ORIE4741 Project Proposal - Mt. Washington Weather (data analysis)
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Github Link: https://github.com/bhmoose/ORIE4741_MtWashingtonWeather

Dear Director of the *Mount Washington Observatory:*
Your organization, the *Mount Washington Observatory,* issues forecasts for the White Mountains of New Hampshire, a region which frequently sees extreme elevation-dependent changes in weather over short distances [1]. Much of weather forecasting is driven by output from dynamical numerical weather prediction (NWP) models such as the *High Resolution Rapid Refresh* (HRRR) model or the *Global Forecast System* (GFS), but many frequently-used operational weather models have resolutions from 3 to ~30 kilometers [2,3,4]. Given the diversity of weather in the White Mountains, there are likely some small-scale, topography-induced dynamics that affect wind speeds and perhaps wind direction, as well as cloud cover, ice and snow accumulation, and other meteorological variables. The scales of these effects may be smaller than those explicitly resolvable by weather models, but prediction of extreme weather in the mountains remains crucial for the safety of hikers and those driving on the Mount Washington Auto Road, in addition to your team of scientists at the observatory itself. Your institution has collected observational datasets of weather conditions on the summit of Mount Washington, and machine learning methods based on NWP model output (regression methods for continuous variables such as wind speed, or classification methods for identification of weather conditions, such as wind gusts, above a certain 'severe' threshold) could provide valuable insight into the predictability of weather on Mt. Washington. Even without extremely high-resolution models, we may be able to apply machine learning to lower-resolution output in an effort to improve local forecasts. Some central questions of our project will likely include:

Can we effectively predict wind speeds [or, if time allows, other meteorological variables] *on the summit of Mt. Washington using machine learning techniques applied to NWP model output? How about predicting the occurrence of wind gusts above a certain threshold (i.e., 70mph)?*

How much of an improvement upon the baseline forecast performance[1] of NWP models can these machine learning methods make, if any?

Dataset 1 - Numerical Weather Prediction Model Output: We plan to train a machine learning model on weather model output from either the North American Mesoscale Model (NAM), High-Resolution Rapid Refresh Model (HRRR), or the Global Forecast System Model (GFS), or perhaps others or some combination of models. Historical forecast model run data is hosted in the cloud by *Amazon Web Services* (among other sources) and can easily be read into Python using the *Herbie* and *xarray* Python packages [3,4,5,6]. HRRR data is available since 2014 (the longest of the available datasets - the other aforementioned models are archived back to 2021 on AWS) [3]. Therefore, HRRR would probably be the best model to use to ensure that we have a long training dataset representative of a variety of different weather conditions. HRRR model output is provided in GRIB files which include a variety of atmospheric variables at a 3-kilometer resolution, multiple vertical levels, and at hourly temporal forecast time

[1] By 'baseline', we mean simply taking the model output at the nearest grid cell to Mt. Washington.

step for lead times up to 18 - 48 hours (the longer runs occur every 6 hours) [3]. One HRRR forecast run was read into Python with *Herbie*, and contains 2215 variable-vertical level combinations for each of the 18 forecast hours across a 1059x1799 horizontal grid. The *large* majority of these billions of data points, however, are unused and never need to be read into Python. Some variables that might be of interest include temperature, relative humidity, the vector wind components at levels in the lower part of the atmosphere, and pressures at various levels near the White Mountains region.

Dataset 2 - Mount Washington Station Observations: Observations at the summit have been compiled by the *Mount Washington Observatory* into monthly PDF files with daily summaries of weather conditions from 2005 to the present (6646 records, 17 features) [7]. These files consist of tables with information about daily precipitation, mean and peak wind speeds, temperatures, number of minutes of sunshine, etc. Furthermore, quasi-hourly observations from the Mount Washington weather station from 1973 to the present are available via the Iowa Environmental Mesonet (357759 records and 29 features, although many of them are often missing) [8]. This data consists of weather conditions including precipitation type, wind direction and speed, and temperatures, as well as other features. This is a messy dataset, with a significant number of missing data points for some fields, and will require data cleaning prior to use.

We hope that this project will assist in forecasting efforts for the Mount Washington area and serve as a useful baseline for further refinement by expert forecasters.

- Ben Moose, Yama Bazger, and Adrianna Ahn

References

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