OPTIMIZING GPP* AND RESPIRATION FLUXES: ASSIMILATION OF ATMOSPHERIC CO_2 AND COS CONCENTRATION IN AN ATMOSPHERIC TRANSPORT MODEL

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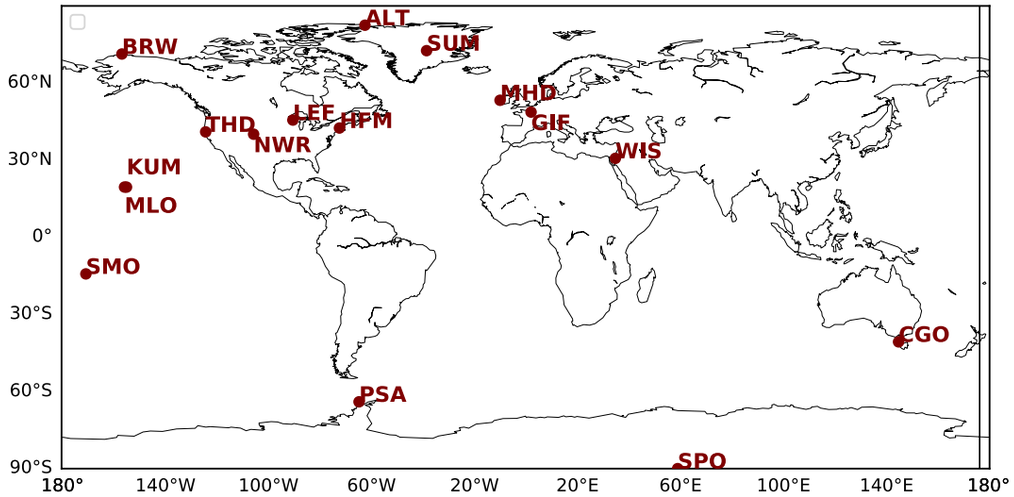
ESTIMATION OF THE CO_2/COS PLANT UPTAKE

To optimize: GPP and Respiration for 15 vegetation types + other sources of COS:

- FCOS=LRU*GPP*$[COS]_{atm}/[CO_2]_{atm}$
- Analytical inversion:
  - Scaling factors varying between ±30%
- Atmospheric transport is represented by a Jacobian matrix G that has been computed by the adjoint code of LMDz. It has been computed once and for all over several weeks and absorbs ~ all of the computing time of the approach.

CO_2 and COS NOAA network



The vector of monthly sources (X) and the a posteriori covariance matrix (R_{post}) are obtained as:

$$X = X_p + R_{post}\mathbf{G}^t R_{obs}^{-1}(H_{obs} - G(X_p))$$

$$R_{post} = (\mathbf{G}^t R_{obs}^{-1}\mathbf{G} + R_{mod}^{-1})^{-1}$$

H_{obs} = observation vector
R_{obs} = observation error matrix
G = transport model
$\mathbf{G}$ = linear tangent
X_p = prior knowledge
R_{post} = posterior matrix

