QUALIFICATION OF THE MYOCEAN GLOBAL OCEAN ANALYSIS AND FORECASTING SYSTEM: A QUARTERLY REPORT OF PERFORMANCE AND SKILL ESTIMATION FOR VARIOUS APPLICATIONS.

M. Drévillon (1), E. Greiner(2), C. Régnier(1), F. Hernandez(1), L. Crosnier(1), N. Verbrugge(2), N. Pene(3), J-M Lellouche(1), B. Tranchant(4), M. Benkiran(2), E. Rémy(4), N. Ferry(1), L. parent(1), G. Garric(1), B. Levier(1), C Maraldi(1), S. Guinehut(2) and the Mercator Océan team

(1) Mercator Océan, 8-10 rue Hermès, Parc technologique du canal, 31520 Ramonville-Saint-Agne, France, Email: mdrevillon@mercator-ocean.fr
(2) CLS, 8-10 rue Hermès, Parc technologique du canal, 31520 Ramonville-Saint-Agne, France
(3) AKKA Informatique & Systèmes, 6 rue Roger Camboulives, 31100 Toulouse, France
(4) CERFACS, 42 avenue Gaspard Coriolis, 31100 Toulouse, France

This paper describes the *quality report* of the Mercator Océan monitoring and forecasting system that is initiated in the context of MyOcean. Measuring the quality of the systems also aims at giving information on the strength and weaknesses of the real time observation network.

1. INTRODUCTION

1.1. MyOcean and Mercator

The operational oceanography European project *MyOcean* is part of the Global Monitoring for Environment and Security GMES program**.** During the next 3 years (April 2009-april 2011), 61 European partners in 29 different countries will work to build a pan European ocean monitoring and forecasting capacity. The “marine core service” will be produced by ocean forecast centers and data assembly centres working together. MyOcean is particularly attentive with the setting of quality control, including the scientific validation of the products.

The global ocean component of MyOcean is run at Mercator-Ocean and is based on the ocean and sea ice modelling system NEMO [2],[1] and on a data assimilation system based on a reduced order Kalman filter using the SEEK formulation [3], [6]. It is declined in eddy permitting and eddy resolving configurations. The current version of the global system [5] has a ¼° horizontal resolution, with a North Atlantic (including the tropics) and Mediterranean zoom at 1/12° , and a global 1/12° system is under development which will be the reference global ocean analysis and forecasting system at the end of MyOcean. The current systems assimilate in a multivariate way RTG-SST (from NOAA) at ½°, SLA from Jason1, Jason2 and Envisat (from DUACS), and in situ temperature and salinity profiles from CORIOLIS (Ifremer) including ARGO floats. The atmospheric forcing comes from ECMWF analyses and forecast.

1.2. Why do we need a regular quality report?

The hereafter described *quality report* (which will probably be updated on a quarterly basis) has two main goals.

- One aim is to measure and keep track of the performance of the system in order to identify possible improvements. This includes measuring the impact of changes in the real time observation network and giving useful information for the improvement of this network.
- A second aim is to be a basis for regular interactions with the scientific community and other users so that they can derive the level of confidence (or the correction they have to make) for the use of the products for their own application.

In order to monitor the quality of the ocean forecast and analyses, we need a sustainable observation network with a relatively high spatial and temporal resolution (Wilson et al., 2009, Harrison et al. 2009, reference is on http://www.godae.org/Invited-papers.html). Today’s medium to high density observation network is a prerequisite for data assimilation in the ocean analysis and forecasting systems as well as for validation purposes. In order to validate the systems and follow their performance we also need reliable long reference time series like ocean reanalyses. The latter are also necessary to provide interannual or decadal anomalies (for instance for users who whish to initialize seasonal forecast, decadal forecast).

The selection of a number of ocean forecast scores has been initiated with the definition of an ensemble of ***metrics*** in the context of the European MERSEA project (http://www.ifremer.fr/merseaip/) and the international GODAE initiative (http://www.godae.org/). These standardized diagnostics have permitted intercomparison exercises at the European and international levels [4].

Following the spirit of the Numerical Weather Prediction centres quality reports and based on the existing ocean metrics and on various data comparisons, the present paper describes the content of a preliminary version of the ocean monitoring and forecasting quality report. A short overview of the quality of the production of Mercator Océan state-of-the-art analysis and forecast system for the last spring season April-May-June 2009 is thus given as an example.

2. CONTENTS OF THE QUALITY REPORT

The following diagnostics are computed for the averaged season, in this first report: April May June 2009. Some of the computations described here are not already displayed, but will progressively be added in the next versions of the report.

