MLH from MWR

a quick review

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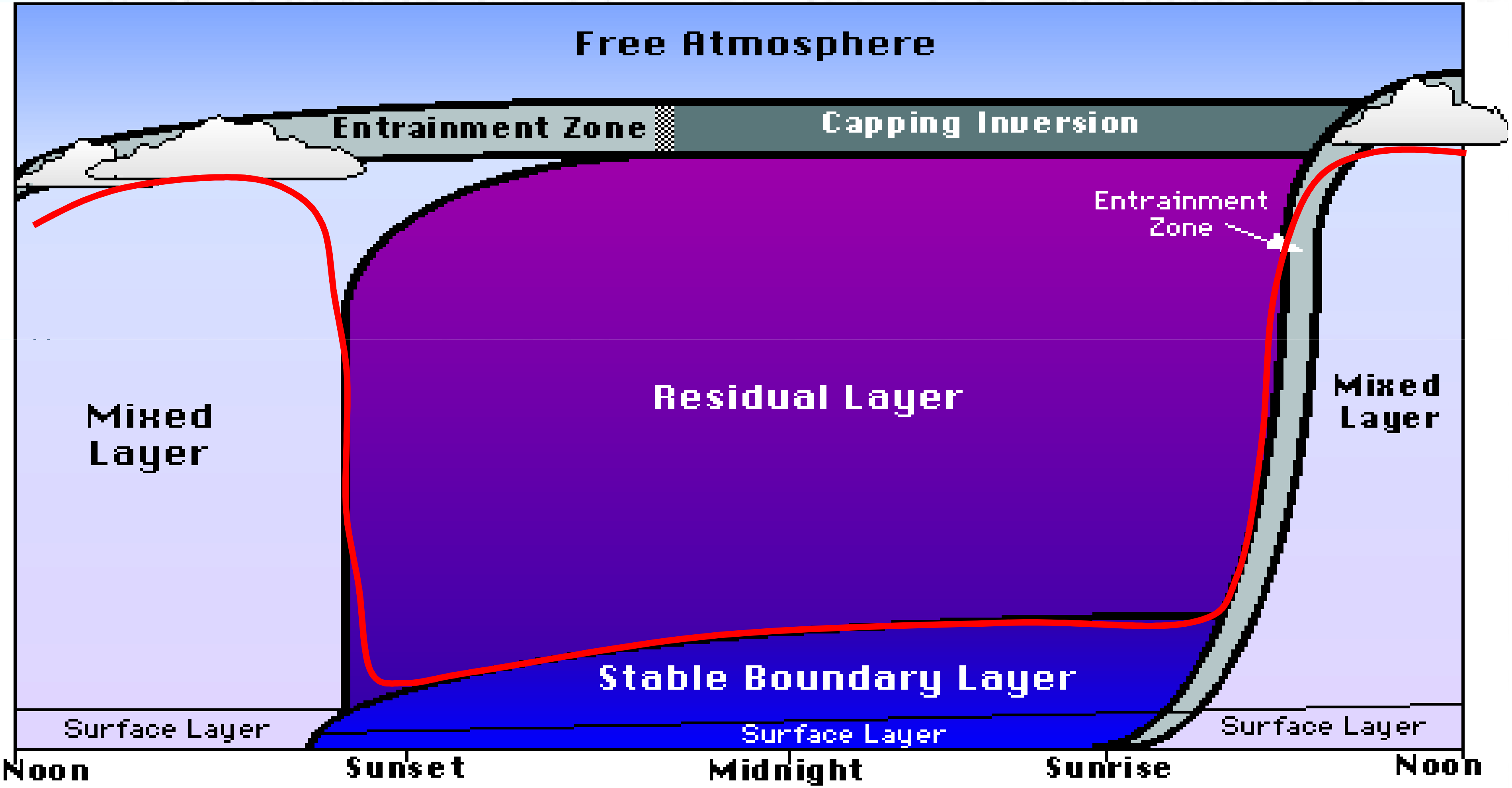
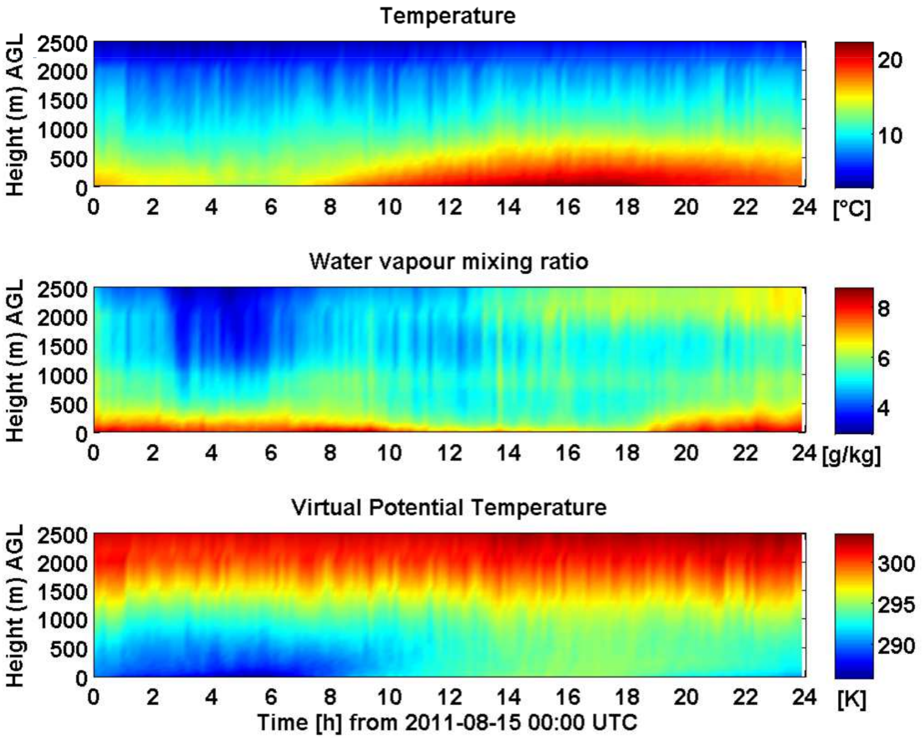


