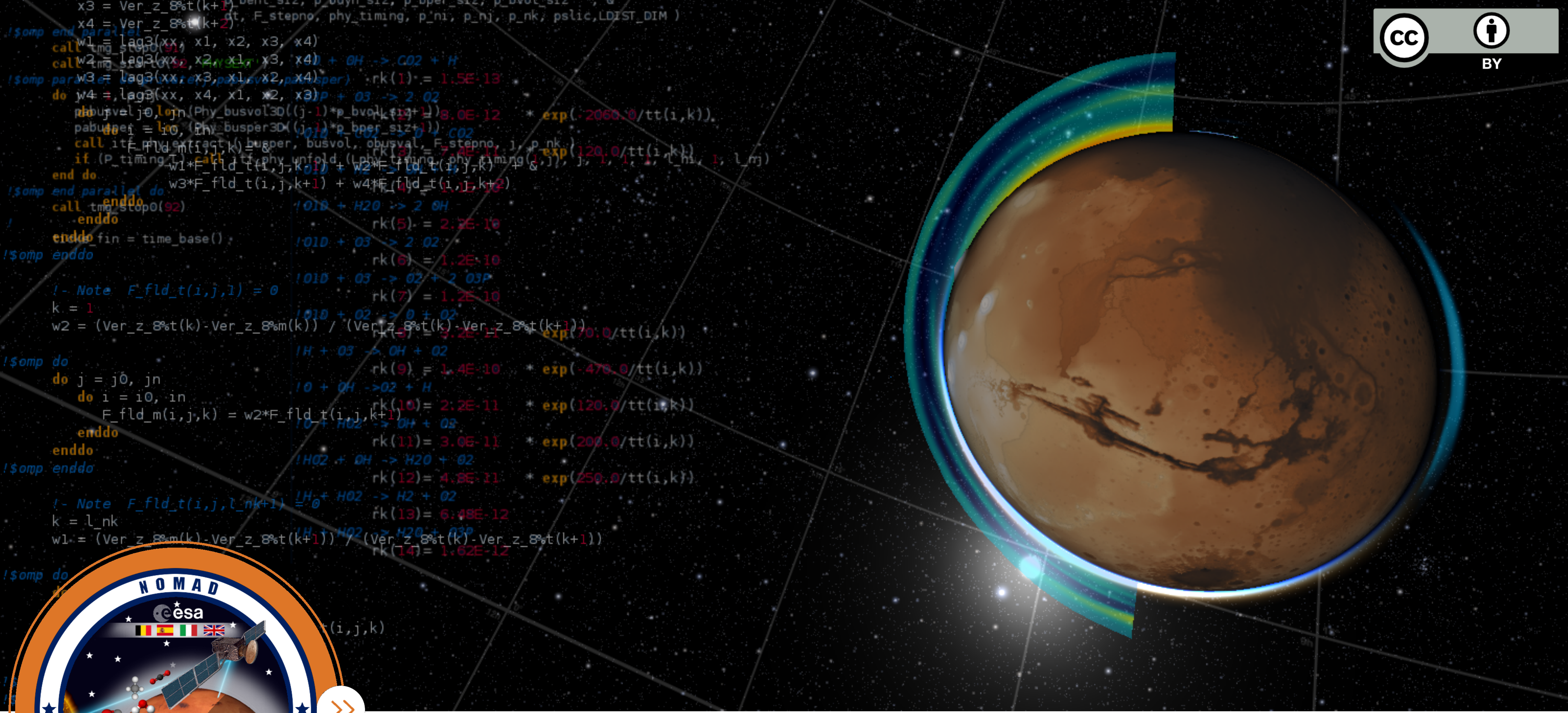

Explanation for the increase in high altitude water on Mars observed by NOMAD during the 2018 global dust storm

Lori Neary, F. Daerden, S. Aoki, J. Whiteway, R. T. Clancy, M. Smith, S. Viscardy, J. T. Erwin, I. R. Thomas, G. Villanueva, G. Liuzzi, M. Crismani, M. Wolff, S. R. Lewis, J. A. Holmes, M. R. Patel, M. Giuranna, C. Depiesse, A. Piccialli, S. Robert, L. Trompet, Y. Willame, B. Ristic, A. C. Vandaele

