

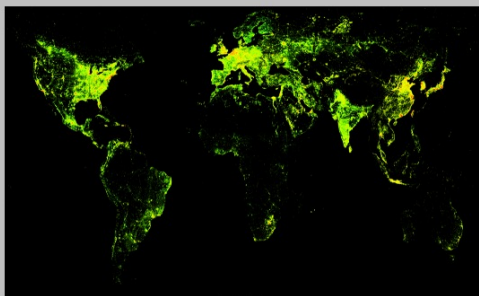


Update on GSFC modeling, information systems, and observations

**Presented by Lesley Ott
Global Modeling and Assimilation Office
NASA Goddard Space Flight Center**

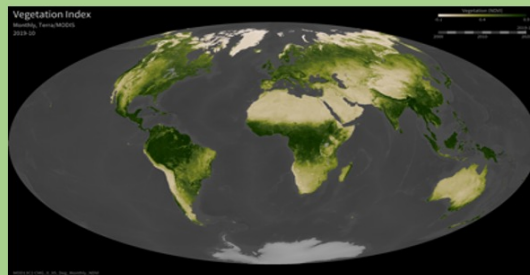
Observationally informed flux estimates

Fossil Fuel Emissions



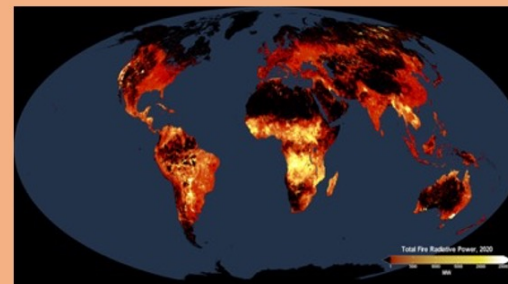
- Provided by the Open-source Data Inventory for Anthropogenic CO₂
- National emissions are redistributed using powerplant database, **nighttime lights observations**
- <http://odiac.org>

Terrestrial Carbon Flux



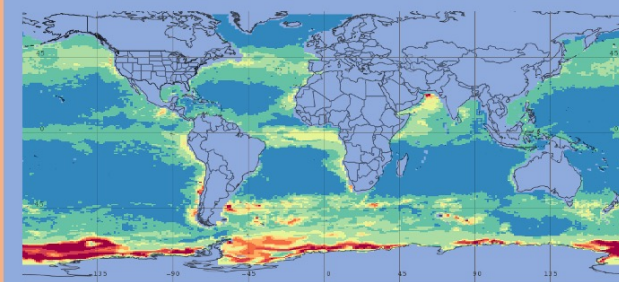
- Provided by the CASA-GFED3 vegetation model
- Driven by MODIS, AVHRR observations of **vegetation greenness, burned area**
- Data available from NASA GES-DISC

Fire Emissions



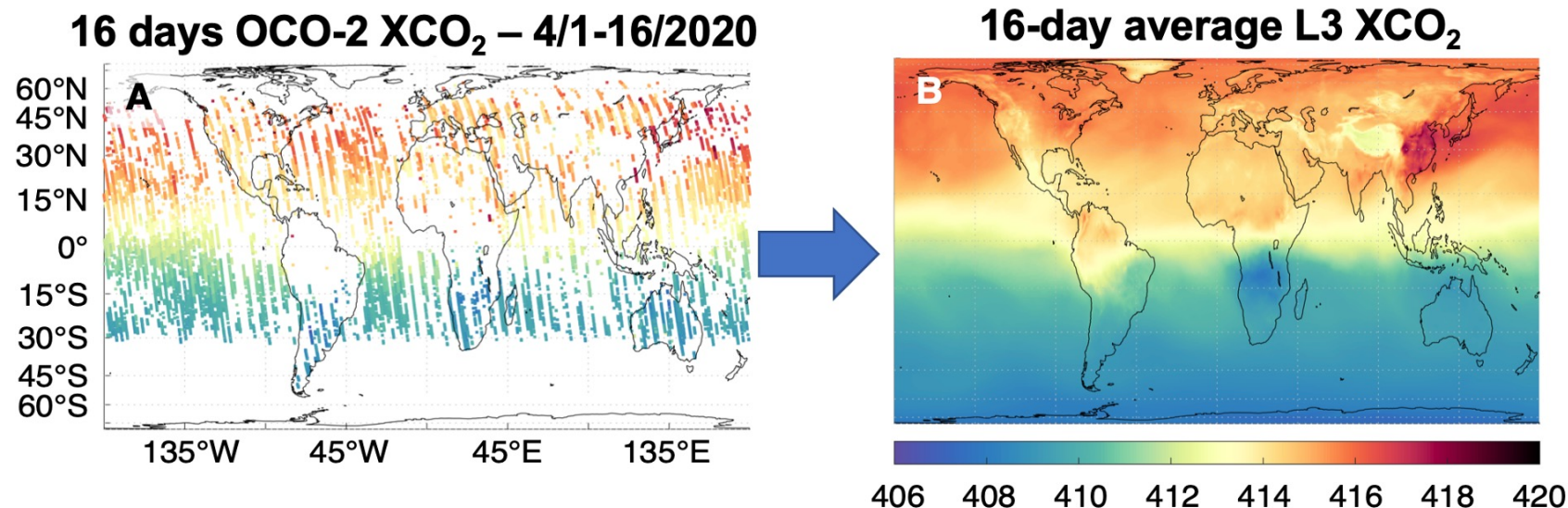
- Provided by the Quick Fire Emissions Dataset (QFED)
- Driven by MODIS **fire radiative power**, calibrated against GFED
- Data available from NASA GMAO

Ocean Carbon Flux



- Provided by the NASA Ocean Biogeochemical Model (NOBM)
- Driven by assimilation of ocean color data, MERRA-2 forcing
- Data available from GES DISC, Giovanni

Atmospheric concentration analysis provides high quality L3 data



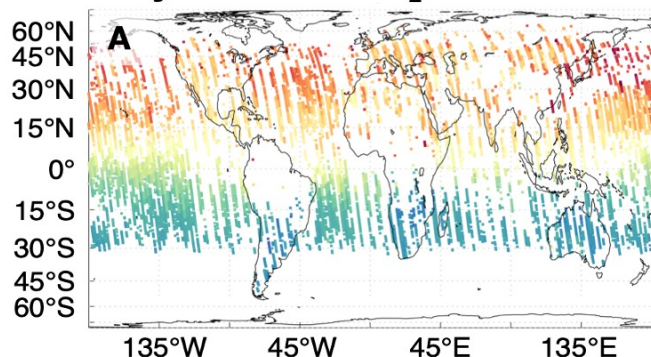
- NASA's OCO-2 satellite, launched in 2014, measures the column-averaged dry air mole fraction of CO₂ (XCO₂) in sunlit, clear sky conditions.
- Bias-corrected OCO-2 retrievals are assimilated into the GEOS Constituent Data Assimilation System (CoDAS) to produce gap-filled 3-dimensional CO₂ fields.
- When OCO-2 data are unavailable, gaps are filled using:
 - All previous good quality OCO-2 retrievals
 - MERRA-2 wind and atmospheric transport fields (~6M per 6-hr period)
 - Observationally-informed flux package (e.g. night lights, NDVI, FRP, surface growth rate)

