IASI Level 2 CO product

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Introduction

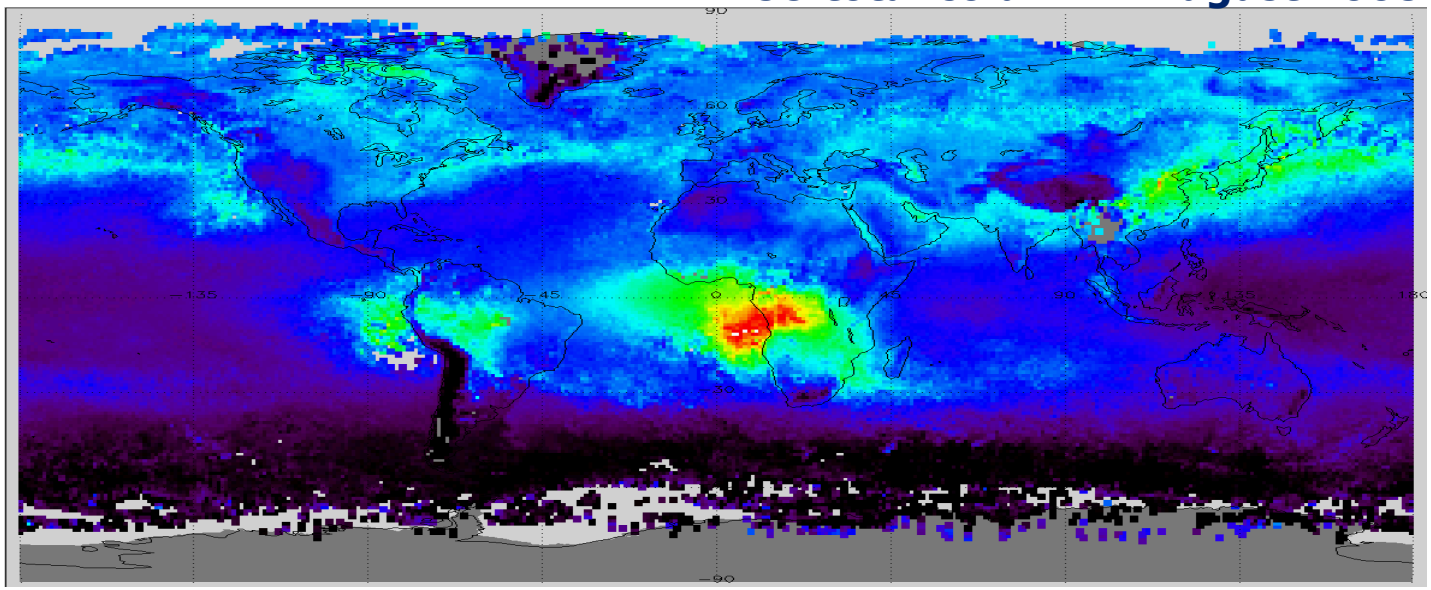
I. Background information

II. The retrieval scheme, upgrades & performances

III. Validation / Intercomparison results

IV. Conclusions & perspectives

CO total column :: August 2008



1 — 4×10^{18} molec/cm^2

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History of the CO product

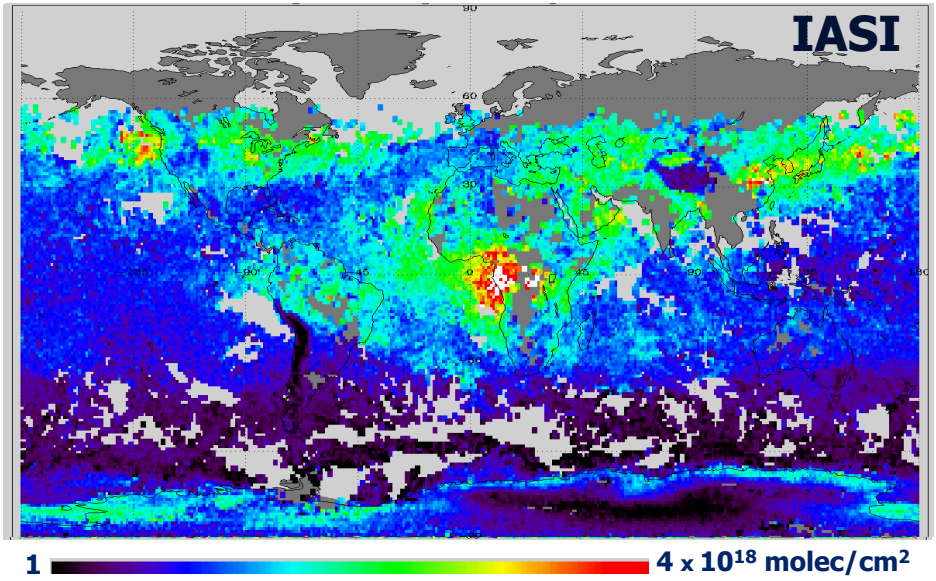
- Chemistry products belong to IASI L2 suite: O_3, **CO**, CH_4, N_2O and CO_2
- **Total columns** + 3 partial columns for ozone
- ANN trace gases retrieval from nadir-looking IR sounder long demonstrated (ref. Clerbaux, Turquety, Hadji-Lazaro, 1998, 1999, 2001…)
- Basis for specifications of IASI L2 processing chain and implementation of the IASI L2 PPF up to version 4
- First trial dissemination in Spring 2008 => CalVal

Initial product characterisation

Main features are captured but

- !! ~~Positive bias~~ –
- !! ~~Failure over elevated surfaces~~
- !! Troubles over ice & desert
- !! Angular dependency

