# Introduction of MW emissivities in the precipitation retrieval algorithms

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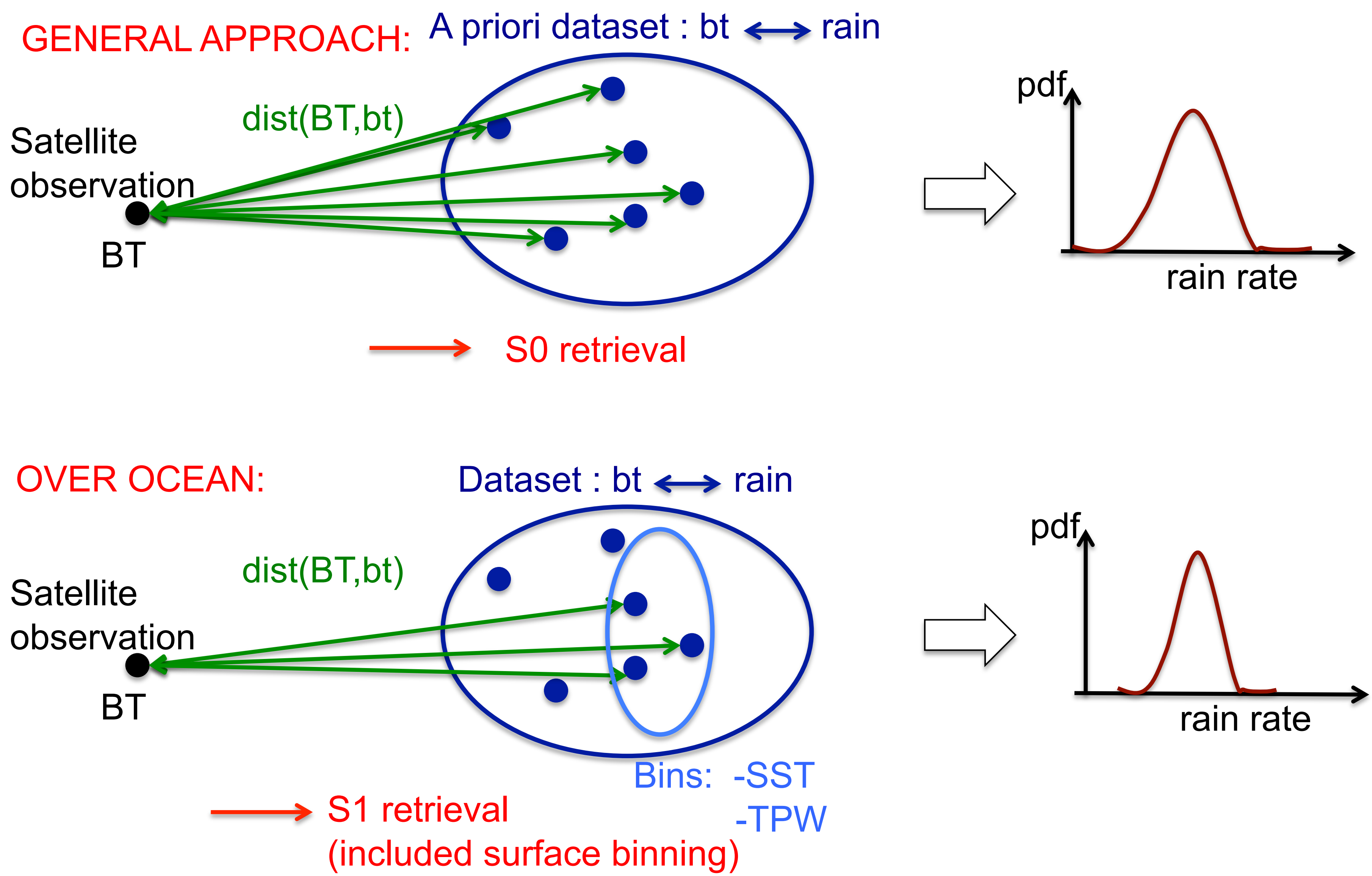
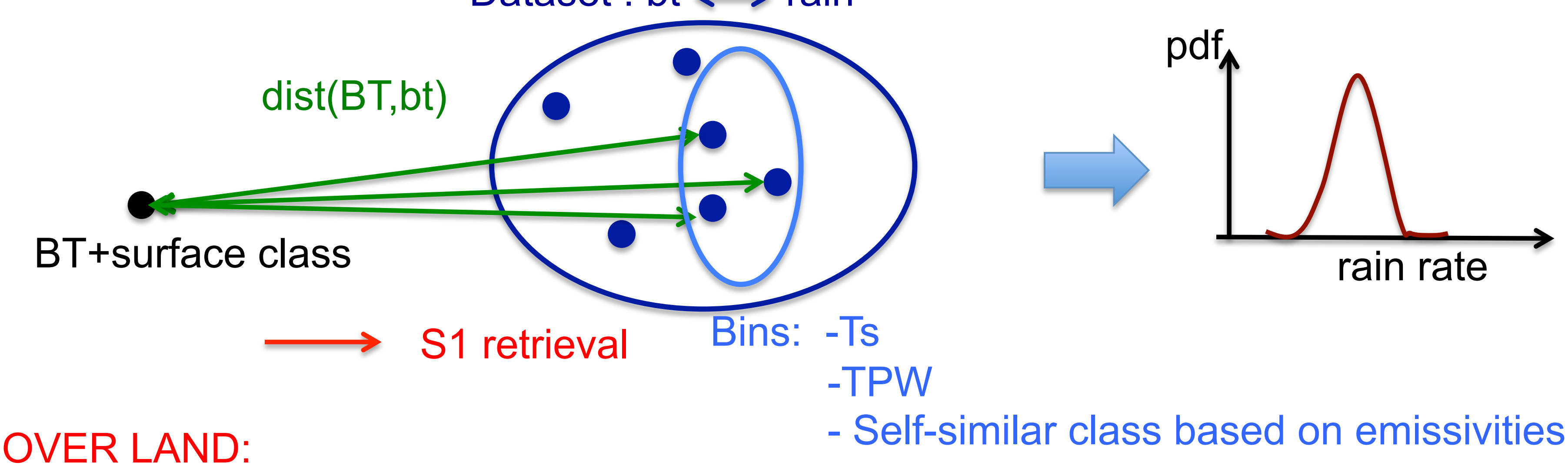
ESTELLUS

# Bayesian retrieval algorithm

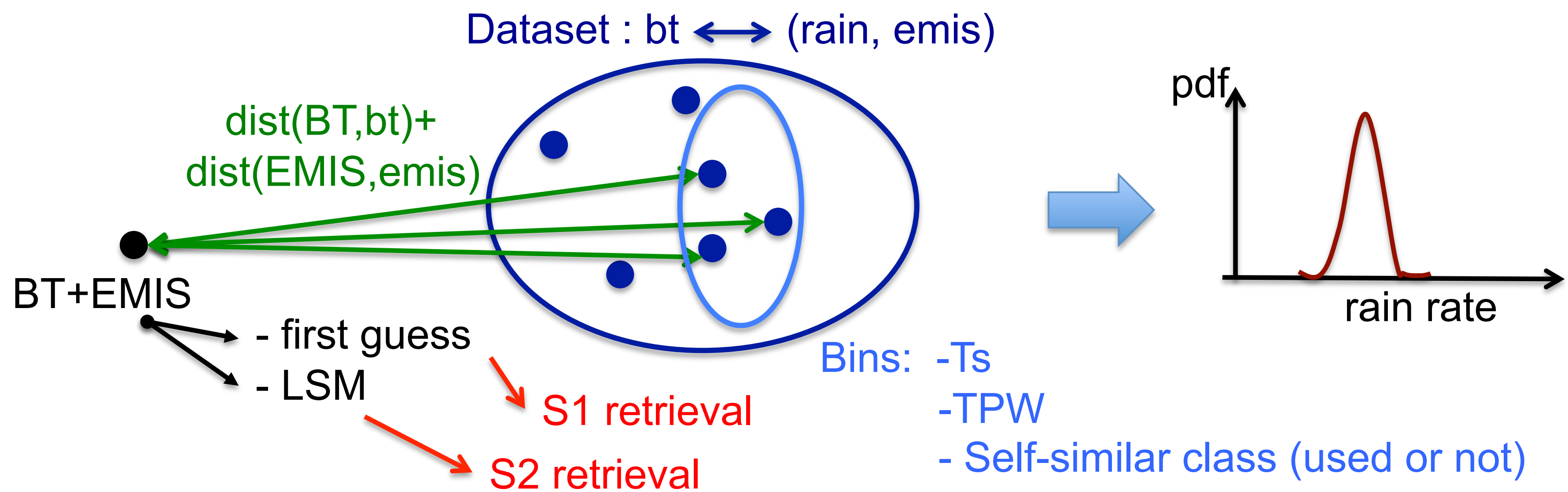


# Bayesian retrieval algorithm

OVER LAND:



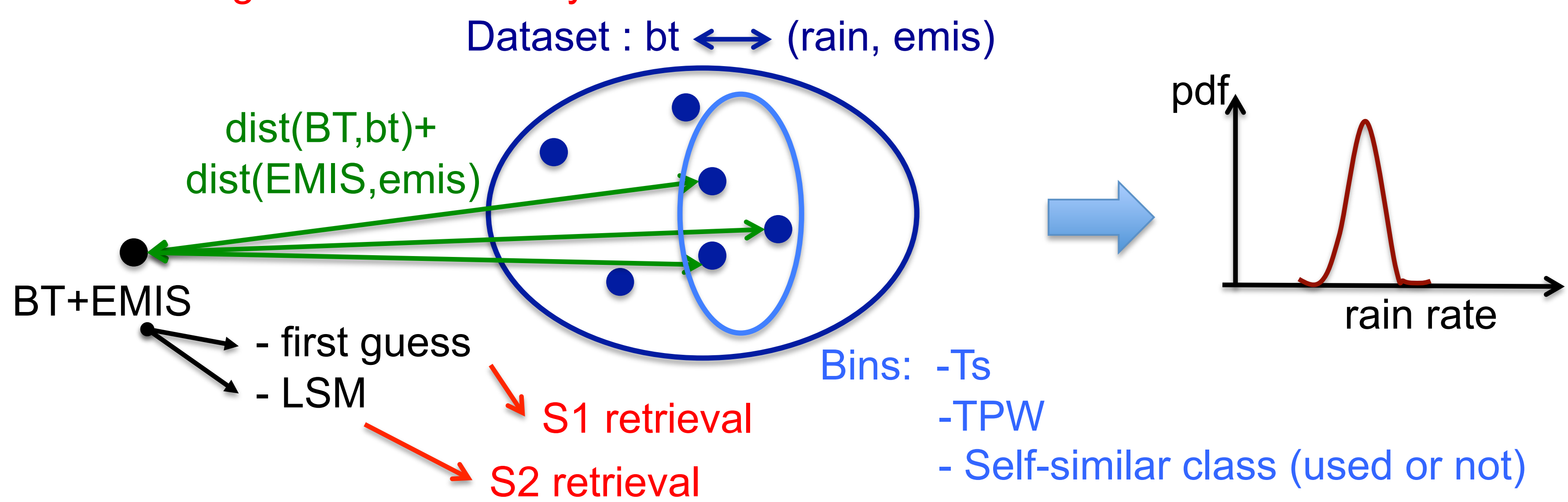

OVER LAND:
with knowledge of the emissivity



# What is needed?

- Datasets of emissivities for the GPM conditions
- Self-similar surface classes based on the emissivities
- A distance to measure discrepancies on emissivities

