New data products from the Mars Odyssey Accelerometer: Report on scientific implications, data processing, validation and archiving

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Outline of presentation

- Boring (but necessary) stuff
  - Current data products at PDS (and motivation)
  - Data processing to generate new data products
  - Density profile for orbit P076
  - Validation of data products
  - Status of archiving and publication plans
- Interesting stuff – Survey of scientific analysis to date
  - Thermal tides at 60-70N, dayside
  - Meridional structure of tides
  - Comparison to MTGCM for dayside densities

Current data products at PDS (and motivation)

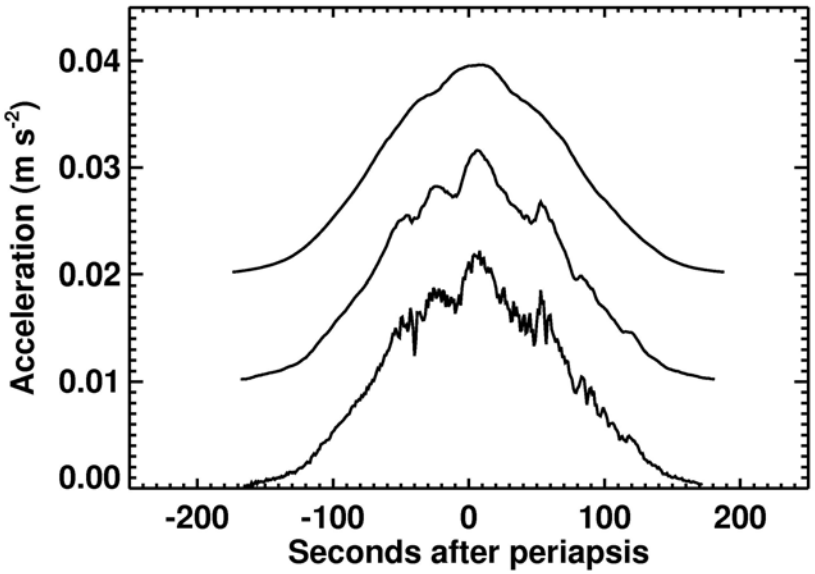
- (1) Available to users since 2003 or 2004
  - Fitted densities and density scale heights at periapsis, 110 km, 120 km
  - No density profiles
  - Minimal documentation
  - Not peer-reviewed
- (2) Delivered a few years ago by Gerry Keating
  - Time series of accelerations in various formats
  - Some documentation
  - Not accessible via web or FTP
- (3) Recently delivered by Bob Tolson
  - Time series of acceleration measurements
  - Density profiles
  - Densities and density scale heights at 100 km, 110 km, 120 km, 130 km, 140 km
  - Likely to be reviewed soon
  - Not yet accessible via web or FTP

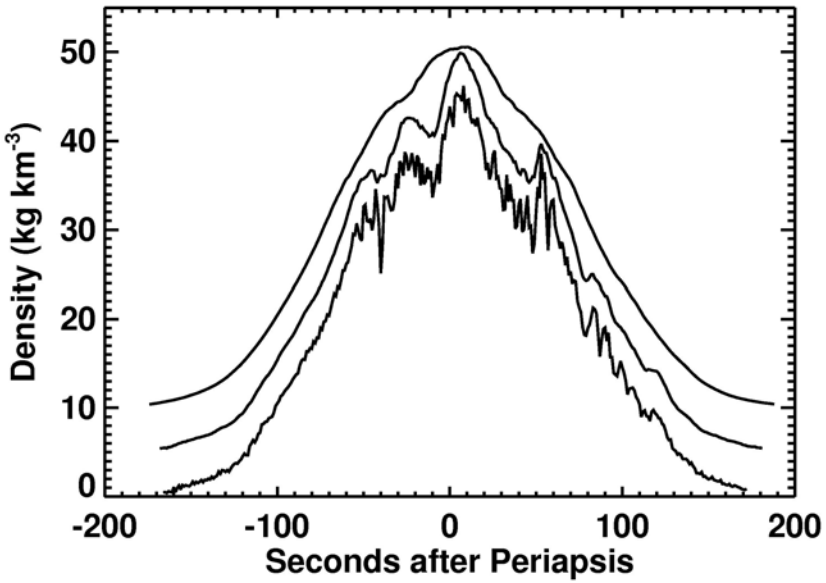
Data processing to generate new data products

