Aerosols and Clouds in the Marine Boundary Layer at the Azores AMF

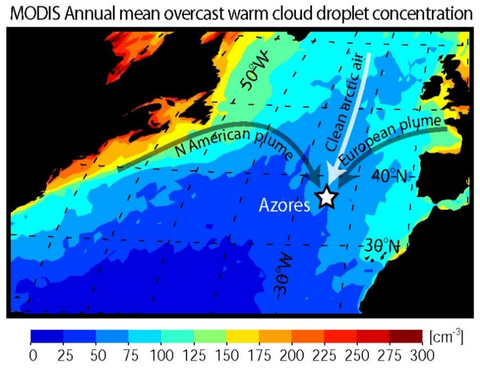
Matthew C. Wyant, Jennifer K. Fletcher, Christopher S. Bretherton, Robert Wood
Department of Atmospheric Sciences, Seattle, Washington, USA

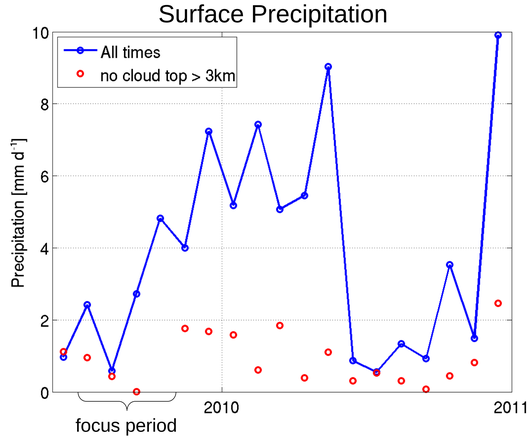
Introduction

The Clouds, Aerosols, and Precipitation in the Marine Boundary Layer (CAP-MBL) project utilizes the ARM Mobile Facility (AMF) deployment on Graciosa Island in Azores for May 2009 - December 2010. This project provides a rich observational data stream with the following features:

- A large suite of continuous measurements including:
  - surface meteorology – anemometer, barometer, rain gauge
  - cloud radar, lidar, ceilometer
  - radiometers, nephelometer, CCN counter, sun photometer
  - 4x-daily rawinsondes
- Long time period
- Relatively undisturbed marine boundary layer
- Transitional cloud regime featuring both shallow cumulus and stratocumulus as well as frontal clouds
- Diverse aerosol conditions

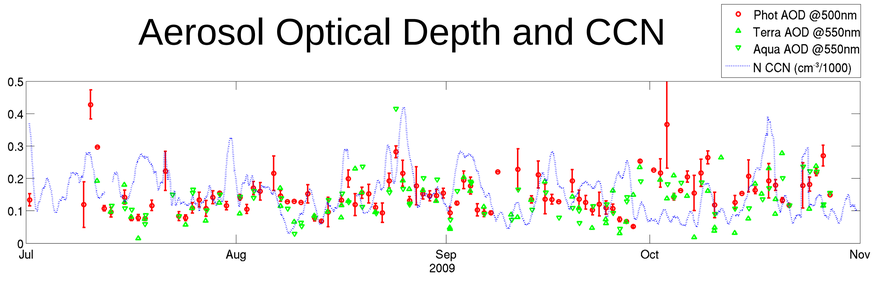
Surface precipitation on Graciosa peaks in the winter. Precipitation during periods of shallow clouds (no clouds above 3km) is significant most months. In this poster we focus on coincident observations and model output from July-October 2009. We are studying relationships between cloud regimes, CCN, aerosols, and precipitation and the extent to which these relationships are well represented in contemporary models.





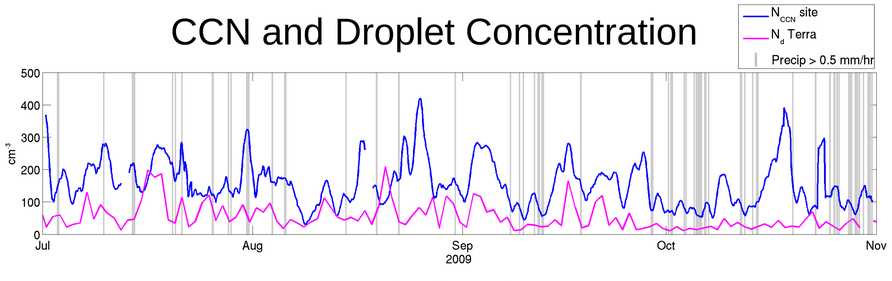
Comparison with MODIS

Aerosol Optical Depth and CCN



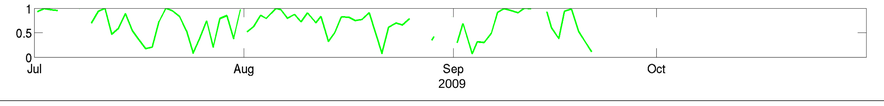
- AOD from in-situ photometer and daily MODIS retrievals (Terra + Aqua) mostly agree.
- CCN concentration from the CCN counter (0.1% supersaturation) show fairly weak correlation with AOD.