Structure of Planetary Boundary Layer

adapted from Stull, 1988.

What ground-based MWR provide?

- Ground-based MWR provide T and H profiles
  - High temporal resolution (~1 min),
  - Low-to-moderate vertical resolution,
  - Information mostly residing in the PBL



Mixing Layer Height (MLH) retrievals

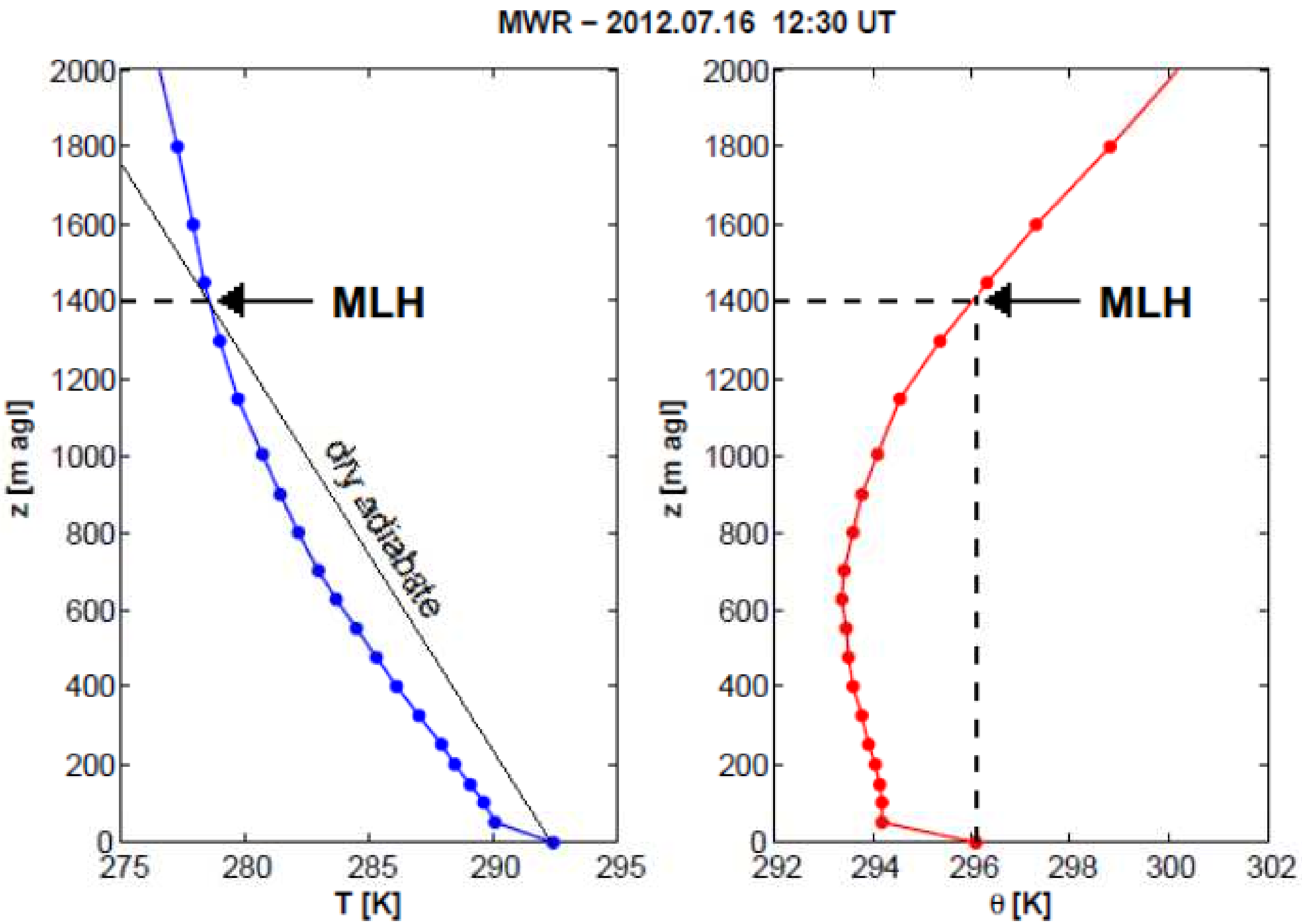
Methods based on *T and H* profiles*

- Parcel Method (PM)
- Surface-Based Temperature Inversion (SBTI)
- Gradient Method (*Liu and Liang Method*)

*Collaud coen et al., 2014; Seibert et al., 2000; Seidel et al., 2010.

Parcel Method (PM)

PM* defines the MLH as the elevation to which an air parcel with ambient surface *T* can rise adiabatically from the ground.



