Contract No:

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We Put Science To Work

New Results with SRNL's Vaisala CL31 Ceilometer

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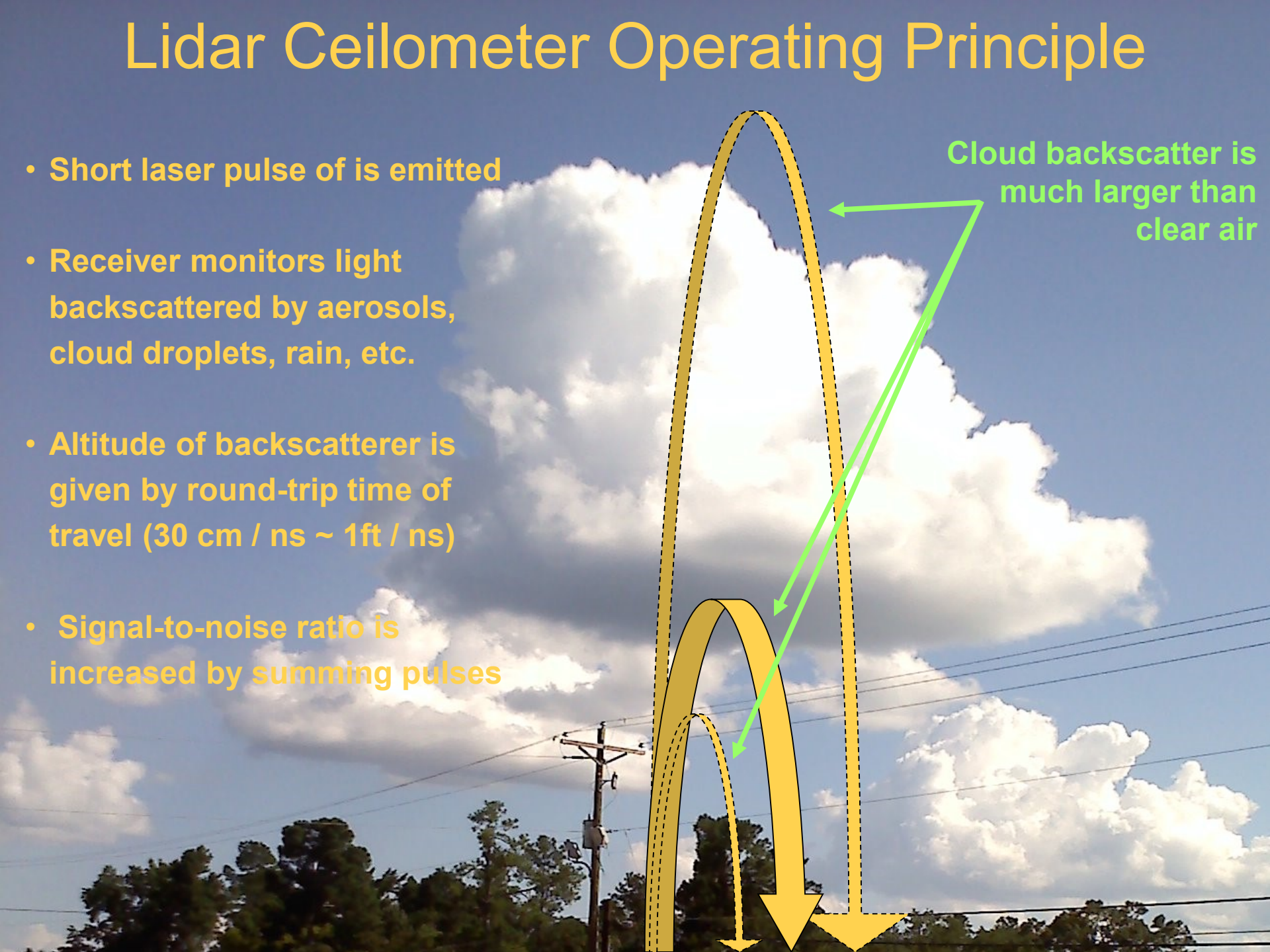
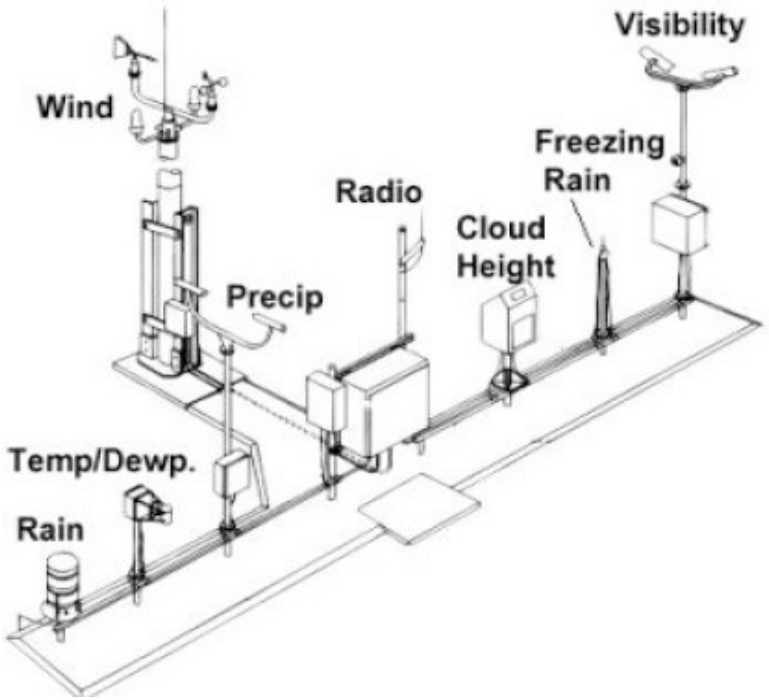
25 th Annual PAMS Allen Weber Mini-Technical Conference, Mar 6, 2019

Lidar Ceilometer Operating Principle

- Short laser pulse of is emitted
- Receiver monitors light backscattered by aerosols, cloud droplets, rain, etc.
- Altitude of backscatterer is given by round-trip time of travel (30 cm / ns ~ 1ft / ns)
- Signal-to-noise ratio is increased by summing pulses





Vaisala CL31 ceilometer and ASOS configuration

Ceilometer variables

The ASOS ceilometer records only cloud heights and sky coverage*.

Ceilometers's can also monitor other quantities of interest.

- **Boundary layer height**
- **Vertical aerosol backscatter**
- **Smoke**
- **Fog**
- **Precipitation**
- **Turbulence (indirectly)**

