Os impactos econômicos das mudanças climáticas
FEA/IEA-USP 17 Março 2010

Monitoramento da concentração de gases de efeito estufa na atmosfera

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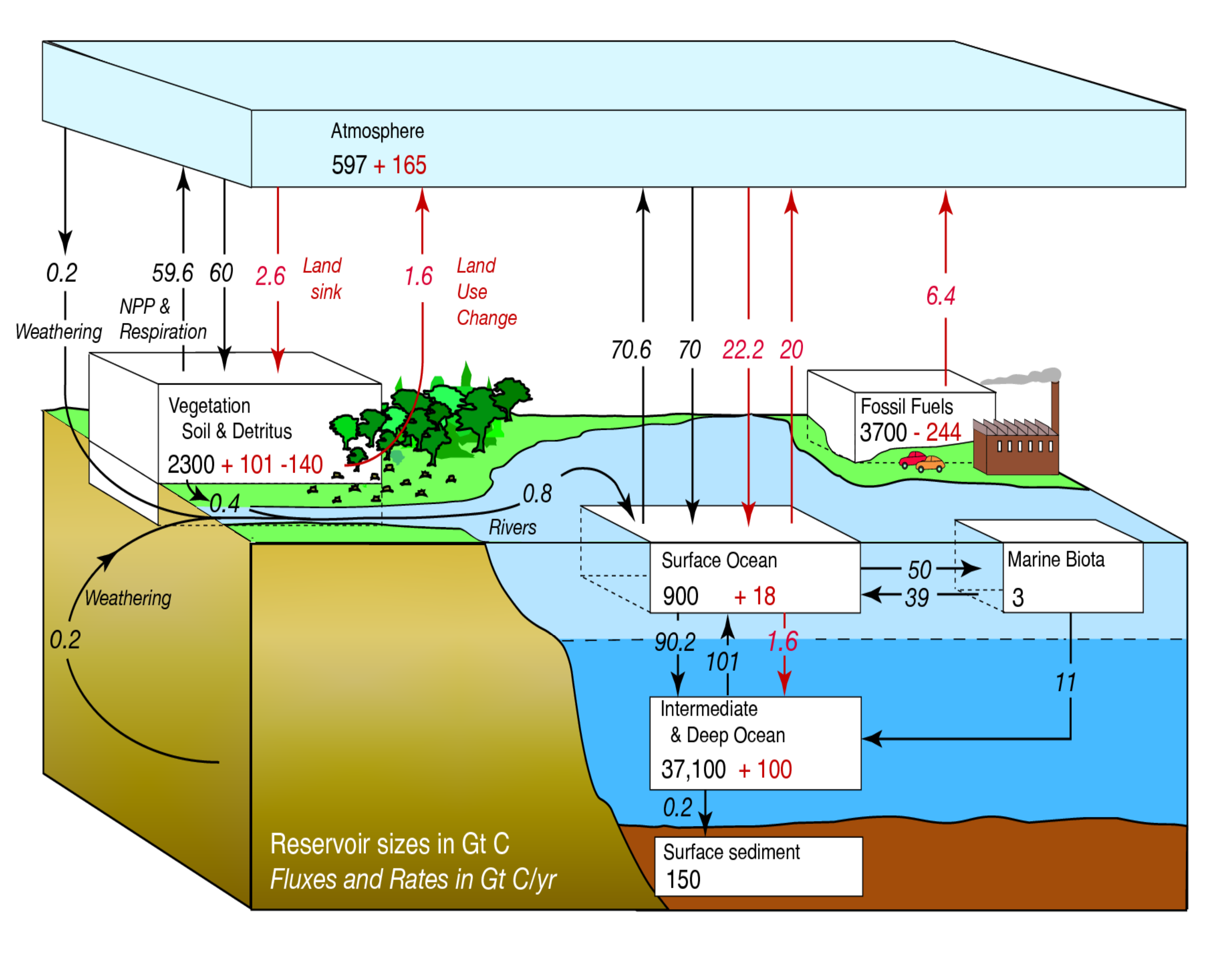
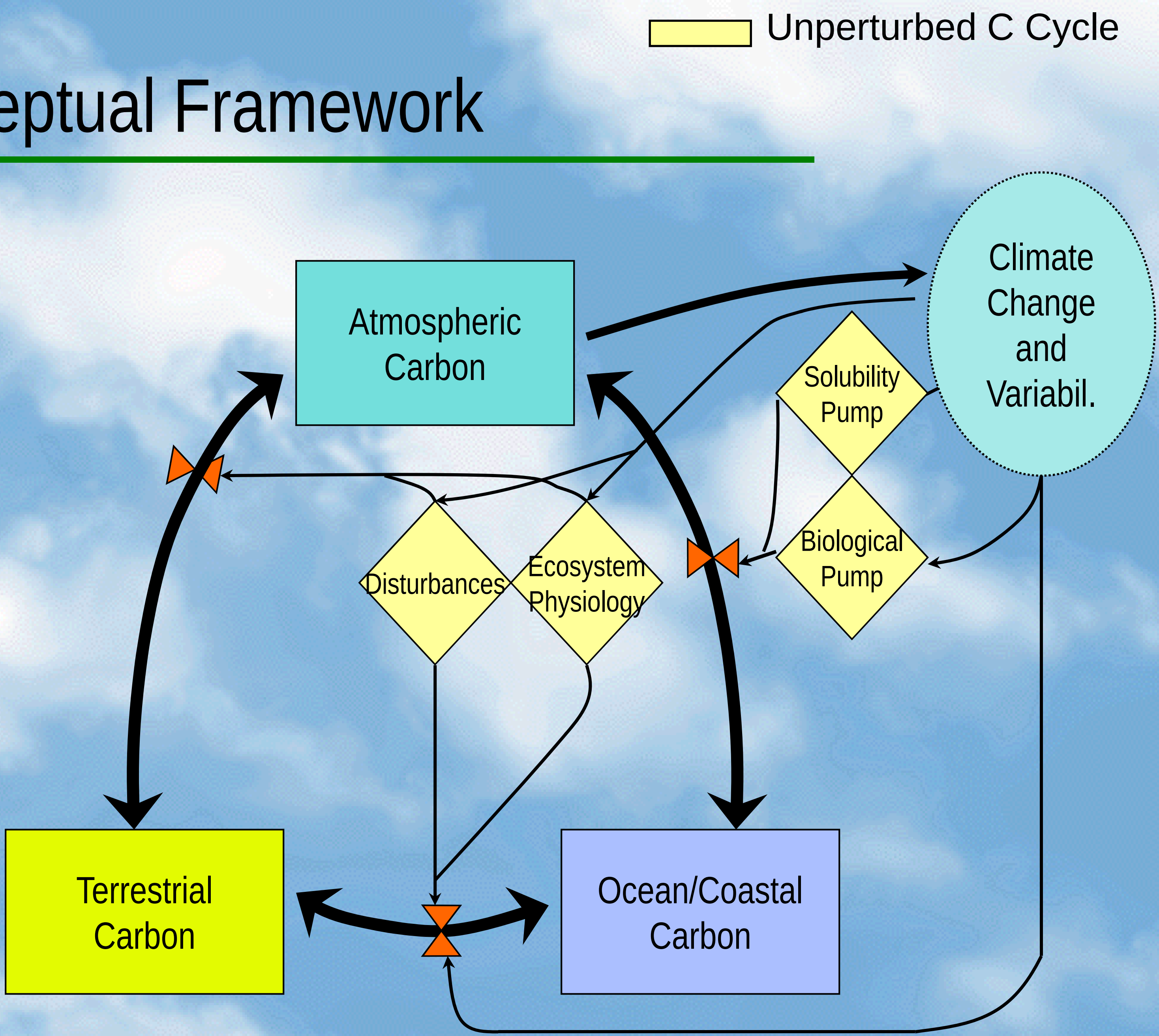
Instituto de Física da USP

How Humans Have Changed the Carbon Cycle

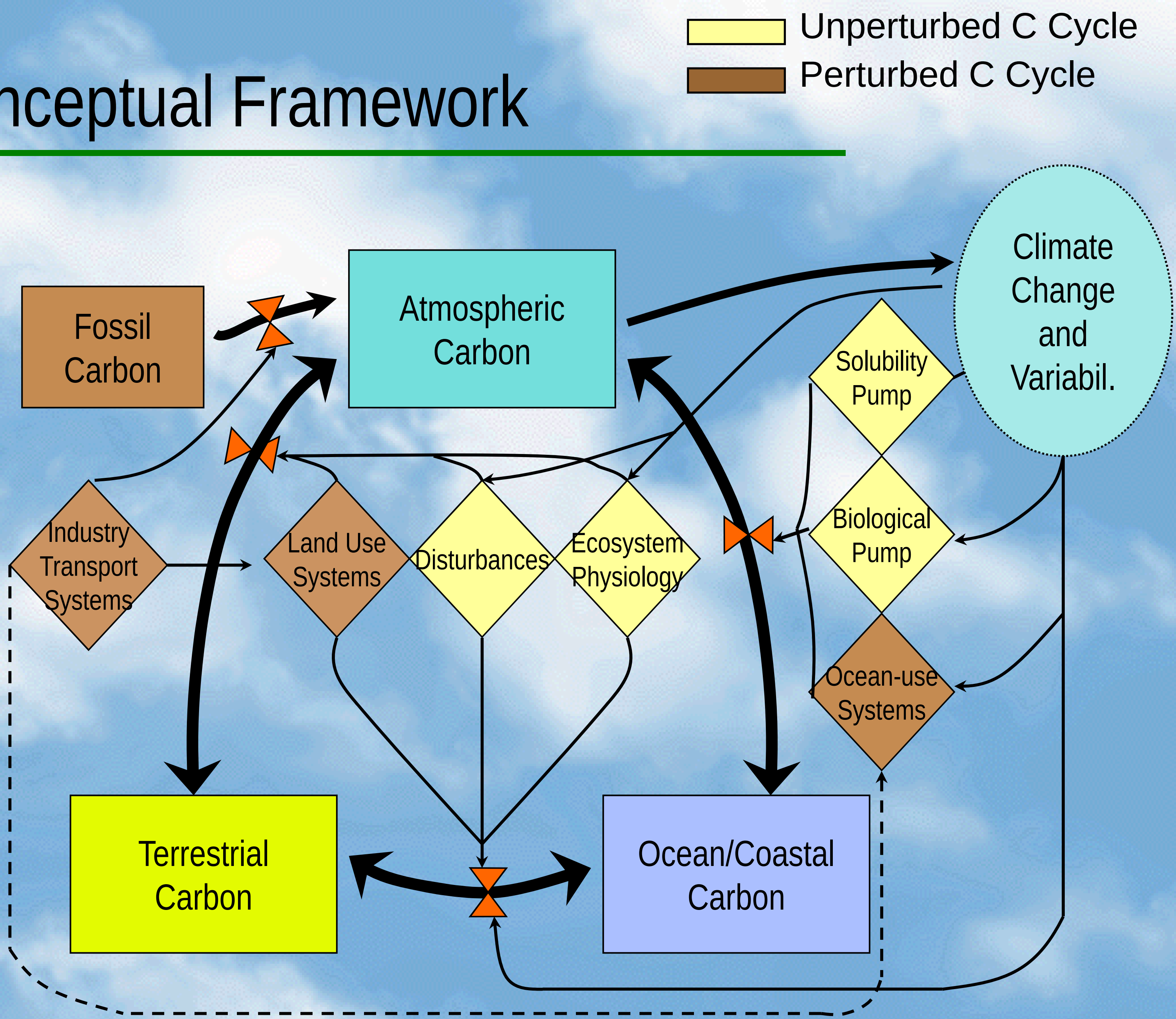


Largest variability & uncertainties are in carbon fluxes from land use change and 'residual terrestrial carbon sink'.

