# THE MARTIAN LOWER ATMOSPHERE

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## Topics:

- **Mass and composition**
- **Photochemical processes**
- **Temperatures and winds**
- **General Circulation**
- **Dust storms**

## BASIC PROPERTIES OF MARS AND EARTH

| PLANETARY PROPERTIES | MARS | EARTH |
|---|---|---|
| MASS, kg | $6.46 \times 10^{23}$ | $5.98 \times 10^{24}$ |
| RADIUS, m | 3394 | 6369 |
| ACCELERATION OF GRAVITY, $m/sec^2$ | 3.72 | 9.81 |
| ORBIT ECCENTRICITY | 0.093 | 0.017 |
| SPIN-AXIS INCLINATION, deg | 25.2 | 23.5 |
| LENGTH OF YEAR, Earth days | 687 | 365 |
| LENGTH OF SOLAR DAY, sec | 88,775 | 86,400 |
| SOLAR CONSTANT, $W/m^2$ | 591 | 1373 |

| ATMOSPHERIC PROPERTIES | MARS | EARTH |
|---|---|---|
| PRINCIPAL CONSTITUENTS, by volume | $CO_2$ (95.3%)<br>$N_2$ (2.7%)<br>$Ar^{40}$ (1.6%)<br>$O_2$ (0.13%) | $N_2$ (78.1%)<br>$O_2$ (20.9%)<br>$Ar^{40}$ (0.9%)<br>$CO_2$ (0.03%) |
| MEAN MOLECULAR WEIGHT | 44 | 29 |
| TOTAL MASS, kg | $2.4 \times 10^{16}$ | $5.3 \times 10^{18}$ |
| MEAN SURFACE PRESSURE, mbar | 6 | 1013 |
| NEAR-SURFACE TEMPERATURE RANGE, K | 145-245 | 220-310 |

