MEX Surface Pressure Measurements

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Background

- MSL needs to know surface pressure (Ps) to ensure a safe landing in 2012
  - Ls = 120-180, below +1 km altitude, within 45 degrees of equator
- Dave Hinson and others are using sophisticated data assimilation models to predict Ps
  - Probably highly accurate, but time-consuming to produce and only produced for small number of seasons and locations
- I have used a range of landed and orbital datasets to develop a simple equation for predicting Ps
  - "Quick-look" estimate, lower accuracy, but easy to use
- I have compared MEX Ps measurements to other datasets and predictions

Source of “Surface Pressure”

- MEX Level 3, V5.4
- Get p(r) from …L04_AIX… files
- Use 16 pix/degree MOLA grid to find radius of surface at relevant latitude and longitude
- Extrapolate pressure profile to surface radius
- 484 surface pressures acquired

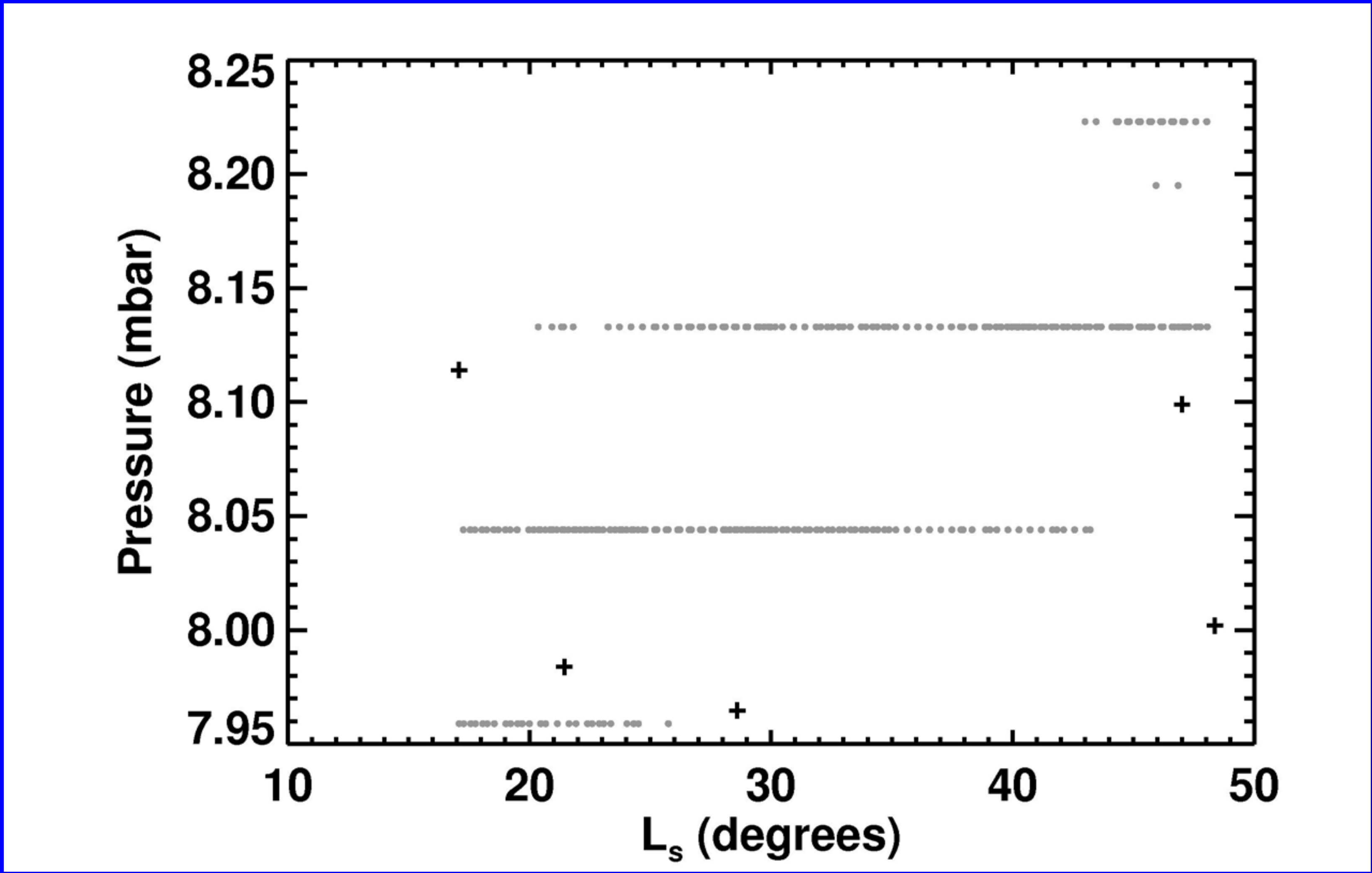
Three MEX File Types: ODF, RSR, ICL

- 2008/DOY_241_5979_DSN/
  - M65ODFXL04_AIX_082411031_54.TAB
    - ODF file, produced by Cologne from DSN closed-loop TNF data?
  - M65RSR0L04_AIX_082411526_54.TAB
    - RSR file, produced by Stanford from DSN open-loop RSR data?
- 2008/DOY_221_5908_NNO/
  - M32ICL1L04_AIX_082210908_54.TAB
    - ICL file, produced by Cologne from ESA New Norcia IFMS data?

Comparison to other datasets

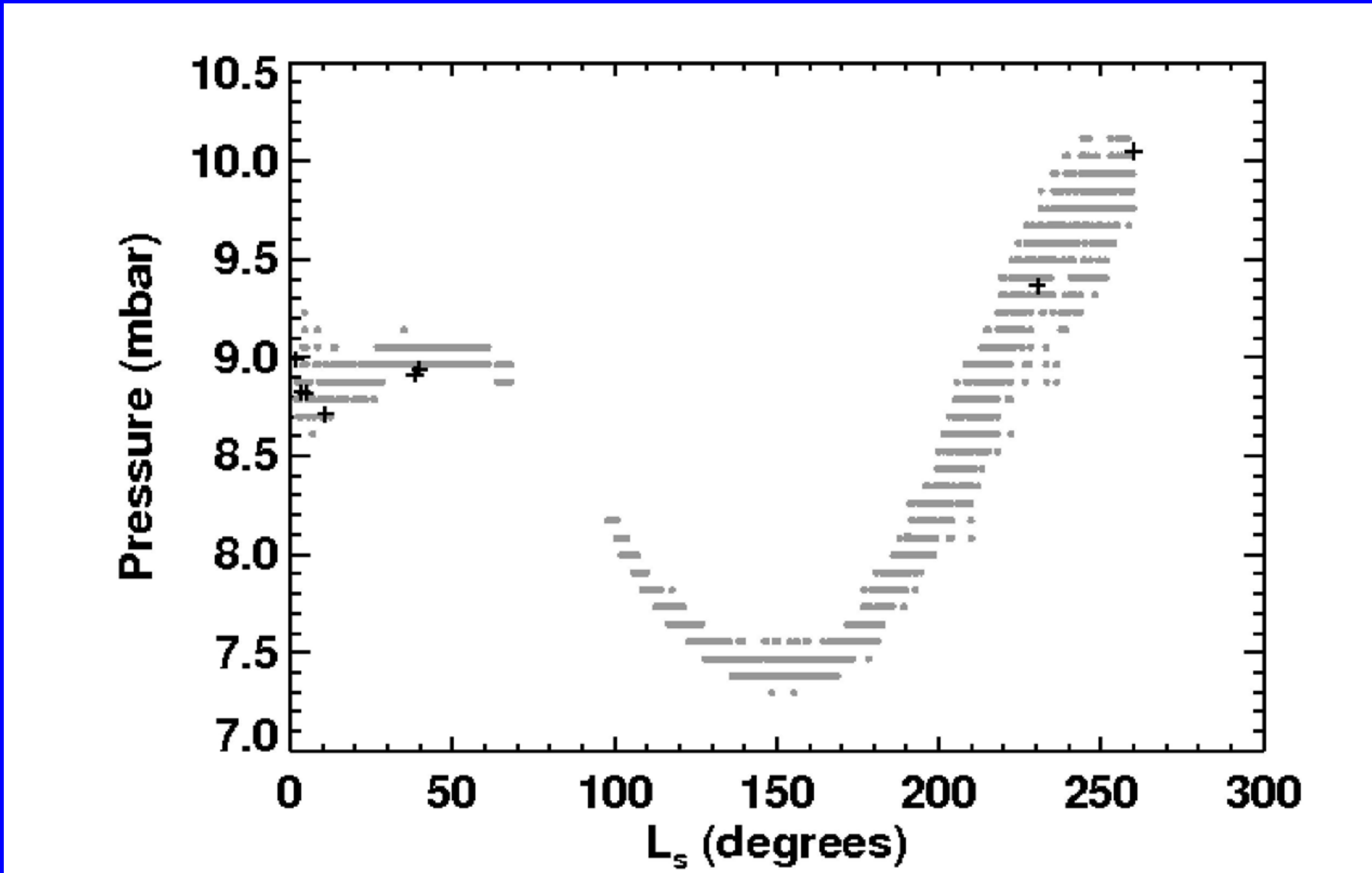
- Landers
  - Some MEX profiles near VL1, VL2
  - No MEX profiles near MPF, PHX
  - No pressure sensors on SPI, OPP
- Other orbiters
  - Mariner 9: Differences between M9 published pressures and other datasets are ~10%
  - VO1, VO2: Only ~20 pressures published
  - MGS: 21235 profiles available, some close to MEX profiles

