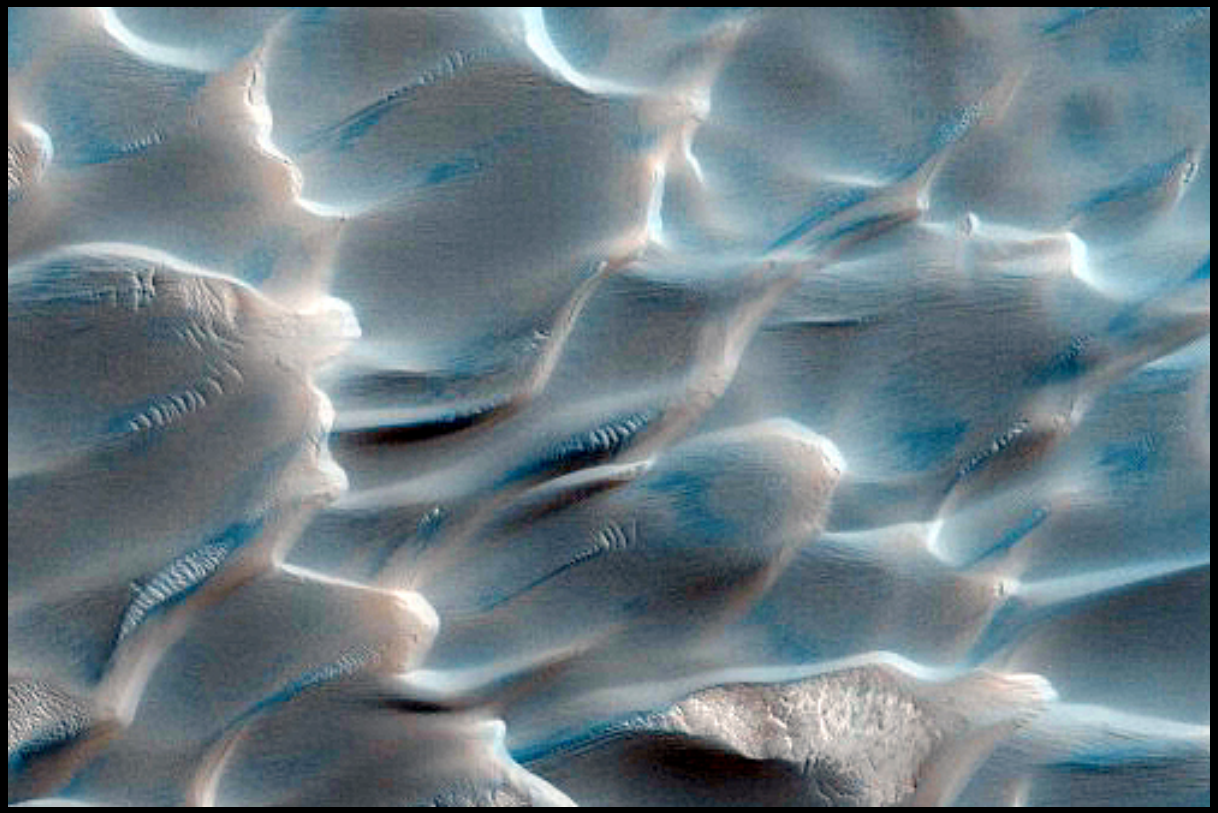


NASA/MRO/HiRISE

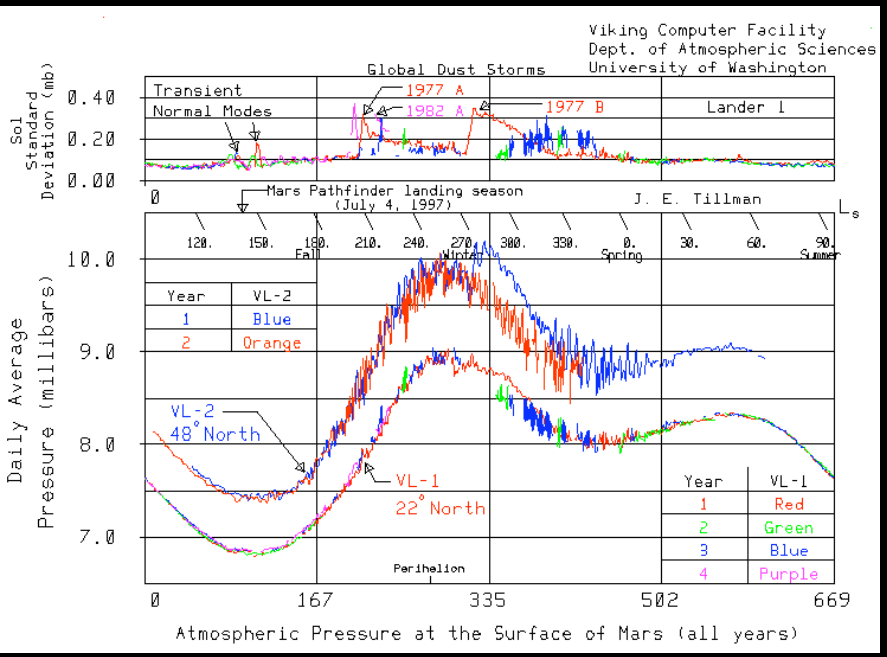
Volatile Exchange on Mars

Maria T. Zuber
MIT
David E. Smith
NASA/GSFC

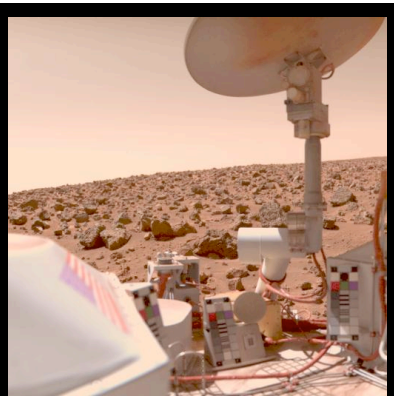
16th International Workshop on Laser Ranging
Poznan, Poland
13 October 2008

