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 Delepouille*, 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)

OSTST meeting, Boulder, Oct 7-11, 2013
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:

\[ PD = FG + \sum_{i=1}^{N} W_i \times (Obs_i - FG) \]

- 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

- This study
- Stum et al, 2011
- Keihm et al., 2000

W (units : 0.1 mm)

PD/W ratio
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

RMS=1.3 cm

J2 vs OA

RMS=1.0 cm
Along-track statistics

Variance of ECMWF - RAD
Mission j2, cycles 148 to 157

Variance of AO - RAD
Mission j2, cycles 148 to 157
Crossover sea surface height analysis

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

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

Time (bottom) or J2 cycle number (top)
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)

SSH crossovers: VAR(SSH with AO) - VAR(SSH with ECMWF) (SL2)
Mission c2, cycles 32 to 36

![Graph showing the difference of variances (cm^2) over time.

Mean = -1.106, StdDev = 0.354.

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

OSTST meeting, Boulder, Oct 7-11, 2013