

Ceilometers for Improved Burn Ban Forecasting: The hypothesis and setup

Hypothesis: A semi-quantitative measure of the boundary layer structure can help identify the synoptic patterns that allow for rapid build up of residential wood smoke (and other BL pollution).

Phil Swartzendruber
Puget Sound Clean Air Agency

WA Ecology Grant to Prevent Non-Attainment (PNA)... (thank you ECY!)

The plan:

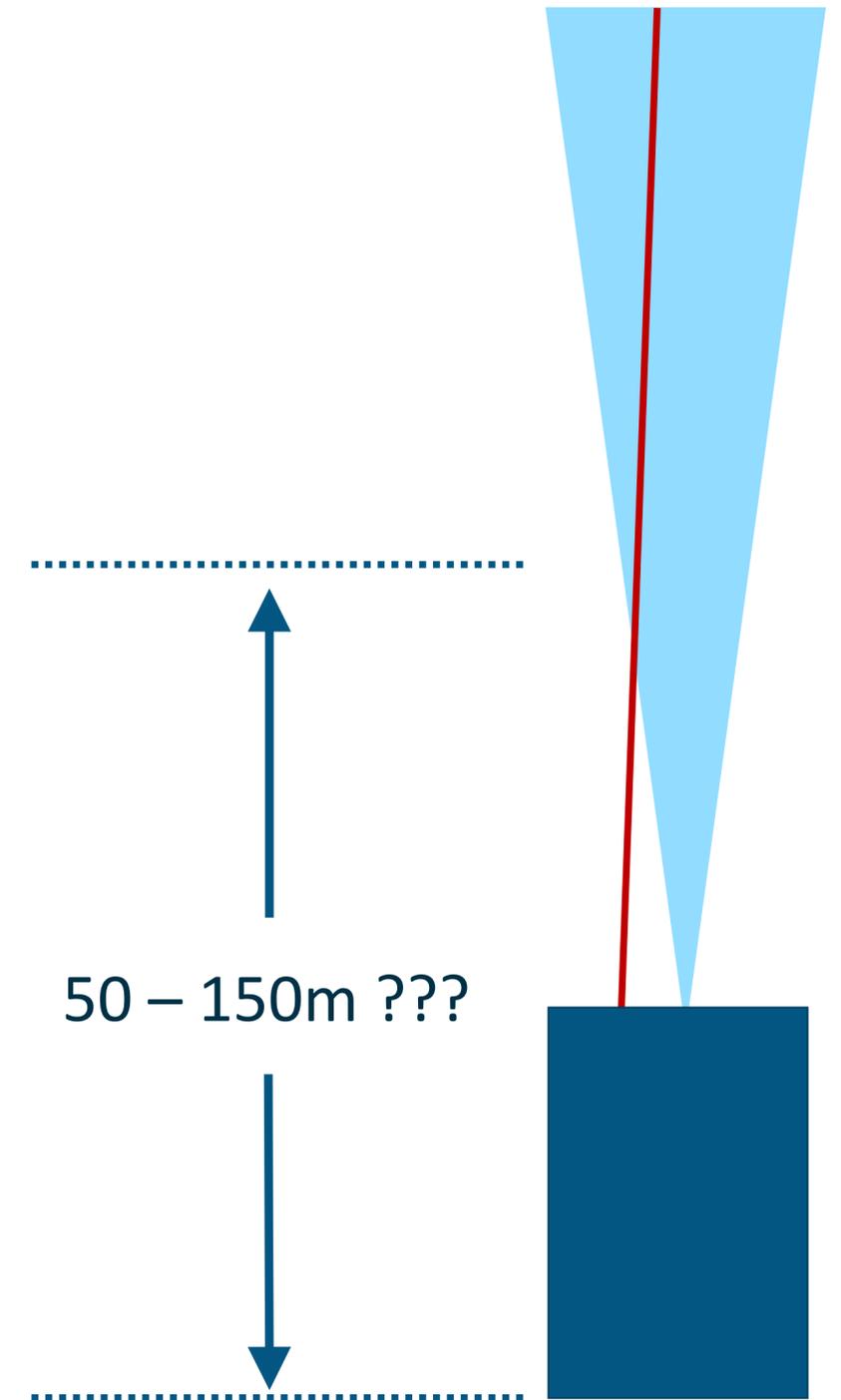
- Deploy ceilometers in two at-risk cities/areas.
- Monitor meteorological conditions for a year (focused on winter).
- Refine a description of the synoptics that allow for high winter-time PM.
- Identify predictive metrics, or model failures where improvement could be made

The equipment:

- We looked at Campbell Scientific, Lufft, and Vaisala
- Key ability was lowest overlap (detection ability) ... CL-31 is best, roughly 50 m
- High *signal:noise* is also critical, since signal from fine PM is \ll signal from larger water/ice clouds droplets/particles
- Vaisala had:
 - same instrument as current (CL-31) with good overlap
 - a new instrument with dual-polarization (CL-61), which could be helpful with seeing smoke vs water cloud

Overlap?

- Detection cone and outgoing beam aren't perfectly concentric and co-linear
- Better cone = more complex optics
- Surface radiatively driven inversions can be 30m or less...
- 50m can be fairly predictive of lower
- Most ceilometers intended for detection at $> 100\text{m}$



Progress:

1. Deployed a CL-31 and -61 side by side at Marysville for about 1-month
2. Setup data flow, display, and archiving (more on this)
3. Moved CL-31 to Darrington
4. Almost ready to make display page public
5. Looking at data and trying to make sense of it...



Ceilometer data display tools

1. Select ceilometer
2. Select height
3. Hit “Switch Inst/...”
4. “Toggle” will toggle between backscatter and depolarization or smoothed backscat
5. “-1 Day” and “-2 Day” will show older

PSCAA ceilometers: Select instrument and height...

Tacoma S. L CL-31 Darrington CL-31 Marysville CL-61
 15 | 7.7 km 4.5 km 1.1 | 0.6 km

-2 Day
(UTC)

-1 Day
(UTC)

