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Understanding and Predicting the Impact of Outflow on Tropical Cyclone Intensification and Structure

Planning Letter Due Date: May 1, 2013

The purpose of this Office of Naval Research Departmental Research Initiative (DRI) is to enhance the understanding of dynamics of the upper-level outflow of tropical cyclones (TCs) and its connection to the larger-scale environment. Changes to TC outflow are increasingly believed to lead to profound changes in storm intensity and structure, but remain a largely unexplored aspect of TC's. Our goal is to improve the prediction of TC intensification and structure changes that occur in response to these influences, which may be due to environmental interactions and/or internal changes that are poorly represented in current models. The outflow characteristics, evolution, and dynamics will be investigated in a comprehensive manner using innovative new observing systems and satellite observations, as well as state-of-the-science models that will allow this upper-level region to be explored for the first time.

Scientific Issues

Investigations should focus on the understanding of the TC outflow region through, for example, theory, simulations, observations and model development. The following are examples of some research topics that are envisioned to address the overarching scientific issues related to the spatial and temporal evolution of TC outflow structure, dynamics, and processes.

1. *The coupling of the TC outflow with the inner-core convection and the relationship of this coupling to intensity changes including rapid intensification:* Strong upper-level outflow is nearly always present in tropical cyclones, particularly in strong and/or large storms. However, it is unknown whether increased upper-level outflow is a consequence of an increase in convection, or if changes in the upper-level outflow facilitate an increase in convection and the subsequent spin up of the TC core.
2. *The relationship between the upper-level outflow and the low-level wind field structure:* Changes in the outflow induce changes in the secondary circulation, which then impact the primary (tangential) circulation. Thus, upper-level outflow and radial inflow changes can directly lead to changes in the low-level wind field and size of the storm.
3. *The interaction of tropical cyclone outflows with larger-scale features:* The environment can also be impacted by interaction with TC outflow. Upper-level outflow can influence the downstream ridge and initiate Rossby wave dispersion, which sets the stage for upscale energy transfer from the TC scale to the planetary scale.
4. *The morphology and evolution of the outflow and its dependence on the environment:*
   a. **Dynamical Processes**: Satellite observations of upper-level outflow confirm the presence of an equatorward outflow channel when a TC is located at lower latitudes. Occasionally, however, a second outflow channel becomes directed poleward of the TC center. The second outflow channel may develop in response to environmental factors or internal factors. The relative role of multiple outflow channels in defining the outflow structure and associated intensity and structure changes are not well understood; due in large part to a lack of observations.
   b. **Thermodynamic Processes**: The outflow temperature gradient has been linked to (radial) structure and intensity changes in TCs. The evolution of the outflow thermal structure has been assumed for decades to depend on the environmental value at outer radii, but has recently been shown to vary as a result of turbulence within the outflow layer. Observations of the thermal structure may now be obtained, however, making the evolution, variability, and impacts of the outflow temperature gradient feasible to assess.

This DRI is expected to run for five years, from FY14 to FY18. Collaboration is encouraged, and it is anticipated that a science team will be formed and workshops held to coordinate research activities. It is anticipated that an observational component will be included in this DRI. For this purpose, ONR has established an initial collaboration with the NASA field program called Hurricane and Severe Storms Sentinel (HS3) taking place over the N. Atlantic from 2012-2014. HS3 will deploy two high-altitude, long-endurance Global Hawk unmanned aircraft equipped with a number of experimental instruments and offers an unprecedented opportunity to observe the TC outflow region. We will also seek to collaborate with other agencies on a potential field program in the Western Pacific by leveraging one or more of the community research projects that are currently in the planning stages.

Planning Letter Content

The letter should include:

Contact information for the principal and co-investigators, including full mailing address, e-mail address and phone number for each

A maximum 3-page synopsis of the proposed research, including a rationale, questions and/or hypotheses to be addressed, the methods to be used, and anticipated results

An estimated budget, with approximate cost per year

Up to one page of relevant references to the literature

A 1-page biographical sketch for each investigator, with a focus on research activities and publications relevant to the proposed research.

Purpose of Planning Letters

The purpose of the planning letter is to allow investigators to submit their ideas for ONR to evaluate, provide feedback and indicate whether full proposals are encouraged. ONR will respond to planning letters with one month of receipt to allow sufficient time for full proposal preparation and submission by August 1, 2013. It is anticipated that awards will be made with funds available in the first quarter of FY14.

Submission of Planning Letters

Planning letters should be submitted no later than May 1, 2013, by email to:

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