Shutdown of the Atlantic Thermohaline Circulation
and its Impact on North Pacific Climate

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Abrupt Climate Changes in Paleorecord

These millennial variations in global climate are related to sudden changes in the Atlantic thermohaline circulation.
Coupled GCM Hosing Experiments (CMIP/PMIP)

Freshwater flux anomaly in the North Atlantic (50-70N) (1Sv X 100 yrs; ~9m increase in sea level)
Stouffer et al. (2006)

Thermohaline Circulation Intensity

1Sv hosing

Yr 20

Yr 100
CGCM Response to THC Shutdown (Yr 71-100, Oct-Feb)

SST/TS (1K), Rain (-1, +1mm/day), Wind stress (N/m²)

CCSM2

GFDL CM2.1

ECHAM5-OM1

HadCM3
Oceanic and Atmospheric Teleconnections

- Bering Strait throughflow
- Annular Mode
- Rossby waves
Oceanic Teleconnections: Role of Bering Strait

SST (1K), Rain (-1, +1mm/day), SLP (1hPa), Yr 71-100, Oct-Feb

Oceanic teleconnection (Aixue Hu)

Atmospheric teleconnection + Air-sea interaction
Atmospheric Teleconnections: Role of Atlantic SSTAs

TS (1K), Rain (-1, +1mm/day), SLP (1hPa), CAM2: Yr 1-30, Oct-Feb

CCSM2: 1Sv freshwater

CAM2: North Atlantic SST'+Ice'

CAM2: Atlantic SST'+Ice'

CAM2: Tropical Atlantic SST'
Atmospheric teleconnections via Tropical Pacific

**Mixed Layer Model**

**TS (1K), Rain (-1, +1mm/day), SLP (1hPa), CAM2-MLM: Yr 1-20**

CCSM2: 1Sv freshwater

CAM2-MLM: Tropical Atlantic SST′
Atmospheric Teleconnections from the Tropical Atlantic: Sensitivity to Mean Convection

SST (1K), Rain (-1, +1mm/day), SLP (1hPa), CAM2: Yr 1-30, Oct-Feb

CAM2: Tropical Atlantic SST’

CAM2: Tropical Atlantic SST’ + HadSST

CAM2: CCSM2 SST

CAM2: HadSST

< 2mm/day

2-4mm/day
Summary

• In response to a shutdown of the Atlantic THC, CGCMs predict deepening of the wintertime Aleutian low and SST cooling along the oceanic frontal region in the North Pacific.

• This Atlantic-North Pacific connection is caused by both oceanic and atmospheric teleconnections:
  
  • For oceanic teleconnections, the reversal of Bering Strait throughflow causes significant cooling in the North Pacific.
  
  • For atmospheric teleconnections, the southward shift of the Atlantic ITCZ acts to deepen the Aleutian low.
  
  • This tropical Atlantic-N Pacific teleconnection is sensitive to the mean convection in the tropical North Atlantic, which many CGCMs underestimate.
  
  • The southward shift of the Atlantic ITCZ may trigger changes in tropical Pacific convection that further deepens the Aleutian low.
Vertical Structure of Geopotential Height Anomalies

CCSM2
1Sv freshwater

CAM2
Atlantic SST’+Ice’

CAM2
Tropical Atlantic SST’

CAM2
North Atlantic SST’+Ice’

200hPa (10m)

1000hPa (5m)
Atmospheric Teleconnections

[CCSM2: 1Sv] - [CAM2: Atlantic SST' + Ice']

200hPa (10m)

1000hPa (5m)

[CCSM2 1Sv] - [CAM2 Atlantic]
Atlantic–N Pacific Connection in Paleoclimate? 

Greenland temperature

Harada et al. (2006)
Multi-decadal (~70 yrs) oscillation in proxy-based SST

Delworth and Mann (2000)