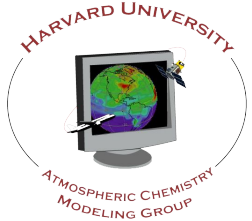


integral earth

Simplifying the IMI

Agenda

- The **need** for Integral Earth
- Integral Earth **user workflow**
- **Use cases / examples**
  - Interpreting output
  - Downloading data
- **Future developments**

The Need for Integral Earth

Increased attention on methane

- Non-experts gaining interest
- Growing importance of satellite data

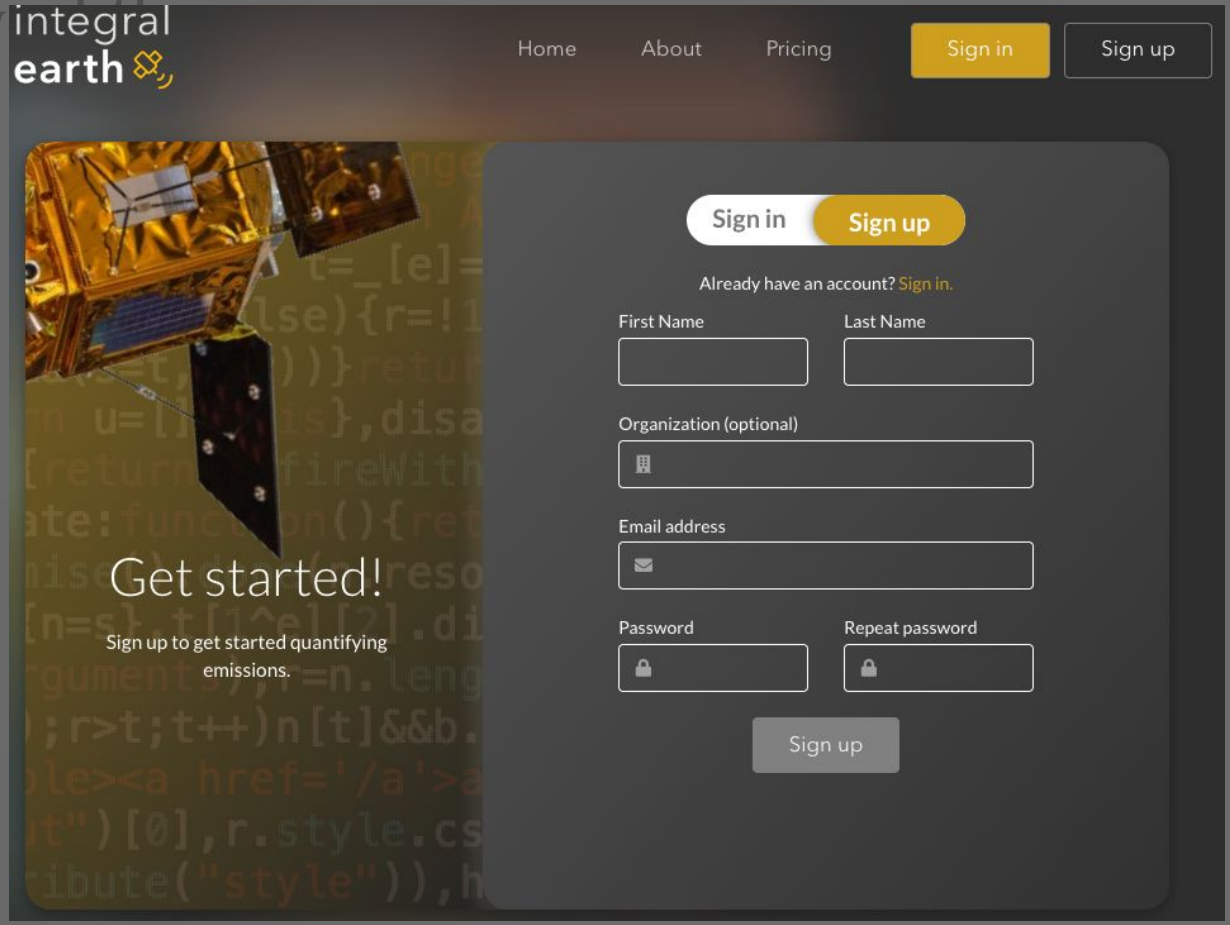
Accessibility issues

- Non-technical/non-scientific users still need a way to access IMI
- Significantly reduces user hands on work

Our goal for Integral Earth

- Democratize access to satellite data for methane quantification by non-experts

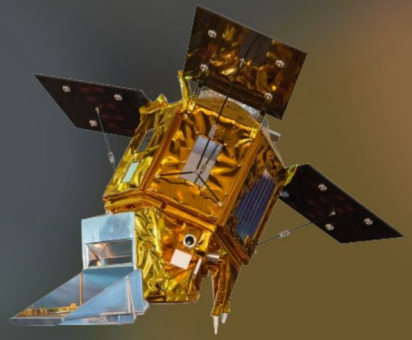
- User w


integral earth
Home
About
Pricing
Sign in
Sign up
Get started!
Sign up to get started quantifying emissions.
Sign in
Sign up
Already have an account? Sign in.
First Name
Last Name
Organization (optional)
Email address
Password
Repeat password
Sign up

- Use

integral earth

Home | Resources | View User Runs | My Data | Submit Inversion +



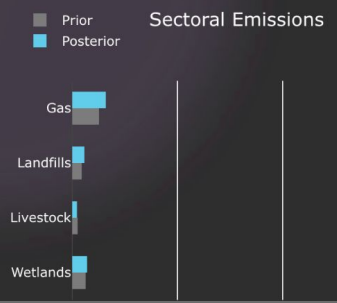
Monitoring Methane Emissions, Simplified

Integral Earth is a user-friendly web interface for quantifying **total methane emissions** with satellite data. Users can map emissions for any region of interest at up to 25-km resolution using public satellite data and transparent, research-grade algorithms, with no learning curve.