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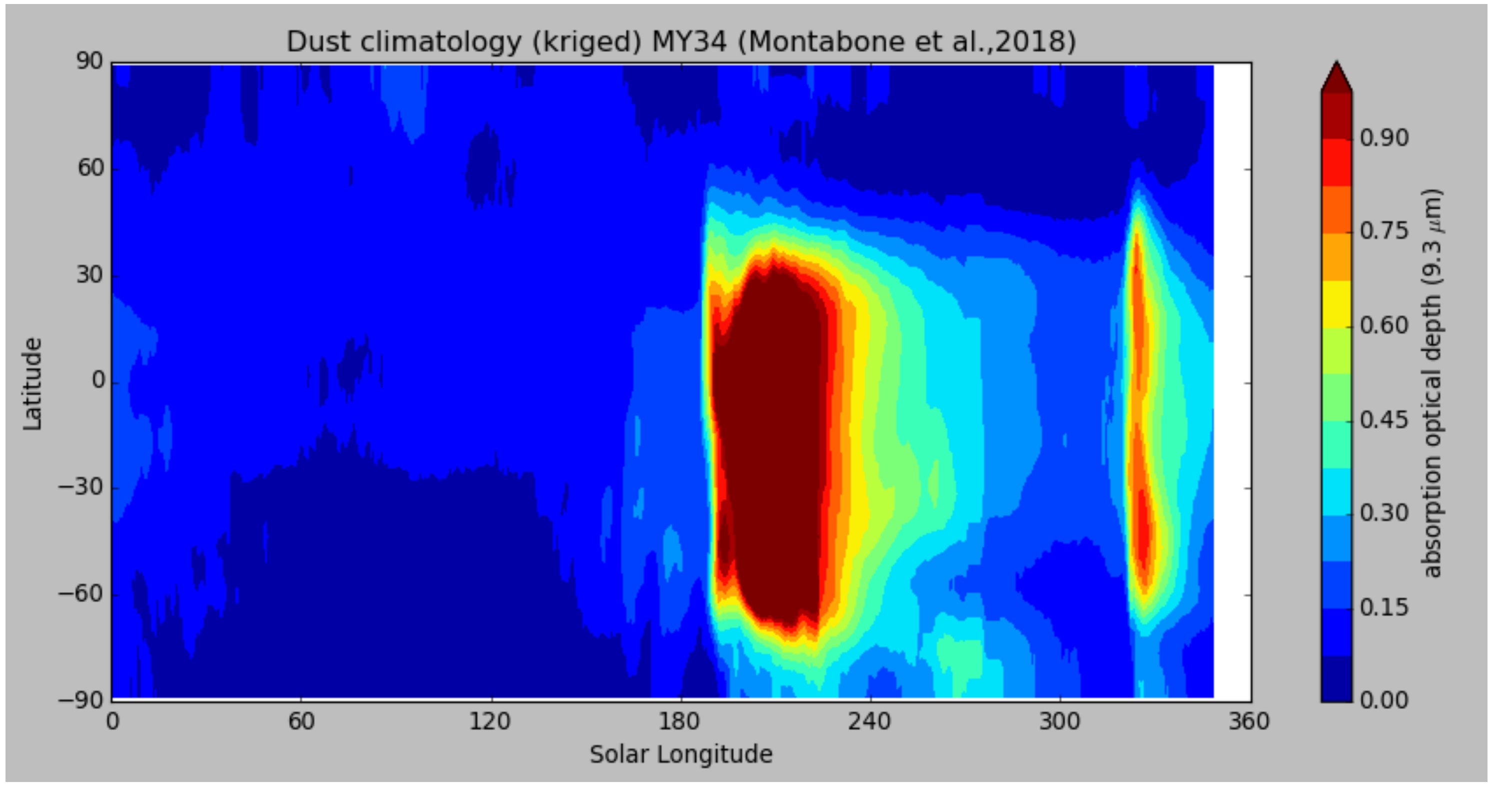
Introduction

- 2018 (MY34) global dust storm characteristics:
  - very rapid onset close to equinox
  - zonal mean optical depths > 2 @ 9.3 μm



- TGO NOMAD saw increased H_2O vapour at high altitudes (40-100 km)

