

# Reprocessing of the ERS-1 & ERS-2 Altimetry Missions

## The REAPER Project



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!!! ERS-1 & ERS-2 REAPER DATA NOW AVAILABLE !!!

**REAPER** is a reprocessing activity intended to produce a homogeneous, improved ERS-1 & ERS-2 Altimetry dataset, processed with a uniform set of algorithms and models, and cross-calibrated with ENVISAT Altimetry data V2.1.

Many improvements have been made to the L1, L2 and Calibration processing of the ERS data. These improvements have largely derived from the processing developed for ENVISAT.

### The issue that the project addresses

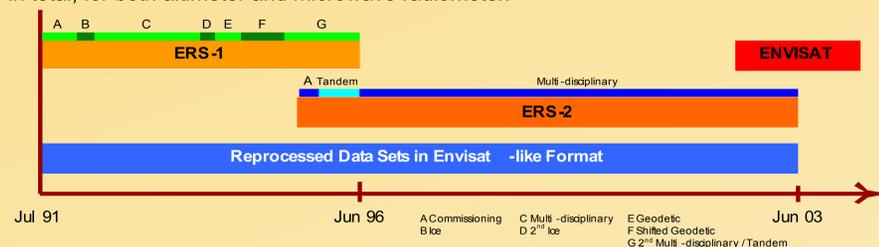
"In building a climate data record of sea level I am constantly faced with unearthing altimeter data and auxiliary data from missions long deceased. Old FTP archives / web pages, etc. disappear, and basic knowledge about the available data withers."

### Project Goals

- To reprocess the ERS 1 & ERS 2 Altimetry data, **July 1991 – June 2003**, using 1 set of algorithms to create a uniform data set.
- To use the best available algorithms, correction models and auxiliary data to achieve the highest accuracy in the geophysical products.
- To regenerate precise orbits across the 12-year span to improve accuracy and continuity.
- To cross-calibrate the products against ENVISAT V2.1 to aid long time-series studies

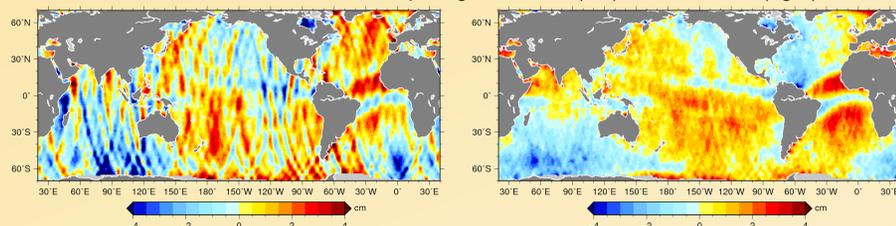
### Scope of the reprocessing

Data covering a 12 year period of the ERS missions will be reprocessed – 17 years of data in total, for both altimeter and microwave radiometer.



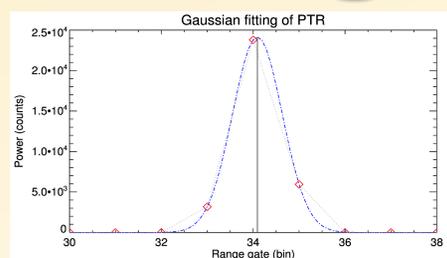
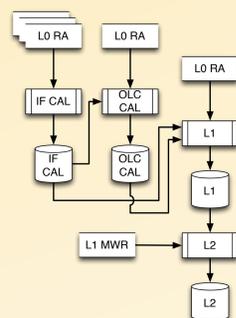
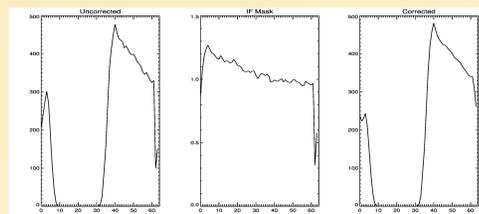
### Improvements to the Orbits

A new precise orbit product has been derived for REAPER, using the ITRF2005 reference frame. An iterative process using SLR and altimeter data was followed by three institutes using different software packages. Orbits followed IERS2003 conventions and used the EIGEN-GL04S gravity field (+ANNUAL), FES2004 ocean tides and corrections for atmospheric effects. The three solutions were cross-compared and the best solution was found by merging the three individual solutions. Radial errors were found to be reduced from ~50mm to ~21 mm compared to DGM-E04 reference orbits. Crossover residuals are reduced by 8 mm for ERS-1 and 9 mm for ERS-2. ERS-2 averaged crossover difference showing the anti-correlated orbit are shown below comparing DGM-E04 (left) and REAPER (right).



### Improvements to L1 / Calibration Processing

Averaged IF masks are created by the IF CAL chain from a number of individual IF measurements made over the course of a month. The averaged mask is then applied to waveform data from that month as part of the L1 processing. During the original processing, ERS data was corrected by the IF mask measured on the ground. The method used here will account for in-flight variations.



PTR records are analyzed to provide correction to both range and backscatter. A Gaussian fit to the PTR waveform provides the position and amplitude of the PTR. The PTR waveform is corrected with the IF mask before fitting.

USO drift correction and time correlation improvements have been made in the L1 processing.

