An ensemble Kalman filter based on 3D GEOS-Chem transport model for estimating CO2 and CH4 surface fluxes from GOSAT XCO2 and XCH4 observations: Preliminary results

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I. Ensemble Kalman Filter

- **Top-down optimal flux estimation**

Posteriori Priori gain observation model

$$\mathbf{x}^a = \mathbf{x}^f + \mathbf{K}(\mathbf{y}_{obs} - \mathbf{H}\mathbf{x}^f)$$

x: regional surface fluxes.

$\mathbf{y_{obs}}$**:** measurements of atmospheric concentrations**.**

H: Jacobian (*GEOS-Chem transport model*).

K=PH^T(HPH^T+R) – Kalman gain matrix.

P: a priori uncertainty matrix

R: observation error matrix

➢ Ensemble Approach

Key features:

(Feng et al., 2009 ; 2011)

•*Represent a-priori uncertainties by an ensemble of flux perturbations*.

•Use a lag windows to limit computational costs.

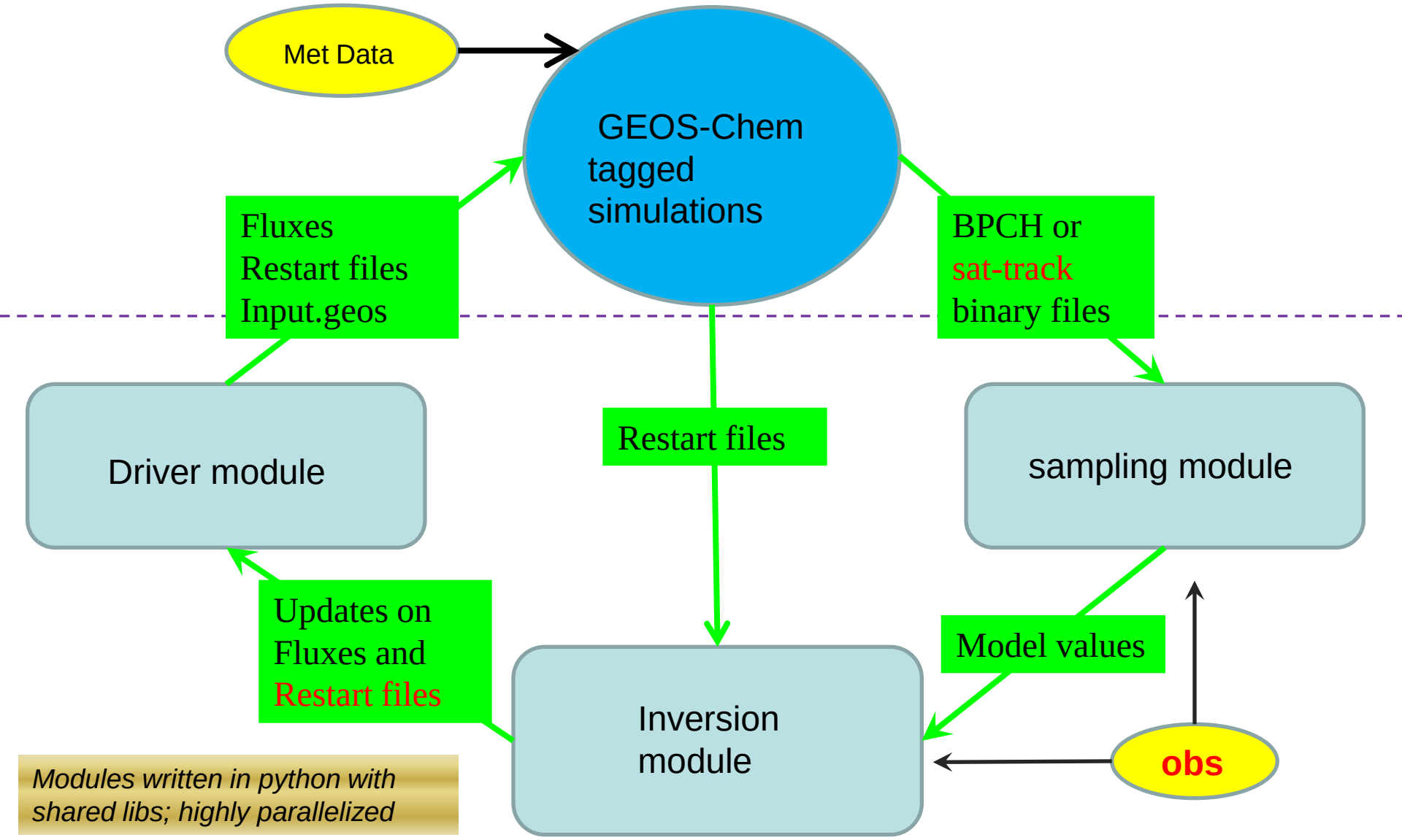
Any emission will only be constrained by observations within a following limited time period. After that period, it is considered to be well-known.