OVER LAND:
with knowledge of the emissivity



# Outline

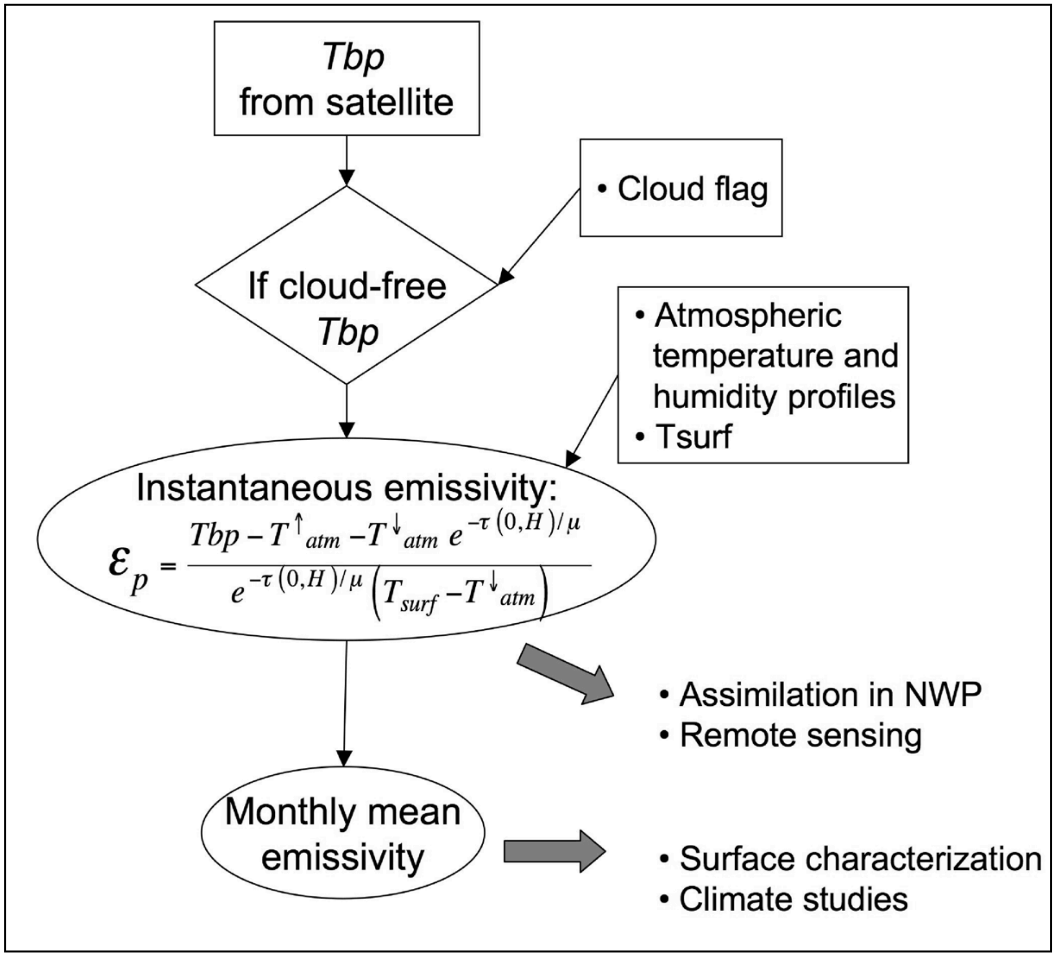
- Retrieval of MW emissivities
- TELSEM tool
  - Principle
  - Application for Megha-Tropiques
  - Assimilation in NWP centers
- **Task 1:** Development of the **emissivity databases** for the GPM conditions
- **Task 2: Self-similar classes** based on the MW emissivities
- **Task 3: Distance** for MW emissivities based of EOF analysis

# The methodology

**A generic method to derive land surface emissivity from satellite that can be applied to microwave imager and sounder window channels**

$$Tb_p = \varepsilon_p.Ts.\tau + (1-\varepsilon_p).Tdown.\tau + Tup$$

$$\varepsilon_p = \frac{Tb_p - Tup - Tdown\ .\ \tau}{\tau\ .\ (Ts - Tdown)}$$




**Specular approximation**
**Ts is the IR surface skin temperature**
**Retrieval of an 'effective' emissivity**

**For the SSM/I processing:**

**ISCCP cloud flag and T surf**
**NCEP reanalysis**
**Liebe gaseous absorption**

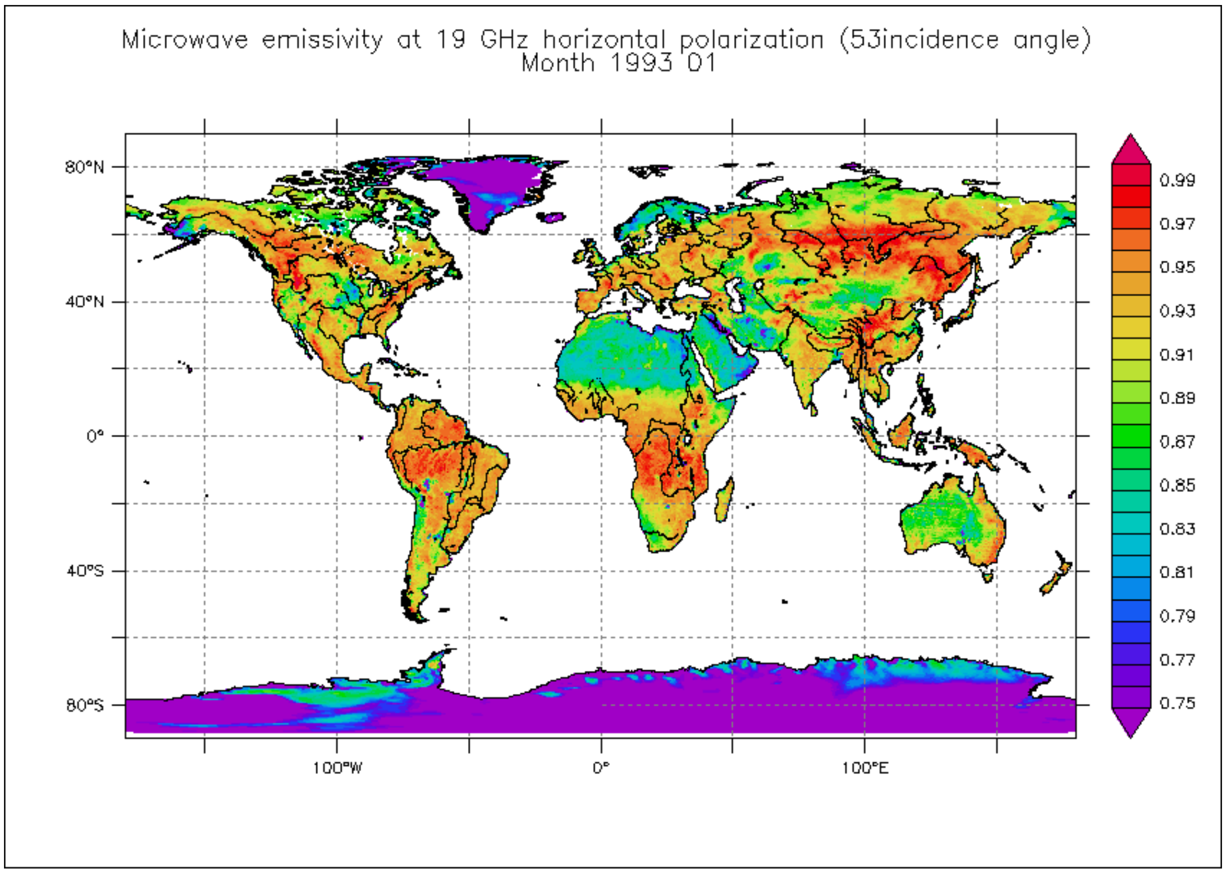
**(Prigent et al., JGR, 1997; BAMS, 2006)**

**A methodology often used since for other instruments: AMSU (Prigent et al., 2005; Karbou et al., 2005), AMSR-E (Moncet et al. , 2008)**

# The results

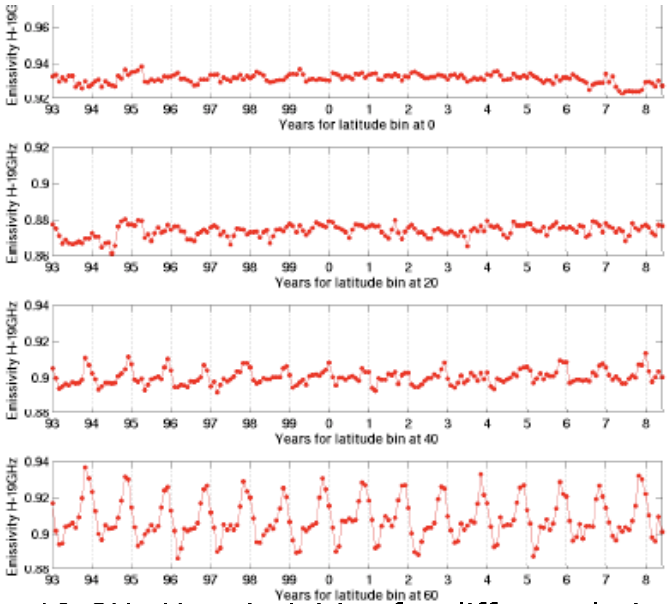
• A robust database of global daily emissivities over 16 years derived from all the available SSMI instruments, along with a few months of other satellite-derived maps.

• A monthly-mean product available to the community with a spatial resolution of 0.25°×0.25° at the equator from 1993 to 2008.