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DOE ARM CL31 specifications

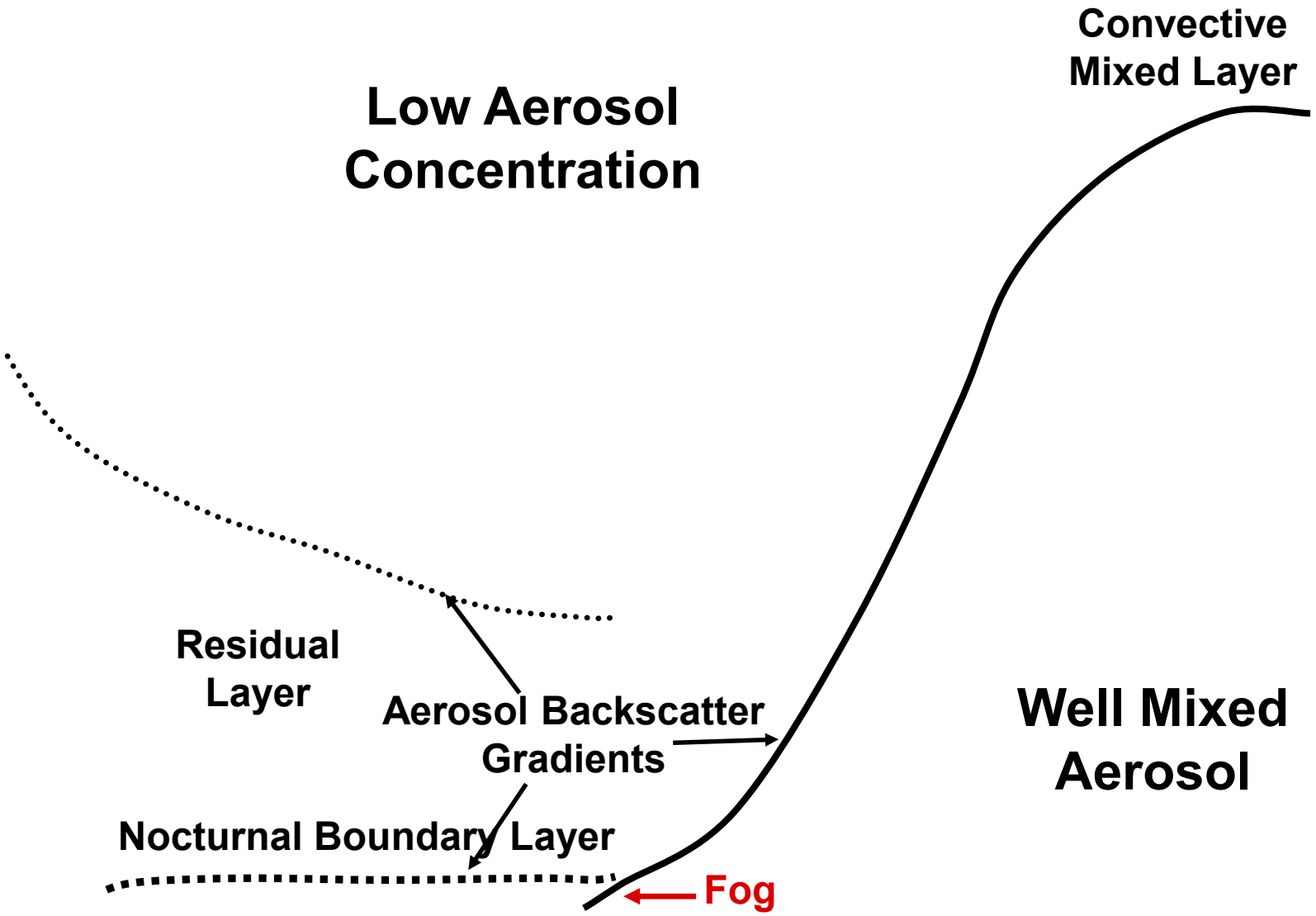
Table 11. Specifications of CL31 Ceilometer, as operated at ARM sites

Property	Value
Range	0–7.5 km
Vertical resolution	10 m
Accuracy (against reflector)	±1% or ±5m
Measurement interval	2 s
Reporting interval	16 s
Wavelength	910 nm at 25°C
Transmitter	Indium Gallium Arsenide pulsed diode laser
Receiver	Silicon Avalanche Photodiode
Field of view divergence	±0.83 mrad
Dimensions	1190 x 335 x 324 mm
Weight	32 kg
Power	115 VAC, 310 W max.

USWS = 20m
SRNL 20m to 5m
On Feb 5, 2019

15 sec

15 sec

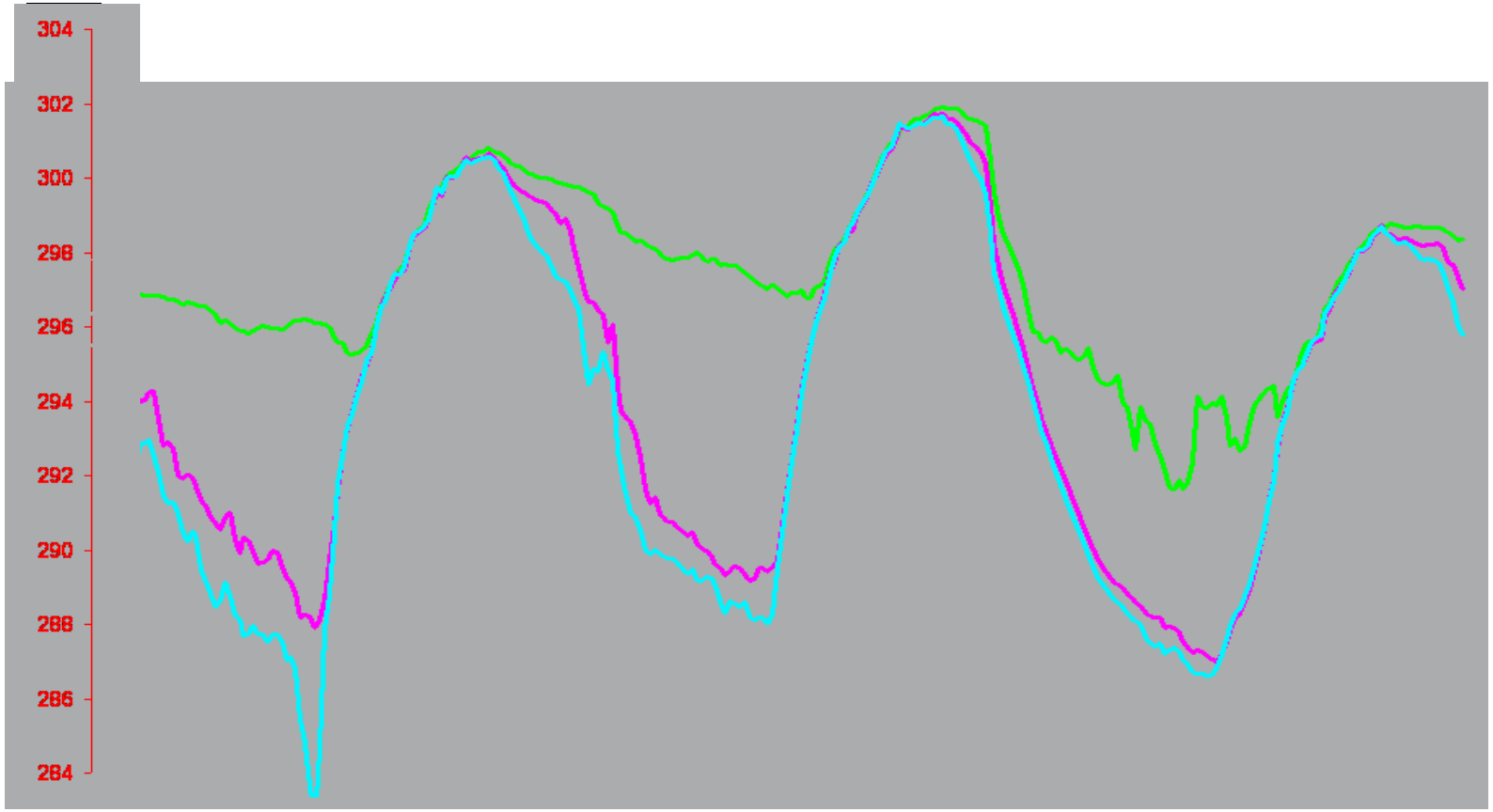

Convective
Mixed Layer
Low Aerosol
Concentration
Residual
Layer
Aerosol Backscatter
Gradients
Well Mixed
Aerosol
Nocturnal Boundary Layer
Fog

Virtual Potential Temperature (SCT)