Get started

Transparent Research-Grade Algorithms

Integral Earth is built on the open-source Integrated Methane Inversion (IMI) software tool. The IMI applies mature and published inverse methodologies continuously developed at Harvard University's Atmospheric Chemistry Modeling Group (ACMG) to infer methane emissions. Integral Earth is a web-based wrapper for the IMI developed and managed by the IMI



- Use

integral earth

Home | Resources | View User Runs | My Data | Submit Inversion +

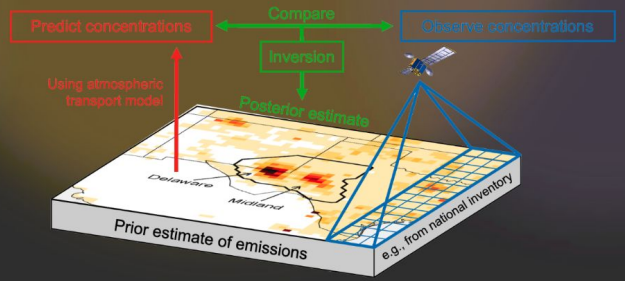
About

Integral Earth is a **user-friendly web interface for quantifying methane emissions** with satellite data. It can be applied to regions of interest ranging in scale from small urban areas to countries or continents, and global applications are also supported. **It is currently available for free while we prototype the system and develop a funding model.**

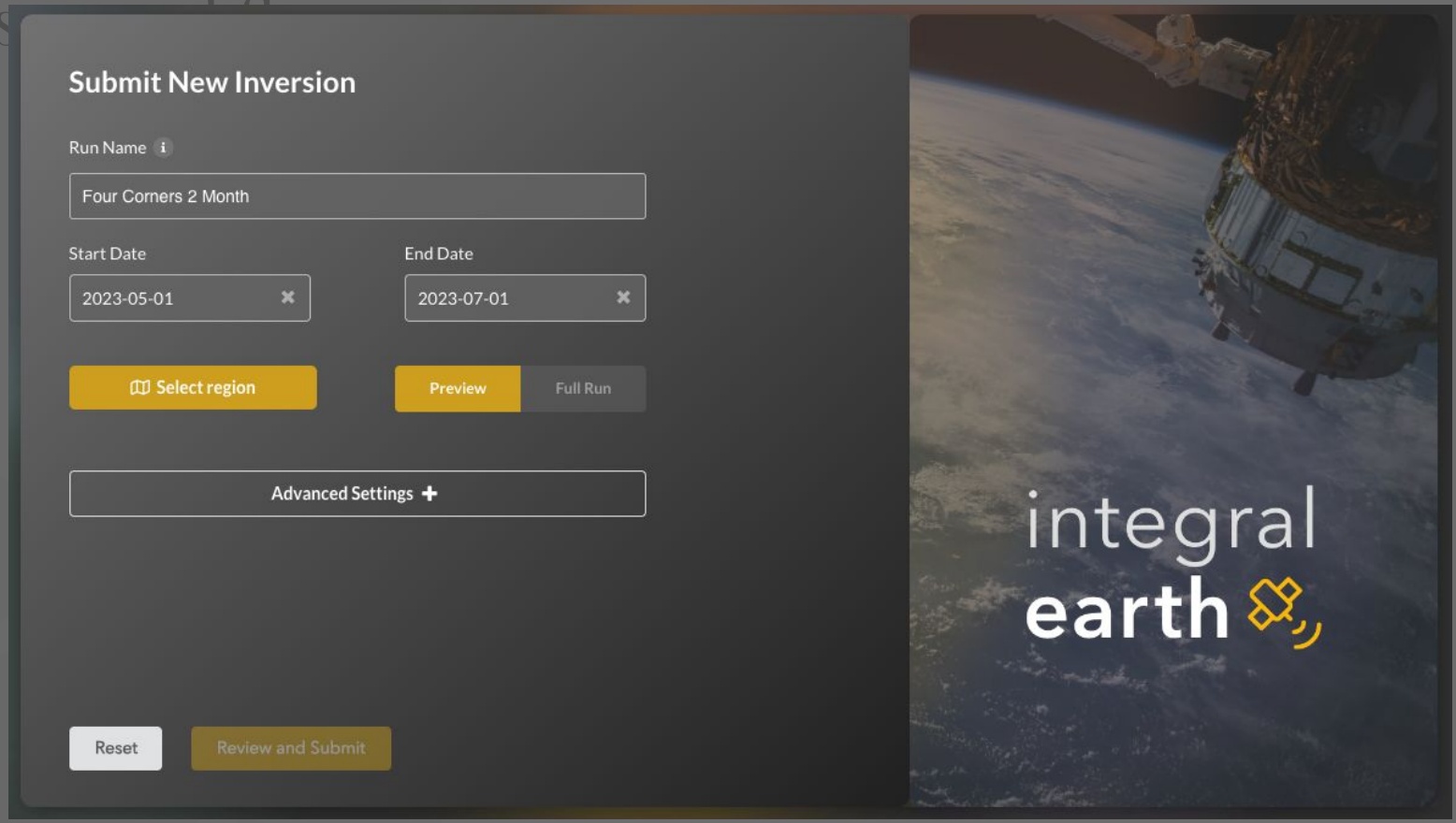
Methodology (The IMI)

Integral Earth is built on the open-source Integrated Methane Inversion (IMI) facility. The IMI infers methane emissions from users' regions of interest at up to 25-km resolution by inverse analysis ("inversions") of satellite observations from the TROPOspheric Monitoring Instrument (TROPOMI).

