Improving the dynamic atmospheric correction for mean sea level and operational applications of altimetry

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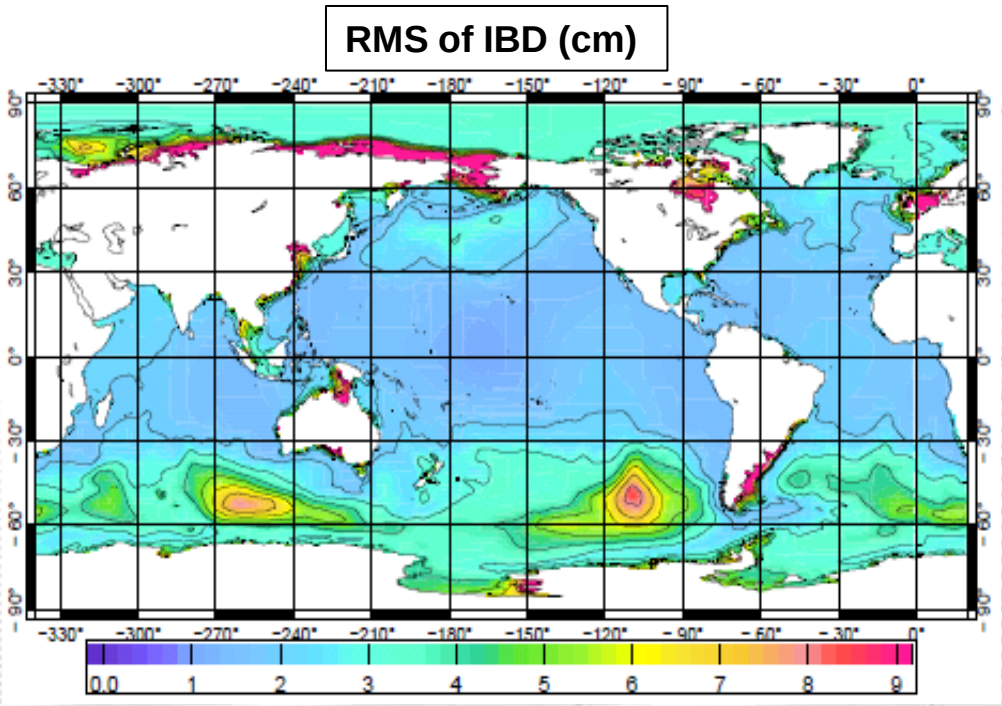
Outline

1. **Presentation of DAC and main issues**
2. **Improving DAC for MSL applications (ERA-interim)**
3. **Improving DAC for operational altimetry**
4. **Conclusions and perspectives**

Dynamic Atmospheric correction

- **Objectives of the DAC**
  - ➢ remove high frequencies signals forced by the atmosphere (pressure and wind) and aliased in altimetric data because of bad temporal sampling of altimeters
- **DAC**
  - ➢ Combination of high frequencies of barotropic model (MOG2D) and low frequencies of IB
  - ➢ Model forced by ECMWF operational analysis (6h)
  - ➢ 6-hours temporal resolution



Dynamic Atmospheric Correction

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- **High frequency filtering**
  - ➢ High-Frequency cut-off at 20 days chosen because
    - ➢ Nyquist period of reference altimeters TPJ
    - ➢ ocean signal mostly barotropic for those HF (Fukumori 1998; Vinogradova 2007)
    - ➢ even at low latitudes, if considering large scale, ocean response is barotropic

DAC issues

- ECMWF forcing: operational analysis are not compliant with climate and Mean Sea Level applications
  - ➢ many jumps exists in the temporal series due to ECMWF evolutions/upgrades =>impact the MSL (IB, Pressure, DT)
  - ➢ the quality of the operational dataset is not homogeneous on all the altimetric period: first years (<~1995) are less accurate because of the use of old versions of the analysis system => impact on DAC

- DAC is not optimal for real-time and near real-time processing
  - ➢ Filtering window is totally decentred due to lack of measurements in future
  - ➢ IB used for RT products

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• DAC is not optimal for real-time and near real-time processing

