



Empa

Materials Science and Technology



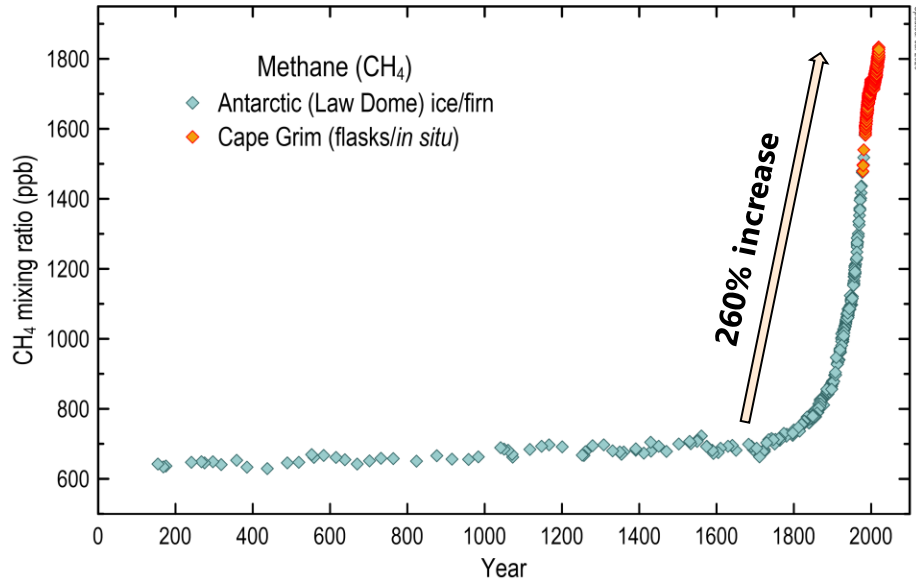
Top-down estimation of CH₄ Emissions

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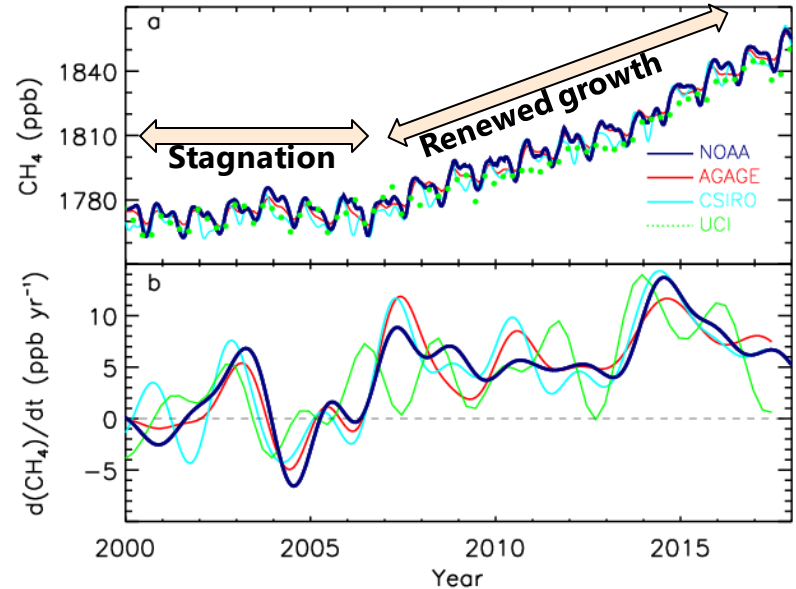
- Global CH₄ budget and trends
- Top-down emission estimation for Europe in project VERIFY
- Top-down emission estimation for Switzerland in support of the Swiss reporting to UNFCCC

Atmospheric CH₄ in the last 2000 years



Etheridge et al., JGR, 1996; 1998
MacFarling Meure et al., GRL, 2006
Rubino et al., ESSD, 2019
Updated to 2020

