Potential of CO_2 retrieval from IASI

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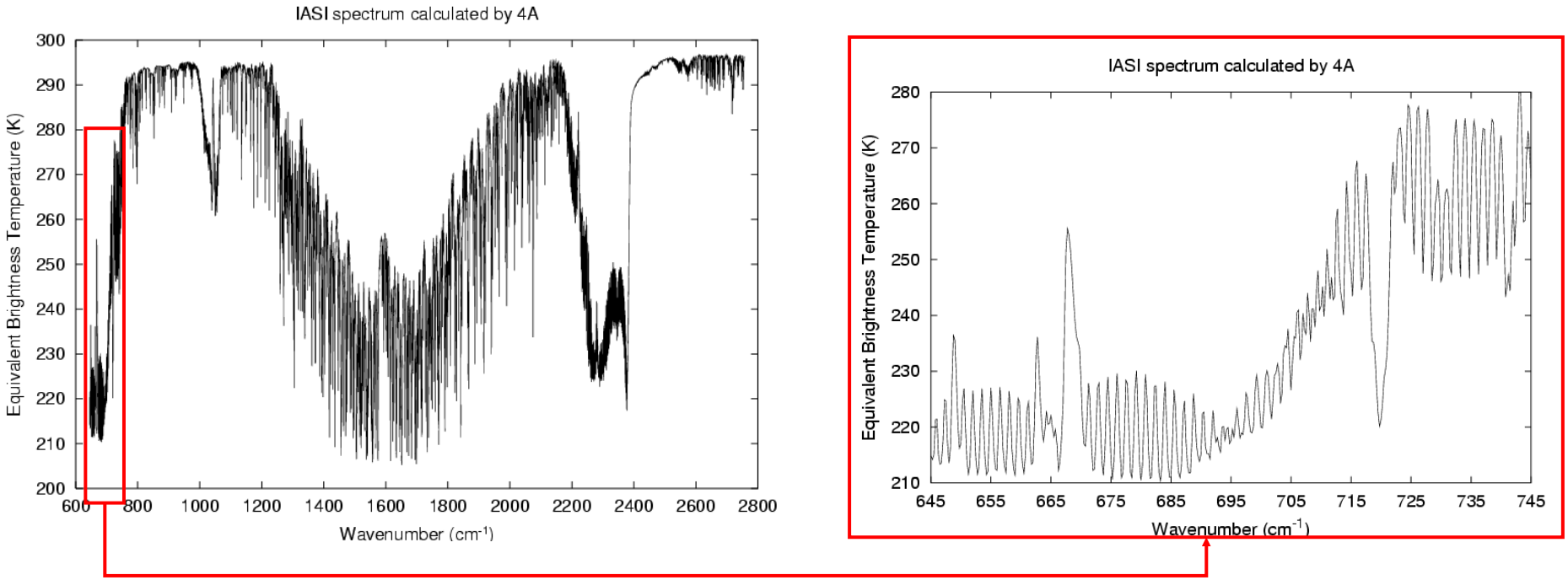
The Infrared Atmospheric Sounding Interferometer (IASI) is one of the potential instruments for monitoring atmospheric CO_2 from space

- ✓ Efficient extraction of the CO_2 signal from the IASI spectrum: specific data processing algorithm
- ✓ Quantitative analysis of the information content for the definition and specification of an optimal product
- ✓ First validation of the retrieval on IASI spectra

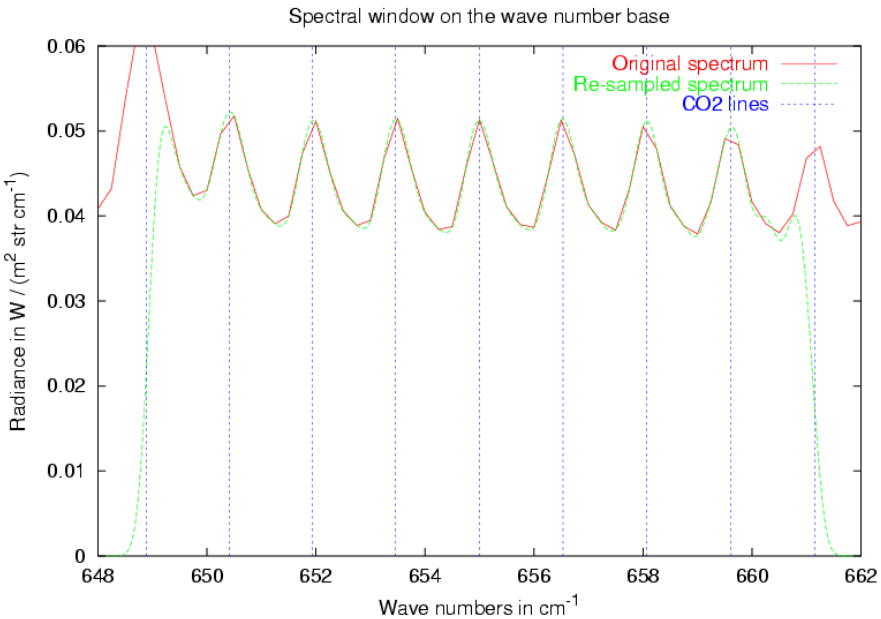
Methodology - Signal processing: data filtering