Patch January 2009



average CO 01-05 August 2008

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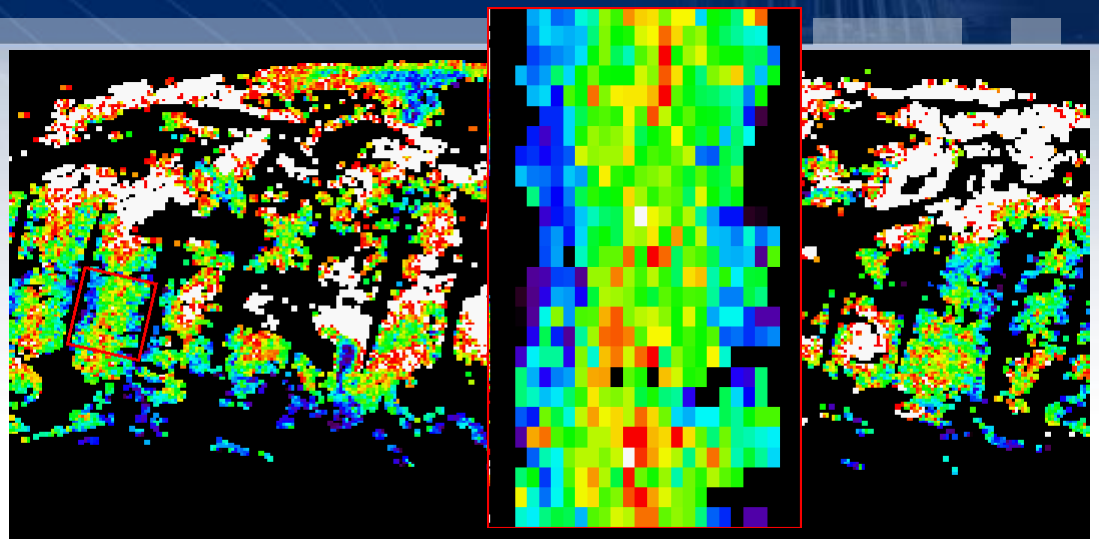
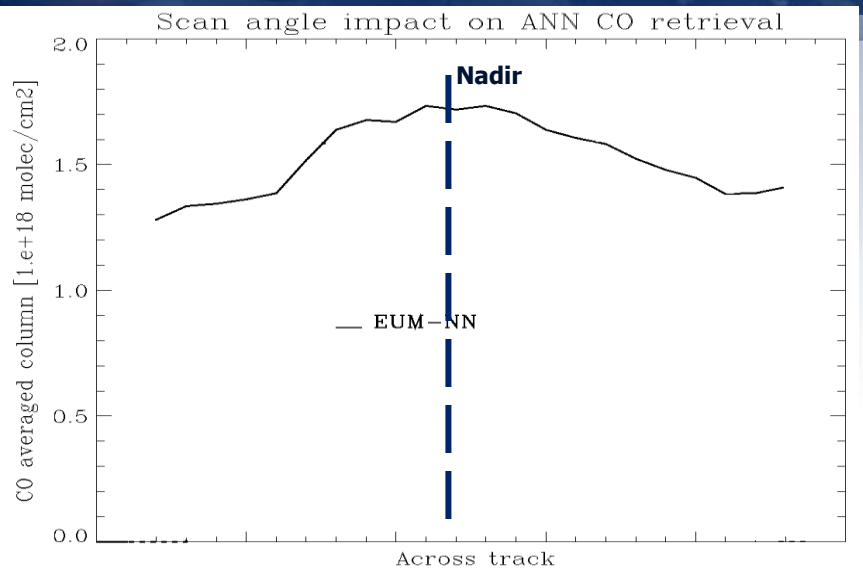
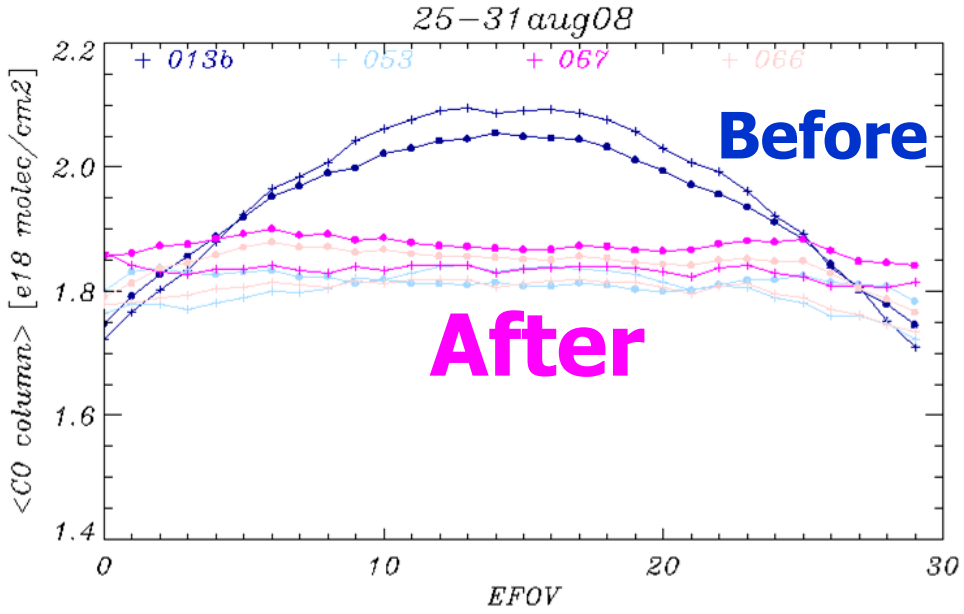
Angular dependency







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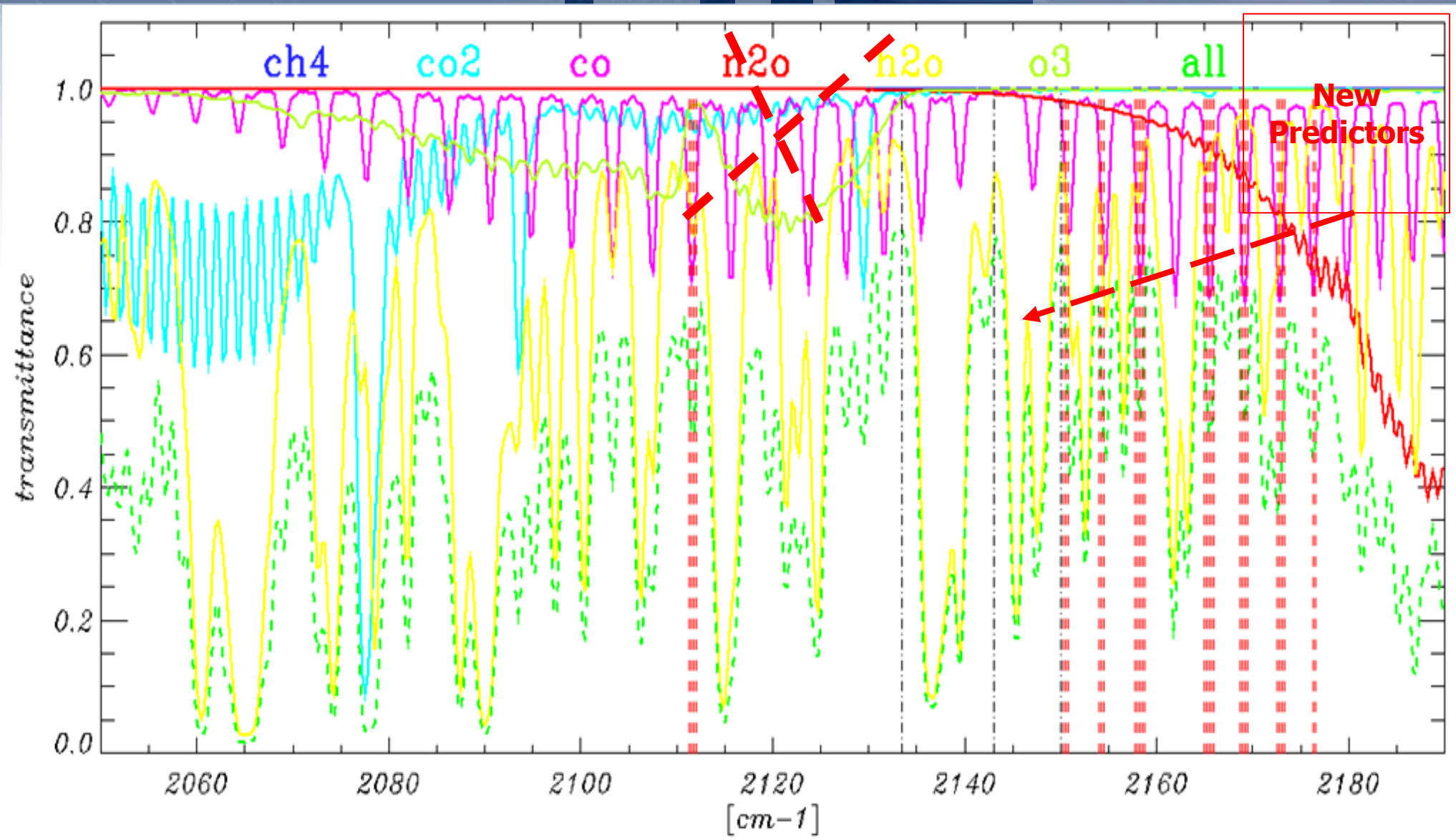
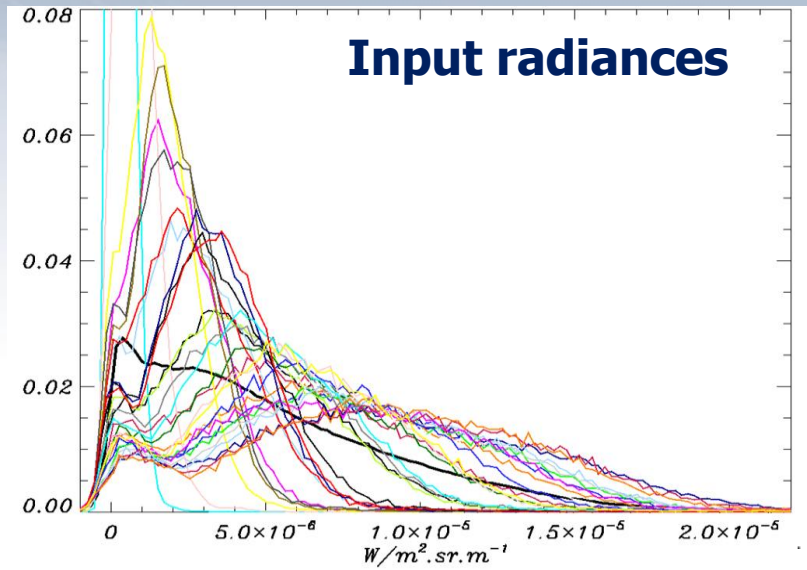
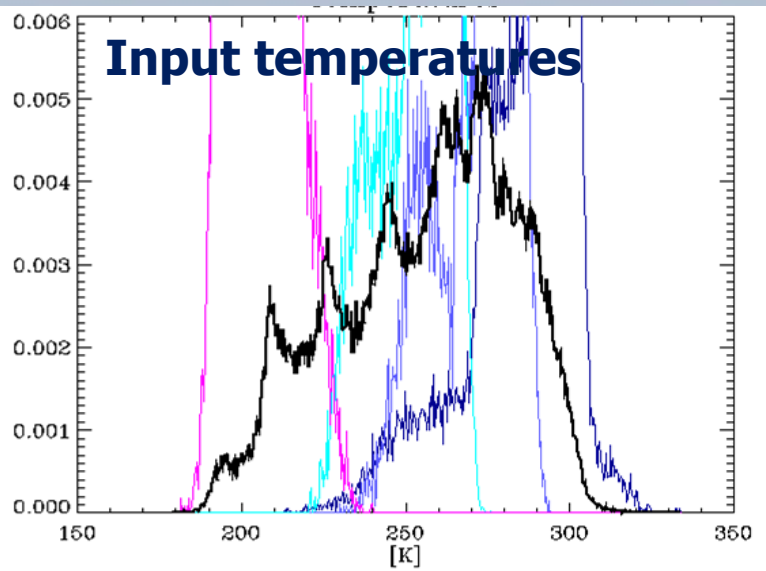
The initial ANN TRGAS retrieval