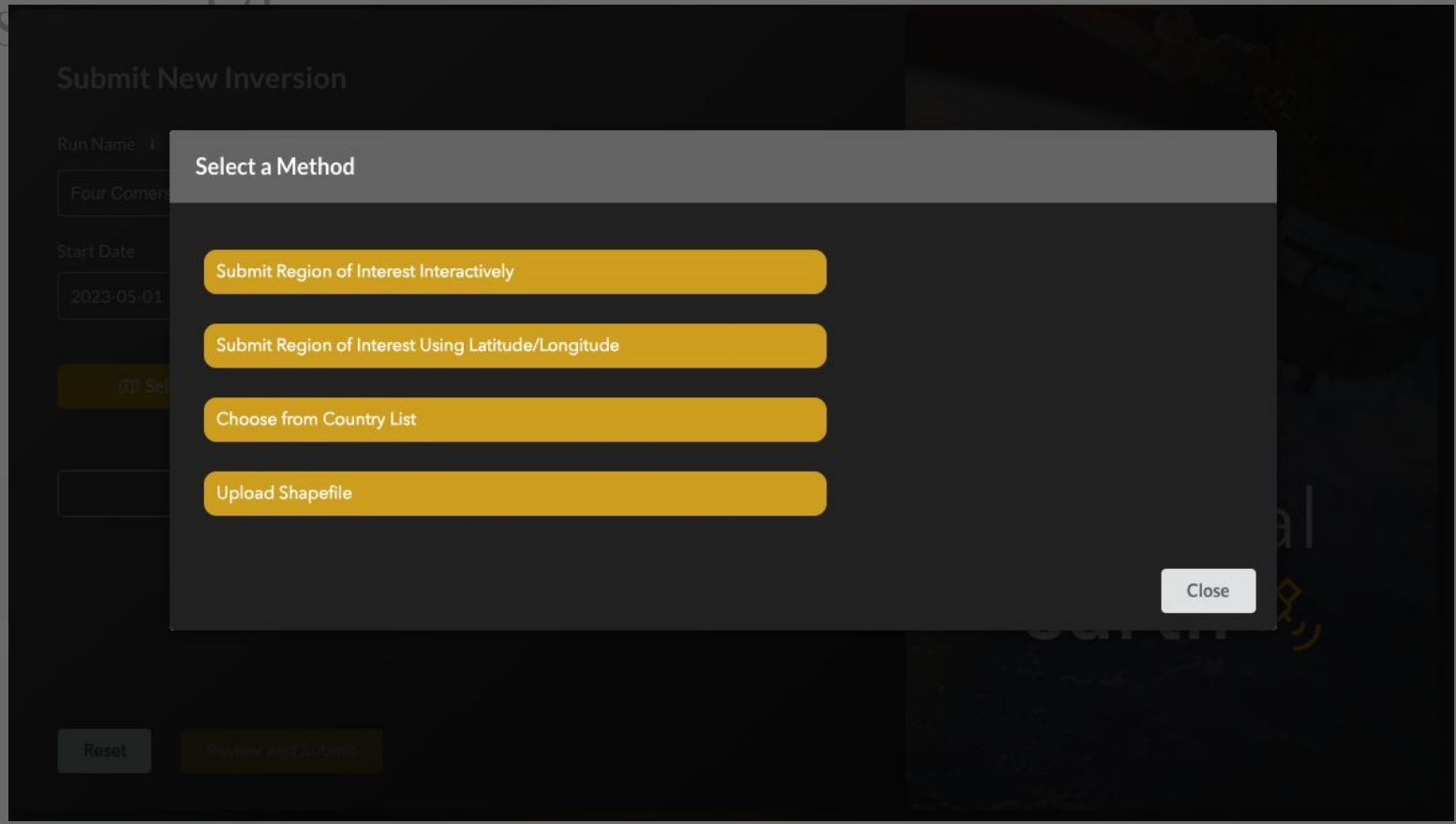
Learn More About the IMI

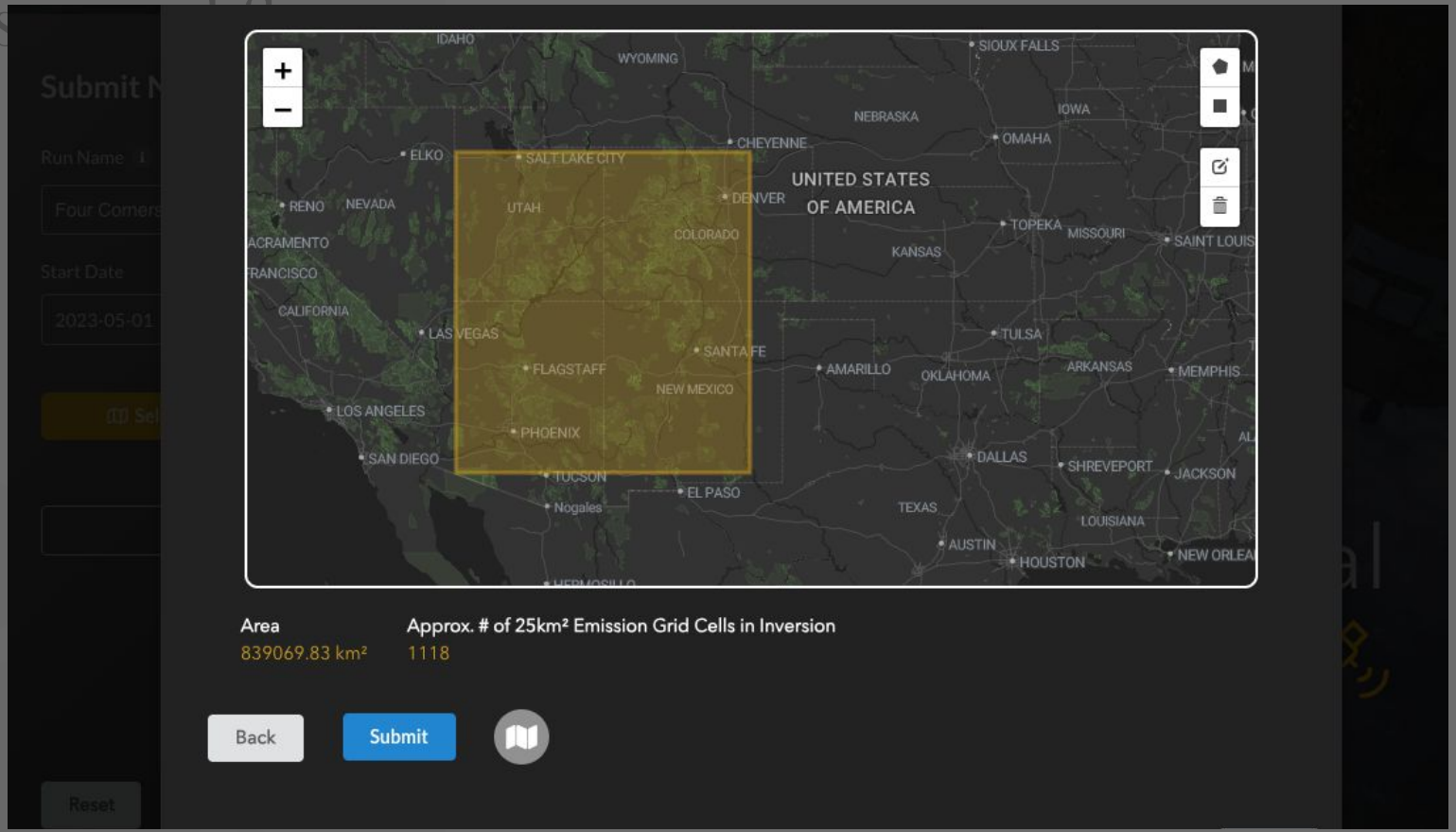


- Us

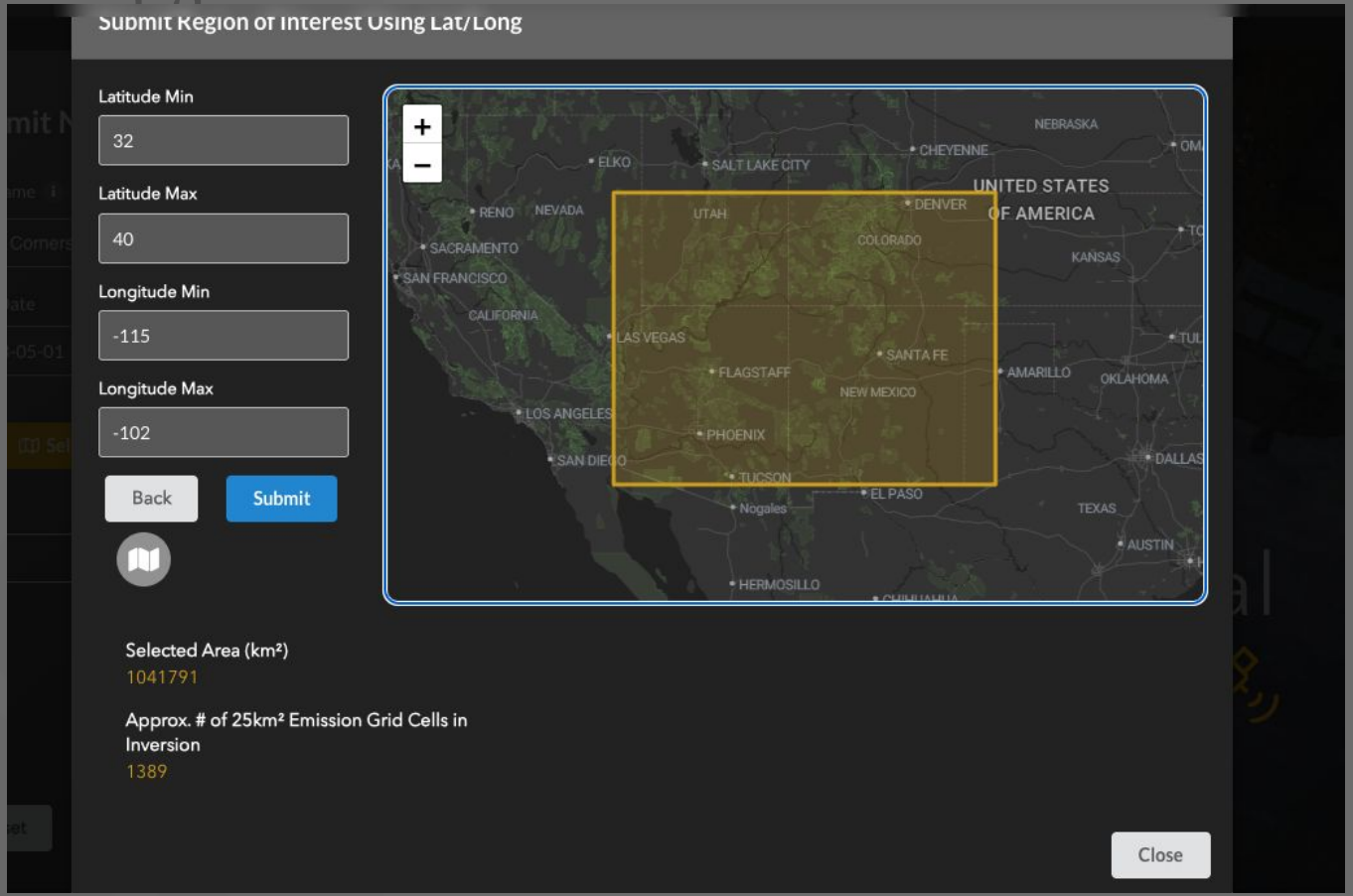

Submit New Inversion
Run Name
Four Corners 2 Month
Start Date
2023-05-01
End Date
2023-07-01
Select region
Preview
Full Run
Advanced Settings +
Reset
Review and Submit
integral
earth

- Us


Submit New Inversion
Run Name
Four Corners
Start Date
2023-05-01
Reset
Select a Method
Submit Region of Interest Interactively
Submit Region of Interest Using Latitude/Longitude
Choose from Country List
Upload Shapefile
Close


IDAHO
WYOMING
SIOUX FALLS
NEBRASKA
IOWA
CHEYENNE
OMAHA
ELKO
SALT LAKE CITY
UNITED STATES
OF AMERICA
RENO
NEVADA
UTAH
DENVER
COLORADO
TOPEKA
MISSOURI
SAINT LOUIS
KANSAS
CALIFORNIA
LAS VEGAS
SANTA FE
TULSA
FLAGSTAFF
AMARILLO
OKLAHOMA
ARKANSAS
MEMPHIS
NEW MEXICO
LOS ANGELES
PHOENIX
SAN DIEGO
DALLAS
SHREVEPORT
JACKSON
TUCSON
EL PASO
Nogales
TEXAS
LOUISIANA
AUSTIN
HOUSTON
Area
839069.83 km²
Approx. # of 25km² Emission Grid Cells in Inversion
1118
Back
Submit

