Toward a better assimilation of IASI data over polar area, in the framework of the Concordiasi campaign.

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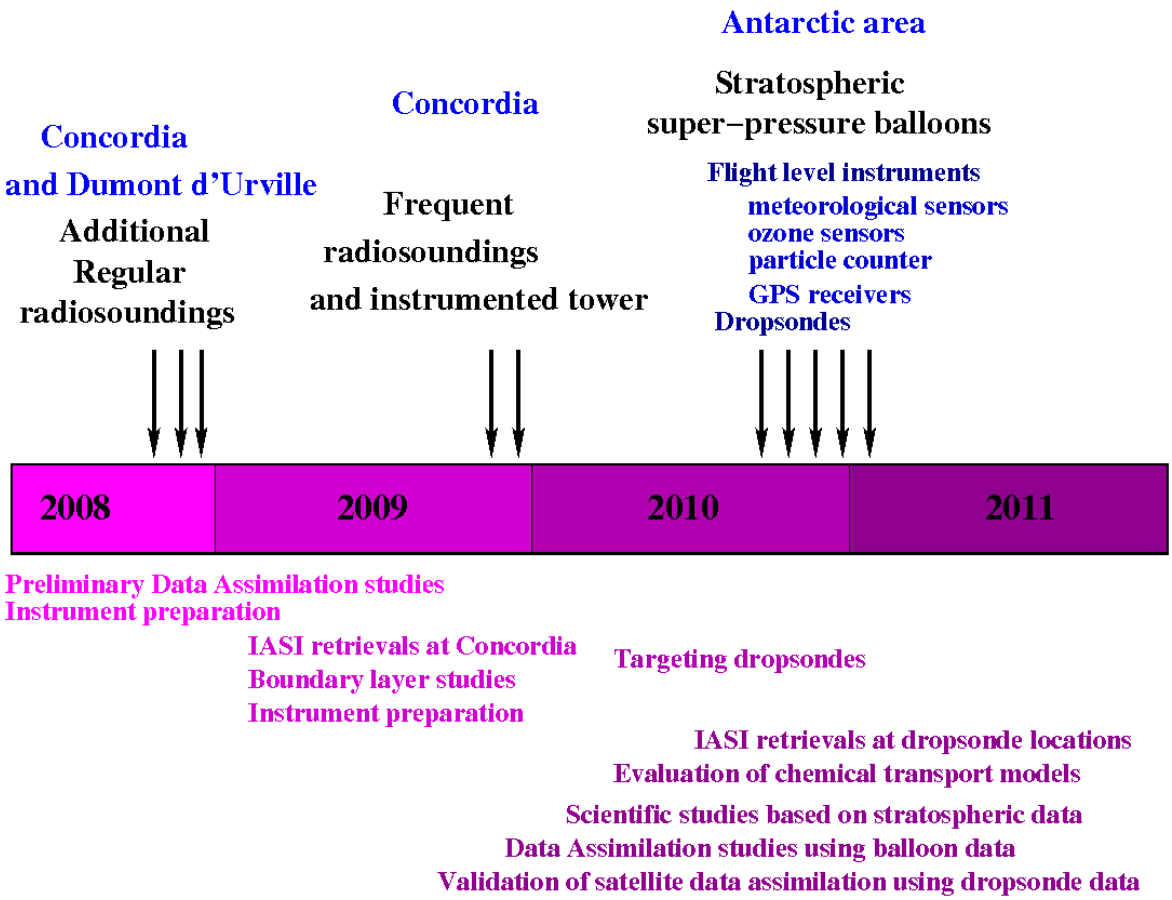
Introduction

The Concordiasi Project

- Field experiment during austral spring 2008-2009- 2010. Part of International Polar Year
- Aims : Improve the assimilation of infrared and microwave satellite observations over high latitudes by comparison with in-situ observations
- Increase of the number of in-situ observations over Antarctica:

Radiosounding & Stratospheric Balloons (12 balloons with 50 sondes & 4 balloons for chemical studies & balloons for GPS radio-occultation)



All data available on the website of the Campaign: http://www.cnrm.meteo.fr/concordiasi-dataset

Preliminary studies

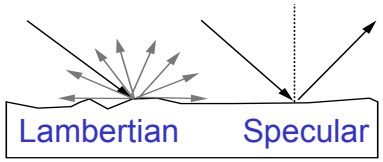
To improve the assimilation of satellite observations in Météo-France global meteorological model ARPEGE

Rabier et al, BAMS, 2010; Guedj et al,IEEE, 2010 et Bouchard et al., MWR, 2010

- Studies on the microwave emissivity to improve the assimilation of AMSU-A & -B

  Based on Karbou's approach (Karbou et al., 2006): estimation of emissivity from satellite observations → Method applied & adjusted to sea-ice surface for AMSU –A & -B sensors

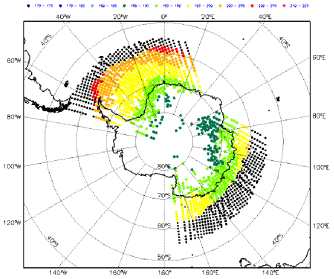
  Studies done by Guedj (Guedj et al. 2009) on the assumption on the surface: test with specular (usual), lambertian & semi-lambertian reflection → Better result with the semi-lambertian reflection over Antarctica



- Assimilation experiment over sea-ice and land with more satellite data infrared & microwave

Black : without additional data

Color : additional IR data



Better fit to ground and airborne observations

Datasets :

austral spring 2008 and 2009

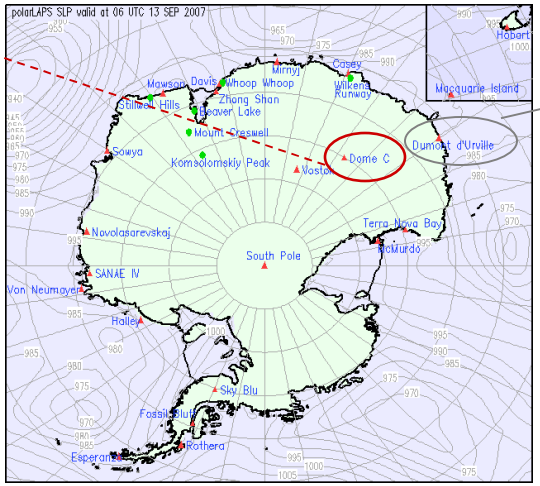
- Time Period : from the 15 September 2008 to 30 November 2008
  and 19 November 2009 to 13 December 2009
- Observations launched :
  - **2008** : Radiosounding at **DomeC** (75°S ; 123°E) & **Dumont d'Urville** (66,40°S;140°E) stations in order to have 2 observations each day at each station, at 0UTC and 12UTC. Complementary launch at the same time of IASI overpass.
  - **2009** : As 2008 for DomeC station + Surface measurements (vertical profile of the ts from -10m to -1m) at the time of the sounding.

DomeC

-Additional data for Concordiasi: 0UTC

- Meteorological conditions :
over 120 cases in 2008: **62% clear sky**
over 17 cases in 2009: **59% clear sky**

-Surface Parameters (in 2009):
-Ps : 648hPa
-Ts measured by Automatic Weather Station (AWS) :
-35.3 °C
-Ts from manual measurement at the snow surface : -33.5°C



Dumont d'Urville

-Additional RS for Concordiasi: 12UTC

- Meteorological conditions :
over 149 cases in 2008: 1**9% clear sky**

Most of time : clear case at DomeC

First Results (1)

1D-VAR

Main Aim : Study the assimilation of more IASI channels over high latitudes

→ Choice of DomeC station – statistics : mostly clear cases

Software used : **1D-VAR** of the **Met Office**, part of the NWP SAF

Principle : from observation and background profile → profil retrieved by minimising the cost function J(x)

Error covariance matrix of the observations **R**, of the backround profile **B**

$$J(x) = (x - x_o)^T B^{-1} (x - x_o) + (y - y(x))^T R^{-1} (y - y(x))$$

x_o:background profile (T, RH)

y : observations (BT) and y(x) the observed radiance for a given atmospheric state x

Methodology

1) Tuning of 1D-VAR in Direct mode:

