Solar Fourier Transform Spectrometry (FTS) to monitor greenhouse gas and co-emitted pollutant emissions from Four Corners, NM power plants

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Innovation for Our Nation

I. Motivation

➢ Verifying CO_2 emissions control agreements will require the detection of a small anthropogenic CO_2 signals (ppm) against a large (390 ppm) and variable (10 ppm) background that is a challenge.

➢ Climate models that parameterize processes at coarse (~100 km) scales need multi-scale (in situ to remote, point to 100km) measurements to integrate over sub-grid variability for validation. Satellite data also needs ground truth.

II. CO_2 Attribution and Climate

➢ Pollutant gases (e.g. NO_2, SO_2, CO) co-emitted with CO_2 by energy production in distinct ratios that depend on sources are ideal for attribution.

➢ Co-emitted species have low backgrounds that are increased by factors of 2-10 by combustion sources and can be measured precisely making them sensitive probes to attribute CO_2 sources.

➢ Co-emitted species have shorter lifetimes than CO_2 whose effects need to be quantified. Emission ratios of multiple species can used concurrently.

V. Four Corners Multi-Scale Measurement-Model Testbed

➢ Our Remote Sensing Verification Project (RSVP) is testing the hypothesis that ratios of co-emitted gases to CO_2 can be used to attribute CO_2 emissions from distinct sources in Four Corners:

1) High and low NOx power plants 12 km apart
2) Semi arid area with small natural CO_2 fluxes
3) Independent multi-scale measurement/model
   a) In stack continuous emission monitoring
   b) *In situ* CO_2, CH_4, NO_2, SO_2, O_3, CO
   c) Fourier Transform Spectrometer (FTS)
   d) Satellite: GOSAT (CO_2, CH_4), OMI (NO_2)
   e) Plume(HIGRAD) & Regional(WRF) Model