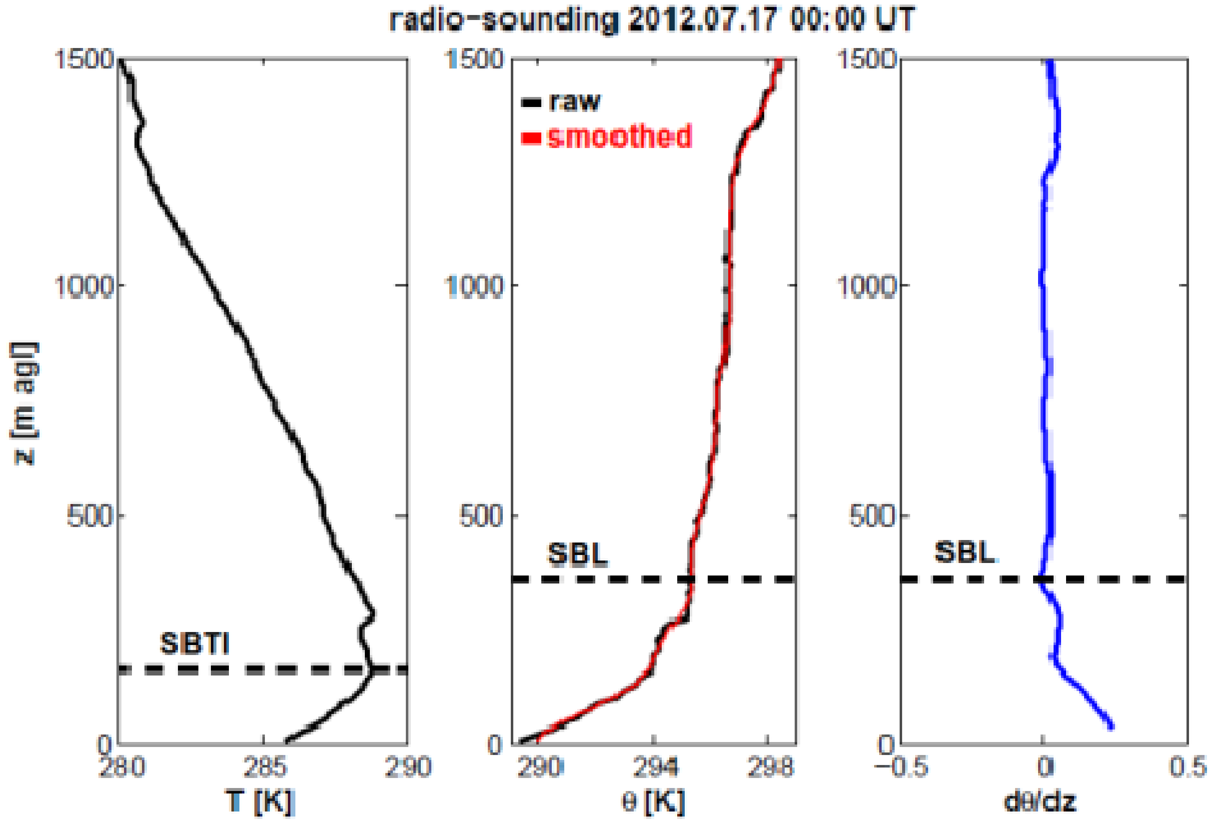
* Holzworth, 1964; Fisher et al., 1998

Parcel Method (PM)

- Advantages:
  - It only needs T (or T and H) → θ or θ_v
  - An estimate of the MLH uncertainty is obtained by varying Ts±0.5 K, resulting in 50-150 m
- Limitations:
  - Ts has a large impact on MLH estimate (it needs a precise measurement)
  - It can only be applied to unstable conditions (Convective BL)

