# New retrieval algorithm for the wet tropospheric correction of altimetry missions

A. Rahmani, E. Obligis and L. Eymard

CLS/LOCEAN

# Introduction

- Altimeters are dedicated to the sea level estimation
- Water vapor in the troposphere creates an additional delay that has to be corrected for
- Quantity between 0 and 50 cm ($\alpha$ integrated water vapor content) and highly variable in space and time
- A dedicated microwave radiometer is added to altimetry missions to get this wet tropospheric correction
- Quality requirements for the wet tropspheric correction are
  - A uniform accuracy in time to get a sea level rise estimation at the mm/year level
  - A uniform accuracy in space to get a consistent global sea level information

Topex-Poseidon/TMR: 18, 21, 37 GHz

Jason1/JMR: 18.7, 23.8, 34 GHz

ERS-1, ERS-2, Envisat/MWRs: 23.8, 36.5 GHz

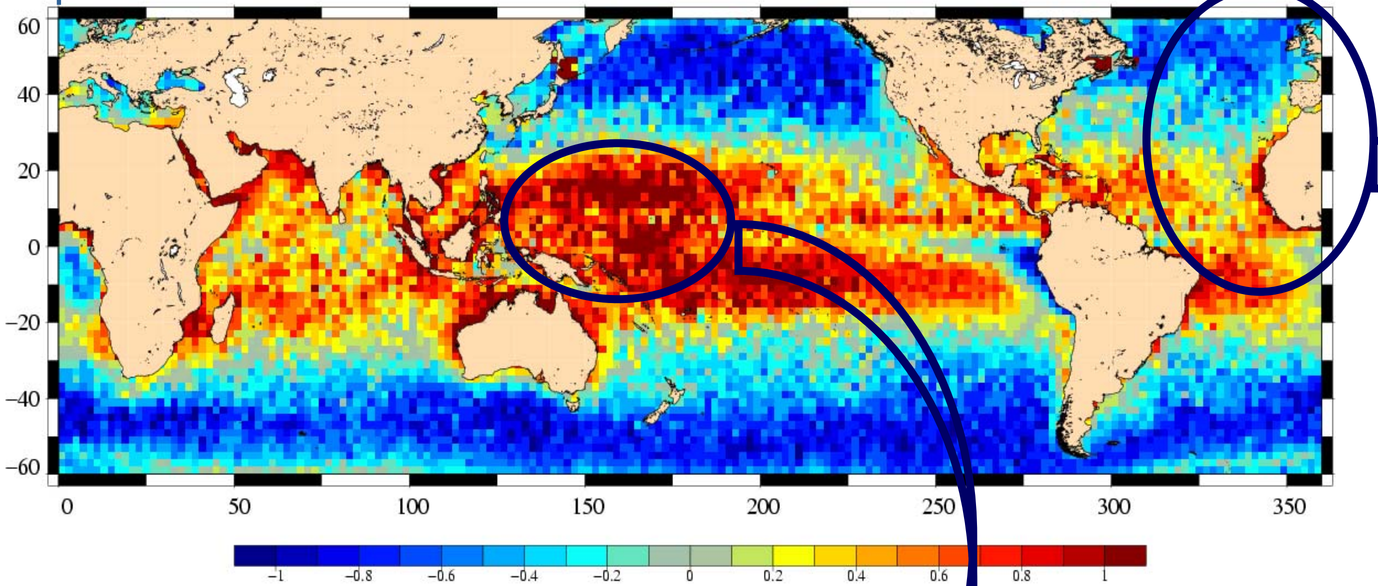
*…Jason2/AMR, AltiKa, Sentinel/MWR…*

# Case of the Envisat/MWR MicroWave Radiometer

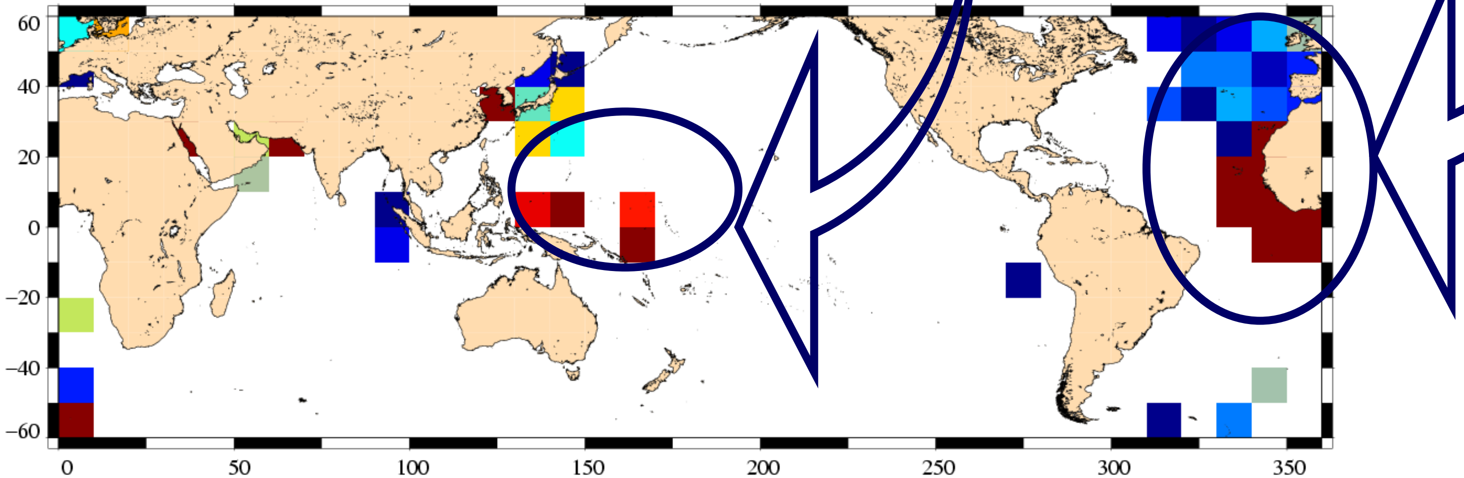
- CLS in charge of the development of the operational retrieval algorithm, of the calibration/validation of level1 and level 2 products (L1B and L2 ESL)
