Inverse modeling contribution to U.S. Greenhouse Gas Center

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GHG Center DEMONSTRATION AREAS: Local to Global

IWG GHG Formation Use Case Development

Demonstration Area: Human emissions, cyberinfrastructure

NASA-EPA Use Case 1. *Improve access and latency to, gridding of anthropogenic CH_4 inventory*

NASA, NOAA, NIST opportunities. *Collaboration on low latency GHG, AQ emissions through GRA²PES*

International. *Make gridding tools open source, support capacity building in other countries, collaborating with State Department.*

REGIONAL

Demonstration Area: Natural sources/sinks, modeling and data assimilation

NASA-EPA Use Case 2. *Complement anthropogenic GHG emissions with natural GHG emissions and fluxes*

NASA, NOAA, NIST opportunities. *Collaboration on quasi-operational modeling, development of consensus GHG products*

International. *Contribute to CEOS Strategy to Support the Global Stocktake and WMO IG3IS and Greenhouse Gas Monitoring Infrastructure initiatives.*

GLOBAL

Demonstration Area: Large emission events, Advancing measurement technology and cal/val

NASA-EPA Use Case 3. *Identify, quantify emissions from, large CH_4 leak events leveraging aircraft and satellite data*

NASA, NOAA, NIST opportunities. *Collaboration on cal/val standards, coordinated measurement deployments*

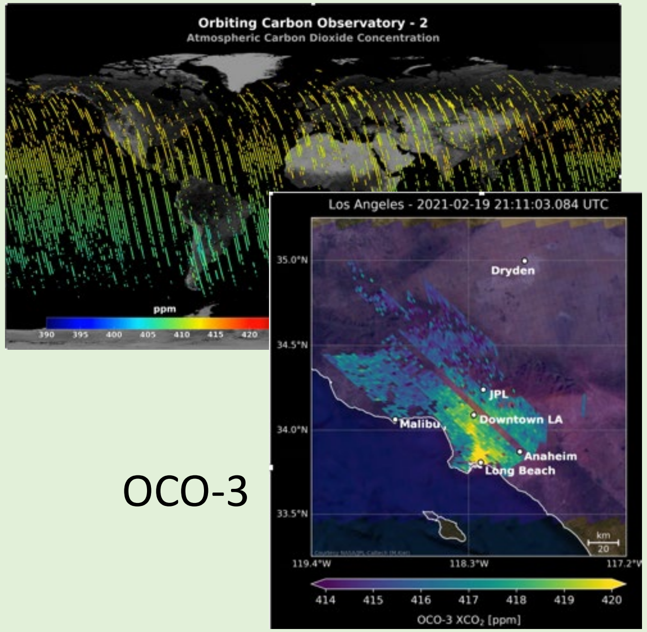
International. *Explore contributions to UNEP IMEO, MARS initiatives to enable timely access of satellite plume mapping data for large/transient emissions detection and inter-comparison of plume mapping instruments with emissions release.*

LOCAL

JPL Inverse Modeling Contribution to GHG Center

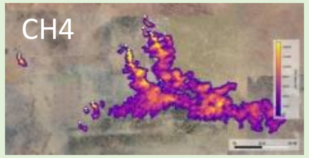
GHG Observations

OCO-2



OCO-3

EMIT

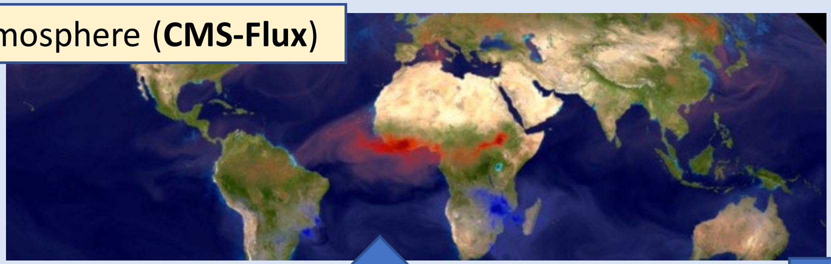


Other Critical Measurements

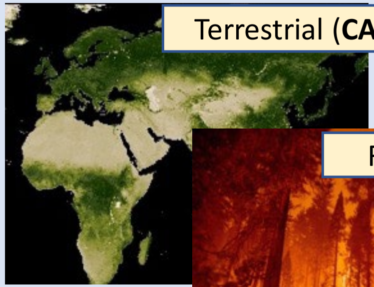
- OCO-2/3 Solar Induced Florescence
- AIRS Carbon Monoxide
- NISAR Biomass
- SMAP/Aquarius Salinity

