SPRITE

Saturn PRobe Interior and aTmosphere Explorer

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Science Overview

- The giant planets in our solar system contain clues to the origin of the planets and the conditions that set up terrestrial planet formation
  - These will be key to also understanding exoplanet systems
- Comparative study of Jovian and Saturnian composition and structure maps gradients in time and space in our protoplanetary disk
  - Jupiter will be well studied after Galileo/Juno, but which of its features (core size, circulation, etc.) are unique vs universal?
  - Cassini will leave remaining knowledge gaps about Saturn that require *in situ* sampling and are needed to fit into the puzzle of solar system formation

Decadal Survey Saturn Probe

PSDS Highest Priority Science Objectives

1. Determine the noble gas abundances and isotopic ratios of H, C, N, and O in Saturn's atmosphere.
2. Determine the atmospheric structure at the probe descent location.

PSDS Lower Priority Science Objectives

1. Determine the vertical profile of zonal winds as a function of depth at the probe descent location(s).
2. Determine the location, density, and composition of clouds as a function of depth in the atmosphere.
3. Determine the variability of atmospheric structure and presence of clouds in two locations.
4. Determine the vertical water abundance profile at the probe descent location(s).
5. Determine precision isotope measurements for light elements such as S, N, and O found in simple atmospheric constituents.

SOURCE: NASA Mission Study (transmitted from Leonard Dudzinski, NASA SMD/Planetary Science Division

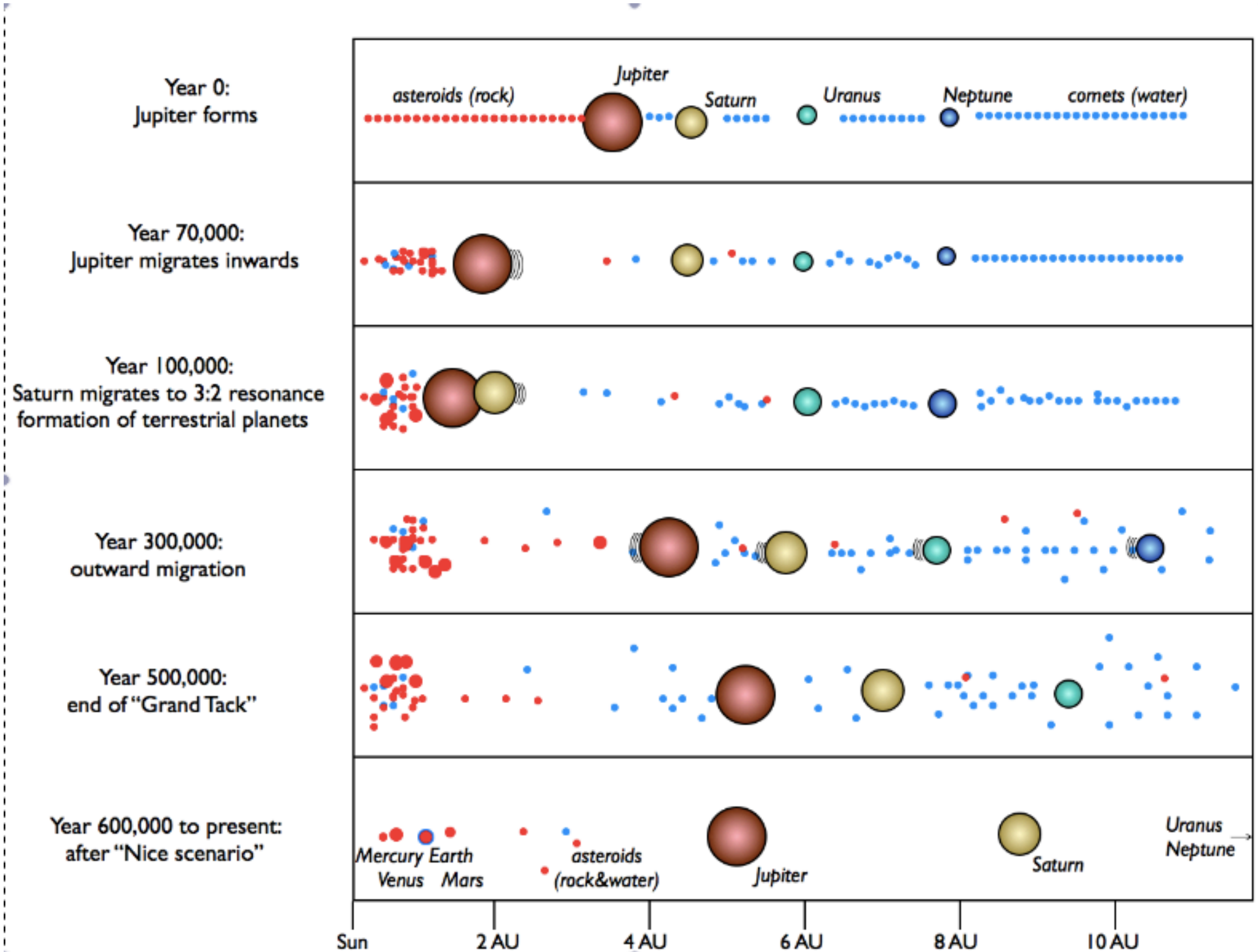
SPRITE Mission Science Goals

- **Mission Science Goal 1** Determine how the giant planets formed and their role in the origin and evolution of the solar system
  - Search for evidence of migration
  - Determine elemental and isotopic composition

