Juno Microwave Radiometer (MWR)

Michael Janssen
Jet Propulsion Laboratory
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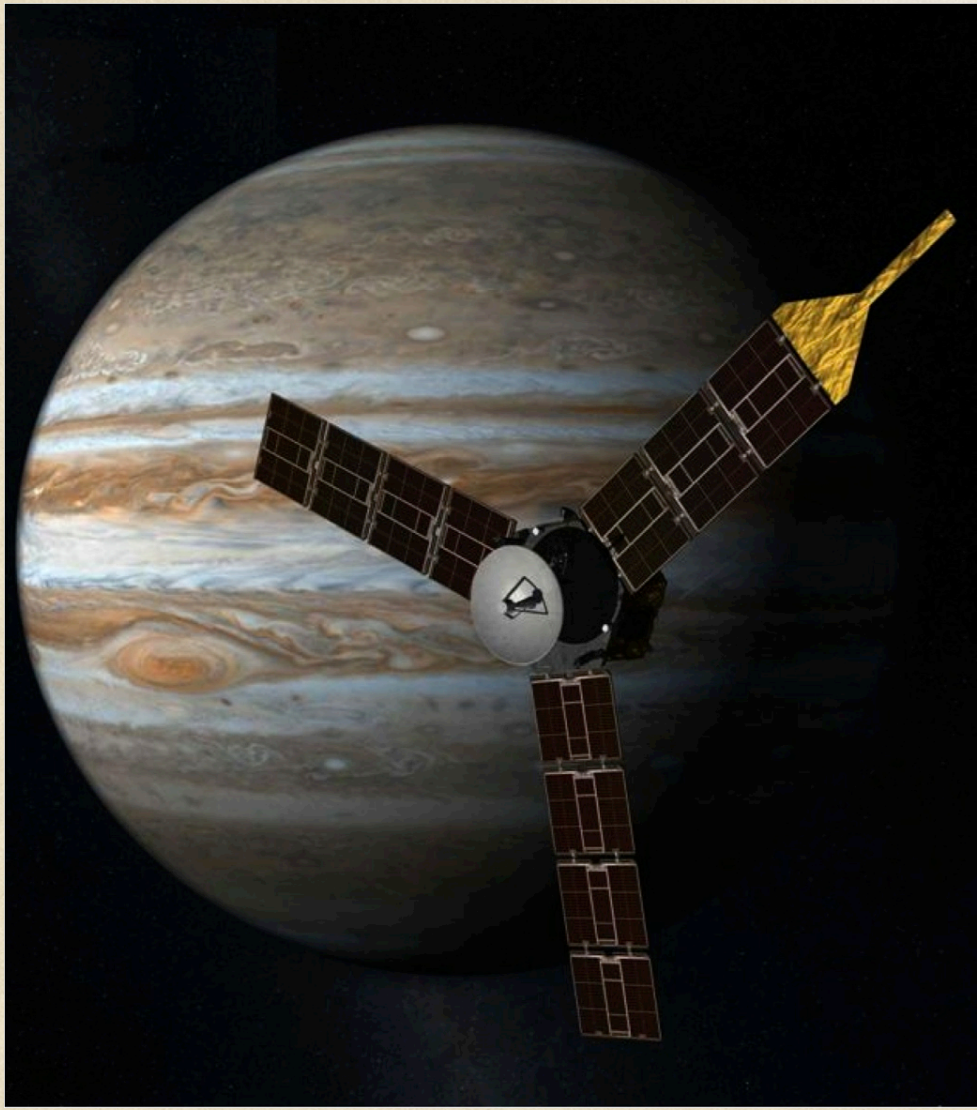
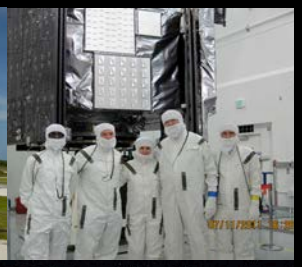
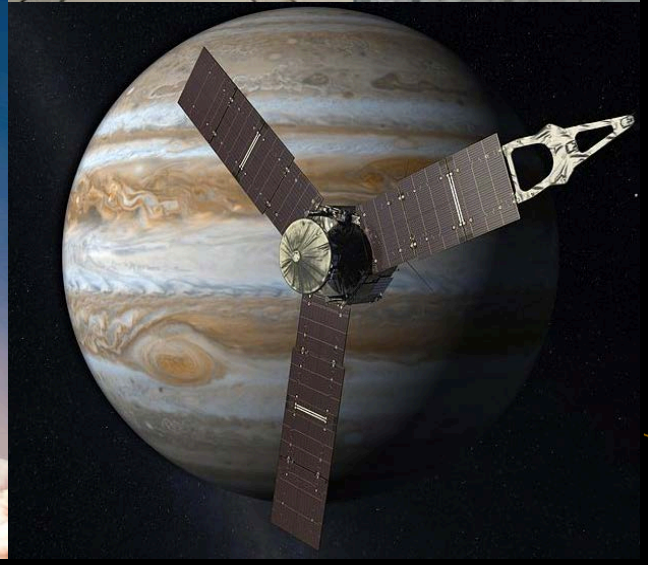


