Avanços e perspectivas da Oceanografia: 2012–2022

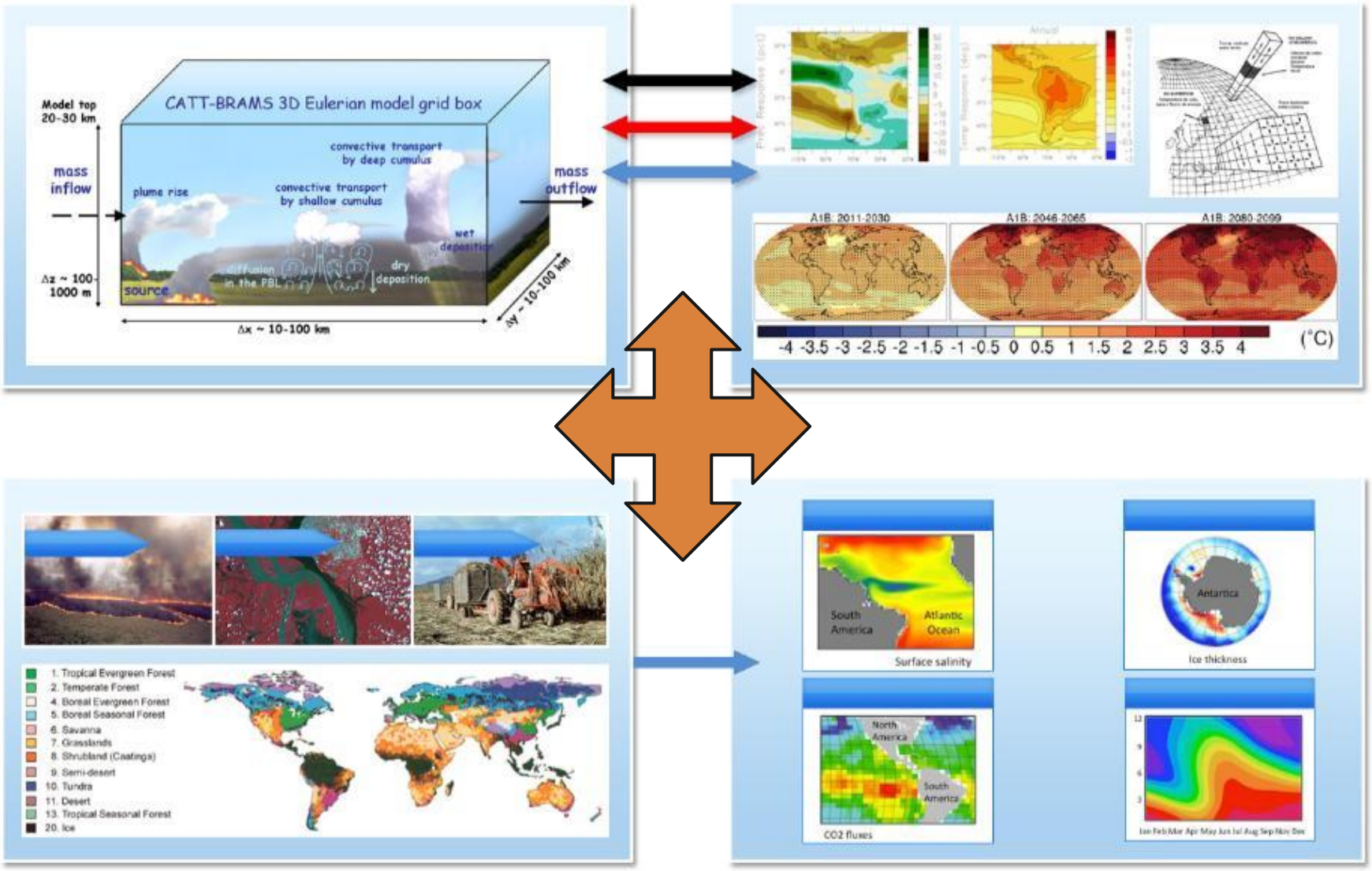
Roberto De Almeida, Paulo Nobre, et al.

Quem sou eu

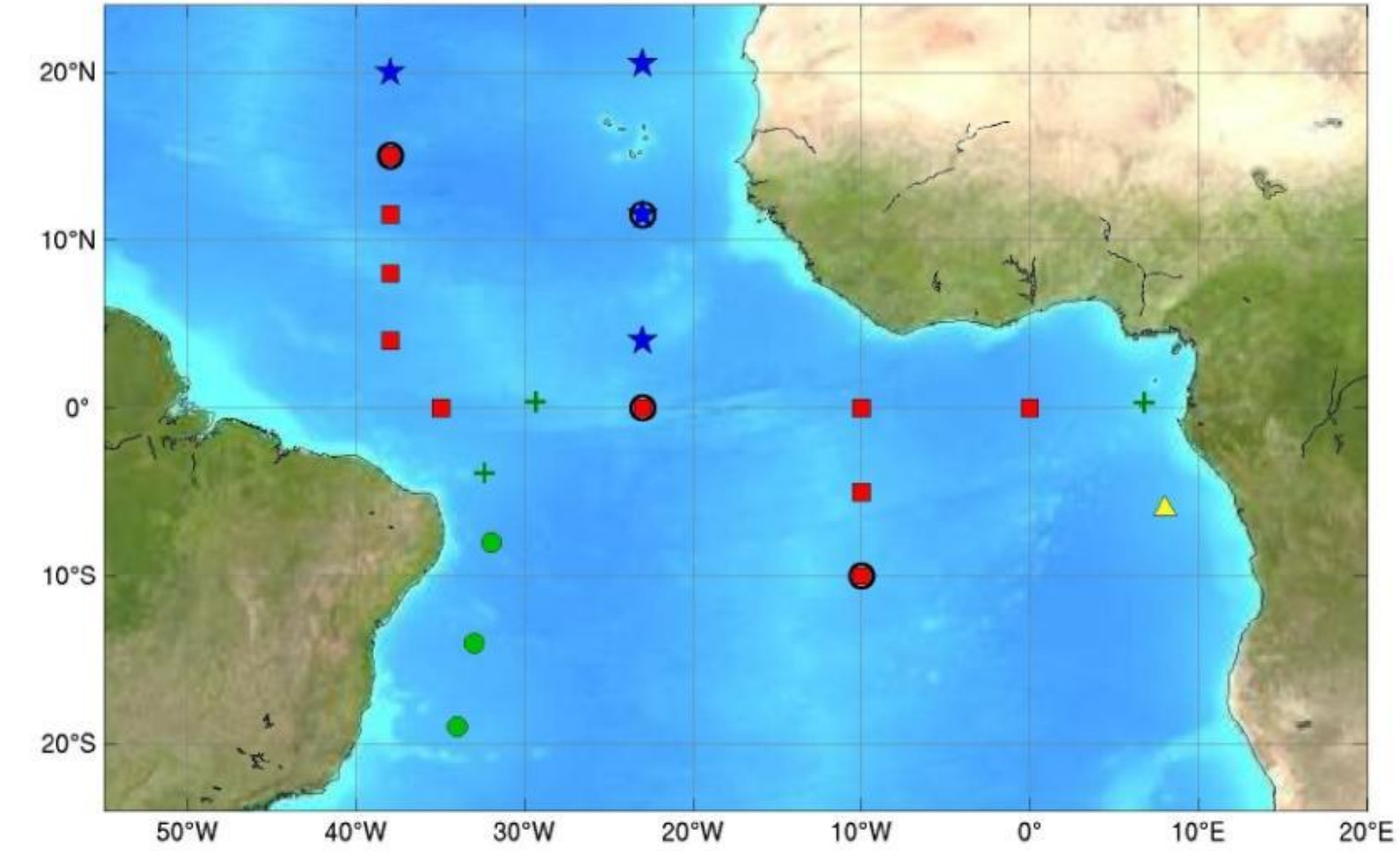
Grupo de Modelagem Acoplada Oceano Atmosfera do INPE:

