

Using Airplane and Ozonesonde Profiles to Estimate Boundary-Layer and Buffer-Layer Depth

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Definitions

- Planetary Boundary Layer (PBL) – The layer that interacts with the surface on a time scale of hours. It may be clear or stratus-capped.
- Buffer Layer (BuL) – The layer overlying the PBL that interacts with the PBL on a time scale of up to several days. Here the BuL encompasses the cumulus cloud layer, the residual layer (i.e. the previous day's PBL), and overlying shear-mixed layers. *The BuL does not always exist.*
- Free Troposphere (FT) – The region above the BuL/PBL. It is stably-stratified and is not turbulently mixed throughout, but may have embedded intermittently turbulent layers and may contain cloud layers

Criteria for Estimating PBL Height

- Constant potential temperature lapse rate from surface up to PBL top, h ; i.e. top is where lapse rate exceeds $\sim 3 \text{ C km}^{-1}$.
- Water vapor and ozone mixing ratios within PBL are \sim constant on large scales and have small-scale fluctuations.
- If RH reaches $\sim 95\%$ and stays constant or increases, clouds likely

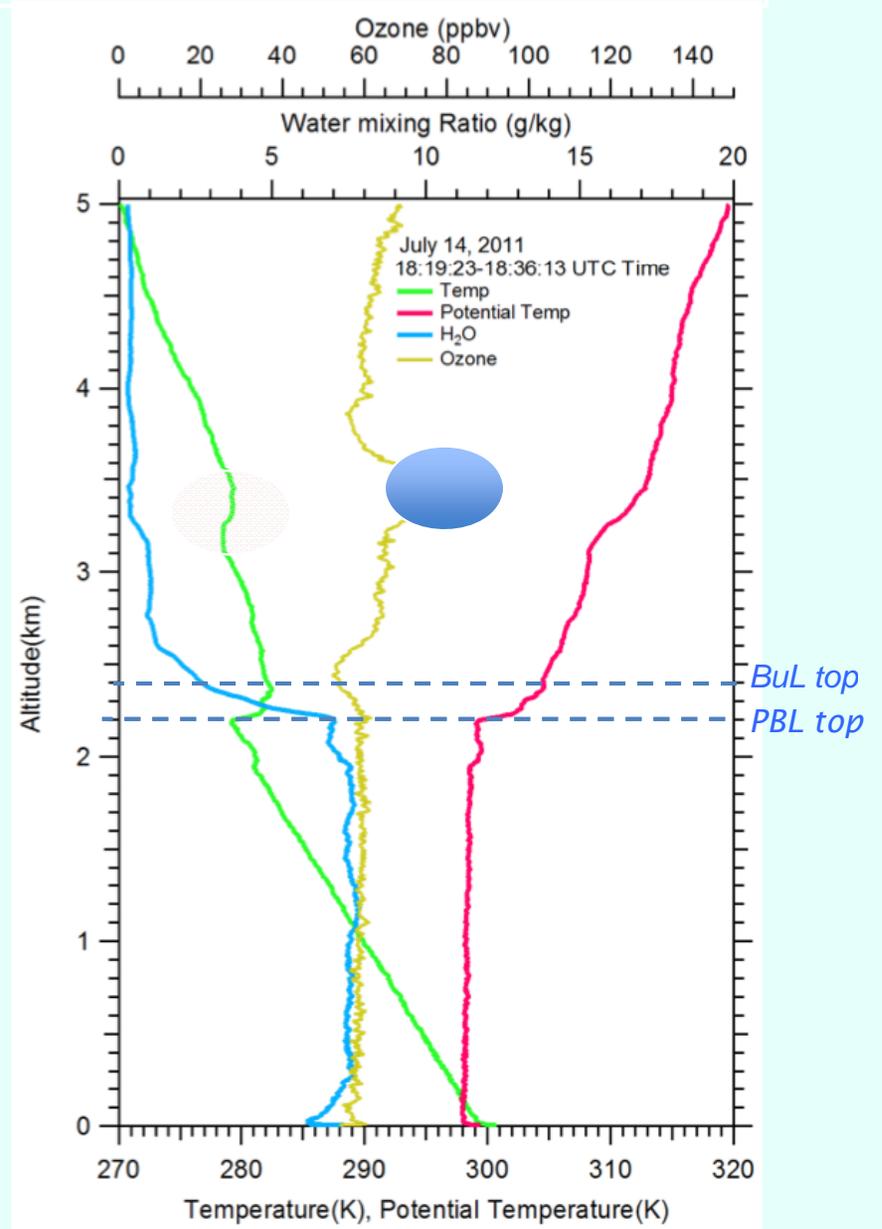
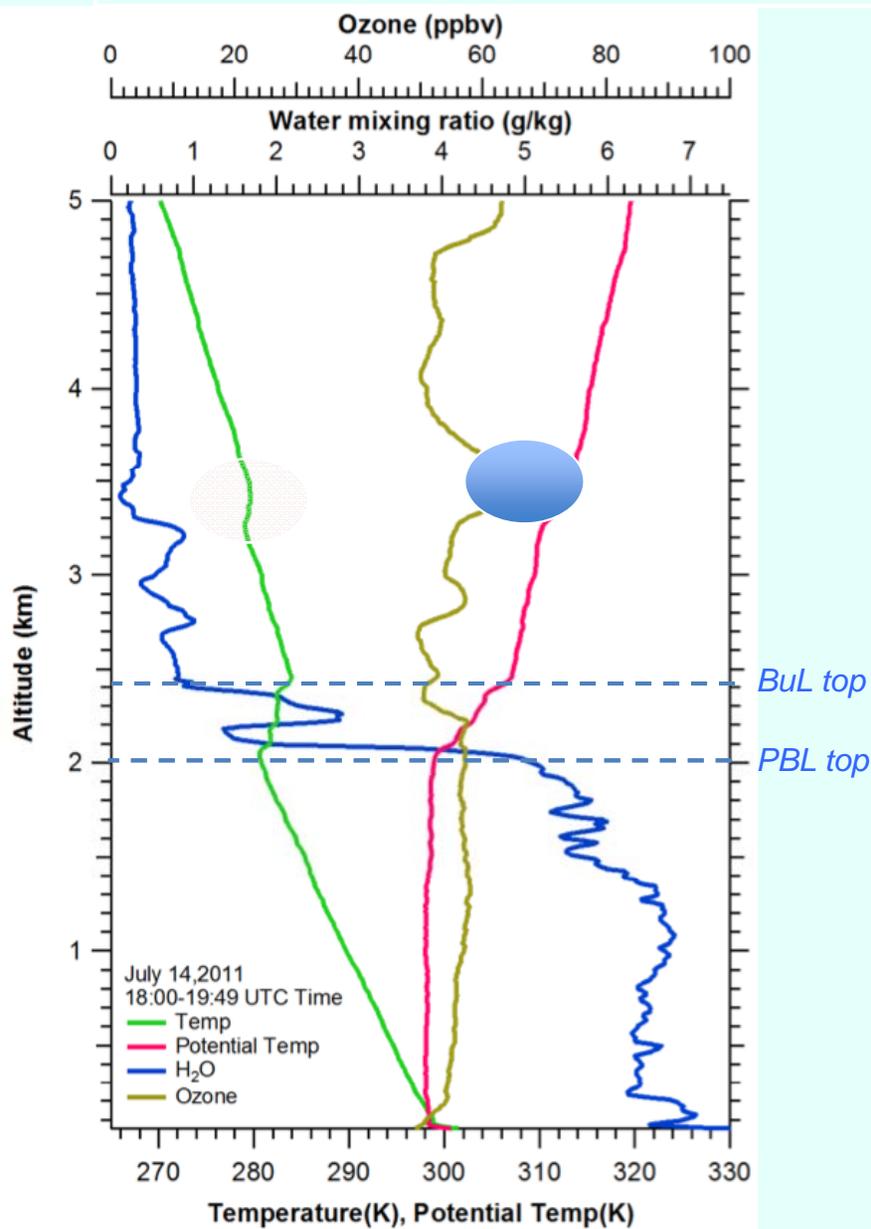
Criteria for Estimating BuL Height

