

# Argon: The mixing standard for methane in Mars' atmosphere

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*Presented by Francois Forget*

"Hello to All, we are sorry we couldn't attend",

*Ann Sprague*  
and  
Bill Boynton

# Noncondensables like Methane should all show similar behaviour

- Seasonal accumulation on polar regions during winter
- Dilution and transport to low latitudes
  - Late winter
  - Spring
- Depletion below average value during summer at some latitudes
- Static instability and vertical mixing

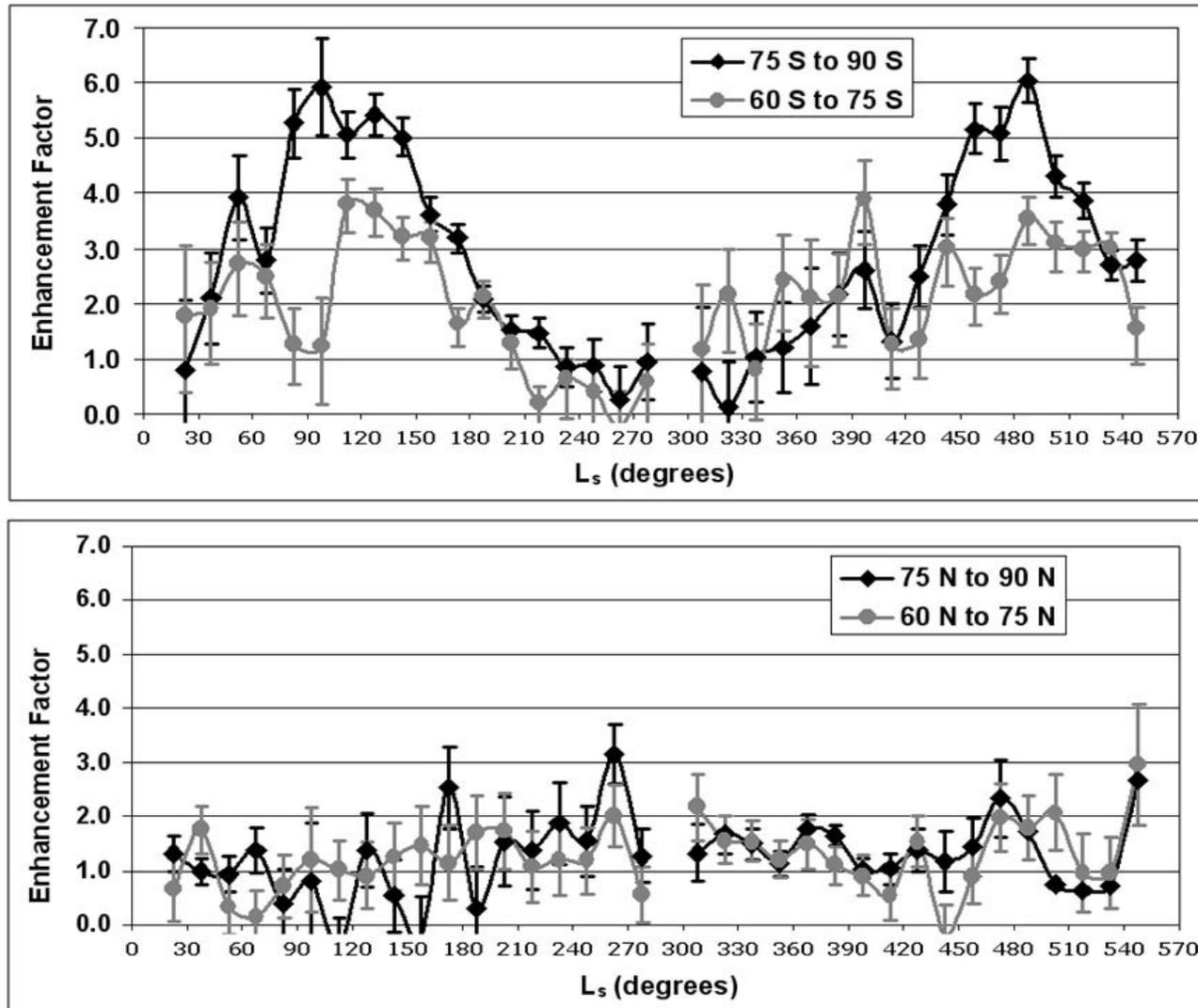
# Observed Noncondensables' in Mars atmosphere

- **N<sub>2</sub>, Ar**
  - neutron spectrometer (N<sub>2</sub> + Ar)
  - gamma ray instruments (Ar 1294 keV  $\gamma$ -ray line)
- **CO**
  - ground based and spacecraft spectroscopy
    - OMEGA, PFS on Mars Express and CRISM on Mars Reconnaissance Orbiter
    - 1.6 and 2.35  $\mu\text{m}$  band depth
- **O<sub>2</sub>**
  - Viking landers (O<sub>2</sub> singlet  $\Delta$  not really relevant here)
- **CH<sub>4</sub>**
  - ground based and spacecraft spectroscopy
    - CSHELL /IRTF and NIRSPEC/Keck-2
    - PFS Mars Express

# Seasonal Picture

- Enhanced mixing ratio at high latitudes during late autumn and early winter
  - **Ar** Sprague et al. (2004, 2007, in progress) shows enhancement of a factor of 6 for three southern winters (MY 26, 27 and 28)
  - **CO** Krasnopolsky (2002)
    - 800 ppm in northern latitudes and 1200 ppm in southern latitudes during northern summer ( $L_s$  112°)
- Dilution and transport to lower latitudes during late winter and spring
  - **CO** : Smith et al (2008) (next slide)
- Depletion below homogeneous (well mixed) mixing ratio for short periods during summer
- Northern winter enhancements chaotic and less pronounced than southern enhancements

