The robustness of the Atlantic meridional overturning circulation (AMOC)

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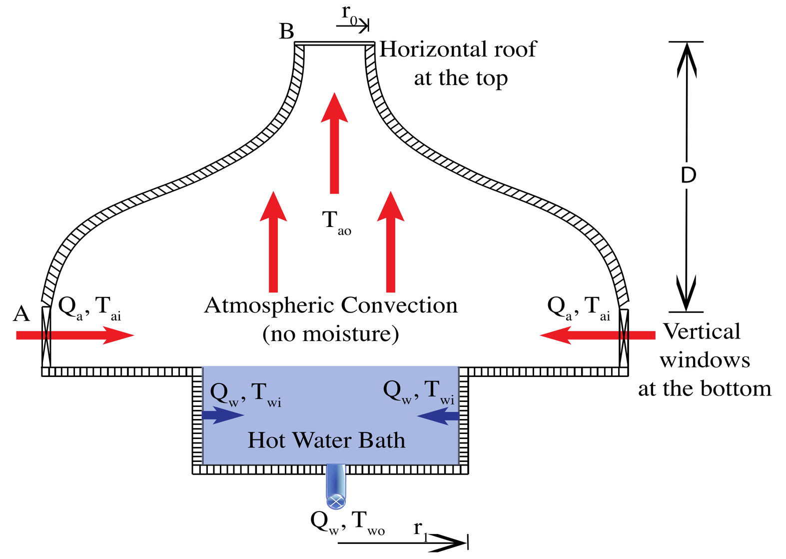
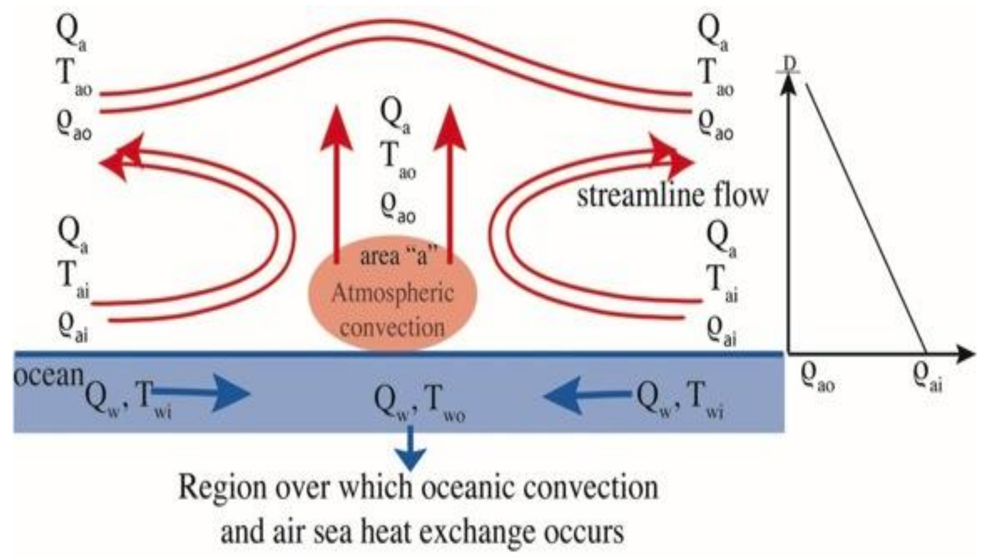
Introduction

The Intergovernmental Panel on Climate Change Fourth Assessment report (2007) concluded that it is “very likely” that there will be a slowdown of the AMOC. The 11 models used in the IPCC rely on reducing the AMOC transport using the familiar ‘‘hosing’’ procedure, i.e., adding freshwater to the surface of the North Atlantic, which reduces the salinity and, hence, the sinking rate. Using buoyancy driven convection equations for the atmopshere and bulk formulas for heat fluxes, we examine the atmospheric and oceanic temperature changes that result from a slowing down of an idealized AMOC. We find that there is a realistic regime, which we call a “saturation state”, where it does not matter what reductions in transport the AMOC suffers, the changes in the atmosphere are minimal. Specifically, even for a significant (50%) reduction in the AMOC transport, there is a small, almost meaningless, atmospheric and oceanic cooling which is associated with both a small reduction in the atmospheric transport and the heat flux from the ocean to the atmosphere.

