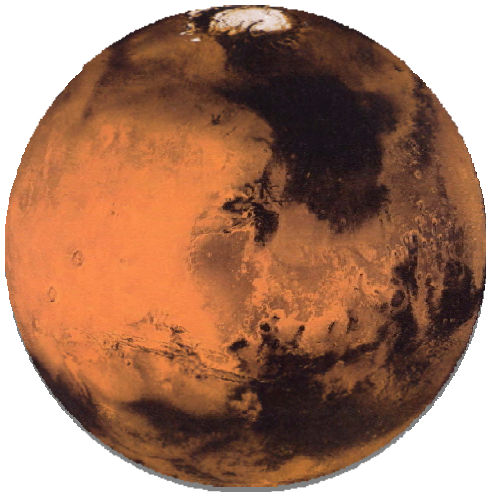
National Aeronautics and Space Administration



Thermodynamic Equilibrium and Photochemical Calculations of Methane on Mars for a Wide Range of Atmospheric Parameters

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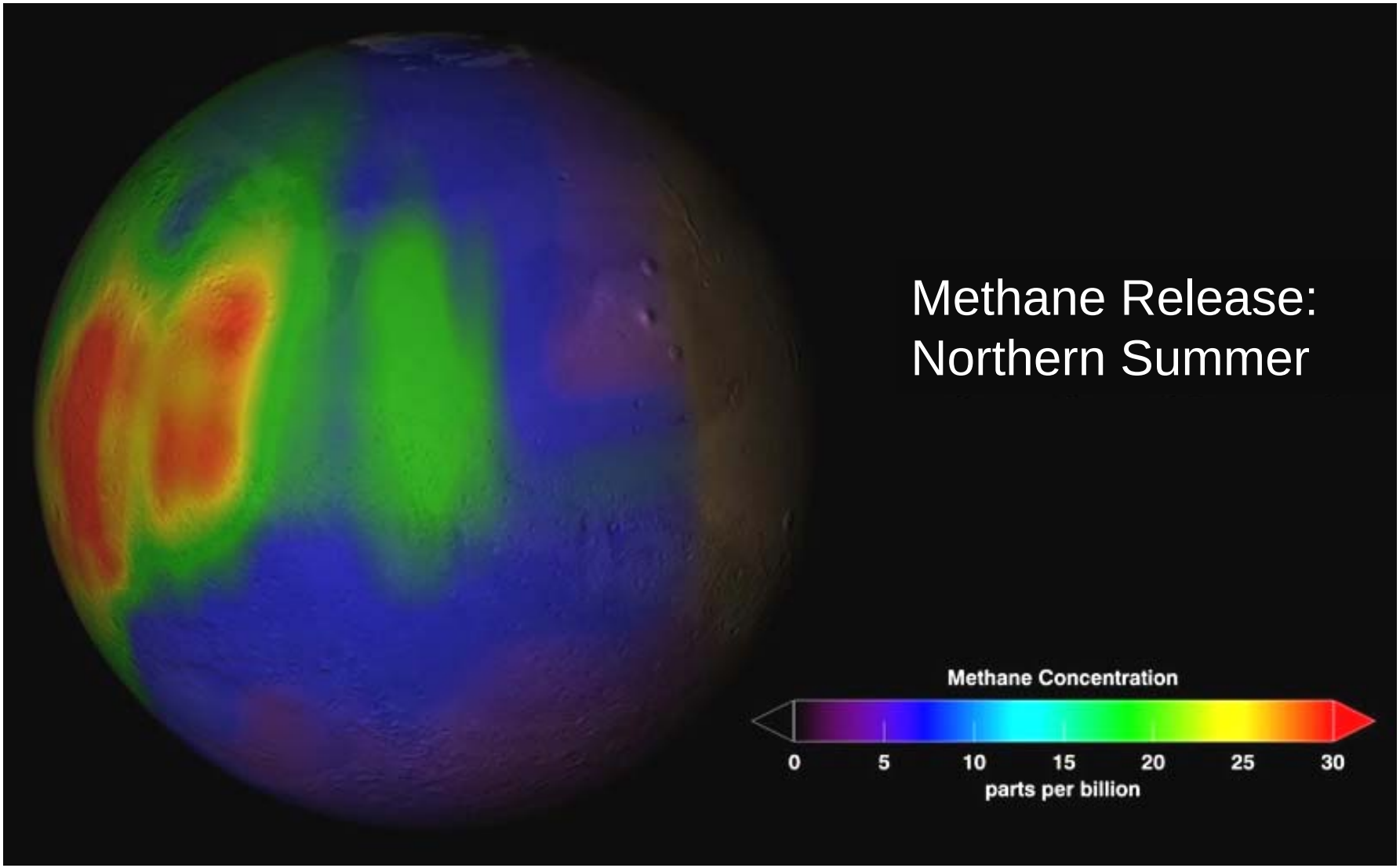
Outline

- Methane on Earth and Mars: Thermodynamic Equilibrium Calculations
- Photochemical Calculations of Methane
- Measurements of Atmospheric Methane with a Mars Aerial Platform

Methane in the Atmosphere of Mars (Mumma et al, 2009)