- 4 oceanógrafos
- 4 meteorologistas
- 4 engenheiros
- 1 geógrafa

Modelagem + observações



Modelo Brasileiro do Sistema Climático Global



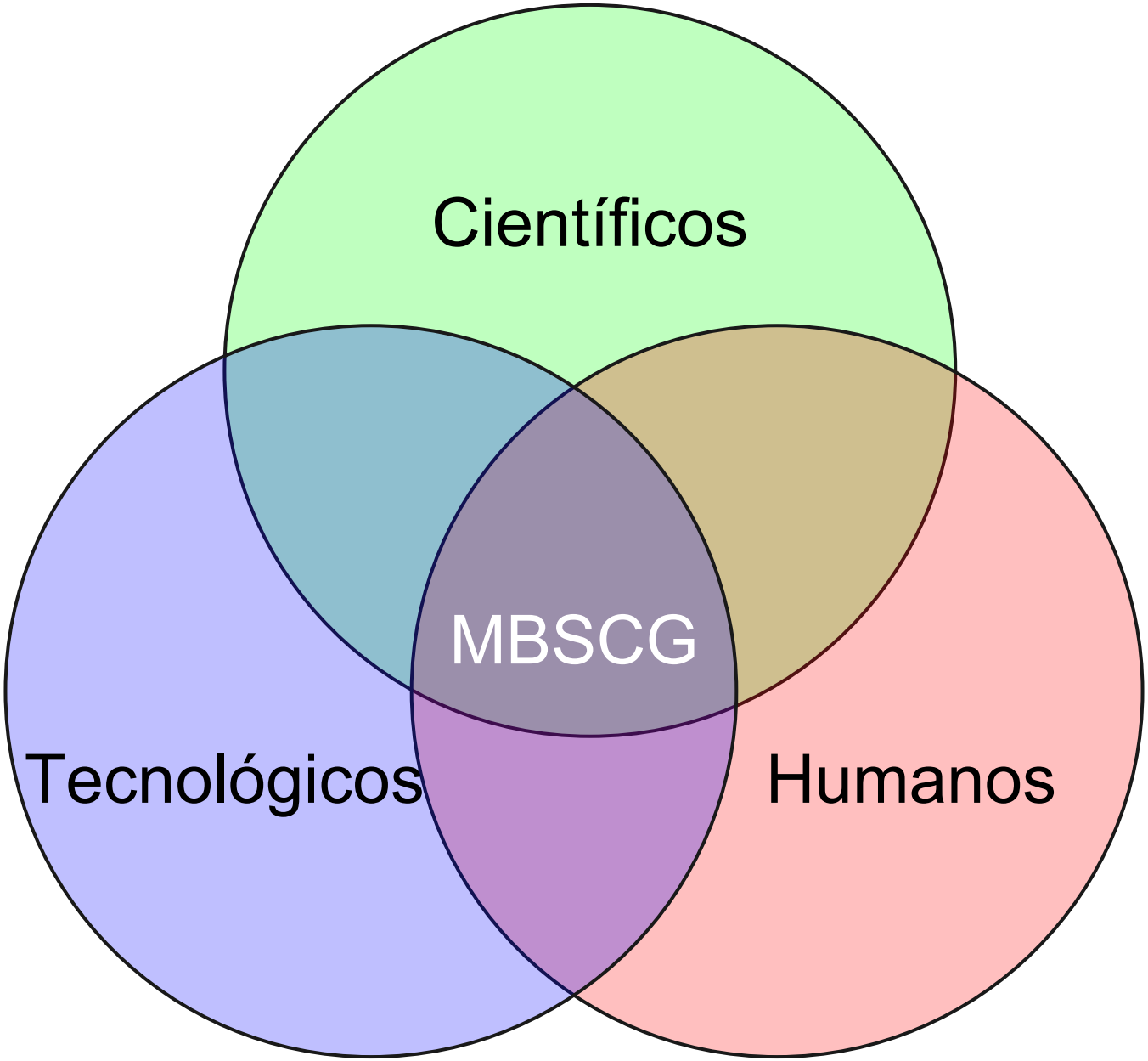
PIRATA

PIRATA

Desafios

Richard Hamming ("You and Your Research", http://www.paulgraham.com/hamming.html):

1. What are the most important problems in your field?
2. Are you working on one of them?
3. Why not?


Científicos
MBSCG
Tecnológicos
Humanos

Grand Challenges for Ocean Sciences Research (Alan Brandt, *Oceanography*, Vol. 19, No. 2, Junho 2006.

1. **Understanding and modeling global climate evolution and humankind's effects.**
2. Understanding and predicting longterm effects of natural and anthropogenic modifications on oceanic ecosystems.
3. Identification of precursors to natural catastrophic environmental events, such as floods, storm surges, tsunamis, and hurricanes.
4. Understanding the long-term effects of short-term, episodic events (e.g., storms, hurricanes, spring freshet) on littoral bio-physical processes.
5. Understanding the mechanisms governing diverse, non-standard life forms discovered in the remote regions of the ocean, such as those present in the vicinity of hydrothermal vents and in submerged Antarctic lakes.
6. Development of viable sources of energy and resources from the sea.

Oceans 2025

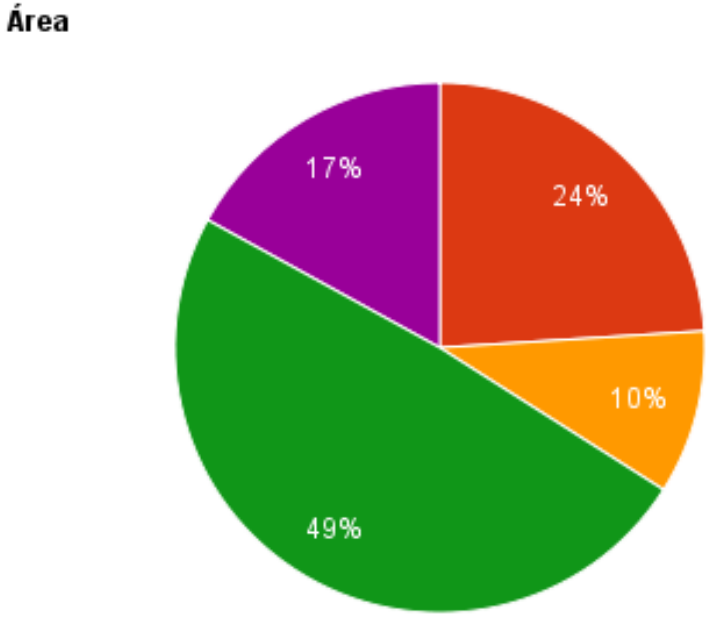
Oceans 2025 addresses nine major science themes:

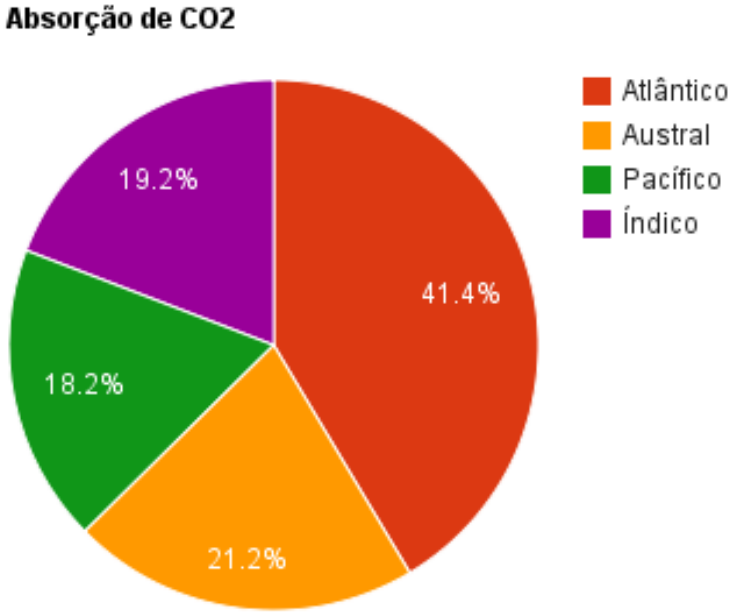
- Climate, ocean circulation and sea level
- Marine biogeochemical cycles
- Shelf and coastal processes
- Biodiversity and ecosystem functioning
- Continental margins and the deep ocean
- Sustainable marine resources
- Technology development
- Next generation ocean prediction systems
- Integration of sustained observations in the marine environment

Por que os oceanos?

"Presently, about one third (approximately 2 Gt C y-1) of anthropogenic emissions of CO2 are believed to be entering the ocean." (Takahashi & al. 2002)

