Keeping the pulse of the carbon cycle

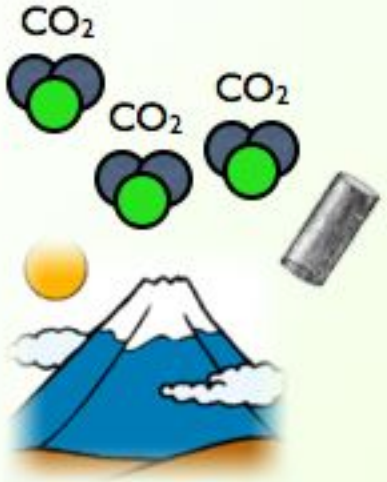
for the next 50 years

Wouter Peters

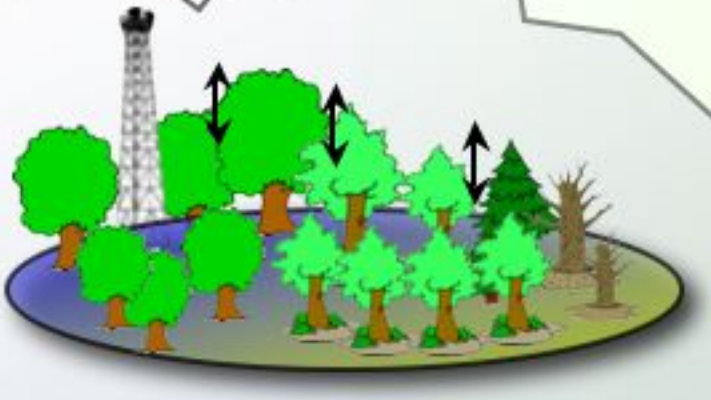
Wageningen University and Research Center, The Netherlands
NOAA Earth System Research Laboratory, USA

Carbon Tracking Strategies

Measure stocks



Measure result



Measure exchange

Mauna Loa CO_2 Conference Nov 2007

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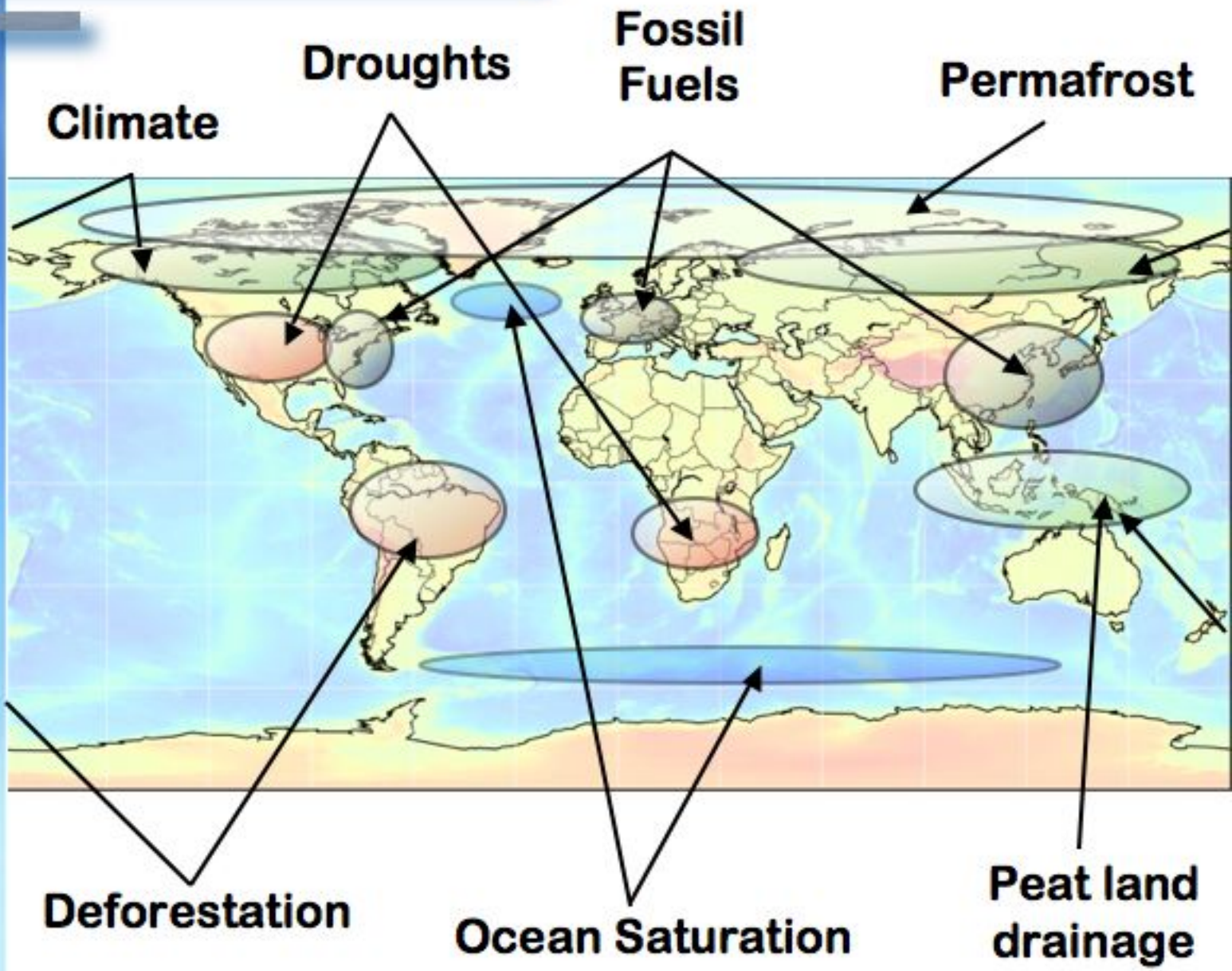
What needs tracking?



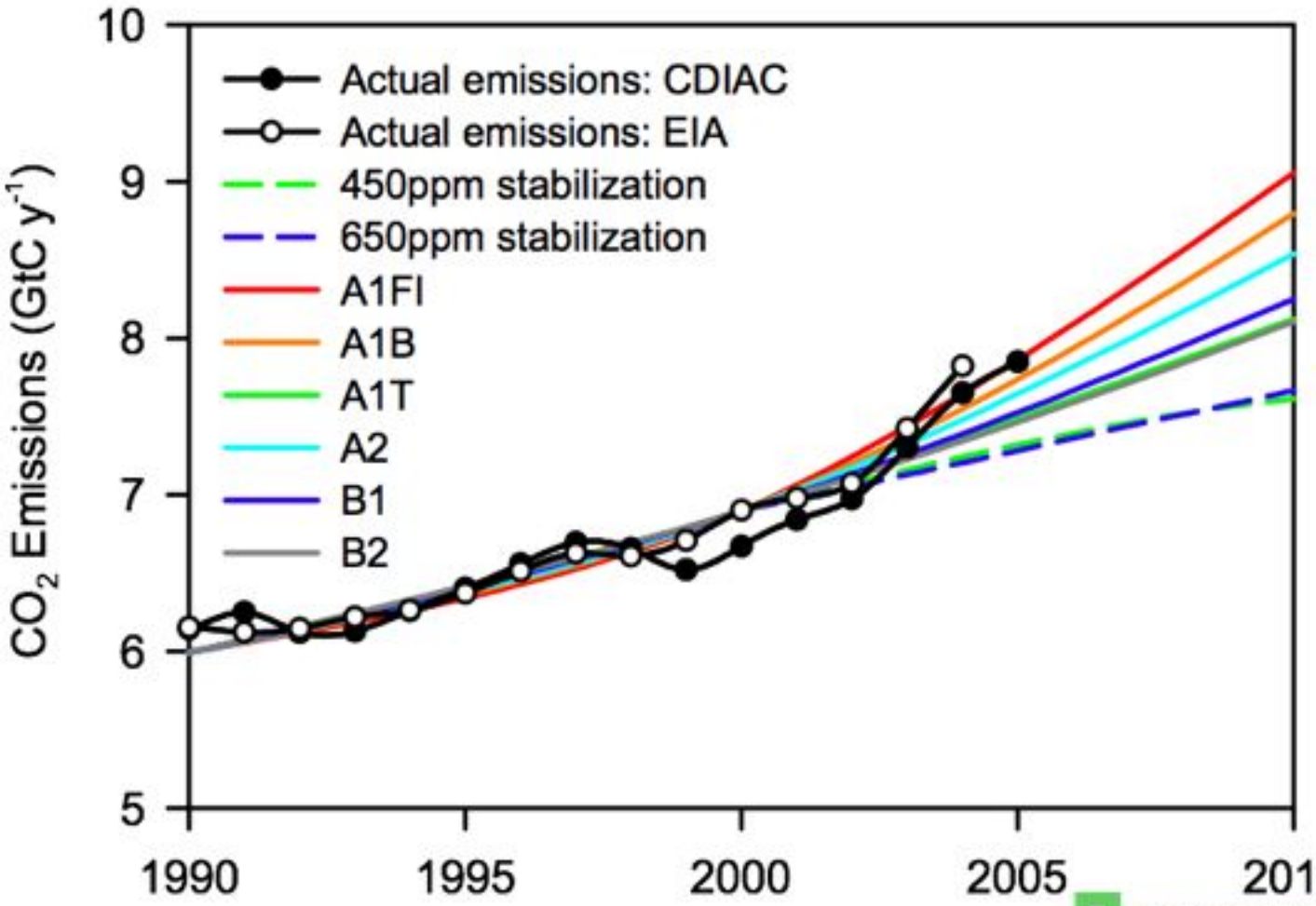
Carbon Tracking toolbox

- Economic activity data
- Ecosystem measurements
- Ocean surveys
- Satellite radiances
- Atmospheric observations
- ....

