IASI Conference

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On the road to MTG IRS retrieval of CO using interferograms – case of IASI

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Background

- Carbon monoxide
  - Key component in the atmospheric chemistry
  - Anthropogenic activity (transport, heating, industry)
  - Fires
- Satellite observations for monitoring CO
  - Maps of column density[1]
  - Flux emissions/origins of the plumes
- Large amounts of data
  - time consuming for full physics retrieval
- Earth atmosphere observation missions based on Fourier Transform spectrometry
  => interferograms => radiances

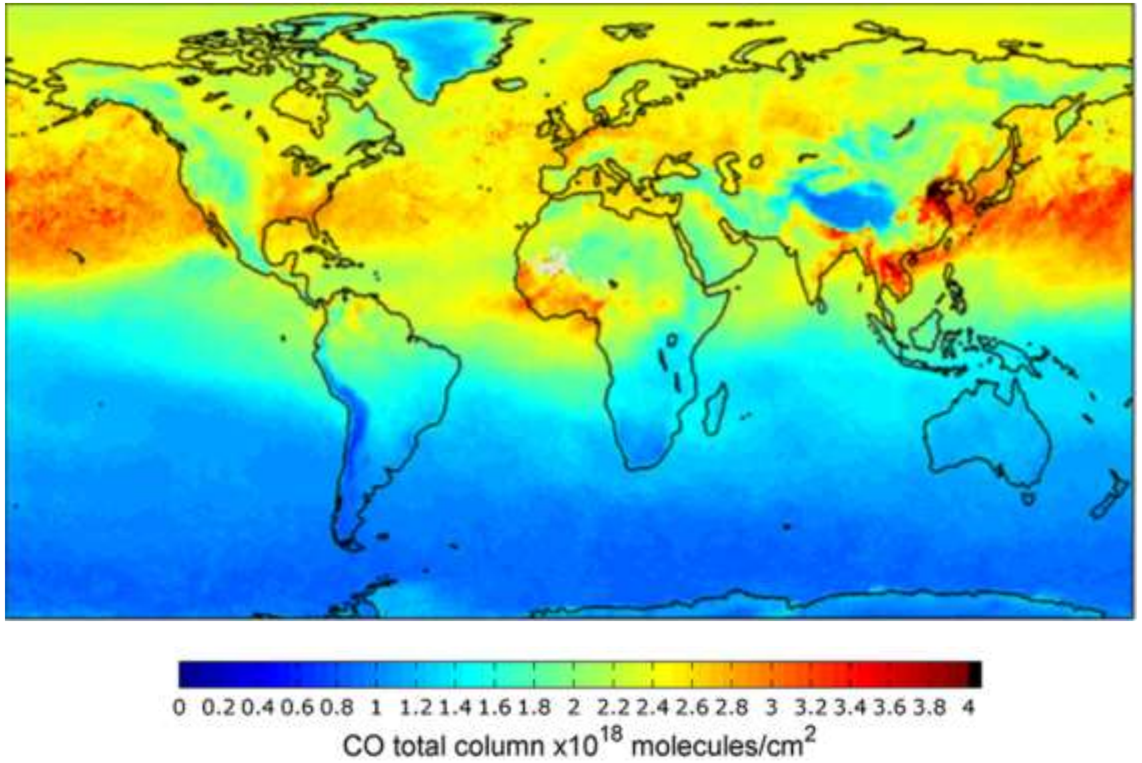


Figure 1 : Map of column density of CO[1]

1. [George et al., 2015]

Introduction

- Useful information concentrated in a small portion of the interferogram[2]
- Interest demonstrated for the nadir measurement of atmospheric trace components (CO_2, CO, CH_4 and N_2O)[3]
- Potential future missions based partial interferograms[4]
- Accelerate retrieval
    - Selection of the best method (classification, principal component, random forest, NN, etc.)
    - Comparison to full physics retrieval

