SOFIA Instrumentation and Goals for Planetary Science

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SOFIA Instruments

Instrument	Wavelength	Capability	Availablity
GREAT	60-200 µm	High-resolution spectra	**Jan 2011**
FIFI LS	42-210 µm	Integral field spectra	early 2013
HAWC	50-240 µm	Filter images	end 2012
EXES	5-28 µm	High-resolution spectra	mid 2013
FORCAST	5-40 µm	Filter images, grism spectra	**Oct 2010**
FLITECAM	1-5 µm	Filter images, grism spectra	mid 2012
HIPO	0.3-1.1 µm	High-time-resolution photometry	mid 2012

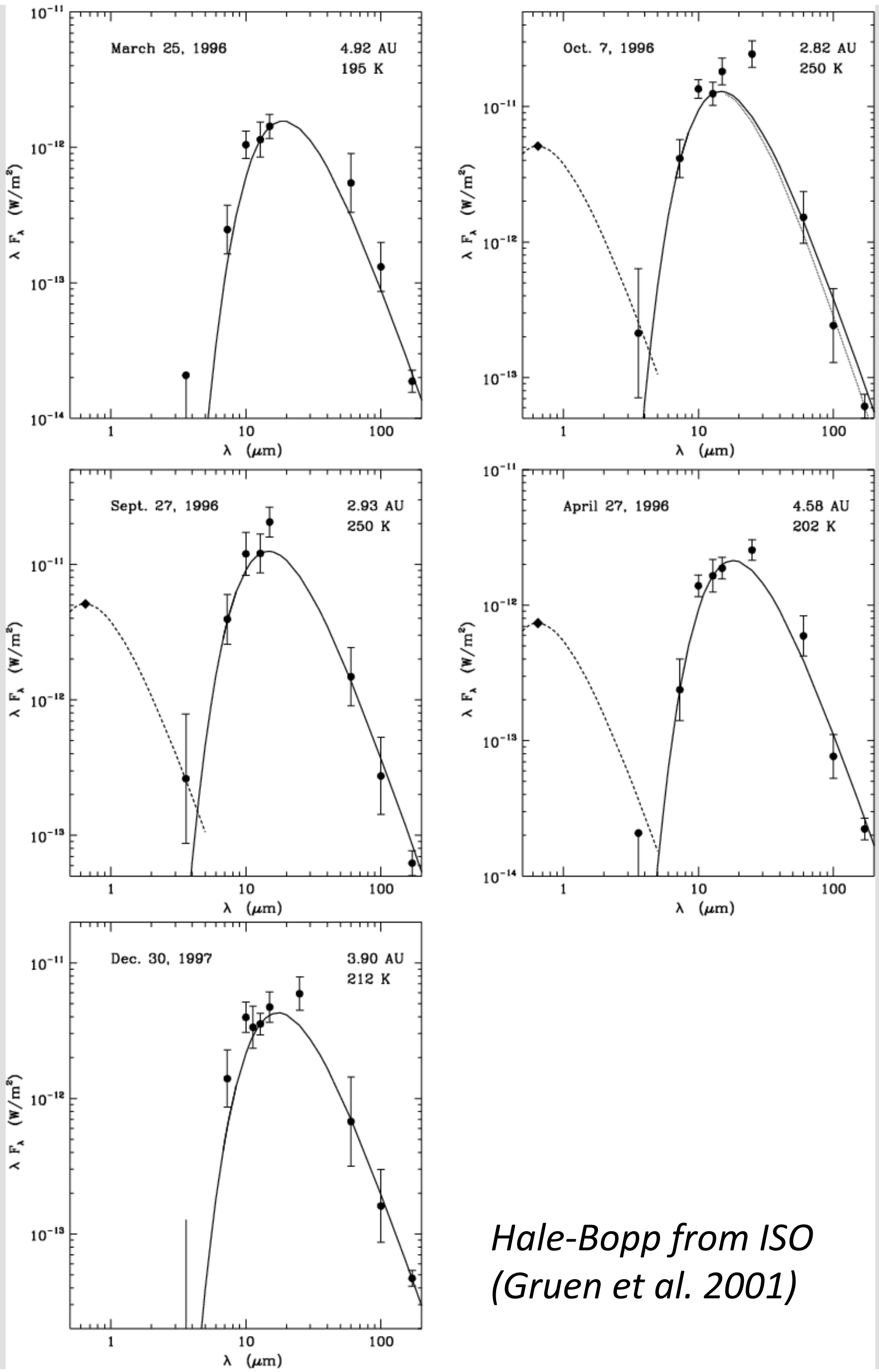
Thermal Emission

- Infrared spectral energy distribution from 1-200 µm
  - Size $$F_\nu = \pi (R/\Delta)^2 B_\nu(T)$$
  - Albedo $$F_{vis} = \pi (R/\Delta)^2 F_{solar} A$$

