A Specific Coastal Wet Tropospheric Correction for the Envisat mission

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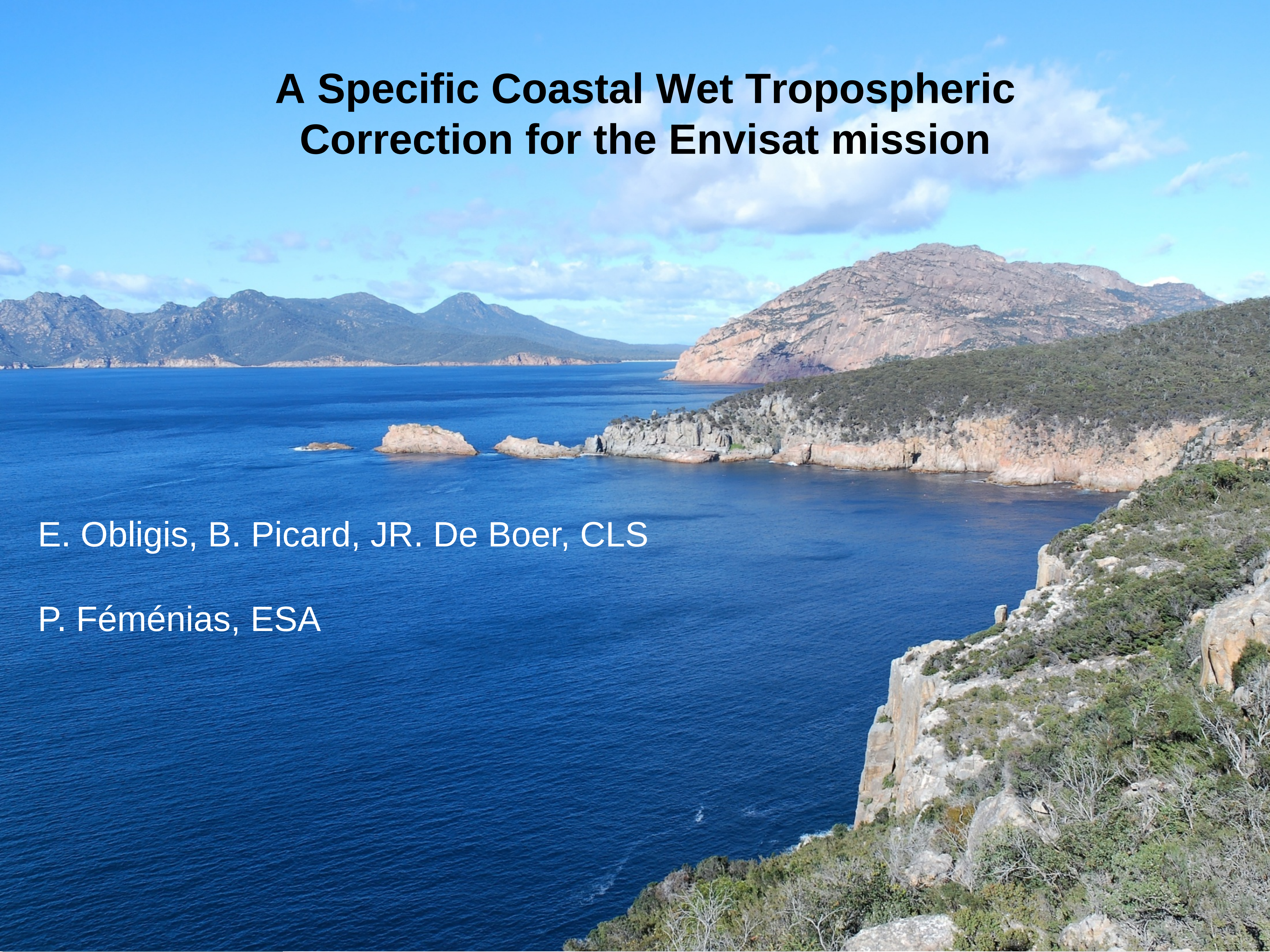
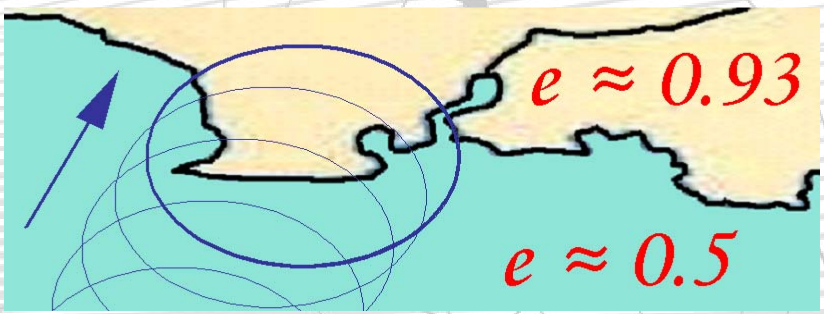