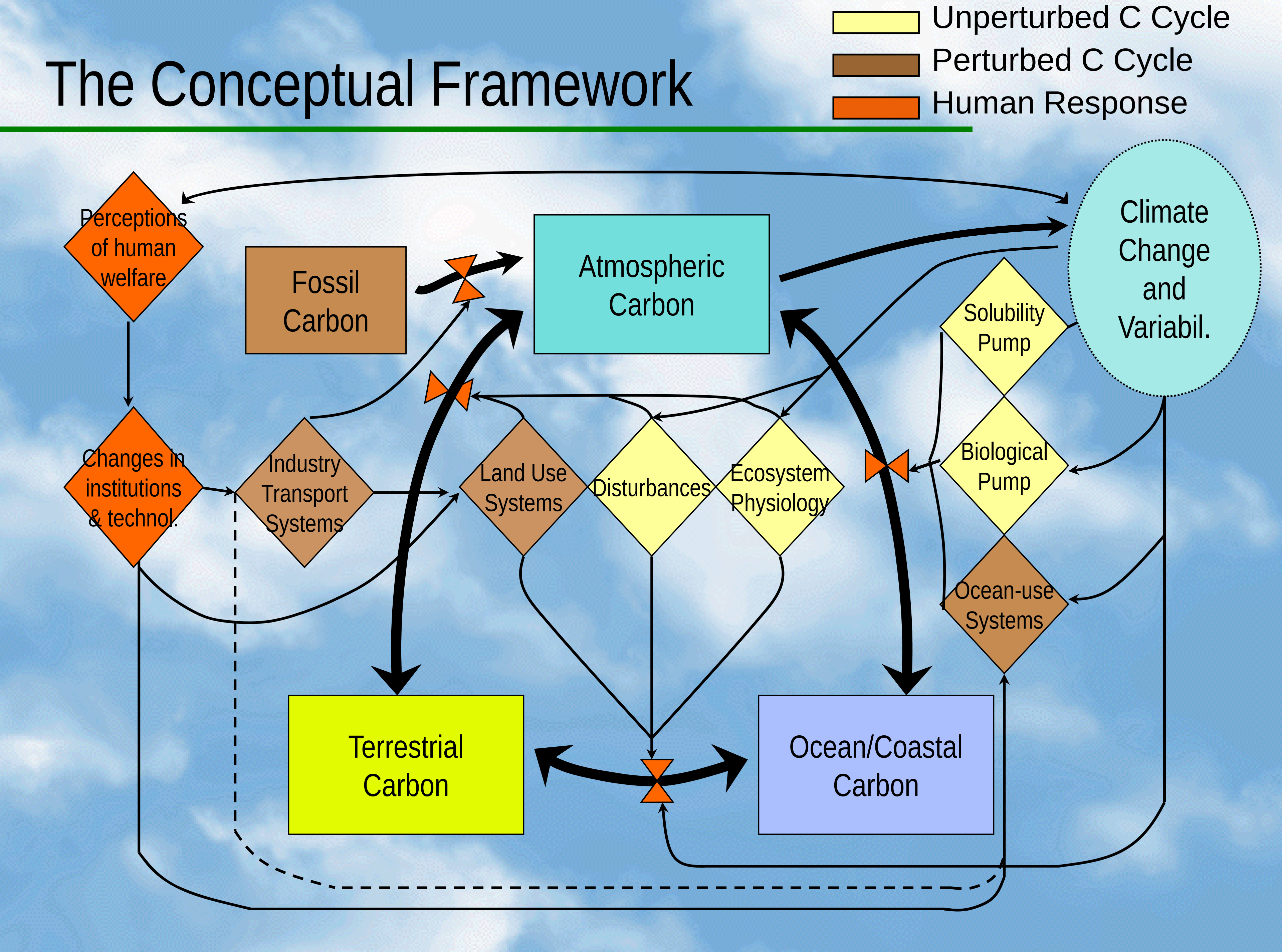
The Conceptual Framework



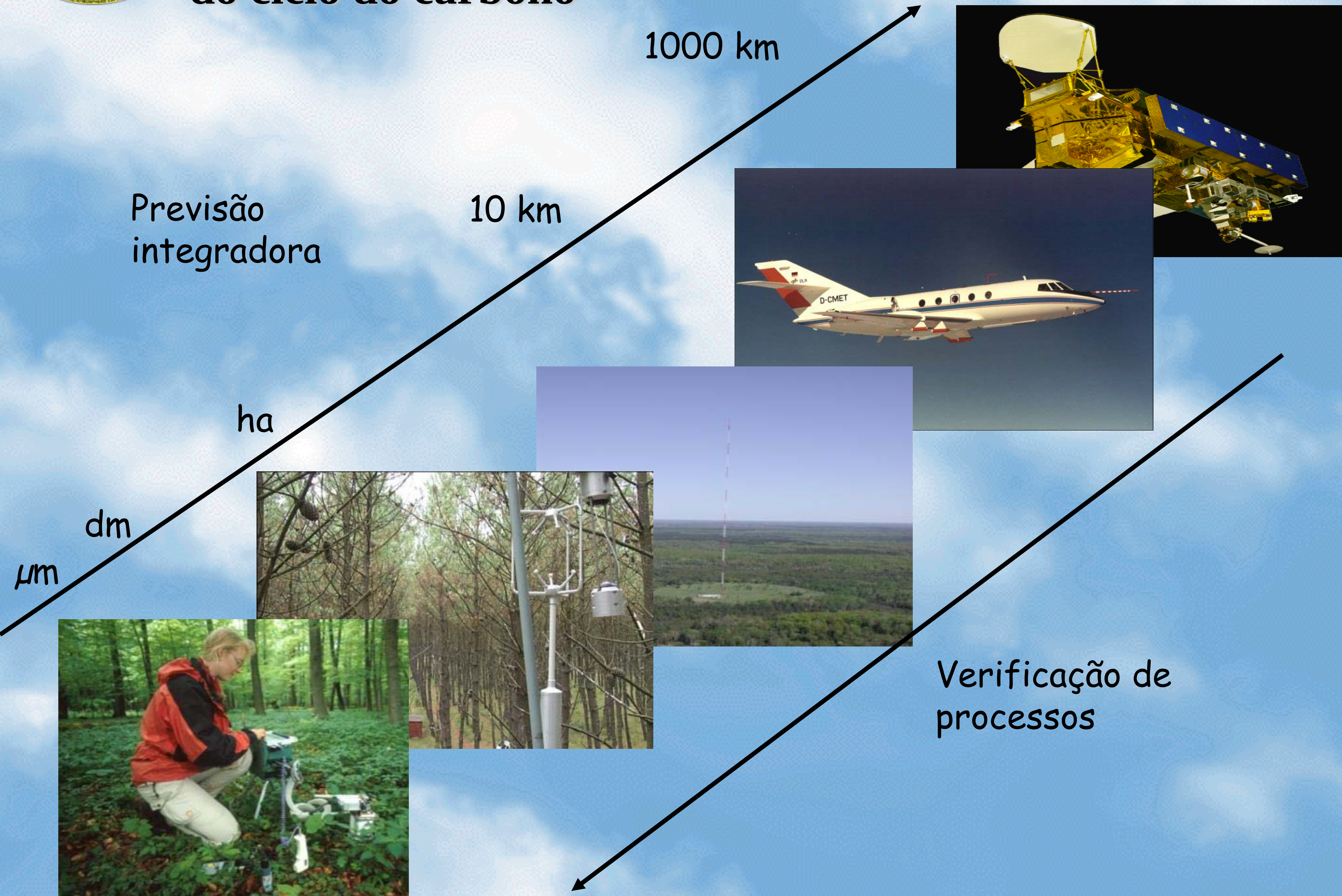
The Conceptual Framework



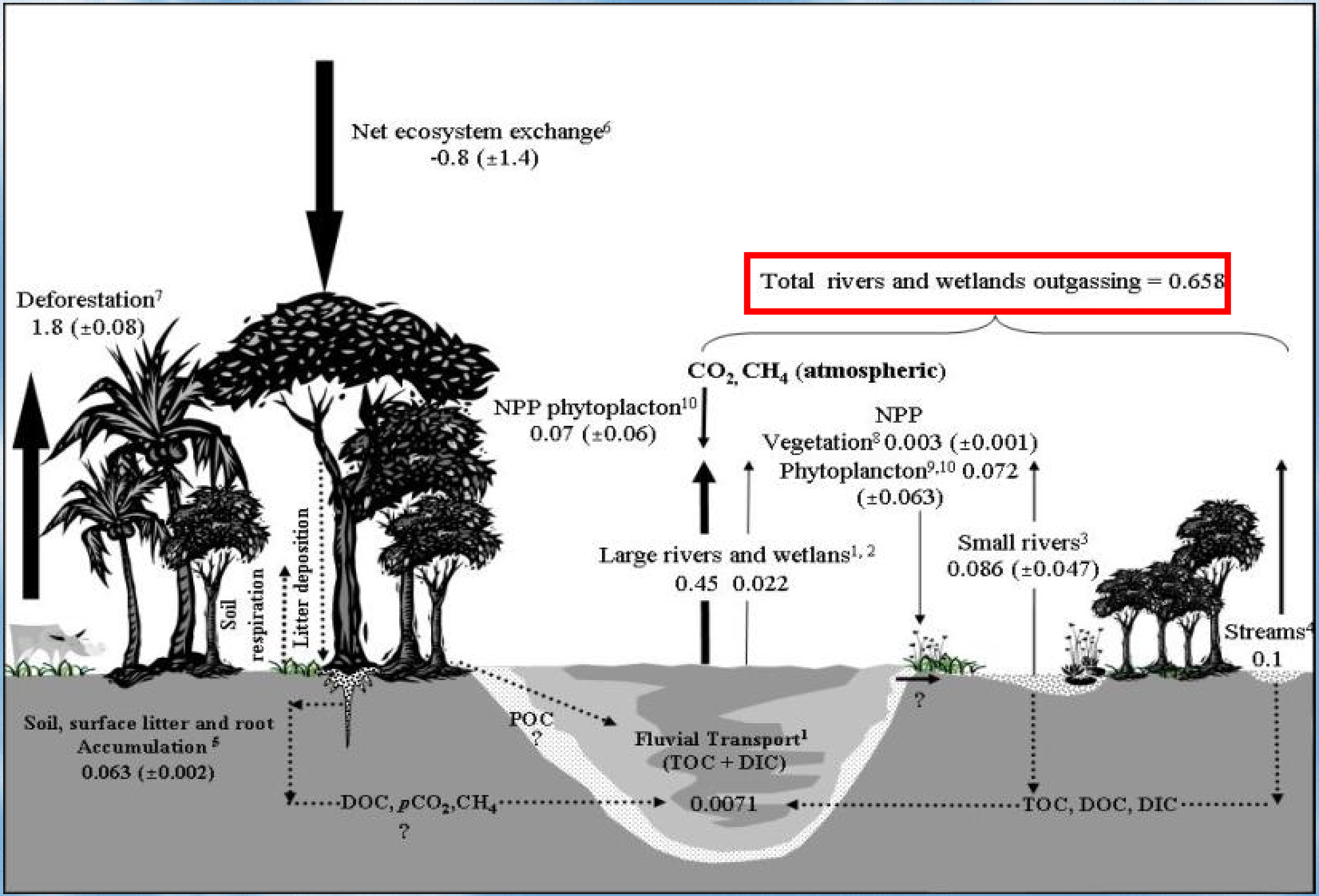
The Conceptual Framework



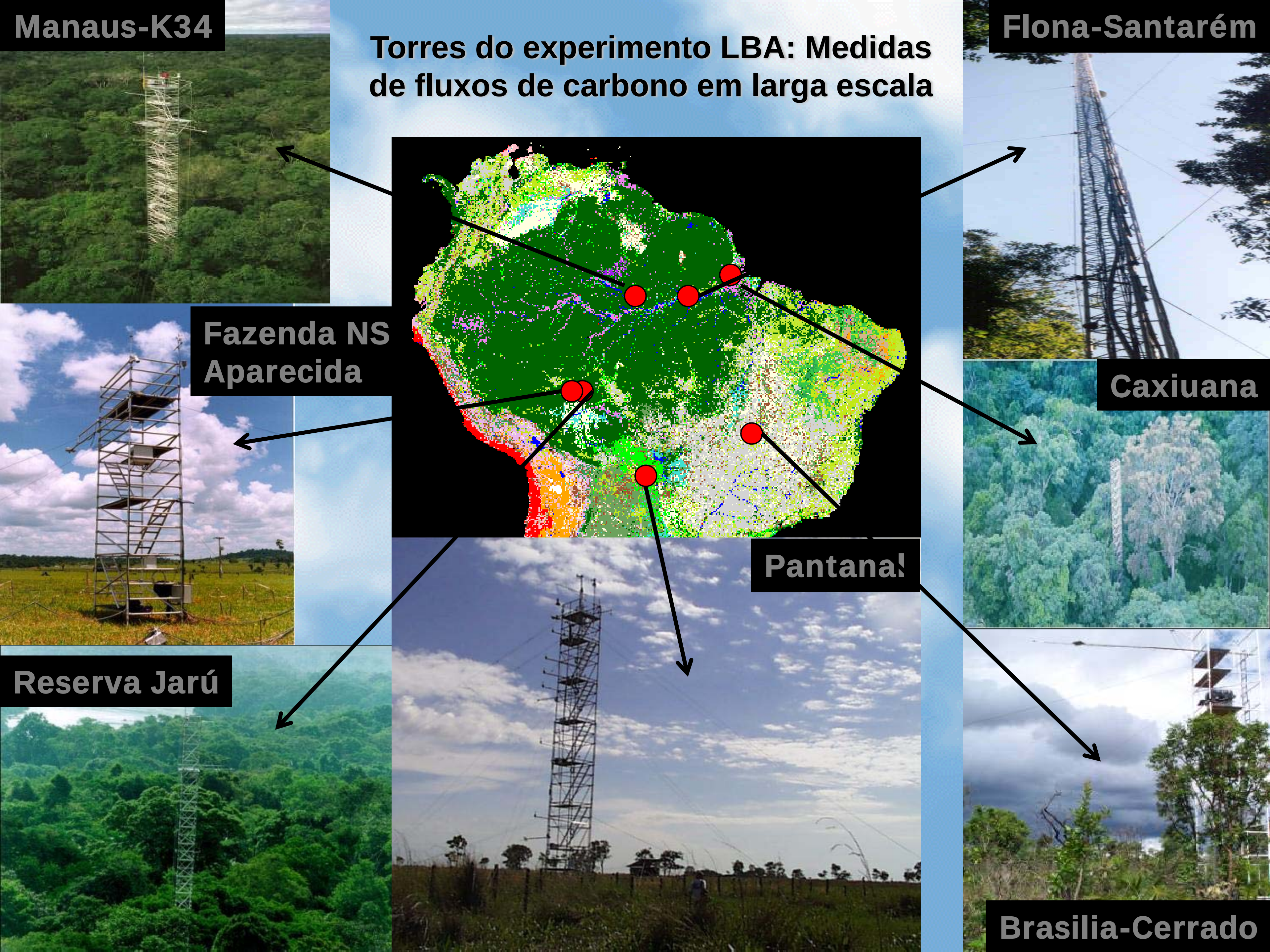
Abordagem integrada de observações do ciclo do carbono



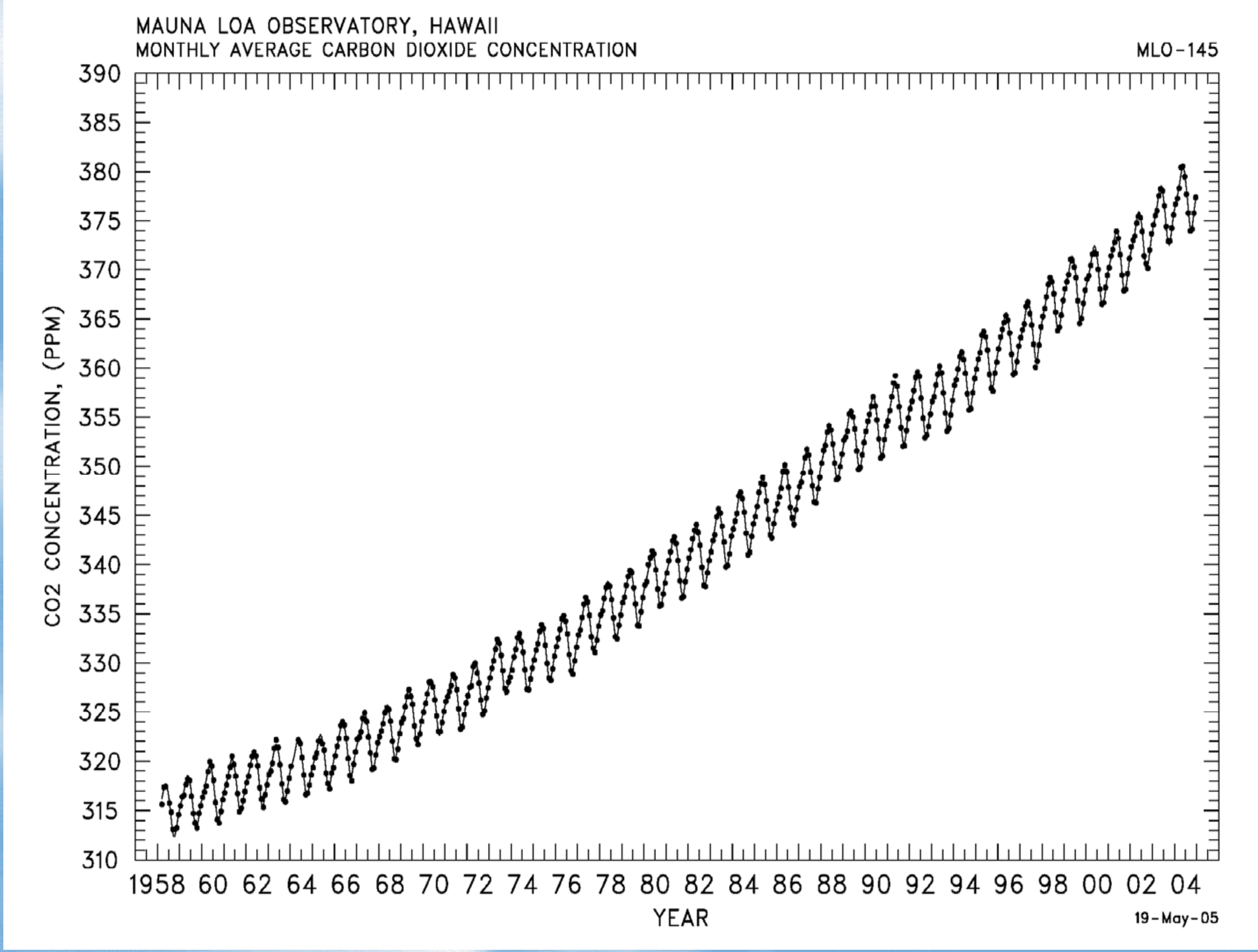
Carbon Balance in Amazonia



1- Richey et al., 2002; 2- Melack et al., 2004; 3 -Rasera et al., unpublish data; 4- Johnson et al., 2006; 5- Telles et al.,2003; 6- Ometto et al., 2005; 7- Houghton et al., 2000; 8- Morison et al.,2000; 9- Putz & Junk, 1997; 10- Wissmar et al., 1981