STATE OF THE ART

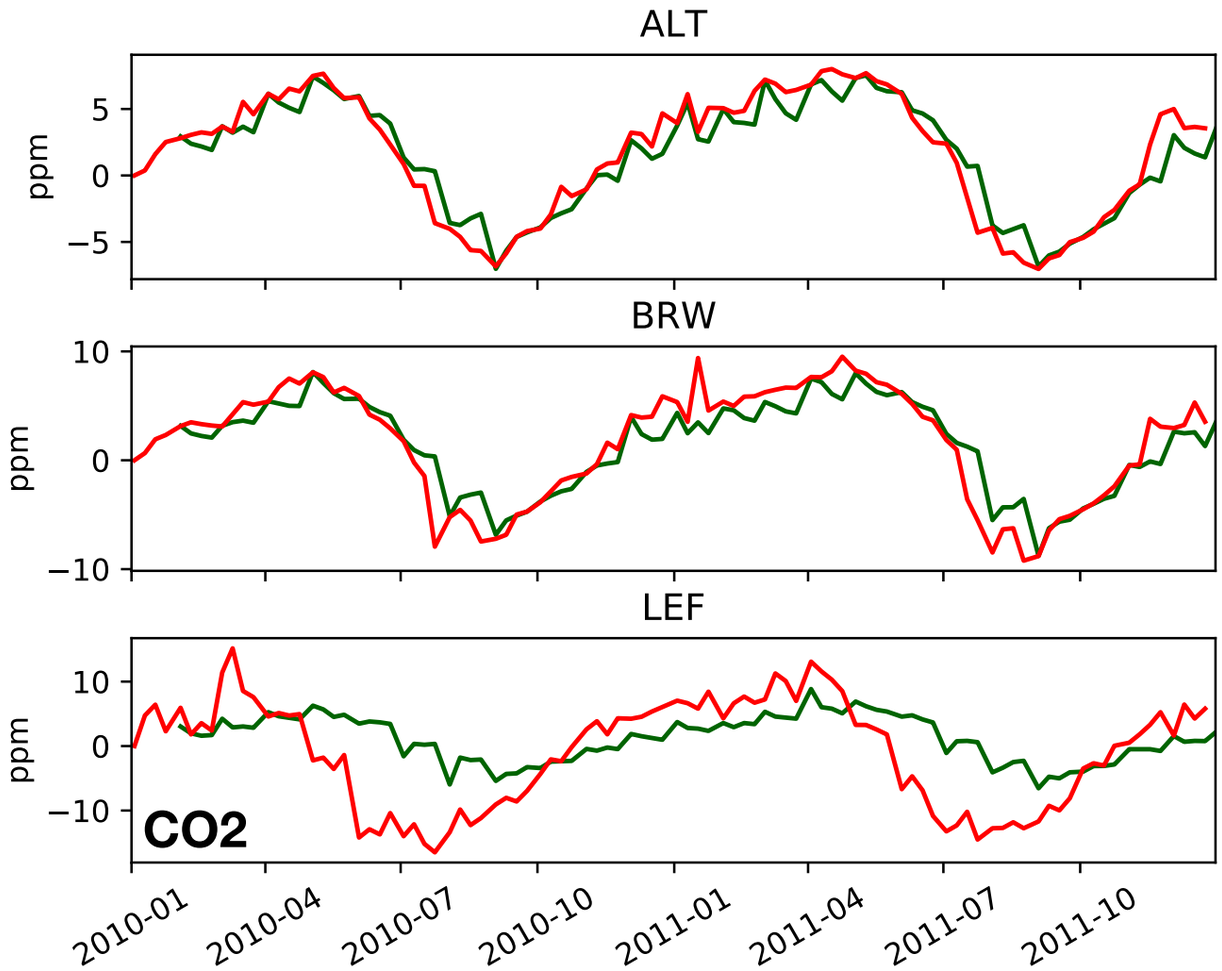
Existing inverse studies

- *Berry et al., 2013*, *Launois et al., 2015:* Assimilation of COS measurements from the NOAA surface network into a transport model
  - Optimization of the annual fluxes
  - Single scaling coefficient per process
  - Oceanic source estimated around 800 GgS/y and vegetation uptake -*700 GgS/y*
- *Kuai et al. , 2015:* Assimilation of COS retrievals from the TES satellite into *a* transport model
  - Satellite retrievals only available over the tropical oceans
  - 24 regions optimized for June 2006
  - Missing tropical oceanic source estimated around 800 GgS/y
- *P. Suntharalingam in progress :* Assimilation of COS surface measurements using a ensemble Kalman Filter
- *Jin et al in progress:* Variational assimilation of COS surface measurements into an atmospheric transport model
  - Global optimization of each pixel

This study:

- Estimate both the GPP and the respiration for each plant functional type using the additional constraint of the CO_2 budget and the SIF
- Determine the seasonal cycle by optimizing the monthly fluxes