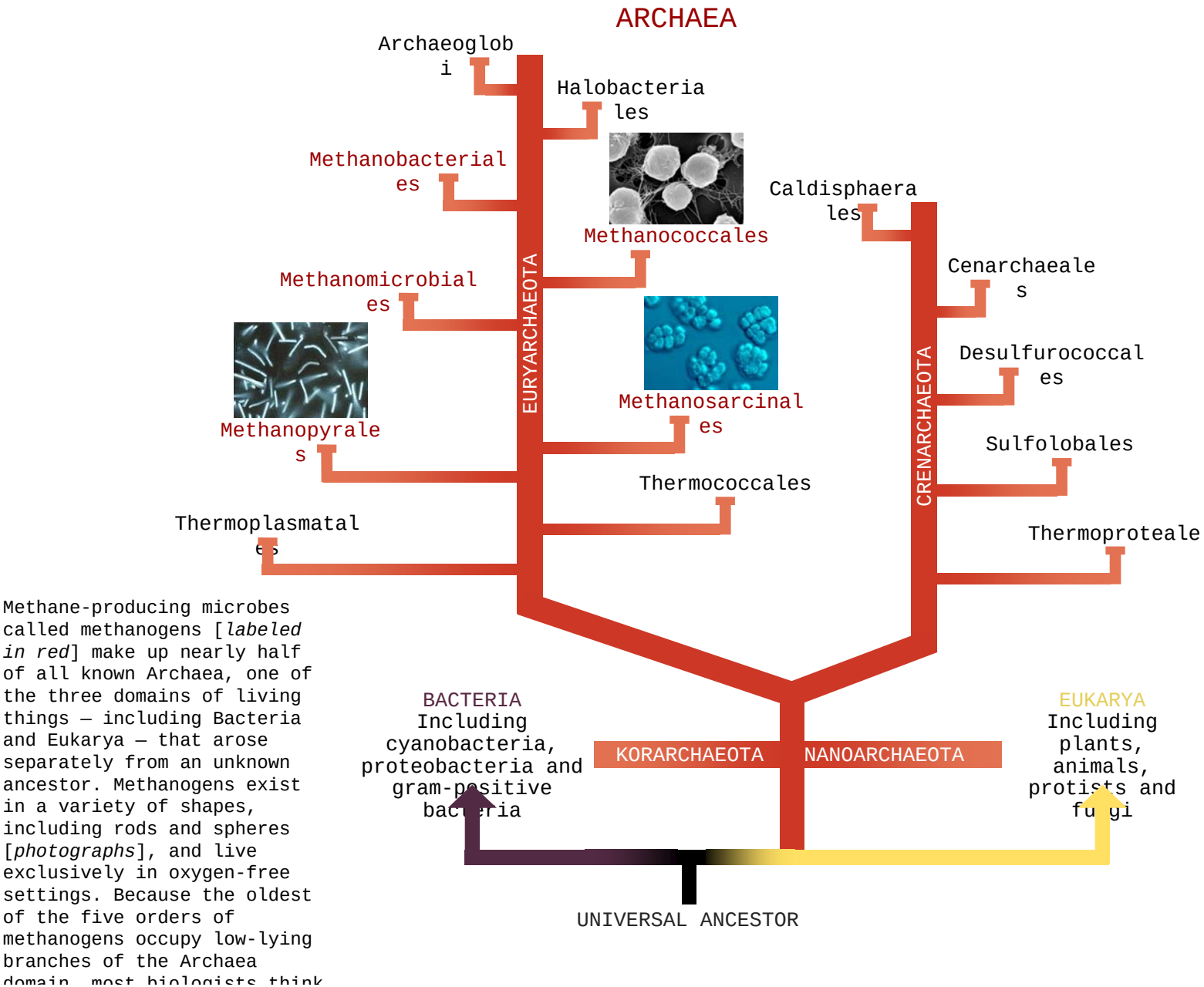


Calculated Trace Gases in the Atmosphere of Earth Based on Thermodynamic Equilibrium Calculations

Results of Thermodynamic Equilibrium Calculations

Gas	Thermodynamic Equilibrium Concentration (Mole Fraction)	Measured Concentration (Mole Fraction)	Atmospheric Enhancement
Methane (CH_4)	10^{-145}	1.7×10^{-6}	10^{139}
Ammonia (NH_3)	2×10^{-60}	10^{-10}	10^{50}
Nitrous oxide (N_2O)	2×10^{-19}	3×10^{-7}	10^{12}

Why There Is Methane in the Earth's Atmosphere!



Methane-producing microbes called methanogens [*labeled in red*] make up nearly half of all known Archaea, one of the three domains of living things – including Bacteria and Eukarya – that arose separately from an unknown ancestor. Methanogens exist in a variety of shapes, including rods and spheres [*photographs*], and live exclusively in oxygen-free settings. Because the oldest of the five orders of methanogens occupy low-lying branches of the Archaea domain, most biologists think

The Composition of the Mars Atmosphere

Assumed Composition of the Atmosphere of Mars:

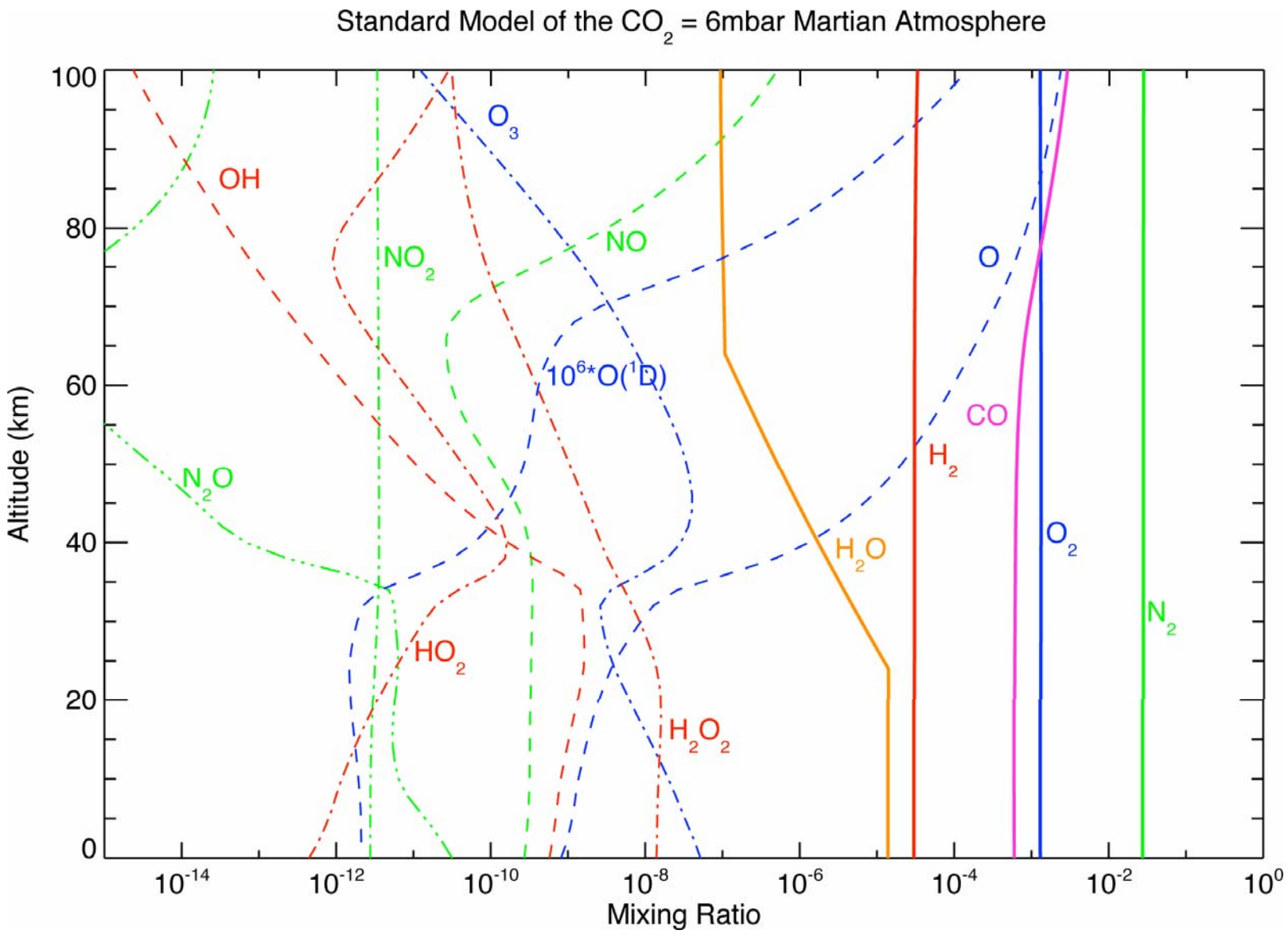
- Carbon dioxide (CO_2): 95.32%
- Nitrogen (N_2): 2.7%
- Argon (Ar): 1.6%
- Oxygen (O_2): 0.13%
- Carbon monoxide (CO): 0.07%
- Water vapor (H_2O): 10 ppmv at surface
- Mean atmospheric surface pressure: 6.4 mb
- Surface temperature range from
  148K (polar winter) to 290K (southern summer)

Calculated Trace Gases in the Atmosphere of Mars Based on Thermodynamic Equilibrium Calculations

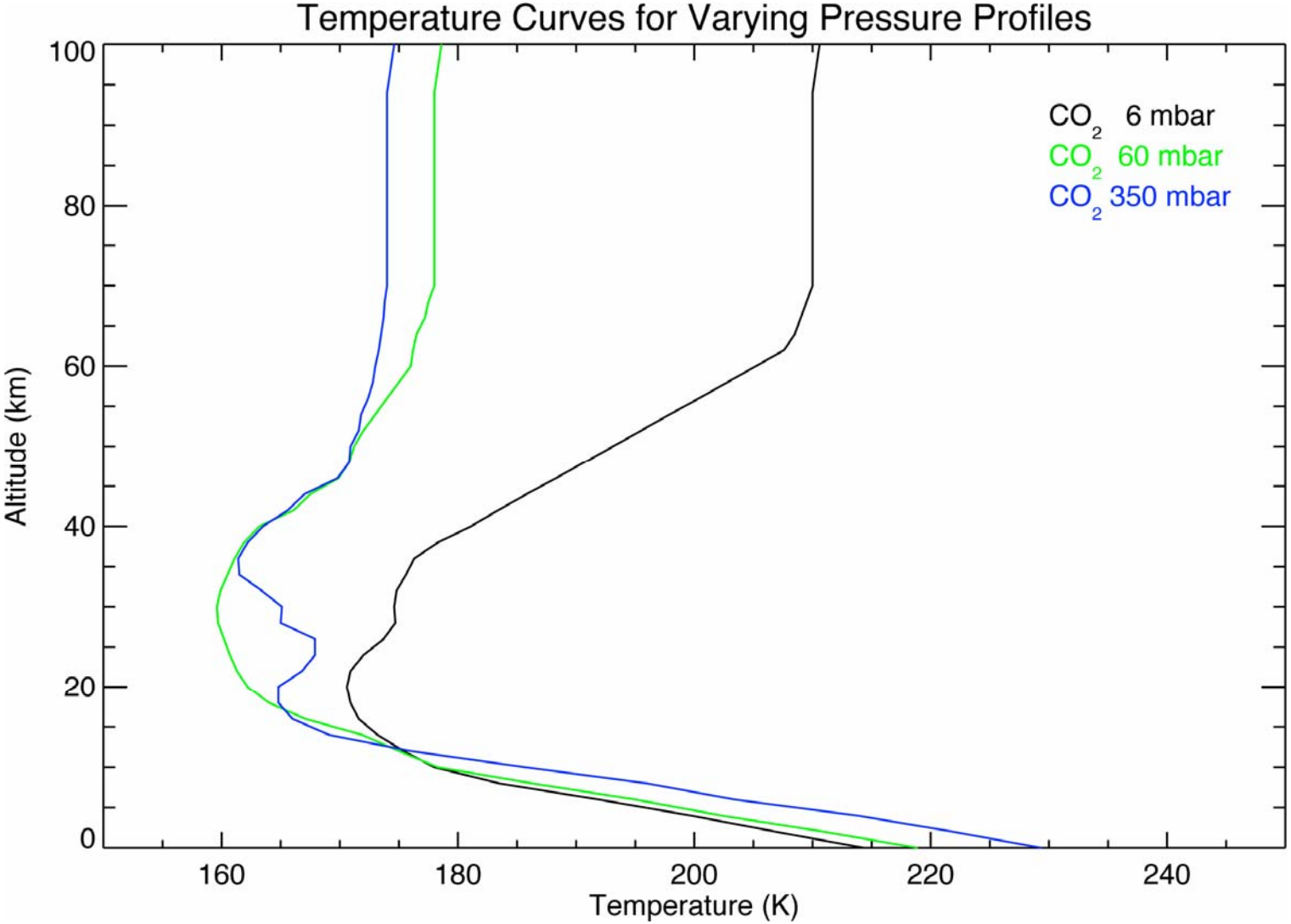
Results of Thermodynamic Equilibrium Calculations

