Addressing Science and Policy Needs with Community Emissions Efforts

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GEIA Global Emissions InitiAtive

ECCAD emissions of atmospheric compounds : compilation of ancillary data

CIERA Community Initiative for Emissions Research and Applications

Acknowledgements

Global Emissions InitiAtive

http://www.geiacenter.org/

Leonor Tarrasón *(Chair)*, Gregory Frost *(Chair)*, Beatriz Cardenas, Hugo Denier van der Gon, Claire Granier *(Past Chair)*, Alex Guenther *(Past Chair)*, Greet Janssens-Maenhout, Johannes Kaiser, Terry Keating, Zbigniew Klimont, Jean-Francois Lamarque, Catherine Liousse, Paulette Middleton *(Network Manager)*, Slobodan Nickovic, Toshimasa Ohara, Martin Schultz, Ute Skiba, John van Aardenne, Yuxuan Wang

Emissions of atmospheric Compounds & Compilation of Ancillary Data

Claire Granier, Catherine Liousse, Sabine Darras, Aude Mieville, Vincent Pignot

http://ether.ipsl.jussieu.fr/eccad

Community Initiative for Emissions Research and Applications

http://ciera-air.org/

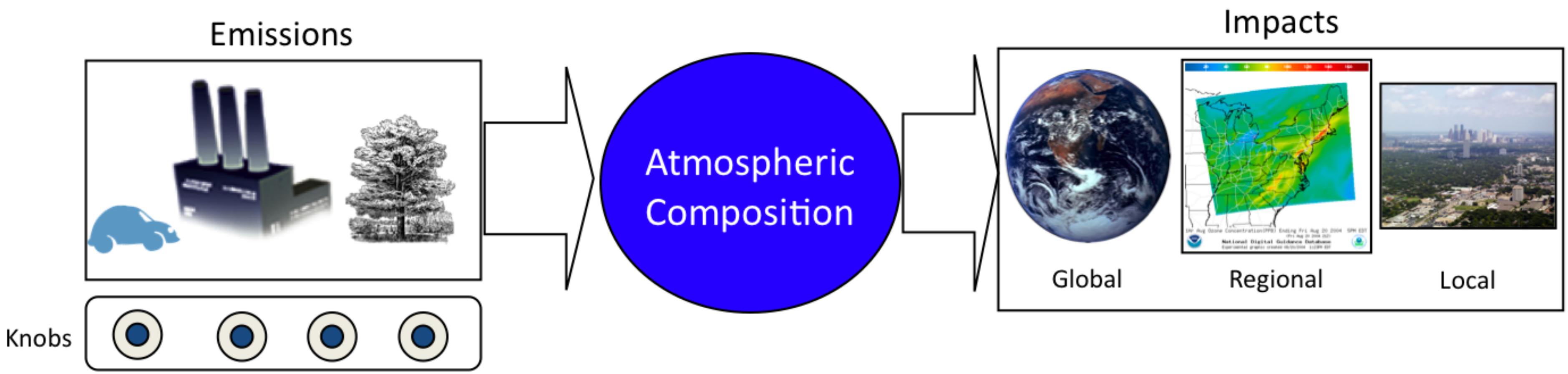
Gregory Frost, Stefan Falke, Claire Granier, Ann Keane, Terry Keating, Jean-François Lamarque, Megan Melamed, Paulette Middleton, Gabrielle Pétron, Steven Smith

Outline

- Emissions information challenges
  - ➢ Global and regional examples
- Emissions evaluations and approaches
  - ➢ Examples of top-down evaluations
- Overview of community emissions efforts
  - ➢ GEIA
  - ➢ ECCAD
  - ➢ CIERA

Motivation for Understanding Emissions

Actions and decisions about the atmosphere focus on emissions



Quantitative emission information is needed for:

- Accounting for the past
- Observing and calculating the present
- Predicting and projecting the future
- Taking action on emissions
- Making choices: Which "knob" to turn? Is one better than the other?

➢ **Do current emissions data meet our needs?**

➢ **How can these data be improved while maximizing sparse resources?**

Emissions Information Challenges





Many emissions data requirements are common to air quality and climate research, regulation, & policy

- Transparency
- Consistency
- Accuracy
- Timeliness
- Uncertainty

At the same time, there are many issues and needs associated with emissions data

Complexity

- Spatial/temporal scales
- Source types
- Interdisciplinary

Development

- Inconsistencies
- Timeliness
- Traceability

Analysis

- Evaluations
- Uncertainties
- Impacts

Communication

- Data access and sharing
- Literature access
- Producer – user feedbacks

Frost et al., Atmos. Environ., 2012

Bottom-up Inventory Methodology

Inventories are an amalgam of calculations and measurements

Total mass emissions of compound X → $E_X = \Sigma_S \, [EF_{X,S} \bullet A_S \bullet (1 - CE_{X,S})]$

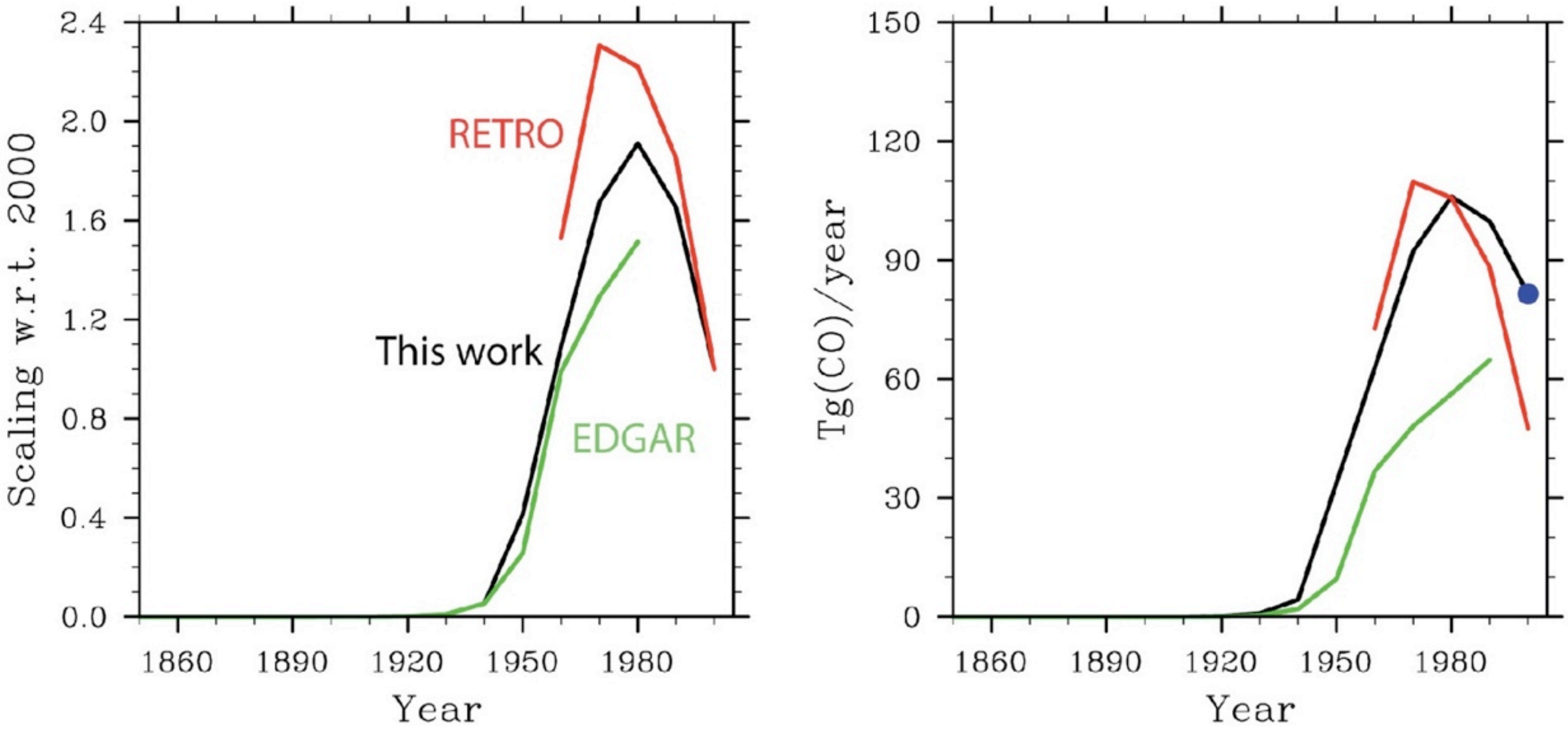
Sum up all sources S	**Emissions factor** = mass of compound X emitted by source S per unit activity; "representative" measm'ts or estimated	**Activity of source S**, e.g., amount of fuel burned, vehicle miles driven, etc.; measured or estimated	**Effectiveness of control measures** for cmpd X at source S; estimated or "representative" measm'ts

