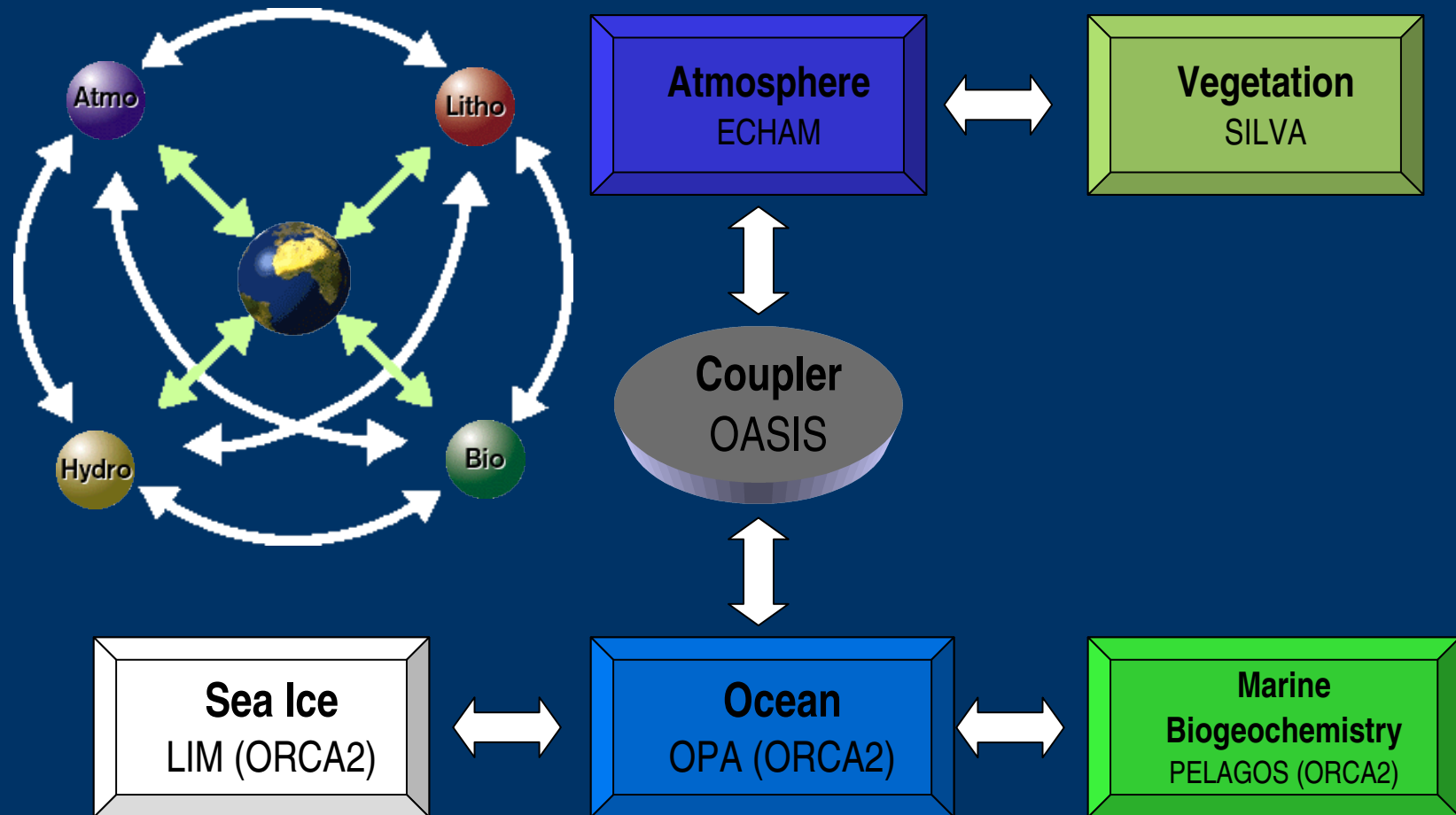# *Current status of the INGV Earth System Model*

M. Vichi, P.G. Fogli, E. Manzini
A. Alessandri, S. Gualdi, S. Masina,
A. Navarra, L. Patara, E. Scoccimarro

The INGV ESM (category: A & C)

# *ESM configuration for <u>Stream1</u>: category A*

- just submitted to IPCC
- configuration
  - **atmosphere** ECHAM4.6@T106L19
  - **ocean** OPA8.2@ORCA2
  - **sea ice**: LIM@ORCA2
  - **coupler**: OASIS2
- runs: Control, 20C3, 21C3 (A1B, A2)

ESM configuration for Stream2: category C

- **Atmosphere**: ECHAM5@T63L31 (*Roeckner et al 2006*)
- **Ocean**: OPA8.2@ORCA2 (*Madec et al 1998*)
- **Sea-Ice**: LIM@ORCA2 (*Timmermann et al 2005*)
- **Marine Biogechemistry**: PELAGOS@ORCA2 (*Vichi et al 2006a,b*)
- **Land, Vegetation, and Terrestrial Carbon**: SILVA@T63 (*Alessandri, 2006; Zeng et al 2004; Ducoudre et al 1993*)
- **Coupler**: OASIS3 (*Valcke et al 2004*)

Control Simulation

Annual Mean SST (Global average) [°C]

