Applied Spectroscopy

Using the full IASI spectrum for the physical retrieval of Temperature, Water Vapour, HDO, Ozone and minor and trace gases: CO, CO_2, CH_4, N_2O, SO_2, HNO_3 and NH_3, OCS, CF_4

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Objective

- Perform a comprehensive retrieval analysis using all IASI channels (8461) and the full non-diagonal covariance matrix (8461×8461) aiming at
  - Assessing the consistency of spectroscopy and forward modelling
  - Setting a reference to the IASI retrieval precision, especially for greenhouse gases.

Tools

- The σ-IASI forward model (see Liuzzi et al. Poster S8-83)
  - Amato et al. (2002), doi:10.1016/S1364-8152(02)00027-0
- The δ-IASI inverse model
  - Carissimo et al. (2004), doi:10.1016/j.envsoft.2004.07.003
- The new CDA (cumulative discriminant analysis) for cloud detection
  - Amato et al. (2014), doi:10.5194/amt-7-3355-2014

Reference Spectroscopy

- LBLRTM AER v3.2 line parameter data base with the continuum absorption MT_CKD 2.5.2
  - (e.g. see http://rtweb.aer.com/lblrtm_frame.html).
- The AER line data base adopts HITRAN2008 with exceptions for H_2O, CO_2 and O_2.
- For what concerns the IASI spectral range, the H_2O line positions and intensities for the wavenumber region from 10 to 2500 cm^{-1} are from *Coudert, 2008*; CO_2 absorption optical depth calculations take advantage of the first order line coupling coefficients re-calculated using the formalism of *Niro, Jucks, and Hartmann, 2005*

Reference state vector: retrieved parameters

Profile

- T, H_2O, HDO, O_3 + surface temperature
- Background: ECMWF model

Column abundance

- CO, CO_2, CH_4, N_2O, SO_2, HNO_3 and NH_3, OCS, CF_4
- Background: basically climatology

Case Study: two-years long IASI record close to Mauna

Mauna Loa Validation Station, Hawaii, Pacific Ocean

Acknowledgement

In situ observations recorded at Mauna Loa and Hilo Observatories in Hawaii have been downloaded from the web page http://www.esrl.noaa.gov/gmd/obop/mlo/.

These observatories are part of the National Oceanic and Atmospheric Administration (NOAA), the Earth System Research Laboratory (ESRL) and the Global Monitoring Division (GMD).
We give credit to the National Oceanic and Atmospheric Administration (NOAA)/Global Monitoring Division (GMD) in Boulder as a source of the data.
Mauna Loa methane data have been provided to us by Dr Ed Dlugokencky, carbon monoxide by Dr Paul Novelli.

- From January 2014 to December 2015:
  - 5908 clear-sky, sea surface **night-time** IASI soundings processed for retrieval

