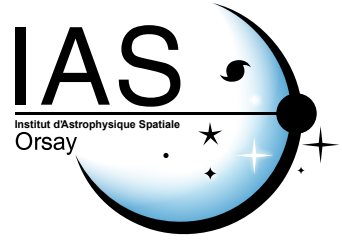
Water ice clouds in the Martian atmosphere during the 2018 Global Dust Storm

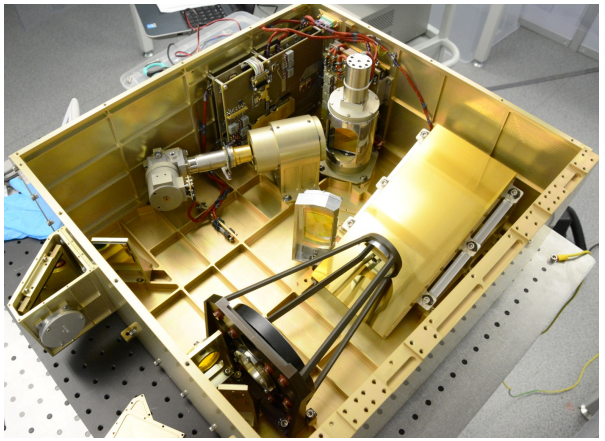
Aurélien Stcherbinine, M. Vincendon, F. Montmessin

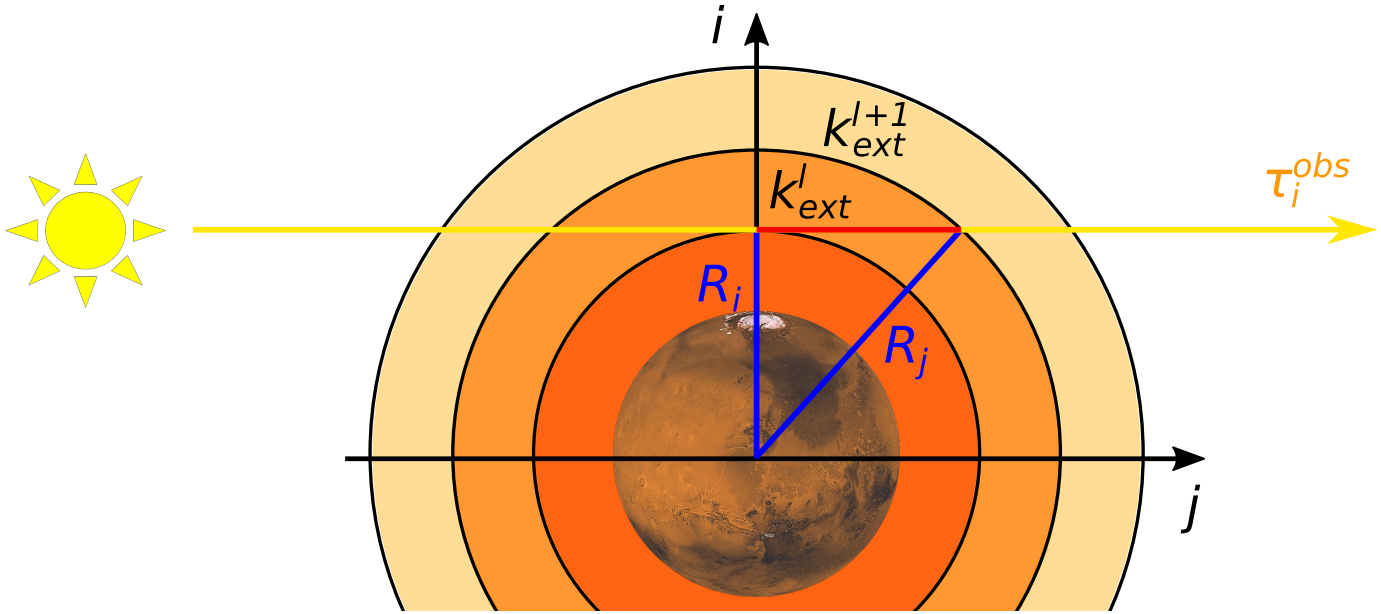
Elbereth Conference - Paris, 28 February 2020

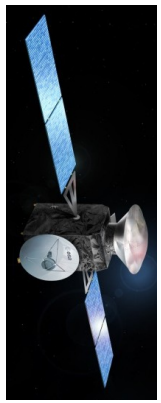


The ExoMars TGO/ACS-MIR channel

- Cross-dispersion echelle spectrometer
- Dedicated to Solar Occultation
- Cover 0.3 µm per measurement among the 2.3 – 4.2 µm spectral range

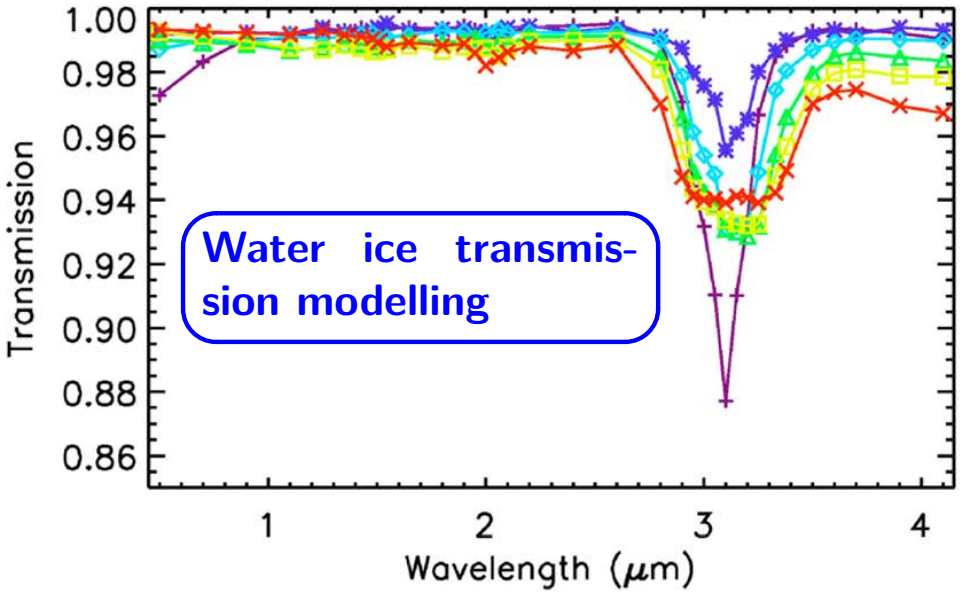






$$\tau_i^{\text{obs}} = \sum_{j=i+1}^{N-1} \left(\sqrt{R_{j+1}^2 + R_j^2} - \sqrt{R_j^2 + R_{j-1}^2} \right) k_{\text{ext}}^j$$

Water ice in the 3 µm spectral range with MIR



} Colors ↔ particle size

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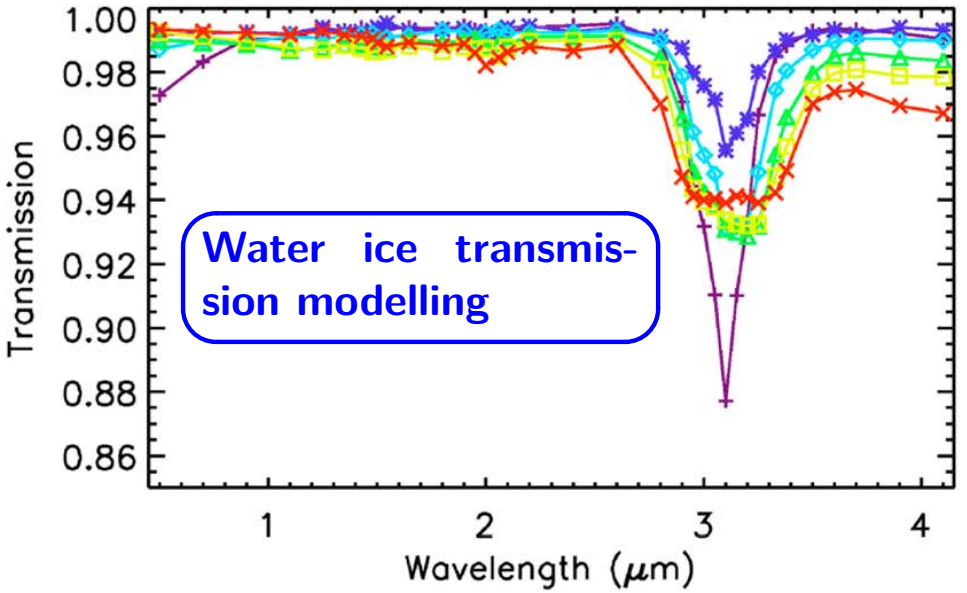

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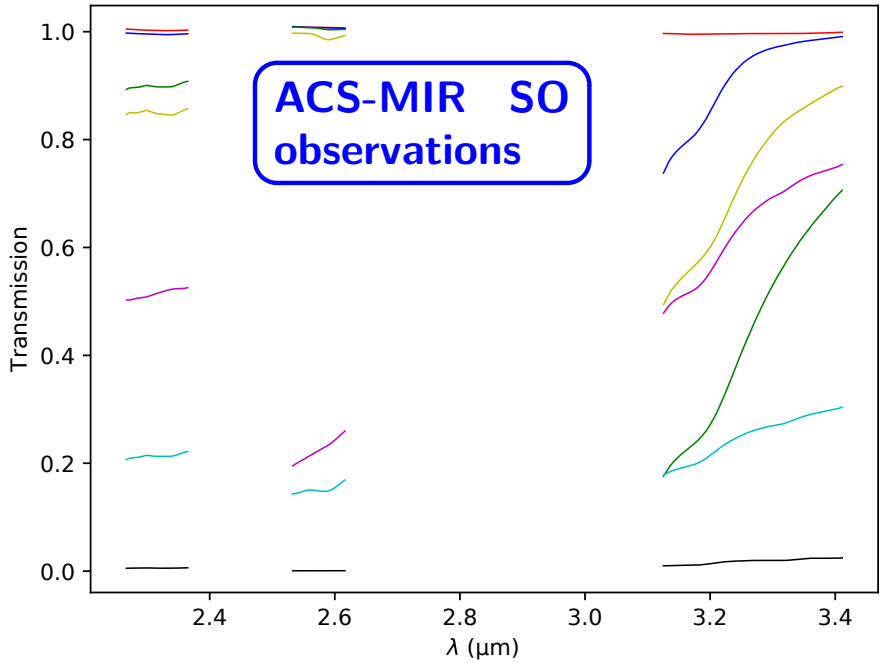

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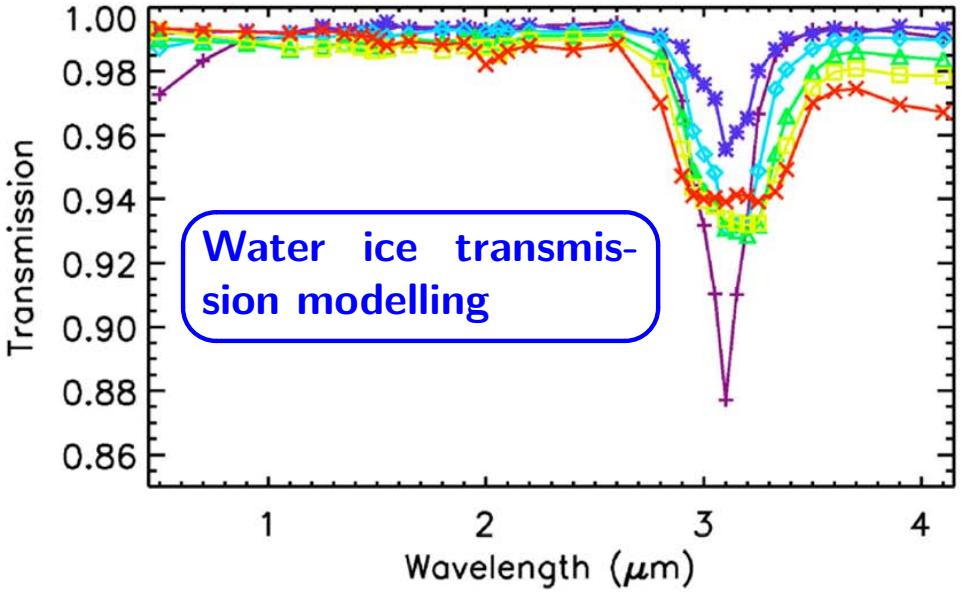

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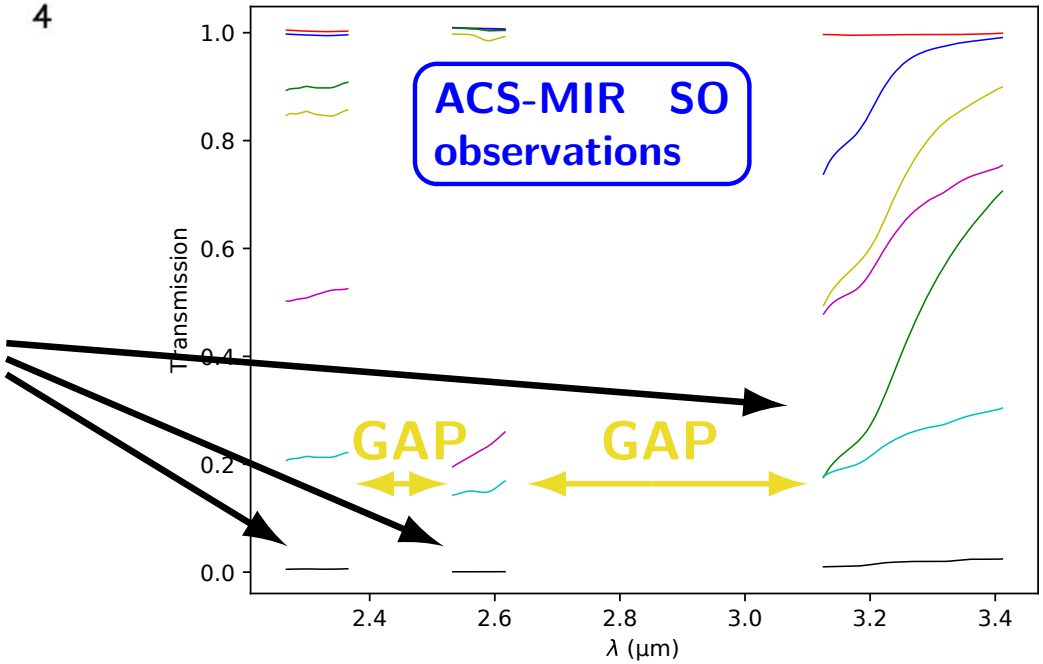
Different observations = different positions and time



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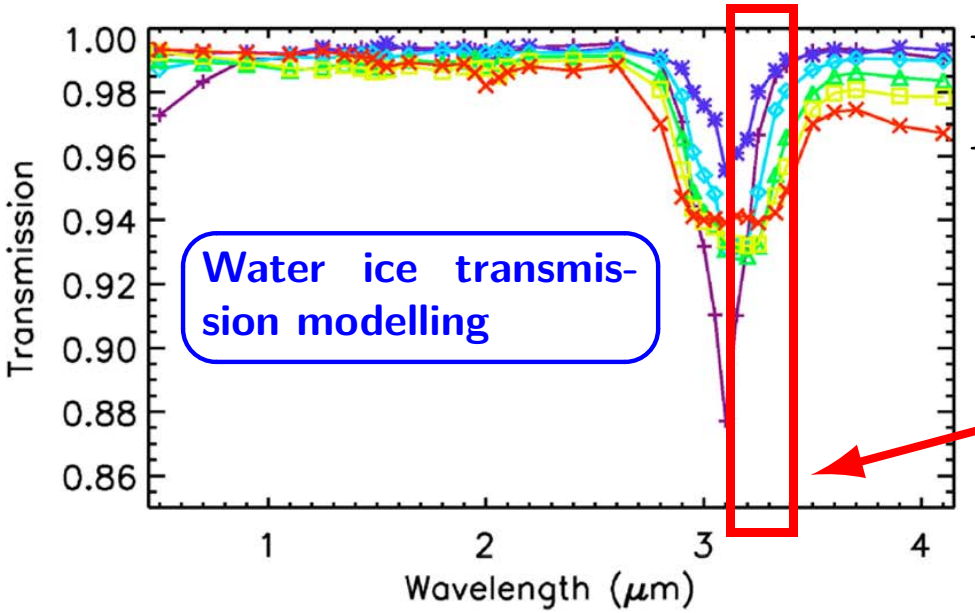

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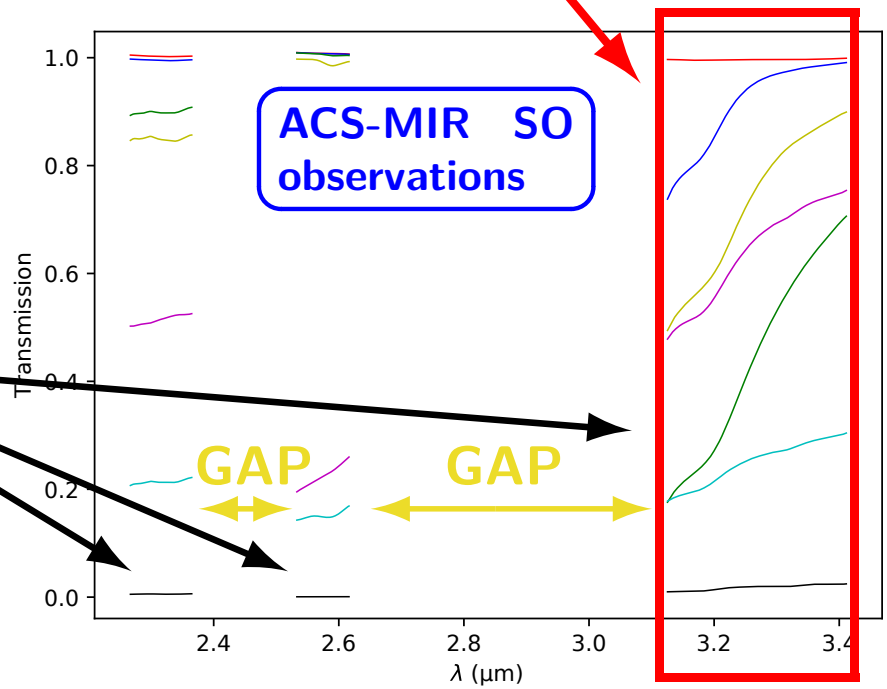
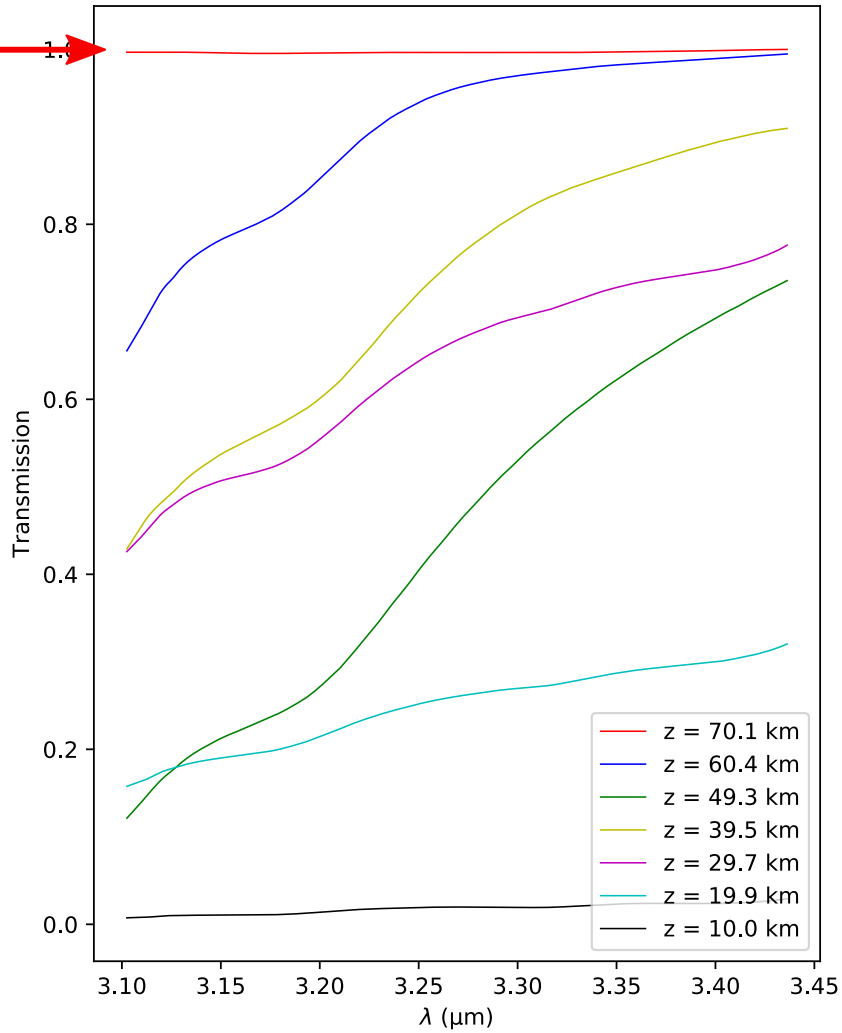
grating position 12



