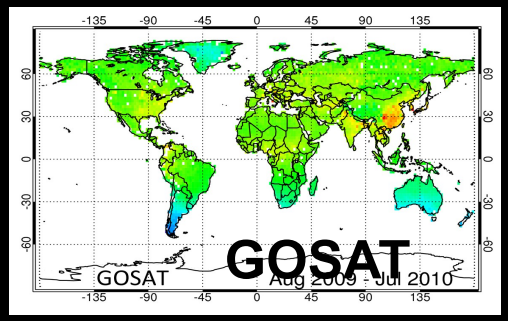
Estimating regional CH_4 fluxes using GOSAT XCH_4 observations.



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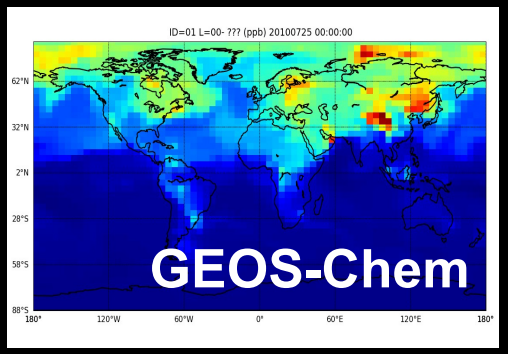
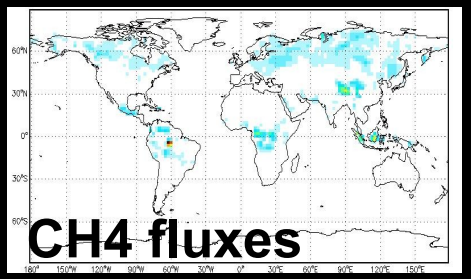


Ensemble

Kalman Filter



Annemarie Fraser, Paul I. Palmer, Liang Feng, Hartmut Boesch, Austin J. Cogan, Robert J. Parker, Ed J. Dlugokencky, Paul J. Fraser, Paul B. Krummel, Ray L. Langenfelds, Simon O'Doherty, Ronald G. Prinn, Marcel van der Schoot, L. Paul Steele, and Ray F. Weiss

