Minor Constituents of Mars Atmosphere

Vladimir Krasnopolsky

- Martian atmosphere consists of CO2 and its products, H2O and its products, N2 and noble gases
- Complicated seasonal variations induced by obliquity of 24o and the elliptic orbit result in a great variety of conditions from T = 145 K at the winter polar regions to 300 K at low latitudes near perihelion

- CO_2 and products: CO, O_2, $O_2(1\Delta g)$, O_3, O

- CO: observations ~1000 ppm, models ~120 ppm
  CO production: CO_2 + hv (7x1011 cm-2 s-1)
  CO loss: $CO + OH \rightarrow CO_2 + H$, $k = 1.5 \times 10^{-13}$

- Variations of CO and O_2 are induced by condensation and sublimation of CO_2 in the polar and subpolar regions

- $O_2(1\Delta g)$: product of O_3 photolysis, dayglow at 1.27 μm, tracer of photochemistry, polar nightglow, nightglow at low latitudes(?)

H2O and products: H, H2, H2O2, OH, HO2

- H2O vertical profiles (continuation of SPICAM-IR)

- H2O2 abundances are diagnostics of variations of odd hydrogen chemistry on Mars
- Ground-based TEXES observations (8 μm):
  0-40 ppb (Encrenaz et al. 2012), within model predictions (Lefevre et al. 2008, Krasnopolsky 2009)

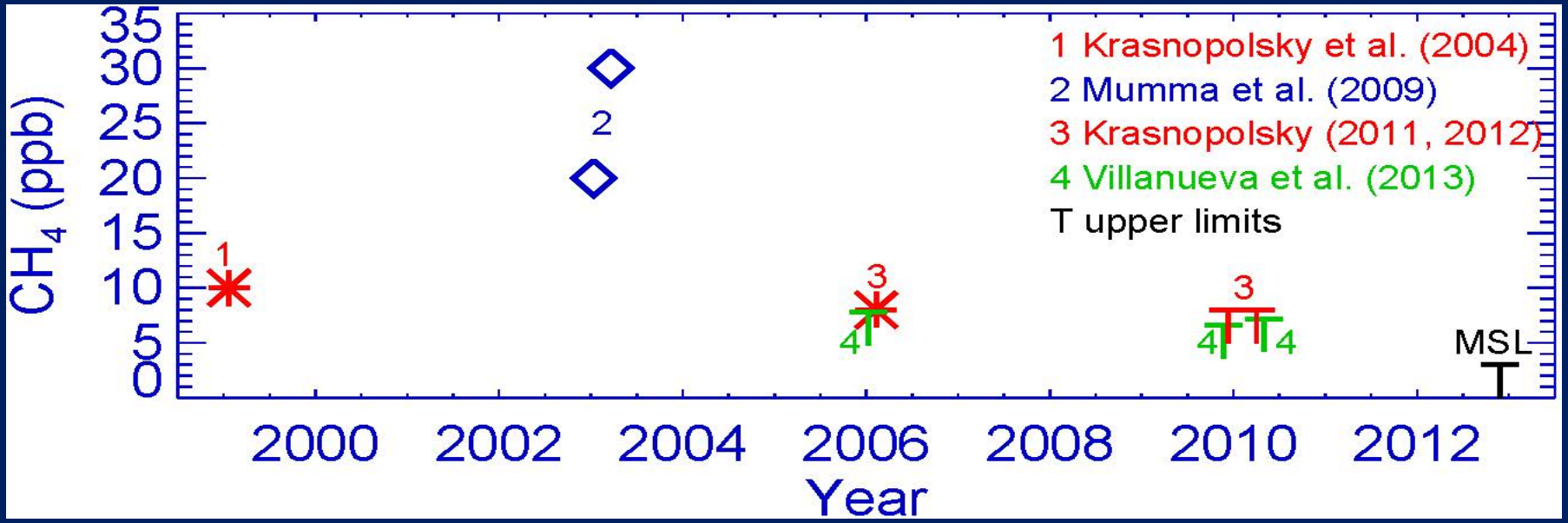
- N2, Ar, He, Ne, Kr, Xe : unmeasurable

- NO ≈ 0.3 ppb (models); less than 1.7 ppb (5.3 μm, TEXES, Kr2006); TIRVIM?

- NO2 ≈ 0.1 ppb (models); less than 10 ppb (M9, 6 μm, Maguire 1977); TIRVIM? 3.45 μm MIR?