# Argon enhancement observed by Mars Odyssey GRS



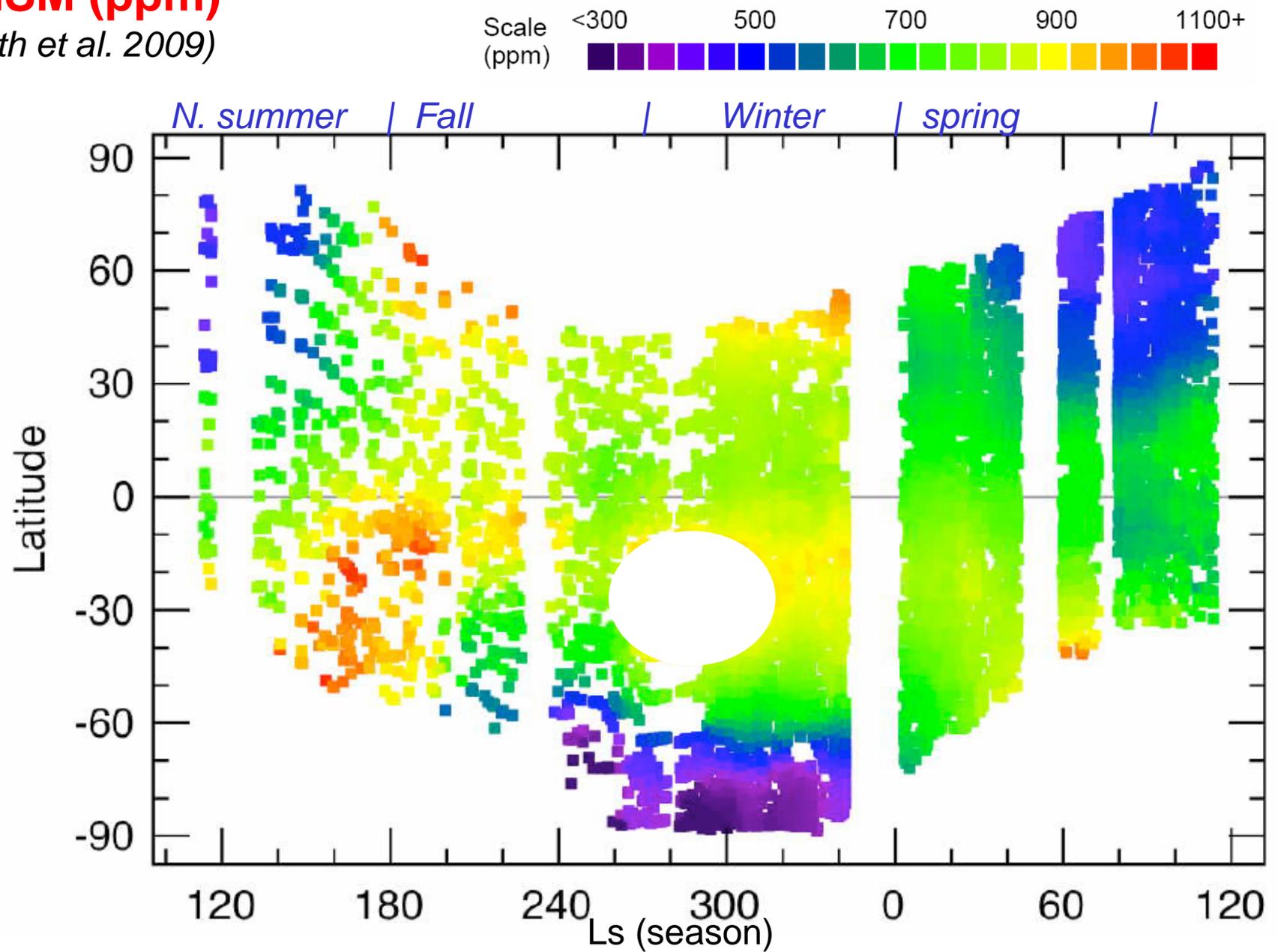
Sprague et al. 2007

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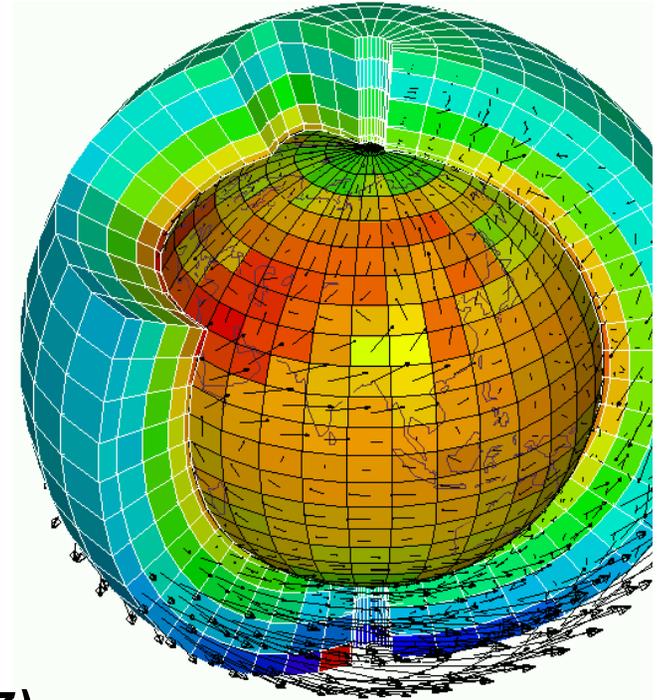
# Observation of CO by CRISM (ppm)

