AN OBJECTIVE ANALYSIS DERIVED WATER VAPOUR PATH DELAY CORRECTION FOR ALTIMETRIC MISSIONS : NRT APPLICATION TO JASON-2 AND CRYOSAT-2 OVER THE OCEAN

Jacques STUM, Antoine Delepoulle*, Philippe SICARD* and Amandine Guillot***

(*) Collecte Localisation Satellites, 8-10 rue Hermès, 31520 Ramonville, France
(**) Centre National d'Etudes Spatiales, 18 avenue Edouard Belin, 31055 Toulouse, France

Introduction

- In case where no radiometer is on board, the ECMWF wet path delay correction may not be accurate enough to derive SSH.
- We propose here to use available ancillary water vapour observations to compute it.
- This talk is devoted to the description of the method, and to its application to operational NRT altimeter data processing

Water vapour observations : which ones ?

3 different sources of worldwide observations have been studied :

- Spaceborne imaging spectroradiometers like MERIS/Envisat
  - Needs cloud-free, bright surfaces : good accuracy over land, but poorer accuracy over the ocean
- GPS ground stations measurements
  - Advantages :
    - Good accuracy
    - High temporal resolution (5 mn for IGS)
  - Drawbacks :
    - Stations are sparse at the global scale
    - No NRT availability (SuomiNet : 3-4 days)
- Spaceborne scanning microwave radiometers
  - Scanning MWR are the only data source, able to provide global observation of water vapour. How to optimally combine all these observations ?

Scanning microwave radiometers

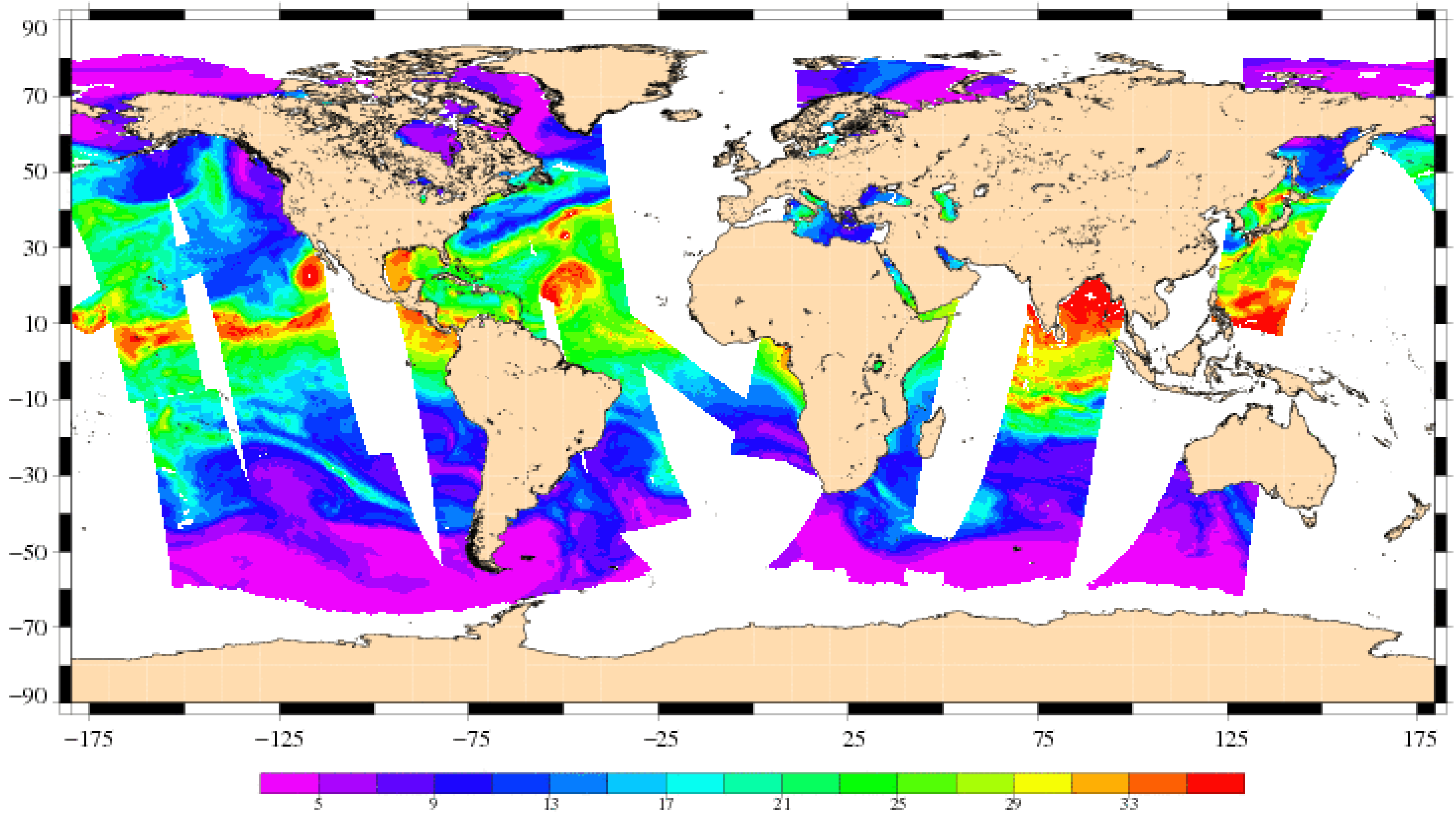
11 scanning MWR available in 2012 :