Seasonal Variation of Surface Pressure

Viking Surface Pressure Measurements

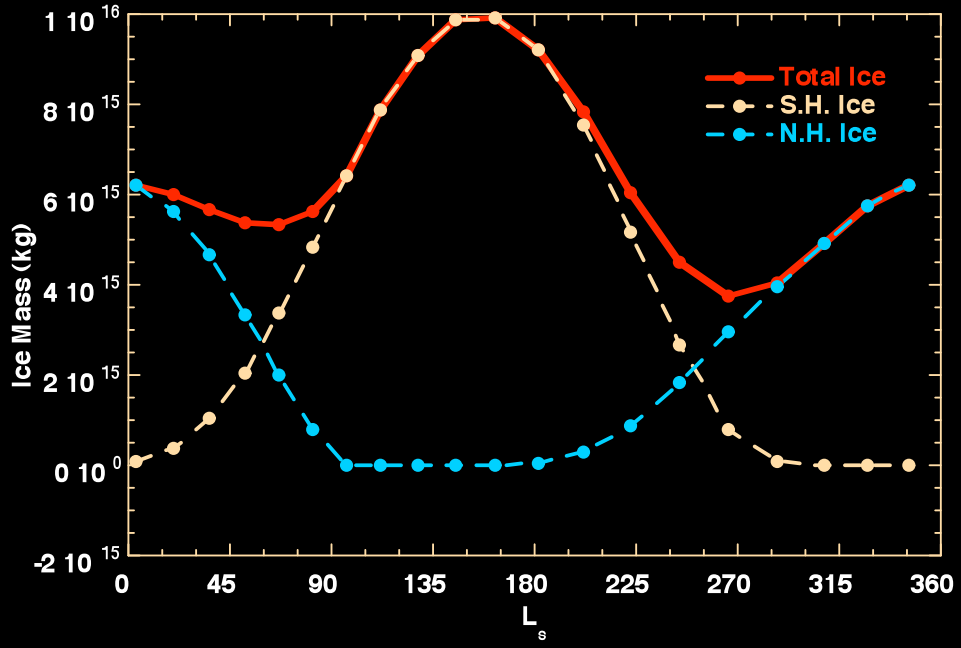


Tillman [1985]



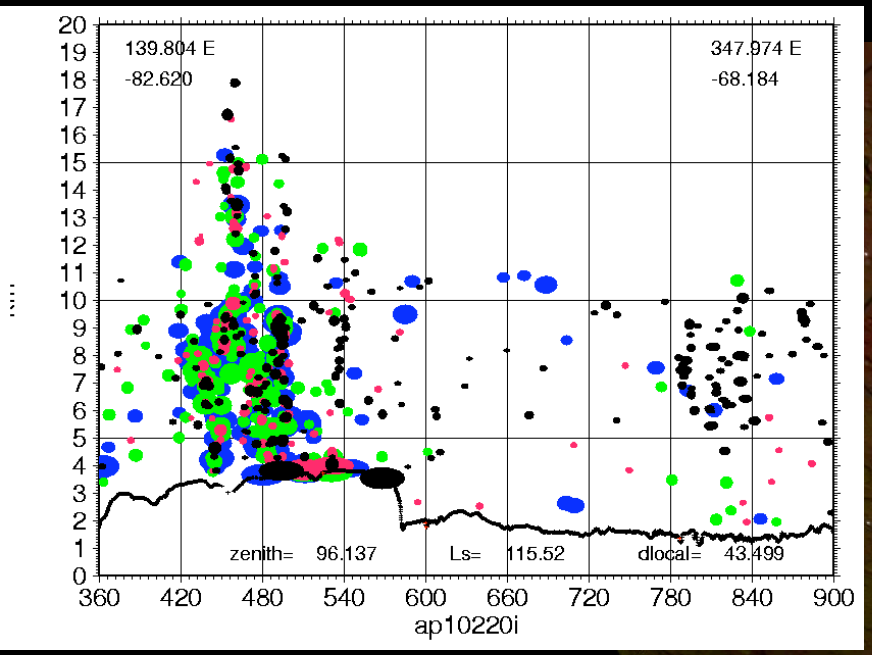
NASA/Viking

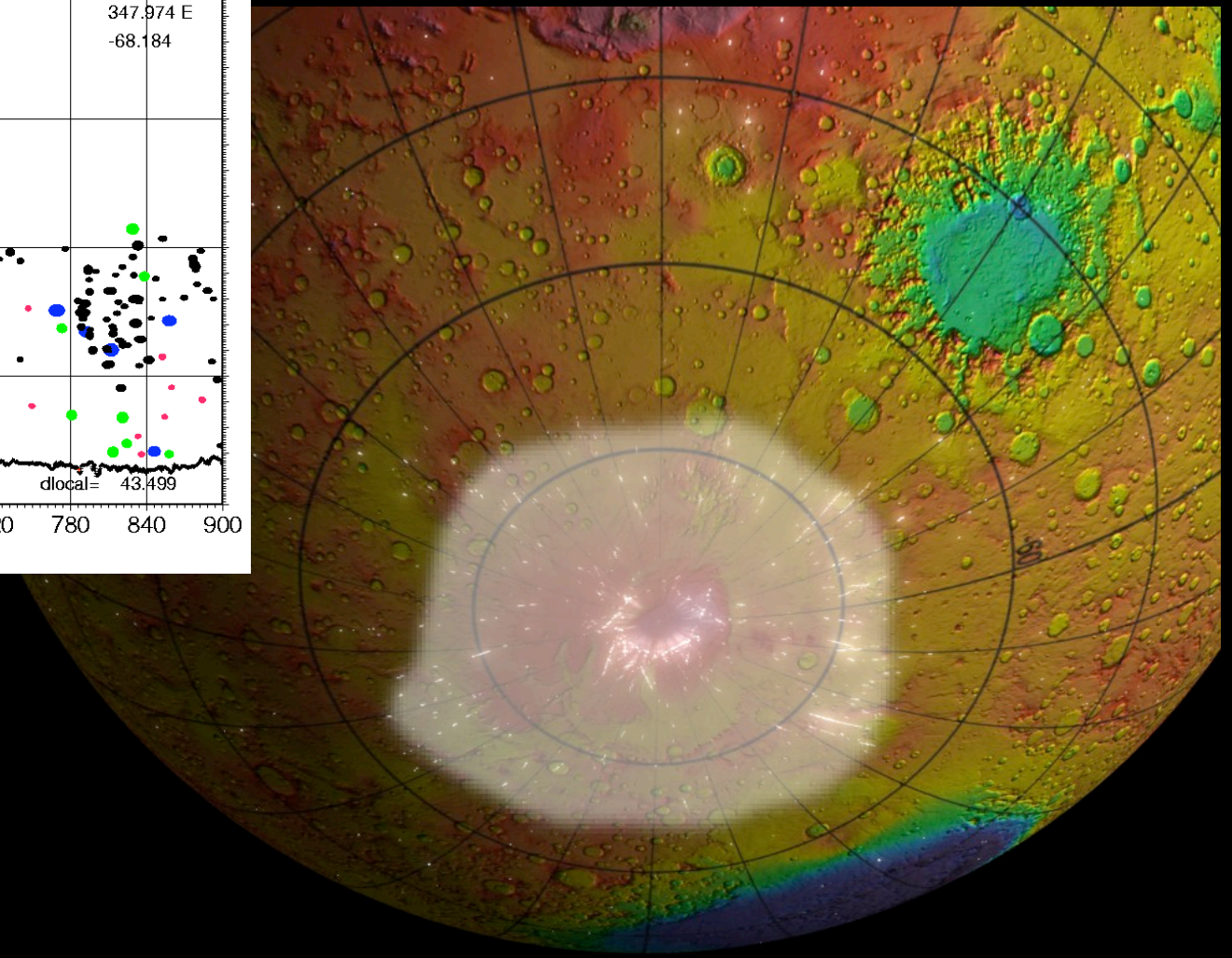
GCM Simulated Seasonal Mass Variation



Smith et al. [1999]