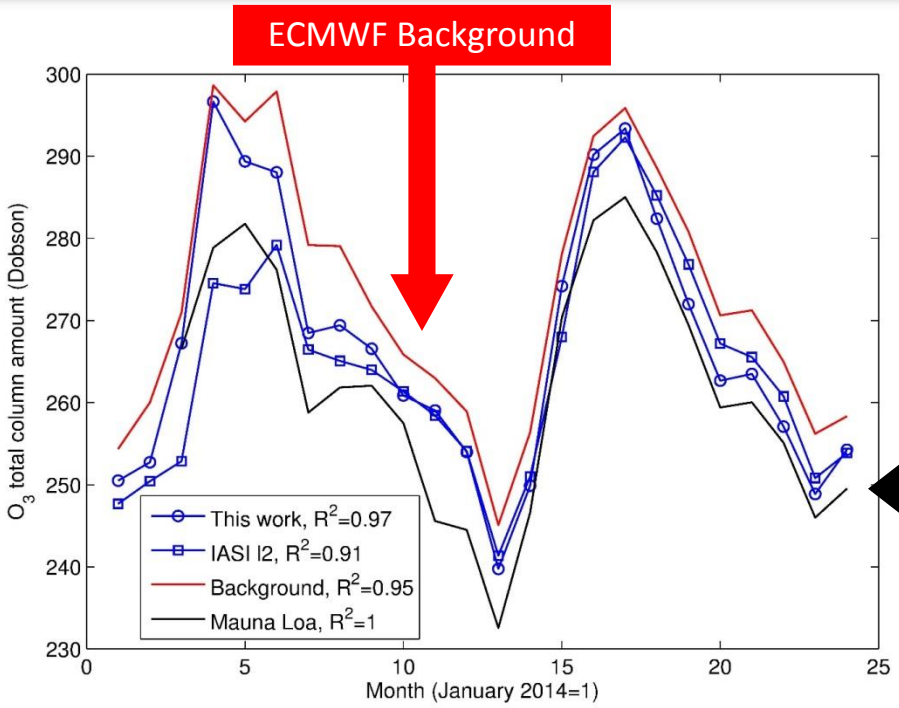
Results

- Retrievals
  - Comparison with
    - Mauna Loa in situ observations,
    - (EUMETSAT) IASI L2 products,
    - AIRS-CO_2
- Profile-species dependent spectral residuals
- Spectroscopy

Results summary for Gases: column abundance

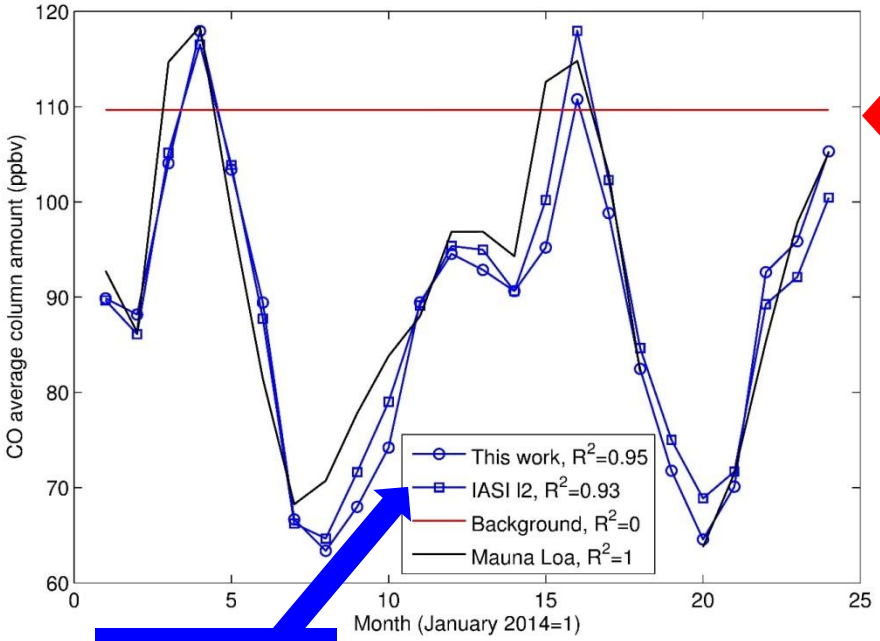
Gas	Background Error (%)	Expected Retrieval error (%)	DOF	Entropy gain (bits)
CO_2	10	0.18	1	5.80
CO	10	1.24	1	3.01
CH_4	10	0.46	1	4.38
N_2O	10	0.42	1	4.57
HNO_3	10	6.10	0.63	0.71
OCS	10	5.57	0.68	0.84
CF_4	10	7.3	0.47	0.44
SO_2	10	10	0	0
NH_3	10	10	0	0

