June 2008, n°1

Users Newsletter

Project News

N. Picot (CNES)

This is the first issue of the entirely new Aviso Newsletter. Distributed only electronically, and dedicated to meeting the needs of data users, this newsletter highlights CNES altimetry-mission activities over the past 6 months. We hope you will share your feedback and expectations with us, to enable us to continue improving this newsletter. We plan to provide regular information on projects (satellites, as well as data processing and reprocessing, current and future), validation, data use examples, outreach information, and a list of events on the agenda.

In-orbit missions

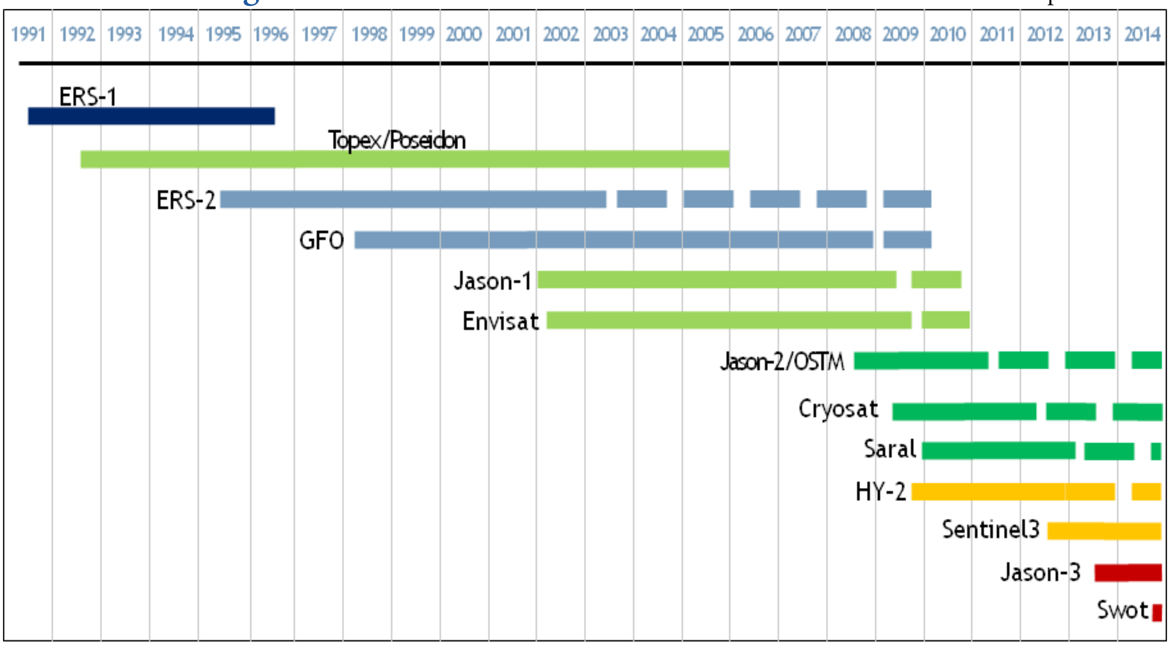
Data from Jason-1, Envisat and GFO continue to be routinely processed on the CNES side to generate GDRs and higher level products.

2007 was marked by several incidents affecting data coverage and the quality of near real time level 3 data. The main problem was on the GFO satellite: due to battery ageing, the payload is now without power whenever the solar panels are not exposed to the sun, leading to an obvious impact on data coverage. On Envisat, several platform and RA2 incidents occurred, leading to data availability falling below 90% (including in January 2008). In early 2008 (on 17 January 2008, 23:23:40, UTC), transmission power for the Envisat S-band altimeter suddenly dropped. Consequently, all S-band parameters, as well as the dual ionospheric correction have now become irrelevant and cannot be used from this date onwards. As a result, ionospheric correction now has to be derived from the model.

