Atmospheric Radiation Analysis
Laboratoire de Météorologie Dynamique/CNRS/IPSL

Interactive use of the new generation of TIR and SWIR space borne instruments to increase the performance of radiative transfer models, spectroscopic and atmospheric databases (4A, GEISA, ARSA)

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On behalf of Raymond Armante (*)

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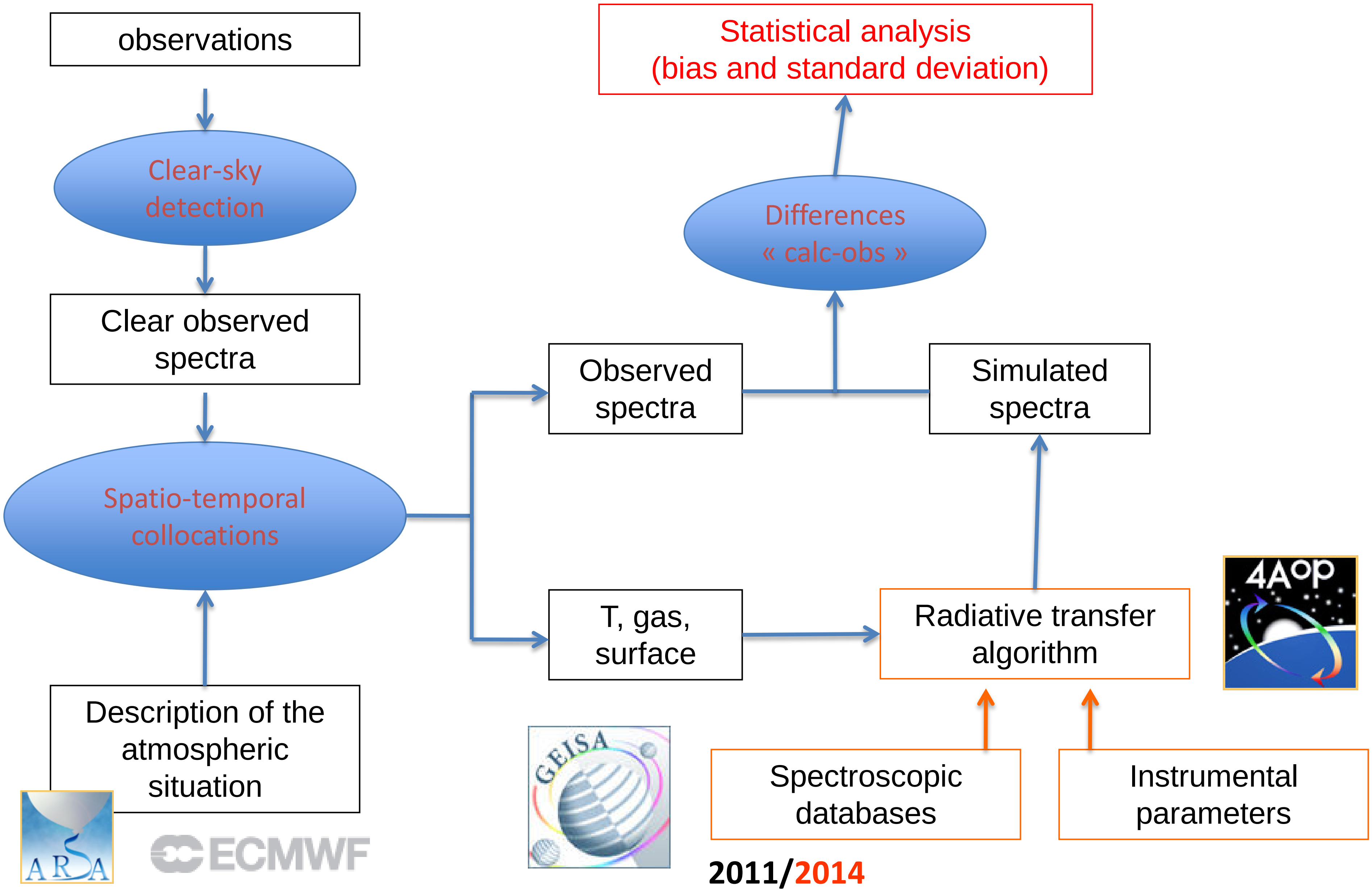
CAL/VAL chain developed at LMD

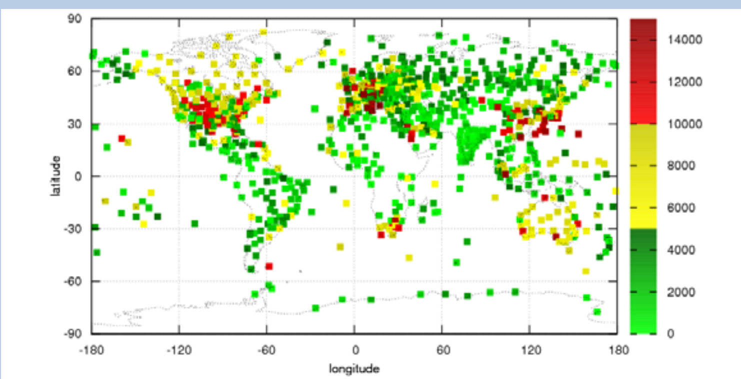


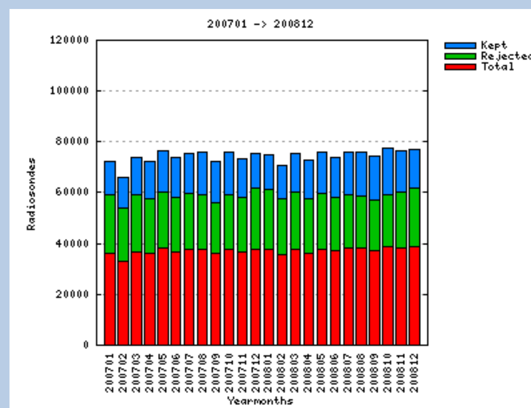
CAL/VAL chain developed at LMD

The Analysed RadioSounding Archive (ARSA)

- ❑ Selection of radiosounding from ECMWF selected on quality criterion (fully automated)
- ❑ Extrapolation of T and H2Oprofile when necessary
- ❑ Add missing parameters such as ozone profile and surface temperature

=> A 43-level description of the atmosphere between surface and 0.0026 hPa including P, T, H_2O, Ozone profiles, surface temperature, Geolocation + date/time





ARSA starts in January 1979 and is extended continously

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

ARSA available at LMD http://ara.abct.lmd.polytechnique.fr/index.php?page=arsa.