- User


Submit Region of Interest Using Lat/Long
Latitude Min
32
Latitude Max
40
Longitude Min
-115
Longitude Max
-102
Back
Submit
Selected Area (km²)
1041791
Approx. # of 25km² Emission Grid Cells in Inversion
1389
Close
NEBRASKA
CHEYENNE
ELKO
SALT LAKE CITY
UNITED STATES OF AMERICA
DENVER
RENO
NEVADA
UTAH
COLORADO
SACRAMENTO
KANSAS
SAN FRANCISCO
CALIFORNIA
LAS VEGAS
SANTA FE
FLAGSTAFF
AMARILLO
OKLAHOMA
NEW MEXICO
LOS ANGELES
PHOENIX
SAN DIEGO
TUCSON
DALLAS
EL PASO
Nogales
TEXAS
AUSTIN
HERMOSILLO

- User w

Albania

Back | Submit

Selected Area (km²)
29722

Approximate Pixels in Inversion
47

Close

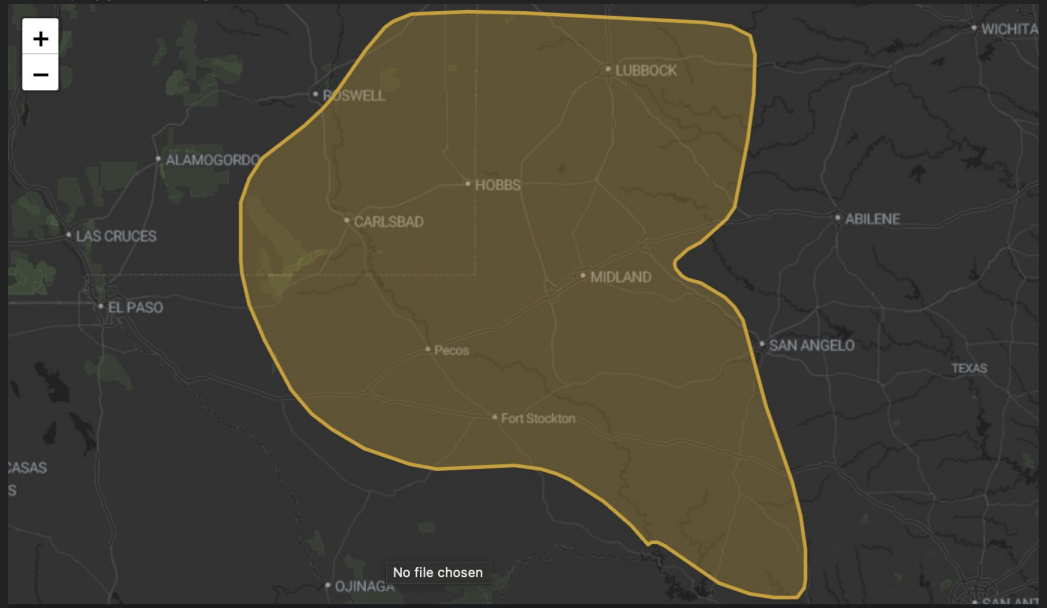
- User w

Upload Shapefile (.shp, .shx, .dbf, .prj)