(Smith et al. 2009)



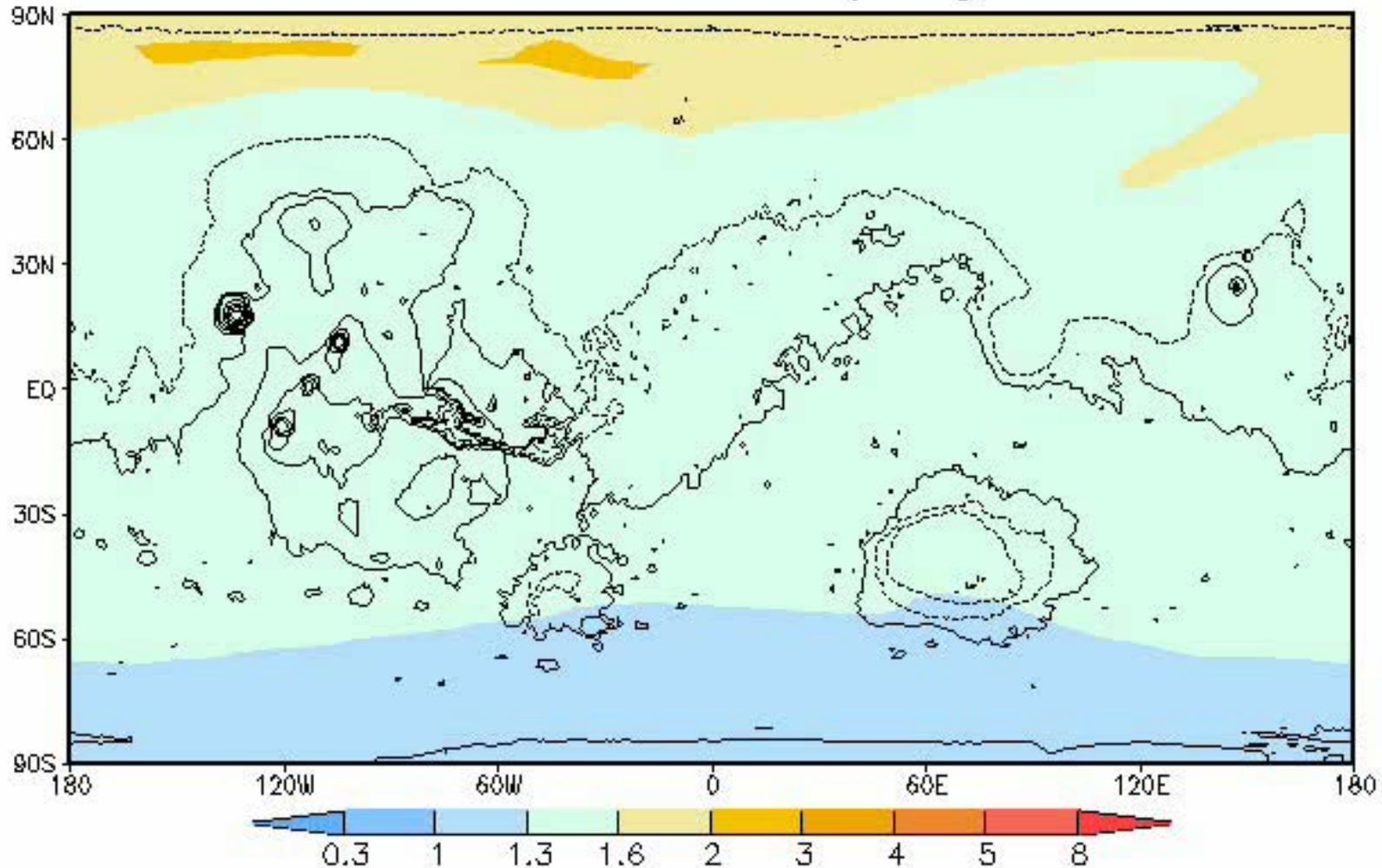
# Simulations in the LMD Global Climate Model

- Forget et al. 1999 GCM
- 64x48 grid, 25 layers
- *Hourdin and Armengaud (1997)* transport scheme
- Compute enhancement and dilution
- Account for 3D change in atmospheric composition to compute convection and turbulence