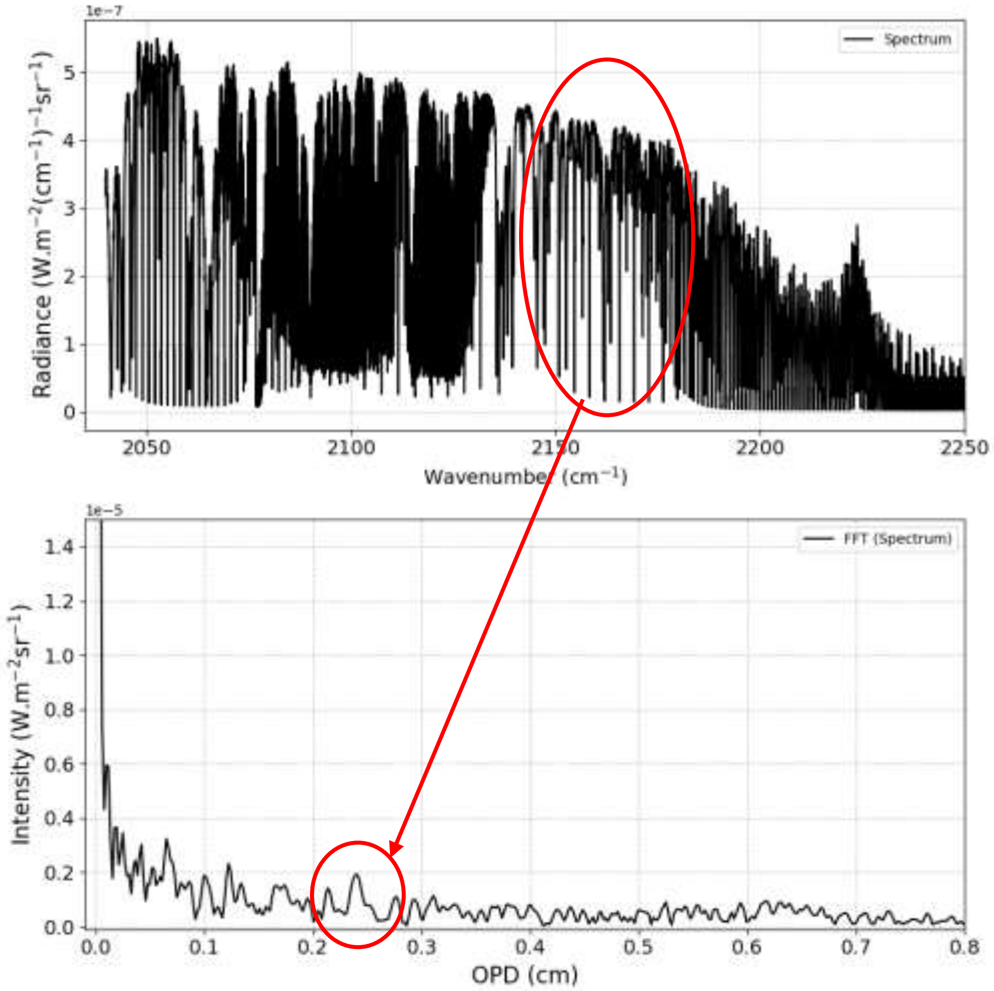


Figure 2 : Spectra and interferogram of the CO signature

Strategy

1. **Full physics retrieval**
   - Optimal estimation method

2. **Classification**
   - Quick estimation of CO column density

DATA

IASI simulations

- Radiative transfer code LARA[5]
- Spectra back to the interferogram domain
- 64680 interferograms

IASI* observations

- Real observations to interferograms

Simulated data : forward

- LARA to simulate HR spectra
- 2311 TIGR* atmospheric states
- 7 surface temperatures
  - Thermal contrast study
- 4 CO profiles
  - Different CO concentrations