MEX Ps near VL1



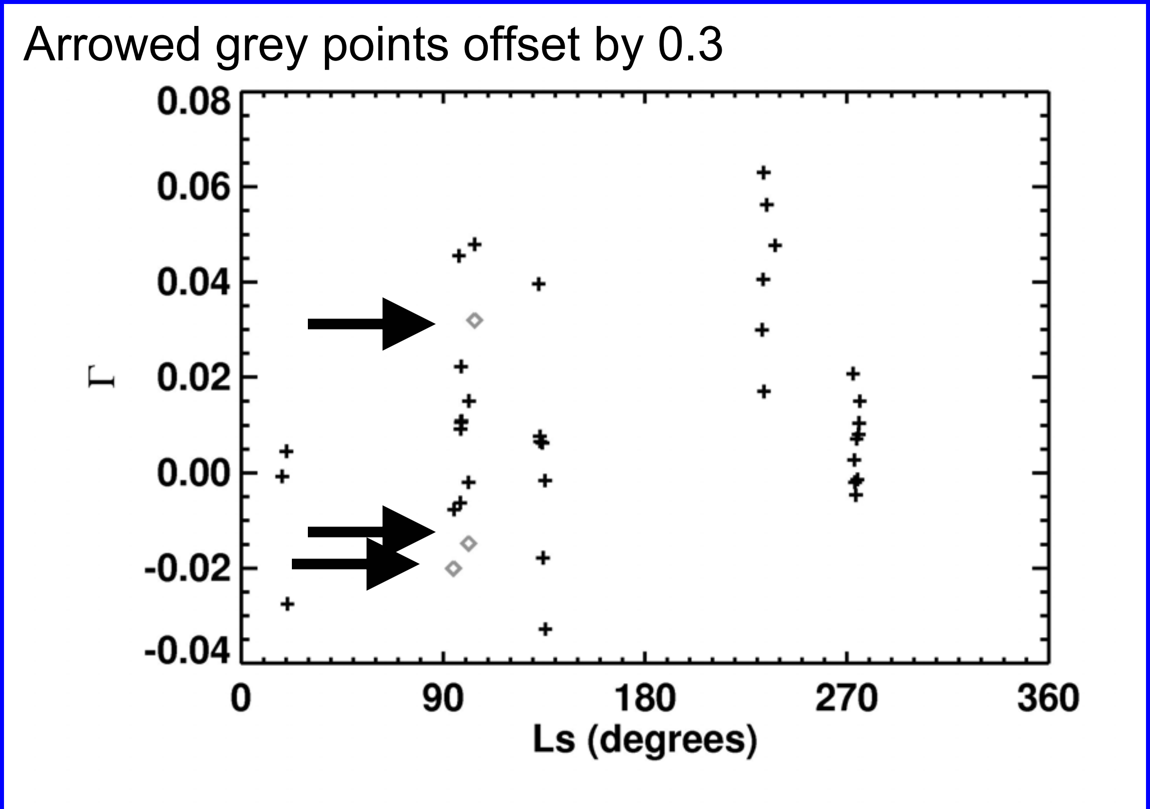
Crosses = 5 MEX measurements, grey dots = 635 VL1 measurements
Agreement to within 0.1 mbar digitization of VL data