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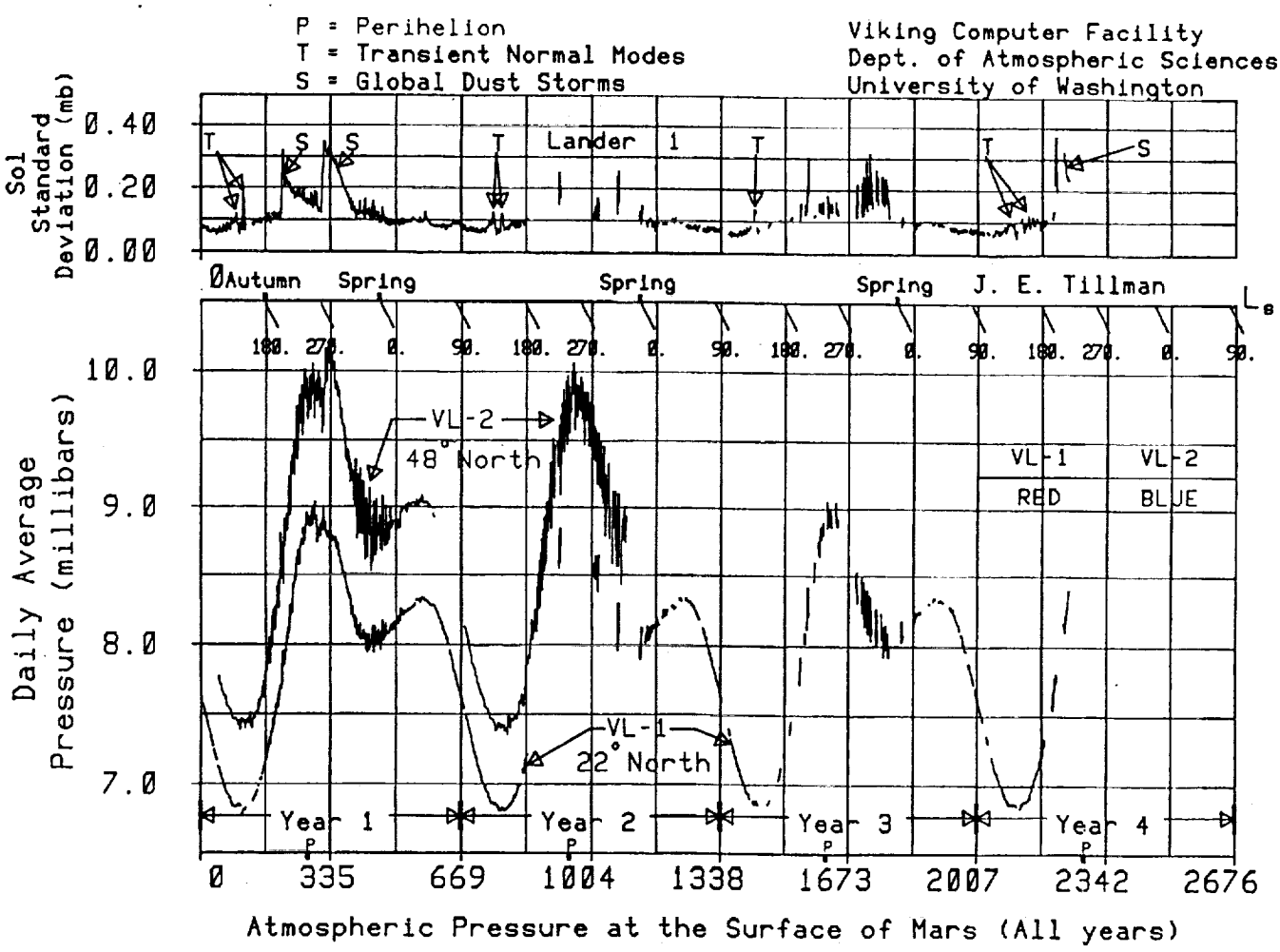