Ongoing developments

Several programmes are currently under development or under analysis. They include Jason-2, CryoSat, SARAL/AltiKa, Sentinel3, Jason-3 and 4, SWOT…, with CNES playing a role in each one. Jason-2 is obviously the most demanding, as the satellite is due to be launched in just a few weeks. The Jason-2 launch campaign continues to go smoothly and is on schedule. Its launch is currently planned for June 15th, 2008 (Vandenberg, California, USA). Jason-2 has started its long journey to its final orbit, first by road from Cannes to Toulouse (on April 24th), then by plane from Toulouse to Vandenberg (on April 28th), and finally on top of the Delta-2 rocket (scheduled for June 20).

Jason-2 will be launched on the same orbit as its predecessors (Topex/Poseidon and



Green: processed by Salp (light green: ongoing – including reprocessing; dark green: future missions to be processed by Salp)

Jason-1). Besides the increased precision, particularly in coastal areas, Jason-2 will bring satellite altimetry into a new era of operational oceanography. NOAA (National Oceanic and Atmospheric Administration) and EUMETSAT, both operational agencies, have joined the program on their respective side of the Atlantic in order to implement the operational goals of the Jason-2 mission.

Delta-2 rocket and Jason-2 ready to be installed on the top of the rocket (Credits left NASA/Dan Liberotti, CNES/T. Lafon)

Jason-2 will be placed about 1 minute behind Jason-1, to enable very tight calibration of both systems. Regarding data products, as is the case for all missions, the launch will be followed by CalVal phases. Products will then be disseminated to selected users (the CalVal team selected by NASA, CNES and EUMETSAT). A first validation workshop will be organized for November 2008 (in Nice, France) mainly to validate the quality of the near real time products (known as OGDR, these products will be routinely generated by both NOAA and EUMETSAT). Once fully validated, OGDR products will be available to the whole community (NOAA and EUMETSAT are the agencies in charge of their distribution). In parallel, off-line products (known as IGDR and GDR, routinely generated by CNES) will also be analyzed and validated by the same CalVal team. A second validation workshop will be organized for March 2009 (San Diego, CA - USA) mainly to validate the quality of the off-line products. Once fully validated, IGDR products will be available to the whole community (CNES and NOAA are the agencies in charge of their distribution). Regular information will be provided on the AVISO web site.

Production status and planned reprocessing campaigns

No changes or significant evolution of the scientific aspects have been implemented in the ground processing segments since the development of GDR_B standards: level 2 products for Jason-1 and Envisat are based on the standards set up in late 2005.

Jason-1 reprocessing in GDR_C is under preparation. We expect to have these new standards ready by early June 2008, followed by reprocessing of the whole mission (retroactive). The fact that Jason-1 GDR_C standards will be the ones applicable to Jason-2 CalVal phases and Jason-1 products are now generated in the same format as Jason-2 products (NetCdf) should facilitate the CalVal campaign.

In parallel, ESA is starting to implement the new processing standards. Envisat GDRs using the same geophysical standards as Jason-1 should be ready by July 2008, and will also be followed by a complete reprocessing campaign. In that context, CNES is preparing the GDR processing segment, the orbit processing segment and everything needed to ensure that the reprocessing is done smoothly.

Moreover, we are also preparing Topex reprocessing. In a close cooperation with NASA/JPL, we are defining a new processing segment to reprocess all 13 years of data using the same GDR_C geophysical standards.

Future developments

To further increase product quality, CNES has undertaken two major studies. The first one is related to coastal altimeter products. The second one covers open ocean altimeter products.

The coastal altimeter products study is known as 'PISTACH', which stands for: 'Prototype Innovant de Système de Traitement pour l'Altimétrie Côtière et l'Hydrologie' (i.e. Coastal and Inland Water Innovative Altimetry Processing Prototype'). The major objectives of PISTACH are:

1. Development of new standards for coastal applications.

2. Generation of GDR products during the Jason-2 CalVal phase, dissemination of these products to PI groups (OSTST PI community and others), validation and evolution, presentation of results during 2009 OSTST meeting.