Different observations = different positions and time

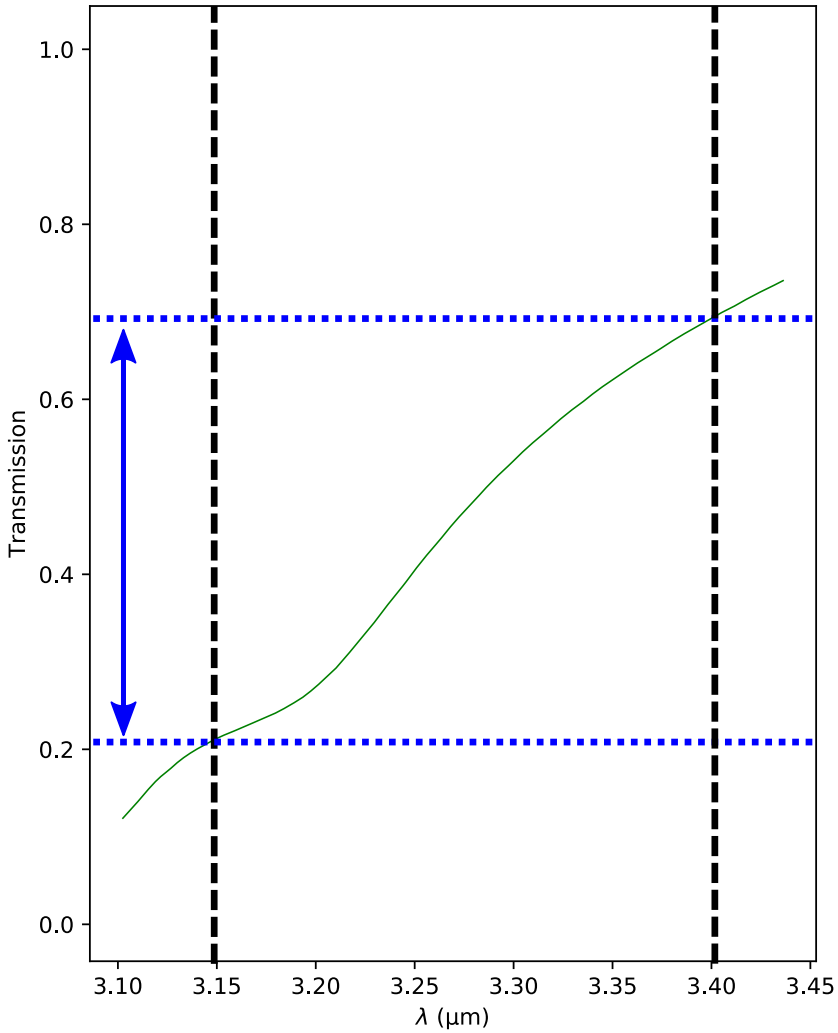
Characterization of the 3 µm water ice band

Haze top



Characterization of the 3 µm water ice band

3 µm absorption band depth



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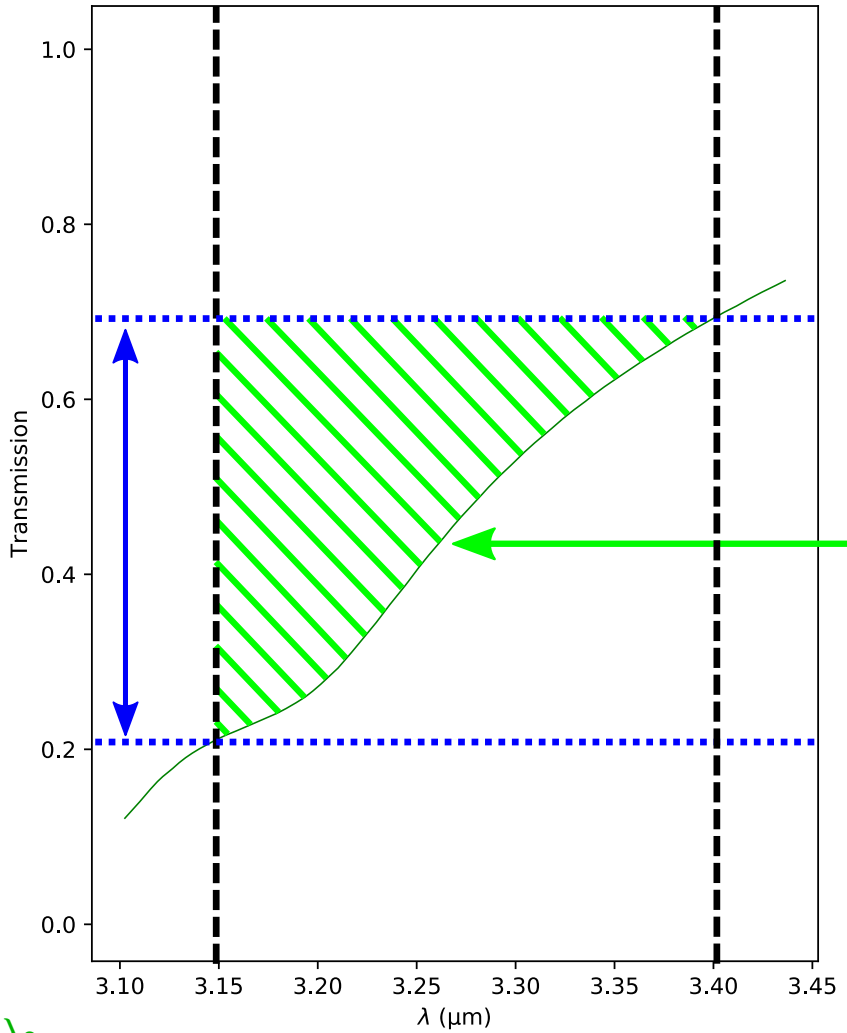
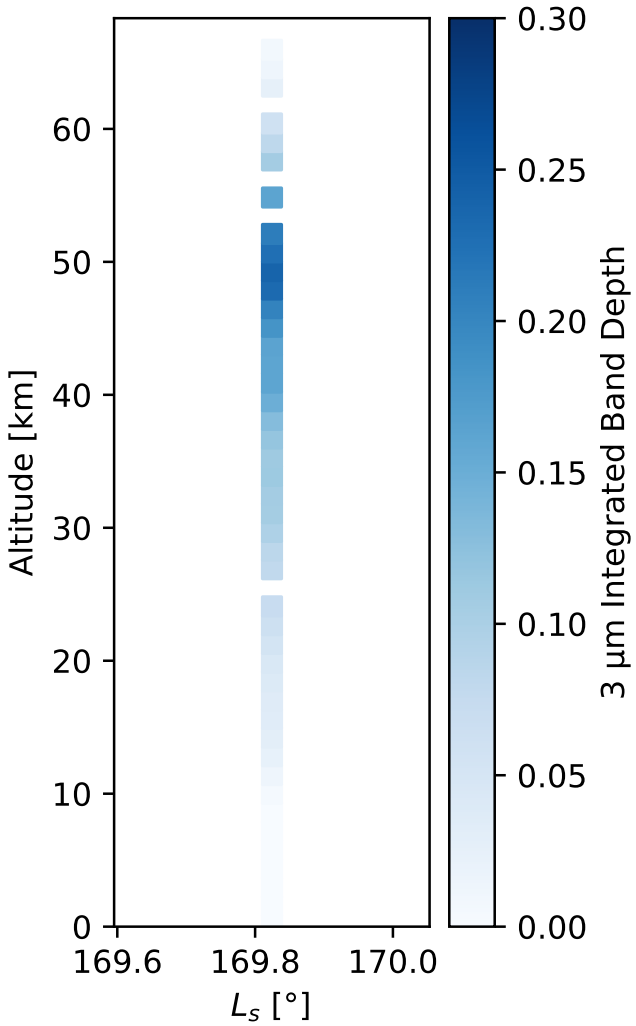


3 µm IBD (Integrated Band Depth)

$$\mathrm{IBD}(Tr, \lambda_1, \lambda_2) = \frac{1}{\lambda_2 - \lambda_1} \int_{\lambda_1}^{\lambda_2} [Tr(\lambda_2) - Tr(\lambda)]\, d\lambda$$

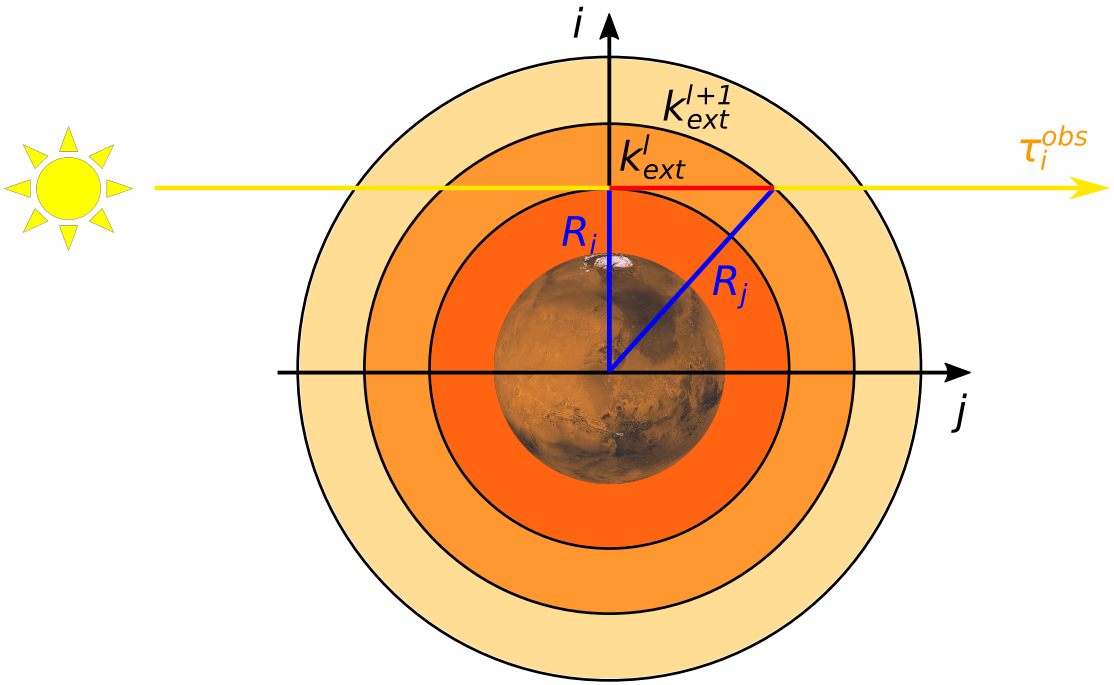
Vertical variations of the Integrated Band Depth

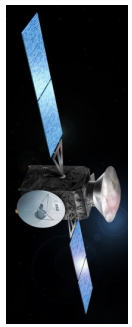


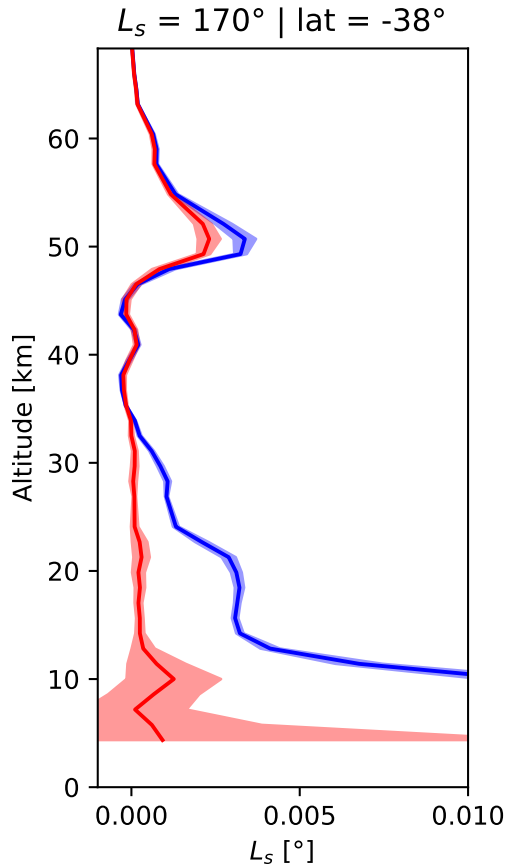
- **1** single ACS-MIR observation
- 3 µm band depth at each observed altitude **below the haze top**

Retrieving the particle size from the spectral shape ?

- Vertical inversion for all wavelength $\rightarrow$ k_{ext} spectra at each observed altitude.







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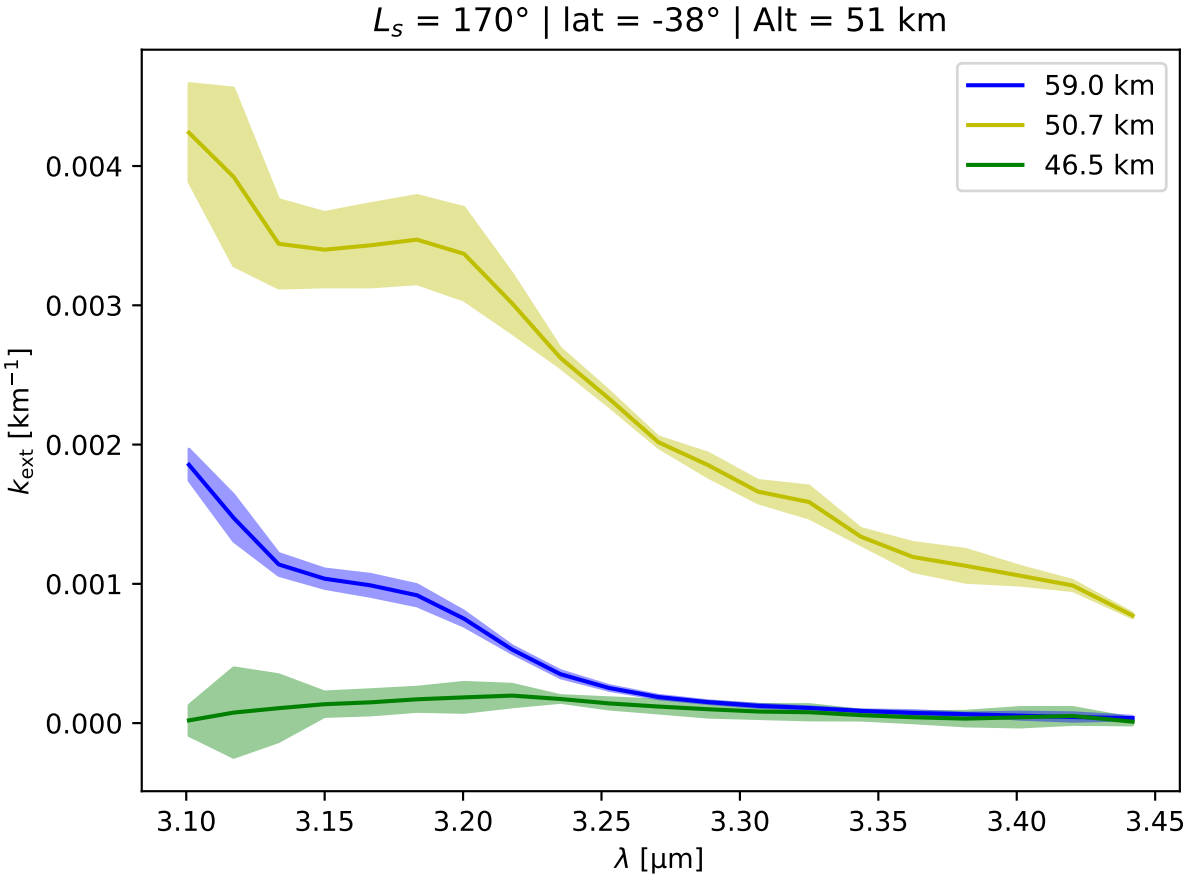
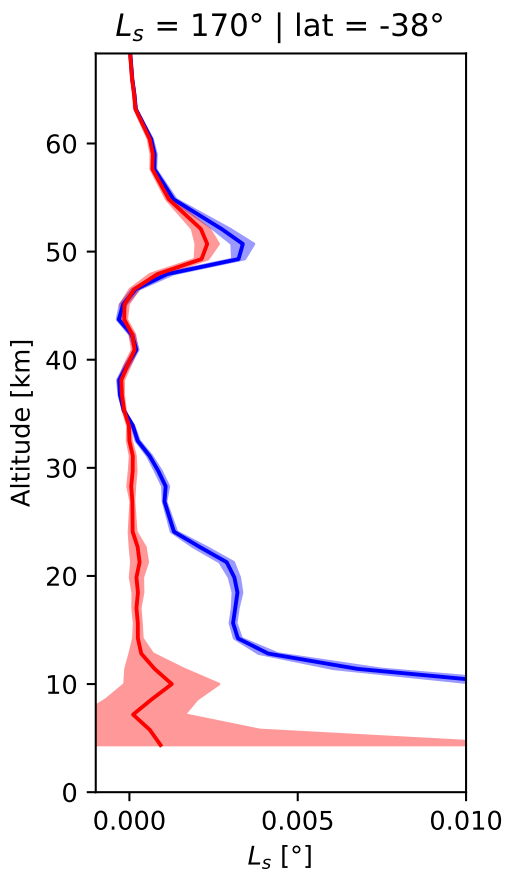


