

Global And Regional Sea Level Changes From Altimetry – Correlation With Sea Surface Temperature And Climate Indices.

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Abstract

TOPEX/POSEIDON (T/P) sea level observations and Reynolds AVHRR sea surface temperature observations over the most recent 9 years have been used to study regional correlations between changes in sea level and sea surface temperature on a 9 year period.

9-years T/P derived sea level changes are correlated in space with changes in the Reynolds AVHRR sea surface temperature observations with a global averaged correlation of 0.62. On regional scales this number becomes higher. Specifically, in the tropical part of the Pacific and Atlantic Ocean where the correlation computed over 20° latitude bands increases to 0.89.

Temporal correlation coefficients were used to study sea level dependence on the NAO climate index in the North Atlantic ocean.

Temporal correlation peaks at 0.71 in the Northern North Sea and -0.7 to the west of Portugal. To study the correlation above 66N, ERS was used. Here slightly smaller correlation is obtained, due to the higher noise floor. However, the spatial patterns were similar.

Data

The NASA Pathfinder altimetric observations were processed using the set of provided standard corrections (including inv. Barometer). Data from repeat 10 through 342 covering 331 repeats was used. This corresponds to exactly 9-year time period between January, 1993 and December 2001. A minimum of 250 repeat observations was required.

Version 9.1 (364 repeats) has corrected the TOPEX Microwave Radiometer (TMR) drift by correcting TB_18 brightness temperatures and re-computing the TMR for the entire mission.

1° by 1° sea surface temperature dataset covering the exact same 9-year period (1993-2001) was used. The Reynolds and Smith (1994) dataset, is based on thermal infrared images collected by the Advanced Very High Resolution Radiometer (AVHRR) onboard the NOAA satellites. The AVHRR images are corrected using sparsely sub-surface temperature measurements by estimating and removing large-scale biases.

Spatial Correlation

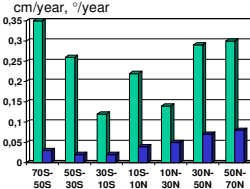
Regional changes in sea level (shown in green) and surface temperature (blue) are shown in the figures above. The values have been computed in 20° latitude bands of the Atlantic, Pacific and Indian Ocean taking into account the difference in area covered by each 1° by 1° cell.

Atlantic Ocean: Coherent increase in sea level and sea surface temperature over most of the Ocean is clearly seen.

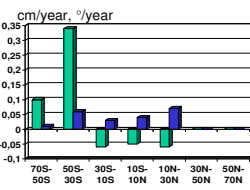
Pacific Ocean: Coherent spatial pattern of both sea level and sea surface change in the Pacific Ocean is found, but being dominated by the ENSO event in 1997.

Indian Ocean: Coherent spatial pattern between sea level and sea surface temperature in southern part. Opposite trend-values found in central Indian Ocean.

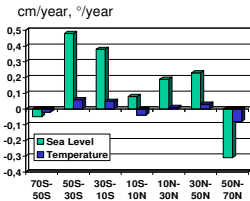
Atlantic Ocean



Indian Ocean

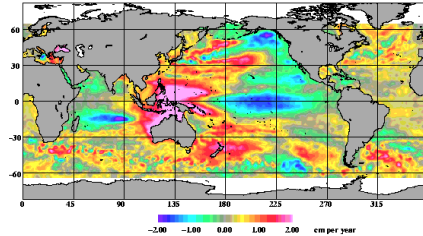


Pacific Ocean



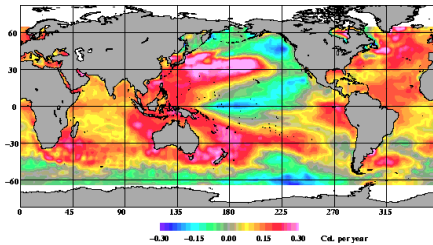
Result

Sea level changes over the most recent 9 years detected by T/P sea level observations are correlated with changes in the Reynolds AVHRR sea surface temperature observations with a global averaged correlation of 0.62. On regional scales this number becomes higher. Specifically, in the tropical part of the Pacific and Atlantic Ocean where the correlation computed over 20° latitude bands increases to 0.89.