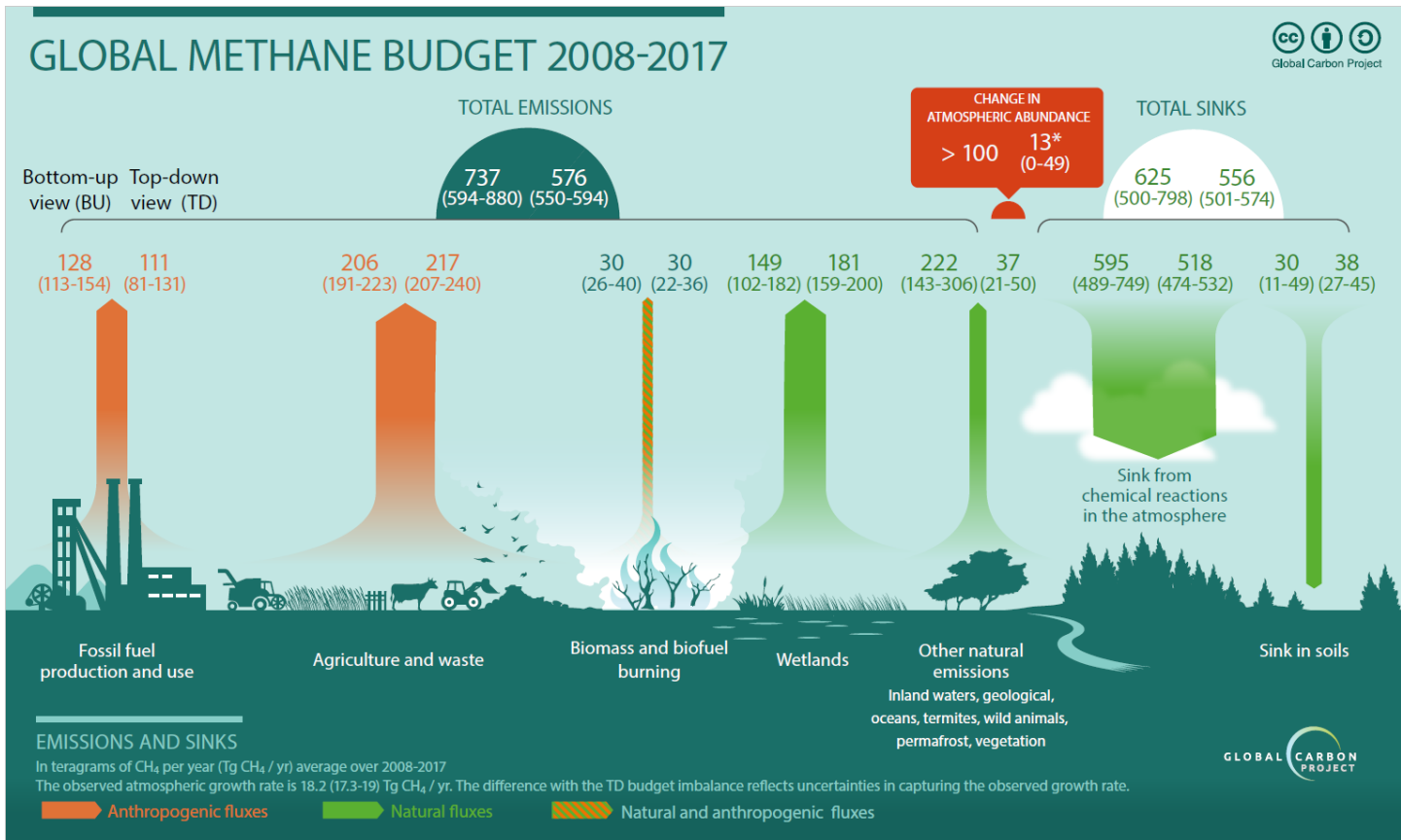
Atmospheric CH₄ since the year 2000



Saunois et al.
Earth Syst. Sci. Data, 12, 1561–1623, 2020
<https://doi.org/10.5194/essd-12-1561-2020>