- Can we model this increase with the **GEM-Mars GCM***?

*General Circulation Model - 3D numerical simulation of the atmosphere

Modelling approach

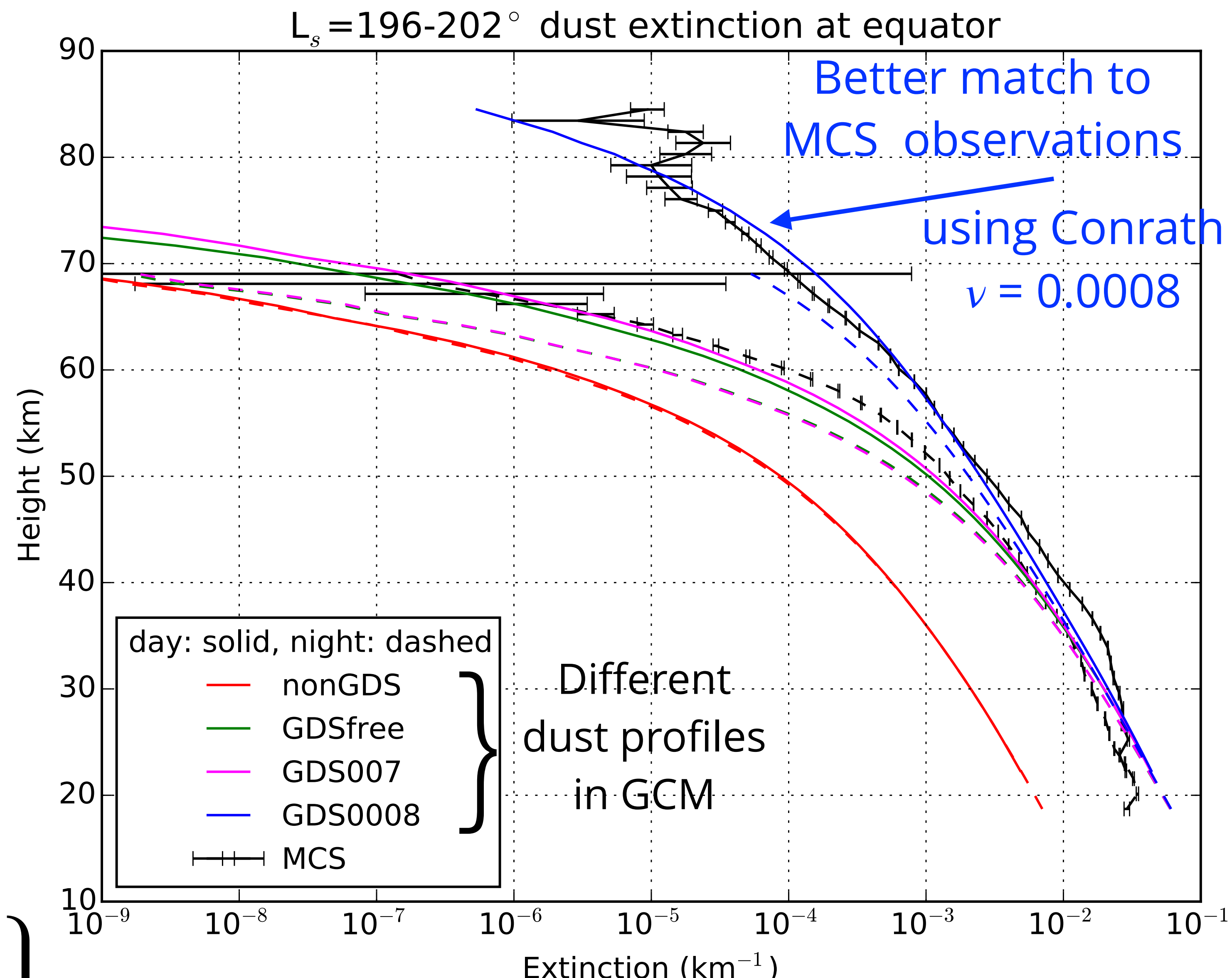
- GEM-Mars has option to run with 'free dust' (lifting by saltation, dust devils) or scale to a climatology