- N2O ≈ 1 ppt (model); <100 ppb (M9, 8 μm, M77), <70 ppb (NIRSPEC, 3 μm, Villanueva13)

Ground-based and MSL observations of methane on Mars



MSL observations of methane neither contradict nor support the ground-based observations

C2H6 < 0.2 ppb (3.3 μm, Kr2012, V2013)

C2H6 >> other hydrocarbons (expected)

Other important species

- $SO_2 < 0.3$ ppb (TEXES, 8 μm, Encrenaz et al. 2011, Krasnopolsky 2012)

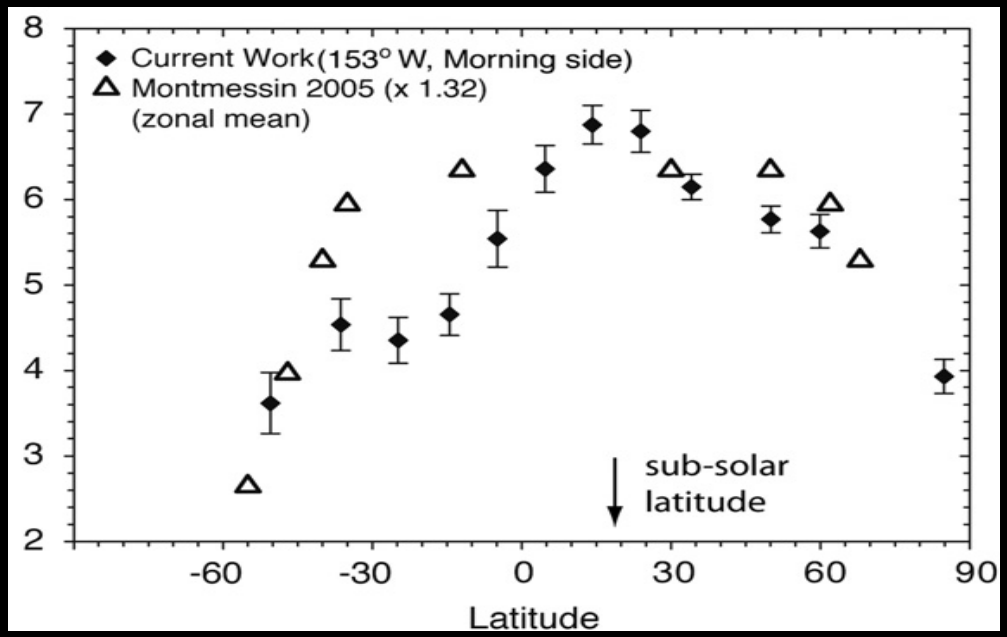
  Martian outgassing is smaller than that on Earth by a factor of more than 2000

- HCl < 0.2 ppb (Herschel, Hartogh et al. 2010); problem of perchlorates

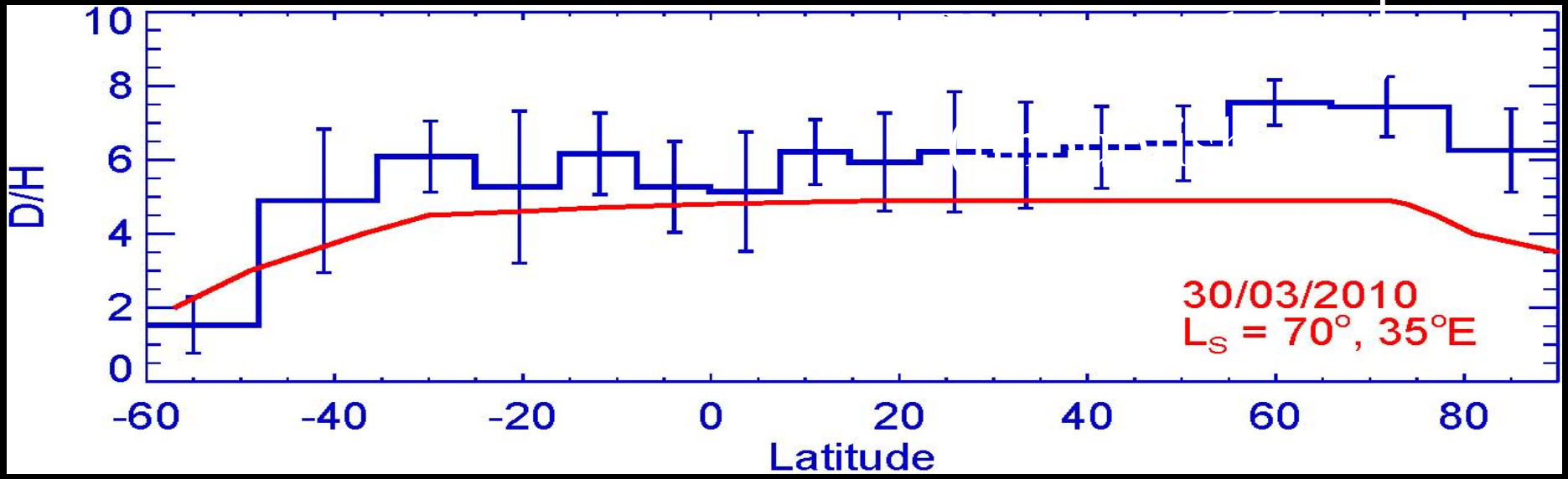
- $H_2CO < 2$ ppb (3.6 μm, Krasnopolsky et al. 1997)

  The most abundant product of methane oxidation

HDO/H2O observations and model



← LS = 50o, Novak et al. (2011)



13C/12C in methane

- If δ13C < -6% then methane is of biologic origin, otherwise it is geological.

- Required uncertainty is ~1%, 13CH4 is less abundant than 12CH4 by a factor of ~100, and measurements of 13C/12C require an increase in sensitivity by three orders of magnitude or more