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Multi-instrument perspective on recent aerosol variability in the lowermost stratosphere

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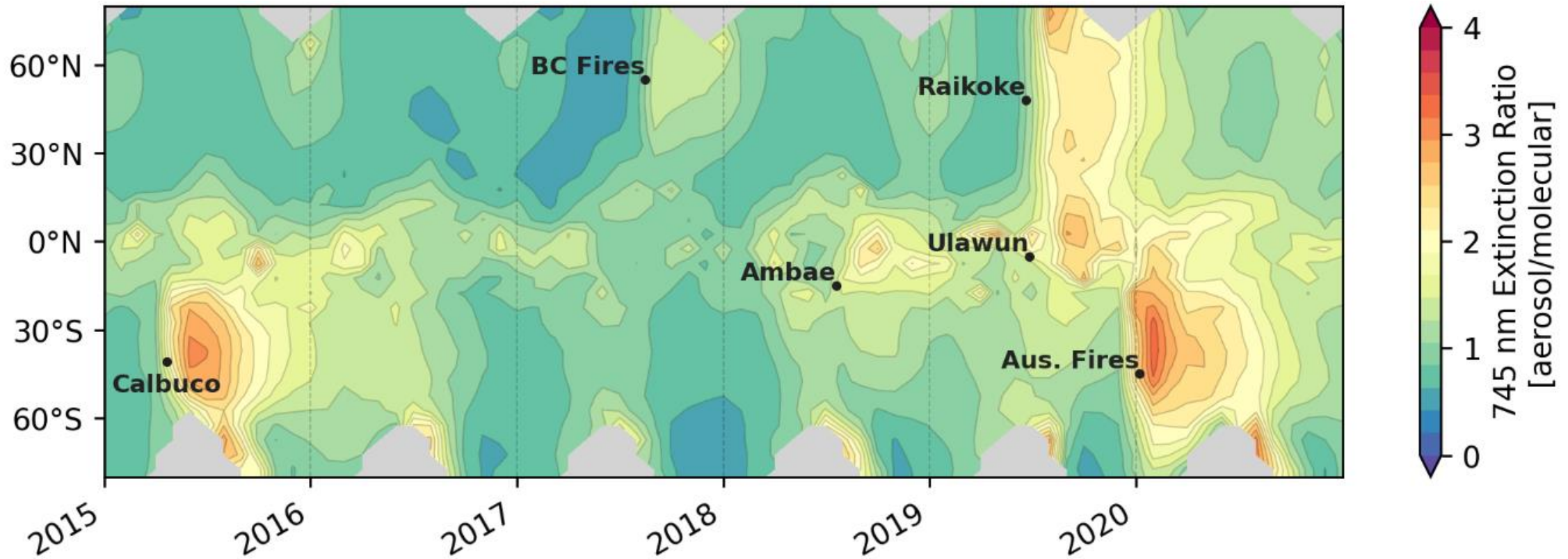


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Motivation

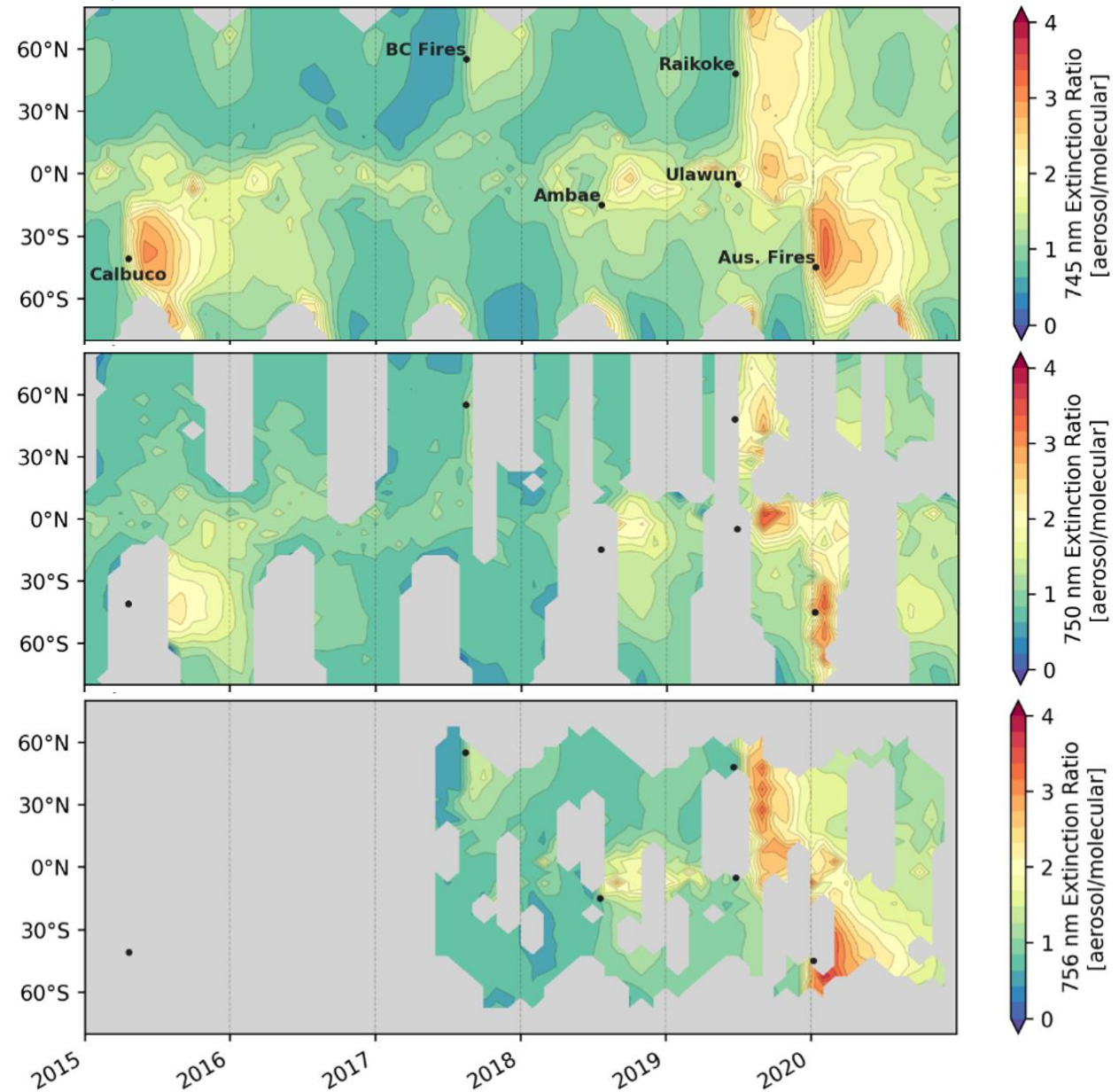
- Highly variable aerosol loading in the UTLS
- A large fraction of the total AOD but:
 - Measurements are sparse (occultation)
 - Difficult (clouds, lidar detection limit, smoke composition)
- A current opportunity with SAGE III/ISS, OSIRIS, OMPS-LP
- Some questions:
 - Are there biases in extinction profile measurements in the UTLS?
 - How robust are zonal average and AOD quantities?
 - What is the dependence on observation geometry, loading condition, and aerosol source?

We live in interesting times...

