A Tool to Estimate Land Surface Emissivities at Microwave frequencies (TELSEM) between 19 and 100 GHz, for use in numerical weather prediction.

Filipe Aires(1), Catherine Prigent(2), Elodie Jaumouillé(2), Frédéric Bernardo(1), Carlos Jimenez(2), Frédérique Chevallier(3), Roger Saunders(4), Pascal Brunel(5)

(1) LMD, Université Paris VI,
(2) Observatoire de Paris,
(3) LSCE, CEA
(4) MetOffice, UK,
(5) Meteo-France, Lannion

THE PROBLEM:

How to estimate accurate global land surface microwave emissivities between 10 and 100 GHz, for all frequencies, angles, polarizations ?

- to be used as first guess for cloud clearing procedure and assimilation of close-to-the-surface sounding channels
- to be used as first guess in Ts retrievals
- for surface background estimate in precipitation and cloud retrievals
- to simulate the responses of future instruments
- ...

Models:

- difficulty to simulate the complex interaction between the radiation and the surface regardless of the surface type (bare soil, vegetation, snow...)
- require a large number of input parameters that are not always available with accuracy on a global basis

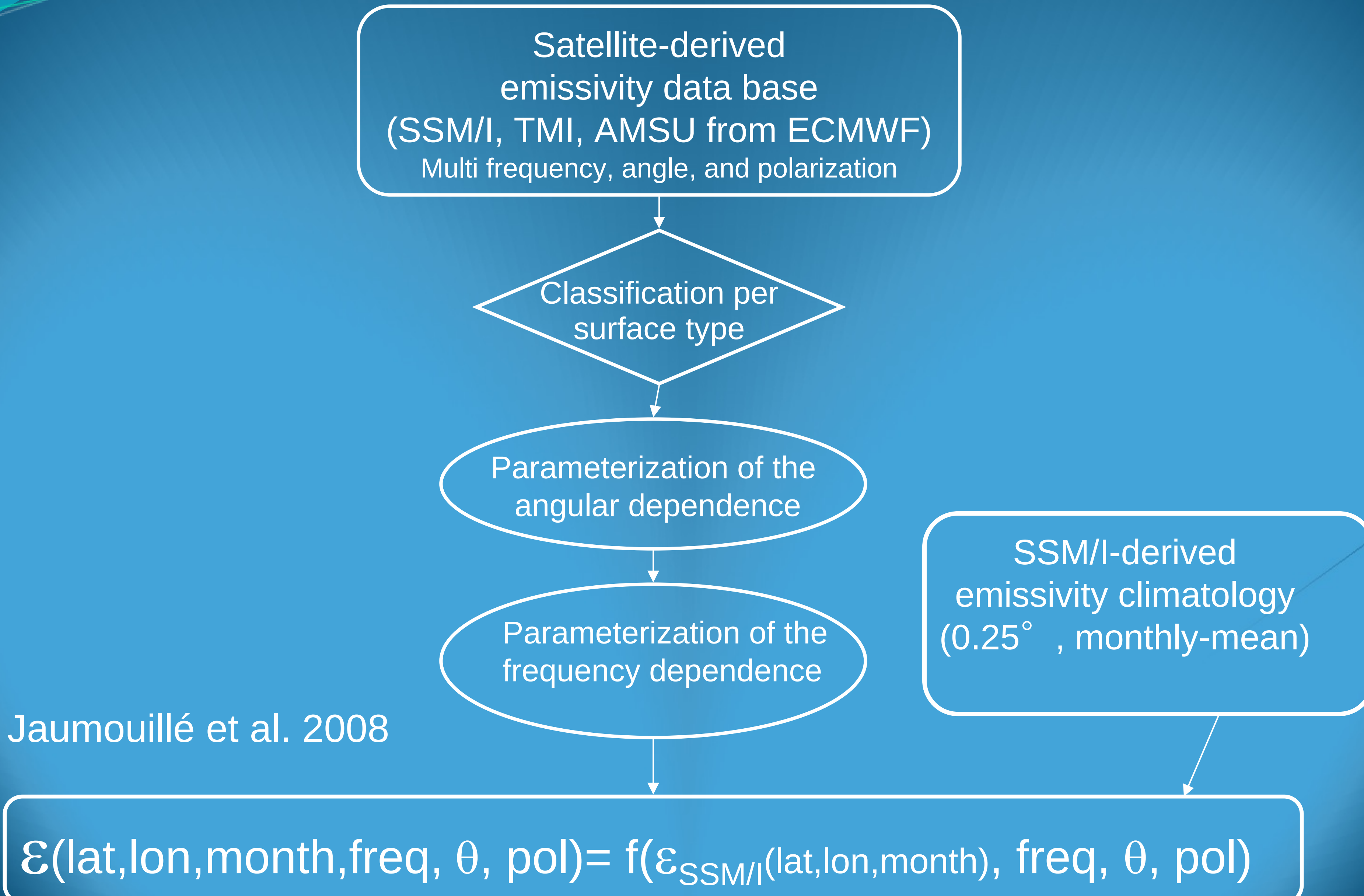
Satellite estimates: (Prigent et al. 1997) algorithm

- limited in observing conditions (frequency, incidence angle, polarization)
- require **reliable estimates of Ts** and **good cloud filtering**
- some instrument estimates have better accuracy, or want to keep independence for assimilations

A SOLUTION:

To derive a parameterization of the emissivity frequency, angular, and polarization dependence anchored on a reliable satellite-derived emissivity data base

THE METHOD (1/4)



Jaumouillé et al. 2008

THE METHOD (2/4)

Emissivity calculation for different frequencies, angles, polarizations

Emissivities directly estimated from satellite observations under clear sky conditions and averaged over the month:

SSM/I: 19.35, 22.235, 37.0, 85.5 GHz at 53° for V and H pol. (22V only)
TMI: 10.65, 19.35, 21.3, 37.0, 85.5 GHz at 49° for V and H pol. (21V only)
AMSU-A: 23.8, 31.4, 50.3, 89.0 GHz from 0 to 55°, for a mixture of V and H pol.

