USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Rocky Mountain Research Station

Science You Can Use *(in 5 minutes)*

JUNE 2021

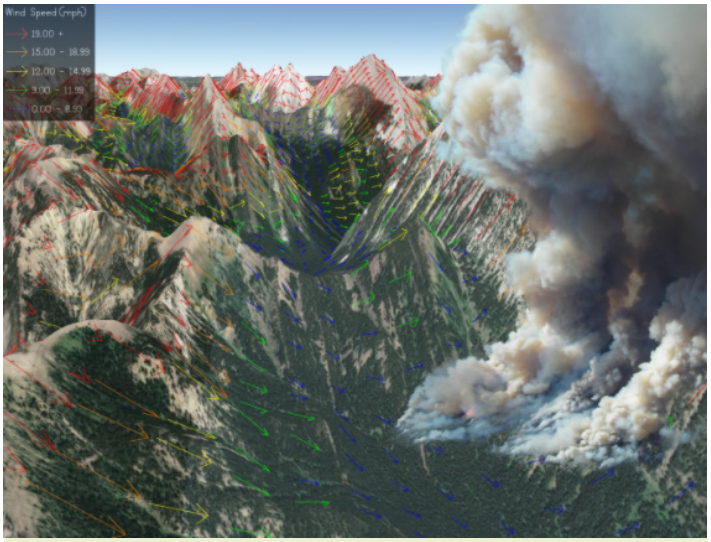
Microscale Wind Modeling: WindNinja for Fire Management

WindNinja, a tool developed by RMRS scientists, delivers high-resolution wind predictions within seconds for emergency fire responders making on-the-ground decisions. The program computes spatially-varying wind fields to help predict winds at small scales in complex terrain. These predictions are extremely important in fire-prone landscapes where local changes in the near-surface wind are not predicted well by either operational weather models or expert judgment but are extremely important for accurate fire behavior predictions.

In 2018, WindNinja provided critical information to the Operations Team on the Cougar Creek Fire on the Okanogan-Wenatchee National Forest in Washington when a Division Supervisor was suddenly unable to drive a stretch of road due to fire behavior under unexpected winds. The Incident Meteorologist (IMET) used WindNinja to assess the wind field in the area, and the simulation showed an eddy on the lee side of the ridge. The IMET, Dan Borsum, from the National Weather Service (NWS) says, “This WindNinja simulation provided the information needed for us to conclude that the wind reversal would be a concern throughout the night, and allowed the Division Supervisor to modify plans to monitor a burnout that had been conducted earlier in the day.”

WindNinja performs microscale wind modeling and is typically run on domain sizes up to 50 kilometers by 50 kilometers at horizontal resolutions around 100 meters. This microscale wind modeling is used for a variety of tasks in wildland fire management, including planning, reconstructing past events, and exploring what-if scenarios. It is embedded within a number of operational systems routinely used by U.S. Interagency Wildland Fire response teams, including the Wildland Fire Decision Support System and FlamMap, and is also regularly used as a stand-alone model by both fire managers and on-the-ground firefighters in the United States and abroad.

WindNinja can be run in three different modes depending on the application and available inputs. The first mode is a forecast, where WindNinja uses coarser resolution mesoscale weather model data from the U.S. NWS to forecast wind at future times. The second mode uses one or more surface wind measurements to build a wind field for the area. The third mode uses a user-specified average surface wind speed and direction.



WindNinja is a model that simulates high-resolution winds in mountainous terrain and is designed specifically for use in operational wildland fire applications. (USDA image)

WindNinja outputs include ASCII raster grids of wind speed and direction for use in spatial fire behavior models such as FARSITE and FlamMap, a GIS shapefile for plotting wind vectors in GIS programs, a geospatial PDF, and a .kmz file for viewing in Google Earth. WindNinja has several unique features, including a diurnal slope flow parameterization and a non-neutral atmospheric stability parameterization. It also has the ability to download digital elevation, vegetation, operational weather model forecast, and observed weather data from a variety of sources for model initialization.

A mobile WindNinja app is also available for iOS and Android from which users can set up and run simulations on a remote server and then download and view the results on a mobile device. The WindNinja team provides more information and tutorials for the main features of the program on their website.

PROJECT LEAD

NATALIE S. WAGENBRENNER is a Research Meteorologist with the Rocky Mountain Research Station. Natalie's research involves measuring and modeling the atmosphere over complex terrain in support of wildland fire applications. She is a co-developer of and project manager for WindNinja. Natalie is also involved with wildland fire management as a Public Information Officer on the Type 2 Northern Rockies Wildland Fire Management Team.

KEY MANAGEMENT CONSIDERATIONS

- WindNinja is a microscale diagnostic wind model, developed for and widely used in operational wildland fire applications both in the United States and abroad.
- WindNinja was developed to be used by emergency fire responders within their typical operational constraints of fast simulation times (seconds), minimal computing requirements (laptop computers), and low technical expertise.
- WindNinja can be run in three different modes: to forecast conditions using data from the U.S. National Weather Service, to build a wind field using surface wind measurements, or to build a wind field using a user-specified average surface wind speed and direction.

WindNinja winds in a fire progression simulation posted in a yurt in fire camp during the Pioneer Fire. (Courtesy photo by Jason Forthofer, Mechanical Engineer, Missoula Fire Sciences Laboratory).

FURTHER READING

Wagenbrenner, N.S.; Forthofer, J.M.; Page, W.G.; Butler, B.W. 2019. Development and evaluation of a Reynolds-Averaged Navier-Stokes solver in WindNinja for operational wildland fire applications. Atmosphere. 10(672). doi:10.3390/atmos10110672.

Wagenbrenner, N.S.; Forthofer, J.M.; Lamb, B.K.; Shannon, K.S.; Butler, B.W. 2016. Downscaling surface wind predictions from numerical weather prediction models in complex terrain with WindNinja. Atmospheric Chemistry and Physics. 16:5229-5241, doi:10.5194/acp-16-5229-2016.

Forthofer, J.M.; Butler, B.W.; Wagenbrenner, N.S. 2014. A comparison of three approaches for simulating fine-scale surface winds in support of wildland fire management. Part I. Model formulation and comparison against measurements. International Journal of Wildland Fire. 23:969-931. doi:10.1071/WF12089.

Background image: A mobile app was developed to make WindNinja even more convenient for users in the field. (USDA Forest Service image).

The Rocky Mountain Research Station is one of seven units within USDA Forest Service Research & Development. RMRS maintains 14 field laboratories throughout a 12-state geography encompassing parts of the Great Basin, Southwest, Rocky Mountains, and the Great Plains. While anchored in the geography of the West, our research is global in scale. RMRS also administers and conducts research on 14 experimental forests, ranges and watersheds and maintains long-term research databases for these areas. Our science improves lives and landscapes. More information about Forest Service research in the Rocky Mountain Region can be found here: https://www.fs.usda.gov/rmrs/.