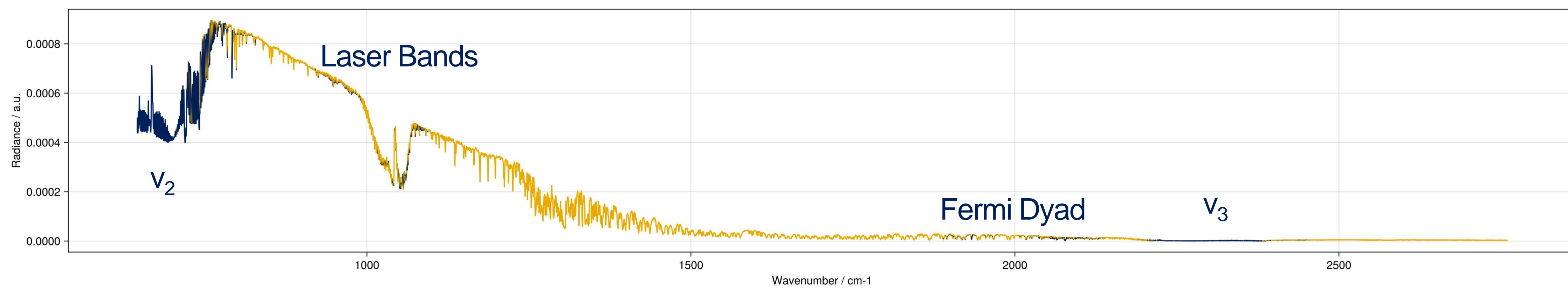


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Vertical Information Content in CO2 Retrievals from IASI

INTRODUCTION

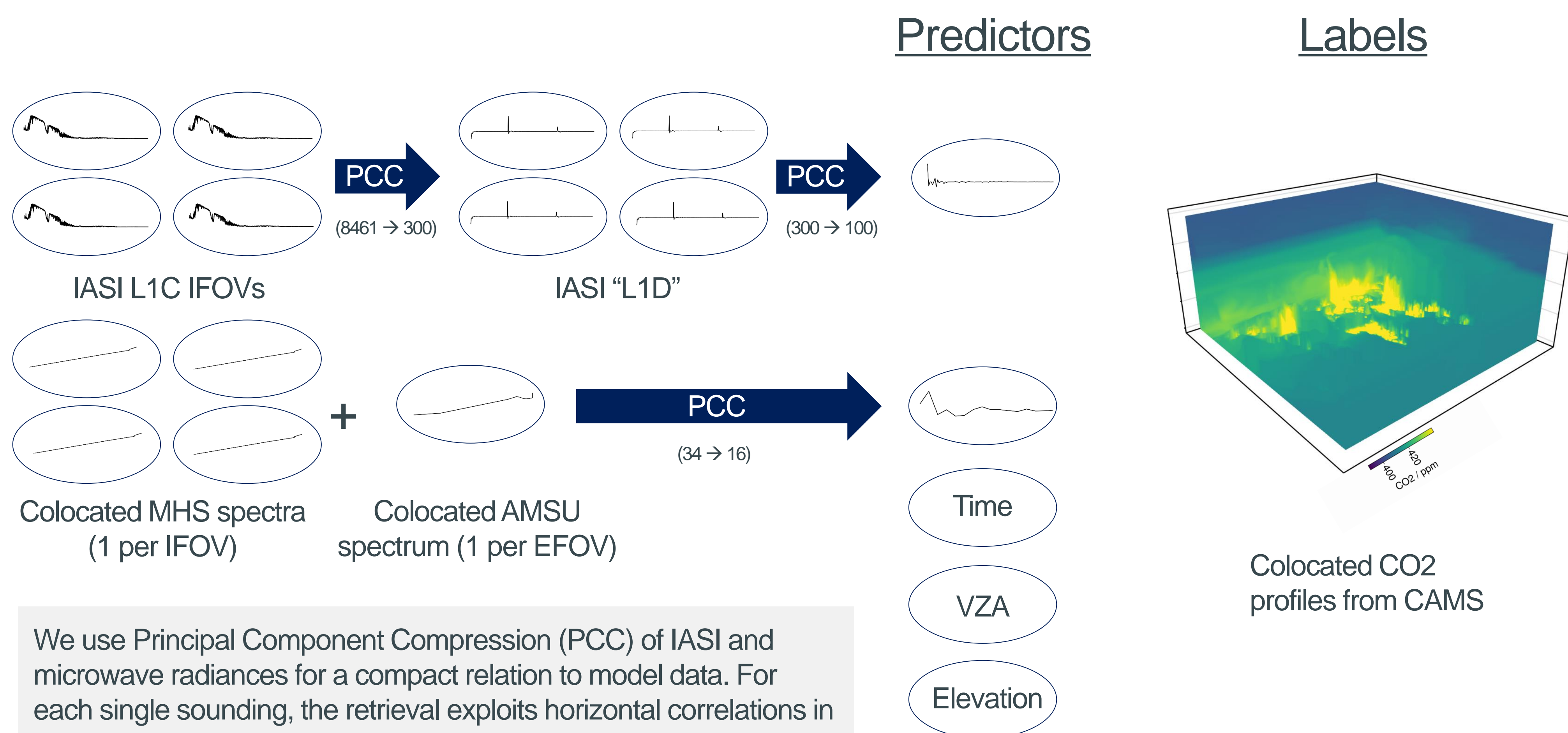
Piece-Wise Linear Regression (PWLR) is a machine learning method for retrieving geophysical variables from hyperspectral infrared satellite measurements. It has been used operationally for inversions of temperature, water vapor and ozone profiles from IASI spectra. Here, we apply the methodology to CO2 retrievals and explore its potential to resolve CO2 concentrations vertically.



