IOAS-AOLS 623

WRF Model Boundary Layer Height Validation Using the Vaisala Ceilometer

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Background

The Planetary Boundary Layer Height (PBLH) continues to be an important meteorological variable that impacts the operations of many portions of the atmospheric science industry. The growth and subsequent depth of the boundary layer is of interest to entities such as air quality agencies, weather forecasters, and most recently, the renewable energy industry. Historically, specification of the PBLH has been limited to using sounding information provided by radiosondes or field study datasets consisting of a some combination of meteorological instrumentation on towers, aircraft measurements, and more recently, ground based remote sensing platforms. These datasets typically suffer from poor spatial and/or temporal resolution. As a result, Numerical Weather Prediction (NWP) has been used in practice to specify the PBLH for regions without measurements and for times between measurements.

For the past 5 years, Vaisala has made available the BLVIEW software package to users of the Vaisala CL31 (Figure 1) and CL51 ceilometers. Embedded within this software is a PBLH retrieval algorithm. For any ceilometer location, BLVIEW can provide the PBLH along with a vertical depiction of the backscatter density above the instrument (Figure 2). The ceilometer therefore provides a cost-effective solution for the limitations associated with typical boundary layer observations.

Given the availability of PBLH observations from the Vaisala ceilometer, the purpose of this study is to validate the specification of PBLH from the Weather, Research, and Forecast (WRF) model V3.4.1 for varying boundary layer parameterizations using the BLVIEW PBLH retrieval.

Methodology

PBLH Observations

The observed PBLH was obtained directly from the Vaisala BLVIEW software using the CL31 located at the Puget Sound Clear Air Agency (with permission). Three months of observations were used to arrive at the conclusions presented in this poster, and a four day period from July 10-13 is presented here.

WRF Configuration

This case study includes four-24 hour simulations, valid 00 UTC each day from July 10 to July 13, 2012. The GFS (0.5 degree) was used as the background field and provided the boundary conditions. A nested domain centered on the CL31 was run with horizontal resolutions of 12 km (outer) and 4km (inner). Thirty-nine vertical levels, many stacked near the surface, were used to provide high resolution coverage of the boundary layer. No data assimilation was applied.

Physics options were held constant with the exception of the boundary layer parameterization and its associated surface layer parameterization. Four boundary layer parameterizations were tested, representing both new and commonly used options. Table 1 outlines the WRF model physics options used.

Figure 1

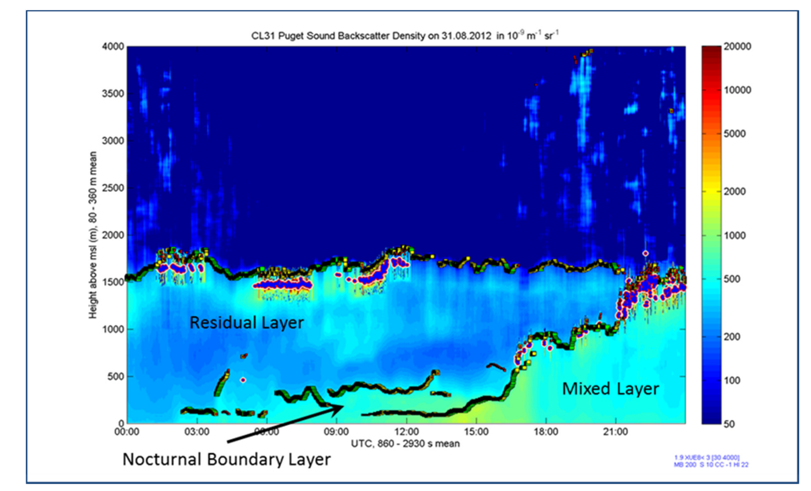


Figure 2

Analysis and Results

Ceilometer Analysis

BLVIEW backscatter density plots with overlaid radiosonde soundings from Quillayute, WA (UIL) are presented in Figures 3-6. Early morning, low level clouds along with the presence of fog (Figure 4,5), rain (Figure 3,5), and drizzle (Figure 6) can be seen for each case day as indicated by high backscatter density returns near or at the surface. These events give way to clearer skies and the eventual growth of the boundary layer. The PBLH each day varies in response to the amount heating the surface is able achieve given the varying amount of cloud cover and precipitation during the morning.

NWP Results

Time series plots for the four day study period presented here are shown in Figures 7-10. The boundary layer parameterizations were mostly in agreement in all cases, with MYNN and YSU providing the most representative boundary layer heights over the study period. The NWP simulations appear to have trouble simulating the presence of light precipitation as indicated by a rapidly growing simulated PBLH instead of suppressed growth due to presence of morning clouds and surface moisture.

