“Should we believe Atmospheric Temperatures…” or Unusual atmospheric temperatures from Mars Pathfinder

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Entry Probes Workshop
2004.08.23 NASA Ames

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Unusual Temperature Inversion prior to Parachute Deployment

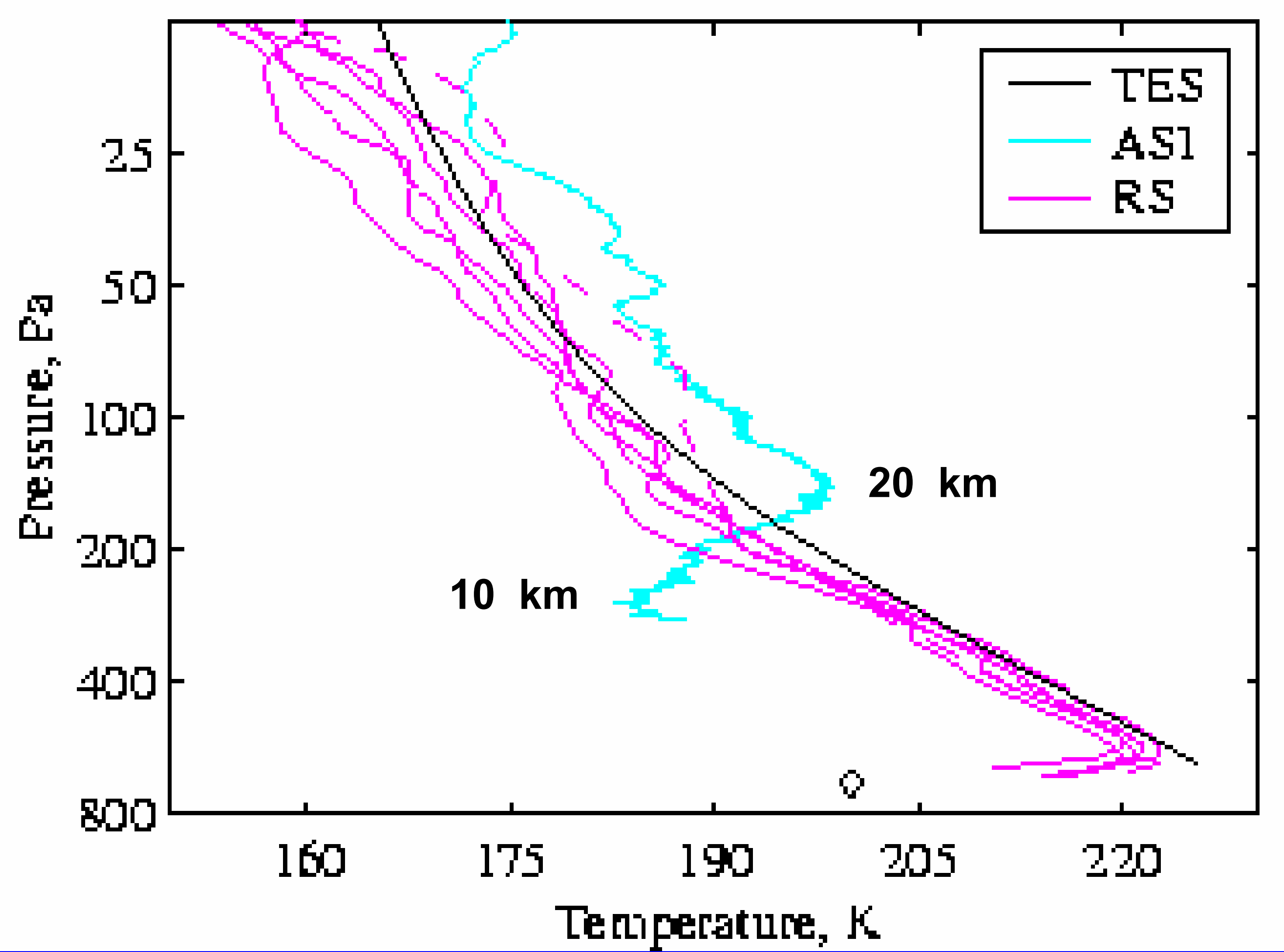
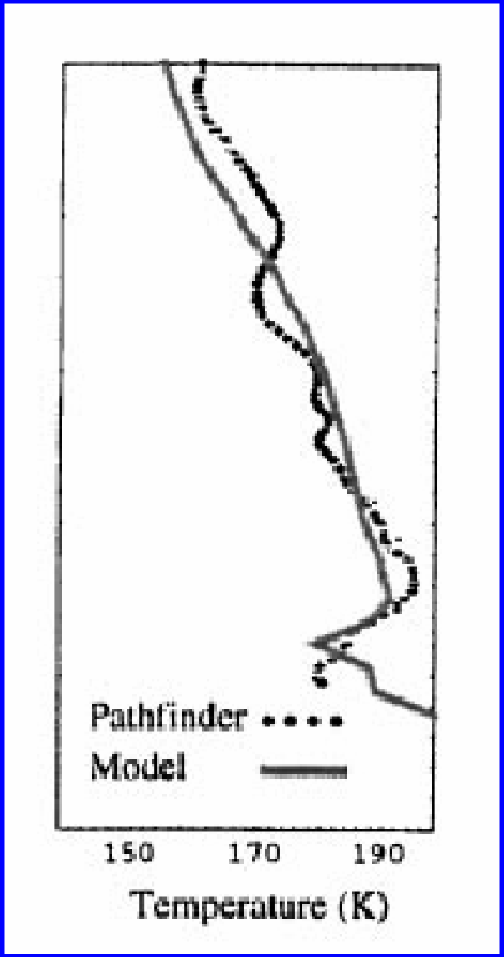