- Potential temperature lapse rate within BuL decreases ~ exponentially to ~ constant lapse rate.
- Water vapor and ozone mixing ratios within BuL change ~ exponentially to “background” free-tropospheric value.
- Increased large-scale and decreased small-scale fluctuations.

Contrasts between PBL, BuL, and FT

- **PBL** -> Well-mixed vertically; well-defined eddy aspect ratio of 0.65 in middle of convective PBL
- **BuL** -> Intermittently mixed vertically via cumulus convection or shear
- **FT** -> Layered structure with limited (in space and time) vertical mixing. Layers are mostly uncoupled with extensive horizontal scales (up to 10's or 100's of km), and vertical scales of ~ 10 m to ~ 1 km.

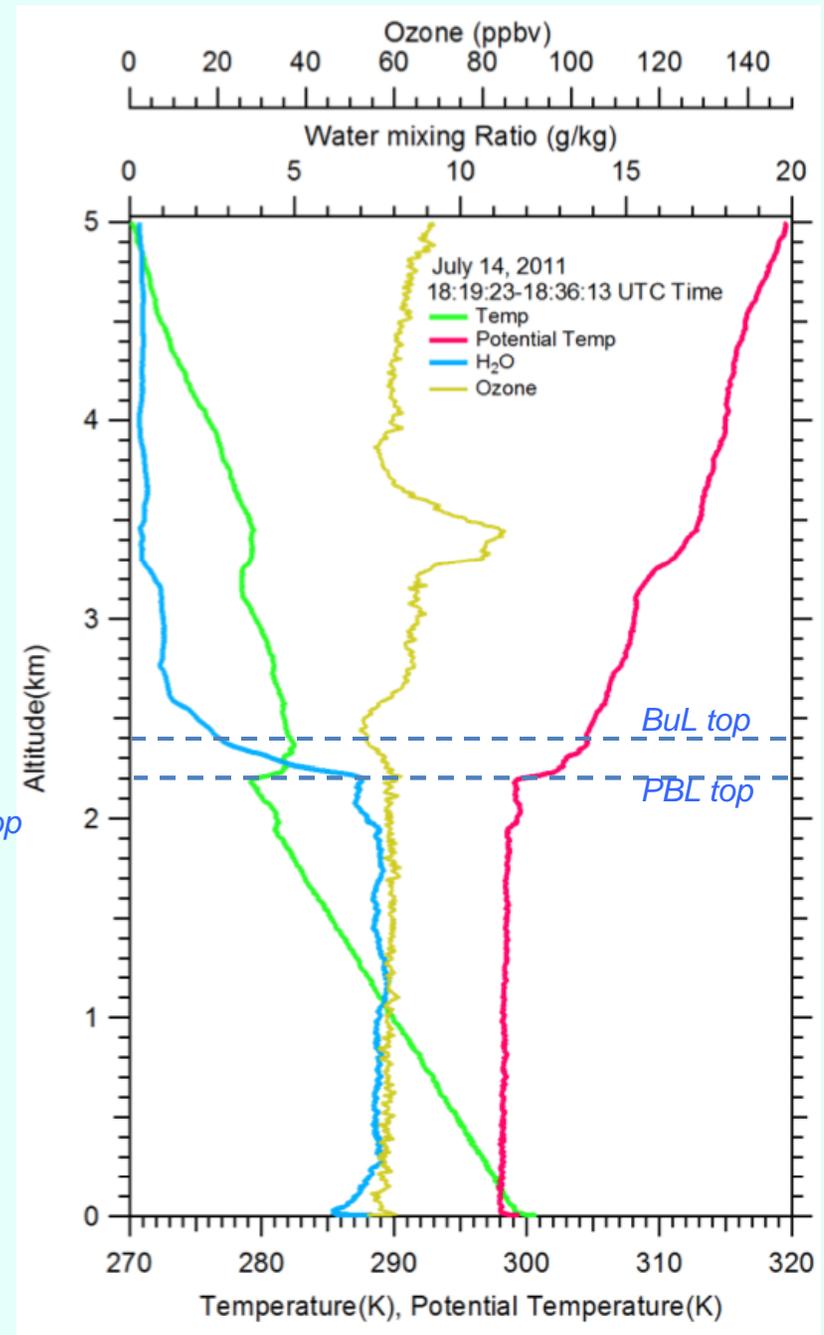
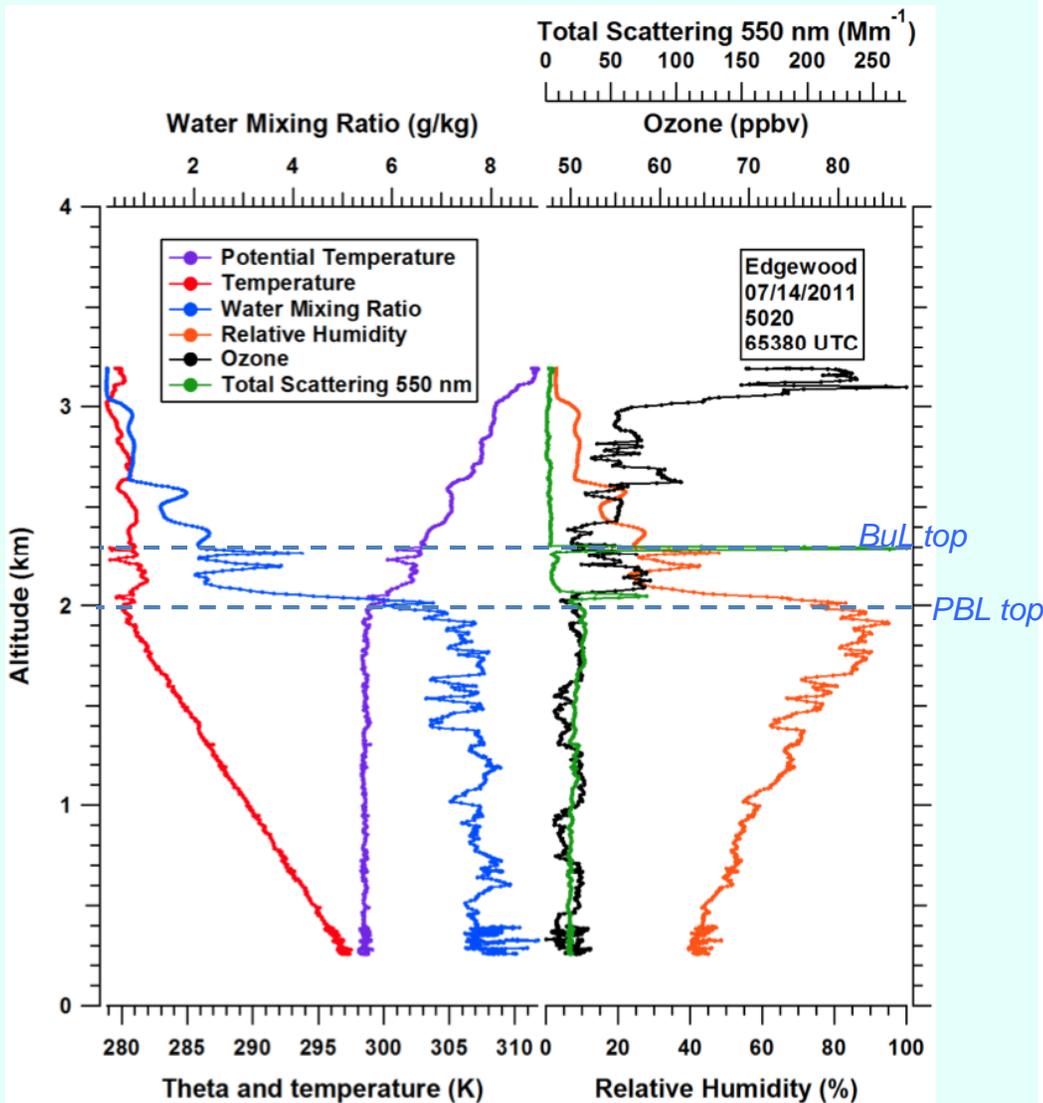
Ozonesonde soundings from Beltsville (left) and Edgewood (right)



Edgewood soundings:

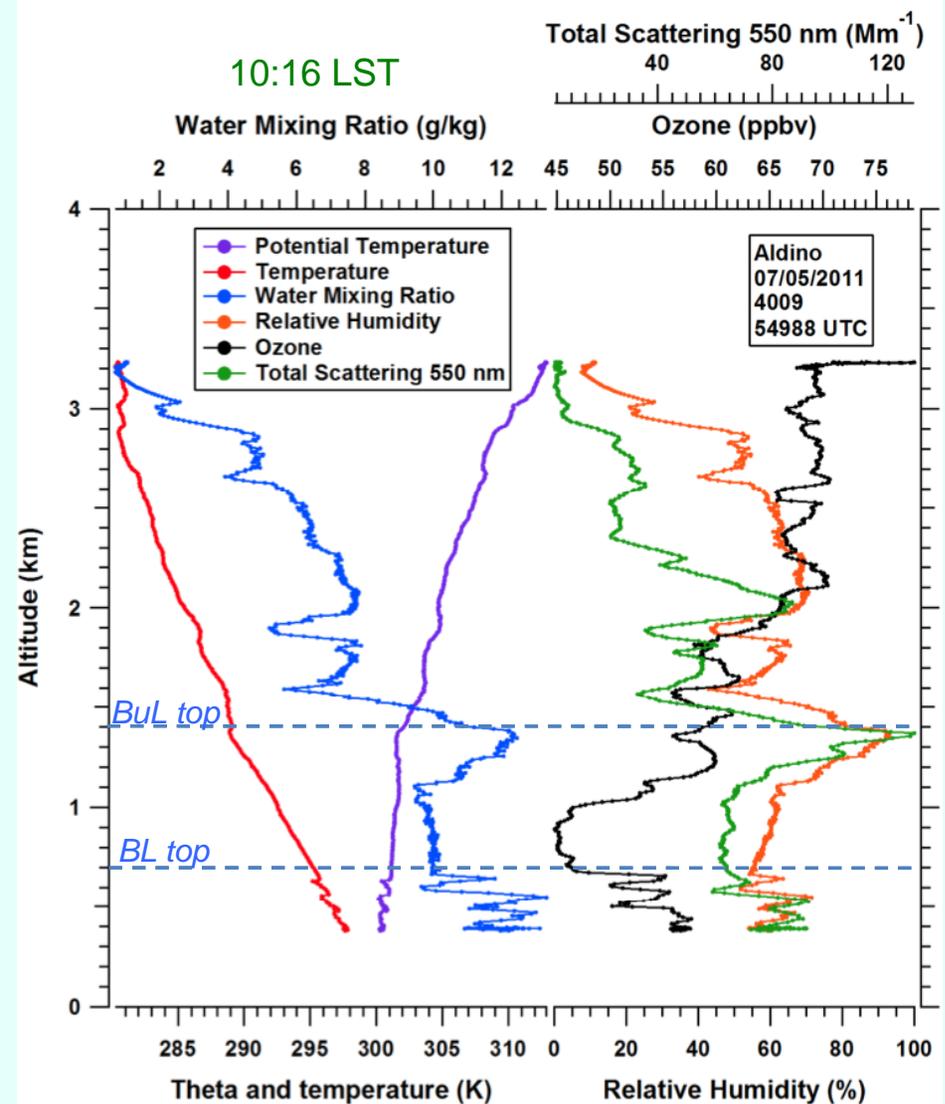
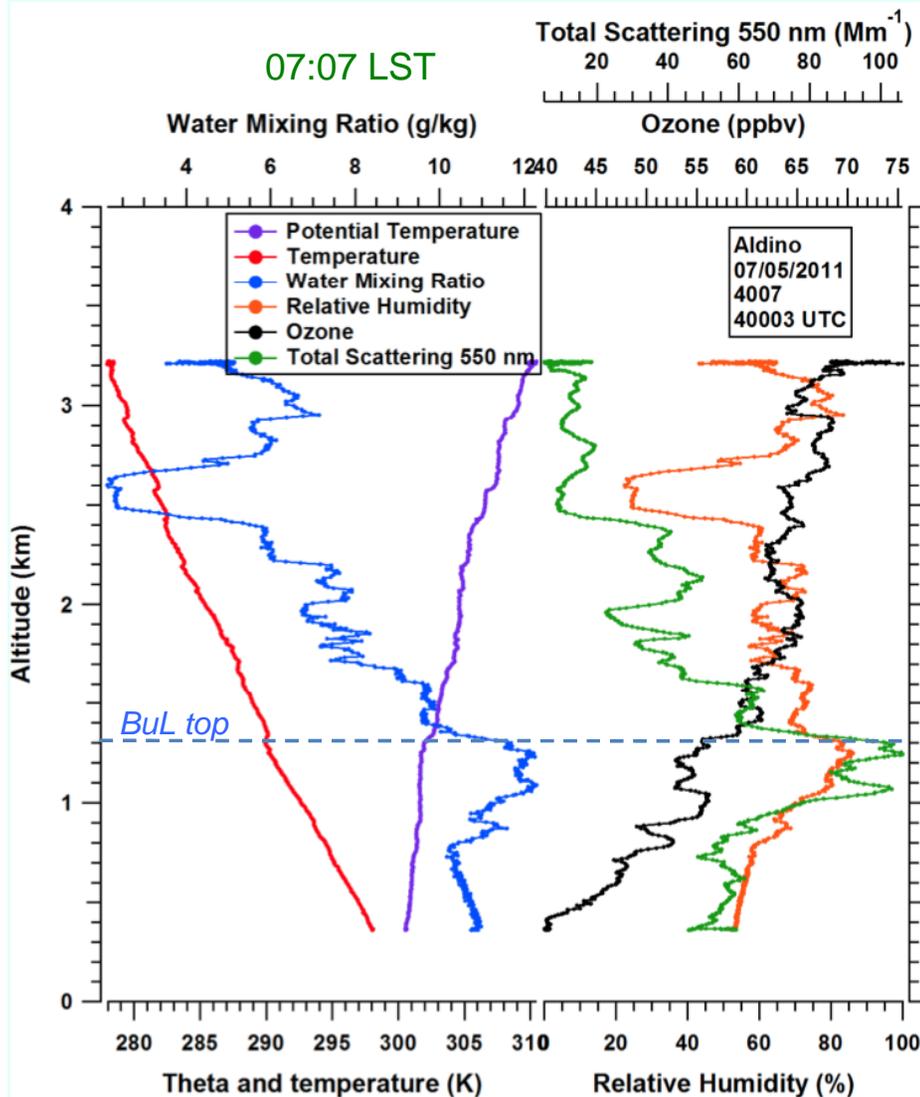
left - airplane

