Potential predictability of the North Atlantic heat transport based on an oceanic state estimate

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Introduction

We examine the potential predictability time scales (PP time scales) for the North Atlantic meridional heat transport (MHT) using hindcast ensembles based on an oceanic data assimilation product.

Model and experimental set-up

We use the GECCO synthesis (1952-2001; Köhl and Stammer, 2008), whose optimized forcing is used for a reference run.
The hindcast ensembles are free forward integrations:

- Initial conditions are provided by the reference run.
  - → 10 ensembles with start dates from 1983 to 1992.
- Forcing is taken from different periods (10-12 years) of GECCO's optimized forcing during the past decades (1959-1982).
  - → 15 to 24 members per ensemble.

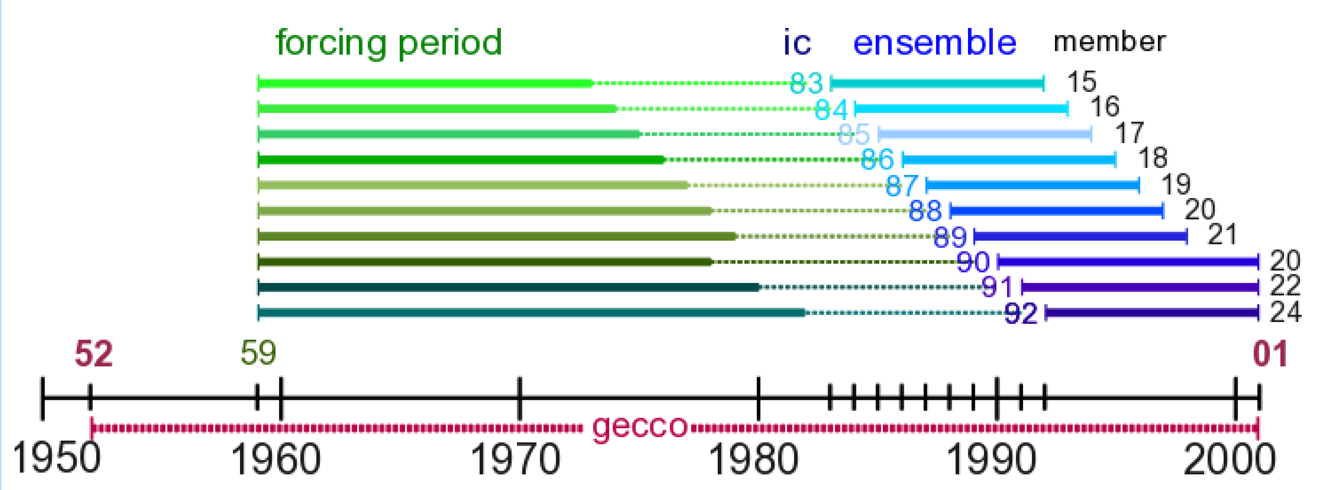

Figure 1: Overview of the experimental set-up: 50-year GECCO period (magenta), the forcing periods of the 10 hindcast ensembles (greenish lines), the periods of the free forward runs (bluish lines). In addition, the start dates and the number of members in each ensemble are shown.