Figure from John Wilson

Is it a real T inversion?

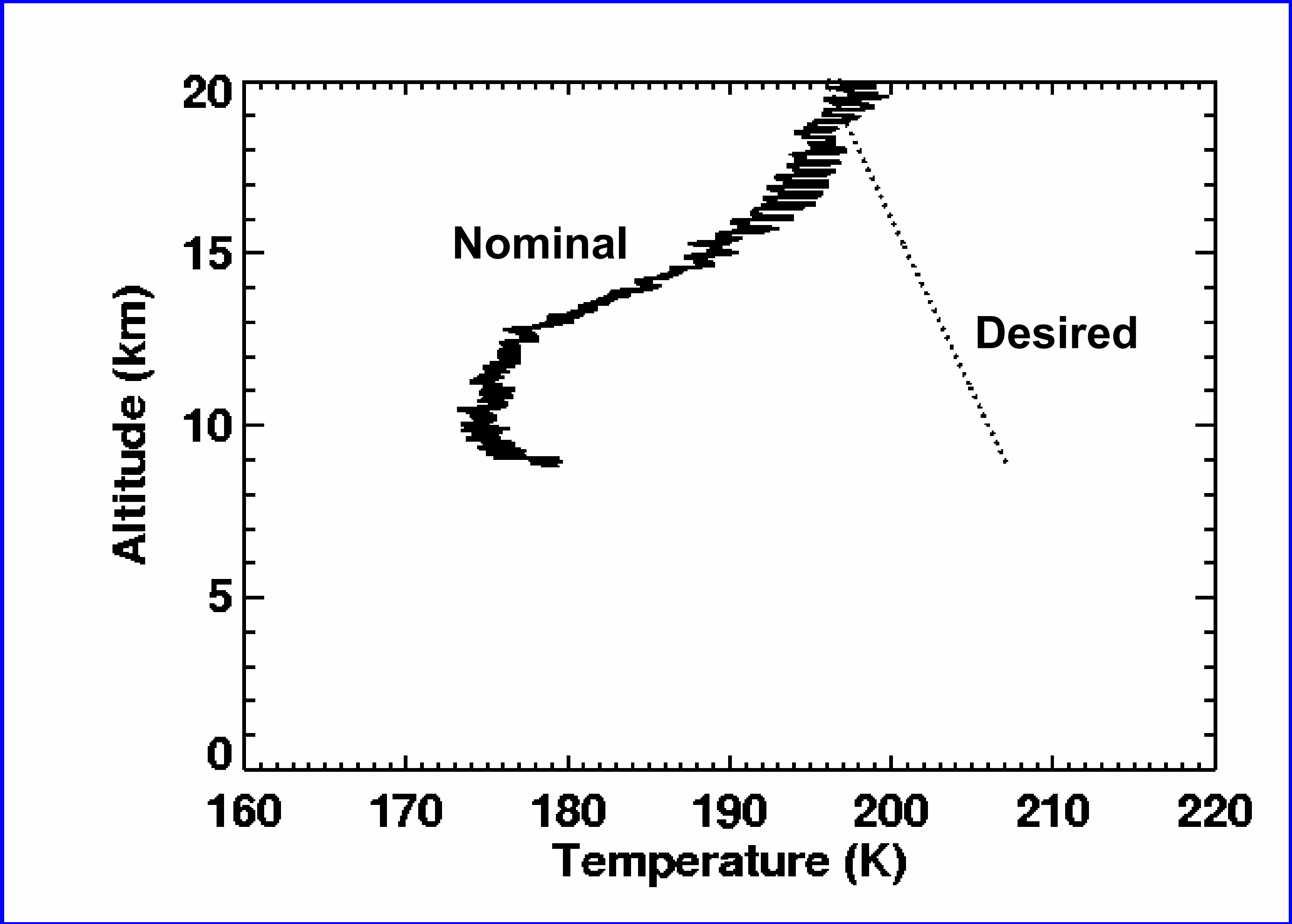
- Modellers (eg Colaprete et al.) have suggested that feature is due to radiative cooling from a water ice cloud
- Hinson and Wilson discuss T inversions in their RS data. Both their inversions (only seen over Tharsis) and modelled inversions are narrower in vertical extent than the MPF inversion and have a more asymmetric vertical profile



