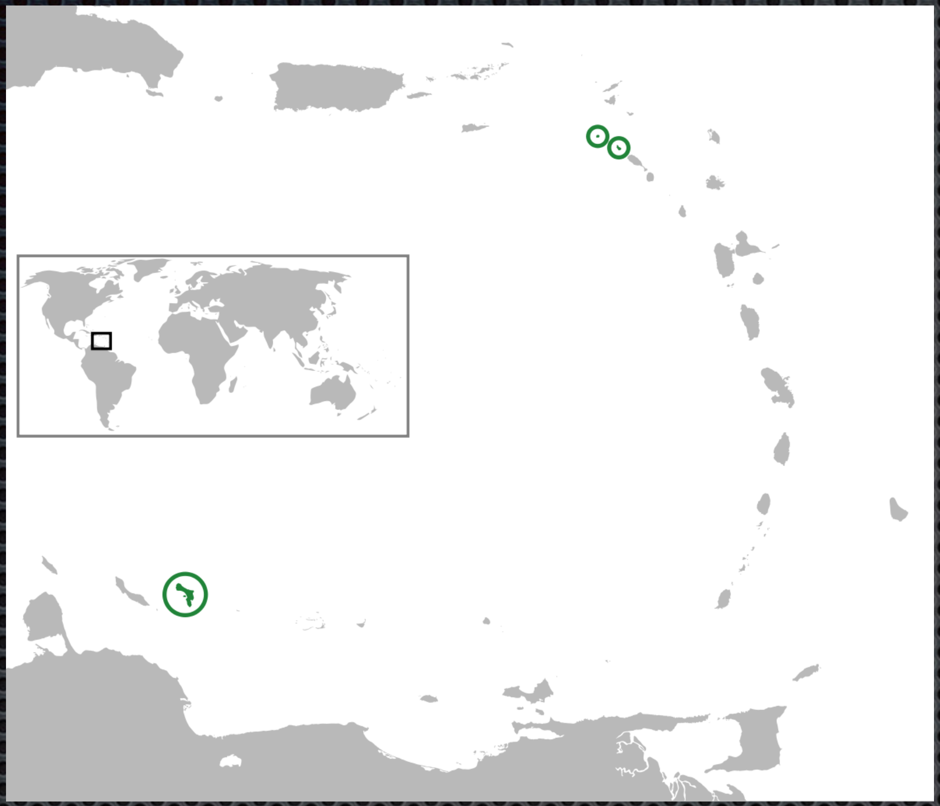
Modeling Present-Day and Future Caribbean Sea Level Changes

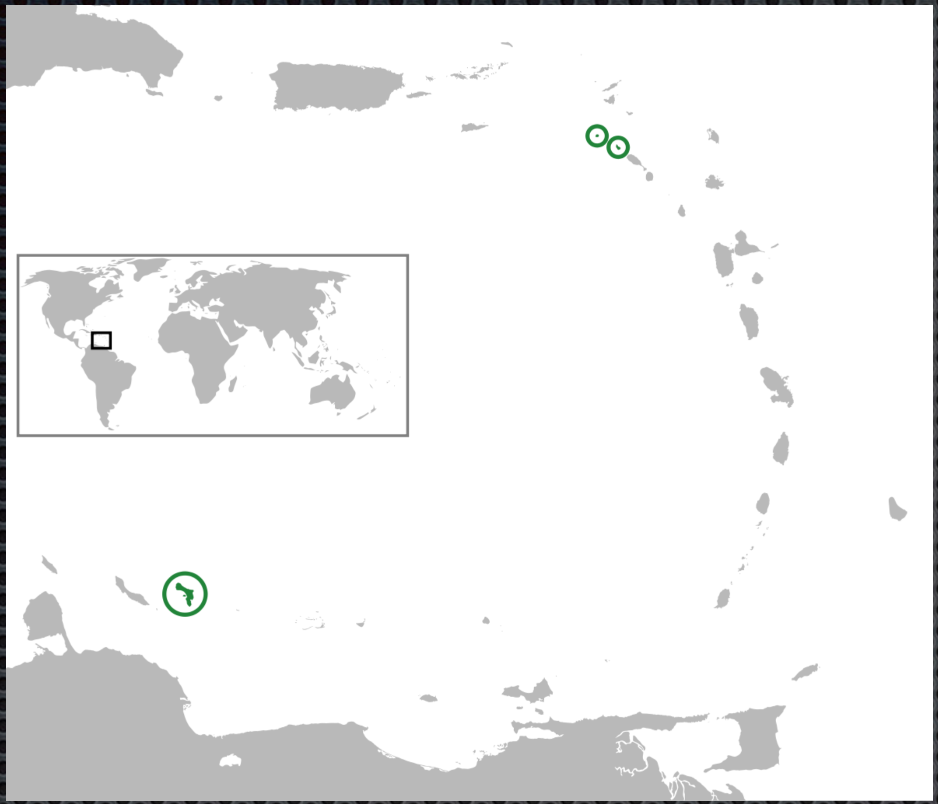


Sandra Brunnabend and Henk Dijkstra
IMAU, Department of Physics and Astronomy,
Utrecht University, The Netherlands

IMAU
Institute for Marine and Atmospheric research Utrecht

Universiteit Utrecht

Modeling Present-Day and Future Caribbean Sea Level Changes



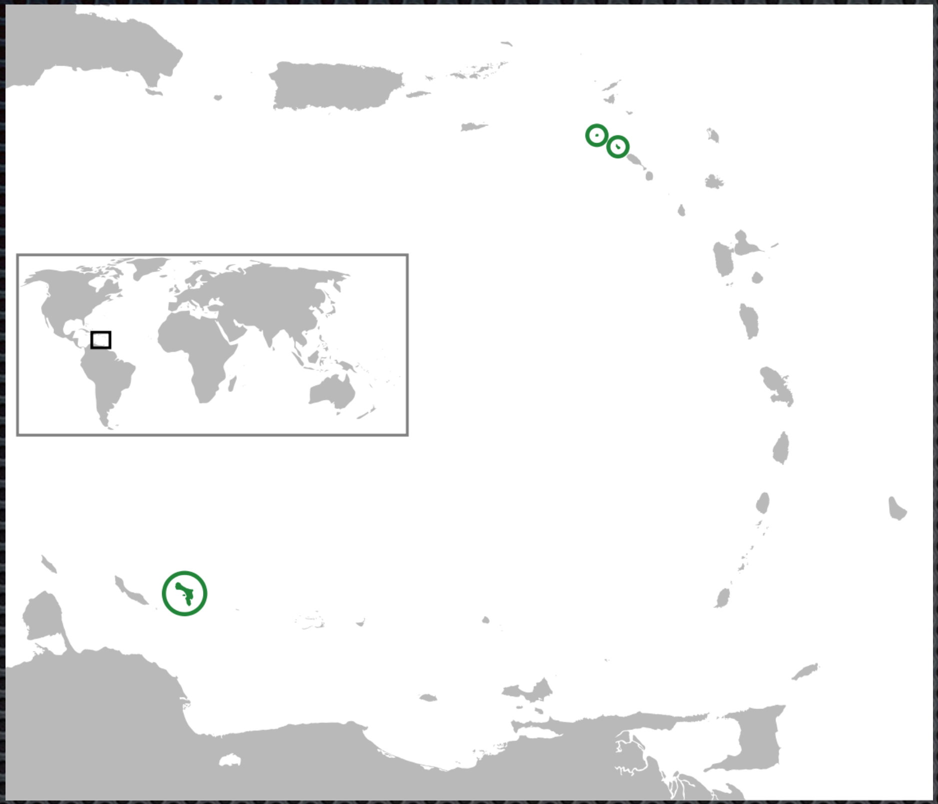
Caribbean Netherlands:

Sandra Brunnabend and Henk Dijkstra
IMAU, Department of Physics and Astronomy,
Utrecht University, The Netherlands

IMAU
Institute for Marine and Atmospheric research Utrecht

Universiteit Utrecht

Modeling Present-Day and Future Caribbean Sea Level Changes



Caribbean Netherlands:

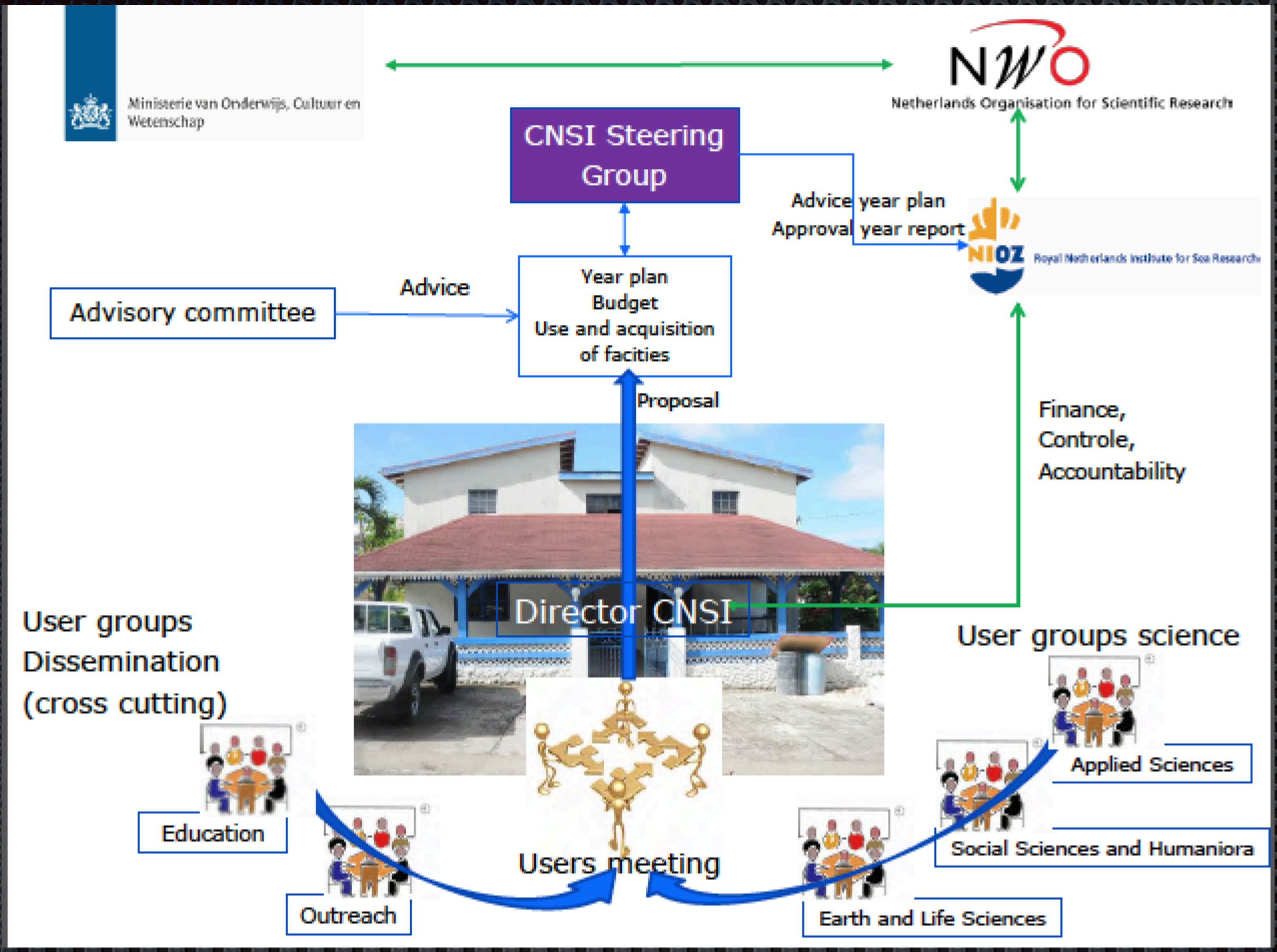
Bonaire
St. Eustatius
Saba

Sandra Brunnabend and Henk Dijkstra
IMAU, Department of Physics and Astronomy, Utrecht University, The Netherlands

IMAU Institute for Marine and Atmospheric research Utrecht

Universiteit Utrecht

Caribbean Netherlands Science Institute
St. Eustatius

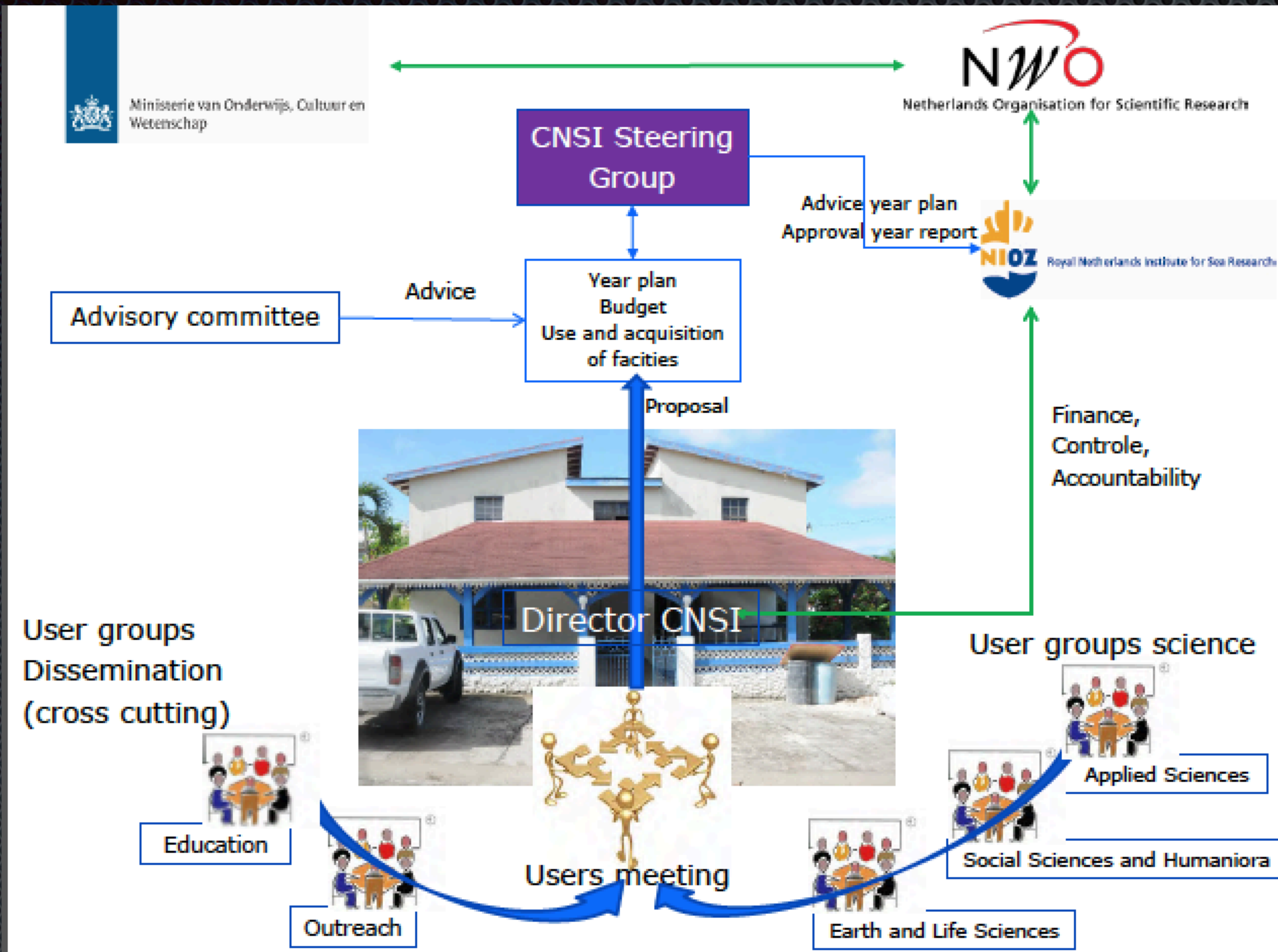


CARIBBEAN NETHERLANDS SCIENCE INSTITUTE

To strengthen the cooperation between Caribbean and European Netherlands, involving local, regional and international partners and knowledge networks focussed on the region.

Opening: April 24-25, 2014

Caribbean Netherlands Science Institute
St. Eustatius

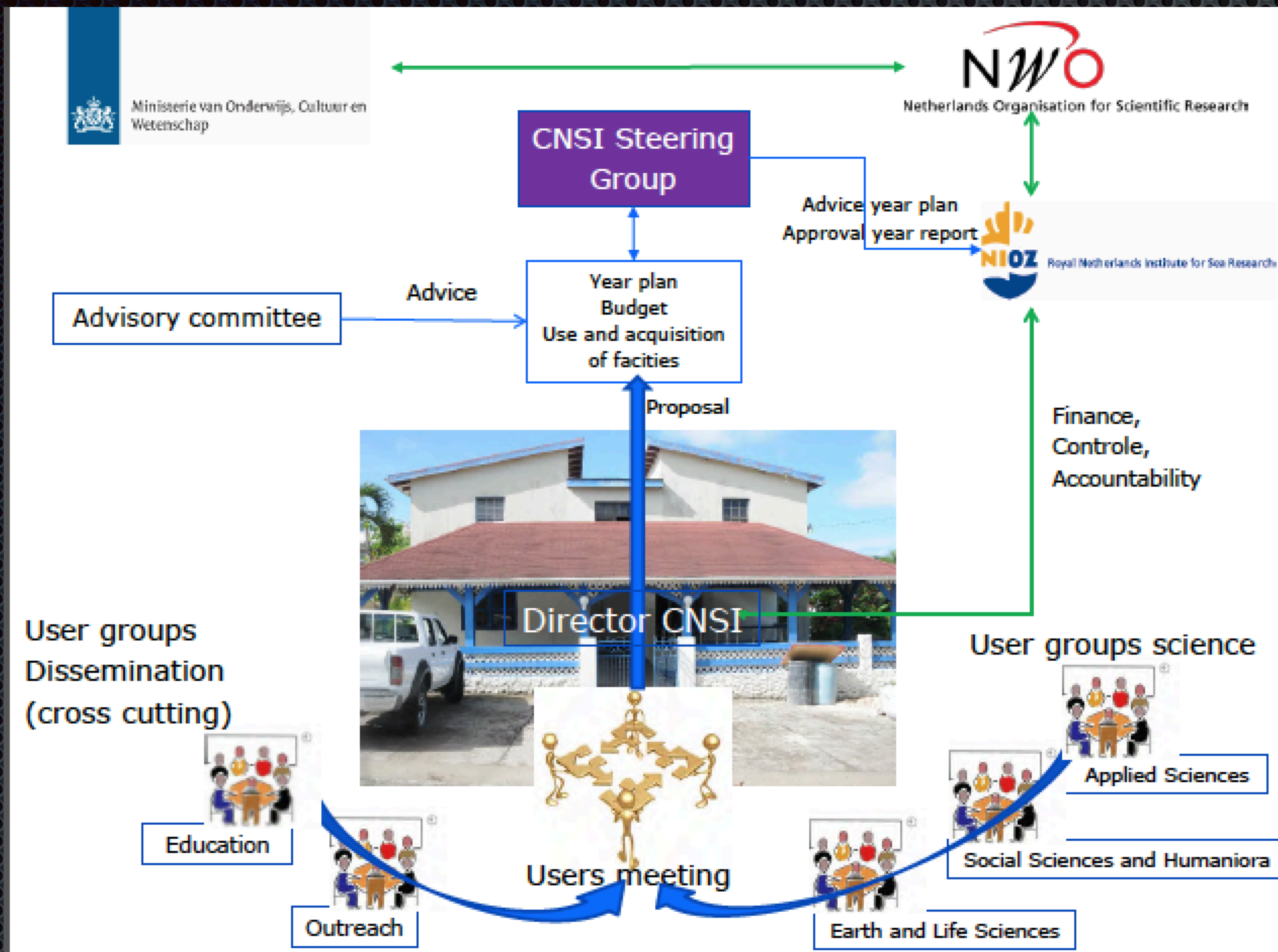


CNSI
CARIBBEAN NETHERLANDS SCIENCE INSTITUTE

To strengthen the cooperation between Caribbean and European Netherlands, involving local, regional and international partners and knowledge networks focussed on the region.

Opening: April 24-25, 2014

Caribbean Netherlands Science Institute St. Eustatius



CARIBBEAN NETHERLANDS SCIENCE INSTITUTE

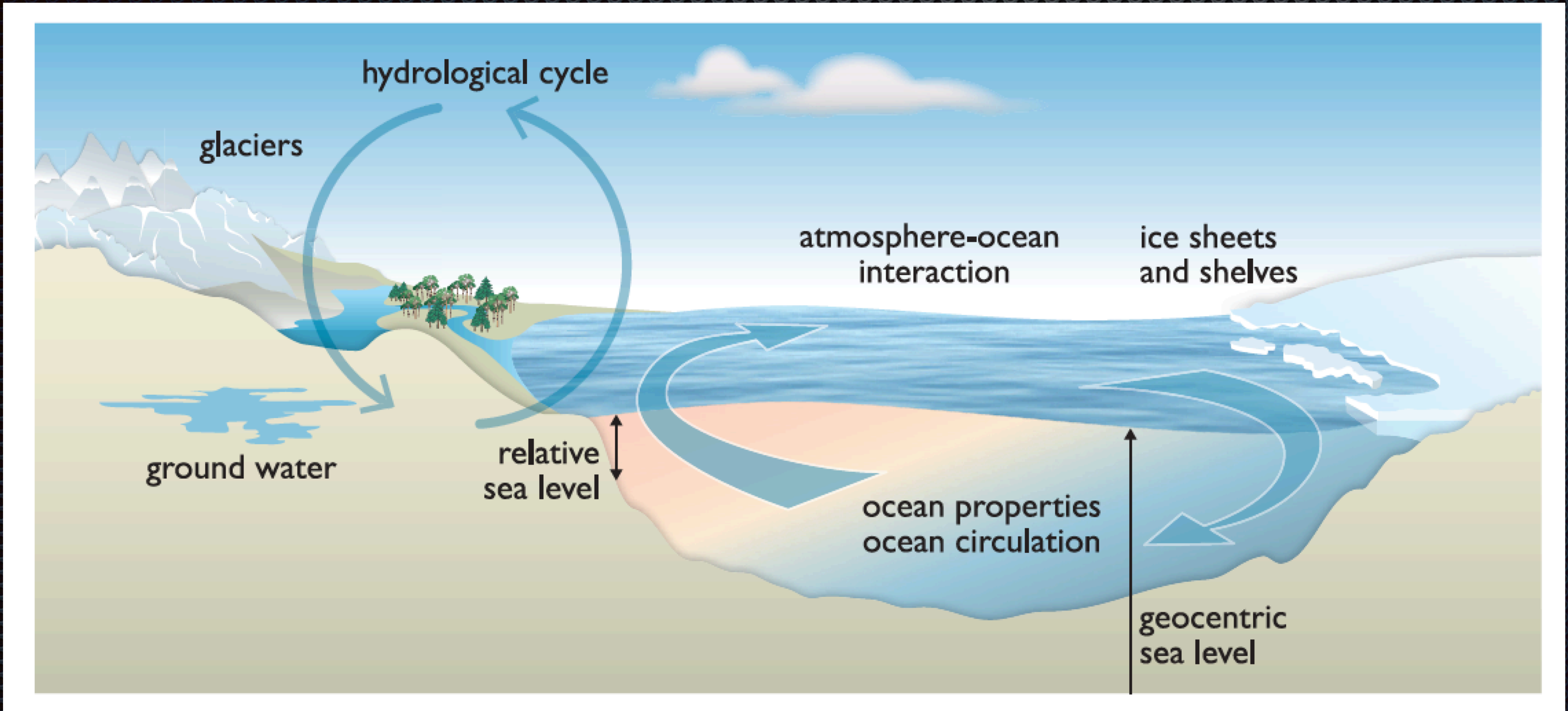
Director: J. Stapel

To strengthen the cooperation between Caribbean and European Netherlands, involving local, regional and international partners and knowledge networks focussed on the region.