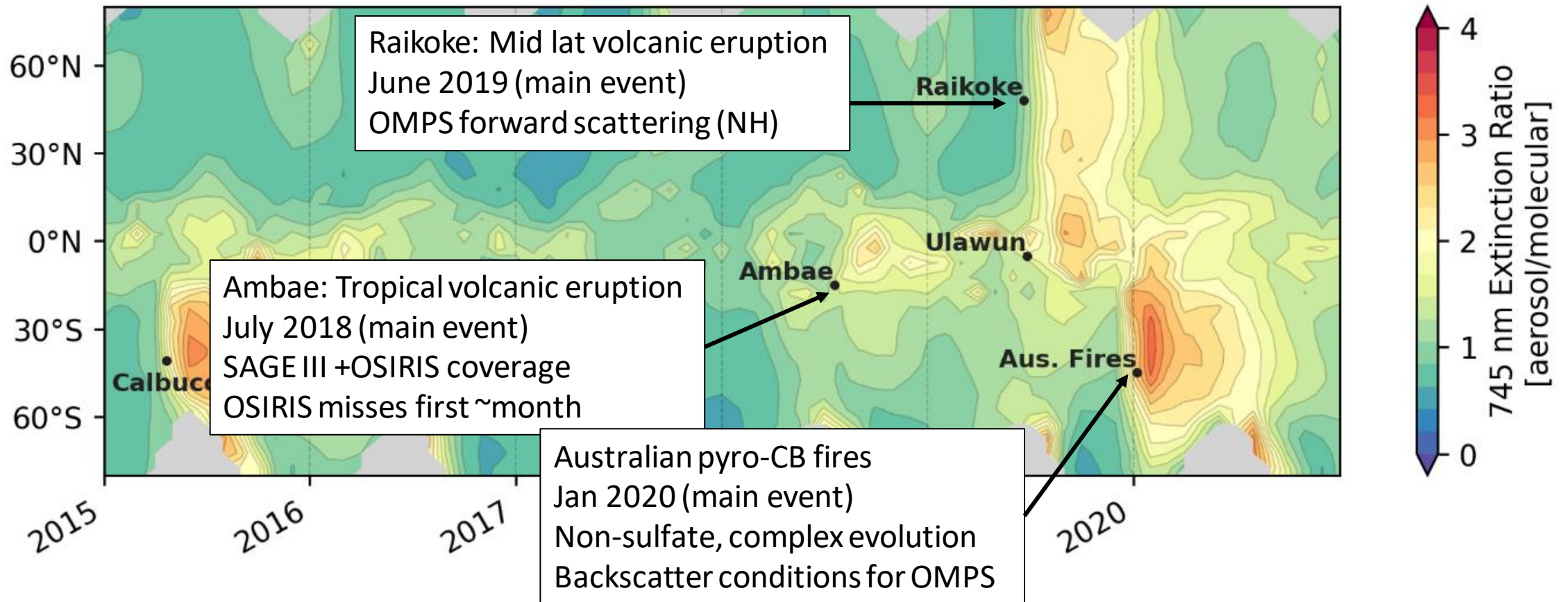


- OMPS-LP aerosol/molecular extinction ratio weighted for UTL (13–22 km) with TLS weighting function
- From Rieger et al., GRL, 2021: Ozone and temperature anomalies associated with Australian fires

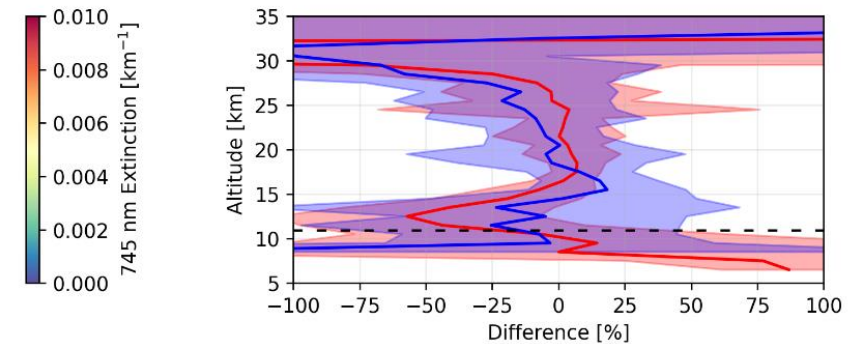
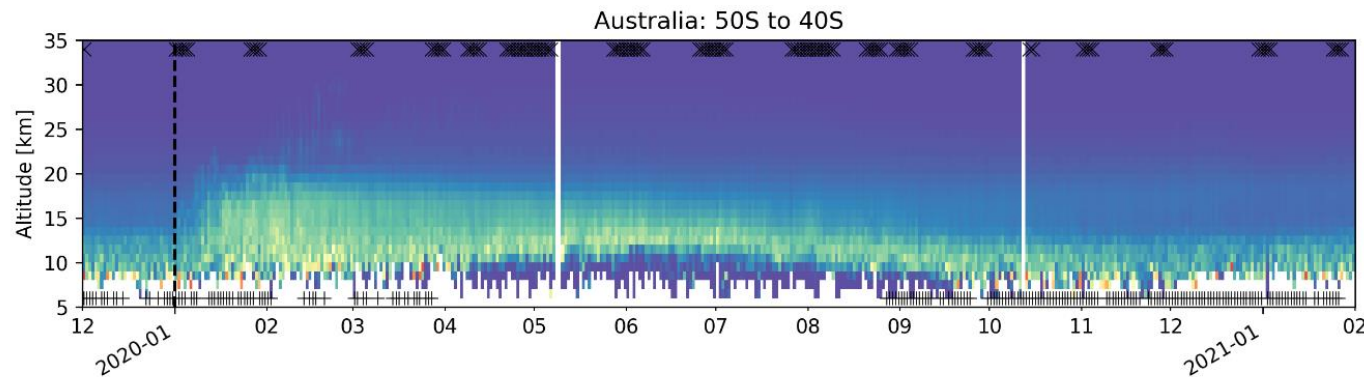
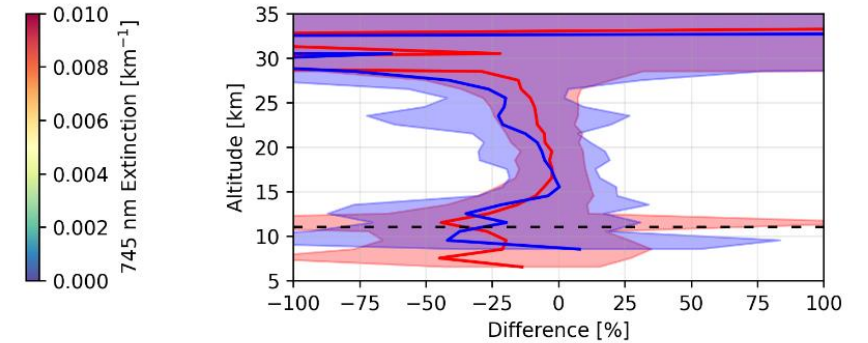
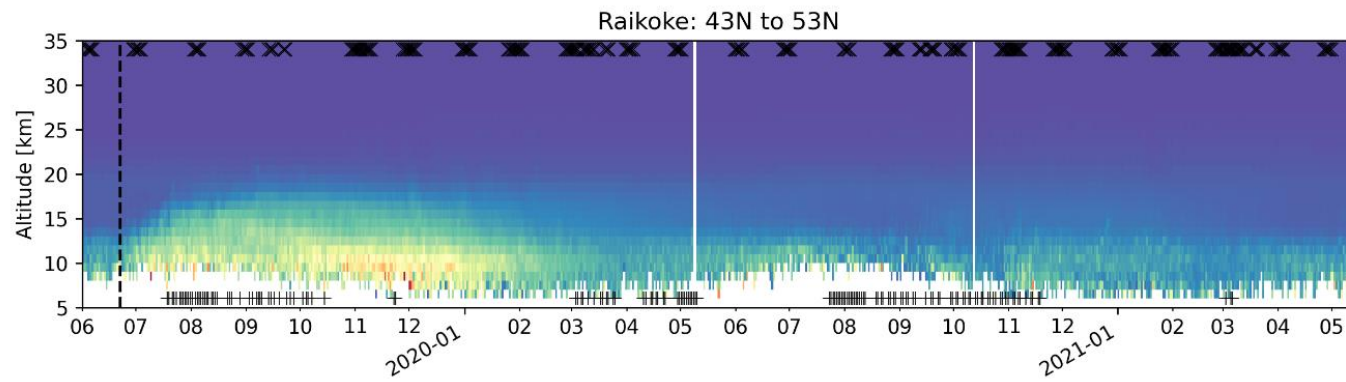
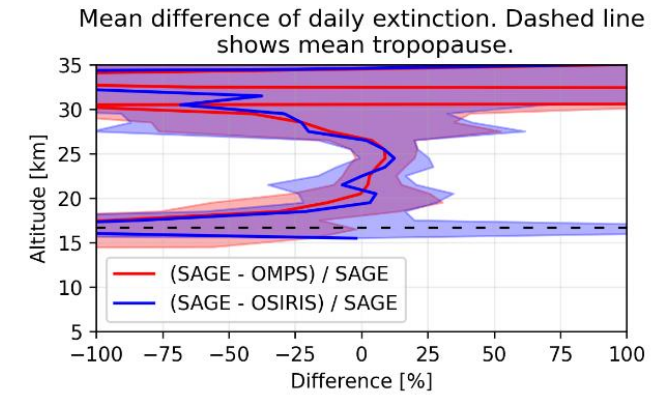
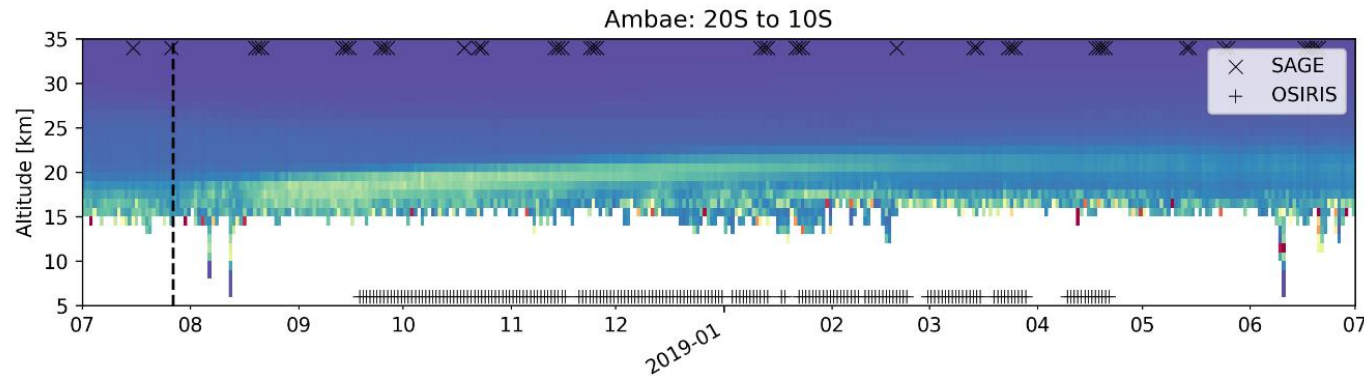
- **OMPS-LP limb scattering**
 - NASA SNPP mission: 2012-present
 - 1330h LTAN: daily, near-global
 - Missing polar “night”
 - SH backscatter, NH forward scatter
-
- **OSIRIS limb scattering**
 - Odin (ESA TPM) mission: 2001-present
 - 0630h LTAN: daily, hemispheric
 - Decreasing duty cycle with age
 - $90^\circ \pm 20^\circ$ scattering angle
-
- **SAGE III/ISS solar occultation**
 - NASA ISS: 2017-present
 - Inclined orbit; 30 profiles per orbit
 - Reaches latitudes $> 60^\circ$
 - Latitude bands move over months



