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

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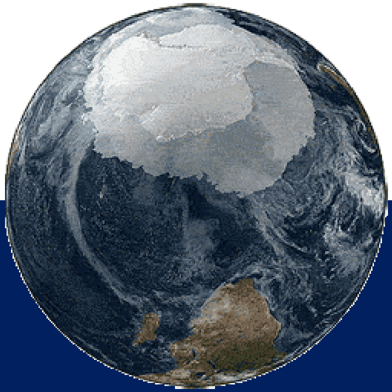
METEO FRANCE
Toujours un temps d'avance

cnrs
dépasser les frontières

1. Introduction



- 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 ?

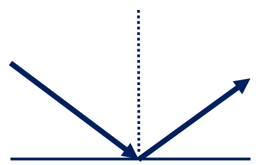
- To evaluate the effect of surface assumption on emissivity : different assumptions have been tested from **specular to lambertian**.

2. Emissivity of Antarctica

Land surface emissivity calculation

SPECULAR ASSUMPTION

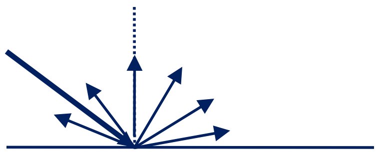
$\theta_{incident} = \theta_{reflected}$



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

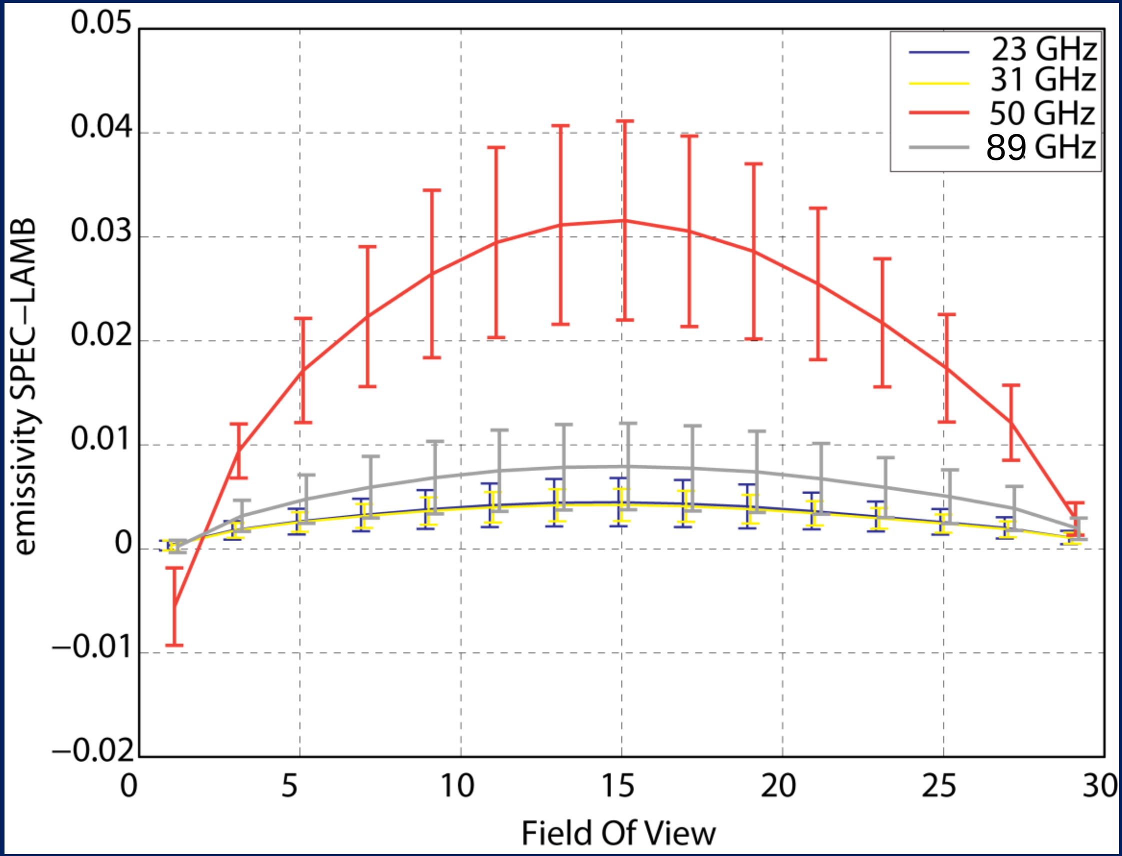
→ PERIOD : 5 approximations x 1 year

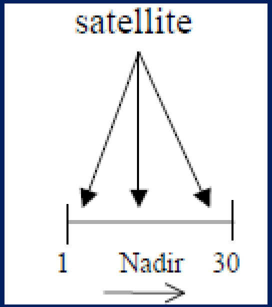
+ Comparison with the OPER2007 version : Empirical emissivity models (Weng et al., 2001 and Grody, 1988)

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)



