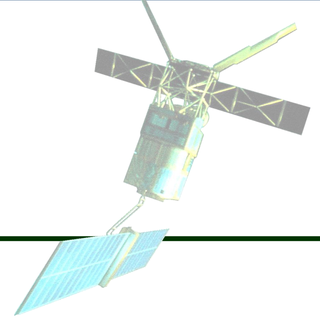
ERS-2: an essential mission for oceanography



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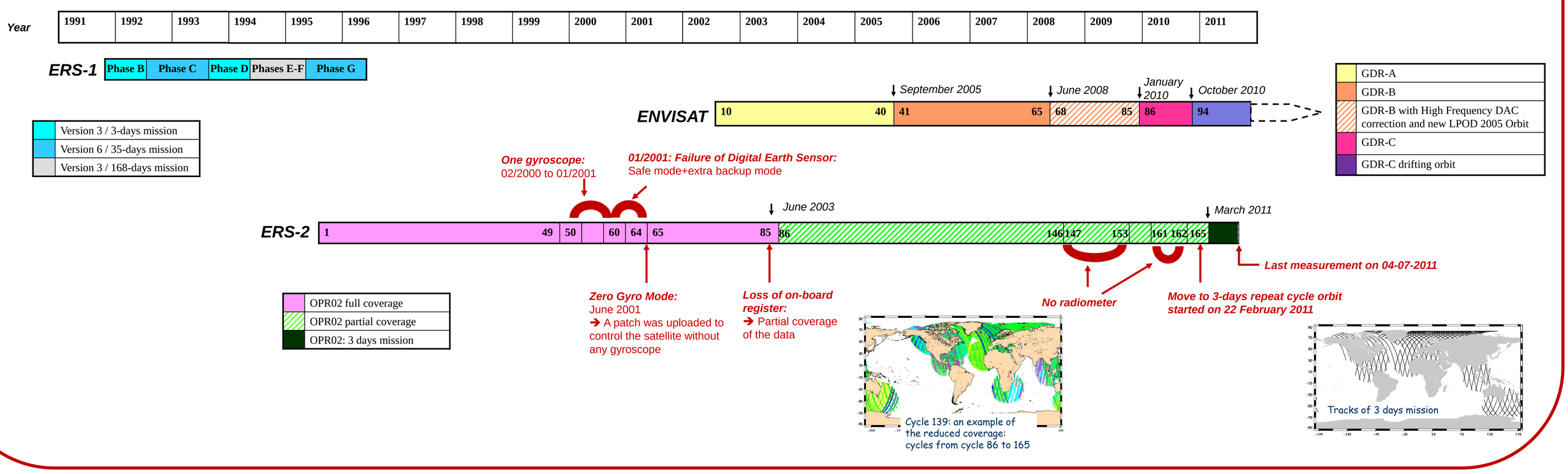
Abstract

After 16 years of successful activity, the ERS-2 satellite has been decommissioned and removed from its operational orbit in July 2011. This is the end of the longest altimetry mission ever flown. ERS-1, ERS-2 and Envisat satellites are widely used for a various range of oceanic applications, from real time mesoscale modeling to fine climatology analysis. Thanks to validation, homogenization and cross-satellite merging methods, ERS-1/2 allowed the raise of operational oceanography and contributed to study the climate change, with a level of accuracy which could not have been achieved with one single satellite. All this has been made possible through the current validation activities (ESA and Ifremer) and the SSALTO/Duacs project (Cnes). During all their lifetime and with the continuous effort of the oceanographic community and Space Agencies, new standards have been regularly updated to provide oceanographers with a multi-mission long time series as precise as possible. Now, new ESA projects such as Reaper and Sea Level Climate Change Initiative (SL-CCI) will dramatically improve the data quality and emphasize the legacy of these missions.

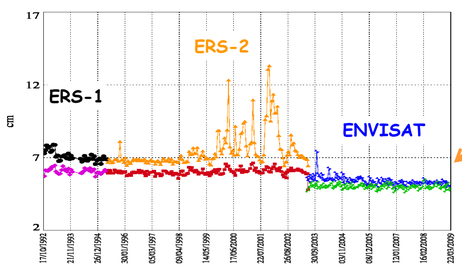
16 years of ERS-2 data

ERS-2 provided data from 1995 to 2011 It has been very useful for oceanographic applications mainly until june 2003 where the on-board register failed.
Fortunately, there was enough data to intercalibrate with Envisat before the failure.
The figure below gives an outline of the different phases and general events.