Above calculation carried out over a particular geographic region (usually national scale, or state/county) for a specific time period (usually annual or monthly)

Additional steps usually needed to use inventory in modeling or analysis

- ***Spatial Allocation***: gridding, spatial scaling
- ***Temporal Variability:*** between and subdivisions of inventory periods
- ***Temporal Extrapolation:*** projections, scenarios
- ***Speciation:*** VOCs, PM, …

Inconsistencies in Global Inventories



ACCMIP Emissions for IPCC AR5

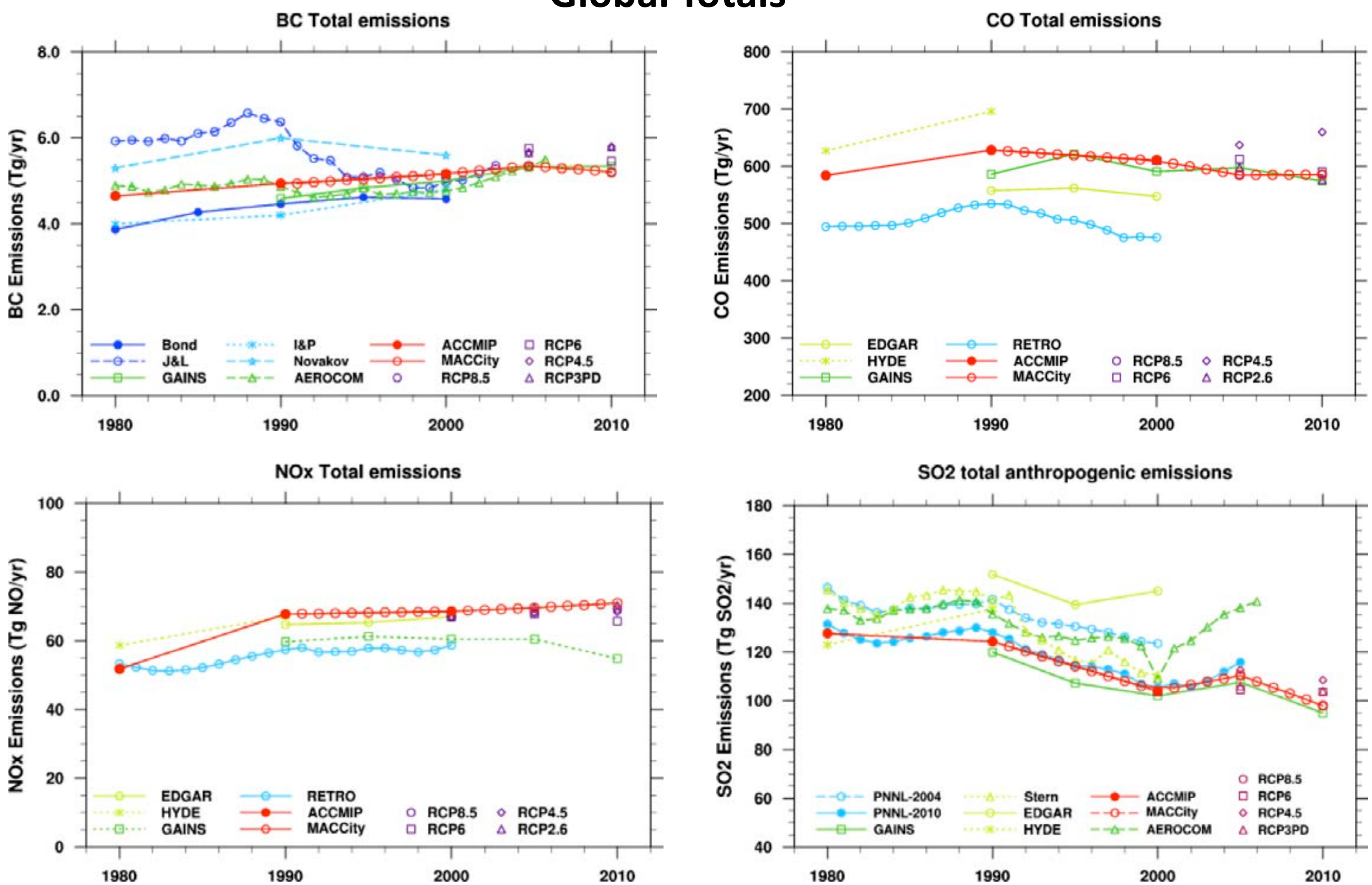
- IPCC 5th Assessment work in progress
- Needed consistent 1850-2000 inventory
- 2000: Scenarios begin
- Different initial inventories give different emissions estimates
- Reconciliation necessary

Lamarque et al., ACP, 2010

Global Inventory Comparisons

Global inventories developed around the world show large differences for most pollutants *(see previous talk)*

Global Totals



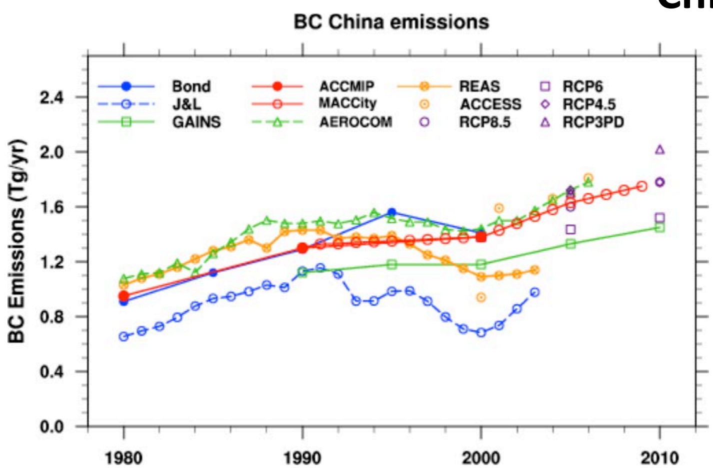
Granier et al., Clim. Change, 2011

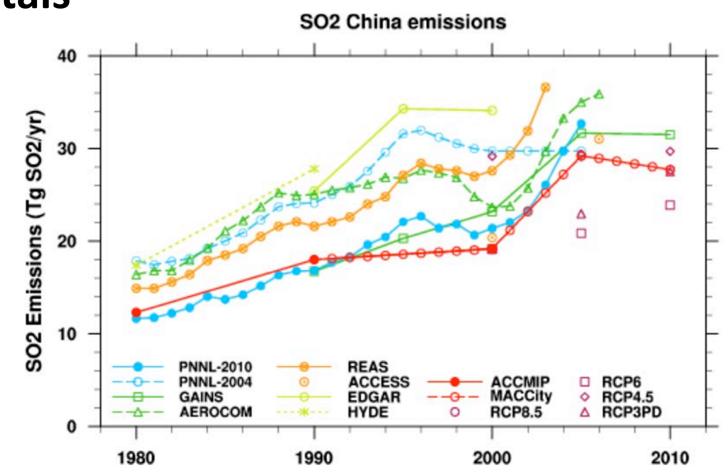
Regional Inventory Comparisons

Regional inventories show even larger differences for some pollutants

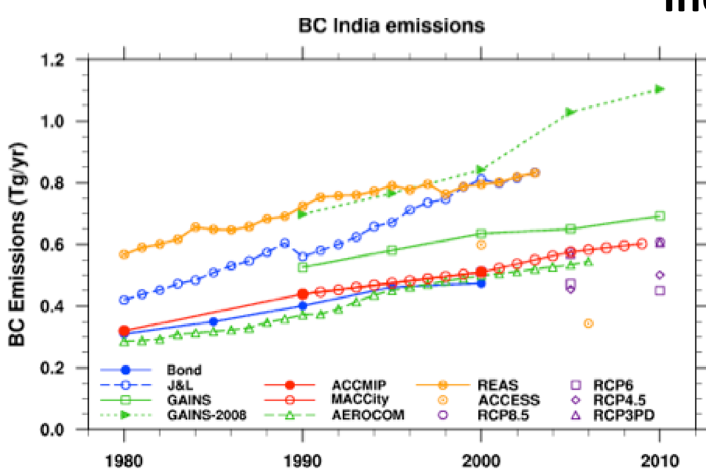
(see previous talk)