- The atmospheric spectrum measured by IASI exhibits a quasi-periodic line structure

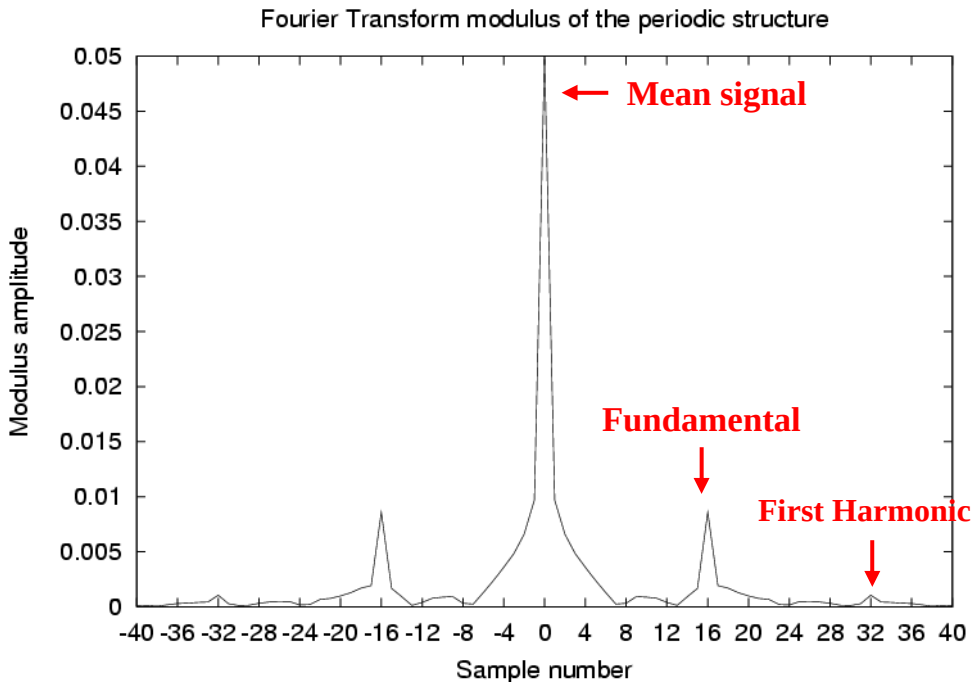


Methodology - Signal processing: data filtering

- Atmospheric spectrum re-sampling on a periodic base built from the spectral transitions of the CO_2 lines



- Application of a Discrete Fourier Transform (DFT) to 16 specific spectral windows



mean signal, fundamental and harmonics: <u>pseudo-data</u>

Methodology - Signal processing: data filtering

- Characteristics of the selected spectral windows

Window designation	Representative wave number (cm^{-1})	Limits (cm^{-1})	Number of spectroscopic lines	Number of corresponding IASI samples (N)
W1	655.0	648.8882 - 661.1602	9	51
W2	682.3	671.2947 - 693.58422	15	91
W3	709.0	699.4146 - 718.4578	13	78
W4	736.3	725.47314 - 746.8401	15	88
W5	754.3	748.34204 - 760.2727	9	50
W6	804.7	796.9102 - 812.48413	11	64
W7	946.1	934.89453 - 956.1851	13	87
W8	974.8	966.25024 - 982.0955	13	65
W9	1048.9	1035.474 - 1060.571	15	103
W10	1077.6	1066.0373 - 1086.87	17	85
W11	2058.2	2047.512 - 2069.0693	15	88
W12	2111.8	2105.5544 - 2118.0332	9	52
W13	2267.0	2251.681 - 2280.33	17	117
W14	2360.3	2349.9172 - 2369.0854	15	79
W15	2412.7	2397.048 - 2426.209	17	118
W16	2441.8	2433.176 - 2449.064	13	66