right - ozonesonde



Diurnal variation at Aldino

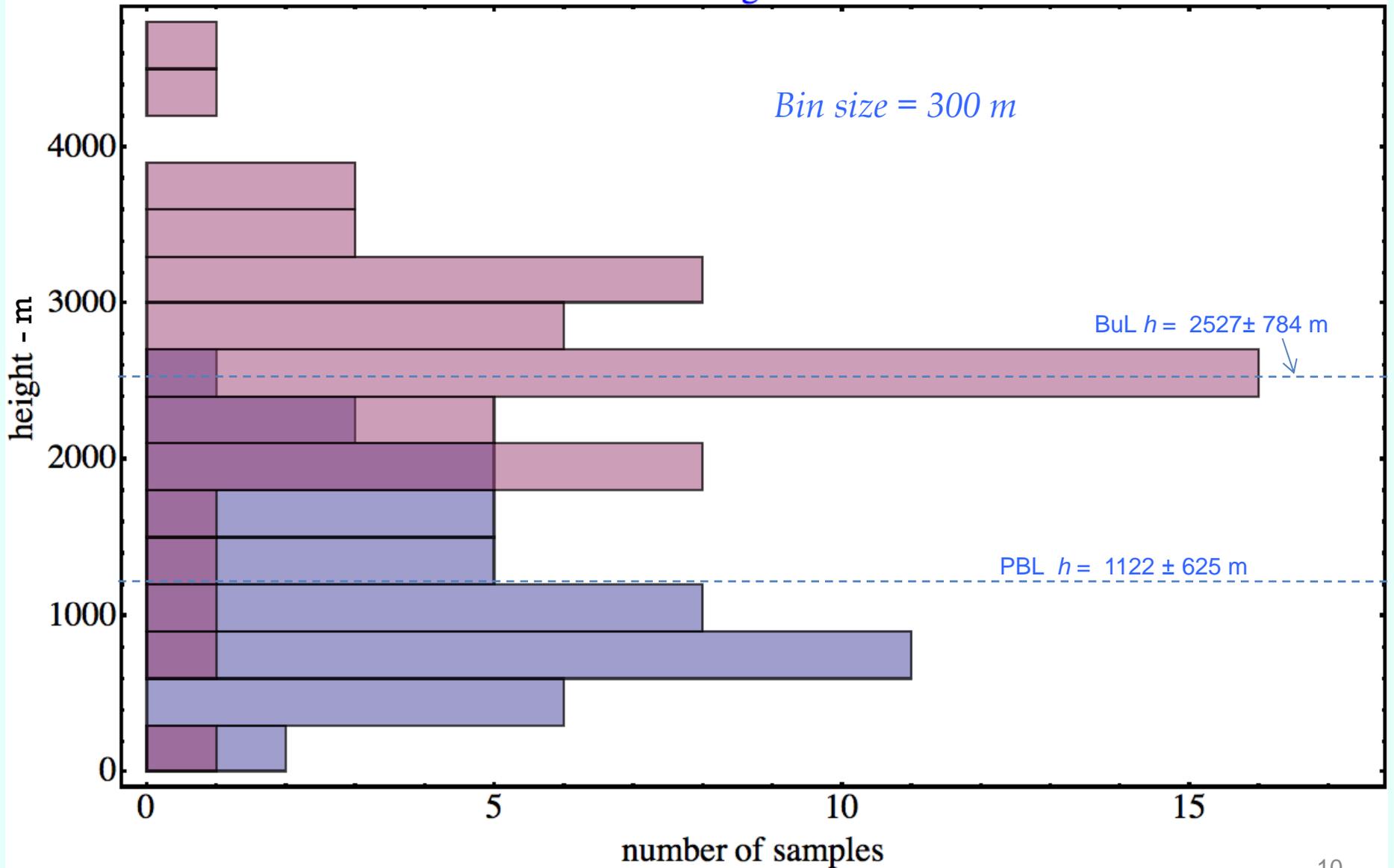
- BL beneath early morning sounding
- BL top at ~700 m at 10:16 LST
- BuL top ~1300 m -> 1400 m



Determination Statistics of Aircraft and Ozonesonde PBL and BuL Heights

	Number of Soundings	Number of indeterminate PBL heights	Number of questionable PBL heights	Number of indeterminate BuL heights	Number of questionable BuL heights
Aircraft Soundings	253	36	17	58	12
Ozonesonde Soundings	63	8	7	3	2