- 6 AMSU-A (2-freq) :
  - NOAA-15, NOAA-16, NOAA-17, NOAA-18, NOAA-19, METOP-A
- 3 SSMI/SSMIS (3-freq) :
  - F15, F16, F17
- TMI (3-freq)
- Windsat (3-freq)

Data products are available at NOAA (AMSU-A), RSS (SSMI and Windsat) and GSFC (TMI) in NRT (less than 48 hours)

Scanning microwave radiometers

1-hour coverage (from 0h to 1h)



Water vapour path delay (cm)

Objective analysis method

- Foundations in Bretherton et al., 1976.
- Applied to SST (Reynolds and Smith, 1994), altimetry (Le Traon et al., 1998), Ocean Colour (Pottier et al., 2006)
- Applied to Water vapour path delay (Stum et al., 2011, IEEE TGRS)

Objective analysis method

Basic equation :

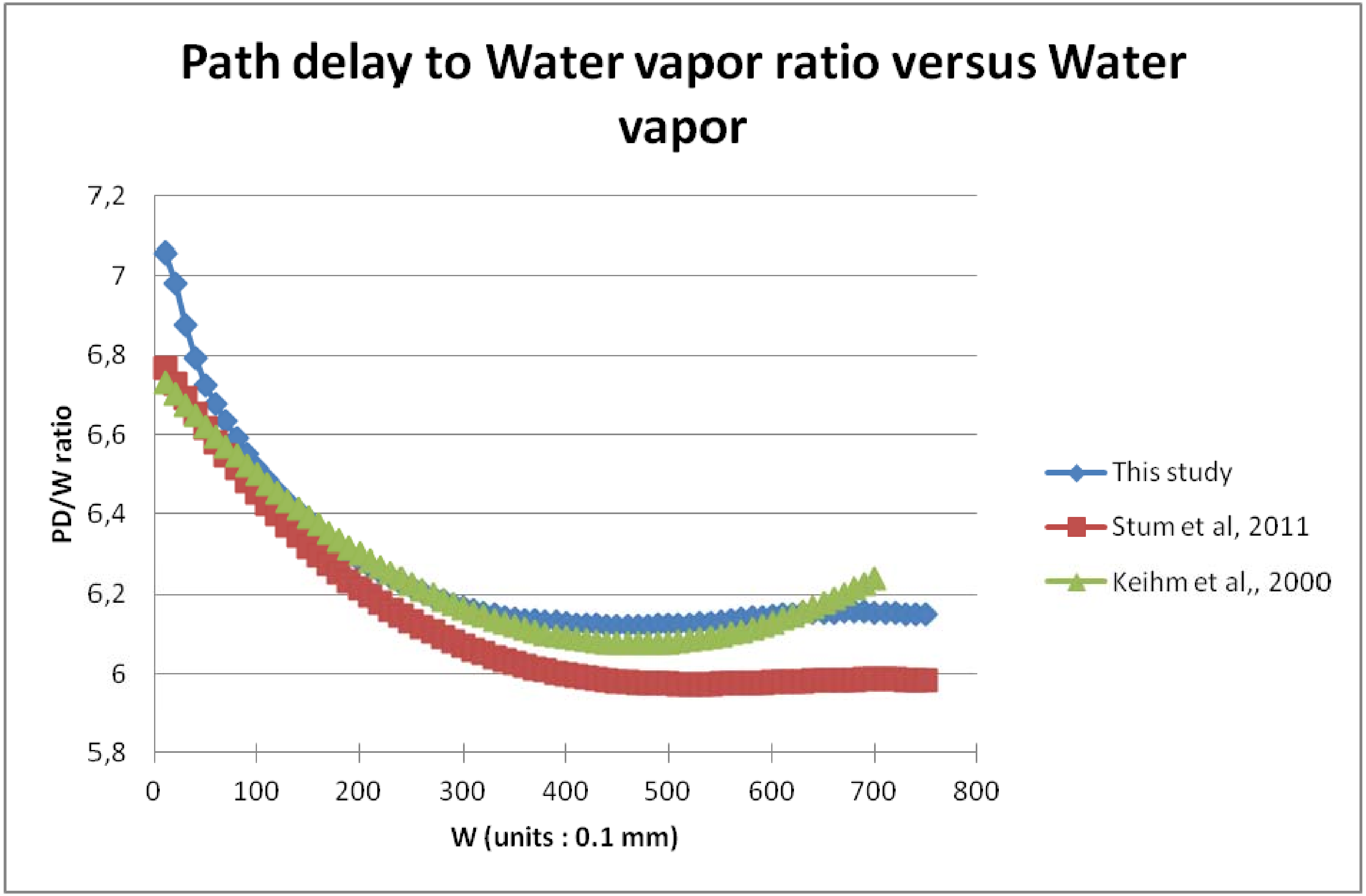
- PD = FG + $\sum_{i=1}^{N} W_i \times (Obs - FG)_i$
  - PD : Path Delay to be estimated at a given position P
  - FG : a first-guess value = ECMWF PD correction
  - Obs_i : the N path delay observations around P
  - Wi : weights (function of accuracy and closeness of Obs_i)
- Choosing ECMWF as first-guess allows one to compute a seamless PD correction

Objective analysis method

- Improvements (relative to Stum et al., 2011) :
  - More radiometers taken into account
  - Better radiometer data processing
  - More accurate variance and correlation radii of the PD anomalies (-> improved Wi estimation)
  - Better characterization of radiometer errors (-> improved Wi estimation)

Radiometer data processing

- Compute PD from WV : use of ERA-Interim temperature and humidity profiles to build the PD/WV ratio LUT
- Editing for rain and sea ice contamination : use of daily ice concentration from O&SI SAF
- For each radiometer : bias removal using LUT built from matchups with Jason-2



Path delay to Water vapor ratio versus Water vapor
7,2
7
6,8
6,6
6,4
6,2
6
5,8
PD/W ratio
0
100
200
300
400
500
600
700
800
W (units : 0.1 mm)
This study
Stum et al, 2011
Keihm et al,, 2000