- **Mission Science Goal 2** Understand the circulations of giant planet atmospheres and how energy is transferred from interior to surface
  - Characterize atmospheric dynamics at probe entry site
  - Constrain helium/neon depletion

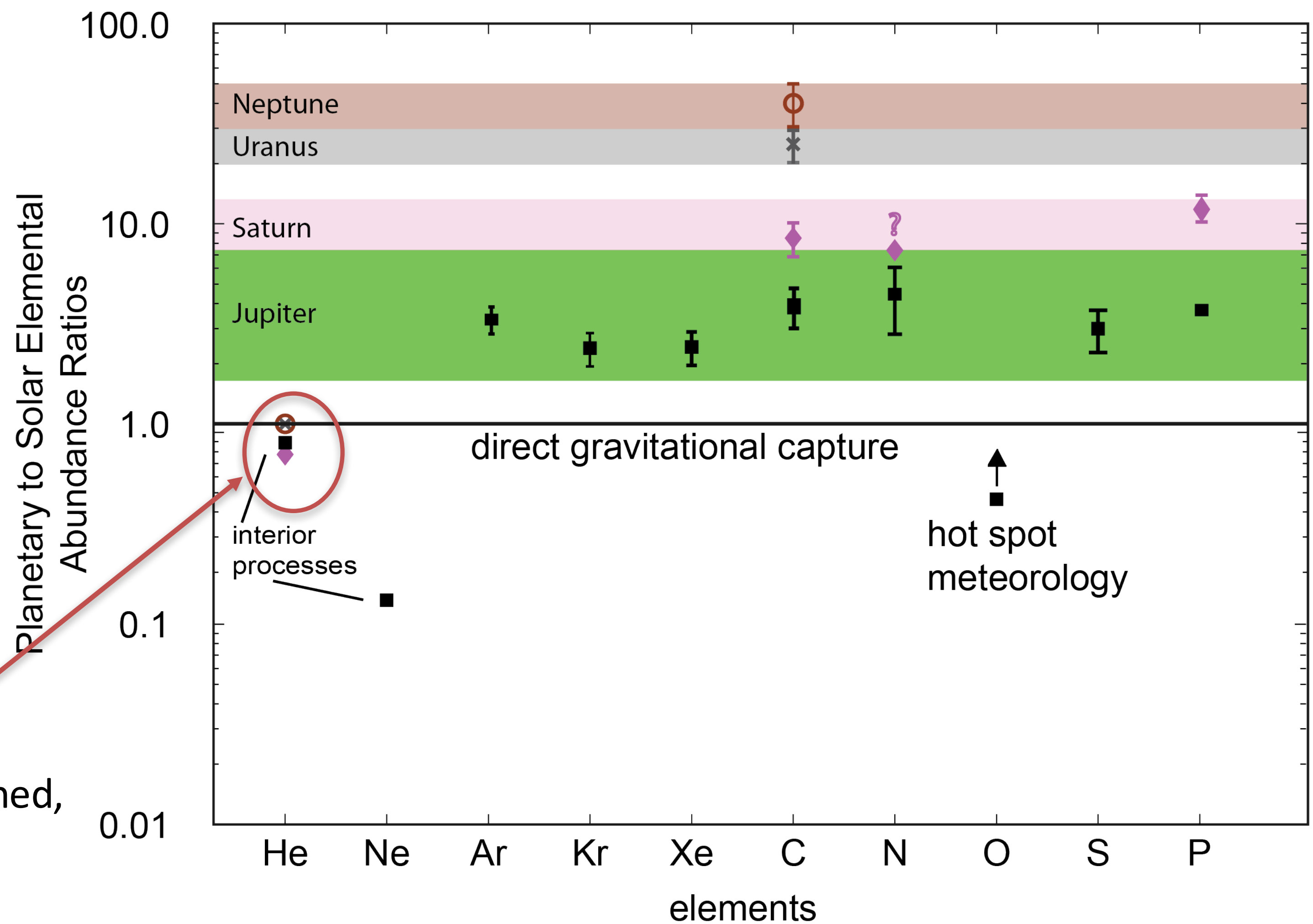
SPRITE Meets the Decadal Saturn Probe Objectives, and provides additional carrier science