Spectroscopic databases

Instrumental parameters

2011/2014

CAL/VAL chain developed at LMD

Radiative Transfer algorithm 4A/OP

- ❑ Fast and accurate line by line developed by LMD [scott et al 1981]
- ❑ operational version maintained by Noveltis, LMD and with the support of CNES.
- ❑ based on pre-computed atlas of optical thicknesses
- ❑ can simulate any instrument and any configuration:
  - « Down » : for ground-based instrument as HR/FTS (TCCON)
  - « Downup » : for satellite such as TANSO (GOSAT, IASI,AIRS, HIRS,AMSU)
  - « limb » : ACE/FTS
- ❑4A/OP chosen as reference for many spatial experiments (in flight or in preparation)
  - IASI/IASI-NG (CNES/EUMETSAT)
  - Microcarb (CNES)
  - MERLIN (CNES/DLR)
- ❑ **available soon in a free licence (GNU/GPL) on http://4aop.noveltis.com/**

ntal
eters

2011/2014

Spectroscopic database GEISA : new update 2015

Scientific update at LMD
http://ara.abct.lmd.polytechnique.fr/

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22 molecules updated
2 new molecules

Distribution/vizualisation
http://ether.ipsl.jussieu.fr/etherTypo/?id=950

Molecule ID.	Code	Contributors
H_2O	1	L.Coudert , J. Tennyson, S. Mikhaïlenko, A.Campargue,O. Naumenko, A. Ruth, J.Orphal **HDO no more considered as an isotopologue of H_2O ; individual molecule [51]**
CO_2	2	R.T. Gamache
O_3	3	S. Mikhaïlenko
CH_4	6	L.R. Brown, V. Boudon, A.Campargue D.C. Benner
O_2	7	S. Yu B. Drouin
SO_2	9	D. Jacquemart
NH_3	11	M. Down, J. Tennyson, L.R. Brown
HNO_3	13	A. Perrin ($H_{15}NO_3$ New isotopologue)
H_2CO	21	D. Jacquemart
C_2H_6	22	L. Brown
CH_3D	23	A. Campargue.
C_2H_2	24	D. Jacquemart
C_2H_4	25	J.-M. Flaud
HCN	27	J. Tennyson
C_2N_2	29	A. Jolly.
C_4H_2	30	A. Jolly
CH_3Cl	34	D. Jacquemart, A. Nikitin
H_2S	36	O. Naumenko
CH_3Br	43	D. Jacquemart.
HNC	46	J. Tennyson
HDO (NEW)	51	S. Mikhaïlenko ,O. Naumenko
SO_3(NEW)	52	J. Tennyson/

Total number of molecules in GEISA-2014: 52

Des... atmospheric situation

Spectroscopic databases

Instrumental parameters

2011/2014

CAL/VAL chain developed at LMD

observations

Clear-sky detection

Clear observed spectra

Spatio-temporal collocations

Description of the atmospheric situation

Statistical analysis
(bias and standard deviation)

fferences

⇒ Several thousands of situationss

⇒ Removes random errors (uncertainties on the thermodynamic profile, instrument noise)

⇒ Highlights systematic errors: RT, spectroscopy, intrumental derive)

