Phoenix lidar measurements of atmospheric dust and clouds

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Introduction:

The Phoenix mission [1] landed on Mars on 25 May 2008. Several instruments for atmospheric measurements have functioned throughout the mission and these have provided measurements of temperature [2], pressure [2], wind [3], humidity, optical depth, composition, and atmospheric imaging. A unique instrument on the Phoenix mission was a lidar [4]. This measured the backscatter of pulsed laser light that is emitted upward into the atmosphere. It is capable of detecting dust and clouds up to heights above 20 km. The lidar was operated typically three times per sol during daylight hours (8am to 6pm), and also whenever the lander was operating at night (6pm to 8am).

The lidar measurements of dust provided a view of how the structure of the boundary layer changed throughout each sol, and over longer time scales with passing weather systems and seasonal progression. The depth of the boundary layer followed a daily cycle with a peak height in the late afternoon. The vertical structure of the atmospheric dust is often remarkably homogeneous, in agreement with modeling [5], but on occasion there are layers of enhanced scattering that are more difficult to explain.

Enhancements in the lidar backscatter signal were interpreted as being caused by water ice clouds. The ratio of the derived extinction and backscatter coefficients was similar to that associated with cirrus clouds on earth. Around the time of summer solstice the most prominent clouds were detected at heights above 10 km. As the season progressed there were observations of clouds at lower heights. The extinction coefficient derived from the lidar signals was used to estimate the ice water content. This analysis was based on comparison with studies of cirrus clouds on earth that involved both lidar and aircraft in situ measurements.

The lidar started detecting ground level clouds about 40 sols after solstice. These clouds resembled ice fog or Diamond Dust, as observed in the polar regions of the earth.

The highlights from the Phoenix lidar measurements will be presented. This will include the daily and seasonal evolution of the vertical distribution of dust and clouds. Discussion will focus on the analysis for estimating the cloud ice water content.

References:

[1] Smith, P., et al. (2008), Introduction to special section on the Phoenix Mission: Landing Site Characterization Experiments, Mission Overviews, and Expected Science, *J. Geophys. Res., 113*, doi:10.1029/2008JE003083.

[2] Taylor, P. A., D. C. Catling, M. Daly, C. S. Dickinson, H. P. Gunnlaugsson, A. Harri, and C. F. Lange (2008), Temperature, pressure, and wind instrumentation in the Phoenix meteorological package, *J. Geophys. Res., 113*, E00A10, doi:10.1029/2007JE003015.

[3] Gunnlaugsson, H. P., C. Holstein-Rathlou, J. P. Merrison, S. Knak Jensen, C. F. Lange, S. E. Larsen, M. B. Madsen, P. Nørnberg, H. Bechtold, E. Hald, J. J. Iversen, P. Lange, F. Lykkegaard, F. Rander, M. Lemmon, N. Renno, P. Taylor, and P. Smith (2008), Telltale wind indicator for the Mars Phoenix lander, *J. Geophys. Res., 113*, E00A04, doi:10.1029/2007JE003008.

[4] Whiteway, J., M. Daly, A. Carswell, T. Duck, C. Dickinson, L. Komguem, and C. Cook (2008), Lidar on the Phoenix mission to Mars, *J. Geophys. Res., 113*, E00A08, doi:10.1029/2007JE003002.

[5] Taylor, P. A., P. Y. Li, D. V. Michelangeli, J. Pathak, and W. Weng (2007), Modelling dust distributions in the atmospheric boundary layer on Mars, *Boundary Layer Meteorol., 125*, 305–328, doi:10.1007/s10546-007-9158-9.