Goal 1: Formation Models and Planetary Migration



http://www.exoclimes.com/wp-content/uploads/2014/07/GrandTackIllustration1.png

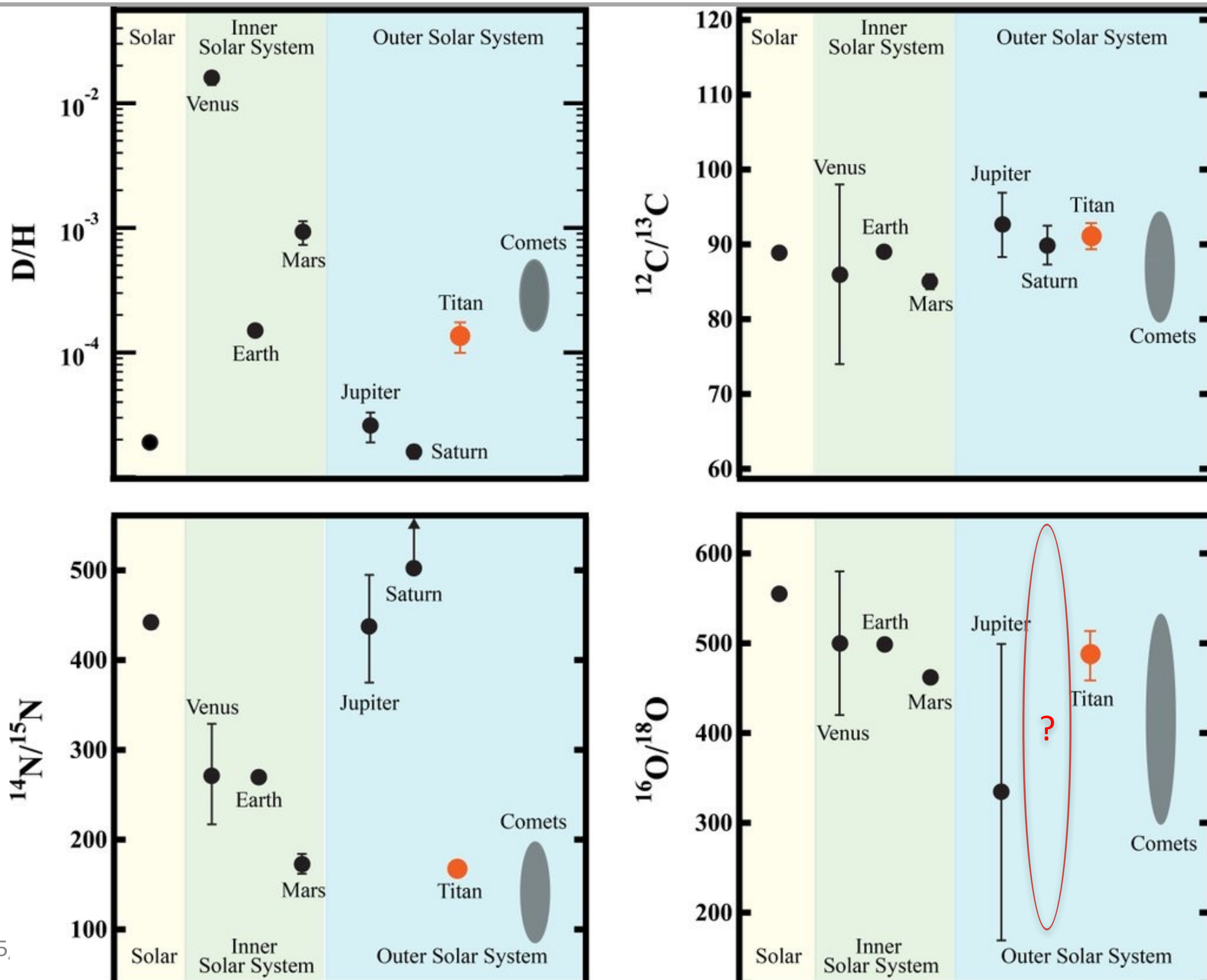
Elemental Composition



Poorly constrained, model-based

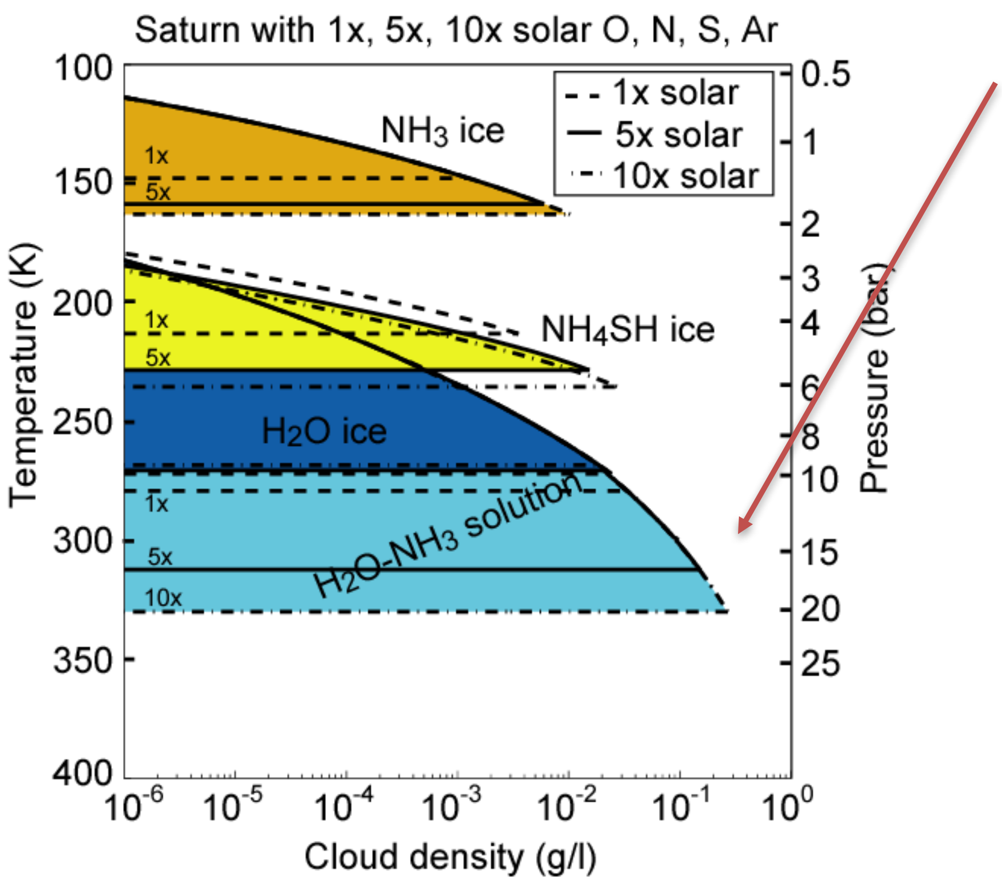
From: R. Han

Isotope Composition



