The Solar System seen by ISO

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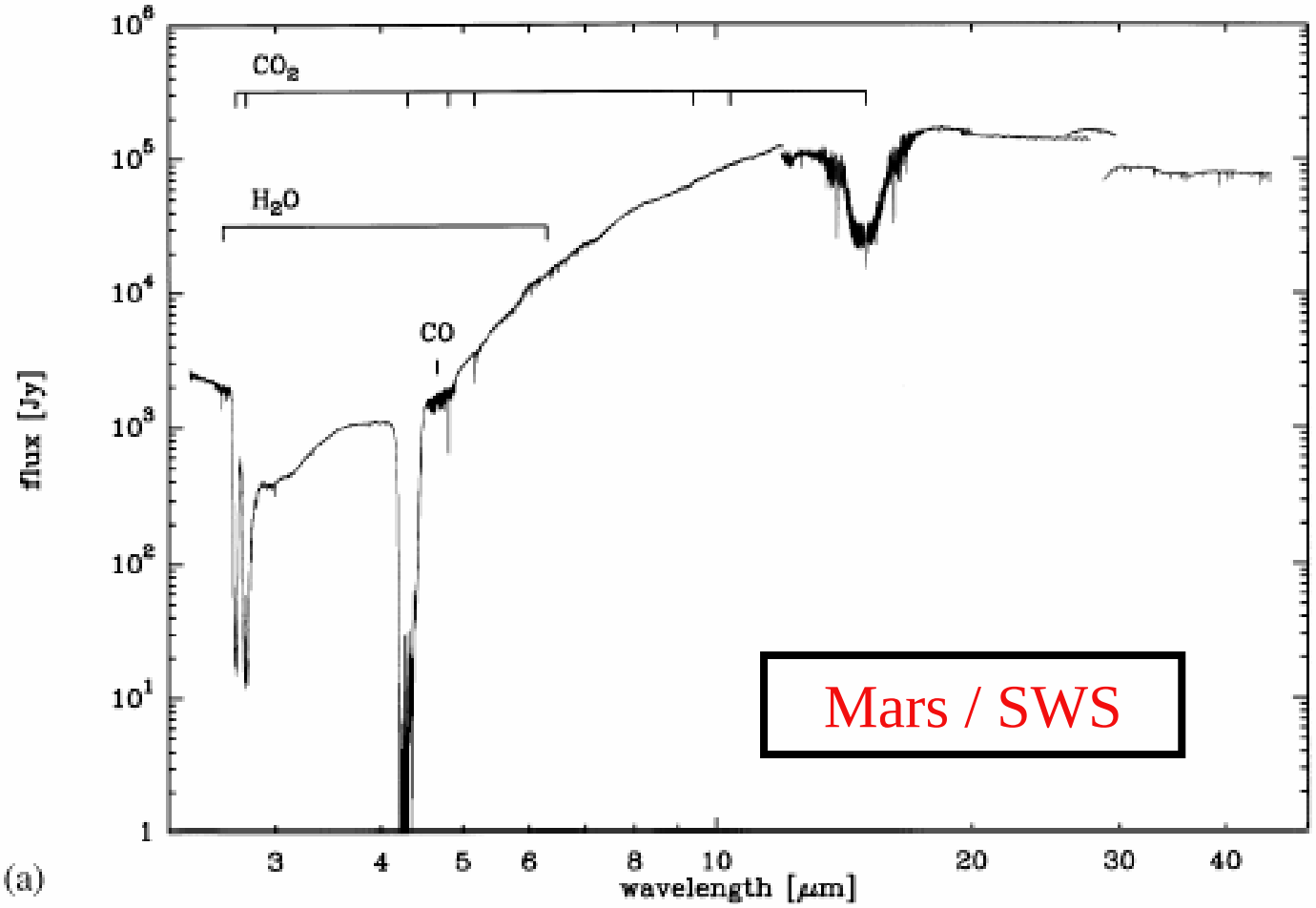
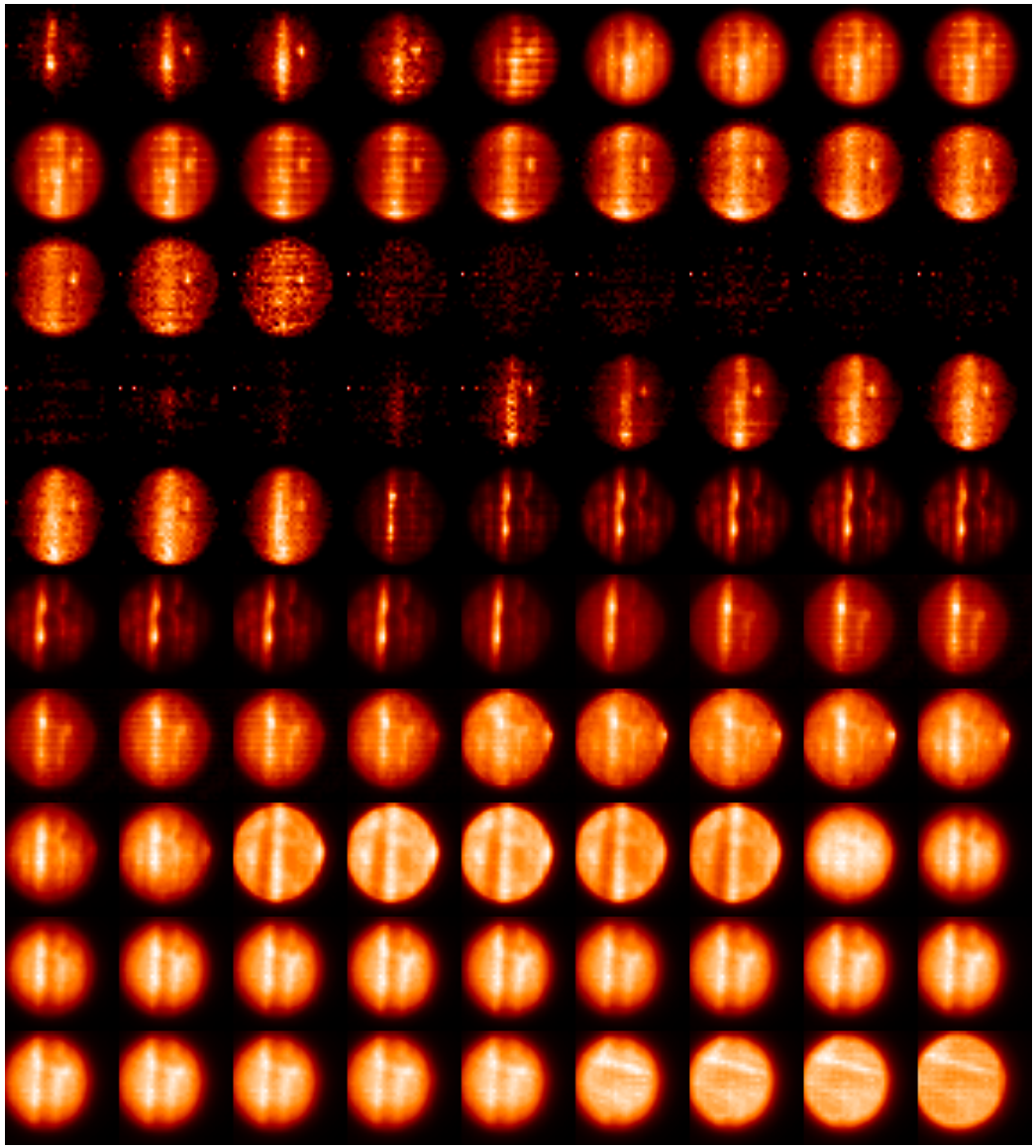
The Solar System before ISO