- Envisat/MWR radiometer measures brightness temperatures at 23.8 and 36.5 GHz at location of the altimeter footprint (nadir measurement)
- Wet tropospheric correction (dh) is retrieved from these two TBs and the altimeter backscattering coefficient in Ku band to get roughness information

# Starting point of the study

- Global map of differences between radiometer and ECMWF dh for 2005




- Global map of differences between radiometer and radiosonde dh for 2005




Similar features for other radiometers

Are these errors due to retrieval algorithms ?

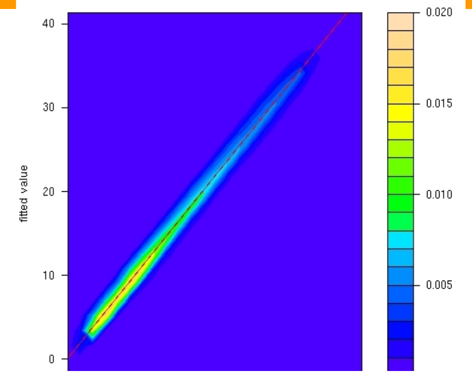
# Algorithm formulation

- 12 global ECMWF analyses at noon, one per month in 2005
- 0.5° resolution, 91 pressure levels
- For each mesh of these global grids, surface parameters (temperature and wind) and atmospheric profiles (temperature, pressure, water vapor, cloud liquid water)
- Simulation of both brightness temperatures (23.8 and 36.5 GHz) and altimeter backscattering coefficient in Ku band

**≈ 1 500 000 data**

- 100000 data for learning database
- The rest for validation to check the generalization power of the algorithm