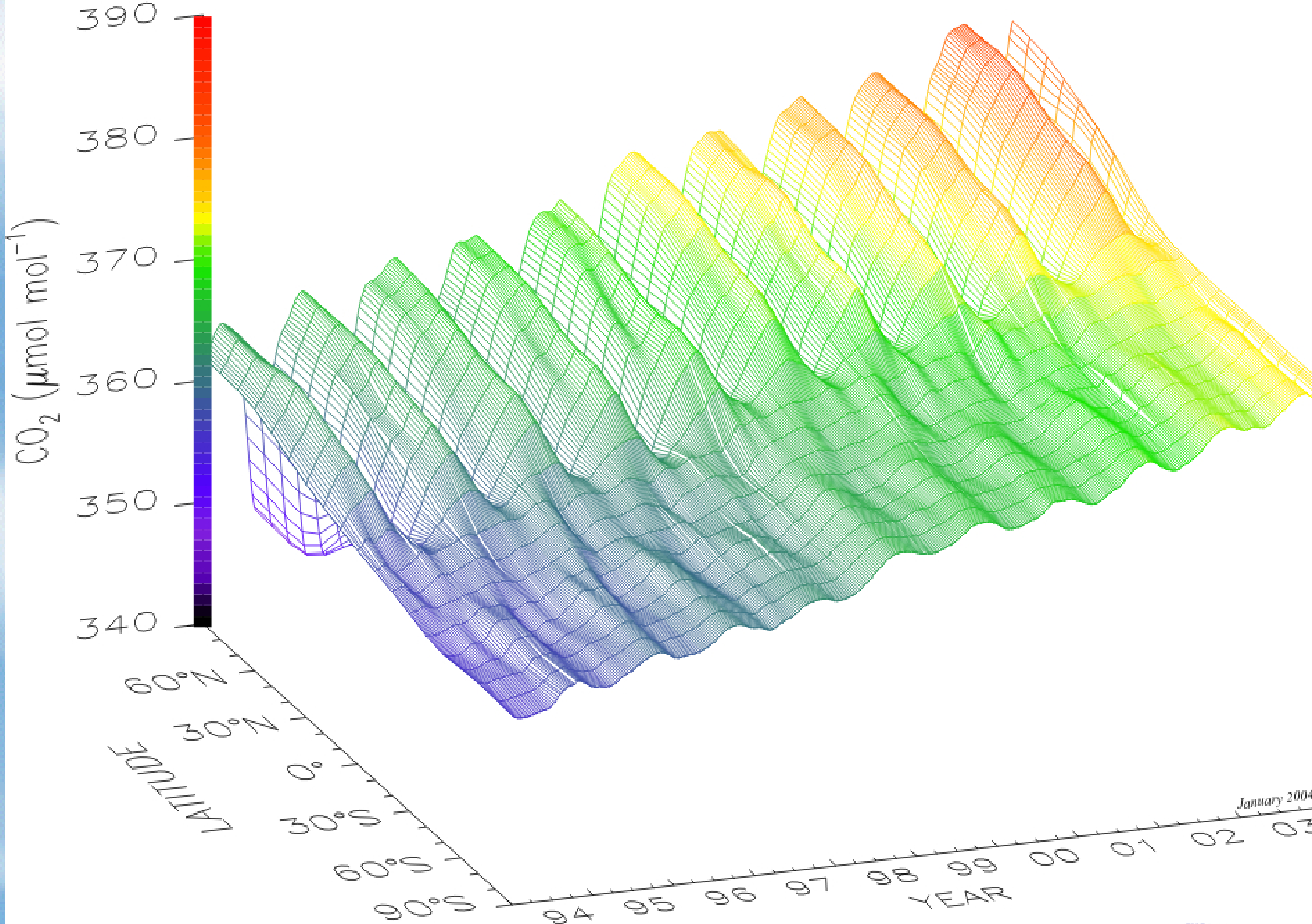

Torres do experimento LBA: Medidas de fluxos de carbono em larga escala
Manaus-K34
Flona-Santarém
Fazenda NS Aparecida
Caxiuana
Reserva Jarú
Pantanal
Brasilia-Cerrado

The "Keeling Curve"



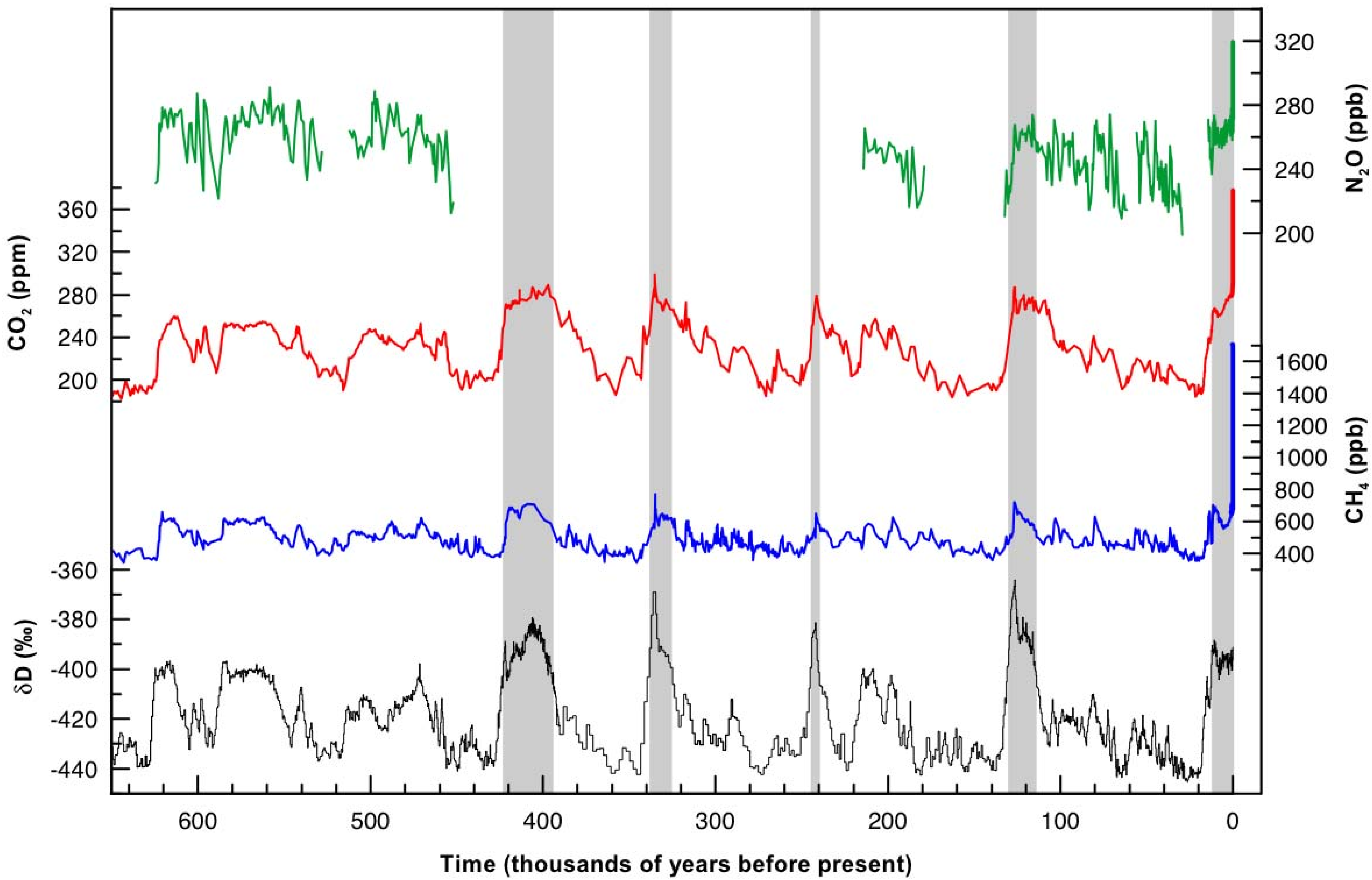
Global Distribution of Atmospheric Carbon Dioxide

NOAA CMDL Carbon Cycle Greenhouse Gases



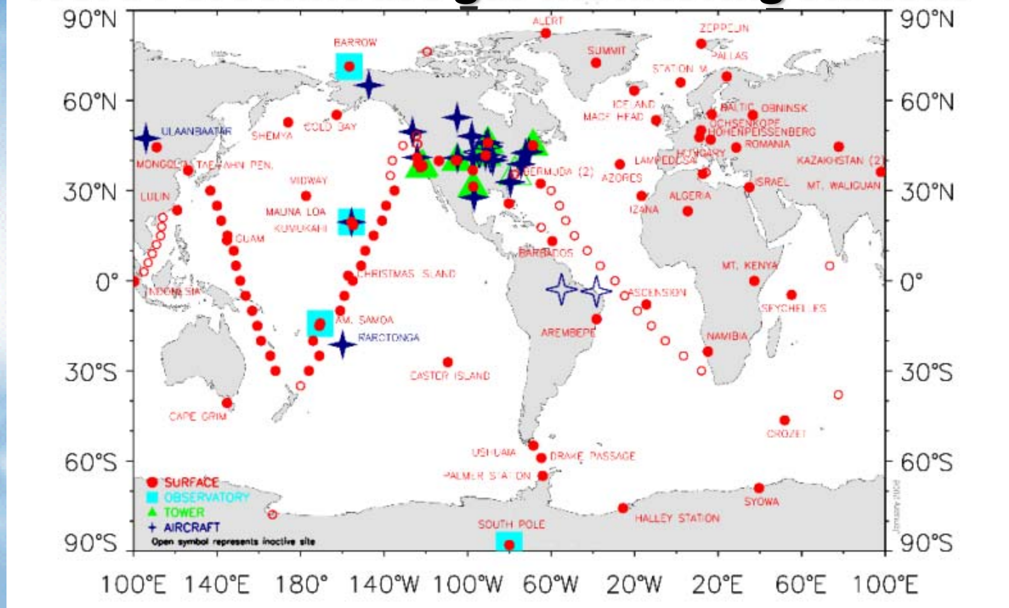
Three dimensional representation of the latitudinal distribution of atmospheric carbon dioxide in the marine boundary layer. Data from the NOAA CMDL cooperative air sampling network were used. The surface represents data smoothed in time and latitude. Principal investigators: Pieter Tans and Thomas Conway, NOAA CMDL Carbon Cycle Greenhouse Gases, Boulder, Colorado, (303) 497-6678 (pieter.tans@noaa.gov, http://www.cmdl.noaa.gov/ccgg).

Concentração de CO_2, metano e óxido nitroso nos últimos 650.000 anos. A linha preta é a temperatura na mesma escala temporal.

