

A Three-Kilometer Atmospheric Boundary Layer on Titan Indicated by Dune Spacing and Huygens Data

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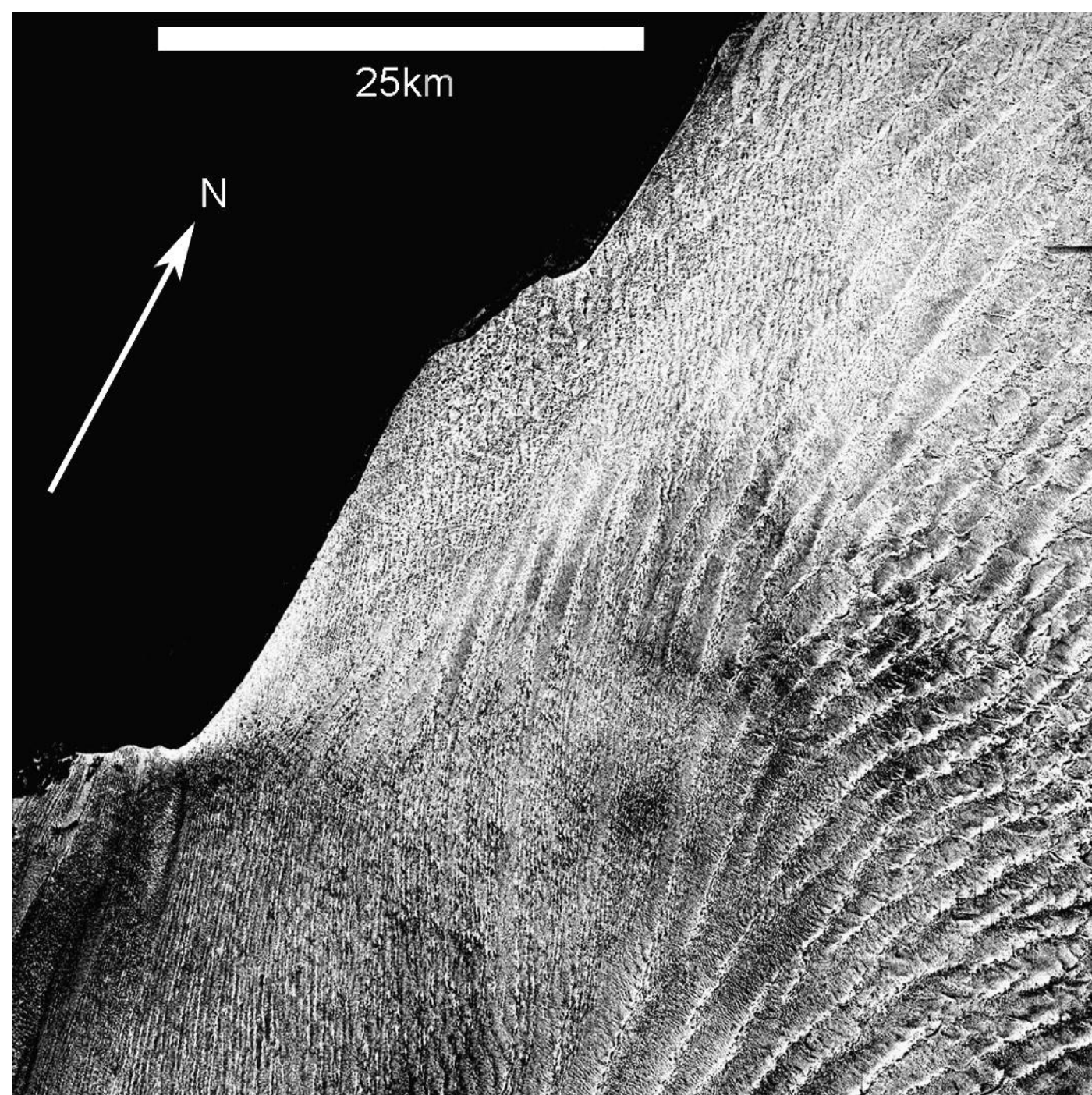
The lowest layer of the atmosphere (a sub-layer of the troposphere).

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The spacing of “giant” sand dunes on Earth peaks at the atmospheric boundary layer height (Andreotti et al. 2009).