Sea-Ice Area [m²]
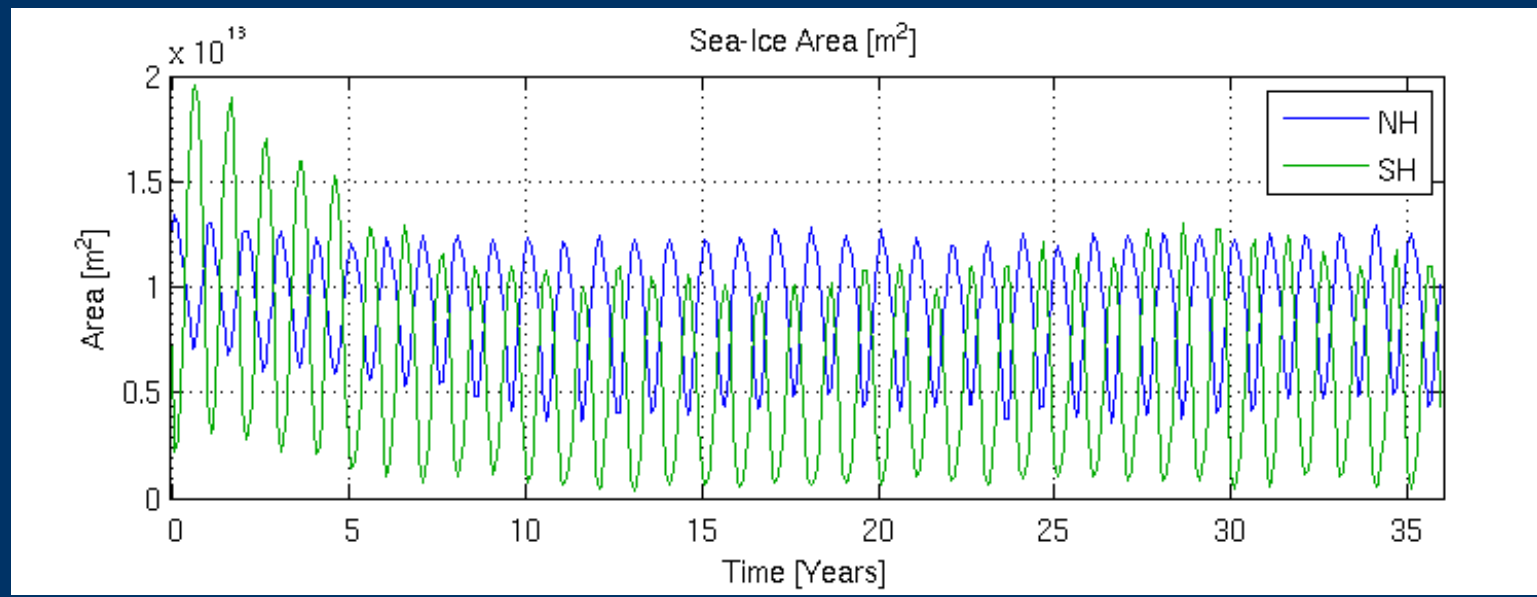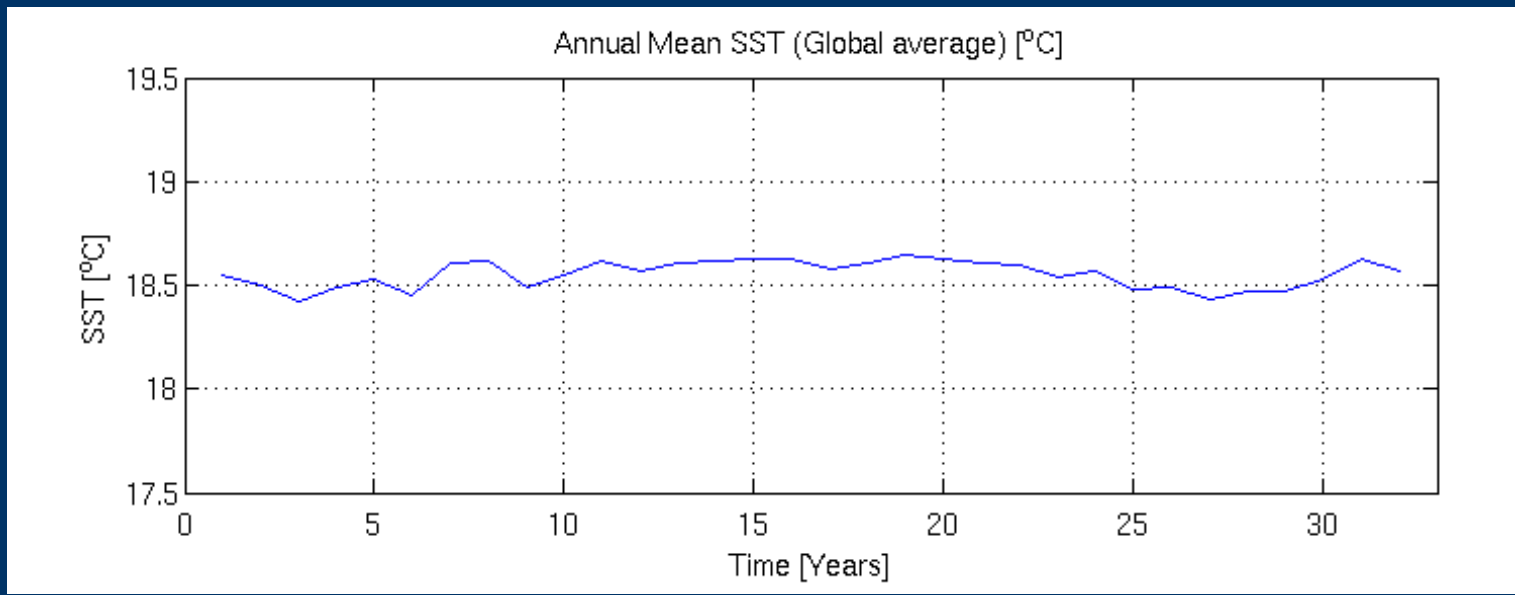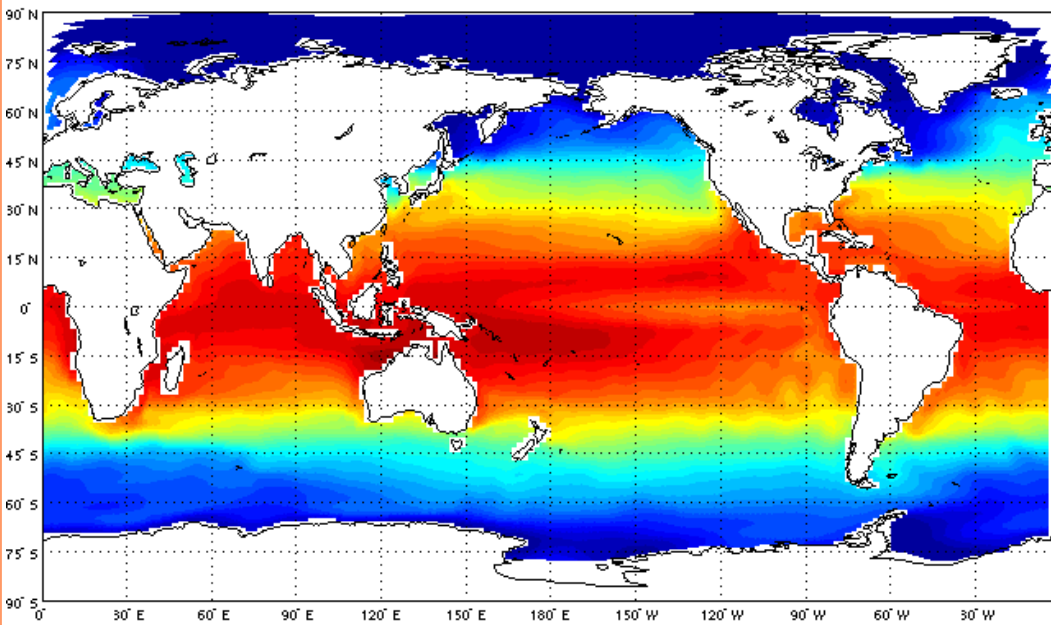