Causes of interannual-to-decadal meridional heat transport variability in the North Atlantic Ocean

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1. Introduction

•Interest in meridional overturning circulation changes (**ΔMOC**) derives from their role in climate through an influence on ocean meridional heat transport changes (**ΔMHT**).

•Past studies (Bingham et al. 2007; Biastoch et al. 2008) elucidate low frequency ΔMOC.

•But factors other than ΔMOC can influence ΔMHT, so it is unclear to what extent these insights apply to ΔMHT.

•Utilizing a data-constrained circulation model (Wunsch et al. 2007), we explore low frequency ΔMHT in the North Atlantic Ocean.

2. Interannual-to-decadal meridional heat transport

•Time mean MHT ranges from 1PW at low latitude to 0.5PW at high latitude (**Fig. 1a**).

•Variations are of order 0.1PW at low latitude and 0.05PW at high latitude (**Fig. 1b**).

•Variations are 10-15% of mean (**Fig. 1c**).

•What are the causes of this variability?

•To address this question, we focus on ΔMHT at three latitudes (shaded bars on right), which are coherent with changes ~10° to the north and south (**Fig. 1d**).

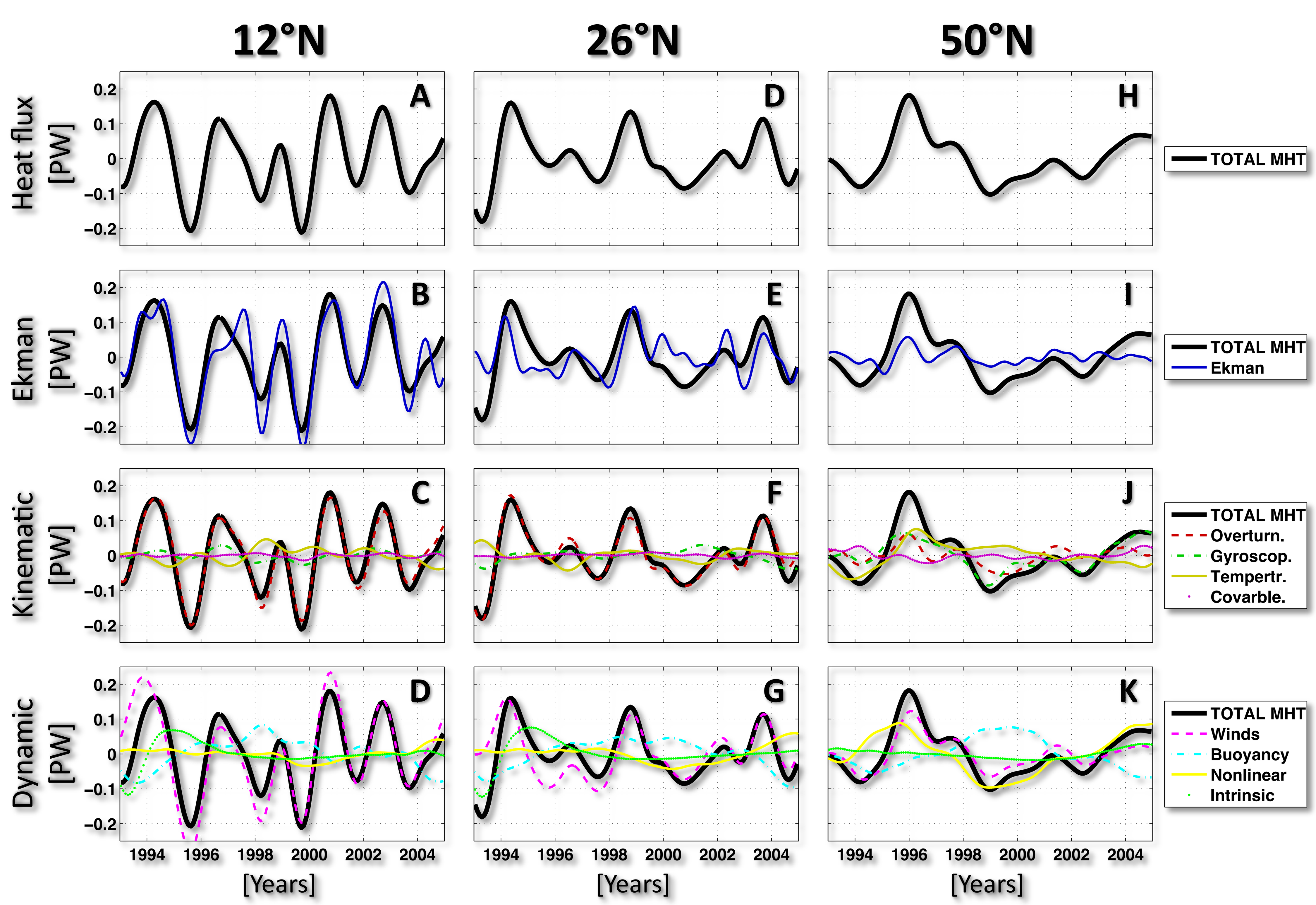

*Figure 2: **(First row)** Total interannual MHT time series at three representative latitudes: 12°N (first column), 26°N (second column), and 50°N (third column). **(Second row)** Total versus Ekman MHT at the three latitudes. **(Third row)** Total MHT alongside kinematic components at the three latitudes. **(Fourth row)** Total MHT shown alongside MHT from the forcing experiments at the three latitudes.*