Currently supports the OCO Science Team and beyond as a an L3 product

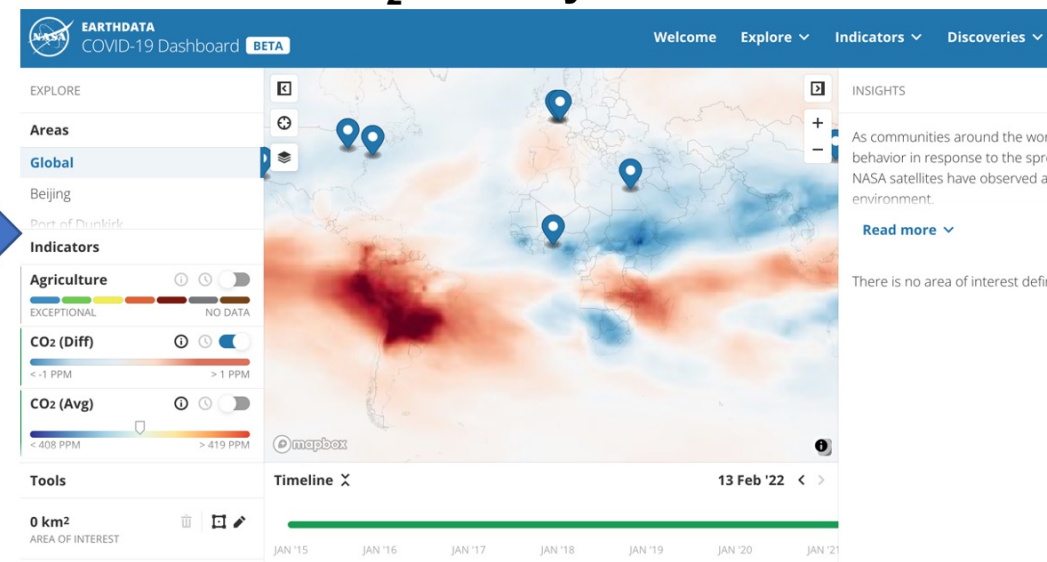
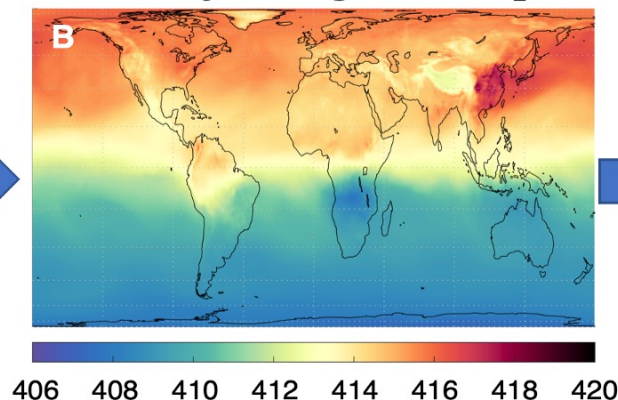
Atmospheric concentration analysis provides high quality L3 data

XCO₂ anomaly estimate

16 days OCO-2 XCO₂ – 4/1-16/2020



16-day average L3 XCO₂



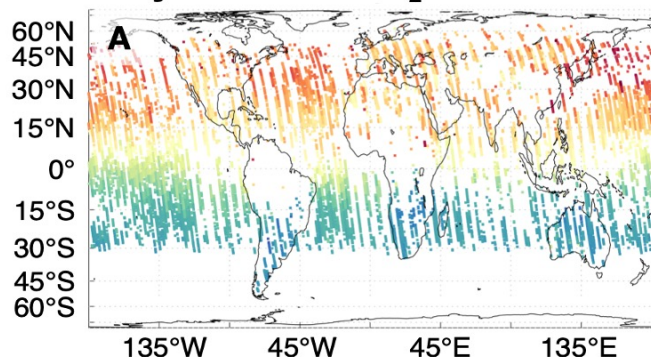
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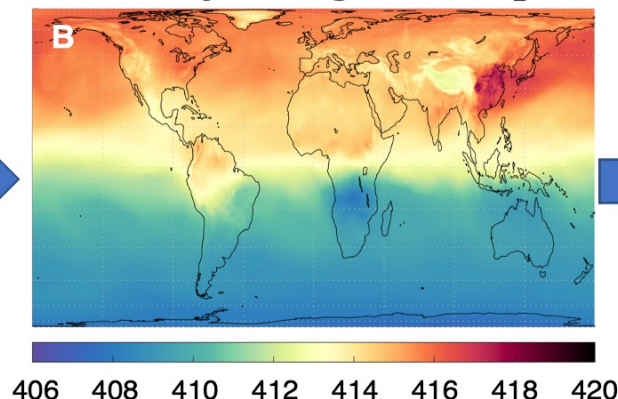
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XCO₂ anomaly estimate

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16-day average L3 XCO₂

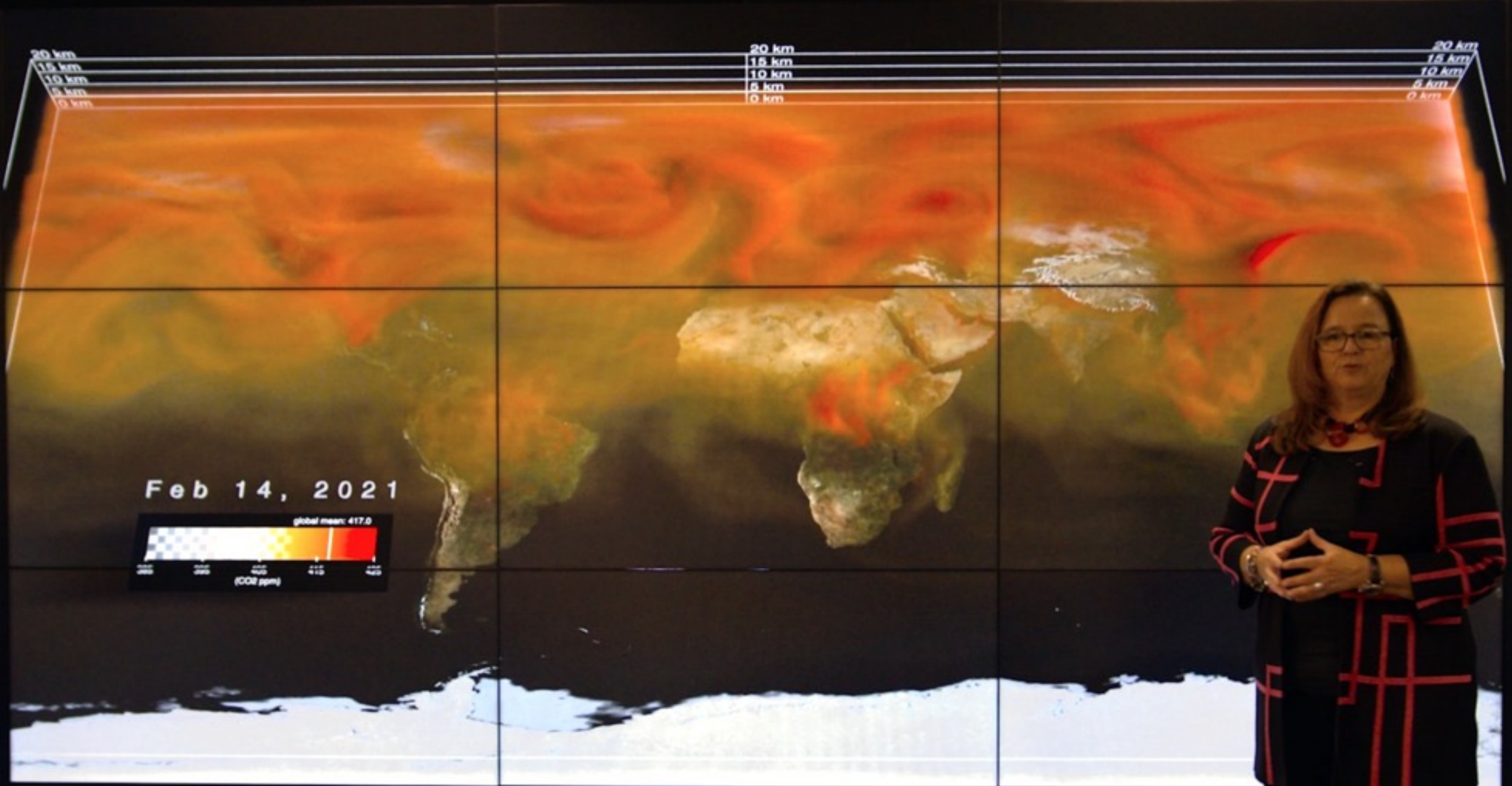


Current status of OCO2-GEOS L3 data:

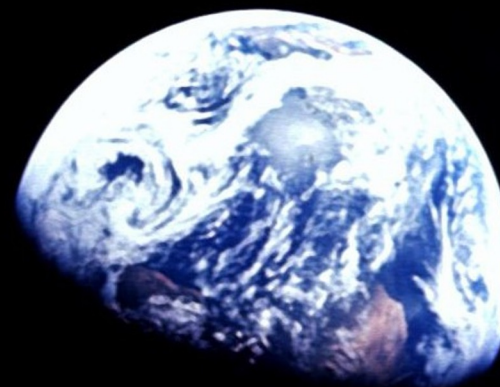
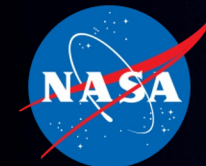
- Typically runs ~1 month behind release of L2 lite files... Except when the retrieval version changes
- Working on v11 reprocessing now
- We process this in parallel streams, which means we can produce L3 data with the current record
- But because anomaly calculations require the full 2017-2019 based period, will have to wait until those L2 data become available.