From:
S. Horst

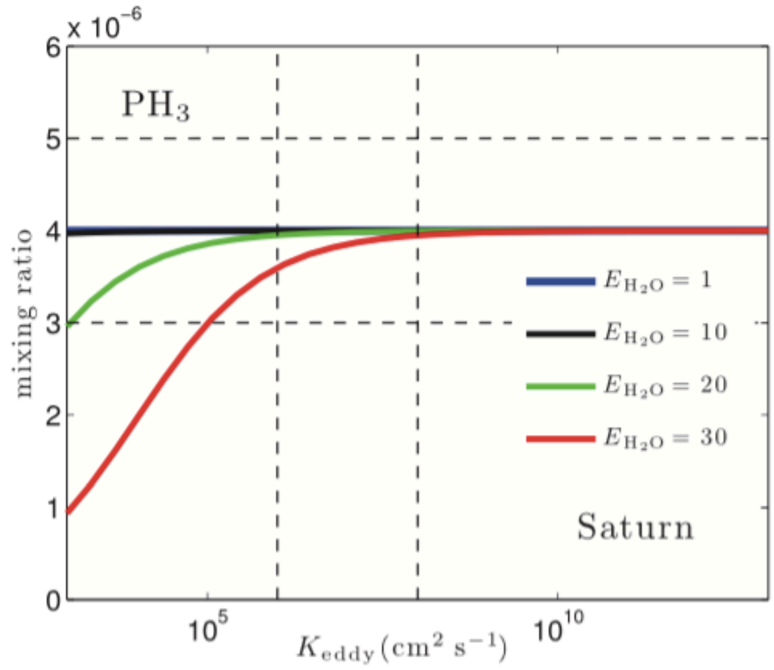
Deep Water



- Water at upper levels appears depleted, while CH_4, PH_3 etc., are enhanced over solar values
- Implies water is enhanced at deep levels
- A 10 or 20-bar probe won't get to well-mixed H_2O region
- Disequilibrium species trace the water

