Observations of the Martian atmosphere by NOMAD on ExoMars Trace Gas Orbiter

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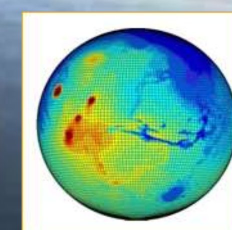
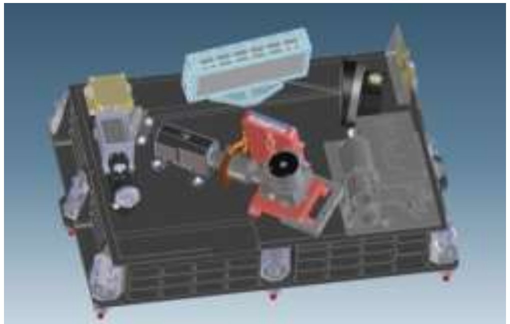
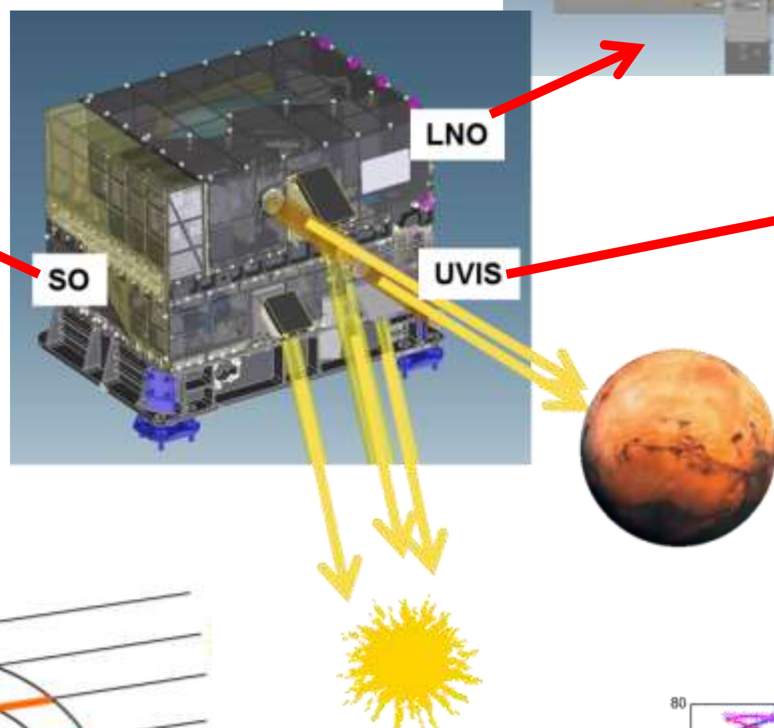


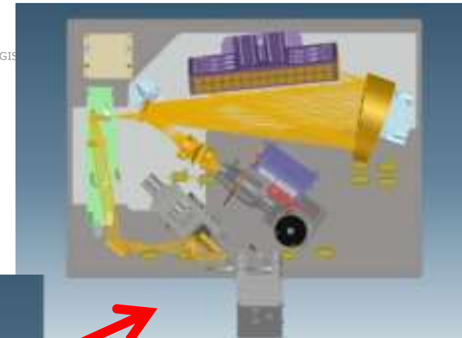
NOMAD



SO channel

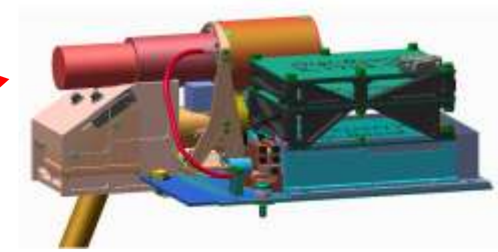
- *Solar occultation*
- *Composition of the atmosphere*
- *Dust, clouds*
- *(SOIR instrument on Venus Express)*





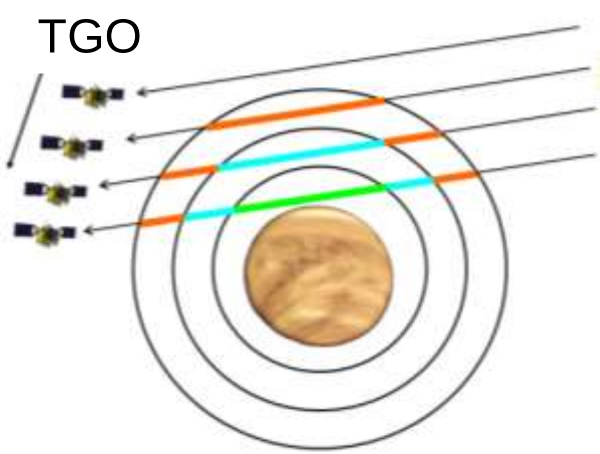
LNO channel

- *Nadir mapping of trace gases*
- *But also Limb and Solar occultation*

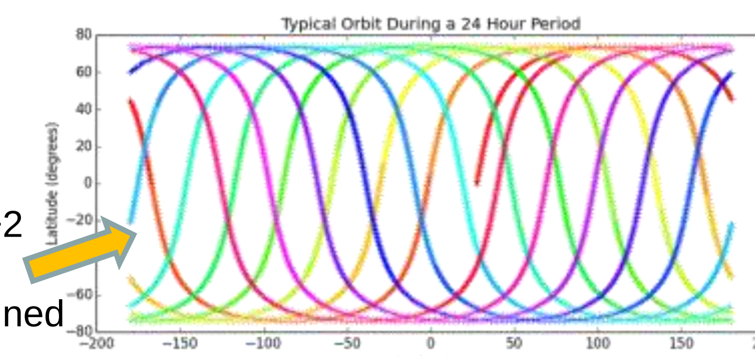


UVIS channel

- *Nadir and Solar occultation*
- *Ozone, UV level*
- *Dust, clouds*



1 day coverage:
One orbit every ~2 hours
400 km - 74° inclined



Instrument status

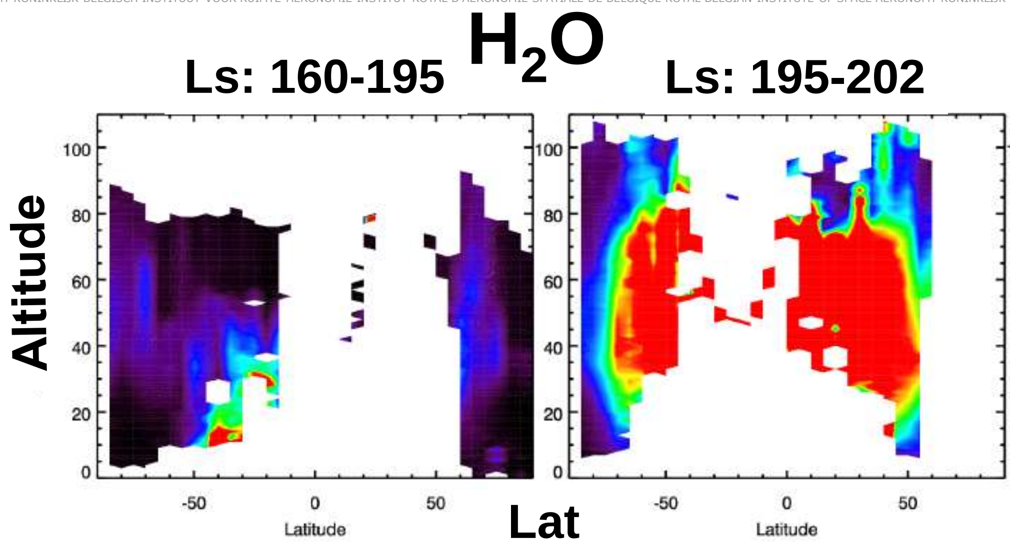
- NOMAD was off 2 weeks during the COVID-19 lockdown
- Was successfully restarted on 11 April

Nb Observations	Type of Observation
4320 (100)	Solar occultation – SO+UVIS (grazing)
4144	Nadir dayside – LNO+UVIS
7448	Nadir dayside – UVIS
81	Nadir nightside – LNO+UVIS
298	Nadir nightside – UVIS

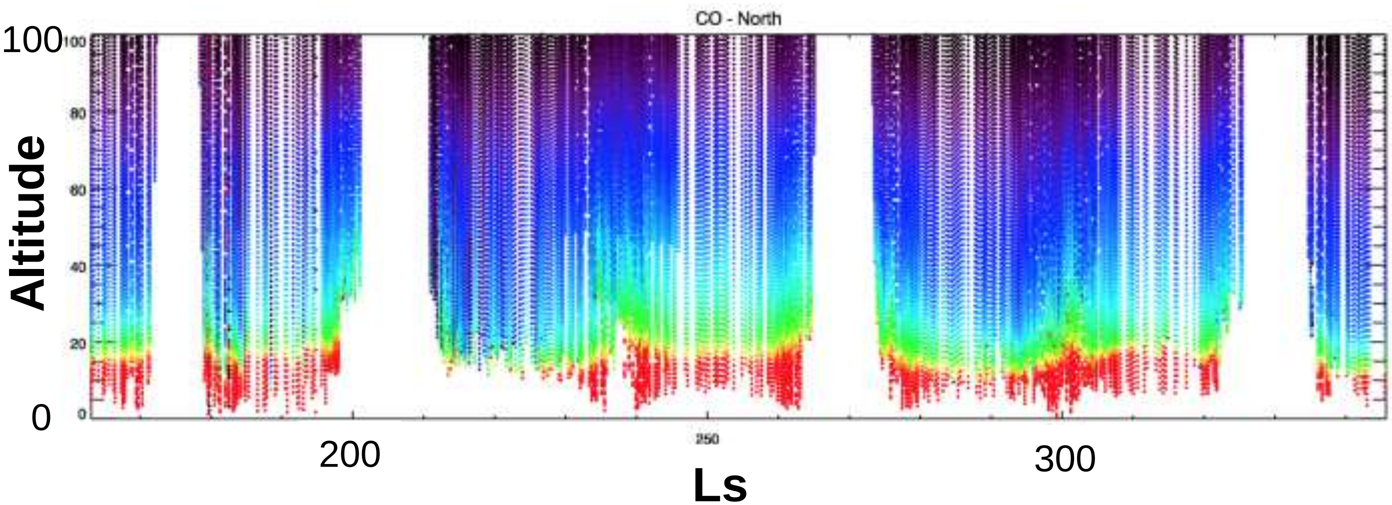
Up to MTP24

NOMAD : Science Objectives

- Chemical composition
  - Detection of a broad suite of trace gases and key isotopes
    - CO_2, CO, O_3
    - CH_4 related : CH_4, $^{13}CH_4$, CH_3D, C_2H_2, C_2H_4, C_2H_6, H_2CO
    - Escape processes : H_2O, HDO -> D/H
    - Volcanism related : SO_2, H_2S, HCl