- As expected, 'free dust' scenario does not result in transport of H_2O vapour to high altitudes

- Using Montabone et al. (2019) scenario (daily maps):
  - Scaling total column dust optical depth to climatology made a difference, but not enough
  - Maybe it is the **vertical distribution of dust**?

Vertical distribution of dust in GEM-Mars

- 2 ways to define dust in vertical:
  - Allow dust to be mixed by eddy diffusion, global circulation
  - prescribe the profile using method of Conrath, 1975



$$q = q_0 \exp\left\{\nu\left[1-\left(\frac{p_{ref}}{p_s}\right)^{70/z_{max}}\right]\right\}$$

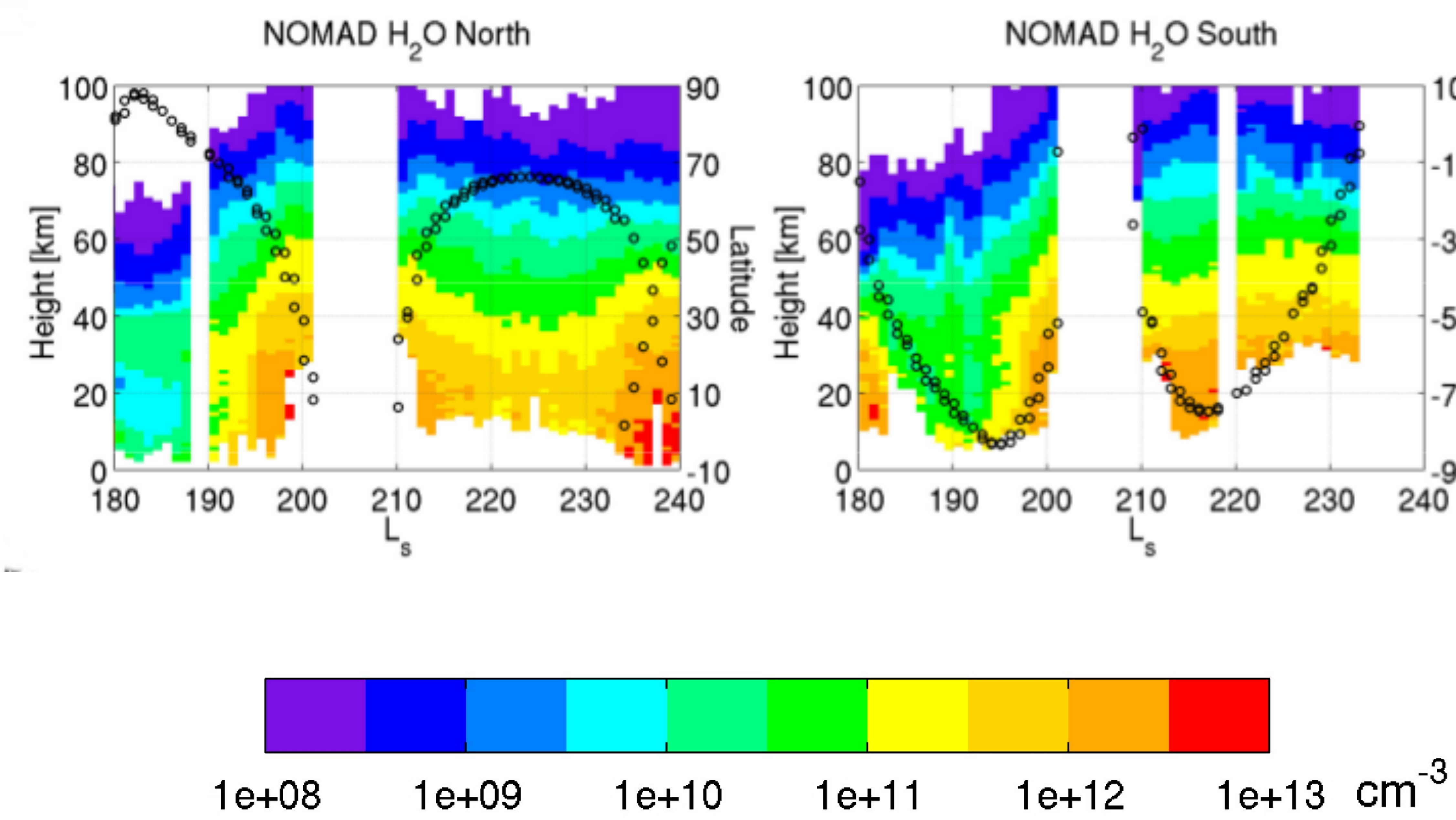
ν → "Conrath" parameter

typical value = 0.007

ν=0.0008 better matches MCS for MY34

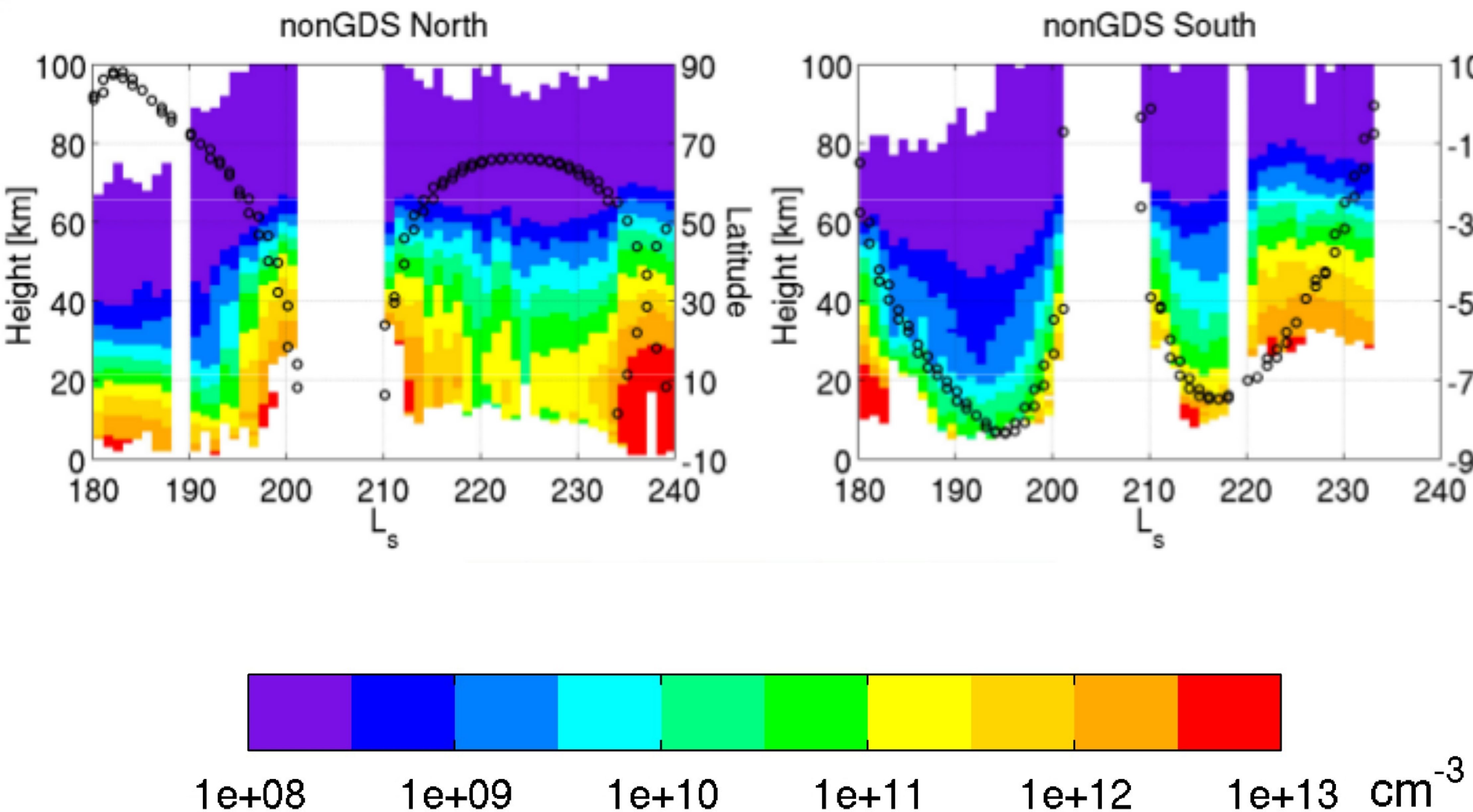
Results - comparison with NOMAD

See Aoki et al., 2019 for more on NOMAD observations of H_2O



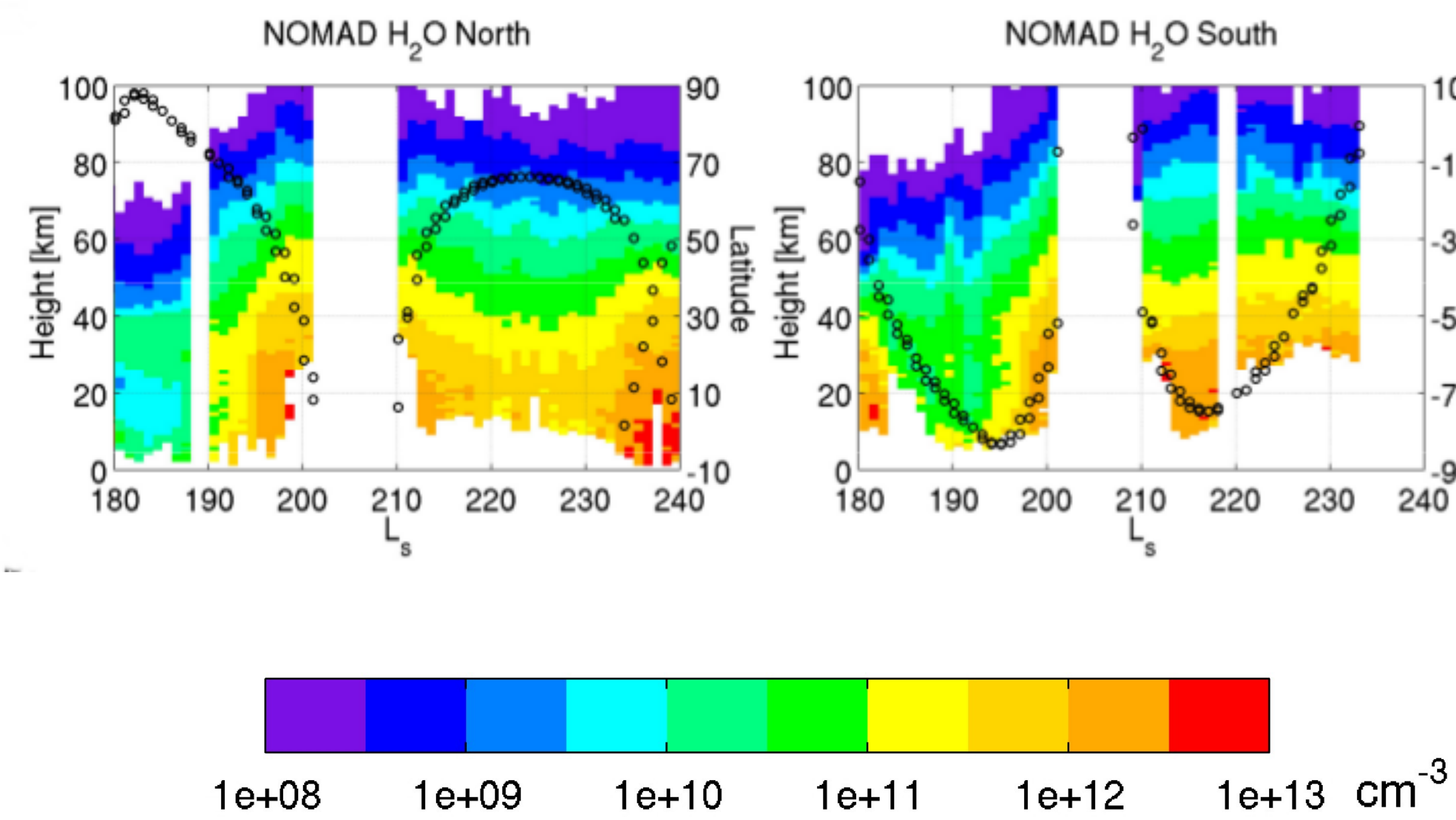
Results - comparison with NOMAD

With no scaling of dust to climatology, not enough H_2O is transported above 60 km



