiment
HYCOM	Hybrid Coordinate Ocean Model
MEC	MERSEA Executive Committee
MDT	Mean Dynamic Topography, also called MSSH (Mean Sea Surface Height)
MERSEA	Marine EnviRonment and Security for the European Area
MICOM	Miami Isopycnal Coordinate Ocean Model
MLD	Mixed Layer Depth
MRCS	POLCOMS Medium Resolution Continental Shelf Model
NDBC	National Data Buoy Center, NOAA, USA
NEA	North East Atlantic region (and forecasting TEP)
NERSC	Nansen Environmental and Remote Sensing Center
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
SLA	Sea Level Anomaly
SOOP	Ship Of Opportunity Program
SST	Sea Surface Temperature
Sv	Sverdrup, transport unit in 10^6 m^3/s
TBD	To Be Defined
TEP	Thematic Portal
TOP	Target Operational Phase
VOS	Voluntaree Observing Ship
WIN	Wide Integrated Network
WOCE	World Ocean Circulation Experiment
WP	Work Package

Reference documents

[REF1]	Assessment during TOP1: guideline for metrics implementation. Delivery D5.4.4. MERSEA-WP05-MERCA-STR-0014.01C”
[REF2]	List of internal Metrics, specification for implementation. WP 5. Authors: L Crosnier, F. Hernandez et al. 24 March 2005. MERSEA-WP05-MERCA-STR0007_01A.doc
[REF3]	Definition of Class 1-4 metrics for the Arctic. Authors: L. Bertino, K. Lisaeter, G. Garric et al. May 2006. Project deliverable D5.4.5. MERSEA-WP05-NERSC-TECN-0017.02A.doc
[REF4]	Guideline for Class 4 implementation. Project deliverable D5.4.5. MERSEA-WP05-MERCA-STR-0018.02A
[REF5]	Guideline for the GODAE providers: Convention for the GODAE files, OpenDap and Live Access Server. L. Crosnier. D5.4.5 .MERSEA-WP05-MERCA-STR0016.01A.doc.
[REF6]	Synthesis of the MERSEA/GODAE implementation status and preliminary inter-comparison results, first assessment report: TOP1 assessment results and TOP2 assessment definition. D5.4.3. MERSEA-WP05-MERCA-STR-0019.01C
[REF7]	Synthesis of the MERSEA scientific assessment: TOP2 assessment. D5.4.9. MERSEA-WP05-MERCA-STR-0031.01D
[REF8]	Atlantic and Mediterranean metrics for TOP2. Project deliverable D5.4.5. MERSEA-WP05-MERCA-STR-0026.01B
[REF9]	Sea Ice diagnostics and global Mercator model assessment. MERSEA_WP09_CLS_STR_001_01A. By Nathalie Verbrugge. 30/09/2007.
[REF10]	Minutes of the Pacific Metrics Workshop. Fabrice Hernandez and GODAE Intercomparison Working Group, August 2007. 26 pp.

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1. INTRODUCTION

1.1. Context

The Global Data Assimilation Experiment GODAE gathers the international ocean modeling and data assimilation communities around global ocean high resolution forecast systems (https://www.godae.org/). GODAE will demonstrate the real time production of global ocean products. At the European level, the Marine Environment and Security for the European Area (MERSEA, 2004-2008) Integrated Project, aims at creating in 2008 the Global Monitoring for Environment and Security (GMES) forecast system [*Ryder and Stel*, 2002]. The initiating MERSEA Strand1 (2003-2004) project [*Johannessen et al.*, 2002; *Johannessen et al.*, 2005] already inter-compared, on a near real time basis, five existing forecast systems for the North Atlantic and Mediterranean.

In the MERSEA Integrated Project, the Work Package 5 aims to design the overall architecture of the forecasting integrated system (more details in http://www.mersea.eu.org). Among the different functions operating this integrated project, the "validation" plays a central role to a) verify the quality of the operational products and b) to ensure that the different developments of the integrated project can afford the requested quality.

In the MERSEA Integrated Project, a first Target Operational Phase (TOP1) has been scheduled from October 2005 to April 2006, in order to validate the integrated system version 1 in operation. Then the Target Operational Phase 2 (TOP2) has been performed to validate the version 2 in operation, from April to October 2007. Assessment conclusions are respectively given in [REF6] and [REF7]. The assessment has been focused on the validation of the five different ocean forecasting systems: the Arctic (TOPAZ from NERSC), the Baltic (BSHcmod, from DMI), the North East Atlantic (FOAM, from NCOF/UK-Met), the Mediterranean (MFS, from INGV), and the Global system from Mercator Océan.

Validation details for TOP1 are given in [REF1], but its design is derived from the MERSEA Strand 1 intercomparison project [*Crosnier and Le Provost*, 2006; *Crosnier et al.*, 2006; *Le Provost et al.*, 2004], see website: http://www.mersea.eu.org. Ocean dynamic's diagnostics are based on four classes of metrics. MERSEA Strand 1 class 1, 2 and 3 metrics are described in [REF2]. These metrics are revisited since the beginning of TOP1. For instance, for the Arctic Ocean, a collaborative work between MERSEA partners has allowed to define a new set of ocean, but also sea ice diagnostics that are described in [REF3] and [REF9]. For the Mediterranean Sea, new metrics have been discussed, following [*Pinardi and Tonani*, 2005]. For TOP2, re-visited metrics for the North Atlantic Ocean, the Mediterranean and Baltic Seas are summarized in [REF8].

In parallel, from GODAE partnership, a set of metrics for the global ocean (class 1, 2 and 3) has been under definition for several years [*Le Provost et al.*, 2001]. The Mercator group, working on the definition of MERSEA system evaluation, proposed diagnostics for Atlantic Ocean (North and South) and European marginal Seas, and also provides the definition for the Arctic Ocean (designed with other MERSEA partners and mentioned above). A first set of Pacific Ocean diagnostics was provided by [*Kamachi*, 2004], and some refinements have been performed with M. Kamachi and C. Maes *[Maes, pers. comm. 2006]*. In the Indian and Southern Ocean, a first set of diagnostics was provided by [*Oke and Brassington*, 2005]. Then new discussions occurred to improve the corresponding metrics [REF10]. Parts of these class 1, 2 and 3 metrics over the different ocean basins have been implemented by the Mercator group to evaluate the MERSEA global system during TOP1 and TOP2.

Note that the performance of forecasting systems, assessing both the forecasting skills (forecast) and the assimilation technique efficiency (best estimate and analysis) have been defined and tested during the MERSEA TOP1 and TOP2: the class 4 metrics that are defined in [REF4].

1.2. Purpose of the document

This document aims to provide the full technical framework for intercomparisons purposes, **in particular, the GODAE intercomparison project scheduled in 2008**.

This document focuses first on the diagnostic definitions, for validating and intercomparing ocean forecasting systems and the outputs they produced in real time. Using the MERSEA IP assessment background, the document describes the Class 1, 2, 3 and 4 metrics for ocean dynamics in the Atlantic, Pacific, Indian and Southern Oceans, and also the Mediterranean Sea. Sea ice Class 1 metrics are also proposed in this document. Note that sea ice and ocean metrics for the Arctic are fully described in [REF3] and [REF9].

Then the document provides the technical aspect for implementing and producing these metrics. In particular a totally recent review of the NetCDF format, COARDS CF convention has been realized, and new guideline are given.

Then, the GODAE Intercomparison plan is outlined, giving a raw work plan for applying some diagnostics, using observations and other dataset.

Note that in the previous MERSEA document describing the metrics at a global level [REF2], all moorings and sections locations were defined point by point in the annex. Due to the number of considered points and locations for the global ocean, **the precise geographical locations of the moorings and sections are given in separate ASCII files,** that can either be printed or just read by any computer software. All these ASCII files are mentioned in this document. Note also that a UNIX “readme” like text file (called **MERSEA-WP05-MERCA-STR-0015-01C.txt**) is associated with this document and the ASCII files.

2. VALIDATION TOOLS

2.1. Overview

The validation of MERSEA or GODAE systems aims to provide “error bars” or “quality numbers” of their different aspects and components. The objective in MERSEA is to perform an overall assessment of the full integrated system, for every single component, while the GODAE intercomparison exercice aims to identify quality and drawbacks of the systems involved for each basin of the world ocean.

From MERSEA Strand1 project, a clear philosophy was raised [*Crosnier et al.*, 2006; *Le Provost*, 2002], in order to perform the intercomparisons and the quality assessment of different systems. From this intercomparison exercise, main benefits were [*Crosnier and Le Provost*, 2006]: i) identification of major errors and problems in each system, ii) overall assessment of the system products over a 6 month period, iii) evaluation of regional relative quality of each system, and iv) definition of rules, and shared methods for common assessment.

In both MERSEA and GODAE projects, it is clear that this validation as to be agreed and shared by all contributors, following mainly two aspects:

- « **the philosophy** »: a set of basic principles to assess the quality of MERSEA products/GODAE systems through a collaborative partnership.
- « **the methodology** »: a set of tools for computing diagnostics, and a set of standards to refer to, for assessing the products quality. Both tools and standard have to be share-able, and usable among the different MERSEA/GODAE members and systems. Both tools and standards should be subject to upgrades and improvements.

For MERSEA Strand1 [*Le Provost*, 2002] proposed the following principles, that are still relevant for MERSEA and GODAE, defined for assessing ocean hindcast and forecast products:

- **Consistency**: verifying that the system outputs are consistent with the current knowledge of the ocean circulation and climatologies
- **Quality** (or **accuracy of the hindcast/nowcast**): quantifying the differences between the system “best results” (analysis) and the sea truth, as estimated from observations, preferably using independent observations (not assimilated).
- **Performance** (or **accuracy of the forecast**): quantifying the short term forecast capacity of each system, i.e. Answering the questions “*do we perform better than persistency? better than climatology?*”…

For MFS assessment, [*Pinardi and Tonani*, 2005] proposed a fourth principle, to verify and take into account the interest/relevance for the customer, and catch intermediate- or end-users feedbacks:

- **Benefit**: end-user assessment of which quality level has to be reached before the product is useful for an application

The validation methodology during MERSEA Strand1 has been built using “metrics”: Mathematical tools that compute numbers from systems outputs, compared to “references” (climatology, observations etc….). Metrics were defined in four types, or “classes”. We propose here to use the same kind of metrics and classes. Each class of metrics is defined below in section 2.2. Then metrics are proposed in section 3.

From Class 1, 2 and 3 metrics, the consistency and quality of each system can be deduced, or intercompared among several systems. The system's performance can be addressed using Class 4 metrics. The "benefit" can also been addressed using a set of Class 1, 2, 3 and 4 metrics. However, new metrics, "user-oriented" might need to be defined to fully address this last principle.

The "share-ability" is the second important aspect of the validation methodology. Because the validation is performed by different teams contributing to GODAE or MERSEA in different places. The purpose of this document is to centralize the metrics definition. Then, once adopted, metrics have to be implemented the same way in the different systems. Finally, resulting standardized output fields and diagnostics have to be distributed via OPeNDAP servers and can be visualized through a Live Access Server (LAS) or with DODS clients (see http://www.opendap.org). In addition, the standardized NetCDF format is chosen. It allows a flexible generation of metrics files. This document does not describe formats and technical aspects that are presented in a companion document [REF5].

2.2. Metrics class definition and purposes

The metrics provide equivalent quantities extracted out of the different systems for the same geographic locations. It is mandatory in the intercomparison exercise because the systems use different vertical coordinates with different vertical resolution, as they all cover different geographical domains with different horizontal resolution.

Class1 to 3 metrics are provided on a real time basis by all teams through their OPeNDAP server for the daily mean best estimates fields (the best estimate corresponds to the best field that each system can produce, i.e. a hindcast or nowcast), as well as for any forecast. These metrics are computed directly "in line" during the system run, or built from the system direct outputs.

Note that the Mersea Strand1 are obsolete. Class 1 metrics have been revisited for the world ocean. Class 2 and 3 metrics have also been upgraded, in particular in the North Atlantic, the Arctic and the Mediterranean Sea. All **metrics are based on ocean variables**, for some areas, **sea ice metrics are also included**.

In some examples given below, Class 1 to Class 3 are used, with respect to observations or climatologies, to assess one given system. Using these metrics, it is straightforward that all GODAE systems could be a) compared to these observations, and b) intercompared, to provide both an "absolute" accuracy and a "relative" quality that can allow in the future some "system ensemble forecast".

2.2.1. Class 1 metrics

Class 1 metrics aims to provide general overview of the ocean and sea ice dynamics provided by the different systems. System's output (e.g. ocean and sea-ice model variables) corresponding to different horizontal and vertical native grids are interpolated into a common set of horizontal and vertical grids over different regions that cover the world ocean, following the **GODAE resolution** (details in sections 3.3 and 3.4). Class1 diagnostics gathers 2-D and 3-D fields (Table 1) interpolated on the GODAE grids, and averaged on daily means. The vertical resolution clearly not allows to fully monitor the ocean water masses variability. However, this is a compromise between a complete view of the ocean dynamics by each system, and the storage capacity needed to have it at the global scale.

Class 1 metrics, i.e. daily means, can be used as “instantaneous” estimates of the ocean mesoscale circulation (assuming that typical time scale of the mesoscale circulation is of the order of few days) for direct comparison to observed quantities: e.g., map of satellite SST, of satellite altimetry SSH, of dynamic height from synoptic hydrographic data set etc…. But preferably, Class 1 metrics are designed for “consistency assessment” and comparison to climatologies or ocean pattern described in the literature. Figure 2-1a gives an exemple of “consistency” assessment using a Class 1 metrics in the North Atlantic area, where the monthly averaged of salinity at 1000m depth from the Mercator system is compared to the WOA05 climatology [*Antonov et al.*, 2006; *Locarnini et al.*, 2006]. While Figure 2-1b and Figure 2-2 provide “quality” assessment using Class 1 metrics. In these examples, the accuracy of the hindcast for a given day can be quantified, compared to observations.

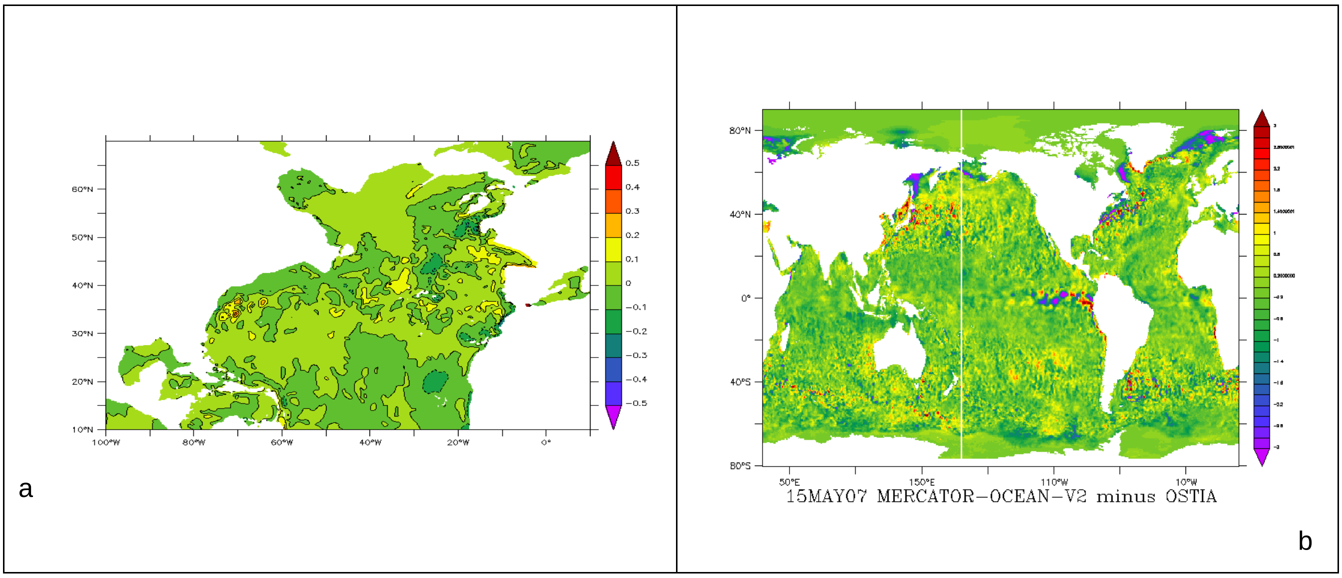


Figure 2-1:a) Class 1 Mercator High resolution North Atlantic 1/15º monthly averaged Salinity Anomaly (psu) with respect to WOA05 in April 2007, at 1000 meters depths. b) Class 1 Mercator global ¼° system Sea Surface Temperature Anomaly (°C) the 15th of May 2007 with respect to OSTIA GHRSST product the same day.

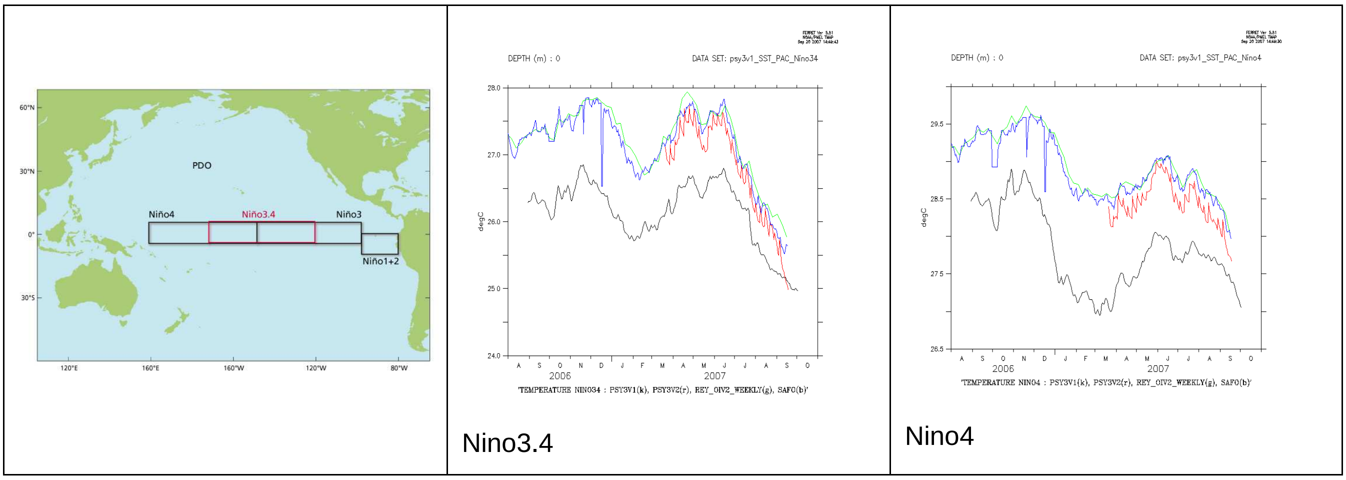


Figure 2-2: Class 1 SST (º C) time series comparison in Nino boxes. Here are plotted daily box averaged SST for the Mercator Global “old” system (black line), and the present one (red line), together with box averages SST from observations: SAFO and Reynolds RTG products (green and blue lines).

2.2.2. Class 2 metrics

Like Class 1, Class 2 metrics are designed to monitor systems outputs (e.g. model variables). But Class 2 metrics are complementary tools to Class 1: wherever high horizontal and vertical resolution is required to analyse the ocean dynamics, and perform the diagnostic, Class 2 are designed as virtual moorings or sections into the model domain. The main advantage is that well chosen sections and moorings represent a reduced amount of stored data compared to Class 1 3D fields that would cover the full system domain at high resolution.

Class2 diagnostics gathers some of the model variables (Table 2) along chosen section tracks or at moorings locations. Along sections, locations have been computed usually every 10 km for global metrics. Every 15 km for Arctic metrics [REF3]. Some of the chosen tracks coincide with oceanographic cruises, ship of opportunity tracks, repeating surveys, or gliders tracks.

From daily class 2 metrics, either consistency or quality assessment can be performed. Figure 2-3 illustrates this: Class 2 daily sections of velocities are used to compute an Eddy Kinetic Energy average from April to August 2007, that is compared to published results. Again, a monthly average of a salinity Class 2 section in the Indian Ocean (Figure 2-4) is compared to the climatology, but also to a WOCE CTD section. By the way, water masses distribution can be checked, and when comparing a CTD or XBT section with daily class 2 metrics, the accuracy and some error value can be calculated.

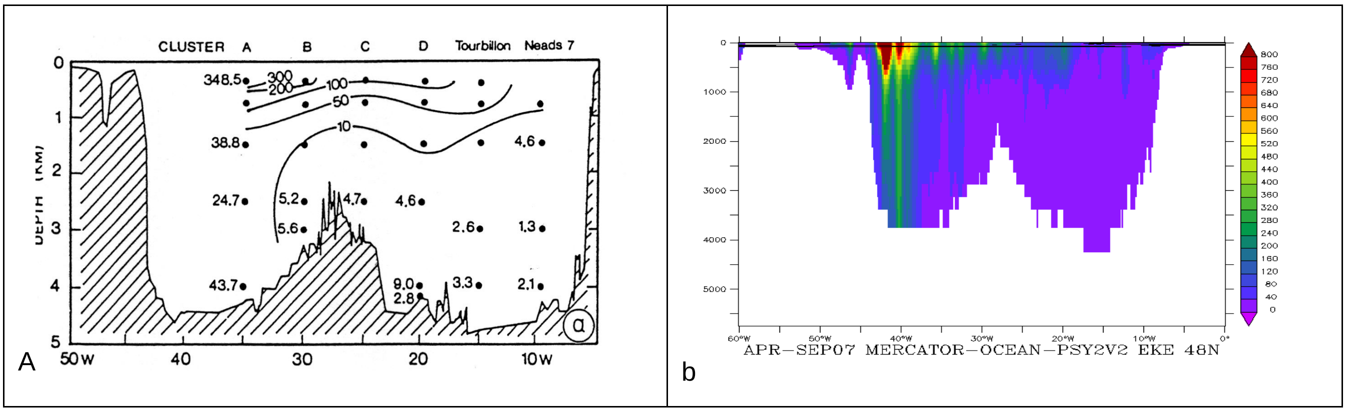
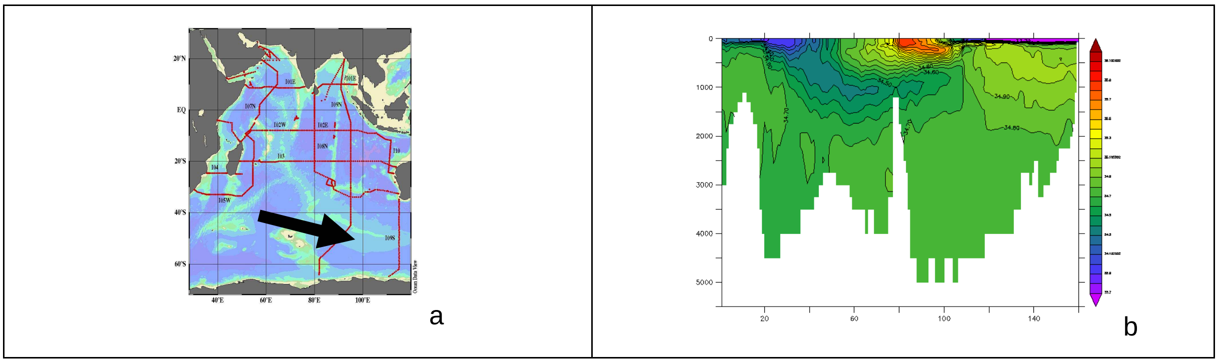


Figure 2-3: EKE (cm^2/s^2) at 48ºN in the North Atlantic Ocean computed from (a) estimation from current meter moorings [Colin de Verdière et al., 1989]; (B) Mercator Class 2 metrics section from April 1st to September 30 2007.



