A prototype for monitoring carbon flux anomalies in near real time using NASA's GEOS system: progress and challenges

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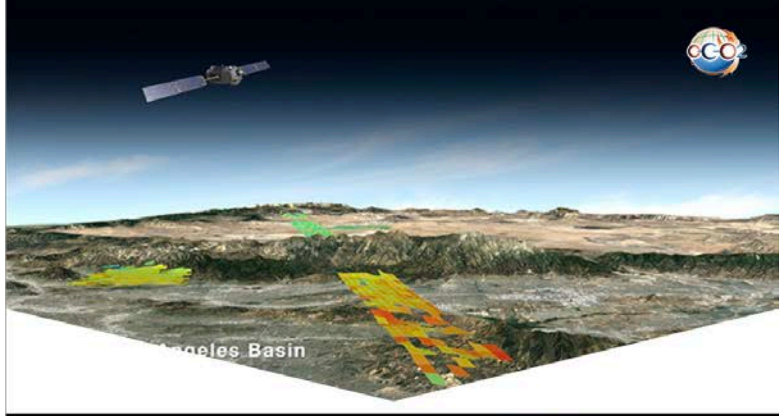
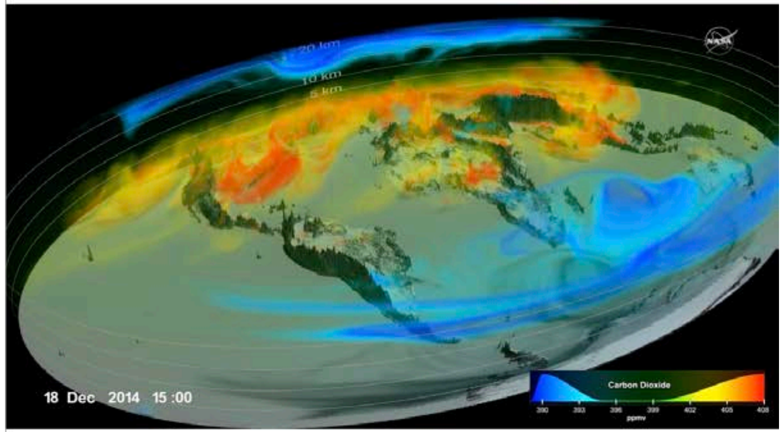
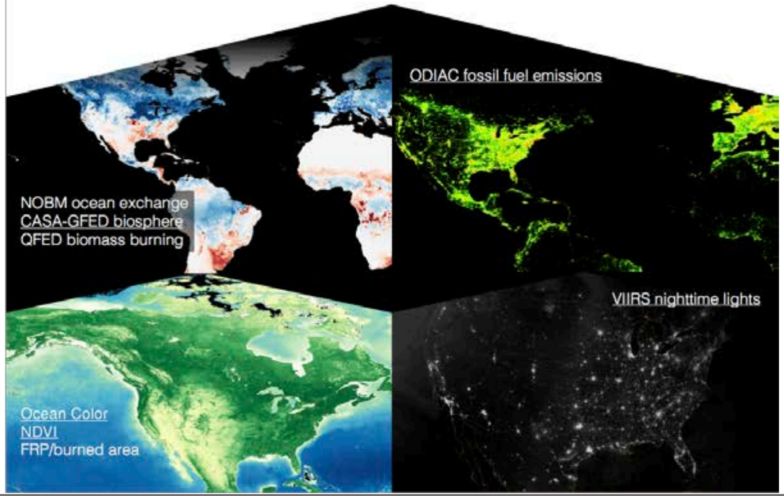






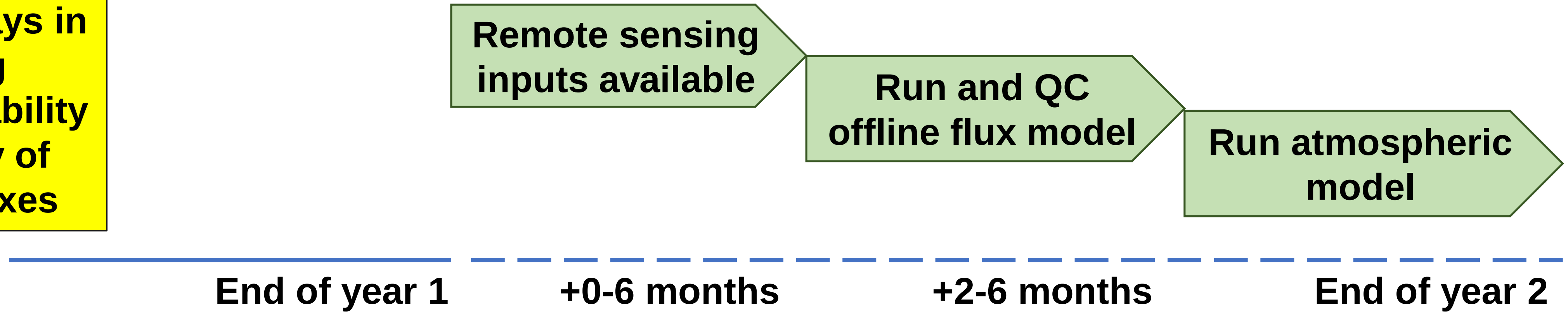
GEOS CMS System Overview

- Satellite observations provide important constraints on carbon flux estimates
- Ocean color and NDVI information inform model-based estimates of ocean (NOBM) and land productivity (CASA-GFED) while observations of fire radiative power, burned area, and nighttime lights support high-resolution fire (GFED, QFED) and fossil fuel (VIIRS) emission inventories
- Flux estimates also incorporate weather information from MERRA-2 to provide a physically consistent flux dataset
- Bottom-up fluxes are transported using NASA's GEOS AGCM, providing high quality, high-resolution simulations of CO_2 and CO
- By assimilating atmospheric CO_2 from OCO-2 and GOSAT, the GEOS-based system also provides atmospheric carbon reanalyses and insights needed to refine flux estimates