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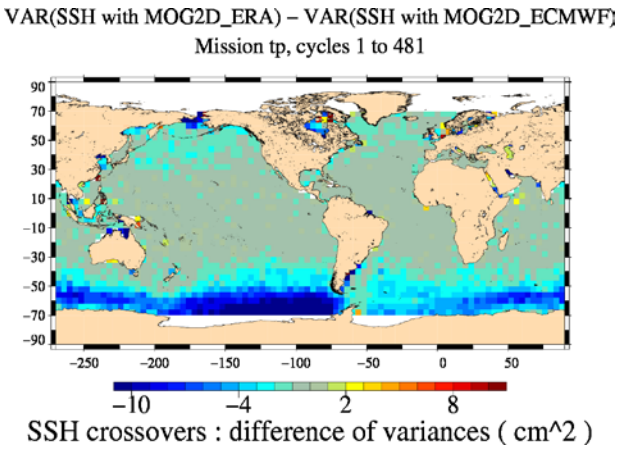
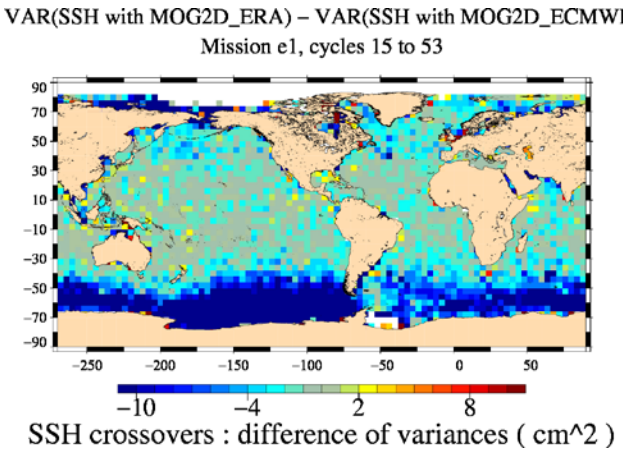
- ➢ IB used for RT products
- ➢ use forecasts

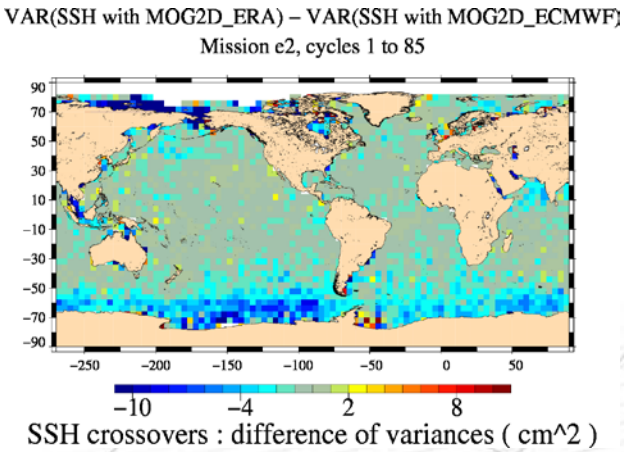
2. Improving DAC for MSL applications – use of ERA Interim

use of ERA Interim – impact on mesoscale

Variance difference at Xovers when using ERA-interim DAC instead of operational DAC, for TP, E1, E2 (cm²)