- Discard isolated acceleration measurements
- Correct for bias
  - Don't correct for angular accelerations because position of center of mass is not well-known
  - Don't correct for thruster firings because timing information not precise and thruster effects hard to quantify
- Reduce noise by 7-point and 39-point averaging
- Discard measurements smaller than relevant uncertainty
- Acquire Odyssey position, velocity, orientation from SPICE kernels; mass history from JPL; drag coefficient from Langley via JPL; area from literature; altitude from MOLA areoid
- Use drag equation to obtain time series of density from acceleration

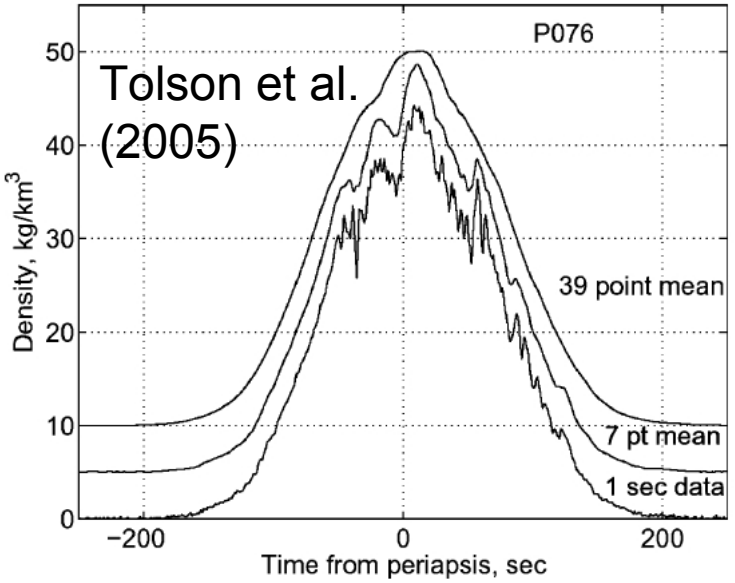
- Profiles of density along trajectory
  - 7-point average reported at 1 second intervals
  - 39-point average reported at 1 second intervals
- Fitted density and density scale height at 100 km, 110 km, 120 km, 130 km, 140 km

Density profile for orbit P076





- Time series of densities agree well with operations team's results
- Also reproduce other time series plots in Tolson et al. (2005) for this orbit, such as angular rates and orientation of spacecraft with respect to wind vector