We consider the full IASI spectral range

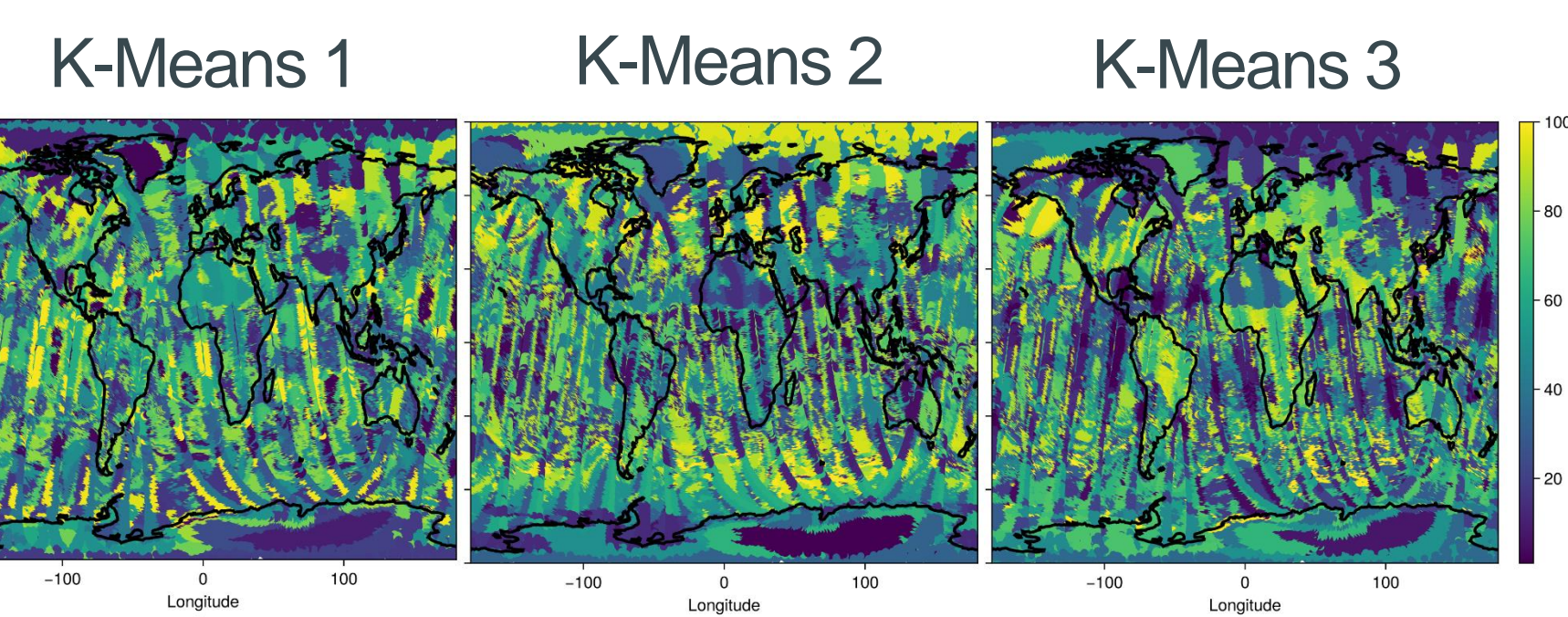
~20% of IASI channels are affected by CO2 transitions with intensities greater than $1e-24$ (shown in blue in the spectrum to the left).

