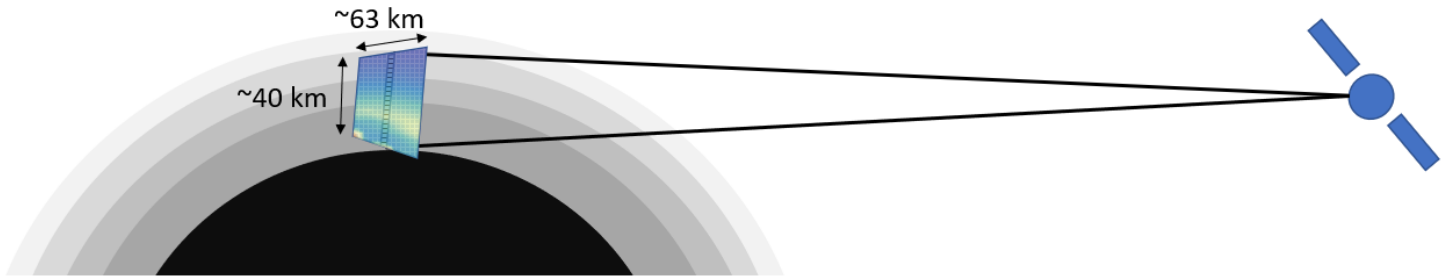
Pushing the limits of limb scatter observations of UTLS water vapour: Spatial Heterodyne Observations of Water (SHOW)

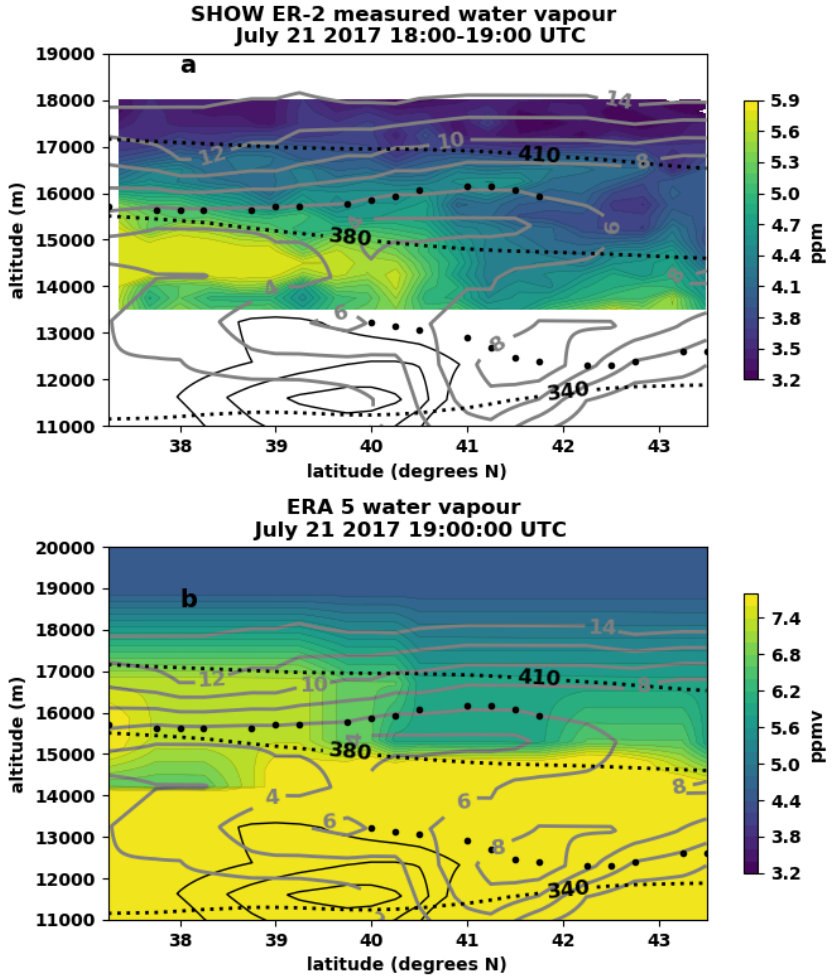
Jeffery Langille[1], Adam Bourassa[2], Doug Degenstein[2], Daniel Zawada[2], Yi Huang[3], Jing Feng[3], Xun Wang[3], Landon Rieger[2], Jean-Pierre Blanchet[4], Yann Blanchard[4], William Ward[1]

[1] ***UNB***, [2] *USASK*, [3] *McGill*, [4] *UQAM*

The need for dense sampling of UTLS water vapour

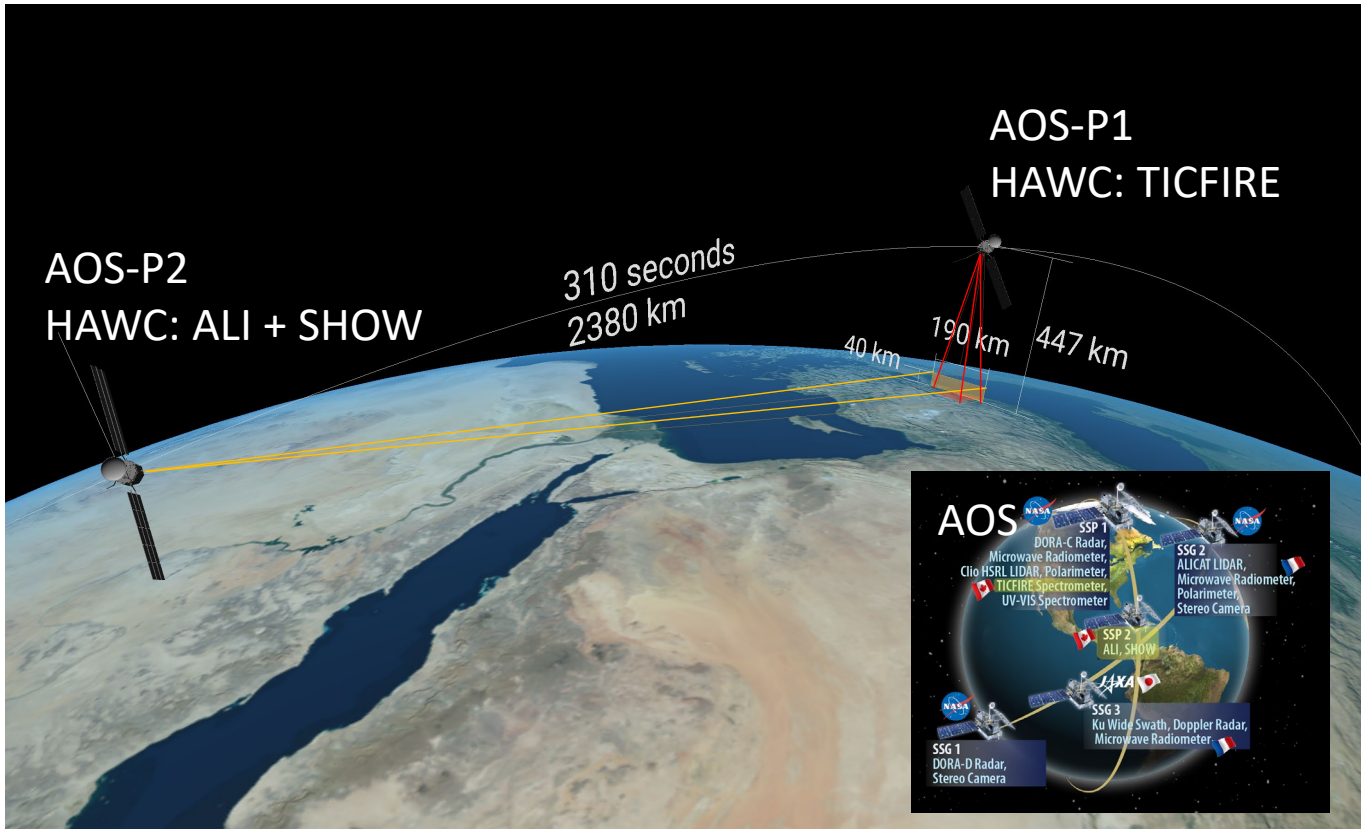
- UTLS water vapour is coupled to climate and weather in a manner that is only poorly understood. Plays an important role cloud dynamics and aerosol processing
- However, important processes near the tropopause are not resolved by current satellite sensors or in models.
- Observing limb scattered radiance in a vibrational band of water provides high sensitivity to low UTLS water concentrations. Imaging the limb without scanning facilitates dense sampling.