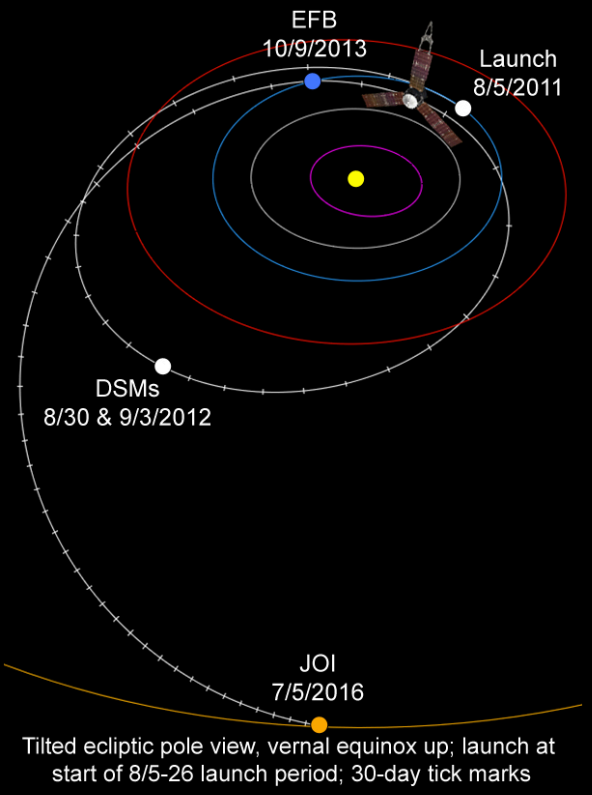
Joint Juno/Cassini Jupiter-Saturn Atmospheric Dynamics Meeting
San Francisco, CA, December 13, 2015

Juno

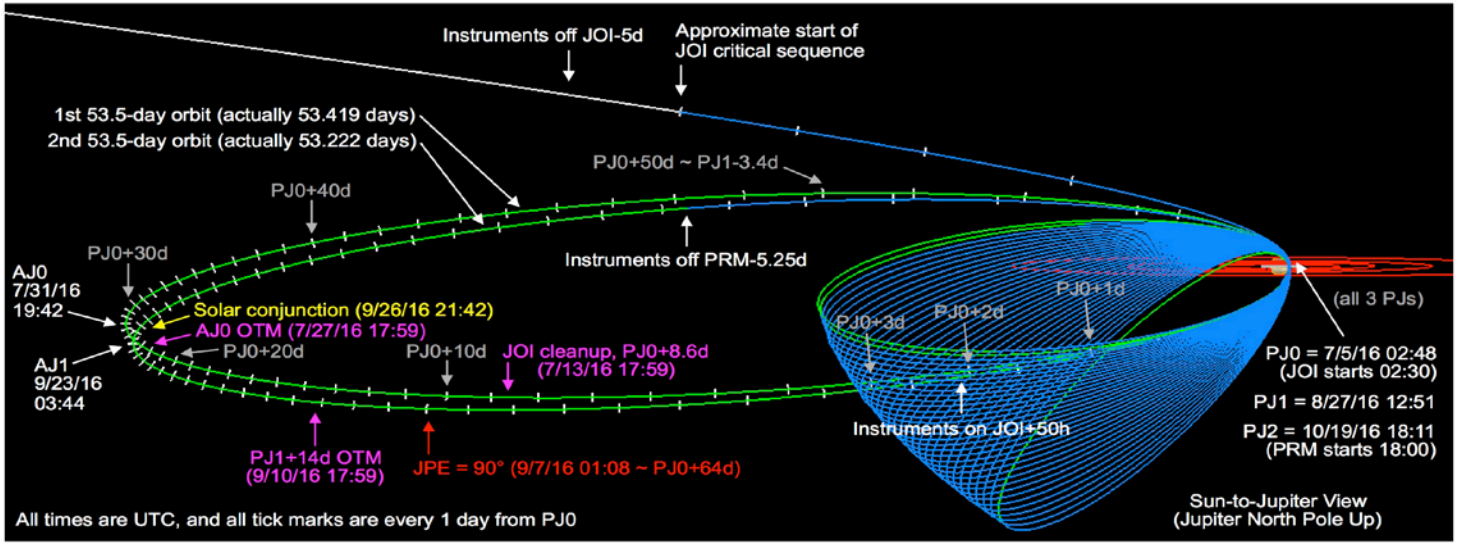
- Launched Aug 5, 2011
- Arrives at Jupiter July 5, 2016