•Project the ensemble of perturbations together with prior estimates into the observation space using GEOS-Chem.

•Use Ensemble Transform Kalman Filter (ETKF) to determine posterior fluxes, and the associated uncertainties from digesting observations.

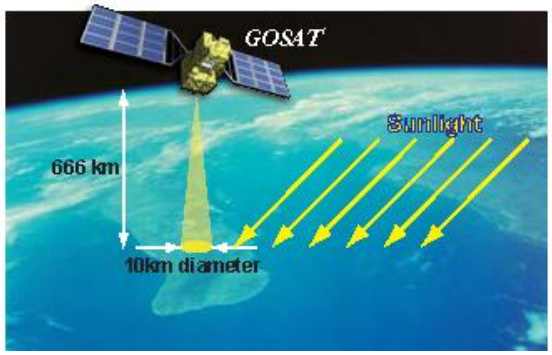
➢ Implementation

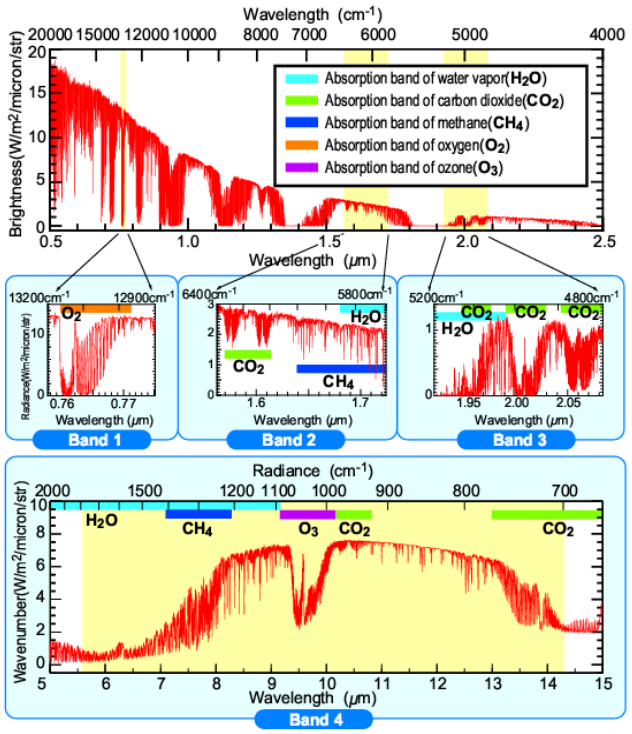
- *Highly flexible ; only small changes needed for GEOS-Chem codes; sufficient diagnostics*