Limitations for near-real-time atmospheric monitoring

1. Availability of observationally constrained flux data

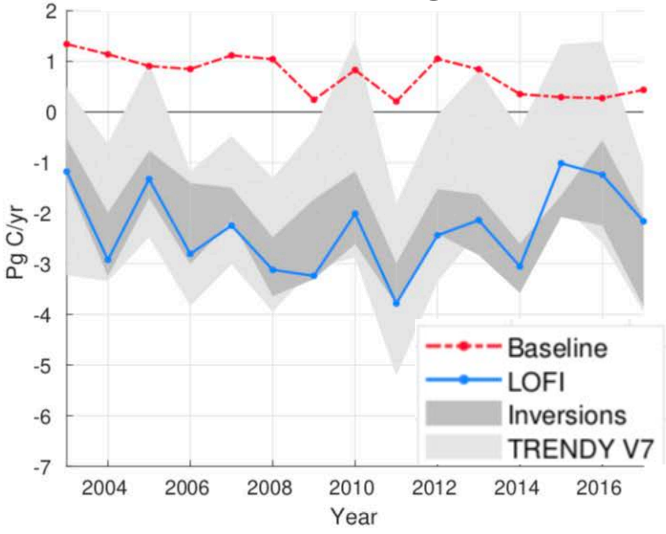
Significant delays in processing decrease availability and reliability of bottom-up fluxes