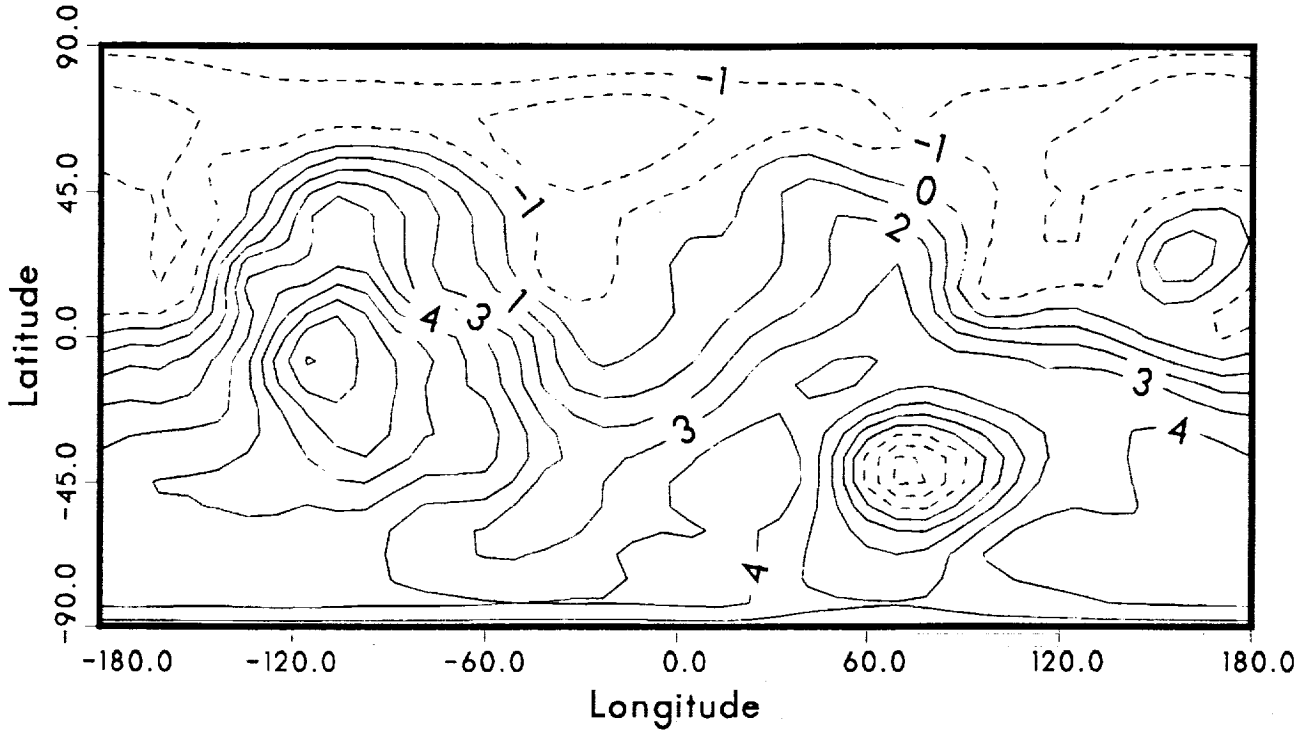
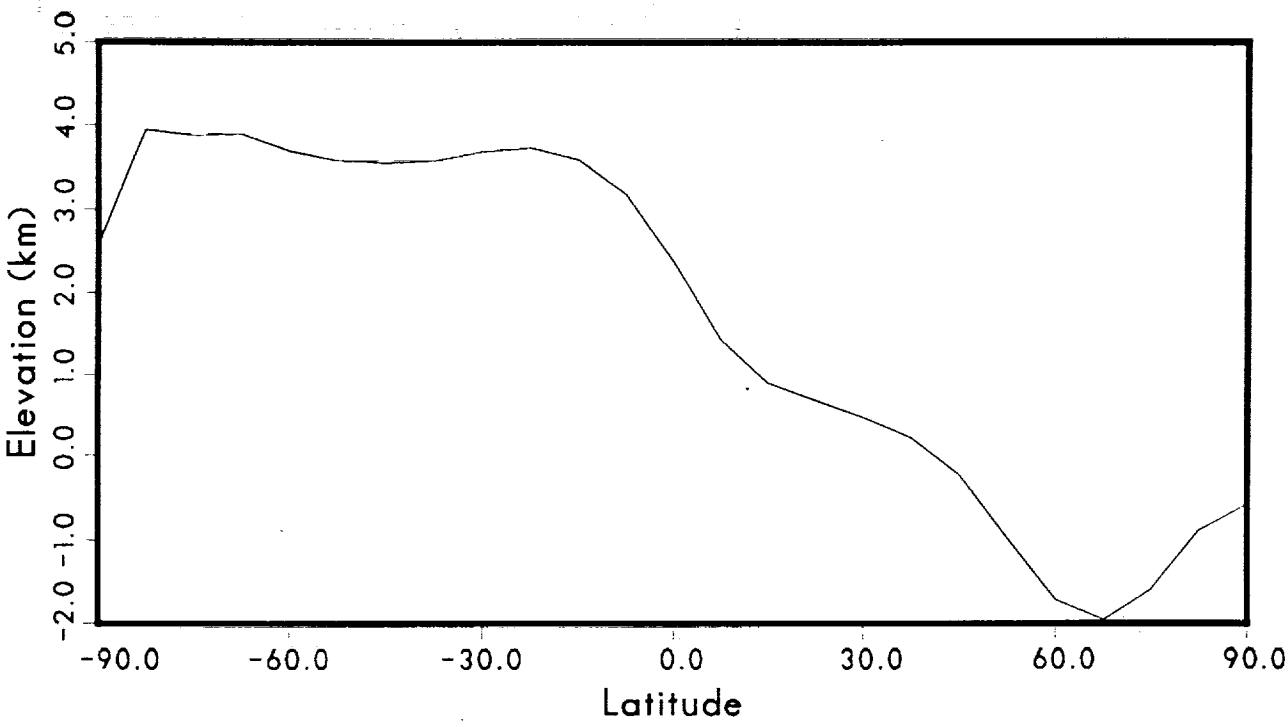
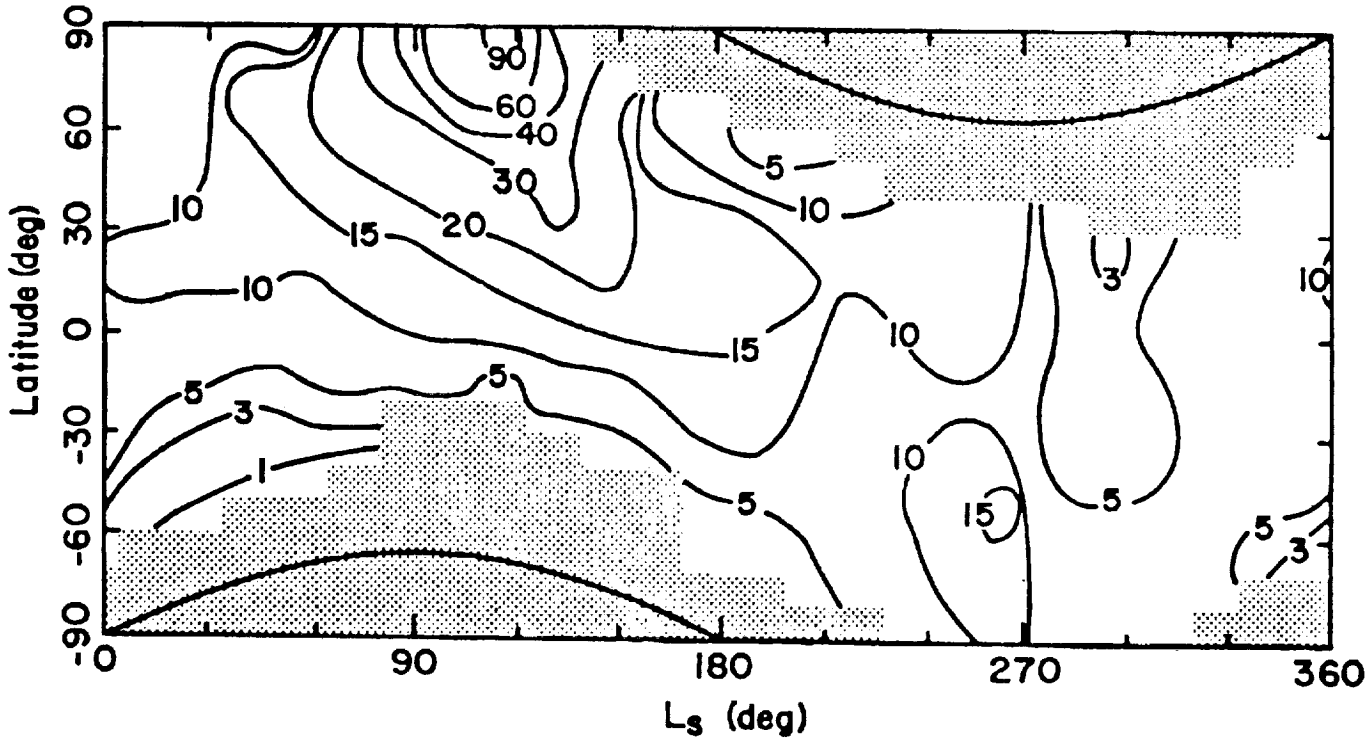


