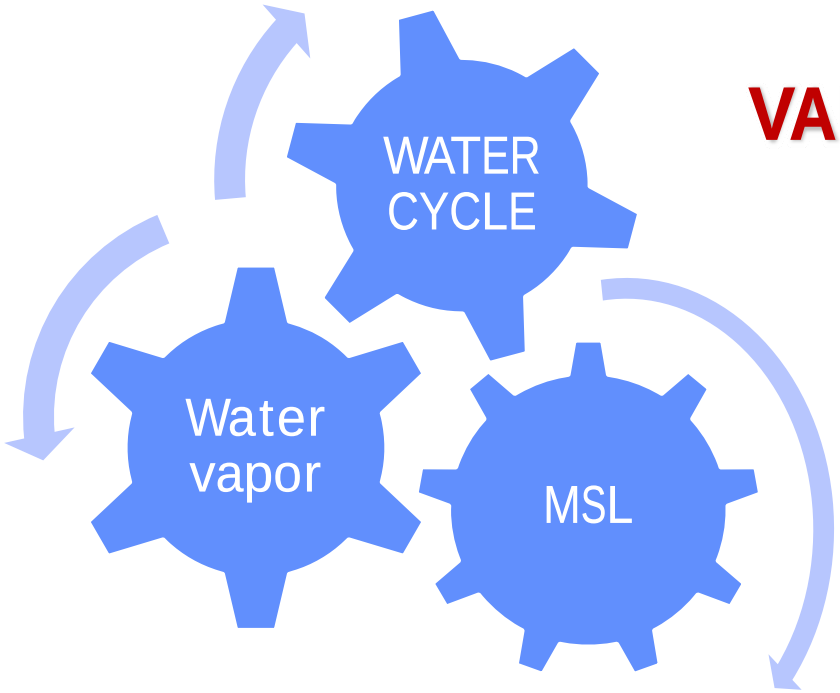



# USE OF SSM/I DATA TO BETTER CHARACTERIZE TREND AND VARIABILITY OF THE ATMOSPHERIC WATER VAPOR

S. Thao, E. Obligis, B. Picard, CLS
L. Eymard, CNRS/LOCEAN

# OUTLINE

- Water vapor: climatic variable itself & direct impact on mean sea level

- Main source of error affecting the MSL estimate
  - ✓ Related uncertainty estimated around 0.3 mm/yr for the global MSL and close to 1 mm/yr focusing in tropical areas

- Potentially contaminated by long-term instrumental drifts or problems
  - ✓ components ageing
  - ✓ internal temperature variations
  - ✓ noise diode instabilities

- Detection of these instrumental problems is difficult because water vapour in the atmosphere is subject to natural variations
  - ✓ Interannual variability (Niño - Niña)
  - ✓ Seasonal cycle
  - ✓ Climate change

# OUTLINE

- The risk is important to interpret an instrumental drift as a geophysical trend or on the contrary to interpret a geophysical signal as an instrumental drift

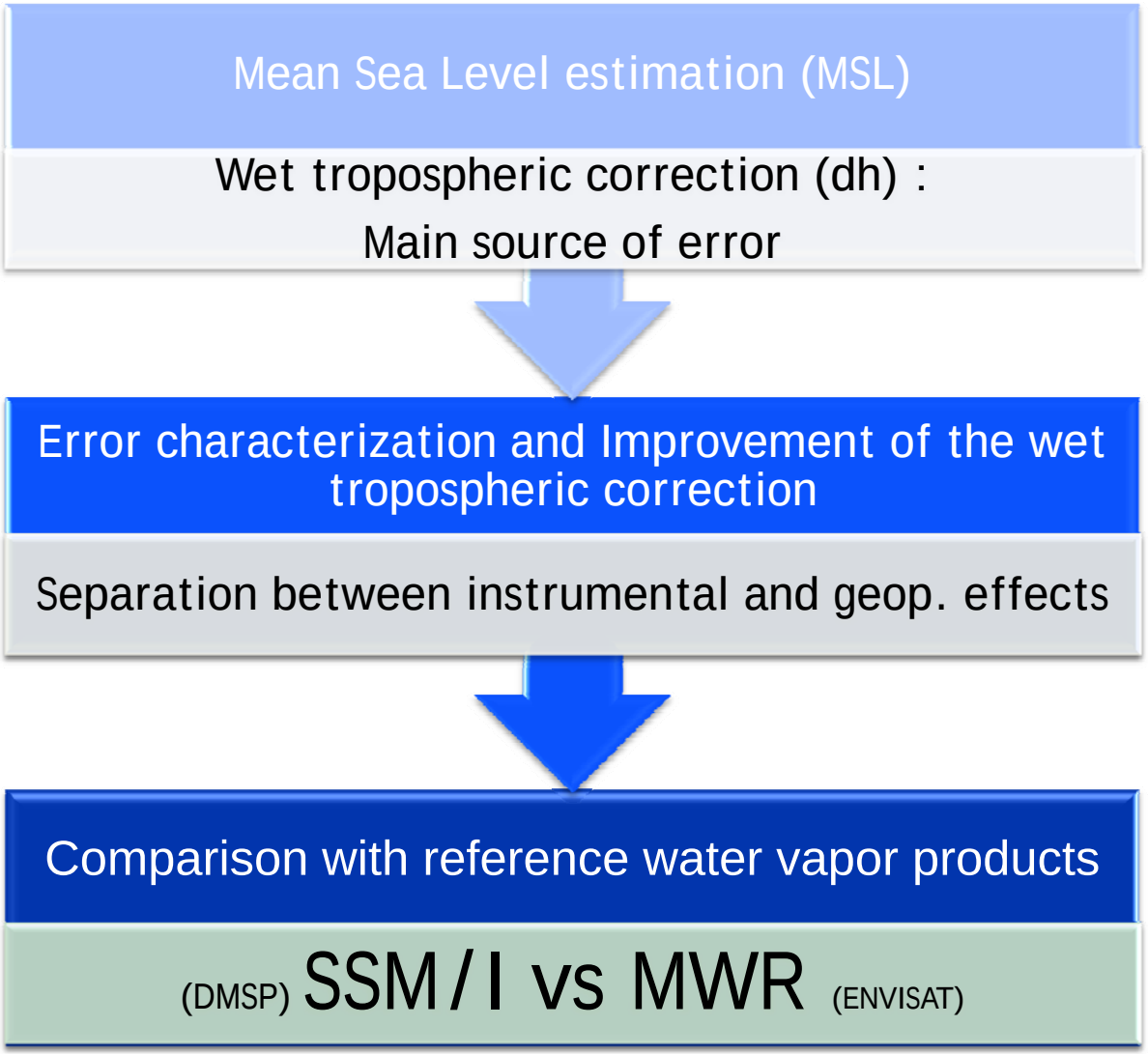
Any error in wet tropospheric correction trend

will induce the same error on mean sea level

➢ New methods are needed to assess the wet tropospheric correction products for altimetry missions and correct them if necessary

- PhD at CNES/CLS/LOCEAN is starting with 3 main objectives :
  - ✓ To analyze in details the differences between different water vapor estimations (altimetry missions, other missions, operational/reprocessed models) available for the altimetry era: differences in intensity, geographical distribution, temporal trends
  - ✓ To give some recommendations for instrument, processing, and calibration activities
  - ✓ To propose a correction strategy for radiometers in order to build a consistent water vapor time series for the altimetry era.