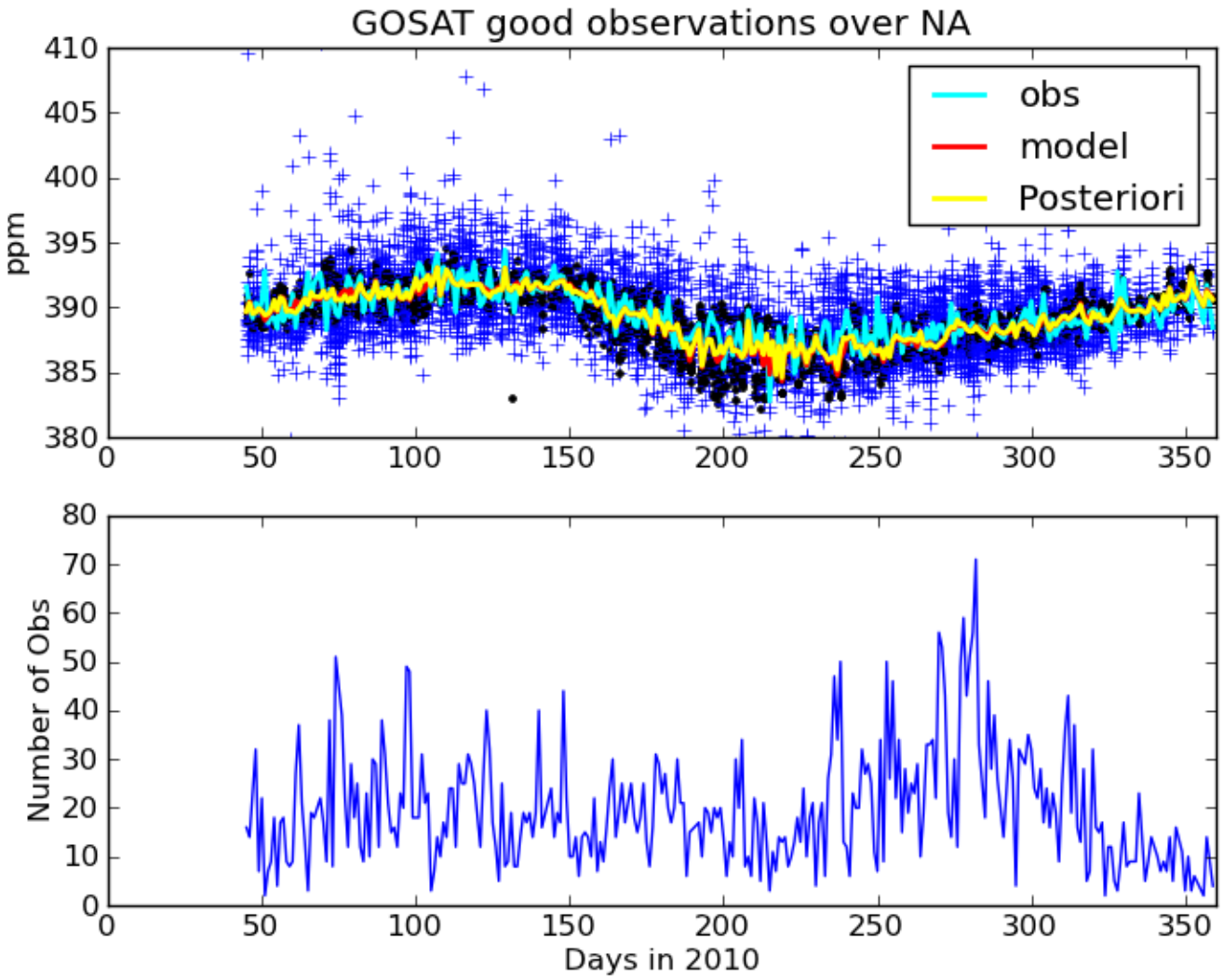


II. GOSAT observations

- Greenhouse Gases Observing SATellite.
- GOSAT is the first dedicated GHG sensor.
- GOSAT provides shortwave-IR and thermal-IR observations of CO2, CH4, O3, H2O, and many minor species.
- We only use XCO2 and XCH4 L2 retrievals with quality flag='GOOD'.
- We apply bias corrections to GOSAT retrievals.
- We inflate observation errors and add spatial correlations.

