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On the predictability of the North Atlantic ocean state

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This study investigates the decadal predictability of the ocean climatic state in the North Atlantic in an ocean-forced context. To assess this oceanic predictability, we compute Linear Optimal Perturbations (LOPs) in a realistic Ocean General Circulation Model in a 2-degree configuration (NEMO-ORCA2) and estimate the maximum impact of small disturbances on ocean dynamics. Our calculations of LOPs involve a maximization procedure based on Lagrangian multipliers in a non-autonomous context. As the metrics of the ocean state we use two different measures: the Meridional Volume Transport (MVT) and the Oceanic Heat Content (OHC), both in the North Atlantic. We show that the two metrics are dramatically different in regard to predictability. Whereas the OHC can be modified only by relatively large-scale anomalies, the MVT is strongly affected by small-scale anomalies as well (acting along the basin eastern and western basin boundaries and changing the East-West density difference across the Atlantic). This suggests that MVT is much less predictable than OHC. It is only when MVT is averaged over climatically relevant timescales (e.g. 30 years) that the two metrics have comparable predictability. This result stresses the need for long-term measurements of the AMOC intensity in order to have climatically relevant data. Our study also suggests that initial errors of a few centi-Kelvins can lead on a decadal timescale to an error of 1 K in North Atlantic mean sea surface temperature estimates. This transient error growth is maximal after about 17 years and can be interpreted as a decadal predictability barrier.