⇒ sensitivity better than the instrumental noise

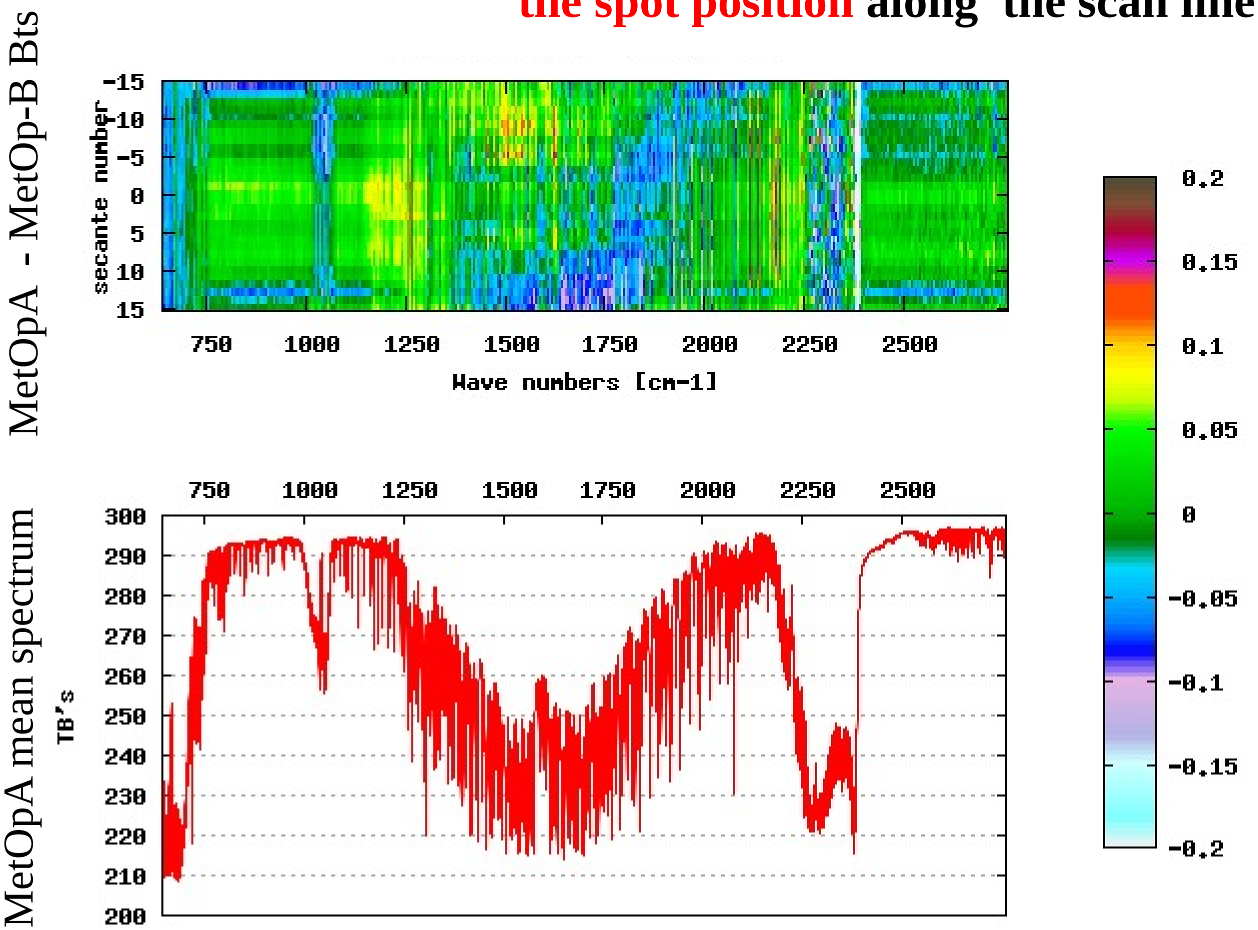
Spectroscopic databases

Instrumental parameters

2011/2014

Lessons learned of the CAL/VAL during early dissemination of MetOp-B

Hovmöller diagram of Double Differences of MetOp-A and MetOp-B BT residuals versus the spot position along the scan line



4A/OP RT algorithms

Thermodynamic informations from ECMWF analysis

Night/Sea/Tropical scenes

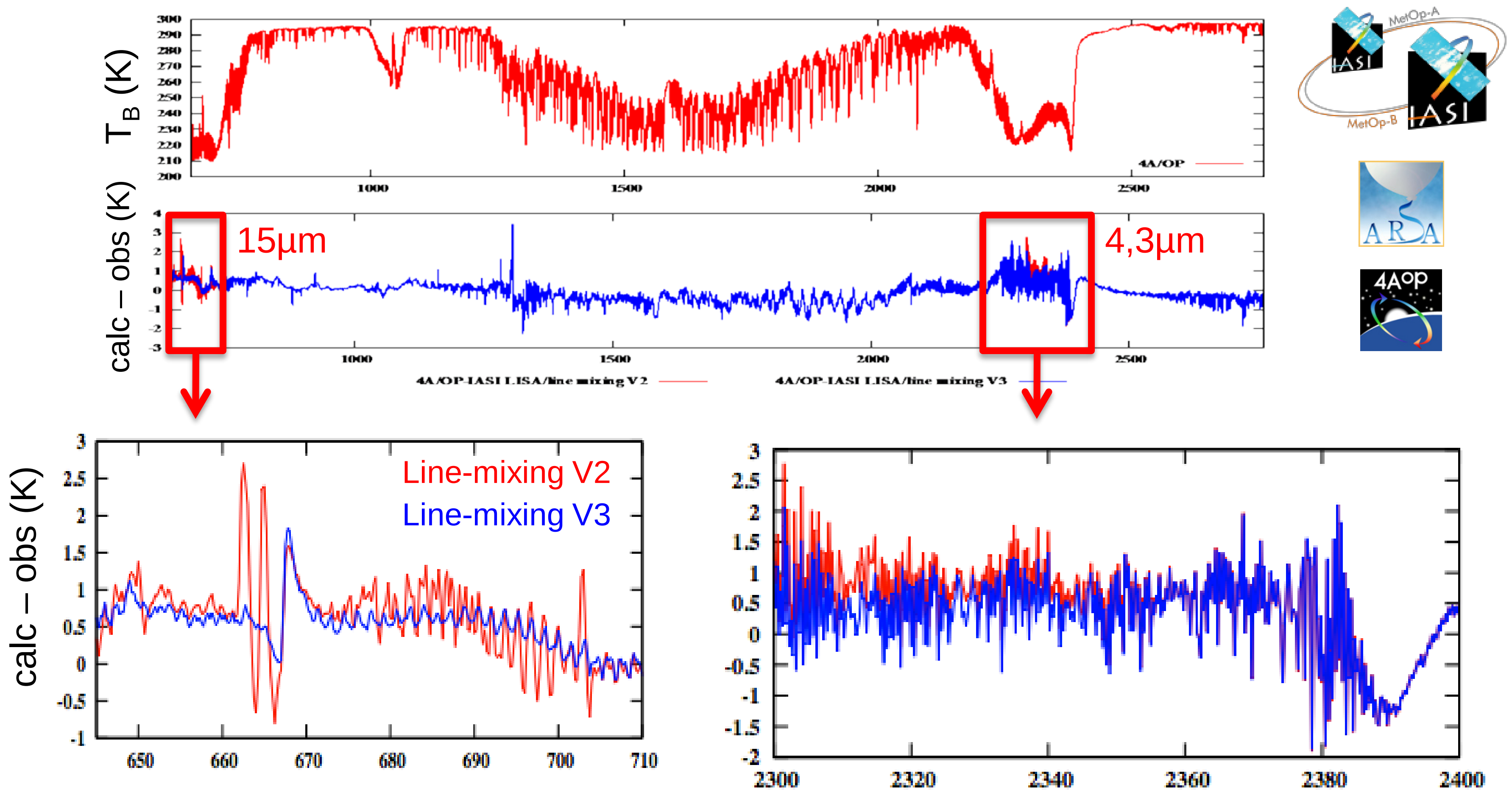
Several thousands of items per scan angle

High stability of level 1 radiances between MetOp A and B, even with the viewing angle (small features less than 0.15 K in absolute value)