Gas	T = 100K	T = 200K	T = 300K
Methane (CH_4)	$<10^{-100}$	$<10^{-100}$	$<10^{-100}$
Ammonia (NH_3)	$<10^{-100}$	2×10^{-89}	4×10^{-62}
Nitrous oxide (N_2O)	6×10^{-54}	4×10^{-30}	5×10^{-23}

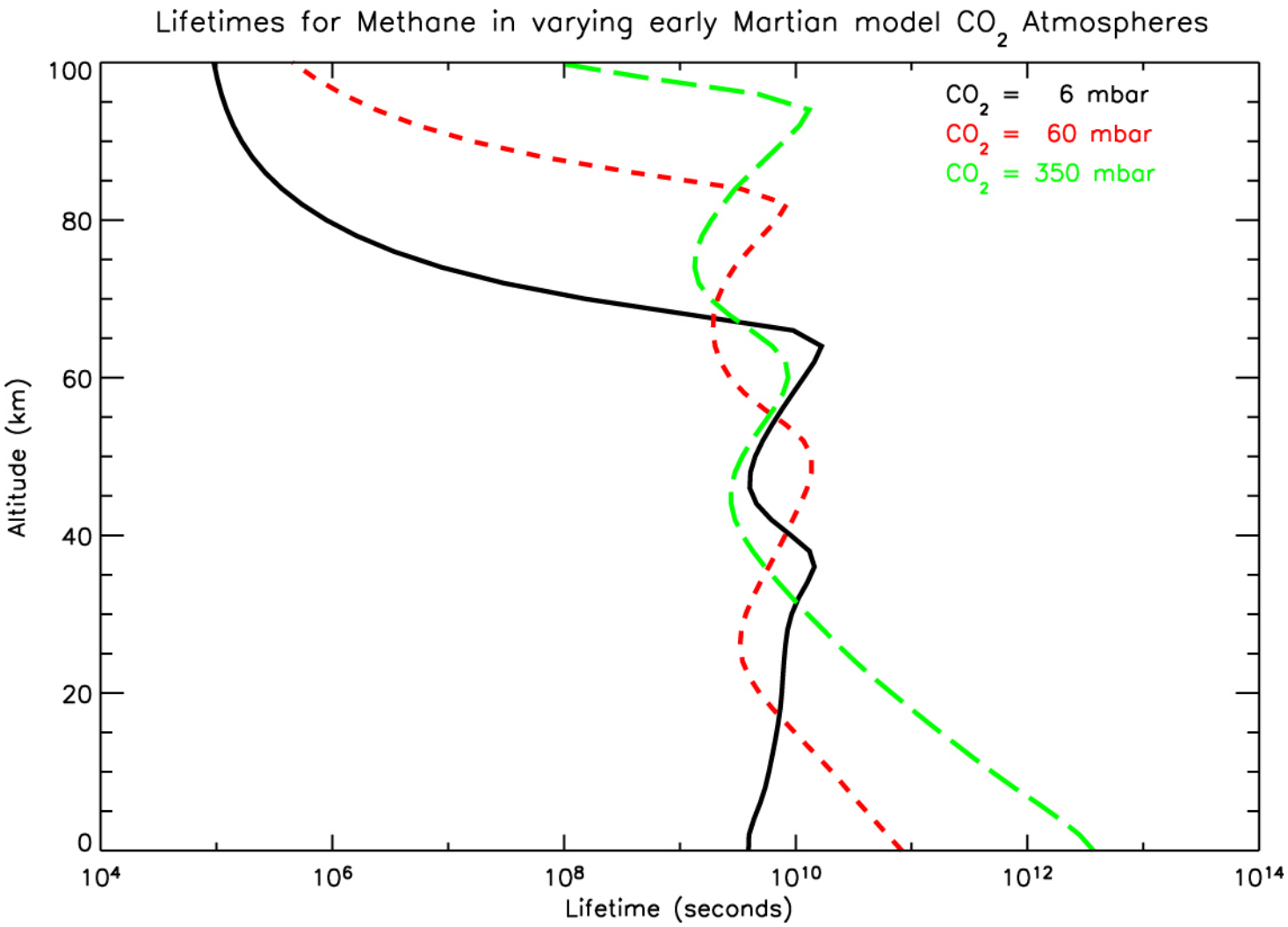