Methodology - Signal processing: data filtering

- Signal to noise ratio (SNR) for the mean signal of DFT compared to the SNR in the spectrum space

Windows	DFT SNR	DFT SNR / √N	Spectrum SNR	Windows	DFT SNR	DFT SNR / √N	Spectrum SNR
W1	1074.8	150.5	138.0	W9	1815.9	178.9	173.7
W2	150.5	142.3	165.2	W10	2559.6	277.6	283.1
W3	138.0	206.7	206.0	W11	831.3	88.6	71.2
W4	1357.7	282.7	216.9	W12	647.6	89.8	94.4
W5	142.3	358.9	296.0	W13	57.8	5.3	3.3
W6	165.2	323.4	333.0	W14	64.8	7.3	9.8
W7	1825.5	312.3	304.6	W15	1076.4	99.1	103.1
W8	206.7	300.8	296.3	W16	689.9	84.9	89.6

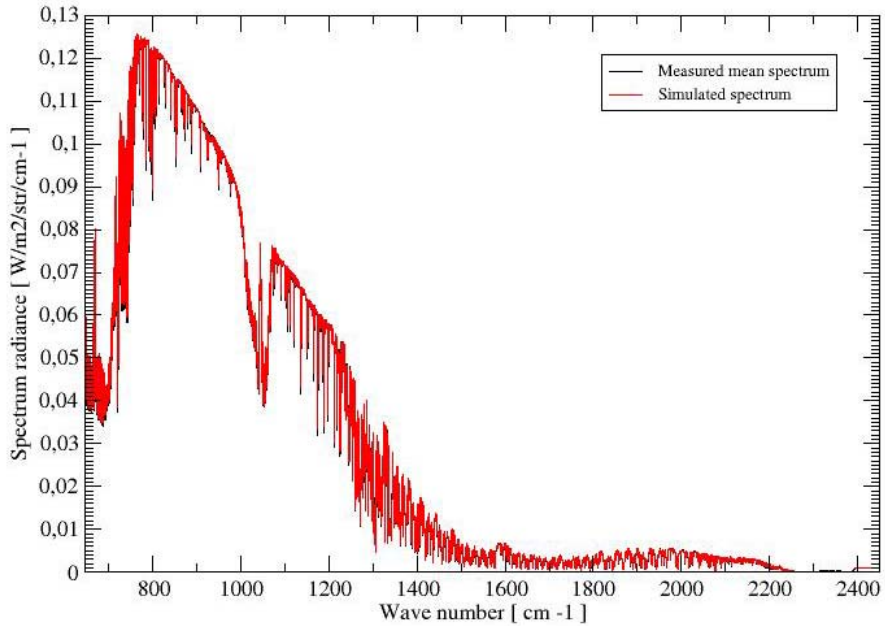
- **The Fourier space analysis method allows information merging by increasing the SNR with a factor √N (number of window samples)**
- **The pseudo-data equivalent to super-channels: data compression**

Analysis from simulated and real IASI data

- 1-DVAR information content analysis

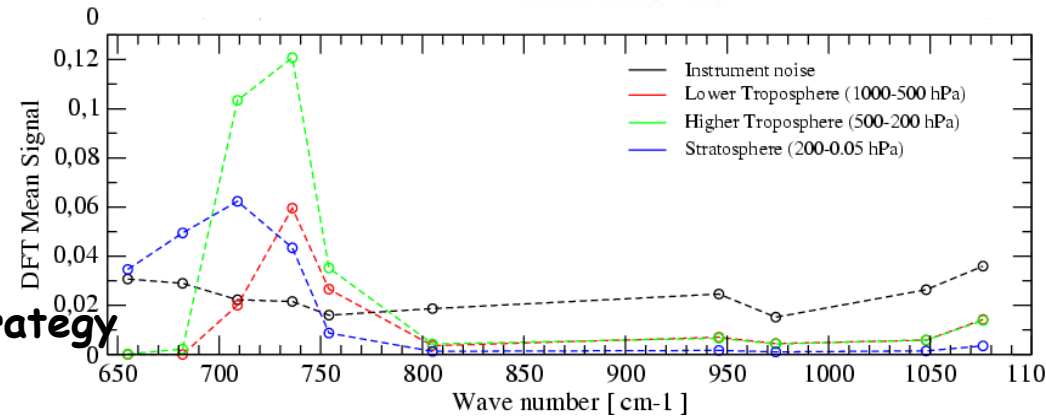
Studies from

- ✓ Synthetic spectra and Jacobians (4A/OP, poster A11)
- ✓ Specific set of real IASI spectra