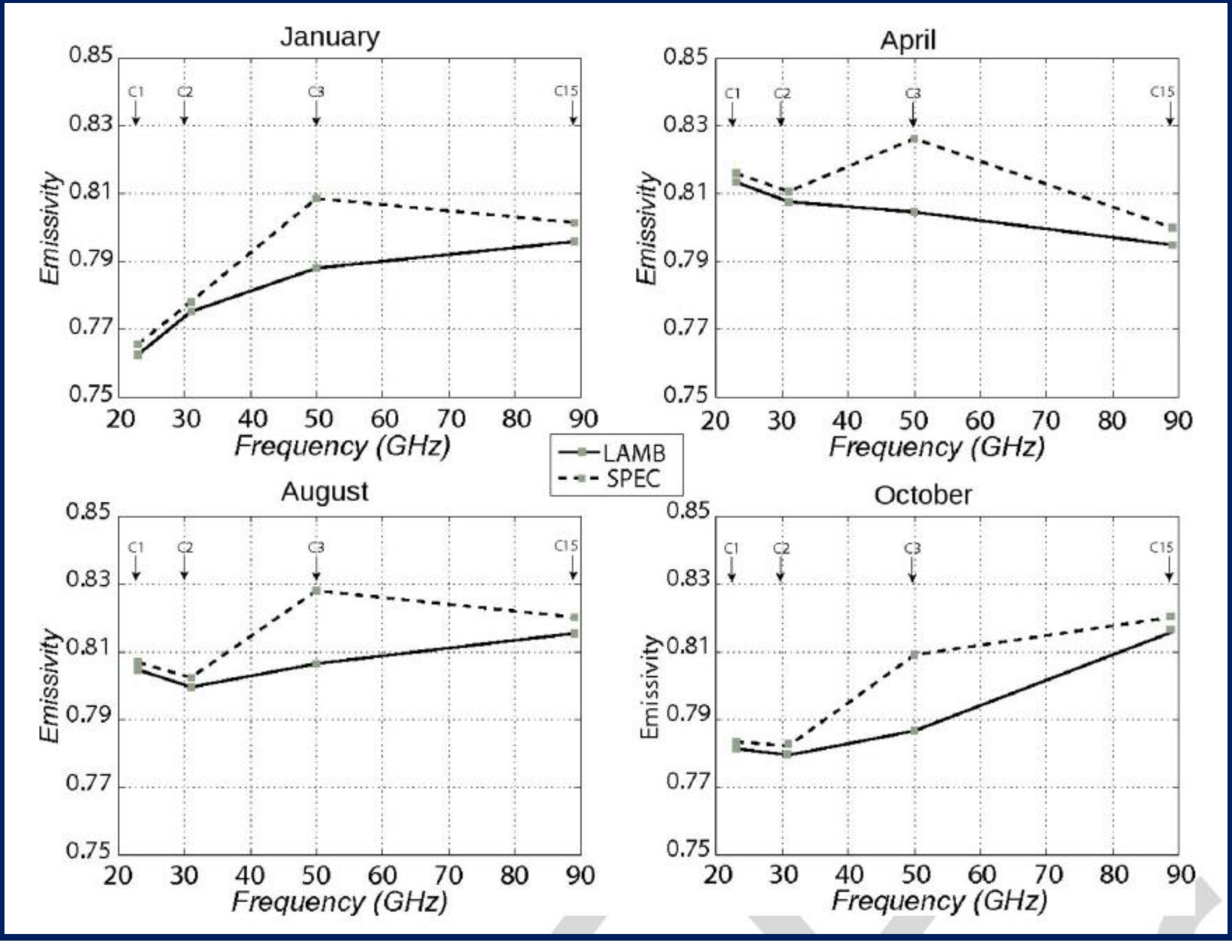


- **surface approximation effects are limited for channel 1,2 and 15**
- **Effects are larger for channel 3 especially for nadir viewing angles (3%)**

2. Emissivity of Antarctica

Analysis of land surface emissivity

Monthly mean ε_{SPEC} and ε_{LAMB} as a function of AMSU frequencies over Antarctica for 4 different months (2007)