Opening: April 24-25, 2014

Live with water, don't fight it !

Processes involved in sea level changes



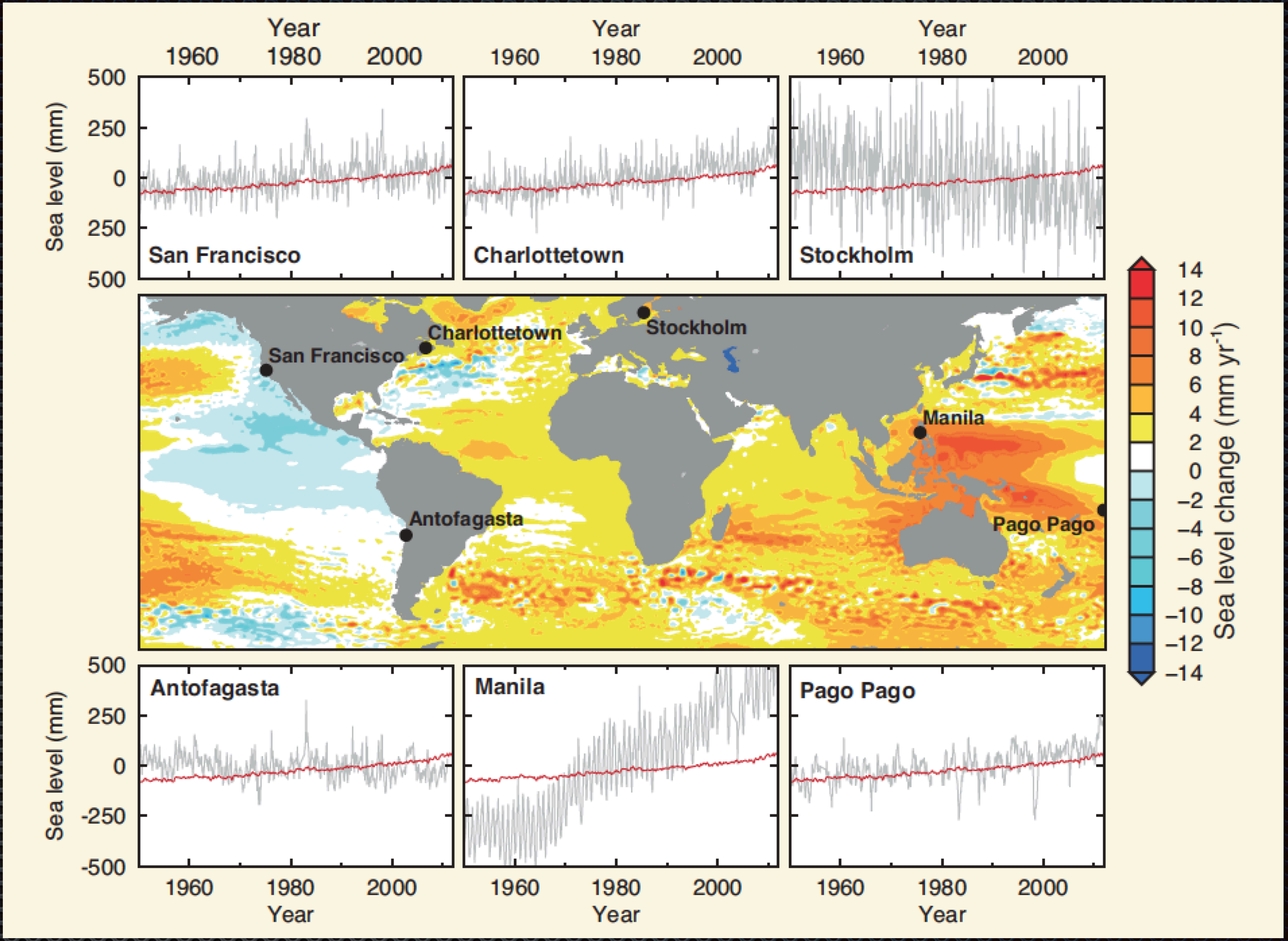
IPCC-AR5
Chapter 13

Ocean: - thermal expansion (steric)
- circulation

Sea level change

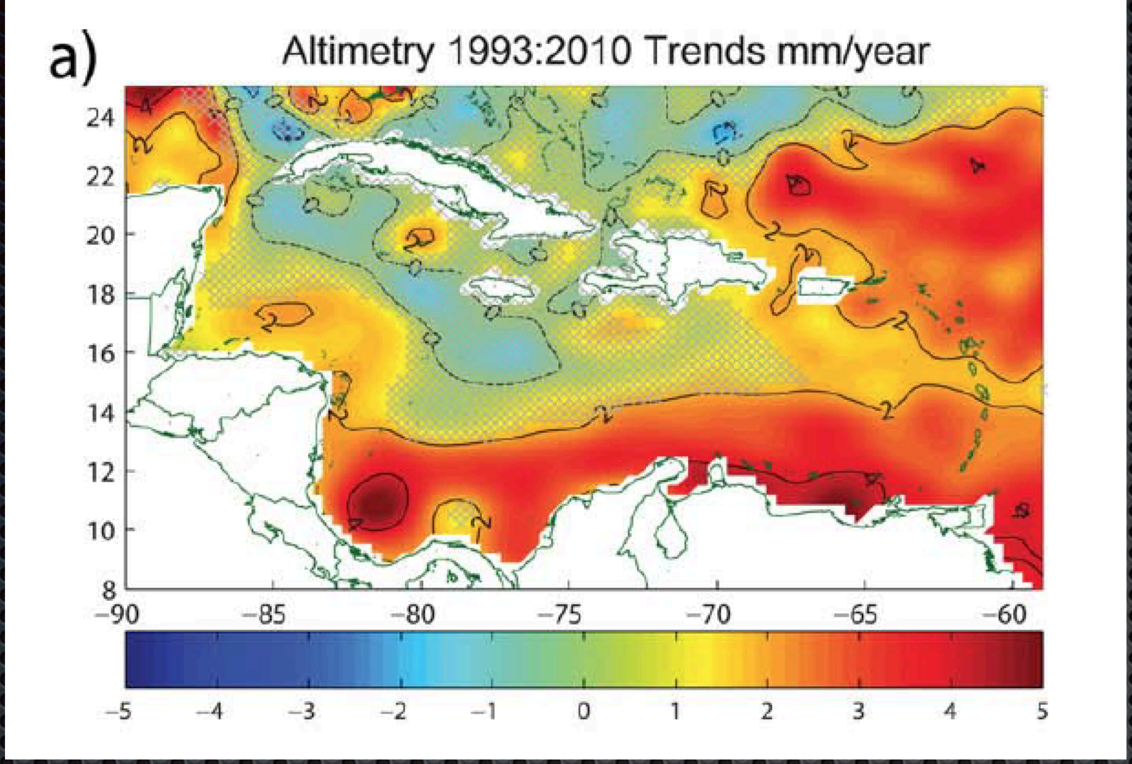
IPCC-AR5
Chapter 13

1993-2012



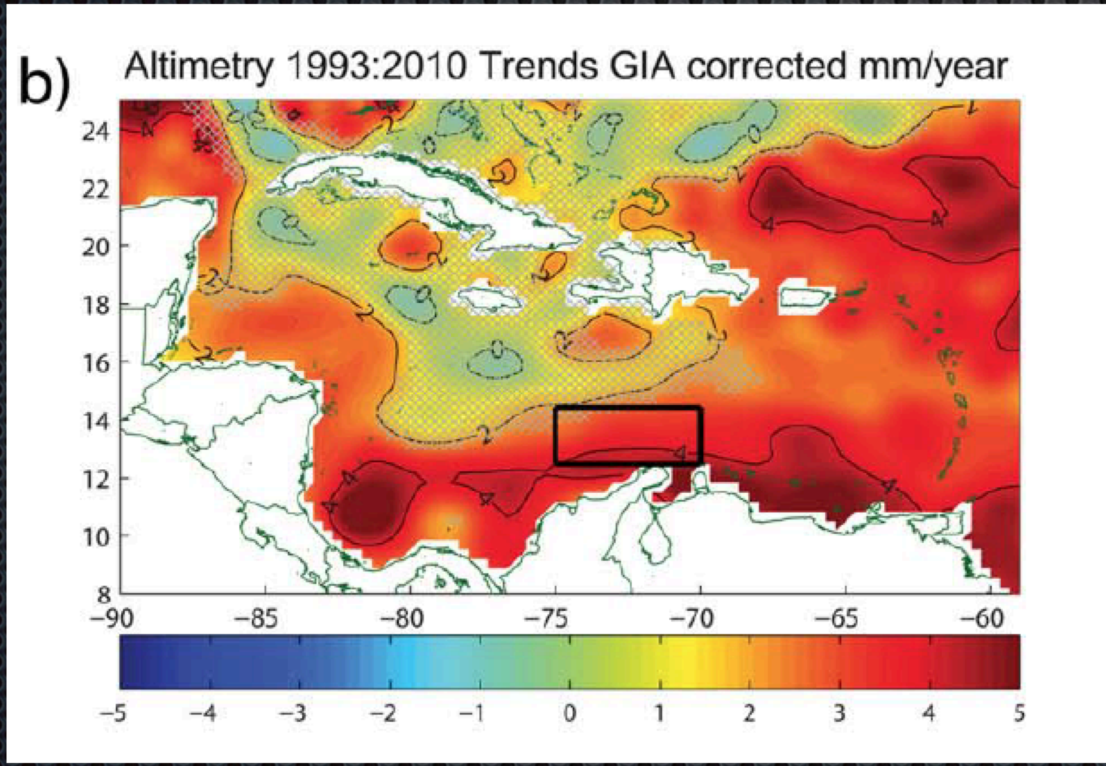
Regional sea level changes can be very different from the global mean change

Caribbean sea level changes

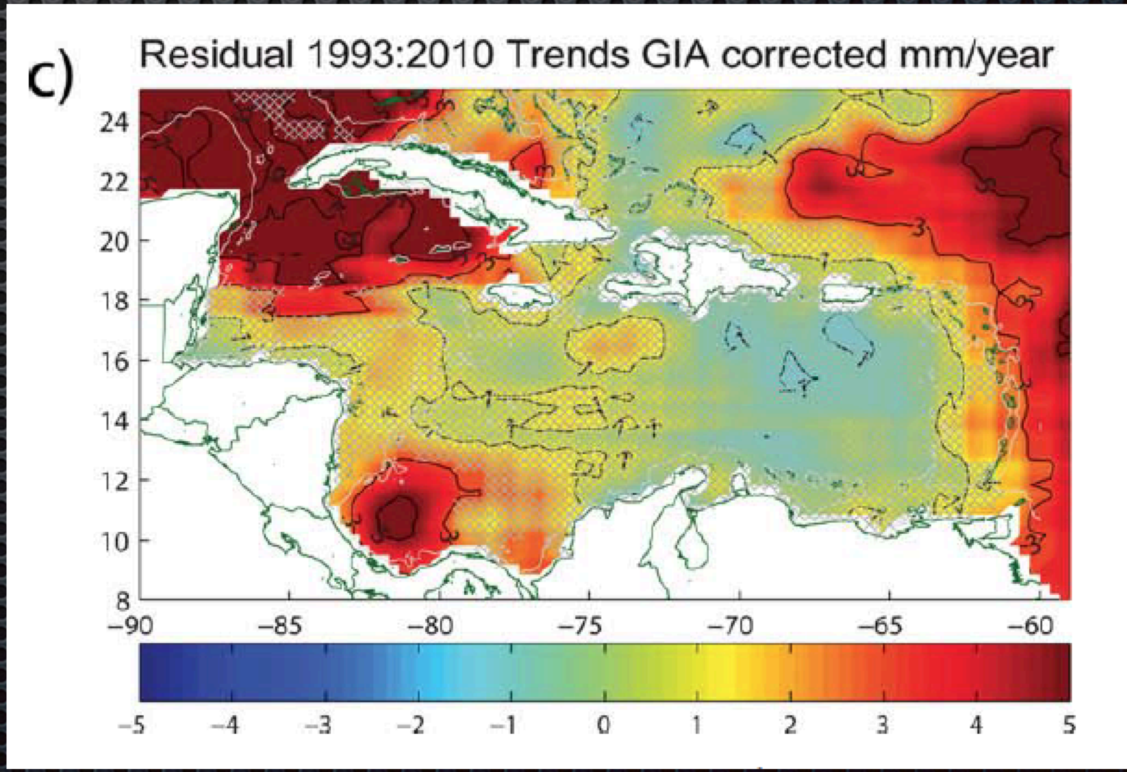


average:
1.7 ± 1.3 mm/yr

corrected for GIA



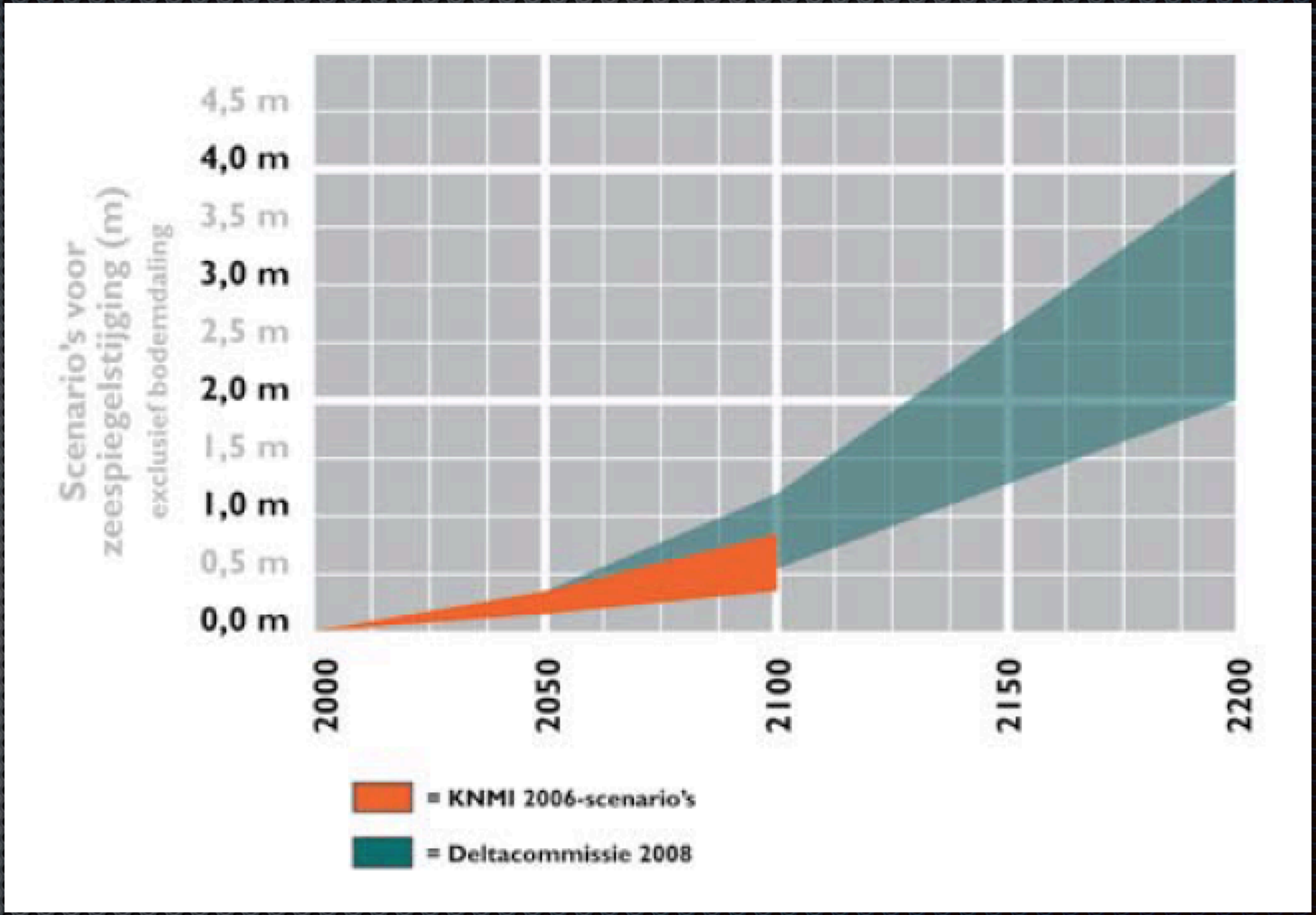
deviation from steric changes



Torres and Tsimplis, JGR, (2013)

Scenario for sea level increase at the Dutch Coast

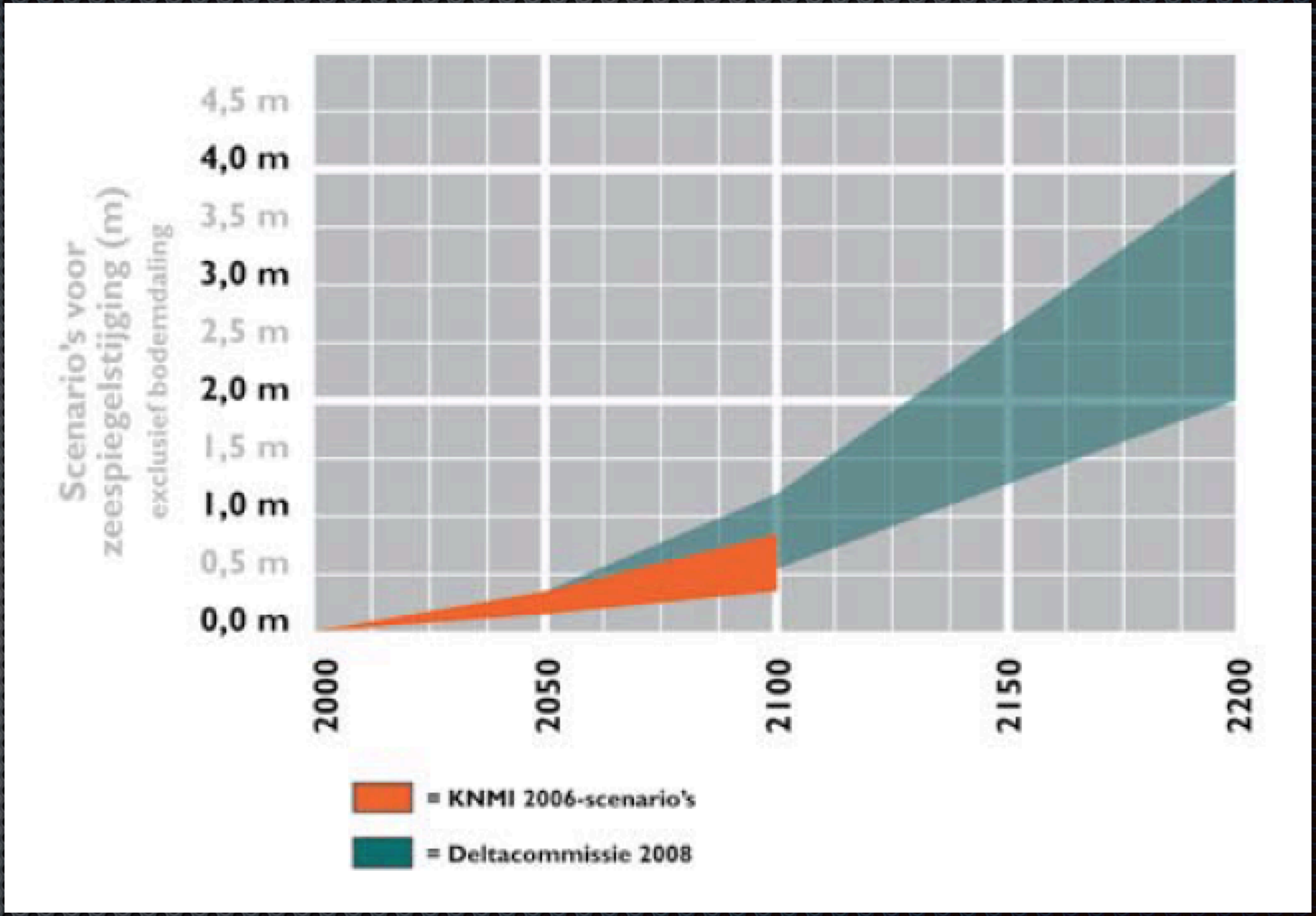
Sea level change (m)



Report
Delta committee, 2008

Scenario for sea level increase at the Dutch Coast

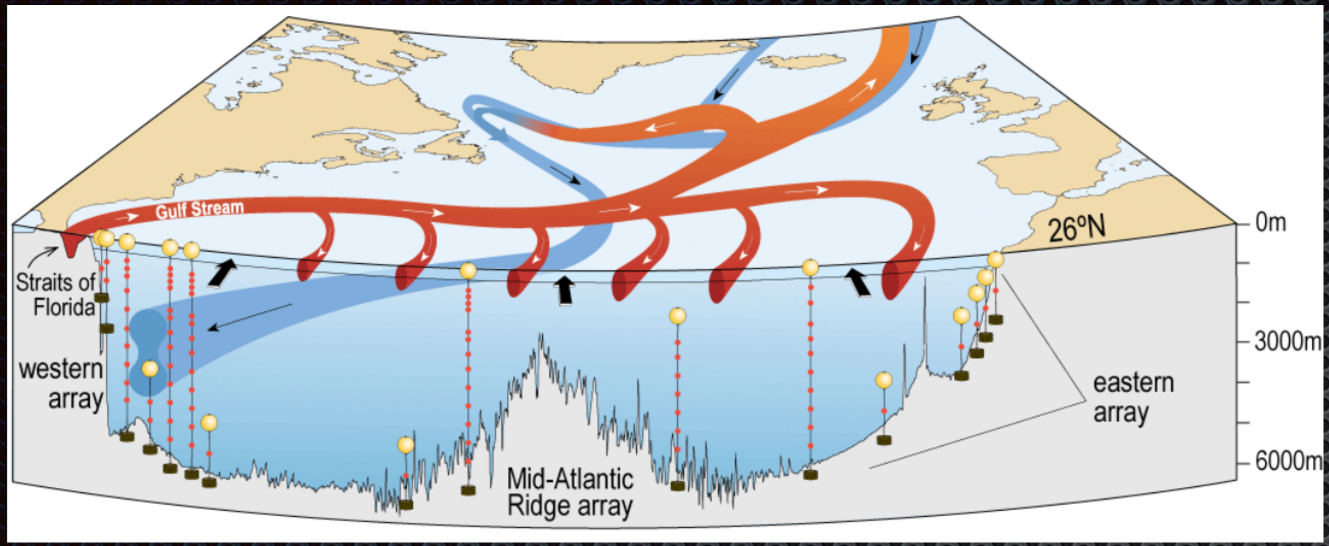
Sea level change (m)