2.1. Input data

A quarterly report is already produced for the input data of the Mercator-ocean systems (SLA and in situ temperature and salinity profiles for the moment). The quality report will display a synthesis of this document including the maps of the spatial coverage of the input data. The main technical informations from the data centers shall also be included.

In addition, data rejected by the data assimilation system will be listed, which will point out undetected biases in the observations.

Consequently this chapter will provide useful material to interact with the data centers.

2.2. Climate signal

Mercator Océan is involved in a monthly meeting of a group of climate and seasonal forecast experts at Météo-France. They analyse the current state of the atmosphere and ocean, as well as all the available seasonal forecast from EUROSIP and WMO (see the following URLs http://www.ecmwf.int/products/catalogue/pseth.html, http://www.wmo.int/pages/prog/wcp/wcasp/clips/producers_forecasts.html). Knowing the quality of each seasonal forecast products, the experts can choose between various scenarios. This work shows that each system has its qualities and flaws depending on the season and the physical mechanism at play, and that identifying them is very important to understand the results.

First, a synthesis of the mean state of the ocean and the atmosphere will thus be included in this report, as well as a note on the verification of the seasonal forecast for the considered period.

This will describe the main large scale atmosphere and climate forcing exerted on the ocean, and the large scale ocean atmosphere couplings that are taking place.

Second, *Ocean climate monitoring metrics* on the global ocean will be defined together with the data centres (MyOcean Thematic Assembly Centres or TAC) and followed in time.

This will provide a basis for interactions with the seasonal forecast scientific community.

2.3. Forecast error

Time series diagrams will be made with the CLASS4 MERSEA metrics. The forecast, nowcast, hindcast, climatology and persistence are co-localized with the observations in space and time. This way the time evolution of the RMS forecast error (as well as nowcast, hindcast, climatology and persistence RMS errors) can be displayed for a given quantity averaged in a given spatial region.

The forecast error can also be defined as the *forecast minus the hindcast* in order to evaluate the forecasting skill of the system. The hincast, also called “best analysis”, is in our case the analysis assimilating the maximum quantity of observations available 2 weeks back from real time which is used as a proxy of the observations.

The 2D maps of both the mean error and the RMS error are computed for the three months period for the following ocean variables: temperature, sea surface height, velocity and mixed layer depth. The errors mostly concentrate on the regions of known biases of the model or of high spatio-temporal variability. The maps that are produced allow the user to quantify the error after 1 week or 2 weeks of forecast.

Forecast error statistics computed on a long time period will also be updated and compared to the quarterly statistics.