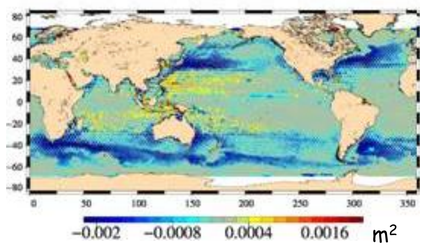
Oceanographic applications

Thanks to ERS data, the interest of mesoscale mapping has increased and allowed the beginning of the dissemination of Duacs products.



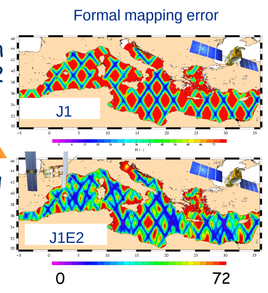
To combine ERS data with other missions an orbit error reduction method was used, taking TP data as a reference to constrain cubic spline adjustment (LeTraon P.-Y. and F. Ogor, 1998, "ERS-1/2 orbit improvement using Topex/Poséidon: The 2 cm challenge", *J. Geophys. Res., 103, C4, 8045-8057.)*
=> continuous and robust estimate over time.

Impact of using ERS-2 with TP for mesoscale activity:
The comparison between 2-satellites and mono-mission constellations highlights the loss of energy in the areas of high mesoscale activity signal when using a mono-mission constellation



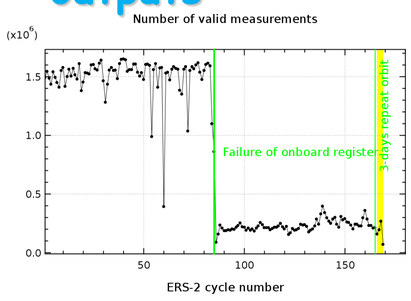
The impact of using 2 satellites instead of one is also visible for example in the Mediterranean Sea for the EKE (left) (increase of 40% when 2 satellites are used instead of 1) and on the formal mapping error (right).

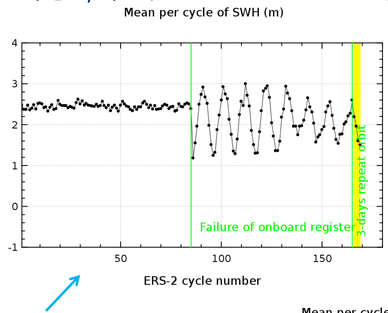
Results from Pascual et al., "Mesoscale Mapping Capabilities of Multisatellite Altimeter Missions: First Tests in the Mediterranean", International Liege Colloquium 2004



Validation outputs

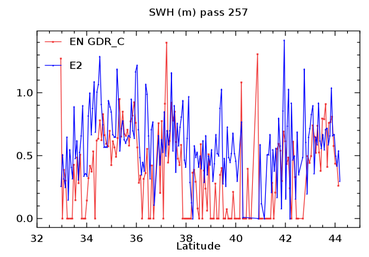
Data avilability and validity, monitoring of the relevant parameters, assessment of the altimeter performances, cross comparisons with other satellites are part of Esa, Ifremer and Cnes activities.



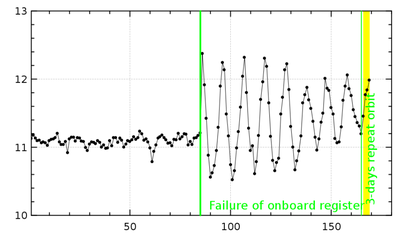


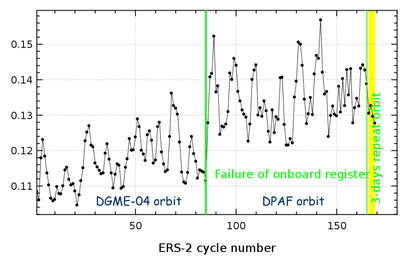
In yellow, the results of 3 days mission are displayed within 35 days means

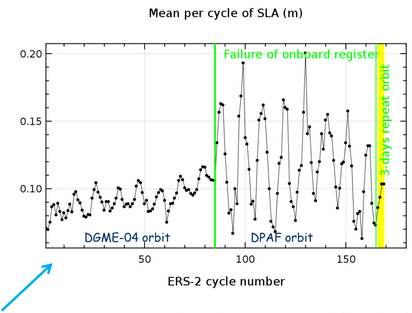
The variability increased because of the reduced coverage and the addition of stations from cycle 136



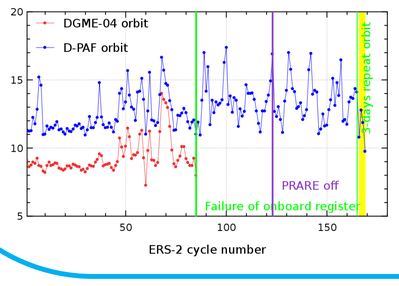
Nevertheless, for cycles >85, cross-comparions can still be done with Envisat data