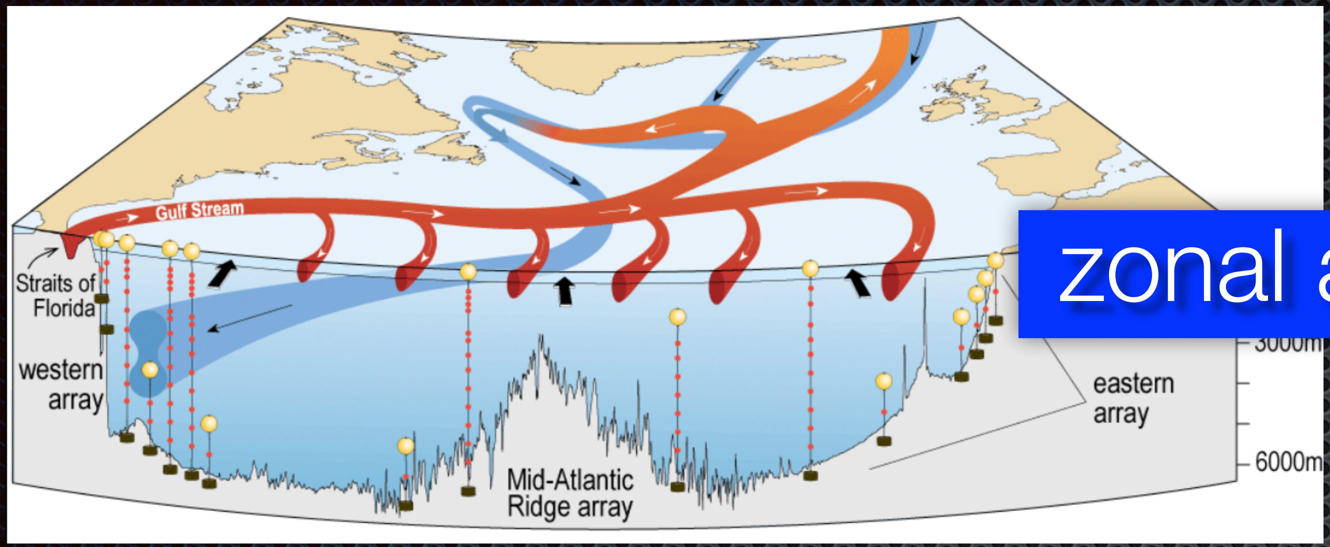
Report
Delta committee, 2008

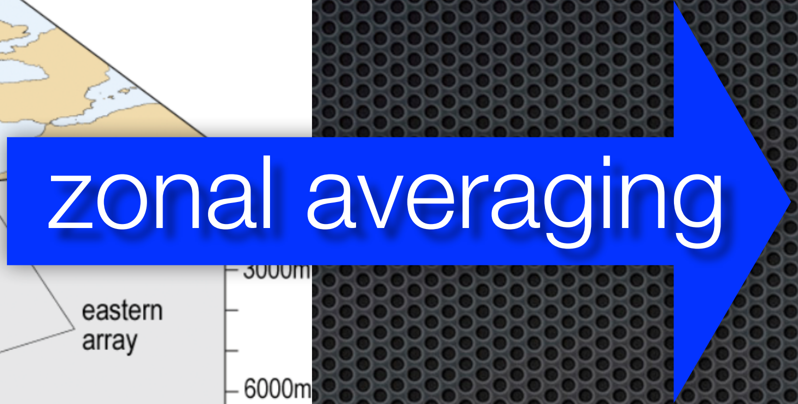
Extreme case:
large ocean circulation changes

Meridional Overturning Circulation (MOC)

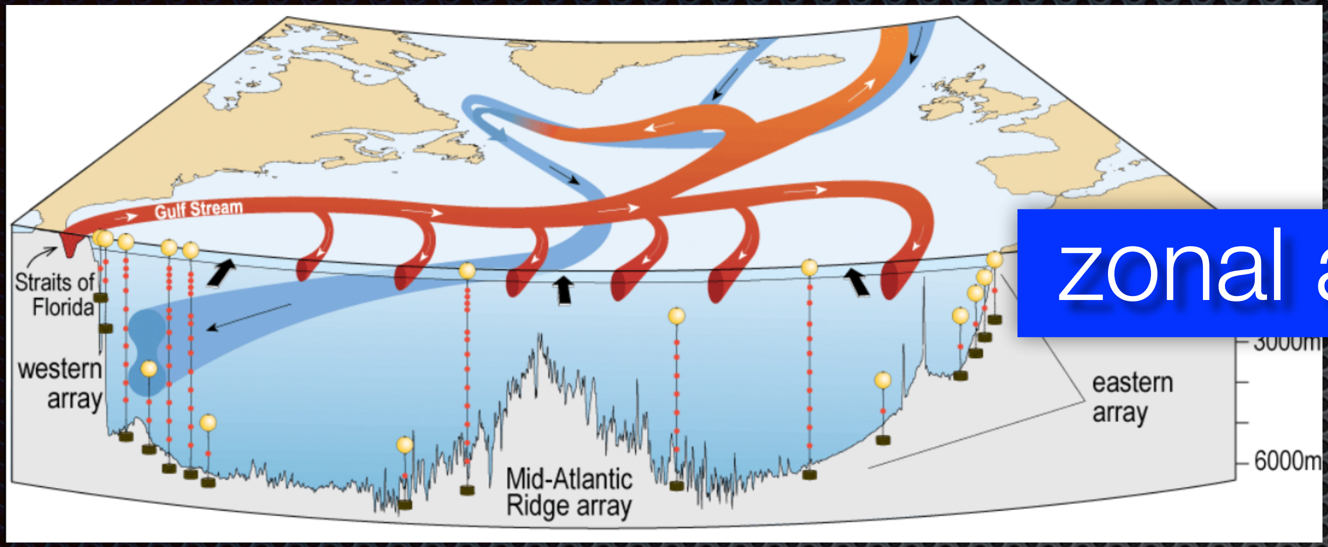


Meridional Overturning Circulation (MOC)



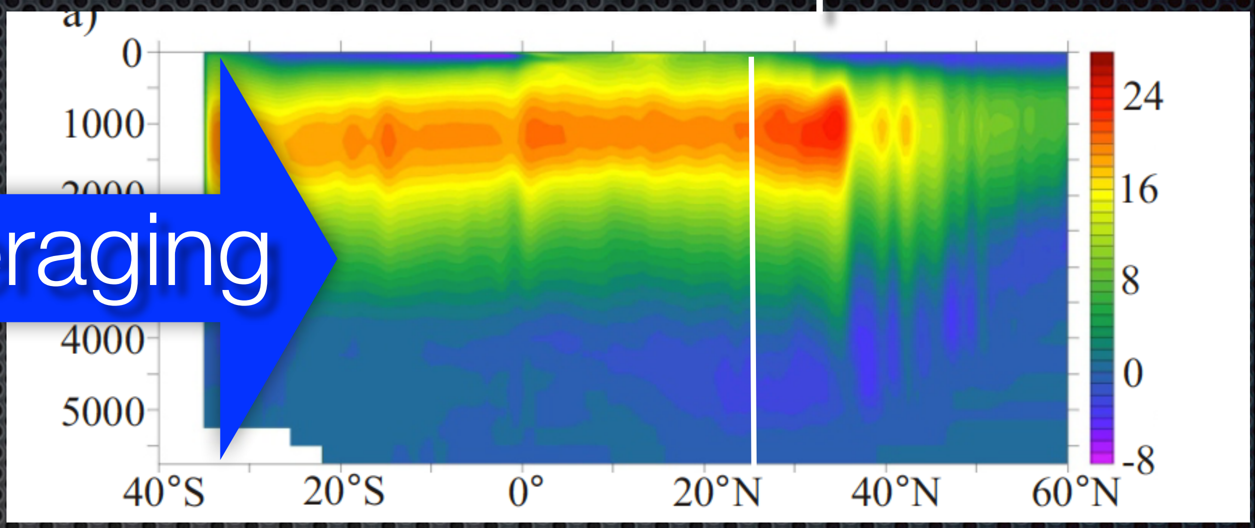


Meridional Overturning Circulation (MOC)



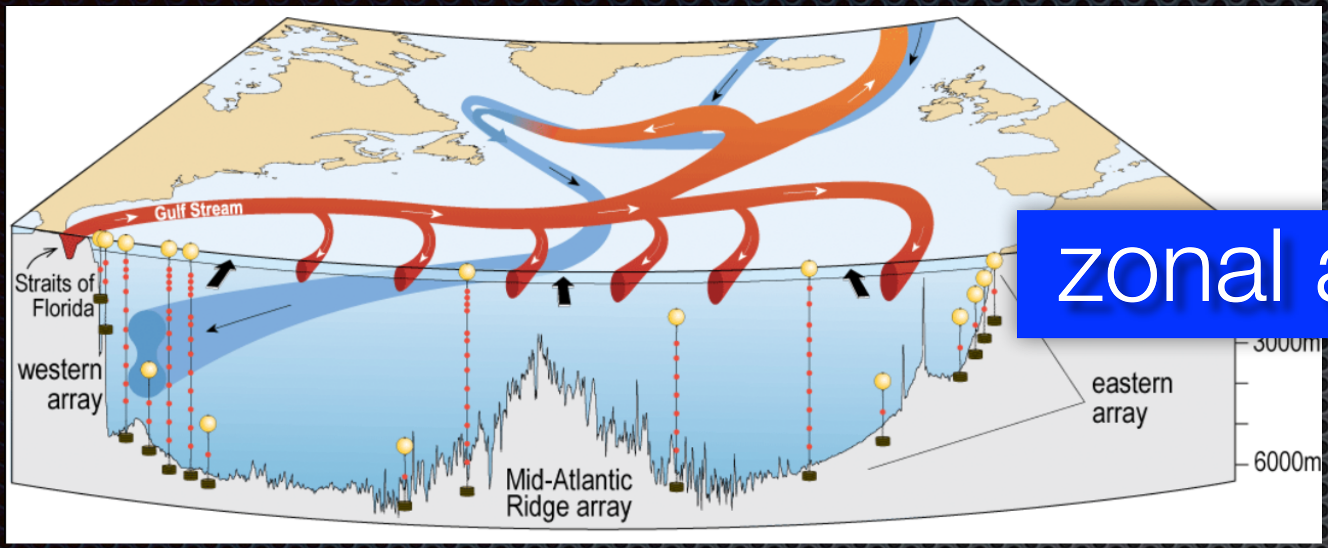
zonal averaging

volume transport



latitude

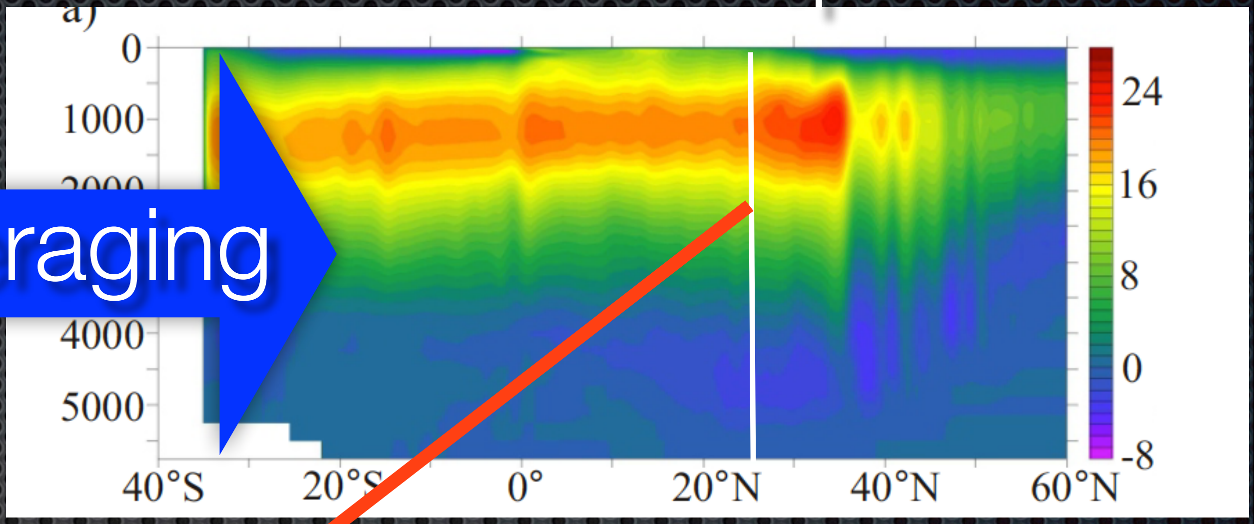
Meridional Overturning Circulation (MOC)



zonal averaging

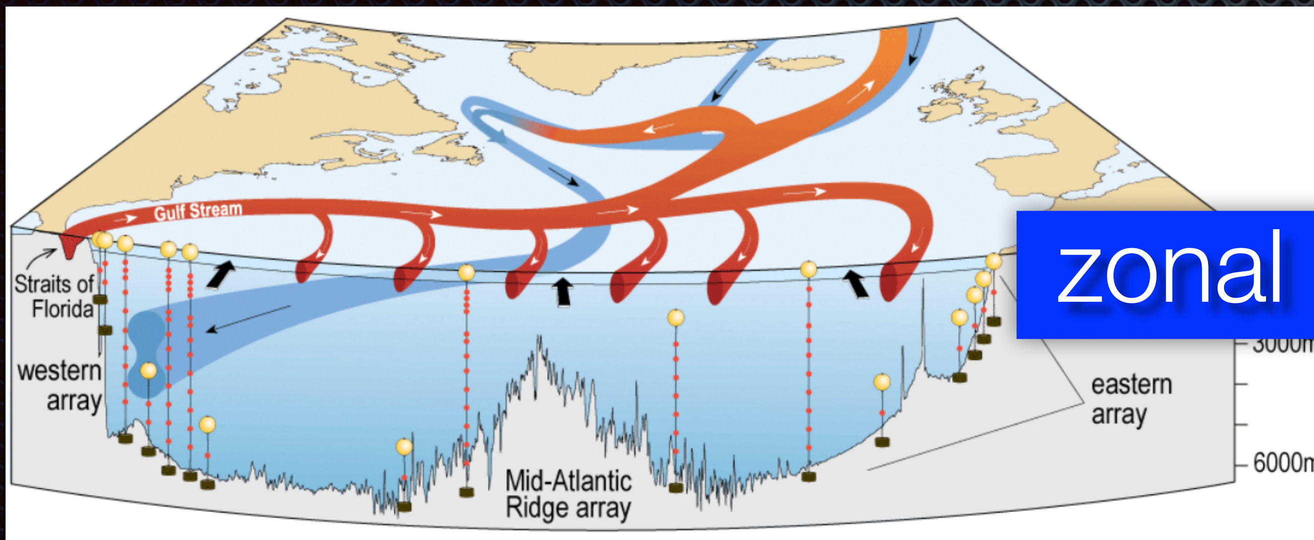
volume transport

depth



latitude

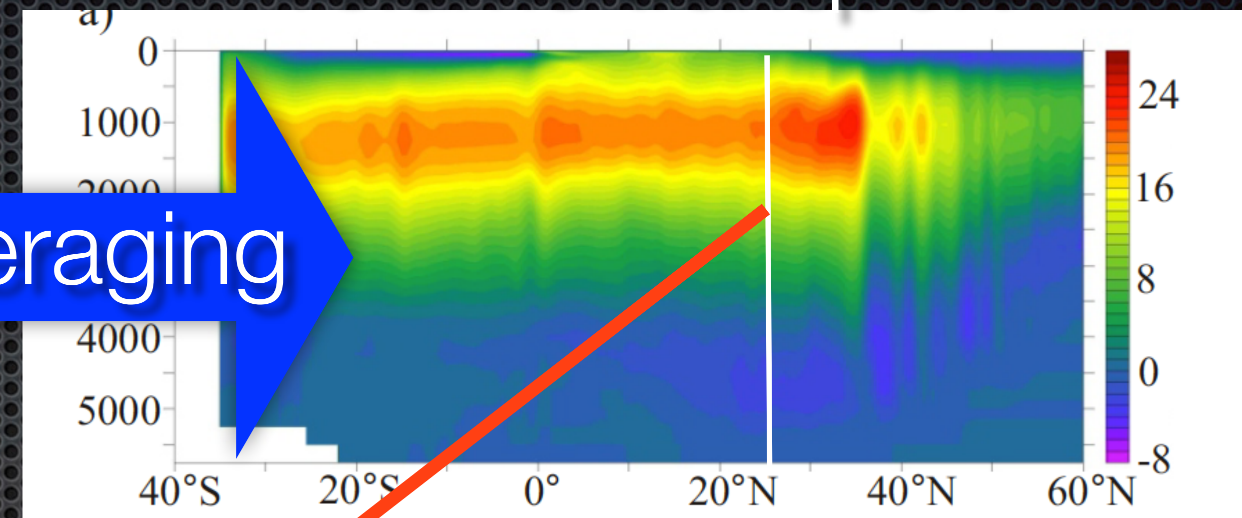
Meridional Overturning Circulation (MOC)



zonal averaging

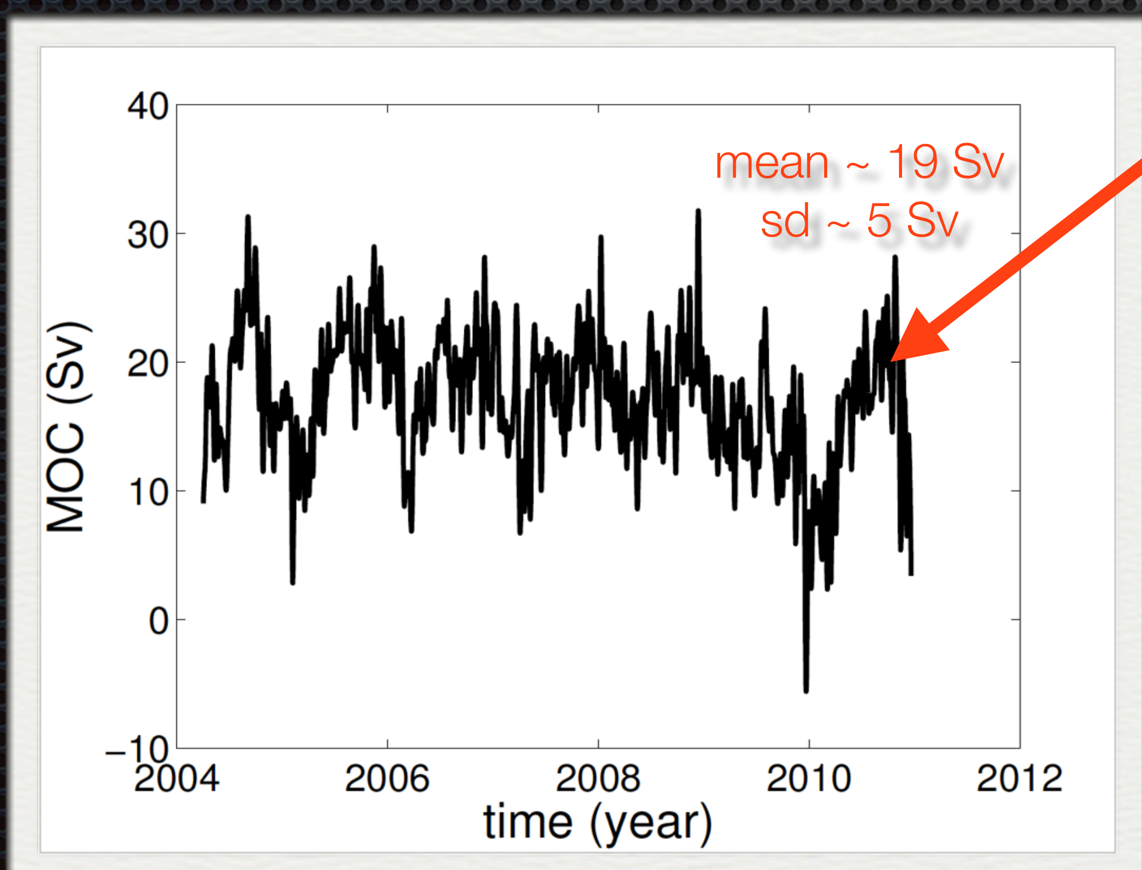
volume transport

depth



latitude

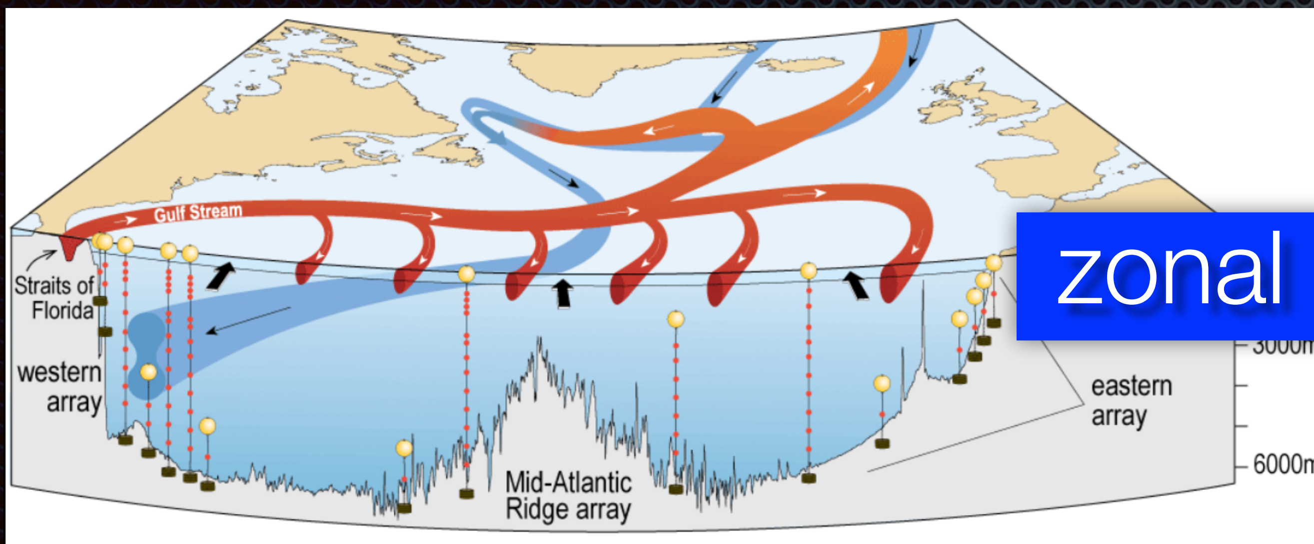
$$1\ Sv = 10^6 \quad m^3 s^{-1}$$



Volume transport Amazon river: 0.1 Sv

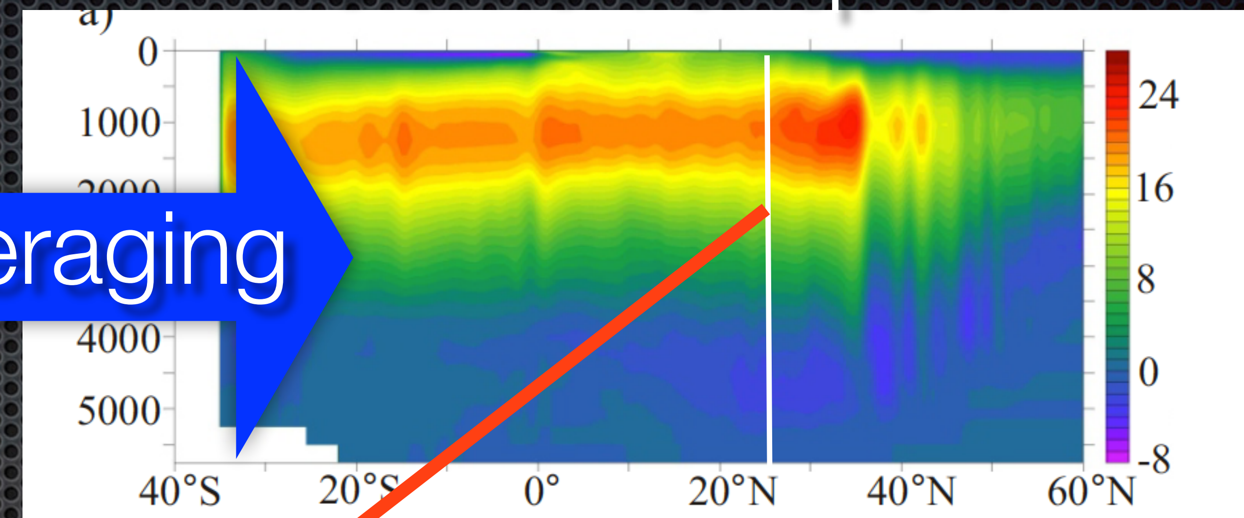
Meridional Overturning Circulation (MOC)