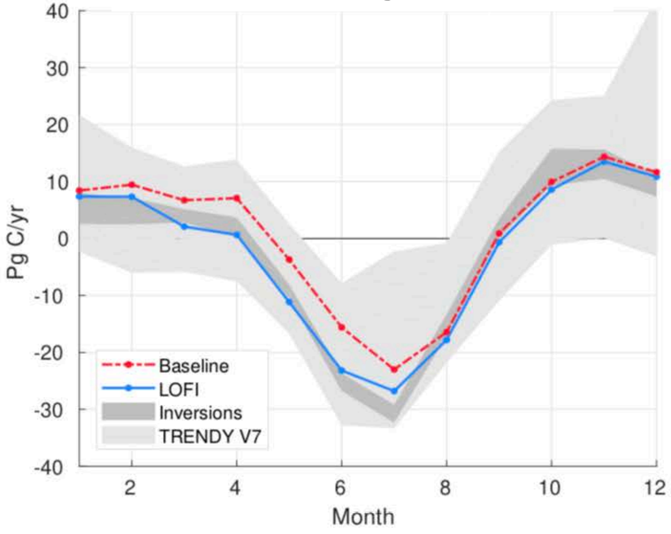
2. Availability of CO_2 observations

1) Improving near-real-time flux estimates

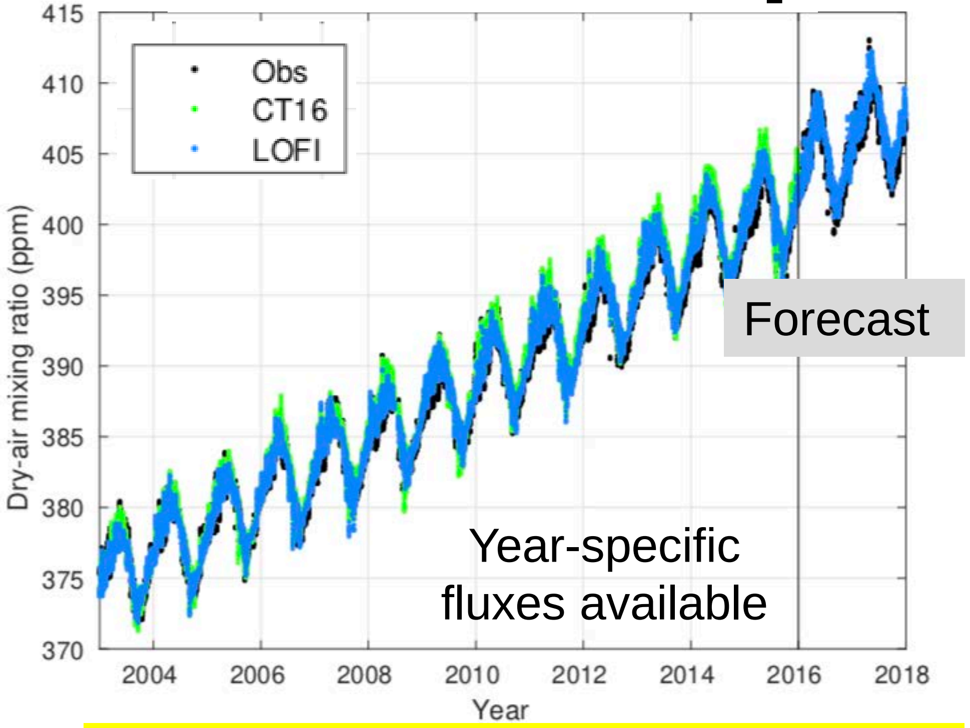
Annual average NBE



Seasonal cycle NBE



Mauna Loa Simulated CO_2



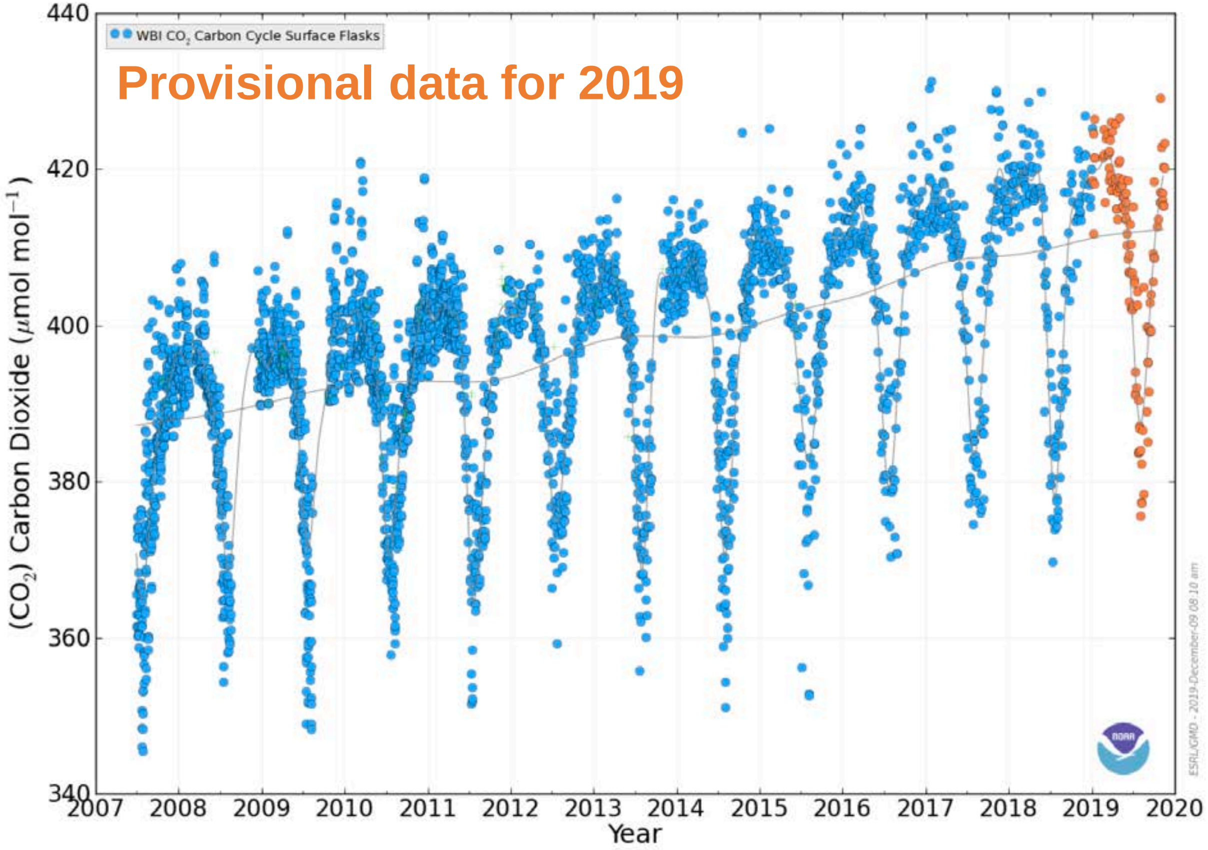
- LoFi flux package uses GEOS CMS bottom up fluxes and adds a land sink constrained by atmospheric growth rate (above)
- When year-specific flux and atmospheric data are not yet available:
  - Climatological spatial distribution is used
  - Flux trends extrapolated
  - Sink magnitude incorporates seasonal forecast of growth rate

Forecast fluxes succeed in reproducing background atmospheric mixing ratios providing support for assimilation of atmospheric obs.