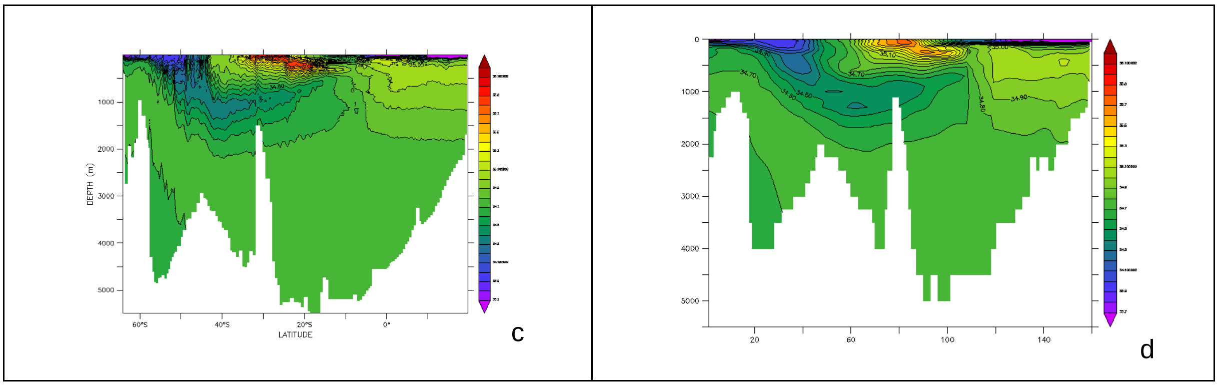


Figure 2-4: Class 2 section consistency assessment along WOCE section (I09, 1995) at 95°E in the Indian Ocean (a). The monthly averaged salinity section in August 2007 (b) is compared to the WOCE section (c), and to the WOA05 climatology (d).

Class 2 metrics can also assess the quality of sea level estimated by the system. Figure 2-5 show that sea level differences with respect to tide gauge data can be monitored, to infer how sea level variations and fluctuations can be reproduced by the system, and when the system is deficient. But also, differences with respect to observations can be quantified, and used to supply "error bars" for to the best estimates provided by the system. The same kind of diagnostic could be performed on several forecasts instead of hindcast. In this case, checking the results for different forecast days will give a "forecasting skill" and a performance assessment.

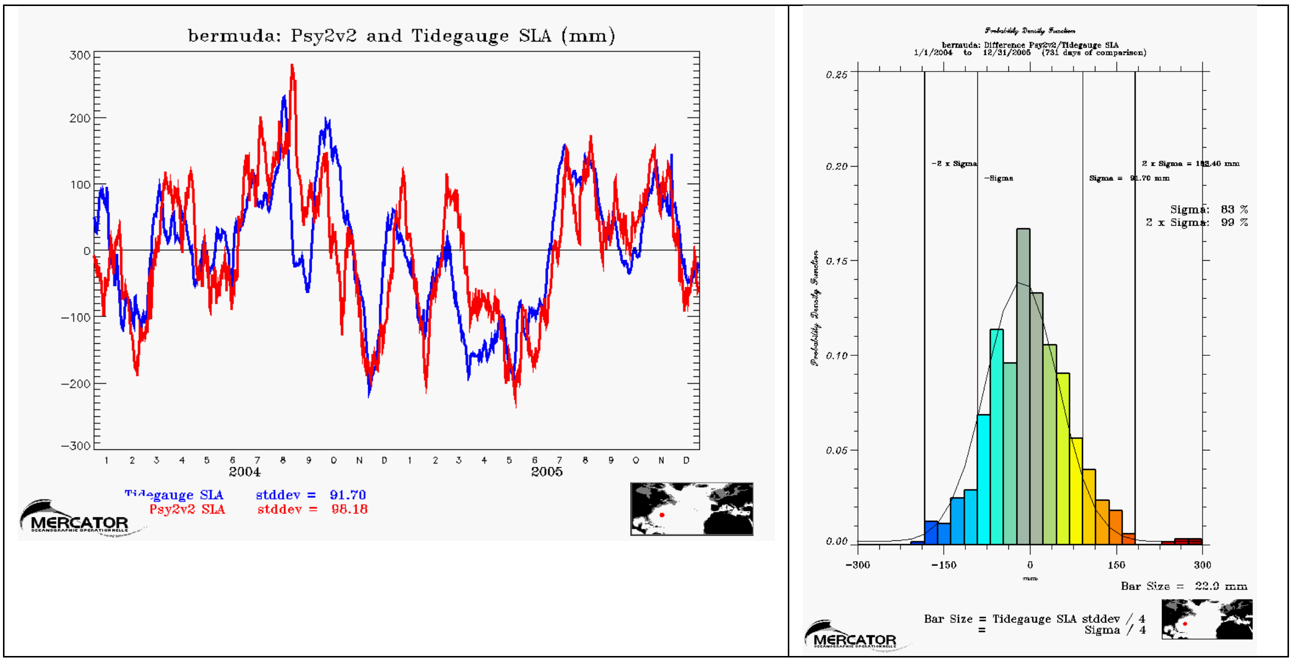


Figure 2-5: Class 2 tide gauge assessment. Left: sea level anomaly comparison (cm) in the western North Atlantic between the Mercator High Resolution system (red) and GLOSS (blue) tide gauges (see map for location). Right: statistics of the differences (probability density function), for the 731 days of comparison (from January 2004 to December 2005).

Class 2 metrics are designed for direct comparison with the finer knowledge of the ocean dynamics and water properties that can be available through in-situ or remote sensing observations.

2.2.3. Class 3 metrics

Class 3 metrics are physical quantities computed using the model variables that can not be derived from Class 1 or Class 2 files (summarized in Table 1 and Table 2). Class 3 metrics need to be computed in-line, during the model run, on the native grid, every time step. Typical Class 3 diagnostics are integrated quantities such as daily volume transport through chosen sections. Note that these sections can be located at the same position that Class 2 metrics, and by this way, allow to assessing both the accuracy of the model variables, and the corresponding dynamics.

Class3 diagnostics are designed to check the model (or system) behaviour through the physical point of view: Eulerian and Lagrangian properties of the ocean and water masses in constant evolution at short scale (e.g. strait transports) or large scale (e.g. Meridional Overturning Streamfunction) can be analysed on a daily basis using Class 3 :

- Volume transports (Sverdrup=10^6 m^3/s) across chosen sections. Depending on the section considered, one has to provide the total (positive + negative component) volume transport or the volume transport per defined potential temperature classes or density classes. Figure 2-6 shows both "consistency" and "quality" assessment. The Class 3 volume transport monitoring across the Florida Straits is plotted, between the Mercator system, and observations given by Cable data (see www.aoml.noaa.gov/phod/floridacurrent/).
- The Overturning Streamfunction (OSF) (Sverdrup=10^6 m^3/s) as a function of latitude and depth (m) or potential temperature (°C) or potential density (kg/m^3).
- The Meridional Heat Transport (MHT) (PW=10^{15} Watt).

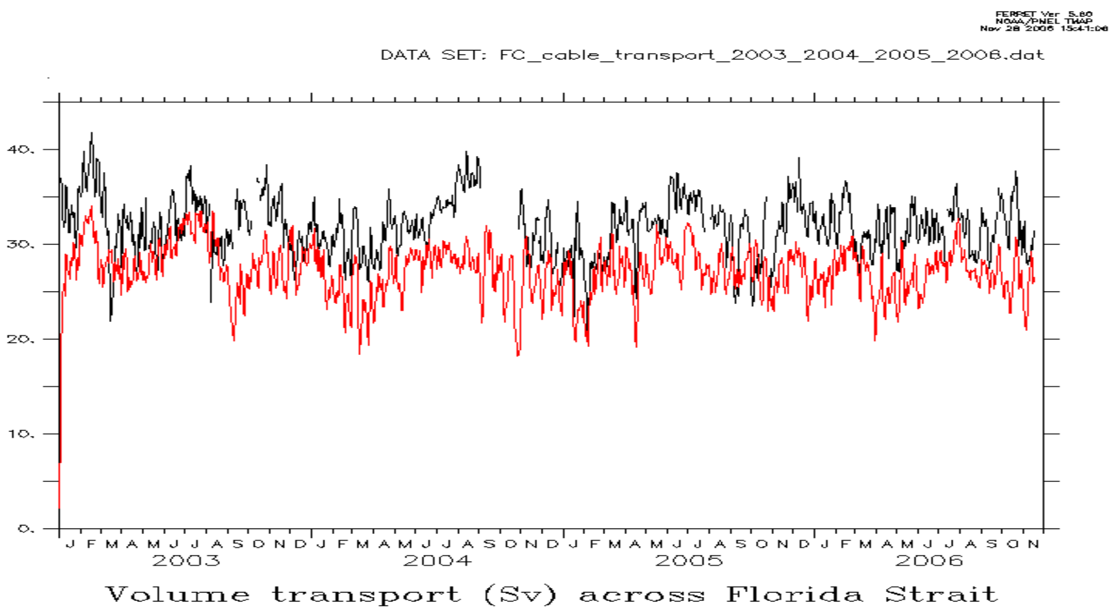


Figure 2-6: Class 3 metrics. Volume transport (Sv) across Florida Strait (Florida-Bahamas section) from January 2003 to November 2006 in the Mercator High Resolution System (red line) and from Observed Florida Cable data (Black line)

2.2.4. Class 4 metrics

Class 1, 2 and 3 metrics can be applied to any field produced by the forecasting system (hindcasts, nowcasts or forecasts). Class 4 metrics aims **to measure the performance of the forecasting system**, its capability to describe the ocean (hindcast mode), as well as its forecasting skill (analysis and forecast mode) **at once**. All fields are evaluated using identical criteria.

From the assimilation point of view, the Class 4 metrics are limited to the "observational space", and not the "model space". In practice, set of observations are chosen (preferably independent from those used during the assimilation procedure) to be compared to all fields that are describing the same situation: i.e., the forecast for a given day as well as the hindcast obtained later for the same day.

As shown in Figure 2-7, the Class 4 metrics is built as a series of statistics obtained by computing the differences between data and model values for several fields produced by the system for each given day: hindcast, analysis, forecast, and also climatology and persistency values representing what we can have if the system is not running a given day.

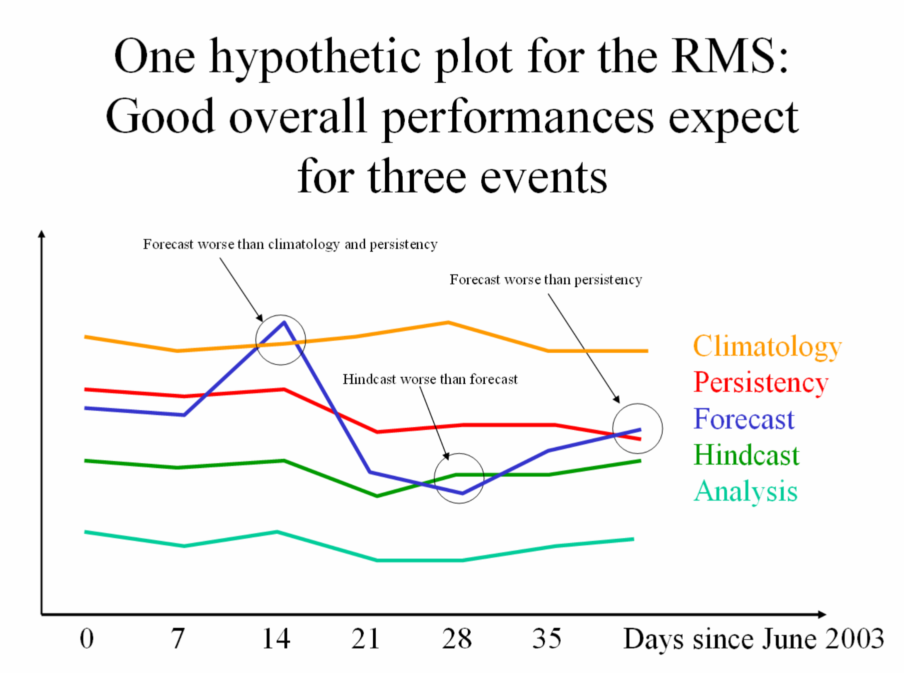


Figure 2-7: Example of the statistical monitoring of model-to-obs differences: Root Mean Square of the differences for each estimates (see colour correspondence) or plotted against time, during the forecasting system operational run. Courtesy of E. Dombrowsky and the Mercator Océan team.

Any set of data can be used in Class 4 metrics, as far as equivalent informations can be computed from the model variables. MERSEA Strand 1 project tested satellite altimetry comparisons. During MERSEA TOP1, in-situ temperature and salinity profiles, sea level from tide gauges, but also satellite sea ice concentrations are used into Class 4-like metrics.

Figure 2-8 provide an example of sea ice concentration performance diagnostic, using Class 4 metrics computed by NERC with the TOPAZ operational system. The root mean square (RMS) error allows to quantify the overall behaviour of the system in a given area: either the quality of hindcasts, but also the absolute error of forecasts, and the forecasting skill relative to persistency.

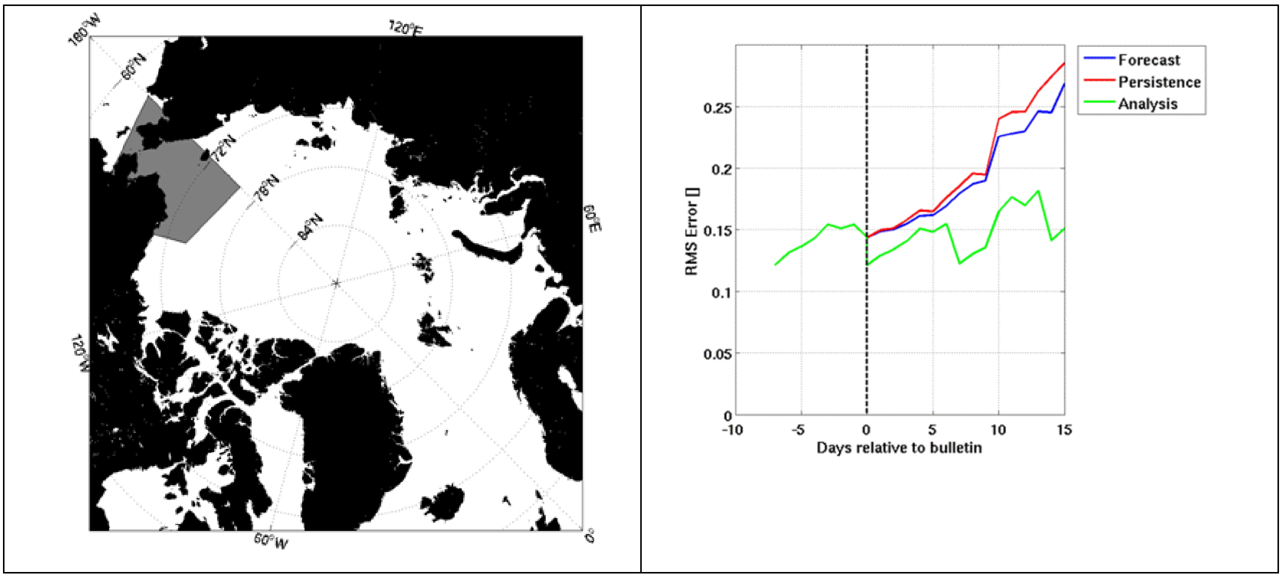


Figure 2-8: Sea Ice performance diagnostic in the Arctic Ocean. From August'06 to February' 07 root mean square daily differences of sea ice concentration between SSM/I observed products and the TOPAZ forecasting system are computed for different outputs: analysis, and forecasts (1 to 15 days ahead).RMS differences are computed in geographical boxes (left panel, the Bering Strait box), then the averaged performance, from hindcast (5 days back), to forecasting capabilities 15 days ahead are plotted for analysis, persistence and forecast (right panel). Courtesy of L. Bertino, NERSC.

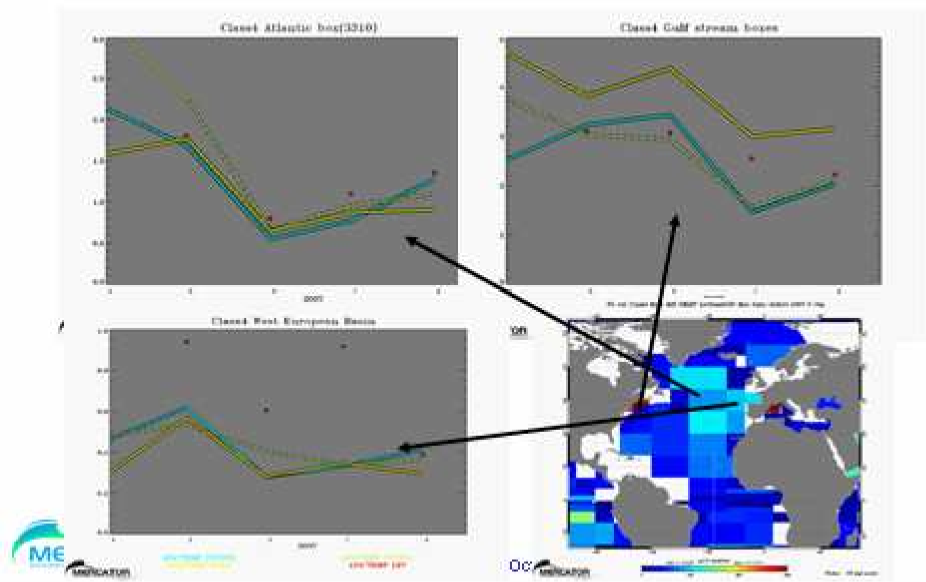


Figure 2-9: Temperature performance assessment in the 0-5m depth layer, by computing box-averaged monthly RMS differences between in situ measurements and 3 forecasting systems: FOAM (UK-Met, yellow line), PSY3V2 (Mercator Océan, blue line), PSY3V1 (former Mercator Océan system, yellow dash line), and the Levitus climatology (red points). Here monthly differences with analysis fields are plotted from April to August'07, for three different boxes in the North Atlantic Ocean, shown in the bottom right panel. Courtesy of L. Crosnier and the MERSEA TOP2 assessment working group.

Figure 2-9 provides another example of the Class 4 metrics possible diagnostics. The same temperature in-situ measurements are compared to several forecasting systems (in this case, the MERSEA forecasting systems) and to the climatology, for their different outputs (best estimates, forecast etc…), then averaged for each month in pre-defined boxes. Then, all systems can be compared for a given output: in this example, month after month, one can quantify the analysis errors for several systems, but also verify if these system are providing better quality than climatology.

2.2.5. Summary for Class 1, 2, 3 metrics

METRIC CLASS	Daily mean values of the following variables, supplied each day, for every hindcast, and possibly nowcast and forecast from 1 to 14 days ahead :
CLASS1	3D FIELDS: Temperature (K) and salinity (psu) Zonal and meridional velocity (m/s) Vertical eddy diffusivity (k_z, in m^2/s) *(*) WOA05 climatology [Antonov et al., 2006; Locarnini et al., 2006], or other temperature and salinity regional climatologies*
CLASS1	2D FIELDS: Sea Surface Height (SSH) (m) Zonal and meridional wind stress (Pa). Over sea-ice the sea ice downward x and y stress (Pa) (**) The surface solar heat flux term (W/m^2), and the Total Net Heat flux (including relaxation) into sea water (W/m^2). Over sea-ice (**), the downward heat flux in air (W/m^2) Total freshwater flux (including relaxation) ($kg/m^2/s$) Mixed layed depth (MLD) (m). Two definitions: temperature MLD(θ) and potential density MLP(ρ). Sea-Ice thickness (m), concentration (%), x and y velocities (m/s), surface snow thickness over sea ice (m), tendency of sea ice thickness due to thermodynamics (m/s) (**) *(*) Mean Dynamic Topography (MDT) (m), also called Mean Sea Surface Height (MSSH) (m) used as a reference sea level during the assimilation procedure.* *(*) SST, surface current, MLD climatologies*
(*) These quantities are "static" values than need to be stored in NetCDF Class 1 files, but not repeated every day. *(**) Sea ice variables are only stored on ARC, ACC, NAT, NPA and GLO areas*	

Table 1: Summarizing internal class 1 metrics, computed on a daily basis.

METRIC CLASS	Daily mean values of the following variables, supplied each day, for every hindcast, and possibly nowcast and forecast from 1 to 14 days ahead :
CLASS2	Temperature (K) and salinity (psu) Zonal and meridional velocity (m/s) Sea Surface Height (m) *(*) Mean Dynamic Topography (MDT) (m)* *(*) SST, surface current, MLD climatologies* *(*) WOA05 climatology [Antonov et al., 2006; Locarnini et al., 2006], or other temperature and salinity regional climatologies*
CLASS3	Volume transports (m^3/s)
CLASS3	Meridional heat transport (MHT) (W) Overturning Streamfunction (OSF) (m^3/s)

Table 2: Summarizing internal class 2 to 3 metrics, computed on a daily basis. (*) These quantities are "static" values than need to be stored in NetCDF Class 2 files, but not repeated every day.

3. CLASS 1 METRICS FOR THE GLOBAL OCEAN

Here are presented in details Class 1 metrics. For the purpose of the GODAE intercomparison project, special attention is paid to these metrics that are mandatory. Class 1 metrics definition has been revisited in 2007, due to discussion among the GODAE partners [REF10] and within the assessment methodology framework the European MERSEA IP project [REF7], [REF8].

3.1. Class 1 variables

Class1 diagnostics gathers 2-D and 3-D fields interpolated on the regional grids. Ocean dynamics variables are present in all Class 1 regional file, while sea ice variables are stored only for some regions (regions are fully described in section 3.3). Note that all ocean variables are grid cell averages. Table 3 summarizes names applied in the NetCDF files, that follow the CF conventions as described in http://cf-pcmdi.llnl.gov/ .

Two dimensions fields (physical meaning, and units), **for all areas** are:

- The zonal and meridional wind stress (Pa) on top of the ocean,
- The total net heat flux (including relaxation term) (W/m^2) into the sea water,
- The surface solar heat (W/m^2) into the sea water,
- The freshwater flux (including relaxation term) ($kg/m^2/s$) into the ocean,
- The Mixed Layer Depth (henceforth MLD) (m). Two kinds of MLD diagnostics are provided, to be compliant with [*de Boyer Montégut et al.*, 2004] and [*D'Ortenzio et al.*, 2005]. A temperature criteria MLD(θ) with temperature difference with the ocean surface of $\Delta T=0.2$°C. And a surface potential density criteria MLD(ρ) with a 0.03 kg/m^3 surface potential density criteria[(1)].
- The Sea Surface Height (SSH) (m).

Two dimensions sea-ice fields (physical meaning, and units), **for ARC, ACC, NAT, NPA** and **GLO** Class 1 files are

- Sea-Ice thickness (m)
- Sea-Ice concentration (%)
- Sea-Ice x and y velocities (m/s)
- Surface snow thickness over sea ice (m)
- Sea ice downward x and y stress (Pa)
- Tendency of sea ice thickness due to thermodynamics (m/s)
- Surface downward heat flux in air (W/m^2)

Two dimensional fields that need to be provided once into a Class 1 file:

- The Mean Dynamic Topography (henceforth MDT) (m) used as a reference sea level during the assimilation procedure. MDT is also called Mean Sea Surface Height (MSSH).
- Climatologies of Sea Surface Temperature (SST) (K), of surface current (m/s), of MLD (m).

[1] Note that these values are different from previous MERSEA definitions.

Three dimensions fields are:

- The potential temperature (K) and salinity (psu).
- The zonal and meridional velocity fields (m/s).
- The vertical eddy diffusivity (k_z, in m^2/s)

Three dimensional fields that need to be provided once into a Class 1 file:

- Climatology of potential temperature (K) and salinity (psu) fields from (T,S) used as a reference.

Variables are written in NetCDF files, where COARDS-CF conventions apply. The following characteristics have to be followed:

- A variable name is given. He could not be the same, but preferably all OpenDAP should be homogenized (eg., water flux are sometimes called “emp” or called “FWFLUX”).
- For each variable, there are attributes. It is mandatory that attributes will be COARDS CF compliant, and corresponds to the list given in Table 3.

Whenever it is possible, to save disk storage, variables have to be written in compressed format. That is, write each value in “short” or “Int16”over 2 bytes, instead of “float 4” or “float 8”, and use the "scale_factor" and "add_offset" attributes for each variable in order to recompute the “physical” value when the NetCDF file is read.