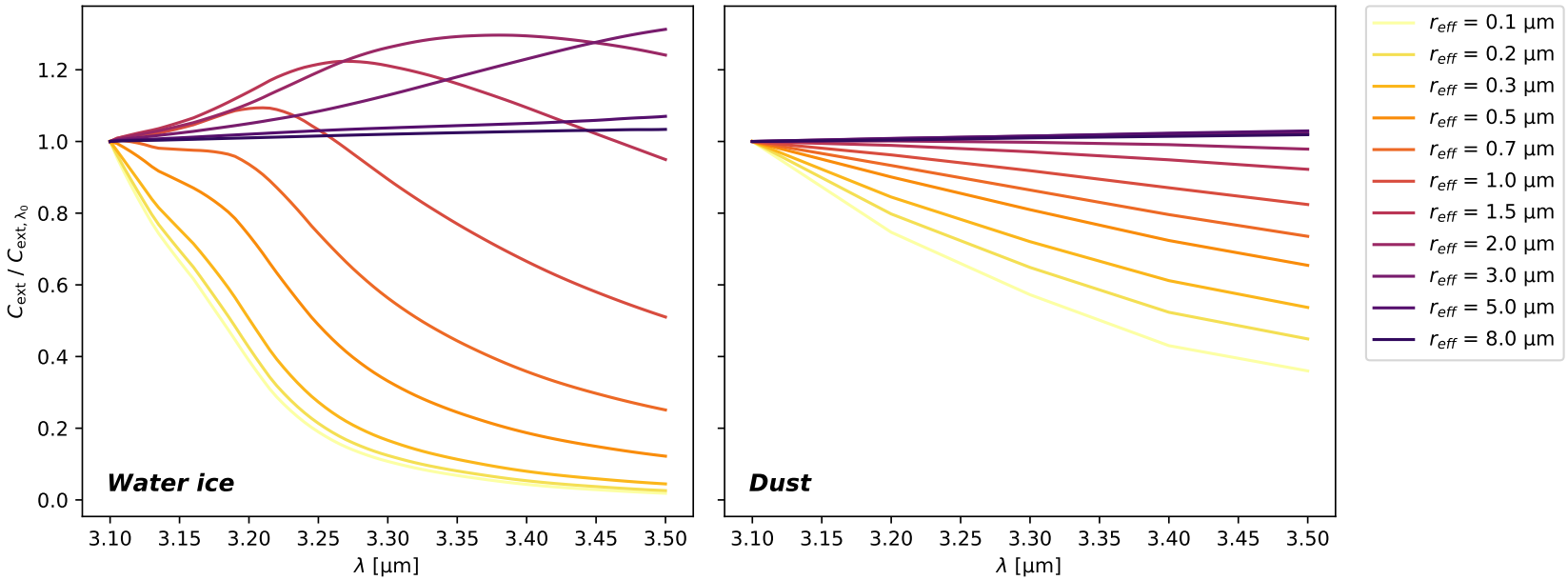


$k_{\text{ext}}(3.2\ \mu\text{m})$ $k_{\text{ext}}(3.2\ \mu\text{m}) - k_{\text{ext}}(3.4\ \mu\text{m})$

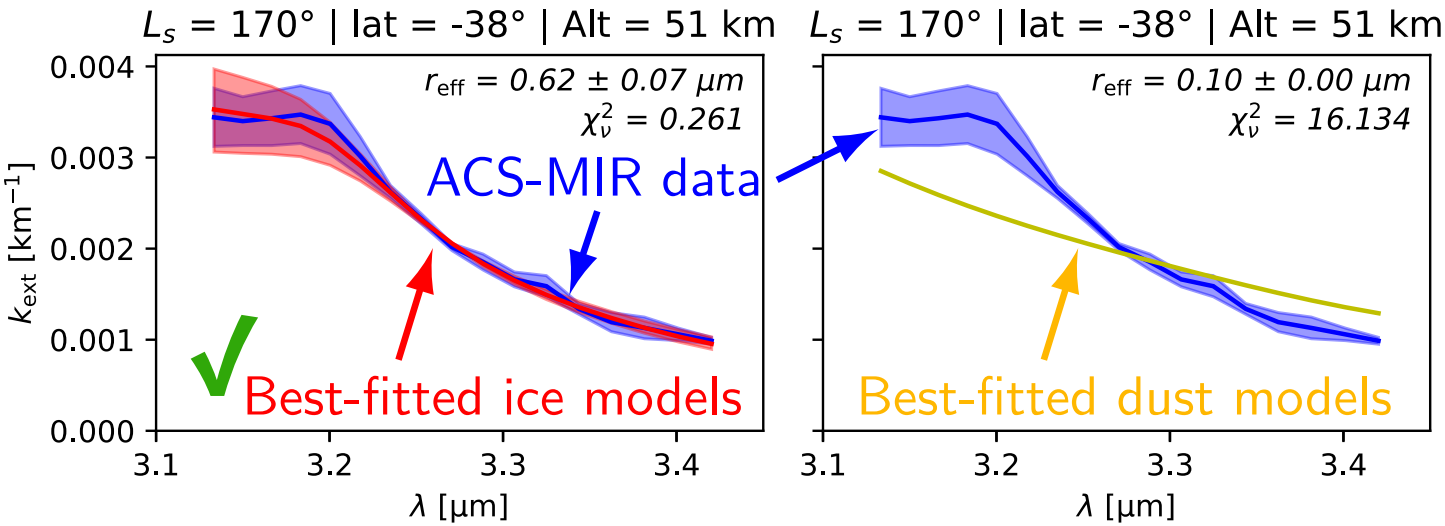
Water ice clouds identification & Particle size retrieving

- After the vertical inversion, we can fit **spherical water ice particles** extinction opacity **models** C_{ext} on the **observed** $\boldsymbol{k_{\text{ext}}}$ **spectra**.
- The water ice fit is considered as relevant if it verifies :

$$\left(\chi^2_{\nu,\,\text{ice}} \leq 9\right) \,\&\, \left(\chi^2_{\nu,\,\text{ice}} \leq \frac{\chi^2_{\nu,\,\text{dust}}}{4}\right) \,\&\, \left(\chi^2_{\nu,\,\text{dust}} > 1\right)$$



Water ice clouds identification & Particle size retrieving



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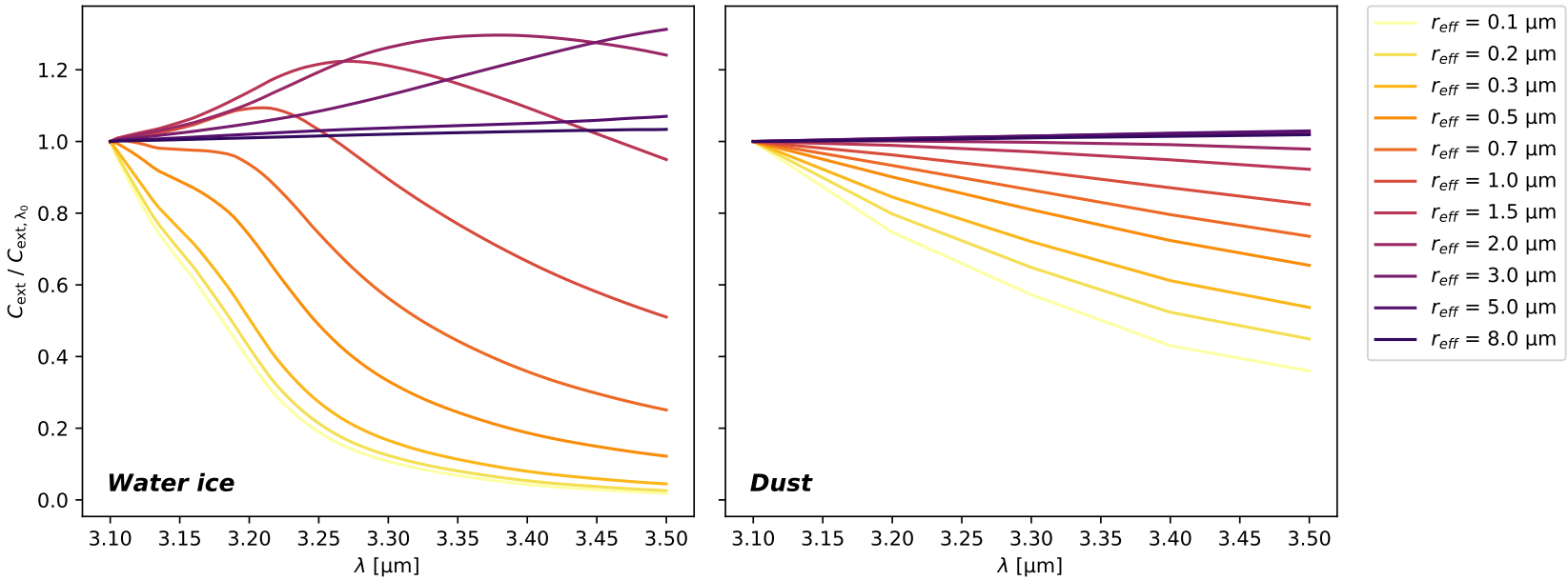

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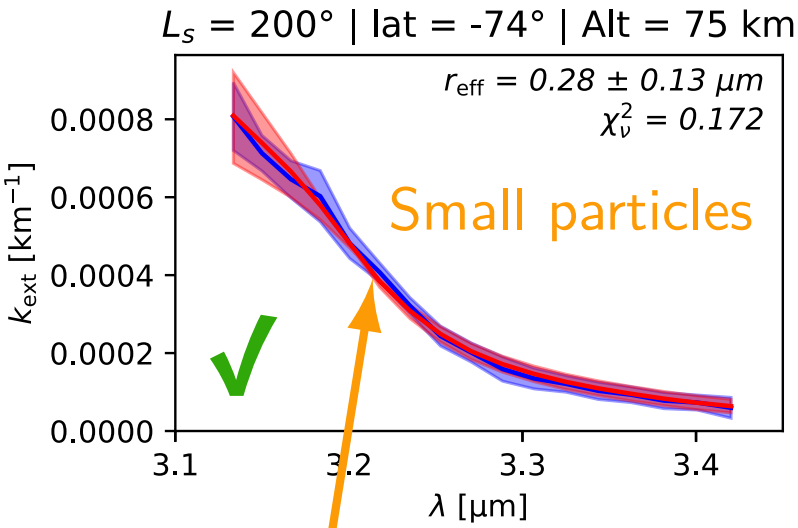

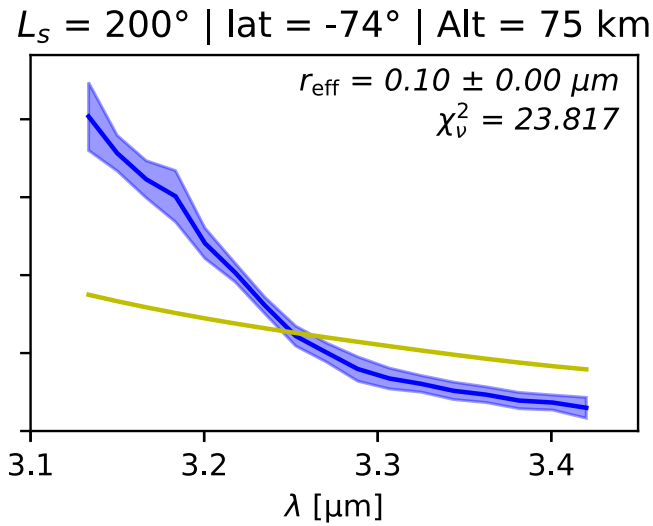

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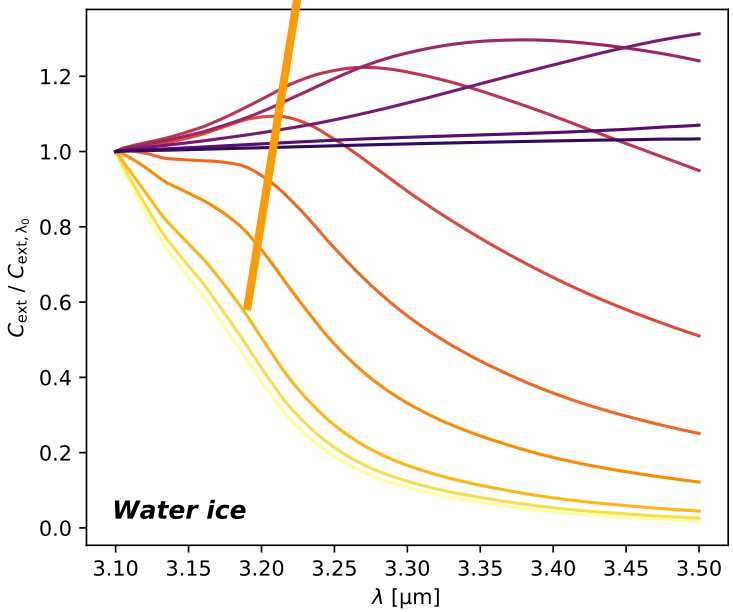

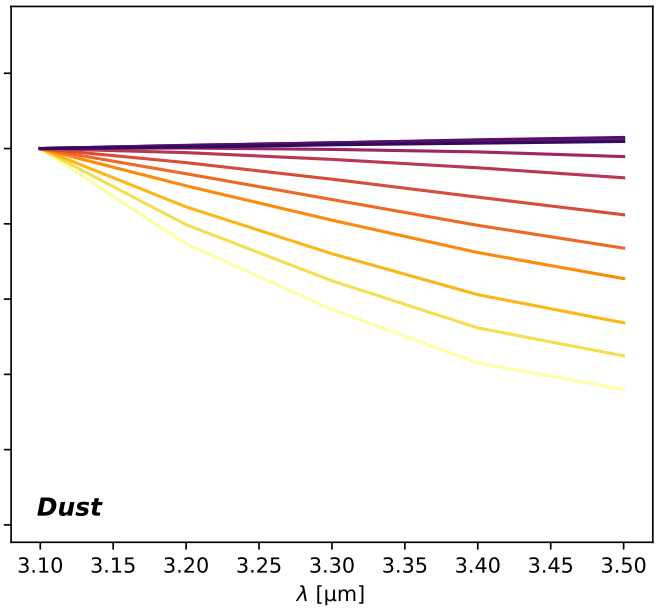

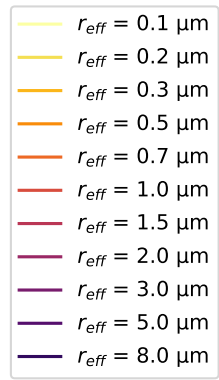

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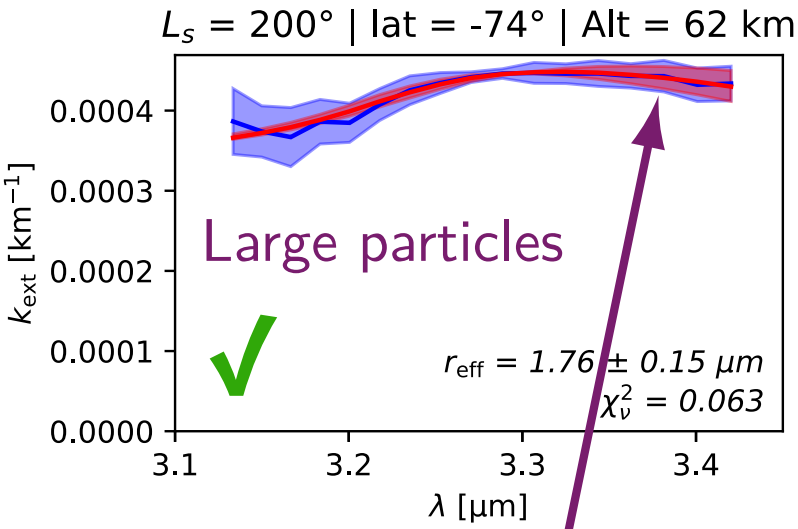

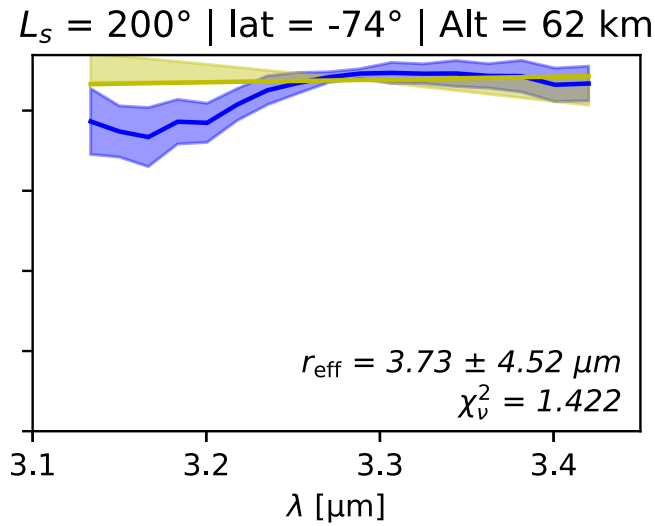

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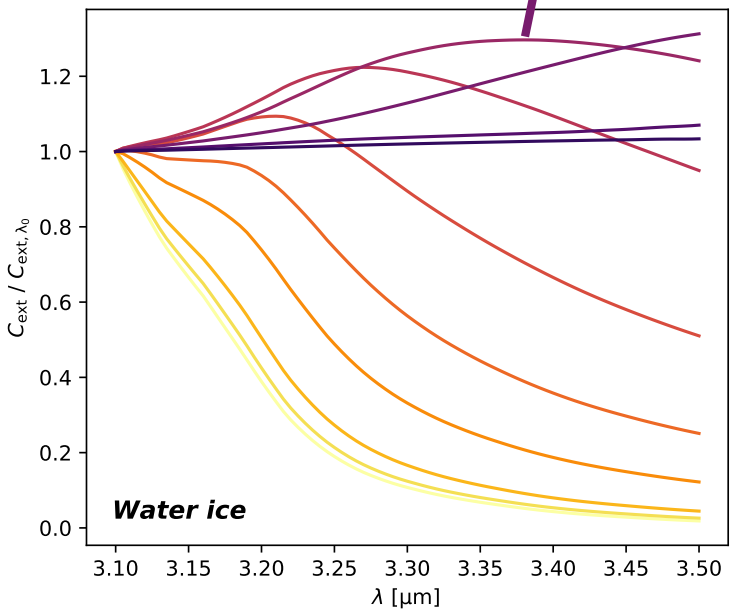
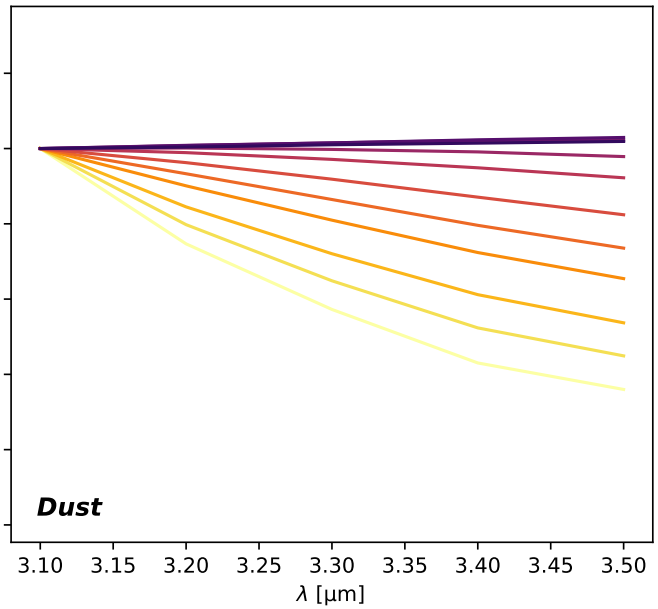
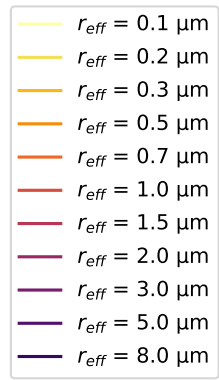
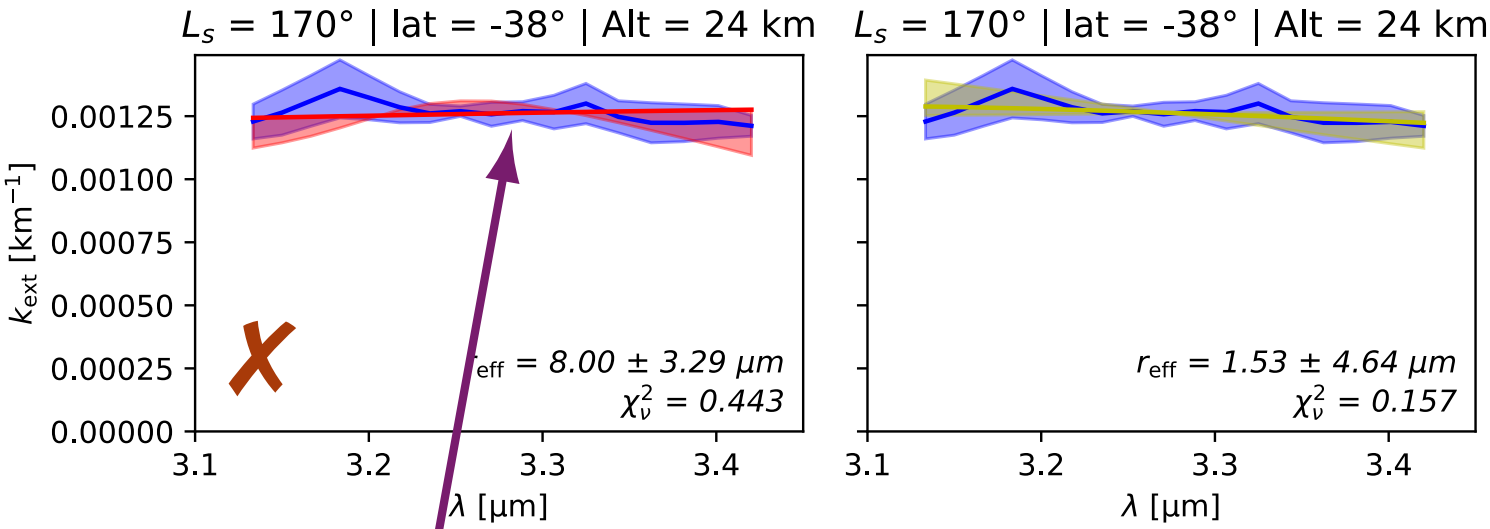