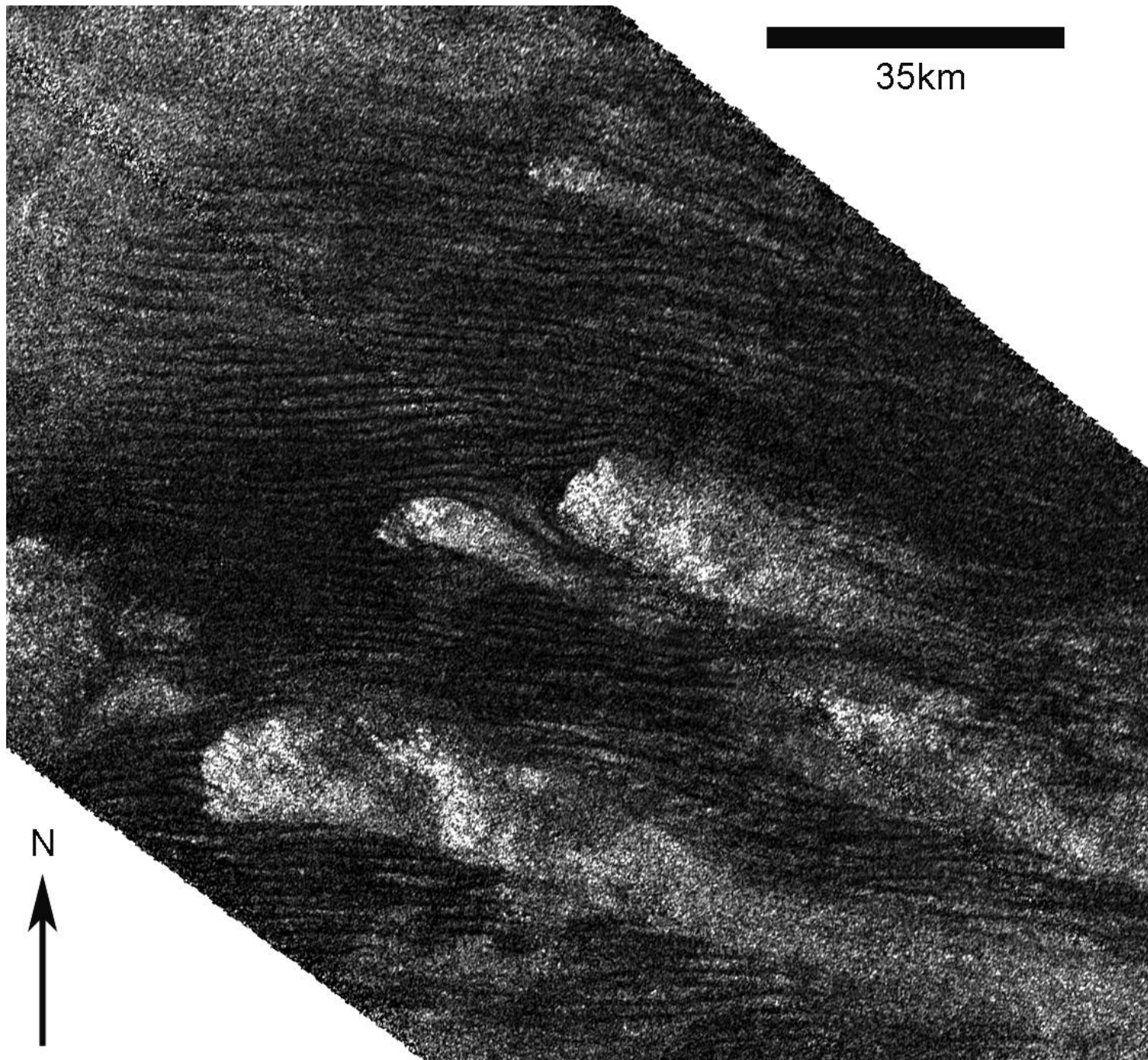
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The Huygens probe provides a temperature profile which can indicate location of atmospheric layers.