➔ ***only possible with a CAL/VAL chain where all the actors are controlled***

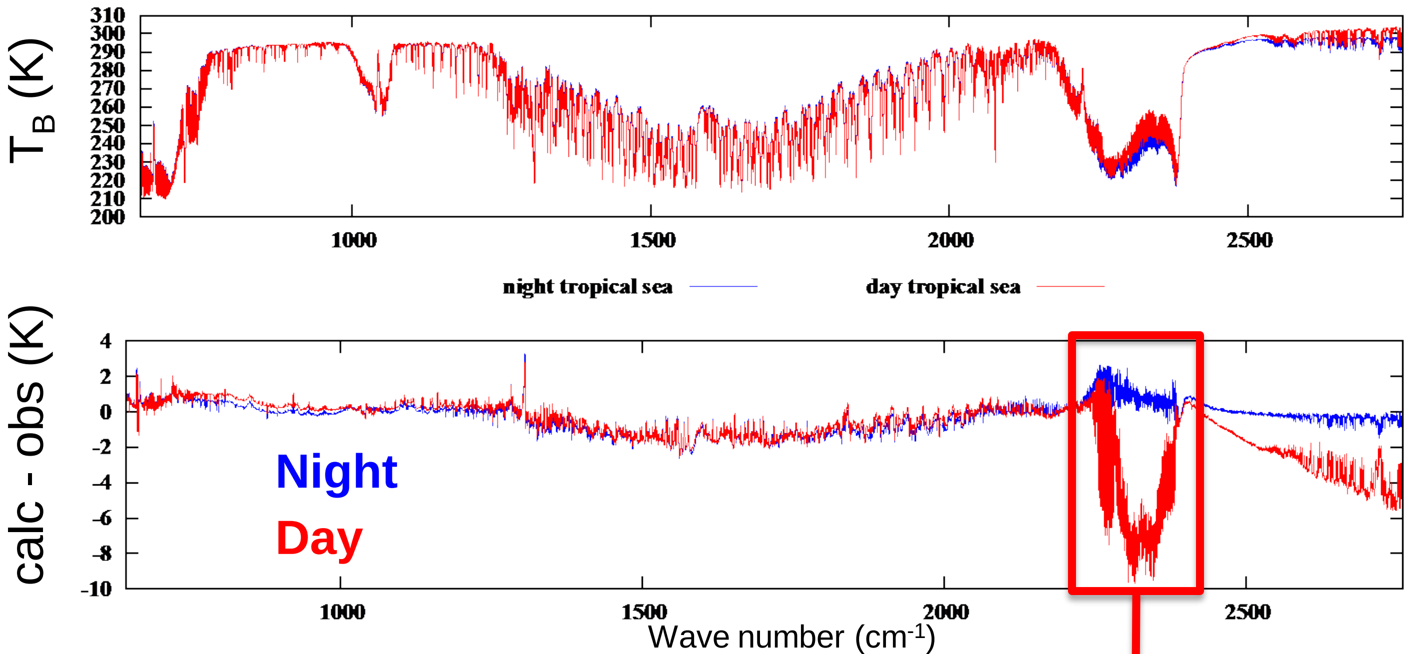
Results often presented at the previous conferences

Spectroscopic studies as Line-mixing of CO_2 at 15 µm and 4.3 µm (Hartmann et al)



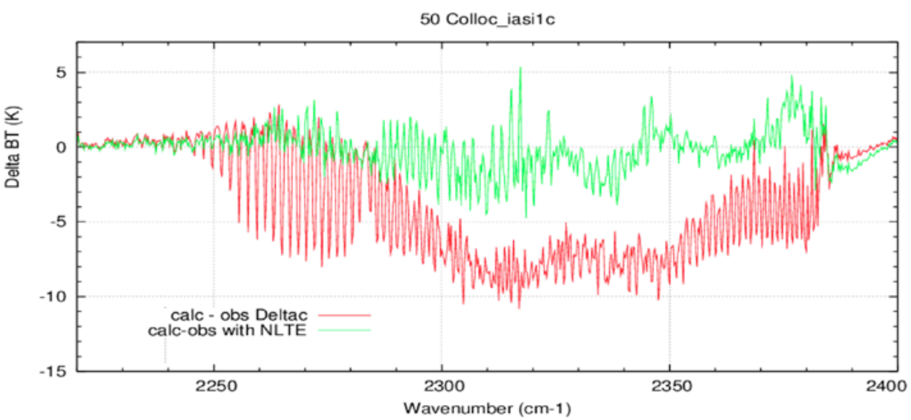
- ✓ **This work is done throughout the year**
- ✓ **What's new at LMD today ?**

Non-LTE



Collaboration with A. Feofilov

Physical approach choosen in 4A/OP



Estimation of vibrational temperature for the main transition

Reading 4A/OP atlases for Tvib against the Kinetic temperature in the normal case (ETL)

