Determining planetary boundary layer (PBL) depth via integrated data viewer (IDV) from atmospheric sounding profile data

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BACKGROUND

Planetary Boundary Layer depth: What is it? Why should you care?

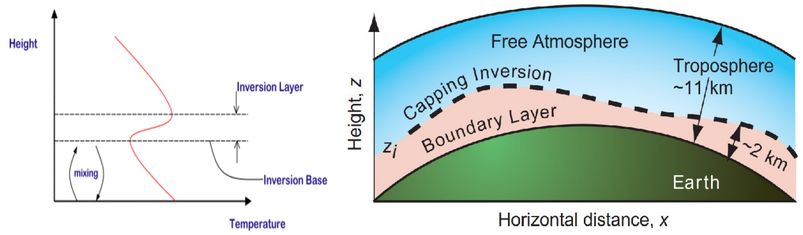


Figure 1. Vertical cross-section of (left) temperature profile and (right) qualitative visualization of PBL (adapted from Breedt (2018))

- Important parameter for weather forecasting and climate models.
- PBL depth impacts the surface air pollutant concentration.
  - Infamous Salt Lake City pollution
- Rising infrastructure and heat in the cities, referred to as urban heat island intensity(UHII), are closely related to PBL depth and transport.
- Important parameter for designing efficient and sustainable urban form.

METHOD & DATASET

Determining PBL depth

- Temperature gradient method (TGRD): PBL depth = First substantial maximum in the lapse rate of potential temperature (Fig. 1) from the surface (Stull 1988).
- Bulk Richardson number method (*Ri*)

Ri : important parameter for diagnosing flow dynamic stability (Stull 1988). For finite differences :

$$Ri_b(z_2) = \frac{g(z_2 - z_1)}{\bar{\theta}_v} \frac{\theta_v(z_2) - \theta_v(z_1)}{[u(z_2) - u(z_1)]^2 + [v(z_2) - v(z_1)]^2}$$

g = acceleration due to gravity, u, v = horizontal and vertical wind component

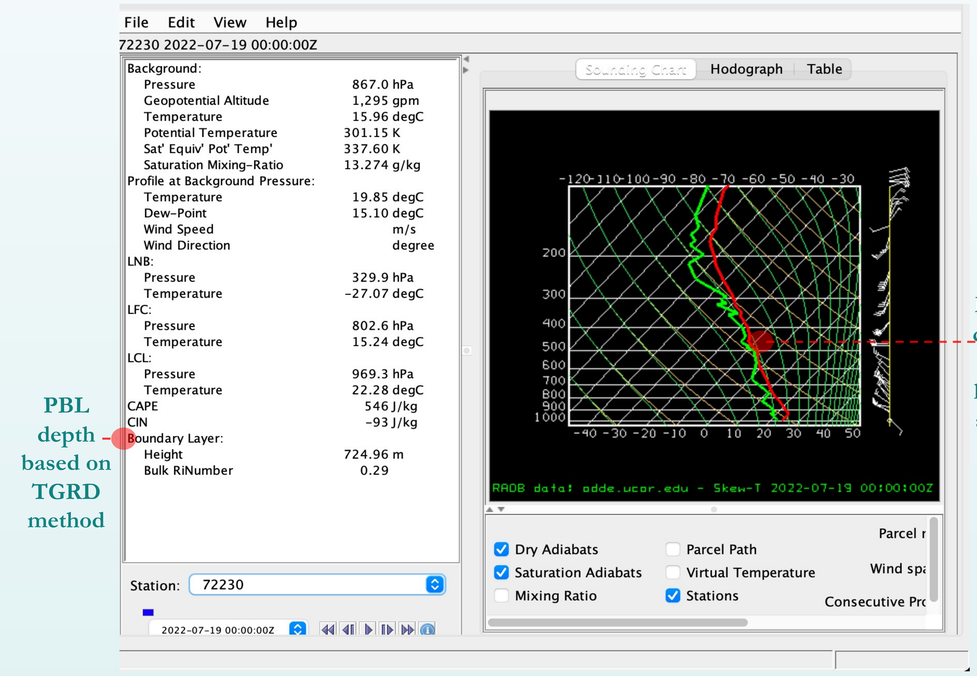
$\bar{\theta}_v$ *= average virtual potential temperature between the two levels* z_1 *and* z_2

PBL depth = *Ri* first becomes greater than a given threshold (*Ri* = 0.25 & 0.5)

- Datasets used: UCAR COSMIC-1 and COSMIC-2 Level 2 data, NASA DISCOVER–AQ – TX & CA (2013) P3-B aircraft data.
- Detailed information on the implemented Python code (relayed to Java for IDV) and the datasets can be accessed on the Git repository.

(Please scan the barcode for access. Alternatively, vist *github.com/sherrydhaliwal2021/PBL_Retrieval*)

DATA VISUALIZATION – INTEGRATED DATA VIEWER (IDV)



PBL depth based on TGRD method

Move your cursor over the line to know *Ri* at any height

Scan for more information on how to view sounding data on IDV

Verification

- The high frequency aircraft measurements by NASA field project on deriving information on surface conditions from column and vertically resolved observations relevant to air quality (DISCOVER) – Texas and California (2013) and UCAR COSMIC – 1 level 2 data were analyzed for verification.
- Spatial analysis could not be achieved due to lack of RO soundings coinciding with DISCOVER data.
- PBL retrieval via critical *Ri* number and TGRD were compared for convective boundary layer.
- The change in *Ri* (critical) did not significantly alter the PBL depth for this dataset.
- The PBL height via TGRD is usually higher than that by critical *Ri number*

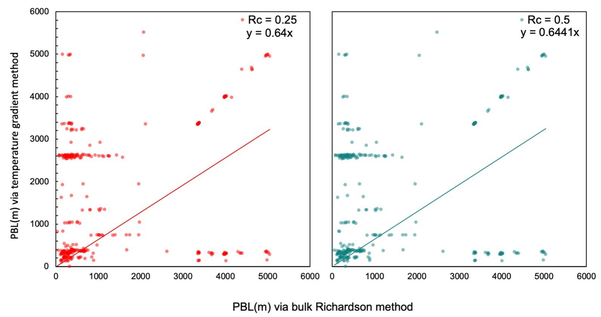


Figure 2. Comparison of PBL retrieval via TGRD and Bulk Richardson Number for NASA DISCOVER aircraft data with critical *Ri* (left) as 0.25 and (right) 0.5

KEY POINTS

- Integrated Data Viewer is a useful tool for real time retrieval of PBL for the benefit of atmospheric science educators, researchers, aviation, and/or weather forecasters.
- TGRD method can be used to retrieve PBL from both radiosonde and RO occultation soundings.
- RO soundings offer a sustainable and cost-effective way to determine ABL top in the future.

FUTURE WORK

- Effective temporal and spatial sub-setting of COSMIC data can make RO data more accessible.
- Refractivity gradient and bending angle can be further explored to identify PBL top from RO soundings (Xie et al.,2012).
- A point-by-point spatial and temporal correlation of PBL depth should be explored for verification.

REFERENCES

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