Variable name and dimensions		Attributes			
		long_name	Cell_methods	Standard_name	units
temperature	3D	Temperature		sea_water_potential_temperature	K[2]
salinity	3D	Salinity		sea_water_salinity	1e-3[3]
u	3D	Eastward velocity		sea_water_x_velocity	m s-1
v	3D	Northward velocity		sea_water_y_velocity	m s-1
kz	3D	Ocean vertical eddy diffusivity		ocean_vertical_eddy_diffusivity[4]	m2 s-1
qsr	2D	Surface downward solar heat flux		surface_net_downward_shortwave_flux	W m-2
qtot	2D	Total net heat flux		surface_downward_heat_flux_in_sea_water	W m-2
emp	2D	Water flux		water_flux_into_ocean	Kg m-2 s-1
taux	2D	Wind stress eastward component		surface_downward_x_stress	Pa
tauy	2D	Wind stress northward component		surface_downward_y_stress	Pa
mlp	2D	Density ocean mixed layer thickness		ocean_mixed_layer_thickness_defined_by_sigma_theta	m
mld	2D	Temperature ocean mixed layer thickness		ocean_mixed_layer_thickness_defined_by_temperature	m
ssh	2D	Sea surface height		sea_surface_height_above_geoid	m
mdt	2D	Mean dynamic topography	time:mean	sea_surface_height_above_geoid	m
uice	2D	Sea ice x velocity	area:mean where sea ice	sea_ice_x_velocity	m s-1
vice	2D	Sea ice y velocity	area:mean where sea ice	sea_ice_y_velocity	m s-1
fice	2D	Ice concentration	area:mean where sea ice	sea_ice_area_fraction	%
hice	2D	Sea Ice thickness	area:mean where sea ice	sea_ice_thickness	m
hsnow	2D	Snow thickness	area:mean where sea ice	surface_snow_thickness	m
tauxice	2D	X wind stress on ice	area:mean where sea ice	sea_ice_downward_x_stress	Pa
tauyice	2D	Y wind stress on ice	area:mean where sea ice	sea_ice_downward_y_stress	Pa
qtotair	2D	Total heat flux in air		surface_downward_heat_flux_in_air	W m-2
htndncyice	2D	Tendency of sea ice thickness due to thermodynamics	area:mean where sea ice	tendency_of_sea_ice_thickness_due_to_thermodynamics	m s-1

Table 3: Class 1 Variables, along with standard_name attribute (NetCDF files) and dimensions. In blue, sea-ice variable, provided in the ACC, ARC, NAT, NPA, and GLO Class 1 files.

[2] Important: units for temperature is Kelvin and not Celsius degrees. However, a possible trick while creating the file is to write the temperature in Kelvin, with an “add_offset” attribute of 273.15
[3] The unit of salinity is PSU, which is dimensionless. The units attribute should be given as 1e-3 or 0.001 i.e. parts per thousand if salinity is in PSU
[4] This standard name still need to be agreed by the NetCDF community. Ongoing work

3.2. Class 1 time, period, frequency

Class 1 variables are **daily averages**.

Ocean forecasting products considered for the Class 1 metrics are:

- **Hindcast, or best estimates (mandatory)**
- Analyses, if different from best estimates (not a priority for the GODAE intercomparison)
- Forecast from 1st to 7th day ahead. Not a priority for the GODAE intercomparison. And, preferably the 6th day forecast.

3.3. Class 1 horizontal resolution

The choice for the horizontal gridding is based on physical considerations rather than the grid size of specific GODAE systems: The Rossby radius has been chosen as the criteria to offer a **qualitative description of the eddy field**. For instance, the choice of 1/6° for midlatitude is independent of the resolution of eddy-permitting systems such as Mercator Océan (1/4°) or BlueLink (variable resolution), or eddy-resolving system like HYCOM (1/12°). Moreover, for most of the regional grids, a Mercator projection is chosen, that allow the latitude spacing to offer an homogeneous description of the physical processes while looking poleward. Two rules have been applied for these new extensions of Class 1 regions:

- Each regional file should be used lonely to study regional processes in a given sub-basin of the world ocean
- Regions are overlapping when necessary to match the first rule.

A global file is also defined, to allow more "general" or "climatic" views. Figure 3-1 and Figure 3-2 provide an overview of the regional Class 1 extensions. The detailed description of each region is given in Table 4. The following points have been considered to redefine the different areas:

- *ARC follows NERSC proposition, contains the Arctic Ocean, but also the North Atlantic subpolar gyre, the Baltic, Okhotsk, Bering Seas.*
- *NPA is limited by the Bering Strait, Panama and the Indonesian Through Flows. Contains the North Pacific Ocean, and in continuity the Japan, China Seas.*
- *NAT contains the North Atlantic Ocean, with only the southern part of the subpolar gyre. Include the Baltic Sea, most of the European shelves Seas (but not the Mediterranean and Black Seas), the North America coastal areas, in particular the Golf of Mexico and the Caribbean areas.*
- *MED is a dedicated Class 1 metrics that contains the Mediterranean and the Black Sea, with a dedicated higher horizontal resolution.*
- *TPA contains the Tropical Pacific system, in particular includes all the Indonesian Area to fully describe the Through Flows*
- *IND concentrates over the Indian Ocean, including the Red Sea and the Arabian Seas.*
- *TAT contains the Tropical Atlantic Ocean and the Caribbean Sea.*
- *SPA contains the South Pacific Ocean, as well as seas around Australia, to provide in one Class 1 file an overlook for the BlueLink system.*
- *SAT contains the South Atlantic Ocean, included Drake Passage, and Agulhas Current systems.*
- *ACC contains the Southern Ocean circulation system, extending to 89°S southward to fully include Ross and Weddel Ice Caps.*

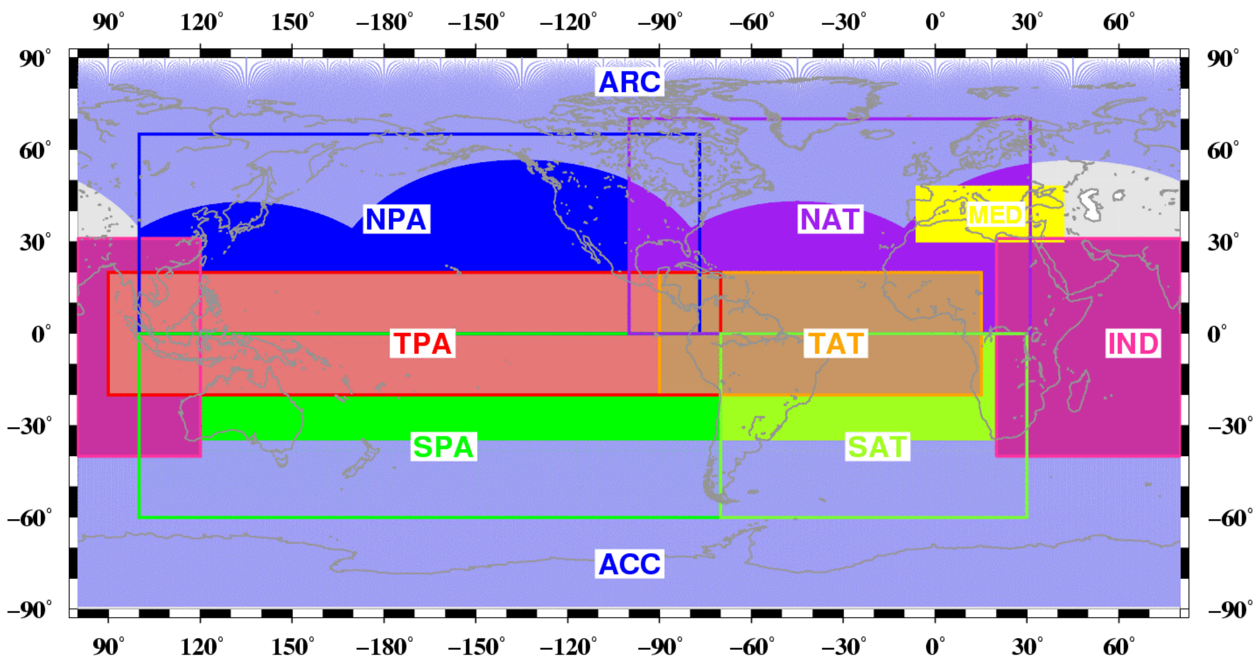


Figure 3-1: The regional description of the Class 1 metrics. See Table 4 for a detailed description. NPA, NAT, SPA and SAT regions are overlapped by tropical and high latitude regions, their limits, with the corresponding colours are overlaid.

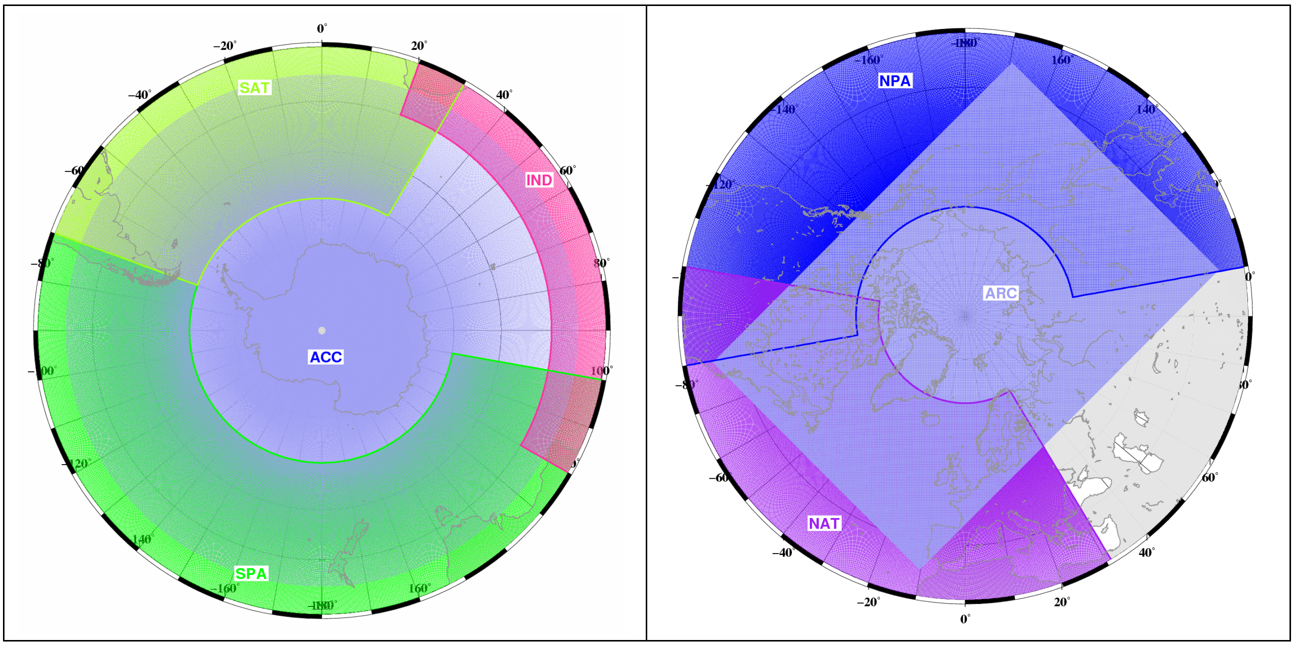


Figure 3-2: Regional Class 1 metrics in the South Pole (left) and North Pole area (right). Same colour code than Figure 3-1.

	Name	Horizontal Resolution		Type of projection	Geographical limits	Specific points
North Atlantic	NAT	1/6°	787 x 597	Mercator	0-70N 100W-31E	Baltic and Caribbean Seas, European shelves, Gulf of Mexico. Sea Ice variables
South Atlantic	SAT	1/6°	601 x 453	Mercator	60S-0S 70W-30E	Drake passage, Agulhas Current
Tropical Atlantic	TAT	¼	421 x 163	Mercator	20S-20N 90W-15E	Caribbean Seas, Gulf of Guinea
North Pacific	NPA	1/6°	1099 x 518	Mercator	0-65N 100E-77W	Japan, China Seas, Panama. Sea Ice variables
South Pacific	SPA	1/6°	1141 x 453	Mercator	60S-0 100E-70W	Circum-Australia Area
Tropical Pacific	TPA	¼ °	801 x 163	Mercator	20S-20N 90E-70W	Indonesian Seas and Straits
Indian Ocean	IND	1/6°	601 x 458	Mercator	20E-120E 40S-31N	Mozambic Chanel, Red and Arabic Seas, Bay of Bengal
Arctic Ocean	ARC	12.5km	609 x 881	Stereo Polar	180W-180E 34N< λ <90N	N. Atl. Subpolar gyre, Baltic, Bering and Okhotsk Seas. Sea Ice variables
Southern Ocean	ACC	¼	1441 x 937	Mercator	89S–35S 0-360E	Antarctic Circumpolar Current system, Ross and Weddel Ice Caps. Sea Ice variables.
Mediterranean and Black Seas	MED	1/8°	385 x 187	Mercator	6E-42W 30N- 48N	Dedicated resolution for the Mediterranean and Black Seas
Global	GLO	½°	721 x 359	Regular	180W-180E 89S-90N	Overview of the world ocean. Sea Ice variables

Table 4: Description of regional NetCDF Class 1 files. Names, limits and gridding, type of geographical projections, and specific features for each Class 1 area.

To ensure a similar computation of the NetCDF Class 1 grids for each region by all GODAE partners, a fortran program called **`Class1Grid.f90`** is given in section 8, and also provided with other technical documents.

3.4. Class 1 vertical resolution

The Class 1 vertical resolution offers a coarse subsampling of the ocean dynamics at depth. Some specific depth levels are chosen to give dedicated information of the ocean subsurface variability. For the different Class 1 areas (Table 4) the selected depth levels are presented in Table 5.

NORTH ATLANTIC (NAT)	**0**	**30**	**50**	**100**	**200**	**400**	**700**	**1000**	**1500**	**2000**	**2500**	**3000**
TROPICAL ATLANTIC (TAT)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
SOUTH ATLANTIC (SAT)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
NORTH PACIFIC (NPA)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
TROPICAL PACIFIC (TPA)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
SOUTH PACIFIC (SPA)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
INDIAN OCEAN (IND)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
MEDITERRANEAN SEA (MED)	**0**	**30**	**50**	**100**	**200**	**500**	**1000**	**2000**				
SOUTHERN OCEAN (ACC)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
ARCTIC OCEAN (ARC)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000
GLOBAL OCEAN (GLO)	0	30	50	100	200	400	700	1000	1500	2000	2500	3000

Table 5: summarizing the Class1 Standard vertical levels (in meters) for each area.

3.5. Class 1 climatology

Class 1 climatological fields also have to be made available from the OpenDAP servers, that is climatological products interpolated into the Class 1 horizontal and vertical grids, and stored in NetCDF files following the Class 1 definitions given in Table 3. Note that specific NetCDF attributes can be used for climatology[(5)]. **Whenever possible, the monthly, seasonal and annual components of the climatology have to be stored**.

- For temperature and salinity, the WOA 2005 climatology [*Antonov et al.*, 2006; *Locarnini et al.*, 2006] is used for all areas (see Table 4). The GDEM3.0 [*Macdonald et al.*, 2001] can be used for the North Pacific region (NPA). The MEDAR/Medatlas climatology [*MEDAR Group*, 2002] can be used for the Mediterranean Sea (MED). Around Australia the CARS climatology [*Ridgway and Dunn*, 2003; *Ridgway et al.*, 2002] could also be used.
- For mixed layer depth, [*D'Ortenzio et al.*, 2005; *de Boyer Montégut et al.*, 2004] can be used.
- For SST, climatology based on NCEP/Reynolds products [e.g., *Smith and Reynolds*, 1998].

3.6. Class 1 technical implementation

3.6.1. Class 1 file name convention

Class 1 files names have to offer a series of useful information (date, origin of the GODAE partner, region). The following name construction is proposed (fix codes are in black and codes that change are in color, explained in Table 6):

CLASS1_XXX_ZZZZ_RRR_mean_YYYYMMDD_RYYYYMMDD.nc

XXX	(3 digit) code of the GODAE partner see Table 20
ZZZZ	(variable length) specific code given to a particular system of the GODAE partner
RRR	(3 digit) code of the area, as given in Table 4
YYYYMMDD	(8 digit) field date YYYY=YEAR, MM=MONTH, DD=DAY: corresponds to the date of the output stored in this file.
YYYYMMDD	(8 digit) bulletin date YYYY=YEAR, MM=MONTH, DD=DAY: corresponds to the date of the analysis, or the run from which the output is produced and the system operated

Table 6: Description of the name codes of the Class 1 file name

For exemple, the Class 1 file of containing the best estimate or hindcast of the 13th of March 2008, produced by Mercator Océan with the analyses of the 26th of March 2008, for the South Pacific area will be:

CLASS1_MER_P3V2R2_SPA_mean_20080313_R20080326.nc

Here, the specific name given by the Mercator Océan for the system is "**P3V2R2**". Each partner can freely give an appropriate code. The only recommendation is to keep the code short as possible.

[5] See discussions in http://cf-pcmdi.llnl.gov/documents/cf-conventions/1.0/ch07s04.html

Note that the “mean” stands for daily means, and not “snap shot” of the system. Note also that comparison between the “bulletin date” (the one after the “R”) and the field date (the first date in the name) allows to identify the type of product… Typically, for most of the systems:

```
If “field date” > “bulletin date” it is a forecast
If “field date” = “bulletin date”, it is an “analysis”
If “field date” < “bulletin date” it is a hindcast, or sometimes a nowcast.
```

3.6.2. Class 1 file NetCDF global attributes

Global attributes are useful information to write into NetCDF files, it is recommended to write the following global attributes, as given through example of a Mercator Ocean file, corresponding to a forecast (bulletin date before field date) over the SAT area[6]:

```
// global attributes:
                :title = "MERCATOR PSY3V2R1 VITRINE (with bathy mask)" ;
                :easting = "longitude" ;
                :northing = "latitude" ;
                :history = "2007/12/05 14:14:13 MERCATOR OCEAN Netcdf creation" ;
                :source = "MERCATOR PSY3V2" ;
                :institution = "GIP MERCATOR OCEAN" ;
                :references = "http://www.mercator-ocean.fr" ;
                :comment = "null" ;
                :conventions = "CF-1.0" ;
                :domain_name = "SAT" ;
                :field_type = "mean" ;
                :field_date = "2007-12-15 00:00:00" ;
                :field_julian_date = 21167 ;
                :julian_day_unit = "days since 1950-01-01 00:00:00" ;
                :forecast_range = "10-day_forecast" ;
                :forecast_type = "forecast" ;
                :bulletin_date = "2007-12-05 00:00:00" ;
                :bulletin_type = "operational" ;
                :longitude_min = -70.f ;
                :longitude_max = 30.f ;
                :latitude_min = -59.93856f ;
                :latitude_max = -0.f ;
                :z_min = 0.f ;
                :z_max = 5500.f ;
```

All these global attributes can be helpful to save time getting informations from a given file by reading the header.

[6] Note that this example comes from an existing file, that do not exactly corresponds to the GODAE definition proposed above. However, the different global attributes of the GODAE Class 1 file should contain similar information.

4. CLASS 2 METRICS FOR THE GLOBAL OCEAN

As defined above, Class 2 diagnostics are given along chosen points and sections, designed to offer a higher horizontal and vertical resolution than Class 1 metrics on specific locations:

- Virtual moorings in the system to match location of in-situ moorings
- Virtual sections to follow observation network (VOS ship etc.…)
- Virtual sections at specific locations to control the dynamics: straits, sections in the middle of the basin to monitor water masses etc.…

These mooring points and sections locations are given in dedicated ASCII files, mentioned in Table 7 and the Class 2 descriptions below. A fortran program called **`lire_metrics_fic.f90`** that reads section files is provided in section 10 and also with other technical documents.

ASCII files	Code
LONLAT_STRAIGHTSECTION_GODAE_20071217.dat	STR
LONLAT_XBT_GODAE_20070906.dat	XBT
LONLAT_GLIDERS_GODAE_20070301.dat	GLI
LONLAT_MOORINGS_GODAE_20071115.dat	MOO
LONLAT_MOORINGS_TIDE_20071115.dat	MOO

Table 7: Name of the Class 2 files, and corresponding 3-digit codes used for each Class 2 mooring or section name.

4.1. Class 2 variables

Class 2 metrics are concentrated on ocean parameters, that are gathered (i.e. interpolated) at the locations given for the Class 2 metrics. The following variables are considered (technical details given in Table 8):

- The potential temperature (K) and salinity (psu).
- The zonal and meridional velocity fields (m/s).
- The Sea Surface Height (SSH) (m).

Variable name in NetCDF file	Variable long name In NetCDF file	Standard_name attribute in Netcdf file	unit	dimensions
temperature	Potential temperature	sea_water_potential_temperature	K[(2)]	2D
salinity	Salinity	sea_water_salinity	1e-3[(3)]	2D
u	Eastward velocity	sea_water_x_velocity	m s-1	2D
v	Northward velocity	sea_water_y_velocity	m s-1	2D
ssh	Sea surface height	sea_surface_height_above_geoid	m	1D

Table 8: Class 2 Netcdf format variable names, along with attributes and dimensions.

4.2. Class 2 time, period, frequency

Class 2 variables are **daily averages**.

4.3. Class 2 vertical resolution

Depending of the ocean depth, at each location, the system outputs have to be interpolated vertically at the depth given in Table 9.

NORTH ATLANTIC (NAT)	TROPICAL ATLANTIC (TAT)	SOUTH ATLANTIC (SAT)	NORTH PACIFIC (NPA)	TROPICAL PACIFIC (TPA)	SOUTH PACIFIC (SPA)	INDIAN OCEAN (IND)	MED SEA (MED)	SOUTHERN OCEAN (ACC)	ARCTIC OCEAN (ARC)
0	0	0	0	0	0	0	0	0	0
10	10	10	10	10	10	10	5	10	10
20	20	20	20	20	20	20	10	20	20
30	30	30	30	30	30	30	20	30	30
50	50	50	50	50	50	50	30	50	50
75	75	75	75	75	75	75	50	75	75
100	100	100	100	100	100	100	75	100	100
125	125	125	125	125	125	125	100	125	125
150	150	150	150	150	150	150	125	150	150
200	200	200	200	200	200	200	150	200	200
250	250	250	250	250	250	250	200	250	250
300	300	300	300	300	300	300	250	300	300
400	400	400	400	400	400	400	300	400	400
500	500	500	500	500	500	500	400	500	500
600	600	600	600	600	600	600	500	600	600
700	700	700	700	700	700	700	600	700	700
800	800	800	800	800	800	800	800	800	800
900	900	900	900	900	900	900	1000	900	900
1000	1000	1000	1000	1000	1000	1000	1200	1000	1000
1100	1100	1100	1100	1100	1100	1100	1500	1100	1100
1200	1200	1200	1200	1200	1200	1200	2000	1200	1200
1300	1300	1300	1300	1300	1300	1300	2500	1300	1300
1400	1400	1400	1400	1400	1400	1400	3000	1400	1400
1500	1500	1500	1500	1500	1500	1500	3500	1500	1500
1750	1750	1750	1750	1750	1750	1750	4000	1750	1750
2000	2000	2000	2000	2000	2000	2000		2000	2000
2500	2500	2500	2500	2500	2500	2500		2500	2500
3000	3000	3000	3000	3000	3000	3000		3000	3000
3500	3500	3500	3500	3500	3500	3500		3500	3500
4000	4000	4000	4000	4000	4000	4000		4000	4000
4500	4500	4500	4500	4500	4500	4500		4500	4500
5000	5000	5000	5000	5000	5000	5000		5000	5000
5500	5500	5500	5500	5500	5500	5500		5500	5500

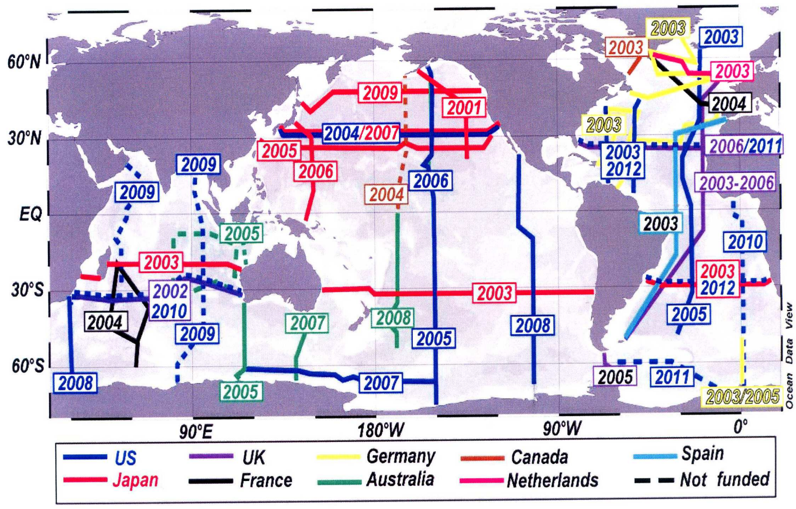
Table 9: summarizing the Class 2 Standard vertical levels (in meters) per basin

4.4. Class 2 straight sections

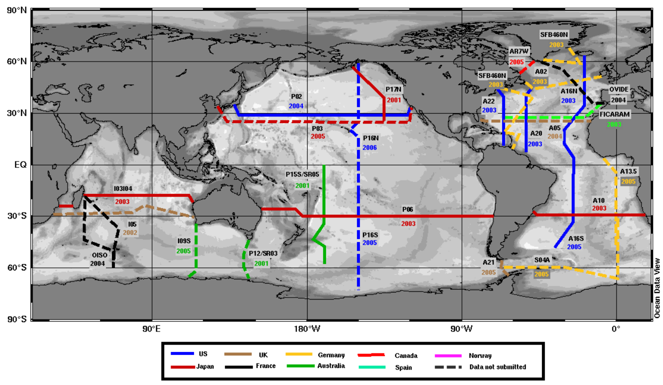
Class 2 straight section tracks (Figure 4-2, Figure 4-3, Figure 4-4, and Figure 4-5) are following the tracks of the main WOCE and CLIVAR repeat sections (Figure 4-1). The Class 2 variables must be extracted along the Class 2 "straight" Sections. Sections (name, latitude and longitude definitions) are given in the ASCII file **LONLAT_STRAIGHTSECTION_GODAE_20071217.dat** . Table 10 summarizes the beginning and ending (latitude,longitude), as well as the names, of the 116 Class 2 straight sections.

