Boundary layer observations with profilers and other ground-based remote sensors

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What's a profiler?

Properly "radar wind profiler"
Sensitive Doppler radar
Vertical beam and 2-4 beams at 15-20° off vertical
Low power, long dwell time, and low cost compared to weather radars
Return signal is Bragg scattered from refractivity variations in clear air
Any hydrometeors or insects may contribute or even dominate
Range depends on frequency
BL profilers are at UHF (typically ~1 GHz)
Radio acoustic sounding (RASS) attachment for temperature profiling

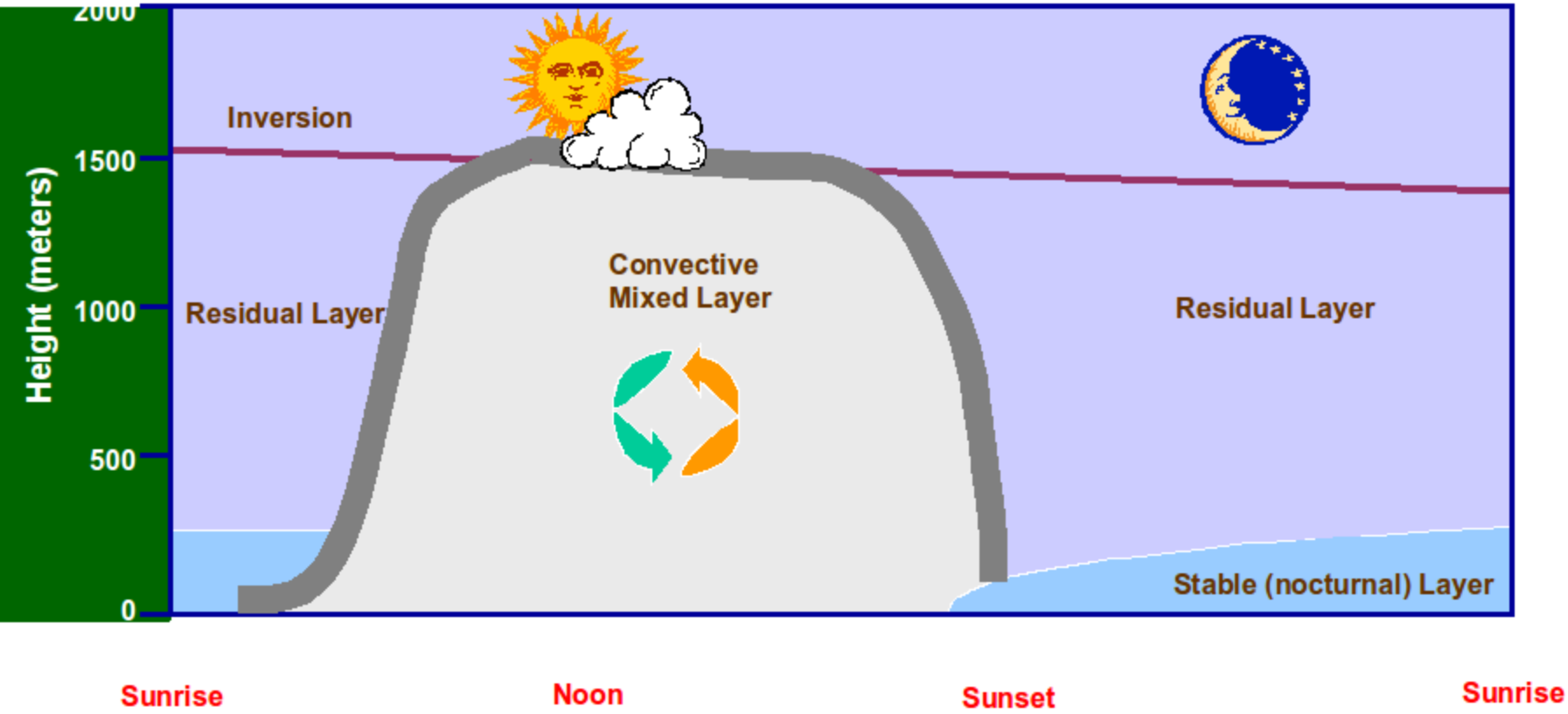
Performance of a typical BL profiler

Wind measurement time 10 – 60 min
Height resolution 100 m – 200 m
Minimum range 120 m
Max range: at least to BL top
Careful QA required:
Low signal
Birds
Hydrometeors

Other ground-based remote sensors

Lidar and Sodar use principles similar to radar
Many types of lidars exist
Lidars provide:
very fine resolution
fast sampling
measurements of water vapor, ozone, particulate characteristics (some types)
Lidar disadvantages:
cost (capital and operational)
limited by cloud
Sodar advantages:
low cost
low minimum range
Sodar disadvantages:
noise pollution
impacted by ambient noise (including wind and rain)
low maximum range

Atmospheric Boundary Layer Diurnal Variation



Morning transition

Establishes initial conditions for ABL growth

Prognostics require initialization

Models must be calibrated and validated

Profiler observations provide estimate of end of transition (onset of daytime convective ABL)

Afternoon transition

Transition between fully-developed daytime convective ABL and nocturnal ABL

How does turbulence vary with time and height in the afternoon?

Sudden collapse or a gradual decline?

When does transition start?

Ground-based remote sensors provide continous data in a column or volume a valuable complement to sparse aircraft measurements

Can be (and usually should be) deployed in groups

Wind profilers are good for much more than just wind

Output must be used carefully – beware of “black boxes”

Upscaling from point (field scale) to grid (landscape scale).

Need for effective surface parameters in weather forecasting, climate modelling, and air pollution modelling.

Relevant surface boundary conditions from satellite images are now available.

ABL depth from profiler reflectivity

Temperature change from RASS (BL average)

Surface fluxes

Radiative heating

The heterogenieties are

variations in surface boundary conditions

Roughness (z0)

Surface temperature (Ts)

Land Surface/Land Use

Surface humidity/Soil Moisture

The spatial scale is important

The microscale aggregation model

1. Land cover type map
2. Roughness map some measured pixels
3. Land cover/Land Use map
4. Surface temperature map
5. Air temperature function of hgt
6. Wind measured function of hgt
7. Soil Moisture

1. The effective roughness for momentum <z0>
2. The effective roughness for temperature <z0t >
3. A friction velocity map
4. A surface sensible heat flux map
5. A Surface latent heat flux map (maybe!)