Improving the knowledge of the atmospheric state using the validation of the level1 radiances of IASI

Raymond Armante

N. Scott, V. Capelle, L. Crépeau, N. Meilhac, A. Chédin, N. Jacquinet, C. Crevoisier
L1 Validation chain at LMD

- Observations
- Clear-sky detection
- Clear observed spectra
- Spatio-temporal collocations
- Description of the atmospheric situation
The Analysed RadioSounding Archive (ARSA)

- Radiosounding from ECMWF selected after severe quality controls (fully automated)
- Extrapolation of T and H\textsubscript{2}O profiles when necessary (ERA\_Interim up to 0.1 hPa, then with, ACE-FTS L2)
- Add missing parameters such as ozone profile and surface temperature

\[ \Rightarrow \text{A 43-level description of the atmosphere between surface and 0.0026 hPa including P, T, H\textsubscript{2}O, Ozone profiles, surface temperature, Geolocation + date/time} \]

\[ \Rightarrow \text{See Poster Scott et al., S2-81} \]

ARSA starts in January 1979 and is extended continuously

So far: A total of > 4.9 million profiles from a total of ~22 millions considered

Validation chain

1. Description of the atmospheric situation
2. Clear sky detection
3. Clear observed spectra
4. Spatio-temporal collocations

- Simulated spectra
- Radiative transfer algorithm
- Instrumental parameters
- Spectroscopic databases

- ARSA T, H_2O, O_3 surface
- Observed spectra
Validation chain

observations

Clear-sky detection

Clear observed spectra

Spatio-temporal collocations

Description of the atmospheric situation

Statistical analysis (bias and standard deviation)

« calc-obs »

Radiative transfer algorithm

Simulated spectra

Observed spectra

ARSA T, H₂O, O₃ surface

Spectroscopic databases

Instrumental parameters

See posters #S2.82, S5.105, S7.14, oral capelle et al

L2 processing
Validation chain: L1

- Observations
  - Clear-sky detection
    - Clear observed spectra
      - Spatio-temporal collocations
        - Description of the atmospheric situation
          - Radiative transfer algorithm
            - Simulated spectra
              - ARSA T, H₂O, O₃ surface
                - Spectroscopic databases
                  - Instrumental parameters
                  - Statistical analysis (bias and standard deviation)
                    « calc-obs »
                      - Observed spectra
                        - ARSA T, H₂O, O₃ surface
                          - Instrumental parameters
"See poster #S2.81"
Validation chain: Radiative transfer

1. Description of the atmospheric situation
2. Clear observed spectra
3. Spatio-temporal collocations
4. Radiative transfer algorithm
5. Simulated spectra
6. ARSA T, H$_2$O, O$_3$ surface
7. Spectroscopic databases
8. Instrumental parameters
9. Statistical analysis (bias and standard deviation)
10. «calc-obs»

See poster #S8.89
Validation chain: Spectroscopic parameters

- Observations
  - Clear-sky detection
  - Clear observed spectra
  - Spatio-temporal collocations
    - Description of the atmospheric situation
  - Statistical analysis (bias and standard deviation)
    - « calc-obs »
      - Observed spectra
      - Simulated spectra
        - Radiative transfer algorithm
          - ARSA T, H₂O, O₃ surface
          - Spectroscopic databases
          - Instrumental parameters

See poster #S8.91

(Armante et al, JMS, 2016 accepted)
This talk: Validation chain for L2 products

- Observations
  - Clear-sky detection
  - Clear observed spectra
  - Spatio-temporal collocations
  - Description of the atmospheric situation + L2

- Statistical analysis (bias and standard deviation)

- « calc-obs »
  - Simulated spectra
  - Radiative transfer algorithm
  - ARSA (T, H₂O, O₃ surface) + L2 products
  - Spectroscopic databases
  - Instrumental parameters

- L2 processing
Results: In the 2500-2760 cm\(^{-1}\) spectral region

Bias between simulated and observed brightness temperatures may be as high as \(1.5\) K especially in the 2720. – 2730 cm\(^{-1}\) spectral region. Sign is negative, indicating too high an absorption in this region. From GEISA \(\Rightarrow\) Main absorber is HDO

Several works indicate a vertical variation of the \(\delta D\) value
\[
\delta D = 1000 \times ([\text{HD}^{(16)}\text{O}]/[\text{H}_2^{(16)}\text{O}] / \text{SMOW} - 1),\]
with Standard Mean Ocean Water SMOW = \(3.1152 \times 10^{-4}\)

Vertical variation of the \(\delta D\) value:
Impact on Simulated vs Observed differences (mean H/D profile applied to each ARSA H\(_2\)O profiles)

Same H\(_2\)O and HDO profiles

GEISA 2015
4AOP-2012

Ratio H\(_2\)O/HDO applied to ARSA

GEISA 2015
4AOP-2012
Sensitivity of IASI channels to various atmospheric variables

- Evaluation of CO₂ retrieved at LMD from IASI/AMSU:
  - Mid-tropospheric column
  - Clear-sky, land/sea, day/night
  - NLIS method with 84 channels
  - Tropics only: 30S-30N

Averaged seasonal cycle

CO₂ (ppmv) by latitude band
IASI vs JAL/CONTRAIL

Per 5° band

North

South
Sensitivity to CO\(_2\): \(~0.035\ \text{K ppm}^{-1}\)

«calc – obs» when assuming a fixed CO\(_2\) at 372 ppm

→ trend and seasonality due to CO\(_2\) (1\(^{st}\) order: 2.1 ppm yr\(^{-1}\))
Carbon monoxide «calc – obs» when assuming a fixed CO$_2$ at 372 ppm $\rightarrow$ trend and seasonality due to CO$_2$ (1st order: 2.1 ppm yr$^{-1}$).

