Dual Satellite Chemistry and Climate Mission Concept From Mars Astrobiology and Climate Observatory (MACO)

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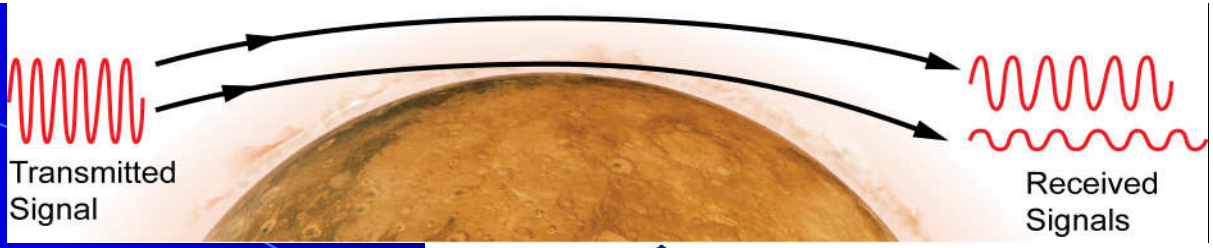
Dual Satellite Mars Chemistry & Climate Mission Concept



Mission concept to characterize

- Trace gas chemistry of Mars
- Water, dust, CO_2 cycles and climate

=> Focused on determining processes

Instrument Suite

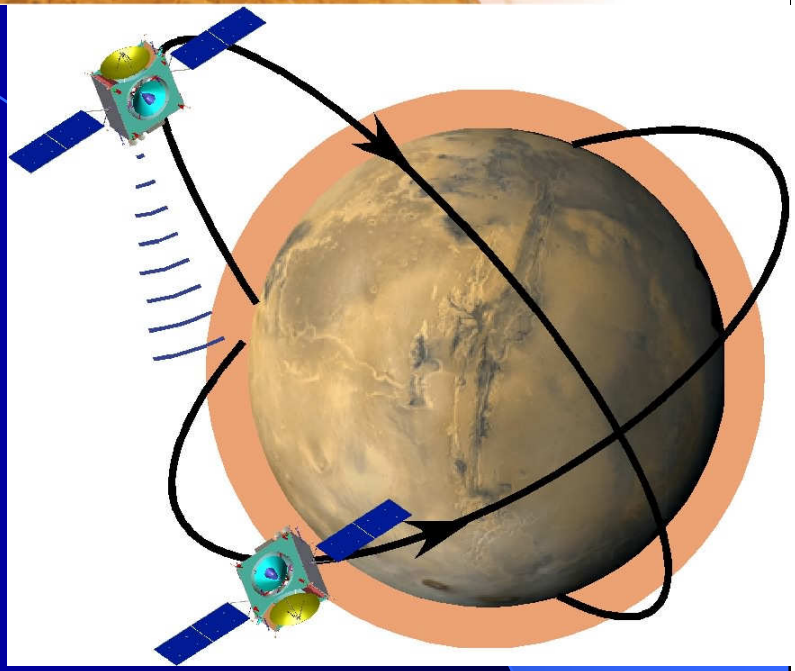
- Solar occultation near-IR spectrometer trace gas
- Millimeter-wave limb sounder
  - Satellite-to-satellite occultations, solar occultations, limb emission
- Thermal IR Ice & Dust sounder co-pointed w/ MMLS