The PWLR CO2 algorithm

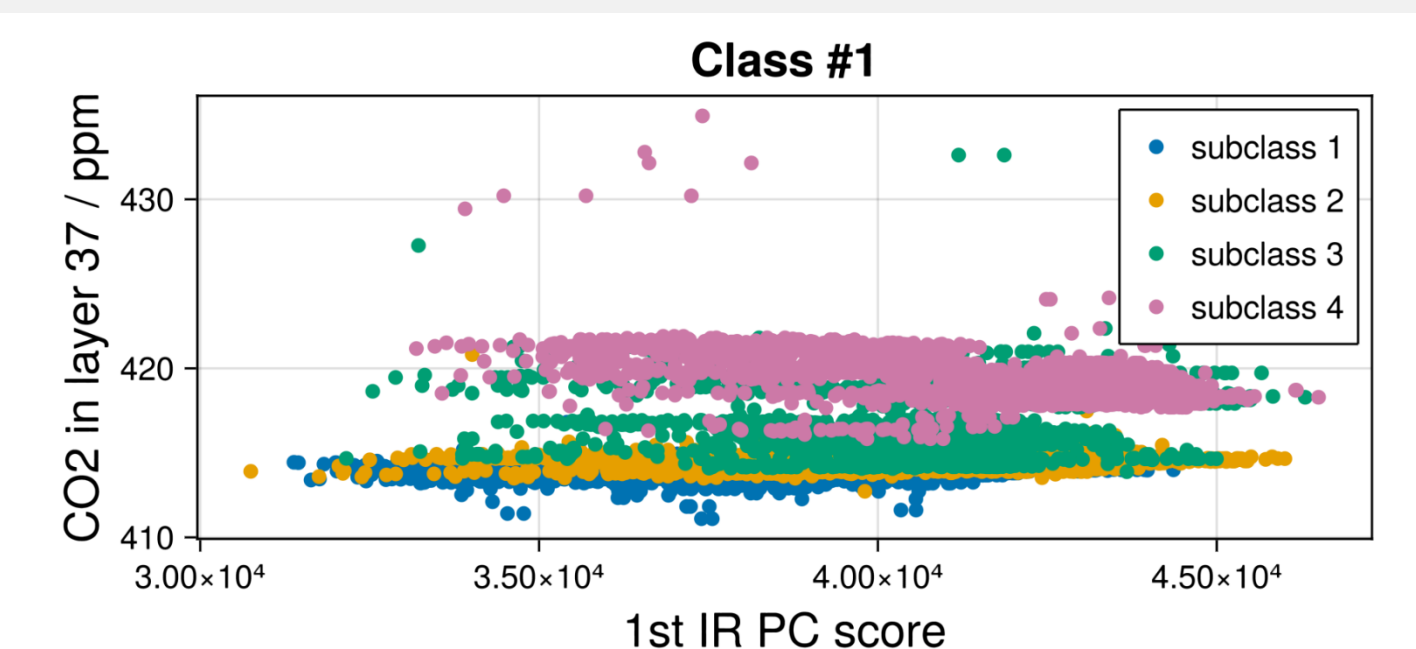


We use Principal Component Compression (PCC) of IASI and microwave radiances for a compact relation to model data. For each single sounding, the retrieval