y ≡ IASI spectrum or pseudo-data

- ✓ IASI data CO_2 channel selection: 1282 spectral samples (SEL)
- ✓ IASI pseudo-data: 48 elements (3 harmonics x 16 windows) (DFT)

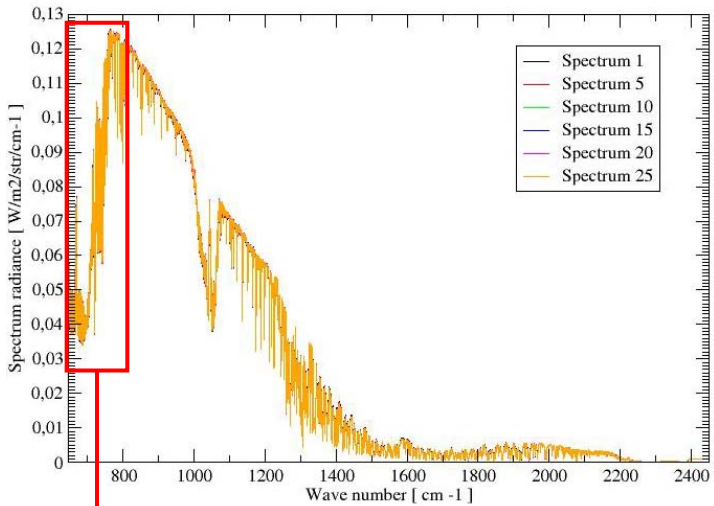


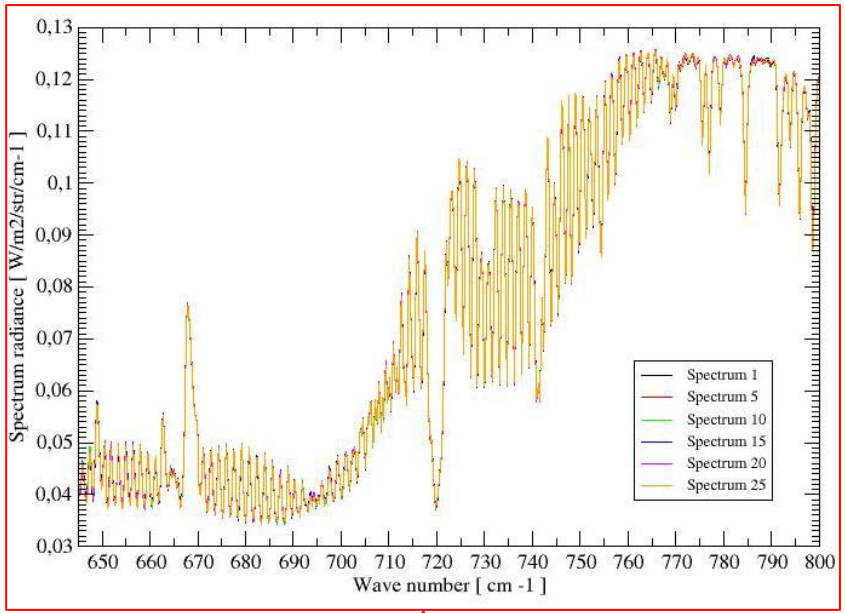
Extended retrieval studies for

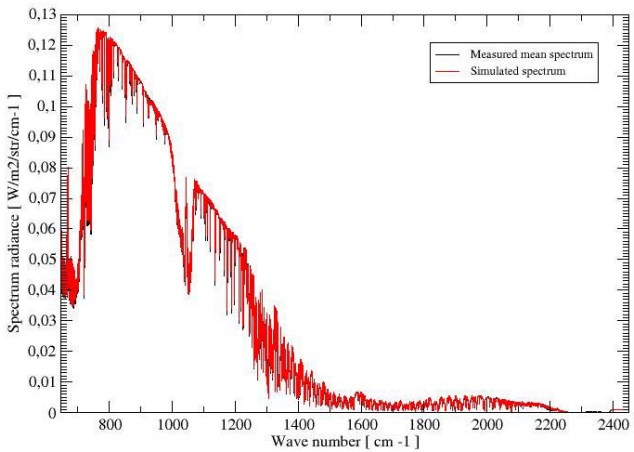
- ✓ Specification of the retrieval strategy
- ✓ Definition of the optimal product
- ✓ Optimisation of the data processing