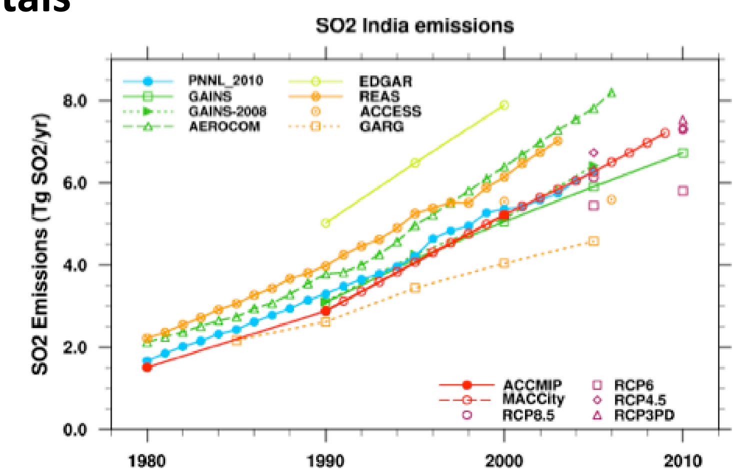
China Totals





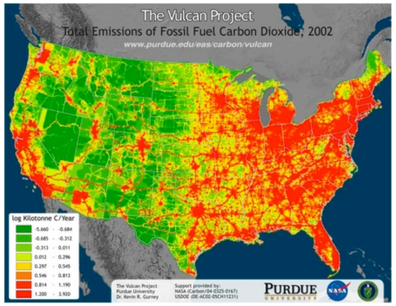
India Totals





Granier et al., Clim. Change, 2011

Emissions Evaluations and Approaches



Inventories

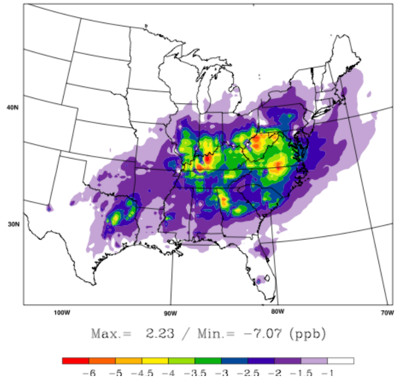
- Consistent inventories for all pollutants relevant to air quality and climate more common
- Alternative hybrid inventory methods now available

Inventories + Observations

- Combination of observing platforms provide data useful for emissions evaluations
- Evaluate inventories using observations
  - Relative and absolute fluxes of pollutants
  - Spatial distributions of emissions
  - Temporal variability
  - Speciation

Inventories + Observations + Models

- Direct and inverse models aid emissions evaluations
- Models needed to understand AQ/climate impacts of emissions changes and feedbacks



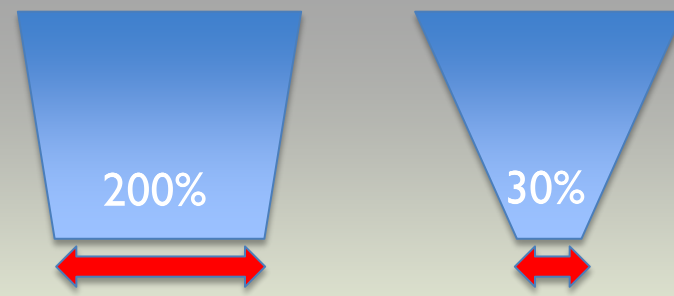
Frost et al., Atmos. Environ., 2012

Top-Down vs. Bottom-Up Emissions Approaches

Top-Down

Research atmospheric measurements and modeling

- Sector specific
- Time specific
- Speciated
- Regional or global scales
- Wide range of uncertainties

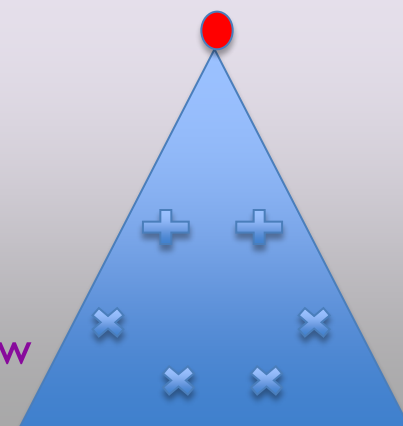


Relies on high quality atmospheric measurements of trace gas enhancements and measurements or modeling of the atmosphere mixing and wind characteristics

Bottom-Up

Regulatory or research emissions inventories

- Sector specific/process specific
- Time specific
- Not always speciated (total VOCs)
- Regional or global scales
- Uncertainty estimates usually non-existent or low
- Rarely up-to-date



Relies on high quality activity data (routine and non routine), emissions factors, estimates of control effectiveness …

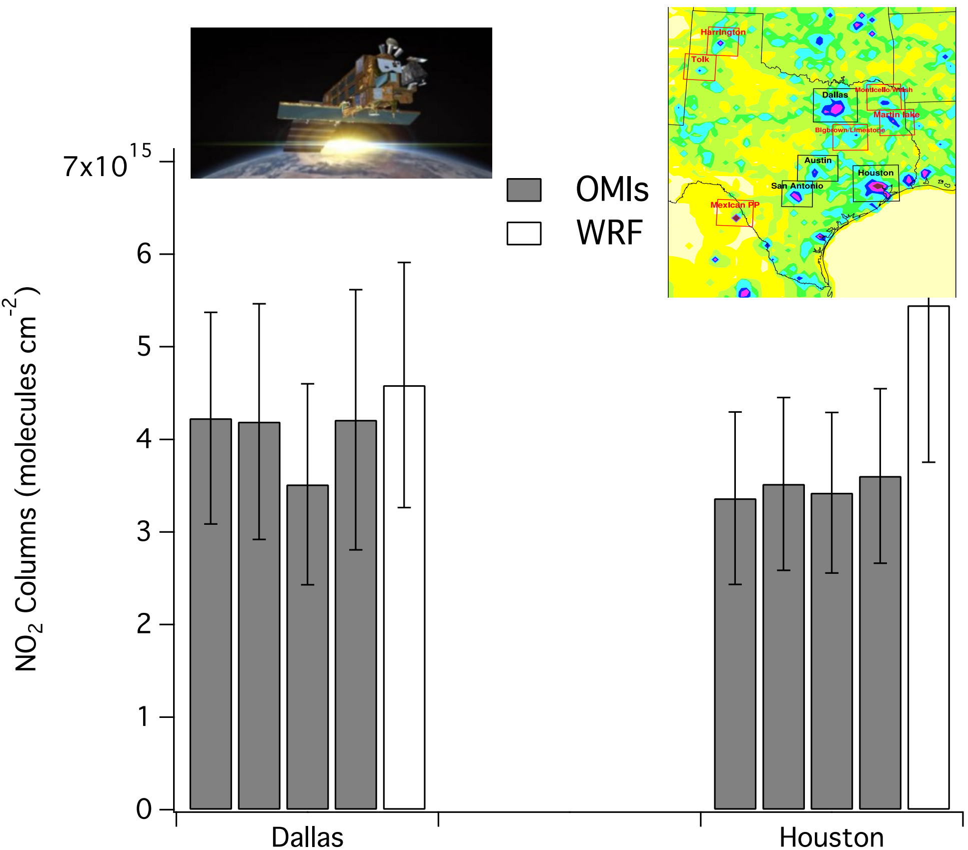
G. Pétron, 2012

Inventories Evaluated by Satellite and Aircraft Data

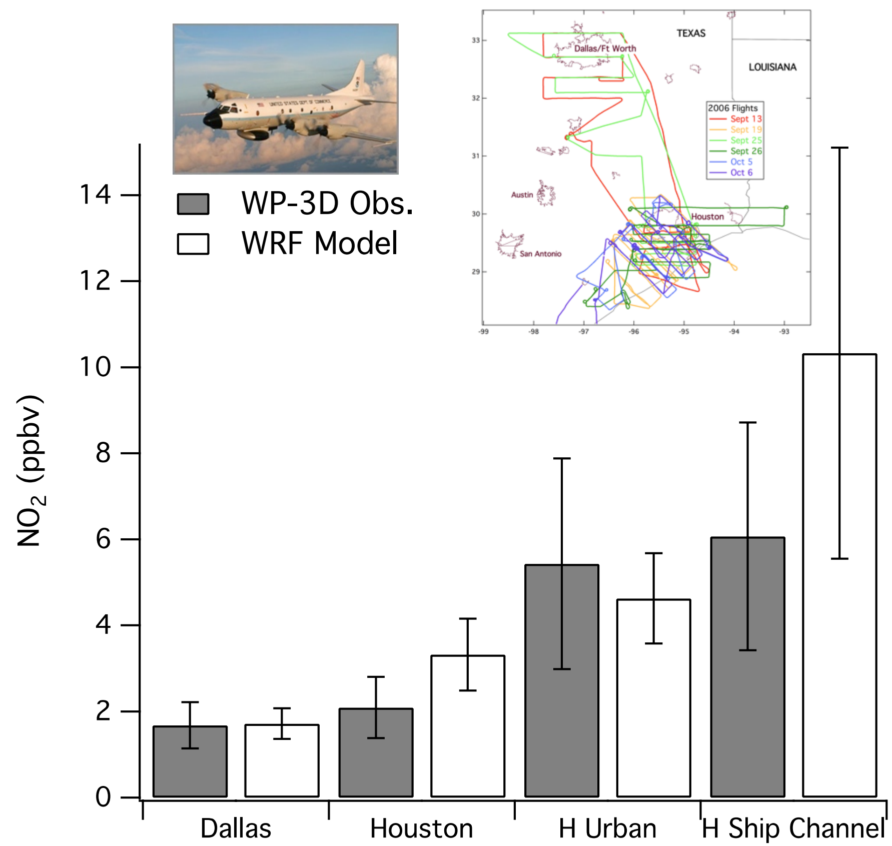
Dallas & Houston NO_x emissions

- Observations consistent with NEI urban NOx emissions when onroad sources dominate
- Top-down analysis highlights NEI biases in industrial point & in-port shipping sources