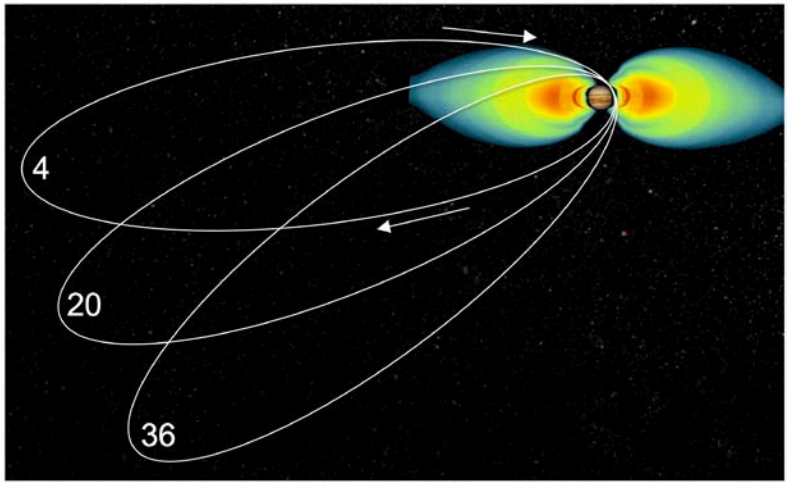




Orbiting Jupiter



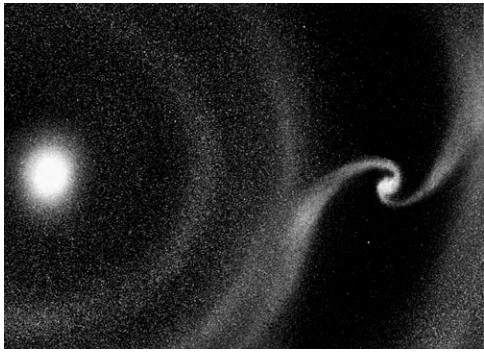
- After two 53.5-day capture orbits followed by two phasing orbits, Juno will begin a series of 33 science orbits
- Eccentric polar orbit gives global coverage, avoids radiation belts



Juno Science Objectives

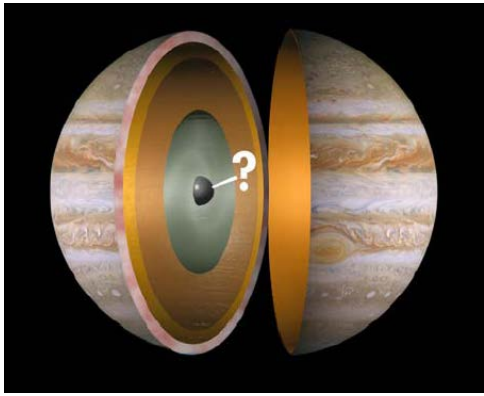
Origin

Determine O/H ratio (water abundance) and constrain core mass to decide among alternative theories of origin.



Interior

Understand Jupiter's interior structure and dynamical properties by mapping its gravitational and magnetic fields

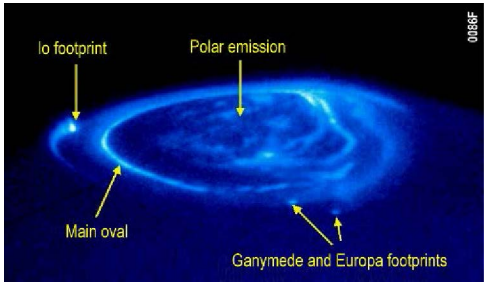


Atmosphere

Map variations in atmospheric composition, temperature, cloud opacity and dynamics to depths greater than 100 bars at all latitudes.

Magnetosphere

Characterize and explore the three-dimensional structure of Jupiter's polar magnetosphere and auroras.

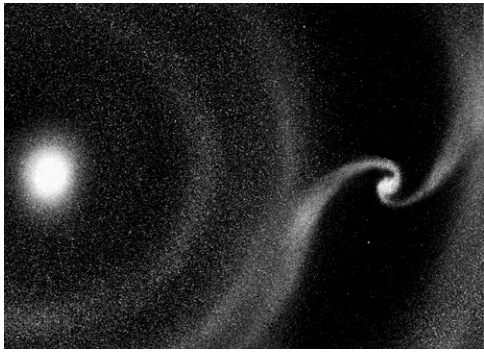


Juno Science Objectives

MWR contribution

Origin

Determine O/H ratio (water abundance) and constrain core mass to decide among alternative theories of origin.