GHG inverse Modeling

Atmosphere (**CMS-Flux**)

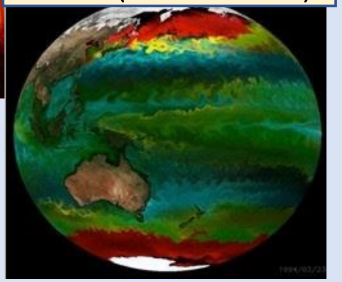


Terrestrial (**CARDAMOM**)



Fires (**MOMO-Chem**)

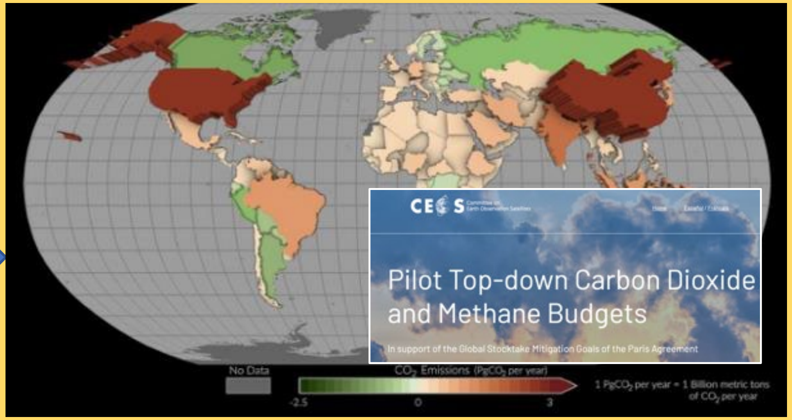
Ocean (**ECCO-Darwin**)



Each **model** is a state-of-the-art Earth System component model with data assimilation capabilities for fusing known physics with available in-situ and satellite observations.

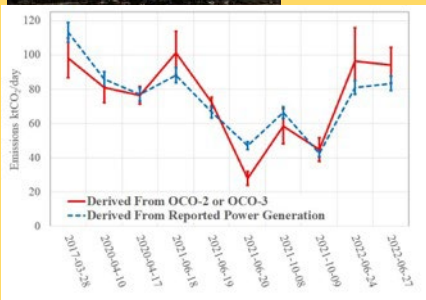
Decision Support

From Global to Facility Scale



Global Stocktake

Byrne et al, 2023



Nassar et al, 2023

Bełchatów Power Station CO2 Emissions, Poland

CH4 Plume Open Data Portal

NASA GSFC contribution to GHG Center Inverse Modeling

Technical details:

Model: TM5-4DVAR

Resolution: Currently 3°×2° with optional 1°×1° nested domains, working towards 1°×1° global

Species: CO_2, CH_4

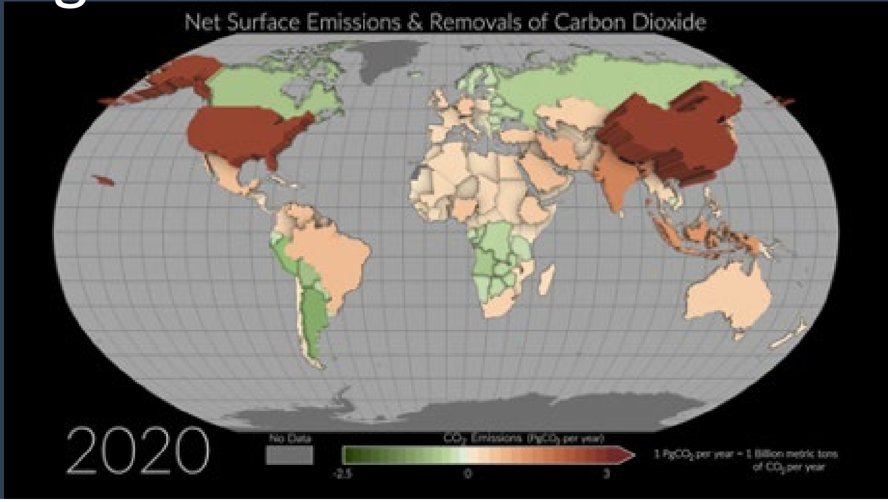
Datasets assimilated: GOSAT (CO_2, CH_4), OCO-2 (CO_2), in situ observations (CO_2, CH_4, $\delta^{13}CH_4$), TROPOMI (CH_4)