Satellite (OMIs) vs. Model (WRF/Chem) NO_2



Aircraft (WP-3D) vs. Model (WRF/Chem) NO_2

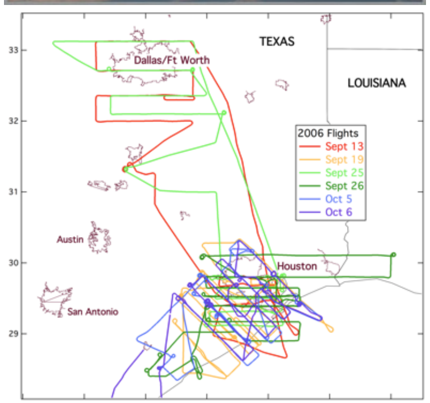


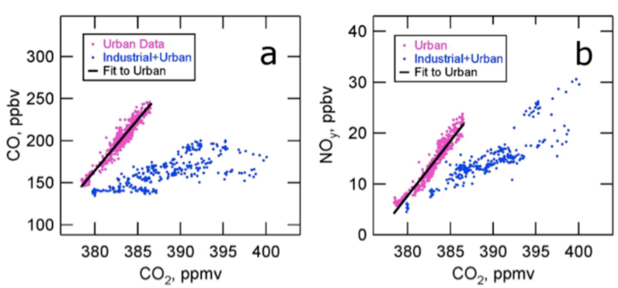
S.-W. Kim et al., Atmos. Chem. Phys., 2011

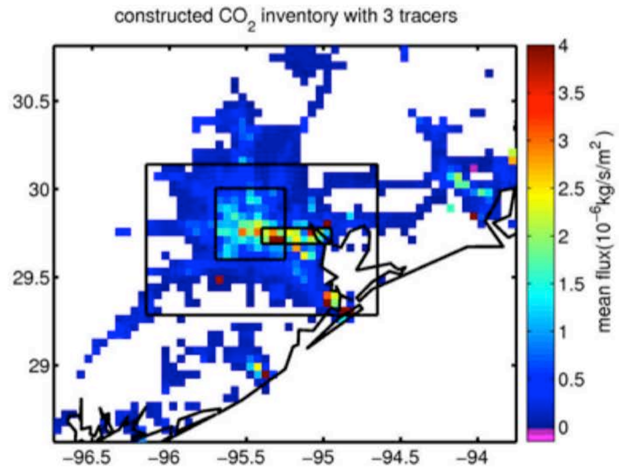
Inverse Modeling of Emissions Using Aircraft Data

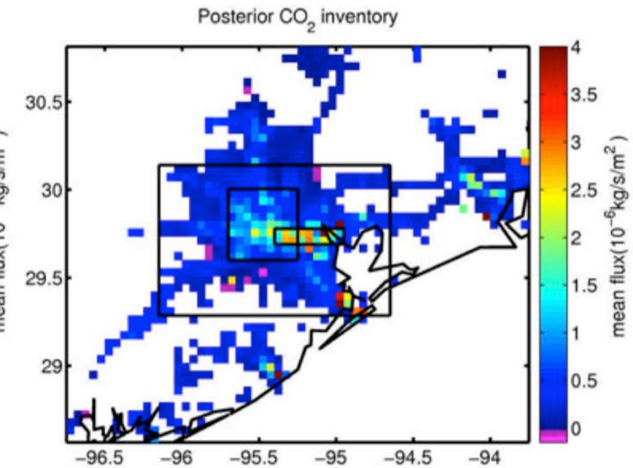
Houston fossil-fuel CO_2 emissions calculated without a prior

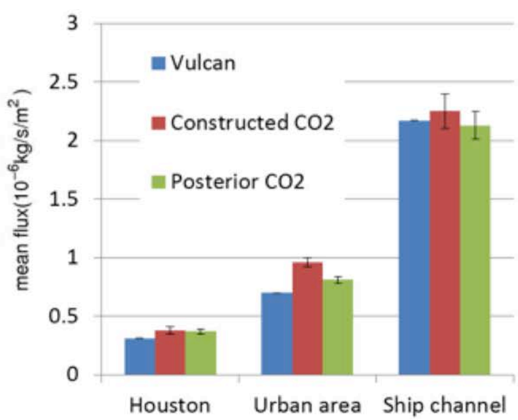
Inverse modeling using correlated observations of combustion tracers (CO, NOx, SO2, CO_2) allows estimate of CO_2 emissions without the use of an explicitCO_2 inventory

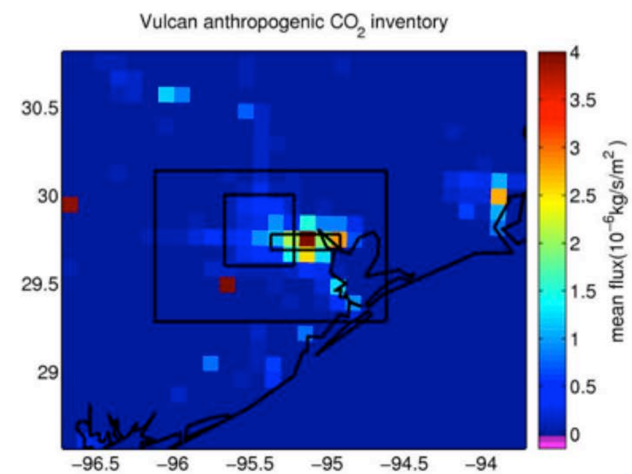








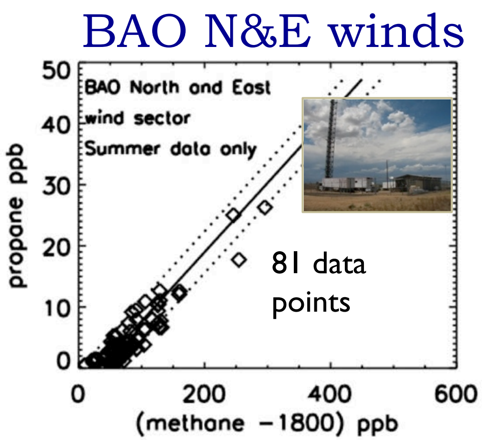


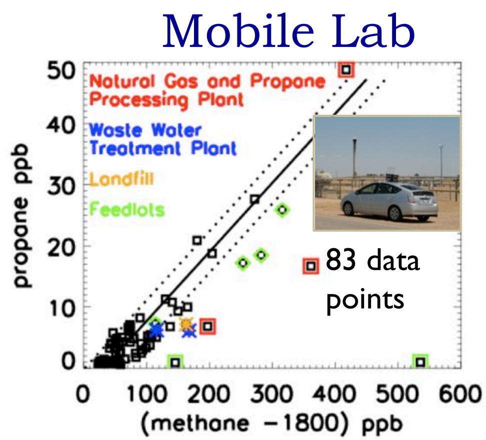


J. Brioude et al., J. Geophys. Res., 2012

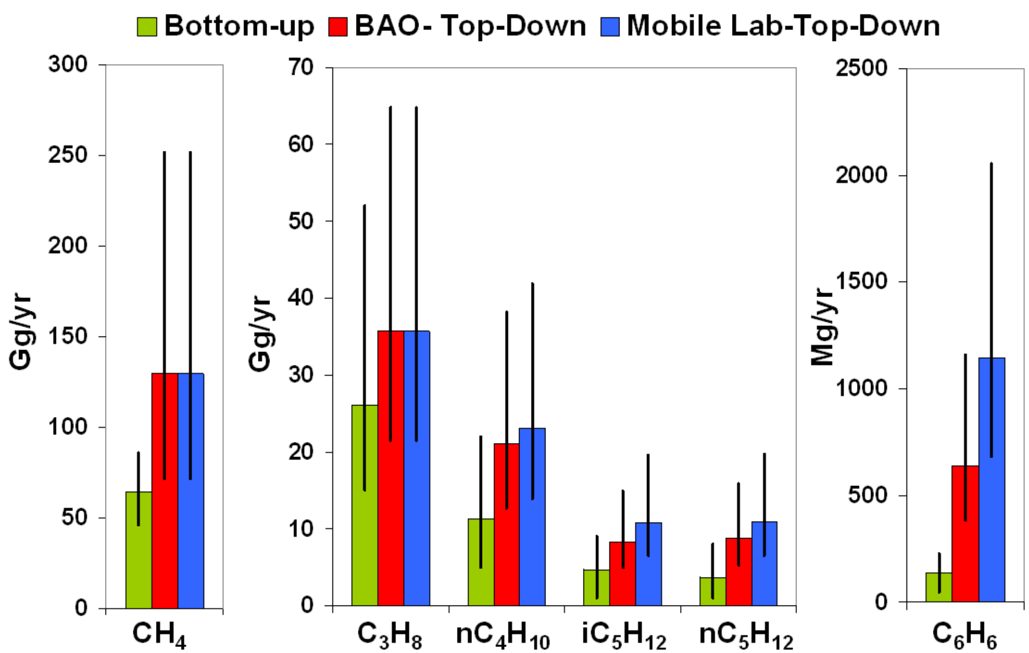
Emissions Inferred from Tower and Mobile Sampling

