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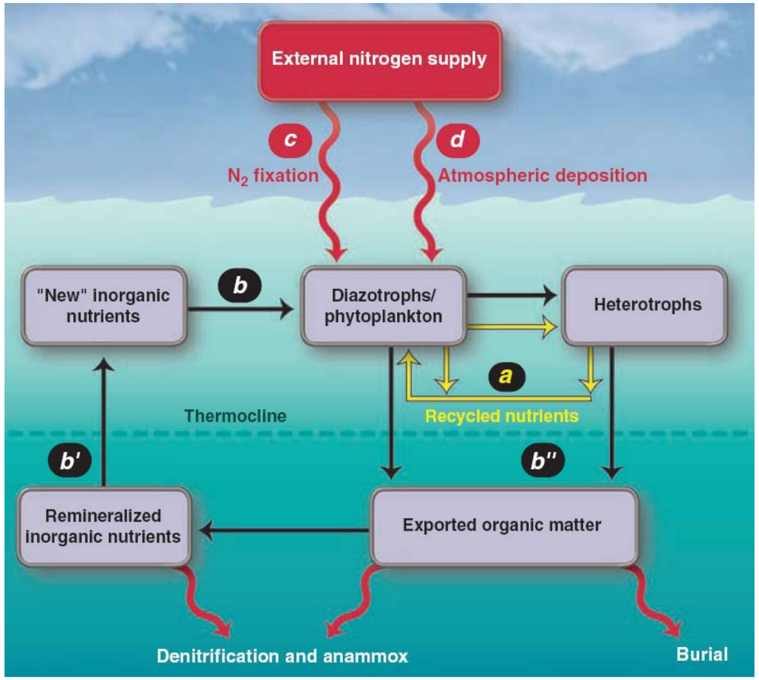
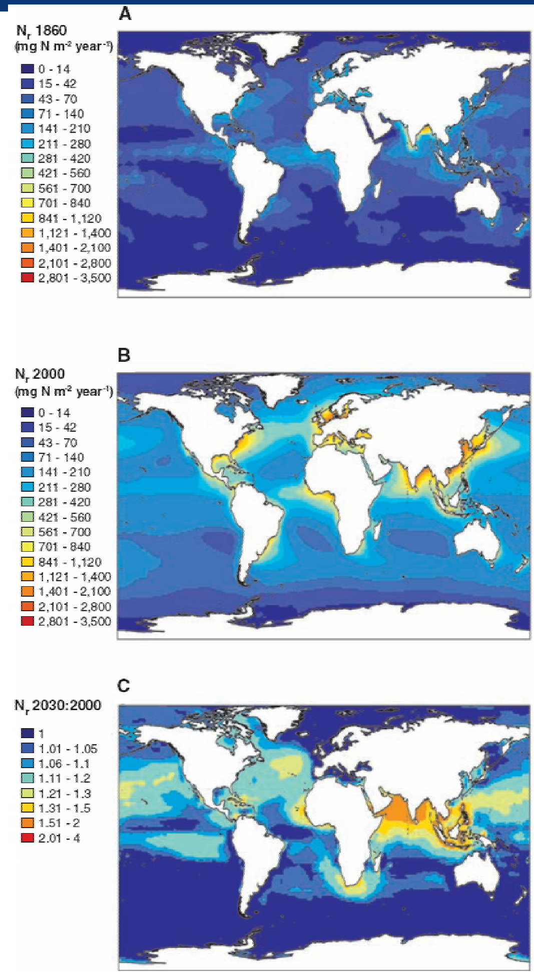
Impacts on the global Nitrogen Cycle and impacts on N_2O

Duce, R.A., et al. 2008. Impacts of Atmospheric **Anthropogenic Nitrogen on the Open Ocean.** Science 320, 893-897.





Although ~10% of the ocean's drawdown of CO2 result from atmospheric nitrogen fertilization, about two-thirds is offset by N2O emissions. This effect is expected to increase in the future.