Outline

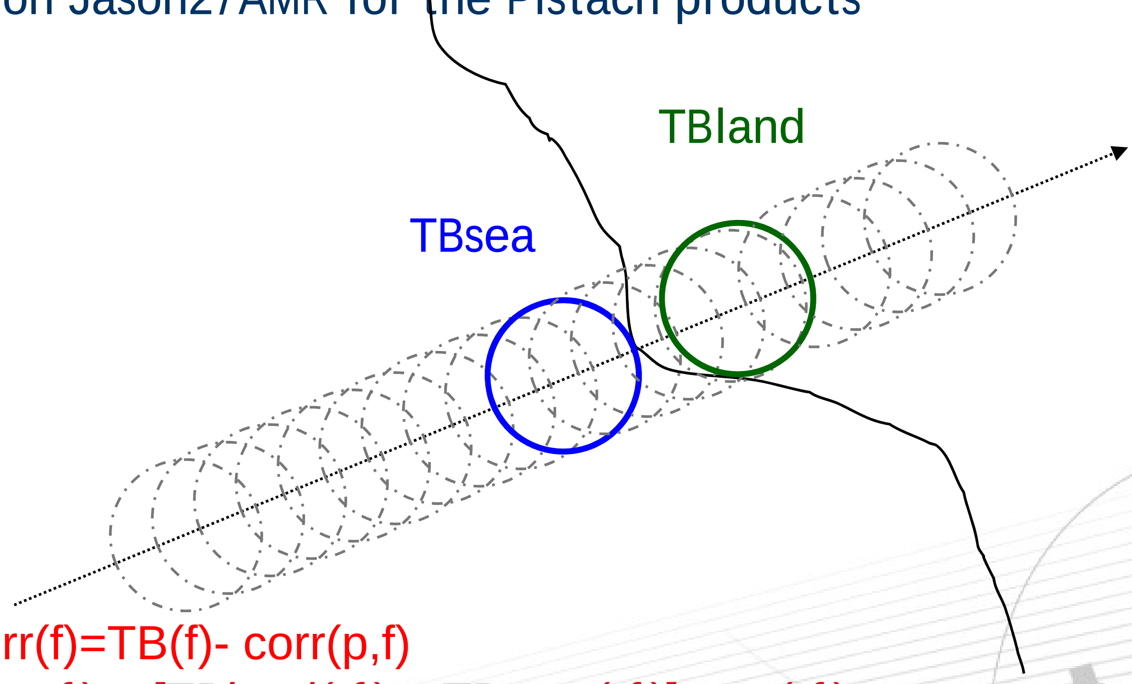
Radiometric measurements

- 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



Desportes, 2008

TB_corr(f)=TB(f)- corr(p,f)

corr (*p* , *f*) = [TBland(*f*) – TBsea (*f*)] × ***p*** (*f*)

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

TBland: closest TB with 100% of land

TBsea: closest TB with 100% of sea

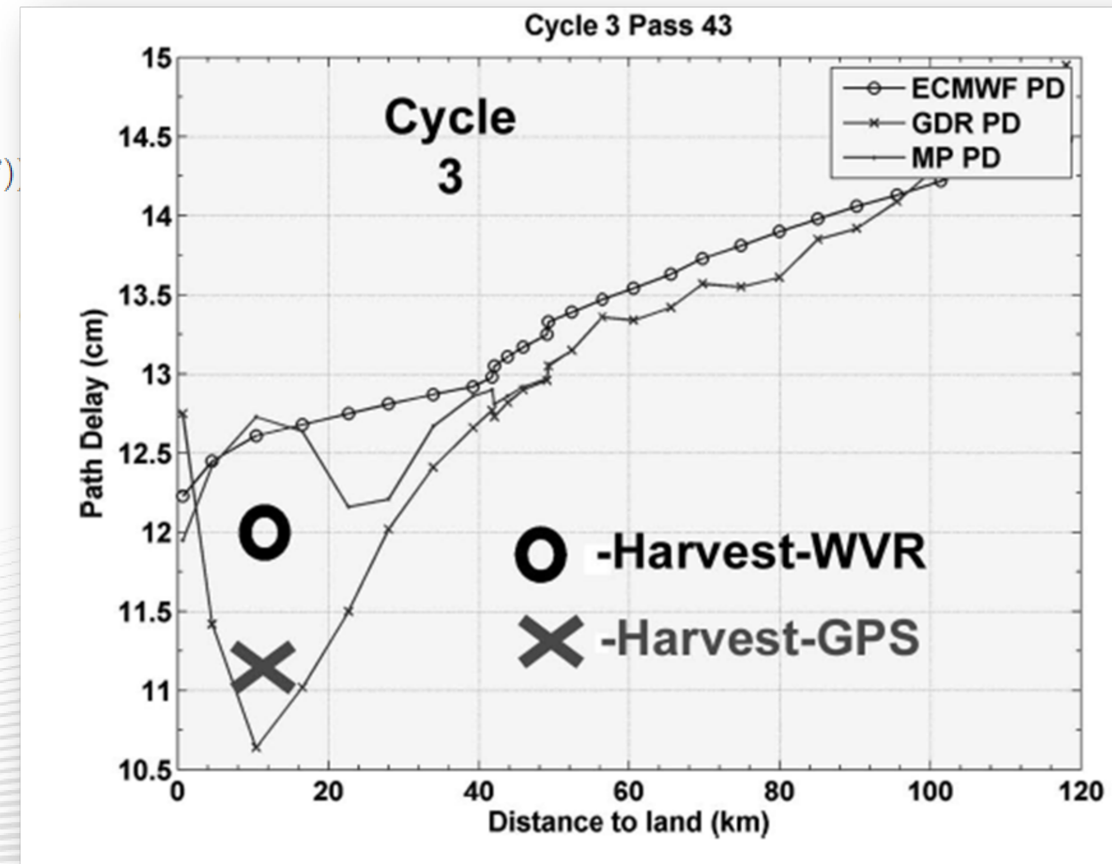
Existing methods

- Land proportion used as external parameter in the L2 retrieval algorithm : **Brown 2010 et al**
- Applied in Jason2/AMR operational products

$$\mathrm{PD}_{\mathrm{MP}} = c_0\left(\mathrm{PD}_0, L_F^{18.7}\right) + \sum_f c_f\left(\mathrm{PD}_0, L_F^{18.7}\right)\log\left(280 - T_B(f)\right)$$

$$T_{\mathrm{MB}}(f) = (1 - L_F(f))\,T_{\mathrm{Ocean}}(f) + L_F(f)T_{\mathrm{Land}}(f)$$

Brown, 2010



Existing methods

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

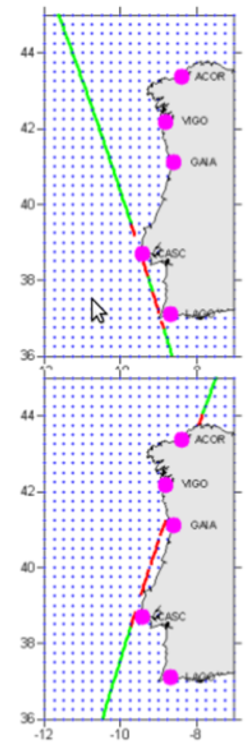
Fernandes, 2010

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)



5th COASTAL ALTIMETRY WORKSHOP 15-18 October 2011 | San Diego, USA

Proposed methodology for RA2-MWR

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

- 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 (TB23.8, TB36.5, σ0_Ku, land_prop23.8, land_prop36.4)