Namib desert
(Earth, 1994 radar)

Dune spacing:
500-600 m
(coastal)
1.5-2.5 km
(inland)

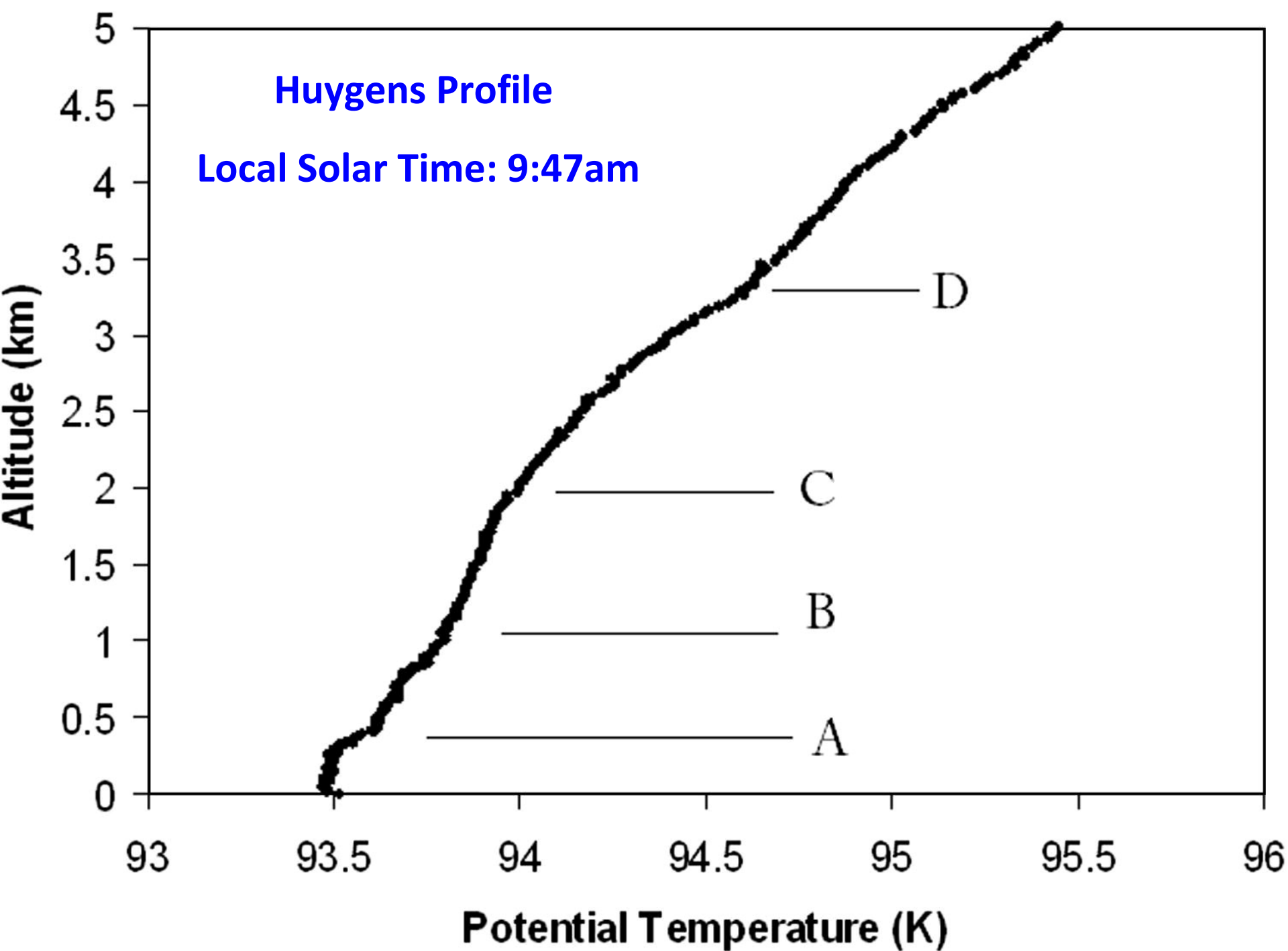


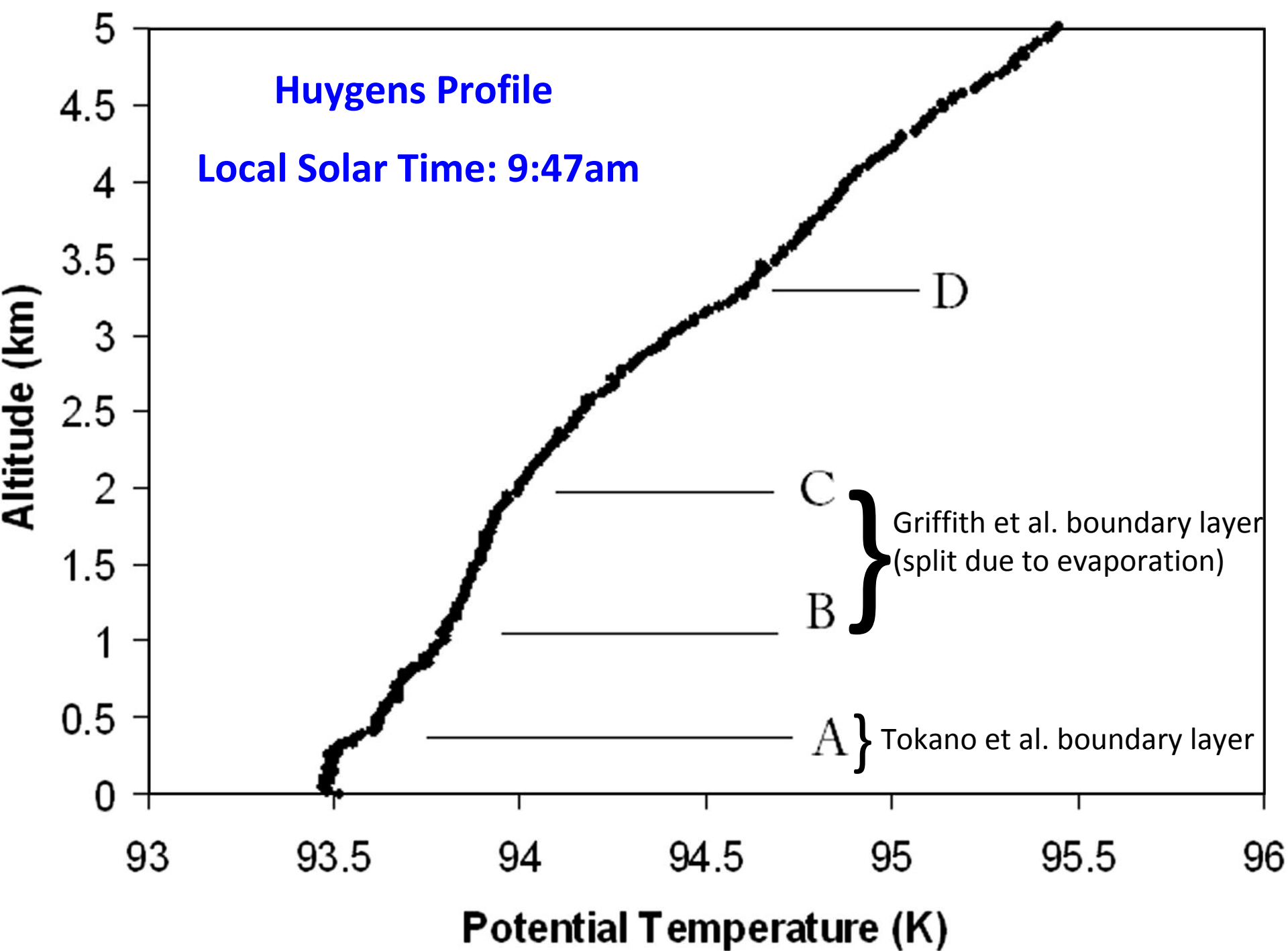
