Continental Giant Topography Effect on Global Freshwater Balance:

Tibetan Plateau VS. Rocky Mountain

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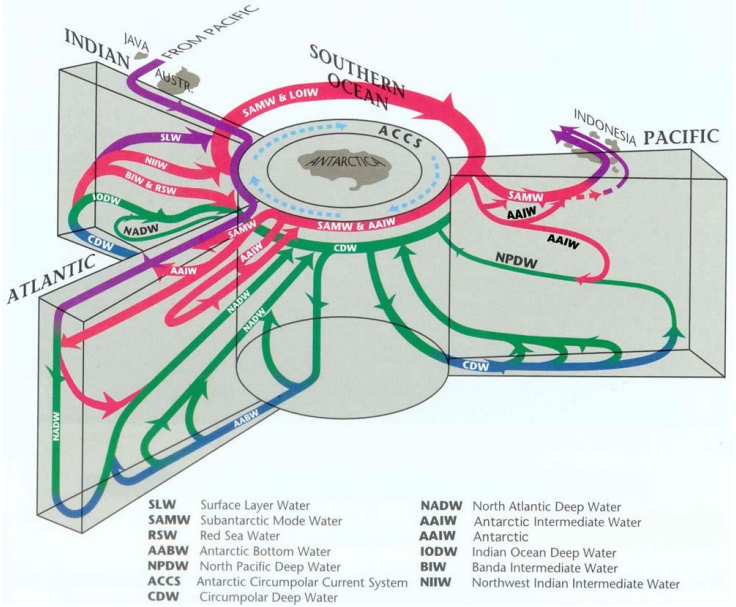
Global Meridional Overturning Circulation

Energy and Freshwater Balance

Weak

AMOC

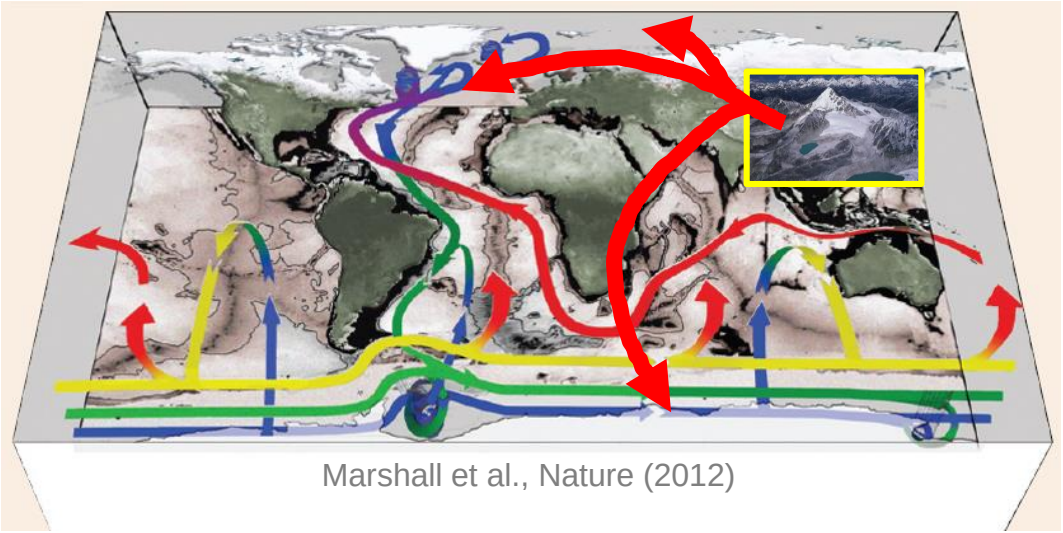


PMOC

Schmitz (1997) Overturning circulation: Southern Ocean View

TP: A *Global* Perspective

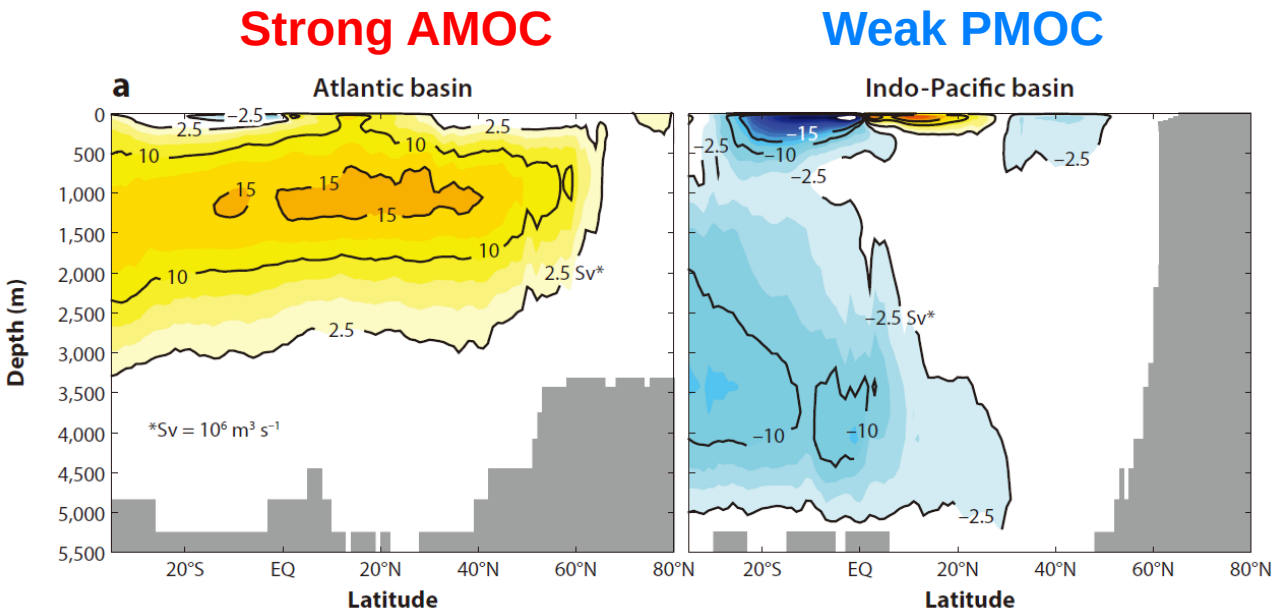
How and to what extent?



Marshall et al., Nature (2012)

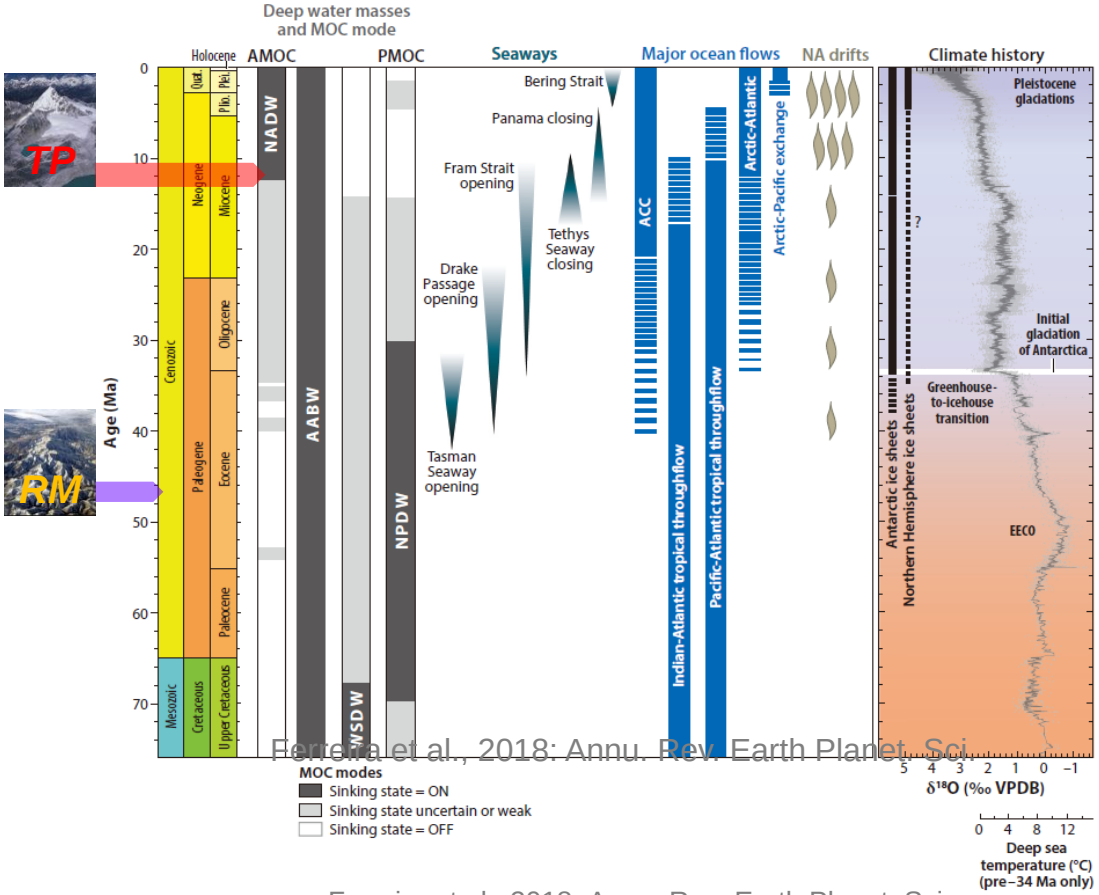
TP → NH vs. SH Asymmetry → Energy & Hydrological Cycle → Wind & Freshwater → Global Conveyor Belt

GMOC Now



Ferreira et al., 2018: Annu. Rev. Earth Planet. Sci.

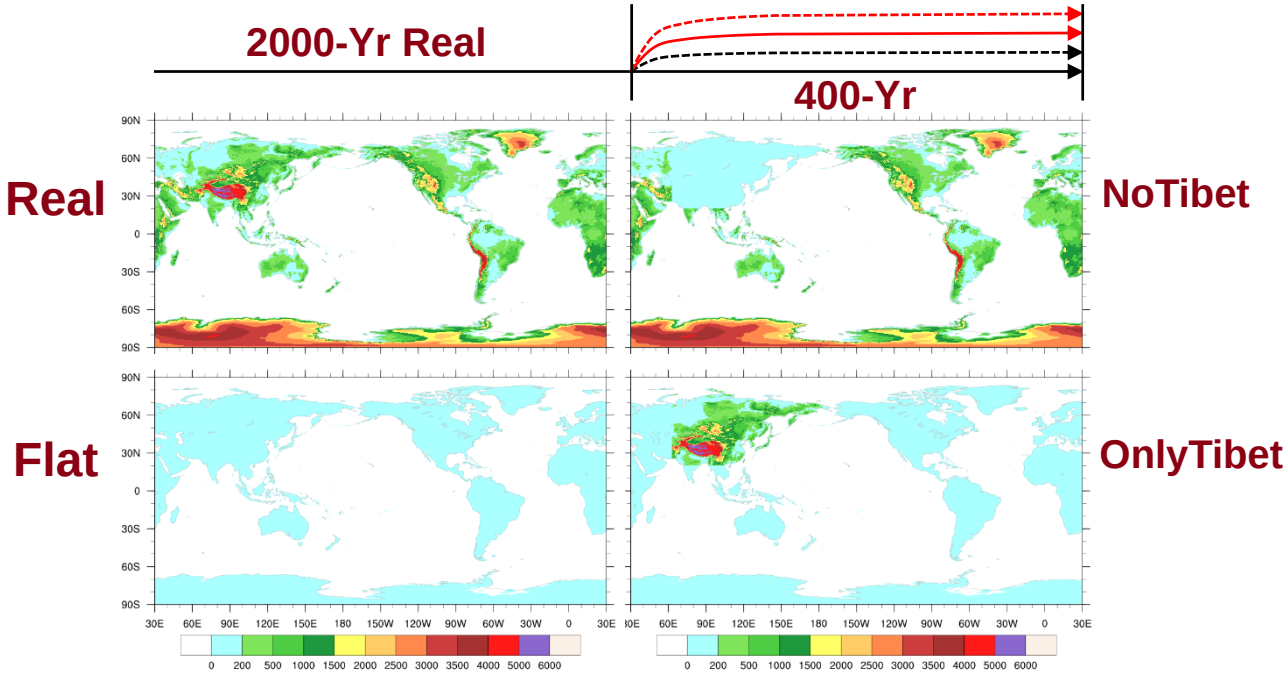
Geological History of GMOC



Ferreira et al., 2018: Annu. Rev. Earth Planet. Sci.