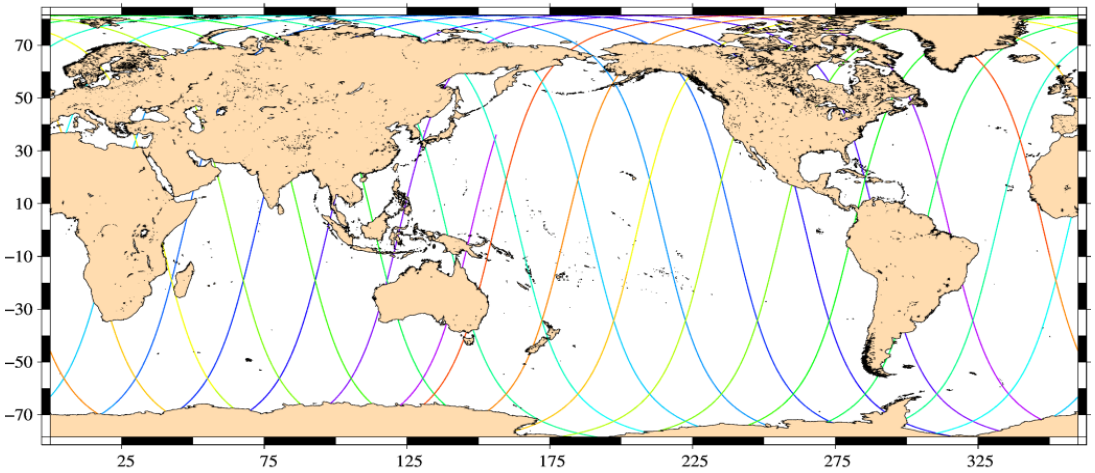
# OUTLINE


Mean Sea Level estimation (MSL)
Wet tropospheric correction (dh) :
Main source of error
Error characterization and Improvement of the wet tropospheric correction
Separation between instrumental and geop. effects
Comparison with reference water vapor products
(DMSP) SSM/I vs MWR (ENVISAT)

# ENVISAT/MWR DATA

| Envisat/MWR | |
|---|---|
| **Satellite** | ENVISAT |
| **Launch on** | 01/03/2002 |
| **Orbit** | circular, sun-synchronous |
| **Altitude** | 782.4-799.8 km |
| **Inclination** | 98.55° |
| **Orbital Period** | 100.6 min |
| **Repetitivity.** | 30-35 days |
| **Spatial Resolution** | 25 km |

| Envisat/MWR | |
|---|---|
| **Technical Characteristics** | |
| **Frequencies :** | 23.8 and 36.5GHz |



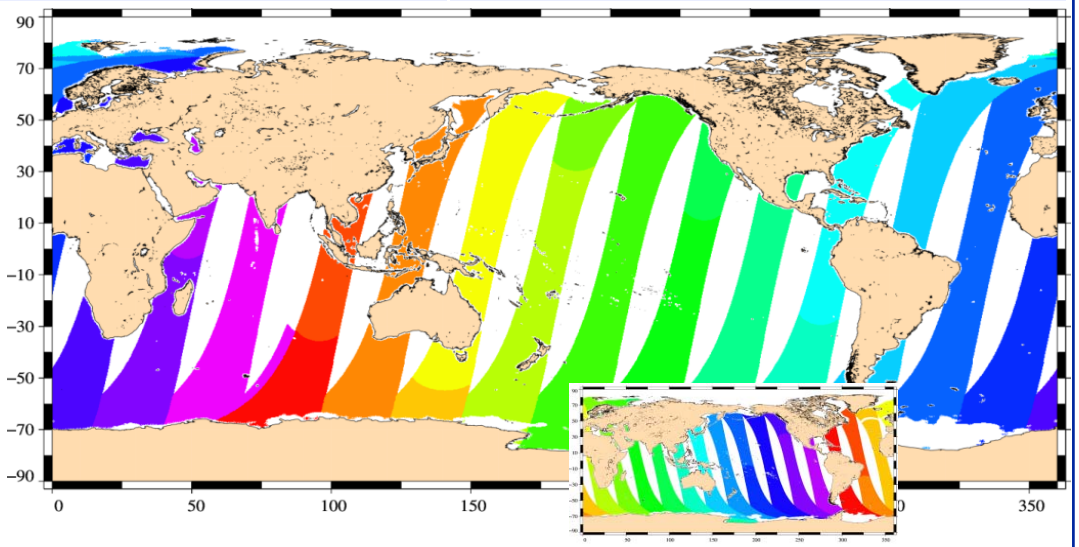

## Data

**Nadir along track 1 Hz measurements**

# SSM/I DATA

| SSM/I radiometer | |
|---|---|
| **Satellite** | DMSP F15 |
| **Launch on** | Dec 1999 |
| **Orbit** | Near circular, sun-synchronous |
| **Altitude** | 835-885 km |
| **Inclination** | 98.8° |
| **Orbital Period** | 102.0 minutes |
| **Swath** | 1400-km |
| **Spatial Resolution** | 56 km |

| SSM/I radiometer | |
|---|---|
| **Technical Characteristics** | |
| **Frequencies/ polar:** | 19.35(V,H) , 22.24(V,H), 37.0(V) and 85.5(V,H) GHz |

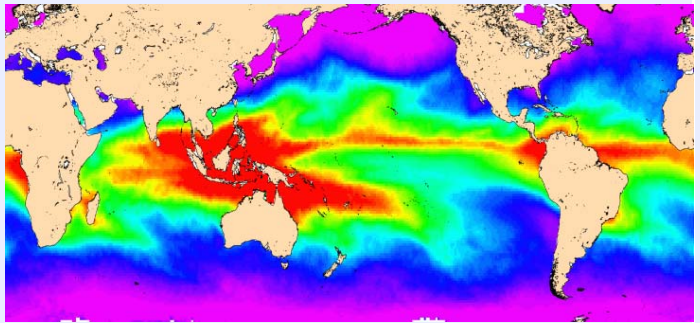
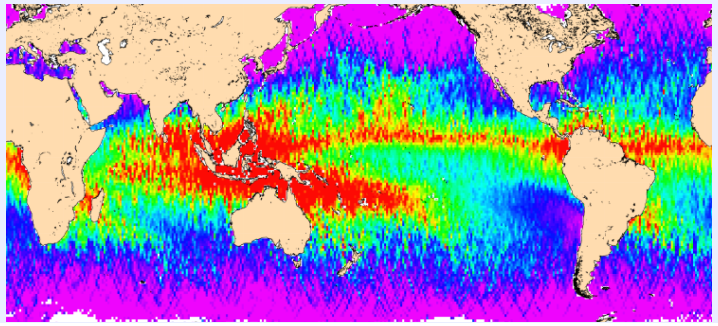
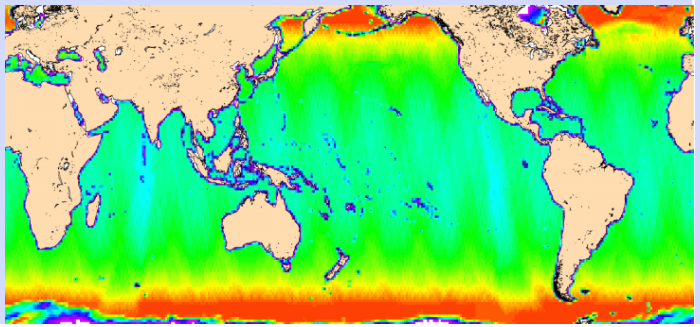
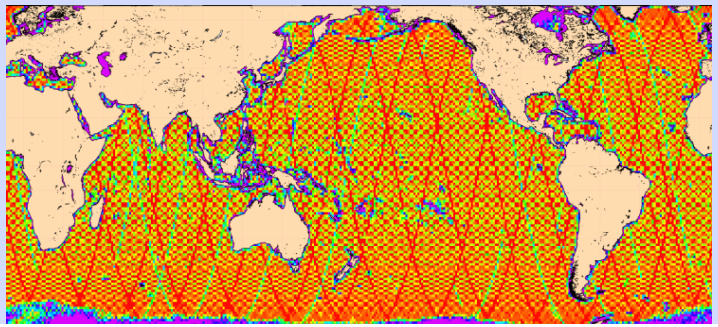



## RSS data –– www.ssmi.com

**Wide swath water vapor products**
**2 daily grids (ascendant & descendent orbits), 0.25x0.25° resolution**

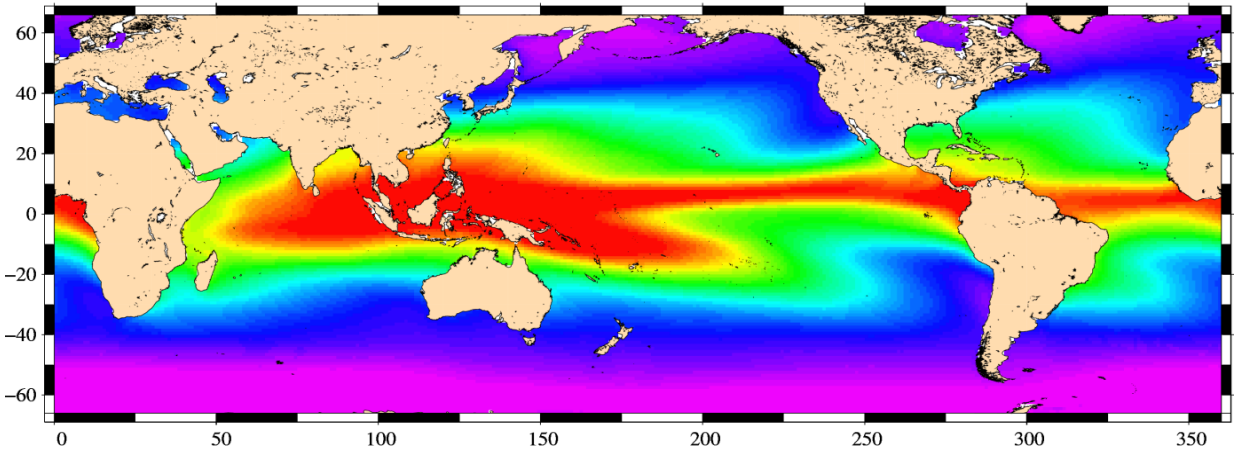
# Data homogenization

- Monthly grids at 1° resolution from March 2002 to December 2010
- Water vapor products ➔ 6 cm of wet tropo. corr ⇔ 1 g/cm$^2$ TWVC