- Infrared was not a virgin territory before 1995
  - Voyager for the outer Solar System : 5-45 μm
  - Pioneer, Venera, Viking for the inner Solar System : 5-45 μm
- ISO improvements:
  - Sensitivity
  - Spectral resolution

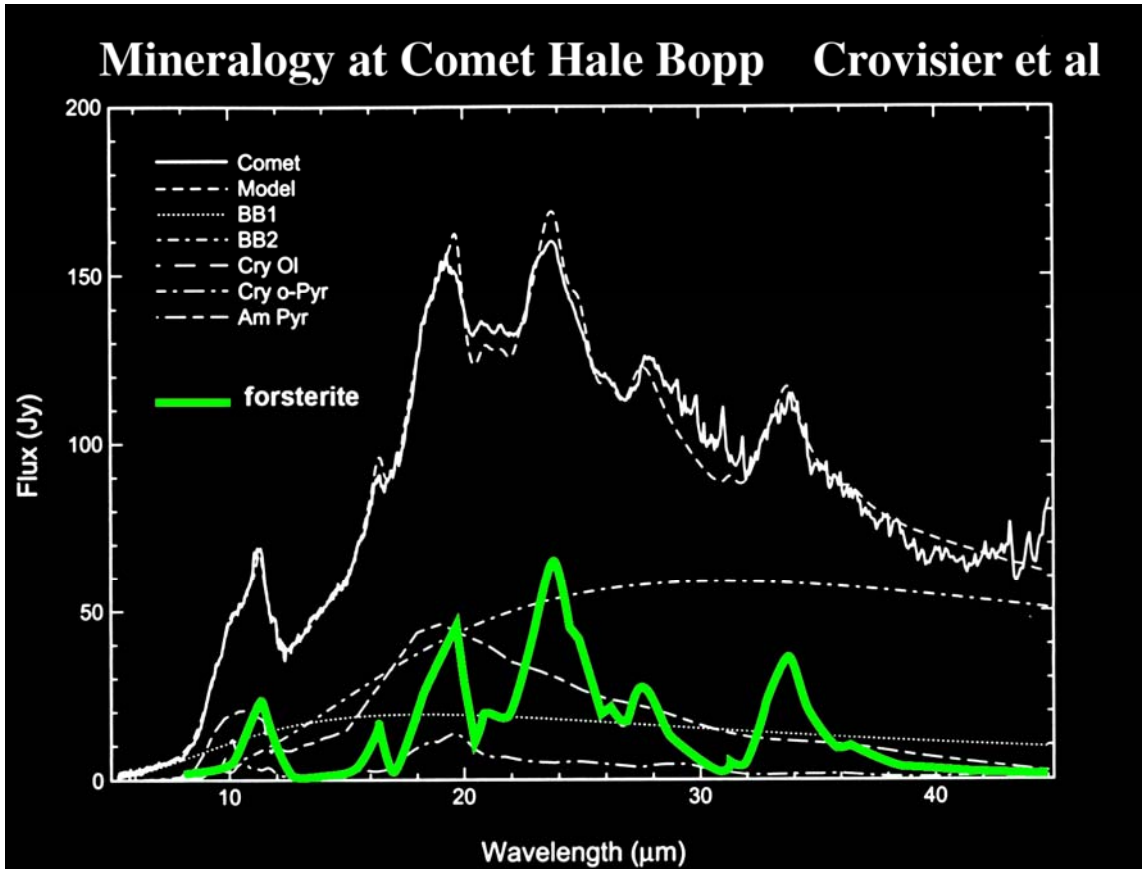

10^6
10^5
10^4
10^3
10^2
10^1
1
flux [Jy]
CO_2
H_2O
CO
3
4
5
6
8
10
20
30
40
wavelength [μm]
Mars / SWS

(a)