Meteorology: ECMWF IFS currently, GEOS in the future

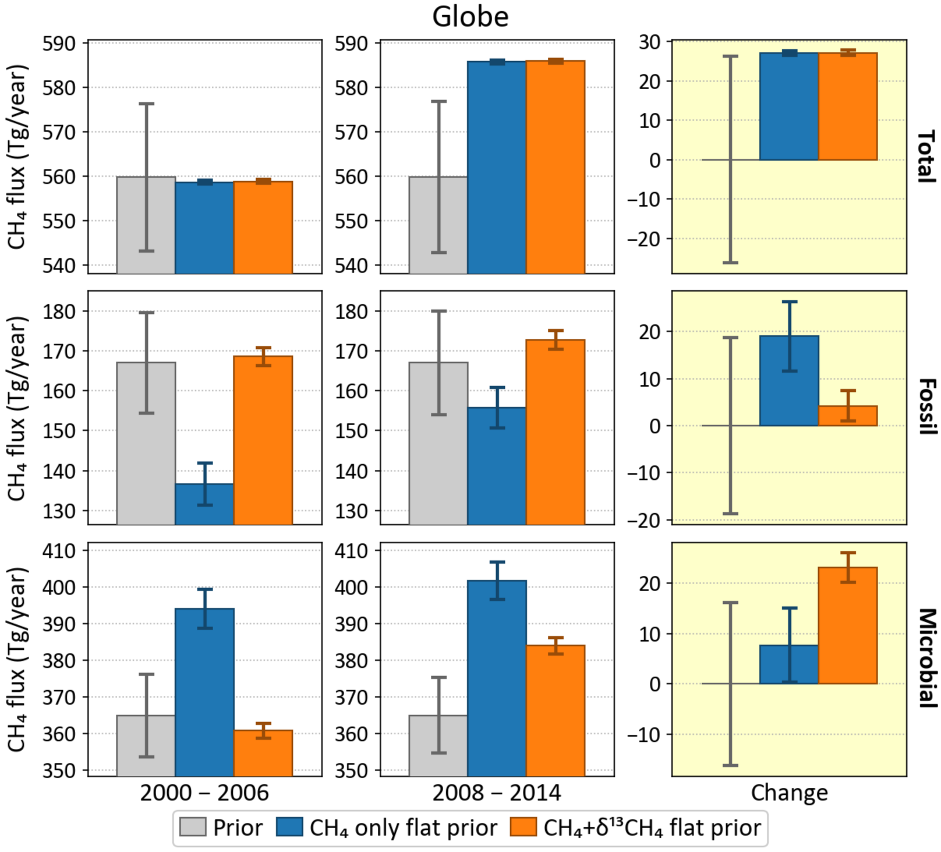
Cadence: Annual updates, year Y fluxes available a few months into year Y+1

Evaluation: Against withheld in situ data and validation data such as TCCON and AirCore

