Estimate of XCO2 and Psurf from OCO-2 measurements using a Neural Network approach

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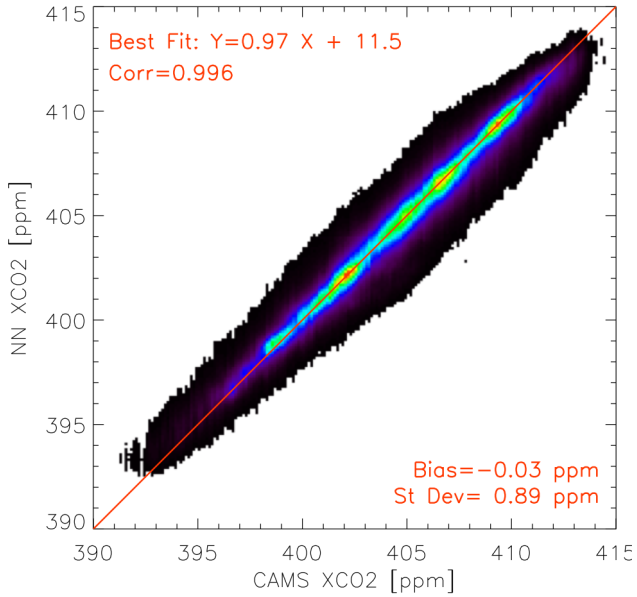
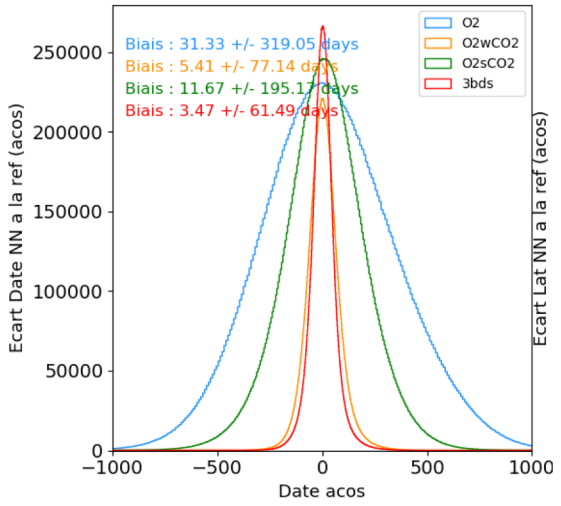
- We apply a Neural Network (NN) approach for the estimate of XCO2 and Psurf from OCO spectra
- A first attempt led to surprisingly good performances in term of reproducing the main XCO2 temporal and spatial patterns, and agreement with TCCON. However, no plumes were reproduced
- Current understanding is that the NN infers the date of observation from the spectra and the latitude from the observation angles. It then generates the large scale XCO2 for this position and date
- Further analysis shows that the date of observation is retrieved by the NN from the weak CO2 band.
- A new NN, that does not use this band (only O2 and sCO2 band) shows an accuracy comparable to that of ACOS and does detect XCO2 plumes that are not in the training dataset
- NN is therefore a promising alternative approach for the processing of atmospheric spectra aiming at XCO2 estimates



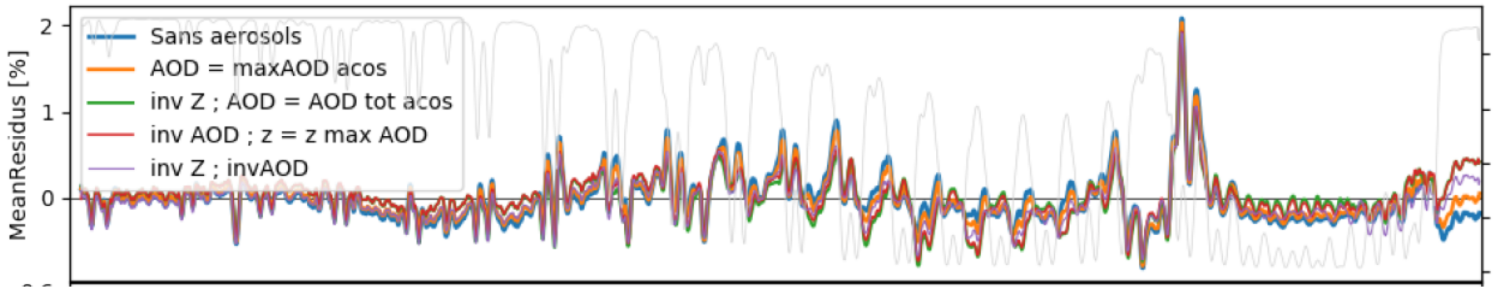
The NN reproduces the CAMS XCO2 with high accuracy