Water ice clouds identification & Particle size retrieving



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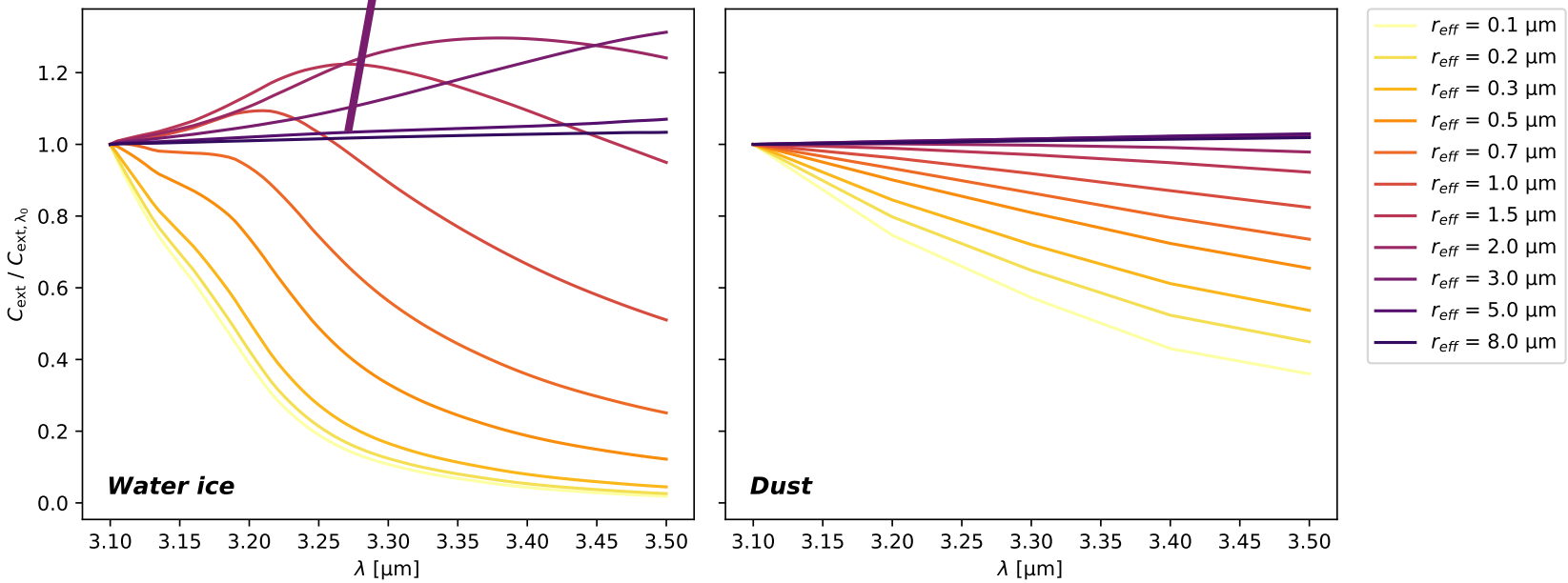

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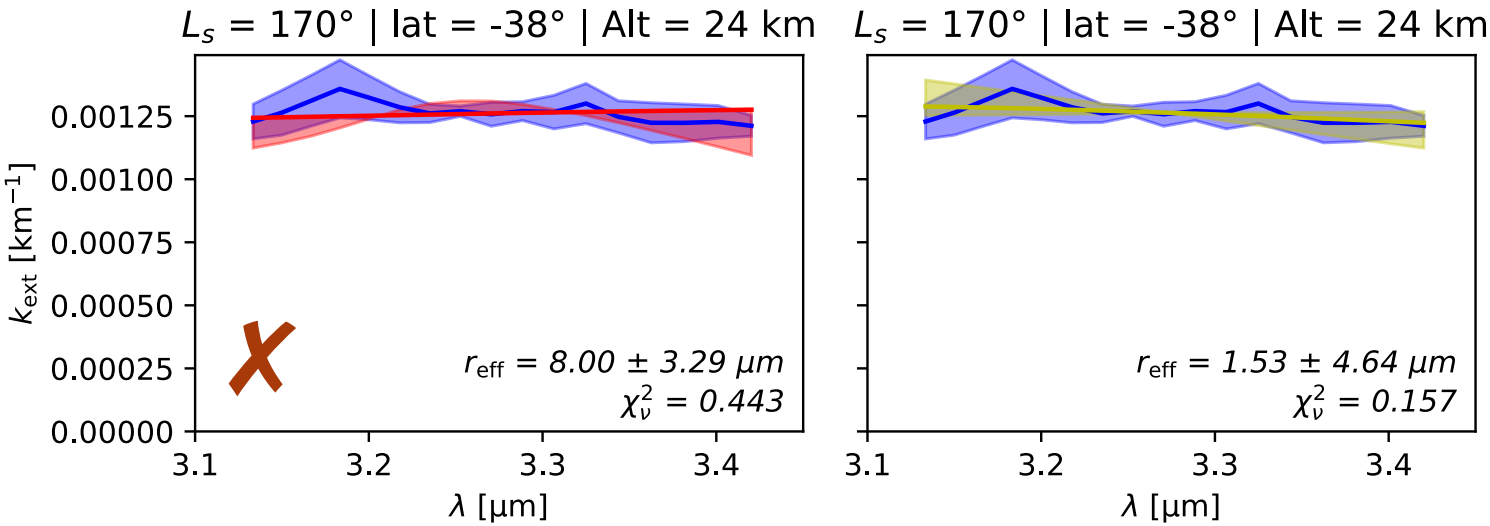

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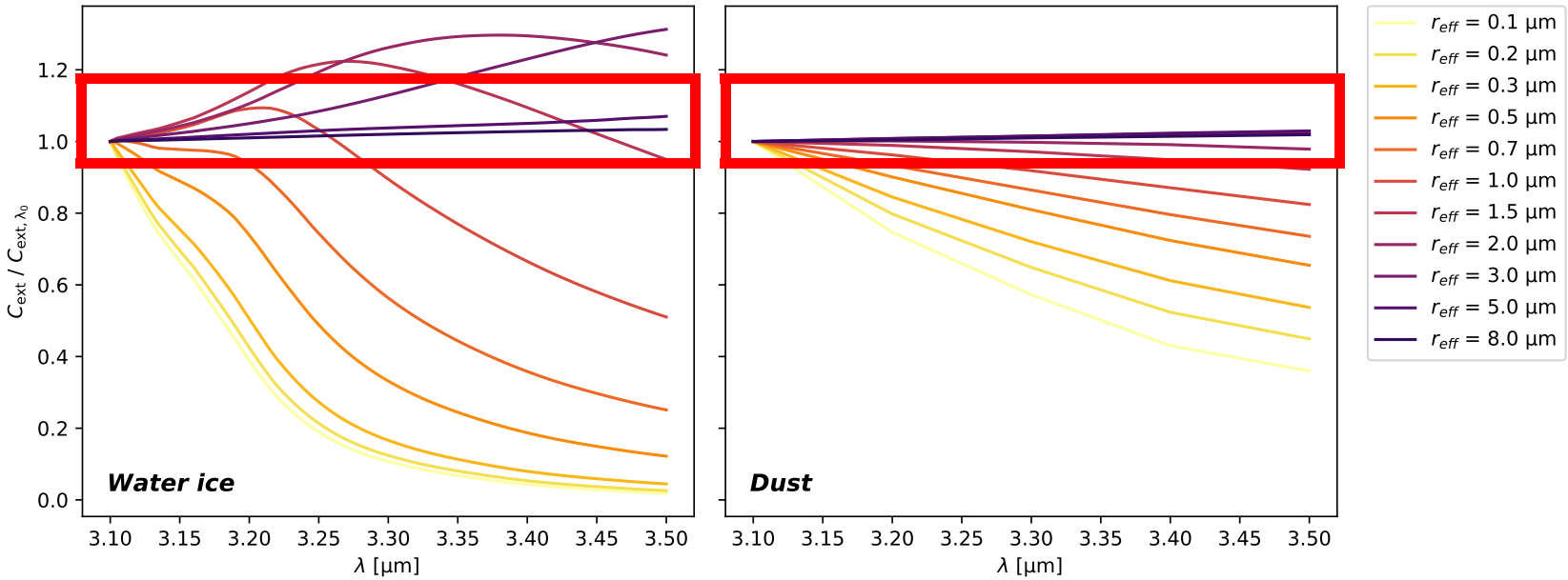
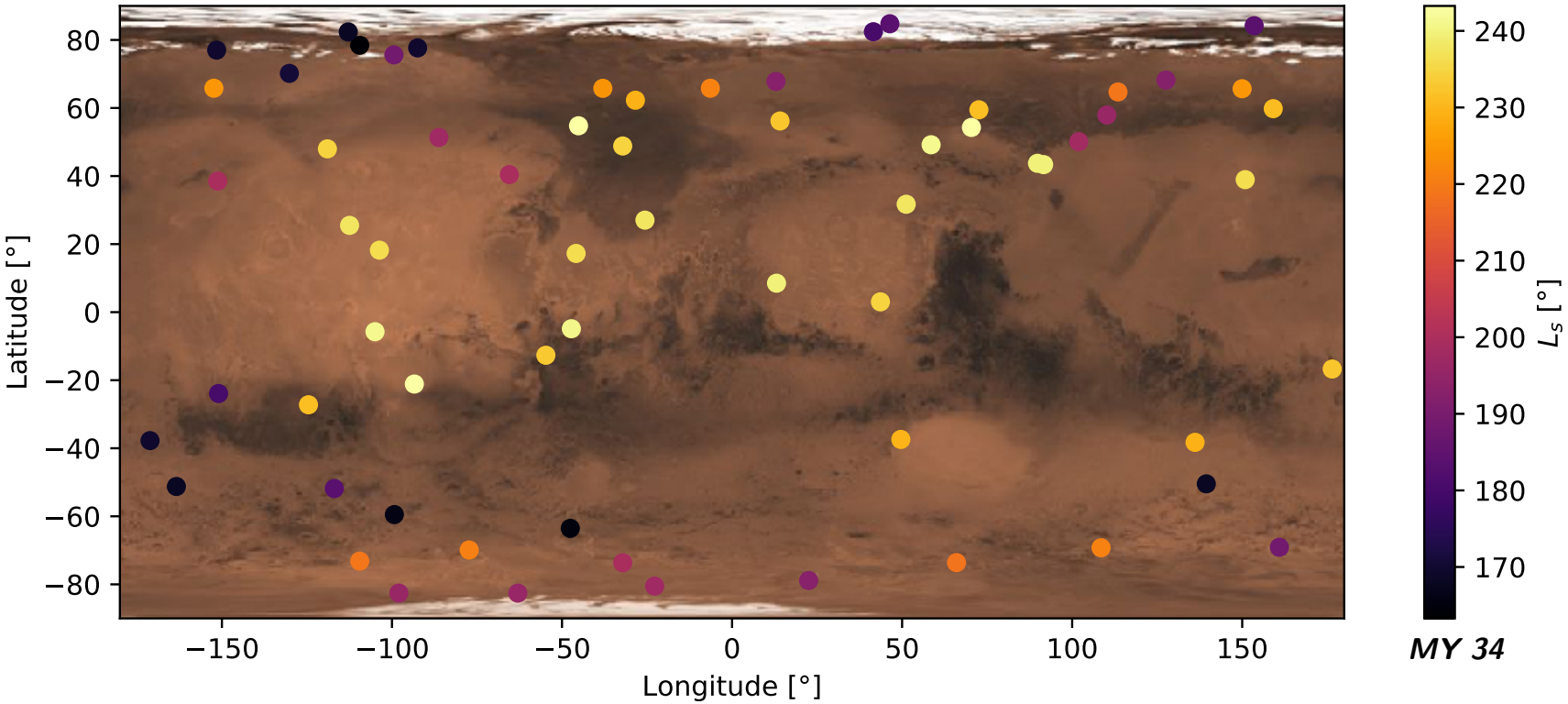
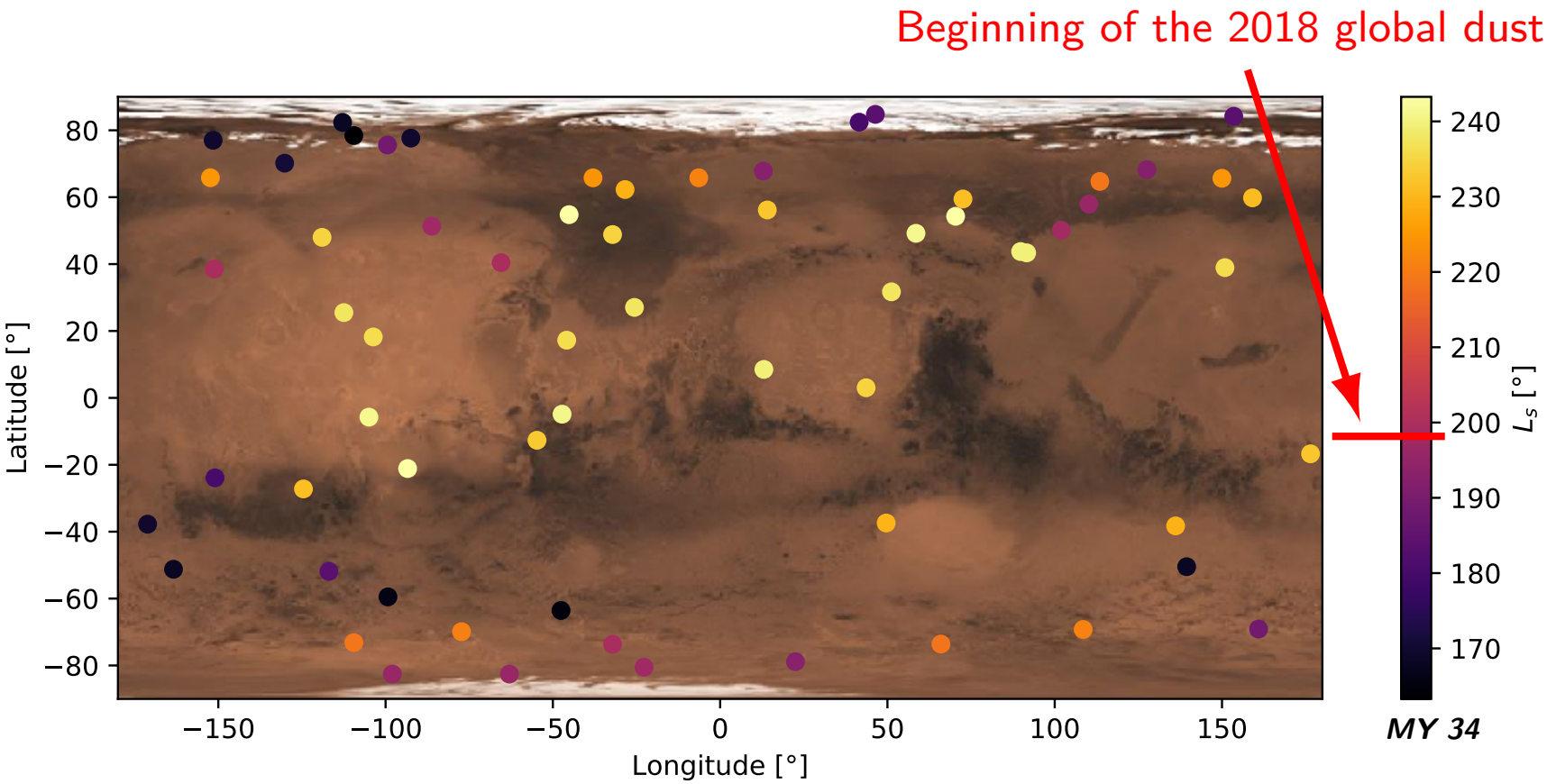