3. As for ocean processing our objective is to obtain OSTST approval for the proposed processing methods.

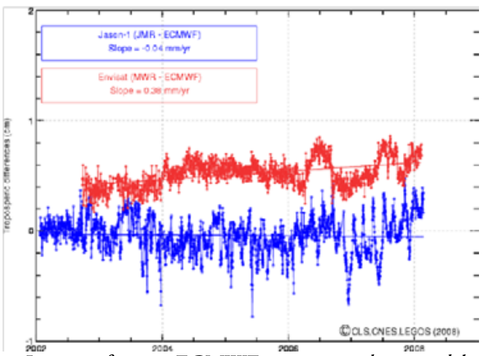
Calval updates: Mean Sea Level

M. Ablain, G. Valladeau (CLS)

Mean Sea Level (MSL) is one of the most sensitive indicators of altimetry data quality. Since the early years of Topex/Poseidon, Calval procedures have always included the monitoring of global MSL, mission by mission, as one of their systematic quality checks. MSL is also, of course, an indicator of global mass, temperature and salinity changes in the ocean, which is used as a reference in climate science and thus has to be as accurate as possible. . Using different data sources for the corrections, and other independent datasets such as in situ data make it possible to estimate the upper bound of MSL errors, as well as to identify the main sources of uncertainties – and thus potentially improve altimetry data quality.

Estimating errors in MSL trends

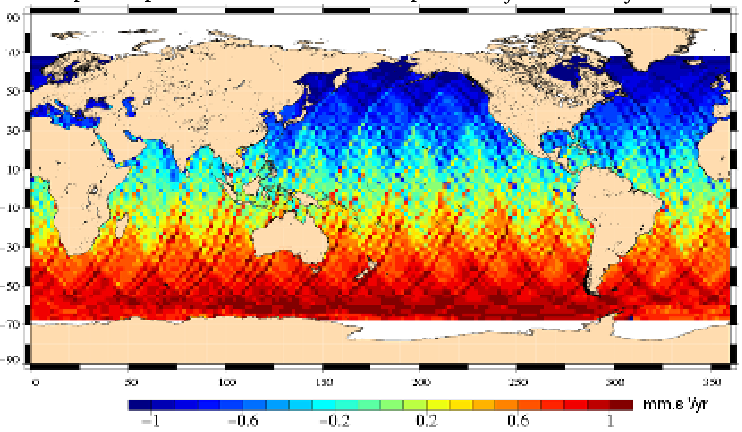
The wet tropospheric correction is the correction that takes into account the fact that the altimetry radar wave is perturbed by the liquid water in the atmosphere. It can be computed from onboard radiometer measurements or from meteorological models. The comparison of long-term stability between wet tropospheric correction from radiometers (TMR on Topex/Poseidon, JMR on Jason-1) and from models (NCEP, ECMWF, ERA40) shows differences of up to 0.4 mm/yr in the global trend, and up to 4 mm/yr regionally in some wet areas. Even if the stability of the models is not necessarily better than that of the radiometers, it is a clear indication that the wet tropospheric correction is an important source of uncertainty in computing MSL trends.



Impact of using ECMWF wet troposphere model on global MSL trend vs Radiometer correction over Jason-1 period

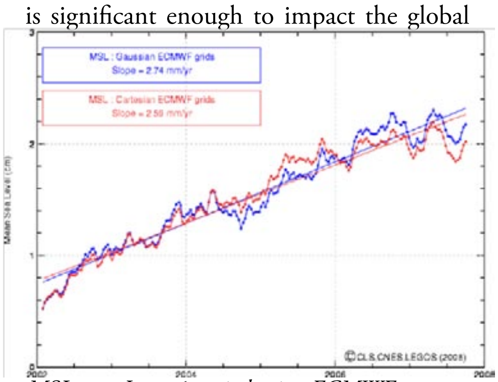
The orbit reference frame is also important in the global error budget. Several studies have shown that the current T/P (ITRF'97 and ITRF2000) and Jason-1 (ITRF2000) orbit reference frames induce, in particular, significant differences between the Southern and the Northern hemispheres (see the "Precise orbit determination and geoid" posters that were displayed at the last OST/ST meeting). ITRF2005 is a new orbit reference frame which uses a new gravity model derived from Grace data. Differences between this new reference frame and the older ones amount to between 0.1 and 0.2 mm/yr. The use of ITRF2005 should improve the accuracy of the data when it is implemented. The products being distributed now have not yet been upgraded, however.