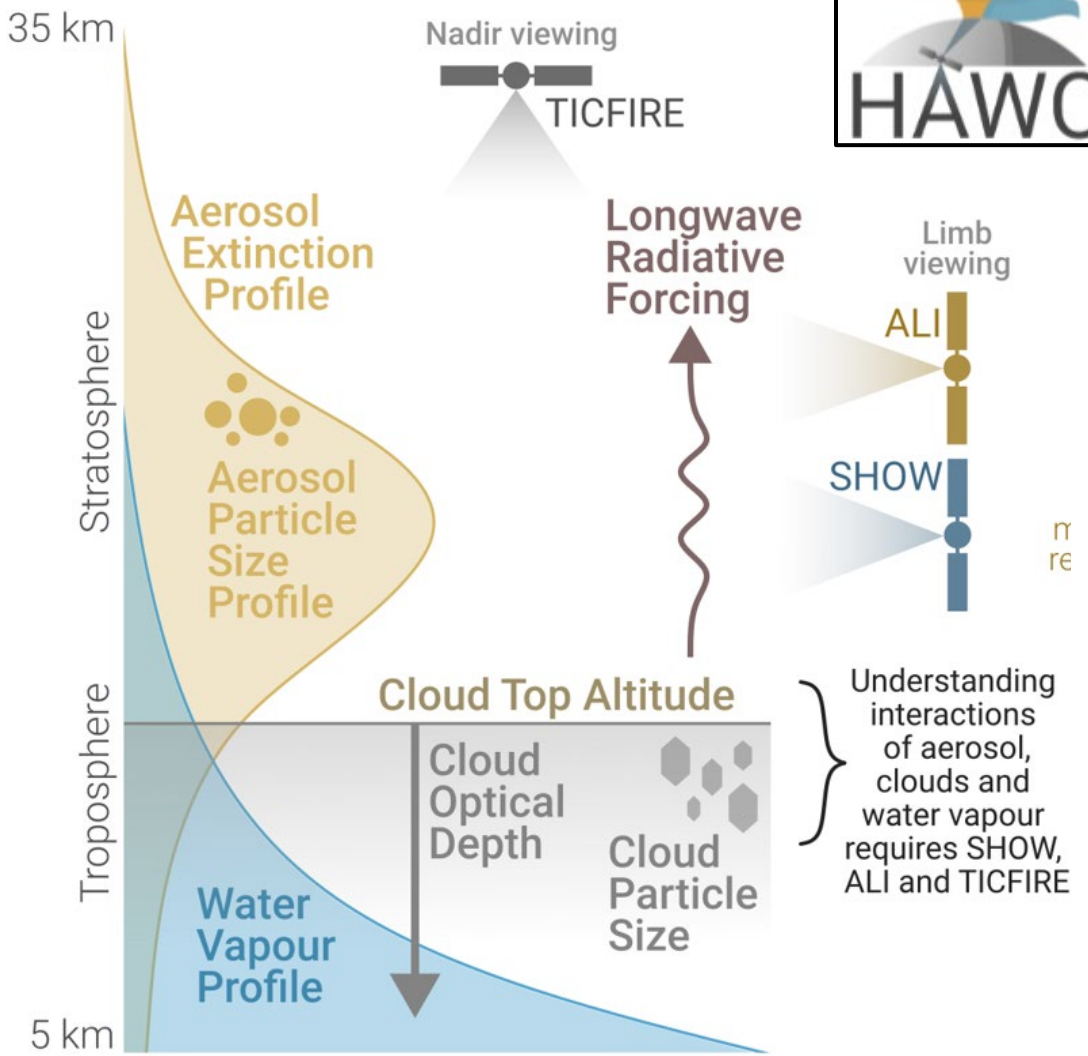




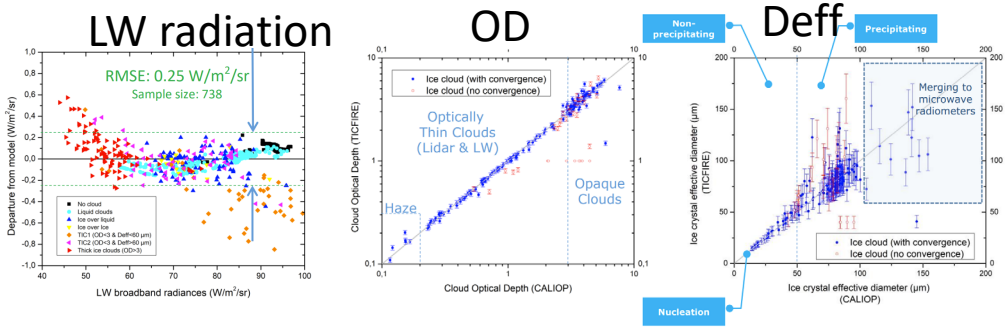
High altitude Aerosol Water and Cloud (HAWC)

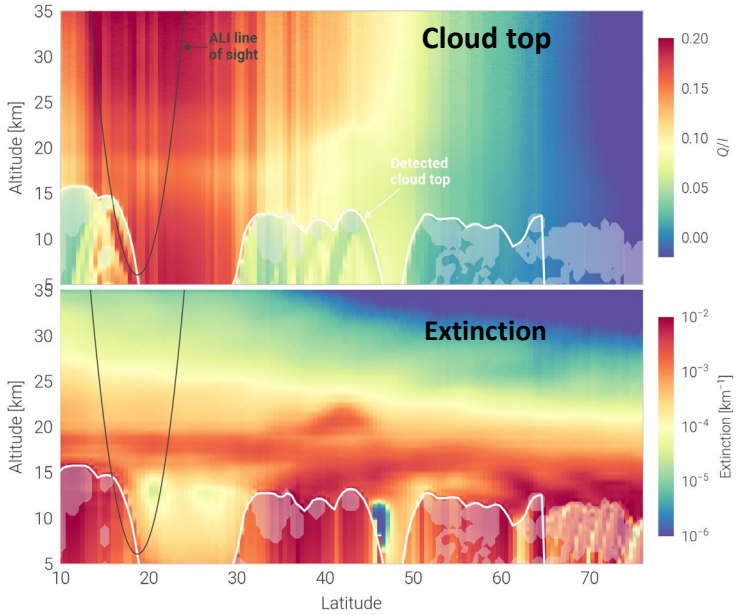
- **HAWC** is Canada's proposed contribution to NASA's Atmospheric Observing System (AOS) mission
- Focused on **cloud**, **water** and **aerosol** and their interactions at high-altitude and cold regions