Choose Files 4 files

Preview

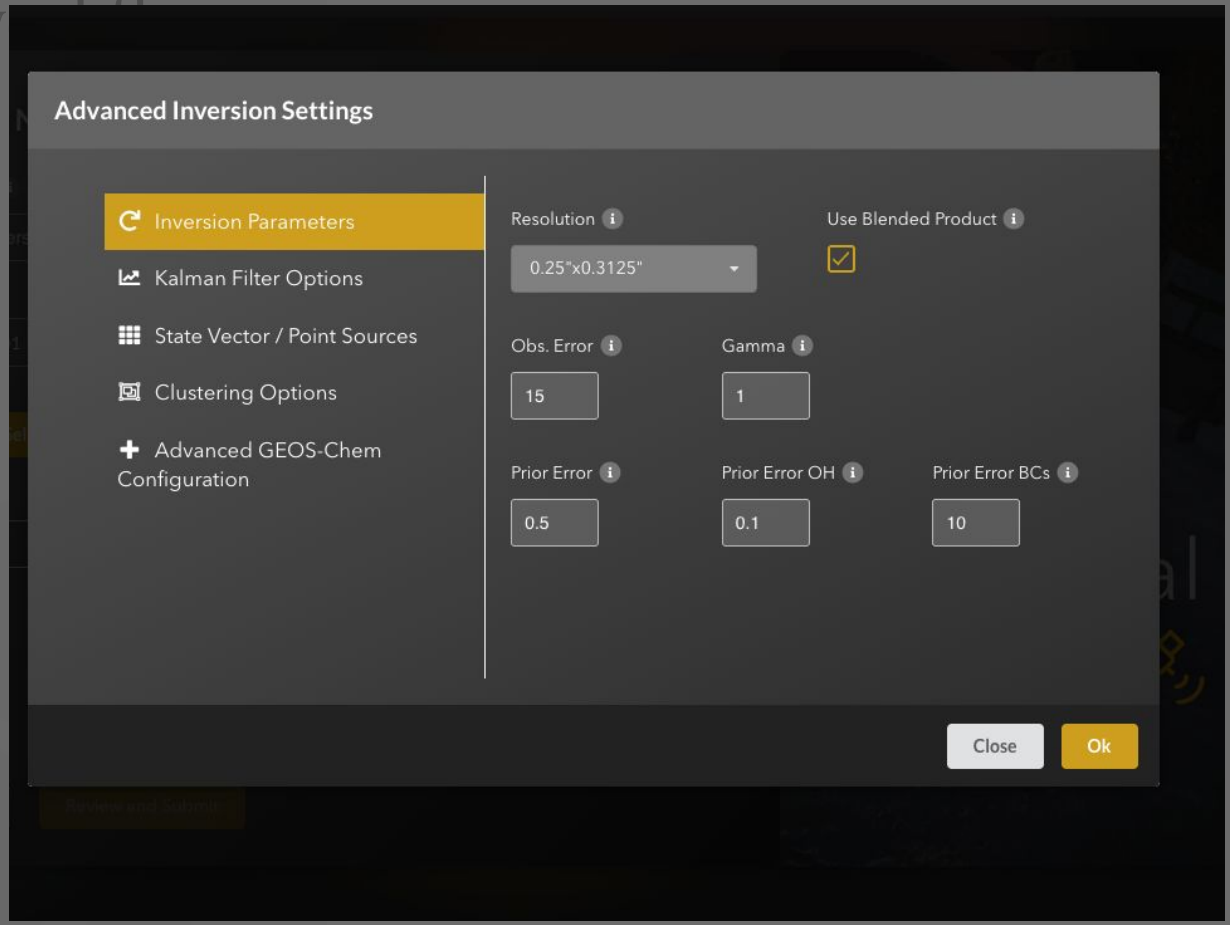
⚠ Multipolygons be merged on submission



Area
165813.24 km²

Approximate Pixels in Inversion
266

- User w


Advanced Inversion Settings
Inversion Parameters
Kalman Filter Options
State Vector / Point Sources
Clustering Options
Advanced GEOS-Chem Configuration
Resolution
0.25"x0.3125"
Use Blended Product
Obs. Error
15
Gamma
1
Prior Error
0.5
Prior Error OH
0.1
Prior Error BCs
10
Close
Ok

