

Titan's Atmosphere

- Before the Voyager several molecules, apart from methane, were detected by infrared spectroscopy (C_2H_6 , CH_3D , and C_2H_2).
- After the observations by the spaceprobe the following molecules were identified: N_2 , H_2 , HCN , C_3H_8 , C_2H_4 , C_3H_4 (CH_3C_2H), C_4H_2 , HC_3N , C_2N_2 , and CO_2 ;
- The Cassini-Huygens mission confirmed that the primary constituents of Titan's atmosphere were nitrogen and methane. It measured the vertical distribution of methane, the isotopic ratio of N in N_2 and the abundances and isotope ratios of noble gases;
- With the end of the Cassini-Huygens mission, the only way to obtain information about the chemical and physical properties of the atmosphere of Titan is through ground base observations;

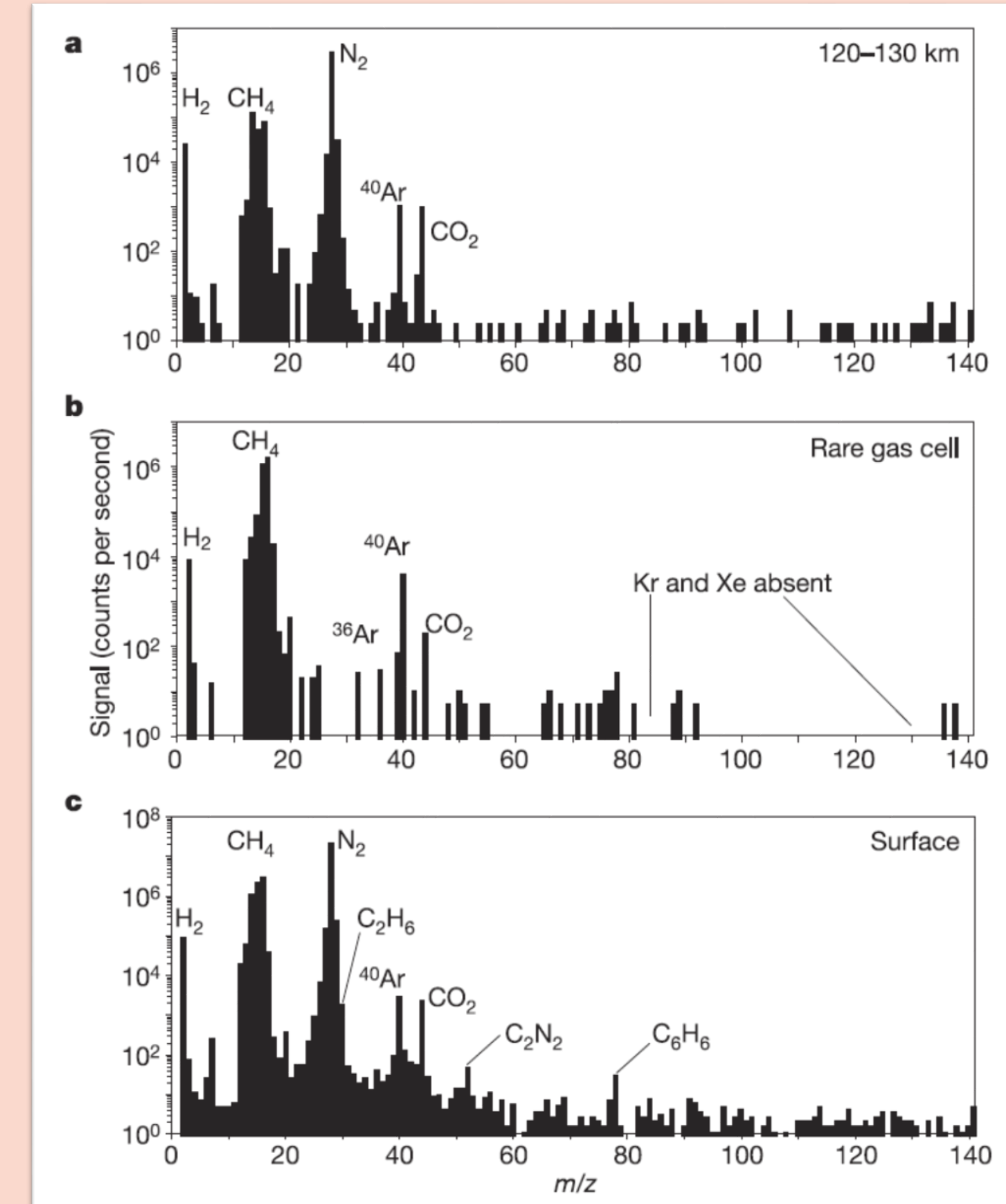


Fig 1: Sample-averaged mass spectra, showing ion count rates per second versus mass per unit charge (m/z) from direct atmospheric sampling. a, An upper atmosphere spectrum from altitudes of approximately 120 to 130 km, averaging 104 mass spectra over 244 s. b, The rare-gas cell measurements (about 75–77 km, averaging 43 mass spectra over 81 s), showing the lack of heavy primordial noble gases. c, A surface spectrum, averaged over 70 min (432 mass spectra) from surface impact until loss of signal.