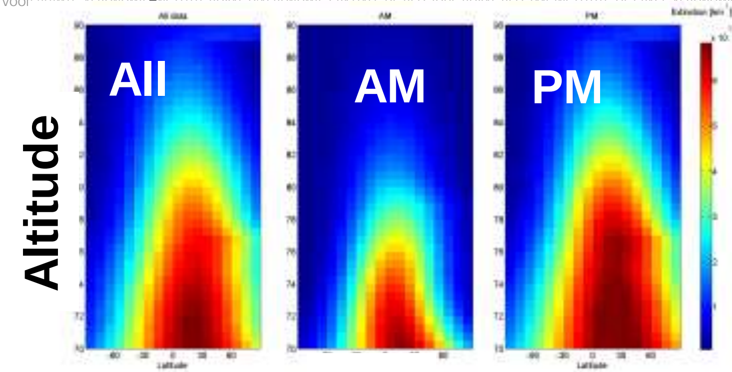
Aoki et al, JGR 2019



CO

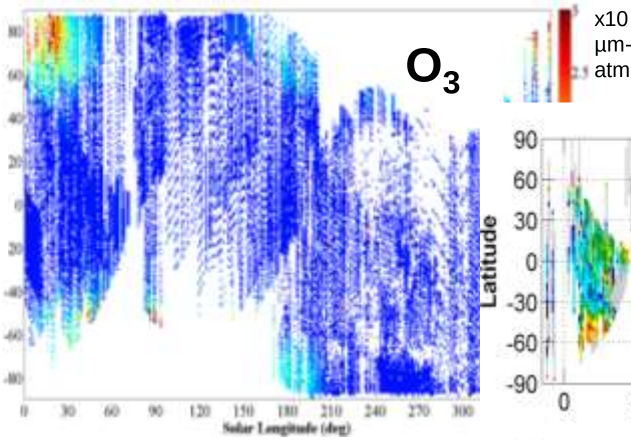
NOMAD : Science Objectives

- Mars Climatology & Seasonal cycles
  - 3D spatial & temporal variability of trace gases and aerosols (dust & clouds)
  - Climatology of O_3 and UV radiation levels



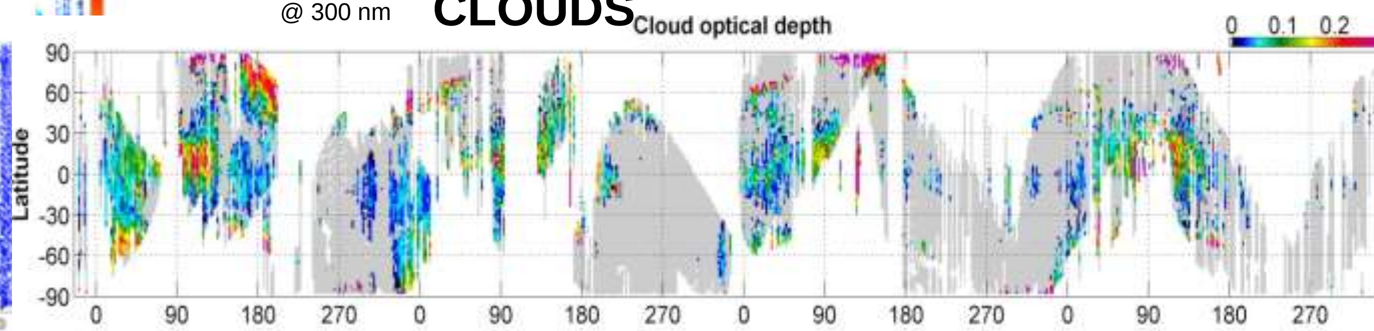
Aerosol Ext. (SOIR/VEX) V. Wilquet

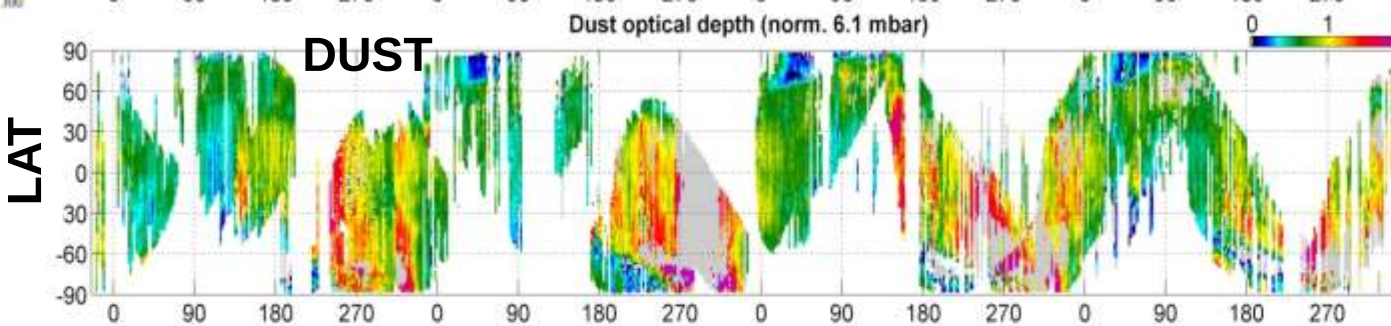
Ozone column



Willame et al, 2017

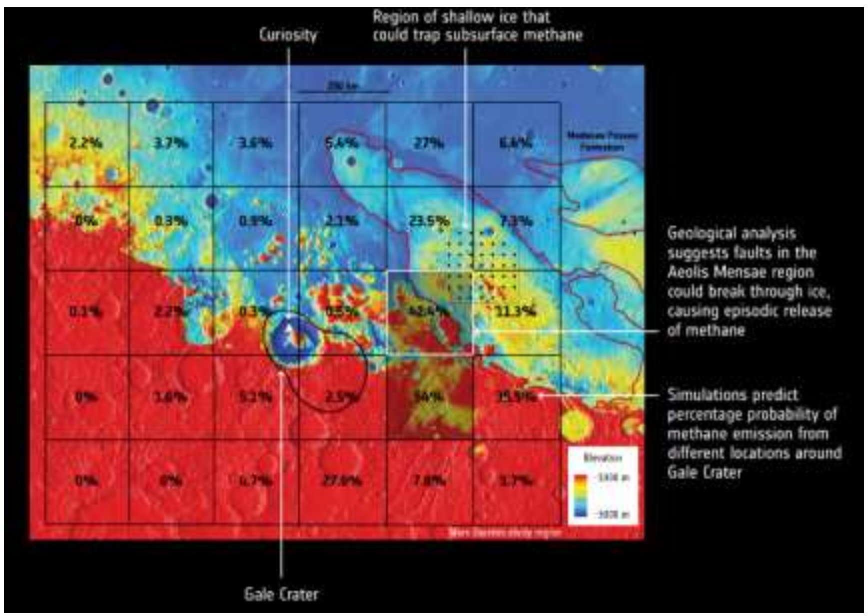
@ 300 nm



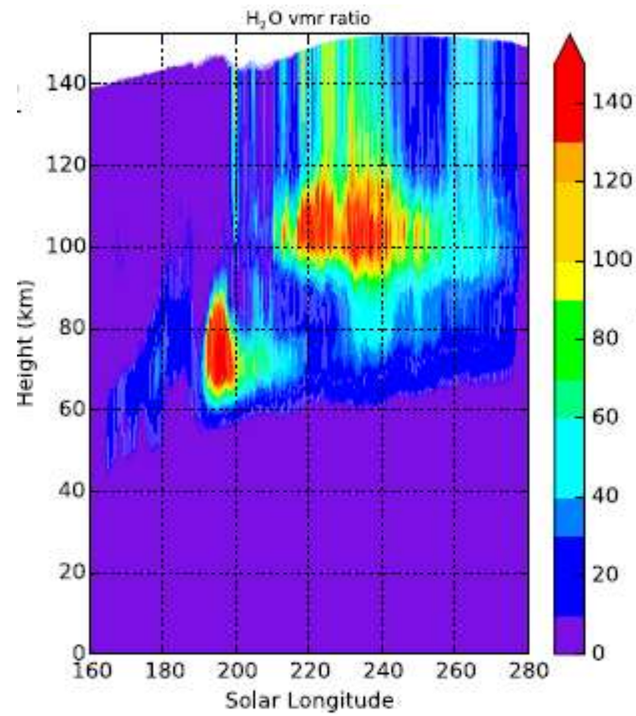


NOMAD : Science Objectives

- Sources & Sinks
  - Analyse correlation trace gases – dust – clouds – T&P
  - Use GCM for interpretation



