A Specific Coastal Wet Tropospheric Correction for the Envisat mission

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Radiometric measurements

- Strongly contaminated by land: the same way as the other radiometers (SSM/I, TMI, AMSU...)
- Land emissivity nearly twice sea emissivity + more variable in space and time
- For a surface temperature of 300K, a 10% land contamination in the sea pixel will increase the TB by more than 10K ➔ several centimeters!
- Classical retrieval algorithms developed assuming sea surface emissivity modeling are no more valid
- BUT only radiometer products can provide the required resolution to detect short scales SSH signals in coastal areas
- Alone or combined with other products (Mercier 2007, J. Fernandes 2011)
Existing methods

- Correction of land contamination before application of the L2 ocean retrieval algorithm: Desportes et al., 2006
- Applied on Jason2/AMR for the Pistach products

\[
\begin{align*}
TB_{corr}(f) &= TB(f) - \text{corr}(p,f) \\
\text{corr}(p,f) &= [TB_{\text{land}}(f) - TB_{\text{sea}}(f)] \times p(f)
\end{align*}
\]

- \( f \): frequency of the 3 channels (18.7, 23.8 and 34 GHz for Jason 1-2)
- \( p(f) \): proportion of land in the footprint taking into account the antenna patterns
- \( TB_{\text{land}} \): closest TB with 100% of land
- \( TB_{\text{sea}} \): closest TB with 100% of sea
• Land proportion used as external parameter in the L2 retrieval algorithm: Brown 2010 et al
• Applied in Jason2/AMR operational products
Existing methods

Combined MWR - ECMWF - GNSS wet tropo. corr through COASTALT ESA initiative (http://www.coastalaltimetry.org/)

Summary of the method

GPD (GNSS-derived Path Delay)
Combines the following data sets (objective analysis):

- GNSS-derived zenith Zenith Total Delays (ZTD) at coastal GNSS stations
- Valid MWR measurements
- ZWD from a Numerical Weather Model, ECMWF (global grids 0.25°×0.25°, every 6h)

Fernandes, 2010
Proposed methodology for RA2-MWR

- RA-MWR: bi-frequency nadir radiometer: 23.8 GHz/36.5 GHz

- What do we need? [adapted from Brown 2010]
  - Measured brightness temperatures (mixed Land/Ocean)
  - Measured altimeter backscattering coefficient in Ku band (to take into account surface roughness)
  - Land proportion in the pixel at both frequencies

\[ dh = NN (TB_{23.8}, TB_{36.5}, \sigma_0_{Ku}, land_{prop23.8}, land_{prop36.4}) \]

Coastal Neural Net algorithm

- Algorithm formulation
  - Building of the learning database
  - Learning of the neural net
Building of the learning database

dh =NN (TB23.8, TB36.5, \( \sigma_0_{\text{Ku}} \), land_prop23.8, land_prop36.5)

- Weighted mean of a 1/30° land sea mask by a sampling of Envisat MWR true antenna pattern
Land proportion

< 0.1
< 0.2
< 0.3
< 0.4
< 0.5
> 0.5
Building of the learning database

dh =NN (TB23.8, TB36.5, σ0_Ku, land_prop23.8, land_prop36.4)

1rst STEP : simulation of Ocean TBs

- A set of ECMWF analyses over sea with wet tropospheric correction, and other needed geophysical parameters: surface temperature and pressure, temperature and humidity profiles, surface wind speed

- Simulation over sea of brightness temperatures at 23.8 and 36.5 GHz thanks to a radiative transfer model

http://www.cls.fr
Building of the learning database

dh = NN (TB23.8, TB36.5, σ0_Ku, land_prop23.8, land_prop36.4)

2nd STEP: simulation of Mixed TBs

TB_{mixed} = (1-LP) \times TB_{Ocean} + LP \times TB_{Land}

- LP randomly chosen in a realistic distribution (obtained from one data cycle)
- TB_{Ocean} simulated by the radiative transfer model
- TB_{Land}: real measurement randomly picked up in a 10° latitude band
Building of the learning database

dh =NN (TB23.8, TB36.5, \(\sigma_0\)_Ku, land_prop23.8, land_prop36.4)

Simulated with the radiative transfer model assuming a sea surface, smaller resolution
• Neural Net formalism to estimate weights and biases that minimize the differences (bias and rms between estimated and reference dh)
• Architecture with 1 hidden layer of 8 neurons
  » allows an optimal regression taking into account non-linearities
SLA variance difference vs ECMWF

Mission en, cycles 55 to 84
ENV: CNN-ECMWF
Mean = 2.914

Mission en, cycles 9 to 93
ENV: GPD-ECMWF
Mean = -1.023

Mission j2, cycles 1 to 147
J2: GDRD-ECMWF
Mean = -2.764
CNN SLA when approaching the coast
SLA variance difference vs GDR

M_RAD_Cotier_NewNN_NewCalib) – VAR(SLA with TRO_HUM_RAD_C
Mission en, cycles 55 to 84

Difference of variances (cm^2)
J2 GDR-D coastal dh

Mean of GdrD (Wet Tropo.) – GdrT (Wet Tropo.)
Mission J2, cycles 1 to 20

VAR(SLA with GdrD (Wet Tropo.)) - VAR(SLA with GdrT (Wet Tropo.))
Mission J2, cycles 1 to 20

SALP, Philipps et al, 2012
• Future altimetry missions defined to increase resolution and accuracy in altimetry measurements (S3/SRAL, SARAL/AltiKa, SWOT/Karin, ...) => will allow a better characterization of SSH coastal variability

• A global, high resolution and accurate wet tropospheric correction will be needed to take advantage of these new instruments

• Only the radiometer estimation, alone or combined with other products (models, GPS) will allow to reach this goal, models presenting insufficient spatial resolution and poor temporal sampling

• We developed a new algorithm derived from previous studies (Desportes, Brown) to improve the coastal wet tropospheric correction

• NN are used to easily and accurately take into account the required additional geophysical parameters
Conclusions & Perspectives

- First results show a significant reduction of SLA variance with respect to the model and reduction of standard deviation of SSH at cross-overs

- For future altimetry missions, other aspects of processing and design of the radiometers should be analyzed and possibly improved:
  - Quality of the side-lobe correction (L1 processing)
  - Potential of the “original” measurements of the instrument (7 Hz for Envisat)
  - Review of the interpolation processing between radiometer and altimeter measurement
  - Enhancement of the radiometer resolution either through better antenna or innovative algorithm (currently used in imagery)
  - Potential of high frequency radiometers (higher spatial resolution, much smaller land impact)