Colaprete et al., 2000

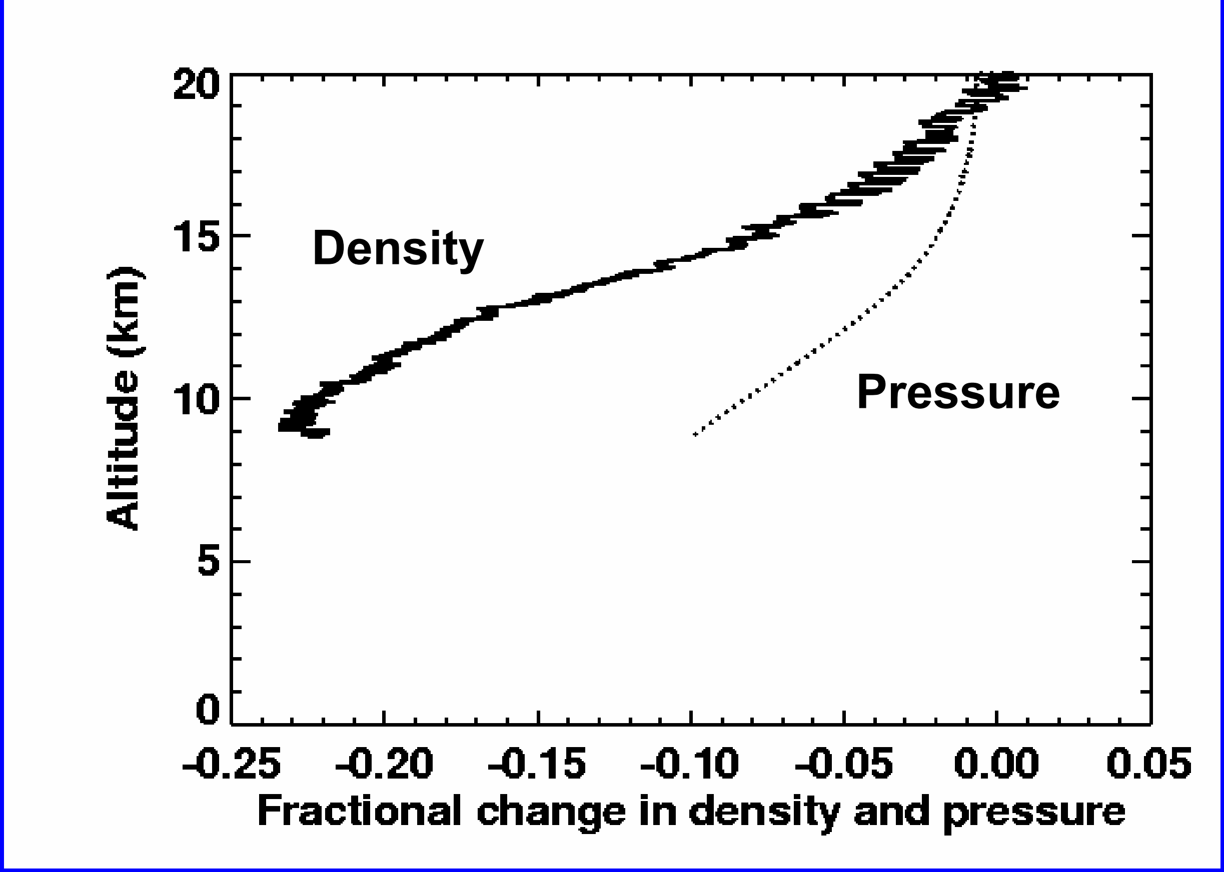
Desired Temperature Profile

- $T/K = 216 - z/km$ 30 K increase desired



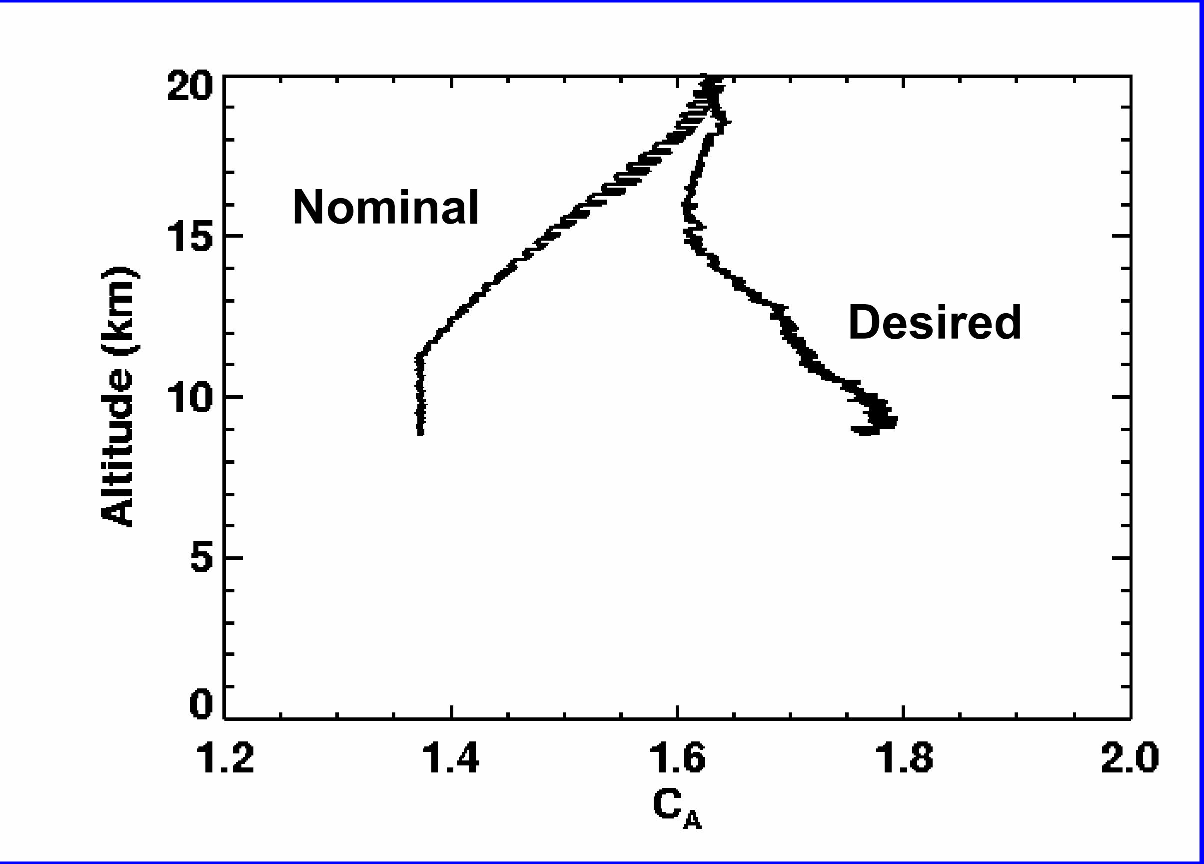
Implications for Density and P

- $T = m_{mean} / k_B \times p / \rho$
- Need continual changes in density



Changes to Aerodynamic Coefficients

- $\rho = -2m/C_A \times a_z/v_R^2$
- Can cloud particles alter drag coefficients?
- $\rho_{atm}=10^{-7}$ g/cc
- $\rho_{cloud}=10^{-12}$ g/cc

