OceanGliders Storms Task Team

Tropical and extra-tropical storms are among the most destructive natural events on Earth. Tropical storms are estimated to cause an average of 10,000 deaths per year and to potentially cost the global economy more than $9.7 Trillion over the next century. Growing coastal populations (already 35% of the global population), coastal urbanization, and rising sea levels magnify our vulnerabilities to storms, escalating the need for more accurate storm track, intensity and impact forecasts. Historical storm tracks demonstrate that this is a global problem.

Significant resources are already being expended to improve tropical and extra-tropical storm observations and forecasts globally. As a result, tropical storm track forecasting has shown steady improvement over the past 25 years due, in part, to the improvements in the global atmospheric forecast ensemble that provide increasingly better estimates of the large-scale steering windfields. But similar improvements in tropical storm intensity forecasting have lagged, in part due to the paucity of upper ocean data to define its heat content, and the uncertainty in the processes that influence the transfer of heat between the ocean heat reservoir and the atmosphere. Tropical storm impacts, such as wind and storm surge, cannot be accurately forecast until both track and intensity forecasts are accurate.

We propose to organize a global OceanGliders Task Team to demonstrate the value and promote the use of autonomous underwater gliders to support tropical and extra-tropical storm forecasting worldwide. Autonomous underwater gliders are complimentary to other storm sampling systems in their ability to rapidly profile and then transmit data to shore each surfacing even during the most severe storm conditions. The gliders provide a unique dataset for scientific studies of rapid upper ocean evolution as well as high-value profile data for assimilation in both operational and research forecast models before, during and after storms. Glider flights can simultaneously support both improved scientific understanding and real time forecasting if the real time data can be distributed beyond the glider operator to operational centers via the Global Telecommunications System (GTS). Gliders can be deployed in targeted areas, such as rapid intensification or de-intensification zones, early in the storm season to better define the deep ocean mesoscale (in particular the warm eddies), or the coastal variability, that the ocean models must have in place before a storm occurs. If a storm approaches, gliders can be switched to a storm sampling mode, or additional rapid response gliders can be deployed, to uniquely capture the detailed rapid evolution of the ocean structure during the storm. After the storm, gliders can persist to survey a broader area to compare pre- and post-storm conditions at a time when response activities are often focused on recovery, not scientific data collection. An immediate objective of any glider activity in storm regions of interest is to compare the glider data to the full suite of ocean models, both research and operational, regardless of whether a storm occurs or not. Actual storm glider flights and model/data comparison studies will depend on the support of individual nations for their researchers. In the event that no storm glider deployments are funded by individual countries during the lifetime of this working

group, gliders of opportunity deployed for other purposes can be used for the model comparisons if the glider data is shared.

Goal:
Over the next two years, bring glider data providers, ocean model data assimilators, and atmospheric storm forecasters together to demonstrate the utility of a globally coordinated storm glider fleet to provide useful ocean data to operational storm forecast centers. An end goal is to persuade the operational centers to endorse the requirements for storm-specific glider flights in critical areas.

Approach:
The global OceanGliders Storm, Hurricane and Typhoon Task Team will:

1) Share new ideas for sensor and glider platform upgrades for storms, as well as encourage sensor and platform suppliers to participate in these upgrades.
2) Coordinate glider flights funded by diverse but complimentary activities to maximize the gap-filling impact of dedicated storm-specific glider deployments.
3) Assist the growing group of glider operators interesting in contributing to storm research with submission of their real-time data to the GTS (for example, through the US IOOS Glider DAC) so that their data is available for assimilation in real-time ocean forecast models.
4) Entrain ocean data assimilators and coupled atmosphere-ocean modelers interested in determining the value of glider data assimilation in storms through research model sensitivity studies.
5) Compare glider data with available operational ocean models to determine how the ensemble of operational ocean models currently represent both pre- and post-storm conditions.
6) Share the results of (a) glider storm data analyses, (b) ocean model validation, sensitivity, process and ocean data assimilation studies, and (c) atmospheric model storm intensity process and sensitivity studies within the OceanGlider Storms Task Team and with the glider community through EGO.
7) Inform operational forecast centers of progress and seek their endorsement and support.

Coordination meetings will occur twice a year, in the spring and fall between the summer tropical cyclone seasons and the winter storm seasons in both northern and southern hemispheres. While face-to-face meetings are preferred and will be attempted, initial coordination will be via conference call and email until a sponsor can be found. The objective of biennial meetings is to share field/modeling results from the proceeding summer/winter storm season and prepare for the upcoming season. Coordination conference calls can occur more frequently based on need.