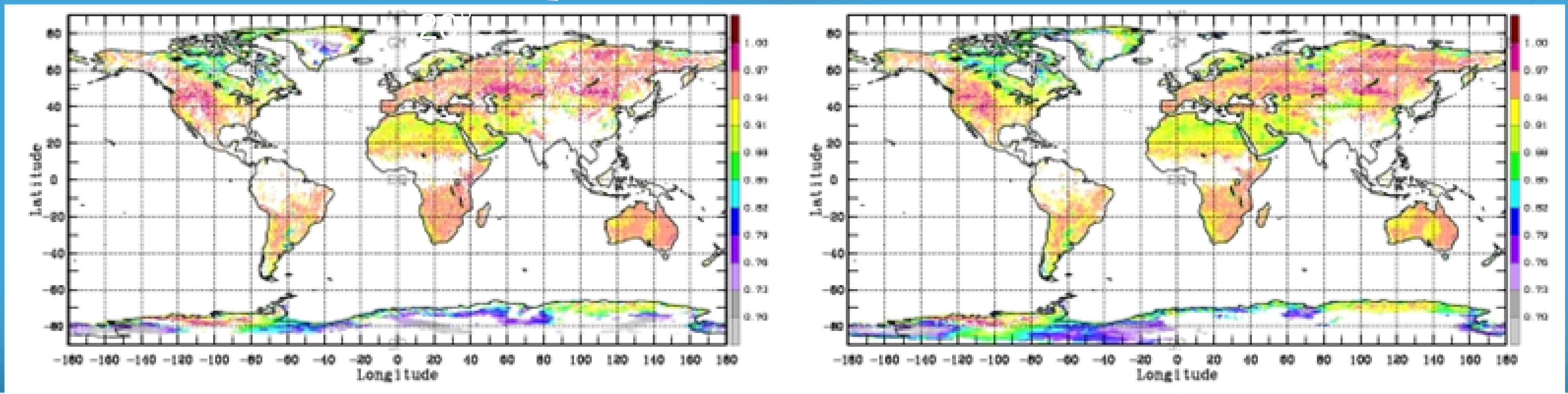
Calculations performed at ECWMF (by F. Chevallier) with the methodology previously described:

- RTTOVS radiative transfer model
- atmospheric profiles, clear sky screening, and Tsurf from the ECMWF forecast

For comparison purposes, emissivities also estimated from model

- Weng et al. (2001) radiative transfert model
- ECMWF forecast inputs

10° - 20° AMSU-A 31.4 GHz 40° -50°



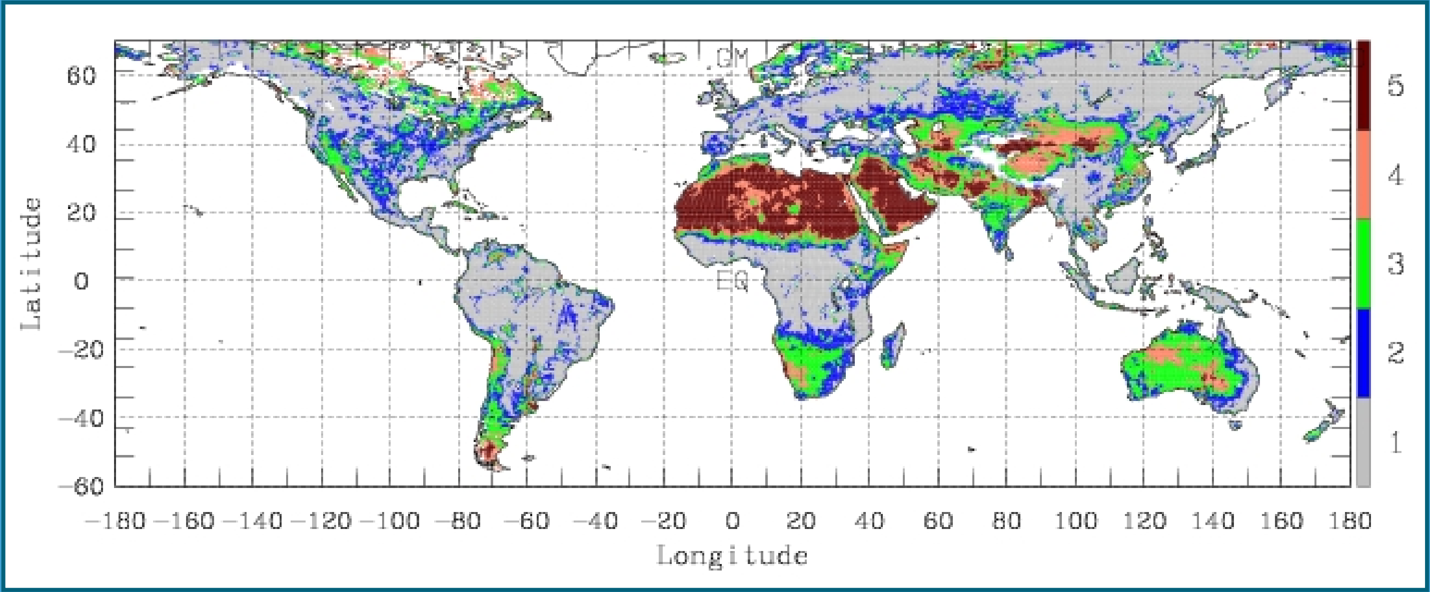
THE METHOD (3 / 4)

Classification of the emissivity estimates

- Data set separated in different surface types, using a clustering method applied to the SSM/I emissivity estimates.