Model for 6 mbar Atmosphere



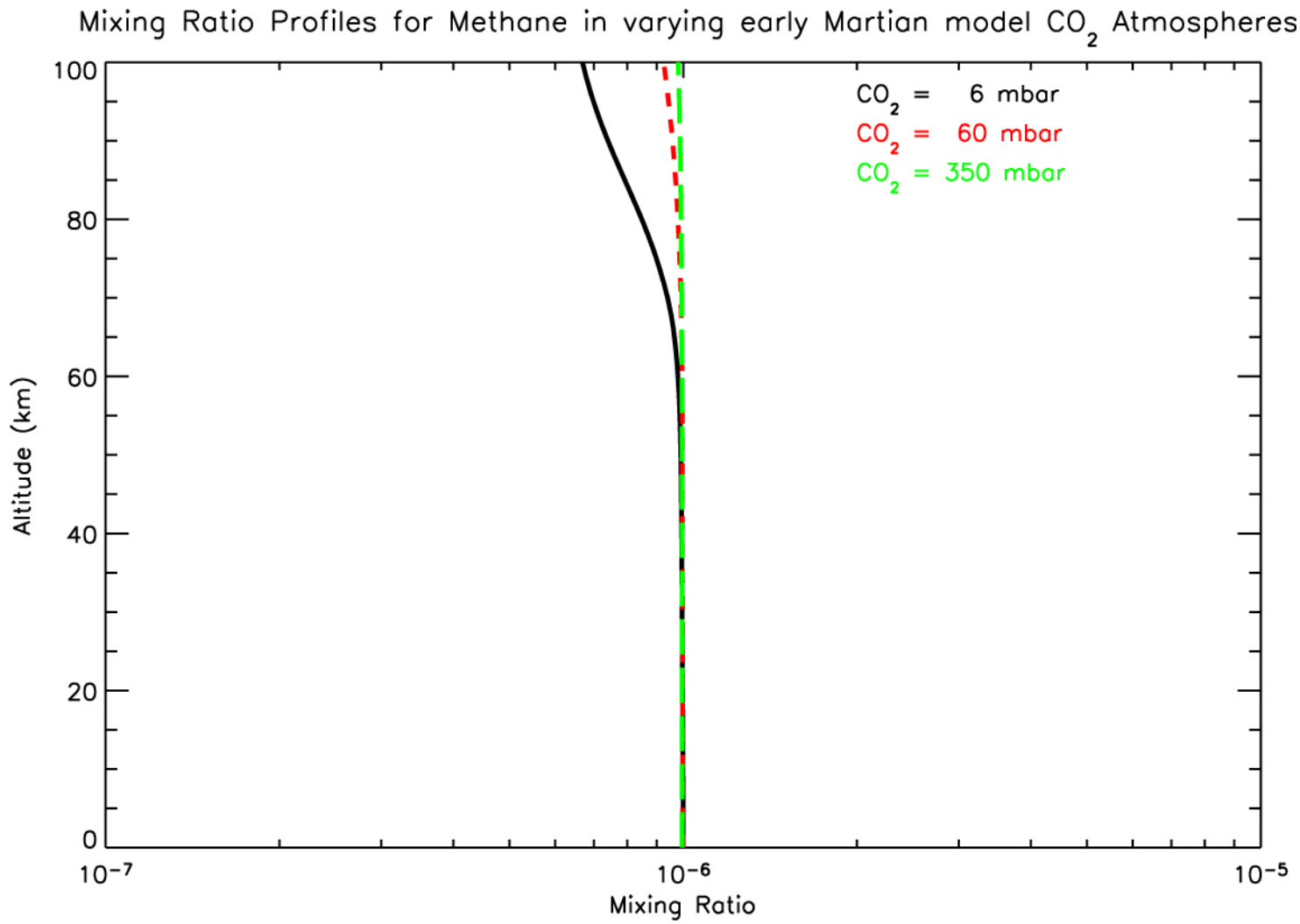
Three Model Atmosphere Cases (after Kasting, 1991)



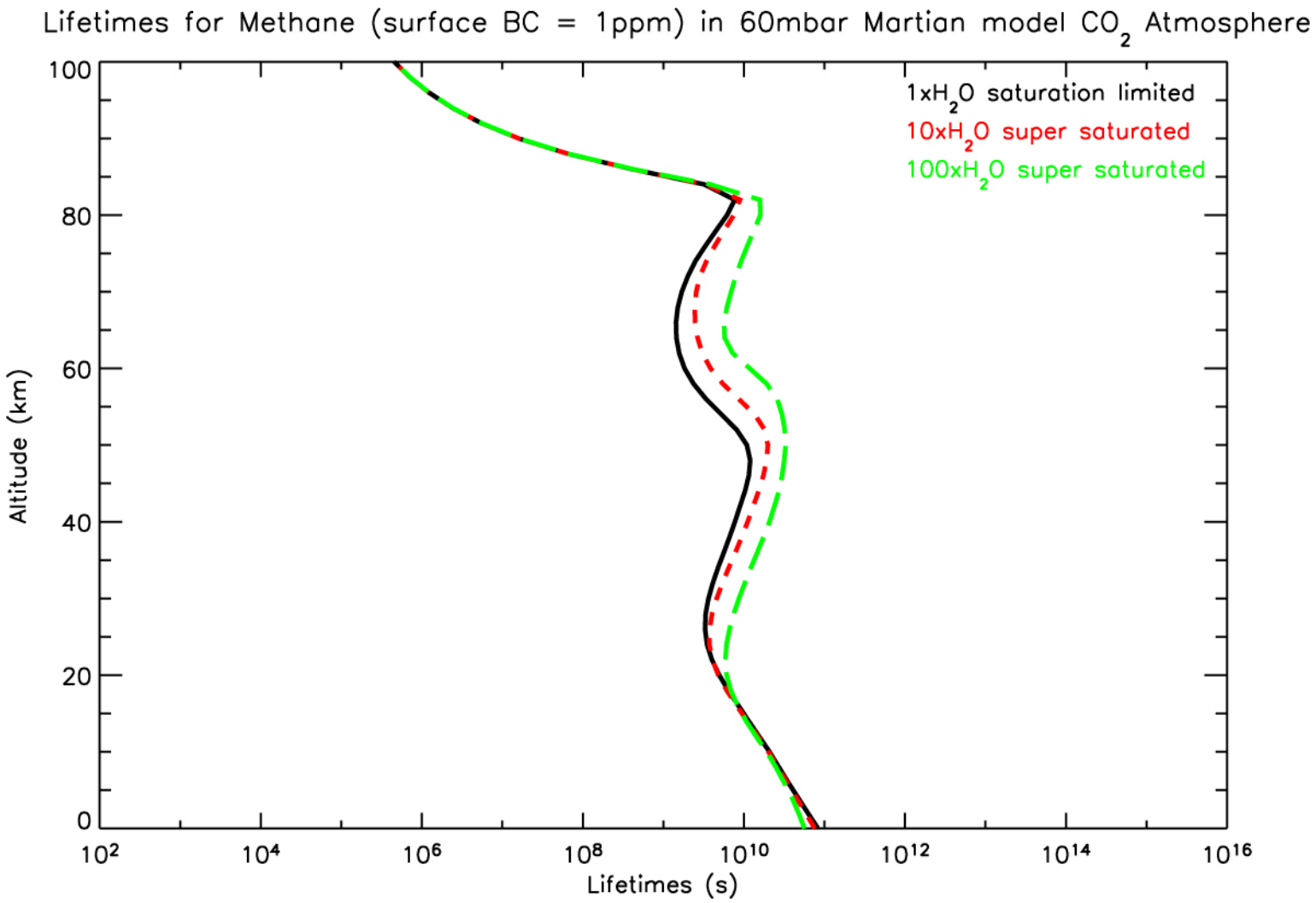
Atmospheric Lifetime of Methane for Varying CO_2 Concentrations



