Emissions for Global Modeling - Trends and Uncertainties

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- Motivation and Methods
- Global/Regional Inventory Comparisons
- Community Historic Emissions Efforts
- GEIA and ECCAD

Acknowledgements

C. Granier, I. Bouarar, S. Darras, H. Denier van der Gon, T. Doumbia, M. Gauss, G. Janssens-Maenhout, T. Keating, Z. Klimont, J.I Kurokawa, J.F. Lamarque, C. Liousse, P. Middleton, A. Mieville, T. Ohara, K. Sindelarova, S. Smith, L. Tarrason, Q. Zhang

Motivations for Understanding Emissions

Actions and decisions about the atmosphere focus on emissions.

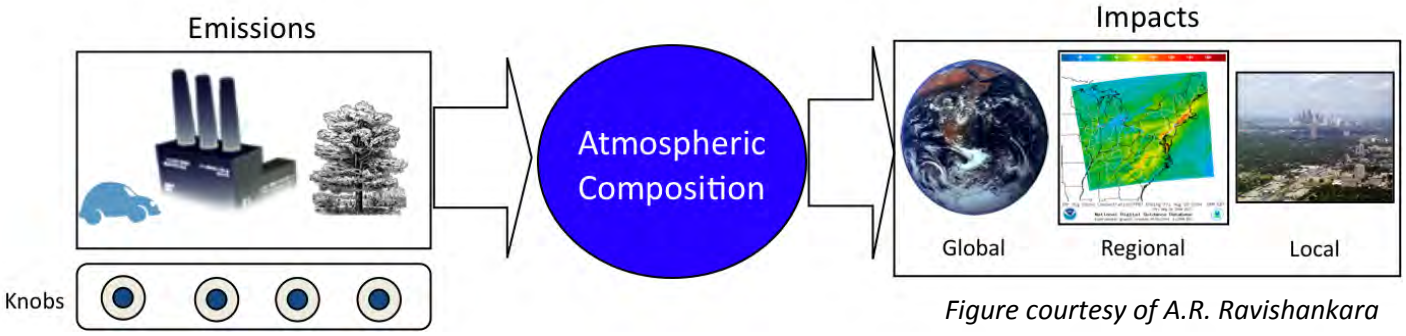


Figure courtesy of A.R. Ravishankara

Accurate emissions information is needed for many purposes.

- *Quantify and predict*
- *Understand changes*
- *Make choices*
- *Evaluate mitigation*
- *Demonstrate compliance*

This is the Century of Accountability.
David Fahey

Societal development and scientific innovation result in new challenges in emissions understanding.

- *Dynamic economies*
- *Changing demographics*
- *Evolving land use*
- *Emerging energy sources*
- *New measurements*
- *Better process descriptions*
- *Improved models*

Stakeholders and decision-makers have common requirements for emissions information, but challenges with emissions information persist.

- *Transparency*
- *Consistency*
- *Accuracy*
- *Timeliness*
- *Uncertainty*
- *Complexity*
- *Development*
- *Analysis*
- *Communication*

G. J. Frost et al., Atmos. Environ., 2012 & 2013

Bottom-Up Inventory Methods

Total mass of compound X emitted

$$E_X = \sum_S [EF_{X,S} \bullet A_S \bullet (1 - CE_{X,S})]$$

Sum up all sources S

Emissions factor = mass of compound X emitted by source S per unit activity

Activity of source S, e.g., amount of fuel burned

Effectiveness of control measures for compound X at source S

Calculated for…
Specific region
Specific time
Also need…
Spatial allocation
Temporal variation
Speciation

Example: On-road motor vehicles

Vehicle fleet

Fuel type

Control technology

Emissions source

Fuel economy

Vehicle condition

Road type

Distance driven

Vehicle load

Global/Regional Inventory Comparisons

- Update of C. Granier et al., *Climatic Change*, 2011
- Only public anthropogenic emissions datasets considered
- SO2, BC, OC, PM2.5/10 discussed here; CO, NOx, VOCs also analyzed
- Global Datasets:
  - MACCity (1980-2010) ≈ AEROCOM-II (Community dataset; Granier et al., Clim Chg, 2011)
  - EDGARv3 (2000), EDGAR v4.2 (1970-2008), HTAPv2 (2008) (JRC, Italy)
  - ECLIPSE FP7 project (2005 and 2010) (IIASA, Austria)
  - PNNL – SO2 (PNNL, USA)
  - Bond (U Illinois, USA)
  - Junker-Liousse (Laboratoire d'Aérologie, France)
  - RCPs (CMIP5 & IPCC AR5 activities)
- Regional Datasets:
  - EPA NEI (1980-2010) for USA (US Environmental Protection Agency)
  - TNO-MACC, TNO-MACCII (2003-2009) for Europe (EU's MACC project)
  - EMEP for Europe (1980-2010) (European Monitoring & Evaluation Programme)
  - GAINS-GEA for Europe (2005 and 2010) (IIASA, Austria)
  - REAS and REAS-v2 for Asia (1980-2020) (NIES, Japan)
  - Lu-Streets for Asia (Argonne Natl Lab, USA & Tsinghua U, Beijing)
  - MEIC for China (2008-2010) (not yet published - Tsinghua U, China)
  - Lei for China (Lei et al., ACP 2011 - Tsinghua U, China)
  - Cao-Zhao for China (Cao et al., AE, 2006 - CAMS, Beijing; Zhao ACP 2011 - Tsinghua U, Beijing)
  - Garg for India (Garg et al., AE, 2006 - Denmark/India)
  - SAFAR for India (Sahu et al., Atmos Polln Res, 2012 – IITM, India)

NOTE:

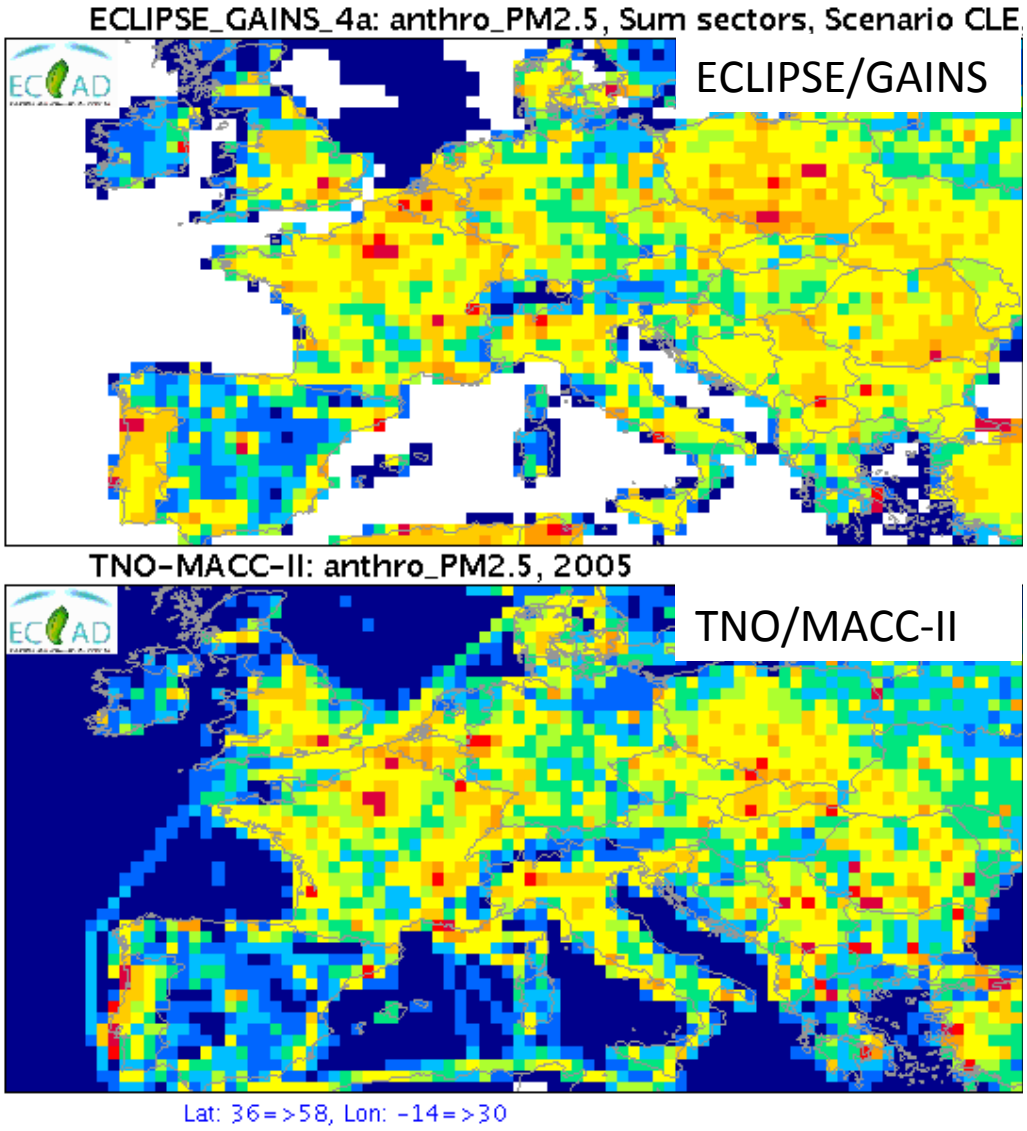
In the original presentation, 7 slides followed that showed historical inventory comparisons/ evaluations carried out by Claire Granier.

These slides contained data which have not yet been published, so the slides have been removed from the posted version of this presentation file.

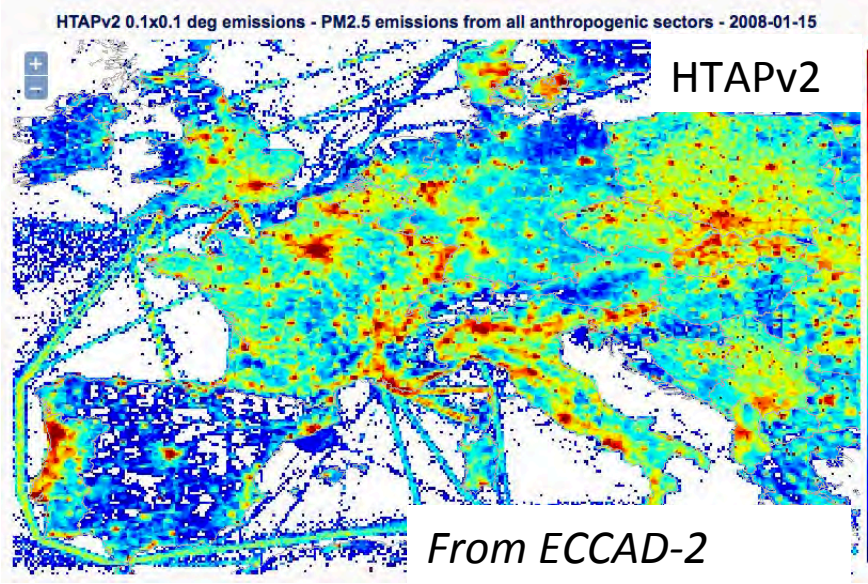
If you are interested in participating in the inventory evaluation, please contact Claire: claire.granier@latmos.ipsl.fr