Retrievals examples, Monthly average of total ozone



The Ozone layer from sea level to Mauna Loa station is 7 to 10 Dobson

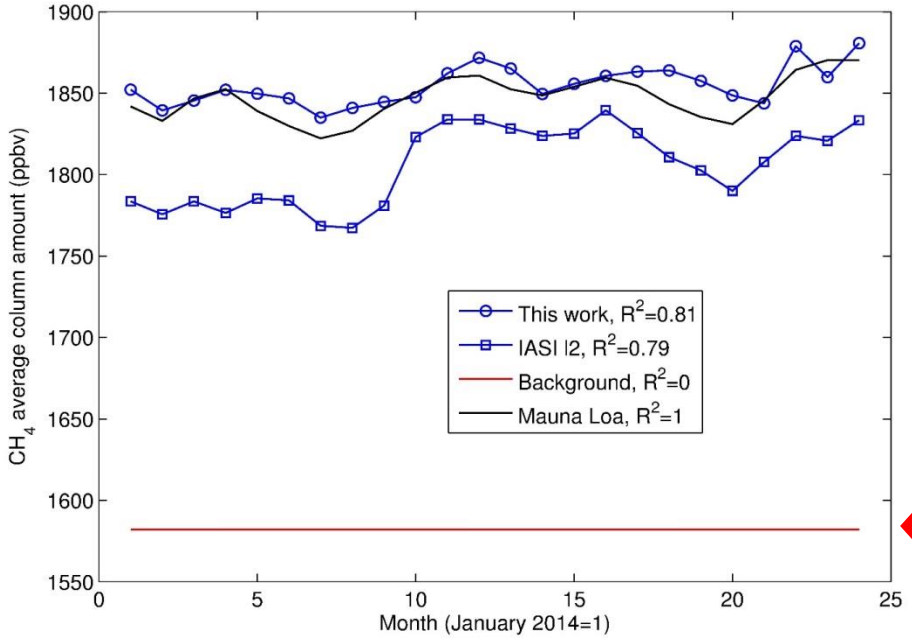
Retrievals examples, Monthly average of CO column