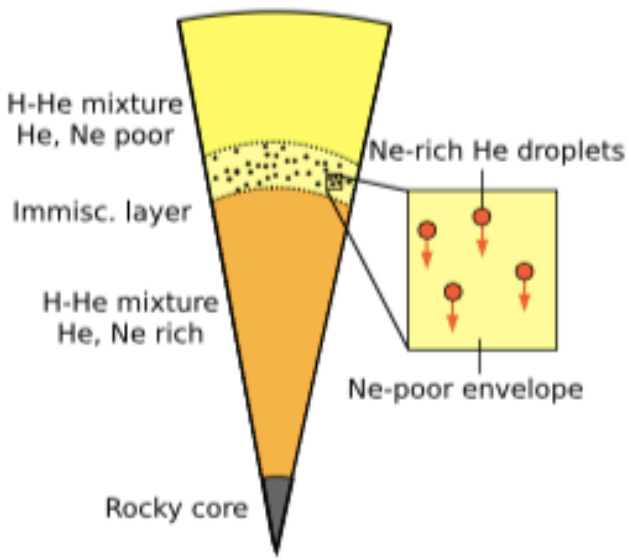
Deep Water

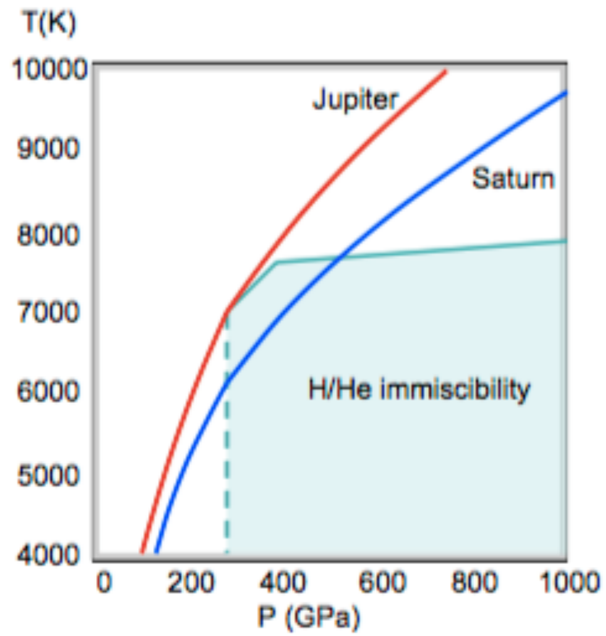
Thermochemical reactions give PH_3 vs P_4O_6, CO vs CH_4/C_2H_2 , etc.
depending on water abundance and local dynamics (eddy diffusion)