Source: Global Carbon Project

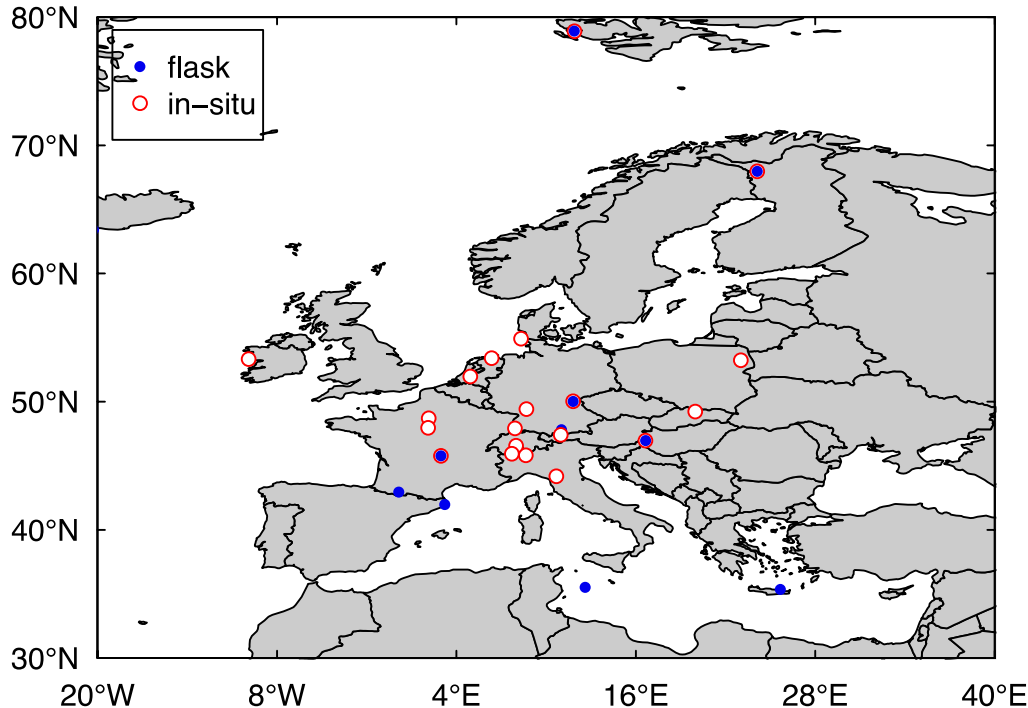
Global budget and trends



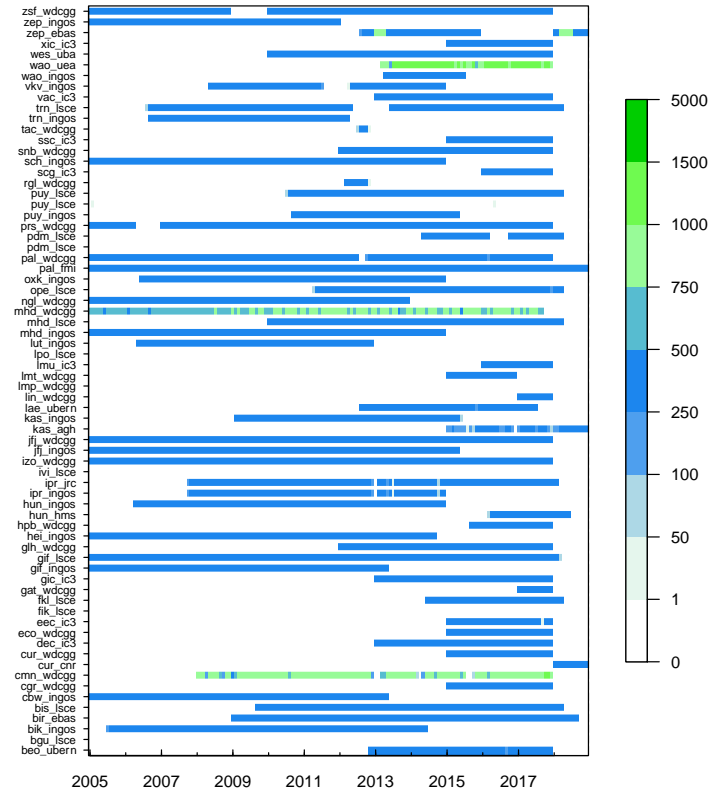
Sauniois et al.
 Earth Syst. Sci. Data, 12,
 1561–1623, 2020

Estimation of European CH₄ emissions

Map of sites with at least 10 years of observations (27 sites within model domain)



Data coverage of all sites 2005-2017



Inversion method

- Source sensitivities (footprints) estimated with Lagrangian model FLEXPART
- Inversion with Extended Kalman Filter (*Brunner et al. 2012*)
- Background CH₄ from global TM5-4DVAR model of P. Bergamaschi

