Bjerknes compensation in the IPSL-CM6A-LR model

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Motivation

In an equilibrium climate the ocean and atmospheric heat transports are of the same magnitude and opposite signs, which is known as Bjerknes compensation (BJC). BJC is a central hypothesis in climate sciences with numerous applications but it's difficult to observe. In this study we use the 2000 years piControl experiment of the IPSL-CM6A-LR model to improve BJC diagnostics, to analyse its dependence on time scales and the involved dynamics.

BJC diagnostics

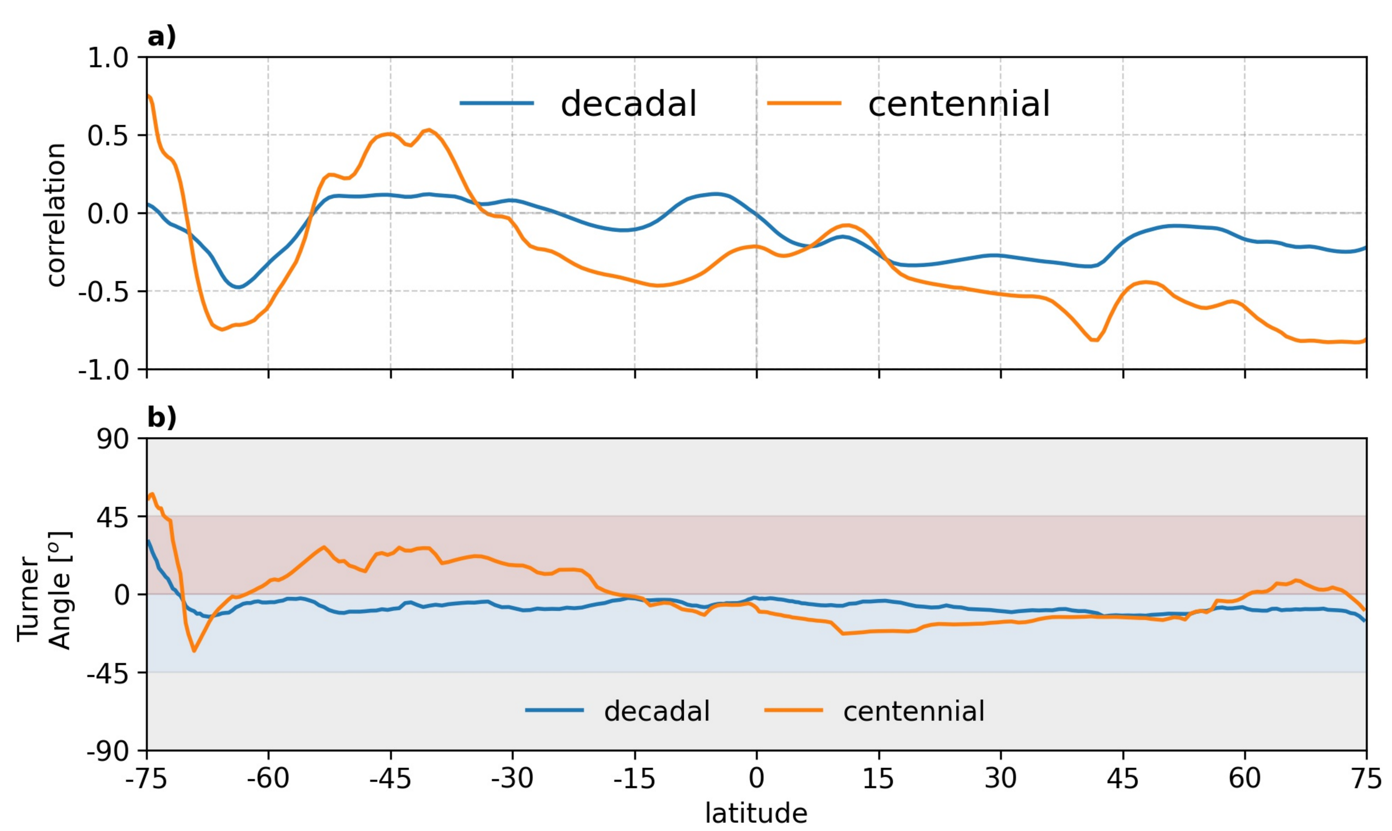

Fig1 | Linear correlation (**a**) and Turner Angle (**b**) between ocean and atmospheric heat transport anomalies.