BASE : operational configuration of ARPEGE

→ Impact of the bias correction on observations y

→ Choice of RTTOV coefficient used

2) Retrieval with 1D-VAR

In order to assimilate more IASI channels

→ Study of **B** and **R** matrix

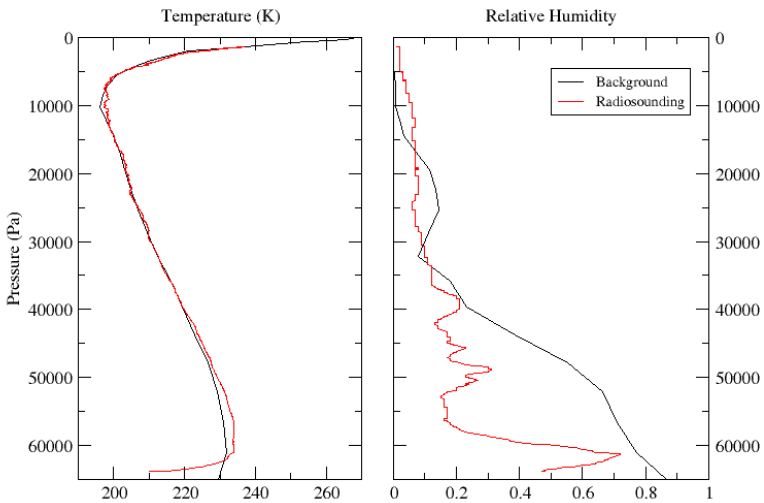
→ Surface parameters

→ Cloud Detection

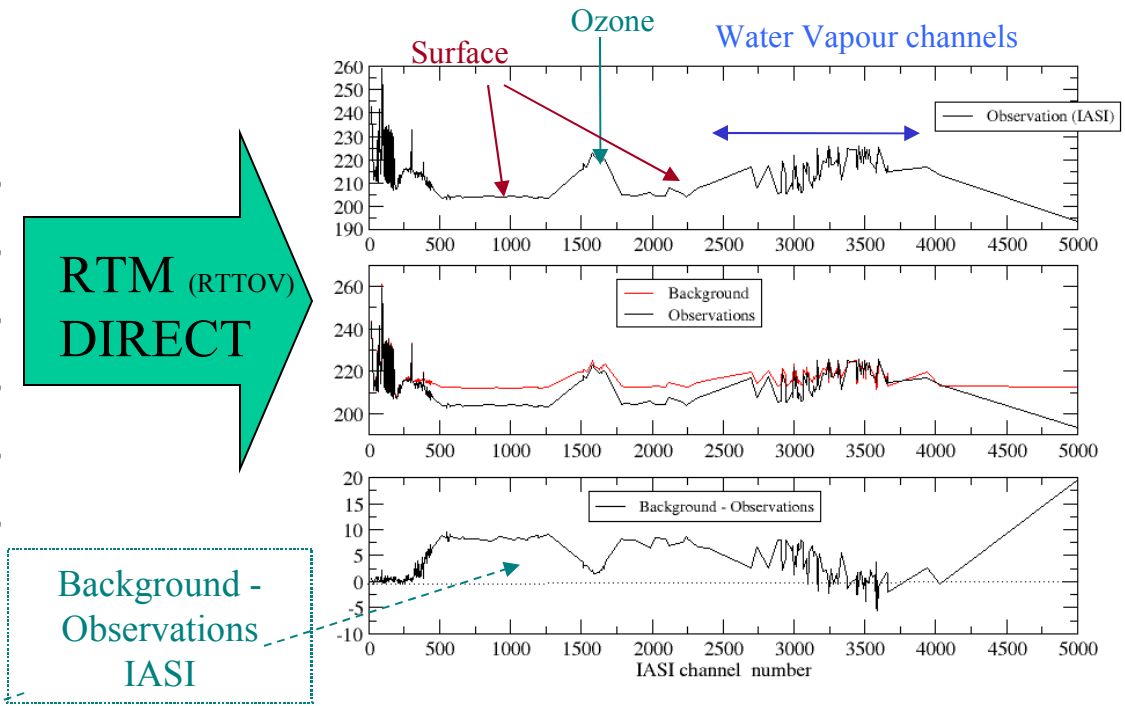
First Results (2)

Study at DomeC with Radiosounding at 0UTC

Temperature & relative humidity profiles : case : 10/05/2008



Output: Brigthness Temperature spectra



RTM (RTTOV) DIRECT

Background - Observations IASI

Profiles come from:

- Radiosounding (red line)
- Background extracted from the model (black line)

To decrease the bias between IASI & Background :

-impact of the model parameters : bias correction, the RTTOV coefficient

-impact of the surface parameters: (emissivity, skin temperature)

First Results (3)

Impact of model parameters

CONTROL : state of ARPEGE configuration

→ Bias correction : VARBC (bias of +1K to 2k)

→ RTTOV coefficients used : GENL2N

→ 50 channels assimilated over land

→ TS from background : model

→ Only clear case determined with Cloud Detection (McNally and Watts, 2003) method activated in ARPEGE

EXPERIMENT : impact of different parameters on the basic configuration

Main impact : the choice of the bias correction:

Experiment : WITHOUT BIAS CORRECTION

Reference : VARBC

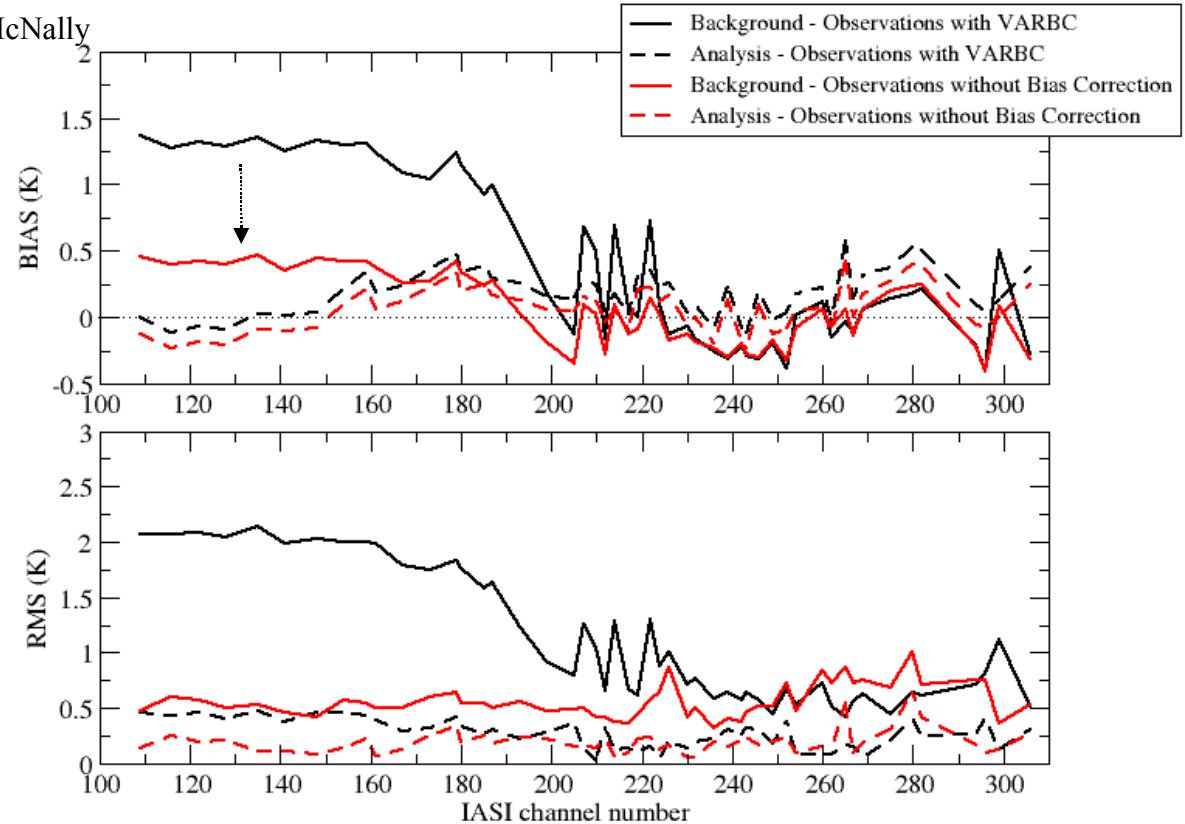
Statistics over 50 cases clear cases

Legend : Solid line : Background - Observations

Dashed line : Analysis - Observations

VARBC : Black

WITHOUT BIAS Correction : Red



First Results (4)