MEX Ps near VL2



Crosses = 8 MEX measurements, grey dots = 12935 VL2 measurements
Agreement to within 0.1 mbar digitization of VL data

MGS-MEX comparison



38 comparisons possible from 484 MEX profiles

35 MEX pressures are consistent with MGS pressures: mean Γ ~1%, std. dev. Γ ~2%

3 MEX profiles have Γ ~ -0.3 (MEX Ps 30% smaller than MGS)

<u>These are the only 3 "ODF" profiles in the 38 selected</u>

Consider each MEX profile in turn.

Use pressure at lowest reported altitude, do not extrapolate to MOLA surface.

Find all MGS profiles whose Ls, lat, lon are within 10 deg of this MEX profile's and whose LST is within 1 hour of this MEX profile's (generally ~10 MGS profiles selected)

Extrapolate to altitude of MEX measurement

Γ = (MEX Ps – mean of MGS Ps) / (mean of MGS Ps)

Three Outliers (all 2008 ODF)

- 2008/DOY_187_5790_DSN/M65ODFXL04_AIX_081871307_54.TAB
  - -65.56N, 275.56E, LST=10.92hr, SZA=91.52deg
  - 13 MGS profiles, std. dev. of 1.4%
- 2008/DOY_202_5843_DSN/M15ODFXL04_AIX_082021832_54.TAB
  - -58.93N, 44.88E, LST=12.73hr, SZA=84.09deg
  - 18 MGS profiles, std. dev. of 2.1%
- 2008/DOY_208_5864_DSN/M15ODFXL04_AIX_082081830_54.TAB
  - -55.99N, 112.95E, LST=13.22hr, SZA=81.87deg
  - 1 MGS profile

What is the problem?

- Stated MEX uncertainties in Ps are <1% (typically 0.2%), even for ODF profiles
- Three outliers in comparison of MEX and MGS are ODF profiles from 2008
- Possible unreliable profiles are:
  - All ODF profiles
  - All ODF profiles from 2008
  - All MEX profiles from 2008 (EXCLUDED)
- 10 non-ODF MEX profiles at Ls=90 are from 2008
- 25 non-ODF MEX profiles at other seasons are from earlier years
- There are no obvious differences between the set of 10 profiles and the set of 25 profiles on earlier Γ comparison figure

Simple prediction for Ps

$$p_s = p_{0,VL1} \exp\left(-\left(z - z_{VL1}\right)/H_0\right) \times \quad (3)$$
$$\left(1 + s_{1,VL1} \sin\left(1L_s\right) + c_{1,VL1} \cos\left(1L_s\right) + s_{2,VL1} \sin\left(2L_s\right) + c_{2,VL1} \cos\left(2L_s\right)\right)$$