- Five classes are isolated, from vegetated regions (class 1) to desert surfaces (class 5).

Classification for July 1992



THE METHOD (4/4)

How the algorithm works:

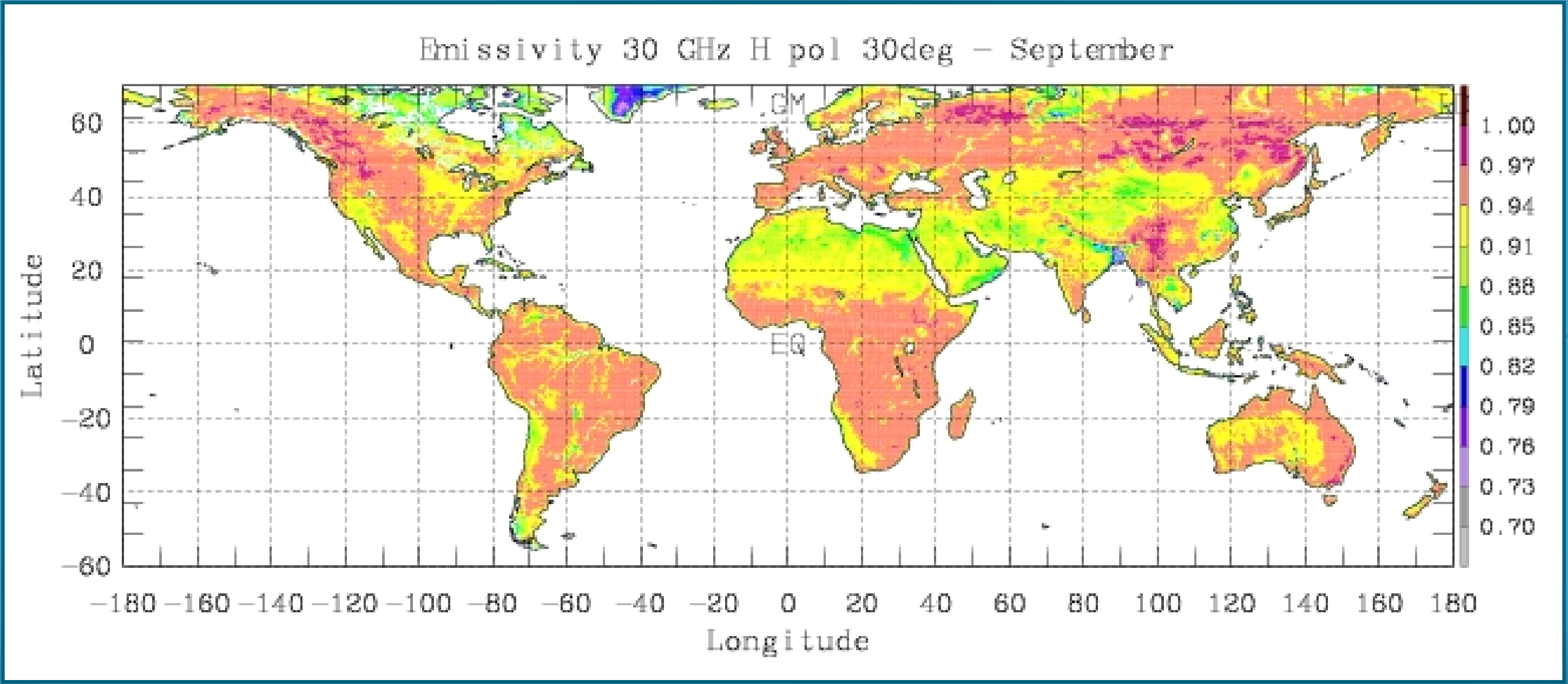
1) Selection by the user of
   - a location on the Earth (lat, lon)
   - a month
   - a frequency, incidence angle, polarization

2) Search for the SSM/I emissivities in the climatological data base for that location and month.

3) Apply the frequency and angular parameterization to derive the emissivity for the observing conditions selected by the user (frequency, angle, and polarization).

THE RESULTS (1 / 5)

