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Analysis of Aircraft Solar and Infrared Irradiance Measurements During UPPEF to Validate Radiative Transfer Schemes Employed in Model Simulations

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LONG-TERM GOALS

The long term goal of this project is to improve the radiative transfer schemes used in Navy regional and Large Eddy Simulation (LES) weather models.

OBJECTIVES

The objective of this project is to test and validate the radiative transfer schemes employed by the Navy Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS[1]) and LES model simulations by performing an in-depth analysis of aircraft solar and infrared (IR) radiative flux measurements made throughout the marine boundary layer off the coast of Monterey, CA during the Unified Physical Parameterization for Extended Forecast (UPPEF) field study in 2012.

APPROACH

Solar radiative heating and IR radiative cooling are two of the primary drivers of turbulent processes in marine stratus and in the evolution and persistence of these clouds, yet there has been very little validation of the radiative transfer schemes used in the Navy COAMPS and LES models that simulate these quantities. During UPPEF the Naval Postgraduate School (NPS) Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS) Twin Otter aircraft performed both constant altitude flight legs and altitude profile descent and ascent 'soundings' through the stratocumulus topped boundary layer (STBL). This dataset is being used to do a rigorous comparison between modeled and measured shortwave and longwave flux values in the STBL environment employing both a case study and a rigorous statistical analysis approach:

1. For particular case study days and specific flight leg segments, comparisons are being carried out between the downwelling (and upwelling) solar and IR radiative flux measured from the aircraft with model generated values. Initial focus is on homogeneous cases (e.g. clear sky, solid overcast) to more easily discern any differences between measured and model generated

[1] COAMPS® is a registered trademark of the Naval Research Laboratory.

fluxes. We will also examine the effect on the upwelling longwave flux across the strong SST gradient observed on the first UPPEF research flight (RF01).

2. We plan to compare the complete set of aircraft irradiance measurements with model values to statistically determine random and systematic bias errors. Part of this analysis will include binning the data (e.g. clear sky cases, overcast cases, and broken cloud cases) to elucidate the conditions where the measured/model values compare better or worse. It will also include computing the radiative forcing characterized by the total divergence of longwave radiative flux across the cloud layer. This parameter may provide key information on how the STBL is driven in both the model forecasts and observations.

WORK COMPLETED

For UPPEF in 2012, customized solar and IR radiometers were mounted on the CIRPAS Twin Otter aircraft and successfully measured the down- and up-welling solar and infrared irradiance on all 12 research flights. Pre- and post-mission calibrations were carried out and analyzed at the CIRPAS Radiometer Calibration Lab. In FY13, these calibrations were then used in the processing and quality-control of the NRL solar and IR broadband radiometer irradiance data. QC'ed datasets, with documentation, of the solar and IR irradiance measured on each flight of the Twin Otter aircraft during UPPEF were submitted to the NPS UPPEF data archive. No funding was available in FY14, but in FY15 work focused on revisiting this dataset:

- All of the radiometer data has been re-examined to verify its quality.
- Particular case study days, and specific flight segments, are being identified to find homogeneous conditions (e.g. clear sky segments, solid cloud segments) where comparisons between the measured and modeled radiative fluxes will be more straightforward. This is being done by examining the flight notes, the archived weather and satellite data, and the radiometer data itself.
- The following flights have been identified as possible good case studies:
    - Clear skies: portions of RF01, RF04, and RF08; all of RF09, RF11, and RF12
    - Overcast: portions of RF01, RF06, and RF08; all of RF02, RF05, RF07, and RF10
- Plans for the COAMPS and LES model runs are in development.

RESULTS

This project is still in progress, so no final results are available yet. Previous preliminary studies (e.g. Wang et al., 2010a,b) have shown general agreement between measured and LES modeled radiative fluxes for the STBL (see Fig. 1). Here a more rigorous comparison, with more case studies, will be carried out.

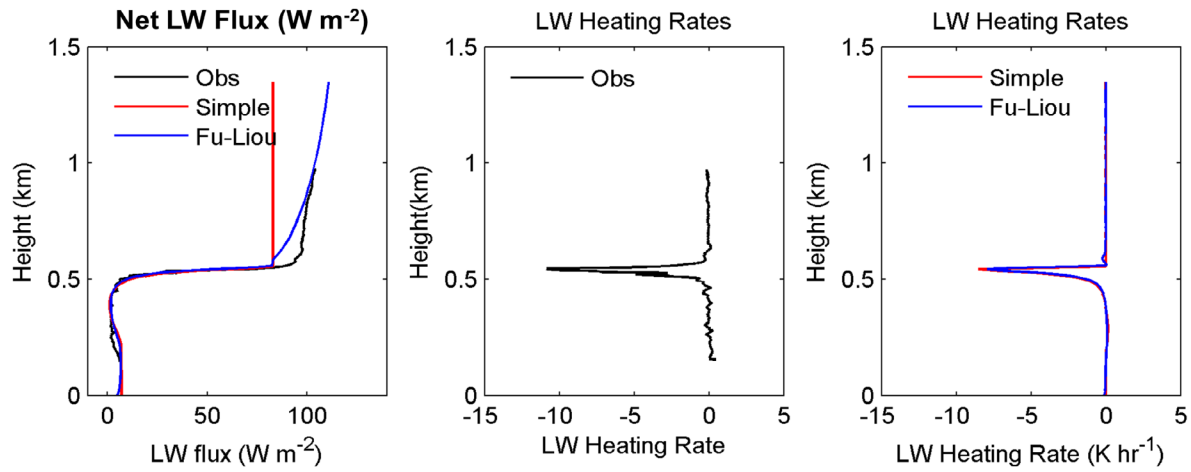

Figure 1. Comparison between measured and modeled longwave (LW) net radiative fluxes and heating rates from the POST aircraft field study. The modeled LW was calculated using the Fu-Liou radiative transfer scheme employed in the Navy LES model.

IMPACT/APPLICATIONS

By testing and evaluating the radiative transfer schemes used in Navy regional and Large Eddy Simulation (LES) weather models, this project will improve the Navy's ability to model the turbulent processes in marine stratus and the evolution and persistence of these boundary layer clouds.

RELATED PROJECTS

Related project is the ONR DRI on Unified Physical Parameterization for Extended Forecast (PI: Qing Wang).

REFERENCES

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