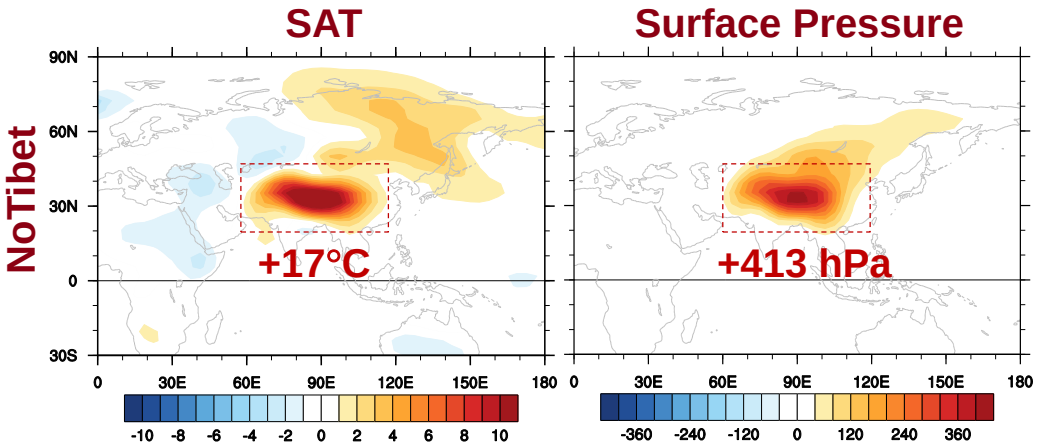
Ferreira et al., 2018: Annu. Rev. Earth Planet. Sci.

Coupled Earth System Model



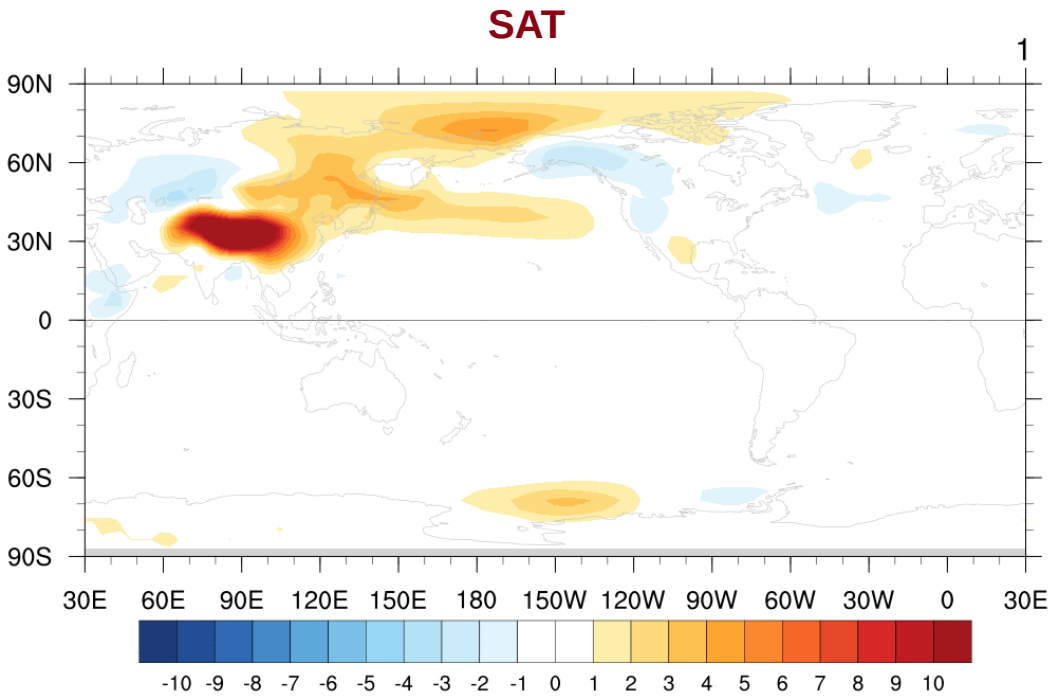
NCAR CESM1.0: CAM5 / POP2 / CLM4 / CICE4 / Glimmer-CISM

TP Forcing: *Thermal* and *Dynamical*

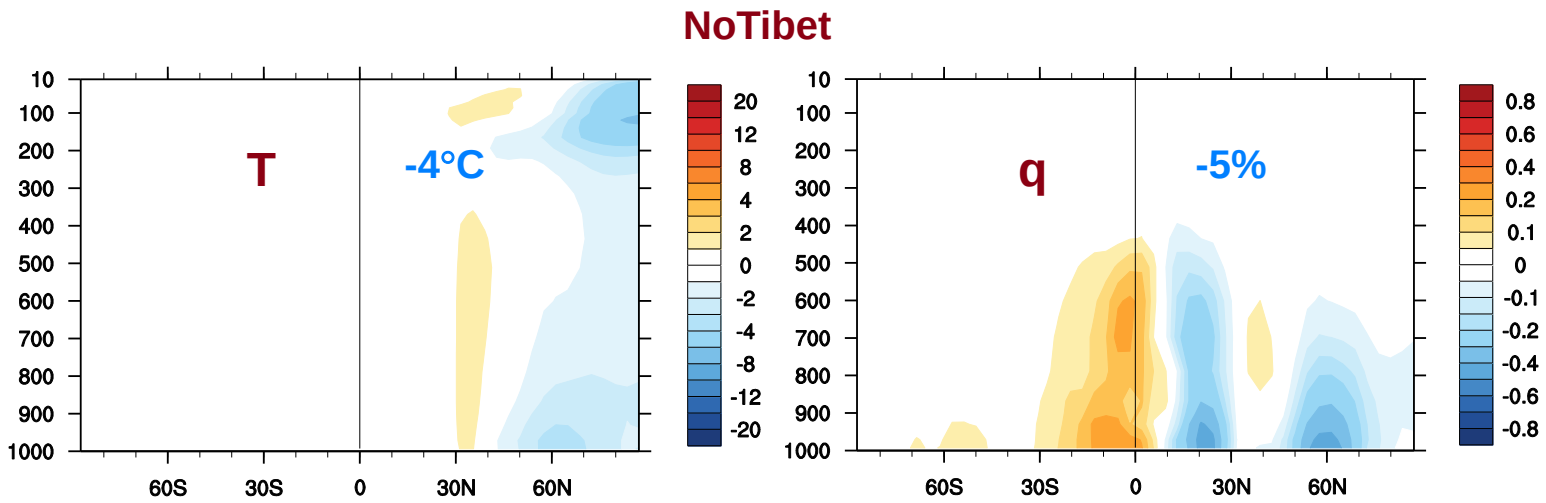


Lapse Rate T **~ 4 km x 7 ~ 28°C**

SAT Evolution w/o TP



Atmosphere T and Moisture



Cold and Dry without TP

Preliminary Results

		NoTibet	OnlyTibet
Atmos	TOA (PW)	+0.2	-0.04
	Air T (°C)	-4.0	+6.0
	SAT (°C)	-18.0	+19.0
	Air q (%)	-5.0	+10.0
	HC (%)	+13	-20
Ocean	SST (°C)	-8.0	+10.0
	SSS (psu)	-4.0	+6.0
	SSD (kg/m^3)	-3.0	+4.0

0 → 1 : Critical in Shaping Global Climate!

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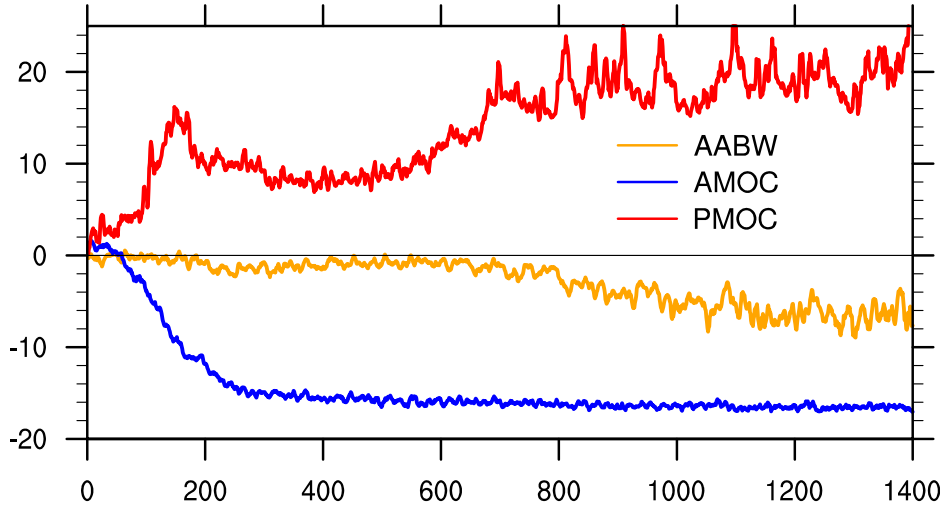
GMOC Index