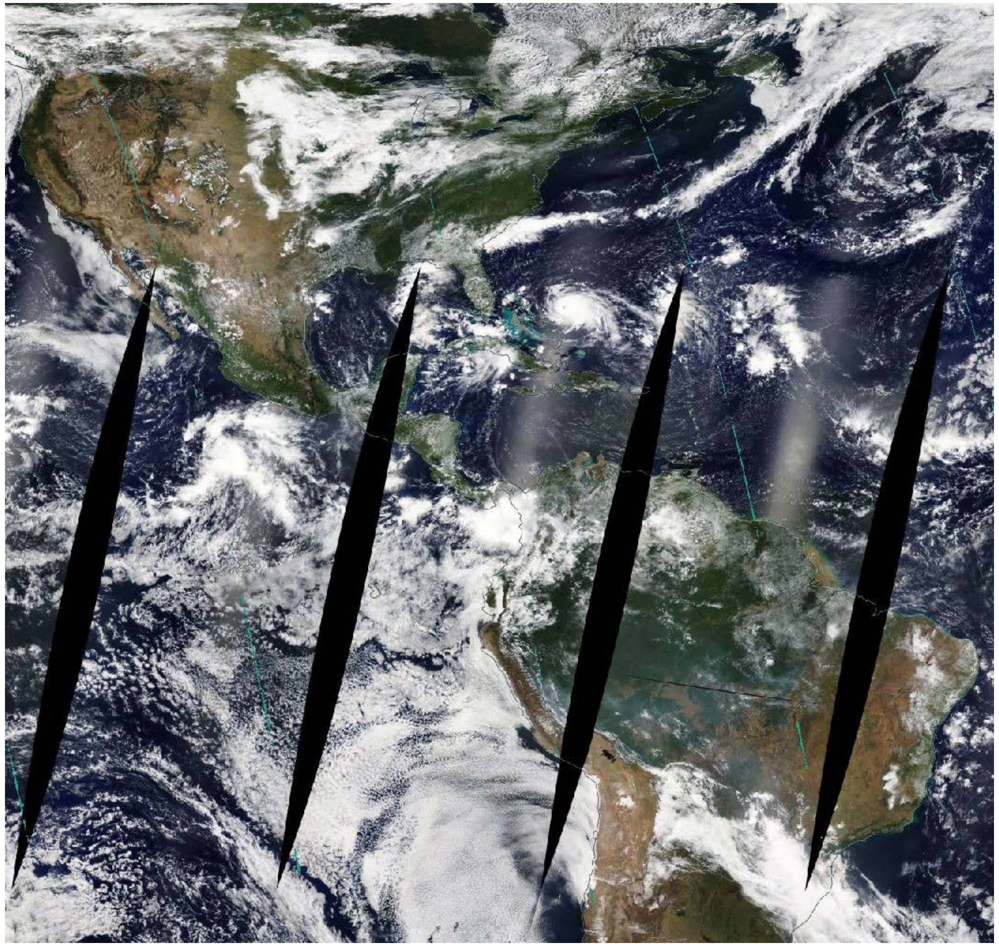
Weir et al., 2019 in prep. for ERL

2) Availability of CO_2 data improving, but latency of 1-3 months remains

NOAA NRT Obspack – West Branch Iowa



NASA OCO-2 Data – 20190831



https://www.esrl.noaa.gov/gmd/dv/iadv/

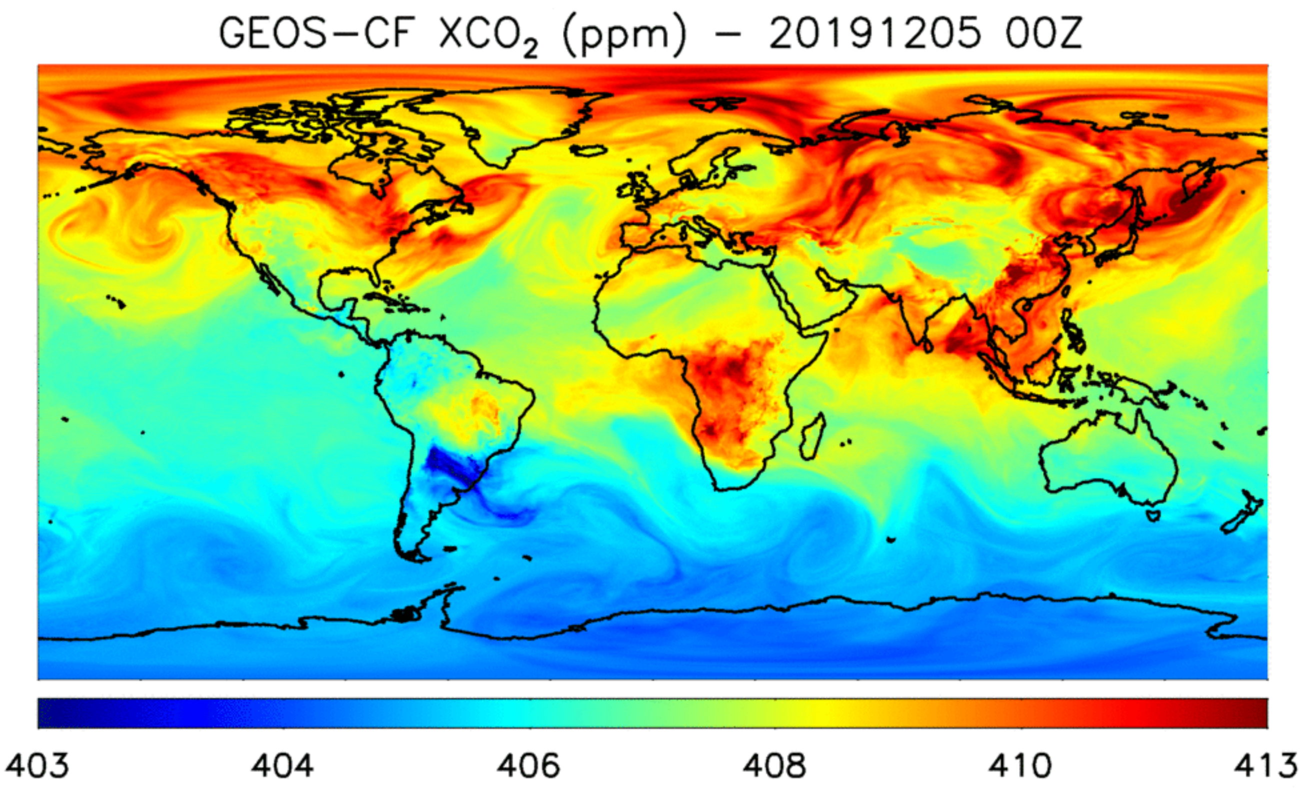
https://worldview.earthdata.nasa.gov/

Ability to simulate and forecast carbon weather in NRT

- GEOS Composition Forecast (GEOS-CF) system produces global, 3D distributions of atmospheric composition and 5-day forecasts

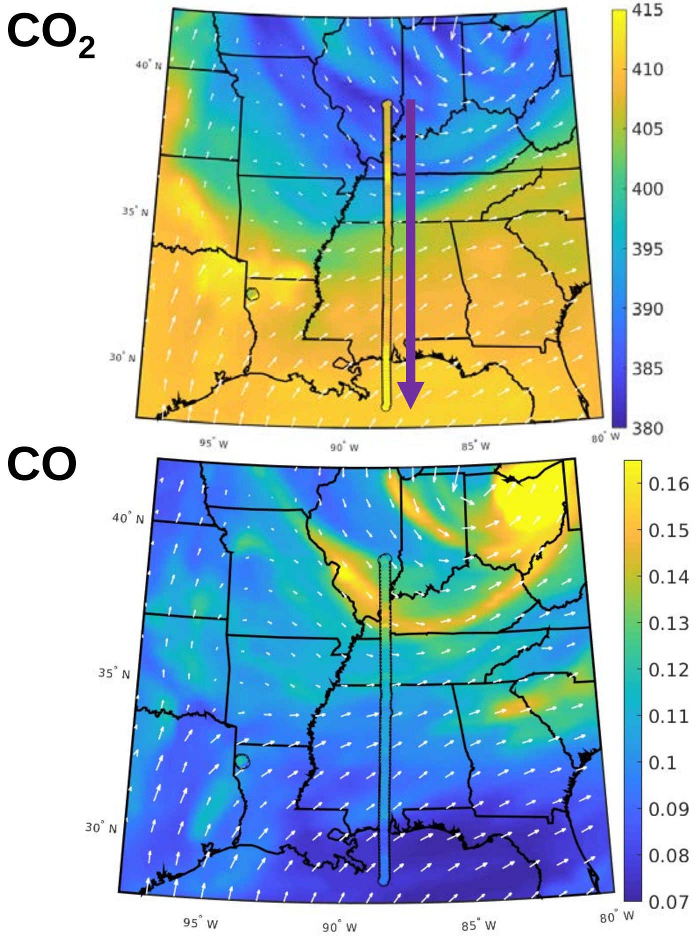
- CO_2 fluxes incorporate NRT biomass burning using MODIS fire radiative power + LoFi ocean, land, and fossil fuel