The web references used to define these sections are:

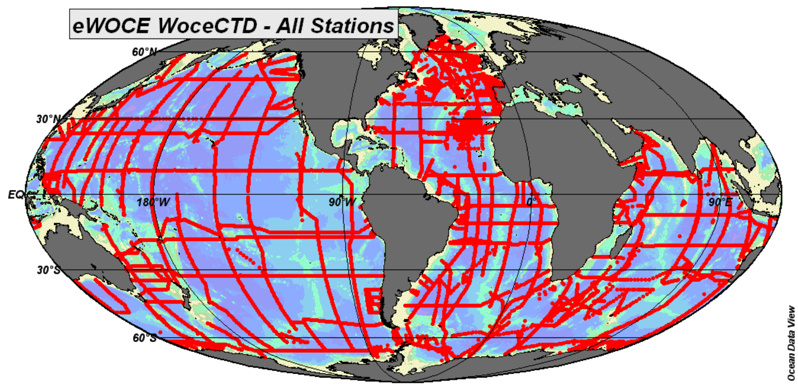
http://whpo.ucsd.edu/
http://whpo.ucsd.edu/maps/ind_map.htm
http://whpo.ucsd.edu/maps/pac_map.htm
http://cdiac.esd.ornl.gov/oceans/RepeatSections/repeat_map.html
http://www.clivar.org/science/global_obs.htm
http://www.clivar.org/data/carbon_hydro/hydro_table.php



a)

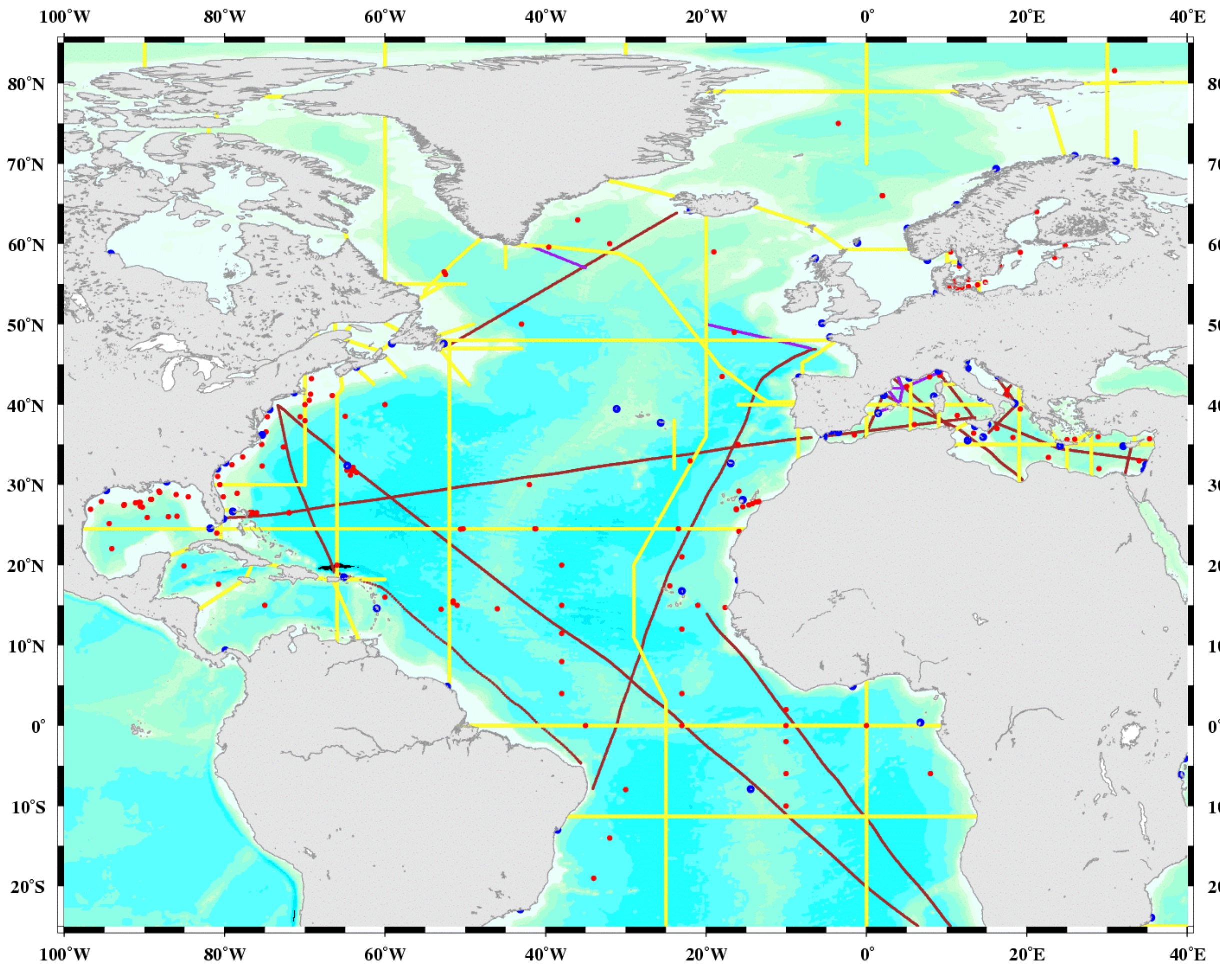


b)



c)

Figure 4-1: a) and b) CLIVAR repeat sections in the Global Ocean, see http://cdiac.esd.ornl.gov/oceans/RepeatSections/repeat_map.html. c) WOCE CTD sections (http://www.ewoce.org/data/whp/WoceCTD_All_StationsMap.gif)



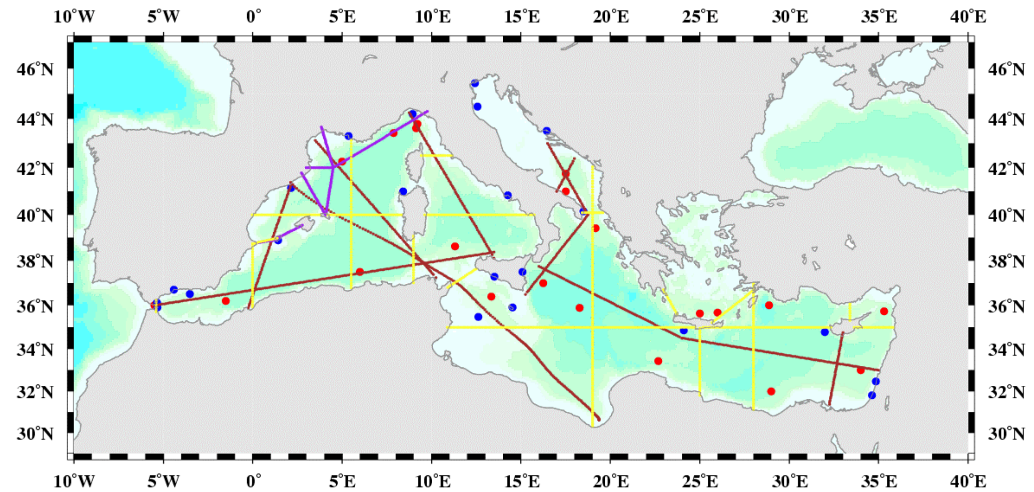


Figure 4-2: Location of the Class 2 metrics in the North Atlantic Ocean, and the Mediterranean Sea: straight sections (yellow); XBT sections (brown); gliders sections (purple); tide gauges (blue), and other moorings (red).

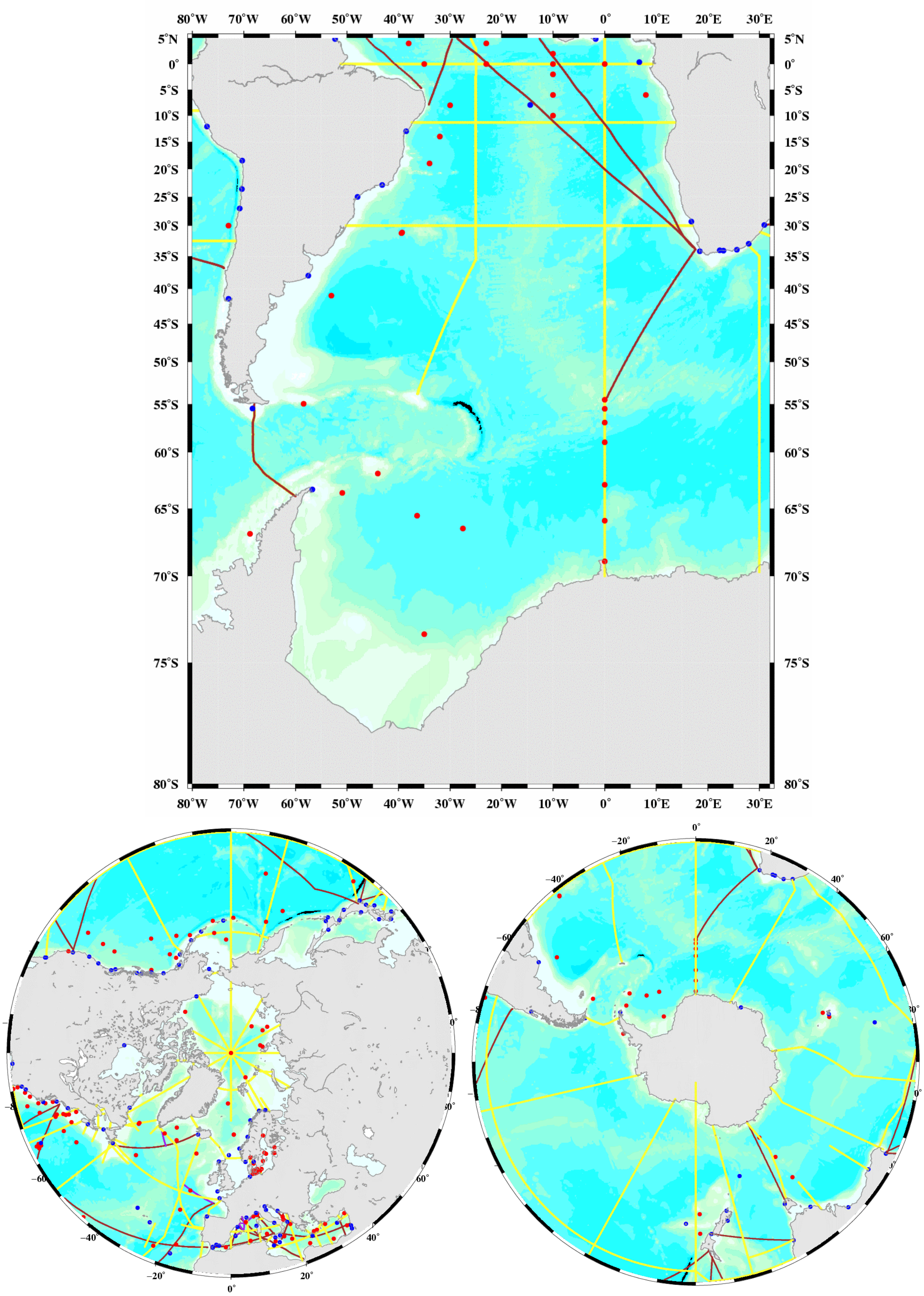


Figure 4-3: Location of the Class 2 metrics in the South Atlantic, Arctic and Southern Oceans: straight sections (yellow); XBT sections (brown); gliders sections (purple); tide gauges (blue), and other moorings (red).

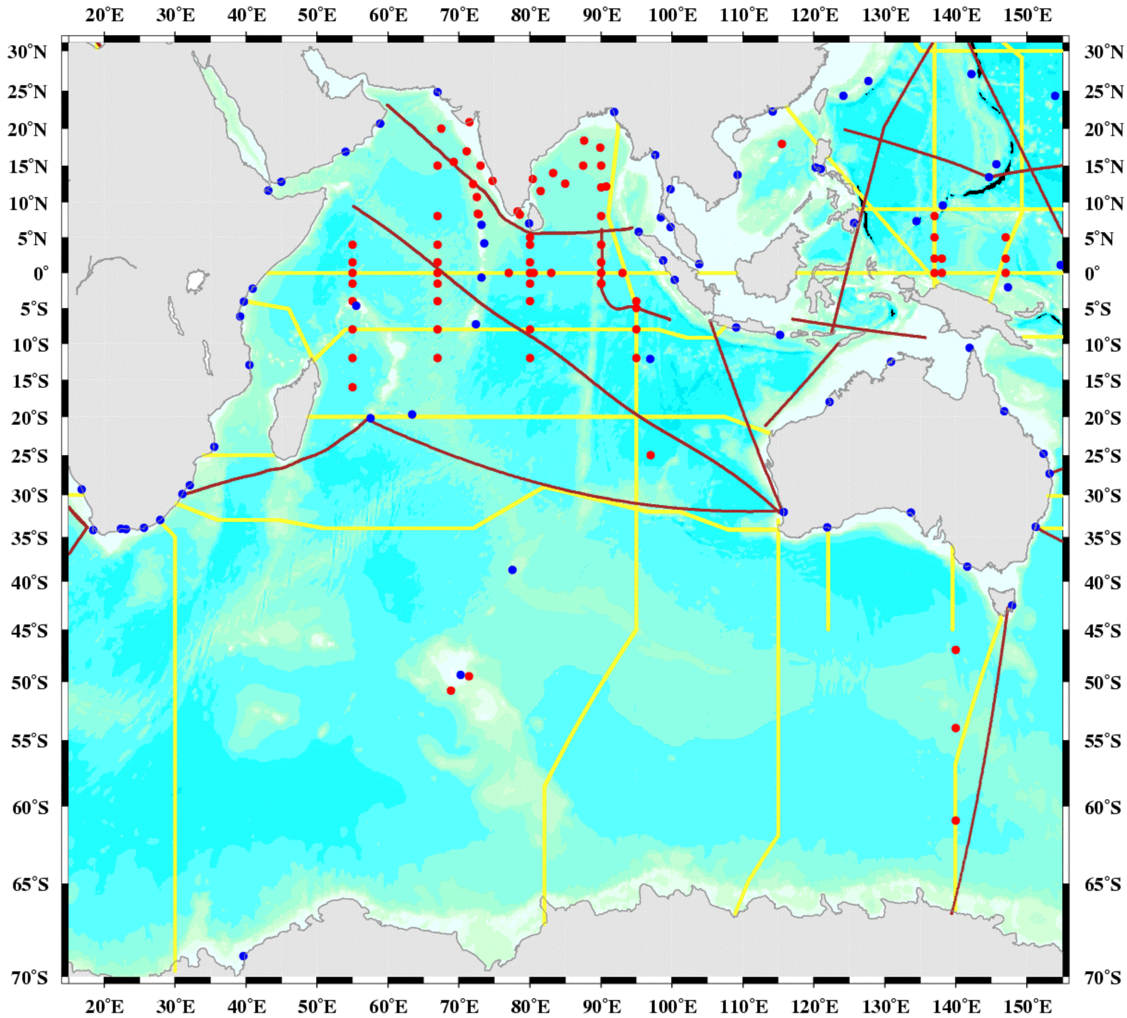


Figure 4-4: Location of the Class 2 metrics in the Indian Ocean: straight sections (yellow); XBT sections (brown); gliders sections (purple); tide gauges (blue), and other moorings (red).

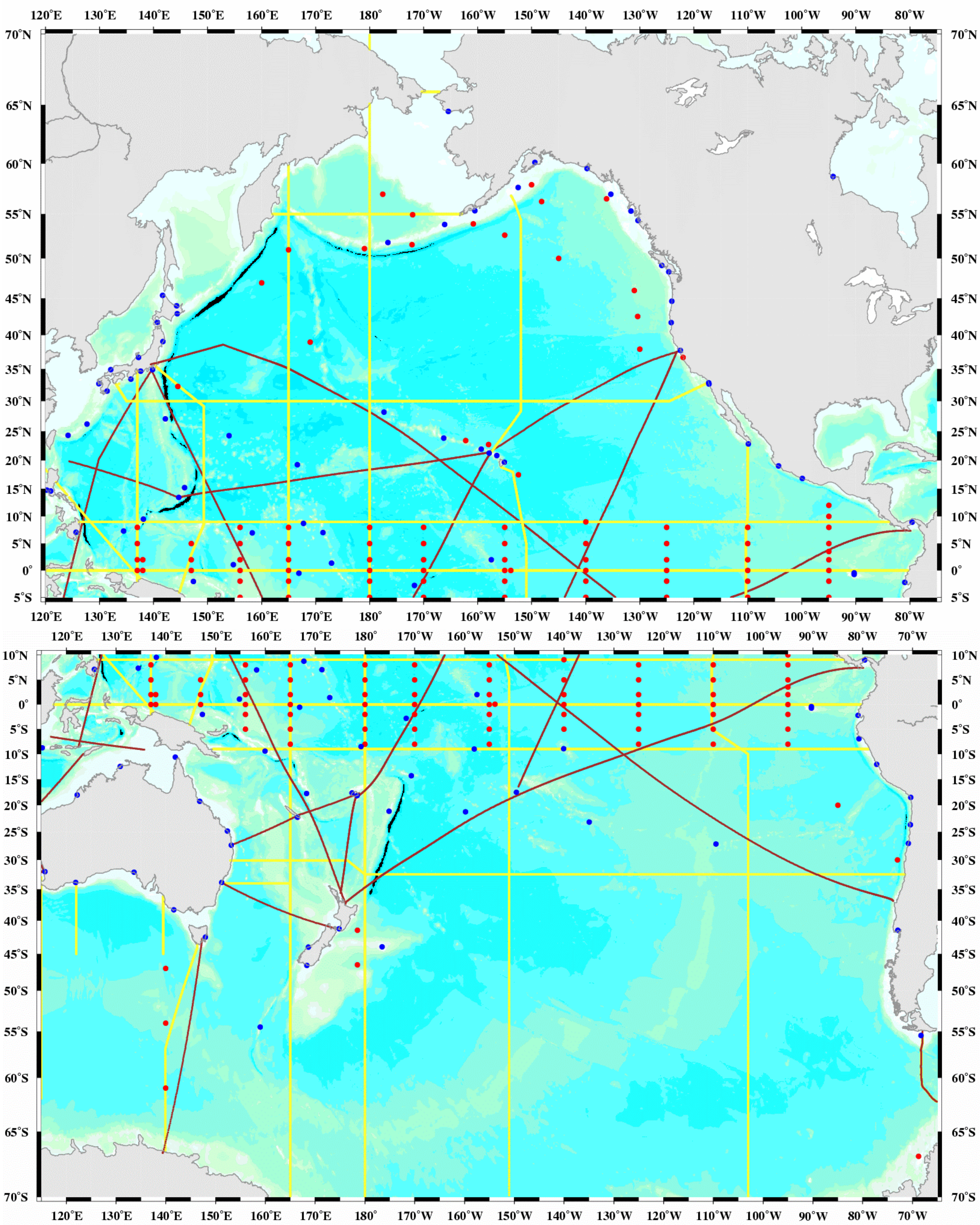


Figure 4-5: Location of the Class 2 metrics in the North and South Pacific Oceans: straight sections (yellow); XBT sections (brown); gliders sections (purple); tide gauges (blue), and other moorings (red).

SECTION NAME	LONGITUDE1	LATITUDE1	LONGITUDE2	LATITUDE2
ARCTIC				
CLASS2_STR_ARC_Lancaster_sound	-82.0000	73.7750	-82.0000	74.4313
CLASS2_STR_ARC_Jones_Strait	-81.0000	75.6625	-81.0000	76.4125
CLASS2_STR_ARC_Robeson_Channel	-75.3750	78.3844	-72.8750	78.3219
CLASS2_STR_ARC_Hudson_Strait	-64.7000	60.4000	-64.9625	61.3625
CLASS2_STR_ARC_Kola_Section	33.5000	69.3125	33.5000	74.0000
CLASS2_STR_ARC_Spitzberg_FJLand	26.9937	80.0172	46.8406	80.1883
CLASS2_STR_ARC_FJLand_NovZemlija	57.4867	80.0867	65.4828	76.5828
CLASS2_STR_ARC_Kara_Gate	57.0000	70.7000	58.3750	70.3563
CLASS2_STR_ARC_Barents_Sea	24.6625	71.0969	22.7875	77.1906
CLASS2_STR_ARC_FramStrait	-20.0000	79.0000	11.5820	79.0000
CLASS2_STR_ARC_BeringStrait	-170.3750	66.0000	-167.0938	66.0000
CLASS2_STR_ARC_0W	0.0000	90.0000	0.0000	70.0000
CLASS2_STR_ARC_30E	30.0000	90.0000	30.0000	70.7812
CLASS2_STR_ARC_60E	60.0000	90.0000	60.0000	70.0000
CLASS2_STR_ARC_90E	90.0000	90.0000	90.0000	75.7031
CLASS2_STR_ARC_120E	120.0000	90.0000	120.0000	73.2031
CLASS2_STR_ARC_150E	150.0000	90.0000	150.0000	71.4844
CLASS2_STR_ARC_180E	180.0000	90.0000	180.0000	69.0000
CLASS2_STR_ARC_150W	-150.0000	90.0000	-150.0000	70.5469
CLASS2_STR_ARC_120W	-120.0000	90.0000	-120.0000	77.0234
CLASS2_STR_ARC_90W	-90.0000	90.0000	-90.0000	82.0703
CLASS2_STR_ARC_60W	-60.0000	90.0000	-60.0000	82.0703
CLASS2_STR_ARC_HUDSON_60W	-60.0000	75.9180	-60.0000	55.2734
CLASS2_STR_ARC_30W	-30.0000	90.0000	-30.0000	83.5938
ATLANTIC and BALTIC SEA				
CLASS2_STR_BAL_SKAGERRAK	10.0800	59.0659	10.0800	57.5500
CLASS2_STR_BAL_KATTEGAT	10.5000	57.7500	11.8300	57.7500
CLASS2_STR_BAL_WESTERNBALTIC	14.0000	55.4062	14.0000	54.0469
CLASS2_STR_ATL_DenmarkStrait_WOCE_AR18	-32.2923	67.9442	-23.9000	65.9000
CLASS2_STR_ATL_Labrador_WOCE_A01W	-55.7500	53.1300	-48.2122	60.6083
CLASS2_STR_ATL_GulfCadiz_WOCE_AR16D	-8.5000	33.2836	-8.5000	37.0274
CLASS2_STR_ATL_Portugal_WOCE_AR16ABCD	-16.0000	40.0000	-9.0617	40.0000
CLASS2_STR_ATL_Biscay_WOCE_AR12D	-4.0000	47.8000	-8.0055	43.8037
CLASS2_STR_ATL_Antilles	-66.4284	17.9342	-63.3432	10.7943
CLASS2_STR_ATL_PortoRico	-65.2627	18.2000	-60.0462	18.2000
CLASS2_STR_ATL_Hispagnola_PortoRico	-67.2533	18.2205	-68.5842	18.4335
CLASS2_STR_ATL_Windward_Passage	-74.6185	20.1237	-73.3831	19.8766
CLASS2_STR_ATL_JamaicaRidge	-77.8895	17.9483	-83.3909	14.3936
CLASS2_STR_ATL_CubaJamaica	-77.2964	18.4480	-76.6119	19.9537
CLASS2_STR_ATL_YucatanStraitKANEC	-86.9501	21.1272	-84.0758	22.1724
CLASS2_STR_ATL_CubaFlorida	-80.5000	22.9885	-80.5000	25.5573
CLASS2_STR_ATL_FloridaBahamas	-80.1951	26.9390	-78.4968	26.5994
CLASS2_STR_ATL_WestAtlantic	-81.3781	30.0000	-70.0411	30.0000
CLASS2_STR_ATL_GulfStream	-70.0000	43.9887	-70.0000	29.9606
CLASS2_STR_ATL_48N	-53.7886	48.0000	-4.5101	48.0000
CLASS2_STR_ATL_24.5N_WOCE_A05_AR01	-98.0000	24.5000	-15.2000	24.5000
CLASS2_STR_ATL_52W_WOCE_A20	-52.0000	4.7000	-53.7886	48.0000
CLASS2_STR_ATL_66W_WOCE_A22c	-66.0000	10.3000	-66.0000	18.0000
CLASS2_STR_ATL_66W_WOCE_A22	-66.0000	18.5000	-65.4000	41.8000