Impact of model parameters

Conclusions of preliminary tests : construction of a new base

Impact of change on models settings :

→ Important impact of the bias correction

New base

→ Bias Correction : no use of bias correction

→ Use of KCARTA for RTTOV coefficients

Toward the assimilation of more IASI channels …

→Aim :**170** channels assimilated over land

- 119 channels in CO2 band
- 29 channels in WV band
- 22 channels in Window Channel

Modifications /Problems tied to the increase of the number of IASI channels assimilated

→Activation of cloud detection in 1D-VAR : CO2 slicing method based on obs-guess

→ Minor impact of the emissivity compared to the surface/skin temperature

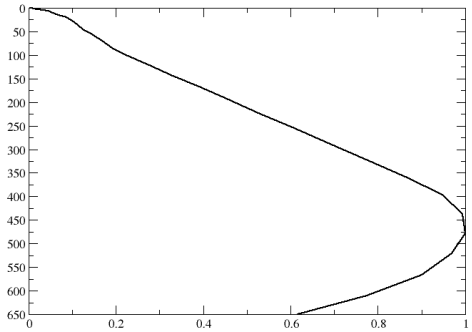
→Problem of the estimation of the skin temperature

→ Increase of the value of the B-matrix for the surface/skin temperature

→ Tests of the use of another source of observations to estimate skin temperature : Retrieval of surface temperature from a IASI window channel

Weighting function of channel 267 (711.5cm^{-1}) at DomeC

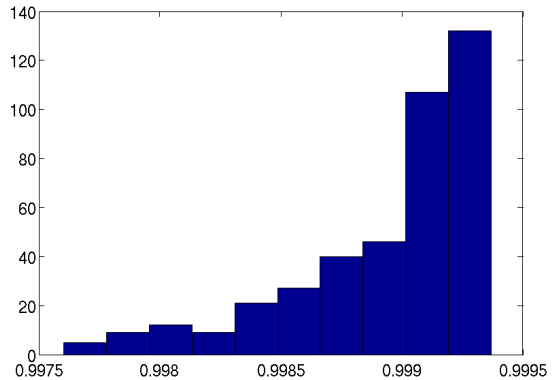
→ Sensibility to the surface



First Results (5)

Impact of surface parameters

Retrieval from a window channel of IASI sensor



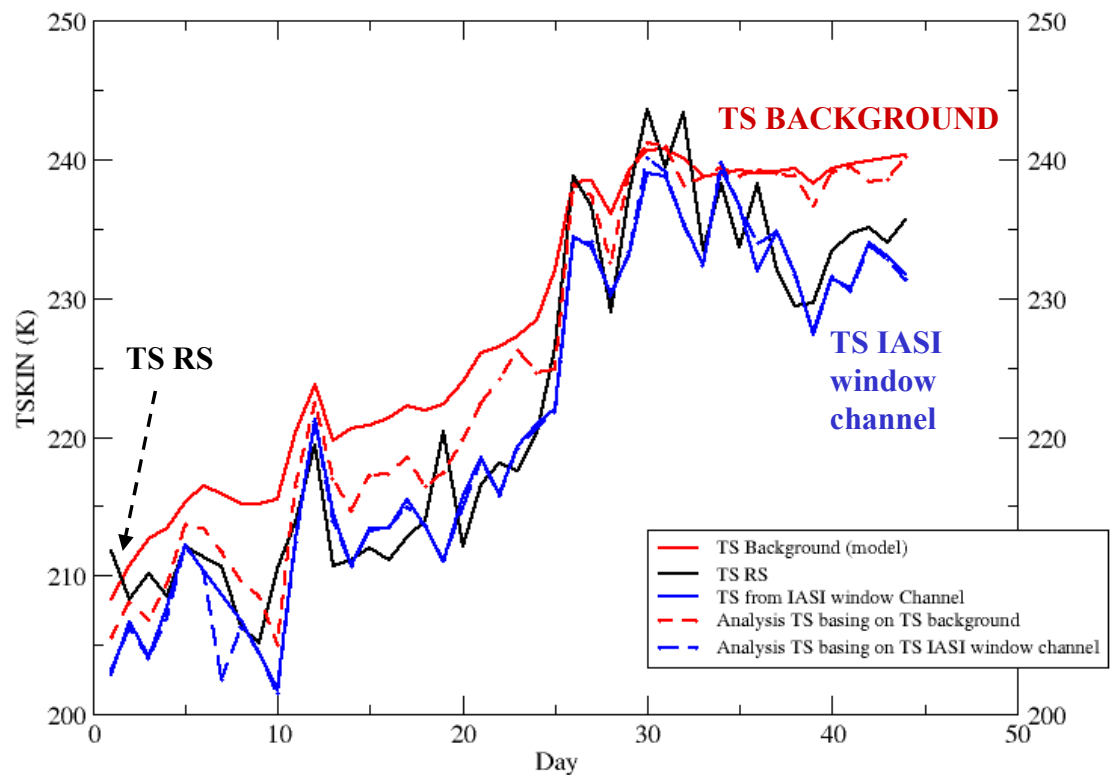
1) Choose of a window channel with a high transmittance: channel 1194 (943,25cm^{-1}) - Mean τ: 0.9989

2) Retrieval of skin temperature (Tskin) from this channel using RTTOV model – Radiative Transfer Equation, with a surface emissivity fixed at 0.99

→Time evolution of the Tskin, over 44 cases cloud or not, from 1st October to 29 November 2008