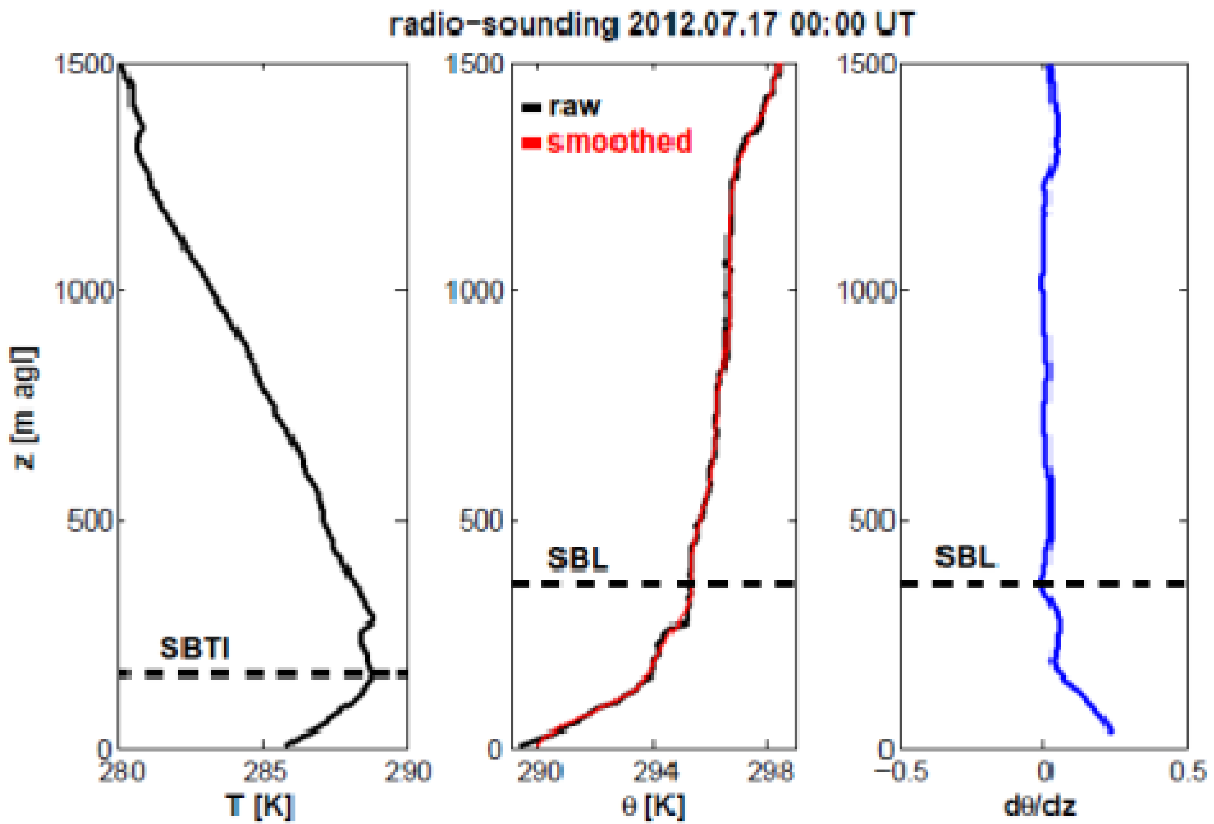
Stable BL

- A surface-based *T* inversion is a clear indicator of a stable BL
- The Surface-Based Temperature Inversion (SBTI) method computes the height of the surface-based *T* inversion
  - where *T* first decreases with elevation (dT/dz=0)



Stable BL

- Another approach is to compute the stable BL (SBL) as the height at which the gradient of θ vanishes, i.e. dθ /dz=0
- SBL is higher than SBTI since the gradient is still positive at the height of the surface-based *T* inversion



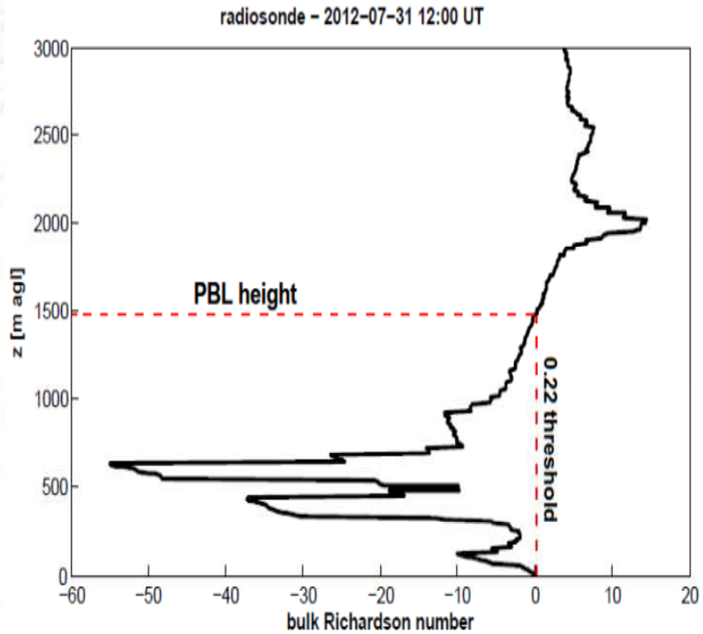
Bulk Richardson Method

- Ri is a dimensionless number relating vertical stability and vertical wind shear (ratio of convective and wind shear produced turbul.)

$$Ri = \frac{g\Delta\theta_v/\theta_v}{[(\Delta U)^2 + (\Delta V)^2]/\Delta Z}$$

- High values indicate unstable and/or weakly sheared conditions;
- Low values indicate weak instability and/or strong vertical shear.