volume transport



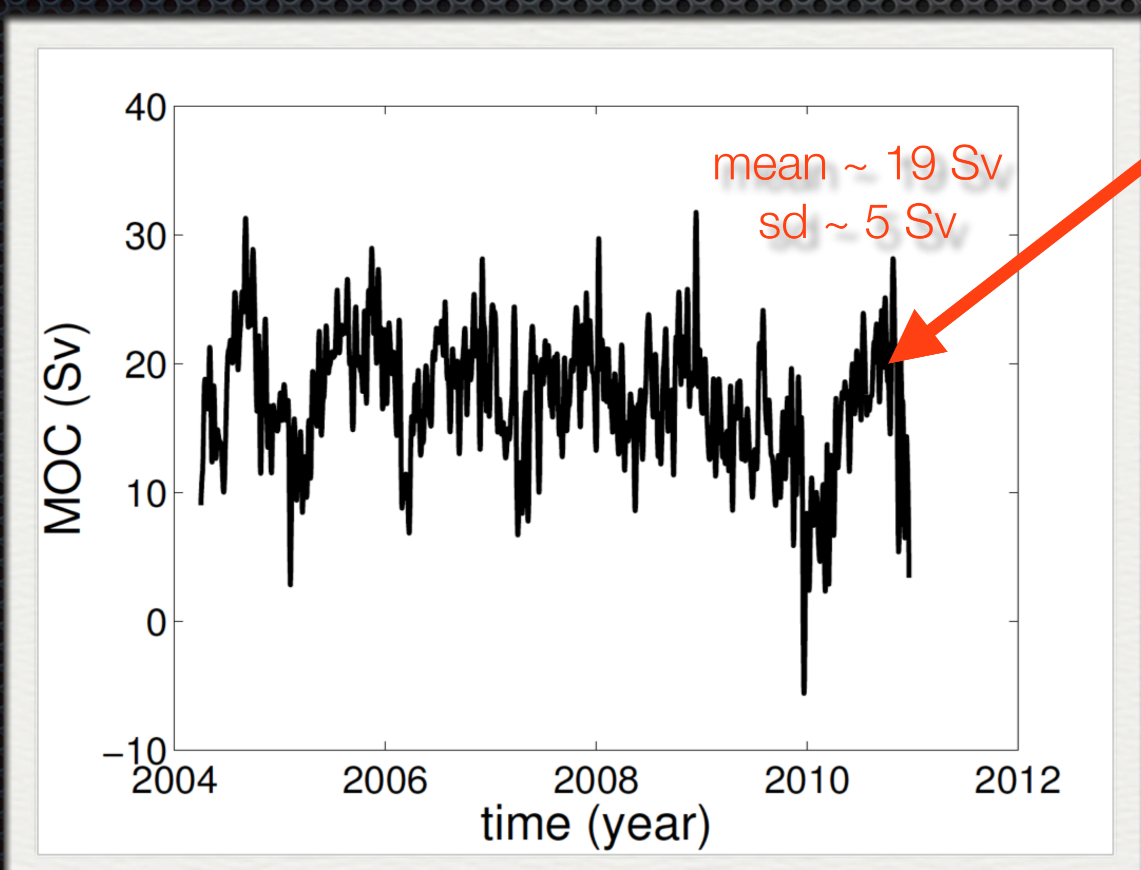
zonal averaging

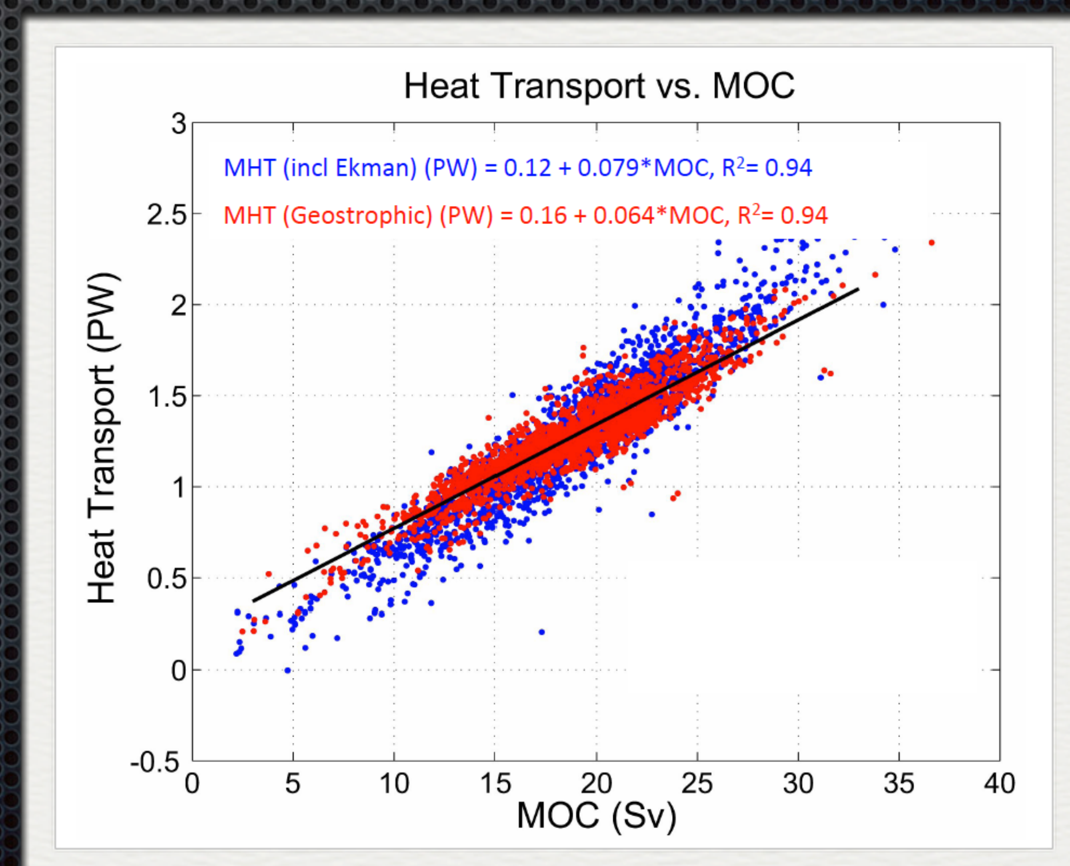
depth



latitude

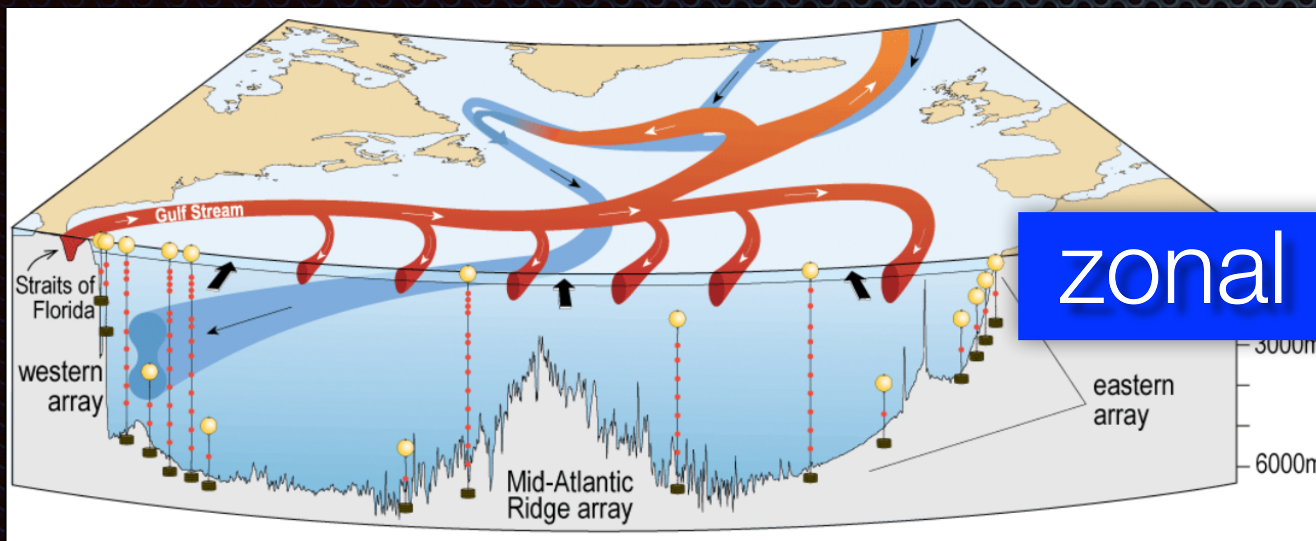
$$1\ Sv = 10^6\ \ m^3 s^{-1}$$





Volume transport Amazon river: 0.1 Sv

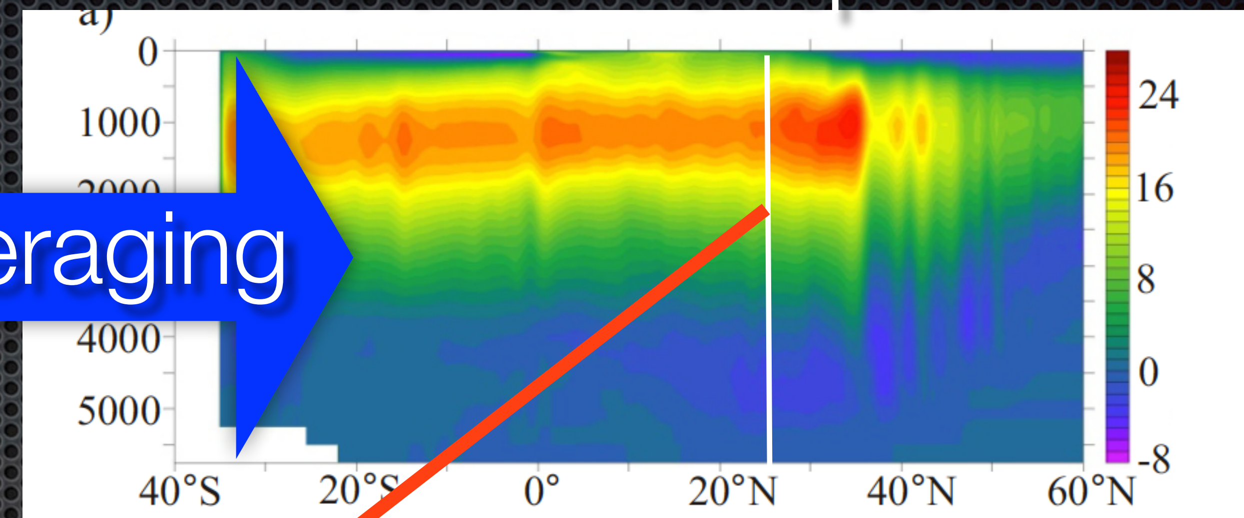
Meridional Overturning Circulation (MOC)



zonal averaging

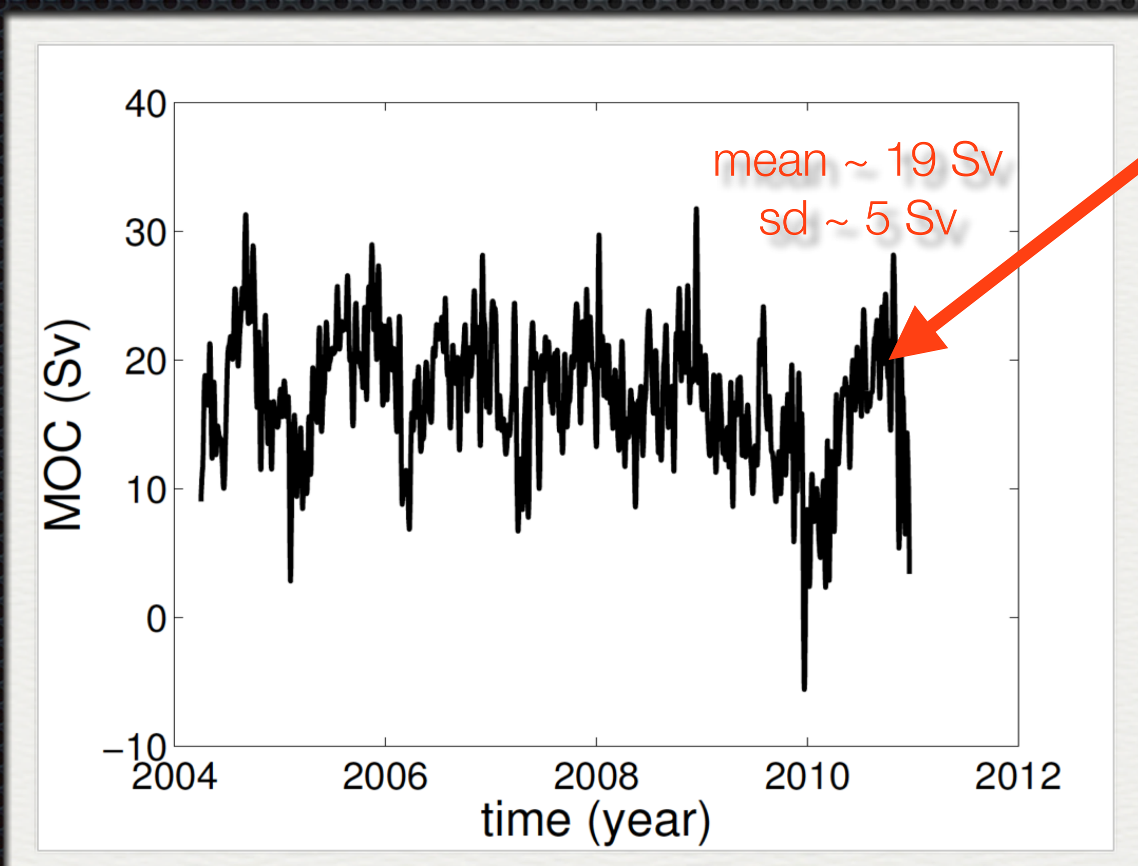
volume transport

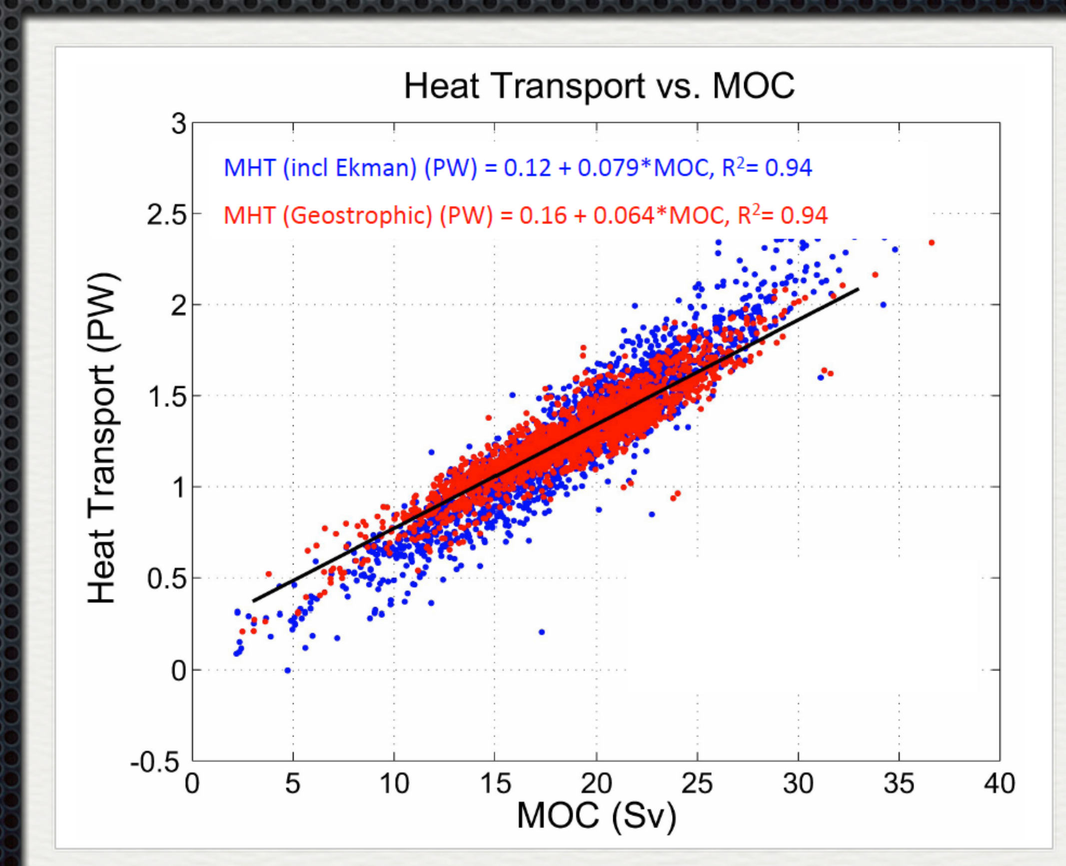
depth



latitude

$$1\ Sv = 10^6\ \ m^3 s^{-1}$$





Volume transport Amazon river: 0.1 Sv

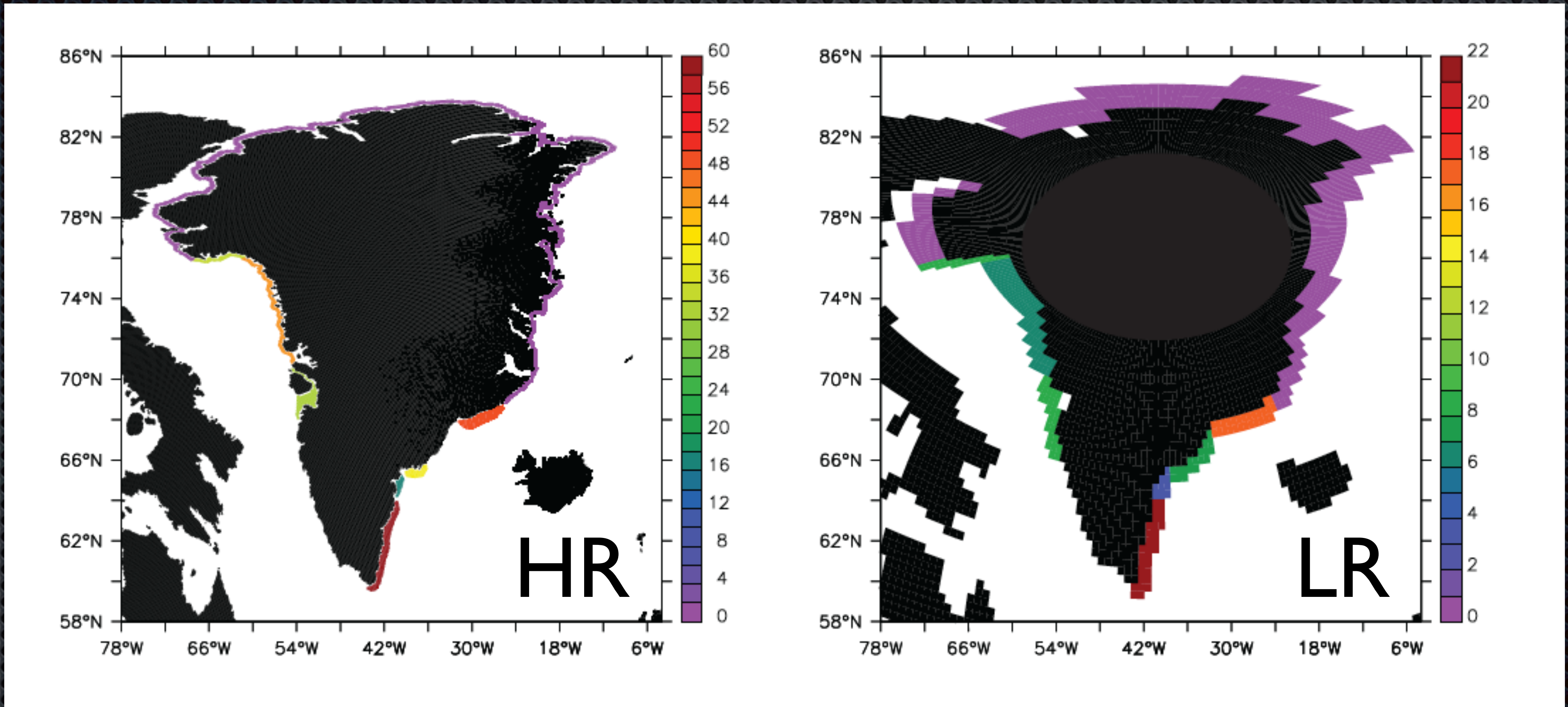
Cunningham et al. (2007)

An extreme scenario: changes in the MOC

Global Ocean Model (POP)