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Effect of Climate Change on Water Runoff (IMAGE)

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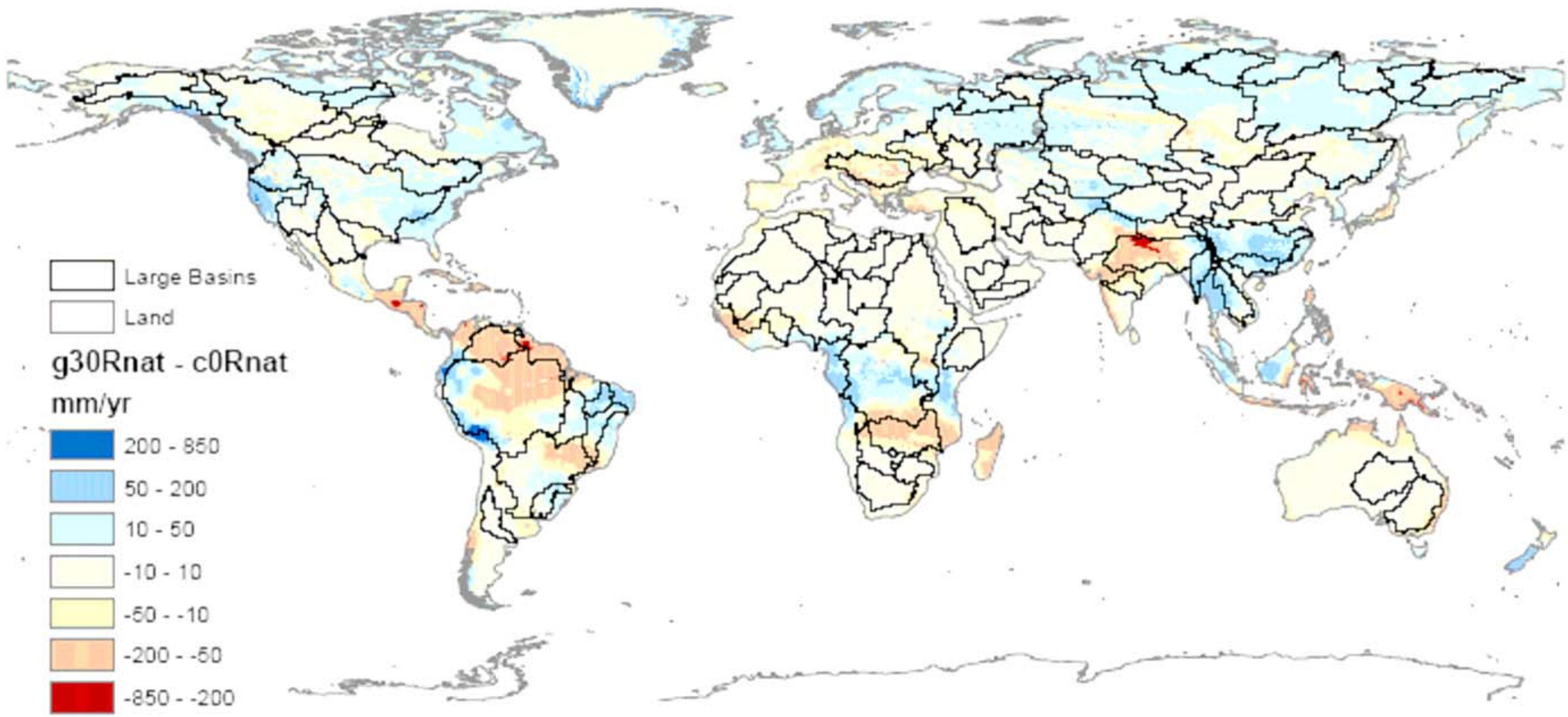
Seitzinger et al. MA scenarios preliminary results



Changes in runoff between 2000 and 2030 in the Global Orchestration scenario (Blue positive values are increases)

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Regional change in Dissolved Inorganic Nitrogen (DIN) Yield from 2000 to 2030