34 meter / 112 ft

68 meter / 223ft

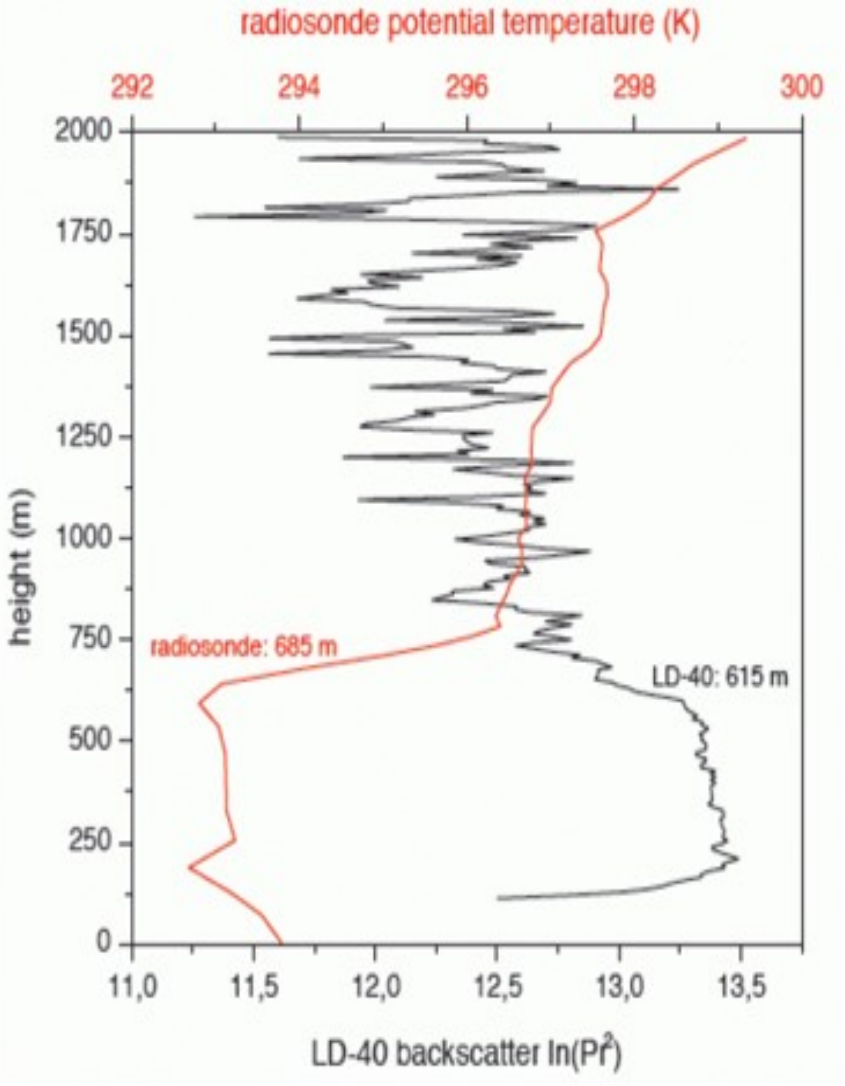
329 meter / 1079 ft



Aerosol backscatter and potential temperature.

Both air mass and mixing (turbulence) are implied by the potential temperature and aerosol backscatter.

Note the noisy signal above the BL.



Kennis and uitleg, 2007. Determination of the mixing layer height from ceilometer backscatter profiles. KNMI

