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A cubesat based atmospheric tomography mission concept for sensing the lower Martian atmosphere

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Abstract

The proposed mission concept is based on a series of cubesats, carried to Mars and injected into different low Mars orbits as secondary payloads on a larger orbiter. For our analysis we assume two types of orbits: a) The first half of cubesats is deployed at various higher altitudes, whereby nodal precession enables dispersion of the satellites over time, see [1]. b) The second half of cubesats is deployed into a circular orbit (h ~ 370 km) with an inclination of about 60 degrees. Therefore, it is assumed that the cubesats can be placed nearly in the same orbital plane with a small separation in mean anomaly of about 1.5 (3, 6) degrees, and that the constellation can be maintained over the lifespan of the satellites. Furthermore, it is expected that each small satellite provides power, attitude control and deployable antenna features for signals in X- and UHF-bands.

Based on the proposed cubesat formation, a set of planetary (cubesat-earth) occultations and cross-link occultations (between cubesats and to existing Mars orbiters like MRO or Mars Express) can be obtained with a large geometrical overlap, see Figure 1. The resulting observation geometry allows for estimation of refractivity profiles along the RO signal paths using tomography principles and therefore, to derive high-resolution 2D temperature and pressure cross-sections through the lower Martian atmosphere.

For the proof of concept, the developed processing strategy has been applied to Mars Reconnaissance Orbiter (MRO) radio occultation and Mars Climate Sounder (MCS) measurements, see [2]. Based on the lessons learned in reprocessing of this dataset, and from further simulations, we expect that the proposed mission concept allows for sensing the lower 40 km of the Martian atmosphere with a vertical resolution about 10 times better than obtained from radiance-based retrievals.

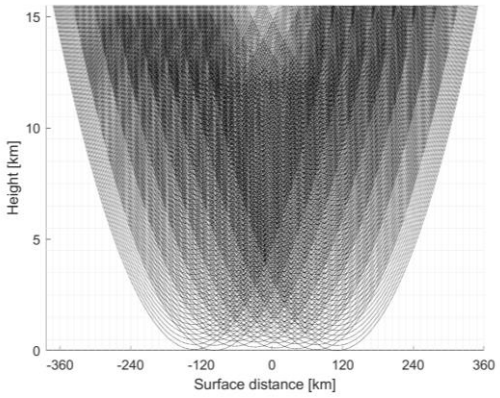

Figure 1: Crossing radio occultation signals as expected during one occultation event between Earth and eight cubesats in a single low Mars orbit

Dependent on the selected orbit, the obtained products will give an insight into various unresolved atmospheric phenomena - especially of those which are characterized by distinct horizontal gradients in pressure and temperature, e.g. as observed at the day-night terminator, during dust storms, over complex terrain or the Northern polar vortex.

References

[1] Williamson W. R., Ao, C. O., Mannucci, A. J.: Radio occultation mission to Mars using cubesats, International Conference on Mars Aeronomy, 15-19 May 2017, Boulder, Colorado, USA

[2] Moeller, G., Ao, C. O., Yang, Y.-M. and Mannucci, A. J.: Analysis of the lower Martian atmosphere by combined processing of radio occultation and Mars Climate Sounder measurements, EGU2019 General Assembly, 7-12 April 2019, Vienna, Austria, doi: 10.13140/RG.2.2.28506.80322