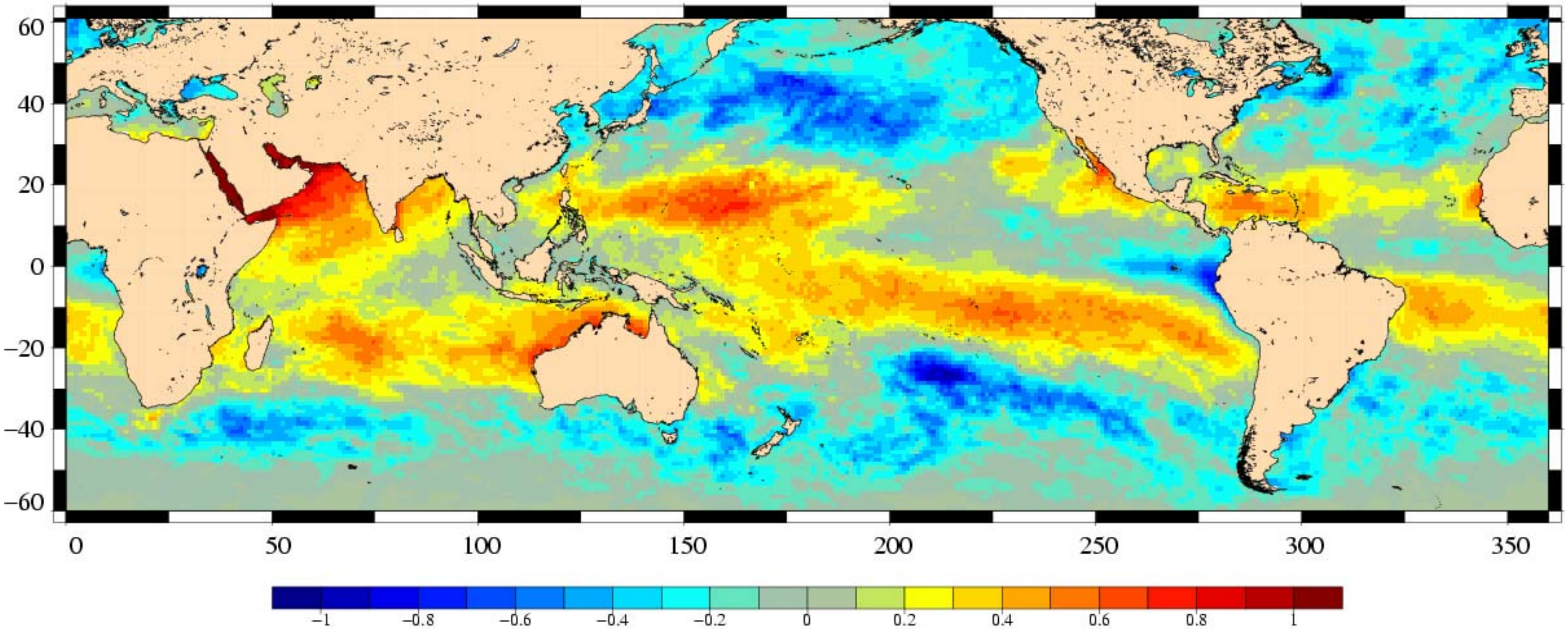
# Classical NN algorithm formulation (Obligis et al, 2006) Operational L2 algorithm for the Envisat/MWR




$dh = NN(TB23.8, TB36.5, \sigma_{0Ku})$

- Bias on the complete database : 0.001cm
- Standard deviation : 0.48 cm

**BUT…**

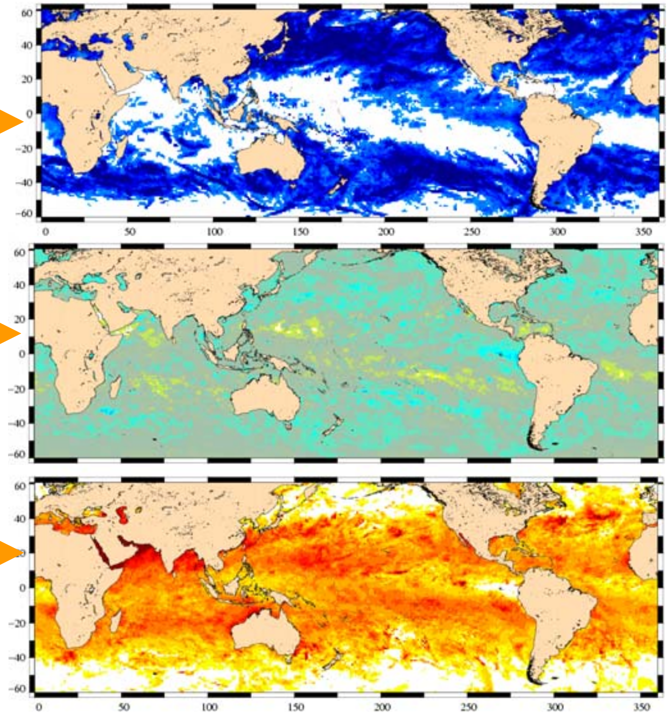



Same structures than over (Rad-ECMWF) map
Error due to retrieval algo
Direct equivalent distortion on sea level map

# Analysis

What are the correlations between the different pertinent physical parameters and the error structures ?