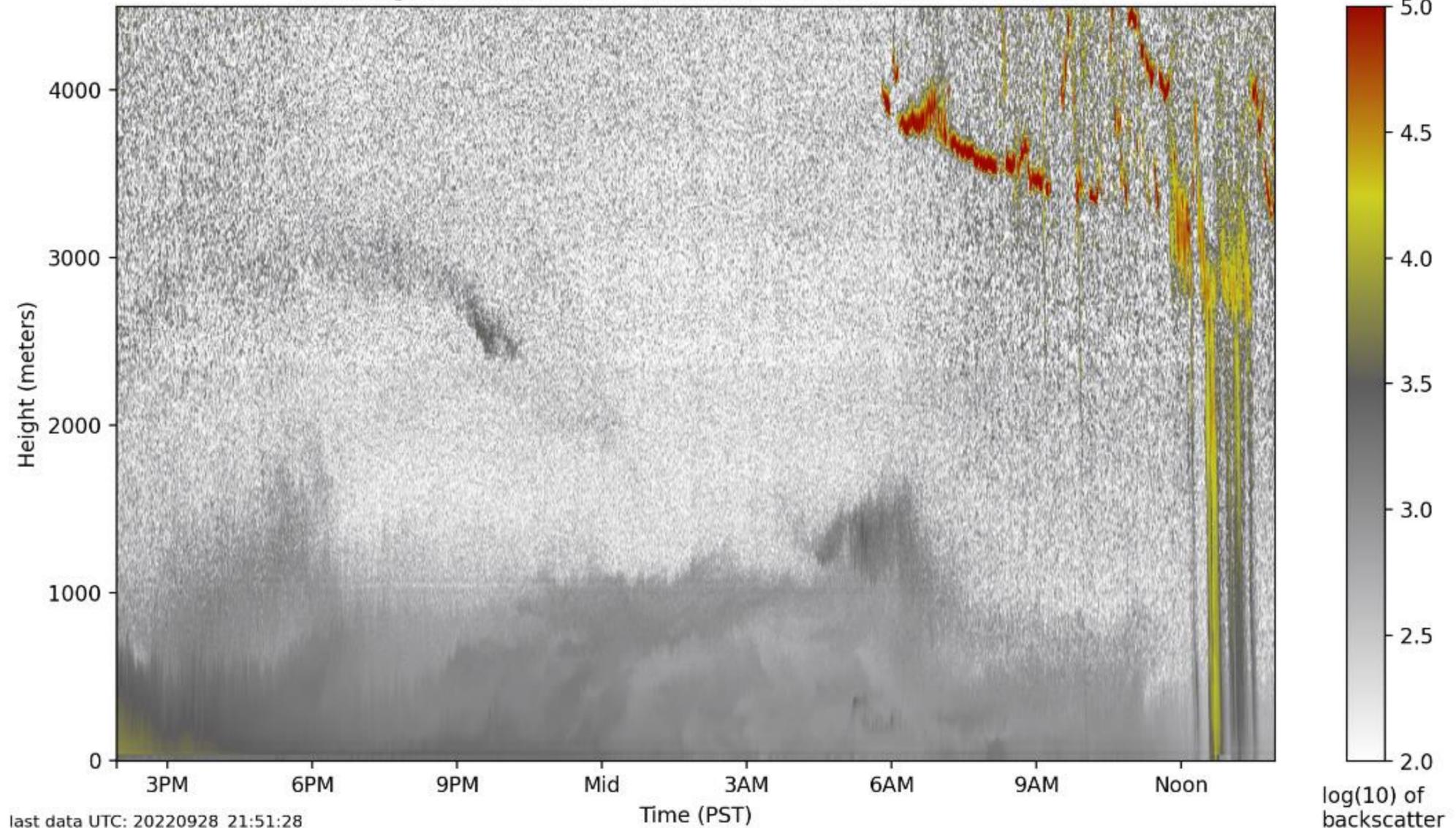
Switch Instr/Height
Show Last 24-hours

Toggle
bscat/depol/smooth

dr3145bs.png

time generated:13:56:02

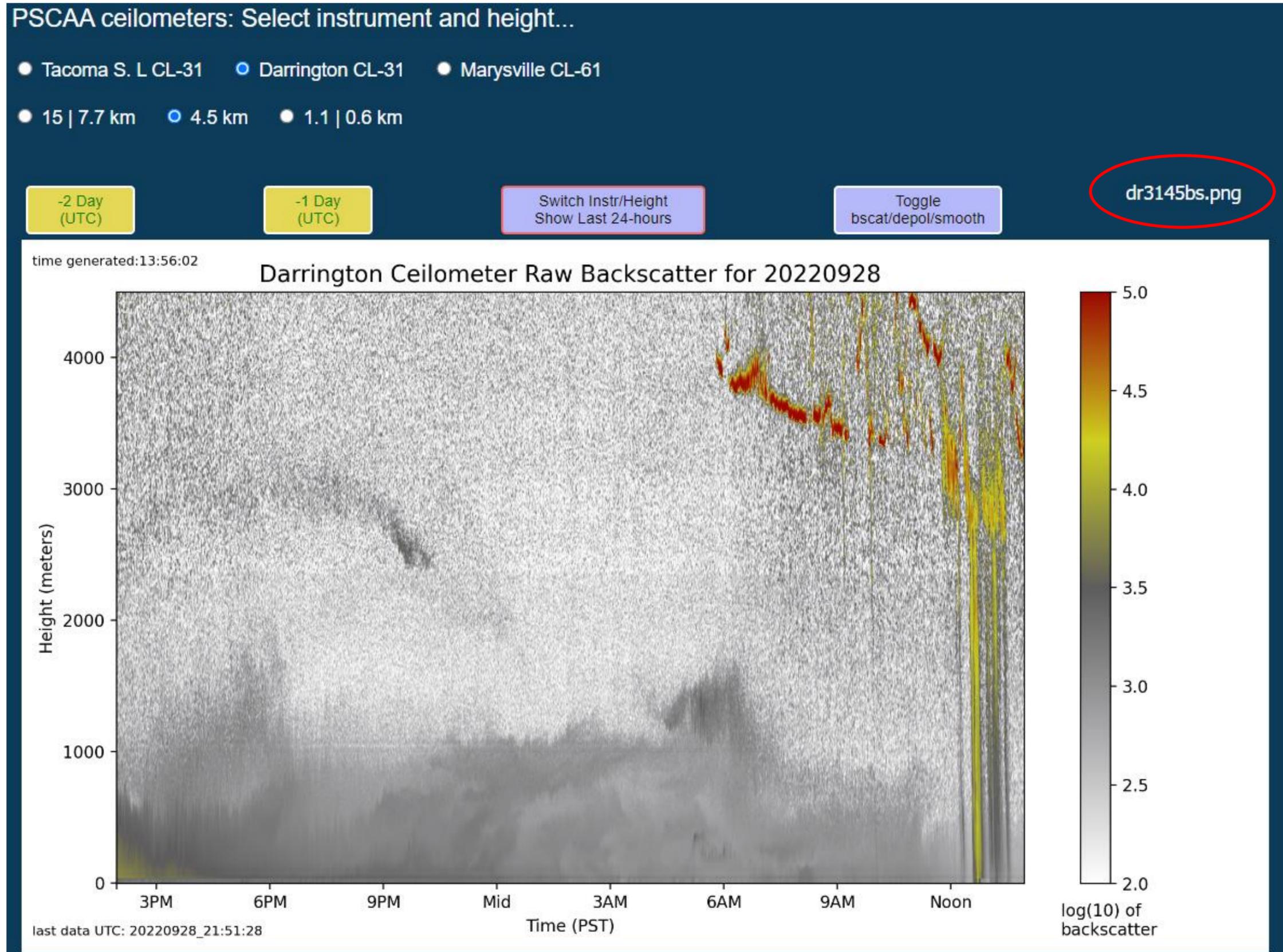
Darrington Ceilometer Raw Backscatter for 20220928



[About +](#)
[Downloads](#)

Ceilometer data display tools

1. More info in [About + Downloads](#)
2. Note graphic name in upper right above the figure
3. Can download archived images using web address, date, and name...



[About + Downloads](#)

Ceilometer data display tools

1. More info in **About + Downloads**
2. Archive images retrieval address
3. Other notes

PSCAA ceilometers: About & Downloads

Use notes:

- after changing instruments or heights, you must press "Switch Instr/Height Show Last 24-hours" to switch
- after you have switched instruments/heights, then you can go back in time with the -1 day, -2 day buttons

Archived images are available for download using addresses formed like this:

pscaa-ceilometerimages-public.s3.us-east-2.amazonaws.com/YYYYMMDD/iiiihhtt.png

where: *YYYY* is year, *MM* is month (numerical), *DD* is day

iiii is the location and instrument: *dr31* is Darrington CL-31, *mv61* is Marysville CL-61, *sl31* is Tacoma South L CL-31

hh is the height: *11* is lowest 0.6 km (-31) or 1.1 km (-61), *45* is about 4.5 km, *mx* is maximum: 7.7 km (-31), 15 km (-61)

tt is the data type: *bs* is backscatter, *dp* is depolarization, *sm* is smoothed backscatter

The corresponding image string is shown just above each image to the right

Other notes:

- depolarization is only on the CL-61
- smoothing is only done for CL-31s for mid and upper heights
- the depolarization signal is screened (out) for backscatter less than ~ 2.5 on the $\log(10)$ scale
- the image archive begins on about 2022-09-08
- Darrington data begin on 2022-09-24

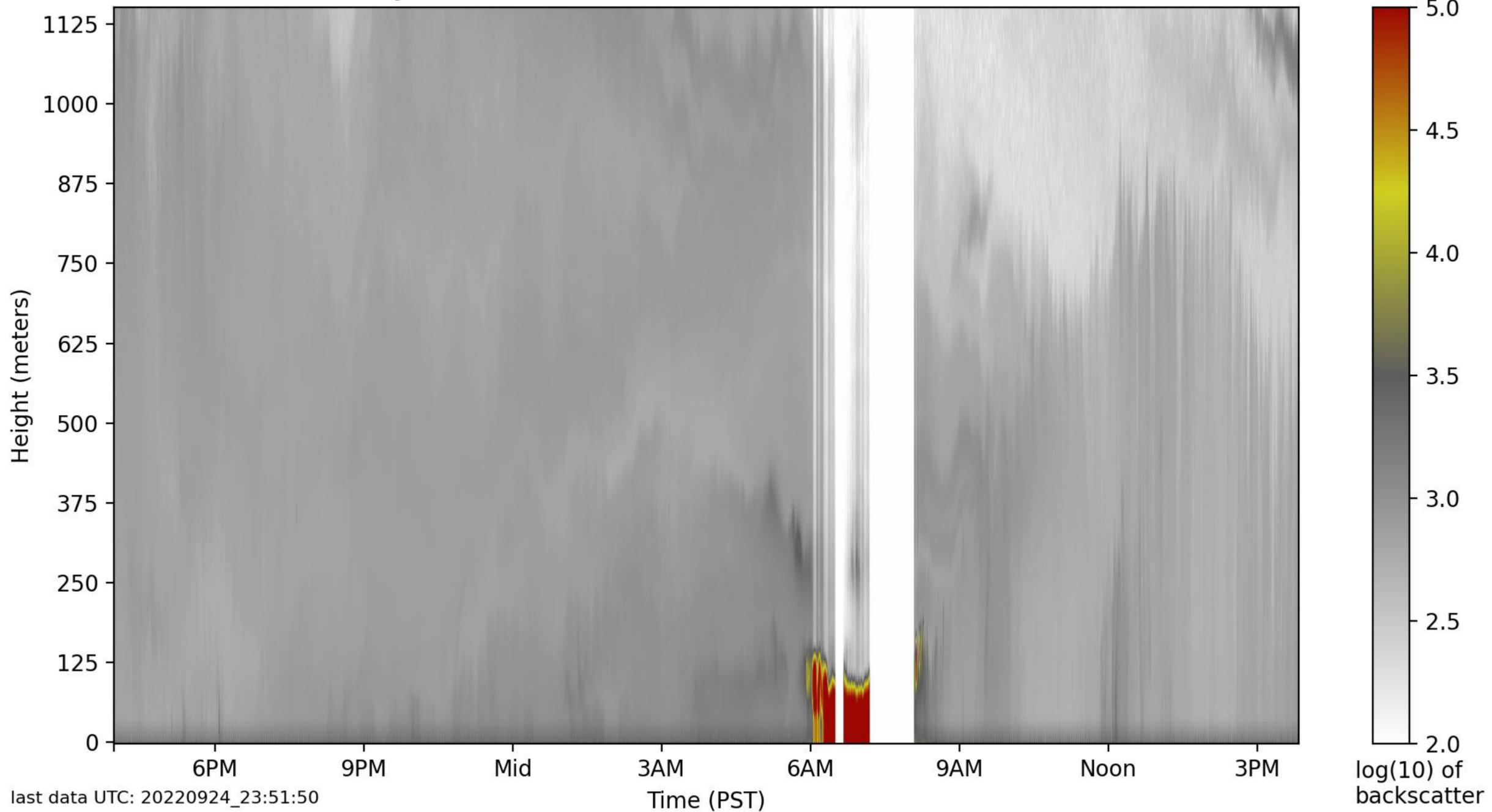
last updated 2022.09.26

questions, comments? contact: phil.swartzendruber at cleanairpugetsound dot net

Marysville inversion event?