Prior fluxes

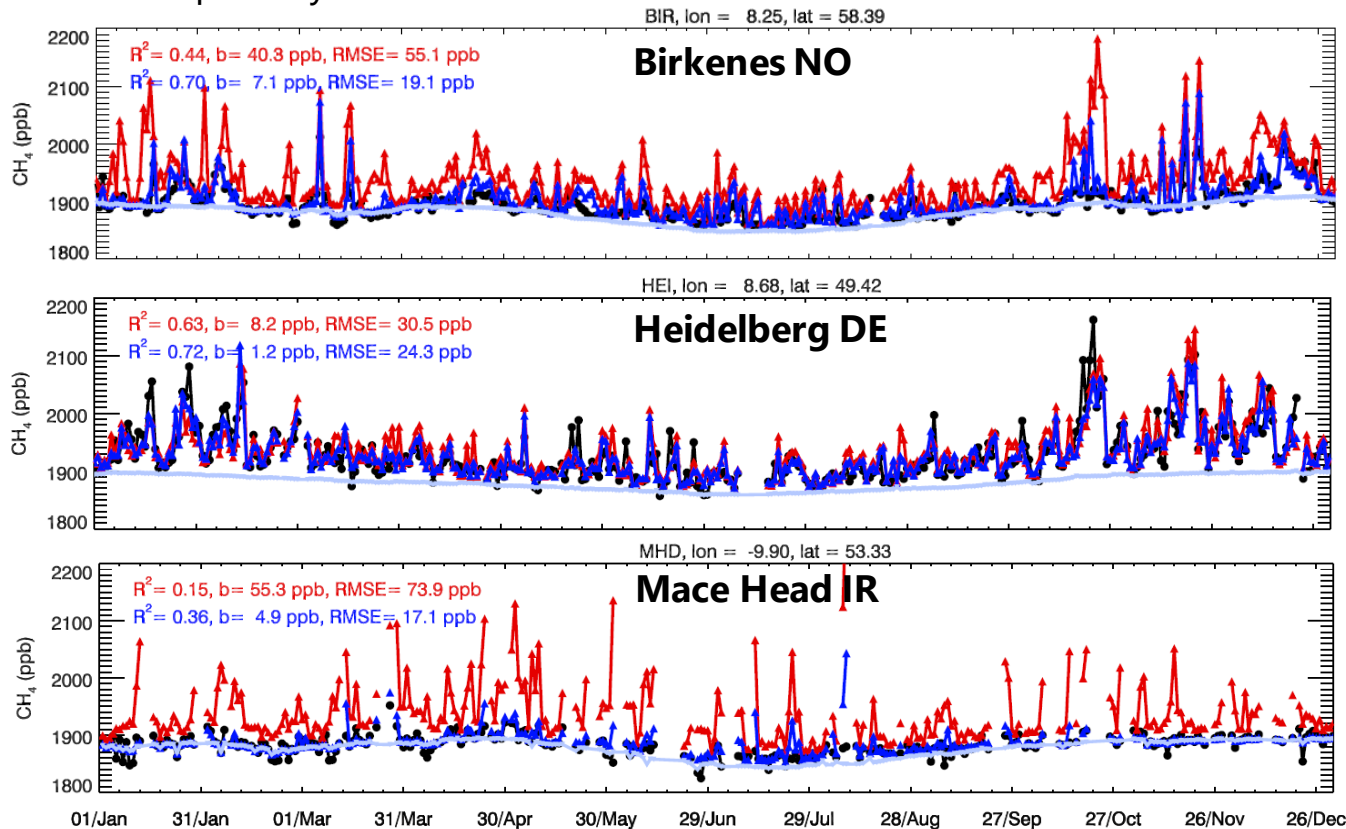
Source	Model/Reference	Resolution/coverage	
Anthropogenic	EDGAR-v5.0 (VERIFY)	Global 0.1°×0.1° monthly	
Wetlands: 1	JSBACH-HIMMELI (VERIFY)	Europe 0.1°×0.1° daily	
Wetlands: 2	GCP-2018	Outside Europe monthly	
Lakes & reservoirs	(VERIFY)	Europe 0.1°×0.1° annual	
Wild fires	GFED-v4.1s	Global 0.25°×0.25° monthly	
Ocean	GCP-2018	Global 1°×1° monthly	
Termites	GCP-2018	Global 1°×1° monthly	
Geological	Etiopie	Global 1°×1° monthly	Not used

Estimation of European CH₄ emissions

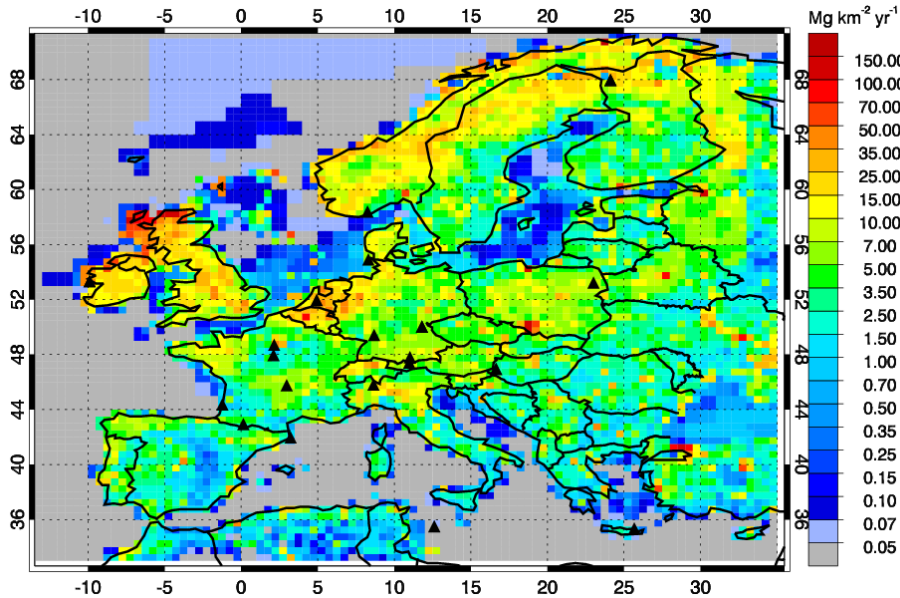
FLEXPART model performance
with prior and
posterior emissions