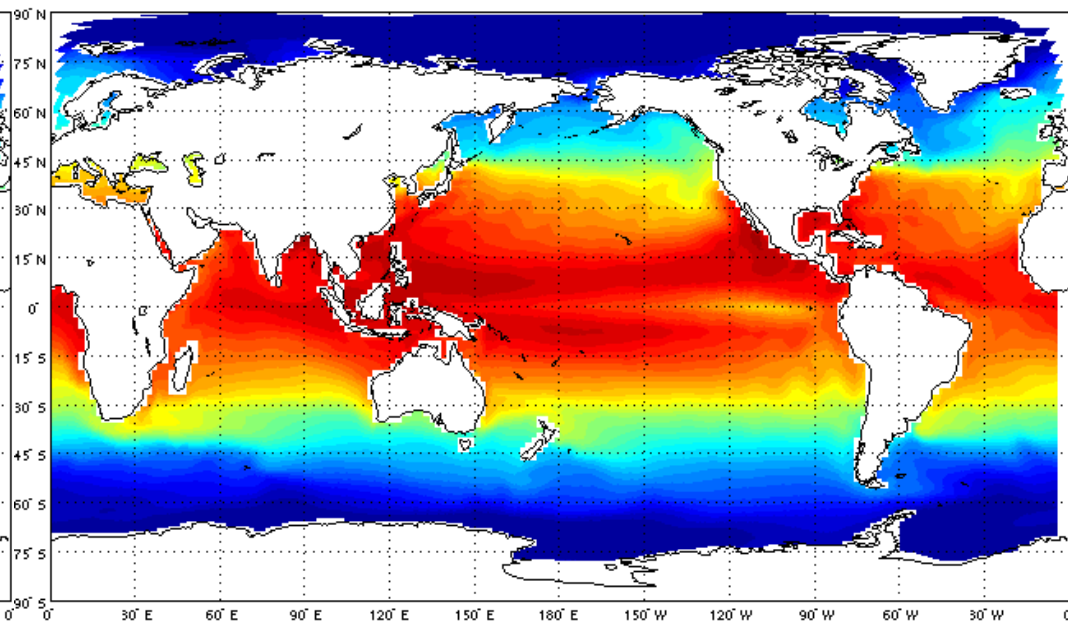
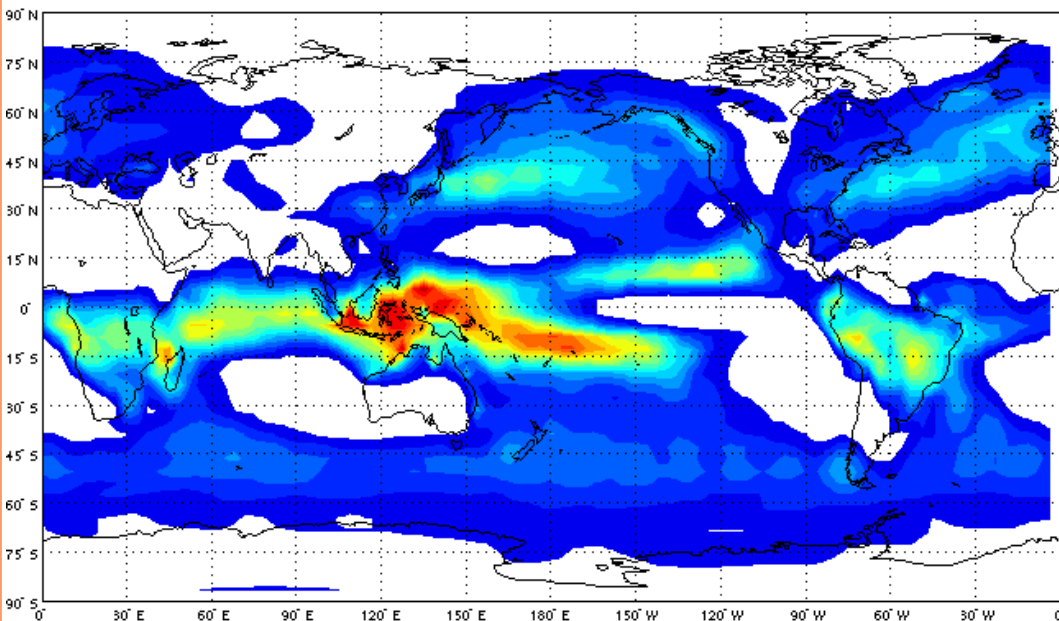# Control Simulation: SST