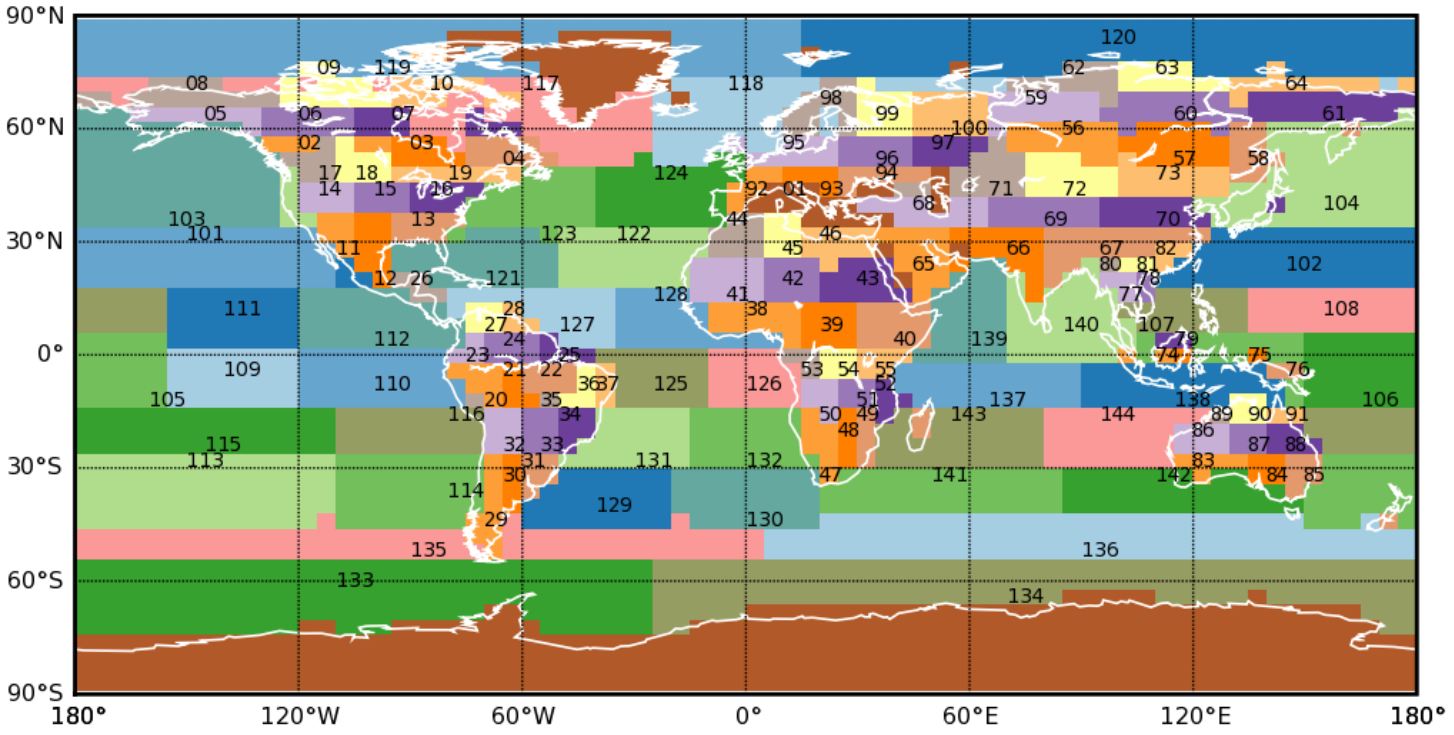





GOSAT good observations over NA
obs
model
Posteriori
ppm
410
405
400
395
390
385
380
0
50
100
150
200
250
300
350
Number of Obs
80
70
60
50
40
30
20
10
0
Days in 2010

III. Inversions for CO2 fluxes

8-day fluxes from 9 11 land regions+4 11 ocean regions.



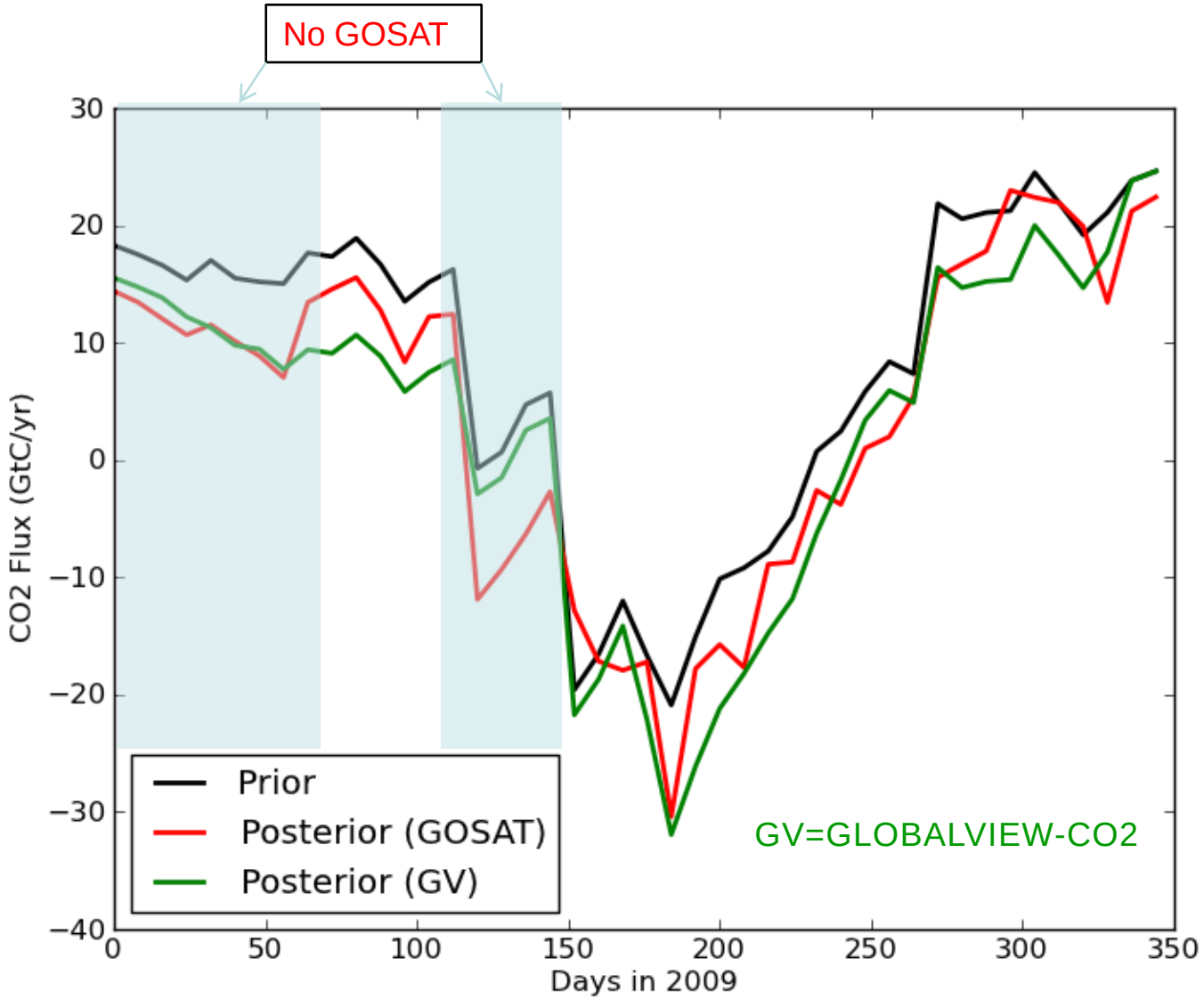
•Prior fluxes: Annual fossil fuel; Monthly biomass burning (GFEDv2); 3-h biosphere (CASA); Monthly ocean fluxes.

