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Quantifying Area Methane Sources With Satellite Observations

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With

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EDF	R. Gautam, M. Omara, D. Lyon, D. Zavala, R. Alvarez, S. P. Hamburg
SRON	I. Aben, S. Pandey, J.D. Maasakkers, P. Sadavarte, A. Lorente, S. Houweling

Regional / Area Methane Sources

Clustered methane sources in an area of 50 – 500 km

- Understand dynamics of a particular source
- Support regional advocacy & policy making

Oil/Gas Field

Rice Paddies

Wetlands

Satellite-based Emission Quantification

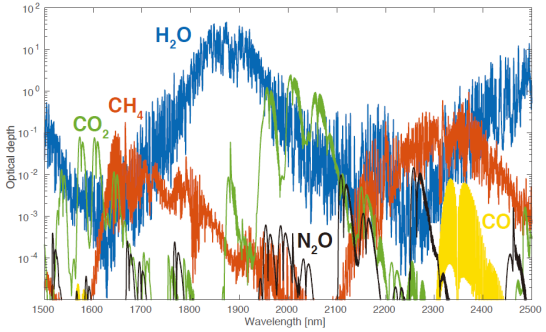
TROPOMI – Sentinel-5P – Launched in 2017

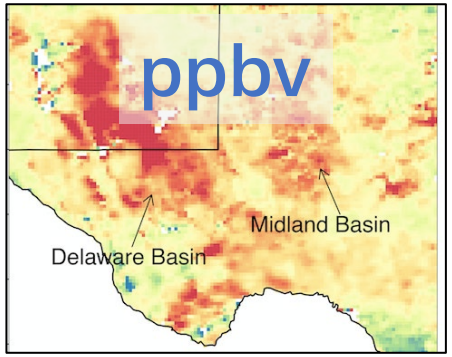
– Gapless mapping – 1 day global coverage

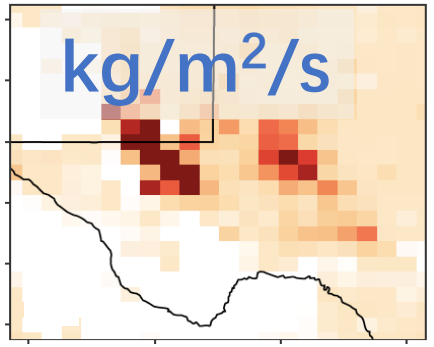
– Precision better than 1% – ~7 km spatial resolution

– Suitable for regional / area source quantification

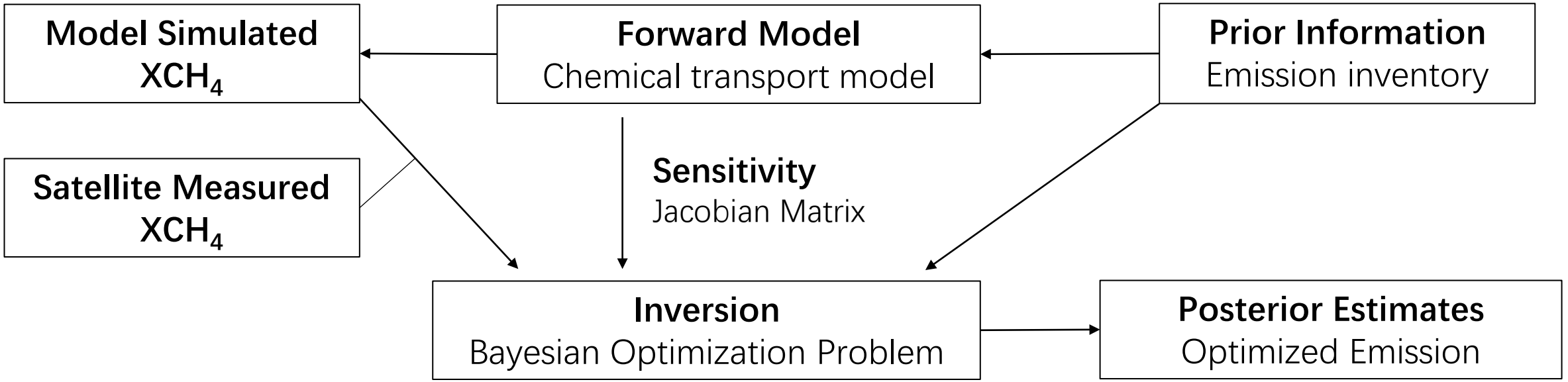
Spectral Signal → Retrieval → Methane concentration → Inversion → Methane Emissions







Atmospheric Inversion



$$J(\boldsymbol{x}) = (\boldsymbol{x} - \boldsymbol{x}_a)^T \mathbf{S}_a^{-1} (\boldsymbol{x} - \boldsymbol{x}_a) + \gamma (\boldsymbol{y} - \mathbf{K}\boldsymbol{x})^T \mathbf{S}_O^{-1} (\boldsymbol{y} - \mathbf{K}\boldsymbol{x})$$