A importância do Atlântico





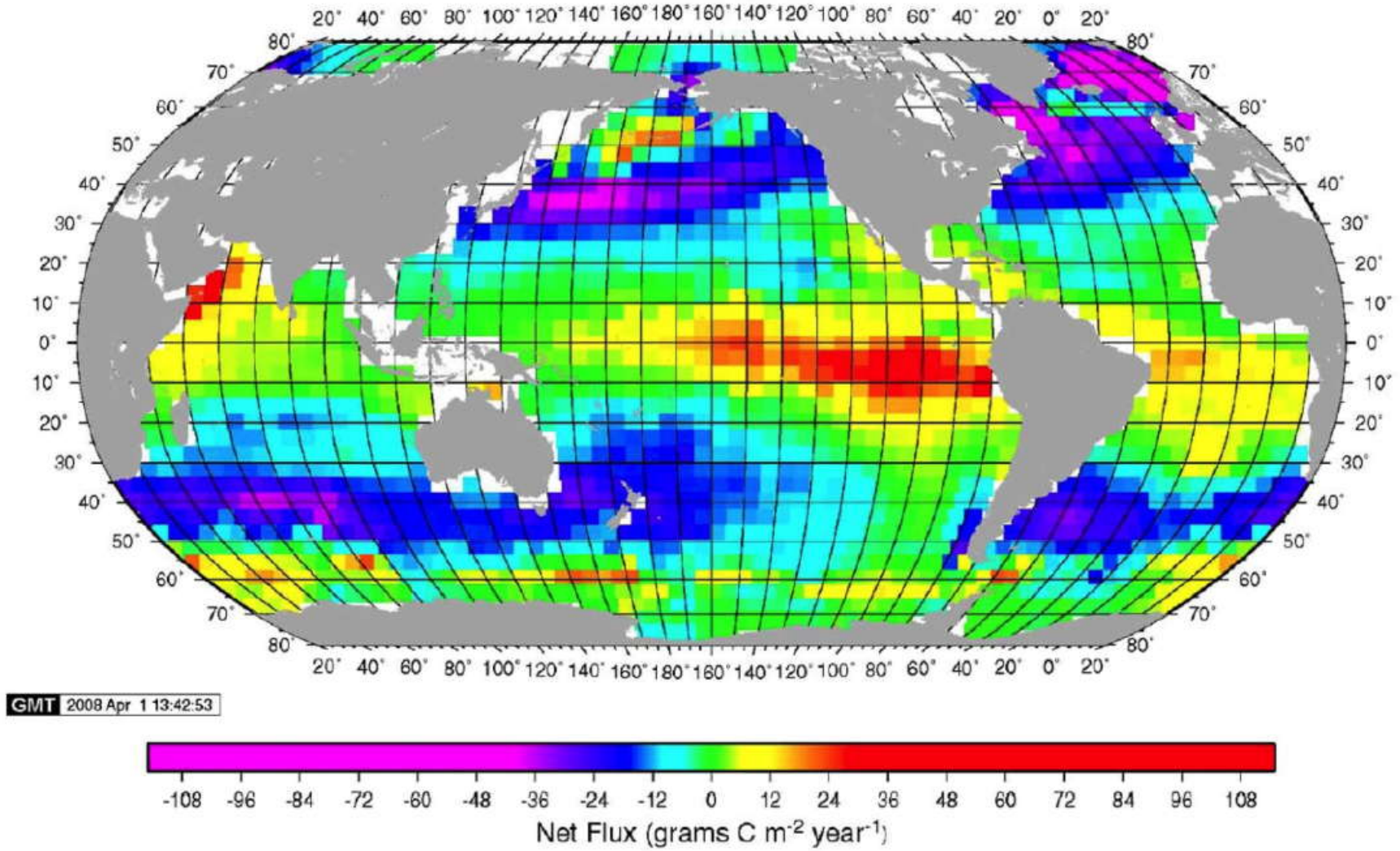
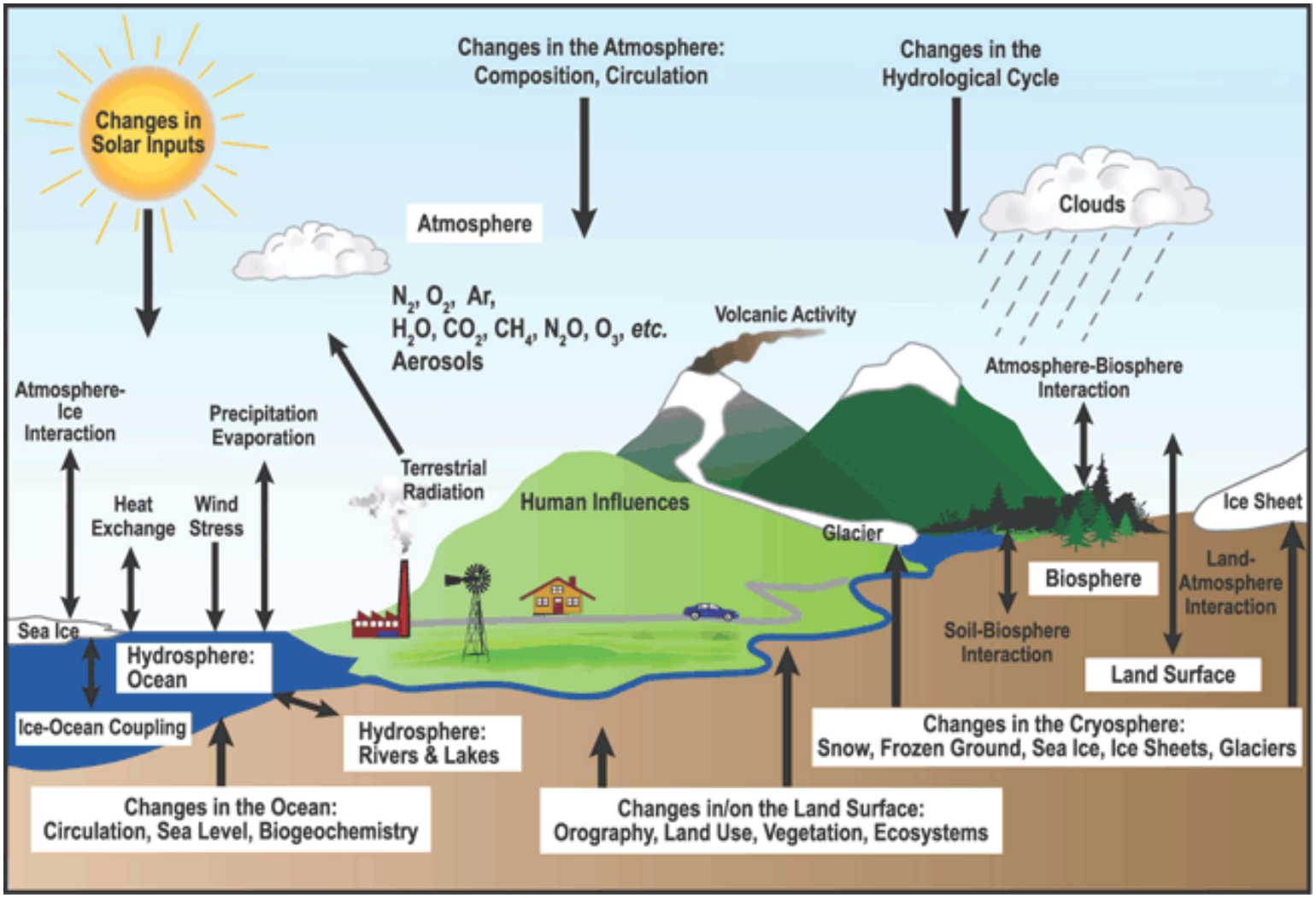
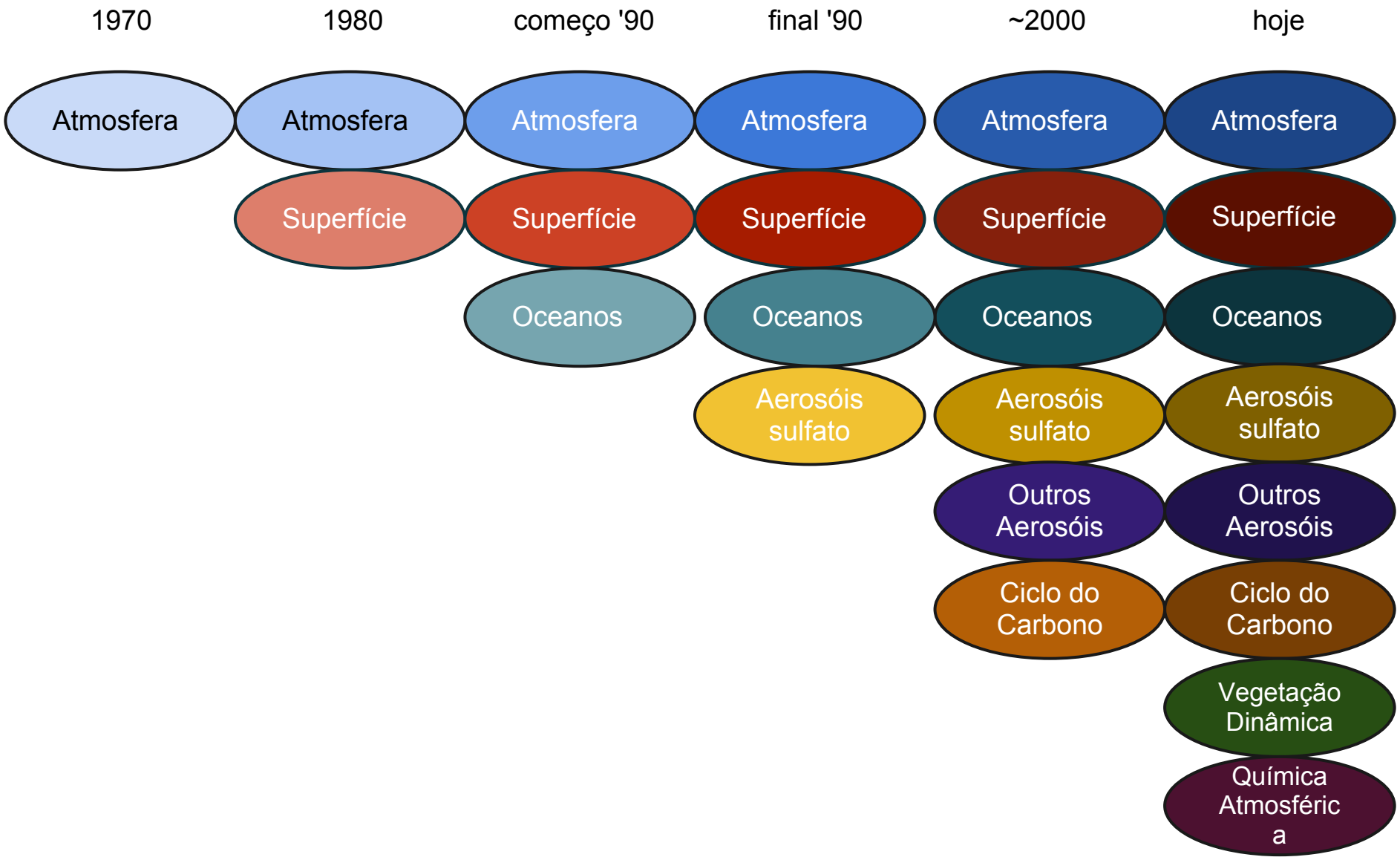