- SOFIA sensitive to asteroids of size >10 km

- Planetary satellites

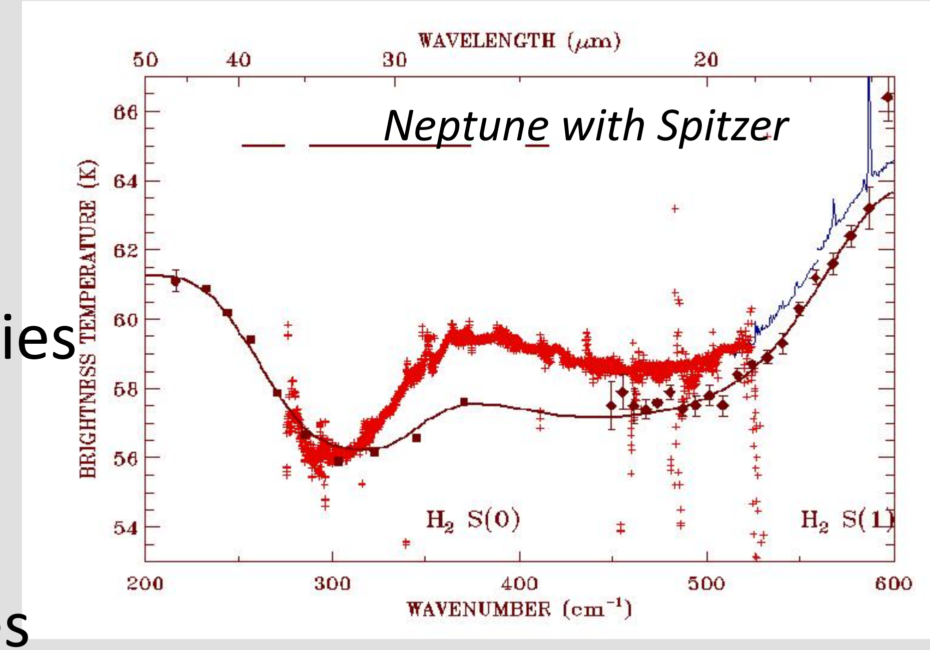
FLITECAM, FORCAST, HAWC



Hale-Bopp from ISO (Gruen et al. 2001)

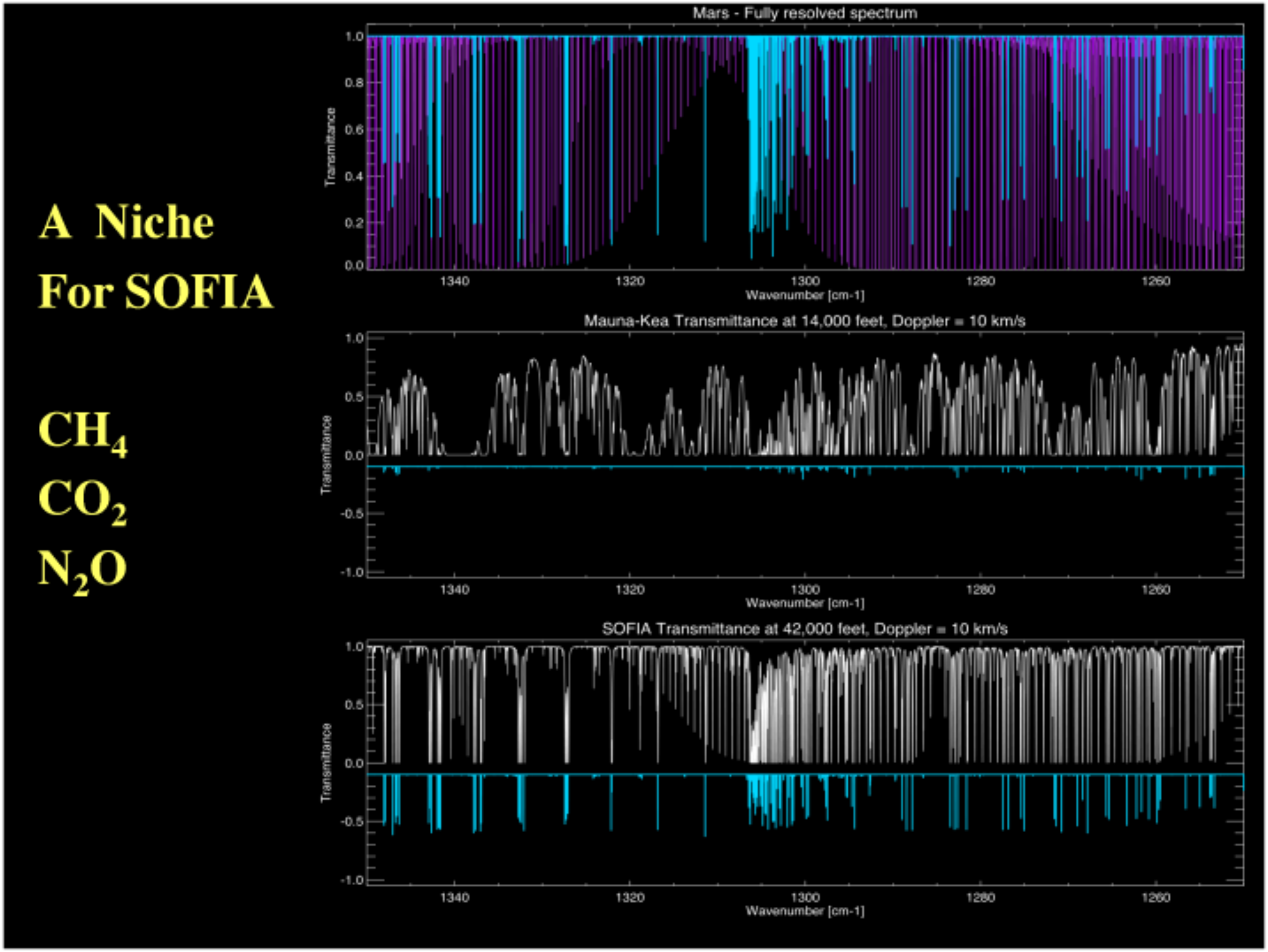
Planetary Atmospheres

- Giant planets
  - Opacity sources
  - monitoring
  - Temperature-sensitive species



