

Ocean Coupling to Topographically-Enhanced Atmospheric Flow

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LONG-TERM GOALS

The goal of this project is to understand and predict oceanic and atmospheric processes in coastal areas where winds are topographically steered and strengthened.

OBJECTIVES

The proposed work aims to probe details of the interaction of mountainous island terrain with synoptic and intra-seasonal disturbances, and the associated ocean response and feedback. The research questions include:

- How do intra-seasonal and synoptic disturbances combine to generate spatial/temporal variability of the ocean and atmosphere on small time and space (e.g., operational) scales?
- How do terrain effects influence local precipitation and wind patterns during atmospheric episodes?
- How do warm wake waters surrounding islands impact the atmosphere during synoptic and intra-seasonal events? What is the evolution of atmospheric and oceanic boundary layers over the course of atmospheric passages, and what role do wind orientation and terrain play?

APPROACH

To accomplish these objectives we employ high-resolution (~1-3 km) two-way coupled ocean/atmosphere modeling to predict, interpret and improve the simulated boundary layer properties. The studies mine the rich datasets of observational programs including land-based meteorological data, satellite, moored and underway observations to form a more complete picture of circulation characteristics in the ocean and atmosphere in complex coastal mountainous regions. The project is a close collaboration with NRL partners on the modeling side (including James Doyle, Paul May and Sue Chen) and field team participants (including Pierre Flament of University of Hawaii, Arnold Gordon of Lamont-Doherty Earth Observatory, Janet Sprintall of Scripps, Craig Lee of University of Washington, Laura David and Cesar Villanoy of University of the Philippines).

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WORK COMPLETED

The Philippines national weather service (PAGASA) has processed 3-hourly meteorological station data at 57 sites throughout the Philippines with funding supplied by ONR Global (Figure 1). The dataset covers the 5-month time period 1 November 2007 – 31 March 2008 and consists of the following fields: wind speed, wind direction, temperature, dewpoint temperature, sea level pressure, rainfall, relative humidity, visibility, and cloud totals.

This dataset has been compared with COAMPS^{®1} simulation results for the same time period, and has been analyzed to examine regional patterns in key meteorological fields.

(¹ COAMPS[®] and COAMPS-OS[®] are registered trademarks of the Naval Research Laboratory.)

RESULTS

During the time period analyzed, a short (24-27 January 2008) easterly monsoon surge and a longer (9-16 February 2008) northerly surge were represented in the model results as well as in QuikSCAT and underway wind data taken during IOP08-2 (Pullen et al., 2011). There is some signature of the easterly surge in the wind data at station Coron (Figure 2). The wind tapers off at Coron, in both the model and observations, during the period of the northerly surge. This suggests the positional sensitivity of different sites to the influence of the wind jets. In general, the magnitude of the modeled winds are within range of the observed winds. At some of the other locations the meteorological station data is not of uniformly high quality – with poor wind measurements at many of the station sites. This may be due to constraints in siting the instruments.

The time period of the observations coincides with enhanced precipitation. The 2007-2008 northeast monsoon season was the rainiest on record in approximately 30 years. This rainfall anomaly was possibly associated with an intra-seasonal oscillation. A cluster analysis of the rainfall data has been undertaken in order to characterize the areas throughout the islands that have the most rainfall during this 5 month period. Some locations on the east side of the islands experienced elevated rainfall, with Tacloban (labeled in Figure 1) having particularly high values.

IMPACT/APPLICATIONS

I am a co-organizer of a special session at the Ocean Sciences 2012 meeting entitled: “Oceanic Impacts of Orographic Flows”, which will examine the impact of these type of processes throughout the world.

Insight into processes in coastal areas subject to topographically-enhanced winds are translatable to other regions of interest to the Navy. Such winds may influence Navy operations near important ports – e.g., Manila.

TRANSITIONS

none

RELATED PROJECTS

This work is related to NRL-Monterey 6.1 projects within PE 0601153N that include studies of air-ocean coupling, boundary layer studies, and topographic flows and 6.2 projects within PE 0602435N that focus on the development of the atmospheric components of COAMPS. This work also draws on efforts conducted within the ONR PhilEx DRI.

REFERENCES

Pullen, J., J. D. Doyle, P. May, C. Chavanne, P. Flament and R. Arnone, "Monsoon surges trigger oceanic eddy formation and propagation in the lee of the Philippine Islands," *Geophysical Research Letters*, 35, L07604, doi:10.1029/2007GL033109, 2008.

PUBLICATIONS

Pullen, J., A. L. Gordon, J. Sprintall, C. M. Lee, M. A. Alford, J. D. Doyle, P. W. May, "Atmospheric and oceanic processes in the vicinity of an island strait," *Oceanography*, 24(1), 112-121, 2011.

May, P. W., J. D. Doyle, **Pullen, J.** and L. David, "Two-way coupled atmosphere-ocean modeling of the PhilEx intensive observational period," *Oceanography*, 24(1), 48-57, 2011.