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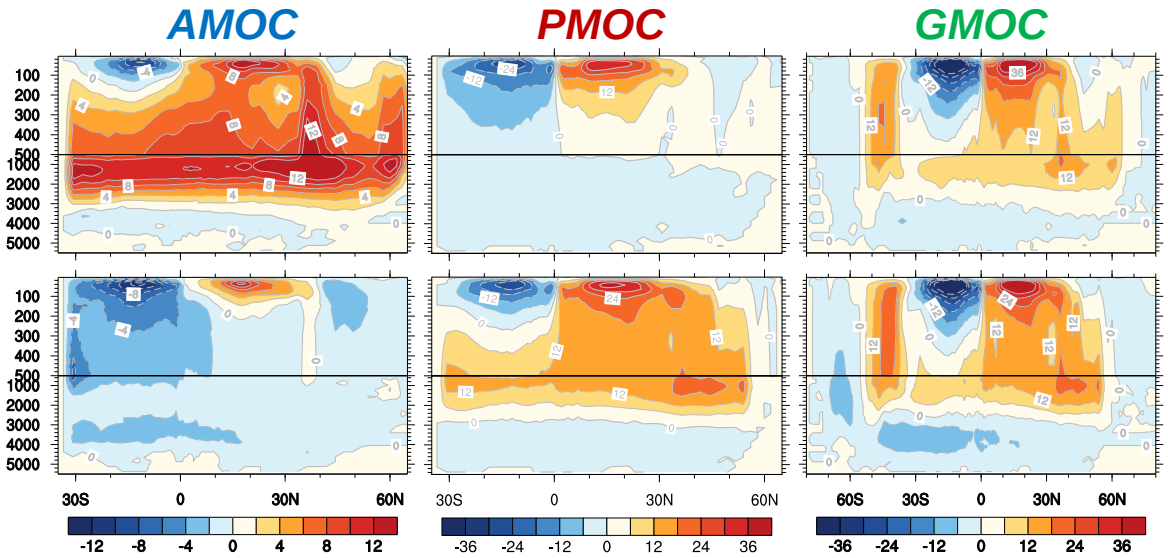
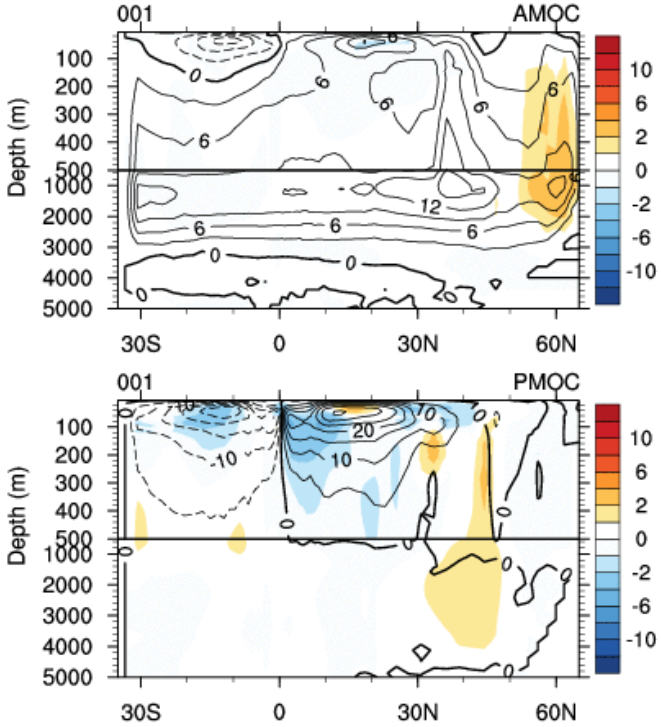
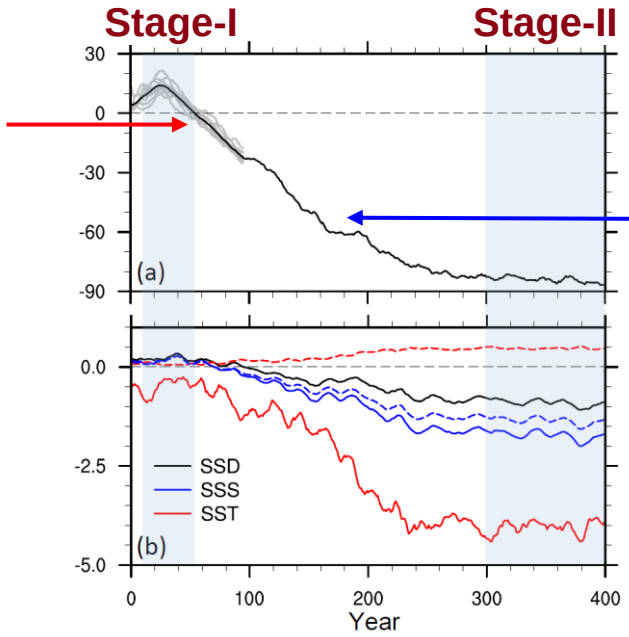
Global MOC


AMOC
PMOC
GMOC
Real
NoTibet
100
200
300
400
500
1000
2000
3000
4000
5000
30S
0
30N
60N
60S
-12 -8 -4 0 4 8 12
-36 -24 -12 0 12 24 36

AMOC vs. PMOC: See-Saw?



AMOC Evolution w/o TP



Atmosphere Dynamics

Sea-ice & Ocean Dynamics

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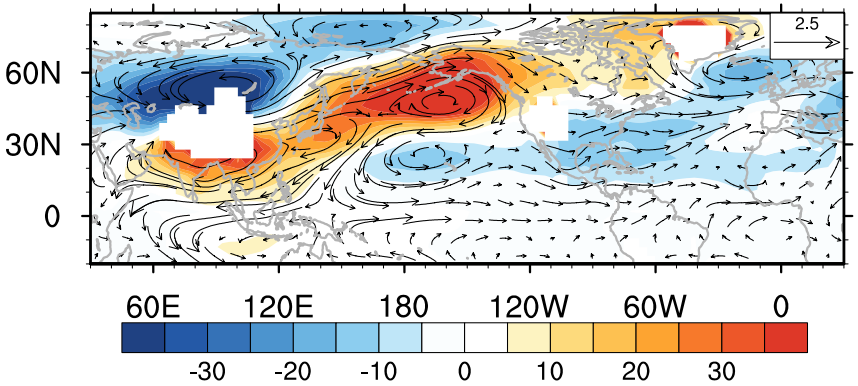
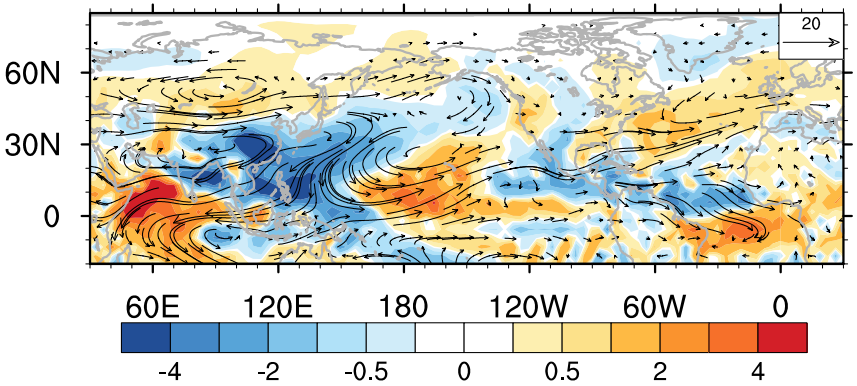
Teleconnection: From *TP* to *Atlantic*

850 hPa GH and Wind



Moisture Transport



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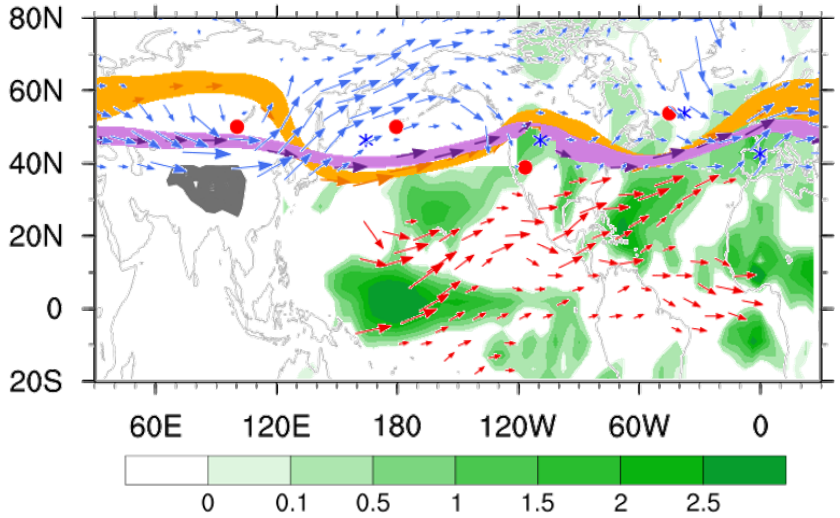
From *TP* to *AMOC: Atmosphere Dynamics*

Stationary Waves with Tibetan Plateau



NoTibet → Annular mode ⇑ → Westerlies ⇑ → Moisture transport ⇑

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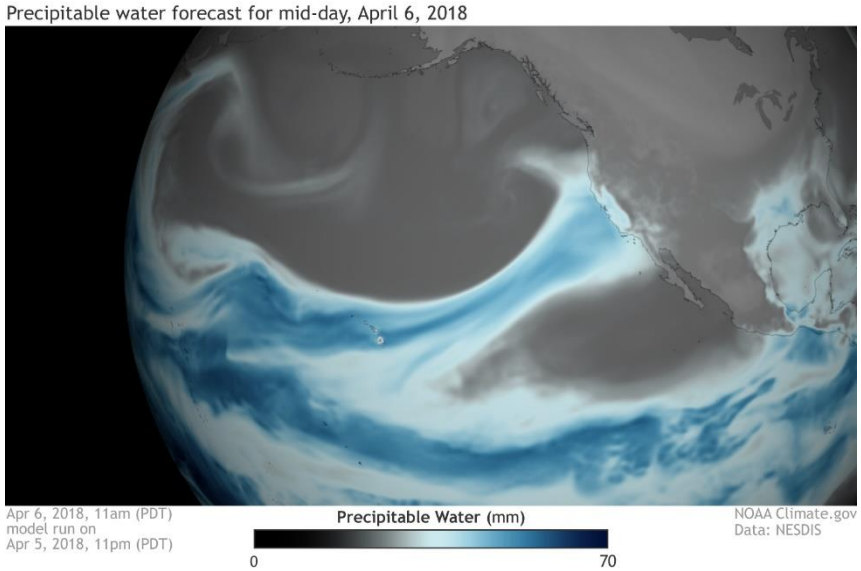
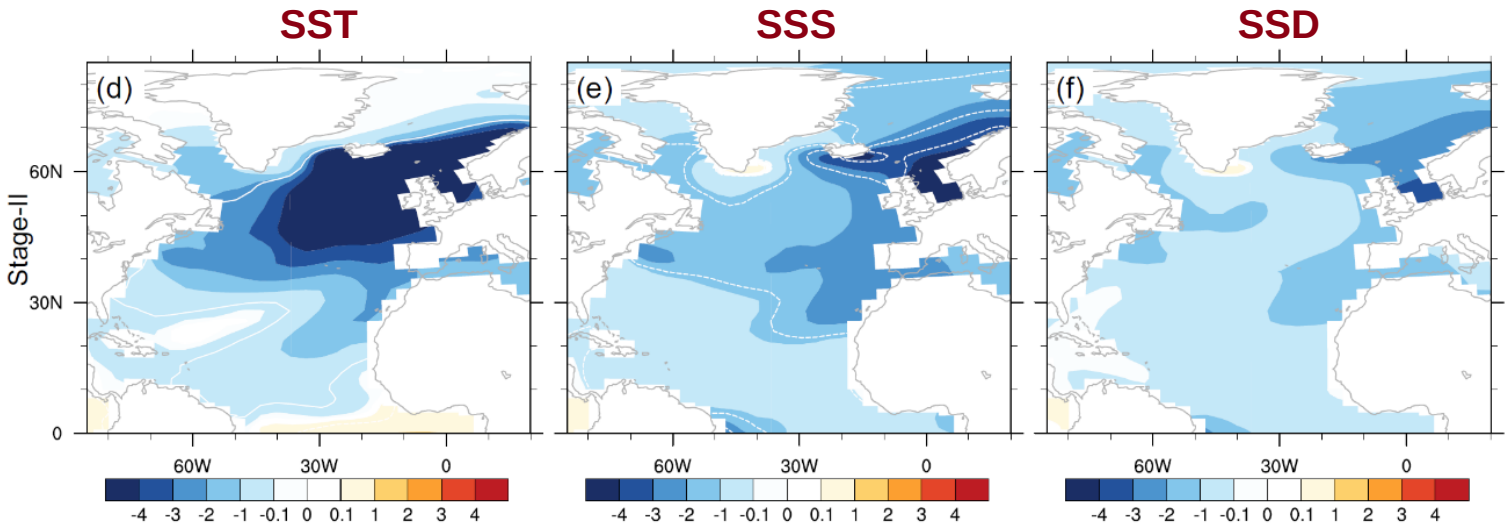
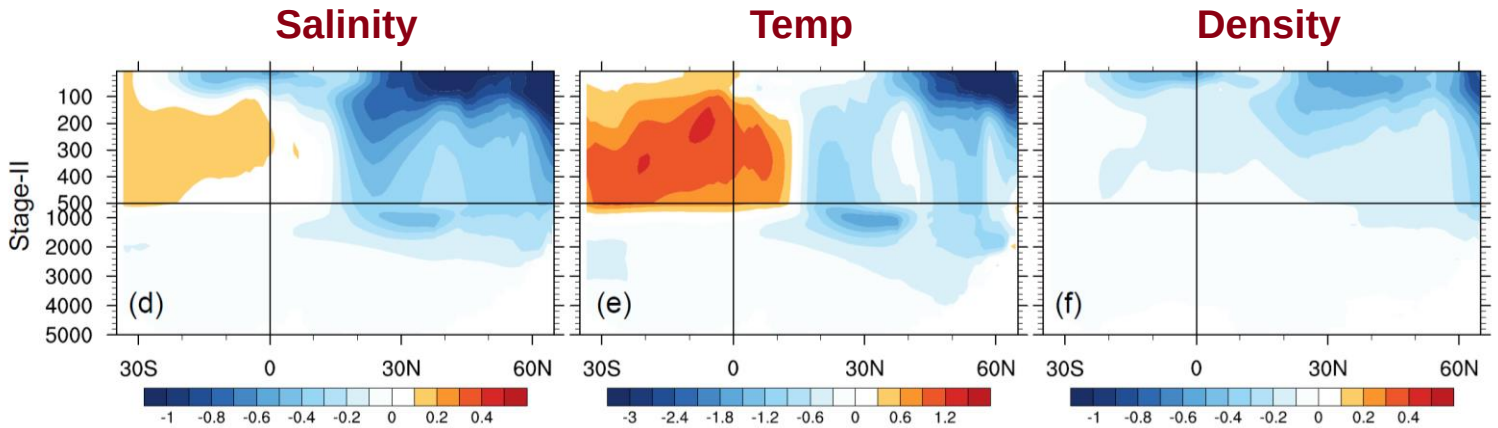
Atmosphere River