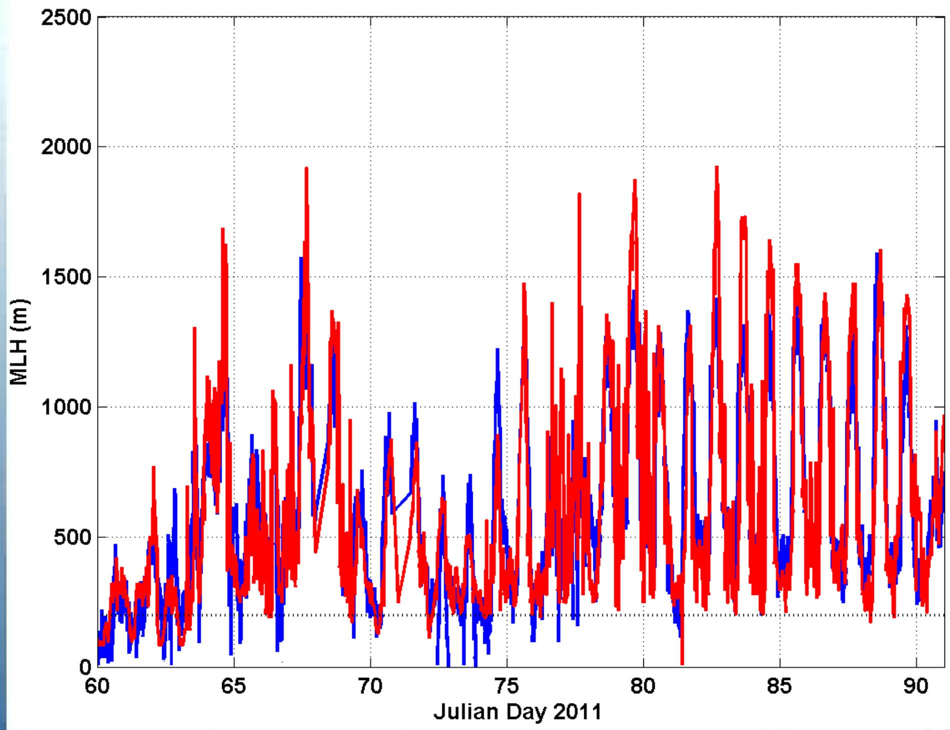
- PBL height corresponds to first elevation for which Rib is greater than a critical threshold (0.22 or 0.33 for day and night conditions

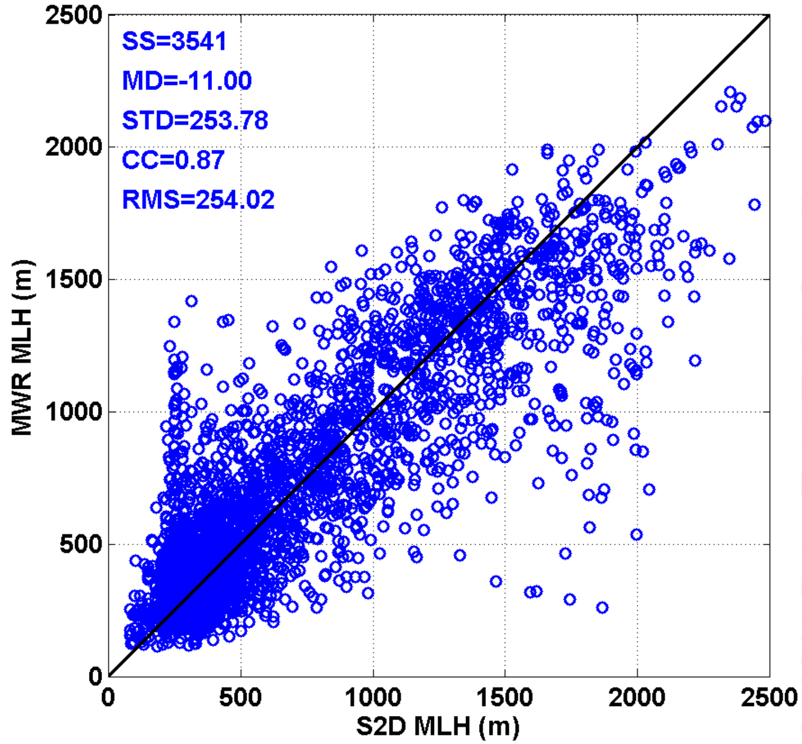


Direct Method

- Direct estimate of MLH and SBL from MWR Tb
  - Regression or Neural Network
  - Reference for training: RS or STRA2D+ (lidar)