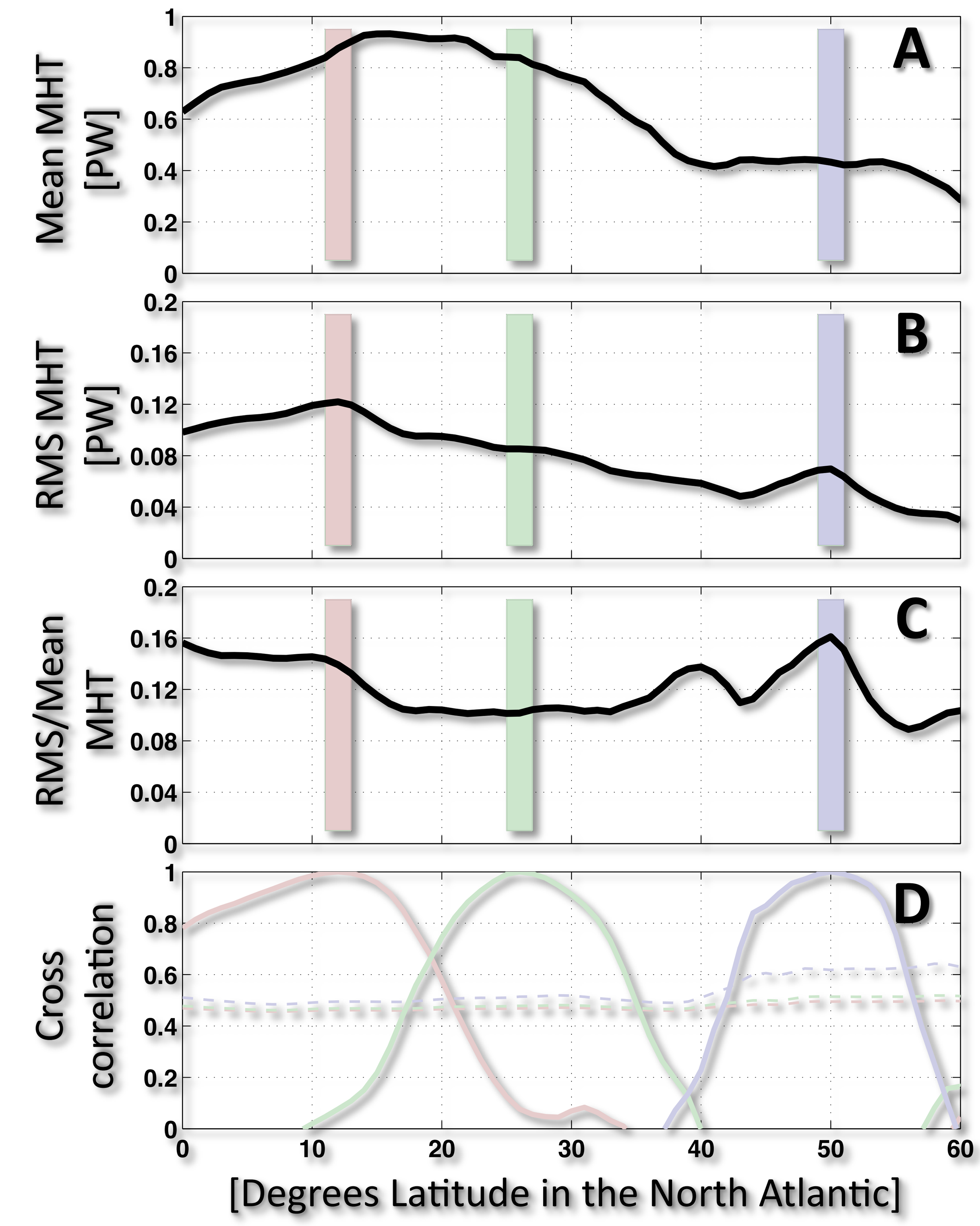

*Figure 1: **(A)** Time-mean MHT and **(B)** RMS interannual-to-decadal MHT over 1993-2004 from the model. **(C)** Ratio of (B) to (A). **(D)** Solid lines are correlations of MHT at 12°N, 26°N, and 50°N [red, green, and blue, respectively] with MHT at other latitudes. Dashed lines are the 95% confidence levels. All time series from Piecuch and Ponte (2012a).*

3. Causes of variability

- We consider low frequency ΔMHT at three latitudes (**Fig. 2 row 1**). Using approximate frameworks, variable decompositions, and numerical experiments, we use model output to:
  - estimate *Ekman ΔMHT* (**Fig. 2 row 2**) (Kraus & Levitus 1986);
  - diagnose *kinematic ΔMHT* from overturning changes, gyre circulations, temperature variations, and velocity-temperature covariability (**Fig. 2 row 3**) (Jayne & Marotzke 2001; Bryden & Imawaki 2001);
  - and assess *dynamic ΔMHT* due to winds, buoyancy, intrinsic variability, and nonlinear response to forcing (**Fig. 2 row 4**) (cf. Piecuch & Ponte 2012b).

4. Summary and prospective

Question\Latitude	12°N	26°N	50°N
Ekman fluxes are mostly sufficient to explain ΔMHT?	✔	✗	✗
Winds are the dominant forcing mechanism?	✔	✔	✗
Overturning changes are most important?	✔	✔	✗
Intrinsic variability at the beginning of the period?	✔	✔	✗
Presence of low-frequency buoyancy-driven changes?	✔	✔	✔
Important contributions from nonlinear adjustment?	✗	✗	✔

•There are major differences between ΔMOC and ΔMHT at high latitudes.

• Thus, future studies will try to understand ΔMHT at these subpolar latitudes

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