35km

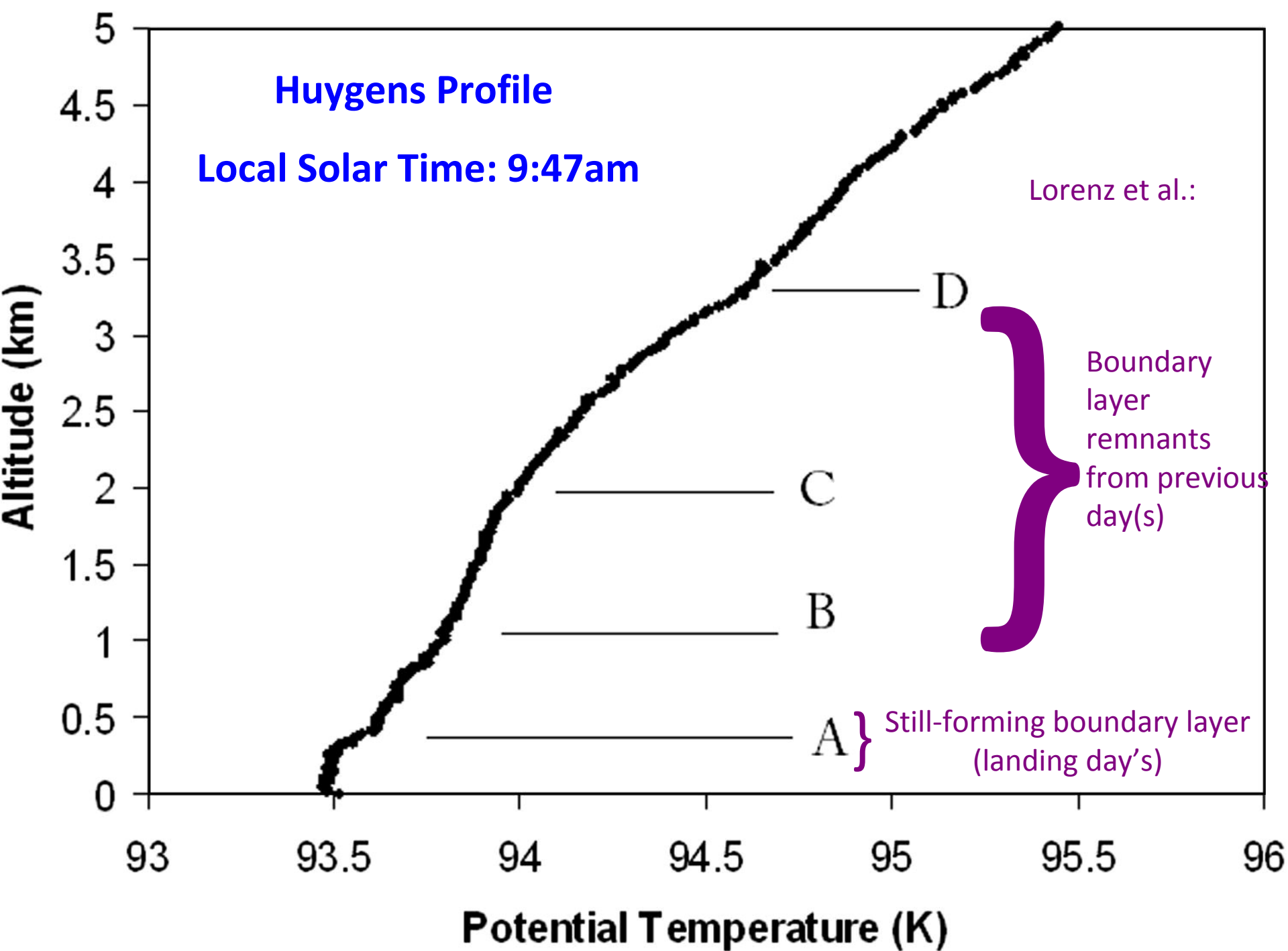
Shangri-La
region
(Titan, Cassini
RADAR)