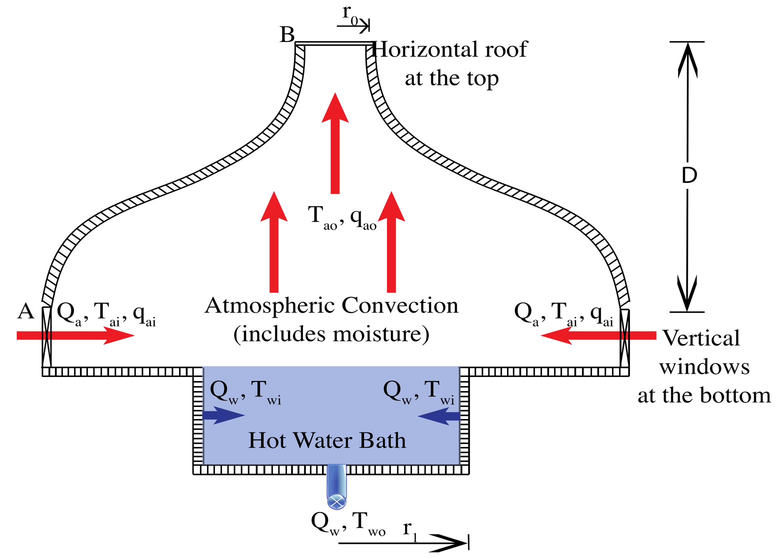
Four conceptual models



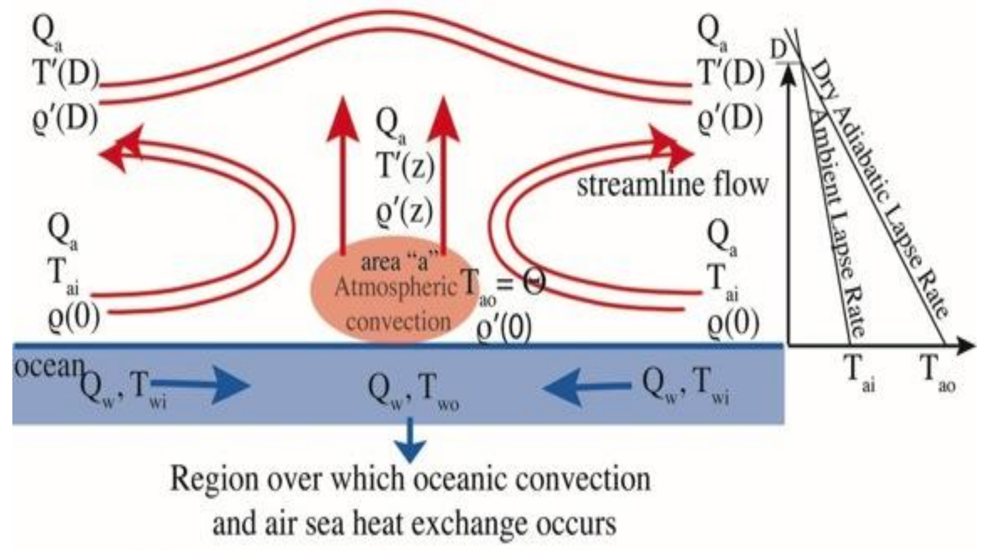
Hot spring model without moisture



Incompressible atmosphere ocean convection model



