# Regional-scale atmospheric inversion estimates of European $CH_4$ and $N_2O$ emissions

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# Motivation

- National anthropogenic $CH_4$ and $N_2O$ emissions in Europe are regularly reported to UNFCCC based on bottom-up estimates

- Independent verification of the reported national emissions?

- Top-down emission estimates based on inversions of atmospheric trace gas measurements can provide a tool for an independent verification

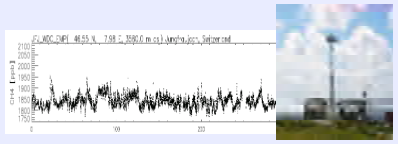
  ➔ High-resolution inversion system capable of accounting for
  - small-scale variability in fluxes and transport
  - large-scale global background

  Coupled inversion system TM3-STILT

# Ingredients for the Inversion

## Measurements of atmospheric GHG concentration

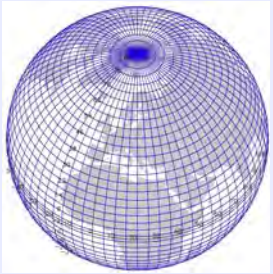
- global flask network
- European flask / continuous stations



## Coupled inversion system

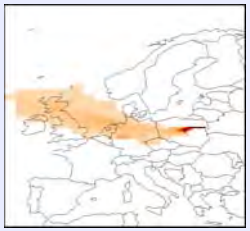
**TM3**
Global Atmosphere Transport Model

Rödenbeck et al., 2005



**STILT**
Stochastic Time-Inverted Lagrangian Transport Model

Lin et al., 2003; Gerbig et al., 2003

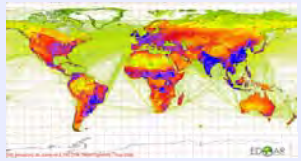


### Two-step nesting scheme

Rödenbeck et al., 2009

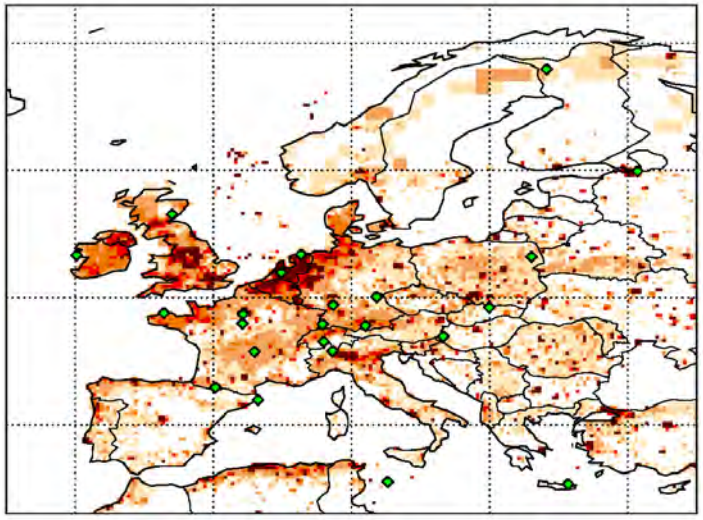
## Prior emission maps

- horizontal resolution: 0.25° x 0.25° – 1° x 1°
- monthly – annual natural and anthropogenic emissions