Validation of data products

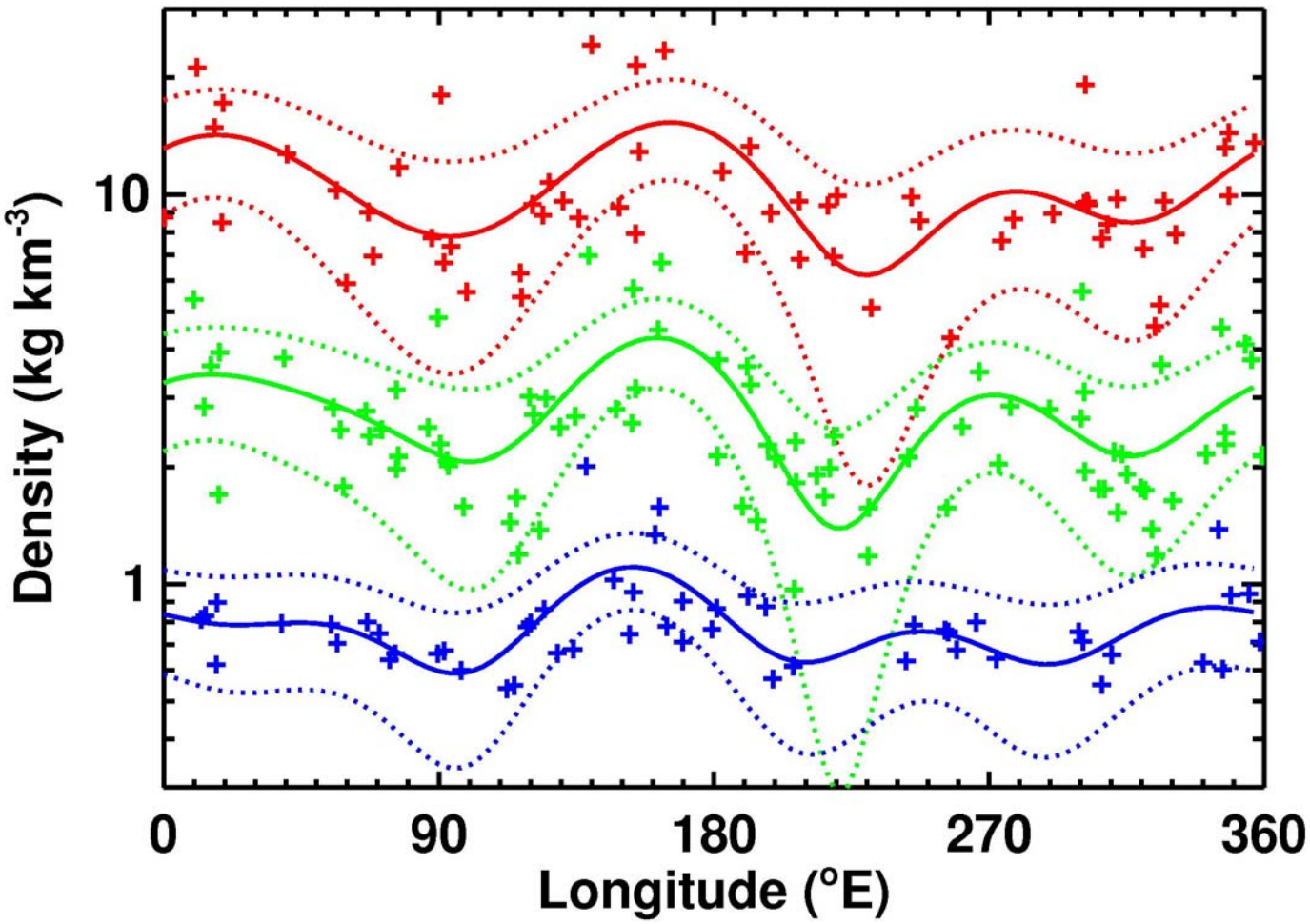
- Compare to a few published density profiles and 110 km/120 km data from PDS
- Differences in, eg, latitude at 110 km consistent with differences in areoid
  - Unspecified areoid used in PDS 110 km/120 km data
- Density differences are ~10%
  - 5% attributable to areoid differences
  - 5% attributable to other differences in data processing
- Scale of differences consistent with expectations

- No indications of irreconcilable differences

Status of archiving and publication plans

- Plan to deliver data products and documentation to PDS
- Plan to submit manuscript focused on science to Icarus, plus make data products available as “supplementary information”
- Need to make some small modifications to documentation and manuscript to reflect Tolson’s recent delivery to PDS
- Days away from delivery and submission

Thermal tides at 60-70N, dayside



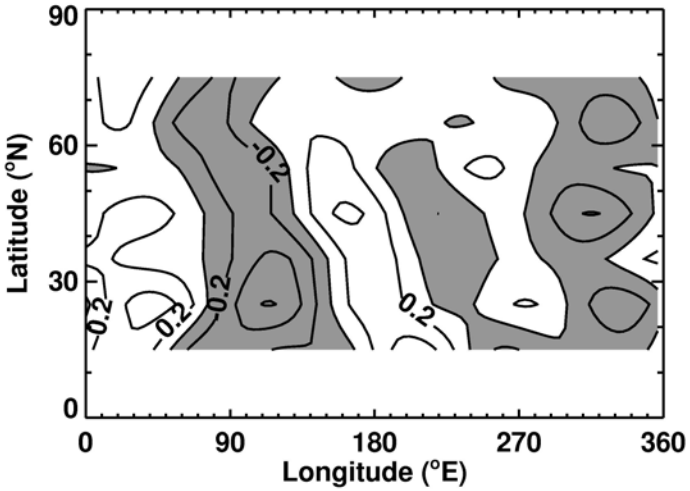
Red = 120 km
Green = 130 km
Blue = 140 km

