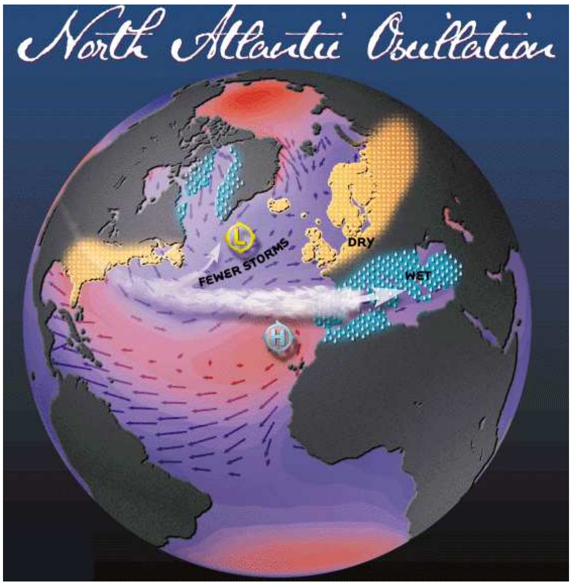
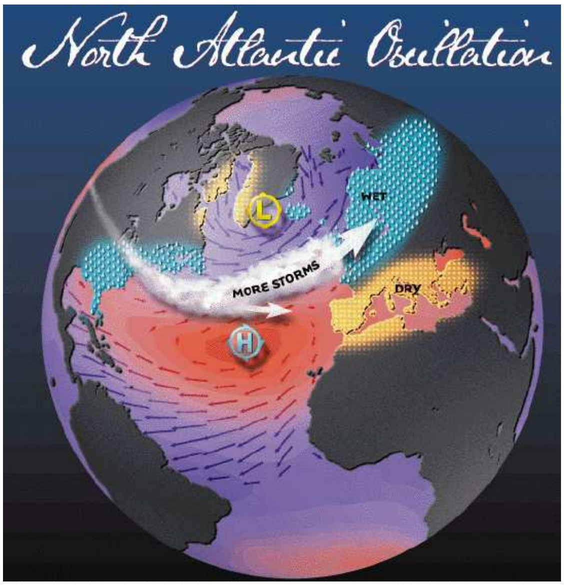
Proposed PhD Research Project:

Atlantic-Pacific Decadal Teleconnections in Coupled Ocean-Atmosphere Models

1. Background





The above Figure shows schematically the negative and positive phases of the North Atlantic oscillation, which is a giant see-saw pattern of the decadal-to-interdecadal climate variability associated with large-scale changes in sea-surface pressure (blue and red color coding), atmospheric storm track position and strength (white cloudy stripe with arrows), and weather patterns (yellow and cyan colors indicating precipitation anomalies) on the surrounding continents. The underlying ocean circulation not only has the corresponding large-scale decadal-to-interdecadal pattern, dubbed as the "Turbulent Oscillator", but may also be important in driving the atmospheric decadal-to-interdecadal variability (Berloff et al. 2007a). There is also qualitatively similar North Pacific oscillation on the other side of the northern hemisphere, and both ocean basins also host the corresponding interdecadal oscillations, which are even less understood.

On the fundamental level, all these climate variability modes can be either intrinsic variability of the oceans, or intrinsic variability of the atmosphere, or coupled ocean-atmosphere variability. Coupled ocean-atmosphere general circulation models do not yet discriminate between these alternatives, because they do not have the required capability to resolve the oceanic "weather" associated with oceanic *mesocale eddies*. Driven by the surging demand of climate science, the last decade witnessed development of *idealized*, intermediate-complexity, midlatitude, quasigeostrophic, ocean-atmosphere coupled models, that, on the one hand, resolve mesoscale eddies, and, on the other hand, permit systematic analyses and theoretical understanding of the climate variability modes and involved dynamical mechanisms and factors controlling them (Kravtsov et al. 2007; Berloff et al. 2007).

2. Statement of the Problem

The *main novelty* of this Project will be significant upgrade of the existing idealized ocean-atmosphere coupled models by considering not one but two differently shaped oceanic basins (i.e., North Atlantic and North Pacific) with eddy-resolving circulations in each of them. The overlying atmospheric model component will force both ocean circulations and provide information exchange between them. The *second novelty* will be consideration of not only dynamical, but also empirical atmospheric model component, which is conceptually similar to the one proposed by Kravtsov et al. (2016). The necessity for such an empirical component is driven by the apparent lack of oceanic influence on the atmosphere in climate models despite observational evidence otherwise.

The *main hypothesis* of the Project is that the oceans will generate their own intrinsic, large-scale decadal-to-interdecadal, "Turbulent Oscillator" variabilities, which will couple with the atmospheric variability and each other. The *main goal* of the Project is to gain complete dynamical understanding of the variability patterns, mechanisms, and dependencies, as well as developing statistical emulators of the variability for practical purposes in climate studies.

The starting point will be development of the coupled ocean-atmosphere model and its computational study. The oceanic model components will be multi-layer quasigeostrophic ones, good for capturing rich mesoscale eddy dynamics with feasible costs. Consideration of realistically shaped ocean basins will be achieved by implementing matrix capacitance method in the direct elliptic solvers for potential vorticity inversion. The oceanic and atmospheric model components will be connected via additional thermodynamically and mechanically active atmospheric and oceanic boundary layers, and the atmosphere will be forced by the incoming solar radiation. Analyses of the coupled solutions will involve disentangling causalities of the ocean-atmosphere and ocean-ocean couplings, as well as understanding the main mesoscale eddy effects and their mechanisms.

The student will benefit from the interdisciplinary nature of the Project that combines a great deal of original and creative research within the remit of Geophysical Fluid Dynamics, Scientific Computing, Statistical Modelling and Climate Change Science. The Project will be a great opportunity for outreaching the climate science community and providing broad and practical impact.

References

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Berloff, P., S. Kravtsov, W. Dewar, and J. McWilliams, 2007a: Ocean eddy dynamics in a coupled ocean-atmosphere model. *J. Phys. Oceanogr.*, **37**, 1103–1121.

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