

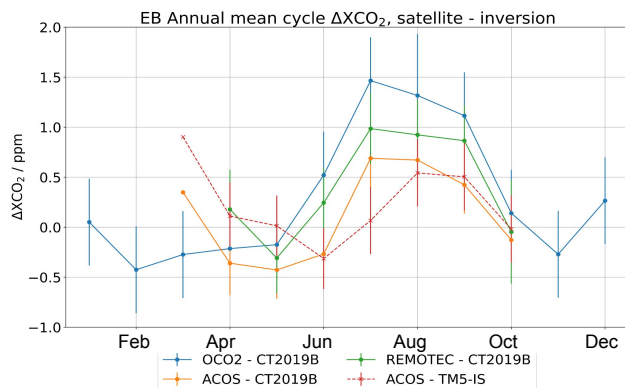
EGU21-15375 BG 3.12: Constraining the Eurasian biogenic boreal carbon cycle



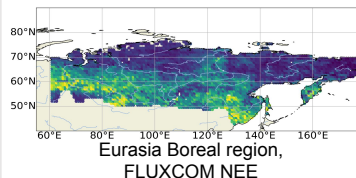
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Atmospheric CO₂

- Comparing XCO₂ from satellite and in-situ inversion model
- Validation: Sub-regional sensitivity study



⇒ In summer: Satellites show higher XCO₂ than models that only assimilate in-situ data.

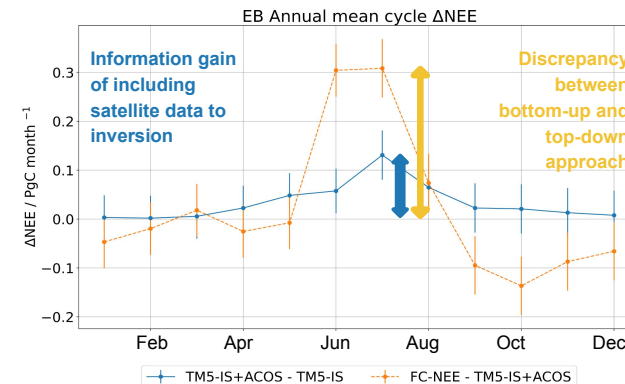


Inversion model

How does ΔXCO_2 translate to ΔNEE ?

Net ecosystem exchange NEE

- Comparing inversion TM5-IS and TM5-IS+ACOS including satellite data



⇒ Higher CO₂-net flux when assimilating satellite and in-situ

What processes (photosynthesis, respiration, ...) drive gap between bottom-up and top-down flux estimates?



EGU21-15375 BG 3.12: Constraining the Eurasian biogenic boreal carbon cycle

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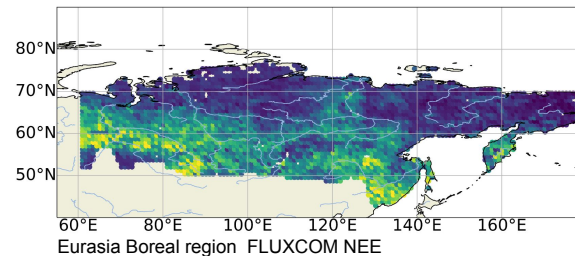
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Constraining the Eurasian biogenic boreal carbon cycle

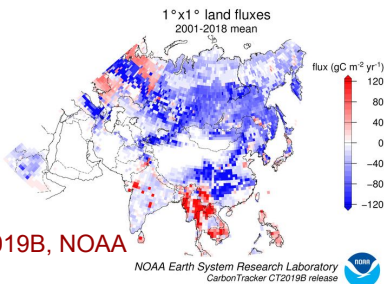


Why?

- Northern boreal region particularly affected by polar amplification warming (e.g. [Smith, 2019](#)).
- Eurasian boreal region is widely vegetated. Biogenic fluxes impact atmospheric CO₂ across northern high latitudes ([Lin, 2020](#); [Jacobs, 2021](#)).
- In-situ data is sparse.



OCO2, JPL



How?

- Satellite data offers wide coverage to investigate atmospheric CO₂ in remote areas.
- Inversion models calculate carbon fluxes to match observed atmospheric CO₂ from in-situ, satellite or both.

What?