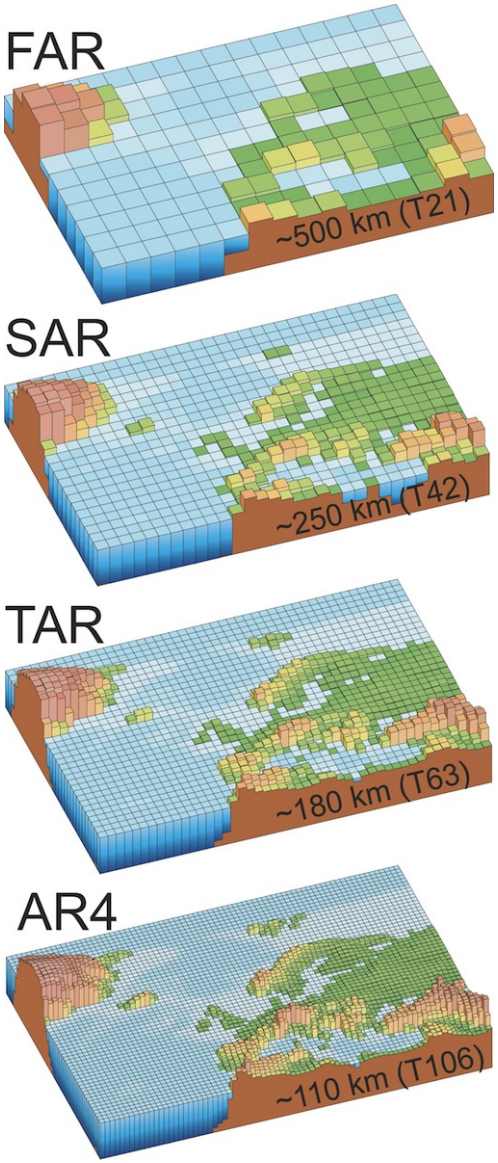
Fig. 13. Climatological mean annual sea–air CO_2 flux (g-C m^{-2} yr^{-1}) for the reference year 2000 (non-El Niño conditions). The map is based on 3.0 million surface water pCO_2 measurements obtained since 1970. Wind speed data from the 1979–2005 NCEP-DOE AMIP-II Reanalysis (R-2) and the gas transfer coefficient with a scaling factor of 0.26 (Eq. (8)) are used. This yields a net global air-to-sea flux of 1.42 Pg-C y^{-1}.



Sistema climático



Evolução da modelagem global



- Resolução espacial
- Descargas fluviais
- Gelo marinho
- Biogeoquímica marinha
- Convecção atmosférica
- Vegetação dinâmica
- Queimadas
- ...

Desafios

Modelagem biogeoquímica marinha

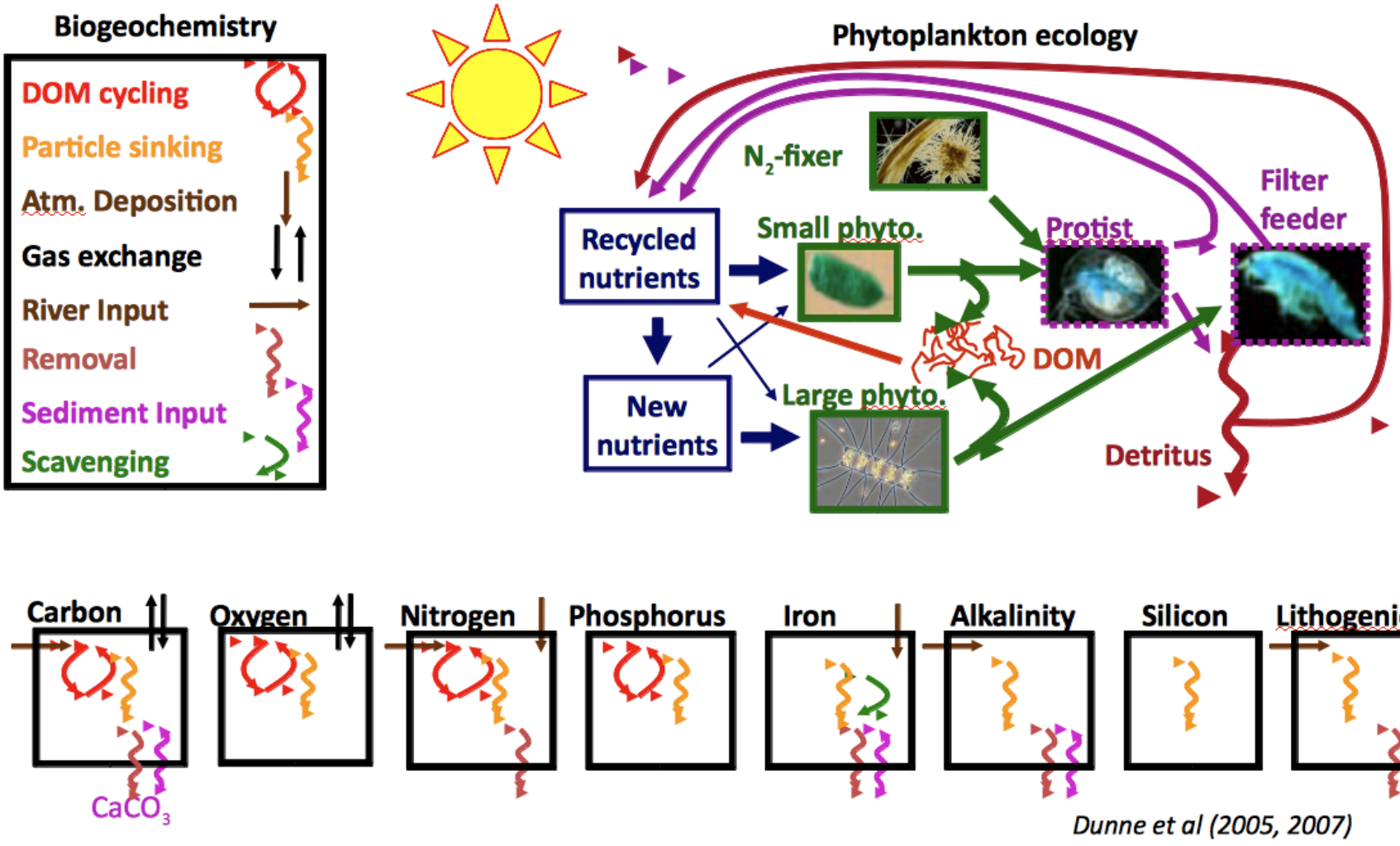
"Phytoplankton and other microbes in the ocean are [...] currently slowing the pace of climate change by their net uptake of CO2 [...]. There is urgent need to know how such processes will change in the next 20-50 years." (Oceans 2025)

TOPAZ: tracers for ocean phytoplankton with allometric zooplankton

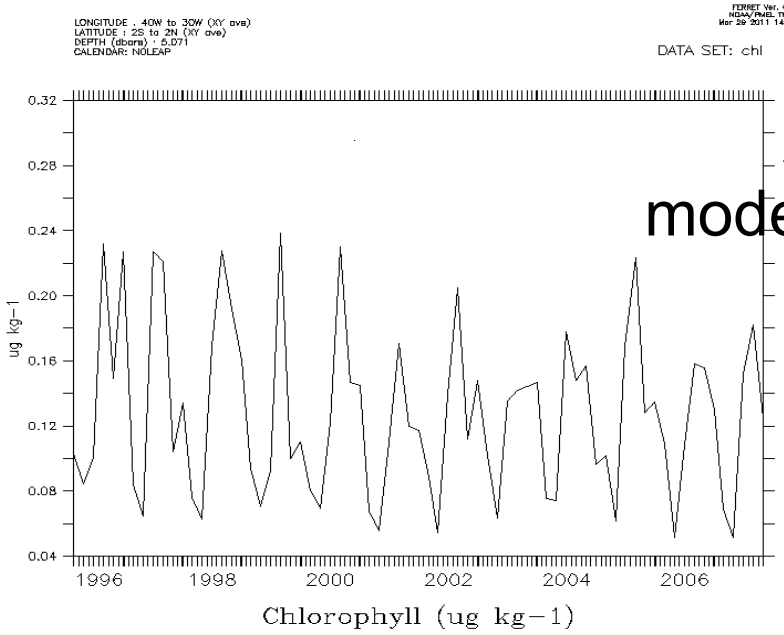
Modelo *state-of-the-art*, representa:

1. diatomáceas grandes
2. diatomáceas pequenas
3. bactérias diazotróficas
4. zoo implícito

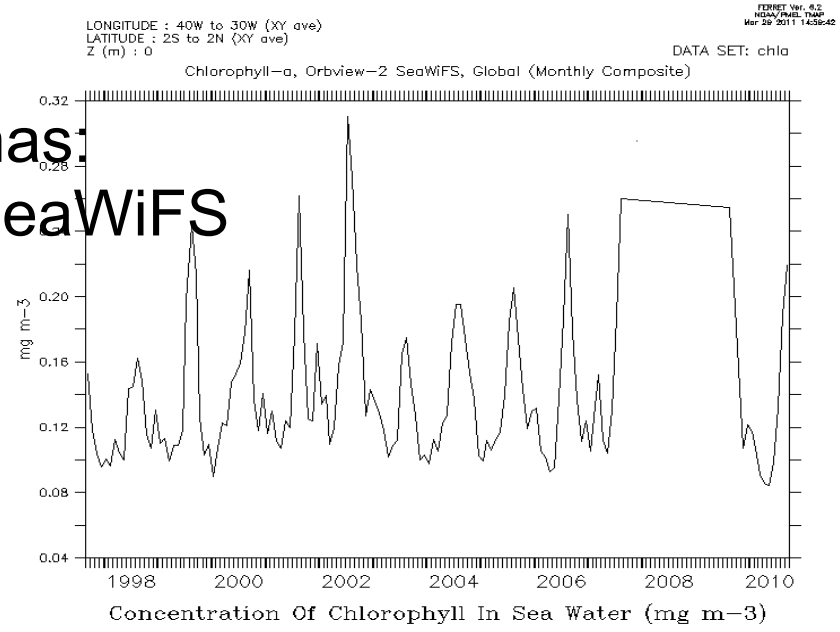
Tracers Of Phytoplankton with Allometric Zooplankton (TOPAZ)