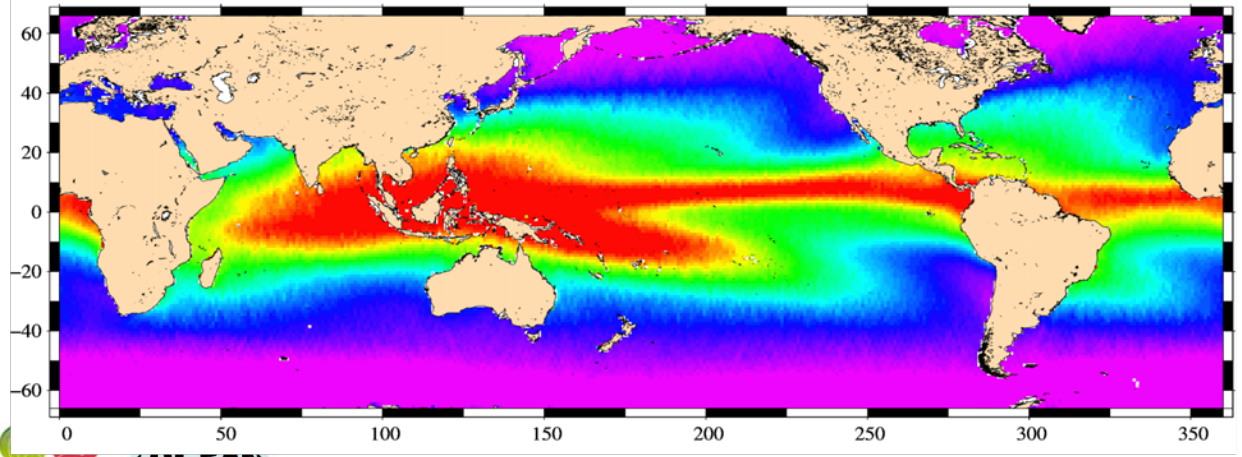
| Exemple: December 2010 | | |
|---|---|---|
| | SSM/I | MWR |
| Mean value |  |  |
| Number of points per boxes per month |  |  |
| | ~ 608 points per box | ~ 23 points per box |

# Water vapor spatial distribution

SSMI, vapeur d'eau (g/cm2), du 2002/03 au 2010/12

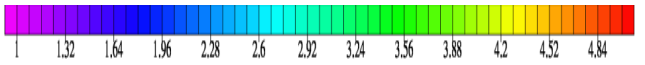



ENVISAT, vapeur d'eau (g/cm2), du 2002/03 au 2010/12

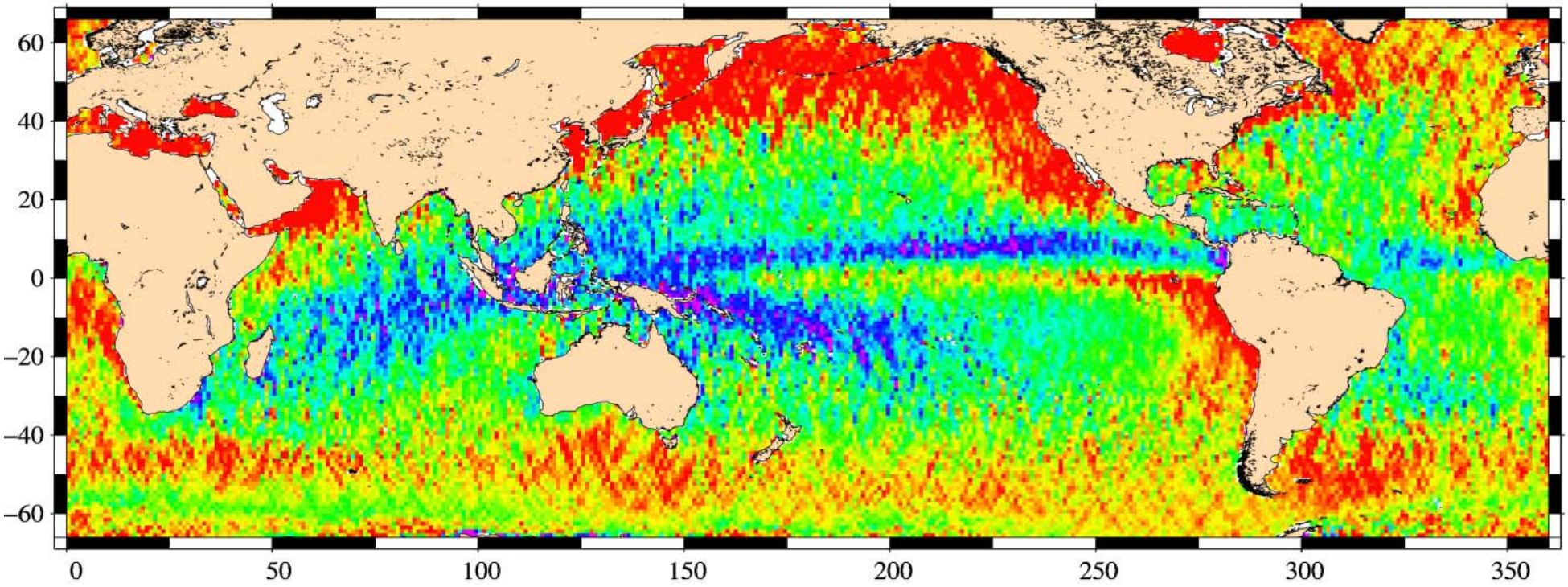



| SSMI | |
|---|---|
| Mean | 2.585 |
| Std | 1.385 |
| Min | 0.191 |
| Max | 5.910 |

| MWR | |
|---|---|
| Mean | 2.485 |
| Std | 1.440 |
| Min | 0.091 |
| Max | 6.200 |