HR : horizontal 0.1 degree; vertical 42 levels

LR : horizontal 1.0 degree; vertical 42 levels

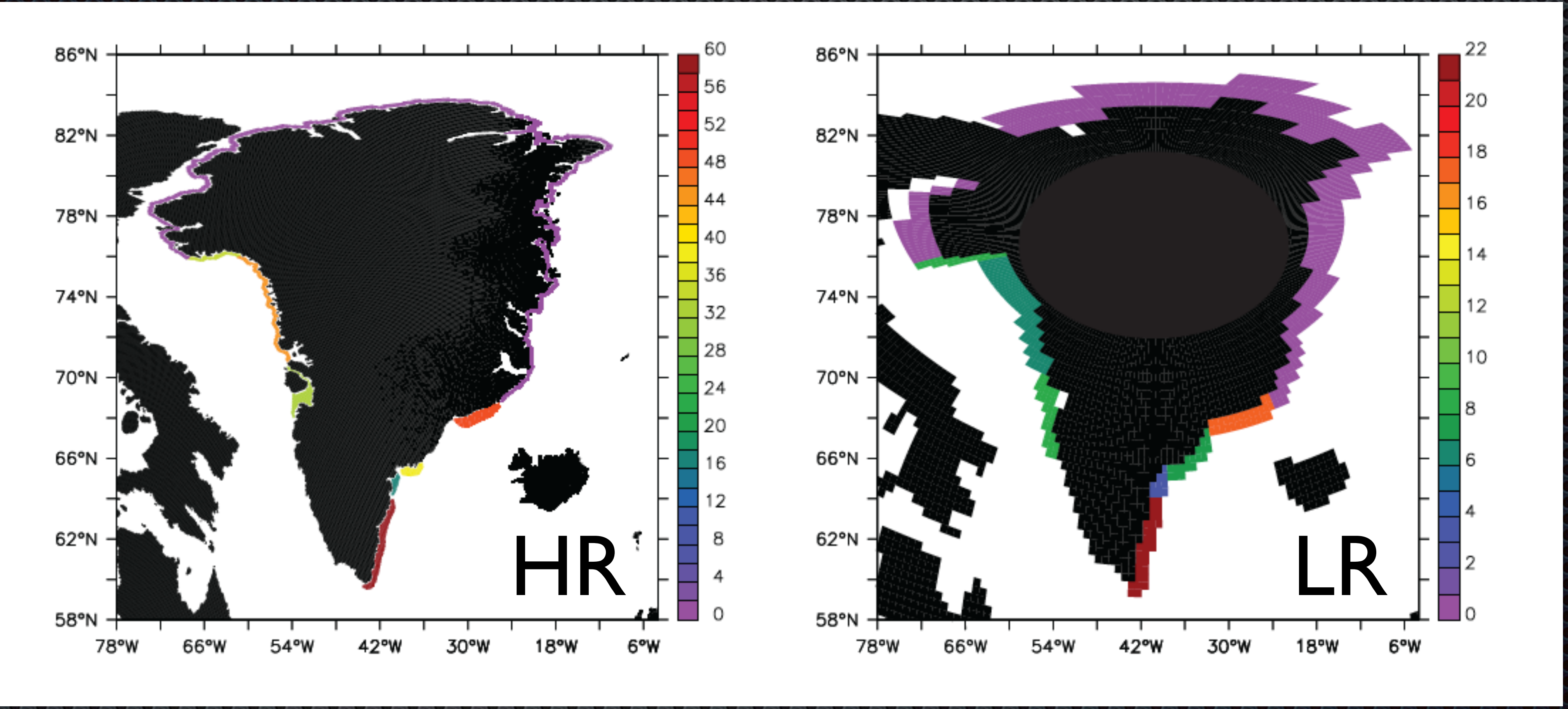


POP: freshwater flux (m/yr), integrated 0.0, 0.1 and 0.5 Sv

Current estimate: ~ 0.01 Sv

An extreme scenario: changes in the MOC

Global Ocean Model (POP)
HR : horizontal 0.1 degree; vertical 42 levels
LR : horizontal 1.0 degree; vertical 42 levels

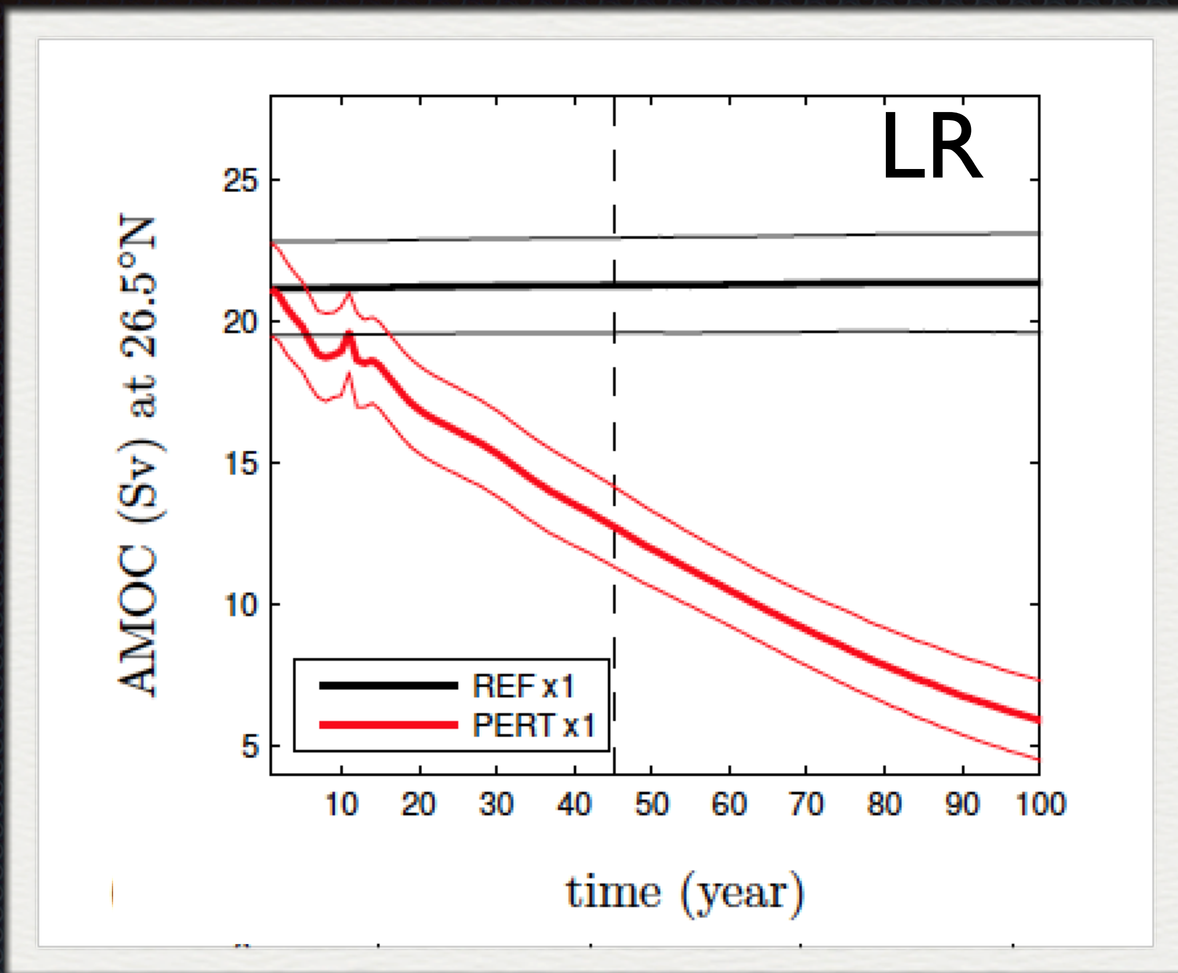


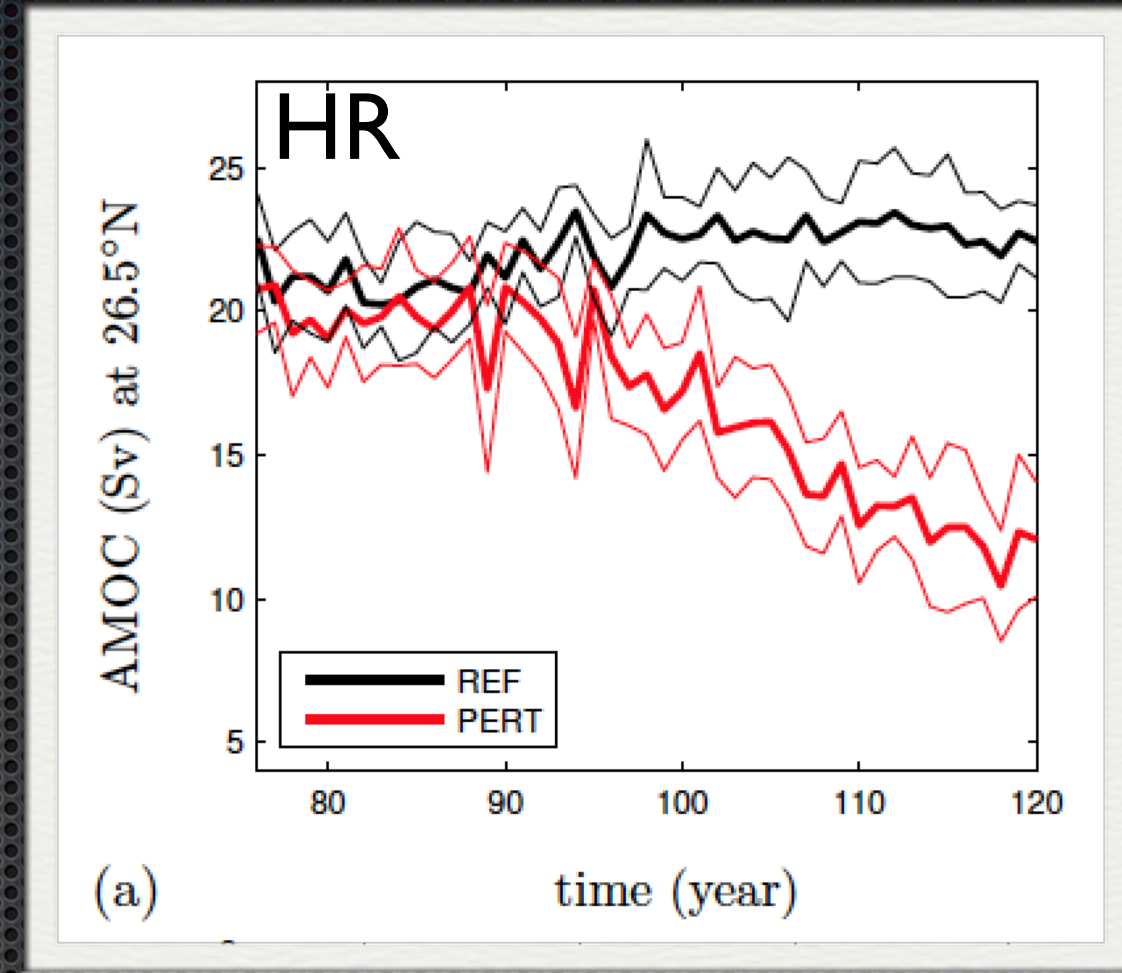
POP: freshwater flux (m/yr), integrated 0.0, 0.1 and 0.5 Sv

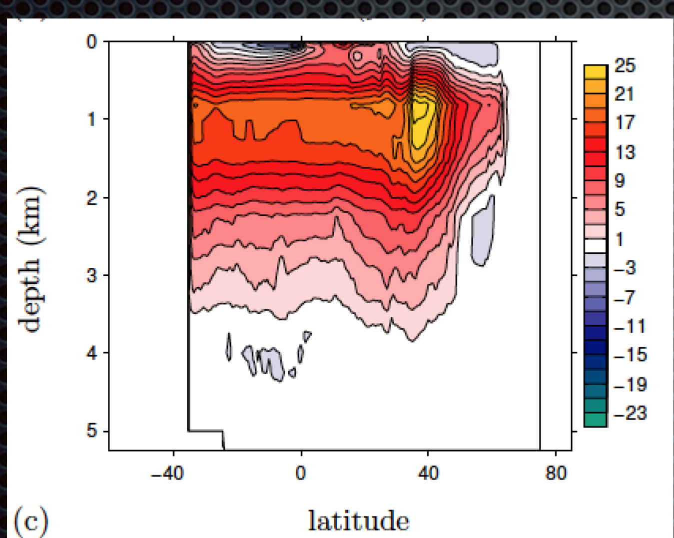
Current estimate: ~ 0.01 Sv

Weijer et al., GRL, (2012)

MOC decline (0.5 Sv)

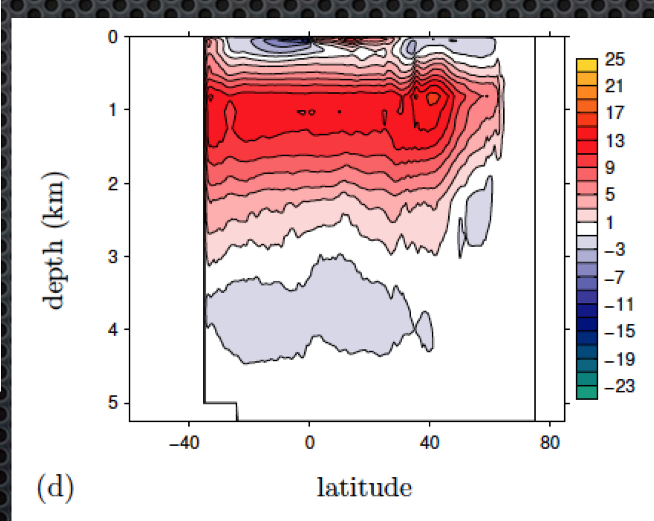




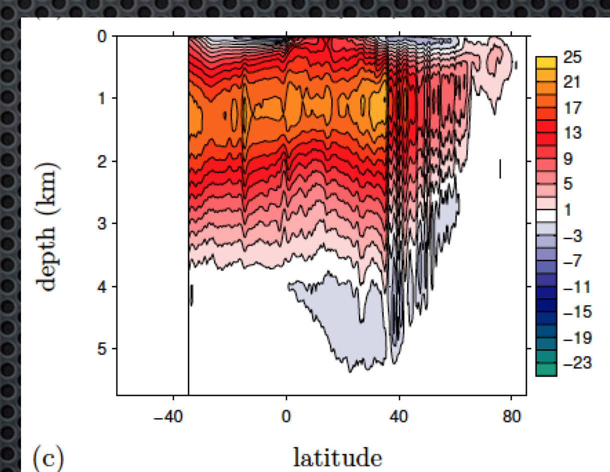


year 1

MOC

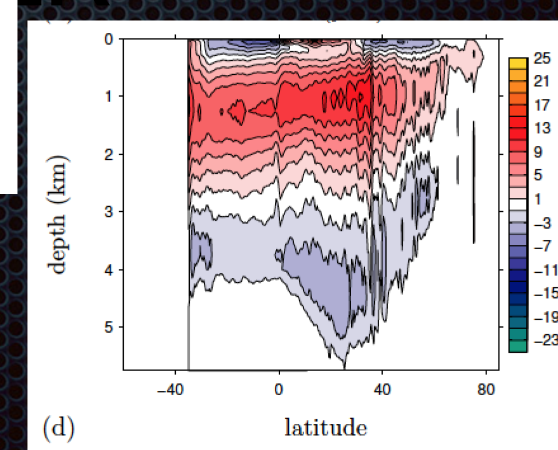


year 41



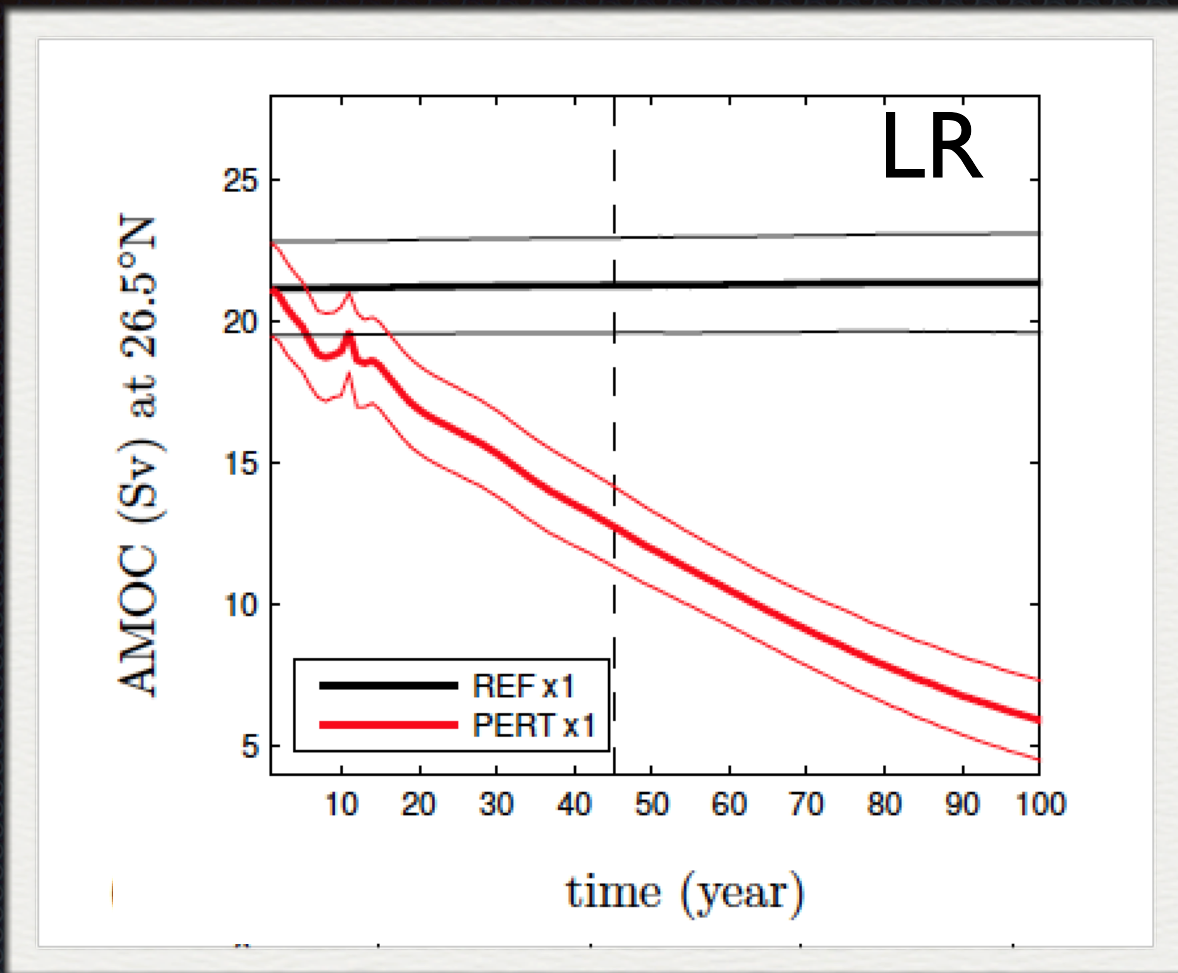
year 76

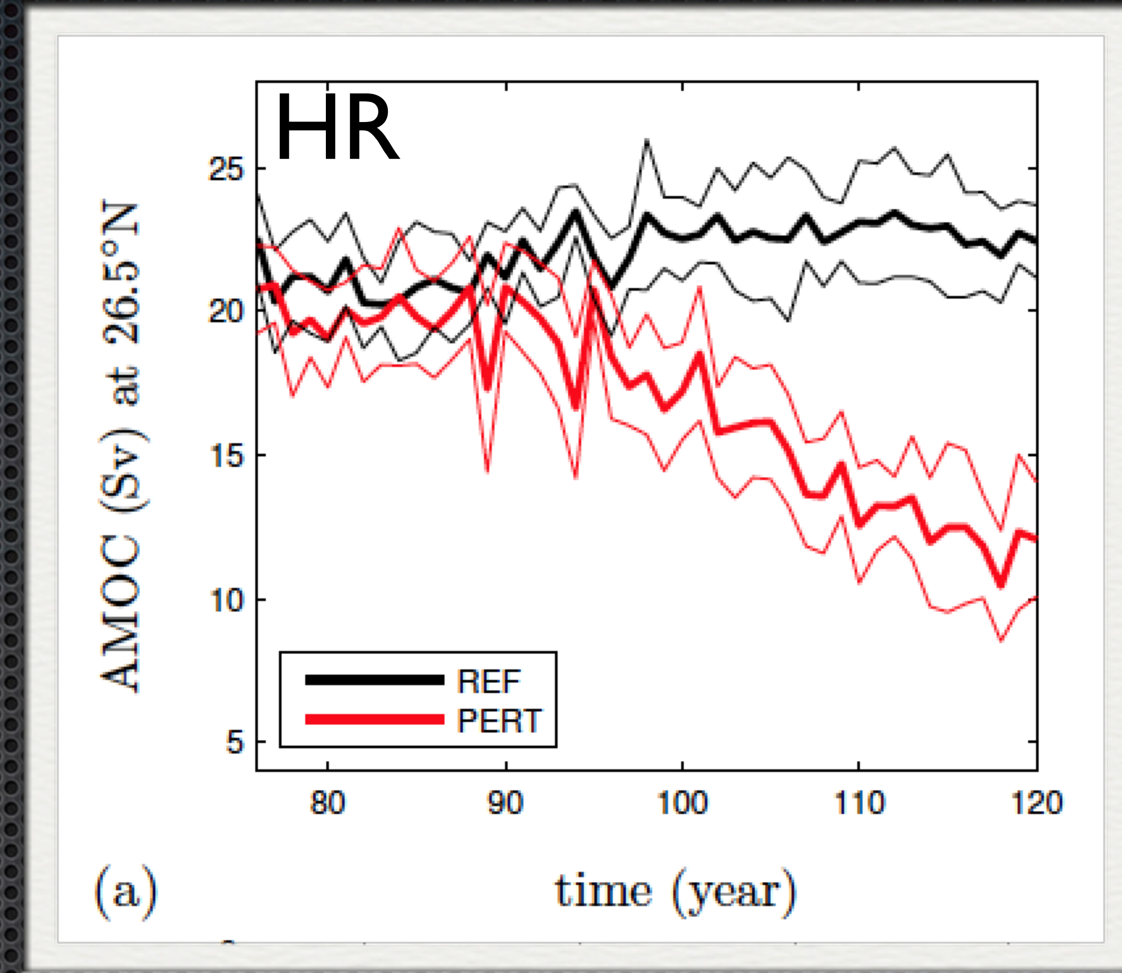
LR MOC

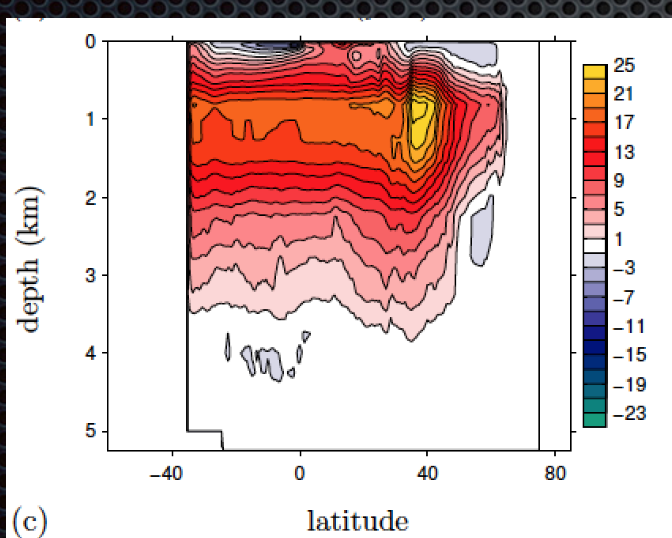


year 116

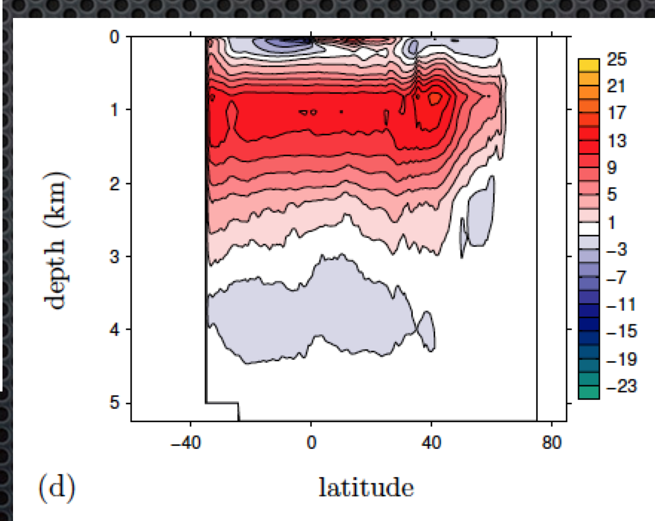
MOC decline (0.5 Sv)