Other updates:

- New version of CASA-GFED3 coming, including capability to run with MODIS drivers - early next year
- TROPOMI state estimation approach in development, see Nikolay Balashov's poster at AGU
- Publicly available CO₂ (and maybe CH₄) forecasts coming this spring from GEOS-CF



Check out a moving version at: <https://svs.gsfc.nasa.gov/4983>,
Karen's presentation at COP26: <https://svs.gsfc.nasa.gov/31168>



Earth Information System - GHG

Lesley Ott (GSFC)
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Mark Carroll (GSFC)
Edil Sepulveda (GSFC/CMS)
George Hurtt (UMD/CMS)
Tom Oda (USRA)

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Anthony Bloom (JPL)
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David Schimel (JPL)
Abhishek Chatterjee (JPL)
Kazayuki Miyazaki (JPL)
Daniel Jacob (Harvard)
Matt Johnson (ARC)

Earth Information System (EIS)

EIS integrates NASA's Earth Science observations and modeling capabilities to produce new science and support decision making. EIS currently comprises four multi-disciplinary topic areas:



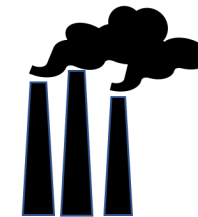
Fire



Freshwater



Sea Level Rise



Greenhouse Gases

Goals:

- Address complex Earth Science Decadal Survey questions using state-of-the-science models and observations from NASA and partners
- Demonstrate innovative and integrative science and applications enabled through ESDS unified cloud infrastructure and collaborative environment
- Deliver timely and accurate actionable information through early and consistent stakeholder engagement and co-production
- Improve transparency and accessibility of data and methods in support of NASA's Transition to Open Science

NASA Uploads Data to the Cloud

- ✓ **Selects** the most useful datasets
- ✓ **Transforms** the data into cloud-ready formats
- ✓ **Uploads** the data to the cloud

Cloud Storage

Datasets are in the same place, the same format, and are ready to use.

Data Visualization and Analysis Tools

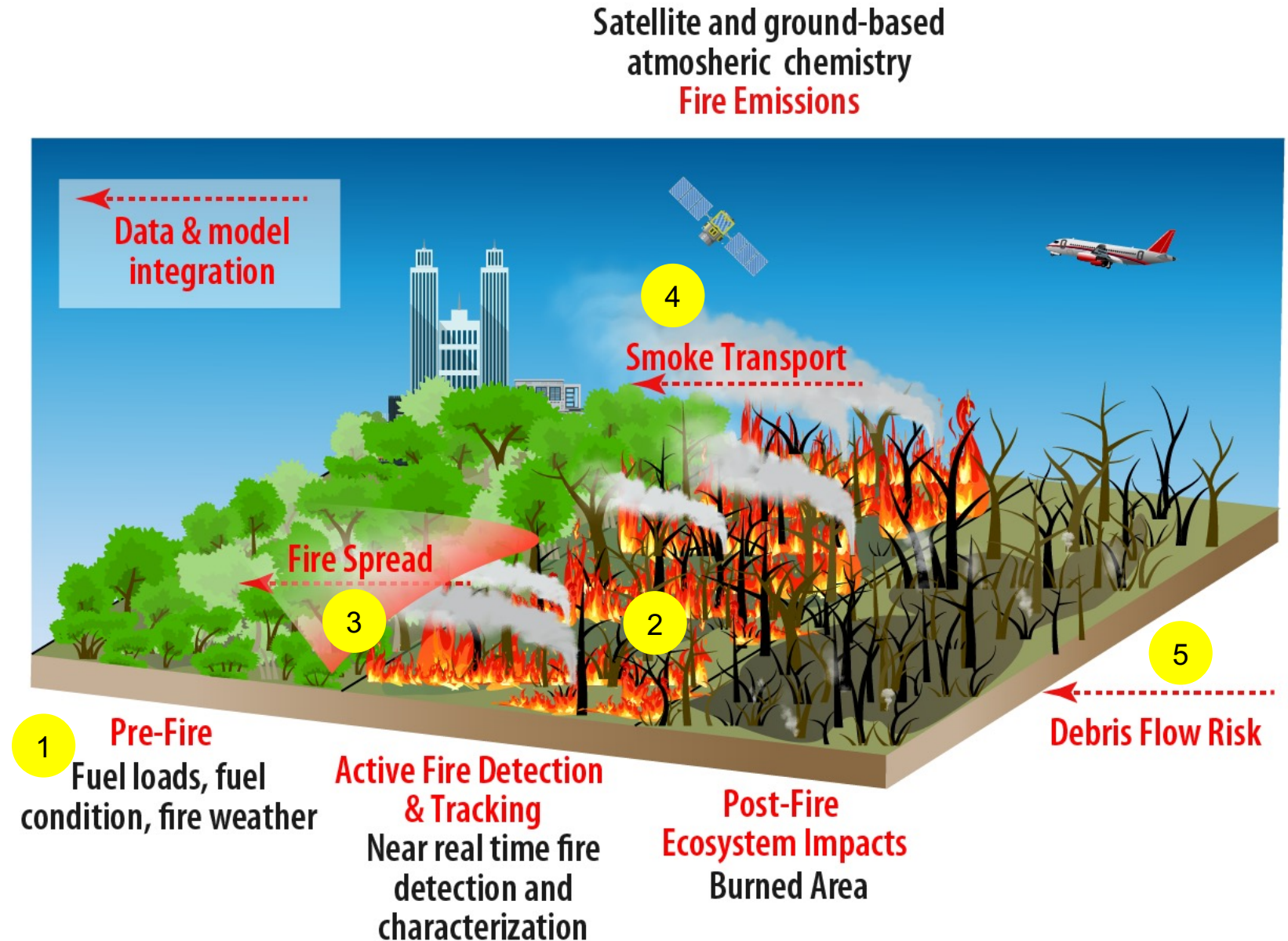
- Tools for analyzing data in GIS
- Visualize and explore data in a web browser
- Develop custom tools for using data

Multi-Mission Algorithm and Analysis Platform (MAAP)

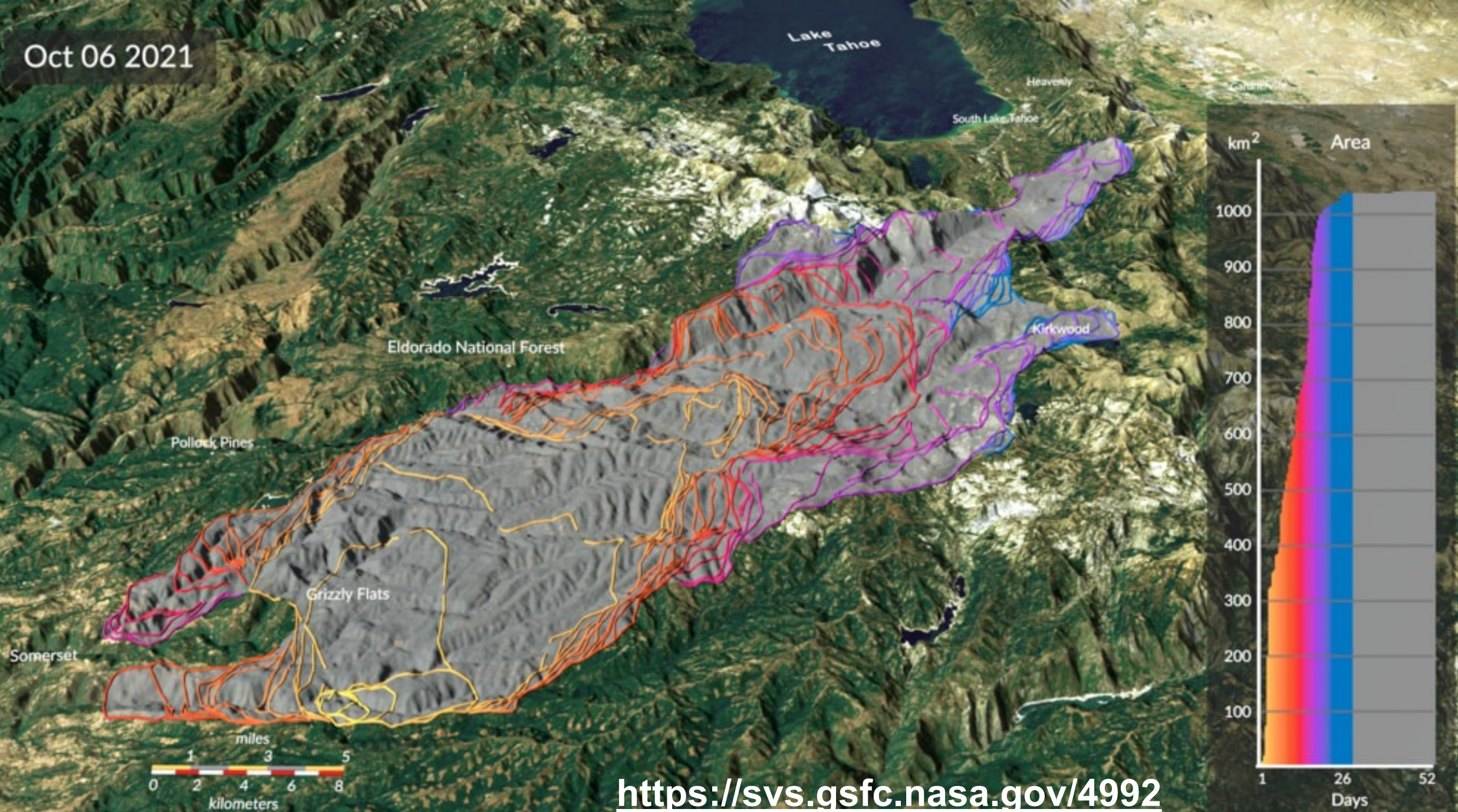
Collaborative cloud environment for data processing, data analysis, and scientific software development