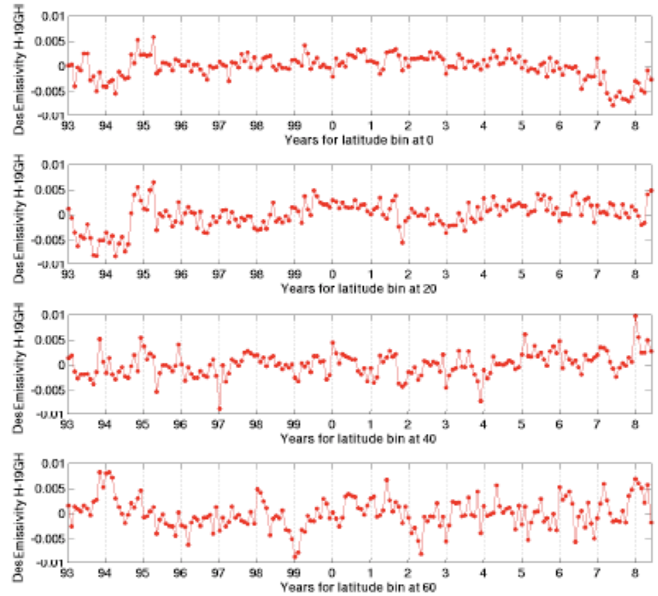


# The results

- **A product carefully analyzed and monitored over the full time series.**




The 19 GHz H emissivities for different latitude bands over 15 years



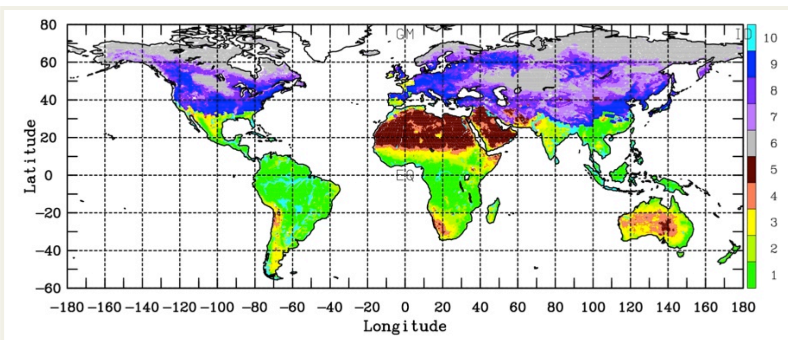

The corresponding deseasonalized over 15 years

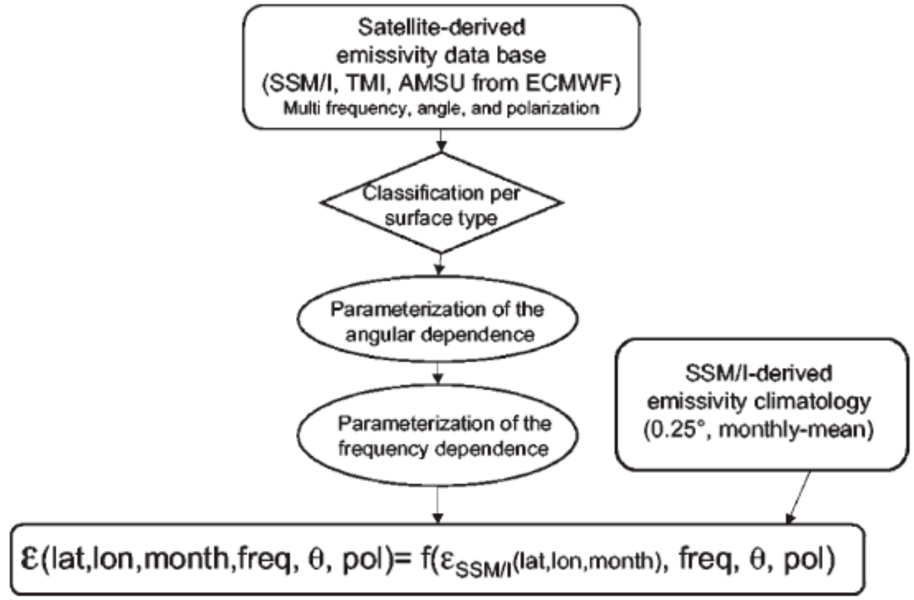
- **A product used for many original applications:**
  - As first guess for
    - Inversion (Operational Megha-Tropiques water vapour retrieval)
    - Assimilation of close-to-the-surface sounding channels (MetOffice)
  - As first guess in “all-weather” emissivity-Ts retrievals(1)
  - For the characterization of land surface (wetland, snow, vegetation, soil moisture…)
  - Simulate the responses of future instruments (Megha-Tropiques / GPM simulator – T. Matsui)
  - For surface background estimate in precipitation and cloud retrievals

(1) **Aires, F., C. Prigent, W.B. Rossow, M Rothstein,** *A new neural network approach including first-guess for retrieval of atmospheric water vapour, cloud liquid water, surface temperature and emissivities over land from satellite microwave observations,* JGR, 106, D14, 2001.

# TELSEM:

• **A parameterization of the emissivity frequency, angular, and polarization dependence anchored on a reliable satellite-derived emissivity data base (Prigent et al. 2008)**



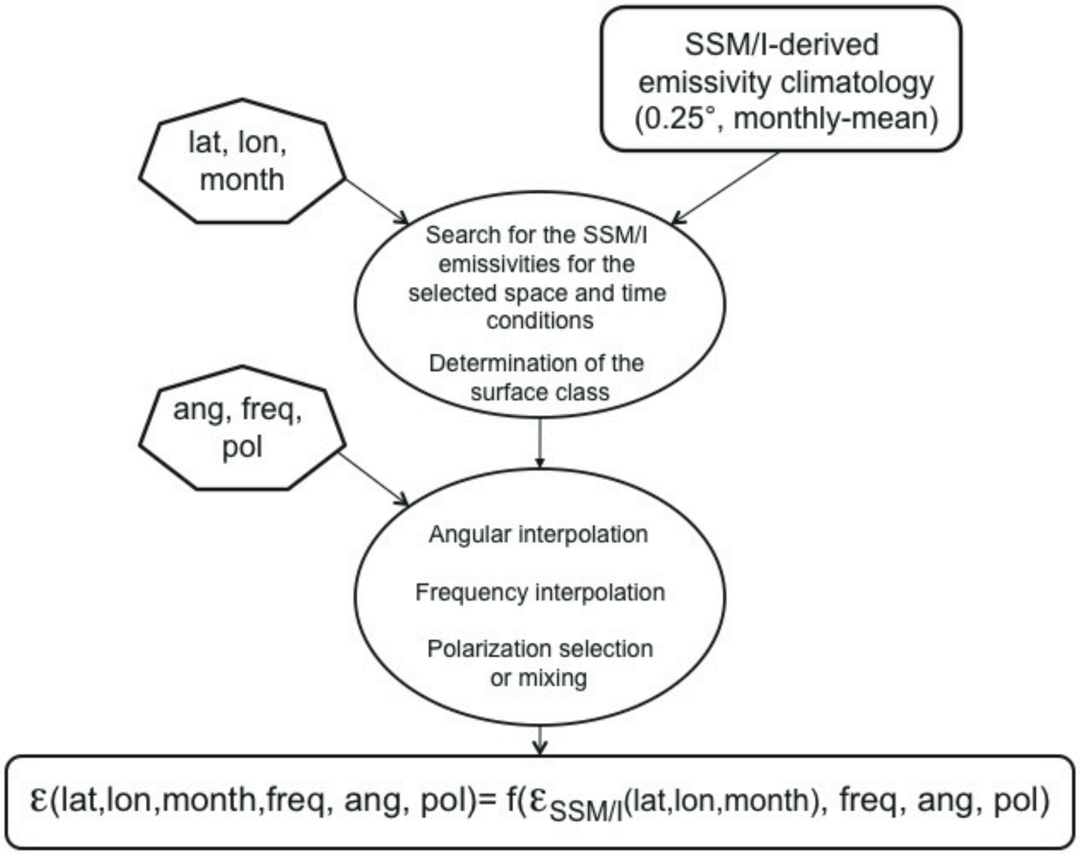




• **Implementation in RTTOV for Eumetsat NWP SAF (Aires et al. 2010)**
  - The interpolator tool can work on different horizontal resolutions
  - Nominal resolution of 0.25°×0.25° equal-area at monthly time scale
  - Provides covariance matrix of the uncertainties (on SSM/I and other instruments)
  - Implemented in Fortran 90
  - Different practical configurations


(1) **Prigent, C., E. Jaumouille, F. Chevallier, and F. Aires,** *A parameterization of the microwave land surface emissivity between 19 and 100 GHz, anchored to satellite-derived estimates,* IEEE Transaction on Geoscience and Remote Sensing , 46, 344-352, 2008.

(2) **Aires, F., C. Prigent, F. Bernardo, C. Jimenez, R. Saunders, and P. Brunel,** *A Tool to Estimate Land Surface Emissivities in the Microwaves (TELSEM) for use in numerical weather prediction schemes.* Q. J. Royal Meteor. Soc. , 137: 690-699, DOI: 10.1002/qj.803, 2011.

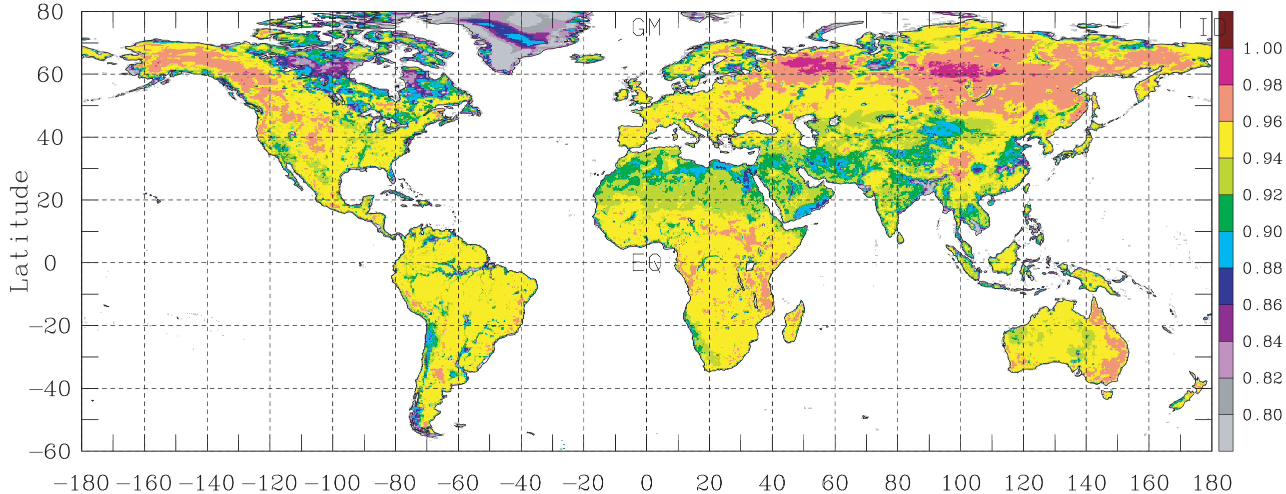
# How to use Telsem?



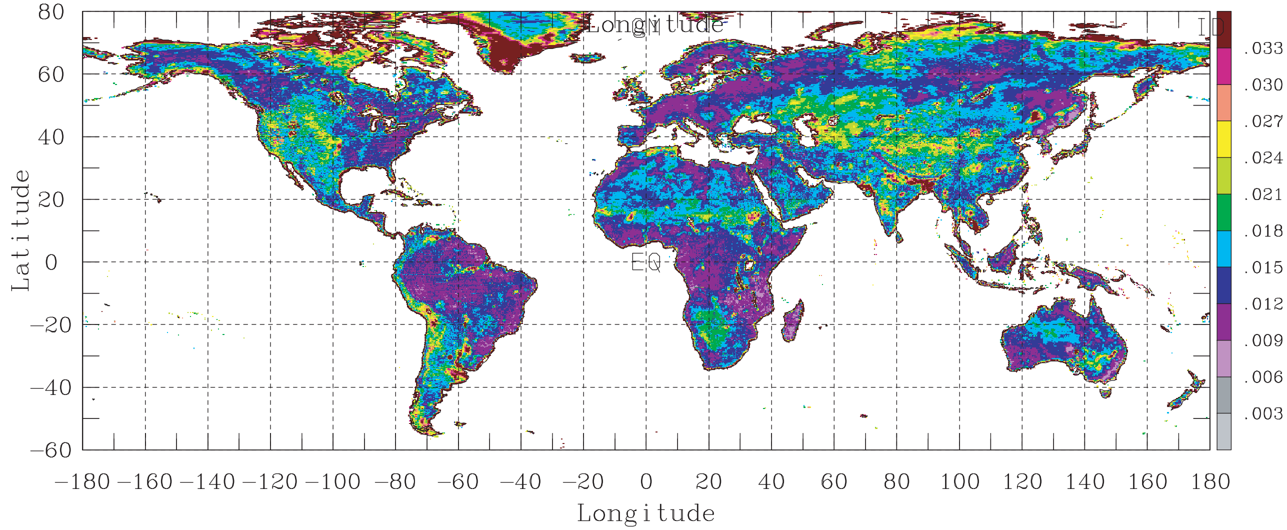

Two paradigms:

- Online: calling Telsem for each new observation
- Off-line: create the atlas for the new instrument once and for all

# Telsem outputs




September, Emissivity at 31.4 GHz (V) at 15° incidence angle.

