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Mid-tropospheric CO_2 retrieval in the tropical zone from AIRS observations

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Introduction

- Distribution of CO_2 in the atmosphere and its time evolution can be used to quantify surface fluxes.

- Retrieving temporal and spatial variability of atmospheric CO_2 with spatial observations has been proven with the low-spectral resolution NOAA/TOVS instruments (*Chédin et al 2002a, b and 2003).*

- The new advanced infrared sounder AIRS, launched in May 2002, may improve our capability to monitor CO_2 from space.

- As for TOVS, a neural network inference scheme is used to estimate mid-tropospheric CO_2 concentration.

- So far, the study is limited to sea/tropics/night cases.

This work is supported by the European COCO project whose aim is to retrieve surface fluxes using CO_2 concentration as estimated from space.

General scheme of the retrieval

CO_2 retrieval from AIRS observation

First
Downloading AIRS observations

NASA
2378 AIRS channels

NOAA NESDIS
324 AIRS channels

Download **BUFR files** every day since **April 2003**

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324 AIRS channels
15 AMSU channels
1/2 AMSU FOVs
9/9 AIRS FOVs

Then
Retrieving CO_2

Selection of a restricted set of CO_2 channels

Training of Neural Networks

Off-line

Trained Neural Network → q_{CO2}

« clear sky » detection

calc-obs bias removal

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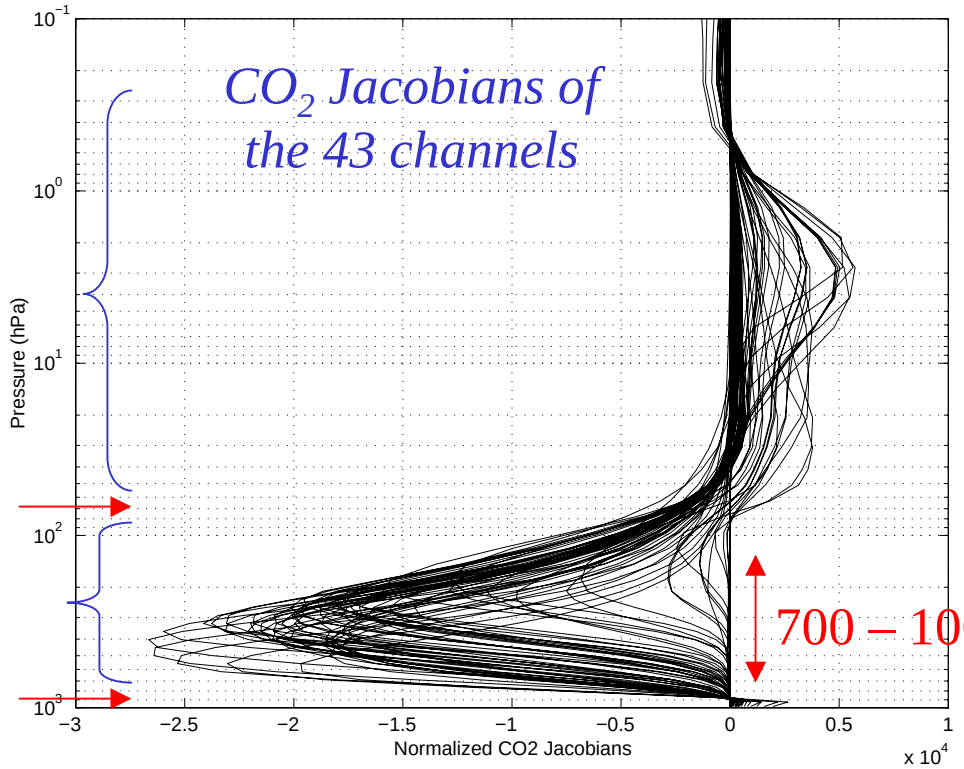
Selection of a restricted set of CO_2 channels

CO_2 retrieval from AIRS observation

A set of 43 AIRS channels is selected with the new Optimum Sensitive Profile method (*Crevoisier et al. QJRMS 2003).* They present :

- a high sensitivity to CO_2 atmospheric variations.
- no or low sensitivity to other atmospheric components (H_2O, O_3, N_2O, CO, surface properties).
- a good distribution along the vertical.