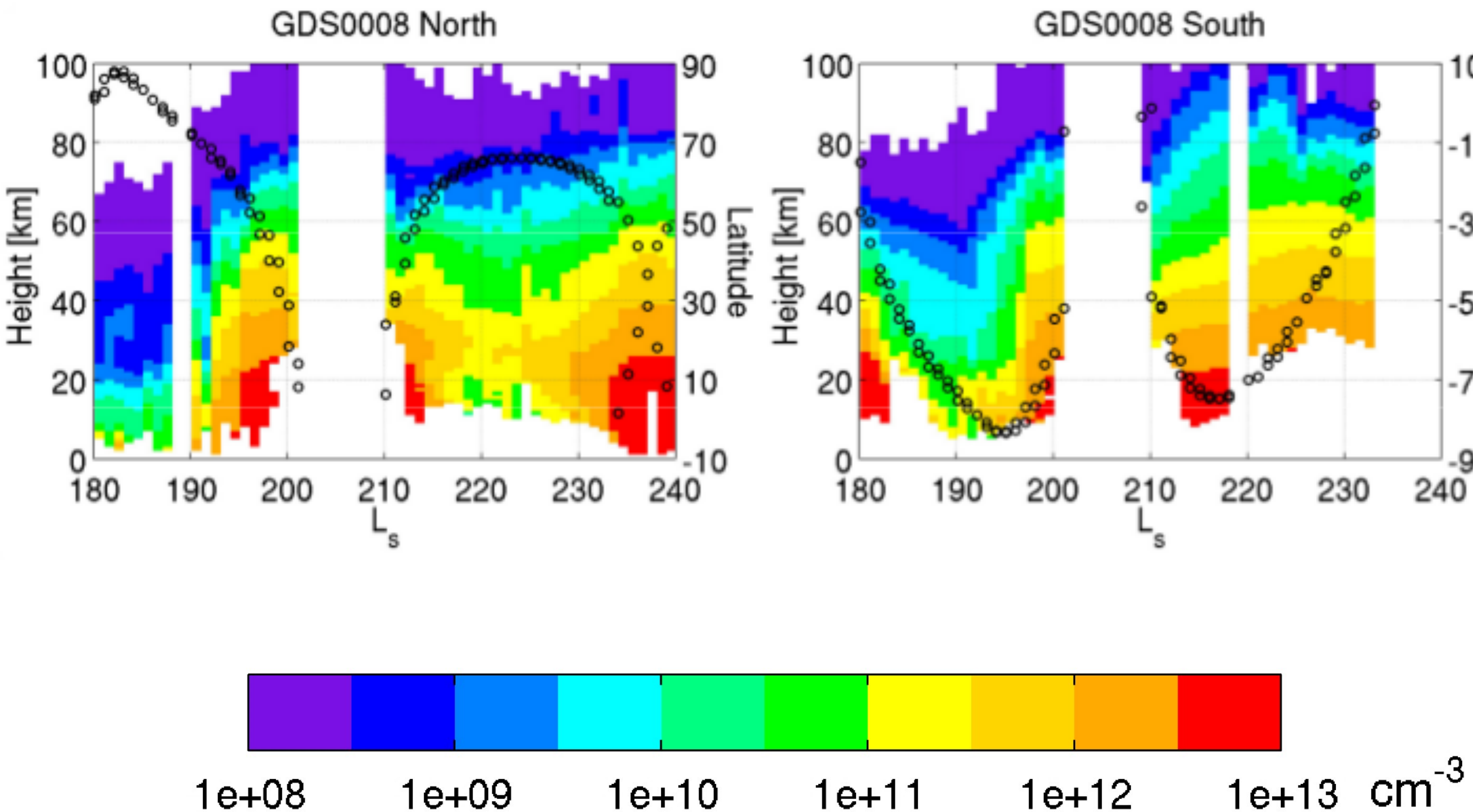
Results - comparison with NOMAD

NOMAD observations again



Results - comparison with NOMAD

Dust scaled to climatology + Conrath ν=0.0008 gives a better match to observations