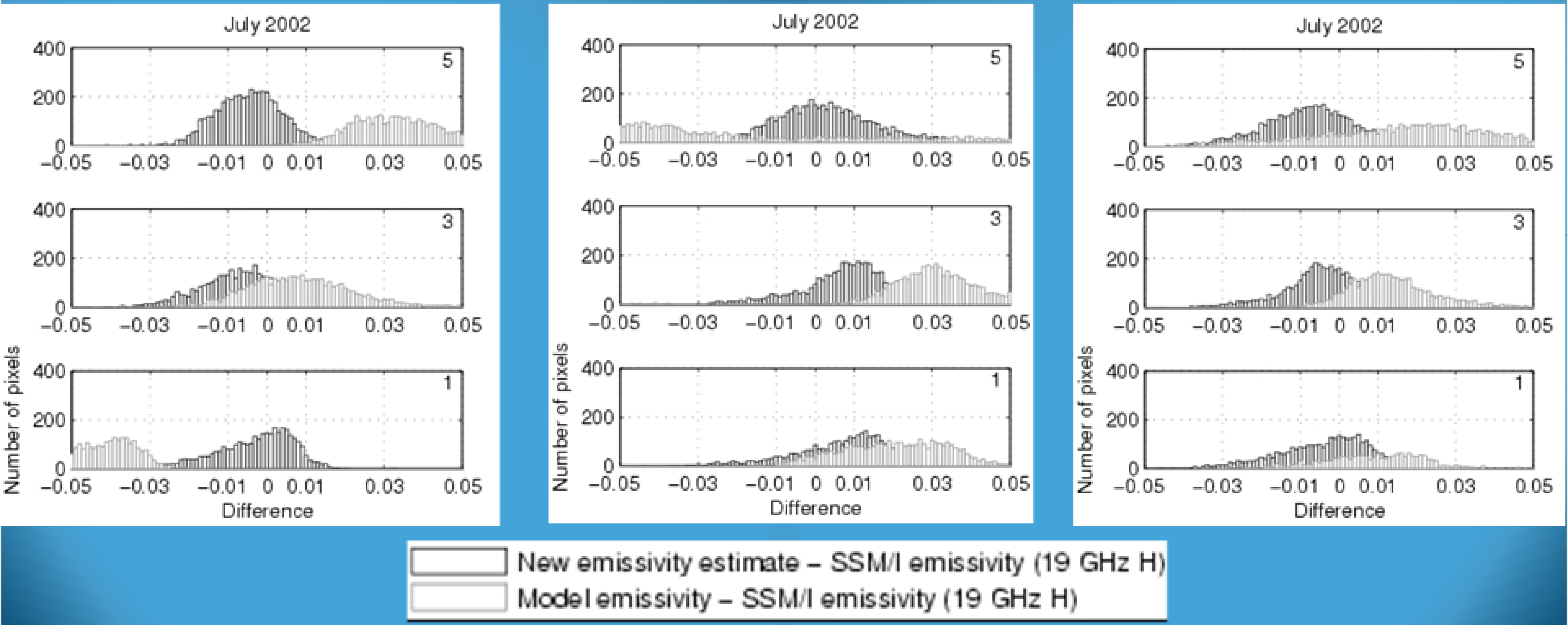
Global map of the estimated emissivity at 30 GHz, 30° incidence and horizontal polarization in September



THE RESULTS (2 / 5)

Histograms of the errors

SSM/I 19GHz H (53°) | AMSU 31.4GHz (5°) | SSM/I 85GHz V (53°)

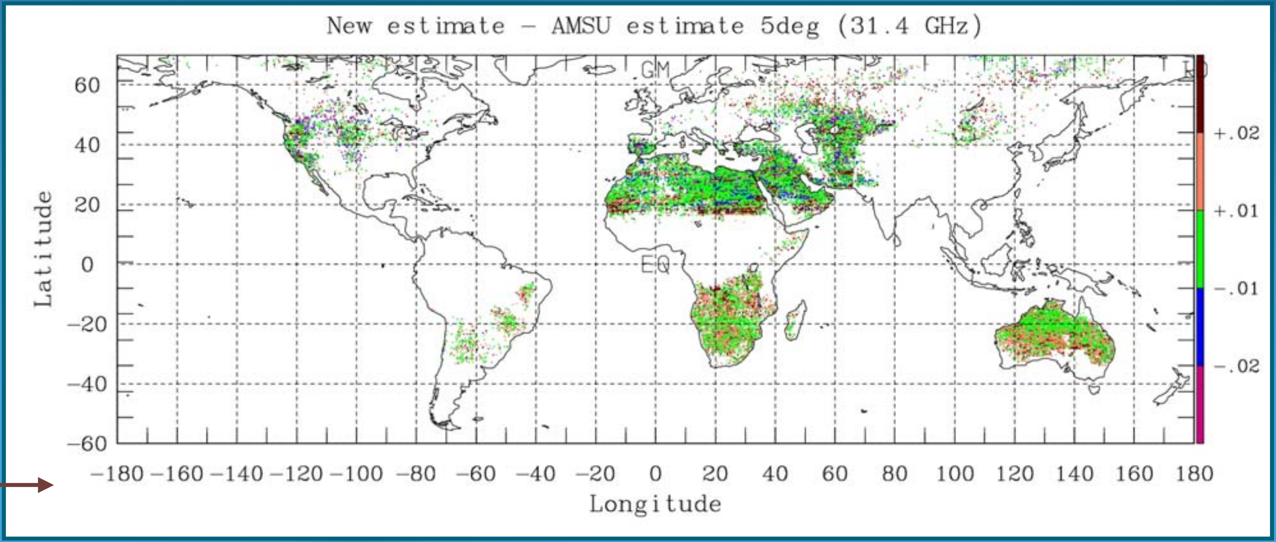


THE RESULTS (3 / 5)