TRANSPORT JACOBIAN MATRIX **G**



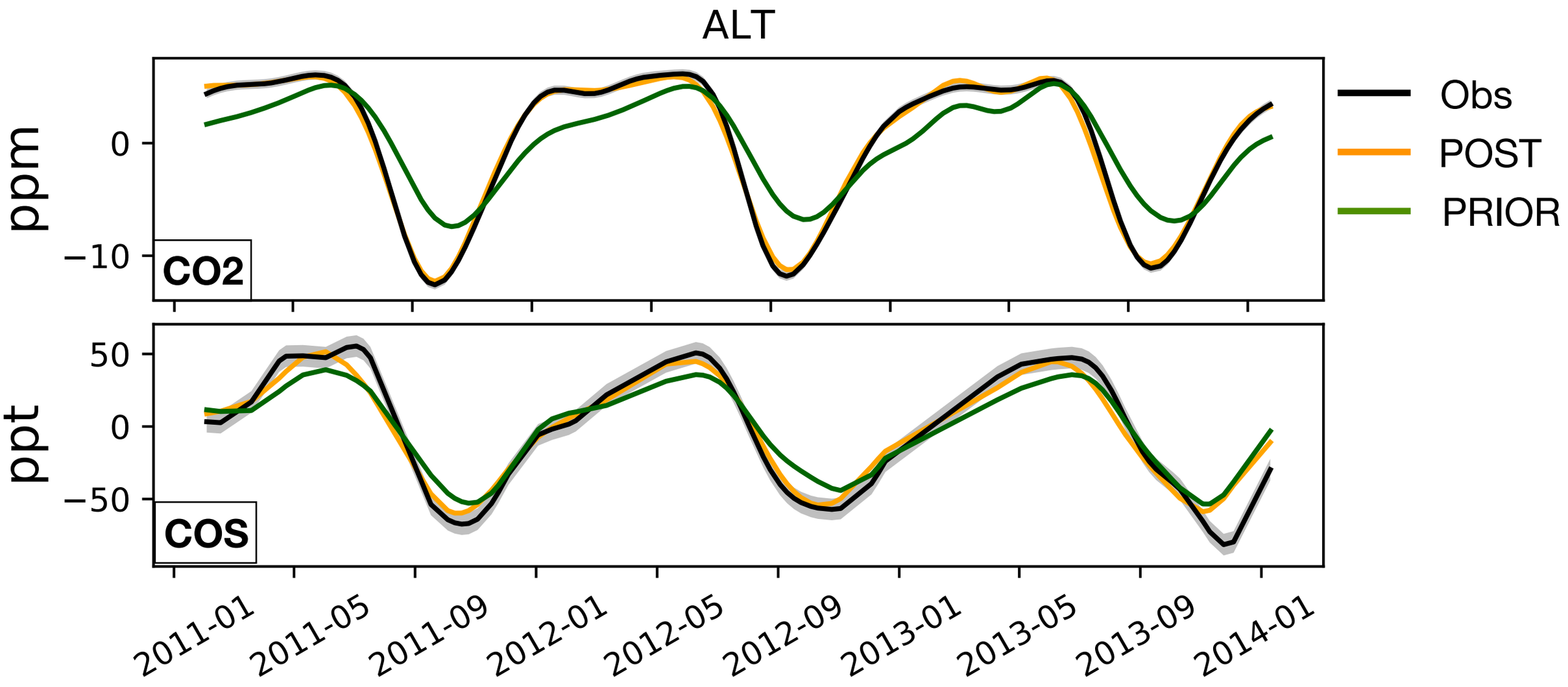
LMDz full model

Reconstructed transport

No trends but some discrepancies are visible, especially for stations located near the sources (LEF, CGO, NWR), that can be caused by:
-non-linearities in the advection scheme (slope limiters) of the full LMDz model
-Diurnal variations of transport that have been averaged before saving the adjoint computations

