

Atmospheric Profiles from Spirit and Opportunity

Paul Withers (withers@bu.edu)

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- Acknowledgements: MER Atmospheric Advisory Team, David Kass, Mike Smith, many others

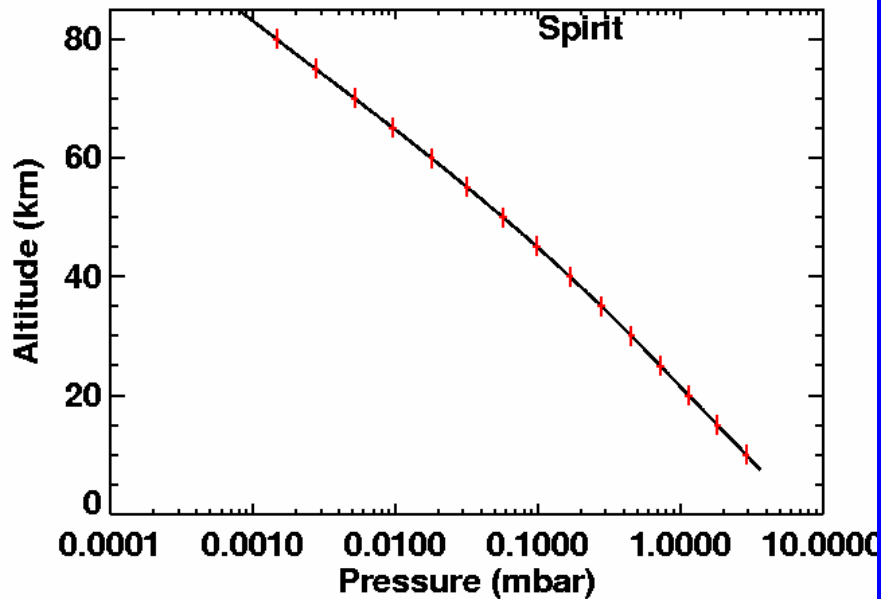
Data on PDS (Aug 2004) or Published

- SCLK / UTC time (4 Hz)
- Accelerations along spacecraft x,y,z axes (300 μg noise level, minimal post-flight calibration)
- J2000 attitude quaternions (caution...)
- Accelerations and angular rates for IMU axes, only partially complete (not currently useful)
- Not – entry states, but enough pieces are published in different places that they can be estimated
- Aerodynamics (graphical, not tabular)
- Not – IMU locations/orientations

Analysis Steps

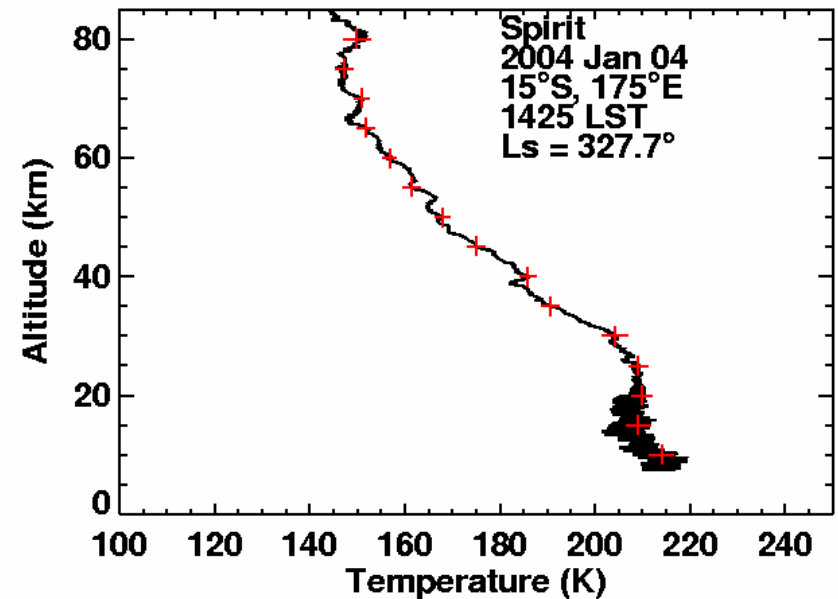
- Entry state, $a(t)$, attitude, gravity give position and velocity profiles
- Drag equation, aerodynamics give density and angle of attack profiles
- Hydrostatic equilibrium, upper boundary condition, give pressure profiles
- Ideal gas law gives temperature profiles
- Monte Carlo uncertainty analysis

