Validation of an advanced ceilometer-based boundary layer height detection algorithm

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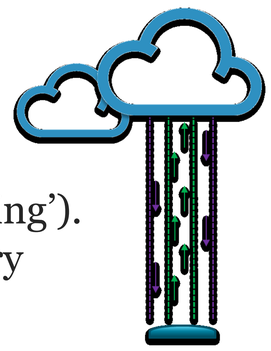
VAISALA

Sonoma Technology, Inc.

I. Ceilometers



- Originally designed and used for detection of cloud based height ('ceiling').
- Widely used for detection of boundary layer structures and height.

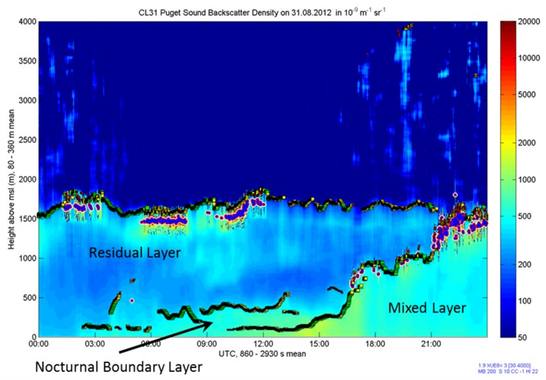
Vaisala CL51:
Laser diode operating @ 910 nm

Dust, smoke, haze, aerosols: 0.5nm to 5mm
Particulate matter: 2.5mm, 10mm
Cloud droplets: ~10mm

II. Boundary Layer: Mixed Layer

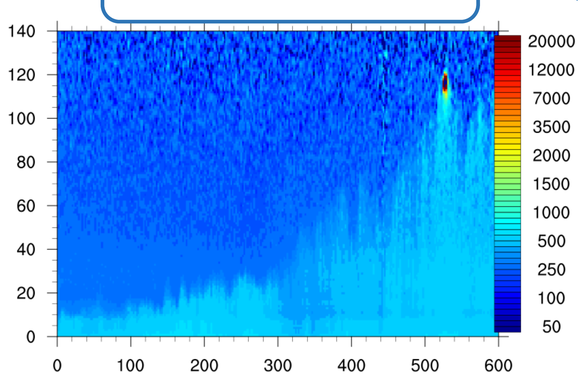
Characteristics:

- "Well mixed"
  - Forced by daytime surface heating
  - Result of eddy mixing
- Full of "backscatterers"
  - Moisture
  - Aerosols and particles
- Presence of backscatter gradients between mixed layer and layers above.

