SSALTO/DUACS and operational altimetry : en route to GODAE

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Abstract

GODAE requires global, near real-time, high accuracy and high resolution observations of sea surface topography. The SSALTO/DUACS system has been designed to meet these requirements and is ready to serve GODAE.

Introduction

The near real time (NRT) processing of altimeter data was developed by CLS as part of DUACS (Developing Use of Altimetry for Climate Studies), a European Commission 3-year project which started in February 1997. DUACS was coordinated by CLS, and gathered four of the major climate research teams in Europe. Since the end of DUACS, the system has continued to provide NRT altimeter data for operational oceanography applications. In the mean time, a new version of the system was also developed and is now operational. The new system called SSALTO/DUACS is part of the CNES SSALTO multi-mission ground segment. It incorporates several improvements in the processing algorithms and is able to merge TOPEX/POSEIDON (TP) , ERS-2 , GEOSAT Follow On (GFO), Jason-1 and ENVISAT data. The most recent geophysical corrections are applied as well as improved orbit error and long wavelength error reduction schemes.

1. Overview

1.1 Data Used

For TOPEX/Poseidon, the SSALTO/DUACS system uses IGDR data from the AVISO website (NAVOCEAN data for TOPEX and SSALTO data for Poseidon). ERS-2 altimeter data are real time FDP data. GFO data are daily IGDR files provided by NOAA. The altimeter data for Jason-1 and ENVISAT are delivered within 48 hours on the SSALTO data server.

Altimetric product	Source	availability	Type of orbit
TOPEX IGDR	Navocean - AVISO	48h	CNES MOE
Poseidon IGDR	AVISO	48h	CNES MOE
ERS-2 FDP (URA)	Meteo-France	< 1 day	DELFT MOE
GFO IGDR	NOAA	72 h	NOAA MOE
Jason IGDR	AVISO	48 h	CNES MOE
ENVISAT IGDR	AVISO	48 h	CNES MOE

Table 1 : **SSALTO/DUACS Input Altimeter Data**

Various Dynamic Auxiliary Data are needed to process these altimeter data. The 24 hour ERS-2 orbit is computed by the Delft University with the DGM-E04 gravity model. The pressure and wet tropospheric correction grids from the ECMWF model are provided by *Météo France*, and the pole tide is computed from IERS data.

1.2 Overview of the processing system

The main processing steps of the SSALTO/DUACS system are (see figure 1):

- •Acquisition of altimeter data and auxiliary data,
- •Update of corrections, homogenization and validation,
- •Orbit error reduction through global crossover minimization,
- •Local inverse method to reduce long wavelength errors,
- •Production along-track Sea Level Anomaly (SLA) data for each mission,
- •Production of maps of Sea Level Anomaly (MSLA),
- •Distribution via ftp/web servers (www.jason.oceanobs.com/html/donnees/duacs)

Off-line validation is also regularly performed by comparing SSALTO/DUACS NRT products with the delayed mode high quality altimeter data distributed by AVISO.

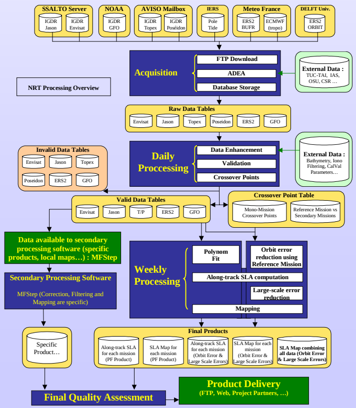

Figure 1 : **NRT Processing Overview**

2. Objective analysis

Global crossover minimizations (Le Traon and Ogor, 1998) and local inverse methods allow us to derive **inter-calibrated and high accuracy SSH** (Sea Surface Height) data. Mean profiles are then used to reference multiple altimeter data.

TP/Jason-1 mean is a 7-year mean (1993-1999). A specific processing was applied to ensure that ERS/ENVISAT and GFO means are consistent with the TP one (Le Traon et al., 2002). This **provides consistent SLA data for the different missions**. Data are then merged through **a global space time objective mapping technique** that takes into account correlated noise (Le Traon et al., 1998; Ducet et al., 2000).

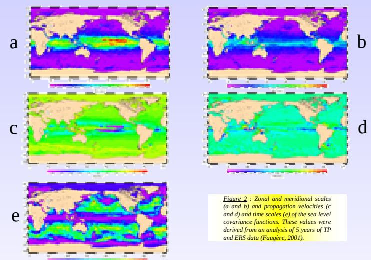

Figure 2 : *Zonal and meridional scales (a and b) and propagation velocities (c and d) and time scales (e) of the sea level covariance functions. These values were derived from an analysis of 5 years of TP and ERS data (Faugère, 2001).*

The mapping and the local inverse methods both use an improved statistical description of sea level variability, noise and Long Wavelength (LW) errors. Therefore, sea level covariance functions include propagation velocities and depend on geographical position (see figures 2a to 2e).

For the error covariance, in addition to instrumental noise, a noise of 10% of the signal variance is used to take into account the small scale variability. LW errors due to residual orbit errors but also tidal or inverse barometer errors and high frequency ocean signals were derived from an analysis of TP and ERS data (figure 3).