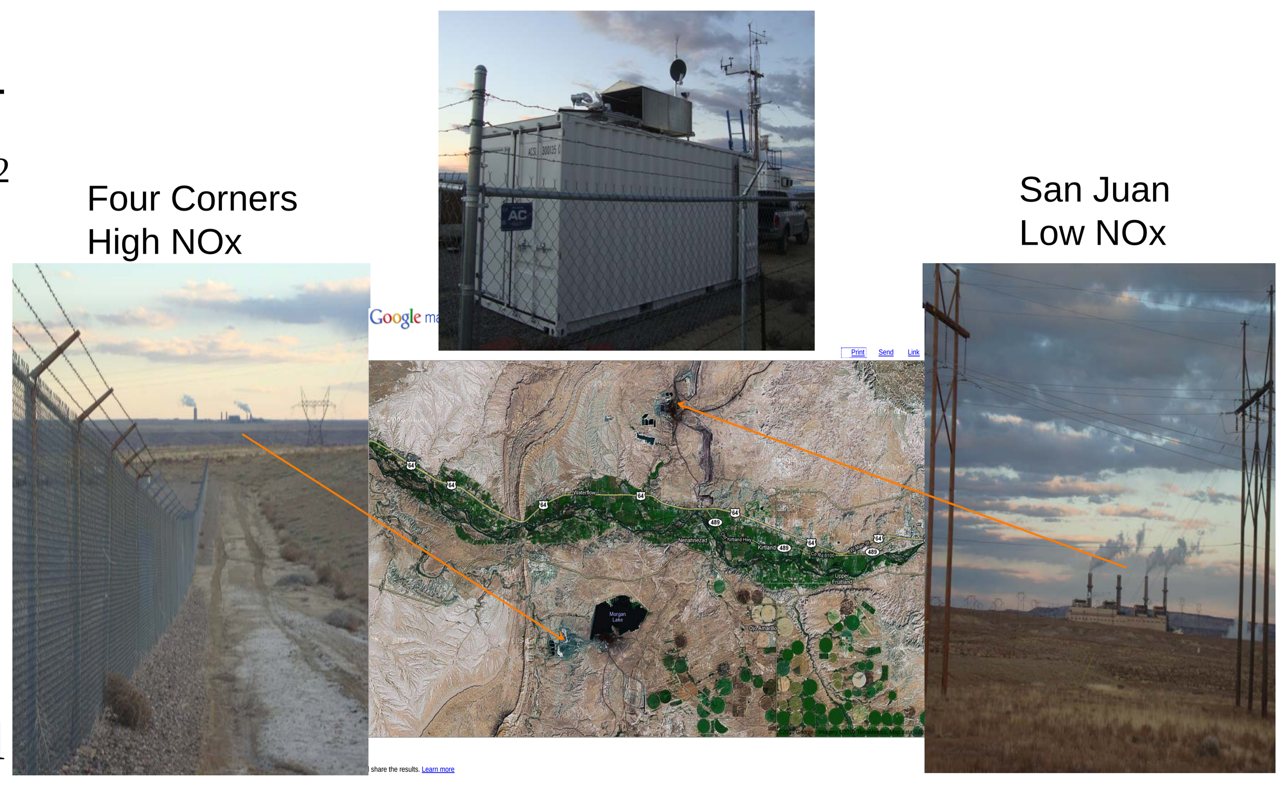

Figure 4. View of Four Corners with the power plants 12 km apart (center) with FTS-RSVP. Pictures of the high NOx Four Corners (left) and the low NOx San Juan (right) plants from our site. https://tccon-wiki.caltech.edu/Sites/Four_Corners

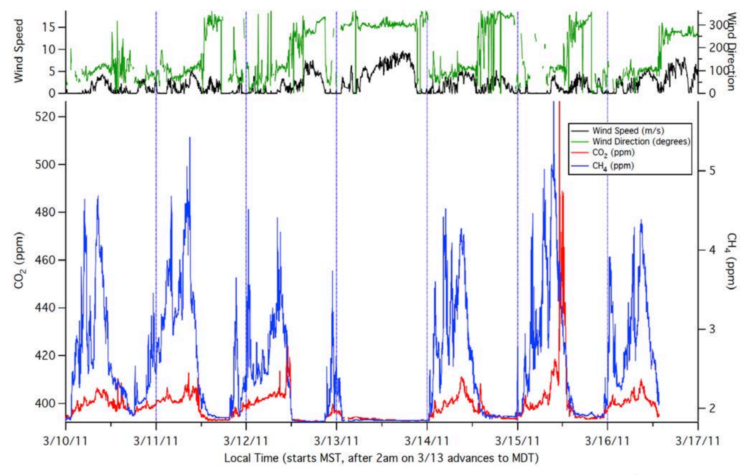

Figure 5. *In situ* CO_2/CH_4 time series from a Picarro cavity ringdown sensor and wind speed/direction

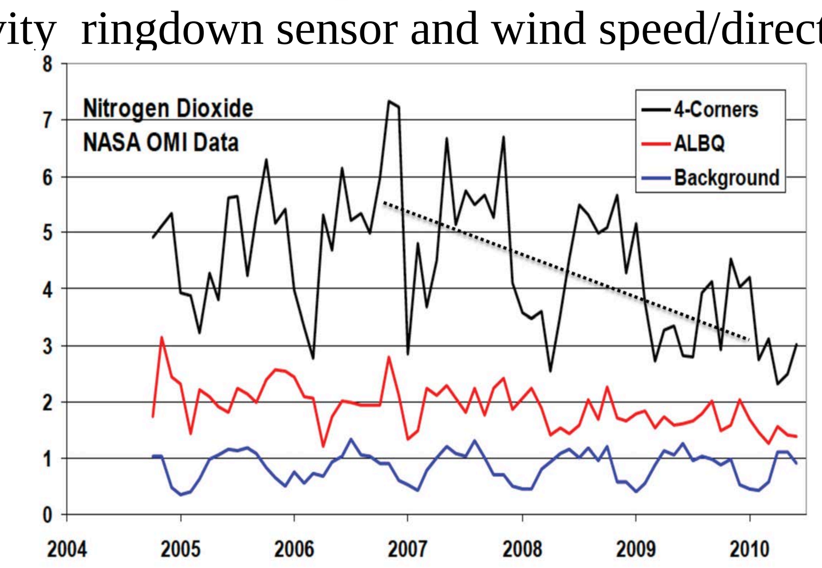

Figure 8. Monthly satellite NO_2 data reveal declining trends at 4-Corners from San Juan plant boiler upgrades

