

11A.6 LIDAR SIMULATIONS OVER HURRICANE BONNIE USING CAMEX -3 DATA, A LIDAR SIMULATION MODEL AND NUMERICAL MODEL ANALYSES

S. Greco*, S.A. Wood, and G.D. Emmitt
Simpson Weather Associates, Inc., Charlottesville, Virginia
and

M. Nicholls and R. Pielke Sr.
Colorado State University, Fort Collins, CO

1. INTRODUCTION

Recent studies have shown that the inclusion of dropwindsonde observations (Aberson and Franklin (1999)) and satellite wind observations (Goerss et al., 1999) made around hurricanes can have a positive and statistically significant impact on the accuracy of hurricane track forecast models. Alternatives to dropwindsondes and satellite winds, such as airborne and space-based lidar-based measurements, may also have significant merit and will be explored here. In 1995, airborne optical remote sensing instruments such as Lidar Atmospheric Sensing Experiment (LASE) and the Multi-center Airborne Coherent Atmospheric Wind Sensor (MACAWS) were used independently to make measurements around hurricanes. In addition, both the MACAWS and LASE instruments were flown aboard NASA aircraft as part of the 1998 CAMEX 3 field campaign. While remote sensing by laser-based systems will ideally provide higher spatial and temporal resolution, the noncontiguous nature of the lidar data products (resulting from cloud impacts) raises issues that may be best addressed with models that would have to assimilate the data.

Collaborative work is ongoing between SWA and Colorado State University (CSU) in which the nested RAMS model is being used to investigate the impact of CAMEX 3 measurements (dropwindsondes and LASE moisture) on hurricane track and intensity forecasts. The 1998 Atlantic Hurricanes Bonnie and Danielle are being used as case studies. The work being described here uses a developed Lidar Simulation Model (LSM) to determine and simulate the potential data coverage that would result from an optimally performing airborne or space-based lidar. Several experiments are underway or being planned in which the analyses and forecast fields of the Eta model, the NCEP Reanalysis, and the CSU RAMS during Hurricanes Bonnie and Danielle are being used to provide the "real" atmosphere for the LSM.

2. LIDAR SIMULATION MODEL

Over the past 10-15 years NASA has funded the development of the LSM (Wood et al., 1993). The LSM

has evolved to where it can be used to simulate the end-to-end performance of either airborne or potential space-based lidars, including DIAL and Doppler Wind Lidars (DWL). The LSM is a fully integrated simulation model that produces global 3-D simulated lidar measurements with realistic errors using either global or mesoscale atmospheric model fields (such as the RAMS). The major model components include the instrument, platform, and atmospheric libraries. The LSM can address various types of questions on the feasibility and optimal functionality of a space-based or airborne lidar system and is also designed to address measurement accuracy and areal coverage. A block diagram of the existing LSM is presented in Fig. 1.

The LSM retrieves atmospheric profiles as a function of latitude and longitude for each laser shot. Each profile also contains aerosol and molecular optical properties, cloud information and terrain. The LSM has been used to simulate lidar winds near a hurricane (Wood et al., 1997). This study used the Eta meso model initial fields to examine the performance of co-located airborne lidar wind and moisture sounders in the environment of the Eta model representation of 1995 Hurricane Allison (June 4, 1995). Figure 2 presents an example of an atmospheric variable (cloud amount) used during LSM experiments of Hurricane Allison. Also included in Fig. 2 is a hypothesized flight track for a lidar bearing aircraft investigating Allison.

3. LIDAR SIMULATIONS OVER HURRICANES

At the time of this writing, results for simulations over Hurricanes Bonnie and Danielle were unavailable but are expected to be ready for the conference presentation. To illustrate the potential results of the LSM experiments, we have chosen to present results from earlier hurricane studies. Figure 3 shows the vertical cross-section profiles of simulated line of sight winds from the Doppler lidar along the diagonal flight tracks, respectively. The effects of cloud obscuration on both systems can be clearly seen. Due to cloud porosity (Emmitt and Seze, 1991) and the smaller diameter of the lidar beam, the Doppler lidar is able to penetrate to the PBL in conditions that appear to be totally cloudy to a passive sensor.

Figure 4 shows the potential for satellite laser wind coverage over a hurricane such as Fran (Sept 1996). The simulation of the satellite orbit is for a proposed NPOESS configuration (i.e., 833-km altitude and 45'

*Corresponding author address: Steven Greco, SWA, 809 E. Jefferson St., Charlottesville, VA 22902; e-mail: sxg@cyclone.swa.com.

nadir scan angle). The figure shows that given ~ 1800 km swath width, twice daily coverage of such storms will provide numerous potential wind estimates.

4. CONCLUDING REMARKS

Optical sensors promise to make high spatial and temporal resolution measurements in hurricane environments, but only as clouds permit. Simulations of this type can help in the design of field experiments and to explore the potential impact of future space-based systems.

REFERENCES

Aberson, S. D., and J. L. Franklin, 1999: Impact on Hurricane Track and Intensity Forecasts of GPS Dropwindsonde Observations from the First-Season Flights of the NOAA Gulfstream-IV Jet Aircraft, *Bull. Amer. Meteor. Soc.*, Vol. 80, NO. 3, 421-427.