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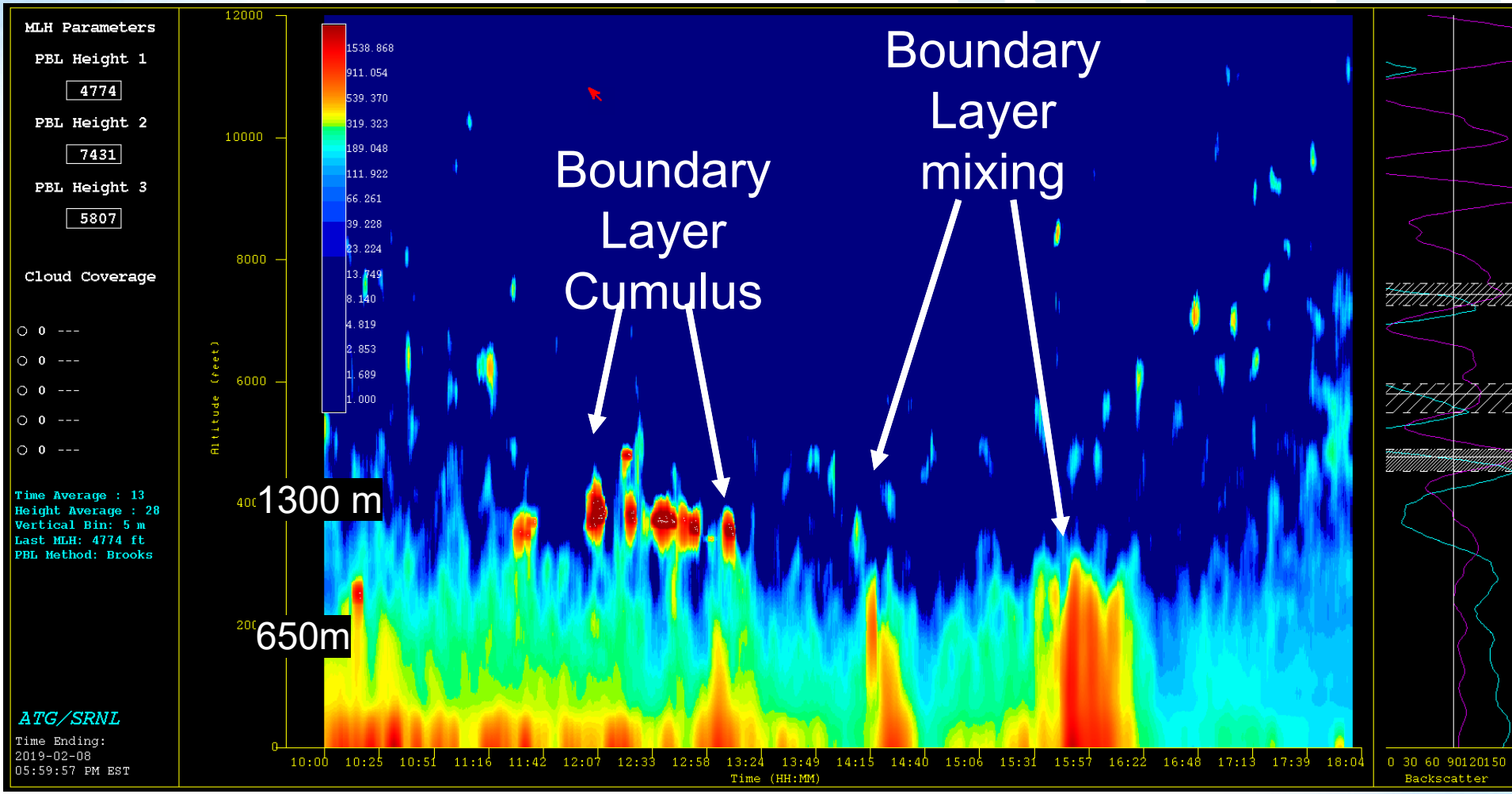
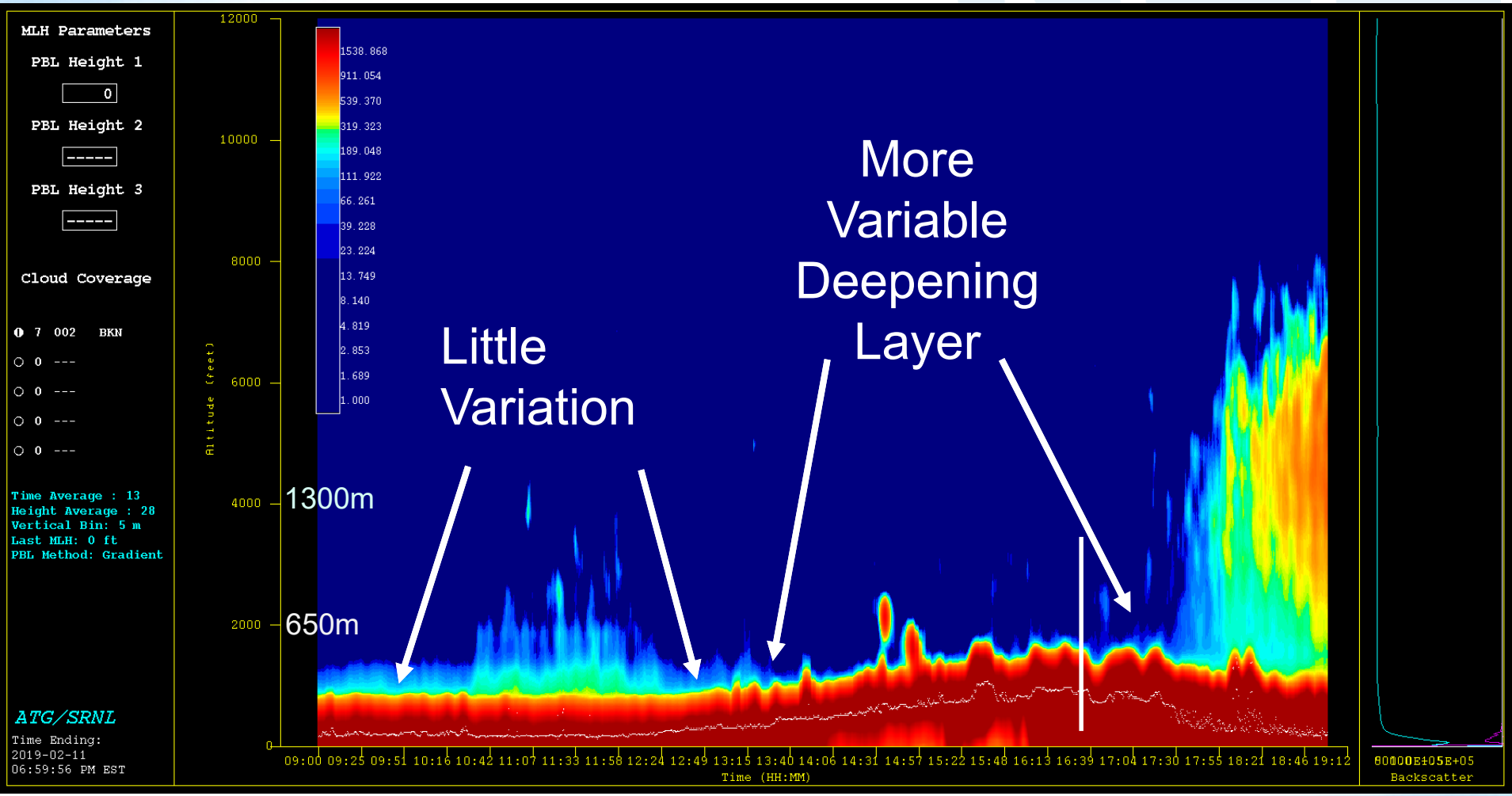
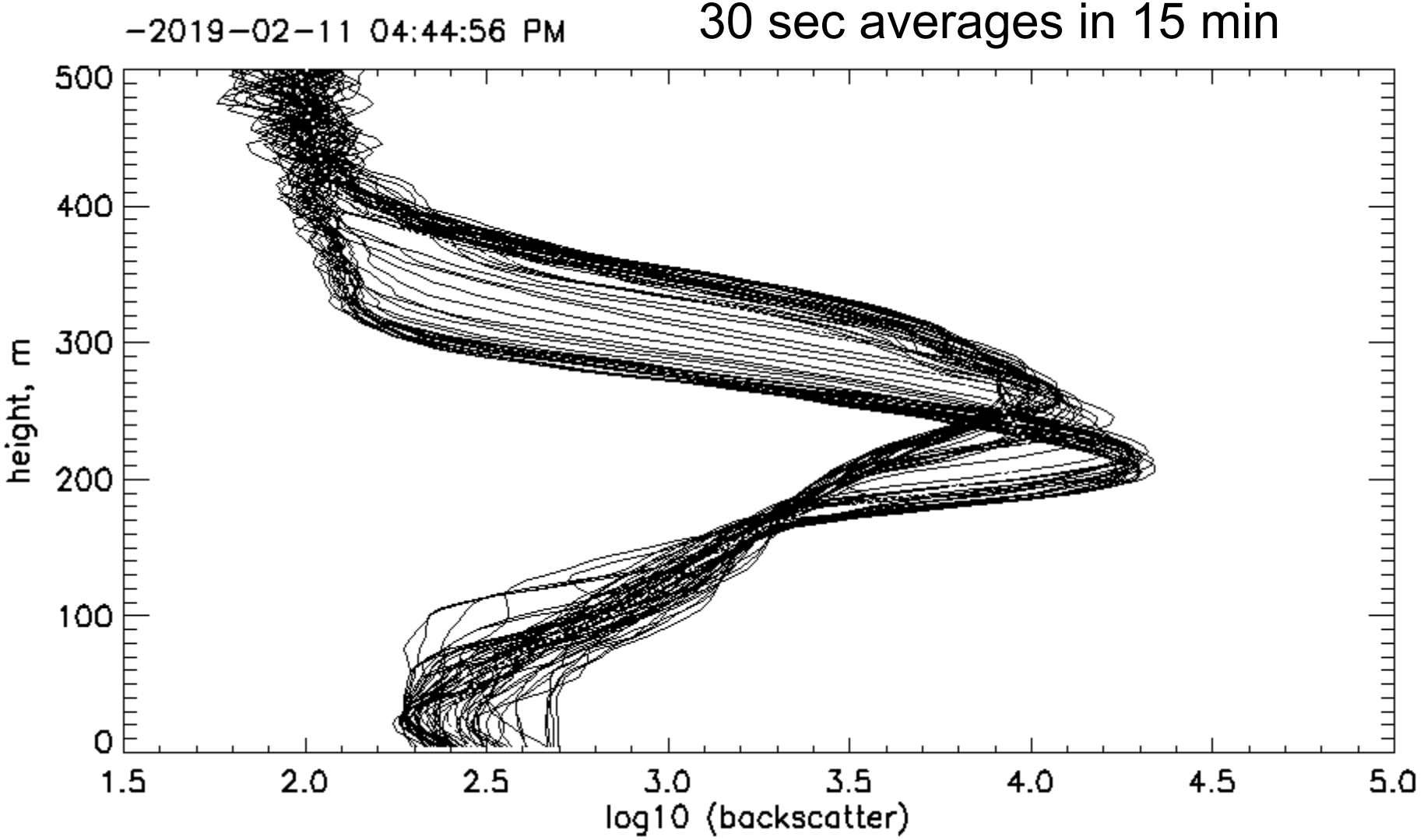
February 8, 2019 10AM-6PM