Dune spacing
~3 km





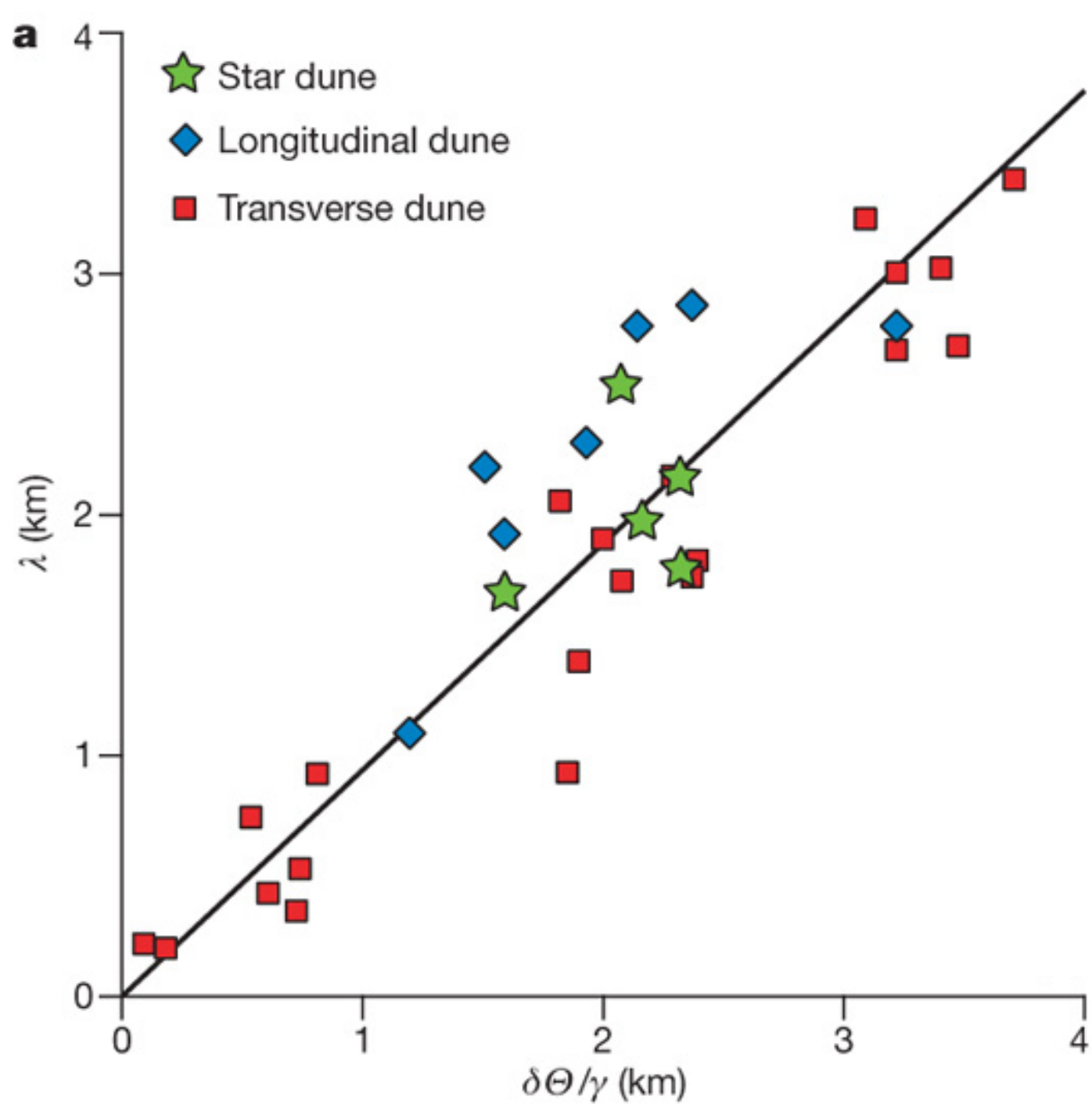




Final Check

The initial dune paper (Andreotti et al.) derived this method of calculating the boundary layer height:

$$\text{Boundary Layer Height} \approx \frac{\text{seasonal temperature variation}}{\text{potential temperature lapse rate}}$$