Constant background

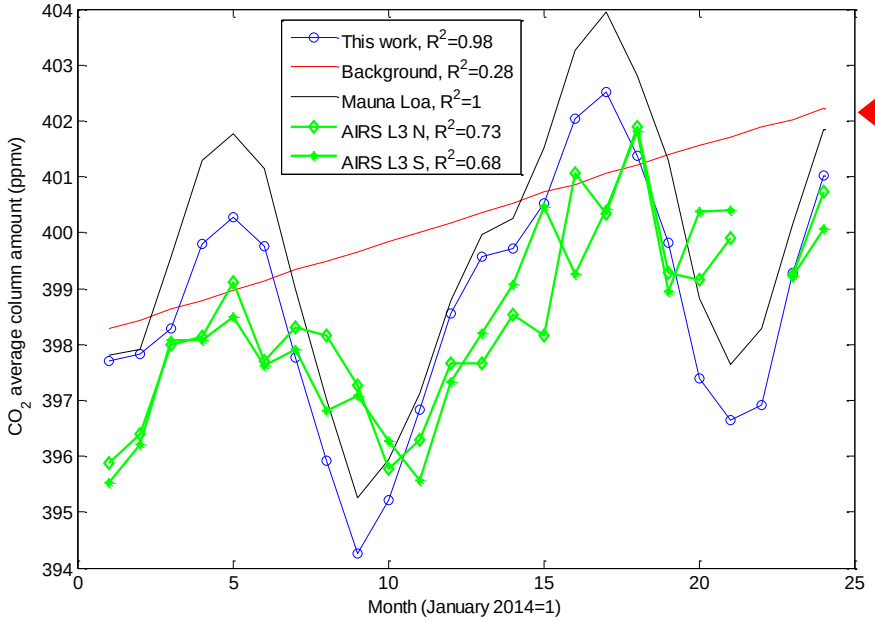
FORLI-CO

Retrievals examples, Monthly average of CH_4



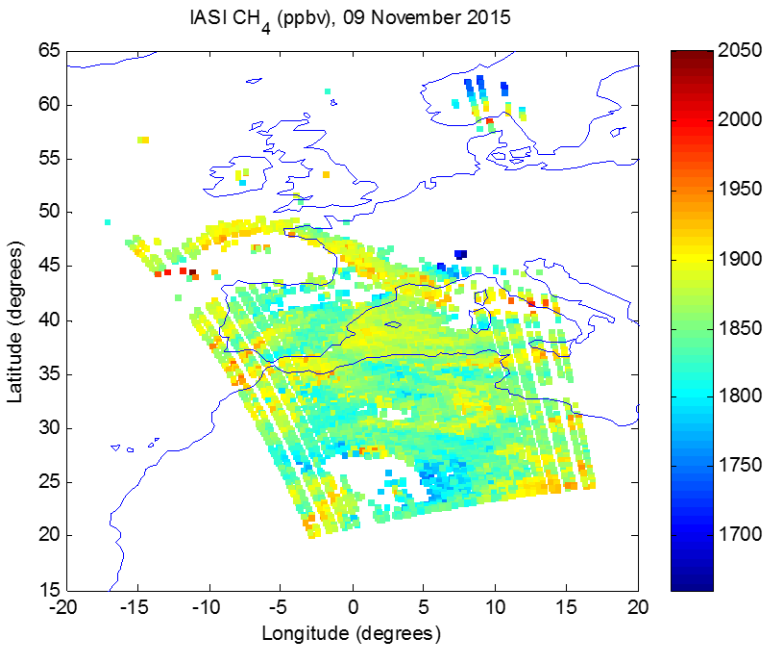
Constant background

Retrievals examples, Monthly average of CO_2



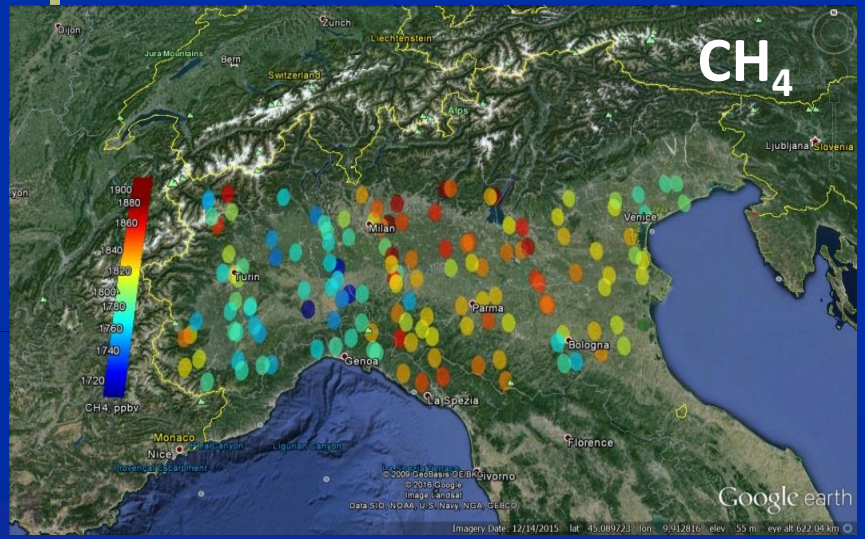
Background with a constant slope of 2 ppmv/year

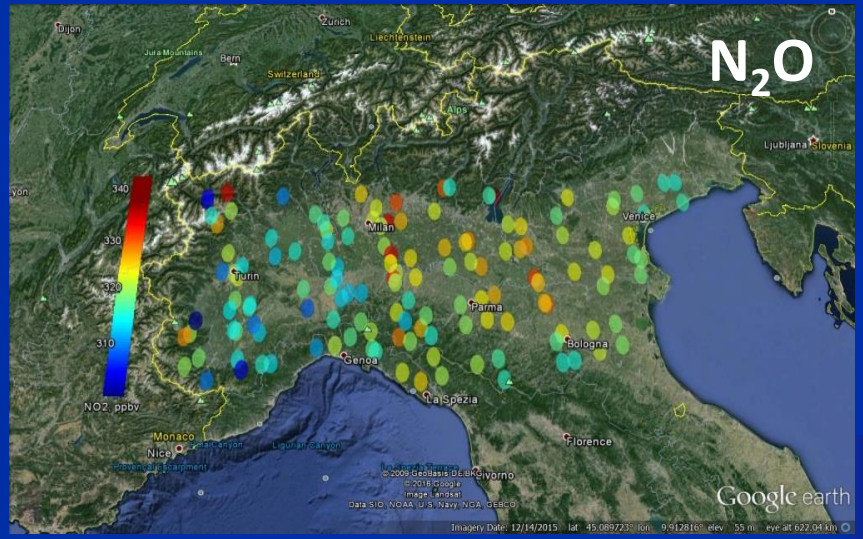
The precision for the single IASI field of view



