Measurements of Winds in the Martian Upper Atmosphere from the MGS Accelerometer

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(* – Postdoc job wanted)

Conclusions

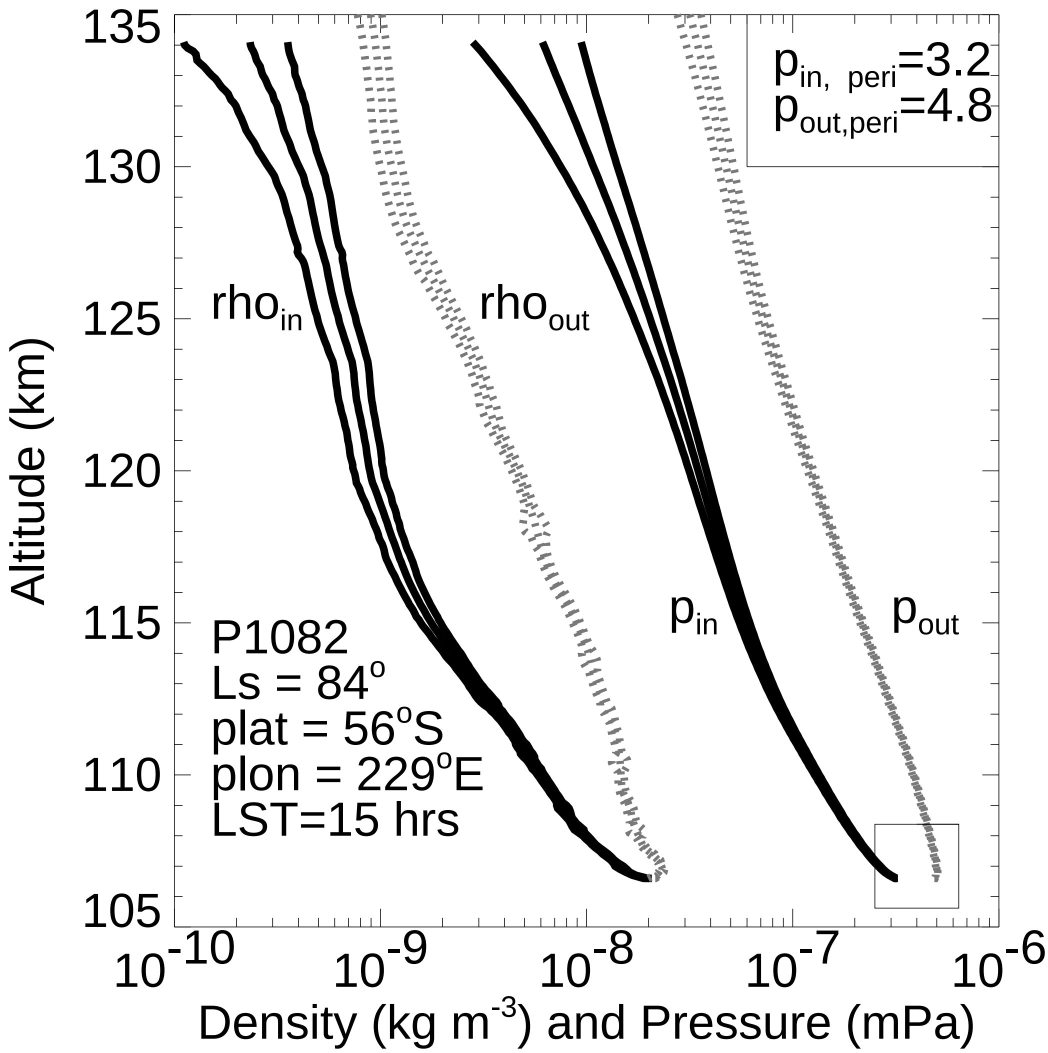
- $\nabla p / \rho = \underline{g}_{eff}$ is insufficient for MGS aerobraking passes as it yields inconsistent periapsis pressures.
- Geostrophic approximation can give a zonal wind estimate and self-consistent p, T profiles for each aerobraking pass.
- Zonal wind speeds at 110 km and Ls ~ 60^{o} are ~ 50 ms^{-1}, (eastward in SH, westward in NH) and these are only partially consistent with zonal mean simulations such as MTGCM.