Partners/Stakeholders

1. Risk modeling: GISS, GMAO, EIS-Freshwater, USFS, NOAA, SJSU
2. Real-time Fire Event Tracking: GSFC, UC-Irvine, DOE, USFS
3. Fire spread Forecasts: GSFC, UC-Irvine, NCAR, NOAA, USFS
4. Fire Emissions: GMAO, LARC, NOAA, WashU, SC-AQMD, EIS-GHG
5. Post-fire Debris Flows: GSFC, USGS, EIS-Freshwater



Oct 06 2021

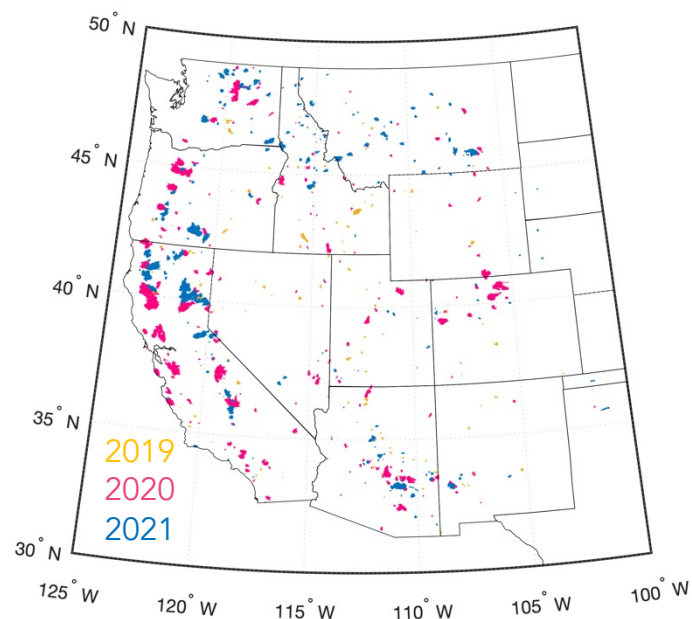


Western US Fire Diurnal Cycles Derived from GOES FRP



Diurnal Cycles Computed for:

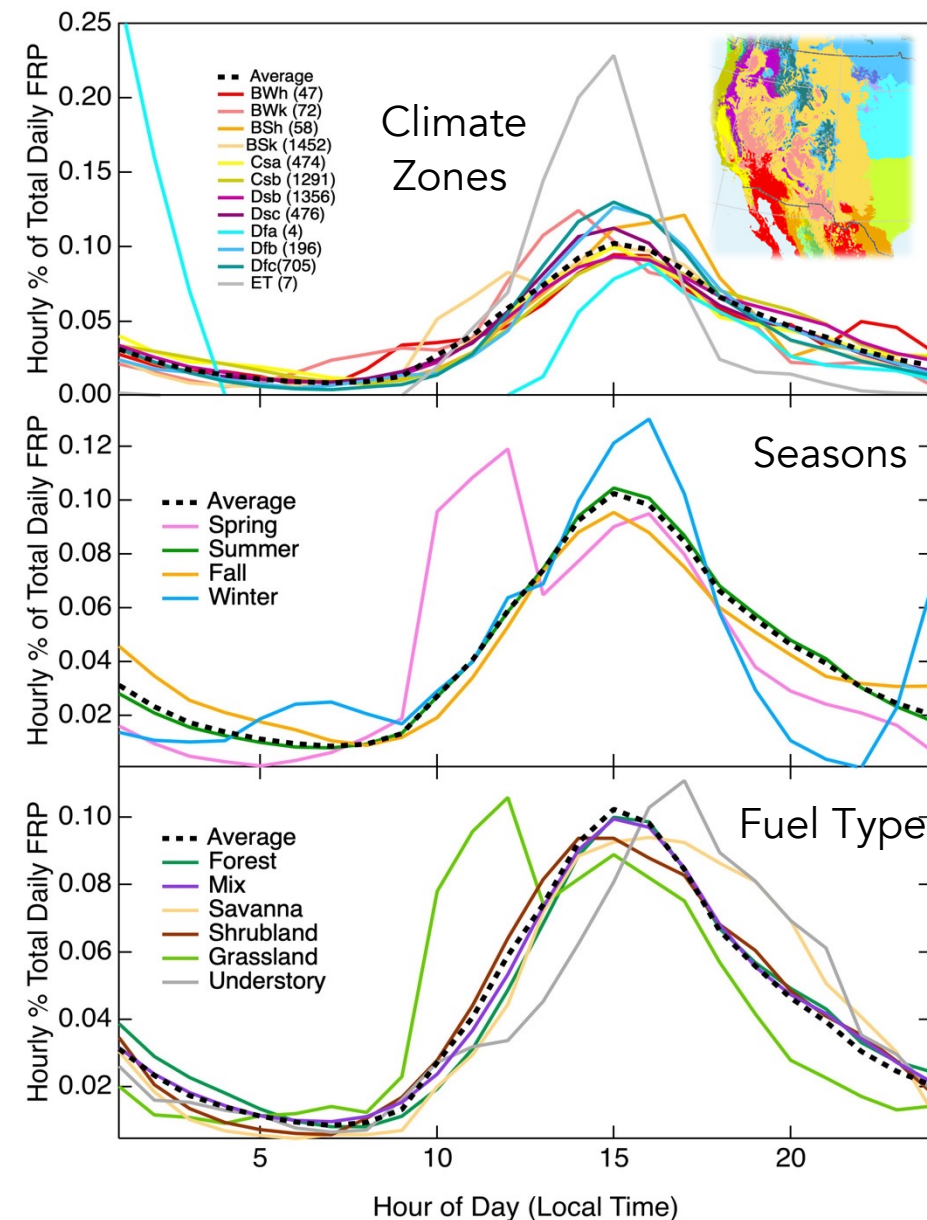
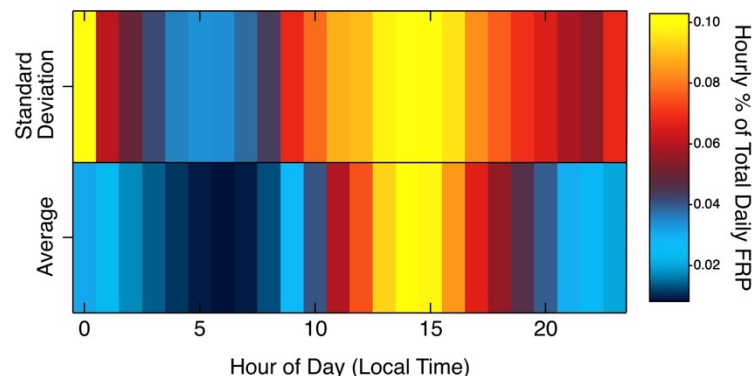
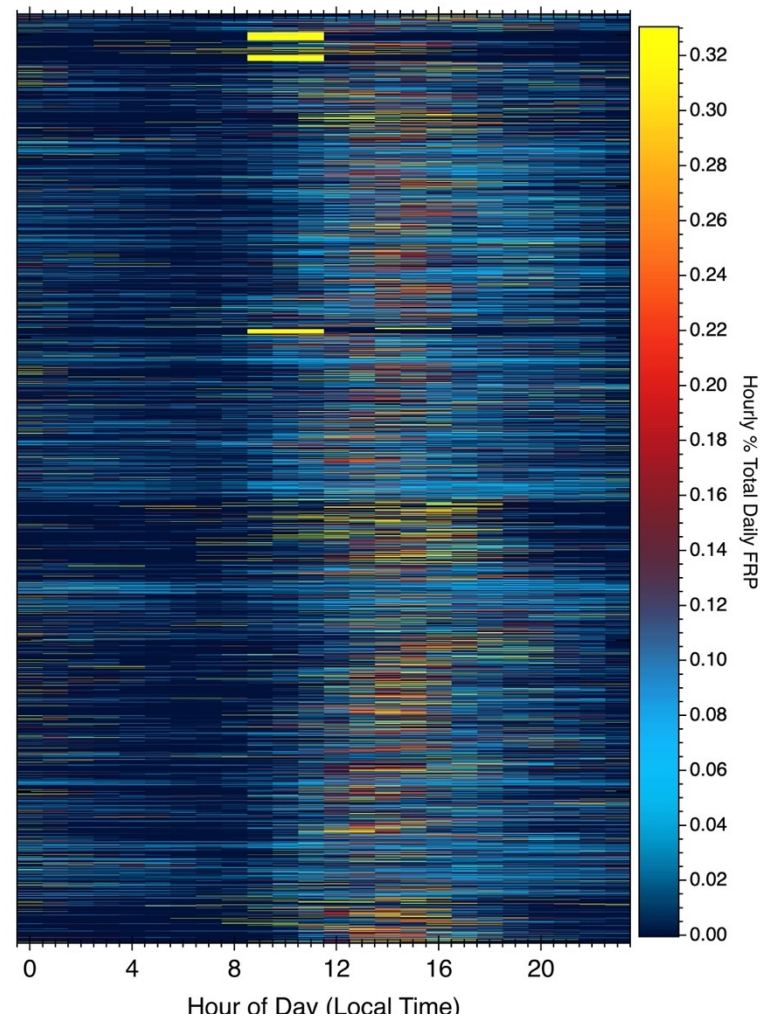
- 550+ individual fires
- Cumulative total of 6000+ days