# Water vapor spatial distribution : differences - 2002->2010

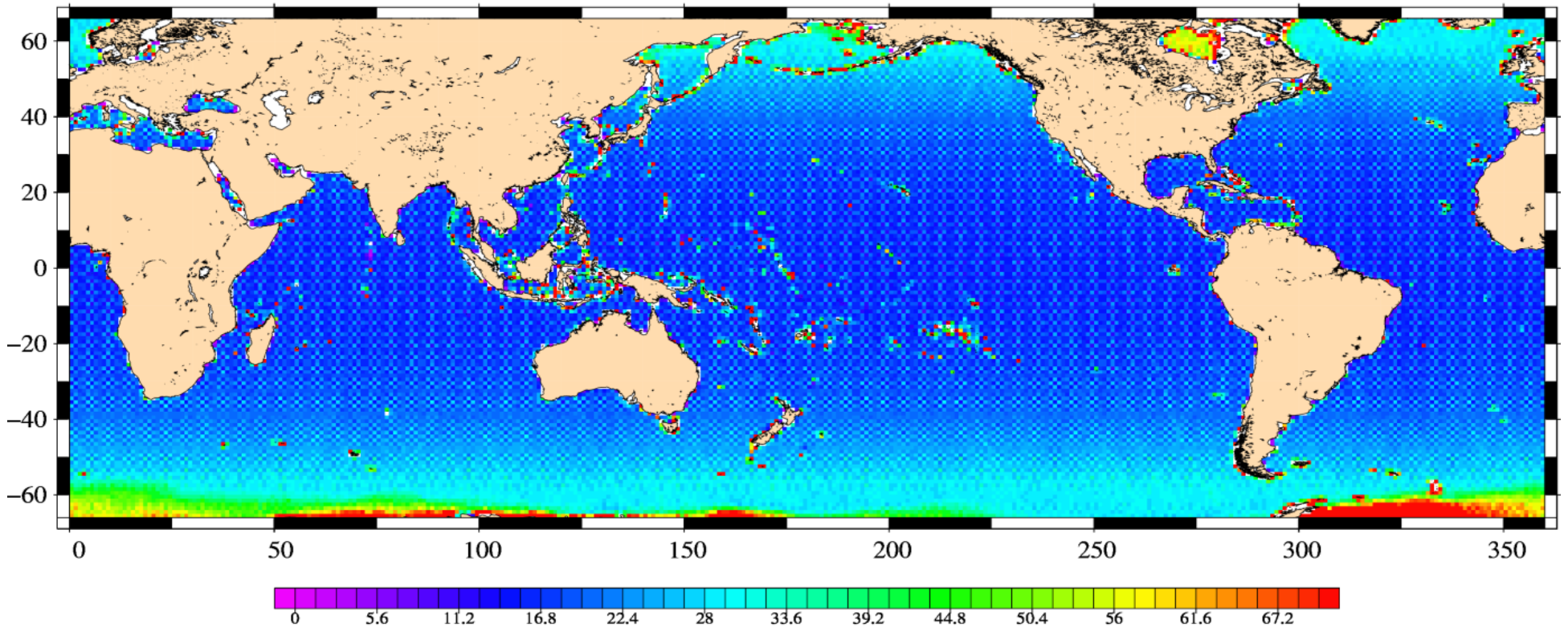



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nb of data | : 33530 | St. Dev | : 0.106873 | Skewness | : 0.005123 | Minimum | : −2.178818 |
| Mean | : 0.088474 | Rms | : 0.138743 | Kurtosis | : 30.858035 | Maximum | : 1.756581 |

Where do these differences come from ?

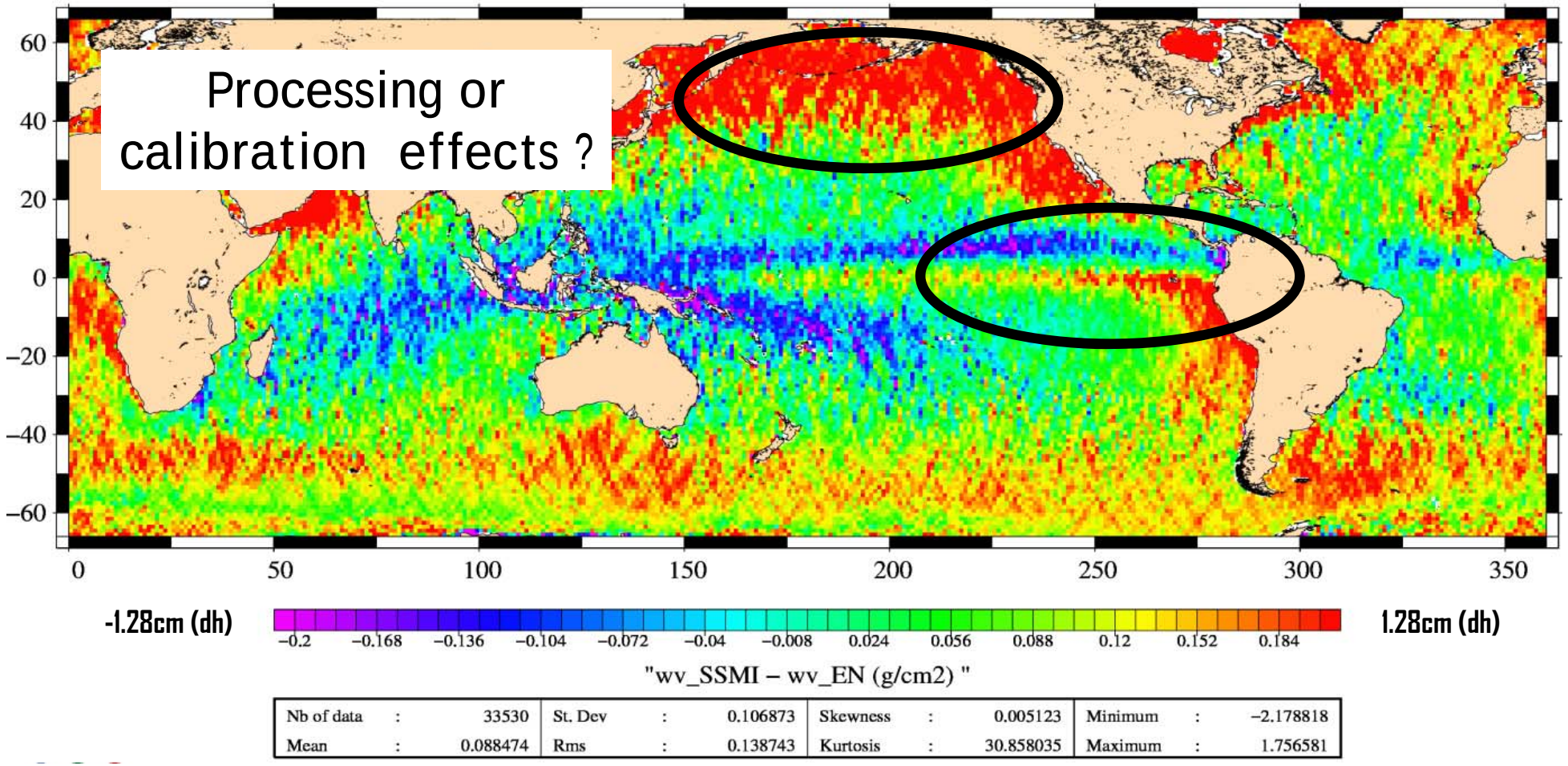
# Water vapor spatial distribution : differences - 2002->2010
# Sampling effect ?

**Ratio SSMI nb points / MWR nb points**



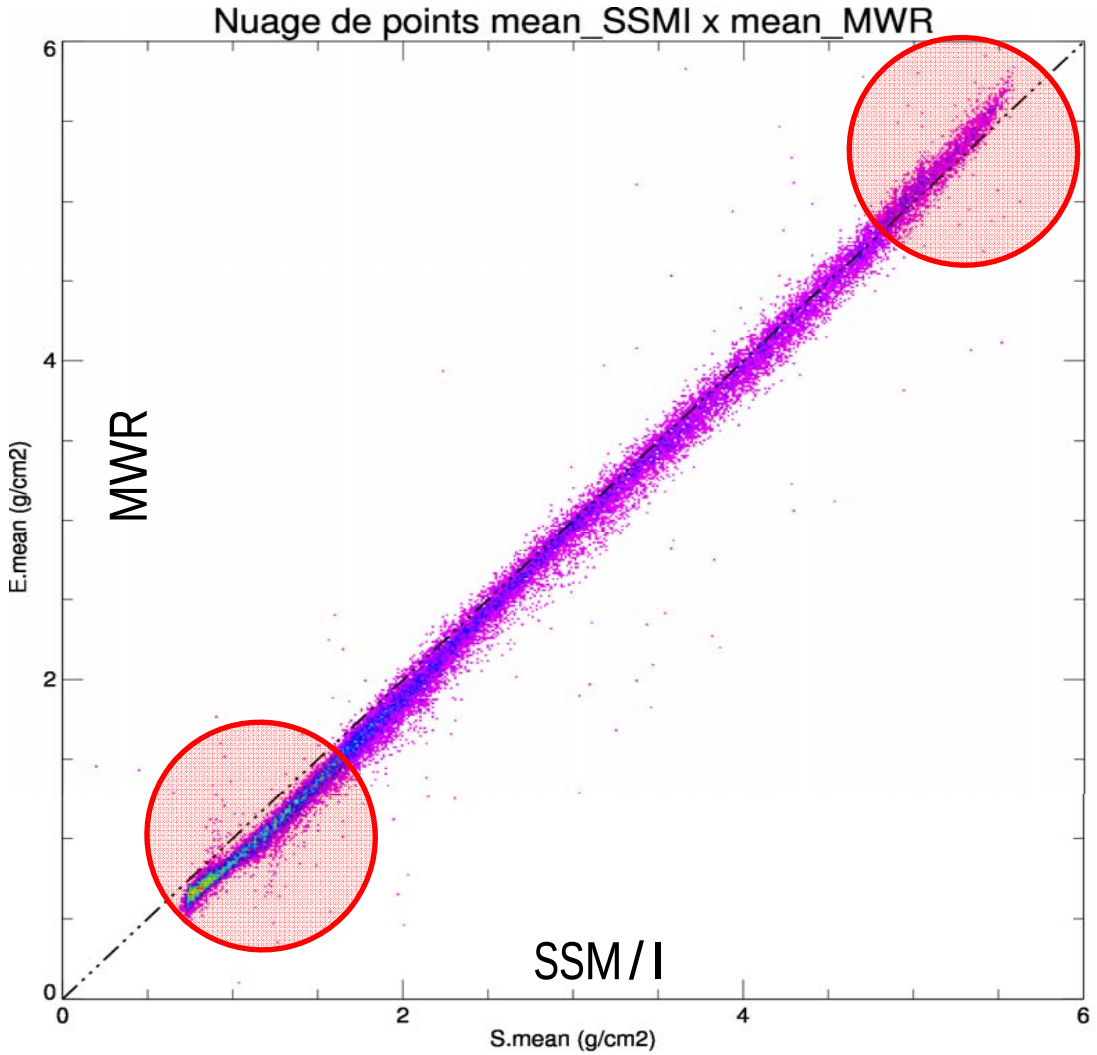

May explain part of the discrepancies but not the large patterns in the differences