Detection of Chemical Species and Determination of the Temperature and Pressure Profiles

- Observations done with VLT using the blue arm of the UVES instrument;
- Scientific data processed using the ESO's UVES pipeline using the EsoReflex software;
- HITRAN and ExoMol databases will be used to identify the presence of chemical species in the spectra;
- NEMESIS Radiative Transfer model will be used to obtain the temperature and pressure profiles and constrain the altitude level;
- Doppler wind velocities will be retrieved as well as the related dynamic atmospheric study as a side product;



Fig 2: Section of the output file produced by the EsoReflex's UVES pipeline viewed using the SAOImageDS9 software for the UVES.2018-06-21T05_25_37.027.fits science file.

Preliminary and Expected Results

- Possible detections of H_2 and HD transitions

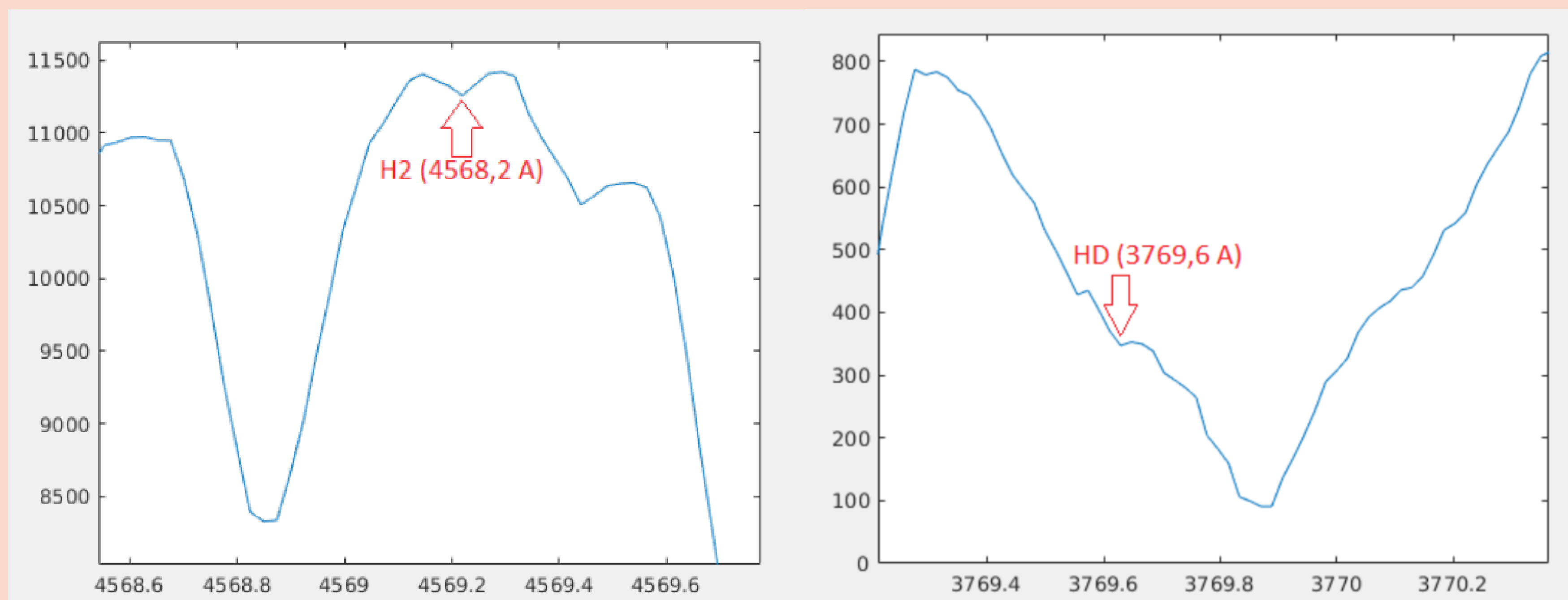


Fig 3: Location of possible transitions of H_2 and HD in the UVES.2018-06-21T05_25_37.027.fits file after data reduction, taking into account the Doppler effect due to the relative motion of Titan, calculated using the HORIZONS Web-Interface tool.