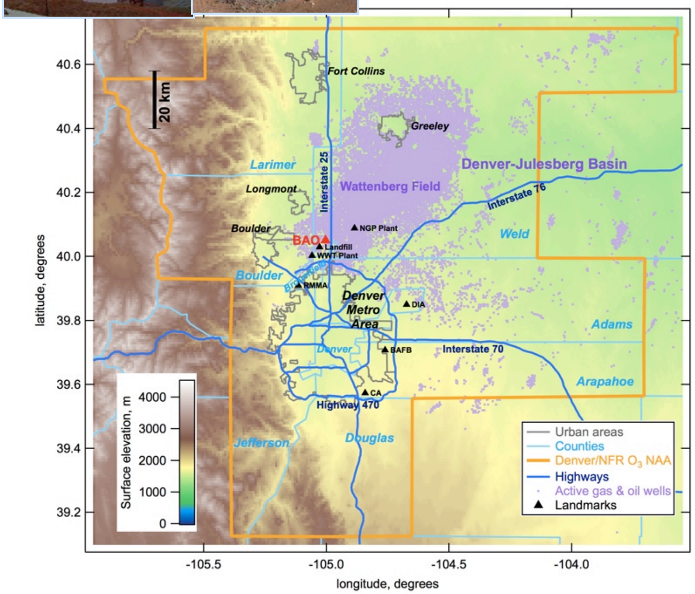
Inferred natural gas CH_4 leak rates in Colorado





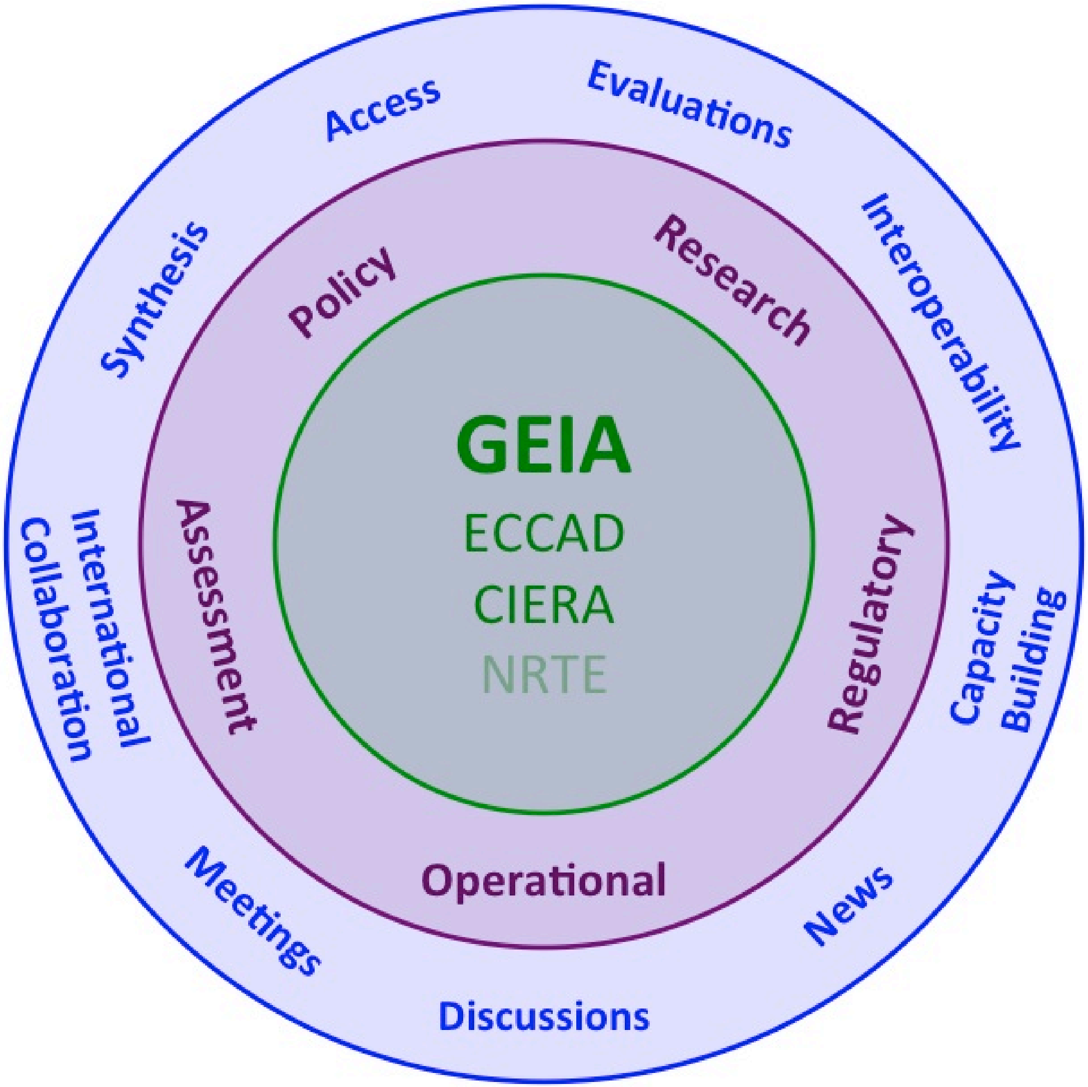
Atmospheric observations point to inventory underestimates of hydrocarbon leakage from production in Colorado oil & natural gas basin





Pétron et al., JGR, 2012

GEIA Communities & Functions



Bringing together people, data and tools to create the highest quality information on global exchange processes

GEIA

Global Emissions InitiAtive

http://www.geiacenter.org/

IGBP/IGAC/iLEAPS/AIMES initiative

Mission since 1990

- Quantify anthropogenic emissions & natural exchanges of trace gases & aerosols
- Facilitate use of this information by research, assessment, & policy communities

Ongoing Activities

- Provide consistent access to global and regional emission inventories
- Organize meetings & schools for inventory developers and users
- Facilitate emissions data evaluations and assessments
- Prepare state-of-the-science emissions summaries
- Support international scientific projects

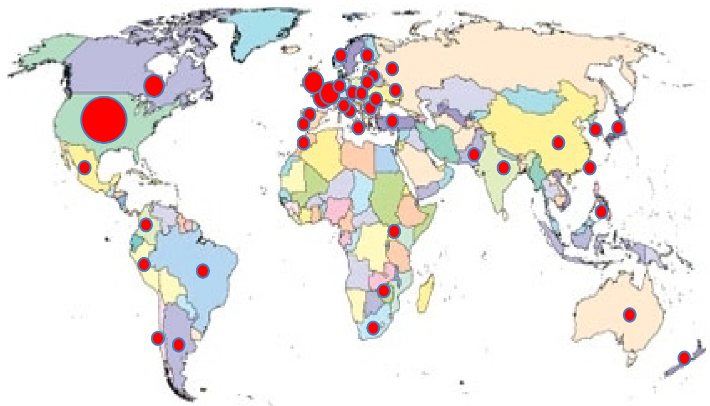
New Directions

Demonstrate potential of improving inventories

- Promote interoperability of datasets & tools
- Make use of near-real-time observations

Funding: NASA, EU programs
Current chairs: Greg Frost, Leonor Tarrasón
Past chairs: Claire Granier, Alex Guenther
Network manager: Paulette Middleton
Steering Committee: Newly formed in 2012

GEIA Network



~1300 data developers and users

GEIA Steering Committee, 2012-2014

Leonor Tarrasón *(Chair)*	NILU, Norway
Gregory Frost *(Chair)*	NOAA & Univ Colorado, USA
Beatriz Cardenas	INE, Mexico
Hugo Denier van der Gon	TNO, The Netherlands
Claire Granier *(Past Chair)*	CNRS & UPMC, France
Alex Guenther *(Past Chair)*	NCAR, USA
Greet Janssens-Maenhout	JRC, Italy
Johannes Kaiser	ECMWF, UK
Terry Keating	EPA, USA
Zbigniew Klimont	IIASA, Austria
Jean-Francois Lamarque	NCAR, USA
Catherine Liousse	Laboratoire d'Aérologie, France
Paulette Middleton *(Network Manager)*	Panorama Pathways, USA
Slobodan Nickovic	WMO, Switzerland
Toshimasa Ohara	NIES, Japan
Martin Schultz	FZ Jülich, Germany
Ute Skiba	CEH, UK
John van Aardenne	EEA, Denmark
Yuxuan Wang	Tsinghua University, China