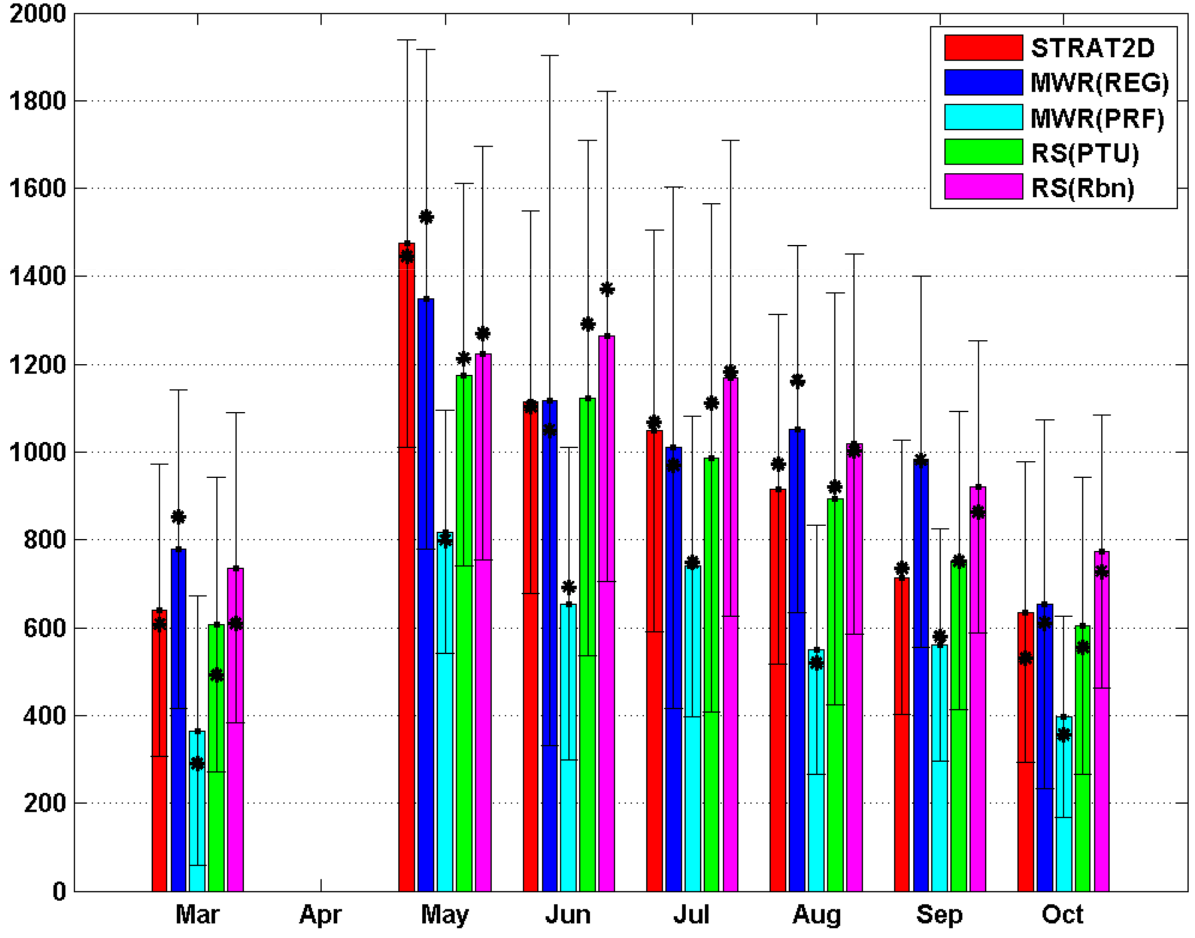
- Validated against reference (independent data)