time generated:15:58:02

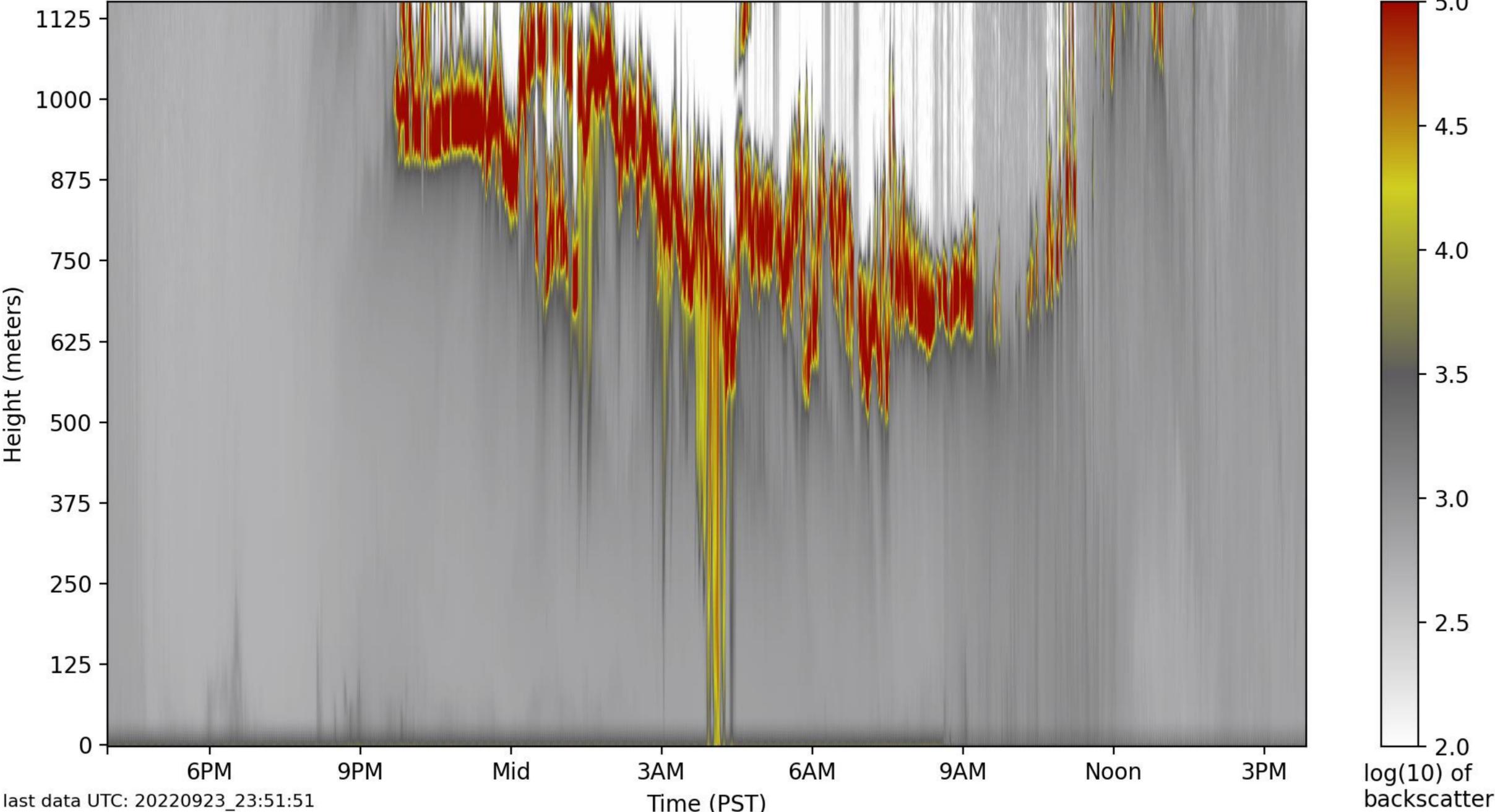
Marysville CL-61 Raw Backscatter for 20220924



Marysville, clouds prevent inversion event?

time generated:15:58:02

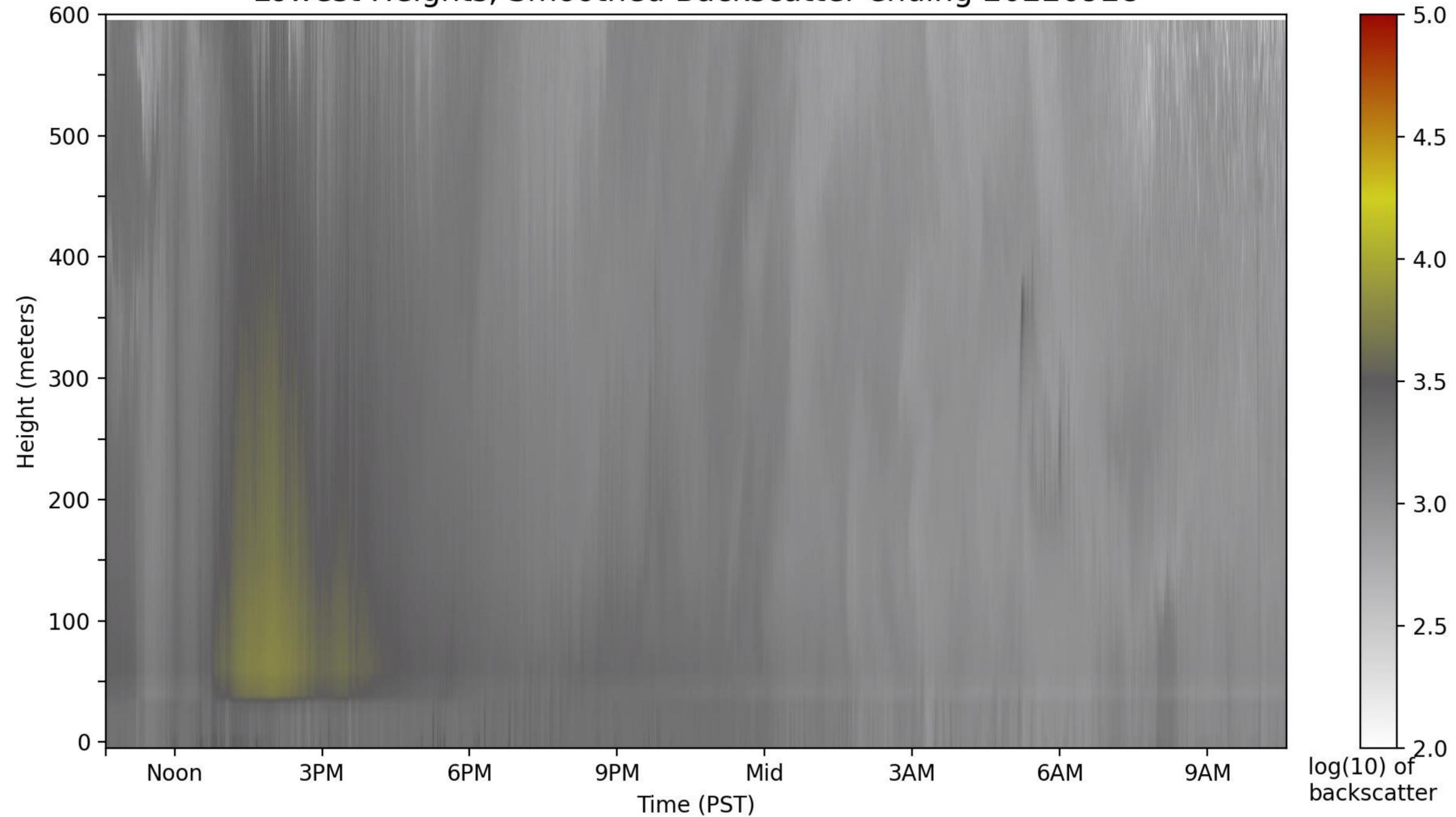
Marysville CL-61 Raw Backscatter for 20220923