1. Classification (K_means) of the differences in 3 classes:
   - Underestimation
   - Good estimation
   - Overestimation



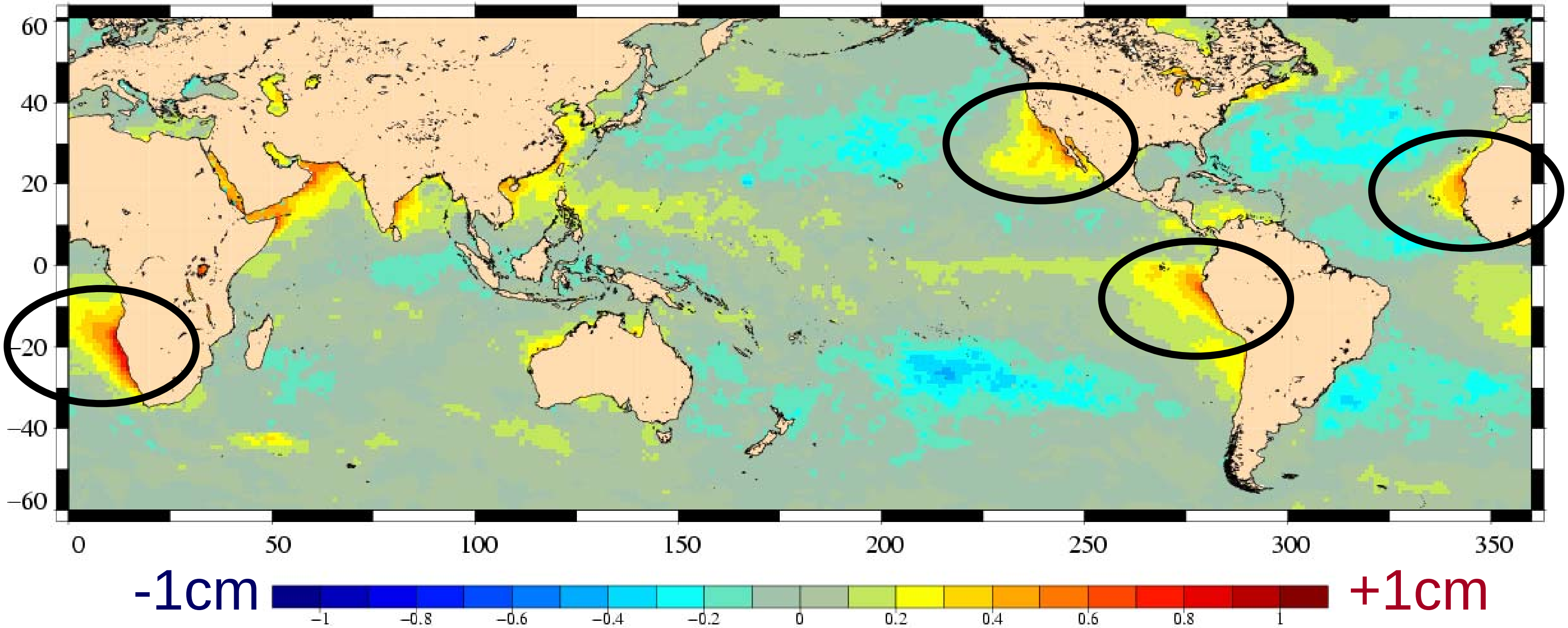
2. Binary tree method to determine the most pertinent variable (predictor) to separate the 3 classes