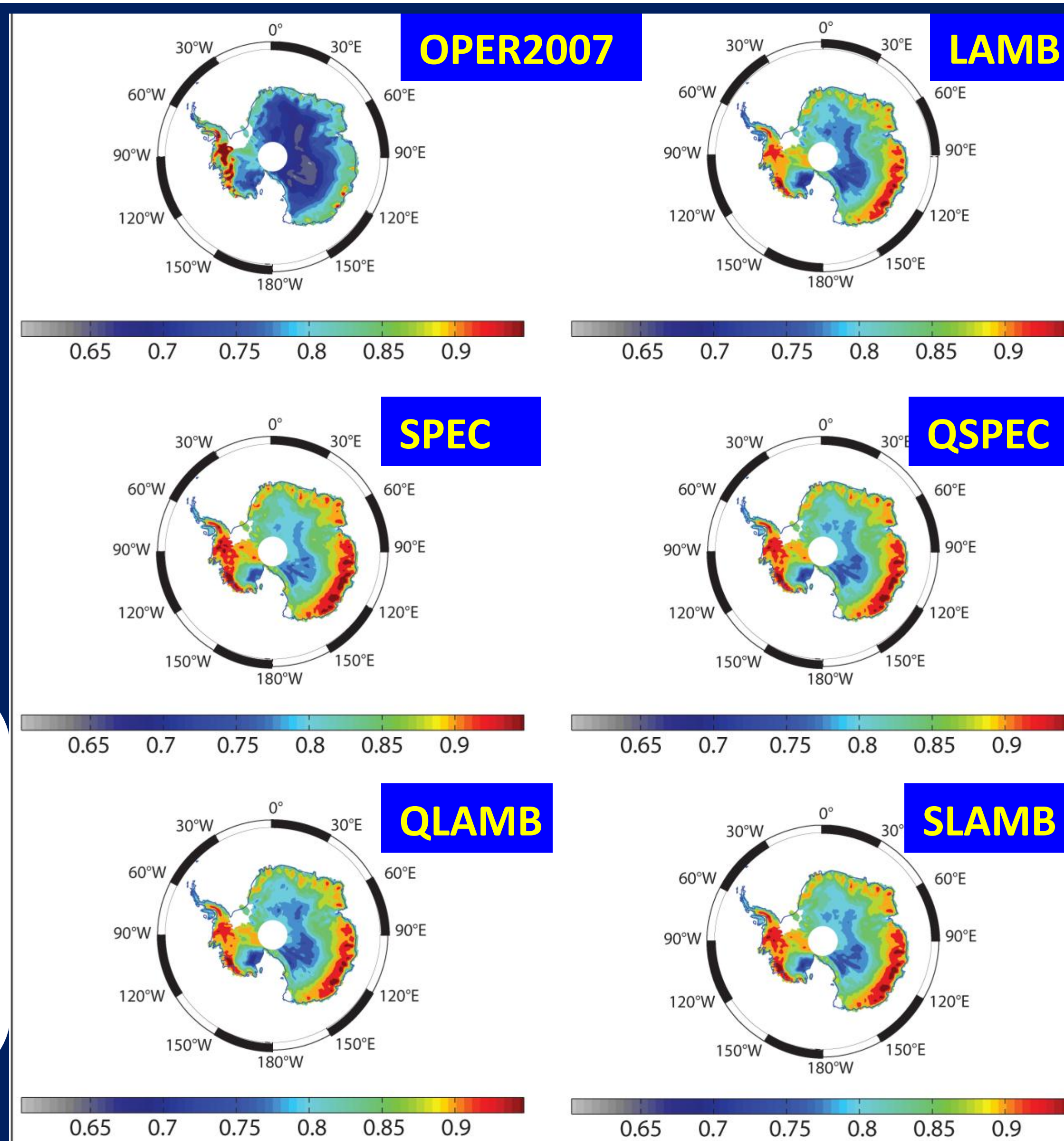


- **For all the selected months, ε_{LAMB} seems to vary smoothy with frequency.**
- **Jump in ε_{SPEC} at 50GHz probably due to unsuitable surface assumption**