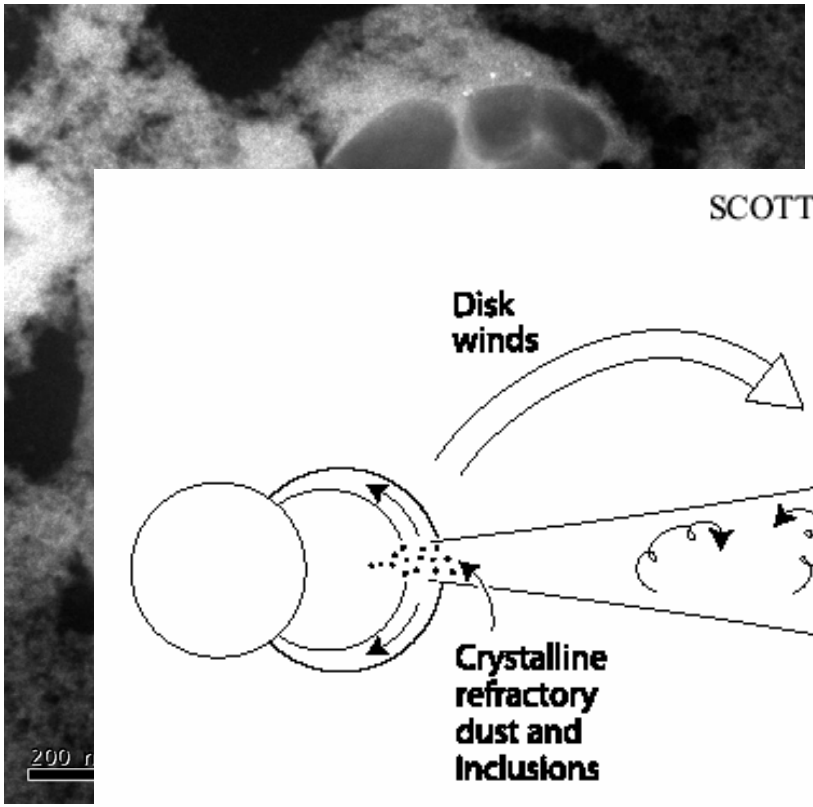


ISOCAM / Jupiter

Forsterite in Hale-Bopp



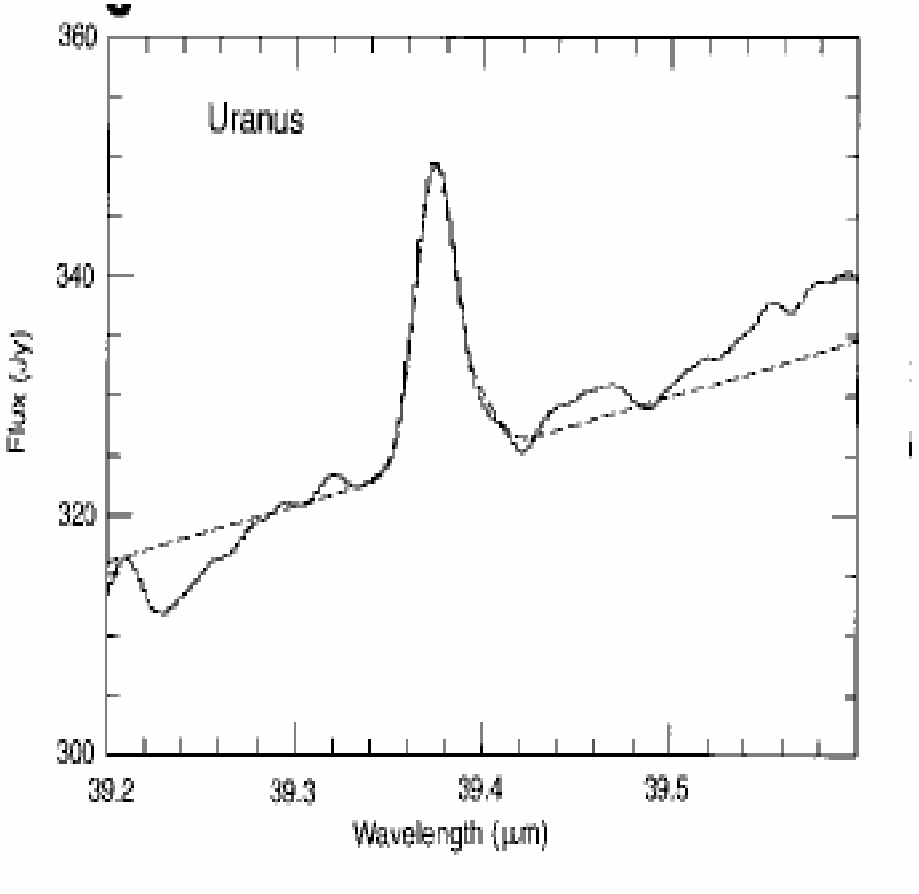
Forsterite in Hale-Bopp

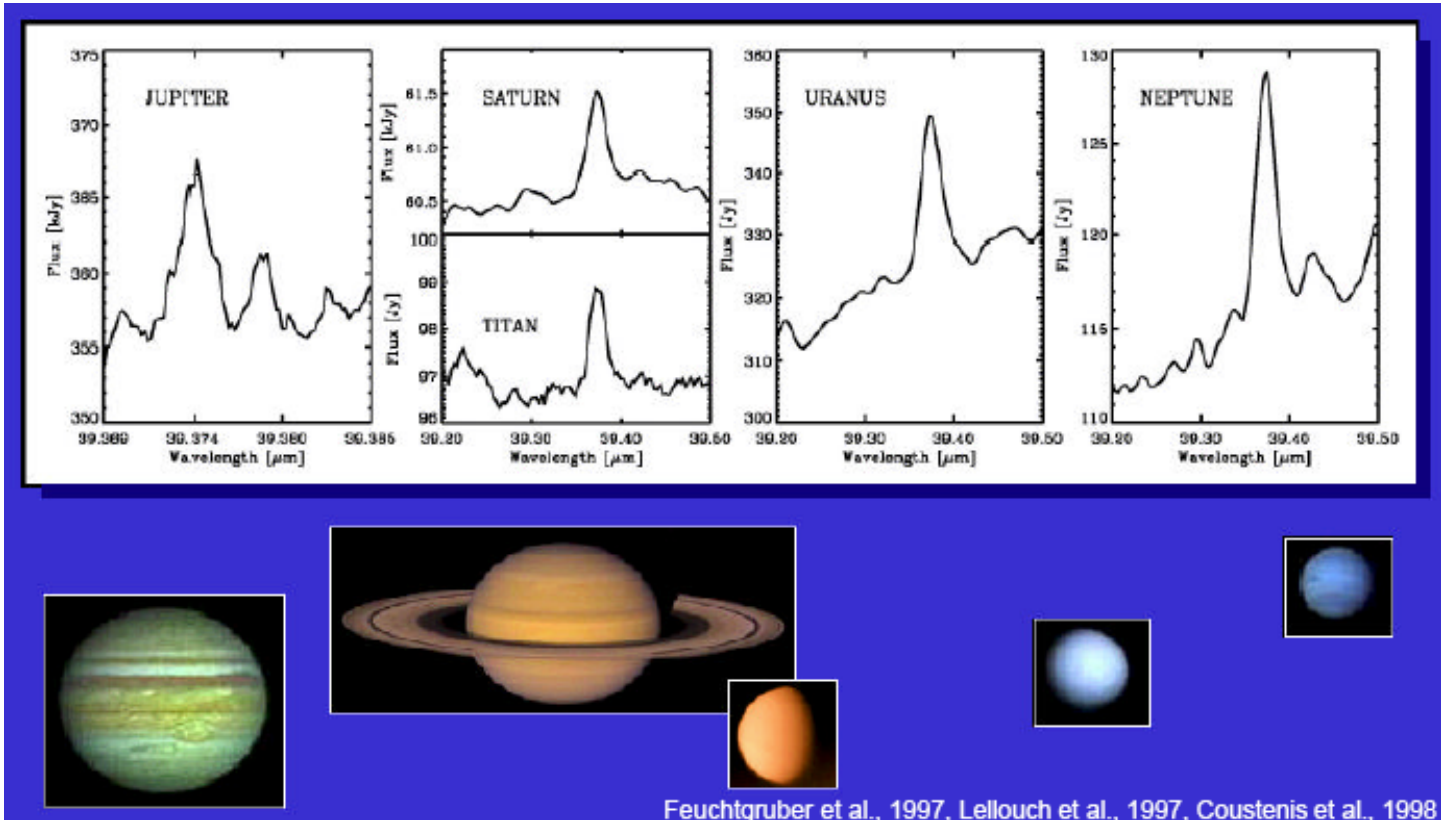


- The solar system nebula was turbulent

Water in the outer Solar System

- First detection of water in Uranus
- Thérèse Encrenaz : remnant feature from previous observations
- Emmanuel Lellouch : There is water in the telescope





- Water and CO_2 in the stratosphere of the four giant planets and Titan
- An external flux of oxygen in the outer Solar System

The source of Oxygen

- Jupiter :
  - The water seen by ISO comes from the SL9 impacts (Lellouch et al. 2002)
  - Evidence for CO deposited from previous impacts : 1 km-object/century (Bézard et al. 2002)
- Neptune :
  - A cometary impact 200 years ago (Lellouch et al., 2005)
- Saturn System
  - The rings for Saturn?
  - Enceladus for Titan?
- Uranus
  - Interplanetary dust particles

Deuterium in Giant Planets

Jupiter	$(2.4\pm0.4)\times10^{-5}$
Saturn	$(1.8\pm0.8)\times10^{-5}$
Uranus	$(5.5\pm2.5)\times10^{-5}$
Neptune	$(6.5\pm2)\times10^{-5}$