5th GOSAT RA PI Meeting
Yokohama, Japan
May 31, 2013

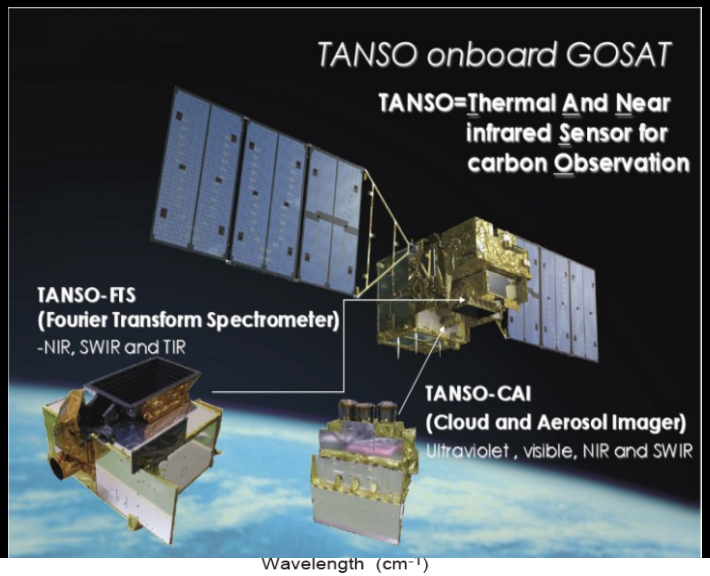
THE UNIVERSITY of EDINBURGH

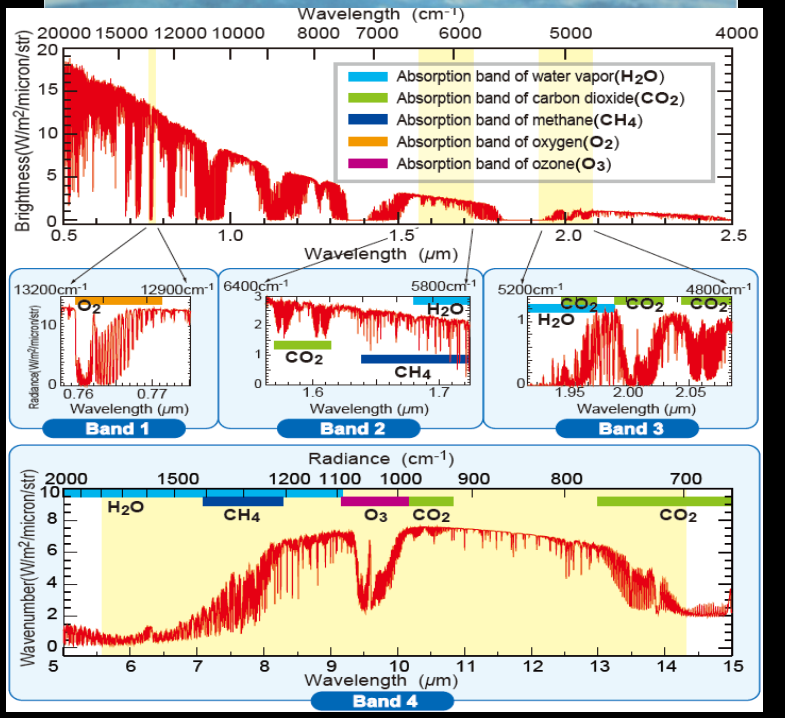
National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

University of Leicester

Data: UoL GOSAT

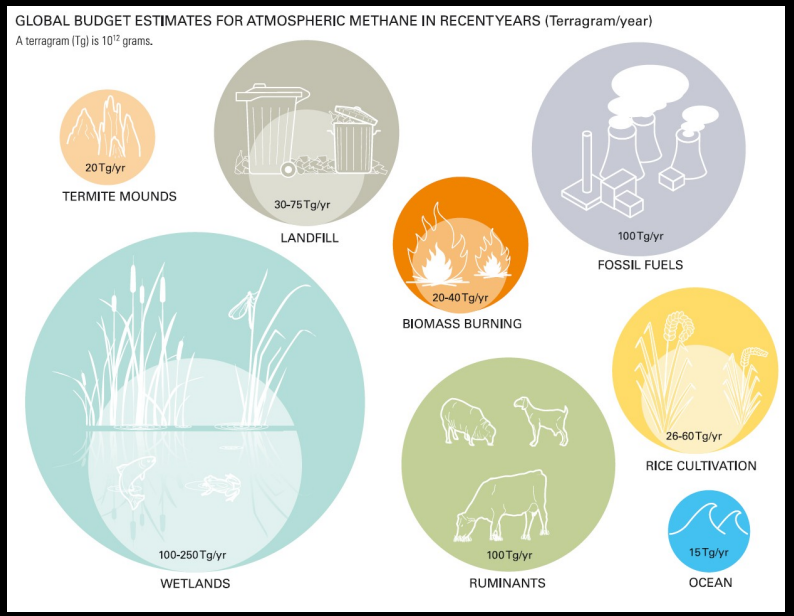
- ★ Greenhouse gases Observing SATellite: launched January 23, 2009
- ★ Data from June 2009 – December 2011
- ★ OCO Full Physics Optimal Estimation algorithm
- ★ CO2 retrieval (full physics):
  - simultaneously fits: 0.76 μm O2 A band, the 1.61 μm and the 2.06 μm CO2 bands
- ★ CH4 retrieval (CH4/CO2 proxy):
  - Fit to CO2 band at 1.61μm and 1.65μm CH4 band
  - $$X_{CH_4,\,proxy} = \left[\frac{X_{CH_4}}{X_{CO_2}}\right]_{GOSAT} \times X_{CO_2,\,model}$$
  - CO2 model is either CarbonTracker (Peters et al., 2007) or GEOS-Chem (Feng et al, 2011) (Both have assimilated surface data.)