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.

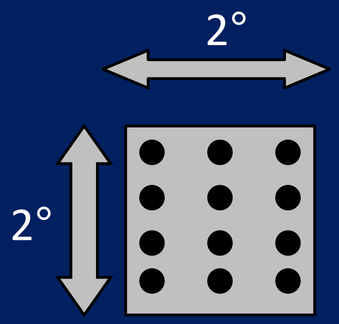
And comparison with observations

3. Evaluation of land surface emissivity

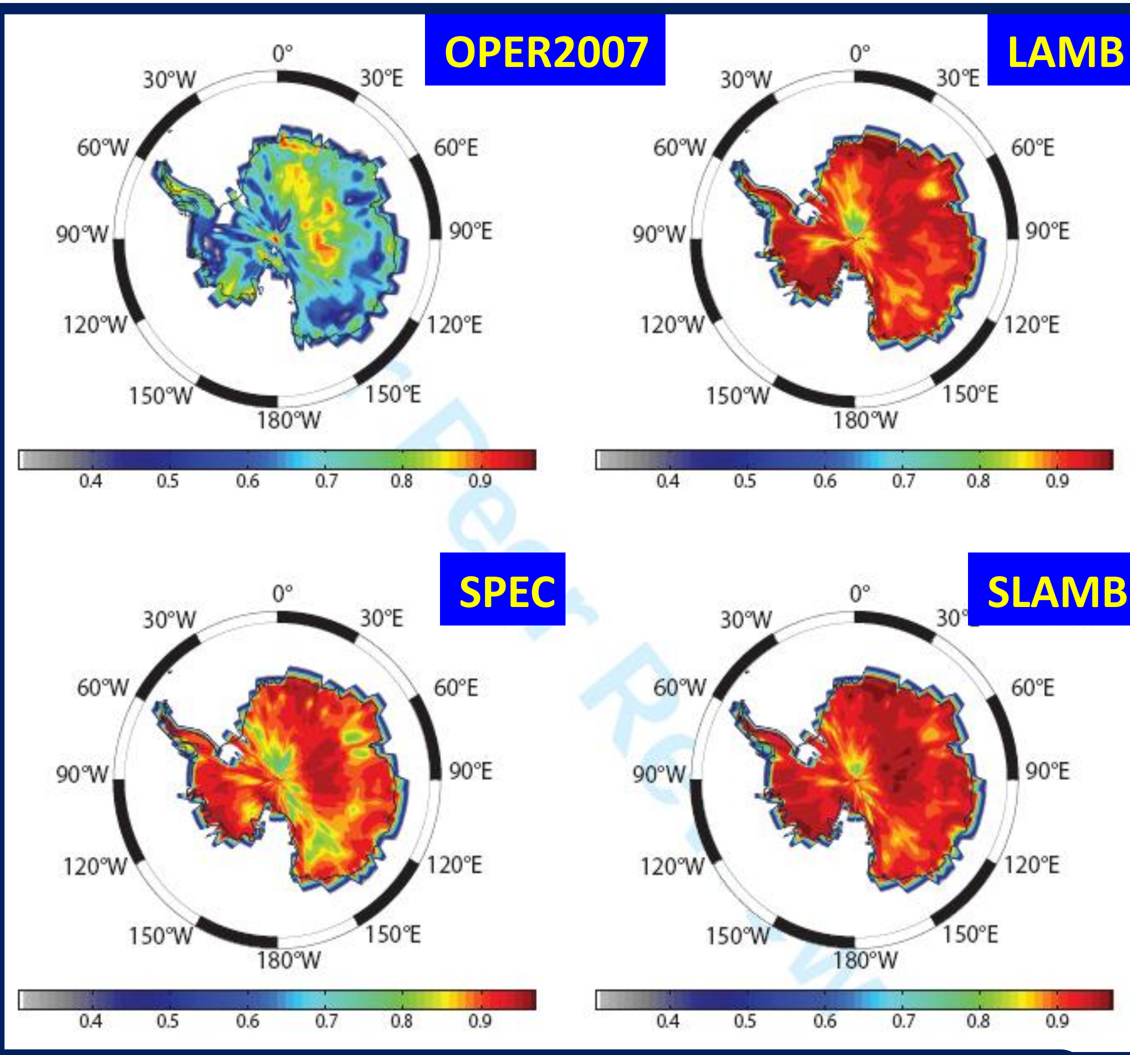
Correlations between Tb_{obs} and Tb_{sim}

