The AMOC’s role in the changing relative importance of the North Atlantic and Southern Ocean in anthropogenic ocean heat uptake

Jia-Rui Shi, Shang-Ping Xie, Lynne D. Talley
Scripps Institution of Oceanography, UCSD

2018 International AMOC Science Meeting, July 26

CMIP5 multimodel mean: Cumulative heat uptake between 1870 to 1995.

Southern Ocean (south of 30°S) accounts for \(75\% \pm 22\%\) of global ocean heat uptake over the historical period. (Frolicher et al. 2015)

Background:

The Southern Ocean currently accounting for most of the global (anthropogenic) ocean heat uptake.

Simulation:
Most of heat gain (67%~98%) occurred in the S.H. extratropical ocean (south of 20°S)
How does the AMOC affect the regional OHU in response to the anthropogenic radiative forcings?

Q: Does the GHG determine the response pattern of ocean heat uptake over the historical period?
Response of surface heat flux:

Ensemble mean of 9 CMIP5 models:

GHG (1861-2005)

Historical (1861-2005)

Area-integration over:

NA: 30°N-70°N, 80°W-10°W
SO: south of 30°S

Cumulative Heat Uptake over the 20th century:

NA: 24%±11%
SO: 45%±10%

NA: 6%±39%
SO: 72%±28%
Response of surface heat flux:

Ensemble mean of 9 CMIP5 models:
Response of surface heat flux:

Ensemble mean of CMIP5 models:

Zonally integrated heat flux trend
Response of surface heat flux:

Ensemble mean of CMIP5 models:

Zonally integrated heat flux trend
Ocean circulation impact:

NA: the AMOC change


Regression maps of the North Atlantic (a) SST and (b) surface heat flux (Qnet) anomalies on the AMOC intensity.
Future projections:

In future projections, will the ocean heat uptake pattern be similar with that in the Historical runs?
Future projections:

Ensemble mean of CMIP5 models:

**Surface heat flux trend**

![Graph showing surface heat flux trend with RCP4.5 and RCP8.5 scenarios.](image-url)
Historical vs RCPs:

AMOC

rated heat flux

Heat

Historical

RCP8.5
### Contribution to global ocean heat uptake

<table>
<thead>
<tr>
<th>Cumulative OHU (ZJ)</th>
<th>Historical</th>
<th>RCP4.5</th>
<th>RCP8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO/Global</td>
<td>190±81 (72%)</td>
<td>829±145 (52%)</td>
<td>1187±208 (48%)</td>
</tr>
<tr>
<td>NA/Global</td>
<td>16±82 (6%)</td>
<td>443±114 (28%)</td>
<td>632±115 (26%)</td>
</tr>
</tbody>
</table>

The relative importance of SO & NA vary between Hist/RCPs:

**different spatial distributions and trajectories of GHG and aerosol radiative forcing.**
Contribution of declining aerosol:

**Simulations:**

A) **LENS**: Large Ensemble from CESM (1920 - 2100, Historical & RCP8.5)

B) **2005Aero**: RCP8.5 with anthropogenic aerosol emissions fixed at 2005-level
**Simulations:**

A) **LENS**: Large Ensemble from CESM (1920 - 2100, Historical & RCP8.5)

B) **2005Aero**: RCP8.5 with anthropogenic aerosol emissions fixed at 2005-level

---

**Contribution of declining aerosol:**

**NA heat uptake (2006-2100):**

\[712 \pm 22 \text{ ZJ} \Rightarrow 503 \pm 17 \text{ ZJ}\]  (decrease by 29%)

\(~15\%\) of global heat uptake is attributed to declining aerosol.
Future projections: 2015-2100

Summary:

1. The AMOC change in response to the anthropogenic radiative forcing is associated with the North Atlantic heat uptake by affecting the meridional heat advection.

2. Less aerosols and higher GHG concentrations will weaken the circulation and strengthen the heat uptake in the North Atlantic, which will join the Southern Ocean into the future as a major repository of anthropogenic heat.