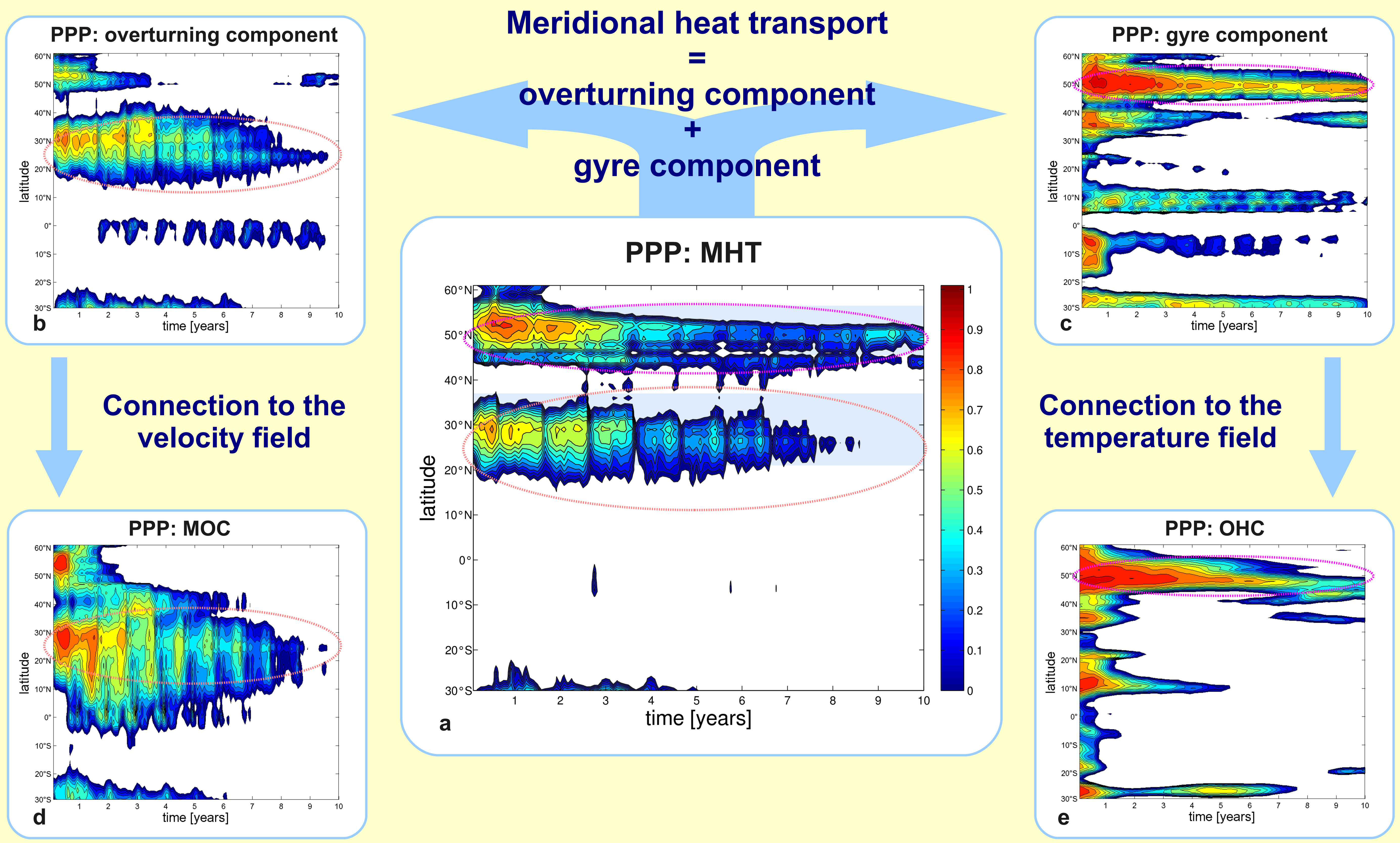

Figure 2: Hovmöller diagram of the prognostic potential predictability (PPP) in the Atlantic from 30°S to 60°N as a function of time for a) the meridional heat transport (MHT), b) the overturning component of the heat transport, c) the gyre component of the heat transport, d) the meridional overturning circulation (MOC), e) the oceanic heat content (OHC), and f) the Ekman transport. Only the areas where the ensemble spread is smaller than the variance of the reference run are coloured. The MHT is smoothed with a 12-month running mean before we start the PPP analysis.

