TCCON Updates and 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\(_2\) (as well as of other atmospheric constituents - CH\(_4\), N\(_2\)O, HF, CO, H\(_2\)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\(_2\) and CH\(_4\) column abundances and in evaluating large-scale carbon models and improving global estimates of the sources and sinks of CO\(_2\) and CH\(_4\).

**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\(_2\)H\(_2\), OCS, NO\(_2\), O\(_3\) and CH\(_3\)O. These products will be released as part of the next version of the TCCON retrieval algorithm (GGGNext).

**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\(_3\), CO\(_2\), CH\(_4\), and H\(_2\)O absorption
    - Implemented line mixing for O\(_3\), CH\(_4\), strong band of CO\(_2\). 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\(_2\) bands

**Going Forward**

- Use the heterogeneity of the vertical abundance of NO\(_2\) with the difference in spectral signal, caused by pressure broadening, to independently retrieve boundary layer NO\(_2\).
- Want to understand the C\(_2\)H\(_2\)/CH\(_4\) ratios to better constrain CH\(_4\) emissions from natural gas sources.
- Compare all near- and mid-IR products with other remote sensing methods.

TCCON data can be found at: https://tccondata.org/

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**TCCON Site Locations**

- **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 Kunz, Norton Allen, Jean-Francois Blavier
  - Collaborators: Doug Worthy, Bob Kessler, Kimberly Strong
  - Operational as of 2018-10-07

- **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\(_2\) 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\(_2\) is available as a part of TCCON’s standard product, with good coverage back to 2004.
- Observations also indicate that CH\(_4\) concentrations have increased substantially since 2006-07.