exploits horizontal correlations in the atmosphere through a spatial PCC step as shown above.

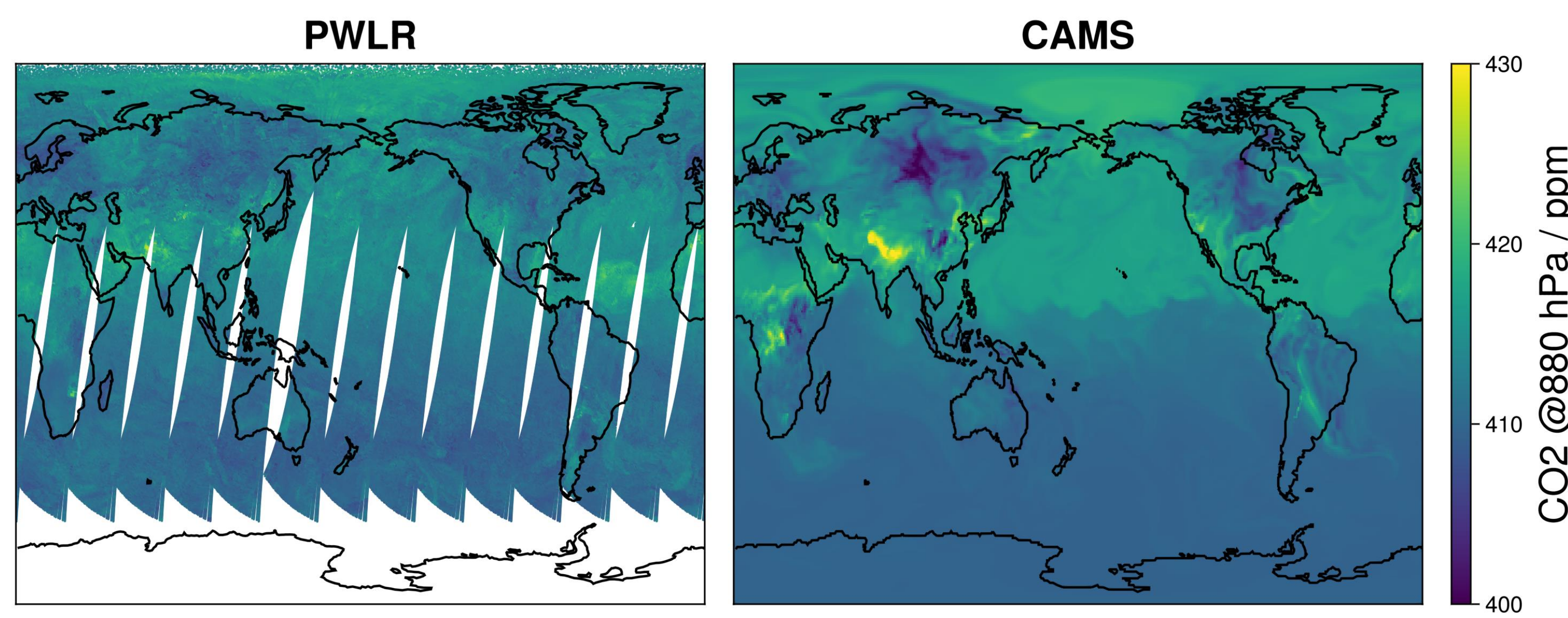
We create an ensemble of K-means clusters based on different combinations of predictors.