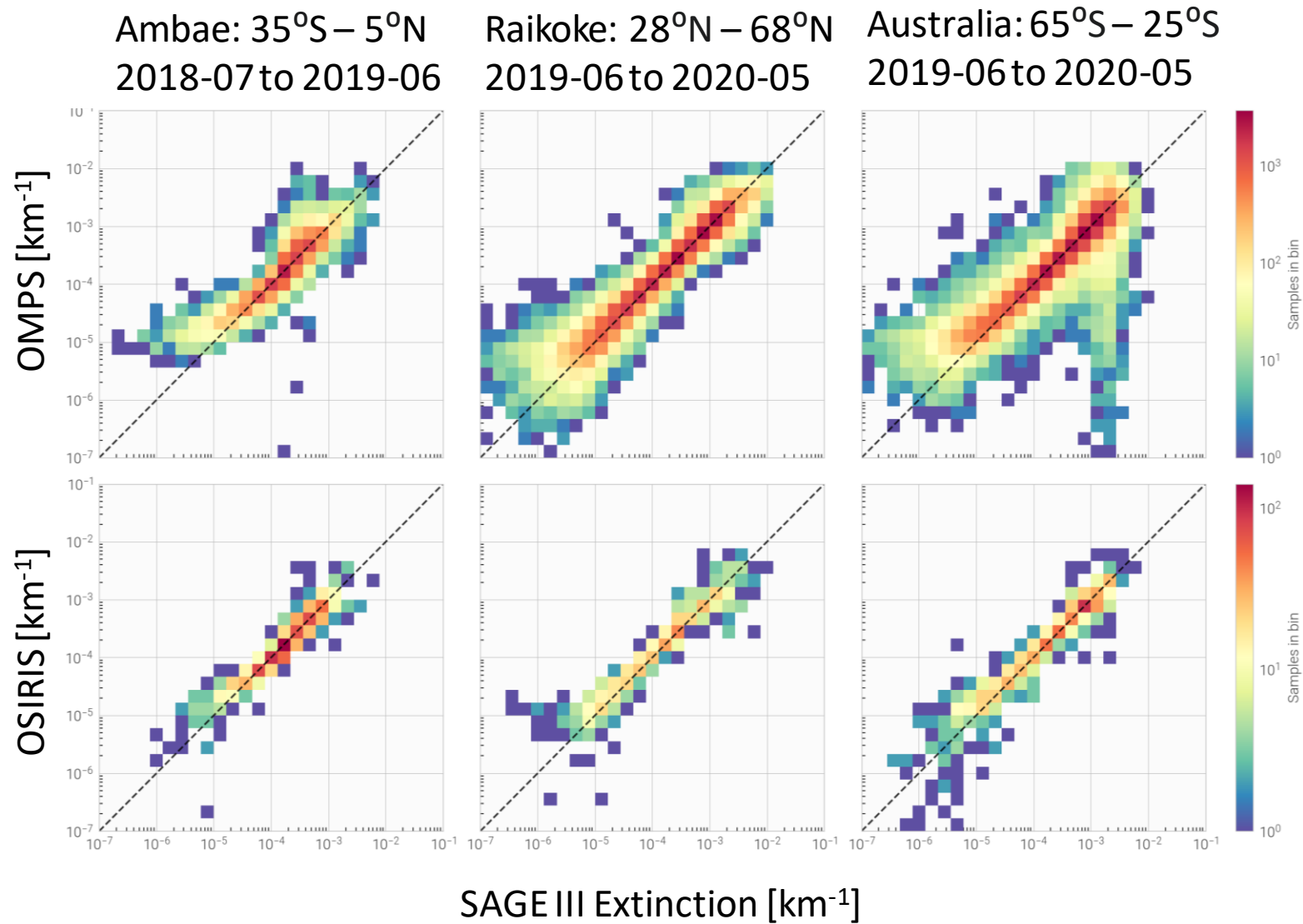
Three case studies:



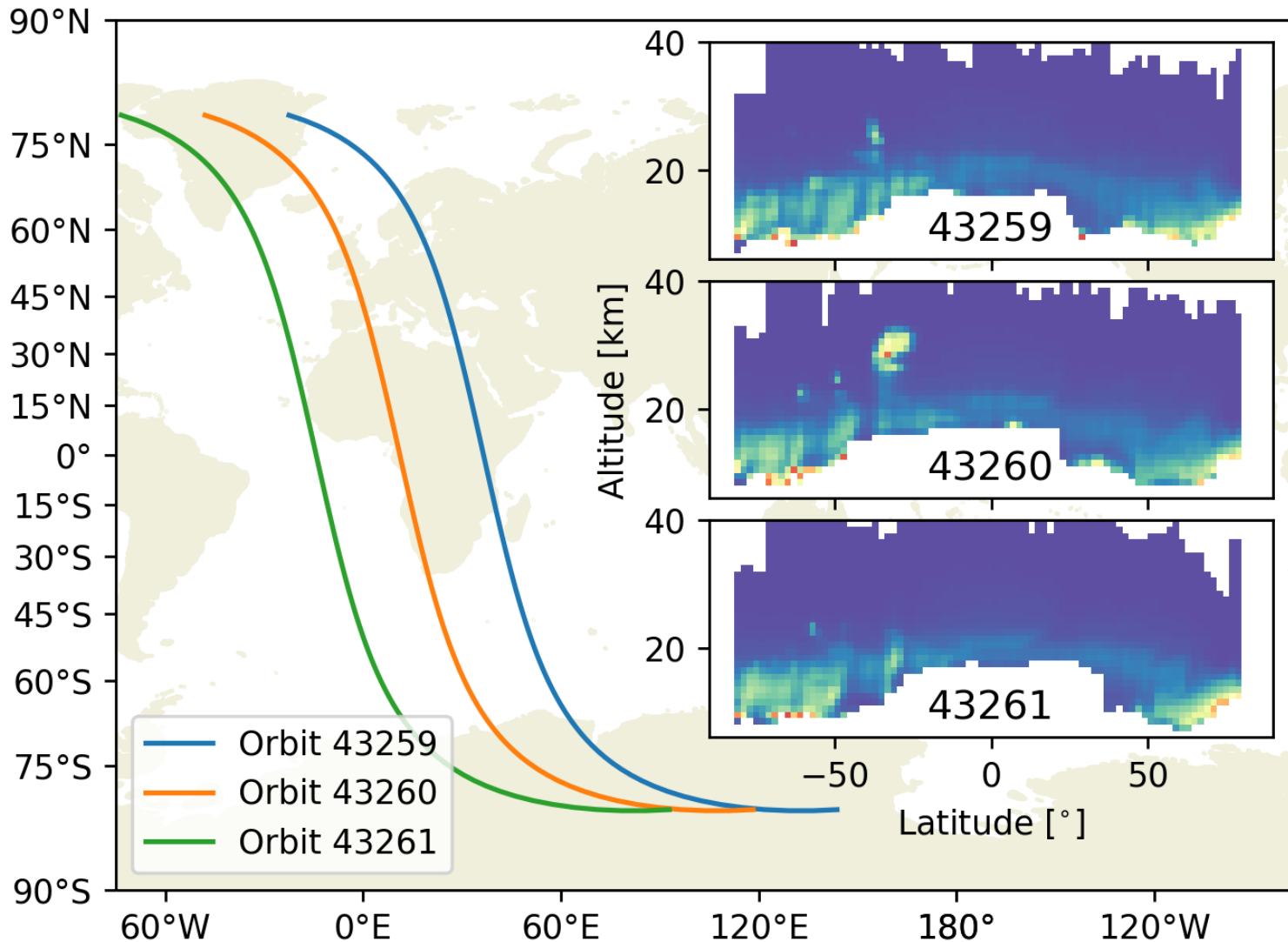
Daily zonal means:



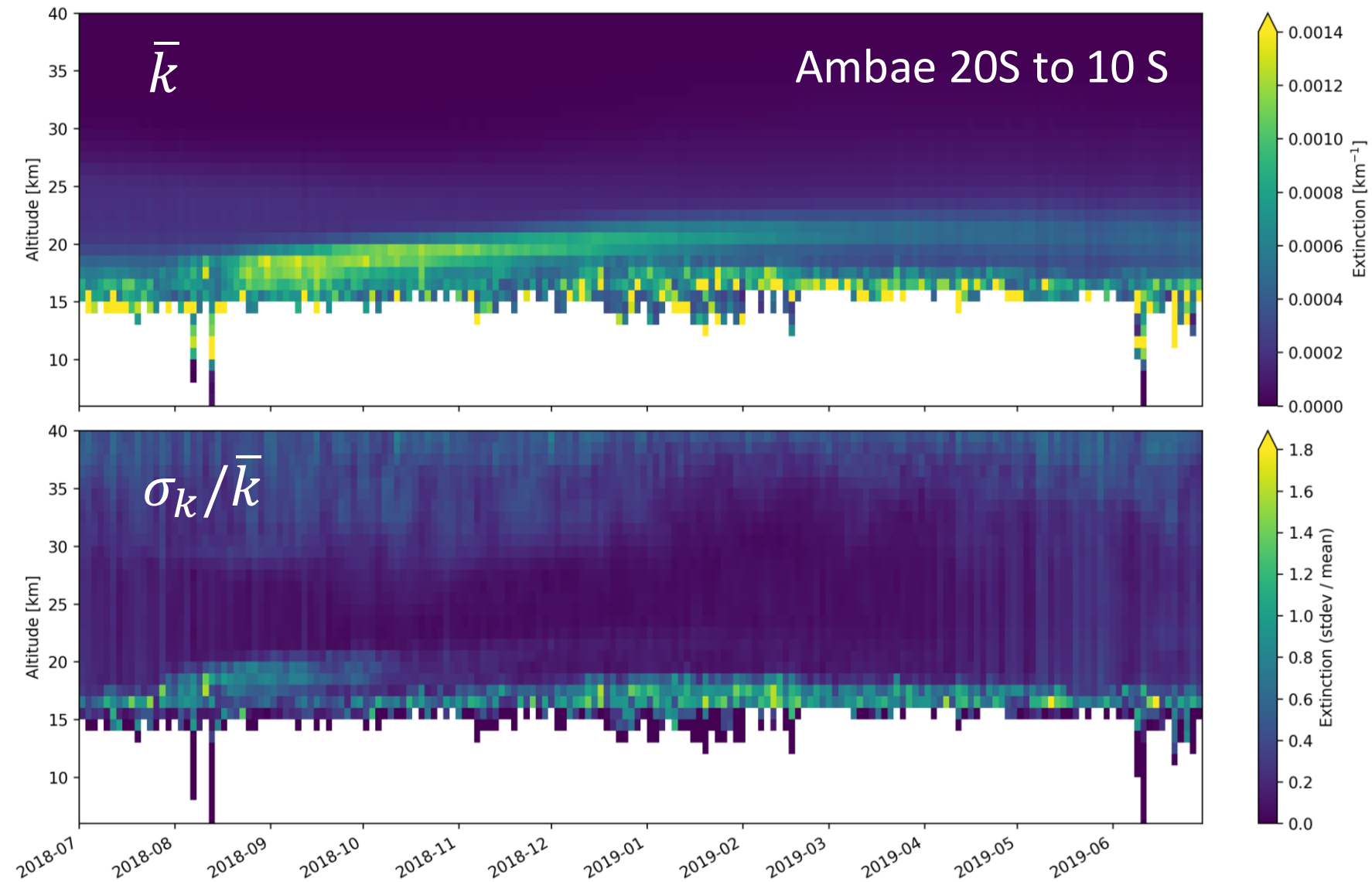
Coincidence with SAGE III:



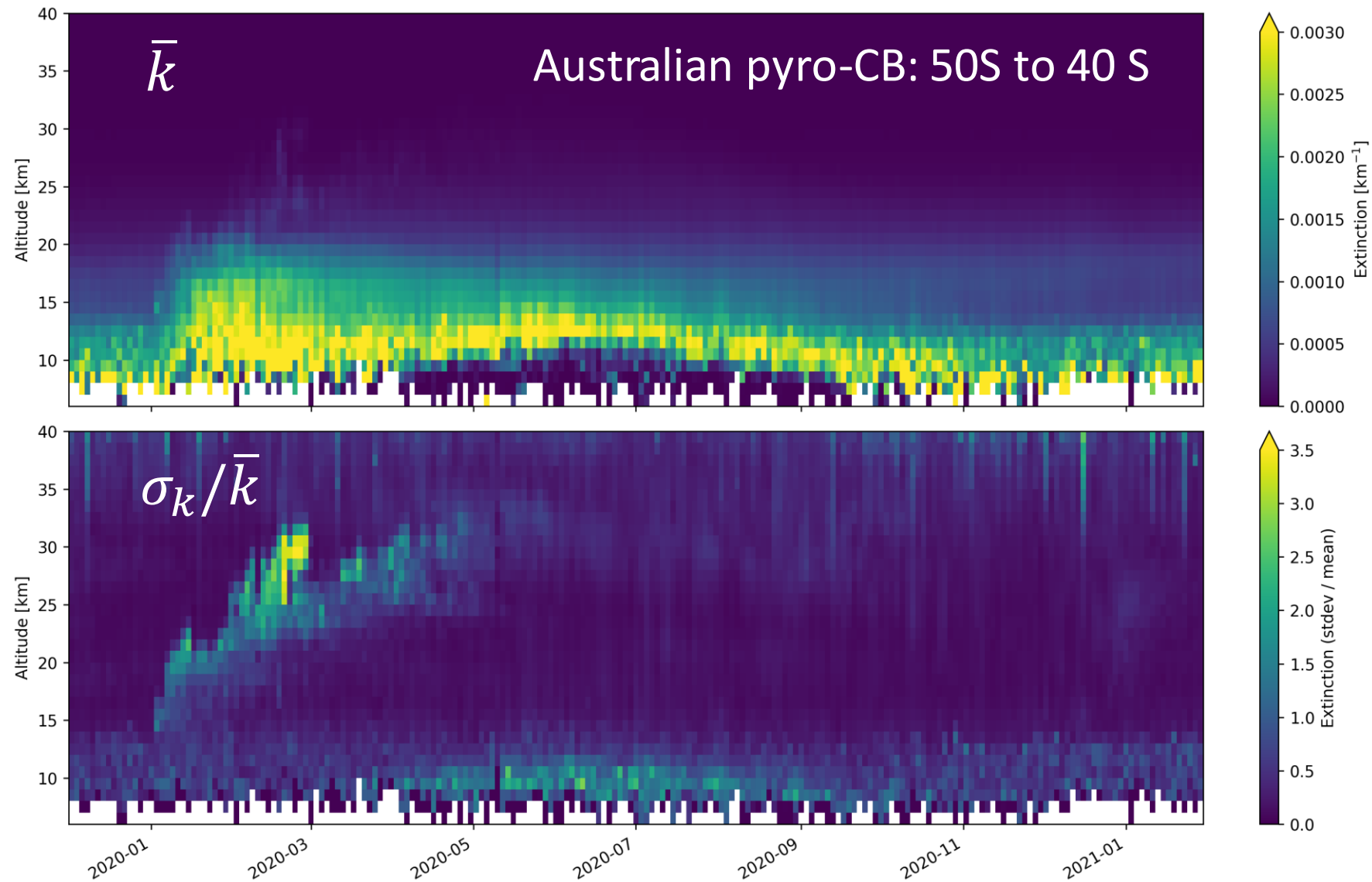
Massive zonal variability in early plume evolution:



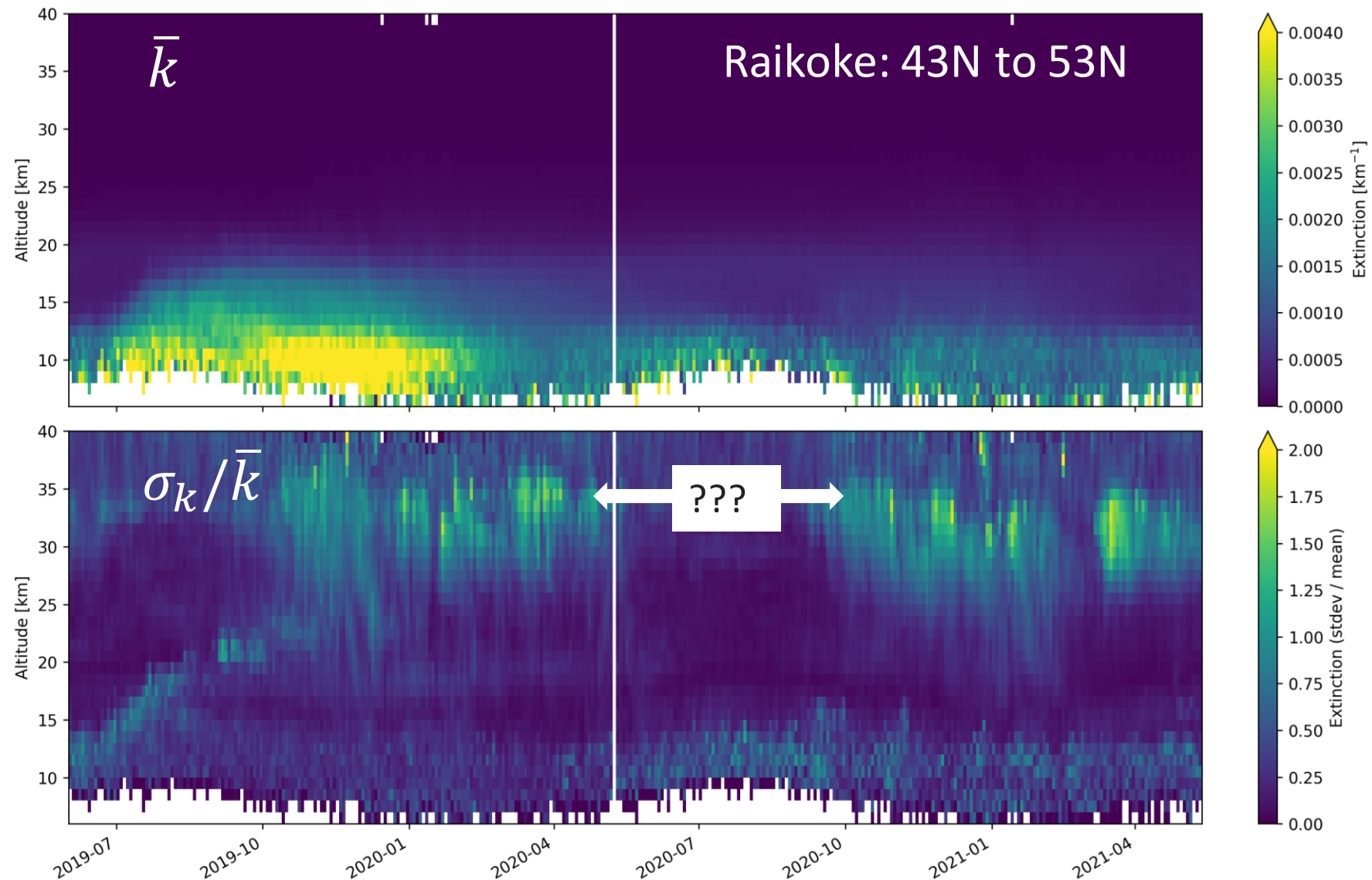
Simple metric for zonal variability: σ_k/\bar{k}