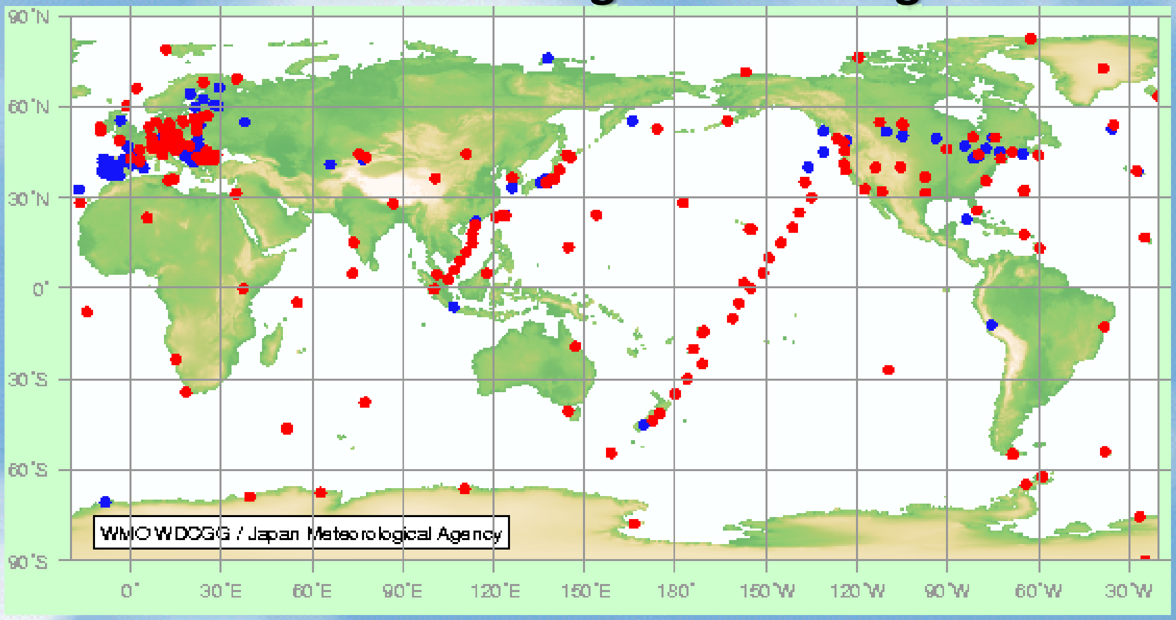


Redes de monitoramento global da concentração de gases de efeito estufa

NOAA Greenhouse gas monitoring stations

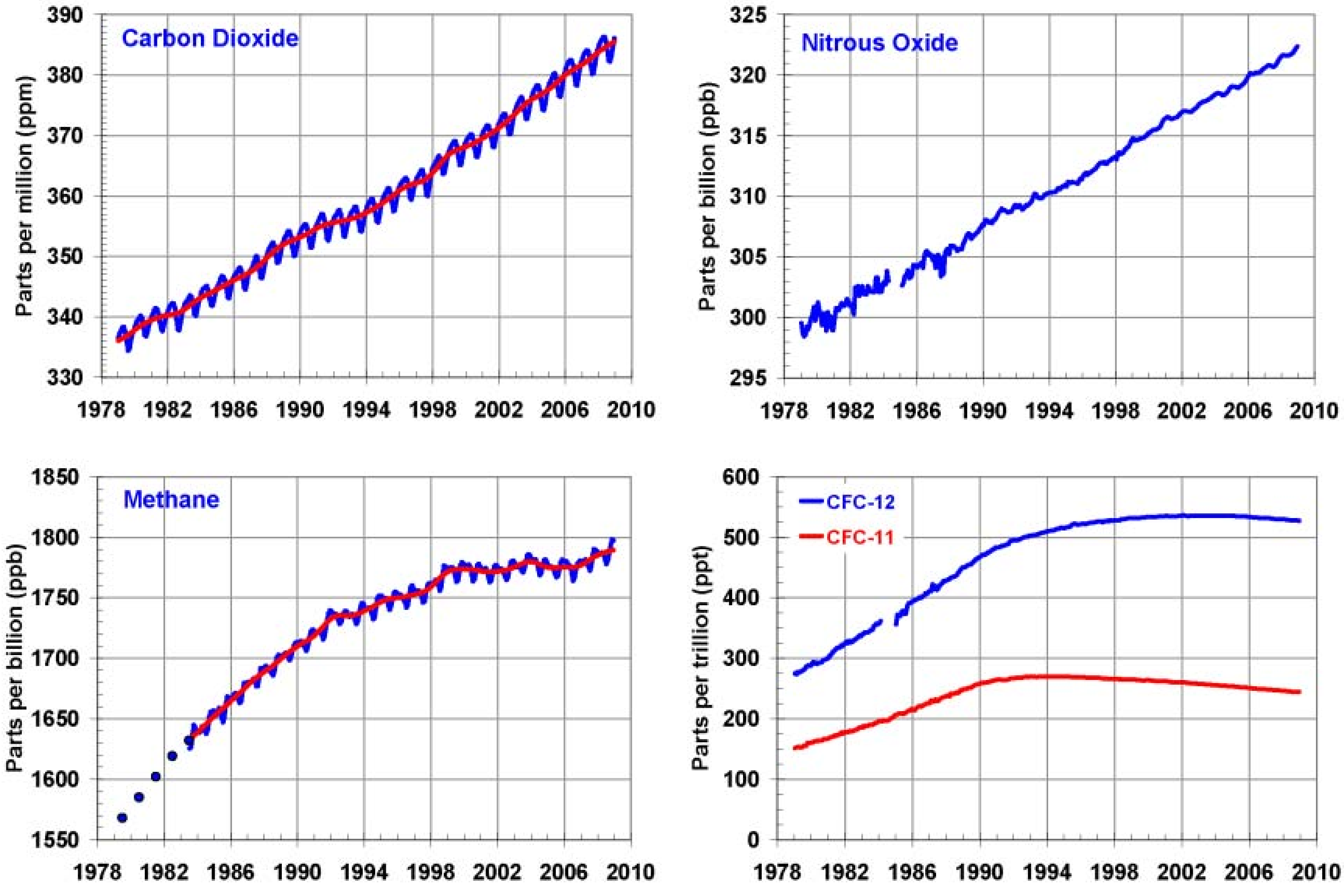


WMO Greenhouse gas monitoring stations



Dados meteorológicos: > 10.000 estações
Dados de concentração de gases: <100

NOAA Greenhouse gas monitoring stations



WMO Greenhouse gas monitoring stations

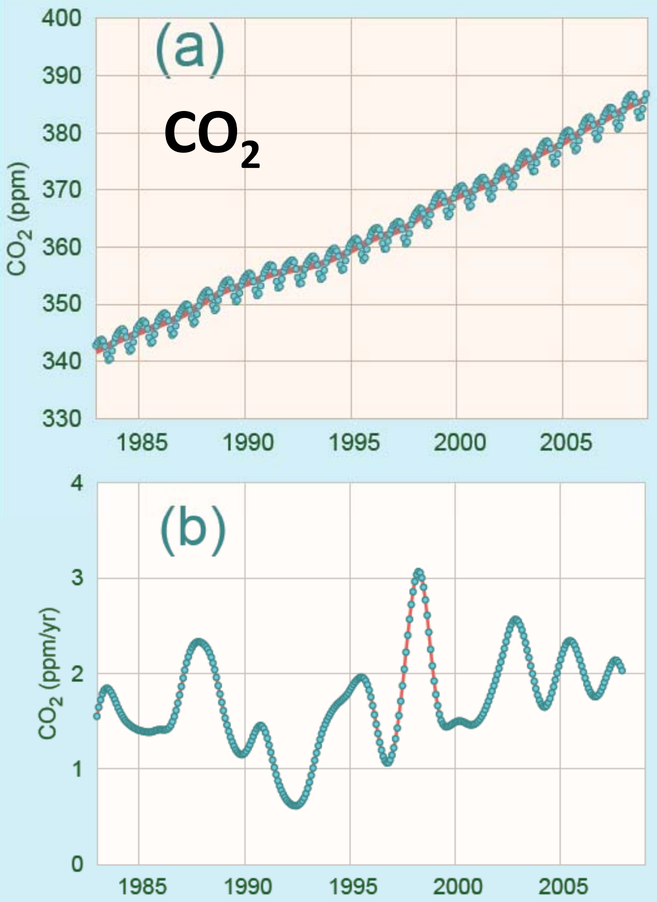


Figure 3. Globally averaged CO_2 (a) and its growth rate (b) from 1983 to 2008.

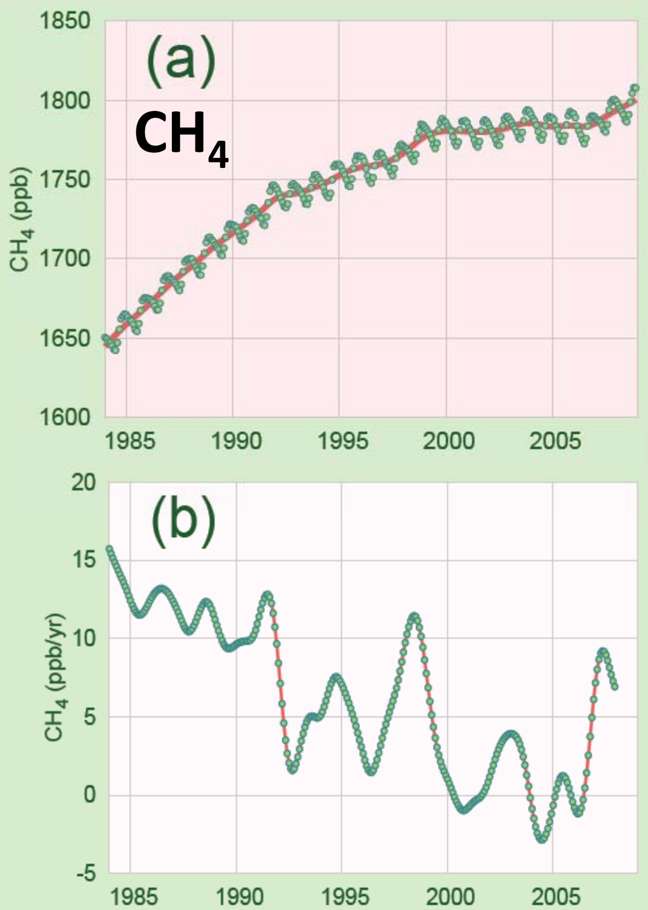


Figure 4. Globally averaged CH_4 (a) and its growth rate (b) from 1984 to 2008.

WMO: medidas de N20, SF6 e outros gases

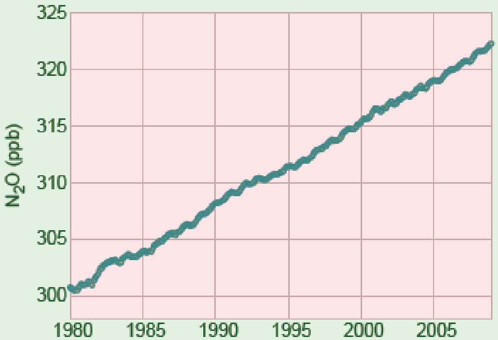


Figure 5. Globally averaged monthly mean mixing ratios of N_2O from 1980 to 2008.

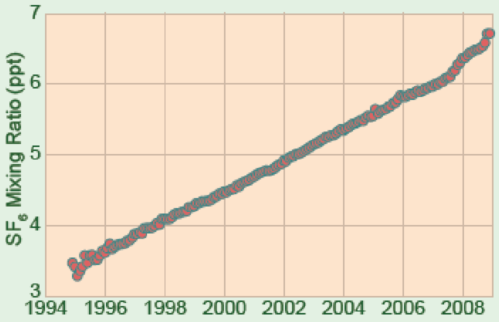


Figure 6. Monthly mean mixing ratios of sulphur hexafluoride (SF_6) from 1995 to 2008 averaged over 24 stations.

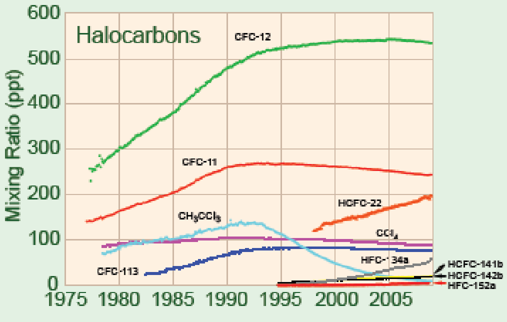
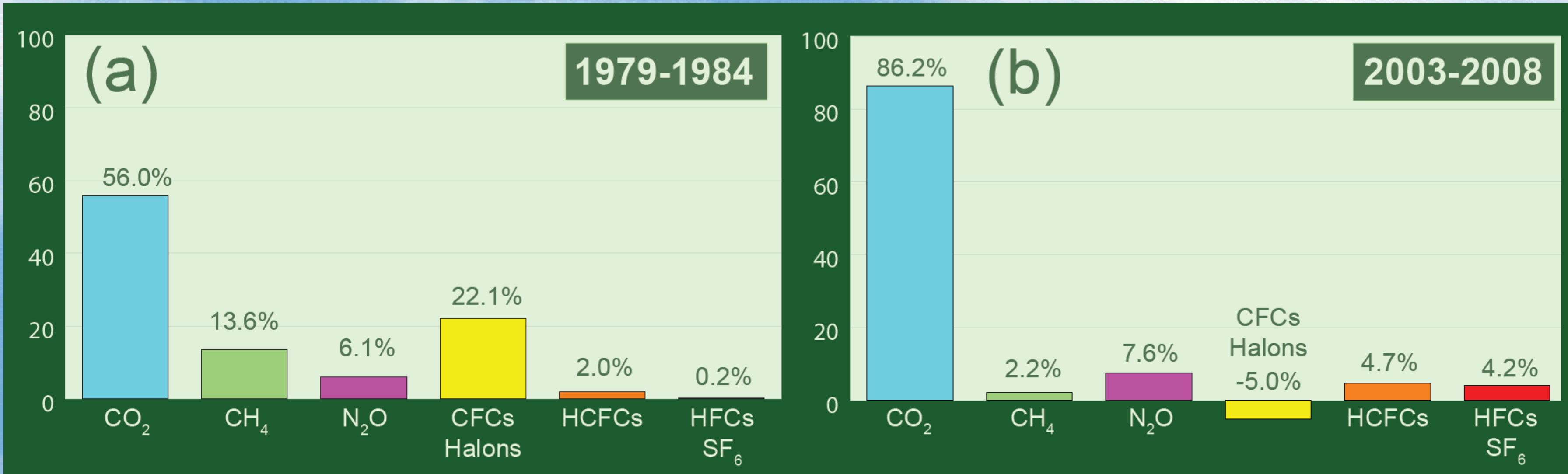


Figure 7. Monthly mean mixing ratios of the most important halocarbons from 1977 to 2008 averaged over the network (between 7 and 56 stations).

Relative contribution of major greenhouse gases to the overall change in radiative forcing between 1979 and 1984



Relative contribution of major greenhouse gases to the overall change in radiative forcing between 1979 and 1984 (a) and from 2003 to 2008 (b). The importance of CO2 has increased substantially.

CO_2 em Mauna Loa de 1958-2010

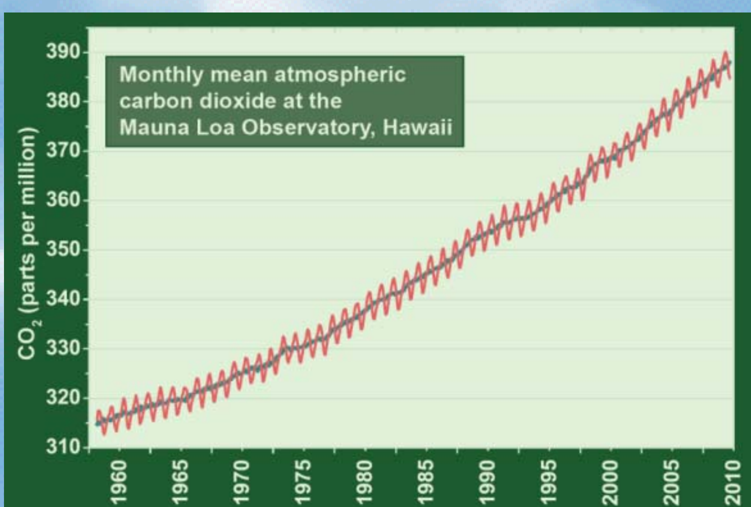


Table 1. Global abundances and changes of key greenhouse gases from the WMO-GAW global greenhouse gas monitoring network. Global abundances for 2008 are calculated as an average over twelve months.

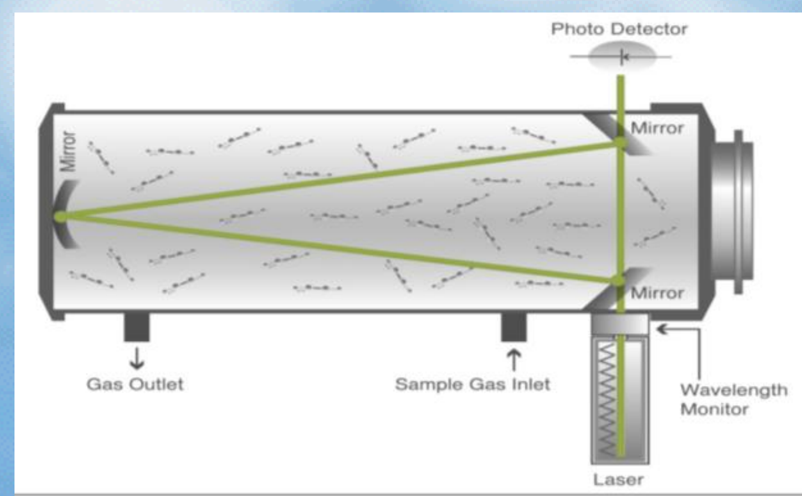
	CO_2 (ppm)	CH_4 (ppb)	N_2O (ppb)
Global abundance in 2008	385.2	1797	321.8
Increase since 1750[1]	38 %	157 %	19 %
2007-08 absolute increase	2.0	7	0.9
2007-08 relative increase	0.52 %	0.39 %	0.28 %
Mean annual absolute increase during last 10 years	1.93	2.5	0.78

[1] Assuming a pre-industrial mixing ratio of 280 ppm for CO_2, 700 ppb for CH_4 and 270 ppb for N_2O.

