Motivation and research questions

Despite various efforts to reduce methane emissions, their global levels have continued to rise in recent years, and the exact causes of the increase are not very well understood. The scarceness of surface network observation stations make it very challenging to estimate the methane fluxes, especially for regions like the Indian subcontinent. The major objectives for this study is as follows:

1. Use the high resolution, wide-area observations from the Tropomi instrument to study the CH₄ distribution over Indian subcontinent.
2. Estimate the enhancements in CH₄ concentrations due to emissions.
3. Quantify the CH₄ fluxes and the concentrations through inverse modeling using the constraint provided by the Tropomi column observations.

Tropomi Column Observations[1]
- Orbiting in a low-earth sun synchronous polar orbit with a swath of 2600 km.
- Gives a daily global coverage at a spatial resolution of 7x7 km².

Bottom fig. shows the seasonal mean XCH₄ concentrations for 2020.

Methodology

Lagrangian model: Flexpart[2]
- Meteorology from ERA5 at 0.5 degree resolution
- Number of particles released: 10,000 (linearly decreases with height)
- Traced backward for 4 days

Computes:
- Potential Emission Sensitivity[3] (H)
- Initial Condition Sensitivity (Hᵢᵢ)

Background mole fractions(XAMS)

\[ X_{AMS} = \sum_i [X_{apriori} + a_i (X_{model, i} - X_{apriori, i})]P_i \]

Prior Methane Emissions

The a-priori emissions of methane fluxes are taken from Eclipse Inventory of IIASA available at a resolution of 0.5x0.5 degrees.

Summary and Remarks

1. CH₄ concentrations are higher over north-eastern and eastern parts of India as seen from the column observations.
2. The methane concentrations are higher towards the post-monsoon and winter seasons.
3. Agriculture sector contributes the major source of methane fluxes.
4. The higher CH₄ fluxes over Indo-Gangetic Plain and Bangladesh are primarily due to the rice cultivation[4].
5. The Lagrangian model simulations shows higher sensitivities over the north-eastern parts of India implying the particles reside longer over these areas.
6. Column CH₄ mole fractions derived from CAMS(XAMS) is biased low on comparison with the Tropomi column mole fractions.

Future Work/ Inverse Modeling

Theory
- Bayesian Approach of Inverse Modeling
  Assuming normal distribution of emissions and the errors associated, the Bayesian estimate of the true state is the one that maximizes the posterior probability.

References
4. Xu et al (2018), Evaluation of One-Class Support Vector Classification for Mapping the Paddy Rice Planting Area in Jiangsu Province of China from Landsat 8 OLI Imagery, 10, 546