Specific IASI data set : external calibration mode

- Redundancy of IASI pixels acquisition at a given location

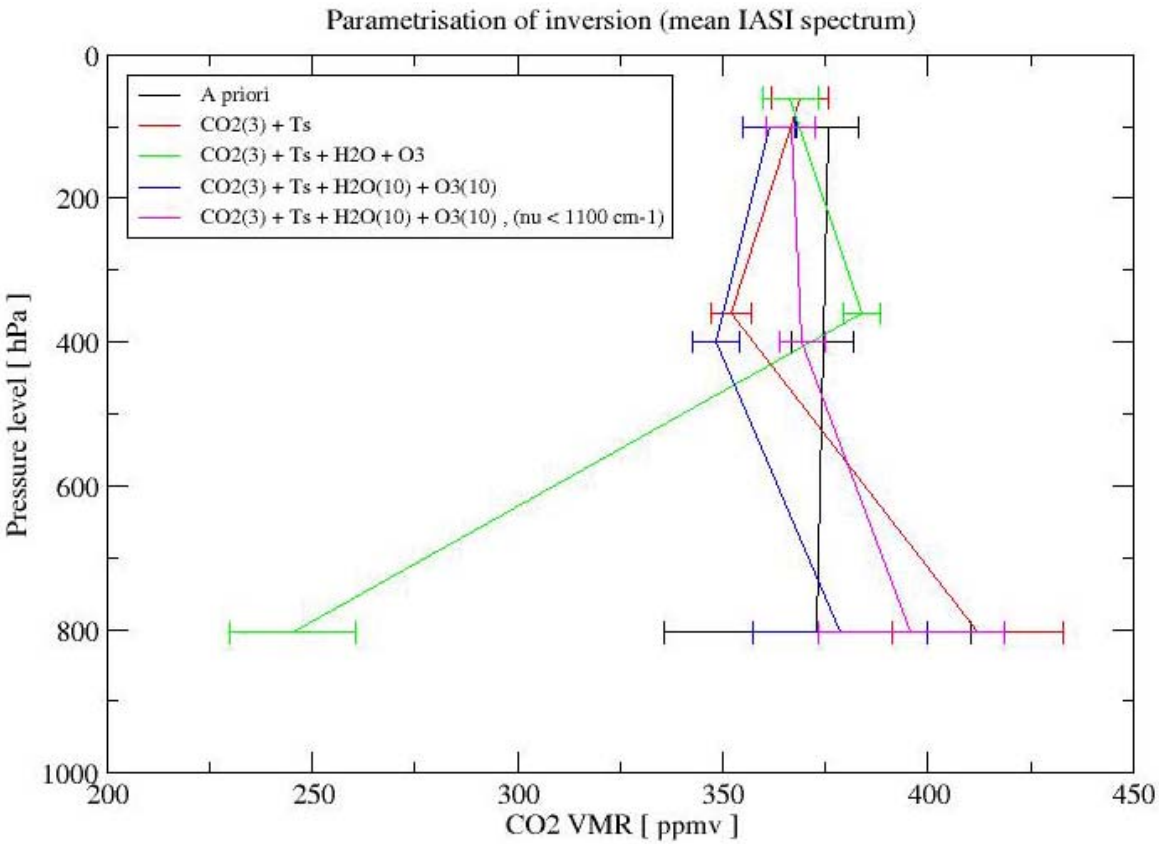






- ✓ Processing of 25 spectra measuring the same atmospheric state (1.4 km between 2 consecutive spectra over clear-sky sea)
- ✓ Use of a low-noise mean spectrum for retrieval optimisation tests