Spatial Distribution of Emissions

0.5 deg x 0.5 deg resolution



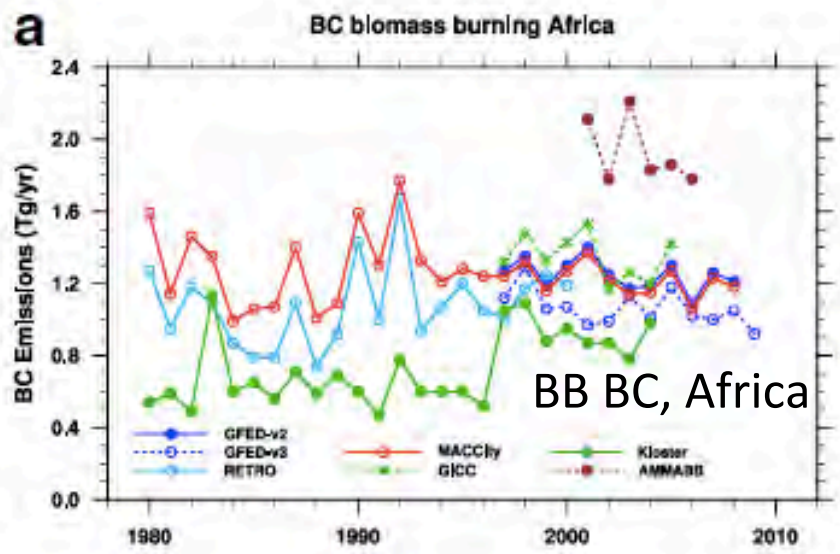
0.1 deg x 0.1 deg resolution

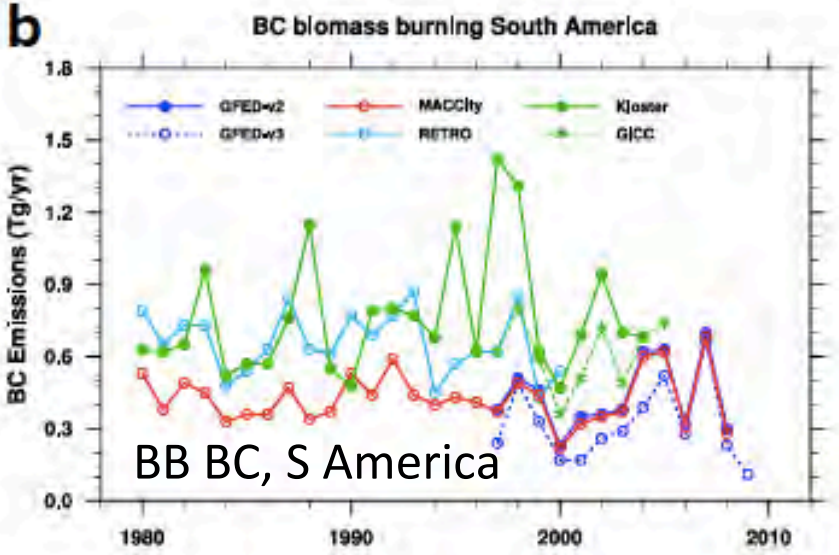


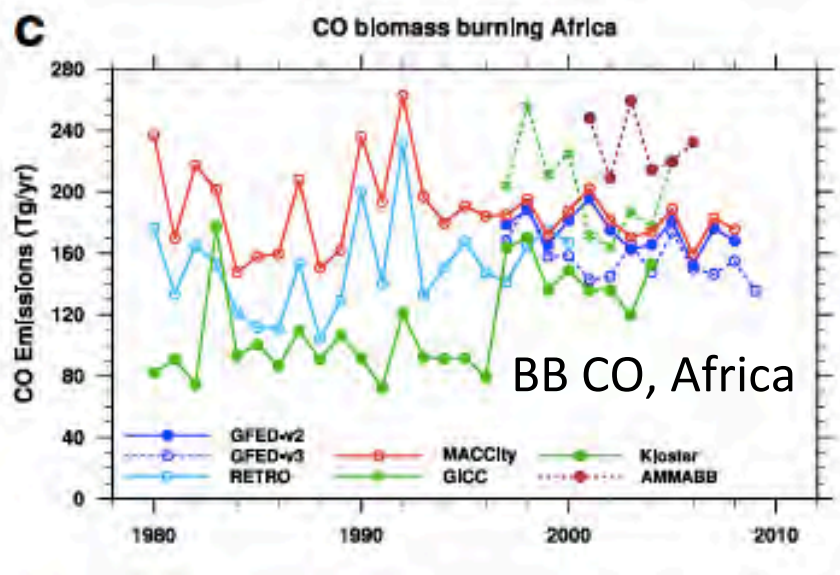
From ECCAD-2

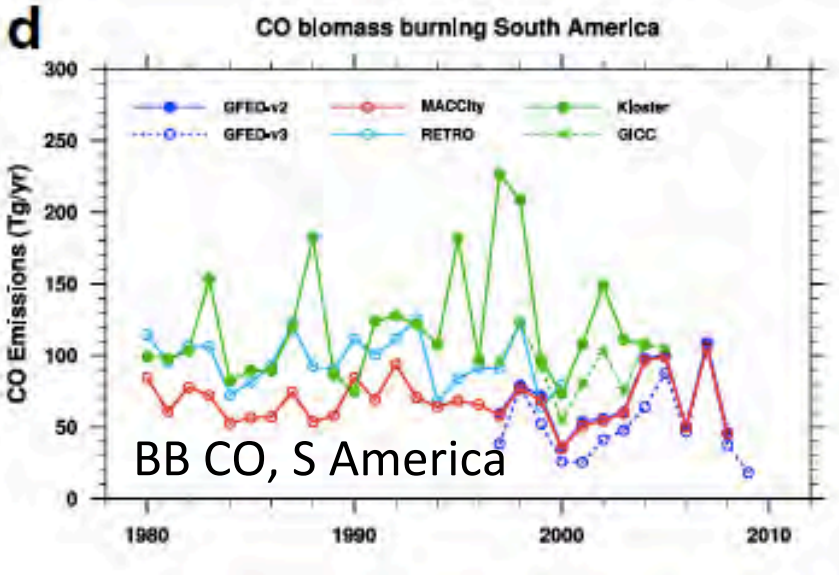
Unpublished data, contact C. Granier before citing

Biomass burning emission datasets





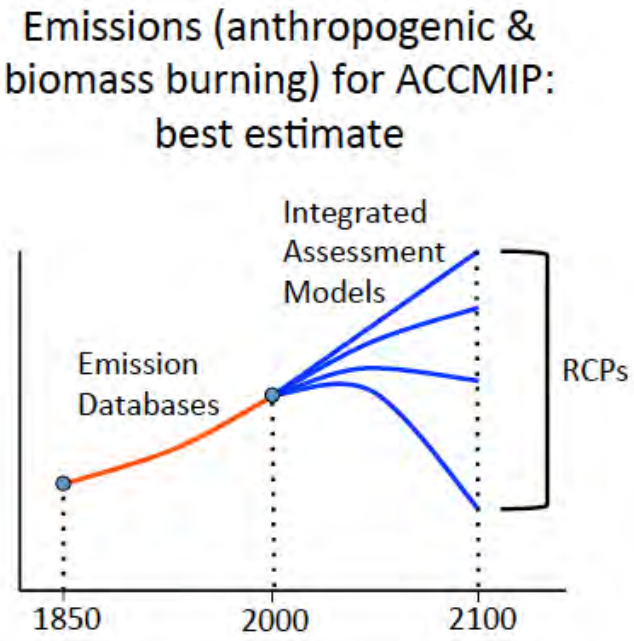




C. Granier et al., *Climatic Change*, 2011

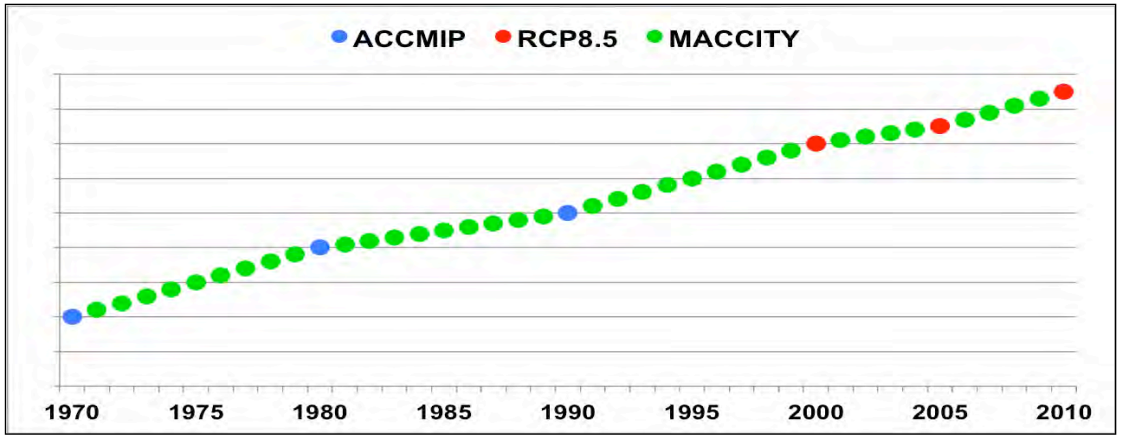
Existing Community Historical Inventories

