

## Changes to Improve to Network Precision

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### TCCON

The Total Carbon Column Observing Network (or TCCON), currently made up of 26 sites internationally, is a network of ground-based Fourier Transform Spectrometers that record direct solar spectra in the near-infrared. Accurate and precise column-averaged abundances of CO<sub>2</sub> (as well as of other atmospheric constituents - CH<sub>4</sub>, N<sub>2</sub>O, HF, CO, H<sub>2</sub>O, and HDO) are retrieved from these spectra. Dating back to 2004, TCCON data have proven to be valuable in providing ground truth for satellite measurements of CO<sub>2</sub> and CH<sub>4</sub> column abundances and in evaluating large-scale carbon models and improving global estimates of the sources and sinks of CO<sub>2</sub> and CH<sub>4</sub>.

### Extended Measurement Capabilities into Mid-IR

Several TCCON sites (Caltech and Lamont) have installed a dual InGaAs/InSb detector arrangement to extend measurement capabilities into the mid-IR and allow for retrievals of HCN, C<sub>2</sub>H<sub>6</sub>, OCS, NO<sub>2</sub>, O<sub>3</sub>, and CH<sub>2</sub>O. These products will be released as part of the next version of the TCCON retrieval algorithm (GGGNext).

### TCCON Site Locations



**\*New\***

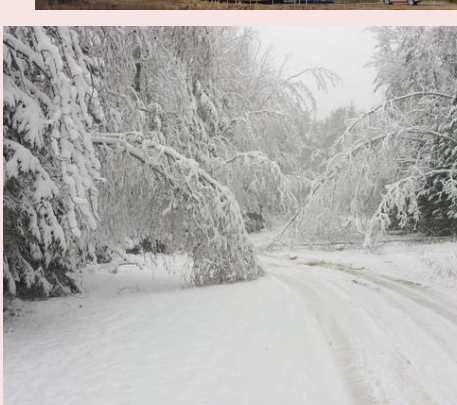
#### East Trout Lake, Saskatchewan, Canada

- Location: 54.353738°N, 104.986667°W, 501.8 masl
- PI: Debra Wunch
- Co-Is: Orfeo Colebatch, Joseph Mendonca, Greg Neufeld, Stephen Springett, Kris Kuntz, Norton Allen, Jean-Francois Blavier
- Collaborators: Doug Worthy, Bob Kessler, Kimberly Strong
- Operational as of 2016-10-07