Spirit Results



$P_s \sim 7.3$ mbar

1σ uncertainties in p/z in red crosses

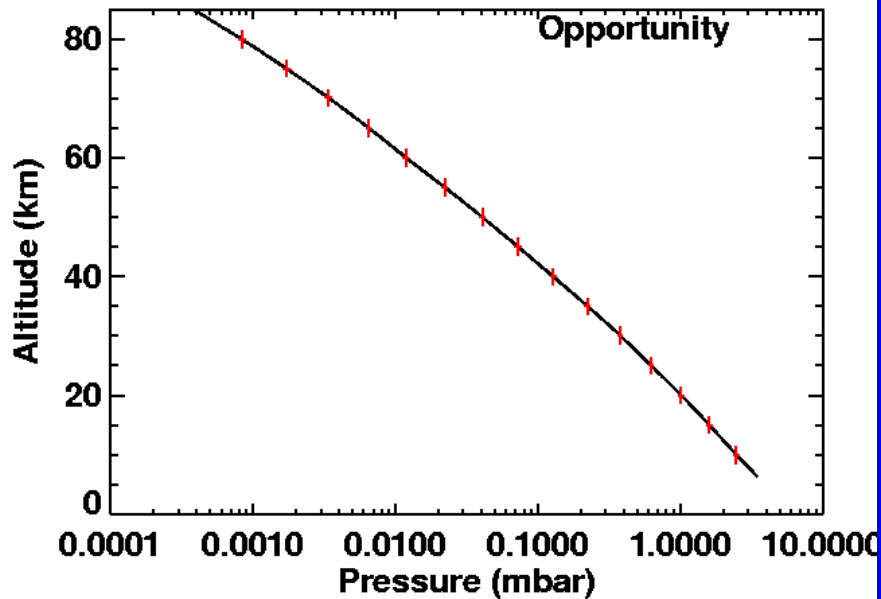


No large waves in middle atmosphere

Unusual behaviour below ~ 20 km,
almost an inversion