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

=> calculation of correlations in grid cell:



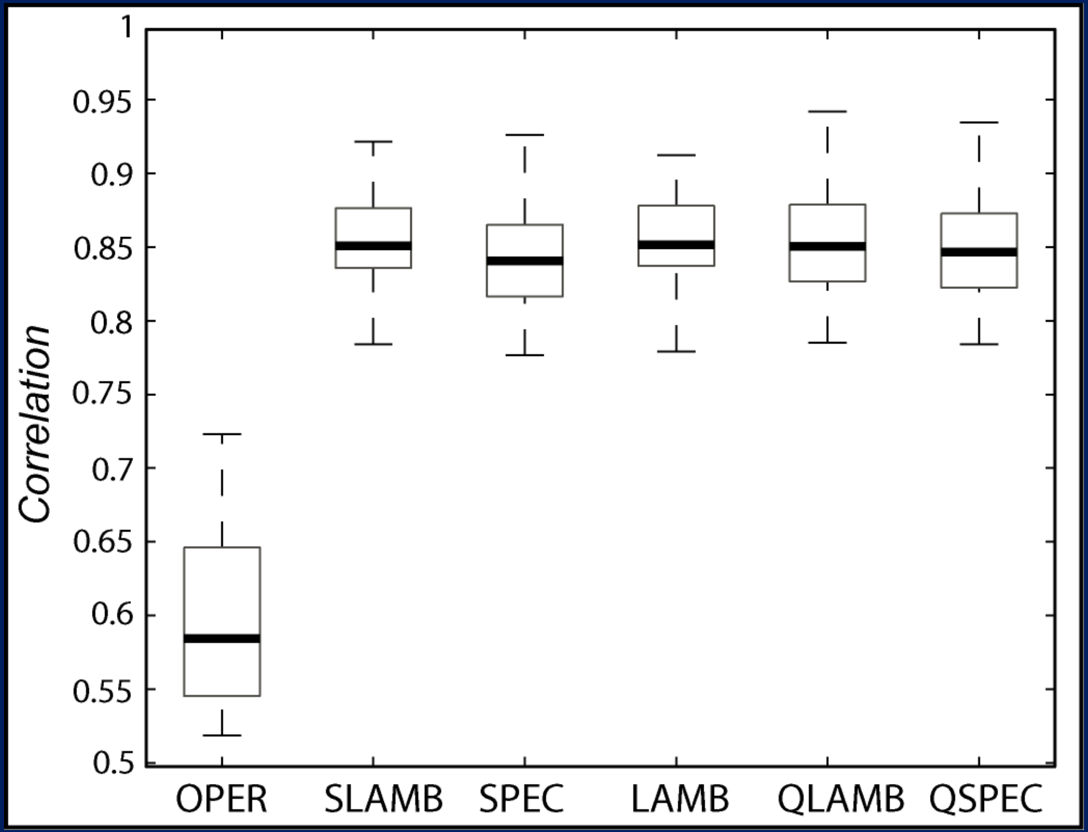
Note : Channel 4 and 5 are located near the oxygene absorption band
⇒ Temperature profiles