# Water vapor spatial distribution : differences – 2002->2010



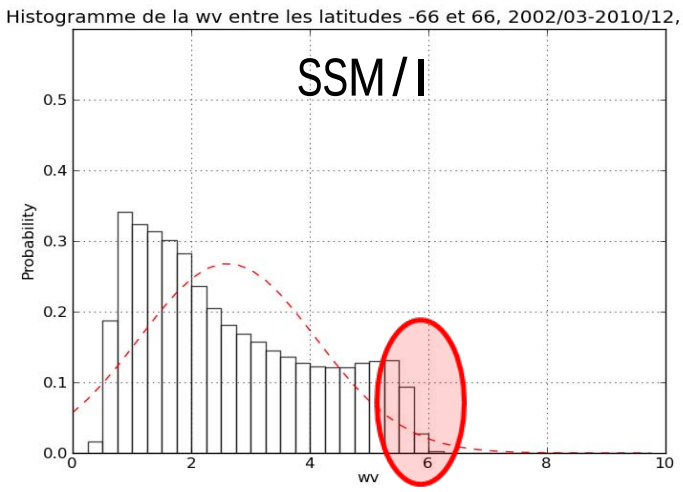

Where do these differences come from ?

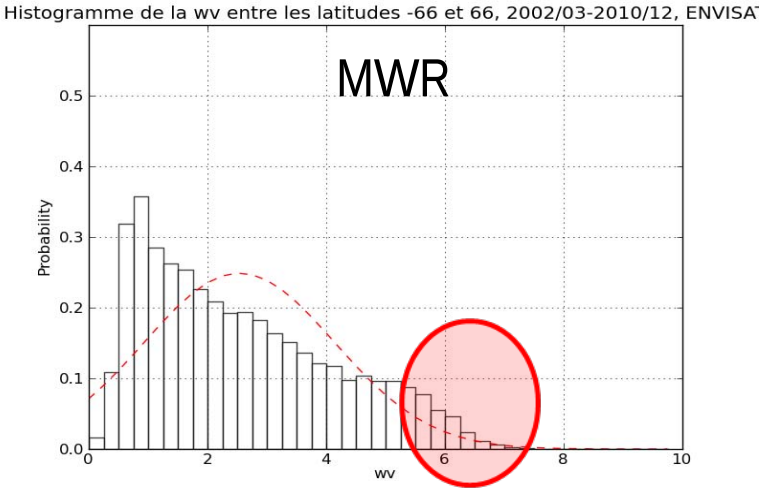
# Scatterplot between SSM/I and Envisat/MWR water vapor