February 11, 2019 9AM-7PM



30 sec averages in 15 min



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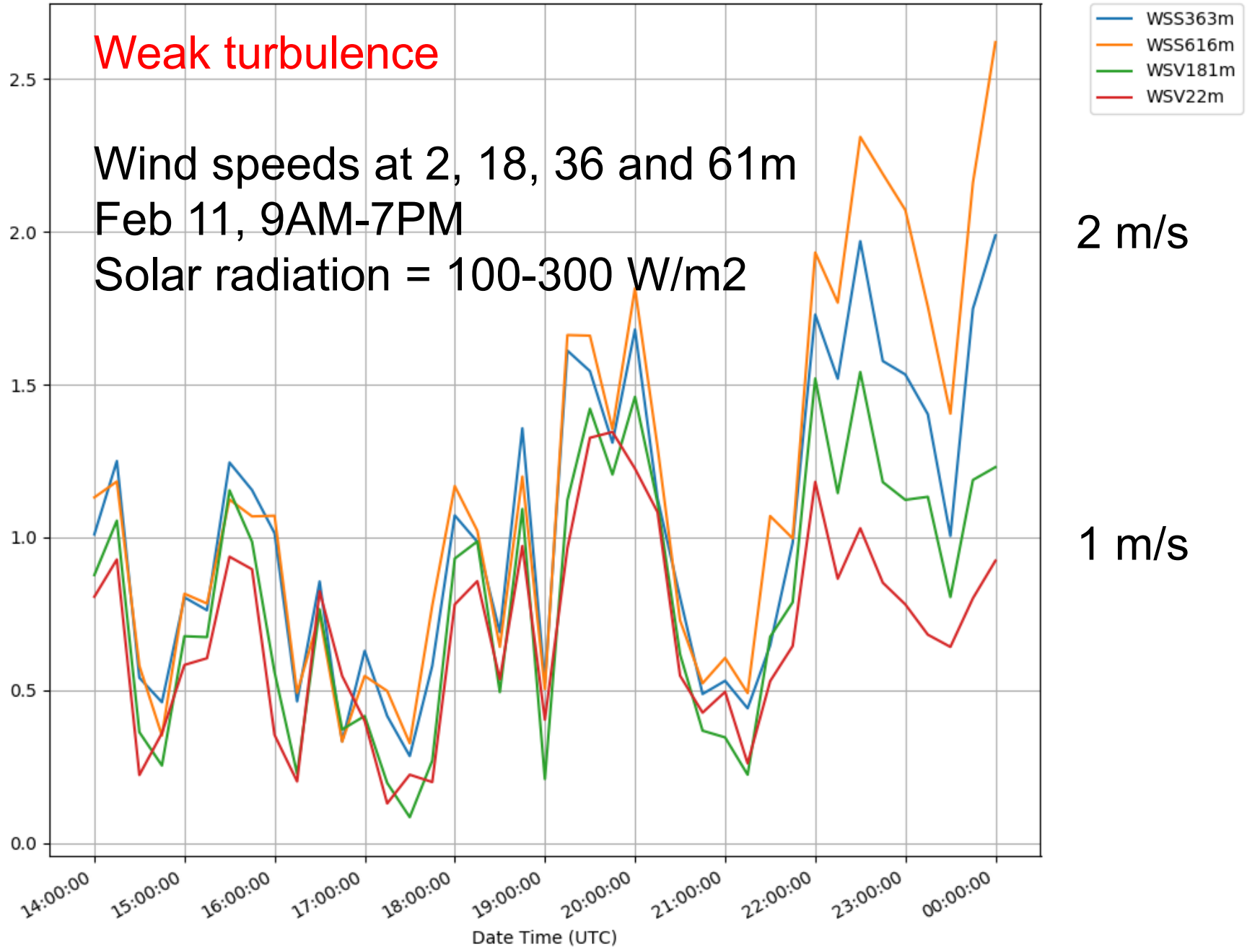
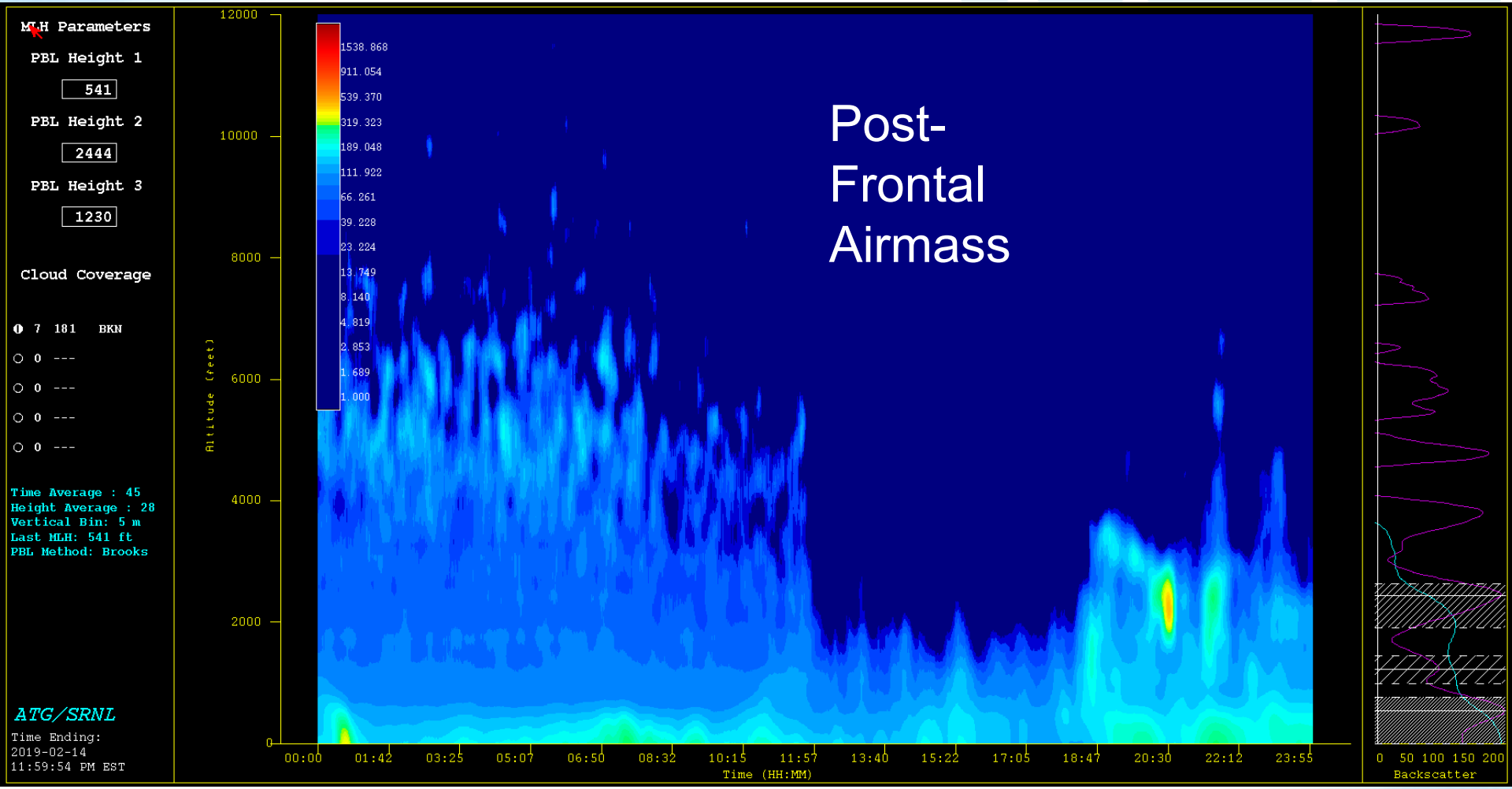

Weak turbulence
Wind speeds at 2, 18, 36 and 61m
Feb 11, 9AM-7PM
Solar radiation = 100-300 W/m2
WSS363m
WSS616m
WSV181m
WSV22m
2.5
2.0
1.5
1.0
0.5
0.0
14:00:00
15:00:00
16:00:00
17:00:00
18:00:00
19:00:00
20:00:00
21:00:00
22:00:00
23:00:00
00:00:00
Date Time (UTC)