Altimetry data need to be corrected for variations in sea surface height due to atmospheric pressure variations (atmospheric loading). Pressure fields used in the Jason-1 products are calculated from operational meteorological models. Because these models are operational, they can be upgraded without reprocessing to provide users with a homogeneous time series. Leaps can thus be observed on two occasions in the Jason-1 pressure fields (derived from ECMWF Gaussian grids).



Impact of using ITRF2005 GFSC orbit on regional MSL trend vs ITRF2000 GSFC orbit (computed only on Jason-1 period).

Plotting a single MSL from Topex/Poseidon and Jason-1 in itself creates uncertainties. Three altimeters (Topex A, Topex B, Poseidon-2) took turns in measuring sea surface heights. In order to connect them correctly, SSH biases have to be applied (Topex A / Topex B = 5 mm +/- 2 mm, Topex B / Poseidon-2 = 75 mm +/- 1 mm). However the uncertainty associated with each SSH bias is significant enough to impact the global MSL trend. When simulating extreme values of SSH bias, the global MSL trend ranges from 2.8 mm/yr to 3.3 mm/yr.



MSL over Jason-1 period using ECMWF pressure fields derived from Gaussian and Cartesian grids

These figures give an upper bound for the MSL trend error (taking only the worse cases into account) of 0.7 mm/yr.

Parameters	Errors in the global MSL trend	
	Optimistic case	Pessimistic case
Wet tropospheric	0.05 mm/yr (J1) /0.1 mm/yr (TP)	0.1 mm/yr (J1) /0.15 mm/yr (TP)
Orbit	0.05 mm/yr (J1) / 0.1 mm/yr (TP)	0.1 mm/yr (J1) / 0.15 mm/yr (TP)
Pressure fields	0.05 mm/yr (J1 and T/P)	0.1 mm/yr (J1 and T/P)
SSH bias	0.15 mm/yr over all the period	0.25 mm/yr over all the period
Others: SSB, Iono, Range	0.05 mm/yr for J1 and T/P	0.10 mm/yr for J1 and T/P

The different studies performed to analyze the uncertainty on the MSL trends lead to the above table where the pessimistic and optimistic errors have been synthesized for each SSH parameter

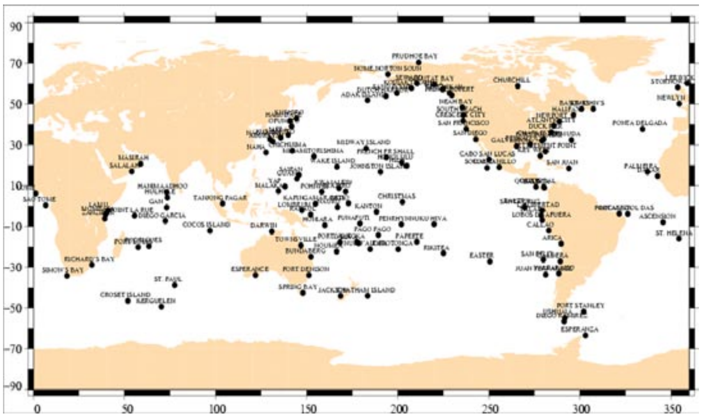
Considering the linear evolution of the MSL, we can use an inverse method [Bretherton et al.] instead of a classical least square method to take into account the different errors impacting the MSL estimate. This makes it possible to estimate the global MSL slope better and to obtain a realistic error of 0.5 mm/yr with a 95 % confidence interval.