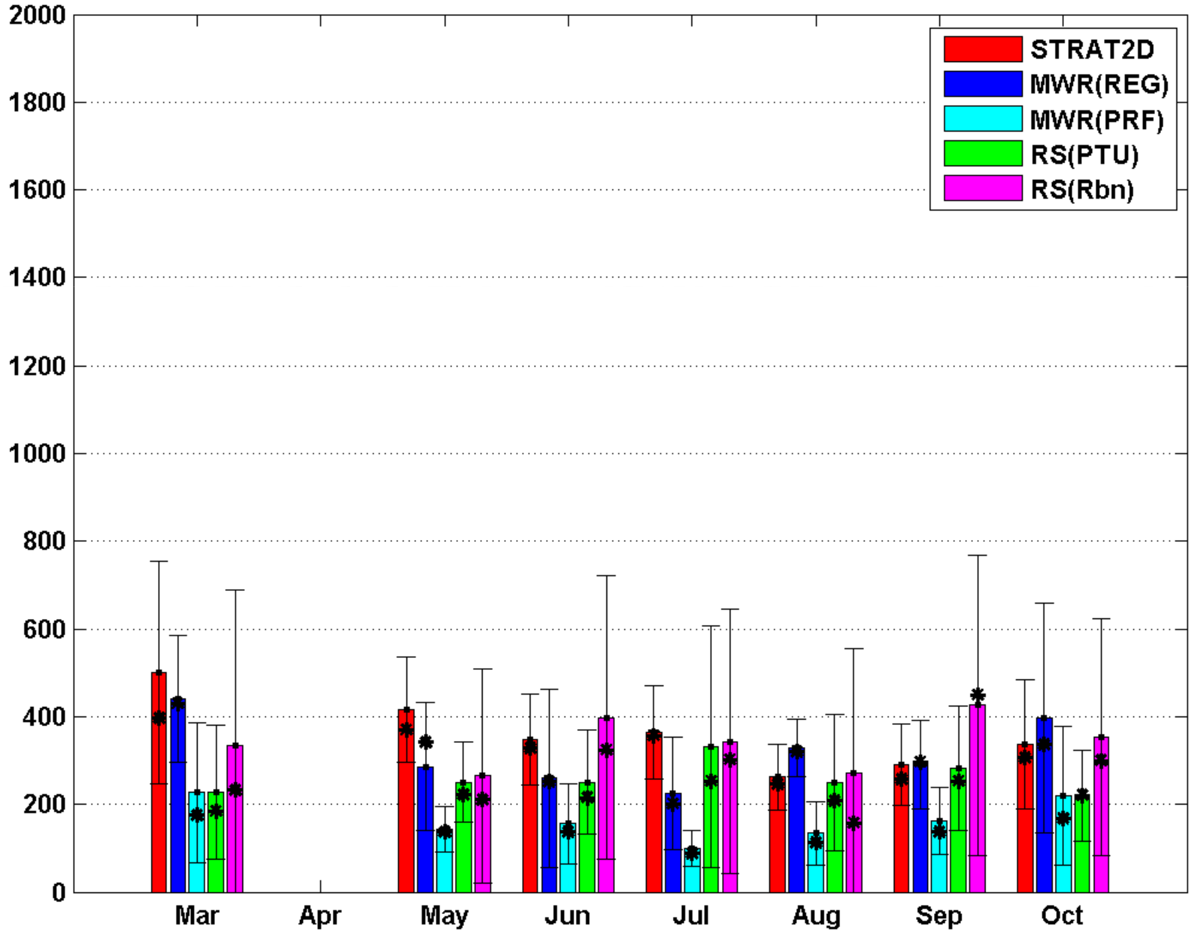
Direct Method

- Convective BL



Direct Method

- Stable BL



Summary

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- Convective BL
  - Good correlations are found with other methods
  - Differences of 100–300m between various instruments and/or methods.
- Stable BL
  - MWR can provide an estimate of SBL, while other methods retrieve the residual layer (RL) height

Bottom line

- High potential for synergy with other instruments

Thank you very much for your attention!!

Relevant publications

- Cimini, De Angelis, Dupont, Pal, and Haeffelin: Mixing layer height retrievals by multichannel MWR observations, Atmos. Meas. Tech., 2013.
- Collaud Coen, M., Praz, C., Haefele, A., Ruffieux, D., Kaufmann, P., and Calpini, B.: Determination and climatology of the planetary boundary layer height by in-situ and remote sensing methods as well as the COSMO model above the Swiss plateau, Atmos. Chem. Phys. Discuss., 14, 15419-15462, doi:10.5194/acpd-14-15419-2014, 2014.
- Seibert, P., Beyrich, F., Gryning, S. E., Joffre, S., Rasmussen, A., and Tercier, P.: Review and intercomparison of operational methods for the determination of the mixing height, Atmos. Environ., 34, 1001–1027, 2000.
- Seidel, D. J., Ao, C. O., and Li, K.: Estimating climatological planetary boundary layer heights from radiosonde observations: Comparison of methods and uncertainty analysis, J. Geophys. Res., 115, D16113, doi:10.1029/2009JD013680, 2010.

Potential Temperature

The **potential temperature** of a air parcel at pressure P is the temperature that the parcel would acquire if adiabatically brought to a standard reference pressure Po, usually 1000 mb.

$$\theta = T\left(\frac{P_0}{P}\right)^{R/c_p},$$

where T is the absolute temperature (in K) of the parcel, R is the gas constant of air, and cp is the specific heat capacity at a constant pressure.