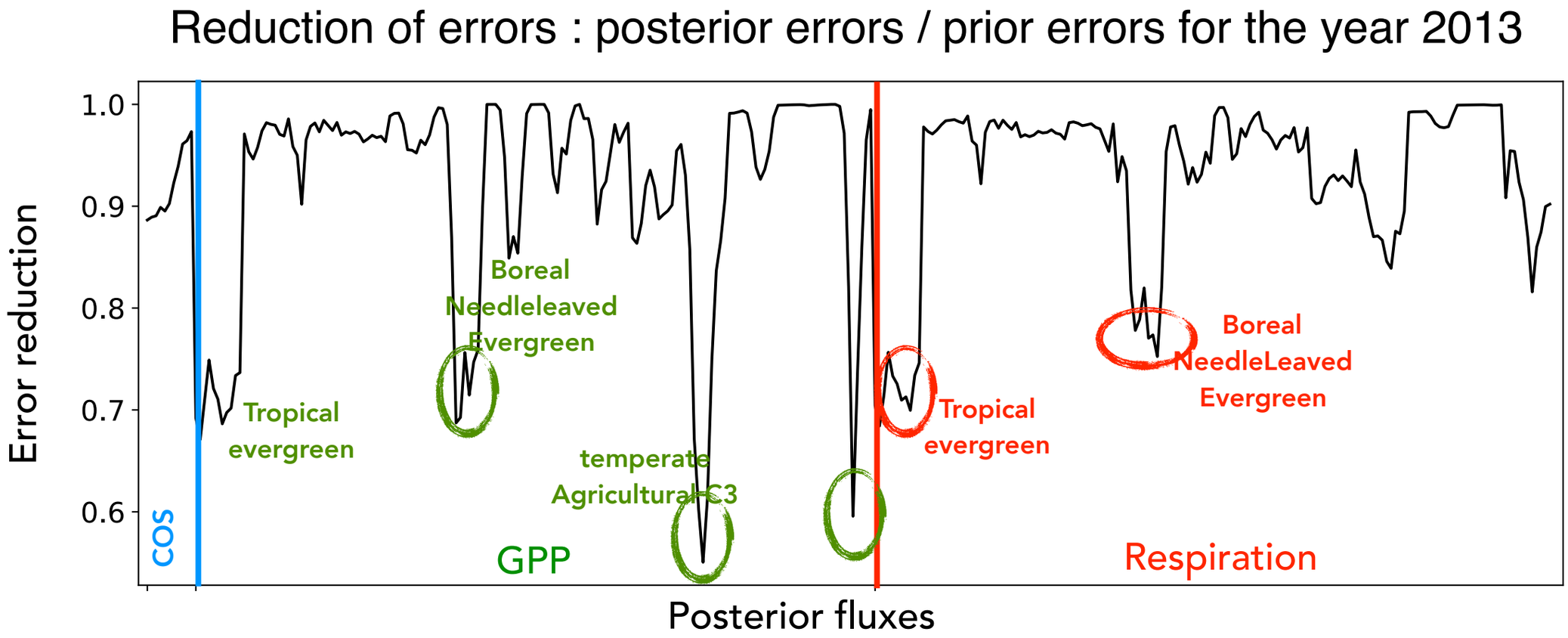
Those issues should mostly vanish when we implement an incremental approach, in which we use of the full LMDz model for the prior trajectory.

INVERSION RESULTS



	GPP	Respiration	Other COS sources	Mismatch
PRIOR	-123.2 GtC	114.6 Gt	471.6 GgS	85 ppt (COS) 8.3 ppm (CO2)
POST	-114.6 GtC	109.7 GtC	714.5 GgS	35 ppt (COS) 2.5 ppm (CO2)

INVERSION RESULTS



- *A significant reduction of uncertainties (from 85 ppt to 61 ppt) come from the increase of the oceanic source.*

WORK IN PROGRESS

- Improvement of the atmospheric transport: implementation of an incremental approach in which the prior trajectory is calculated by the full LMDz model
- Need of additional constraints on the system:
  - combine the PFTs that are correlated
  - Combine SIF data to fix the GPP
- Update of the prior fluxes
- Optimization per regions