Selected MGS Accelerometer Data

- Approx 500 aerobraking passes in Sep 1998 – Feb 1999.
- Non-vertical, unlike entry probe
- $L_s = 30^o$ to 90^o
- Periapsis latitude = 60^oN to 60^oS
- Periapsis LST = 17 to 15 hrs
- Periapsis altitude ~ 110 km
- Pass height ~ 30 km with total width of pass ~ 30^o latitude
- Sunsynchronous orbit means no change in longitude during pass

Typical Aerobraking Density Profile

- Pressure from $\nabla p/\rho = \underline{g_{eff}}$, but periapsis pressures do not agree.



Geostrophic Approximation

$$\frac{\partial \underline{v}}{\partial t} + (\underline{v}.\nabla)\underline{v} + 2\underline{\Omega} \times \underline{v} =$$

$$-\nabla p/\rho + \underline{g_{eff}} + visc + MHD$$

Assume reasonable values, work in spherical polar coordinates, neglect ϕ component, result is invalid within ~20^o of pole or equator

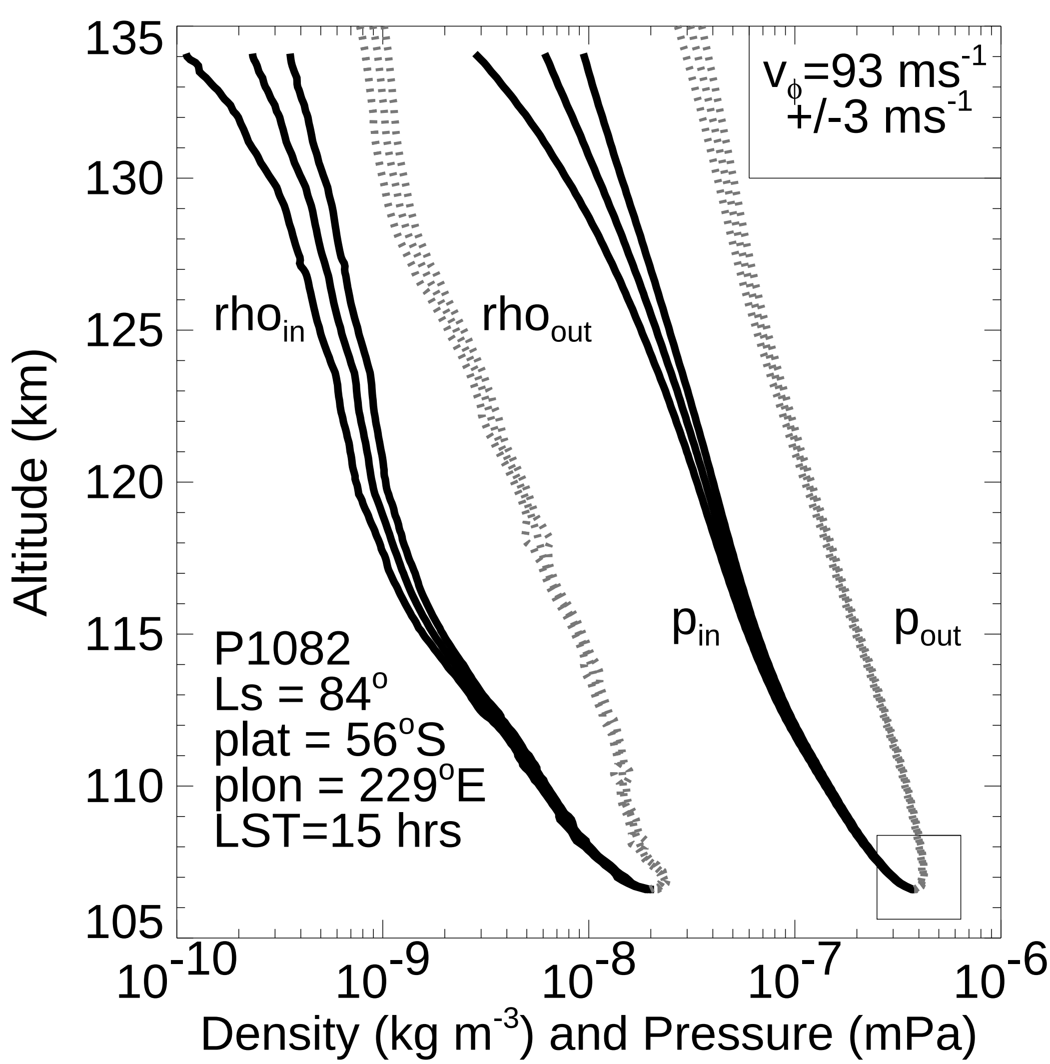
v_ϕ is zonal wind, positive eastward

$$\frac{1}{\rho}\frac{\partial p}{\partial r} = g_{eff,r}$$

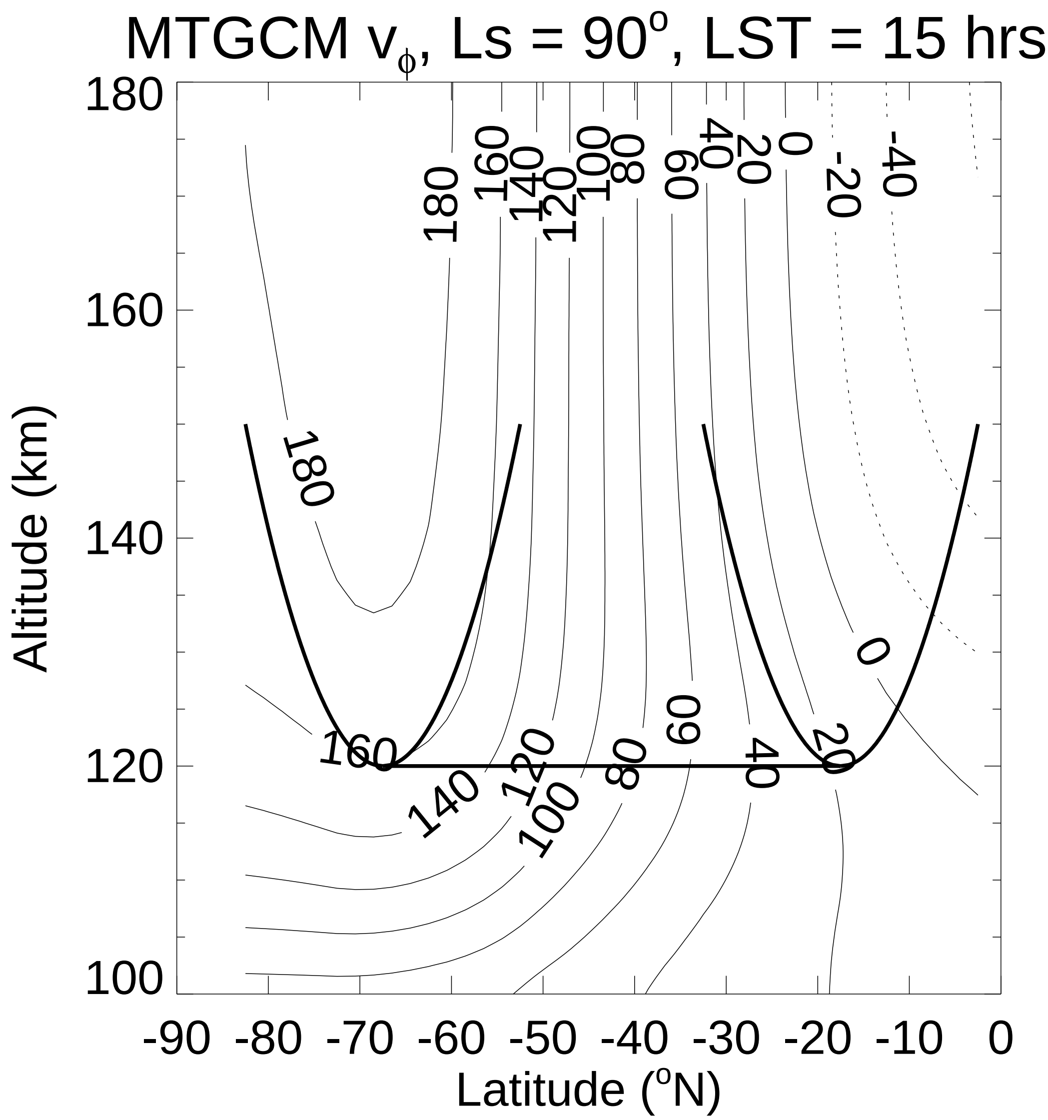
$$\frac{1}{\rho r}\frac{\partial p}{\partial \theta} = 2\Omega v_\phi \cos\theta + g_{eff,\theta}$$