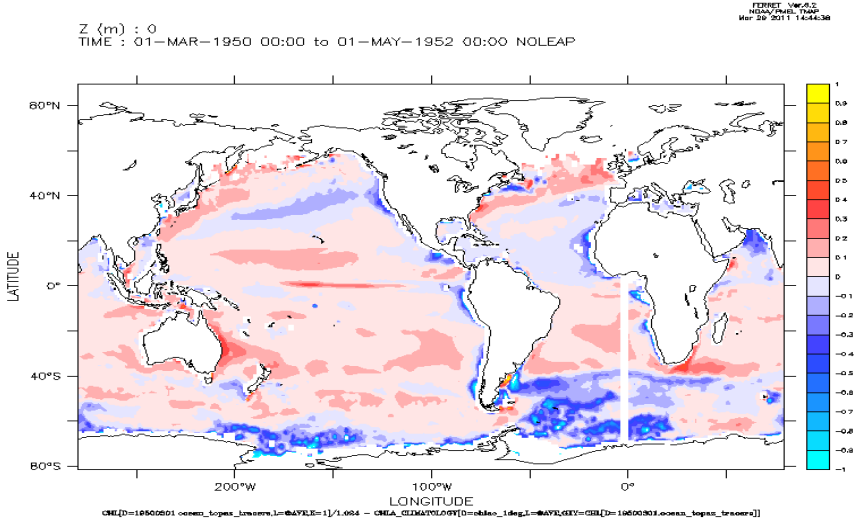


Dunne et al (2005, 2007)



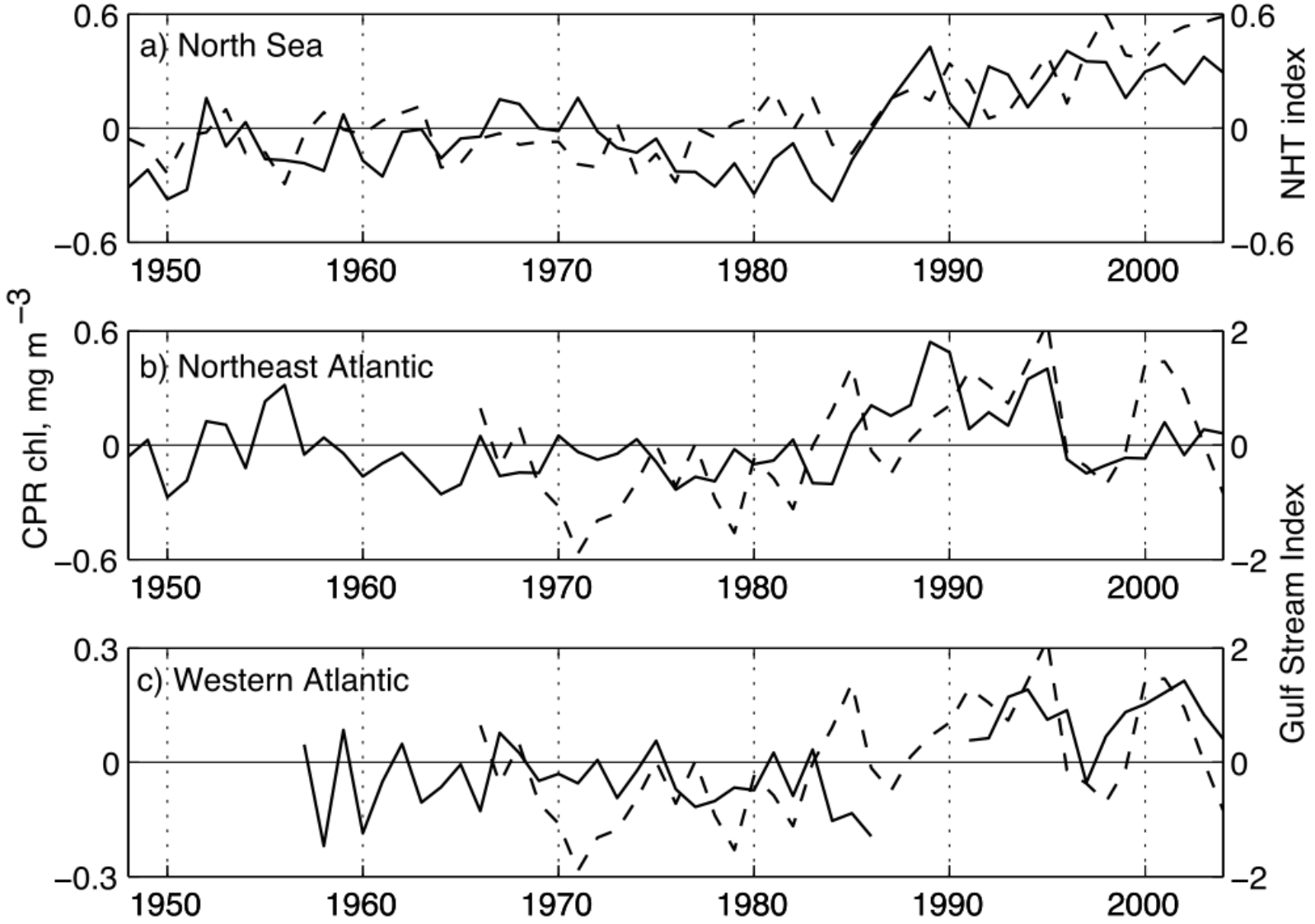
Amazonas: modelo vs. SeaWiFS





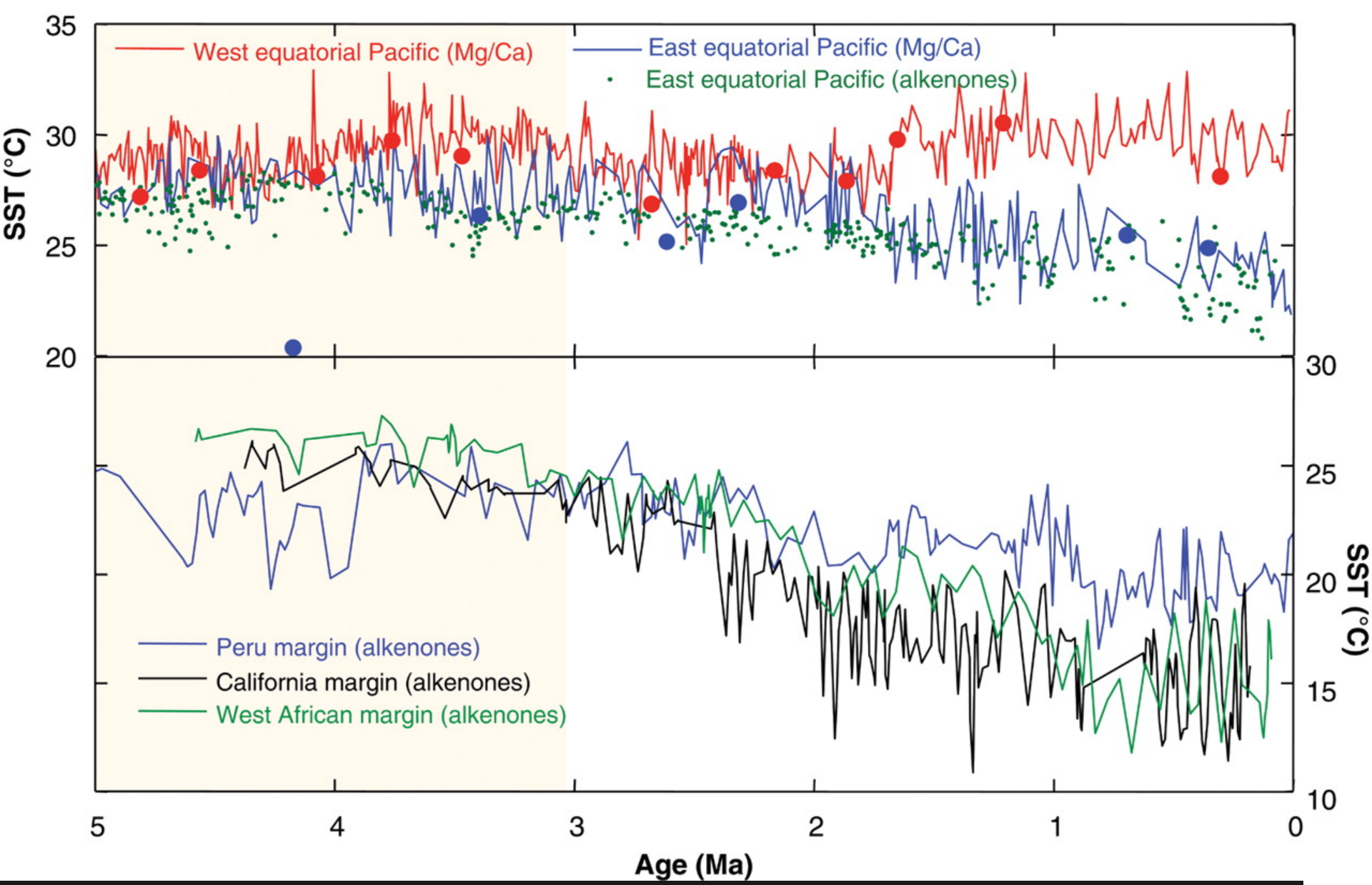
Subramanian et al. (2008): pluma do Amazonas responsável por 4% do input global de CO2.