Giuranna et al, Nature Geoscience 2019

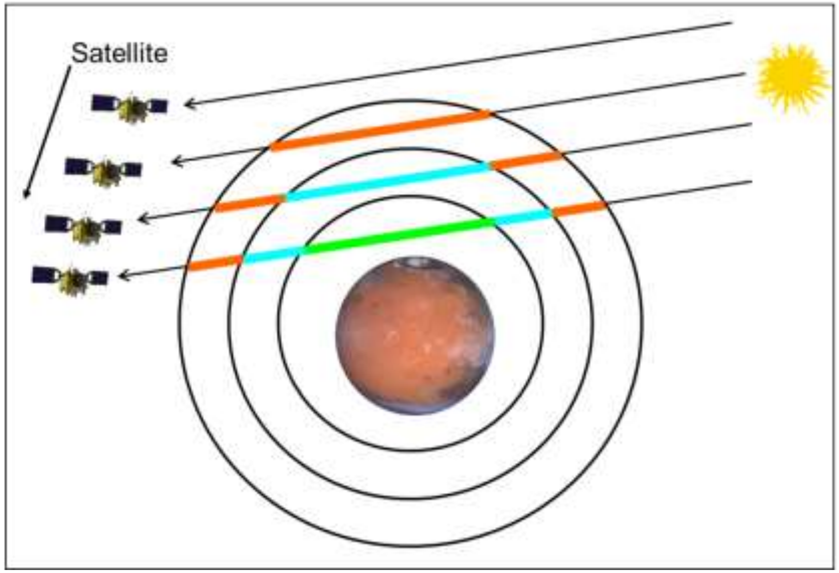


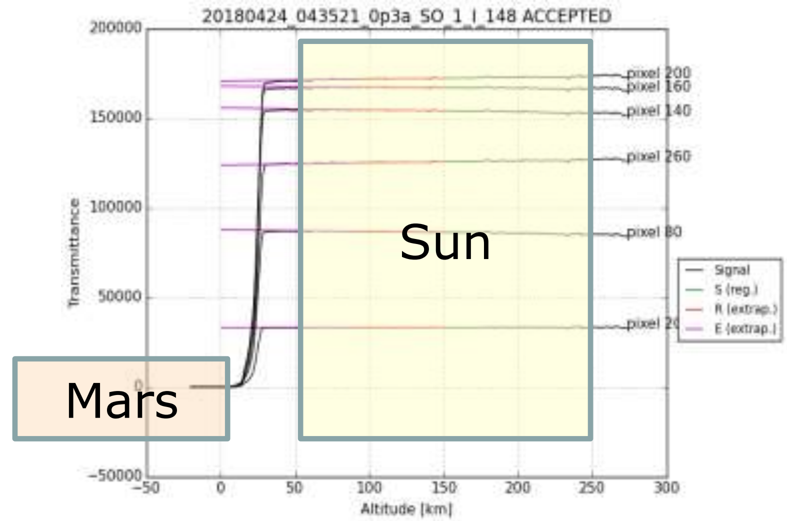
GDS0008 H_2O

nonGDS H_2O

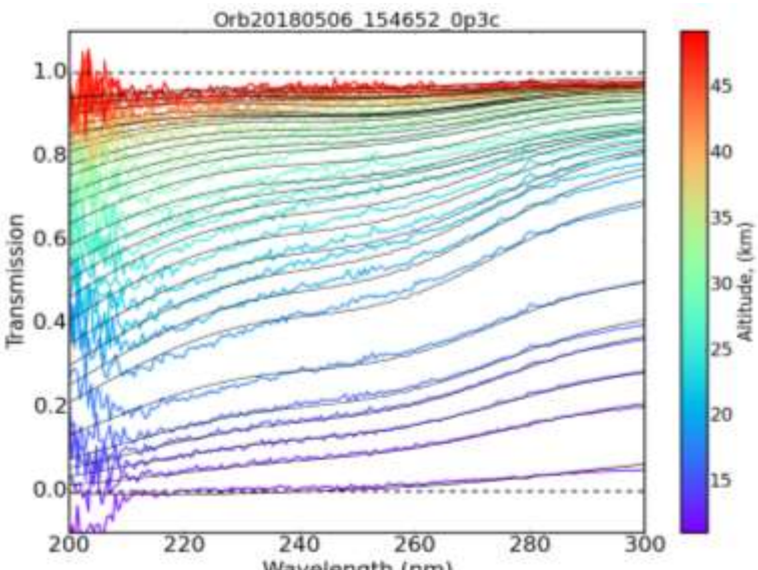
Neary et al, GRL 2020

SO & UVIS - Solar occultation

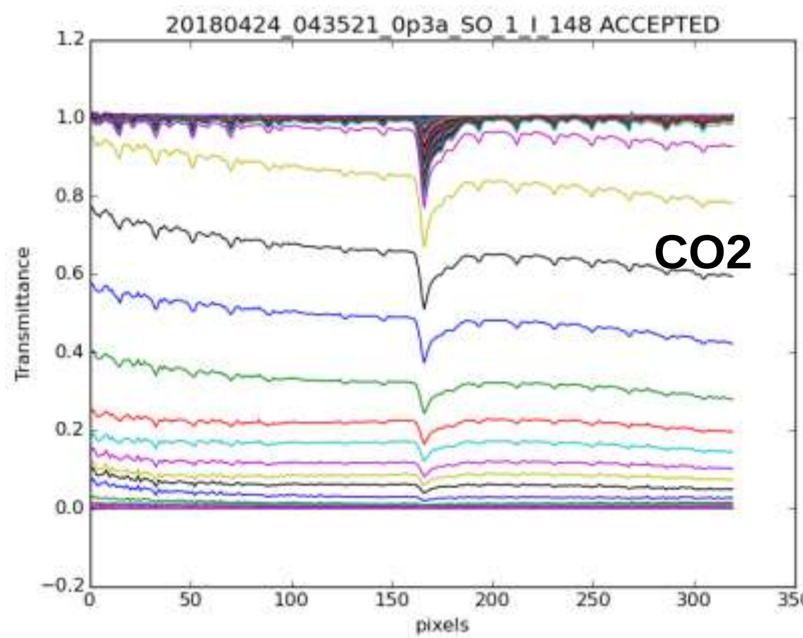




UVIS

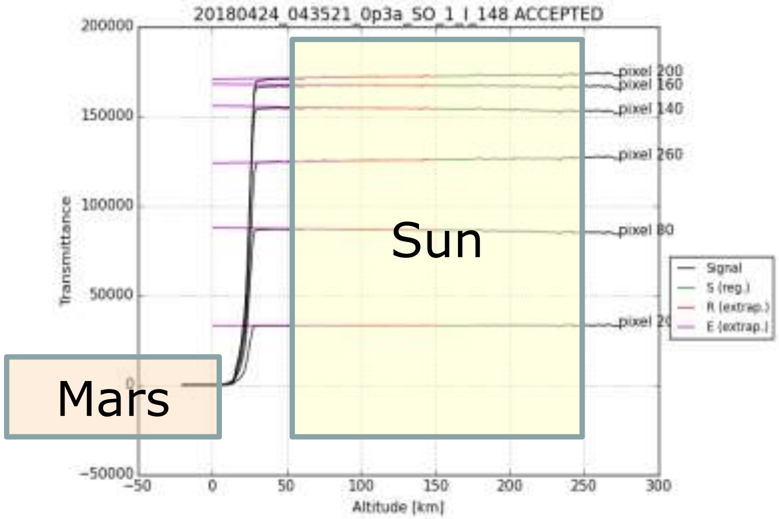


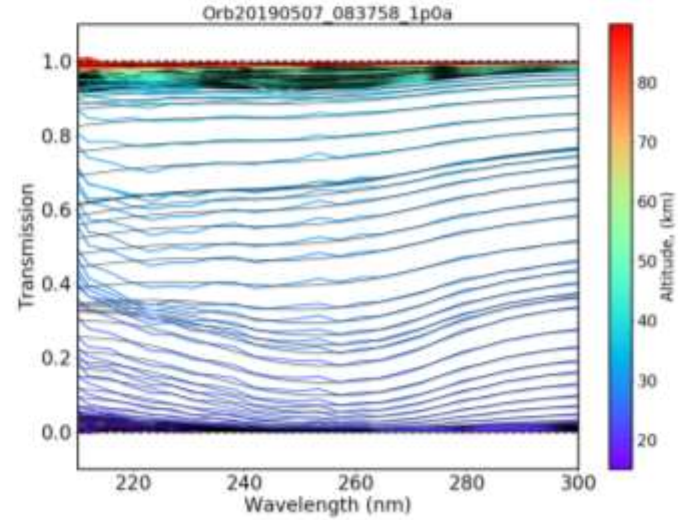
SO

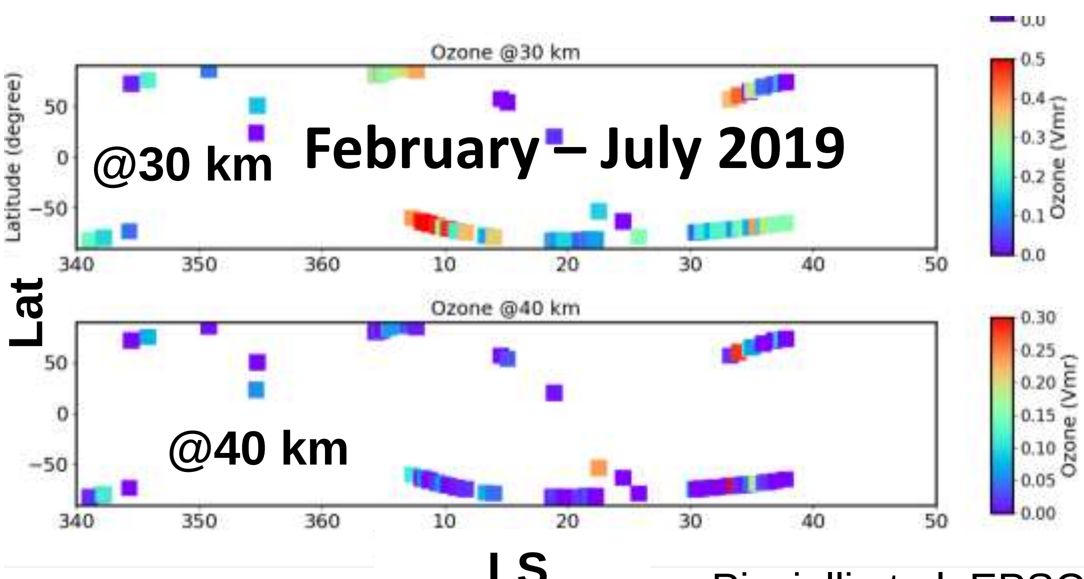


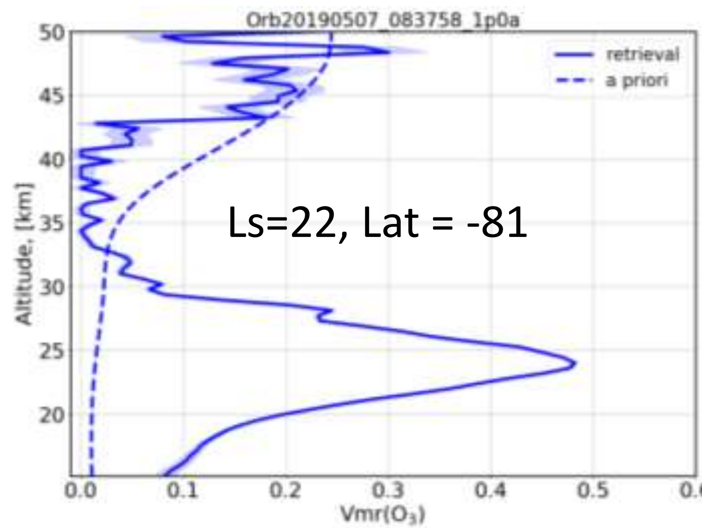
UVIS - Solar Occultation

- Determination of transmittance based on Trompet et al. (2016)