Hershell will reduce the error bars

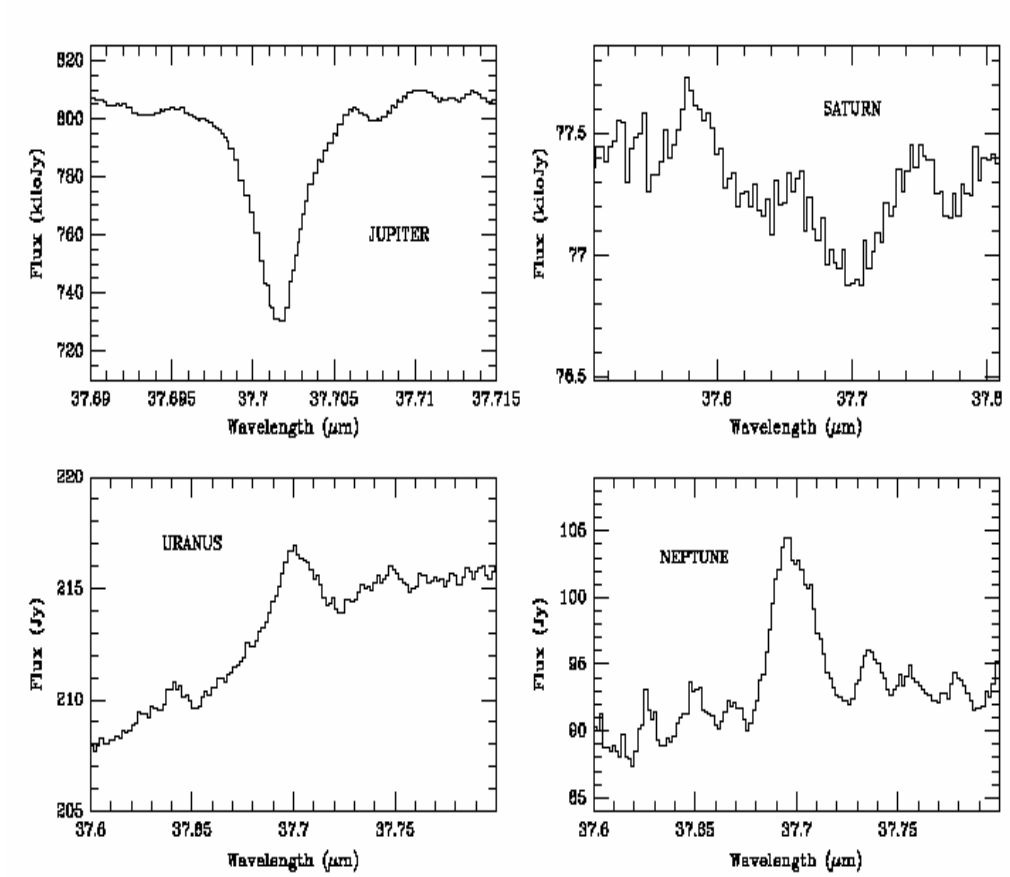
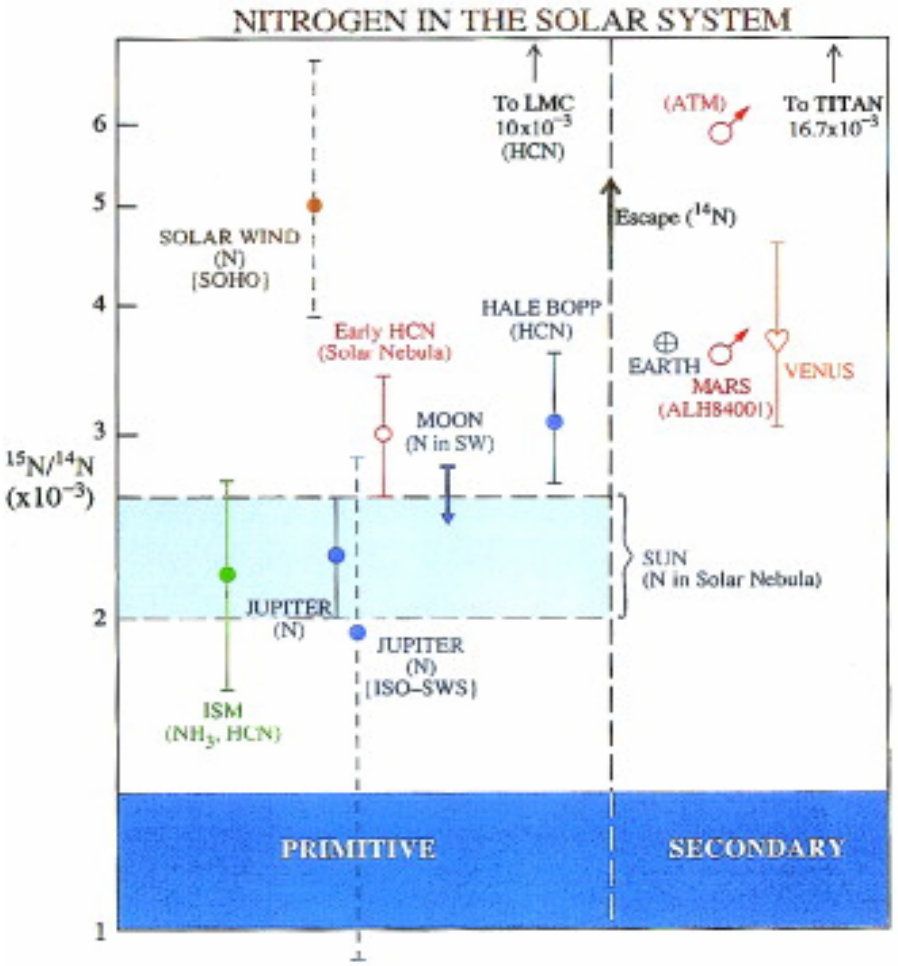