→ TS from IASI channel close to TS from RS

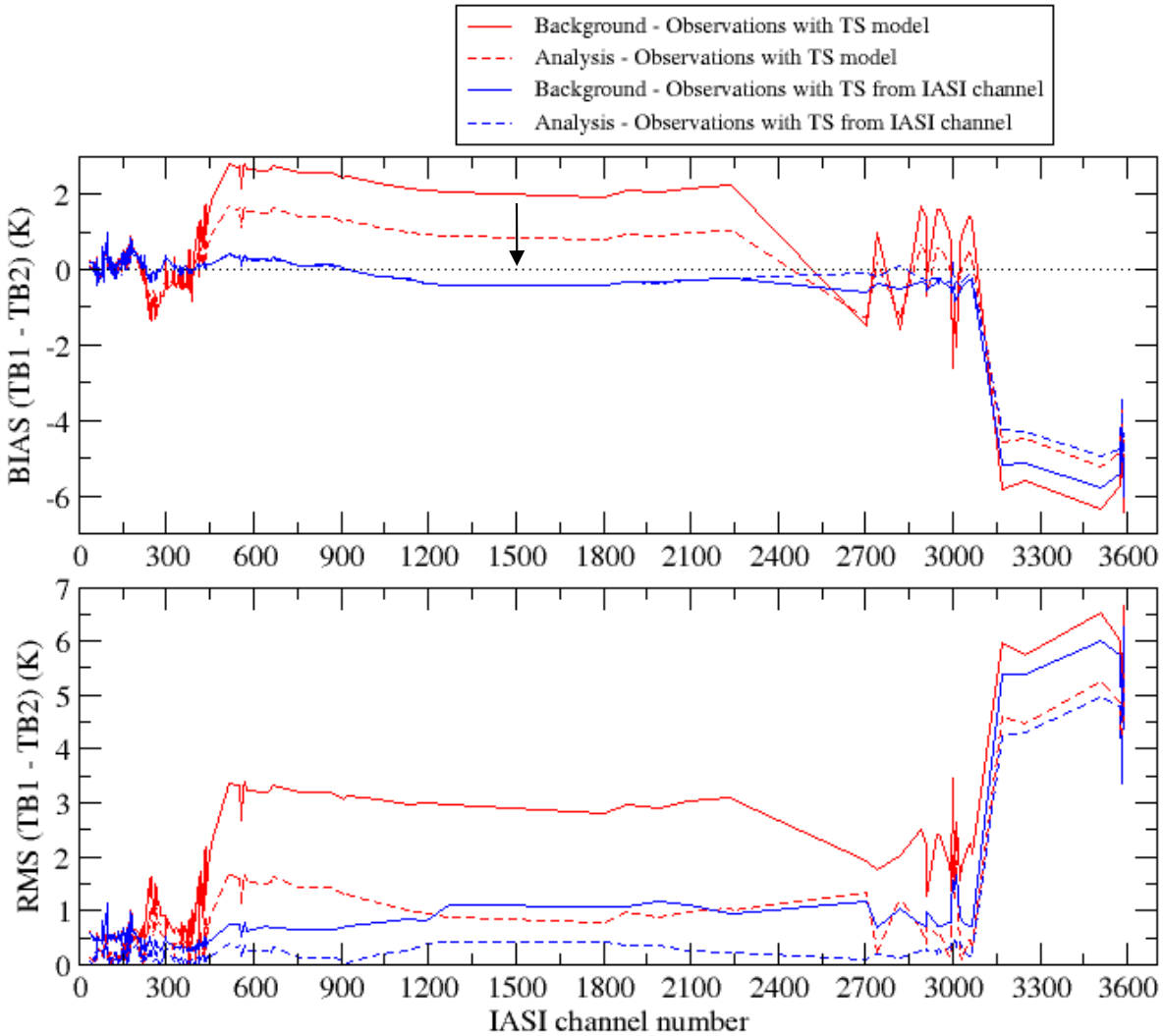
→ Use of 1D-VAR cloud detection



First Results (6)

Impact of surface parameters

3) Impact on the Brigthness Temperature Spectra of the use of the Tskin from IASI window channel



→Statistics, over 44 cases cloudy or not, from 1st October to 29 November 2008

→ Use of 1D-VAR cloud detection

➡ Improvement of the result with Tskin from IASI window channel (1194) : **decrease of bias and rms**

Conclusion & Outlook

Study in 1DVAR en 2008

Preliminary test :

- Large impact of the bias correction chosen → decided to use no correction
- Minor impact of the B-matrix
- In progress: work on the R-matrix

Test done in order to assimilate more IASI channels:

- Importance of the skin temperature used
  - Tskin of the model-background seems too large
  - Better result with Tskin from the RS
  - Retrieval of Tskin with one IASI window channel promising
  - Problem : impact of the cloud detection

➡ Importance of the estimation of the skin temperature in the model, for the snow : work of E. Brun on snow surface properties

CONCORDIASI Workshop

29 to 31 Mars 2010, Toulouse, France

Submission of abstract to
Florence Rabier :
florence.rabier@meteo.fr

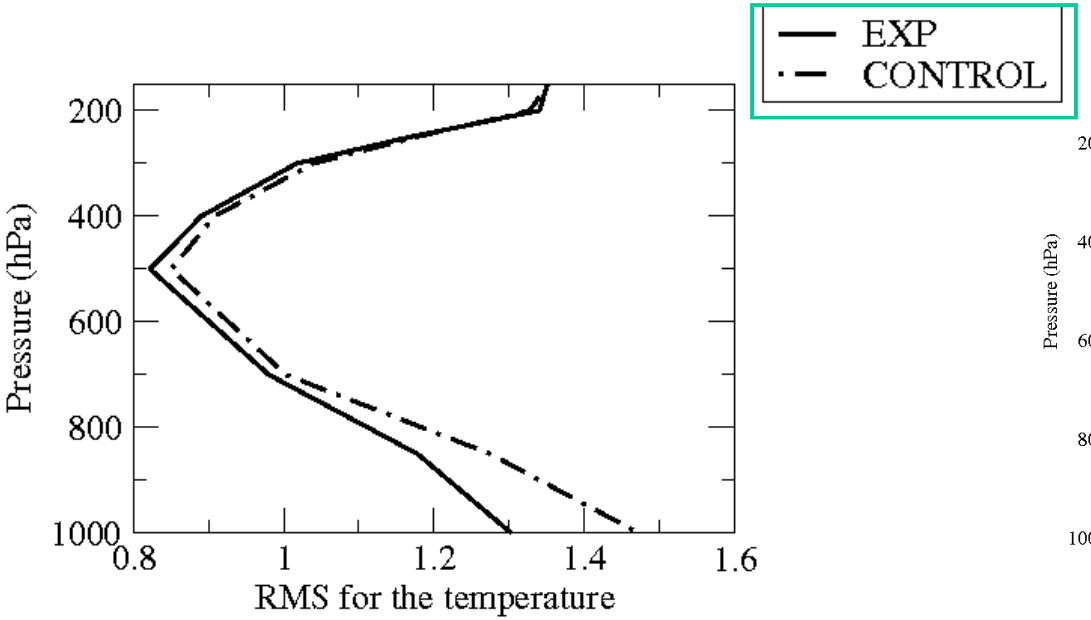
Deadline of abstract submission : 5 Février 2010


Thank you
Concordiasi

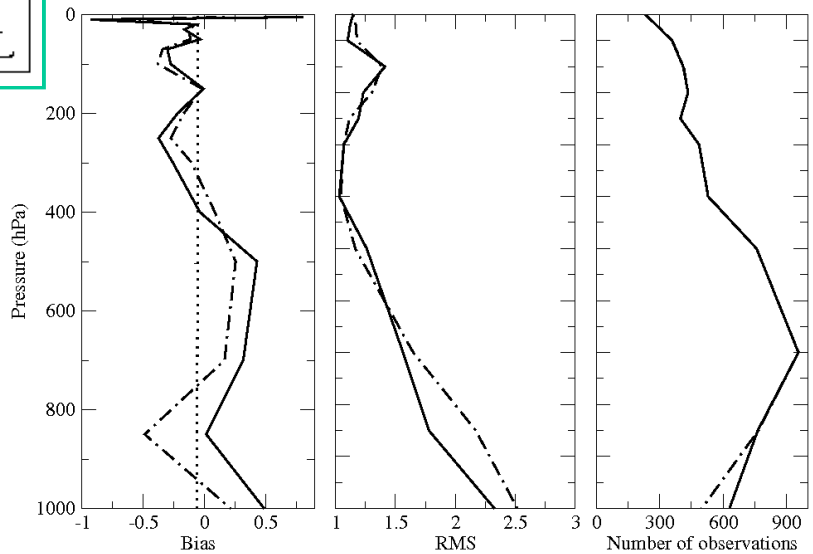
Impact on the assimilation (better fit to ground and airborne observation)

Assimilation experiment over sea-ice and land with more satellite data infrared & microwave

Obs – guess for the temperature for a period of 20 days during austral winter 2007