# Topography (DTM)

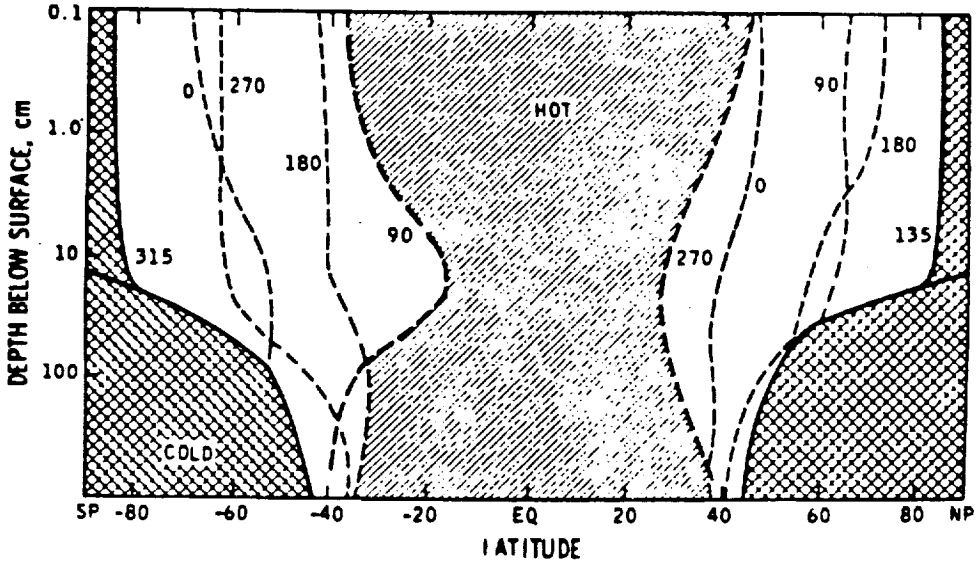



# Zonally Averaged Topography






Jarosky, B.M. and Farmer, B., J. Geophys. Res., 87, 2999-3019, 1982, copyright by the American Geophysical Union.