•Uncertainties based on TransCom 3 experiments.

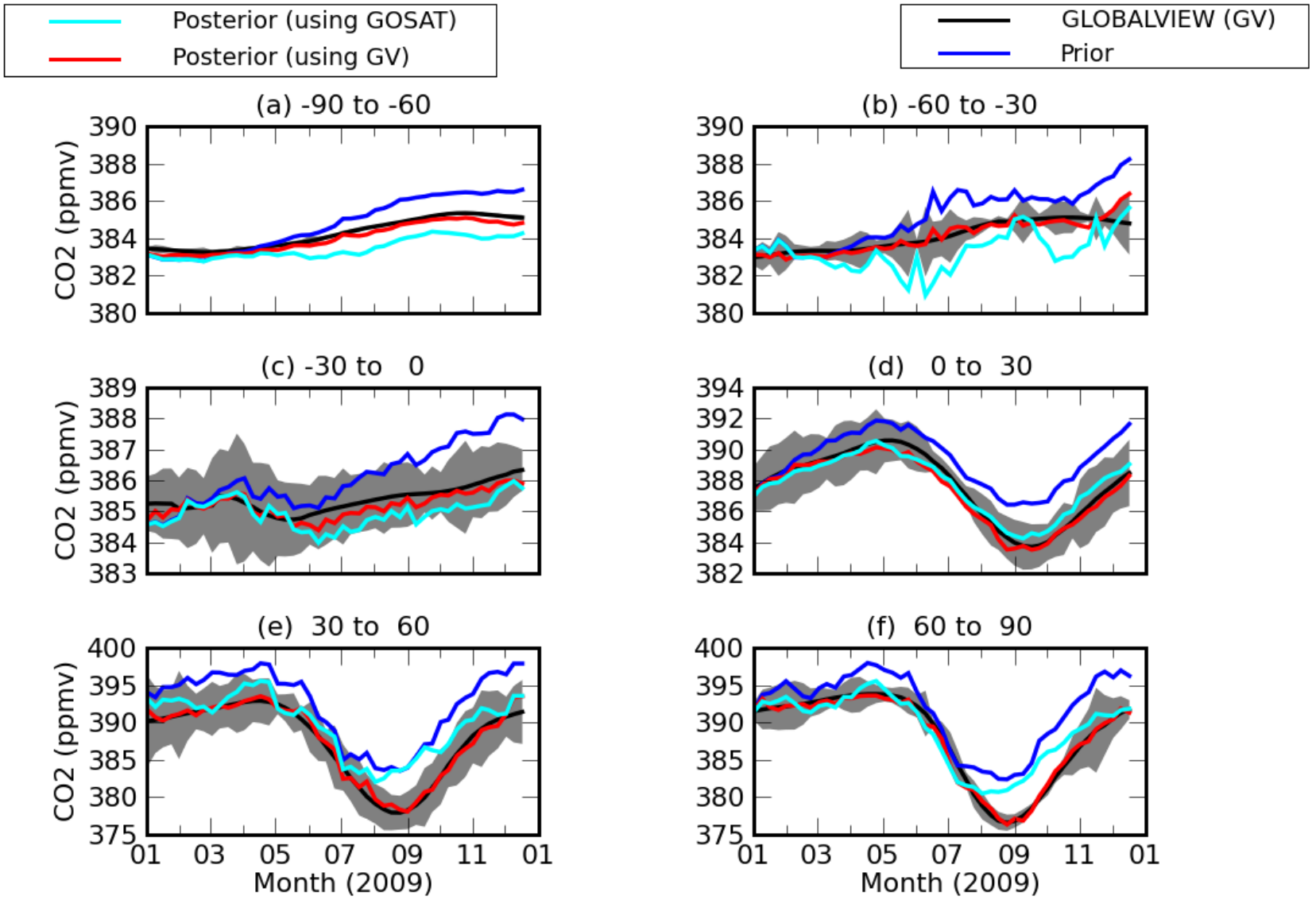
•112-day lag windows.