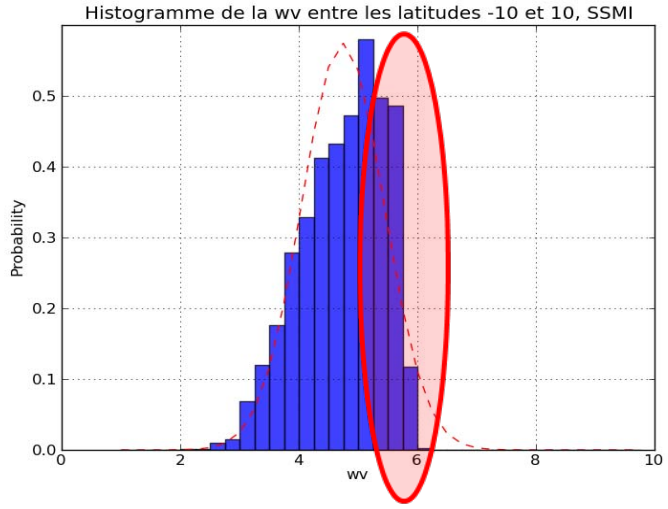
# Water vapor statistical distribution

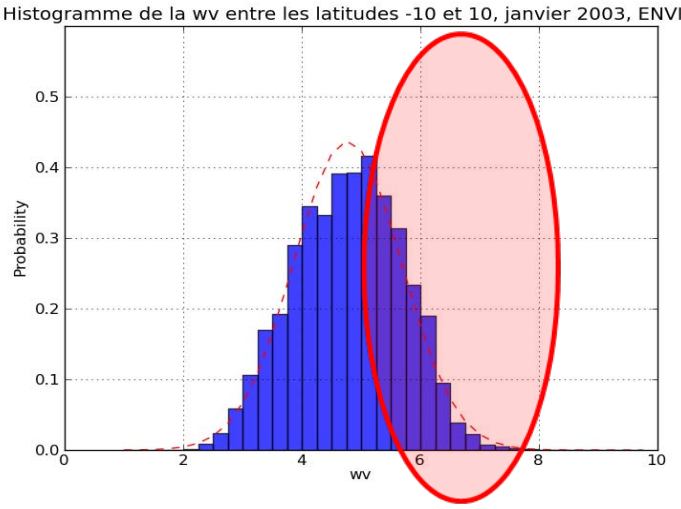
-66°<lat< 66°



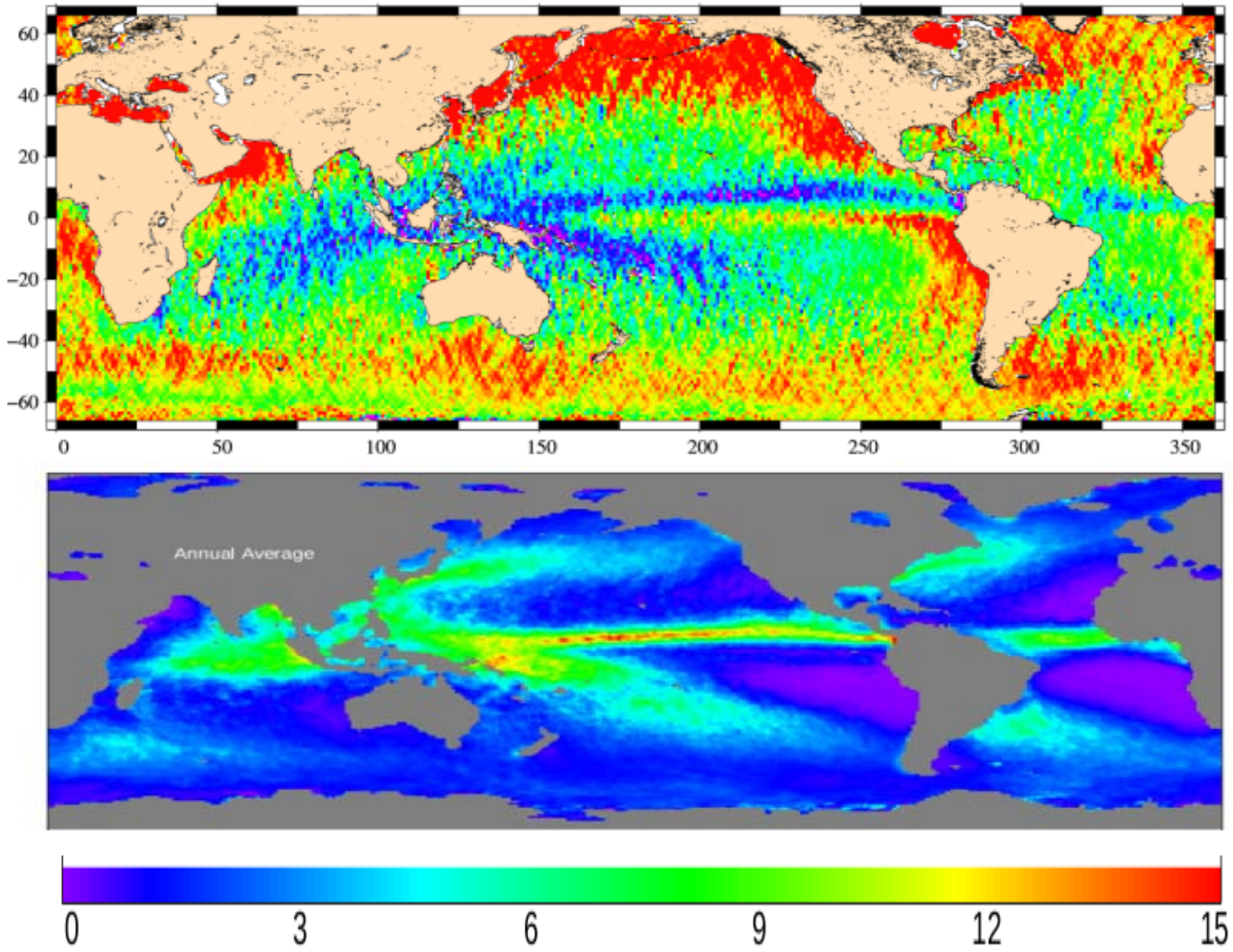

-10°< lat<10°



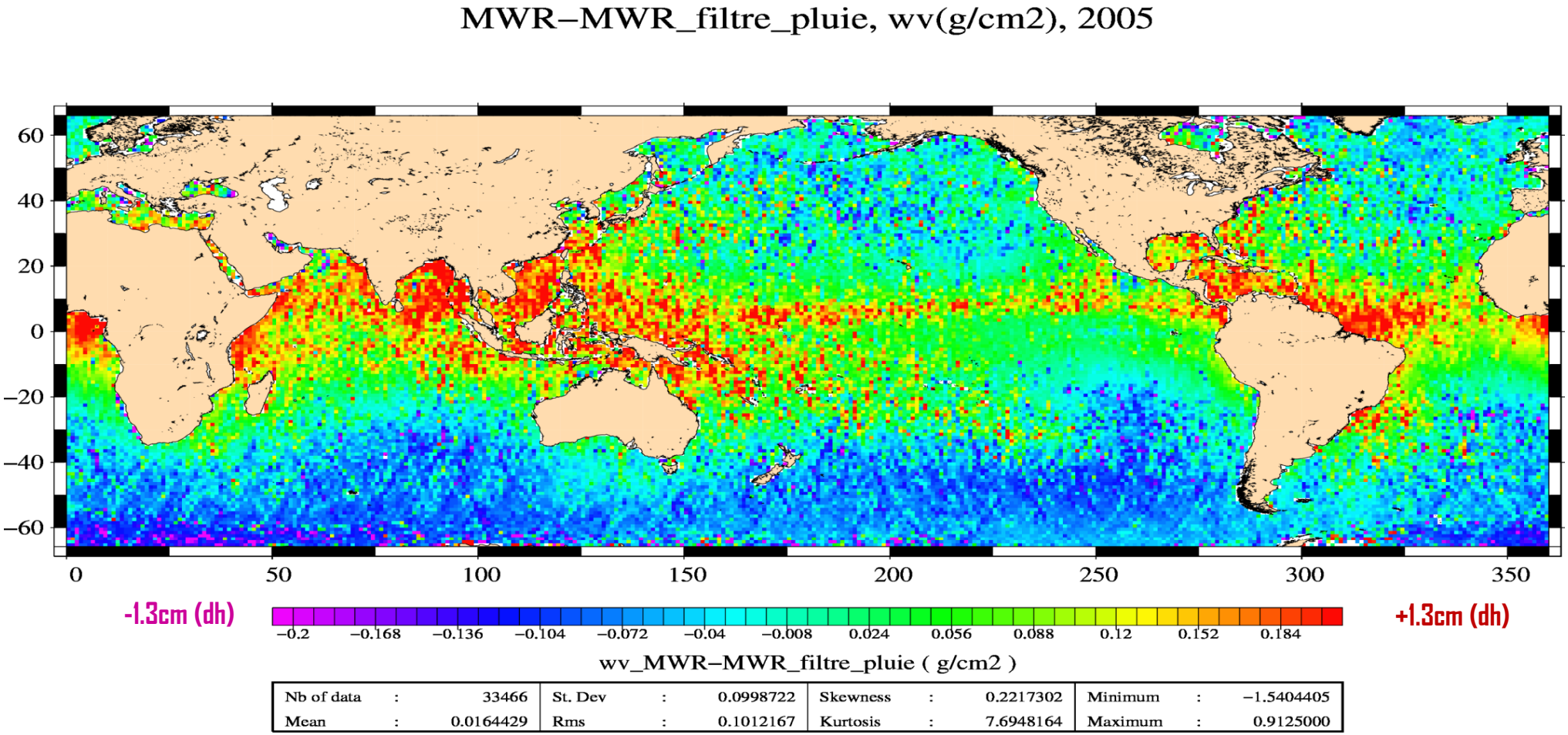
# Rain effect

"Differences des wv entre SSMI et ENVISAT sur la periode 2002/03–2010/12"




Rain rate (mm/day)
WENTZ 1996

# Valid rain flag only for 2005
# MWR with and without rain editing

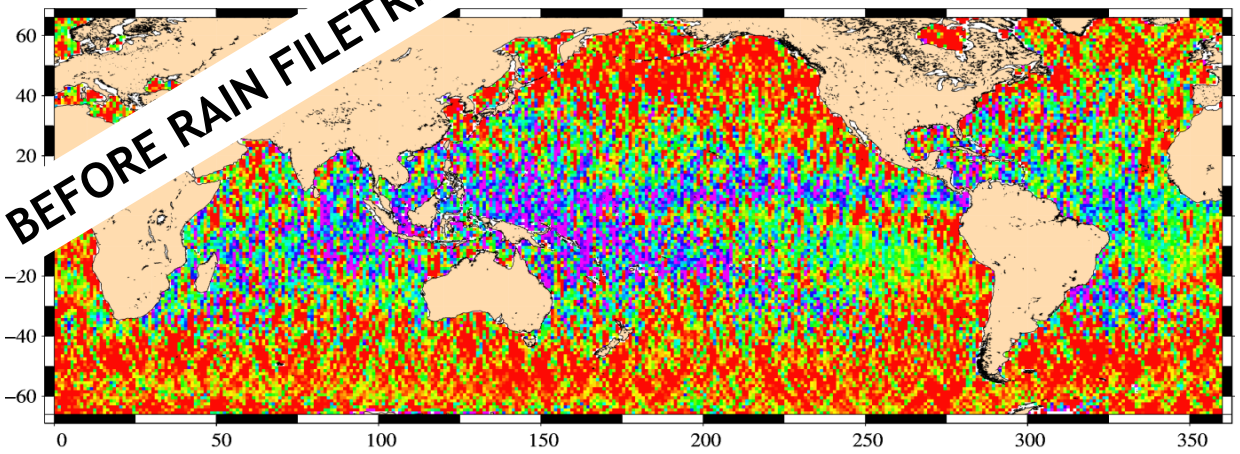



| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Nb of data | : 33466 | St. Dev | : 0.0998722 | Skewness | : 0.2217302 | Minimum | : –1.5404405 |
| Mean | : 0.0164429 | Rms | : 0.1012167 | Kurtosis | : 7.6948164 | Maximum | : 0.9125000 |

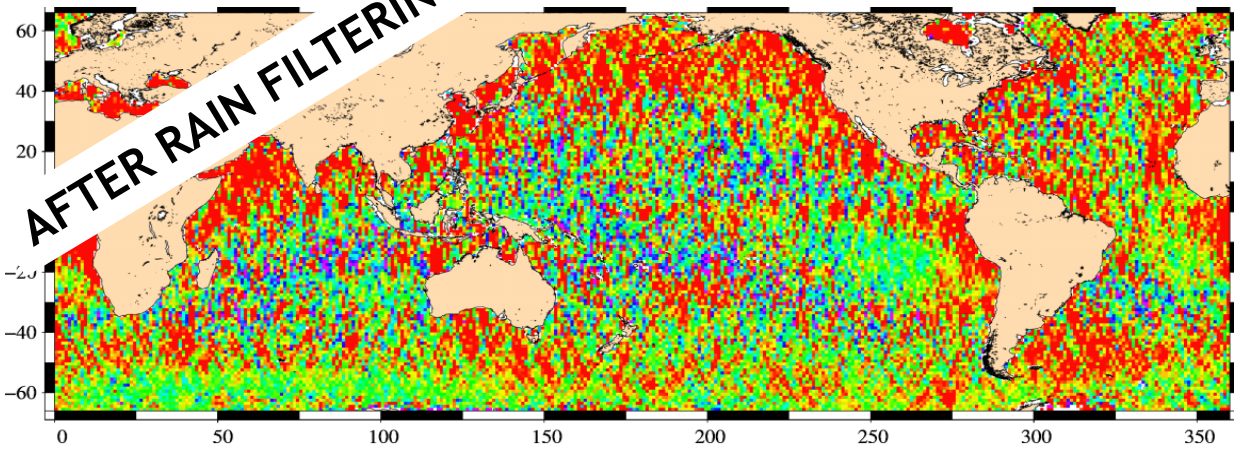
➢Strong impact of rain editing on the mean water vapor maps