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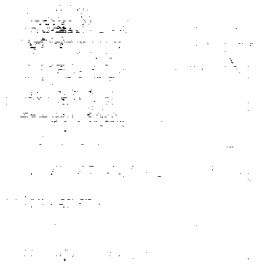

| Particles in the atmosphere | Measurement | Model | Ideas | Notes |
|---|---|---|---|---|
| composition | | < 60% $SiO_2$<br>1% magnetite | | $SiO_2$ measurement based on inferences from Mariner 9 IRIS spectra - loosely constrained. Value quoted is higher than Viking lander soil elemental composition measurements. |
| density | | | $\rho$ = 2-3 gm/cm$^3$ | Based on typical silicate rock densities. Considered a good estimate. |
| size distribution | | range: r = 0.1 - 10 μm<br>mean: r = 0.4 - 2.5 μm | | Measurements based on inferences from Mariner 9 IRIS spectra, and Viking Lander Sun Diode images. Considerable uncertainty in concentrations of sub-micron particles. Means are cross-sectional weighted. |
| concentration | | $N \sim N_0 \tau \exp(-z/H)$<br>where $N_0$ = 6 particles/cm$^3$, $\tau$ is the visible optical depth, z is height (km), and H = 10 km is an atmospheric scale height. | | Based on the Mariner 9 inferred particle size distribution assuming r = 2.5 μm and $\rho$ = 3 gm/cm$^3$. See Appendix A. |

| | | | | |
|---|---|---|---|---|
| vertical distribution | Background dust haze extends 30-70 km above the surface. During great dust storms, particles can reach 70 km. | | Background dust haze: particles are unifromly distributed with height. Developing storms: particles are concentrated near the surface in source regions; aloft elswhere. Particles with radii >> 5 μm fall out quickly. | Consistent with twilight observations and sky brightness measurements. Loosely constrained. |
| geographical distribution | Dust storm periods: regional to global. Non-dust storm periods: localized storms can occur anywhere. | | Maximum concentrations tend to occur in tropical regions. | Highly variable. |
| seasonal variability | Maximum dust loading occurs during southern spring and summer. | | | |
| optical properties | Solar optical depth varies from 0 to 6 or above. | $\tau_{vis}/\tau_{ir} \sim 2$<br>solar transmissivity ~ $(1+\frac{\tau}{2\mu})^{-1}$ | | Optical depth always > 0.2 at the Viking lander sites. Solar transmissivity is that for purely scattering dust particles, and is therefore an approximation. |
| ground visibility | | Visual Range (km) ~ 10 / $\tau$ | | Visual range for distinguishing a black target against a diffuse white background. |
| space-to-ground visibility | No surface features were visible from orbit during the first half of the 1971 storm. | | | |



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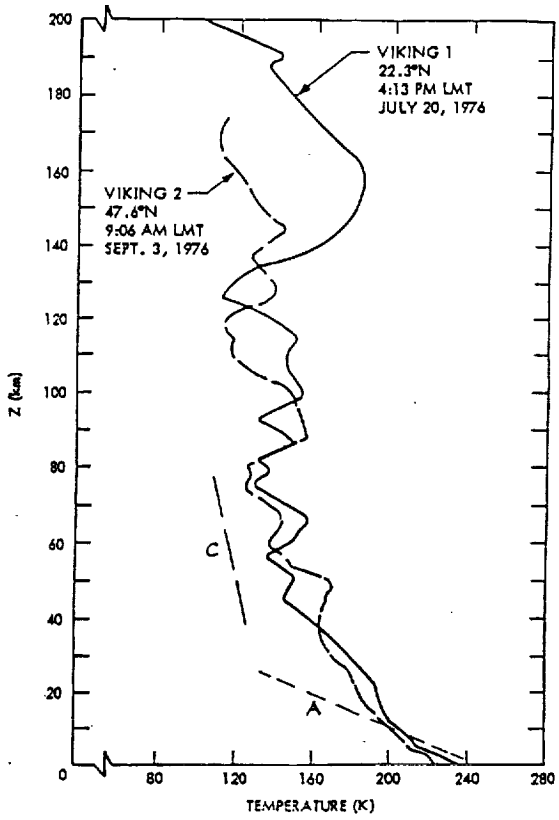
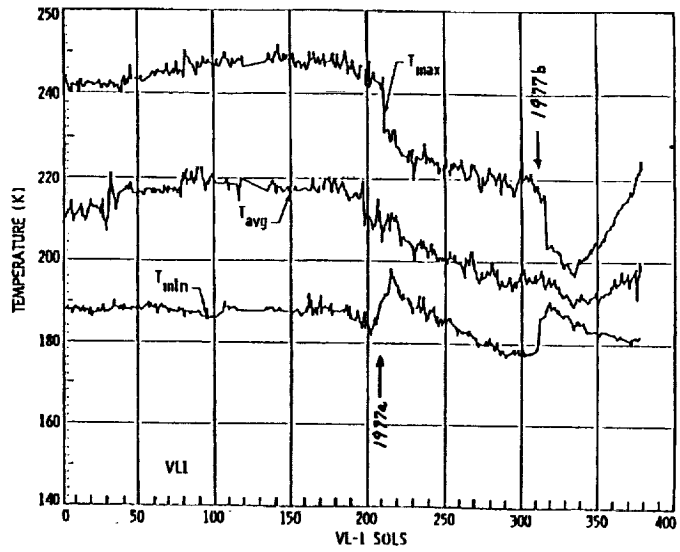