- GEOS-CF also provides estimates of species like CO and NO_2 that provide additional information that may be used for source attribution

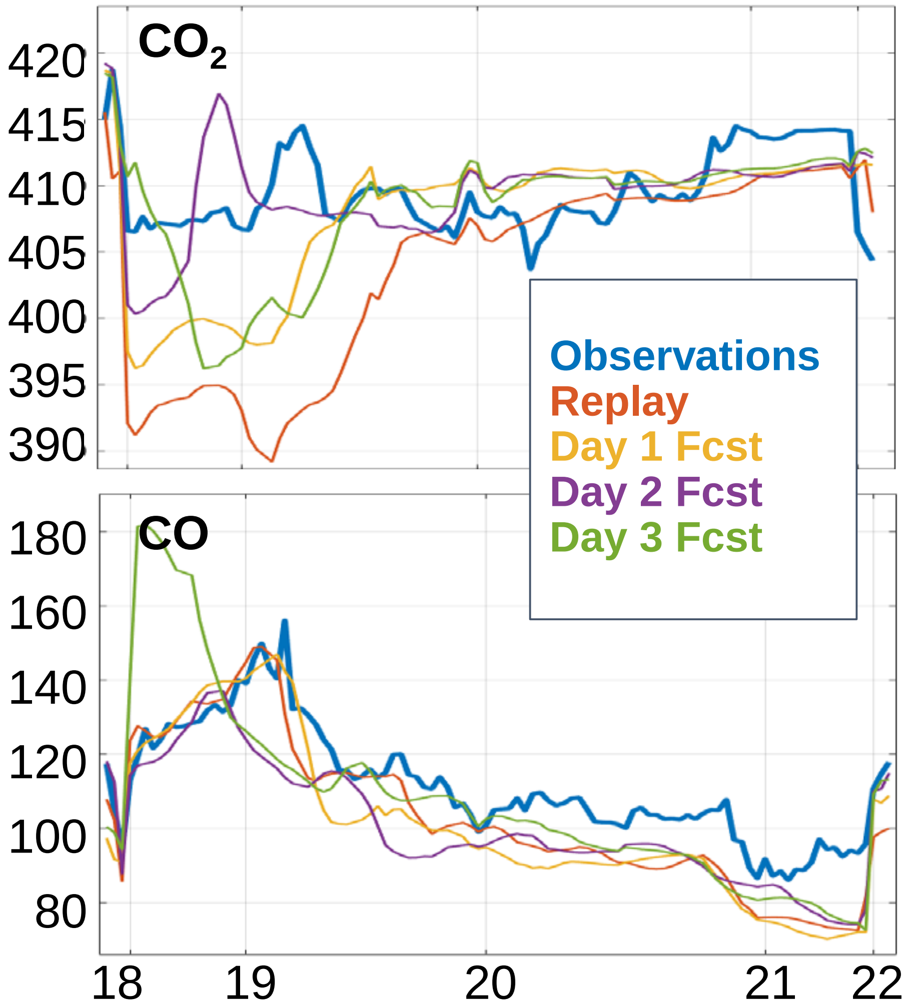


Case study: GEOS-CF forecasts in support of ACT-America

6/20/19
GEOS-CF Replay at 500 m vs. Boundary Layer Aircraft Data



GEOS-CF Replay and Forecasts vs. Obs.