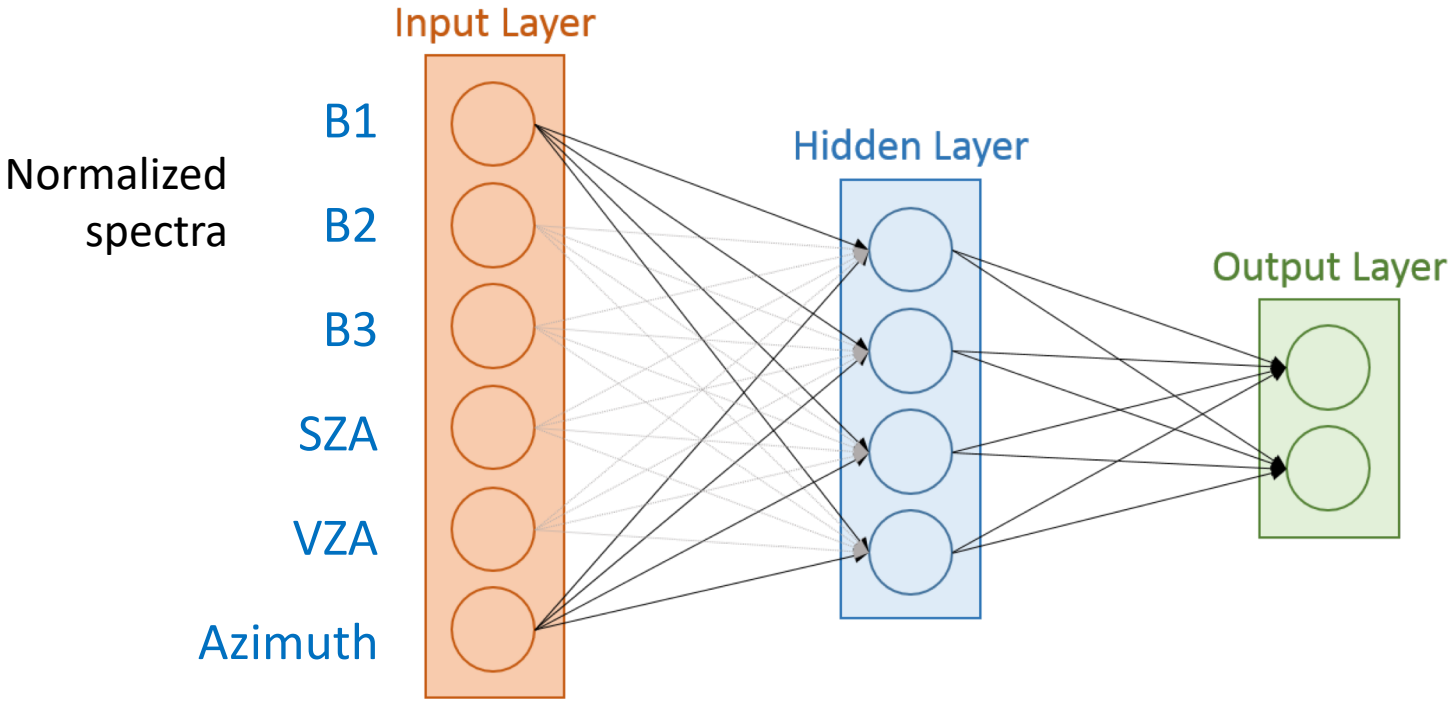
NN performance for retrieving the obs date, depending on input data

