PRESSURE DATA FROM THE PHOENIX LANDING SITE. Peter A. Taylor[1], Wensong Weng[1], Clive Cook[1], Cameron Dickinson[1], Ayodeji Akingunola[1], Jouni Polkko[2] and Henrik Kahanpää[2], [1]Centre for Research in Earth and Space Science, York University, Toronto, Ontario, M3J 1P3, Canada (pat@yorku.ca), [2]FMI, Helsinki, Finland.

Introduction: During the Phoenix mission air temperatures were measured at three levels on a 1-m mast and pressure was measured with a Barocap/Thermocap system housed on the deck of the lander, itself about 1 m above ground level [1]. Measurements were made at 0.5 Hz and ran almost continuously through the landed mission apart from short daily breaks for data transfers. The diurnal temperature data were generally very similar from one day to the next throughout the first 60 sols of the mission with daily maxima of around -30C and minima of -80C. These match our boundary-layer model predictions. The calculation of pressure from the raw Barocap output dependes on sensor temperature, T_b, which is initially assumed to be that measured by an adjacent Thermocap, at temperature T_T. The assumption is not always valid due to a nearby heat source and the pressure data needed some post-processing to correct for the effects. However the time scale of the adjustments is of order 60 s and the uncorrected data could be used to clearly identify the passage of dust devils and dustless vortex features (usually several per sol, near mid-day and early afternoon) with a shorter time scale. These are discussed by Ellehøj et al [2] while the present paper discusses the pressure corrections and longer time scale features.

The Pressure Data Adjustment: Adjustments are needed because the Barocap sensor head has a weaker thermal contact to the pressure sensors Printed Circuit Board (PCB) than the Thermocap. Because of this a temperature gradient is formed between these components if temperature rises or falls fast. During rising temperature the Barocap stays a little bit colder than the Thermocap and during falling temperature the Barocap stays a little bit warmer. Hence the calibration in the onboard data processing does not work perfectly in rapidly changing temperature. The result is that the raw pressure values of the Barocap are a little high in rising temperature and a little low in falling temperature.

The Thermocap temperature sensor heads have a strong thermal coupling to the PCB. Hence the temperature measured by the Thermocaps is practically the same as the temperature of the PCB. The thermal contact between the PCB and the Barocap sensor heads is much weaker. In Martian pressures the effect of heat transfer by gas convection is negligible. Hence only heat transfer by conduction needs to be taken into account when calculating the temperatures of the Barocaps. Our simple approach is to apply Newton's law of thermal conductivity so that

$$\frac{dT_b}{dt} = \frac{1}{\lambda}(T_T - T_b) .$$

Here λ is the time constant of temperature change which we determine to be 78.7s.

Ideally we would have T_T data at the same 2-s rate as other quantities but unfortunately these were not transmitted to Earth and, in general, we only have the T_T data once every 512 s that were transmitted to Earth. We therefore must interpolate these 512-s data, using a natural cubic spline, to obtain simulated 2-s T_T data. We then solve the thermal conductivity equation above for T_b and obtain a pressure correction, Δp based on

$$\Delta p = (\partial p/\partial T)(T_b - T_T)$$

with $\partial p/\partial T$ determined to be approximately 5.34 Pa/K.

Long term Pressure Variations: We have not yet applied the pressure adjustment to the full data set but for seasonal and synoptic time scale features the impact will be small. Figure 1 below shows uncorrected pressures throughout the full mission. The steady reduction in pressure during most of this period, from about 860 Pa to near 720 Pa is due to the deposition of CO_2 ice at the South polar cap.

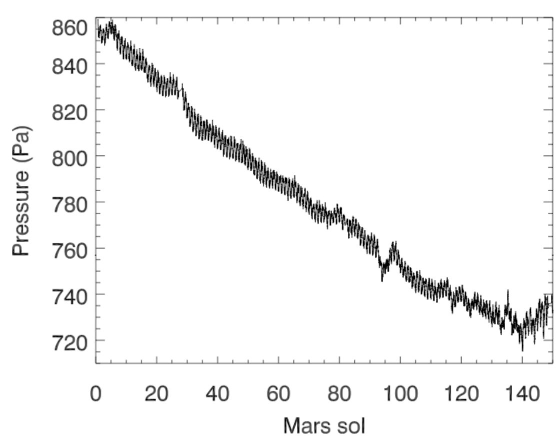

Figure 1 Surface Pressures (uncorrected), Sol 0-150 (Ls 77-148)

Note Mars global pressure minimum is expected at about Ls 140, and SOL 135 is approximately Ls 140 – we just caught it before Phoenix went into safe and then Lazarus modes. There are regular diurnal cycles in pressure, discussed below, but also occasional “synoptic” features associated with meteorological events.

There is a "High" pressure departure from the steady decline around Sol 28 (sols measured from the start of the mission at Ls 77) and a low pressure system at around Sol 95. Ellehøj's presentation [2] will highlight the much increased dust devil and vortex activity at that time.