Wang et al. 2016

Goal 2: Atmospheric Circulation and Heat Transport

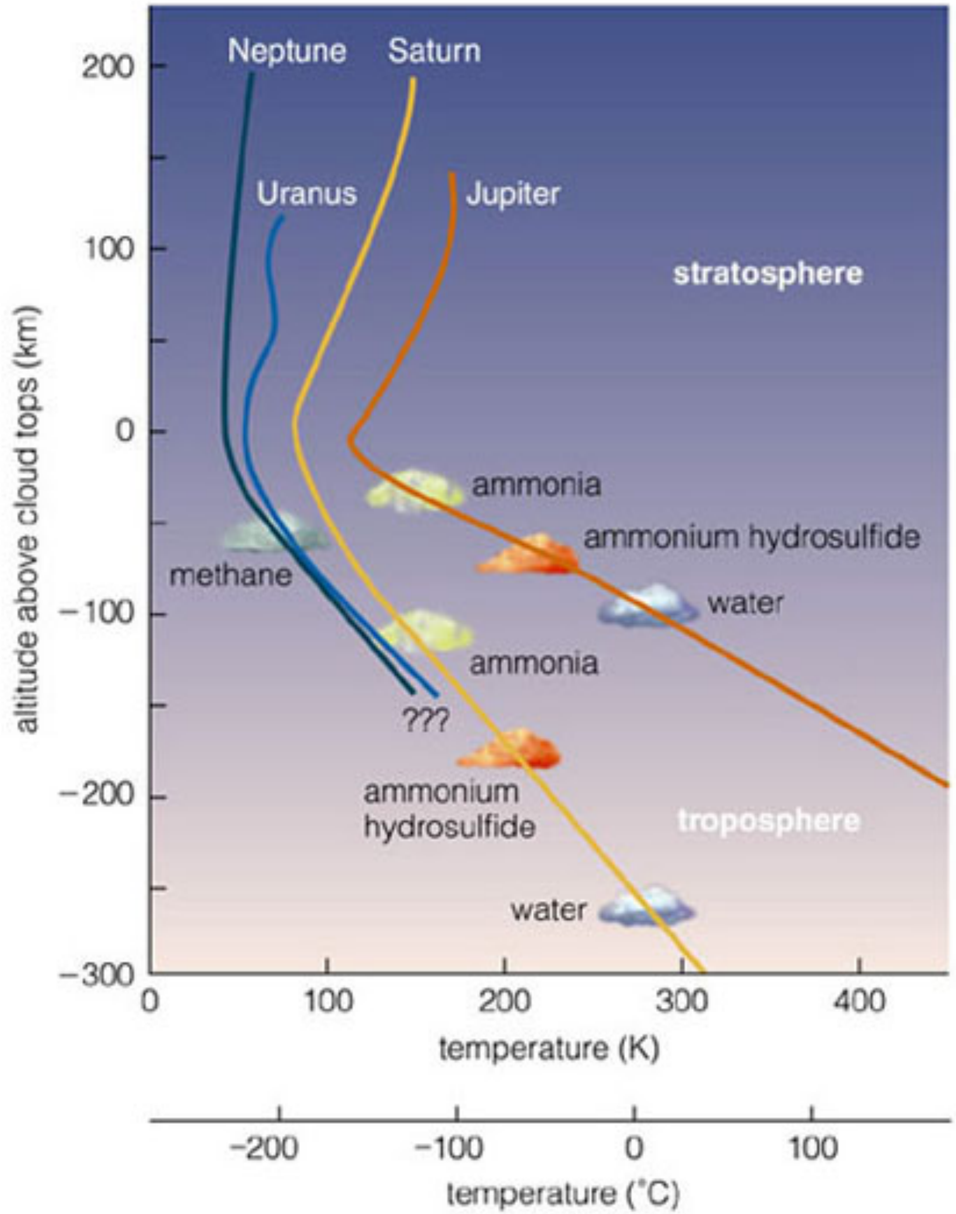




Wilson and Militzer
2010

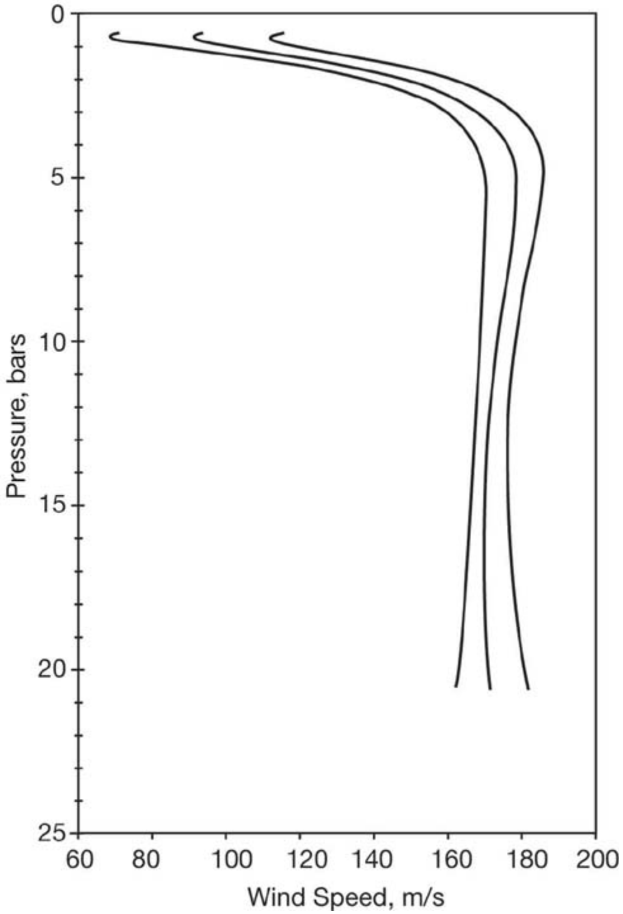
- Helium and dissolved neon can rain out in Saturn's atmosphere
- Changes the atmospheric equation of state

