EPSC Abstracts
Vol. 11, EPSC2017-282, 2017
European Planetary Science Congress 2017

Evidence for an aging process of the haze material on Saturn and Titan

R. Courtin (1), S. J. Kim (2), T. S. Stallard (3), and A. Bar-Nun (4)
(1) LESIA, CNRS/Observatoire de Paris, Meudon, France (regis.courtin@obspm.fr), (2) School of Space Research, Kyung Hee University, Yongin, South Korea (sjkim1@khu.ac.kr), Department of Physics and Astronomy, University of Leicester, Leicester, UK (tss8@leicester.ac.uk), Department of Geosciences, Tel-Aviv University, Tel-Aviv, Israel

Abstract

The 3-µm spectral characteristics of the haze material on Saturn and Titan show marked variations with altitude. We interpret these variations in terms of a chemical alteration during atmospheric motions, a transition between the aromatic and aliphatic spectral types of hydrocarbons, known as aging or annealing.

1. Introduction

From stellar occultation and limb-viewing measurements performed at Saturn by the VIMS experiment on Cassini [1,2], and from solar occultation measurements at Titan [3], we have retrieved the 3-µm spectral properties of the stratospheric haze material in both atmospheres, as well as their variation as a function of altitude [4,5].

2. Results

2.1 Titan

On Titan, our results are relevant to the 250-700 km altitude range at one particular location (71°S). We find a marked change in the relative amplitudes of the 3.3 µm and 3.38 µm features, which are characteristic of aromatic (double C=C chains or rings) or aliphatic (single C–C chains) structural groups, respectively. The "aromatic-to-aliphatic index" η – i.e. the ratio of the 3.33 µm to the 3.38 µm band, uncorrected for the absolute band strengths – varies from 3.3 at 580-700 km to 0.9 at 350-450 km, and 0.5 around 250 km (see Figure 1). The structural change from aromatic to aliphatic type between 580 and 480 km appears to correspond to a spontaneous "aging" of the particles – a transition between unannealed and hardened particles [6,7] – while the further decrease of this index below 480 km may be related to the coating of the core particles by condensates such as heavy alkanes [8].

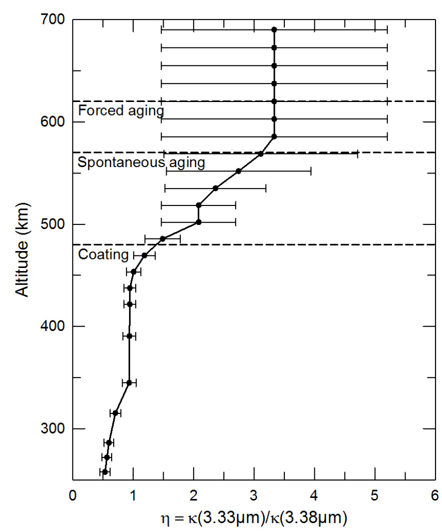

Figure 1: Variation of the aromatic-to-aliphatic index of the haze material, as a function of altitude on Titan.

2.2 Saturn

On Saturn, our results are relevant to the 260-490 km altitude range at 55°N, and to the 375-825 km range at 78°N. The two altitude intervals overlap only by 115 km because of very different viewing conditions. The "aromatic-to-aliphatic index" values are 0.7-0.8 at 55°N, and 1.6-2.2 at 78°N (see Figure 2). In this case, the observed differences in the η values can hardly be interpreted as a consequence of a variation with altitude, since the two profiles differ even in the overlapping zones. Instead, we suggest that in the atmosphere of Saturn, the aging process of the haze material occurs during the latitudinal transport, by advection and/or diffusion, from the polar regions to mid-latitudes, while in the atmosphere of Titan, aging occurs during the vertical precipitation of the haze particles.

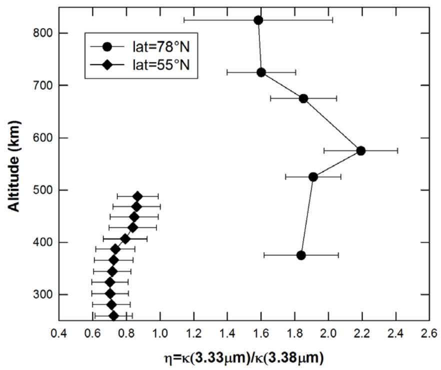

Figure 2: Same as Fig. 1 for Saturn.

3. Summary and Conclusions

In both Saturn and Titan atmospheres, we see evidence for a chemical alteration of the haze material as the particles are transported along with the atmospheric dynamics. On Titan, the change from the aromatic to the aliphatic spectral type of organic compounds occurs around 500 km altitude during the settling down motion, whereas on Saturn, it seems to occur below 400 km during the meridional transport between the polar and mid-latitude regions. These alterations are best interpreted as the consequence of an aging or annealing process, corresponding to the opening up of the triple and double bonds of hydrocarbons under some external effect (e.g., UV photolysis, magnetospheric particles, cosmic rays ionization, etc.).

Acknowledgements

RC acknowledges support from the Centre National d'Etudes Spatiales. SJK acknowledges support from the Brain Korea 21 Plus (BK21+) program through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology, and from the Korean Astronomy and Space Science Institute. TS acknowledges support from a Research Councils UK Fellowship and from the UK Science and Technology Facilities Council.

References

[1] Nicholson, P.D., Hedman, M.M., Gierasch, P.J., and the Cassini VIMS Team. Probing Saturn's atmosphere with Procyon. 38th AAS/DPS Meeting, October 2006, Pasadena, CA, USA, Bull. Am. Astron. Soc., Vol. 38, p. 555. 2006.

[2] Stallard, T.S., Melin, H., Miller, S., Badman, S.V., Brown, R.H., and Baines, K.H. Peak emission altitude of Saturn's H_3^+ aurora. Geophysical Research Letters, Vol. 39, L15103, 2012.

[3] Bellucci, A., Sicardy, B., Drossart, P., Rannou, P., Nicholson, P.D., Hedman, M., Baines, K.H., Burrati, B. Titan solar occultation observed by Cassini/VIMS: Gas absorption and constraints on aerosol composition. Icarus Vol. 201, pp. 198-216, 2009.

[4] Kim, S.J., Sim, C.K., Lee, D.W., Courtin, R., Moses, J.I., and Minh, Y.C. The three-micron spectral feature of the Saturnian haze: Implications for the haze composition and formation process. Planetary and Space Science, Vol. 65, pp. 122–129, 2012.

[5] Kim, S.J., Jung, A., Sim, C.K, Courtin, R., Bellucci, A., Sicardy, B., Song, I.O., and Minh, Y.C. Retrieval and tentative identification of the 3-μm spectral feature in Titan's haze. Planetary and Space Science, Vol. 59, pp. 699–704, 2011.

[6] Dimitrov, V., and Bar-Nun, A. Aging of Titan's aerosols. Icarus, Vol. 156, pp. 530-538, 2002.

[7] Dimitrov, V., and Bar-Nun, A. Hardening of Titan's aerosols by their charging. Icarus, Vol. 166, pp. 440-443, 2003.

[8] Courtin, R., Kim, S.J., and Bar-Nun, A. Three-micron extinction of the Titan haze in the 250–700 km altitude range: Possible evidence of a particle-aging process. Astronomy & Astrophysics, Vol. 573, A21, 2015.