Predicting Terrain-Influenced Winds with WindNinja

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Background

Every year, forest fires in Montana occur that pose a threat to life and property. One of the main dangers that wildland fire fighters face is unpredictable fire behavior from erratic wind conditions in complex terrain. Finding a way to be able to predict the velocity of the wind, even for just a few hours in advance, can mitigate dangerous situations and increase resource allocation efficiencies. A program called WindNinja, developed by the U.S. Forest Service’s Missoula Fire Sciences Laboratory, can take generally available wind information and produce a wind simulation vector field at high resolution for a given digital elevation model. If the initial data is forecasted and then inserted into WindNinja, WindNinja can predict how the wind, and by extension the fire, will behave up to several hours in advance.

Introduction

In this project, we will be focusing on validating WindNinja; this software was designed to make wind vector simulations over complex terrain and output them into Google Earth (Figure 1). Our validation goal is to see if WindNinja is more accurate due to its higher resolution grid than National Weather Service model data such as RUC, NAM, GFS and NDFD. With Incident Meteorologists (Figure 2) using WindNinja they might be able to predict wind patterns with higher accuracy. We are taking the wind vectors WindNinja outputs, and the output wind vectors from weather models to compare them against data we will be collecting. The collected data will come from two sources. One will be from a RAWS, which is a Remote Automated Weather Station. These stations are located all over the US. They collect wind velocity, temperature, pressure, and humidity. The RAWS data we will be collecting. The collected data will come from two sources. One will be from a RAWS, which is a Remote Automated Weather Station. These stations are located all over the US. They collect wind velocity, temperature, pressure, and humidity. The RAWS data we will be collecting. The collected data will come from two sources. One will be from a RAWS, which is a Remote Automated Weather Station. These stations are located all over the US. They collect wind velocity, temperature, pressure, and humidity.

Methods of Evaluation

1. Obtain data from RAWS database.
2. Obtain weather model data for a specific model (RUC, NAM, NDFD, and GFS) covering a bounded region and input into WindNinja.
3. Extract WindNinja outputs for RAWS location.
4. Extract raw weather model outputs for RAWS location.
5. Compare WindNinja and raw weather model outputs with RAWS data.

Step 1

We are currently in the process of writing a Python script to go to a remote database to collect RAWS data. These data points will be used to compare against the inputs and outputs of WindNinja.

Step 2

Initialization of WindNinja with separate weather models and it’s terrain options with a unique command line configuration file. Note: WindNinja has a diurnal wind option that we will be testing. Diurnal winds are the up slope and down slope winds caused by the heating and cooling of near surface air due to daytime sun and nighttime surface radiation loss.

Step 3

Implementation of Python data point extraction code that collects the WindNinja outputs and weather model inputs, finds closest grid location to RAWS latitude and longitude to compare against each other.

Error Analysis

To quantitatively compare the wind speed values of the weather models, WindNinja, and RAWS the errors will be calculated using the following equations:

\[ \text{RMSE} = \sqrt{\frac{\sum_{i=1}^{N} (u_i - \bar{u})^2}{N}} \]
\[ \text{MAE} = \frac{\sum_{i=1}^{N} |u_i - \bar{u}|}{N} \]

Where \( u_i \) is a value that can be from Windninja or the weather model to be compared, and \( \bar{u} \) is the value measured at the RAWS, and \( N \) is the number of data points. We will use both Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) to sufficiently articulate variances in the data.

DEM Location

For this Evaluation, We are choosing a region of mountainous terrain with high density of RAWS. The Criteria for the site location is as follows:

- 25 mile by 25 mile area
- In mountains similar to Montana’s
- At least 3-5 RAW stations
- RAW stations that are currently active and transmitting data.
- Within a reasonable distance to Missoula so we can launch Radiosondes for comparable data.

We have tentatively chosen a site in Montana that currently has five active RAWS located in the southern Bitterroot Valley.

Works Cited


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Figure 1. WindNinja output on Google earth

Figure 2. incident meteorologist http://www.ncdc.noaa.gov/features_02_monitoring/raews.html

Figure 3. GRAW radiosonde launch 8/17/11, Missoula, MT