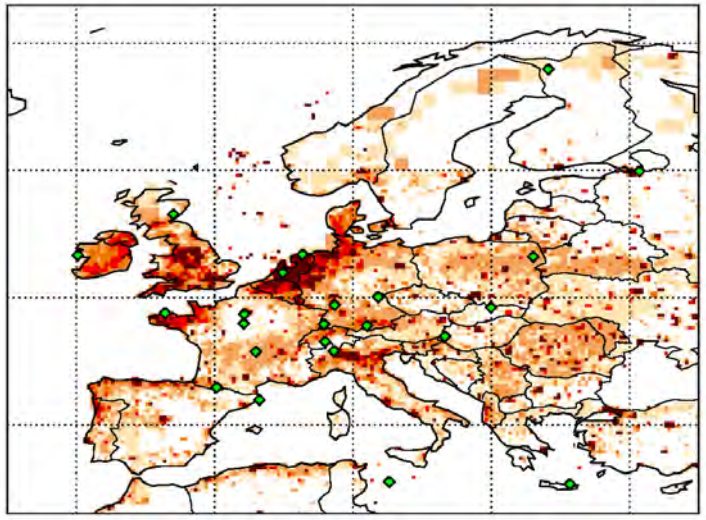


# $CH_4$ regional inversion results: 2011

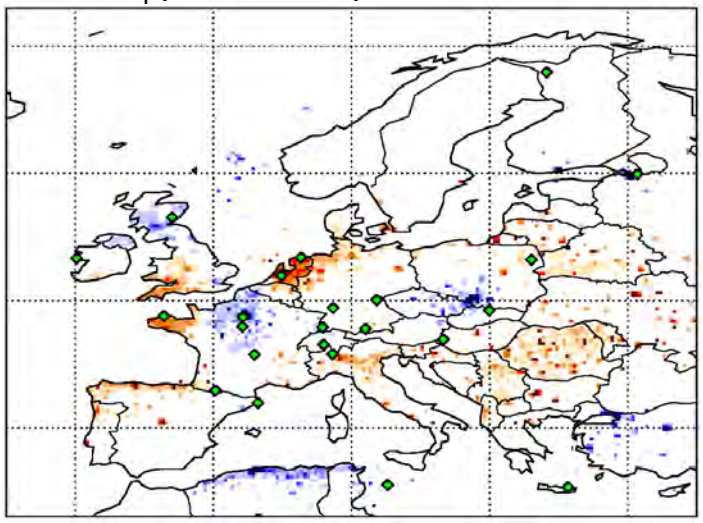
$CH_4$ prior emissions



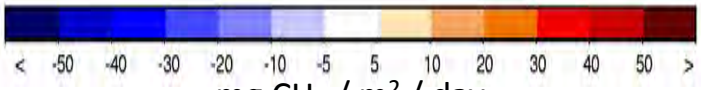
$CH_4$ posterior emissions



$CH_4$ posterior - prior emissions



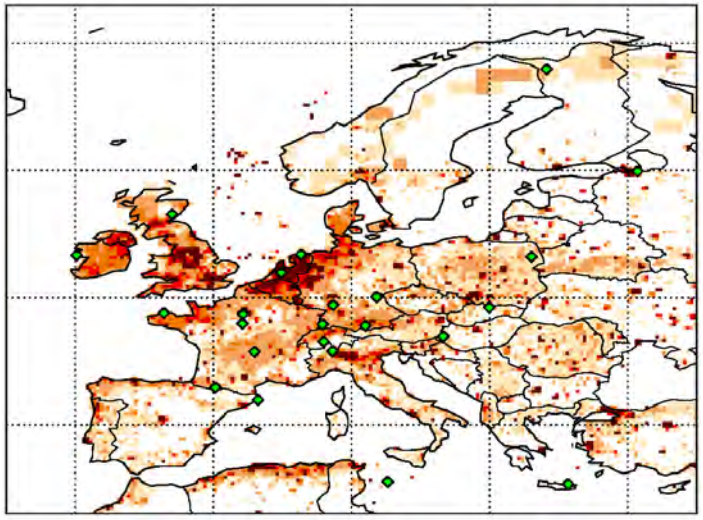
TM3-STILT 0.25° x 0.25°



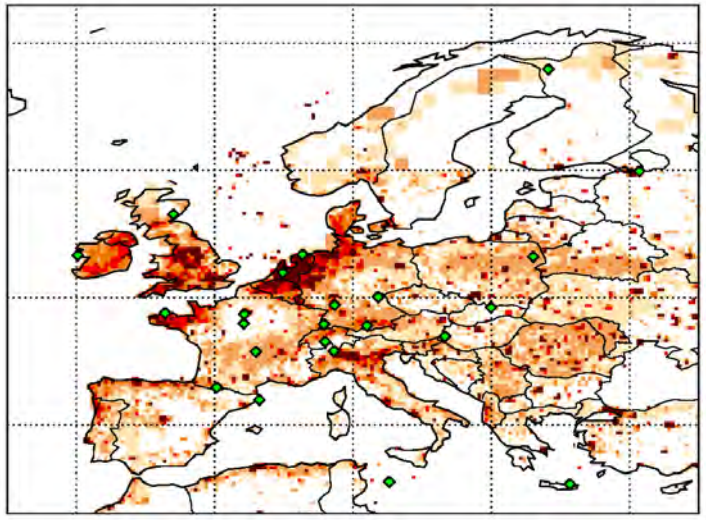

mg $CH_4$ / $m^2$ / day

# $CH_4$ regional inversion results: 2011

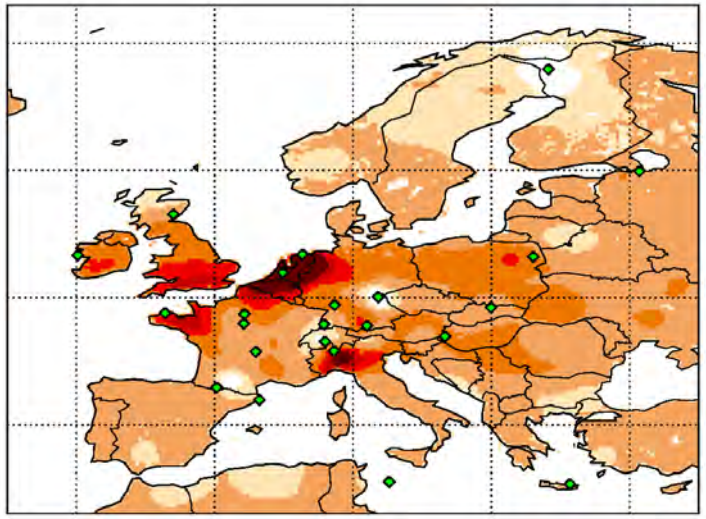
$CH_4$ prior emissions



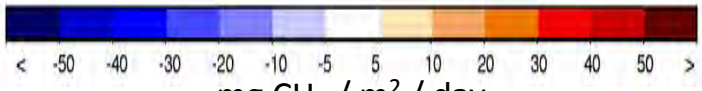
$CH_4$ posterior emissions



$CH_4$ posterior emissions (flat prior)