The ACS-MIR dataset



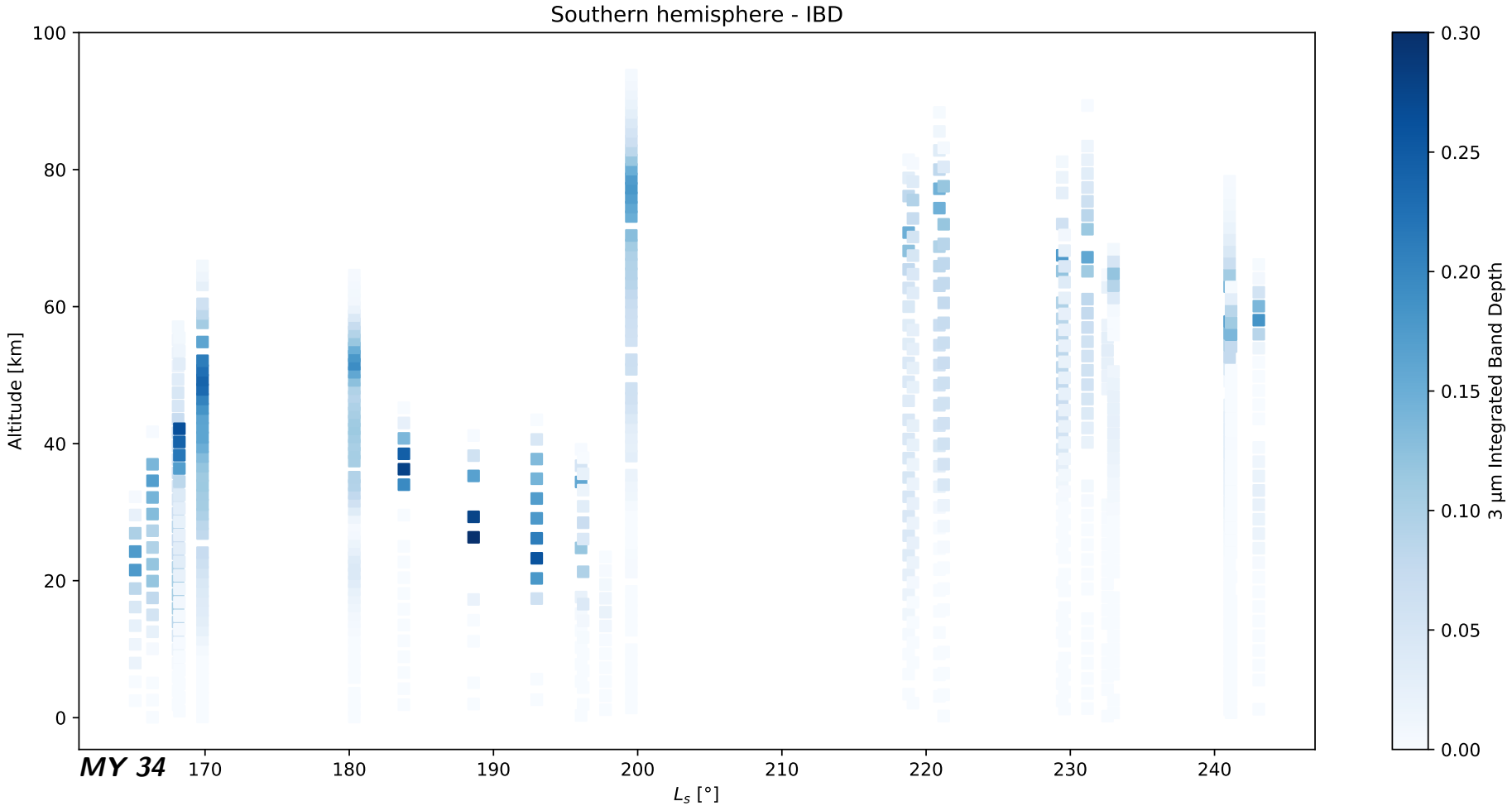
Distribution of the ACS-MIR observations in the *grating position 12* in terms of latitude, longitude, and Solar longitude.

The ACS-MIR dataset

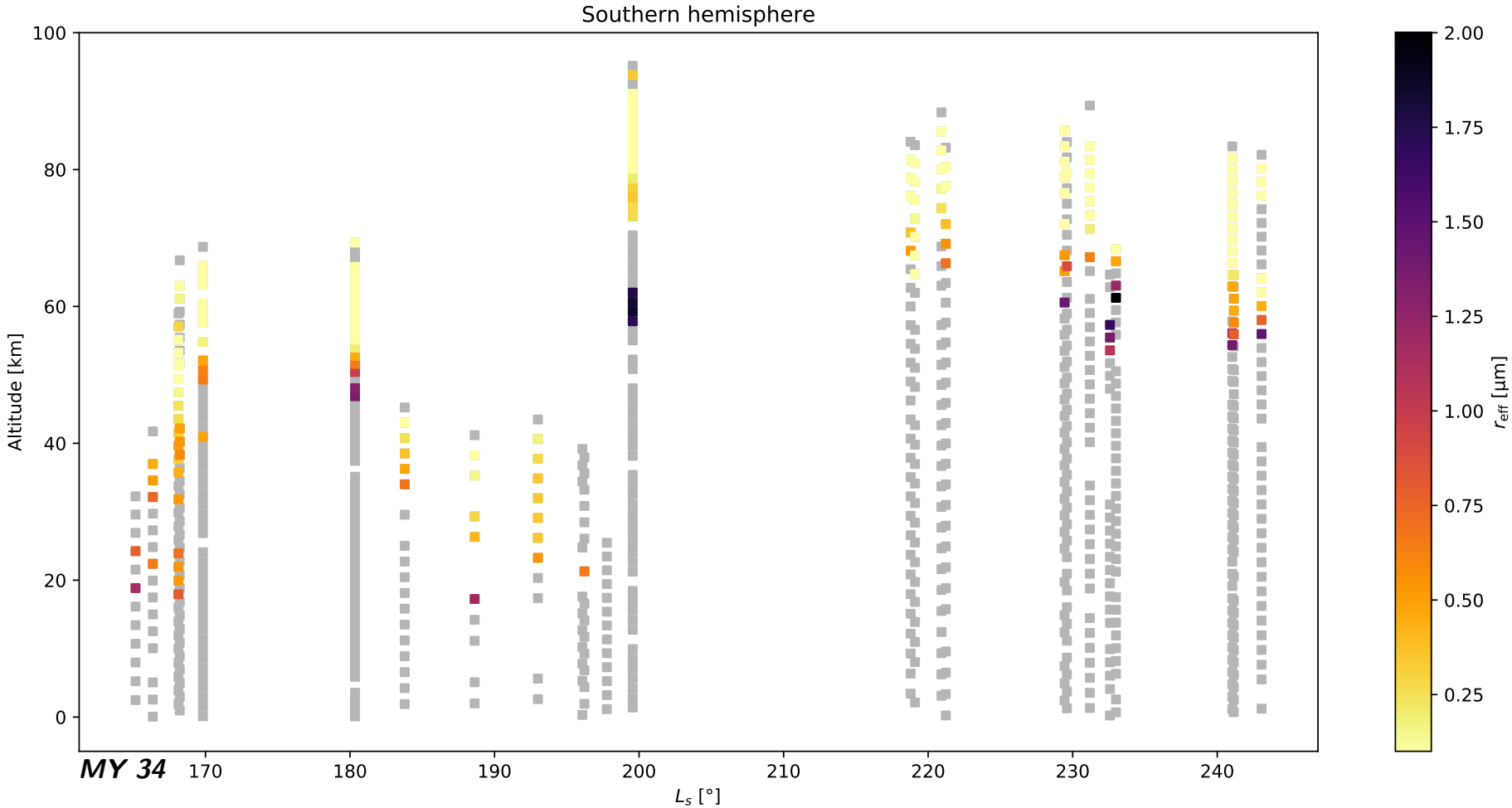


Distribution of the ACS-MIR observations in the *grating position 12* in terms of latitude, longitude, and Solar longitude.

3 µm atmospheric absorption



Water ice clouds identification



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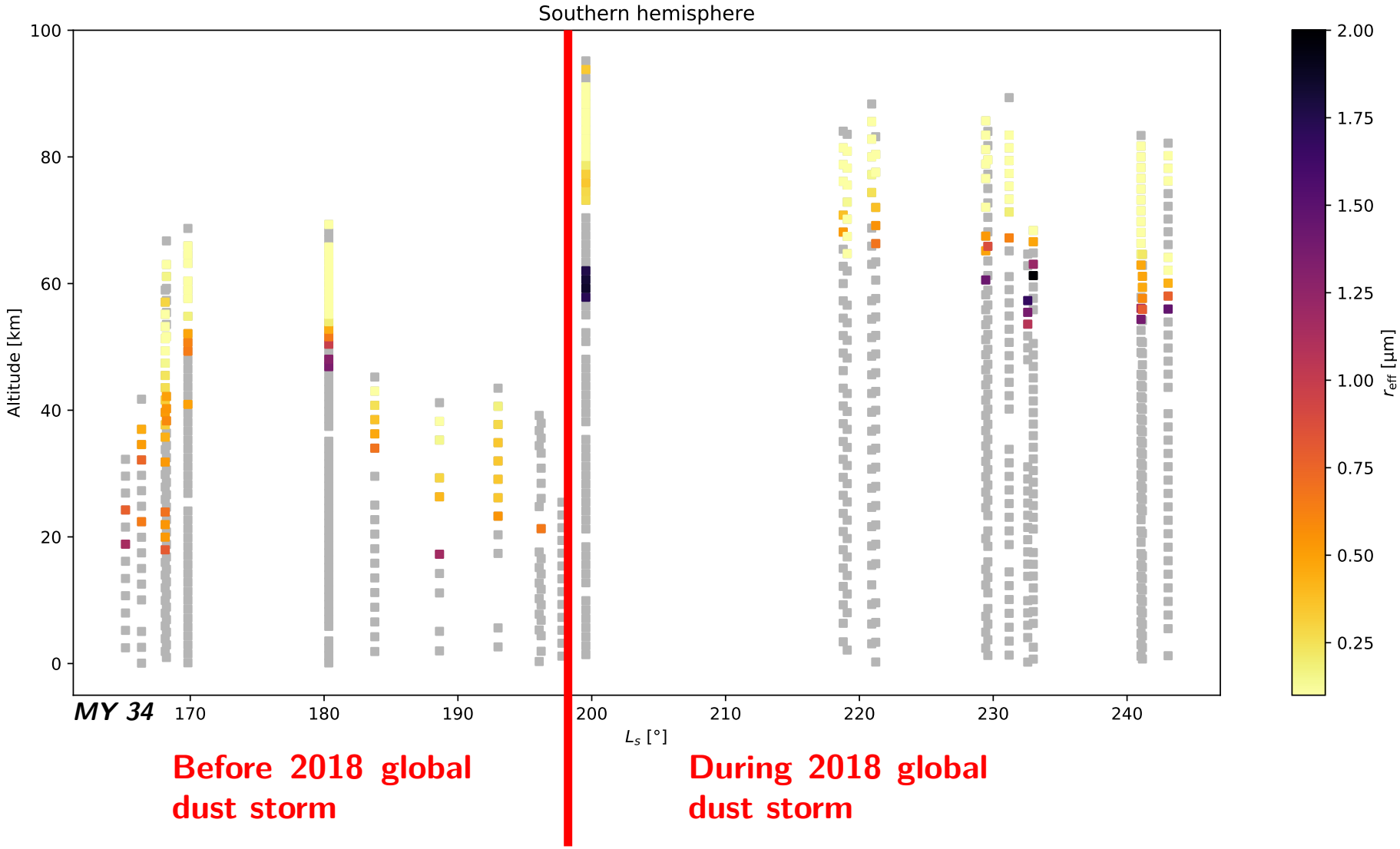

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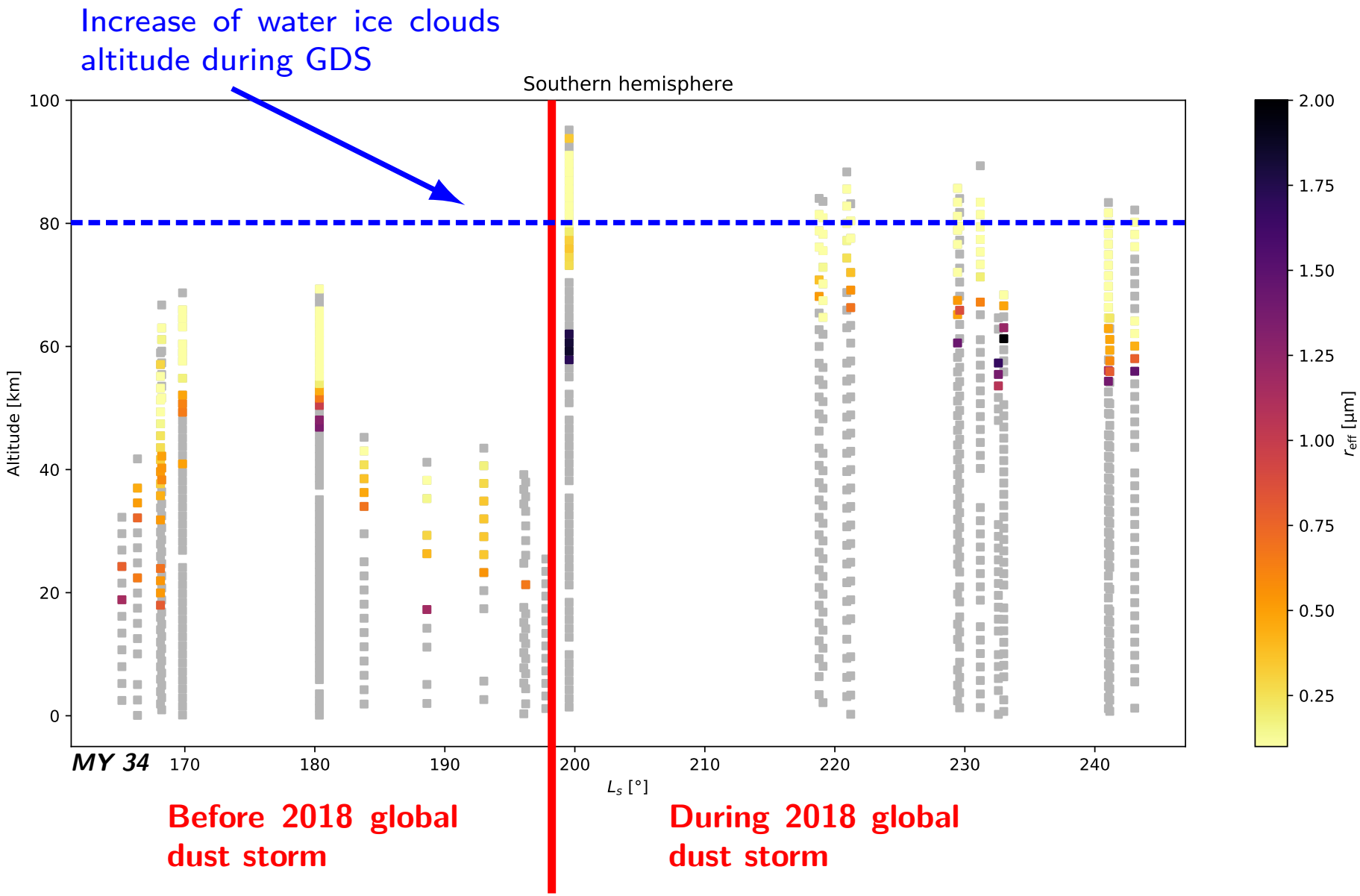
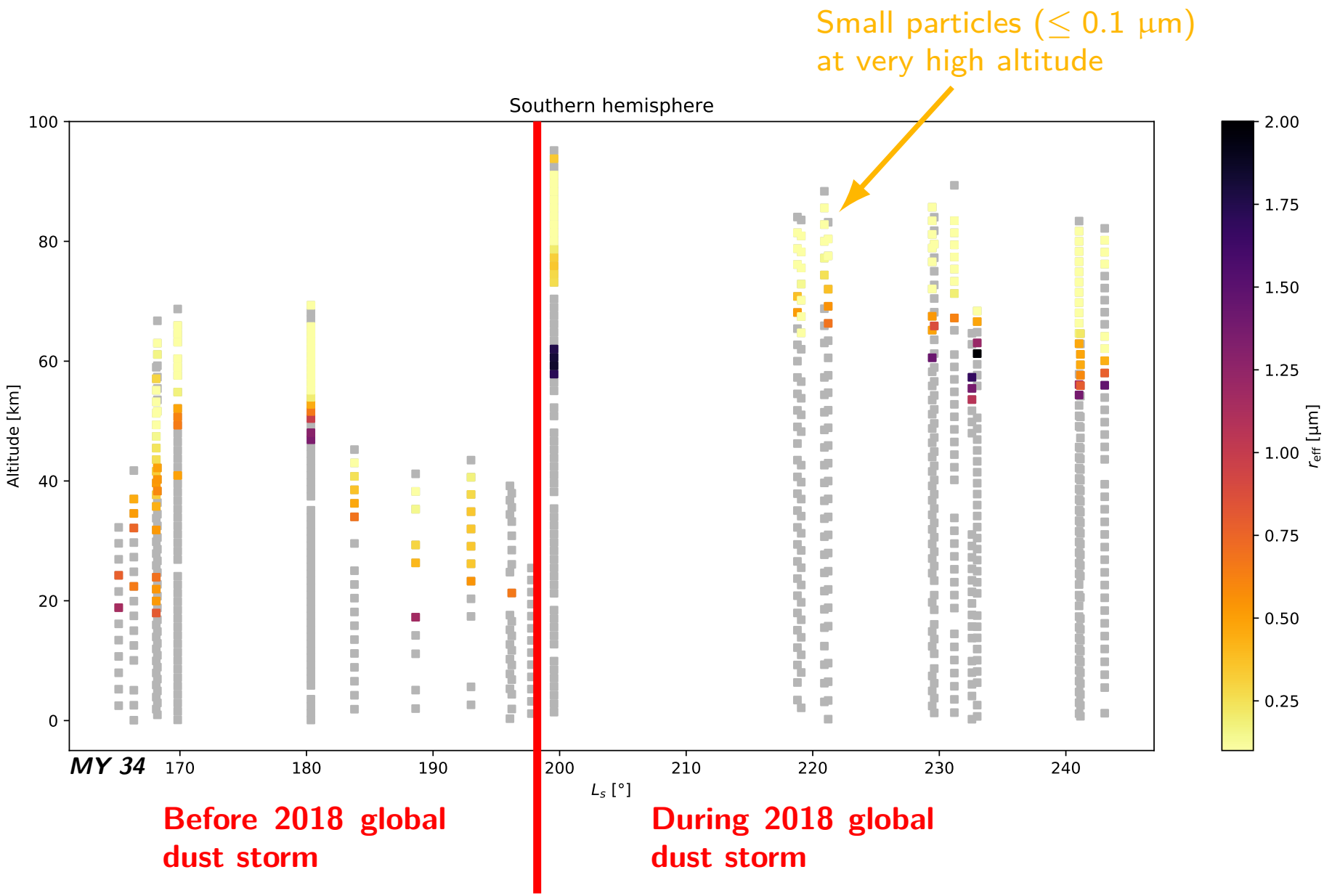