The larger the timescale (centennial) the stronger the BJC. Two maxima are found around the storm track and the Marginal Ice Zone.

The Turner Angle allows to distinguish the role of the ocean and the atmosphere in setting up the BJC. The ocean dominates BJC in the north hemisphere at decadal and centennial timescales.

The AMOC centennial mode drives most of the Atlantic heat transport variability.

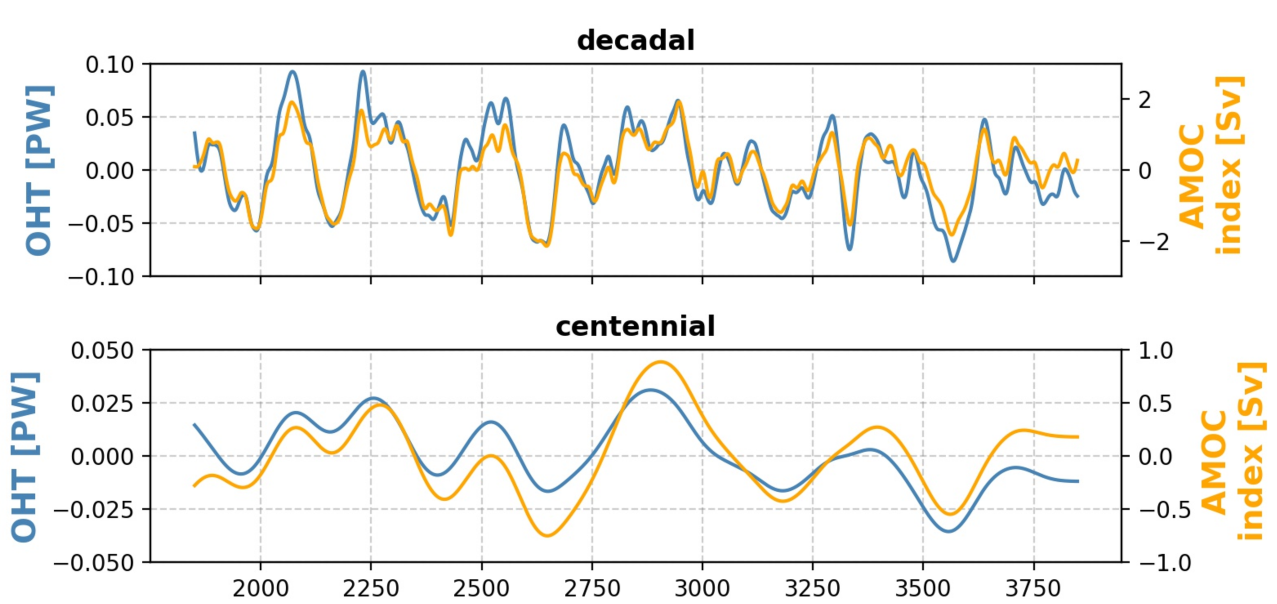

Fig2 | Atlantic ocean heat transport at the storm track and AMOC index.