(WMO Greenhouse gas bulletin 2010)

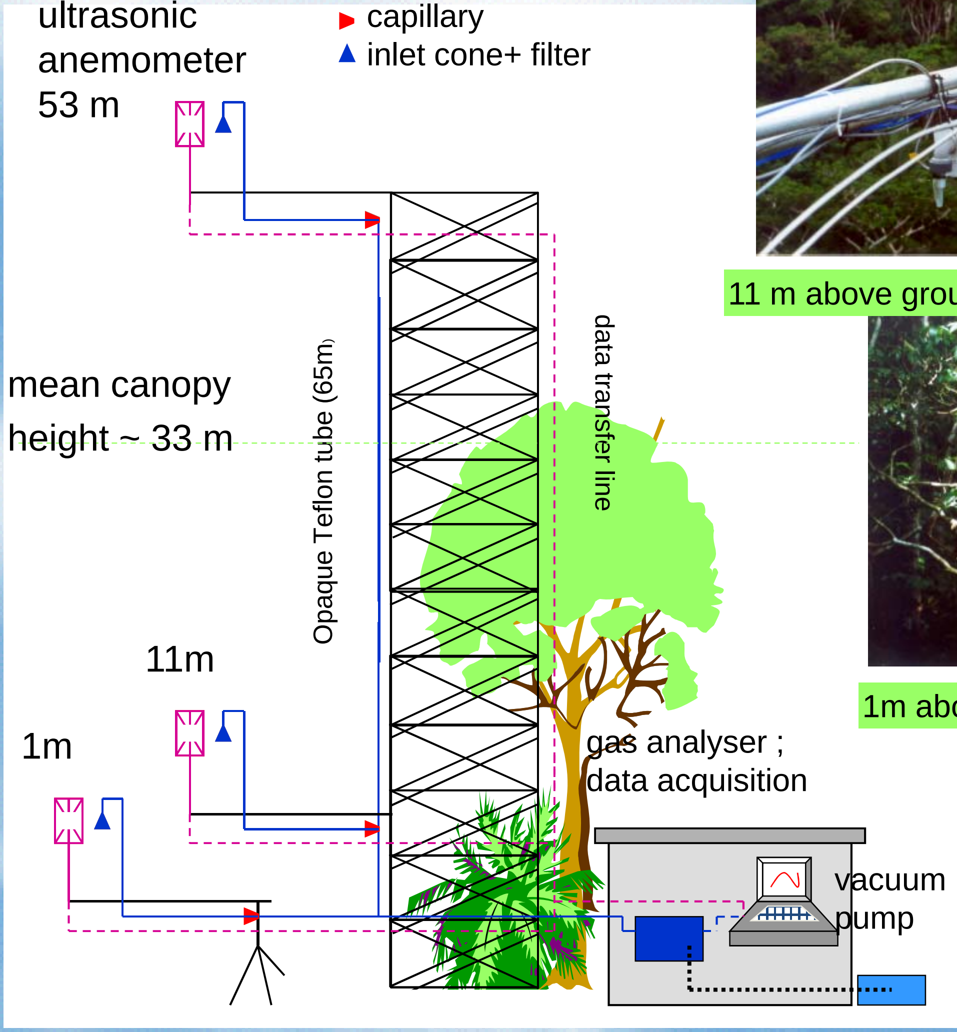
Medidas de CO_2 por espectroscopia de infravermelho não dispersiva

Medidas de CO_2 por "Wave Length Scanning Cavity Ring Down Spectroscopy "



Very long effective path length (~14 km)

Medidas de Fluxos de CO_2 por Eddy Correlation

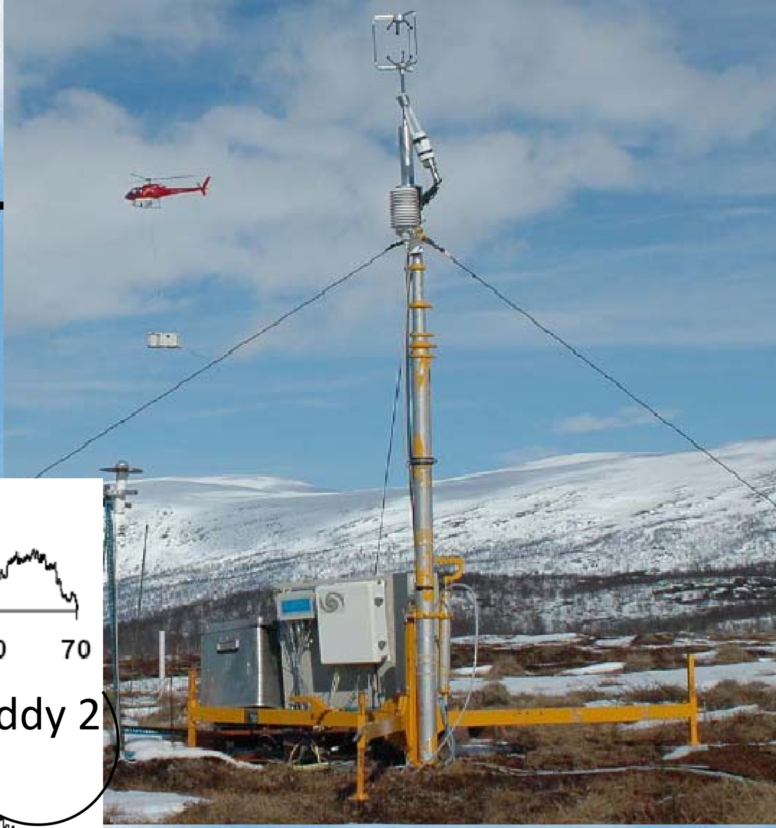


20 m above canopy height

11 m above ground (stem space)

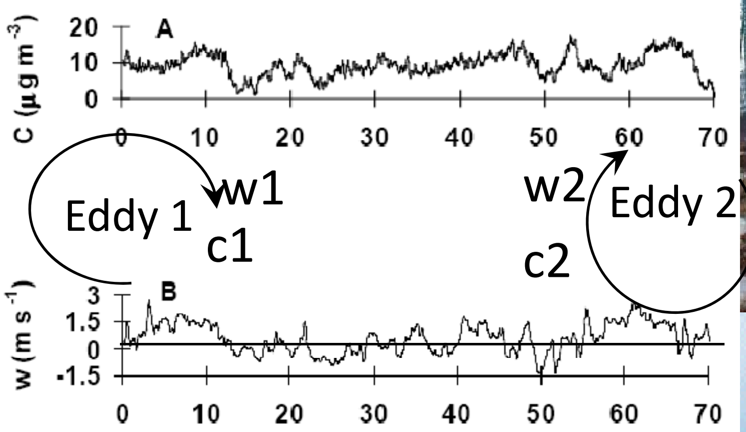
1m above forest floor

NEE measurements



1) Eddy covariance: CO_2, CH_4, H_2O, H

Concentration and wind speed measurements above a forest canopy
Sampling rate = 10 Hz

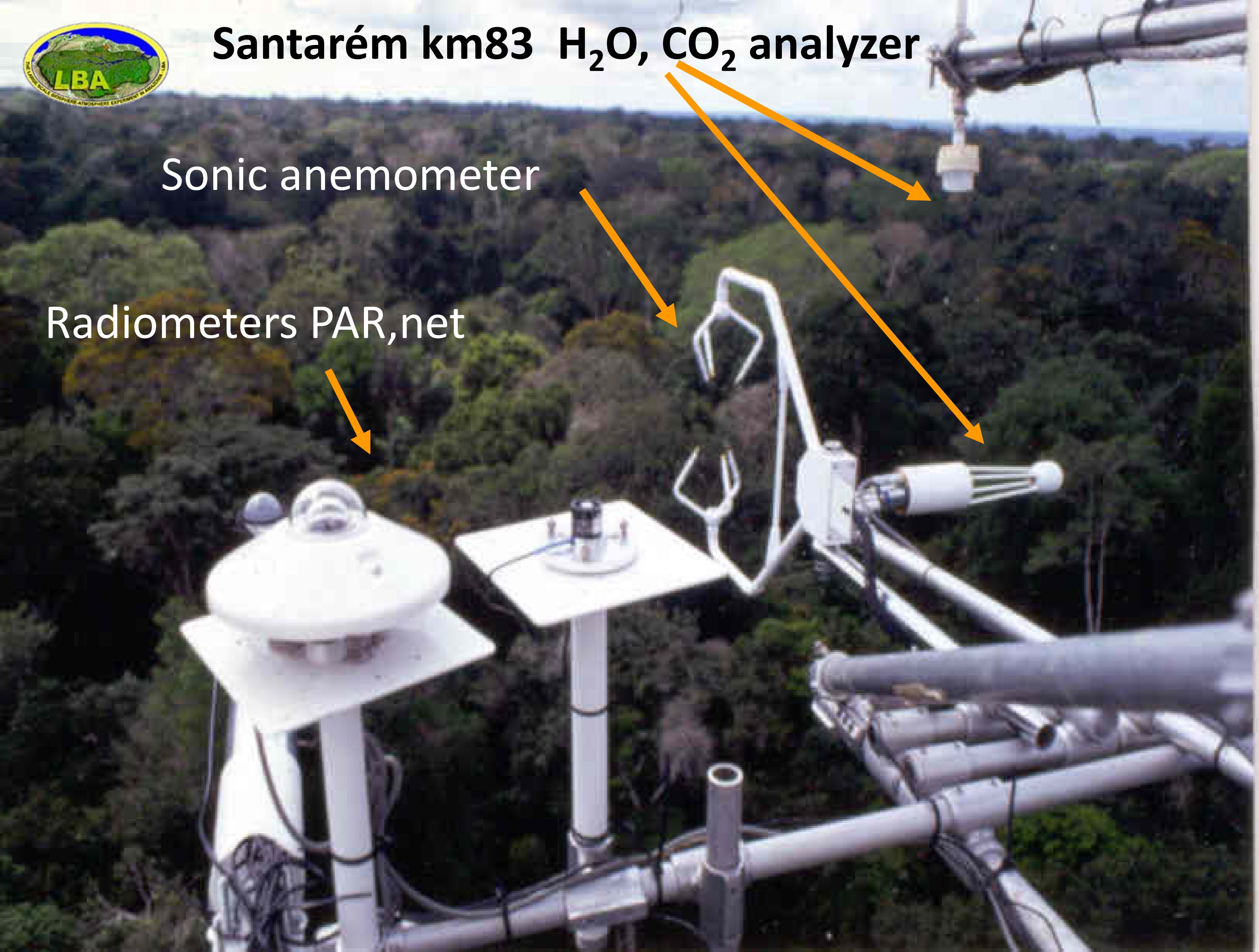


Time (seconds)

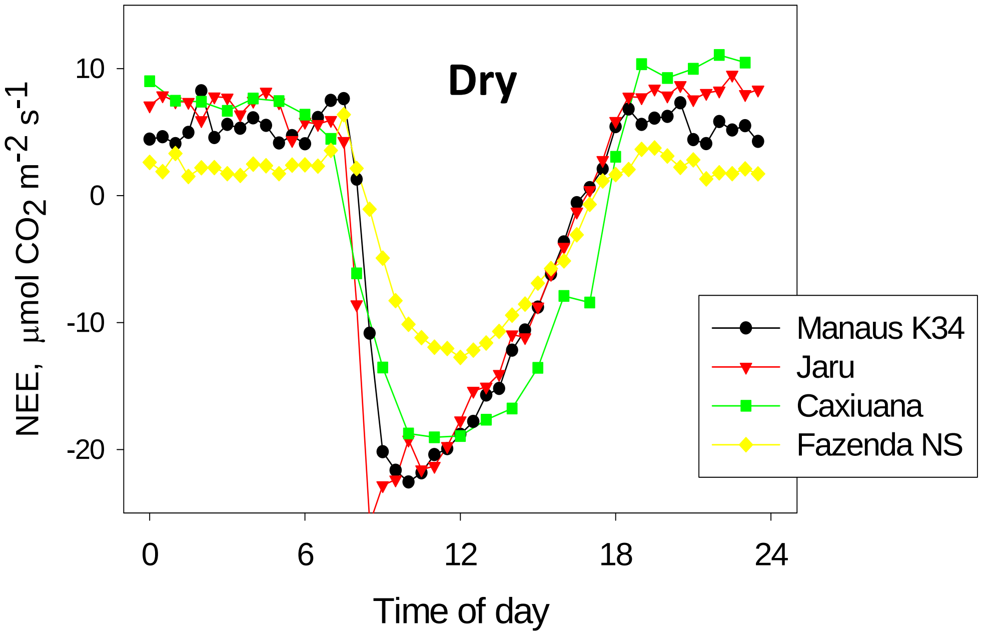
$$F_c \approx \overline{w'c'}$$

2) Automated chambers, connected to GC

Santarém km83 H_2O, CO_2 analyzer

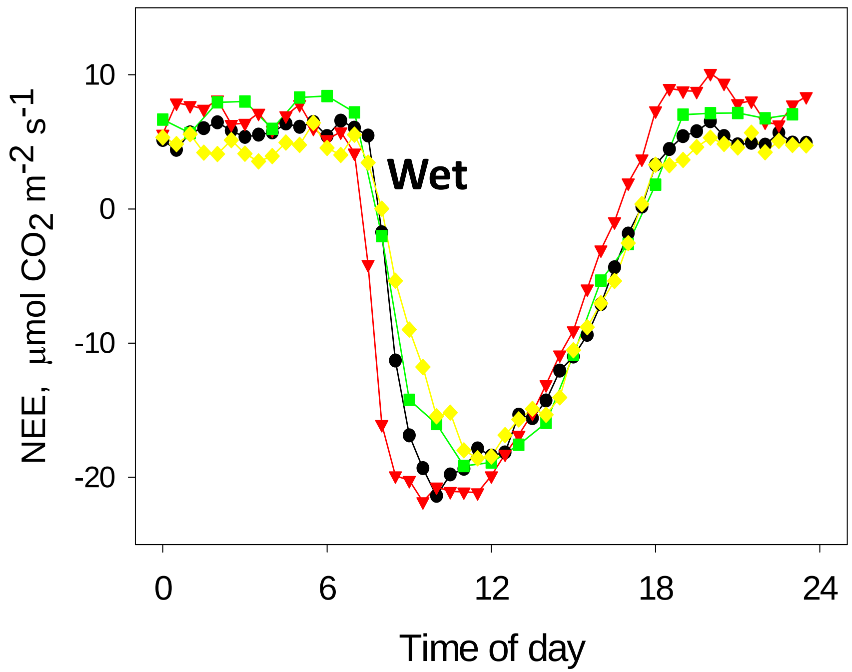


Mean Diurnal trend of CO_2 fluxes at four LBA sites



Dry seasons:

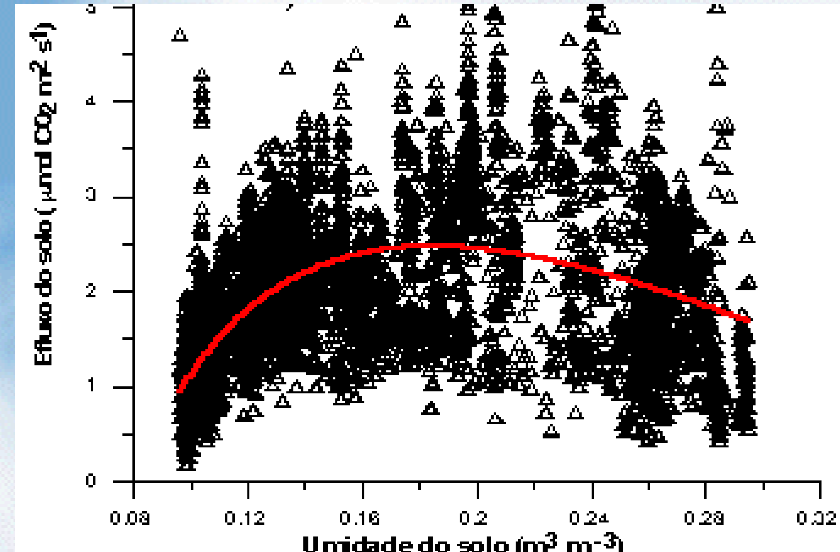
- Forest peak uptake similar, nights different.
- Pasture lower uptake!



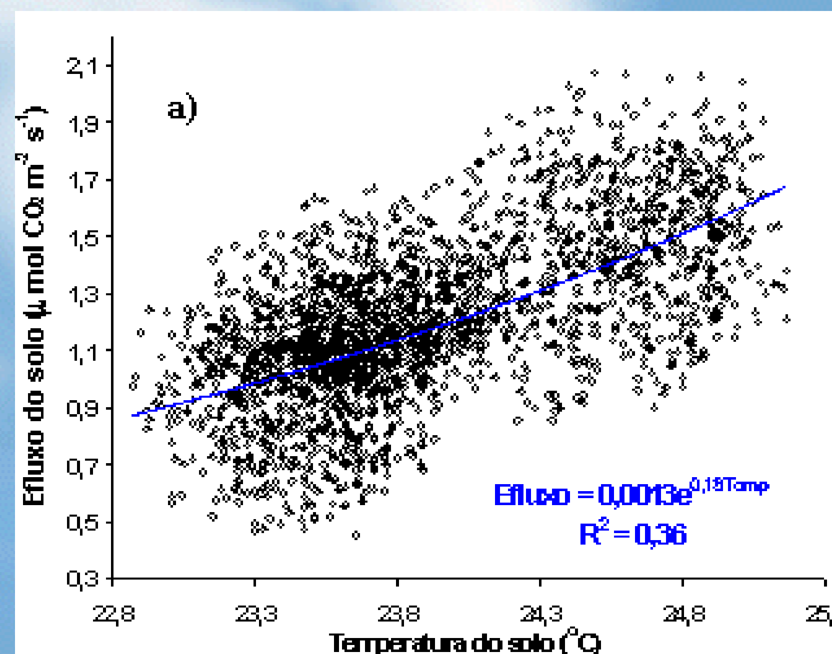
Wet seasons:

- Forests and pasture very similar.