Results

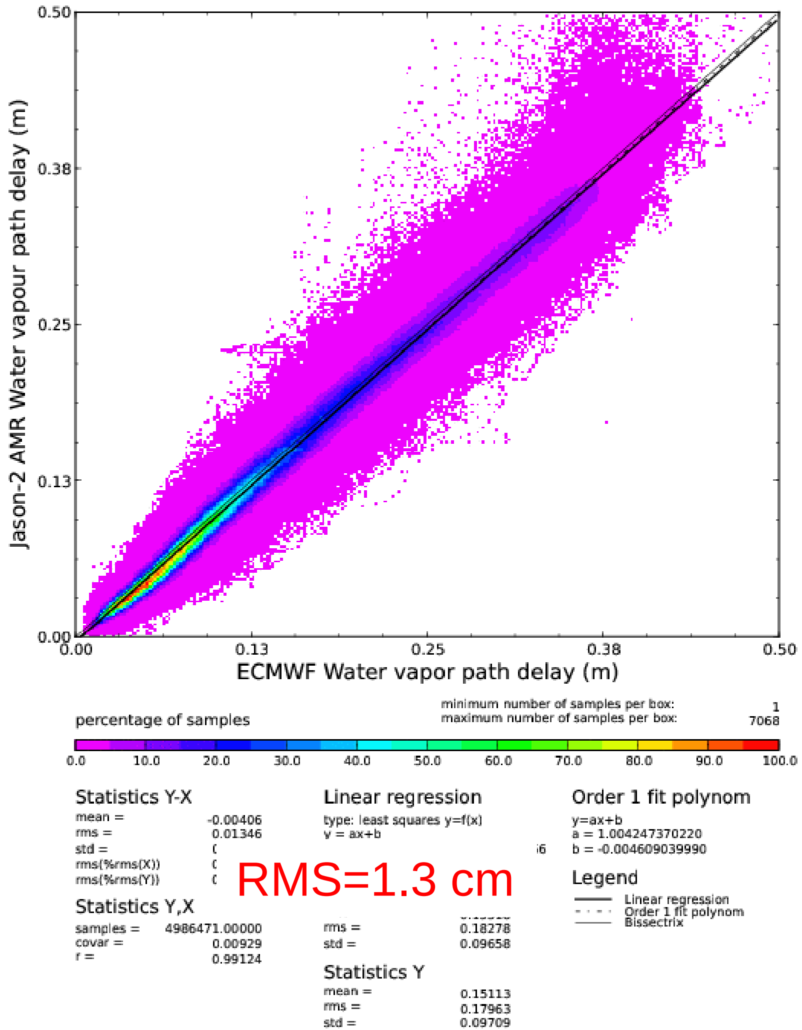
- Validation of the new OA wet PD correction has already been done on a 2008 dataset with Jason-1 (Stum et al., 2012, Venice OSTST meeting)
- The method has now been applied in NRT (start : July 1st, 2012) to check its applicability to Jason-2 and Cryosat-2 IGDR processing

Application to NRT Jason-2 altimeter data processing

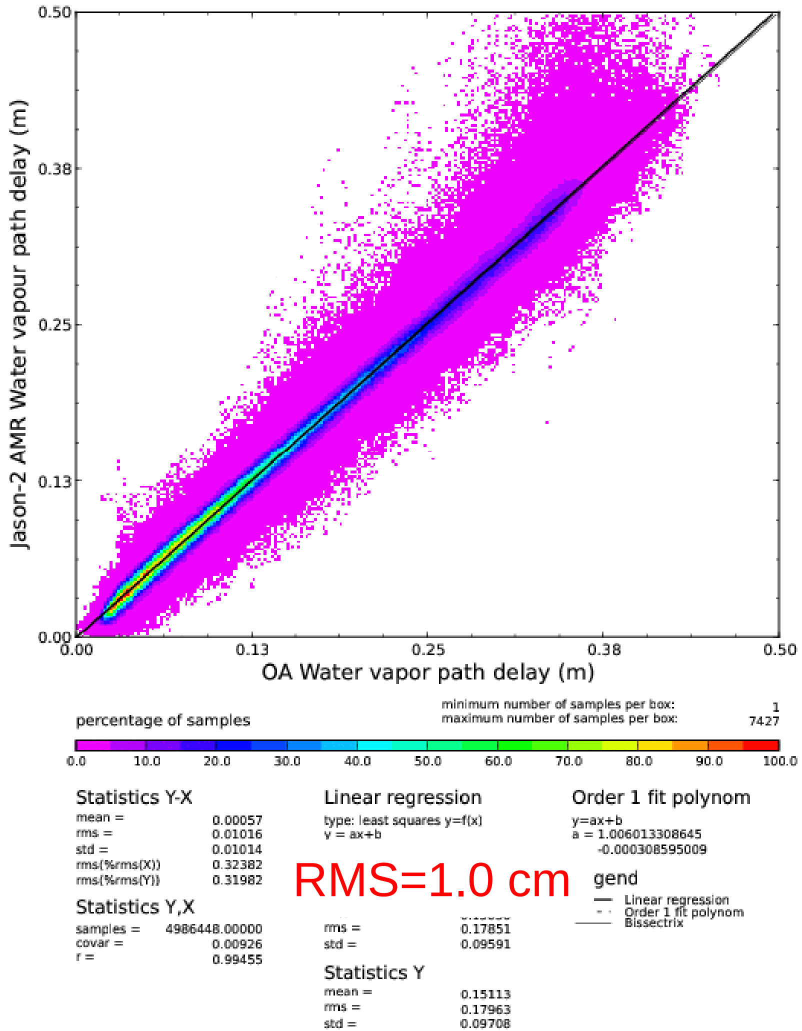
- Duration of the experience : 6 months (end 2012)
- Data acquisition from providers every 3 hours starting at 5h (Sea ice conc. needed first)
- Validation is performed against J2 AMR and ECMWF corrections (along-track and crossover statistics)