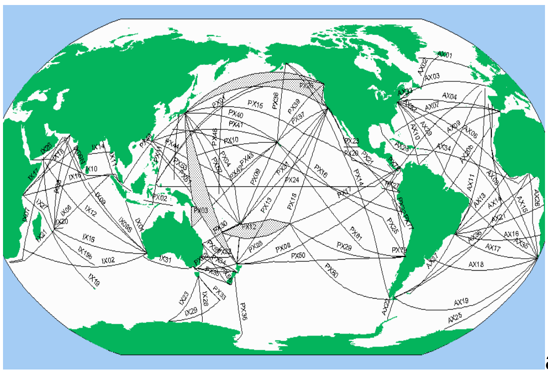
CLASS2_STR_ATL_LABRADOR_55N	-58.9597	55.0000	-50.0102	55.0000
CLASS2_STR_ATL_SOUTHGREENLAND	-45.0000	57.0000	-45.0000	60.2823
CLASS2_STR_ATL_AZORES_24W	-24.0000	32.0000	-24.0000	38.0490
CLASS2_STR_ATL_OVIDE_CLIVAR_A25	-43.9075	59.8336	-8.9197	40.3328
CLASS2_STR_ATL_EQUATOR	-51.2000	0.0000	9.3000	0.0000
CLASS2_STR_ATL_WOCE_A16NCS	-20.0033	63.2930	-36.3256	-53.8282
CLASS2_STR_ATL_0E_WOCEA12_CLIVAR_A13	0.0000	-70.0000	0.0000	5.6000
CLASS2_STR_ATL_11S_WOCE_A08	-37.4000	-11.3300	13.7000	-11.3300
CLASS2_STR_ATL_30S_WOCE_A10	-50.2000	-30.0000	17.1000	-30.0000
CLASS2_STR_ATL_DrakePassage_WOCEA21	-68.0279	-55.2468	-60.3291	-63.8932
CLASS2_STR_ATL_CANADA_Bonavista	-53.6000	48.5500	-49.0000	50.0000
CLASS2_STR_ATL_CANADA_FlemishCap	-52.8300	47.0000	-43.0000	47.0000
CLASS2_STR_ATL_CANADA_SealIsland	-55.7500	53.1300	-52.5000	55.0700
CLASS2_STR_ATL_CANADA_SouthEastGrandBanks	-53.1000	46.6800	-49.5200	42.4000
CLASS2_STR_ATL_CANADA_HalifaxLine	-63.6500	44.5500	-61.4000	42.5300
CLASS2_STR_ATL_CANADA_LouisbourgLine	-59.9500	45.9300	-57.5300	43.4700
CLASS2_STR_ATL_CANADA_BrownsBank	-65.4800	43.5000	-65.3500	41.8200
CLASS2_STR_ATL_CANADA_CabotStrait	-60.3700	46.8600	-59.3400	47.5800
CLASS2_STR_ATL_CANADA_BonneBay	-60.0300	50.1500	-58.2100	49.1900
CLASS2_STR_ATL_CANADA_Anticosti	-64.8000	49.2200	-64.3600	49.7900
CLASS2_STR_ATL_CANADA_Estuary	-68.4700	48.5600	-68.8000	48.8800
CLASS2_STR_ATL_CANADA_Sept_Iles	-66.2000	49.2400	-66.3000	50.2500
CLASS2_STR_ATL_CANADA_Iles_de_la_Madeleine	-65.0500	48.1500	-61.0000	46.7500
CLASS2_STR_ATL_EnglandFaroe	-6.6844	62.0761	-2.7753	59.3025
CLASS2_STR_ATL_Iceland	-7.1836	62.3620	-14.0685	64.6856
CLASS2_STR_ATL_EnglandNorway	-2.8000	59.3200	5.8516	59.3200
MED SEA				
CLASS2_STR_MED_Gibraltar	-5.4000	35.7000	-5.4000	36.2455
CLASS2_STR_MED_0E	0.0000	38.7500	0.0000	35.9159
CLASS2_STR_MED_Ibiza	0.0000	38.7500	1.3668	38.9941
CLASS2_STR_MED_5.5E	5.5000	36.7828	5.5000	43.1268
CLASS2_STR_MED_40N	-0.0296	40.0000	15.7292	40.0000
CLASS2_STR_MED_SardiniaChannel	9.0000	37.0254	9.0000	39.0827
CLASS2_STR_MED_CorsicaChannel	9.4222	42.5000	11.1329	42.5000
CLASS2_STR_MED_Sicily	10.8983	36.8078	12.5027	37.6449
CLASS2_STR_MED_35N	10.8798	35.0000	35.8453	35.0000
CLASS2_STR_MED_OtrantoStrait	18.4178	40.1000	19.5956	40.1000
CLASS2_STR_MED_19E	19.0000	30.3125	19.0000	42.0436
CLASS2_STR_MED_CretanPassage	25.0000	31.8172	25.0000	34.9447
CLASS2_STR_MED_Rhodesgyre	28.0000	31.1152	28.0000	36.9864
CLASS2_STR_MED_KassosStrait	25.6859	35.2177	28.0347	36.7053
CLASS2_STR_MED_Cilician_channel	33.4000	35.3104	33.4000	36.0864
CLASS2_STR_MED_Kytheron	22.9642	36.7072	23.7272	35.6051
INDIAN OCEAN				
CLASS2_STR_IND_S2_139E	139.5000	-36.1406	139.5000	-45.0000
CLASS2_STR_IND_S1_122E	122.0000	-33.8766	122.0000	-45.0000
CLASS2_STR_IND_WOCE_I06_30E	27.8700	-33.2000	30.0000	-69.7266
CLASS2_STR_IND_WOCE_I09S_115E	115.0000	-33.0000	108.9000	-66.7500
CLASS2_STR_IND_WOCE_I08S_I09N_95E	92.4000	20.5500	82.0000	-67.3281
CLASS2_STR_IND_WOCE_I05P_35S	30.1875	-31.0625	114.9375	-34.1700
CLASS2_STR_IND_WOCE_I03_20S	48.7627	-20.0000	113.7969	-22.1603
CLASS2_STR_IND_WOCE_I04_25S	34.0000	-25.0000	44.0000	-25.0000

CLASS2_STR_IND_WOCE_I02_8S	39.6000	-3.9800	107.4700	-7.6200
CLASS2_STR_IND_IndonesianThroughflow2	116.1200	22.8600	137.5000	-1.4600
CLASS2_STR_IND_EQUATOR	43.0000	0.0000	99.6000	0.0000
CLASS2_STR_IND_CHINA_SEA_EQUATOR	103.7000	0.0000	109.1000	0.0000
PACIFIC				
CLASS2_STR_PAC_137E	137.0000	-2.0000	137.0000	34.7000
CLASS2_STR_PAC_BeringSea55N	162.0000	55.0000	-162.9000	55.0000
CLASS2_STR_PAC_165E	165.0000	-70.5000	165.0000	59.8000
CLASS2_STR_PAC_E2_34S	151.2000	-34.0000	165.0000	-34.0000
CLASS2_STR_PAC_P18_WOCE_100W	-103.0000	-72.7000	-110.0000	22.9000
CLASS2_STR_PAC_180E	180.0000	-83.8000	180.0000	65.1000
CLASS2_STR_PAC_P16_WOCE_150W	-153.8000	56.9000	-151.0000	-77.3438
CLASS2_STR_PAC_P10_WOCE_150E	140.4000	35.5000	144.7500	-4.1000
CLASS2_STR_PAC_P02_WOCE_30N	133.6000	32.7500	-117.4000	32.9500
CLASS2_STR_PAC_P06_WOCE_30S	153.0000	-30.0800	-71.5039	-32.5000
CLASS2_STR_PAC_P12_SR03_WOCE_Tasmania_Antarct	146.3500	-43.6000	139.9000	-66.5336
CLASS2_STR_PAC_9N	126.2000	9.0000	-83.8000	9.0000
CLASS2_STR_PAC_EQUATOR	117.5000	0.0000	-80.3000	0.0000
CLASS2_STR_PAC_9S	149.5000	-9.0000	-78.8000	-9.0000

Table 10: Summary definition of the Class 2 straight sections in the Global Ocean

4.5. Class 2 XBT sections

The chosen Class 2 XBT sections correspond to the most frequently visited XBT SOOP lines (Figure 4-6a, see http://www.brest.ird.fr/soopip/graph_ref/lines_global.gif) during the time period 2000-2005. The methodology used to choose the main SOOP lines is the following: XBT data during 2000-2005 from the Coriolis datacenter have been binned in 0.25*0.25degrees boxes. Boxes with more than 3 observations are plotted in Figure 4-6b and show the main XBT lines visited at least 3 times during the time period 2000-2005. 35 of these lines have been selected, and are shown in Figure 4-2, Figure 4-3, Figure 4-4, and Figure 4-5, and summarized in Table 11.


a)

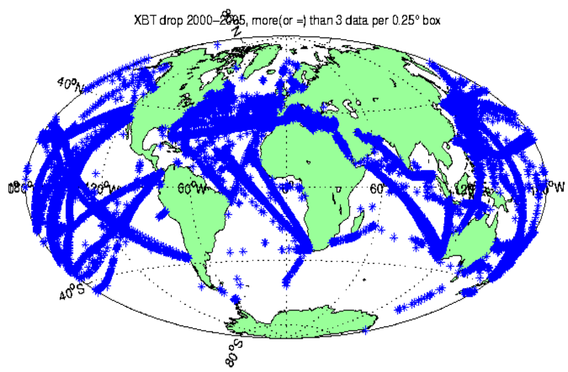

b)

Figure 4-6: a) location of the SOOP XBT sections, and b) location of the XBT sections visited at least 3 times during time period 2000-2005 in the Global Ocean.

XBT SECTION NAME	LONGITUDE1	LATITUDE1	LONGITUDE2	LATITUDE2
ATLANTIC				
CLASS2_XBT_ATL_AX02	-52.3333	47.1961	-23.6667	63.8577
CLASS2_XBT_ATL_AX25	17.6250	-33.8750	0.1250	-54.6200
CLASS2_XBT_ATL_AX22_Drake	-67.9950	-55.0000	-60.0000	-64.0000
CLASS2_XBT_ATL_AX11_Rio_CapeVerde_Brest	-34.1250	-7.8750	-6.3750	46.8750
CLASS2_XBT_ATL_AX10_AX29_NY_PuertoRico_Recife	-73.3750	39.8750	-35.6250	-4.6250
CLASS2_XBT_ATL_AX07_Florida_Bahamas_Gibraltar	-79.8750	25.8750	-6.8750	35.8750
CLASS2_XBT_ATL_AX15_Dakar_CapeTown	-19.8750	13.8750	17.6250	-33.8750
CLASS2_XBT_ATL_AX08_NY_CapeTown	-73.3750	39.8750	17.6250	-33.8750
MED SEA				
CLASS2_XBT_MED_Sete_Tunis	3.5000	43.1250	10.2500	37.2500
CLASS2_XBT_MED_Genova_Palermo	8.7500	44.2500	13.5000	38.1250
CLASS2_XBT_MED_Adriatic	17.0000	41.0000	18.0000	42.3750
CLASS2_XBT_MED_Chypre_PortSaid	33.0000	34.7500	32.2500	31.3750
CLASS2_XBT_MED_Barcelona_Oran	2.1250	41.2500	-0.2500	35.8750
CLASS2_XBT_MED_Gibraltar_Sicily	-5.5000	36.0000	13.5000	38.3750
CLASS2_XBT_MED_Adriatic_Syracusa	16.5000	43.0000	15.2500	36.5000
CLASS2_XBT_MED_Sicily_Haifa	16.0000	37.7500	35.0000	33.0000
CLASS2_XBT_MED_Sete_Lybia	2.1250	41.3750	19.3750	30.6250
INDIAN OCEAN				
CLASS2_XBT_IND_IX01_Fremantle_SundraStrait	115.4600	-31.8000	105.3300	-6.7200
CLASS2_XBT_IND_IX12_Fremantle_RedSea	55.1250	9.3750	115.1250	-32.1250
CLASS2_XBT_IND_IX15_Mauritius_Fremantle	57.3500	-20.4600	115.5800	-31.8900
CLASS2_XBT_IND_IX22_PortHedland_Japan	113.1400	-21.1700	123.4800	-9.9200
CLASS2_XBT_IND_IX28_Hobart_DumontDUrville	147.3000	-42.9000	139.4000	-66.7000
CLASS2_XBT_IND_IX10_GulfOman_Sumatra	59.8750	23.1250	94.3750	6.3750
CLASS2_XBT_IND_IX21_Durban_Mauritius	31.3750	-29.8750	57.3750	-20.1250
CLASS2_XBT_IND_Nicobar_Djakarta	90.1250	6.1250	99.6250	-6.6250
PACIFIC				
CLASS2_XBT_PAC_PX08_NewZealand_Panama	176.1250	-37.1250	-79.8750	7.3750
CLASS2_XBT_PAC_PX40_PX81_Japan_Chile	139.5000	35.7000	-73.8750	-36.8750
CLASS2_XBT_PAC_PX44_PX10_PX37_HKong_SF	124.3750	19.8750	-122.8750	37.6250
CLASS2_XBT_PAC_PX05_Japan_NewZealand	139.6250	34.8750	176.1250	-37.3750
CLASS2_XBT_PAC_PX06_PX09_PX37_NewZealand_SF	175.1250	-35.6250	-157.6250	21.1250
CLASS2_XBT_PAC_PX18_SF_Tahiti	-149.1250	-16.3750	-123.1250	37.6250
CLASS2_XBT_PAC_PX02_BandaSea	116.9600	-6.5400	135.6900	-9.1200
CLASS2_XBT_PAC_PX11_FloresSea_Japan	122.4600	-8.5700	139.7800	35.0000
CLASS2_XBT_PAC_PX30_Brisbane_Noumea_Fiji	153.2000	-27.3400	178.8900	-17.6700
CLASS2_XBT_PAC_PX34_Sydney_Wellington	151.0300	-33.7900	175.1000	-41.4000

Table 11: Summary definition of the Class 2 XBT sections in the Global Ocean

The detailed locations of XBT sections (latitude, longitude, and names) are given in the ASCII file **LONLAT_XBT_GODAE_20070906.dat**.

4.6. Class 2 glider sections

Like XBT lines, in order to compare the model fields where gliders sections are available, two and five gliders sections are defined in the North Atlantic Ocean and the Mediterranean Sea respectively, as shown in Figure 4-2. Name and ending section points are given in Table 12.

Detailed description of location of each point along the section (approximately every 10km) is given in **LONLAT_GLIDERS_GODAE_20070301.dat**.

GLIDER SECTION NAME	LONGITUDE1	LATITUDE1	LONGITUDE2	LATITUDE2
ATLANTIC				
CLASS2_GLI_ATL_1	-7.0000	47.0000	-20.0000	50.0000
CLASS2_GLI_ATL_2	-42.5000	60.0000	-35.0000	57.0000
MED SEA				
CLASS2_GLI_MED_3	0.1700	38.7800	1.2800	38.9200
CLASS2_GLI_MED_4	1.3546	38.9600	2.7800	39.5500
CLASS2_GLI_MED_5	4.0700	40.0100	2.7300	41.7800
CLASS2_GLI_MED_6	4.0900	40.0300	3.8400	43.6700
CLASS2_GLI_MED_7	3.0000	42.0000	9.7600	44.3000

Table 12: Summary definition of the Class 2 Glider sections in the Global Ocean

4.7. Class 2 moorings and tide gauges

Class 2 moorings are separated in 215 tide gauges, and other 354 moorings (Figure 4-2, Figure 4-3, Figure 4-4, and Figure 4-5) that are chosen at location where real time observations are available (PIRATA, TAO, GLOSS…). The detailed locations of each point (longitude, latitude, and name) are given in two ASCII files: **LONLAT_MOORINGS_GODAE_20071115.dat** and **LONLAT_MOORINGS_TIDE_20071115.dat**.

Web site to obtain mooring information are:

http://www.pmel.noaa.gov/
http://uhslc1.soest.hawaii.edu/uhslc/fast.html
http://www.oceansites.org/
http://www.oceansites.org/network/index.html
http://www.soc.soton.ac.uk/CLIVAR/organization/indian/IOOS/obs.html
http://www.soc.soton.ac.uk/CLIVAR/organization/indian/IOOS/IOtimeseries.htm
http://ndbc.noaa.gov/
http://www.bodc.ac.uk/projects/uk/rapid/moorings/#scucoords
http://hahana.soest.hawaii.edu/hot/locations.html
http://bats.bbsr.edu/bats_map.html

4.8. Class 2 climatology

Like for Class 1 metrics, climatological fields have to be made available from the OpenDAP servers, along the Class 2 sections and moorings. The climatology mentioned in section 3.5 have to be considered.

4.9. Class 2 technical implementation

4.9.1. Class 2 file name convention

Similarly to Class 1 files, Class 2 files are written in NetCDF format, compliant to COARDS-CF convention (http://cf-pcmdi.llnl.gov/). For each section or mooring, the file contains the daily average, and the following file name construction is proposed (fix codes are in black and codes that change are in color, explained in Table 6):

***CLASS2_LLL_RRR_NAME_XXX_ZZZZ*_mean_YYYYMMDD_RYYYYMMDD.nc**

Note that "***CLASS2_LLL_RRR_NAME*"** exactly corresponds to the name of each section given in Table 10, Table 11, and Table 12, and also in mooring definition files (names given in Table 7).

LLL	(3 digit) code of the type of Class 2 metrics see Table 7
RRR	(3 digit) code of the area, as given in Table 4
NAME	(variable length) specific name given for each section of mooring
XXX	(3 digit) code of the GODAE partner see Table 20
ZZZZ	(variable length) specific name given to a particular system of the GODAE partner
YYYYMMDD	(8 digit) field date YYYY=YEAR, MM=MONTH, DD=DAY: corresponds to the date of the output stored in this file.
YYYYMMDD	(8 digit) bulletin date YYYY=YEAR, MM=MONTH, DD=DAY: corresponds to the date of the analysis, or the run from which the output is produced and the system operated

Table 13: Description of the name codes of the Class 2 file name. Note that the first 3 codes (LLL, RRR, and NAME) are already defined in the name given for each section (Table 10, Table 11, and Table 12).

For instance the Class 2 file corresponding to the XBT section `CLASS2_XBT_ATL_AX11_Rio_CapeVerde_Brest` interpolated on the Mercator Ocean system, for the 13th of March 2008, from the bulletin of the 26th of March 2008 will be:

CLASS2_XBT_ATL_AX11_Rio_CapeVerde_Brest_MER_P3V2R2_mean_20080313_R20080326.nc

4.9.2. Class 2 NetCDF format

Sections can be considered as a series of "stations", profiling at some "depth". Moorings are just sections of only one "station". Thus, Class 2 file dimensions are:

`station`	i.e., the number of locations defining a section, the value is "1" in the case of a mooring
`depth`	the different standard vertical levels as defined by Table 9

Table 14: Dimensions of Class 2 files

The different variables are written following the NetCDF formatting, below a created example of the `CLASS2_STR_ARC_Hudson_Strait` section in the Arctic Ocean. Note that some informations (fill values etc....) are "forecast center dependant": they can be chosen different by the different GODAE partners :

```
dimension:
    station = 15 ;
    depth = 33 ;
variables:
    float station(station) ;
        station:long_name = "Station" ;
        station:units = "" ;
        station:axis = "X" ;
    float depth(depth) ;
        depth:long_name = "Depth" ;
        depth:units = "m" ;
        depth:valid_range = 0.0, 3001.0 ;
        depth:standard_name = "depth" ;
        depth:positive = "down" ;
        depth:axis = "Z" ;
    float longitude(station) ;
        longitude:_CoordinateAxes = "station " ;
        longitude:units = "degrees_east" ;
        longitude:valid_range = -180.0, 180.0 ;
        longitude:long_name = "Longitude" ;
        longitude:standard_name = "longitude" ;
    float latitude(station) ;
        latitude:_CoordinateAxes = "station " ;
        latitude:units = "degrees_north" ;
        latitude:valid_range = -90.0, 90.0 ;
        latitude:long_name = "Latitude" ;
        latitude:standard_name = "latitude" ;
    float temperature(depth,station) ;
        temperature:_CoordinateAxes = "depth station " ;
        temperature:add_offset = 273.15 ;
        temperature:comment = “by not applying add_offset, values are readable in degrees
Celsius”
        temperature:_FillValue = -1.0E14 ;
        temperature:missing_value = -1.0E14 ;
        temperature:long_name = "Potential temperature" ;
        temperature:units = "K" ;
        temperature:standard_name = "sea_water_potential_temperature" ;
    float salinity(depth,station) ;
        salinity:_CoordinateAxes = "depth station " ;
        salinity:_FillValue = -1.0E14 ;
        salinity:missing_value = -1.0E14 ;
        salinity:long_name = "Salinity" ;
        salinity:units = "1e-3" ;
        salinity:standard_name = "sea_water_salinity" ;
    float u(depth,station) ;
        u:_CoordinateAxes = "depth station " ;
        u:_FillValue = -1.0E14 ;
        u:missing_value = -1.0E14 ;
        u:long_name = "Eastward velocity" ;
        u:units = "m s-1" ;
        u:standard_name = "sea_water_x_velocity" ;
    float v(depth,station) ;
        v:_CoordinateAxes = "depth station " ;
        v:_FillValue = -1.0E14 ;
        v:missing_value = -1.0E14 ;
        v:long_name = "Northward velocity" ;
        v:units = "m s-1" ;
        v:standard_name = "sea_water_y_velocity" ;
    float ssh(station) ;
        ssh:_CoordinateAxes = "depth station " ;
        ssh:_FillValue = -1.0E14 ;
        ssh:missing_value = -1.0E14 ;
        ssh:long_name = "Sea Surface height" ;
        ssh:units = "m" ;
        ssh:standard_name = "sea_surface_height_above_geoid" ;
// global attributes:
        :title: "CLASS2 MERSEA TOPAZ model results for Hudson_Strait " ;
        :comment: "Daily Averaged fields" ;
        :institution: "NERSC, Thormoehlens gate 47, N-5006 Bergen, Norway" ;
        :history: "20070208:Created by program hyc2stations, version V0.1" ;
        :source: "NERSC-HYCOM model fields" ;
        :references: “http://topaz.nersc.no” ;
        :field_type: "Daily average fields" ;
        :Conventions: "CF-1.0" ;
        :field_date: "2007-02-03" ;
```

```
        :bulletin_date: "2007-02-07" ;
        :field_julian_date = 20852 ;
        :bulletin_julian_date = 21001 ;
        :julian_day_unit = "days since 1950-01-01 00:00:00" ;
        :station_number: 15 ;
        :section_name: "CLASS2_STR_ARC_Hudson_Strait" ;
        :section_limits: “64.70W 60.40N / 64.9625W 61.3625N” ;
        :bulletin_type: "Hindcast" ;
        :bulletin_type = "operational" ;
```

Some global attributes like **station_number**, **section_name,** and **section_limits** are proposed to allow a better understanding of the file through a quick look of the header.

5. CLASS 3 METRICS FOR THE GLOBAL OCEAN

Class 3 metrics are clearly not a priority for the GODAE intercomparison project. However, some partners can rely on it to perform dedicated assessment. Three diagnostics are proposed: volume transport, meridional heat transport, and overturning stream function.

5.1. Class 3 variables, times and periods

Class 3 metrics are daily averaged based on best estimates. Table 15 summarizes the variables for volume transport, and heat transport and meridional overturning stream function in the Atlantique, Pacific, Indian and global oceans.