Particle size



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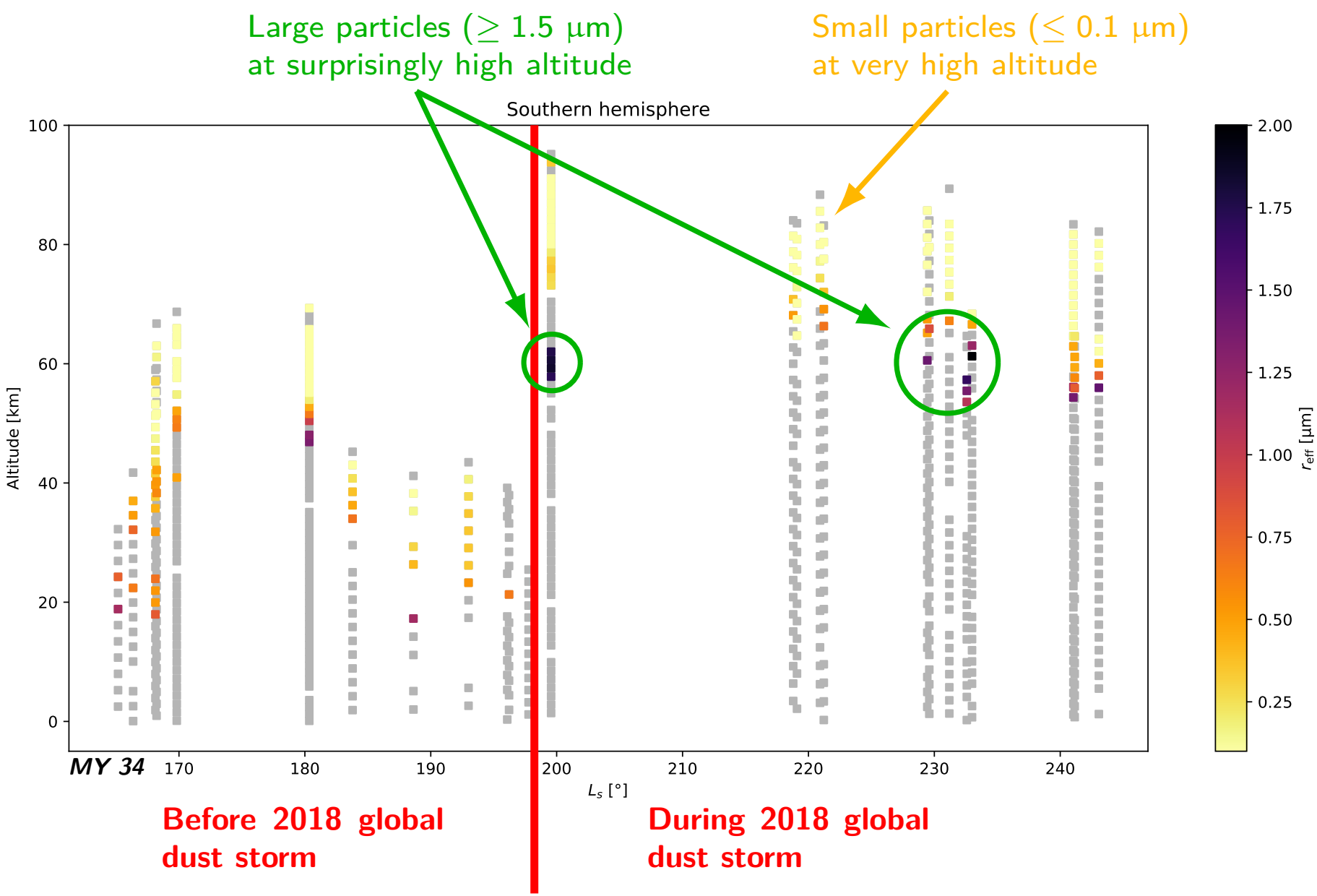
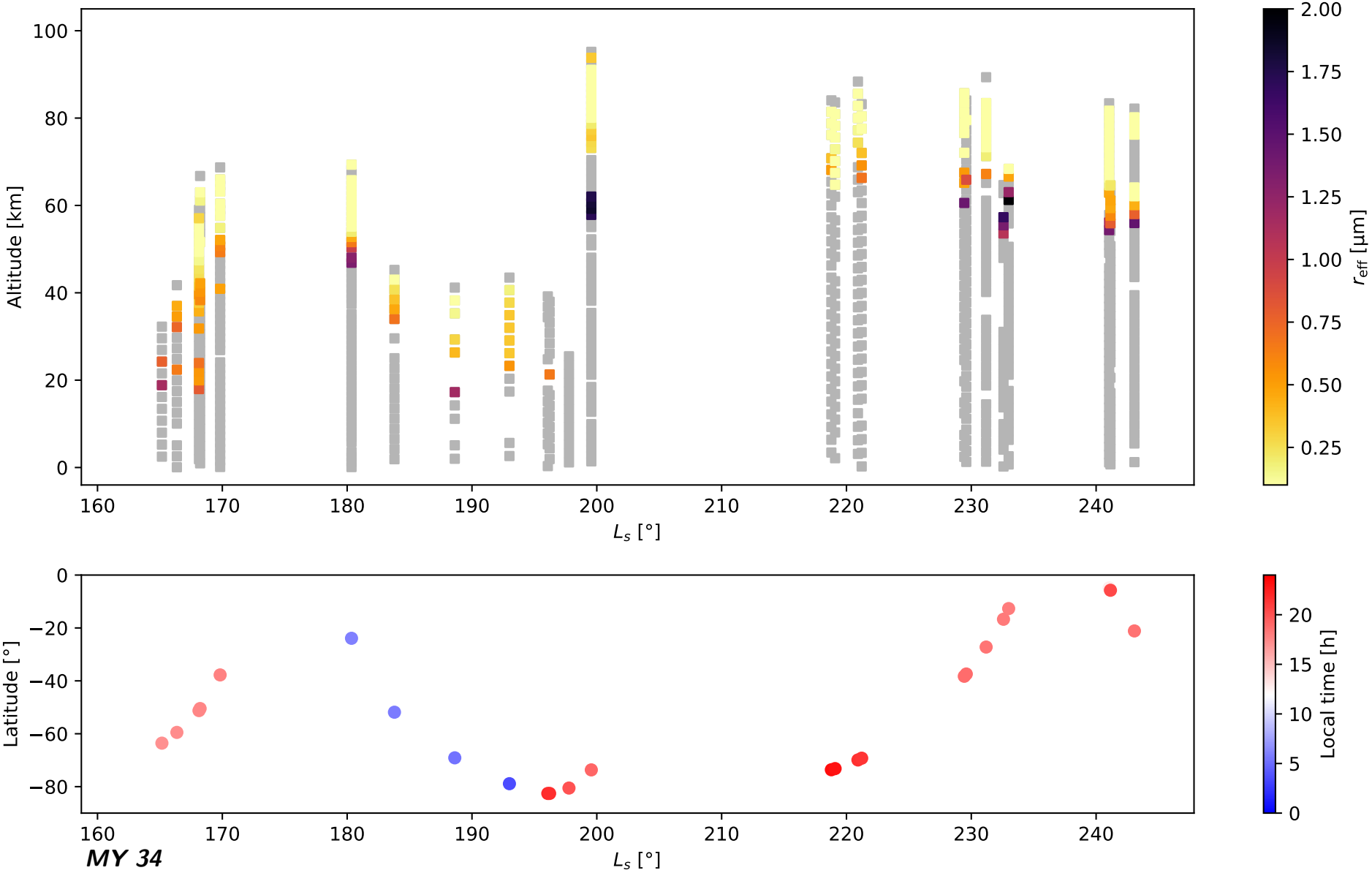


Links with latitude and local time ?



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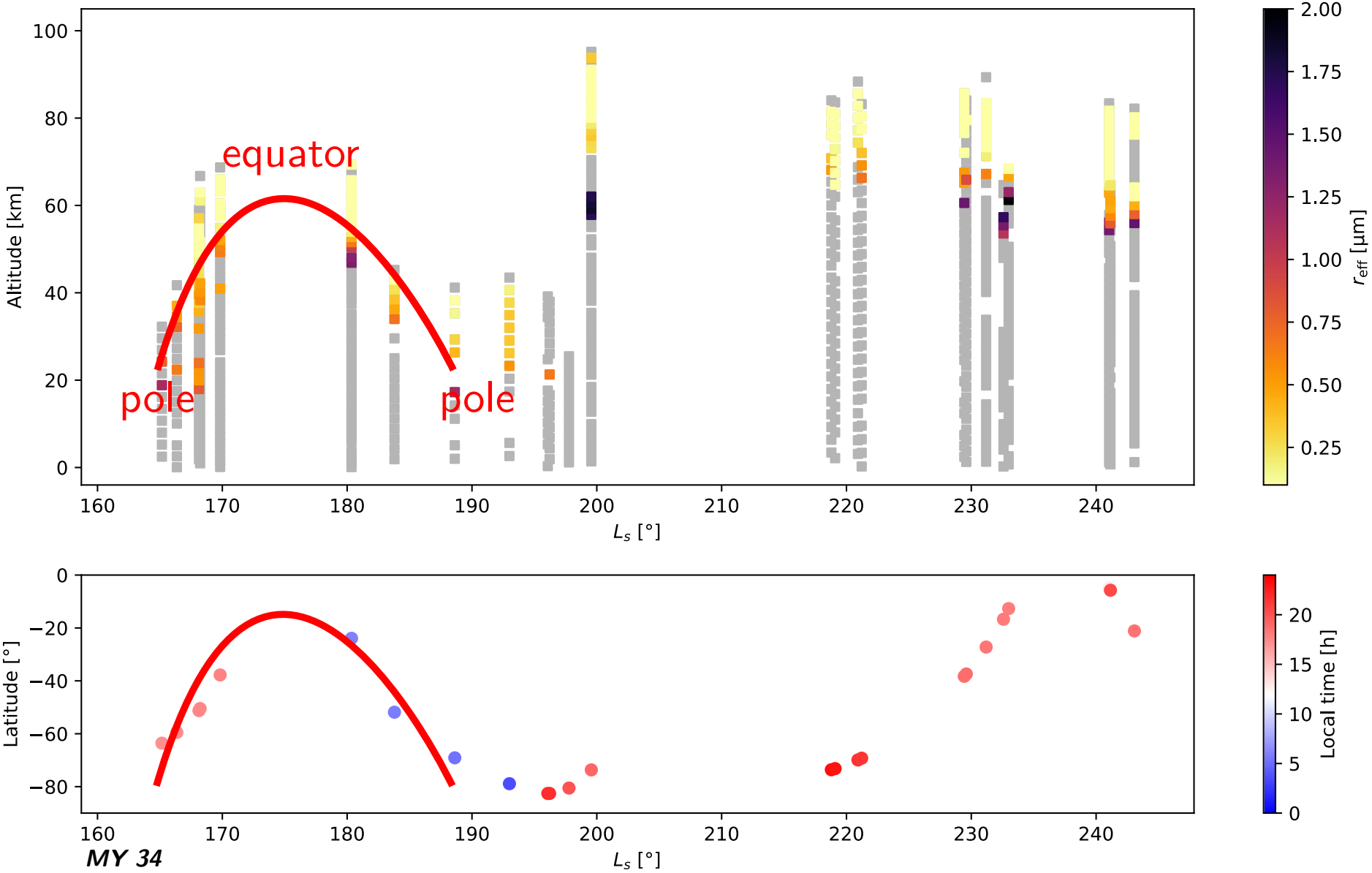

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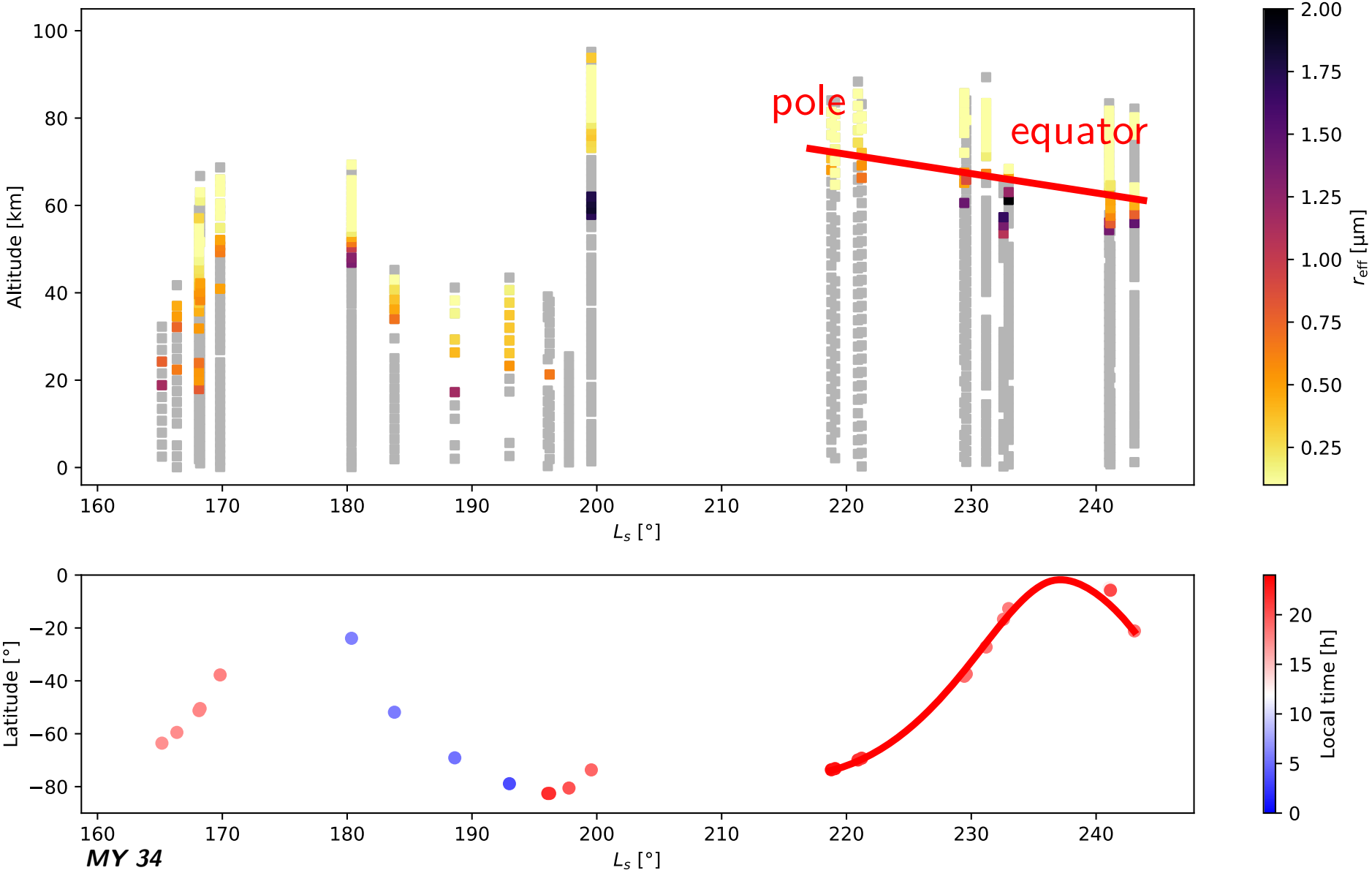