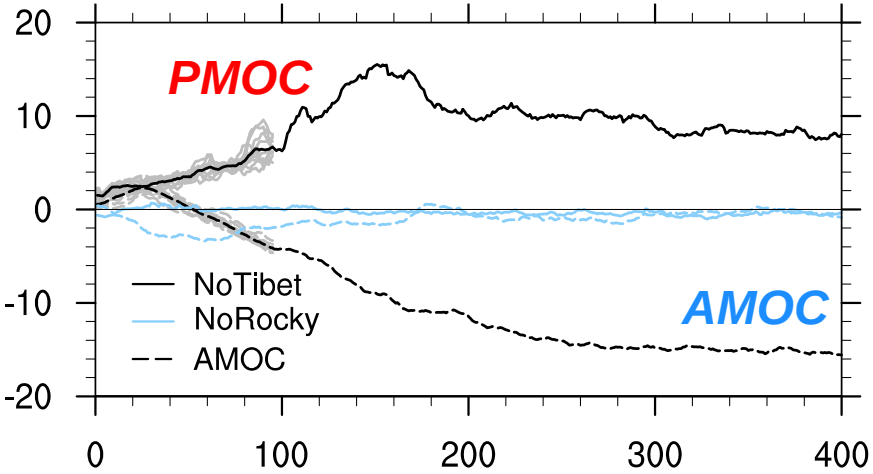
Ocean Change



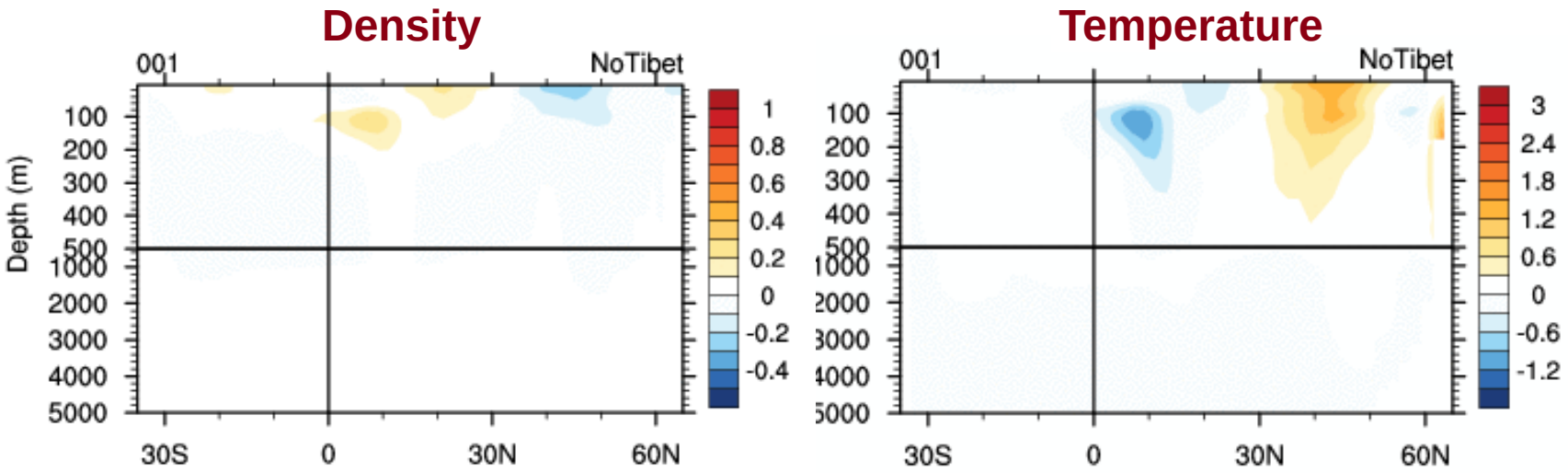
Ocean Change



AMOC vs. PMOC

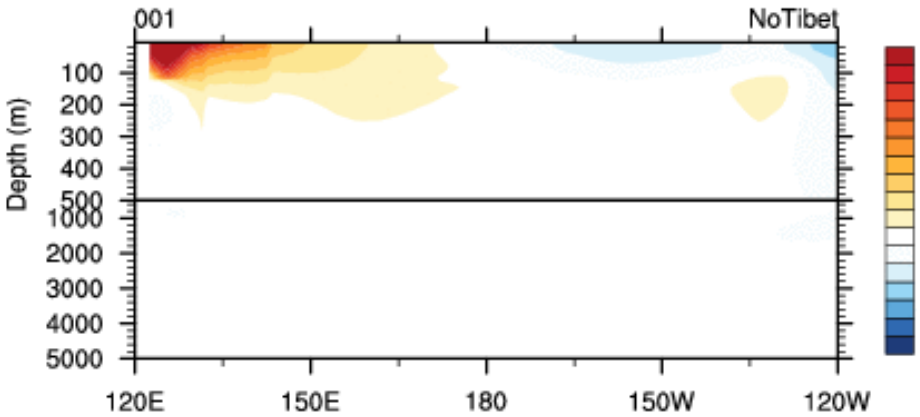


PMOC: Mechanism?

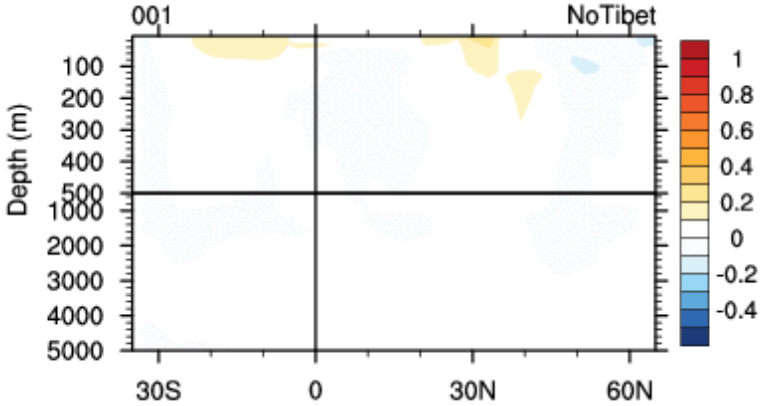


PMOC: *Salinity* Mechanism

Eastward



Southward & Downward



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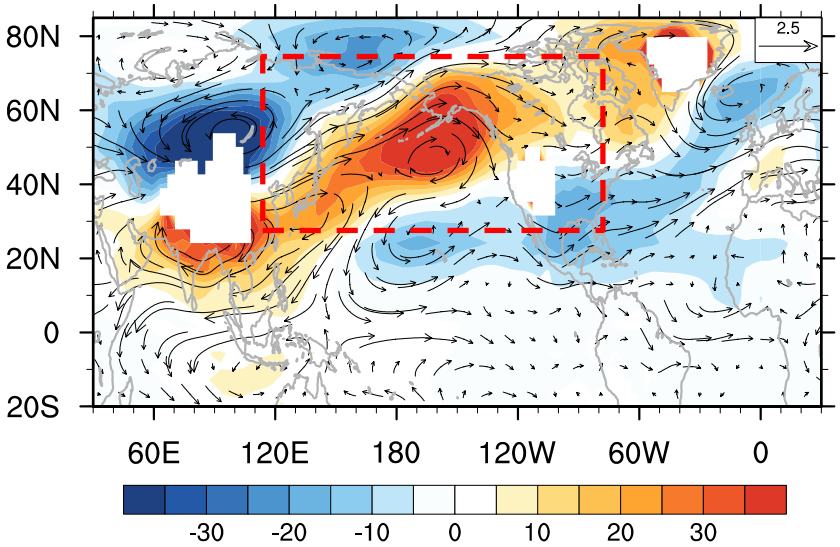
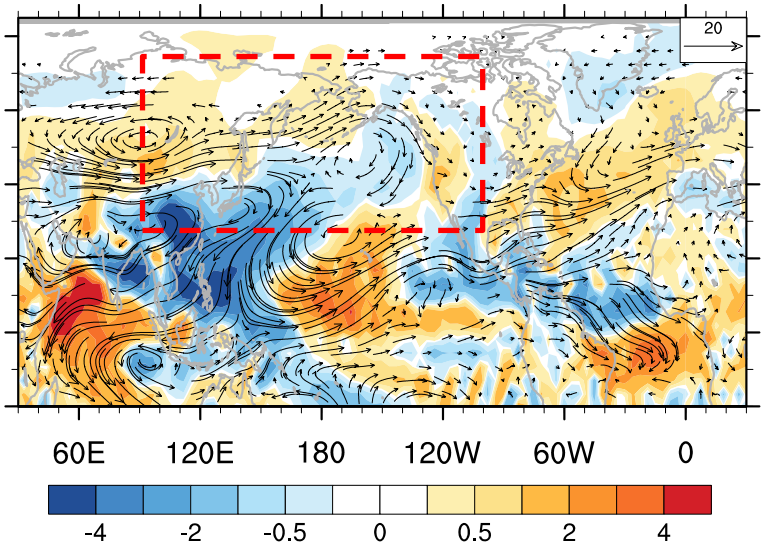
Atmospheric Changes

