A Coherent Lidar Simulation Model for Simulating Space-Based and Aircraft-Based Lidar Winds

S.A. Wood, G.D. Emmitt, D. Bai, L.S. Wood and S. Greco

Simpson Weather Associates, Inc.
809 E. Jefferson Street, Charlottesville, VA 22902
Telephone: (804)979-3571

The U.S. Air Force (USAF) seeks reliable measurements of winds in the vicinity of clouds from the perspective of a satellite platform or high altitude aircraft. These wind observations may be used as input to tactical decision aids or assimulated into weather forecast models. There is also interest in making direct wind measurements below clouds by sampling through optically thin gaps. To develop an optimal design concept for such lidar platforms, a simulation model has been developed to address questions of optimum laser wavelength, pulse length, minimum power, scanning strategies , optimal signal processing and wind computation algorithms. This paper presents an operational simulation model (Defense Lidar Simulation Model (DLSM)) for space-based/airborne coherent Doppler lidar wind sounders that produce simulated lidar winds using either global or mesoscale atmospheric model wind fields.

1.0 The Defense Lidar Simulation Model

The DLSM is an evolution of existing coherent Doppler lidar simulation models (Wood et al., 1993; Emmitt et al., 1990) that are currently used for spaced-based Doppler lidar wind simulations (Baker et al., 1995). The DLSM adds to the existing models an airborne simulation model, mesoscale field atmospheres and a high resolution optical property model. The DLSM is a fully integrated Doppler lidar simulation model that can address a number of issues ranging from lidar system trade studies to global numerical model assimulation and impact studies with an emphasis on sampling in cloudy environments. The DLSM runs on the HP 715/33 platform.

2.0 Model Operation

The DLSM greeting screen, shown in Figure 1, contains three menus: Actions, Options and Help. From the Actions menu, the user controls the DLSM's inputs, outputs, graphics and operation. The user can review his inventory of operational, platform/orbital and meteorological input files, load existing input and output files, edit existing files, create orbital and aircraft data sets and create atmospheric libraries for model simulation. Action also contains a scrollable window with documented text that gives an overview of the DLSM and its operation. In the Options menu, the user is allowed to customize the non-mandatory limits for the model inputs.

The DLSM operation is managed by three model configuration screens: Operations, Platform/Lidar and Atmospheric Library. Figure 2 is an example of the Operations input screen which controls the type of simulation the user wants to run. Currently, the user can only choose a coherent Doppler lidar for the lidar type. It is intended that incoherent lidar and DIAL will be added to the menu at future dates. The user can keyboard/mouse enter inputs or load an existing operational configuration data file. The user can choose to simulate the lidar platform through either a global or a mesoscale atmospheric field.

From the Platform/Laser configuration screen the user can choose either an existing orbit/aircraft file from inventory or create a new platform file. The DLSM currently has 10 pre-defined orbit configuration data sets and 21 real aircraft data sets that were taken from a series of real investigations studying the mesoscale atmospheric environment of the Amazon Basin (ABLE-2A). The user has the option to view the orbit/aircraft geographic coverage data. The Platform/Laser configuration screen also defines the laser configuration (i.e., laser wavelength, pulse length, etc.), scanner, signal processing, shot management and power budget.

The Atmospheric configuration screen allows the user to choose from the atmosphere library an existing global circulation data set or a mesoscale data set. Gridded output from the National Meteorological Center's ETA weather

forecast model, shown in Figure 3, is an example of a mesoscale field. The user can also generate control fields such as divergence, vorticity and deformation for system trade studies.

3.0 Model Products

The DLSM provides simulated line-of-sight and horizontal wind products, laser shot coverage products, system power budget and lidar performance files.

The line-of-sight wind products are aerosol backscatter, signal-to-noise, grid scale variance, sub-grid scale variance, pulse scale variance and simulated lidar line-of-sight winds. The horizontal wind products are simulated lidar horizontal wind components and associated wind errors. An example of global space-based Doppler lidar simulated lidar winds is shown in Figure 4.

The DLSM also produces performance output files for the line-of-sight and horizontal wind products. The line-of-sight wind performance files give the percentage of time the lidar system can make useful measurements in terms of sufficient backscatter from aerosols, clouds and cirrus clouds. The files also show the percentage of no returns due to clouds. The horizontal wind performance files give the percentage of time that a lidar system can make good horizontal wind estimates for 5 categories ranging from 1 m/s accuracy to 5 m/s accuracy. Also shown is the percentage of time the system has an insufficient number of shots in the grid area to make a wind estimate. Examples of the line-of-sight wind and horizontal wind performances for a 20 Joule/9.1μm space-based lidar system are shown in Figures 5 and 6, respectively.