In-/Output scaling





$$normalisedInput^i = 0.9 \times (input^i - C^i_{11}) / C^i_{22}$$

$$normalisedOutput^k = 0.9 \times (output^k - C^k_1) / C^k_2$$

➔ input Є [-1,1]

Y. LeCun et al, "Efficient backprop" in Neural Networks, Springer, 1998

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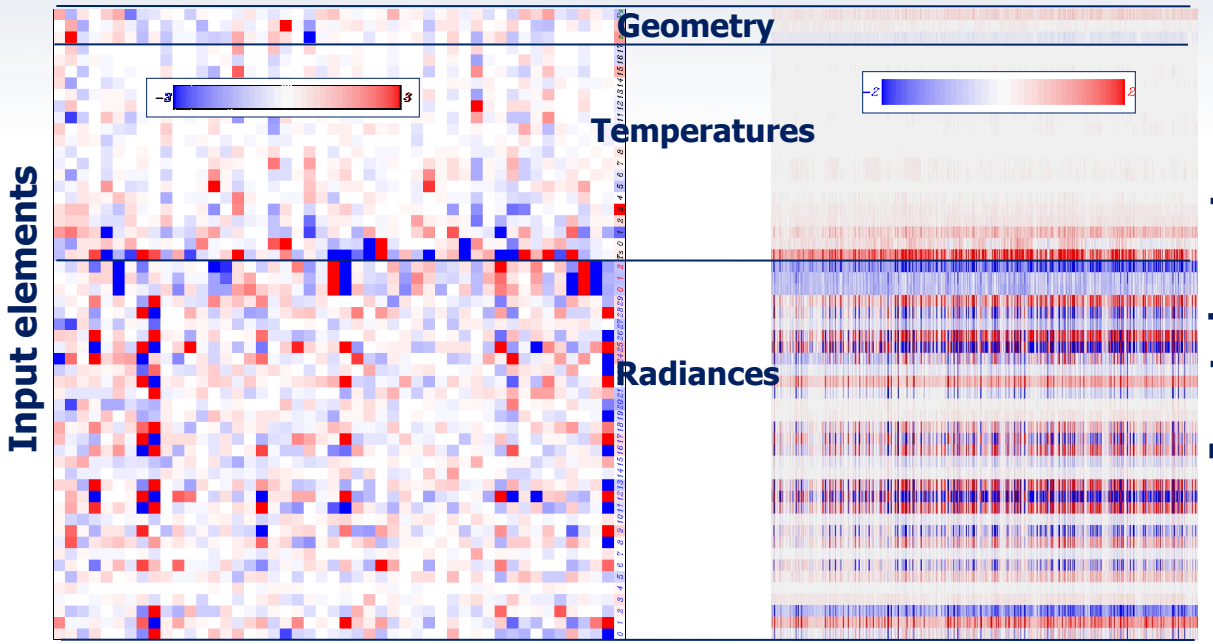
The geometry

- **Two additional predictors:**
  - *Satellite zenith angle (secant)*
  - *Surface pressure*

- **Subsurface T levels:**
  Isothermal extension of the coarse input T profile below the surface



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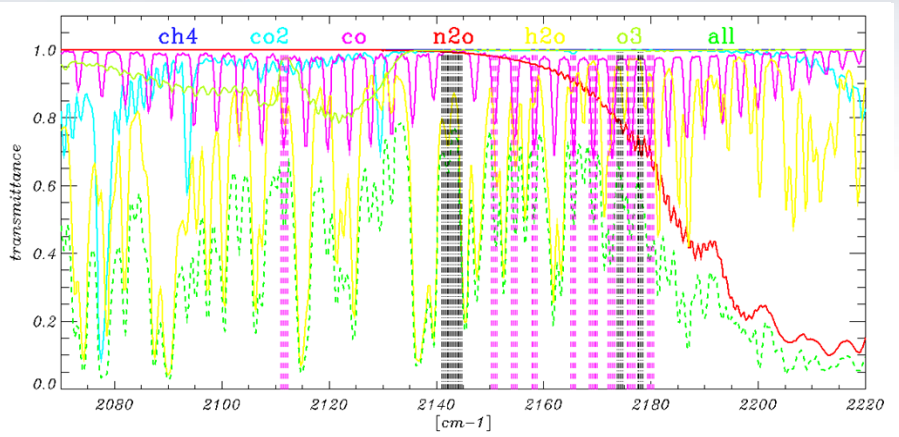
Spectral information