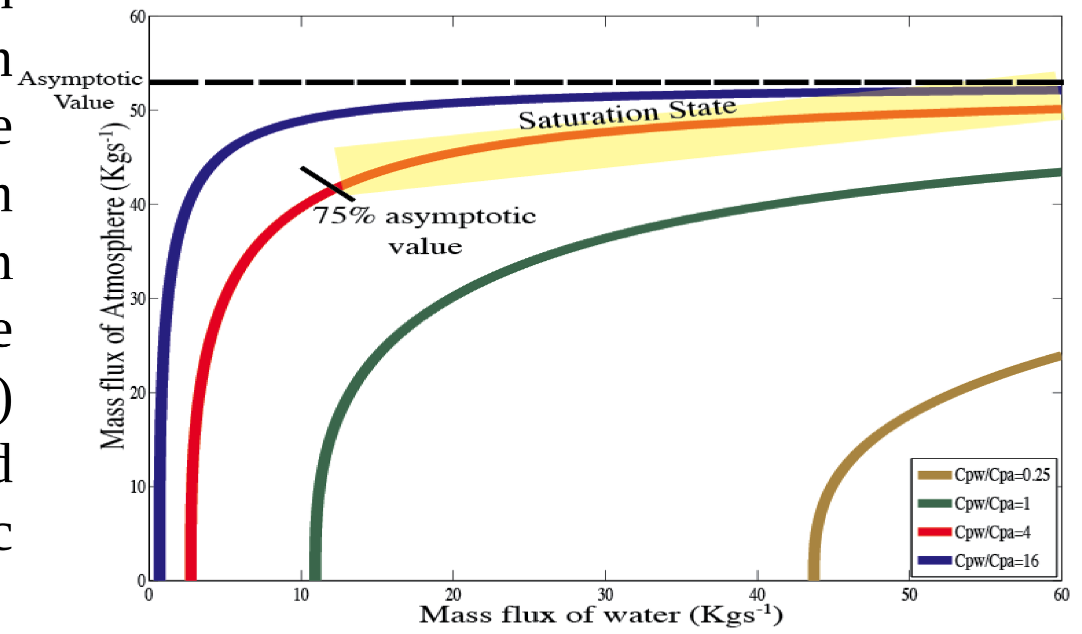
Hot spring model with moisture



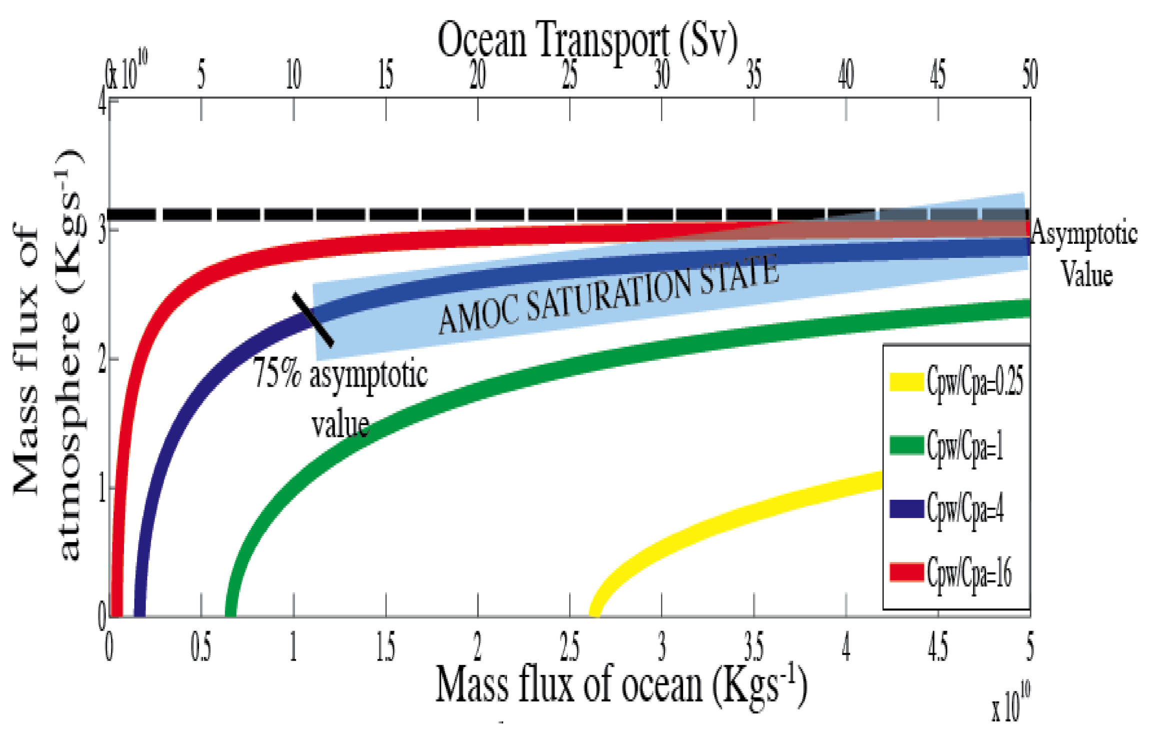
Compressible atmosphere ocean convection model