Forest in Rondonia
Soil respiration with automatic chambers



Dependency of soil moisture



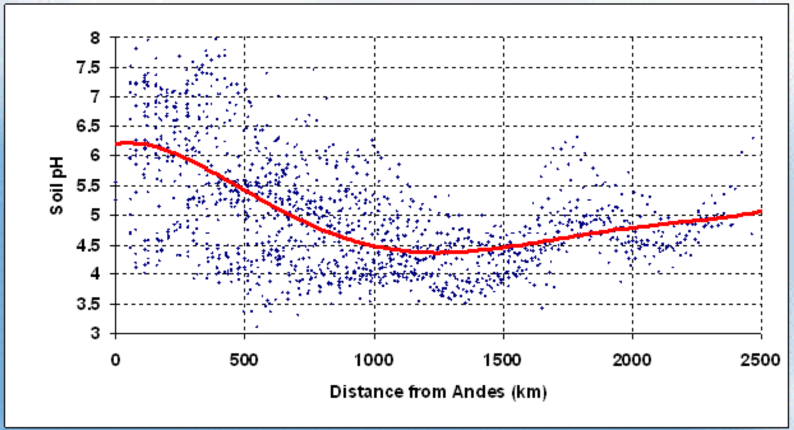
Dependency of soil temperature

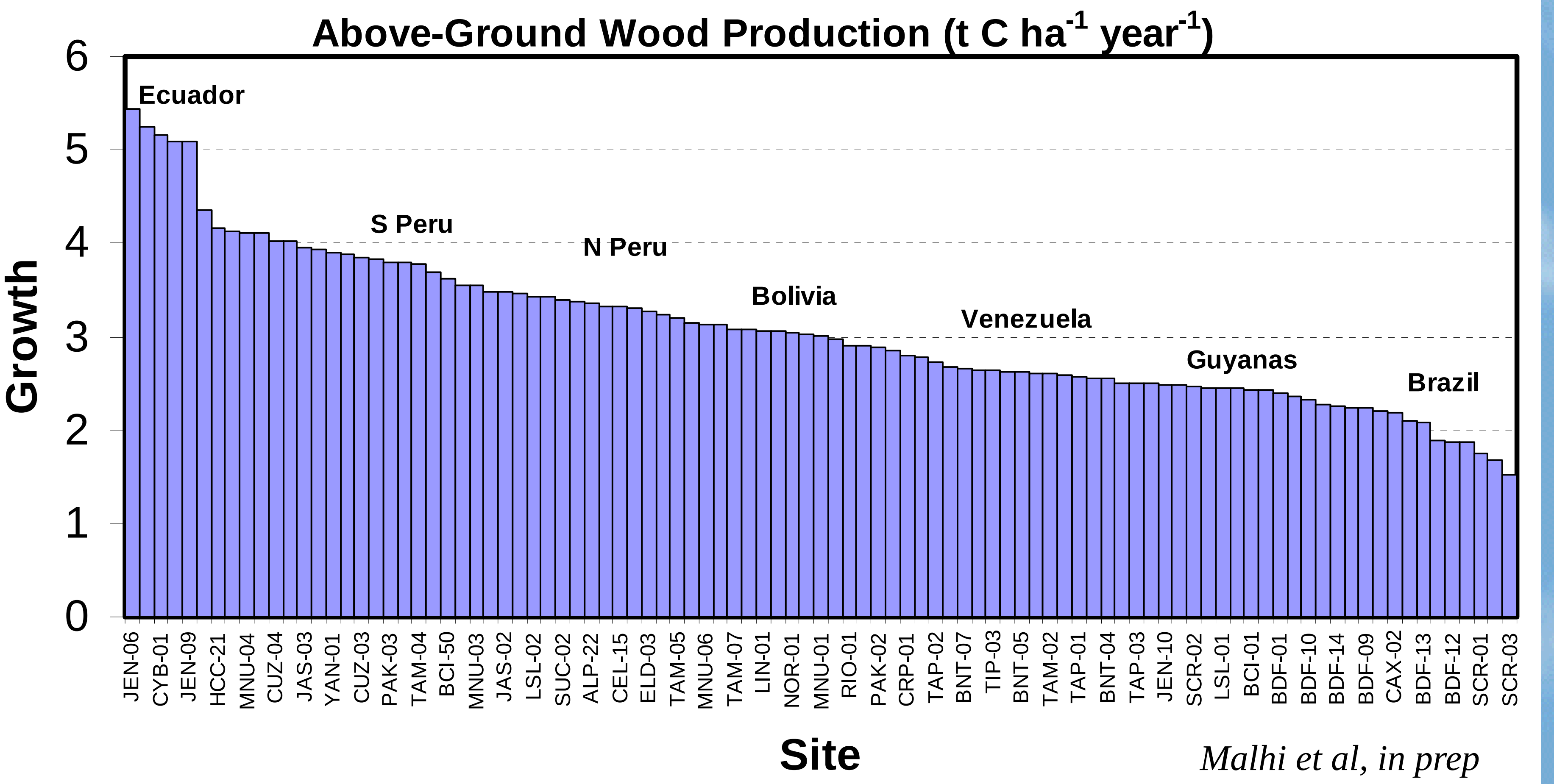
RAINFOR (Rede Amazonica de Inventários Florestais)

The Use of Biometric Techniques to Estimate the Carbon Balance and Carbon Dynamics of Amazonian Forests

Malhi et al 2002, *Journal of Vegetation Science*, 13, 429-450

RAINFOR - Above - ground wood production for 97 sites



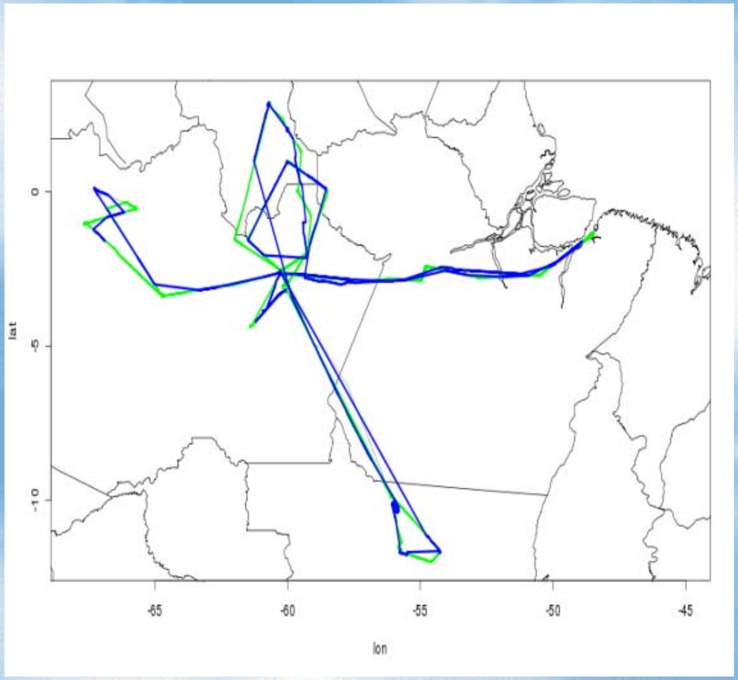


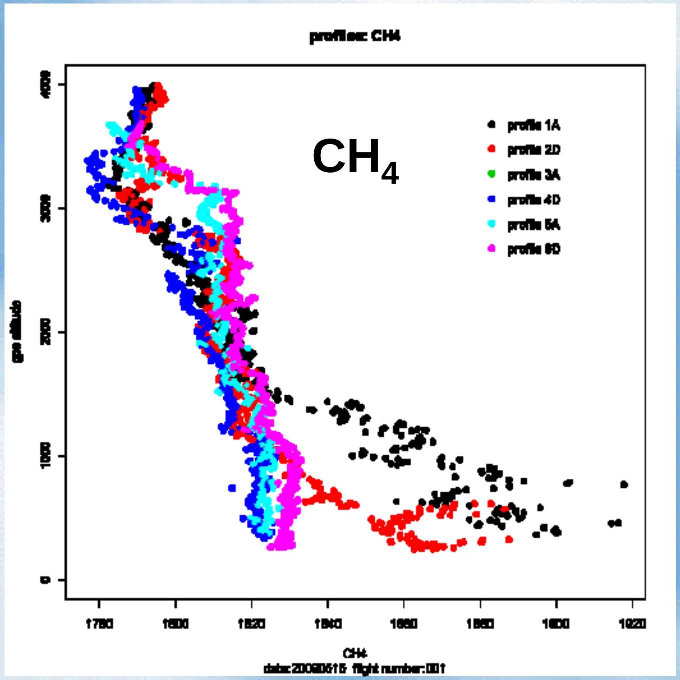
Malhi et al, in prep

Medidas de gases de efeito estufa em larga escala

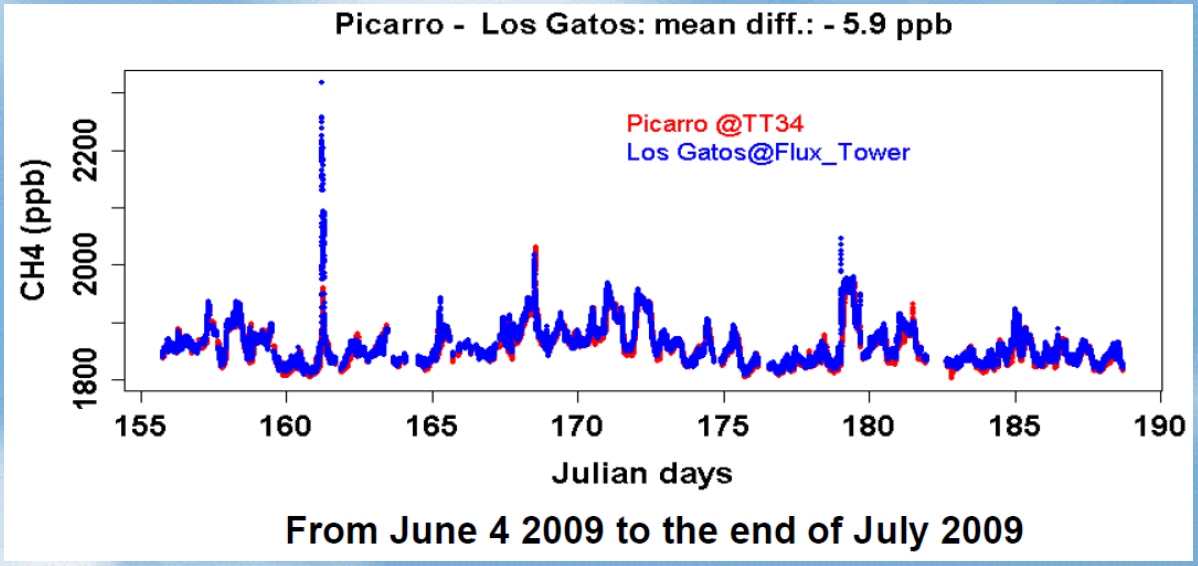
LBA BARCA – Balanço regional de Carbono na Amazônia