- Expected kind of results

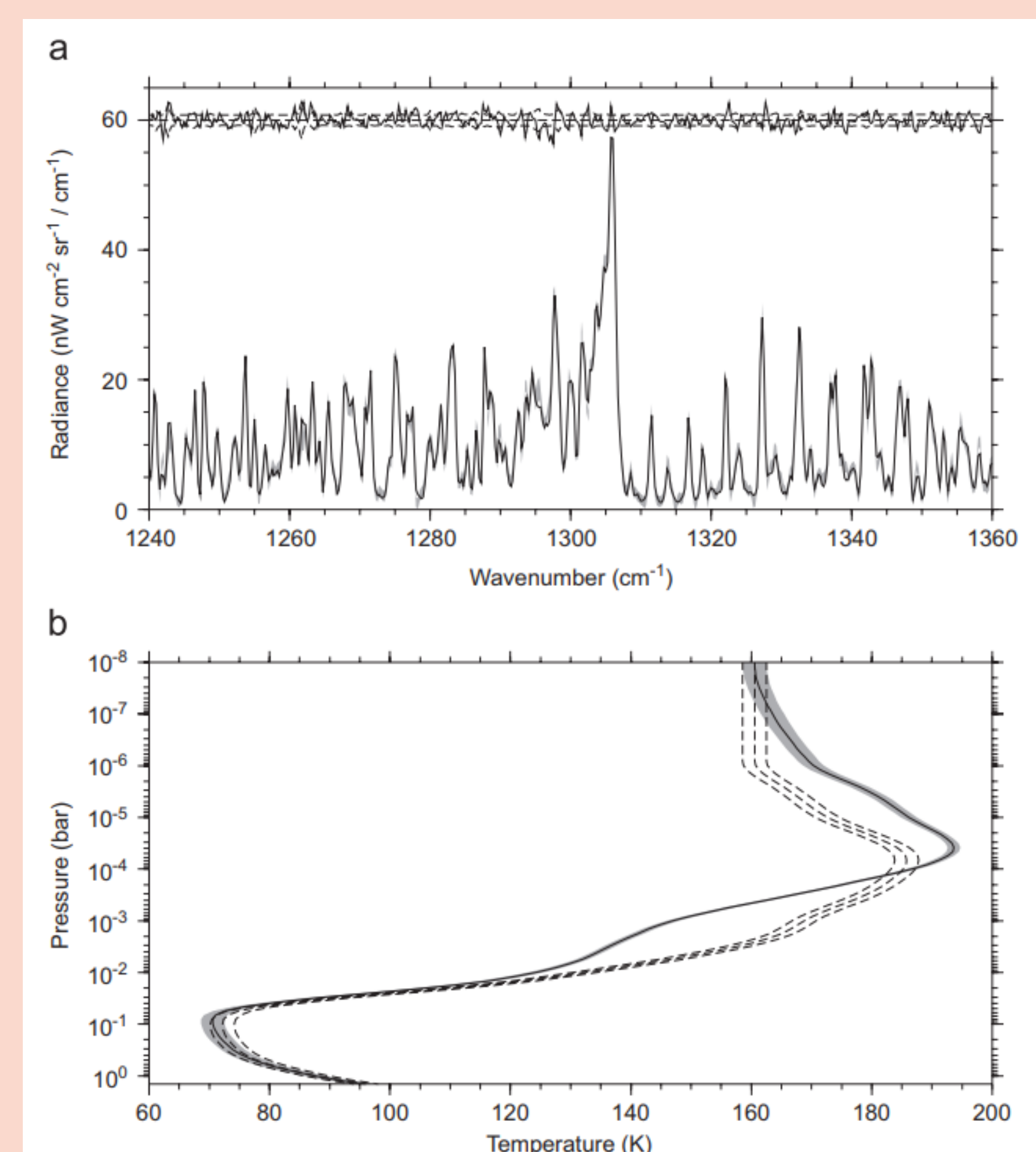


Fig 4: Example of a NEMESIS thermal emission temperature retrieval for a Cassini/CIRS near-nadir observation of Titan.

a - Measured spectrum and error limits in grey in the v_4 methane absorption band between 1240 and 1360 cm^{-1} and the solid line is the NEMESIS fitted spectrum.
b - Retrieved vertical temperature profile, where the solid line is the retrieved profile and the grey shaded regions is the error.

References

- R. A. Hanel, B. J. Conrath, D. E. Jennings, and R. E. Samuelson. *Exploration of the Solar System by Infrared Remote Sensing*. Cambridge University Press, 2nd edition, 2003; P. Irwin. *Nemesis. Atmospheric, Oceanic and Planetary Physics*, Oxford, April 2012. Doc No. CIRS/OXTR/1392; P. Irwin, et al. *The NEMESIS planetary atmosphere radiative transfer and retrieval tool*. Journal of Quantitative Spectroscopy & Radiative Transfer, 109:1136–1150, 2008; P. Irwin. *Giant Planets of Our Solar System*. Springer, 2nd edition, 2009; A. Kauler, et al. *UV-Visual/Echelle Spectrograph User Manual*. European Southern Observatory, December 2007. Doc No. VLT-MAN-ESO-13200-1825; Pedro Mota Machado. *Dynamics of Venus' Atmosphere - Characterization of its Global Circulation with Doppler velocimetry*. Scholar's Press, 2013; H. B. Niemann, et al. *The abundances of constituents of Titan's atmosphere from the GCMS instrument on the Huygens probe*. Nature, 438:779–784, December 2005. doi:10.1038/nature04122; Agustín Sánchez-Lavega. *An Introduction to Planetary Atmospheres*. CRC Press, 1st edition, 2010; T. Encrenaz, et al. *The Solar System*. Springer, 3rd edition, 2003; Dekker, H. et al. 2000, SPIE, 4008, 534.