IV. Preliminary Results

- Global net flux

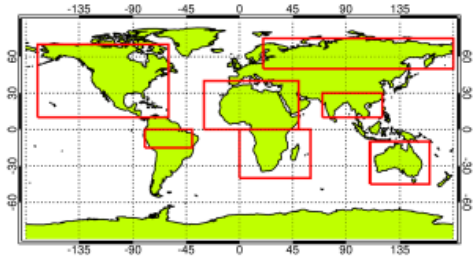


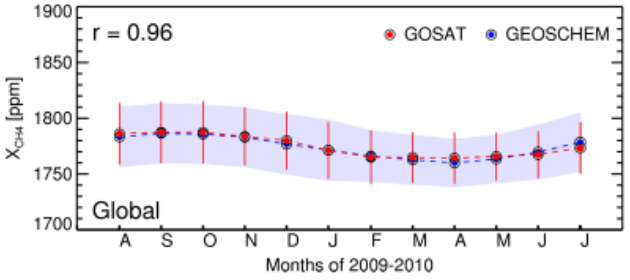
➢ Comparison with surface CO2 observations

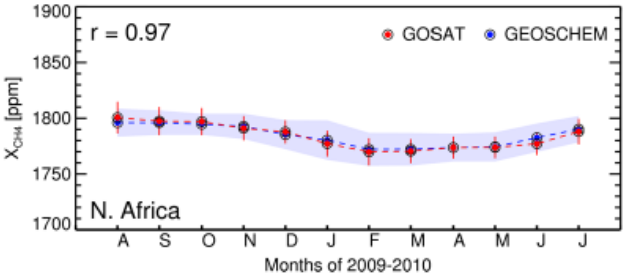


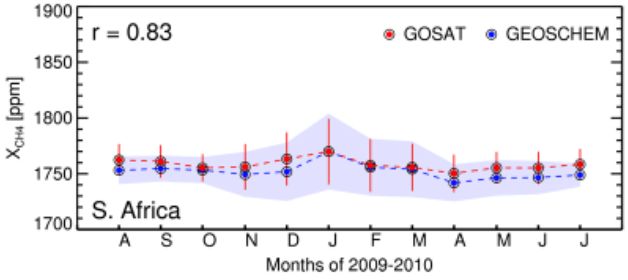
V Preliminary results for CH4 fluxes.

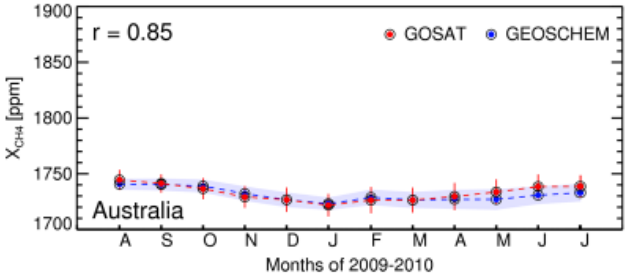
- Prior model values in good agreement with GOSAT