Experimento LBA BARCA – Balanço Regional de Carbono na Amazonia



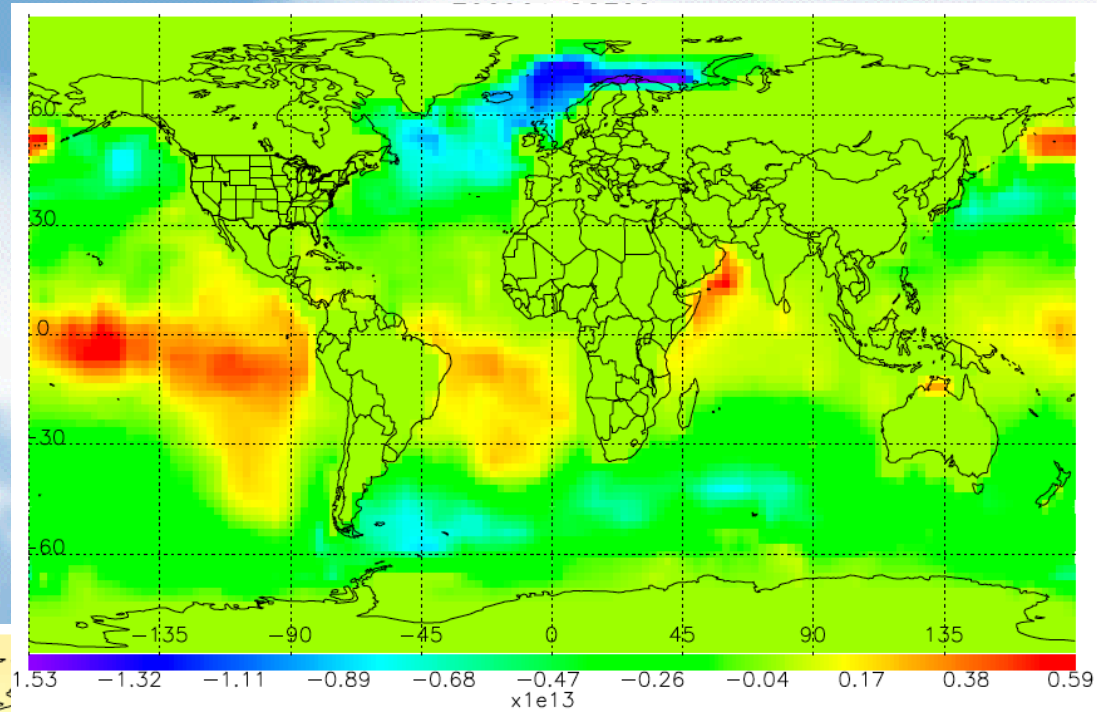


Medidas contínuas de metano e CO_2 em Manaus



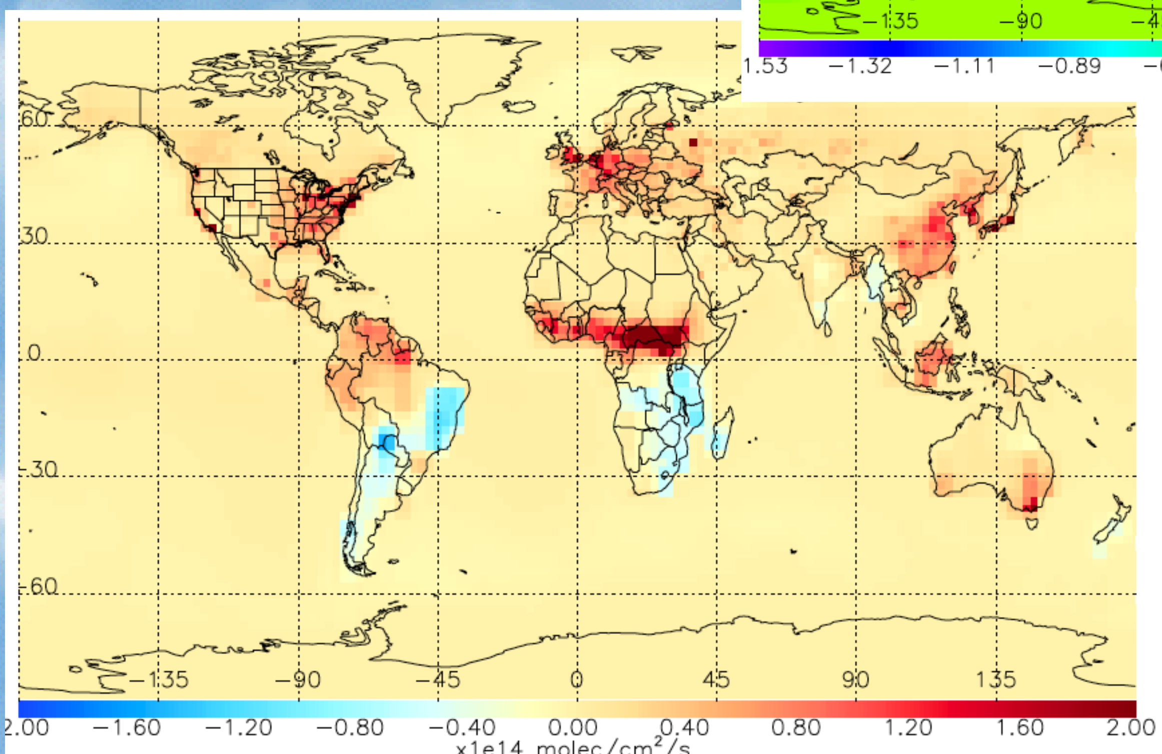
Medidas combinadas com modelos globais

GEOS-CHEM
CO_2 surface fluxes



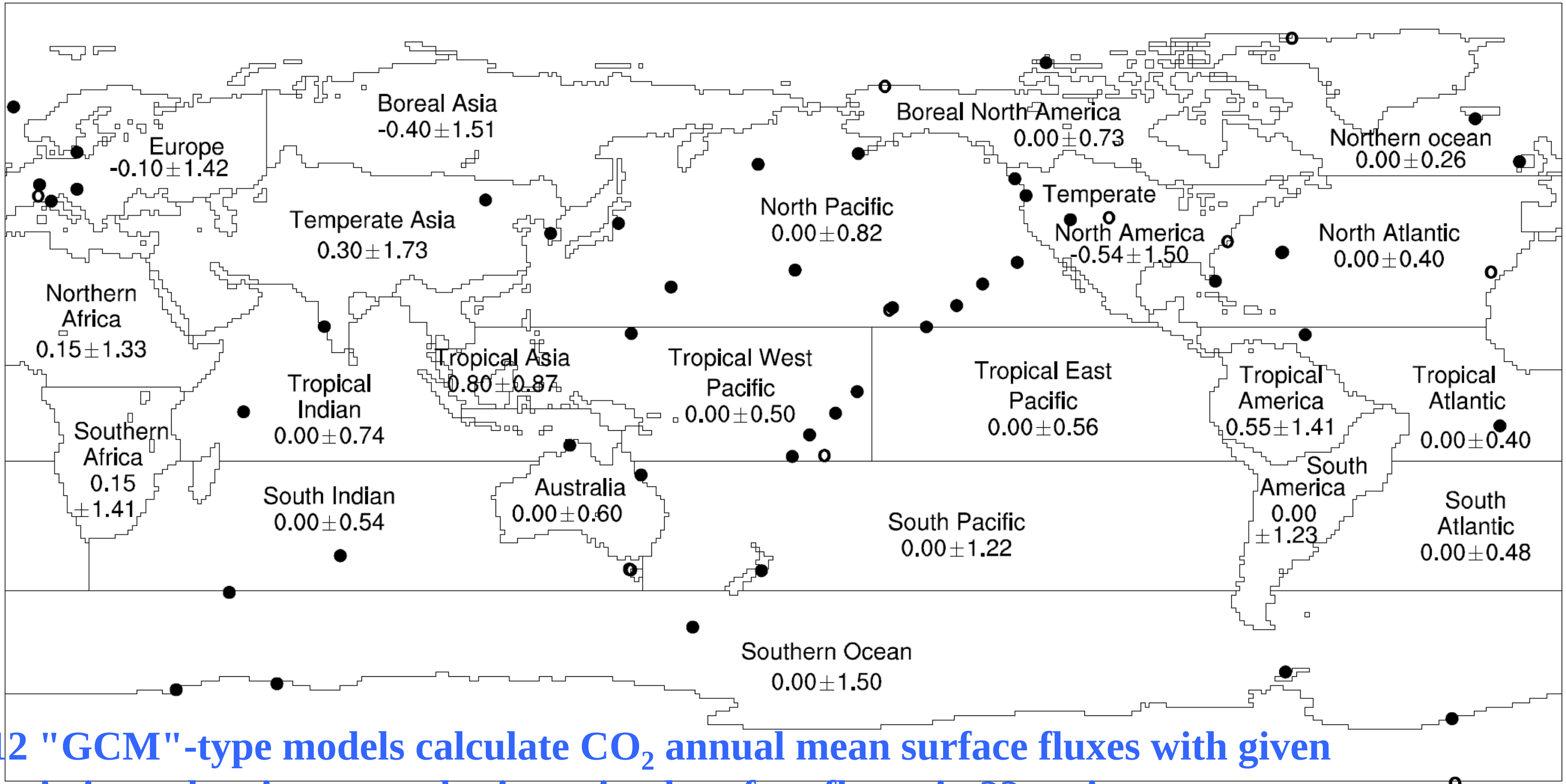
Ocean fluxes (10^{13} $cm^{-2}s^{-1}$)

$1x10^{13}=0.16$ μmole m^{-2} s^{-1}



Land fluxes (10^{14} $cm^{-2}s^{-1}$)

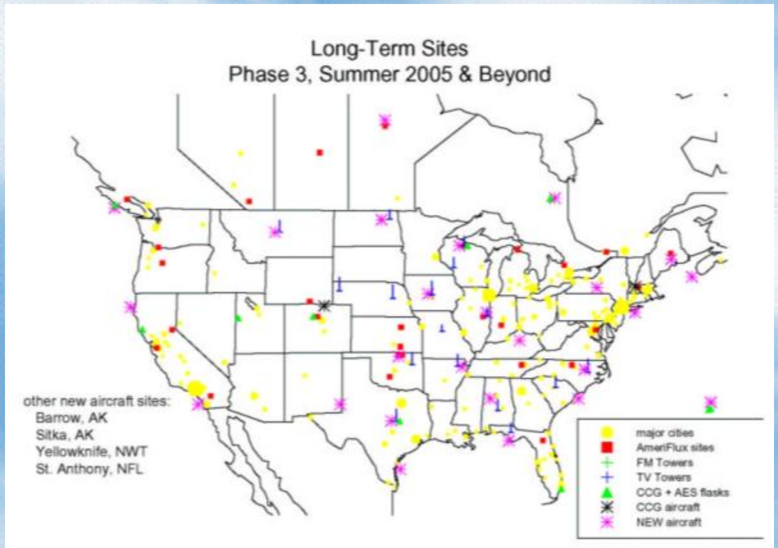
Modelamento global de fontes e sorvedouros de carbono
"Inverse Modeling"



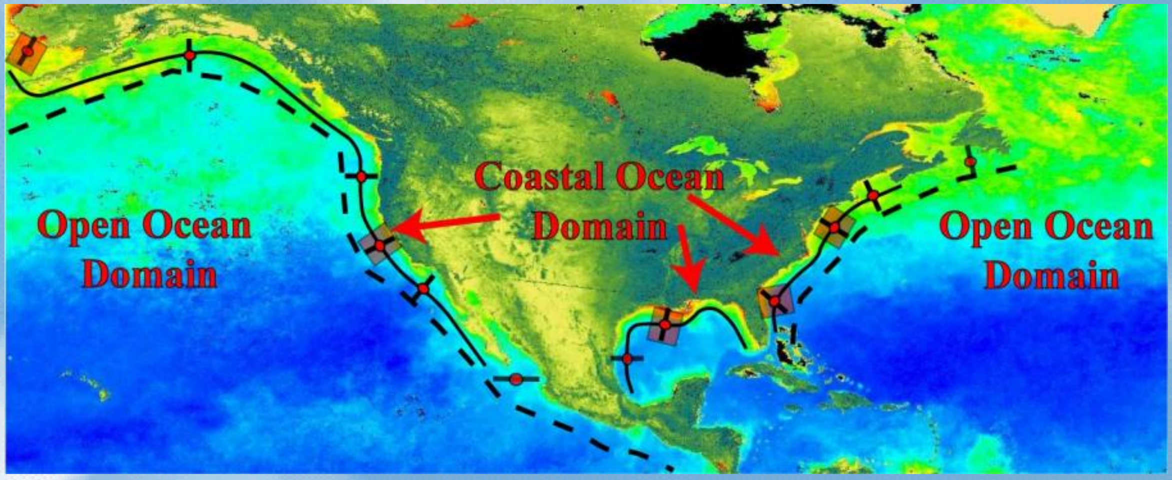
12 "GCM"-type models calculate CO_2 annual mean surface fluxes with given emissions, then invert to obtain optimal surface fluxes in 22 regions

Fig. 1. Basis function regions and the locations of the 76 CO_2 observational records used in the inversion. Multiple records exist at some locations and are denoted by open circles. The prior flux and prior flux uncertainties are shown for each basis function region (Gt C yr^{-1}). The prior constraint on the atmospheric growth rate is 3.274 Gt C yr^{-1} with a prior uncertainty of 0.074 Gt C yr^{-1}. The prior global offset concentration is 355 ppm with a prior uncertainty of 100 ppm.

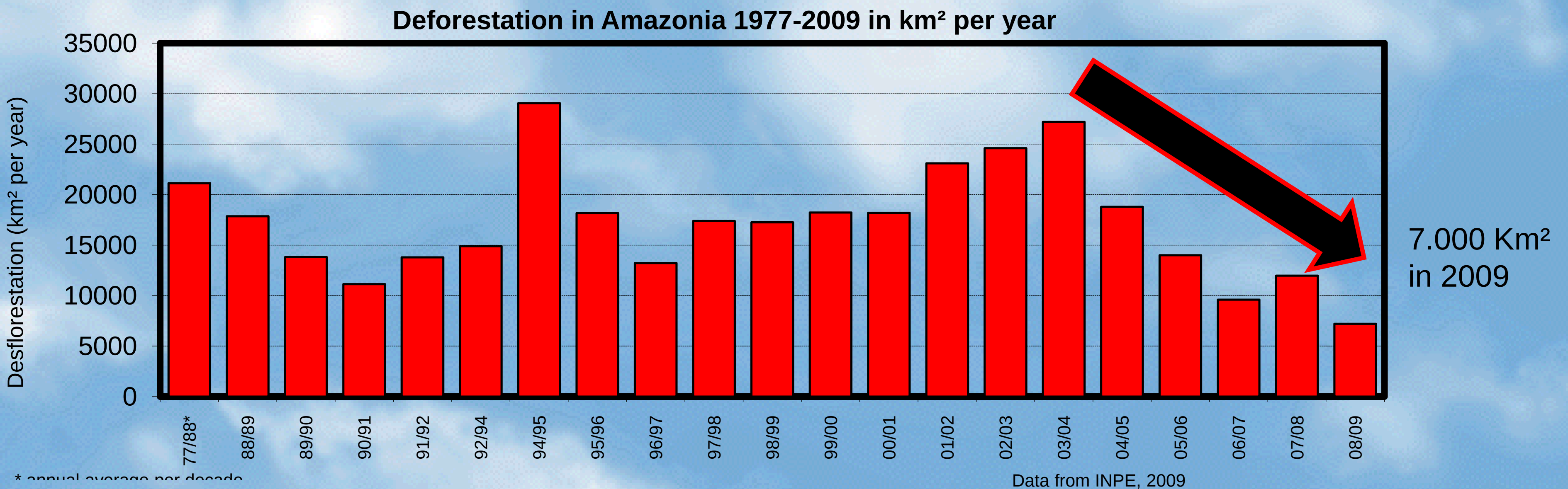
North American Carbon Program - Continental scale
Monitoring CO_2 and tracers across North America



- Estimate carbon balance over large areas
- Quantify variations in fluxes in response to climate variation
- Optimized system for atmospheric flask and in-situ sampling
- Improve top down approaches to better scale the fluxes to the regional level



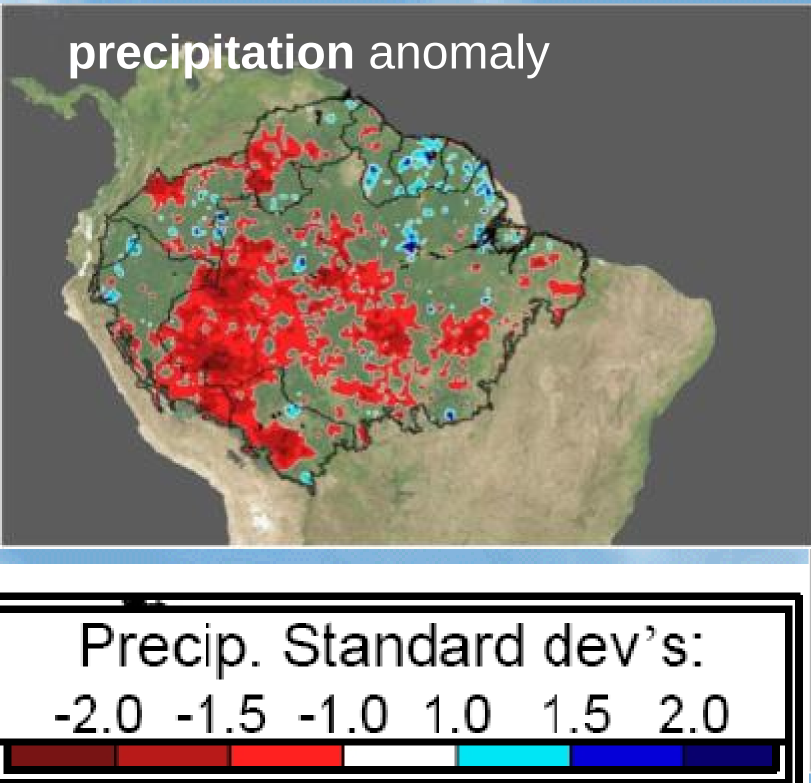
As of 2008, 17% of Amazonia was deforested. By 2050, if current trends continue, about 40% of the forest could be cleared.

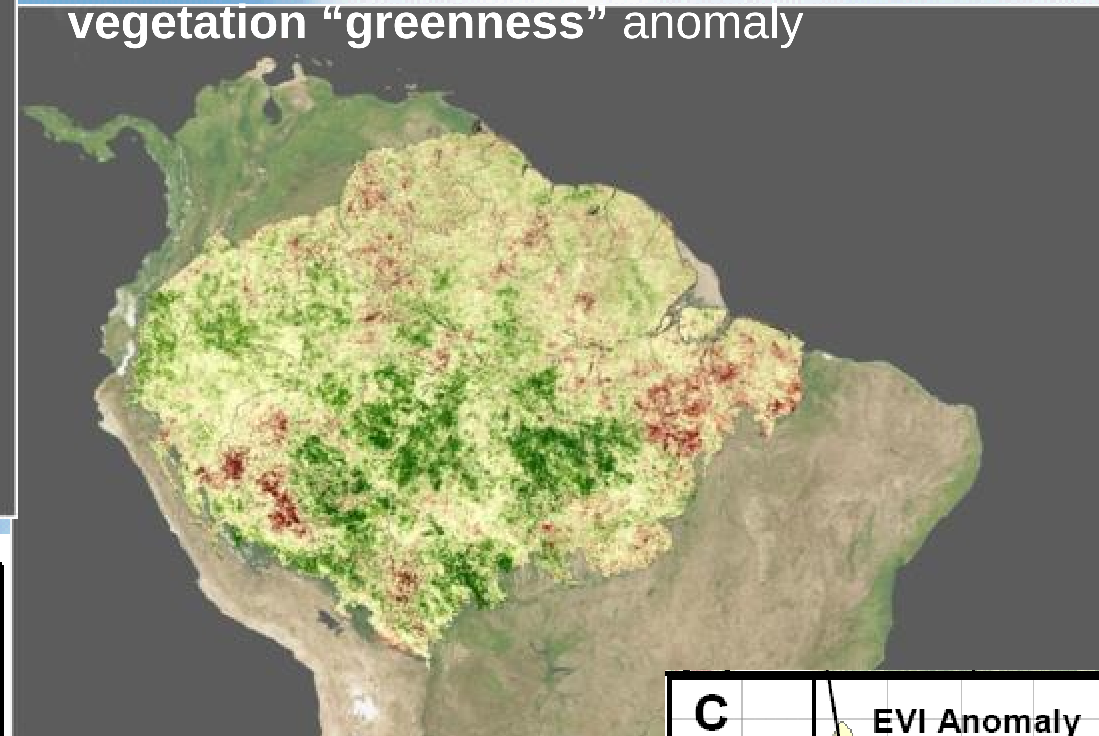


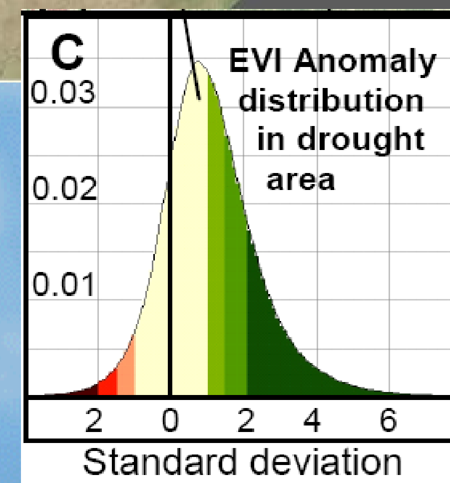
What public policies are needed to sustain this reduction?

