EPSC Abstracts
Vol. 13, EPSC-DPS2019-1001-1, 2019
EPSC-DPS Joint Meeting 2019


EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

# Assessing Observability of Mars Winds Using Various Options in Sub-mm Limb Sounding

Don Banfield (1), Leslie Tamppari (2), Nathaniel Livesey (2)
(1) Cornell Center for Astrophysics and Planetary Science, Ithaca, NY, USA (banfield@astro.cornell.edu), (2) Jet Propulsion Laboratory, Pasadena, CA, USA

## Abstract

We have developed and used a simplified OSSE (Observing System Simulation Experiment) to test various options in implementing a sub-mm limb sounder at Mars with metrics determined by the ability to identify key aspects of the zonal mean, forced and free wave modes of the atmosphere. We have used this to tune the design of the WAVE sub-mm sounder instrument proposed for a Mars-focused Discovery mission. Additional instrument types and mission concepts could (should) be addressed with this approach to allow for quantitative assessment of the relative value of certain instrument trades, both within a particular instrument choice, and also among various possible instruments or instrument suites.

## 1. Introduction

The JPL members of our team have developed a heterodyne sub-mm limb-sounder operated near 450 GHz for Mars with the capability to detect line-of-sight winds, temperatures, and water vapor abundances from near the surface to many scale heights altitude [1]. However, the specific trades between the look-angles, spacing between limb scans, maximum elevation scanned, orbit ground-track, and a host of other instrument parameters should be optimized to ensure that this proposed instrument produces the most valuable scientific results for the investment. Banfield has previously assessed the zonal mean and forced and free wave modes in Mars atmosphere using model-free data analysis [2,3,4].

## 2. Methods

As a starting point, we use the Mars general circulation model (GCM) output from the *Laboratoire de Météorologie Dynamique* (LMD) GCM (Courtesy, F. Forget), which we consider the "truth" data representing the Martian atmosphere. We sample the output to create vertical profiles of temperature along the measurement track of a potential orbital platform carrying a limb-sounding sub-mm experiment. We will then apply an instrument observation operator to the sampled profiles (i.e., we will multiply them by representative averaging kernel matrices, which describe the vertical resolution of the measurements, and add appropriate noise, see Fig. 1) to generate simulated "Level 2" (along-track) geophysical data.

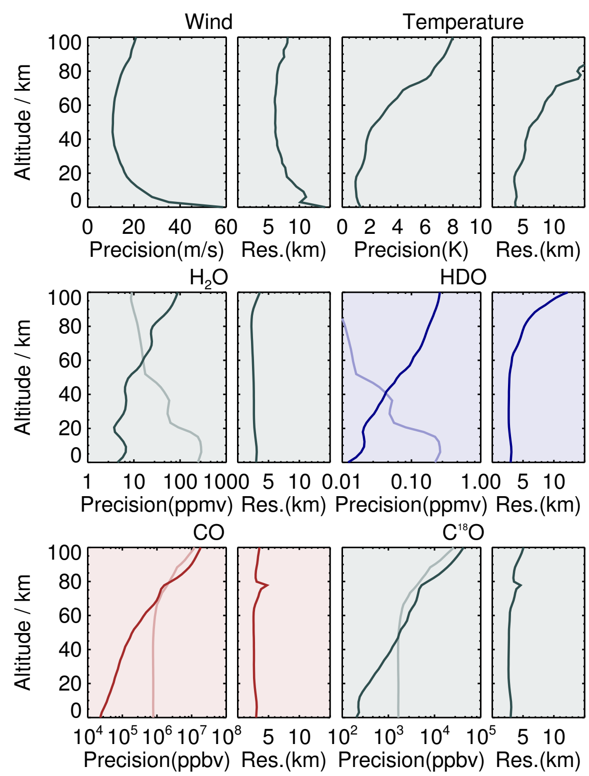


*Figure 1. Examples of precision and vertical resolution for several quantities retrieved by a particular configuration of the Martian sub-mm limb sounder.*

The synthetic level 2 data is then ingested into the atmospheric wave analysis system that Banfield has used for MGS/TES and MRO/MCS data previously. We have had to make minor adaptations to the system to handle not only temperatures, but also the water vapor abundances as well as vector winds that the sub-mm sounder yields. The analysis suite divides the data up into discrete latitude and altitude bins and then within each of those, casts the data onto zonal wavenumbers (from 0-4 or higher depending on the observing frequency per son). Additionally, for sun-synchronous orbits (or those nearly so), it also separates the data into daytime and nighttime components to explicitly track the effects of diurnal tides. This yields meridional cross-section maps of the various observed quantities, broken down into zonal mean and forced wave modes of various zonal wavenumbers. We also remove these forced modes from the data and analyze the residuals for coherent propagation at a range of resolvable phase speeds to yield the free wave modes.

As a metric of observability, we also use this same system to ingest the complete data from the GCM history tapes, resulting in an analysis that has complete, perfect observations of the assumed "truth". We can then compare the analyzed synthetic data and that of the truth data to assess how well the synthetic data allows key aspects of the circulation to be observed. We expect to compare not only the zonal means states, but also the most grave forced and free wave modes in all quantities observed (i.e., temperature, water vapor abundance and zonal and meridional winds).

Once this study is completed for the first choice of instrument parameters, we will use the shortfall in the results to decide on changes to make to the instrument and repeat the analysis with a differently configured hypothetical instrument. Eventually, the expectation is that after a few iterations, we will find an optimal choice between the engineering considerations for the instrument, and its ability to return data with maximum scientific impact.

## 3. Conclusions

We will present the results of our ongoing study, showing the evolution in performance of the instrument in various configurations to best observe Mars circulation (as demonstrated through our OSSE analysis). We expect that this same technique could and should be applied to other instruments or instrument suites in consideration for flight on future missions to Mars (both orbital and in situ).

## Acknowledgements

We acknowledge the JPL SURP program for enabling this research.

## References

[1] Read, W. G., L. K. Tamppari, N. J. Livesey, R. T. Clancy, F. Forget, P. Hartogh, S. C. R. Rafkin, and G. Chattopadhyay: "Retrieval of wind, temperature, water vapor and other trace constituents in the Martian atmosphere." *Plan. & Sp. Sci.*, 161 (2018): 26-40. doi.org/10.1016/j.pss.2018.05.004

[2] Banfield, D., Gierasch, P.J., Conrth, J., Pearl, J., Smith, M., Christensen, P.: Thermal tide and stationary waves as revealed by MGS TES, J. Geophys. Res., 105, 9521-9538, 2000.

[3] Banfield, D., Conrath, B.J., Pearl, J., Smith, M.D., Wilson, R.J.: Forced waves in the Martian atmosphere from MGS TES nadir data, Icarus, 161, 319-345. 2003.

[4] Banfield, D., Conrath, B.J., Gierasch P.J., Wilson, R.J., Smith, M.D.: Traveling waves in the Martian atmosphere from MGS TES nadir data. Icarus, 170, 365-403, 2004.