Distribution of Heights for BL and BuL

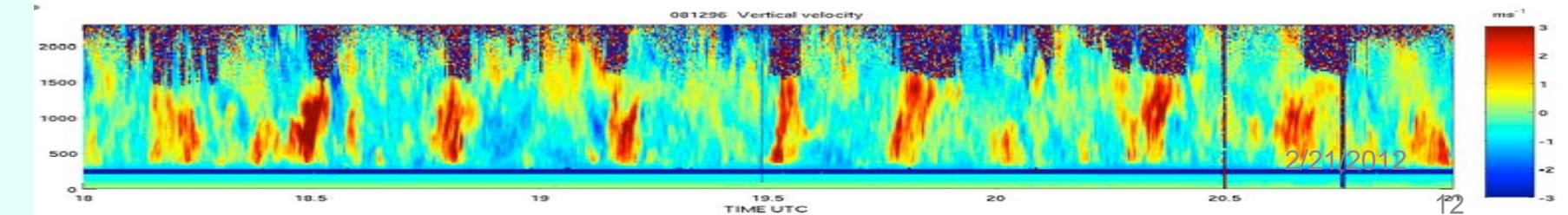
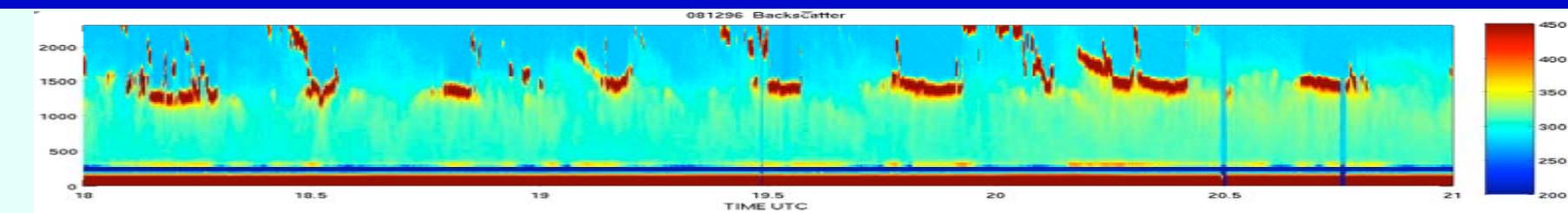
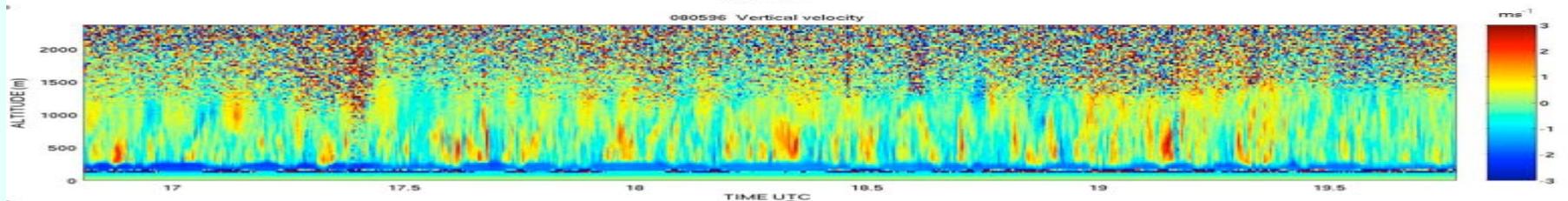
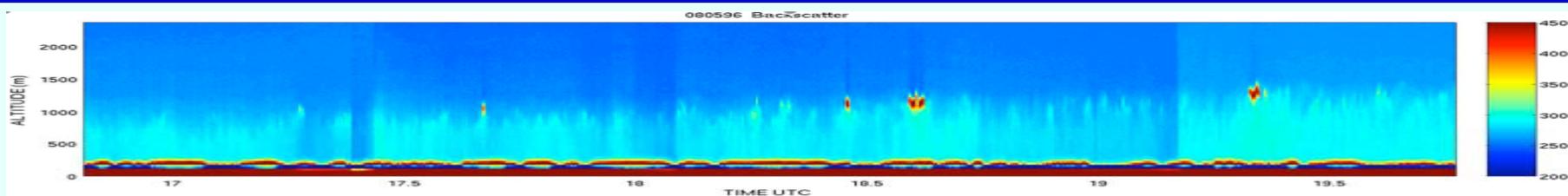
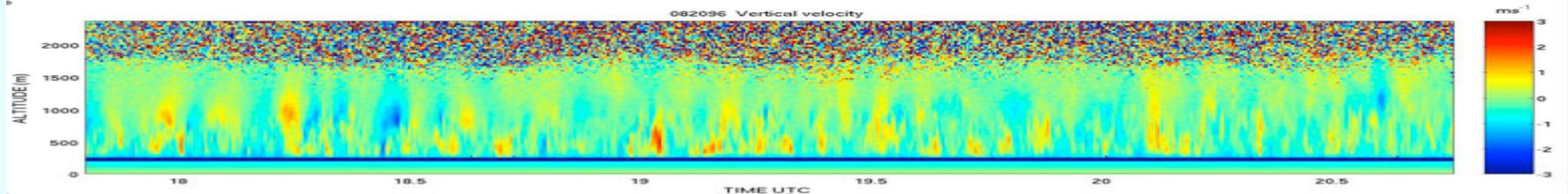
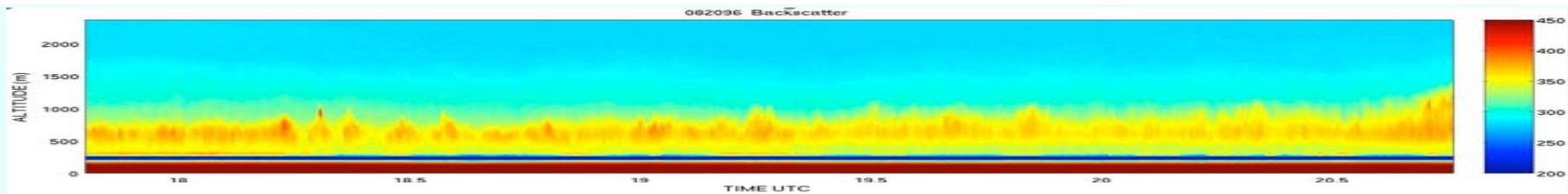