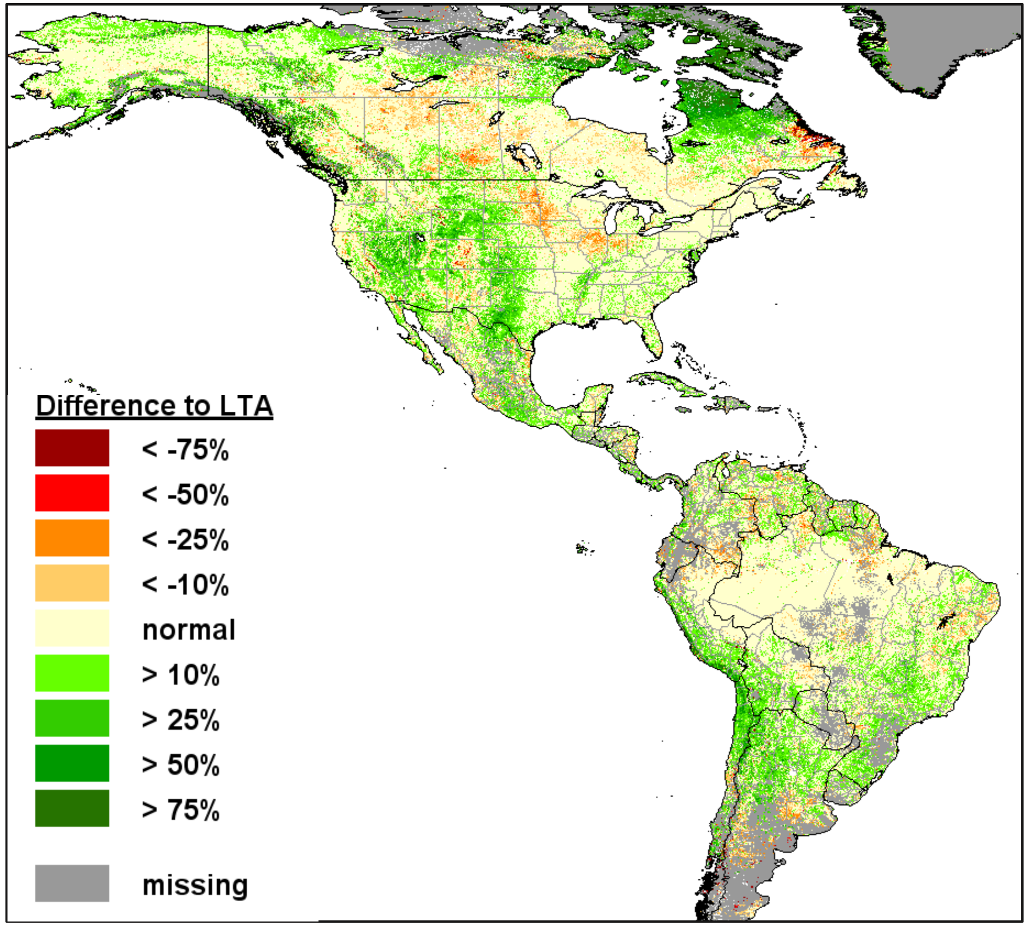


- Two day forecasts tend to predict frontal structures and gradients well (see CO)
- Lack of dynamic emissions can hurt skill for CO_2 but mismatch provides valuable information into flux processes

A53I-07 - Nikolay Balashov

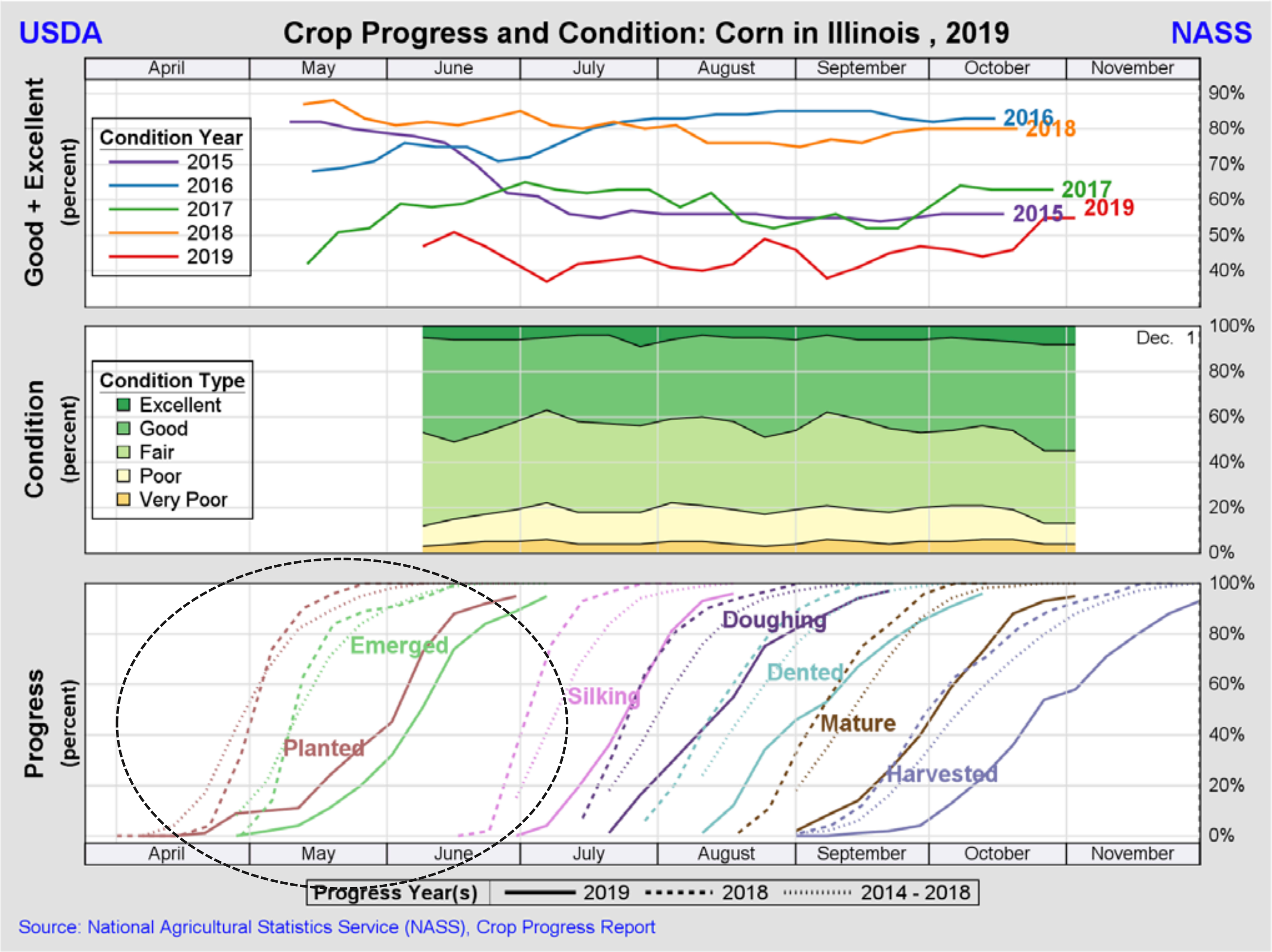
2019 Agricultural anomalies after record floods