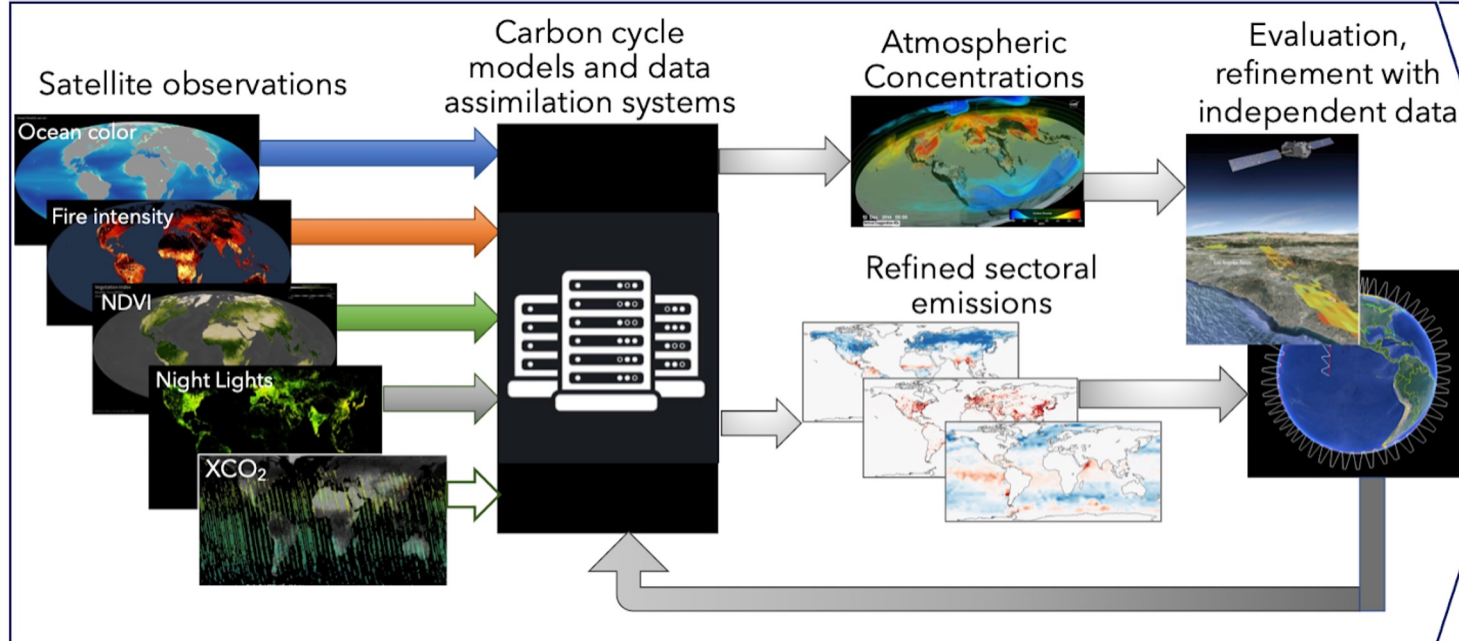
Climatology is clear and *surprisingly consistent*



However, day-to-day variability is **HUGE** ...even for a single fire



Analysis from L. Wiggins (NASA LaRC)



VEDA: A platform for Earth data visualization and analysis

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Data Visualization and Analysis Tools

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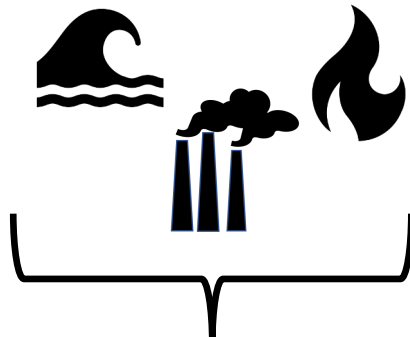
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Collaborative cloud environment for data processing, data analysis, and scientific software development

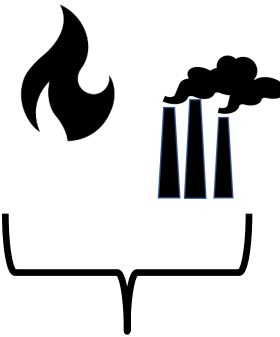
Synergy across EIS



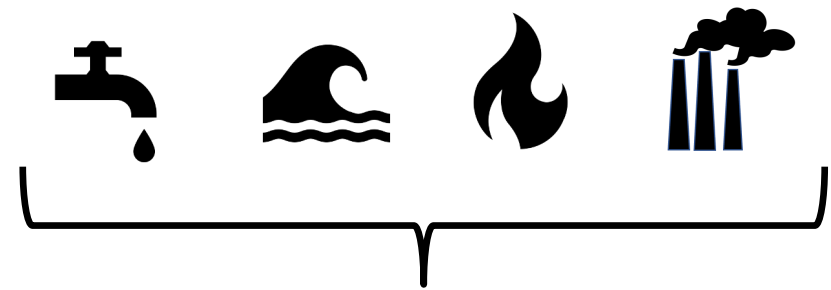
Freshwater, GHG: Shared input data, connection between carbon, air quality, and water cycles