Goerss, J. S., C. S. Velden and J. D. Hawkins, 1999: The Impact of Multispectral GOES-8 Wind Information on Atlantic Tropical Cyclone Track Forecasts in 1995. Part II: NOGAPS Forecasts, *Mon. Wea. Rev.*, Vol. 126.

Emmitt, G. D. and G. Seze, 1991: Clear Line of Sight (CLOS) Statistics within Cloudy Regions and Optimal Sampling Strategies for Space-based lidars, *Proc. AMS Seventh Sump. On Meteor. Observa. and Instru.* New Orleans, LA January 14-18..

Wood, S. A., G.D. Emmitt, M. Morris, L. Wood and D. Bai, 1993: Space-based Doppler lidar sampling strategies -- algorithm development and simulated observation experiments. Final Rept. NASA Contract NAS8-38559, Marshall Space Flight Center, 266 pp.,

Wood, S. A., G. D. Emmitt and S. Greco, 1997: Optical Remote Sensors as Components of an Airborne Hurricane Observing System, *Preprints of the First Symposium on Integrated Observing Systems*, 39-44

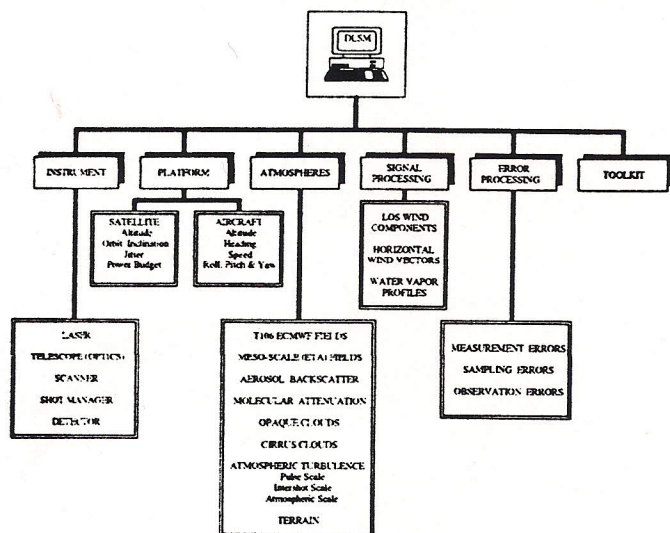


Fig. 1. Block diagram of the LSM.

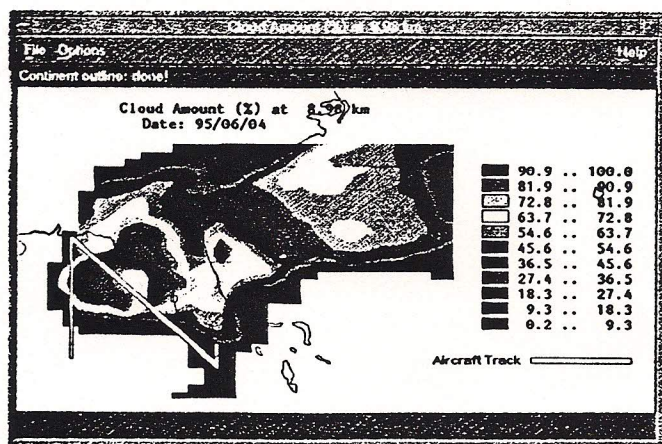


Fig. 2. Simulated aircraft track over eta cloud field of Hurricane Allison.

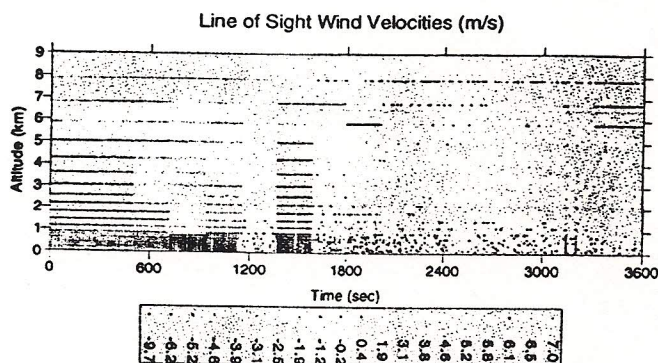


Fig. 3. Vertical cross-section of simulated Doppler lidar winds (m/s).

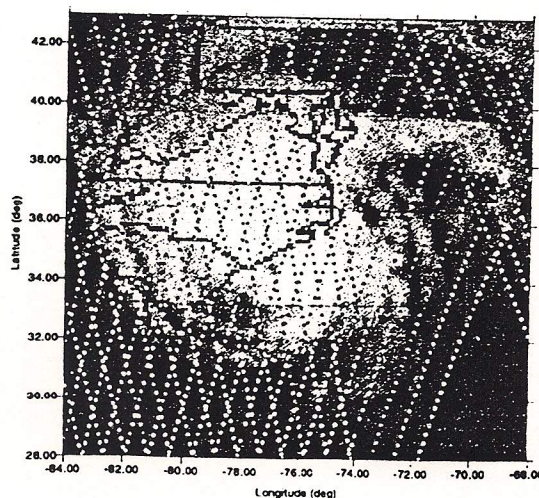


Fig. 4. Simulated 24-hr Doppler wind lidar coverage over Hurricane Fran (9/6/96).