#### Burgos, Philippines

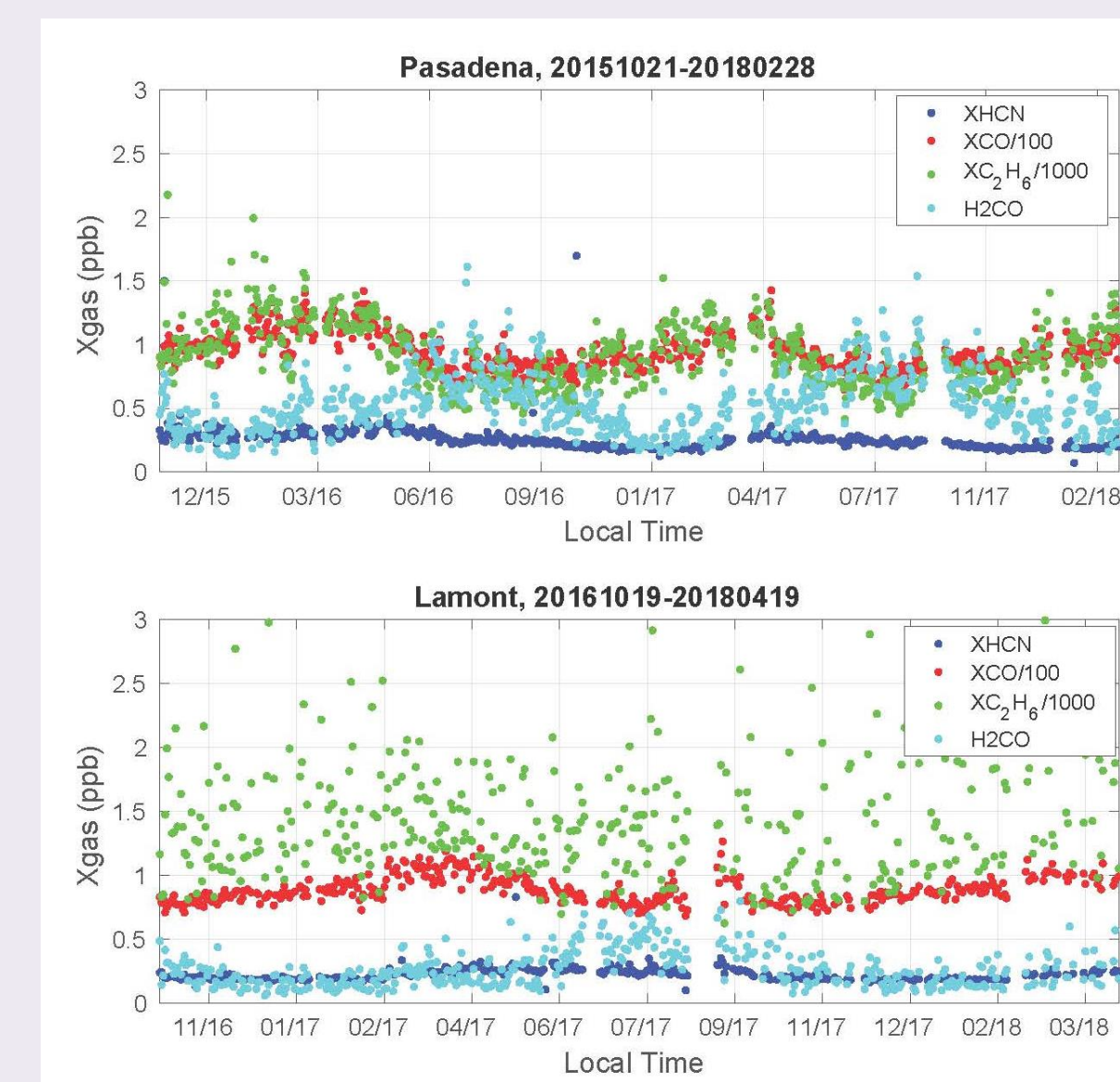
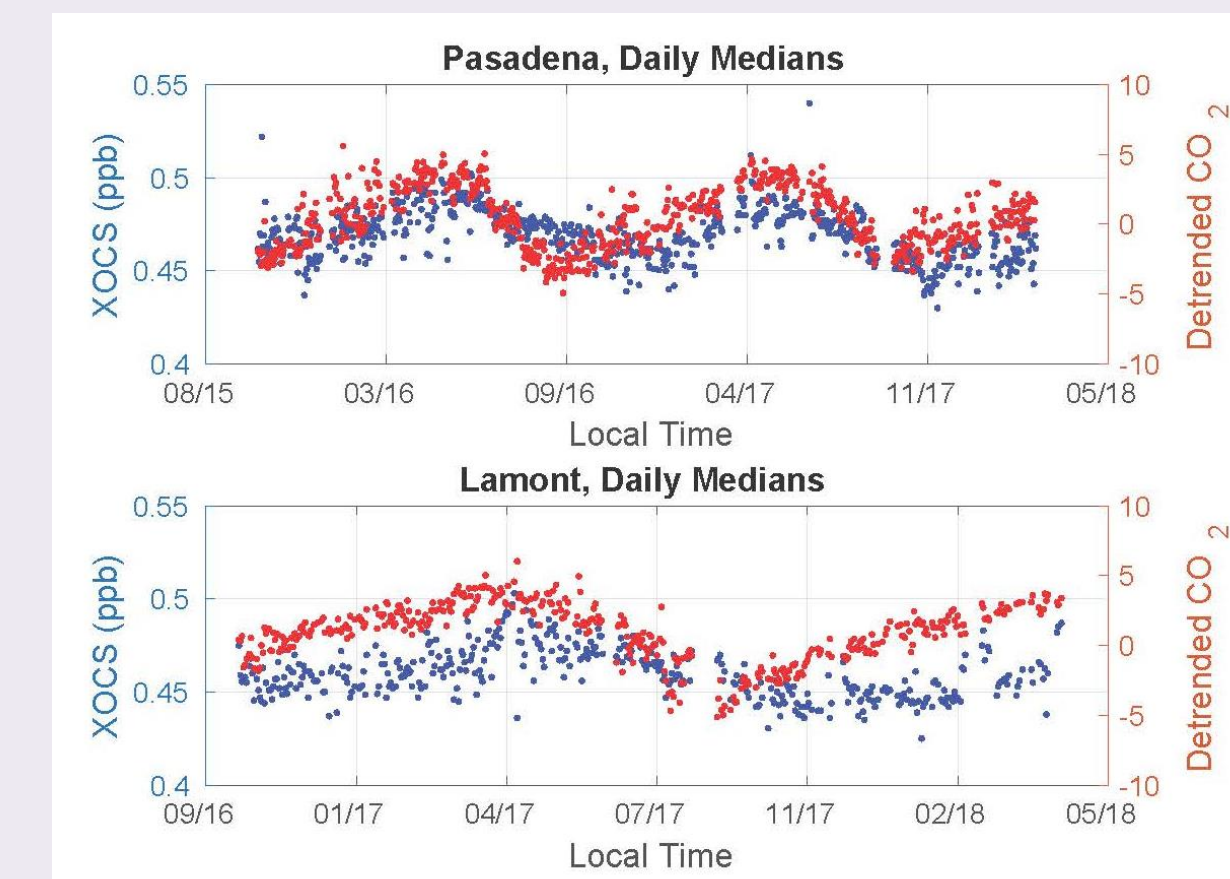