Sea level, Fire, GHG: Shared modeling components



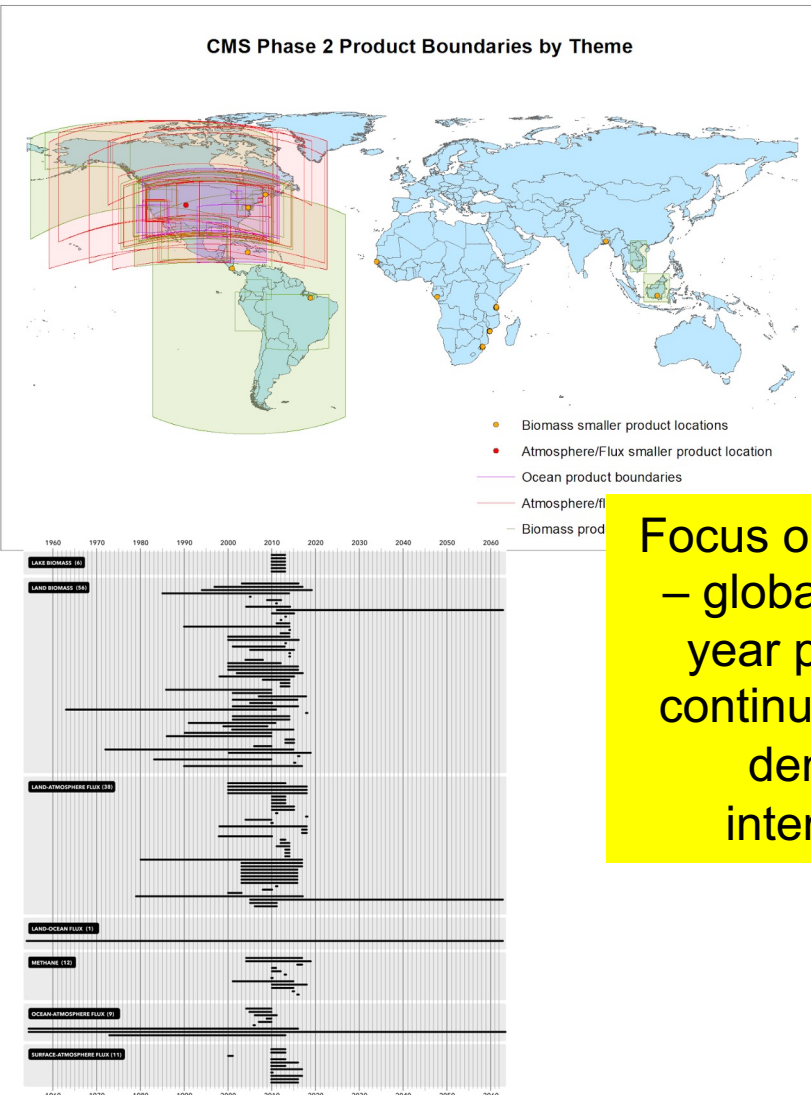
Fire, GHG: Complementary output for understanding connections between anthropogenic and natural GHGs



Across EIS: Common cyberinfrastructure facilitates interoperability between components and connection between carbon stocks (biomass, MAAP) and GHG emissions, fluxes

- **Goal:** Provide comprehensive information needed to characterize the state of the greenhouse gases with reliability, transparency, and low latency
- Emphasize 2 timescales: low-latency for monitoring rapid changes in emissions and carbon-climate interactions, and retrospective for more complete information on processes.
- Y1 goals:
 1. **Work with ESDS to design and prototype a data system for NASA GHG monitoring products that supports carbon cycle research and applications**
 2. **Deliver high quality, low latency information about changes in GHGs**
 3. Provide rigorous benchmarking for NASA GHG products in support of open source science
 4. Demonstrate cross-cutting analysis: Balance of natural and anthropogenic anomalies on the carbon balance during the COVID era (2020-2021)
 5. Promote community engagement and report key findings including scoping needs for coherent, long term GHG monitoring and information system

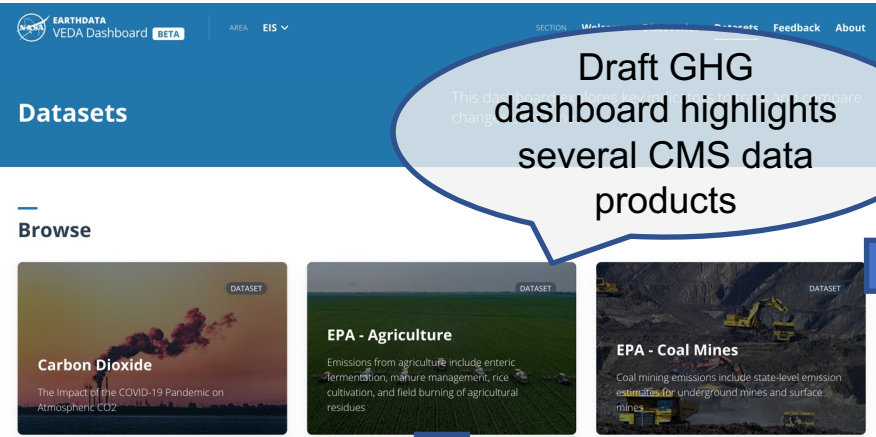
Preliminary product table examples



Focus on subset of US
– global scale, multi-
year products with
continued updates to
demonstrate
interoperability

	Product	Quantities	Domain	Resolution	Time
Diagnostic land fluxes	CARDAMOM (diag.)	CO2 NBE, GPP, Rh, Delta C	Global	4x5 (monthly)	2001-2020
	CASA-GFED3 v3 (diag.)	CO2 NBE, GPP, Rh, Fire <u>emis.</u>	Global	0.5x0.625 (monthly plus 3-hrly for NBE and daily for Fire <u>emis.</u>)	2001-2019
	LIS (EIS-Freshwater)	CO2 NBE, GPP, Rh	Global	0.25x 0.25 (3-hrly)	2001-2022
Prognostic land fluxes	LPJ (prog.)	CO2 NBE, GPP, Rh, Fire <u>emis.</u> , CH4 from wetlands	Global	0.5x0.625 (daily)	1980-2022
	Catchment-CN (prog.)	CO2 NBE, GPP, Rh, Fire <u>emis.</u>	Global	0.5x0.625 (daily, monthly)	1980-2022
	Global ED (prog.)	CO2 NBE, GPP, Rh	Global	0.5x0.625 (monthly, diurnally varying)	1980-2022
Observationally derived flux components	Total Carbon/Live Vegetation	Stock Change Emission: (<u>Defor.</u> , <u>Degrad.</u> , Fire, Removal)	Global	10 km (annual)	2000-2021
	FluxSat	GPP	Global	0.05x0.05 (daily)	2000-2022

	Product	Quantities	Domain	Resolution	Time
Inverse-derived fluxes	CEOS GST	CO2 NBE, CO2 NCE, Stock change	Global	1x1* (annual) Country (annual)	2015-2020
	CEOS GST	CH4 flux Sectors	Global	1x1* (annual) Country (annual)	2019
	CMS-Flux (GCP)	CO2 NBE, CO2 NCE	Global	1x1* (monthly)	2020-2021
	Harvard CH4 NA	CH4 trends	North America	0.5° × 0.625° (annual)	2010-2017
	CH4 oil/gas emissions	CH4 emissions	US	25 km (annual)	2018-2020
	TM5-4DVar	CO2 NCE	Global	2x3 (monthly)	2015-2021
	Low Order Flux Inversion (LoFI)	CO2 NEE, Ocean/atm CO2	Global	0.5x0.625 (3-hrly for NEE, monthly for FCO2)	2001-2022
Concentration analyses	OCO2-GEOS	XCO2, 3D CO2	Global	0.5x0.625 (3-hrly)	2015-2021