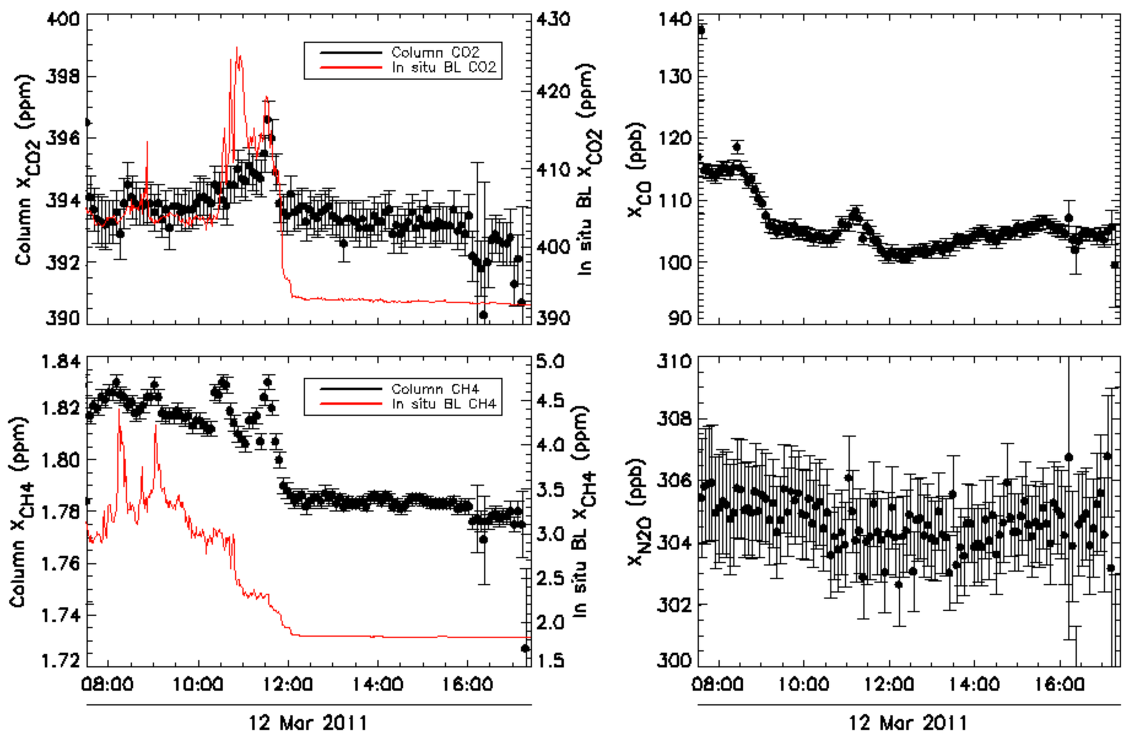

Figure 6. Column and in situ CO_2,CO, CH_4, N_2O at Four Corners

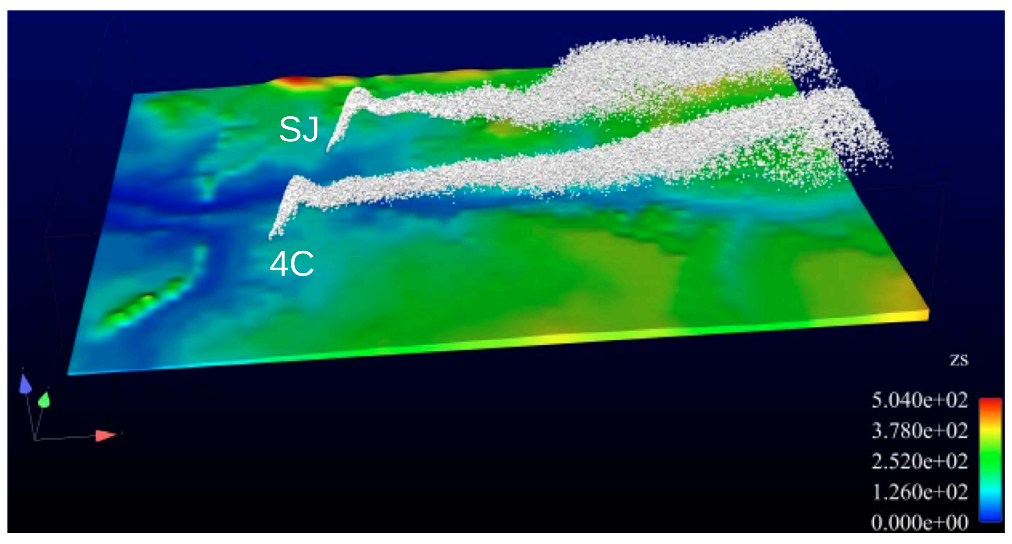

Figure 7. Realistic HIGRAD Simulation of the CO_2 plumes dispersing in atmosphere (Res 100m, 10m, Dom 50km, 2km)

III. Solar FTS: Pagosa Springs Study

➢ Automated solar observatory collects high spectral resolution (0.02 cm^{-1}) solar transmission spectra in the mid-near infrared and visible-ultraviolet range with a Fourier Transform Spectrometer (FTS, Bruker 125HR).