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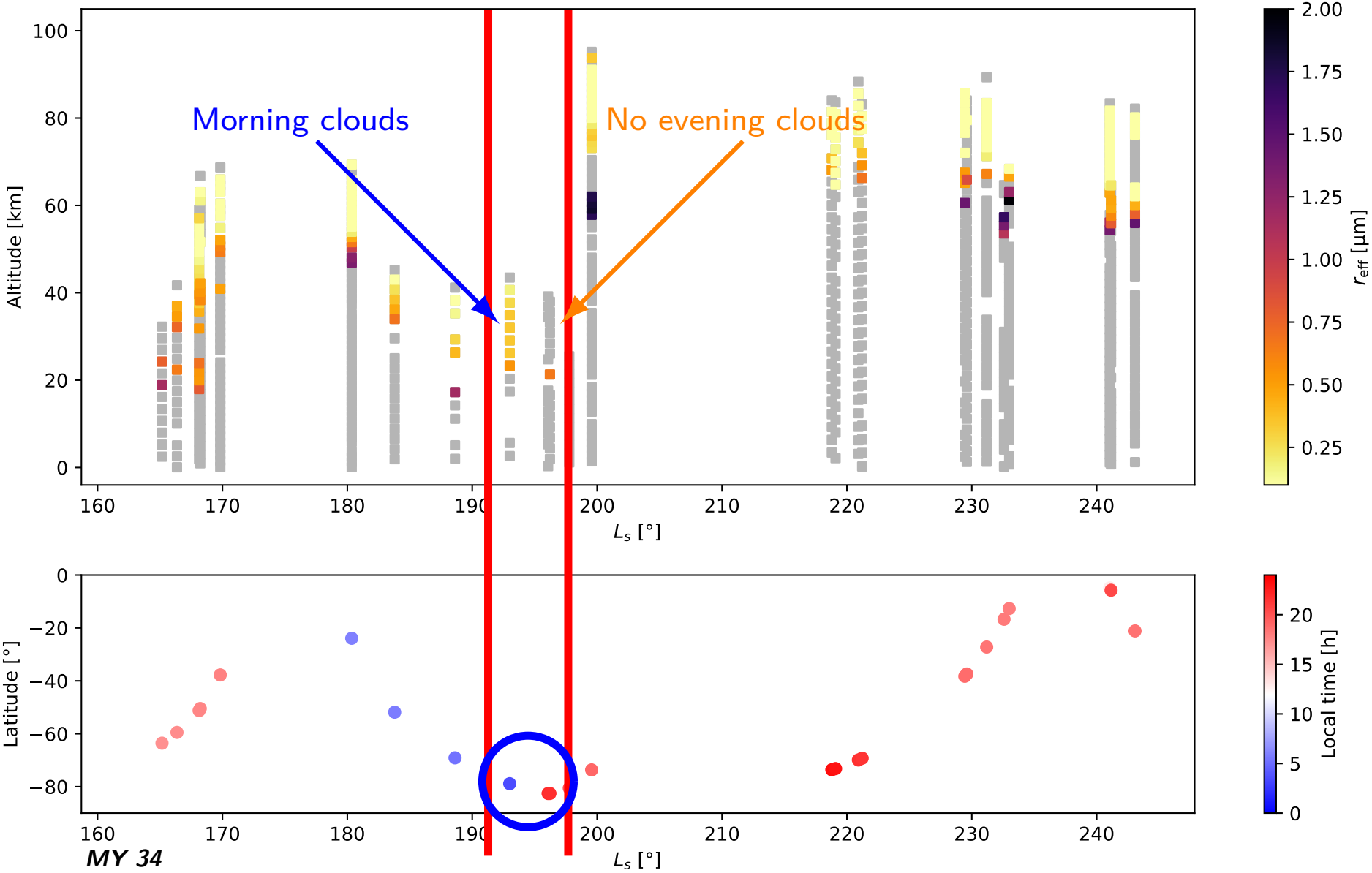
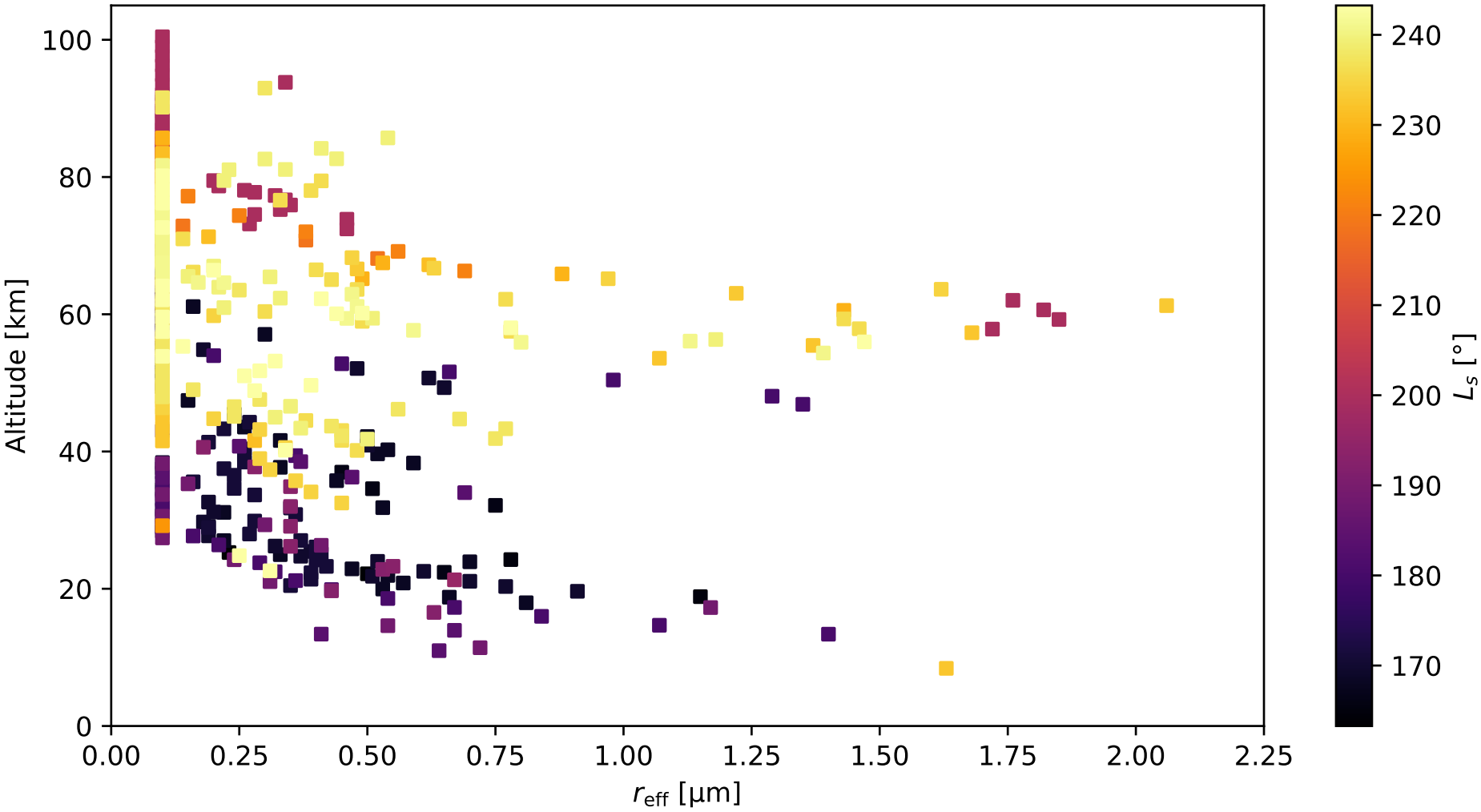
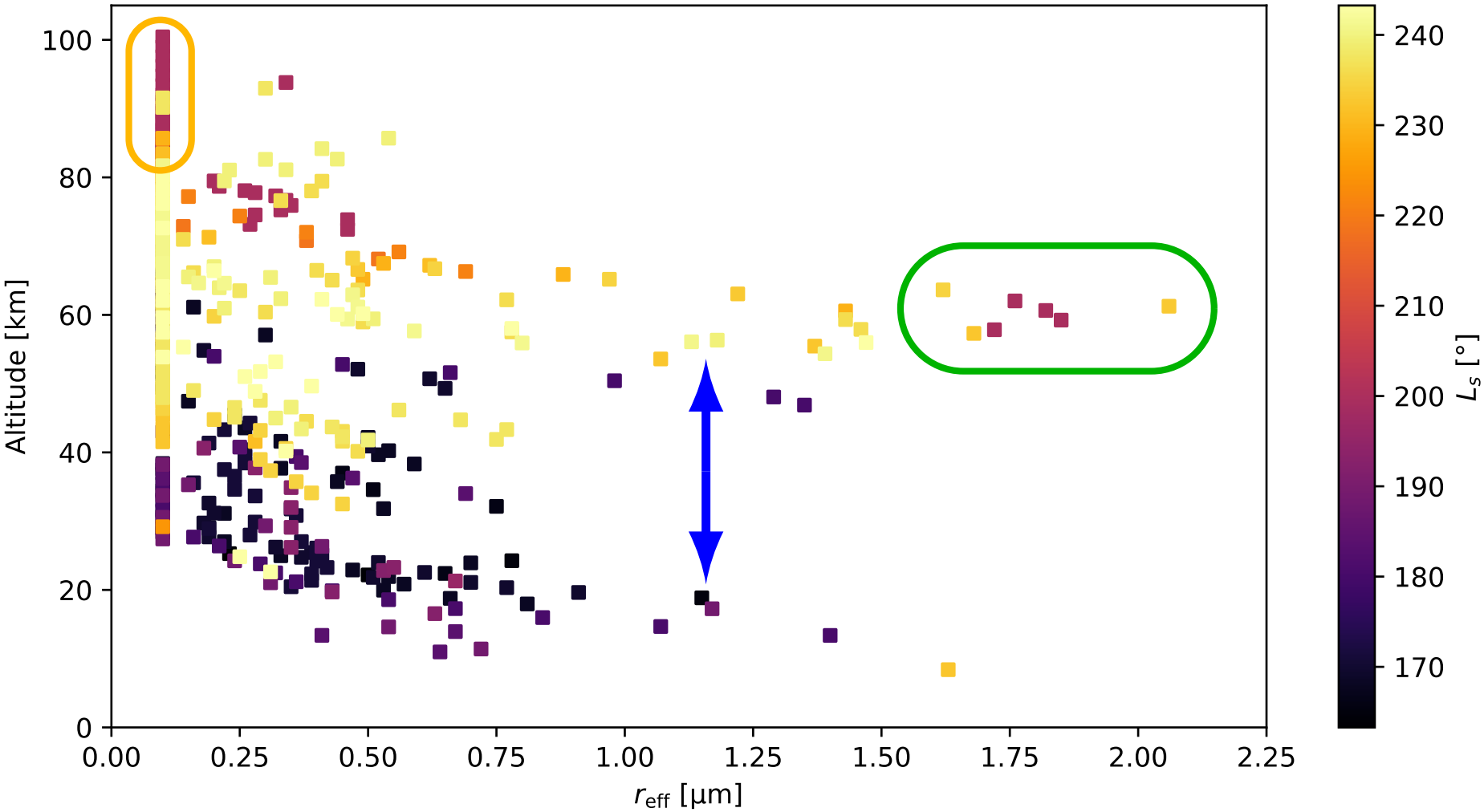


Particle size altitude dependence



- Particle size decrease when getting higher.

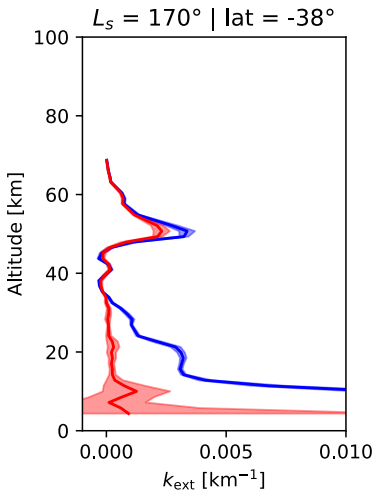
Particle size altitude dependence

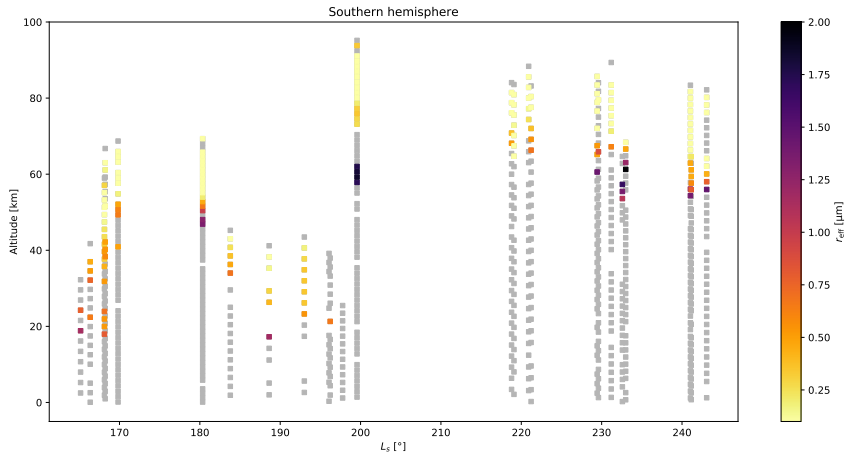


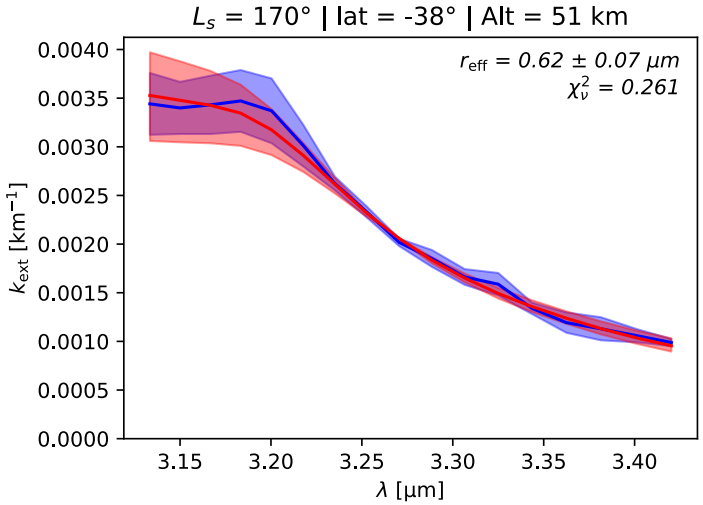
- Particle size decrease when getting higher.

Summary

- Use of ACS-MIR SO observations to **monitor the evolution** of the **atmospheric water ice spectral signature around 3 µm**, before and during the 2018 global dust storm.
- **Inversion** of **optical depth** to retrieve local extinction of aerosols.
- Fit of the **particles size** with a spherical water ice particles model : **identification** and **characterization** of **water ice clouds**.

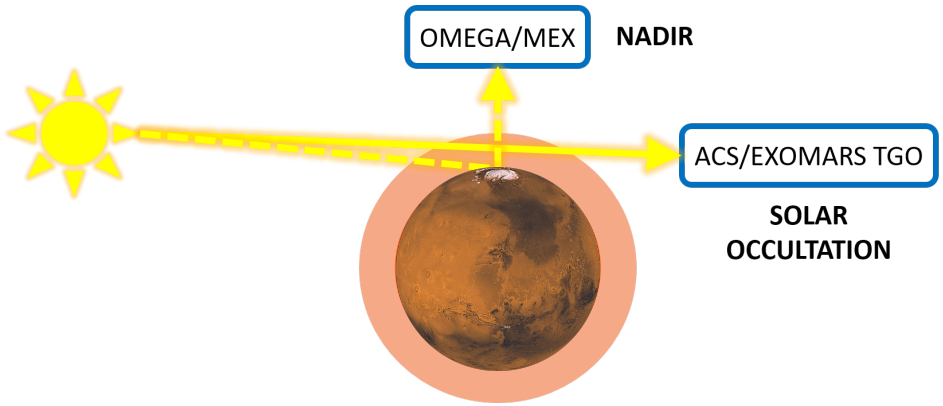




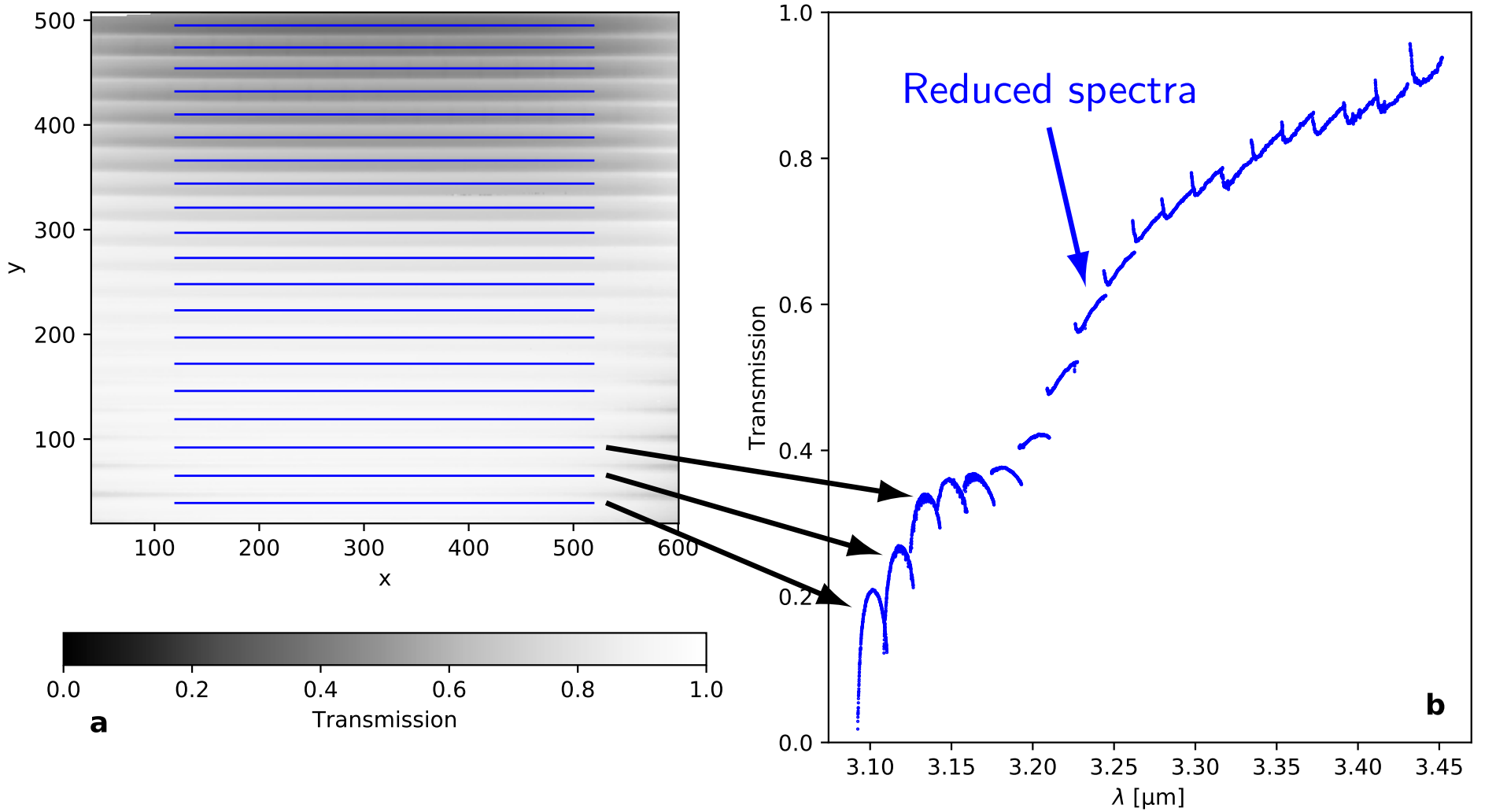


What's next ?

- Apply the algorithm to an **entire Martian year**.
- Searching for the effects of the **season** and **daily cycle**.
- Analysis of **limb** and **nadir** observations *(OMEGA/MEX)*.



Continuum extraction



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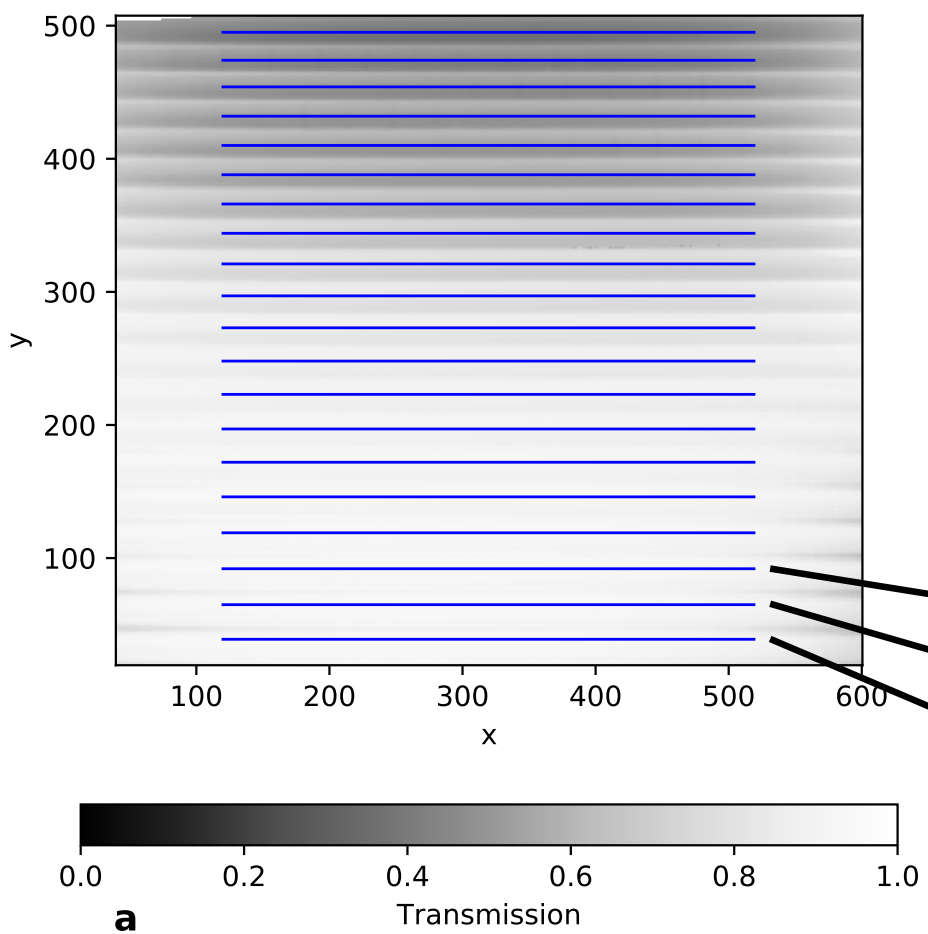