- Key information driving the retrieval
- Channel selection complemented with interfering species (H_2O, N_2O)
- Extended channel selection:
  - 52 CO absorption channels *(30)*
  - 26 baseline+interf channels *(3)*
- Baseline channels become additional inputs
- Explicit Ts, no longer use of an arbitrary ε



baseline – absorption channels

input T profile

H $_2$O, N_2O channels

Baseline channels, Ts

$$\frac{dI_\nu}{dS} = J_\nu - K_\nu I_\nu$$

Geometry

CO content to be retrieved with the ANN

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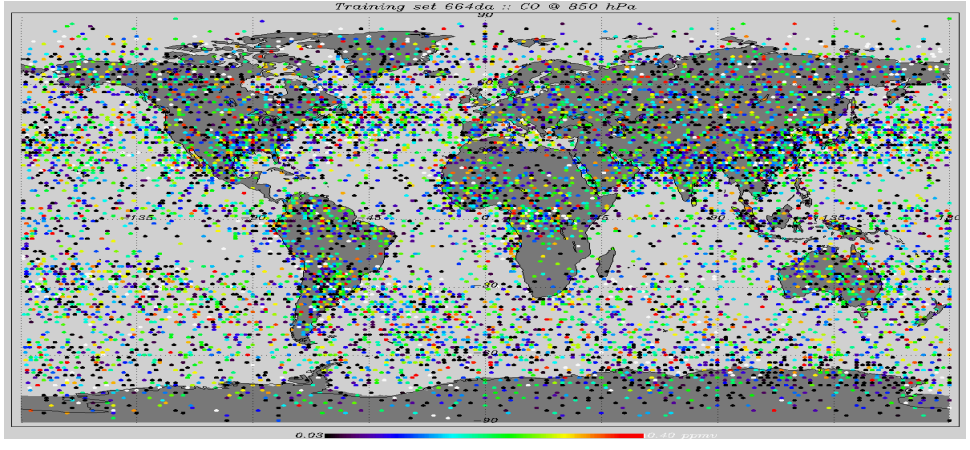
The training base

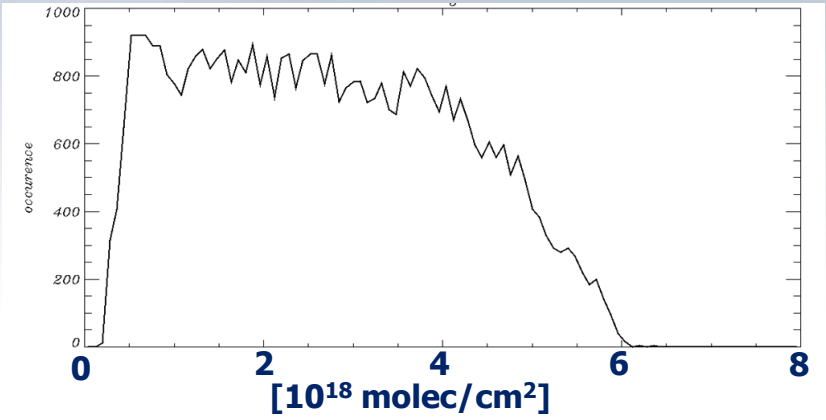
- ~ **200 000 training patterns** (day/night, land/sea)
- atmospheric state vectors (T, q, Ps, wind) subsampled from ECMWF 40-year reanalysis
- **Trace gas profiles** generated with random variations around standard profiles sampled from **MOZART 3D** calculations (from D.Cunnold's runs in 2001).
- The surface emissivity:
  - Sea: Masuda's model and its extension by Watts.
  - Land: Combination of up to 3 pure surfaces ems from the MODIS UCSB emissivity library (www.icess.ucsb.edu/modis/EMIS/html/em.html).
- synthetic IASI spectra with **RTIASI-5.3** for all viewing geometries.
- Synthetic spectra degraded with the **instrument noise** characteristics
- Gaussian **errors** added to the teaching **input temperatures**
- No clouds nor aerosols ➔ **cloud-free conditions** is the only domain of validity for the retrieval.