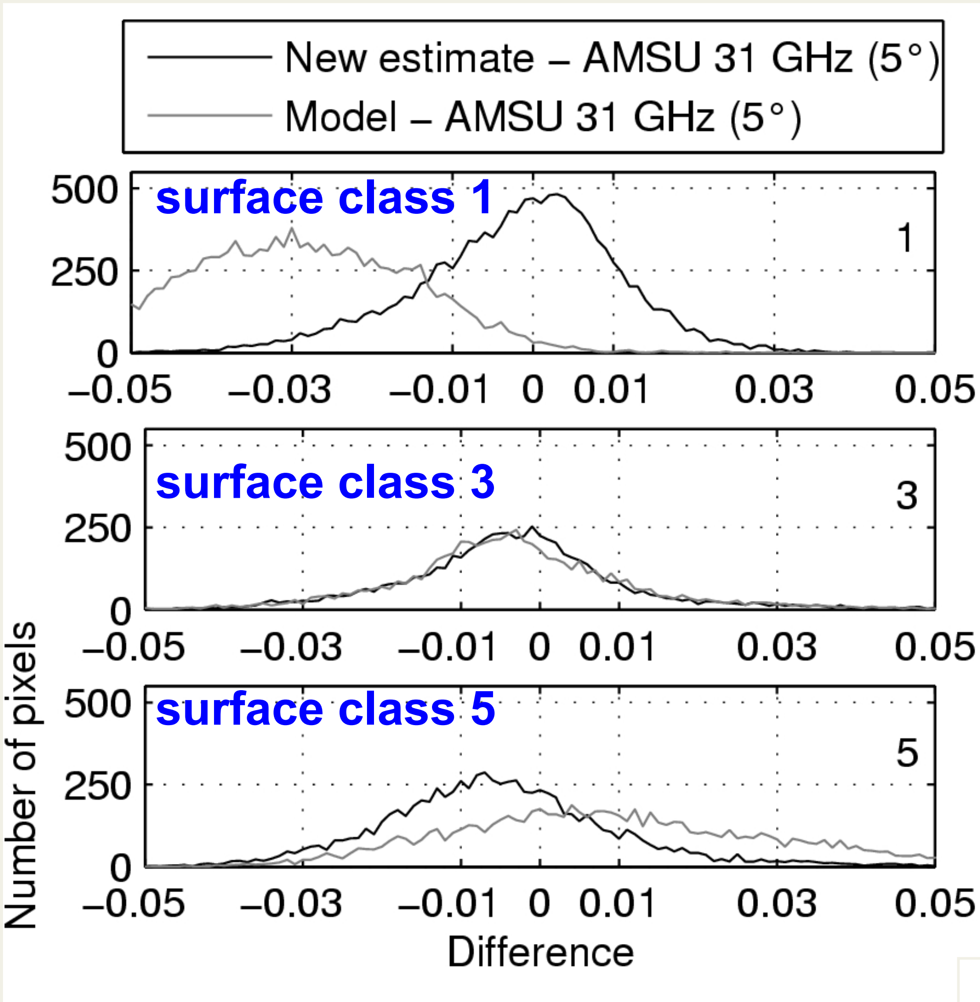



Corresponding uncertainty estimate.