**SST**

$dh = NN(TB23.8, TB36.5, \sigma_{0Ku}, SST)$

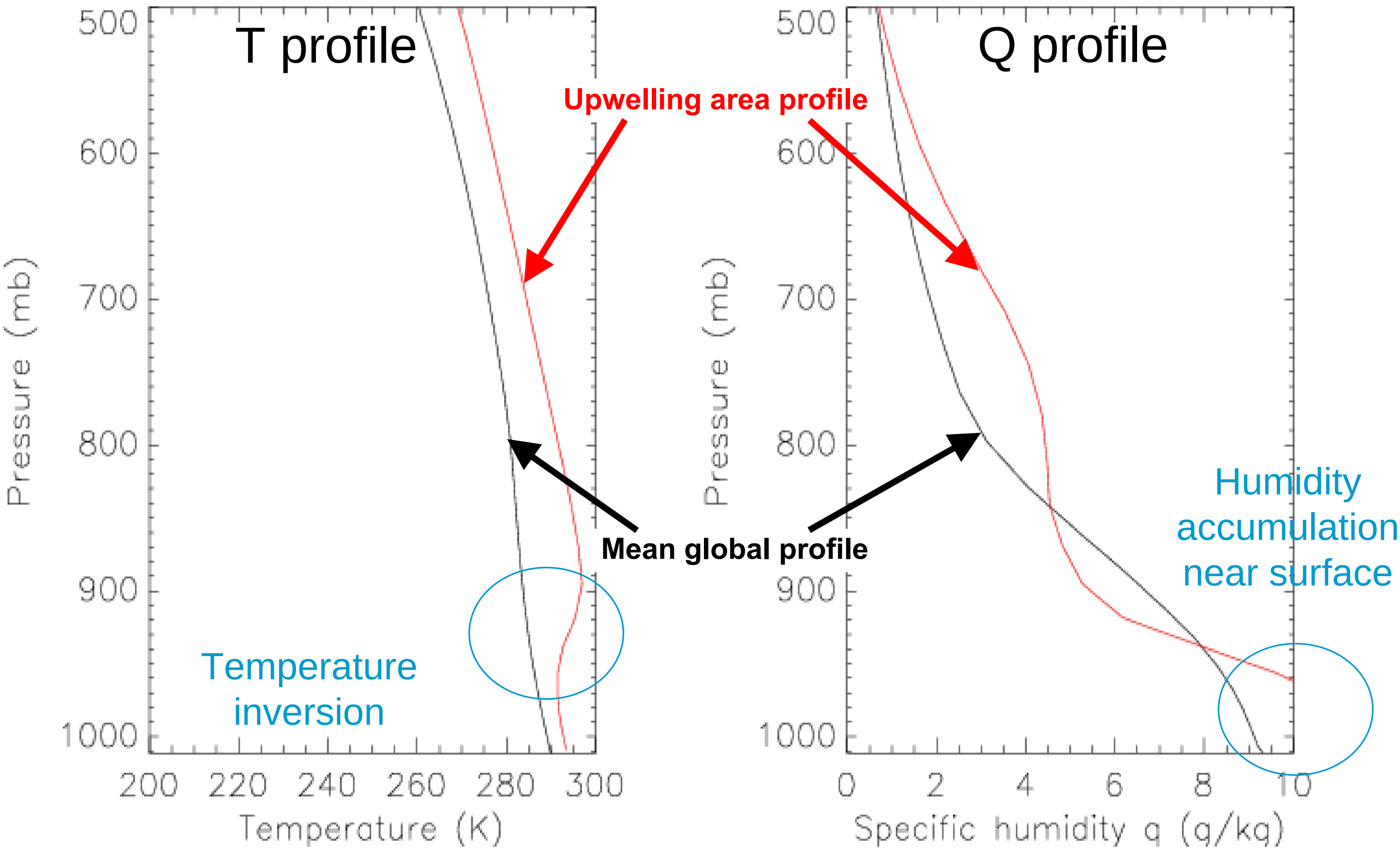
**BUT…**

Standard deviation : 0.12 cm




- Error structures remain in the eastern part of the subtropical basins
- Located in oceanic upwelling areas associated to strong atmospheric subsidence (temperature inversion, humidity accumulation near the surface)
- Specific atmospheric profiles -> **Global statistical method fails**