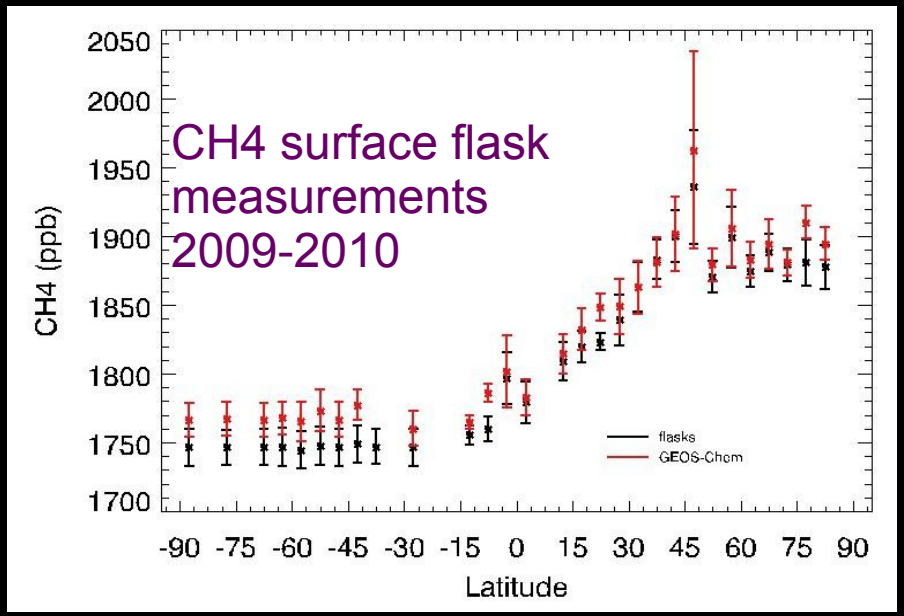


Model: GEOS-Chem

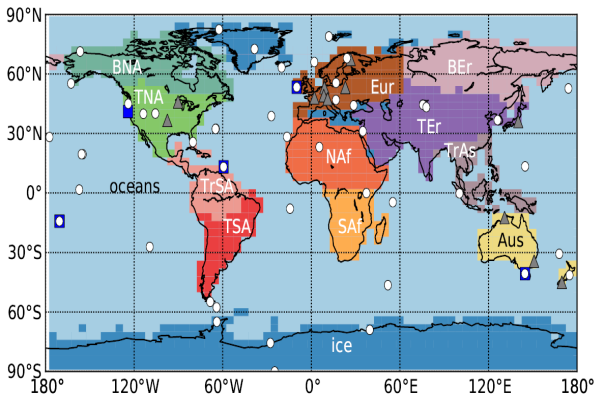
- ★ GEOS-Chem is a 3D chemical transport model, driven by assimilated meteorological fields (GEOS v5.2)
- ★ Resolution of 4 lat x 5 lon x 47 vertical levels
- ★ Emissions from global inventories
  - Anthropogenic: EDGAR 3.2FT
  - Biomass burning: GFEDv3.0
  - Wetlands and rice: Bloom et al., 2012
- ★ Tropospheric OH sink: monthly mean 3D fields



Palmer and Bloom, 2010



GOSAT vs. GEOS-Chem



GOSAT v3 **GOSAT v4** **GEOS-Chem**

Top-down emissions estimates

★ In a Kalman filter, the analysis is given by:

analysis forecast observations observation operator

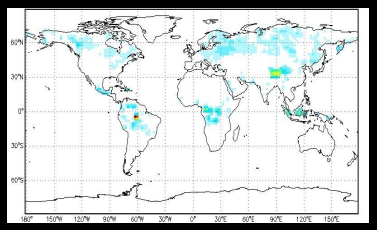
$$x^a = x^f + K\,[\,y_{obs} - H(x^f)]$$

Kalman Gain (weighting function)

★ In our case:

GOSAT data

GEOS-Chem, averaging kernels



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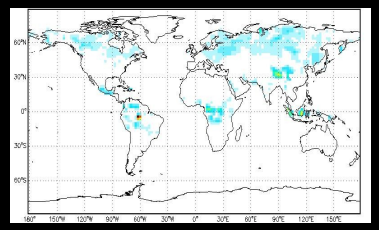
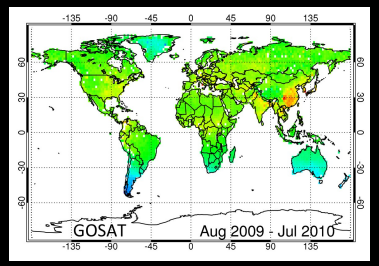
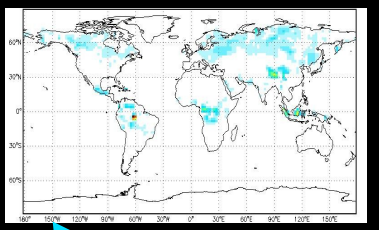


