A 3 KM ATMOSPHERIC BOUNDARY LAYER ON TITAN INDICATED BY DUNE SPACING AND HUYGENS DATA[1]

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ABSTRACT

Titan, one of the largest and arguably most fascinating moons of our solar system, has long been known to have a complex atmosphere and is, in fact, the only solar system moon of its kind. Only in the last decade, however, has the Saturnian moon received the observation focus it needs to truly develop our understanding of its complexities, and this is due to the invaluable dataset provided by the Cassini-Huygens mission. While the dataset is not yet large, the quality and relevance of the results have led to many publications and findings of both the tentative and assertive variety. One such finding is given by a 2010 *Icarus* paper by Ralph D. Lorenz et al.

The authors of the selected paper argue that Titan's atmospheric boundary layer, the lowest layer of the Titan troposphere, extends three kilometers above the surface. The primary reference for the authors in developing this assertion is a paper led by one of the co-authors, Bruno Andreotti, on the analysis of sand dunes, both large and small, found exclusively on the Earth[2]. This Andreotti et al. paper argues that the dune spacing of "giant" (separation scales on order of kilometers, heights about twelve times smaller) dunes found in varied locations on the Earth is limited by, and even defined by, the height of the terrestrial atmospheric boundary layer. They also define this height in terms of measurable atmospheric parameters:

$$H \approx \frac{\delta\Theta}{\gamma}$$

where Θ is the potential temperature, $\delta\Theta$ is the change in Θ near the surface, and $\gamma = d\Theta/dz$, the potential temperature lapse rate.

Lorenz et al. deem the assertions and approximations presented by Andreotti et al. applicable to Titan because of the "coincident scale size" of the large dunes covering twenty percent of the moon's surface to the large dunes found on our planet. They measure an average dune spacing with Cassini RADAR images of 2-3 km, with no apparent latitude dependence, which is just what Andreotti et al find with the giant Earth dunes located far from major water features. They use Adobe Photoshop to measure this spacing, and then find an independent H value using the equation reproduced above and defined by Andreotti et al. The values on the left-hand-side of the equation are determined using the Huygens data and separate rough calculations.

The authors attempt to support their argument with a potential profile derived from the data of the Huygens probe, from which both supporting and contradicting determinations of boundary layer height have been found. The authors recognize the other conclusions found in the literature, but either disagree with or enhance the earlier findings.

These calculations are somewhat back-of-the-envelope; the authors count dunes and divide by the known scale of the image to determine a rough value for mean spacing, and they have but one set of observations (from the Huygens descent) and a few other approximations of temperature variations to provide an H value. They recognize the limitations of the current data, but assert that their conclusions are the best – have the best agreement and make the most sense – for even this limited dataset, though they certainly recognize the need for more and better measurements to confirm their findings.

References:

[1]Lorenz, R. D., Claudin, P., Andreotti, B., Radebaugh, J., Tokayo, T., 2010. A 3 km atmospheric boundary layer on Titan indicated by dune spacing and Huygens data. Icarus 205, 719-721.

[2]Andreotti, B., Fourriere, A., Ould-Kaddour, F., Murray, B., Claudin, P., 2009. Size of giant Aeolian dunes limited by the average depth of the atmospheric boundary layer. Nature 457, 1120-1123.