Economic Activity

Global and regional drivers of accelerating CO_2 emissions

Michael R. Raupach*†, Gregg Marland‡, Philippe Ciais§, Corinne Le Quéré¶, Josep G. Canadell*, Gernot Klepper**, and Christopher B. Field††



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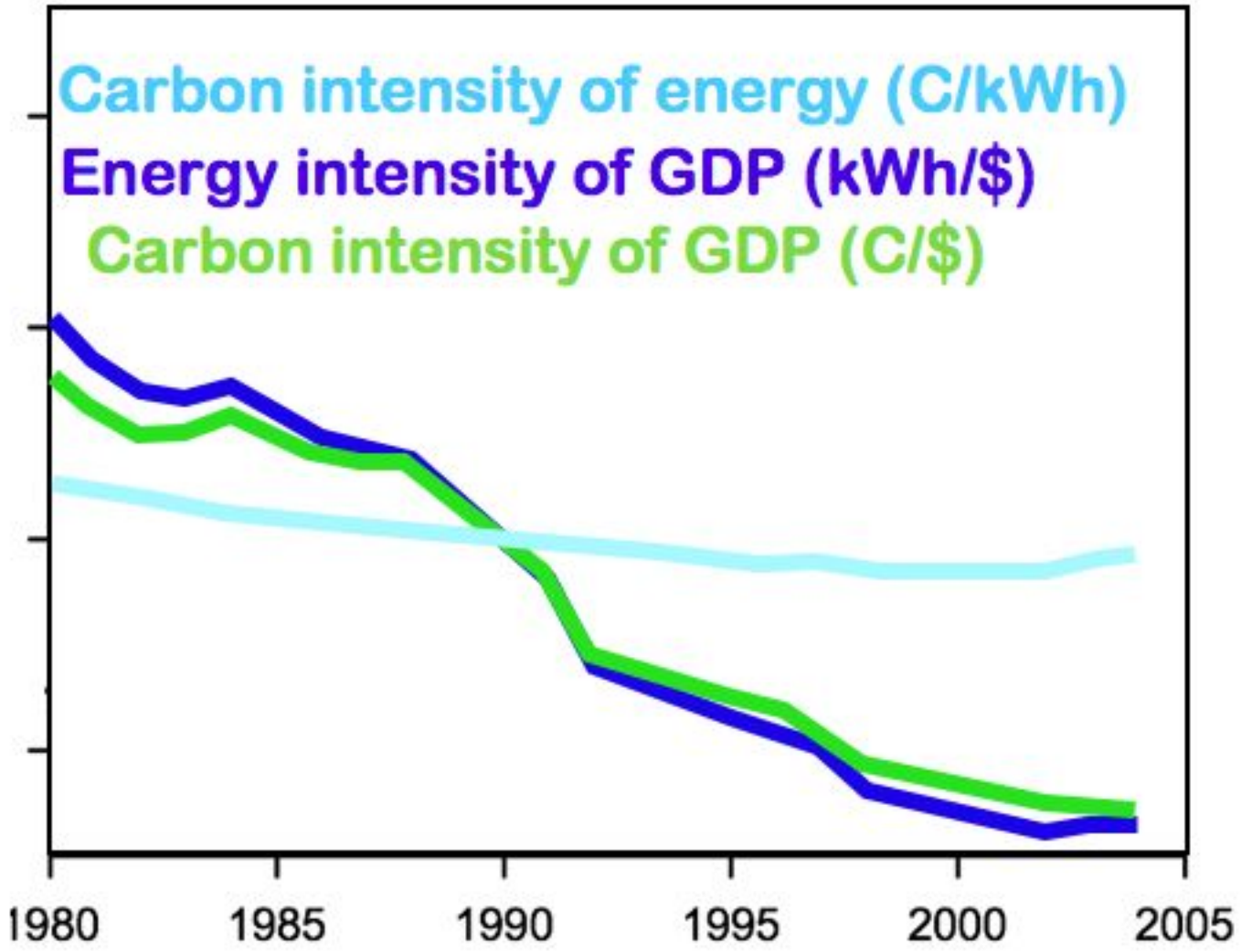

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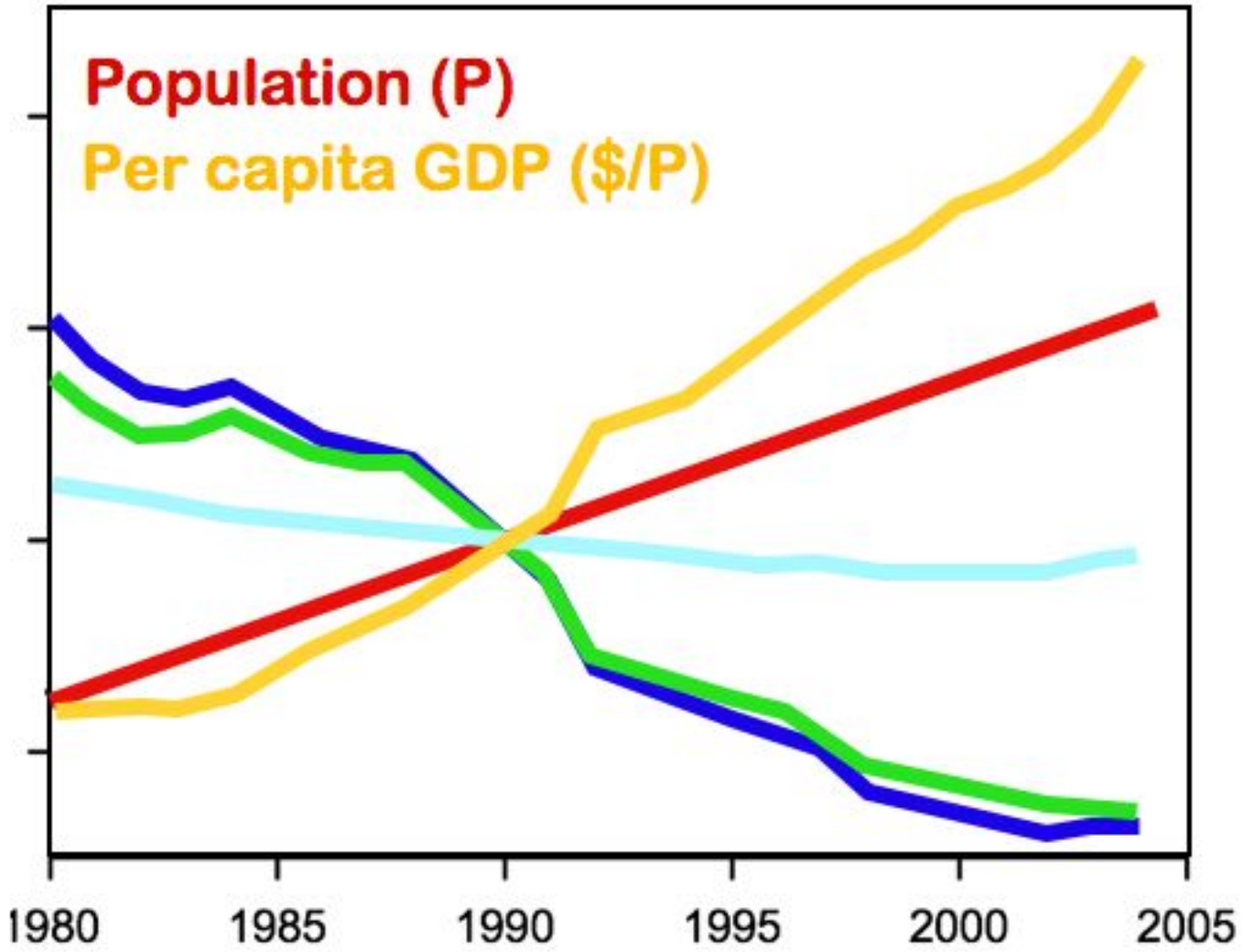

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Global and regional drivers of accelerating CO_2 emissions

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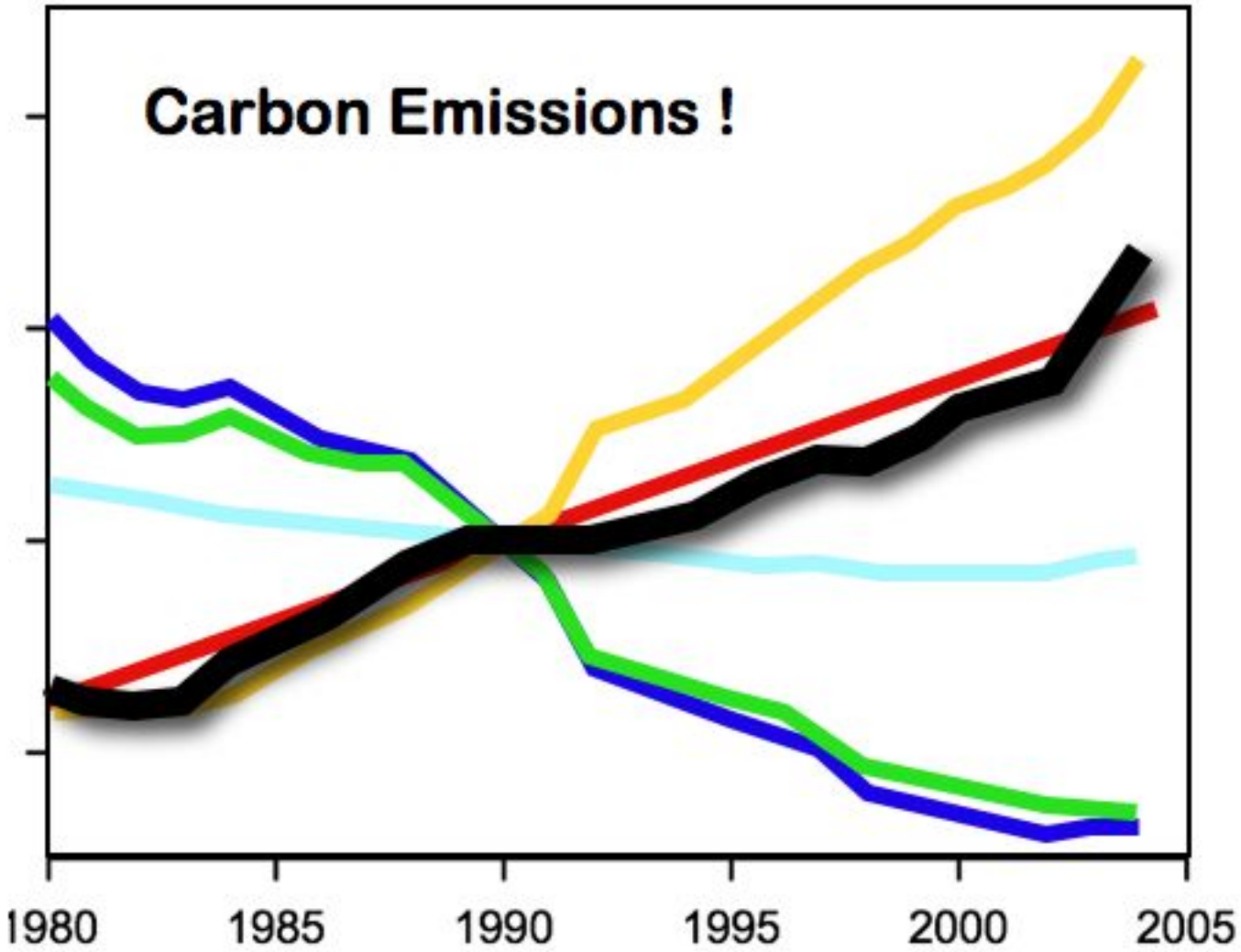