CO_2 Condensation During South Polar Night

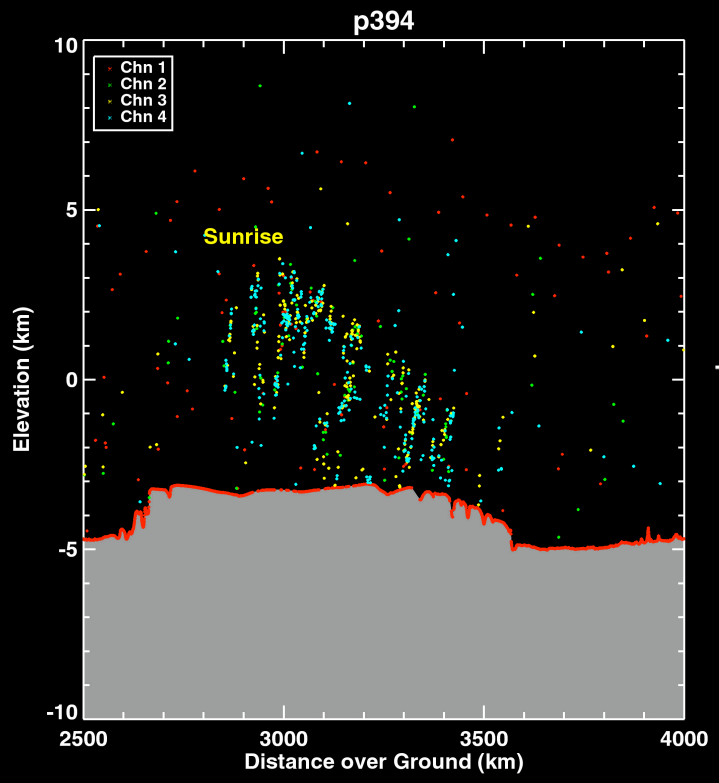




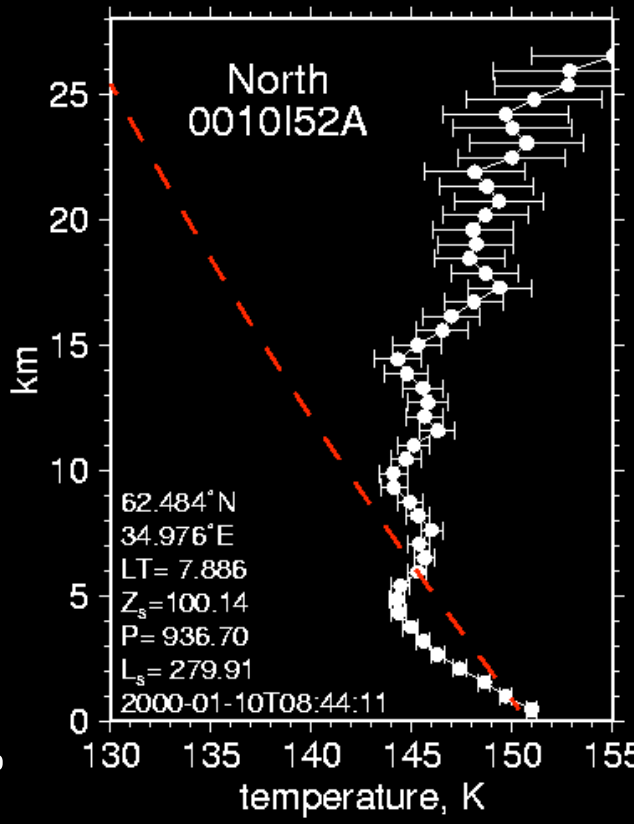
Channel 1 - 3 m (BLACK)
Channel 2 - 9 m (RED)
Channel 3 - 27 m (GREEN)
Channel 4 - 81 m (BLUE)

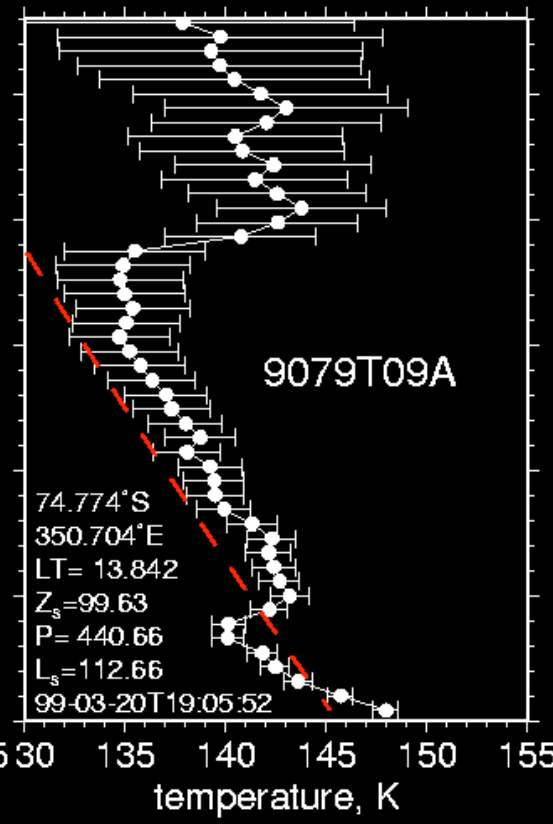
Neumann et al. [2003]

Temperature Profiles from Radio Science During Polar Winter Night



Neumann et al. [2002]