Additional coordination opportunities will be sought through member participation in complimentary meetings such as EGO in Europe, the annual “Capacity Building Workshop of the WMO/IOC Data Buoy Collaboration Panel (DBCP) for the North

Pacific Ocean and its Marginal Seas (NPOMS): Application of Regional Ocean Observations for Increasing Society's Understanding and Forecasting of Typhoons" in Asia, and the annual Hurricane Forecast Improvement Program (HFIP) meetings in the United States. Members of the OceanGliders Storm Task Team have existing contacts with groups such as the US National Hurricane Center and the Joint Typhoon Warning Center that will be used to enhance communications.

Benefits:
The proposed activity will contribute to the ongoing global effort to improve storm, hurricane and typhoon intensity forecasting through:

1) Improved scientific understanding of rapidly evolving ocean processes occurring during strong storm forcing in critical regions to ensure storm forecast models can support the proper ocean evolution and air-sea interaction physics.
2) Improved ocean datasets for forecast model assimilation before, during and after extreme events in targeted regions.
3) Improved ocean representations in coupled atmosphere-ocean forecast models to better represent the feedbacks between the two components.
4) Improved intensity forecasts to augment storm wind and surge impact forecasts.

Milestones:
There is an annual cycle to operational tropical storm forecast activities that is offset by six months in each hemisphere. The OceanGliders Storm Task Team will account for this annual but offset cycle in both hemispheres to maximize the impact of its data and scientific results with the global operational communities. The program assumes a start during Northern Hemisphere Spring, 2017. Assuming a two-year program, each hemisphere will experience two summer and two winter sampling seasons. Spring and fall seasons will be used for analysis, for process and sensitivity studies, and for communication with operational centers. A milestone schedule includes:

1) Spring 2017 - Coordinate glider flights for the upcoming storm season. Share model-data comparison tools between Task Team members.
2) Summer 2017 – Storm season sampling and model/data comparisons. Report to NPOMS Typhoon Workshop. Entrain participants from Asia.
3) Fall 2017 – Share glider data comparisons with the suite of research and operational ocean models from the past hurricane season. Coordinate process/data assimilation studies based on the past season. Coordinate glider flights for the upcoming season.
4) Winter 2018 – Storm season sampling and model/data comparisons. Report to HFIP. Entrain U.S. Participants.
5) Spring 2018 – Share glider data comparisons with the suite of research and operational ocean models from the past hurricane season. Coordinate process/data assimilation studies based on the past season. Coordinate glider flights for the upcoming season.

6) Summer 2018 – Storm season sampling and model/data comparisons. Report to NPOMS Typhoon Workshop
7) Fall 2018 - Share glider data comparisons with the suite of research and operational ocean models from the past hurricane season. Coordinate process/data assimilation studies based on the past season. Coordinate glider flights for the upcoming season.
8) Winter 2018 – Storm season sampling and model/data comparisons. Report to HFIP.
9) Spring 2018 – Final coordination meeting. Prepare final results.

Membership:
Proposed membership includes internationally distributed glider operators interested in storm data collection and dynamics as potential data providers, and ocean data assimilators as well as coupled ocean-atmospheric modelers interested in storm forecasting as data users. Membership will also be drawn from both the research and operational communities to enable discussions within the research to operations to research (R2O2R) development cycle.

Proposed Members (membership not closed):

- Scott Glenn, Rutgers, Steering Team Member and Task Team Co-Chair
- Chari Pattiaratchi, University Western Australia, Steering Team Member and Task Team Co-Chair
- Gustavo Goni, NOAA AMOL, Glider Operator
- Ruth Curry, Bermuda Institute of Ocean Sciences, Glider Operator
- Steve DiMarco, Texas A&M University, Glider Operator
- Seb Swart, South Africa & Sweden, Glider Operator
- Sik Huh, KIOST, Glider Operations Contact for Korea
- Yi Chao, Seatrec & JPL, Glider Operations Contact for China
- Sue Chen, NRL-Monterey, Coupled Atmosphere-Ocean Modeler
- James Cummings, NRL-Monterey, Ocean Data Assimilation
- Richard Crout, NRL-Stennis, Ocean Data Assimilation and Coupled Atmosphere-Ocean Modeling
- Avichal Mehra, NOAA NCEP, Coupled Atmosphere-Ocean Modeler