Advancing Understanding of Planetary Boundary Layer Height: Insights from the ACTIVATE Field Campaign and Comparative Assessment of Estimation Algorithms from Dropsondes

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Motivation

- Our 2nd manuscript: PBLH estimation from dropsondes
- Extend dropsondes' PBLH estimate from ACTIVATE to a worldwide application

Data & Method

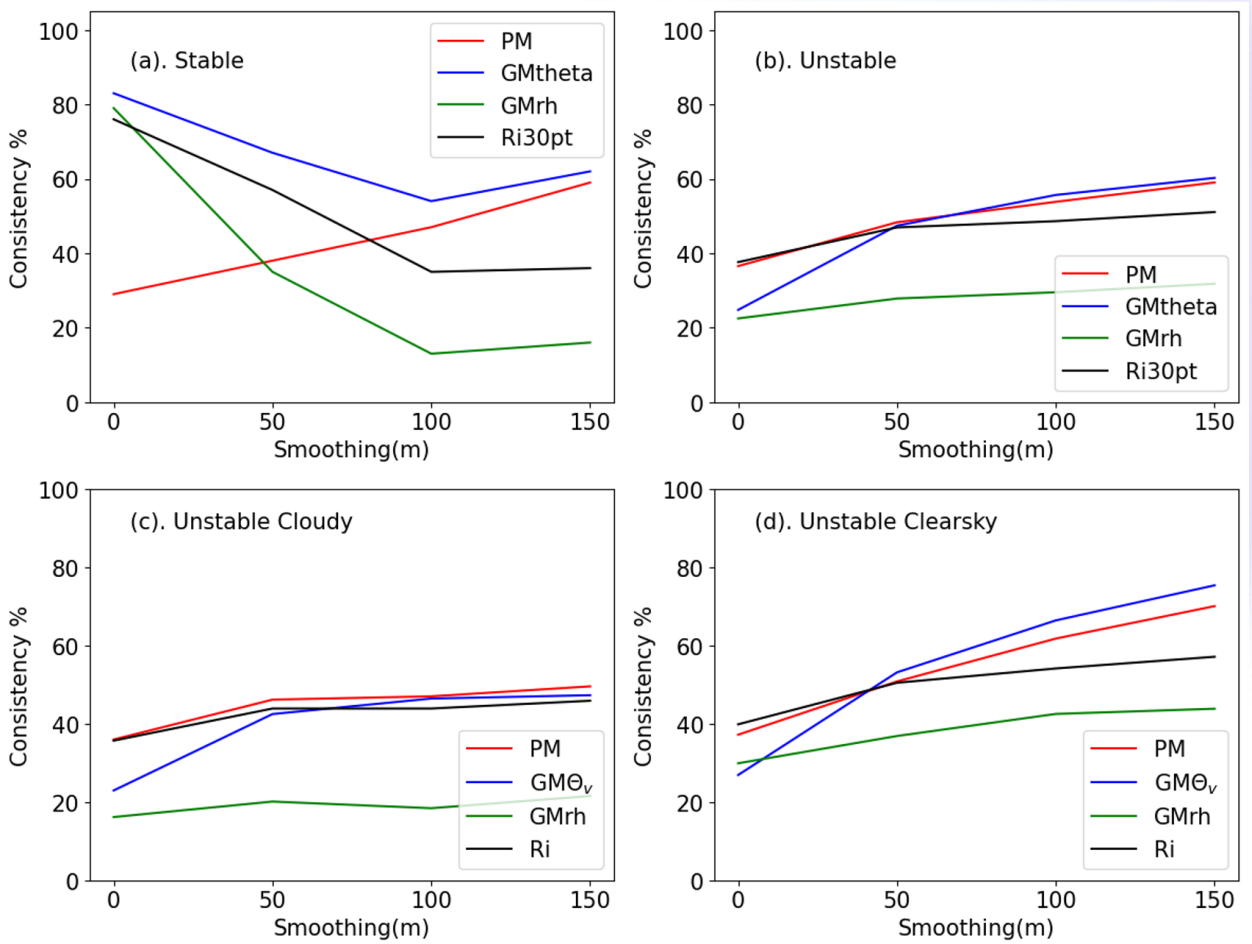
- All 760 dropsondes & HSRL cloud top height
- Evaluated four PBLH estimation method:
  - The parcel methods (PM) : Xu et al., 2023, submitted
  - The gradient method of θv (GMθv) : >0.003 K/m
  - The gradient method of relative humidity (GMrh):
    <0%(stable), minimum gradient (unstable)
  - The Richardson number (Ri): >0.25
- Four levels of smoothing (0m, 50m, 100m, 150m)
- Consistency test

Results – What is the sensitivity of these methods to variations in resolution?

