**High-resolution North American methane emissions inferred from an inversion of 2019 TROPOMI satellite dthis ata**

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**Abstract.** …

**1 Introduction**

**2** **Data and methods**

We fit TROPOMI methane columns to simulated concentrations from the GEOS-Chem chemical transport model (CTM, [www.geos-chem.org](http://www.geos-chem.org)) to infer the emissions that best explain the observations. We calculate the optimal emissions by finding the analytical minimum of a Bayesian cost function regularized by a prior emissions estimate. The cost function minimizes the distance between the observation vector , which contains the 2019 TROPOMI observations over North America,

How to describe an inversion in 30 seconds

* We fit observed methane columns to simulated atmospheric concentrations
  1. **State vector and error covariance**

We optimize emissions in 23,691 grid cells at 0.25° x 0.3125° resolution over North America, including all terrestrial grid cells and any oceanic grid cells with sufficiently large methane emissions in the prior estimate.

* Figure 1 (REMAKE with December 2019 emissions)
* anthropogenic emissions provided by the national inventories prepared by Scarpelli et al. and Maasakers et al. (2016)
  + EPA oil and natural gas emissions are replaced by Bram’s updated estimate
  + (Hopefully eventually we’ll have the new EPA inventory)
* wetland emissions provided by the high performance WETCharts ensemble v…
* Fires
* Termites
* Geological seeps

**2.2 TROPOMI observations**

[This section should probably be slightly longer to include validation]

* Launched in October 2017, the TROPOMI instrument aboard the Sentinel-5 Precursor satellite has been observing dry column methane mixing ratios in the SWIR since May 2018 (CHECK)
* TROPOMI retrieves global methane concentrations at 7x7 km2 pixels, recently updated to 5.5x7 km2 (check that Lorente et al. uses this retrieval)
* TROPOMI observes at 2.3 um and uses a full physics retrieval that is limited by cloud cover, variable topography, albedo, and high aerosol loading. As a result, TROPOMI has a %% (CALCULATE) retrieval rate over the North American domain for 2019.
* We use the retrieval described by Lorente et al. (2021), which includes an updated albedo correction (do I need to describe this?). Lorente et al. find a precision of … ppb and a relative bias of … ppb compared to the Total Carbon Column Observing Network.
* We also implement the blended albedo filter recommended by Lorente et al. (2021) and described by Wunch et al. (year?) to filter out snow- and ice-covered scenes, where albedo biases may persist. We find a blended-albedo threshold of 1, which preserves %% of the data.
* We validate this product by comparing to …

**2.3 Forward model**

* Nested version of the GEOS-Chem chemical transport model v 12.7 (CHECK) at 0.25° x 0.3125° resolution over North America
* Driven by GEOSFP (CHECK) meteorological fields from …
* Methane loss …
* The simulation is initialized in January 2019 with concentration fields from the posterior of Qu et al. (in prep), a global 2° x 2.5° inversion of TROPOMI observations for 2019.
* Boundary conditions are archived every three hours from the same posterior simulation, providing an unbiased fit to the global TROPOMI data
* We find a residual latitudinal bias after the albedo correction and filtering on the basis of the blended albedo filter; we remove this bias by fitting a linear function to the TROPOMI – GEOSChem difference as a function of latitude.
* The Jacobian is constructed using the reduced-rank method introduced by Nesser et al. (2020).
  + We construct the initial Jacobian matrix estimate using a mass-balance approximation. To decrease the sparsity of the Jacobian matrix and the resulting eigendecomposition, we spread emissions from the source grid cell over five concentric rings, allocating %% of the emissions from the source grid cell to the outer ring, respectively.
  + The initial eigendecomposition shows…

**2.4 Observational error covariance matrix**

**2.5 Inversion procedure**

**3 Results and discussion**

**4 Conclusions**