Comparisons to in situ data and estimation of errors in the Dynamic Atmospheric Correction

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Introduction

Altimeter measurements are corrected for several geophysical effects in order to isolate the oceanic variability. The dynamic atmospheric correction (DAC) allows for the removal of high frequency variability induced by the atmospheric forcing and aliased by the altimetric measurements.

The high frequency part of the DAC is based on a barotropic model simulation forced by atmospheric pressure and winds (MOG2D; Carrère and Lyard 2003); the low frequency part is an inverse barometer response. A 20-day cutoff-period for the high frequency part was chosen because it corresponds to the Nyquist period of T/P-Jason reference altimeters' sampling and because the variability is mostly barotropic in this high frequency band.

The purpose of this study is to perform an exhaustive validation of the operationnal DAC (Delayed-time correction) considering a large network of in situ data (tidal gauges and bottom pressure records) and considering different time scales (periods <20 days and longer periods). The residual signal allows an estimation of the DAC error on the global ocean.

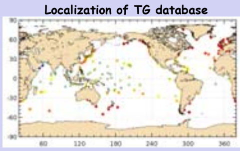
In situ data used

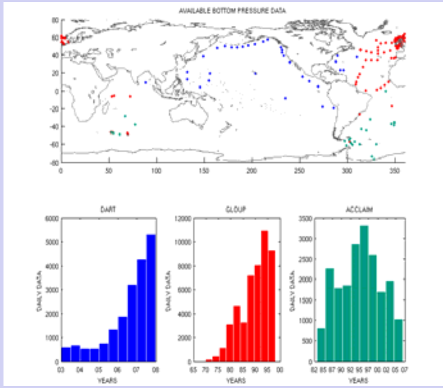
Two complementary databases have been used here :

- **Tidal Gauges (TG)** = WOCE, IMEDEA, REFMAR networks, which are coastal/island data. Time resolution is 1 hour.
- **Bottom Pressure Records (BPR)** = DART, GLOUP, ACCLAIM networks, which are deep ocean data. Time resolution is 24h. BPR generally give ocean bottom pressure measurements, thus data have been specifically processed to get an equivalent Sea Level.

The period of analysis is 2008-2013 for TG and 1992-2009 for BPR. In situ measurements have been corrected for oceanic tides using a Demerliac filter.

Localization of TG database

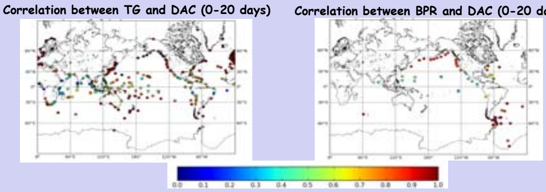




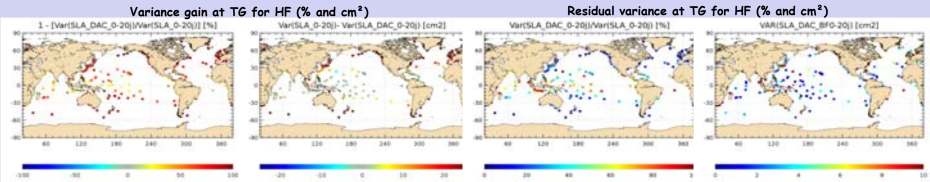
High frequency band (T < 20 days)

The variance reduction for in situ time series corrected using DAC is maximum at high latitudes and weaker for lower latitudes, and the correlation between DAC and in situ measurements shows same patterns. This is coherent with the fact that the DAC has a maximum variability at high latitudes where the atmospheric forcing is more energetic and also in coastal areas. Moreover the ocean response is mostly barotropic at high frequencies in those regions, whereas the baroclinic component becomes important in the tropical regions, which explains the lower efficiency of the DAC in this area.
The variance gain of the DAC is very important (65%) for the high frequency range. TG and BPR variance gains have similar patterns/values.