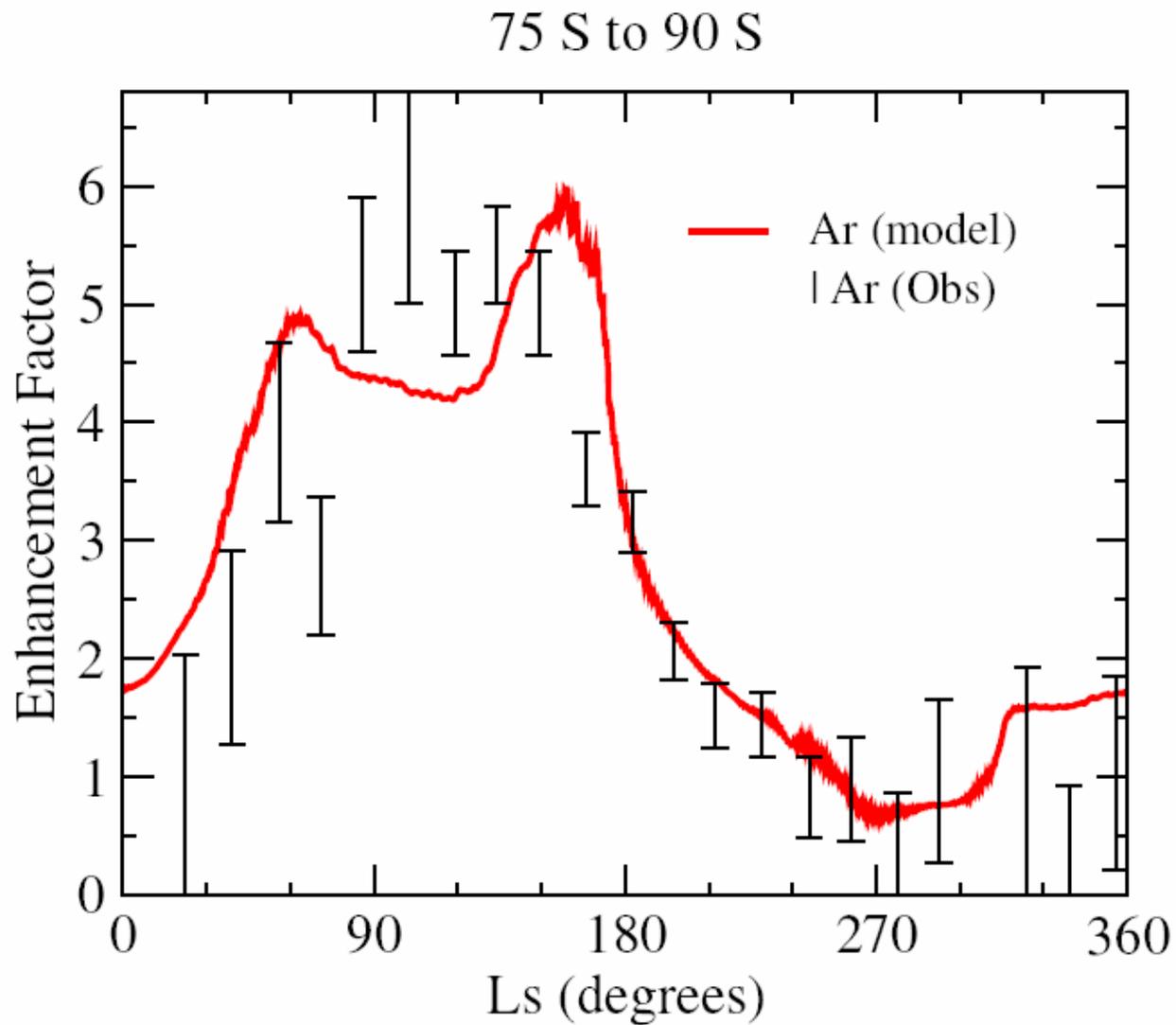


# Simulated Argon column averaged mixing ratio (%)

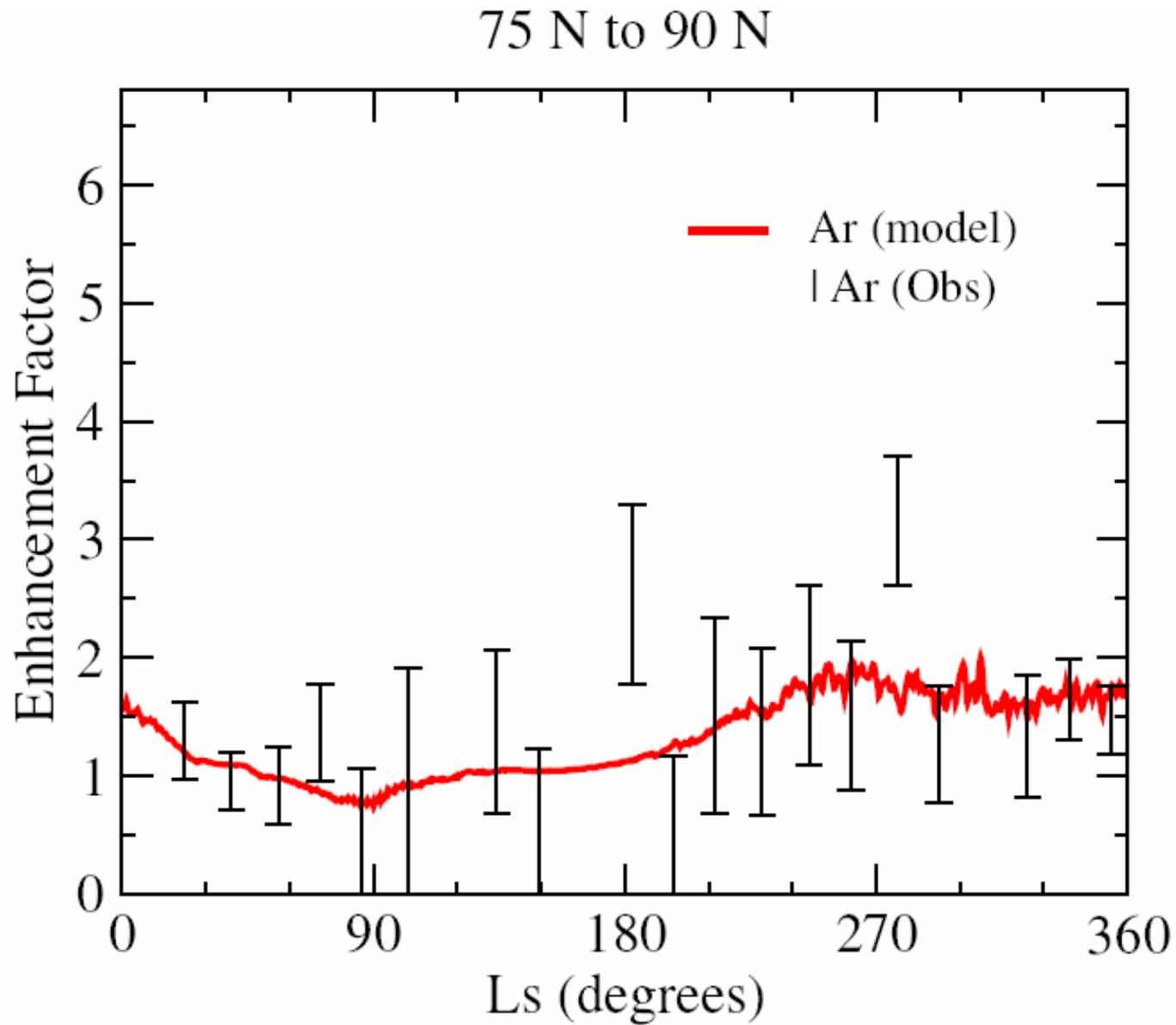
sol = 0.0 N. Spring



## Comparison with Argon measurements

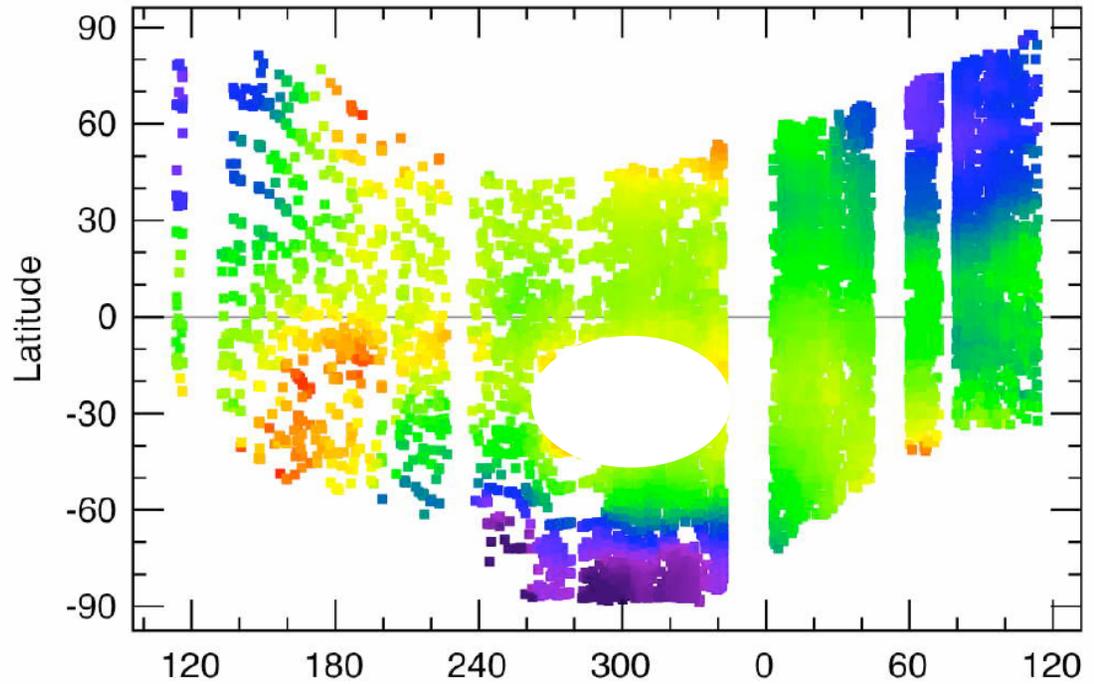