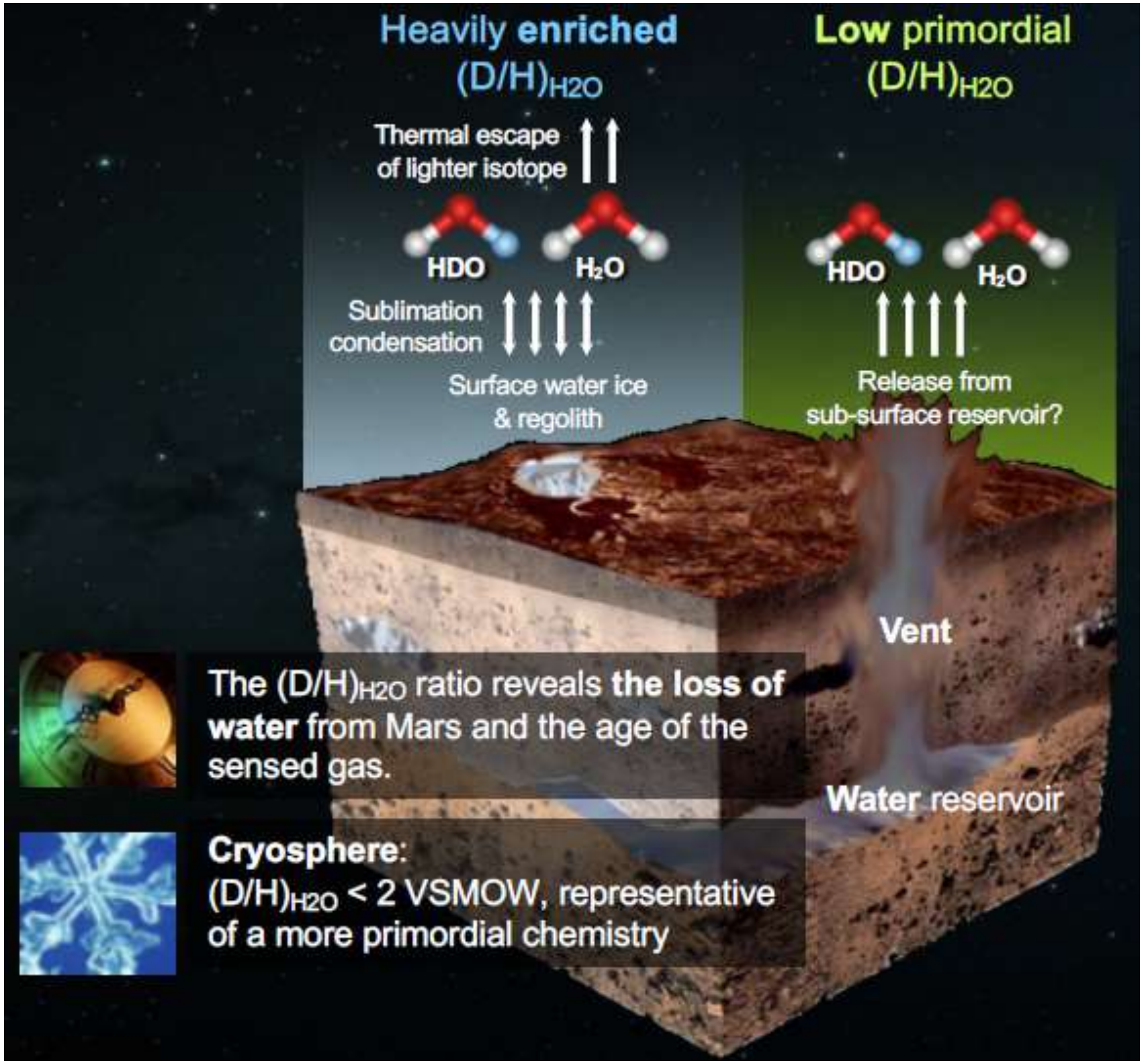






Piccialli et al, EPSC (2019)

