Uranus Atmospheric Model for Engineering Application. Gary A. Allen Jr.[1], Mark S. Marley[2] and Parul Agrawal[3], [1]NASA Ames Research Center, ERC, Moffett Field, CA 94035 gary.a.allen@nasa.gov, [2]NASA Ames Research Center, Moffett Field, CA 94035 mark.s.marley@nasa.gov, [3]NASA Ames Research Center, ERC, Moffett Field, CA 94035 parul.agrawal-1@nasa.gov .

In order to simulate Uranus atmospheric probe entry trajectory and aero-thermal heating, it is necessary to have a reliable atmospheric model. Most of what was known about the Uranus atmosphere came from the Voyager-2 fly-by that occurred on 24 January 1986. No other spacecraft has since travelled near Uranus. The seminal atmospheric model related publications originating from this flyby were by G.F. Lindal, et al [1] for the lower atmosphere and F. Herbert, et al [2] for the upper atmosphere. Herbert's original paper was later superseded by a paper by J. Bishop, et al [3]. Users of this Voyager era-derived model should be mindful that there is evidence for seasonal variation in the thermal profiles [4]. A single use data management program was written to read in data from these different atmospheric models interpolating them into a single atmospheric model that was cast in thermodynamic parameters useful for trajectory and aero-thermal simulation.

The Uranus atmospheric model is based upon the usual convention for ice and gas giant atmospheric models of assuming zero altitude at 1 bar pressure. Figure 1 shows the pressure versus temperature profiles for the new engineering model for altitudes up to 500 km. Figure 2 shows the altitude versus temperature profiles for altitudes up to 5000 km (note the high temperature that was actually measured by Voyager-2) All the constituent models from the literature survey are also shown for comparison in the plots. The entry altitude for atmospheric entry into Uranus should be such that the initial heating on the aeroshell is negligible (this insures that the time integrated aeroshell heat load is correct). For Uranus, this altitude was found to be near 3000 km. Consequently, it was important to have a good engineering atmospheric model that extended beyond 3000 km altitude. The best stratospheric atmospheric model that was found, comes from Table 1 of Bishop, et al's paper [3]. A significant aspect of Bishop's model was its clear indication of a mesopause. When the Bishop model was plotted on top of the Justh and Lindal models, it was discovered that the Justh model tended to better overlay [5].

References:

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[2] "The Upper Atmosphere of Uranus: EUV Occultations Observed by Voyager 2", Floyd Herbert, B.R. Sandel, R.V. Yelle, J.B. Holberg, A.L. Broadfoot, D.E. Shemansky, S.K. Atreya and P.N. Romani, J. of Geophysical Research, Vol. 92, No. A13, Pg. 15,093-15,109, 30 Dec 1987.

[3] "Reanalysis of Voyager 2 UVS Occultations at Uranus: Hydrocarbon Mixing Ratios in the Equatorial Stratosphere", J. Bishop, S.K. Atreya, F. Herbert and P. Romani, Icarus, Vol. 88, No. Pg. 448-464, 1990.

[4] "Post-Equinoctial Observations of the Ionosphere of Uranus", Melin, Henrik, et al, Icarus, Volume 223, Issue 2, p. 741-748, 2013.

[5] *private communications*, Hillary Justh, NASA, Marshall Space Flight Center.

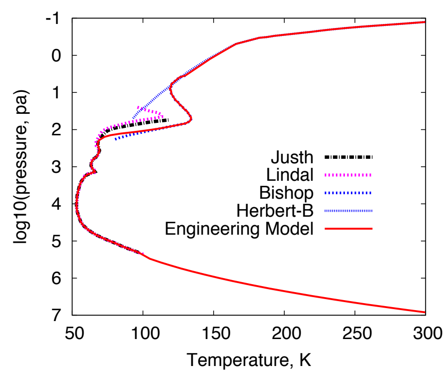

Figure 1-Temperature versus Log10(Pressure) profile comparing different atmospheric models.

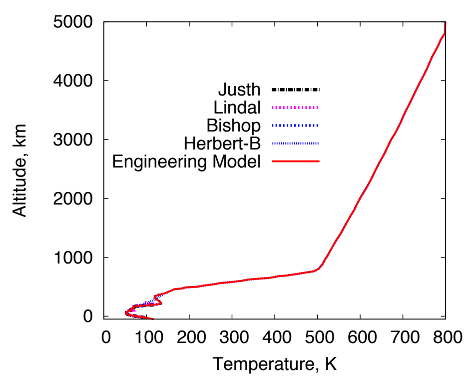

Figure 2- Temperature versus altitude profile comparing different upper atmospheric models.