- The precision for the single IASI field of view is as good as to avoid spatial and/or temporal smoothing (example from a single IASI orbit: 09 November 2015)

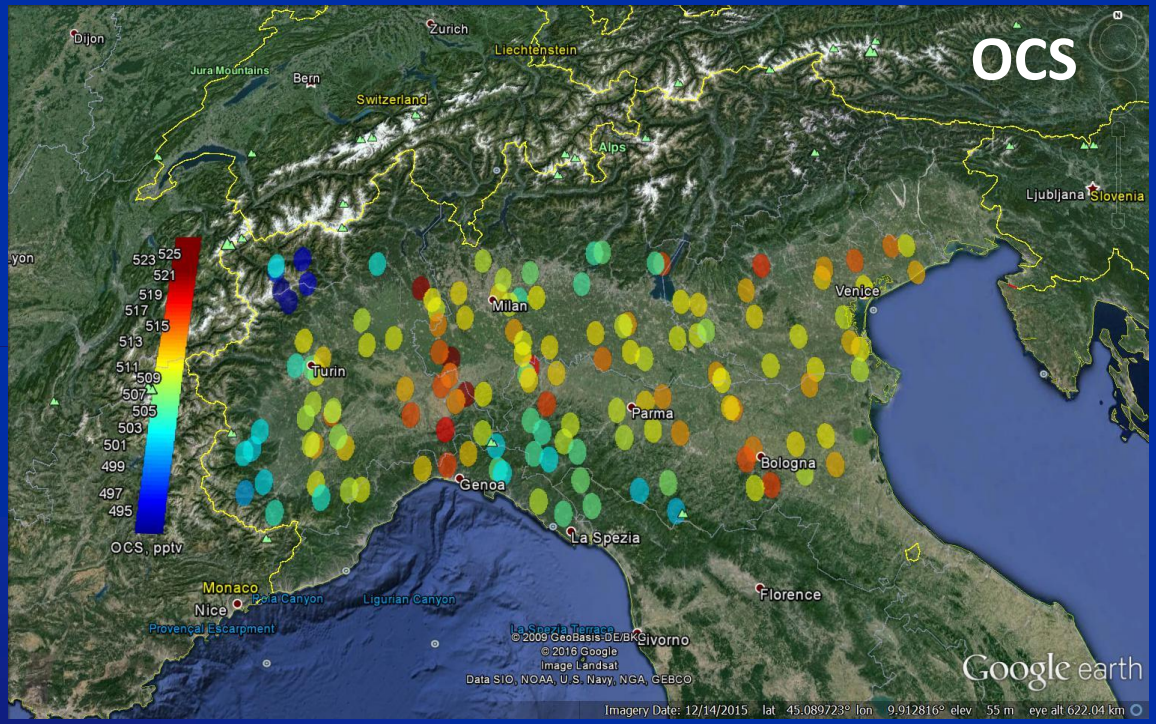
The precision for the single IASI field of view





- The precision for the single IASI field of view is as good as to avoid spatial and/or temporal smoothing (this allows us to see local spatial patterns)
  - *IASI-A and IASI-B, 1 orbit 2015-01-27*