References

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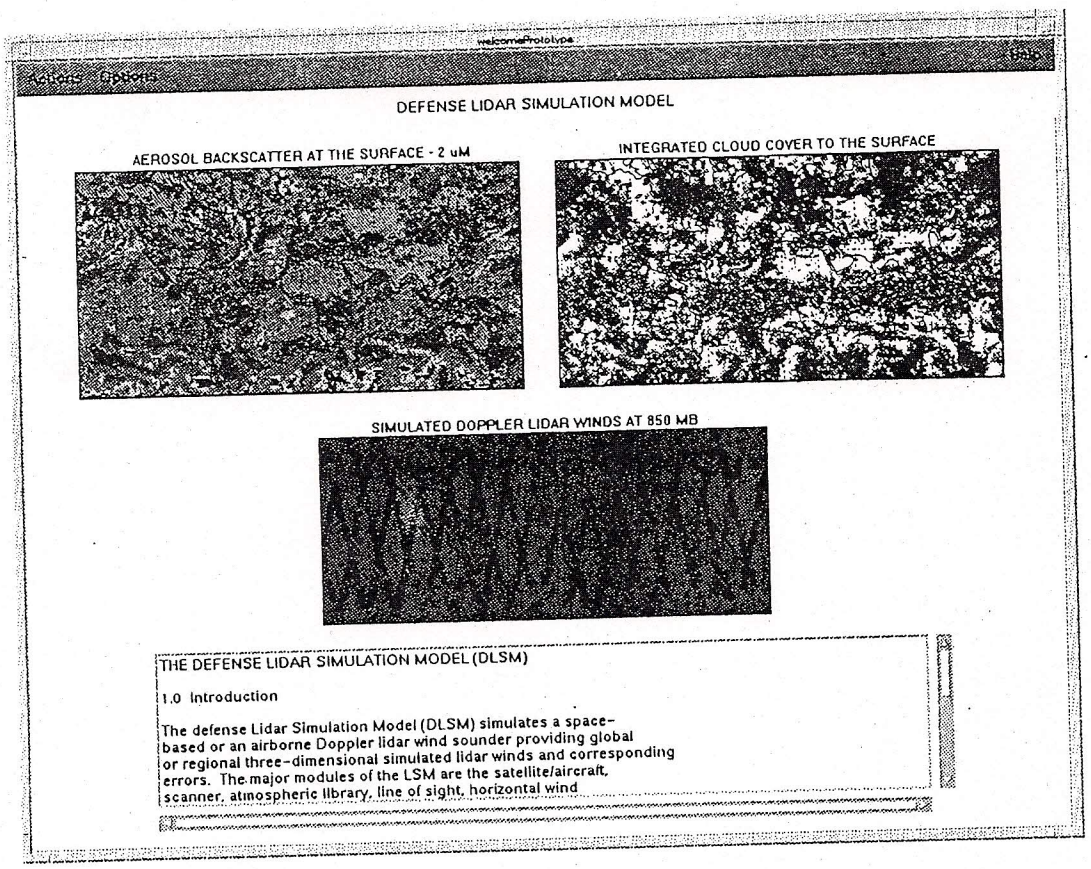

Fig. 1. DLSM main screen.