Diurnal Pressure and Temperature Variations: Figure 2 below shows air temperature 1m above the deck (2m above ground) and corrected pressure data for the period from Sols 54-58, a relatively settled period according to Figure 1 above.

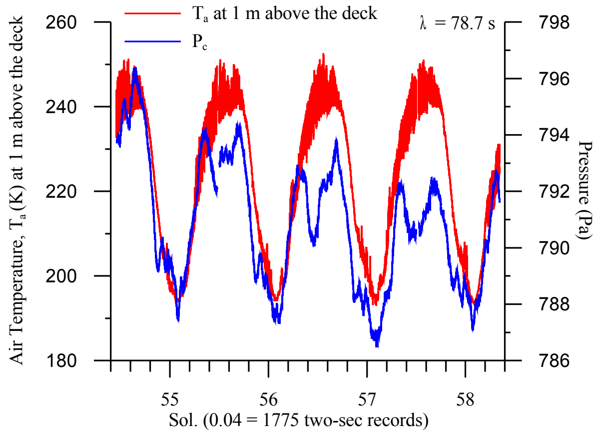

Figure 2 Phoenix MET, corrected pressure and thermocouple (T1) data for Sols 54-58 (Ls 101).

The temperatures show a regular diurnal cycle from a maximum of about 250K to a night-time minimum of near 195K. Mid-sol conditions are characterised by large turbulent fluctuations while evenings are calm. It is not entirely clear what causes the nocturnal fluctuations in temperature but winds are from an Easterly direction and pass over the lander before reaching the mast. Heimdal crater is also to the East, about 20 km away and could generate wave distrubances. Spectral analysis of the pressure records is planned.

The diurnal and semi-diurnal pressure variations are assumed to be caused by a mix of solar tides and Kelvin waves [3]. The apparent similarity in phase between the diurnal temperature and pressure variations was initially a cause for concern – just in case the air temperature was affecting the pressure measurement. Checks against AMES and York University Mars GCM output did however confirm that, at the Phoenix site at this time of year, the pressure maximum should occur near 1300-1400 local Mars time. Normalised pressure ranges are slightly less than 1% (amplitude < 0.5%) which is also consistent with the GCM model output although absolute values differ slightly. Further investigation and more comparisons with GCM output are planned. Figure 3 below shows output from a version of the York University Mars GCM [4]. There is less of a semi-diurnal component in the GCM results but the phase and amplitude of the diurnal tide match the observations reasonably well.

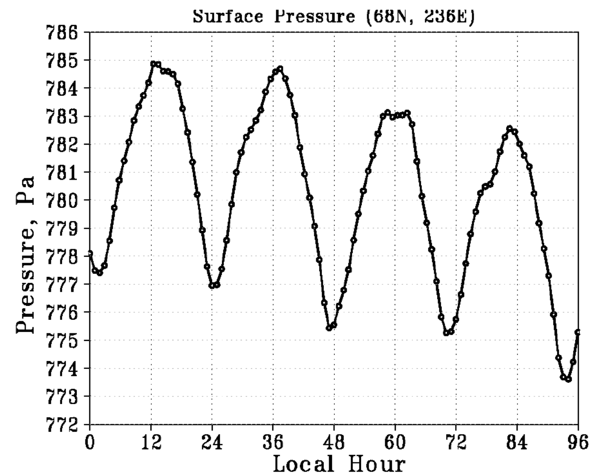

Figure 3 York Mars GCM results for the Phoenix site, Plotted results start at Ls 100.

Conclusions: Despite problems associated with the placement of a heat source close to the pressure sensor, which we were unaware of due to ITAR restrictions, the Barocap has provided a significant data set covering events on a wide range of time scales from 20-s vortex and dust devil events to a part of the annual cycle. Further analyses of the adjusted pressure data are in hand.

References: [1] Peter A. Taylor, David Catling, Mike Daly, Cameron Dickinson, Haraldur Gunnlaugsson, Ari-Matti Harri and Carlos Lange, 2008, Temperature, Pressure and Wind instrumentation on Phoenix MET. J. Geophys Res.- Planets 113, E00A10, doi:10.1029/2007JE003015.
[2] M. D. Ellehoj, H. P. Gunnlaugsson, P. A. Taylor, B. T. Gheynani, J. Whiteway, M. T. Lemmon, K. M. Bean, L. K. Tamppari, L. Drube, C. Von Holstein-Rathlou, M. B. Madsen, D. Fisher, P. Smith 2009, Dust Devils and Vortices at the Phoenix Landing Site on Mars. LPSC 2009, Abstract 1558.
[3] R.J. Wilson and K. Hamilton 1996: Comprehensive model simulation of thermal tides in the martian atmosphere. *Journal of the Atmospheric Sciences* 53 1290-1326.
[4]Mouden, Y., and J. C. McConnell , 2005, A new model for multiscale modeling of the Martian atmosphere, GM3, J. Geophys. Res., 110, E04001, doi:10.1029/2004JE002354.