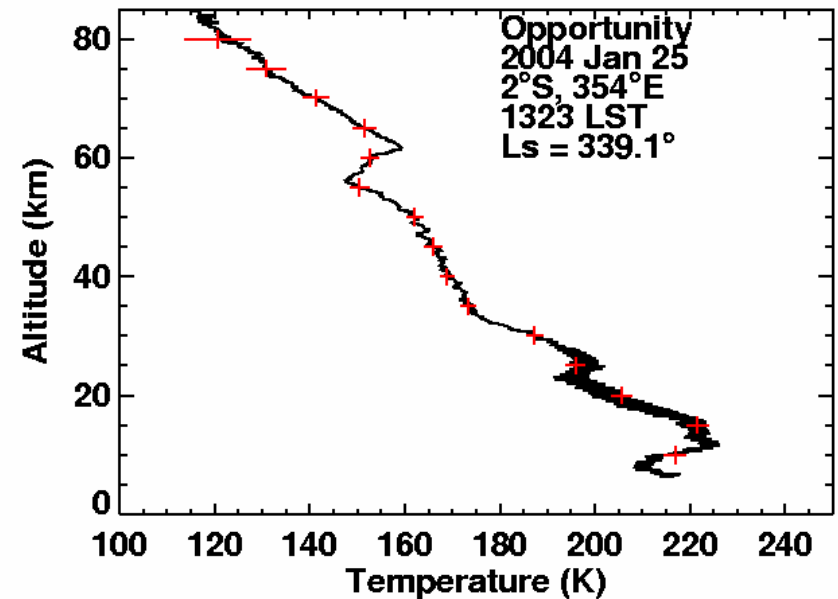
1σ uncertainties in T/z in red crosses

Opportunity Results



$P_s \sim 6.1$ mbar

1σ uncertainties in p/z in red crosses

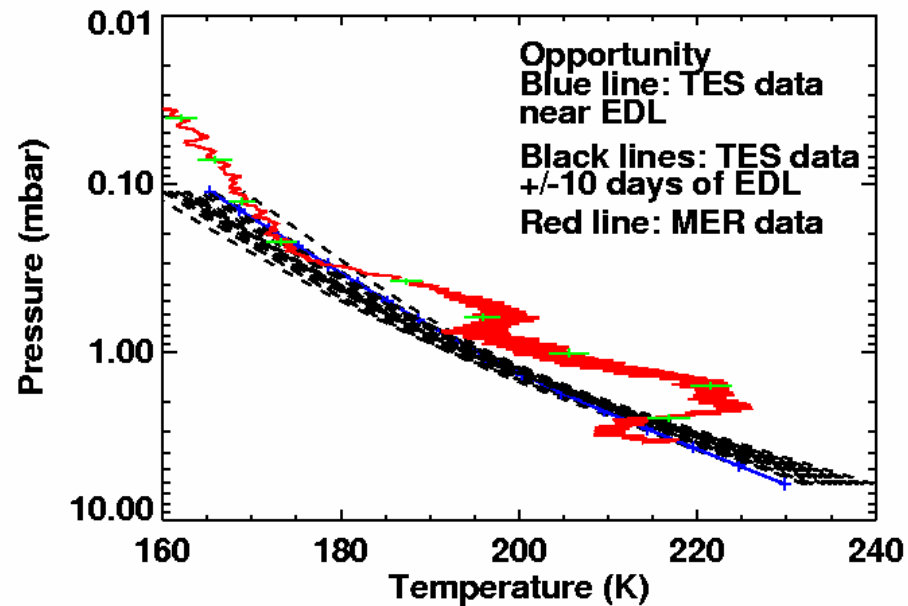
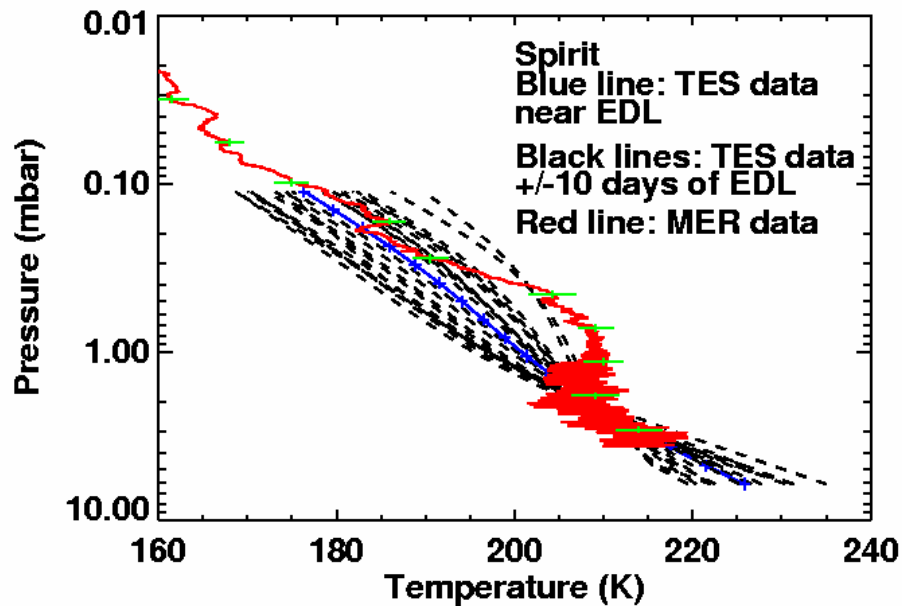


