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Latest Results on Jupiter's Atmosphere and Radiation Belts from the Juno Microwave Radiometer

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Abstract

The Juno Microwave Radiometer (MWR) was designed to investigate Jupiter's atmosphere and radiation belts as one of a suite of instruments that form the core of the Juno mission [1]. Results from the first fourteen periapsis passes on the atmosphere and the radiation belts will be summarized.

1. Introduction

Jupiter's neutral atmosphere is shrouded by clouds that are impervious to all but microwave radiation. Our view from Earth is impeded further by intense synchrotron radiation that obscures all but the shortest-wavelength microwave radiation emanating from above the few-bar pressure level of the atmosphere. Juno's highly elliptical polar orbit allows the MWR to avoid these obstacles by observing the atmosphere during a periapsis pass from a vantage point between Jupiter and the radiation belts. This enables the measurement of longer-wavelength atmospheric thermal radiation from pressure depths of hundreds of bars, and also provides a unique view of the inner radiation belts that enables a more complete study of their structure.

2. Observational Approach

The MWR comprises six radiometric channels operating at wavelengths from 1.4 cm to 50-cm wavelength. The MWR antennas are mounted on the sides of the spinning Juno spacecraft so that they observe along the subspacecraft track as the spacecraft moves from north to south through periapsis. Collectively they sample the thermal emission from pole to pole with better than 1° resolution in latitude at periapsis, and from the cloud tops to pressures as deep as a few hundred bars.

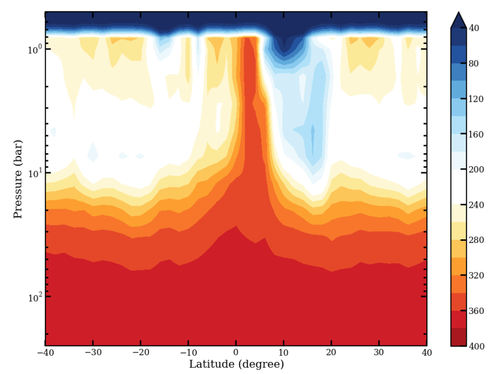

Figure 1: Ammonia abundance (ppm) derived from MWR observations on perijove 1 [3].

The observational data are the mean radiances in the antenna beams converted by Planck's law to blackbody temperatures and accordingly given in units of Kelvin (antenna temperatures). For atmospheric data, these are corrected for the beam averaging to obtain source brightness temperatures, or the effective mean radiance of Jupiter in the beam at the boresight axis, for each observation. The absolute accuracy of each measurement is 2%, uncorrelated among channels, while the relative accuracy at each wavelength is 0.1%. The radiation belt data consist of antenna temperatures from latitudinal scans from a (mostly) radiation-free perspective inside the belts.

3. Data Products

The atmospheric scans along the sub-spacecraft track yield both absolute brightness temperatures and, since many points are observed over a range of emission angles, their dependence on emission angle. The data products derived from these data include latitudinal tracks of absolute nadir brightness temperatures, where off-nadir measurements are extrapolated to nadir using their simultaneously-obtained emission angle dependencies; and emission angle dependence in terms of limb-darkening parameters. The former are useful in the determination of large-scale structure in the subcloud atmosphere due to opacity variations, which are not limited by 2% absolute uncertainties. These also are useful in the constructions of partial 3D maps, which show brightness structure as a function of latitude, longitude, and wavelength (a proxy for depth). Emission-angle dependencies allow fine structure with depth to be obtained with accuracy limited only by the 0.1% relative accuracies of the measurements at each wavelength. The radiation belt data consist of antenna temperatures from latitudinal scans from a radiation-free perspective inside the belts, useful for comparison with synthetic data obtained by computations using parameterized models of the belts.

4. Results

The trace of absolute nadir brightness temperature for the first perijove pass has been used to infer a striking variation in the distribution of NH_3, which is the dominant source of microwave opacity in the atmosphere [2]. This variation implies a previously unexpected deep circulation (Fig. 1) with exciting implications for gas-giant planets in general [3].

The accumulation of data from subsequent perijove passes will be shown to demonstrate the longitudinal, temporal, and depth dependencies of observed structures. Multiple perijove passes show temporal and longitudinal repeatability of all the major features, as well as identifying a few specific features which are unique to a particular longitude. Partial 3D maps will show the structure and depths of specific features on Jupiter, notably the polar regions and the Great Red Spot. Finally, efforts underway to determine the water abundance will be described.

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