Note that for being compliant with the COARDS-CF format (http://cf-pcmdi.llnl.gov/), units have to be Watt (W) for heat transport, and m^3/s for volume transport, although these quantities are usually discussed in PetaWatt and Sverdrup. To solve this problem, the "scale_factor" attribute can be used: volume transport and overturning stream function values can be divided by 10^6, then written, together with a scale factor attribute of 10^6. Thus, by reading the variable "`VolT_p`" and not applying the scale factor, one would directly have a quantity in Sverdrup. In the same way, heat transport values can be divided by 10^{15} before writing in NetCDF, associated with the scale factor of 10^{15}. For these different cases, the "comment" attributes can be added in the NetCDF file, with a text that emphasizes this "trick" (see examples below).

Concerning transport and overturning circulation, some references from the literature can be used; here is a first list that needs to be extended:

- [*Ganachaud*, 2003; *Ganachaud and Wunsch*, 2003; *Ganachaud et al.*, 2000]
- [*Friedrichs and Hall*, 1993]
- [*Lux et al.*, 2001]
- [*Rintoul*, 1991]
- [*Speer et al.*, 1996]
- [*Wijffels et al.*, 1996]

Variable Name **(To appear on OpenDAP servers)**	**Long name & Standard_name attribute in Netcdf file**	**unit**	**dimen-sions**
VolT_p	Positive ocean volume transport across section ocean_volume_transport_across_line	m3 s-1	1D
VolT_n	Negative ocean volume transport across section ocean_volume_transport_across_line	m3 s-1	1D
MOSFz_glo	Global ocean meridional overturning streamfunction defined by depth ocean_meridional_overturning_streamfunction_defined_by_depth	m3 s-1	2D
MOSFs_glo	Global ocean meridional overturning streamfunction defined by density ocean_meridional_overturning_streamfunction_defined_by_sigma_theta	m3 s-1	2D
MOSFt_glo	Global ocean meridional overturning streamfunction defined by temperature ocean_meridional_overturning_streamfunction_defined_by_theta	m3 s-1	2D
MHT_glo	Global ocean meridional heat transport northward_ocean_heat_transport	W	1D
MOSFz_atl	Atlantic ocean meridional overturning streamfunction defined by depth ocean_meridional_overturning_streamfunction_defined_by_depth	m3 s-1	2D
MOSFs_atl	Atlantic ocean meridional overturning streamfunction defined by density ocean_meridional_overturning_streamfunction_defined_by_sigma_theta	m3 s-1	2D
MOSFt_atl	Atlantic ocean meridional overturning streamfunction defined by temperature ocean_meridional_overturning_streamfunction_defined_by_theta	m3 s-1	2D
MHT_atl	Atlantic ocean meridional heat transport northward_ocean_heat_transport	W	1D
MOSFz_ind	Indian ocean meridional overturning streamfunction defined by depth ocean_meridional_overturning_streamfunction_defined_by_depth	m3 s-1	2D
MOSFs_ind	Indian ocean meridional overturning streamfunction defined by density ocean_meridional_overturning_streamfunction_defined_by_sigma_theta	m3 s-1	2D
MOSFt_ind	Indian ocean meridional overturning streamfunction defined by temperature ocean_meridional_overturning_streamfunction_defined_by_theta	m3 s-1	2D
MHT_ind	Indian ocean meridional heat transport northward_ocean_heat_transport	W	1D
MOSFz_pac	Pacific ocean meridional overturning streamfunction defined by depth ocean_meridional_overturning_streamfunction_defined_by_depth	m3 s-1	2D
MOSFs_pac	Pacific ocean meridional overturning streamfunction defined by density ocean_meridional_overturning_streamfunction_defined_by_sigma_theta	m3 s-1	2D
MOSFt_pac	Pacific ocean meridional overturning streamfunction defined by temperature ocean_meridional_overturning_streamfunction_defined_by_theta	m3 s-1	2D
MHT_pac	Pacific ocean meridional heat transport northward_ocean_heat_transport	W	1D

Table 15: Class 3 Variables, along with standard_name attribute (NetCDF files) and dimensions.

5.2. Class 3 Volume transport

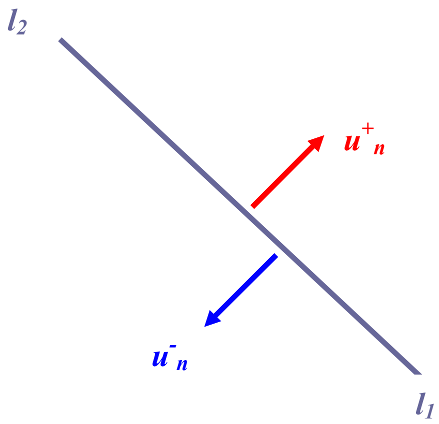
Volume transports (Sverdrup=10^6 m^3/s) across chosen sections are detailed in Figure 5-1 and Table 16. For easier implementation, a ASCII Class 3 file is also provided:

LONLAT_CLASS3_SECTION_20071203.dat. Depending on the section considered, one has to provide the total (positive + negative component) volume transport or the volume transport per defined depth classes or potential temperature classes or density classes.

The $VolT^+$ and $VolT^-$ transports are defined as daily estimates and calculated as:

$$VolT^+ = \int_{l_2}^{l_1} dl \int_{-z_b}^{\eta} u^+{}_n \, dz$$

$$VolT^- = \int_{l_2}^{l_1} dl \int_{-z_b}^{\eta} u^-{}_n \, dz$$



where l_1, l_2 are the extremes of the section, $u^+{}_n$ and $u^-{}_n$ are the velocity components normal to the section in the positive and negative direction, η is the free surface and z_b is the bottom depth. Positive direction is taken to the north for the non-meridional sections and to the east for the meridional sections. $u^+{}_n$ and $u^-{}_n$ are defined as :

$u^+{}_n$ (z) = $\delta(+1)$ u_n(z) with $\delta(+1)=1$ if u_n(z) >0 and $\delta(+1)=0$ if u_n(z) <0

$u^-{}_n$ (z) = $\delta(+1)$ u_n(z) with $\delta(+1)=1$ if u_n(z) <0 and $\delta(+1)=0$ if u_n(z) >0

Daily estimates of transports $VolTr_i^+$, $VolTr_i^-$ through sections in density, potential temperature or salinity classes with r =Δρ, Δθ or ΔS are defined as a daily estimate and calculated as:

$VolT^{+/-} = \int_{l_2}^{l_1} dl \int_{zp1}^{zp2} u^{+/-}{}_n \, dz$ where l_1, l_2 are the extremes of the section, u_n is the velocity component normal to the section in the positive and negative direction, $zp1$ and $zp2$ are the depths bounding the density, potential temperature or salinity classes considered.

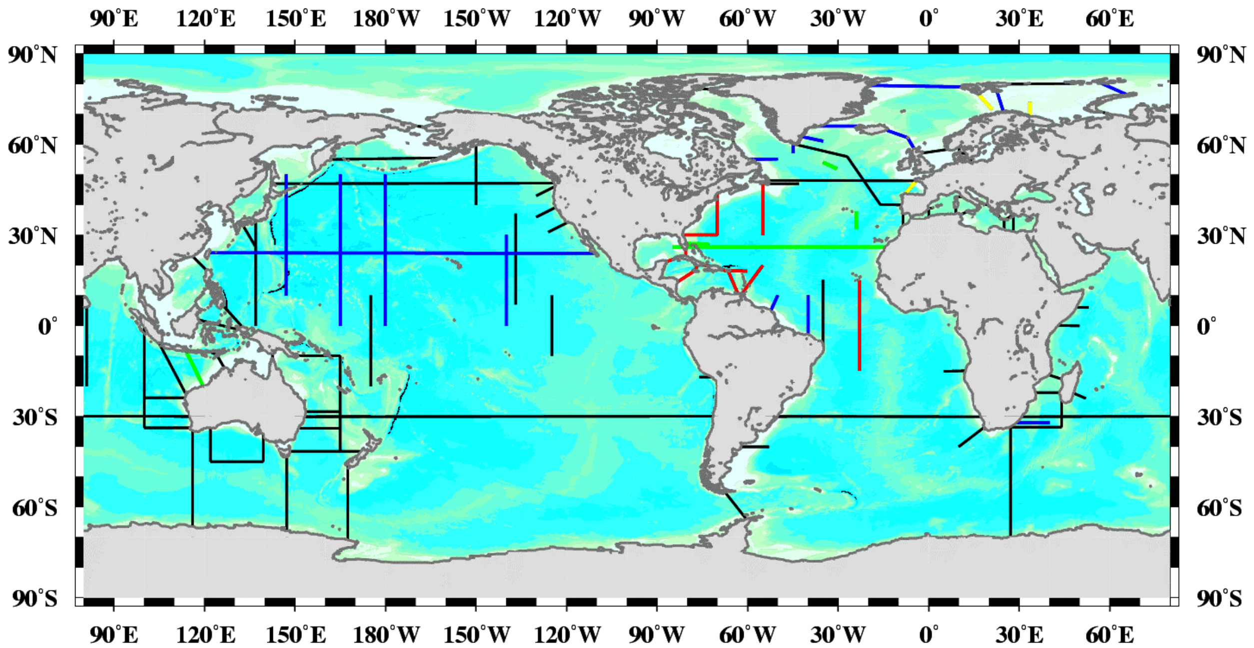


Figure 5-1: Class 3 volume transport sections. In black, sections without specific class of computation on the vertical. Then, transport computed with classes: temperature (red), salinity (yellow), density (blue) and depth (green).

	Lon 1	Lat 1	Lon 2	Lat 2	Transport classes
Antartic Ocean					
ACC_Drake_Passage	-68.0	-54.5	-60.0	-64.7	No
ACC_LeCap	27.0	-73.0	27.0	-30.0	No
ACC_WAUS	116.0	-70.0	116.0	-33.8	No
ACC_TAS	147.3	-70.0	147.3	-41.0	No
ACC_NZ	167.4	-73.0	167.4	-45.5	No
Arctic Ocean					No
ARC_Lancaster_sound	-82.0	73.4	-82.0	74.9	No
ARC_Jones_Strait	-81.0	75.1	-81.0	76.6	No
ARC_Robeson_Channel	-76.0	78.4	-72.0	78.3	No
ARC_Hudson_Strait	-64.6	60.3	-65.0	61.5	No
ARC_Bear_Island	20.9	71.5	16.0	77.0	S < 34.9 psu S > 34.9 psu
ARC_Kola_Section	33.5	68.0	33.5	74.0	same as above
ARC_Spitzberg_FJLand	25.0	80.0	48.2	80.2	No
ARC_FJLand_NovZemlija	57.0	80.3	65.9	76.4	$\sigma_0 < 27.8$ $27.8 < \sigma_0 < 30$
ARC_Kara_Gate	57.0	70.7	59.0	70.2	No
ARC_Barents_Sea	25.0	70.0	22.6	77.8	$\sigma_0 < 25$ $25 < \sigma_0 < 27.8$ $27.8 < \sigma_0 < 29$
ARC_Fram_Strait	-21.5	79.5	15.0	79.0	$25 < \sigma_0 < 27.8$ $27.8 < \sigma_0 < 29$
Atlantic Ocean					
ATL_West_Atlantic_27N	-81.0	27.1	-73.0	27.0	$0 < z < 1000$ $1000 < z < 6000$
ATL_Tropical_Atlantic_35W	-35.0	15.1	-35.0	-8.0	No
ATL_South_West_Atlantic	-63.0	9.0	-55.0	20.0	$T < 4.5$

ATL_Gibbs	-35.0	54.0	-30.5	52.0	z > 3000m
ATL_North_Brazil_Current_40W	-40.0	-4.0	-40.0	10.0	σ0 < 27.45
ATL_North_Brazil_Current_10N	-55.0	-1.0	-50.0	10.0	σ0 < 24.5 24.5 < σ0 < 27.125 27.125 < σ0 < 27.45 27.45 < σ0
ATL_Brazil_Current_30S	-53.0	-30.1	-40.0	-30.0	No
ATL_Falklands_Current_40S	-63.0	-40.1	-53.0	-40.0	No
ATL_Atlantic_Equatorial	-23.0	-15.0	-23.0	15.0	T < 4.5 4.5 < T < 7 7 < T < 12 12 < T
ATL_Benguela_Current_15S	5.0	-15.1	13.0	-15.0	No
ATL_Agulhas_Zone_30S	10.0	-40.0	22.0	-31.0	No
ATL_Trans_Atlantic_30S	19.0	-30.1	-54.0	-30.0	No
ATL_FlemishCap	-53.5	47.0	-43.0	47.0	No
ATL_England_Faroe	-7.0	62.2	-4.5	58.0	25 < σ0 < 27.8 27.8 < σ0 < 29
ATL_Iceland_Faroe	-15.0	65.0	-7.0	62.2	same as above
ATL_Denmark_Strait	-37.0	66.1	-22.5	66.0	same as above
ATL_East_Greenland	-44.0	63.0	-35.0	61.0	same as above
ATL_South_Greenland	-45.0	60.9	-45.0	57.0	same as above
ATL_Labrador_55N	-50.1	55.1	-61.0	55.0	same as above
ATL_England_Norway	8.0	58.5	-2.5	57.0	No
ATL_Gibraltar	-5.7	35.5	-5.7	36.5	No
ATL_Gulf_Cadiz	-8.5	32.0	-8.5	38.2	No
ATL_Ovide1	-44.0	60.0	-27.0	56.0	No
ATL_Ovide2	-27.0	56.0	-16.0	40.0	No
ATL_Portugal	-16.0	40.1	-8.1	40.0	No
ATL_Biscay	-4.0	48.2	-8.1	43.1	S < 35 35 < S < 35.6 35.6 < S
ATL_South_Canaries	-14.0	26.1	-22.0	26.0	No
ATL_Acores_24W	-24.0	32.0	-24.0	37.9	Z > 800 m Z < 800 m
ATL_Antilles	-66.4	18.1	-63.0	10.0	T < 4.5 4.5 < T < 7 7 < T < 12 12 < T
ATL_Porto_Rico	-60.1	18.1	-66.5	18.2	same as above
ATL_Hispagnola_Porto_Rico	-66.5	18.1	-68.9	18.5	same as above
ATL_Windward_Passage	-75.0	20.2	-72.6	19.7	same as above
ATL_Jamaica_Ridge	-77.5	18.2	-84.0	14.0	same as above
ATL_Cuba_Jamaica	-77.5	18.0	-76.5	20.3	same as above
ATL_Yucatan_strait_KANEC	-87.3	21.0	-84.0	22.2	same as above
ATL_Cuba_Florida	-80.5	22.5	-80.5	25.5	same as above
ATL_Florida_Bahamas	-78.5	26.7	-80.5	27.0	same as above
ATL_West_Atlantic_30N	-70.0	30.1	-82.0	30.0	same as above
ATL_Gulf_Stream	-70.0	45.0	-70.0	30.1	same as above
ATL_Gulf_Stream_2	-55.0	30.0	-55.0	47.9	same as above
ATL_Atlantic_48N	-55.0	48.1	-3.9	48.0	No
ATL_Atlantic_26N	-85.0	26.1	-10.8	26.0	0 < z < 1000 1000 < z < 6000
Indian Ocean					
IND_W1	100.0	-23.9	115.0	-23.9	No

IND_W2	100.0	-33.8	117.0	-33.8	No
IND_W3	100.0	-33.8	100.0	2.0	No
IND_S1	122.0	-45.0	122.0	-30.0	No
IND_S2	139.5	-45.0	139.5	-32.0	No
IND_S3	122.0	-45.0	139.5	-45.0	No
IND_E1	150.0	-28.5	165.0	-28.5	No
IND_E2	148.0	-34.0	165.0	-34.0	No
IND_E3	146.0	-41.7	165.0	-41.7	No
IND_E4	165.0	-41.7	165.0	-28.5	No
IND_E5	165.0	-10.0	165.0	-28.5	No
IND_E6	149.0	-10.0	165.0	-10.0	No
IND_E7	165.0	-41.7	173.0	-41.7	No
IND_N1	115.0	24.0	122.0	17.0	No
IND_N2	125.0	8.0	134.0	-2.0	No
IND_N3	114.1	-8.45	118.9	-8.45	No
IND_N4	121.8	-8.7	124.1	-9.7	No
IND_N5	124.1	-9.7	127.0	-15.0	No
IND_N6	115.0	-25.0	104.0	-4.0	No
IND_N8	116.0	2.3	134.0	-2.0	No
IND_AG1	33.0	-22.2	45.0	-22.2	No
IND_AG2	25.0	-33.65	44.0	-33.65	No
IND_AG3	44.0	-22.2	44.0	-33.65	No
IND_Australia_Bali	114.0	-8.5	120.0	-21.0	0 < z < 200 200 < z < 500 500 < z < 2000
IND_Somali_Current	45.0	6.1	53.0	6.0	No
IND_Mozambique_Current	39.0	-16.0	45.0	-18.0	No
IND_Agulhas_Current_32S	27.0	-32.1	40.0	-32.0	$\sigma_0 < 26.5$ $26.5 < \sigma_0 < 26.75$ $26.75 < \sigma_0 < 27.$ $27. < \sigma_0 < 27.4$
IND_Bab_El_Manded	43.25	12.65	43.75	12.9	No
IND_Indian_Equatorial	41.0	0.1	50.0	0.0	No
IND_Indian_80E	81.0	-20.0	81.0	8.0	No
IND_West_Australia	115.0	-30.1	109.0	-30.0	No
IND_Madagascar	52.0	-24.0	47.0	-22.0	No
IND_Indian_30S	25.0	-30.1	120.0	-30.0	No
Pacific Ocean					
ARC_Bering_Strait	-171.5	66.2	-166.0	65.7	No
PAC_Subarctic_Gyre_47N	-120.0	47.1	142.5	47.0	No
PAC_OffCalif1	-122.0	47.0	-130.0	43.0	No
PAC_OffCalif2	-122.0	40.0	-130.0	36.0	No
PAC_OffCalif3	-118.0	35.0	-126.0	31.0	No
PAC_North_Pacific_24N	121.0	24.1	-110.6	24.0	$\sigma_0 < 27.0$ $\sigma_0 > 27.0$
PAC_North_Pacific_137W_NEC	-137.0	7.0	-137.0	25.0	No
PAC_North_Pacific_137W_Kuroshio	-137.0	25.0	-137.0	37.0	No
PAC_Kuroshio	132.8	33.0	137.0	26.0	No
PAC_Pacific_Equatorial_175E	175.0	-20.0	175.0	10.0	No
PAC_Pacific_Equatorial_125W'	-125.0	-10.0	-125.0	10.0	No
PAC_Peru_Current	-70.0	-17.1	-76.0	-17.0	No
PAC_East_Australia	152.0	-30.1	175.0	-30.0	No
PAC_Torres_Strait	142.5	-8.0	142.5	-13.0	No

PAC_Pacific_147E_10N_50N	147.0	10.0	147.0	50.0	σ0 < 26.6 26.6 < σ0 < 26.7 26.7 < σ0 < 26.8 26.8 < σ0 < 27.2 27.2 < σ0
PAC_Pacific_165E	165.0	0.0	165.0	50.0	same as above
PAC_Pacific_180E	179.9	0.0	179.9	50.0	same as above
PAC_Pacific_140W	-140.0	0.0	-140.0	30.0	same as above
PAC_Alaskan_Gyre	-150.0	40.0	-150.0	60.5	No
PAC_Bering_Sea	161.0	55.0	-162.0	55.5	No
PAC_JMA_137E_0N_35N	137.0	0.0	137.0	36.0	No
PAC_Pacific_30S	150.0	-30.1	-70.0	-30.0	No
Mediterranean Sea					
MED_0E	0.0	38.75	0.0	35.36	No
MED_Ibiza_Channel	0.0	38.75	1.37	39.0	No
MED_Sardinia_Channel	9.0	36.8	9.0	39.37	No
MED_Corsica_Channel	9.3	42.5	11.68	42.5	No
MED_Sicily_Strait	10.5	36.6	12.9	37.85	No
MED_Otranto_Strait	18.3	40.1	20.07	40.0	No
MED_Cretan_Passage	25.0	31.5	25.0	35.05	No
MED_Rhodes_Gyre	28.0	30.8	28.0	37.32	No
MED_Kassos_Strait	25.5	35.1	28.6	37.07	No
MED_Cilician_Channel	33.4	35.0	33.4	36.36	No
MED_Kytheron_Strait	22.9	36.8	23.85	35.42	No
Baltic Sea					
BAL_WesternBaltic	10.08	60.0	10.08	56.0	No
BAL_Kattegat	10.0	57.0	13.0	57.0	No
BAL_Skagerrak	14.0	57.0	14.0	53.0	No

Table 16: Definition of Class 3 volume transport sections over the Global Ocean. A colour is applied for the different transport classes: density criteria in (blue), potential temperature criteria in degrees Celsius (red), depth criteria in meters (green), and salinity in psu (orange).

5.3. Class 3 Overturning Stream Function

The Overturning Stream Function (OSF) (Sverdrup=10^6 m^3/s), per ocean basin (Atlantic, Pacific and Indian) as well as the Global Ocean, as a function of :

- Latitude and depth. At each latitude band on the basin, the zonal integral of the meridional velocity is first computed, then integrated **from surface** z_0 **to the bottom** z_b, for each depth:

$$MOSFz(y,z) = \int_{x_1}^{x_2} dx \int_{z_0}^{z_b} v(x,y,z)\, dz$$

, sampled along latitude[7], and the Class 2 levels given in Table 9.

[7] It is recommended to sample the OSF regularly along latitude, typically every ¼° or 1/8°

- latitude and potential temperature (℃). At each latitude band on the basin, the zonal integral of the meridional velocity is first computed, then integrated **from surface** to **the bottom**, by potential temperature ranges (℃) from $\theta_0 = 40$ to $\theta_b = -2$ and steps $\Delta\theta = 0.5$. Note that in this case, on the vertical, velocities are first binned for each vertical potential temperature step:

$$MOSFt(y,\theta) = \int_{x_1}^{x_2} dx \int_{\theta_0}^{\theta_b} v_\theta(x,y,\theta)\, d\theta, \quad \text{with} \quad v_\theta(x,y,\theta) = \frac{1}{z_\theta - z_{\theta+\Delta\theta}} \int_{z_\theta}^{z_{\theta+\Delta\theta}} v(x,y,z)\,dz,$$ sampled along latitude(7), and potential temperature range (℃).

- latitude and potential density (kg/m³). At each latitude band on the basin, the zonal integral of the meridional velocity is first computed, then integrated **from surface to the bottom**, by potential density anomaly range (kg/m³) from $\sigma_0 = 20$ to $\sigma = 28$ and steps $\Delta\sigma = 0.75$, and from $\sigma = 28$ to $\sigma_b = 30$ and steps $\Delta\sigma = 0.1$. Note that in this case, on the vertical, velocities are first binned for each density anomaly step:

$$MOSFs(y,\sigma) = \int_{x_1}^{x_2} dx \int_{\sigma_0}^{\sigma_b} v_\sigma(x,y,\sigma)\, d\sigma, \quad \text{with} \quad v_\sigma(x,y,\sigma) = \frac{1}{z_\sigma - z_{\sigma+\Delta\sigma}} \int_{z_\sigma}^{z_{\sigma+\Delta\sigma}} v(x,y,z)\,dz,$$ sampled along latitude[7] and potential density anomaly range.

On a Arakawa C grid, MOSF is computed as :

$$MOSF_{jk} = \sum_{i_1}^{i_2} \sum_{k_1}^{k_2} V_{ijk} \cdot e^{1v}{}_{ij} \cdot e^{3t}{}_k \times 10^{-6}$$, with k_1, k_2 the depths, or the depth bounding the potential density anomaly, or potential temperature; $e^{1v}{}_{ij}$ the longitudinal scale factor at V point for the grid cell ij ; and $e^{3t}{}_k$ the vertical scale factor at theta point for depth (or temperature or density ranges) k.

5.4. Class 3 Meridional Heat Transport

The Meridional Heat Transport (MHT) (PW=10^{15} Watt) per ocean basin (Atlantic, Pacific and Indian) as well as the Global Ocean Meridional Heat transport, computed at each latitude as the zonal and vertical integral of the meridional heat flux at each cell:

$$MHT(y) = \rho_0\, C_p \int_{z_b}^{z} dz \int_{x_1}^{x_2} v(x,y,z) \cdot \theta(x,y,z)\, dx$$, and sampled on the 1/8° standard grid, using the value of $\rho_0\, C_p = 4{,}09\, 10^{-6}$ J.K^{-1}.m^{-3} .