Large wave in middle atmosphere,
possible large inversion above 85 km

Unusual inversion below 10 km,
similar to Pathfinder

1σ uncertainties in T/z in red crosses

MER – TES Comparison



Possibly too hot below 0.3 mbar

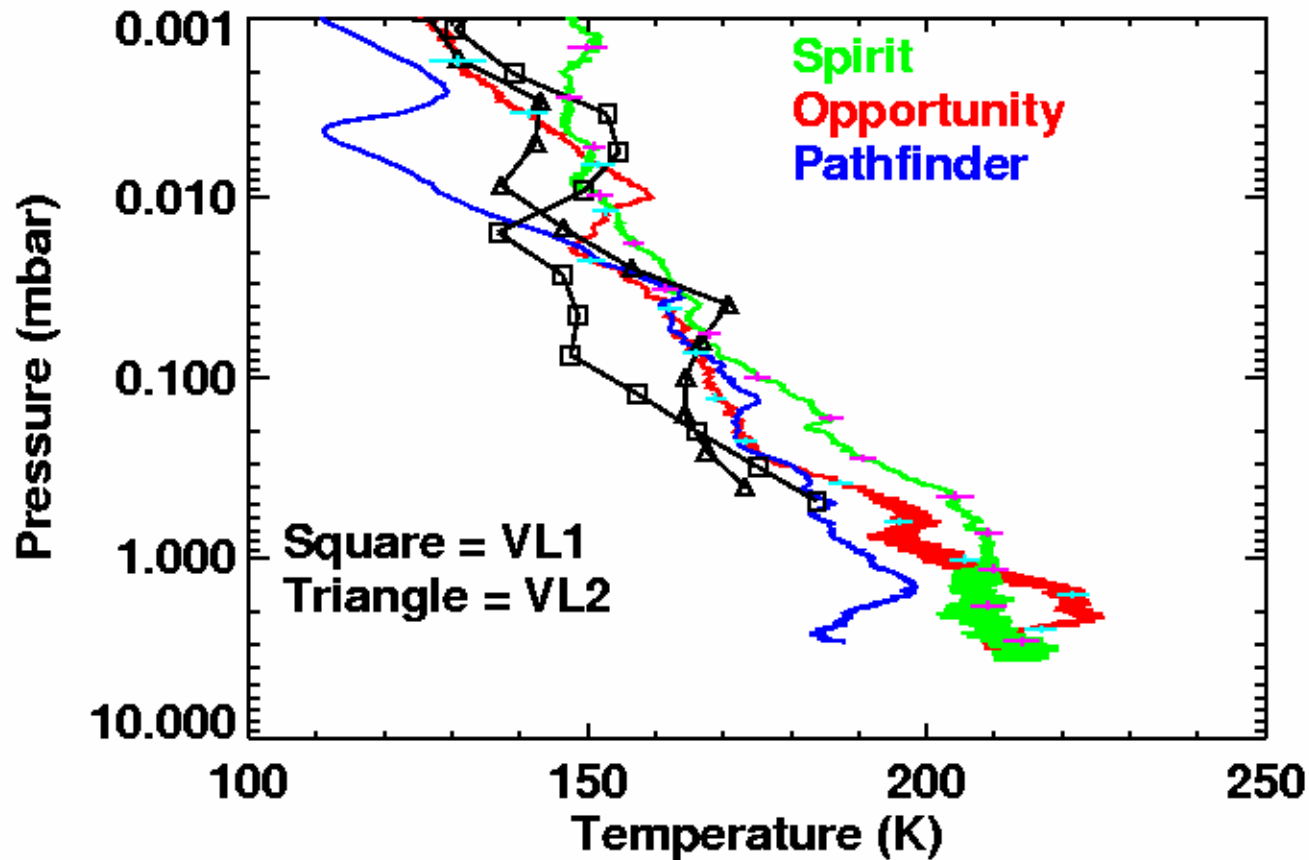
Shape consistent with some of the TES profiles

Thanks to Mike Smith for TES profiles

5-10 K too hot below 0.3 mbar

Shape consistent with all of the TES profiles except for lowest few km

Viking – Pathfinder – MER Comparison



Spirit's profile is remarkably free of large waves

Opportunity and Pathfinder identical between 0.02 – 0.2 mbar

Between 0.1 – 1 mbar, Spirit's profile is the warmest

Profiles are Important Because...

- Are MER profiles “too warm” like VL/MPF?
 - If Yes – systematic flaw in measurement technique, impact on Venus, Jupiter, Titan?
 - If No – error in VL/MPF datasets?
- Did mesoscale and other models work?
Implications for future EDL
- Many other atmospheric measurements, global and local, before and after EDL
- First profiles soon after a large dust storm

My Next Steps

- My results not yet published because:
 - Aerodynamics only recently cleared ITAR restrictions
 - Chance of recalibration and re-release of data at any time, say one week after publication
- Publish results
- Archive/distribute results and software
- Collaborate with those who use models and/or other datasets

MER Entry

- Hypersonic, ballistic, direct entry to ~10 km, then parachute, retrorockets, airbags
- IMUs: Two Litton LN-200S (similar to LN-200 on AMRAAM missile) on each MER, 3 axis acc and 3 axis gyro
- No science team, so no “instrument paper”, no Science paper, minimal PDS archiving
- “Atmospheric Advisory Team” existed for operational support, but that work is secret
- Ask David Kass about data quality, archiving
- Engineers working on a parallel reconstruction with different goals

Data Flow

- Six measurements (3 acc, 3 angular rates) at various places within an IMU, IMU converts them to a common reference position and orientation within IMU
- MER converts each set of 3 acc and 3 angular rates to its CM and spacecraft axes
- MER converts angular rates + initial attitude into current attitude (quaternions)
- All positions/orientations must be known and correctly typed into software, transformation equations must be correct in software, initial attitude must be correct
- MER transmitted full set of J2000 quaternions and accelerations at spacecraft CM in spacecraft frame, but only partial set of raw data – so I hope processing was correct