DJF

JJA

DJF SST [°C]

JJA SST [°C]

Resolutions
ECHAM5: T31L19
OPA8.2: ORCA2

Control Simulation: Total Precipitation
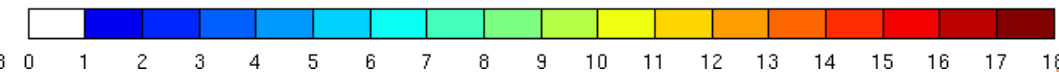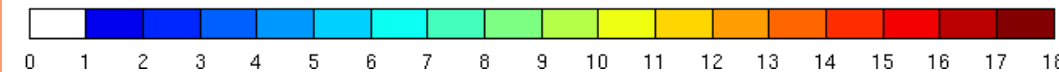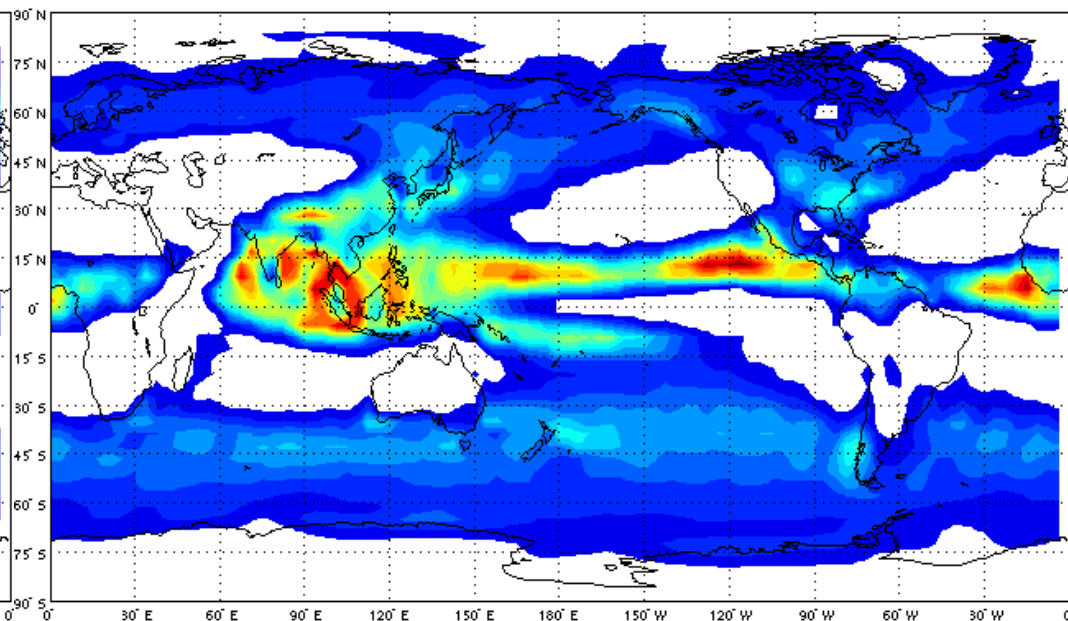

DJF

JJA

DJF Total Precipitation [mm/d]

JJA Total Precipitation [mm/d]

Resolutions
ECHAM5: T31L19
OPA8.2: ORCA2

Control Simulation: Zonal wind (850mb)

DJF

JJA
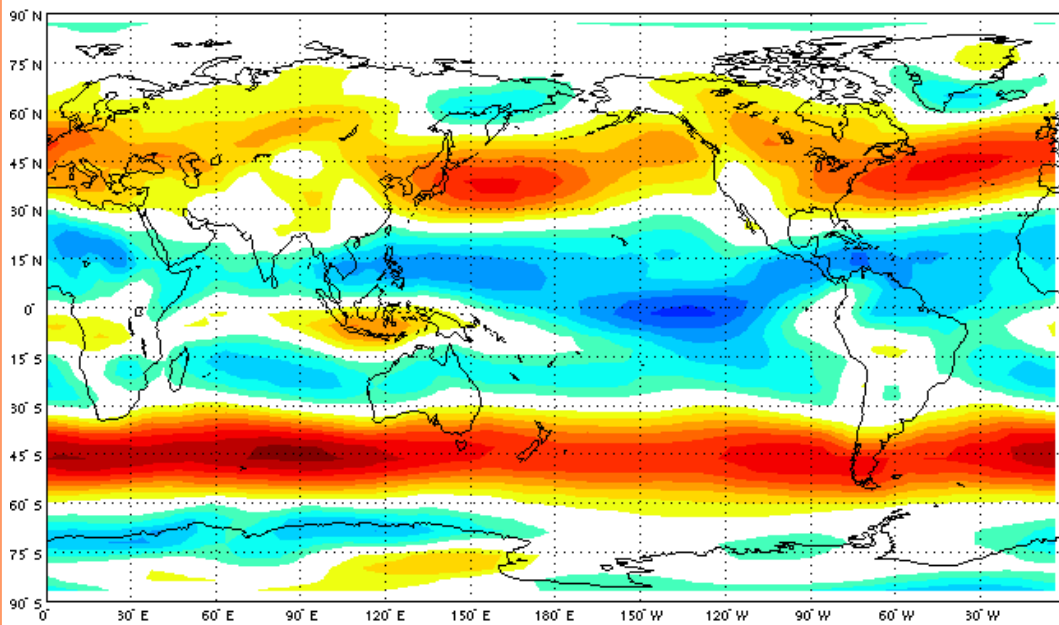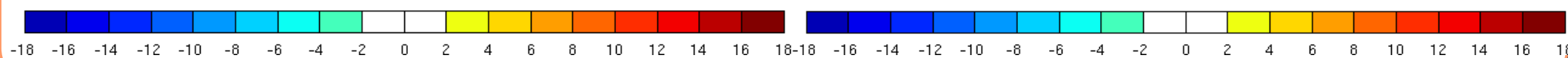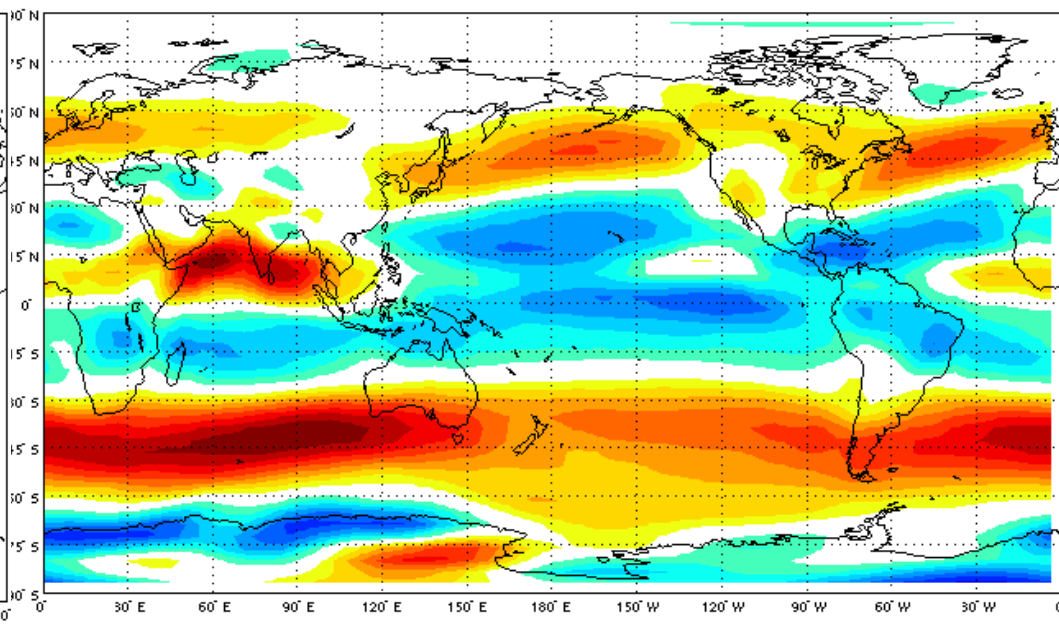
Resolutions
ECHAM5: T31L19
OPA8.2: ORCA2