The precision for the single IASI field of view



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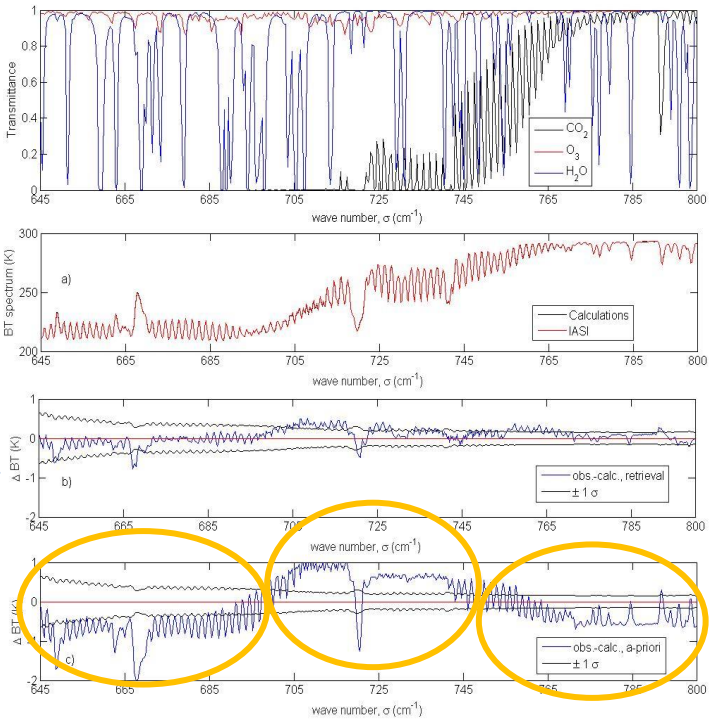
T-Profile-dependent spectral residuals