ACCMIP

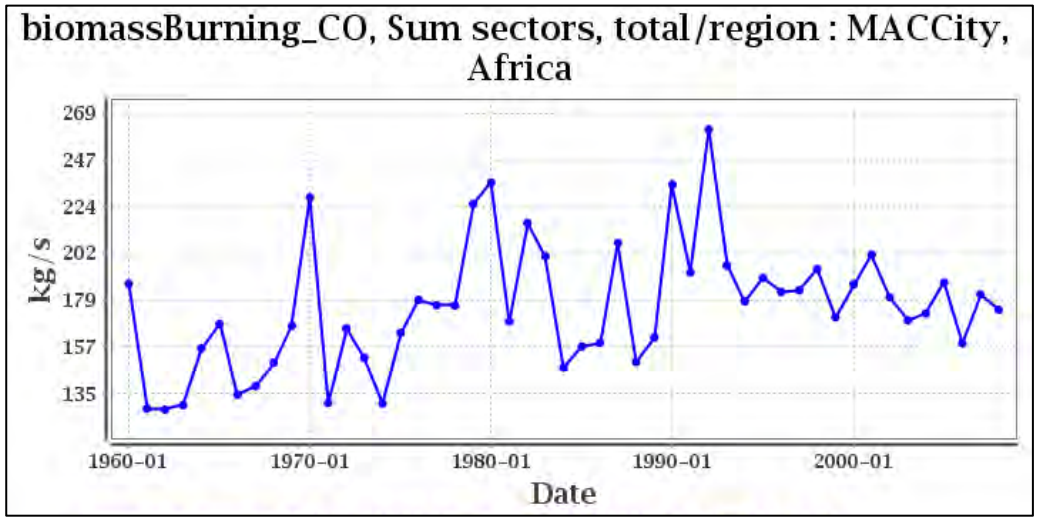


J.-F. Lamarque et al., *Atmos. Chem. Phys.*, 2010

MACCity≈AEROCOM-II anthropogenic



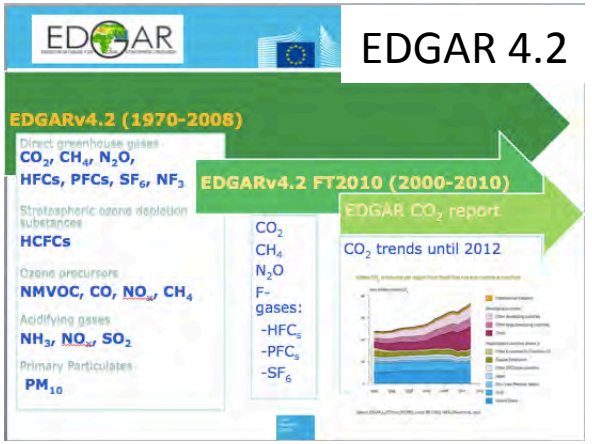
MACCity/AEROCOM-II fires in Africa

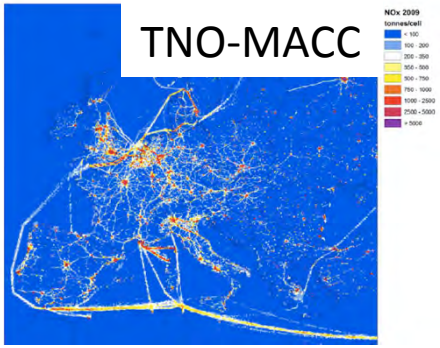


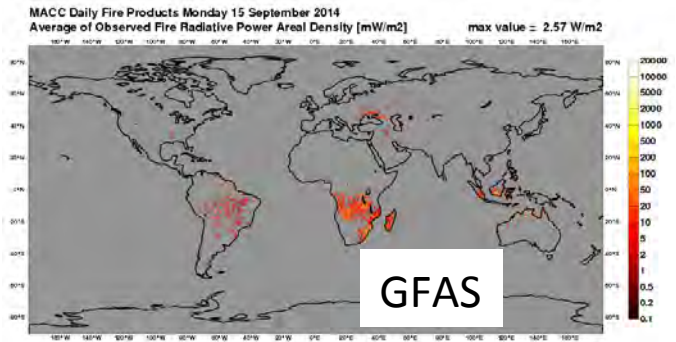
C. Granier +25 co-authors, *Climatic Change*, 2011

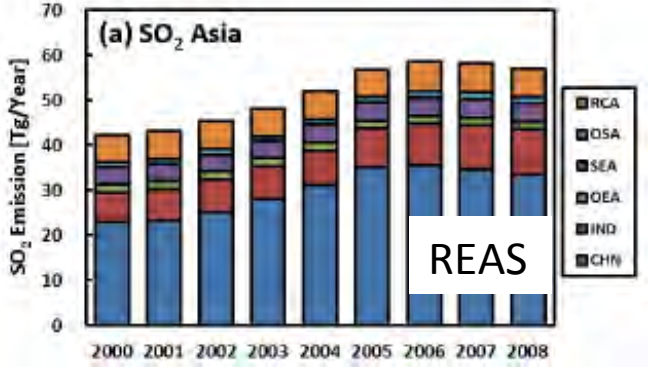
New Community Historical Inventory

- Organized by Global Emissions InitiAtive (GEIA)
- Uncertainty by emission and sector
  - → Historical emissions ensembles
  - → Inventory comparisons can inform uncertainty estimates
- Consistent historical trends
- Seasonality in anthropogenic emissions
- Consistent with CO_2 emissions
- Annual emissions by country (& state)
- Additional sectoral detail
- Better NMVOCs speciation
- 0.1x0.1 degree resolution when possible
- First data available in time for CMIP6 model runs