PELAGOS: PELAgic biogeochemistry for Global Ocean Simulations
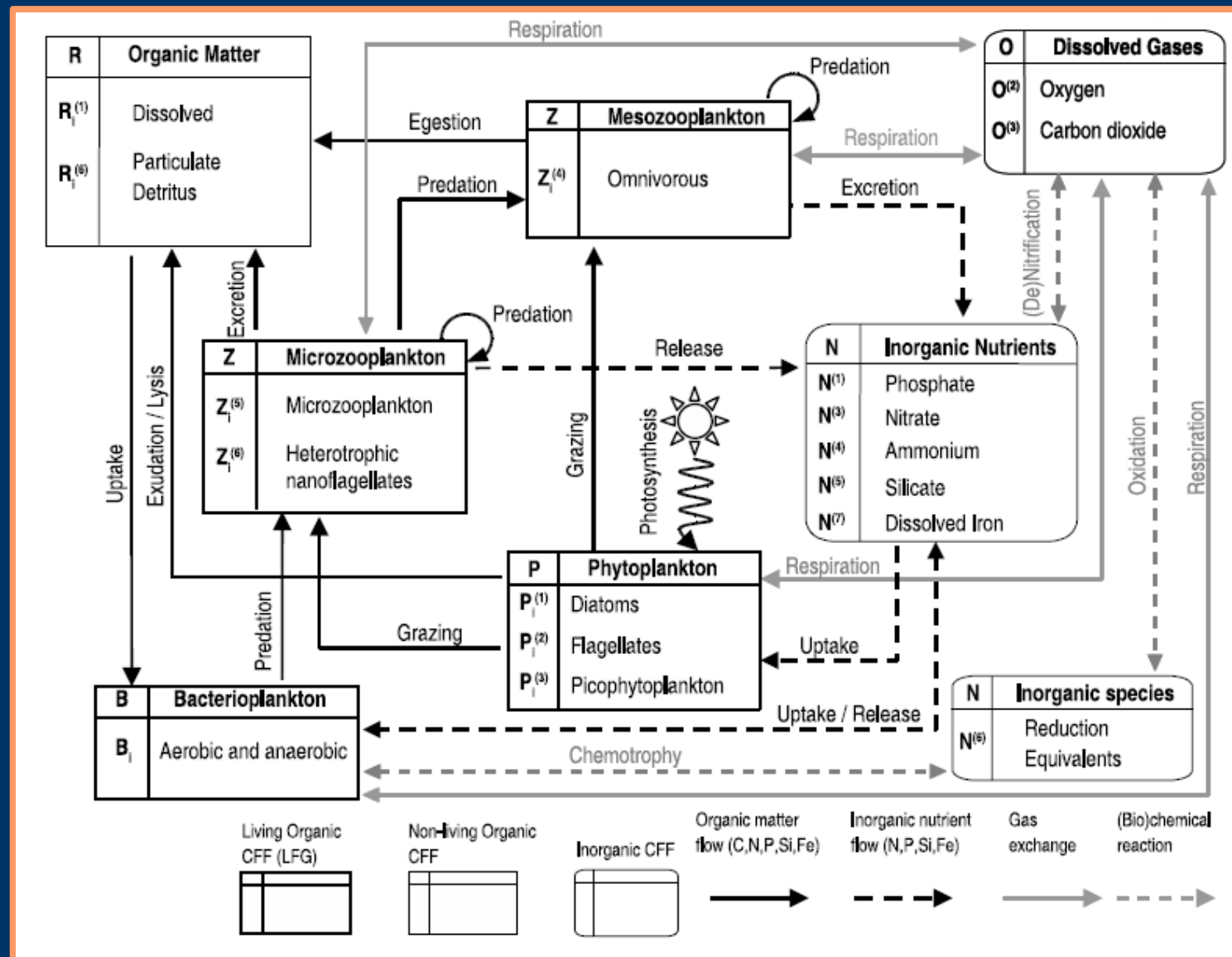
Scheme of the state variables and pelagic interactions of the biogeochemistry model. Living (organic) Chemical Functional Families (CFF) are indicated with bold-line square boxes, non-living organic CFFs with thin-line square boxes and inorganic CFFs with rounded boxes (modified after Blackford and Radford (1995)).