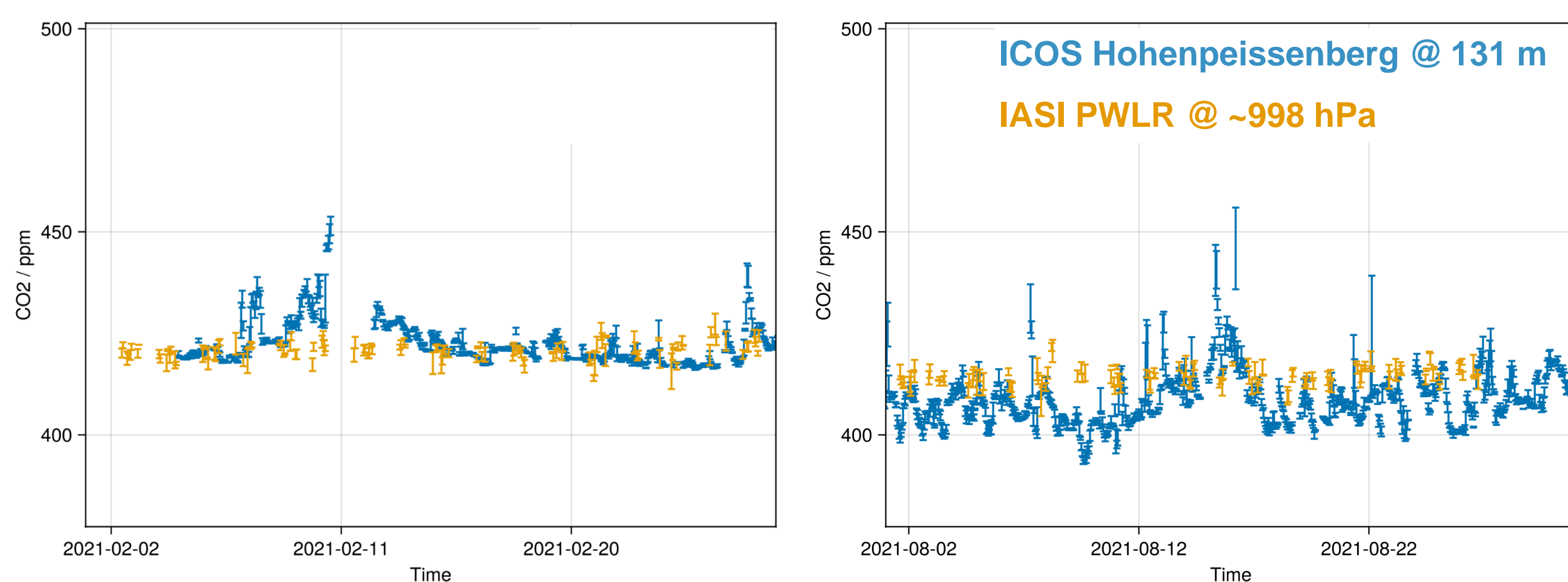
In each class, a 4-way split establishes linear relationships between predictors and labels, enabling linear regression retrievals with robust error characterization.



Preliminary Retrieval Results



IASI-B CO2 retrievals at 880 hPa on 2020-06-25, no cloud screening (above) – some tropospheric features are picked up.