Motivations and method

Systematic spectral residus (O_2 band) after inversion



- Uncertainties in radiative transfer modelling and instrument defects lead to systematic residues in the spectra => EOF
- Biases in the XCO2 estimates impose an empirical correction
- These suggest an attempt with a full empirical approach

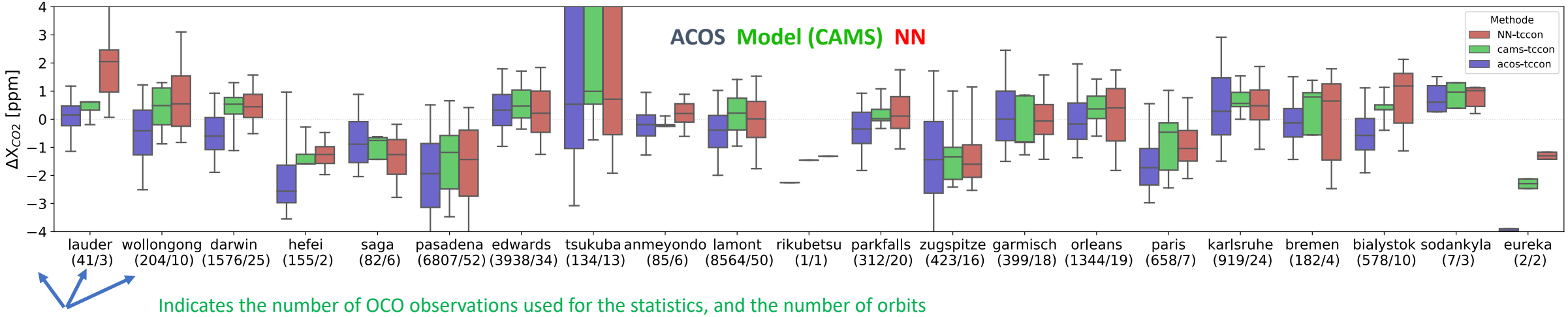


The training dataset uses the CAMS 4D simulation where the atmospheric concentrations are constrained by the surface observations

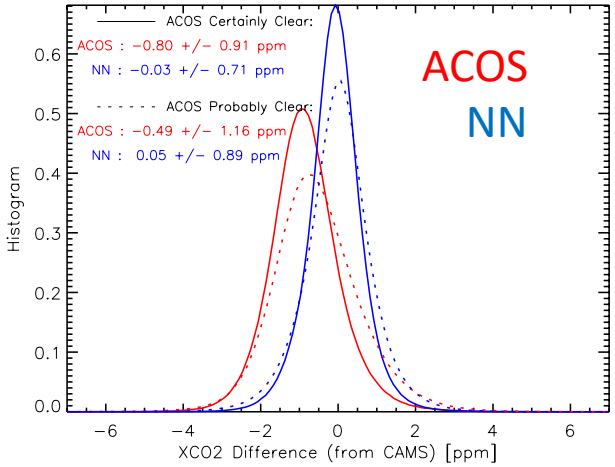
The NN weights are optimized to minimize the differences between CAMS and the NN estimates of XCO2