Coastal **N**eural **N**et algorithm

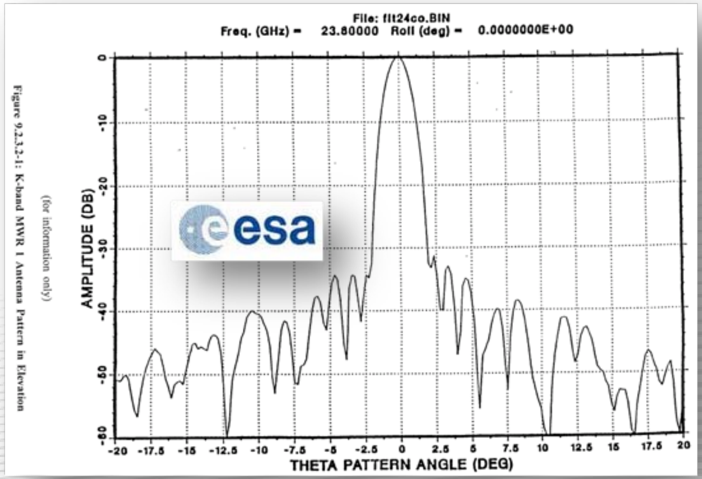
- Algorithm formulation
  - Building of the learning database
  - Learning of the neural net

Building of the learning database

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

land proportion

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



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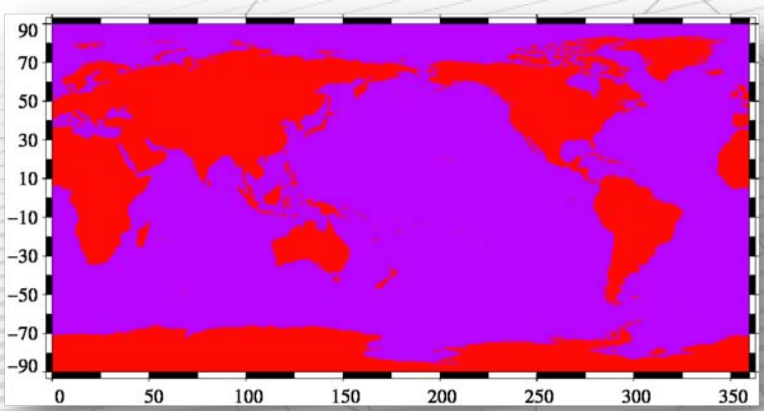
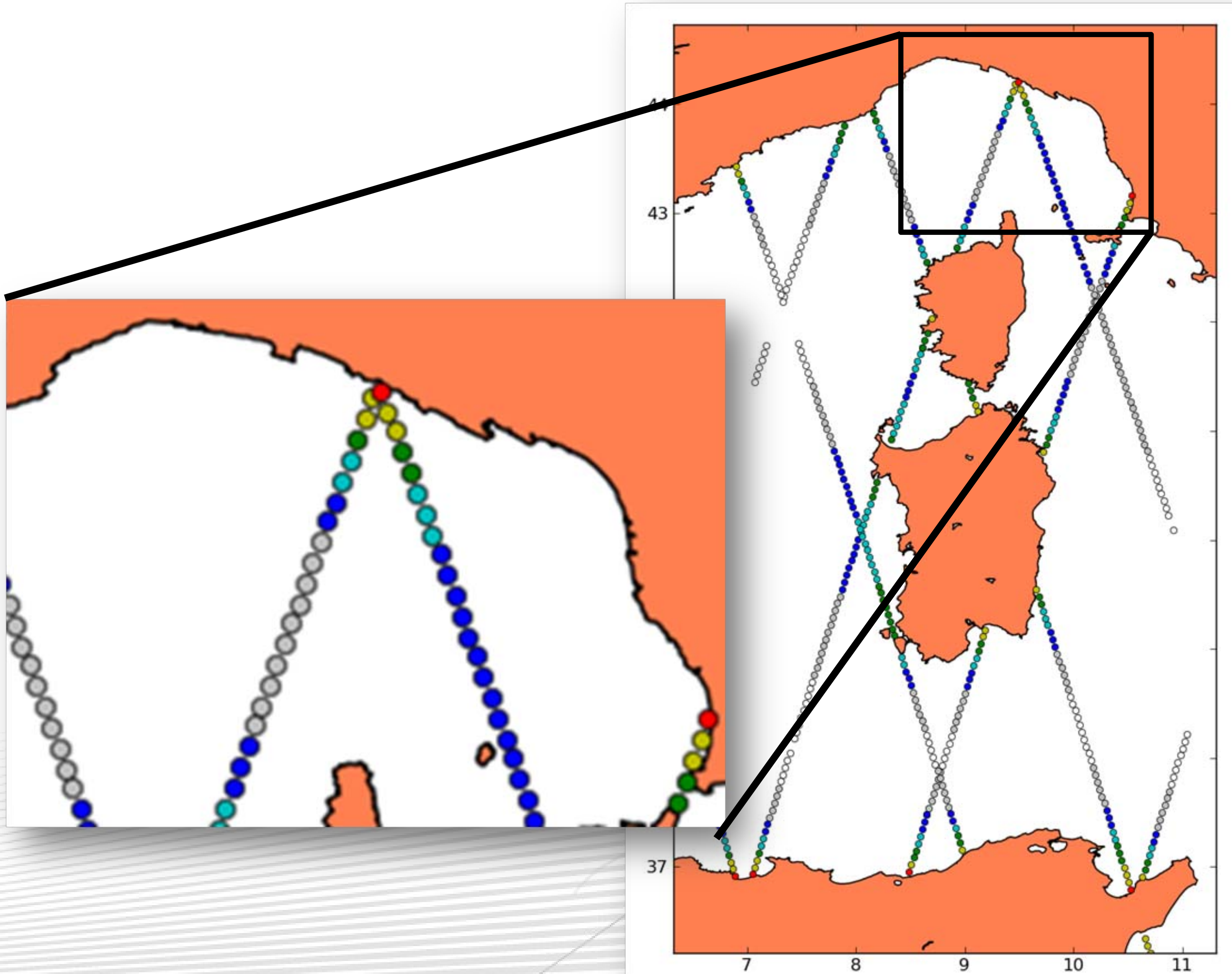