	Stats	PM	GMθv	GMrh	Ri
0m vs. 50m	Median Diff (m)	0.00	-114.15	-4.25	-22.35
	IQR Diff (m)	17.91	360.90	40.13	46.15
	R^2	0.91	0.34	0.42	0.91
100m vs. 50m	Median Diff (m)	-2.88	8.35	3.20	27.35
	IQR Diff (m)	21.82	99.65	48.13	33.85
	R^2	0.95	0.70	0.53	0.92
150m vs. 50m	Median Diff (m)	-5.84	28.65	6.30	53.95
	IQR Diff (m)	47.51	182.30	83.45	59.60
	R^2	0.93	0.59	0.47	0.87

PM is the least sensitive to different resolutions.

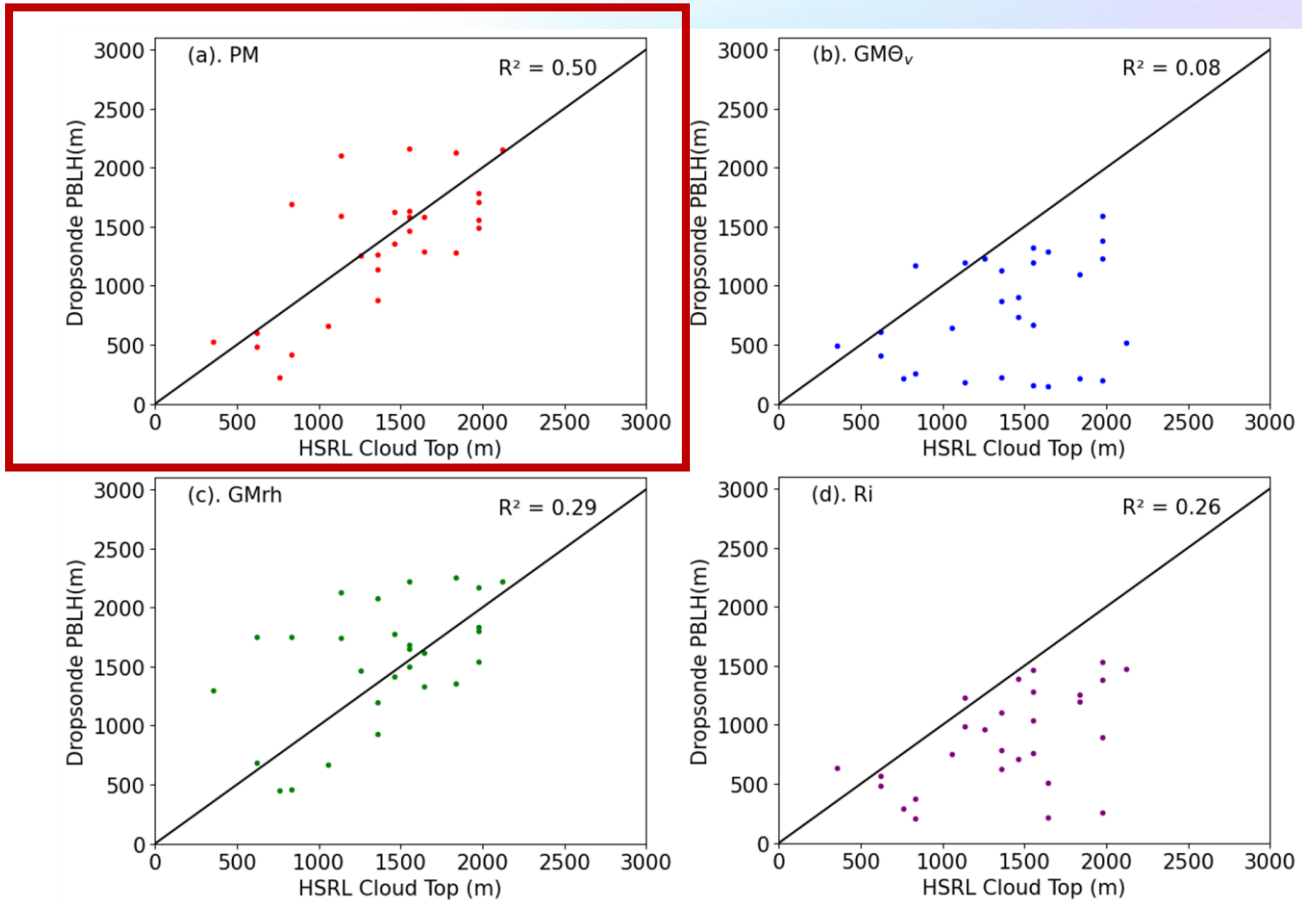
Results – How consistent are them with each other?



- Ri and GMθv are the most consistent for stable PBLs.
- Parcel method is the most consistent for unstable PBLs.

Results– Relationship with cloud top height?

