Improving the Dynamic Atmospheric Correction for altimetry – impact of 3-hours meteorological fields

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Introduction

Altimeter measurements are corrected for several geophysical effects in order to isolate the oceanic variability: the DAC allows for the removal of high frequency variability induced by the atmospheric forcing and aliased by the altimetric measurements. Note that the processing of the DAC and the tide corrections are correlated due to the S1 and S2 signals.

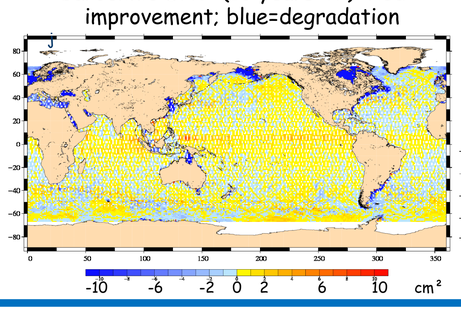
Until a few years ago, a classical inverse barometer (IB) correction was used to remove the static part of the ocean response to pressure forcing. Indeed several studies have shown the importance of the dynamic response of the ocean to pressure and wind forcing at high frequencies, and a DAC has been developed based on the high frequencies (HF) simulated by a barotropic model (MOG2D; Carrère and Lyard 2003). The DAC has been recently improved by the use of a higher resolution grid.

The purpose of the study was to improve the processing and the performances of the DAC for users of altimetry. Several analyses have been performed using multi-mission (Topex-Poseïdon, Jason-1) analysis of crossovers differences (SSH) and sea level anomalies (SLA) and also comparison to in-situ measurements (tide gauges from several databases).

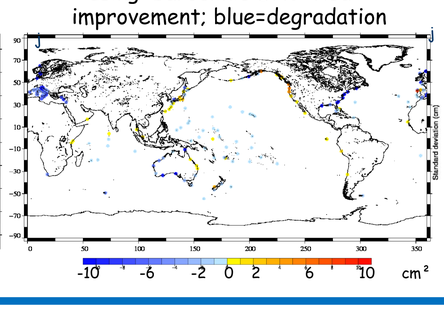
Using a baroclinic model instead of a barotropic one

- We used ten years of ECCO-GODAE daily estimates (http://www.ecco-group.org/)
- Daily means of operational DAC are used for comparison (strongly deteriorated if compared to 6-h)
- Results :
  - the baroclinic correction seems useful in the equatorial band for small spatial scales.
  - strong degradation in shallow waters due to the lower resolution of the ECCO-GODAE model + non optimized areas.
  - analysis for tide gauges does not show any improvement even in equatorial region
  - using this model for the DAC correction is not recommended now.
- impact on climate signals (global+regional MSL) may be tested within ESA CCI project in 2011.

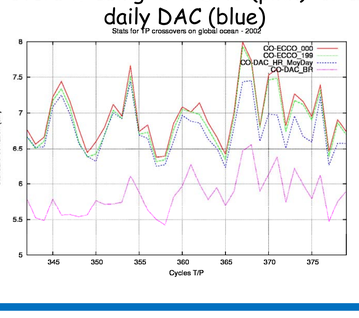
SLA variance reduction if using baroclinic DAC (10 years TP): Red = improvement; blue=degradation



variance reduction at tidal gauges if using baroclinic DAC Red = improvement; blue=degradation



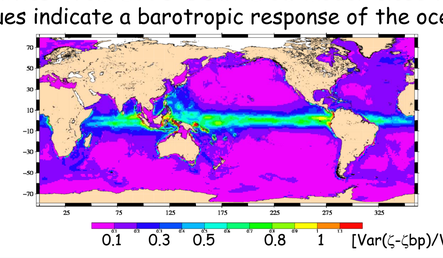
Mean variance reduction at TP X-overs if using 6-h DAC (pink) or a daily DAC (blue)



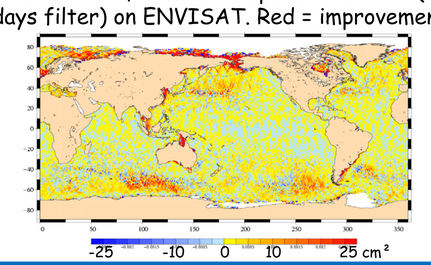
Point on the filtering of DAC

- **DAC = MOG2D_HF (T < 20 days) + IB_LF (T > 20days)**
- Choice of the 20-day cutoff-period
  - =Nyquist period of T/P-Jason altimeters
  - ocean response mostly barotropic for this HF band.
  - even at low latitudes for large spatial scales
- in mono-mission context (L2 products) :
  - Could envision a filter adapted to each mission (70 days for EN) ⇒ new altimeter database needed
- in multi-missions context:
  - need same corrections and filtering for all missions
  - HF residual signals are smoothed thanks to LWE (=Long Wavelength Errors bias estimation) correction during constitution of L3-L4 products.