+ K(



- H



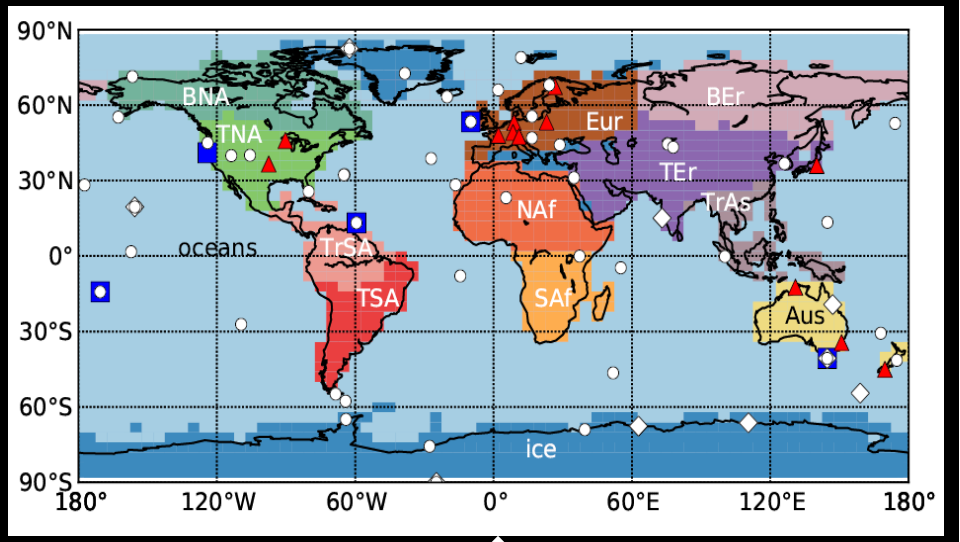
)

