Toward a better modeling of surface emissivity to improve AMSU data assimilation over Antarctica

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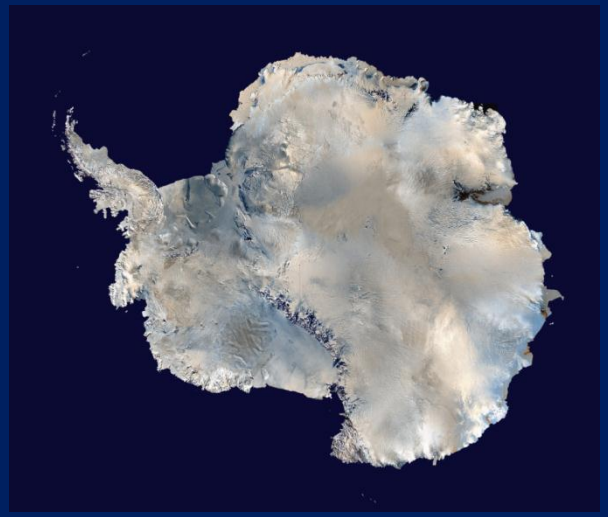


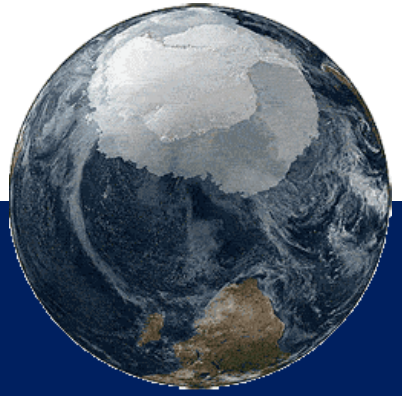
International TOVS Study Conference, Monterey, California (14-20 April 2010)

METEO FRANCE
Toujours un temps d'avance

cnrs
dépasser les frontières

1. Introduction

METEO FRANCE
Toujours un temps d'avance



- CONCORDIASI project :

  - To improve our understanding of the ozone depletion over Antarctica
  - To study potential interaction with lower latitudes
  - **To get more accurate NWP analyses and forecasts**

- Satellite data assimilation in NWP in polar region (Polar orbiting)

  - Choice of microwave instruments (AMSU-A & AMSU-B)
  - main features : cross-track scanning
  - Measurements in 20 frequencies:

    Humidity & Temperature profiles + **surface**

=> Surface emissivity can be retrieved from satellite observations

2. Emissivity of Antarctica

Land surface emissivity calculation

- Land surface emissivity is usually retrieved from satellite observations assuming the surface to be **flat and specular** (Prigent et al., 1997 among other)

- Mätzler (2005) has found questionable the use of this assumption for nadir viewing angles for some specific surface types

- Karbou and Prigent (2005) have shown that the specular assumption can be used for **snow-free areas**

- But can we use the specular assumption to retrieve AMSU emissivities over Antarctica ?

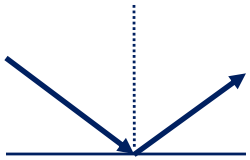
- To evaluate the effect of surface assumption on emissivity : different assumptions have been tested from **specular to lambertian**.

2. Emissivity of Antarctica

Land surface emissivity calculation

SPECULAR ASSUMPTION

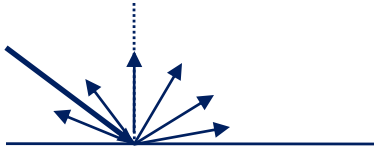
$\theta_{incident} = \theta_{reflected}$



Flat surface

LAMBERTIAN ASSUMPTION

$\theta_{incident} \neq \theta_{reflected}$



Rough surface

$\theta_{effective}$: Average angle replacing the integration over all directions

(Mätzler, 1987 and Ingold et al., 1998)

Mätzler (2005) : suggest to use a specularity parameter to describe natural surface

=> Intermediaries assumptions

2. Emissivity of Antarctica

Land surface emissivity calculation

5 approximations to retrieve emissivity at AMSU-A frequencies :

	Specularity Parameter
- SPECULAR	1
- LAMBERTIAN	0
- SEMI-LAMBERTIAN	0.5
- QUASI-LAMBERTIAN	0.25
- QUASI-SPECULAR	0.75