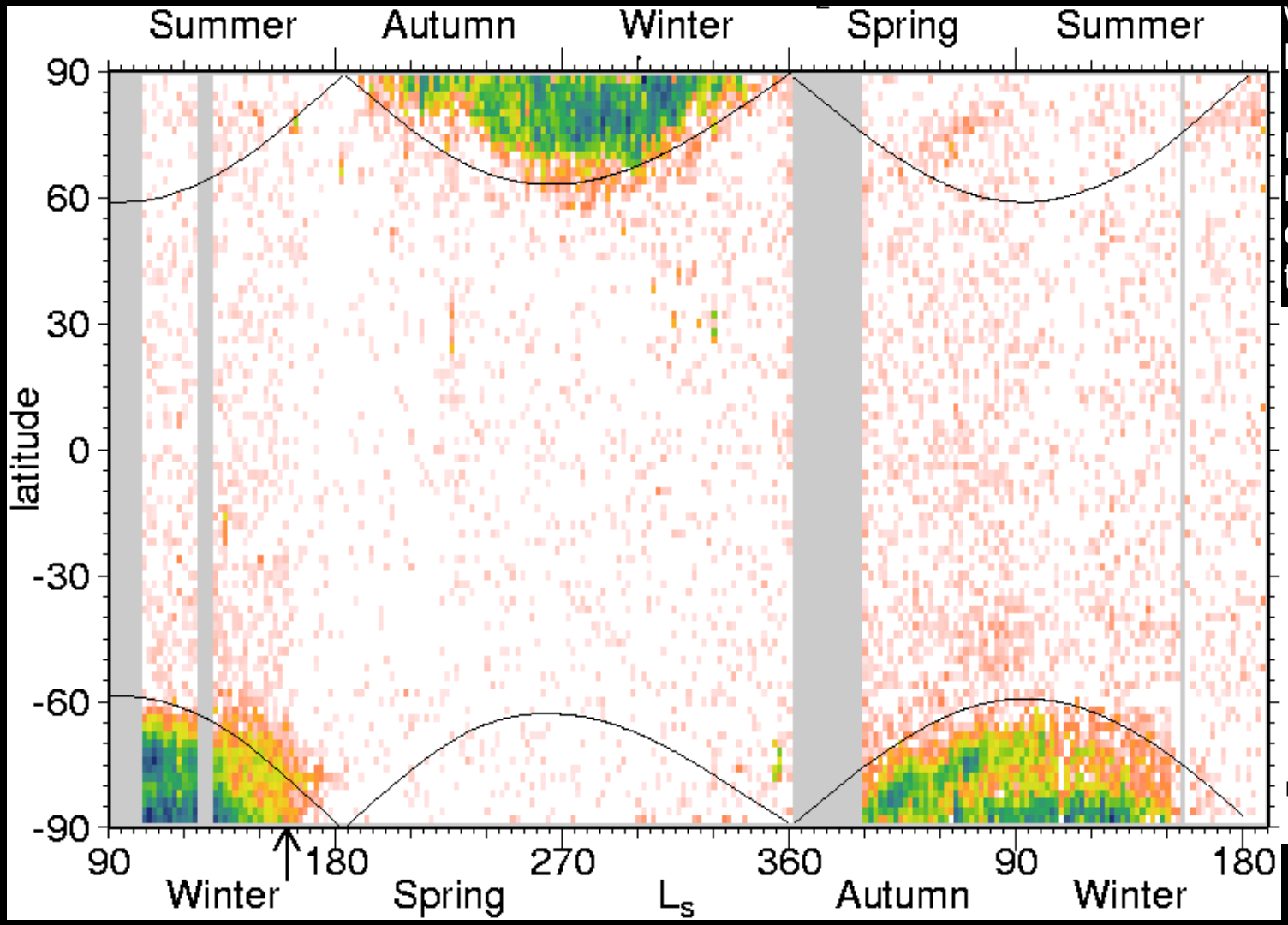




Hinson et al. [1999; 2001]

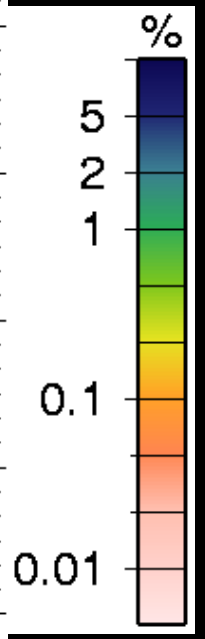
- Near-surface temperatures buffered by CO_2 ice, hovering near CO_2 saturation with a lapse rate of -0.85 K km^{-1}.
- CO_2 clouds nucleate spontaneously at 2 K below saturation, possibly as snow.
- Equilibrium restored as clouds release latent heat and lower PCO_2. Neumann et al. [2003]

Cloud Density Averaged by Latitude and L_s



Noise level varies with threshold and laser output.

Dark curves show limits of along-track day/night terminator.



Cloud returns as % of shots

Neumann et al. [2003]