The NN is then tested against an independent set of observations

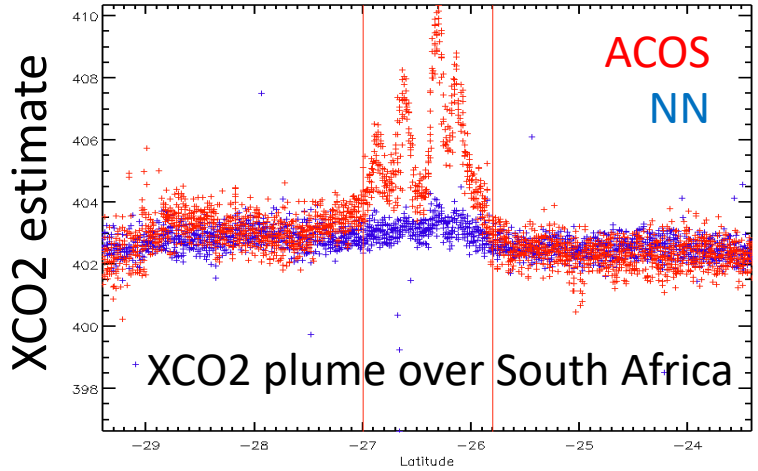
First attempt : the NN shows high accuracy but only reproduces the training dataset signal



Indicates the number of OCO observations used for the statistics, and the number of orbits



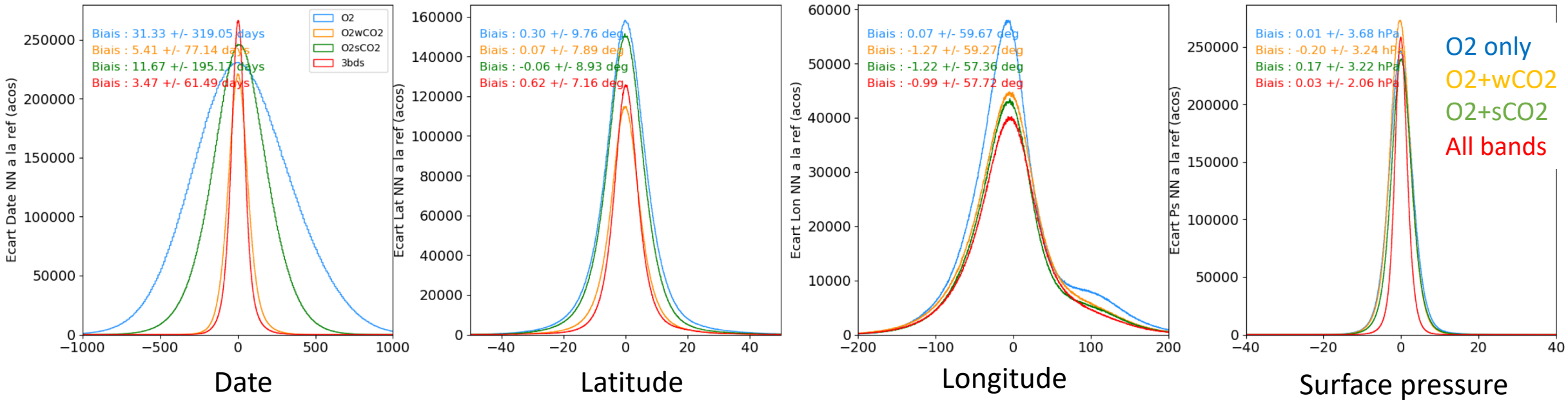
- The NN estimates are compared to the TCCON observations
- Results show an accuracy that is similar to that of ACOS, although the CAMS model shows even higher agreement
- Comparison against CAMS shows a better agreement of the NN than the ACOS estimates



However, the NN does not retrieve XCO2 plumes:

It only produces features that are in the training dataset

Interpretation: the NN finds the date and the location from the input data (spectra and geom)



Histogram of the NN errors when attempting to retrieve the date and location. Several configuration (# bands as inputs)