— observation
— model prior
— model posterior

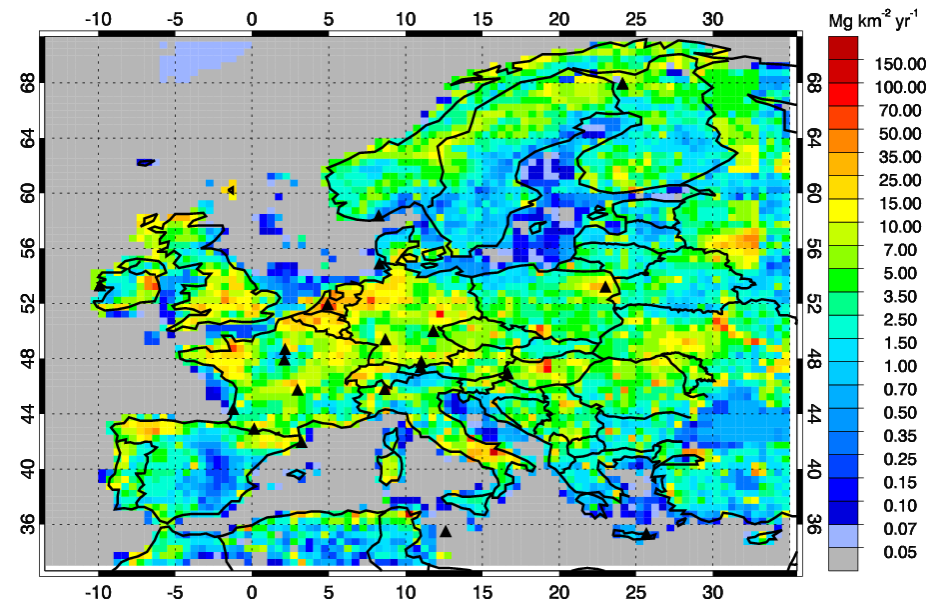
Example for year 2012



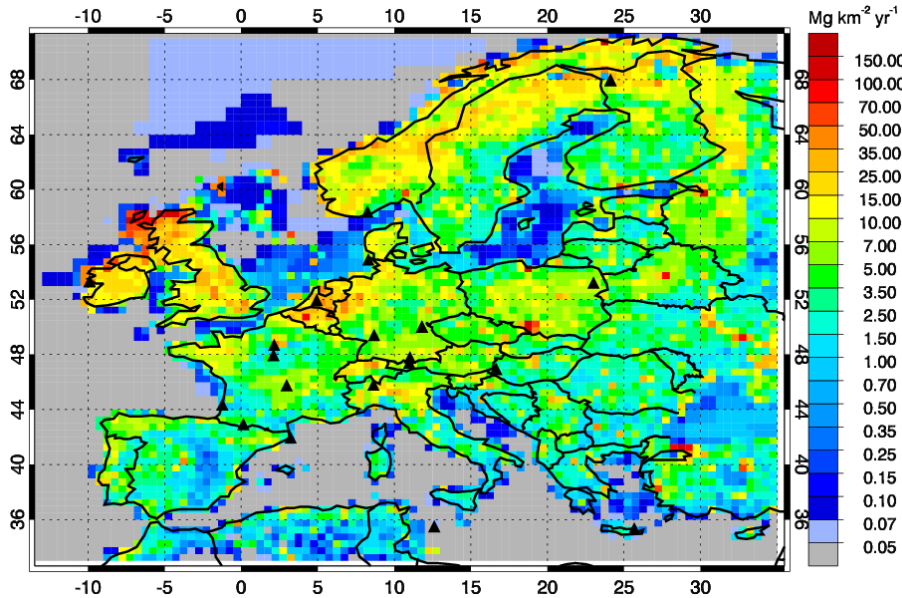
Prior emissions 2012



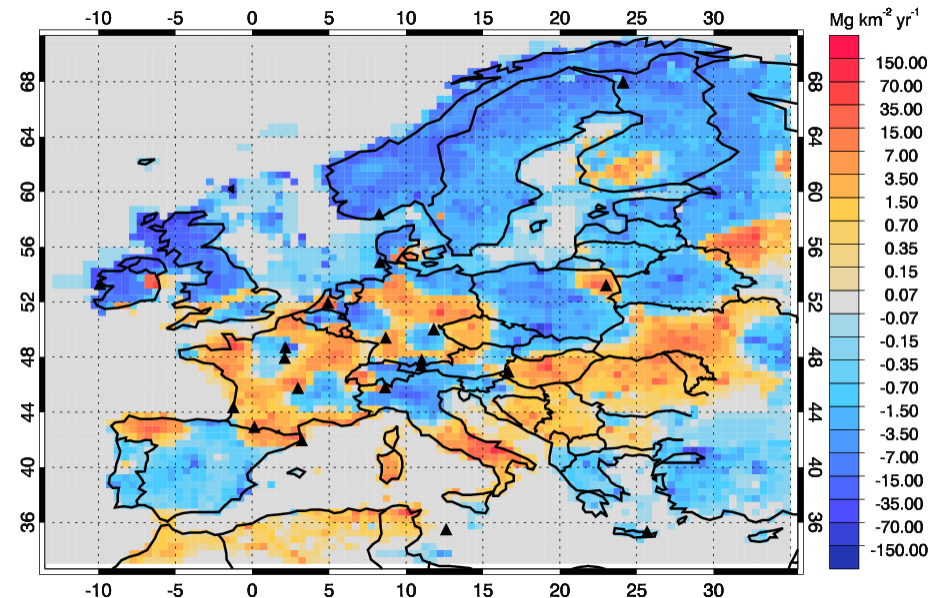
Posterior emissions 2012



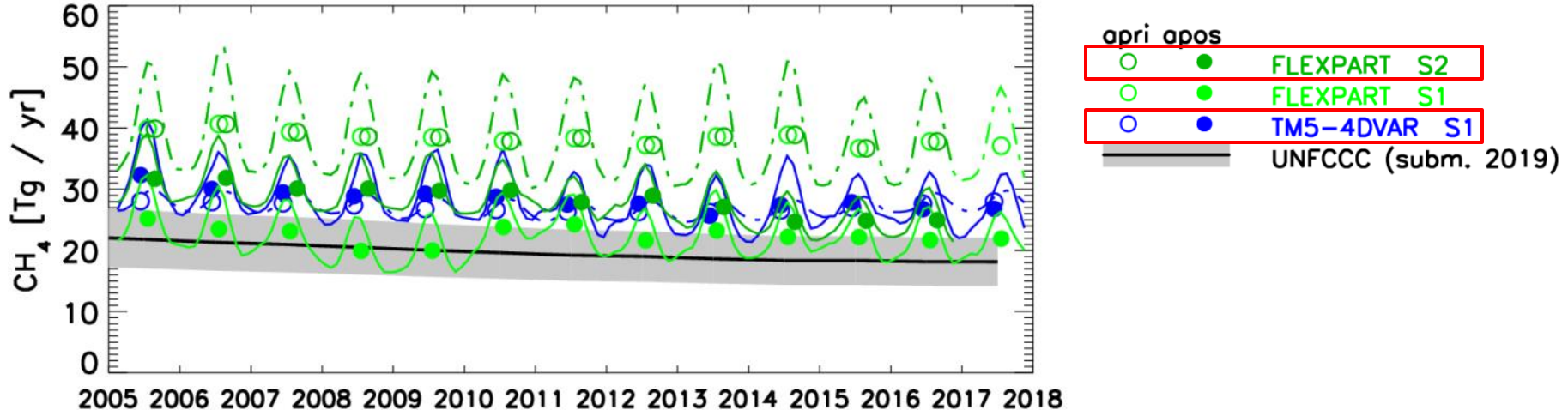
Prior emissions 2012



Change posterior - prior



Comparison of two top-down inversions with UNFCCC submissions for EU-28



- **FLEXKF inversion** results agree well with **TM5-4DVAR inversion** of Peter Bergamaschi