Prior

Uncertainty of prior

Satellite

Uncertainty of observations & model

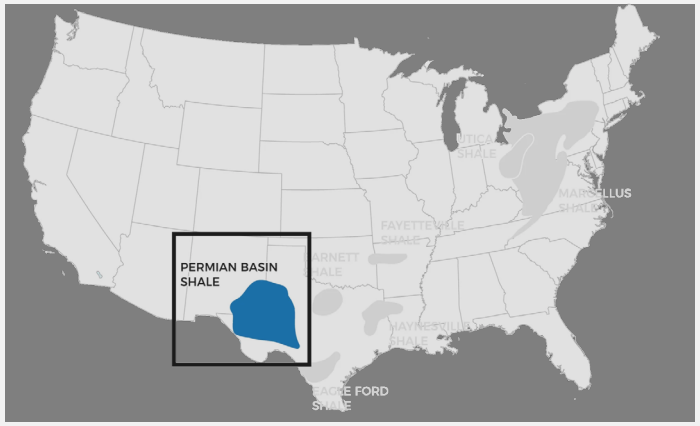
Forward model: sensitivity to emissions

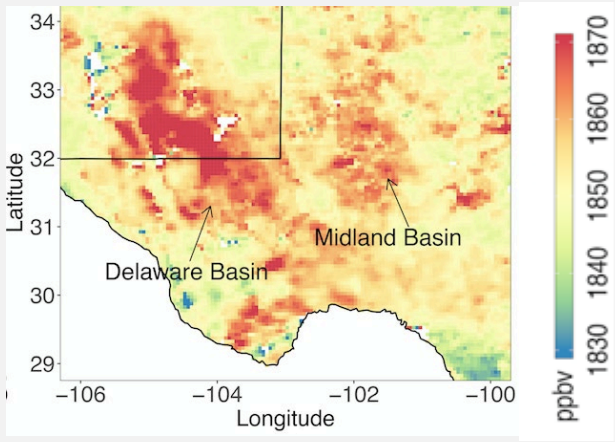
Atmospheric Inversion of TROPOMI Data: Permian Basin

Zhang et al., Science Advances, 2020

Methane Column

TROPOMI
5/2018-3/2019





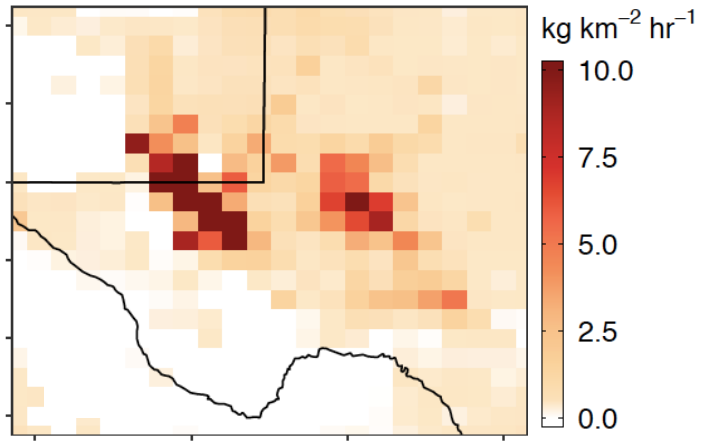
Atmospheric Inversion

CH_4 Emission Flux

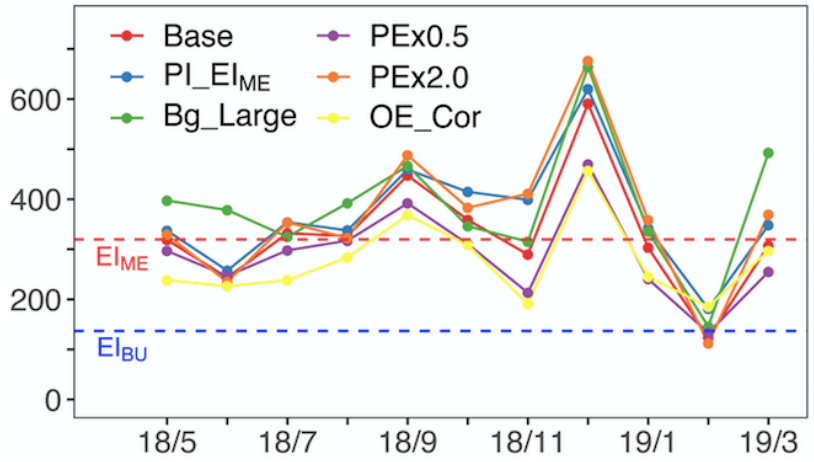
Basin Total: 2.7 Tg a^{-1}

>2x higher than bottom-up estimate

Spatial Distribution [0.25 degree]



Temporal Changes [Monthly]



Fast Methods To Quantify Area Sources

– Fast screening & tracking – Large volume of satellite data

Atmospheric Inversion

- Full account of wind information
- Sensitivity computation
  – Multiple model runs expensive

Model Enhancement Scaling

$$E = \frac{\Delta \mathrm{XCH}_{4,\mathrm{obs}}}{\Delta \mathrm{XCH}_{4,\mathrm{model}}} \cdot E_{\mathrm{model}}$$

- Only 1 forward model run
- Requires prior emission

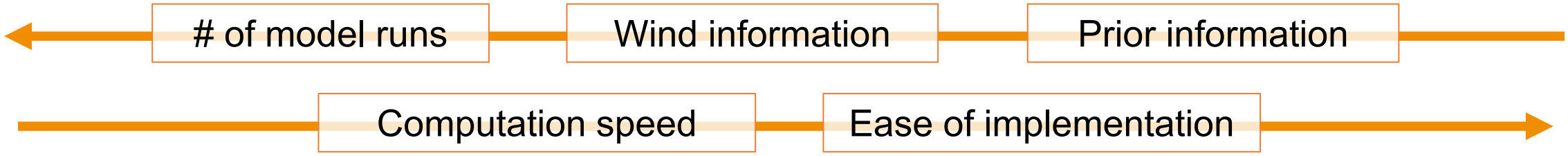
Kort et al., 2014
Pandey et al., 2019

Mass Balance Method

$$E = C \cdot \Delta \mathrm{XCH}_4 \cdot u$$

- **No** model run needed
- **No** prior emissions needed
- Area mean wind speed

Buchwitz et al., 2017
Schneising et al., 2020



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