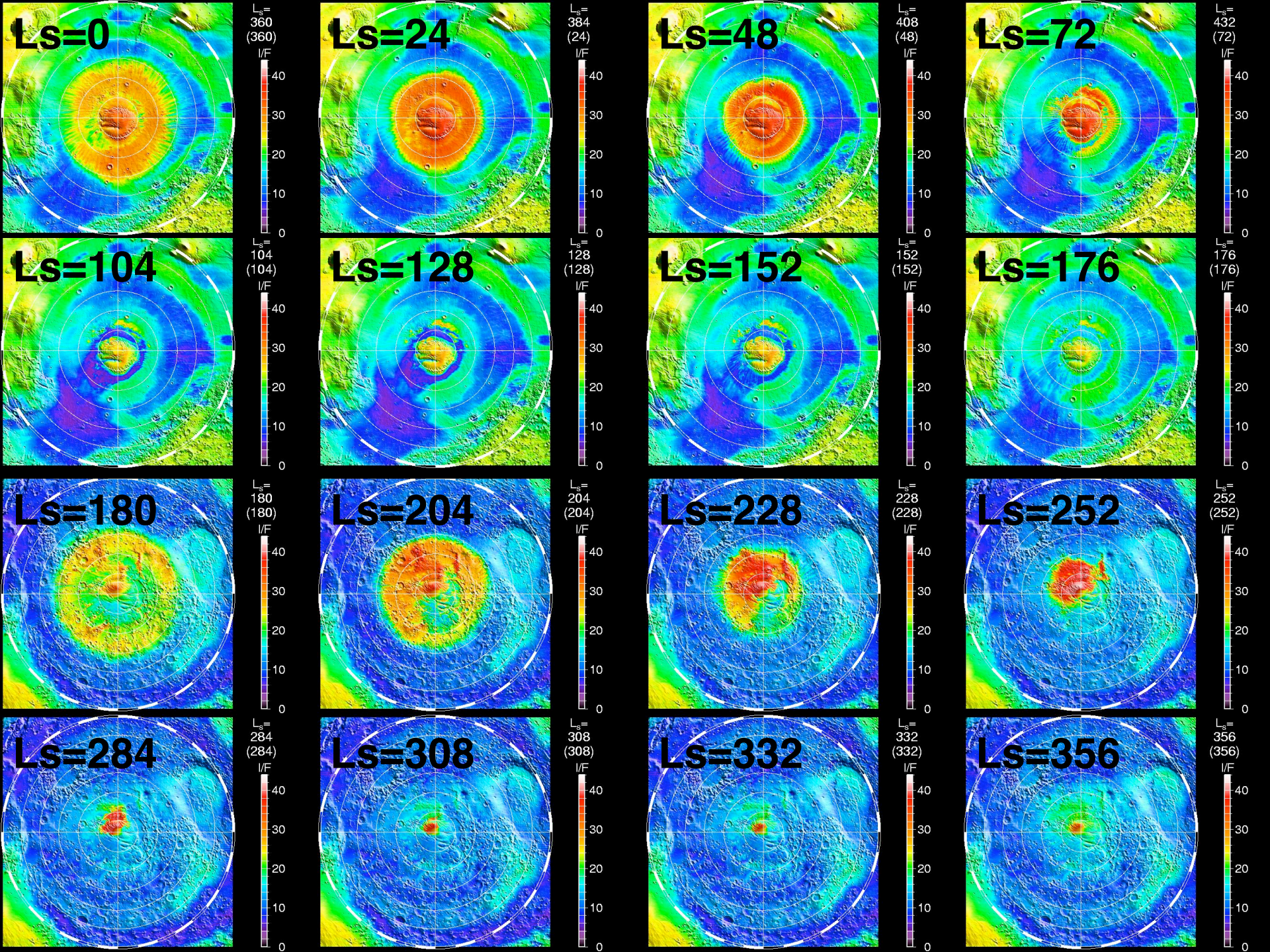
Approach

- Model seasonal CO_2 mass exchange between Martian atmosphere and polar caps.

- Treat season caps as “mascons” and solve for mass within specified geometric shapes every 5 days.

- Use Mars Global Surveyor (MGS) thermal emission (TES) and altimetry (MOLA) data to model latitudinal extent of condensed CO_2 and MOLA altimetry to approximate the vertical dimension of shape of anomalous masses.

- Estimate mass of material exchanged with atmosphere from perturbations of orbit of MGS spacecraft from X-band tracking data.


Ls=0
Ls=24
Ls=48
Ls=72
Ls=104
Ls=128
Ls=152
Ls=176
Ls=180
Ls=204
Ls=228
Ls=252
Ls=284
Ls=308
Ls=332
Ls=356
I/F
0
10
20
30
40

Details

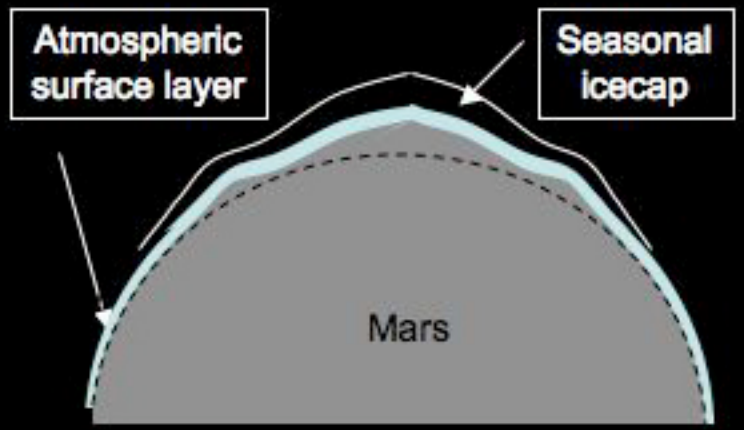
- Model season polar caps, and seasonal variations in atmospheric mass.

- Treat seasonal polar caps as cones that overlie topography with radial extent coming from TES bolometric observations and elevation from MOLA.

- Model variable component of seasonal atmospheric mass as a surface layer overlaying the topography.
  - *Model 1* assumes atmosphere is a surface layer between the polar caps.
  - *Model 2* assumes atmosphere is a global surface layer.