- Decrease 2005-2017 agrees reasonably well with **UNFCCC** for EU-28
- Difference to UNFCCC could be due to natural emissions

Results from project CLIMGAS

supported by Swiss Federal Office for the Environment
published in Annex 5 of Switzerland's official NIR

Switzerland's
Greenhouse Gas Inventory
1990–2018

National Inventory Report

Including reporting elements under the Kyoto Protocol

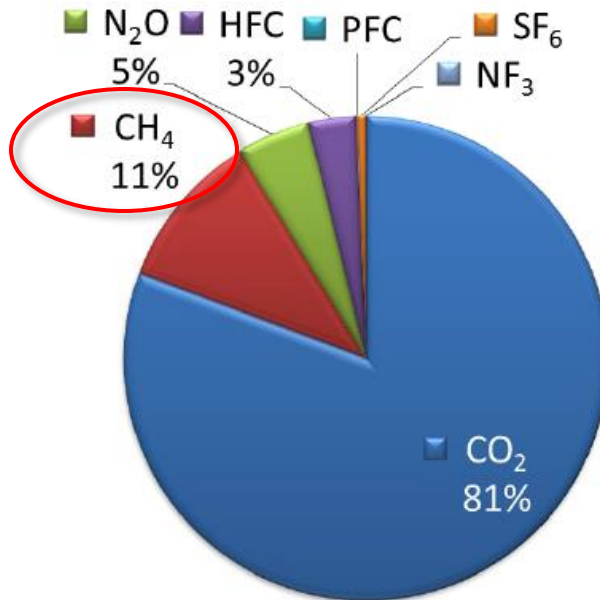
Annex 5 Additional information on verification activities