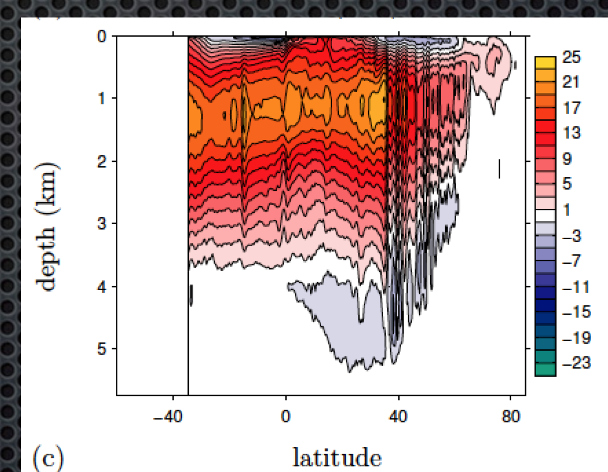




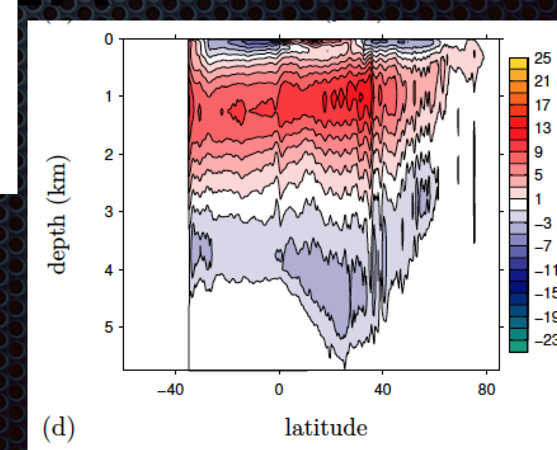
year 1



year 41



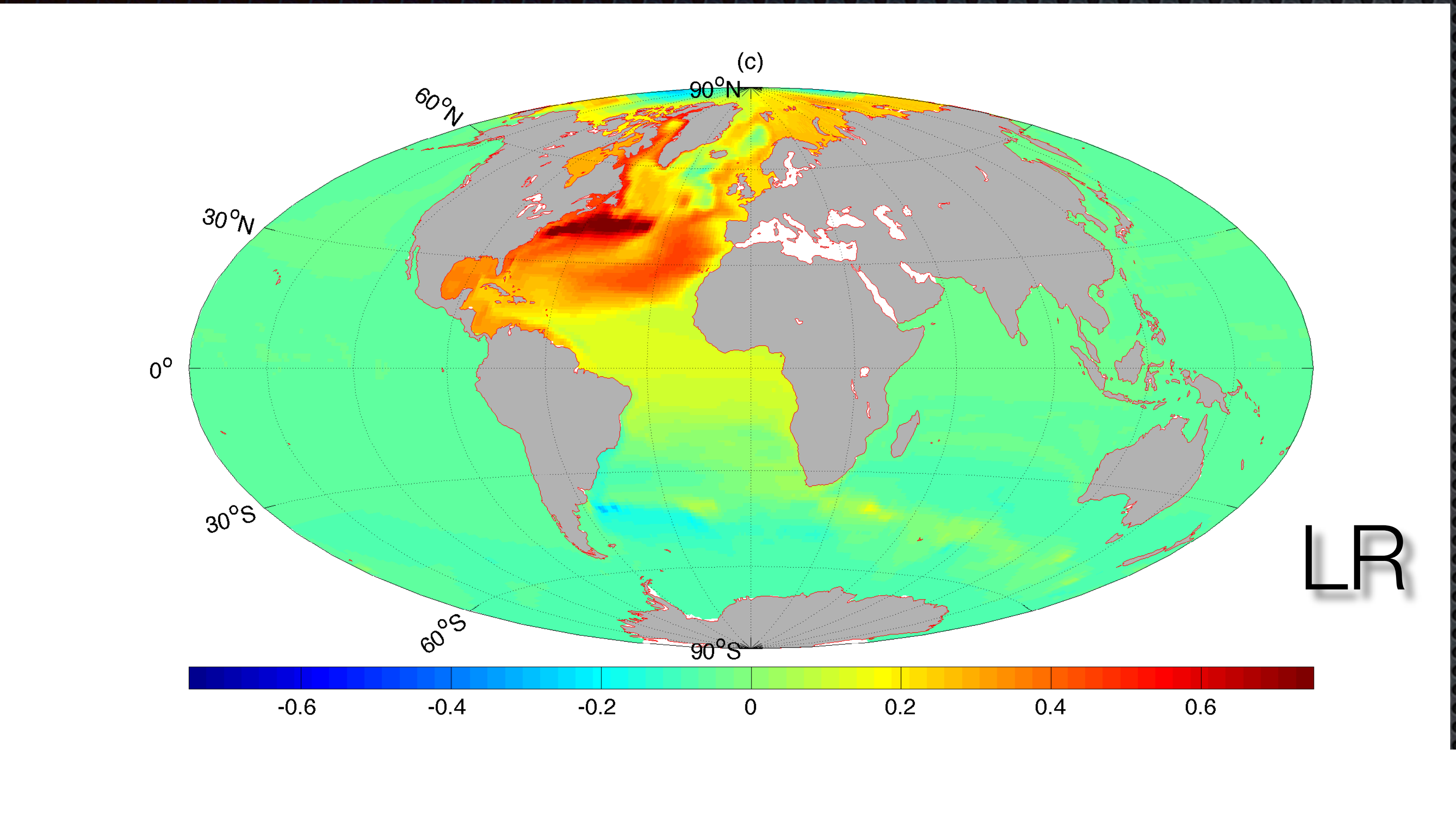
year 76



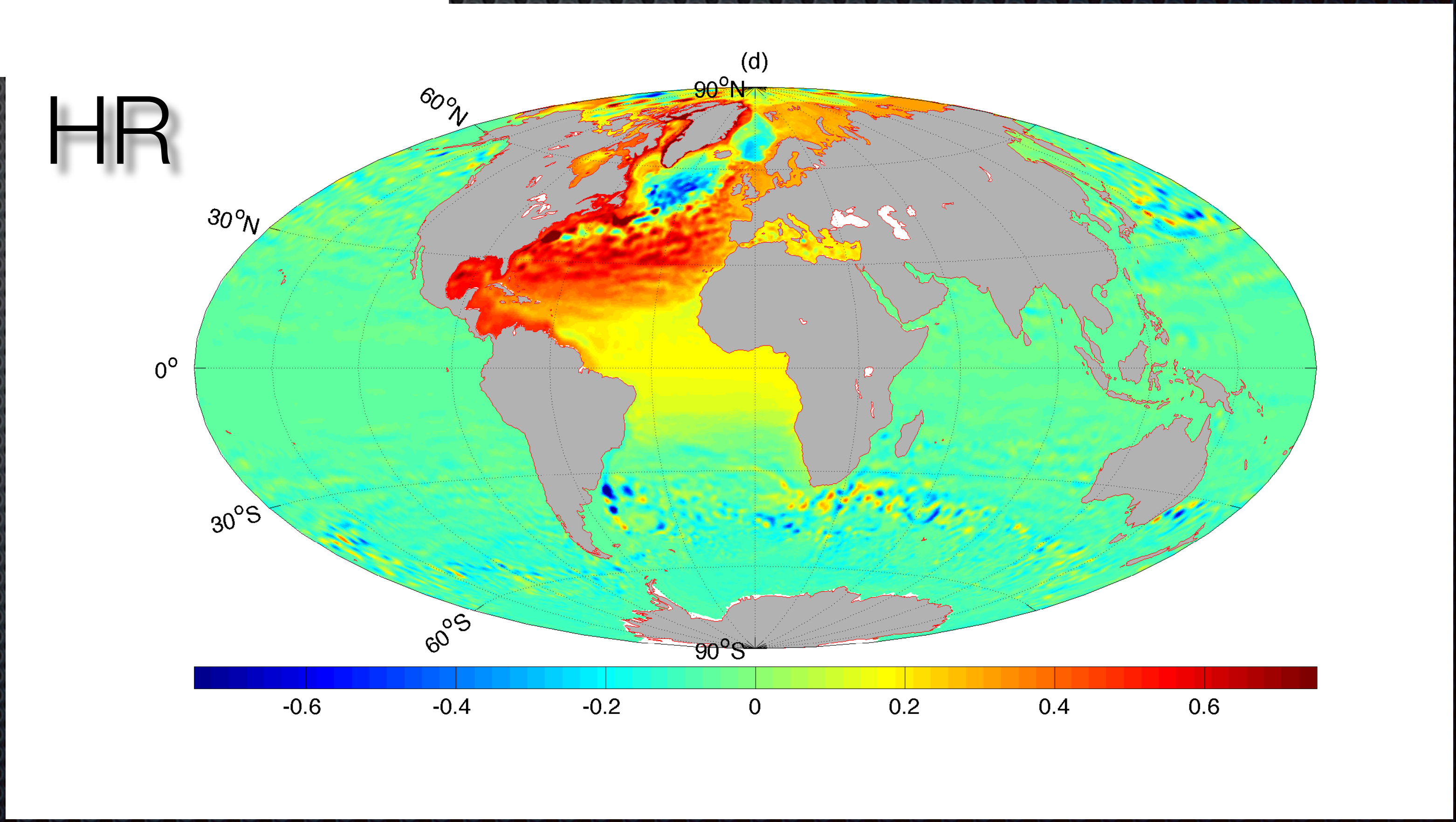
year 116

Den Toom et al., JPO, (2014)

Sea surface height (SSH) changes (m) after 50 years

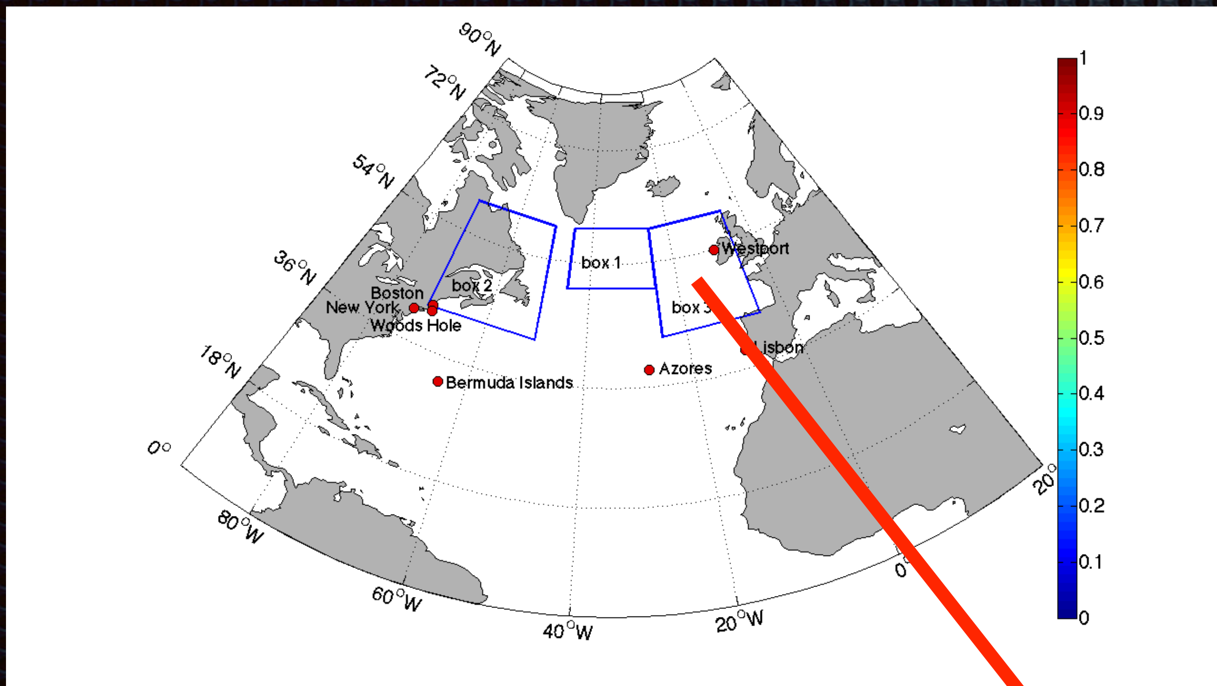


change = perturbed
- control



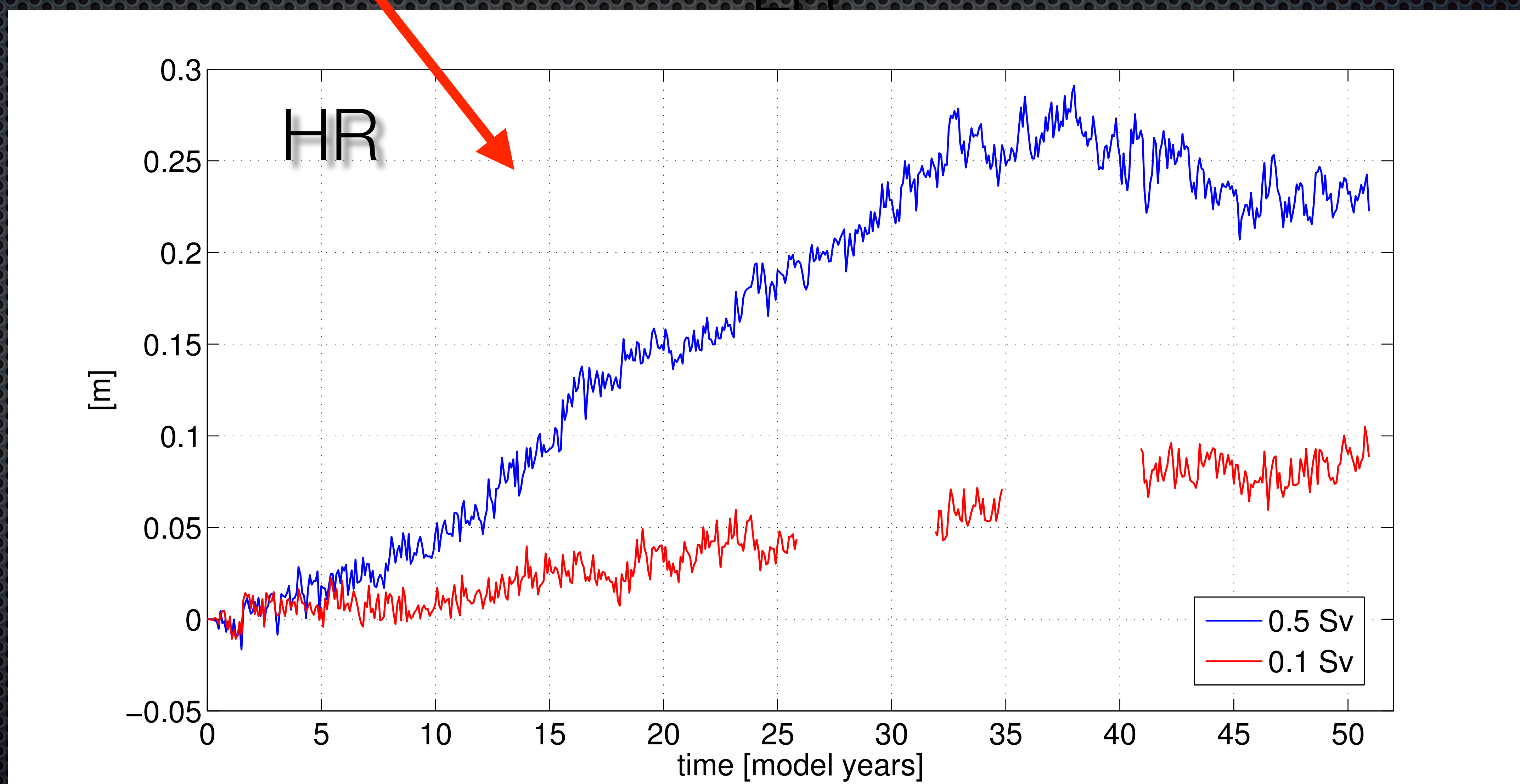
HR model gives more detailed view on sea level change than LR model

Regional changes in SSH

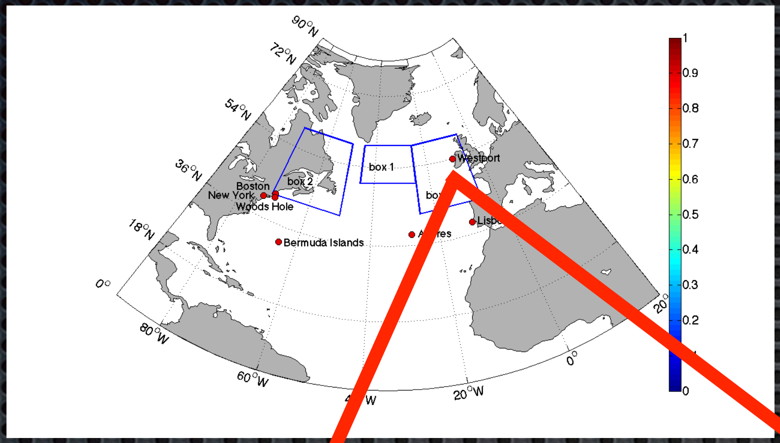


Mean SSH over the indicated area (daily data)