ECCAD

http://ether.ipsl.jussieu.fr/eccad

Emissions of chemical Compounds & Compilation of Ancillary Data

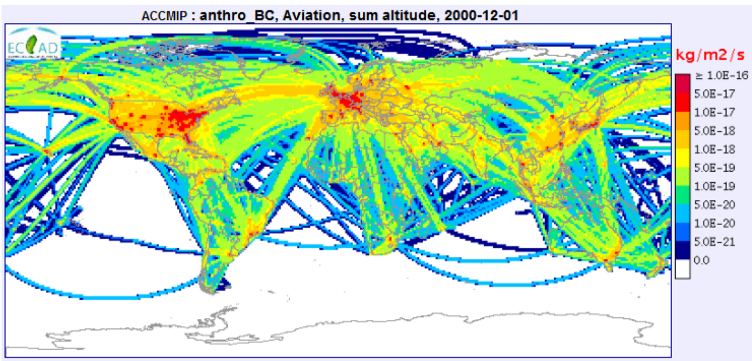
GEIA's new interactive emissions data portal

Consistent access to GEIA's inventories and ancillary data with easy-to-use tools

Supports EU science & forecasting projects

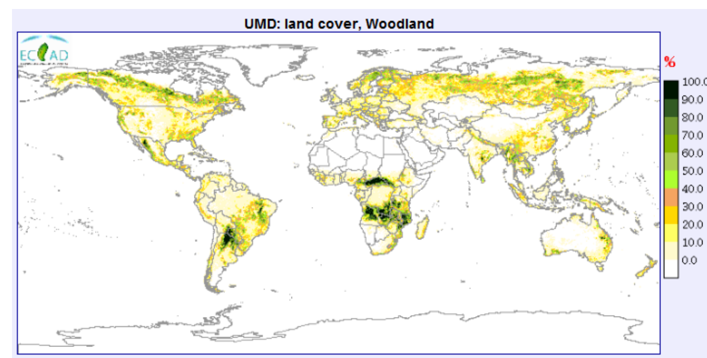
Funding: French National Center for Space Studies

PIs: Claire Granier, Cathy Liousse



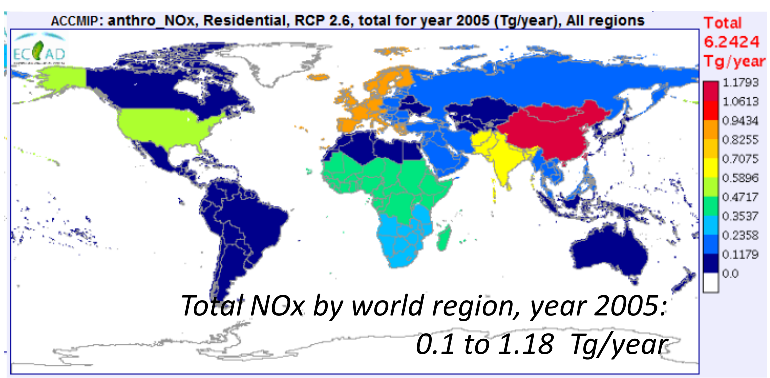
Emissions Inventories

Relational database with all inventories previously in GEIA and most recent global and regional inventories



Ancillary Data

Access to ancillary data used to construct emissions inventories: population, vegetation, & fire data

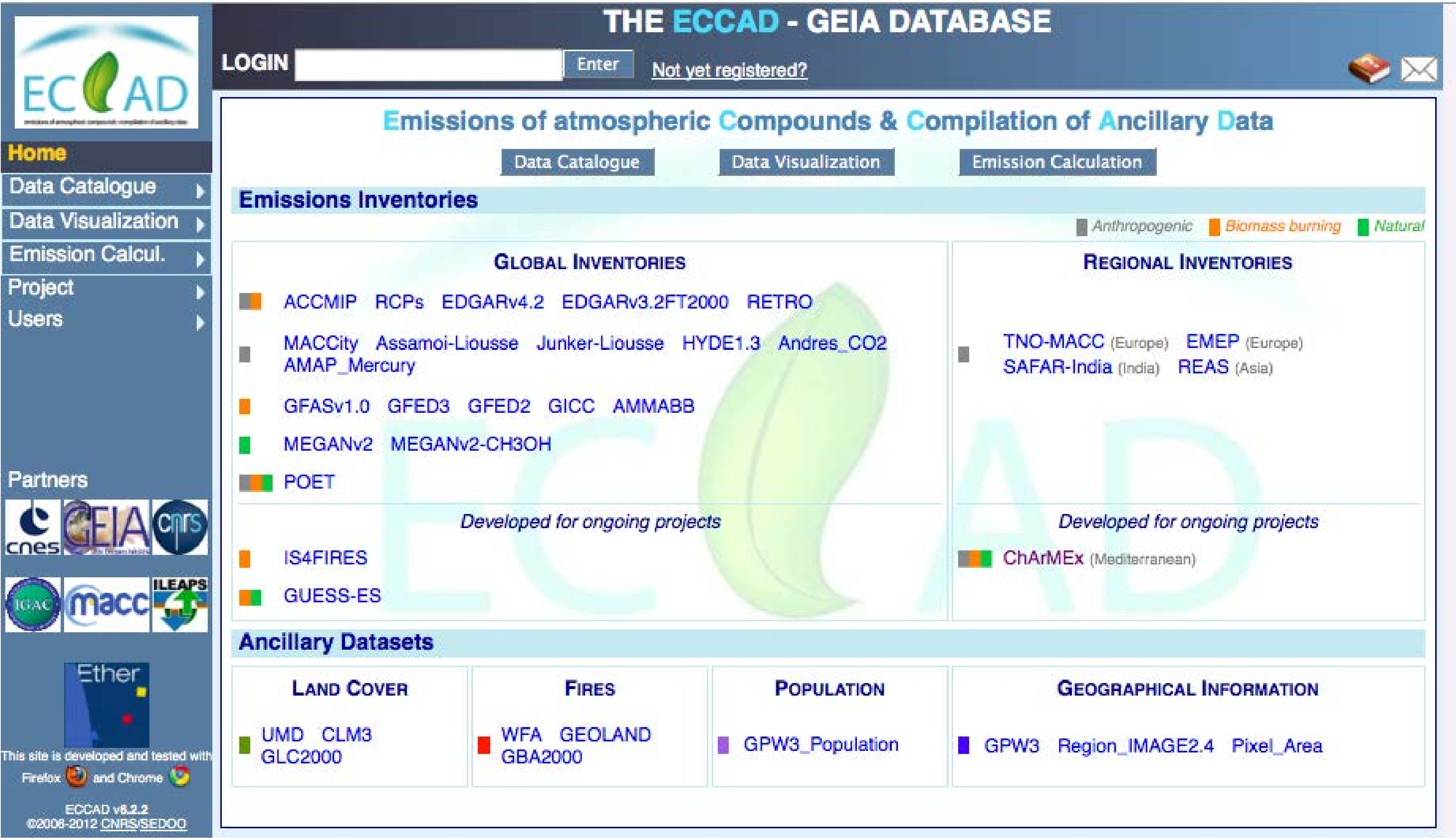


Total NOx by world region, year 2005: 0.1 to 1.18 Tg/year

Interactive Graphical Tools

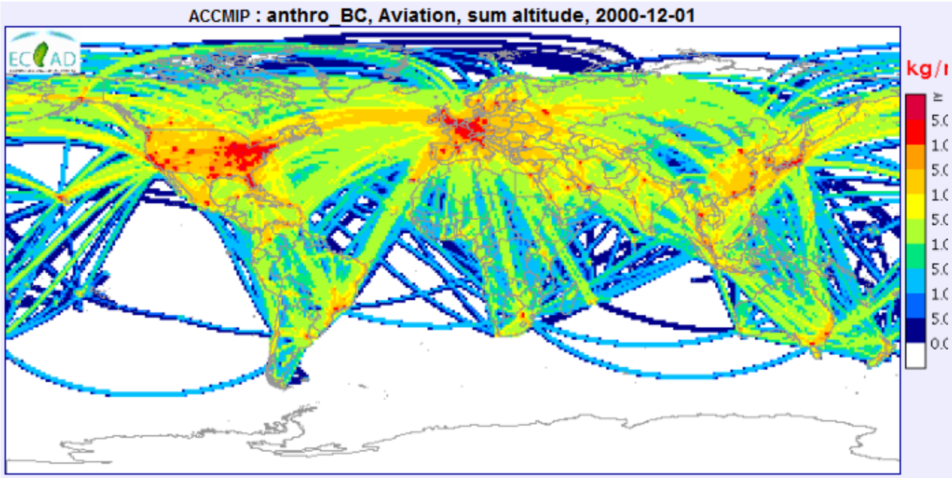
Online maps, time series, and data analysis