- Venus
  - Inaccessible from space based infrared telescopes
  - Achieve part of science objectives of *Venus Express* (Planetary Fourier Spectrometer)
  - mid-infrared CO_2, DCl, SO_2

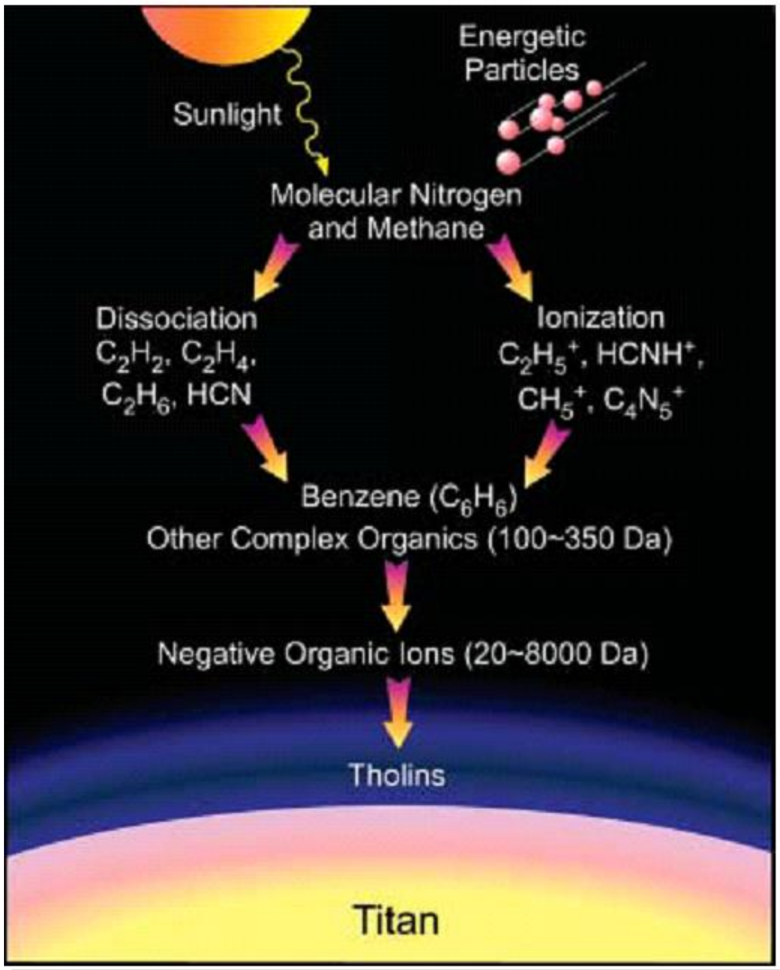
GREAT, EXES; FLITECAM & FORCAST grisms, FIFI LS