On a Arakawa C grid, MHT in PW is computed as :

$$MHT_j = \sum_{k_1}^{k_2} \sum_{i_1}^{i_2} \Theta_{i\,j+1/2\,k} V_{ijk} \cdot e^{1v}{}_{ij} \cdot e^{3t}{}_k \times 10^{-15}, \quad \text{where} \quad \Theta_{i\,j+1/2\,k} = \frac{1}{2}\left(\Theta_{i\,j-1\,k} + \Theta_{i\,j\,k}\right)$$ is the potential temperature value at V_{ijk} location.

5.5. Class 3 technical implementation

5.5.1. Class 3 file name convention

For volume transport, names of daily files will be similar to Class 2, using the name given for the section:

***CLASS3_VOLT_NAME_XXX_ZZZZ*_mean_YYYYMMDD_RYYYYMMDD.nc**

NAME	(variable length) specific name given for each section in Table 16
XXX	(3 digit) code of the GODAE partner see Table 20
ZZZZ	(variable length) specific name given to a particular system of the GODAE partner
YYYYMMDD	(8 digit) field date YYYY=YEAR, MM=MONTH, DD=DAY: corresponds to the date of the output stored in this file.
YYYYMMDD	(8 digit) bulletin date YYYY=YEAR, MM=MONTH, DD=DAY: corresponds to the date of the analysis, or the run from which the output is produced and the system operated

Table 17: Description of the name codes of the Class 3 file name

For instance, the Class 3 volume transport file for the section Atlantic_48N computed from the Mercator Océan system, for the 13th of March 2008, from the bulletin of the 26th of March 2008 will be:

CLASS2_VOLT_Atlantic_48N _MER_P3V2R2_mean_20080313_R20080326.nc

For Meridional Heat Transport, depending only on the basin (**RRR** values for **ATL**, **IND**, **PAC** or **GLO**) the name of daily files is (see Table 17 for the other codes):

***CLASS3_MHT_RRR_XXX_ZZZZ*_mean_YYYYMMDD_RYYYYMMDD.nc**

The Meridional Overturning Stream Function depends both on the basin (**RRR** values for **ATL**, **IND**, **PAC** or **GLO**), and the reference for computation (**V**, either **Z** for depth, **S** for sigma theta, and **T** for theta). See Table 17 for the other codes:

***CLASS3_MOSF_V_RRR_XXX_ZZZZ*_mean_YYYYMMDD_RYYYYMMDD.nc**

5.5.2. Class 3 Volume transport NetCDF format

The volume transport computed across a section is defined at least by two values: the sum of all positive cell transports across the section, stored in the variable **`VolT_p`**, and the sum of all negative cell transports across the section, stored in the variable **`VolT_n`**. If the water column is cut in segment defined by classes (temperature, salinity, density, depth) the number of transport values corresponds the number of classes + 1, due to the fact that the positive and negative total transport over the water column are also stored **(convention: always the last value of the variable transport array)**.

Each file contains the daily averaged transport values for a given section. In order to store the transport values, but also the bounding values of the classes, two dimensions have to be defined: **`transport`** and **`classbnd`**. For instance:

For the **PAC_Pacific_147E_10N_50N** section, the water column is layered in 5 classes, that is, 4 bounding values (i.e., σ_θ=26.6, 26.7, 26.8, 27.2), and 6 positive and 6 negative transport values (by including the total transport)

For the **BAL_WesternBaltic** section, **there are no classes**, thus one positive, and one negative transport values, and no bounding values. In this case, to avoid complexity with a null dimension in the NetCDF file, **it is recommended to put classbnd = 1 , and a missing value in the classes array**.

For the array of the different transport classes, Table 18 gives the **classes** attributes. Again, for temperature, given in Kelvin, there is the possibility to play with the "add_offset" value to get directly temperature in ℃.

Class of transport	dimension **classbnd**	long name	standard name	units
no	1	No transport classes		
temperature	n	Temperature transport classes	sea_water_potential_temperature	K
salinity	n	Salinity transport classes	sea_water_salinity	1e-3
density	n	Density transport classes	sea_water_sigma_theta	kg m-3
depth	n	Depth transport classes	depth	m

*Table 18: Attributes for the variable "**classes**" depending on the different possibilities. The "n" corresponds at the number of classes given by Table 16.*

Below is created a NetCDF file format example for the **PAC_Pacific_147E_10N_50N** section :

```
dimension:
    classbnd = 4 ;
    transport = 6 ;
variables:
    float classes(classbnd) ;
        classes:long_name = "Density transport classes" ;
        classes:standard_name = "sea_water_sigma_theta" ;
        classes:missing_value = -1.0E35 ;
        classes:units = "kg m-3" ;
        classes:positive = "down" ;
        classes:axis = "Z" ;
    float volt_p(transport) ;
        volt_p:units = "m3 s-1" ;
        volt_p:long_name = "Positive ocean volume transport across section" ;
        volt_p:standard_name = "ocean_volume_transport_across_line" ;
        vol_p:comment = "by not applying scale_factor values are readable in Sverdrup"
        volt_p:scale_factor = 1.0E6;
        volt_p:_FillValue = -1.0E35 ;
        volt_p:missing_value = -1.0E35 ;
    float volt_n(transport) ;
        volt_n:units = "m3 s-1" ;
        volt_n:long_name = "Negative ocean volume transport across section" ;
        volt_n:standard_name = "ocean_volume_transport_across_line" ;
        vol_p:comment = "by not applying scale_factor values are readable in Sverdrup"
        volt_n:scale_factor = 1.0E6;
        volt_n:_FillValue = -1.0E35 ;
        volt_n:missing_value = -1.0E35 ;
// global attributes:
        :title: "CLASS3 MERSEA TOPAZ model results for PAC_Pacific_147E_10N_50N" ;
        :comment: "Daily Averaged fields" ;
        :institution: "NERSC, Thormoehlens gate 47, N-5006 Bergen, Norway" ;
        :history: "20070208:Created by program hyc2stations, version V0.1" ;
        :source: "NERSC-HYCOM model fields" ;
        :references: "http://topaz.nersc.no" ;
        :field_type: "Daily average fields" ;
        :Conventions: "CF-1.0" ;
        :field_date: "2007-02-03" ;
```

```
        :bulletin_date: "2007-02-07" ;
        :field_julian_date = 20852 ;
        :bulletin_julian_date = 21001 ;
        :julian_day_unit = "days since 1950-01-01 00:00:00" ;
        :transport_classes: “density“ ;
        :section_name: "PAC_Pacific_147E_10N_50N" ;
        :bulletin_type: "Hindcast" ;
        :bulletin_type = "operational" ;
```

Some global attributes like **transport_classes**, and **section_name** are proposed to allow a better understanding of the file through a quick look of the header.

5.5.3. Class 3 MHT NetCDF format

The MHT corresponds to four daily averaged values, for the Global, Pacific, Atlantic, and Indian Oceans respectively. Thus four variables are necessary, that depend on latitude. To only use one latitude array, the longest one, that corresponds to the global MHT, is used for the four MHT latitudes. A NetCDF file format example is created below :

```
dimension:
    latitude = 1431 ;
variables:
    float latitude(latitude) ;
        latitude:_CoordinateAxes = "latitude " ;
        latitude:units = "degrees_north" ;
        latitude:valid_range = -90.0, 90.0 ;
        latitude:long_name = "Latitude" ;
        latitude:standard_name = "latitude" ;
        latitude:axis = “Y” ;
    float mht_glo(latitude) ;
        mht_glo:units = "W" ;
        mht_glo:long_name = "Global ocean meridional heat transport" ;
        mht_glo:standard_name = "northward_ocean_heat_transport" ;
        mht_glo:comment = “by not applying scale_factor values are readable in PetaWatt”
        mht_glo:scale_factor = 1.0E15;
        mht_glo:_FillValue = -1.0E35 ;
        mht_glo:missing_value = -1.0E35 ;
    float mht_atl(latitude) ;
        mht_atl:units = "W" ;
        mht_atl:long_name = "Atlantic ocean meridional heat transport" ;
        mht_atl:standard_name = "northward_ocean_heat_transport" ;
        mht_atl:comment = “by not applying scale_factor values are readable in PetaWatt”
        mht_atl:scale_factor = 1.0E15;
        mht_atl:_FillValue = -1.0E35 ;
        mht_atl:missing_value = -1.0E35 ;
    float mht_pac(latitude) ;
        mht_pac:units = "W" ;
        mht_pac:long_name = "Pacific ocean meridional heat transport" ;
        mht_pac:standard_name = "northward_ocean_heat_transport" ;
        mht_pac:comment = “by not applying scale_factor values are readable in PetaWatt”
        mht_pac:scale_factor = 1.0E15;
        mht_pac:_FillValue = -1.0E35 ;
        mht_pac:missing_value = -1.0E35 ;
    float mht_ind(latitude) ;
        mht_ind:units = "W" ;
        mht_ind:long_name = "Indian ocean meridional heat transport" ;
        mht_ind:standard_name = "northward_ocean_heat_transport" ;
        mht_ind:comment = “by not applying scale_factor values are readable in PetaWatt”
        mht_ind:scale_factor = 1.0E15;
        mht_ind:_FillValue = -1.0E35 ;
        mht_ind:missing_value = -1.0E35 ;

// global attributes:
        :title: "CLASS3 MERSEA TOPAZ model results for Meridional Heat Transport" ;
        :comment: "Daily Averaged fields" ;
        :institution: "NERSC, Thormoehlens gate 47, N-5006 Bergen, Norway" ;
        :history: "20070208:Created by program hyc2stations, version V0.1" ;
        :source: "NERSC-HYCOM model fields" ;
        :references: “http://topaz.nersc.no” ;
```

```
        :field_type: "Daily average fields" ;
        :Conventions: "CF-1.0" ;
        :field_date: "2007-02-03" ;
        :bulletin_date: "2007-02-07" ;
        :field_julian_date = 20852 ;
        :bulletin_julian_date = 21001 ;
        :julian_day_unit = "days since 1950-01-01 00:00:00" ;
        :bulletin_type: "Hindcast" ;
        :bulletin_type = "operational" ;
```

5.5.4. Class 3 OSF NetCDF format

Depending on the reference for computation (depth, potential density, or potential temperature) three files are defined, with similar structures. In each file, the Meridional Overturning Stream Functions is stored for the 4 basins (GLO, PAC, IND and ATL) in four variables, as indicated in Table 15. Each variable depends on latitude and either depth, sigma-theta, or theta. Like for MHT definition, the latitude array is chosen as the global array. Below is the NetCDF file format example created in the case of the density reference:

```
dimension:
    latitude = 1431 ;
    sigma = 32 ;
variables:
    float sigma(sigma) ;
        sigma:_CoordinateAxes = "sigma" ;
        sigma:long_name = "Potential density anomaly reference" ;
        sigma:standard_name = “sea_water_sigma_theta“ ;
        sigma:units = "kg m-3" ;
        sigma:valid_range = 20.0, 30.0 ;
        sigma:positive = "down" ;
        sigma:axis = "Z" ;
    float latitude(latitude) ;
        latitude:_CoordinateAxes = "latitude " ;
        latitude:units = "degrees_north" ;
        latitude:valid_range = -90.0, 90.0 ;
        latitude:long_name = "Latitude" ;
        latitude:standard_name = "latitude" ;
        latitude:axis = “Y” ;
    float mosfs_glo(sigma,latitude) ;
        mosfs_glo:_CoordinateAxes = " sigma latitude " ;
        mosfs_glo:scale_factor = 1.E6 ;
        mosfs_glo:comment = “by not applying scale_factor values are readable in Sverdrup”
        mosfs_glo:_FillValue = -1.0E35 ;
        mosfs_glo:missing_value = -1.0E35 ;
        mosfs_glo:long_name = " Global ocean meridional overturning streamfunction defined
by density " ;
        mosfs_glo:units = "m3 s-1" ;
        mosfs_glo:standard_name =
"ocean_meridional_overturning_streamfunction_defined_by_sigma_theta" ;
    float mosfs_ind(sigma,latitude) ;
        mosfs_ind:_CoordinateAxes = " sigma latitude " ;
        mosfs_ind:scale_factor = 1.E6 ;
        mosfs_ind:comment = “by not applying scale_factor values are readable in Sverdrup”
        mosfs_ind:_FillValue = -1.0E35 ;
        mosfs_ind:missing_value = -1.0E35 ;
        mosfs_ind:long_name = "Indian ocean meridional overturning streamfunction defined by
density " ;
        mosfs_ind:units = "m3 s-1" ;
        mosfs_ind:standard_name =
"ocean_meridional_overturning_streamfunction_defined_by_sigma_theta" ;
    float mosfs_pac(sigma,latitude) ;
        mosfs_pac:_CoordinateAxes = " sigma latitude " ;
        mosfs_pac:scale_factor = 1.E6 ;
        mosfs_pac:comment = “by not applying scale_factor values are readable in Sverdrup”
        mosfs_pac:_FillValue = -1.0E35 ;
        mosfs_pac:missing_value = -1.0E35 ;
        mosfs_pac:long_name = "Pacific ocean meridional overturning streamfunction defined
by density " ;
        mosfs_pac:units = "m3 s-1" ;
```

```
        mosfs_pac:standard_name =
"ocean_meridional_overturning_streamfunction_defined_by_sigma_theta" ;
    float mosfs_atl(sigma,latitude) ;
        mosfs_atl:_CoordinateAxes = " sigma latitude " ;
        mosfs_atl:scale_factor = 1.E6 ;
        mosfs_atl:comment = “by not applying scale_factor values are readable in Sverdrup”
        mosfs_atl:_FillValue = -1.0E35 ;
        mosfs_atl:missing_value = -1.0E35 ;
        mosfs_atl:long_name = "Atlantic ocean meridional overturning streamfunction defined
by density " ;
        mosfs_atl:units = "m3 s-1" ;
        mosfs_atl:standard_name =
"ocean_meridional_overturning_streamfunction_defined_by_sigma_theta" ;

// Global attributes:
        :title: "CLASS3 MERSEA TOPAZ model results for MHT reference by density " ;
        :comment: "Daily Averaged fields" ;
        :institution: "NERSC, Thormoehlens gate 47, N-5006 Bergen, Norway" ;
        :history: "20070208:Created by program hyc2stations, version V0.1" ;
        :source: "NERSC-HYCOM model fields" ;
        :references: “http://topaz.nersc.no” ;
        :field_type: "Daily average fields" ;
        :Conventions: "CF-1.0" ;
        :field_date: "2007-02-03" ;
        :bulletin_date: "2007-02-07" ;
        :field_julian_date = 20852 ;
        :bulletin_julian_date = 21001 ;
        :julian_day_unit = "days since 1950-01-01 00:00:00" ;
        :mosf_reference: "Density" ;
        :mosf_sigma_integration: “20 to 28 by 0.75, then 28 to 30 by 0.1” ;
        :bulletin_type: "Hindcast" ;
        :bulletin_type = "operational" ;
```

6. CLASS 4 METRICS FOR THE GLOBAL OCEAN

The Class 4 metrics are not detailed in this document. As already mentioned in the introduction (section 2.2.4), the keypoints for the Class 4 metrics are:

- Limited to “observational space” and not “model space” diagnostics, which means that observations are compared to forecasting system outputs.
- Performed off-line: the different system outputs are interpolated at the exact location and date of the chosen observations.
- Using a well identify and common set of observations. This is the most important point, which guarantees that all forecasting systems are going to be identically assessed, and moreover, that their performance can be inter-compared.

Two kinds of comparisons have been implemented and tested within MERSEA, and can be performed during the GODAE intercomparison project:

- Comparison to temperature and salinity in situ data. The implementation guideline is described in [REF4], where it is explained how differences to in-situ profile have to be managed. Then, at a monthly rate, diagnostics based on these differences have to be performed on 412 geographical boxes (Figure 6-1) and 6 depth classes (0-5m, 5-100m, 100-500m, 500-2000m, 2000-5000m, Total: 0-5000m). Example of this kind of diagnostic is given in Figure 2-9.
- Comparison to sea ice concentration, and drift. For the Artic Ocean, implementation guideline is described in [REF3] and [REF9]. SSM/I sea ice concentration and drift maps are compared to system outputs. Differences are computed, then diagnostics are computed in 16 boxes, described in Table 19. Example of this kind of diagnostic is given in Figure 2-8.

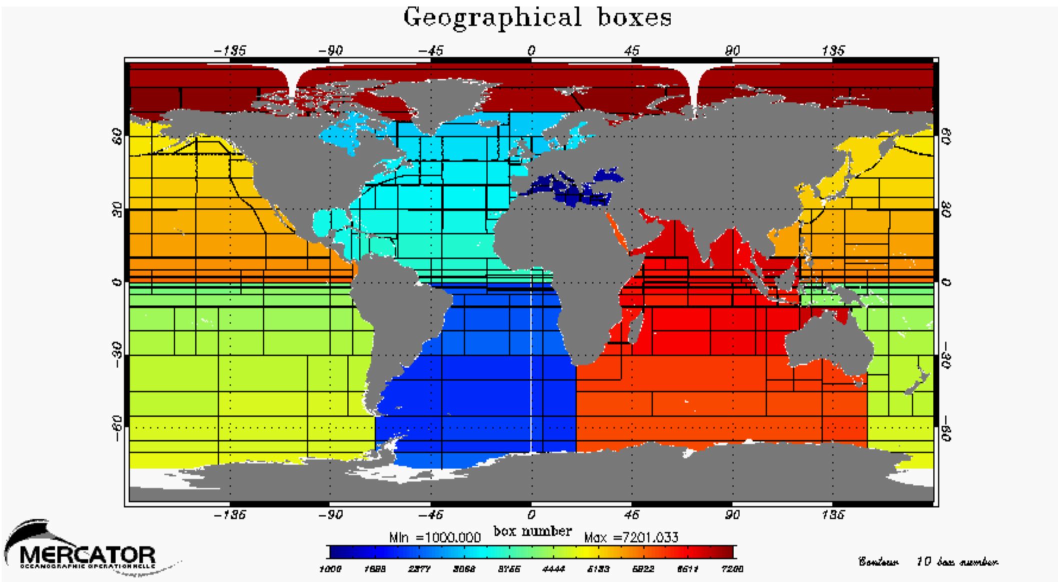


Figure 6-1: Elementary boxes for temperature and salinity Class 4 statistics.

Box number	Name
1	North Pole : Deep Ocean
2	Queen Elisabeth Islands
3	Beaufort Sea
4	Chuckchi Sea
5	Siberian Sea
6	Laptev Sea
7	Kara Sea
8	Barents Sea
9	Greenland Basin
10	Southeast Greenland
11	Bafin Bay
12	Hudson Bay
13	Labrador Sea
14	Bering Sea
15	Okhotsk Sea
16	Baltic Sea

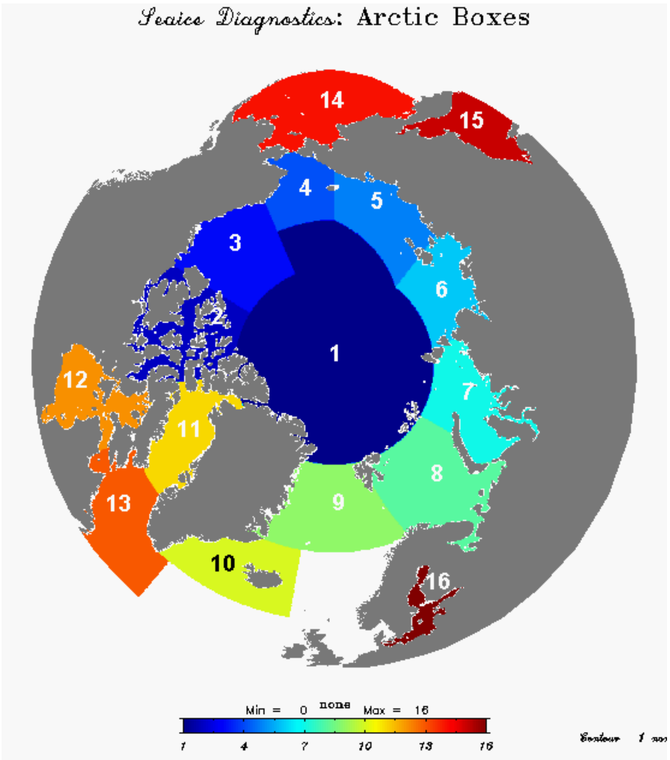


Table 19: Numbers and names of the Arctic boxes, and geographic limits

Class 4 based on sea level differences with tide gauges can also be considered, using all the Class 2 tide gauge moorings already defined (see section 4.7). In this case, a dedicated common tide gauge delivery center has to be identified. In the same idea, Class 4 metrics based on sea level comparison with along-track or mapped sea surface height can also be considered, using the box averaging defined above (Figure 6-1). Note that technical implementation need to be defined.

7. PLAN FOR INTERCOMPARISON BETWEEN GODAE PARTNERS

The intercomparison projects aims to show that:

- GODAE forecasting centers are producing ocean hindcasts and forecasts in real time
- GODAE forecasting centers are associated into a network that allows a common and distributed assessment of their products, sharing methods and data for validation

The main outcome expected from this intercomparison is:

- Allowing the GODAE forecasting centers to identify strength and weaknesses of their respective systems in operation
- Share, and improve a set of methods –or standards- that can be endorsed at the international level, as a basis of assessment tools.

7.1. Intercomparison calendar

In practice, the following calendar and actions are scheduled:

Implement the metrics, till February 2008. Class 1 metrics are off line computation, as well as Class 4 metrics. Both rely on interpolation scheme that can produce the different metrics using the “native grid” products. Class 2 and 3 need a dedicated implementation in-line, that will run while the systems are operatated.

Run the system in real time from beginning of February to end of April 2008, compute in real time the metrics. Metrics file have to be stored in OpenDAP servers.

Assessment and validation conclusions will be raised in May and June 2008, in order to be presented for the GODAE meetings.

7.2. Consistency assessment

As mentioned in section 2.2, the first step of the assessment consist in verifying that ocean products delivered by the different GODAE partners offer a consistent view of the ocean dynamics and variability. The following diagnostics have to be performed by each GODAE center using the “best estimate” or “hindcast” products, then these diagnostics can be compared among the different partners:

- Ocean surface elevation:
  - Using Class 1 gridded files, compare the 3-month average (February-March-April) to equivalent mean SSH deduced from AVISO altimeter maps
  - Using Class 1 gridded files, compare monthly averaged SSH to equivalent mean SSH deduced from AVISO altimeter maps:

- Ocean circulation (both wind driven and thermohaline, at the surface and at depth):
  - Using Class 1 files, compare the Mean Kinetic Energy over the three month period to equivalent of OSCAR or SURCOUF averaged surface current
  - Using Class 1 gridded files and Class 2 sections, compare the Mean Kinetic Energy to known values at depth.
  - Using Class 3 volume transport sections, compute the averaged over the three month period and compare to known values at different location in the ocean.
  - Using Class 3 MHT and OSF, compute the averaged over the three month period and compare to known values for the world ocean and in the different basins.
- Water masses:
  - Using Class 1 gridded files, compare the monthly averaged temperature and salinity fields at the different depths to WOA monthly climatological values.
  - Using Class 2 sections, compare the monthly averaged temperature and salinity fields at the different depths to WOA monthly climatological values.
  - Same diagnostics can be performed using other regional climatologies
- Mesoscale activity:
  - Using Class 1 gridded files, compare the 3-month EKE statistics (February-March-April) to equivalent mean SSH deduced from AVISO altimeter maps
- Surface conditions:
  - Using Class 1 gridded files, compare the monthly averaged MLD to the climatology [*D'Ortenzio et al.*, 2005; *de Boyer Montégut et al.*, 2004].
  - Using Class 1 gridded files, compare the monthly averaged SST to NCEP/Reynolds climatology.
  - Using Class 1 gridded files, draw vs latitude, globally and in each basin, and for each month: a) the zonally average surface net heat flux (including restoring terms); b) the zonally average SST; c) the zonally average surface net fresh water fluxes (including restoring terms); d) the zonally average SSS; e) the zonally average MLD
- Sea Ice:
  - Using the Class 1 gridded files, compare the monthly averaged sea-ice concentration to equivalent mean values from SSM/I sea-ice concentration products.