\+ IR & visible aerosol particle size & surface frost

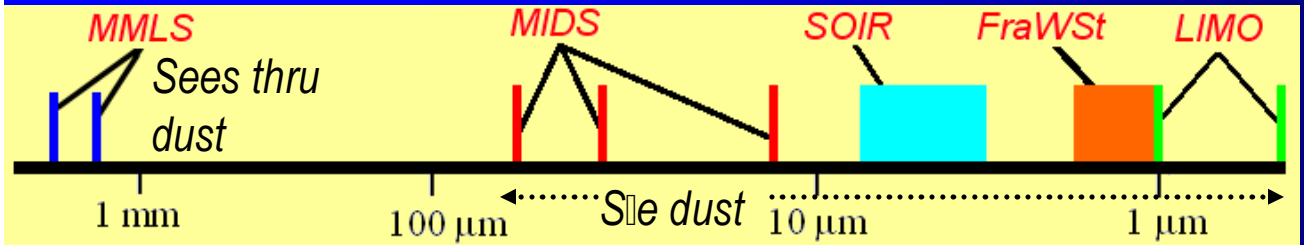
\+ Context imager

Rapidly precessing, high inclination orbits

- Global coverage for solar occultations in ~44 sols
- Full diurnal coverage for MMLS & MIDS in 44 sols

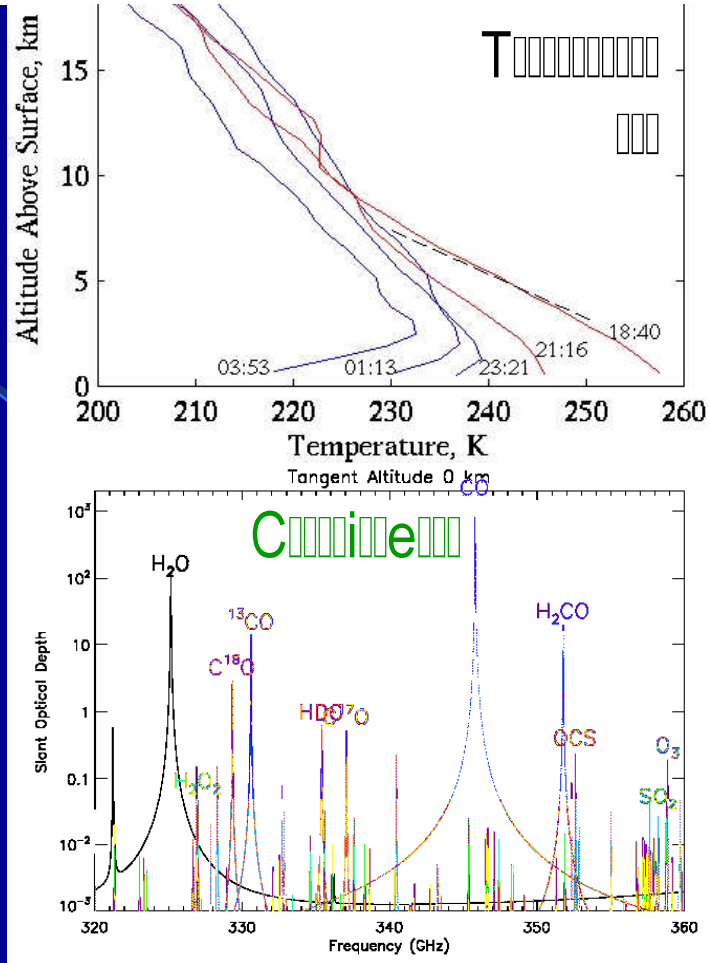


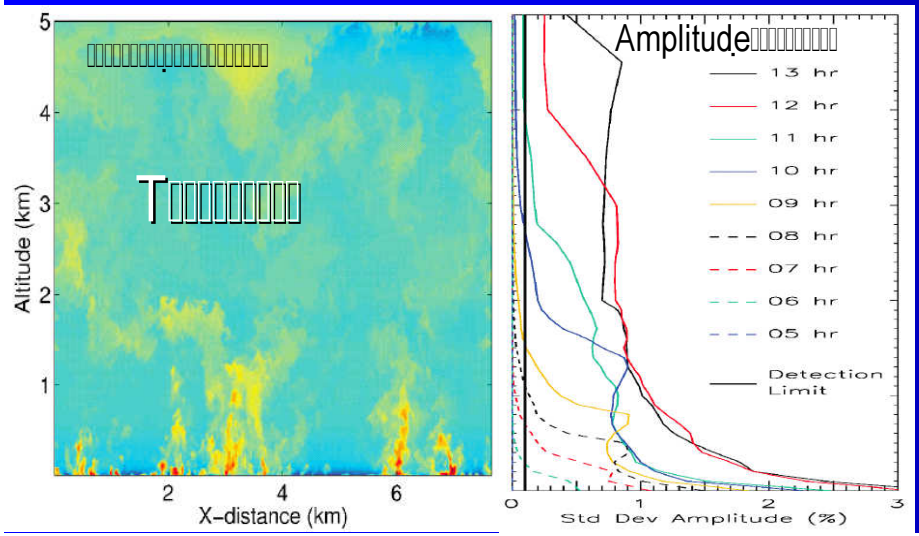
Proposed as Scout in 2006. Received highest science rating but too risky with 2 satellites in Scout budget