- User w

Review Job Submission

Run Name // **Central Europe 1 Year**

Time Range //

Start Date: **May 1, 2022**

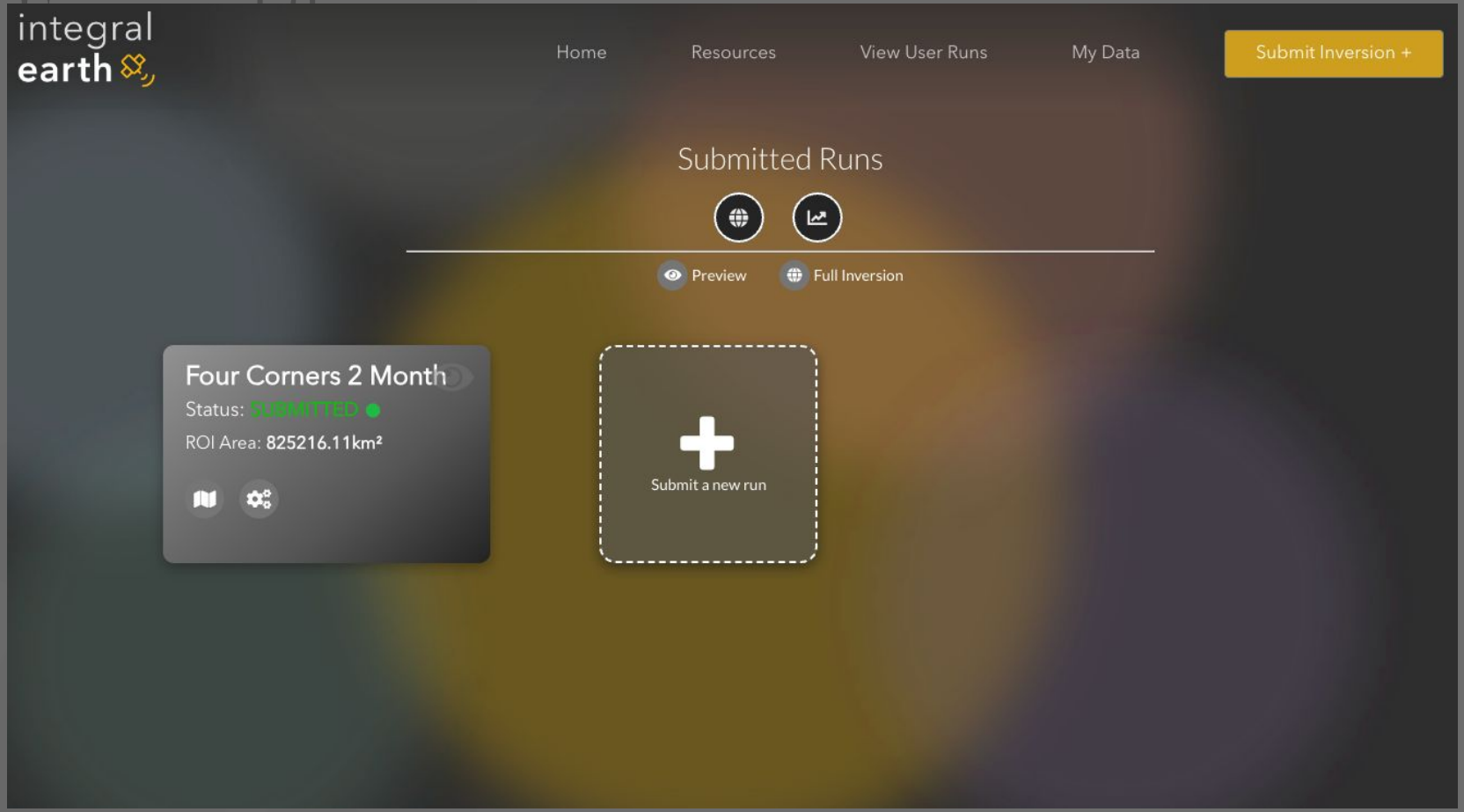
End Date: **May 1, 2023**

Run Type // **Full Run**

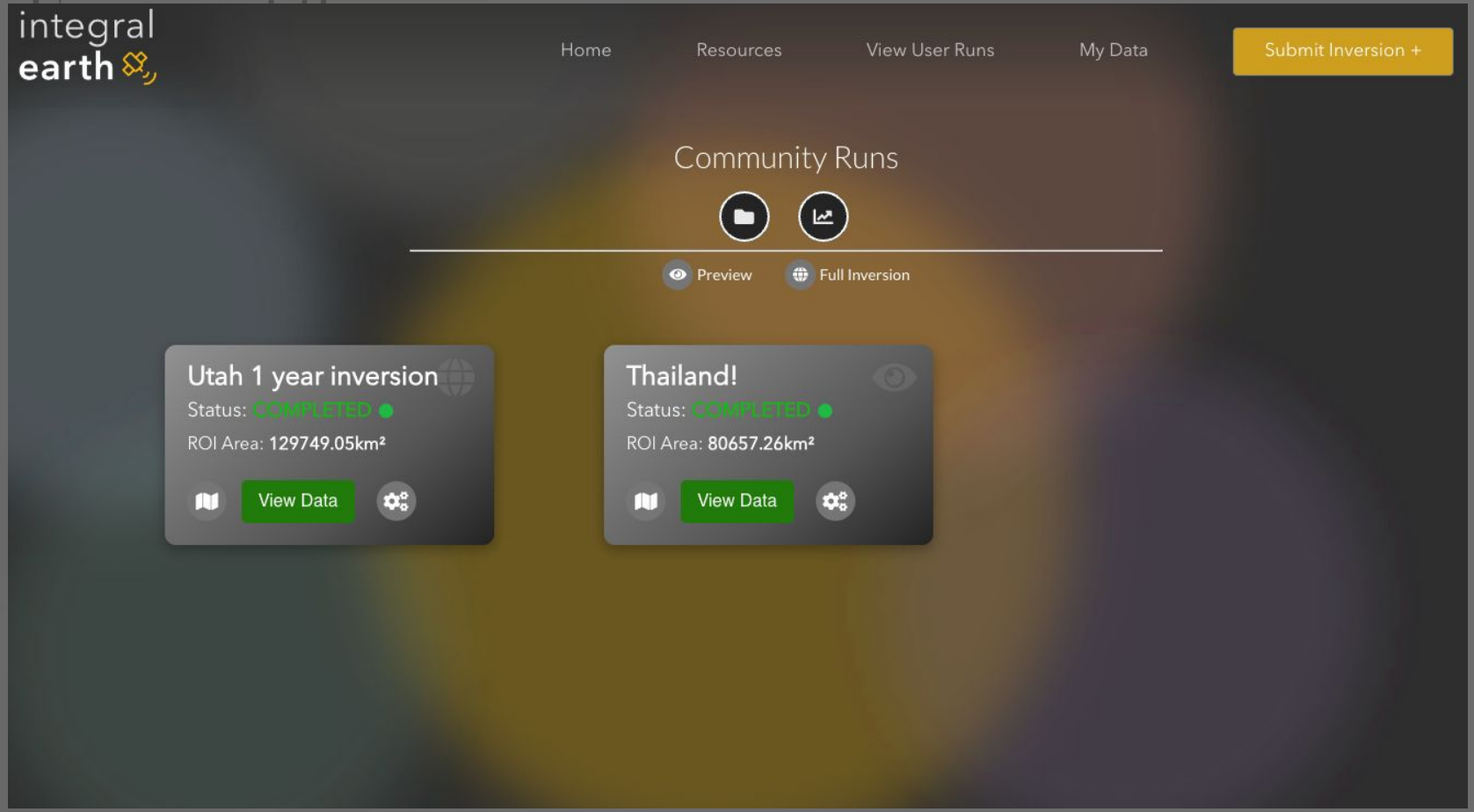
Requested Domain Area // **329030.70 km2**

Return and Edit | Submit for Approval

Reset


integral earth
Home
Resources
View User Runs
My Data
Submit Inversion +
Submitted Runs
Preview
Full Inversion
Four Corners 2 Month
Status: SUBMITTED
ROI Area: 825216.11km²
Submit a new run

User Submission	Automated Validation	Submission to AWS	Results
The user will submit an inversion configuration request through our easy-to-use form.	In the backend, the users' inversion request will be validated based on best practices. If adjustments are needed, the IE team can work with the user to ensure a viable product.	Upon validation, the run will process on AWS based on requested parameters.	Inversion results will be displayed in a dashboard on Integral Earth, showing plots, error characterization, and emissions trends.


integral earth
Home
Resources
View User Runs
My Data
Submit Inversion +
Community Runs
Preview
Full Inversion
Utah 1 year inversion
Status: COMPLETED
ROI Area: 129749.05km²
View Data
Thailand!
Status: COMPLETED
ROI Area: 80657.26km²
View Data

Products

- Reference map
- Plots and statistics from IMI
  - Prior/Posterior Emissions
  - Bias/Error characterization
  - Averaging kernel sensitivities
  - And more!
- Sectoral breakdown of emissions
- Emissions over time (for KF mode)

Example Case

- Preview: Four Corners
  - Two month period in 2023
  - Default settings

- Full: Permian Basin
  - Four month period in 2023
  - Time series mode (Kalman filter)
    - 1 week intervals
  - Log normal errors

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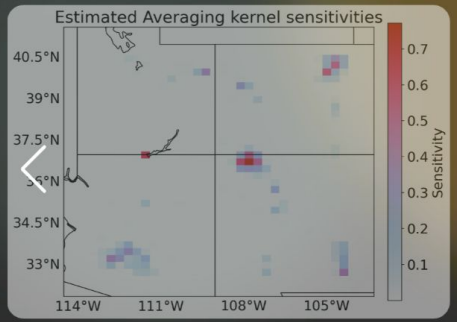
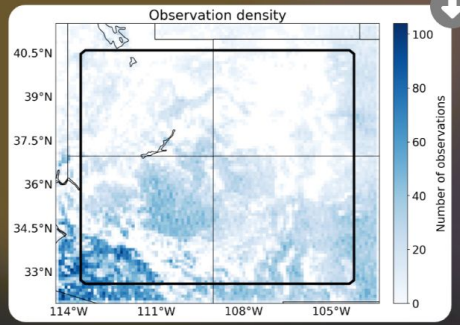
Home | Resources | View User Runs | My Data | Submit Inversion + | JT