850 hPa GH and Winds



Moisture transport and divergence



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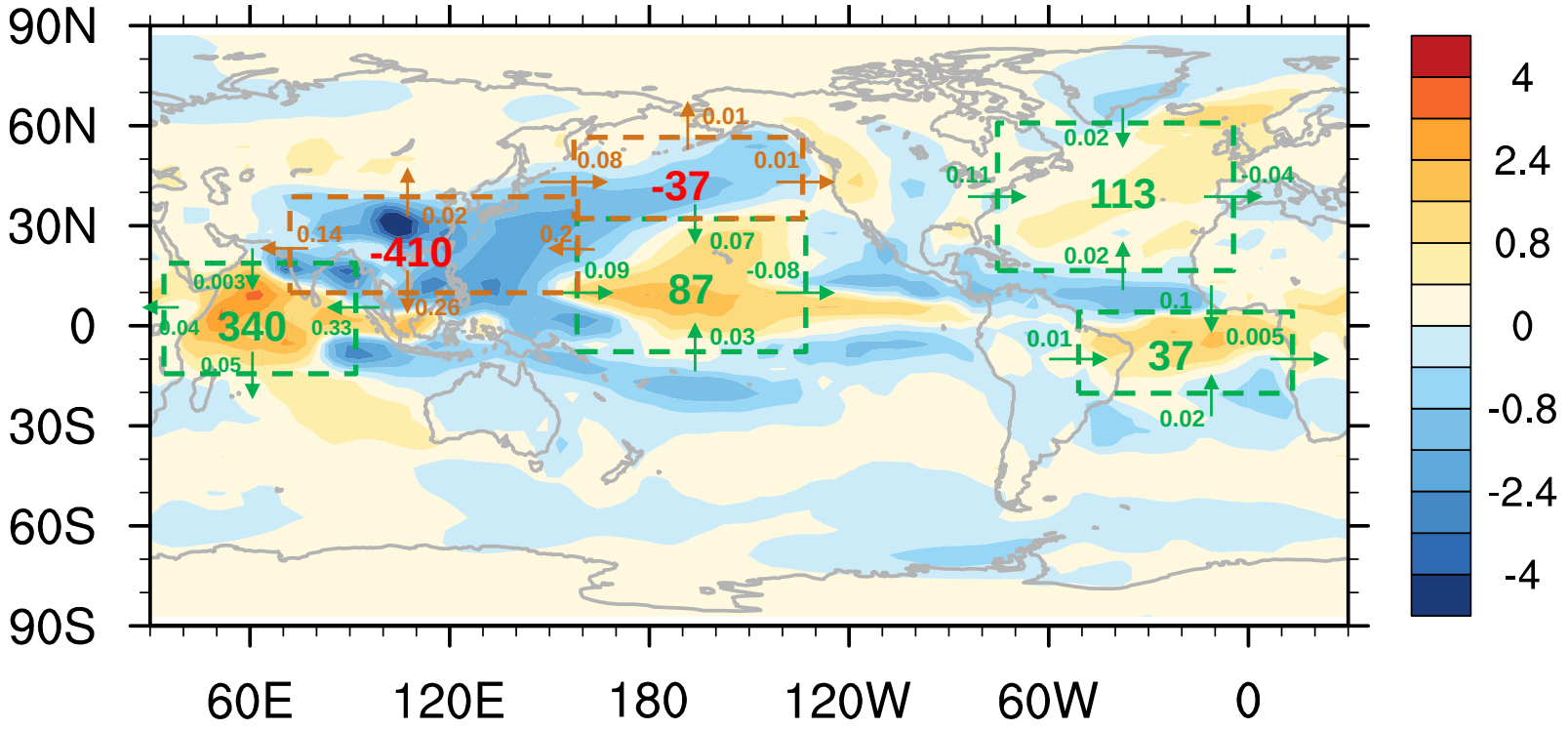
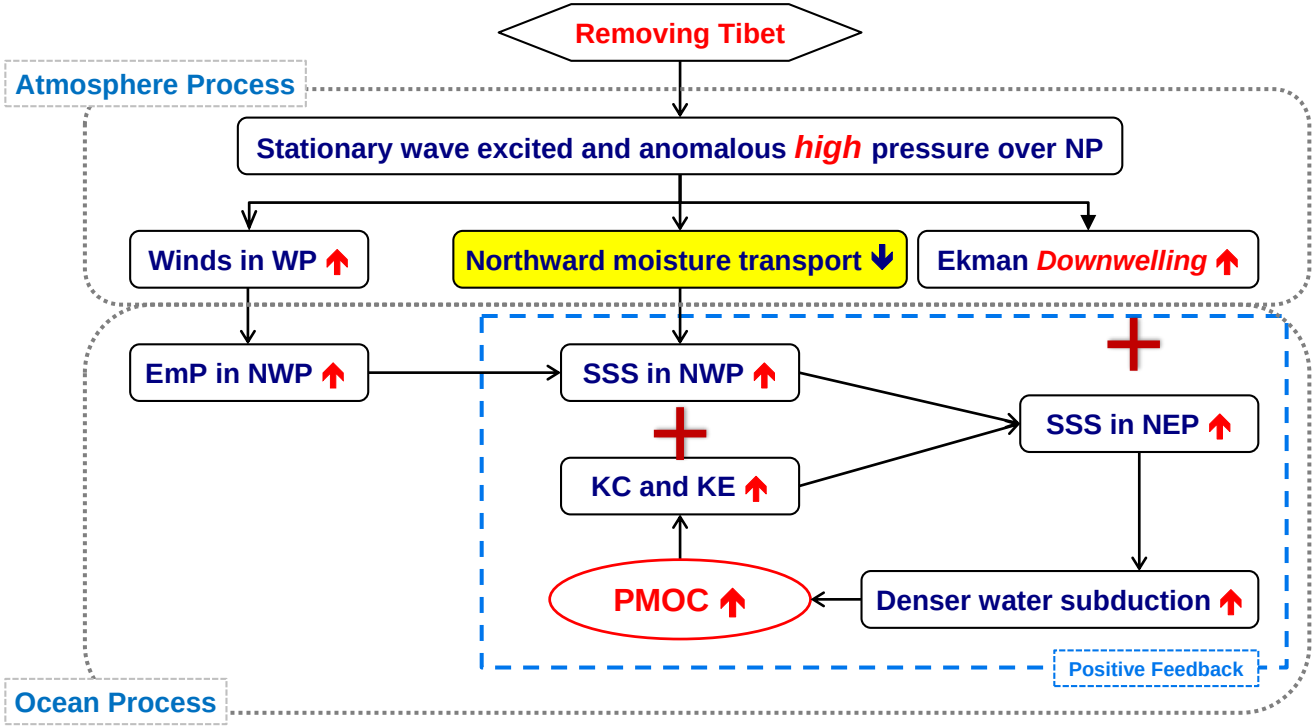
TP: Global Freshwater Budget

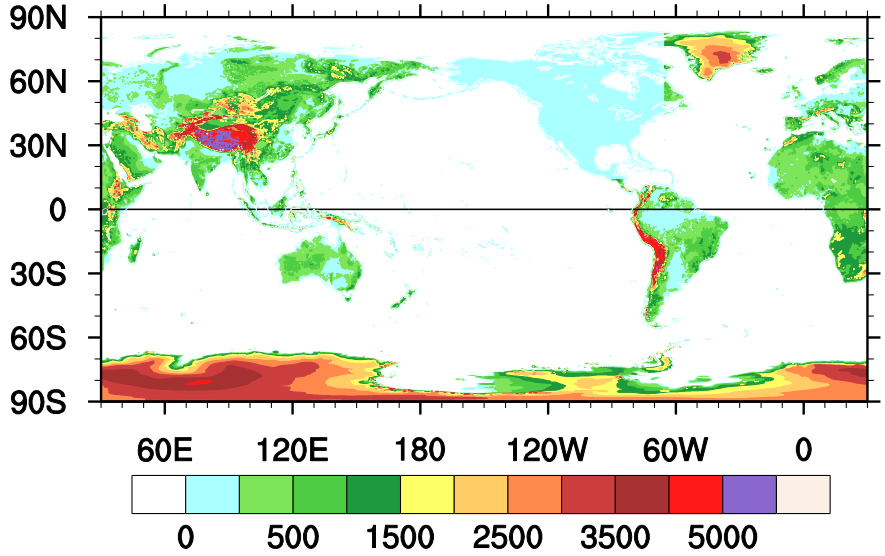


Water vapor transport across boundaries (Sv) and its convergence (mm/year)

Mechanism


Removing Tibet
Atmosphere Process
Stationary wave excited and anomalous high pressure over NP
Winds in WP
Northward moisture transport
Ekman Downwelling
EmP in NWP
SSS in NWP
SSS in NEP
KC and KE
PMOC
Denser water subduction
Positive Feedback
Ocean Process

Role of *Rocky* Mountain?



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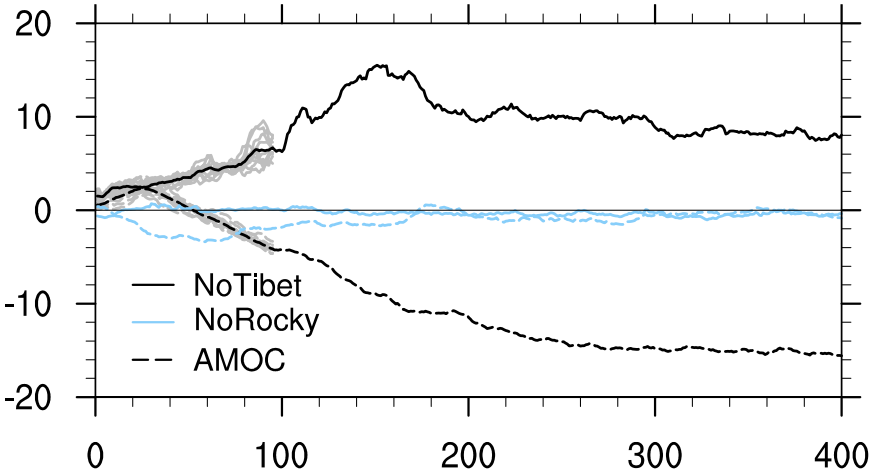
Rocky Mountain: No Role?