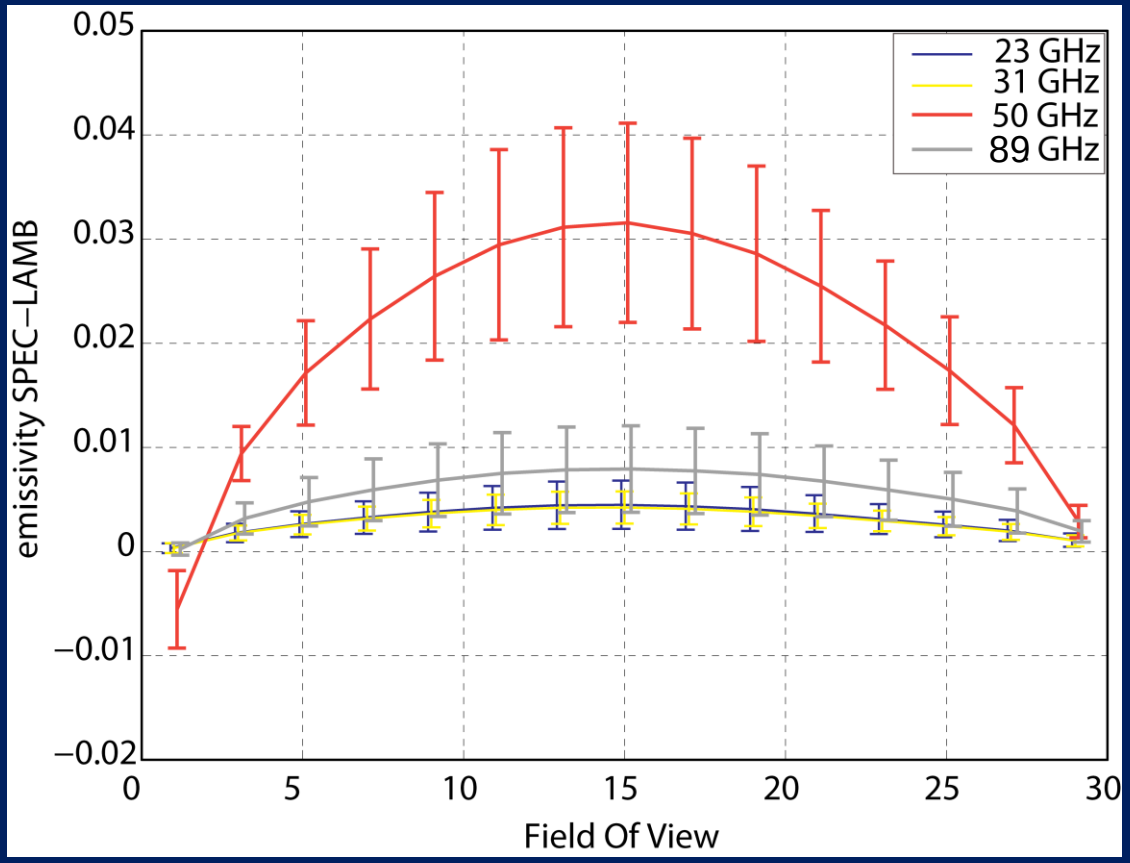
→ PERIOD : 5 approximations x 1 year

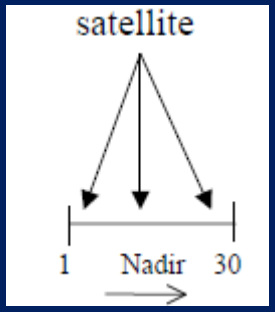
+ Comparison with the OPER2007 version : Empirical emissivity models (Weng et al., 2001 and Grody, 1988)

2. Emissivity of Antarctica

Analysis of land surface emissivity

Monthly mean "ε_{SPEC} minus ε_{LAMB}" as a function of field of view positions over Antarctica for AMSU-A observations. (January 2007)