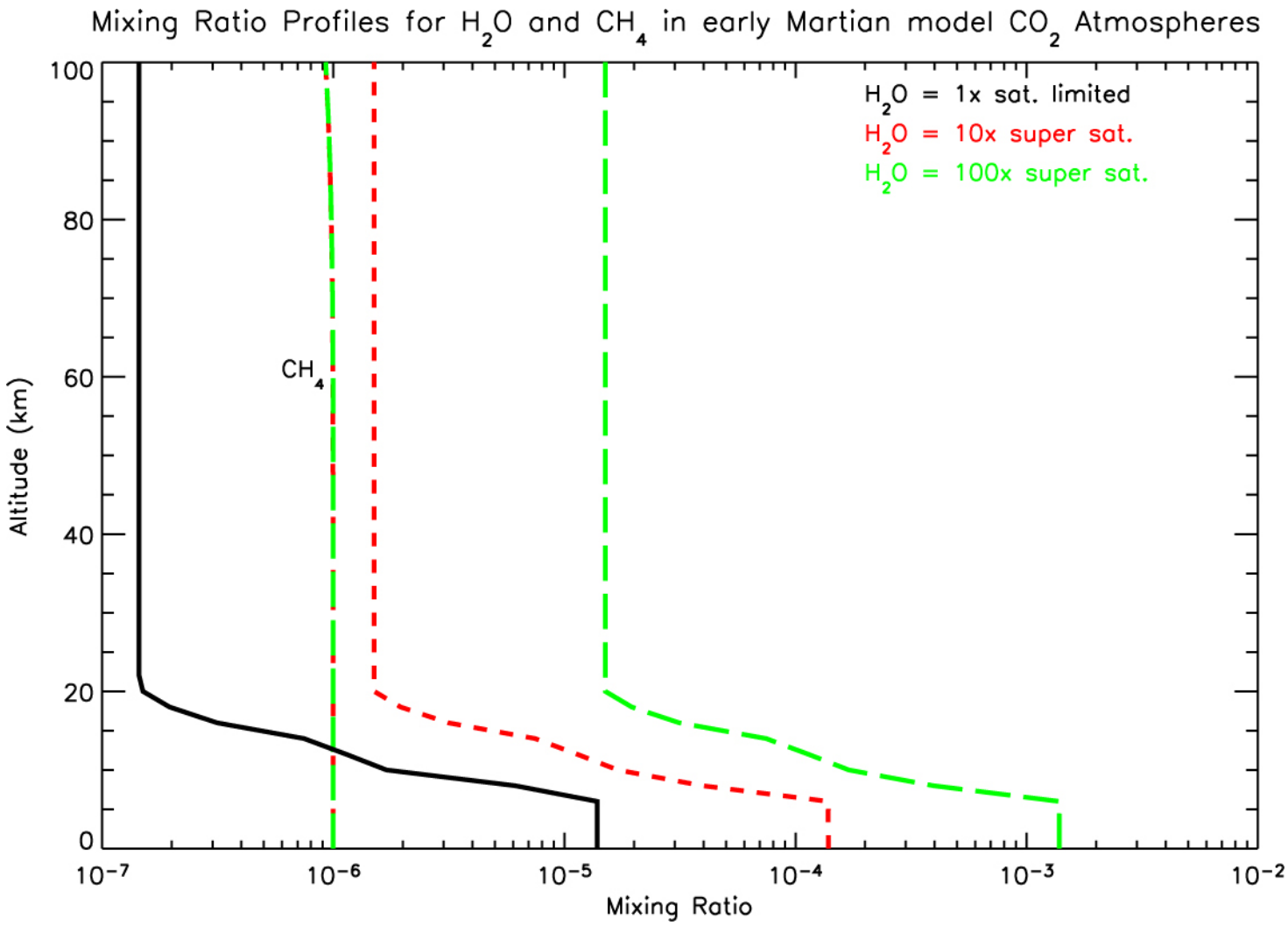
Vertical Distribution of Methane for Varying CO_2 Concentrations