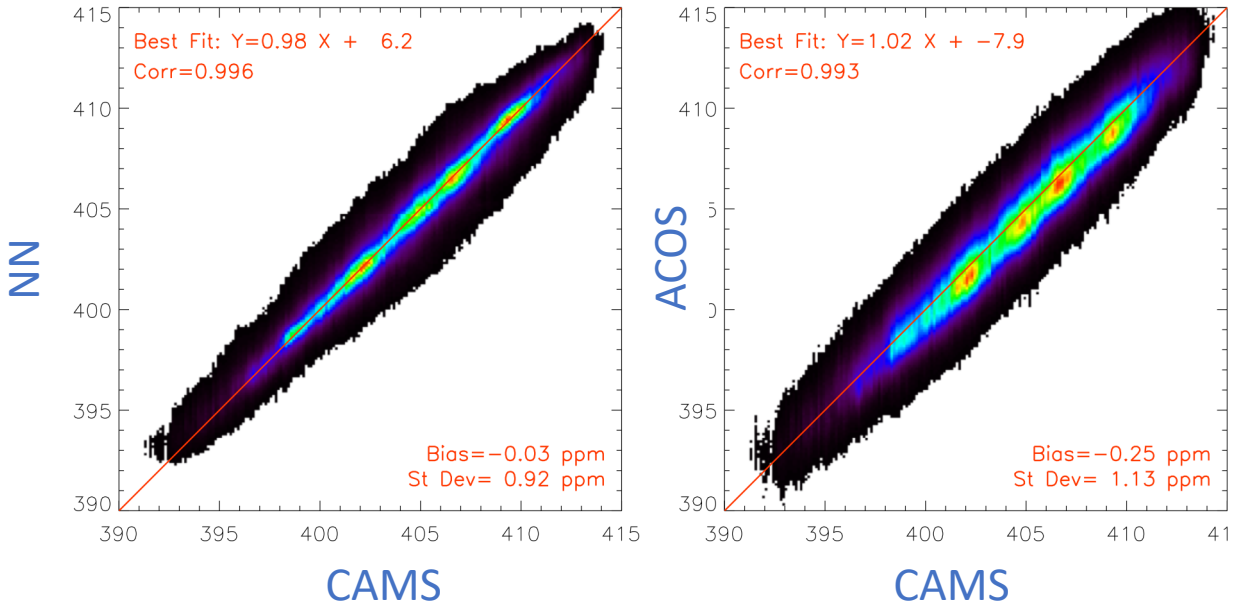
With the same inputs (Spectra, obs. geometry) a similar NN approach is able to estimate the date and location with various levels of accuracy

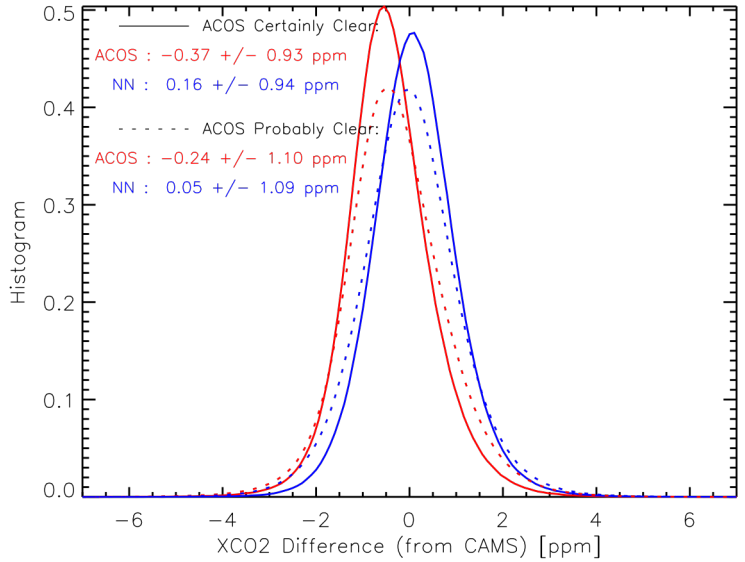
With this information, it is then “easy” to use the training dataset XCO2 for this date and location

Note that the uncertainty on the longitude is much larger than that on the latitude (information from the obs. geometry

The information on the date lies in the weak CO2 band. Hypothesis : Indirect information from the stratospheric CO2