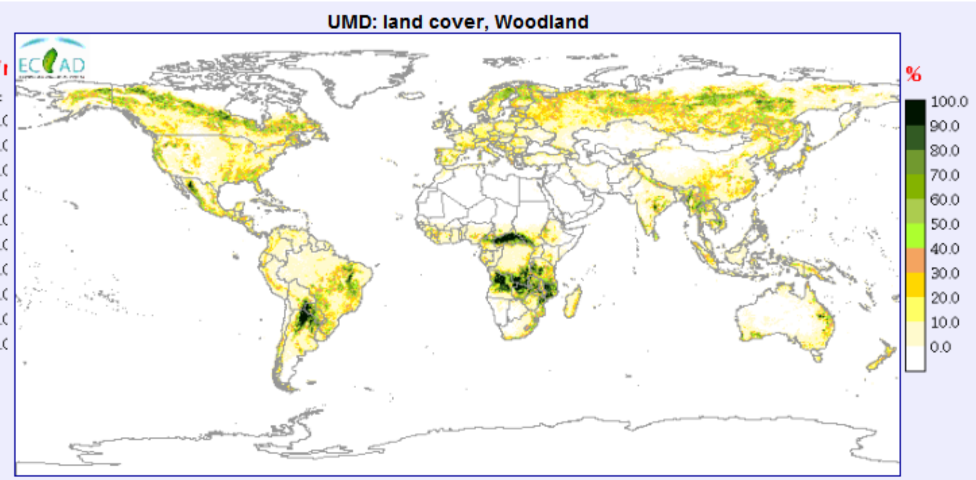
ECCAD Datasets



http://ether.ipsl.jussieu.fr/eccad

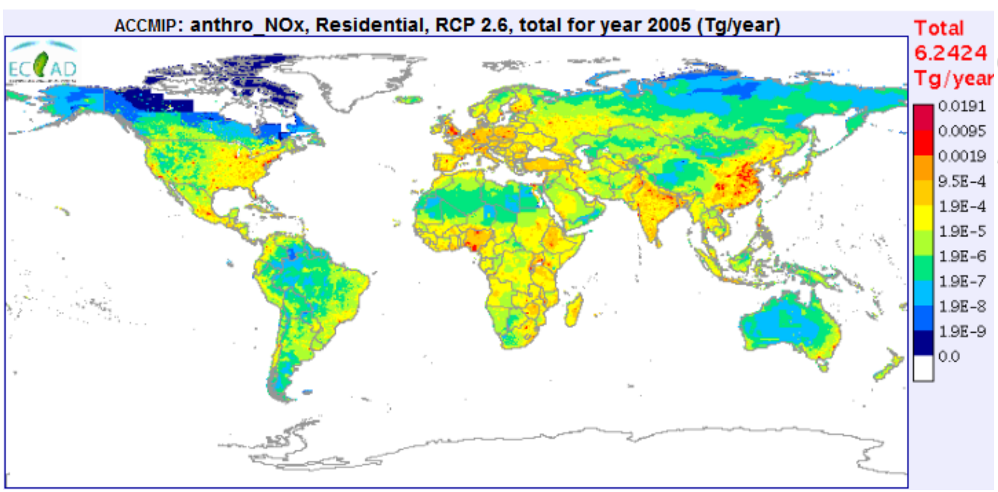
ECCAD Maps & Tools



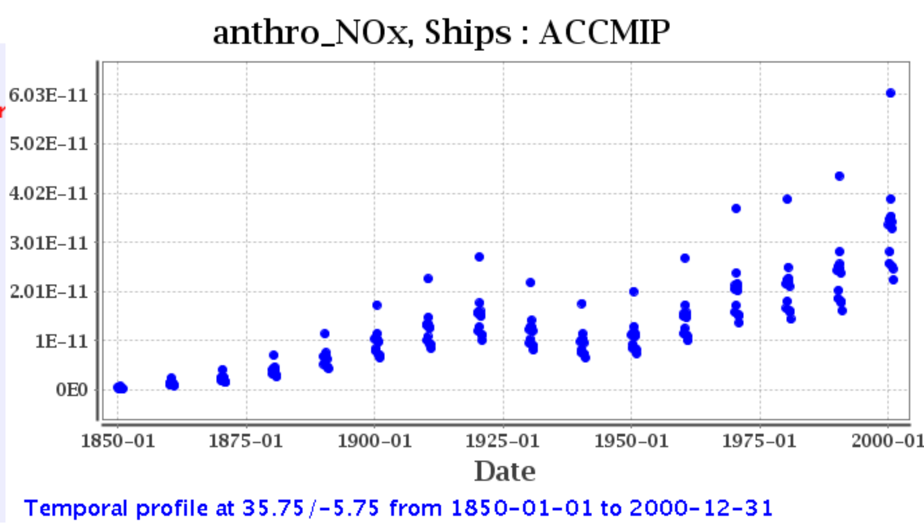


Global Totals

NOx, Residential, year 2005: 6.24 Tg/year



NOx, ships, 1850 to 2000, over strait of Gibraltar



http://ether.ipsl.jussieu.fr/eccad

CIERA

http://ciera-air.org/

Community Initiative for Emissions Research and Applications

Holistic community effort to improve emissions information

GEIA's new emissions collaboration space

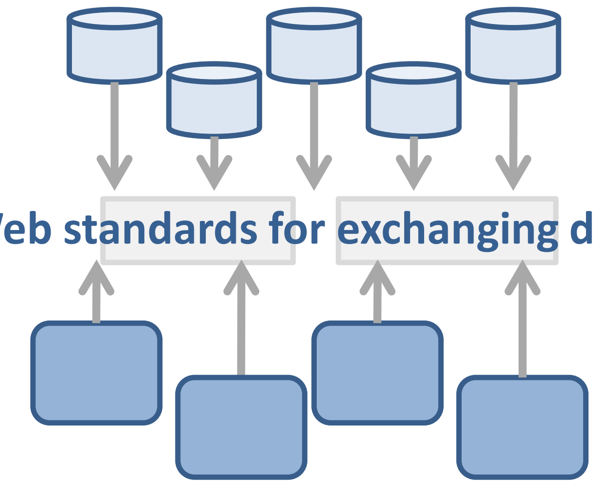
- Developing interoperability
- Facilitating evaluations
- Innovating in communication
- Community developed and driven

Emissions information resources

- Sharing analyses
- Blogs and web forums
- Emissions bibliography
- Emissions lexicon