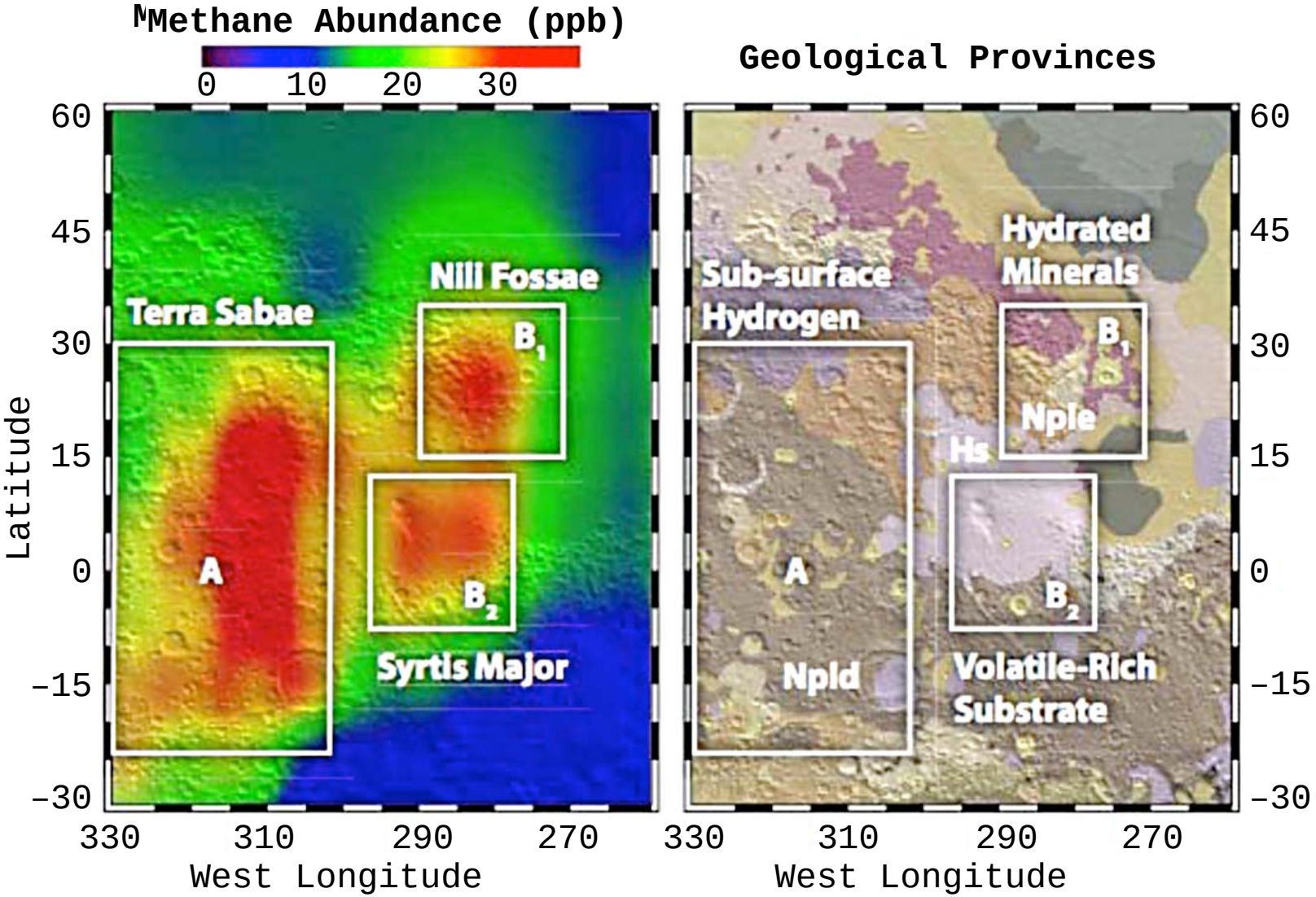
Lifetime of Methane (Surface BC = 1ppm) in 60 mbar Martian CO_2 Atmosphere