# Example of atmospheric profiles in upwelling areas



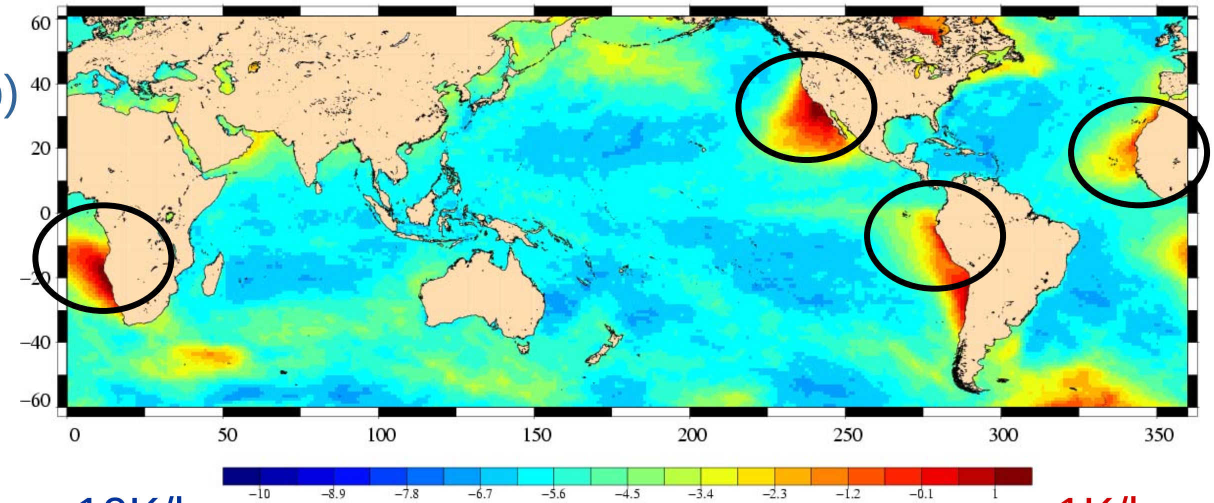

$\Gamma$ lapse rate (K/km) = the decrease rate of the temperature with altitude

# A new parameter to characterize the atmospheric stratification

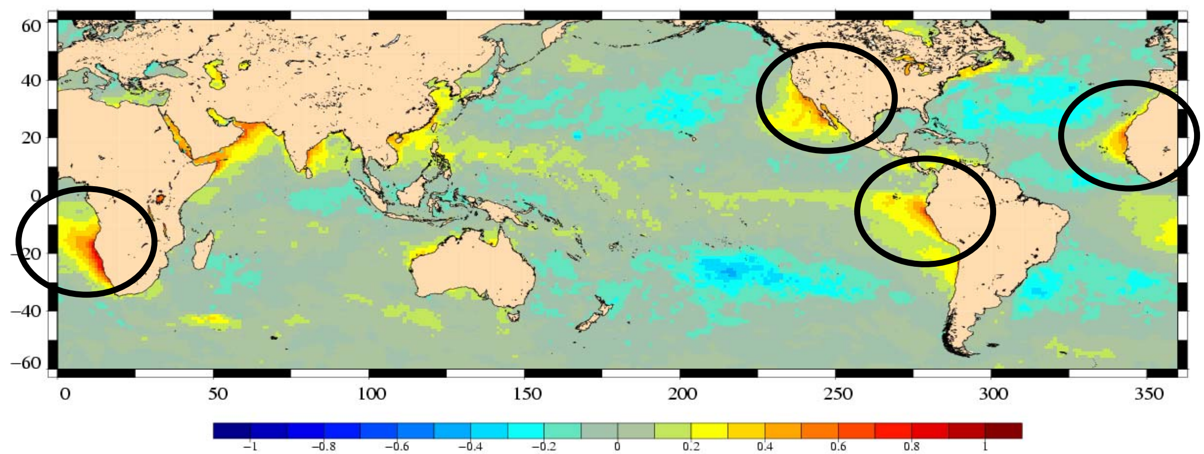
$\Gamma$: lapse rate (up to 800mb)