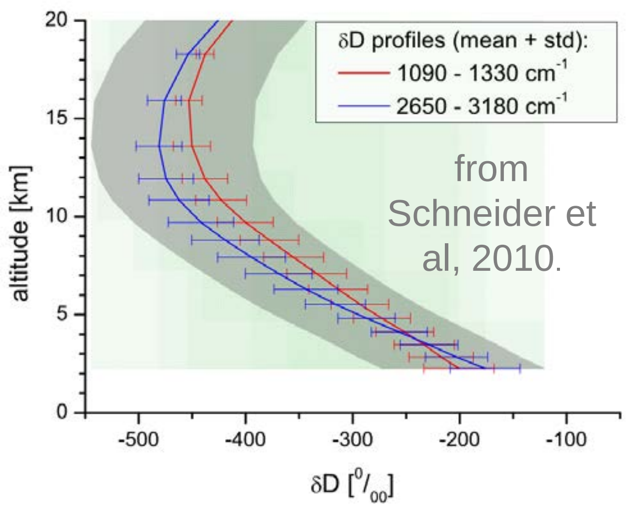
← Results for the main band

Validation of the band 3 of IASI

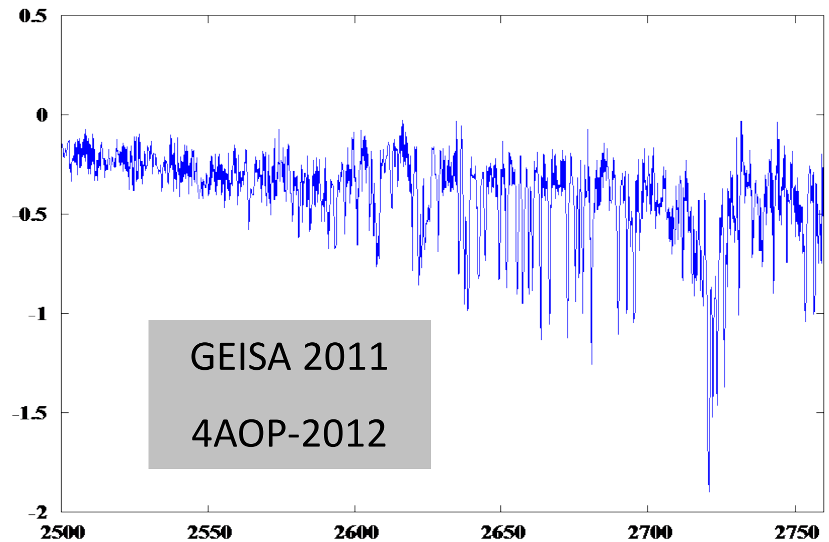
Results : In the 2500-2760 cm-1 spectral region

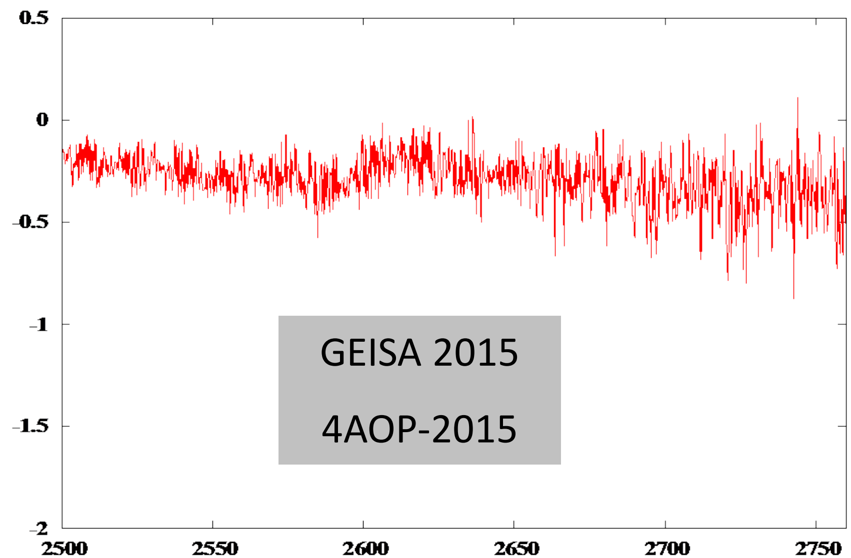
Bias between simulated and observed brightness temperatures may be as high as **1.5 K** especially in the 2720. – 2730 cm-1 spectral region. Sign is negative, indicating too high an absorption in this region.
From GEISA ➔ Main absorber is ***HDO***

Several works indicate a vertical variation of the δD value
$\delta D = 1000 \times ([HD^{(16)}O]/[H_2{}^{(16)}O] / SMOW - 1)$, with Standard Mean Ocean Water $SMOW = 3.1152 \times 10^{-4}$

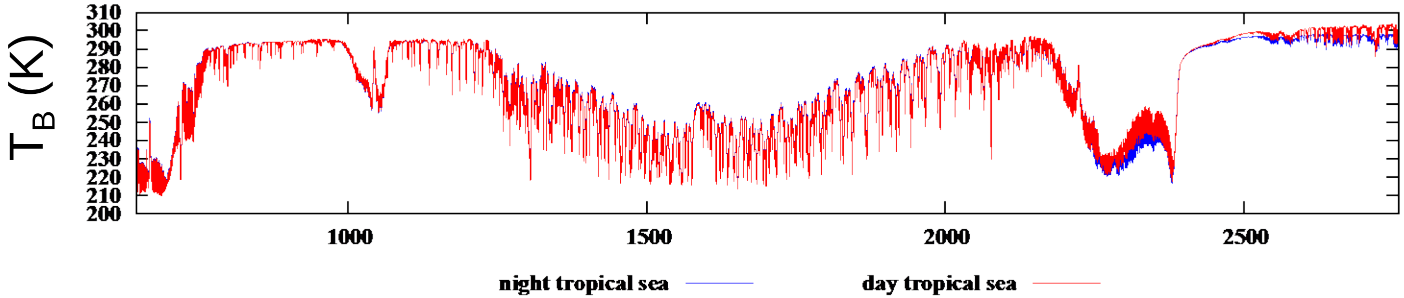


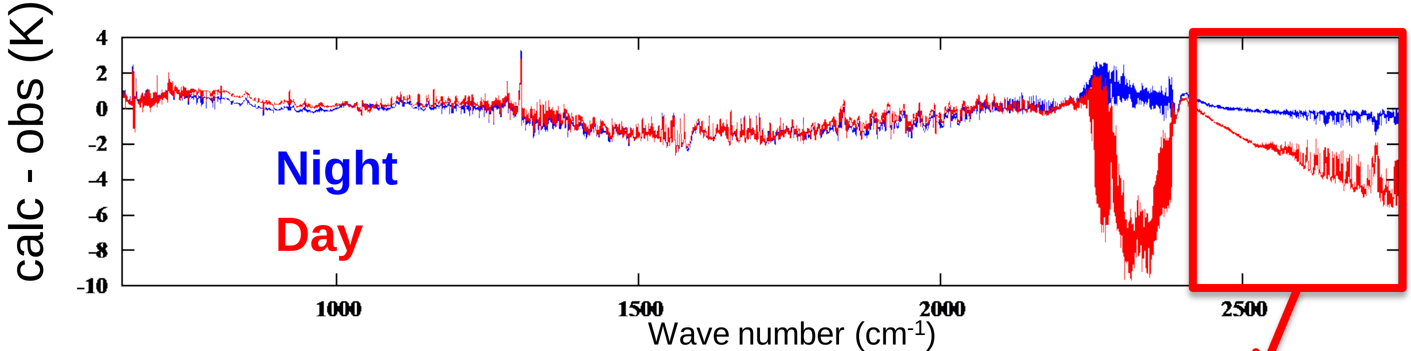
Vertical variation of the δD value :
Impact on Simulated vs Observed differences (mean H/D profile applied to each ARSA H_2O profiles)