Satellite to Satellite Occultations

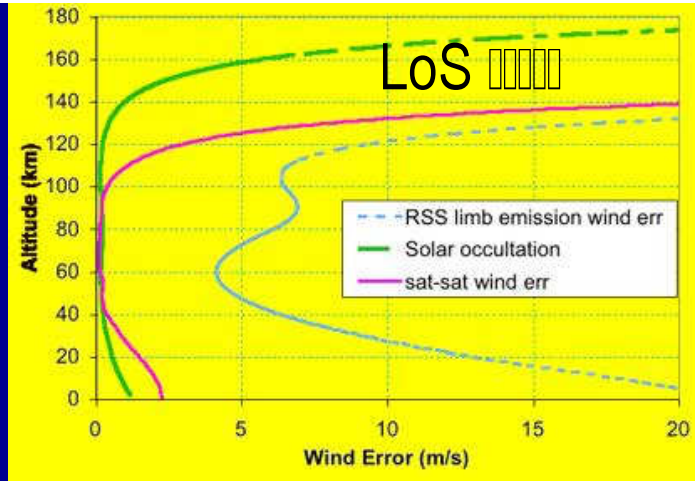
- Vertical resolution 60m at 320-360 GHz (1 mm wavelength)
- Profile to surface, insensitive to dust & surface emissivity
- Temperature <0.5K (0-50km); Pressure 0.1%
- H_2O(0-50 km) concentration & mixing ratio: 1-3%; ***better***
  Relative humidity: 4-6%, ***with***
  HDO(0-20 km) 3%, ***averaging***
- Profile ppb: H_2O_2 5; H_2CO 0.1; O_3 4; SO_2 1; OCS 0.3;
- Winds: LOS from CO,^{13}CO, C^{17}O, C^{18}O <2.5 m/s
  Balanced winds from pressure gradients
- Turbulence via scintillations (twinkling of a star)
- Coverage: Global; Full diurnal coverage in 44 days
  ⇒30,000 ~entry probe quality profiles/Mars year
  ⇒Limb emission 200,000 profiles/yr (between sat-sat occ)
  ⇒Sol. occ. provide spectroscopic calibration





differential absorption

- Brown Univ.



Probing the near surface environment from orbit

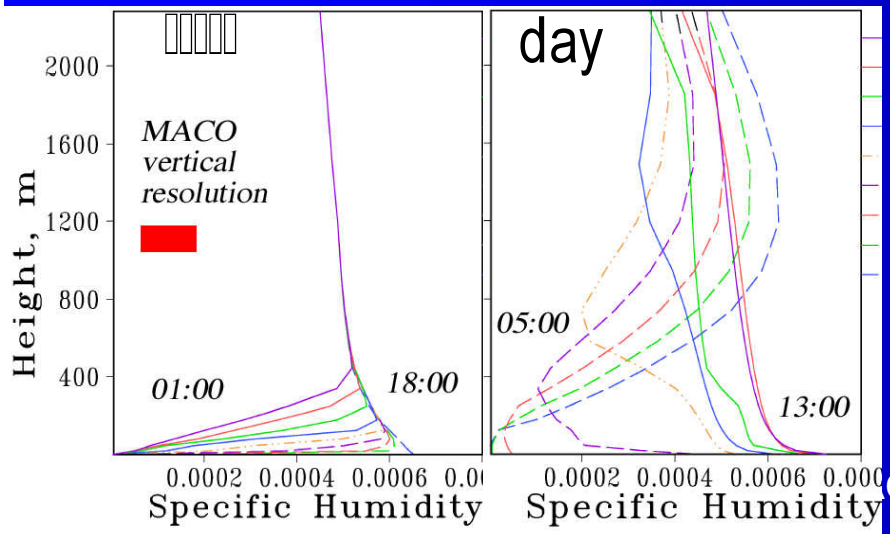
Simultaneously profile mm-wave variables and dust & ice via thermal IR