Climatological value

Around -5K/km

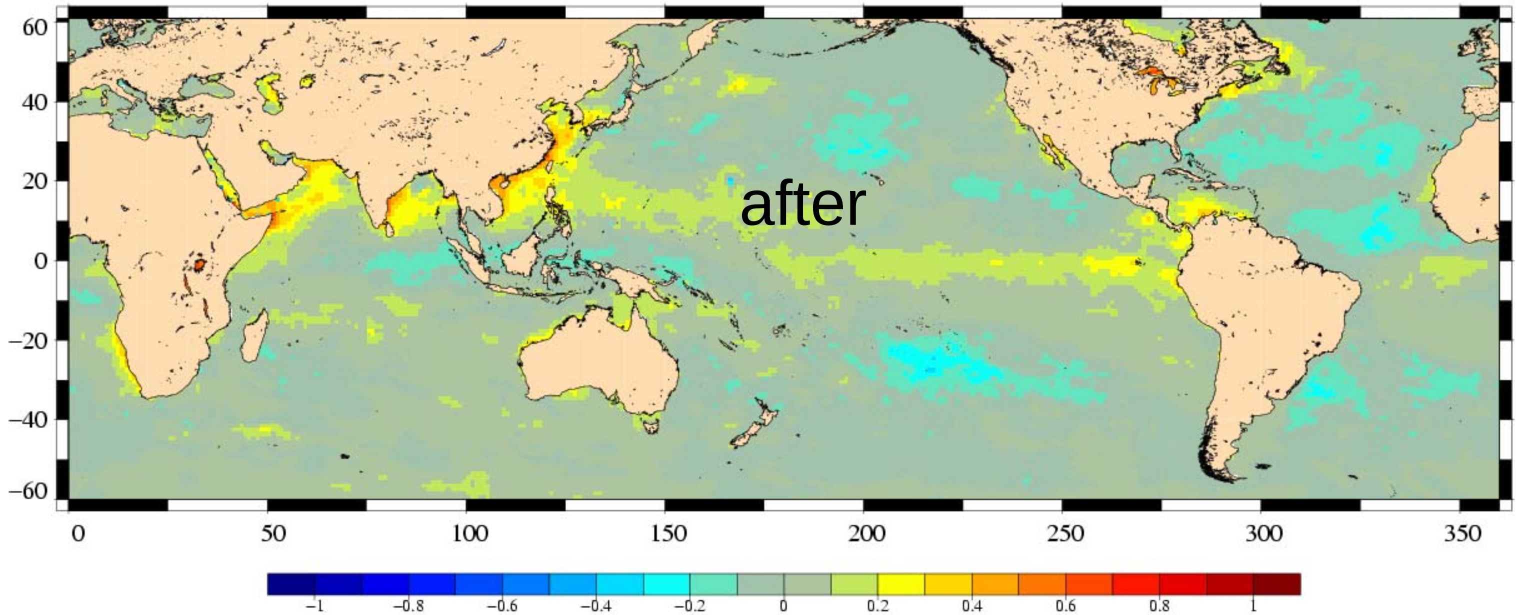


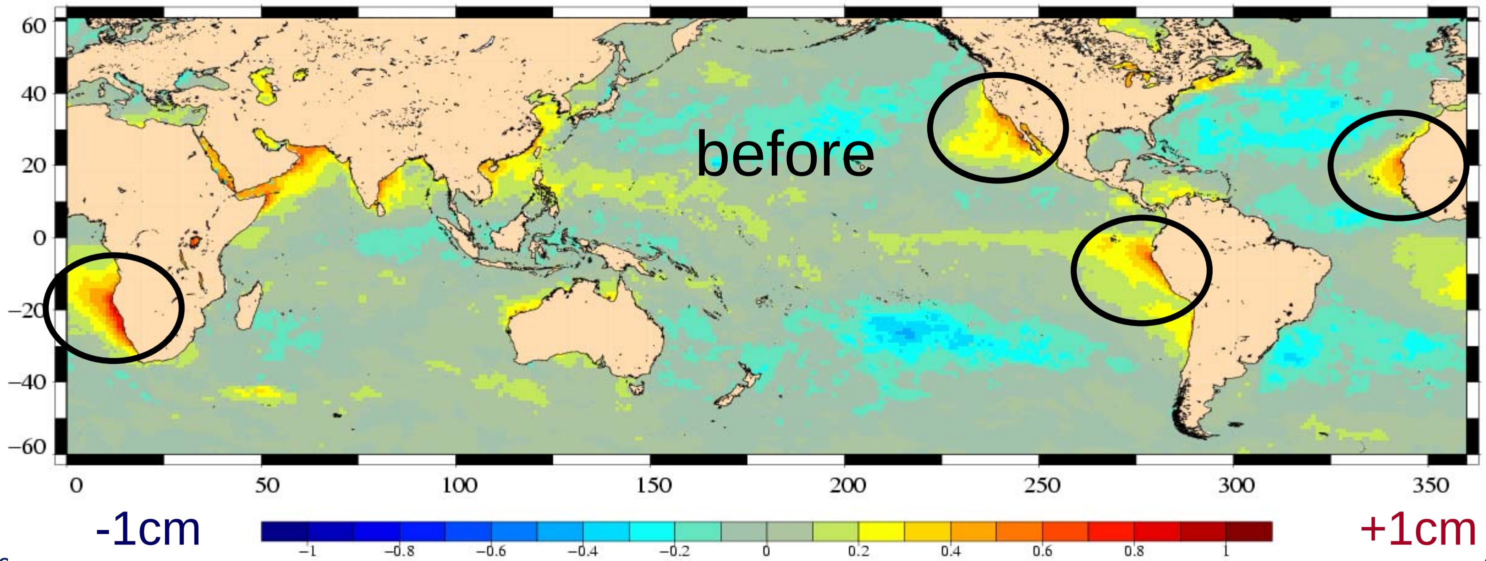

Error structures



# Γ as a new input

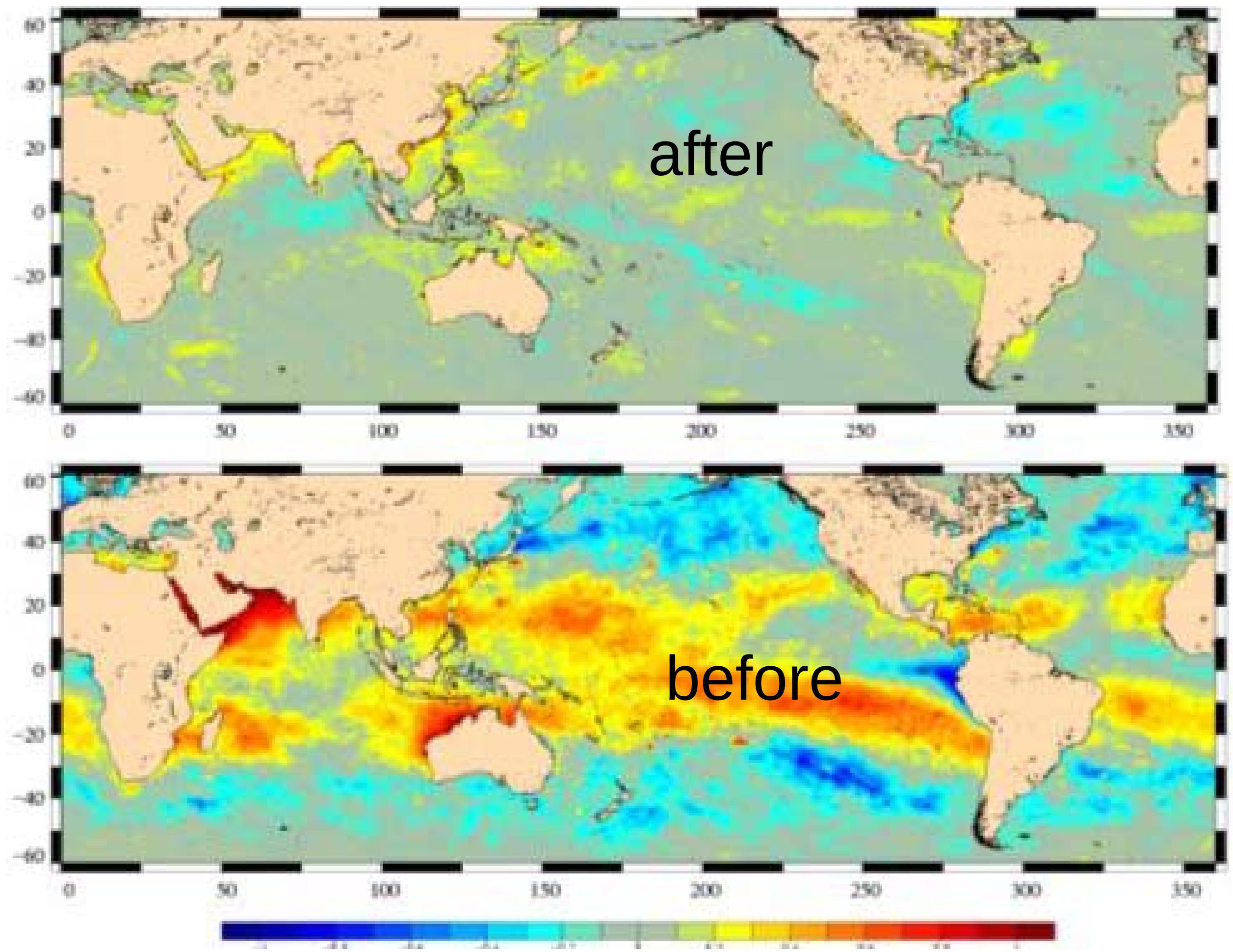
$dh = NN(TB23.8, TB36.5, \sigma_{0Ku}, SST, \Gamma)$



# 2005 algo on 2003 simulations…
# SST and $\Gamma$ from seasonal global tables 1°x1° for year 2005

$dh = NN(TB23.8, TB36.5, \sigma_{0Ku}, SST, \Gamma)$




-1cm +1cm

# Performances of different 2005 algorithms over 2003 data

| 2003 | Biais | Ecart type |
|---|---|---|
| **Parametric model** | -0.02 | 0.57 |
| **NN(TB23.8,TB36.5, $\sigma$0Ku)** | 0.04 | 0.47 |
| **NN(TB23.8,TB36.5, $\sigma$0Ku, SST, $\Gamma$)** | 0.01 | 0.25 |

# CONCLUSIONS AND PERSPECTIVES

Conclusions

- Global statistical approaches create systematic correlated errors on global humidity fields
- Actual products suffer for strong error structures related to SST variations (especially for bi-frequencies radiometer) and oceanic upwelling phenomena
- Similar behavior for other altimetry missions (Jason 1)
- Taking SST and lapse rate as new parameters in the Envisat algorithm improves significantly the error maps
- Direct impact on final altimeter products

Perspectives

- To propose an operational definition of the algorithm (SST and $\Gamma$ information in auxiliary tables)
- To perform a more extended validation on real measurements
- To test this new algorithm on Jason2/AMR data (launch planned for June 2008)
- To propose this type of algorithm for future missions (AltiKa planned in 2009-2010)