Obs : AIREP (airborne data) between 20°S and 50°S



Obs : Radiosounding

For latitude below 65°S

CONTROL : lists of characteristics

→ Bias correction : VARBC

→ RTTOV coefficients used : GENL2N

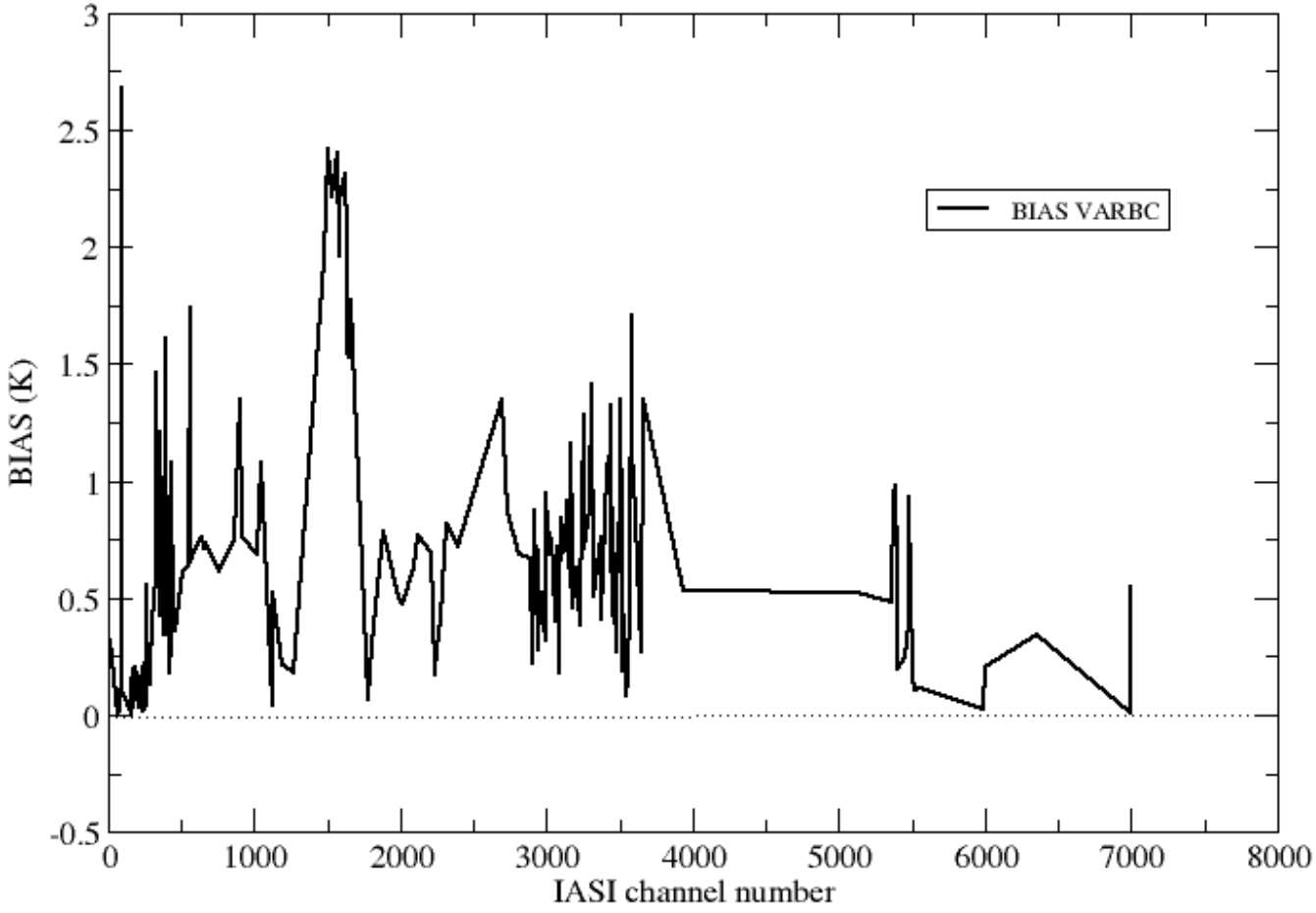
→ R-matrix : diagonal

→ B-matrix : no correlation between T, Q, Surface parameters

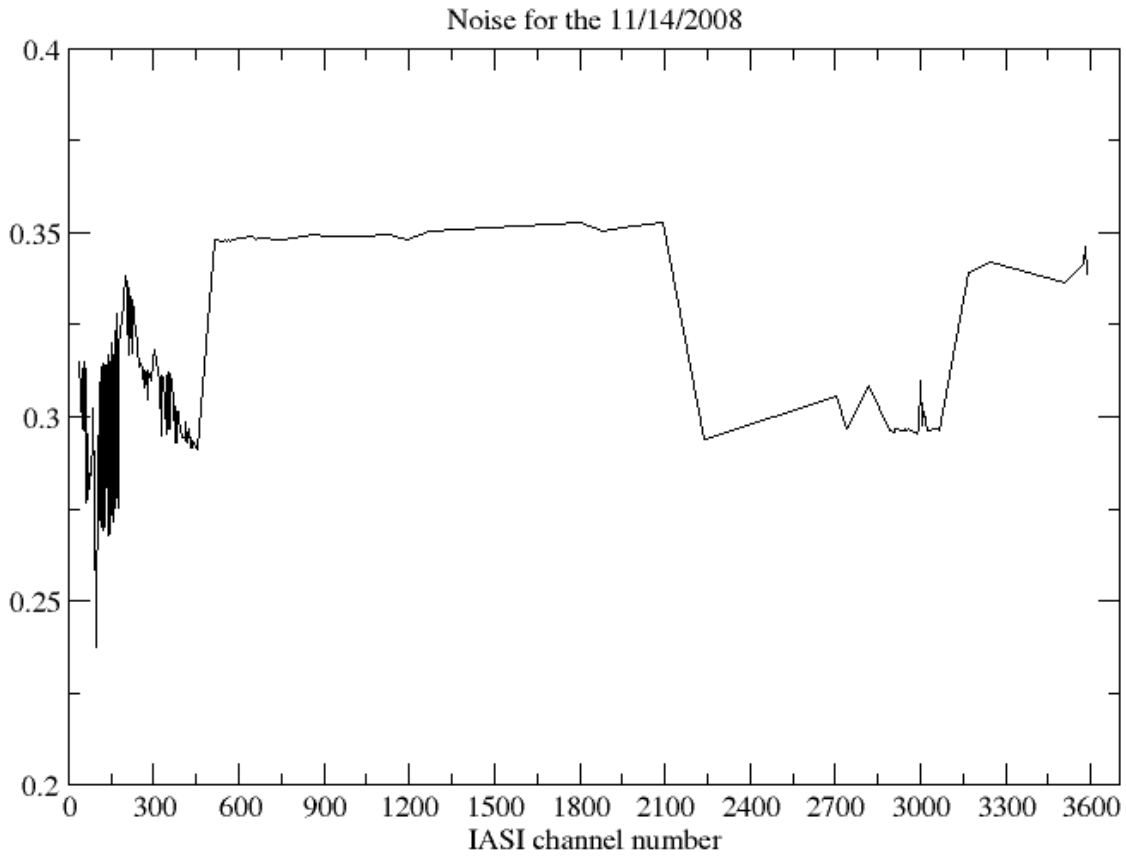
→ 50 channels assimilated over land

→ TS from background : model – CLEAR CASE

Mean Bias correction with 1D-VAR



Rapport signal sur bruit (calculé à partir du bruit à 280K)



Impact of the cloud detection with ts from IASI window channel

Example with different day (cloudy and clear case not): impact on the Brigthness Temperature Spectra of the activation of the cloud detection

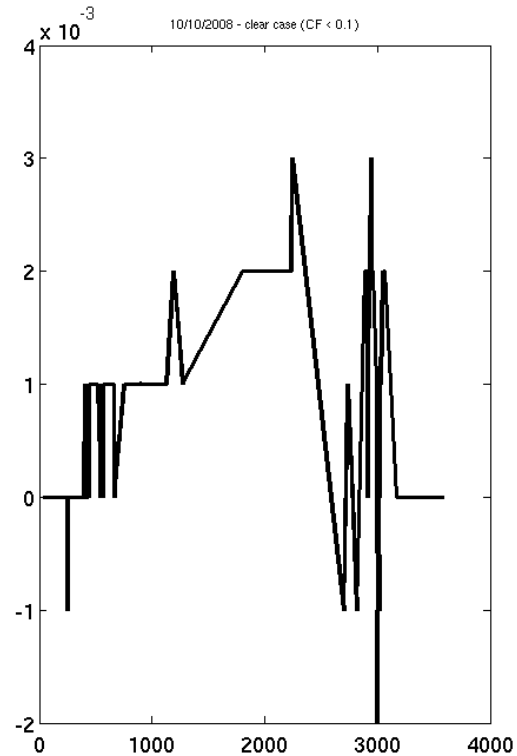
Difference on tb with the activation or not of the cloud detection :