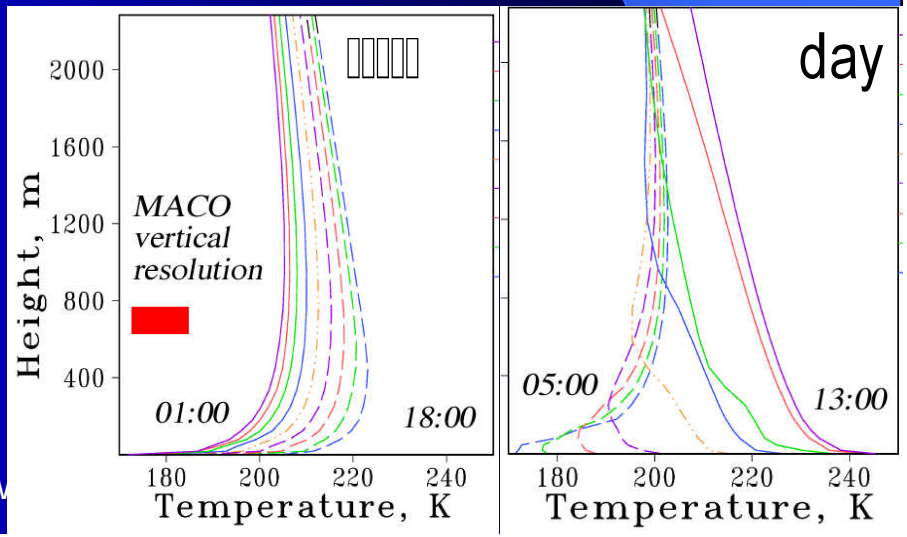
Many science questions are tied to understanding near surface environment

- Water: exchange between surface & atmosphere, ID subsurface reservoirs via D/H ratio, transfer between hemispheres via flux & D/H (lower-upper atmo fractionation processes)
- Dust: lifting, storm trigger events & evolution
- Chemistry: CH_4, O_3, SO_2 distribution, tie plumes to sources, heterogeneous chemistry
- Winds: spatial/temporal distribution of horizontal winds, tracers, lower-upper atmo coupling

Answers: near-surface measurements of constituents & dynamics, global & diurnal coverage

- *Global field campaign*: Build up profiles of regional diurnal sampling ~15 times per year to infer exchange of water vapor exchange and energy between atmosphere and surface
- Orbital periods can be chosen to produce random coverage or repeating pattern such as twice per day at ~20 global locations radiosondes on Earth





Heterogeneous Chemistry

Explanation for rapidly loss of methane & oxidized surface?

- Dissociative electron attachment (DEA) reactions
  - Involves generation of electric fields via saltation and dust lifting followed by ion recombination chemistry

How do we evaluate whether it is true

- Probe near surface environment looking for predicted enhancement in H_2O_2 (~1,000) as a function of dust, winds, turbulence and H_2O (as limiting source molecule)

Solution

- Sat-sat occultations precisely profile H_2O_2, H_2O, winds and turbulence down to surface with ~100 m vertical resolution, independent of dust, full diurnal coverage
- Co-pointed MIDS profiles dust with 2 km vert. res.
- Look into the dusty areas, measure H_2O_2 enhancement and determine how important heterogeneous chemistry is and how it works