Comparing SSH (ζ) and bottom pressure (ζbp) variabilities from ECCO-GODAE 3D model: close to zero values indicate a barotropic response of the ocean



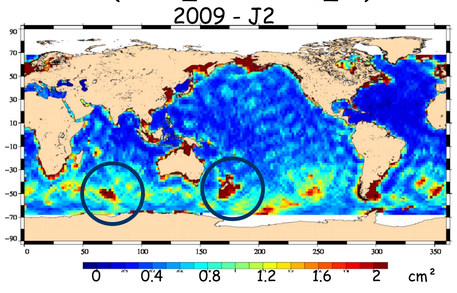
SLA variance reduction if using 70 days filtered DAC , instead of operational DAC (20 days filter) on ENVISAT. Red = improvement



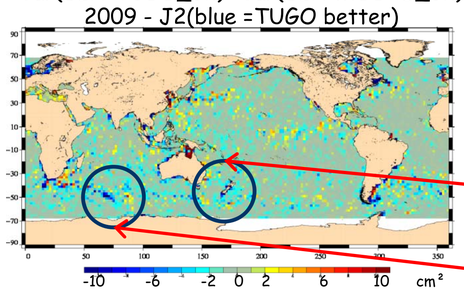
Using T-UGO global barotropic model instead of MOG2D-G

- T-UGO is a new release of MOG2D model, developed at LEGOS.
- Tests made with 3-hours forcing : better results with T-UGO
- But if compared to the operational 6-hours DAC (forced by 6-hours met.), T-UGO is equivalent : better on north-east and south-east American coasts, North and Baltic seas, and worse north of Australia, around New-Zealand, west of Galapagos and in bay of Biscay.
- comparisons might be corrupted by 3-hours met. forcing : T-UGO seems more stable, but need to compare with 6-h met.

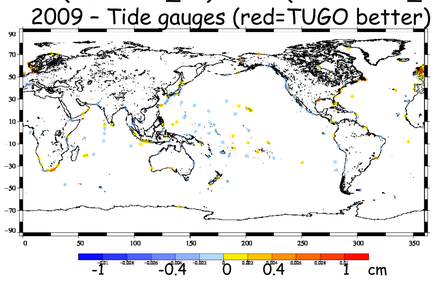
Var(TUGO_3h - MOG2D_3h) 2009 - J2



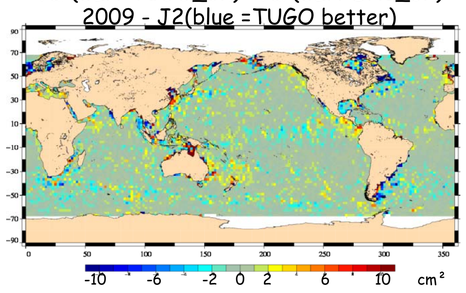
Var(SLA-TUGO_3h) –Var(SLA-MOG2D_3h) 2009 - J2(blue =TUGO better)



stdev(SLA-DAC_6h) –stdev(SLA-TUGO_3h) 2009 – Tide gauges (red=TUGO better)



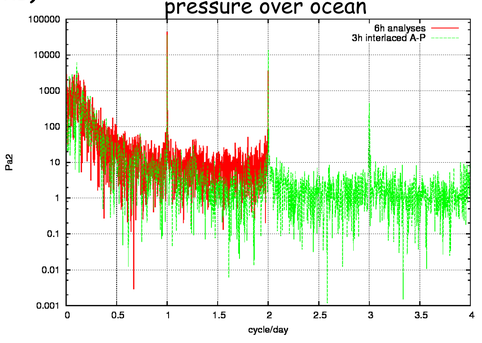
Var(SLA-TUGO_3h) –Var(SLA_DAC_6h) 2009 - J2(blue =TUGO better)



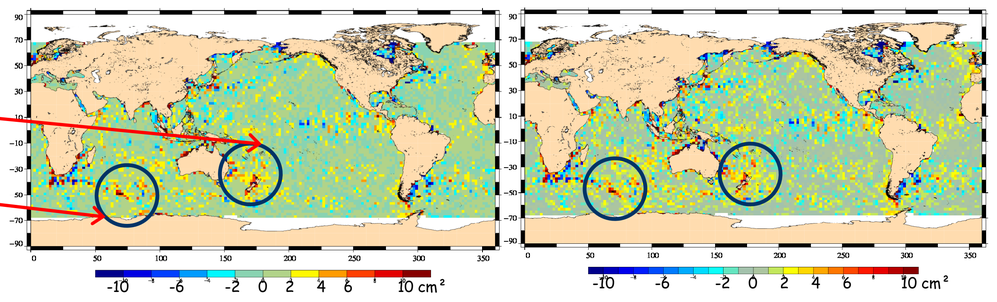
Impact of the 3-hours meteorological fields on DAC and atmospheric corrections

- 3-hours data = ECMWF analysis, N400 gaussian grid, interlaced analysed-predicted fields: AN00h, PR03, PR06, PR09, AN12h , PR15, PR18, PR21
- Atmospheric tides better represented in the 3-hours forcing : more realistic amplitude and propagation for S2, signature of S3 tide
- Impact of 3-hours data on DAC :
  - change S1S2 processing (see below)
  - 3-hours DAC has worse results than 6-hour's, whatever the S1S2 processing
  - likely due to a stability problem of the model (New-Zealand + Kerguelen regions) and/or to the use of non optimal 3-hours forcing