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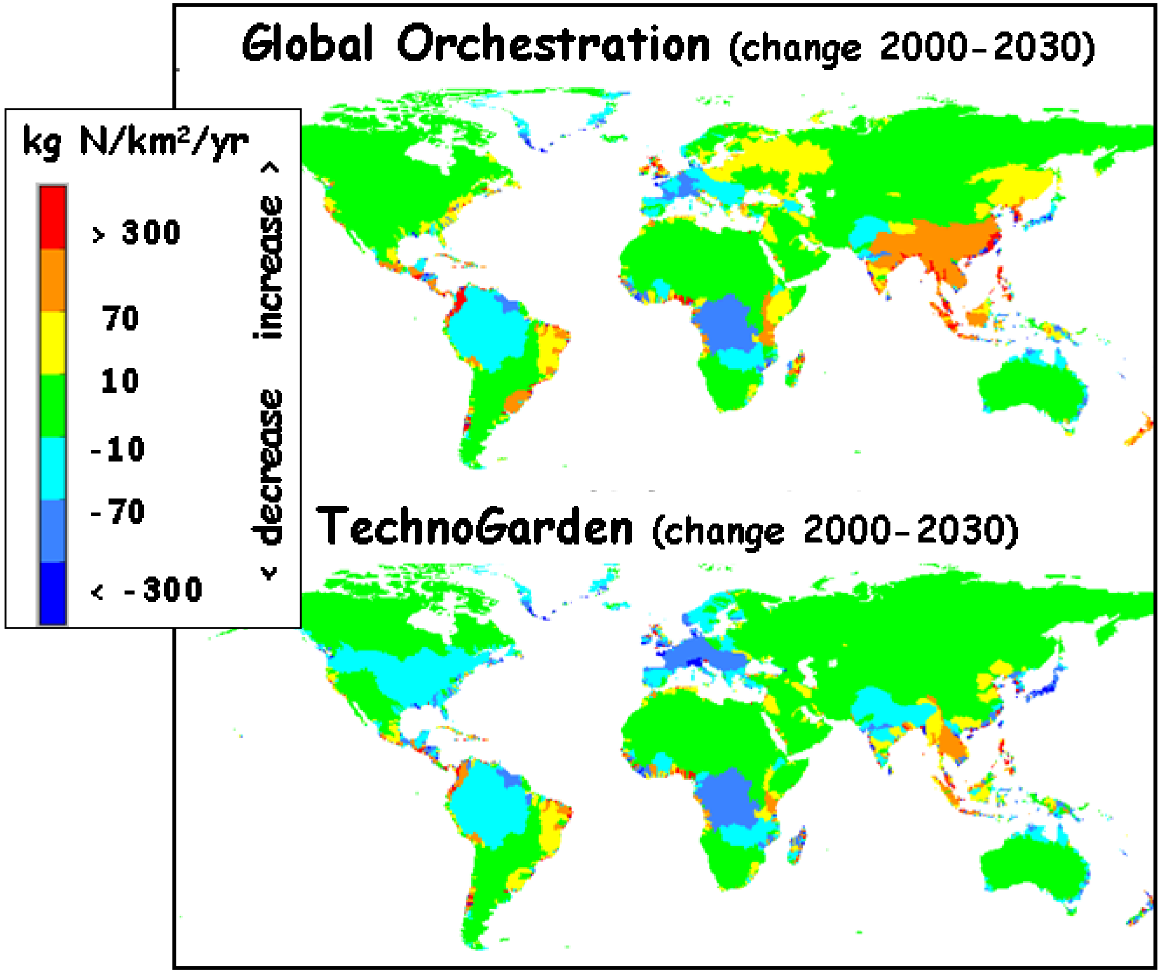
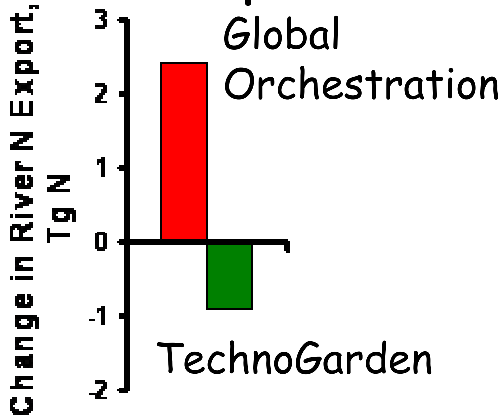
Seitzinger et al. MA scenarios preliminary results



Global Change in DIN Export



Large regional differences: N yield to coastal water strongly influenced by management, runoff, dams, agriculture, climate change and other feedbacks.