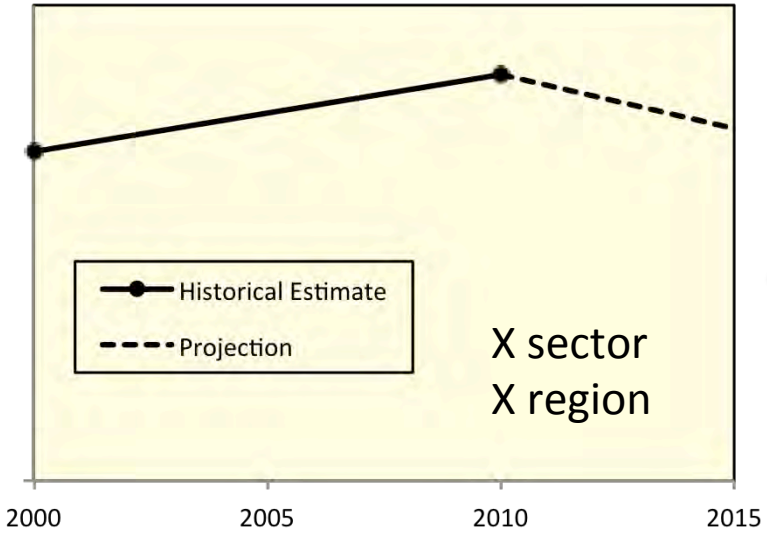




Community Emissions Data System

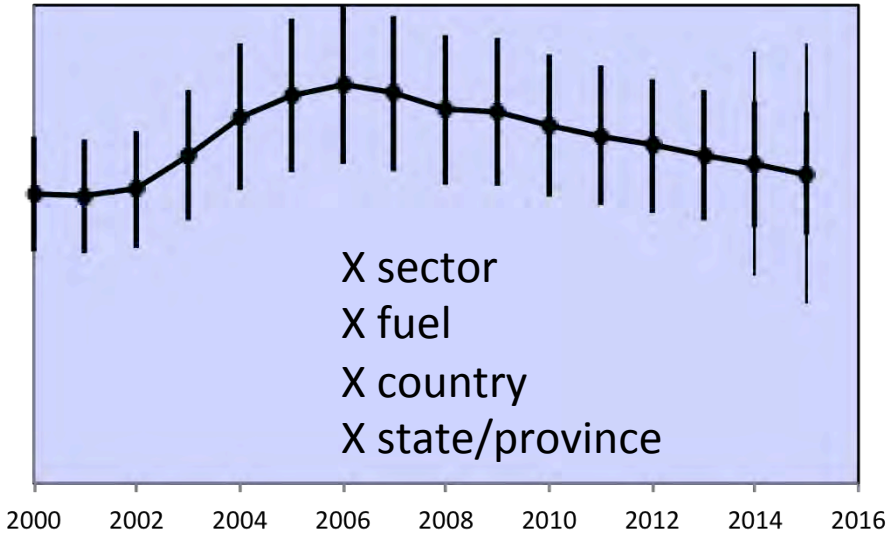
Produce timely estimates for emissions of aerosol (BC, OC) and aerosol precursor compounds (SO_2, NO_x, NH_3, CH_4, CO, NMVOC)

Instead of this



Uncertainty essential if extended to more recent years.

Produce

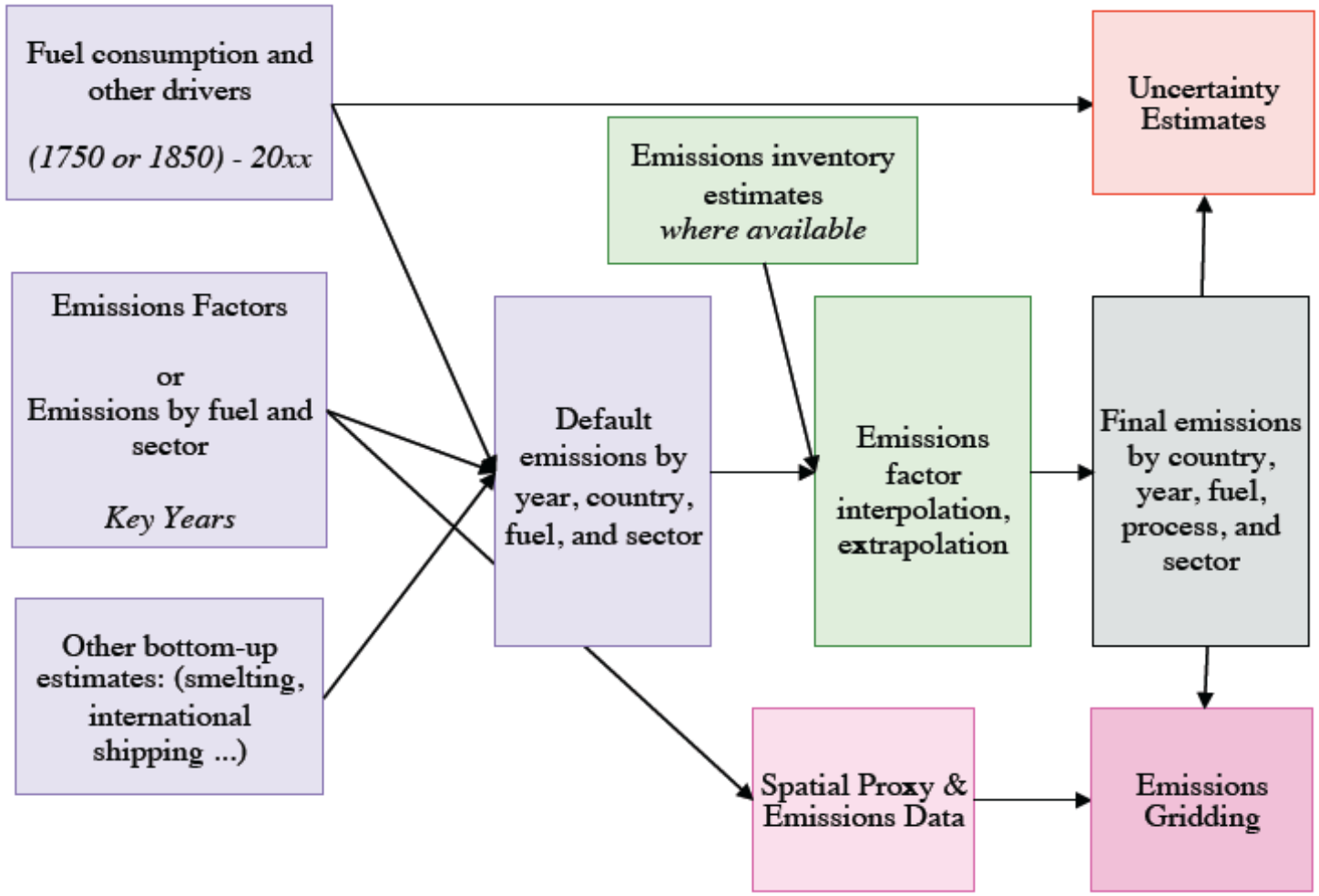


Produced using an open-source data system to increase data transparency and facilitate research advancements.

Steven Smith (PNNL/Univ. Maryland, USA)