H_2O and HDO

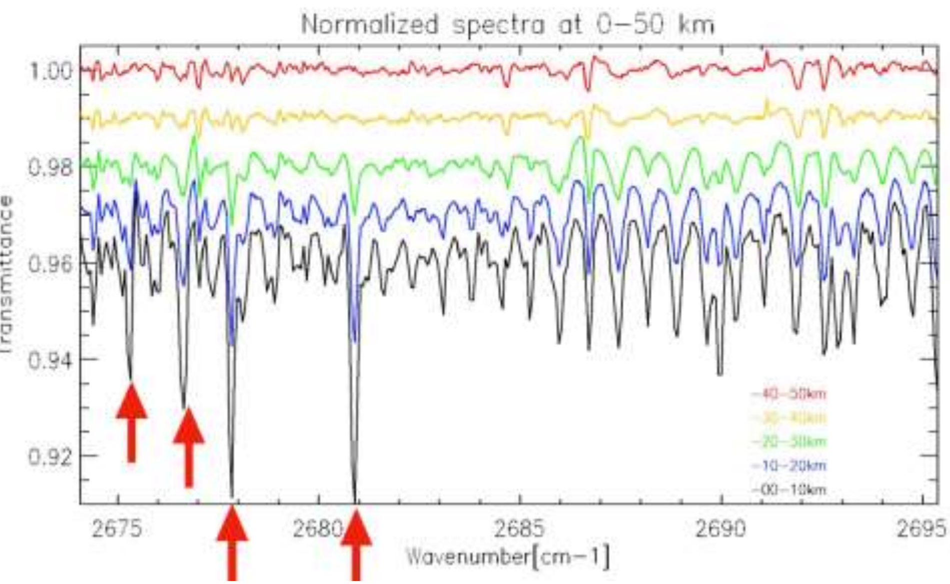


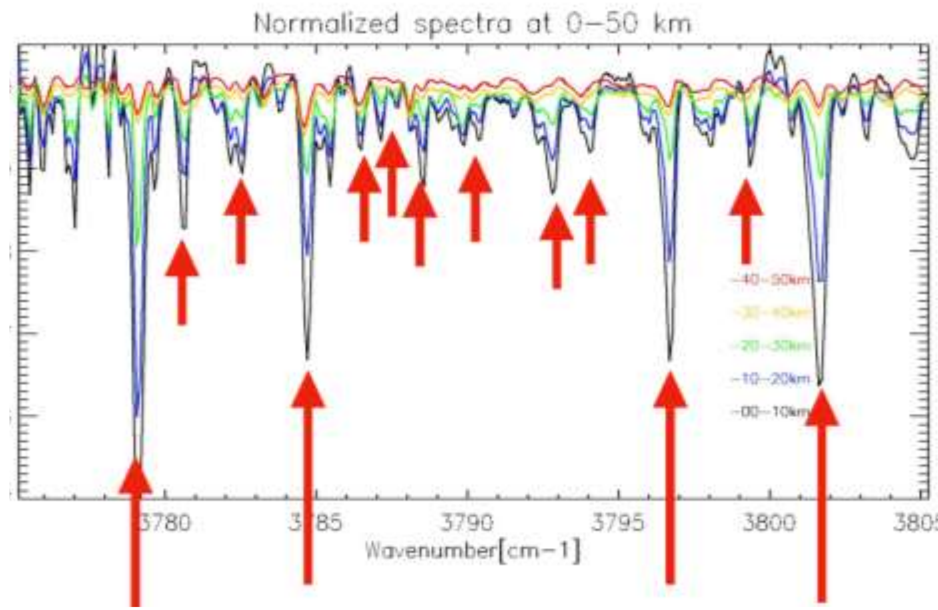
S. Aoki, G. Villanueva,
G. Liuzzi

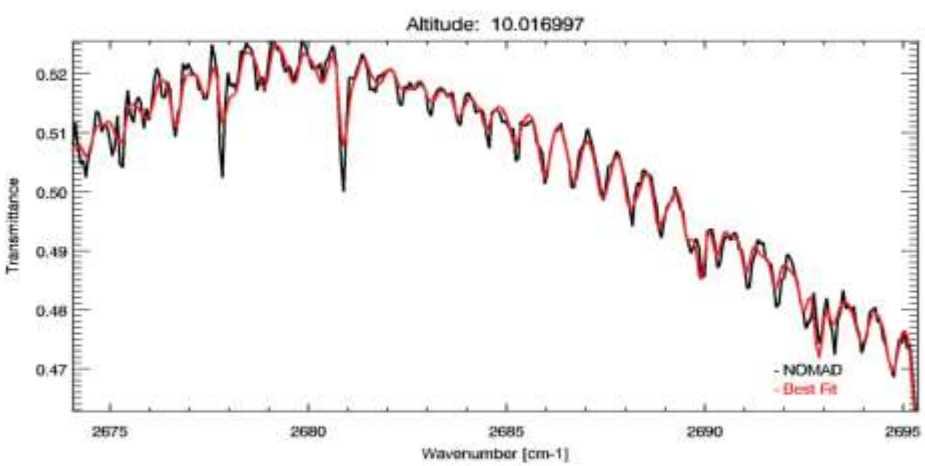
Villanueva et al., DPS 2018

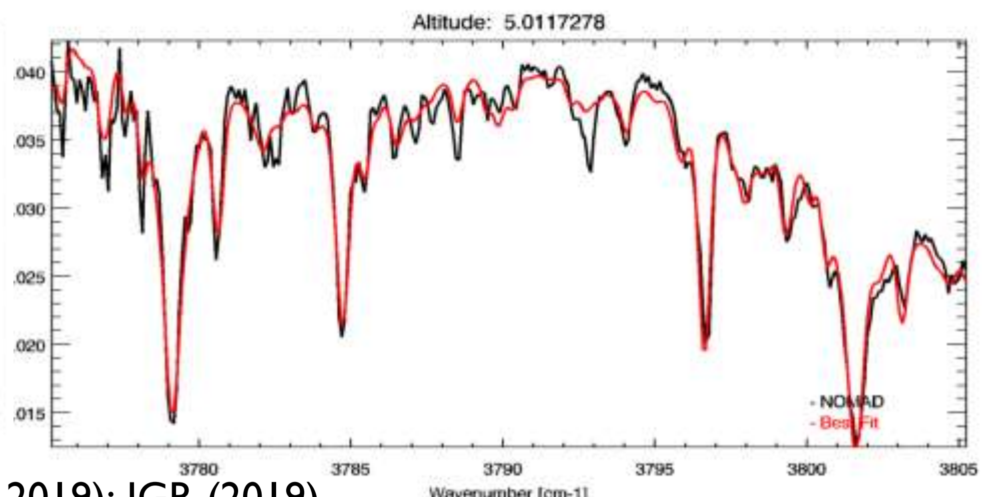
HDO

H_2O





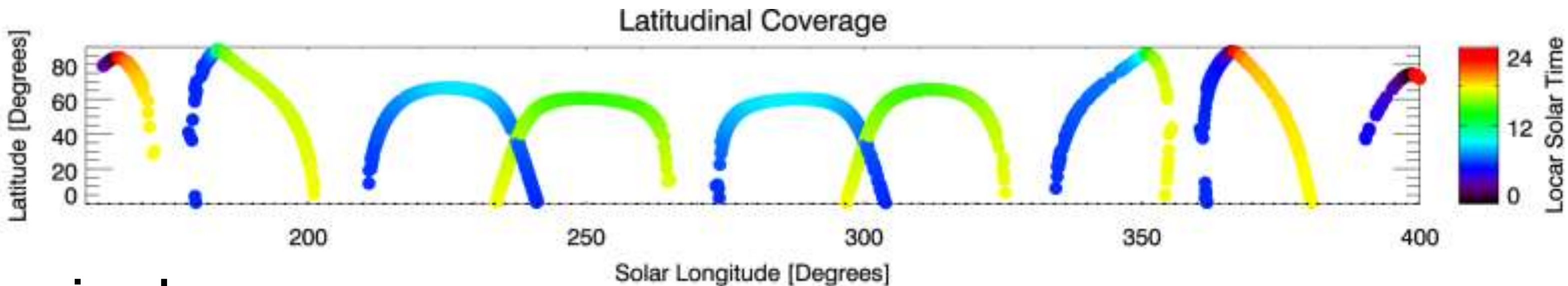




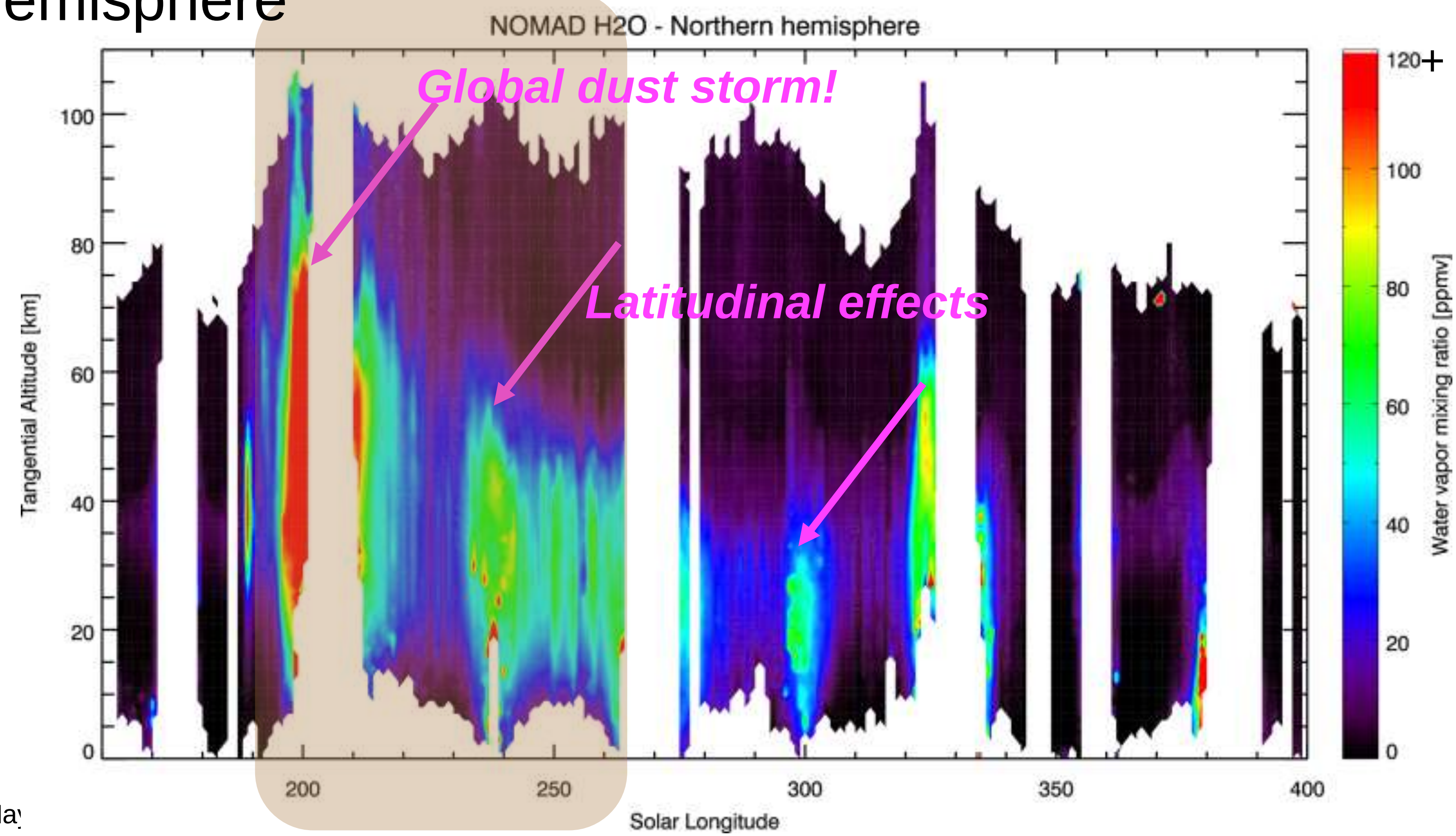
Aoki et al., EPSC (2018,2019); JGR (2019)

Dust storm & H_2O

Aoki et al., JGR (2019)

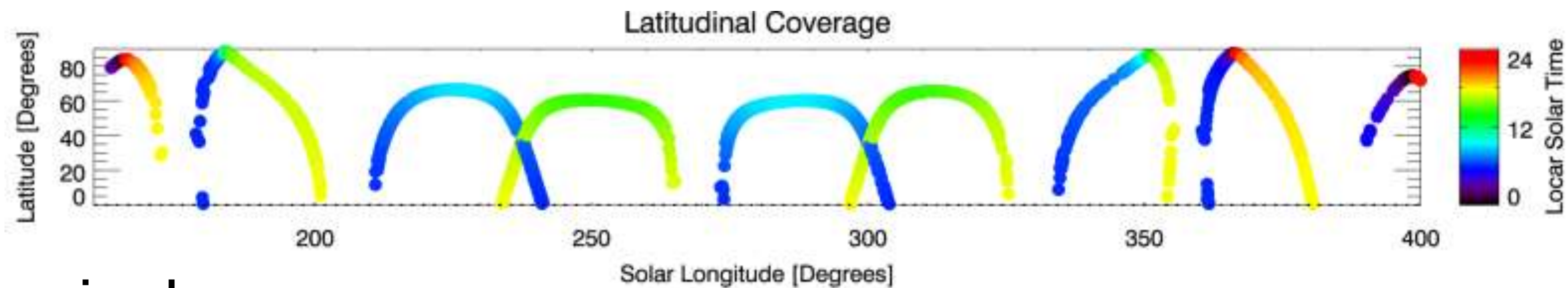


N hemisphere

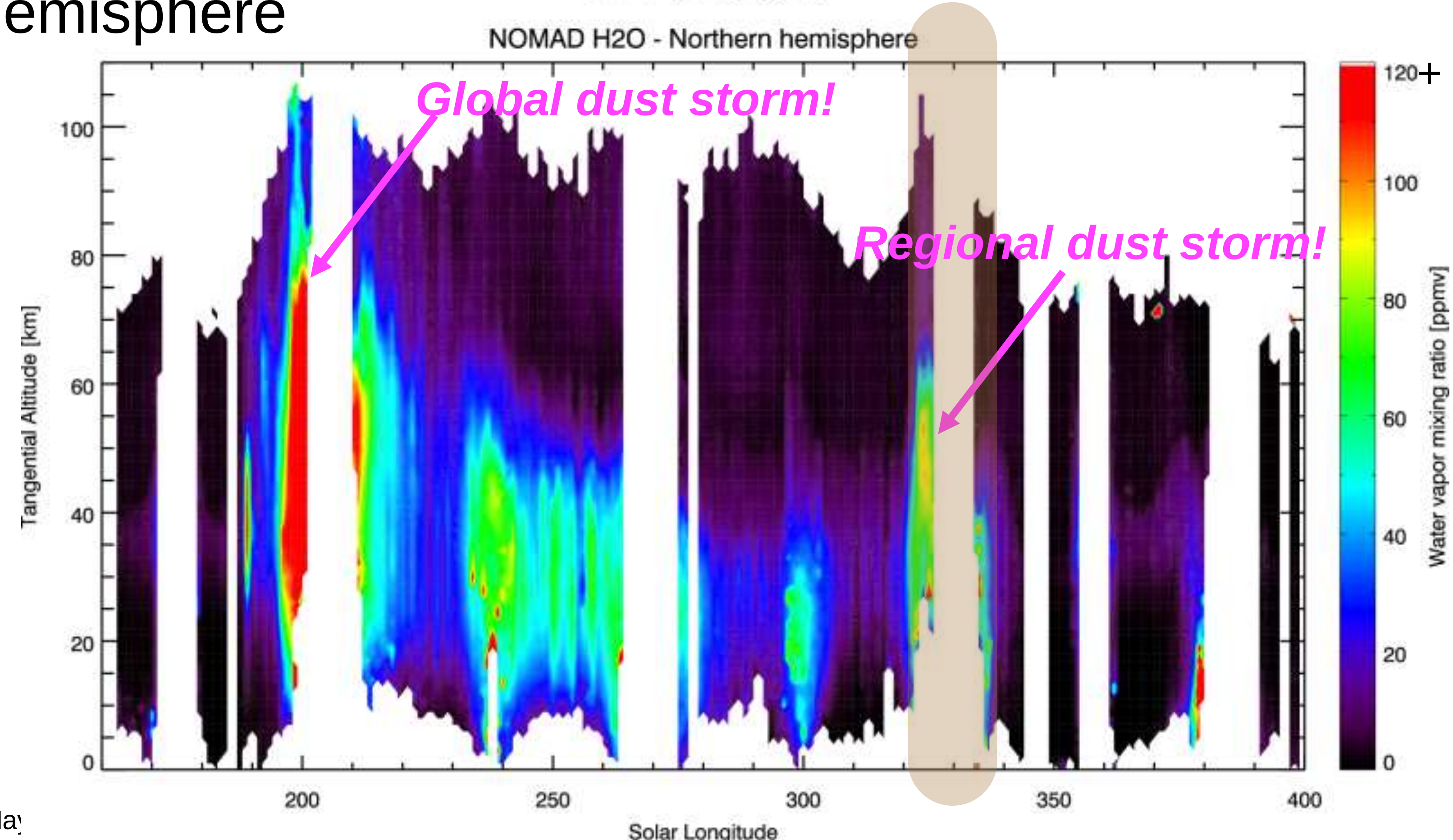


Dust storm & H_2O

Aoki et al., JGR (2019)