February 2021

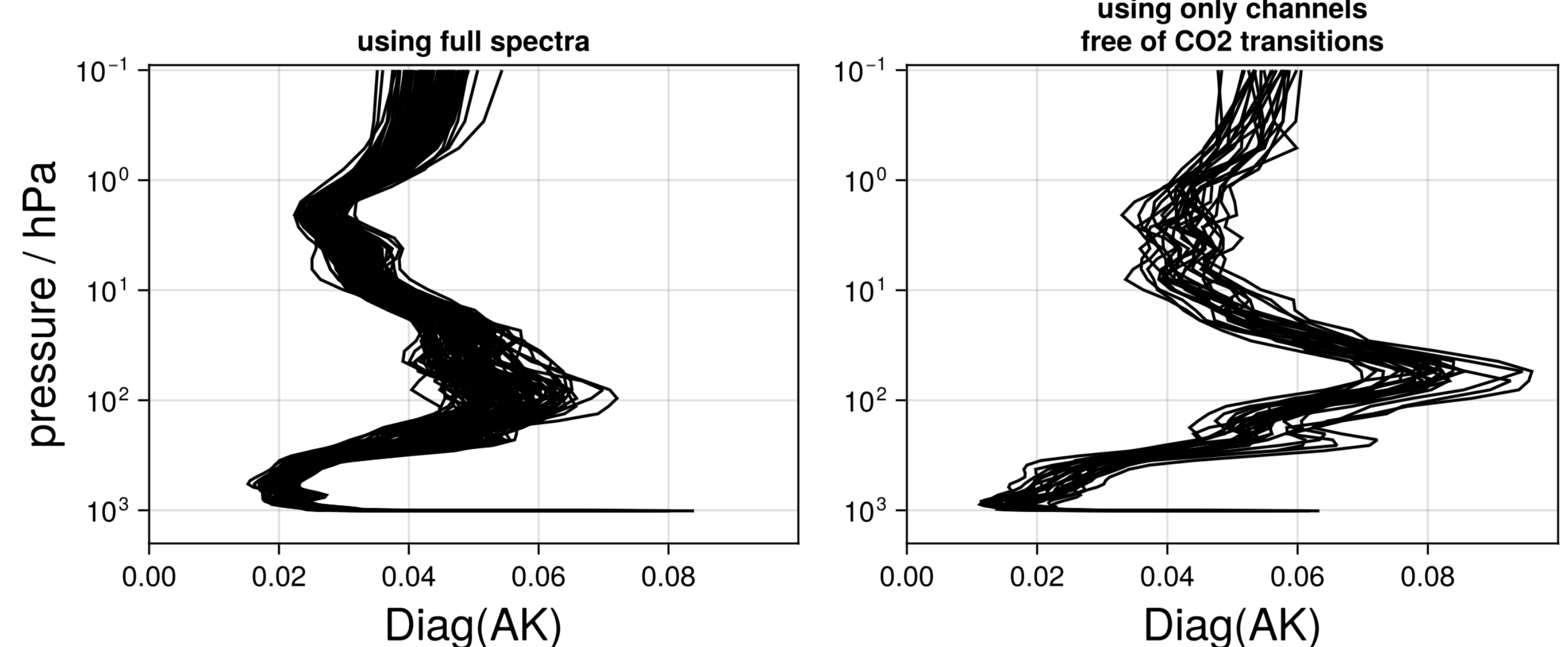
August 2021

Above: Retrieval comparison to ICOS in-situ tower data at Hohenpeissenberg, Germany.

The seasonal cycle of CO2 (and hemispheric gradients, not shown here) is not correctly retrieved. Nonetheless, there is promising performance for CO2 columns, with XCO2 bias and standard deviation relative to TCCON remaining below 3 ppm globally.