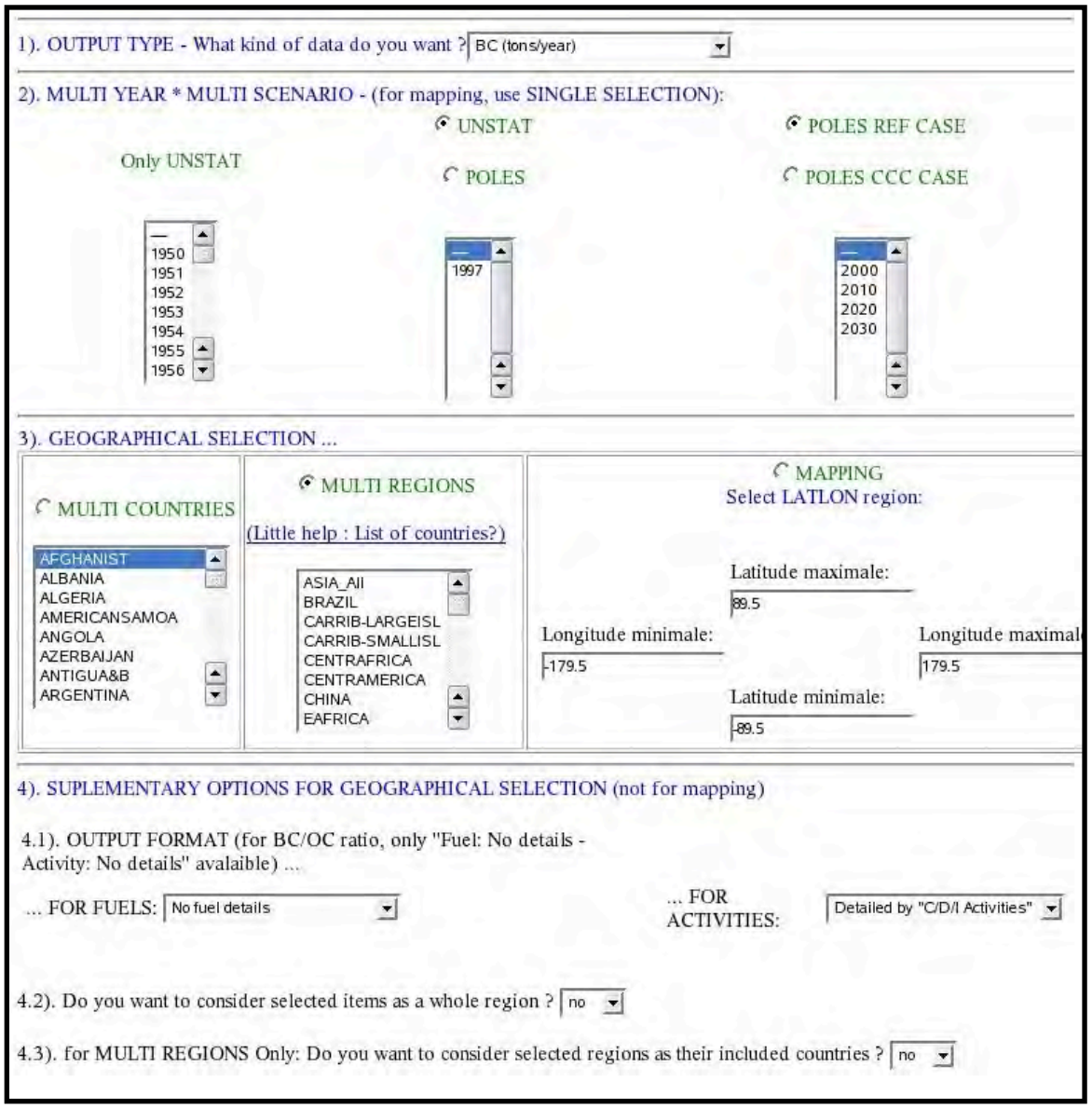
Community Emissions Data System

System under development at PNNL/Univ. Maryland, USA (Steven Smith et al.)



Community Emissions Data System

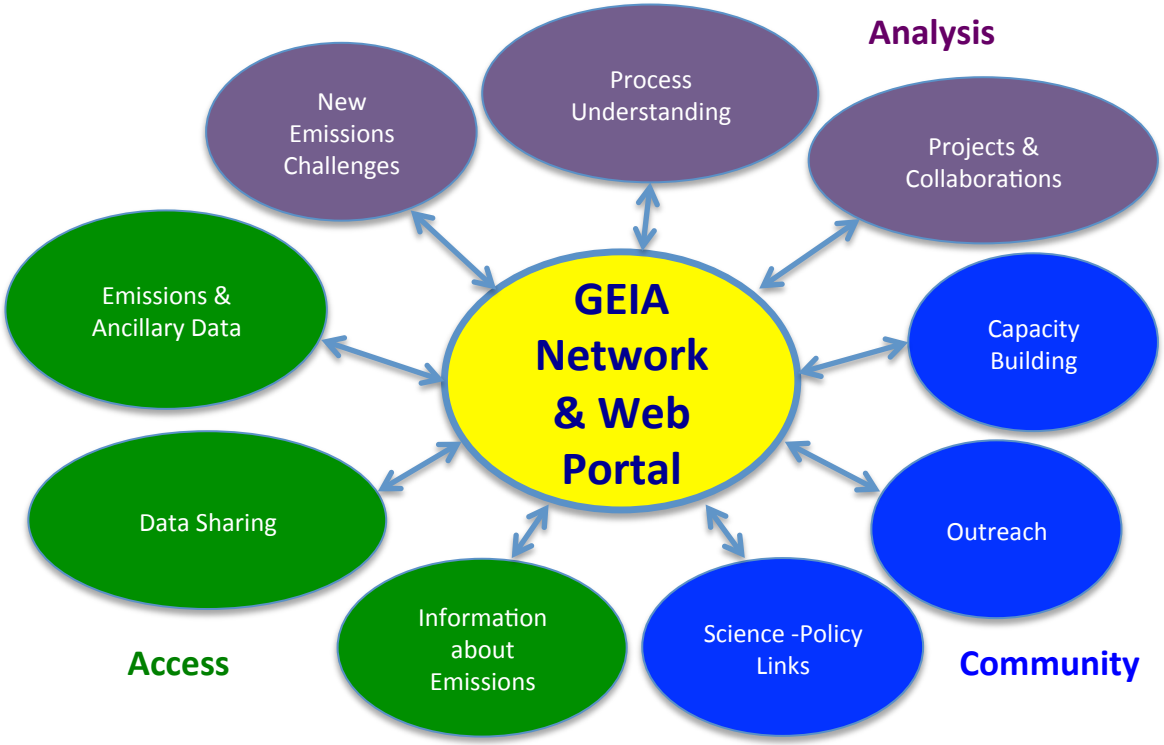
System under development at Laboratoire d'Aérologie, France (Cathy Liousse et al.)



GEIA
Global Emissions InitiAtive

Mission **GEIA** is a community initiative that builds bridges between environmental science and policy, by bringing together people, data, and tools to *create* and *communicate* the highest quality information about ***emissions***.

Goals **GEIA** aims to be a key forum for emissions knowledge serving stakeholders and decision-makers in a rapidly evolving global society.



*Building the scientific basis for emissions data by enhancing **analysis** of emissions processes*

*Promoting broad and consistent **access** to emissions information*

*Strengthening the **community** of emissions stakeholder groups*

G. J. Frost et al., Atmos. Environ., 2013

GEIA Leadership 2014-2016

Executive Committee

Co-Chairs: Gregory Frost, Leonor Tarrasón

Database Manager: Claire Granier

Network Manager: Paulette Middleton

Scientific Steering Committee*

Alexander Baklanov (*Switzerland*)
Beatriz Cardenas (*Mexico*)
Hugo Denier van der Gon (*The Netherlands*)
Gregory Frost (*USA*)
Claire Granier (*France, USA, Germany*)
Alex Guenther (*USA*)
Greet Janssens-Maenhout (*Italy*)
Johannes Kaiser (*Germany*)
Terry Keating (*USA*)
Zbigniew Klimont (*Austria*)
Catherine Liousse (*France*)
Paulette Middleton (*USA*)
Toshimasa Ohara (*Japan*)
Martin Schultz (*Germany*)
Ute Skiba (*UK*)
Leonor Tarrasón (*Norway*)
Yuxuan Wang (*China*)