## Comparison with Argon measurements

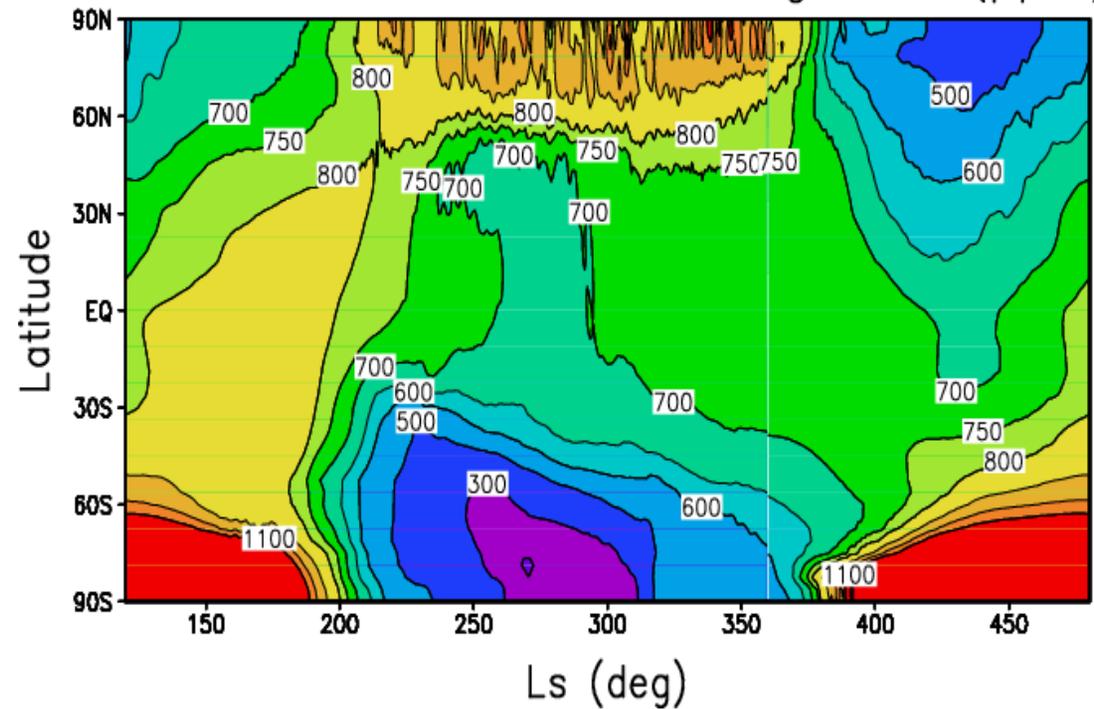


**Comparison with  
CO observations by  
CRISM (ppm)**  
*(Mike Smith 2008)*

**Observations**



**Model**



# Departures from the simple picture

- Influence of topography