Zonal Wind Estimate

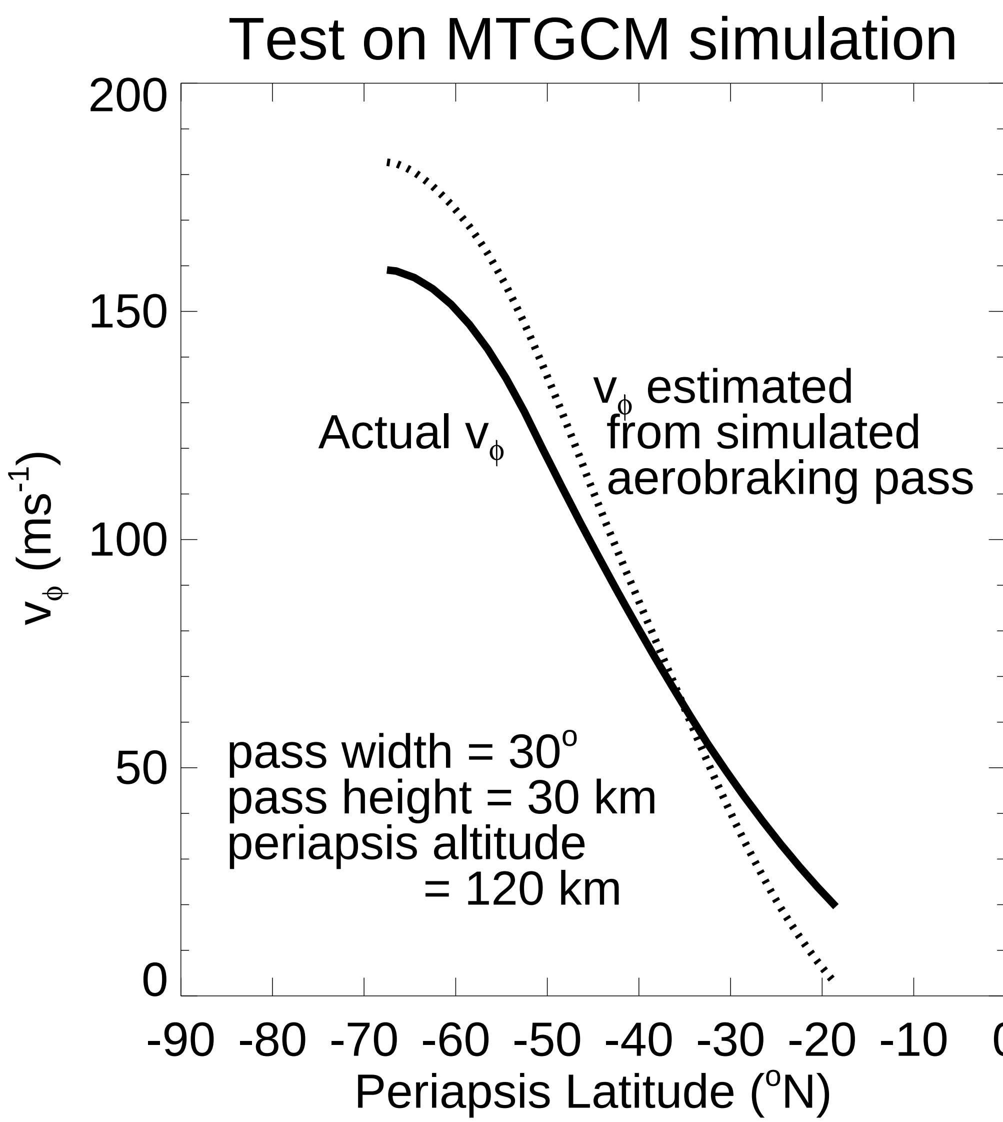
- Isothermal upper boundary gives constant of integration
- v_ϕ assumed constant and uniform, result is most sensitive to winds within a few km of periapsis



Take density profile through simulated atmosphere, then test whether estimate of wind from profile matches the actual wind



Excellent agreement in simulated atmosphere



MGS Results

- In NH, $L_s \sim 30^o$, LST ~ 16 hrs, periapsis altitude ~ 114 km, $v_\phi \sim -74\ ms^{-1}$ +/- $5\ ms^{-1}$:westward
- NH, MTGCM has $v_\phi \sim +20\ ms^{-1}$

- In SH, $L_s \sim 90^o$, LST ~ 15 hrs, periapsis altitude ~ 108 km, $v_\phi \sim +38\ ms^{-1}$ +/- $6\ ms^{-1}$:eastward
- SH, MTGCM has $v_\phi \sim +100\ ms^{-1}$

- In SH, v_ϕ can change by $\sim 50\ ms^{-1}$ over 30^o longitude

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