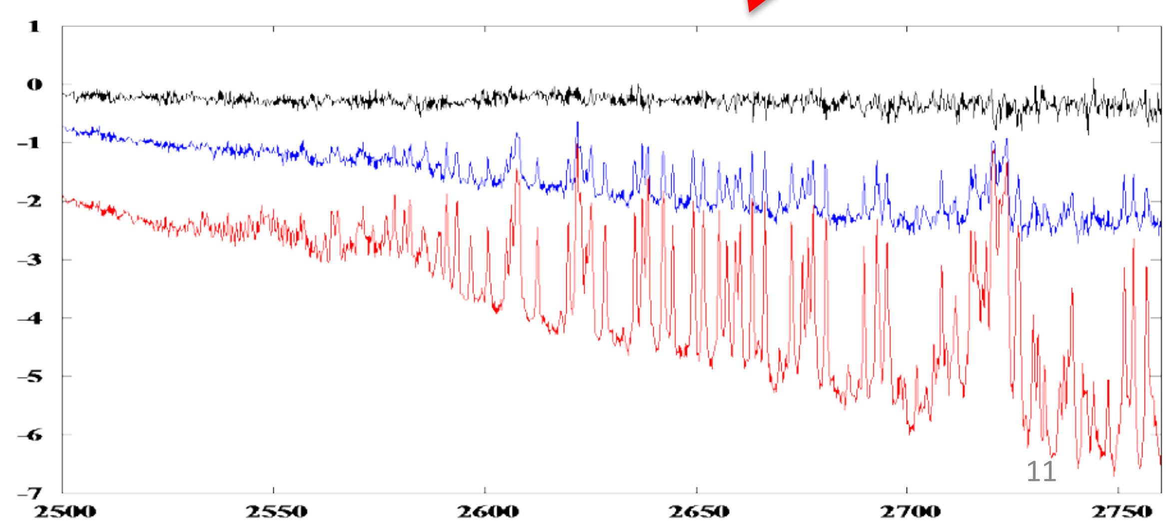




Solar contribution







Sea/**Night**

Sea/Day without solar contribution

Sea/Day with solar contribution

(Residuals obtained with HDO and H_2O dissociated)

Solar contribution

channel 7428 (2501.75 cm-1) of IASI

- ✓ Total transmission function approximatively 0.93 over sea (weak absorption of the atmosphere)
- ✓ TB(7428) near the SST for clear sky
- ✓ TB(7428) < SST without solar contribution

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Sea/Day without solar contribution

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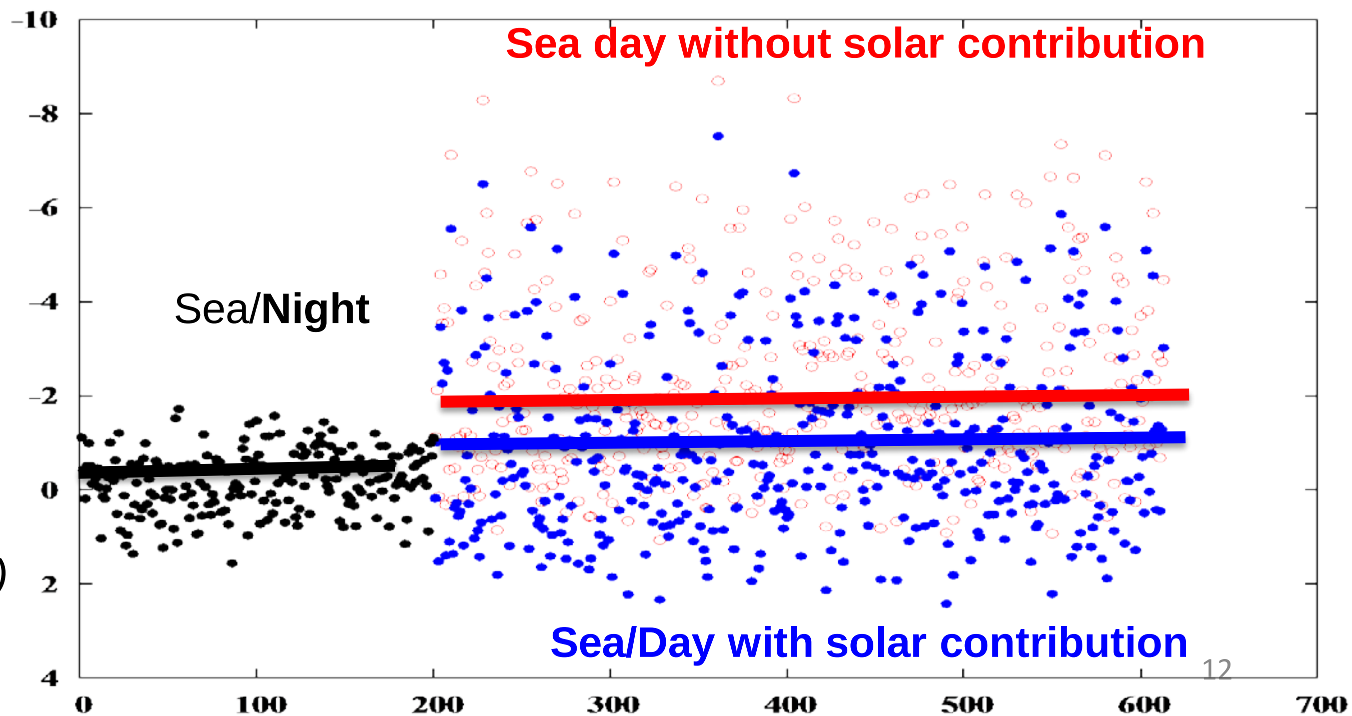