- Dropsonde PBLH vs HSRL Cloud top height for thin clouds



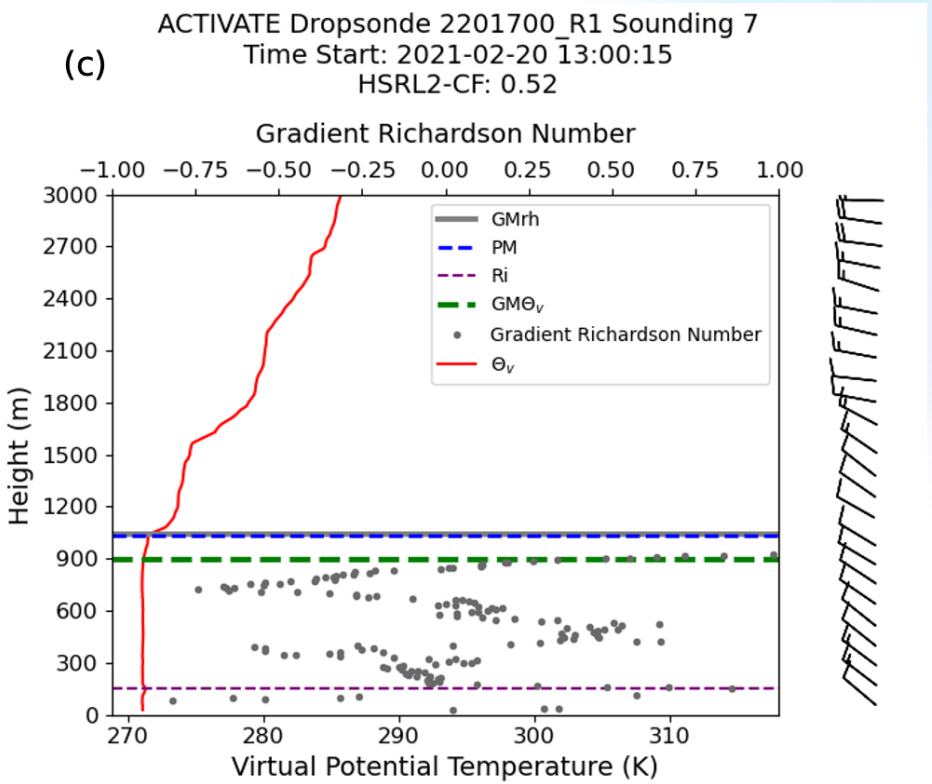
- HSRL cloud binned every 100m (>5 points).
- PM has the highest correlation with cloud top height.

Results – Can we improve these methods? Richardson number

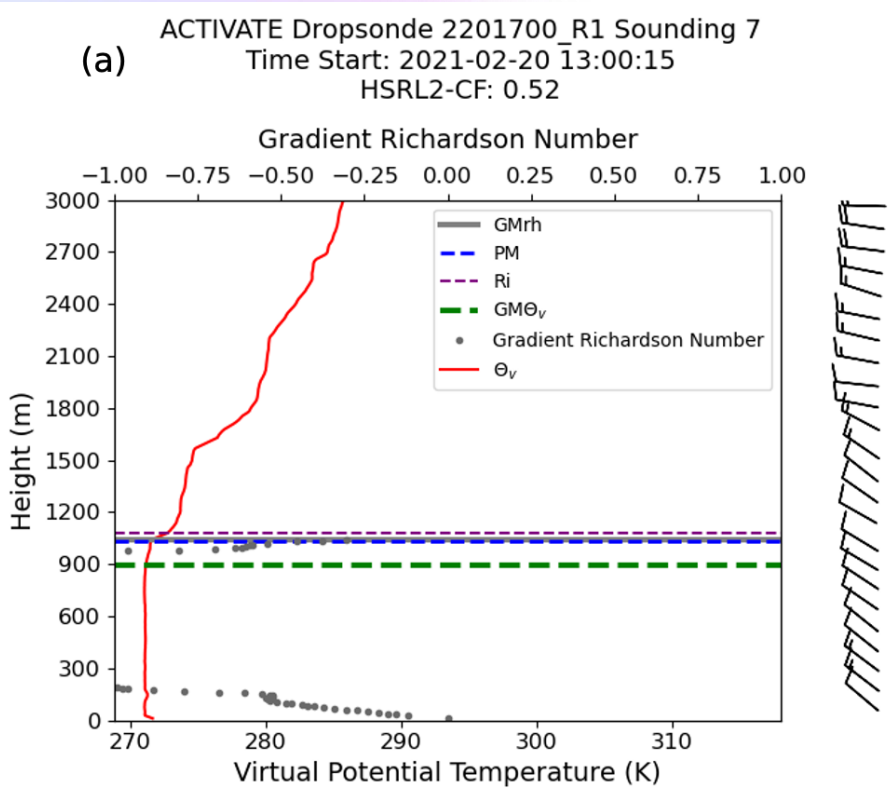
$$Ri = \frac{g}{\theta_v}\left(\frac{d\theta * dz}{(du)^2 + (dv)^2 + bu^{*2}}\right)$$

$$u^* = \frac{0.4 * \sqrt{u_s^2 + v_s^2}}{\ln(z_s * 10^4)}$$

No bu* term



With bu* term



Take home points

- PM is the least sensitive to different resolutions.
- PM is the most consistent for unstable PBLs, and Ri is the most consistent for stable PBLs.
- We have modified these four methods to improve PBL estimates.