Figure 1. The HD R(2) rotational line observed on the four giant planets.

Nitrogen isotope in Jupiter

- $^{15}N/^{14}N = (1.9\pm1)\times10^{-3}$: Represent the protosolar value
- Terrestrial N is different from the main N carrier in the nebula
- Confirmed by Galileo
- Many observations of $^{15}N/^{14}N$ in solar system objects
- Genesis



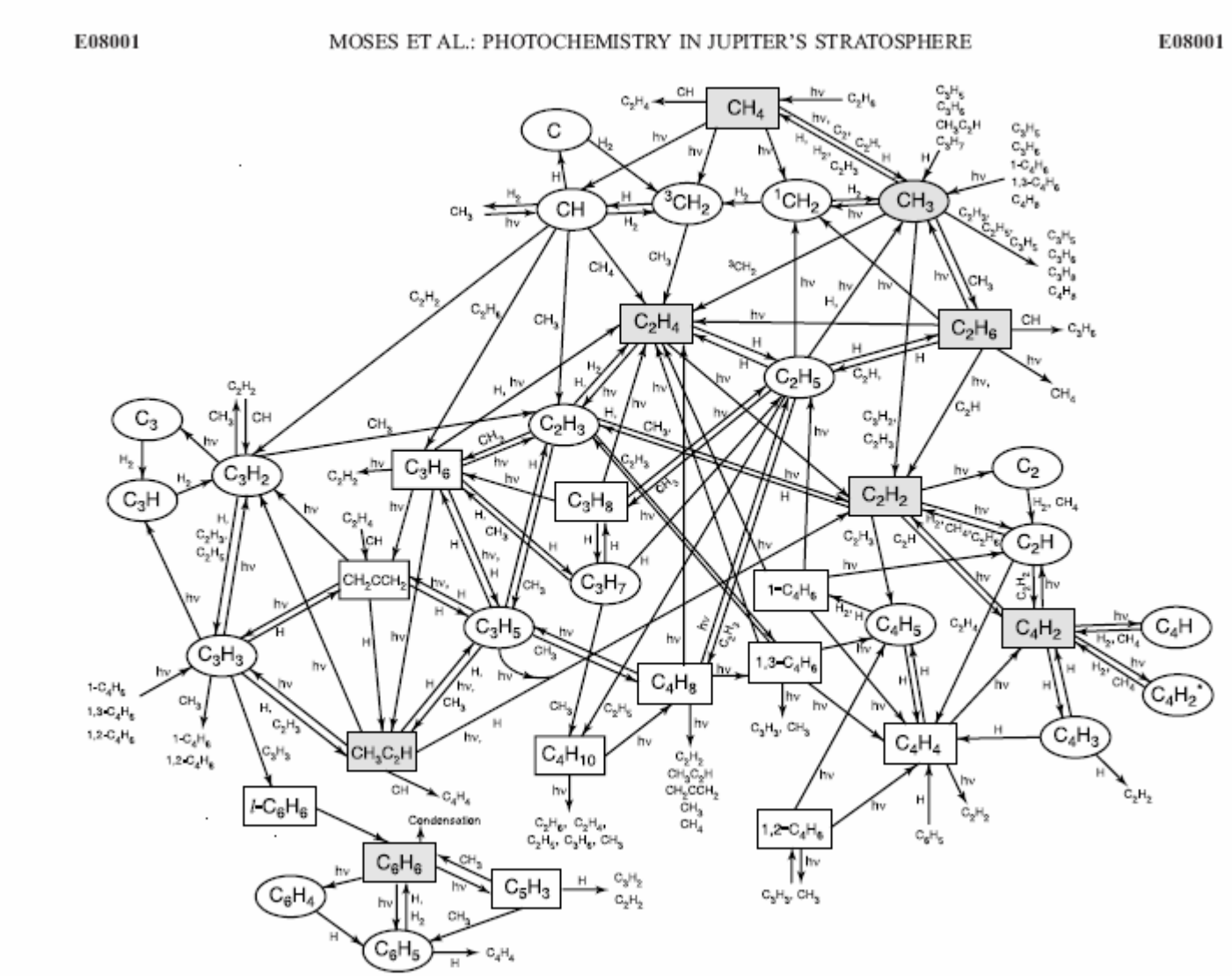
Nitrogen isotope in Jupiter

Hydrocarbons

- Chemistry was simple before ISO : CH_4 photolysis yielded C_2H_6, C_2H_2
- Many new radicals and molecules detected