Using *in situ* measurements to assess the error in the global MSL trend

Another way to validate altimetry data for the estimated MSL trend is to use other, independent, datasets, such as in situ datasets (tide gauges and Temperature/Salinity profiles). The basic idea is to assess the error in the altimetry MSL global trend, on the assumption that differences between in situ and altimetry measurements should not have any drift or bias over long time scales.

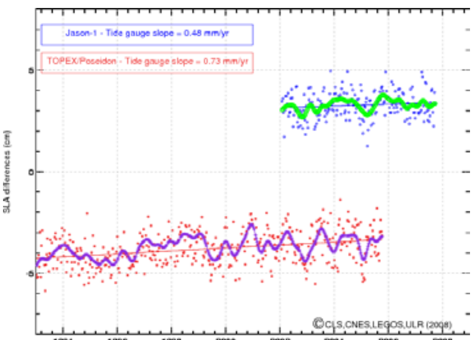
However, Altimetry and tide gauge sea surface heights are not directly comparable, so pre-processing is necessary to take into account differences in references (between altimetry and tide gauges, as well as between different tide gauges), distance between measurements, etc. Then it is also essential to co-locate the two measurement types. Moreover, tides gauges are on solid ground, and move with it; so drifts due to tectonic plates have to be dealt with.

Signals between tide gauge measurements and (T/P+Jason-1) data correlate well for the whole period of the study (1993-2008). It can thus be concluded that a combination of altimetry data and tide gauge measurements is effective for assessing the upperbound of the error in the global MSL trend.The results using GLOSS/Clivar tide gauge network lead to a upper value of the trend of 0.7 mm/year without crustal drift.



Map of the tide gauge network used

The value of using tide gauge data networks for calibrating satellite altimetry has been demonstrated by several authors (Mitchum [1994, 2000], Chambers et al. [1998], Cazenave et al. [1999]…). As for Temperature/Salinity profiles, this innovative method is trying to achieve the same goals using thousands of free-drifting profiling floats from the Argo network. Both methods complement each other since the first one (tide gauges) covers coastal areas while the second one (T/S profiles) is widespread enough to get an assessment of MSL in the open ocean.



Trends of differences between altimetric and in-situ tide gauge SLA without crustal drift correction for Topex/Poseidon and Jason-1

The method for Argo data also includes homogenisation between the two datasets [Guinehut et al., 2006], computing the steric part of altimetry sea level anomalies on the one hand, and computing a dynamic height using T/S profiles over a depth of 700 m on the other. Co-location is also of foremost importance to be able to compare what is comparable (even if Argo sampling is much closer to satellite sampling than the use of tide gauges). Comparing the different altimetry missions co-located with Argo and Argo data shows good correlation, albeit over a short period, since the method can't be used prior to 2004 (owing to the deployment of the Argo array).

The preliminary results are very encouraging but data series are currently too short (2004-2008) to get a really accurate assessment of the error in the global MSL trend.

The results (derived from T/G and altimeter comparisons) make it possible to estimate an upper bound in the error in the global altimetry MSL trend of 0.7 mm/yr, consistent with the estimate from the error budget on altimetry and corrections. This error is an upper bound for the MSL error, since it is taking into account in situ data errors (including crustal drift), as well as errors from the co-localisation of altimetry and tide gauges.

Conclusion

These results allow us to have a better confidence in the long-term MSL evolution. MSL error can be realistically estimated at 0.5 mm/yr, in agreement with in situ and altimetric comparisons. Further studies will refine the slope and the error estimation by analysing more thoroughly the different parameter contributions and their error modelling.

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Data Use Case: Monitoring El Niño

El Niño is a climate phenomenon occurring in the Pacific Ocean every two to ten years. During an El Niño event, a few months before Christmas, there is an anomalous accumulation of warm water off the coast of Peru. The El Niño event that occurred in 1997 was a good example of where satellite altimetry made a major contribution to monitoring such phenomena.