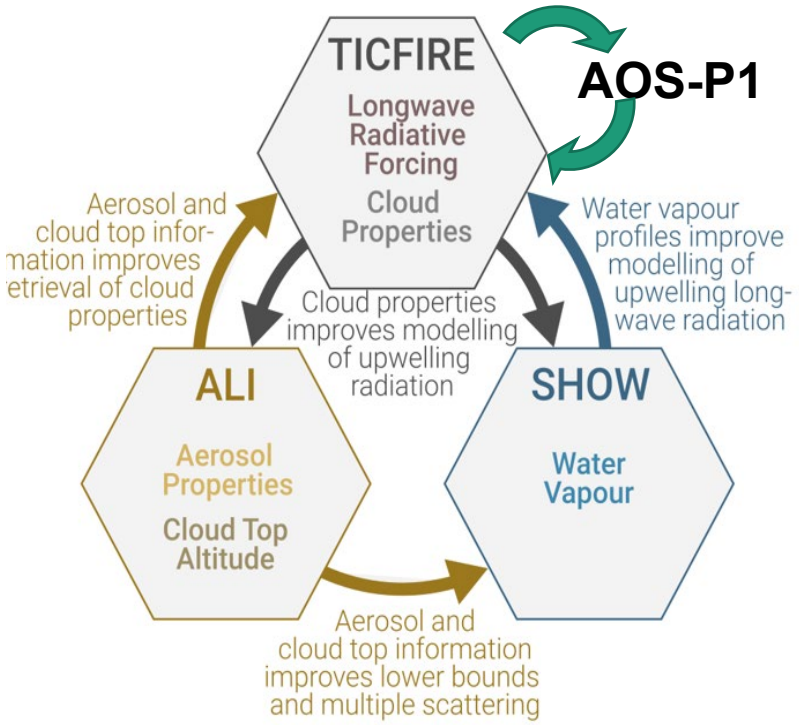


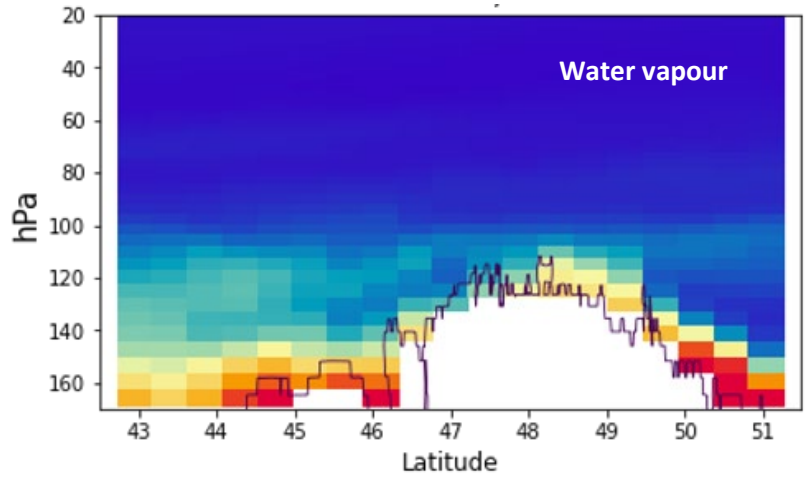
HAWC: a cohesive mission





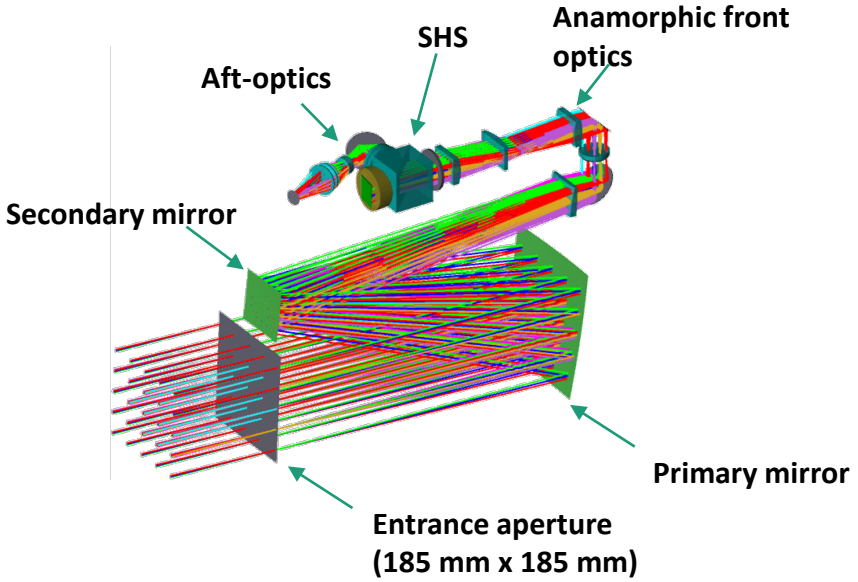
Reff: 40nm to 400nm

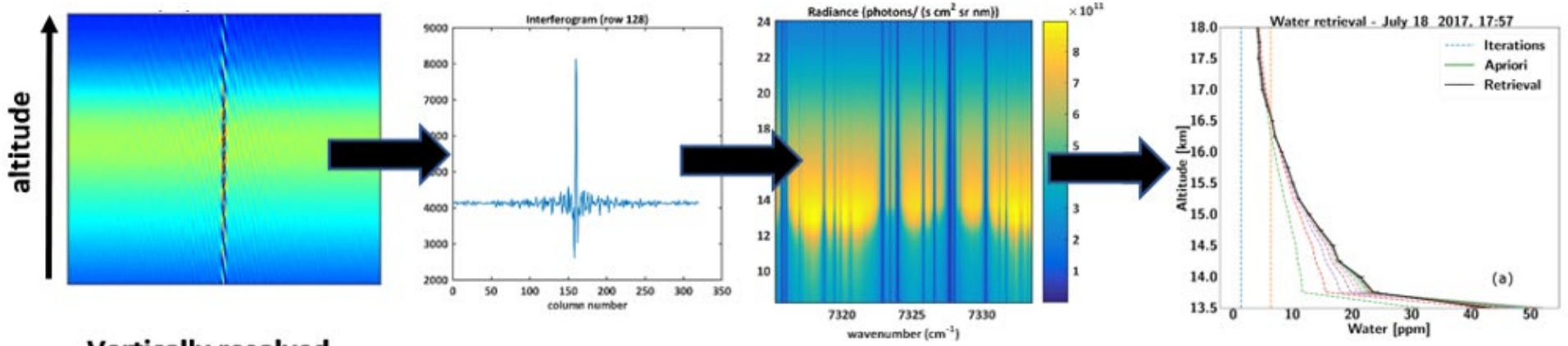




Spatial Heterodyne Observations of Water (SHOW)

- Field widened Spatial Heterodyne Spectrometer (SHS) configured to image the limb radiance without scanning
- The SHS technique achieves a high spectral resolution combined with a large throughput without scanning
- Vertically resolved images of the limb radiance are obtained with each frame which are then inverted to extract the vertical water vapour profile.
- Allows for dense (vertical and along-track) sampling of the water distribution