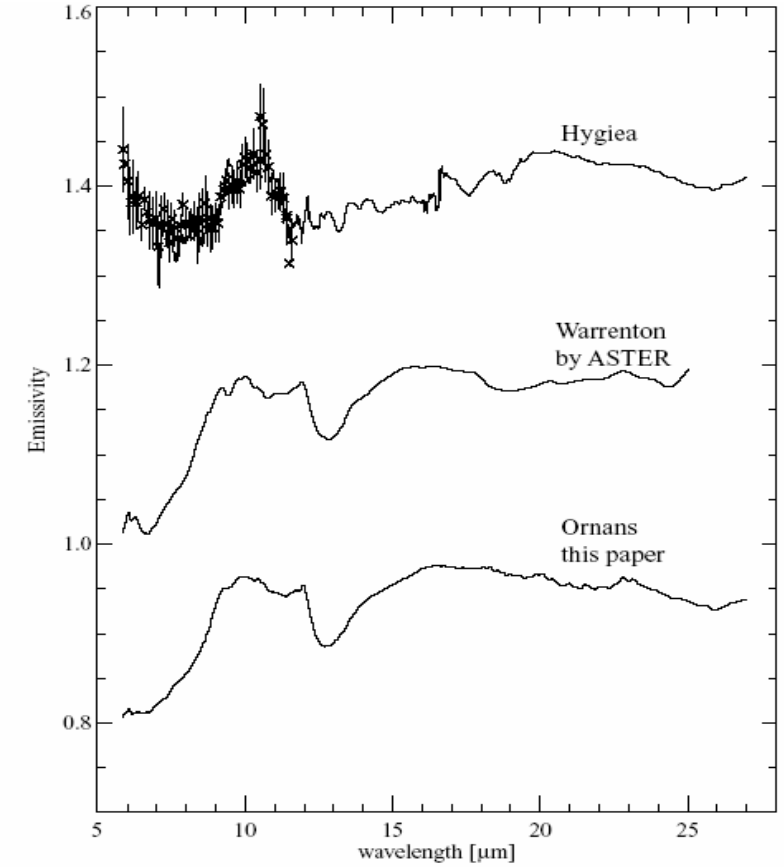
Jupiter	CH_3C_2H, C_6H_6
Saturn	CH_3, CH_3C_2H, C_4H_2, C_6H_6
Titan	C_6H_6
Uranus	Upper limits on CH_4
Neptune	CH_3, C_2H_4

Hydrocarbons



Asteroids

- Evidence for mineralogical relations between asteroids and meteorites
- Thermophysical studies of asteroids
  - Low thermal inertia of the regolith



Conclusions

- Extremely fruitful mission
- Many “firsts” were achieved, open new perspectives on formation, chemistry and dynamics of the planetary objects
  - Spitzer
  - Herschel
  - Cassini (CIRS)