Tidal phases stay constant as z changes

Tidal amplitudes decrease as z increases

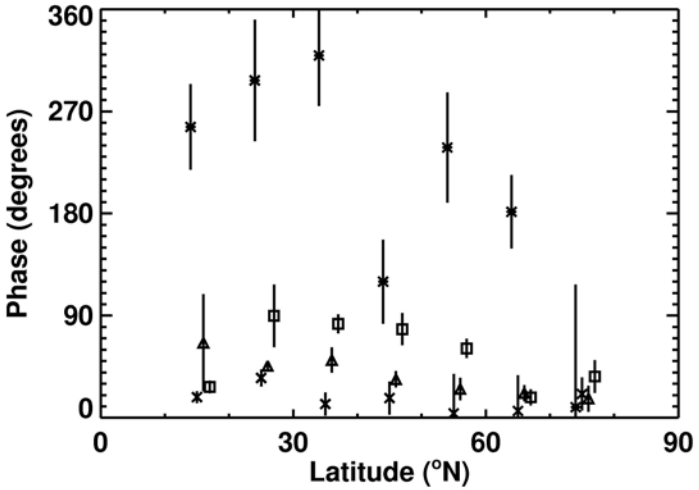
Zonal mean density decreases as z increases

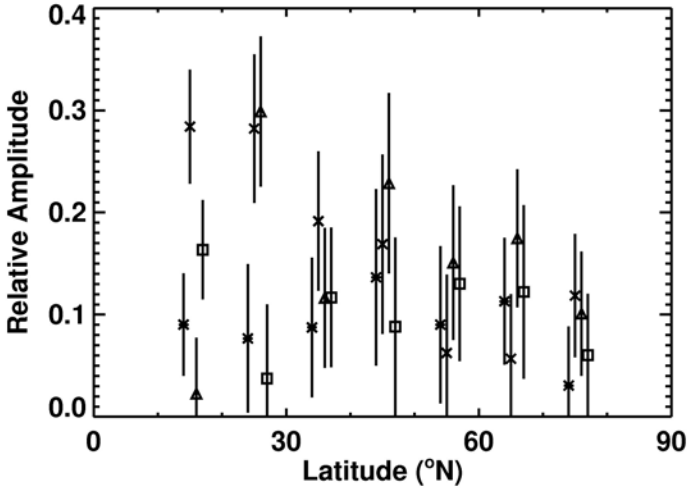
Meridional structure of tides



Upper left - Inbound densities at 120 km (nightside) Normalized fitted densities with contour intervals of 0.2 (dimensionless) and negative regions (low densities) shaded)

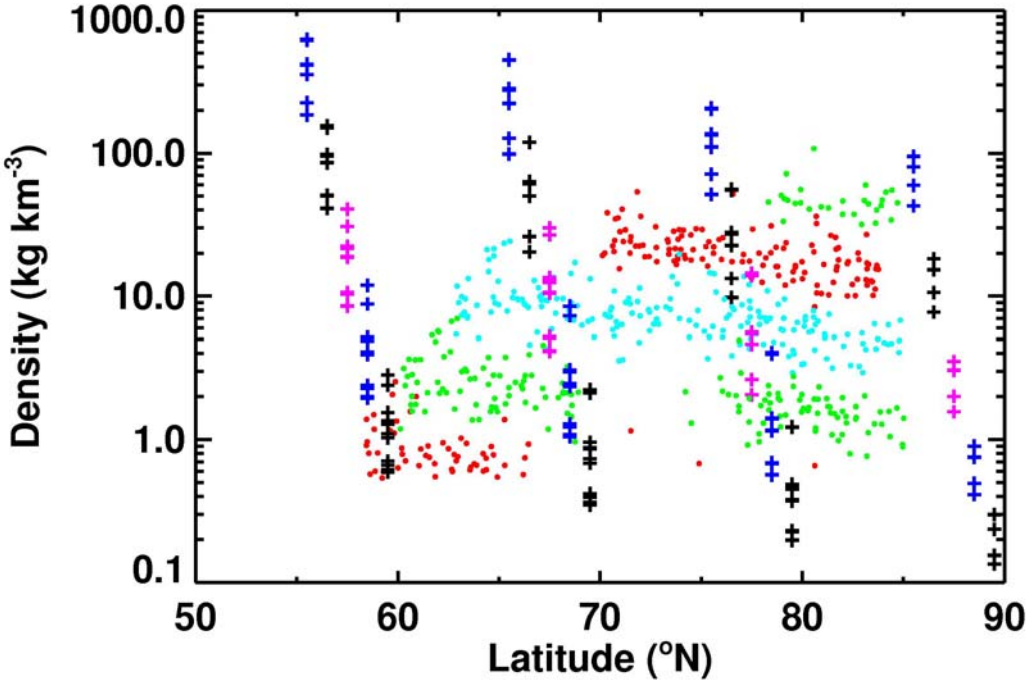
Lower left – Phases from corresponding wave-4 fits. Wave-1 = asterisks, wave-2 = crosses, wave-3 = triangles, wave-4 = squares.
Maximum value of wave-n phase is 360/n





Lower right – Amplitudes.

