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A Sensitive search for organics (C_2H_6, CH_3OH, H_2CO, C_2H_2, C_2H_4), water (H_2O, HDO), and nitrogen compounds (NH_3, HCN, HC_3N) on Mars using ground-based high-resolution spectroscopy

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Abstract

In our latest Mars observational campaign (August/2009 to June/2010) we acquired the deepest and most comprehensive search for biomarkers on Mars, using powerful infrared high-resolution spectrometers (CRIRES, NIRSPEC, CSHELL) at high-altitude observatories (VLT, Keck-2, NASA-IRTF). Among ground-based and spacecraft spectrometer/telescope combinations at infrared wavelengths, these instruments provide the highest spectral resolving power for spatially-resolved spectra in the 2-5 μm region, making these measurements of unique value

1. Observations

The measurements span a broad range of seasons on Mars: $L_S = 324$ to 24° for the blue Doppler shift data, and $L_S = 69$ to 102° for the red Doppler shift. By orienting the instrument's slit East-West and North-South on the planet, we obtained a global and comprehensive sample of the seasonal and diurnal variations of the atmosphere on Mars. For certain observations, we enabled the adaptive optics mode, obtaining the highest spatial resolution achievable from Earth.

2. Methodology

We developed new data processing techniques to analyze this extraordinary volume of data, which for this campaign only is an order of magnitude greater than all our previous datasets combined. In particular, the richness of this spectral region demands extremely high spectral resolution in order to reduce confusion among telluric, Martian, and Fraunhofer (in reflected solar radiation) lines. Since many of the targeted species are observed on the wing of the strong telluric counterparts, precise modeling of telluric features and fine frequency calibration (to better than one-hundredth of a pixel) was required. To that end, we have greatly improved our synthesis of telluric and solar spectra, and developed new quantum mechanical models for species (e.g. C_2H_6) with strong transitions in the prime region used to search for biomarker gases on Mars.

3. Summary and conclusions

From the high signal-to-noise Martian residual spectra, we extracted sensitive measurements for several biomarker gases, including 6 organic species (CH_4, C_2H_6, CH_3OH, H_2CO, C_2H_2, C_2H_4), 2 water isotopologues (H_2O, HDO), and 3 nitrogen compounds (NH_3, HCN, HC_3N). We will present our results in the context of the strong methane release that we observed in 2003 [1], and will discuss possible temporal and spatial variability.

Acknowledgements

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References

[1] Mumma, M.J. et al., Science 323:1041-1045, 2009.