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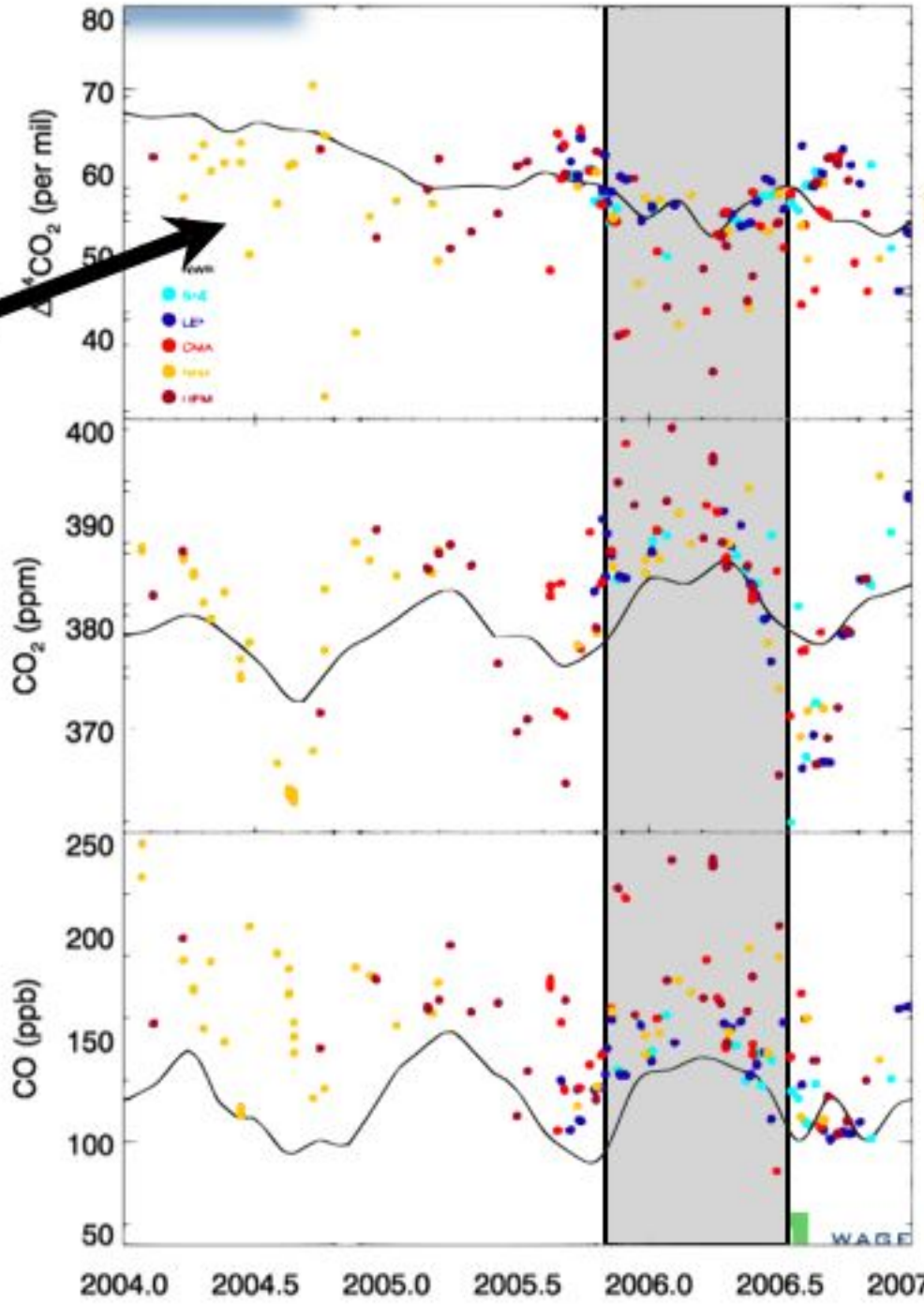
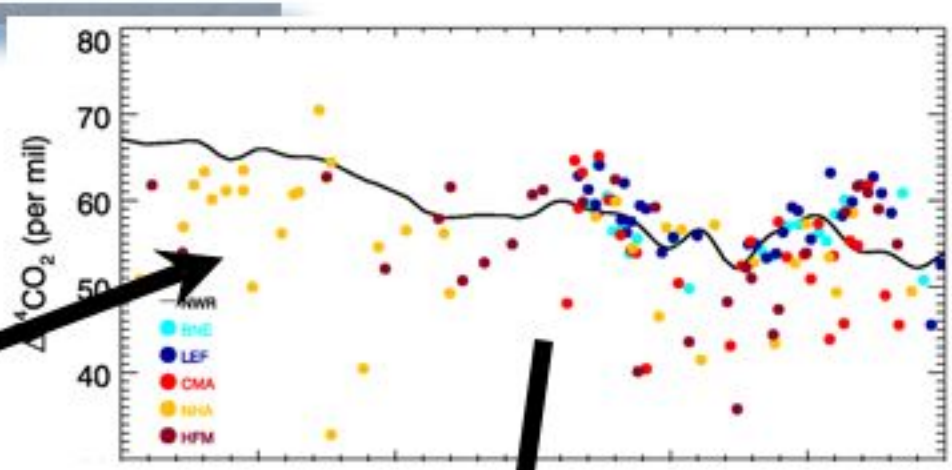
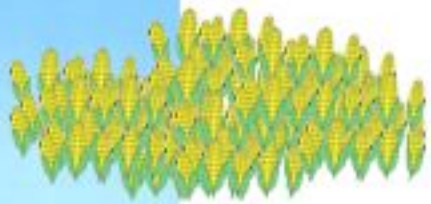
$^{14}CO_2$