Bjerknes-like inter-basin compensation

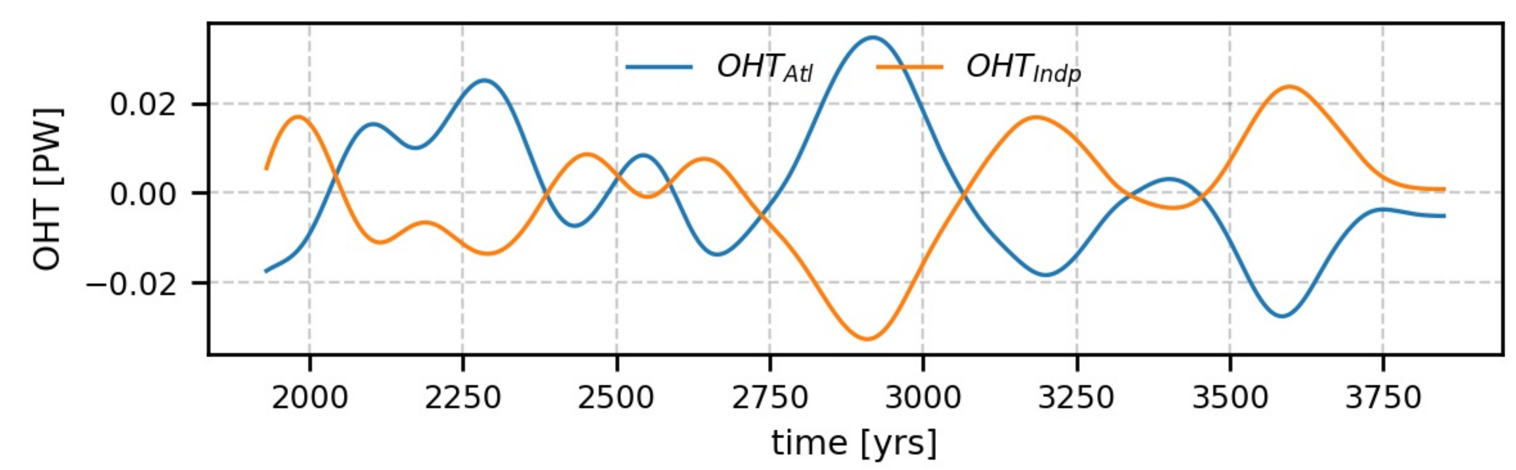

Fig3 | Meridional ocean heat transport at 35 °S.

The Atlantic and Indo-Pacific basins show a strong seesaw pattern of heat exchange at centennial time scales. But, does it take place through the **ocean** or the **atmosphere**?

We compute the heat budget of the Southern Ocean (south of 35 °S) using the equation below. The term containing atmospheric heat fluxes (green) is smaller in magnitude compared to the ocean-driven meridional and zonal heat transports. This shows that the inter basin exchange takes places through the ocean.

$$\frac{\partial OHC}{\partial t} = \int Q_{sfce}\, dA + OHT_{\lambda} + OHT_{\phi}$$