Land proportion

< 0.1
< 0.2
< 0.3
< 0.4
< 0.5
> 0.5



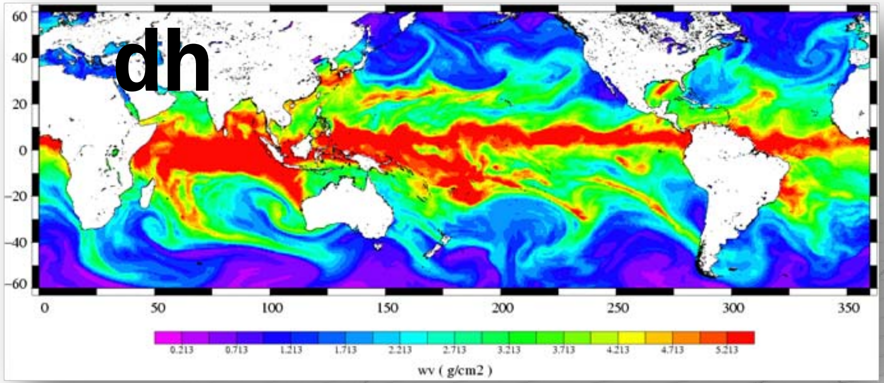
Building of the learning database

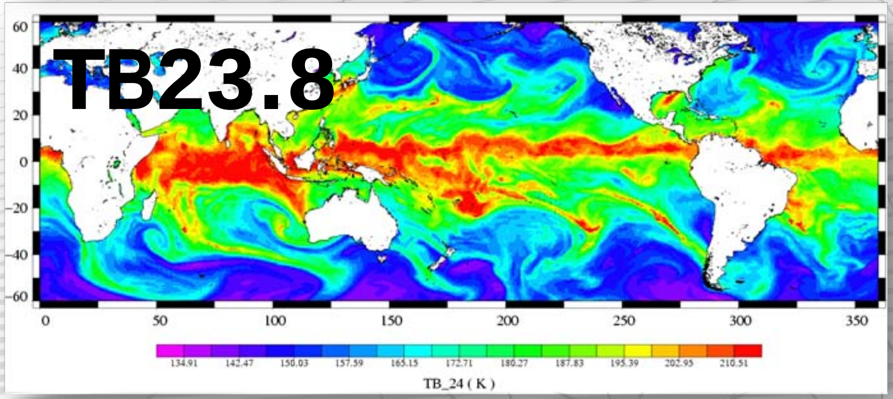
dh =NN (TB23.8, TB36.5, σ0_Ku, land_prop23.8, land_prop36.4)

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





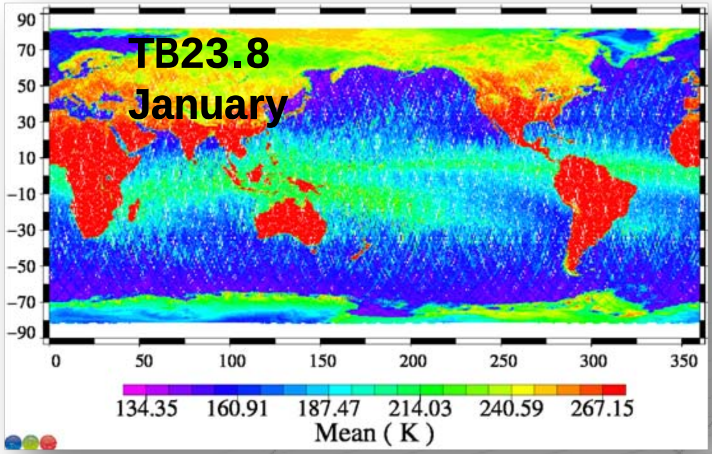
Building of the learning database

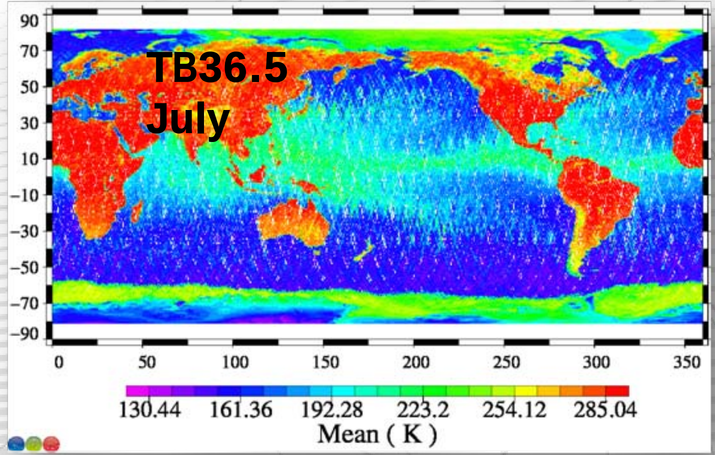
dh =NN (TB23.8, TB36.5, σ0_Ku, land_prop23.8, land_prop36.4)

2nd STEP : simulation of Mixed TBs

TB_mixed = (1-LP)*TB_Ocean + LP*TB_Land

- LP randomnly 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

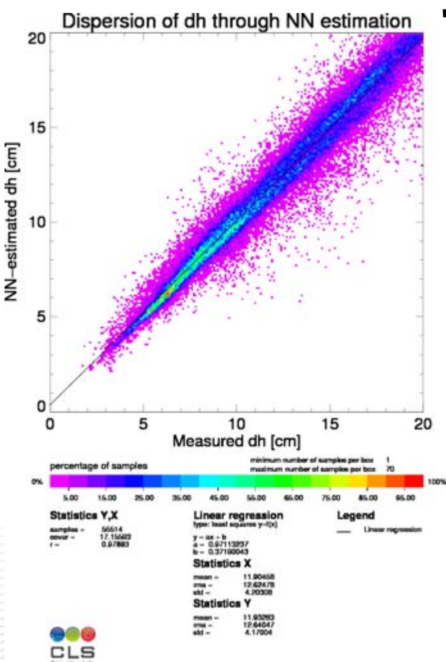
dh =NN (TB23.8, TB36.5, σ0_Ku, land_prop23.8, land_prop36.4)