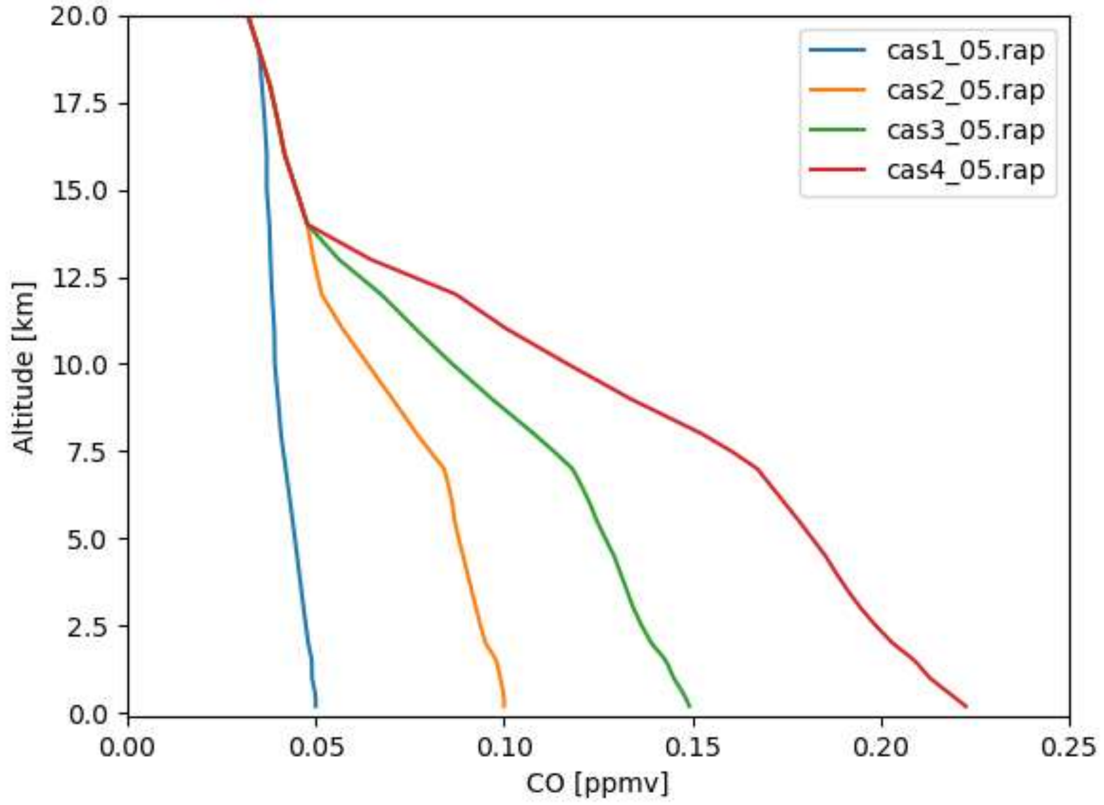
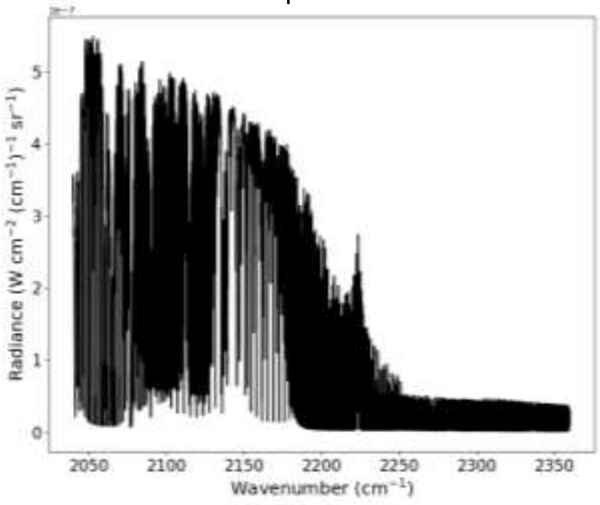