Radiation Balance and Clouds

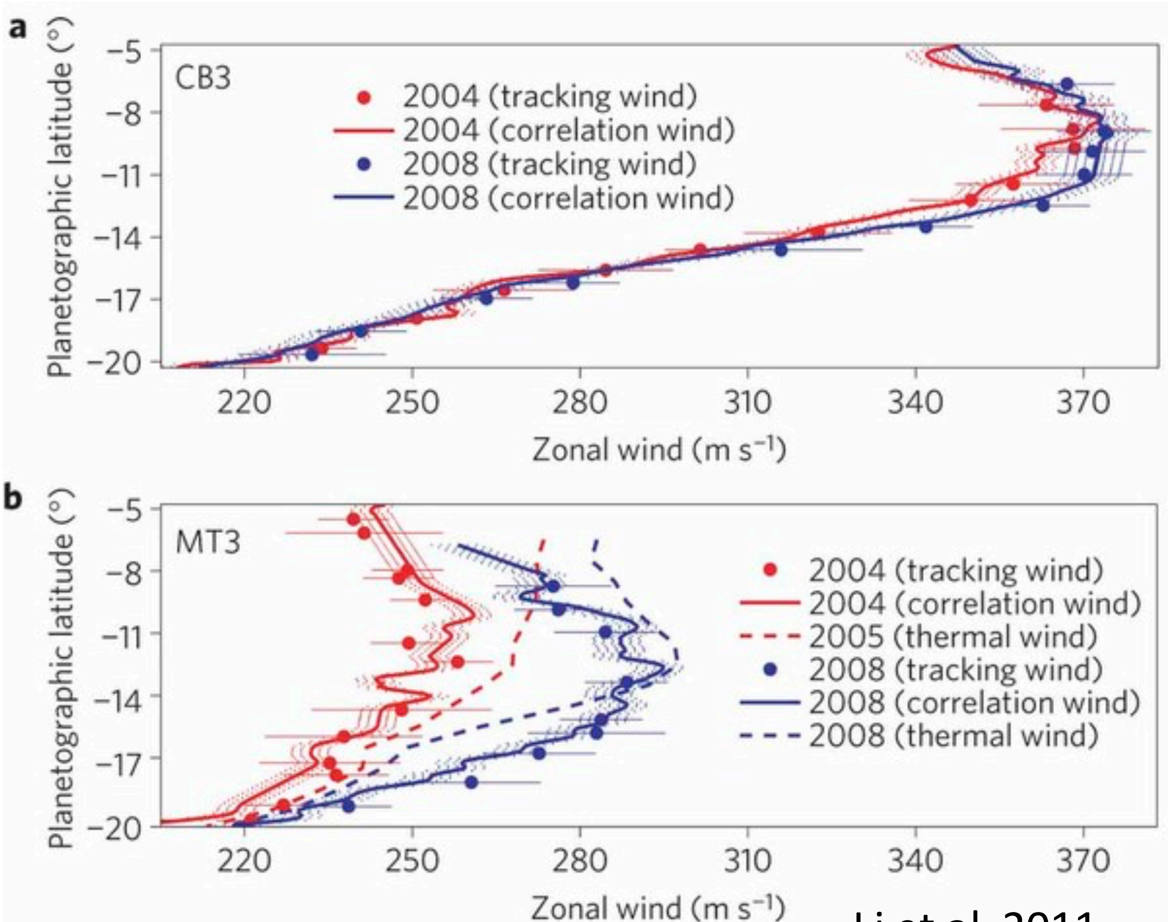


- Remote sensing provides some constraints on cloud structure, but relies heavily on assumptions
- A probe provides ground truth, connection to observed cloud top motions
- *In situ* measurements of pressure/temp can determine atmosphere wet vs dry adiabat

Winds and Waves



Saturn's winds vary at low latitudes over time and altitude

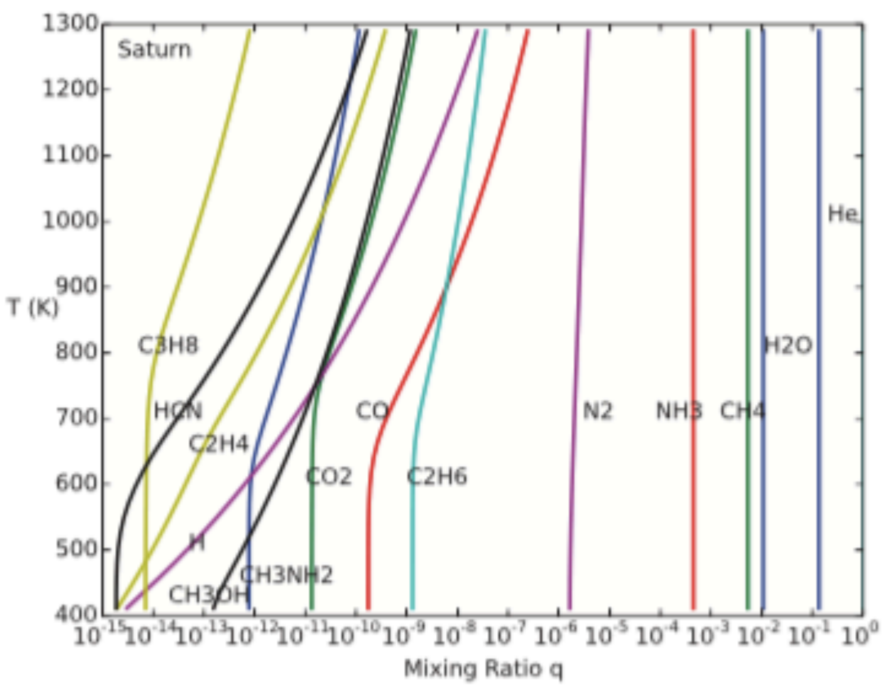


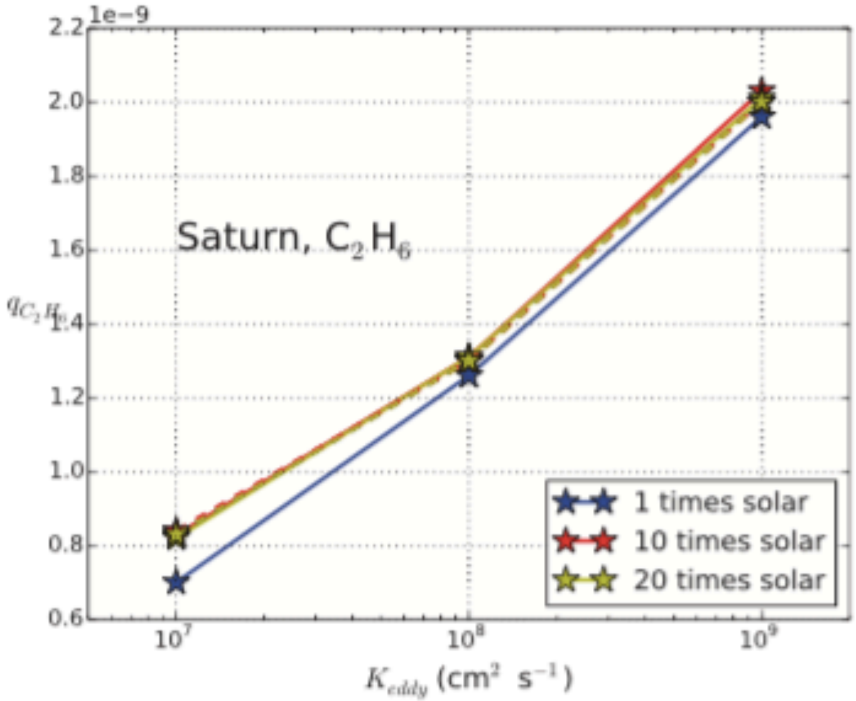
Galileo Probe showed high speed winds below Jupiter's clouds, and waves above