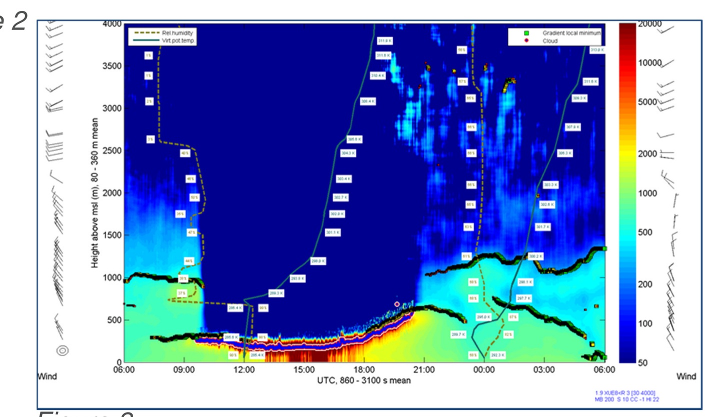


Figure 3

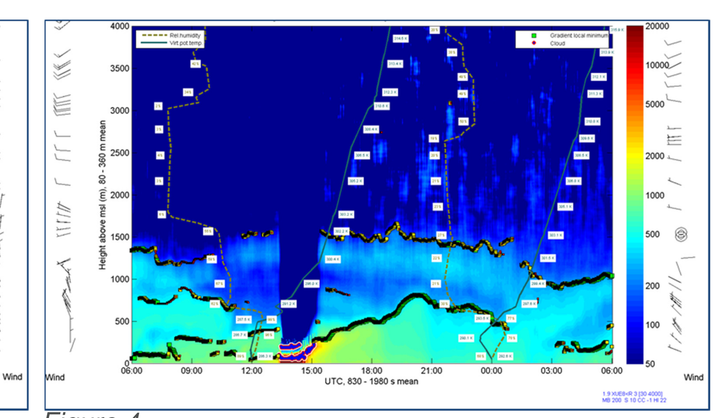


Figure 4

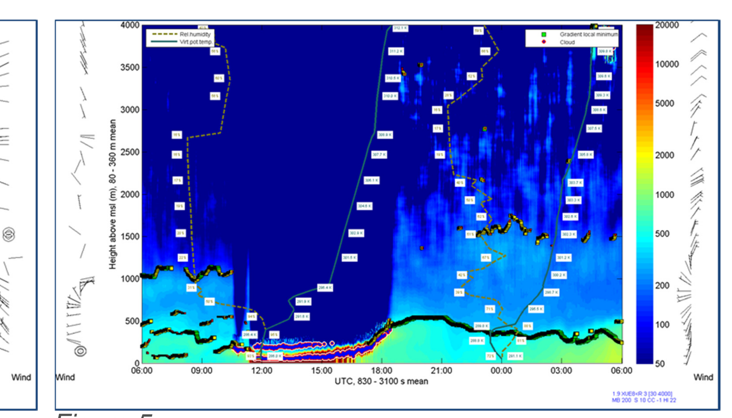
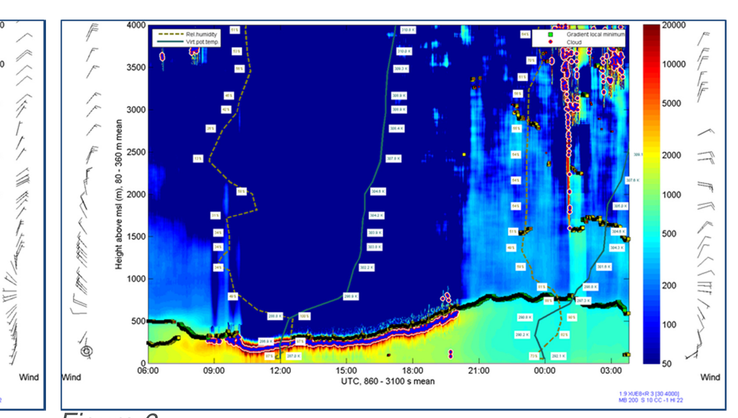