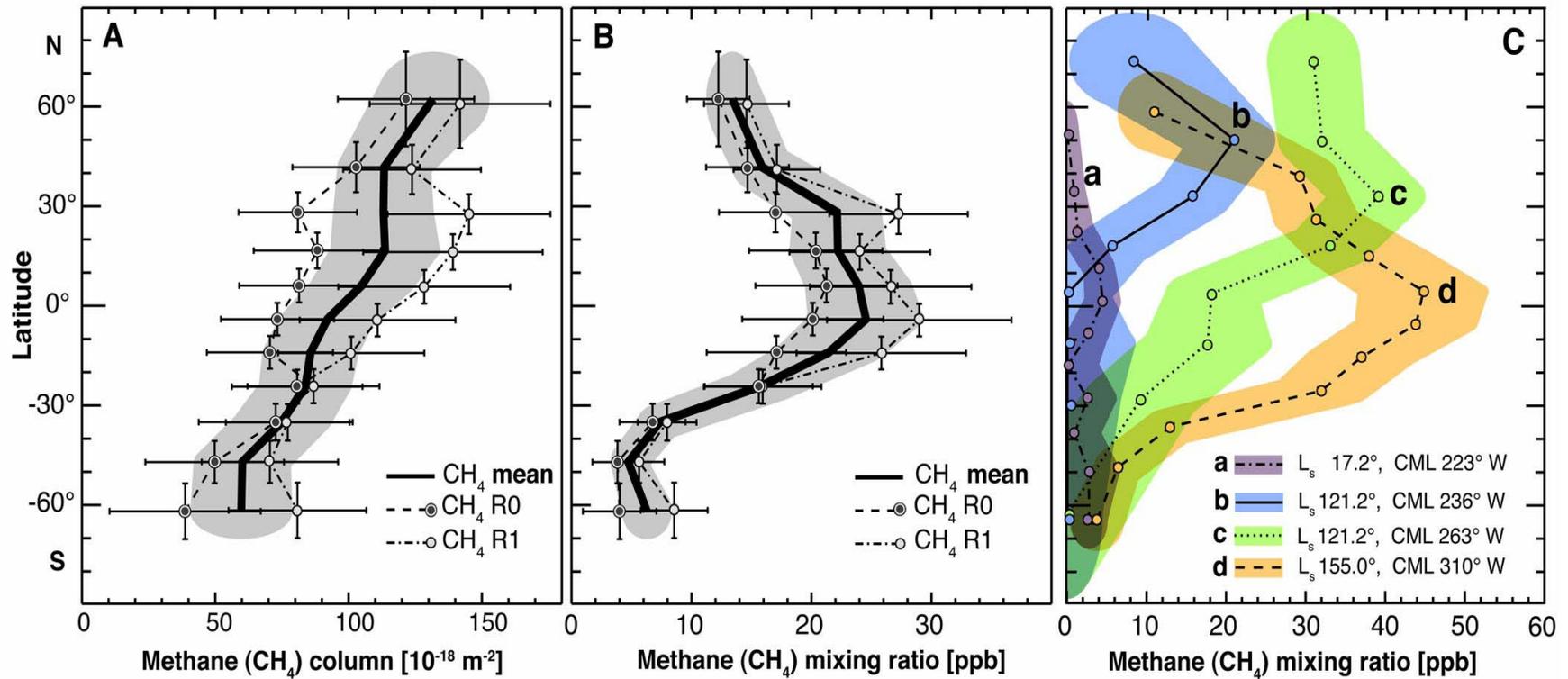
- **CO** Encrenaz et al. (2006) OMEGA data - enhancement of 2 over Hellas at  $L_s = 130-150^\circ$  (*end of southern winter compared to southern summer*)
- **Ar** Sprague et al. work in progress  
Hellas longitude sector MY 26 ?