New emissions

Prior emissions

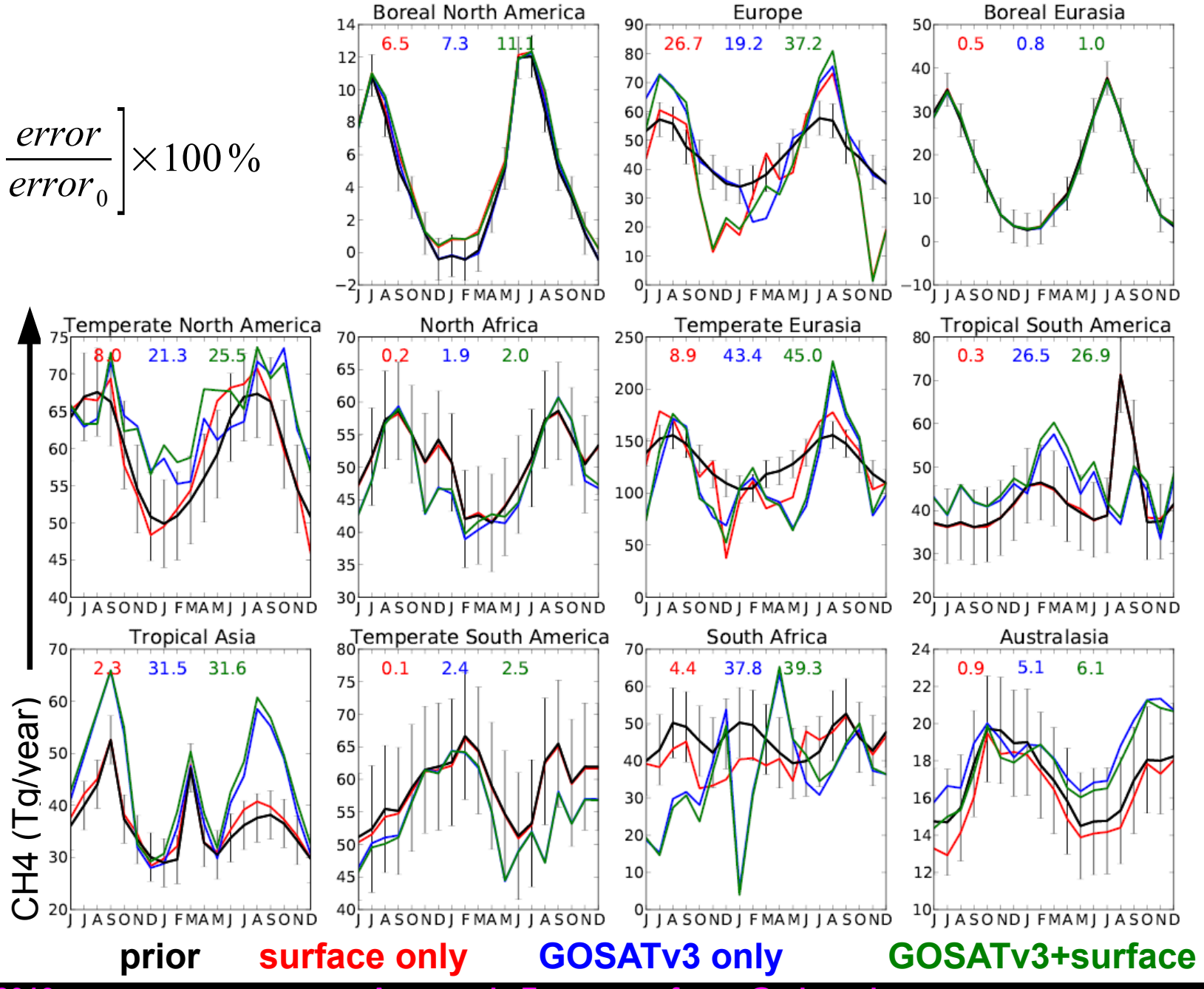
EnKF for methane

- ★ We assimilate XCH4 proxy GOSAT and ESRL and GASLab surface flask CH4 data (57 sites) filtered for:
  - fit quality
  - clouds
  - only H-gain
  - no observations poleward of 60°
- ★ Five inversions: surface only, GOSAT only (x2 proxies), GOSAT and surface data (x2 proxies)
- ★ Inversion performed on monthly time intervals, for 13 regions taken from Transcom regions (11 land + ice + oceans)
- ★ Land regions are further divided into 9 source categories
- ★ Prior errors of 50% for the seasonally varying emissions and 25% for the other emissions
- ★ We fit a latitudinally-varying bias



Effect of GOSAT data

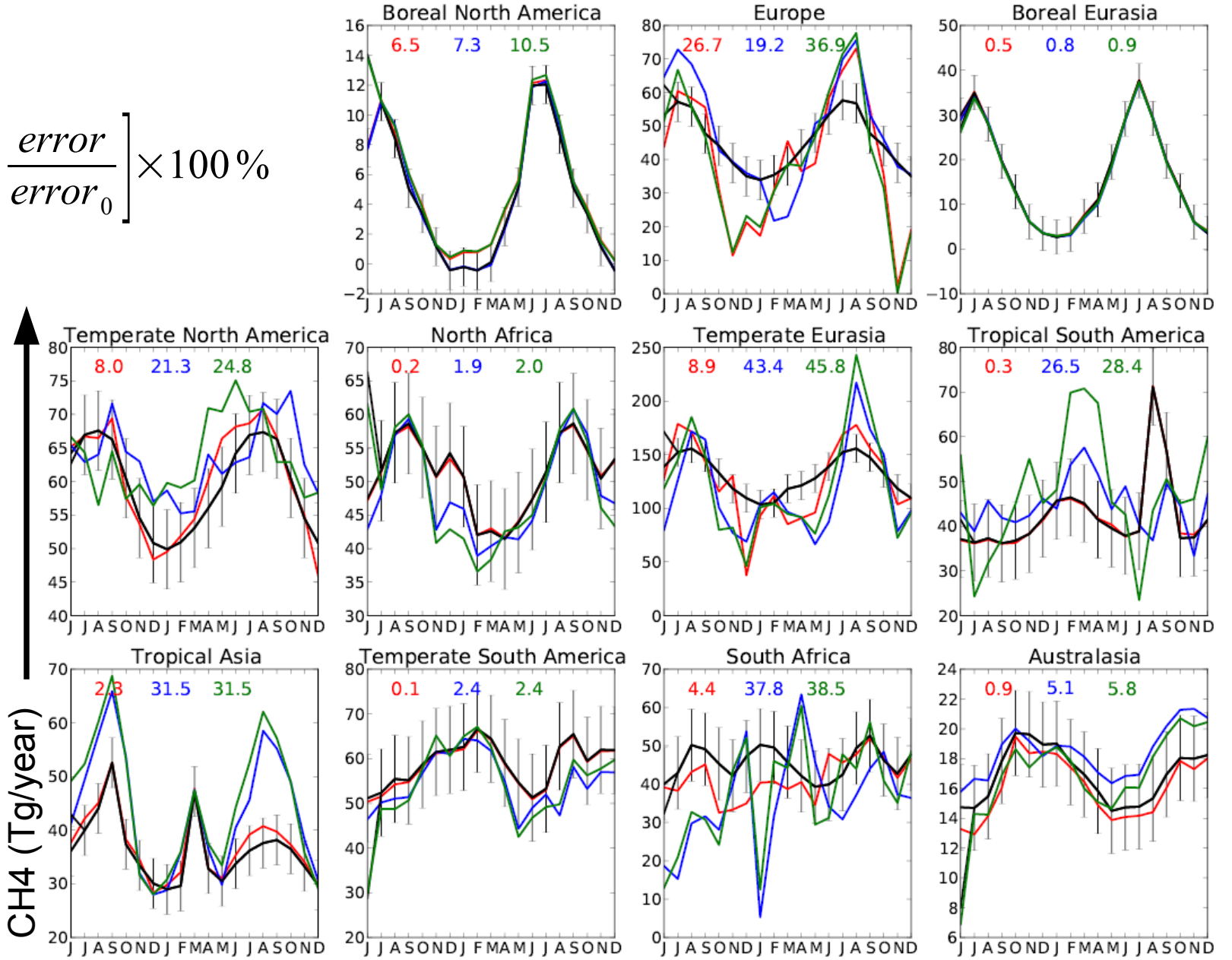
$$\gamma = \left[1 - \frac{error}{error_0}\right] \times 100\,\%$$