Darrington wildfire smoke event

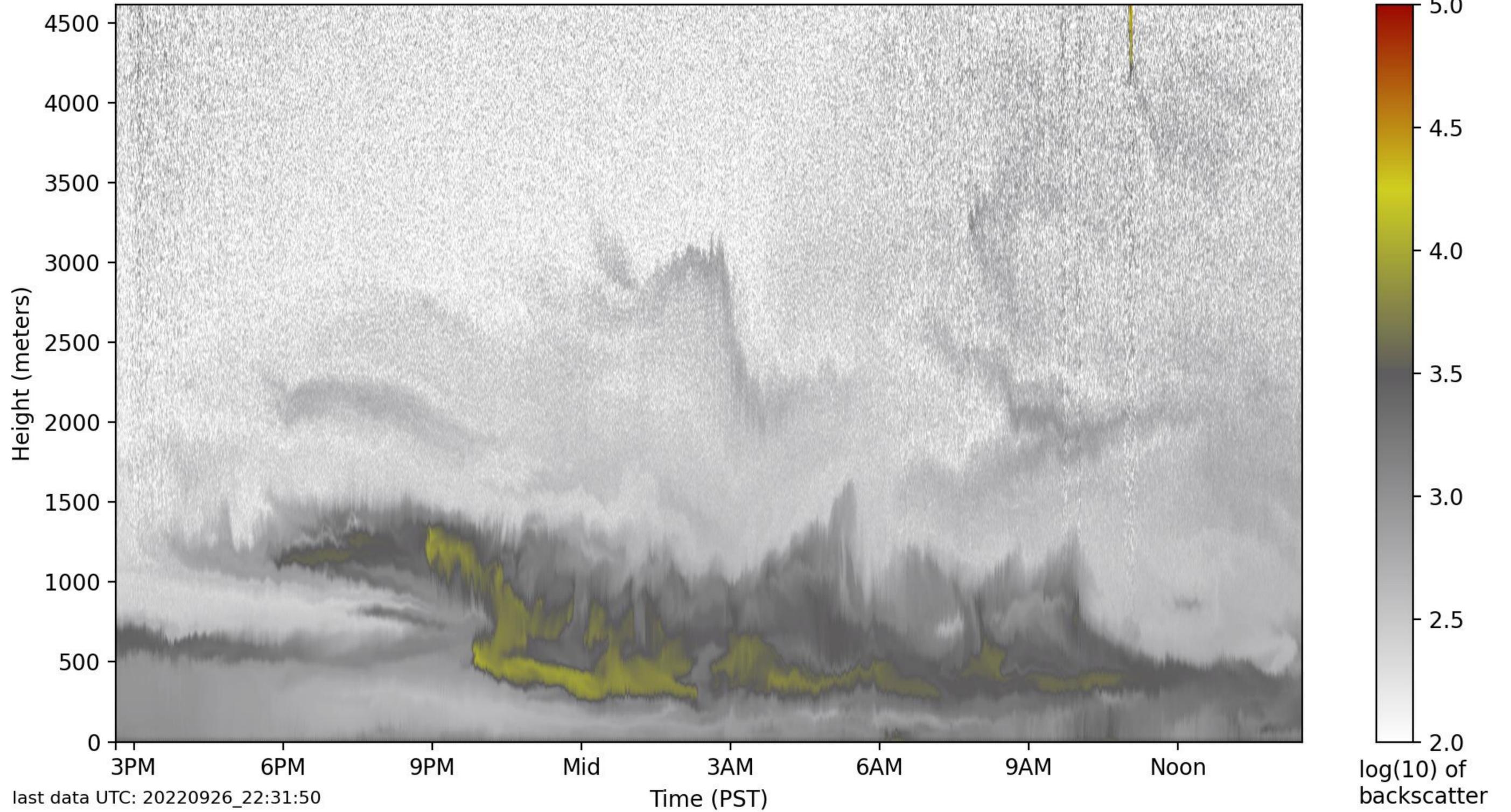
time generated:10:36:01

Lowest Heights, Smoothed Backscatter ending 20220928



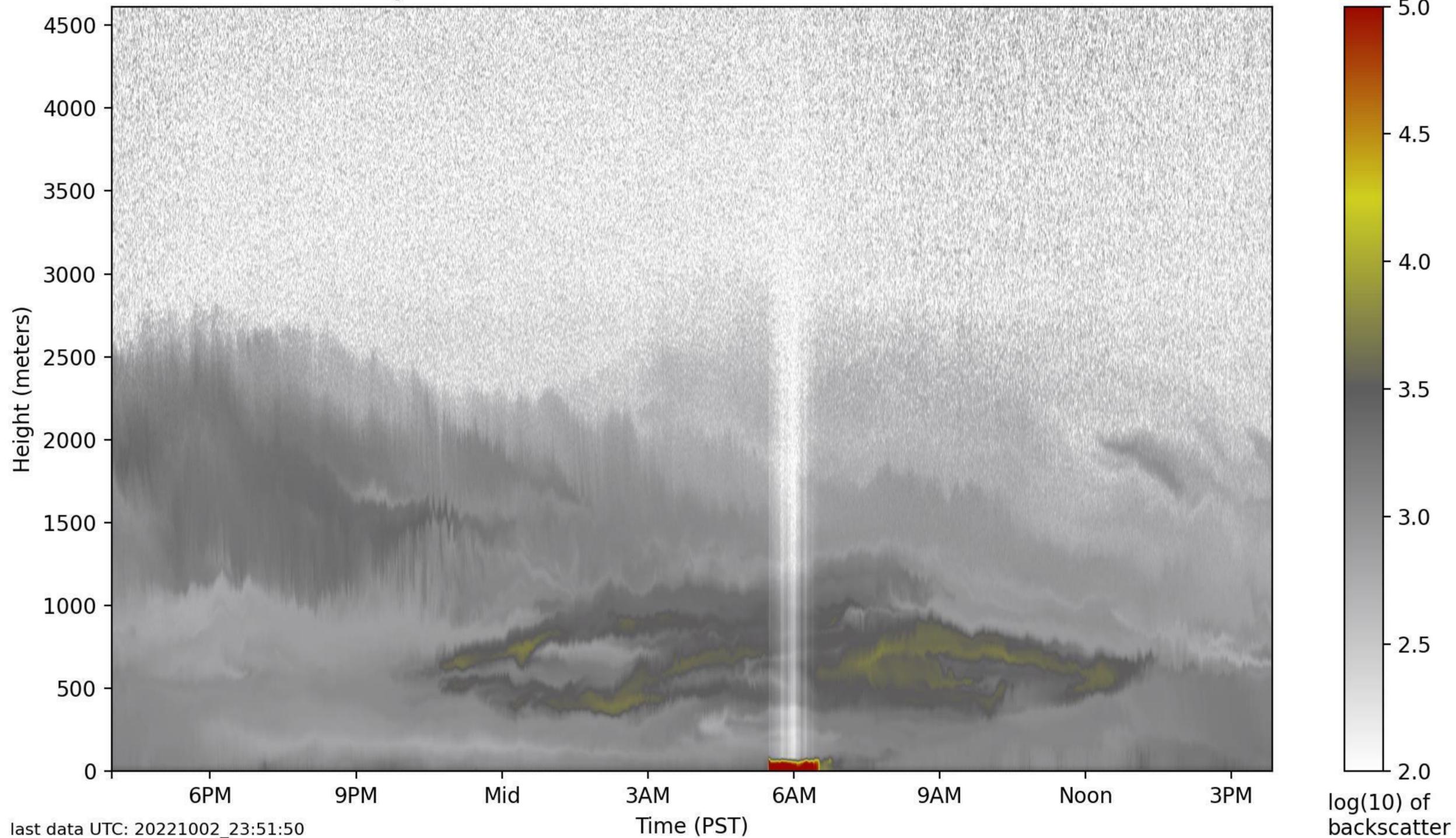
time generated:14:38:02

Marysville CL-61 Raw Backscatter for 20220926



time generated:15:58:02

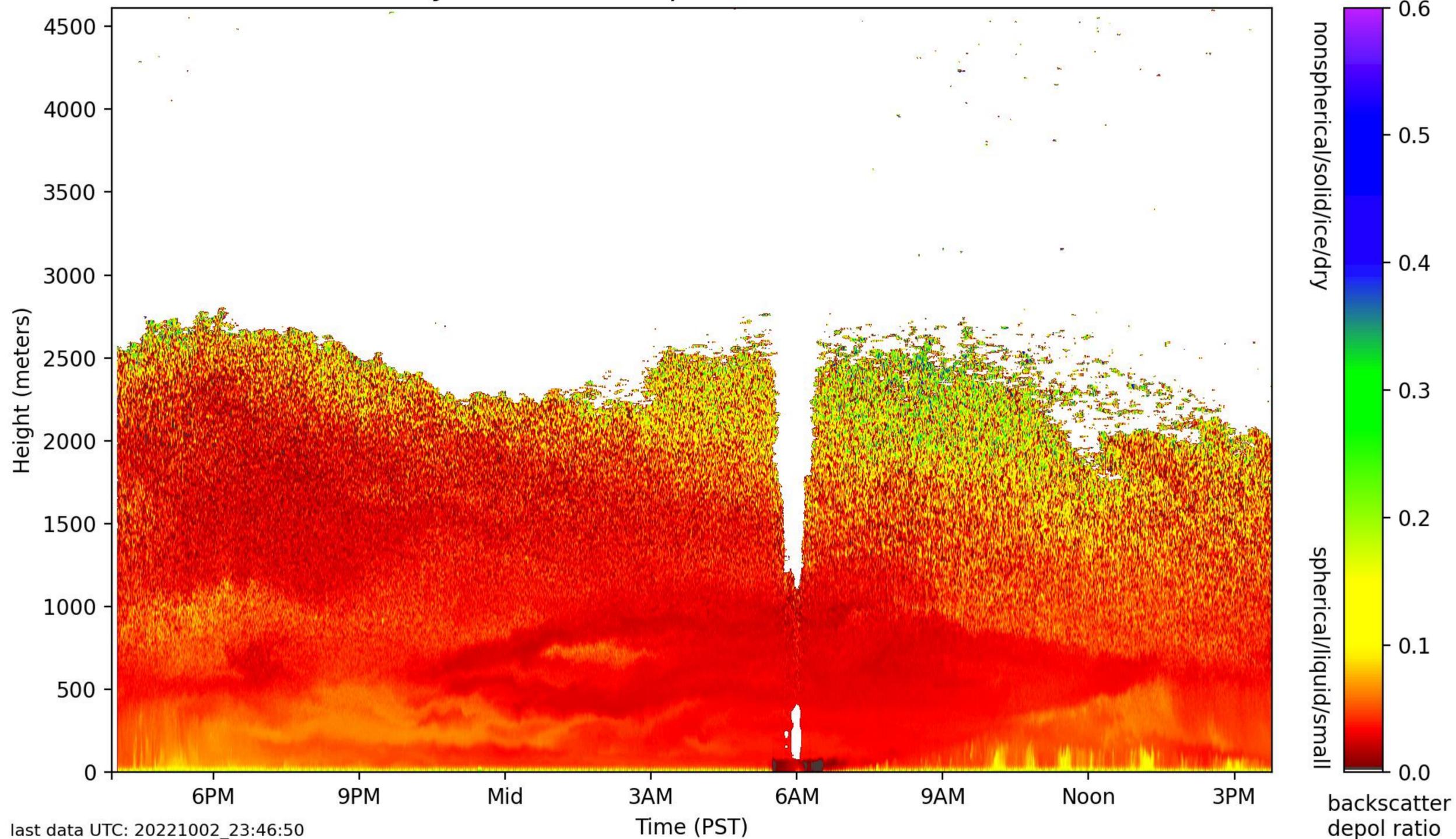
Marysville CL-61 Raw Backscatter for 20221002