Mixing Ratio Profiles for H_2O and CH_4 in Early Martian Model CO_2 Atmospheres

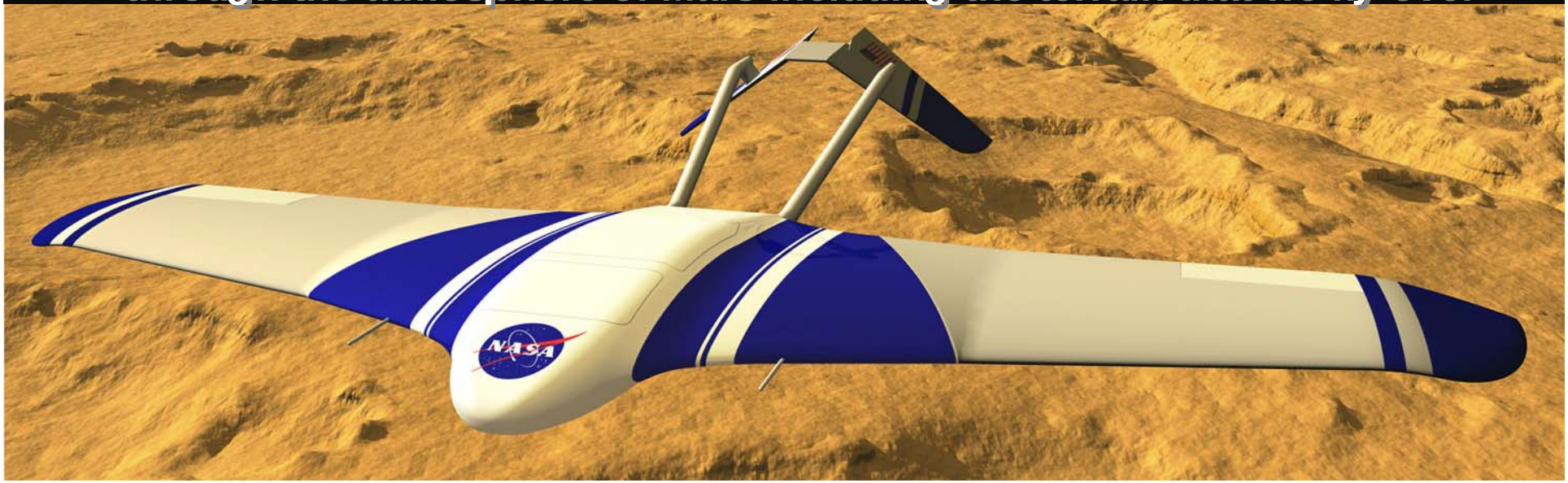


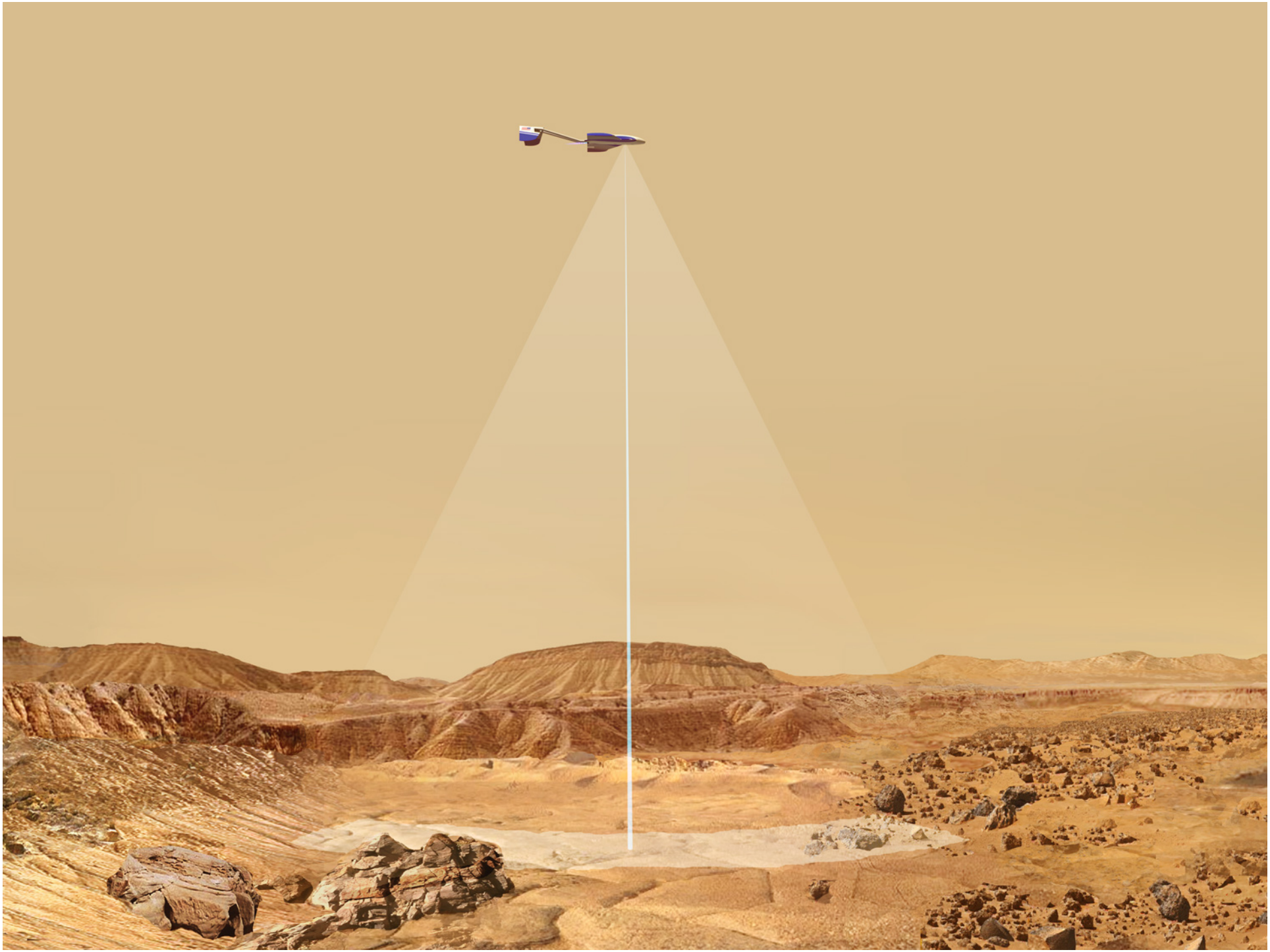
Methane in the Atmosphere of Mars (Mumma et al, 2009)



ARES, a Robotic, Rocket-Powered Airplane

- **Flies about 1 mile above surface of Mars and covers 100s of miles at a speed of about 450 miles per hour**
- **Pre-programmed traverse (pattern can be modified after launch)**
- **Instrument payload includes a mass spectrometer to measure methane, magnetometers to measure surface magnetism and a neutron spectrometer to measure subsurface water, all with high spatial resolution**
- **Downward-viewing and forward-viewing cameras record the flight through the atmosphere of Mars including the terrain that we fly over**





Dilution of Point Source Gas Concentration Due Solely to Atmospheric Diffusion

- For t = 1 hour:

  dilution from point source:

  10^{-4} to 10^{-5} at a distance of 50 km away

- For t = 1 year:

  dilution from point source: 10^{-8}

Reference: Wong et al., 2003