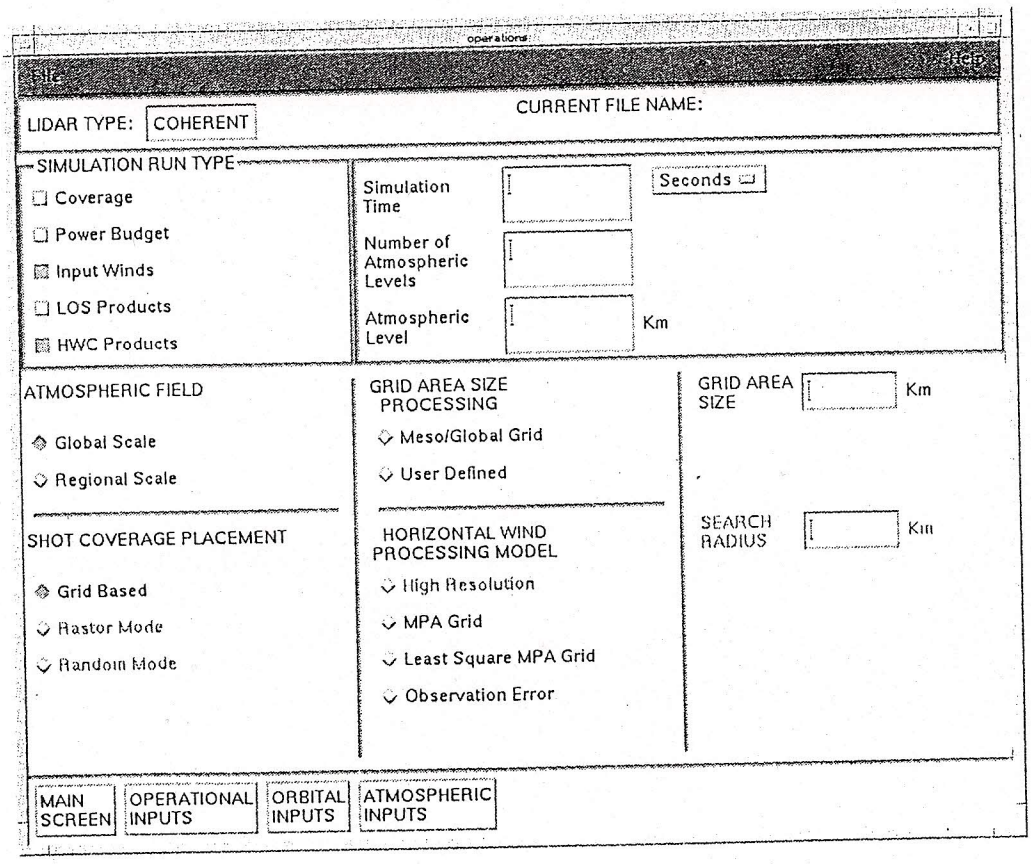

Fig. 2. DLSM operations screen.

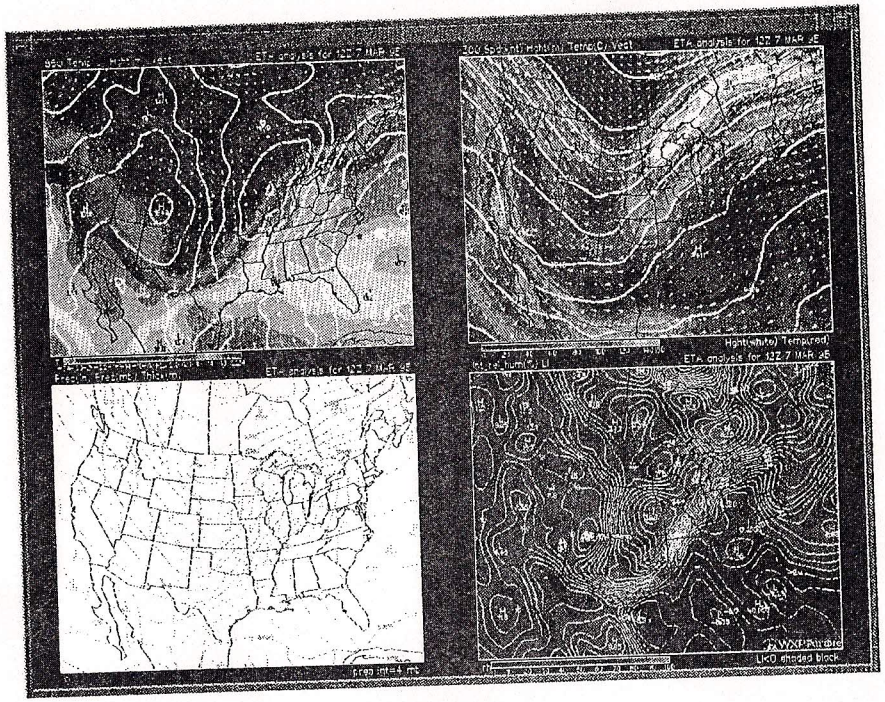

Fig. 3. Atmospheric fields - mesoscale.