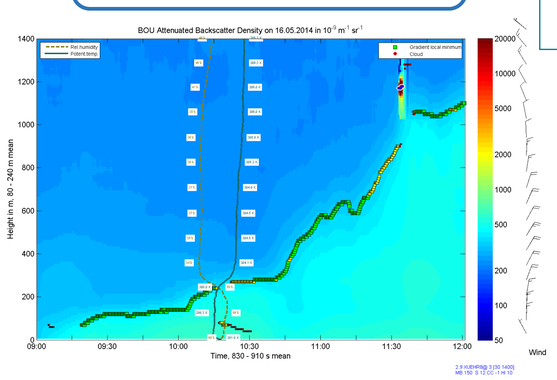


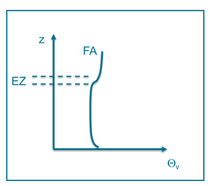
III. Boundary Layer Detection

Backscatter data is noisy

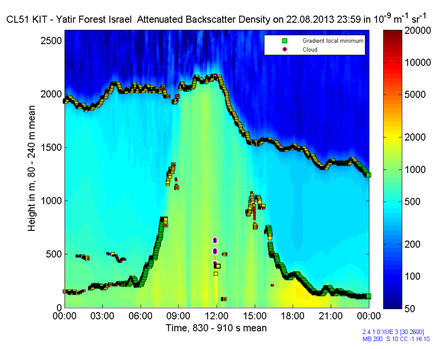


Step 1: Average and Filter data
Step 2: Apply Gradient Method

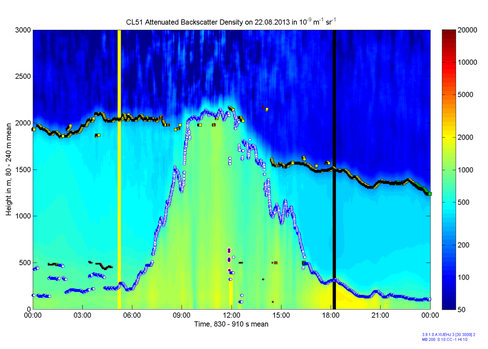




Challenge: Multiple layer detection



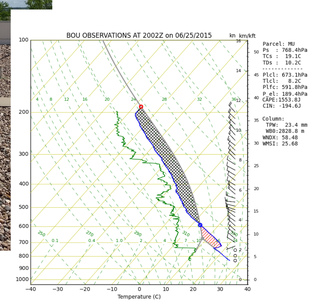
Goal: The boundary layer



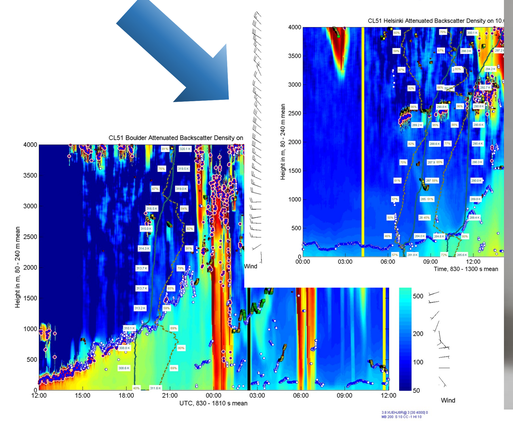
IV. Advanced Algorithm Exploration and Validation

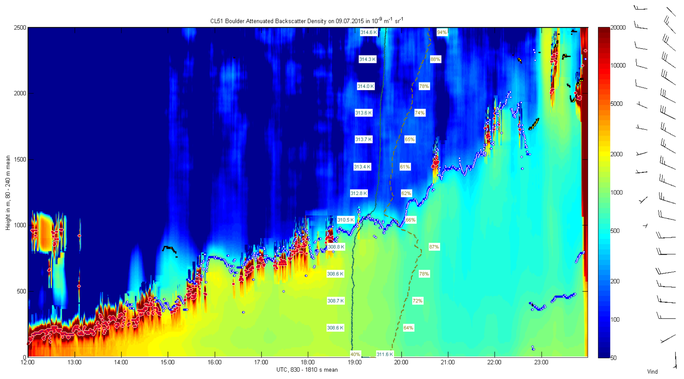
- Focus first on mixed layer using:
  - Gradient method
    - Results in multiple layers
  - TOPROF methods – STRAT+
    - Under continuous development
  - Wavelet method
    - Worked well for sharp gradients, marginal during convective rise
  - Profile fitting
    - Worked well for convective rise, but had some challenges
- Best performance was reached via:
  - Profile fitting + Gradient method applied to average data
- Validation:
  - Launch 35 radiosondes (Boulder, CO and Helsinki, Finland)
  - Compare observation to algorithm
  - Excellent agreement found for all cases.

Step 1: Radiosonde field campaign

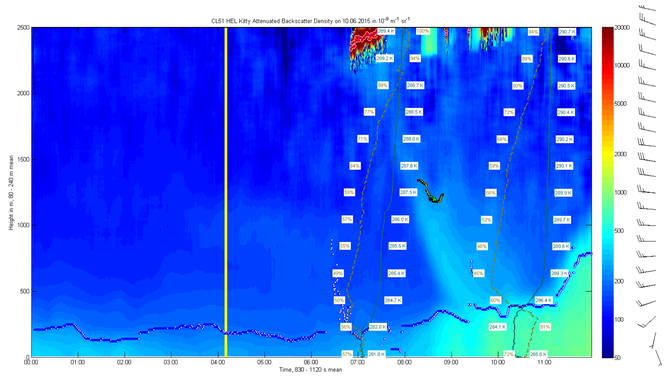


Step 2: Merge data and validate





Example: Boulder Colorado



Example: Helsinki Finland