PATENTS

none

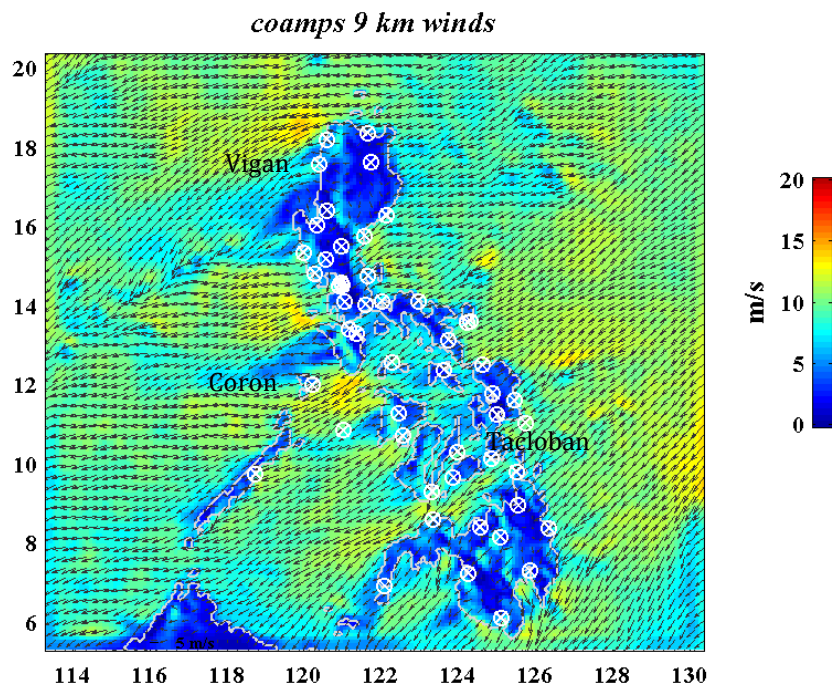


Figure 1: Location of the meteorological stations. COAMPS wind fields for January 26, 2008 are also shown to relate the wind jets to the station positions. The Vigan and Coron stations used in Figure 2 are labeled. Station Tacloban had particularly high rainfall.

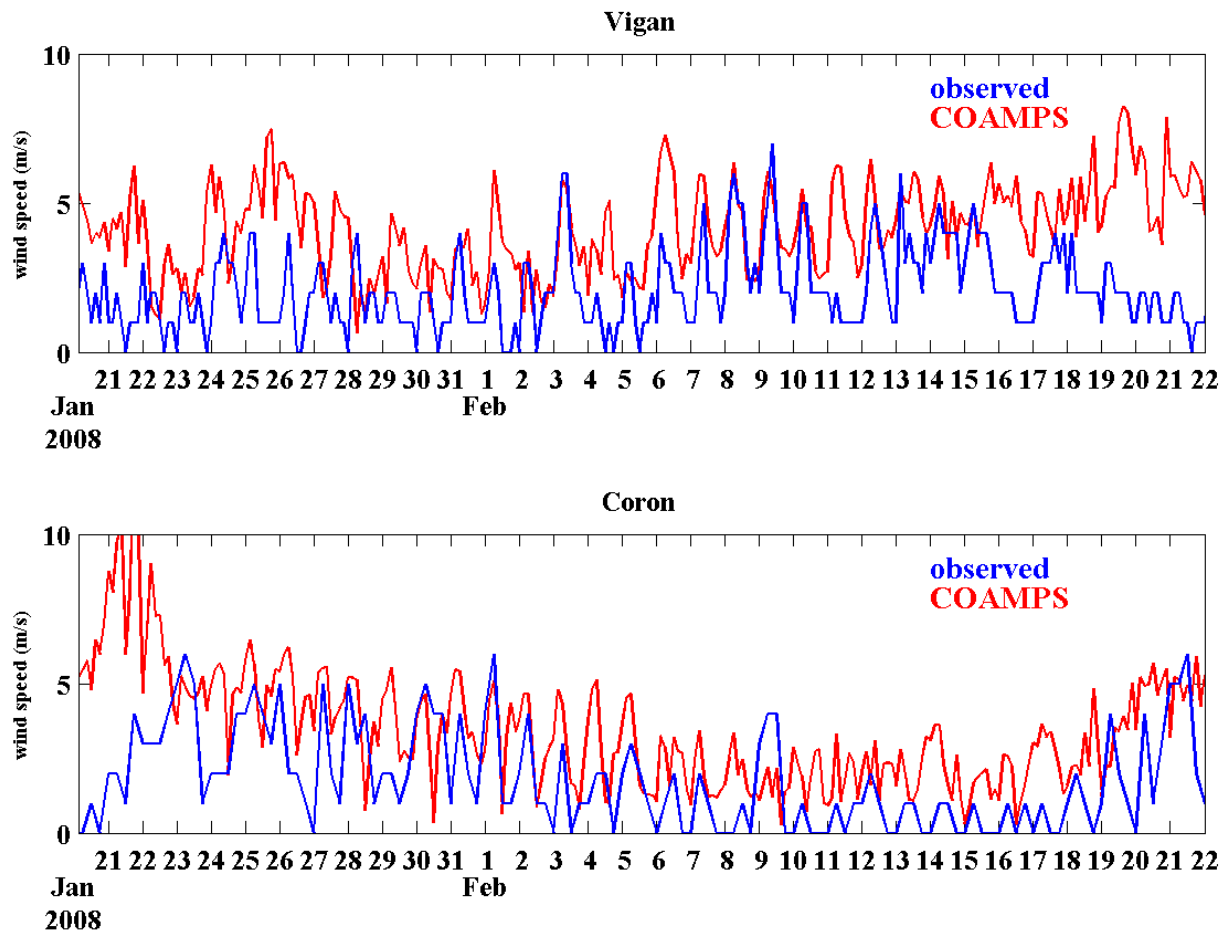


Figure 2: Near-surface winds ($m s^{-1}$) from COAMPS (9 km resolution) and the observations at two stations: Vigan and Coron.