Datasets

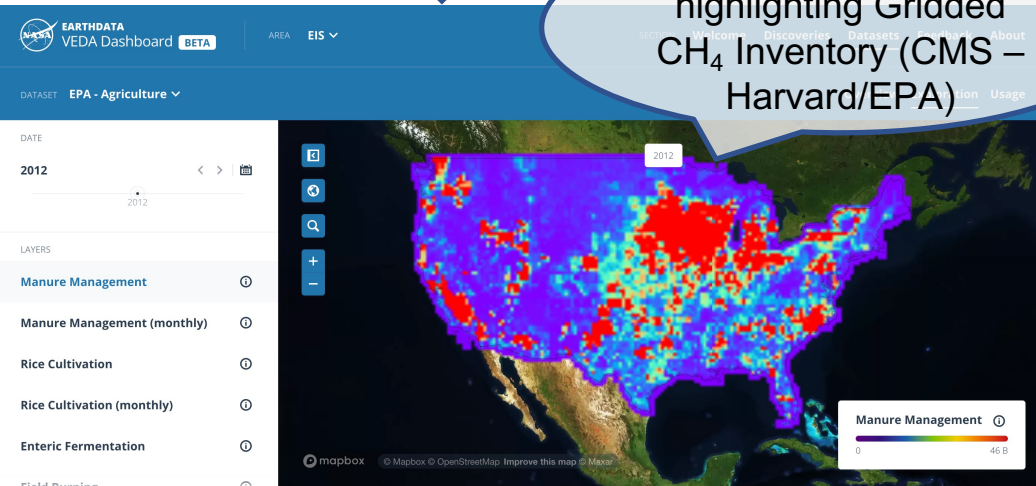
Browse

Carbon Dioxide
The Impact of the COVID-19 Pandemic on Atmospheric CO₂

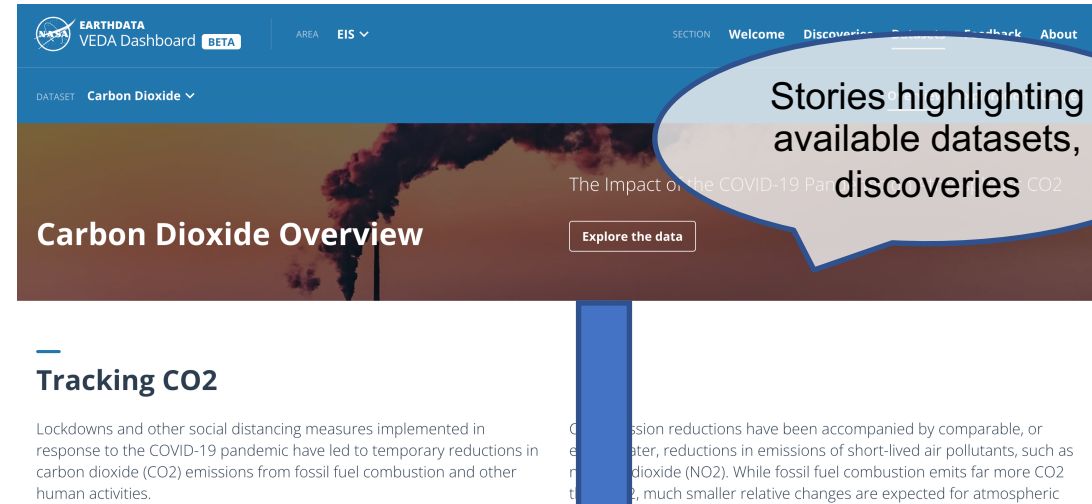
EPA - Agriculture
Emissions from agriculture include enteric fermentation, manure management, rice cultivation, and field burning of agricultural residues

EPA - Coal Mines
Coal mining emissions include state-level emission estimates for underground mines and surface mines

Draft GHG dashboard highlights several CMS data products



Interactive data viewer highlighting Gridded CH₄ Inventory (CMS – Harvard/EPA)



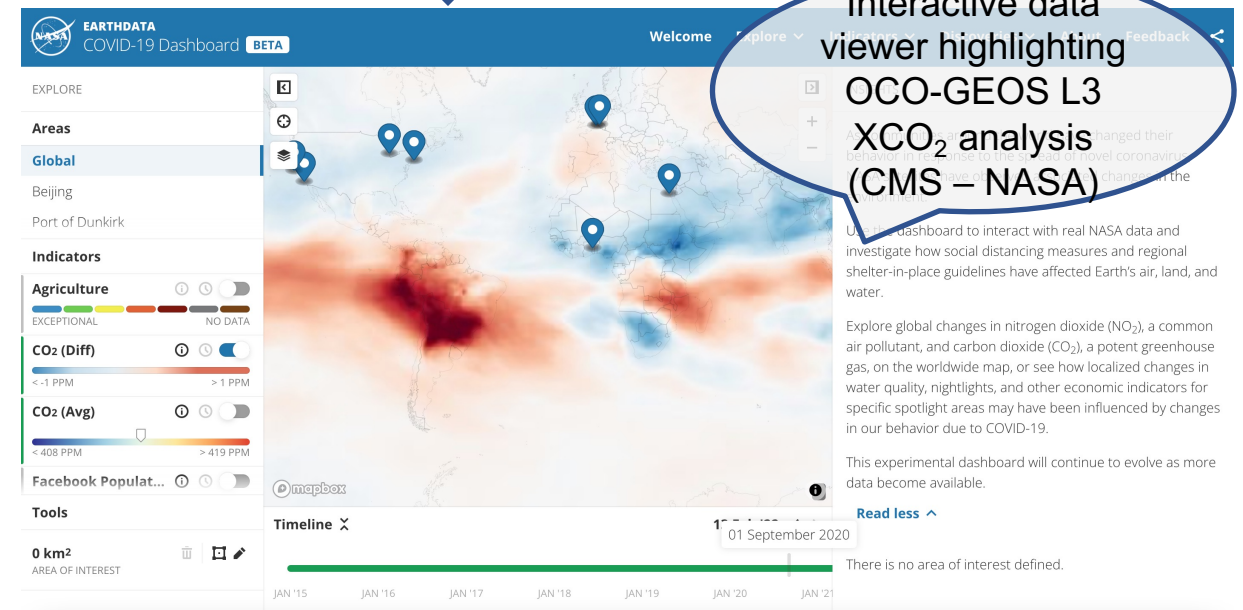
Carbon Dioxide Overview

The Impact of the COVID-19 Pandemic on Atmospheric CO₂

Tracking CO₂

Lockdowns and other social distancing measures implemented in response to the COVID-19 pandemic have led to temporary reductions in carbon dioxide (CO₂) emissions from fossil fuel combustion and other human activities.

Stories highlighting available datasets, discoveries



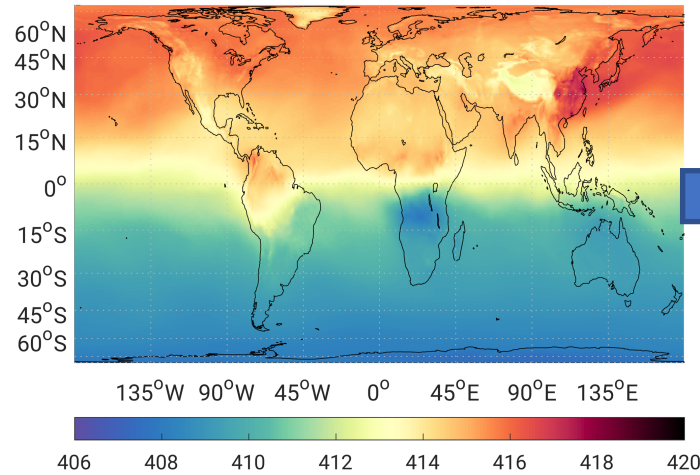
Interactive data viewer highlighting OCO-GEOS L3 XCO₂ analysis (CMS – NASA)

Example of low latency tagged tracers

OCO2-GEOS L3 XCO2

Analysis monthly mean XCO2 (ppmv)

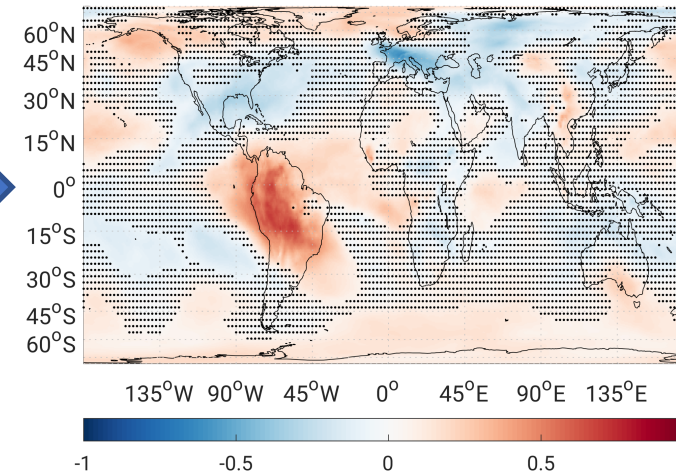
April 2020



Anomaly (weather signal removed)

Analysis - Baseline monthly mean XCO2 (ppmv)

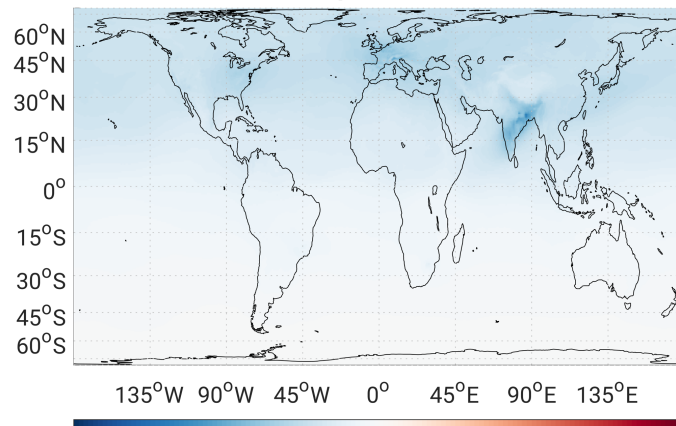
April 2020



CarbonMonitor Low Latency FF

Fossil monthly mean XCO2 (ppmv)