Along-track statistics

J2 vs ECMWF



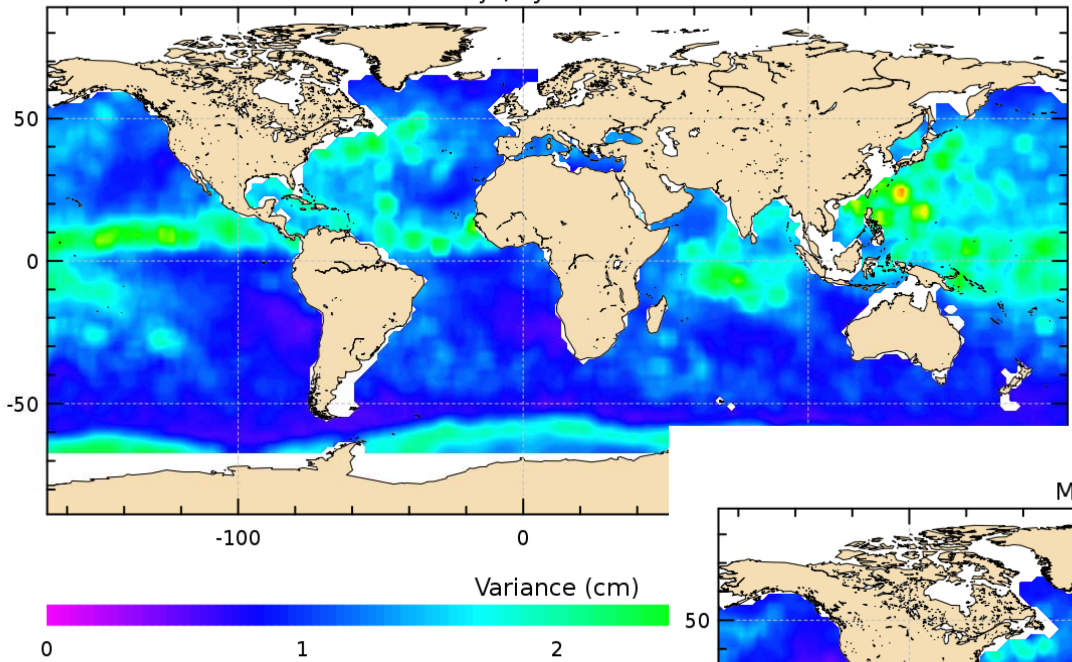
J2 vs OA



Along-track statistics

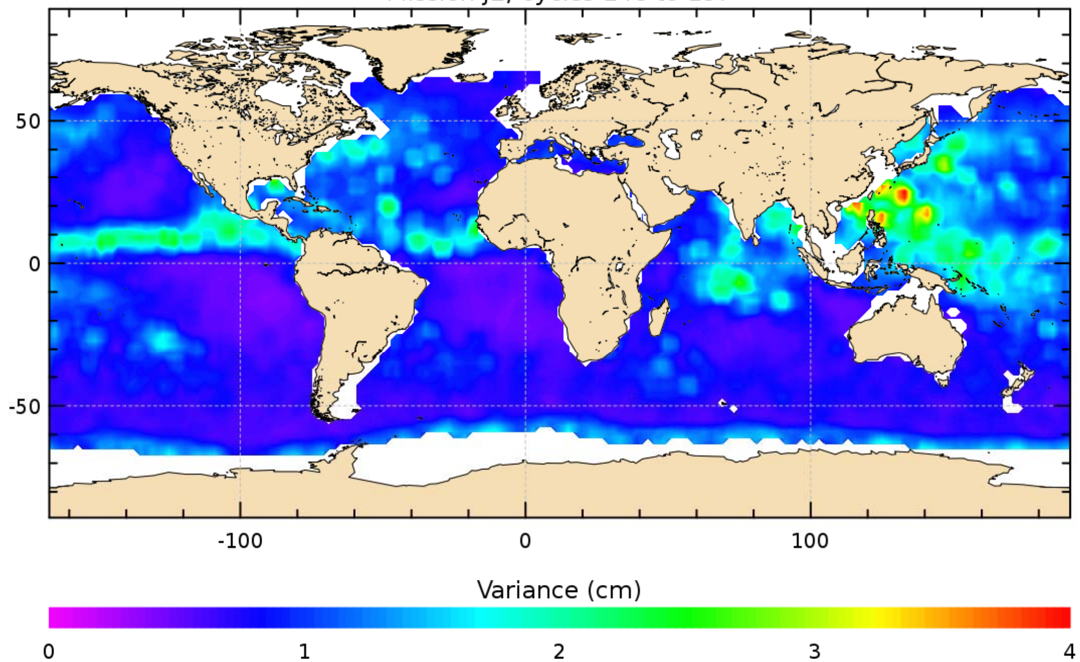
Variance of ECMWF - RAD

Mission j2, cycles 148 to 157



Variance of AO - RAD