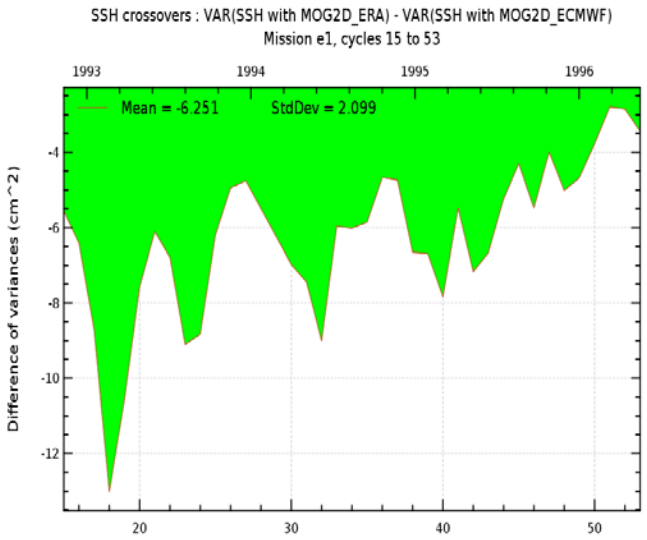


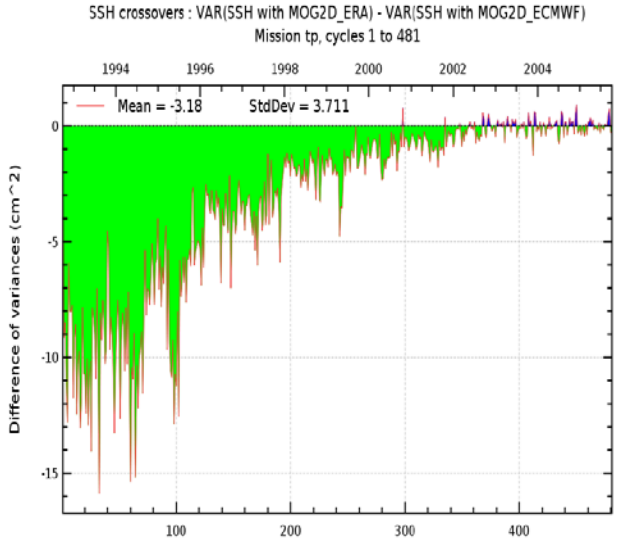


- Improvement visible on all missions TP, E1,E2
- Strong positive impact mostly located at high latitudes where the variability of the correction and the forcing is maximum (>10 cm²)
- Significant reduction of SSH variance in Bering Strait + Hudson Bay

use of ERA Interim – impact on mesoscale

Temporal evolution of the mean variance difference at Xovers when using ERA-interim DAC instead of operational DAC, for E1 and TP (cm²)

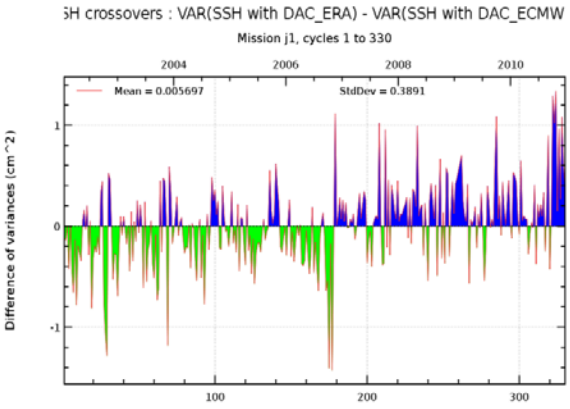


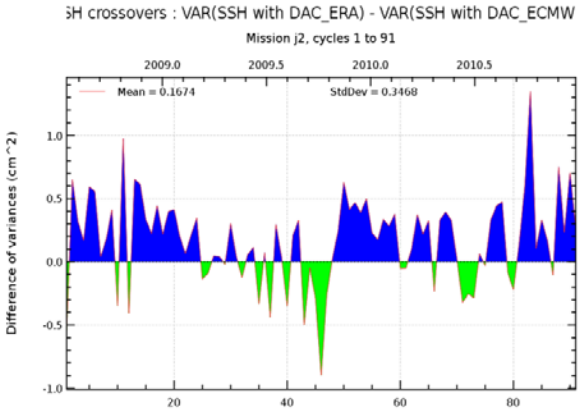


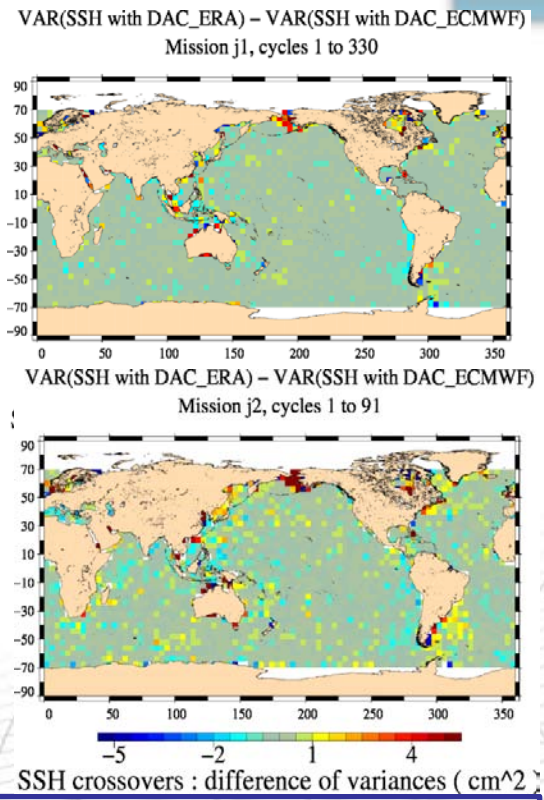
- Improvement evolves with time
- Maximum on the first years of altimetry, where quality of operational ECMWF analysis was not as good as today
- ERA Interim and operational DAC have similar results from 2002-2003

use of ERA Interim – impact on mesoscale

Variance difference at Xovers when using ERA-interim DAC instead of operational DAC, *for J1 and J2* (cm²)