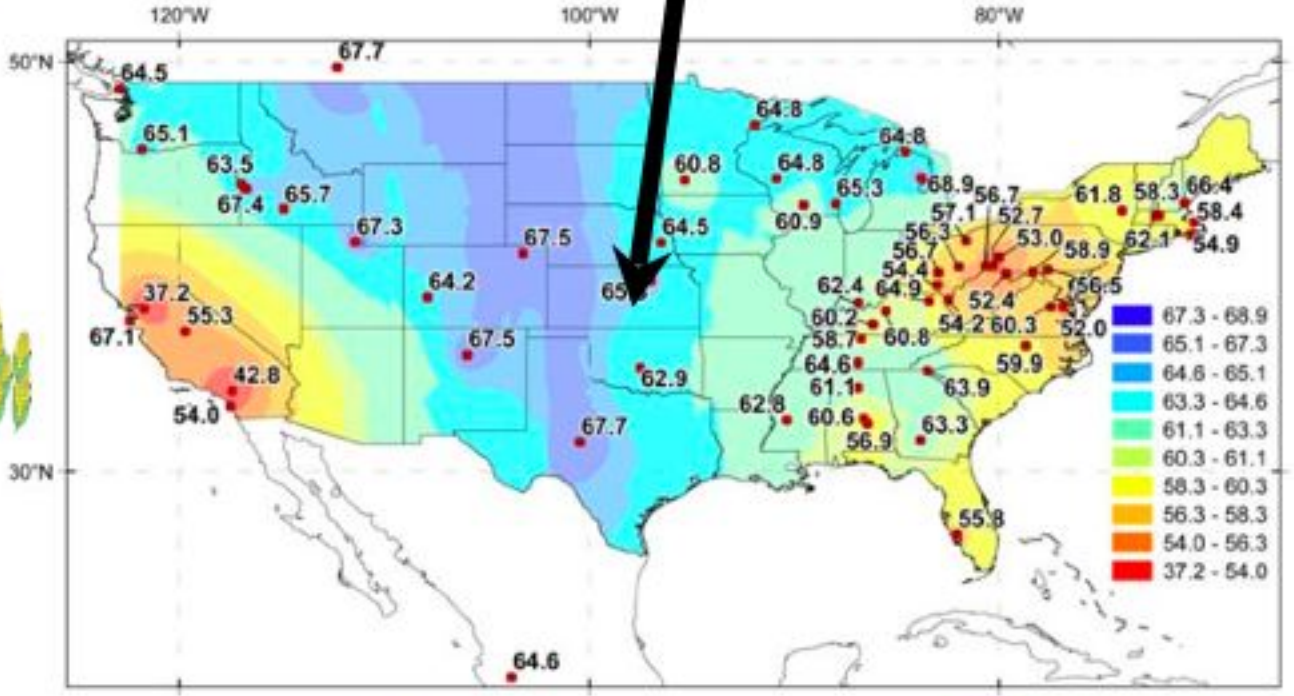
Turnbull et al., 2006





$^{14}CO_2$





Hsueh et al., 2007

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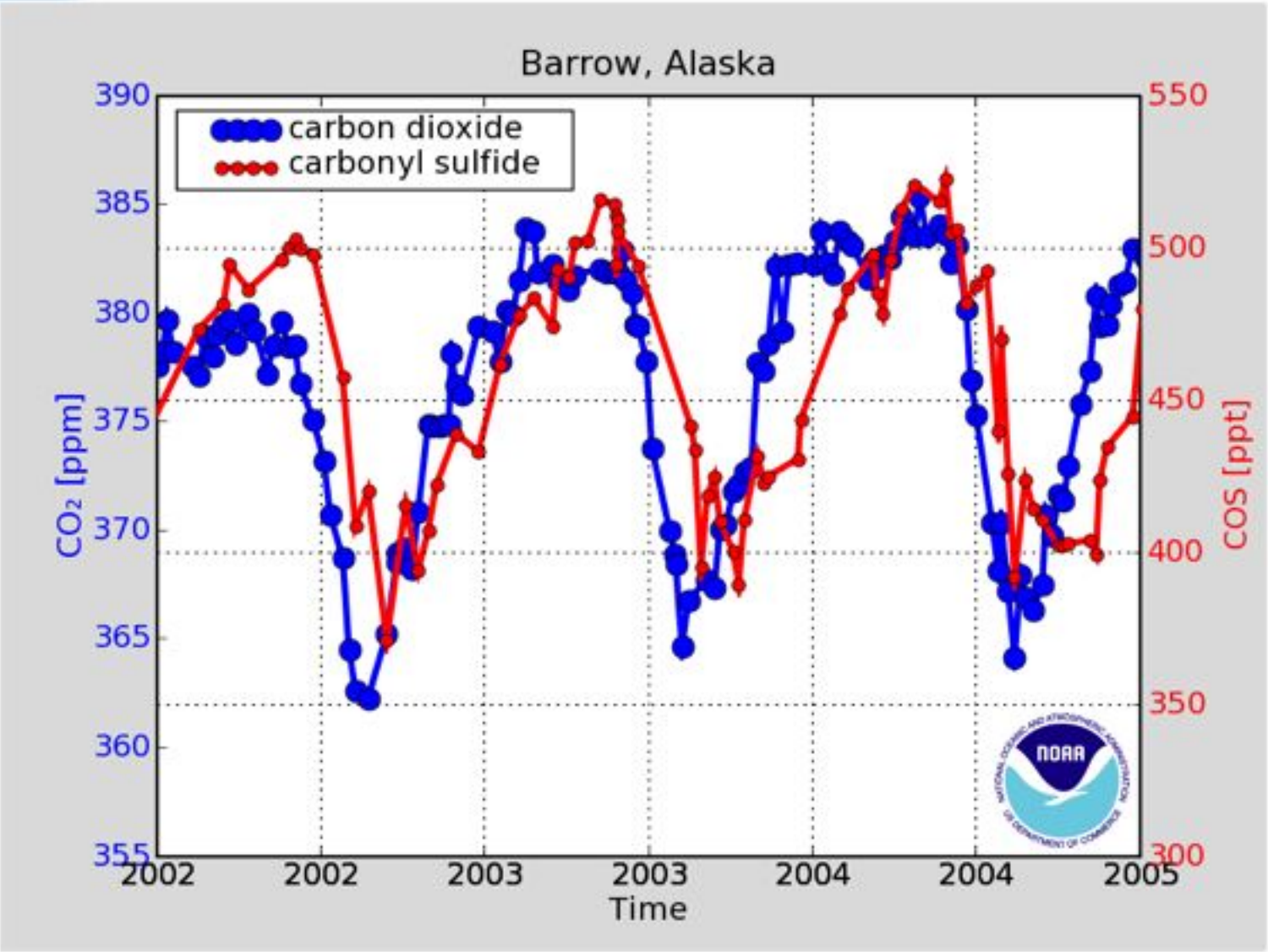
Carbonyl Sulfide

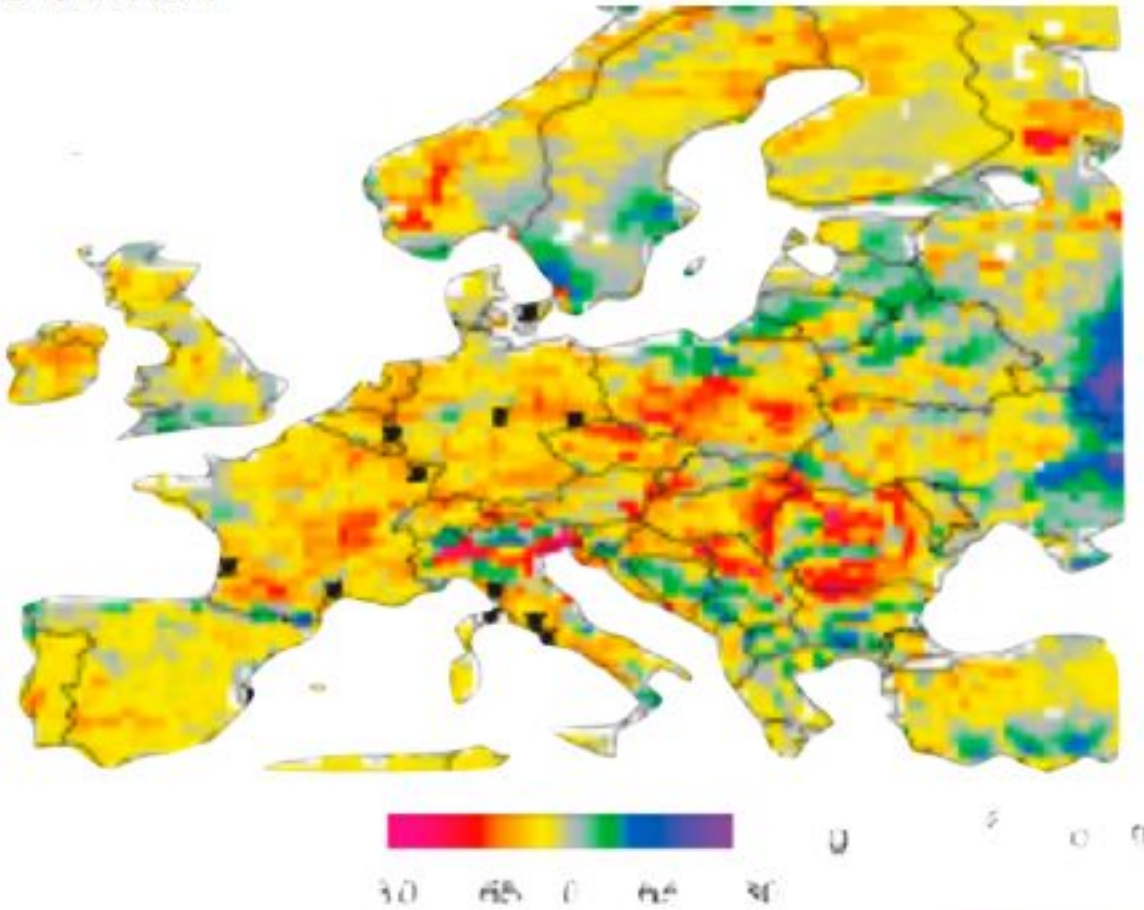


COS data provided by Steve Montzka

Droughts

Europe-wide reduction in primary productivity caused by the heat and drought in 2003

Ph. Ciais[1], M. Reichstein[2,3], N. Viovy[1], A. Granier[4], J. Ogée[5], V. Allard[6], M. Aubinet[7], N. Buchmann[8], Chr. Bernhofer[9], A. Carrara[10], F. Chevallier[1], N. De Noblet[1], A. D. Friend[1], P. Friedlingstein[1], T. Grünwald[9], B. Heinesch[7], P. Keronen[11], A. Knohl[12,13], G. Krinner[14], D. Loustau[5], G. Manca[2]†, G. Matteucci[15]†, F. Miglietta[16], J. M. Ourcival[17], D. Papale[2], K. Pilegaard[18], S. Rambal[17], G. Seufert[15], J. F. Soussana[6], M. J. Sanz[10], E. D. Schulze[12], T. Vesala[11] & R. Valentini[2]



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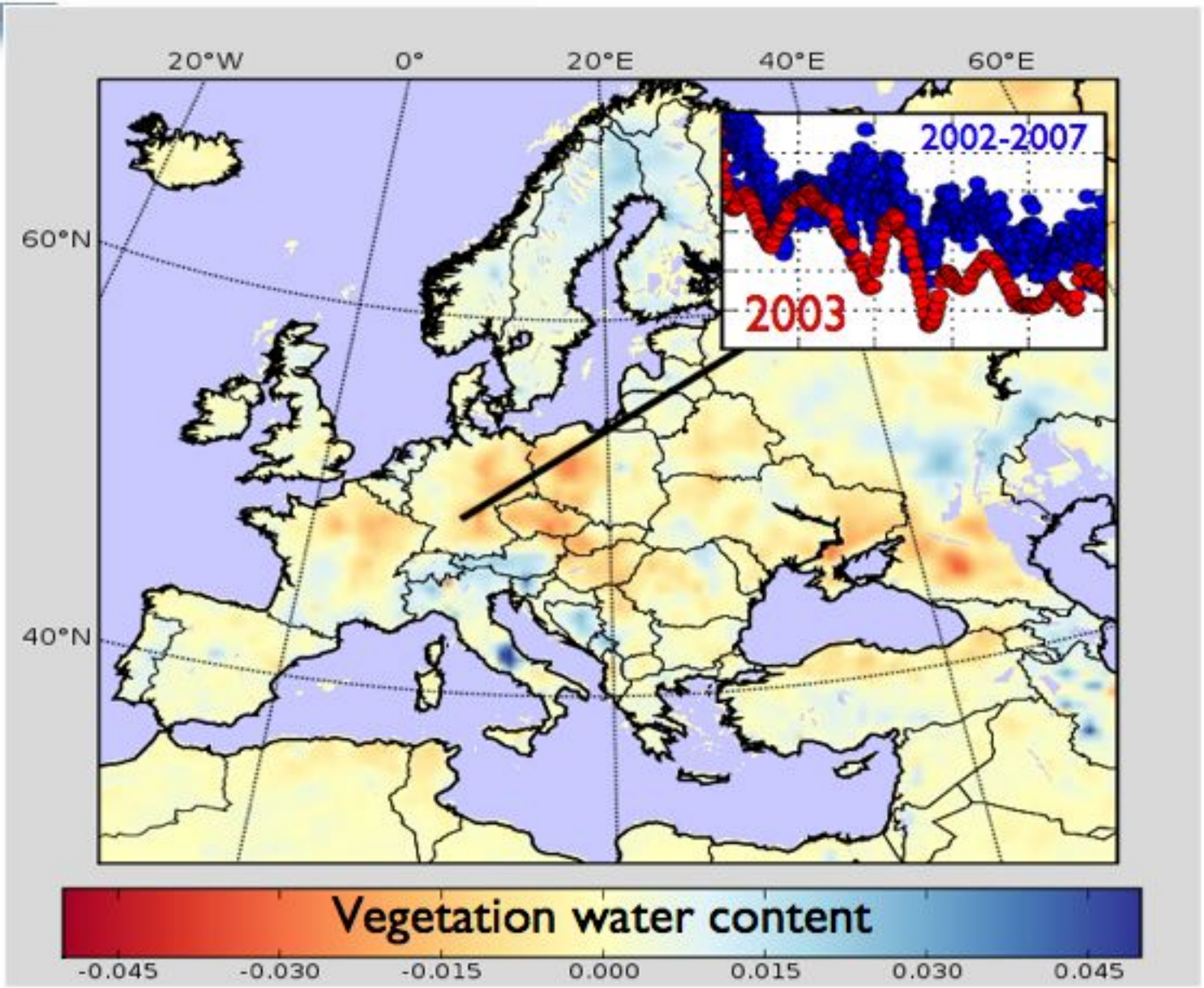
Droughts