TB_WITH – TB_WITHOUT

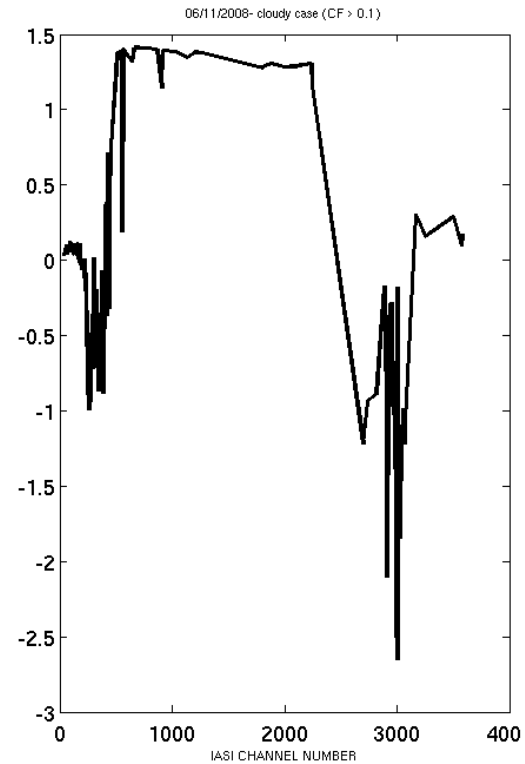
Few gap in clear case

Bigger gap in cloudy case

→ Error can be done for these case on the skin temperature retrieved



Clear case



Cloudy case

Study of the case of the 9 October 2010 (j = 7/44)

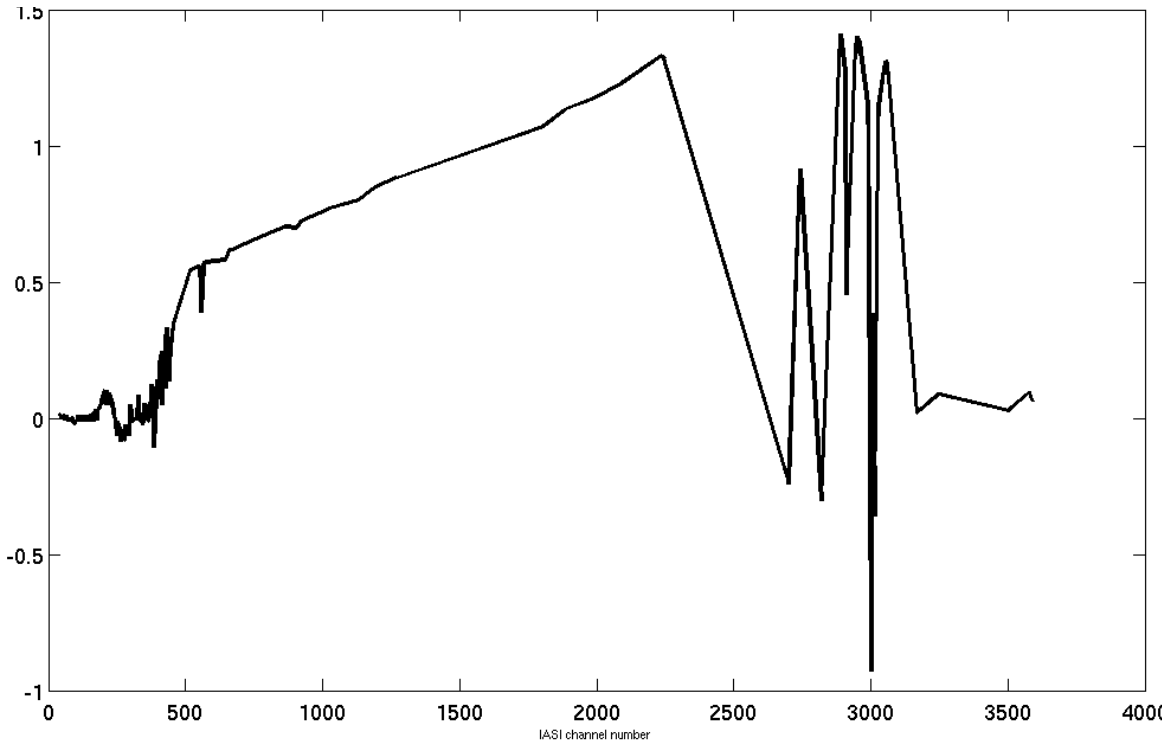
TS RS : 210.65K /TS background-model : 215.93K