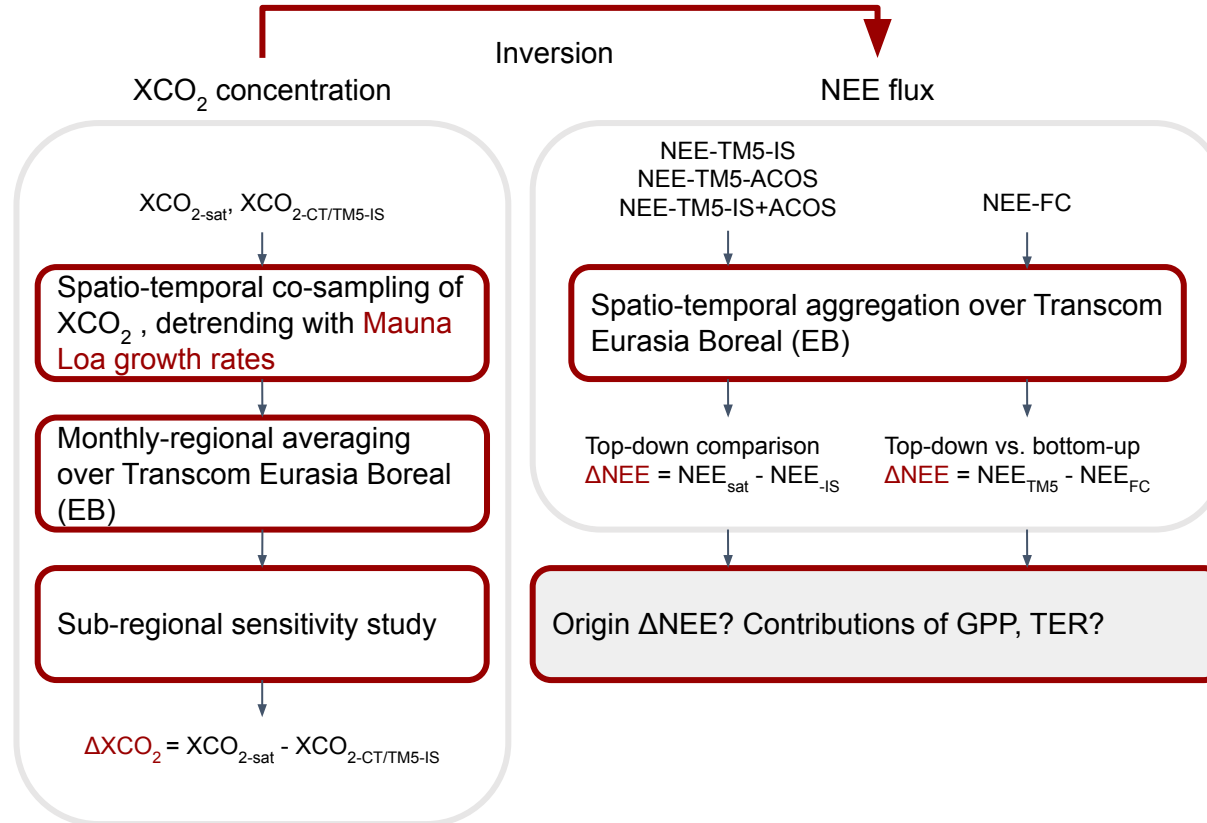
- Uncertainties in atmospheric CO₂
- Uncertainties of top-down flux estimates
- Comparison to bottom-up estimates

⇒ [Summary](#)

Methods



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Overview data

Satellite XCO₂:

- OCO-2 **v10r** (2014-2019), GOSAT-ACOS **v9r** (2009-2019), GOSAT-RemoTeC **v.2.3.8.** (2009-2019)

CarbonTracker **CT2019B** (2009-2018):

- Global optimized flux inversion
- Assimilated against in-situ (IS) XCO₂

TM5-4DVar, **Basu et al.**, (2009-2019):

- Global optimized flux inversion
- Assimilated against in-situ (IS), GOSAT-ACOS, GOSAT-IS+ACOS XCO₂
- Corresponding optimized NEE fluxes

FLUXCOM (FC, 2009-2019) :

NEE.RS_V006.FP-NONE.MLM-ALL.METE O-NONE.4320_2160.8daily.yyyy

- NEE machine learning in-situ upscaling product

EB bias in co-sampled monthly XCO_2 from satellites OCO2/GOSAT and inversion model CarbonTracker CT2019B