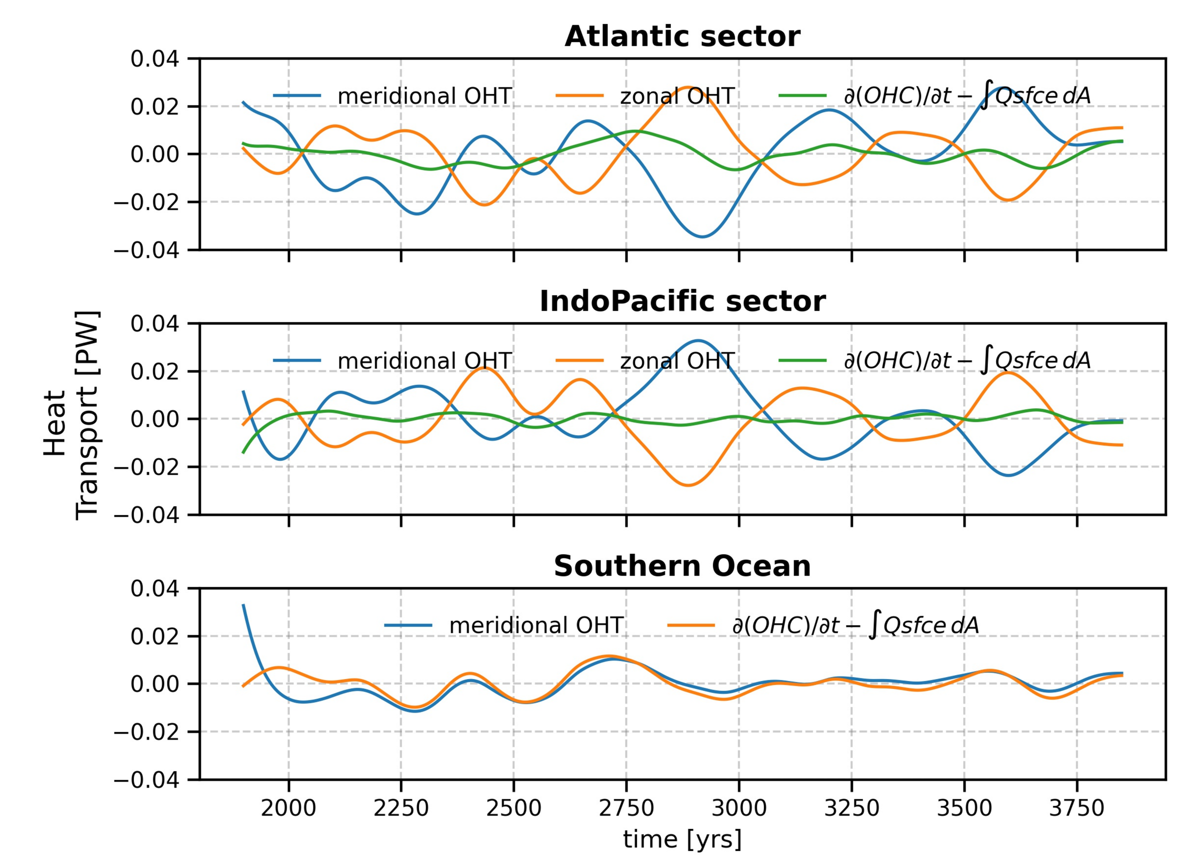

Fig4 | Heat budget analysis of Southern Ocean.

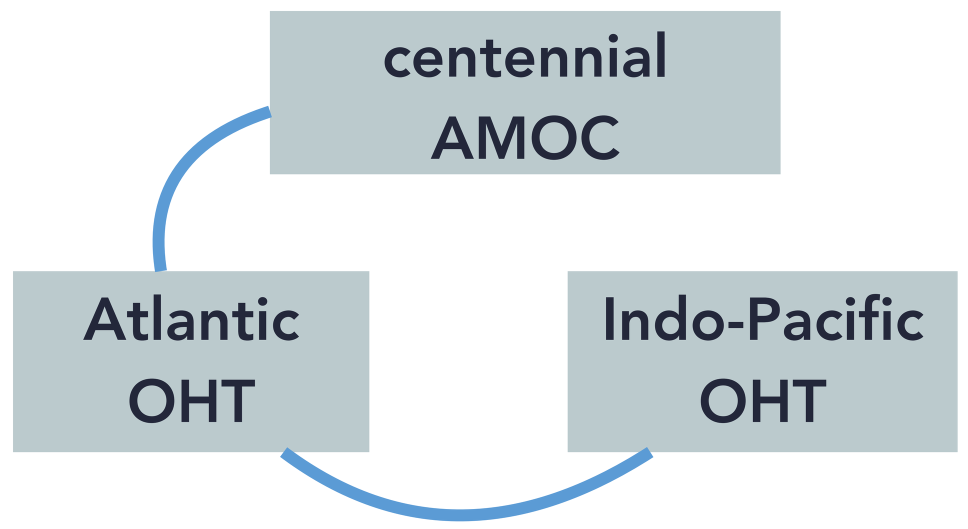

Fig5 | Schematics illustrating the inter-basin exchange mechanism.

Key points

BJC is stronger at larger timescales (centennial), with two maxima at the storm track region and Marginal Ice Zone. Ocean heat transport anomalies have a larger contribution in BJC. The centennial variability of the Atlantic ocean heat transport is AMOC-driven and generates the inter basin Bjerknes-like compensation. The heat budget analysis of the Southern Ocean confirm that this exchange takes place through the ocean.

References

Bjerknes J. (1964): Atlantic air-sea interaction. *Advances in Geophysics* Vol. 10, Academic Press, New York, 1 82. DOI: https://doi.org/10.1016/S0065-2687(08)60005-9

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