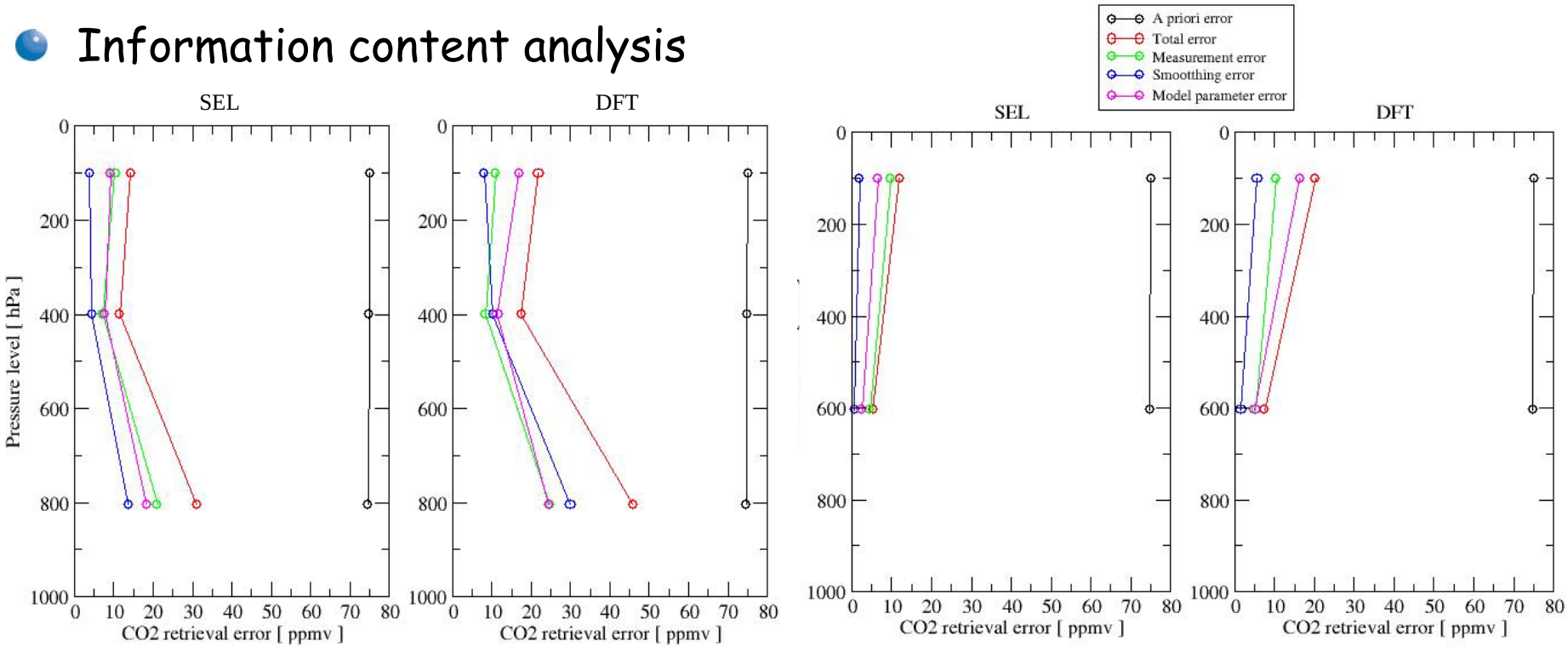
- Retrieval strategy



Different parametrisation tests

- ✓ CO_2 plus surface temperature (T_S)
- ✓ CO_2, T_S plus column of contaminating species
- ✓ CO_2, T_S plus profiles of contaminating species
- ✓ **CO_2, T_S, plus proper transport of species profile errors**