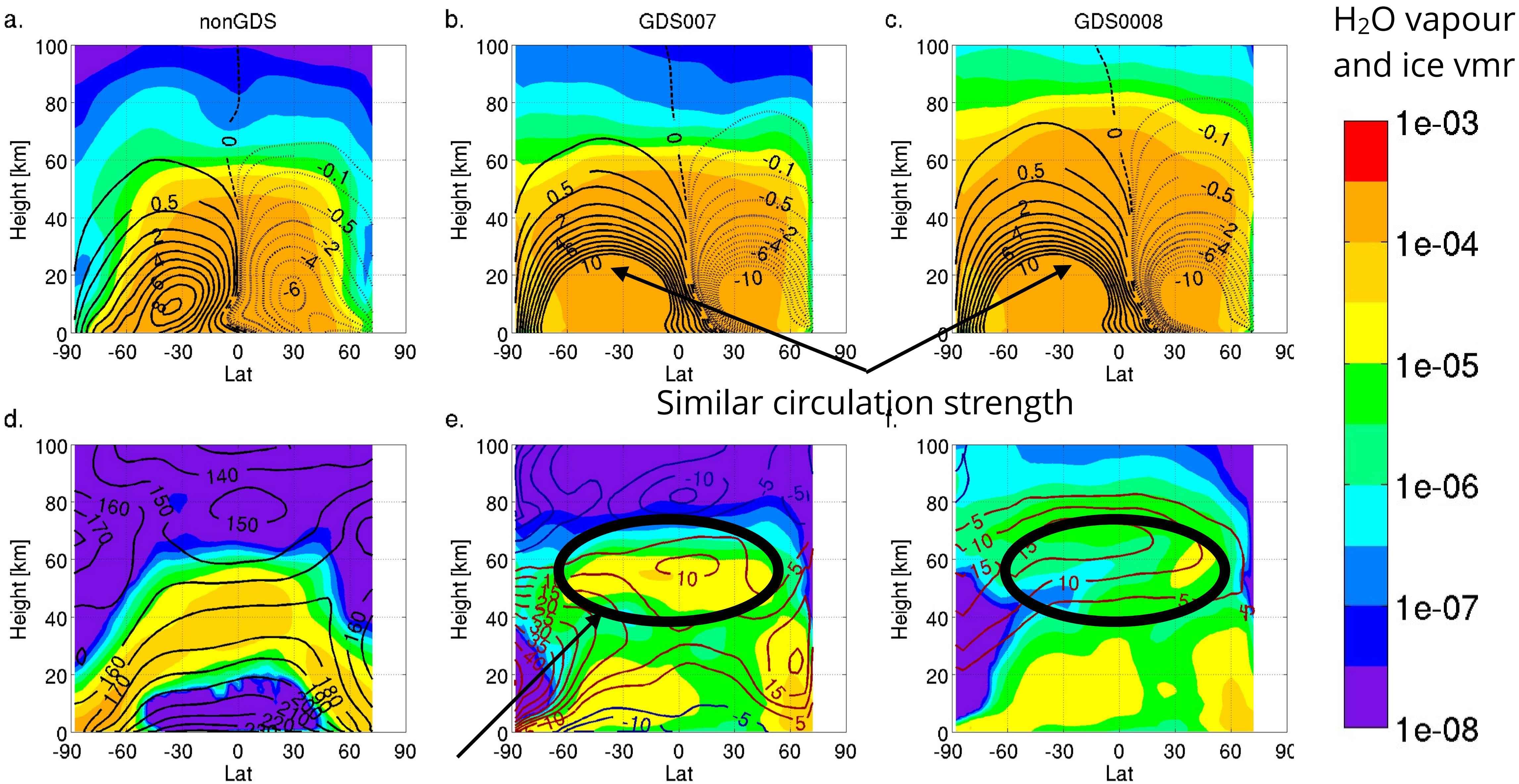


Discussion: 3 GCM simulations

Daytime zonal mean profiles L_S=196°-202°

H_2O vapour + meridional mass stream function

H_2O ice + temperature, differences



Clouds block transport of H2O

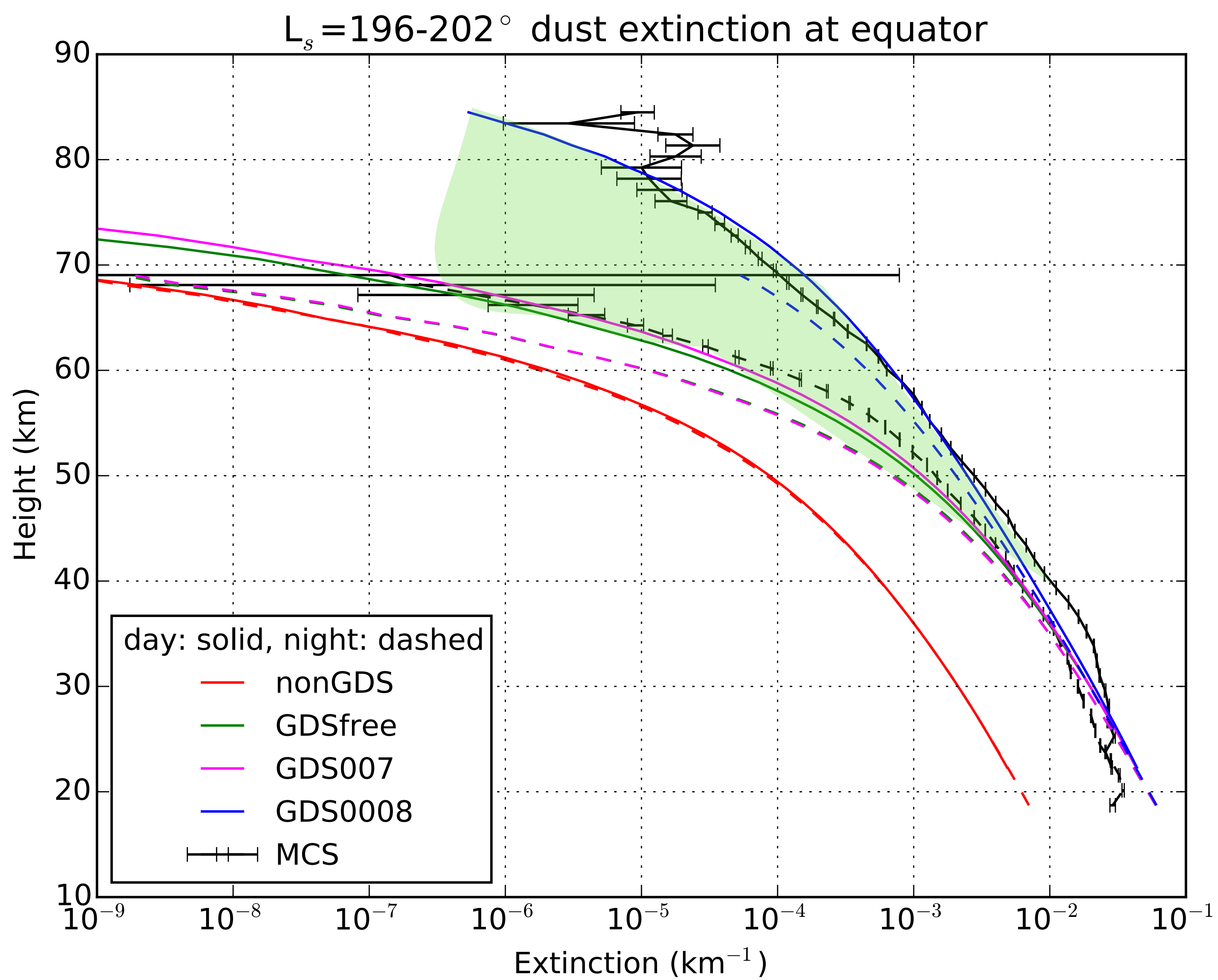
NonGDS (no scaling)

