Oceanic chaos modulated by the atmosphere: insights from the OCCIPUT ensemble simulation

Thierry Penduff*[1], Stéphanie Leroux[1], Laurent Bessières[2], Guillaume Sérazin[1,2], Pierre-Vincent Huot[1], Alexandre Jaymond[1], Jean-Marc Molines[1], Bernard Barnier[1], and Laurent Terray[2]

[1]Laboratoire de glaciologie et géophysique de l'environnement (LGGE) – CNRS : UMR5183, OSUG, INSU, Université Joseph Fourier - Grenoble I – Domaine Universitaire 54 Rue Molière - BP 96 38402 ST MARTIN D HERES CEDEX, France

[2]Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (CERFACS) – CERFACS – France

Abstract

The CHAOCEAN OST-ST project has shown that in the eddying regime, the global ocean circulation spontaneously generates a low-frequency chaotic intrinsic variability (LFCIV), which reaches basin scales and 1-100-year timescales, and strongly imprints climate-relevant variables like SLA, SST, Oceanic Heat Content (OHC), or AMOC. This LFCIV is almost zero in laminar ocean models used in most recent climate projections (CMIP5, AR5 IPCC report) but gives a marked stochastic flavor to the low-frequency variability in eddying ocean models, which are being coupled to the atmosphere for the CMIP6 exercise (and future IPCC climate projections). These results motivated the companion OCCIPUT project, which adopts a fully-probabilistic modelling approach: we performed a pioneering long (1960-2015), large (50-member) ensemble of global ocean/sea-ice 1/4◦ hindcasts; the ensemble members were started from slightly different initial conditions and driven by the same full (reanalyzed) atmospheric forcing. Resulting ensemble statistics give access to the time-varying forced and chaotic oceanic variabilities, and to the time-varying atmospheric imprint on the ocean chaos over a wide range of spatiotemporal scales.

Results show that the oceanic variability should be seen as a broadband atmospherically-modulated "chaos". Chaotic ocean dynamics shapes the SLA statistical structure (i.e. PDF) in very contrasting ways, and the atmospheric modulation of instantaneous PDFs (i.e. the probability that the ocean is in a given state) varies in time and space. This provides new insight into the causes of the ocean variability, and raises new detection/attribution issues from simulations and observations: in key regions, the oceanic chaos can mask atmosphere- and climate-related SLA, AMOC, SST and OHC evolutions, even at large spatiotemporal scales: the LFCIV can locally mask the observed 20-30 year SLA/OHC regional trends due to climate change, or make the interannual-to-decadal SLA/OHC/SST/AMOC regional variability partly random (uncorrelated with the forcing) in key areas of the global ocean.

In short, the daily-to-multidecadal variability of the turbulent ocean is influenced by the atmospheric variability but is substantially chaotic in key regions (which is new for large time and space scales). We will discuss potential consequences for the analysis and interpretation of observational oceanic data.

*Speaker