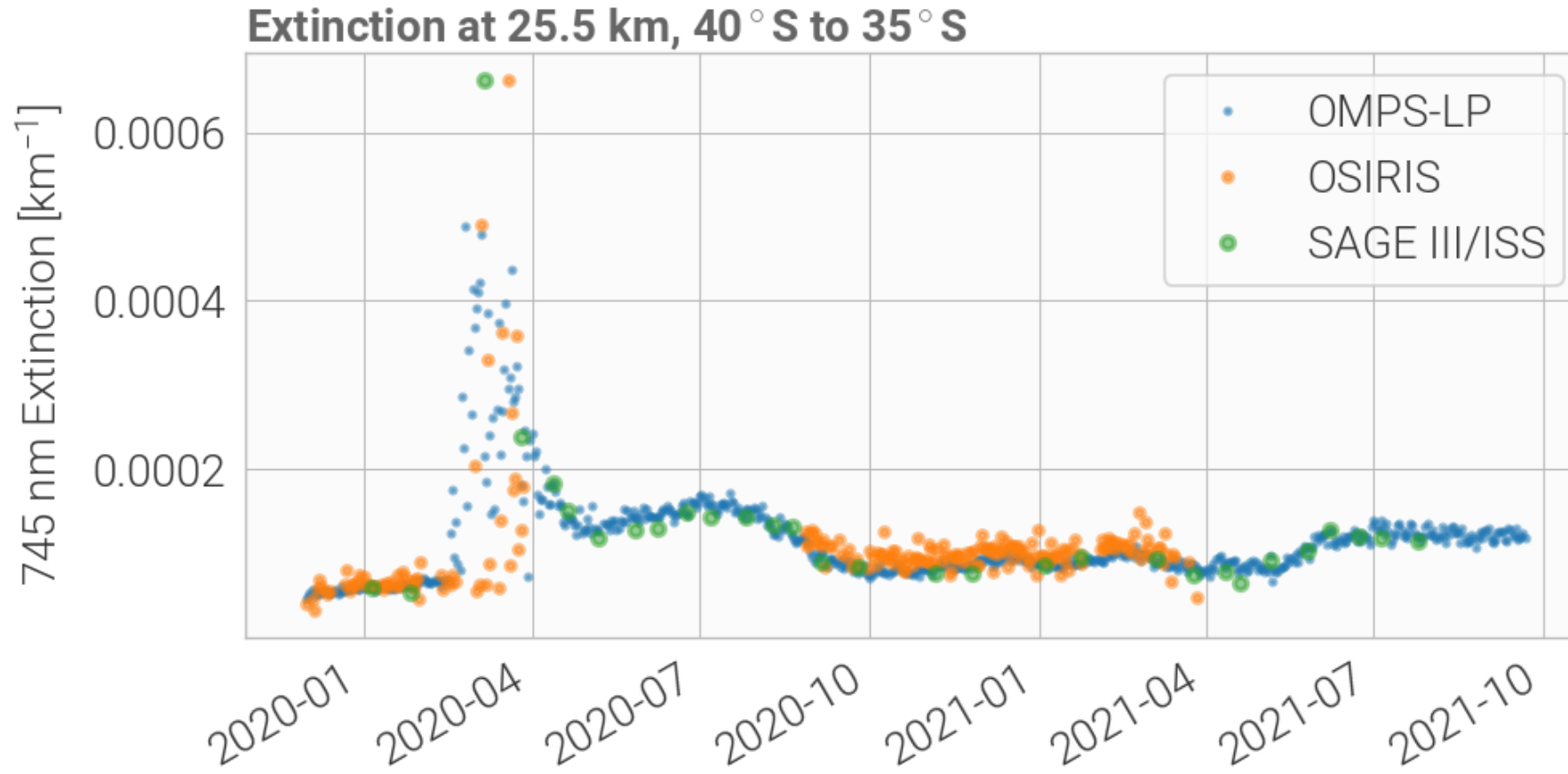
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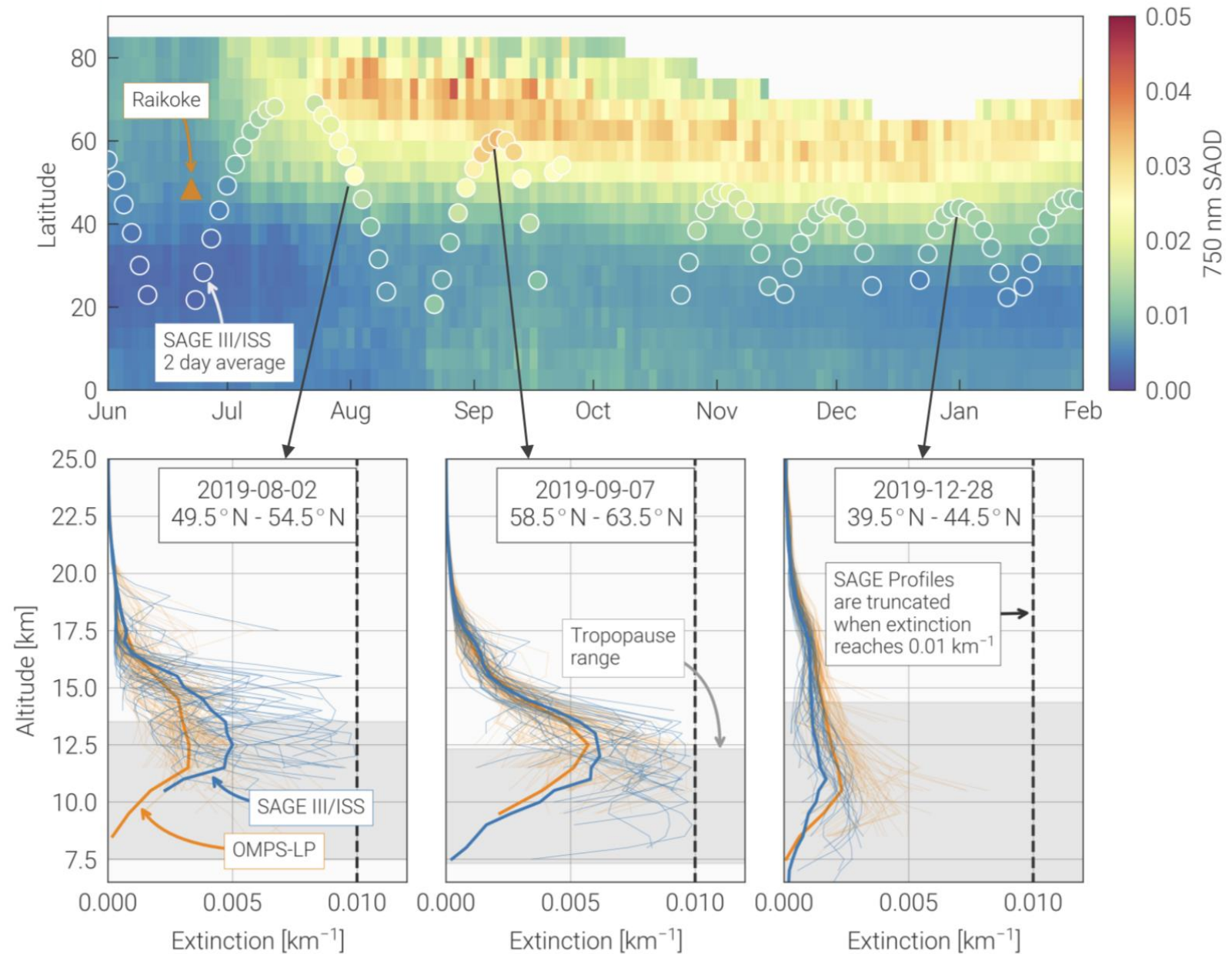
Simple metric for zonal variability: σ_k/\bar{k}