L2 Validation: GHG (CO$_2$ at 15 $\mu$m)

$\text{Sensitivity to CO}_2$: $\sim$0.035 K ppm$^{-1}$

«calc – obs» when using ARSA and the retrieved CO$_2$ column

«calc – obs» when assuming a fixed CO$_2$ at 372 ppm $\rightarrow$ trend and seasonality due to CO$_2$ (1st order: 2.1 ppm yr$^{-1}$)

Ch 218: used in the retrieval.
Carbon monoxide \( \Delta c-o \) \([372\text{ppm}]\) (K)

« Calc. – Obs. » 4A/OP, ARSA, Tropical, Sea, Day

L2 Validation: GHG (\(\text{CO}_2\) at 15 \(\mu\text{m}\))
• Taking L2 CO₂ yields radiative residuals Δc-o closer to 0 for channels mostly sensitive to CO₂ (wave numbers < Q-Branch at 720 cm⁻¹).

→ Good consistency between CO₂ retrieved from IASI and... IASI radiances.

• For ω > 720 cm⁻¹, seasonality and trend mostly removed but any spectroscopy issues could remained as well as high sensitivity to H₂O and O₃ has to be studied.
L2 Validation: GHG (CO at 4.6 µm)

ARSA (T, H2O, O3, Temp. Surface) + CO (LMD)

Ch. 6126
**Method**: Physical inversion of the RTE using a fast RT model (Péquignot et al., 2006, Capelle et al., 2012)

**outputs**:

- Sea: Surface Temperature
- Land: Surface temperature and emissivity continuous spectrum at 0.05 µm resolution between 3.7 and 14.0 µm for monthly grid (0.5° X 0.5°)
- ST and aerosols AOD for each IASI spot

See poster #S8.91
L2 validation: Impact of two different SST on the L1 “calc-obs” (1/2)

- NB: an alternative/first method developed at LMD was a regression using channels around 2143 cm\(^{-1}\)

- tropical, sea, night, 2007/07 → 2012/12 (snyder emissivity used)

60000 atms
L2 validation: The SST

- regression using the 2143.50 cm\(^{-1}\) IASI channel (blue)
- Physical method (red) (use of the emissivity of snyder)

2011 : 13000 atms
L2 validation: The SST

- regression using the 2143.50 cm⁻¹ IASI channel (blue)
- Physical method (red) ➔ emissivity of Snyder
L2 validation: The LST and emissivity

- Regression using the 2143.50 cm\(^{-1}\) IASI channel (blue)
- Physical method (red) → temperature and emissivity

Saharan collocations (100 km)
L2 validation: The LST and emissivity

- regression using the 2143.50 cm\(^{-1}\) IASI channel (blue), emiss.=0.98
- Physical method (red) \(\rightarrow\) temperature and emissivity

Saharan collocations (100 km)

Bias=0.85 K, Stdv=1.2 K

Poster #S5.105
Conclusions:

✓ Study of radiative biases give a way of evaluating the consistency of the retrievals
✓ Knowledge of channel characteristics vs. L2 is needed (e.g. tropo. vs strato, interferences between species, etc.) to refine the analysis
✓ Good constistency of the time series for one parameter at a time (HDO, GHG, Surface properties)
✓ Goal: 0 K radiative bias... if spectroscopy, RT code (e.g. line-mixing), instrument, etc. all properly taken into account!

Perspectives:

✓ Over sea, estimate also the emissivity and test it in the validation chain
✓ Look at the residuals as a function of the viewing angle to detect possible angular effect in the inversion (AMSU asymmetry, ...)
✓ Take into account various variables simultaneously.
✓ Validation with the use in the chain of other datasets: ECMWF, Eumetsat L2, ...
L2 validation: Thank you!

- **Clear-sky detection**
  - Clear observed spectra
  - Spatio-temporal collocations
  - Description of the atmospheric situation

- **Statistical analysis** (bias and standard deviation)
- **Calc-obs**
  - Observed spectra
  - Simulated spectra
  - Radiative transfer algorithm
  - ARSA T, H2O, O3 surface + L2 gases
  - Spectroscopic databases
  - Instrumental parameters

- **L2 processing**
  - T, GHGs, Surf.prop., HDO/H2O, ...

- **L2 observations**
- **EUMETSAT**
- **ARSA**
- **GEISA**
- **ECMWF**