2.4. Data assimilation diagnostics

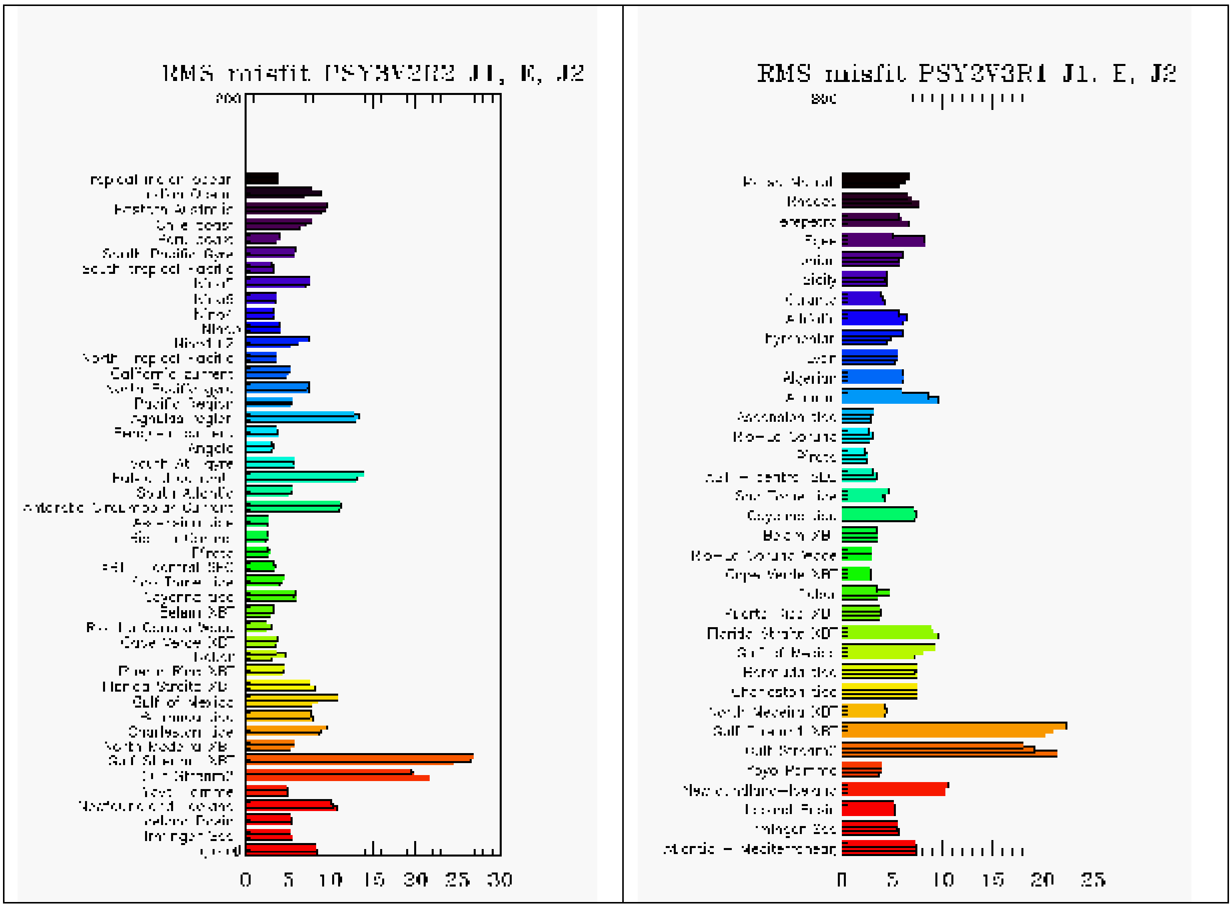

Figure 1: RMS misfit of SLA data (m) averaged in spatial regions, on the left for the global system at ¼° and on the right for the North Atlantic and Mediterranean system at 1/12°. The three columns for each region stand for the three satellites Jason 1 (J1), Jason 2 (J2), and Envisat (E)

Synthesis tables of the classical data assimilation statistics (average and RMS of innovation) will be displayed for predefined spatial regions and for each type of assimilated data (satellite altimetry, in situ temperature and salinity profiles, and SST).

The different running systems will be inter-compared, for instance in Fig. 1, where we can see that in the “Gulf Stream1 XBT” region (in orange) the RMS misfit is slightly lower in the high resolution zoom of the North Atlantic and Mediterranean compared to the global system.

The performance will be compared with the canonical performance of the systems (computed on several years) for this season.

This information for all type of assimilated data will contribute to identify the major biases of the system, and what has to be improved. Fig. 1 confirms that we have to improve the high resolution zoom in order to better reduce the RMS error with respect to the lower resolution global system.

2.5. Comparisons with independent data

Comparisons are also made with observations that are not yet assimilated in the system, like high resolution SST (OSTIA, ODYSSEA), or tide gauges (the low frequency component of the tide gauges signal for the current systems, but also the high frequency component for the future IBI system which will be operational at the end of MyOcean. This system covers the European coast from Ireland to Portugal and the western Mediterranean Sea at 1/36°).

Comparisons with currents at 15m derived from drifting buoys show that the directions of the hindcast currents are satisfactory, as most of the angles with the observed current are smaller than 45°. In terms of velocity, the hindcast surface currents are generally underestimated by the Mercator Océan system (Fig. 2). This bias has already been identified in NEMO and is under investigation. A part of this difference may be due to a tendency of drifting buoys to follow strong currents: a shift of a small jet of a few kilometres in the model with respect to the reality could induce large velocity differences. If the small jet is transient and not representative of the currents in the region, then we need other current observations to conclude.