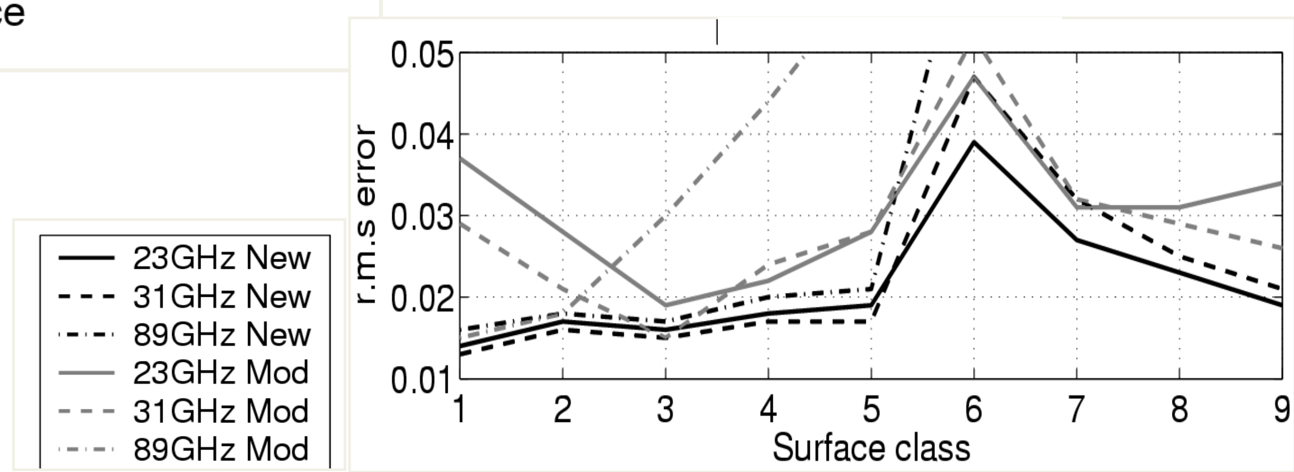
↓

We provide the full covariance matrices

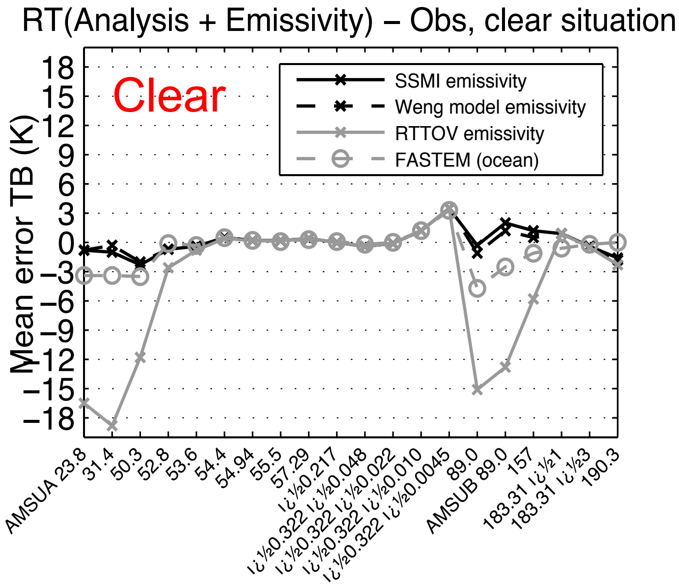
# Validation of TELSEM emissivities

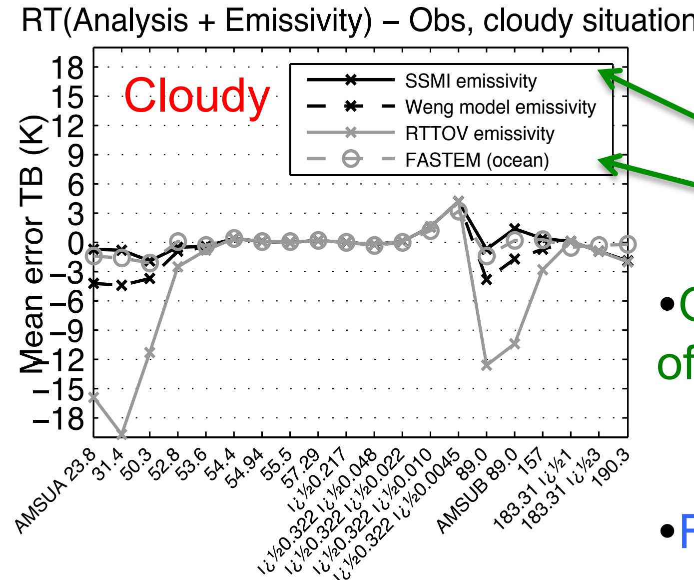



**Comparison between AMSU estimates and direct calculation RMS error as a function of frequency and classes**



# Validate using TB simulations

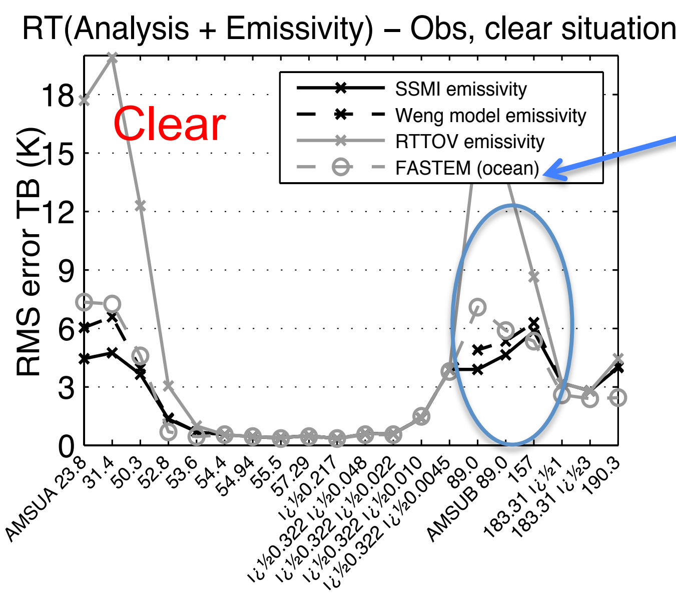


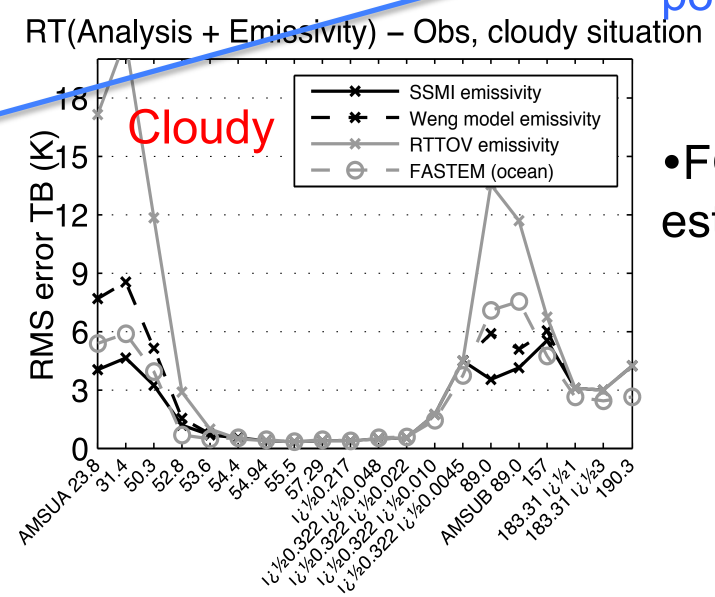




**BIAS**

- Ocean & land Emis. of similar quality

- Frequency extrapolation has a positive impact

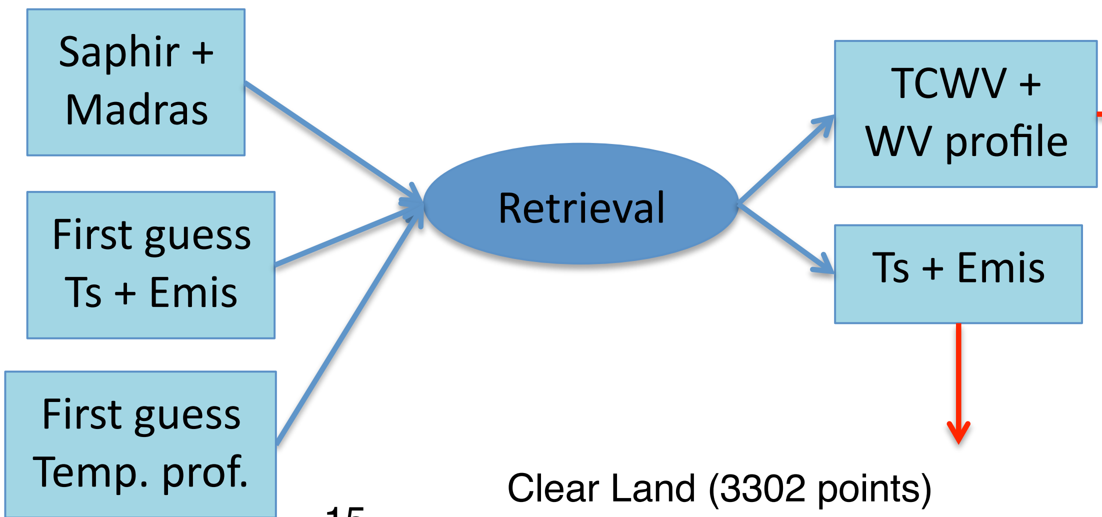


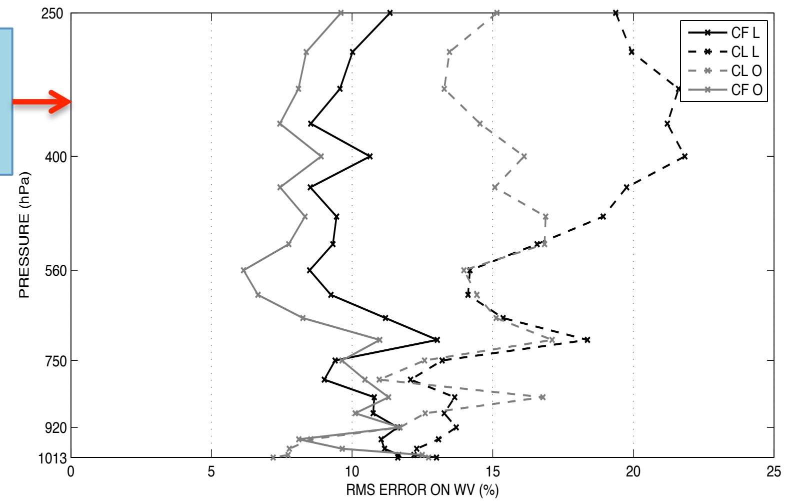




**RMS**

- FG is already a good estimation

# **First application**: retrieval of WV over land using Megha-Tropiques observations



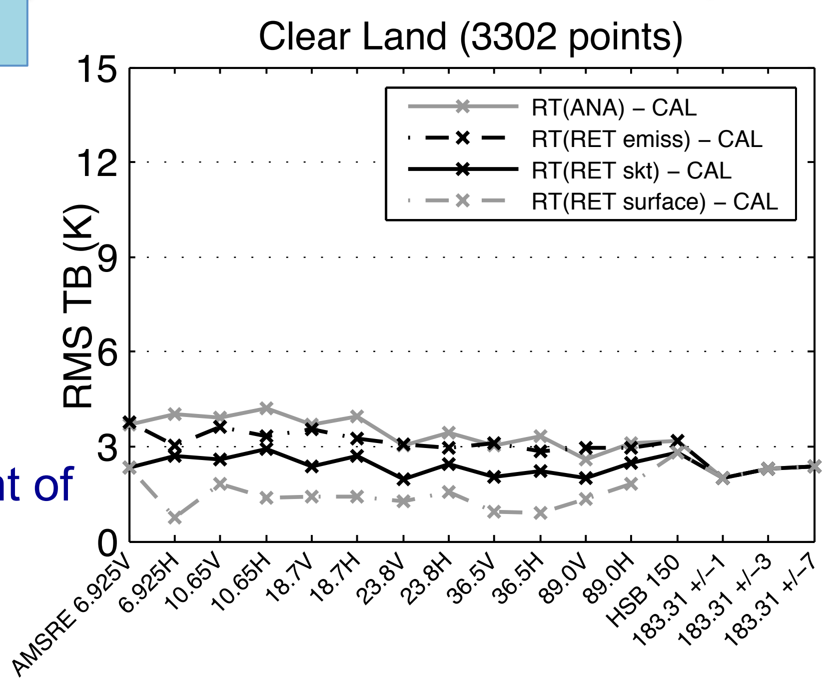

Water vapour statistics

CL: cloudy

CL: clear

O: ocean

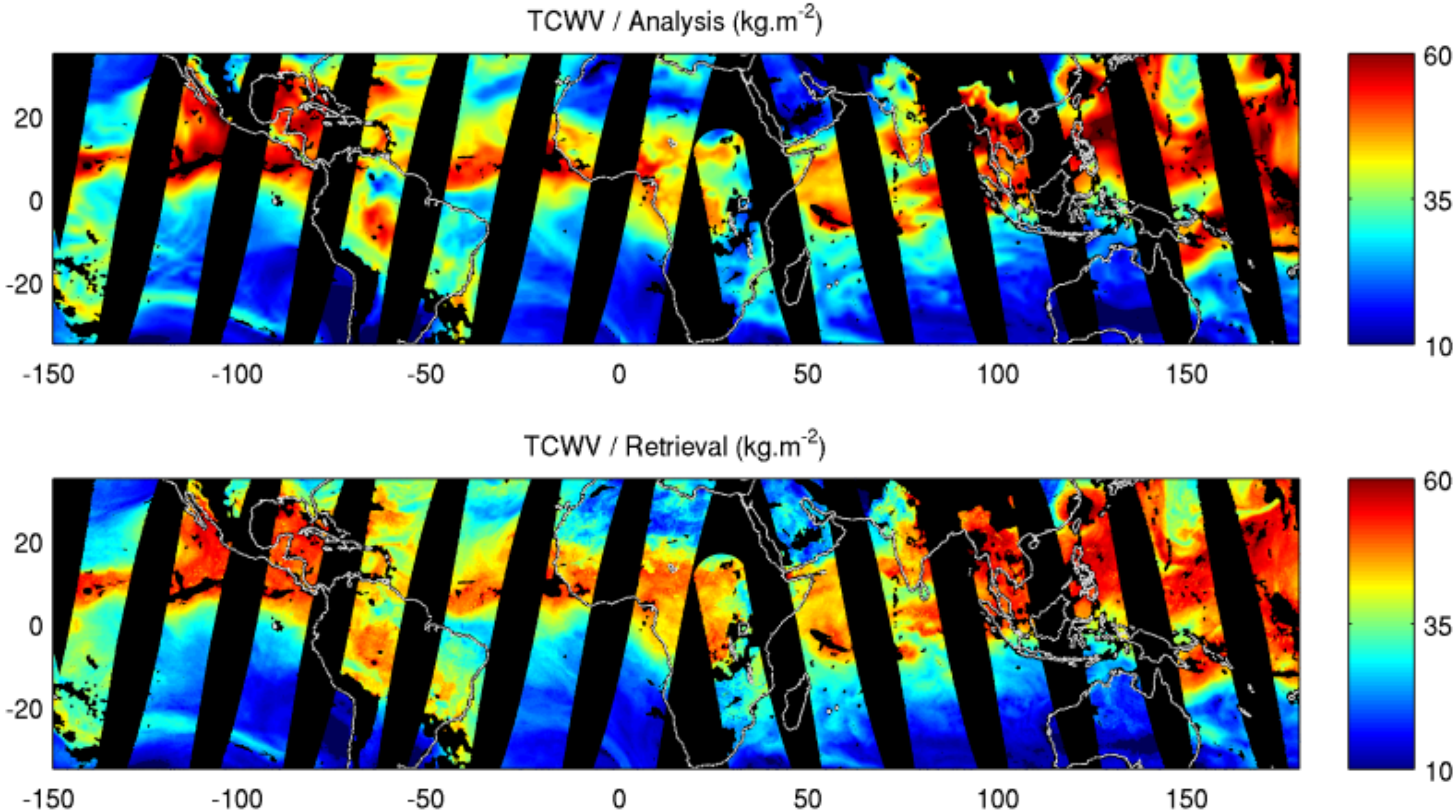
L: land




Impact of improvement of surface FG

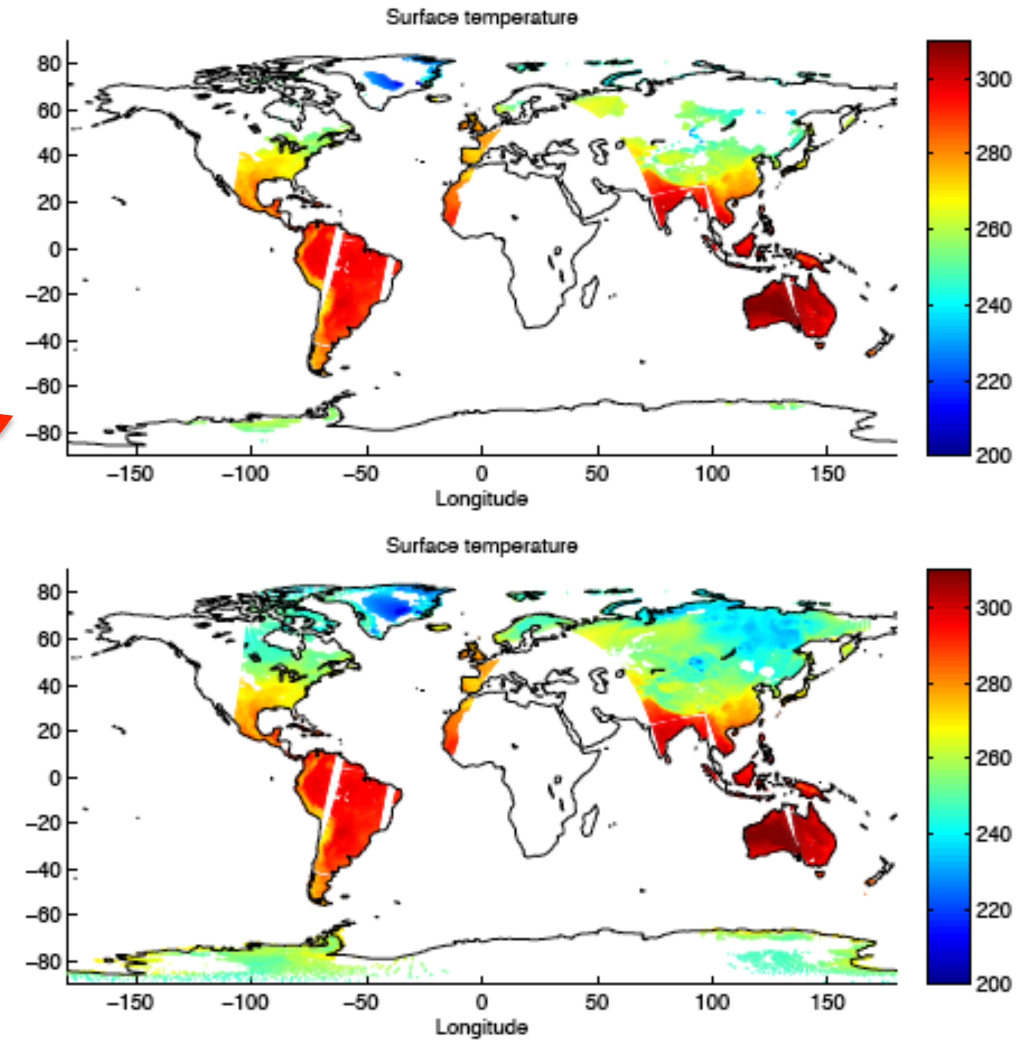
- TELSEM makes possible the retrieval over land
- TELSEM FG can be improved in the retrieval