N hemisphere

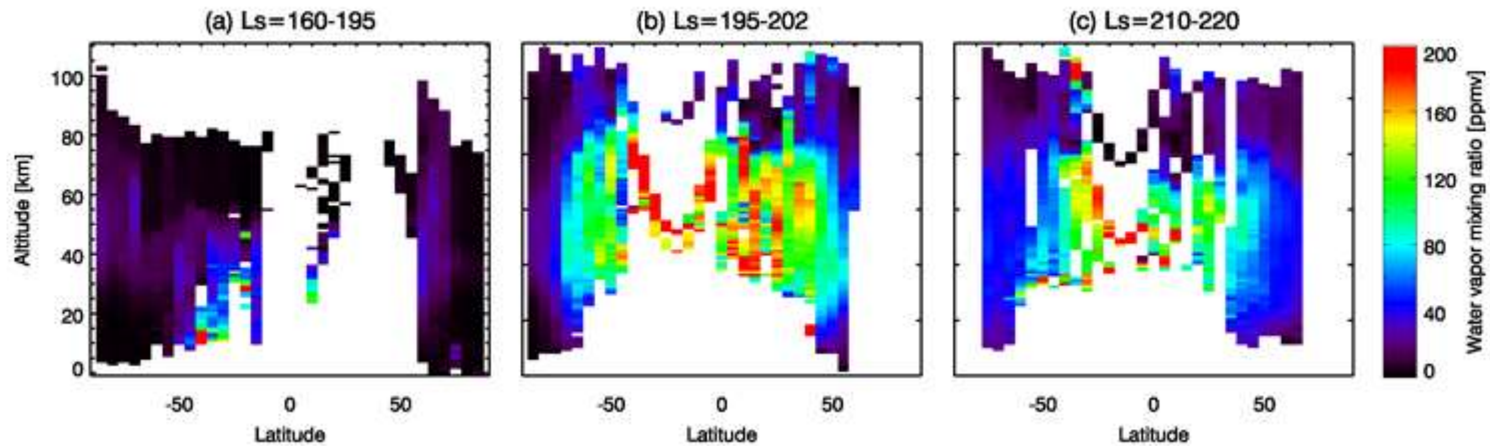


Dust storm & H2O

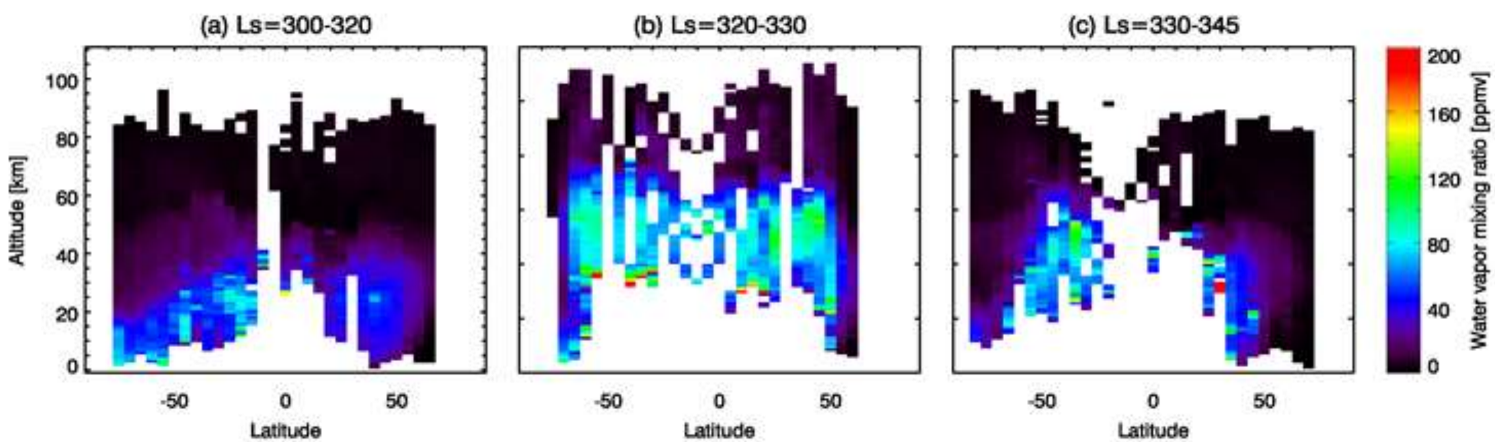
Aoki et al., JGR (2019)

- Latitudinal variation

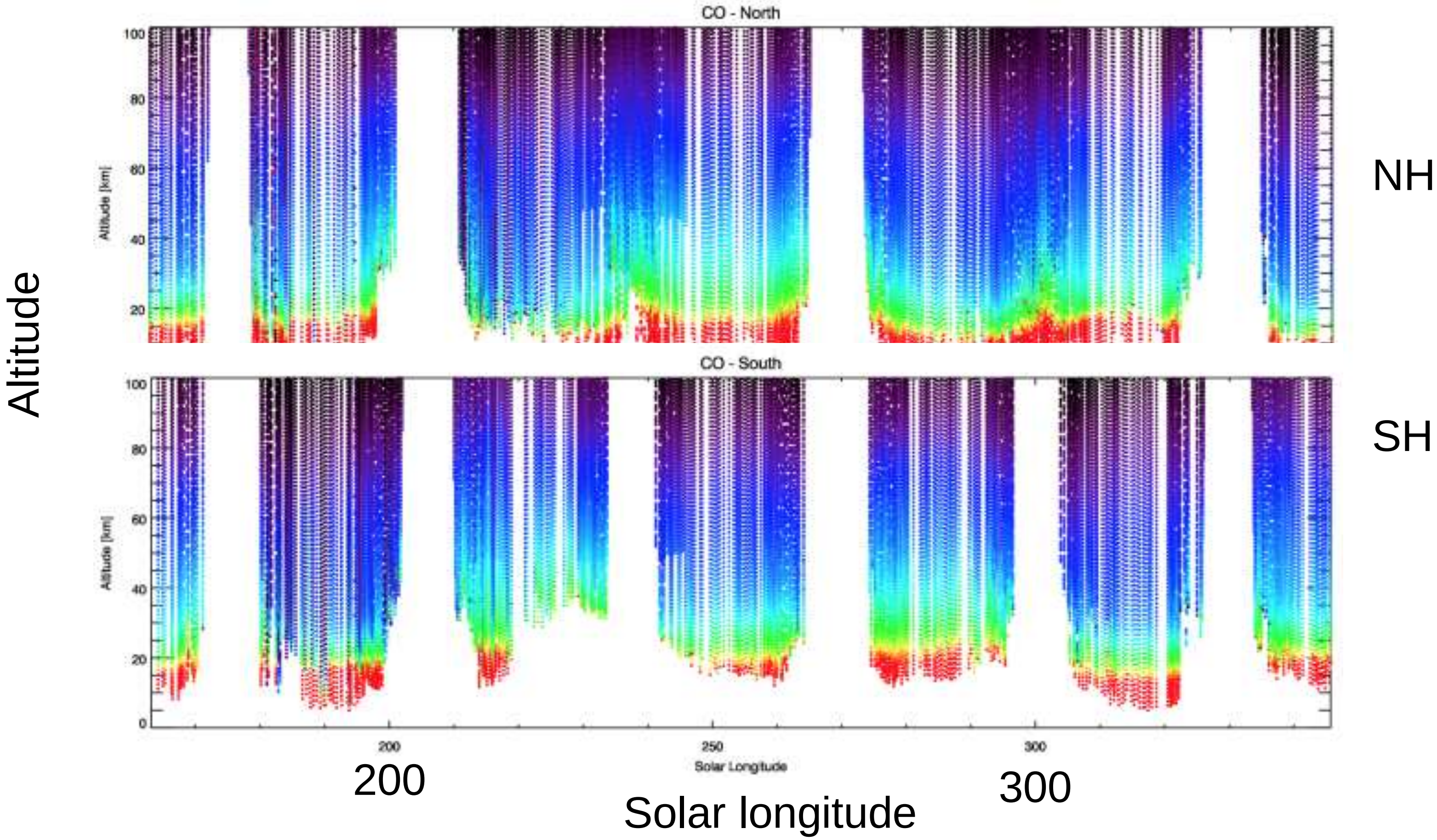
Global dust storm



Regional dust storm



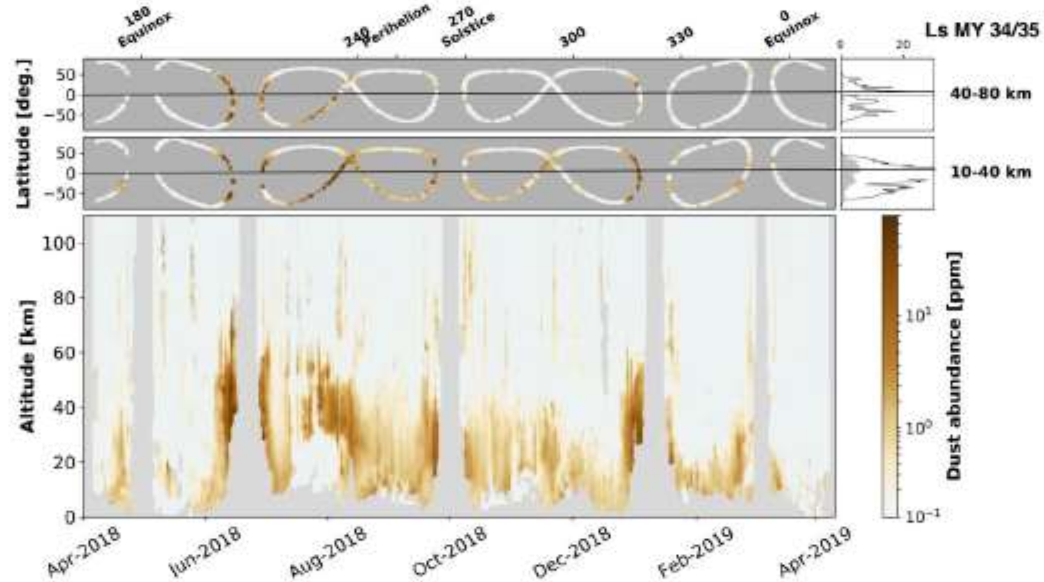
CO retrieval



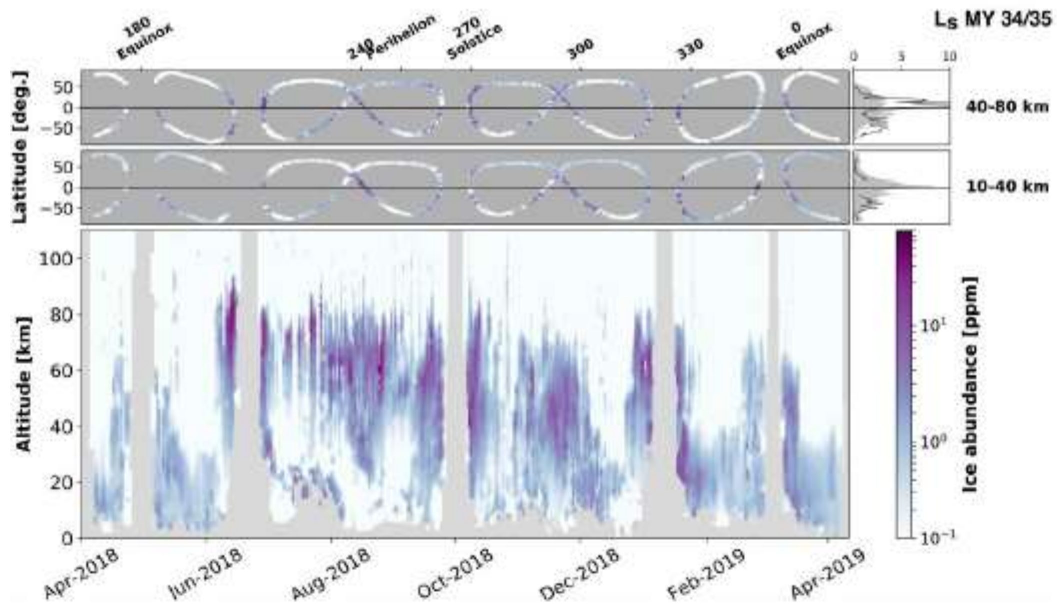
BIRA.IASB

Dust characterization (Liuzzi et al., JGR 2020)

- Dust loading

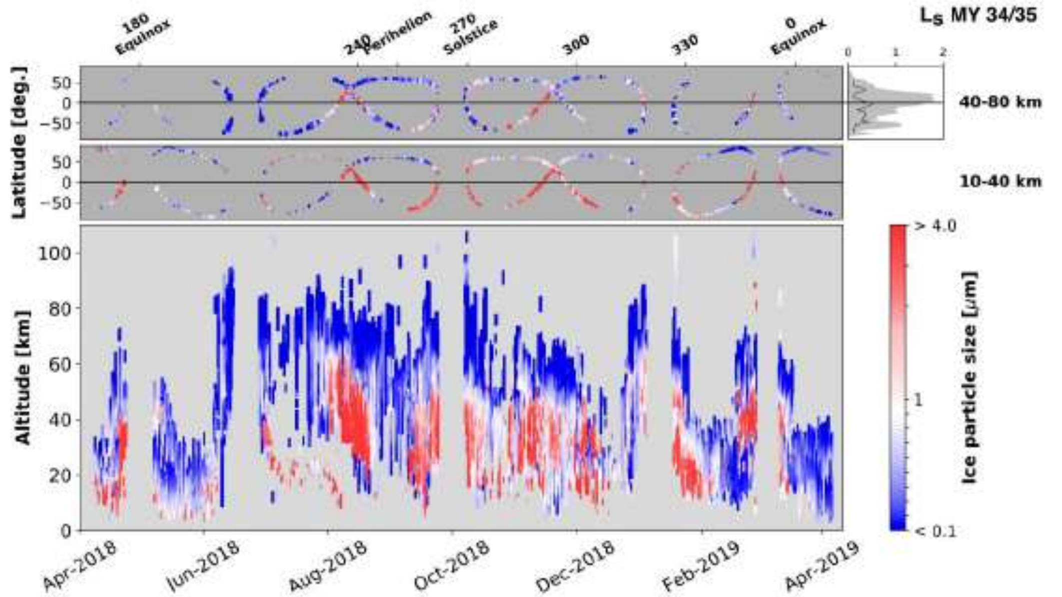


- Water ice abundance
  - Altitude of water ice condensation slowly declines (90 -> 50 km)
  - Following the Dust decreases