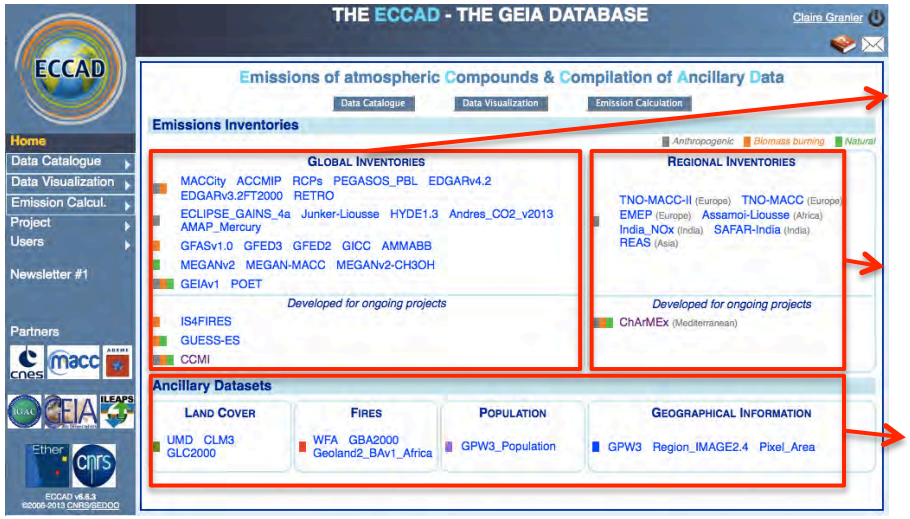
** SSC adding 1-2 new members in 2014, to replace outgoing members (J.-F. Lamarque, J. van Aardenne) and to increase representation from outside USA & Europe*

ECCAD

Emissions of Atmospheric Compounds & Compilation of Ancillary Data

GEIA's emissions database & visualization/analysis platform

- Distributing data for research & assessment efforts



Global Inventories

Regional Inventories

Ancillary Datasets

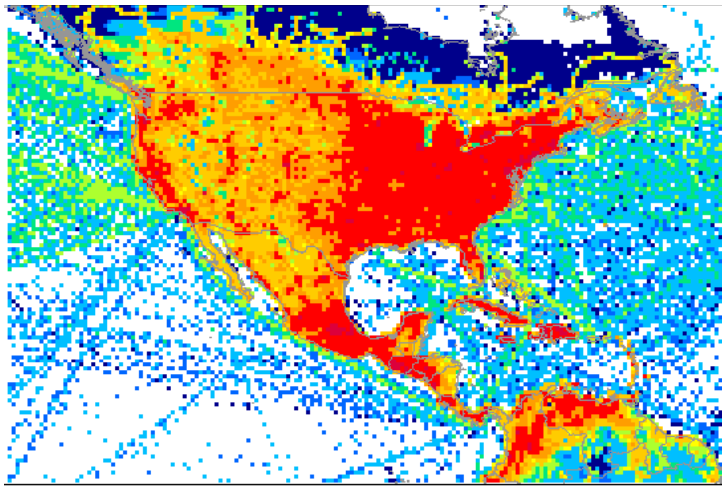
http://pole-ether.fr/eccad

Work underway on new ECCAD database, platform, and interface

- Any lat/lon resolution data
- Regrid to any lat/lon grid
- Adapted to interoperability
- Detailed documentation

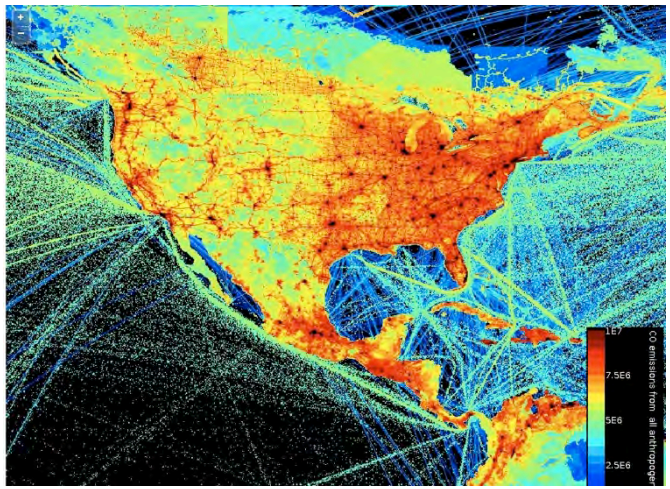
Current Resolution

MACCity CO Emissions, 0.5° grid spacing



Future Resolution

HTAPv2 CO Emissions, 0.1° grid spacing



ECCAD Datasets

http://pole-ether.fr/eccad

Many different inventories, including global and regional datasets

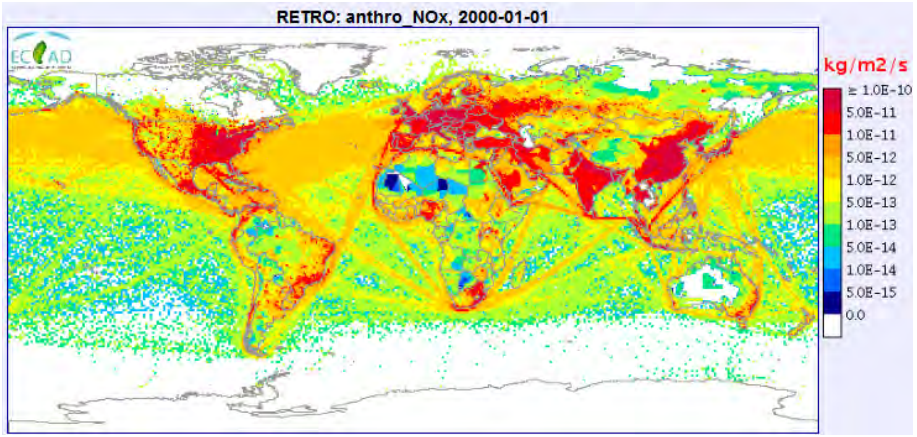
Product (release year)	Temporal Coverage	Time resolution	Category (Hover to see Species)	Grid size	Data provider	Metadata
GLOBAL INVENTORIES (22)						
MACCity 2010	1960 - 2020	Monthly	Anthropogenic Biomass burning	0.5°		
ACCMIP 2010	1850 - 2000	Decadal Decadal-Monthly	Anthropogenic Biomass burning	0.5°		
RCPs 2010	2005 - 2100	Decadal Decadal-Monthly	Anthropogenic Biomass burning	0.5°		
PEGASOS_PBL 2013	1990 - 2100	Yearly	Anthropogenic Biomass burning	0.5°		
EDGARv4.2 2011	1970 - 2008	Yearly	Anthropogenic Biomass burning	0.5°		
EDGARv3.2FT2000 2005	2000	Yearly	Anthropogenic Biomass burning	1°		
RETRO 2005	1960 - 2000	Monthly	Anthropogenic Biomass burning	0.5°		
ECLIPSE_GAINS_4a 2013	2005 - 2050	Yearly	Anthropogenic	0.5°		
Junker-Liousse 2008	1860 - 2003	Decadal/Yearly	Anthropogenic	1°		
HYDE1.3 2001	1890 - 1990	Decadal	Anthropogenic	1°		
Andres_CO2_v2013 2013	1751 - 2010	Yearly	Anthropogenic	1°		
AMAP_Mercury 2005	1995 - 2000	Half-decadal	Anthropogenic	0.5°		
GFASv1.0 2012	2003 - 2013	Daily	Biomass burning	0.5°		
GFED3 2010	1997 - 2010	Monthly	Biomass burning	0.5°		
GFED2 2005	1997 - 2005	Monthly	Biomass burning	1°		
GICC 2010	1900 - 2005	Decadal-Monthly/ Monthly	Biomass burning	0.5°		
AMMABB 2009	2000 - 2006	Daily	Biomass burning	0.5°		
MEGAN-MACC 2012	1980 - 2010	Monthly	Biogenic	0.5°		
MEGANv2 2009	2000	Monthly	Biogenic	0.5°		
MEGANv2-CH3OH 2011	2003 - 2009	Yearly (seasonal)	Biogenic	0.5°		
GEIAv1 1990	1984 - 1990	Yearly Monthly : NOx Ligthning, NOx from Soils, BC Biom. Burn.	Anthropogenic Biomass burning Biogenic Oceanic Lightning Volcanic Total	1°		
POET 2003	1990 - 2000	Yearly Monthly Monthly Yearly	Anthropogenic Biomass burning Biogenic Oceanic	1°		