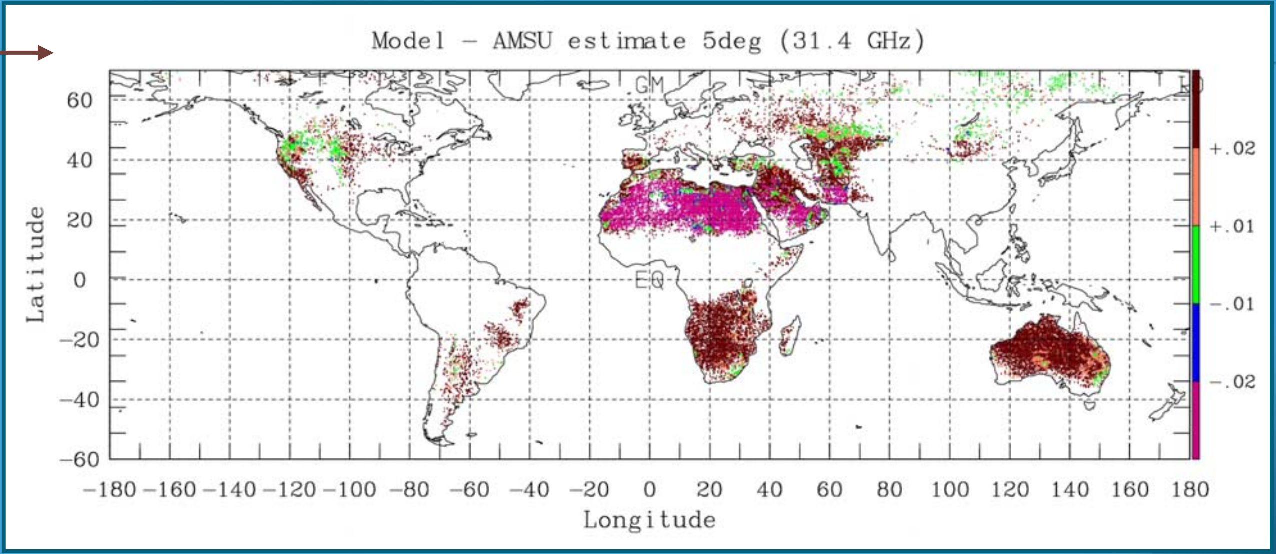
Map of the errors

Example at 31.4 GHz at 5° incidence angle

New estimate - AMSU derived estimate



Model - AMSU derived estimate



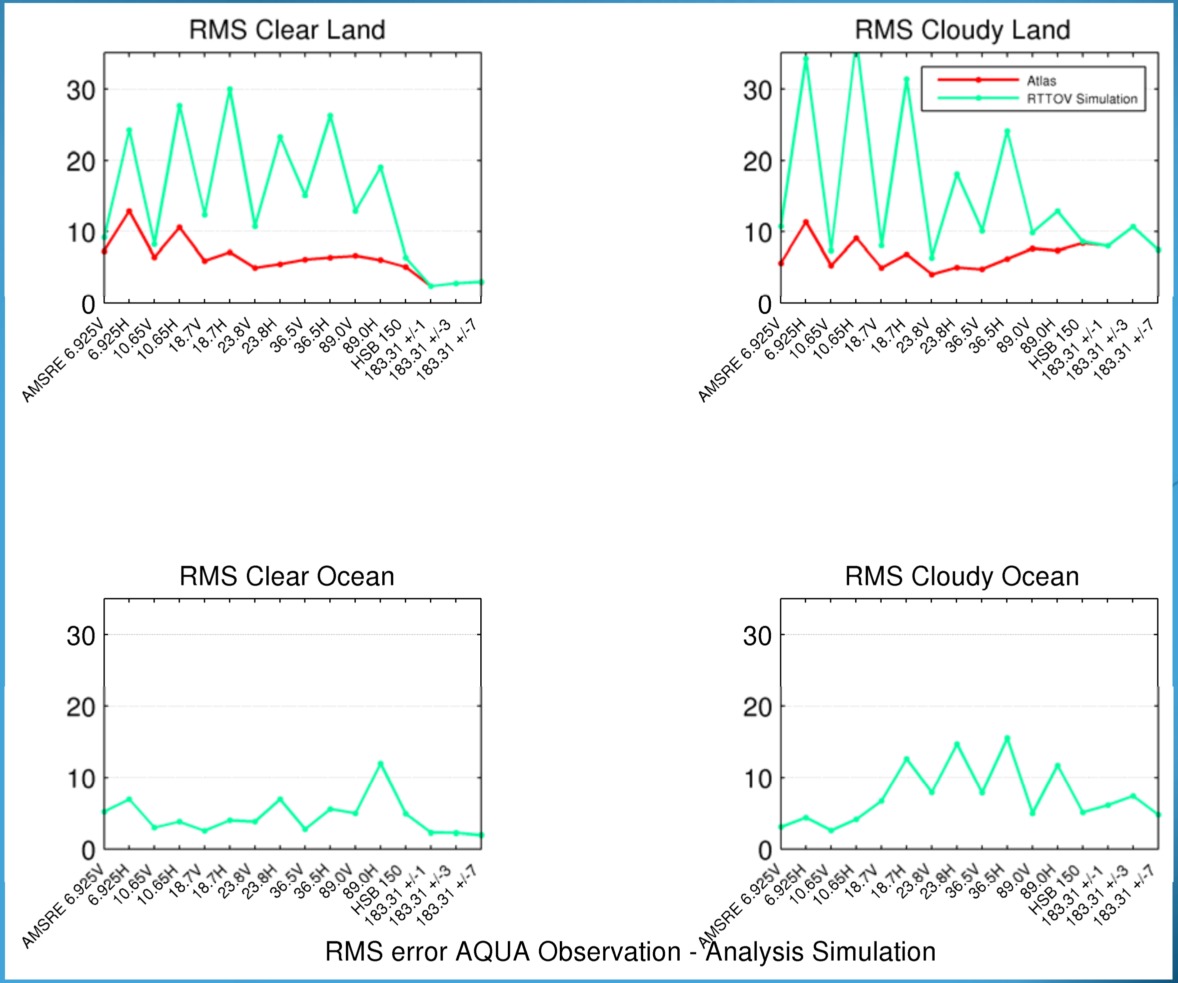
- Quality of the input parameters in the model?
- Ability of the model to represent the complexity of the radiation / surface interaction