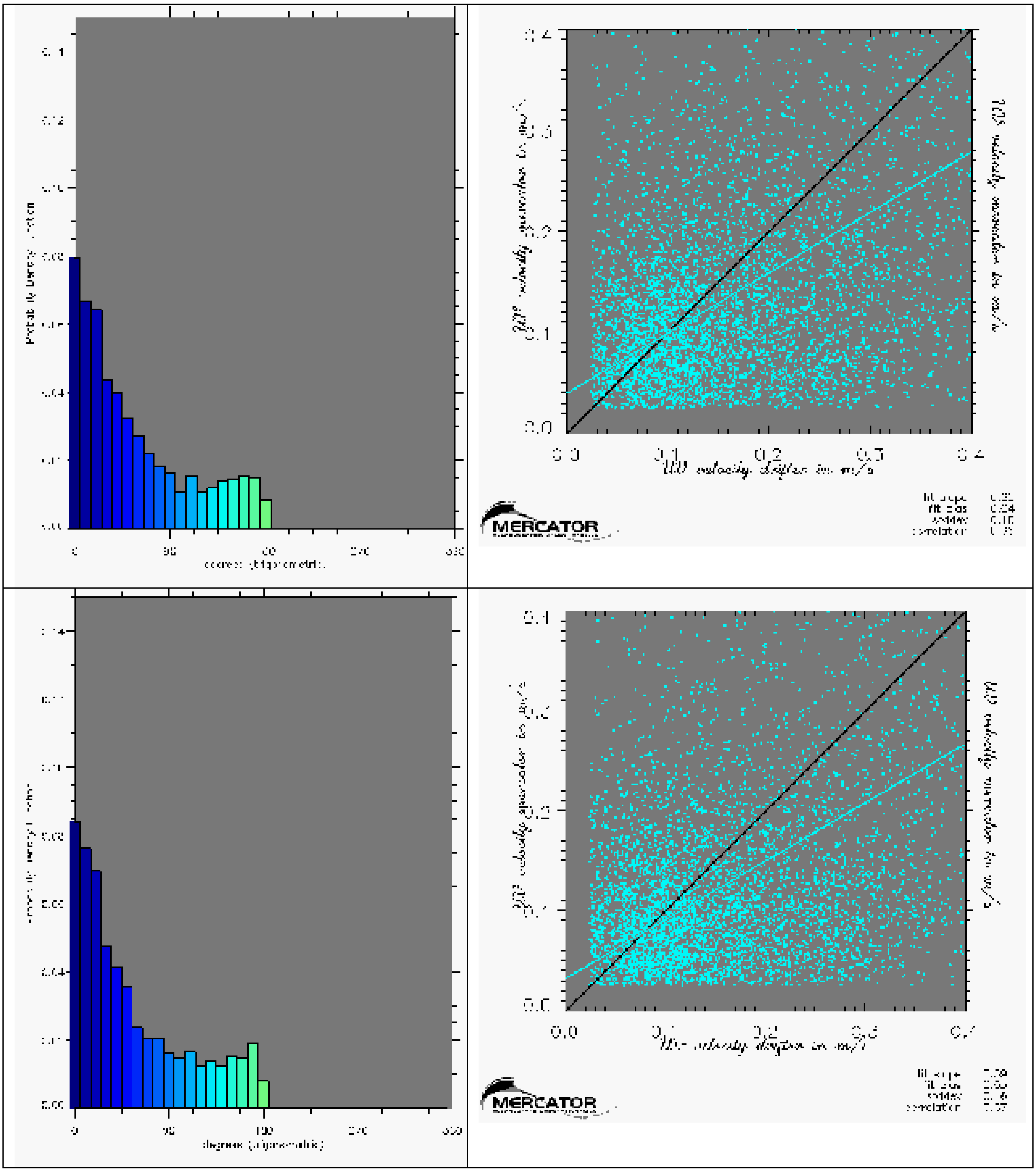

Figure 2: Comparisons between drifting buoys current at 15 m (in m/s) and the global ¼° system currents (lower panels) and North Atlantic and Mediterranean zoom (upper panels). On the left a probability density function of the angle (degrees) between the observed and the system current (hindcast) is displayed. On the right a dispersion diagram between the observed velocities (m/s, on the x-axis) and the hindcast velocities (m/s, on the y-axis) is displayed.

3. CONCLUSION

A quarterly quality report is thus "under construction" at Mercator Océan in the context of MyOcean. MERSEA CLASS4 metrics, 2D maps of forecast errors, data assimilation statistics, and comparisons with independent data will be followed in time. These performance diagnostics will be assorted of information on the status of input data and of a brief description of the climatic context. These diagnostics altogether will help to derive general 2d error maps for the ocean forecast and analysis products such as surface currents, temperature, mixed layer depth etc…

The report also has the ambition to serve as an interactive platform with different communities of users of the operational oceanography products including the data centres. It could also constitute a basis of future intercomparisons at international level (like GODAE-OceanView for example).

This way we hope to provide error bars for ocean analysis and forecast adapted to each user, as well as useful information for the improvement of their application.

When building this report we note that many ideas can be derived from the NWP and seasonal forecast community, and the report points out the interest of *intercomparing systems* in order to better understand each system but also to identify regions or phenomena that have a good level of predictability. A recommendation is to *maintain and develop in a concerted way common metrics* for the MyOcean and GODAE-OceanView systems.

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