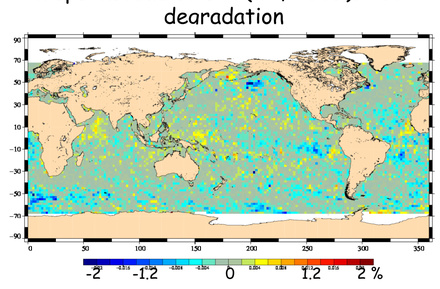
Variance preserving spectrum of average pressure over ocean



SLA variance reduction when using 3-h DAC instead of 6h DAC (cm²; Jason-2; 2009):
left : DAC without S1S2 tested;
right: DAC without S2 and with S1 tested.



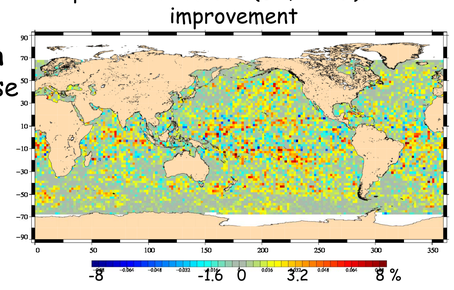
SLA variance reduction if using 3-h dry tropo instead of 6-h (J2, 2009). Red= dearadation



Impact of 3-hours data on dry tropospheric correction

- 3-hours dry-tropo = no correction from S1S2 atmospheric tides is needed
- Analysis shows a positive impact in southern Ocean, Atlantic, north and east-equatorial Pacific

SLA variance reduction if using 3-h wet tropo instead of 6-h (J2, 2009). Blue= improvement



Impact of 3-hours data on wet tropospheric correction

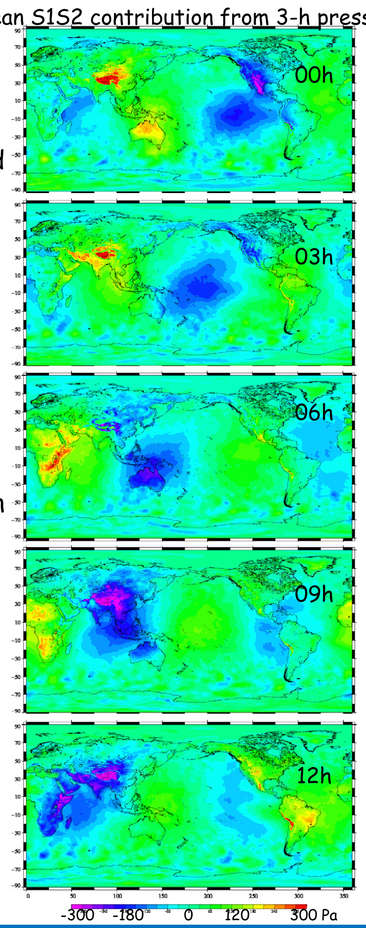
- Negative impact of 3-hours data which tend to raise the residual variance of SLA

Focus on the S1S2 processing for DAC and tide corrections

- 6-hours met. fields alias the S2 atmospheric tide: actual methodology is to remove the S1S2 signals from pressure forcing using monthly climatologies and then to force MOG2D-G model with this corrected forcing ⇒ altimetry corrections used are DAC without S1S2 signal + S1S2 tide signals (from global tide models).
- with 3-hours data :
  - S1 and S2 signals are better represented in pressure field ⇒ radiationnal tide will be more realistic
  - better theoretical methodology could be :
    - to keep S1 in the DAC and remove it from the tide correction
    - to remove S2 from DAC and keep it in the tide correction
    - use annual climatologies for S2 to keep interannual variability
    - but still need an external S1 correction which can be given by the mean S1 DAC computed with 3-h data
  - no pertinent results if using the 3-h gaussian interlaced forcing described above: the 3-hours dataset used may be not optimal ?
  - with more « optimal » 3-hours forcing (used at LEGOS), using the S1 DAC showed small improvement (see tide session).

S1 (right) and S2 (left) radiational tides computed from MOG2D-G forced with 3-h met.

Mean S1S2 contribution from 3-h pressures



Conclusions and perspectives

- To answer to different needs
  - we could have different corrections in a new altimeter database
  - more tests will be done in MyOcean-TAPAS project (test of a pressure only forced DAC, …)
- Future improvements concern
  - improvement of the modelling : semi-permanent ice cover, refined bathymetry and mesh
  - use a better forcing : ECMWF wind stresses, better spatial resolution
  - use optimal 3-hours meteorological fields and check S1S2 processing
  - regional modelling
  - Near Real Time (DAC IGDR)/Real Time purposes (DAC OGDR) :
    - IGDR: recentring the filtering window thanks to the use of predictions of DAC
    - OGDR : use predictions of DAC instead of IB

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