**First application**: retrieval of TCWV over land using Megha-Tropiques observations



# **Second application**:
# assimilation at MetOffice NWP centre

- 1-D var experiment
- Using AMSU-A observations
- One cycle:
  - 67537 = all pixels
  - 26567 = when using fixed emis.
  - 48563 = when using TELSEM



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- TELSEM tool
  - Principle
  - Application for Megha-Tropiques
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- **Task 3:** EOF analysis of the MW emissivities

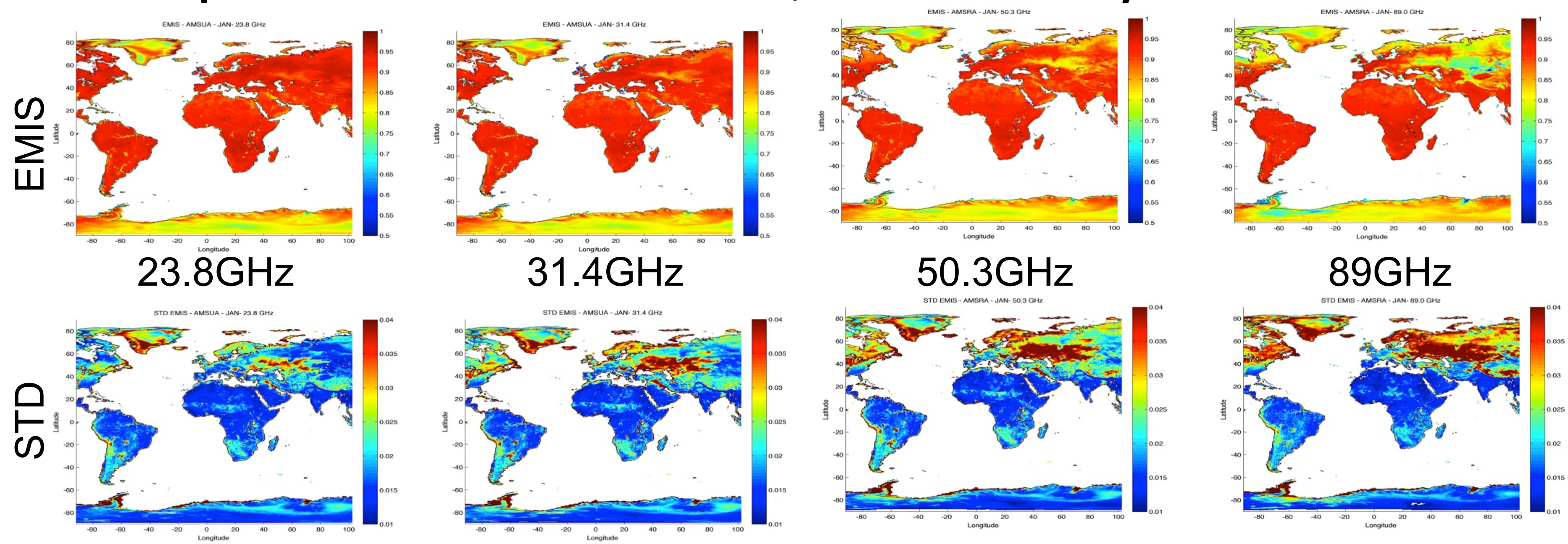
# **Task1**: Surface MW emissivities for the GPM mission

| AMSU-A | MHS | TMI | GMI | AMSR-E | SSMI |
|---|---|---|---|---|---|
| 0, 10, 20, 30, 40 & 50° | 0, 10, 20, 30, 40 & 50° | 53.4° | 52.8° | 55° | 53° |
| | | | | 6.92 V&H | |
| | | 10.65 V&H | 10.65 V&H | 10.65 V&H | |
| | | 19.35 V&H | 18.70 V&H | 18.70 V&H | 19.35 V&H |
| 23.8 | | 22.23 V | 23.90 V | 23.80 V | 22.23 V |
| 31.4 | | 37.00 V&H | 36.50 V&H | 36.50 V&H | 37.00 V&H |
| 50.3 | | | | | |
| 52.8 | | | | | |
| 53.6 | | | | | |
| 54.4 | | | | | |
| 54.9 | | | | | |
| 55.5 | | | | | |
| 57.3 | | | | | |
| 89.0 | | 85.50 V&H | 89.00 V&H | 89.00 V&H | 85.50 V&H |
| | 89.00 | | | | |
| | 157.00 | | | | |
| | 183.31±1 | | | | |
| | 183.31±3 | | | | |
| | 190.31 | | | | |

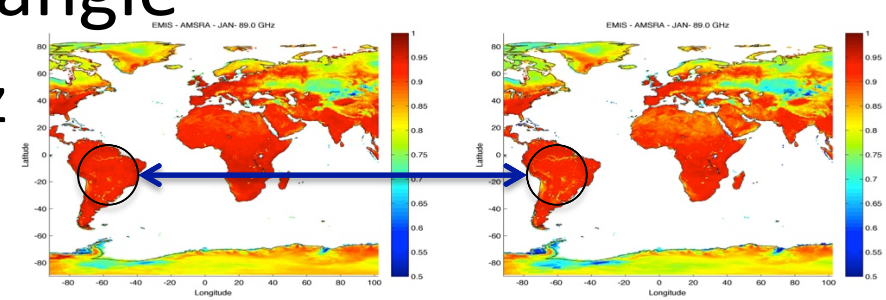
**Table 1: Instruments for which the emissivity datasets have been built. The incidence angles are indicated, together with the polarization of the channels (when no polarization is indicated, an instrument dependant polarization mixture is calculated).**

## Development of the databases to the GPM observing conditions

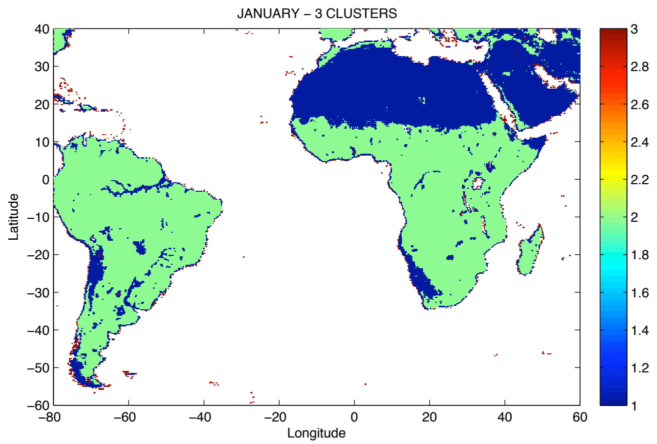
- Interpolation for AMSU-A, for January:



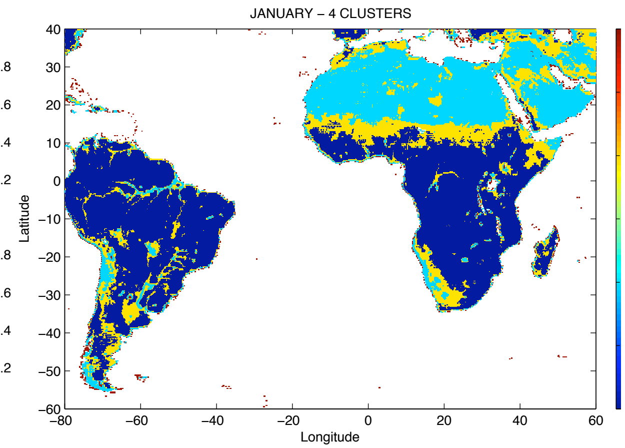

- Dependency on incidence angle
  - For AMSU-A channel 89GHz
  - At 0° (left) and 50° (right)



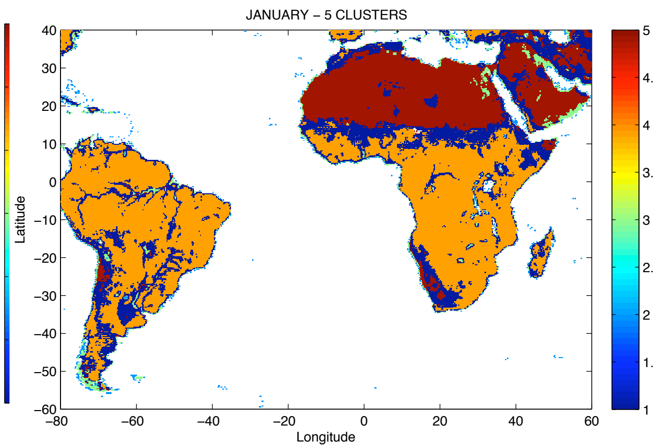
# Task 2: Clustering of emissivities to obtain self-similar surface classes