Distributed Emissions Data System

Inventories, observations, model output

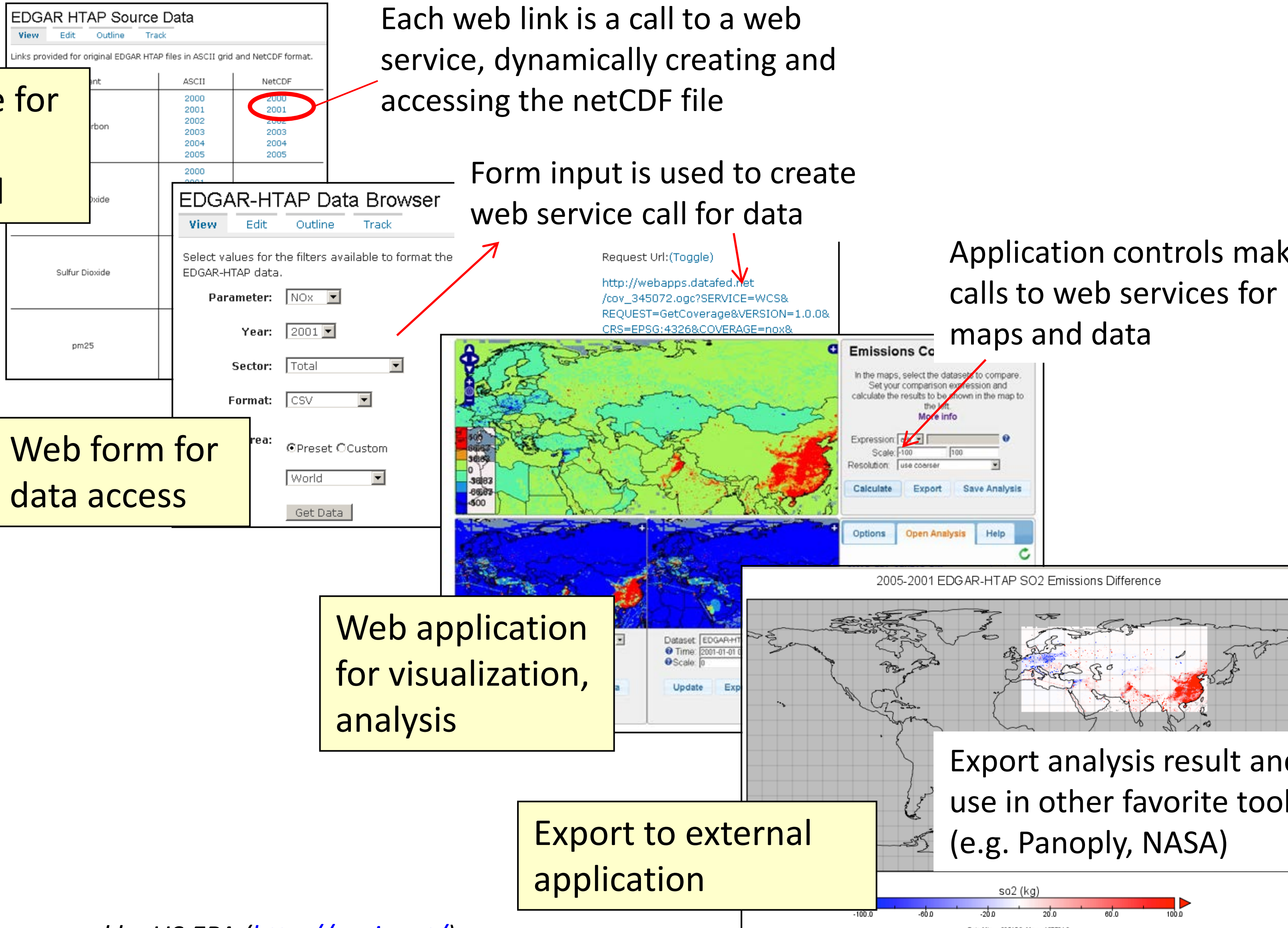


Standardized tools to visualize, analyze data

Support: EPA, NOAA, ESIP
Working Group: Greg Frost, Stefan Falke, Claire Granier, Ann Keane, Terry Keating, Jean-François Lamarque, Megan Melamed, Paulette Middleton, Gabrielle Pétron, Steven Smith

CIERA - Using Emissions Web Services

Standardized web service access to emissions data allow them to be used in online tools



Web page for data file download

Each web link is a call to a web service, dynamically creating and accessing the netCDF file

Form input is used to create web service call for data

Application controls make calls to web services for maps and data

Web form for data access

Web application for visualization, analysis

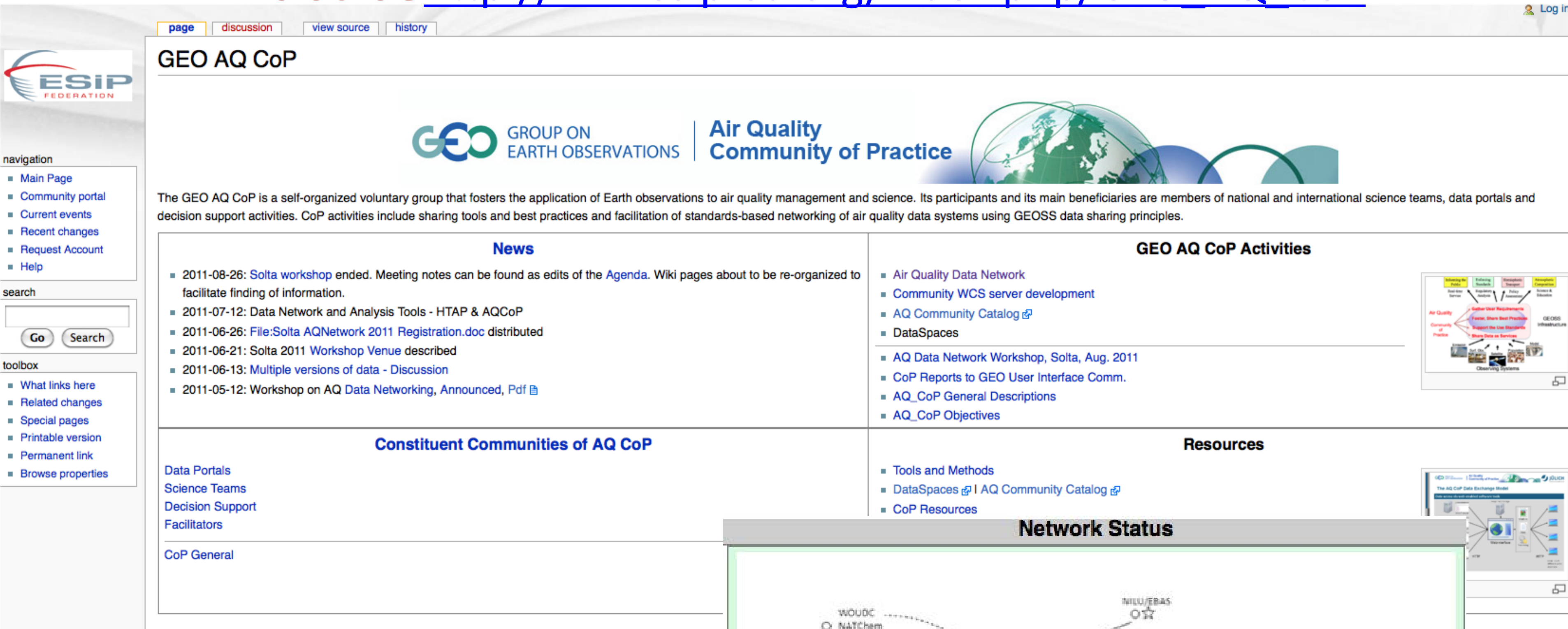
Export analysis result and use in other favorite tools (e.g. Panoply, NASA)

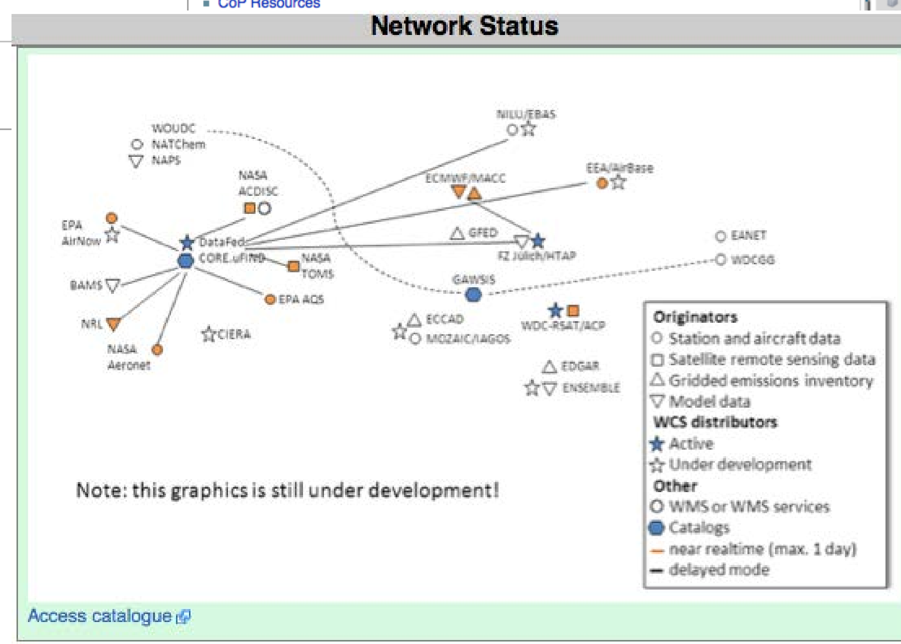
Export to external application

Development sponsored by US EPA (http://cyair.net/)

Hosted by Federation of Earth Science Information Partners (http://esipfed.org/)

Air Quality Community of Practice http://wiki.esipfed.org/index.php/GEO_AQ_CoP





CIERA is part of AQ CoP, an international community of data providers working on

- Common data structures
- Data standards & conventions
- Standardized tools

GEIA Strategic Planning

GEIA is formulating a strategic plan for the next 5+ years, based on feedback from our 2012 GEIA Conference Town Hall and Steering Committee meetings.

Proposed GEIA focus areas:

1. Cross-regional Collaboration
    - Building stronger links to emerging nations
2. Links to Regulatory Community
    - Working closer with regulatory community to establish priority needs
    - Determining how science community can better help meet those needs
3. Capacity Building
    - Synthesizing the science and what it means
    - Recommending best practices
    - Providing access to relevant data
    - Exposing new techniques
    - Facilitating evaluations and assessments
4. Interoperability of Databases
    - Improving access to inventories, observations, and models

Take-Home Messages

- High quality emissions information is critical to understanding the atmosphere and making good decisions about how to manage it
- Bottom-up methodologies are integral to these efforts, but there are challenges associated with these complex datasets
- Top-down methods based on observations and modeling provide alternative approaches to understanding emissions
- Community emissions efforts seek to bring together people, data and tools to provide the best information on emissions
- The research and regulatory communities need to work together for these emissions efforts to succeed
    - ➢ *Please contact the GEIA, ECCAD, & CIERA teams!*

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