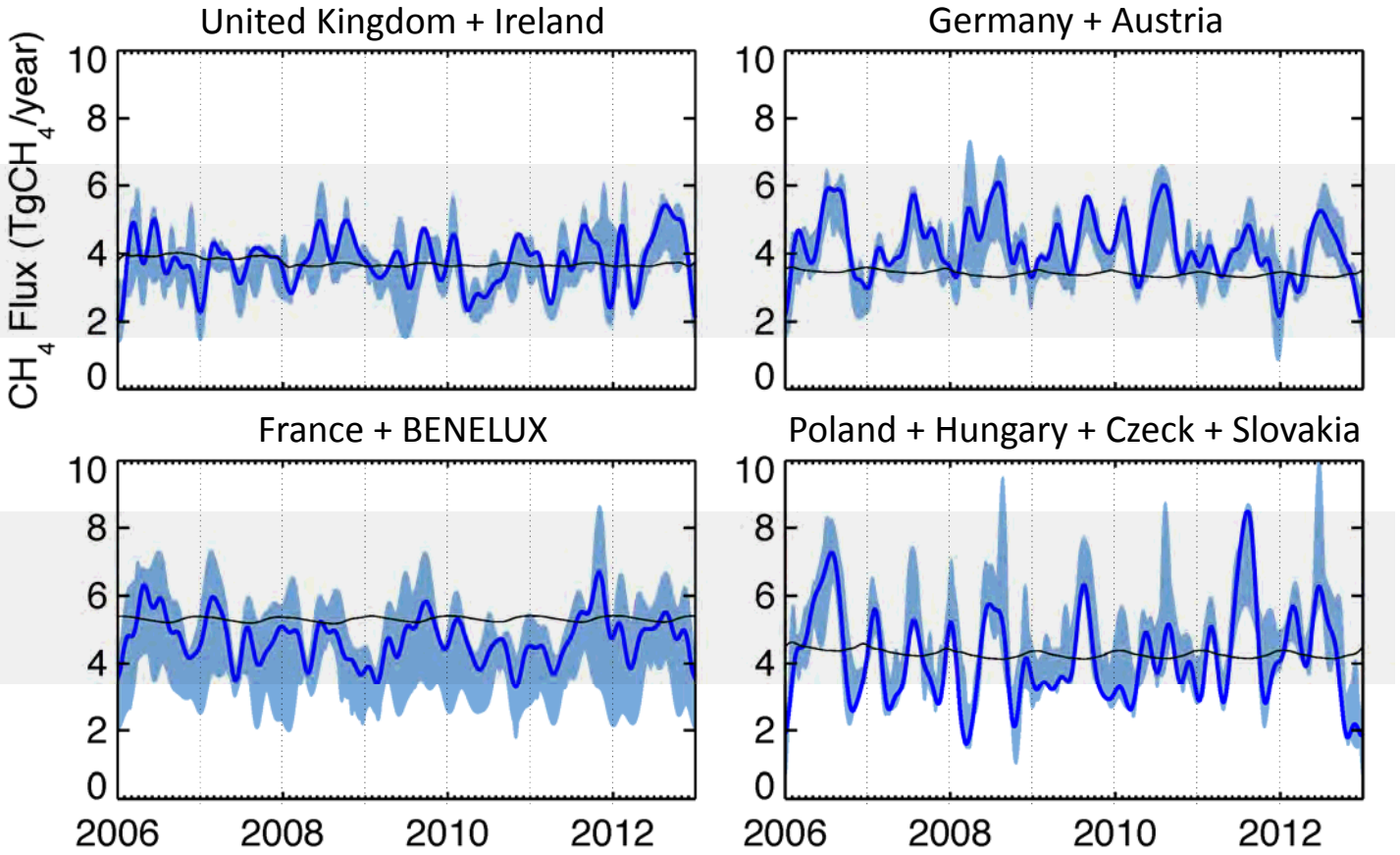


TM3-STILT 0.25° x 0.25°



# Regional $CH_4$ emissions

- Inversion estimates of weekly emissions