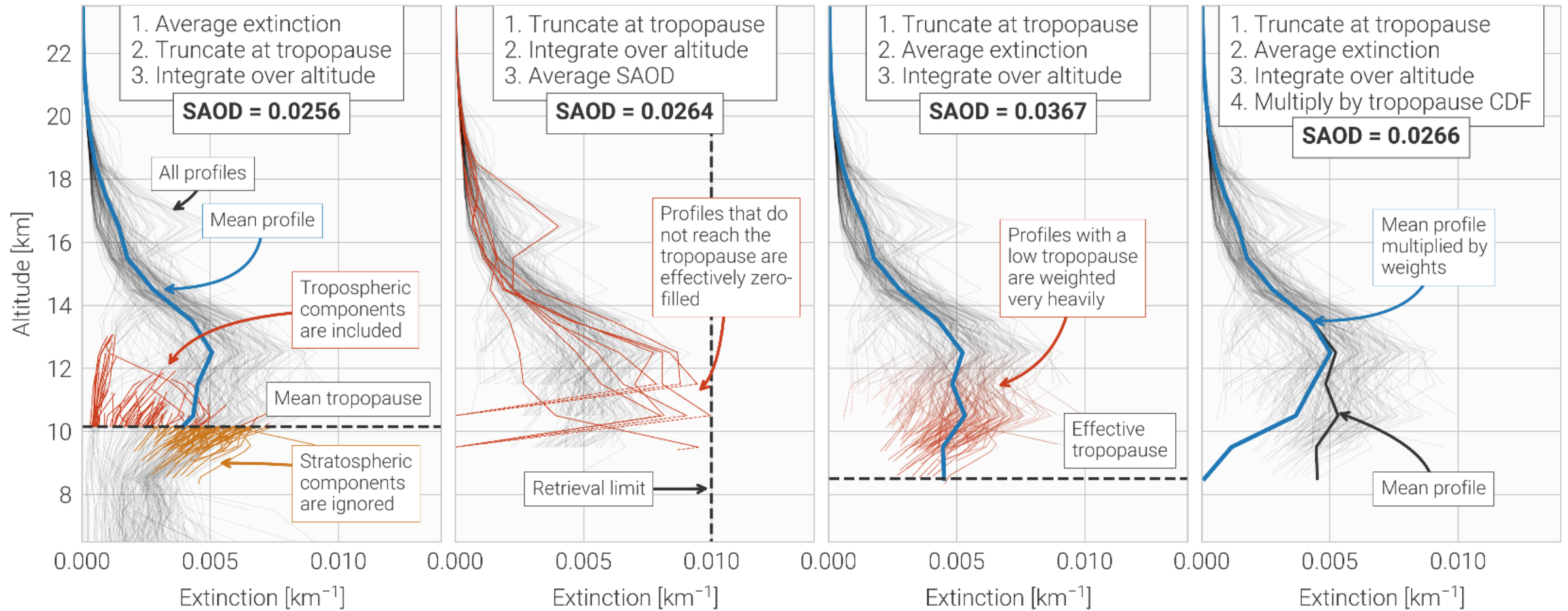
Sampling of zonally asymmetric plumes



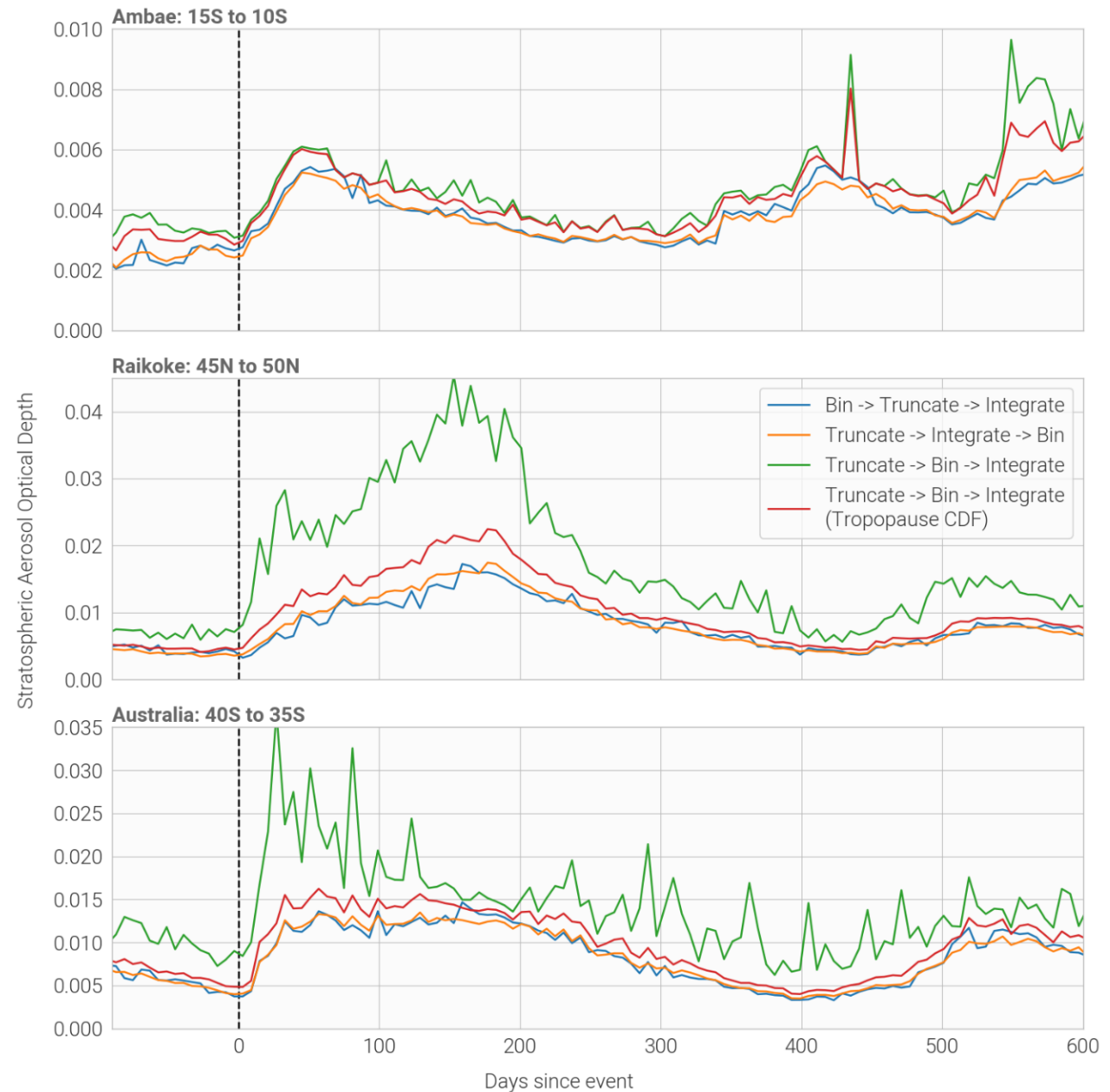
What about stratospheric aerosol optical depth (SAOD)?