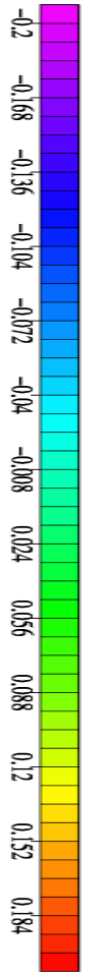
# SSM/I - MWR differences - 2005

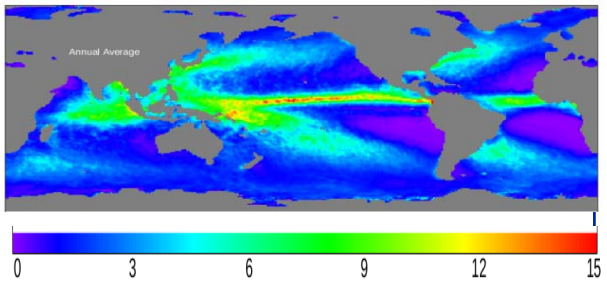
BEFORE RAIN FILETRING




AFTER RAIN FILTERING



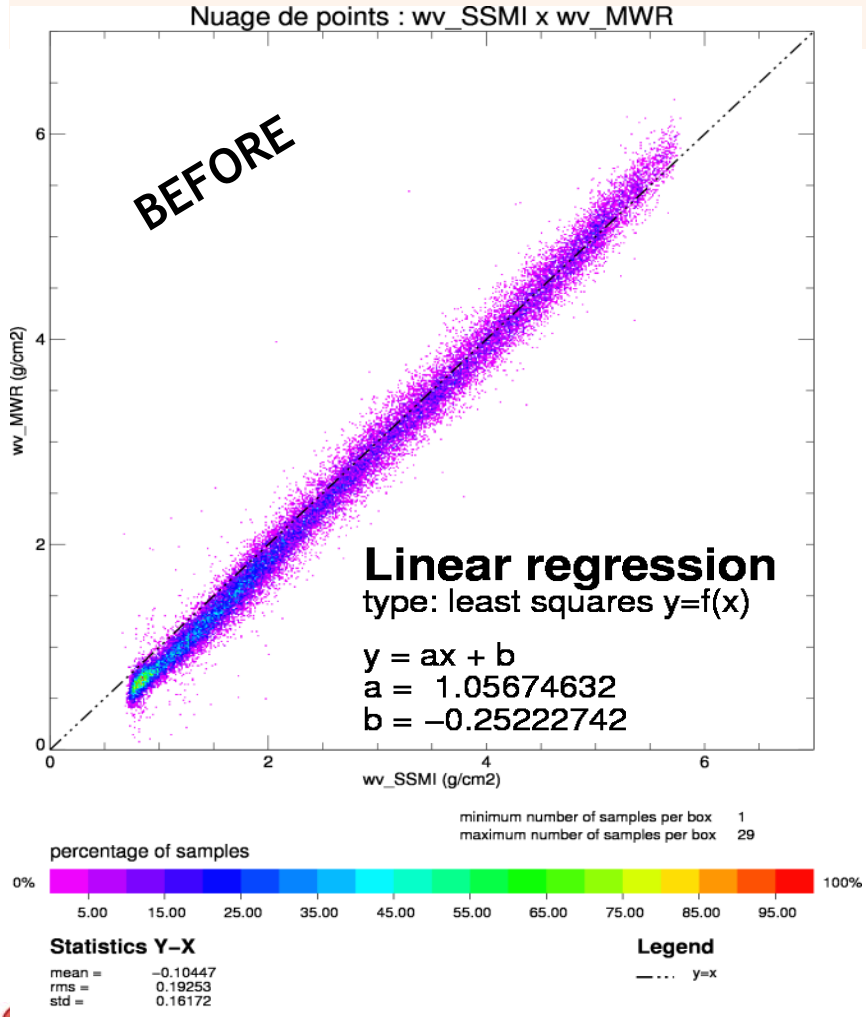



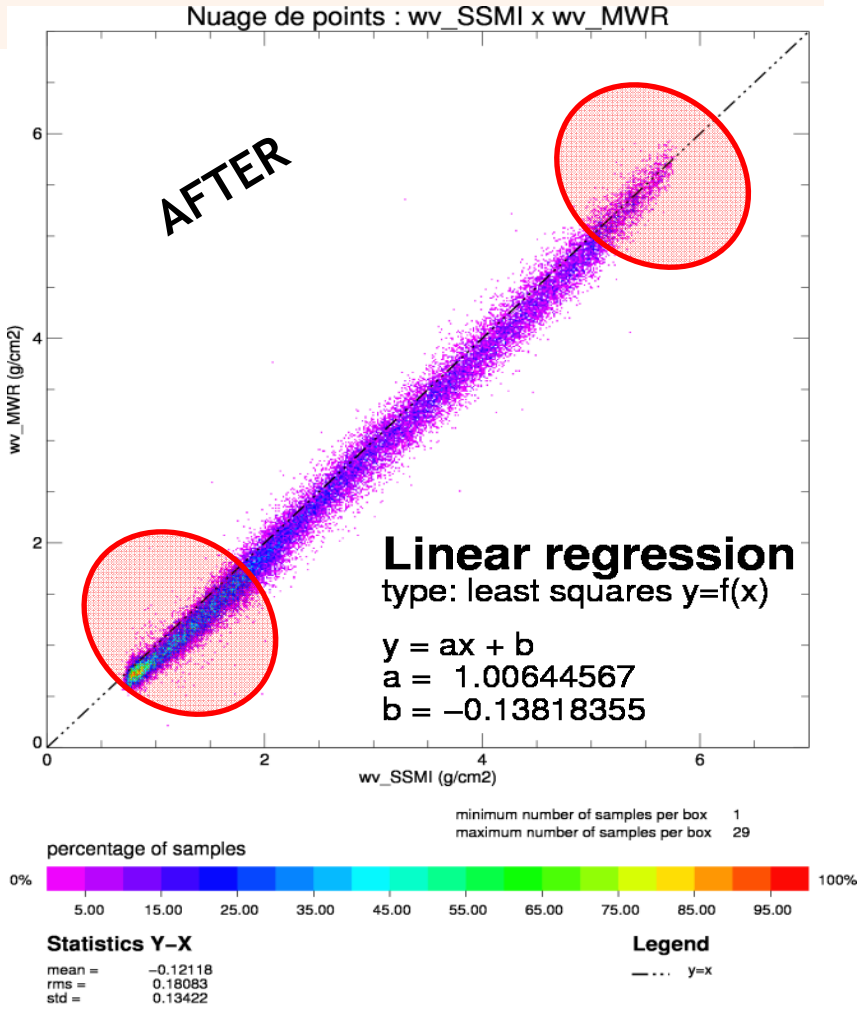

Rain rate (mm/day)
(WENTZ 1996)

