Attachment 1

DESIGN ATMOSPHERES

for use in

GTWS CONCEPT STUDIES**

provided by the

Science Definition Team

for the NASA/NOAA

Global Tropospheric Wind Sounder

September 22, 2001

Purpose

Having a common scattering target with internally consistent backscatter wavelength dependence enables meaningful "equal resource/equal target" comparisons of GTWS concepts that employ Doppler lidars. While the Science Definition Team (SDT) realizes that aerosol backscatter from the atmosphere will vary over several orders of magnitude, will vary over altitude, latitude and season and will also vary over space/time scales that are not readily modeled, the GLOBE , SABLE/GABLE backscatter surveys, and the AFGL MODTRAN aerosol data bases provide a nearly consistent picture of backscatter climatology.

To establish a set of bounding profiles, the SDT has chosen (1) the "background" distribution of $\beta(\pi)$ that appears in most stacked histograms of the GLOBE/SABLE/GABLE data sets and (2) the distribution of "enhanced" backscatter opportunities that are most apparent during the summer seasons and more common in the northern hemisphere (Srivastava, et al, 2001). The background mode value should not be interpreted as representing the minimum value of the aerosol cross section to be found. Rather, it represents a low cross section modal peak for aerosols in tropospheric air that does not have loading enhancement due to identifiable aerosol transport. There is a distribution of values and measurements indicating that the lowest aerosol cross sections can be an order of magnitude lower than the mode in some cases. The actual distribution of cross sections in the background mode are not well known. Measurements indicate that the background aerosol mode is present in large regions of the globe, mostly in the upper troposphere but can also be found in the boundary layer. The global distribution of these modes is not known, nor is the correlation of these modes with regions of ageostrophy. Therefore, these profiles should only be used to develop system point designs for concept evaluation and comparisons.

It is expected that these profiles will be used to simulate the performance of a DWL concept for multiple levels within the troposphere and lower stratosphere. For example, for a shot reaching the altitude of 8 km in the "Background mode of GLOBE" atmosphere, the simulation of a .355 µm system scanned at 45° nadir should produce a distribution of velocity errors as a function of $\beta(\pi)$ with a 2-way transmission of .498, a mean velocity of 25 m^{-1} s^{-1}, a layer mean shear of 15.0 E-3 s^{-1}, and a "shot scale" turbulence with a standard deviation of 3.5 m s^{-1}. The distribution would be for the "background" aerosol mode that has a geometric mean of 4.4 E-8 m^{-1} sr^{-1} and a width of ln(s) = .8. A complete description of the point design including the energy/pulse, prf, integration time, mirror diameter, etc. should accompany any presentation of the simulated results.

The effort to provide common reference atmospheres is on-going. Suggestion for improving these profiles and/or their application should be communicated to the co-chairs of the SDT (atlas@dao.gsfc.nasa.gov or James.G.Yoe@noaa.gov).

References

Srivastava, V. , J. Rothermel, A. D. Clarke, J. D. Spinhirne, R.T. Menzies, D.R. Cutten, M.A. Jarzembski, D.A. Bowdle, and E.W. McCaul, 2001: Wavelength dependence of backscatter by use of aerosol microphysics and lidar data sets: application to 2.1um wavelength for space-based and airborne lidars. Applied Optics, V40, 4759-4769.

Caveats

1. These atmospheres are meant only for the purpose of enabling "equal target" comparisons of different DWL concepts and their potential LOS data products. Emphasis is on measurement accuracy and not representativeness or coverage. Furthermore, there is no claim to the frequency of occurrence of the two backscatter modes.

2. The wavelength dependency of the backscatter coefficient across the 1-2 orders of magnitude width of the background mode is thought to vary from λ^{-3} on the left side (lower on the left side (lower β) to $\lambda^{-1.5}$ on the right side (higher on the right side (higher β)). A $\lambda^{-2.5}$ was used in these tables going from 1.06 µm data to 2.0518 and .355 µm at and above 3 km. Since a different λ coefficient was used below 3 km, some smoothing of the resulting profiles has been done to make the transition more realistic. Even so, there are some “jumps” between the mid-troposphere and boundary layer values due in part to the use of different phase functions for the aerosol attenuation in those two regions.

3. Issues related to sampling and averaging (or co-processing) within regions of realistic wind variability are not addressed with these reference atmospheres. Significant differences will result from different scanning patterns and laser shot densities.

Definitions

Wavelength: expressed in micro-meters. Number in () is the line (cm^{-1}) used in FASCODE.

Background mode: based upon GLOBE data representing the "background" aerosol mode found in both northern and southern hemisphere data sets.

Enhanced mode: based upon GLOBE data taken during periods when aerosol backscatter was clearly enhanced over the background cases. Enhancement includes effects of elevated dust layers, convective pumping, biomass burning, etc.

MODTRAN: based upon the atmospheric transmission data for a maritime tropical airmass with 50km visibility and 23km visibility in the boundary layer.

Altitude: taken to be the top of the layer; data is assumed to be a point value for that altitude, except for surface wind which is taken to be at 10 m. For example the value of “B-back” = 0.490E-07 in the .355 tables (background mode) is to be interpreted as being at 3km. To obtain the average aerosol backscatter for the layer between 2 and 3 km, the value of 0.700E-07 at 2km should be used to compute the layer average of .595E-07. (units: km)

B-back: assumed to be the geometric mean of a lognormal distribution of GLOBE "background" aerosol mode data with ln(s) = .8 (units: m^{-1} sr^{-1}). “s” is the distribution width.

B-enhan: values provided are the geometric layer mean of a lognormal distribution of the backscatter events that are in excess of the "background" aerosol mode of backscatter, sometimes referred to as the convective mode. The width of this distribution is ln(s) = 1.0.

B-MOD: values of aerosol backscatter from MODTRAN data bases.

A-totl: total attenuation coefficient (aerosol scattering, aerosol absorption, molecular scattering, molecular absorption) based on FASCODE (units: km^{-1}).

M-back: molecular backscatter $\beta(\pi)$ taken from MODTRAN (units: m^{-1} sr^{-1})

U: based upon global averages from ECMWF T106 Nature Run; exception is the jet superimposed at 10 km (units: m s^{-1})

Sigma: "reasonable" values of uncorrelated wind variability on scales less than 10 km (units: m s^{-1})

Cld: clouds are expressed in terms of their optical depth (units: km^{-1}). The physical thickness is assumed to be 1 km (eg. cloud listed at 10km is located between 9 and 10km). The percent coverage of the Target Sample Volume(TSV) is taken to be 100% for the cloud between 9 and 10 km and 50% for the cloud between 2 and 3 km. The cloud between 2 and 3km is assumed to be composed of scattered small clouds that have horizontal dimensions equal to the spacing between individual lidar shots. Thus each shot has the same probability of being terminated by a cloud.

A-ext: aerosol extinction coefficient derived using the same backscatter/extinction ratios as those used in MODTRAN (units: km^{-1})

M-scat: attenuation due to molecular scattering (units: km^{-1})

M-abs: attenuation due to molecular absorption (units: km^{-1})

Trans(2x): two way transmission from space (nadir looking) to the bottom of the layer and back (units: fraction)