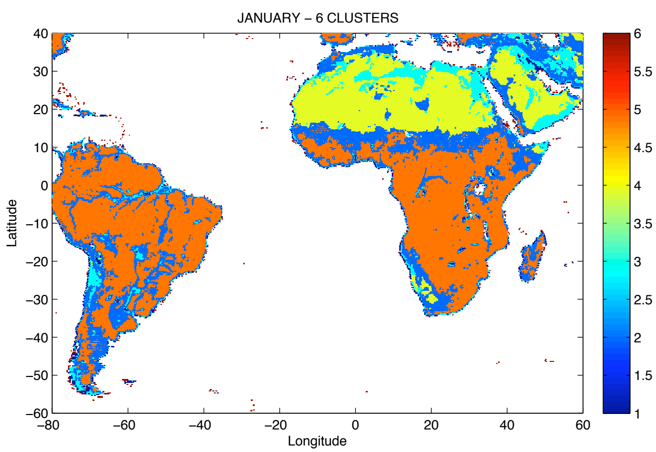
3 clusters



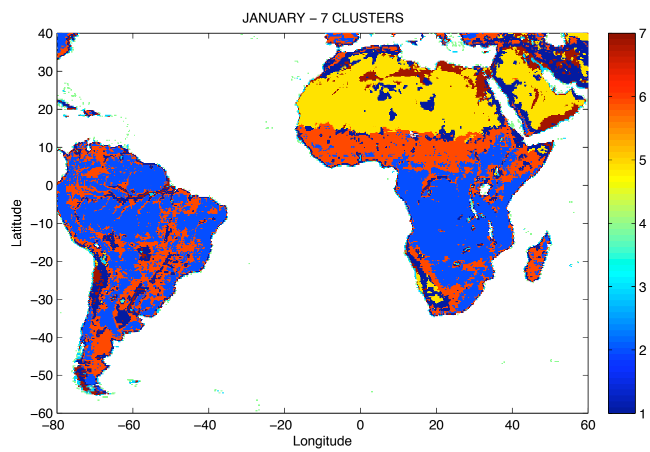
4 clusters



5 clusters



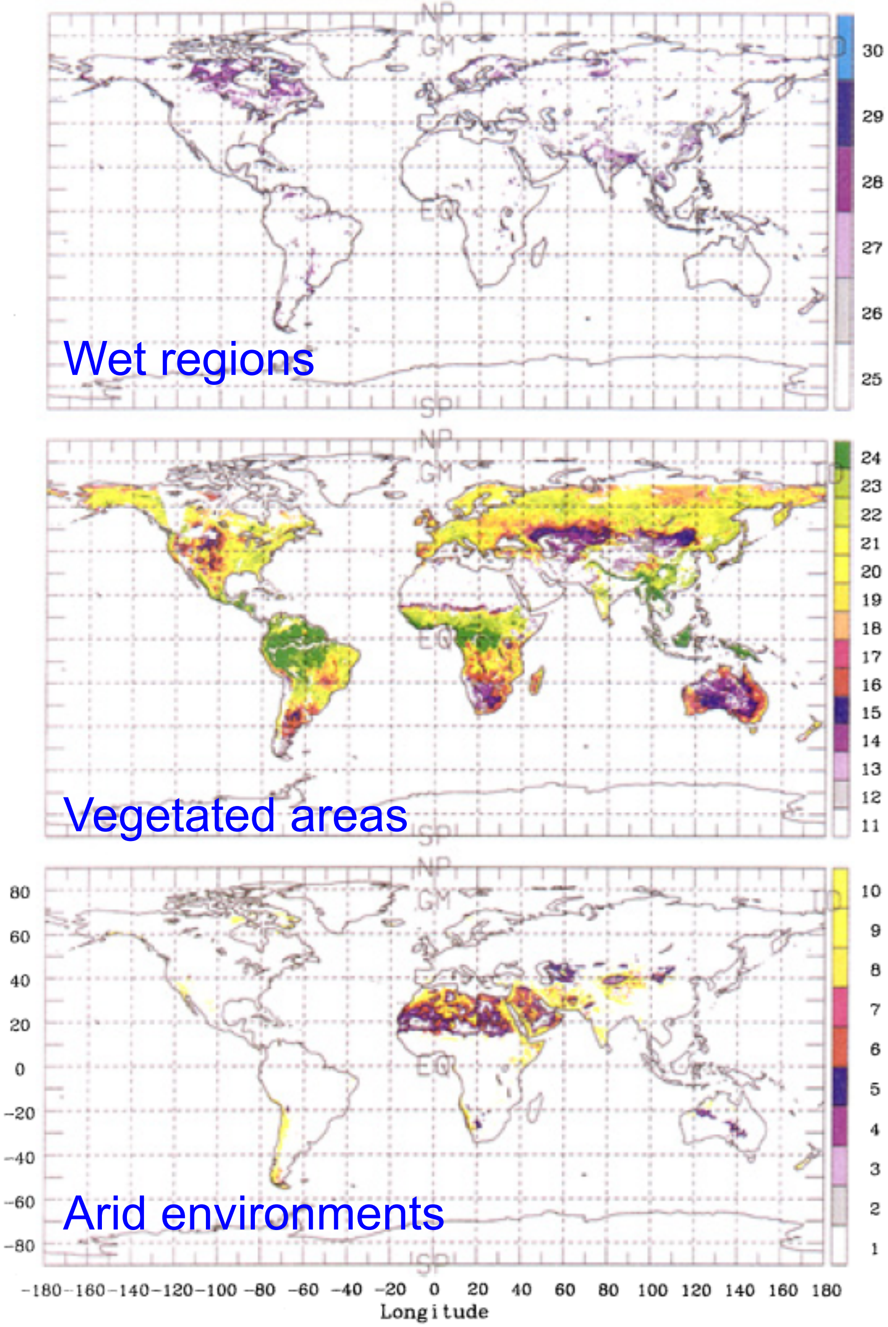
6 clusters



7 clusters

- ➔ Self-similarity emissivity classes
- ➔ But, becomes difficult when working at the global scale

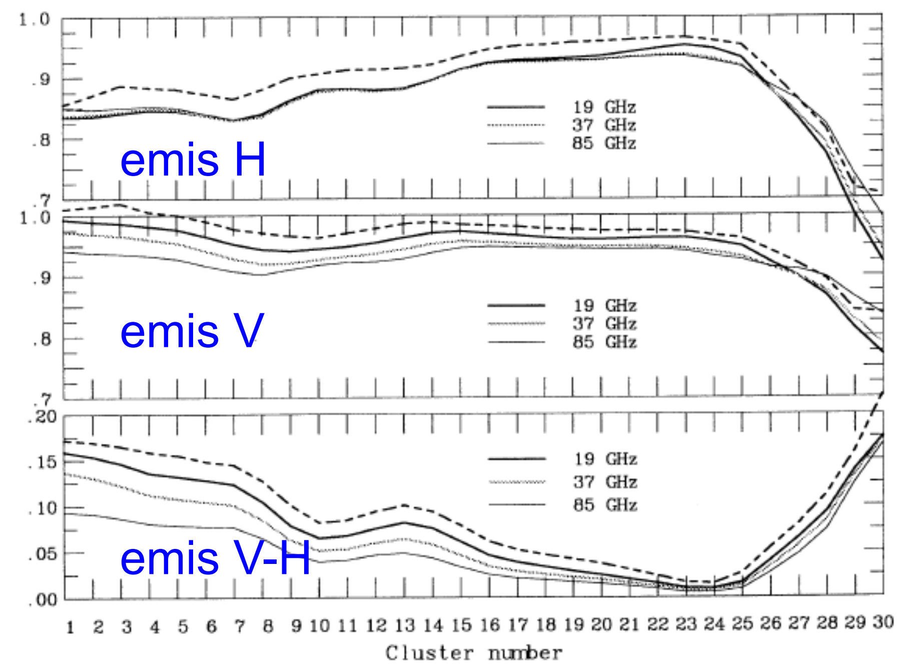
August 1992




# Clustering vegetation

**Kohonen clustering:**

- Snow and ice filtered
- Use of SSMI, ERS1, and AVHRR data
- Obtain 30 surface classes excluding snow




**Prigent, Aires, Rossow, & Matthews,** *Joint characterization of the vegetation by satellite observations from visible to microwavelengths: a sensitivity analysis*, JGR, 106, D18, pp. 20,665-20,685, 2001.

# Clustering snow/ice

**Kohonen clustering:**

- Use of SSMI, ERS1, and AVHRR data
- Obtain 8 snow classes

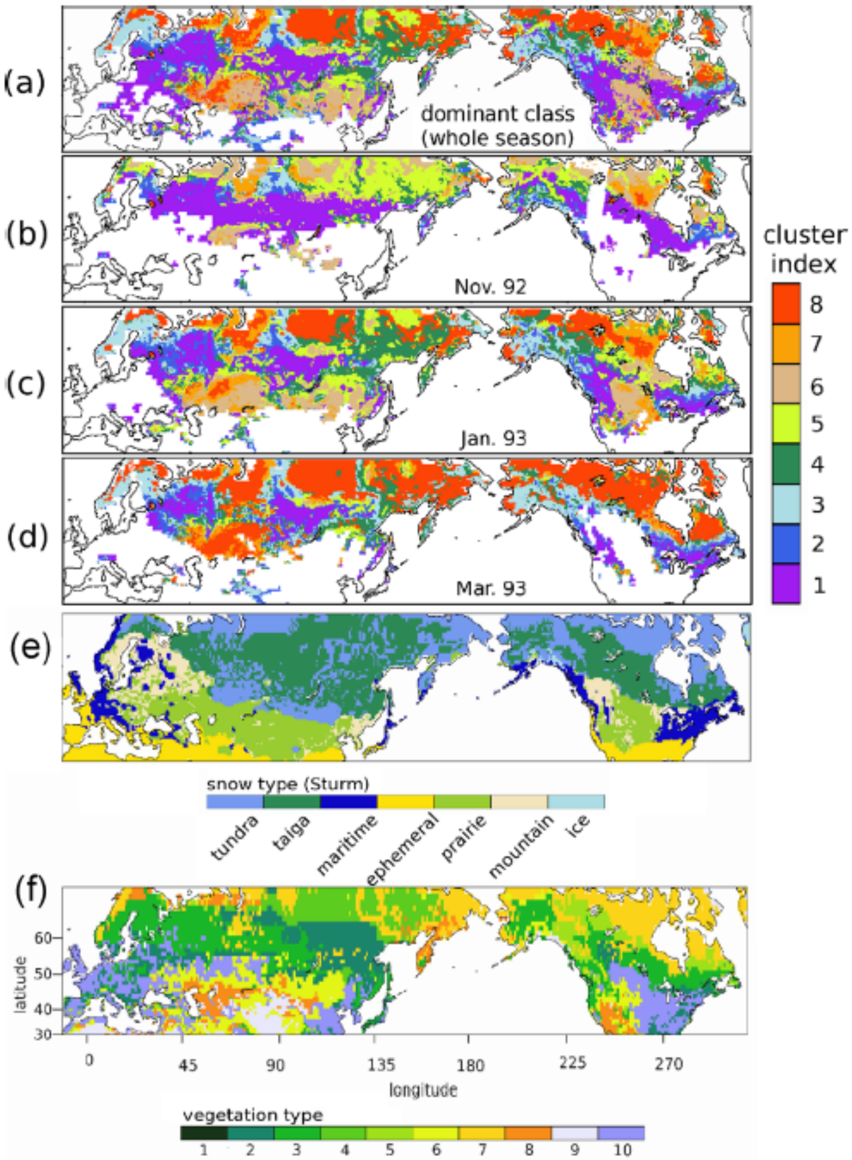



**Figure 12.** Maps of the clustering results. (a) Dominant class for the winter, (b–d) the results for 3 different months in the winter, (e) the snow classification by *Sturm et al.* [1995], and (f) the vegetation classification by *Matthews* [1983].