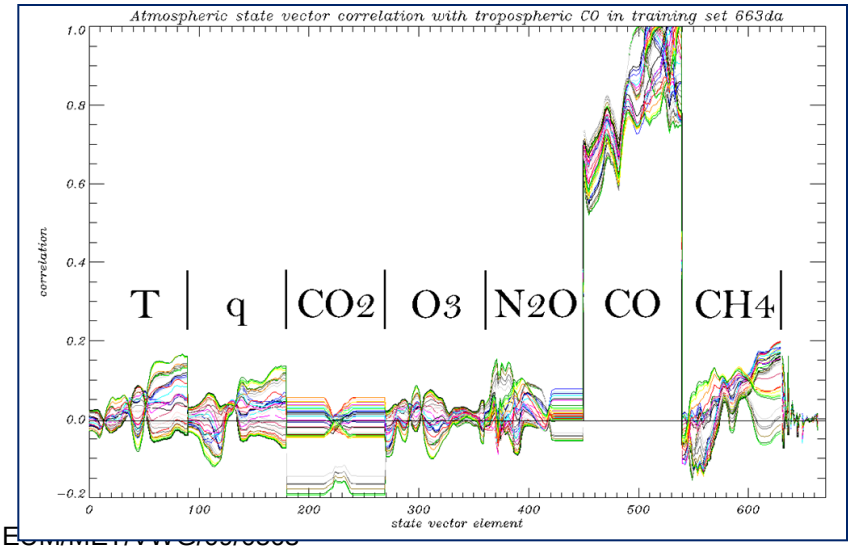
Background CO

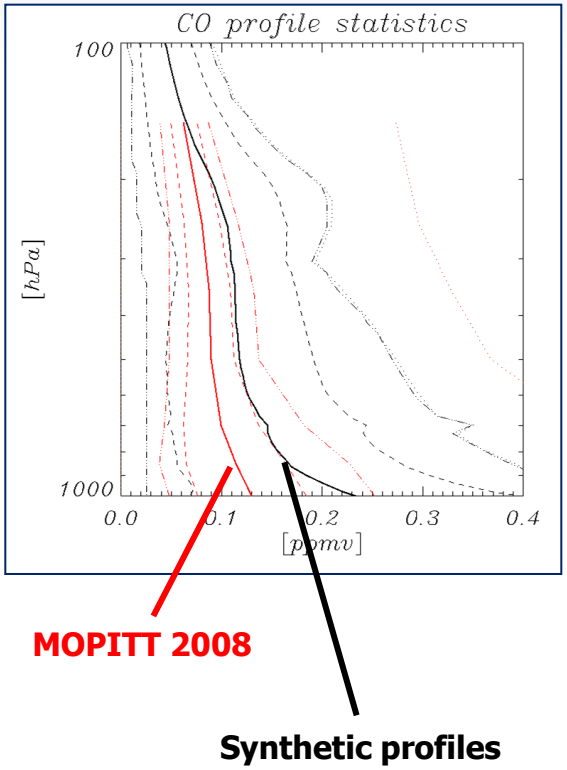
CO statistics in the training set

CO total column distribution

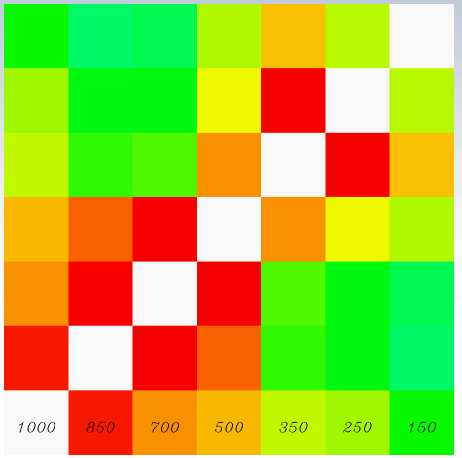


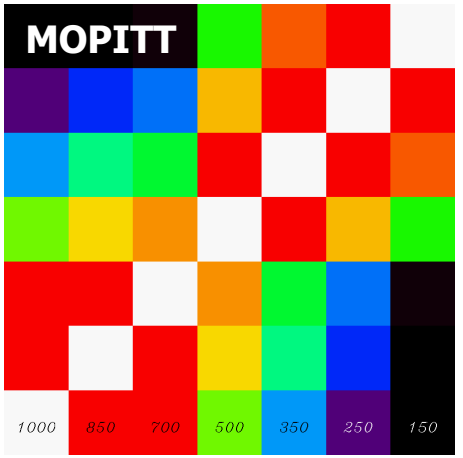
Tropo CO correlation with atm. state vector





Vertical correlation





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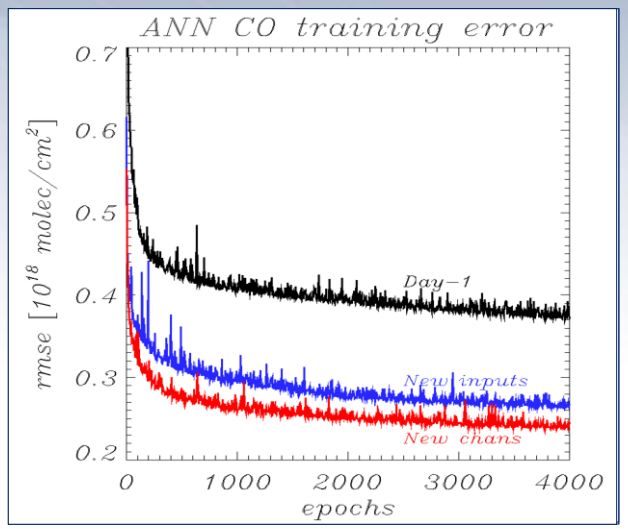
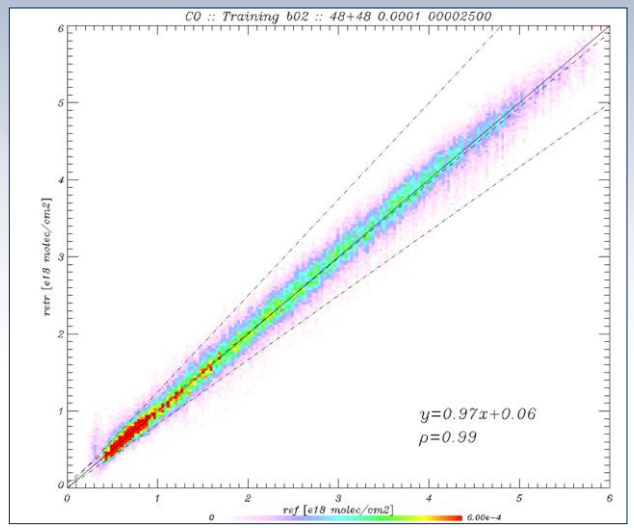
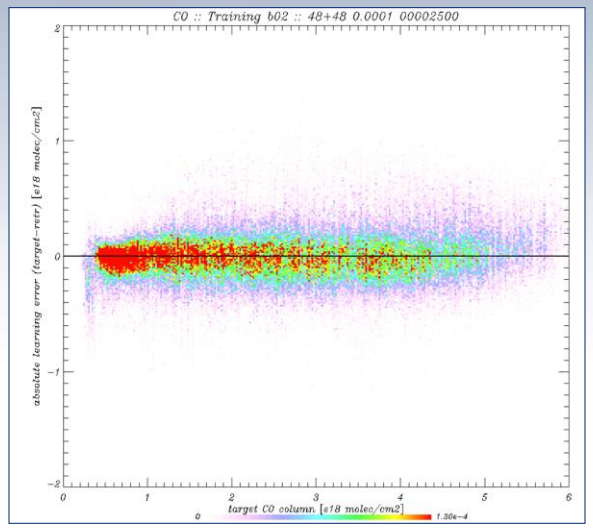
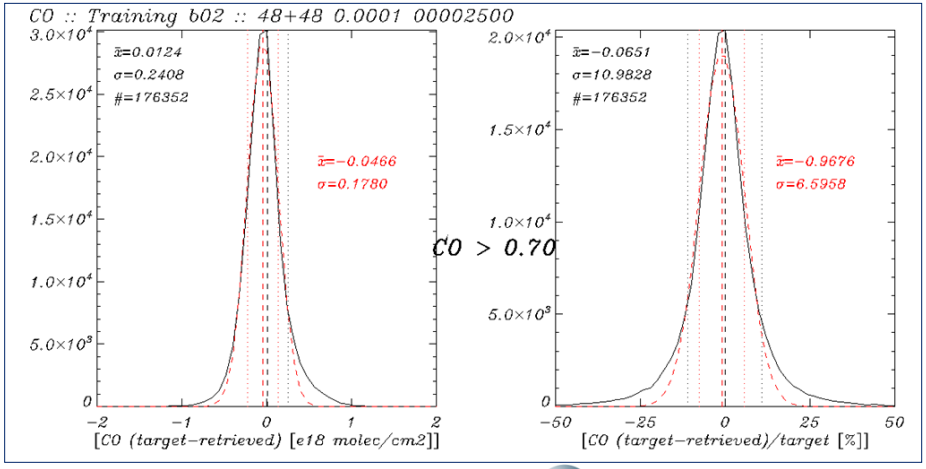
Theoretical performances







- Upgrades improved learning speed and accuracy
- ~99% correlation with target output
- Training error constant with CO content
- Non-Gaussian error
  - 0.18 to 0.24 x 10^{18} molec/cm^2
  - 7 to 11 %



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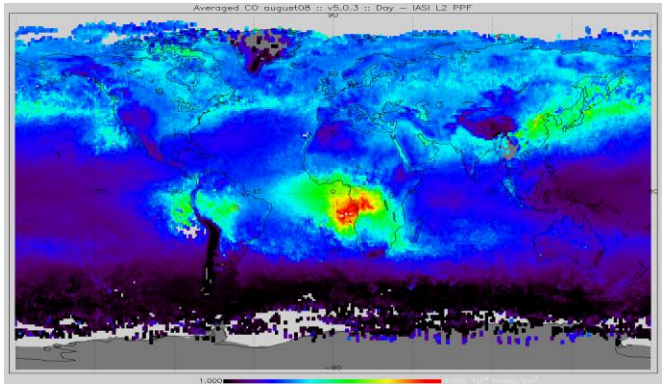
Data description