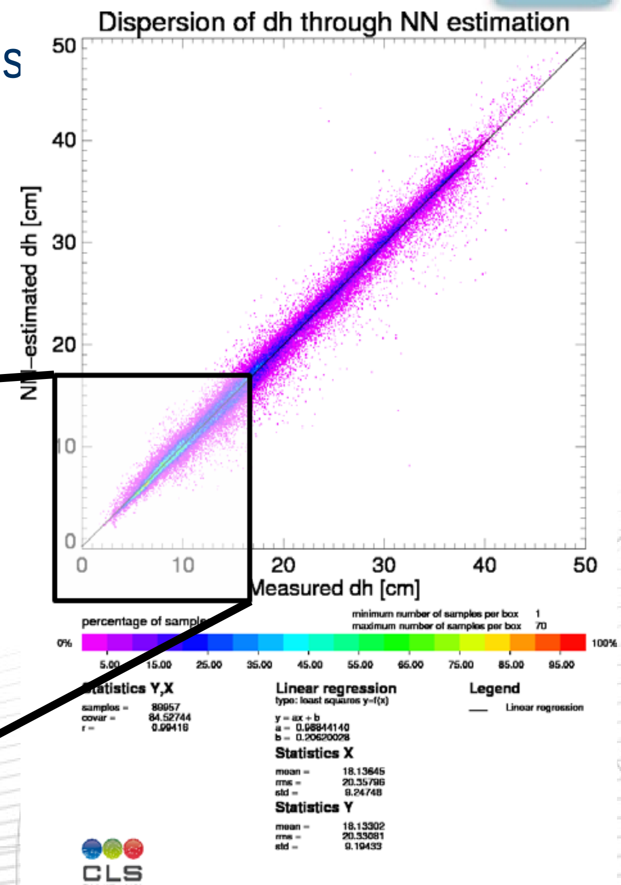
Simulated with the radiative transfer model assuming a sea surface, smaller resolution

Algorithm formulation

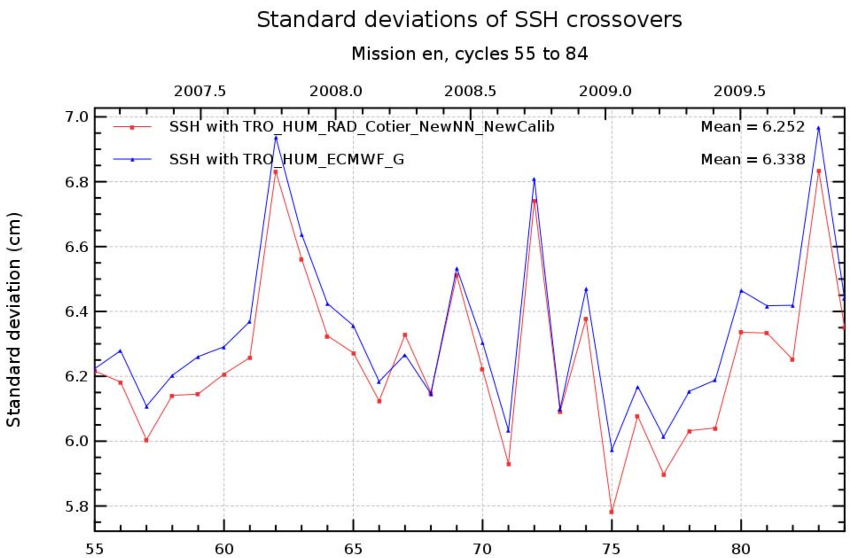
- Neural Net formalism to estimate weights and biases that minimize the differences (bias and rms between estimated and reference dh
- Architecture with 1 hidden layer of 8 neurons

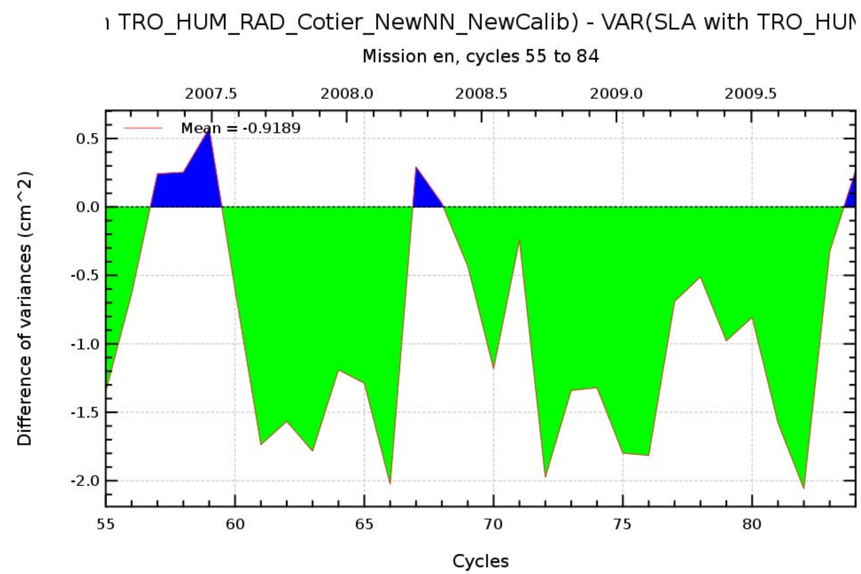
➔ allows an optimal regression taking into account non linearities