Seiff, A. and Kirk, D.B., J. Geophys. Res., 82, No. 28, 4364-4378, 1977, copyright by the American Geophysical Union.

DAILY AIR TEMPERATURES AT VIKING LANDER 1

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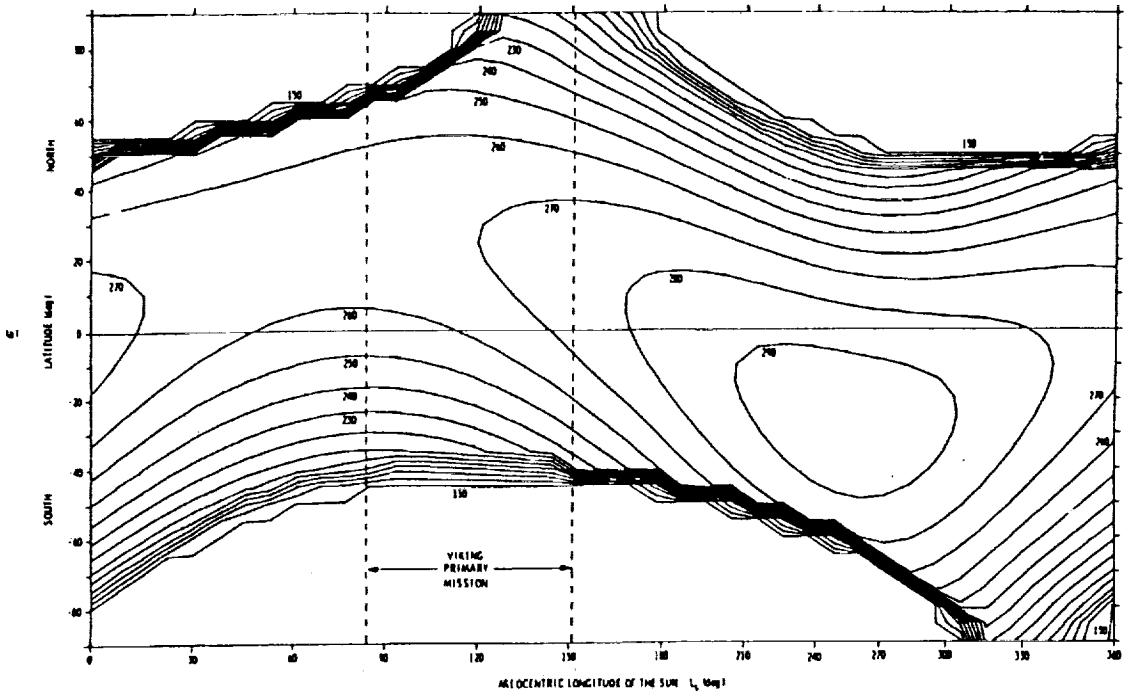