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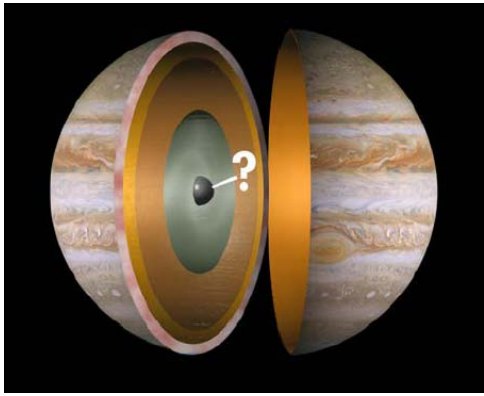

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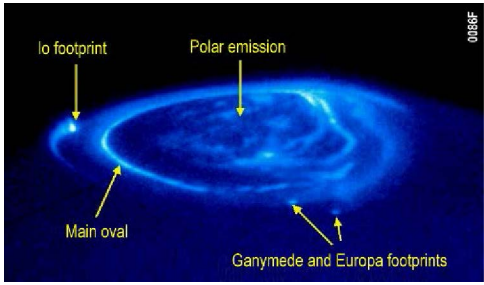


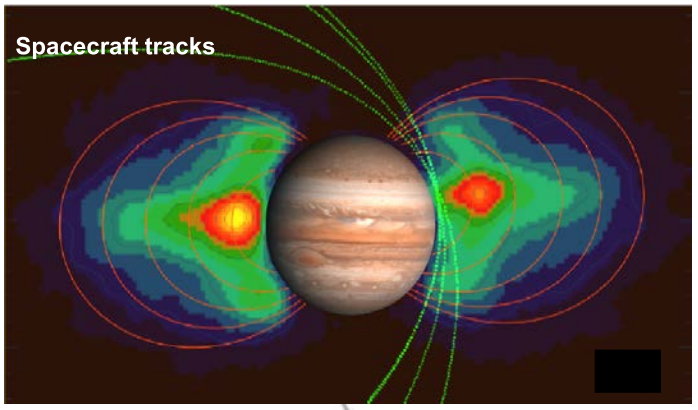
Microwave Radiometer

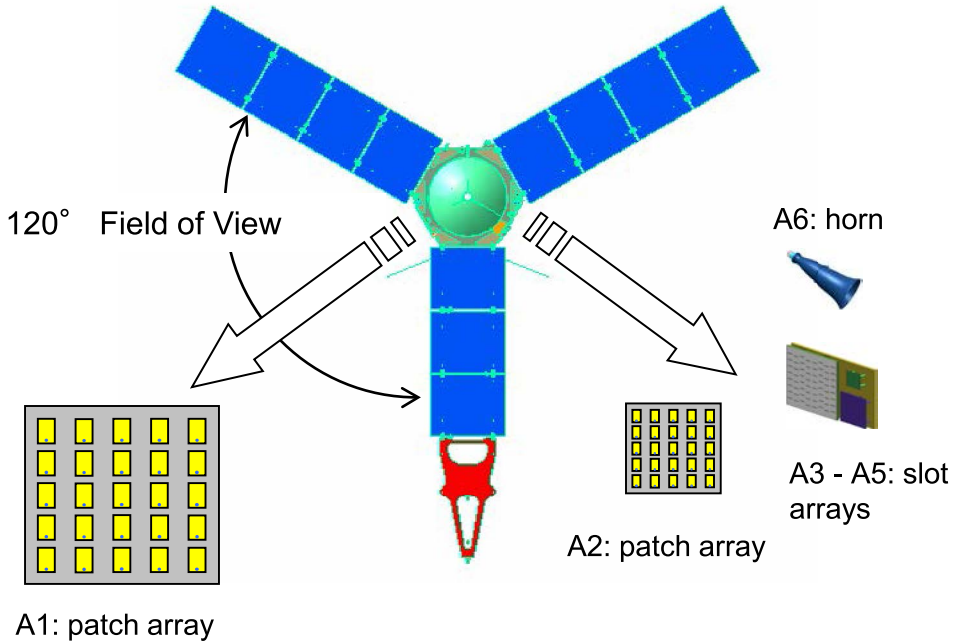
- The microwave system comprises six radiometers operating at wavelengths from 1.4 cm to 50 cm

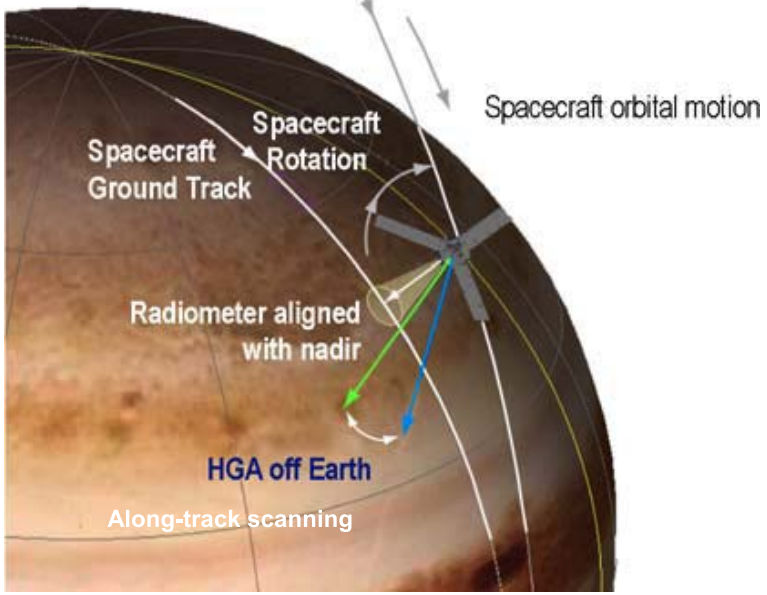
- The microwave antennas are distributed around the spacecraft and view perpendicular to the spacecraft spin axis