last data UTC: 20221002_23:51:50

time generated:15:54:13

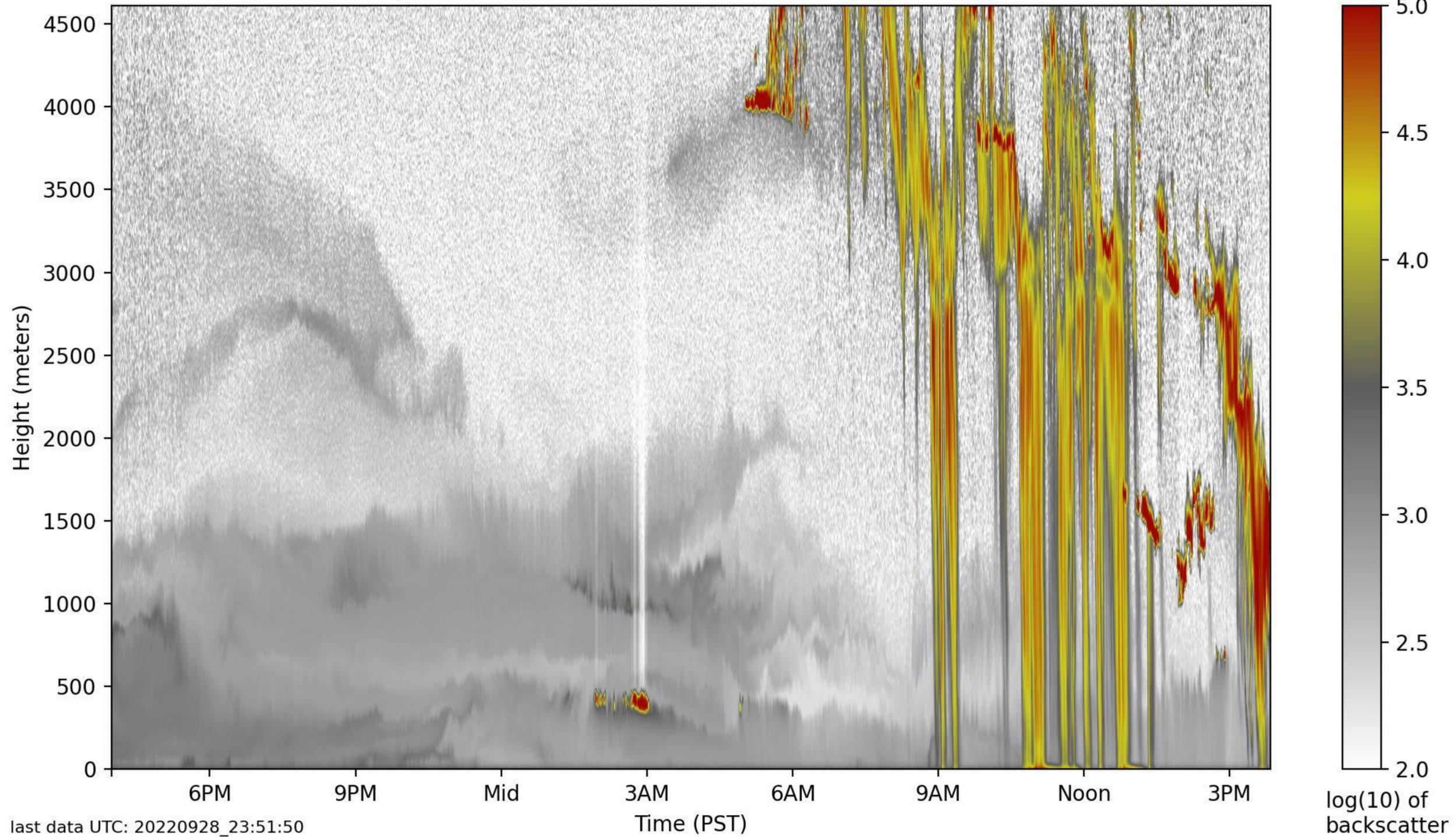
Marysville CL-61 Depol Ratio for 20221002



last data UTC: 20221002_23:46:50

time generated:15:58:02

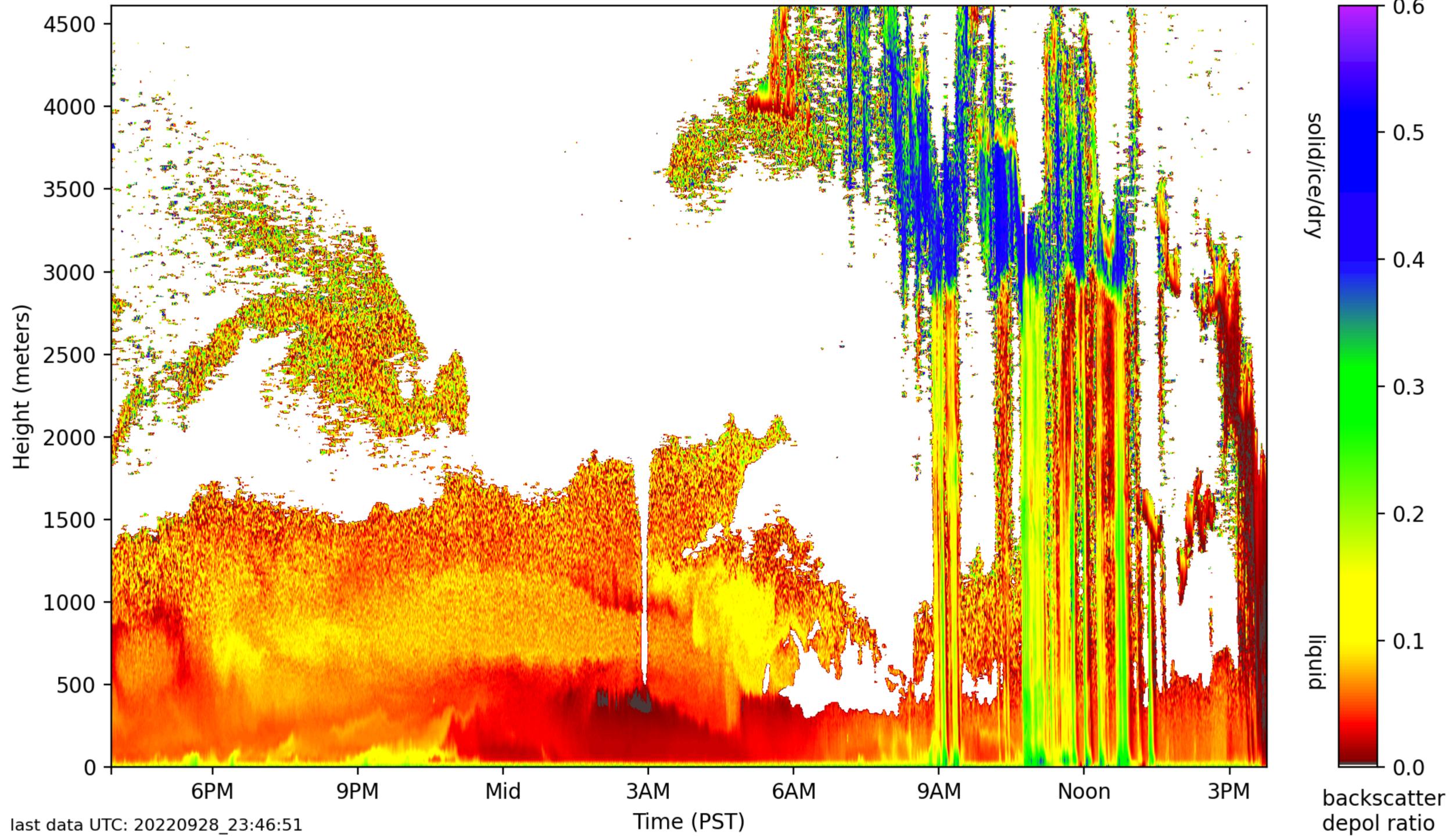
Marysville CL-61 Raw Backscatter for 20220928



last data UTC: 20220928_23:51:50

time generated:15:54:10

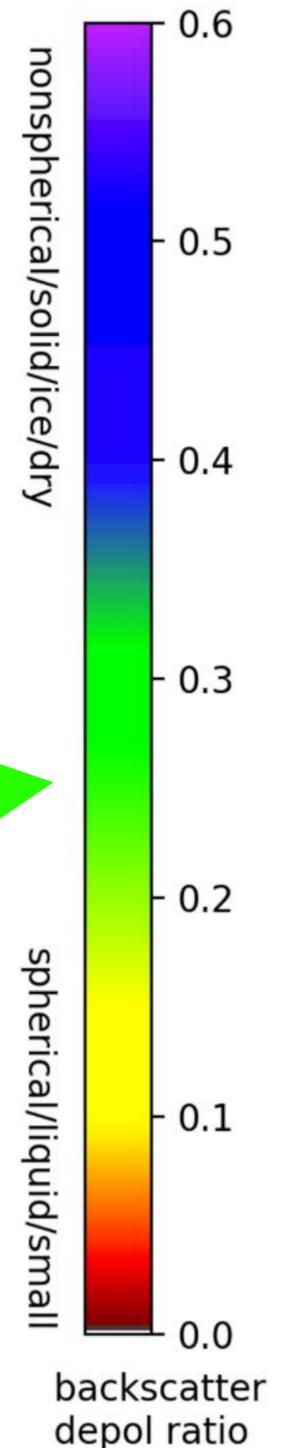
Marysville CL-61 Depol Ratio for 20220928