IASI/Metop

- 09.30 a.m. Orbit (descending)
- Period: Aug & Nov08, Feb09
- L2 PPFv5 retrieval:
  - IFOVs #3 and #4
  - Noise-filtered radiances
  - Input T,Ts from EOF regression
  - IASI stand-alone cloud filtering

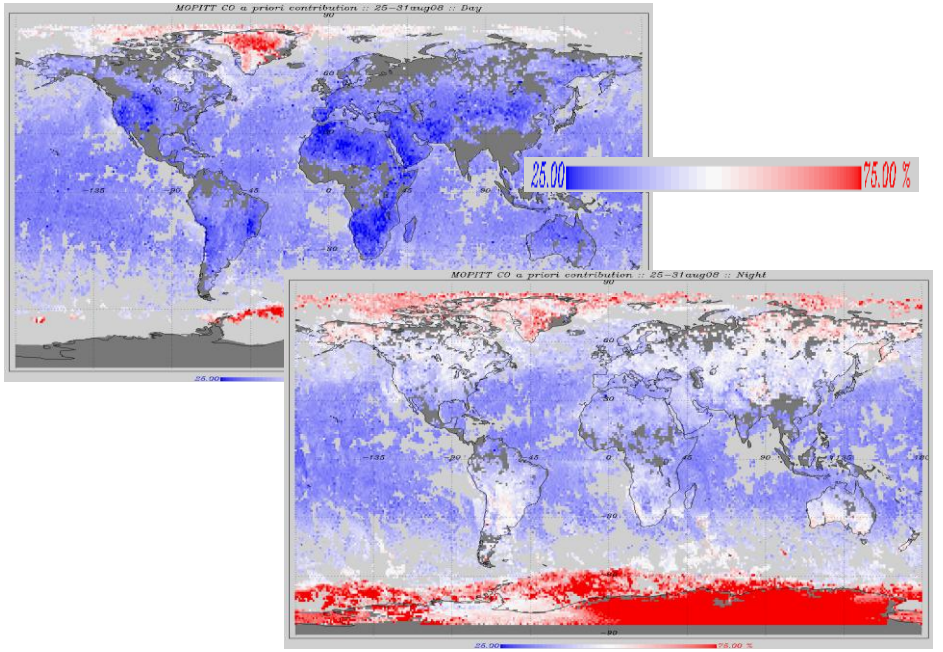


MOPITT/Terra

- 10.30 a.m. Orbit (descending)
- L3 daily 1°x1° gridded CO, v1

https://wist.echo.nasa.gov

- *a priori* contribution < 50%



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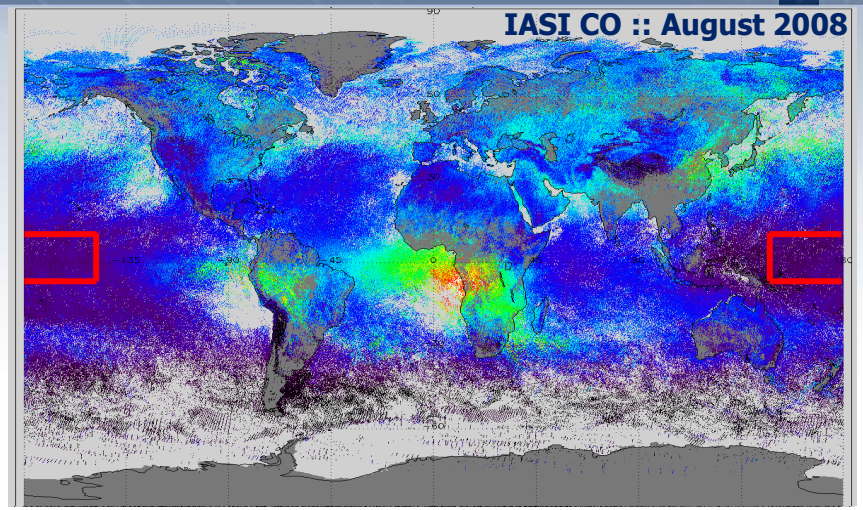
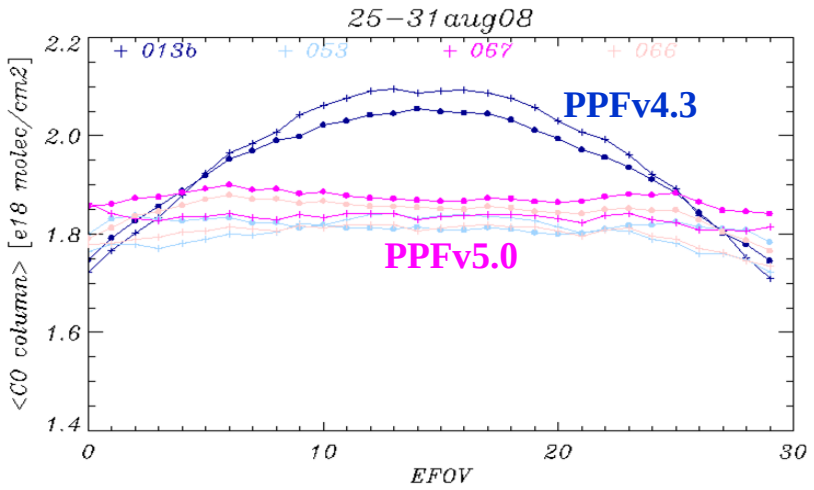
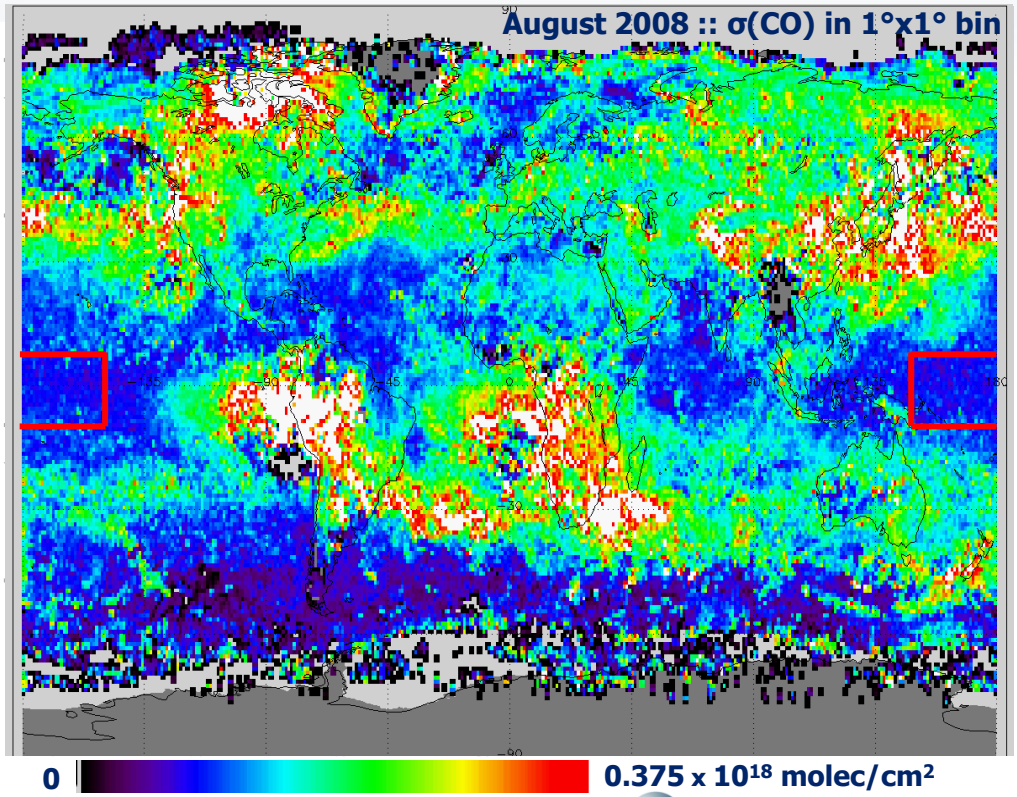
IASI CO self consistency