Simple Model of Mars' Seasonal Polar Caps of Mars

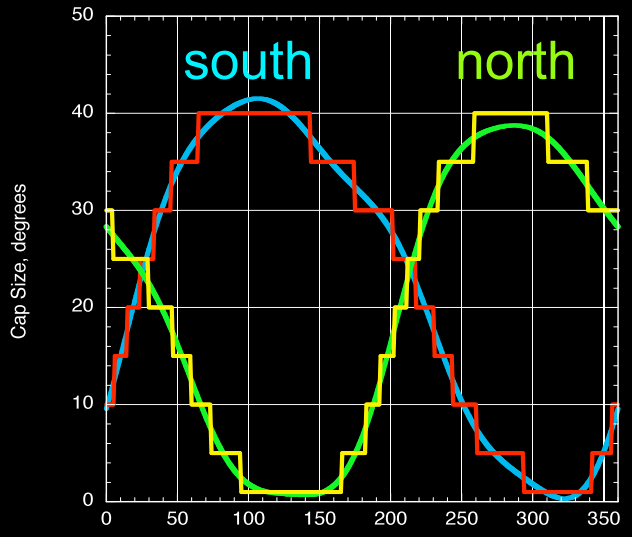
1



Cap Model

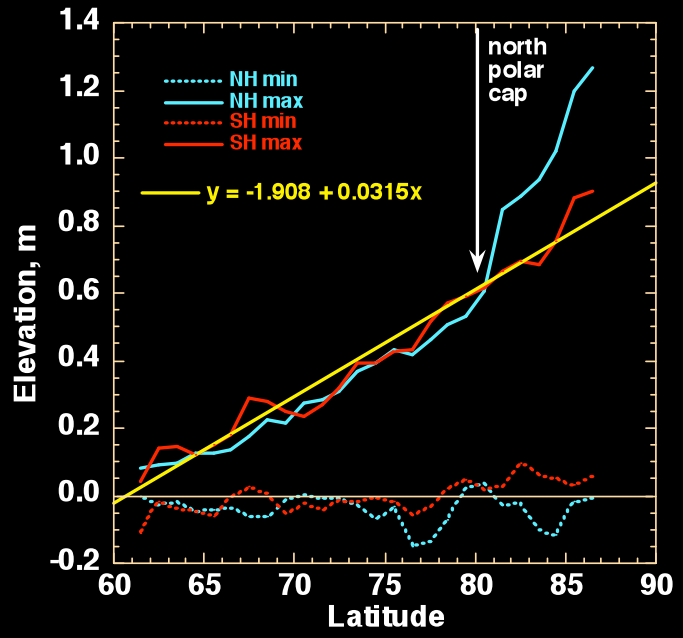
2

Cap sizes from MGS-TES



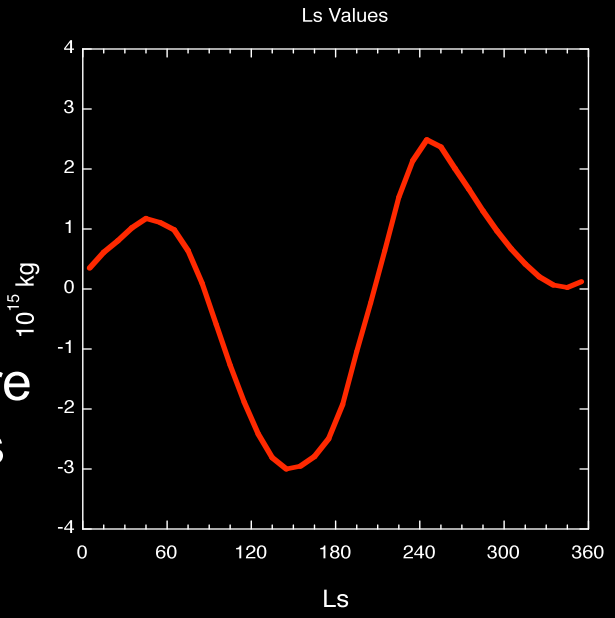
3

CO_2 snow depth from MGS-MOLA

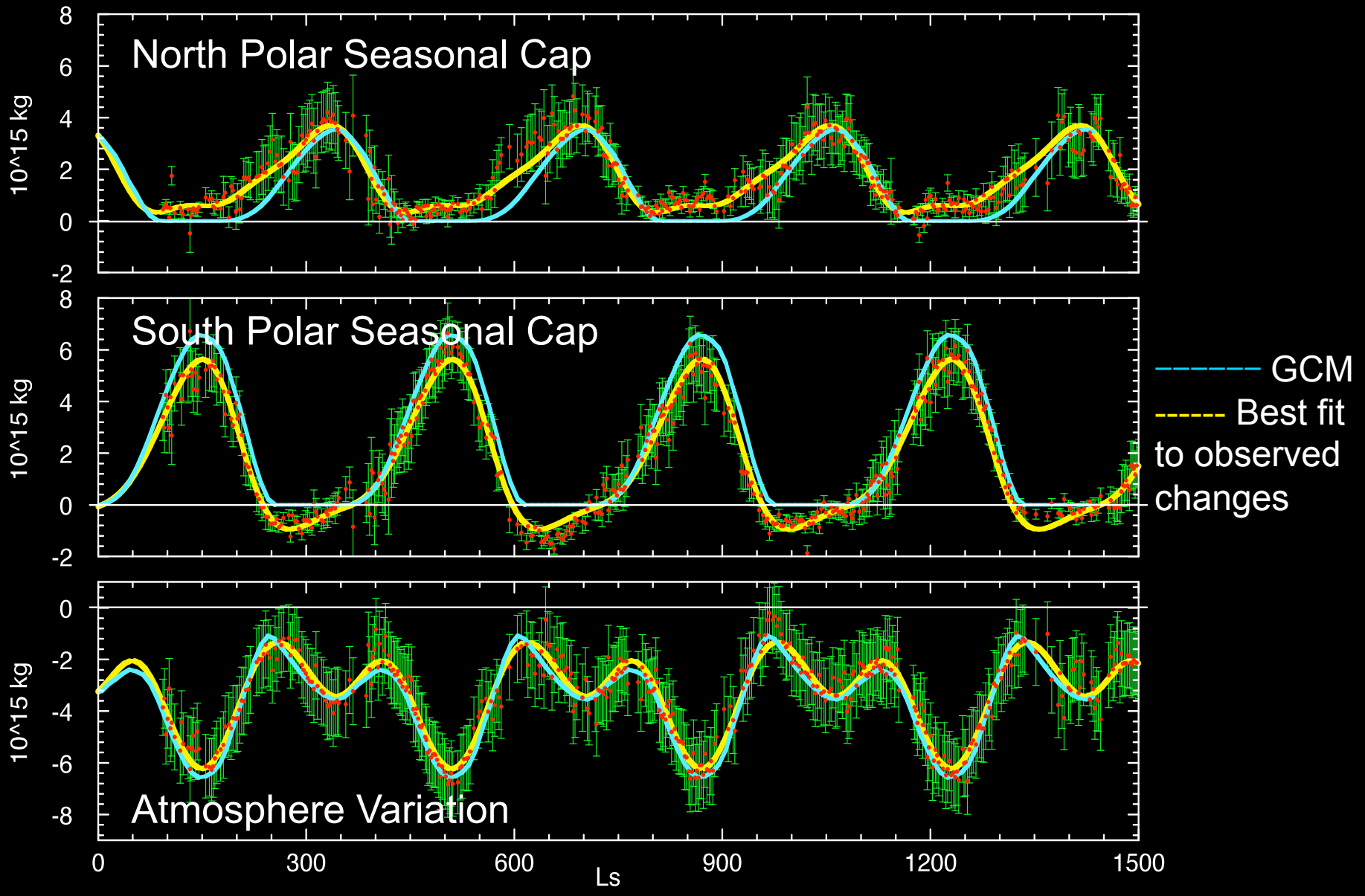


4

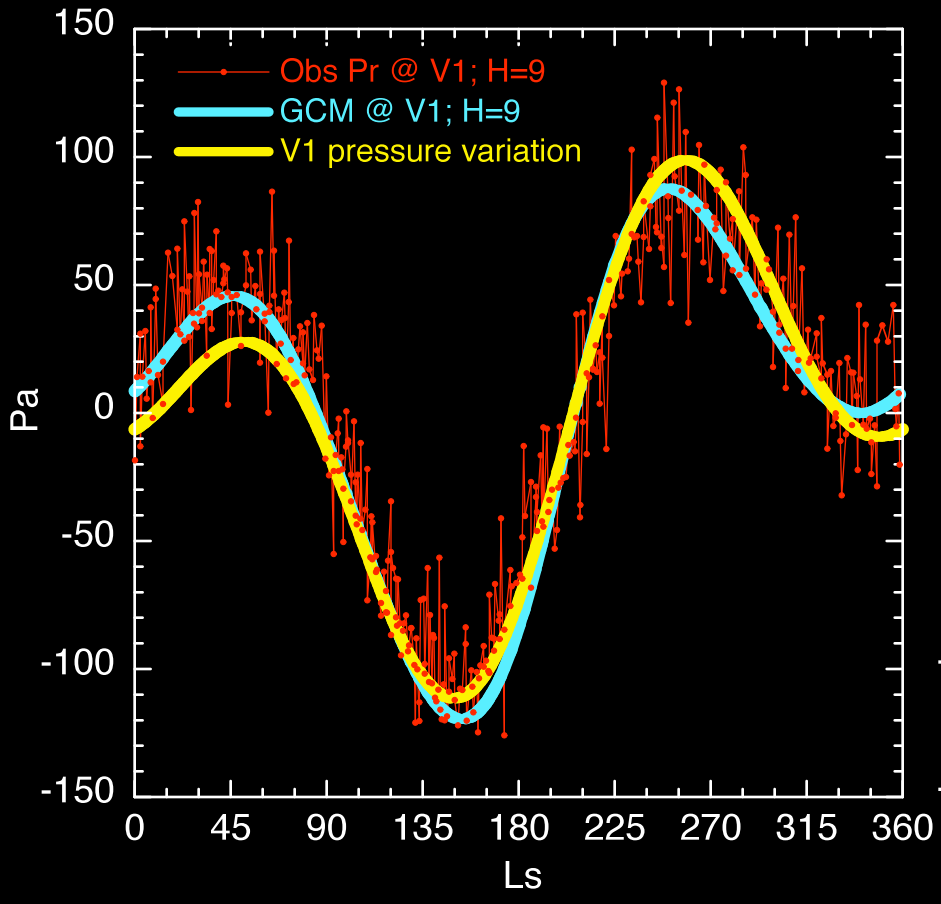
A priori atmosphere from Ames GCM

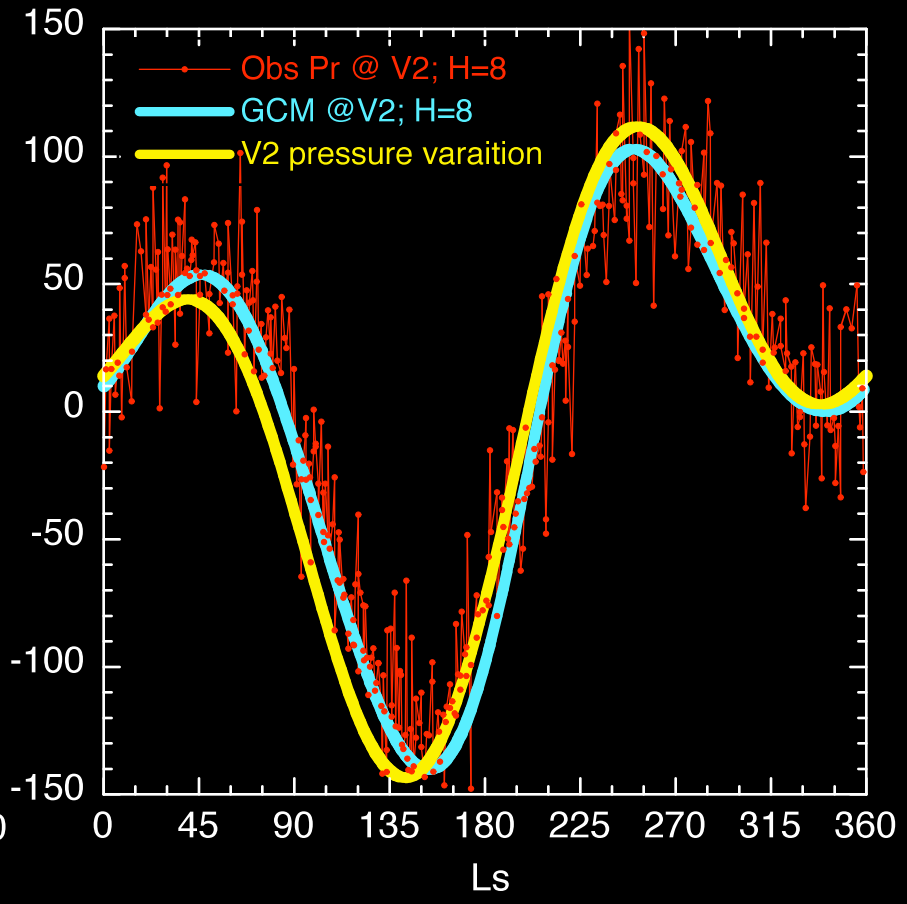


Seasonal Mass Changes over 4 Mars Years



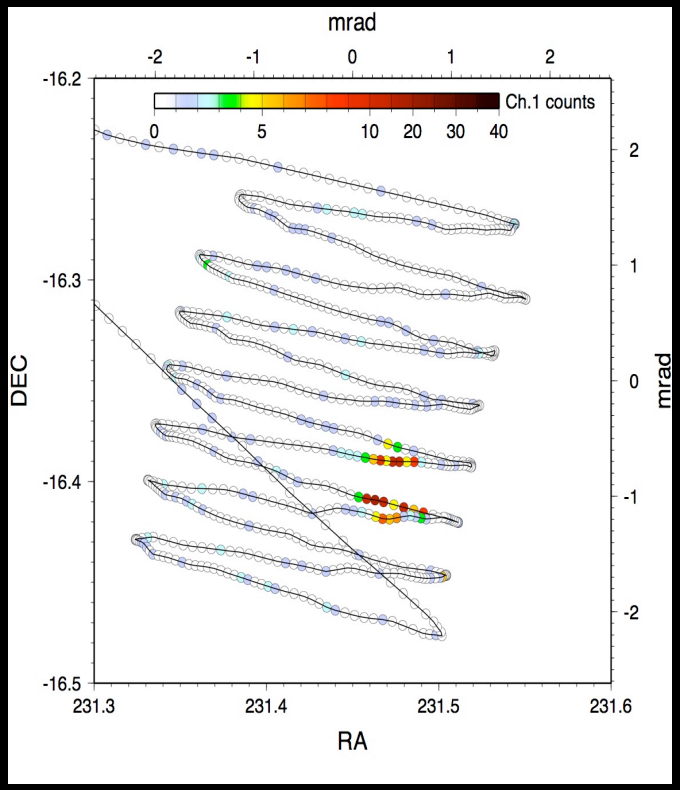
Mean Atmospheric Pressure @ V1 and V2

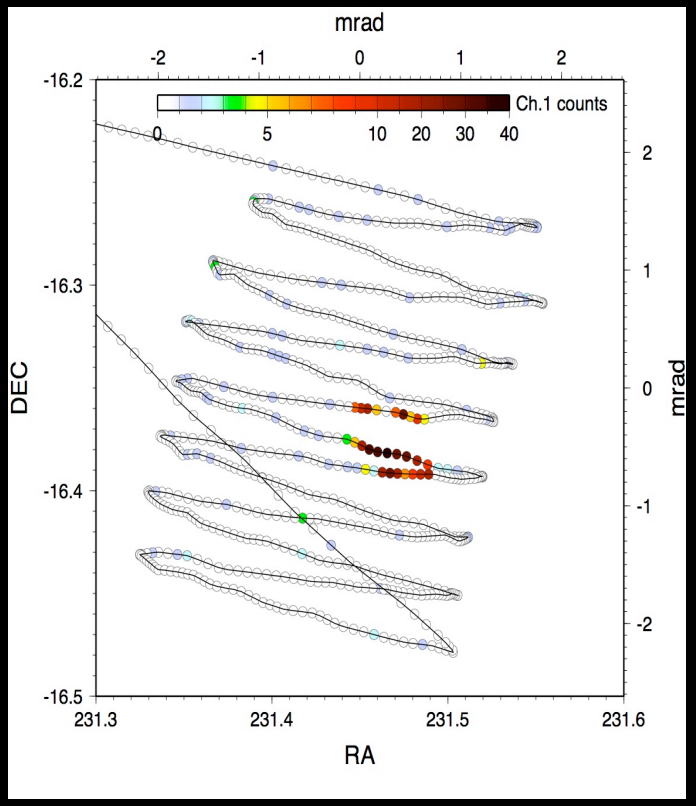