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Development of the global water use scenarios

Alcamo et al. 2008. Global Water Outlook to 2025

Global water use scenarios (13 scenarios, 5 international studies)

(Uncertainty of, for example, population, economic activity, rate of technological change):

- Increase between 2000 and 2050 for nearly all scenarios
- Mean changes between 2000 and 2050: +38% (+25 to +84%)

Pattern of change → accelerating and then slowing

Large regional differences

- Industrialized countries: water withdrawals stabilizing or sinking
- Developing countries: pressure on water resources growing up to 2050

Most rapidly growing water sectors in Africa & rapidly developing world: both **domestic & industry**

Applied Earth System Science and ESSP Rapid BIOFUELS assessment (with SCOPE)

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AIMES
analysis, integration, and modeling of the earth system

Global Carbon Project

Global LAND Project

What are the policy issues?

What are the earth system linkages, land use needs, systemic feedbacks and uncertainties?

What are plausible scenarios?

What are the key vulnerabilities?

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an international programme of biodiversity science

GLOBAL IGBP CHANGE

IHDP

WCRP
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Methane budget and isotopic structures of source and sinks

Sources	A Priori Estimates, Tg CH_4/yr	Range of Estimates Reported by *IPCC* [2001], Tg CH_4/yr	Mean Isotopic Signature
Total wetlands		92–237	−58‰[b]
Swamps	91[c]		
Bogs and tundra	54[c]		
Rice agriculture	60[d]	25–100	−63‰[b]
Ruminant animals	93[d]	80–115	−60‰[b]
Termites	20[e]	20–20	−70‰[b]
Biomass burning	52[f]	23–55	−25‰[b]
Energy		75–109	
Coal	38[d]		−37‰[b]
Natural gas and other industrial	57[d]		−44‰[b]
Landfills	50[g]	35–73	−55‰[b]
Ocean	10[h]	10–15	−60‰[b]
Hydrates	5[h]	5–10	−60‰[b]
Total source	**530**	**500–600**	~−53‰[b]

Sinks	A Priori Estimates, Tg CH_4/yr	Range of Estimates Reported by *IPCC* [2001], Tg CH_4/yr	Isotopic Fractionation
Tropospheric OH	507[i]	450–510	5.4‰[j]
Stratospheric loss	40[k]	40–46	12‰[l]
Soils	30[k]	10–30	22‰[m]
Total	**577**		~6.7‰

Mikaloff-Fletcher et al. (2004) *Global Biogeochemical Cycles*

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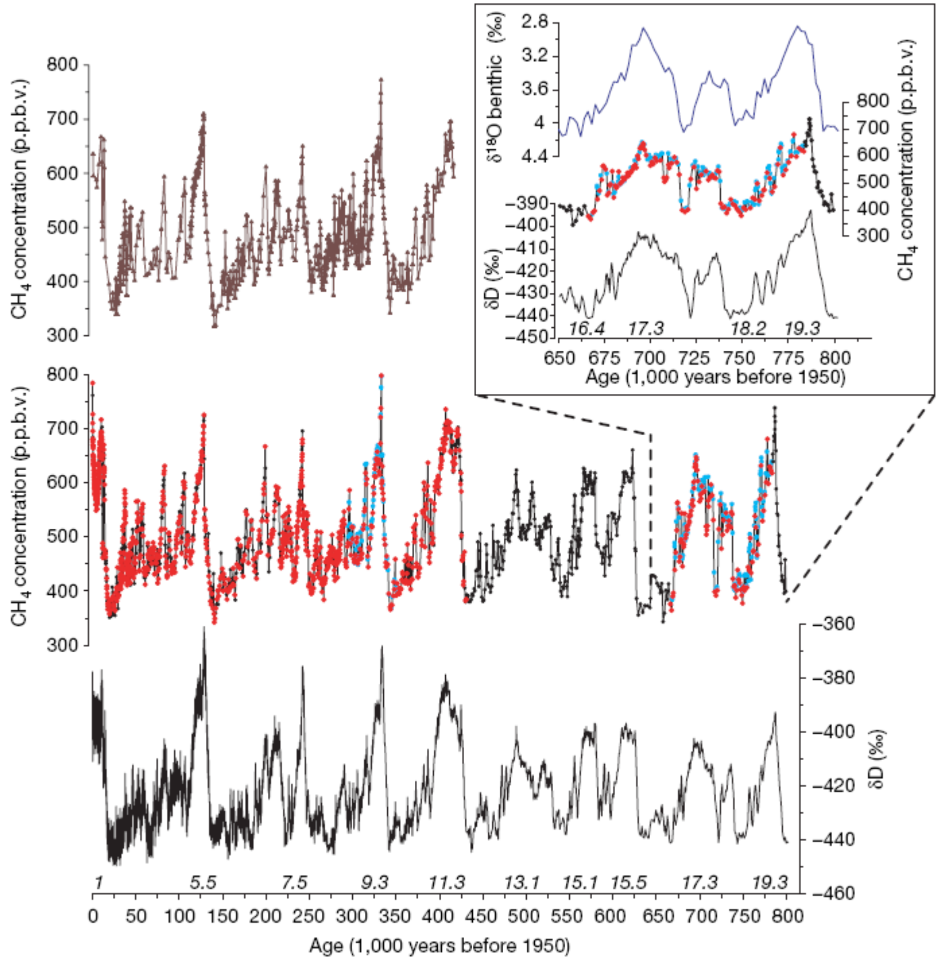
Methane records and EPICA/Dome C *and* D