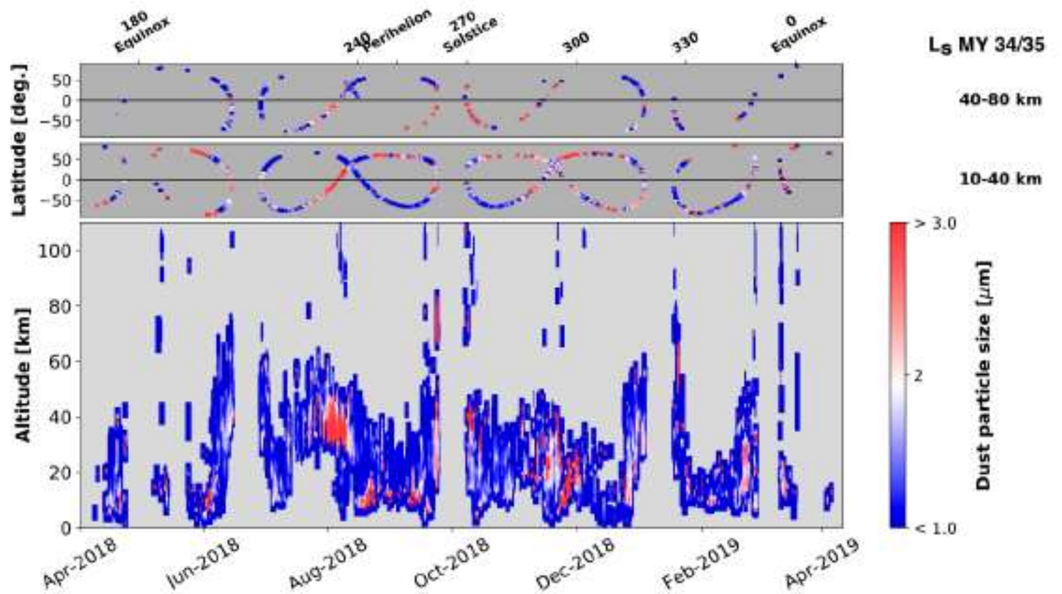


Dust characterization (Liuzzi et al., JGR 2020)

- Ice particle size



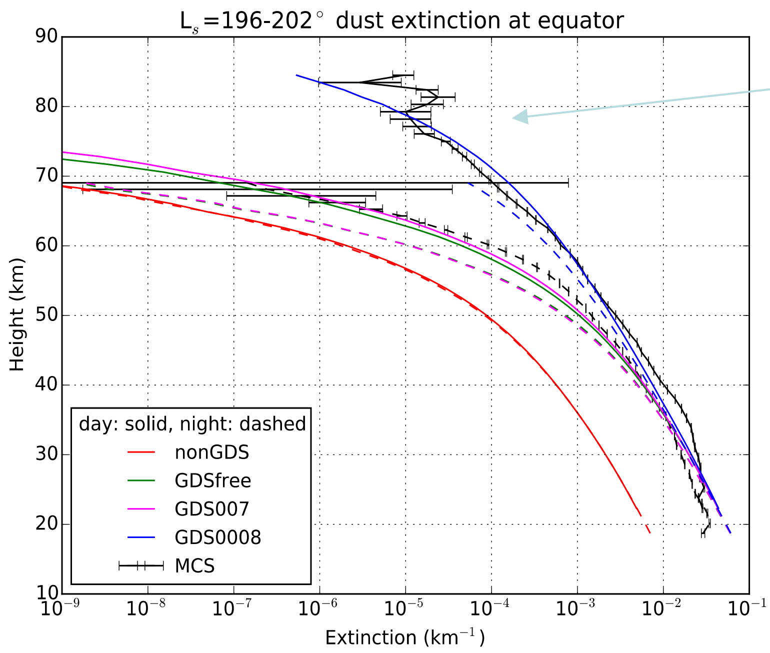
- Dust particle size



GCM simulations to explain high altitude water vapor during 2018 dust storm

Neary et al., GRL 2020
EGU2020: D3010/EGU2020-14498

- Vertical distribution of dust is a key factor for the transport of water vapor through the equatorial hygropause