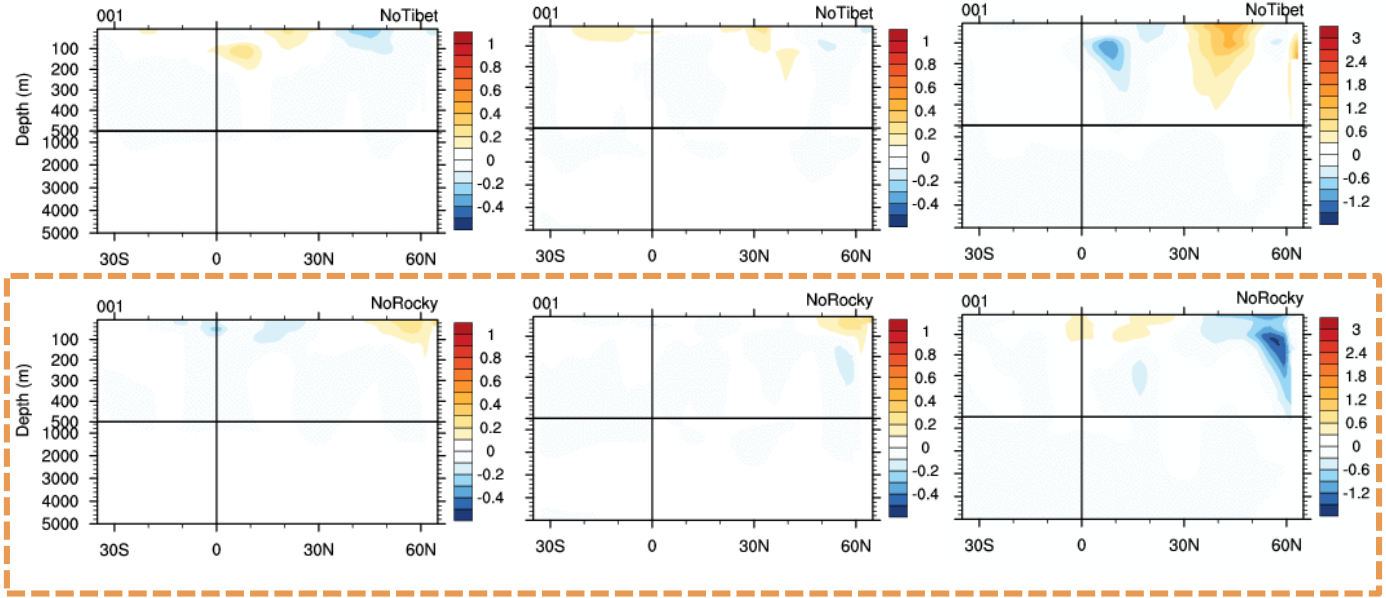


Rocky Mountain: No Role in MOC

Density **Salinity** **Temperature**

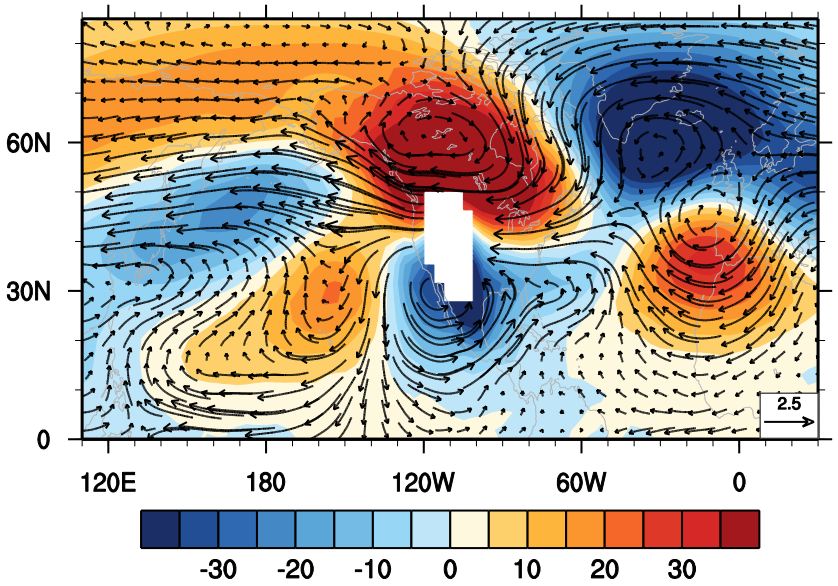
Tibet

Rocky

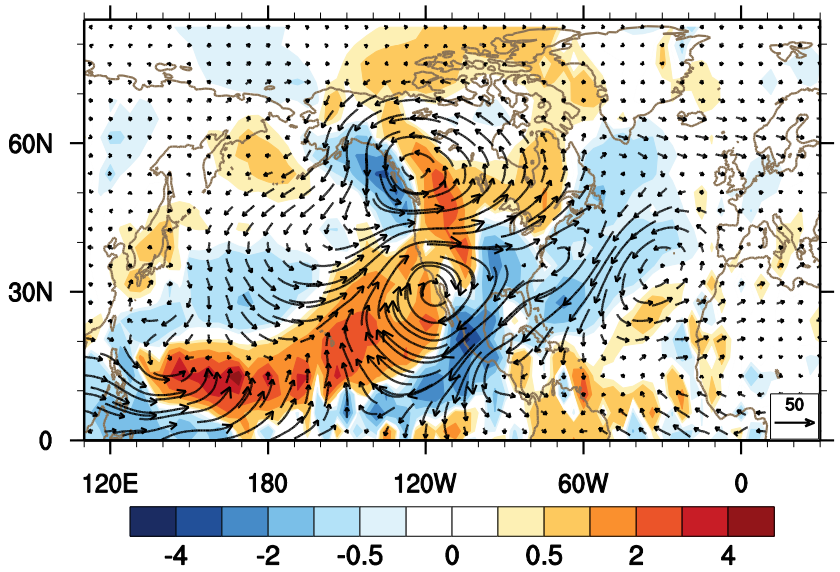


Atmospheric Changes

850 hPa GH and Wind



Moisture Transport



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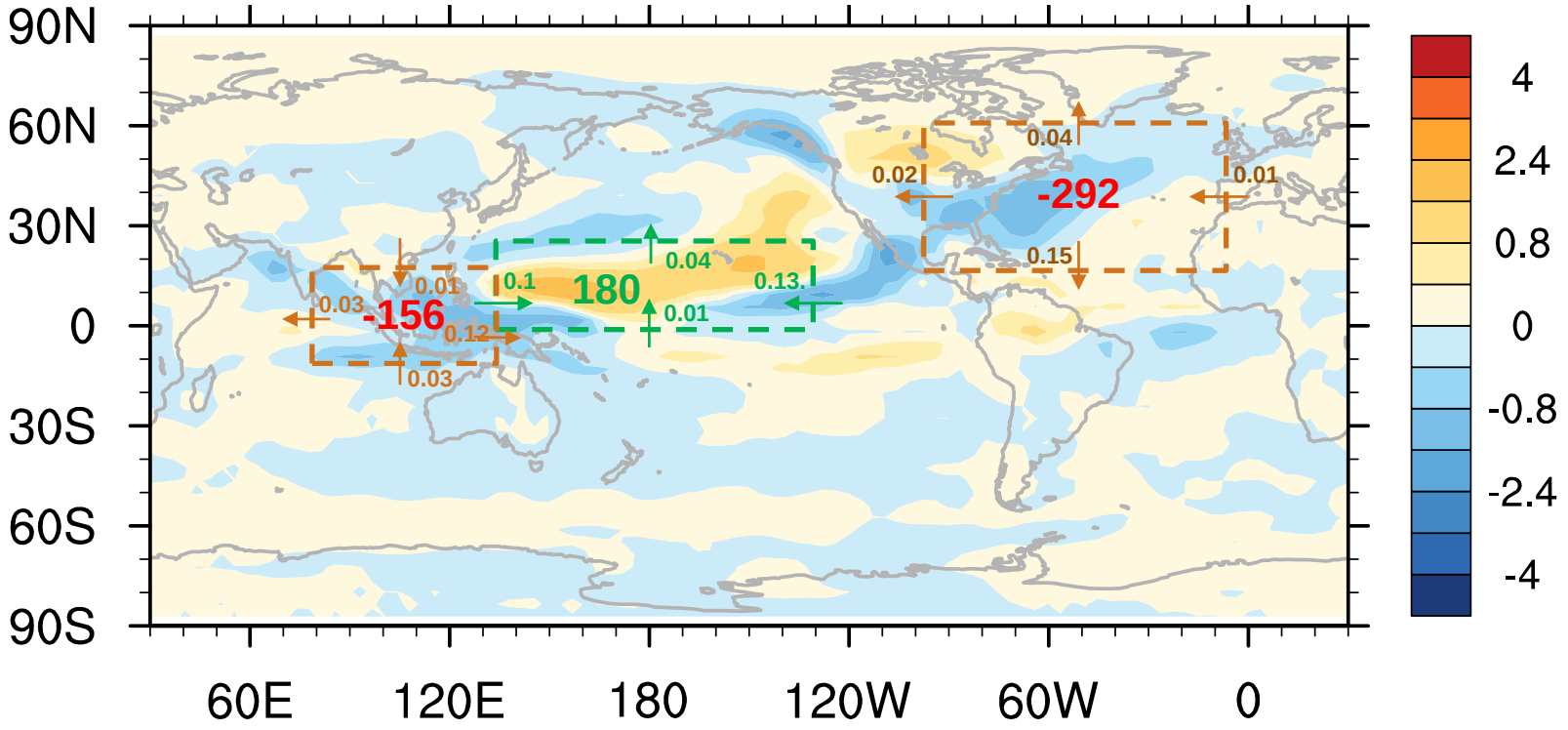
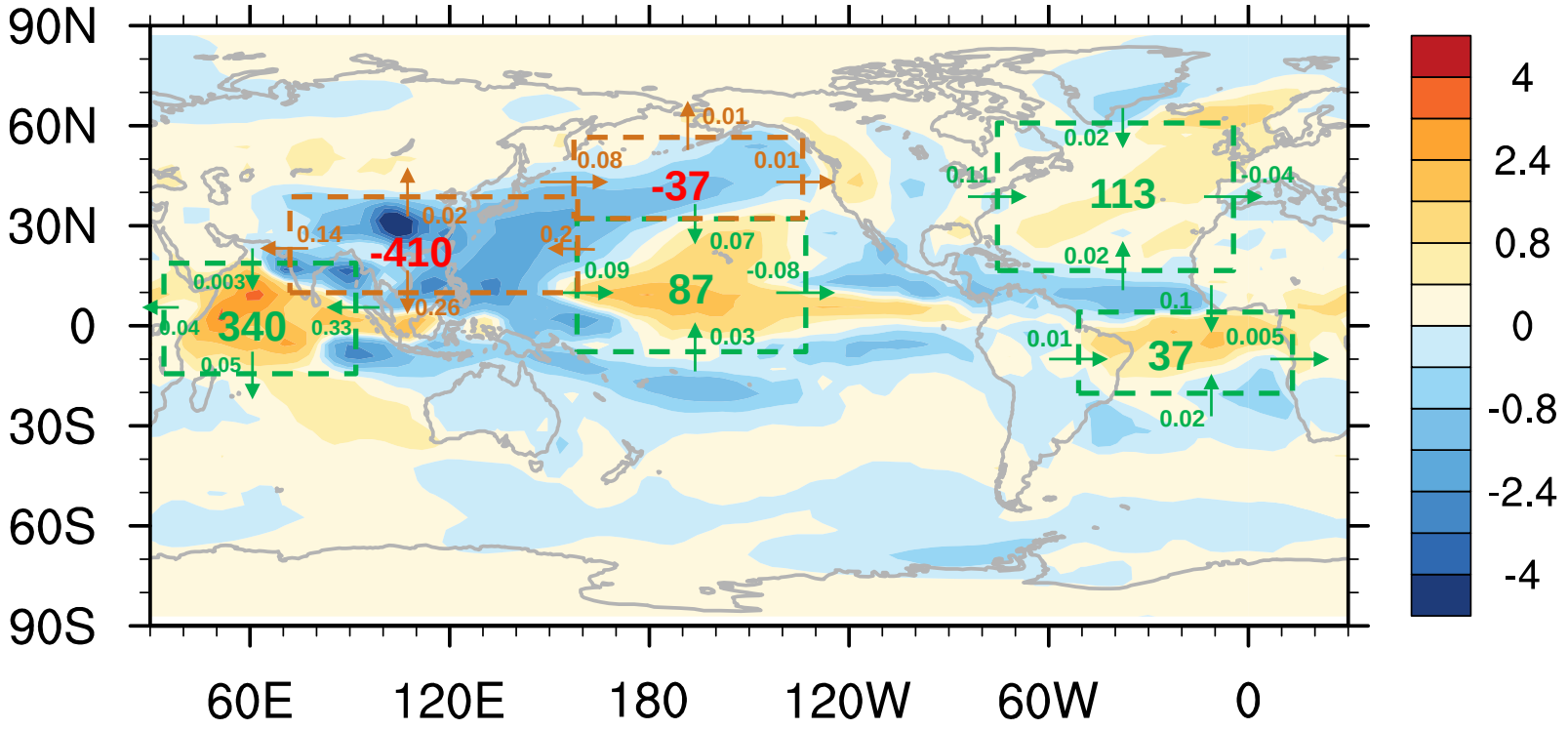
RM: Global Freshwater Budget