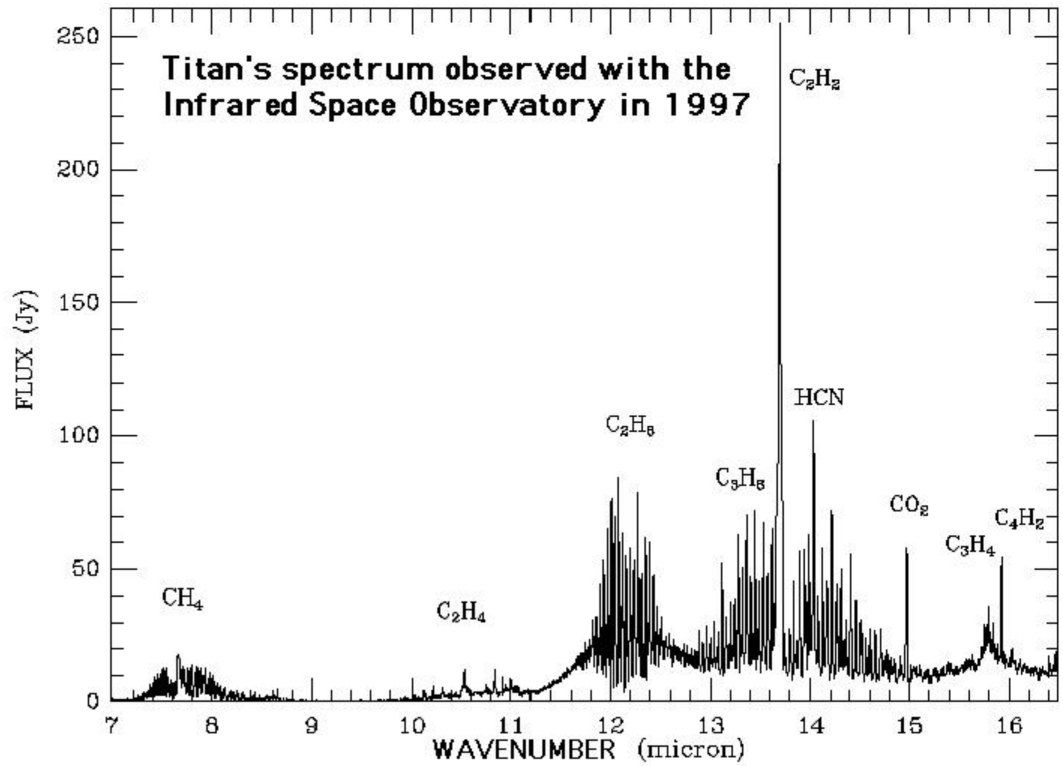


EXES

Mumma SCTF talk; Villanueva & Mumma (2009) paper

Titan

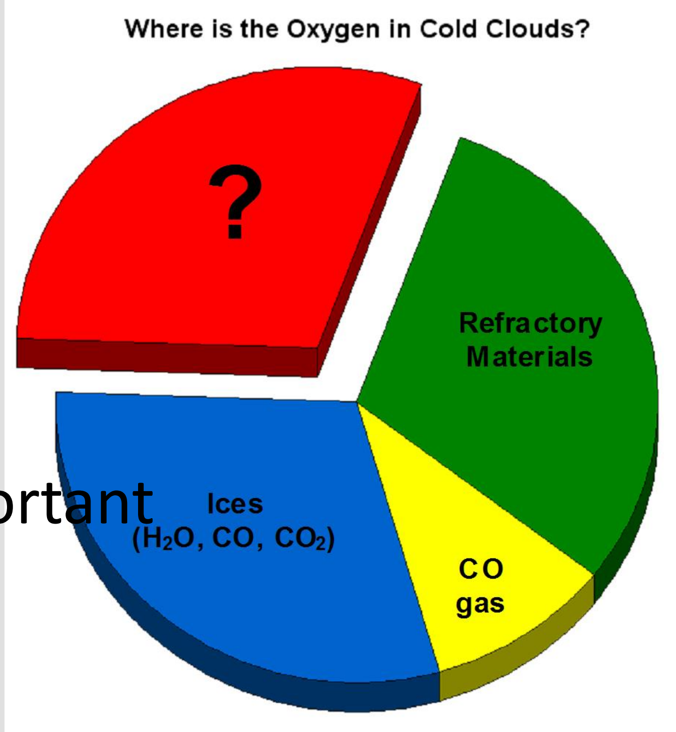




EXES, FORCAST grism, GREAT, FIFI LS *High-resolution mid-infrared spectroscopy*

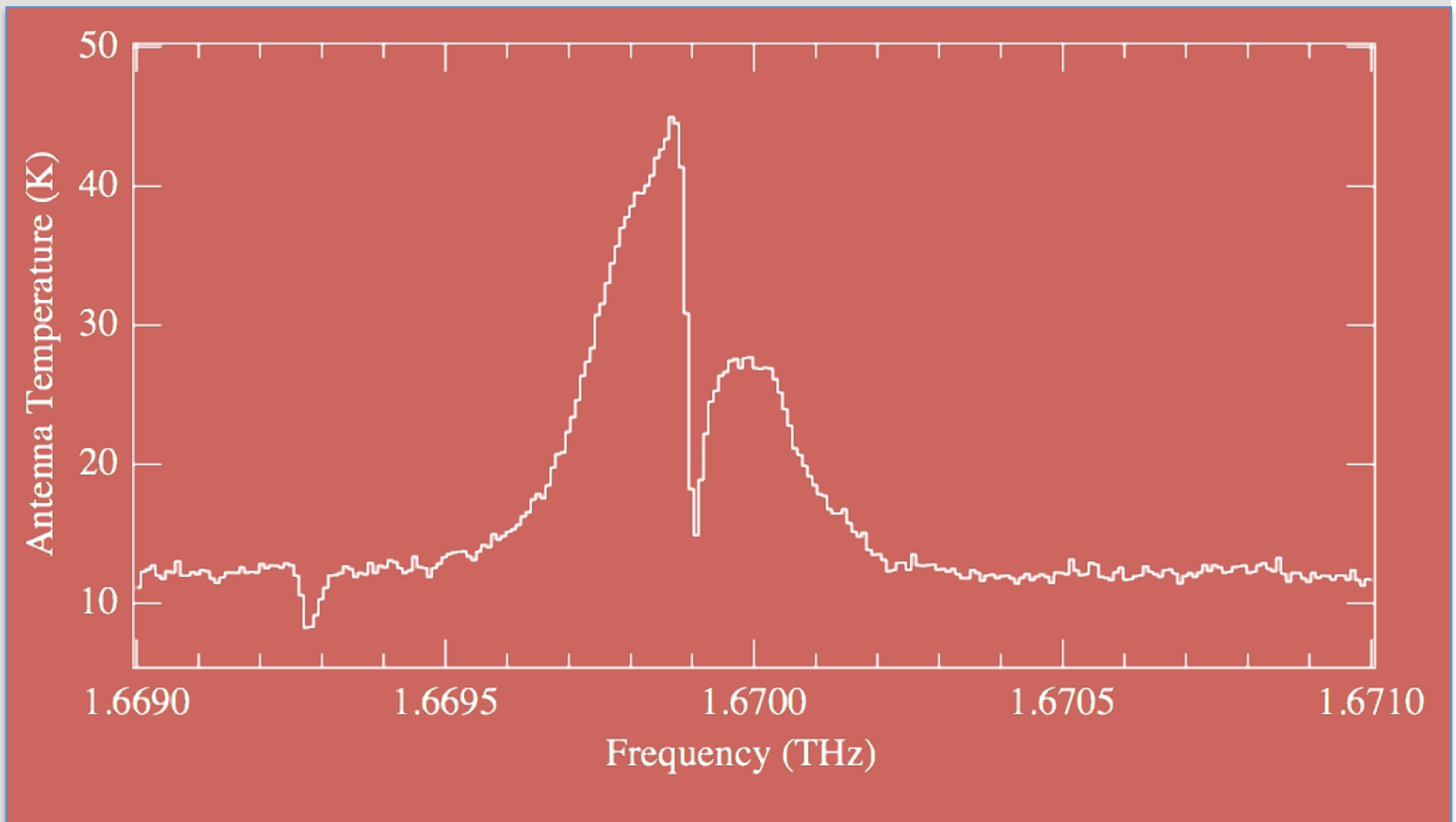
Astrochemistry

- Oxygen
  - O I lines at 63 and 145 µm
  - OH 119 µm
- Water
  - Where water forms, it is an important coolant and solvent
  - Shock chemistry, water survival
- Dark gas (not traced by HI or CO)
  - HD in the diffuse ISM
  - 112 µm ground rotational state