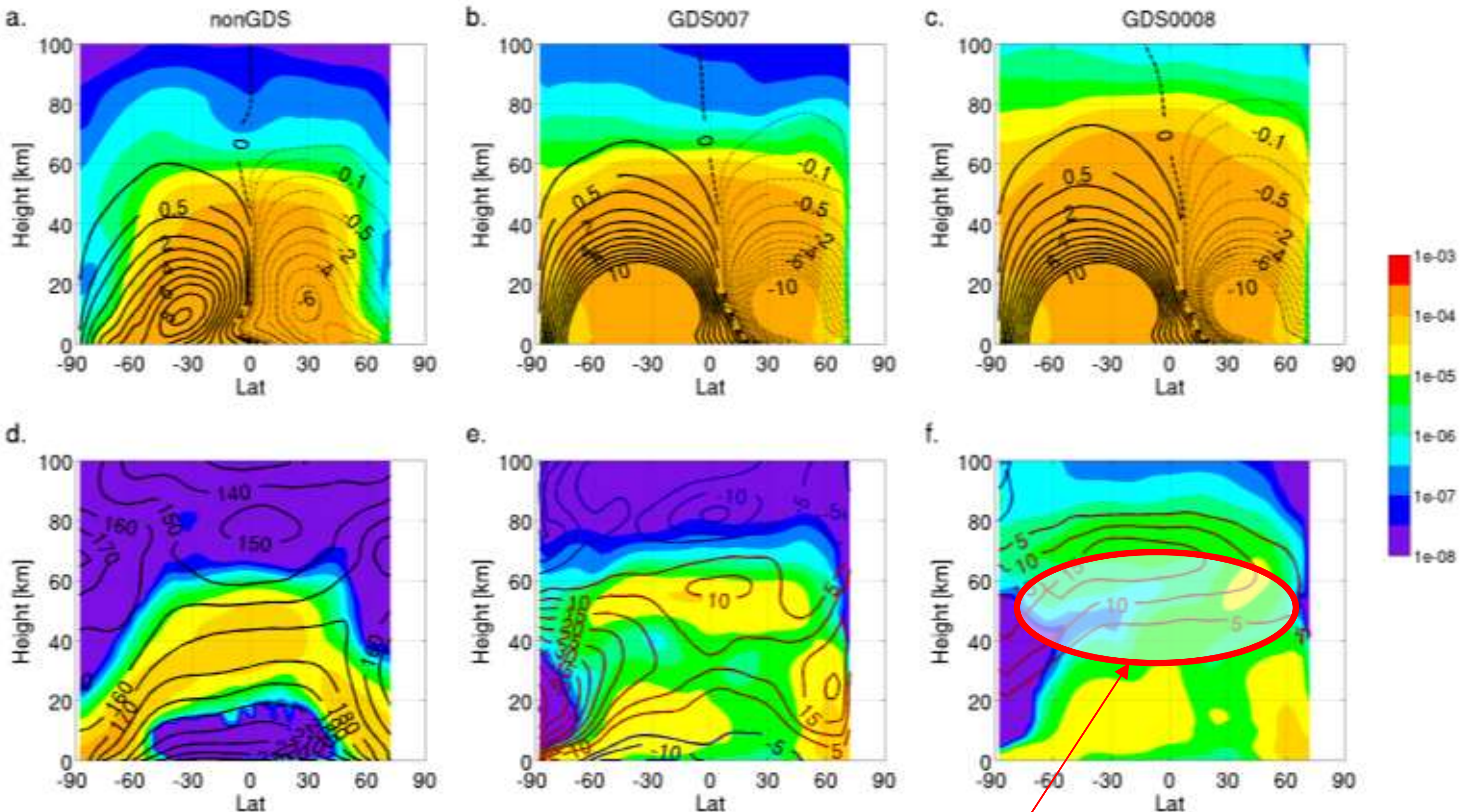


New profile better matches MCS dust extinction profile

Non dust storm | Old dust profile | New dust profile

circulation + water vapor

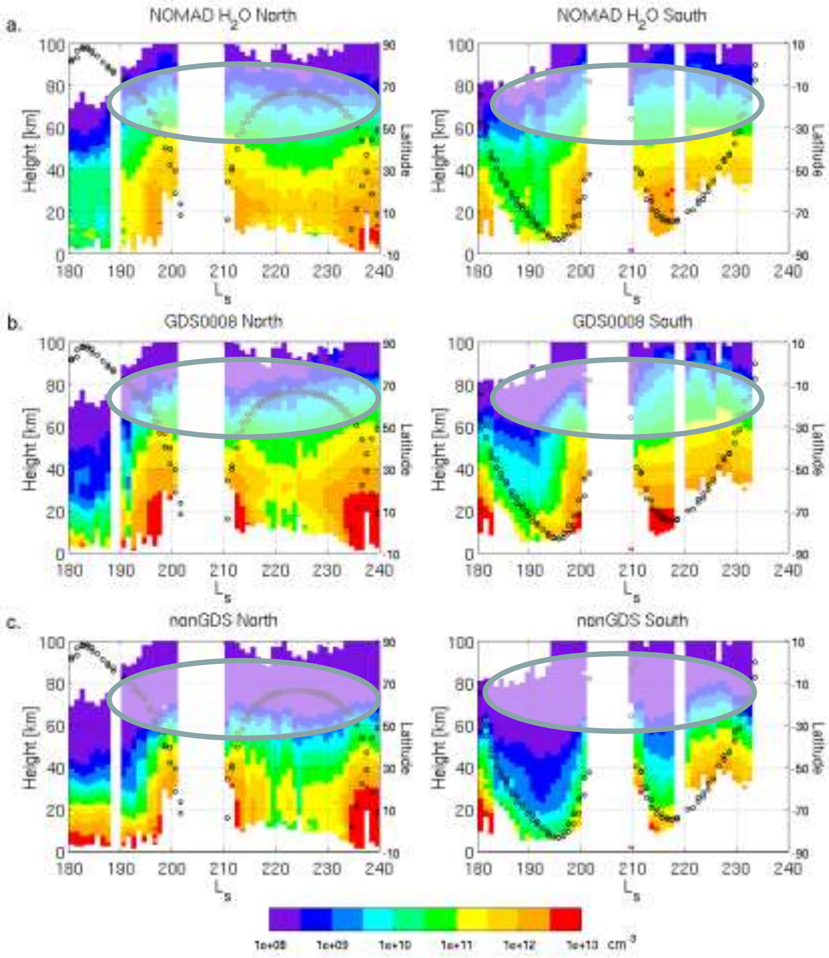
temperature + water ice



higher altitude dust ⇨ warmer temperatures ⇨ fewer water ice clouds

⇨ transport of water vapor to high altitudes

New dust profile better simulates high altitude water during dust storm

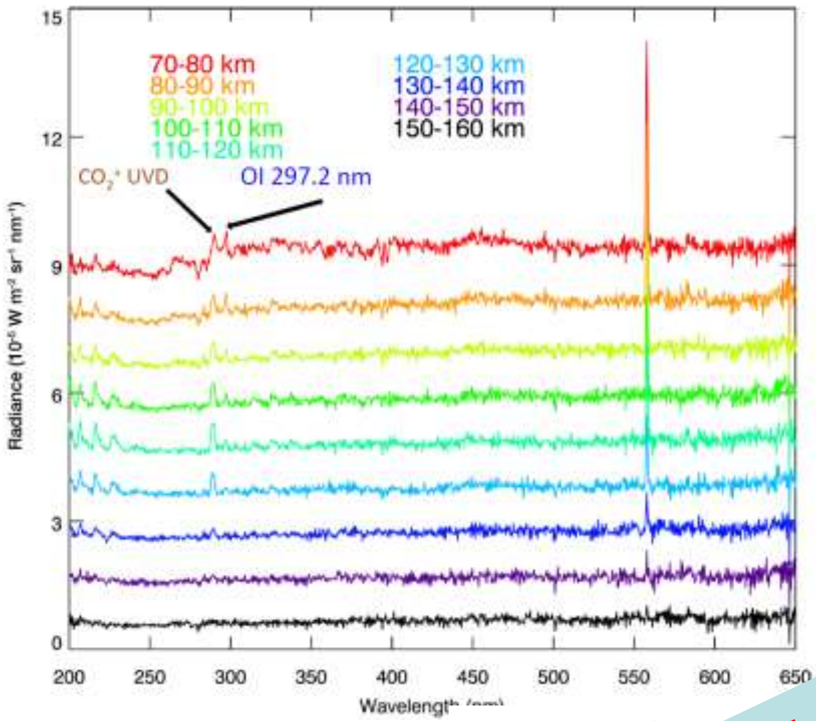


NOMAD observations of water vapor profiles

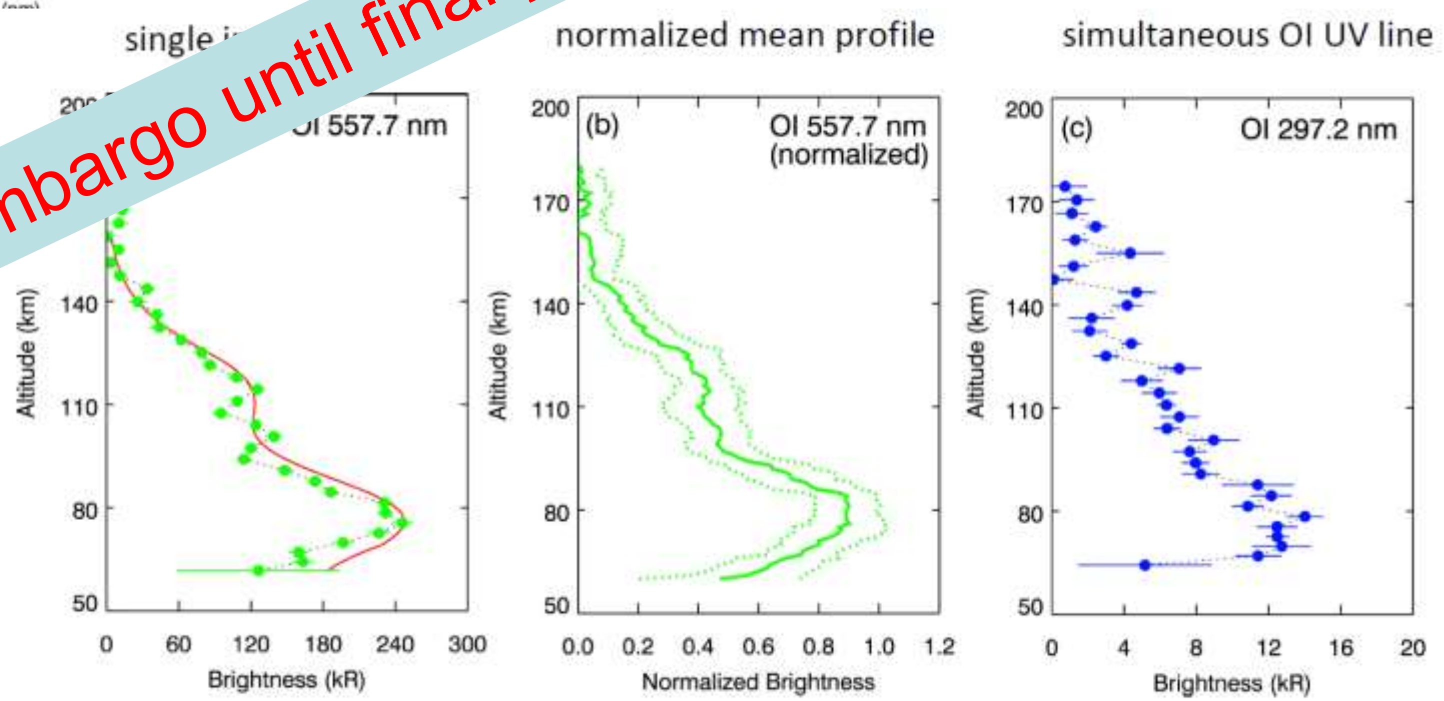
GCM simulation with new dust profile

GCM simulation of non dust storm case

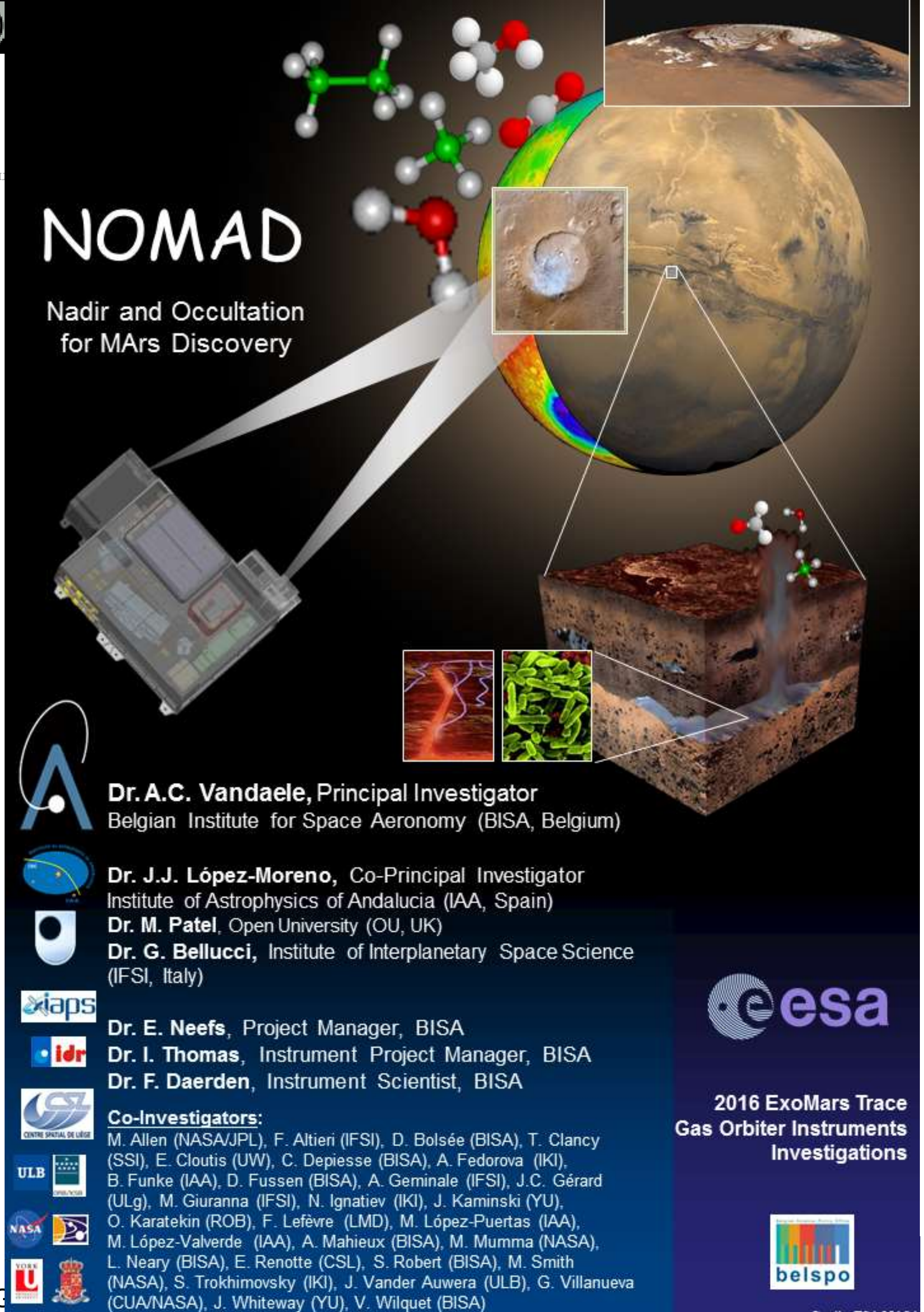
Green line



I(557.7 nm) /I(297.2nm)	
Theoretical calc. (NIST)	16.7
Average of Obs	9.4±1.0
NOMAD	16.5±1.3



J.-C. Gérard,
ULiège
Paper acc.
Nature Astron.



The NOMAD Science Team

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The NOMAD Tech Team

Alonso-Rodrigo, Gustavo; Aparicio del Moral, Beatriz; Barzin, Pascal; Beeckman, Bram; BenMoussa, Ali; Berkenbosch, Sophie; Biondi, David; Bonnewijn, Sabrina; Candini, Gian Paolo; Clairquin, Roland; Cubas, Javier; Giordanengo, Boris; Gissot, Samuel; Gomez, Alejandro; Hathi, Brijen; Jeronimo Zafra, Jose; Leese, Mark; Maes, Jeroen;Mazy, Emmanuel; Mazzoli, Alexandra; Meseguer, Jose; Morales, Rafael; Orban, Anne; Pastor-Morales, M; Perez-grande, Isabel; Queirolo, Claudio; Ristic, Bojan; Rodriguez Gomez, Julio; Saggin, Bortolino; Samain, Valérie; Sanz Andres, Angel; Sanz, Rosario; Sellers, Graham; Simar, Juan-Felipe; Thibert, Tanguy; Trompet, Loïc