➢ The sun is tracked all day to collect spectra every 4 minutes at 10-100 km scales. Spectra are fit to retrieve columnar CO_2, CO, CH_4, N_2O, H_2O, HOD (near-infrared) and stratospheric composition (mid-infrared).

➢ High resolution visible-UV spectra can be used to retrieve pollutants (NO_2, SO_2, O_3), aerosol optical and cirrus cloud properties and test radiative transfer codes for climate.

➢ Our FTS was assembled, calibrated and tested in Pagosa Springs, CO. Test spectra collected on 23rd July 2010 were analyzed using protocols of the Total Column Carbon Observing Network (TCCON) to demonstrate accuracy. We show that increases in CO associated with a combustion plume are much greater than CO_2.

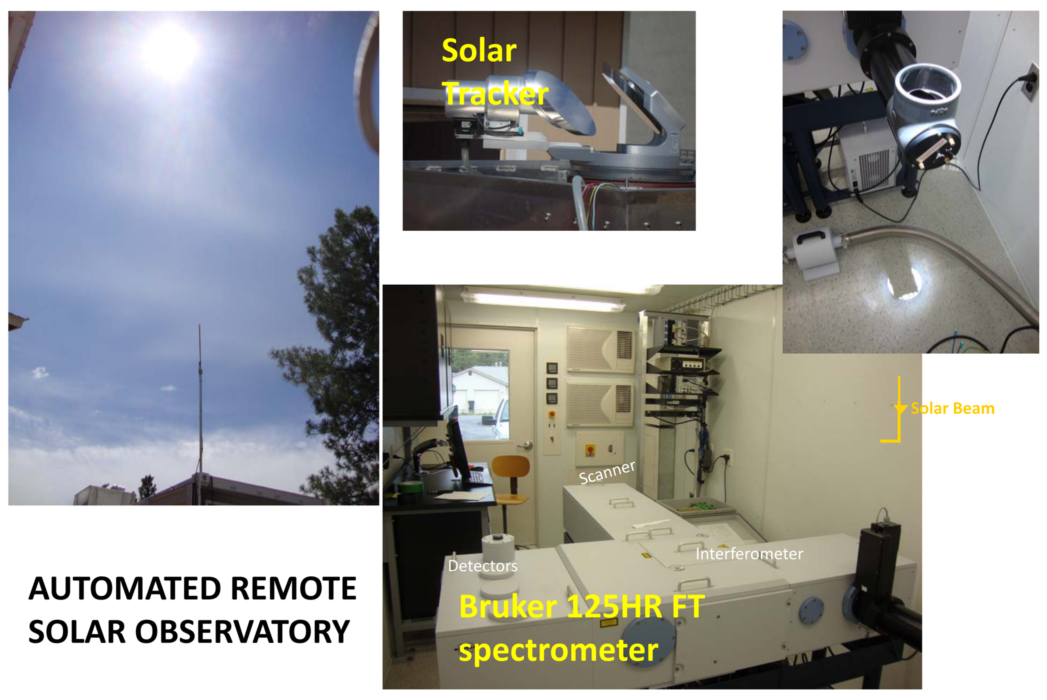

Figure 1. Solar tracking FTS configuration and operation