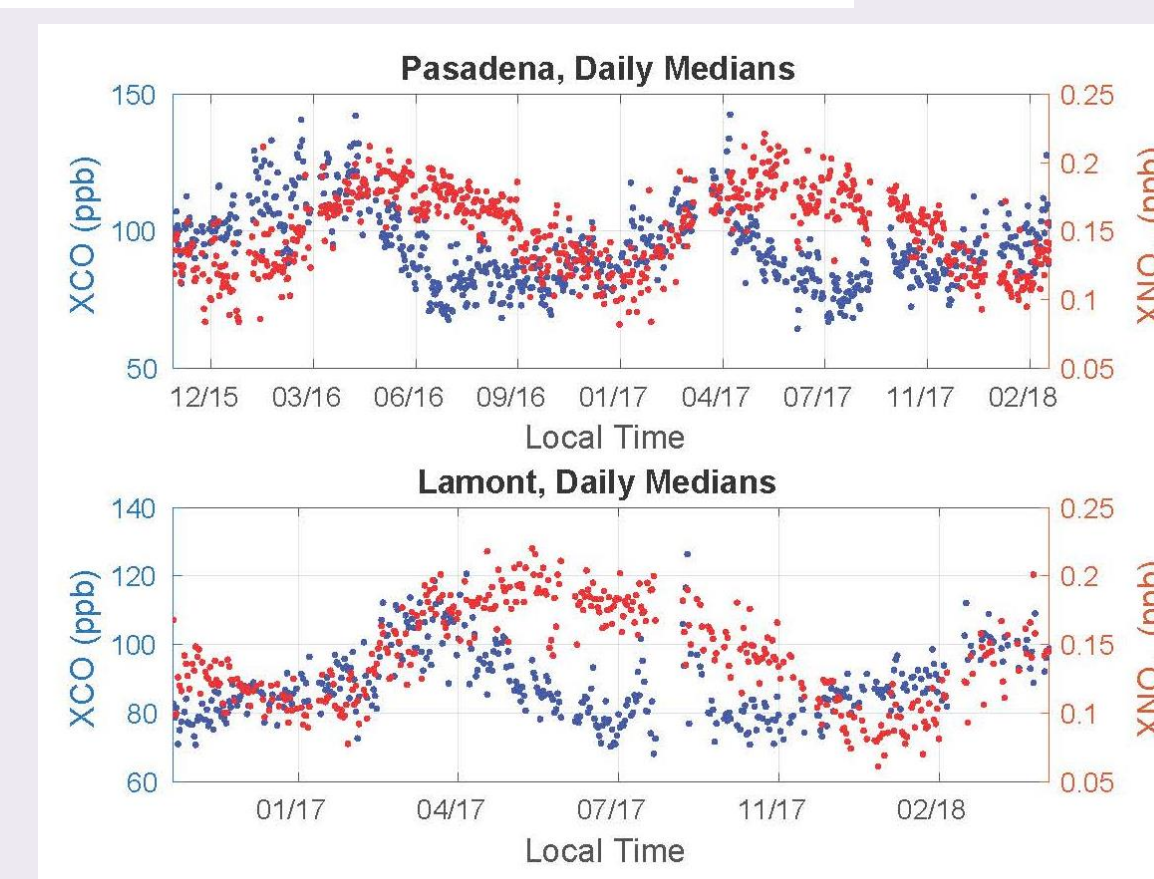
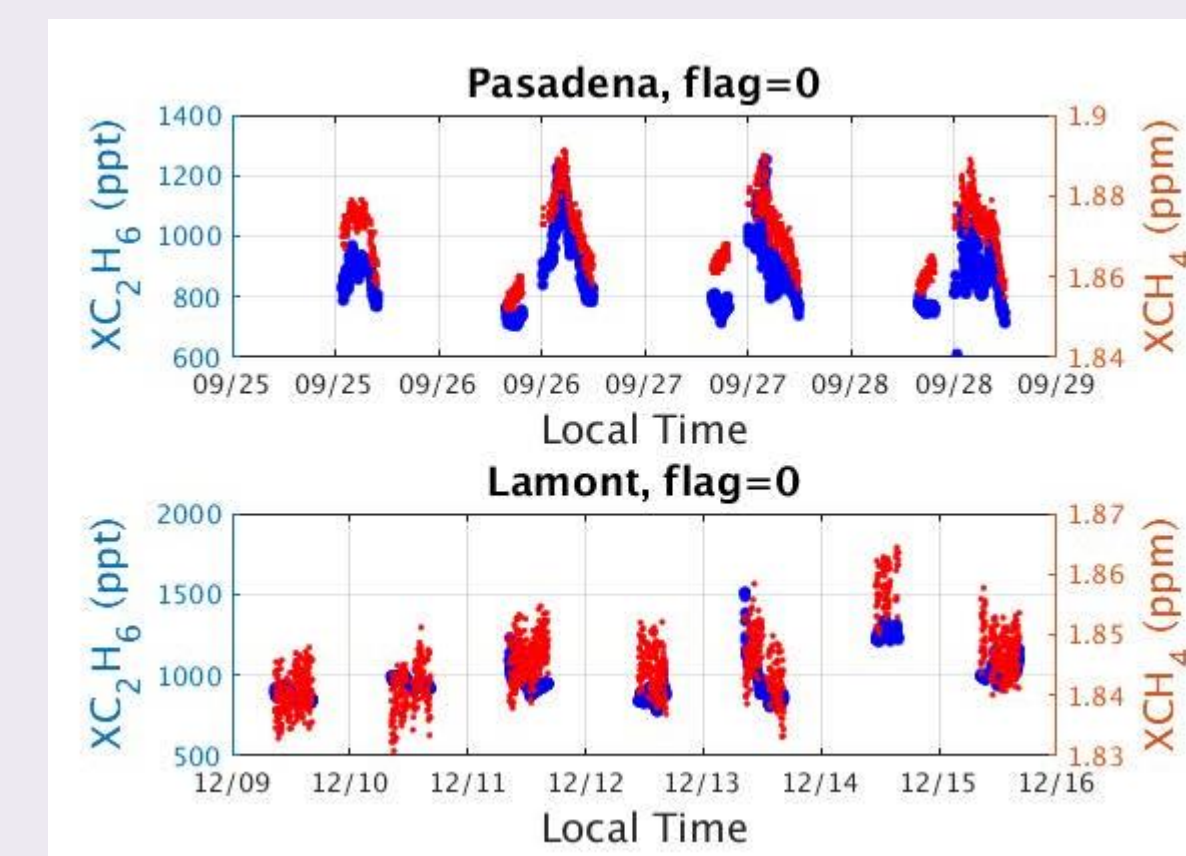
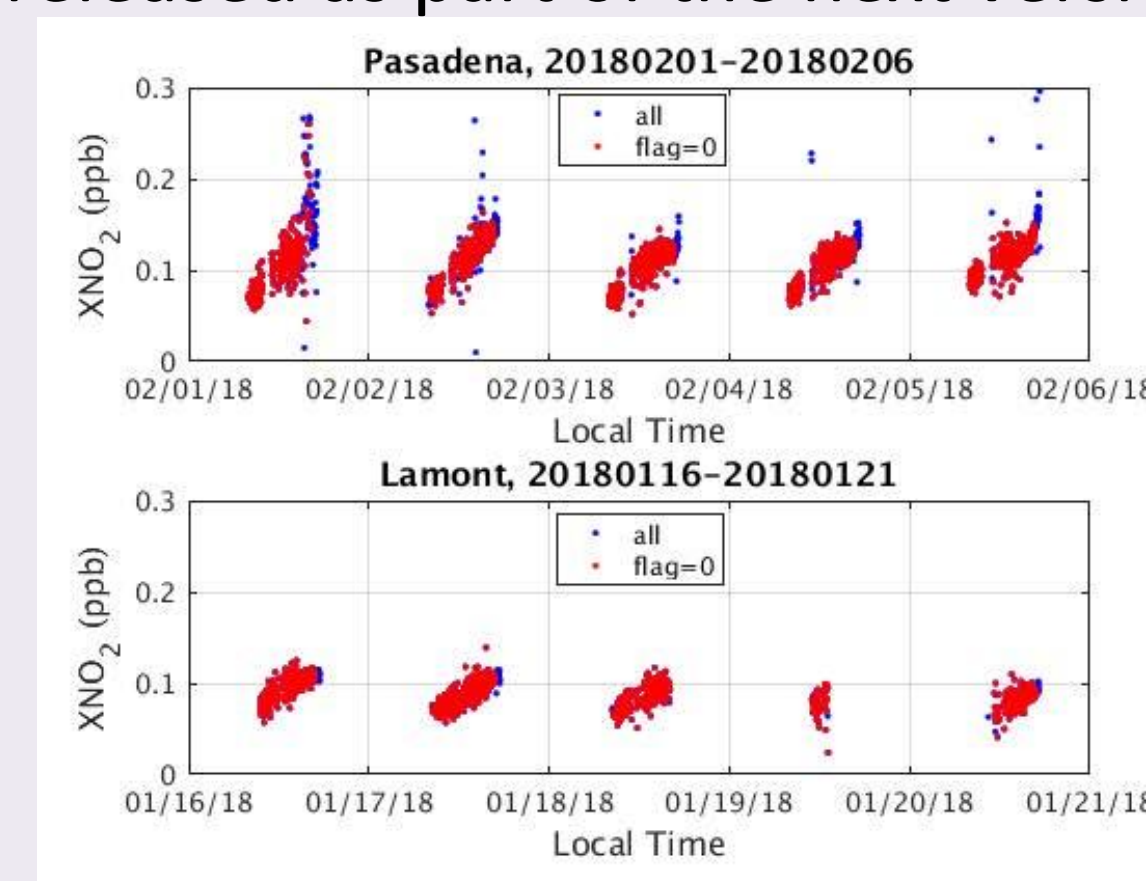
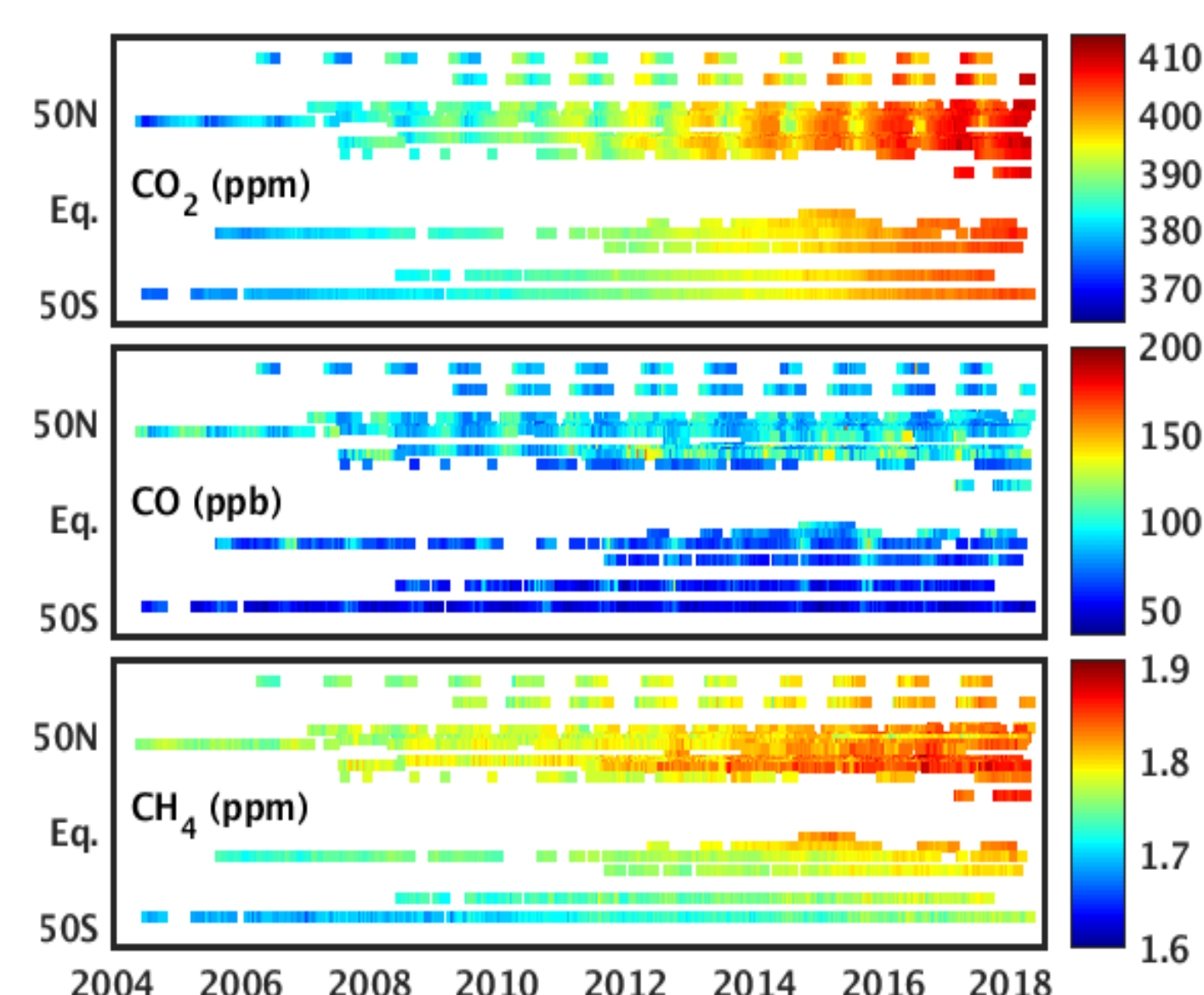
- Location: 18.5325°N, 120.6496°E, 35 masl
- Operated by National Institute for Environmental Studies, University of Wollongong, Energy Development Corporation and supported in part by the GOSAT project
- Operational as of 2017-03-03