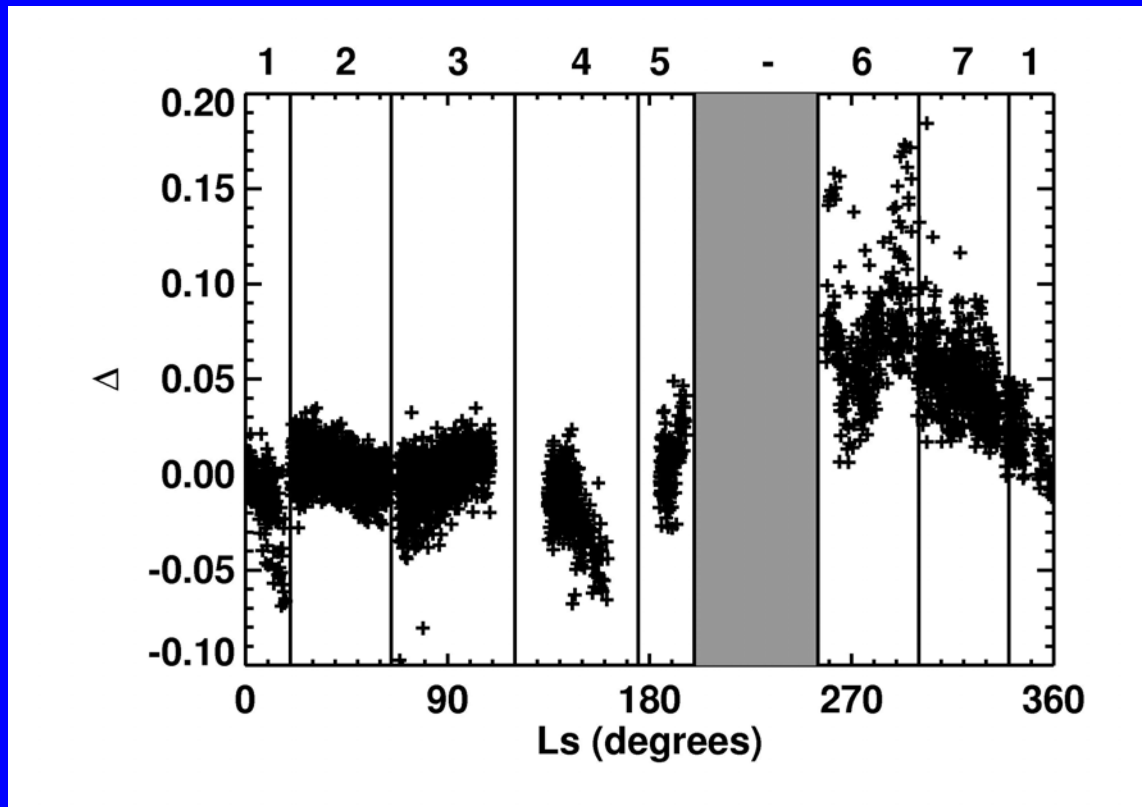
Parameter	VL1
p_0 (mbar)	7.9723740
s_1	-0.068622849
c_1	0.060390972
s_2	0.044663631
c_2	-0.050183946

z_{VL1} = -3.63 km
H_0 = 11 km

Seasonal pressure cycle from fit to VL1 data
Altitude dependence from optimizing against MGS data

Test whether prediction and data agree using Delta:
Δ = (p-pred – p-meas) / p-meas