Clorofila modelada vs. SeaWiFS



Henson et al. 2009

Our analysis suggests that while the model has skill at representing variability within an ecosystem state, as driven by, for example, variability in nutrient supply, it cannot simulate transitions between states as driven by, e.g., phytoplankton species compositional shifts.

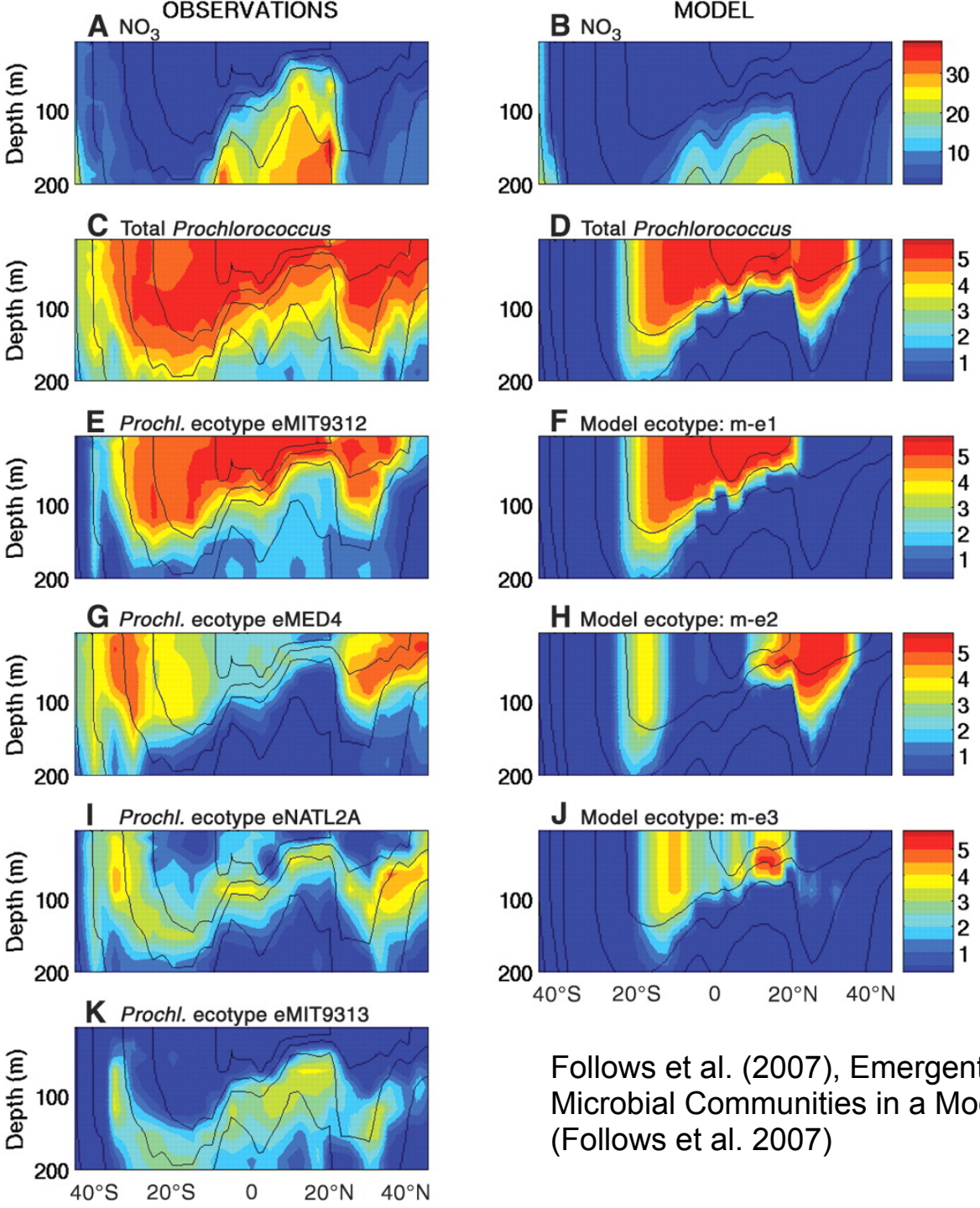


O Paradoxo do Plioceno (Fedorov et al. 2006)

Soluções?

Mais grupos funcionais: PlankTOM10

Modelos emergentes: *Emergent Biogeography of Microbial Communities in a Model Ocean*, Follows et al. (2009)



Follows et al. (2007), Emergent Biogeography of Microbial Communities in a Model Ocean (Follows et al. 2007)

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Se há alguns anos a falta de dados limitava os avanços da ciência, hoje o problema se inverteu. O desenvolvimento de novas tecnologias de captação de dados, nas mais variadas áreas e escalas, tem gerado um volume tão imenso de informações que o excesso se tornou um gargalo para o avanço científico.

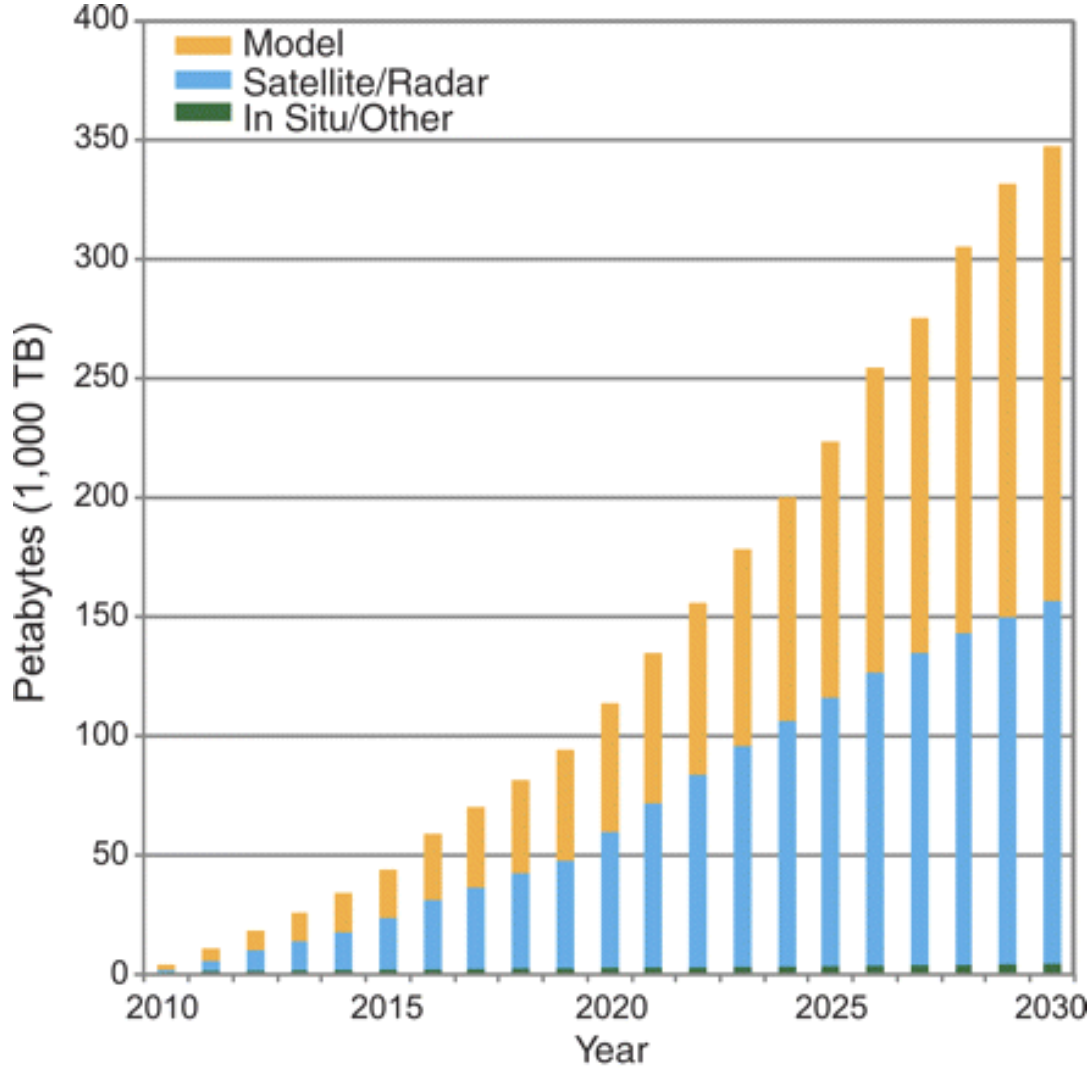
Desafios do "tsunami de dados", FAPESP

"Tsunami de dados"