Figure 5



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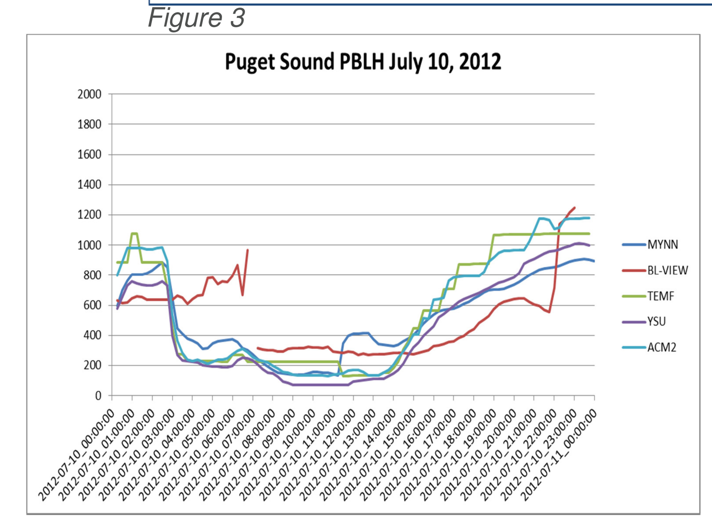
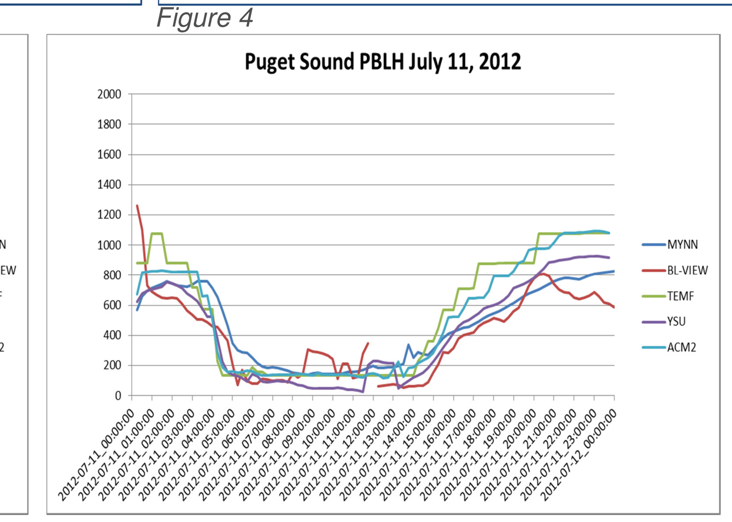


Figure 7



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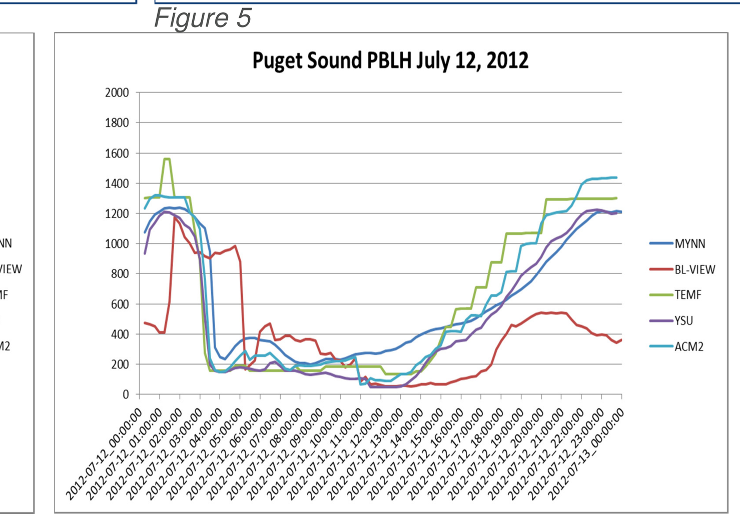

Figure 9

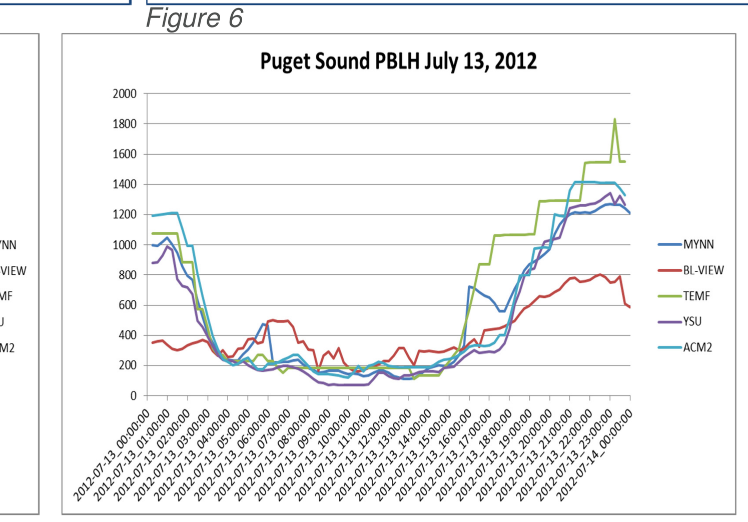

Figure 10

Boundary Layer Parameterization	Abbreviation
Mellor-Yamada Nakanishi and Niino 2.5 order	MYNN
Yonsei University	YSU
Asymmetric Convective Model	ACM2
Total Energy – Mass Flux	TEMF

Parameterization	Option
Land Surface	NOAH
Longwave Radiation	RRTM
Shortwave Radiation	Dudhia
Cumulus (outer domain only)	Grell 3D
Microphysics	Thompson

Table 1

Findings

The retrieval of PBLH from the Vaisala ceilometer was able to provide a reliable and accurate measurement as verified by radiosonde. It is quite apparent that the presence of an observational instrument is superior to relying on model output alone. In addition, the BLVIEW PBLH was available throughout the day providing a superior temporal resolution to the radiosondes, and if widely deployed, would provide a superior spatial resolution.

Special Thanks to pscleanair.org Puget Sound Clean Air Agency