# Scatterplot between SSM/I and Envisat/MWR water vapor

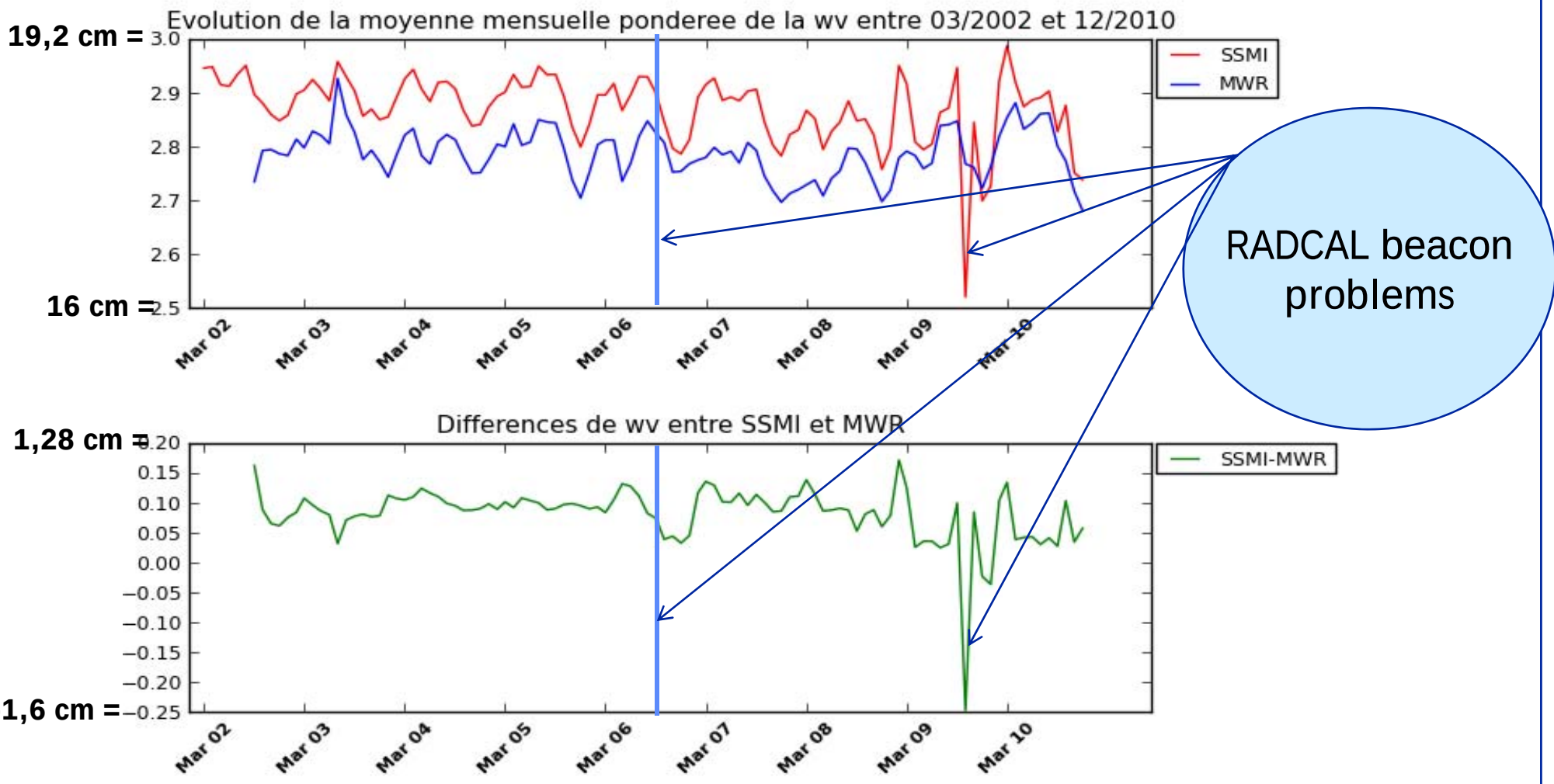
## Envisat/MWR without rain filter



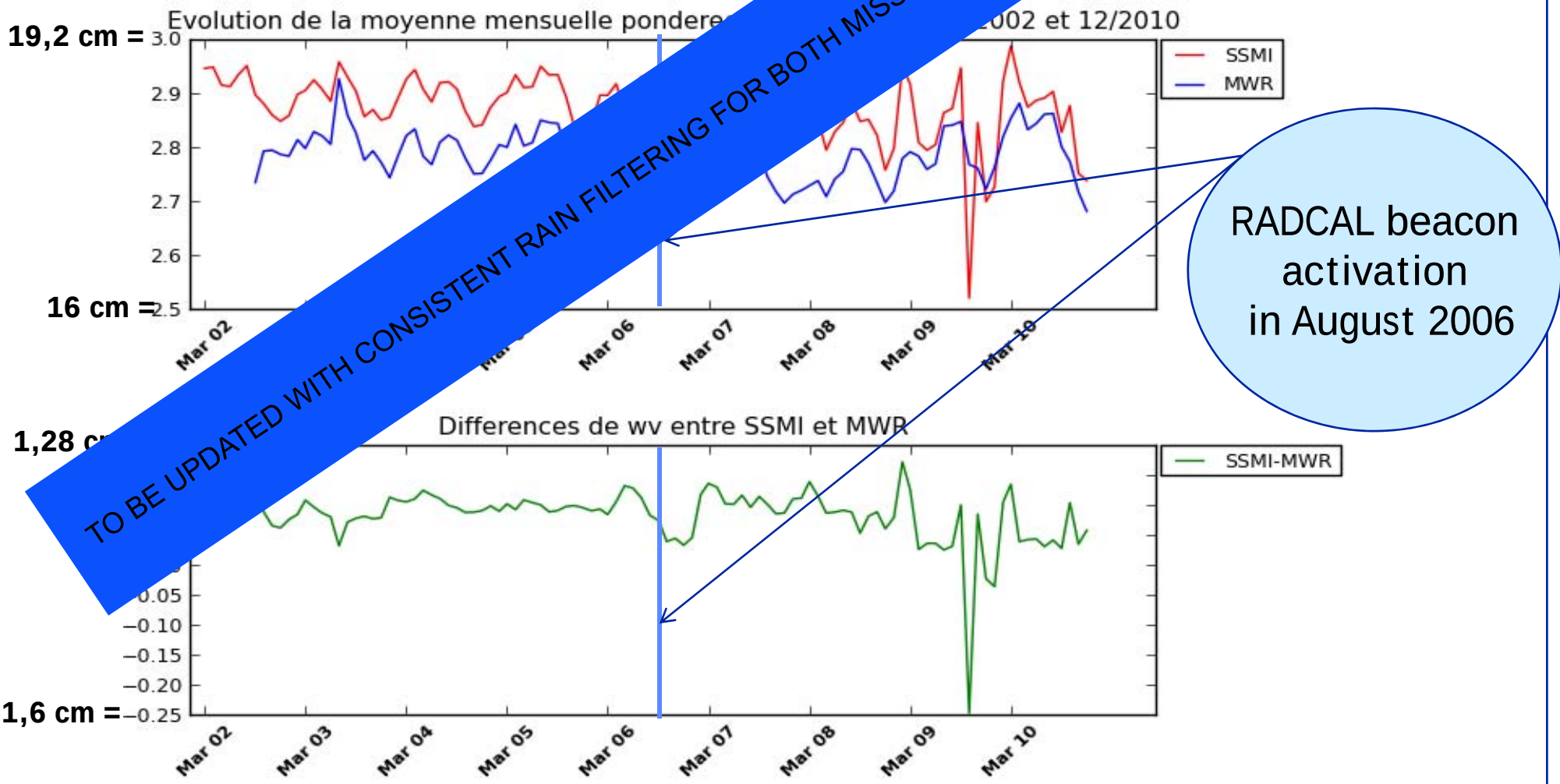

## Envisat/MWR with rain filter



# Temporal trends



# Temporal trend




TO BE UPDATED WITH CONSISTENT RAIN FILTERING FOR BOTH MISSIONS

RADCAL beacon activation in August 2006

# Conclusions

- PhD at CNES/CLS/LOCEAN is starting to analyze in details the differences between available water vapor products
- First part of the study is dedicated to an in-depth analysis of differences between SSM/I and Envisat/MWR radiometer products
  - Geographical distribution of the differences
  - Temporal variations of the differences
- We highlighted the strong effect of rain filtering in the geographical distribution of the differences => may have a significant impact on the temporal evolution of the differences

➢ First results show that the comparison between products from different missions with different sampling, calibration, processing, editing is not strait forward

➢ Data processing and especially editing in altimetry data creates a coupling with other geophysical parameters (rain, ice extent, clouds, SST…)

➢ They should be consistent for meaningful comparisons between missions

# Perspectives

- This analysis will be extended to better assess the impact of processing and editing on the different water vapor products with emphasis on
  - Rain
  - Ice extent
  - Clouds
  - SST

- This study will be extended to the comparison
  - with other missions (TOPEX, Jason1, Jason2, ERS-1, ERS-2)
  - With models, operational (ECMWF) or reanalyzed (ERA-40, ERA-interim)
  - With in-situ data (radiosondes, GPS)

- Statistical methods like EOF will be used for an efficient analysis of the differences that will be observed