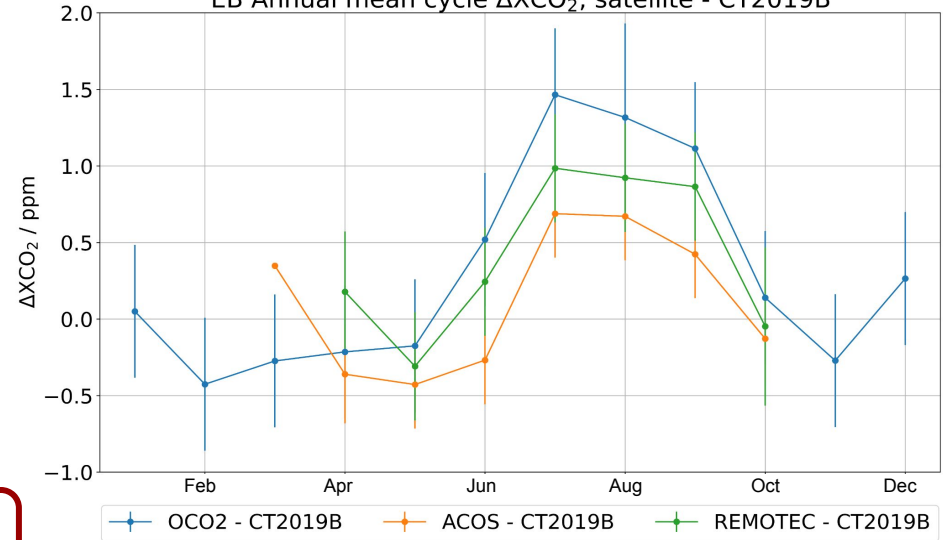


Comparison of XCO_2 from multiple satellite datasets with CT2019B inversion assimilated to in-situ XCO_2

- $\Delta\text{XCO}_2^{\text{sat.-CT2019B}}$ of annual mean cycle between 0.7 and 1.5 ppm in summer
- Errorbars: $\sigma_{\text{month}}/\sqrt{N}$ with N = number of years
- Bias found for ΔXCO_2 from OCO2, GOSAT-ACOS, GOSAT-RemoTeC against cosampled CT2019B, respectively
- Sub-regional spatial sensitivity study revealed robust signal across entire Transcom region Eurasia Boreal (EB)

⇒ XCO_2 from satellite shows higher XCO_2 than in-situ data in summer.

EB Annual mean cycle ΔXCO_2 , satellite - CT2019B



Next: Comparison of satellite XCO_2 and inversion TM5-4DVar. Does ΔXCO_2 behave similarly for different inversion model?

EB bias in co-sampled monthly XCO_2 from GOSAT-ACOS and inversion model TM5-4DVar



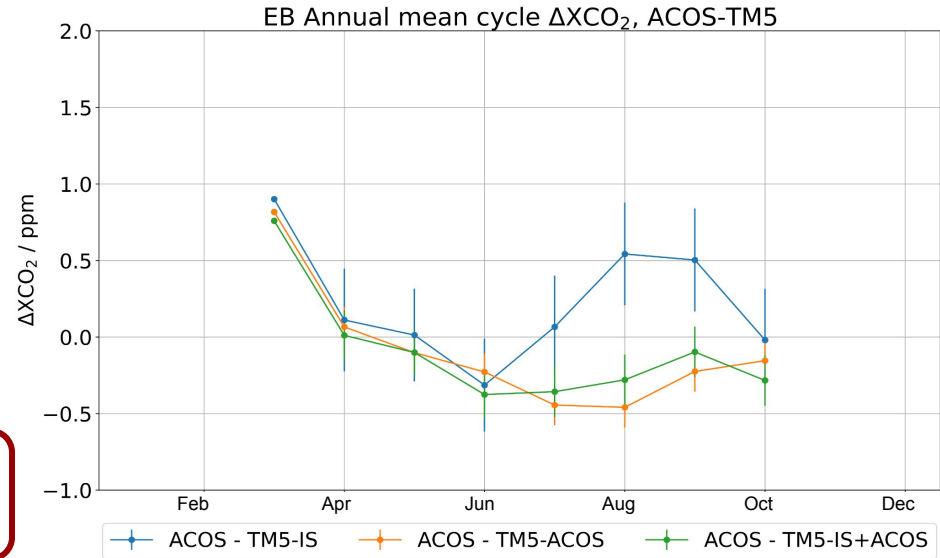
Observed XCO_2 from GOSAT-ACOS compared with XCO_2 from TM5-4DVar assimilated against XCO_2 from in-situ (IS), GOSAT-ACOS or ACOS+IS