Future sites: Edwards, CA, USA; Harwell, Oxfordshire, UK, Hefei, Anhui, China, and Los Alamos, NM, USA

### Column averaged dry-air mole fractions

- XCO<sub>2</sub> have increased by more than 40 parts per million (ppm) since TCCON measurements commenced, approaching or exceeding 410 ppm at all sites in the Northern Hemisphere this past winter (2017-18).
- XCO is available as a part of TCCON's standard product, with good coverage back to 2004.
- Observations also indicate that CH<sub>4</sub> concentrations have increased substantially since 2006-07.



Inspired by work in Wunch et al.:  
<http://www.atmos-chem-phys.net/16/14091/2016/>

### GGGNext: Improved Precision

We are completing the development of the next version of the TCCON retrieval algorithm. We expect substantial improvements in a number of products.

- Improved our priors by
  - Using new in situ network, aircraft, and AirCore observations
  - Putting better constraints on stratosphere (with Arlyn Andrews)
  - Updated handling of specific humidity
- Improved representation of instrument transmission function in the retrievals
- Improved spectroscopy through
  - Refined descriptions of O<sub>2</sub>, CO<sub>2</sub>, CH<sub>4</sub>, and H<sub>2</sub>O absorption
  - Implemented line mixing for O<sub>2</sub>, CH<sub>4</sub>, strong band of CO<sub>2</sub>. This greatly reduces the air mass dependence of the retrievals.
- Switching from NCEP reanalysis data to GMAO Merra2, with increased spatial and temporal resolution
- Improved phase description in the Fourier transform
- Adding *NEW* research products
  - Mid-IR products
  - Retrievals on different CO<sub>2</sub> bands

### Going Forward

- Use the heterogeneity of the vertical abundance of NO<sub>2</sub> with the difference in spectral signal, caused by pressure broadening, to independently retrieve boundary layer NO<sub>2</sub>.
- Want to understand the C<sub>2</sub>H<sub>6</sub> / CH<sub>4</sub> ratios to better constrain CH<sub>4</sub> emissions from natural gas sources.
- Compare all near- and mid-IR products with other remote sensing methods.