### Improvements to Level 2 Processing

Four retracking solutions (OCOG, Sea-Ice, Ice2 and Ocean MLE3) are computed globally. 20 Hz measurements are used to compute additional, averaged 1 Hz measurements. Standard deviation of SWH and ocean range has been found to be reduced compared against OPR.

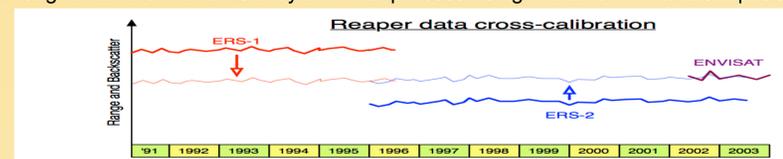
### REAPER auxiliary model datasets

A uniform set of auxiliary models will be used to correct the entire REAPER dataset and remove such features. The models in use are:

- Mean Sea Surface : CLS01 and UCL04 (improved at high-latitude)
- Geoid: EGM2008
- Slope model : A new model derived during project commissioning
- Sea-state Bias : A new model derived during project commissioning.
- Wind Table : ECMWF S. Abdallah's model from Envisat
- ODLE : MACCESS
- Surface type mask : Terrain base
- Meteorological Corrections : ERA-Interim ECMWF
- Ionospheric : GIM (and NIC09 when GIM is unavailable)
- Ocean Tides : GOT 4.7 and FES 2004
- Long Period Tides : FES 2008
- Solid Earth Tide : Cartwright
- Pole Tide : Wahr

### REAPER data cross-calibration

The REAPER L2 ERS-2 products have been cross-calibrated with ENVISAT using 1 year of data from the tandem phase of those missions. The REAPER L2 ERS-1 products have been then brought into line with ERS-2 by a similar process using the ERS-1/-2 tandem phase.



### Reaper Products Validation Results

The system performance of REAPER ERS-1 and ERS-2 satellite altimetry data has been done using 1 Hz data over the oceanic domain. The work was based on about thirty ERS cycles of COM6 Commissioning Dataset generated by the REAPER team.

### Crossovers analysis

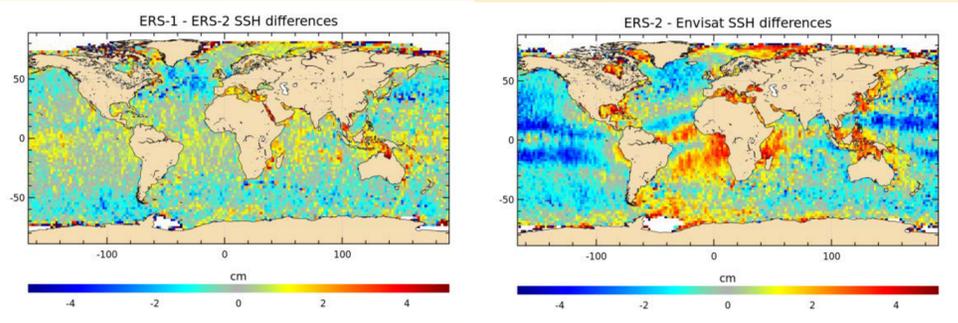
The main mission performance indicator comes from estimating SSH differences at crossovers. On the short data period assessed, the REAPER satellite altimetry data shows a better performance level than the current improved OPR data set for both ERS-1 and ERS-2, based on the standard deviation of SSH differences at crossovers. Regarding the mean, the data are still impacted by a ~0.6 ms time-tag bias, variable in time.

### Global SLA analysis

The analysis of global SLA variability displays positive results as REAPER data seems to improve the consistency between missions, either comparing ERS-1 to ERS-2, ERS-2 to Envisat or ERS to TOPEX/Poseidon. We do raise a concern about the temporal evolution of ERS-2, especially at the beginning of the period where an important drift with respect to TOPEX/Poseidon is suggested; however the time period is too short to draw a firm conclusion.

### Data Availability

Less data are missing in the REAPER products than in the OPR, however these new data are located at high latitudes where the editing leads to rejection. The final number of valid measurements is therefore not significantly changed.



Maps of mean SSH differences between ERS-1 and ERS-2 (left) and between ERS-2 and Envisat over the two verification phases.

### Availability, Data Access and further information

The REAPER processing chains were designed and built by scientists and software engineers at isardSAT, CLS, Altimetrics, and at CPOM and MSSL within University College London. The system was integrated by UCL and delivered to IFREMER (CERSAT) in Brest for the reprocessing activity.

### Data Access

The ERS-1/2 REAPER products have been released in September 2014 in NetCDF v3 format. The dataset is composed of the following three product types and is now freely accessible online upon **Fast Registration**:

- GDR - (ERS\_ALT\_2\_)
- SGDR - (ERS\_ALT\_2S)
- METEO - (ERS\_ALT\_2M)

For more information on REAPER data access contact ESA [eohelp@esa.int](mailto:eohelp@esa.int)

For more information on REAPER project see <http://reaper.mssl.ucl.ac.uk/> or contact [reaper@mssl.ucl.ac.uk](mailto:reaper@mssl.ucl.ac.uk)

### Future Reprocessing

ESA is planning to further improve the ERS Altimetry dataset by extending the time coverage up to 2011 and also continuing to increase the data quality. For this reason a future reprocessing is foreseen by the end of 2015.

Any feedback or recommendation for additional improvement from the user community is welcome through **EOHelp** ([eohelp@esa.int](mailto:eohelp@esa.int))