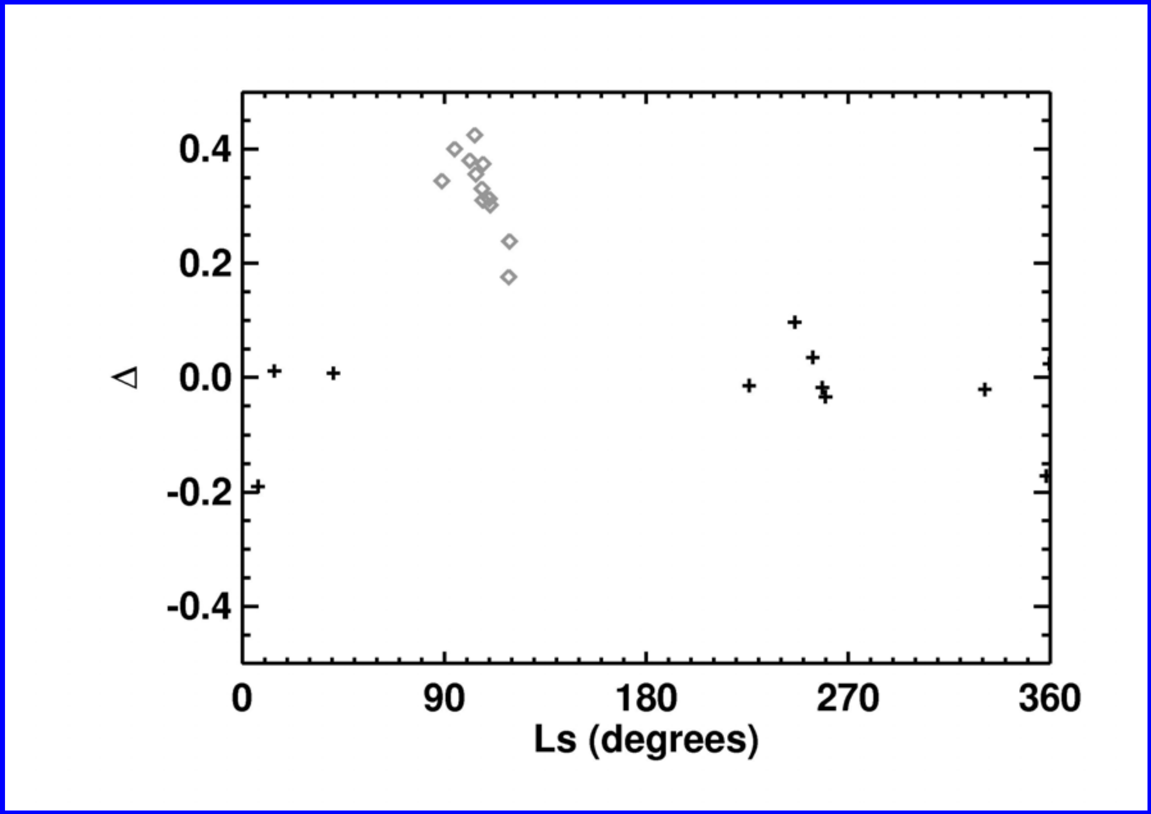
Predictions of Ps for MGS



3066 MGS profiles below +1 km altitude and within 45 degrees of equator
Predictions worst at Ls=250 to 340, probably due to interannual dust variability

Typical value of Delta is a few percent

Predictions of Ps for ODF MEX profiles



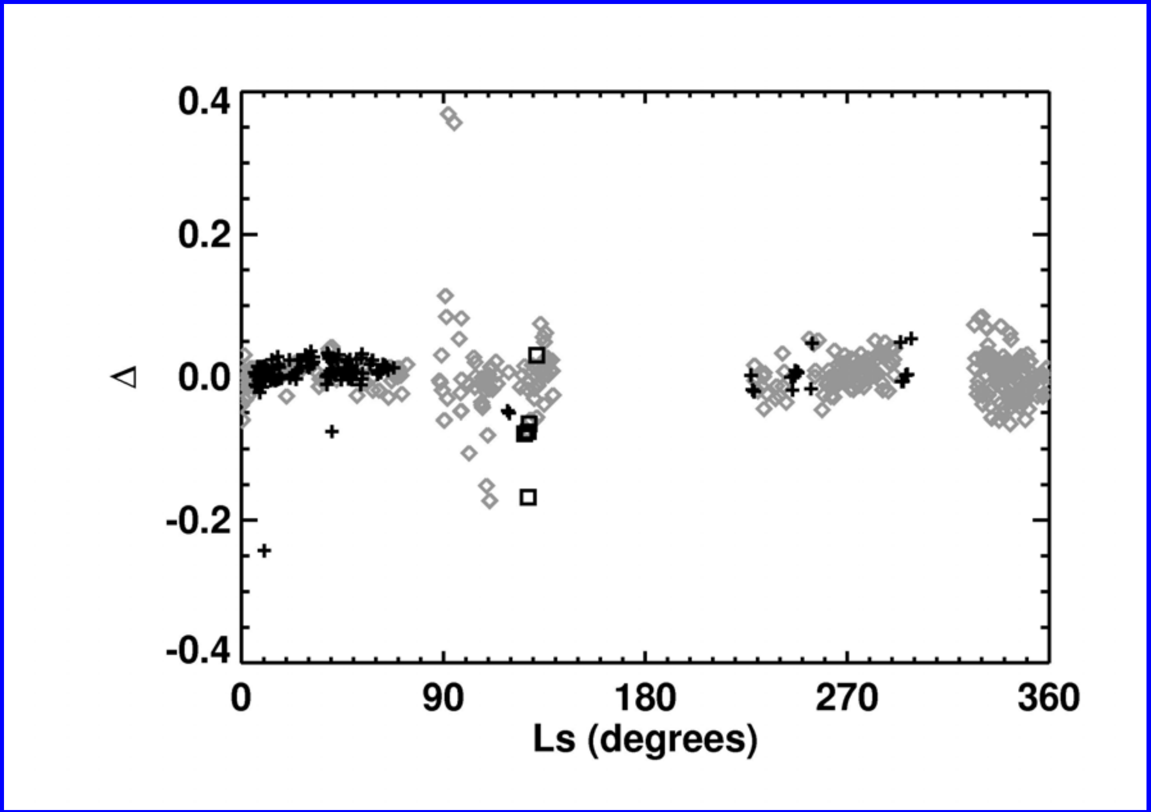
23 MEX ODF profiles
11 from 2008 (grey diamonds)
12 from earlier years (black crosses)

