Estimating global carbon fluxes with GOSAT observations

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Contents

Basic procedure for standard GOSAT Level 4 product: Estimations of monthly CO₂ regional fluxes by using existing surface network and GOSAT observations.

- Expected GOSAT data and its use in flux estimation
- Inverse estimation with total column CO₂ data
- Inverse model estimates of the flux uncertainty
- Summary
Inverse model of the regional CO₂ fluxes.

1. Monthly emission pulse of 1GtC/year is prescribed for each region and each month, then inverse problem is solved to find optimal flux distribution that fits to observations.

2. Estimated CO₂ flux uncertainty is dependent on (1) Observation errors, (2) transport sensitivity, (3) prior constrains on fluxes.

Map of inverse model regions

Problem: \( \mathbf{x} - \mathbf{T F} = \min \)
\( \mathbf{x} \) concentration, \( \mathbf{F} \) fluxes, \( \mathbf{T} \) - transport matrix

Flux solution: \( \mathbf{F} = \mathbf{F}_0 + [T^T \mathbf{C}_x^{-1} T + \mathbf{C}_{F0}^{-1}]^{-1} T^T \mathbf{C}_x^{-1} [\mathbf{x} - T \mathbf{F}_0] \quad (2') \)

Flux error covariance: \( \mathbf{C}_F = [\mathbf{C}_{F0}^{-1} + T^T \mathbf{C}_x^{-1} T]^{-1} \)
Inverse model fluxes, with 64 region model

left model grid, right region average
CO2 flux uncertainties (GtC/year) without using GOSAT data

Large uncertainties exist in the regions of poor observational coverage

Estimated: monthly mean flux uncertainties for each region during 1 year (flux climatology)
GOSAT simulation

Monthly mean (July) CO₂ concentration along GOSAT orbit, with global offset subtracted
Average number of observations per month and monthly mean cloud cover

- Average cloud cover (%) per month for July. 7.5x7.5 degree grid
- Average number of observations over land in July. 7.5x7.5 degree grid
Regional CO2 flux uncertainties

- CO2 flux uncertainties for 2005. Surface stations only were used in inversion.

- CO2 flux uncertainties for 2005. Surface stations AND simulated GOSAT data were used in inversion.
Mean regional flux uncertainty (relative to surface network) against the precision of column CO2 data.

**Error model:**

\[ \sigma(X_{CO2}) = \sigma_s(X_{CO2}) + \frac{\sigma_r(X_{CO2})}{\sqrt{N}} \]

where

\[ \sigma_{single\_shot}(X_{CO2}) = \sigma_s(X_{CO2}) + \sigma_r(X_{CO2}) \]

\[ \sigma_r(X_{CO2}) = \text{random\_error} \]

\[ b = \sigma_s(X_{CO2}) - \text{systematic\_error} \]

To approach to 50% reduction target bias \((b)\) should be reduced below 0.5 ppm
Summary

Evaluation of the expected contribution by GOSAT CO2 observations

• Inverse model was used to estimated CO2 flux uncertainty reduction due to use of the CO2 (column average) observations with TANSO-FTS (SWIR) sensor on GOSAT. Realistic cloud frequency and orbit are used in estimation

• Conclusion: average 50% flux uncertainty reduction is possible for many regions to achieve if the systematic retrieval error is kept below 0.5 ppm and single shot random error of 2.5 ppm (0.6%)