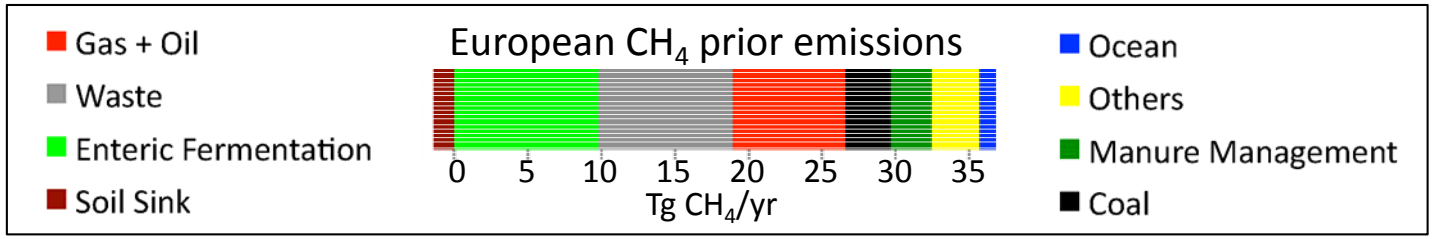



Prior

TM3 + STILT

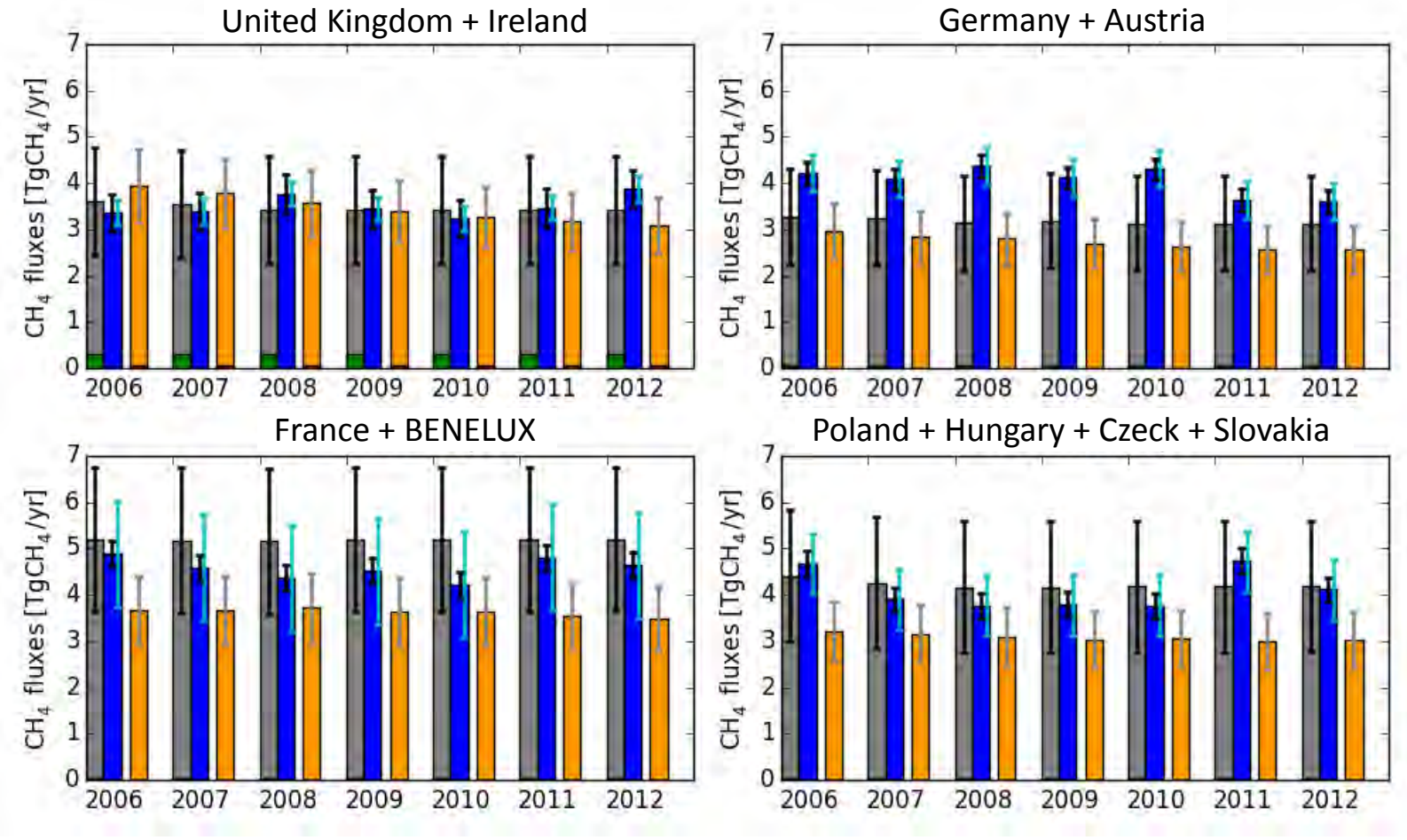
uncertainty estimated based on sensitivity studies varying:

- model-data uncertainty
- prior uncertainty
- error correlation
- station set



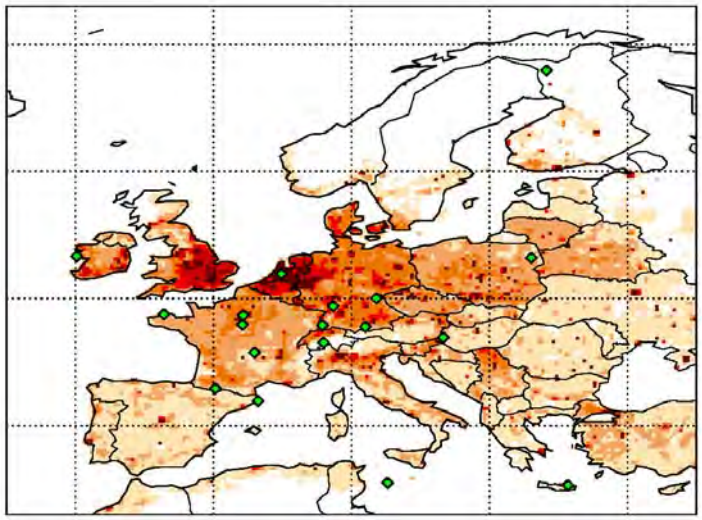
# Regional $CH_4$ emissions

- Comparsion of annual emissions to UNFCCC

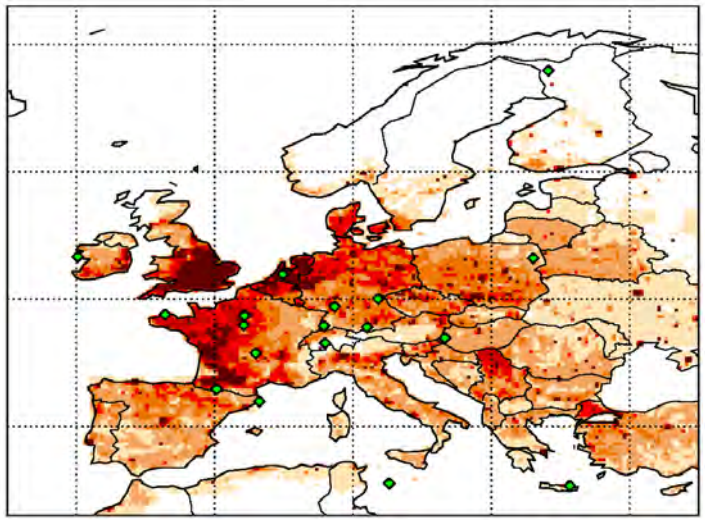


# $N_2O$ regional inversion results: 2011

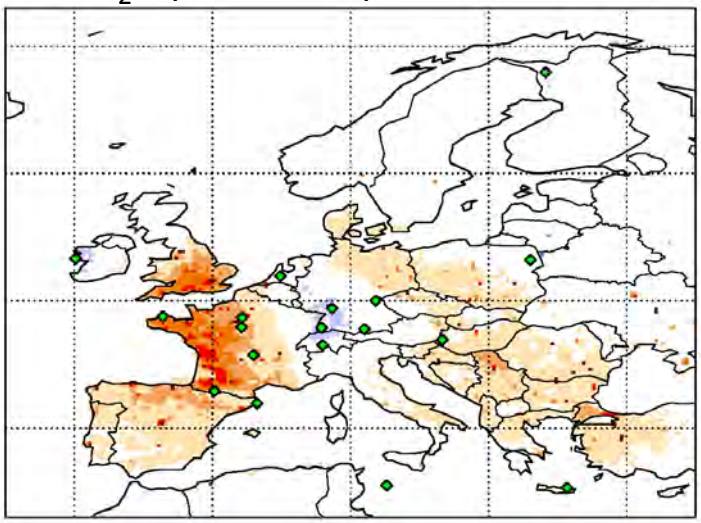
$N_2O$ prior emissions



$N_2O$ posterior emissions



$N_2O$ posterior - prior emissions