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
Distribution of correlations in 2007

Boxplot of monthly mean AMSU-A channel 4 (52 GHz) correlations between Tb_{obs} and Tb_{sim} over Antarctica



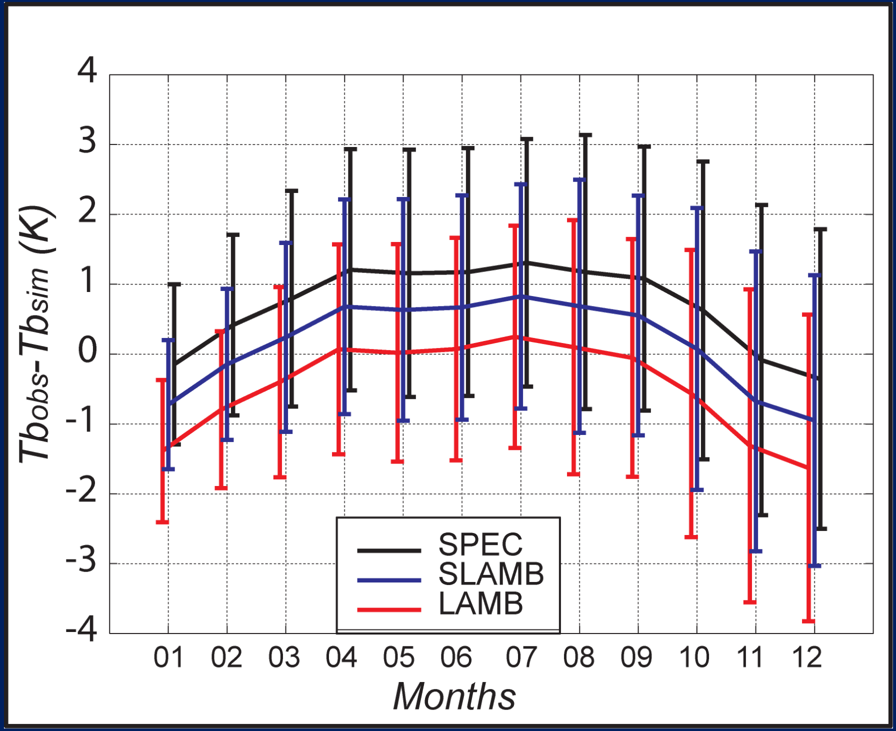
- *Boxes contains the middle half of the scores in the distribution.*
- *The median is shown as a line across the box.*

Correlations of all approximations seem generally higher than the OPER2007

3. Evaluation of land surface emissivity

Seasonnal dependence

Mean Fg-Departures (Tbobs-Tbsim) 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 surface approximation effects are larger for AMSU-A channel 3.
- Comparison between observed and simulated Tb have shown that the LAMB approximation could be more suitable during winter and the SLAMB and SPEC approximation could be used during summer.

4. Conclusion and future developments

- Over Antarctica sea-ice surfaces, Bouchard et al. (2009) have already shown that the SPEC approximation provided satisfactory results.
- SPEC, QSPEC, …. have been interfaced with RTTOV as options and can be activated in ARPEGE using logical keys as inputs
- However, 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, to be published

Thank YOU