THE RESULTS (4 / 5)

Coincidence between:

- **BT simulations:**
  - **ECMWF analysis**
  - **& RTTOV simulations**
- **BT observations**
  - **Aqua (AMSR-E & HSB)**

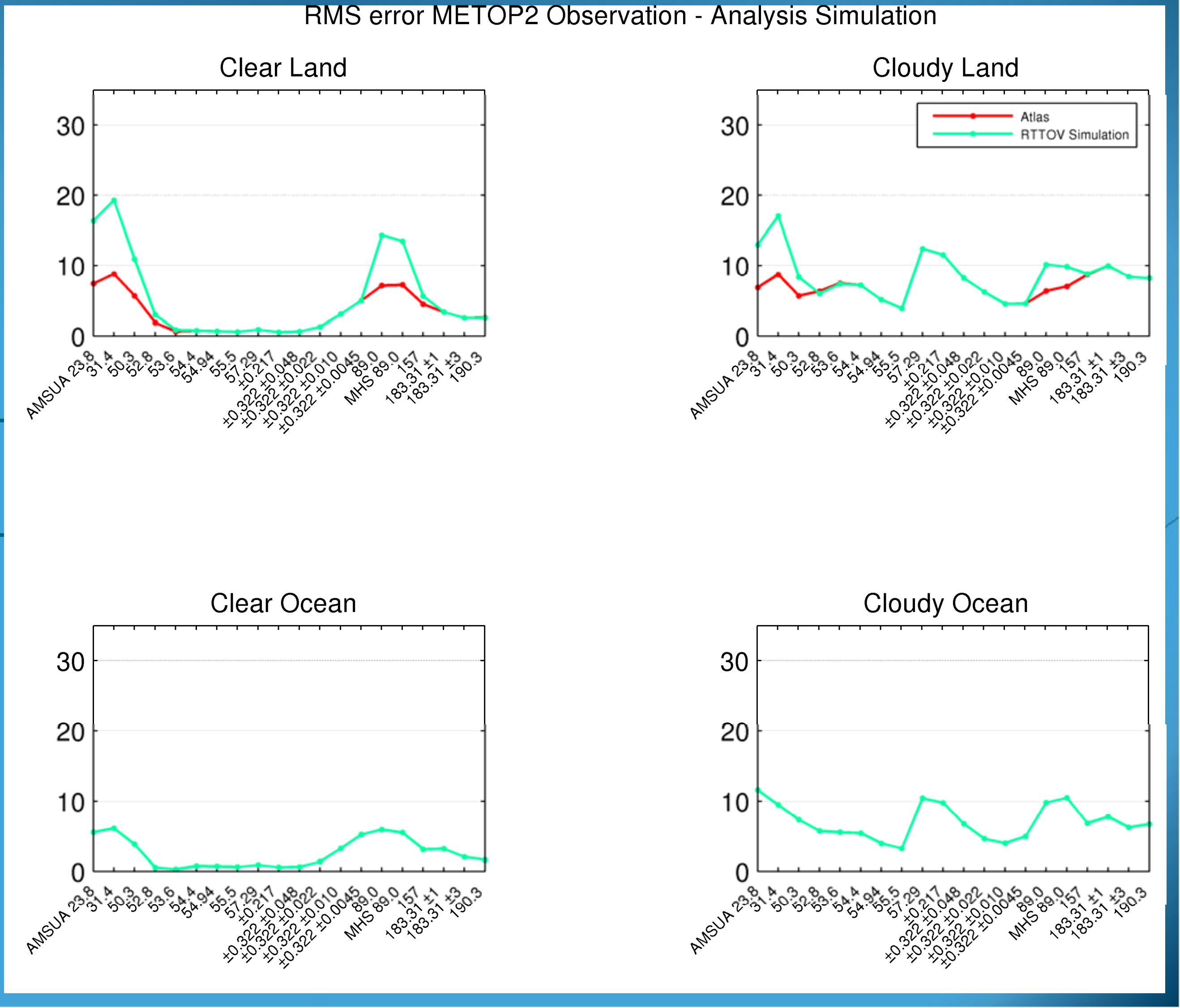
➔RMS errors with and without the emissivities



THE RESULTS (5 / 5)