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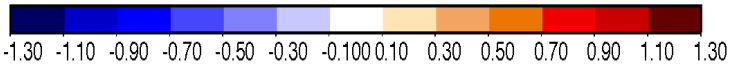
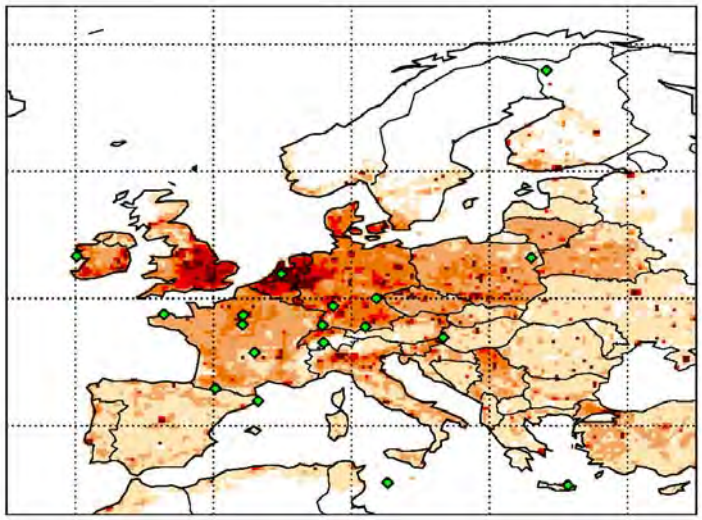


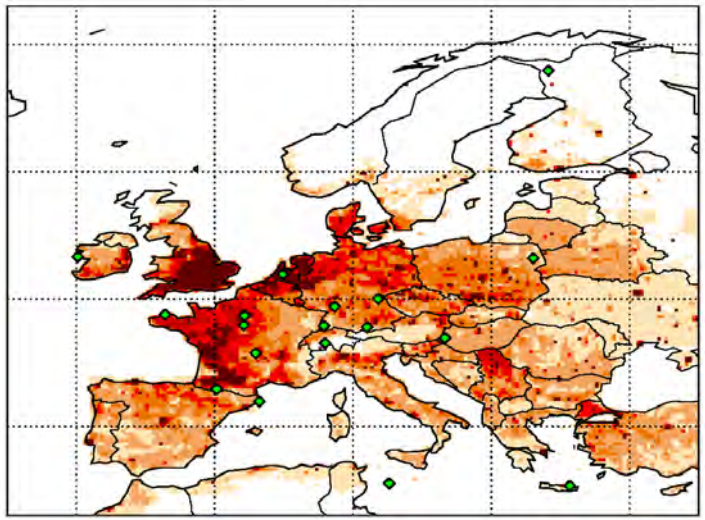

mg $N_2O$-N / $m^2$ / day

# $N_2O$ regional inversion results: 2011

$N_2O$ prior emissions



$N_2O$ posterior emissions



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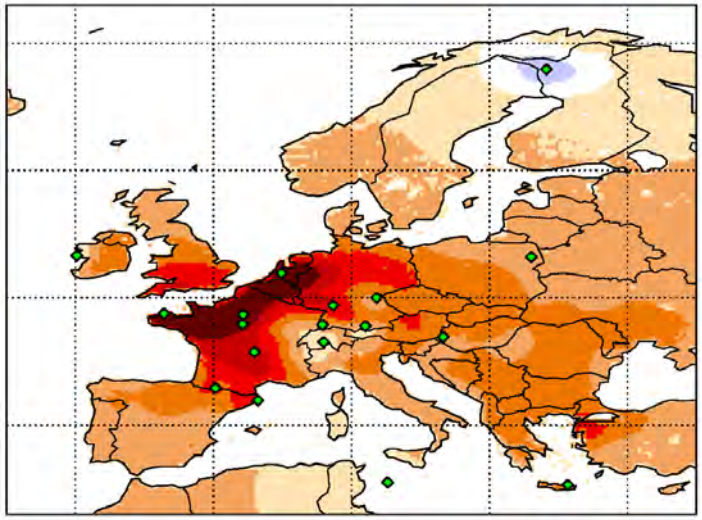