- Sources

- **CH<sub>4</sub>** Geminale et al. (2008)
- **CH<sub>4</sub>** Mumma et al. (2009)

- Sinks

- photochemistry
- photolysis



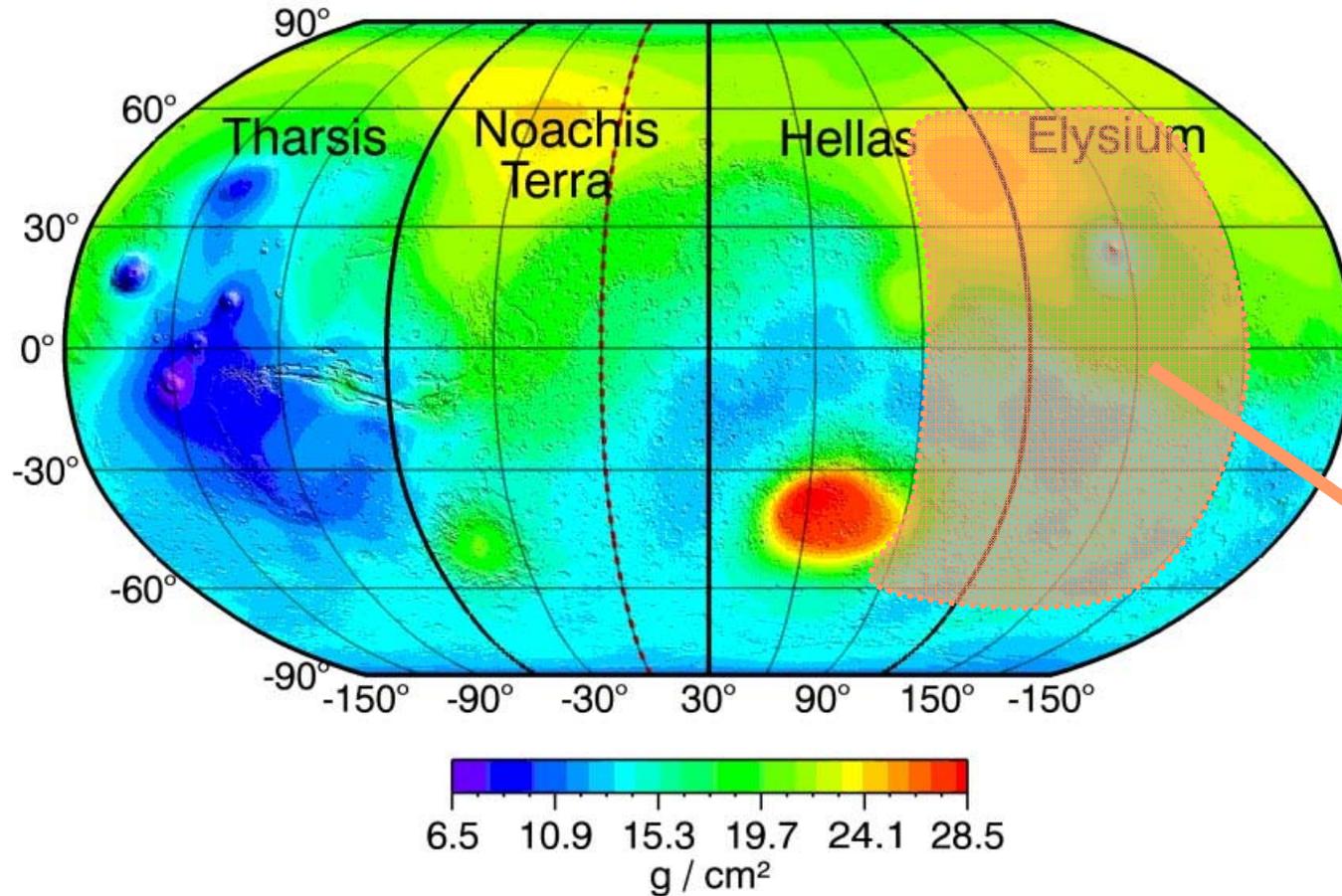
**Figure from Mumma et al. 2009 Science paper shows absolute abundances as a function of latitude and  $L_s$ :**

- A.** Total  $\text{CH}_4$  column density in molecules/  $\text{m}^2$  in two way path
- B.** Local mixing ratio in parts per billion
- C.** Geographic and temporal variability

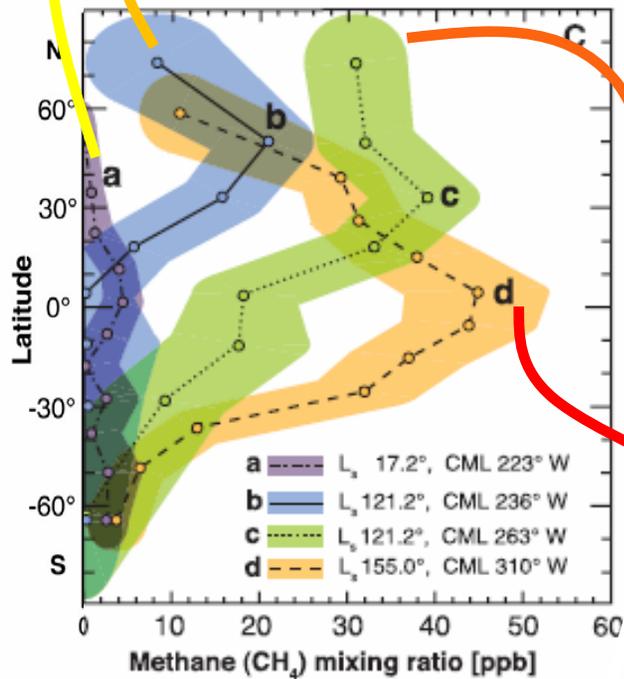
## In the next slide

- Compare Ar data to CH<sub>4</sub> data
  - CH<sub>4</sub> data from Mumma *et al.* 2009
  - Ar data from GRS  $\gamma$ -ray measurements
    - Approximate the ground-based CH<sub>4</sub> longitudes and latitudes by using data from a 90° longitude sectors in 30° increments of latitude that encompass the ground based measurements
    - The two relevant longitude sectors are Elysium and Hellas