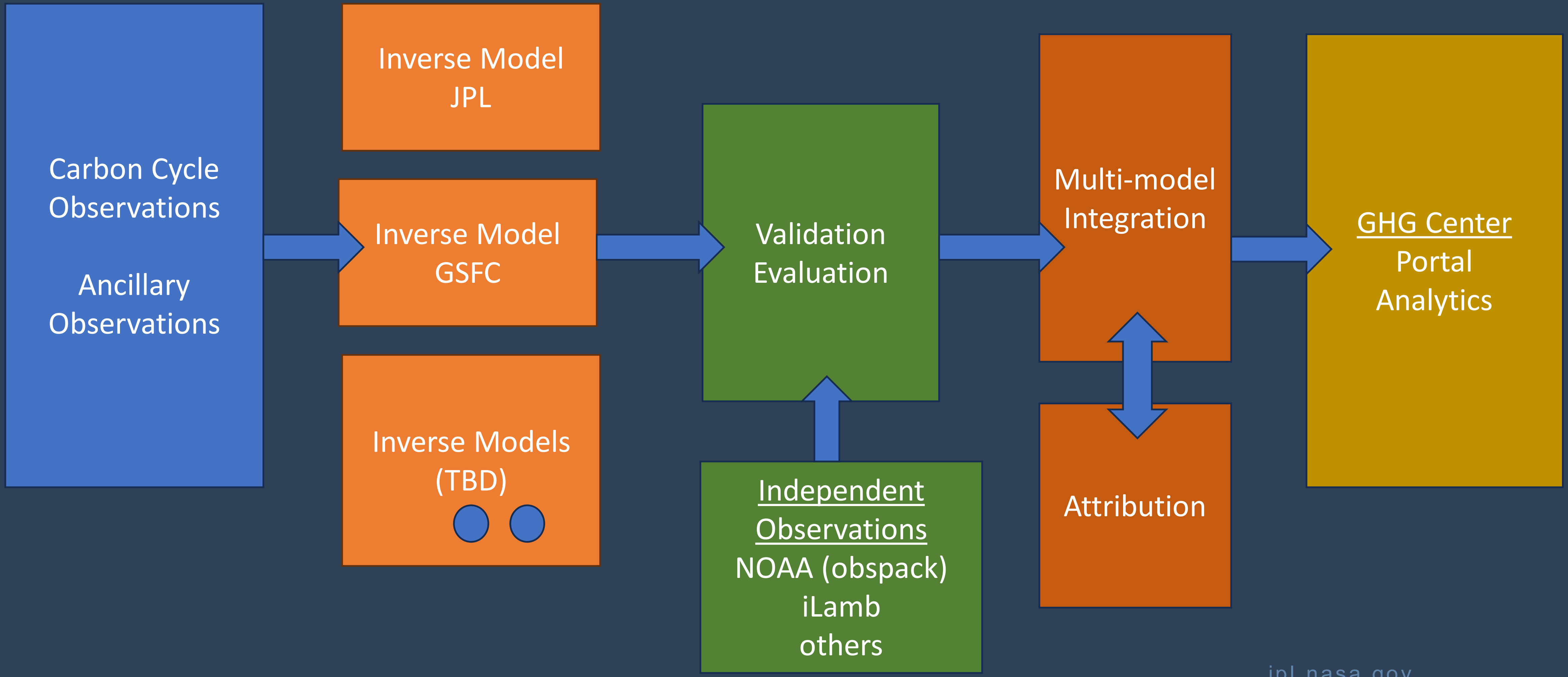
Error estimation: Statistical error estimates based on prior inventory errors and measurement errors, and systematic error estimates based on