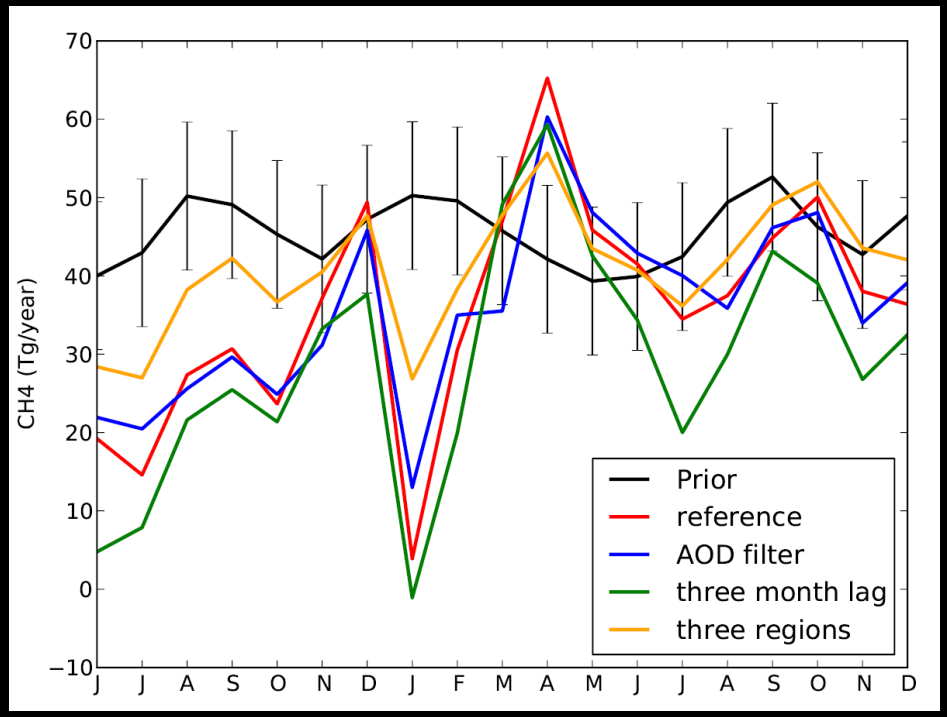
Fraser et al., ACP, 2013

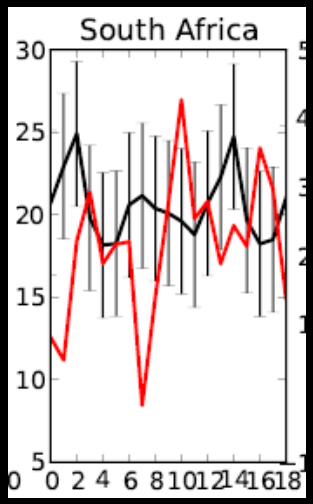
GOSATv4

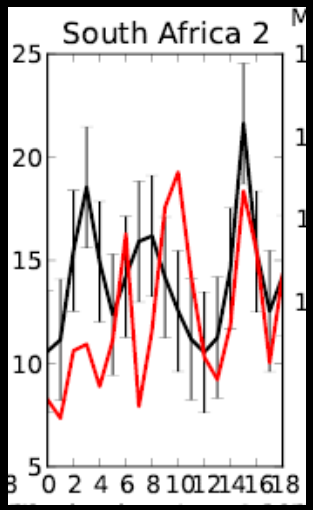
$$\gamma = \left[1 - \frac{error}{error_0}\right] \times 100\,\%$$

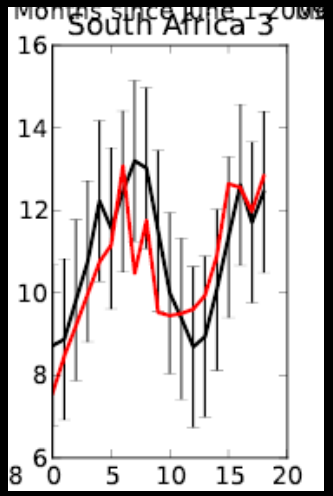


South Africa









- ★ AOD filter:
  - Filter data where ACOS AOD retrieval > 0.15
- ★ Thee month lag:
  - Allow fluxes to be affected up to three months after the observation
- ★ Three regions:
  - Divide South Africa into three regions latitudinally and perform the inversion
- ★ OSSEs show that this region can be problematic for the EnKF