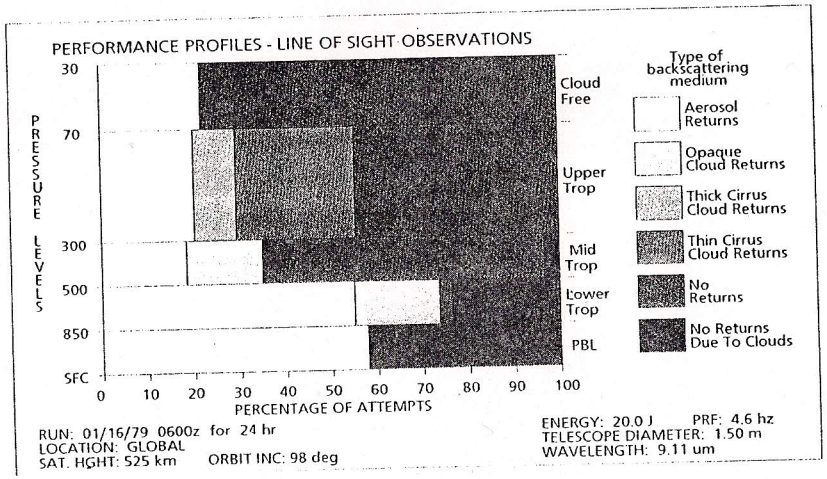

Fig. 5. Simulated line-of-sight performance.

24 HOUR COVERAGE OF SIMULATED
SPACE-BASED DOPPLER LIDAR WINDS IN THE PBL

(horizontal winds)

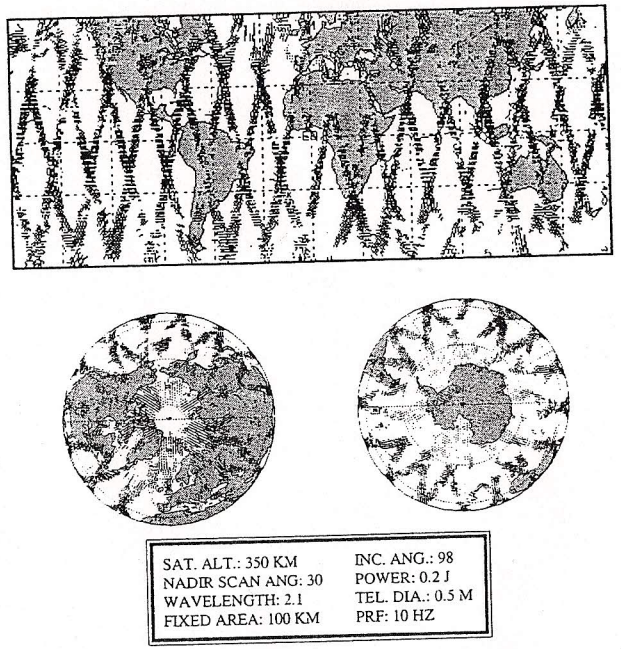

Fig. 4. 24-hour simulated winds.

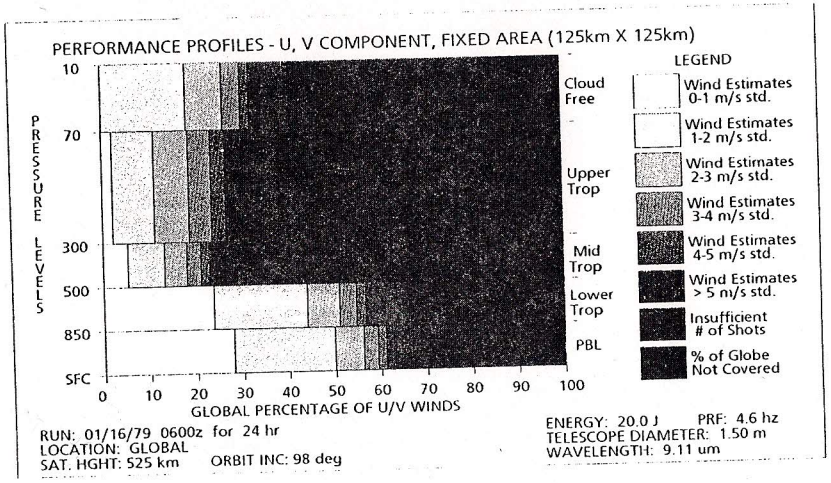

Fig. 6. Simulated horizontal laser wind performance.