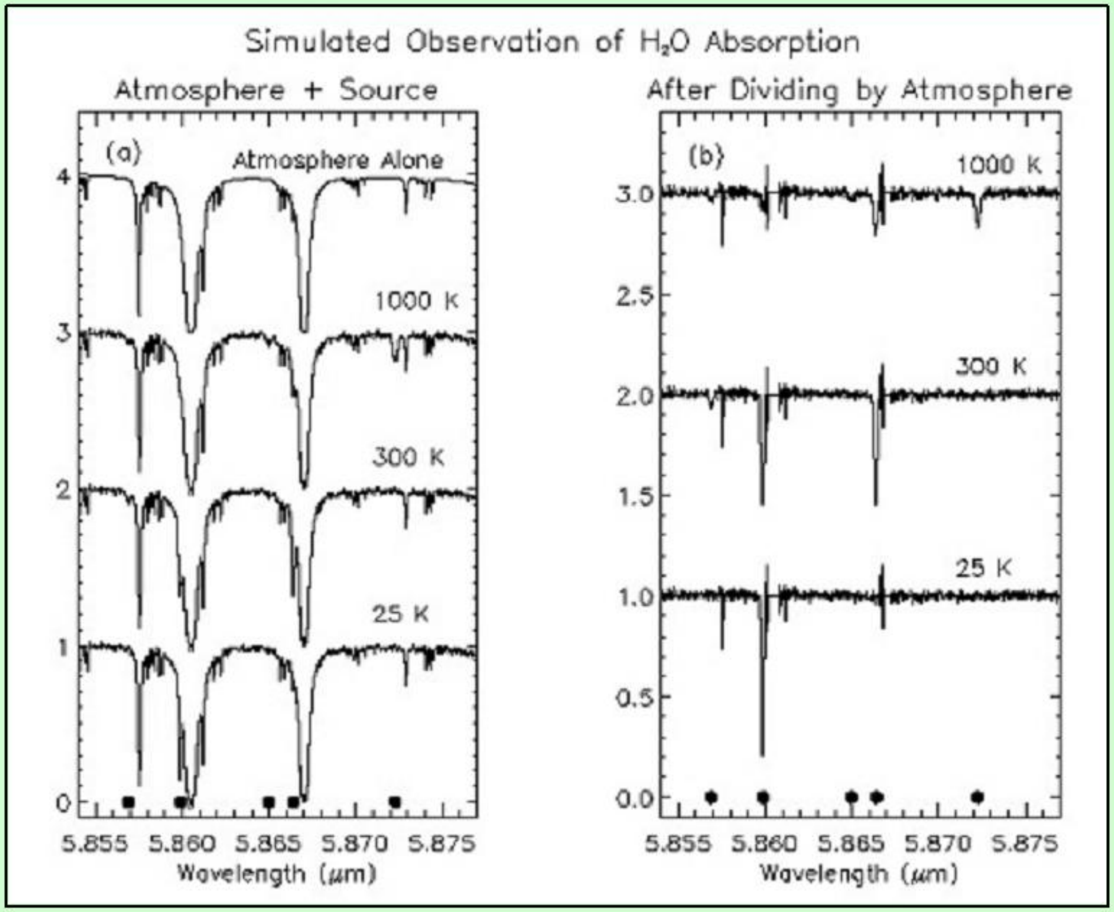


Water Spectroscopy w/*Herschel*

- H218O Orion KL
- Warm outflow gas plus cold line-of-sight absorption



Water with SOFIA

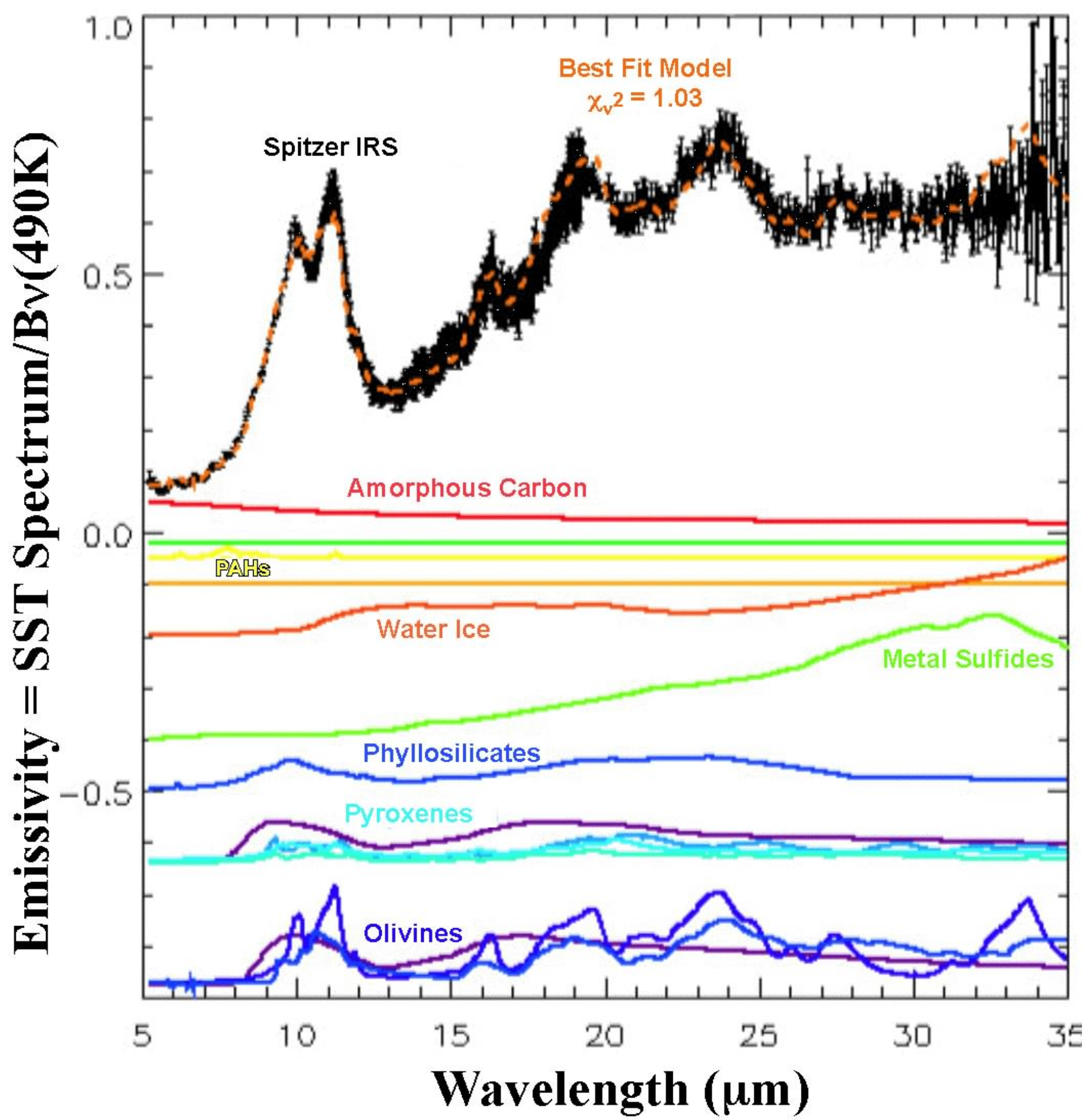


Detecting Water with SOFIA

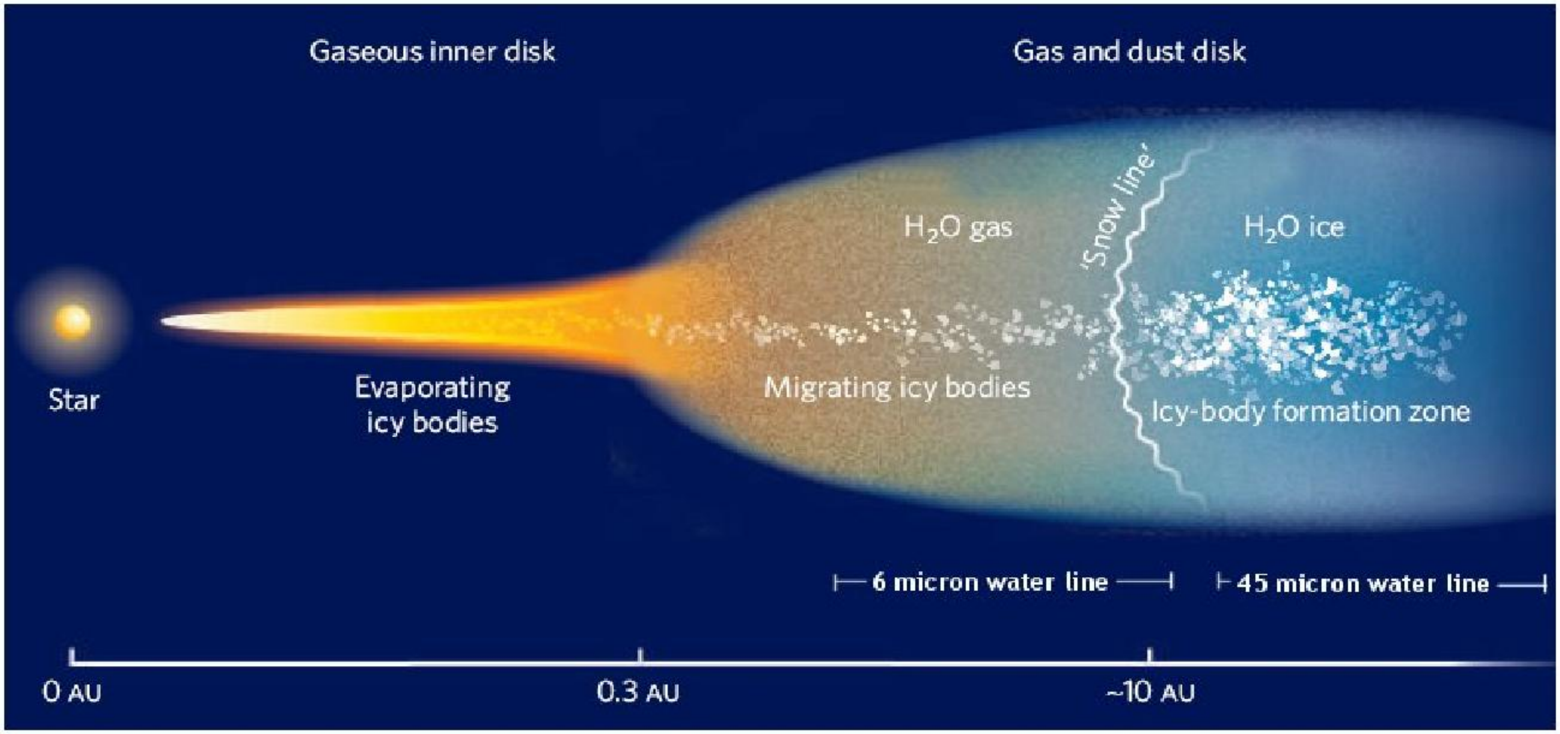
Though SOFIA will fly above 99% of the water vapor in the Earth's atmosphere, there still will be enough telluric water present to require special observations to be employed for studying the 6 μm water features from astronomical sources. (a) The top spectrum is of the atmospheric transmission appropriate for 7 μm of precipitable water and a 45 degree zenith angle. Subsequent curves simulate the addition of water gas absorption from astronomical sources with temperatures of T=1000, 300, and 25 K and $N(H_2O)=10^{18}$ cm^{-2}. The black dots on the bottom of the plot denote the locations of the water lines in the astronomical source. The model assumes that the flight is constructed to create a Doppler shift of -30 km/s between the astronomical and telluric lines. (b) The same spectra after dividing by the atmosphere. The water lines from the astronomical source are clearly resolved. The spectral resolving power used in the simulation was $R=10^5$, and the plots represent the wavelength coverage of a single EXES setting. (From Richter et al. 2000)