Li et al. 2011

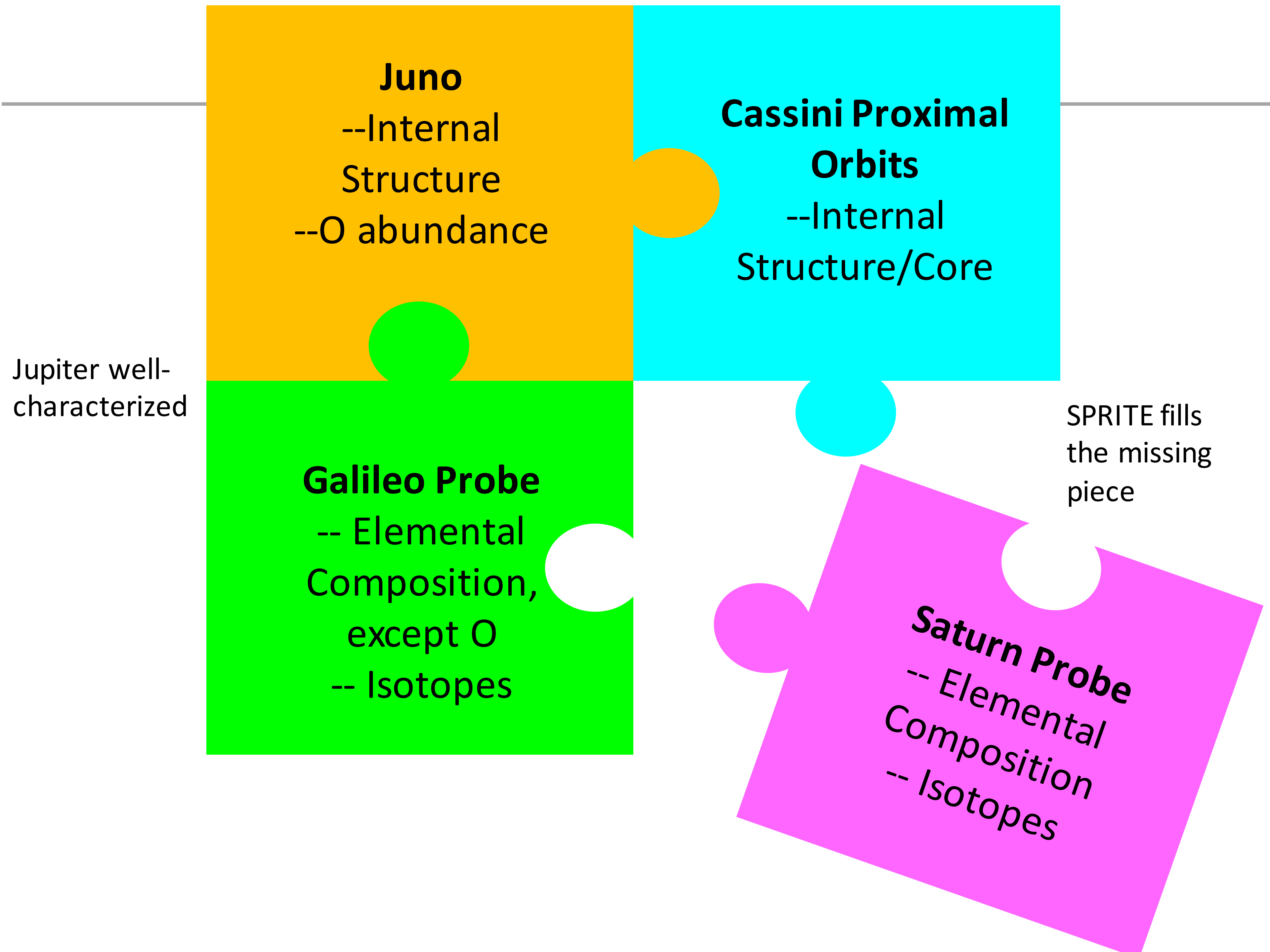
Disequilibrium Species

Abundance profiles of many species depend on water, temperature AND mixing, when compared with chemical equilibrium





Wang et al. 2016


Juno
--Internal Structure
--O abundance
Cassini Proximal Orbits
--Internal Structure/Core
Jupiter well-characterized
Galileo Probe
-- Elemental Composition, except O
-- Isotopes
SPRITE fills the missing piece
Saturn Probe
-- Elemental Composition
-- Isotopes

Acknowledgment:

Saturn PRobe Interior and aTmosphere Explorer (SPRITE).

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