201906 NDVI Anomaly



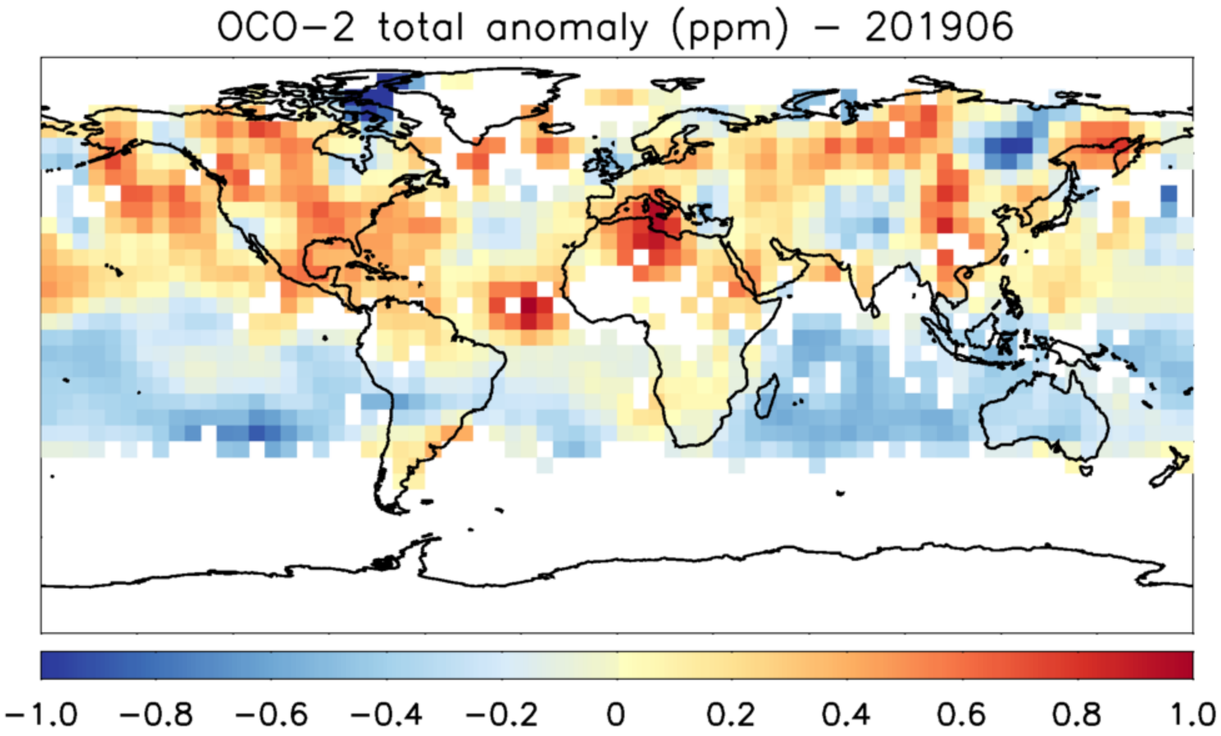
http://www.fao.org/

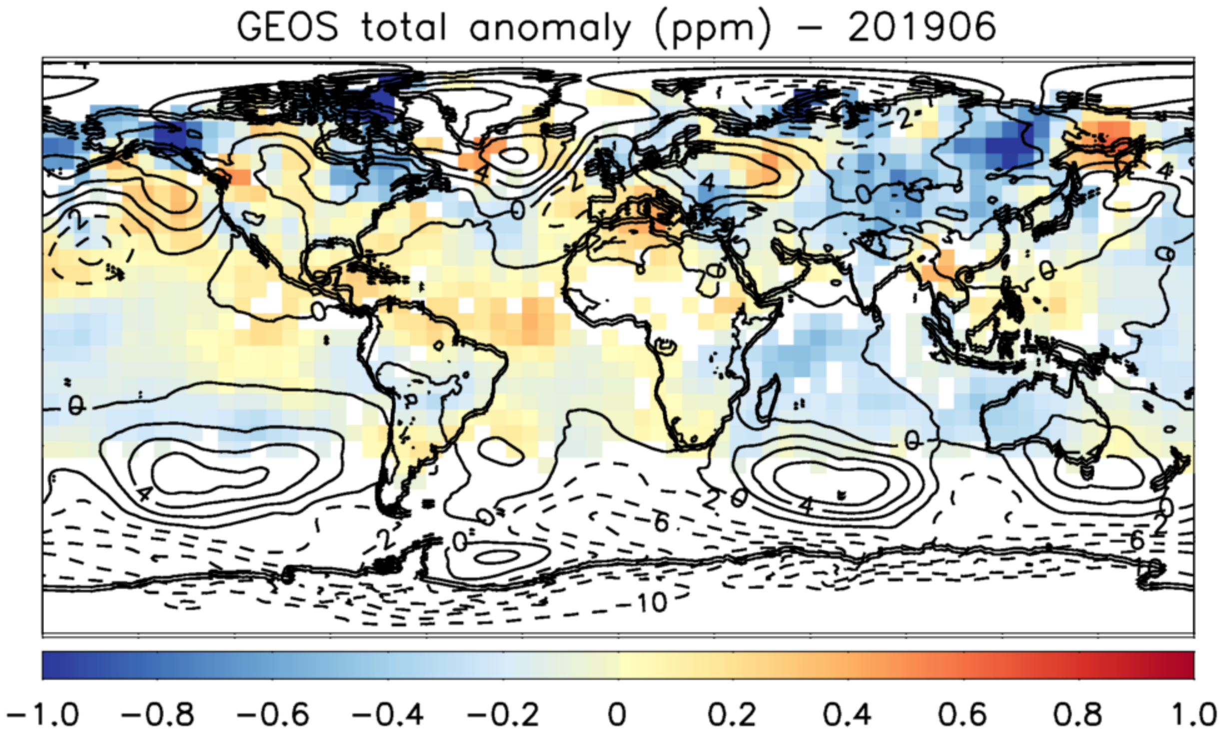
USDA Illinois Corn Progress



https://www.nass.usda.gov/

Disentangling flux and weather influences

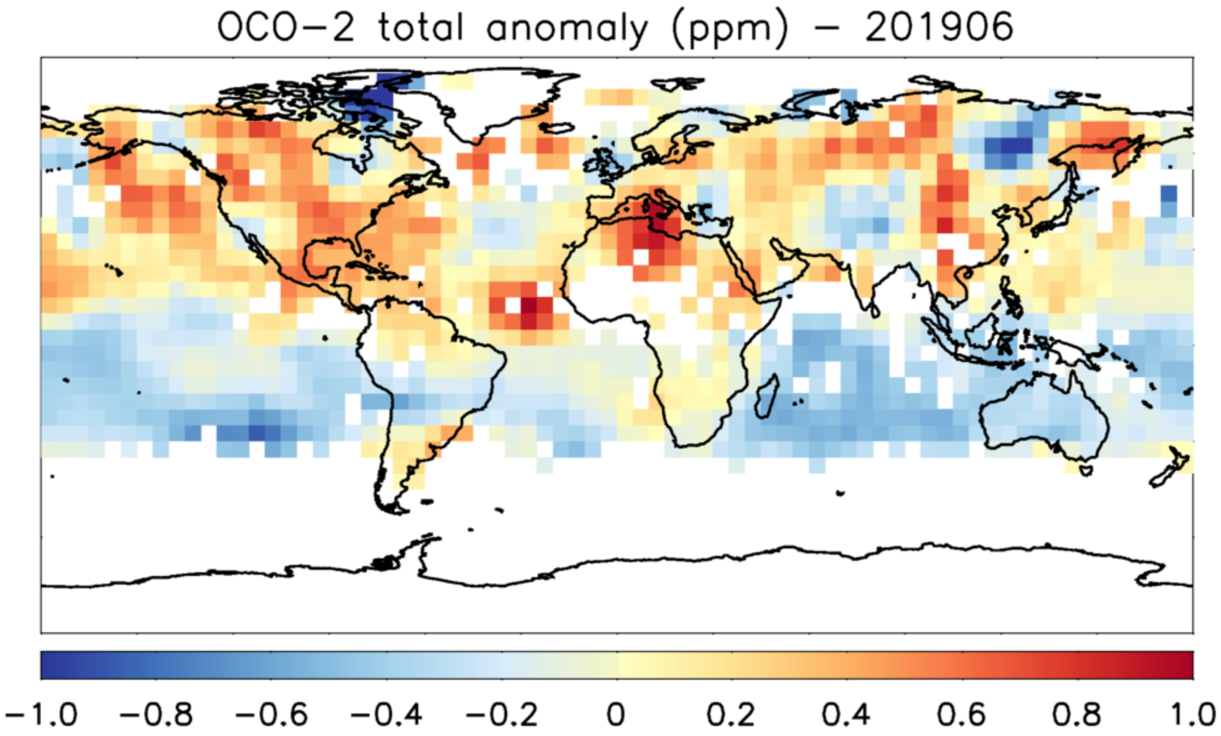


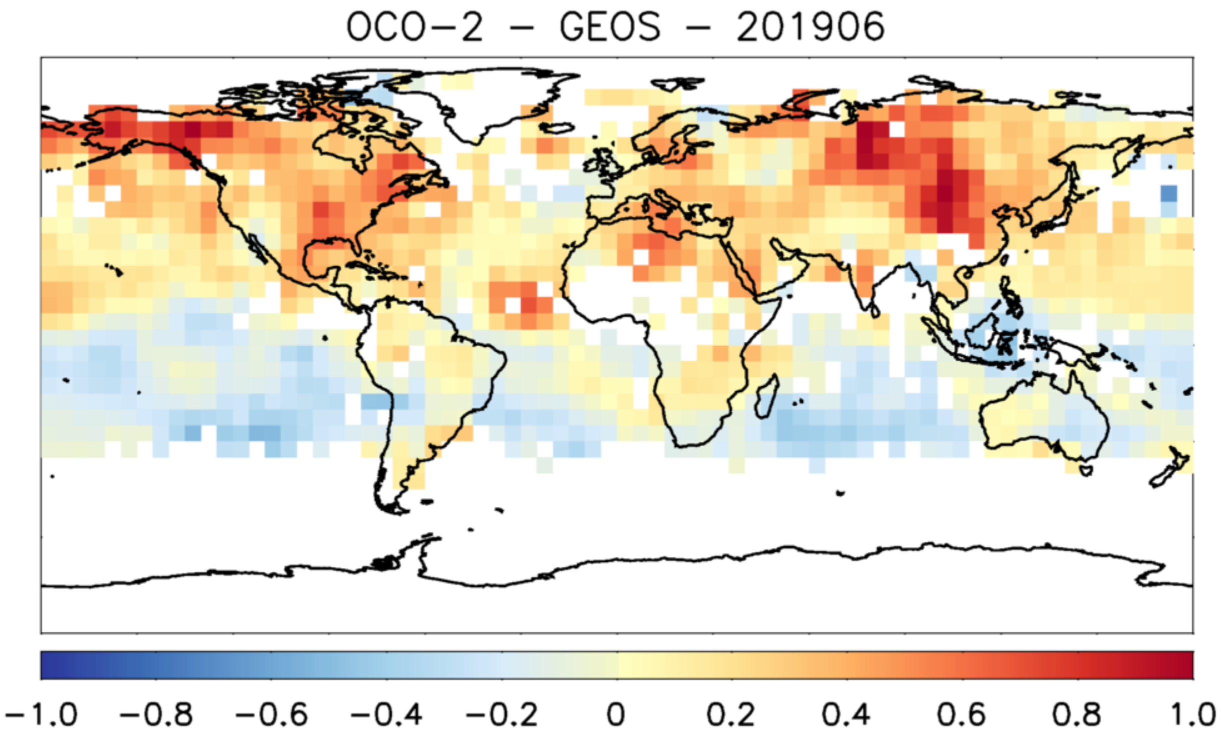


OCO-2 XCO_2 anomaly from 201906 shows the collective influence of weather and flux changes

Anomaly from GEOS run with LoFi fluxes represents weather changes + a small contribution from fires

Disentangling flux and weather influences





Difference in anomalies highlights the role of flux anomalies over US., Europe

Summary and future directions

- Data-driven modeling tools supported by CMS provide the capability to improve understanding of carbon flux changes as they happen
  - Response to 2019 midwestern floods provides an example where an agricultural anomaly can be rapidly identified and analyzed
- Remaining challenges:
  - Availability of CO_2 data limits ability to estimate concentrations, fluxes with less than 2-3 month latency
  - Progress in bottom-up modeling tools can help bridge the gap, but work needs to be done to incorporate NRT information
- CMS has a valuable role to play in understanding user needs - who needs low latency concentration and flux data and what are their requirements?