TS IASI : 208.67K → TS analyse : 202.52 K

CF RS<0.1

CF IASI ~0.38 : found cloudy by the method

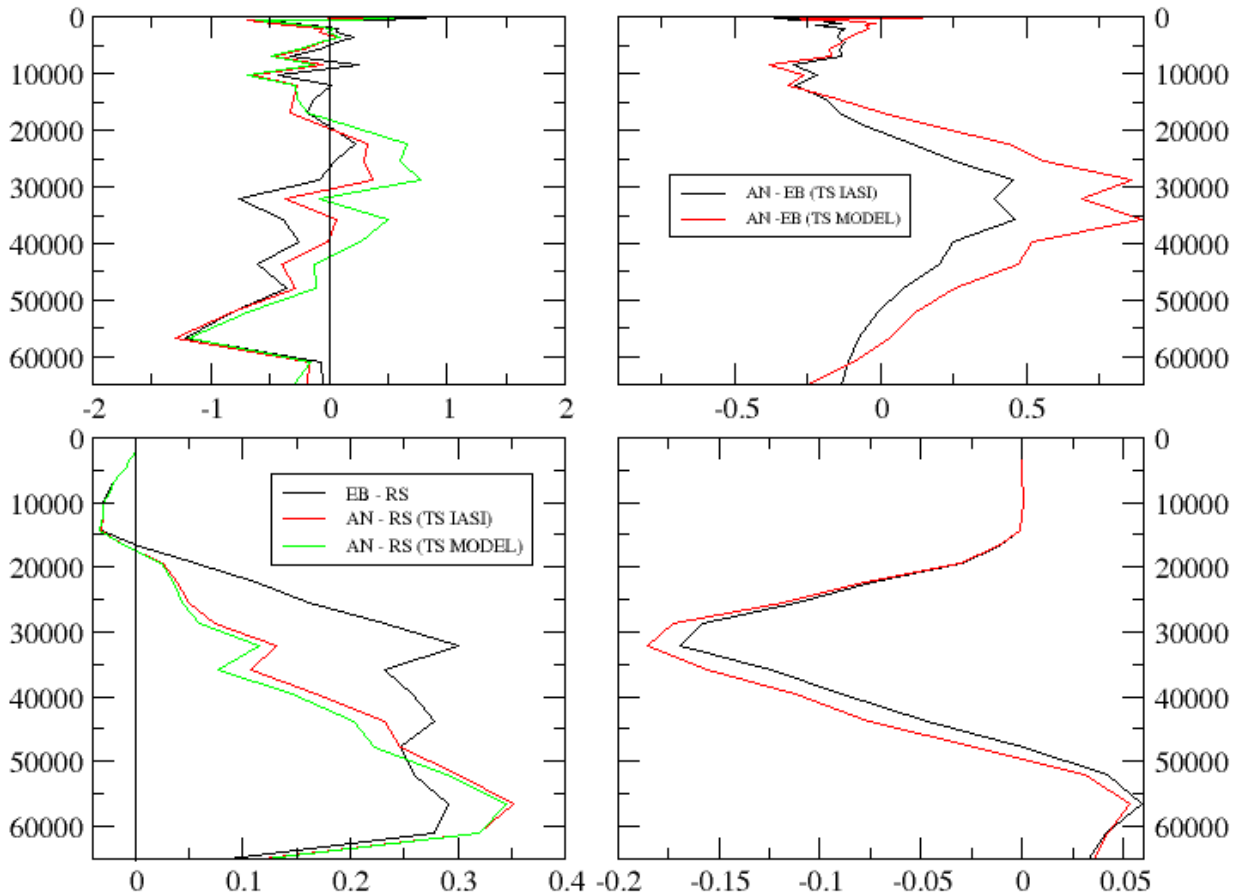
CTP RS:83hPa – CTP IASI : surface



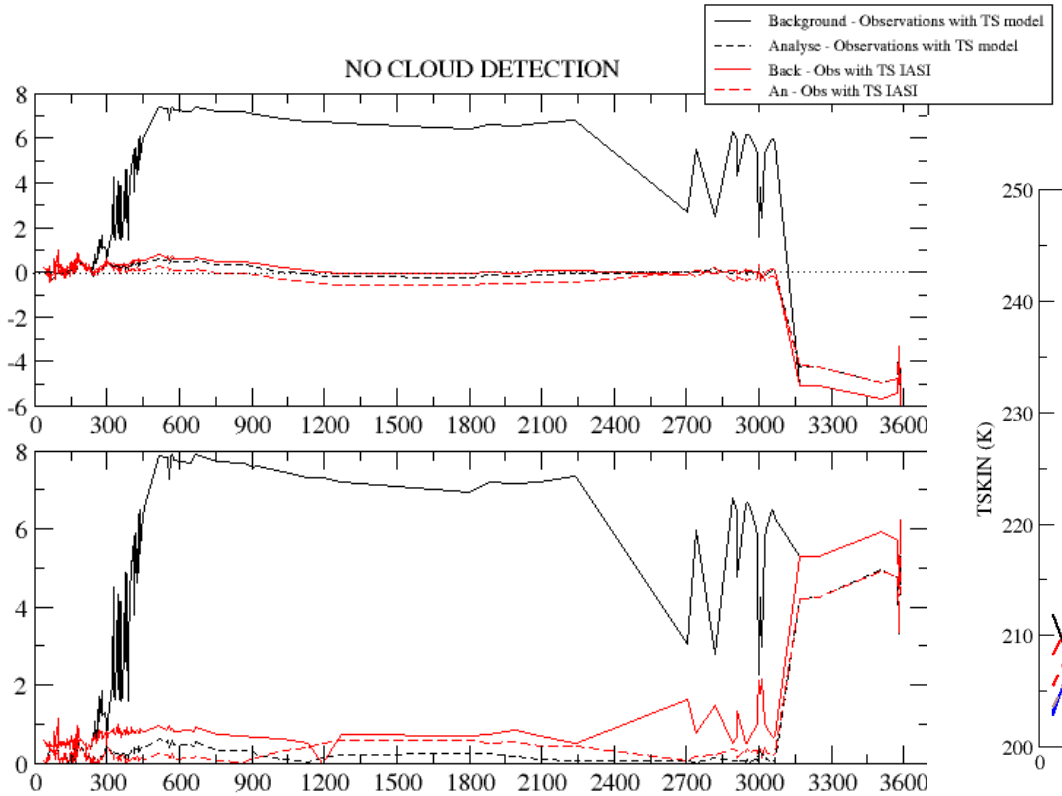
On 44 cases, only 4 have CF > 0.1

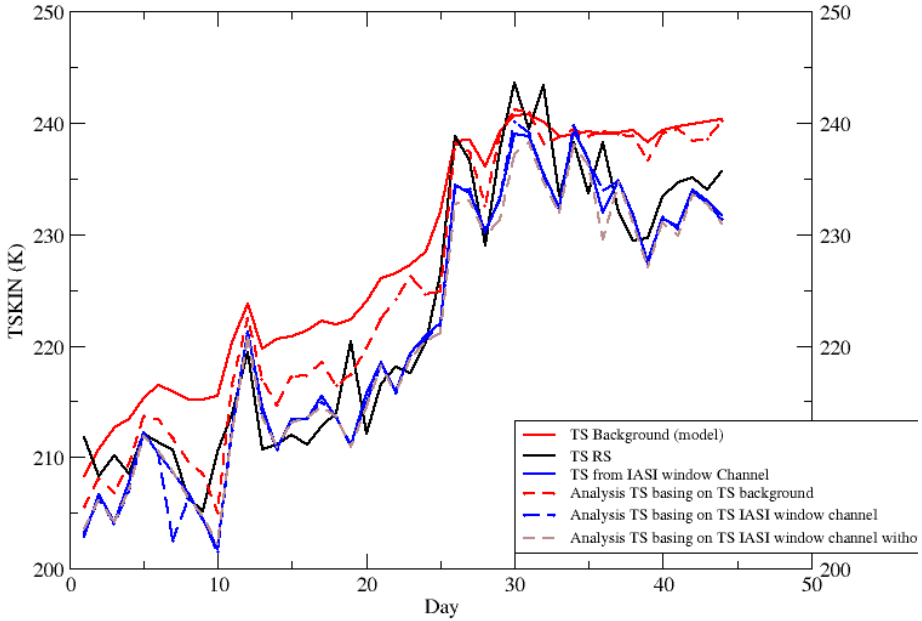
Impact of the skin temperature from model and from IASI window channel on temperature and relativ humidity profiles

With cloud detection



Impact of the skin temperature from model and from IASI window channel on BT profiles without activation of cloud detection





Conclusion & Outlook (1)

The first part of the campaign: Radiosounding launched at DomeC & Dumont d'Urville twice a day.

Based on Radiosounding launched at 0UTC at DomeC, preliminary studies for 1D-VAR have been performed:

- Good agreement with Radiosounding using as reference

- Improvement of the assimilation of satellite data using 1D-VAR

In the second part of the campaign in 2009: Frequent radiosounding at DomeC & instrumented tower

- Studies at DomeC : at mesoscale, in the boundary layer, use of the instrumented tower, representation of the snow in the meteorological model…

In the third part of the campaign in 2010: Stratospheric Balloons launch at McMurdo, dropping sondes over Antarctica and sea-ice

- Validation of IASI assimilation in model

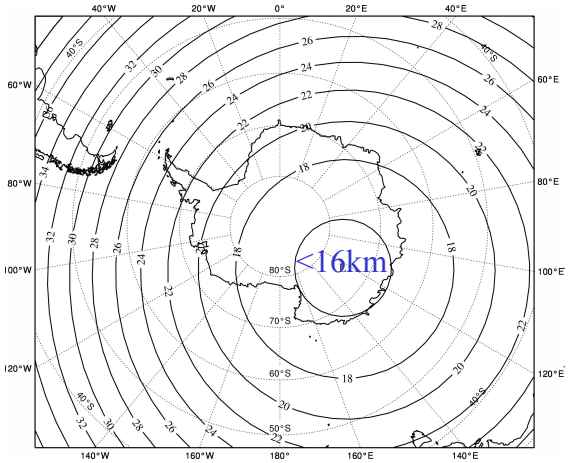
-Stratospheric studies -Evaluation of chemical transport model ….

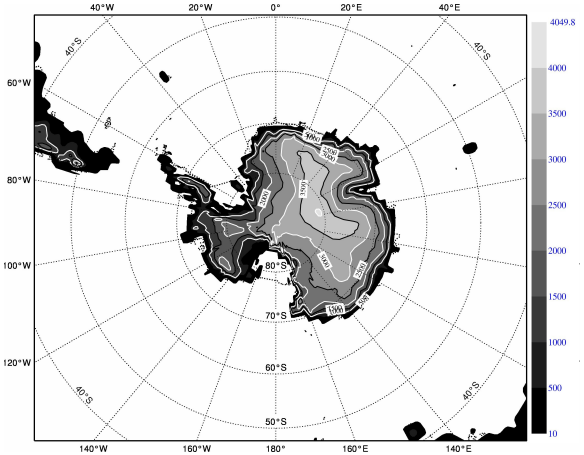
Preliminary studies

To improve the assimilation of satellite observations in Météo-France global meteorological model ARPEGE

Studies on emissivity & evaluation of assimilation of more satellite data over sea-ice & land

The model has been tuned for Antarctica studies : in order to have a better representation of the orography