Rain Exclusion Experiments in LBA

Tropical forests are resilient to seasonal droughts, but after a few years, carbon losses are very significant.







Drought of 2005: unxpected effects in the Amazonian Ecosystem

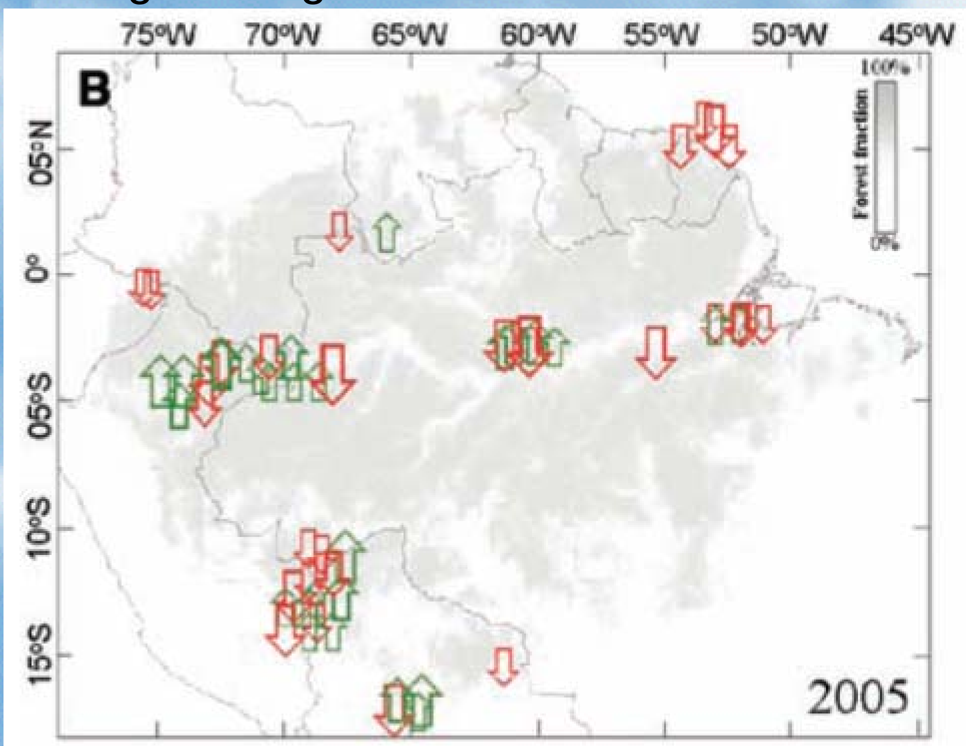
Amazon Forests Green-Up During 2005 Drought

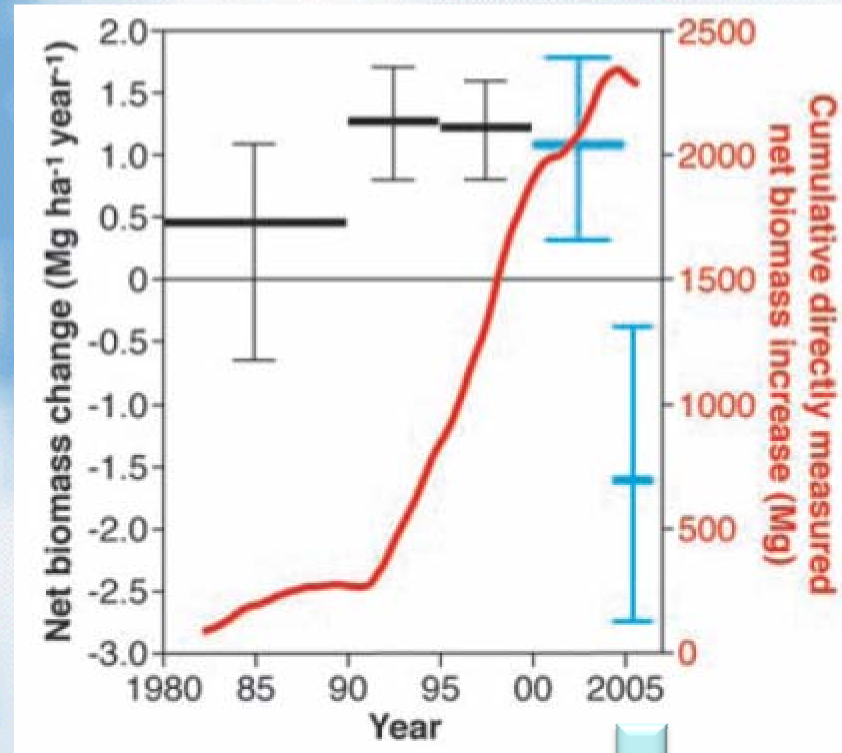
Scott R. Saleska,[1*†] Kamel Didan,[2*] Alfredo R. Huete,[2] Humberto R. da Rocha[3]

26 OCTOBER 2007 VOL 318 **SCIENCE** www.sciencemag.org

Drought sensitivity of the Amazon Rainforest

Annual aboveground biomass change during the 2005 interval.

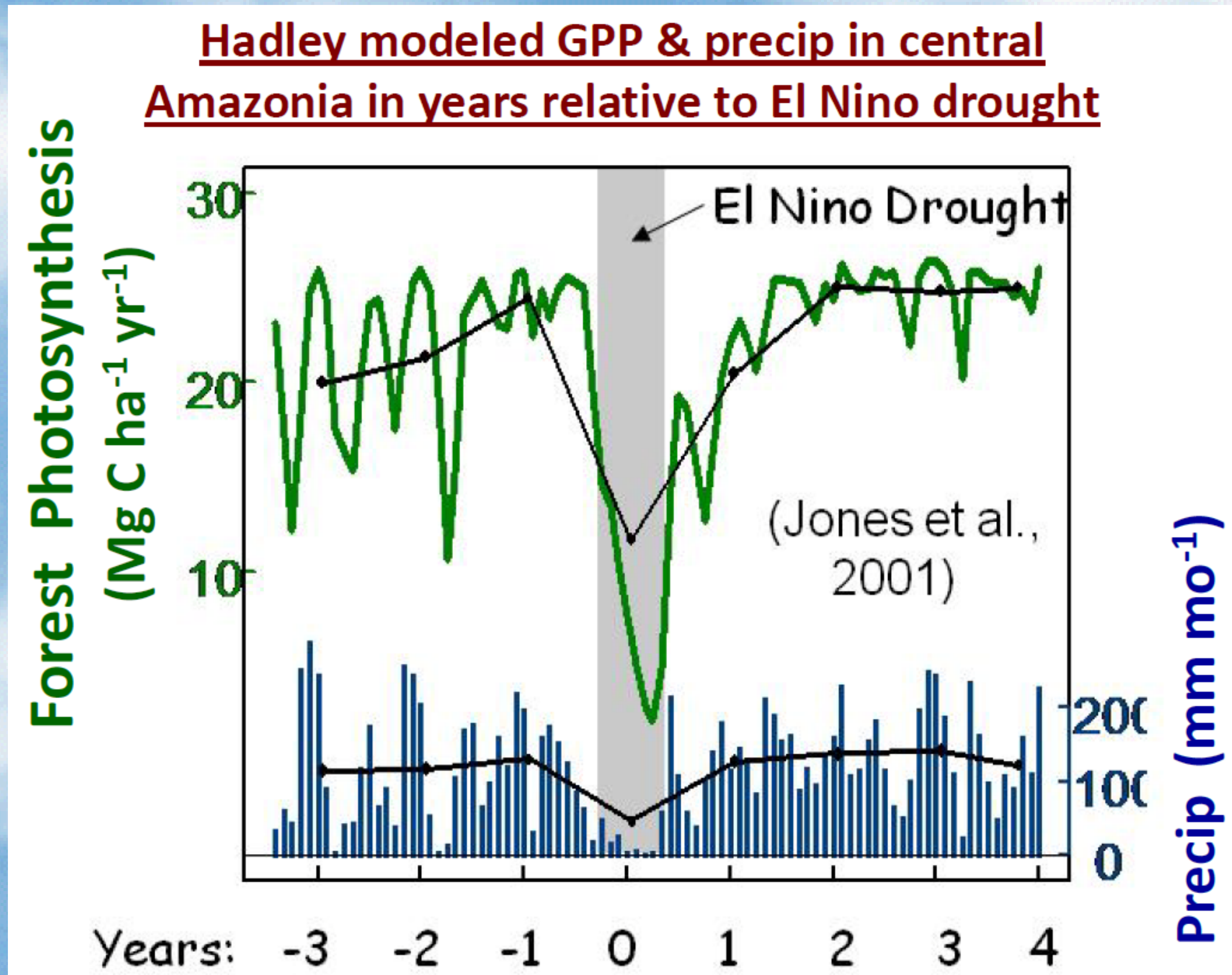




Effect of the 2005 drought in the carbon balance in Amazonia

Phillips et al. 2009 *Science*

Somente com medidas cuidadosas e de longo prazo respondemos a questões cruciais:

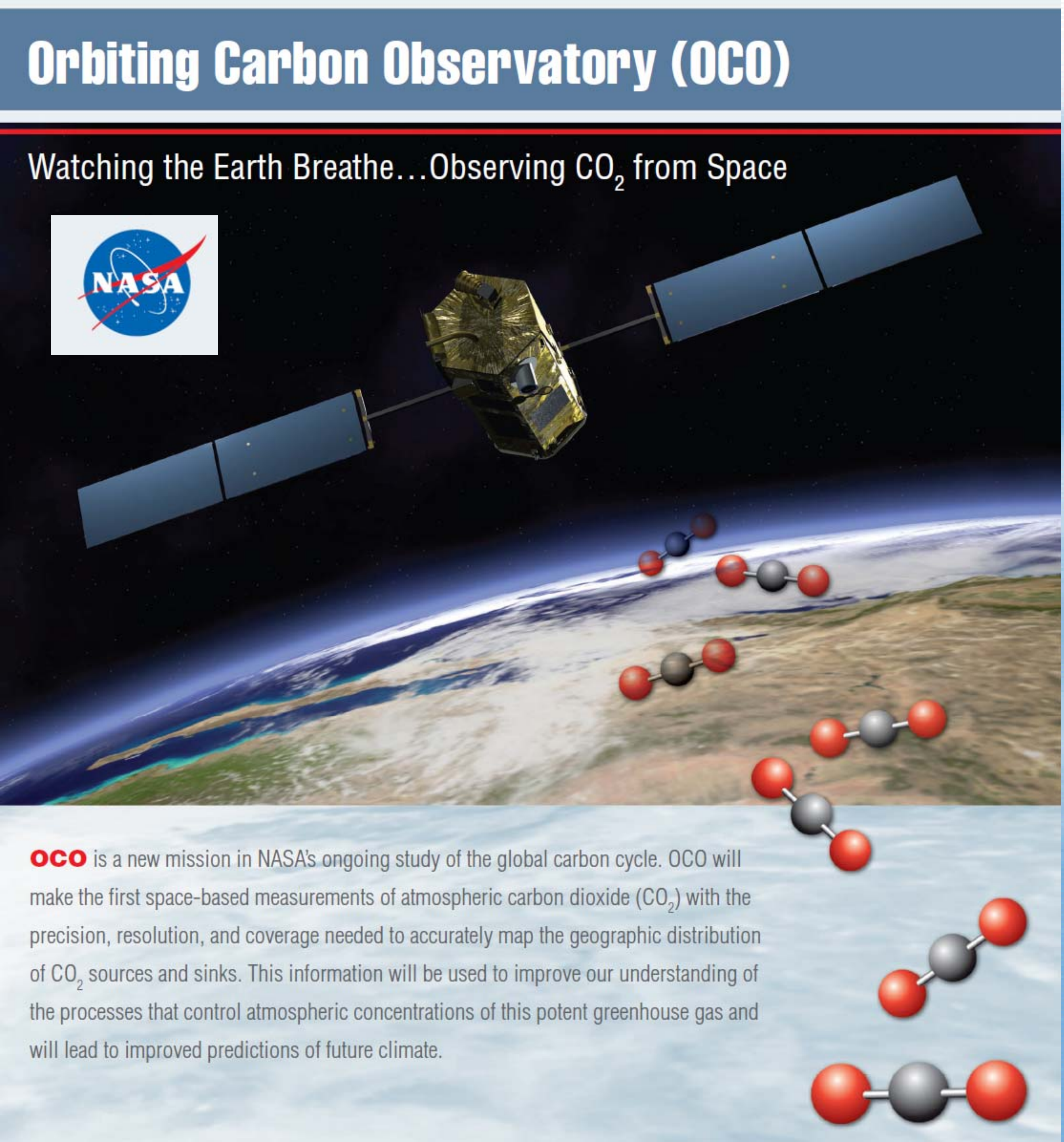


Saleska et al., (2007) **Amazon forests green-up during 2005 drought**. *Science, 318: 612.*

Samanta et al. (2010) **Amazon forests did not green-up during the 2005 drought.** *GeophysRes. Lett. 37, L05401.*

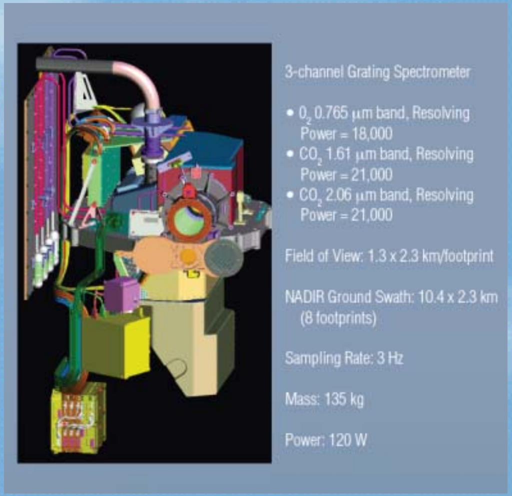
Amazonian Tall Tower Observatory ATTO – 320 meters

Long term broad objectives observatory



Medidas de CO_2 do espaço

Parte do A-Train da NASA, constelação de 8 satélites



WMO – GEOSS - Global Earth Observation System of Systems

Obrigado pela atenção !!!