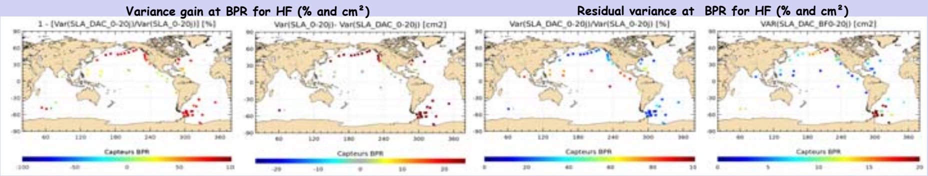
Correlation between TG and DAC (0-20 days) Correlation between BPR and DAC (0-20 days)



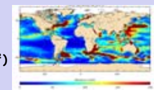
Variance gain at TG for HF (% and cm²) Residual variance at TG for HF (% and cm²)



Variance gain at BPR for HF (% and cm²) Residual variance at BPR for HF (% and cm²)



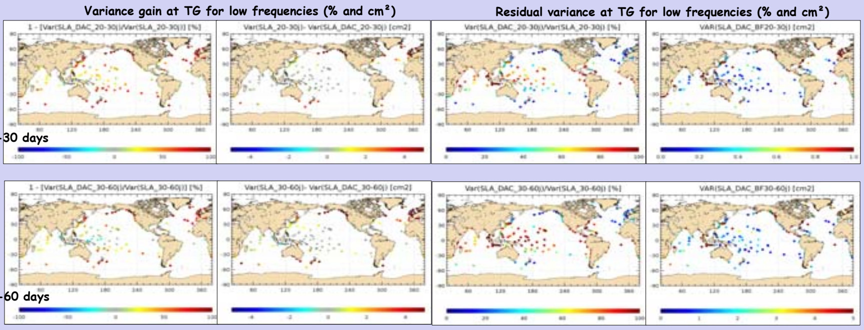
The estimation of the in situ residual signal variance gives an estimation of the DAC absolute error at each TG site, considering both modelling errors (mesh, bathymetry, …) and representation-omission errors because the barotropic model cannot represent baroclinic effects…
The mean residual variance is the low for HF (11 cm²for TG and 16 cm² for BPR) with values spanning from about 1 cm² to more than 10 cm² (sometimes > 20cm² for BPR). Smallest absolute values (< 2-4 cm²) are located in the tropical regions, which is the less energetic area, while a stronger residual variance is observed near coasts and at high latitudes. Stronger values are also noticed for some BPR sites at high latitudes (Drake passage, south Alaska).
The ratio between residual variance and observed variance is generally smaller than 10-30 % at high latitudes, and reaches more than 70-80% in the tropical regions.
If compared to the altimeter measurements variance (Jason-1 here), we can say that about 11-16 cm² of altimeter variance (between a few percent until ~30 % of altimeter variance) can still be aliased variance due to the incomplete job done by the DAC in removing variance at HF.



Variance of SLA Jason-1 (0-200 cm²)

Lower frequencies (T > 20 days)

Variance gain at TG for low frequencies (% and cm²) Residual variance at TG for low frequencies (% and cm²)



20-30 days

30-60 days

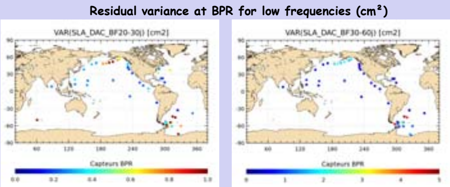
For periods over 20 days, we see the impact of the IB (inverse barometer) due to the construction of the DAC.

Although it is known that IB has large representation errors, the mean residual variance for long periods (between 20 days and 60 days) is weaker than for HF (0.8 cm² for the 20-30 days period and 1.6 cm² for the 30-60 days range), because the SSH variance is weaker at these time scales. Same geographical patterns are observed: weak values in the tropical regions and stronger values at high latitudes and near the coasts, where dynamic ocean response is stronger.

This residual variance for long periods (20-60 days) gives an estimation of the quantity of signal that can still be aliased in ERS-EN-AltiKa time series: 2.4 cm².

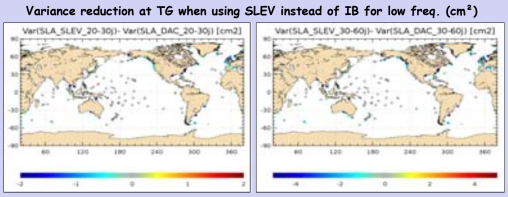
Values obtained for TG and BPR are consistent but a few BPR stations show a different behaviour (Drake Passage and south Alaska), with significantly stronger residual variance, and would need some more investigation …

Residual variance at BPR for low frequencies (cm²)



Right hand side plots show the variance gain obtained when correcting the TG temporal series by the MOG2D sea level instead of the IB for low frequencies. We note that MOG2D sea level allows reducing the residual variance for many locations, mostly located at high latitudes and in some coastal areas. This shows that the barotropic model is able to get a part of the ocean lower frequency variability; Vinogradova et al. (2007) showed it is mostly large scale. Those results are coherent with previous analysis made for altimeter data.

Variance reduction at TG when using SLEV instead of IB for low freq. (cm²)



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