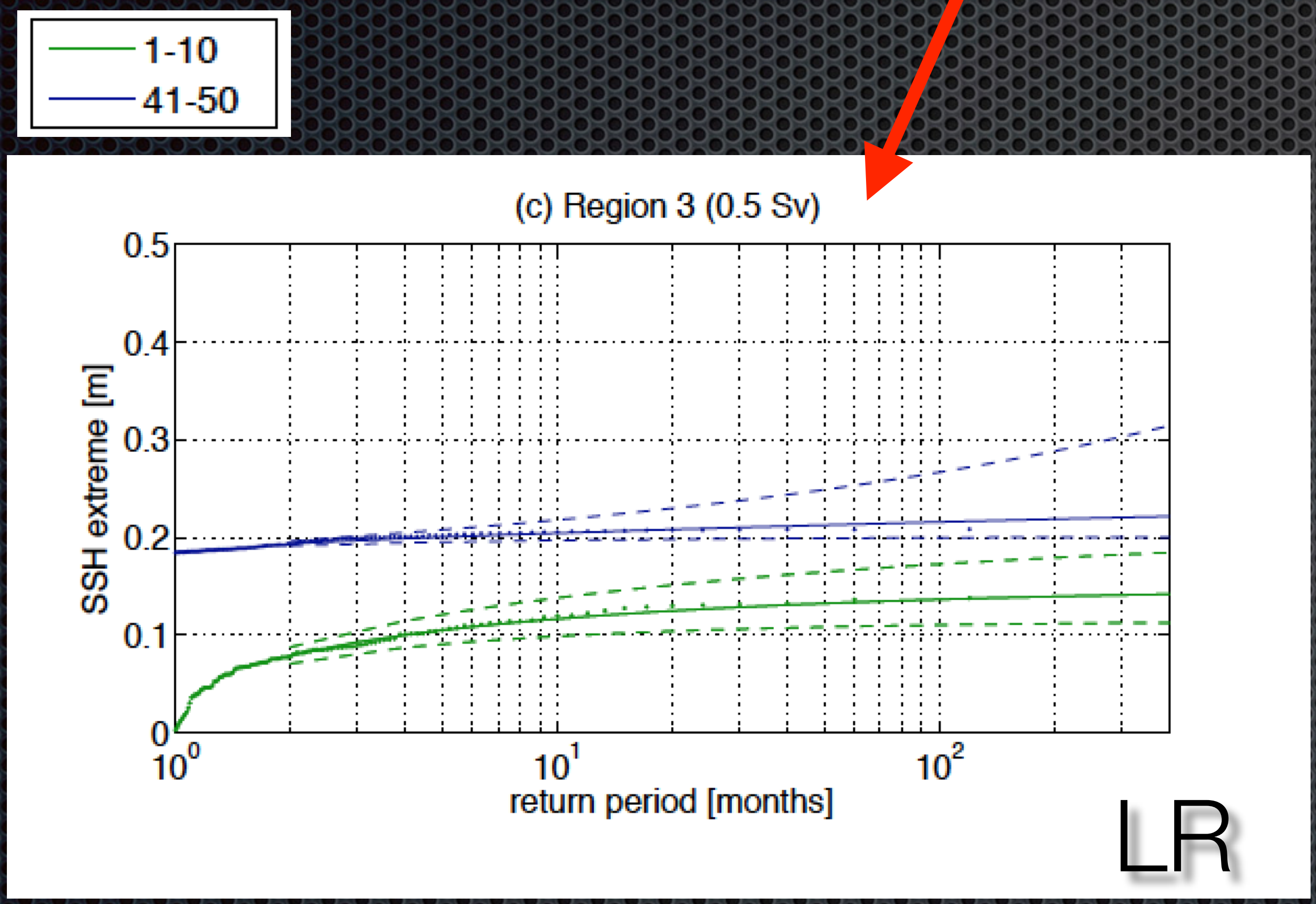
LR

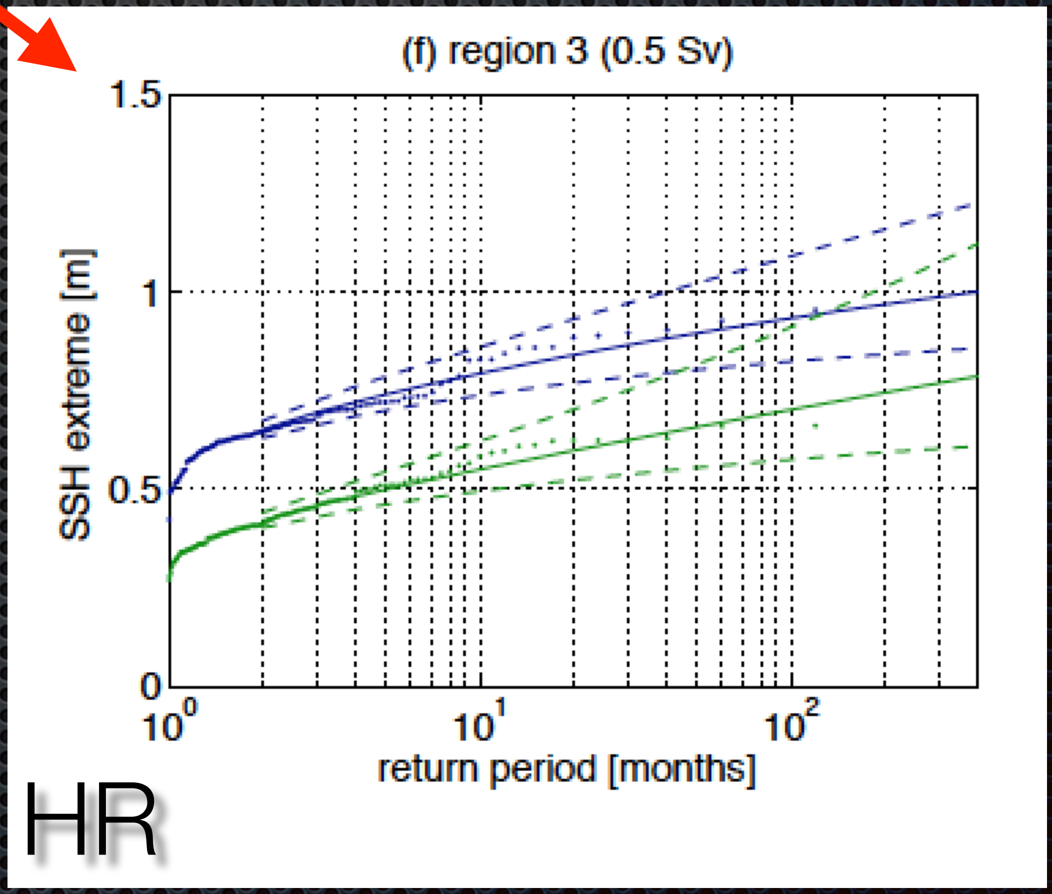


Changes in regional SSH extremes



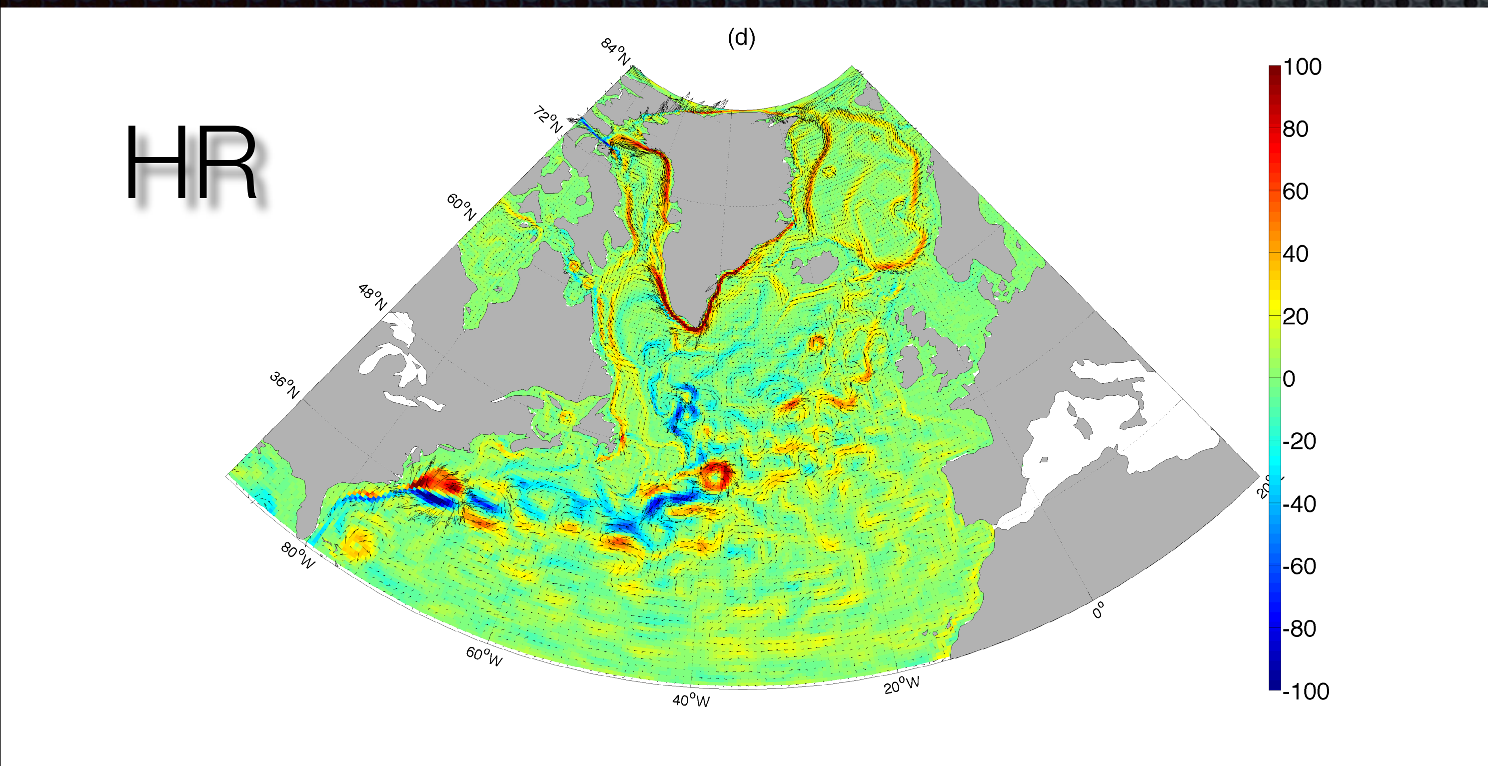
monthly maxima





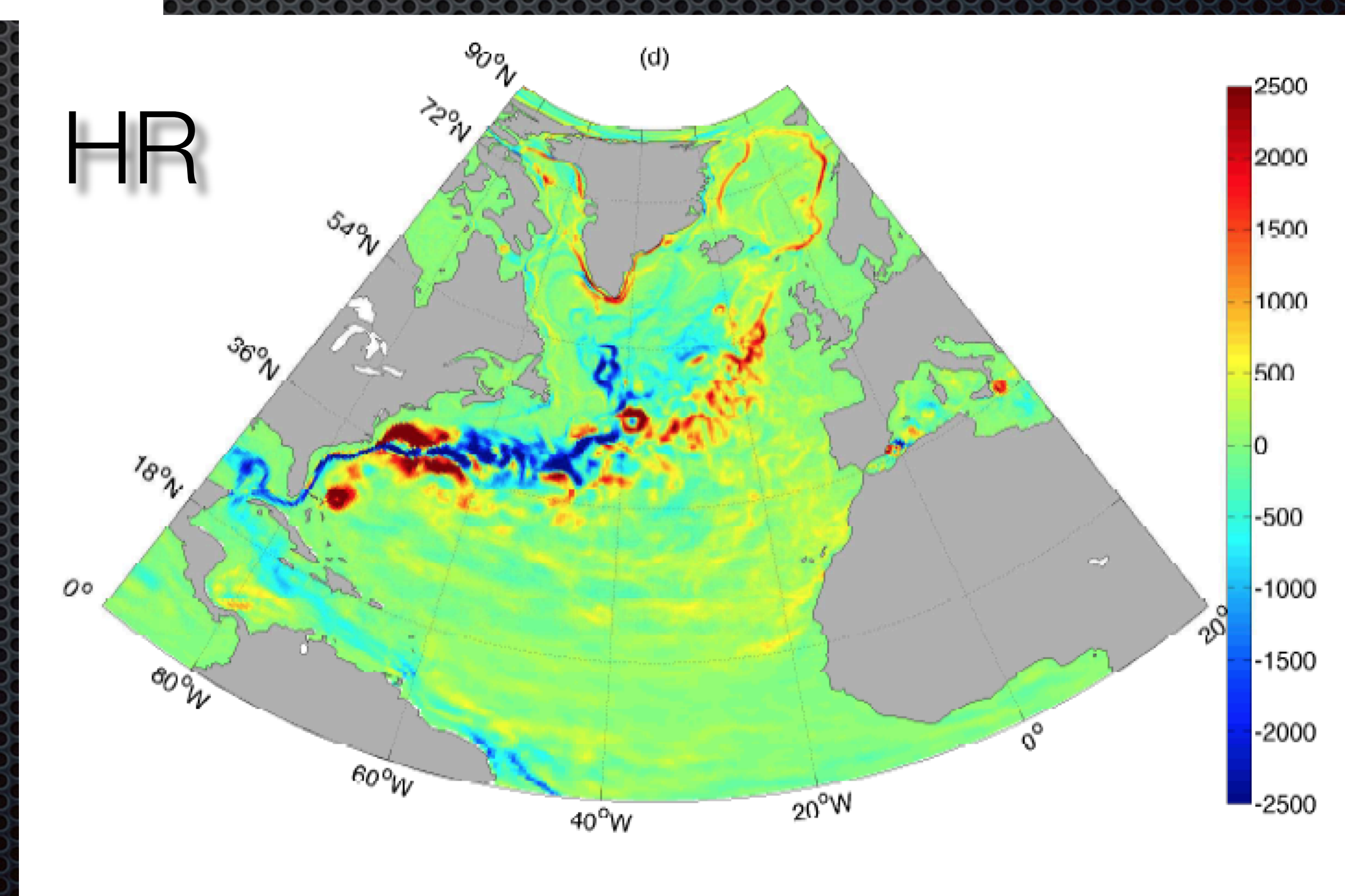
Generalized Extreme Value Distribution fits

Reason: meso-scale flow changes

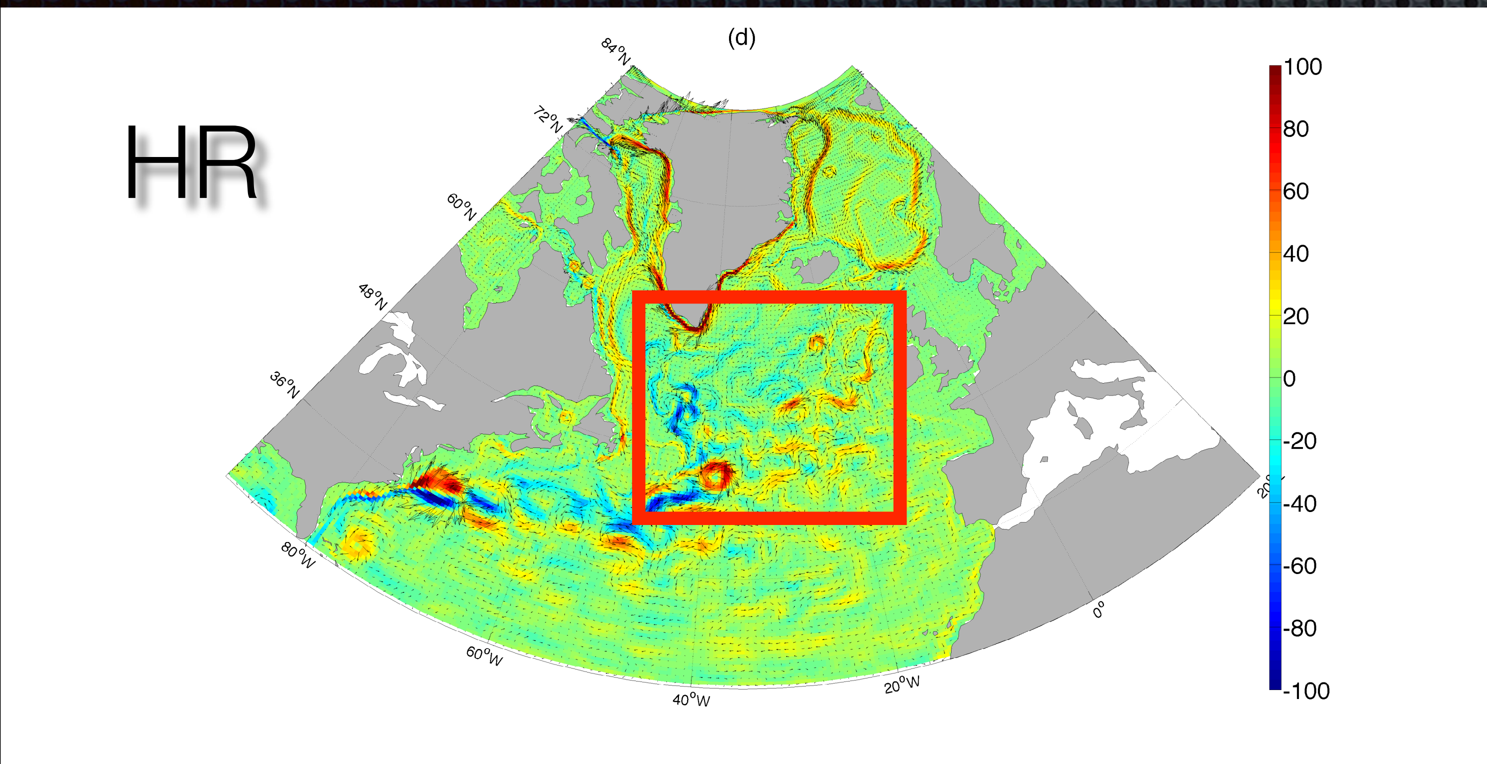


change in horizontal velocity after 50 years

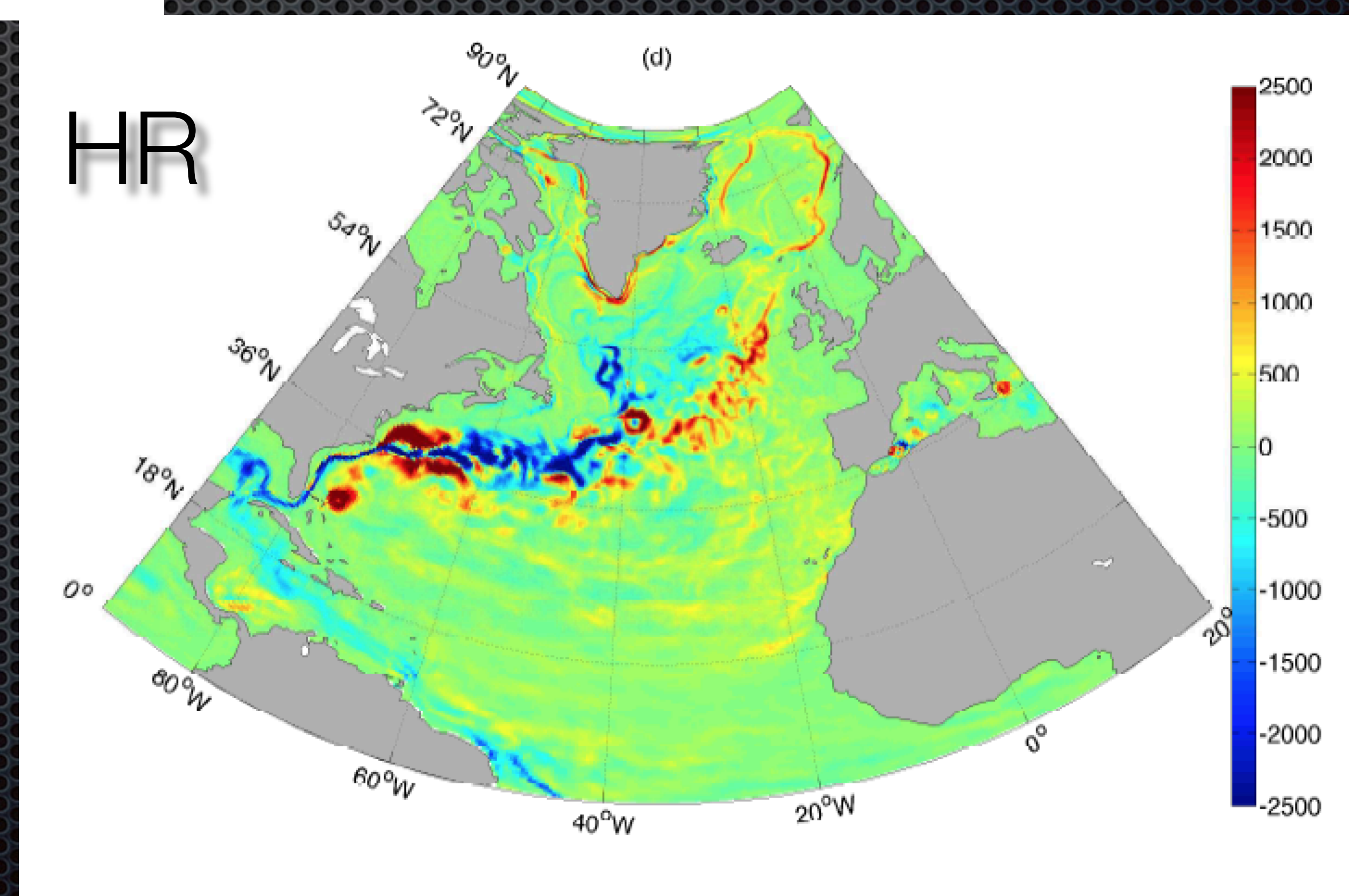
change in eddy kinetic energy (cm^2/s^2) after 50 years