A5.1 Independent verification of the Swiss National Inventory for F-gases

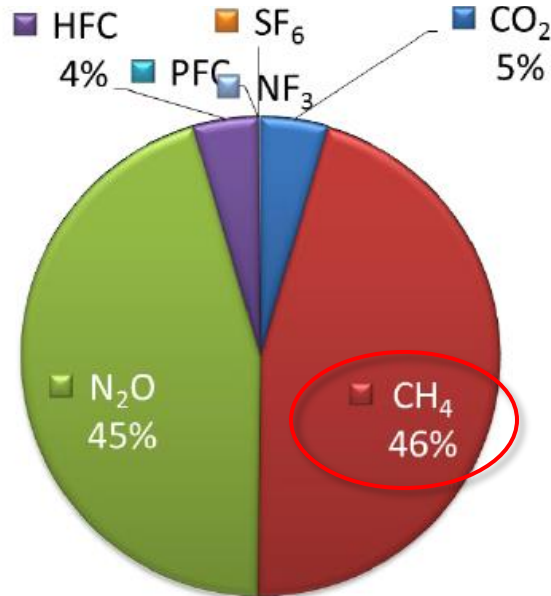
A5.2 Independent verification of methane and nitrous oxide emissions by inverse modelling

Relative contribution to total GHG emissions (CO₂-eq.) in Switzerland 2018

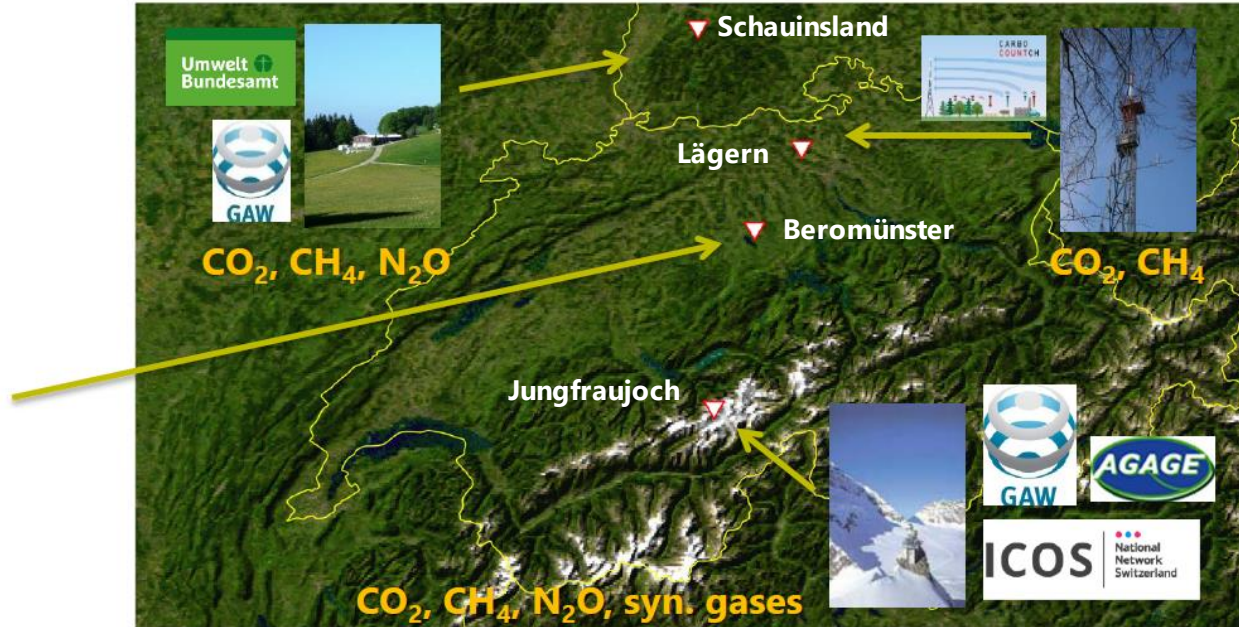
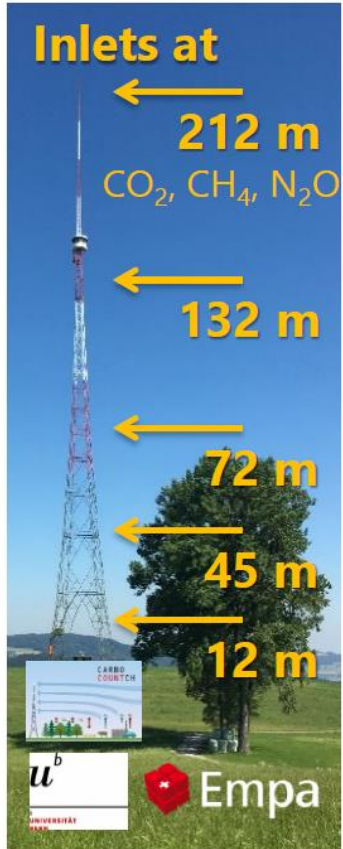
Contribution to emissions