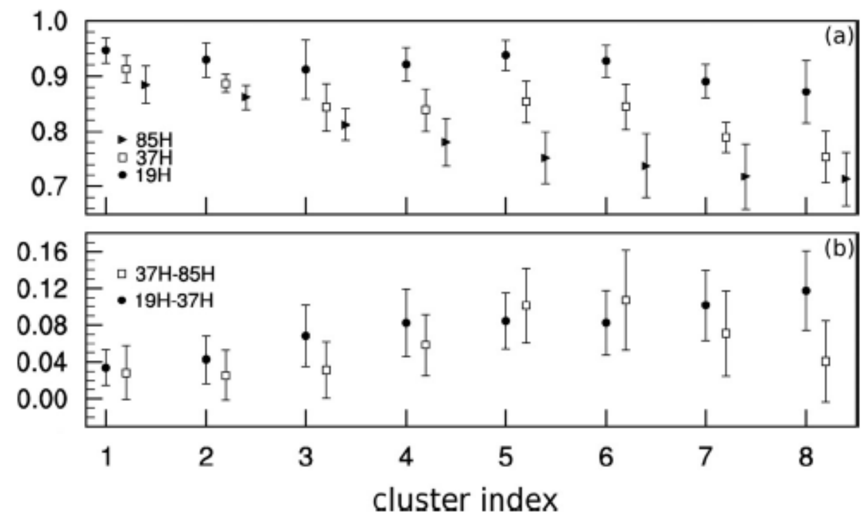
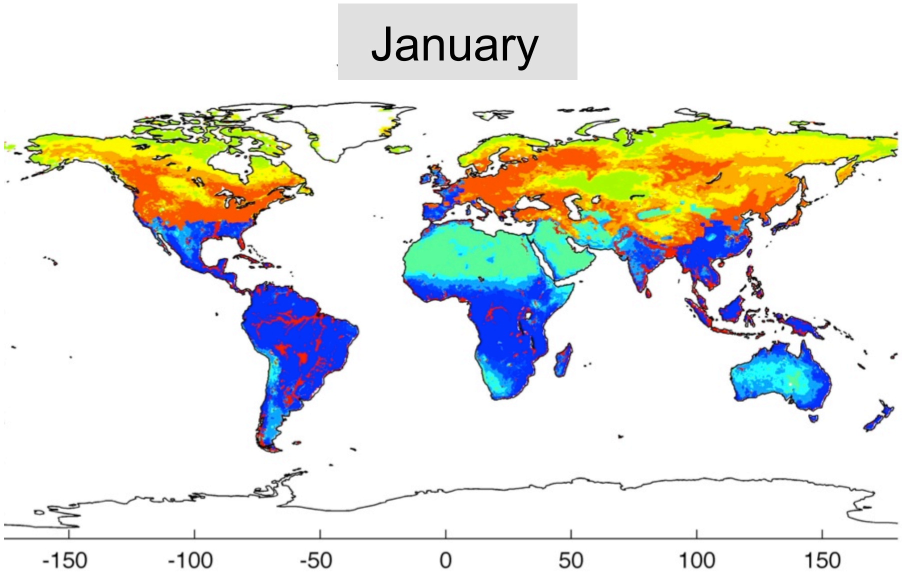
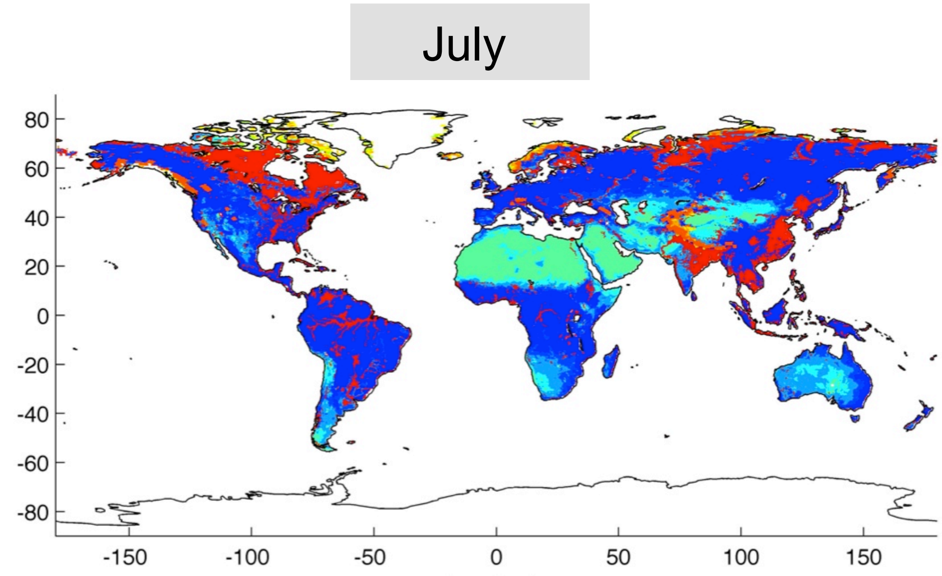



**Figure 11.** Result of the multisatellite classification. (a–c) Variation of the center of each cluster for each piece of information along with its standard deviation around the center value. (d) Corresponding values for the visible reflectances.

**E. Cordisco, C. Prigent, and F. Aires,** *Snow characterization at a global scale with passive microwave satellite observations.* JGR , 111, D19, D19301, 2006.

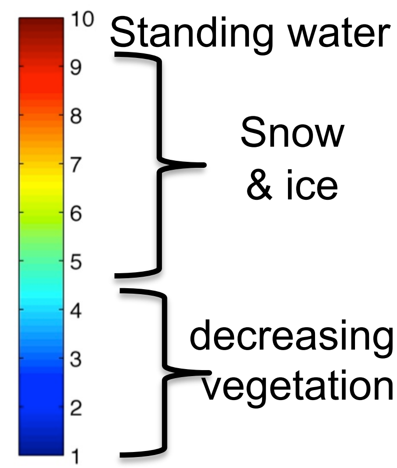
# Clustering of emissivities for surface classes: A first 10 surface classes



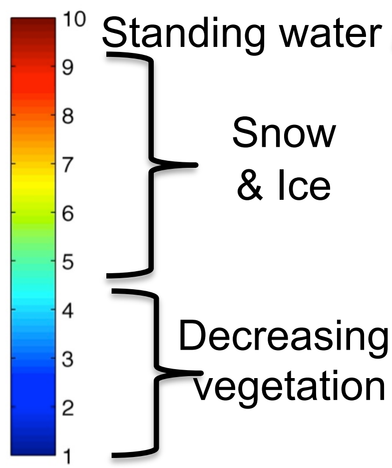




**Methodology**:

- traditional k-means clustering
- use of NSIDC data for snow
- use of our global wetland dataset



# Sub-clustering of each one of the initial 10 surface classes

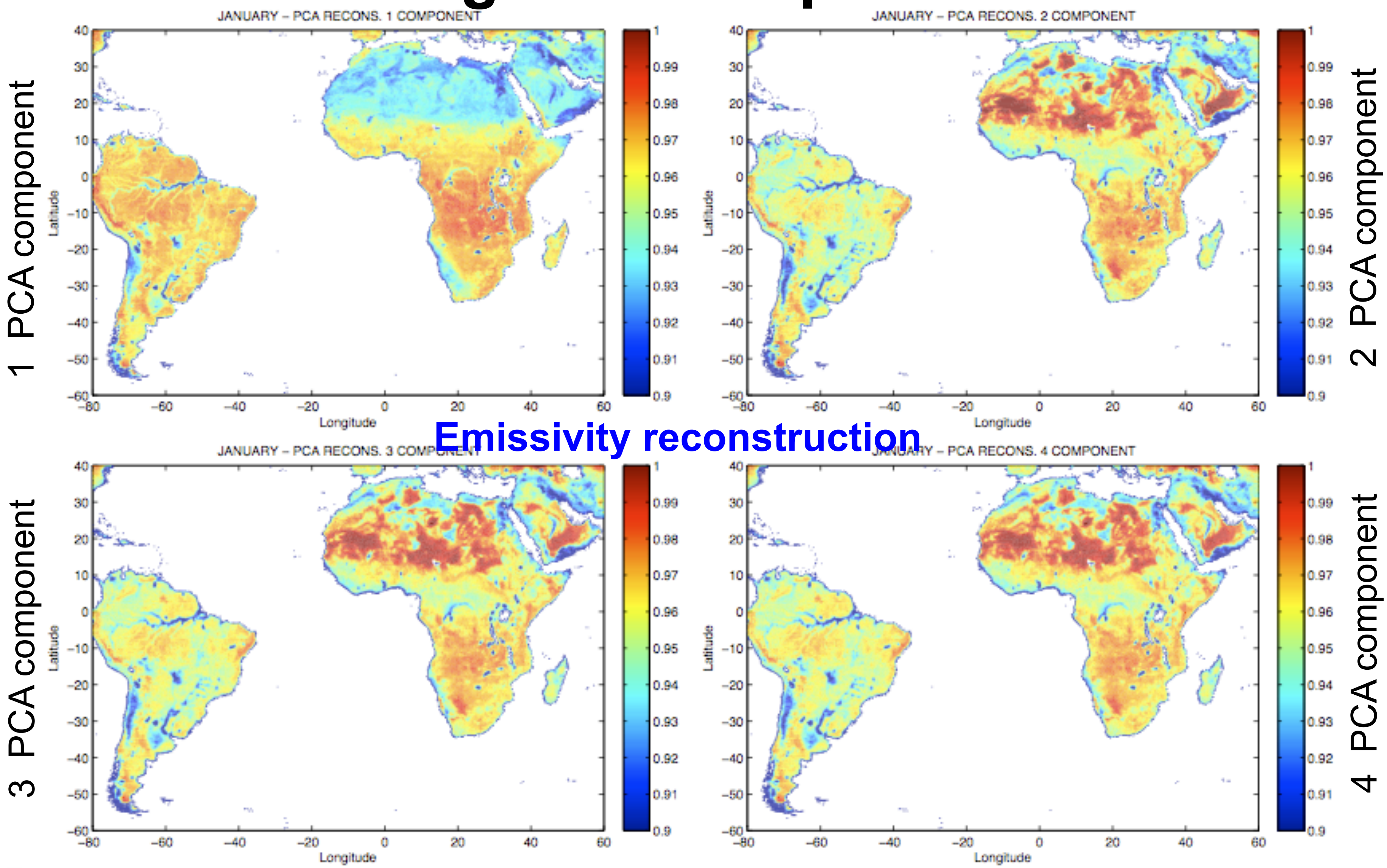



- Traditional k-means clustering
- Number $N_{10}$ of classes: to be defined by algorithm team, depends on size of the global dataset
- Use of emis + covariances

sub-class 1
sub-class 2
.
.
.
sub-class $N_{10}$

Remark: even if no surface binning is used in the S2 retrieval, it would be good to use at least the 10 first self-similar classes in order to reduce significantly time computation.

# Task 3: Efficient distance for emissivities using PCA compression




➔ **Mahalanobis distance when using 1, 2, 3, 4 components**

# Conclusion and perspectives

**Conclusion:**

- Task 1: Emissivity datasets
- Task 2: Self-similar classes
- Task 3: Emissivity distance for the Bayesian approach

**Perspectives**

- S2 retrieval: Intercomparison of model/retrieved emissivities, at the global scale, in order to better understand and improve LSM
- Emissivity FG for wet conditions

# “Dry” and “wet” emissivity atlas

The actual atlas has been developed on clear sky scenes. It includes dry and wet scenes (this variability is included in the covariance matrices).

In order to better characterize the state of the surface (lower emissivity uncertainties), we propose to construct a “dry” and “wet” atlas:

- Introduce emissivity estimates for cloudy cases (Aires et al. 2001)
- Analyze the time evolution of the emissivities after a precipitation event using CEOP network *in situ* data (2001-2004) and US radar network NEXRAD. (see Joe Turk poster)
- Based on this analysis, built a climatology and atlas for dry and wet surface conditions
- Adapt the TELSEM tool to this atlas