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Methane emission estimate using ground based remote sensing in complex terrain

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In order to infer greenhouse gas emissions from a source region, several top-down approaches can confirm or constrain the existing emission inventories. In this work an adopted version of a Bayesian inversion framework [1] will be presented. Methane emissions are derived from the column concentrations measured with six EM27/SUN FTIR spectrometers using ground based direct sunlight spectroscopy. The measurement campaign was carried out in the San Francisco Bay Area in 2016.

The framework uses the STILT generated footprints, which represent the surface-interaction of an air-parcel on its trajectory to the measurement site and thus describe the sensitivity of the measured concentration at a certain location to its surrounding source emissions. The dot product of the footprint matrix with a gridded emission inventory matrix results in expected concentration enhancements at the measurement site as a prior estimate. Here, we use the 1km-gridded local methane inventory by the Bay Area Air Quality Management District (BAAQMD).

Due to the long-term stability of methane, the air parcel holds a non-zero background concentration, which is not negligible. This poses a major challenge in the inversion. The existing Bayesian framework constrains a background concentration as well as a scaling factor for the inventory from the measurements. Within the existing framework, the assumption is made that all instruments eventually experience the same, time dependent background concentration. This assumption holds well for flat terrain with undisturbed wind-fields.

However, in the presence of complex topography, such as San Francisco Bay Area, the background source regions may differ significantly for the individual measurement sites. Here, we present an

approach to account for differing background concentrations seen by multiple measurement sites:

The adopted inversion allows to have individual background concentrations for each measurement site. This is strongly constrained by background covariances, which represent the background in common with the remaining measurement sites. These covariances are calculated from the STILT trajectories.

[1] Jones, T. S., Franklin, J. E., Chen, J., Dietrich, F., Hajny, K. D., Paetzold, J. C., Wenzel, A., Gately, C., Gottlieb, E., Parker, H., Dubey, M., Hase, F., Shepson, P. B., Mielke, L. H., and Wofsy, S. C.: Assessing Urban Methane Emissions using Column Observing Portable FTIR Spectrometers and a Novel Bayesian Inversion Framework, Atmos. Chem. Phys. Discuss. [preprint], https://doi.org/10.5194/acp-2020-1262, in review, 2021.