last data UTC: 20220928_23:46:51

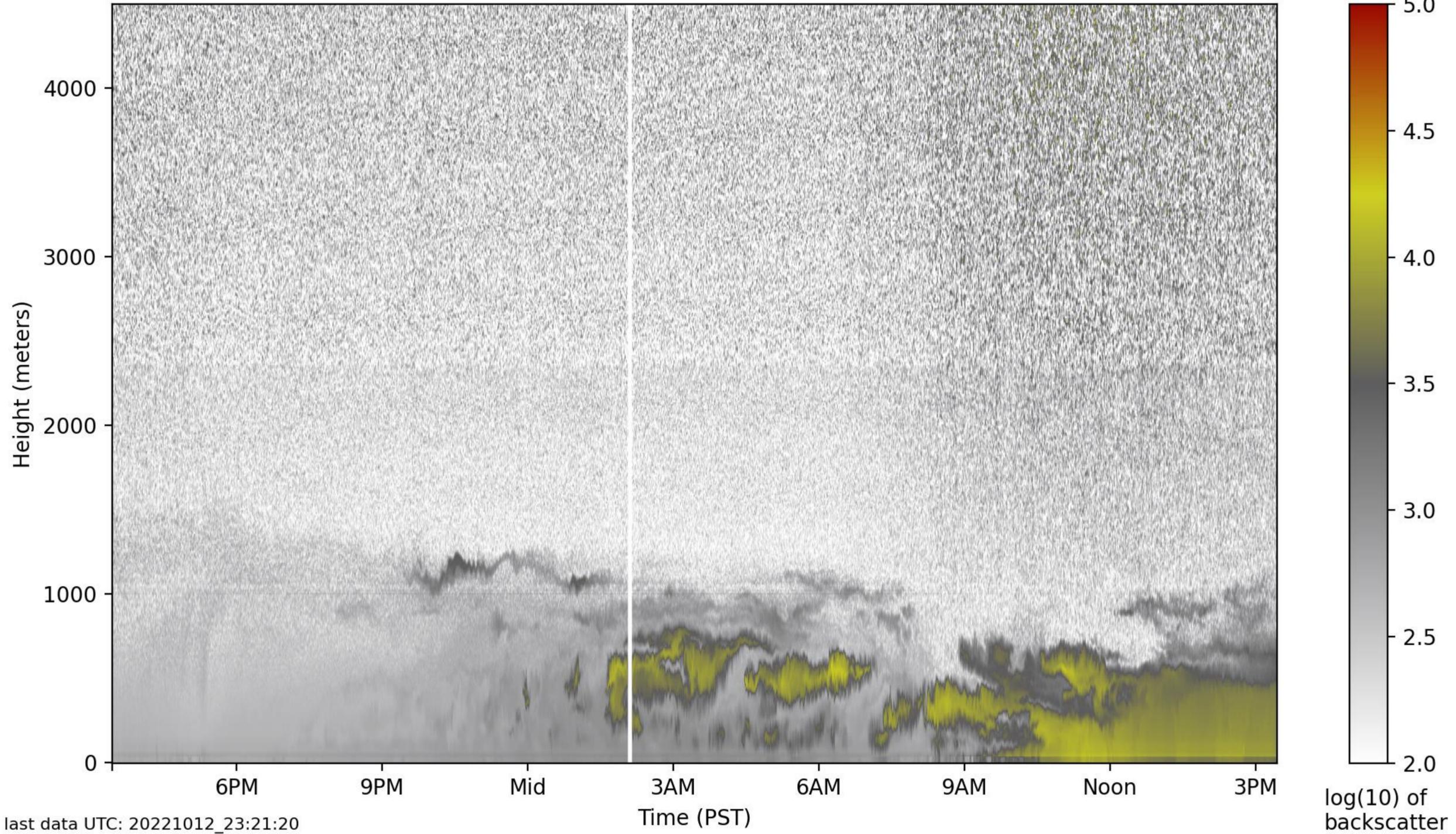
Depolarization

- ... still figuring this out, but my best understanding based on Vaisala and a limited lit. search...
- Depolarization is ratio of perpendicular polarization(changed) to parallel (same)
- Non-spherical and dryish particles can change polarization due to multiple scatterings and interactions (liquid layer?)
- Further through water clouds will report depolarization due to multiple interactions – NOT a frozen top
- Large droplets that flatten might depolarize (?)
- Small particles (<1 um) not capable of multiple scattering/influence as are < wavelength of the light
- Spherical water droplets, e.g. small rain and cloud drops will have little depol. The ratio is close to 0



time generated:15:26:01

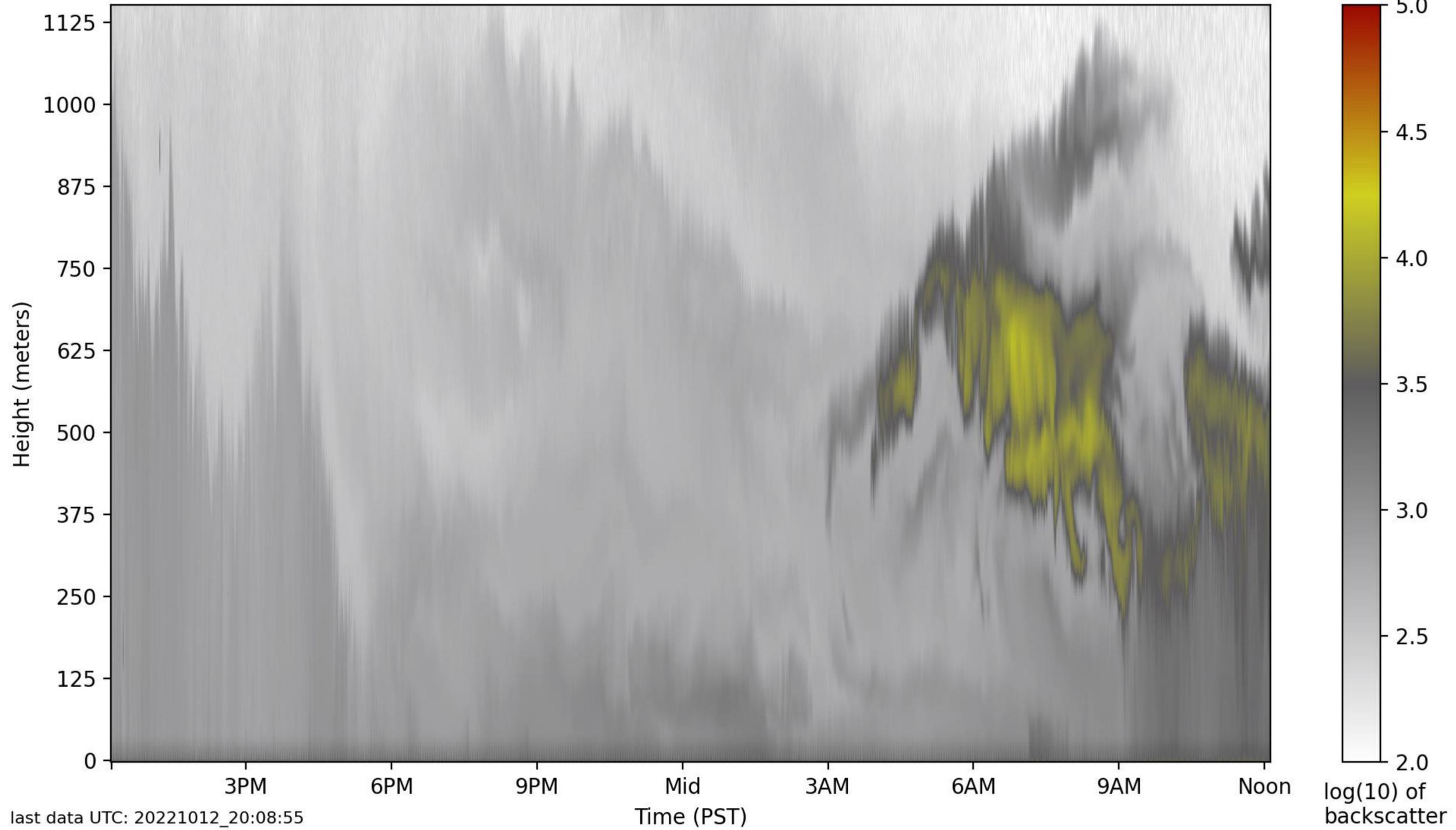
Darrington Ceilometer Raw Backscatter for 20221012