Microwave Radiometer (MWR) Observations

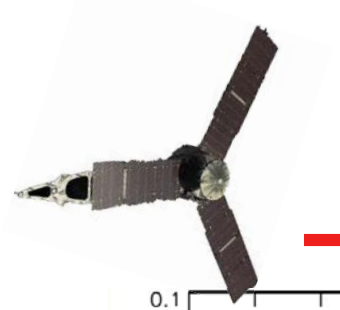
- Unique microwave measurements are obtained
  - Synchrotron emission avoided
  - High spatial resolution obtained
- Emission angle dependence uniquely measured by along-track scanning

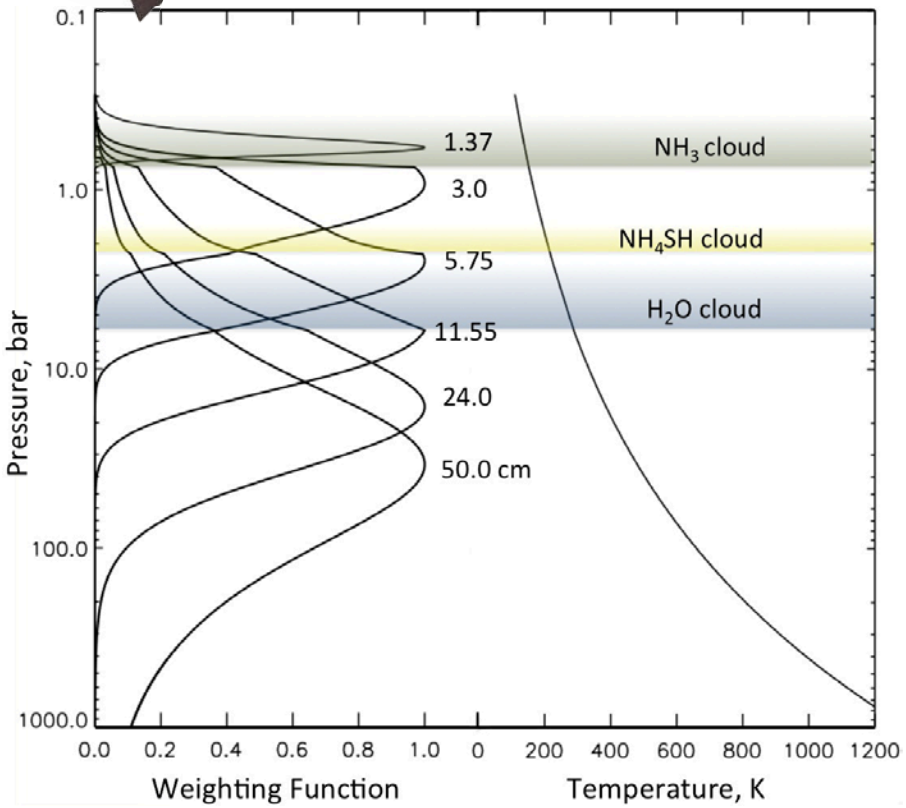


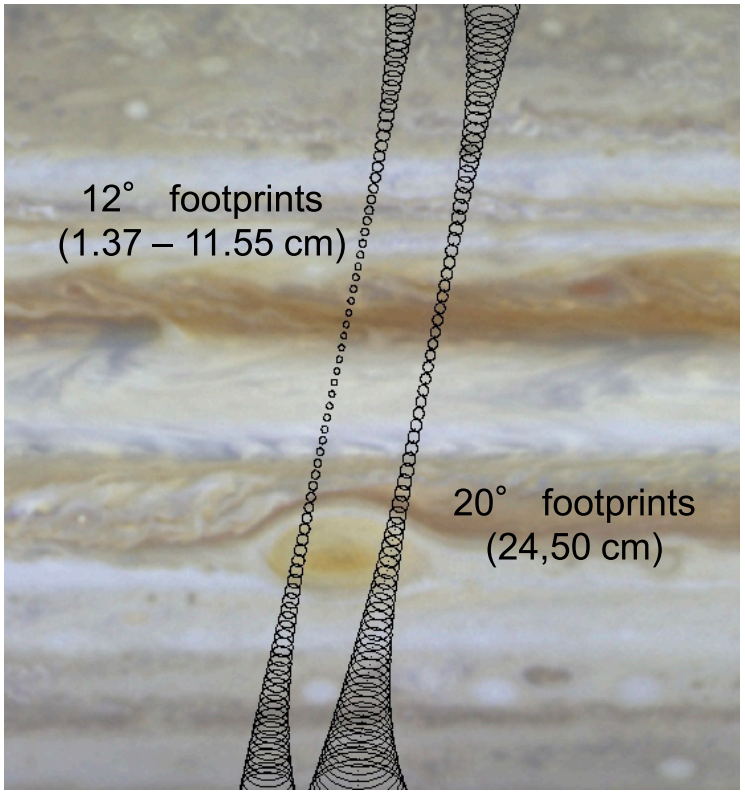




Microwave Sounding