Product (release year)	Temporal Coverage	Time resolution	Category (Hover to see Species)	Grid size	Data provider	Metadata
GLOBAL INVENTORIES DEVELOPED FOR ONGOING PROJECTS (3)						
IS4FIRES 2012	2000 - 2011	Daily	Biomass burning	0.5°		
GUESS-ES 2011	1970 - 2009	Monthly	Biomass burning Biogenic	1°		
CCMI 2013	2000	Yearly/Monthly	Anthropogenic Biomass burning Biogenic Volcanic Total	0.5°		

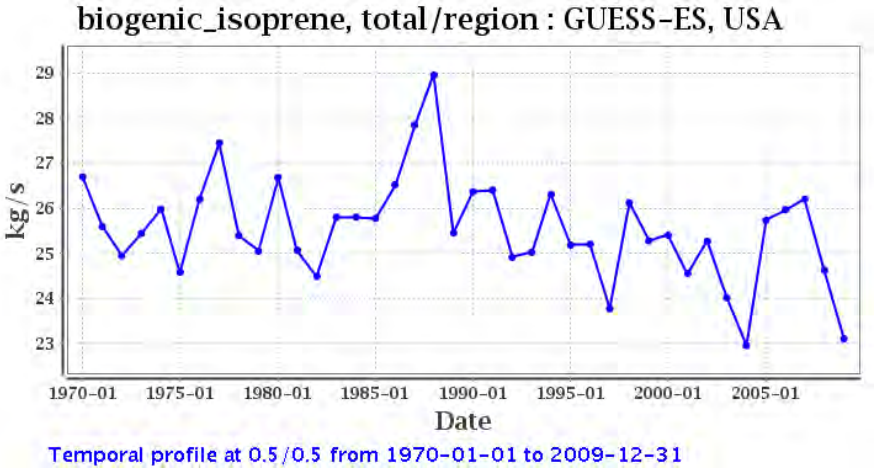
ECCAD Tools

http://pole-ether.fr/eccad

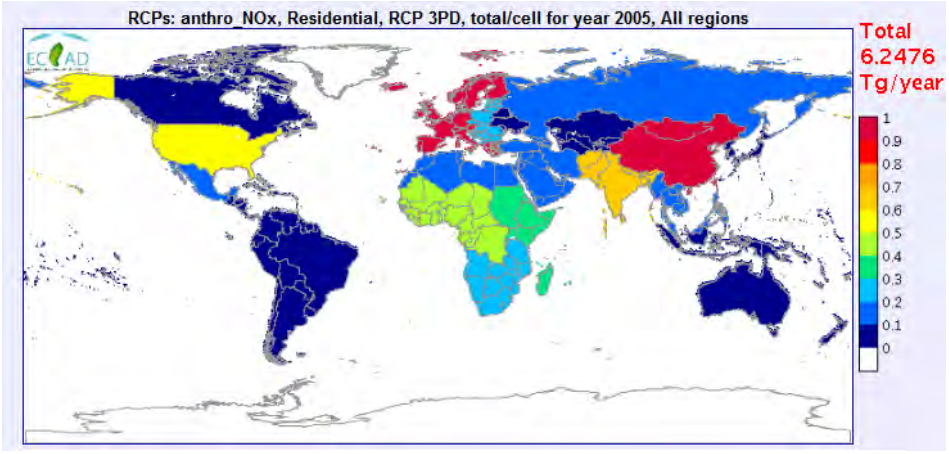
Visualization of emissions maps



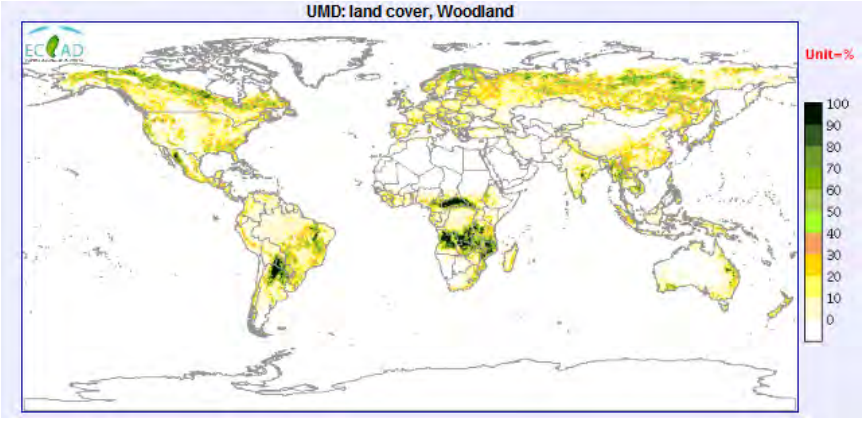
Temporal variation of national



Total emitted for different regions



Ancillary data



Currently under development: maps of comparison calculations, scatter plots

Be Active in the Emissions Community

- Contact us to get involved in any projects discussed here
- Use GEIA/ECCAD platforms to access & analyze data
- Tell us about errors and ask questions about the data
- Contribute to next community historic emissions meeting
  - 4 November, Amsterdam (NCGG7): http://doodle.com/zacdaxbdi8zac9pg
- Let us know what you think about any of these activities

Contacts

Inventory comparisons: Claire Granier (claire.granier@noaa.gov)
Community historic inventory: Claire Granier (claire.granier@noaa.gov)
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Cathy Liousse (Cathy.Liousse@aero.obs-mip.fr)
GEIA: Greg Frost (gregory.j.frost@noaa.gov)
ECCAD: Claire Granier (claire.granier@noaa.gov)