CCN and Droplet Concentration



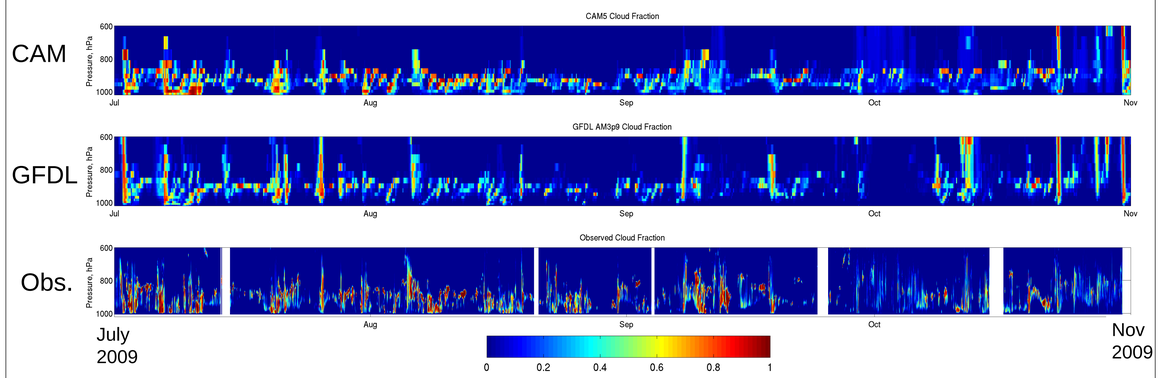
- Some correlation between CCN concentration and MODIS-Terra derived cloud droplet concentration (N_d), but not universal.
- Surface remote sensing-derived N_d would provide important constraints.

Cloud Fraction



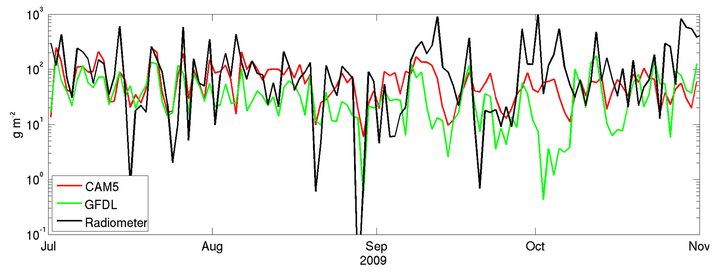
Comparison with GCM Forecasts

Cloud Fraction

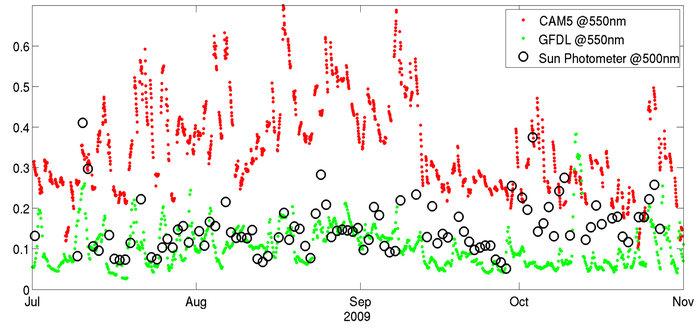


- GCMs are run in forecast mode initialized by ECMWF YOTC Analysis.
- Model columns near Graciosa Island are analyzed for forecast hours 24-48.
- NCAR CAM 5.0 and GFDL A3p9 have aerosols interactive with cloud microphysics.
- Surface pressure and horizontal winds (not shown) agree very well between models and observations.
- Vertical velocity (not shown) agrees well between models.
- Boundary layer depth and clouds agree fairly well with radar/lidar.
- LWP agrees fairly well with microwave radiometer.
- Significant bias in CAM5 AOD during summer months.

Liquid Water Path (daily mean)



Aerosol Optical Depth



Conclusions

- Variations in AOD as measured by sun-photometer are fairly well characterized by MODIS retrievals.
- Variations in CCN concentrations do not track column AOD variations closely.
- GCMs run in forecast mode simulate the clouds in the marine boundary layer reasonably well.
- Biases in AOD are seen in the GCM forecasts. Some aspects of seasonal and daily AOD variations are captured.

Acknowledgements

We would like to thank Cecile Hannay at NCAR and Yanluan Lin at GFDL for conducting GCM simulations and providing model output and documentation. Most observational data were obtained from the Atmospheric Radiation Measurement (ARM) Program sponsored by the U.S. Department of Energy, Office of Science, Office of Biological and Environmental Research, Climate and Environmental Sciences Division. Cloud top and some cloud fraction data were obtained from NASA Langley (Patrick Minnis). This work was supported by the US. Department of Energy Atmospheric System Research Award DE-SC0002081.

email: mwyant@atmos.washington.edu