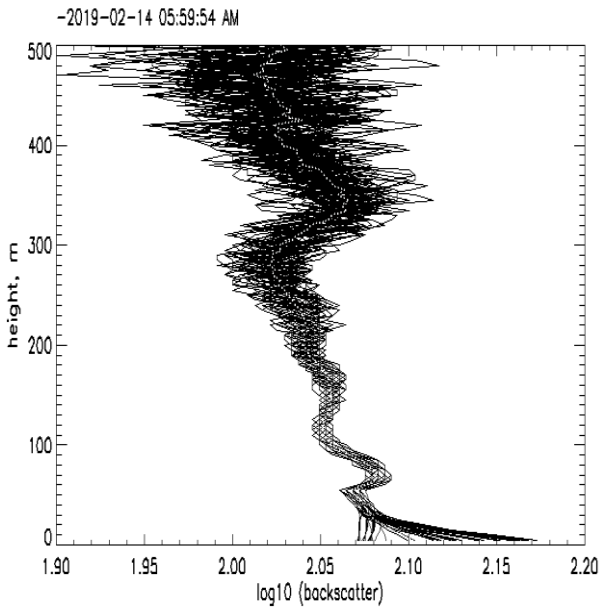
2 m/s

1 m/s

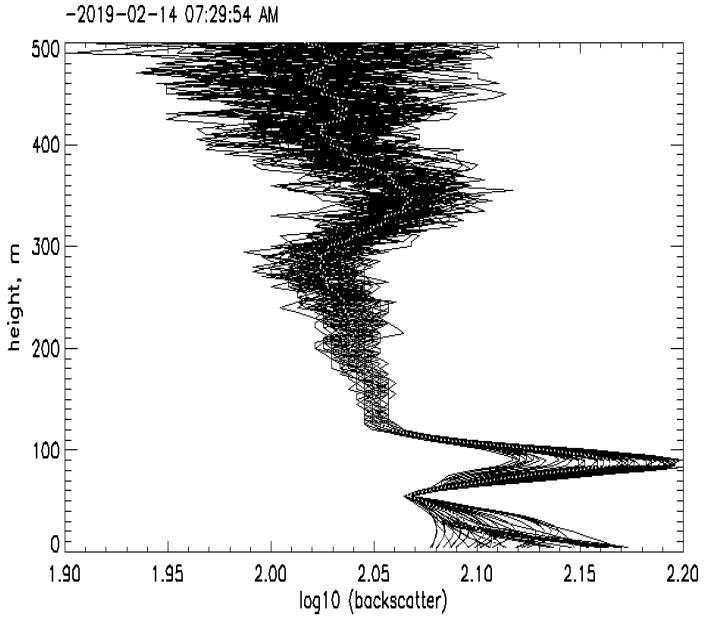
February 14-15, 2019 12AM-12AM



An aerosol layer begins above the boundary layer near 60m at 6AM EST on Feb 14.