- Information content analysis



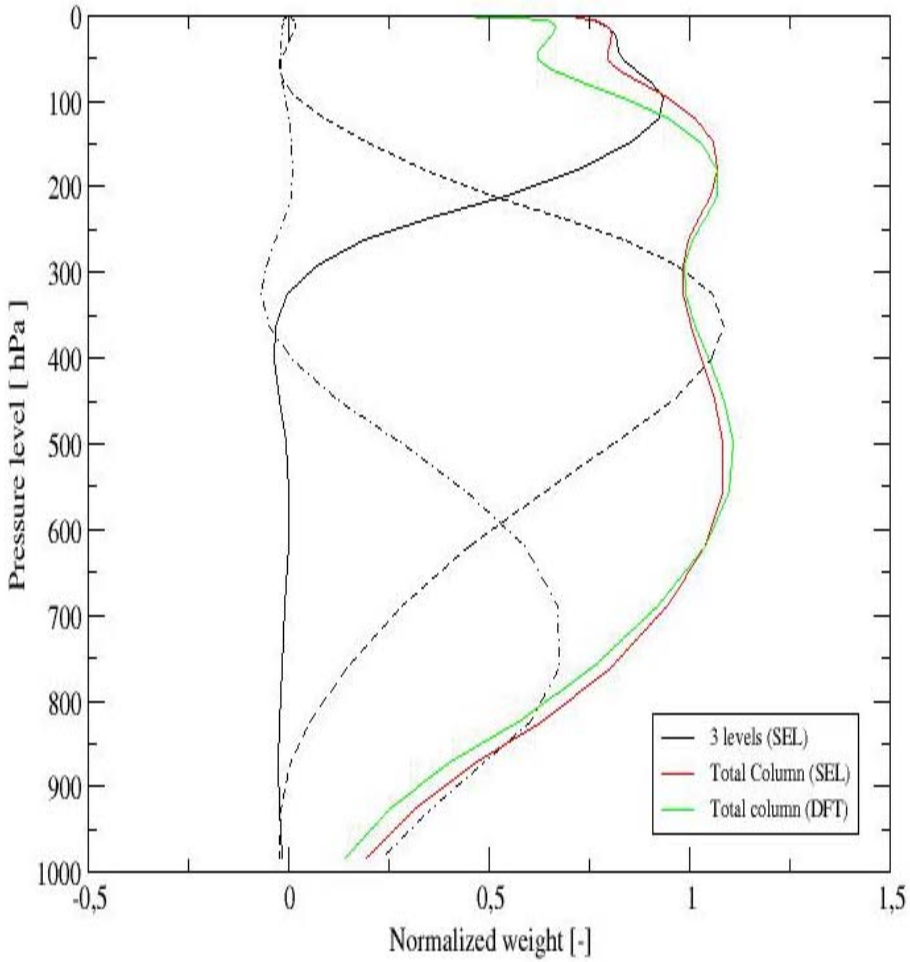
3-levels profile retrieval errors

2-levels profile retrieval errors

- **Definition of the optimal product : retrieval error**

- ✓ **CO_2 mean VMR : 2.3 ppmv, driven by measurement error**
- ✓ **2 pieces of information profile : tropo: 5 ppmv, strato: 10 ppmv**
- ✓ **3 pieces of information profile : low tropo: 35 ppmv, high tropo: 10 ppmv, strato: 15 ppmv**