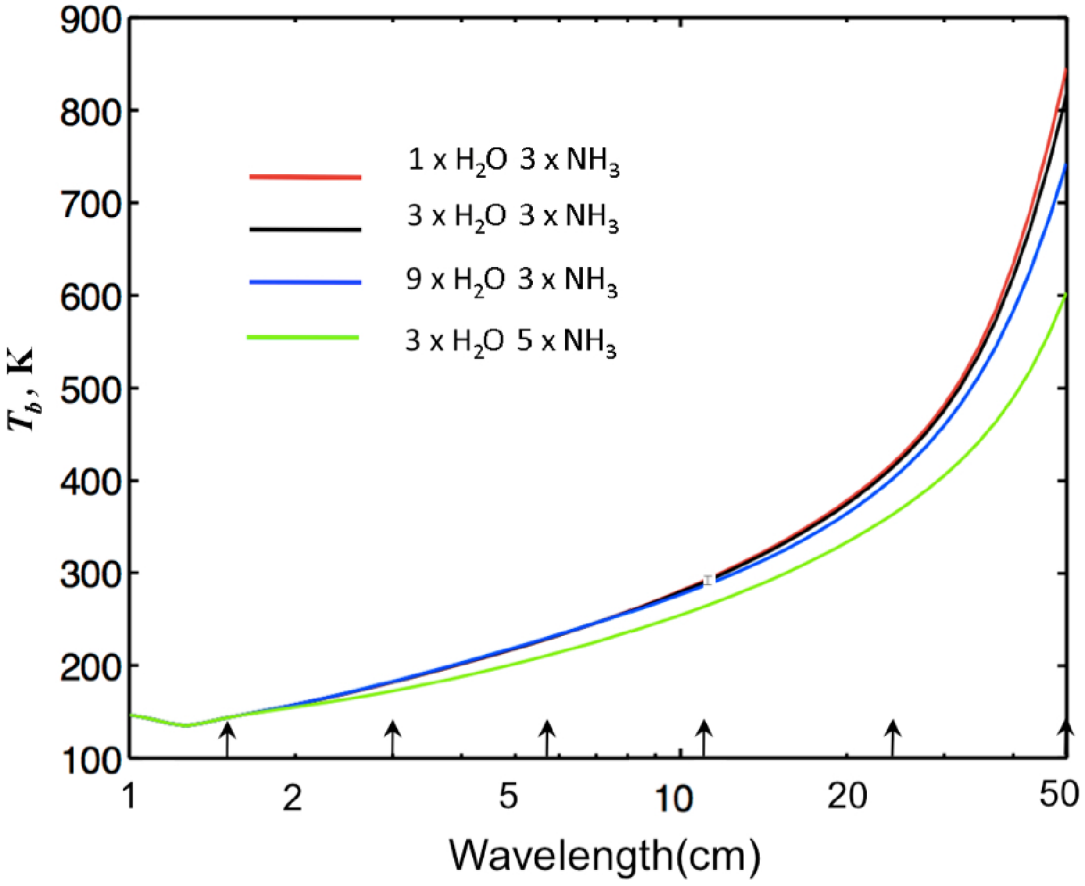




Weighting functions: Measurement wavelengths sample atmosphere from cloud tops to ~ 100 bar. Shown for normal incidence in nominal atmosphere

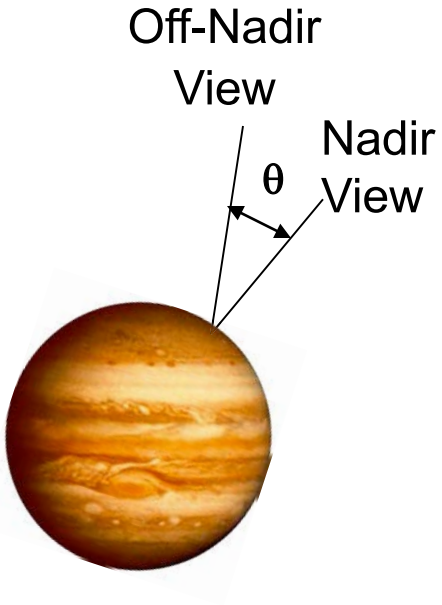
Footprints: atmosphere densely sampled along spacecraft subtrack. 12° and 20° footprints are coaligned but shown separately here for illustration. Only 1 of every 1200 footprints is shown.