Similar experiment

with BT observations from METOP:
AMSU-A & MHS



RTTOV IMPLEMENTATION

The interpolator tool can work on any horizontal resolution

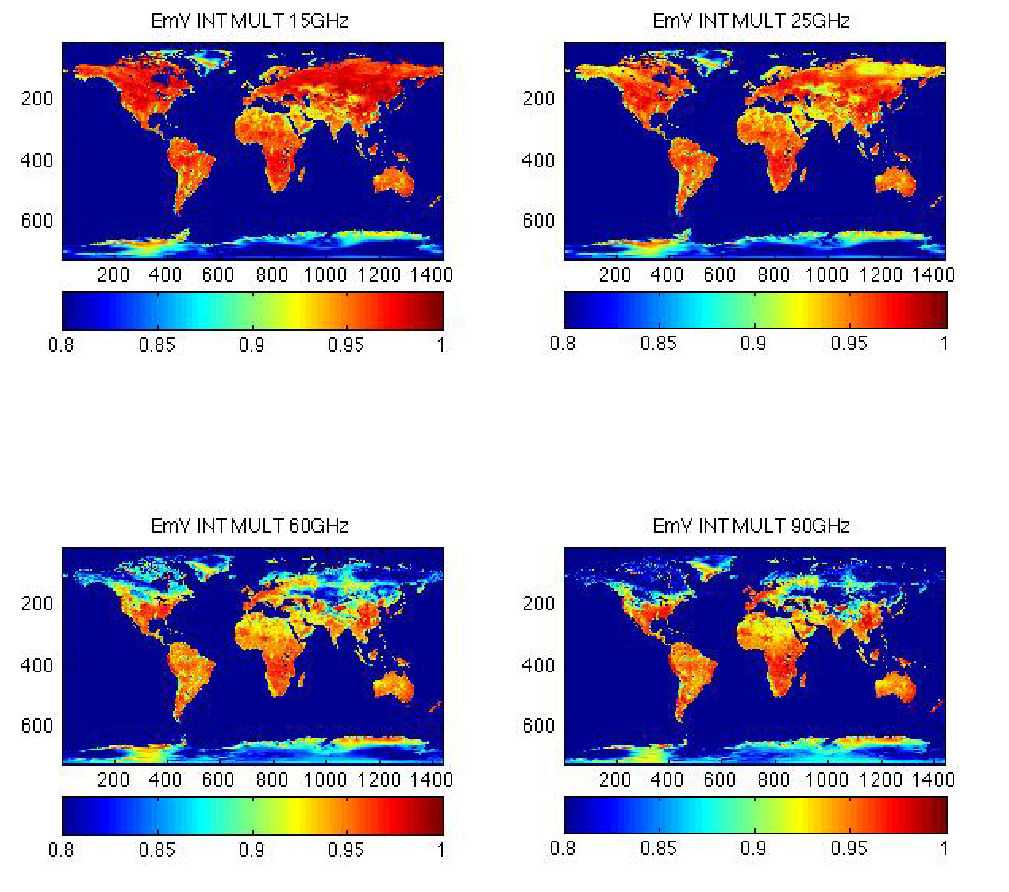
Nominal resolution of 0.25 equal-area and monthly

Provide Covariance matrix of the uncertainties

In Fortran 90

Different practical configur.

Available upon request



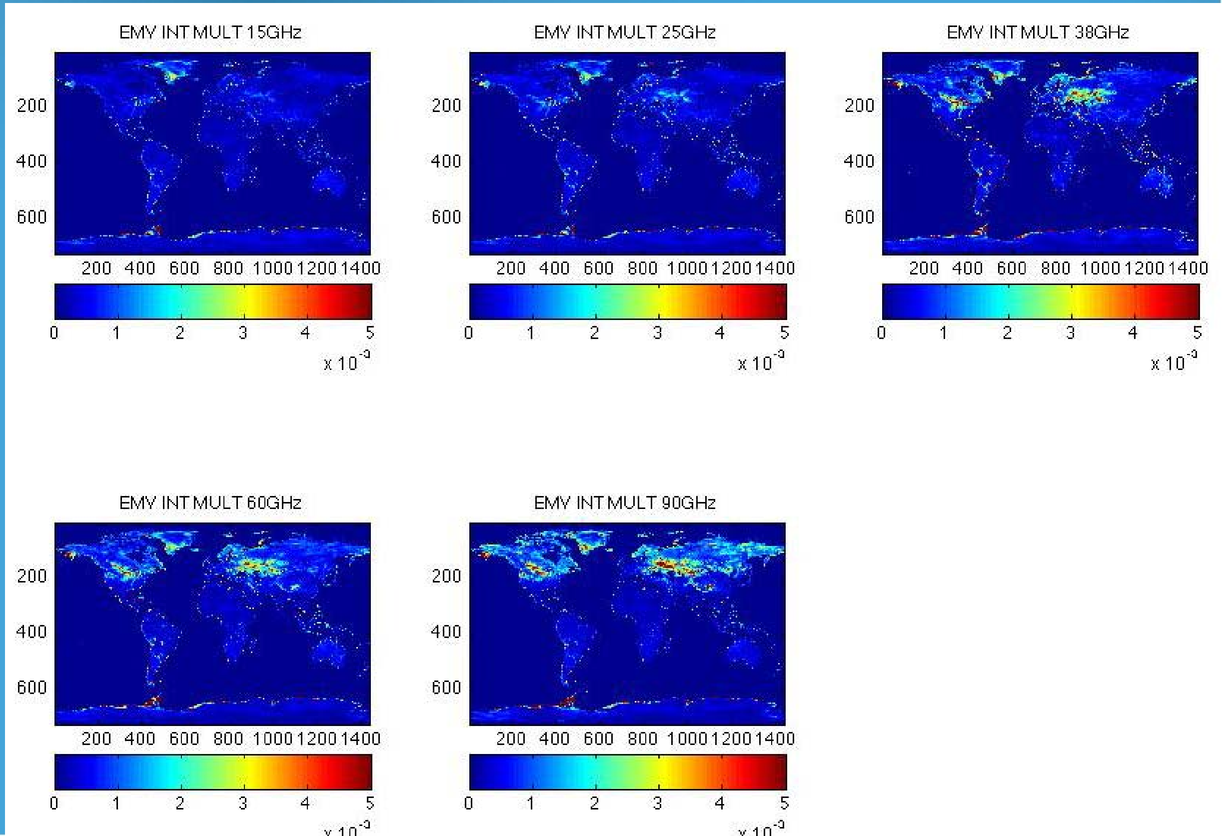
RTTOV IMPLEMENTATION: UNCERTAINTIES

Original SSM/I atlas possess 7×7 covariance matrix of uncertainties = C
➔ each location, 0.25° ×0.25° , monthly

From statistics: identical correlations structure inside each of 10 surface classes, but different standard deviations.