Vertically resolved limb image

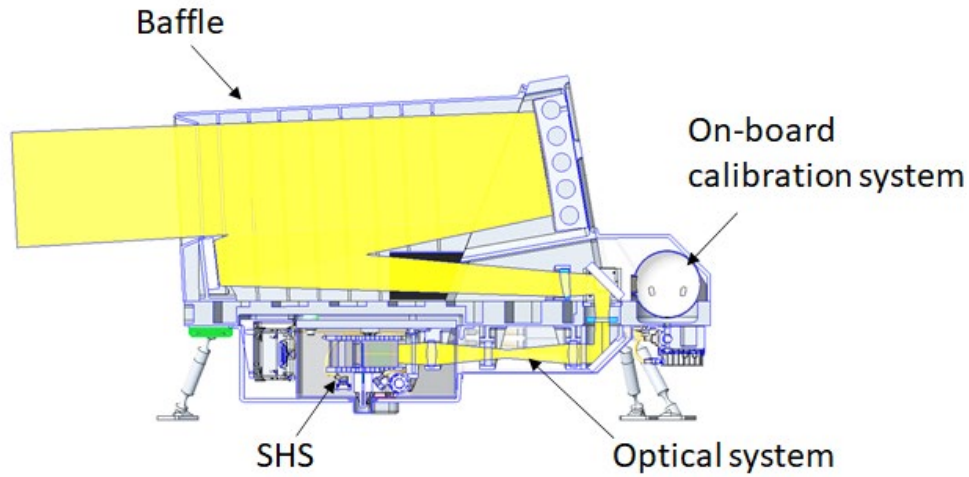
Row cut

Vertically resolved Spectra

Water profile

Phase 0 instrument design

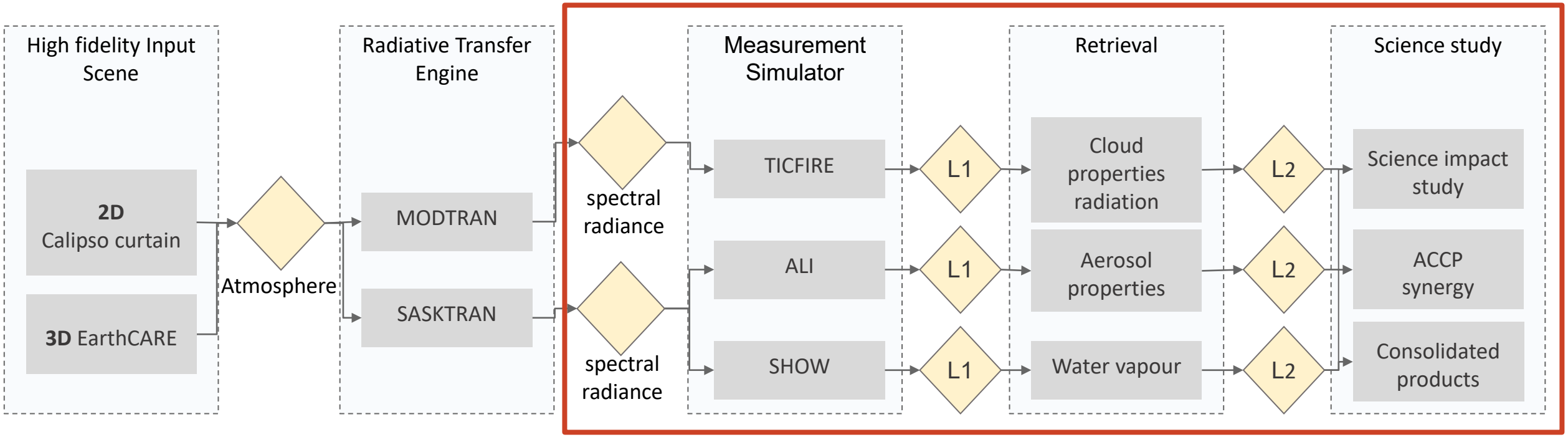
Parameters	Values	Unit
Spectral Range	1364 to 1368	nm
Spectral Sampling	0.0248	nm
Unapodized Resolution	0.03	nm
Max FOV Height	40	km
Min FOV Height	0	km
Vertical Sampling	125	meters
Vertical Resolution	250	meters
Horizontal Sampling	1.5	deg
Along Track Sampling	2 per 2	images / s
Horizontal Image Size	512	pixels
Vertical Image Size	327	pixels
Troughput per pixel	7.07E-07	cm^2 sr
Mass	59	kg
Volume	51×56×90	cm^3
data Rate	3.4	Mbps
Volume per orbit	2400	MB
Lifetime	3 to 5	years



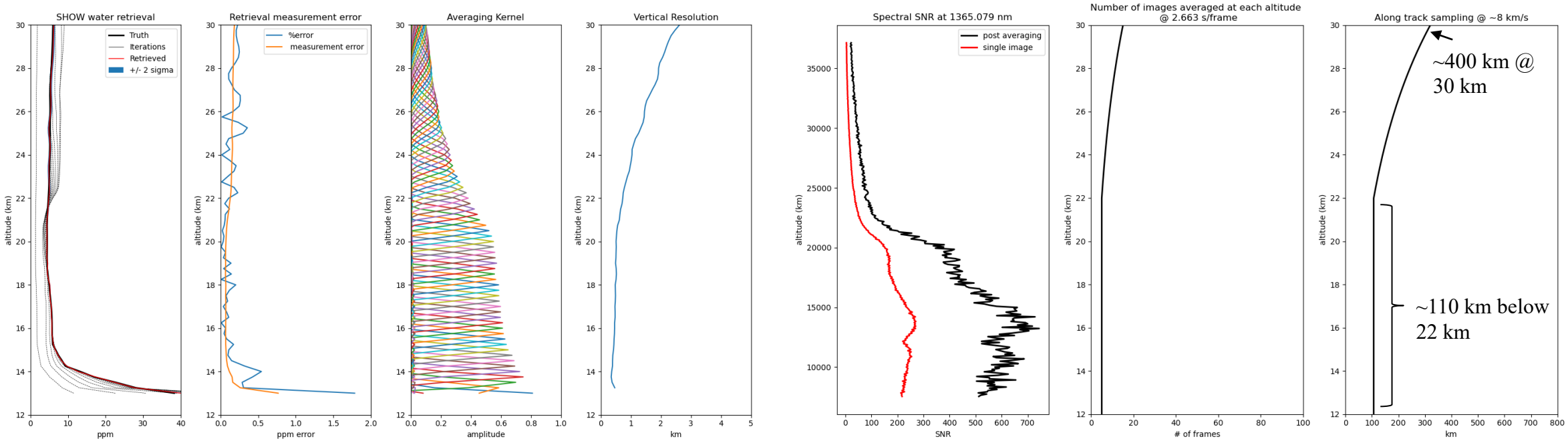
ABB

End-to-End Simulator

- Input scenes developed from CALIPSO/OMPS and EarthCARE are used in conjunction with RTMs to simulate realistic scenes for the instrument models.
- Instrument models are used to turn radiance fields into simulated Level 1 measurements.
- Retrievals are performed using synthetic Level 1 products to produce Level 2 products.
- Synergy is studied with synthetic retrieval products.

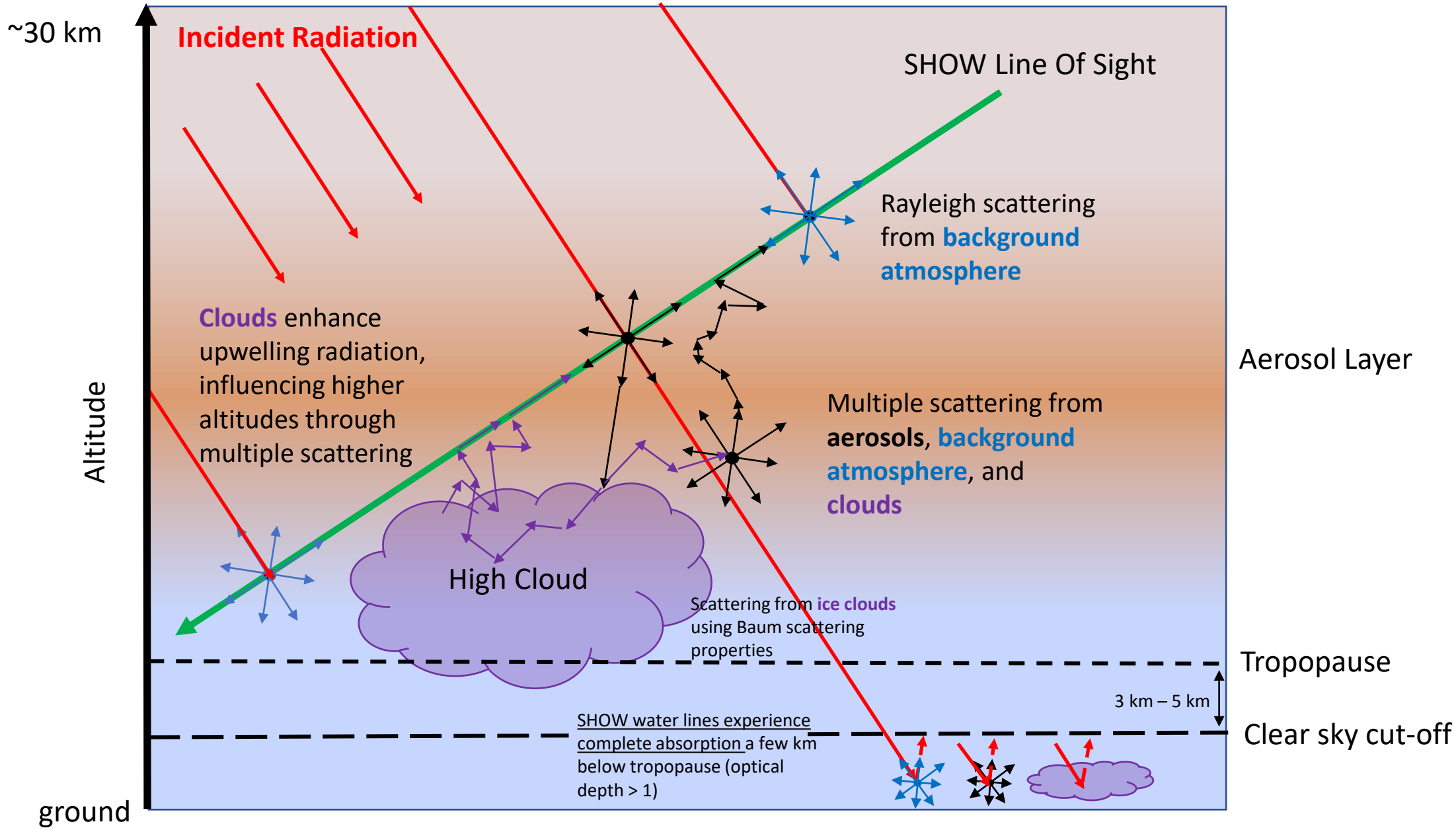


Clear sky retrieval



Parameter	Altitude Range	V res goal	V res Th	H res goal	H res Th	Precision Goal/Th	Accuracy Goal/Th
	(km)	(km)	(km)	(km)	(km)	%	%
UTLS	8 -25	0.5	1	50	200	5%/10%	5%/15%
Stratosphere	25-30	1	2	200	400	5%/10%	5%/15%

