SAILING INTO A SEA OF EXCITEMENT: An Earth System Perspective on Marine Research in the Next Decade

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4 glacial cycles recorded in the Vostok ice core

Set points at ca. 200 & 290 ppm

The Vostok Challenge

What are the forcings and feedbacks that move the Earth System between glacial and interglacial states?
What are the important marine processes in these forcings and feedbacks?

What is the role of the ocean in controlling the set points?

How important is marine biology in the self-regulation of the Earth System as seen in the Vostok record?
From Ridgwell 2002
From Piketh et al. 2000
The Role of the Ocean in the Planetary Machinery

How important is marine biology in the functioning of the Earth System?

How important is the complexity of marine ecosystems? Of higher trophic levels in food webs?

How critical is the linkage between land and ocean in the functioning of the Earth System?
From Schellnhuber 2002
Abrupt Changes?

Records from the past have shown us that the Earth System is capable of abrupt changes that could devastate modern civilisations. For example, the mean temperature in the North Atlantic region has changed by 10 deg C in a decade. Could such changes happen again? Could global change act as a trigger for such changes? Are human pressures on the Earth System pushing the System towards or away from these changes?
From Rahmstorf and Alley 2002
Oceanic Conveyor Belt

After Broecker 1991

Atlantic ocean

Warm surface current

Indian ocean

Cold saline deep current

After Broecker 1991
Change in the strength of the North Atlantic meridional overturning circulation (svds) in a number of simulations with increases in greenhouse gases

Source: Cubasch et al. 2001
Atlantic Thermohaline Circulation: Abrupt Changes: Future Surprises?

• the Atlantic THC can have multiple equilibria which implies thresholds

• reorganisations of the THC can be triggered by changes in the surface heat and freshwater fluxes

• most models indicate a weakening of the THC in the next 100 years. This implies an approach towards possible thresholds

• crossing of thresholds and associated irreversible changes of ocean circulation cannot be excluded within the range of projected climate changes of the next century.
From Takahashi et al. 1997
Biological Carbon Pump in the Oceans
Adapted from Fromentin and Planque 1996
Ocean Dynamics, Thresholds, Regime Shifts and Abrupt Changes

What are the critical thresholds and switches in the ocean?

How are abrupt changes and regime shifts in one aspect of Ocean dynamics processed through the entire physical-Chemical-biological system?

What are the best techniques for analysing and predicting Abrupt changes and regime shifts?

Adapted from the GAIM 'Earth System Questions'
Vostok Ice Core

Mauna Loa Record

Human perturbation

Vostok Ice Core
IPCC Projections
2100 AD

Adaptation - Sustainability

Survival

N.H. Temperature (°C)

Global Temperature (°C)

PAOES
Ocean Dynamics and Global Change in the 21st Century

What and where are the vital aspects/components of marine biology and chemistry in terms of Earth System functioning?

What and where are the switch-points that can be triggered by direct human actions?

Will the ocean act as a brake on or an accelerator of global change in the 21st century?