Theoretical constructs:
Living Functional Groups (LFG)
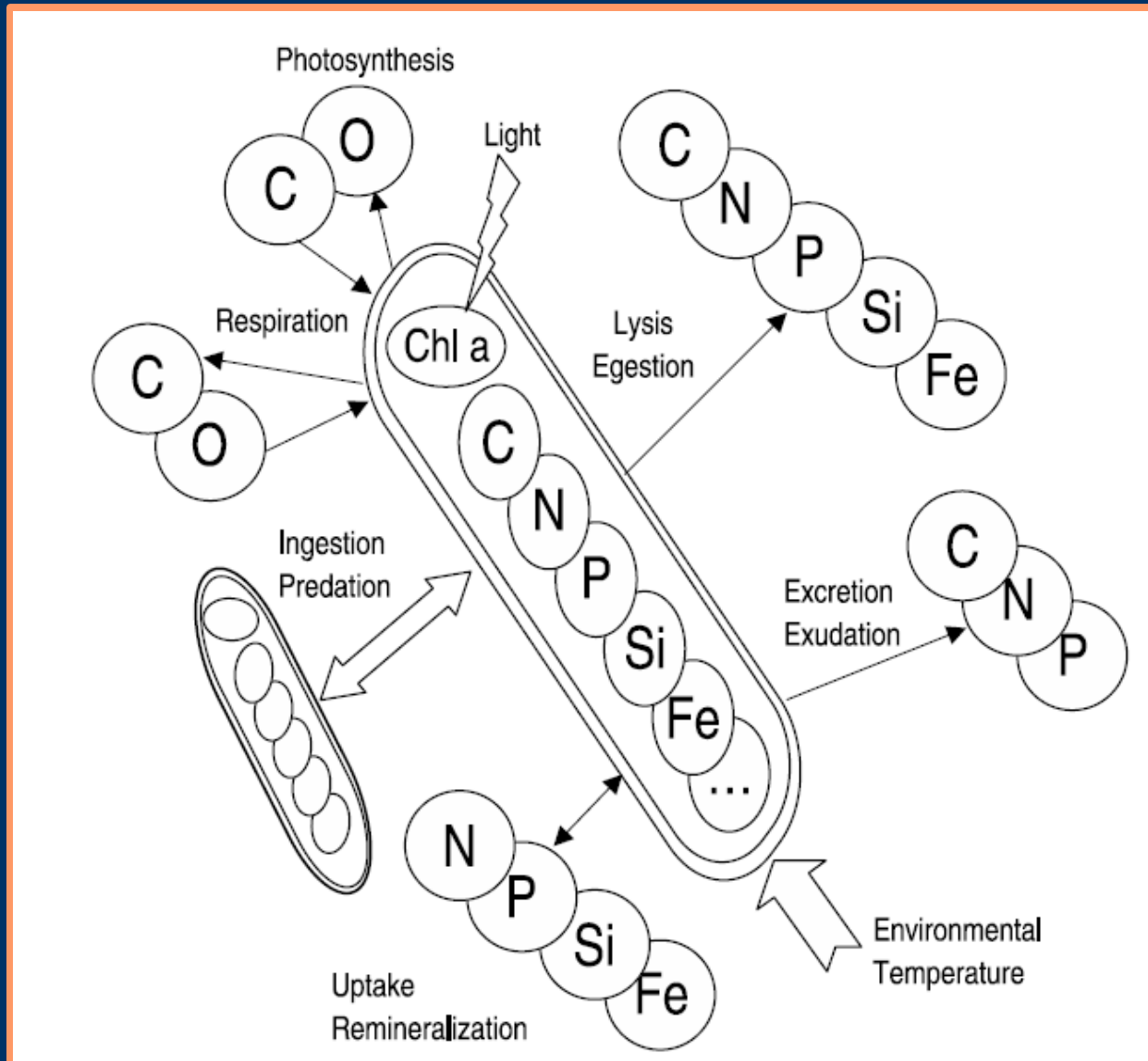
Scheme of the **standard organism**, which is the prototype of any Living Functional Group (LFG), and the physiological/trophic relationships among the Chemical Functional Families and major environmental forcings.

The standard organism is a theoretical representation of the real organisms and can describe both an autotroph, a heterotroph or a mixotroph, depending on the choice of the (internal) living CFFs and the process equations that link them.

SILVA: Surface Interactive Land VegetAtion

The model can be run with fixed observed vegetation distribution or with vegetation-carbon dynamics activated

- Contains an hydrology module with 2 soil layers
- Soil thermodinamics module (7 layers soil diffusion)
- Computes fluxes and solves surface energy and water balance at the interface with the atmosphere
- Surface parameters such as albedo, roughness and surface conductance to evapotranspiration are computed interactively

SILVA: interactive vegetation (on-going)

Atmosphere
ECHAM

Surface fluxes

Implicit Coupling with a Neumann closure at the interface

Lower boundary Atmospheric variables and radiative fluxes

SILVA

Land surface model

LAI, Vegetation cover & height, stomatal conductance, ...

Soil Temperature & humidity, ...

Vegetation and Carbon model
· 4 PFTs : Broadleaf and needleleaf trees and cold/warm grass
· 3 vegetation carbon pools: leaf, root and wood
· 3 carbon pools in soil: slow, intermediate and fast degradable

• Prognostic carbon pools (updated following growth and respiration/turnover)
• Competition between PFTs determined by resource allocation strategies, tolerance to stress and natural disturbances as well as bioclimatic preferences.