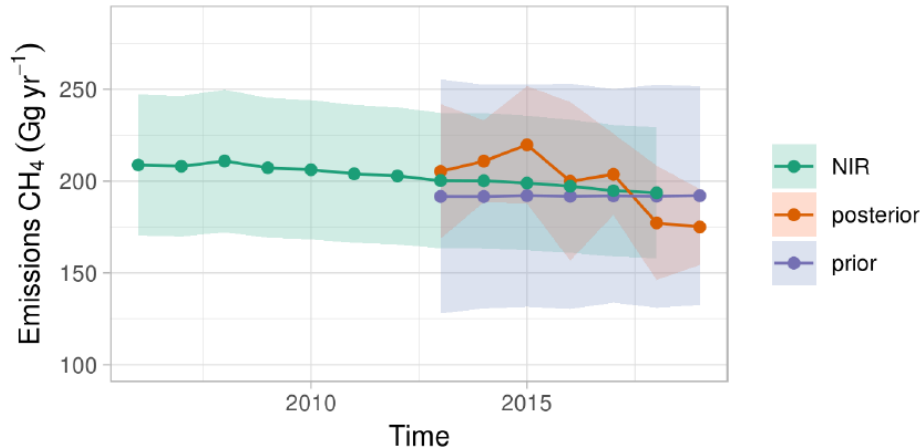
Contribution to uncertainty



Swiss CH₄ observation network



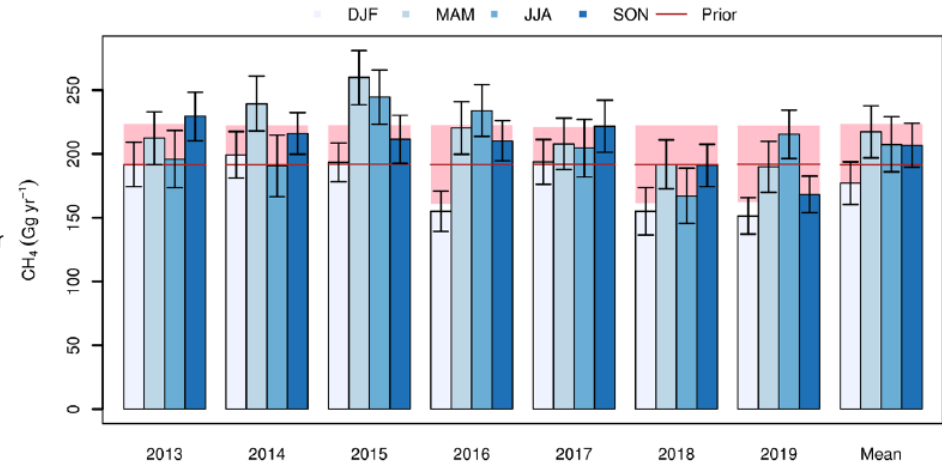
Temporal evolution of CH₄ emissions



2013-2018 mean

- Swiss NIR: 198 ± 36 Gg yr⁻¹
- Inversion: 202 ± 31 Gg yr⁻¹
- TD and BU highly consistent in Switzerland

Seasonal variability



- Spring maximum
- Winter minimum
- Seasonal amplitude ~20%

- CH₄ is arguably the most suitable GHG for TD inversions today
 - Long lifetime: OH is main sink, little relevant for regional inversions
 - Quite large uncertainty in BU estimates
 - Comparatively dense in-situ network, satellite observations improving
 - Clear regional signals well above measurement detection limits
- Robust estimation of long-term emission trend requires long-term continuity in observation coverage
- Range of TD estimates for Europe still large, reasons not well understood (model resolutions, observation input, a priori?)
- Swiss Federal Office for Environment supports measurement activities for TD emission estimation: Fruitful dialogue between policy makers and scientists