last data UTC: 20221012_23:21:20

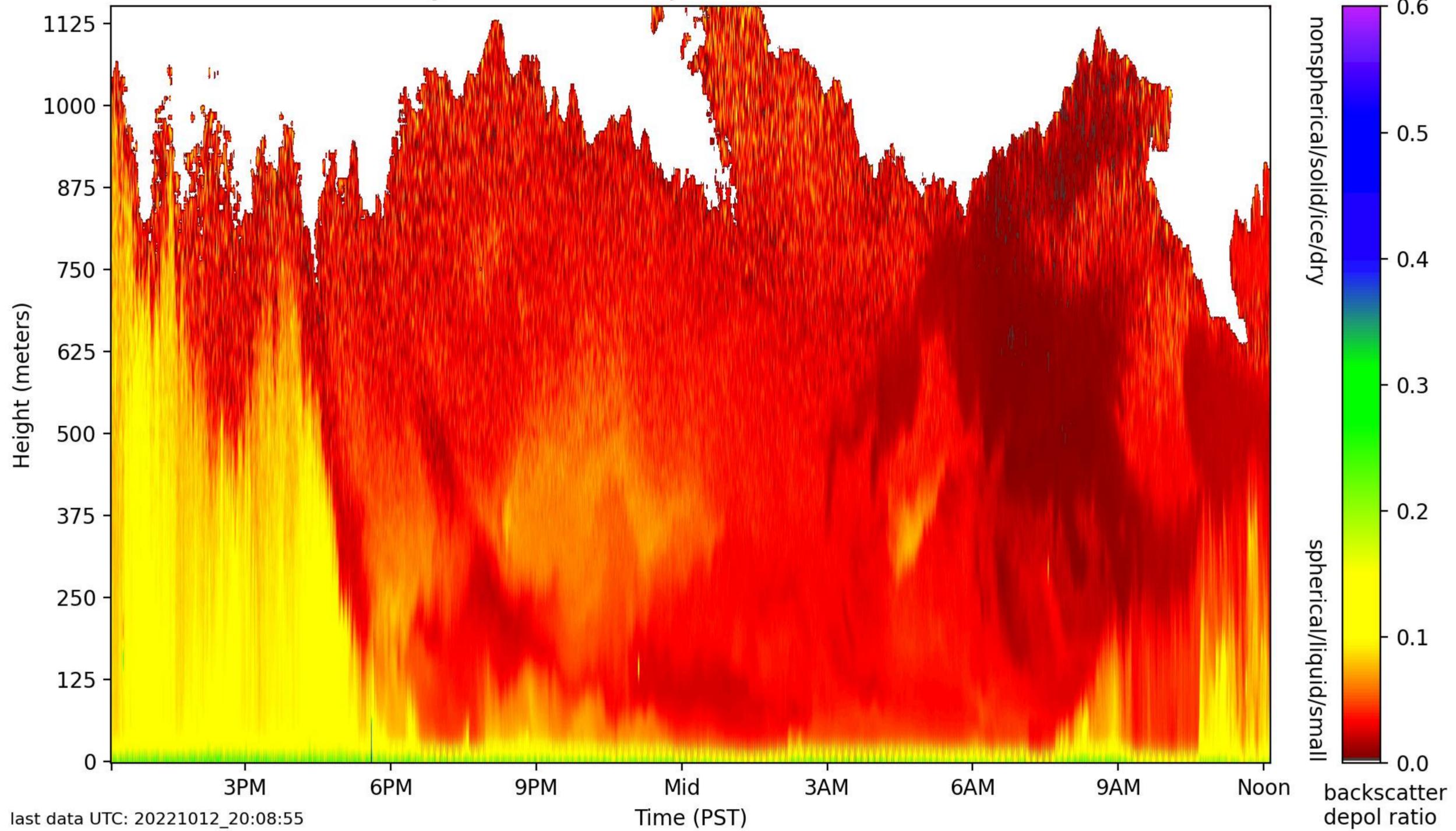
time generated:12:13:02

Marysville CL-61 Raw Backscatter for 20221012



time generated:12:14:11

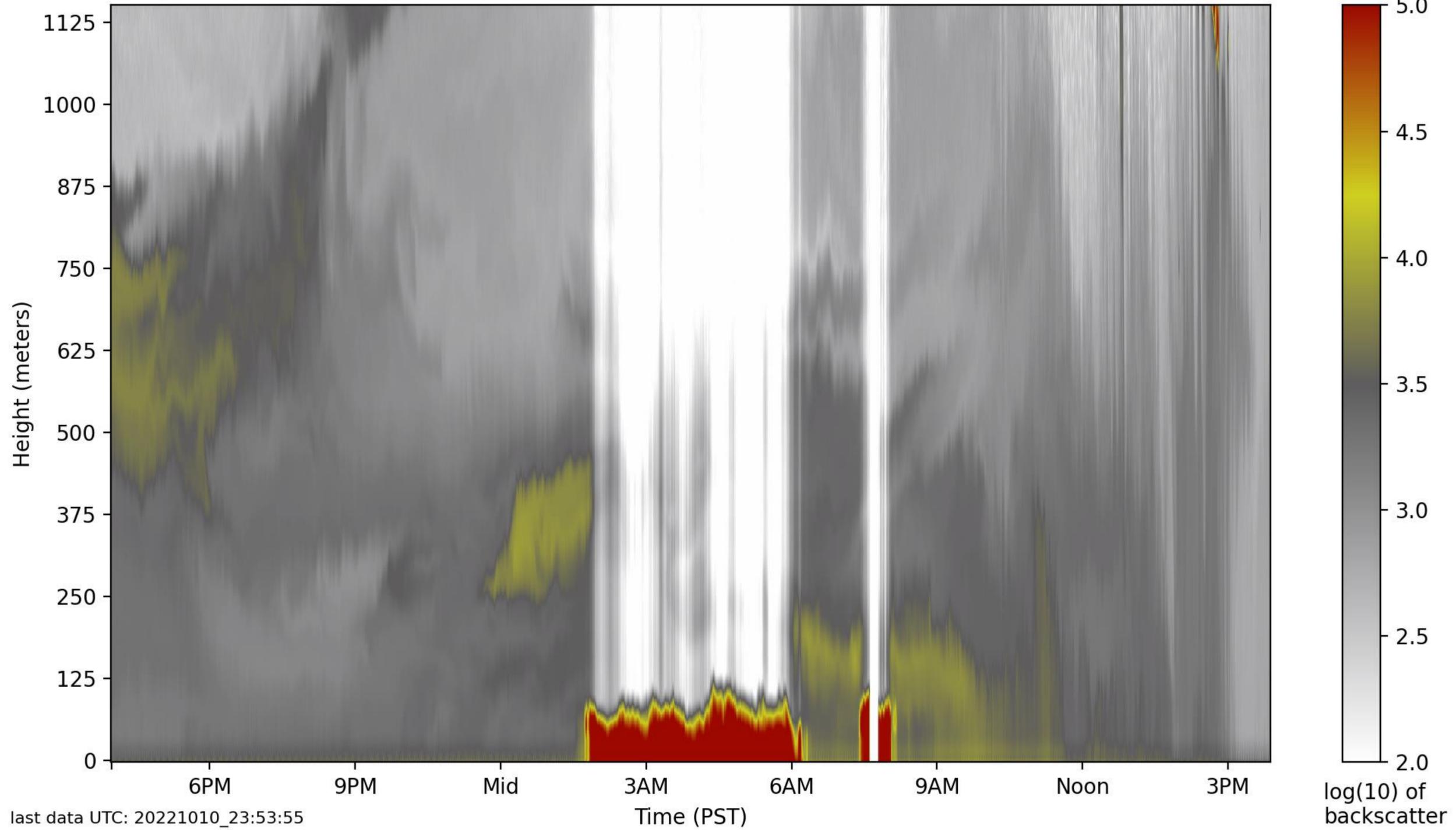
Marysville CL-61 Depol Ratio for 20221012