GDS with normal Conrath parameter

GDS with lower Conrath parameter

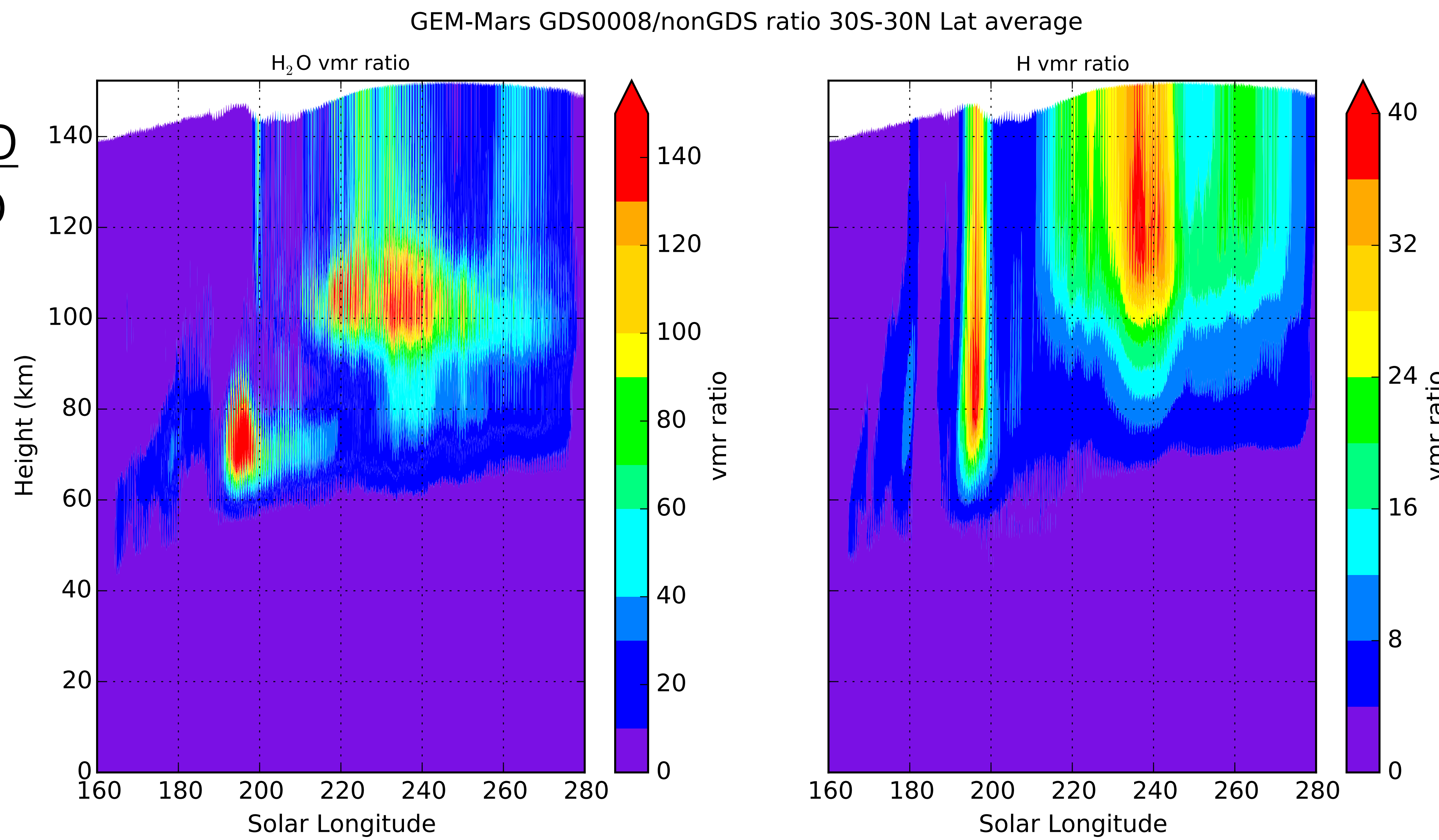
Discussion

- Both GDS cases show increased Hadley circulation but it is not enough to transport H_2O
- In the GDS0008 case, more dust above 40 km $\Longrightarrow$ increased temperatures $\Longrightarrow$ less water ice cloud formation

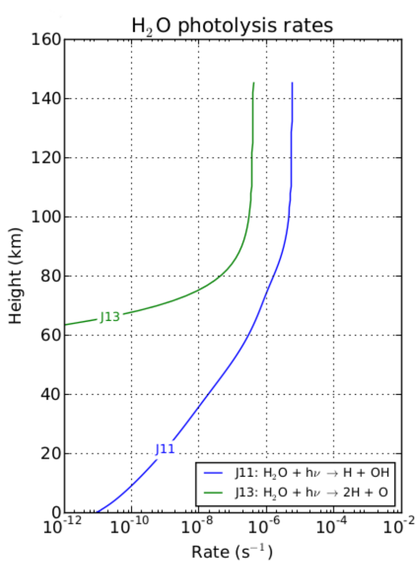


Implications for hydrogen escape

$$\frac{\text{GDS0008 } H_2O}{\text{nonGDS } H_2O}$$



$$\frac{\text{GDS0008 H}}{\text{nonGDS H}}$$



- Ratio of GDS/nonGDS simulated H_2O and H from L_s 160°-280° between 30° N/S
- $H_2O + h\nu \rightarrow H + OH$ rate above 80 km ~1-3x10^{-6} s^{-1} $\Longrightarrow$ lifetime ~ 3-11 sols

Summary

- Vertical distribution of dust is a key factor for the transport of water vapour through the equatorial hygropause
- Stronger Hadley circulation alone does not explain transport of H_2O to high altitudes
- Increase in temperatures due to dust above 40 km prevents water ice clouds from forming, allowing H_2O to be transported to heights of 70-100 km
- Due to strong H_2O photodissociation above 80 km, we simulate an increase in H a few days after the onset of the dust storm

THANK YOU!
MORE INFO?

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More about TGO NOMAD @ EGU:
S. Viscardy D3009 (this session)
A. Piccialli D3036 (10:45 today)
A. C. Vandaele D3033 (10:45 today)

This work can be found in Neary et al., 2019, GRL
https://doi.org/10.1029/2019GL084354