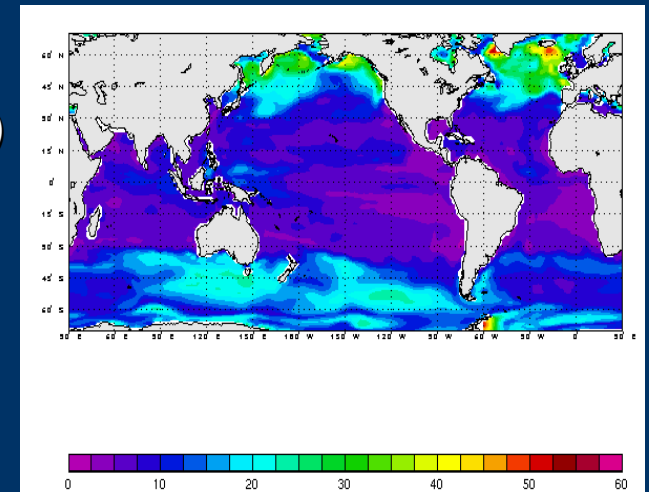# *Bio-optical feedbacks in the equatorial Pacific*

Blue Ocean

Green Ocean

ATMOSPHERE   OCEAN/SEA-ICE   MARINE BIOGEOCHEMISTRY
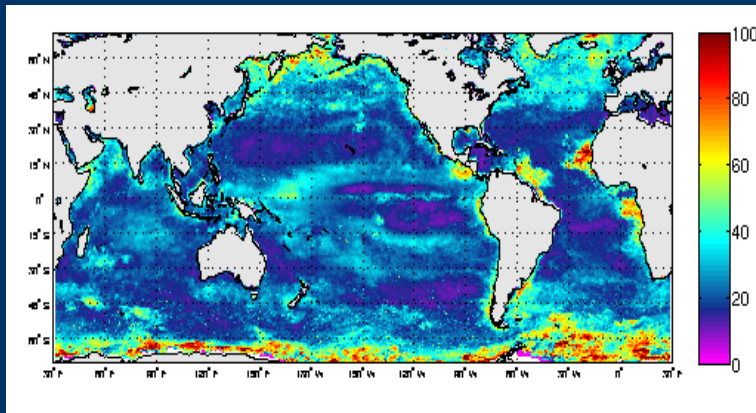
SeaWiFS (1997-2004)
Chl variability
(normalized stdev of anomalies)

Model (40 years)
Chl variability
(normalized stdev of anomalies)

Previous results don't agree...

Deepening of the mixed layer · SST increases	Shoaling of the mixed layer · SST decreases

- Deepening of the mixed layer

- SST increases

- Shoaling of the mixed layer

- SST decreases

- Wetzel et al., (in press)
- Marzeion et al., 2005
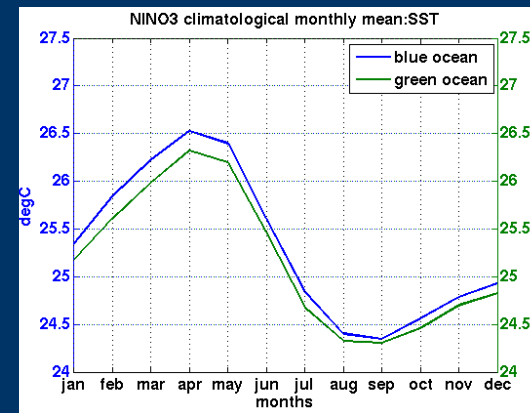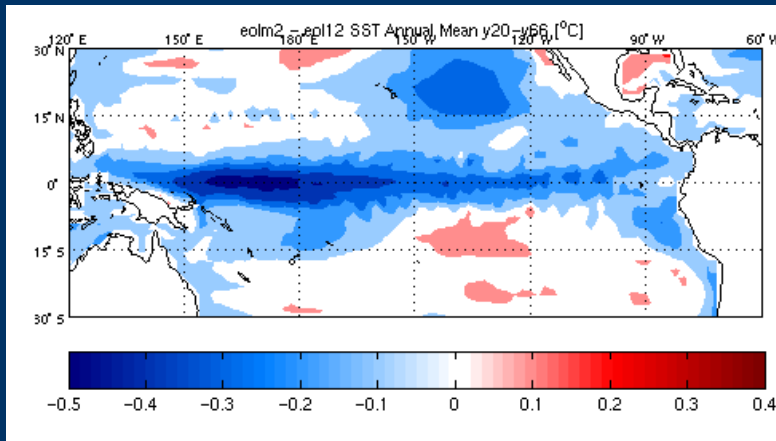- Murtugudde et al., 2002