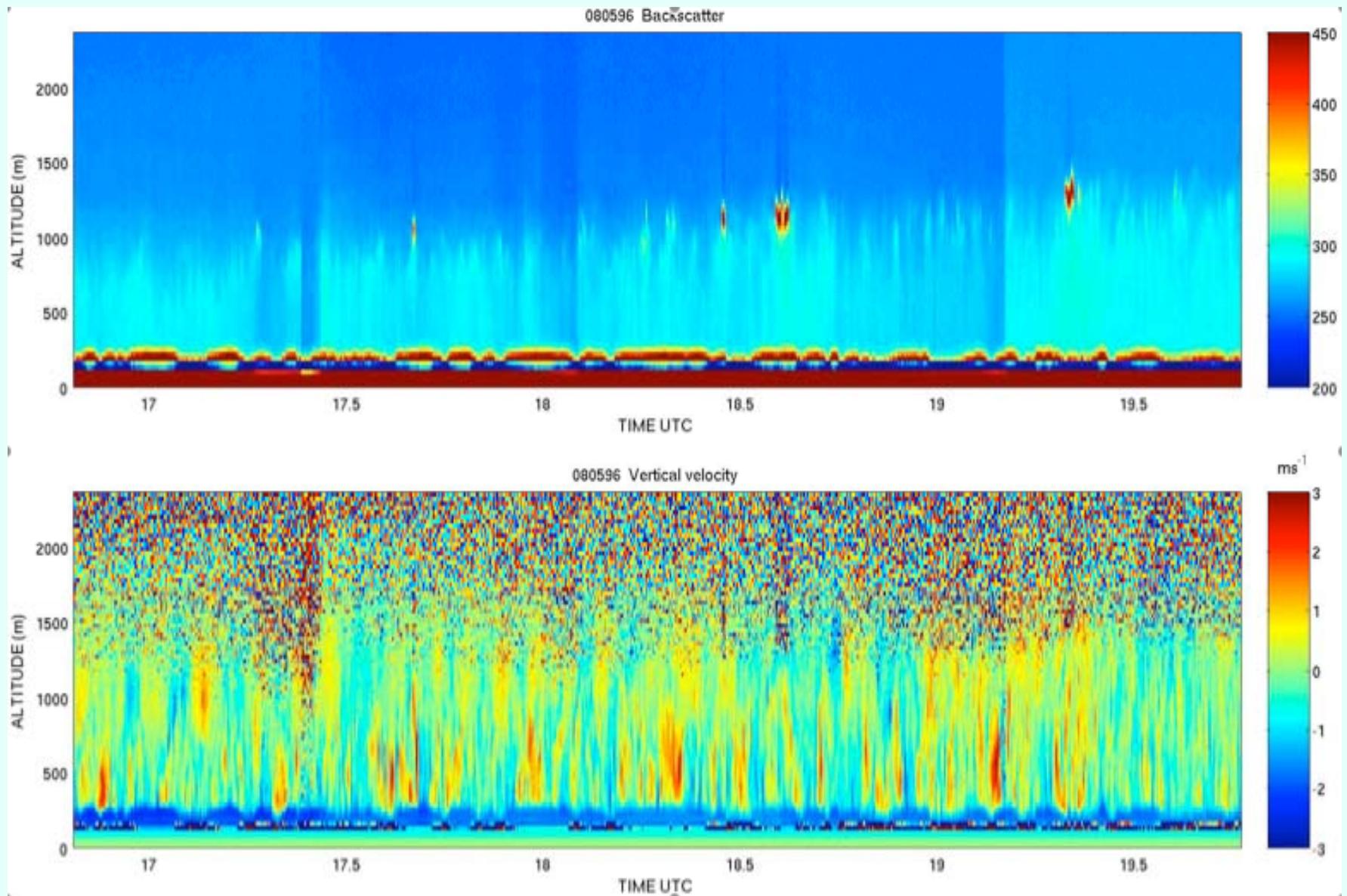
Summary

- 21% of the PBL and 28% of the BuL aircraft soundings were indeterminate or questionable.
- 24% of the PBL and 8% of the BuL ozonesonde soundings were indeterminate or questionable.

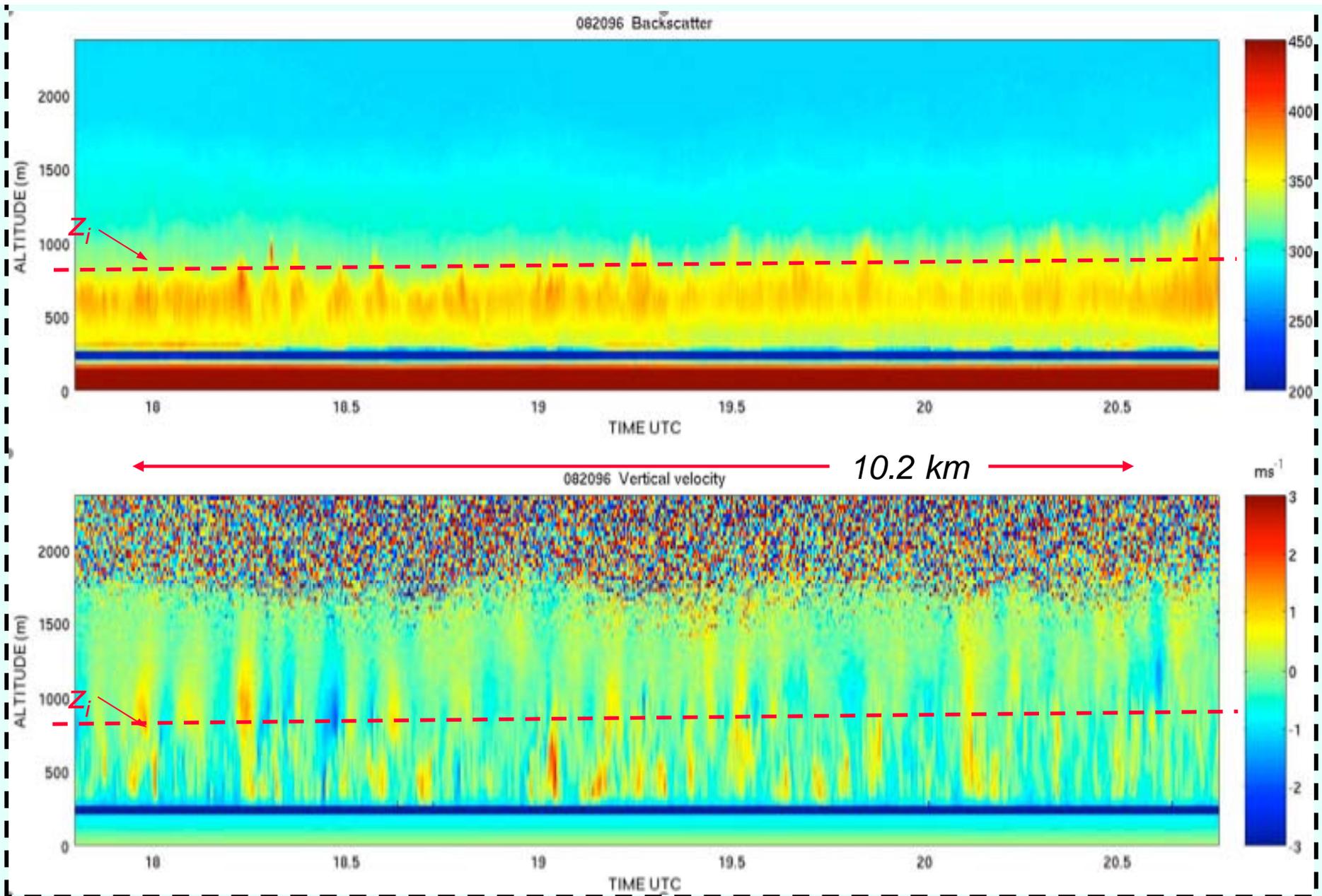
Comments:

1. Ozonesondes covered greater depth and had slower instrument response
2. Aircraft incorporates horizontal variation during soundings
3. Ozonesondes started nearly at surface; aircraft from ~300 m above surface

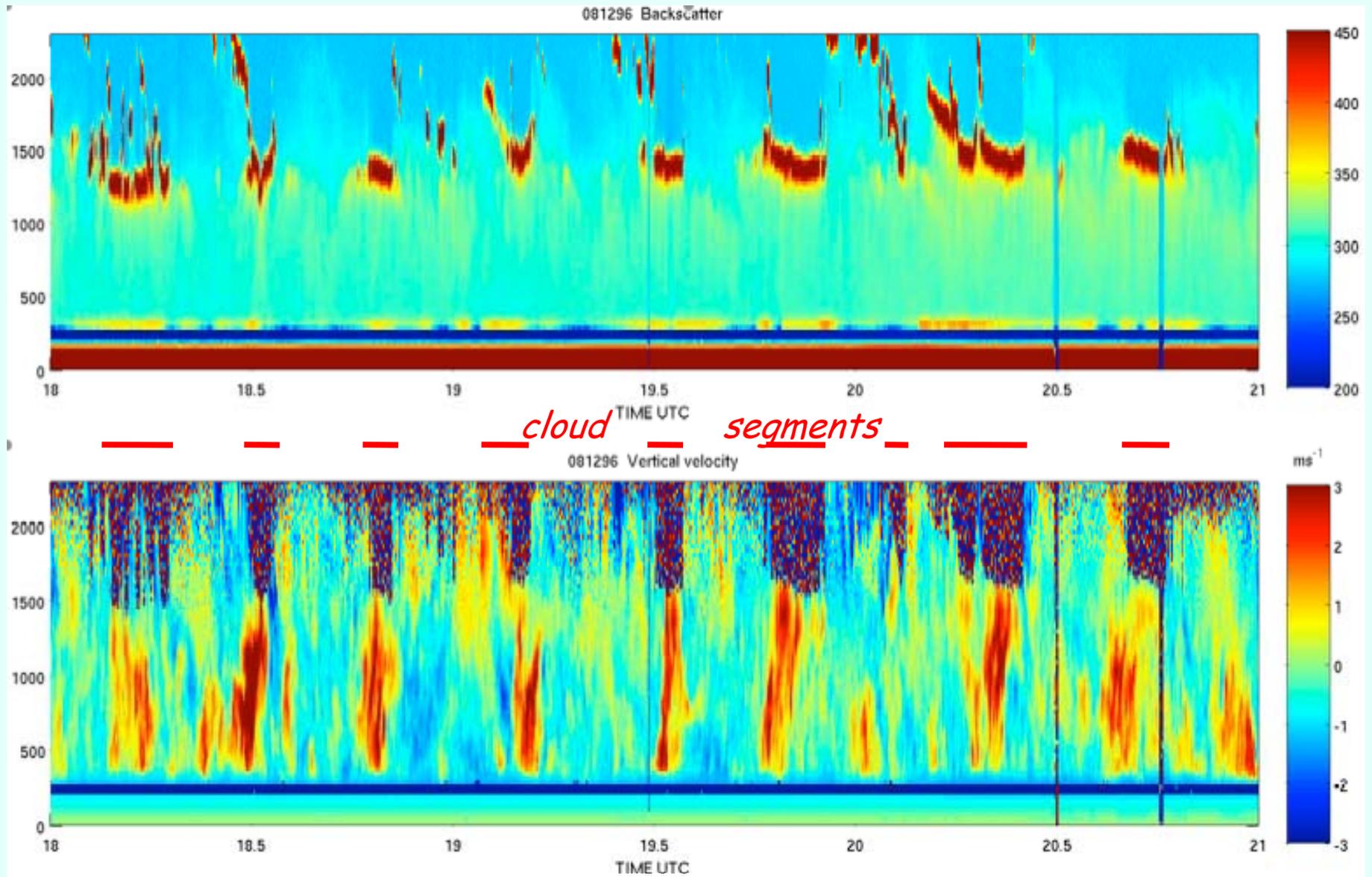




High-Resolution Doppler Lidar (HRDL) measurements w from LIFT on 5 August 1996; a typical fair-weather day. 2/21/2012



High-Resolution Doppler Lidar (HRDL) measurements w from LIFT on 20 August 1996. $z_i = 960$ m, $U = 6.8$ m/s, $\Delta U = 3.1$ m/s, $\partial\theta/\partial z = 1.2$ C/km in FT.



High-Resolution Doppler Lidar (HRDL) measurements w from LIFT on 12 August 1996; CBL modulated by fair-weather cumulus.

2/21/2012