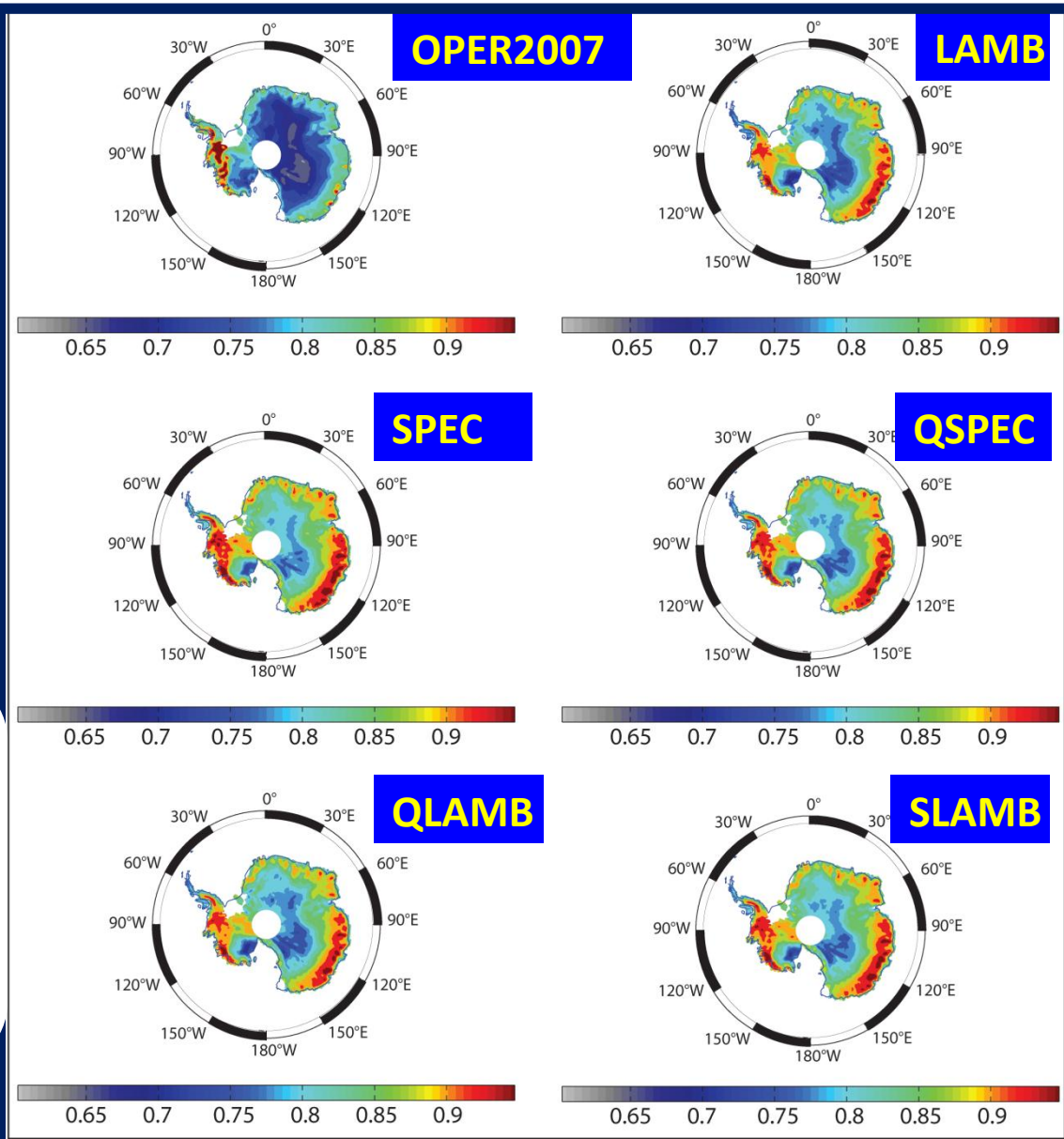


- surface approximation effects are limited for channel 1,2 and 15
- Effects are larger for channel 3 especially for nadir viewing angles (3%)

2. Emissivity of Antarctica

Analysis of land surface emissivity

Monthly mean emissivity maps for AMSU-A channel 3 (50 GHz) over Antarctica, for January 2007



- **Emissivity is low in the centre and increases towards the coastline**
- **Emissivity values:**
  OPER2007 < others
- **Some differences between approximations but …**

2. Emissivity of Antarctica

Analysis of land surface emissivity

- Surface approximation effects are larger for AMSU-A Channel 3
- Some differences between approximations but which one is the more realistic ?

Problem : No independant observation is available to select the best approximation

$\Rightarrow$ One Solution : Simulation of sounding brightness temperature using emissivity of channel 3 (50 GHz) as input.