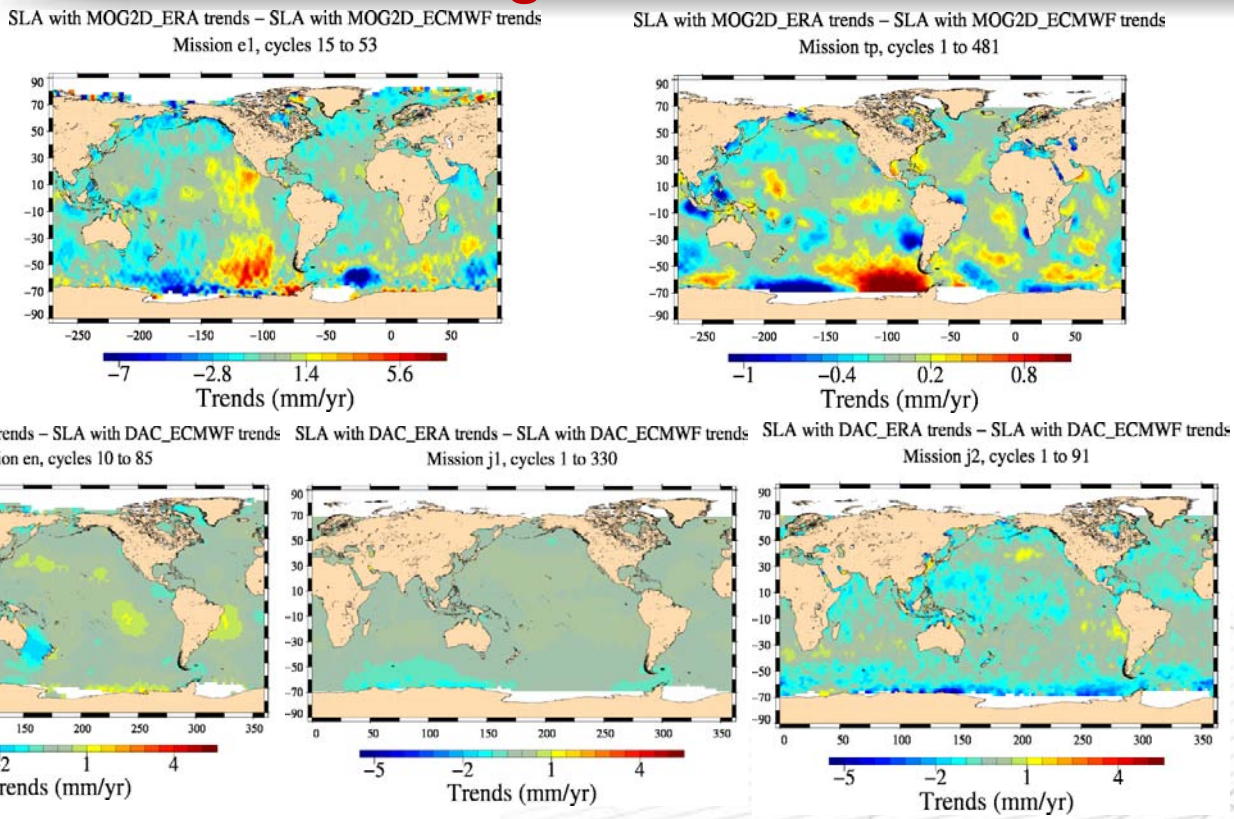






- results are very similar : mean difference < 1 cm²
- on average on global ocean, ERA Interim DAC gives slightly better results until 2006, and then operational DAC becomes better (operational N400 in 2006)
- regionally, both DACs are similar in deep ocean but DAC ERA-interim raises the residual crossovers variance in some shallow water regions, and in some deep ocean regions for J2

use of ERA Interim – impact on regional MSL



- Visible in many regions
- Strong : several mm/yr
- On recent mission : impact smaller but not negligible

use of ERA Interim – impact on global MSL

Altimetry missions	DAC (Reference)	DAC ERA-Interim
ERS-1	6.34 mm/yr	6.27 mm/yr **(-0.07/Ref)**
ERS-2	2.53 mm/yr	2.5 mm/yr **(-0.03/Ref)**
TP	3.01 mm/yr	3.03 mm/yr **(+0.02/Ref)**