Data used

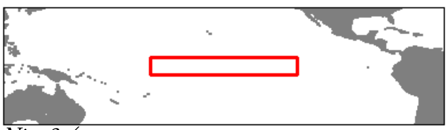
Altimeter datasets such as the SSALTO/DUACS multi-mission merged gridded datasets have been optimised for such ocean dynamics applications. We will use Maps of Sea Level Anomalies (MSLA). As combined data offer the best quality, and delayed-time the optimal orbit, we have chosen the merged DT-MSLA dataset, up-to-date ('Upd') data for better quality for a given date.

Download MSLAs from 1992 to 2005 (you can reduce the data period from 1996 to 2000. The main advantage of selecting such a long time period is to put the El Niño event into context. Data selection concerns the Pacific Ocean, and specifically the following coordinates: 30°S-30°N, 170°W-120°W

You can also use the data extraction tool available on Aviso web site (which will enable you to perform geographic and temporal extraction before downloading)

Methodology

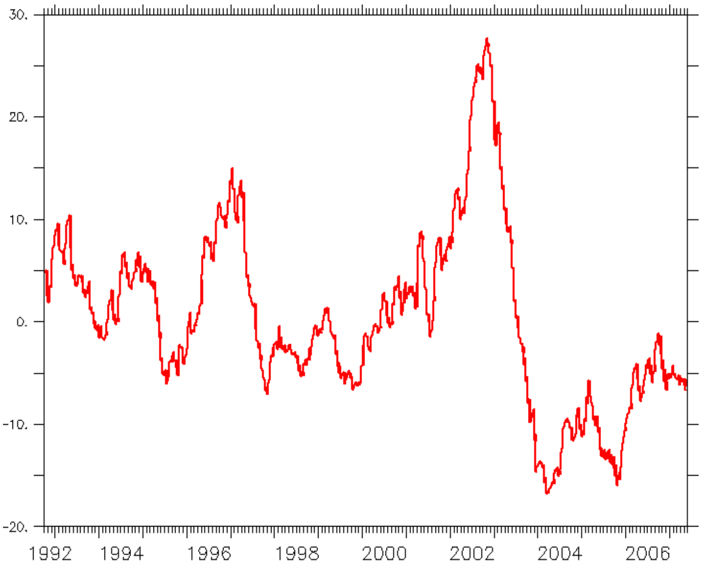
• Compute the geographic average for SLAs corresponding to the area defined by (5°S-5°N, 170°W-120°W) (Nino3.4 area). The value obtained, for a given time, represents the mean sea level anomaly over the equator in the Pacific Ocean. This averaged SLA shall now be referred to as M.



Nino3.4 area

• Plot the curve M=f(t) in order to show the temporal variations in M throughout the chosen period.

The curve shows periodic oscillations in M and illustrates the annual variability in sea surface height. Moreover M's value significantly increased in 1997 to over 25 cm: the signature of an El Niño in progress. Then, from summer 1998, sea surface height oscillations resumed.