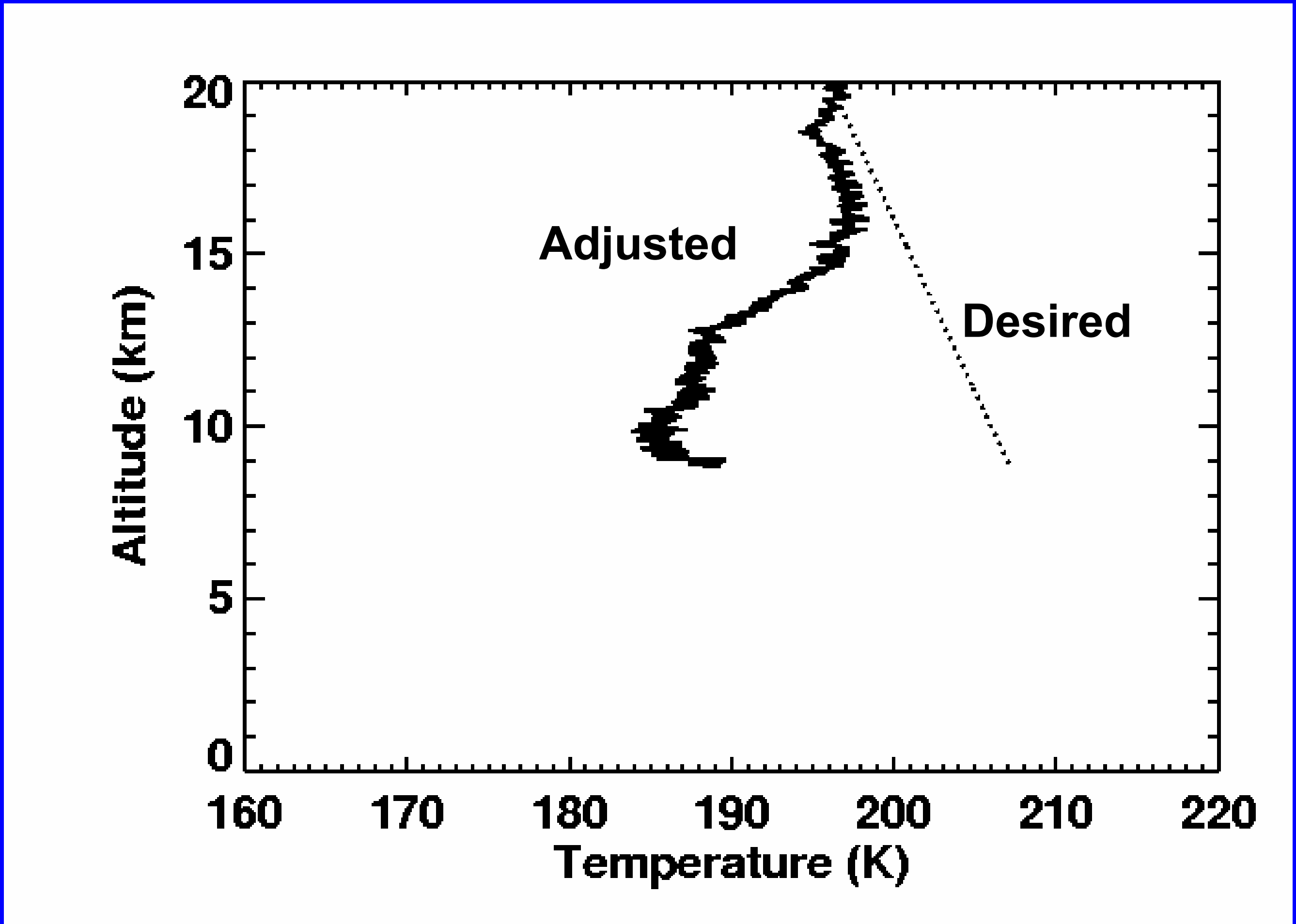


Aerodynamic Database (Gnoffo et al., 1996)

- Ma = 9.4, C_A = 1.64, z = 22.1 km
- Ma = 6.6, C_A = 1.60, z = 19.4 km
- Ma = 2.0, C_A = 1.34, z = 9.9 km