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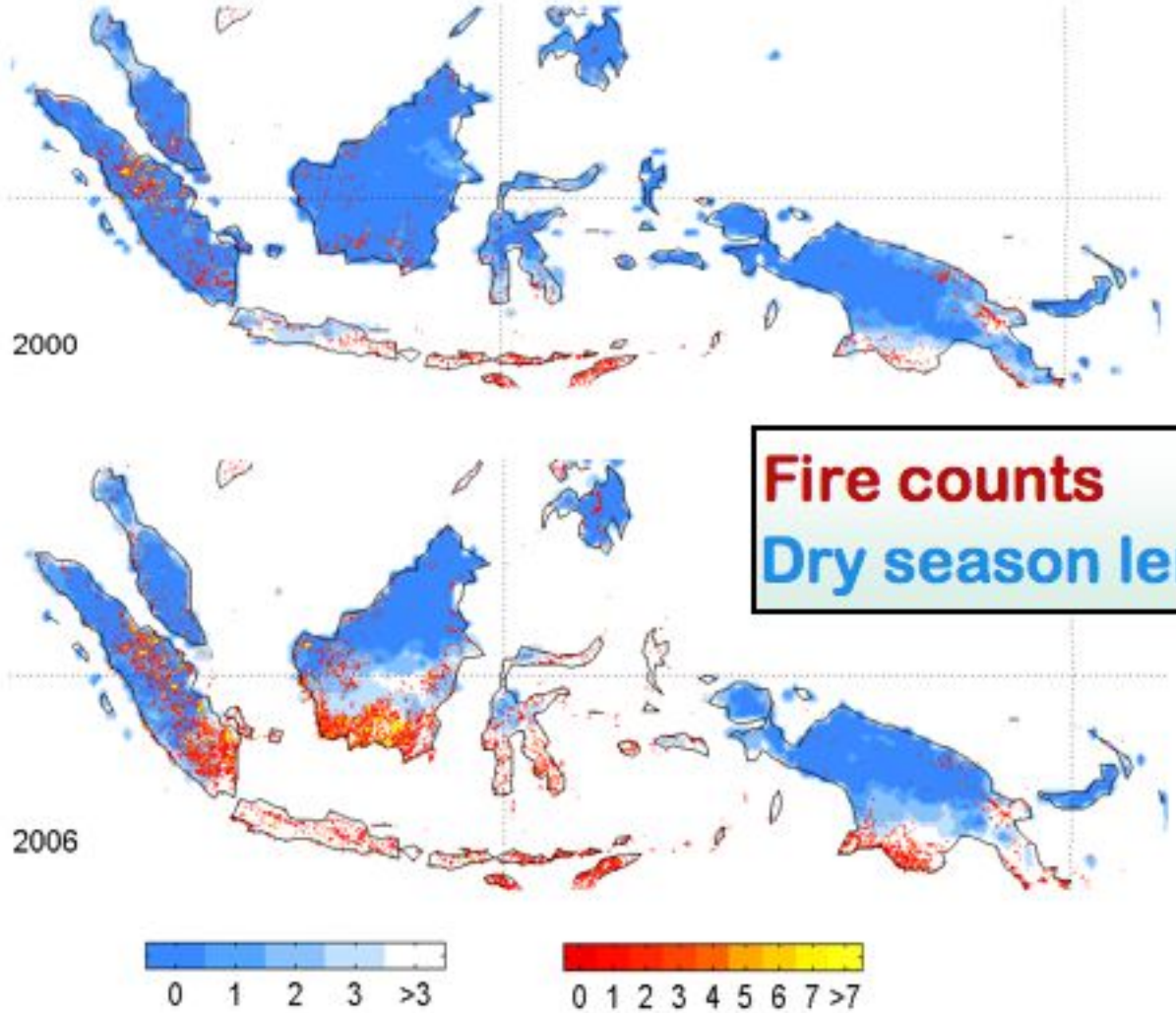
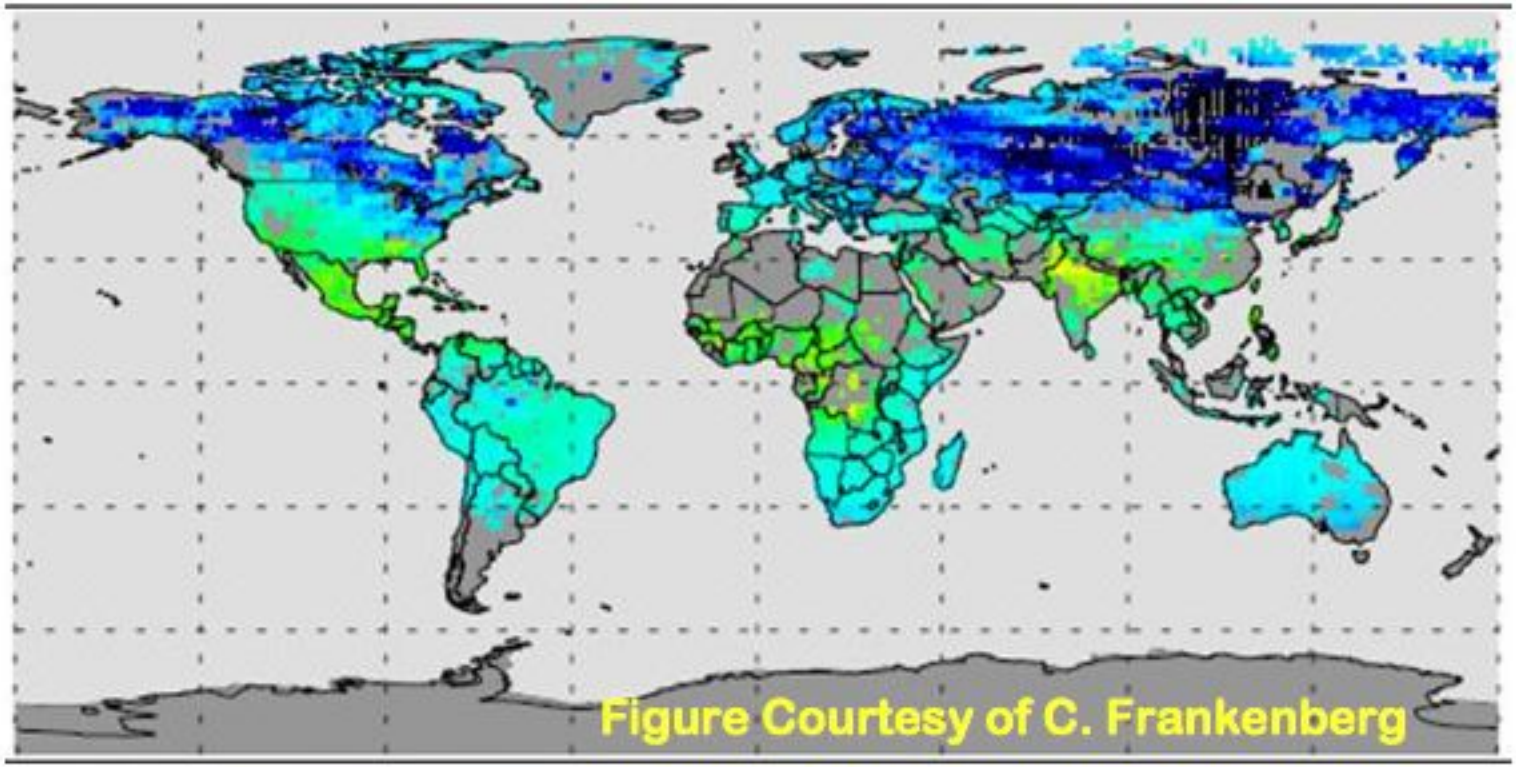
Indonesia during wet (2000) and dry (2006) years

Fires/De-forestation



Courtesy Guido van der Werf

SCIAMACHY column CO_2



2009: Orbiting Carbon Observatory, GoSat

Space based CO_2 ?

Challenge

- Combine information from diverse sources
- In a system that balances their strengths and weaknesses
- Based on understanding of processes to:
  - provide objective information
  - predict the future

Integrated Carbon Cycle Monitoring System

CarbonTracker

Website

http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/

U.S. Department of Commerce | National Oceanic & Atmospheric Administration | NOAA Research

Earth System Research Laboratory
Global Monitoring Division

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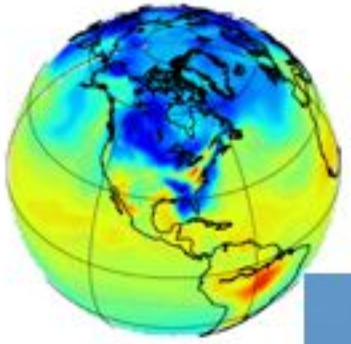
Resources

CarbonTracker

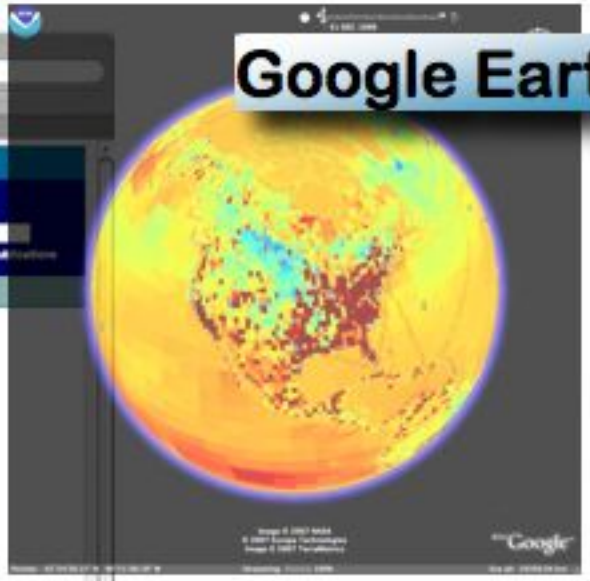
What is CarbonTracker?
A system to keep track of carbon dioxide uptake and release at the Earth's surface over time. [read more]

Who needs CarbonTracker?
Policy makers, industry, scientists, and the public need CarbonTracker information to make informed decisions to limit greenhouse gas levels in the atmosphere. [read more]