Mission j2, cycles 148 to 157

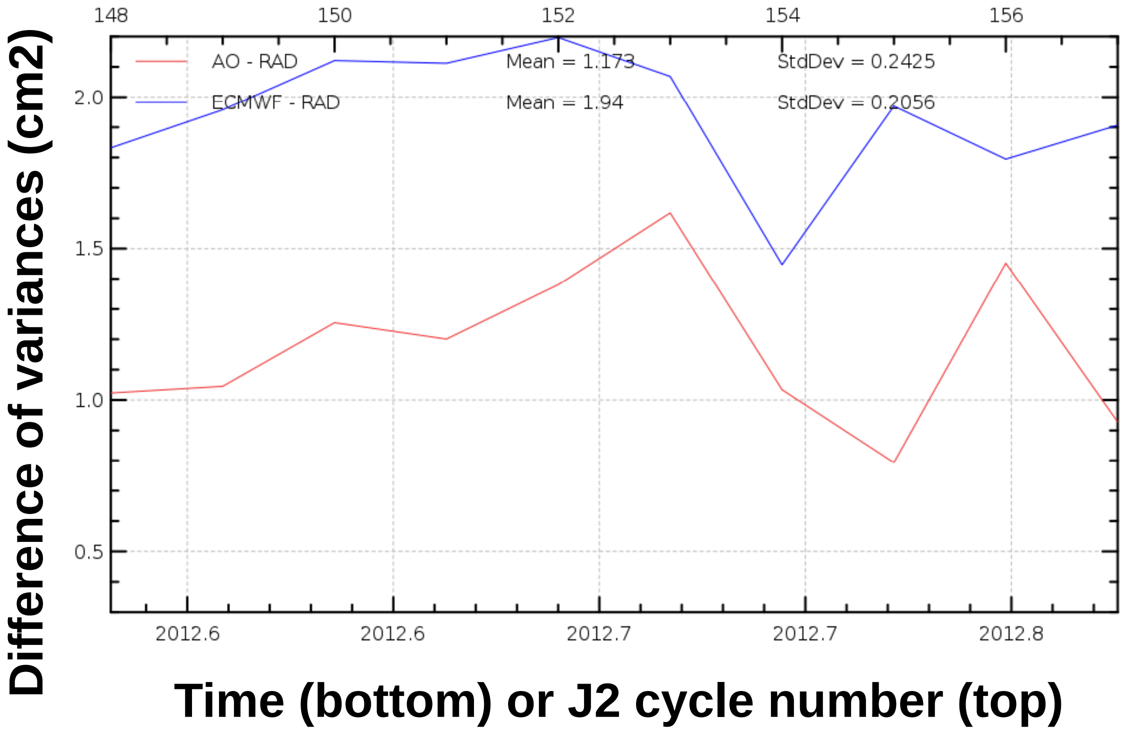


CLS cnes

Crossover sea surface height analysis

Var(DeltaSSH with OA) – Var(DeltaSSH with AMR)

Var(DeltaSSH with ECMWF) – Var(DeltaSSH with AMR)