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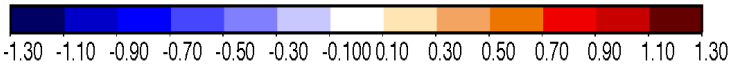
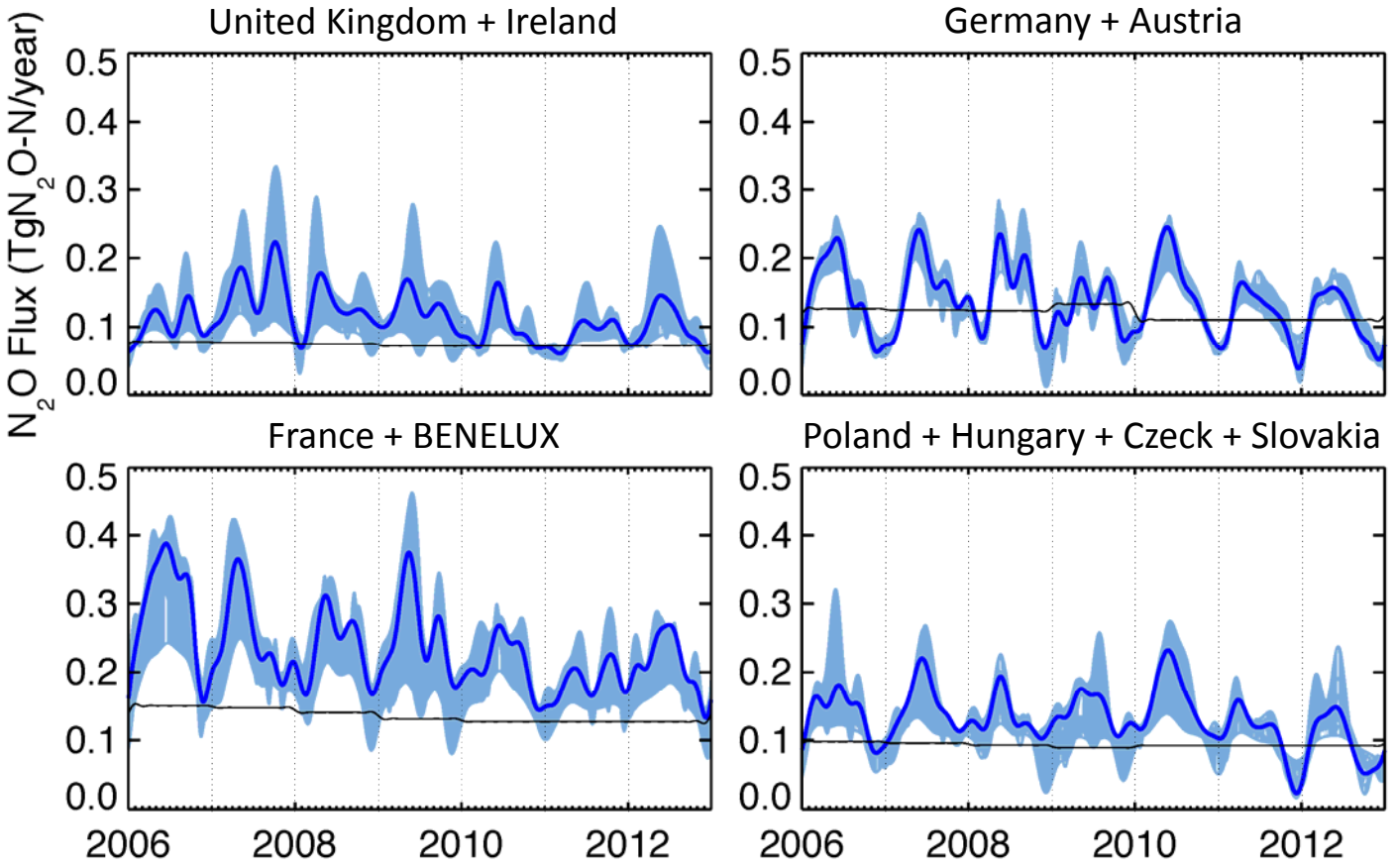