Loulergue, L. et al. 2008. Orbital and millennial-scale features of atmo-spheric CH4 over the past 800,000[thinsp]years. Nature 453, 383-386.



They suggest that changes in the strength of tropical methane sources and sinks (wetlands, atmospheric oxidation), possibly influenced by changes in monsoon systems and the position of the intertropical convergence zone, controlled the atmospheric methane budget.

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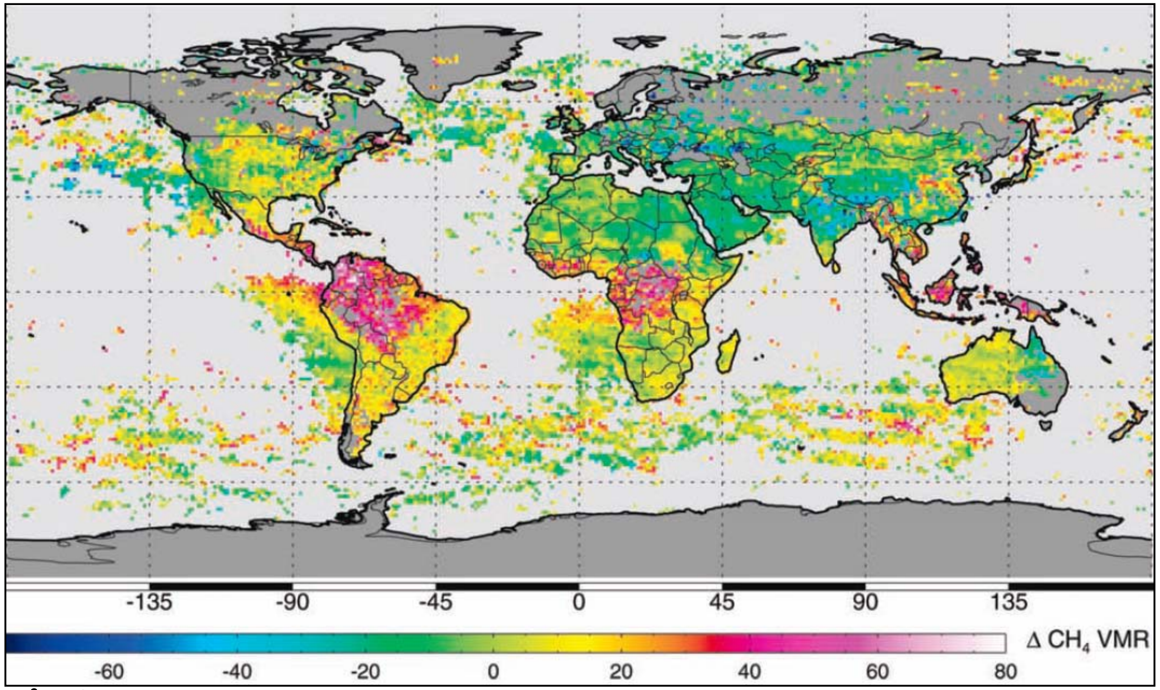
Satellite SCIAMACHY Retrieval of methane source and sinks



Frankenberg *et al.*, 2005 *Science*

An Amazon CH_4 Anomaly?