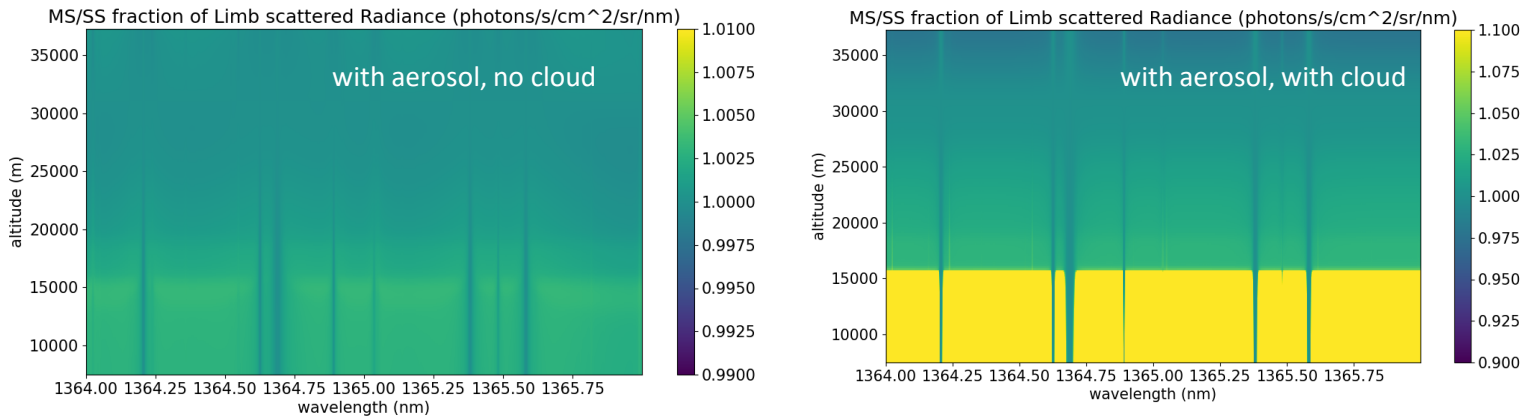
Impact of Aerosol and Cloud



Optimizing the Forward Model

Upwelling

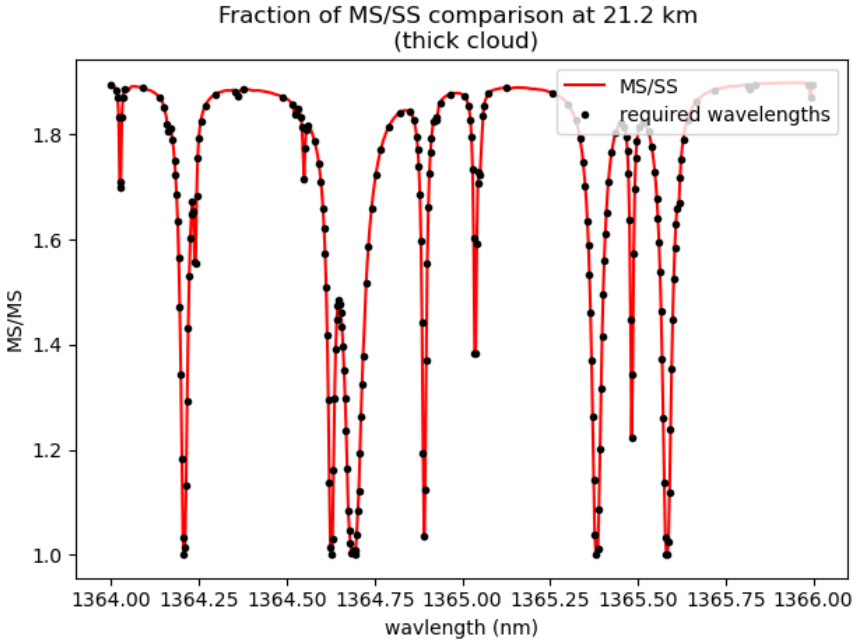
Apply high altitude normalization and include a baseline correction in the state vector (either aerosol or air density)



Speed

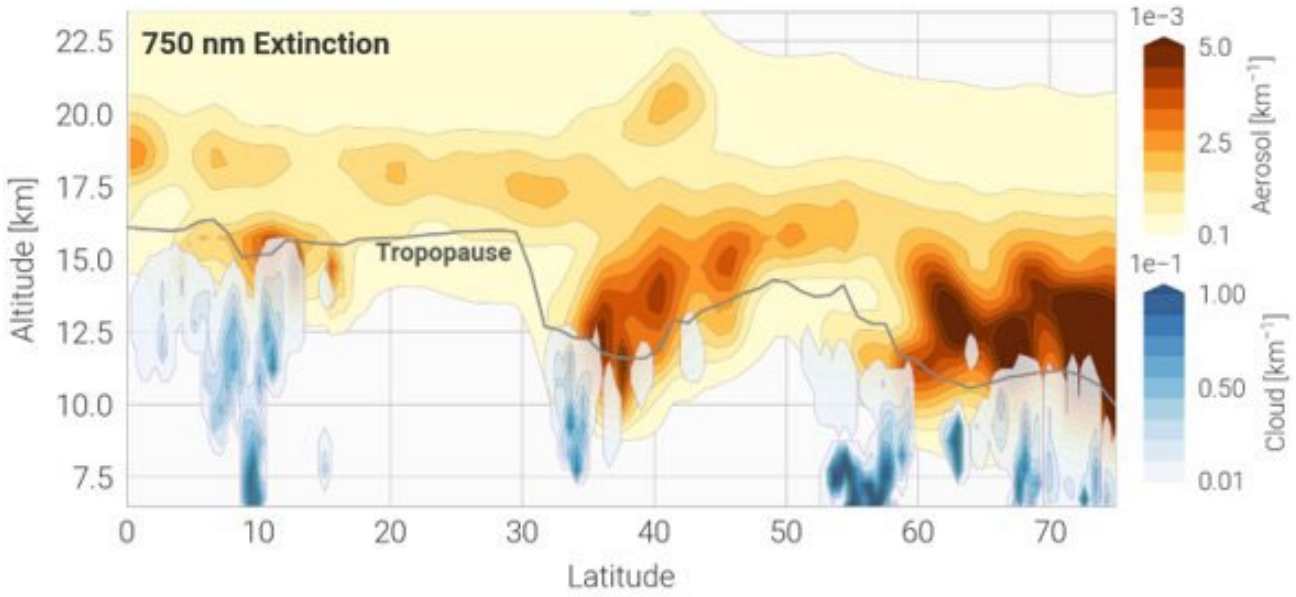
Apply a high-resolution single scatter approximation to speed up the radiative transfer calculations