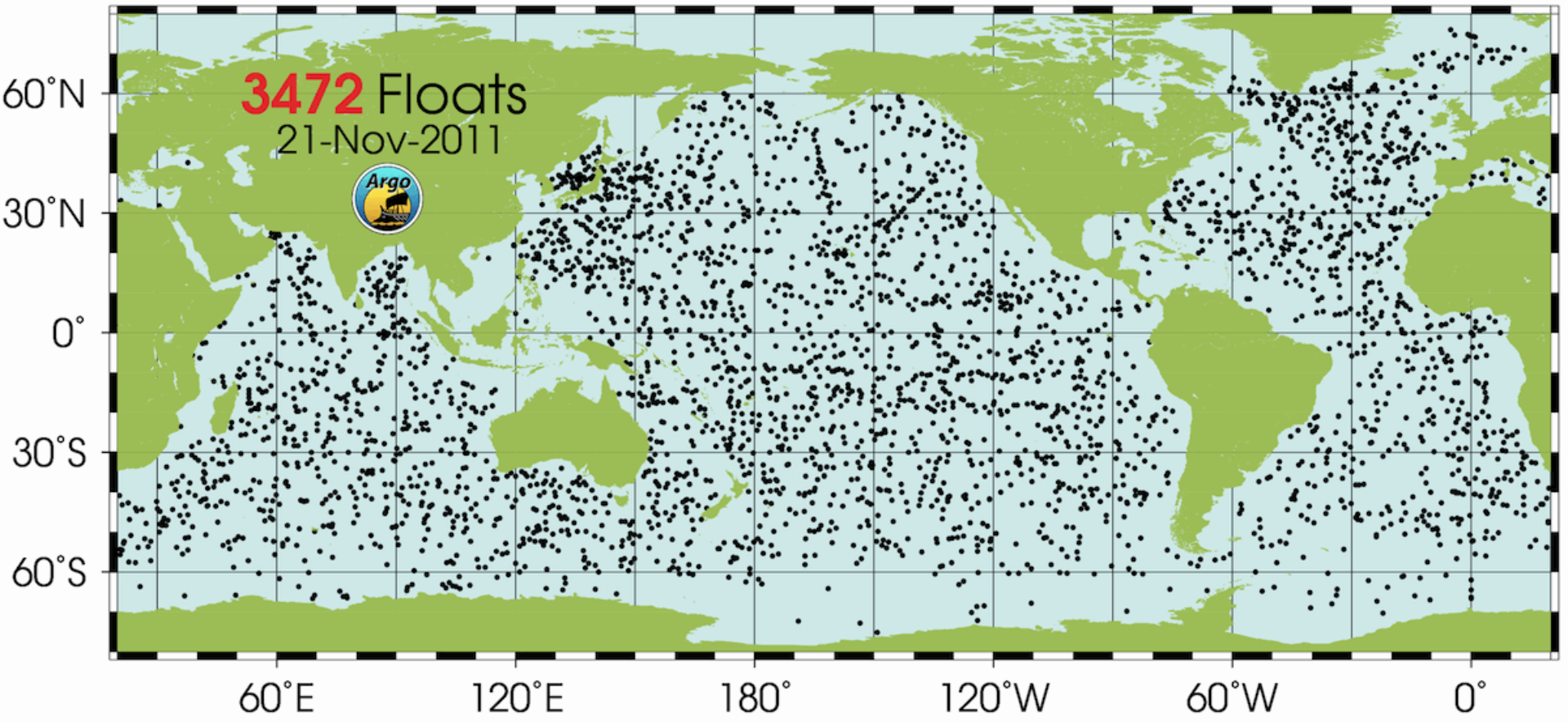
Volume de dados científicos dobra a cada ano [Szalay & Gray (2006), Science in an expontial world, *Nature*, **440**, 23.]

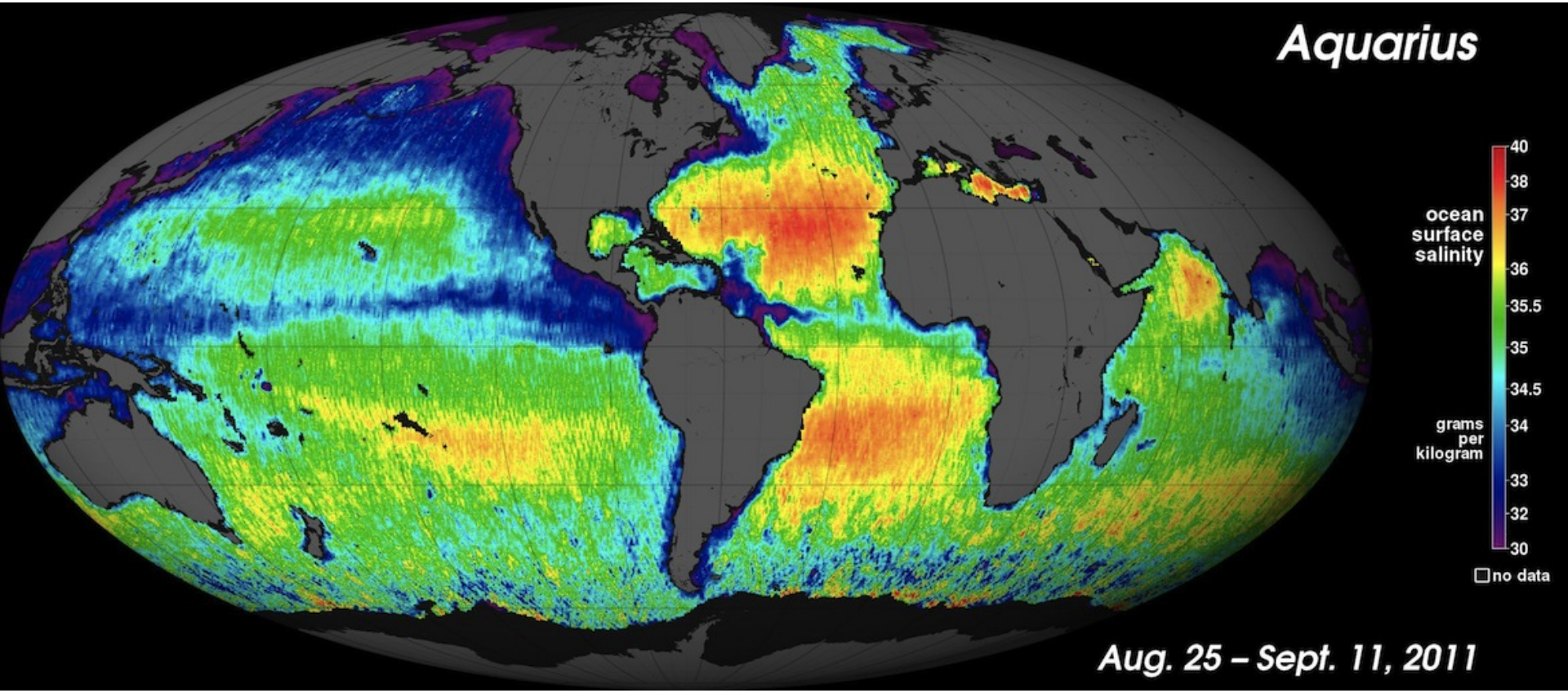
Integrações para o CMIP5 no INPE: **300 TB**

CMIP1: 1TB
CMIP3: 36TB
CMIP5: ~2500 TB



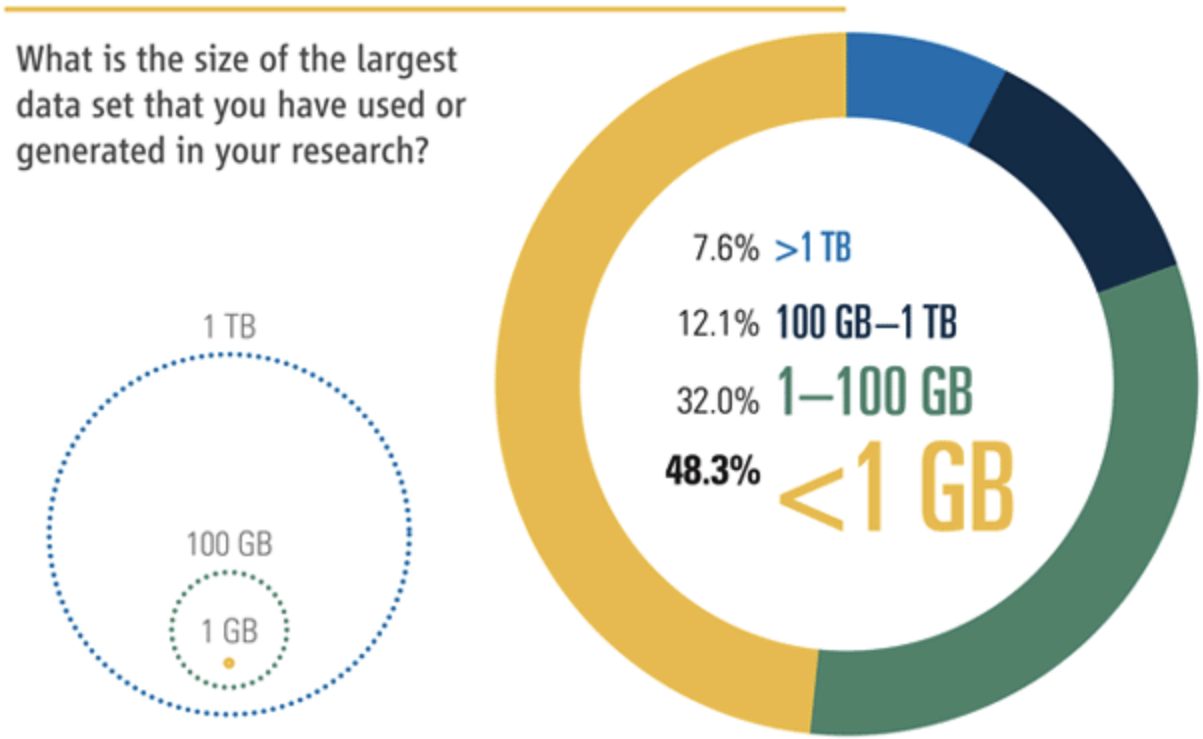
Volume de dados climáticos (Overpeck et al. 2011)