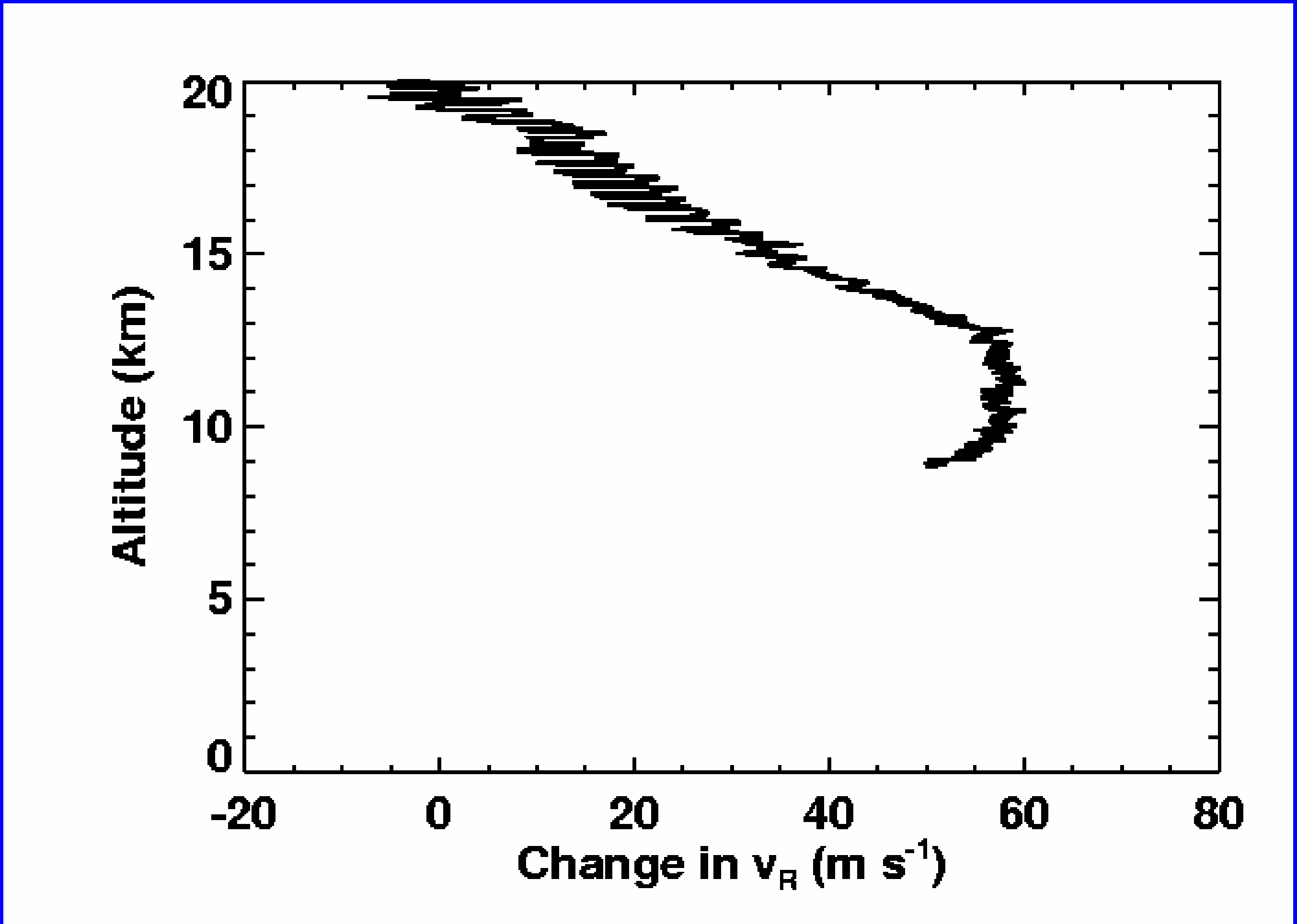
- How does C_A vary between 19.4 and 9.9 km? Linearly with Ma? Hard to interpolate.
- What are uncertainties in C_A?
- Is the Ma = 2.0 result reliable?