New NN : Using only the O2 and Strong CO2 bands

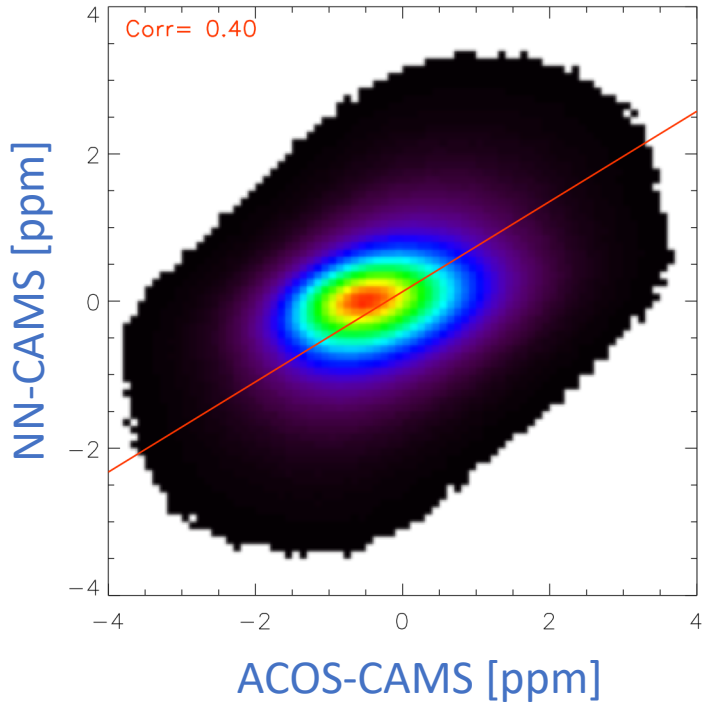




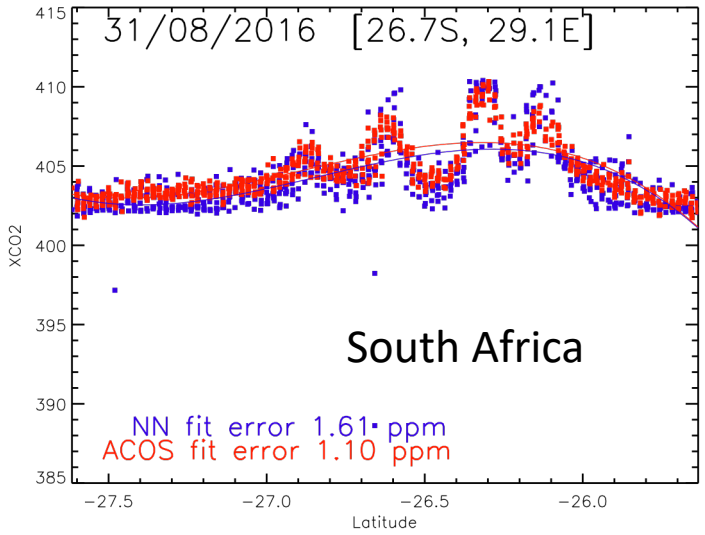
We apply a similar NN approach, but without the wCO2 band, for the estimate of XCO2 from OCO spectra

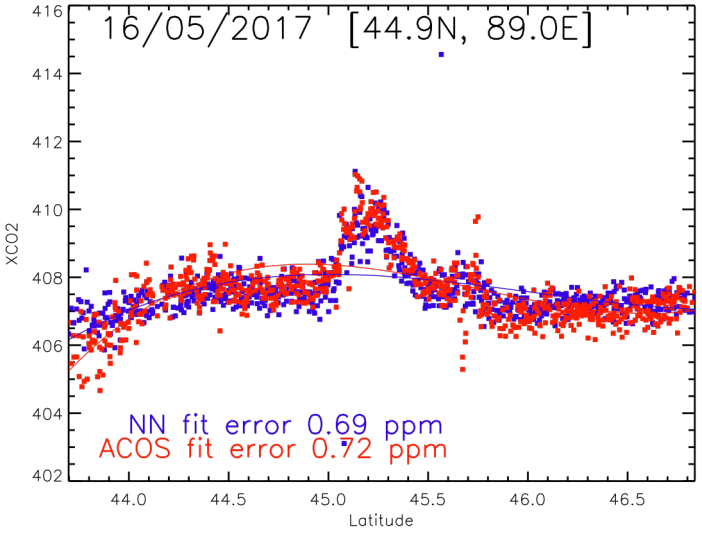
The accuracy of the estimated (quantified through the difference with CAMS) remains high, slightly better than that of ACOS