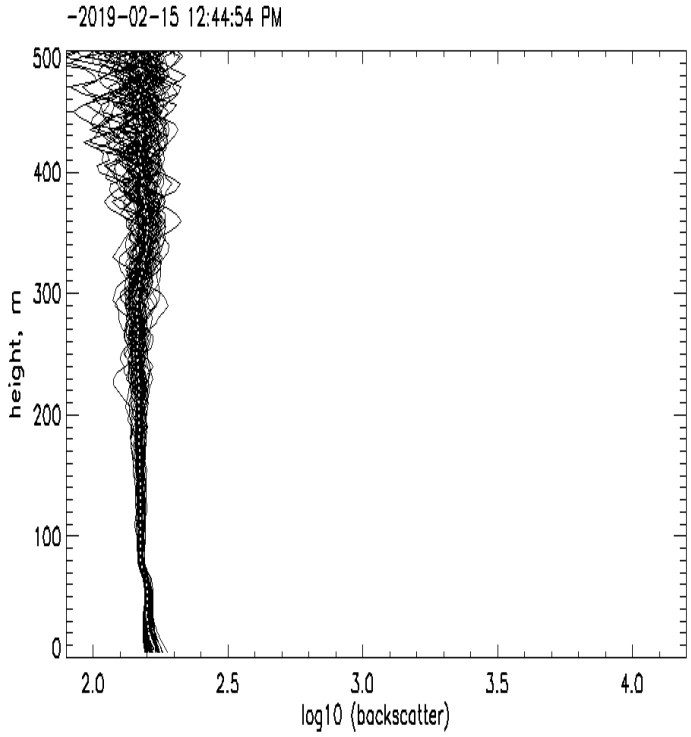


The aerosol layer increases in density, but note very low turbulence at 50m

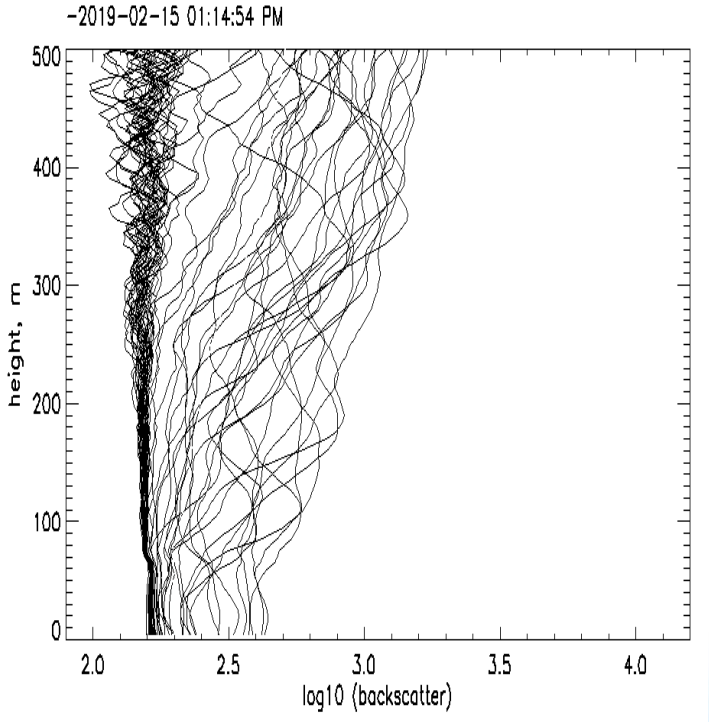


Convective conditions

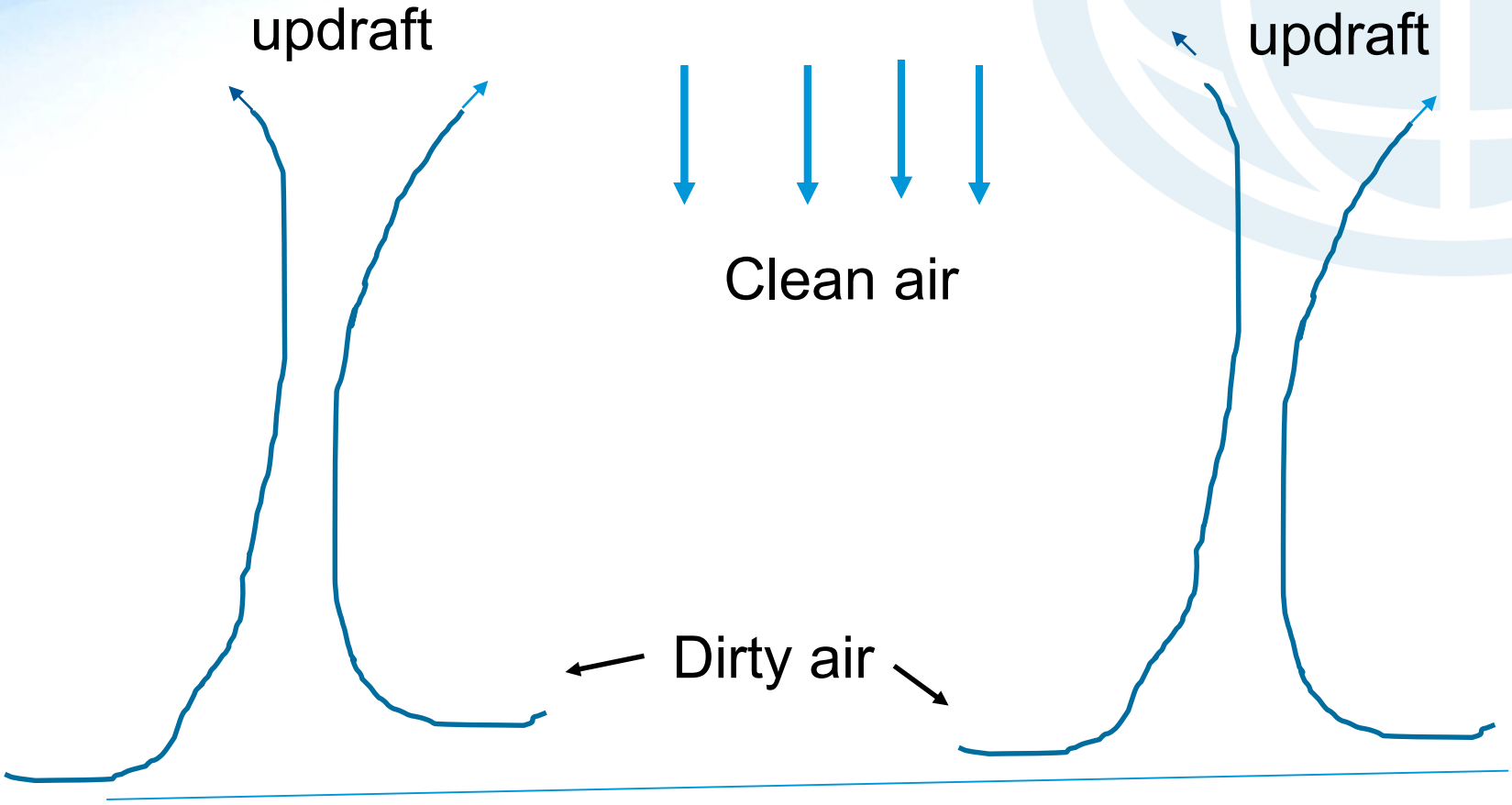
Downdraft of clean air at 12:45 EST on Feb 15



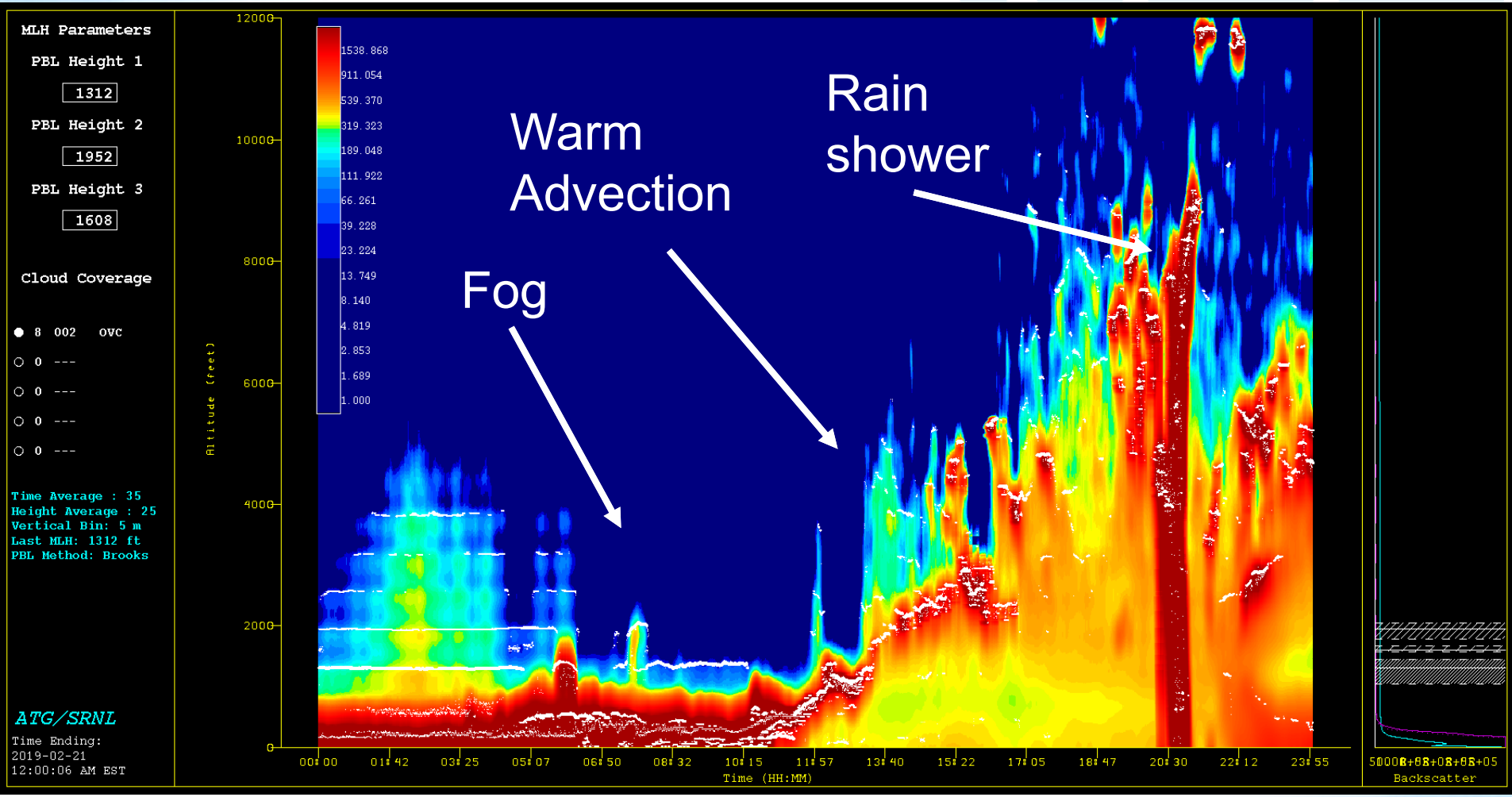
Downdraft + updraft (with aerosol) at 13:15 EST on Feb 15.