Each emissivity input is a linear combination of the SSM/I emissivities so uncertainty on new estimates is $N(0, F^t \bullet C \bullet F)$

Important for assimilation purpose

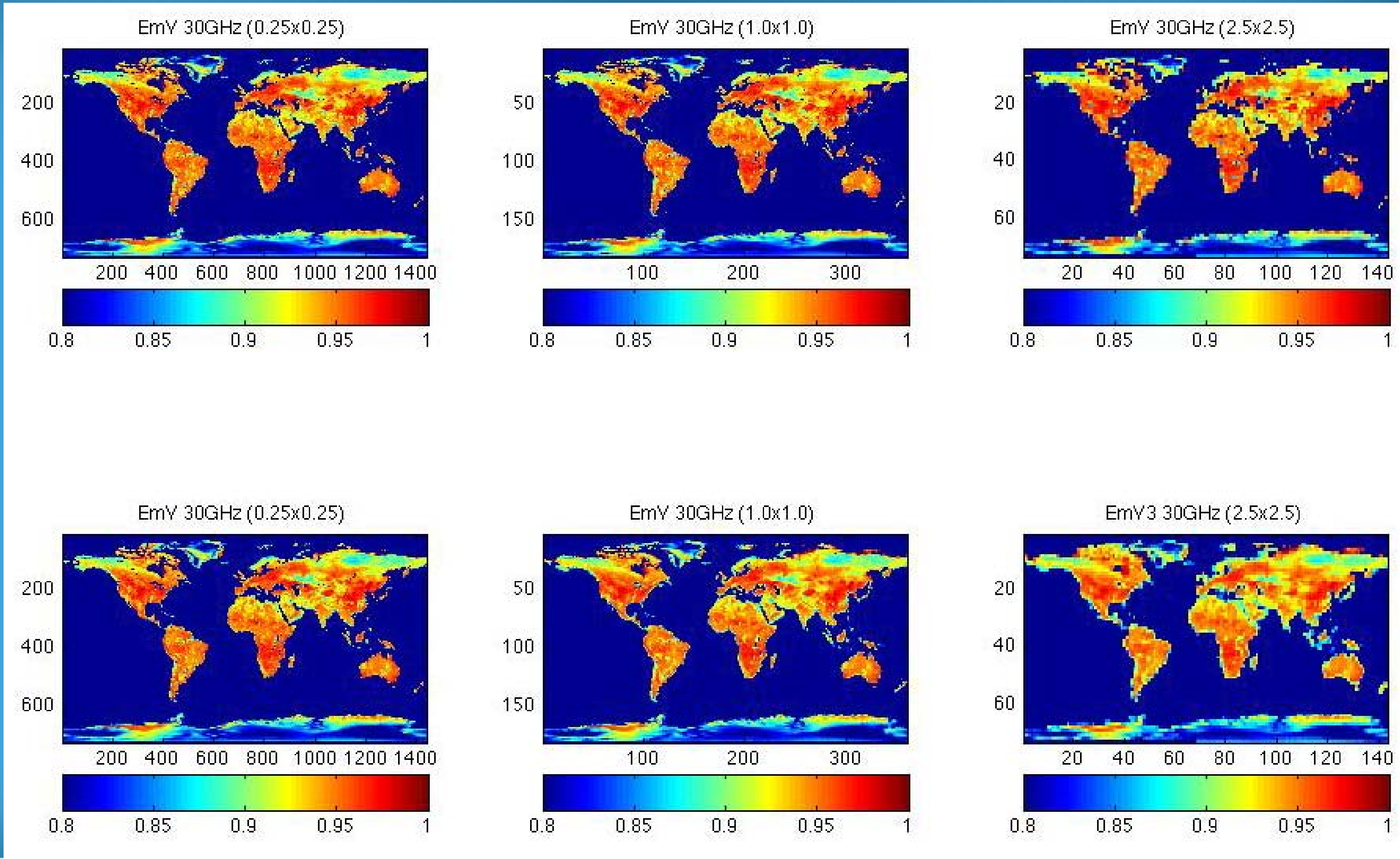


RTTOV IMPLEMENTATION: HORIZONTAL RESOLUTION

The interpolator tool can be used at any horizontal resolution

Unique original pixel

Multiple original pixel



CONCLUSION

A method developed to estimate global microwave emissivities in the 19-90 GHz range (potentially higher frequency), for all incidence angles and both orthogonal polarizations. It is anchored to a monthly-mean emissivity climatology derived from SSM/I observations over a decade.

- to be used as first guess for cloud clearing procedure and assimilation of close-to-the-surface sounding channels
- to be used as first guess in emis/Ts retrievals
- for surface background estimate in precipitation and cloud retrievals
- to simulate the responses of future instruments

Comparisons performed with model outputs, and RT simulations compared to real satellite observations.

Impact on RT simulations for AQUA (AMSRE/HSB) and METOP (ASMUA/MHS) show strong positive impact: recommend the use of emis atlas and Ts a priori FGs and then simultaneous retrieval or assimilation.

RTTOV implementation (Fortran90+Atlas) available upon request