τ

BT

This work

ECMWF



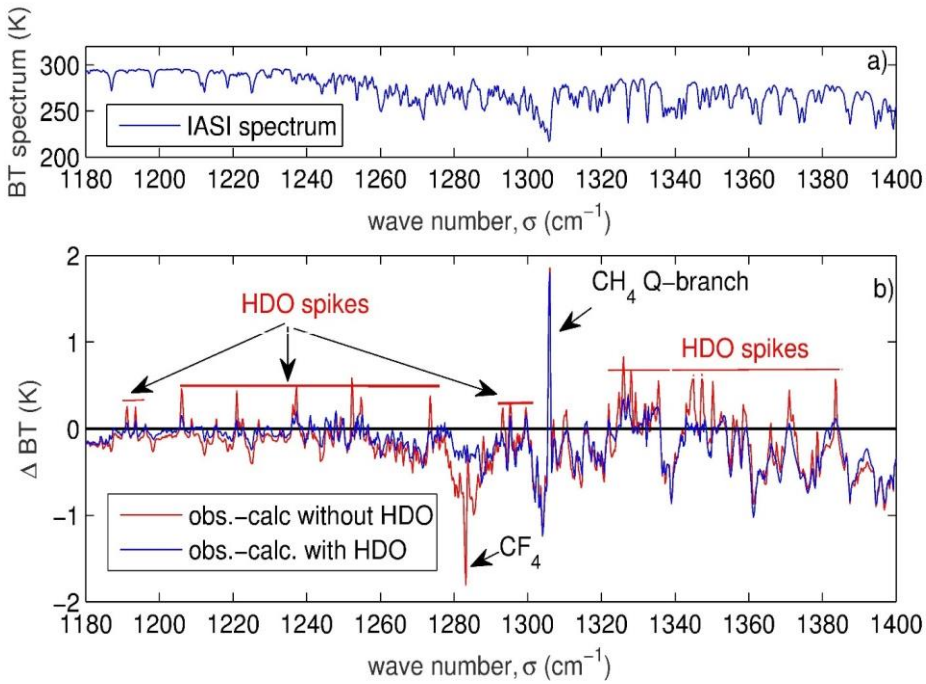
Average over 5908 IASI soundings

Stratopause too warm

Tropopause too cold

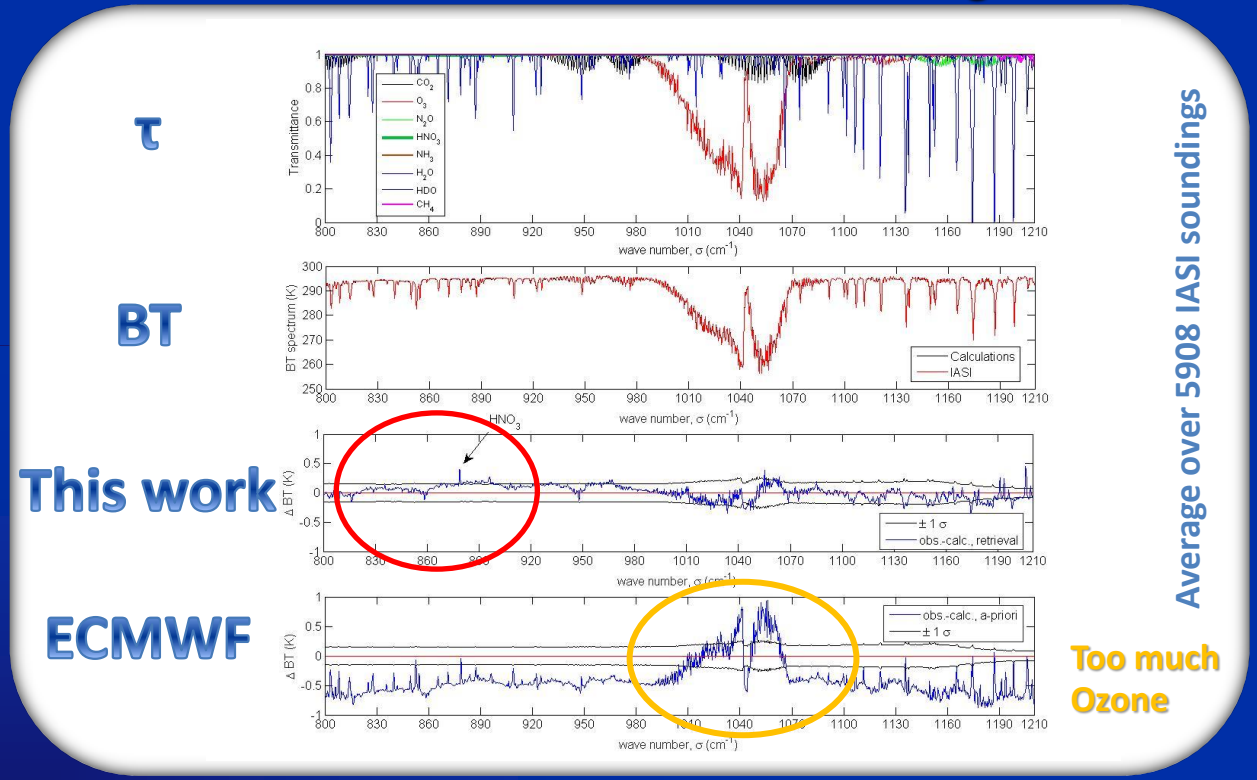
Surface Temperature too warm

Species-dependent residual: HDO and CF_4



Average over 5908 IASI soundings

Species-dependent residual: ECMWF O_3



- The positive bias @ 879 cm^{-1} for is a clue of spectroscopic issue (line mixing in Q-branches)
- the same misfit has been also evidenced with limb (MIPAS) observations,
  - J. Plieninger, et al. 2012, JQSRT, doi:10.1016/j.jqsrt.2012.02.008.

