# A New Mean Sea Surface DNSC07.

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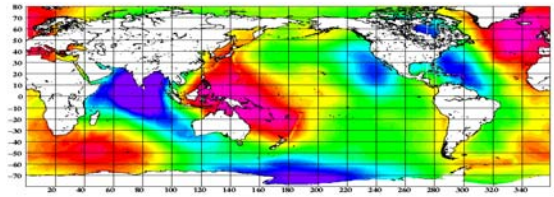
## ABSTRACT

Satellite altimetry is one of the key elements in global high resolution gravitational models. In this presentation we will focus on the latest development in the accuracy and processing of satellite altimetry focusing on a presentation of the DNSC07 Mean sea surface which is an important quantity for accurate geoid determination. Both the DNSC07 gravity field and the DNSC07 mean sea surface have been derived with a spatial resolution of 1 minute by 1 minute and cover all marine regions of the world including the Arctic Ocean up to the North Pole.

Amongst the improvement in satellite altimetry are retracking of the entire ERS-1 GM mission using a highly advanced expert based system of multiple retrackers to gain data from both the open sea surface and from all ice-covered regions within the coverage of the ERS-1, in order to derive products with higher accuracy that are presently available. Also the GEOSAT GM data which have been reprocessed and retracked by NOAA, and have also been included in the DNSC07MSS.

The DNSC-MSS06 mean Sea Surface (MSS) is an updated version of the older KMS04 MSS. It is the physically observed time-averaged height of the ocean's surface derived from a combination of 12 years of altimetry from a total of 8 different satellites missions covering the period 1993-2004.

Inclusion of ICESAT have extended the MSS up to 86N. These data has very short timespan and are only included where no other data are available from ERS-2 or ENVISAT.



**The DNSC06 mean sea surface.** −60.0 60.0 m

## DERIVATION

The DNSC07 MSS was derived using a 3-steps procedure designed to map the different spatial scales in the MSS and to ensure that all data reference to the 1993-2004 time frame. . Initially the long wavelength are mapped from T/P-JASON alone. Then the medium wavelength (100-500 km) are mapped and added and finally the fine scales (20-100 km) are mapped and added to give the final MSS.

The first step is a fitting of all the various mission onto the T/P 12-year reference frame. All altimetric data are fitted to a 12 year T/P-Jason reference frame.

The medium wavelength MSS I was derived from T/P ERM data supplemented with the adjusted ERS-2 / ENVISAT and ICESAT data outside 66° latitude. Inside the 65 latitude. All available ERM data were used. Within 30° of the Equator existing MSS data from the CLS01MSS (adjusted to 12 year) were introduced as 0.25° spatial averaged values to provide observation in-between the ground-tracks of the ERM data. Inclusion of the GM data highly improved the representation of the shorter wavelength of the MSS close to the Equator where the tracks become almost North-south going

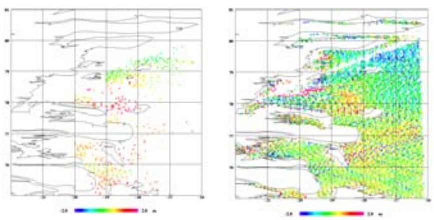
During the final step all ERM and GM data are merged together and the high resolution MSS is computed on 1 minute using cross-over adjusted data to the medium wavelength MSS.

## MULTI MISSION SATELLITE ALTIMETRY USED TO DERIVE THE DNSC07MSS.

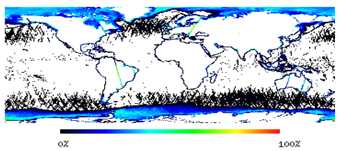
| DNSC07 MSS | T/P -JASON ERM | ERS2 ERM | T/P TDM | ENVISAT ERM | GFO ERM | GEOSAT GM | ERS-1 GM | ICESAT GM |
|---|---|---|---|---|---|---|---|---|
| Selected time period | 1993-2004 12 years (cycles 10-452) | 1995-2002 8 years (cyc 1-74) | 2002-2003 1.5 years (cyc 371-471) | 2002-2004 3 years (cycle 15-45) | 2000-2002 3 years | 1985-1986 1.5 years (cycles 1-25) | 1994-95 ERS-1 phase E ERS-1 phase G | Release 26 3 Month |
| Coverage | 66°S-66°N | 82°S-82°N | 66°S-66°N | 82°S-82°N | 72°S-72°N | 72°S-72°N | 82°S-82°N | 86°S-86°N |
| Post Processing | Pathfinder Merged GDR. | Pathfinder GDR Adjusted to T/P | DEOS | DEOS | DEOS -13 cm offset applied south of 65S. | Retracked by Smith, Sandwell and Lillibridge | Retracked by P. Berry, ESPRS 11 Retracker syst | Saturation correction applied 20 cm offset at S. Hemisphere app |
| Groundtracks spacing | 320 km | ~80 km | 320 km | ~80 km | 150 km | ~6 km | ~8 km | ~20 km |
| Comments | Used to reference all other data Used for inter-ann variatiliby estimate. | Referenced to 12 Y T/P data. Used with T/P+TDM+ENVISAT to derive coarse MSS. | Referenced to 12 Year T/P dat. Xover corrected sea surface heights used | Referenced to T/P – used with T/P-ERS2 to derive coarse I MSS Good coverage over ice | Referenced to 12 Year T/P+ERS/ENVISAT MSS xover corrected sea surface heights used | Used to resolve fine spatial scale signals xover corrected sea surface heights used | Used to resolve fine spatial scale signals xover corrected sea surface heights used | Only used outside 65S and 70N parallel to resolve mean and fine scale signal |

## RETRACKING

ERS-GM have been retracked using the EAPRS rule-based Expert System (P. Berry - De Montford University).