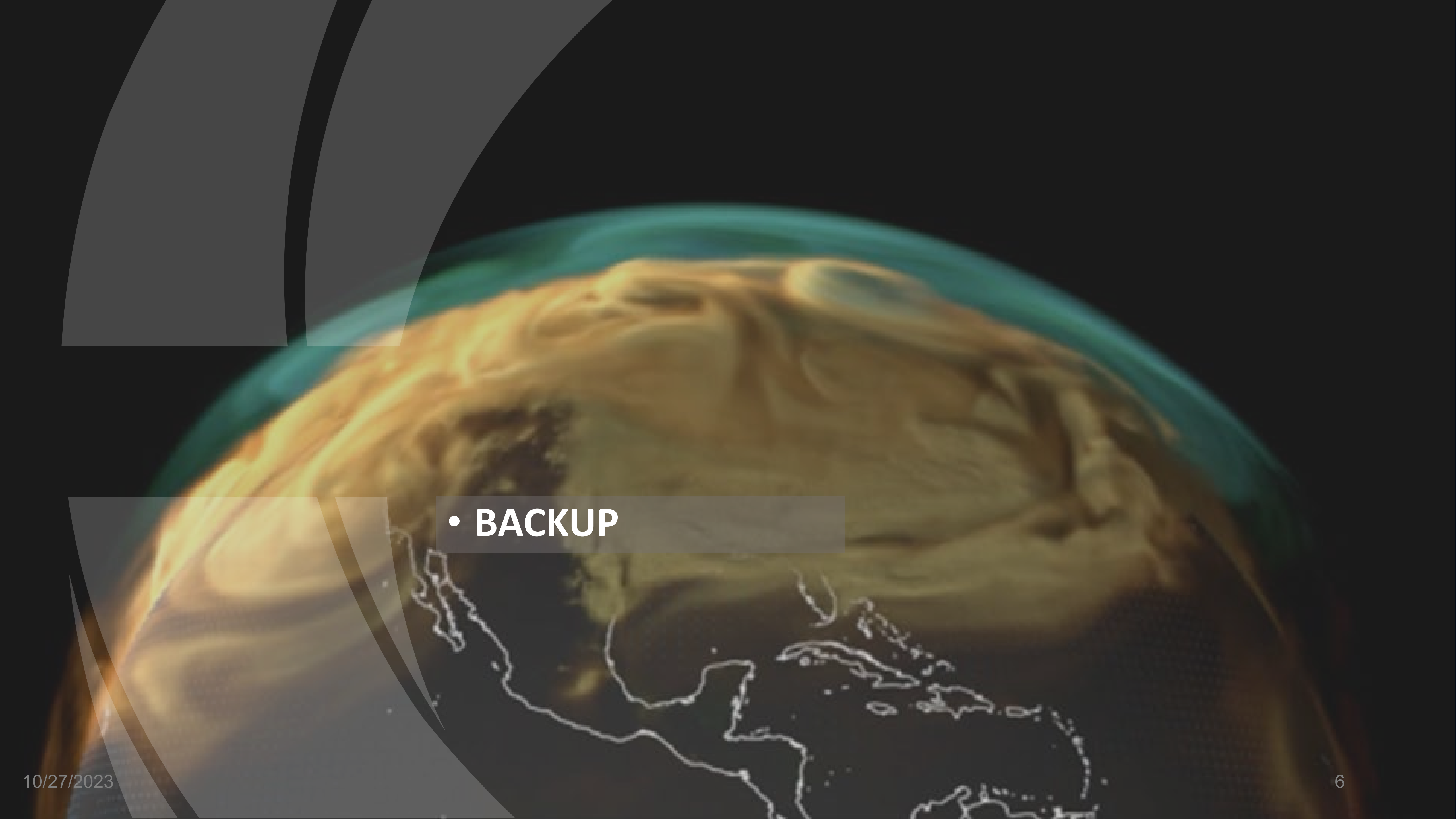


Examples of contribution to OCO2 MIP, CH_4 isotope-based inversion to attribute emissions and trends to sources