7.3. Quality assessment

As mentioned in section 2.2, the quality assessment aims to verify the accuracy of the hindcast, that is, measure the precision of daily estimates of the ocean and sea ice circulation and dynamics provided by the different GODAE systems in operations. The following diagnostics have to be performed:

- Ocean surface elevation:
  - Using Class 1 gridded files, compute daily differences to AVISO SSH, then map statistics of differences (mean, RMS).
  - Using Class 2 mooring, compute daily differences to tide gauge sea level measurements, then map time series and corresponding statistics (mean, RMS and correlations).

- Ocean circulation and mesoscale activity:
  - Using Class 1 gridded files, compare the surface currents to OSCAR or SURCOUF equivalent products (at least weekly).
  - Using Class 1 gridded files, compare at a weekly rate large scale currents meandering with AVISO satellite altimetry maps.
  - Using Class 1 gridded files and Class 2 sections (e.g., equatorial sections), draw Howmuller diagrams of sea level changes (i.e., identify wave propagations over the three month period).
  - Using Class 3 volume daily transport sections, compare time series of transport with observations (statistics of the differences: mean, RMS, correlation).
- Water masses:
  - Using Class 2 sections and moorings, compare to available data (XBT lines, WOCE/CLIVAR sections etc…).
  - Using Class 2 moorings (like TAO moorings), draw Howmuller diagram of temperature and salinity fluctuations from GODAE products, and observations.
  - Using Class 4 metrics T/S files, compare hindcast every week, for each basin, for the same depth average than Class 4 diagnostics. Compare also θ-S diagram whenever it is possible (when both temperature and salinity profiles are available).
- Surface conditions:
  - Using Class 1 gridded files, compare the daily SST to observed SST products from GHRSST, at global or regional scales. Compare SST time series averaged in boxes (Nino boxes etc….).
- Sea Ice:
  - Using the Class 1 gridded files, compare daily sea ice concentration and drift with values from SSM/I sea-ice products.

7.4. Performance assessment

As mentioned in sections 2.2.4 and 6, Class 4 metrics are implemented off-line. These metrics are not fully described in this document. If diagnostics based on Class 4 metrics are decided among the GODAE partners, informations will be given to ensure efficient implementations by the different partners.

Class 4 metrics based on temperature and salinity in-situ data can be implemented rapidly: the ARGO Coriolis center at Ifremer is already delivering daily file in the framework of MERSEA. Same thing for sea ice Class 4 metrics.

7.5. Observation/measurement availability

The assessment proposed in sections 7.2, 7.3, and 7.4 relies on observations and measurements obtained and available for the 3 months period. A first list of identified sources is:

- Satellite altimetry and AVISO maps are available at http://www.aviso.oceanobs.com/
- Surface currents maps: OSCAR maps are available at http://www.oscar.noaa.gov/index.html . SURCOUF products, prepared by CLS will be made available.
- Sea Surface Temperature: from GHRSST, different products are available
- SSM/I sea ice concentration and drift: available for MERSEA participants, a check is needed for providing these products to all GODAE partners
- Sea level from tide gauges: these data might have some delay. Data available from the GLOSS database: http://www.gloss-sealevel.org/ . Eventually, tide gauge data, reprocessed and filtered from tide signal could be made available by Mercator Océan for the three months period.
- In situ temperature and salinity (from moorings, ARGO floats, XBT VOS lines etc…..): a dedicated delivery is produced operationally, every day, by the Coriolis Data Center in the framework of the MERSEA assessment activities. A check is needed to see if this delivery can be proposed to all GODAE participants.

This list could be extended. Moreover, as soon as possible, the availability of data listed above will be confirmed.

8. CONCLUDING REMARKS

This document offer a self consistent set of information for implement diagnostics (Class 1, 2 and 3 metrics) for the GODAE intercomparison project in 2008.

However some points still need to be clarified, and could not at this stage for several reasons:

- Some NetCDF formatting quantities (like standard name) are rather new, and have not been fully endorsed by the COARDS CF groups. Actions are made to push for an endorsement of what it is proposed in this document.
- Some set of data proposed for the intercomparison are yet not made available for all GODAE partners. This will be check rapidly, and agreement searched with the different delivery centers.

It is important to take into account that this metrics definition has been the opportunity to review many technical aspects, in particular standardization for file productions. And it appears that standards have evolved since previous metrics definition, in particular, in the framework of MERSEA. **It is thus highly recommended that every GODAE partner check carefully the metrics definition, in order to modify their implementation, and guarantee similarities for all.**

It is also recommended, to save disk storage, in particular for Class 1 metric files, to take benefit of the compression capabilities offered by the NetCDF formats. However, even if compression is not adopted, this is not a problem for exchanging data, since OpenDAP servers, but also most of the programming tools that read these NetCDF files can automatically adapt their reading procedures.

This document is associated with a series of ASCII files, and fortran programs that will allow every GODAE partner to get the same precise implementation informations.

9. ANNEX: COMPUTATION OF CLASS 1 GRIDS

This is a small fortran 90 program that a) defines the 11 different areas, and b) gives the computation of longitude and latitude points of each grid.

```
PROGRAM Class1Grid

  !
  !**** Class1Grid
  !
  !
  !     Purpose :
  !     Compute the Lon/lat of regional grids, Class 1 or "vitrine" type
  !     for three type of grids:
  !                             Regular (DEG)
  !                             Mercator projection (MER)
  !                             StereoPolar (STP)
  !     This program is self-sufficient for computing Class 1 grids for
  !     the GODAE project, because ALL GODAE Class 1 grids are defined below
  !     and can be computed.
  !
  !     History
  !     -------
  !      Version    Programmer    Date       Description
  !      --------------------------------------------
  !       1.0       FHZ         3/05/2007    created and named calc_GrilleVitrine
  !       2.0       FHZ         10/12/2007   modif. Rename Class1Grid
  !                                          modif for all GODAE grids
  !
  !*------------------------------------------------------------
  !

  !
  !** ++  Local Declarations
  !

  IMPLICIT NONE

  !!  1D LON/LAT Mercator or Regular projection computation:
  !!  ---------------------------------------------------
  !!  rd_lonmin       The minimum longitude value of the grid.
  !!  rd_lonmax       The maximum longitude value of the grid.
  !!  rd_lonres       The resolution value of the longitude axis.
  !!                    (Ex: for 1/4 deg. resolution, value is 4)
  !!  rd_latmin       The minimum latitude value of the grid.
  !!  rd_latmax       The maximum latitude value of the grid.
  !!  rd_latres       The resolution value of the latitude axis.
  !!                    (Ex: for 1/4 deg. resolution, value is 4)
  !!  cl_area         The area
  !!  cd_gridtype     Type of grid: regular degrees (DEG), or
  !!                                mercator projection (MER)
  !!  rla_lonVect     1D Array of longitude values
  !!  rla_latVect     1D Array of latitude values

  REAL(KIND=4) :: rd_lonmin, rd_lonmax, rd_latmin, rd_latmax,&
       & rd_lonres,rd_latres
  REAL(KIND=8) :: rl_dx, rl_dy
  INTEGER(kind=4) :: il_nbx, il_nby,il_ji, il_nbsouth, il_nbnorth, il_jmin, il_jmax
  INTEGER(kind=4) , PARAMETER :: ip_dim=5000
  REAL(KIND=8), DIMENSION(ip_dim) :: rla_northlat, rla_southlat
  REAL(KIND=8), PARAMETER :: rl_northlimit=89., rl_southlimit=-89.
  REAL(kind=4),DIMENSION(:),ALLOCATABLE :: rla_lonVect,rla_latVect
  CHARACTER(len=3)                      :: cl_area,cd_gridtype
  INTEGER(kind=4)                       :: il_nlon,il_nlat
  REAL(KIND=8) :: rl_pi

  !! 2D LON/LAT Stereo Polar computation
  !! ----------------------------------
  !!  id_nx           The number of points along X axis
  !!  id_ny           The number of points along Y axis
  !!  rd_psclon       The polar stereographic central longitude
  !!  rd_psclat       The polar stereographic central latitude
```

```
!!  rd_proj         The proj_conv_fac (to obtain distance in Km)
!!  rla_lonGrid     2D array of longitude values.
!!  rla_latGrid     2D array of latitude values.

INTEGER :: id_nx,  id_ny
INTEGER :: id_nxcenter,id_nycenter
REAL(KIND=4) :: rd_psclon  ! polar stereographic central longitude
REAL(KIND=4) :: rd_psclat  ! polar stereographic central latitude
REAL(KIND=4) :: rd_proj    ! proj_conv_fac
REAL(KIND=4), DIMENSION(:,:),ALLOCATABLE :: rla_lonGrid,rla_latGrid
REAL(KIND=4), PARAMETER :: rl_rade = 57.29577951 ! radian to degree conv factor
REAL(KIND=4), PARAMETER :: rl_re = 6378.273 ! radius of earth
REAL(KIND=4) :: rl_x, rl_y,rl_rho,rl_c
INTEGER ::  il_jii, il_jj, il_jjj



!
!*---------------------------------------------------------------
!
rl_pi = 4.*ATAN(1.)


! Ask for area
WRITE(0,'(a,$)')'Area :'
READ(5,'(a)')cl_area

! Define area parameters
IF ( cl_area == 'NAT' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    787
   il_nlat       =    597
   rd_latmin     =    0.
   rd_latmax     =    70.
   rd_lonmin     =   -100.0
   rd_lonmax     =   31.
   rd_lonres     =   6.
   rd_latres     =   6.
ELSE IF ( cl_area == 'SAT' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    601
   il_nlat       =    453
   rd_latmin     =   -60.
   rd_latmax     =   0.
   rd_lonmin     =   -70.0
   rd_lonmax     =   30.0
   rd_lonres     =   6.
   rd_latres     =   6.
ELSE IF ( cl_area == 'IND' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    601
   il_nlat       =    458
   rd_latmin     =   -40.
   rd_latmax     =   31.
   rd_lonmin     =   20.
   rd_lonmax     =   120.0
   rd_lonres     =   6.
   rd_latres     =   6.
ELSE IF ( cl_area == 'NPA' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    1099
   il_nlat       =    518
   rd_latmin     =   0.
   rd_latmax     =   65.
   rd_lonmin     =   100.
   rd_lonmax     =   283.0
   rd_lonres     =   6.
   rd_latres     =   6.
ELSE IF ( cl_area == 'SPA' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    1141
   il_nlat       =    453
   rd_latmin     =   -60.
   rd_latmax     =   0.
   rd_lonmin     =   100.
```

```
   rd_lonmax     =   290.0
   rd_lonres     =   6.
   rd_latres     =   6.
ELSE IF ( cl_area == 'TAT' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    421
   il_nlat       =    163
   rd_latmin     =   -20.
   rd_latmax     =   20.
   rd_lonmin     =   -90.
   rd_lonmax     =   15.
   rd_lonres     =   4.
   rd_latres     =   4.
ELSE IF ( cl_area == 'TPA' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    801
   il_nlat       =    163
   rd_latmin     =   -20.
   rd_latmax     =   20.
   rd_lonmin     =   90.
   rd_lonmax     =   290.0
   rd_lonres     =   4.
   rd_latres     =   4.
ELSE IF ( cl_area == 'ACC' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    1441
   il_nlat       =    937
   rd_latmin     =   -89.
   rd_latmax     =   -35.
   rd_lonmin     =   -180.0
   rd_lonmax     =   180.0
   rd_lonres     =   4.
   rd_latres     =   4.
ELSE IF ( cl_area == 'MED' ) THEN
   cd_gridtype   = 'MER'
   il_nlon       =    385
   il_nlat       =    187
   rd_latmin     =   30.0
   rd_latmax     =   48.0
   rd_lonmin     =   -6.0
   rd_lonmax     =   42.0
   rd_lonres     =   8.
   rd_latres     =   8.
ELSE IF ( cl_area == 'GLO' ) THEN
   cd_gridtype   = 'DEG'
   il_nlon       =    721
   il_nlat       =    359
   rd_latmin     =   -89.
   rd_latmax     =   90.
   rd_lonmin     =   -180.0
   rd_lonmax     =   180.0
   rd_lonres     =   2.
   rd_latres     =   2.
ELSE IF ( cl_area == 'ARC' ) THEN
   cd_gridtype   = 'STP'
   id_nx = 609
   id_ny = 881
   rd_psclon = -45.0
   rd_psclat = 90.0
   rd_proj = 0.08
ELSE
   PRINT*,'NO AREA'
   GOTO 9999
ENDIF

!* Resolutions
rl_dx = 1./rd_lonres
rl_dy = 1./rd_latres

!
!*------------------------------------------------------------
! Longitude for Regular of Mercator projection

IF ( cd_gridtype .EQ. 'DEG' .OR. cd_gridtype .EQ. 'MER' ) THEN
   !** Define longitude array
```

```
    il_nbx = NINT((rd_lonmax-rd_lonmin)/rl_dx) + 1
    IF ( ALLOCATED(rla_lonVect) ) DEALLOCATE(rla_lonVect)
    ALLOCATE ( rla_lonVect(il_nbx) )

    !* Compute longitude array
    DO il_ji=1,il_nbx
       rla_lonVect(il_ji) = REAL(rd_lonmin +(il_ji-1)*rl_dx,4)
    ENDDO

 ENDIF

 !
 !*-------------------------------------------------------------
 ! Latitude array computation: depending on Regular and Mercator projection

 !** Regular projection
 IF ( cd_gridtype .EQ. 'DEG') THEN

    il_nby = NINT((rd_latmax-rd_latmin)/rl_dy) + 1
    IF ( ALLOCATED(rla_latVect) ) DEALLOCATE(rla_latVect)
    ALLOCATE ( rla_latVect(il_nby) )
    DO il_ji=1,il_nby
       rla_latVect(il_ji)  = REAL(rd_latmin + (il_ji-1)*rl_dy,4)
    ENDDO

    !** MERCATOR projection
 ELSE IF ( cd_gridtype .EQ. 'MER') THEN

    !** Computation of all possible latitudes on the northern hemiphere
    il_ji=1
    rla_northlat(1)=0.
    DO WHILE (rla_northlat(il_ji) < rl_northlimit)
       il_ji=il_ji+1
       IF ( il_ji > ip_dim ) THEN
          PRINT*,'STOP: rla_northlat il_ji > ip_dim'
          GOTO 9999
       ENDIF
       rla_northlat(il_ji) = ASIN(TANH((0. +(il_ji-1)*rl_dy)*rl_pi/180.))* 180./rl_pi
       il_nbnorth=il_ji-1
    ENDDO

    !** Computation of all possible latitudes on the southern hemiphere
    il_ji=1
    rla_southlat(1)=0.
    DO WHILE (rla_southlat(il_ji) > rl_southlimit)
       il_ji=il_ji+1
       IF ( il_ji > ip_dim ) THEN
          PRINT*,'STOP: rla_southlat il_ji > ip_dim'
          GOTO 9999
       ENDIF
       rla_southlat(il_ji) = ASIN(TANH((0. - (il_ji-1)*rl_dy)*rl_pi/180.))*180./rl_pi
       il_nbsouth=il_ji-1
    ENDDO

    !** Test for the Northern Hemisphere
    IF (rd_latmin >= 0.) THEN

       !* look for min indices of rla_northlat
       il_ji = 1
       DO WHILE (il_ji < il_nbnorth .AND. rla_northlat(il_ji) < rd_latmin )
          il_ji=il_ji+1
       END DO
       il_jmin=il_ji
       !* look for max indices of rla_northlat
       IF ( rd_latmax >= rla_northlat(il_nbnorth) ) THEN
          il_jmax=il_nbnorth
       ELSE
          il_ji=il_jmin
          DO WHILE (il_ji <= il_nbnorth .AND. rla_northlat(il_ji) < rd_latmax )
             il_ji=il_ji+1
          END DO
          il_jmax=il_ji-1
       ENDIF

       !* Define latitude array
```

```
      il_nby=il_jmax-il_jmin+1
      IF ( ALLOCATED(rla_latVect) ) DEALLOCATE(rla_latVect)
      ALLOCATE ( rla_latVect(il_nby) )
      rla_latVect(1:il_nby) = REAL(rla_northlat(il_jmin:il_jmax),4)

      !** area on both south and north hemisphere
   ELSE IF ((rd_latmin < 0.) .AND. (rd_latmax > 0.)) THEN

      !* look for min indices of rla_southlat
      DO il_ji=1,il_nbsouth
         IF (rla_southlat(il_ji) >= rd_latmin) il_jmin=il_ji
      ENDDO
      !* look for max indices of rla_northlat
      DO il_ji=1,il_nbnorth
         IF (rla_northlat(il_ji) <= rd_latmax) il_jmax=il_ji
      ENDDO

      !* Define latitude array
      il_nby=il_jmin+il_jmax-1
      IF ( ALLOCATED(rla_latVect) ) DEALLOCATE(rla_latVect)
      ALLOCATE ( rla_latVect(il_nby) )
      DO il_ji=1,il_jmin-1
         rla_latVect(il_ji) = REAL(rla_southlat(il_jmin-il_ji+1),4)
      ENDDO
      DO il_ji=il_jmin,il_nby
         rla_latVect(il_ji) = REAL(rla_northlat(il_ji-il_jmin+1),4)
      ENDDO

      !** Test for the Southern Hemisphere
   ELSE IF ((rd_latmin < 0.) .AND. (rd_latmax <=0.)) THEN

      !* look for max indices of rla_southlat
      il_ji = 1
      DO WHILE (il_ji < il_nbsouth .AND. rla_southlat(il_ji) > rd_latmax )
         il_ji=il_ji+1
      END DO
      il_jmax=il_ji
      !* look for min indices of rla_southlat
      IF ( rd_latmin <= rla_southlat(il_nbsouth) ) THEN
         il_jmin=il_nbsouth
      ELSE
         il_ji=il_jmax
         DO WHILE (il_ji <= il_nbsouth .AND. rla_southlat(il_ji) > rd_latmin )
            il_ji=il_ji+1
         END DO
         il_jmin=il_ji-1
      ENDIF

      !* Define latitude array
      il_nby=ABS(il_jmax-il_jmin)+1
      IF ( ALLOCATED(rla_latVect) ) DEALLOCATE(rla_latVect)
      ALLOCATE ( rla_latVect(il_nby) )
      DO il_ji=1,il_nby
         rla_latVect(il_ji) = REAL(rla_southlat(il_jmin-il_ji+1),4)
      ENDDO

   ENDIF

   !
   !*-------------------------------------------------------------
   ! Latitude and Longitude 2D array computation for StereoPolar

ELSE IF ( cd_gridtype .EQ. 'STP') THEN

   !* Define latitude array
   IF ( ALLOCATED(rla_latGrid) ) DEALLOCATE(rla_latGrid)
   ALLOCATE ( rla_latGrid(id_nx,id_ny) )

   !* Define longitude array
   IF ( ALLOCATED(rla_lonGrid) ) DEALLOCATE(rla_lonGrid)
   ALLOCATE ( rla_lonGrid(id_nx,id_ny) )

   id_nxcenter = id_nx/2
   id_nycenter = id_ny/2
```

```
     DO il_ji=1, id_nx
        DO il_jj=1, id_ny

           !* compute the X and Y coordinates on the regular stereopolar grid
           rl_x = (il_ji-id_nxcenter)/rd_proj
           rl_y = (il_jj-id_nycenter)/rd_proj

           !* compute the distance to the center of the grid
           rl_rho =SQRT(REAL(rl_x*rl_x+rl_y*rl_y,4))
           rl_c = 2*ATAN(rl_rho/(2*rl_re))

           !* compute the latitude
           rla_latGrid(il_ji,il_jj) = rl_rade*ASIN(COS(rl_c))

           !* compute the longitude
           IF (il_jj .EQ. id_nycenter) THEN
              IF (il_ji .LE. id_nxcenter) THEN
                 rla_lonGrid(il_ji,il_jj) = rd_psclon - 90
              ELSE
                 rla_lonGrid(il_ji,il_jj) = rd_psclon + 90
              ENDIF
           ELSE
              IF (il_jj .LE. id_nycenter) THEN
                 rla_lonGrid(il_ji,il_jj) = rd_psclon +  &
                      & rl_rade*ATAN(-(REAL(il_ji-id_nxcenter,4)) / &
                      & (REAL(il_jj-id_nycenter,4)))
              ELSE
                 IF (il_ji .GT. id_nxcenter) THEN
                    rla_lonGrid(il_ji,il_jj) = rd_psclon +  &
                         & rl_rade*ATAN(-(REAL(il_ji-id_nxcenter,4)) / &
                         & (REAL(il_jj-id_nycenter,4))) + 180
                 ELSE
                    rla_lonGrid(il_ji,il_jj) = rd_psclon +  &
                         & rl_rade*ATAN(-(REAL(il_ji-id_nxcenter,4)) /  &
                         & (REAL(il_jj-id_nycenter,4))) - 180
                    IF ( rla_lonGrid(il_ji,il_jj) .LT. -180.0 ) THEN
                       rla_lonGrid(il_ji,il_jj) = 360 + rla_lonGrid(il_ji,il_jj)
                    ENDIF
                 ENDIF
              ENDIF
           ENDIF

           WRITE(12,*)rla_lonGrid(il_ji,il_jj),rla_latGrid(il_ji,il_jj)

        ENDDO
     ENDDO


  ENDIF

  IF ( cd_gridtype .EQ. 'DEG' .OR. cd_gridtype .EQ. 'MER' ) THEN
     DO il_ji=1,il_nbx
        DO il_jj=1,il_nby
           WRITE(12,*)rla_lonVect(il_ji),rla_latVect(il_jj)
        ENDDO
     ENDDO
  ENDIF


9999 CONTINUE
END PROGRAM Class1Grid
```

10. ANNEX: READ THE SECTIONS FILES

This is a small fortran 90 program that allows to read easily the different “sections” files

```
PROGRAM lire_metrics_fic
  ! FAbrice Hernandez, April 2007
  ! Mercator OCean
  ! Fortran 90 Code to read MERSEA/GODAE metrics files
  ! in collab. with Laurence Crosnier

  ! compil:
  ! pgf90 -r4 -o lire_metrics_fic.exe lire_metrics_fic.f90

  IMPLICIT NONE

  CHARACTER (len=255) :: cl_nomfic
  CHARACTER (len=255) :: cl_nom,cl_dum
  REAL (kind=4) :: rl_lon,rl_lat
  REAL (kind=4),DIMENSION(:),ALLOCATABLE  :: rla_lon,rla_lat
  INTEGER :: il_nb,ib

  !** Type the file name on screen
  WRITE(*,'(a,$)')'Metrics File Name: '
  READ(5,*) cl_nomfic

  ! Open the file
  OPEN(unit=10,file=TRIM(cl_nomfic),status='old')
640 FORMAT(2f10.4,2x,a46,i6)
641 FORMAT(2f10.4,2x,a46)
642 FORMAT(a46,1x,4f10.4)

  !** Read the first line, that contains the number
  ! of points for the section
100 READ(unit=10,fmt=640,END=1000)rl_lon,rl_lat,cl_nom,il_nb

  !** allocate lon/lat array for the current section.
  ALLOCATE (rla_lon(1:il_nb))
  ALLOCATE (rla_lat(1:il_nb))
  rla_lon(1) = rl_lon
  rla_lat(1) = rl_lat
  !** Read the rest of the section
  DO ib = 2 , il_nb
     READ(unit=10,fmt=640)rl_lon,rl_lat,cl_dum
     ! check for errors in the section name
     IF ( .NOT. (TRIM(cl_dum)==TRIM(cl_nom))) THEN
        PRINT*,rla_lon(1),rla_lat(1),cl_nom,il_nb
        PRINT*,rl_lon,rl_lat,cl_dum
        GOTO 9999
     ENDIF
     rla_lon(ib) = rl_lon
     rla_lat(ib) = rl_lat
  ENDDO
  ! write just for testing
  write(*,642)adjustl(cl_nom),rla_lon(1),rla_lat(1),rla_lon(il_nb),rla_lat(il_nb)
  IF ( ALLOCATED(rla_lon)) DEALLOCATE(rla_lon)
  IF ( ALLOCATED(rla_lat)) DEALLOCATE(rla_lat)

! loop      back on the next section
  GOTO 100
1000 CONTINUE
  CLOSE(10)

9999 CONTINUE

END PROGRAM lire_metrics_fic
```

11. ANNEX: TECHNICAL IMPLEMENTATION INFORMATION

11.1. Code for GODAE partner names

Mercator Océan	MER
UK-Met	UKM
NERSC, TOPAZ system	TOP
BlueLink	BLK
INGV, MFS system	MFS
JMA-MRI	MRI
HYCOM-US	HYC

Table 20: Name code for GODAE partners