9-year Sea Level Trend (1993-2001) from TOPEX/POSEIDON Pathfinder data

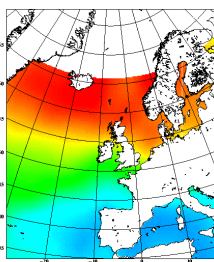
The colour scale is tuned so Greyish colours correspond to no change in sea surface temperature or sea level. Yellow and Red colours correspond to an increase. Blue and Green to a decrease.



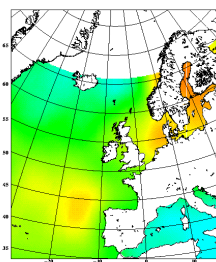
9-year Sea Surface Temperature Trend (1993-2001) from Reynolds AVHRR data

Sea level dependence on the NAO Index in the North East Atlantic and European Seas – Temporal correlation

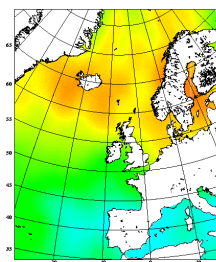
Temporal correlation between monthly NAO and T/P and ERS sea level (annual signal removed) was computed in 2° by 2° blocks over the North Atlantic Ocean. Annual variations have been removed from altimetry. The NAO value is defined as the normalized pressure difference between a station on the Azores and one on Iceland. High NAO values corresponds to low atmospheric in the north leading to hydrostatic increase in sea level in the north. Vice versa for low NAO



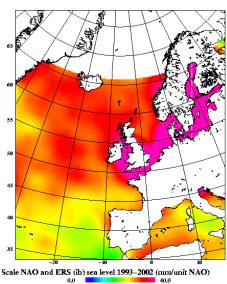
Correlation between NAO and T/P (no ib applied). Temporal correlation peaks at +70% in the northern North Sea/Baltic and -70% to the west of Portugal.



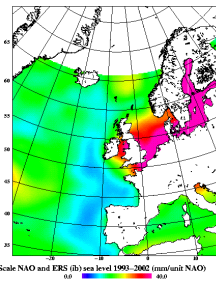
Correlation between NAO and T/P corrected for the hydrostatic IB component. Most of the correlation related to the IB have gone. In particular the north-south pattern. Temporal correlation peaks at +49% in the northern North Sea/Baltic and -56% in the Mediterranean.



Correlation between NAO and ERS. Temporal correlation peaks at +52% in the northern North Sea/Baltic and -59% in the Mediterranean. Notice the extended coverage above 66N.



Scale/sensitivity between NAO and T/P in mm/unit NAO. The scale reaches 70 mm in the Eastern North Sea and in the Baltic Sea.

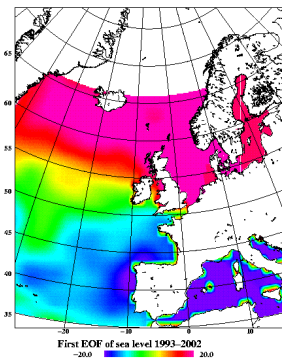
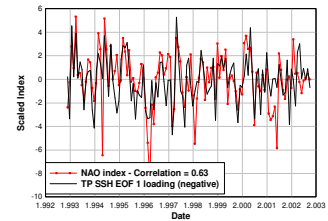


Scale/sensitivity between NAO and T/P on correcting for the hydrostatic IB component. The scale still reaches 60 mm in the Eastern North Sea indicating the important relationship between westerly winds in this region.

EOF Analysis

The correlation between the loading of the first EOF mode of T/P (no ib) and the NAO index has been investigated.

The Correlation between monthly TP and NAO values is 0.63 for the first EOF of T/P sea level.



First EOF of sea level 1993-2002