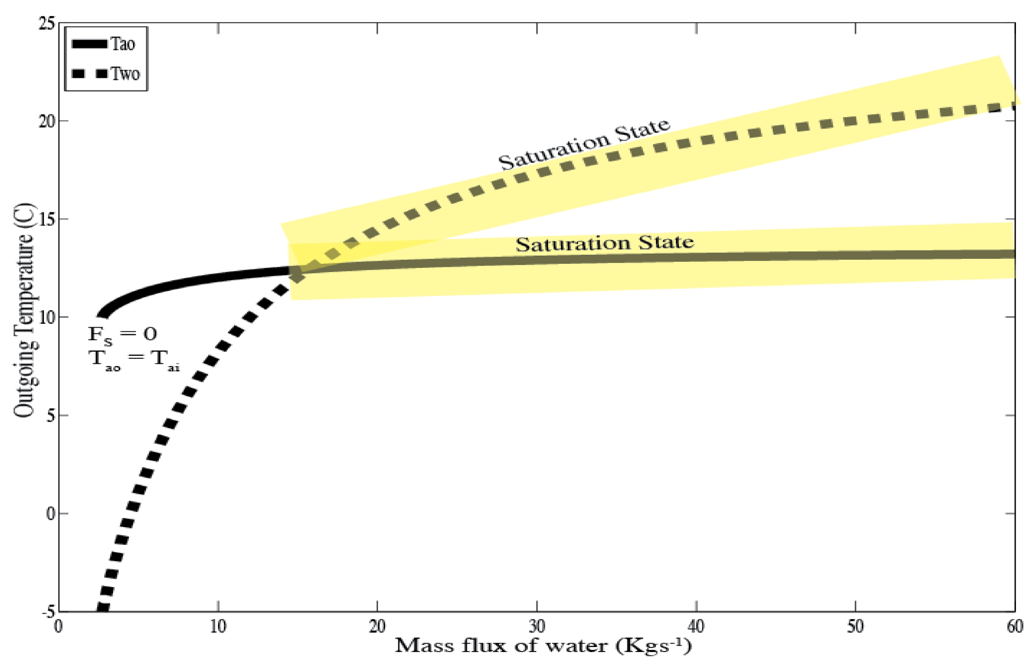
Results

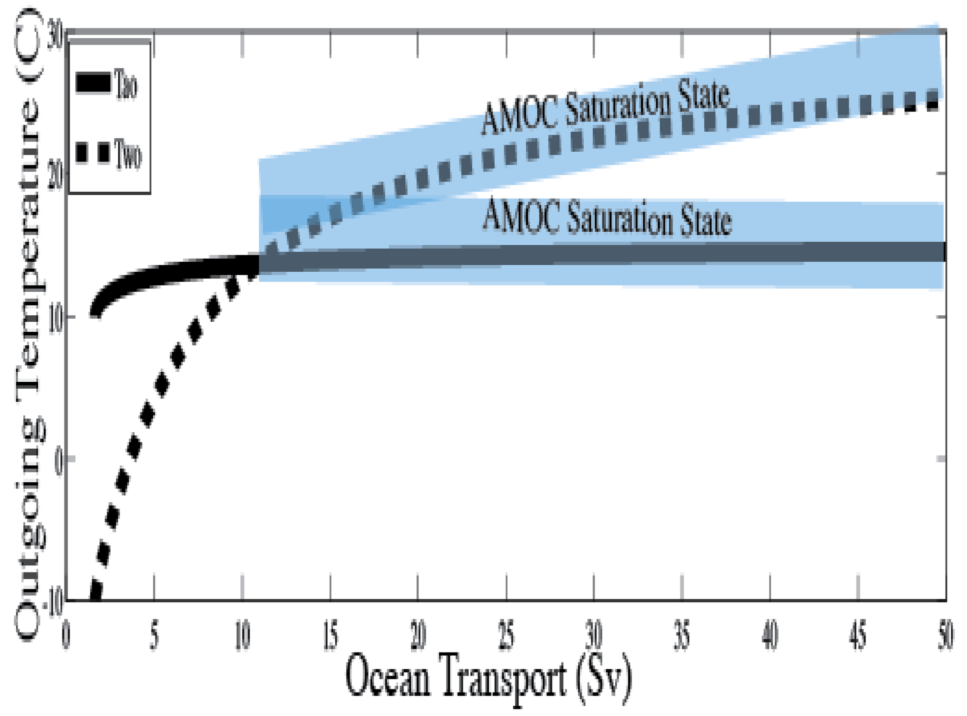
Hot spring model without moisture

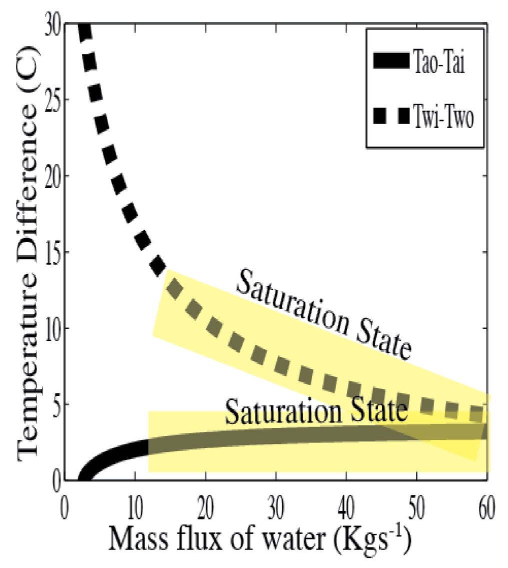


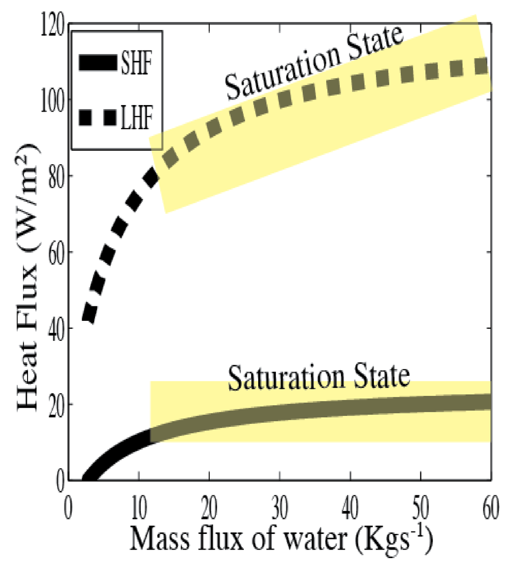
Compressible atmosphere ocean convection model

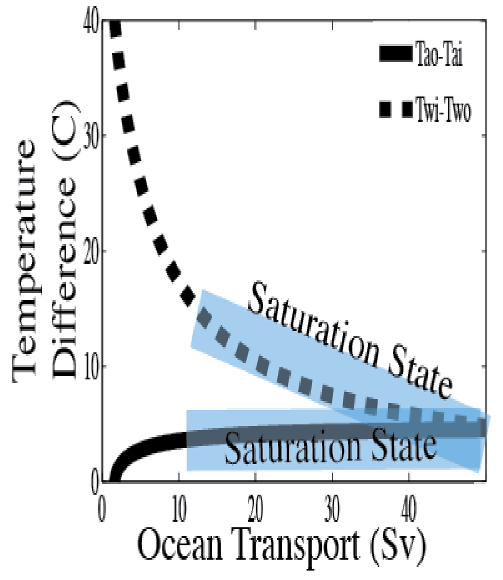


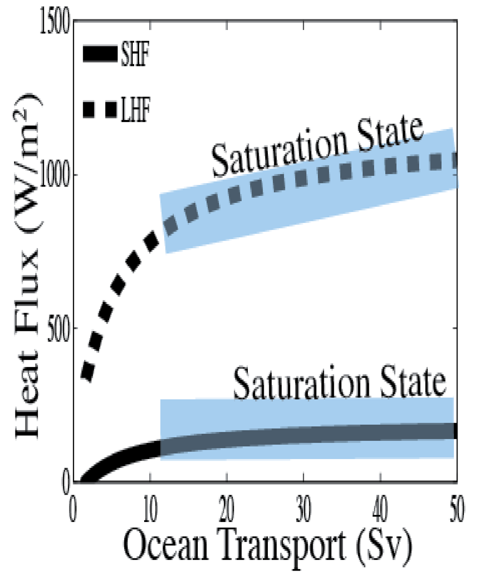












Discussion and Summary

Saturation State

- Non-linear dependence of atmospheric mass transport on the transport of water
- The dependence of atmospheric transport on the large specific heat capacity ratio of water to air (~4)
- The fact that ocean is warmer (by 10-20 degrees) than the air
- The observation that the heat-flux is usually proportional to the temperature difference between the ocean and the air

References

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Sandal C, Nof D. 2008. A new analytical model for Heinrich events and climate instability. J. Phys. Oceanogr., 38: 451–466.

Acknowledgements

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