Altimetry missions	DAC (Reference)	DAC ERA-Interim
EN	0.71 mm/yr	0.76 mm/yr **(+0.05/Ref)**
J1	2.55 mm/yr	2.55 mm/yr **(0)**
J2	2.39 mm/yr	2.13 mm/yr **(-0.26/Ref)**

- Weak impact on most missions
- Impact stronger on J2 (shorter period …)

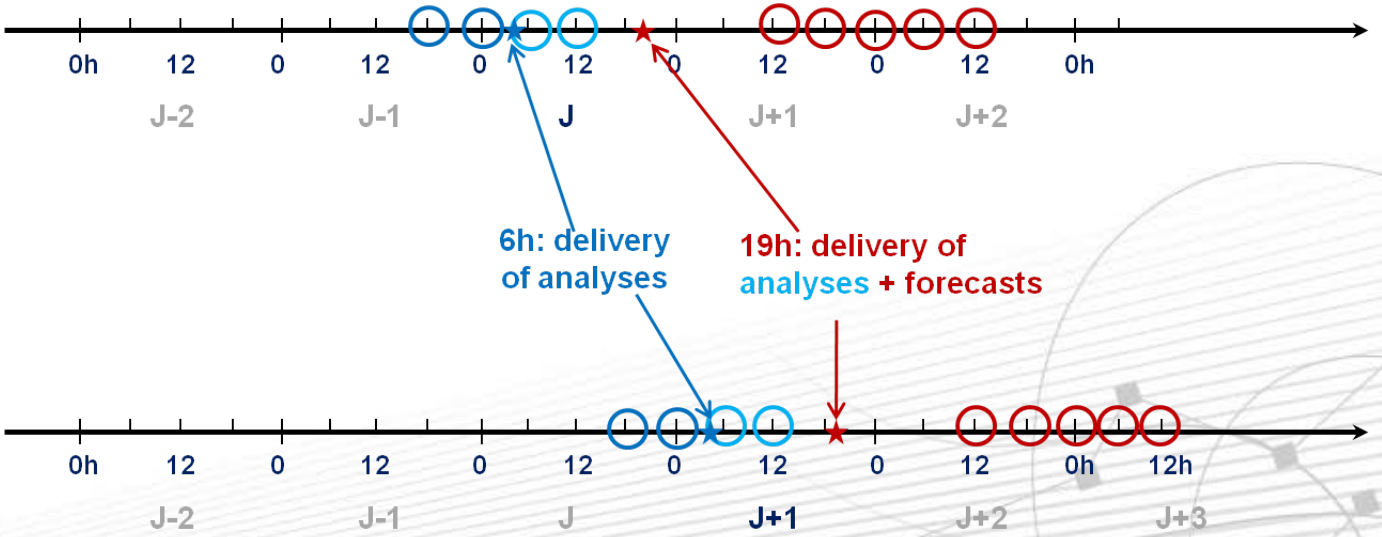
3. Improving DAC for operational altimetry

Improving DAC for operational altimetry

- Using model forecasts to improve DAC for IGDR and OGDR products
  - DAC = MOG2D_HF(T<20 days) + IB_LF(T>20 days)
  - IGDR :
    - Improvement= improving the 20 days filtering while re-centering the real-time filtering window using forecasts.
  - RT/OGDR :
    - No DAC used for the moment (only IB)
    - Improvement = using a forecasted DAC instead of the forecasted IB for DUACS RT. Allows taking into account the dynamic response of ocean to atmospheric forcing.
    - But only for internal DUACS/RT use to avoid real time constraints