Stratosphere
10 channels

Tropopause

Troposphere
33 channels

(computation from the 4A model for a tropical situation)

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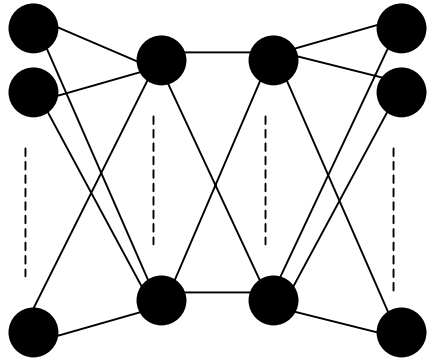
Neural Network training

33 AIRS T_B

5 AMSU T_B

1 window channel



2 hidden layers

33 $T_B^{qref} - T_B^{qCO2}$

$q_{ref} - q_{CO2}$

- The networks are trained on the TIGR database : 872 tropical atmospheric situations (T(P), Q(P), O3(P) and constant profiles for trace gases - CO_2 varies in the range of 352-392 ppmv).

  ➡ No preliminary first guess.

- Brightness temperatures are computed using the 4A radiative transfer forward model (*Scott and Chédin 1981 http://ara.lmd.polytechnique.fr 2003).*
- Noised T_B.
- One network for each scan angle.

- The RMS convergence of the network is 1.8 ppmv (TOVS: 4 ppmv).

Bias removal

The neural networks are trained with simulated data.

→ biases between simulations and observations must be removed

ECMWF MARS archive

Download **analyses** one day per week

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atm situations
$T(P)$, $q_{H2O}(P)$, $q_{O3}(P)$,…

$T_B^{calc}(\nu)$

observed AIRS situations
$T_B^{obs}(\nu)$

Collocations

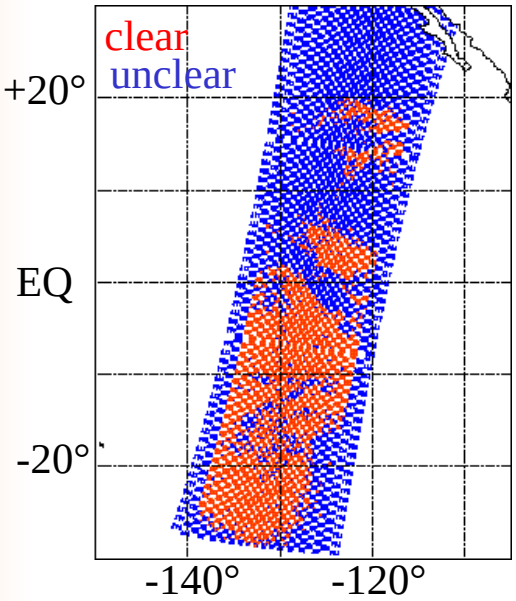
$T_B^{calc}(\nu) - T_B^{obs}(\nu)$

Spatial and temporal average of the bias

Clear sky detection

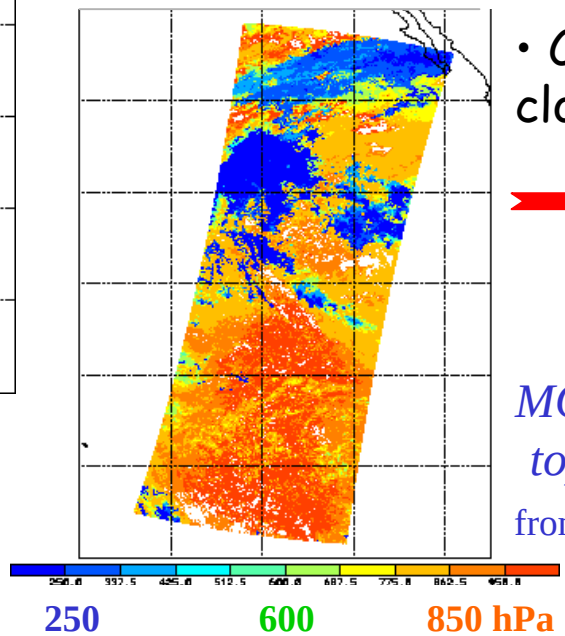
CO_2 retrieval from AIRS observation

- Three kinds of tests detect the unclear fields-of-view:
  - 1- 8 differences T_B(AIRS)-T_B(AMSU)
  - 2- 5 estimations of T_B(AIRS) from T_B(AMSU) through regressions
  - 3- 2 differences between window channels



AIRS clear sky detection

- Over sea in the tropics, 82 % of the situations are found unclear.