Predictions are much worse for 2008 ODF profiles than earlier ODF profiles

Predictions of Ps for ODF MEX profiles

- 23 ODF MEX profiles
  - Mean Δ = 16.0%, SD Δ = 19.6%
- ODF MEX profiles at Ls=88 to 120
  - 12 profiles, Mean Δ = 32.9%, SD Δ = 6.9%
  - 2008 DOY 174 to DOY 241
- ODF MEX profiles at other seasons
  - 11 profiles, Mean Δ = -2.5%, SD Δ = 8.5%
  - 2005 to 2007

Predictions of Ps for non-ODF MEX



Black squares are 5 MEX profiles between Ls=120 and L=180, below +1 km altitude and within 45 degrees of equator (mean D = -7.1%, SD D = 7.0%)

Black crosses are 132 MEX profiles at other seasons that are below +1 km and within 45 degrees of equator

Grey diamonds are 324 remaining MEX profiles. 23 ODF MEX profiles not shown

Predictions of Ps for non-ODF MEX profiles (2)

- All 461 non-ODF MEX profiles
  - Mean Δ = 0.2%, SD Δ = 4.0%

- Ls=120 and L=180, below +1 km altitude and within 45 degrees of equator
  - 5 MEX profiles, mean Δ = -7.1%, SD Δ = 7.0%
- Below +1 km altitude and within 45 degrees of equator
  - 137 MEX profiles, mean Δ = -0.2%, SD Δ = 3.3%

- 52 non-ODF MEX profiles in 2008
  - Mean Δ = 0.3%, SD Δ = 8.7%
- 409 non-ODF MEX profiles in earlier years
  - Mean Δ = 0.2%, SD Δ = 2.9%
- Non-ODF MEX profiles from 2008 have much more scatter about predicted surface pressure than non-ODF MEX profiles from earlier years, although there are no systematic errors

Predictions of Ps for non-ODF MEX profiles (3)

- Eight of 461 non-ODF profiles have $|\Delta| > 0.1$
- Six of these eight are near Hellas or Argyre
  - Local variations in topography are a problem?
- Six of these eight were acquired in 2008
  - Processing of data is still in progress?

List of the 8 non-ODF MEX profiles that have $|\Delta| > 0.1$

- 2004/DOY_347_1155_NNO/M32ICL2L04_AIX_043470654_54.TAB
- 2006/DOY_042_2678_NNO/M32ICL2L04_AIX_060421223_54.TAB
- 2008/DOY_179_5761_NNO/M32ICL2L04_AIX_081791037_54.TAB
- 2008/DOY_182_5771_NNO/M32ICL2L04_AIX_081820705_54.TAB
- 2008/DOY_188_5792_NNO/M32ICL2L04_AIX_081880652_54.TAB
- 2008/DOY_203_5844_NNO/M32ICL2L04_AIX_082030305_54.TAB
- 2008/DOY_220_5904_NNO/M32ICL2L04_AIX_082200545_54.TAB
- 2008/DOY_223_5915_NNO/M32ICL2L04_AIX_082230904_54.TAB

Conclusions

- (1) Surface pressures in ODF MEX profiles from 2008 are 30% smaller than (A) observed by MGS and (B) predicted
- Surface pressures in ODF MEX profiles from earlier years appear OK
- Surface pressures in ODF MEX profiles from 2008 have similar scatter about predictions as from earlier years

- Mean surface pressures in non-ODF MEX profiles from 2008 and earlier years are consistent with predictions
- (2) Surface pressures in non-ODF MEX profiles from 2008 have 3x scatter about predictions than from earlier years

- Can the causes of effects (1) and (2) be identified?

Return to VL1 and VL2

- MEX – VL1 comparison
  - 5 MEX profiles from 2004 to 2006, all ICL or RSR profiles
- MEX – VL2 comparison
  - 8 MEX profiles from 2004 to 2007, 1 ODF profile at Ls=260
- So effects (1) and (2) identified in conclusions should not spoil MEX-VL comparison, and they don't