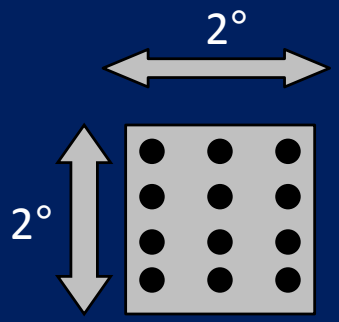
And comparison with observations

3. Evaluation of land surface emissivity

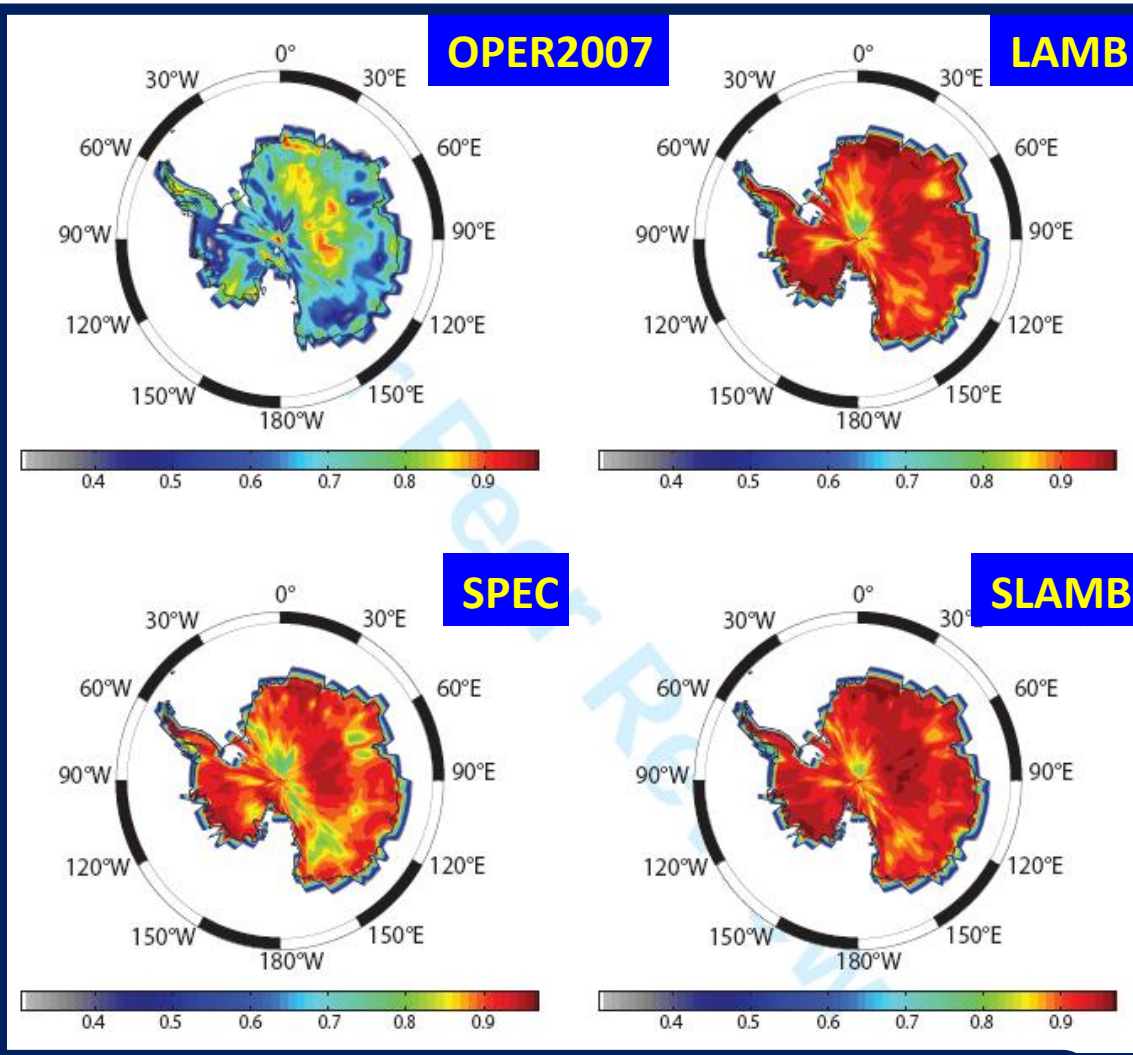
Correlations between Tb_{obs} and Tb_{sim}