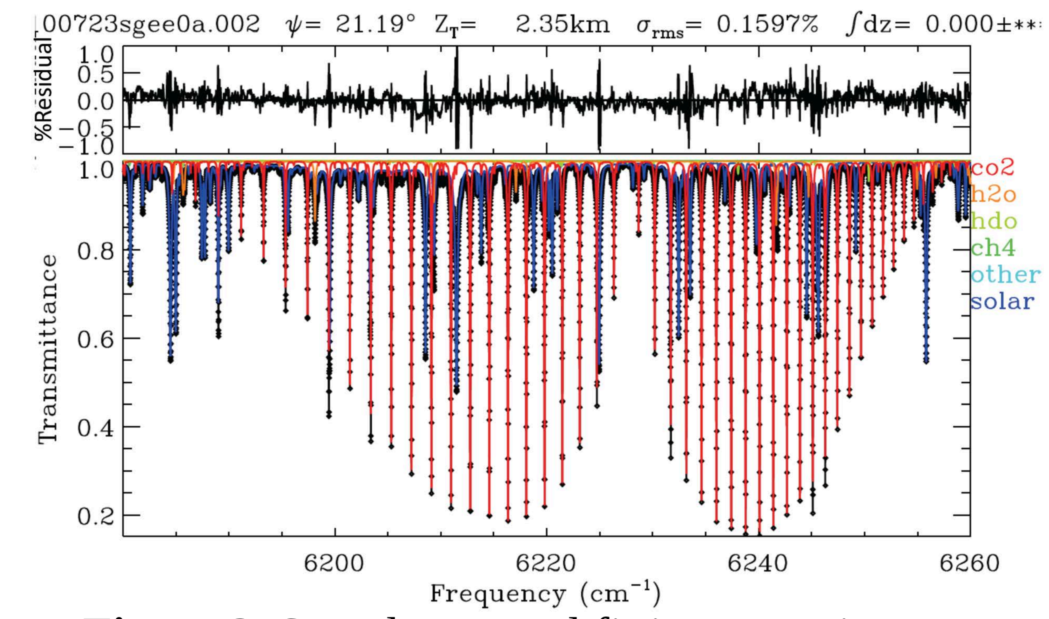

Figure 2. Sample spectral fitting to retrieve gases

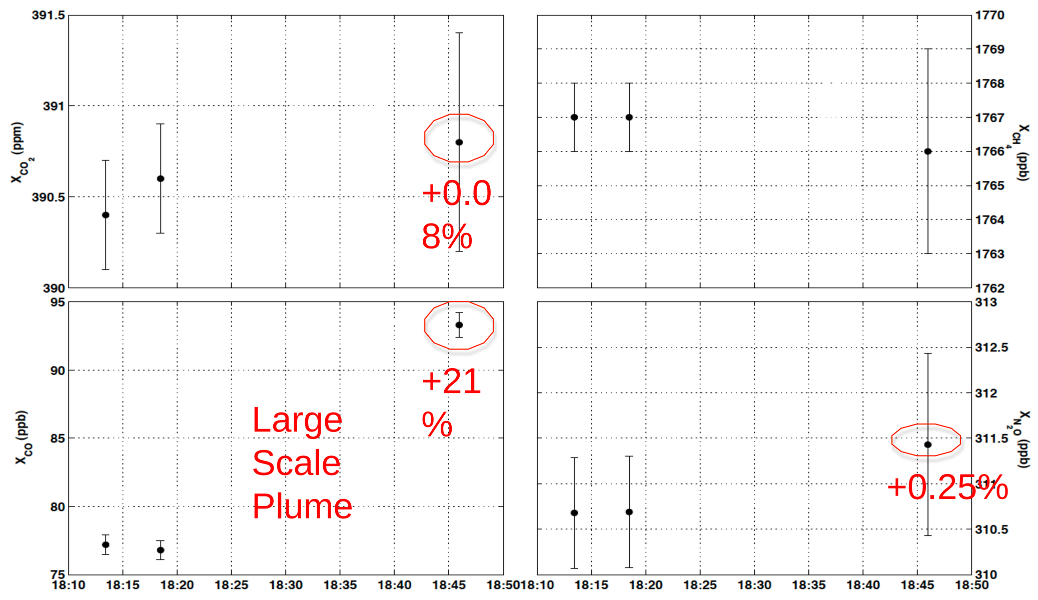

Figure 3. Column CO_2,CO, CH_4, N_2O concentration 7/23/10 see a combustion plume at later time with larger increase in CO than CO_2

VI. Future Work and Plans

➢ Site is operational collecting data and automation of analysis is in progress. Switch beamsplitter/ detector for vis-uv/mid-ir spectra.

➢ Measure airborne vertical CO_2 profiles above during NSF's HIPPO campaign to validate FTS.

➢ Target Japanese GOSAT satellite at our site for validation. FTS deployment in Brazil for ARM '14 campaign and OCO-2 validation.

➢ Propose Field Campaign to ARM in 2012

Acknowledgements

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