mg $N_2O$-N / $m^2$ / day

# Regional $N_2O$ emissions

- Inversion estimates of weekly emissions

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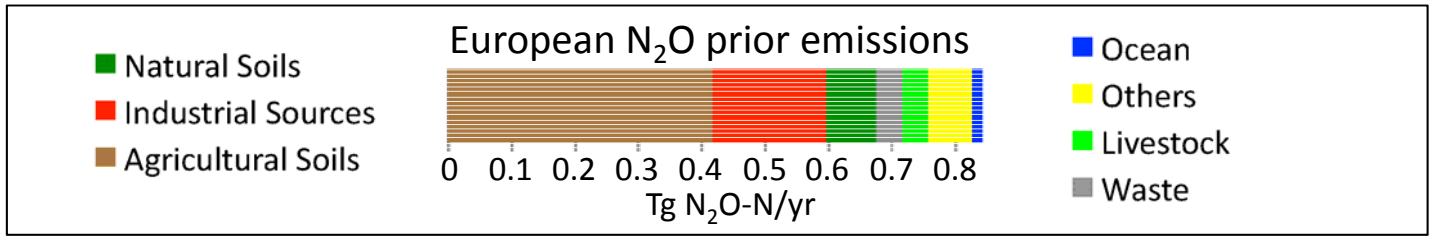
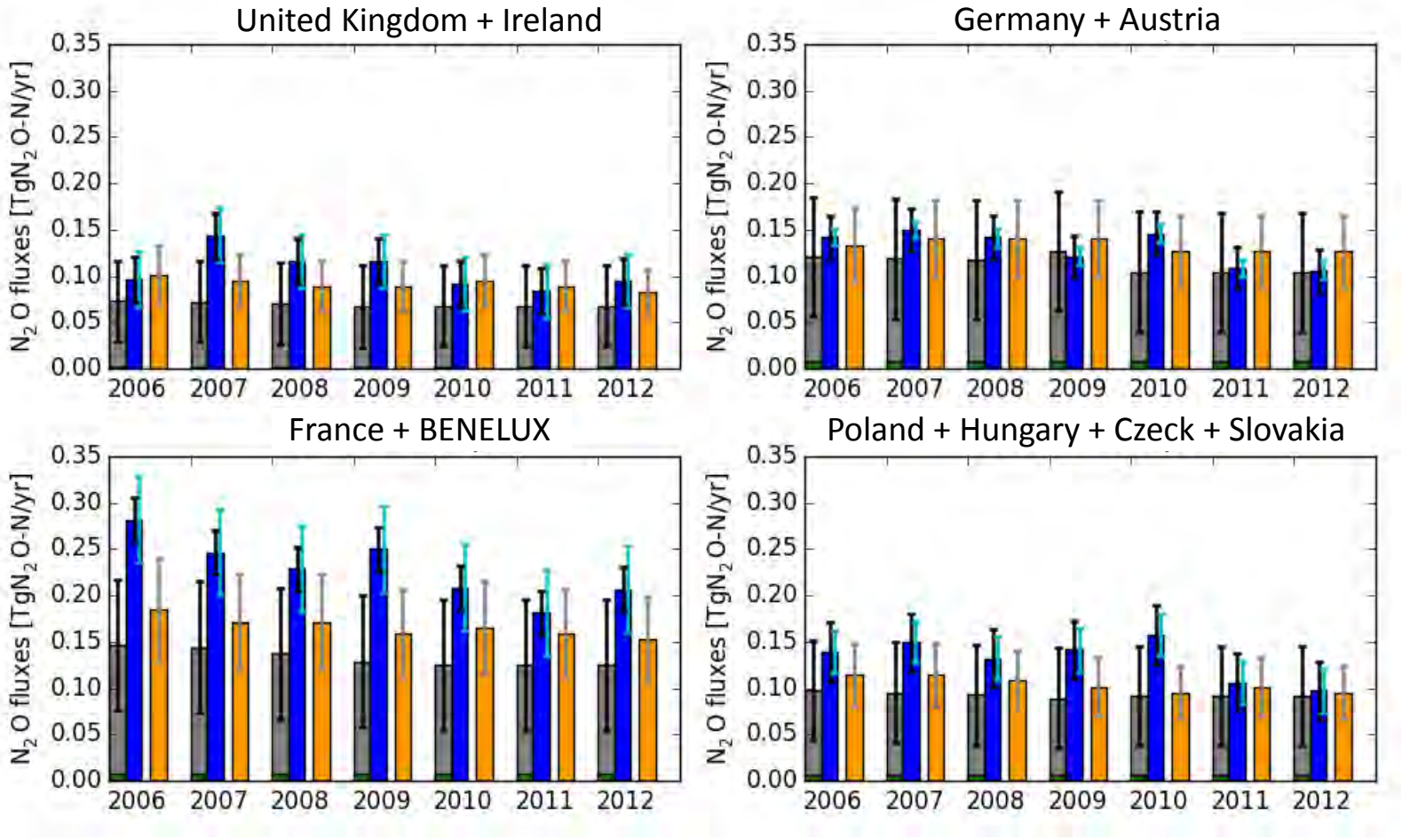


# Regional $N_2O$ emissions

- Comparsion of annual emissions to UNFCCC



# Summary

- Regional inversion system TM3-STILT
  - High-resolution emission estimates for Europe
  - Step towards validation of emissions on country level
- Uncertainties in the inversion need to be carefully assessed before a validation of national emission reports will be reliable

  ➔ Ongoing systematic evaluation of all components of the regional inversion system:
    - Validation of the transport model
    - Assessment of model, data and prior uncertainties
- Full uncertainty estimates would require an ensemble of independent inversion systems (c.f. previous talk by Peter Bergamaschi)
- Temporal variations of the estimated emissions need to be validated
- Denser network required to retrieve fine structure of emissions

Thank You!