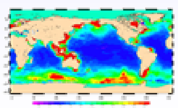

Figure 3 : *TP Long Wavelength errors. Units are cm².*

This improved statistical characterization of errors is crucial to reduce aliasing problems due to high frequency signals and for deriving precise estimates of the velocity field (Le Traon et al., 1998; Le Traon et al., 2001; Le Traon et al., 2002).

3. SSALTO/DUACS Products

Every week, the following products are distributed :

- Along-track Sea Level Anomaly (SLA) from TP/Jason-1, ERS-2/ENVISAT and GFO.
- High resolution Maps of SLA and their formal errors on a 1/3° MERCATOR grid (figures 4 and 5)

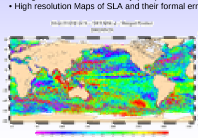

Figure 4 : **MSLA combining data from T/P, ERS and GFO.**

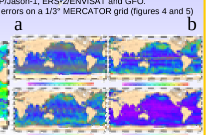

Figure 5 : **Formal mapping error (in % of signal variance)for T/P (a), ERS2 (b), GFO (c) and T/P+ERS2+GFO (d).**

4. Merging contribution

The processing system and the merging of multiple altimeter missions allow us to produce high quality and high resolution altimeter data in near real time. SSALTO/DUACS products can thus be used both for climate and mesoscale applications. As can be seen on figure 6, the merging of TP and ERS is crucial to better resolve the mesoscale variability.

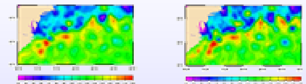

Figure 6 : **Comparison of absolute dynamic topography in the Gulf Stream (December 5, 1999) from T/P only (left) and from the combination of T/P and ERS 2 (right).**

Effective techniques to merge GFO with TP and ERS data were also developed (Le Traon et al., 2002). Thanks to these techniques, we have shown that GFO can be combined with TP and ERS and that the combination provides a significant improvement in the description of the mesoscale ocean circulation (figure 7).

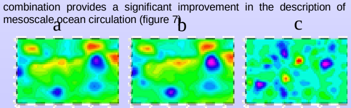

Figure 7 : **Sea level Anomaly maps derived from the merging of TP+ERS 2 (a) and TP+ERS 2+GFO (b) in the Gulf Stream region on January 4, 2001. The difference is shown in c.**

5. Evolutions

5.1 Mean Dynamic Topography

As part of the EC ENACT and MERCATOR projects, a 7-year mean dynamic topography is being computed to get absolute dynamic topography measurements from altimetry (see Rio et al. poster). This should have a large impact for the use of altimeter data in operational applications.

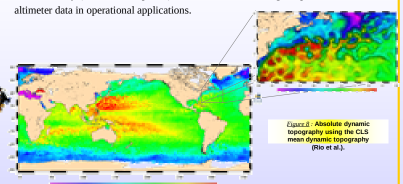

Figure 8 : **Absolute dynamic topography using the CLS mean dynamic topography (Rio et al.).**

5.2 Using Jason and Envisat

The system will incorporate Jason-1 and ENVISAT data as soon as they are readily available. First tests with NRT Jason-1 data are very encouraging and Jason-1 will soon replace T/P data for the operational products.

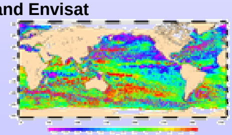

Figure 9 : **MSLA from Jason 1, ERS 2 and GFO (May 1, 2002).**

6. Applications

The main objective of SSALTO/DUACS is to provide MERCATOR, GODAE and climate forecasting centers with directly usable high quality NRT altimeter data.

6.1 Mercator and GODAE

SSALTO/DUACS has been serving the MERCATOR and SOAP modeling and data assimilation centers for the last two years. Its data are now used by other GODAE partners (DIADEM/TOPAZ, FOAM) and for the Mediterranean Forecasting System (MFS). These centers have a strong requirement for multiple altimeter data sets (mesoscale applications).

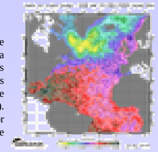

Figure 10 : **Sea level and ocean circulation forecast from the first MERCATOR prototype.**

6.2 Seasonal and Climate forecasting

Since the beginning of DUACS, the system has been serving seasonal and climate forecasting centers. The focus here is on high accuracy. Main centers in Europe and in the US are now using SSALTO/DUACS products : ECMWF, UKMO, LDEO, NOAA, MPI, CERFACS

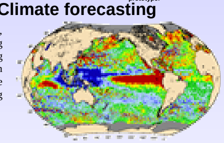

Figure 11 : **Real time monitoring of the 1997/1998 El Nino event.**

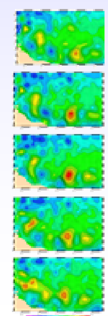

Figure 12: *Real-time monitoring of North Brazil Current Rings for offshore applications.*

6.3 Offshore and fisheries

On the commercial side, SSALTO/DUACS products have been successfully tested by fishing fleets to help locate favorable fishing grounds. The same information can be used by national agencies in charge of managing fish stocks to help them better assess these stocks and understand how they are impacted by changes of the oceanic environment.

Similarly, SSALTO/DUACS products are tested to plan and monitor operations on offshore drilling sites. This is done, in particular, through the ESA EMOFOR project which gathers CLS, the Nansen Center and Fugro GEOS.

6.4 Conclusions

SSALTO/DUACS is now serving a wide range of users. Using common processing facilities to jointly serve scientific (e.g. scientific cruise optimization), operational (mesoscale and climate) and commercial customers [illegible]s to all users.

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