Maps of correlations between Tb_{obs} and Tb_{sim} of AMSU-A channel 4 (August 2007)

=> calculation of correlations in grid cell:



Note : Channel 4 and 5 are located near the oxygen absorption band
⇒ Temperature profiles

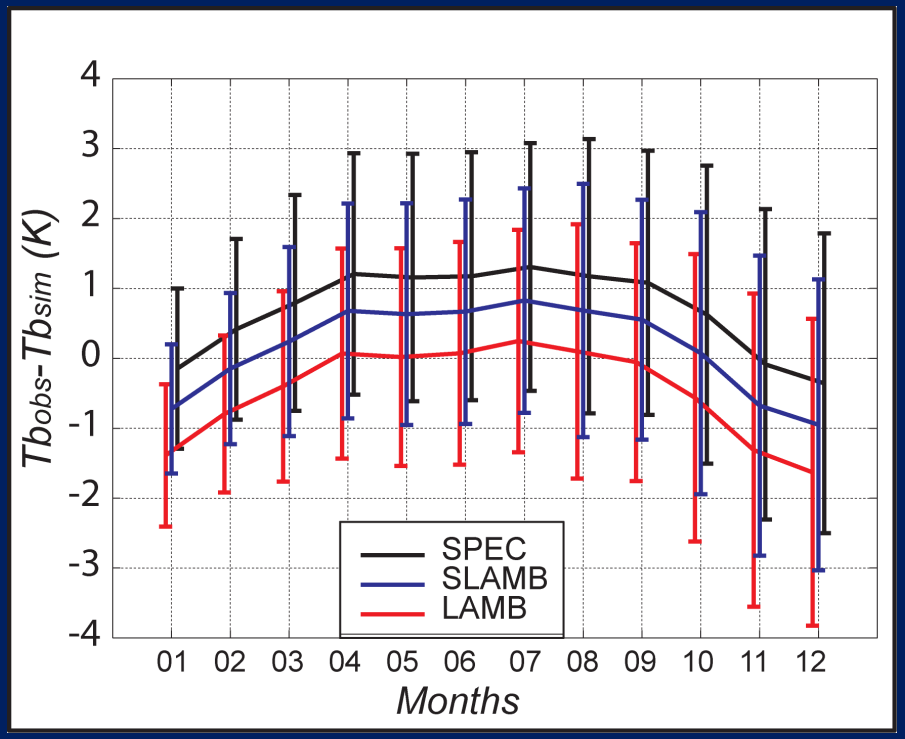


Correlations between observed and simulated Tbs have been improved by comparison to OPER2007 especially by LAMB and SLAMB in August …

3. Evaluation of land surface emissivity

Seasonnal dependence

Mean Fg-Departures (Tb_{obs}-Tb_{sim}) of channel 4 (52 GHz) as a function of months over Antarctica.
Errorbars represent the STD

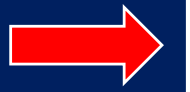


Fg-Departures (K)
(First-guess Departures)
=
Observations
-
Simulations

- **Important seasonnal dependance**
- **LAMB approximation would be more suitable during the winter period**
- **SLAMB or SPEC approximations could be used during summer**

4. Conclusion and future developments

- The aim of this work was to extend the use of AMSU data over Antarctica (from mid-atmosphere to surface)
- Snow surface emissivity has been calculated from 1 year of AMSU-A measurements using 5 approximations assuming the surface to be : specular (SPEC), lambertian (LAMB), and also using a specularity parameter (QLAMB, SLAMB and QSPEC)
- The LAMB approximation could be more suitable during winter and the SLAMB and SPEC approximation could be used during summer.
- SPEC, QSPEC, …. have been interfaced with RTTOV as options and can be activated in ARPEGE using logical keys as inputs : more tests are still needed before operational implementation of one of these methods (SPEC is already oper)



Guedj S., F. Karbou, F. Rabier and A. Bouchard, 2010, Toward a better modeling of surface emissivity to improve AMSU data assimilation over Antarctica, IEEE TGRS, 48, n°4, pp. 1976 - 1985

Thank YOU