What does CarbonTracker tell us?
North America is a source of CO_2 to the atmosphere. The natural uptake of CO_2 that occurs mostly East of the Rocky Mountains removes only ~30% of the CO_2 released by the use of fossil fuels. [read more]



Google Earth



FTP

Mauna Loa CO_2
Conference Nov 2007

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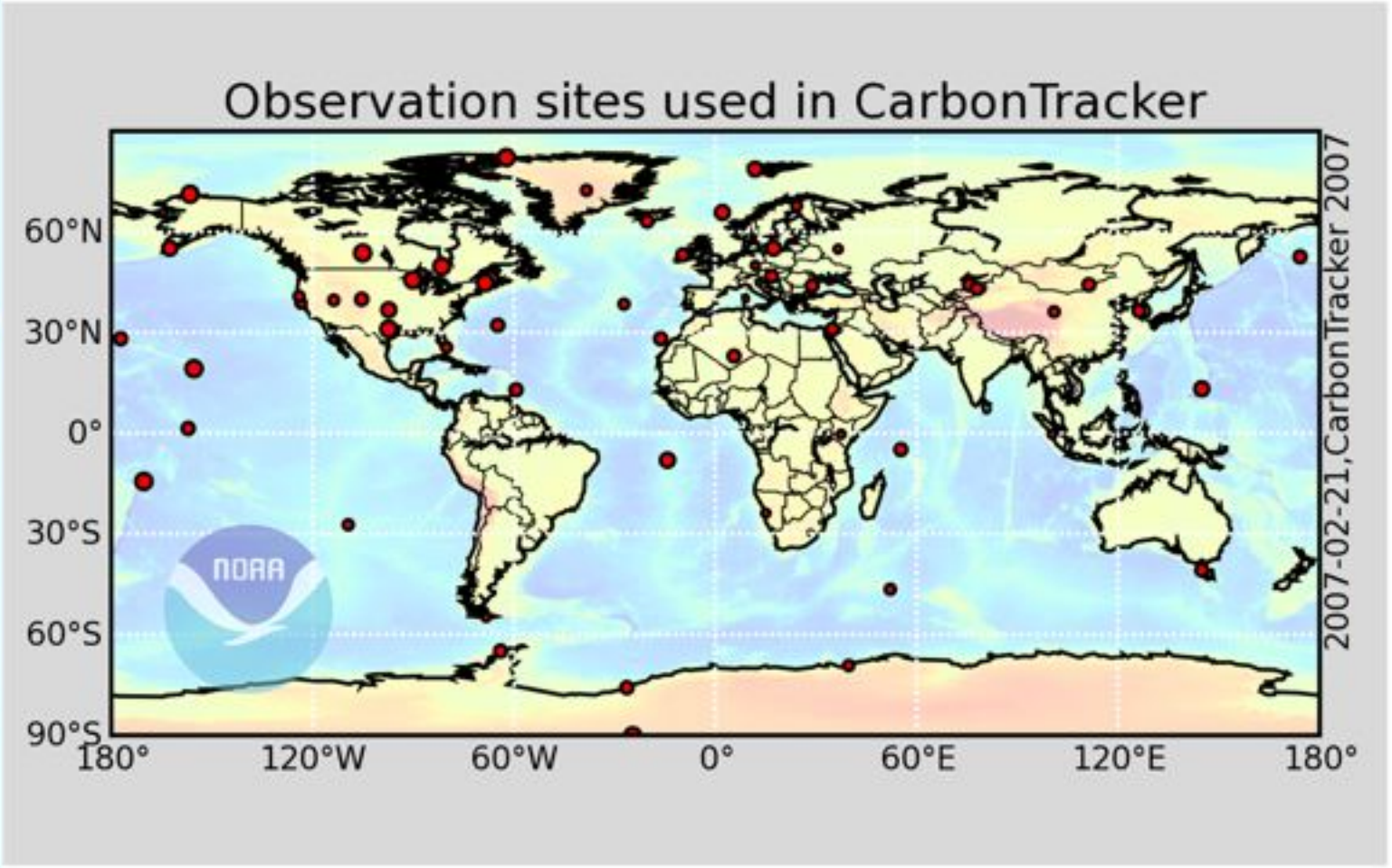
CarbonTracker



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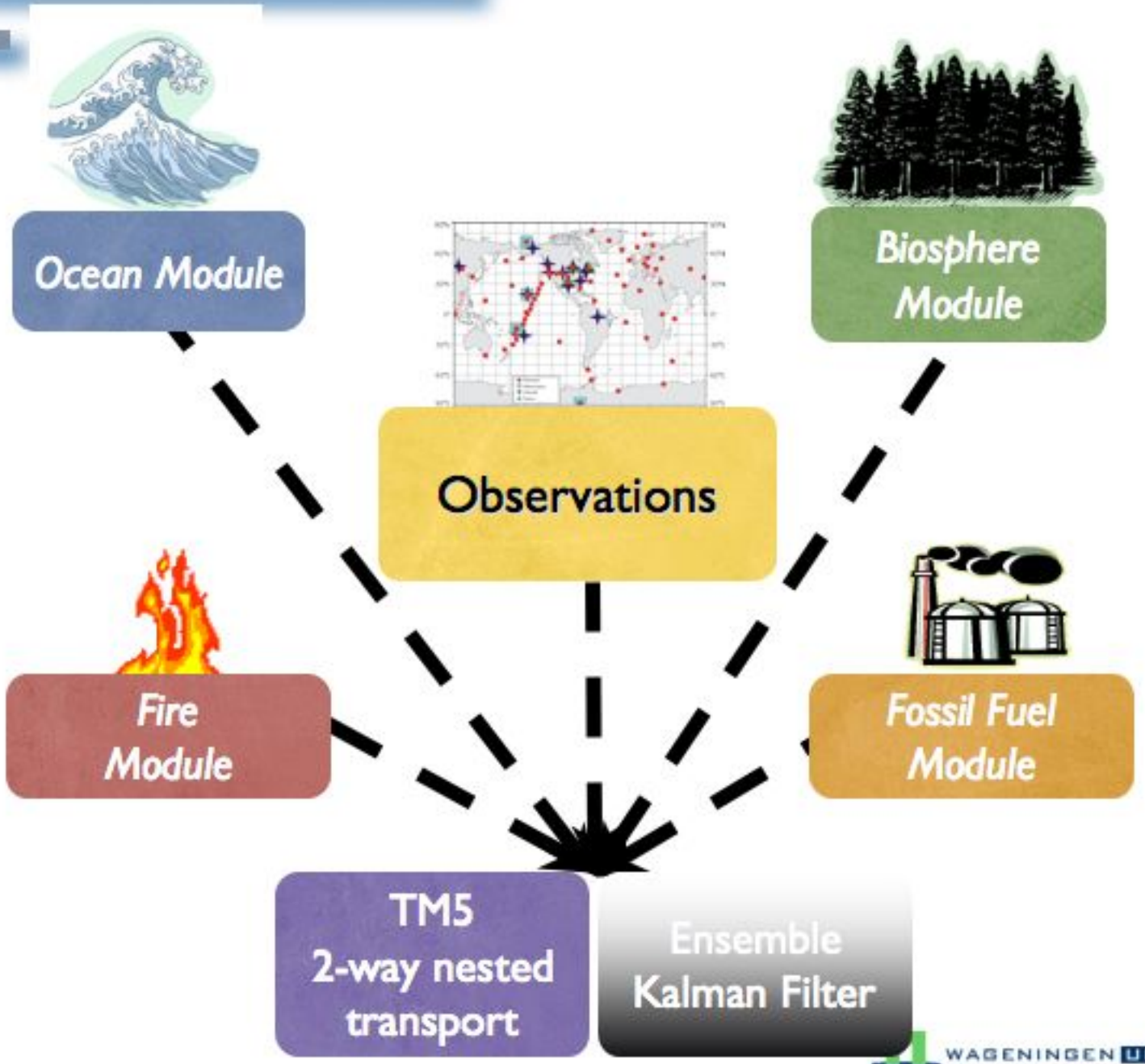
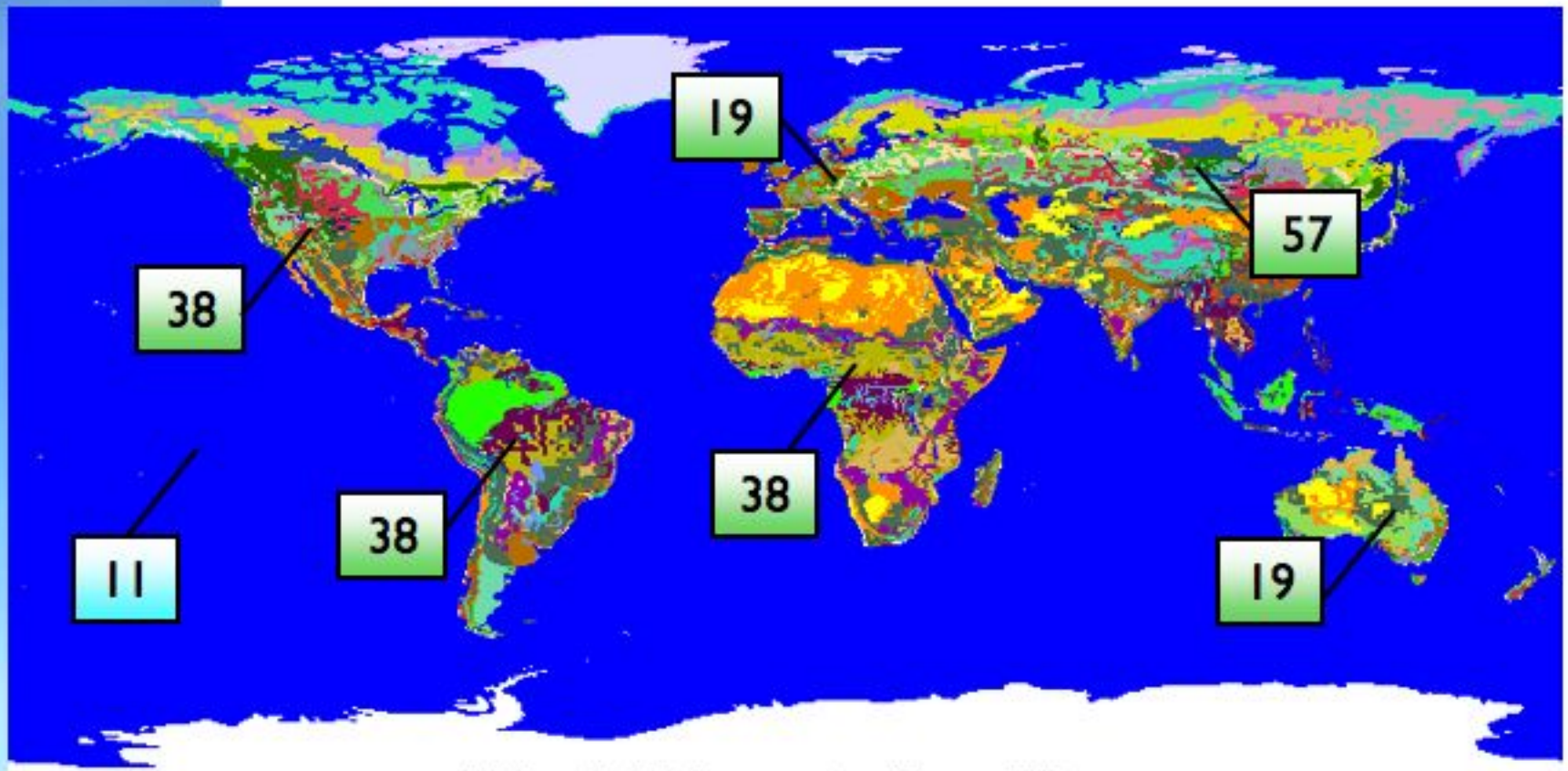