Information content metric

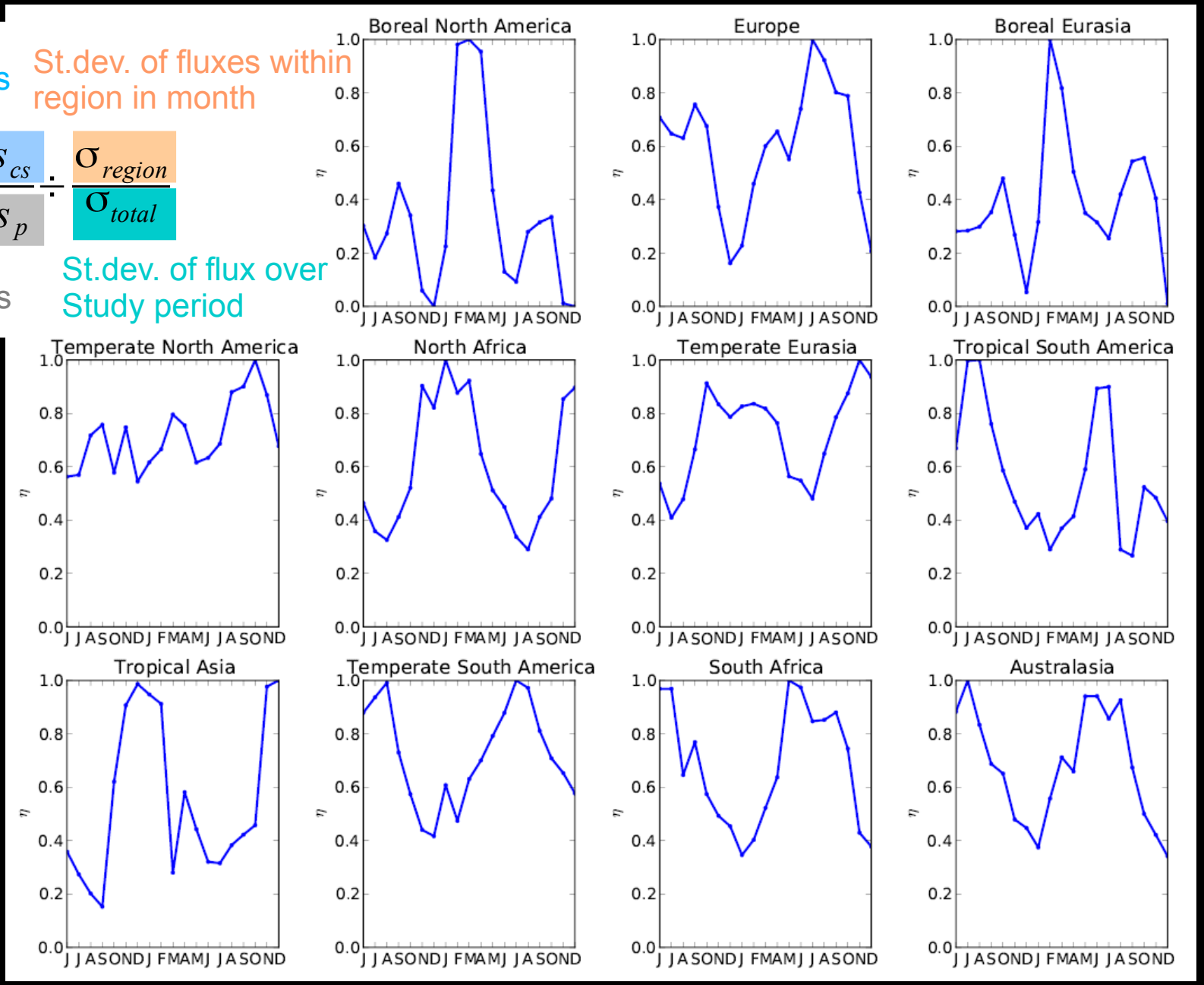
clear-sky obs

St.dev. of fluxes within region in month

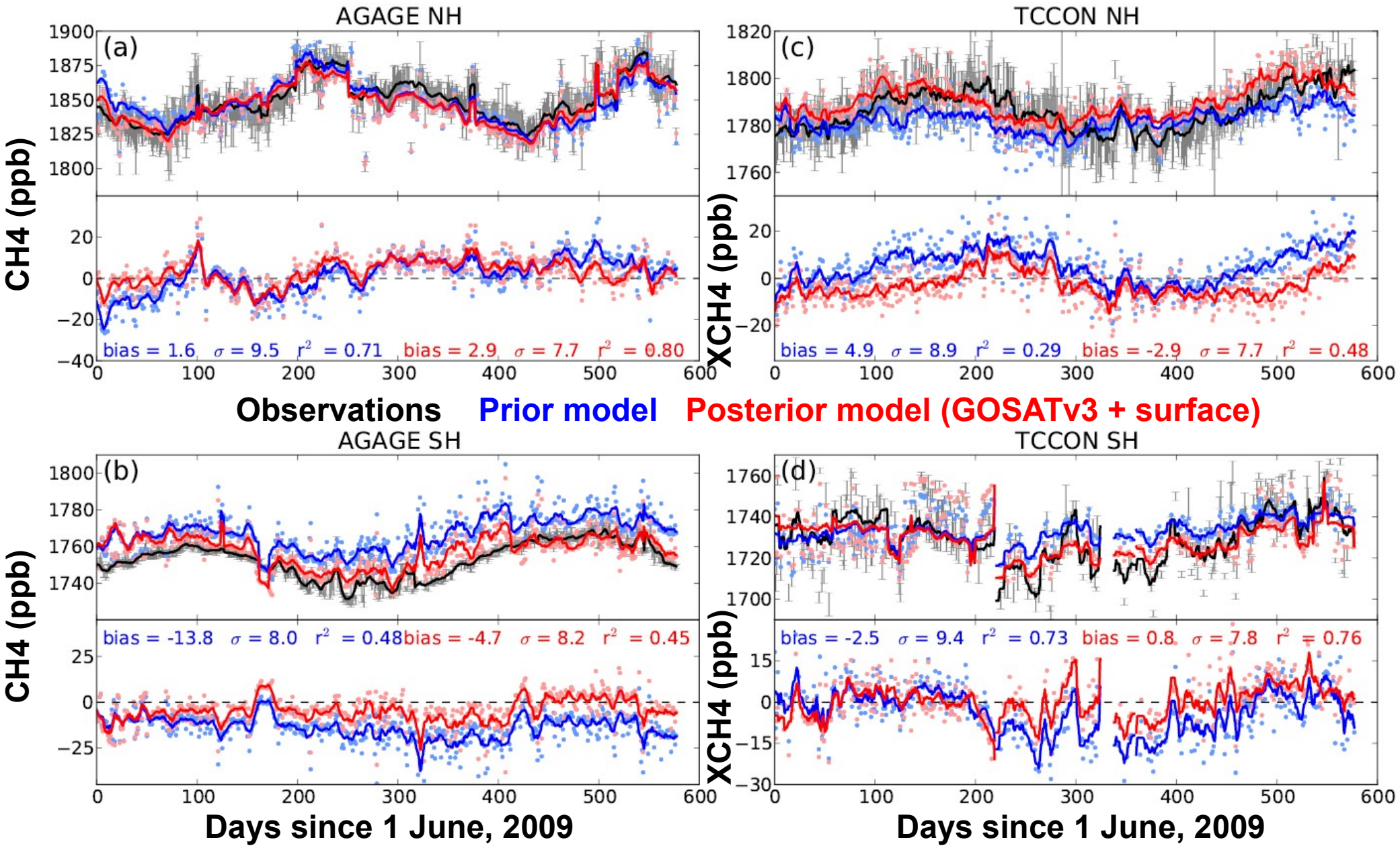
$$\eta = \frac{obs_{cs}}{obs_{p}} \div \frac{\sigma_{region}}{\sigma_{total}}$$

St.dev. of flux over Study period

possible obs



Comparisons to independent data



Fraser et al., ACP, 2013

Summary

- We are assimilating GOSAT XCH4 and XCO2 data with GEOS-Chem using an ensemble Kalman filter
- Error reductions for inversions using the GOSAT data are at least twice the error reductions if only the surface data are assimilated with two exceptions:
  - In Europe, where the surface network describes fluxes on our spatial and temporal grid
  - In boreal regions, due to the satellite's orbit and a data filter
- Posterior fluxes from GOSATv3 and v4 are consistent, with some differences that need to be further examined
- We have defined an information content metric, to help identify regions where the inversion has difficulty
- We see marginal improvement with independent measurements from the AGAGE and TCCON networks