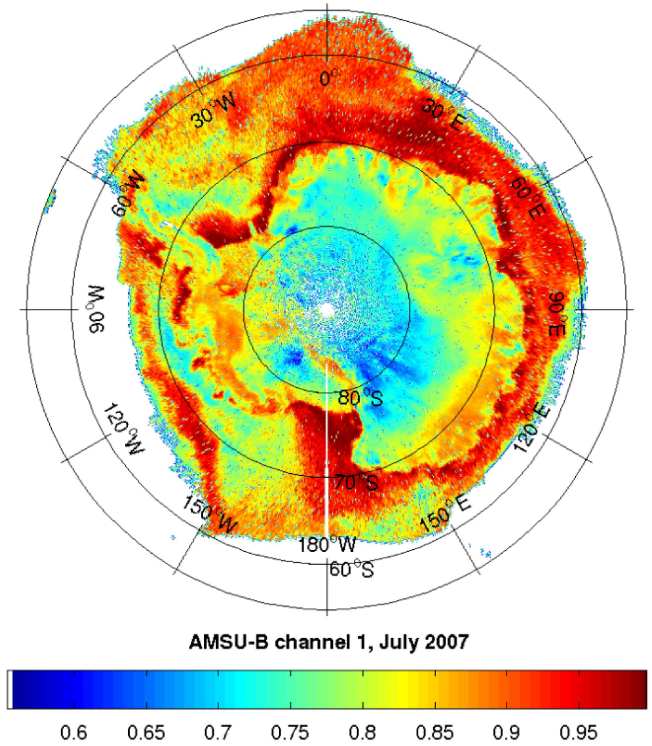




Preliminary studies (1)

To improve the assimilation of satellite observations in Météo-France global meteorological model ARPEGE

Studies on the microwave emissivity to improve the assimilation of AMSU-A & -B

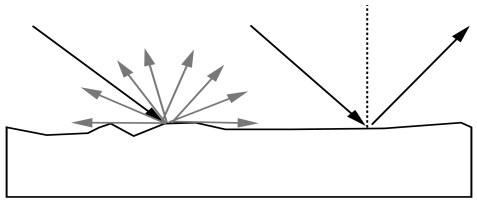


Map of microwave emissivity from AMSU-B, channel 1

- Based on Karbou's approach (Karbou et al., 2006): estimation of emissivity from satellite observations

  → Method applied & adjusted to sea-ice surface for AMSU –A & -B sensors

- Studies done by Guedj (Guedj et al. 2009) on the assumption on the surface: test with specular (usual), lambertian & semi-lambertian reflection



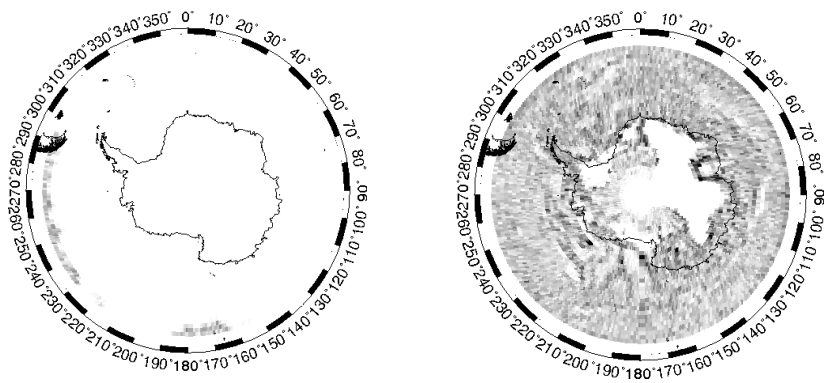
→ Better result with the semi-lambertian reflection over Antarctica

Preliminary studies (2)

Assimilation experiment over sea-ice and land with more satellite data infrared & microwave

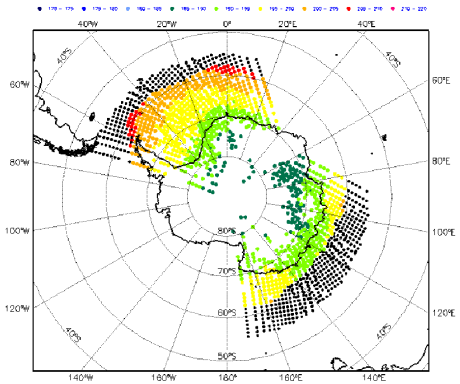
More satellite data: increase of the number of assimilated data

Microwave data



AMSU-B, channel 3: before (left) after modification (right)

Infrared data



Black : without additional data

Color : additional IR data

Impact on the assimilation:

better fit to ground and airborne observations

Rabier et al, BAMS, 2010; Guedj et al,IEEE, 2010 et Bouchard et al., MWR, 2010

Datasets :

austral spring 2008 (1)

- Time Period : from the 15 September 2008 to 30 November 2008

- Observations launched : Radiosounding at **DomeC** (75°S ; 123°E) & **Dumont d'Urville** (66,40°S;140°E) stations in order to have 2 observations each day at each station, at 0UTC and 12UTC. Complementary launch at the same time of IASI overpass.

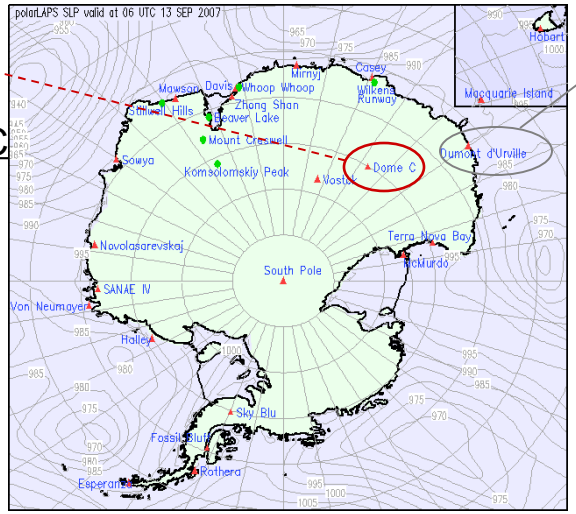
- Statistics at these stations during the first part :

DomeC

- Usual hour of launch: 12UTC
- Additional data for Concordiasi: 0UTC

- Meteorological conditions over 120 cases:
- **62% clear sky**
- 29% almost cloudy
- 10% cloudy

-Alt max balloon reached: 39km (4,7 hPa)



Dumont d'Urville

- Usual hour of RS launch: 0UTC
- Additional RS for Concordiasi: 12UTC

- Meteorological conditions over 149 cases:
- **19% clear sky**
- 35% cirrus
- 39% Ac/As
- 48% Stratocumulus

-Alt max balloon reached: 27.6km (15,9hPa)

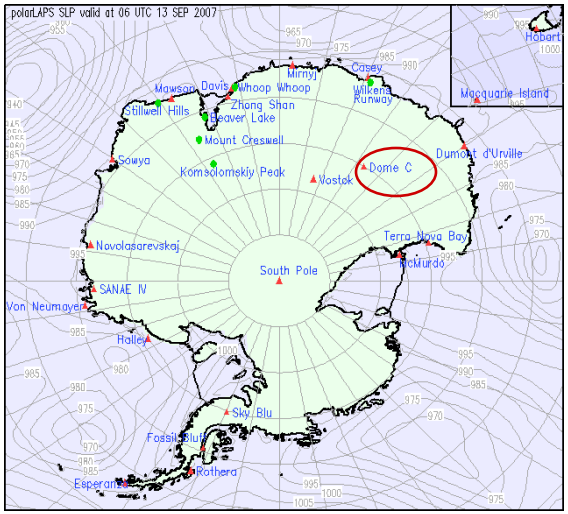
Datasets :
austral spring 2009 (2)

- Time Period : from the 19 November 2009 to 13 December 2009
- Observations launched : Radiosounding at **DomeC** station (75°S ; 123°E) in order to have 2 soundings each day at 0UTC and 12UTC. Sounding at 0hTU is launched in function of IASI swath.
- Surface measurements (vertical profile of the ts from -10m to -1m) at the time of the sounding.
- Statistics at **DomeC** station :

- Usual hour of launch: 12UTC
- Additional launch for Concordiasi: 0UTC

- Meteorological conditions over 17 cases at 0hTU:
- **59% Clear Sky**
- 23% Cloudy
- 17% others (almost clear-not very cloudy)

-Alt mean balloon reach: 28km (26 hPa) / alt max : 36km (5hPa)



-Surface Parameters :
- -Ps : 648hPa
- -Ts measured by Automatic Weather Station (AWS) :
- -35.3 °C
- -Ts from manual measurement at the snow surface : -33.5°C

Most of time : clear case at DomeC & Dts = 2K