Adjusting exchange



World Vegetation Map

Olson

135 linear model parameters associated with 124 land ecosystems and 11 ocean basins

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Available Observations

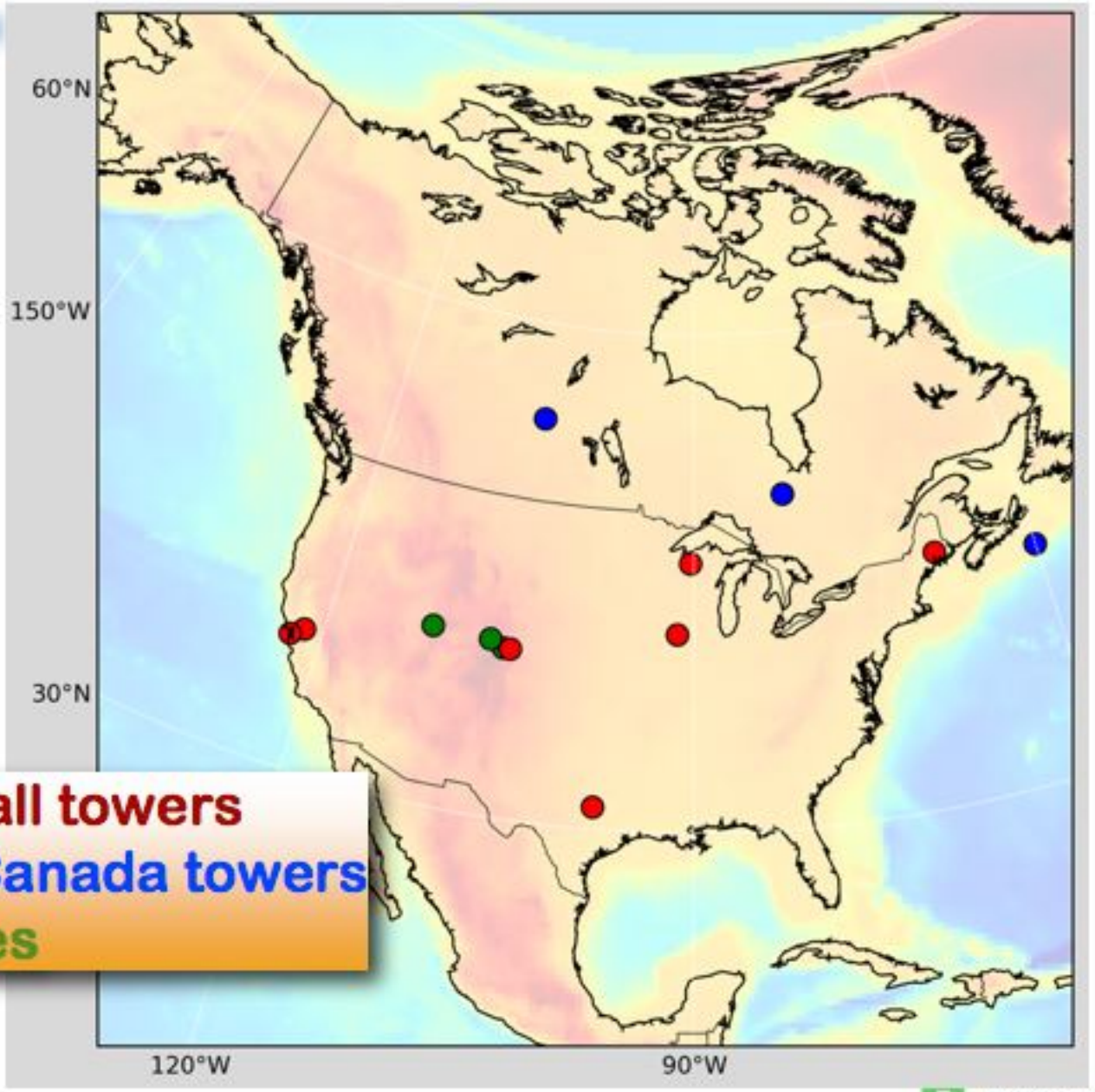
CarbonTracker

- Observatory Program..... : 8,738
- Cooperative Air Sampling Program : 13,964
- Tall Tower Program+EC..... : 5,128
- **Total Assimilated.....** : **27,830**
- **Aircraft Program (validation).....** : ~13,000