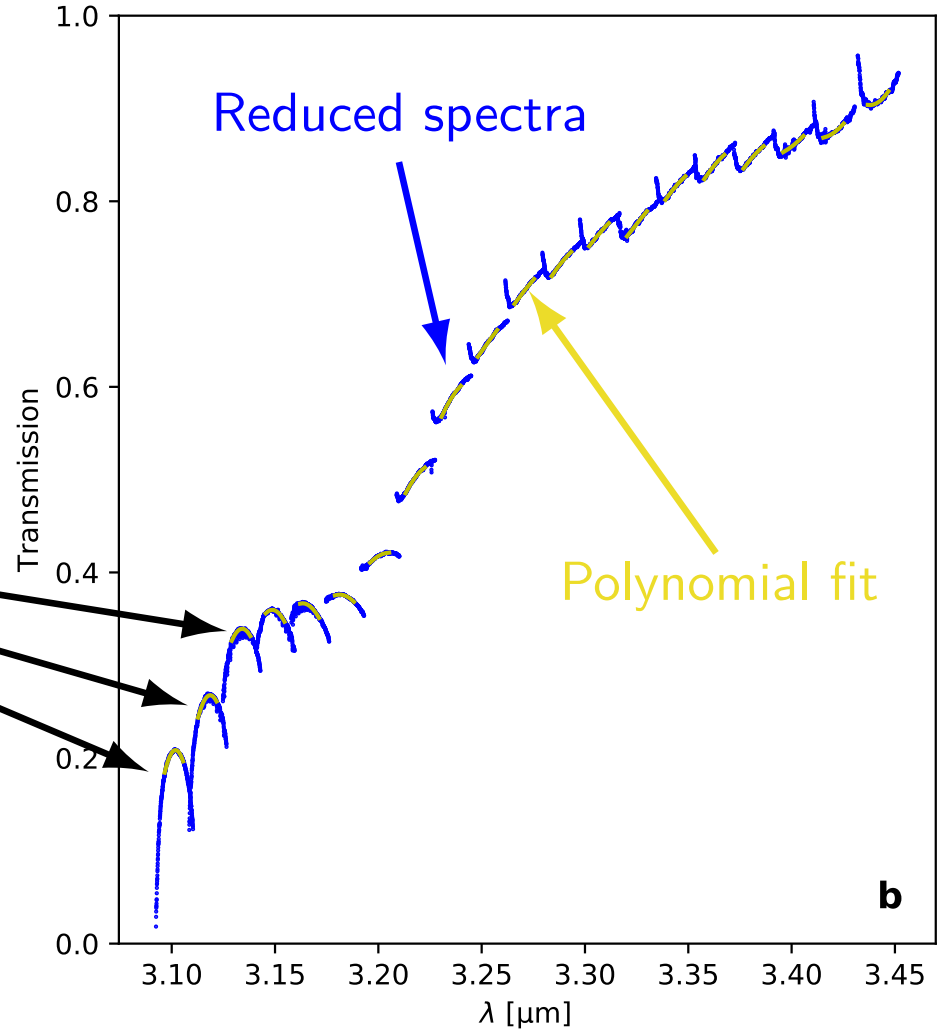

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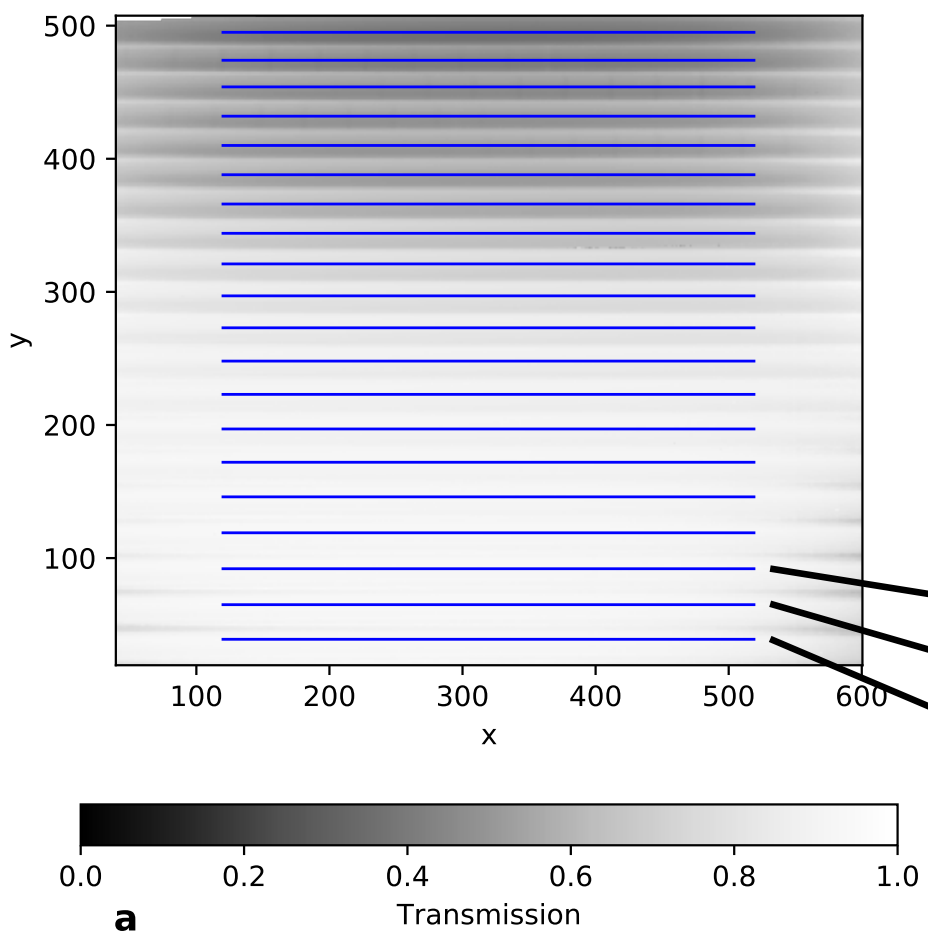
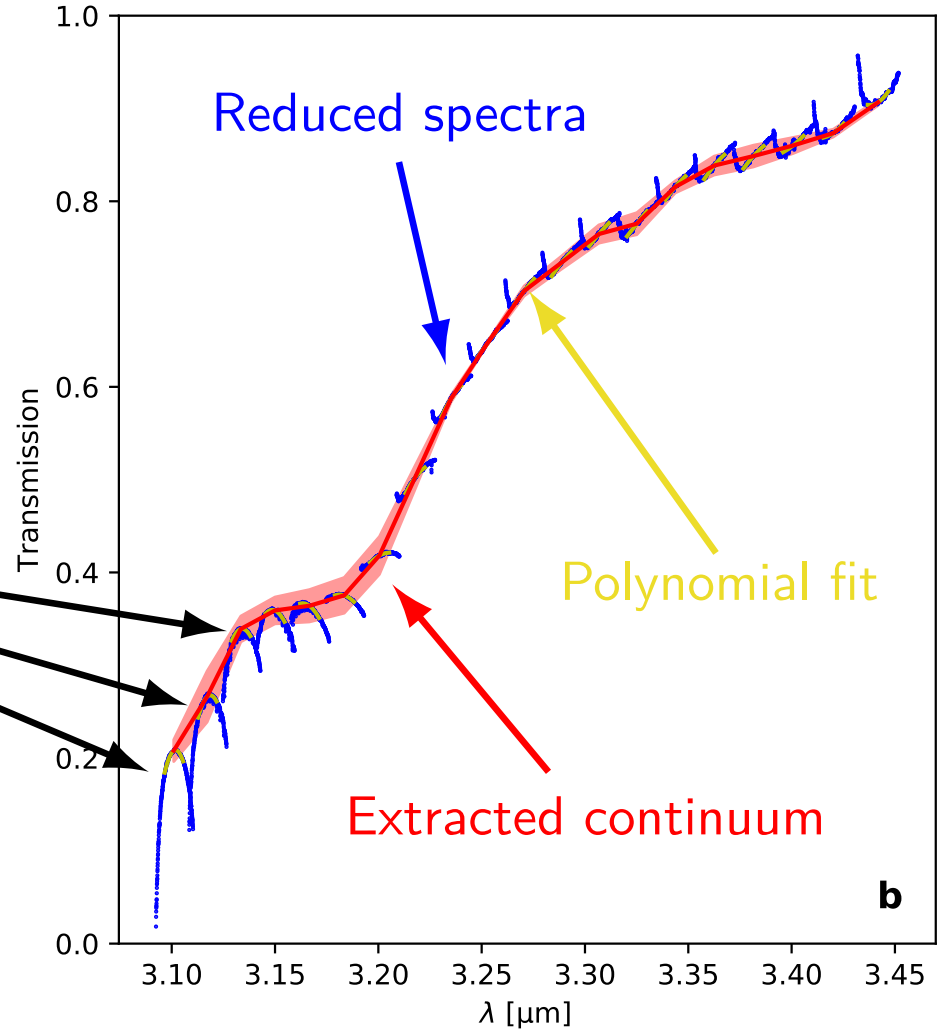
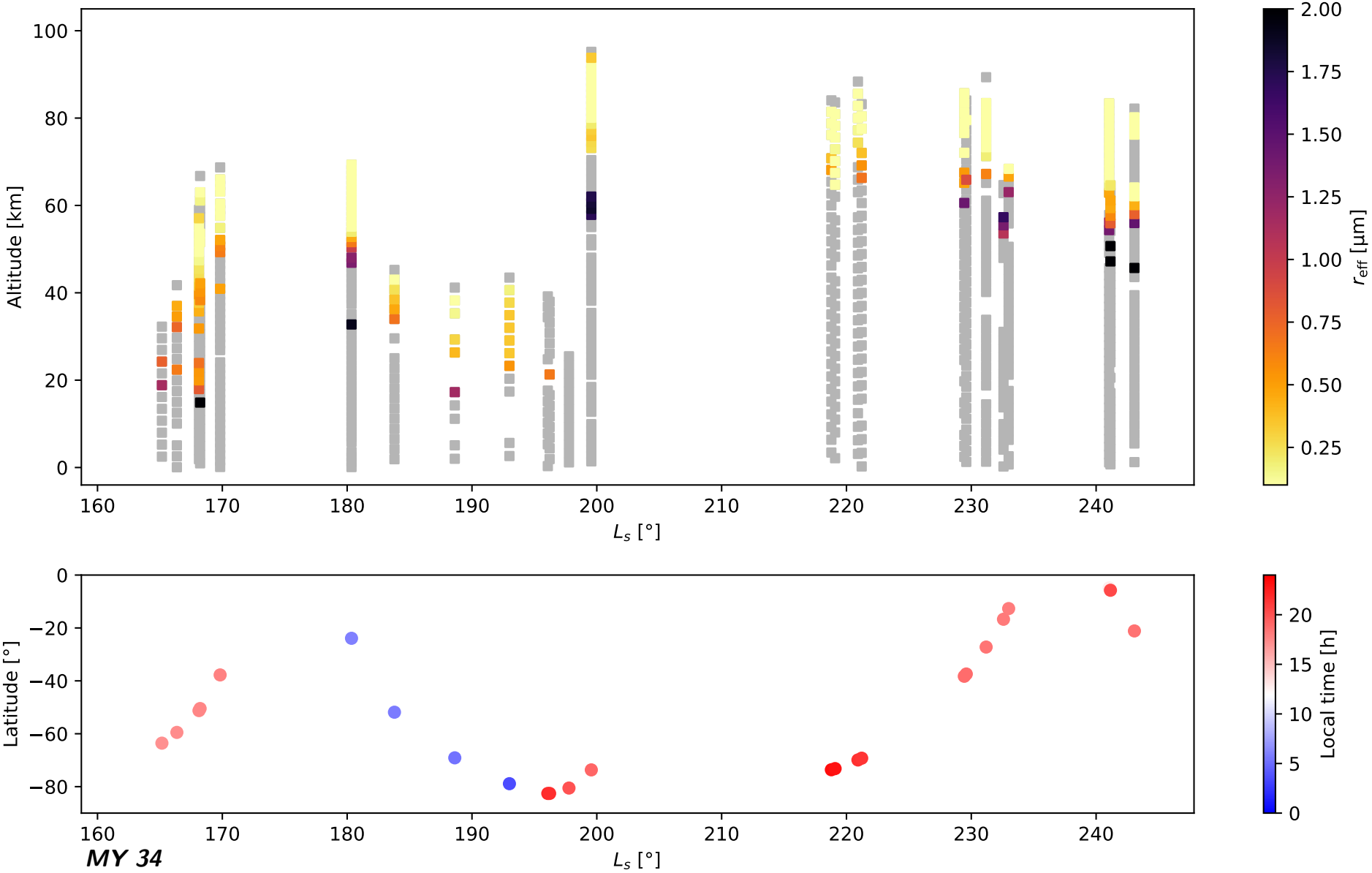
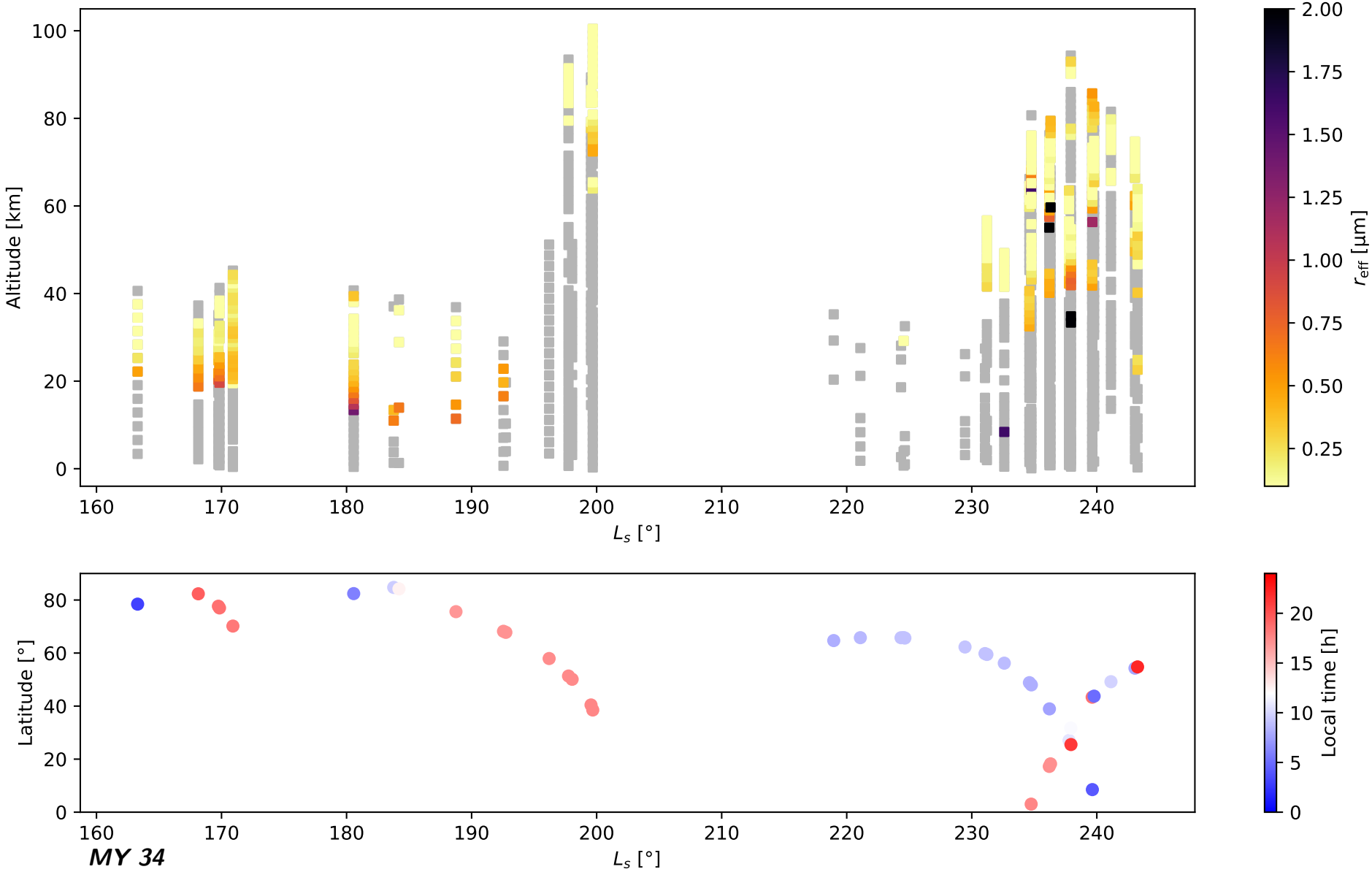




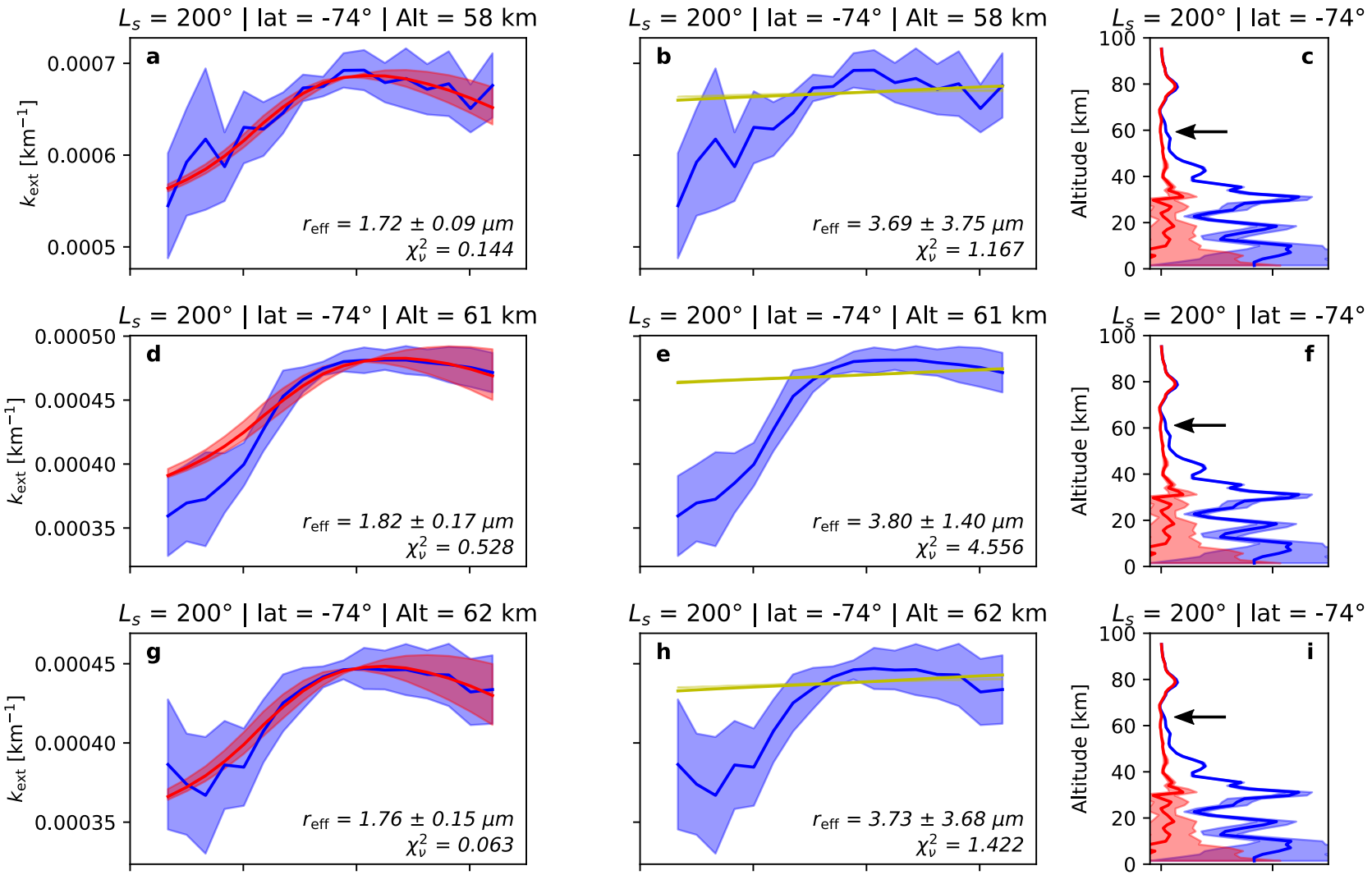
Profiles - Southern hemisphere



Profiles - Northern hemisphere



High-altitude large particles fitting



High-altitude large particles fitting