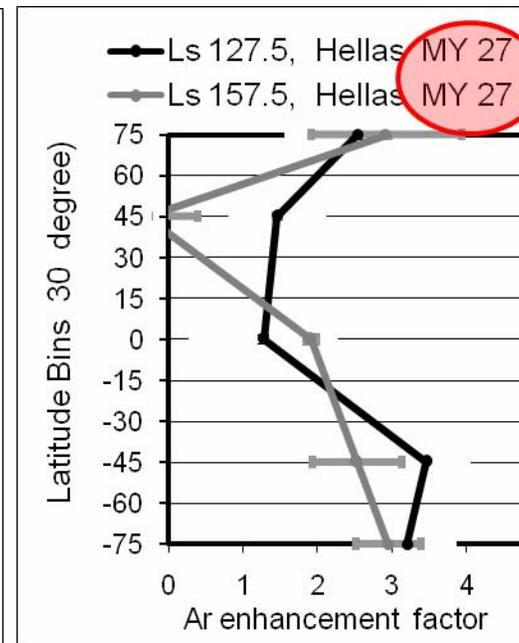
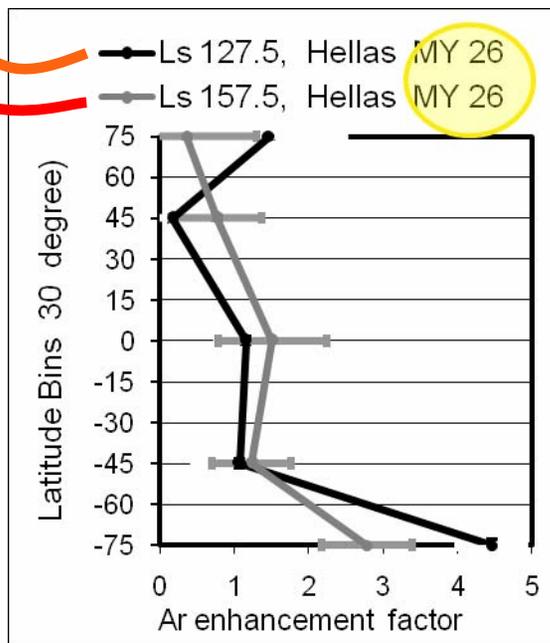
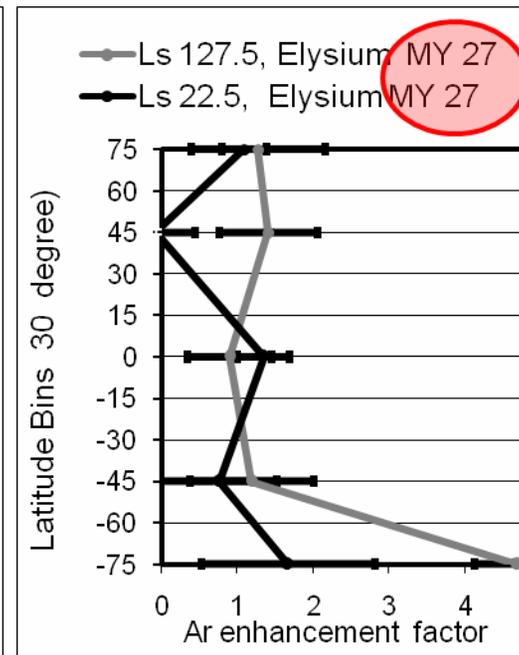
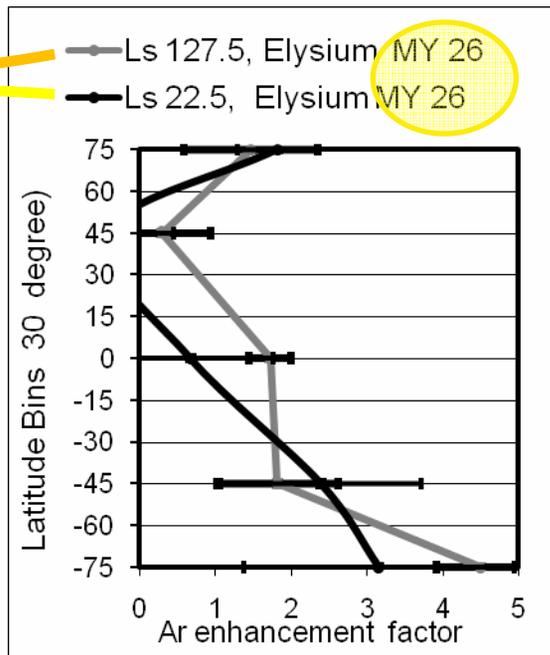
# Mars with 90 degree longitude sectors of topographic regions



The opaque “blob” indicates approximate regions over which ground-based CH<sub>4</sub> observations were obtained



Telescope  
CH<sub>4</sub> data



- Compare Ar data to CH<sub>4</sub> data
  - CH<sub>4</sub> data from Mumma *et al.* 2009
  - Ar data from GRS  $\gamma$ -ray measurements
  - Ar represents the “background noncondensable gas”
    - Only the spring telescopic CH<sub>4</sub> data have a similar latitude distribution to the Ar data
    - The CH<sub>4</sub> data depart significantly from the Ar data and show a definite unique enhancement at mid latitude

# Summary

- Ar and CO are good tracers for the movement and concentration of noncondensable atmospheric species
  - *In the absence of short time scale sources/and or sinks*
- Comparison of other noncondensable atmospheric species to Ar concentrations and distributions give some insight
  - *To the possibility of sources and/or sinks*