Figure : CO profiles used for simulations

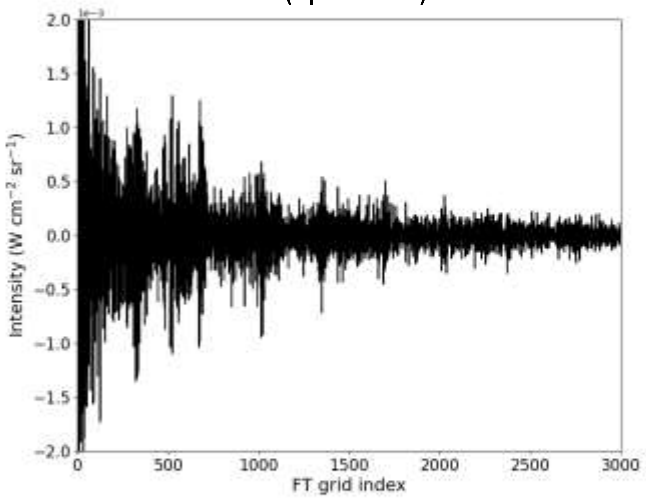
Interferogram simulations : forward

Spectrum

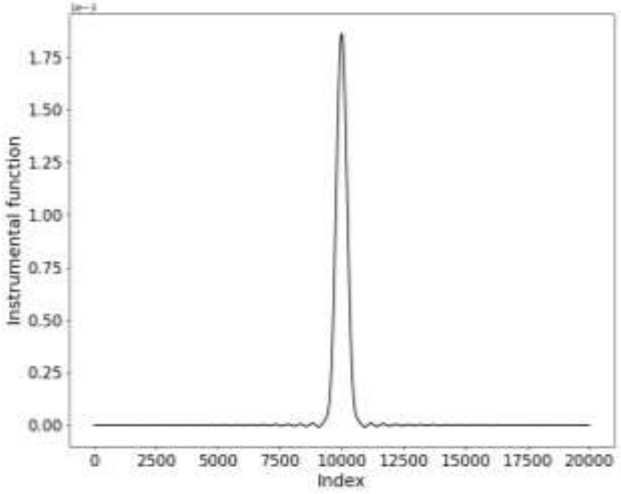


FT

FT (Spectrum)

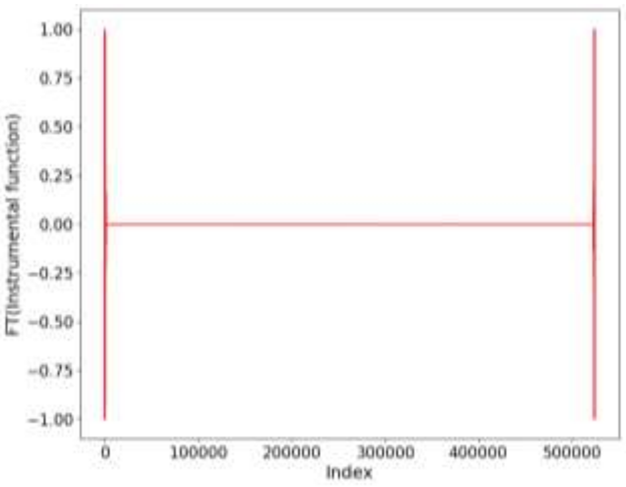


Instrumental function



FT

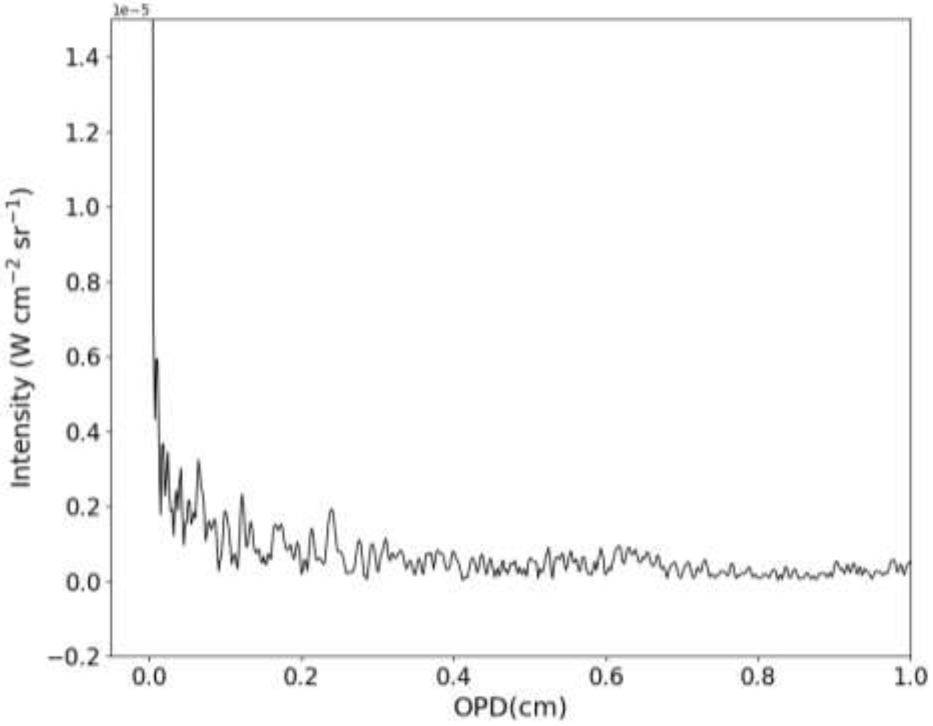
FT (Instrumental function)