- Comparison with *Aqua/MODIS* cloud detection :

→ All the clouds over 800 hPa are detected.

MODIS cloud top pressure *(27 April 2003)*

from http://modis-atmos.gsfc.nasa.gov/

→ The remaining clear situations are then presented to the networks.

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Estimation of CO_2

Maps of retrieved mid-tropospheric CO_2 concentrations are produced on a two-week basis at a resolution of $15° \times 15°$ for the period April-August 2003.

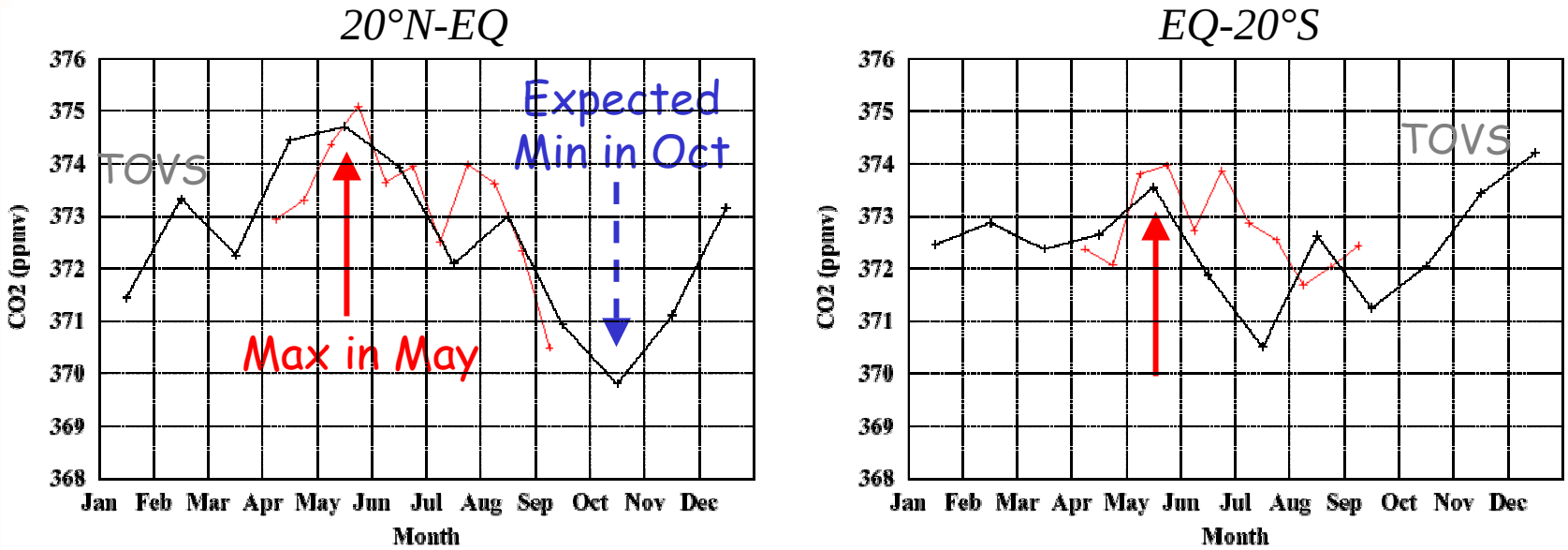
Estimation of CO_2

CO_2 retrieval from AIRS observation

Our present knowledge of the distribution of mid-tropospheric CO_2 is very limited : a few commercial air-liner observations since 1993 (*Matsueda et al. 2002*), CO_2 concentration retrieved from TOVS observations (*Chédin et al. 2003*).

➡ Study of the seasonal cycle.

Two-week mean of CO_2 concentrations as retrieved from AIRS for the northern and southern tropics



TOVS = monthly mean of CO_2 for the year 1990

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Conclusion…

• Mid-tropospheric CO_2 concentration has been retrieved from AIRS observations in the tropics, over sea at night from April to August 2003 on a two-week basis.

→ Plausible seasonal cycle.
Realistic geographical structures.

… and future works

• New networks are being trained with an improved set of channels in order to increase the quality of the retrieval.

• The retrieval will be extended to land/daytime cases.

• A preliminary study has shown the feasability of extending the retrieval to temperate regions that seem out of reach for TOVS.

• Finally, the retrievals will be used in synergy with transport models to constrain the retrieval of surface carbon sources and sinks.