Seasonal Variation of Surface Pressure

Viking Surface Pressure Measurements

<table>
<thead>
<tr>
<th>Year</th>
<th>VL-2</th>
<th>VL-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>23°N</td>
<td>22°N</td>
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</tbody>
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Tillman [1985]

GCM Simulated Seasonal Mass Variation

Smith et al. [1999]

NASA/Viking
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]
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. [2002]

Hinson et al. [1999; 2001]
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.
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
   - Atmospheric surface layer
   - Seasonal icecap

2. Cap sizes from MGS-TES
   - South
   - North

3. CO₂ snow depth from MGS-MOLA
   - CO₂ snow depth
   - Elevation, m
   - Latitude
   - y = -1.908 + 0.0315x

4. A priori atmosphere from Ames GCM
   - Ls Values
   - 10^-15 kg
   - Ls
   - 0 to 360
Seasonal Mass Changes over 4 Mars Years

North Polar Seasonal Cap

South Polar Seasonal Cap

Atmosphere Variation

GCM

Best fit to observed changes
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.
• Laser ranging would improve s/c position & ephemeris of Mars.
  ➔ reduce systematic errors ideally enabling detection of subtle longterm effects.
• 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
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.