Jupiter Spectrum Measurement



Absolute errors are ~ 2% (at best) at each wavelength

Angular Dependence of Emission

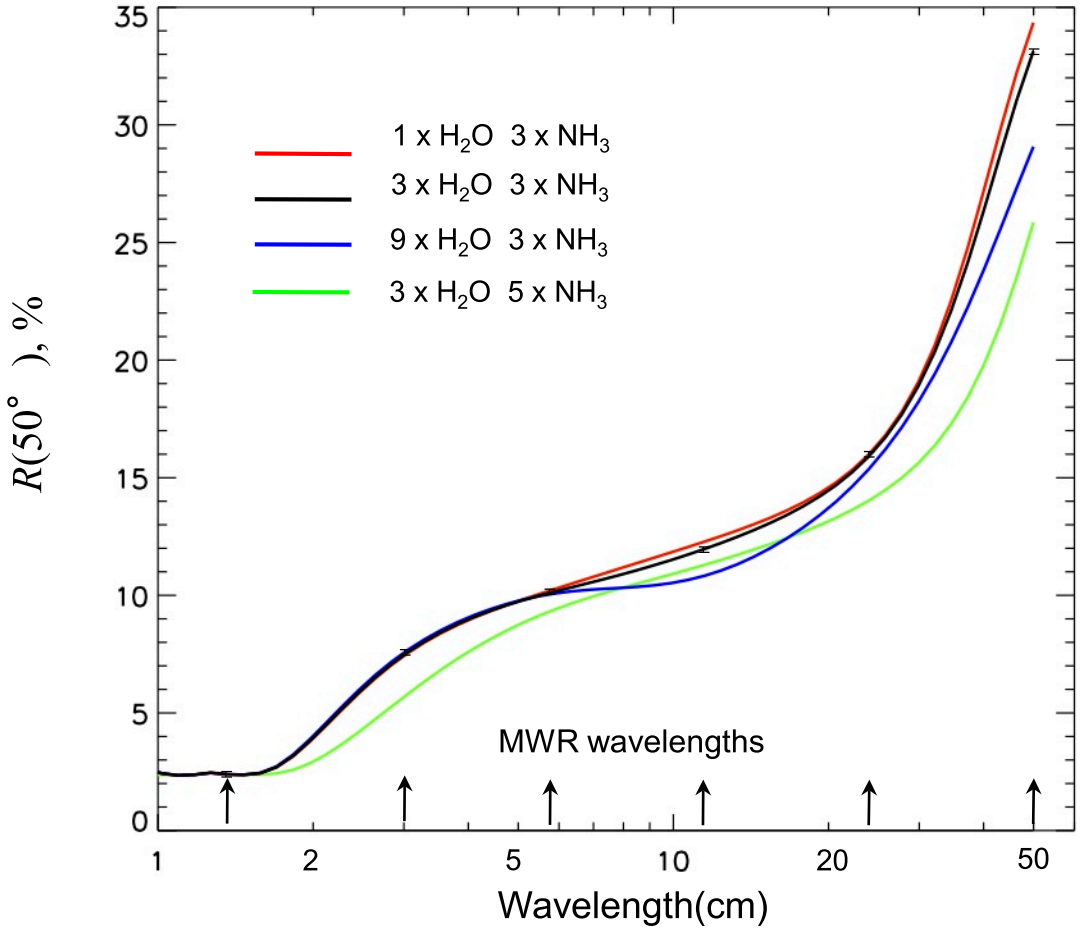


Limb darkening parameter:

$$R(\theta) = \frac{T_b\,(nadir) - T_b\,(\theta)}{T_b\,(nadir)} \times 100\ \%$$

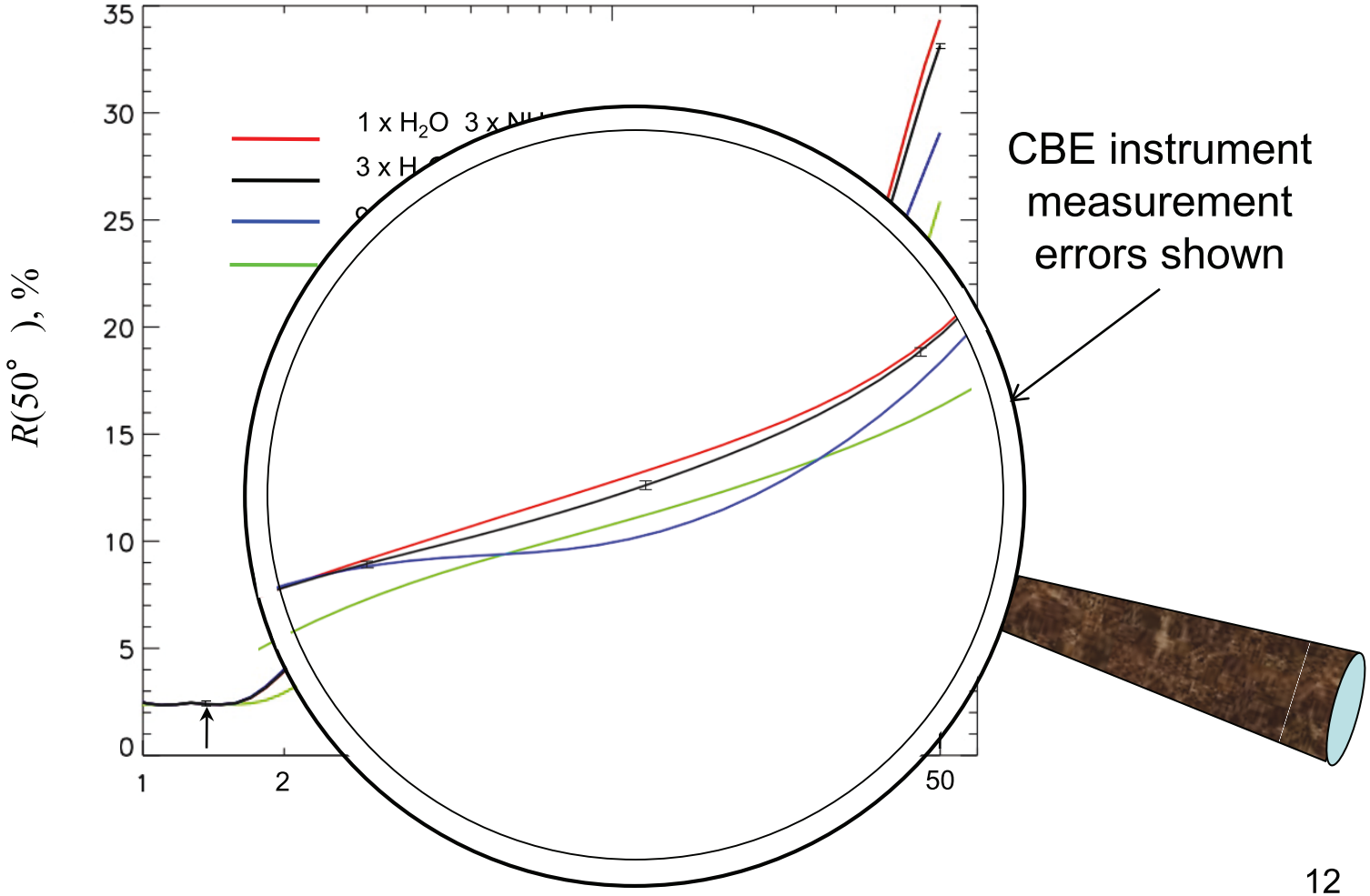
- $R(\theta)$ is a dimensionless parameter that can be determined with high accuracy from emission-angle dependent measurements
- Final error estimate for $R(50^\circ)$, ε < 0.1 % for all receivers

Limb Darkening Models



Measurement Uncertainties

(With magnifying glass to see measurement errors)



Atmospheric Variations

- There are many possibilities for Jupiter's composition and structure
- Modeling parameters include
  - subcloud distribution of condensable and chemically active constituents and cloud-level humidity variations
  - Lapse rate variations due to moisture condensation, horizontal and vertical mixing
  - Upwelling and downwelling of air parcels
  - Etc.
- We will see many variations of atmospheric parameters across Jupiter
- The microwave data will be used to extract the parameters

Observational Timeline

- Nominal Plan: MWR always on after JOI, but with different geometries

	Perijove	Date (UTC)
	JOI	7/5/16
a	1	8/27/16
b	2	10/19/16
c	3	11/2/16
	4	11/16/16
	5	11/30/16
	6	12/14/16
	7	12/28/16
	8	1/11/17
	9	1/25/17
	10	2/8/17
	11	2/22/17
	12	3/8/17

	Perijove	Date (UTC)
	13	3/22/17
	14	4/5/17
	15	4/19/17
	16	5/3/17
	17	5/17/17
	18	5/31/17
	19	6/14/17
	20	6/28/17
	21	7/12/17
	22	7/26/17
d	23	8/9/17
	24	8/23/17
	25	9/5/17

	Perijove	Date (UTC)
	26	9/19/17
	27	10/3/17
	28	10/17/17
	29	10/31/17
	30	11/14/17
	31	11/28/17
	32	12/12/17
	33	12/26/17
	34	1/9/18
	35	1/23/18
	36	2/6/18
	37	2/20/18

a	1st perijove after JOI, MWR ride-along with along-track scanning
b	Period Reduction Maneuver, MWR ride-along w/ cross-track scanning
c	MWR on as ride-along during Trim Maneuver
	Gravity Pass (HGA to Earth)
	MWR Pass (Scan through Jupiter nadir)
	MWR Pass with special Geometry
d	MWR to target Great Red Spot
	MWR orbit optional

Takeaway

- Microwave measurements provide unique access to deep atmospheres to address fundamental questions about composition and dynamical properties
- Juno MWR observations promise order-of-magnitude improvement in resolution and radiometric accuracy
- Many atmospheric states will be seen
- We need models to interpret the data
  - New-generation radiative transfer model is in development
  - Deep atmosphere dynamical models are being developed