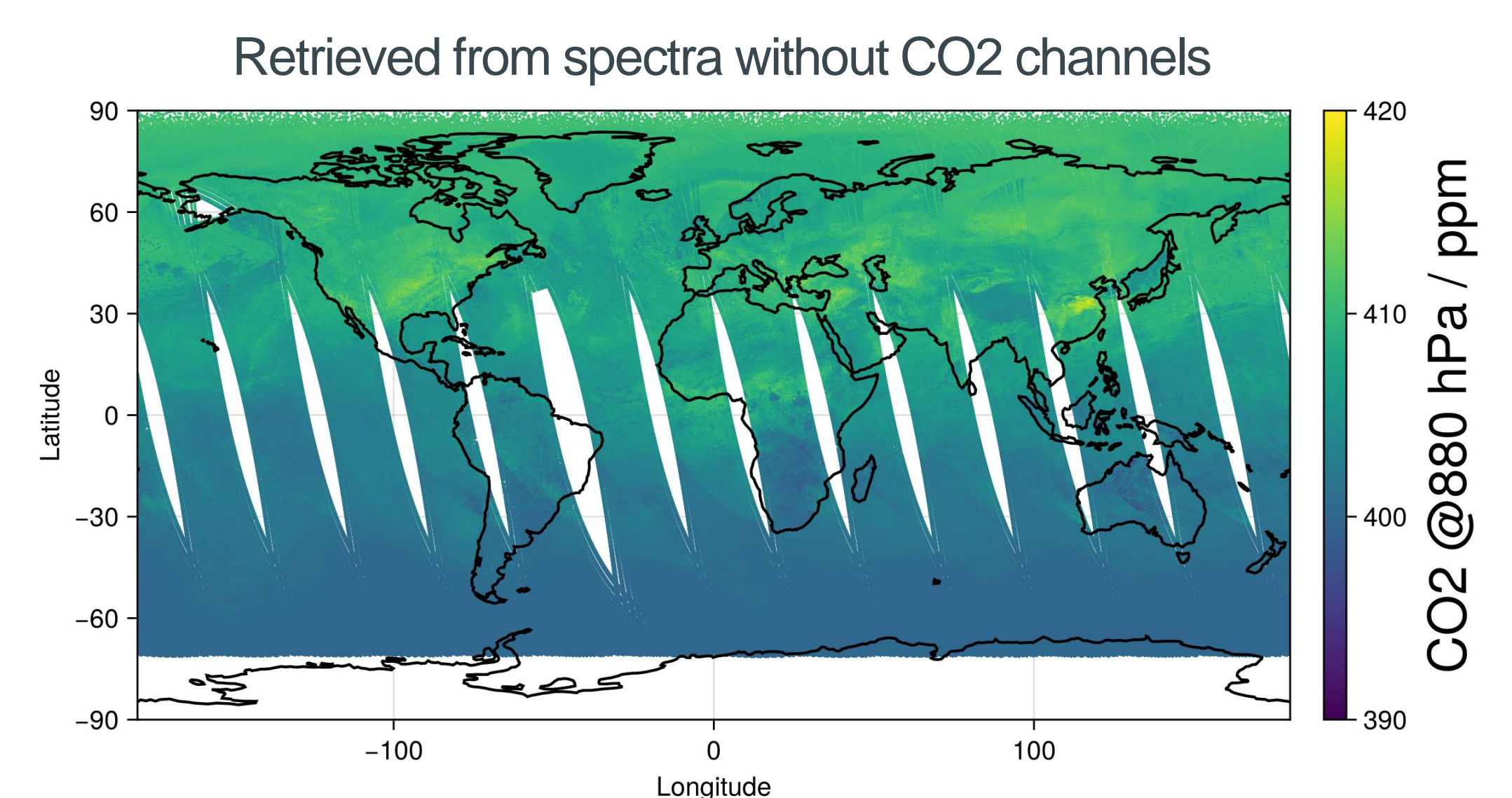
Averaging Kernels

average AKs in the KMeans classes



The averaging kernel shapes are qualitatively consistent across all retrieval classes, with a surface sensitivity spike. Shown are kernels from retrievals using full L1C spectra (above left) and spectra excluding CO2 transitions (above right). We consistently find average vertical degrees of freedom for signal greater than 2.

The unchanged kernel shapes suggest vertical information content may be obtained indirectly, e.g. via dependencies on other variables. Retrievals of lower tropospheric CO2 (IASI-B, 2017-01-26, without cloud screening) are displayed below for the retrieval that omits CO2 spectral channels.



Summary and outlook

The CO2 retrieval is still under development to address several performance issues and investigate the origin of the vertical information content, yet preliminary results are encouraging and demonstrate its ability to retrieve some CO2 profile information.

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