- Manizza et al., 2005
- Nakamoto et al., 2001

Mean fields and seasonal cycle
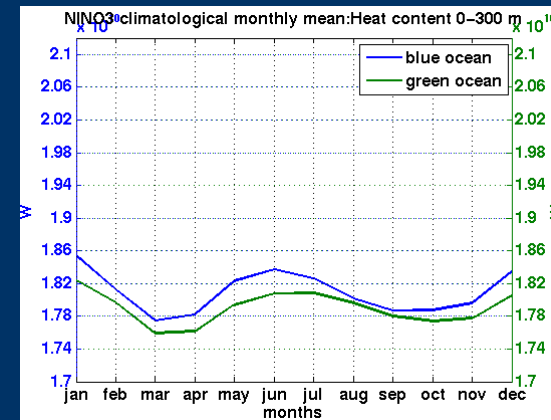
Green ocean – Blue ocean
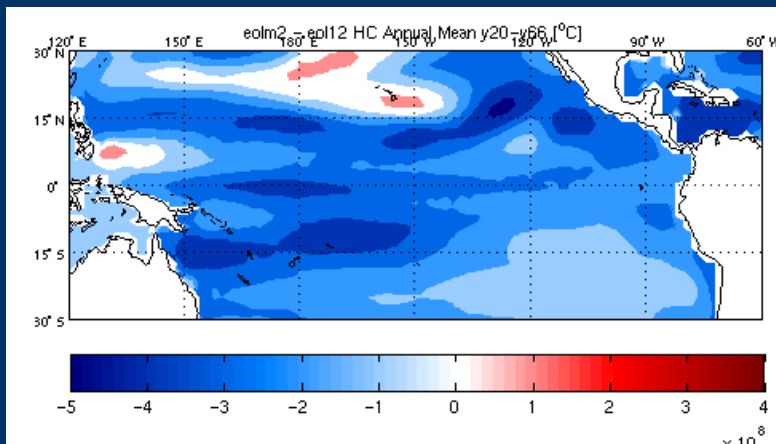
NINO3 region:
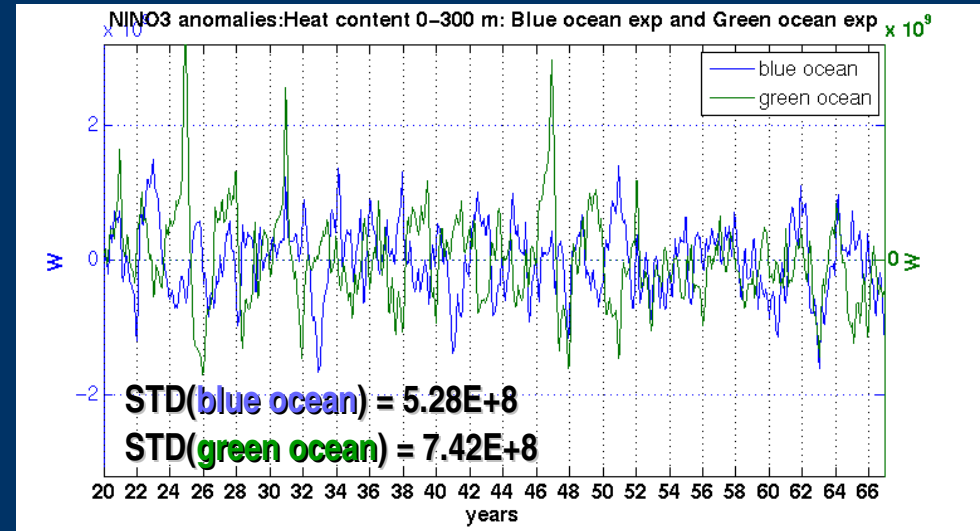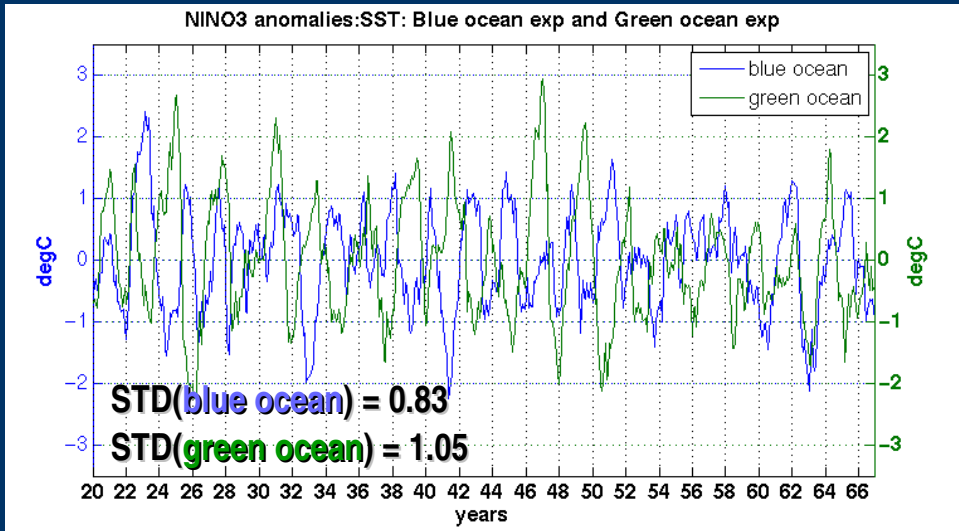**Green Ocean (green) Blue Ocean (blue)**

SST (degC)

SST monthly climatology (degC)

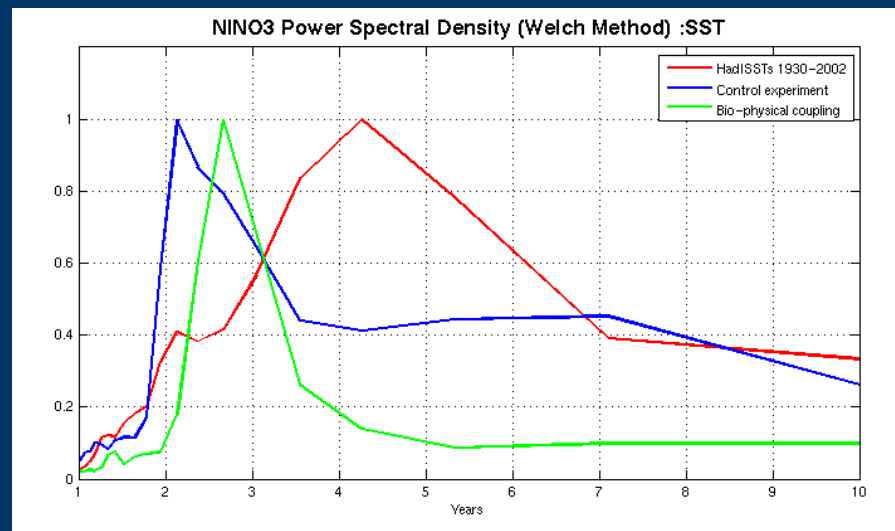**Heat Content (W)**

Heat Content monthly climatology (W)

Variability

NINO3 anomalies:SST: Blue ocean exp and Green ocean exp

STD(blue ocean) = 0.83
STD(green ocean) = 1.05

SST anomalies (degC)

NINO3 anomalies:Heat content 0–300 m: Blue ocean exp and Green ocean exp

STD(blue ocean) = 5.28E+8
STD(green ocean) = 7.42E+8

Heat Content anomalies (W)

47 years time series Green Ocean (green) Blue Ocean (blue)

NINO3 Power Spectral Density (Welch Method) :SST

HadISSTs 1930–2002
Control experiment
Bio–physical coupling

HadISST (red)   Green Ocean (green)   Blue Ocean (blue)

Summary

- Control simulation for Stream2 ready to start
- Closure of the terrestrial and marine carbon cycle on-going

- Coupled Dynamic Green Ocean Model produces a reasonable biology in the Equatorial Pacific area
- The coupling of biology with the physical model in the Equatorial Pacific produces *(to be confirmed with longer runs)*:
    - a *slight* cooling (SST and heat content)
    - a *slightly larger* variability in the SST and heat content anomalies
    - *comparable* ENSO phase