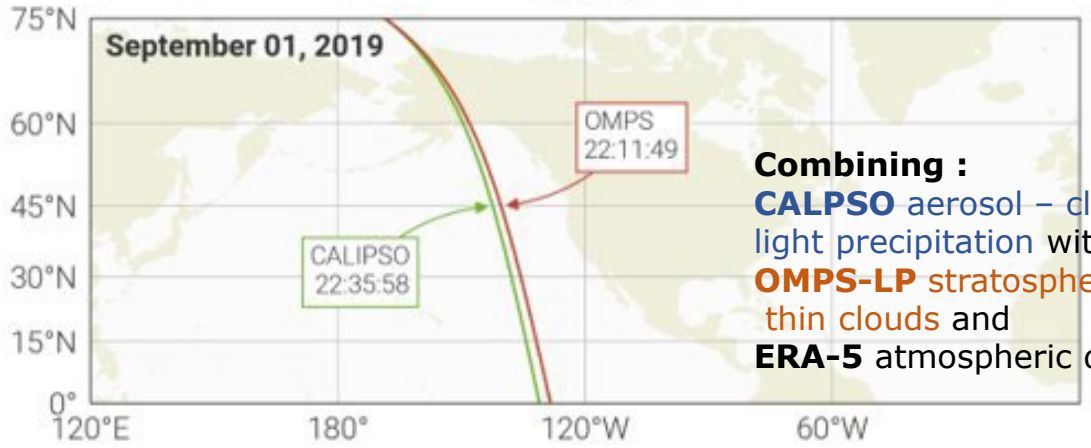
- Determine number of required wavelengths to accurately simulate the fraction of SS/MS radiance
- Only perform MS calculations at required wavelengths



Test Scenes

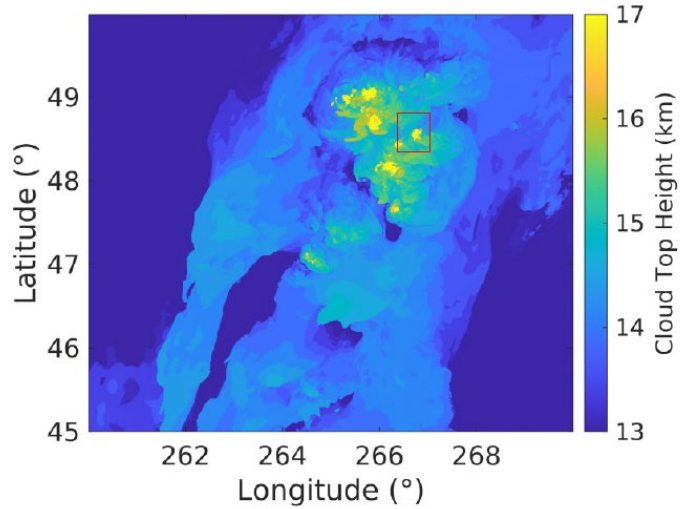
Thin cloud and fine aerosol

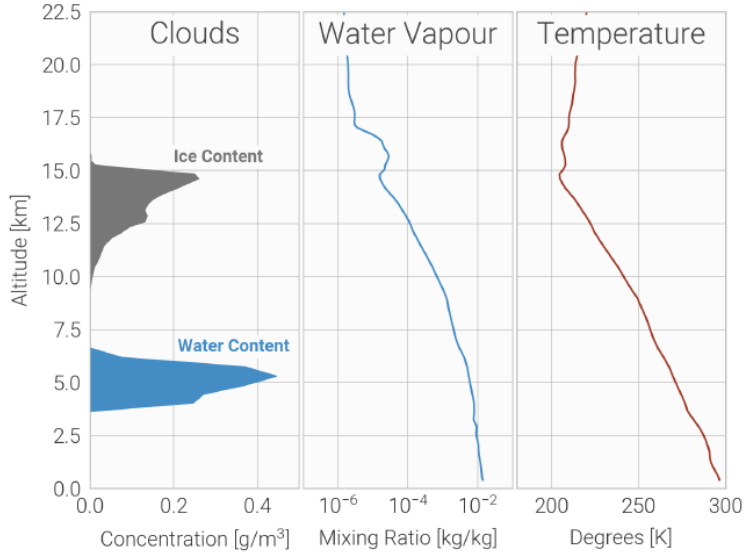




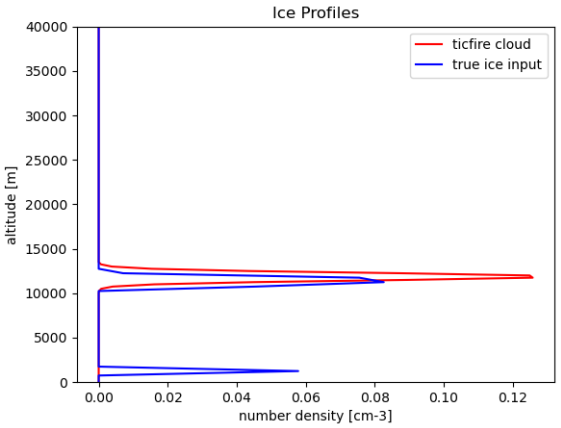
Combining :
CALPSO aerosol – clouds – light precipitation with
OMPS-LP stratospheric aerosol – thin clouds and
ERA-5 atmospheric data analysis

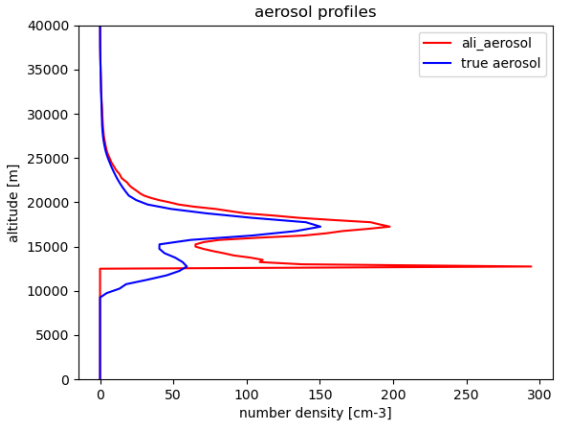
Deep Convection (GEM MACH)