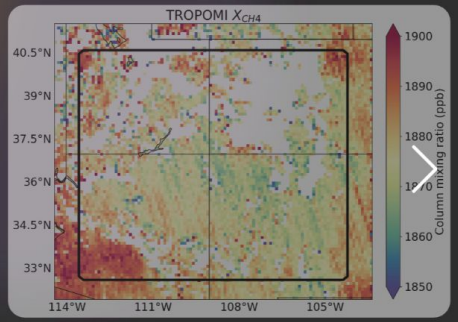
{ Four Corners 2 Month }

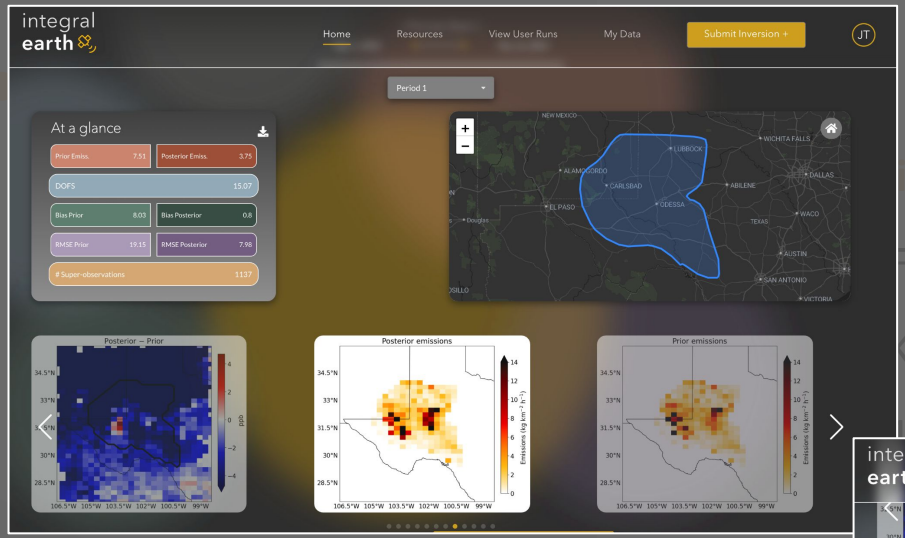
May 1, 2023 — July 1, 2023

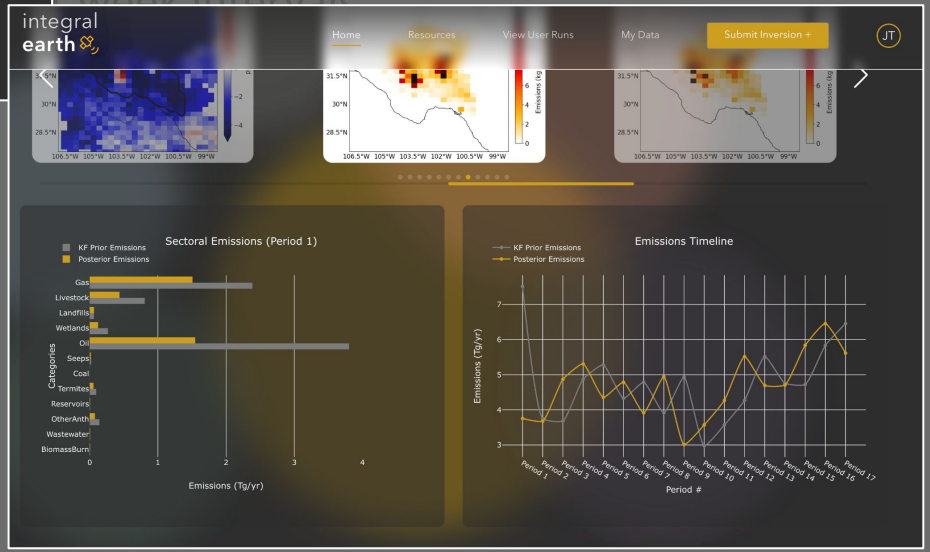
Observation Count	Estimated Cost (USD)	Prior Estimate	Expected DOFS
2442675	$65.95	1.162 Tg/yr	15.463








integral earth
Home
Resources
View User Runs
My Data
Submit Inversion +
JT
Period 1
At a glance
Prior Emiss. 7.51
Posterior Emiss. 3.75
DOFS 15.07
Bias Prior 8.03
Bias Posterior 0.8
RMSE Prior 19.15
RMSE Posterior 7.98
Super-observations 1137
Posterior – Prior
Posterior emissions
Prior emissions


integral earth
Home
Resources
View User Runs
My Data
Submit Inversion +
JT
Sectoral Emissions (Period 1)
KF Prior Emissions
Posterior Emissions
Gas
Livestock
Landfills
Wetlands
Oil
Seeps
Coal
Termites
Reservoirs
OtherAnth
Wastewater
BiomassBurn
Categories
Emissions (Tg/yr)
Emissions Timeline
Period #

- Prod

Future Developments

- Automatic monitoring
  - Hands-off long term methane quantification
- More granular job status
  - Updates at each stage of inversion process
  - More transparent process
- Customized Dashboards
  - Custom data and custom UI

Closed Beta Testing

Full Public Release

Email **integral.earth.team@gmail.com** to sign up for free beta testing access.

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integral earth

IMI

HARVARD UNIVERSITY

ATMOSPHERIC CHEMISTRY MODELING GROUP

To get more information and to access the IMI:

The IMI is openly accessible on the AWS Marketplace:

- Read the documentation at imi.readthedocs.io

Visit the IMI website: integratedmethaneinversion.github.io

Reach out with questions to: **integrated-methane-inversion@g.harvard.edu**

Contact the IMI team:

- Daniel Jacob (djacob@fas.harvard.edu, IMI Principal Investigator)
- Daniel Varon (danielvaron@g.harvard.edu, IMI Co-Principal Investigator)
- Lucas Estrada (lestrada@g.harvard.edu, IMI Lead Developer)
- Melissa Sulprizio (mpayer@seas.harvard.edu, Software Engineer)
- John Thomas (johnthomas@g.harvard.edu, IE Lead Developer)
- Mira Nagarajan (mnagarajan@mba2026.hbs.edu, IE Business Consultant)