Fig. 18*a*

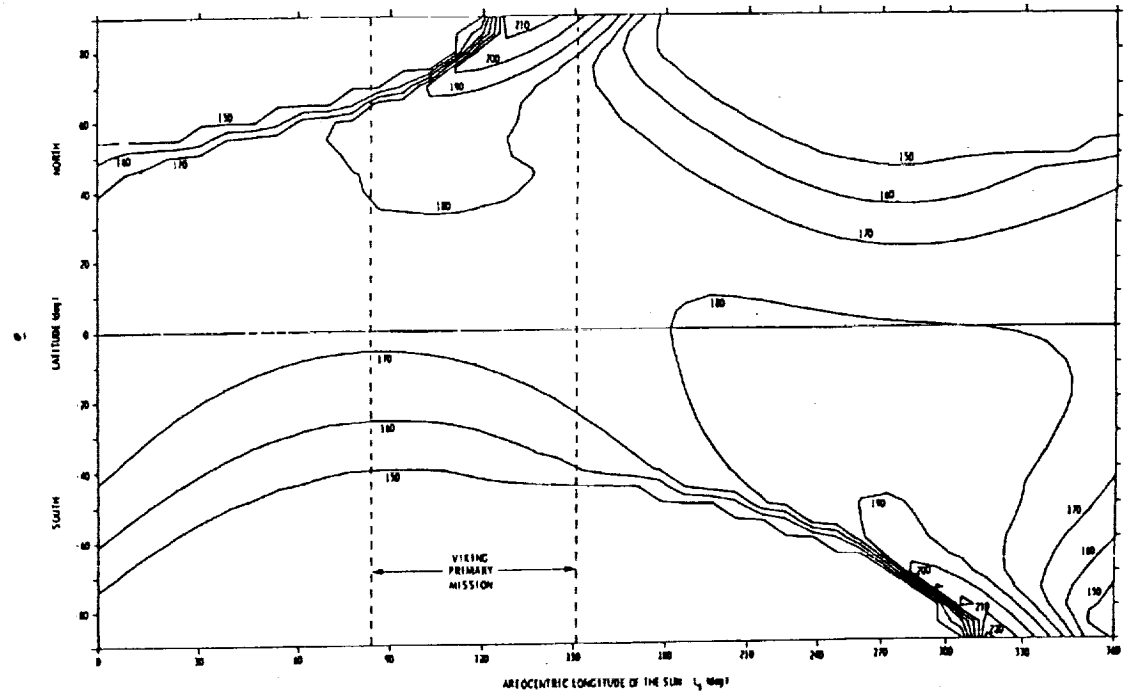
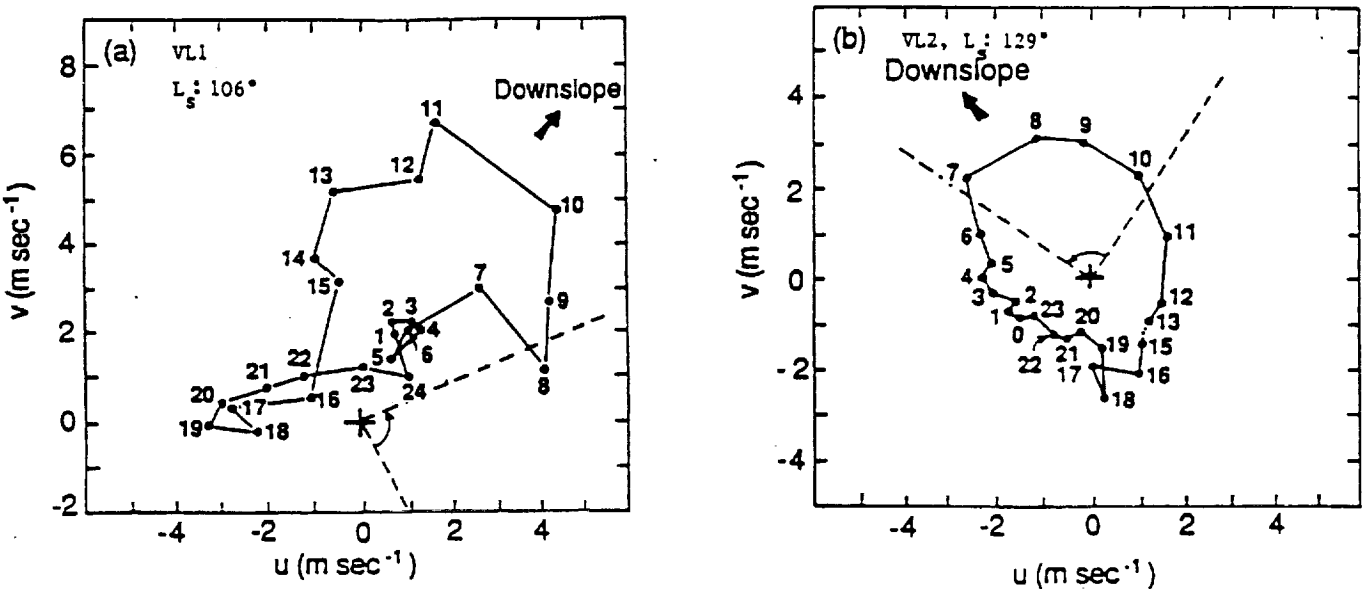