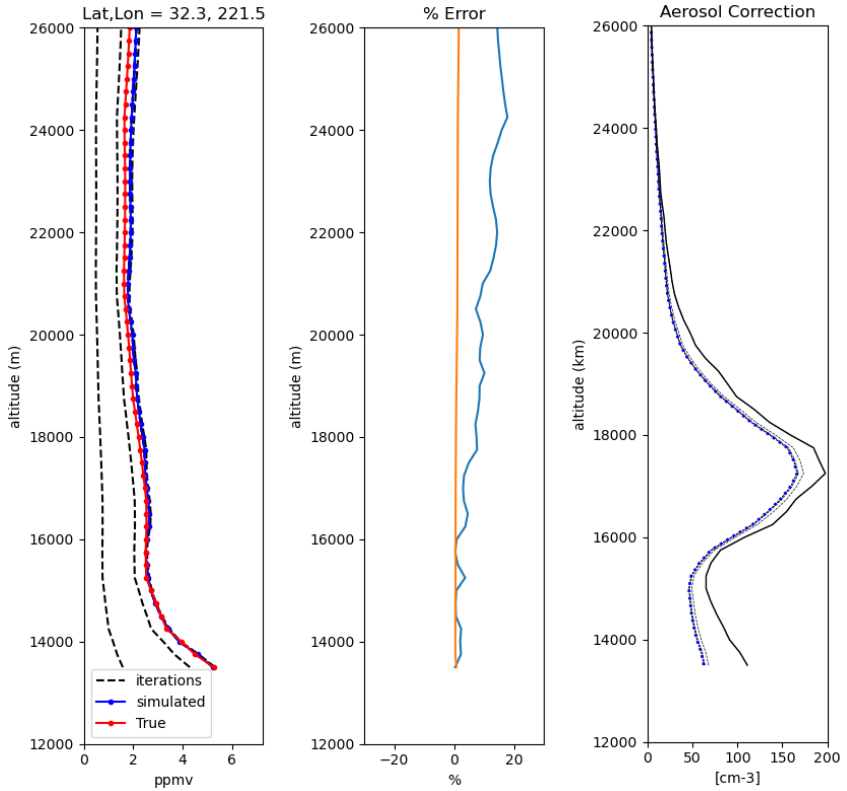


Example Retrieval using the CALIPSO/OMPS scene

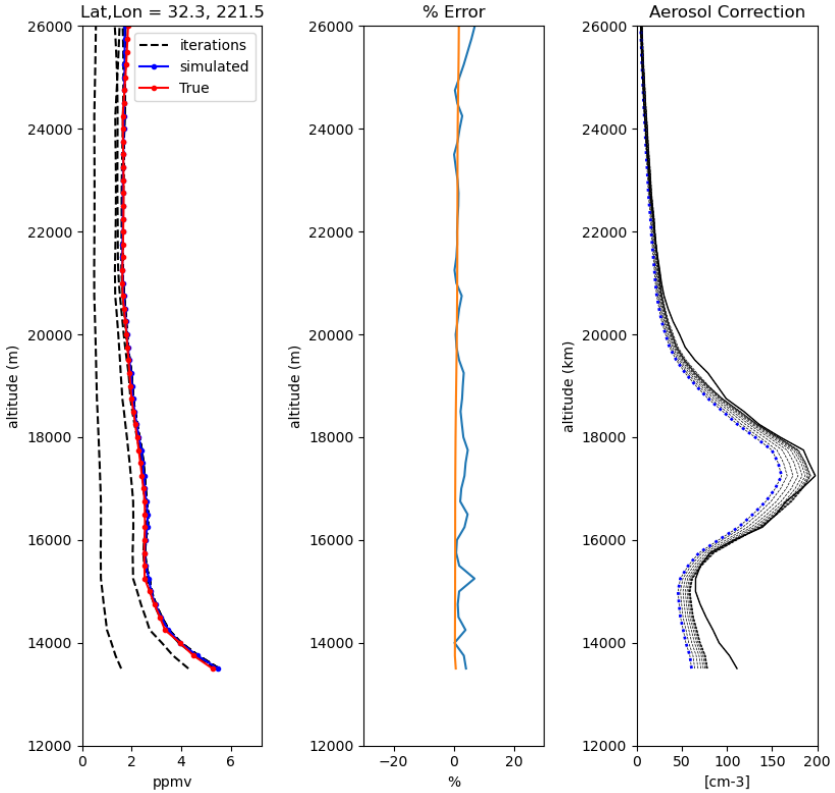




No cloud, no cloud & apply the aerosol correction

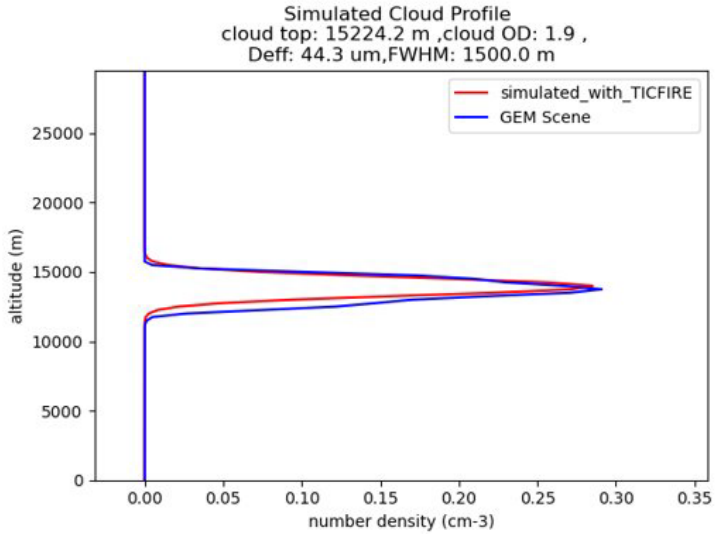


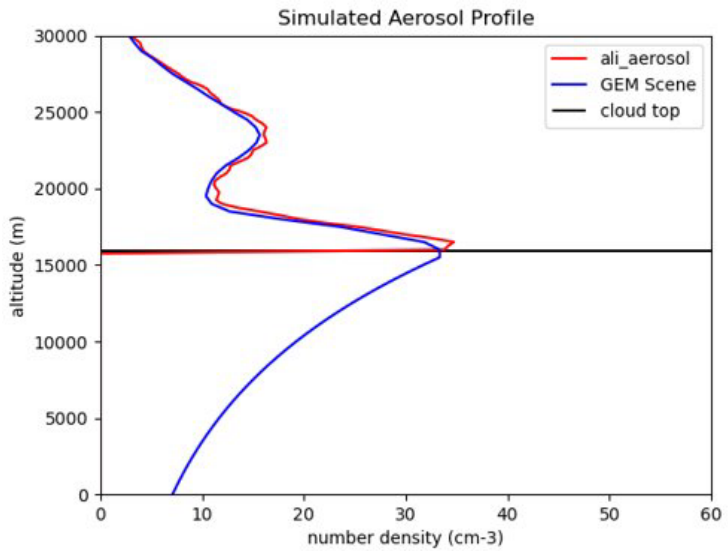
ALI Aerosol, TICFIRE cloud & apply the aerosol correction