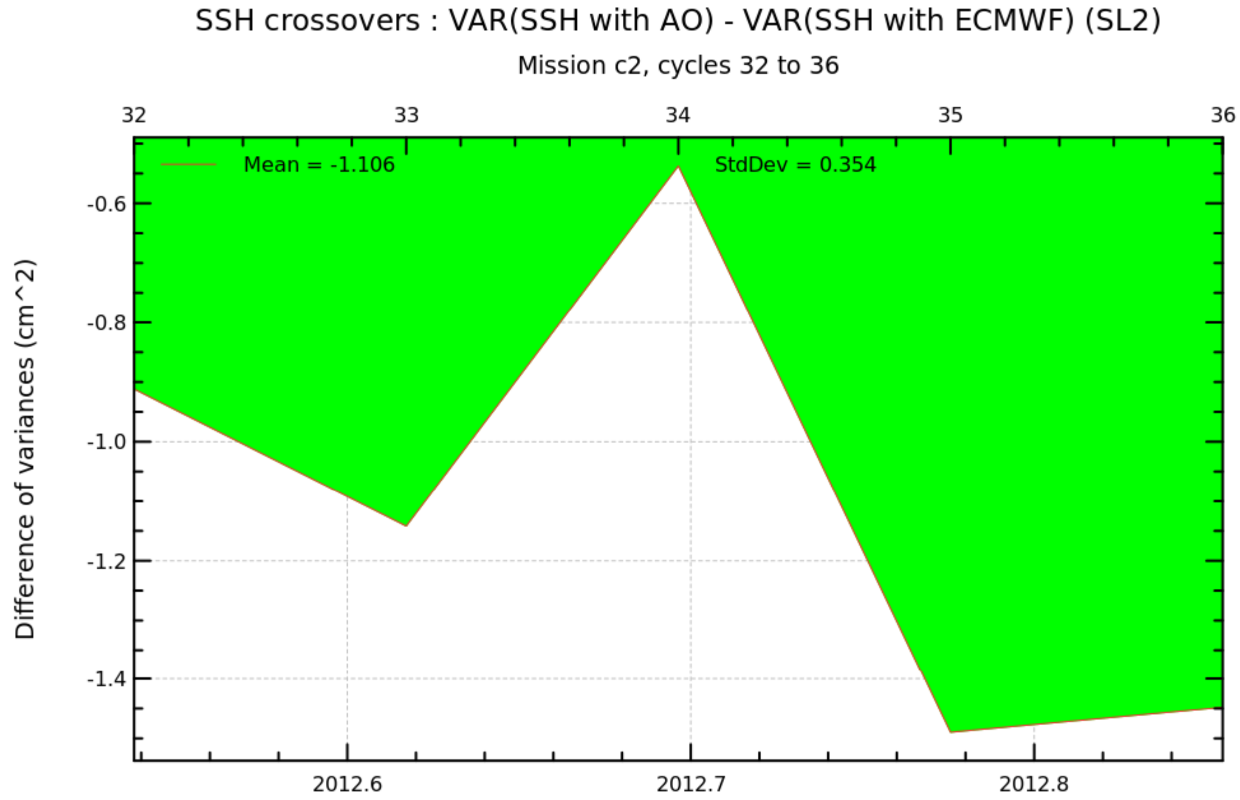
Application to NRT Cryosat-2 altimeter data processing

- Duration of the experience : 6 months (end 2012), covering Cryosat cycles 32 to 36
- Validation is performed against ECMWF correction (no radiometer on board)

Crossover sea surface height analysis

Cryosat-2 mission :
Var(DeltaSSH with OA)
– Var(DeltaSSH with ECMWF)

Difference of variances (cm2)



Time (bottom)
or Cryosat-2 cycle number (top)

Conclusions

- The new OA correction performs significantly better than the ECMWF one.
- Today the attainable accuracy of the OA correction is limited by the number and accuracy of the input sensors.
- A new series of accurate sensors will be available in 2013 (SSMIS/F18, AMSR2/GCOM-W1) and the AMSU-A series will continue with METOP-B
- The application to Jason-2 and Cryosat-2 NRT has demonstrated the applicability of the method to operational altimeter data processing
- Cryosat product available for independent assessment

Jacques.Stum@cls.fr