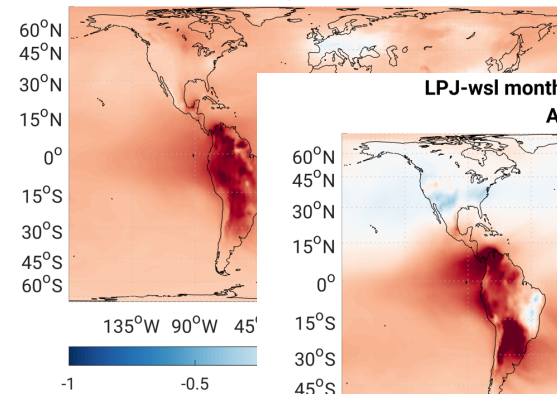
April 2020



Land flux ensemble

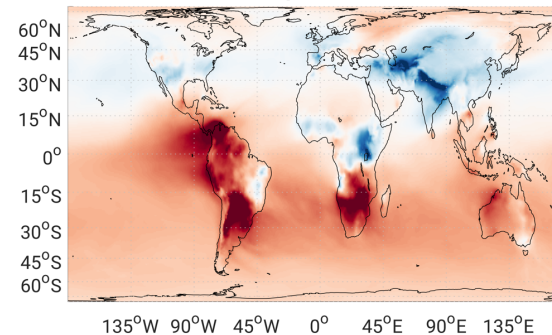
Catchment-CN monthly mean XCO2 (ppmv)

April 2020



LPJ-wsl monthly mean XCO2 (ppmv)

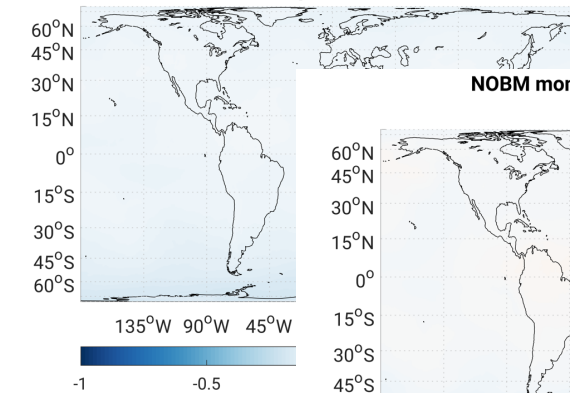
April 2020



Ocean flux ensemble

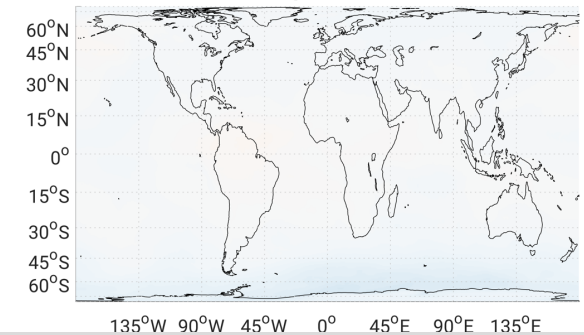
Landschutzer monthly mean XCO2 (ppmv)

April 2020



NOBM monthly mean XCO2 (ppmv)

April 2020



- **Why should scientists care?** EIS-GHG is working to demonstrate integration across datasets needed to:
 - Provide a consensus view on GHG changes by combining multiple NASA products
 - Help users navigate and make informed choices about products related to carbon monitoring
 - Make our own research more efficient by facilitating collaboration across institutions
 - Build a more timely, comprehensive outreach presence
- **Next steps**
 - Surveying NASA products to find candidates for VEDA pilot. Current products have been US-global scale, multi-year, with regular update schedule, priority given to those demonstrating interagency collaboration.
 - Working with other NASA Application efforts to broaden the reach of GHG products, expand user base beyond current CMS stakeholders.
 - Working to coordinate hands-on demos for interested science and applications users.
 - Following up with progress updates at AGU, future science team meetings.

If you're interested in learning more, providing feedback, or finding ways to get involved please follow up with Lesley Ott or Kevin Bowman.

Coming Soon! NASA Student Airborne Research Program (SARP) – East Coast

VCU Surface-based Instrumentation

VCU-RRC Ameriflux Tower and
vegetation instrumentation & add'l
micromet

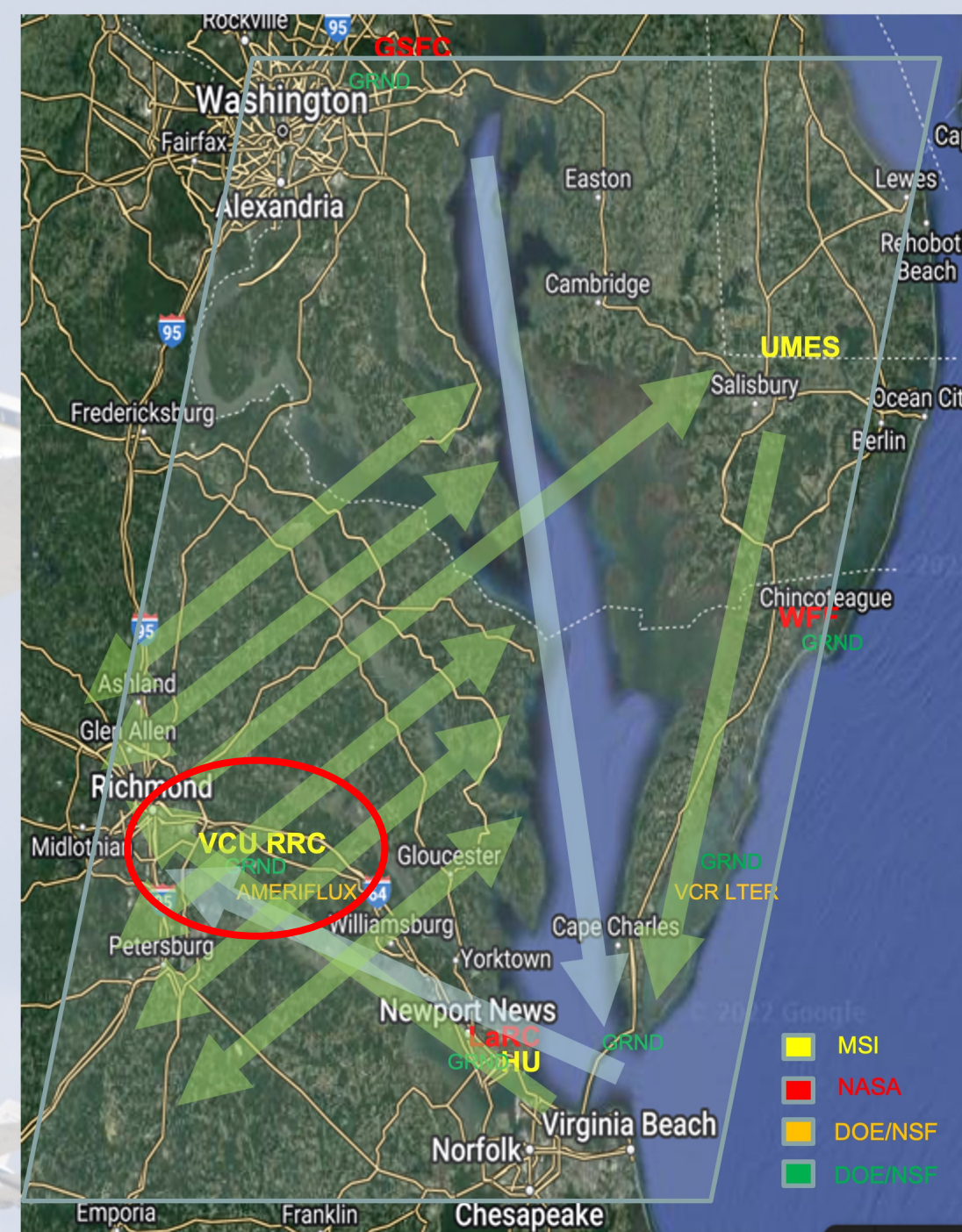
2 VCU-RRC Parker Research
Vessels for AQ & Biogeochemistry

VCU Hand-held POM's (6)

VCU Ground-based vegetation
Lidar instrumentation

NASA ASD for use by students and
faculty during field campaign to
characterize vegetation

EPA in-situ AQ equipment and
Ceilometer and possibly Picarro C-
Isotope Analyzer



NASA SARP- East – New GHG measurements!

New in 2023 - VCU Surface-based Instrumentation

Additional EOY Augmentation
Instrumentation related to Satellite
Cal/Val/Verification (Courtesy
NASA HQ, LandSat-9):

- 2 x Bruker EM27/Sun instruments - CO₂, CH₄ column measurements for cal/val.
- 1 x Picarro 2401 - CO, CO₂, CH₄ in situ, deployed at VCU
- 1 x Picarro 2307 - HCHO in situ, deployed at VCU
- 1 x Vaisala ceilometer - deployed at VCU
- 2 x Vaisala weather stations - deployed with EM27s