CONVOLUTION

$$R(x) = \int_{-\infty}^{+\infty} r(\sigma) e^{i\,2\pi\sigma x} d\sigma$$

Partial interferogram



Retrieval approach

- **Line by line radiative transfer model** - LARA retrieval algorithm[5]
- Previously used for limb IR balloon spectroscopy and IASI satellite measurements analysis, etc.
- **LARA modified for retrieval from interferogram**
- **Inputs**:
  - HITRAN 2016: spectroscopic parameters
  - T and H_2O vertical profiles: Thermodynamic Initial Guess Retrieval (TIGR)*
- **CO Full physics retrievals :**
  - State vector = T_{surf} , H_2O, CO_2, O_3, N_2O, CO scaling factor
  - Spectrum window: 2150 - 2250 cm^{-1}
  - Interferogram window: 0 - 2 cm

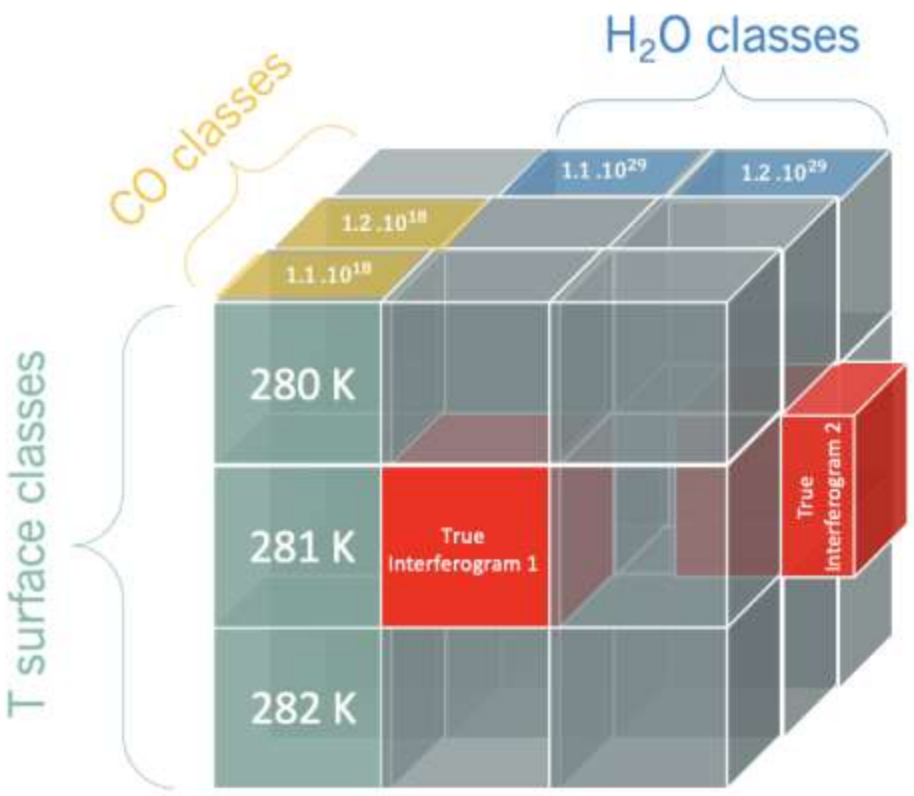
Retrieval: spectra VS interferogram

- Preliminary results (22731 cases) : comparison of standard deviation
- Large variance a priori for parameters to be retrieved
- Same state vector (State vector = T_{surf}, H_2O, CO_2, O_3, N_2O, CO scaling factor)
- IASI noise (diagonal covariance matrix S_y)
- Retrieval for the same initial conditions for both spectrum and interferogram