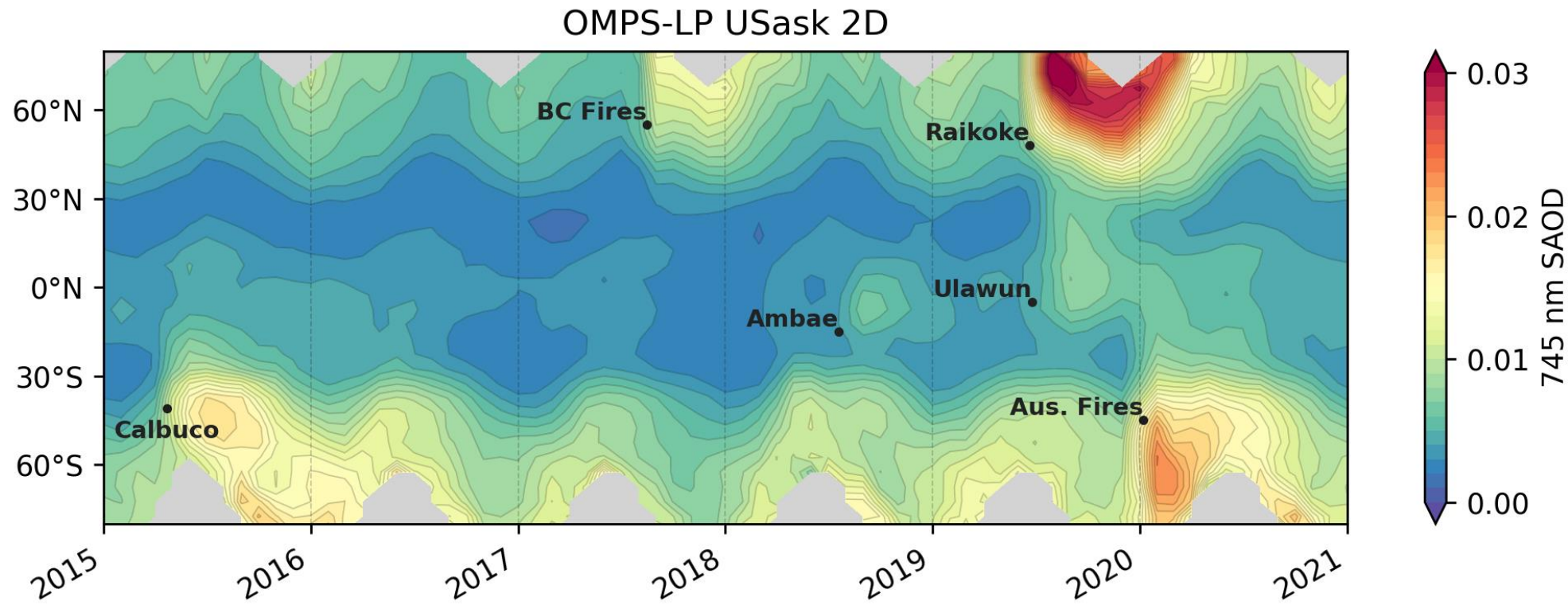
SAOD: maybe not so simple



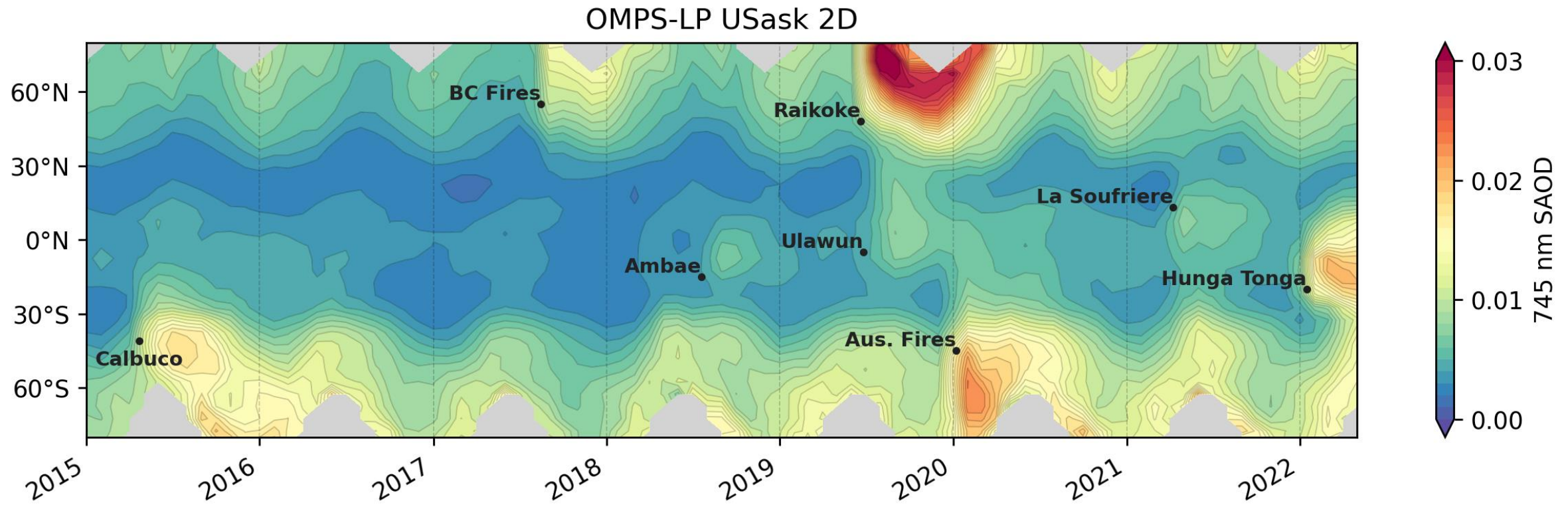
SAOD: A major source of “uncertainty” from calculation approach



SAOD: The tropopause CDF approach



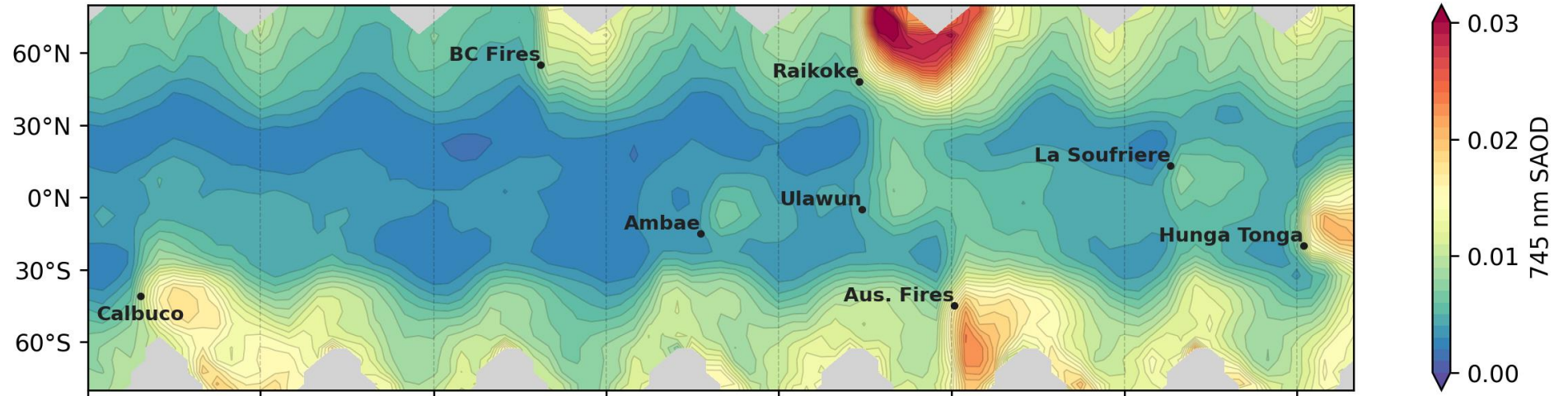
SAOD: The tropopause CDF approach



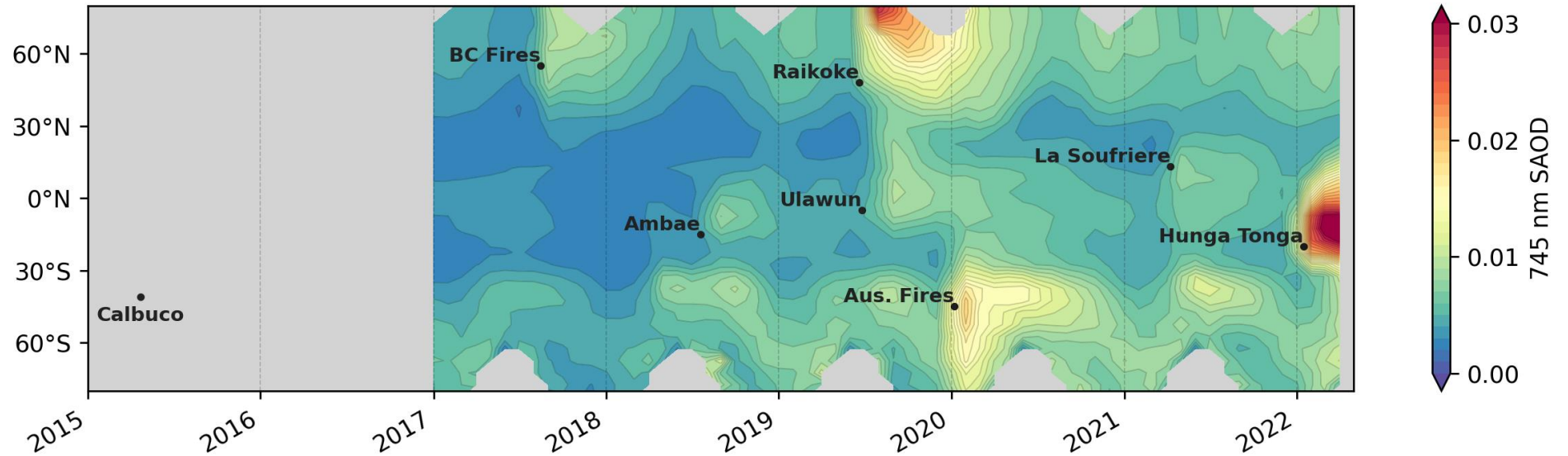
The interesting times continue....

Differences in retrieval approach

USask 2D
tomographic
inversion



NASA
official
product



Conclusions

- OMPS and OSIRIS limb scattering retrievals agree surprisingly well with SAGE III/ISS solar occultation
 - Robust under fire smoke and volcanic conditions
 - Biases in OMPS depend on extremes in extinction & geometry
- Zonal averages are representative only after 2+ months
 - Strongly depend on event type and location
 - Simple stddev/mean metric shows asymmetry
 - Sampling is critical – multi-instrument study is key
- Caution in AOD calculations – consider tropopause CDF method
- Retrieval approach needs investigation for largest eruptions