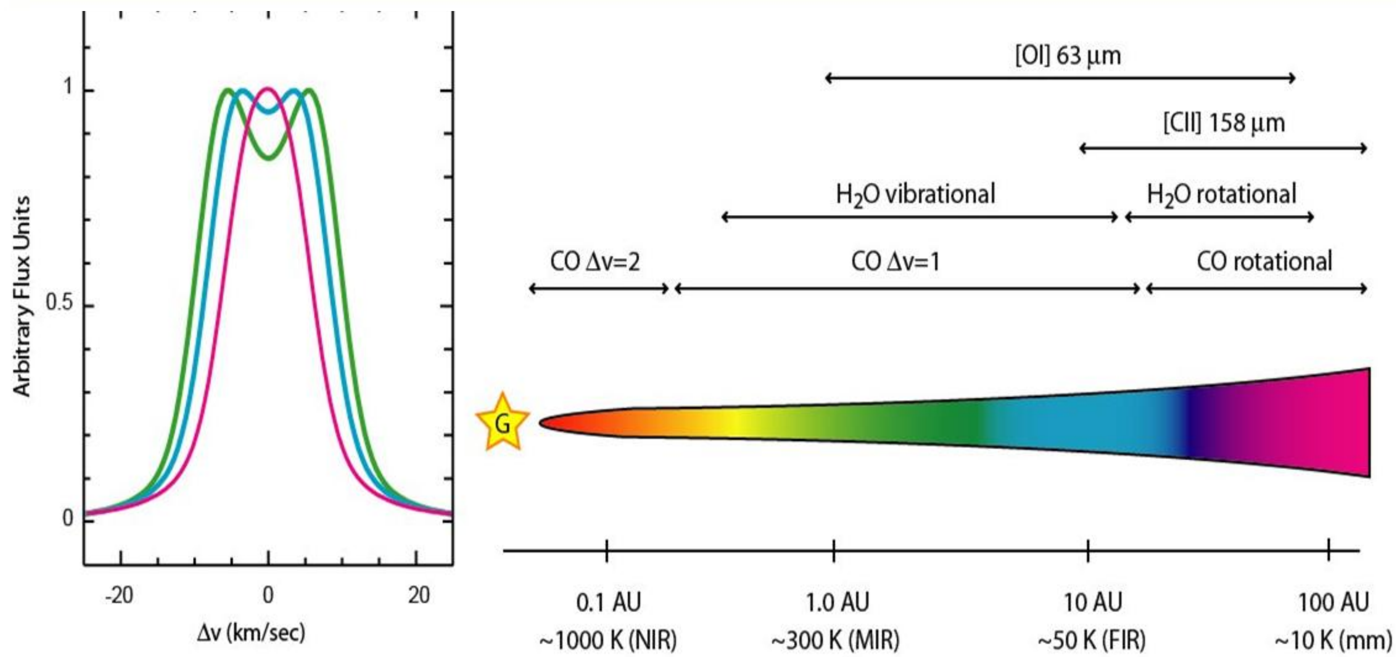
Debris Disks and Comet Dust

- SED
- Filters
- Low-res spectroscop



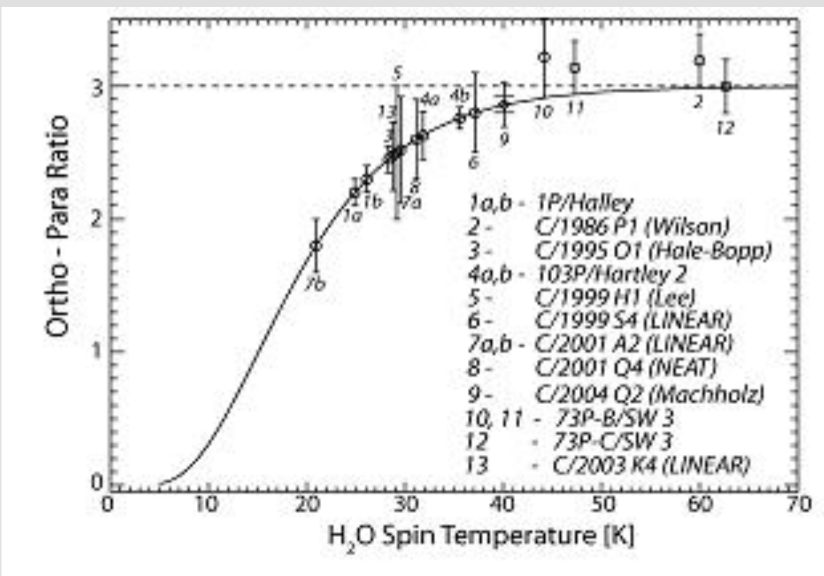
FORCAST, HAWC

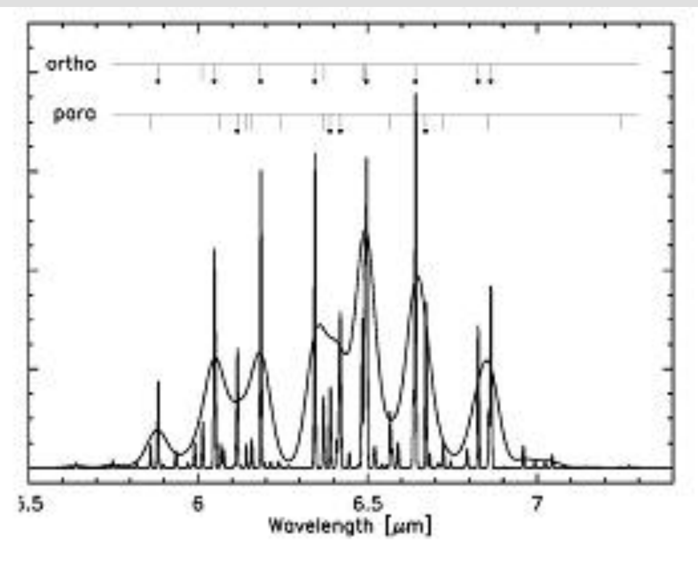

Gaseous inner disk
Gas and dust disk
'Snow line'
H_2O gas
H_2O ice
Star
Evaporating icy bodies
Migrating icy bodies
Icy-body formation zone
6 micron water line
45 micron water line
0 AU
0.3 AU
~10 AU


Arbitrary Flux Units
1
0.5
0
-20
0
20
Δv (km/sec)
[OI] 63 μm
[CII] 158 μm
H_2O vibrational
