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Lightning on Jupiter: Correlations of lightning observed by the Juno Microwave Radiometer with cloud properties derived from contemporaneous NASA/IRTF SPeX camera images

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Abstract

We present initial results of our analysis of near-IR cloud properties associated with lightning events observed by the Microwave Radiometer (MWR) [1] onboard the Juno Jupiter orbiter. Radiative transfer analysis of near-IR thermal and reflected sunlight images obtained by the NASA/IRTF SpeX guiding camera at 5, 1.6 and 2.1 µm reveal in particular the properties of deep clouds in the vicinity of the ~ 6-bar level of lightning generation. This reveals correlations between the occurrence of lightning clusters on Jupiter and the spatial/vertical morphology of associated cloud structures. In particular, we tentatively find that lightning is most prevalent in clouds with 5-µm thermal opacities of ~2.6, corresponding to an overlying mass burden of ~0.0018 gm/cm^2 assuming 1-µm radius Mie scattering spherical particles with a density of 1 gm/cm^3.

1. Introduction

Clusters of lightning have been found by the Microwave Radiometer (MWR) onboard the Juno Jupiter orbiter [1] The method for lightning detection utilizes a frequency of 600 megahertz, which - unlike visual imaging techniques - is unaffected by the opacity of overlying clouds, thus providing a more faithful record of where lightning occurs. Jupiter has been probed for lightning for several hours during each of Juno's perijove passes, when the spacecraft is within ~100,000 km of the cloud tops. The coverage varies from orbit to orbit, but generally extends from pole-to-pole and is more limited in longitudinal extent near the equator. Contemporaneously, our team has obtained near-infrared global maps of Jupiter at the IRTF with the SpeX instrument guide camera. Good global or near-global coverage occurred contemporaneously with MWR during Juno perijoves 4, 6, 8, 13, and 14. We are using the NEMESIS radiative transfer software [2] to analyze these images. This program is capable of analyzing both (1) thermally-generated radiation, such as is generated at 5-µm by the relatively warm temperatures found in the 6-8-bar region, and (2) solar-reflected sunlight (e.g. [3.4]). With such a deep-level source of lighting, the 5-µm images are particularly effective at measuring the cloud burden in the vicinity of lightning generation, thought to be generated near the 5-bar freezing level of water.

2. Initial Results

Figure 1 shows a 5-µm cylindrical map of Jupiter mosaicked from our IRTF images observed on May 22, 2018, 2 days prior to the Juno PJ13 perijove pass during which lightning was observed by MWR. Superimposed on the mosaic are the MWR lightning strike locations, appropriately adjusted by the zonal winds [5,6].

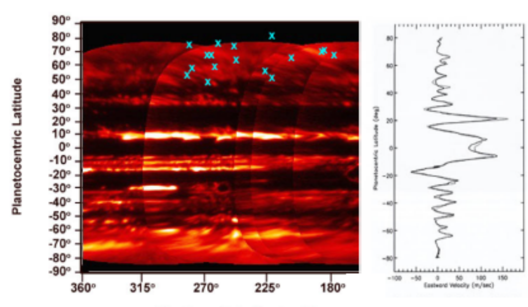

Figure 1: 5-µm Jupiter mosaic obtained May 22, 2018, 2 days prior to Juno PJ13 pass. The zonal winds of Porco et al [5] (solid curve, right) were used to adjust the MWR-observed lightning site longitudes to reveal their associated clouds. Zonal winds of Limaye [6] (dashed) also shown. Polar winds where lightning predominates are relatively light.

Figure 2 shows a preliminary map of 5-µm opacity derived by our NEMESIS radiative analysis, assuming a cloud base of 5 bar (i.e., at the water freezing level where lightning likely originates and slightly above the altitude of maximum 5-µm thermal radiation generates), a particle-to-gas scale-height of 1.0, and Mie scattering particles of 1-µm radius throughout the cloud. For this preliminary analysis, we assumed that the observed radiation is solely thermal, without any backscattering of solar radiation by aerosols or by Rayleigh scattering. Over the 15 points shown on this image of a portion of the northern hemisphere, we find a 5-µm opacity of 2.6 ± 0.4, corresponding to a cloud mass burden of 0.0018 ± 0.0003 gm/cm^2.

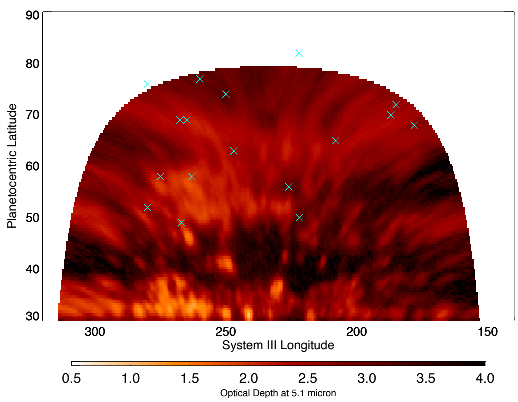

Figure 2: 5-µm opacity map of a portion of the Jupiter mosaic shown in Figure 1. Superimposed are the lightning sites (X's) adjusted for the longitudinal displacement caused by the zonal winds [5,6]. The opacity scale is shown at the bottom.

3. Conclusions

We have shown here preliminary analysis for a portion of the PJ13 encounter. We find that lightning occurs predominantly in clouds of 5-µm opacities of 2.1 - 3.0 and overlying column mass densities of 0.0015-0.0021 gm/cm^2, assuming an aerosol particle mass density of 1 gm/cm^3. There are presently four other encounters of interest (i.e., PJ4, PJ6, PJ8, and PJ14) for which we have good global 5-µm coverage and we are planning to analyze and discuss, including the effects of scattered sunlight. Additional constraints on deep-cloud opacities may also come from the analysis of our contemporaneously acquired reflected sunlight images at 1.58 and 2.1 µm that sense and constrain the opacities of upper-level clouds. In the end, we plan to report the distribution of cloud opacities and column mass densities of deep -level clouds observed at over 100 lightning strike events over these five Juno perijoves.

Acknowledgements

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References

[1] Brown, S., Janssen, M., Adumitroaie, V., et al.: Prevalent lightning sferics at 600 megahertz near Jupiter's poles, Nature, https://doi.org/10.1038/ s41586-018-0156-5, 2018.

[2] Irwin, P. G. J., Teanby, N. A., de Kok, R., et al.: The NEMESIS planetary atmosphere radiative transfer and retrieval tool, Journal of Quantitative Spectroscopy & Radiative Transfer, 109, pp. 1136-1150, 2008.

[3] Giles, R. S., Fletcher, L. N., Irwin, P. G. J., Latitudinal variability in Jupiter's tropospheric disequilibrium species: GeH_4, AsH_3 and PH_3, Icarus 289, 254-269, 2017.

[4] Giles, R. S., Fletcher, L. N., Irwin, P. G. J., Orton, G. S., Sinclair, J. A., Ammonia in Jupiter's troposphere from high-resolution 5-micron spectroscopy, GRL 44(21), 10838-10844, 2017.

[5] Porco, C. C., West, R. A., McEwen, A., et al.: Cassini imaging of Jupiter's atmosphere, satellites, and rings, Science, 299, pp. 1541-1547, 2003.

[6] Limaye , S. S.: Jupiter: New estimates of mean zonal flow at the cloud level, Icarus, 65, pp. 335 - 352,1986.