Improvement of land surface emissivity and surface temperature estimates for the assimilation of IASI data over land.

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Plan

1. IASI data assimilation over land at Météo-France.

2. Importance of surface parameters over land.


4. Emissivity atlases over land and impact on brightness temperature simulations.

5. Conclusion.
IASI data assimilation over land at Météo-France

The limits of the use of IASI data over land

- Important radiative impact of clouds on infrared radiances that limits the information from advanced sounders => use of radiances in clear sky conditions for the retrievals.
- Uncertainty on emissivity and surface temperature.
- Good use of these data over sea but limited over land => less IASI data used in NWP over land.

Study on the subset of 314 IASI channels.
IASI data assimilation over land at Météo-France.

Importance of surface parameters over land

**Measurements at infrared frequency:** Instruments receive an electromagnetic signal.

**Observed brightness temperature** \((\upsilon)\):

\[
T(\upsilon) = \varepsilon(\upsilon) \cdot T_s \cdot \tau + (1 - \varepsilon(\upsilon)) \cdot \tau \cdot T(\upsilon \downarrow) + T(\upsilon \uparrow)
\]

- **Emissivity**
- **Surface temperature**

➢ In operations: constant \(\varepsilon\) and \(T_s\) bad estimated

➢ Over land, emissivity varies in time and space, with wavenumbers, surface types, roughness and moisture content.

➢ With RTTOV, \(T_s\) can be calculated:

\[
T_s = \frac{T(\upsilon) - (1) - (2)}{\varepsilon(\upsilon) \cdot \tau}
\]
The importance of surface parameters over land.

Impact of emissivity on brightness temperature simulations

Differences between BT simulated with the constant emissivity 0.98 and the BT simulated with other emissivity values.

Average on the globe, the 1\textsuperscript{st} July 2011 at 0 UTC.
The importance of surface parameters over land.

Impact of surface temperature on brightness temperature simulations

Differences between the BT simulated with the background LST of ARPEGE and the BT simulated adding a factor between [-10 K,10 K] to the background LST.

Average on the globe, the 1st July 2011 at 0 UTC.

=> Larger impact of LST than emissivity on simulated BT.
The importance of surface parameters over land.

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Retrievals of land surface temperature and impact on brightness temperature simulations.

The inversion method

- Dynamical calculation of LST inverting the equation of the RTTOV radiative transfer model from a single IASI channel and from a combination of several channels.
- In a first time, LST is retrieved using a **constant emissivity equal to 0.98**.
Retrievals of land surface temperature and impact on brightness temperature simulations.

The inversion method

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**Evaluation of the retrievals**

- Evaluation for **5 days from 1st to 5 July 2011** of the retrieved LST with 2 products:
  - the **IASI Level 2 (L2) products** of LST from EUMETSAT (August et al, 2012; Zhou et al, 2011)
  - the **MODIS LST products** for the Terra platform from the Nasa (Wan, 2008; Hulley & Hook, 2009; Wan & Dozier, 1996).

- Evaluation for **clear sky cases** according to the AVHRR imager and according to cloud detect method (McNally and Watts 2003).

**Channels used for the retrievals**

- Retrievals calculated for each surface channel in the wavebands between **773 and 962 cm\(^{-1}\)** and between **1091 and 1168 cm\(^{-1}\)**.

- Retrievals also calculated using **combination of 2 or 3 channels**. Calculation of the LST averaging the estimated LST for each channel in the combination.

- Combination with channels selected for:
  - their almost constant emissivity with respect to soil type
  - the good correlations between the IASI observations and the products
  - the high transmittance of channels and high number of observations for comparison with products.

- Combination **1191+1271** is chosen (942.50 and 962.50 cm\(^{-1}\)).
MODIS products

Channels 1191 + 1271

IASI L2 products

Clear cases according to AVHRR

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<th>ST-STprod</th>
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<td>Bias</td>
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<td>Corr</td>
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<td>0.993</td>
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<tr>
<td>Std</td>
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<td>3.139</td>
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<tr>
<td>Bias</td>
<td>-0.221</td>
<td>-3.549</td>
</tr>
</tbody>
</table>
Impact on simulated brightness temperature

- Study period: July 2011 and January 2012.

- Clear cases determined according to the AVHRR imager and the cloud detect method.
Clear cases: AVHRR Channel 515 (773.50 cm$^{-1}$)

Obs-guess with the **retrieved LST**

- Min = -2 K, max = 2 K
- Mean bias = -0.25 K

Obs-guess with the **background LST**

- Min = -12 K, max = 12 K
- Mean bias = -2.18 K
Obs-guess with the **retrieved LST**

**JULY 2011**

- Mean bias = -0.25 K
- Min = -2 K, max = 2 K

**JANUARY 2012**

- Mean bias = -0.36 K
- Min = -12 K, max = 12 K

Obs-guess with the **background LST**

- Mean bias = -2.18 K
- Min = -12 K, max = 12 K

Mean bias = -3.74 K
JULY 2011  |  Clear cases: AVHRR  |  JANUARY 2012

**Surface**

**Bias**

- *Bias - OPER*
- *Bias - retrieved ST 2chan + emiss=0.98*
- *Standard deviation - OPER*
- *Standard deviation - retrieved ST 2chan + emiss=0.98*

**Standard deviation (K)**

IASI wavenumber (cm⁻¹)

**DAY**

**NIGHT**

IASI wavenumber (cm⁻¹)
Number of clear channels with cloud detect method (McNally and Watts 2003)

- IASI canal 373 - 738 cm\(^{-1}\) => x 8.4
- IASI canal 1191 - 942.5 cm\(^{-1}\) => x 18.4

=> larger number of potential observations for assimilation
Emissivity atlases over land and impact on brightness temperature simulations.

The atlases

- Impact of the combination of LST retrievals with atlas emissivity. Two atlases are used:
  - the **IASI L2 products** of emissivity from EUMETSAT (August et al, 2012)
  - the global high spectral resolution infrared land surface emissivity database (called **UWIREMIS atlas**) developed by the UW/CIMSS (Seeman et al, 2008; Borbas and Ruston 2010)

Impact on brightness temperature simulations

- Good impact of the emissivity atlases in the window (sensitive to the surface) between 1091 and 1168 cm$^{-1}$.
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- Impact of the combination of LST retrievals with atlas emissivity. Two atlases are used:
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Impact on brightness temperature simulations

- Good impact of the emissivity atlases in the window (sensitive to the surface) between 1091 and 1168 cm\(^{-1}\).
Conclusion of this study

- Realistic estimate of the retrieved LST compared with MODIS products and IASI L2 products.

- Importance of accurate land surface temperature and emissivity in the brightness temperature simulations.

- Good impact of the LST retrievals on cloud detection. More clear cases detected and so more potential channels per observation could be used in the assimilation.

- Good impact of the emissivity atlases in the window (sensitive to the surface) between 1091 and 1168 cm⁻¹.

Future work

- Assimilation experiments using LST retrievals and emissivity atlases into the ARPEGE NWP of Météo-France with channel selection.