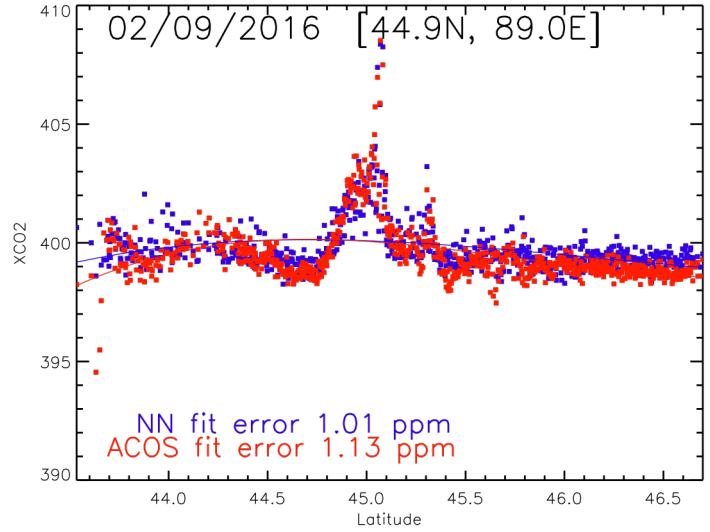
Interestingly, the increment (differences with CAMS) are correlated; the two approaches “see” similar corrections to be applied to CAMS



The new version of the NN (without wCO2 band) sees XCO2 plume



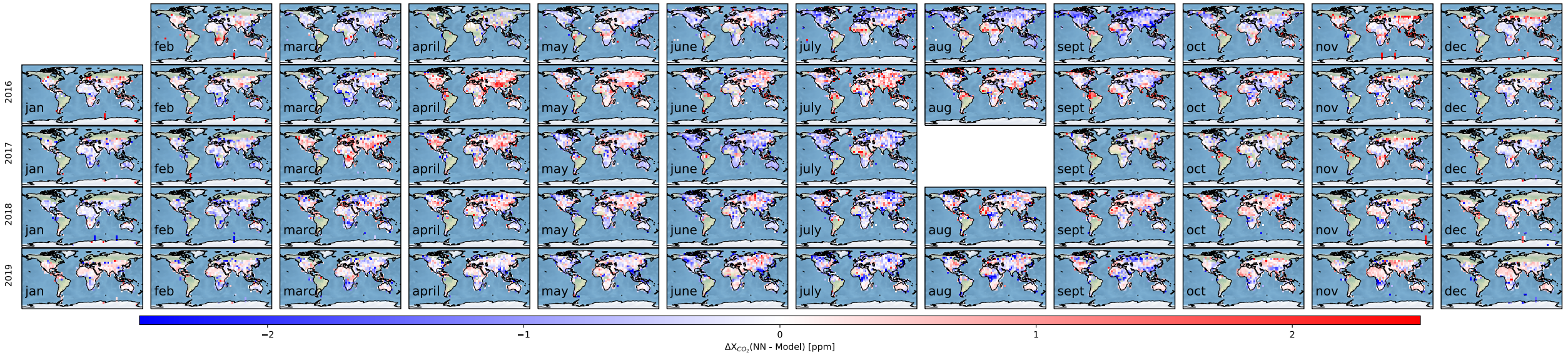




The new version of the NN sees XCO2 plume, similarly as the ACOS algorithm product

This demonstrates that the NN is able to retrieves XCO2 features that are not in the training dataset

Monthly mean NN estimate with respect to mode



The monthly maps of the differences with CAMS do show spatio-temporal patterns. The next step is then to interpret these patterns in terms of CO2 fluxes.