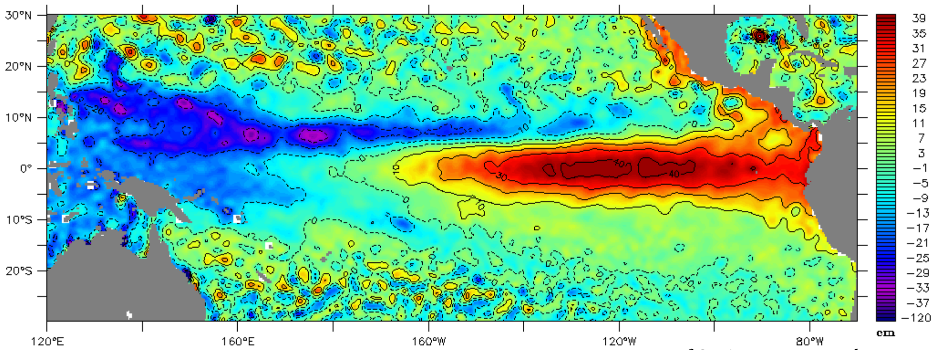


Mean of SLAs over the Nino3.4 area from 1992 to 2007

The 1997 El Niño

Focusing on 1997 enables us to consider specifically the month of November as an indicator of El Niño's intensity. Using only the four MSLA files available for November 1997, a new monthly mean map can be plotted (fig 3, simply re-enlarge the selected area to 30°S/30°N). This gives an overview of El Niño's distribution throughout the Equatorial Pacific Ocean during the month of November.

It is now acknowledged that an El Niño event is caused by significant changes in wind stress; it thus provides a good example of existing interactions between ocean and atmosphere. However, changes in sea surface slope, in terms of space and time scales, involve planetary waves (i.e. those with long wavelengths, that can travel thousands of kilometres). These are known as Kelvin and Rossby waves.



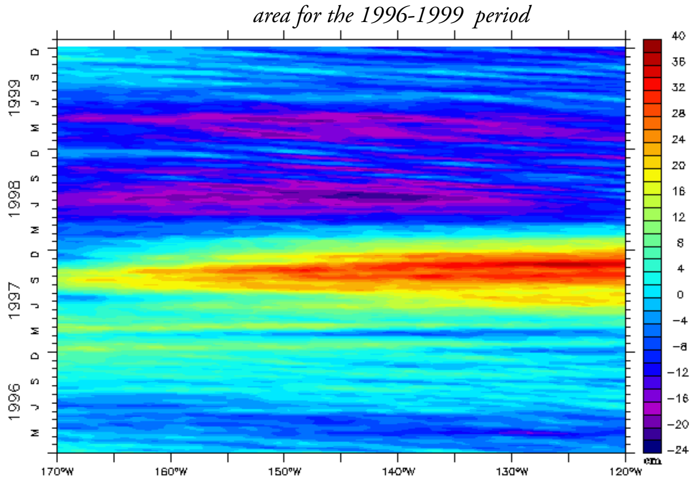
Mean of SLAs over November 1997

Hovmoller diagram

In a Hovmoller diagram, variations are plotted for time and longitude at a fixed latitude, which for SLAs highlights the role of waves.

To plot such a diagram on the area (5°N-5°S, 135°E-75°W), select your time period (in the example the datasets go from the beginning of 1996 to the end of 1999), then compute the averaged SLA for latitude. Then plot this mean SLA for longitude, for the whole time period.

Hovmoller diagram over the Nino3.4 area for the 1996-1999 period



In this diagram, SLA appears to be streaked with colours: these straight lines represent ocean waves. The red area shows the El Niño event, where maximum values reached 40 centimetres at around 125°W, at the end of 1997.

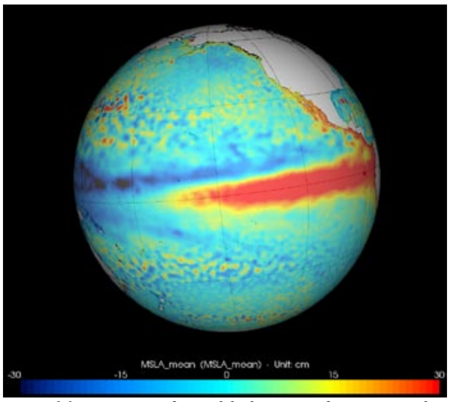
Planetary waves transport heat and energy across the oceans, and satellite altimetry allows us to detect them because of the variations in sea level they generate.

Outreaching to users: The Basic Radar Altimetry Toolbox and the Radar Altimetry Tutorial: a new set of tools for altimetry users

An all-altimeter tool and a comprehensive tutorial on radar altimetry dedicated to the users are now available online at www.altimetry.info, or on DVD on request.