Summary of the potential predictability time scales

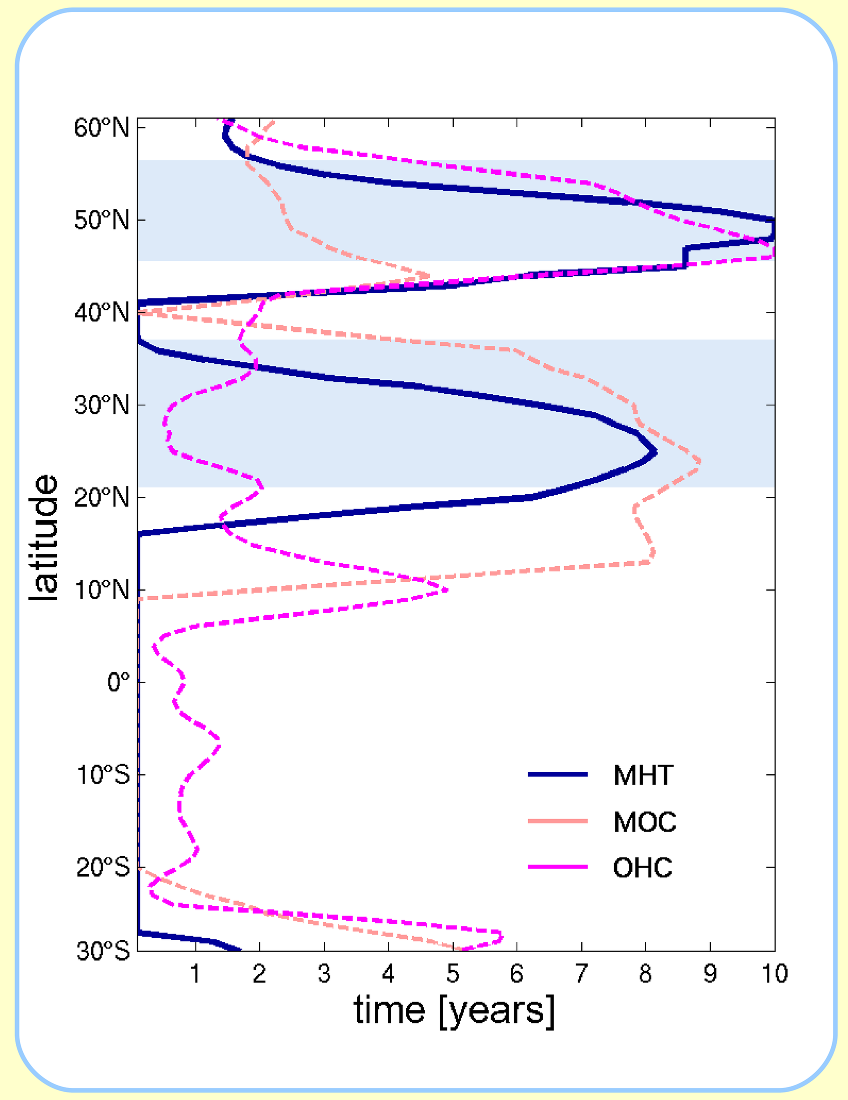

Figure 3: Potential predictability time scales of Figure 2 of the MHT (blue), the MOC (orange) and the OHC (magenta). The light blue bars show the regions where the PPP value of the Ekman transport is increased.

Method

We calculate the prognostic potential predictability (PPP) following Pohlmann et al. (2004):

$$\mathrm{PPP}(t) = 1 - \frac{1}{N}\sum_{j=1}^{N} \frac{\text{ensemble spread}_j(t)}{\text{variance of reference run}_j}$$

We assume that variations of a quantity are potentially predictable as long as the ensemble spread is smaller than the range of variance of the reference run (i.e. PPP<0).

References: H. Pohlman et al. (2004): JClim 17: 4463-4472
A. Köhl and D. Stammer (2008): JPO 38: 1913- 1930.

Results

- In the analyzed model, we find that the MHT is potentially predictable for 7-8 years between 20°N and 35°N and for the whole investigated period of 10 years between 45°N and 55°N (Figure 2a). In GECCO, the separation between the subtropical and subpolar gyre is located around 40°N.
- The PPP pattern of the MHT can be reconstructed from the individual consideration of the PPP patterns of the overturning component and the gyre component (Figure 2b and 2c).
- Further, the Ekman transport has a significant influence on the region where the MHT is potentially predictable (light blue bars in Figure 2a and 3), but it does not determine the lengths of the PP time scales.

Conclusions

- The lengths of the PP time scales of the MHT greatly varies with latitude, with prominent influence of the potential predictability of the temperature field at subpolar latitudes (above 45°N; OHC; Figure 2e), and prominent influence of the potential predictability of the velocity field at subtropical latitudes (20°N-35°N; MOC; Figure 2d).
- In turn, we find that the PP time scales of the MOC cannot be directly transferred to the PP time scales of the MHT. The PP time scales of the MOC are shorter at higher latitudes and slightly longer between 25°N and 35°N than the PP time scales of the MHT (Figure 3).