MM5 and WRF Intercomparison for Trade Wind Shear Zone in the Lee of Kauai

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1. INTRODUCTION

During the normal trade wind flow regime of summer, the four largest islands of the Hawaiian archipelago (Hawaii, Maui, Oahu, Kauai) block the easterly to northeasterly flow. This blocking depends on characteristics of the large-scale flow: wind speed and direction; depth of the sub-cloud mixed layer and trade wind shallow-cumulus layer; Brunt-Vaisala frequency; and strength of the trade inversion. Blocking is also local, depending on island features such as island shape, orographic height, and characteristics of the topography.

Mount Waialeale on Kauai is one of the rainiest places on earth, with rain falling regularly in many different synoptic situations in all seasons. Even with a generally single-mountain, symmetric topography, there is significant orographic detail on Kauai: the flat Lihue plane on the windward side; steep cliffs leading to mountain top; two crests, with the famed Waialeale actually the smaller; a high mountain swamp; steep topography in the Little Grand Canyon; and the secluded Napali coast.

As one might expect, in the lee of Kauai there is a significant “calm” zone, with the trade flow passing around the island. This characteristic causes two strong shear zones, cyclonic on the north and anticyclonic on the south. The transition from moderate/strong trade winds to a much calmer environment can be both pronounced and small-scale, quite visible from aircraft by the change in sea state.

Boundary layer turbulence is affected not only by the general tropical pattern of strong surface heat flux, but also by the diurnal heating of the land surface (land-breeze, sea-breeze) and the time-dependent wind shear. The local and temporal characteristics of the turbulence in the mixed layer and the trade wind layer are not well understood, either observationally or theoretically. In particular, we inquire whether there may be very strong turbulent flow, which could be a hazard for small aircraft, in the planetary boundary layer (i.e., below altitude 2 km).

This small-scale, topographically induced flow anomaly provides an excellent meteorological environment for exercising meso- and micro-scale models with high resolution.

2. FIELD OBSERVATIONS

We obtained detailed observations of the local winds and turbulent characteristics through a series of six instrumented aircraft flights in August, September, and October 2003. Flight #4 on the morning of September 13 is selected as typical of the trade wind regime.

3. MESOSCALE MODELING

One of our objectives is to intercompare the MM5 and WRF models at high horizontal resolution. This case with complex small-scale topography, significant diurnal surface heating over land, and land-sea contrast provides an excellent test of mesoscale model performance. We report on the preliminary results from execution of these two models. Where possible, similar physics schemes are chosen in order to facilitate model intercomparison.

a. MM5

The MM5 is run in a nested grid format at resolutions of 54, 18, 6, and 2 km. We experienced difficulty in getting MM5 to operate in its expected highest resolution grid of 1 km.

We use the following physics: Grell cumulus parameterization above 10 km horizontal resolution; MRF planetary boundary layer scheme; Goddard microphysics; RRTM longwave radiation and cloud-radiation shortwave; no shallow convection.

b. WRF

The WRF has previously been run in version 1.3, but for purposes of this workshop we are attempting to present results from the very recently released version 2.0. New results will be presented at the workshop. In addition, we are attempting the new nest-down capability, using MM5 output as the imposed outer grid for WRF.

We have adopted the following physics packages: Ferrier (new ETA) microphysics; RRTM longwave radiation; Dudhia shortwave radiation; Monin-Obukhov (Janjic ETA) surface-layer physics; NOAH land surface physics; Mellor-Yamada-Janjic TKE boundary layer scheme; Betts-Miller-Janjic cumulus scheme for domains with grid size larger than 10 km, no cumulus parameterization at smaller grids.

4. Model runs, model intercomparison, and comparison with observations

To be provided at the workshop.

5. Acknowledgments

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