Comparison to MTGCM for dayside densities



Simulations publicly available from Steve Bougher's website

MTGCM simulations cover 16, 17, 18 hrs LST, tau = 0.3, 1.0, 3.0, Ls = 256, 277, 297 degrees

Hence range in simulated atmospheric conditions

Dayside MTGCM (crosses) and ODY (small filled circles) densities. All MTGCM results at X7.5 degrees latitude, but some are shifted in latitude for clarity.
MTGCM – Dark blue = 100 km and 130 km, black = 110 km and 140 km, pink = 120 km
ODY – Green = 100 km and 130 km, red = 110 km and 140 km, light blue = 120 km

Observed and simulated densities are very consistent.

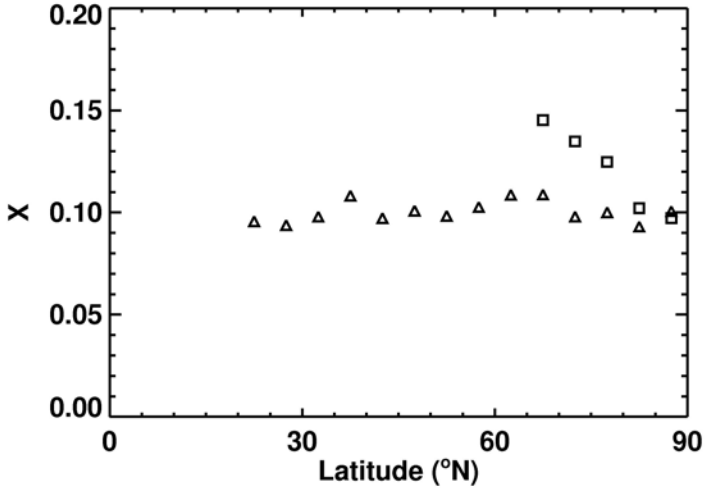
Conclusions

- Complete set of Odyssey density profiles and constant altitude densities has been produced from raw acceleration measurements
- Dataset documented and prepared for delivery to PDS
- There will be overlap with the data products recently delivered to the PDS by Bob Tolson

- These new data products are useful for research on the upper atmosphere of Mars

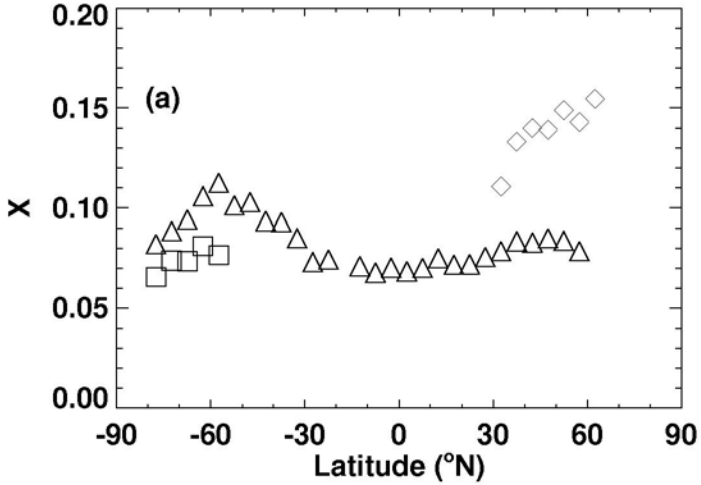
Backup

Small-scale structure (gravity waves?) in density profiles



$$Y = 2\frac{(\rho_7 - \rho_{39})}{(\rho_7 + \rho_{39})}$$

$$X = \sqrt{\overline{Y^2}}$$



- Left – Odyssey results. Squares are dayside profiles and triangles are nightside profiles.
- Right – MGS results. Diamonds are Phase 1, squares are Phase 2/nightside and triangles are Phase 2/dayside
- Large values of X at 60 degrees S/N
- Little variability in X in tropics and mid-latitudes

Raw data acquired from the PDS

- ASCII files (pXXXacc.txt) containing time series of low rate 3-axis acceleration measurements at 1 second intervals
- MATLAB files (LOPXXX.mat) containing time series of high rate 3-axis acceleration measurements at 1 second intervals
- Some other information on angular rates, thruster firings, etc – not used