last data UTC: 20221012_20:08:55

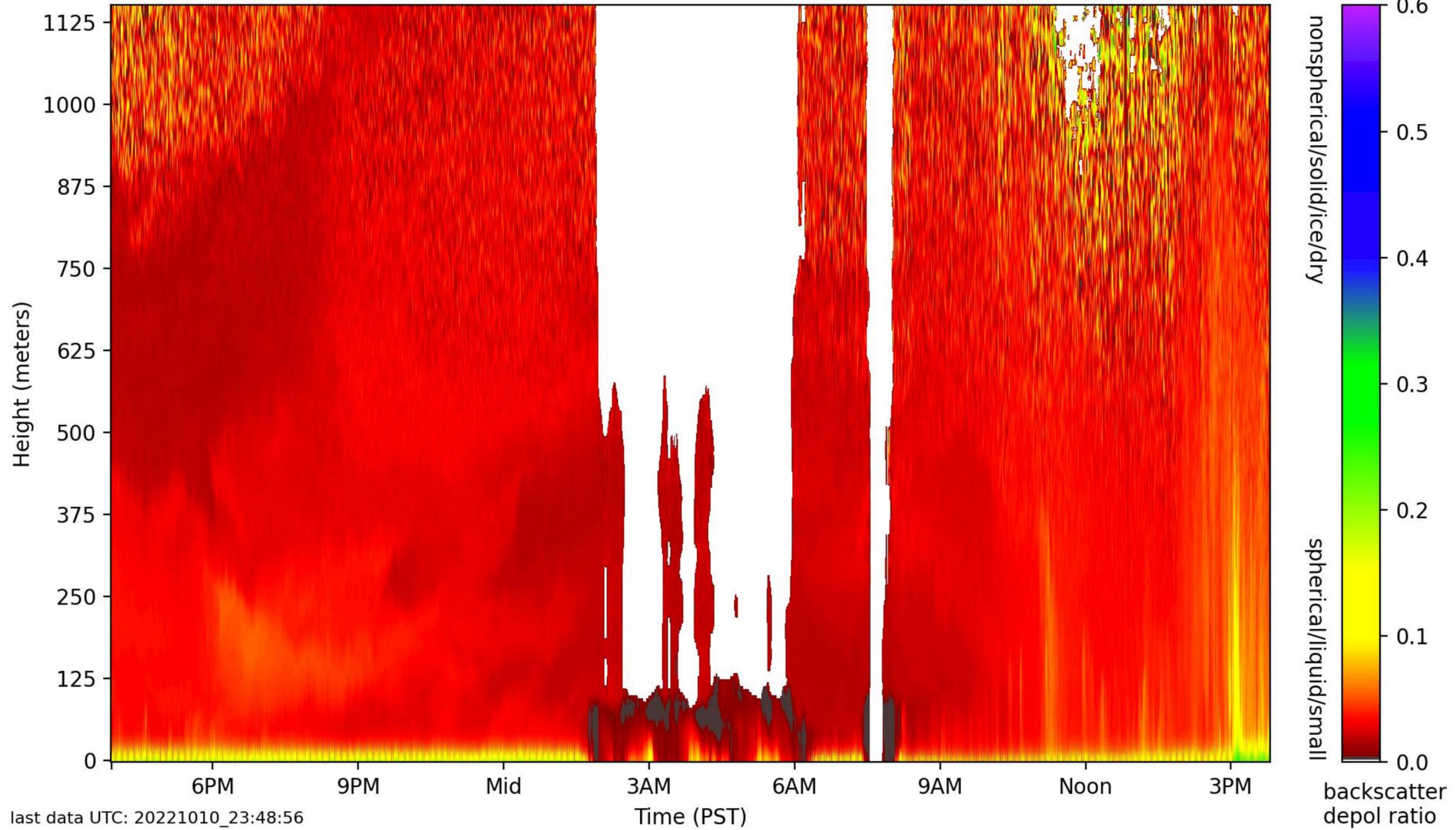
time generated:15:58:02

Marysville CL-61 Raw Backscatter for 20221010



time generated:15:54:17

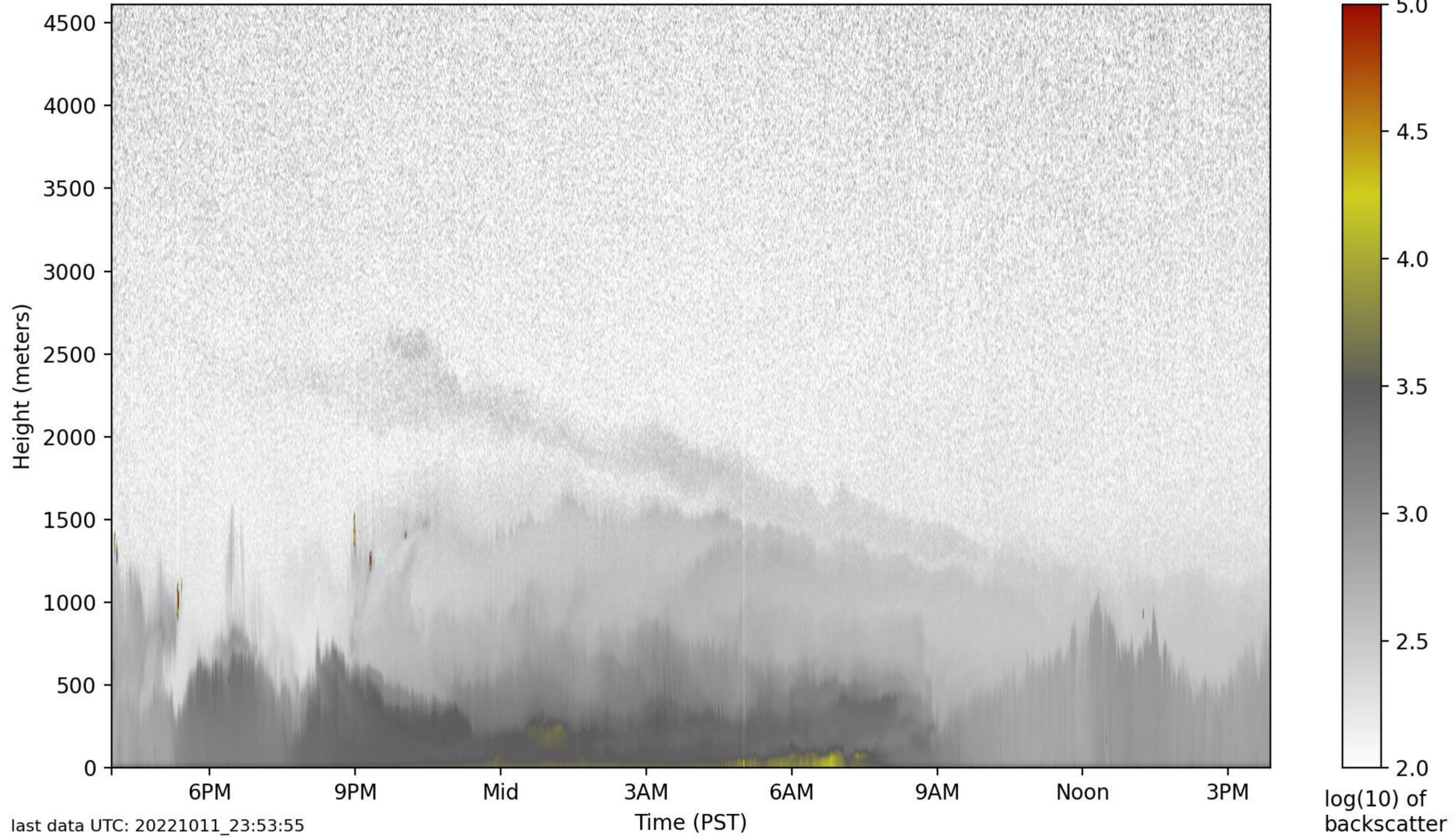
Marysville CL-61 Depol Ratio for 20221010



last data UTC: 20221010_23:48:56

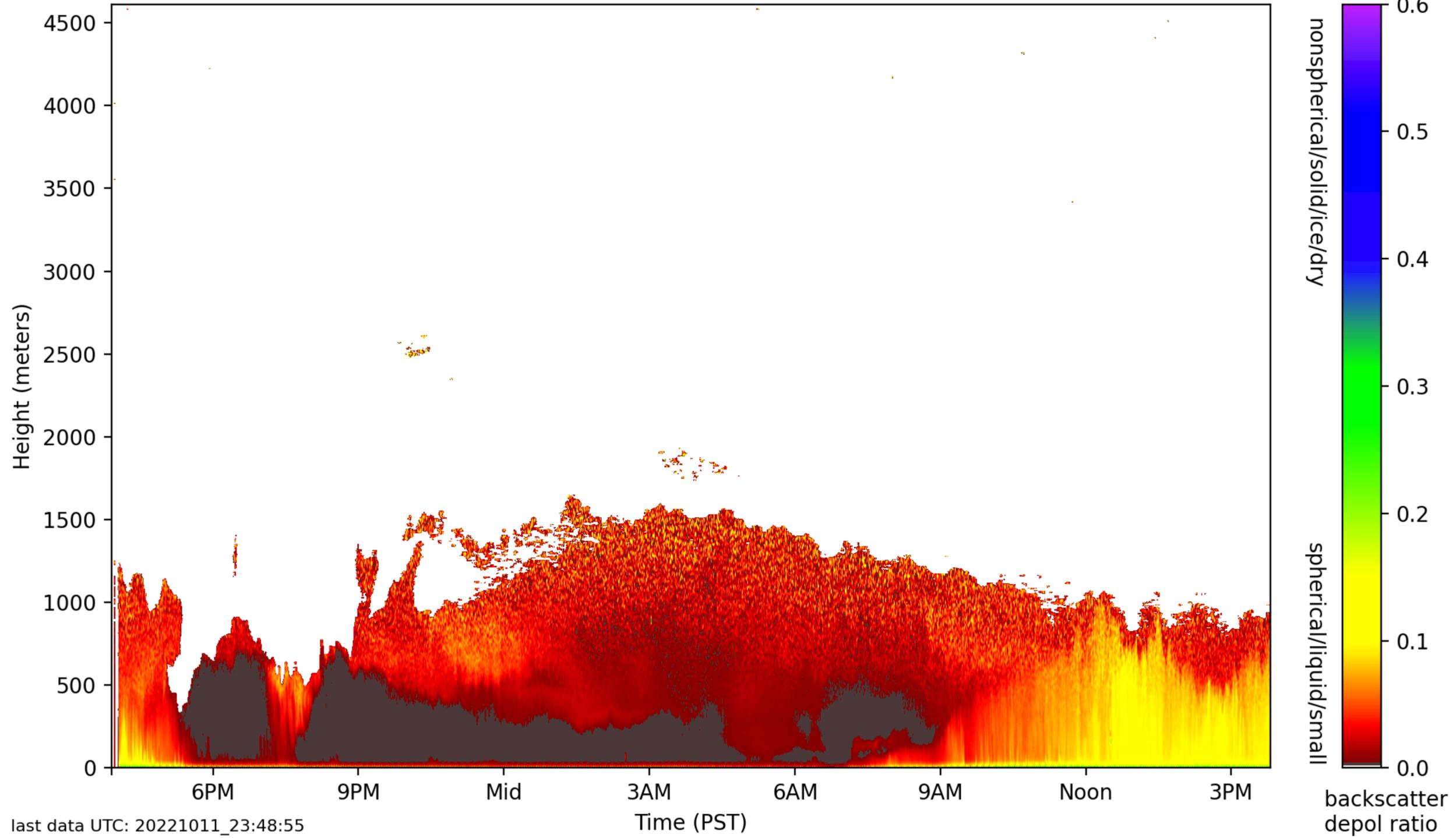
time generated:15:58:02

Marysville CL-61 Raw Backscatter for 20221011



time generated:15:54:15

Marysville CL-61 Depol Ratio for 20221011



last data UTC: 20221011_23:48:55

Thank You!

Questions, Comments??

- Interface/web site?
- Data products?
- Meteorological use?
- Interpretation?