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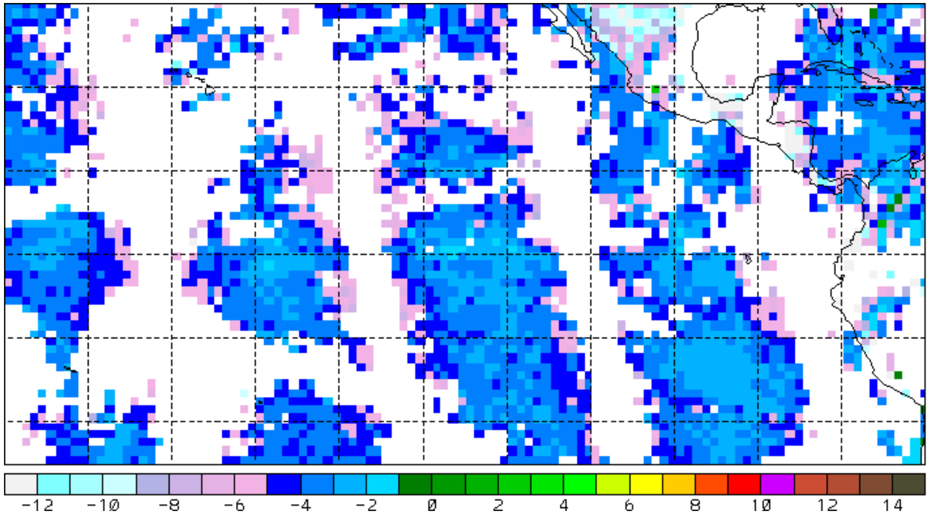
2013/01/03 differences TB IASI clear observations and ECMWF SST analyses (night)



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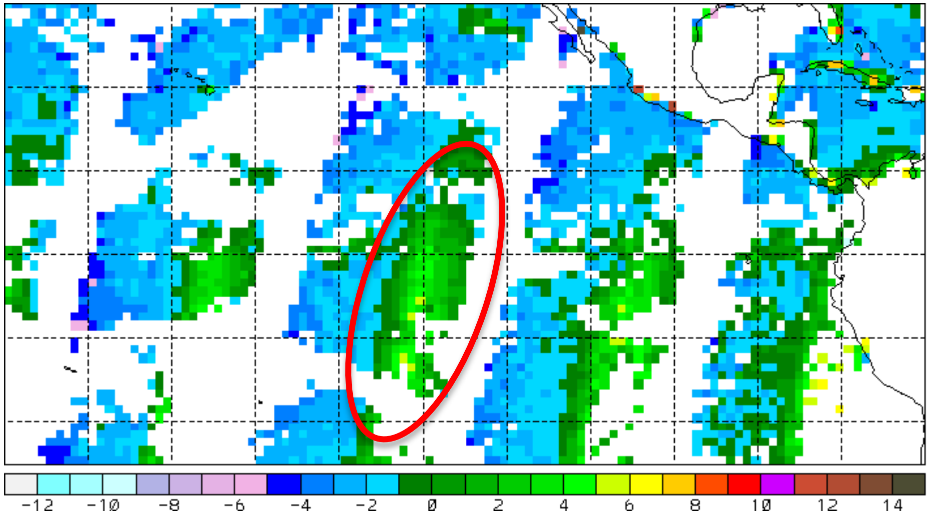

Glint effects (VZA = SZA) ?

Study of the impact of the use of BRDF rather than emissivity in RT models

➔ Cox and Munk BRDF in 4A/OP (work in progress with Noveltis)

Validation of the spectroscopic database GEISA 2015

SWIR

Ground-based data - TCCON network

Fourier transform spectrometer (HR/FTS)

- 2 detectors:
  - Ingaas (4000-11000 cm^{-1})
  - Si-diode (11000-13000 cm^{-1})

Spectral resolution : $7.3x10^{-3}$ cm^{-1}

https://tccon-wiki.caltech.edu/

✓*Control the quality of the proposed updated*

✓*Able to discriminate which parameters are involved*

✓*Sensitivity of residuals to pressure shift*

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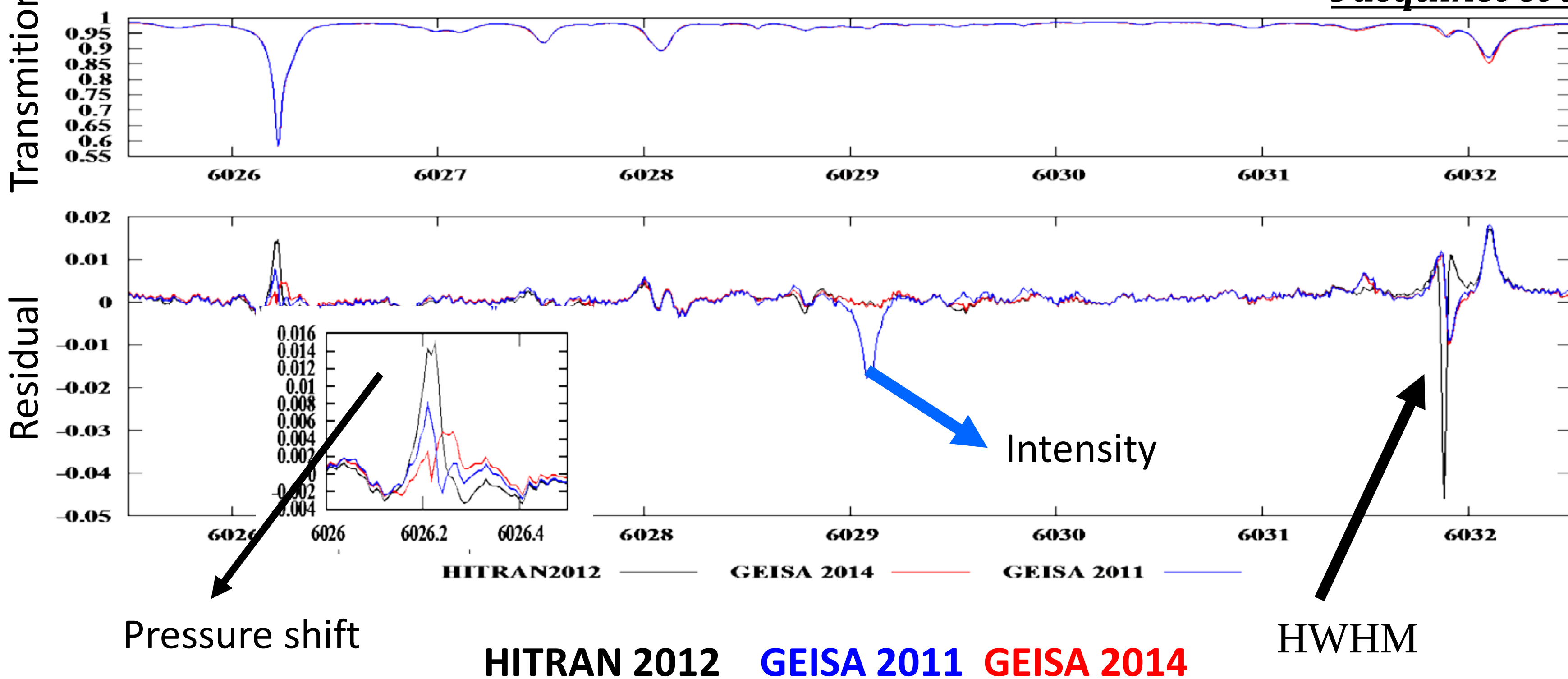
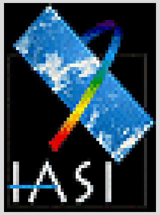


