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CO_2 Plume Detection, Verification, and Flux Determination Using OCO-2 Data: Volcanoes and Power Plants

Florian M. Schwandner (1), Vincent J. Realmuto (1), Simon A. Carn (2), Brian Kahn (1), Tomohiro Oda (3,4), Akihiko Kuze (5), Fumie Kataoka (6), Thomas Krings (7), Peter J. Rayner (8), and Kei Shiomi (5)

(1) NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena CA 91109, USA (florian.schwandner@jpl.nasa.gov), (2) Michigan Technological University, Houghton MI 49931, USA, (3) Global Modeling and Assimilation Office, NASA Goddard Space Flight Center, Greenbelt MD 20771, USA, (4) Goddard Earth Science Technology and Research, Universities Space Research Association, Columbia MD 21046, USA, (5) Japan Aerospace Exploration Agency, Tsukuba-city, Ibaraki, 305-8505, Japan, (6) Remote Sensing Technology Center of Japan, Tsukuba-city, Ibaraki, 305-0032, Japan, (7) University of Bremen, Institute of Environmental Physics, 28334 Bremen, Germany, (8) School of Earth Sciences, University of Melbourne, Parkville VIC 3010, Australia

Carbon dioxide (CO_2) plumes from non-erupting active volcanoes, power plants, and other point source emitters are continuous but their plume characteristics differ due to individual source strength, injection altitude, prevailing winds, local topography, time dependent variability, and other factors. For example, power plant emissions vary by demand & load cycles, while volcanic CO_2 emissions follow less regular natural time dependent oscillations. We investigate the best approach to detect, verify, and determine the flux of CO_2 emissions from power plant and volcanic point sources using space borne infrared absorption spectra from NASA's Orbiting Carbon Observatory 2 (OCO-2) satellite.

Two polar orbiting sun-synchronous satellites currently measure atmospheric CO_2 with sufficient sensitivity and spatial resolution to detect point sources and their plumes: GOSAT and OCO-2. GOSAT, launched in January 2009 by JAXA, provides 260 km spaced single-sounding grid points at a 3-day repeat cycle with a circular field of view of 10km diameter, at $\sim$0.25/s samples. OCO-2 (leading the A-train on the CALIPSO ground track, repeat cycle 16 days), launched in July 2014 by NASA continuously collects eight $<$3 km2 cross-track elements at 24/s samples along a $\sim$10 km wide swath either along-track (nadir), or in glint direction. GOSAT has an agile pointing system, permitting a large number of custom targets per orbit, at the expense of spatial context. OCO-2 provides up to 10,000 soundings over a different pre-programmed $\sim$100 km^2 area each day. Consequently, observation strategies for point sources differ between the two missions. GOSAT can precisely and frequently and repeatedly target at the central emission point, providing a great opportunity for time series observations at its fast repeat cycle. In contrast, OCO-2 is targeting mainly validation sites (maximum 1 per orbit), thus maximizing spatial data continuity. However, close incidental flyby detection of plumes, with some along-swath spatial context, is possible with OCO-2.

Synergetic opportunities exist to aid in CO_2 plume identification, verification and validation. For OCO-2, other A-Train instruments (e.g., OMI, MODIS, Calipso, TES) provide independent measurements of co-emitted species such as SO_2, NO_2, CO, as well as cloud and aerosol information. GOSAT TIR data can be used to retrieve SO_2 values, providing plume validation, together with the GOSAT's spatial aerosols data. GOSAT and OCO-2 offer synergies between each other through several near-coincident measurements per day, permitting direct cross-validation, as well as making use of the combination of incidental OCO-2 flybys at point sources and their plumes, and target mode time series from GOSAT.

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