Excess ~26 Tg CH_4 y^{-1} over the Amazon in 1998-1999 according to Mikaloff-Fletcher et al. (2004)

Possible sources: Wetlands (Melack et al. 2004), Land Use Change (Steudler et al. 1996; Keller et al. 2005) or Upland Forest (Carmo et al. 2006)

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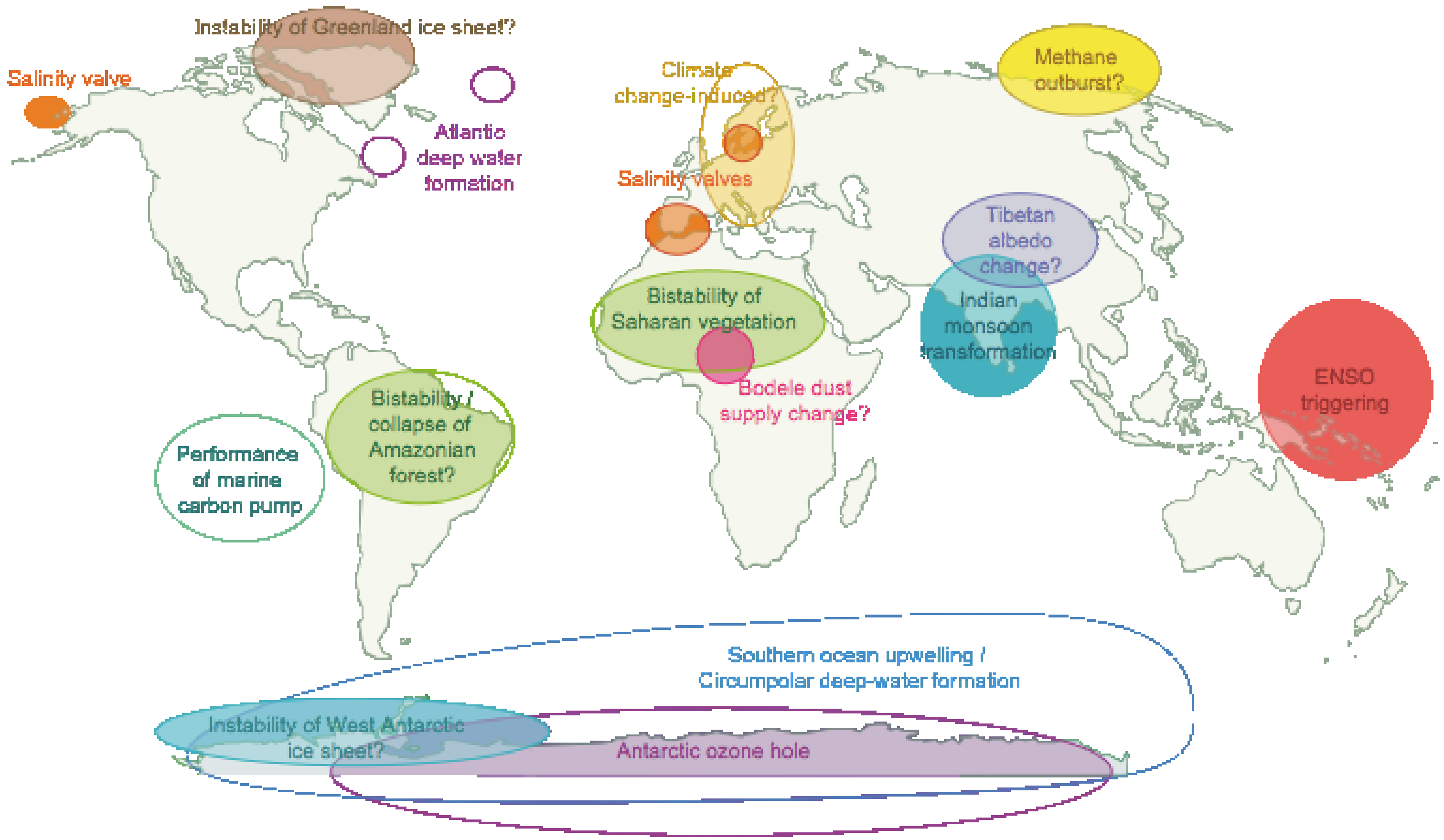
Switch and choke points



Lenton, T.M., Held, H., Kriegler, E., Hall, J.W., Lucht, W., Rahmstorf, S., Schellnhuber, H.J., 2008. Tipping elements in the Earth's climate system. PNAS 105, 1786-1793.