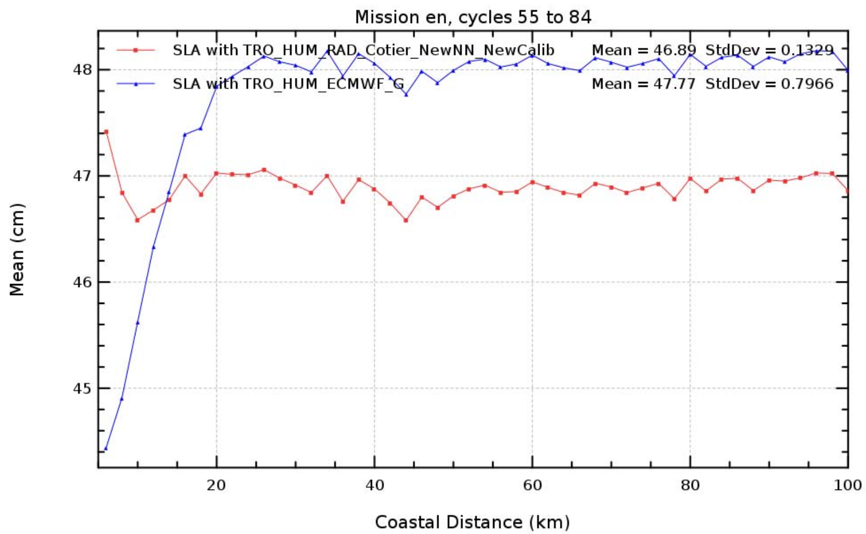


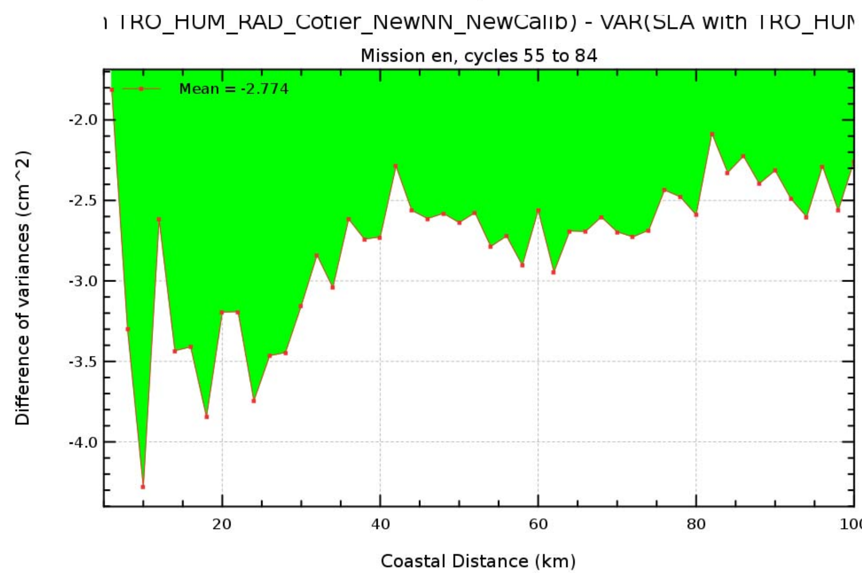


CNN vs ECMWF estimation

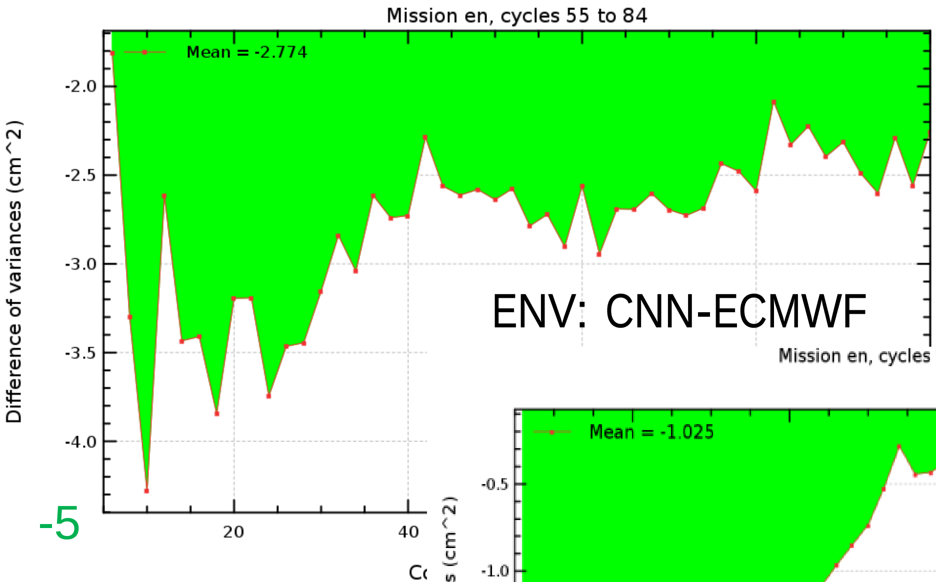


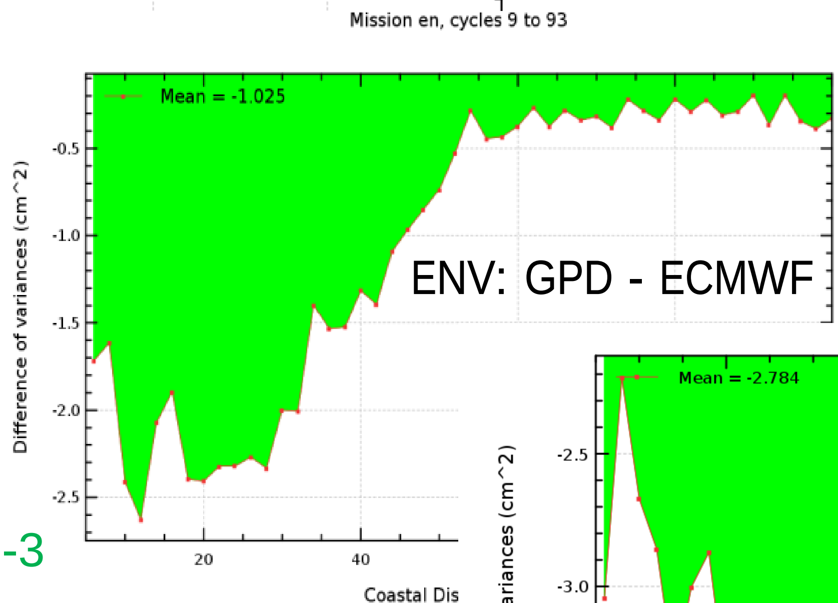


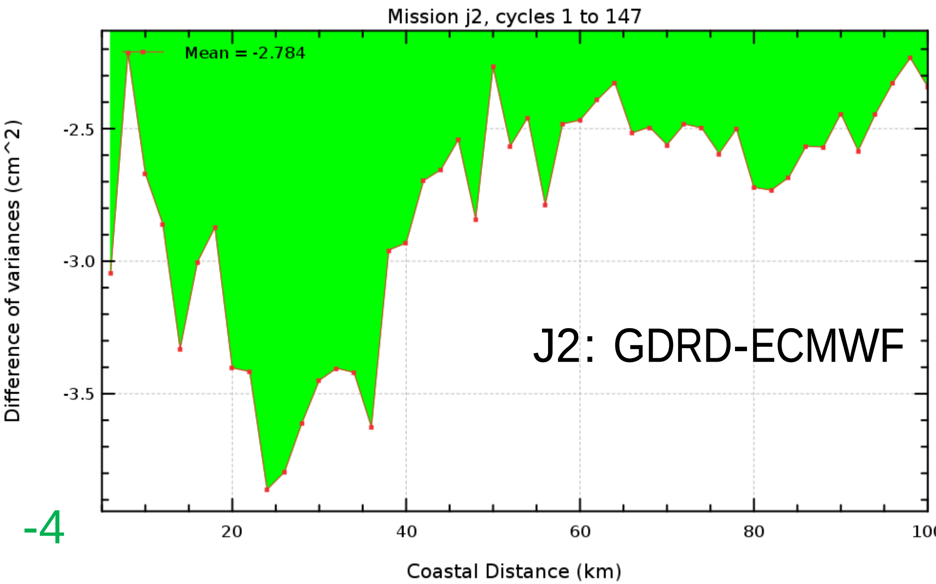