GHG Center Inverse Model Framework



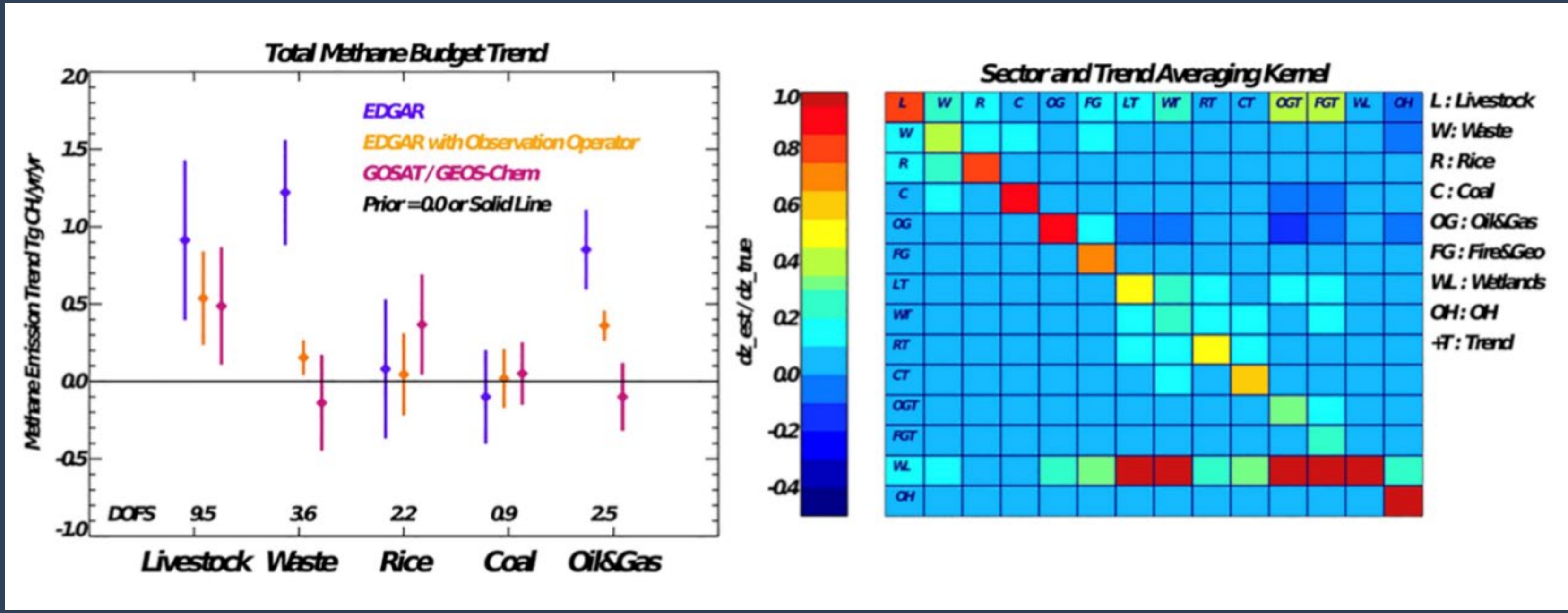


- **BACKUP**

Greenhouse Gas Inventory Evaluation

2019 IPCC refinement: “An ideal condition for verification is the use of fully independent data as a basis for comparison. Measurements of atmospheric concentrations provide such datasets, and recent scientific advances allow using such data as a basis for emission modeling.”

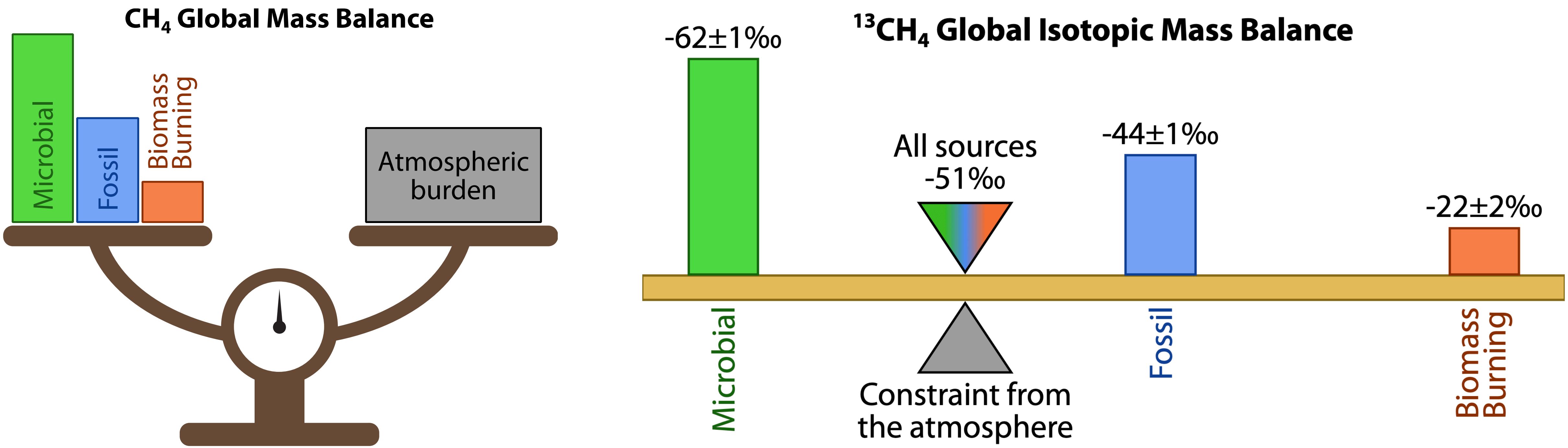
New methods can be used to compare against GHGI.



Worden et al, AGU Adv., 2023

We use $\delta^{13}CH_4$ to distinguish between methane source types

CH_4 from different formation mechanisms have different ^{13}C:^{12}C ratio, and in situ measurements of that ratio tell us that ~85% of the post-2006 CH_4 growth is from microbial sources



We will use available $\delta^{13}CH_4$ data for our CH_4 flux estimation, and our CH_4 priors for TROPOMI+GEOS state estimation are informed by $\delta^{13}CH_4$ data as well

Basu et al (2022), ACP