Combining in-situ and satellite observation of CO_2 in a synthesis inversion framework for the US corn belt

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Overview

Goal: Carbon Monitoring System for the US Corn Belt that integrates bottom-up and top-down approaches to constrain the carbon budget.

The NASA Integrated Carbon Monitoring System for the US Corn Belt

Bottom-Up Estimation

Task 1: Improving cropland inventory using satellite/field-level solar-induced fluorescence (SIF)

Task 2: Spatially explicit parameterization of CLM-APSIM by assimilating multi-source satellite data

Task 4: Integrating bottom-up and top-down approaches for joint constraints and verification

Top-Down Estimation

Task 3: Improving atmospheric inversion through integrating satellite XCO_2 and in-situ measures

Introduction

Agriculture has been central to the Anthropocene, is intricately tied to recent and projected increases in global population, and is fundamentally coupled to the global carbon cycle. Farming activity contributes a substantial portion of the total anthropogenic-greenhouse gas emissions but intensification and advances in technology have also resulted in high levels of crop photosynthesis (GPP). As a result, intensively managed, high-productivity agricultural areas such as the US corn belt exhibit the largest growing season fluxes globally. Increases in crop GPP are also due to CO_2 fertilization. However, higher CO_2 levels and rising temperatures also reduce stomatal conductance, thereby suppressing carbon uptake. Together, these factors complicate our ability to accurately model crop yield responses to climate change and carbon-climate feedbacks. This study aims to use newly available measurements and state of the art modelling techniques to accurately monitor and predict crop yield responses to changing climates.

Atmospheric Inversion

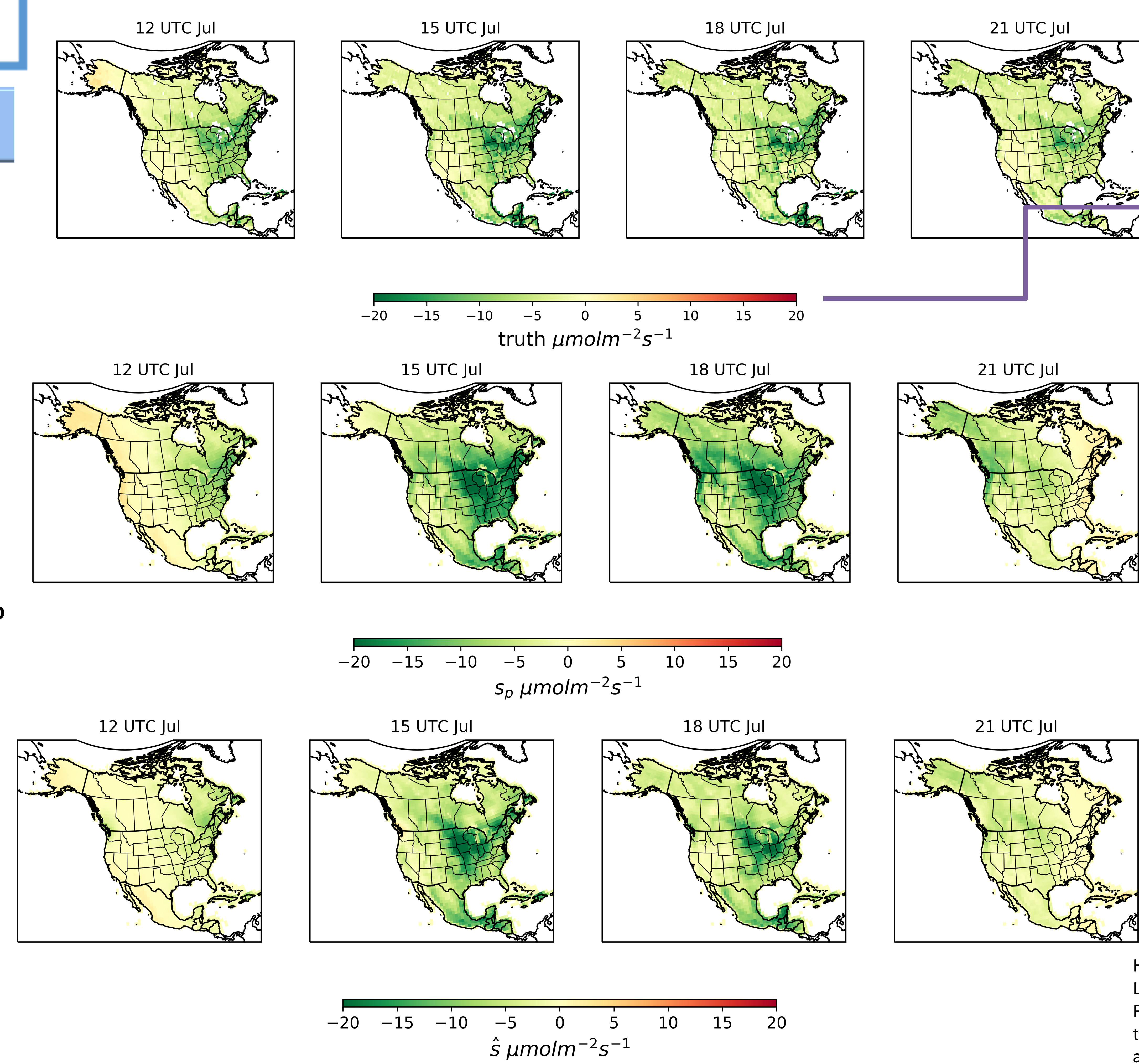
CarbonTracker-Lagrange (Hu et al., in press) is a tool for estimating CO_2 surface fluxes that assimilates observations of CO_2 concentrations in a regional Bayesian Inverse modeling framework. Surface sensitivity footprints are from Lagrangian particle dispersion models (e.g. STILT) driven by a high resolution high-resolution meteorological simulation (e.g. WRF). New developments for this work include: bias correction and incorporation of satellite χCO_2, and incorporation of new crop-specific prior flux estimates.