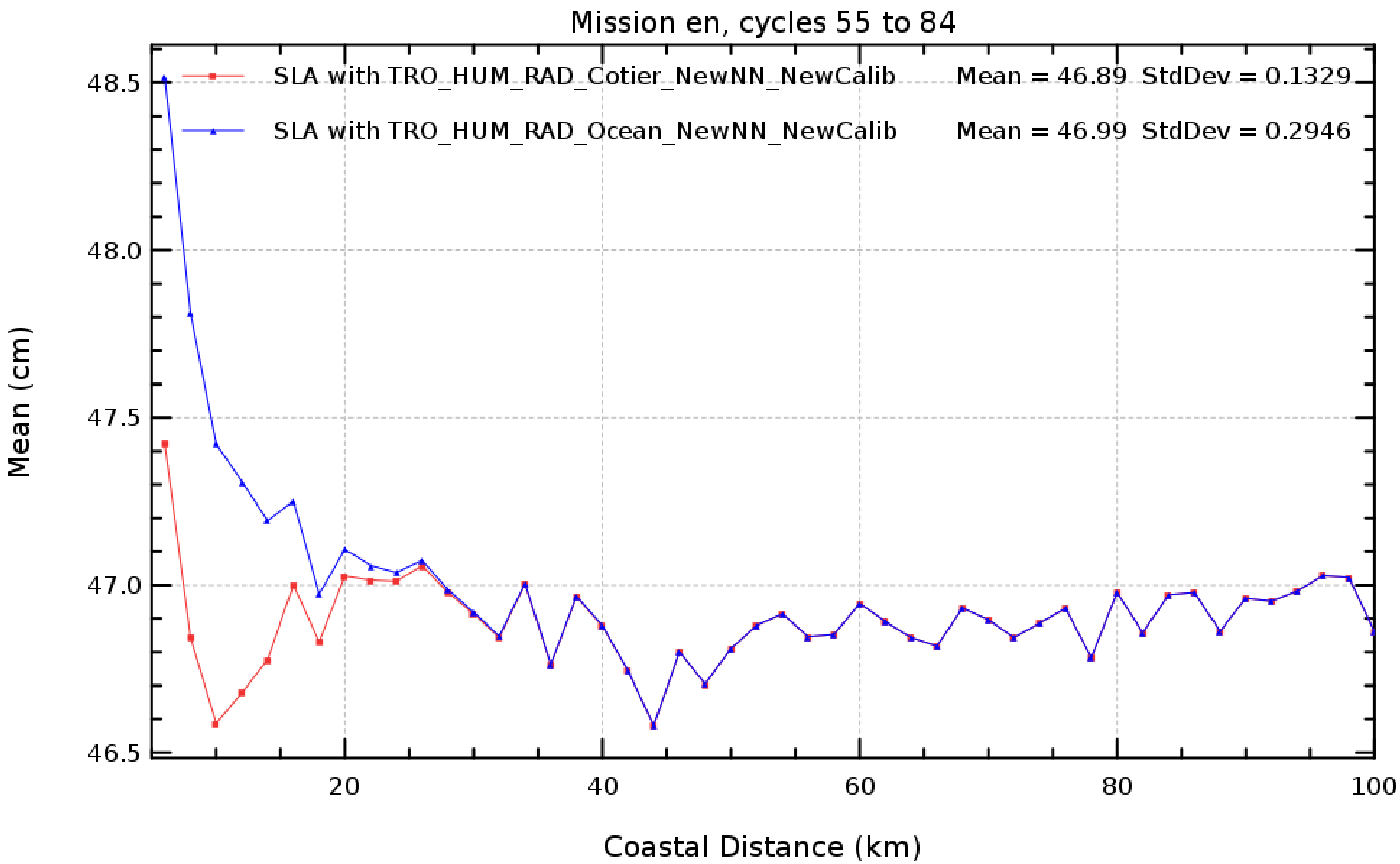
SLA variance difference vs ECMWF



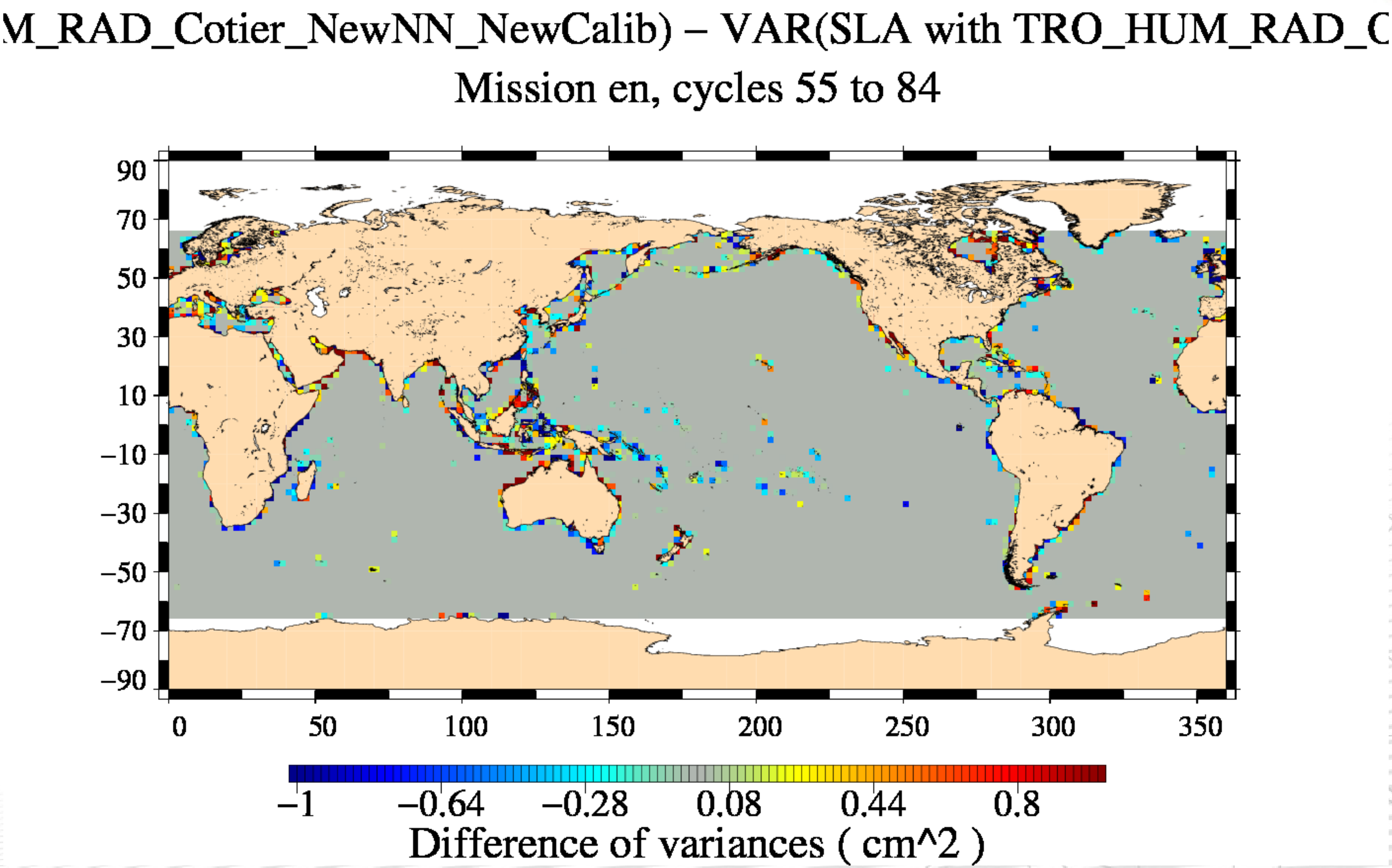




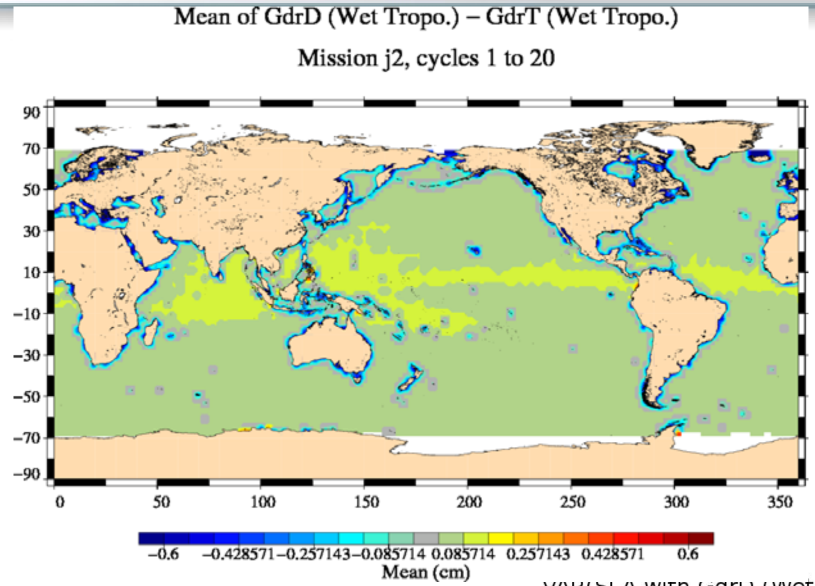
CNN SLA when approaching the coast

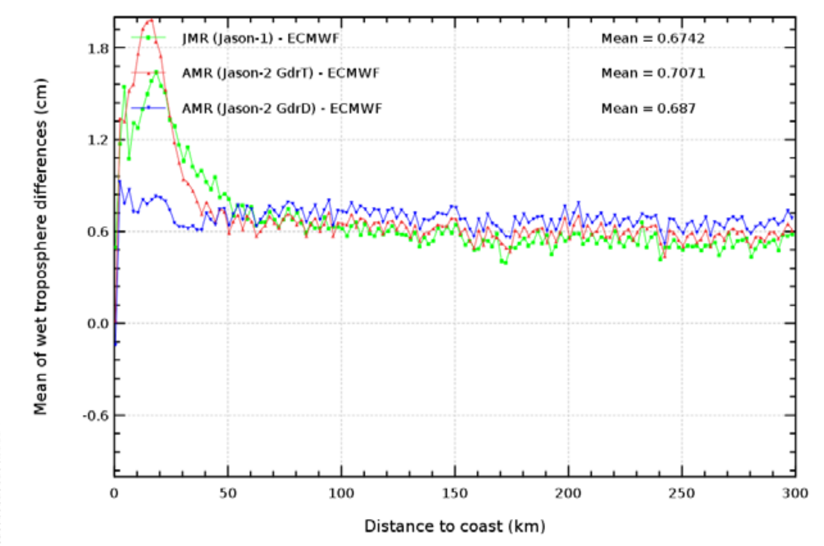