3472 Floats
21-Nov-2011
Argo
60°N
30°N
0°
30°S
60°S
60°E
120°E
180°
120°W
60°W
0°


Aquarius
ocean surface salinity
grams per kilogram
40
38
37
36
35.5
35
34.5
34
33
32
30
no data
Aug. 25 – Sept. 11, 2011

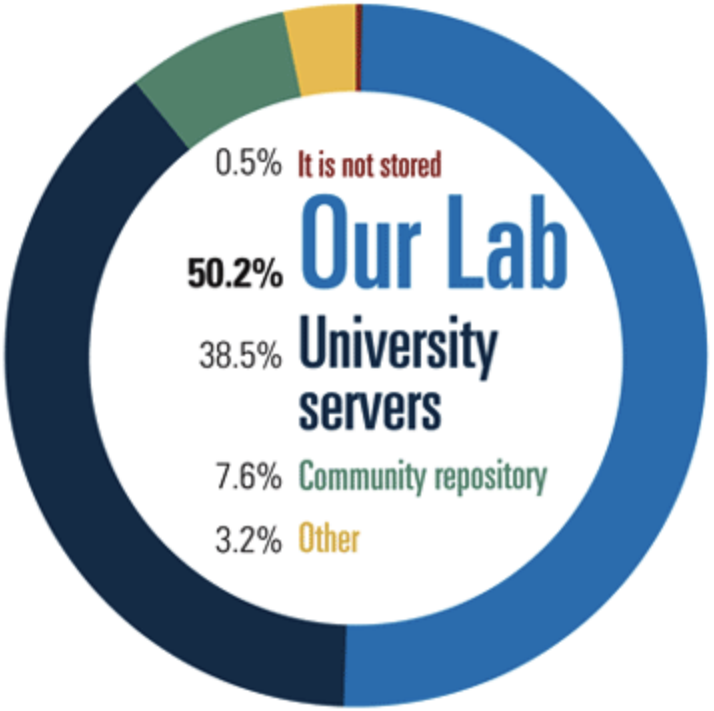
Problemas

- **Acesso**: disponibilidade, "consumibilidade", padronização (formato, semântica)
- **Análise**: ferramentas, visualização, interoperabilidade, reprodutibilidade
- **Compartilhamento**: armazenamento, confiabilidade
- **Curadoria**: permanência de dados e ferramentas



Tamanho dos conjuntos de dados

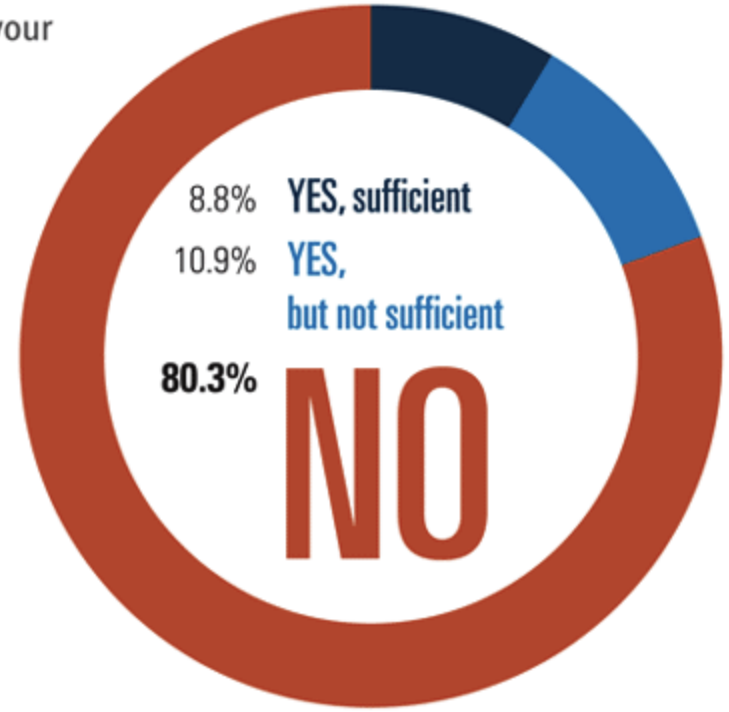
Where do you archive most of the data generated in your lab or for your research?



> Even within a single institution **there are no standards for storing data**, so each lab, or often each fellow, uses ad hoc approaches.

Armazenamento dos dados

Is there sufficient funding for your lab or research group for data curation?



> There are many tales of early archaeologists burning wood from the ruins to make coffee. If we fail to curate the environmental archives **we collect from nature at public expense**, we essentially repeat those mistakes.

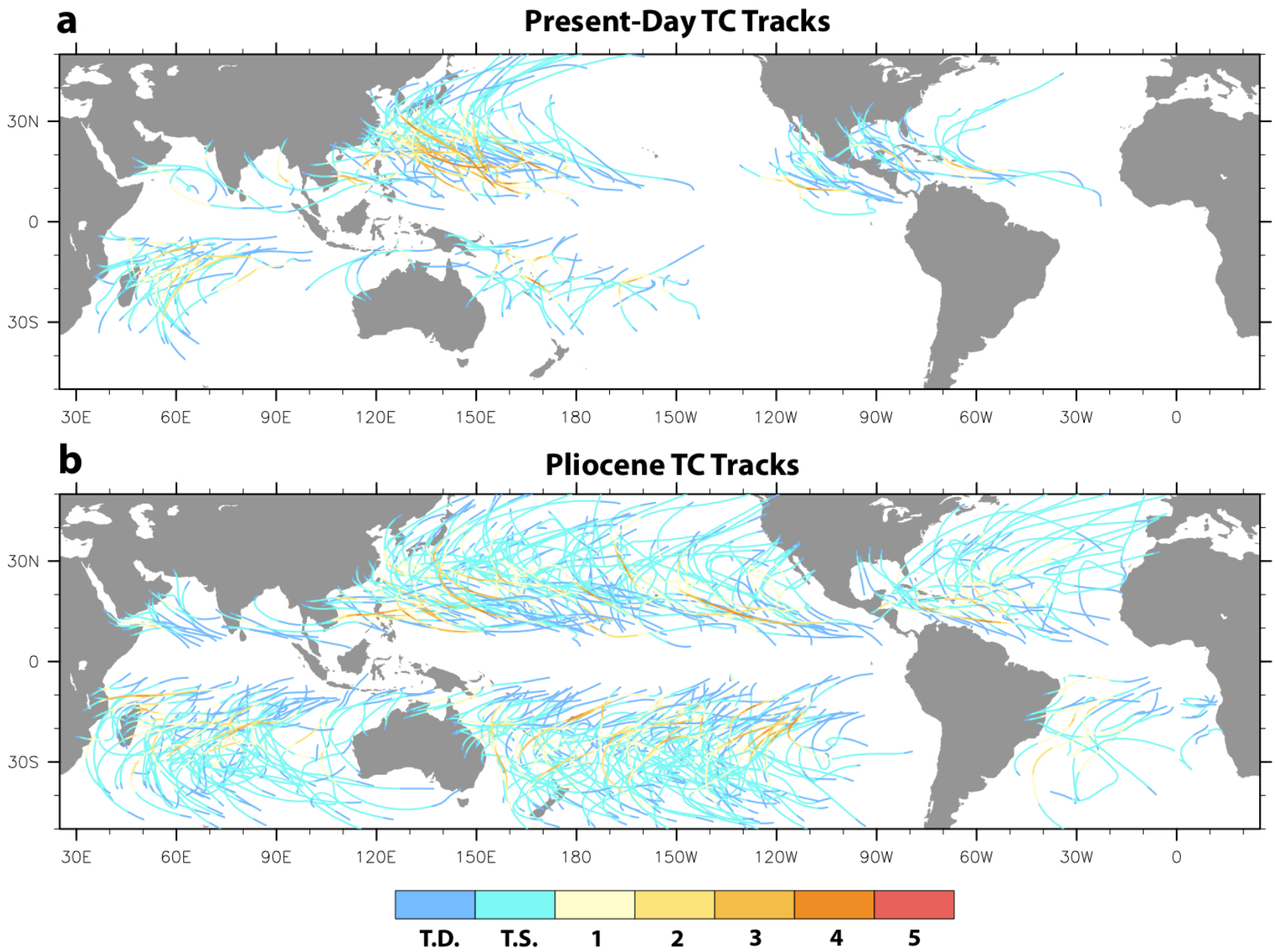
Fundos para curadoria

Richard Hamming ("You and Your Research", http://www.paulgraham.com/hamming.html):

1. What are the most important problems in your field?
2. Are you working on one of them?
3. Why not?

Obrigado

roberto@dealmeida.net


a
Present-Day TC Tracks
30N
0
30S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
b
Pliocene TC Tracks
30N
0
30S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
T.D.
T.S.
1
2
3
4
5