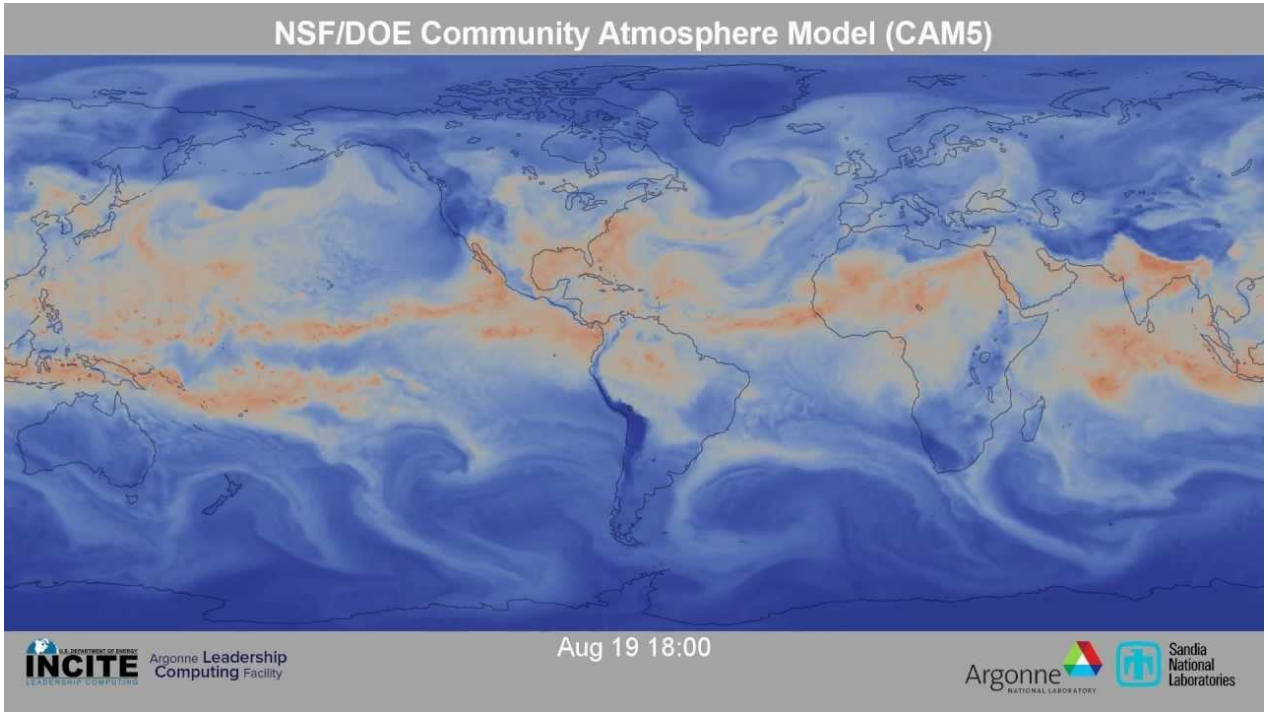
Water vapor transport across boundaries (Sv) and its convergence (mm/year)

TP: Global Freshwater Budget



Water vapor transport across boundaries (Sv) and its convergence (mm/year)

Atmosphere River



Summary

0 → 1 : Critical to AMOC, PMOC,

Energy and moisture transport

in / between SH and NH

1 → ∞ ……

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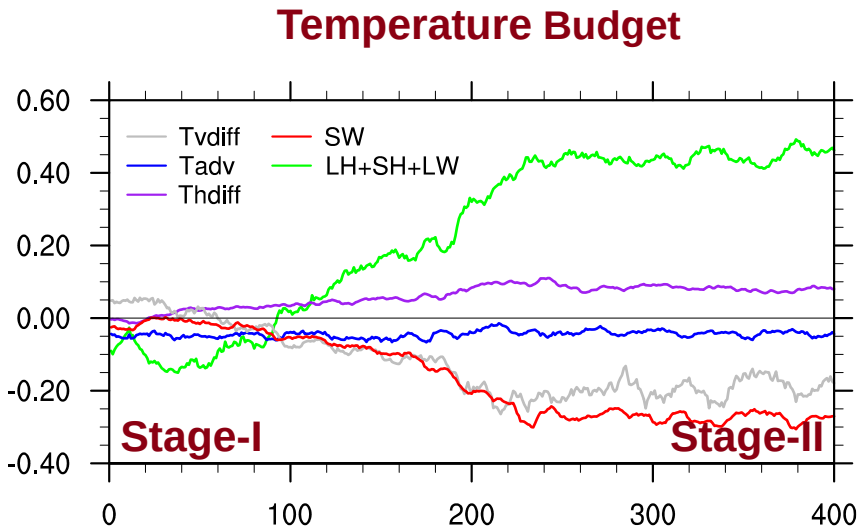
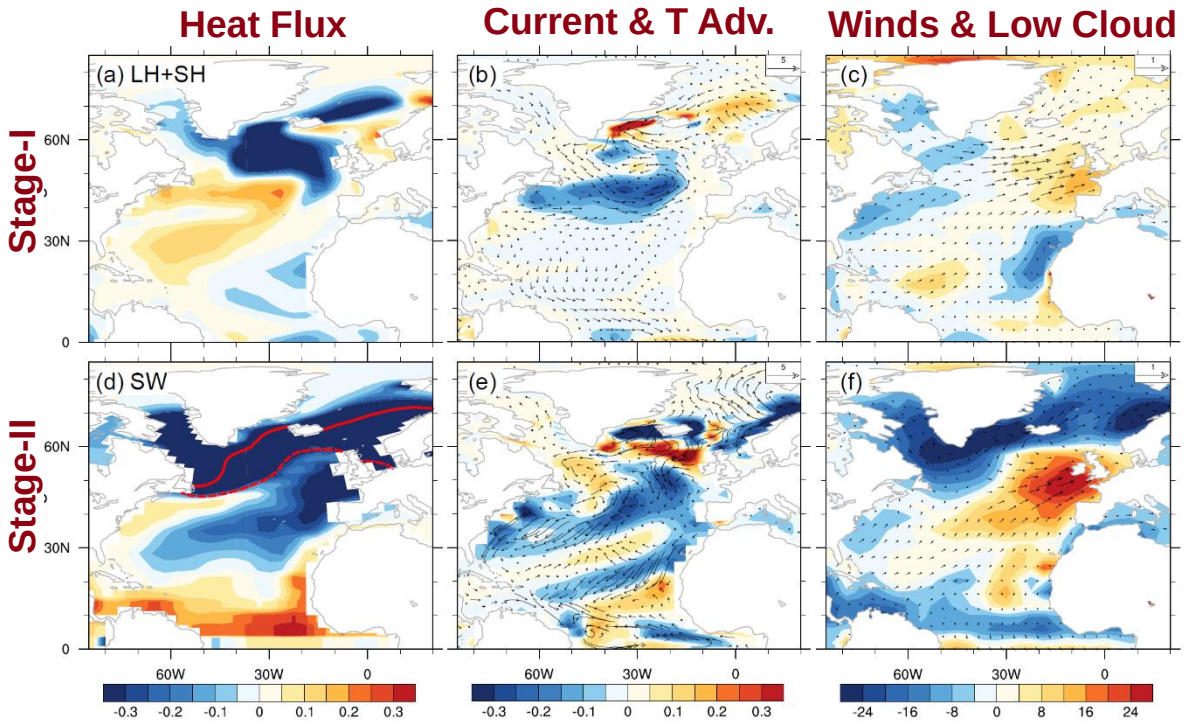
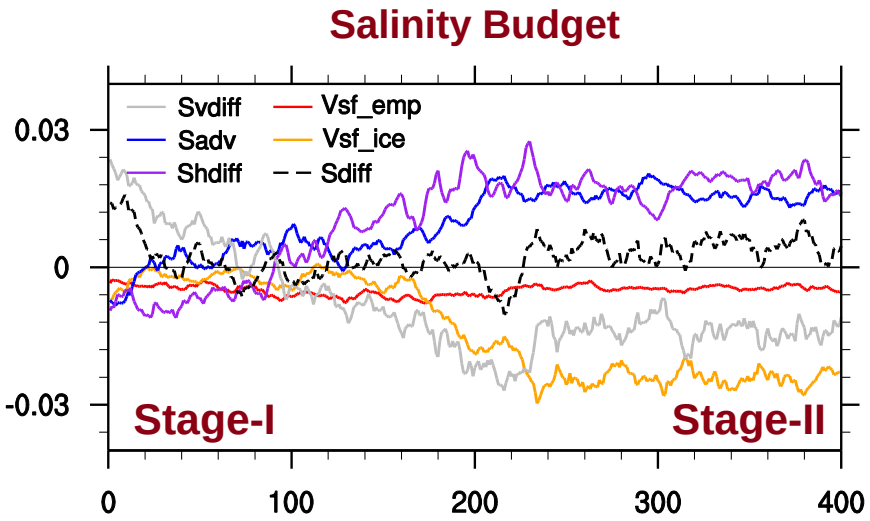
Mechanism for *Temp* Change