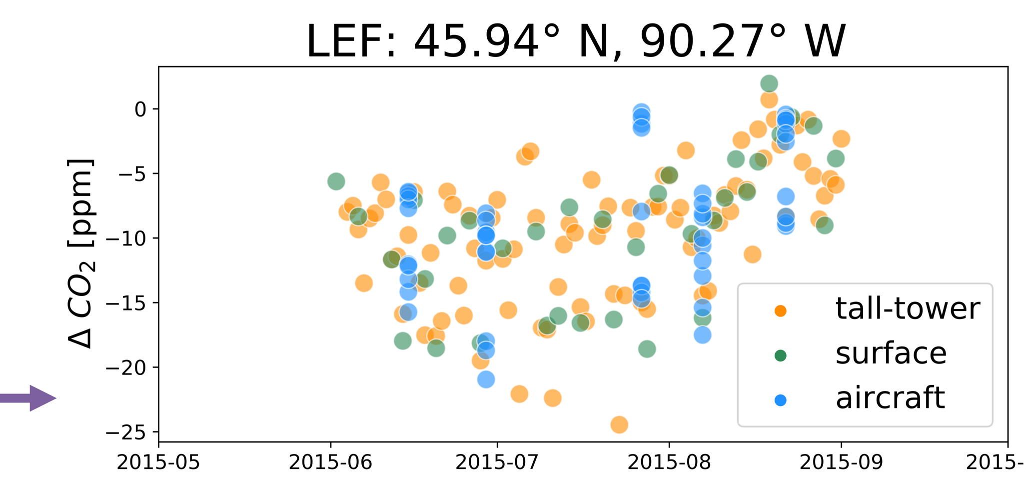
$$\hat{s} = s_p + QH^T(HQH^T + R)^{-1}(z - Hs_p)$$

$\hat{s}$: Optimized CO_2 flux
s_p: Prior flux (mechanistic model)
Q : Prior error covariance matrix
H: Transport model [ppm/μ mol m^{-2} s^{-1}]
R: Covariance matrix for model-data mismatch
z: observations `

Synthetic data study: Summer 2015

OSSEs are an important tool for model testing. Here, we use a known flux ('truth') to simulate CO_2 concentrations, which are assimilated in the inversion. Preliminary results with *in situ* data are shown below; as a next step we will include satellite χCO_2





Next steps

Model testing

- Compare multiplicative and additive scaling factors
- Continue OSSE (synthetic data studies) using different prior and 'true' fluxes
- Real data inversions

Incorporate Satellite data (GOSAT and OCO2)

- Forward comparisons of CT-Lagrange and satellite retrievals
- Test bias correction methods for satellite retrievals OSSE
- Assimilate satellite data in real data inversions

Incorporate UIUC- based priors

- MODIS LAI, SMAP, CERES and SIF based inventory data
- Crop specific parametrization of the Community Land Model (CLM-APSIM)

Refs. and Acknowledgements

Hu et al., North American terrestrial CO_2 fluxes between 2007 and 2015 derived from CarbonTracker-Lagrange

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