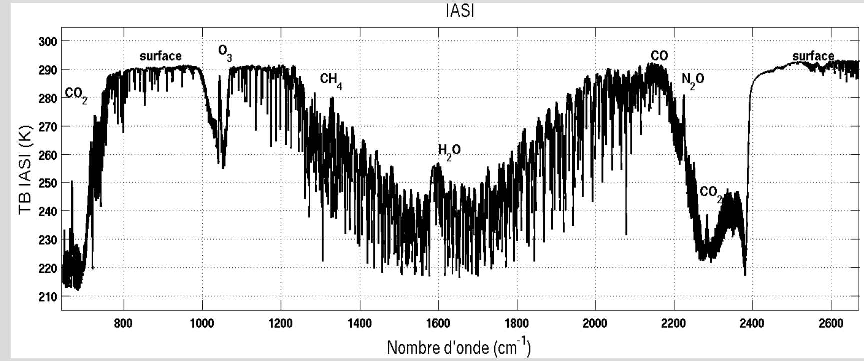
Validation of the spectroscopic database GEISA 2015

The IASI instrument



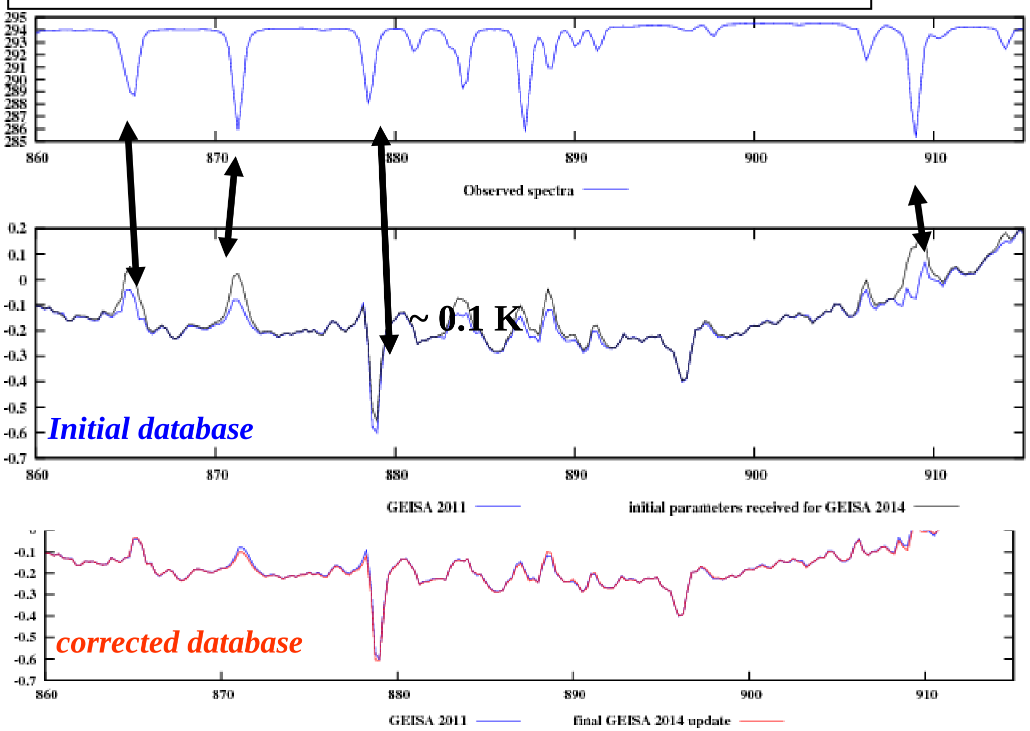
IASI characteristics :

- 8461 spectral channels between 645 and 2760 cm^{-1} (15.5 - 3.63 µm)
- spectral resolution of 0.5 cm^{-1} after apodisation ("Level 1c" spectra)
- spectral sampling interval is 0.25 cm^{-1}
- nadir FOV: 12 km



IASI instrumental noise ~ 0.25 K

New update of H2O/HDO in GEISA 2015



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➔ **Systematic 0.1 K biases observed with the new dataset of H_2O/HDO**

➔ **residual analysis permits to identify a bad estimation of the HWHM parameter**

➔ **returns to the laboratory and corrections done (red curve)**

Error < 10% in HWHM values detected

Conclusions

Chain able to validate all the actors:

- ✓ **Instrumental (CAL/VAL activities)**
- ✓ **Thermodynamic (ARSA reference for GEWEX)**
- ✓ **Cloud detection (clear case selection)**
- ✓ **RT algorithms (line mixing, N-LTE, solar, …)**
- ✓ **Spectroscopic parameters**

even if their signature on residuals is weak and much lower than instrument noise

➔ Important for future mission as IASI-NG