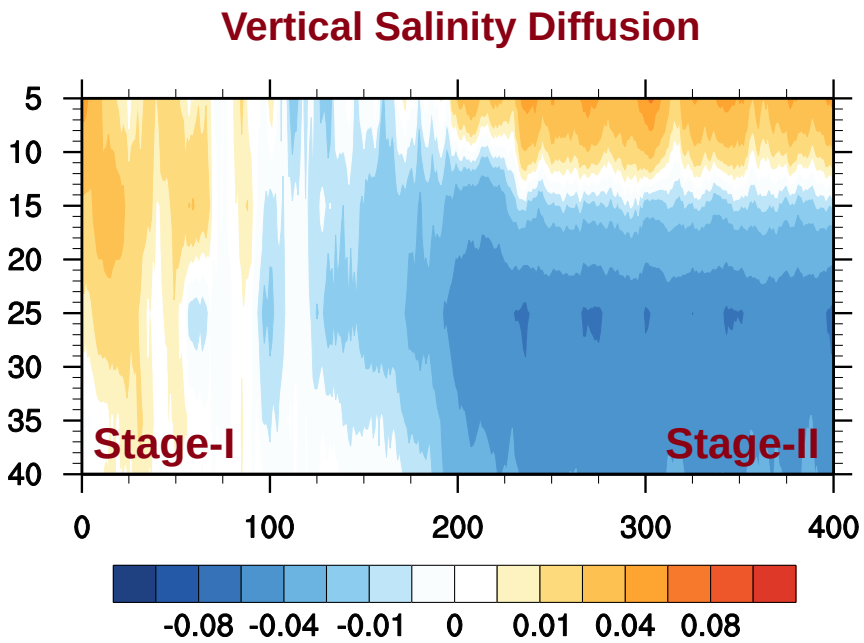
Mechanism for *Temp* Change



Mechanism for *Salinity* Change



Mechanism for *Salinity* Change



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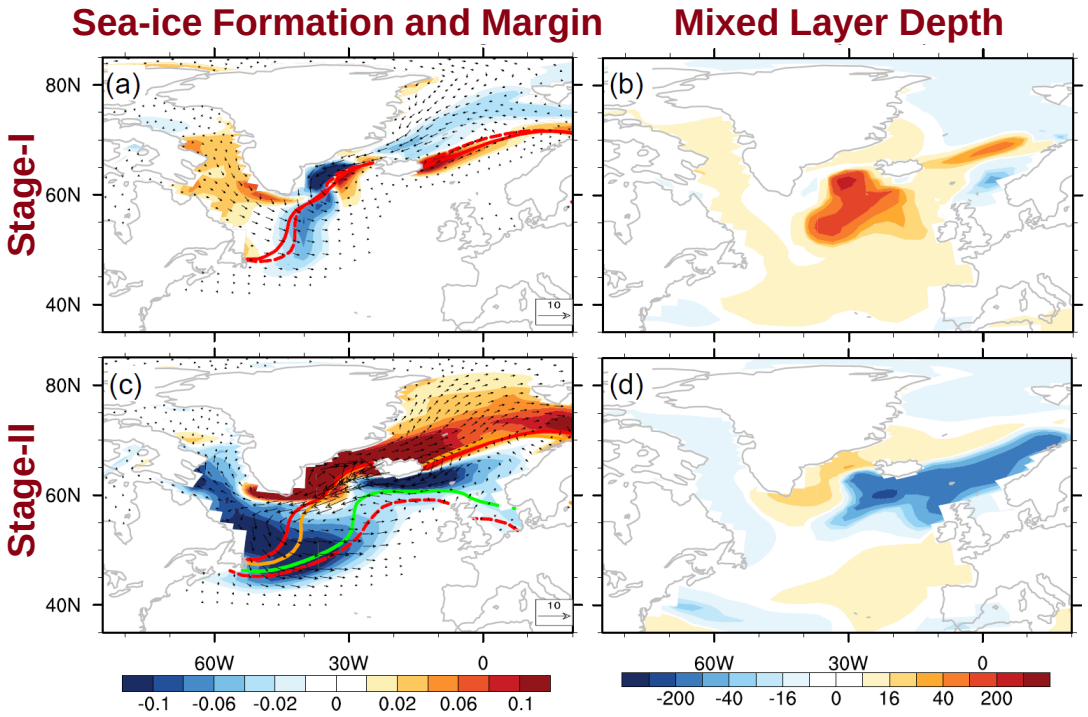
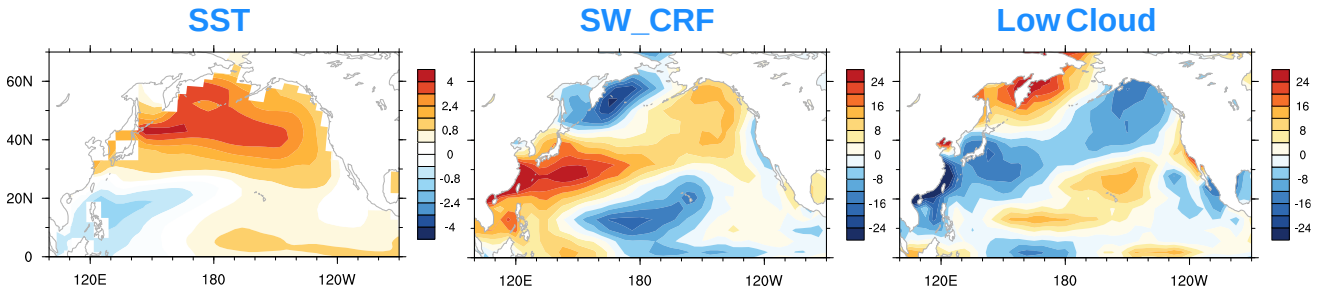
Mechanism for *Salinity* Change



SST Change



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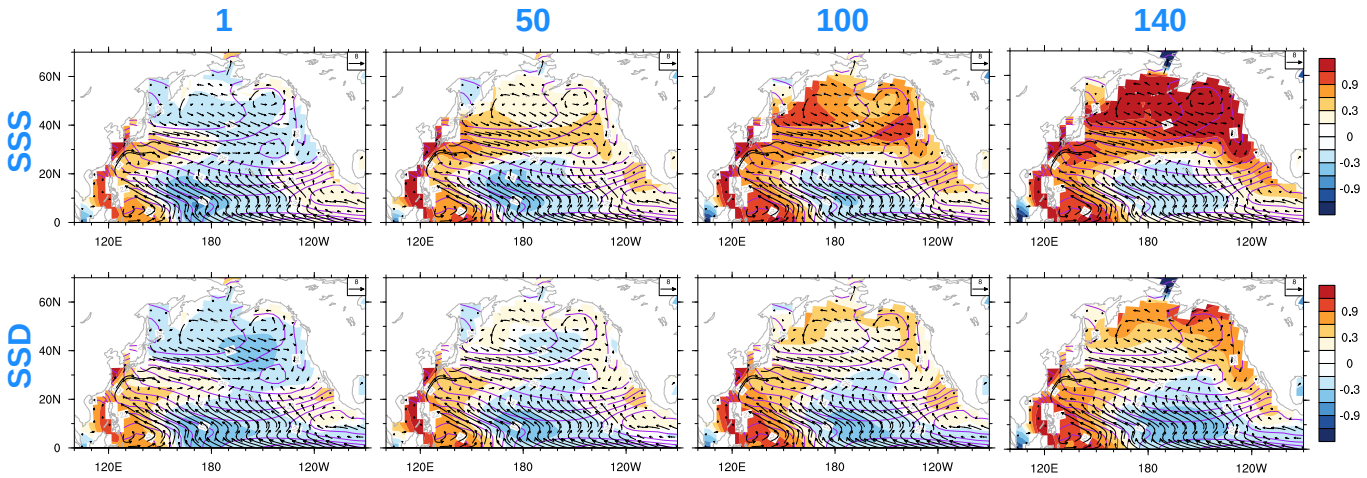
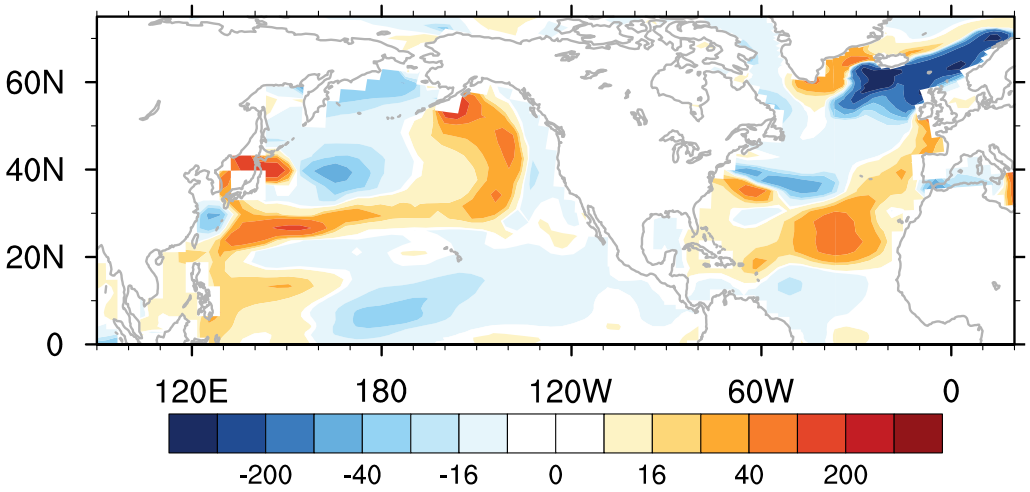
Surface Salinity and Density Changes



Mixed Layer Depth Change



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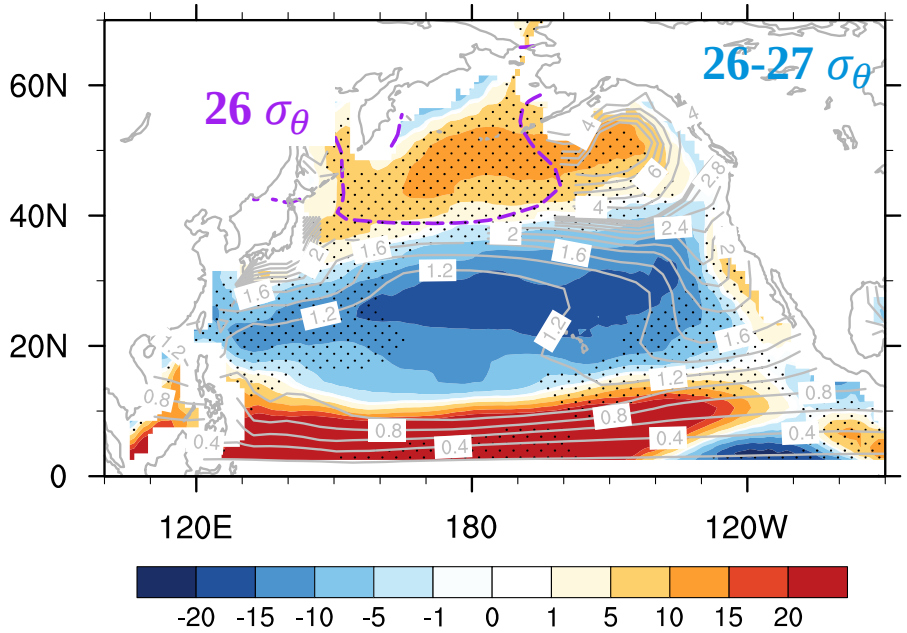
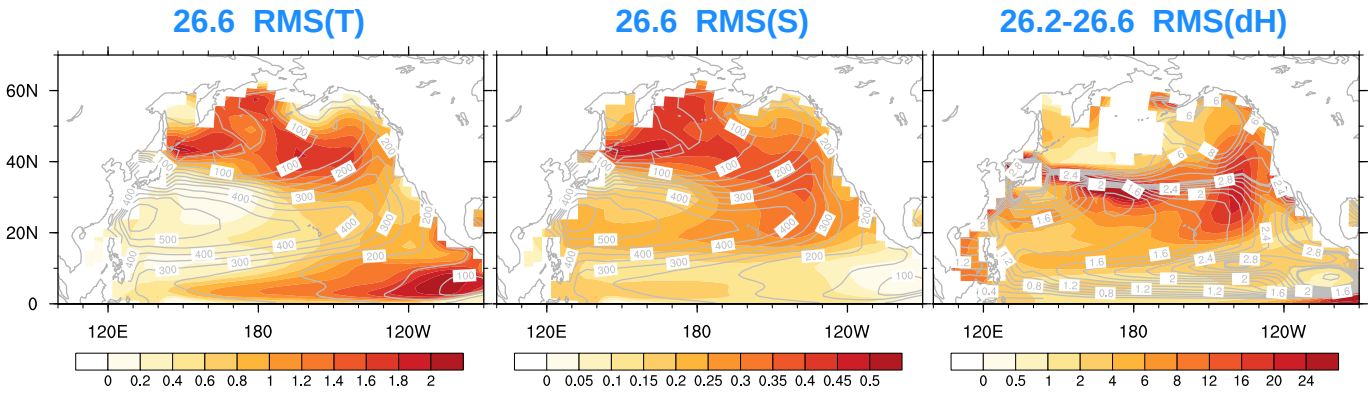
Ekman Pumping and PV



Black Dots: Enhanced Ekman Downwelling

RMS of *Temp*, *Salinity* and *Thickness*



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Salinity Subduction