Reason: meso-scale flow changes

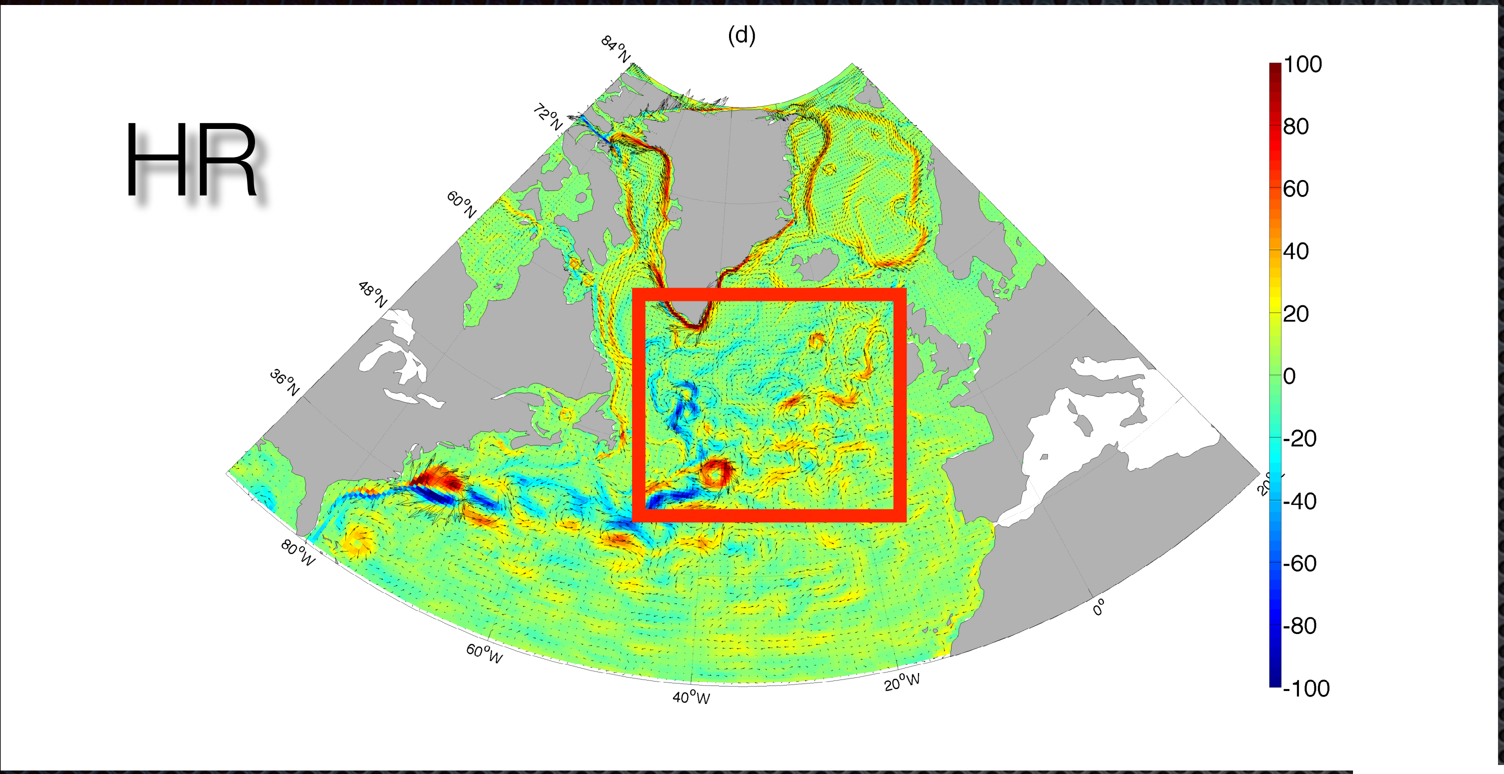


change in horizontal velocity after 50 years

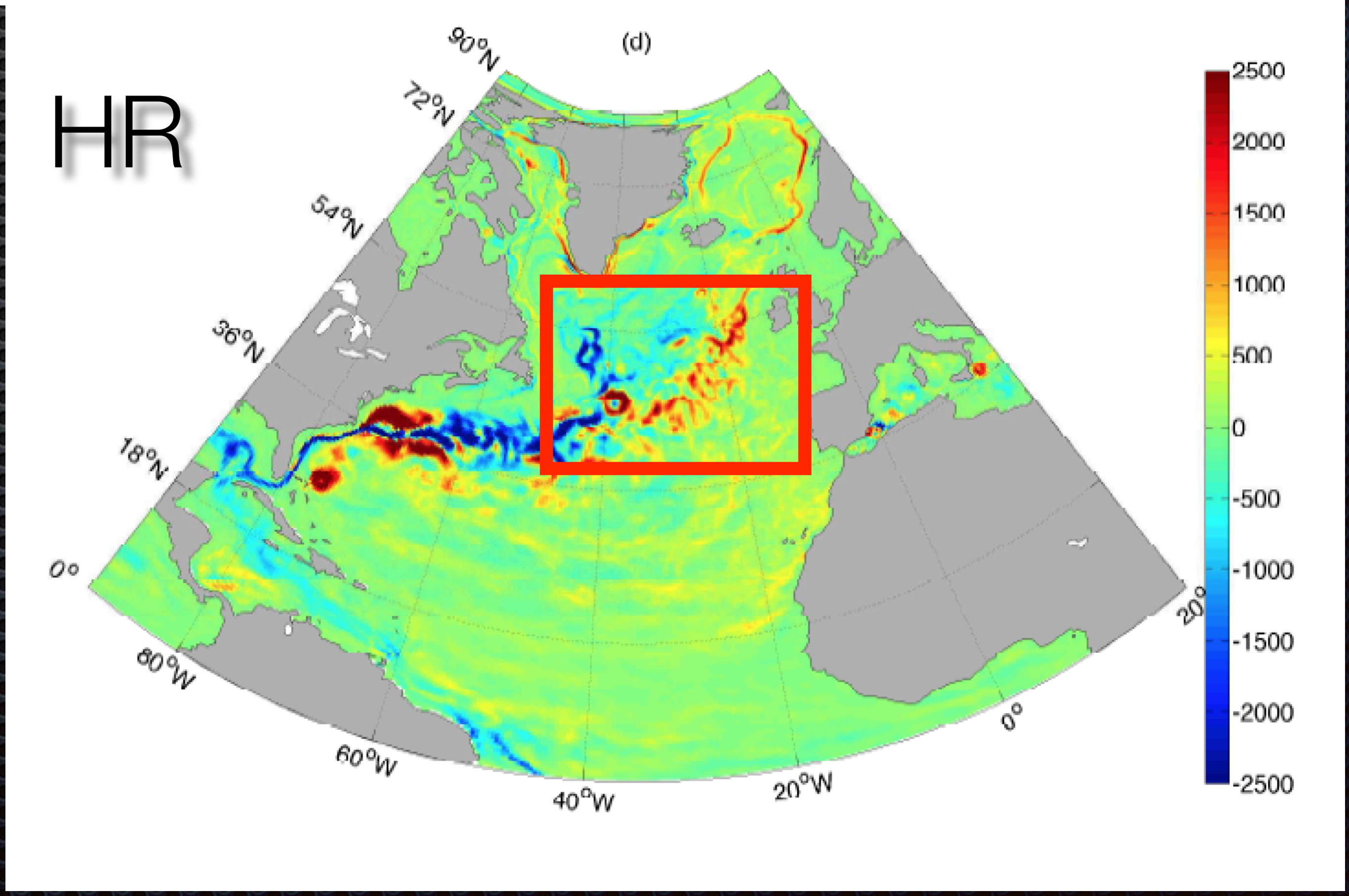


change in eddy kinetic energy (cm^2/s^2) after 50 years

Reason: meso-scale flow changes

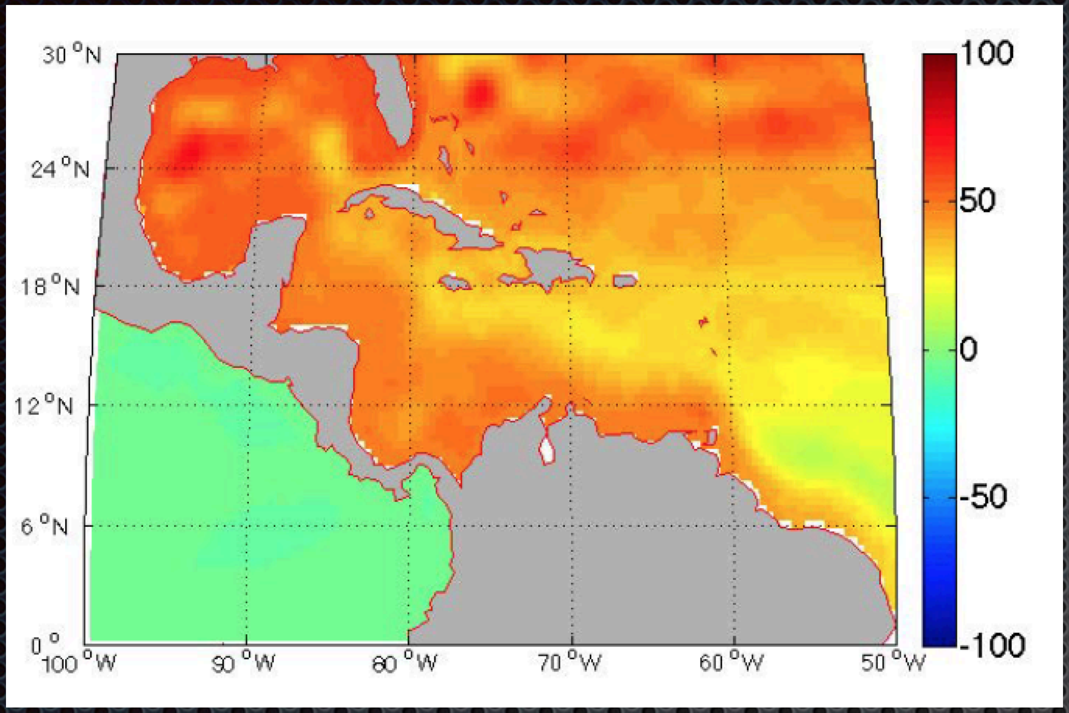


change in horizontal velocity after 50 years

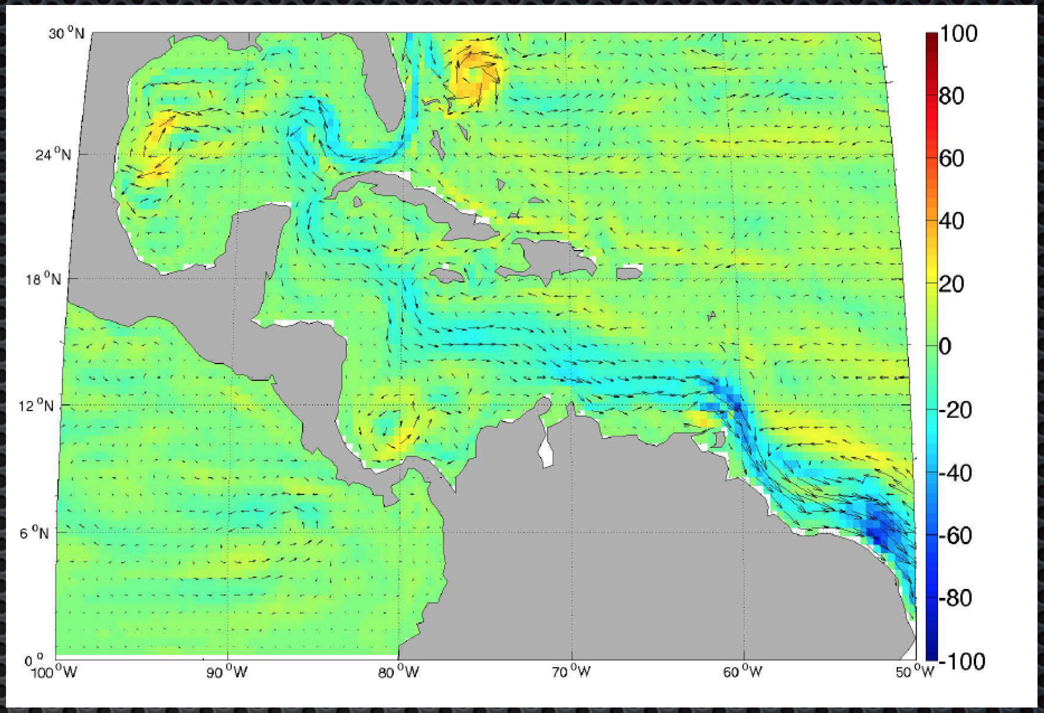


change in eddy kinetic energy (cm^2/s^2) after 50 years

Dynamic sea level changes Caribbean Sea

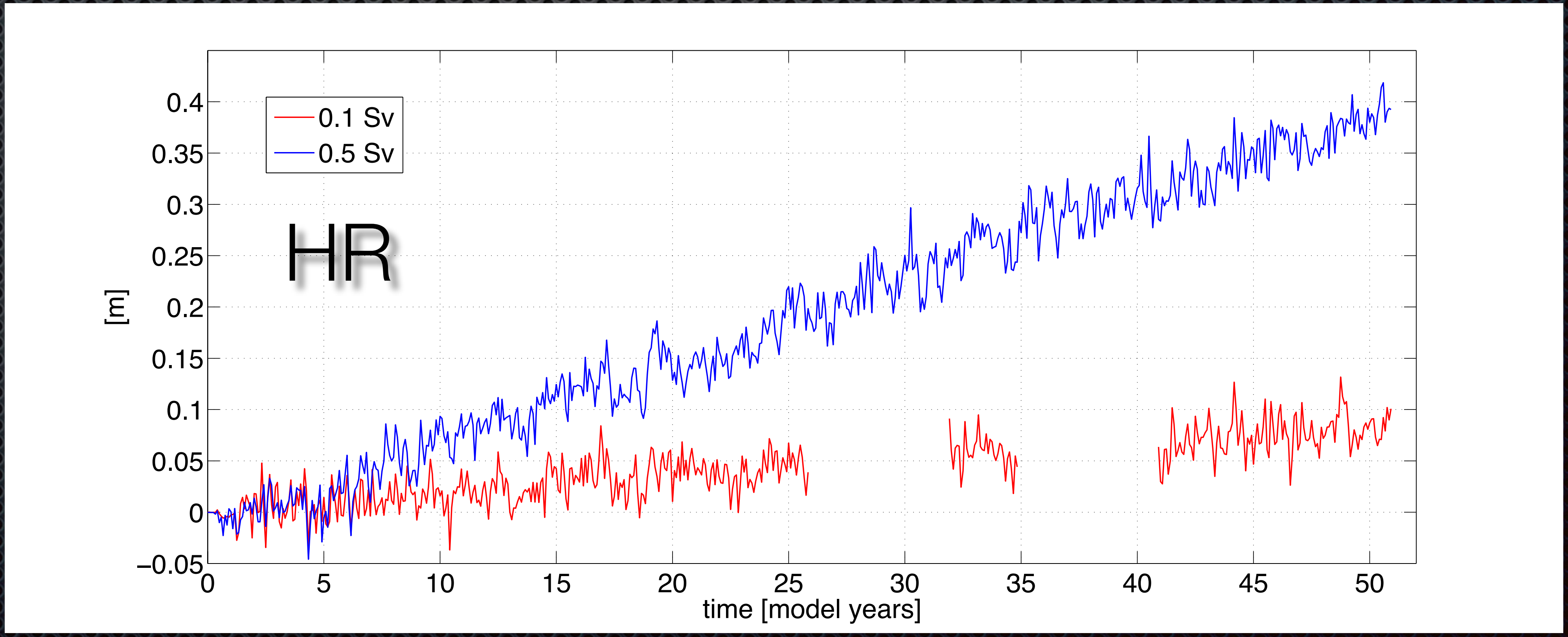


SSH change (cm)

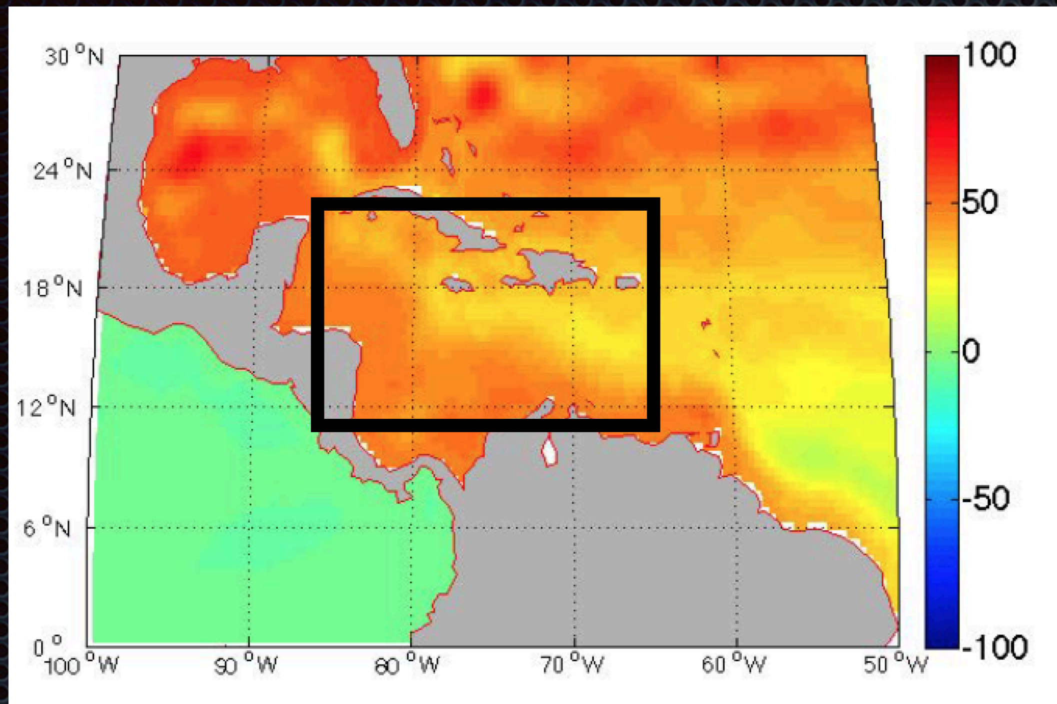


surface velocity change (cm/s)

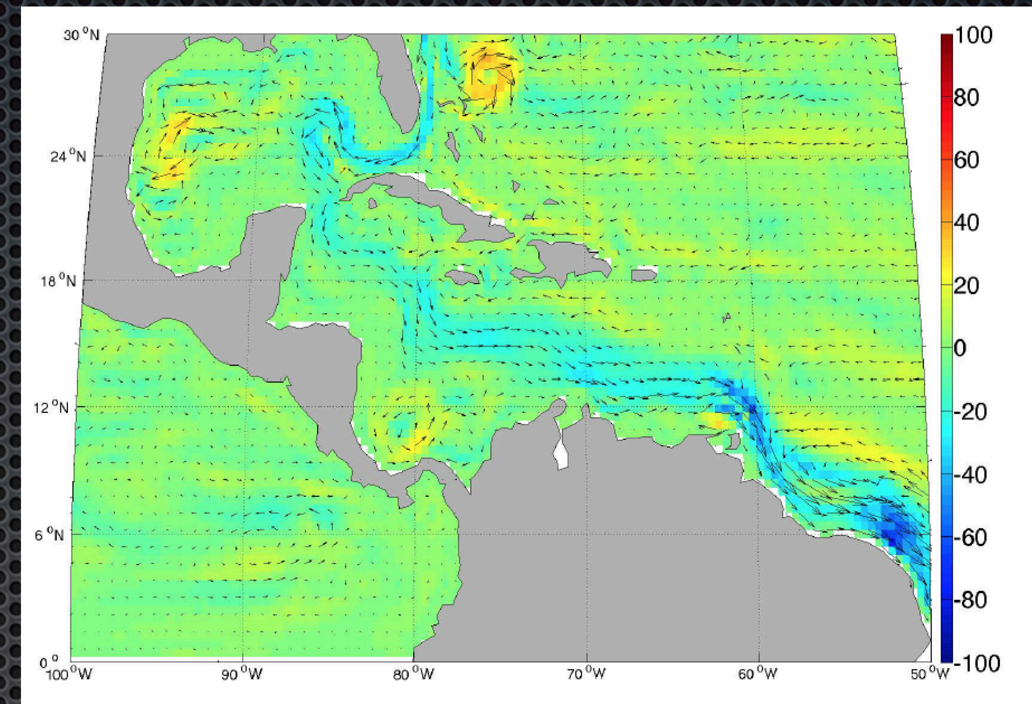
Area mean SSH change



Dynamic sea level changes Caribbean Sea

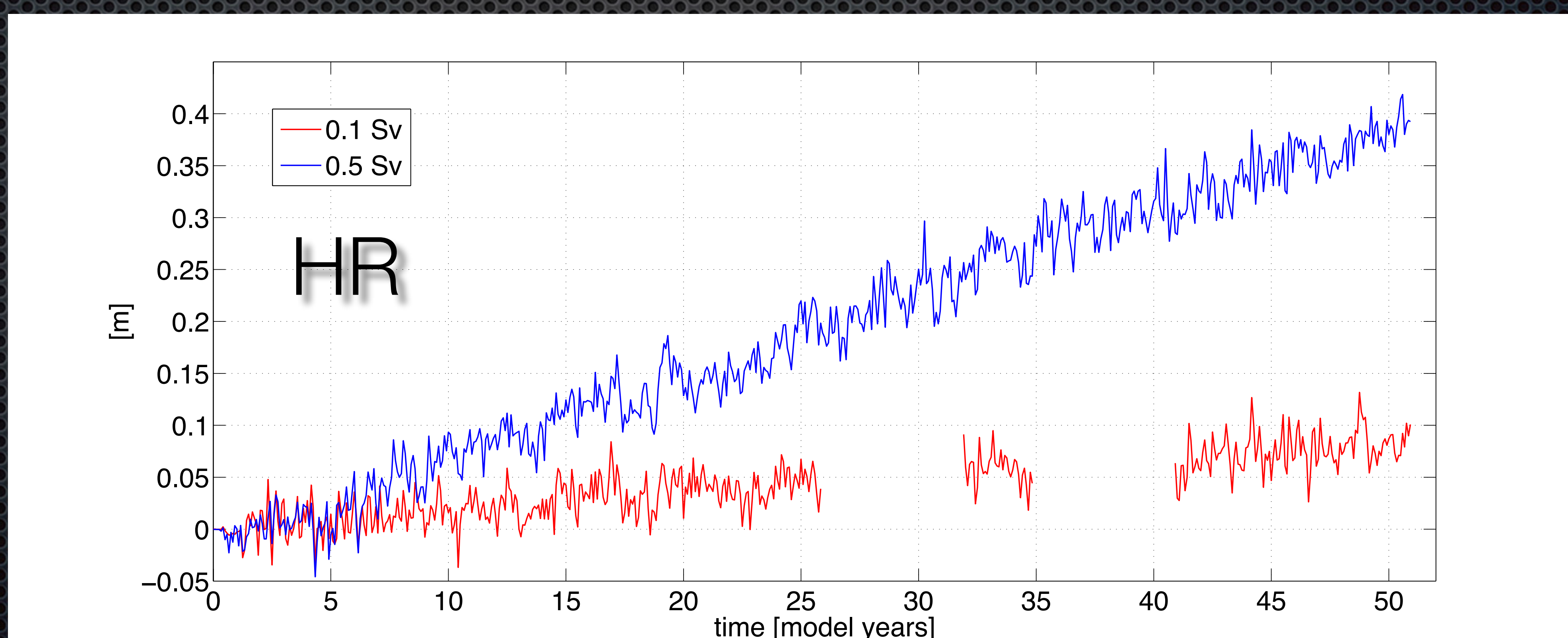


SSH change (cm)

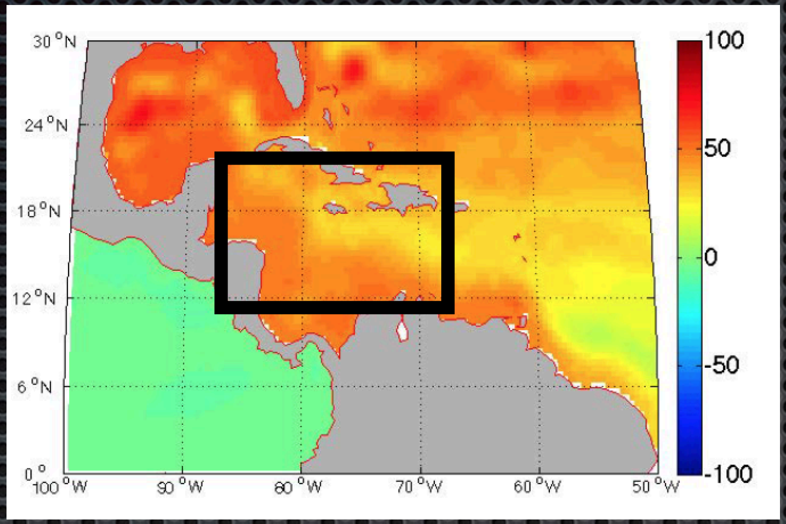


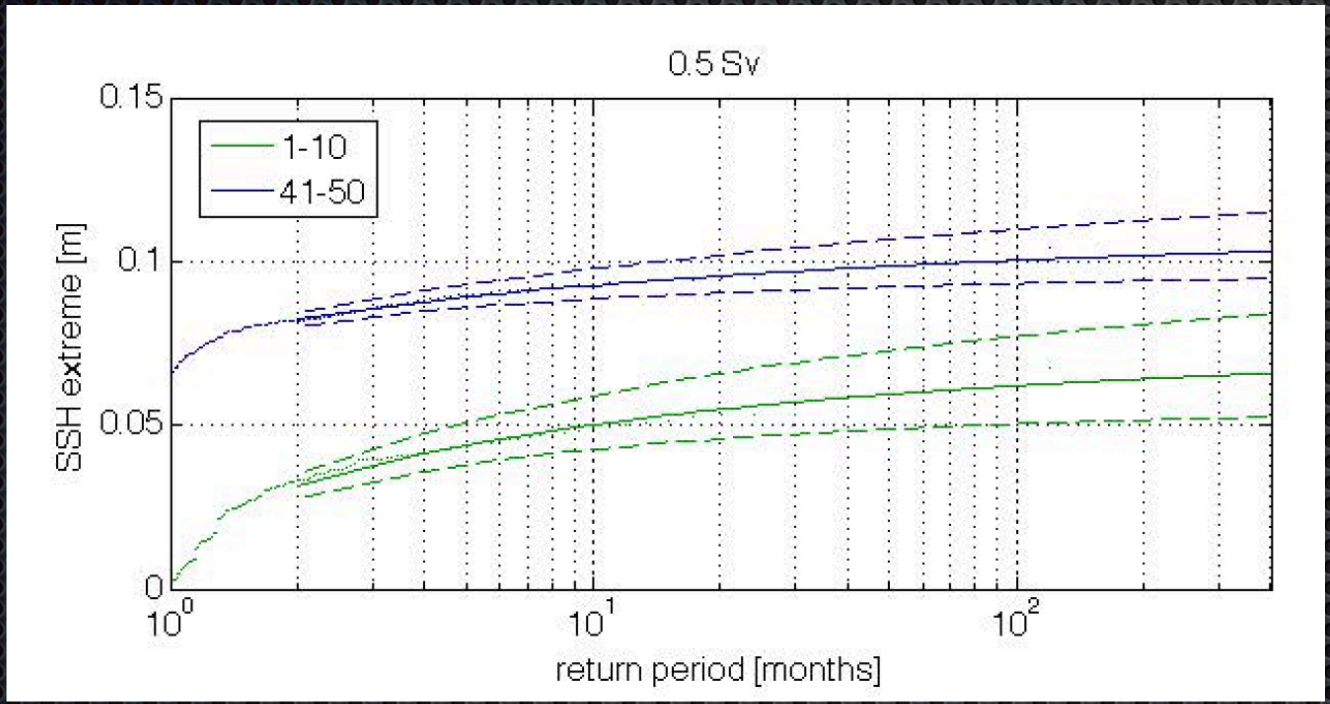
surface velocity change (cm/s)

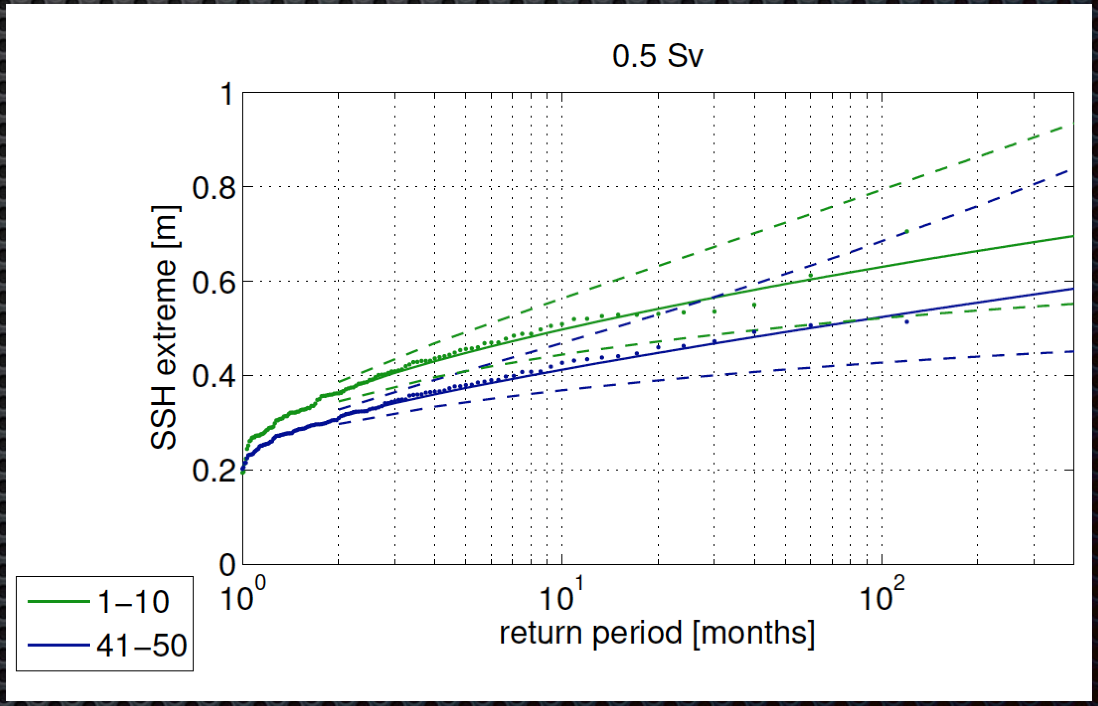
Area mean SSH change



Changes in Caribbean SSH extremes







LR model results

HR model results

Opposite sign of changes in extremes!

Summary & Conclusions

A weakening of the MOC in the North Atlantic leads to an extreme scenario of sea level change in the Atlantic

Changes in meso-scale flows are important for extremes in sea level change

High-resolution ocean models are crucial to determine regional extreme sea level changes due to ocean circulation changes

To be continued ...

Caribbean Netherlands Science Institute at St Eustatius

First research projects
(total 5 ME)
will start in 2014

Our proposal: (Pietrzak, Herman, Dijkstra):

Stability of Caribbean coastal Ecosystems uNder future Extreme Sea level changes (SCENES)

Coupling of global strongly eddying ocean models to wave -current models (SWAN/ADCIRC) and biogeomorphological models (Delft3D)