H_2O rotational
CO Δv=2
CO Δv=1
CO rotational
G
0.1 AU
~1000 K (NIR)
1.0 AU
~300 K (MIR)
10 AU
~50 K (FIR)
100 AU
~10 K (mm)

Cometary gas

- High-res spectra
- Water: ortho/para ratio
- D/H



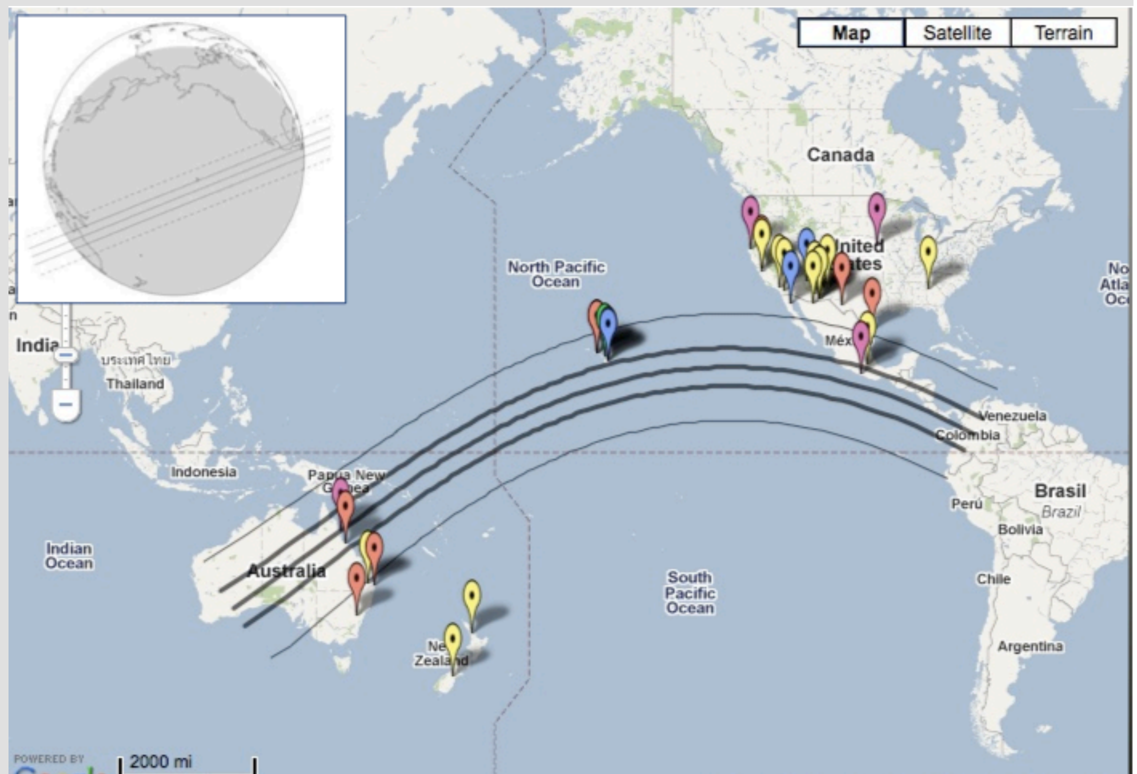


FORCAST grism, EXES

Comet C/2003 K4; Spitzer/IRS; Woodward et al. (2007)

Occultations and transits

- KBOs and Exoplanets using high-speed photometry [talk by Dunham]



Predicted shadow path and observing stations for 20091009 55636 occultation.

HIPO