- Sea/land continuity
- Flat response to scan angle
- Moderate incidence of Ts error
- Spatial coherence < 0.15x10^{18} molec/cm^2





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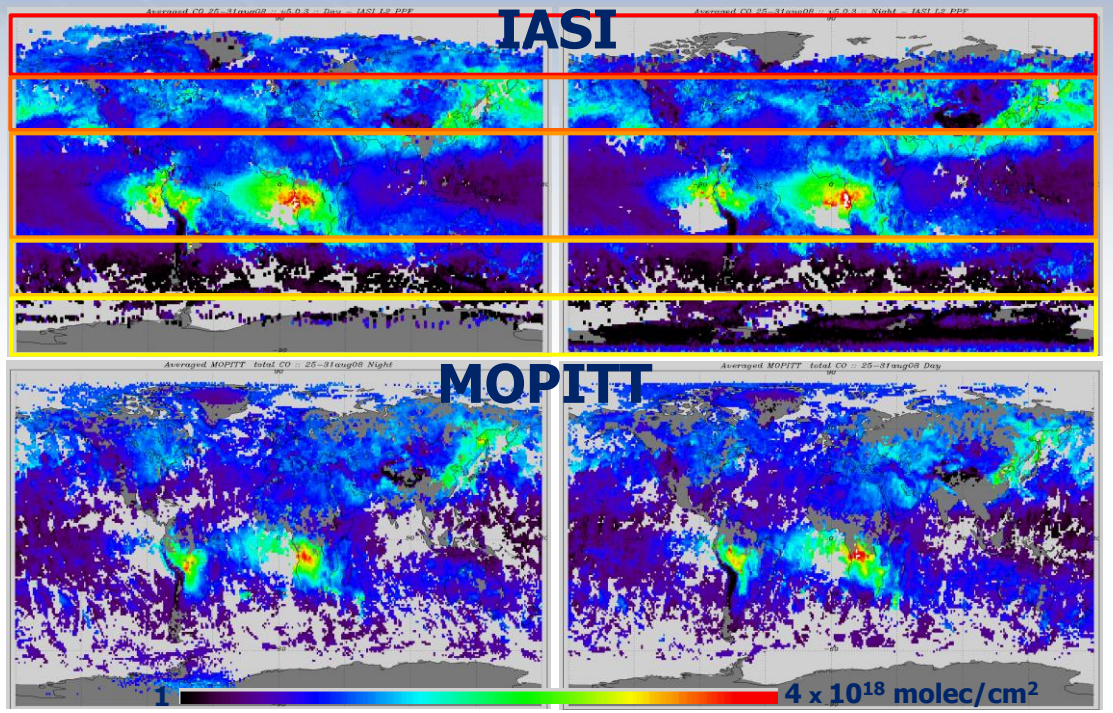
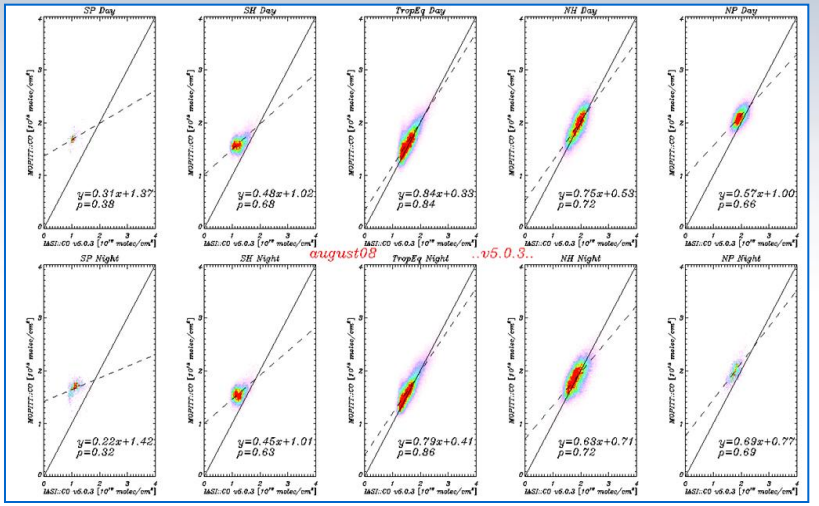
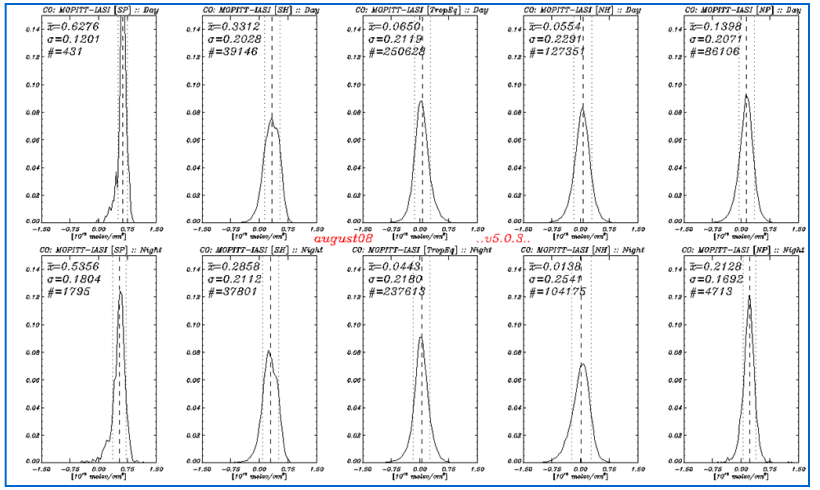
III. Validation w. satellite products (3/5) Intercomparison with MOPITT



August 2008





- Best match in [30°S ; 60°N]
- Consistent standard deviation:
  - 0.17 to 0.25 x 10^{18} molec/cm^2
  - 8 to 15 %
- Bias variation with latitude