Unadjusted altimetric geoid height observations in the ice-covered regions east of Greenland. The left figure shows the 1Hz data in the Radar Altimeter Database System (RADS), which uses the data delivered by the ESA retracking system, and the figure to the right shows the available 1 Hz retracked altimetric data.

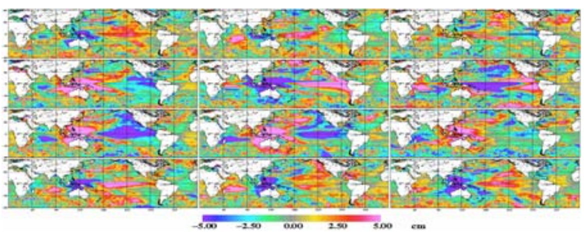


The Sea Ice retracker picks up many data in i.e. polar regions that is not ocean retracket. This retracker also picks up data near coast and in currents (correct echoes are similar in shape)

Large distribution of patch waveforms (44%) within 5 km of the coastline, and around 10% from about 25 km from the coast can be seen.
At about 50 km from coastline only 60% of waveforms in this region are ocean retracked.

## MSS AND INTER-ANNUAL OCEAN VARIABILITY

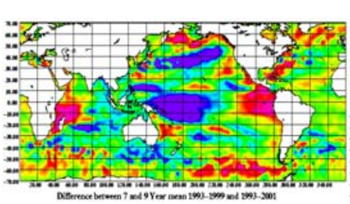
In the computation of the long wavelength part of the MSS, a 4 parameter fit to the altimetric time series of TOPEX/JASON-1 is made in which the largest contributions to sea level variations are modelled. This is the mean value, a linear sea level change (over the 12 years) and the annual cycle in sea level like: $h_{obs} = h_0 + h_1 t + h_2 \cos(\omega_{ann} t) + h_3 \sin(\omega_{ann} t) + e$
where $\omega_{ann}$ is the annual cycle.



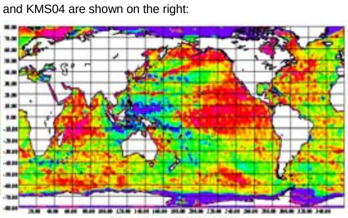

By subtracting the mean as well as the linear sea level change and the annual sea level change from the altimetric observations the inter-annual sea level anomalies can be obtained by averaging the residual observations within each year. These values are shown above for the period 1993-2004, computed from T/P and JASON-1 satellite altimetry. The El Nino – La Nina related sea level signals can be seen for almost all years, but the El Nino in 1997-1998 is particularly dominating. During this period sea level where displaced by more than 15 cm in the central Pacific Ocean averaged over the entire year.

Inter-annual variability affects the computation of MSS. Going from 7Y TPX averaging to 9Y averaging the effects of the interannual variability may be studied using the CLS01 (7y) and the KMS04 (9Y) MSSs.

Diff between 7Y and 9Y means are shown on the left. Diff CLS01 and KMS04 are shown on the right:



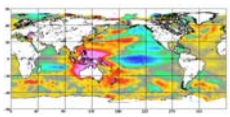
Difference between 7 and 9 Year mean 1993-1999 and 1993-2001



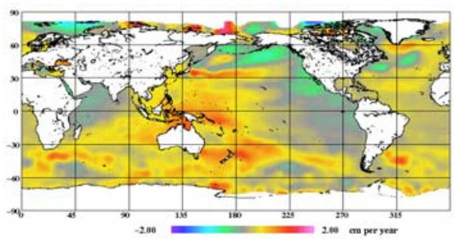
Difference between KMS03 and CLS01

Colorscale ranges +/- 5 cm

## SEA LEVEL TRENDS



8 Years Sea Level Change (1993-2000)

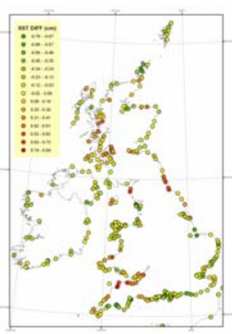



12 Years Sea Level Change (1993-2004)

The regional characteristics of the sea level trends that have been estimated from the 12 years series are shown above to the right. For comparisons a map showing trends estimated from 8 years time series is shown above to the left. The effects of having longer time series are evident. Using 12 years of data a large part of the regional signals have been vanished through the averaging. This indicates that the 12 years means are much less affected by inter-annual variability.

## VALIDATION / COMPARISON

The figure to the right present a comparison between the DNSC06MSS-IB corrected and 320 Tide gauges re-observed with GPS is presented. The DNSC06MSS and tide gauges compares with a mean difference of 1.24cm and a std of 16 cm.



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