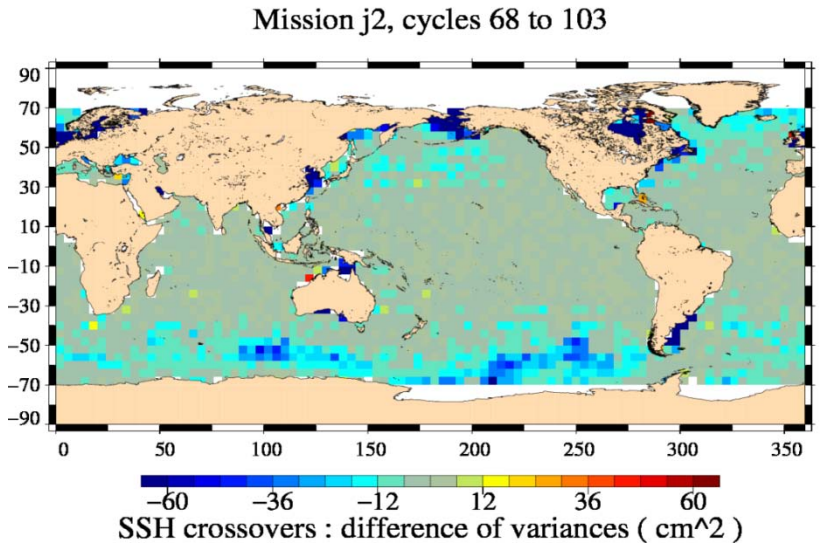
Improving DAC for operational altimetry

- Meteo forecasts available
  - Meteo forecasts delivered in real time for OGDR production
  - 5 files delivered each day (from forecast run of J 12h) : J+1, 12h … J+2, 12h
  - Database is not optimal (no continuity between forecasts …) but can be improved
  - Forecasted DAC can then be computed



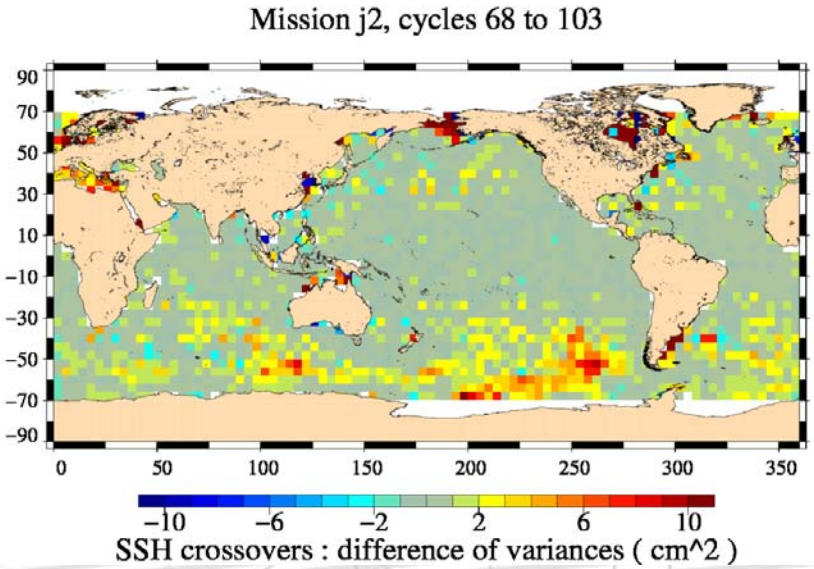
Operationnal ECMWF meteorological fields delivery

Impact of improved DAC for RT and NRT products



Variance reduction at J2 crossovers when using the new forecasted DAC instead of the forecasted IB: VAR(SSH-**DAC_forecast**) – VAR(SSH-IB_forecast) in cm². Blue points show improvement of the new forecast DAC.

Variance reduction at J2 crossovers when using the new improved IGDR DAC instead of the operationnal one: VAR(SSH-DAC_IGDR_operational) – VAR(SSH-**DAC_IGDR_optimised**) in cm². Red points show improvement of the new IGDR DAC.



Conclusions

DAC forced by ERA Interim

- Use ERA-interim DAC on old altimeter missions
- Use ERA-interim DAC for all missions for climate applications at the cost of some lower accuracy in some regions (shallow waters)

RT and NRT DAC

- Use the improved NRT DAC for IGDR products
- Use forecasted DAC for DUACS/OGDR instead of the forecasted IB

- We need better meteo forecasts
  - continuous forecasts on several days
  - 5 days forecasts at least

Perspectives

- **improved NRT and RT DAC**
  - Implementation planned in 2013
- **improvement of DAC modeling**
  - new bathymetry (current one is derived from Gebco 1m), new mesh
  - both could benefit from new parameters developed within new FES2012 tide model
  - MOG2D → TUGO
  - better modelling of the ice cover effect
    - using a varying sea-ice cover database (monthly climatologies or operational data) could help improving simulations at high latitudes, at least seasonally
  - better wind stress forcing (ECMWF wind-stress fields)
- **Improvement of meteorological data**
  - Higher resolution analysis coming this year
  - Higher resolution reanalysis (ERA-interim) planned
  - Better 3h meteorological data to improve high frequencies modelling