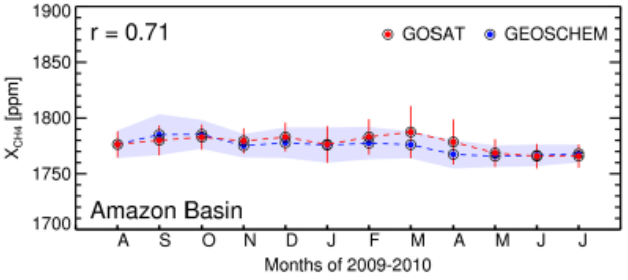


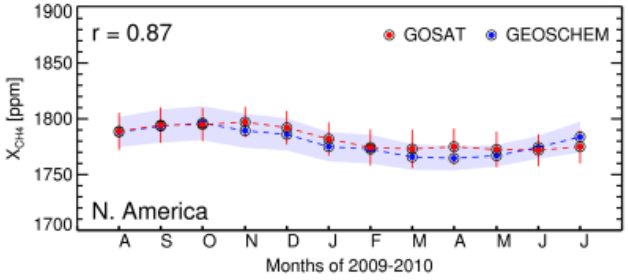


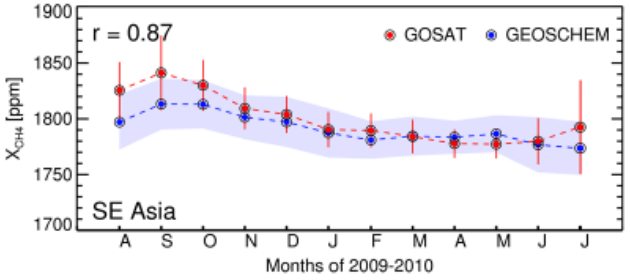


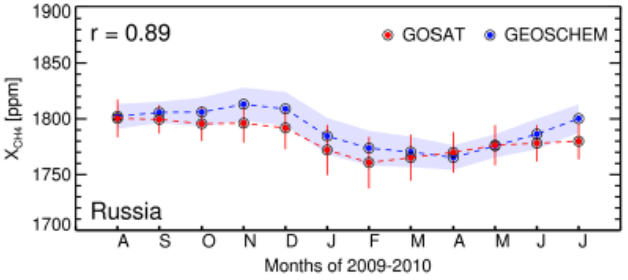




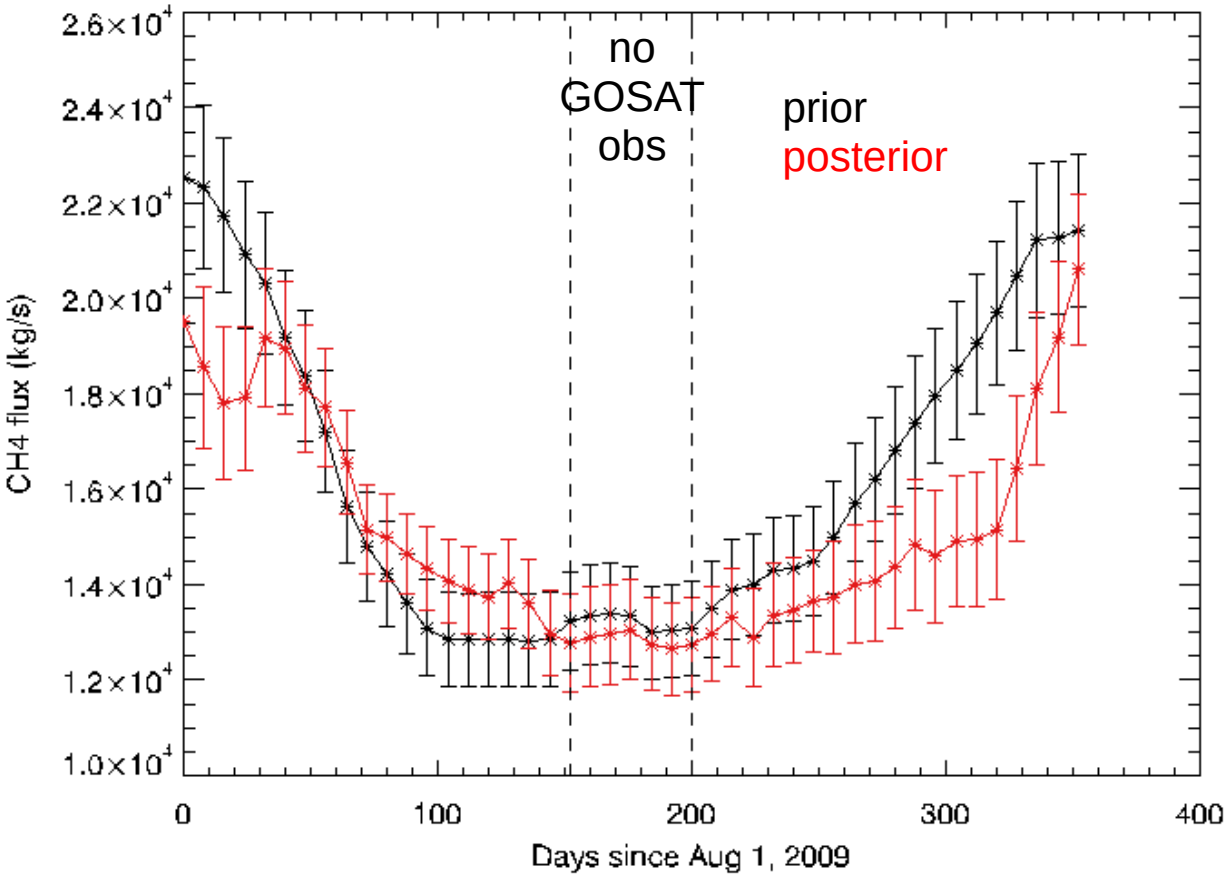






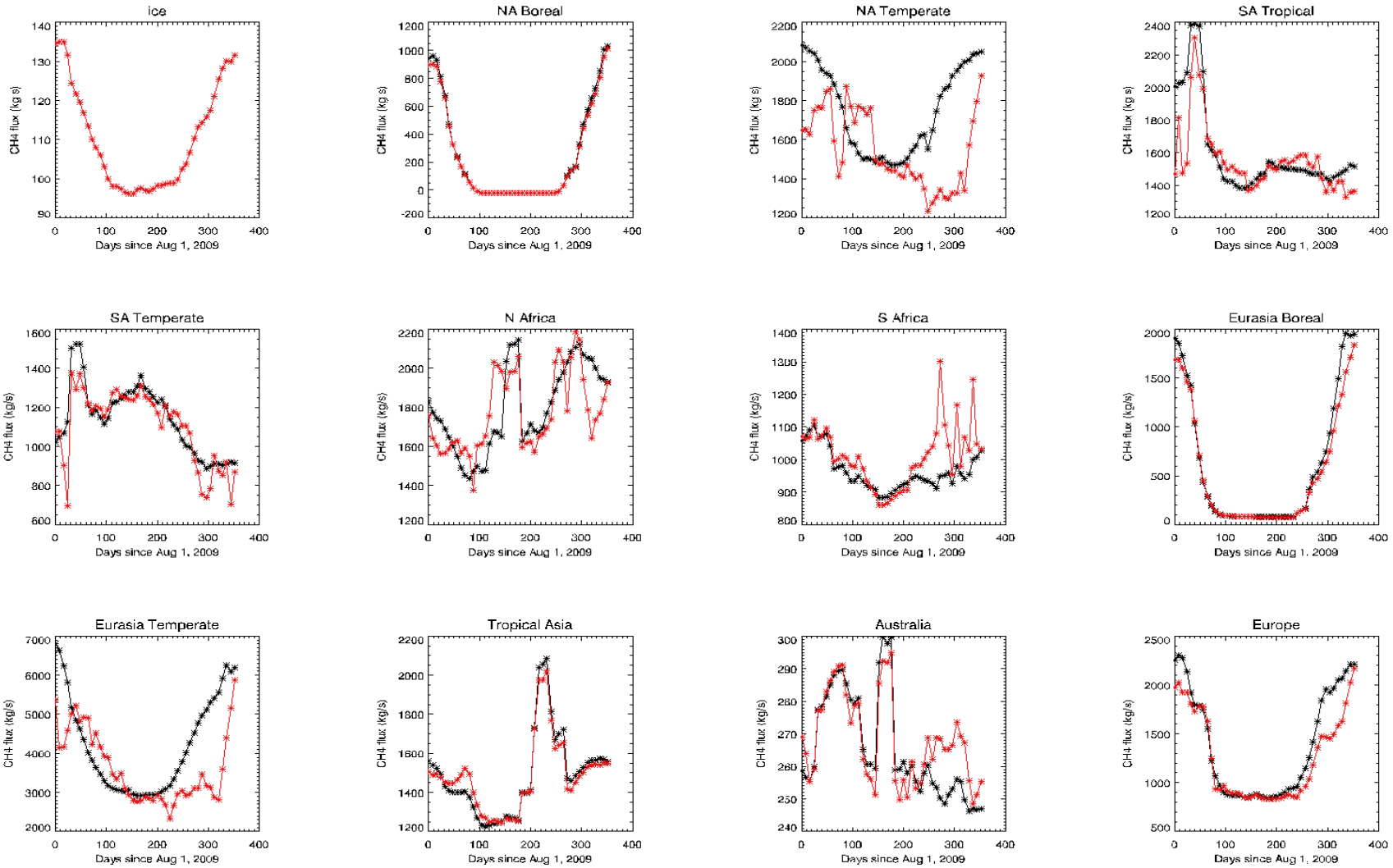


➢ PRELIMINARY posterior CH4 Global Fluxes



➢ Fluxes over TransCom land regions

prior posterior



Concluding Remarks

- We have developed an EnKF assimilation tool for interpreting X_{CO2} and X_{CH4} data.
- Preliminary results are encouraging.
- There are issues on how to choose and use current GOSAT retrievals .