The standard deviation for cycles >85 of SLA along track is globally below 14 cm



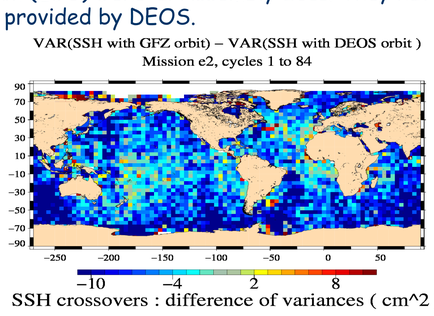
At crossovers, the standard deviation for cycles >85 is correct compared to the intial coverage with DPAF orbit

And now…

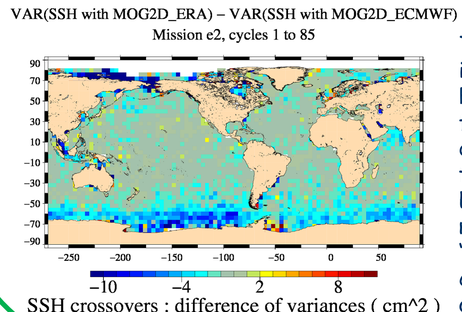
Thanks to **Esa projects such as Reaper and Sea Level Climate Change Initiative (SL-CCI**: see poster "Sea Level CCI project" by Faugère et al.) new standards are beeing or will be calculated and studied in order to improve the quality of all missions. They cover as well altimeter parameters (retracking,…), orbit determination and fields to correct the SSH. Two examples are given here:

❖The **Reaper orbits** are computed in the LPOD2005 terrestrial reference frame using the models and input data described in the poster presentation "Improvements in ERS-1 and ERS-2 precise orbit determination" by S. Rudenko, M. Otten, P.Visser, R. Scharroo and T. Schoene, presented at the European Geosciences Union (EGU) General Assembly 2011. They have also been studied in the frame of SL-CCI project and compared to other orbits provided by DEOS.

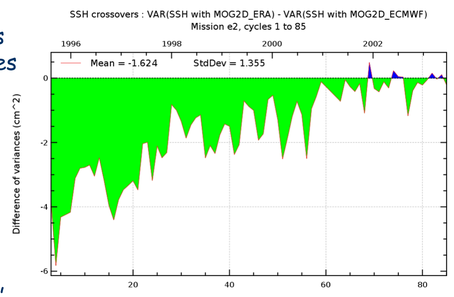
The GFZ orbit greatly improves the quality of ERS-2 data compared to DEOS-DGME-04 orbit (the one used at present in Duacs products) as shown on the difference of variance at crossovers. This strong improvement provided by new Reaper orbit is mainly due to the new standards used in the orbit calculation as the new model of the Earth gravity field.



❖**DAC models** (combination of the high frequencies of a barotropic model forced by pressure and wind (MOG2D model: Carrere and Lyard 2003; SWT New Orleans 2002) and the low frequencies of the Inverted Barometer):
The ERA Interim DAC (MOG2D_ERA) correction is computed from ERA Interim pressure fields which correspond to the latest global atmospheric reanalysis produced by the European Centre for Medium-Range Weather Forecasts (ECMWF) (see The ERA-Interim reanalysis: configuration and performance of the data assimilation system (Q. J. R. Meteorol. Soc. 137: 553-597, April 2011 A)). It is compared to the DAC (MOG2D_ECMWF) correction computed from the ECMWF operational model pressure fields as done in Cnes/Aviso.



The variance reduction at crossovers is mainly located in Southern latitudes but it is significantly higher for the first cycles of the mission and decreases with time, correlated to the improvements made on the ECMWF model all along the ERS-2 mission. Other results in the poster "Improving the dynamic atmospheric correction for mean sea level and operational applications of altimetry" from Carrère et al.



To conclude

The ERS missions were a key for the oceanographic community: thanks to validation activities and combining methods with other satellites, they allowed the raise of operational applications and studies on mesoscale activities.
Since 2003, the ERS-2 mission has been less valuable but can still be used for comparisons to Envisat.

As errors on altimetric standards will continue to be reduced in the future, the interest of ERS datasets will therefore increase for climate and oceanic applications and studies. For instance, Esa projects such as **Reaper and CCI** are on-going and will allow improving dramatically those datasets:

- ✓Within the Reaper project, all ERS data will be reprocessed and validated in 2012.
- ✓Within the SL-CCI, new ERS-2 products (FCDR) will be available in 2012 dedicated to climate studies (see http://www.esa-cci.org/)

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OSTST San Diego, October 2011