- $\Delta\text{XCO}_{2\text{ACOS} - \text{TM5-IS}}$ around 0.5 ppm in summer, similar to comparison against CT2019B (previous slide)
- Opposite sign in summer for

$\Delta\text{XCO}_{2\text{ACOS} - \text{TM5-ACOS}}$ and $\Delta\text{XCO}_{2\text{ACOS} - \text{TM5-IS+ACOS}}$

⇒ Points towards an overestimation of regional XCO_2 dynamics from in-situ data in summer.

Next: TM5-4DVar inversion allows comparison of corresponding assimilated fluxes. How does uncertainty in XCO_2 propagate to uncertainty in NEE?



EB annual mean flux comparison of monthly TM5-4DVar NEE and FLUXCOM NEE



TM5-4DVar NEE top-down estimates:

- **NEE** assimilated to GOSAT ACOS is ~20% lower than **NEE** assimilated to in-situ in summer
⇒ Adds up to **$0.7 \pm 0.3 \text{ PgC yr}^{-1}$**
- **NEE** assimilated to GOSAT ACOS and in-situ is ~15% lower than **NEE** assimilated to in-situ in summer
⇒ Adds up to **$0.4 \pm 0.2 \text{ PgC yr}^{-1}$**

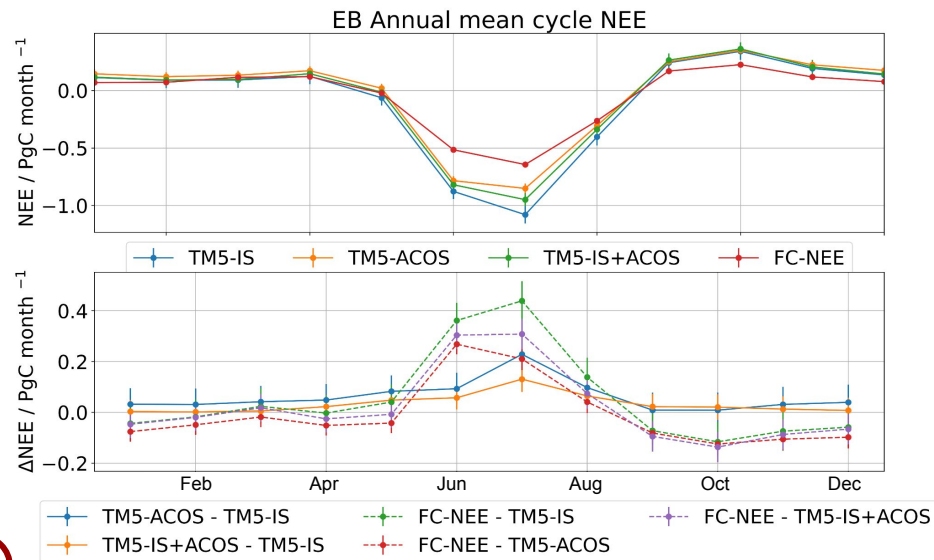
Bottom-up vs top-down:

- **FLUXCOM NEE** is between -30 and -50% lower than NEE estimated by different TM5-4DVar assimilations.

Errorbars: $\sigma_{month} / \sqrt{N}$ with N= number of years

⇒ NEE based on satellite (+in-situ) assimilation reveals a reduced flux strength in summer compared to in-situ assimilated NEE.

⇒ Bottom-up NEE sink in summer as low as 50% of top-down NEE.



Summary



- **Method:** Inversion allows to analyze differences of optimized fluxes corresponding to differences in assimilated atmospheric CO₂ concentration.
- In summer, **in-situ XCO₂ seems to overestimate the regional concentration minimum by 0.5-1.5 ppm** compared to XCO₂ from satellite.
- NEE assimilated to satellite and in-situ CO₂ adds up to ca. **0.4 PgC yr⁻¹ less carbon uptake** compared to NEE assimilated to in-situ CO₂.
- Bottom-up vs. top-down: Bottom-up NEE is up to **ca. 50% lower** than top-down estimates in summer (prelim.).

What next?

- Where do differences in top-down and bottom-up NEE originate from?
- How do underlying processes such as photosynthesis, respiration etc. contribute?
- **Ideas, discussions and questions welcome!**