What if C_A = 1.50, not 1.34?



Effects of Winds

- $\rho = -2m/C_A \times a_z/v_R^2$ 15 m s^{-1} likely



Angular Accelerations (1)

- $\rho = -2m/C_A \times a_z/v_R^2$
- Need ~ 0.5 – 1.0 m s^{-2} decrease in all axial accelerations below 20 km (cf actual values of 30 m s^{-2} at 18 km and 8 m s^{-2} at 9 km)
- Changes to normal accelerations can't really affect results sufficiently
- Too big for simple instrumental error
- Az measured "on" z-axis 50 mm from CofM where "on z-axis" means <15 mm from axis

Angular Accelerations (2)

- Have not looked at full rigid body equations, but measured accelerations will contain additional terms like $\Omega^2 r$ or $d\Omega/dt\ r$
- Pre-entry roll rate => Ω=0.06 rad s^{-1}
- Angle of attack periodicity => Ω=4.5 - 2.5 rad s^{-1}
- $\Omega^2 r$, r = 50 mm, gives 1.0 – 0.3 m s^{-2}

- Potentially very interesting, but needs careful study. MER acc/gyro data will be useful for better understanding motions of entry vehicle

Refined Hydrostatic Equilibrium

- $\Delta p = \rho \, (g_r \, \Delta r + g_\theta \, r \, \Delta\theta + g_\phi \, r \sin\theta \, \Delta\phi)$
- Contributions to g_r and g_θ from planetary rotation and oblateness, $g_\phi = 0$
- Effects small for steep entry or E-W entry
- Effects large for shallow entry or N-S entry
- Pathfinder T, p changed by <1%
- Atmospheric dynamics also affect above equation, but effects are 10x smaller.

Unresolved Paradox

- (1) T(z) from ACC is in error by 30 K
- (2) T(z) from RS, TES, and models is in error by 30 K
- Which is it? This is an important question
- My best guess: $\Omega^2 r$ and C_A errors at low Ma

- Does this have any impact on Huygens? Maybe
- Possible help from Galileo/PV (direct p, T sensors after chute deploy) and MER (acc/gyros give full dynamical history)
- I worry about C_A interpolation at low Ma when it changes rapidly and how this affects derived angle of attack, atmospheric structure – what is appropriate error analysis?