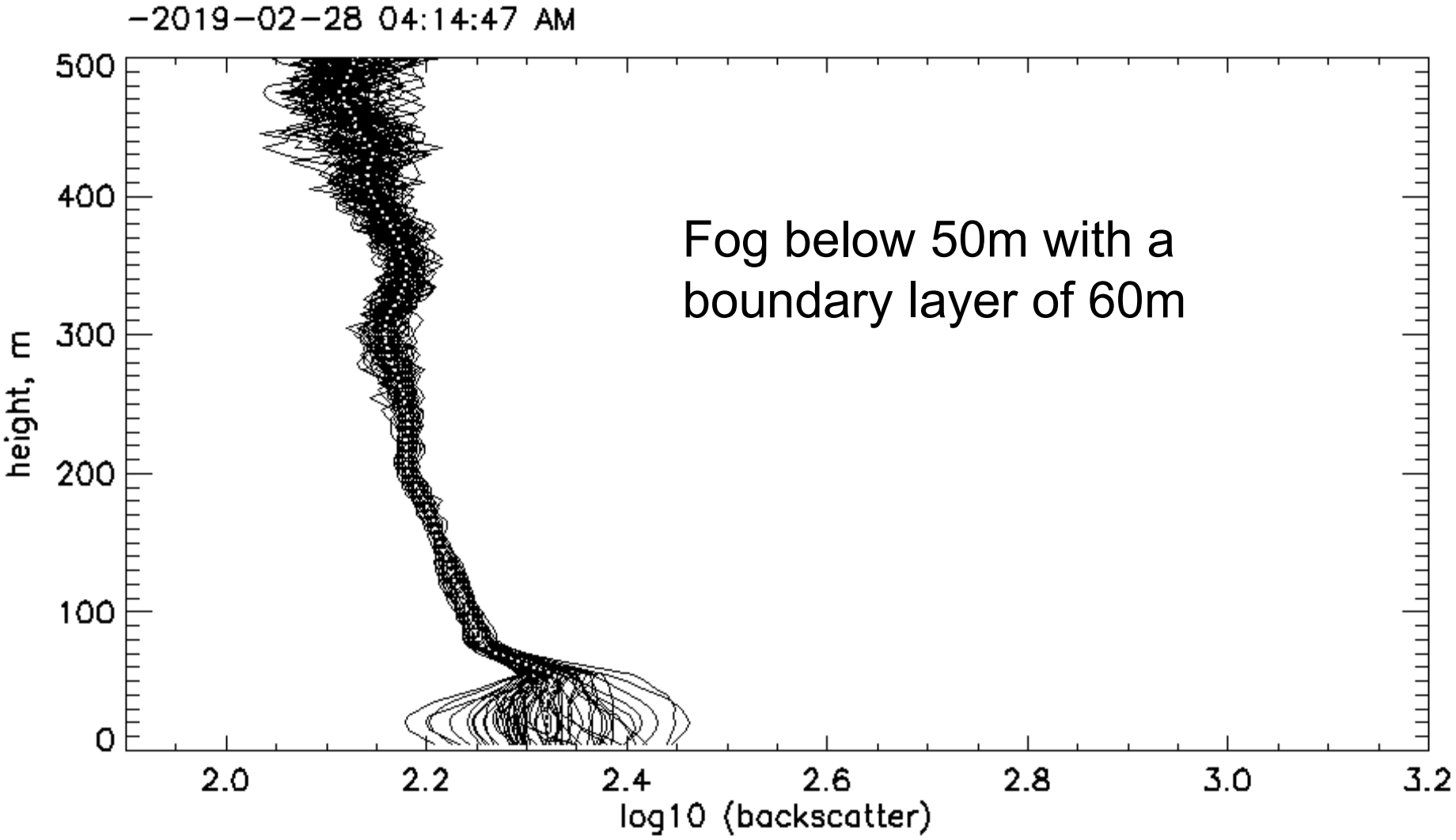


Convective boundary layer



February 21-22, 2019 12AM-12AM




-2019-02-28 04:14:47 AM
500
400
300
200
100
0
height, m
2.0
2.2
2.4
2.6
2.8
3.0
3.2
log10 (backscatter)
Fog below 50m with a boundary layer of 60m

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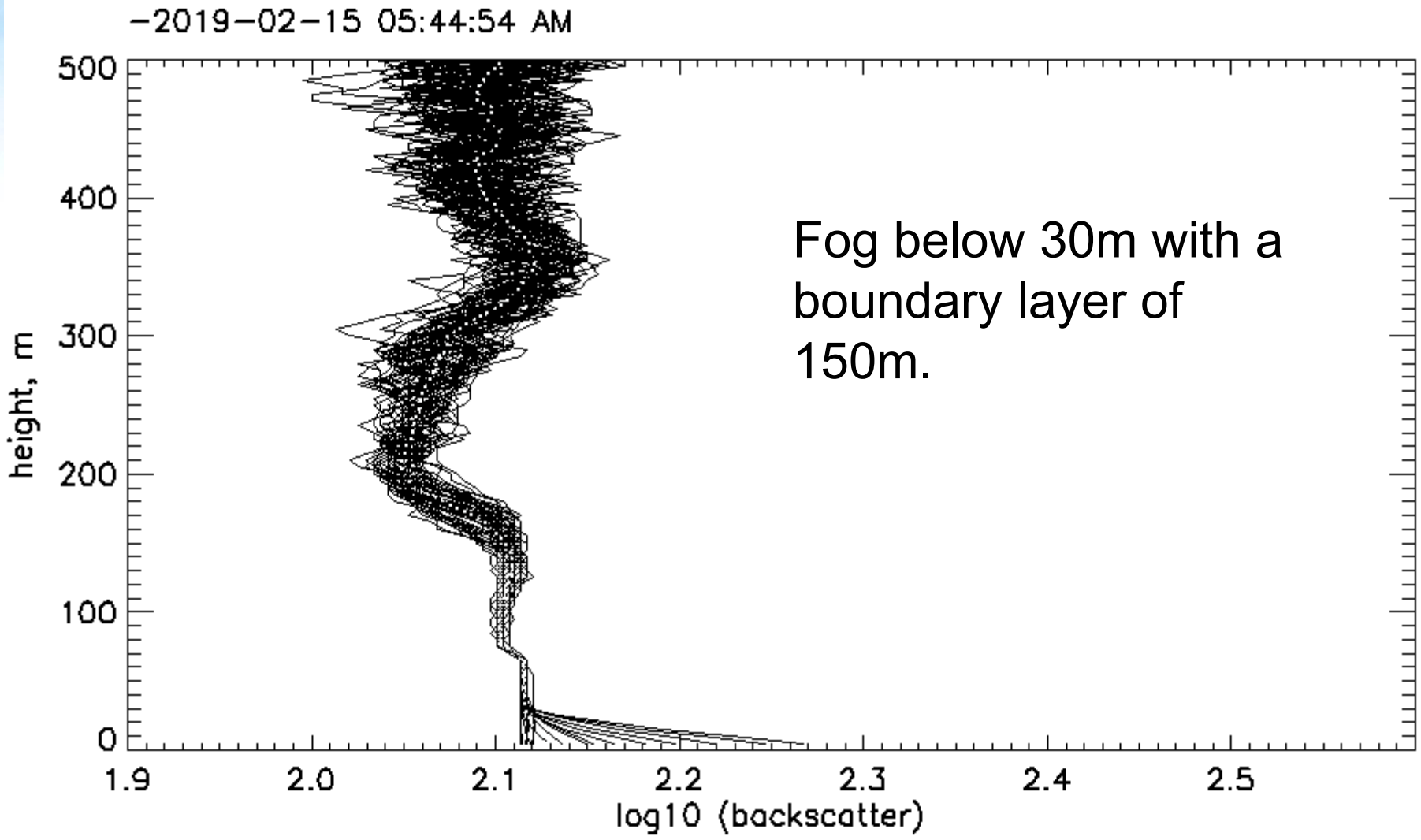

Fog below 30m with a boundary layer of 150m.

Conclusions

- The CL31 ceilometer provides more information about the boundary layer than is currently saved or disseminated. Backscatter data is best understood in conjunction with other met data.
- The boundary layer depth is of most value but automatic detection algorithms can sometimes yield more than one value.
- 5-meter resolution aids in delineation of elevated aerosol layers and turbulence.
- The aerosol backscatter can reveal microfronts and turbulence aloft but experience is required for interpretation.
- Since the backscatter is a weak signal, more careful processing is necessary than for cloud heights.
- The standard deviation in the backscatter during the averaging period should be saved.

The National Weather Service Ceilometer Planetary Boundary Layer Project

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The CL31 PBL Project initiated in 2012 by the ASOS Product Improvement Program (now managed by NWS/STI) in response to NRC

GOAL: To show viability of ASOS ceilometer ***detect mid level cloud bases above 12,000 ft***

archive vertical backscatter data

monitor mixing heights and elevated aerosol layers

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