Definition of the optimal product : weighting function

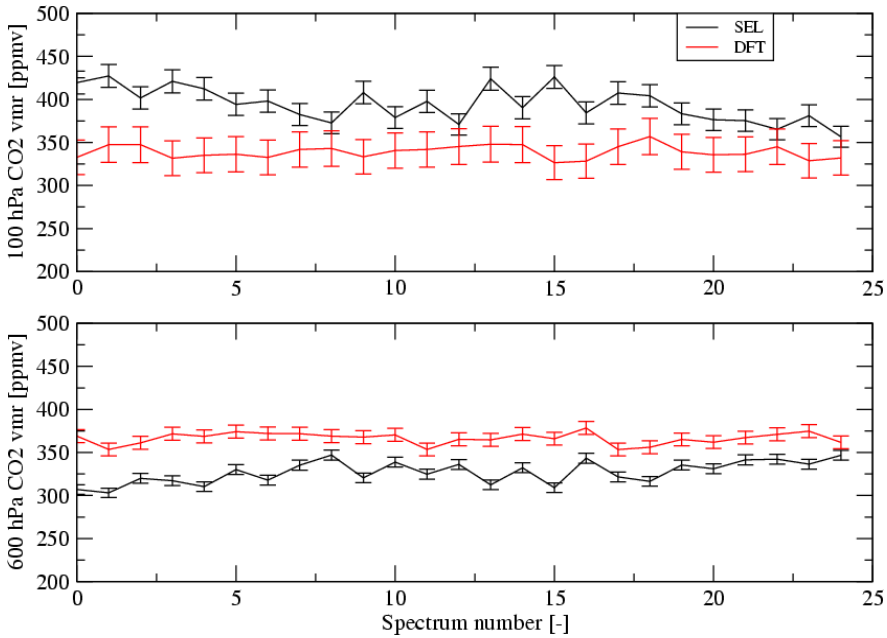


- ✓ Mean VMR, SEL
- ✓ Mean VMR, DFT
- ✓ 3 pieces of information profile

2 pieces of information profile should be optimal

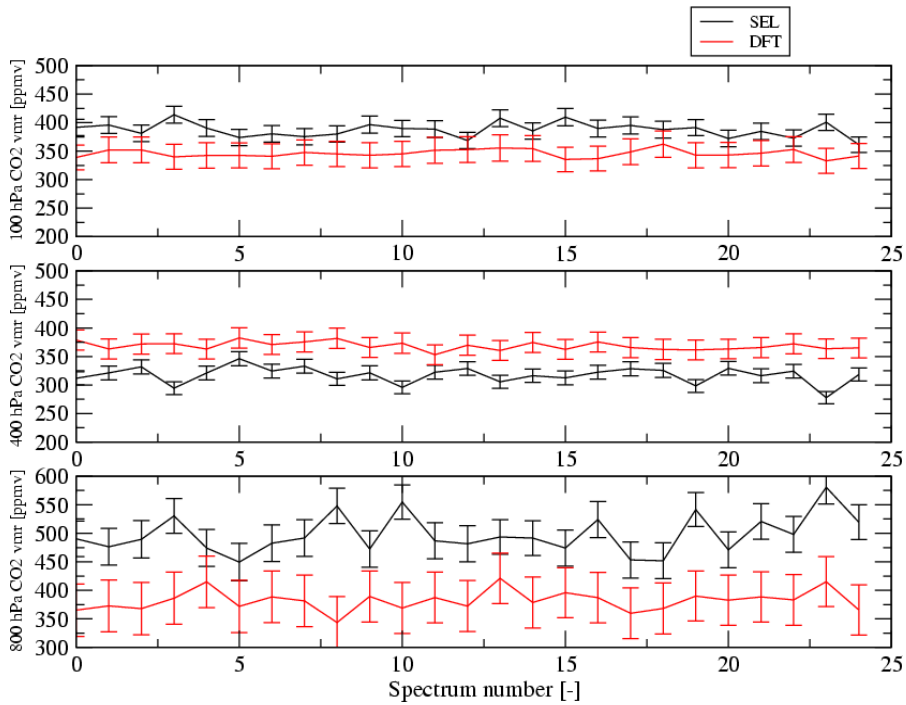
DFT slightly degrades the information content

Time series of CO_2 retrieval from IASI data set: optimisation of processing



Data processing

- ✓ Classical channel selection (SEL)
- ✓ DFT processing



Temporal and vertical stability of the DFT processing

Filtering of elements which pollutes the CO_2 signal

Summary (Analysis from simulated and 25 real IASI data)

- ✓ **CO_2 mean VMR, as well as CO_2 stratospheric and tropospheric partial VMR, can be retrieved from IASI spectrum with a reasonable accuracy**

- ✓ **An optimised processing for the CO_2 retrieval is defined :**
  - DFT data processing ensures efficient and stable retrieval via information compression and filtering
  - CO_2 is retrieved simultaneously with surface information
  - T/H_2O auxiliary information from IASI retrieval should be used (no optimal in our experiments)
  - Trace gases error is properly considered

- ✓ **A full product characterisation is provided by the retrieval algorithm (error estimate, weighting function)**

- Work in progress
  - ✓ Extended validation on IASI data
    - ➢ Global statistics obtained from about 800 inversions on homogeneous scenes classified as "clear over sea" at different locations compared to the theoretical analysis
      - Noise retrieval (precision: relative standard deviation)

Method / CO_2 product	DFT				SEL			
	Theory		Measures		Theory		Measures	
VMR	1.14 %		0.89 %		0.72 %		0.50 %	
2 layers (TR-ST)	2 %	5.5 %	2.8 %	5.8 %	1.5 %	3.5 %	2.5 %	9.7 %

      - These preliminary results confirm previous results:
        - The DFT method needs to be optimised for the mean VMR
        - The DFT method is more robust and stable to retrieve 2 pieces of information profile

Work to be done

- ✓ Extended validation on a representative data set
- ✓ Impact studies of IASI CO_2 product through inverse modelling
- ✓ Possibility to improve CO_2 product through spatial and temporal averaging or specific processing
- ✓ Coupling with efficient cloud processing to increase the availability of IASI accurate information
  - ➢ Poster B04: "Processing of IASI heterogeneous scenes"