➔ Mean atmospheric pressure derived from global variation in atmospheric mass and used to infer pressure at the two Viking lander sites taking into account their altitudes.

The Future





Abshire et al. [2008]

- Laser ranging would improve s/c position & ephemeris of Mars.
  - ➔ reduce systematic errors ideally enabling detection of subtle longterm effects.

Summary

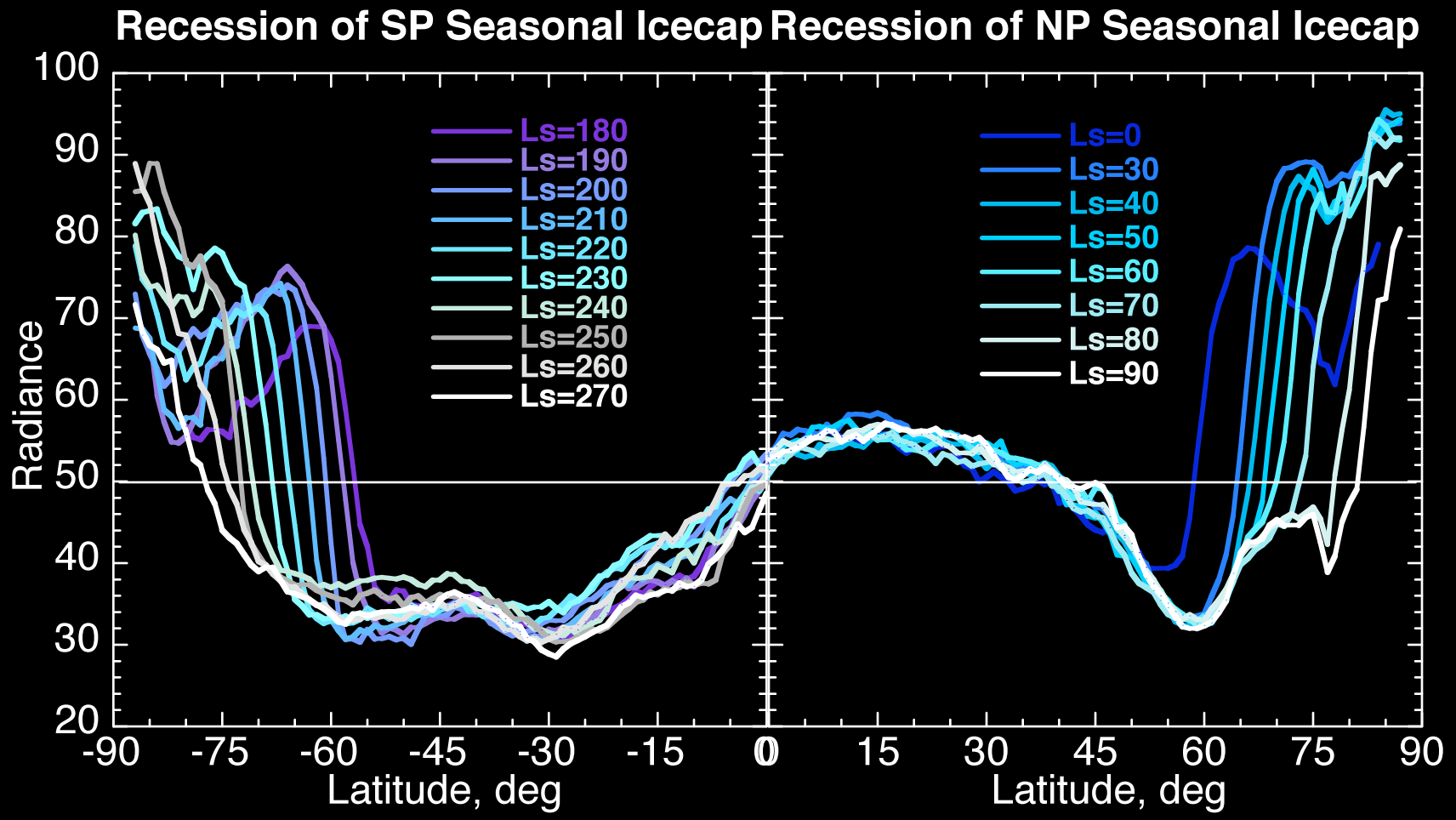
- Analyzed >4 Mars years (~8 Earth-years) of X-band tracking data from MGS.

- Excellent agreement on magnitude of signal with NASA/Ames GCM, but differences also exist:
  - more rapid accumulation in Fall season
  - non-zero “summer” mass

- MRO is extending time series and will eventually reduce systematic errors in gravity field recovery, but challenge to merge different spacecraft observations.

- Goal is to detect interannual (decadal) variability in seasonal mass exchange.
  - laser ranging would help

NASA/MRO/HiRISE



Passive radiometry data provides variation in radiance with latitude averaged over all longitudes.
The edge of the cap is taken to have a radiance of 50 and used to monitor the size of each seasonal icecap.