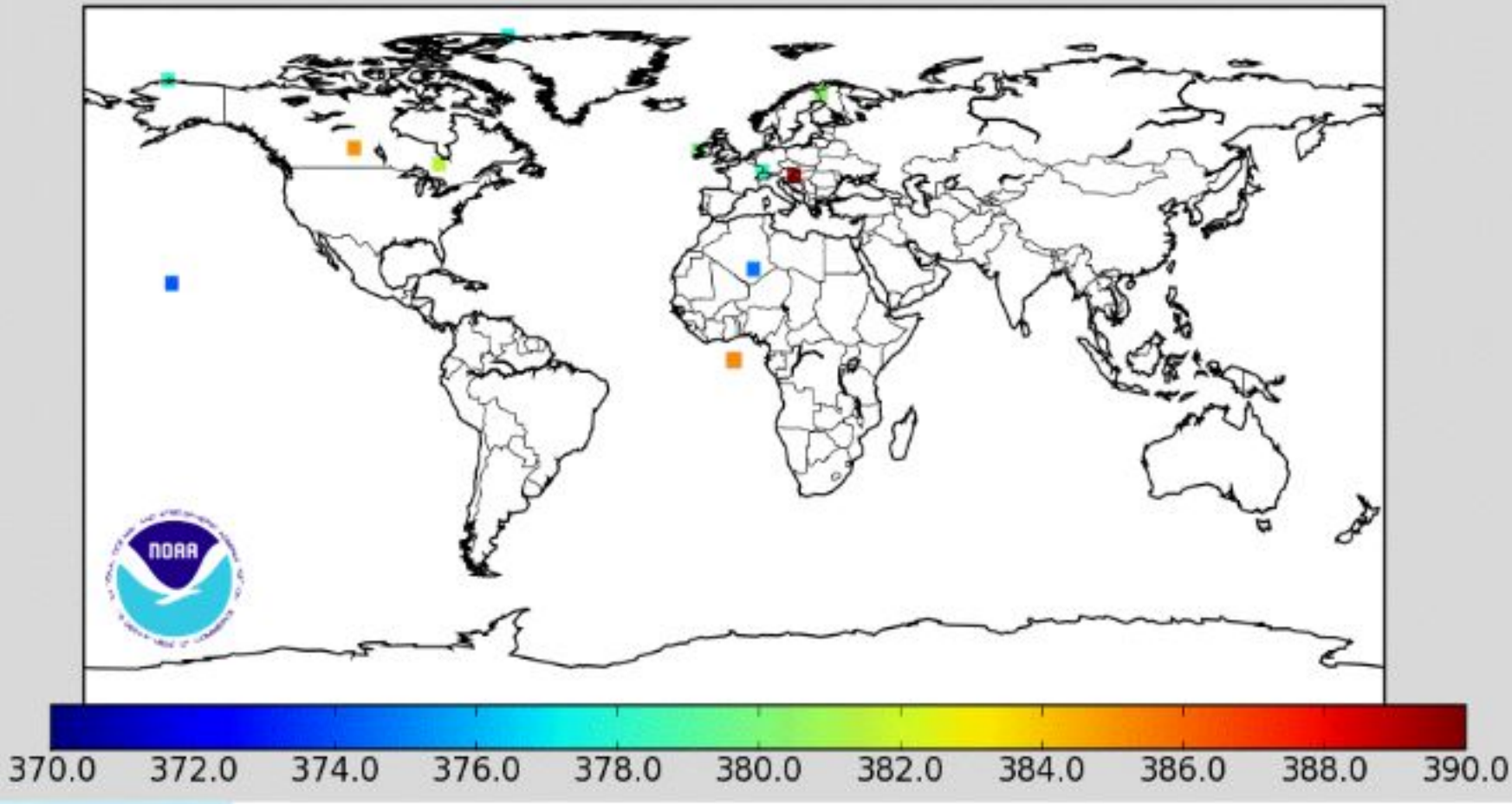
01/01/2000 to 01/01/2006

01/01/2000 to 01/01/2007: ~36,000 obs

Continuous Observations



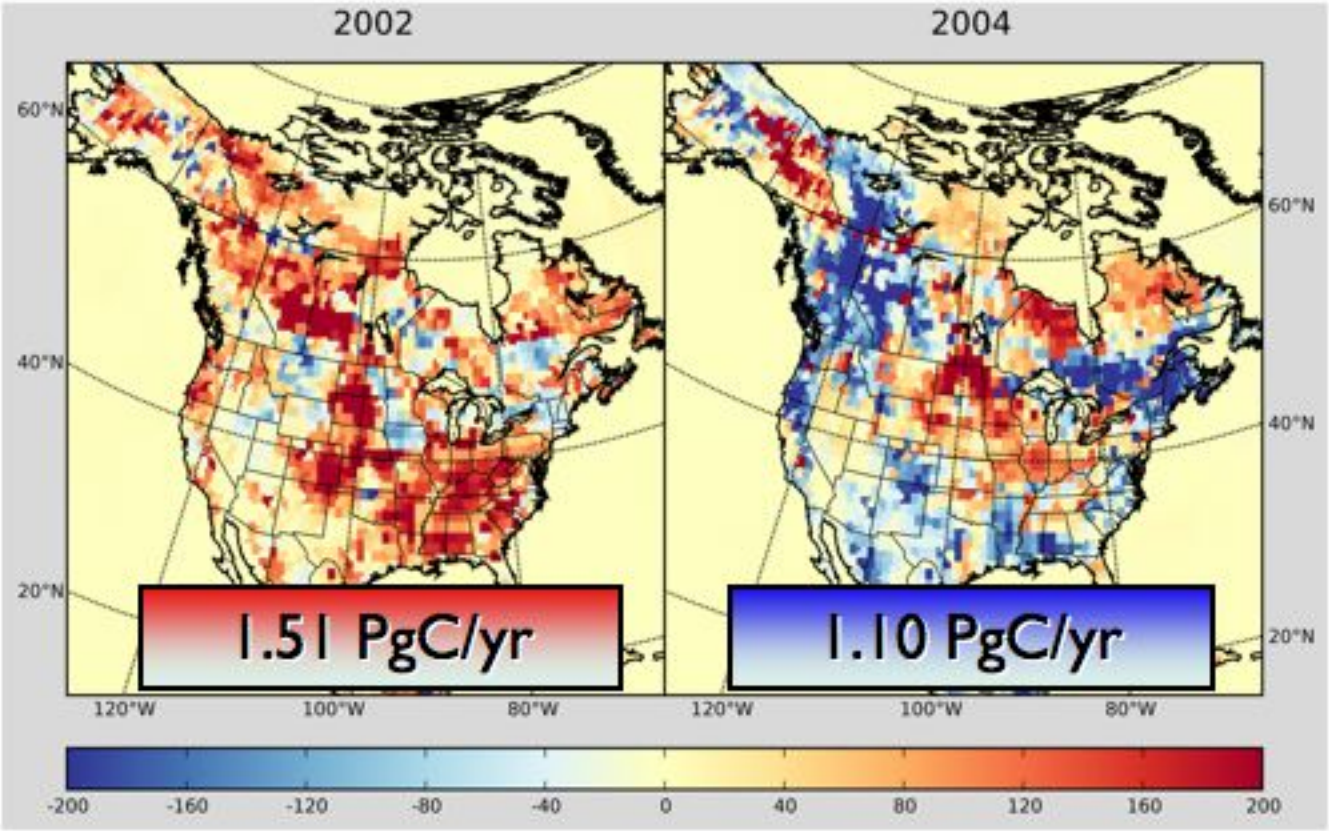
NOAA ESRL Tall towers
Environment Canada towers
RACCOON sites



Carbon Tracker

An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker

Wouter Peters*†‡, Andrew R. Jacobson*†, Colm Sweeney*†, Arlyn E. Andrews*, Thomas J. Conway*, Kenneth Masarie*, John B. Miller*†, Lori M. P. Bruhwiler*, Gabrielle Pétron*†, Adam I. Hirsch*†, Douglas E. J. Worthy§, Guido R. van der Werf¶, James T. Randerson||, Paul O. Wennberg**, Maarten C. Krol††, and Pieter P. Tans*



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Carbon Tracker vs SOCCR

An atmospheric perspective on North American carbon dioxide exchange: CarbonTracker

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Top-down vs Bottom-up

	CarbonTracker	SOCCR
Total	$-0.65^{-0.40}_{-1.02}$	-0.681 (±50%)
Forest	-0.39	-0.383
Cropland	-0.11	0.0*
Grasslands&Shrubs	-0.10	-0.12**

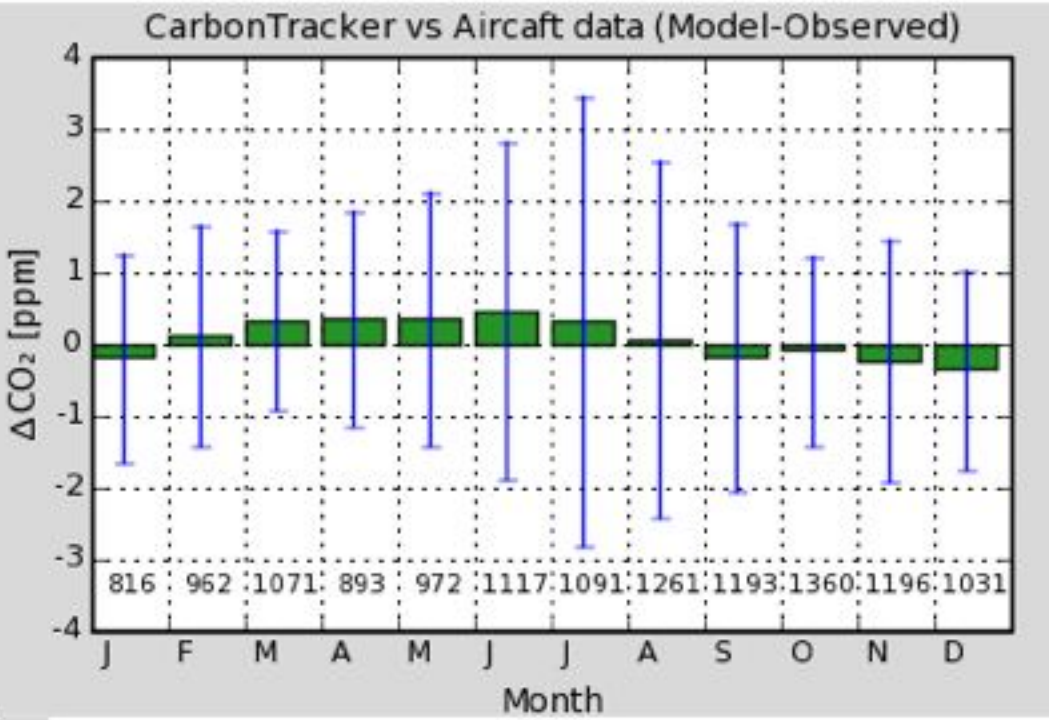
PgC/yr

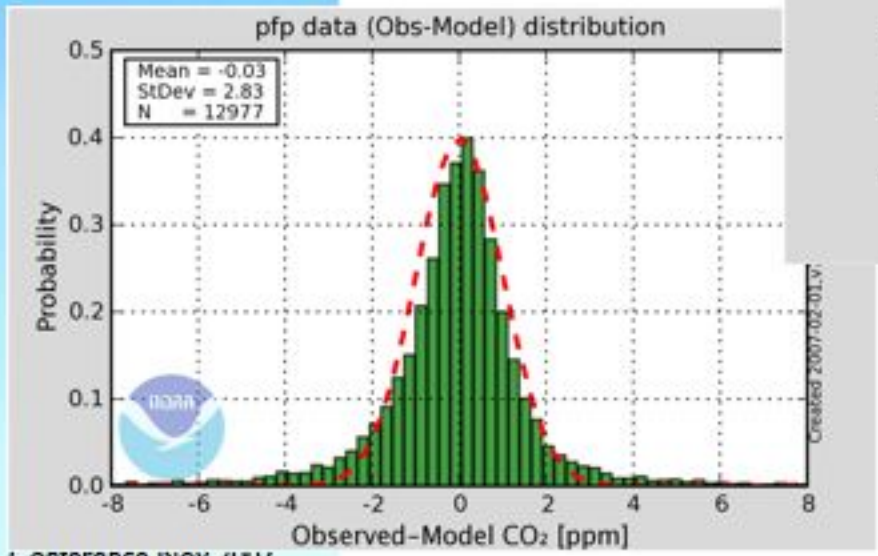
*Lateral transport of harvest products: -0.16 PgC/yr

**Woody encroachment estimate

- Estimates highly consistent with independent aircraft data
- Shows no large tropics-to-mid latitudes flux

	NH Land	Tropical Land
Jacobson	-2.88	+4.18
T3L2	-2.58	+1.86
Baker	-2.42	+1.80
CT	-1.80	+0.09
Stephens	**-1.5**	**+0.1**





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Next 50 years

- Observations are key, investments needed
- Continuation of 'traditional' records
- Exploration of new ones
- Modeling capacities need to grow alongside
- Invest in people
- Are we observing at the right places?? No
- ...

Acknowledgments

- Andy Jacobson, Arlyn Andrews, Tom Conway, Ken Masarie, John Miller, Gaby Petron, Adam Hirsch, Colm Sweeney, Pieter Tans
- Guido van der Werf, Christian Frankenberg, Jim Randerson, Paul Wennberg, Doug Worthy, Maarten Krol, Jocelyn Turnbull

Thank you

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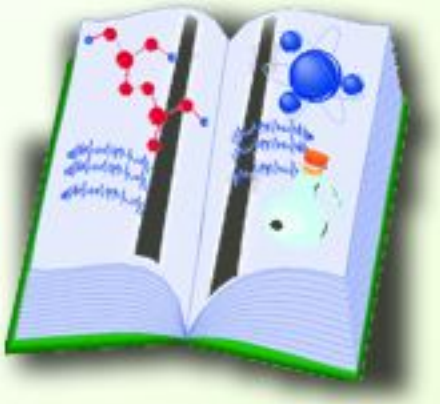
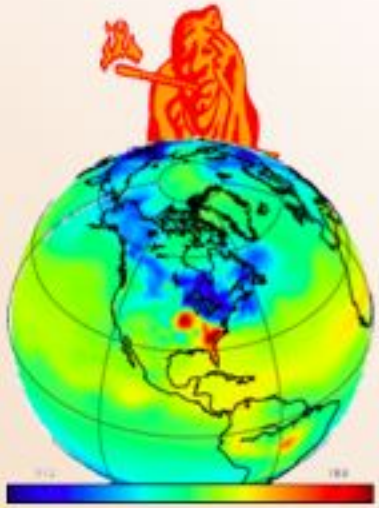
Why Track Carbon?

Business

Science



Policy



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Satellite Radiances

- Biomass greenness
- Deforestation
- Droughts, Fires, Pests, Blow-downs
- Algae blooms, winds, SST
- CO2, CH4, CO

The atmosphere

- CO2
- 13CO2
- 14CO2
- COS
- CO, CH4