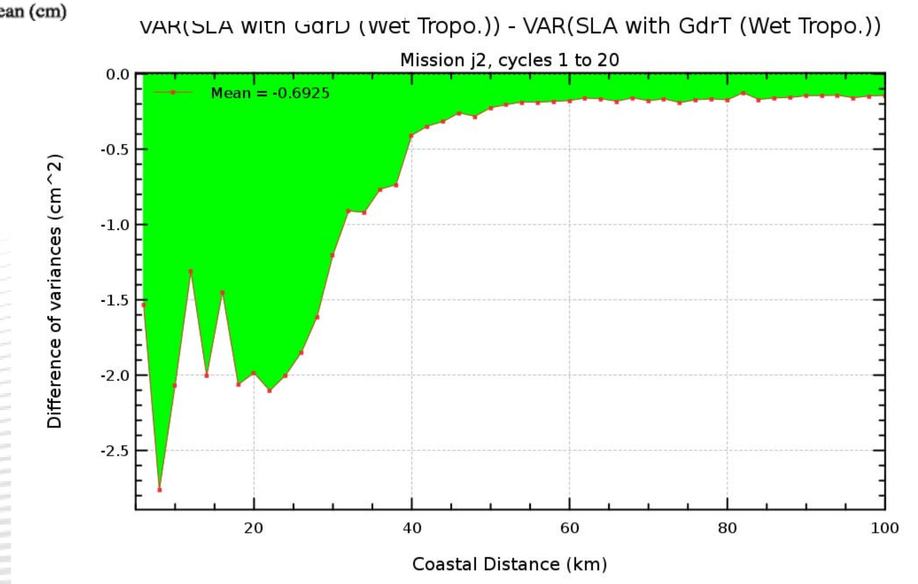
SLA variance difference vs GDR



J2 GDR-D coastal dh







SALP, Philipps et al, 2012

Conclusions & Perspectives

- 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)