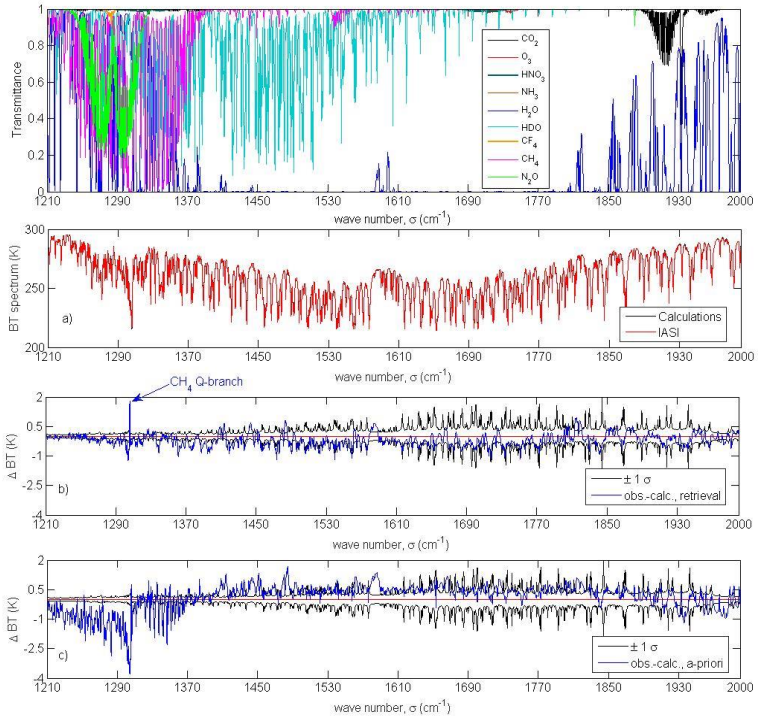
Spectroscopy: H_2O

τ

BT

This work

ECMWF



Average over 5908 IASI soundings

- For the water vapour a cold bias remains in the whole ν_2 band, which cannot be explained with profiles-species effects.

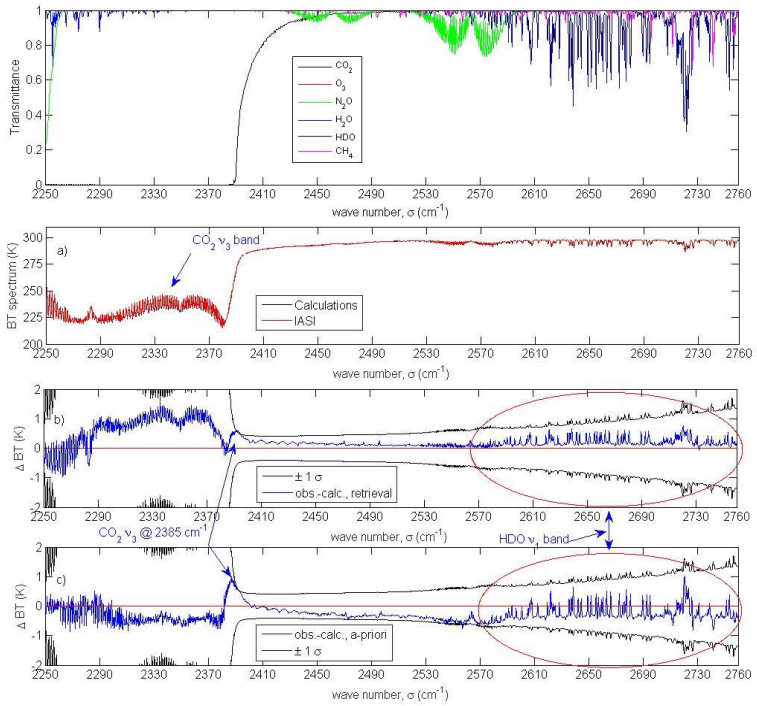
Spectroscopy: CO_2

τ

BT

This work

ECMWF



Average over 5908 IASI soundings

- The band-head at 4.3 µm still poorly reproduced, inconsistency of CO_2 stratospheric channels, colder in long-wave, warmer in shortwave

Conclusions

- Retrieval with all IASI channels is practical and reliable and shows
- IASI is not yet fully exploited for CO_2, N_2O and CH_4
- IASI retrieval of HNO_3, OCS and CF_4 is feasible
- ECMWF temperature biases are evident in spectral residuals:
  - Spectroscopy (?)
  - IASI is not yet correctly assimilated (?)
- Spectroscopy is still an issue in IASI band 2 (H_2O) and band 3 (CO_2)