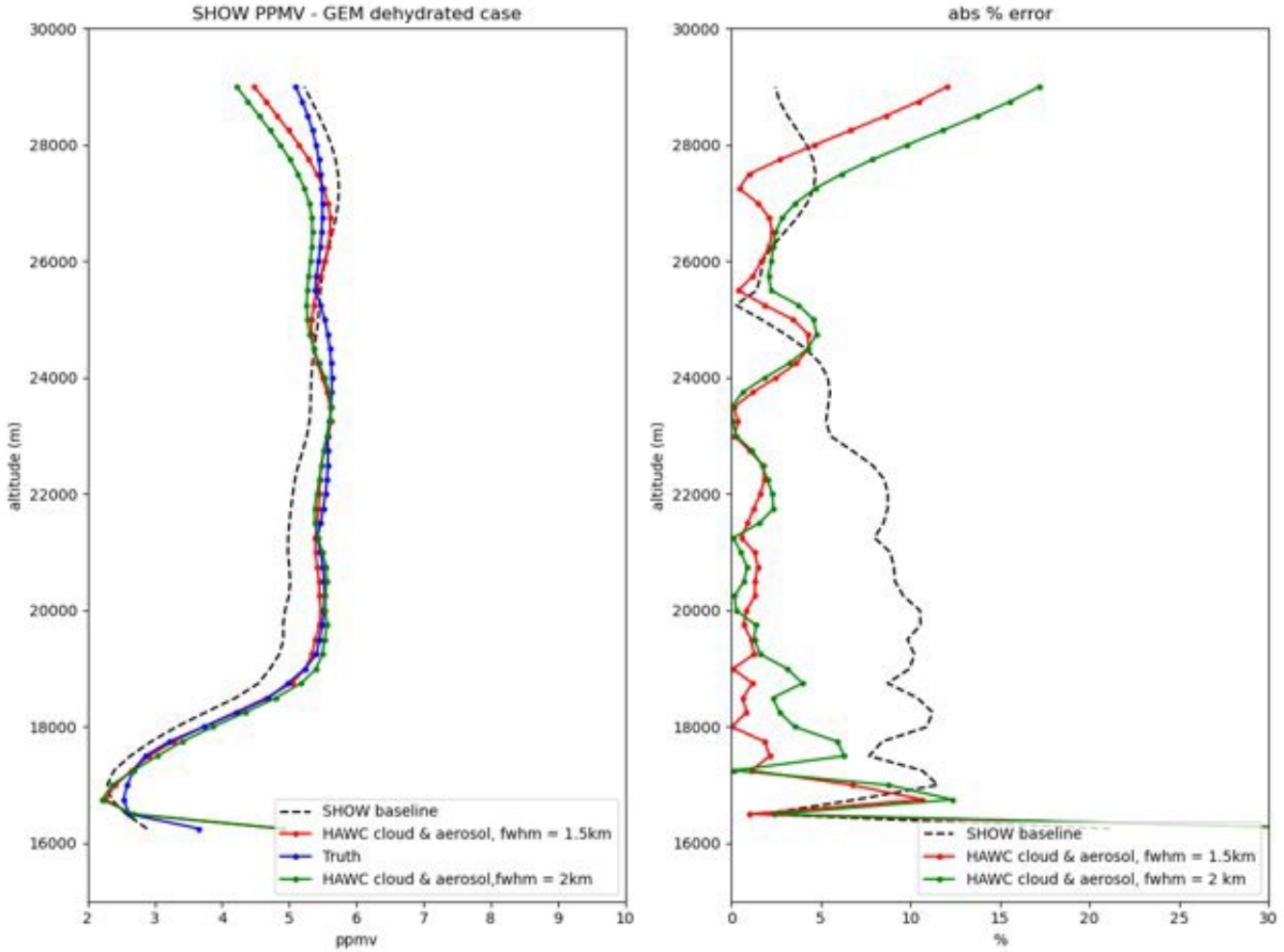
Example Retrieval using the GEM scene

ALI and TICFIRE information

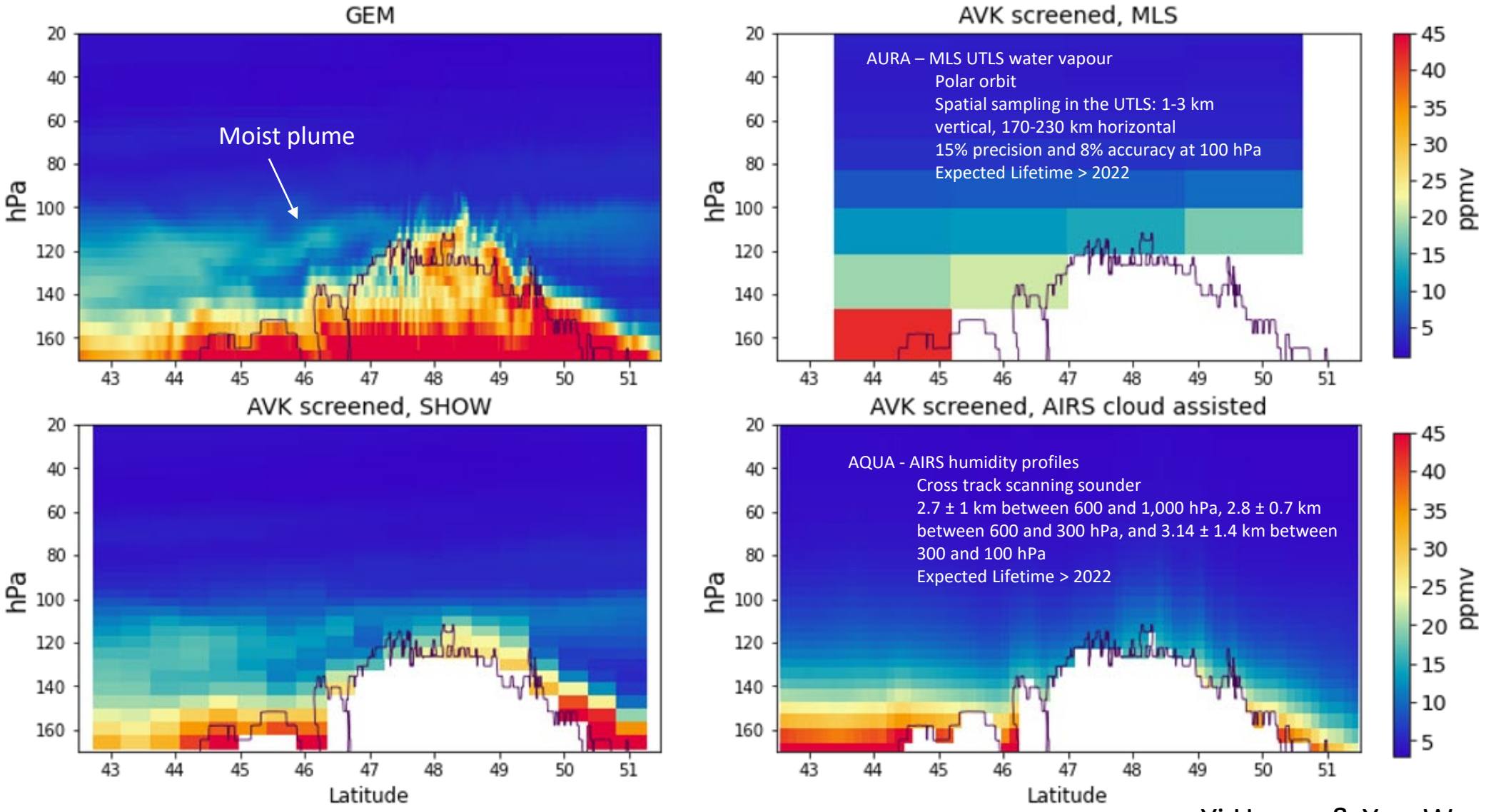




Improvement to SHOW retrieval

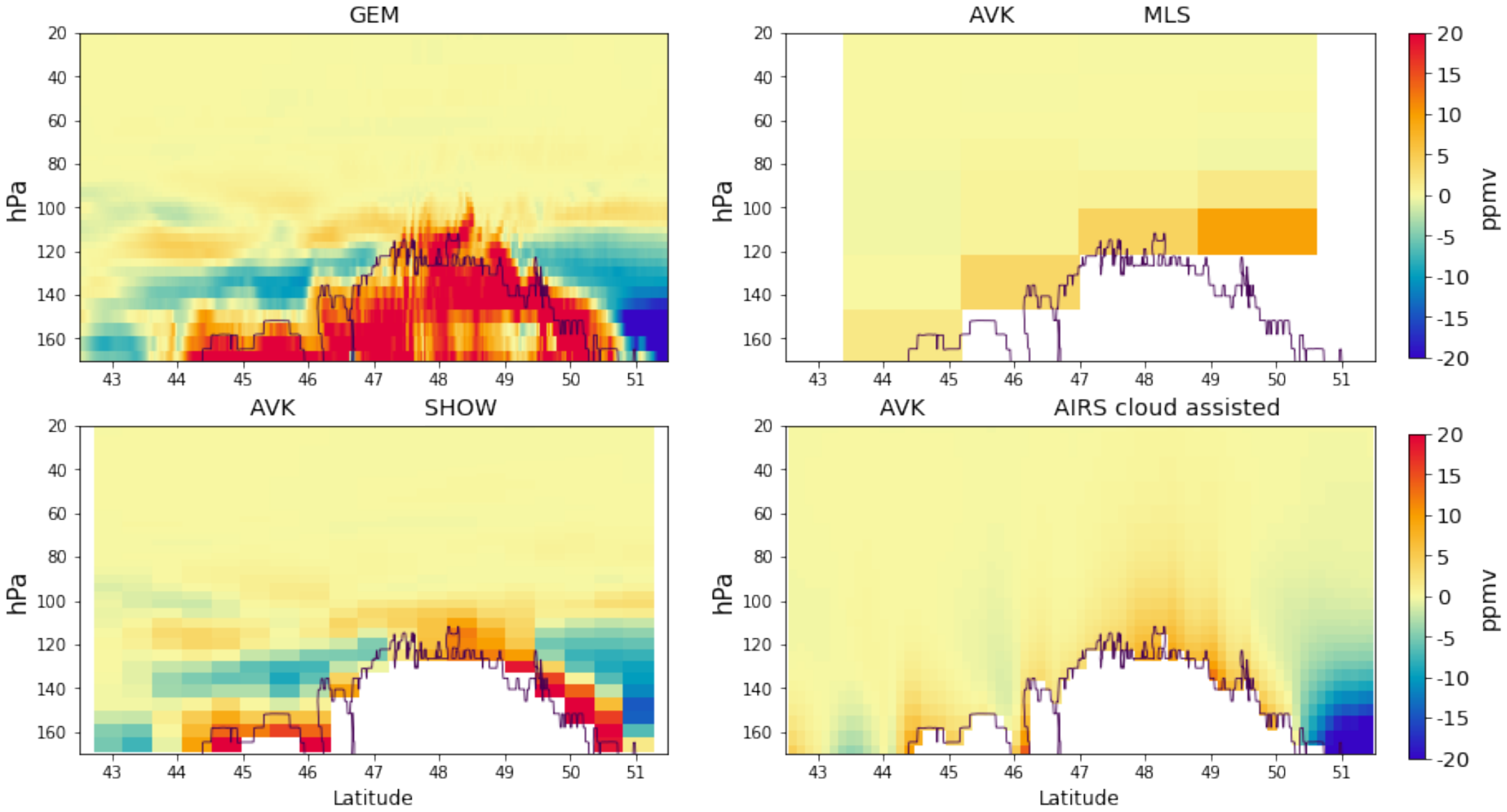


Convective Overshooting



Yi Huang & Xun Wang

Anomaly



Yi Huang & Xun Wang

Thank you!