Fig. 18*b*

Fig. 18. Diurnal surface temperature mean and extremes for the primary Viking thermal model ($A^* = 0.25$ and $I = 6.5$). The dashed lines indicate the seasonal range of the primary mission. (*a*) Maximum temperatures. (*b*) Minimum temperatures. (*c*) Mean temperatures.

Keiffer, H. et al., J. Geophys. Res., 82, No. 28, 4249-4291, 1977, copyright by the American Geophysical Union.

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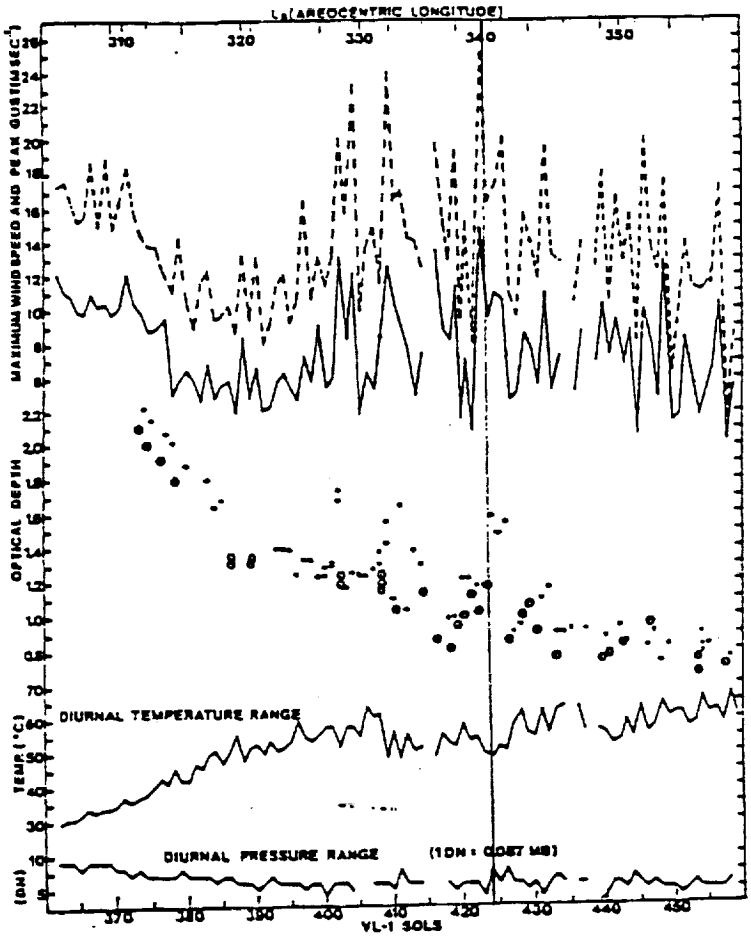


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# Dust Storm Characteristics

- Require strong near-surface winds (> 30 m/s)
- Occur on a variety of scales
- Local dust storms
  - last a few days
  - spatially confined (< 25 km, < 10**6 km**2)
  - occur every year and probably in every season
  - there are preferred locations, but can occur anywhere
  - visible opacities vary: $\tau$ ~ 1-6

-Regional dust storms
  - last from days - months, cover large areas, extend to great heights
  - start small then expand
  - tend to occur during southern spring and summer
  - may envelop much of the planet
  - visible opacities vary: $\tau$ ~ 2-6



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