	Interferogram	Interferogram stdv	Spectrum	Spectrum stdv
Mean T_{surf}	269.41 K	0.046 K	269.43 K	0.043 K
Mean X_{H2O}	0.999	0.010	0.9795	0.050
Mean CO column	2.126×10^{18} molecules/cm^2	9.57×10^{16} molecules/cm^2	2.147×10^{18} molecules/cm^2	1.11×10^{17} molecules/cm^2

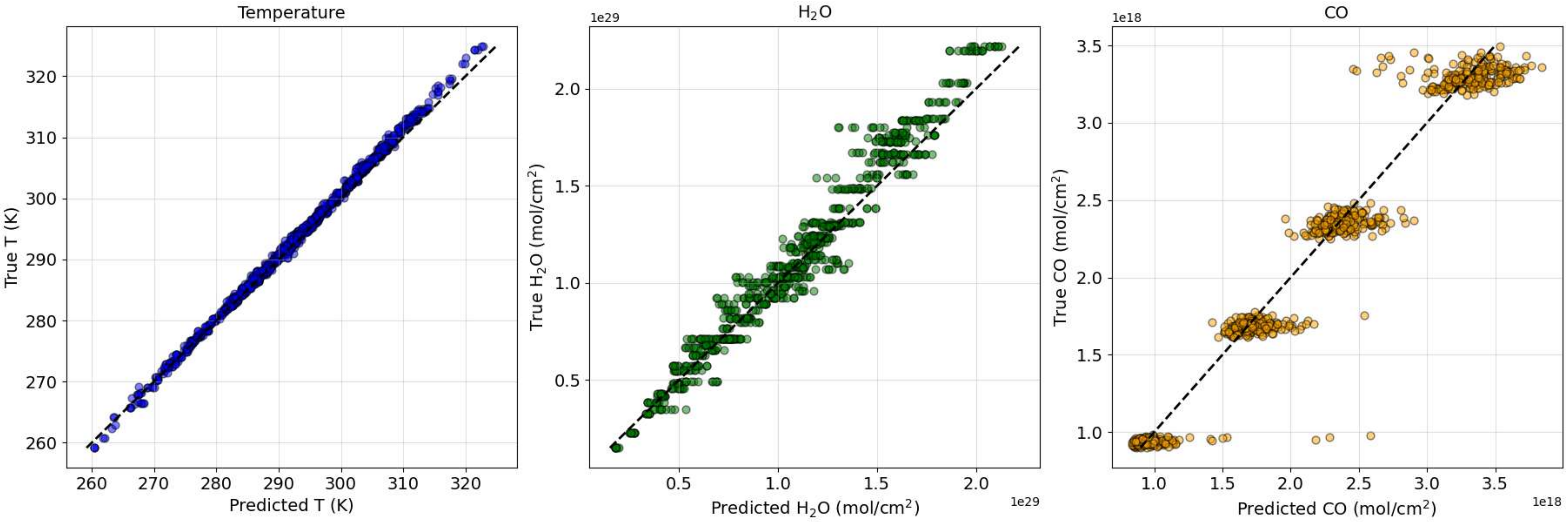
Classification: methods

- Quick prediction of surface temperature, CO and H_2O SCD for any interferogram
- Utilise only radiances at specific OPDs
- 2 different approaches based on data binning:
  - Radiance classes
  - Geophysical-parameter classes
- 1 Neural Networks approach



Schema 1 : 3D control set

Classification: results Neural Networks



Error type	T_surface (K)	H_2O (mol/cm^2)	CO (mol/cm^2)
Mean absolute percentage error - No noise	0.2%	7%	6%
Mean absolute percentage error - Noised* interferograms	0.2%	12%	23%

[Ećo et al. in prep]

Conclusion and outlook

- **Full physics retrieval**:
  - Retrieval from interferograms overall better for retrieval of CO
  - Test the impact of other parameters (line of view angle, surface albedo...)

- **Classification** :
  - Provides faster predictions to conventional methods (MTG IRS- 4 min)
  - Neural networks approach with higher accuracy

- Next steps:
  - Choice of noise
  - test retrieval on IASI "observed” interferograms* for both full physics retrieval and for classification

Thank you for your attention!

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