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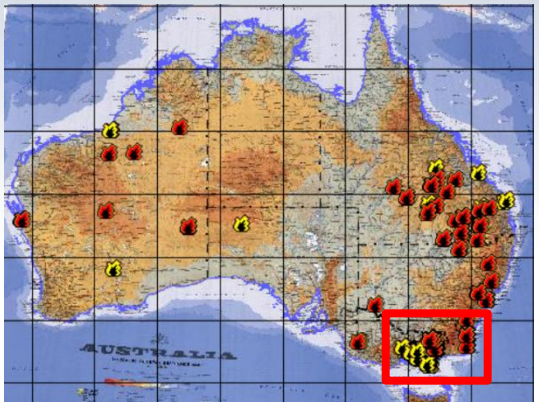
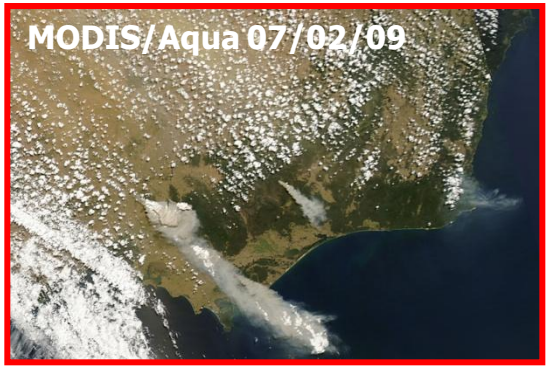
Australian wild fires

February 2009

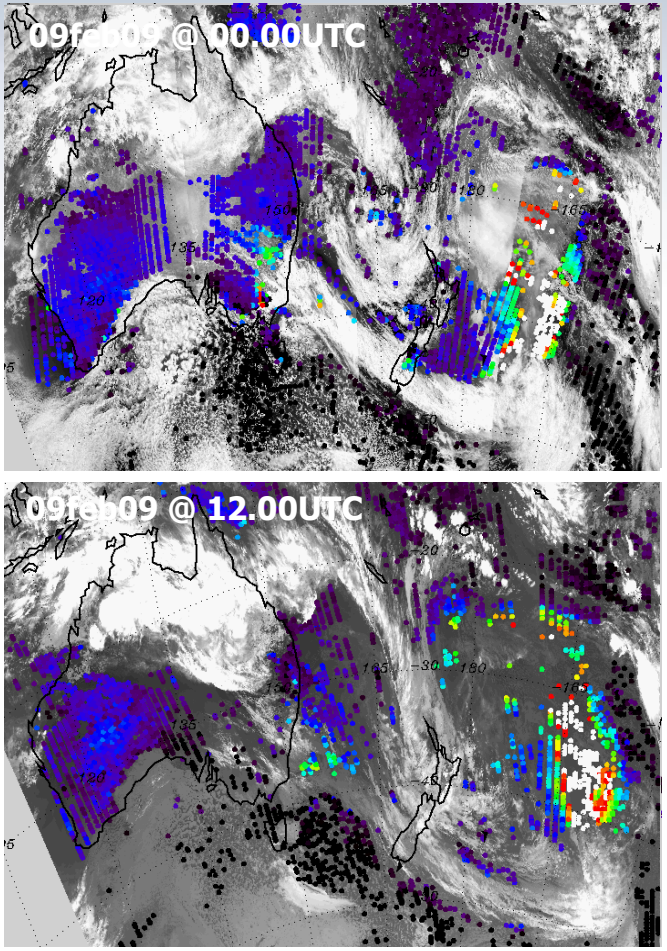


sentinel.ga.gov.au

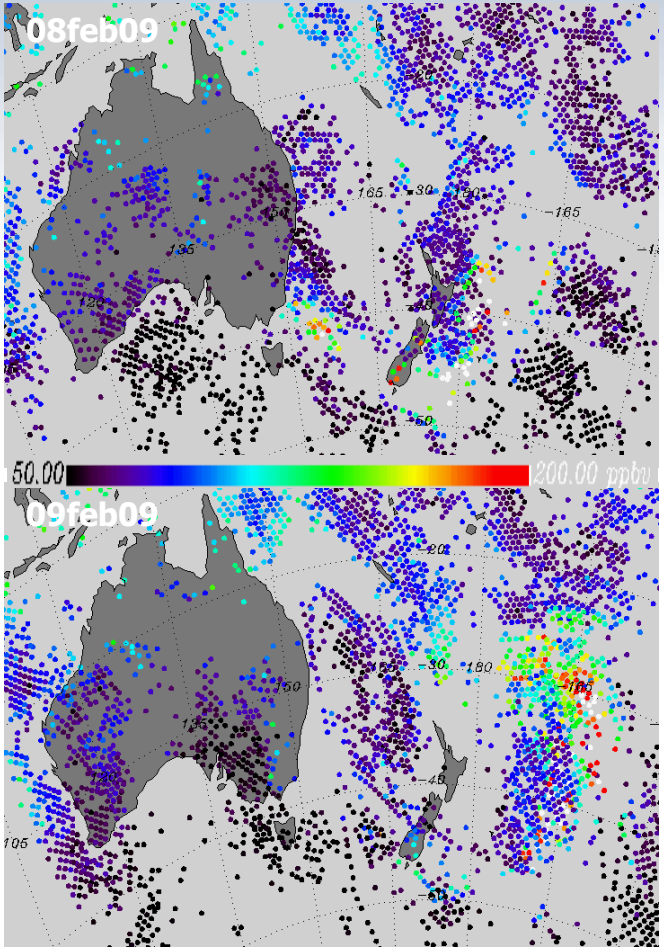


rapidfire.sci.gsfc.nasa.gov

IASI CO total column



AIRS CO@500hPa



Courtesy of Dr. Joanna Joiner

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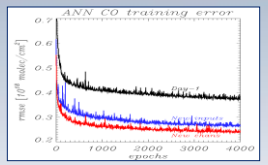
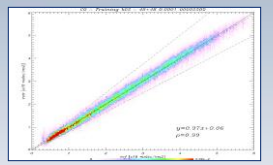
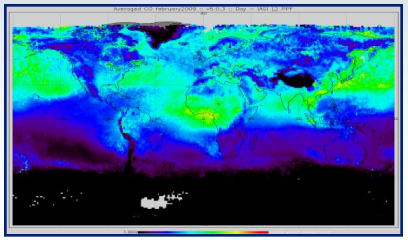
Australian wild fires

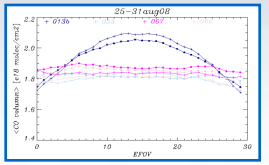
Conclusion

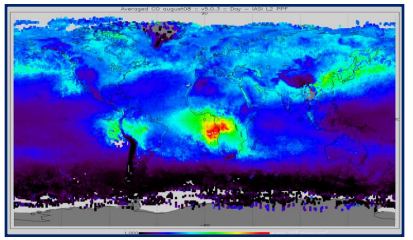
Summary











- ✓ IASI ANN CO algorithm & configuration greatly improved
  - ***no angular effect***
  - ***all surfaces and elevations retrieved***
- ✓ characterised the theoretical performances
  - ***error ~7-11%***
- ✓ **Positive** initial **validation** and intercomparisons of **CO** with **satellite** data
- ✓ Competitive computation time
- ✓ Product available with IASI L2 PPFv5 (Q1-2010)

Future work

- ➢ Cloud filtering, impact of cloud contamination
- ➢ Training set with RTTOV-9 (updated spectro)
- ➢ Further diversify background CO profiles:
  - vertical correlation
  - capture more extreme events
- ➢ Extend and monitor intercomparison with other satellite products over longer period
- ➢ Absolute calibration with ground-based FTIR measurements (NDACC)...
- ➢ Assess potential additional benefits of an OEM. ANN possibly used as first guess.
- ➢ Extend method to other trace gases

Thank you for your attention

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