Outreaching may be directed to the general public, but it can also be user-oriented. One of the recurring questions to the Aviso users helpdesk has always been ‘how to read the data?’. Indeed, it must be noted that a wide range of data format exists, which are not always very user-friendly for beginners and/or users with little or no computer support team. Reading software might be missing – or at least, reading software adapted to operating systems like Windows are, most of the time. Moreover, newcomers to altimetry may not have easy access to the background information they need or they may be interesting in about altimetry.

Thus ESA and CNES decided to join forces on developing an all-altimeter tool and a comprehensive tutorial on radar altimetry dedicated to the users.



Monthly mean of gridded SLA for November 1997

The Basic Radar Altimetry Toolbox is a collection of tools and documents designed to facilitate the use of radar altimetry data. It can read most distributed radar altimetry data, from ERS-1 & 2, Topex/Poseidon, Geosat Follow-on, Jason-1, Envisat to the future Cryosat missions, and can perform processing and data editing, extraction of statistics, and visualisation of results. Through a graphical user interface, you can define a dataset using one of all the kind of data that can be read by the toolbox, define the operations you wish to apply on some fields of those data – or simply the fields you wish to visualise – process this operation (output is a NetCDF file), and last but not least, visualize all or part of the result of the processing.


Data Use Case about hydrology in the Radar Altimetry Tutorial

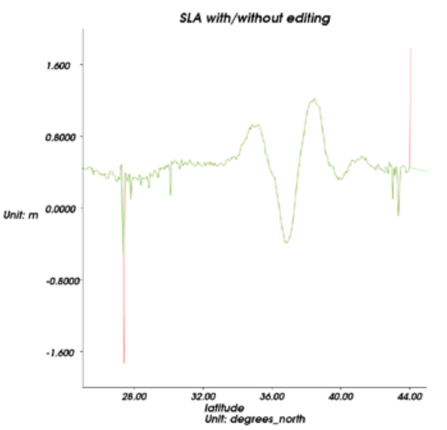
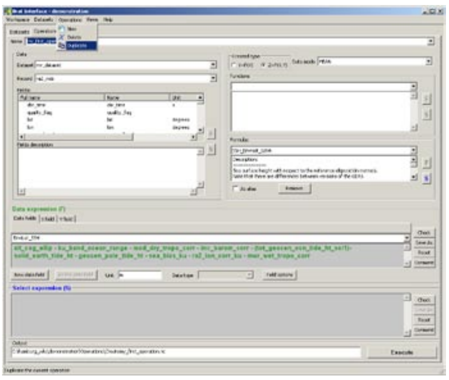


Figure computed from Envisat GDR, with (green) and without (red) data editing


Screenshot of the Graphic User Interface.

The Radar Altimetry Tutorial describes applications, examples (data use cases) and techniques, including standard data processing, as well as the various satellite missions that have carried, are carrying or will carry a radar altimeter onboard, plus a range of altimetry products (data, software and documentation).

For the more experienced users, such tools can also be of use. For one part, because quite a lot of them are also teaching. And for the other, because a handy tool for beginners is still a handy tool for an experienced user.

Further information:

http://www.altimetry.info

Events

June 20, 2008: Jason-2 launch

end of July 2008: distribution of first Jason-2 OGDR and IGDR data to PIs

September 8-12, 2008: Eumetsat meeting (Darmstadt, Germany)

September 10, 2008: GOCE launch

October 2008: distribution of first Jason-2 GDR data to PIs

November 2008: end of Jason-2 Calval phase for OGDRs

November 10-12, 2008: OST/ST meeting (Nice, France)

November 12-15, 2008: Final GODAE symposium (Nice, France)

November 12-15, 2008: IDS workshop (Nice, France)

Following Nice OST/ST: first Jason-2 OGDR data distribution to users

March 2009: end of Jason-2 Calval phase for (I)GDRs

March 2009: OST/ST meeting (San Diego, USA)

following San Diego OST/ST: first Jason-2 (I)GDR data distribution to users

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