From Andreotti
et al. 2009

Final Check

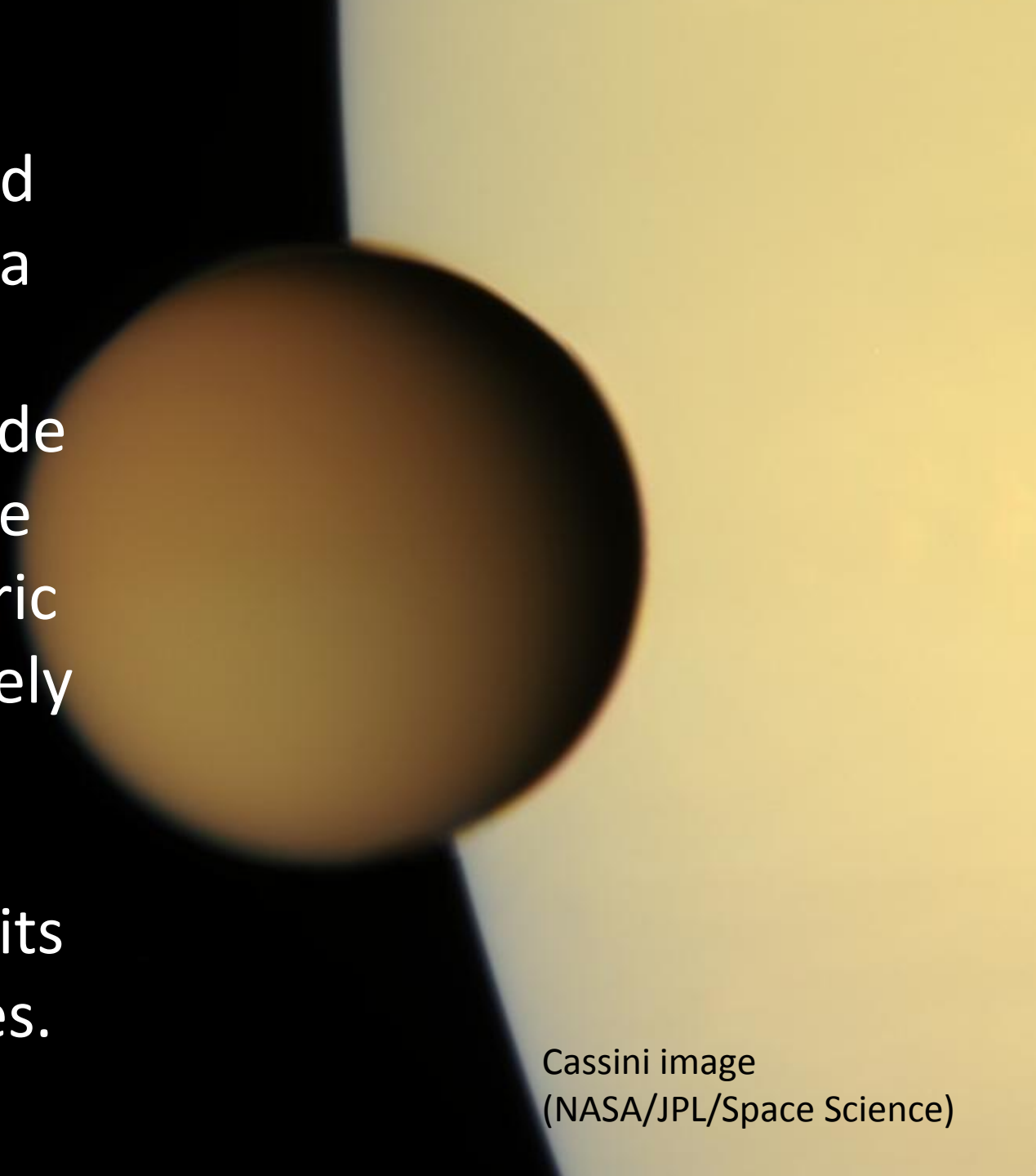
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$$\text{Boundary Layer Height} \approx \frac{\text{seasonal temperature variation}}{\text{potential temperature lapse rate}}$$

For a temperature variation $\approx 1\text{-}2$ K (Tokano 2005) and lapse rate $\approx 0.5\text{K/km}$ (Huygens):

$$H \approx 2 - 4 \text{ km}$$

Conclusion: Based upon current data and/or extrapolations made from trends in the Earth's atmospheric structure, Titan likely has a 3 km atmospheric boundary layer in its equatorial latitudes.



Cassini image
(NASA/JPL/Space Science)

References/Further Information

- Focus paper:** Lorenz, R. D., Claudin, P., Andreotti, B., Radebaugh, J., Tokano, T., 2010. A 3 km atmospheric boundary layer on Titan indicated by dune spacing and Huygens data. *Icarus* 205, 719-721.
- Initial (Earth) dunes paper:** Andreotti, B., Fourrière, A., Ould-Kaddour, B., Murray, B., 2009. Size of giant aeolian dunes limited by the average depth of the atmospheric boundary layer. *Nature* 457, 1120-1123.
- Initial temperature profile and boundary layer analysis:** Tokano, T., Ferri, F., Colombatti, G., Mäkinen, Fulchignoni, M., 2006. Titan's planetary boundary layer structure at the Huygens landing site. *J. Geophys. Res.* 111, E08007.
- Chemical abundances in Titan's atmosphere from Huygens data (relevant for γ , among other things):** Niemann, H. B. et al., 2005. The abundances of constituents of Titan's atmosphere from the GCMS instrument on the Huygens probe, *Nature* 438, 779-84.