# WIND RESOURCE MAPS & DATA

## Methods and Validation

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# INTRODUCTION

Established in 1983, AWS Truepower is one of the world's leading renewable energy consulting firms providing planning and evaluation services to project developers, electric utilities, government agencies and financial institutions. Our company has an extensive background in wind and solar energy applications and supports the complete development lifecycle. Our firm is well known for its expertise in plant siting and design, field measurements, resource modeling, technology assessment, performance evaluation, and forecasting. We have evaluated over 80,000 MW of planned and operational projects in over 80 countries.

This report describes the methods and models behind the validated wind resource maps and the supporting data available on AWS Truepower's Wind Site Assessment Dashboard.

# METHODS AND MODELS

There are three types of data available through the Wind Site Assessment Dashboard: wind resource maps, wind resource distribution charts and tables, and virtual met masts. The following sections describe the methods and models used to create these products.

## Wind Resource Maps

High resolution maps of estimated mean annual wind speed are created with AWS Truepower's proprietary MesoMap® system. They are subsequently fine-tuned with direct measurements from a large network of wind monitoring stations. Figure 1 illustrates the process.

The *MesoMap* system is a combination of two atmospheric models: a mesoscale numerical weather prediction model (MASS[1]) and a microscale wind flow model (WindMap[2]). The mesoscale model simulates weather conditions for a representative meteorological year (366 days sampled from a recent 15-year period) on a horizontal grid of 2.5 km. The microscale model then refines the wind fields from the mesoscale model to capture the local influences of topography and surface roughness changes at a resolution of 200 m.

The atmospheric models use meteorological and geophysical data from a wide variety of sources. The mesoscale simulations are initialized by the NCAR/NCEP Global Reanalysis (NNGR) database, which provides a snapshot of weather conditions every 6 hours on a 2.5-degree resolution grid. NNGR incorporates weather observations from many thousands of platforms around the world, including surface stations, rawinsonde stations (instrumented balloons that provide soundings from the surface to high in the atmosphere), satellites, aircraft, and others. In the course of the simulations, MASS also assimilates observations directly from rawinsonde stations. The geophysical data include topography, land cover, sea-surface temperatures, and soil temperatures and moisture.

The objective of the fine tuning is to minimize discrepancies between predicted and observed mean wind speeds. To accomplish this AWS Truepower creates databases of long-term mean wind speeds for numerous surface weather stations, as well as tall towers instrumented for wind resource assessment. The data come from a wide range of sources, including public, private, and governmental sources. Public data is often available through various state-or-province-level wind resource assessment programs, or from the academic or research disciplines. Many countries also maintain government-sponsored or funded measurement programs. Privately-funded data is often provided by clients of AWS Truepower and is used only with permission. Where possible, the mean speeds from short-term measurement programs are adjusted to represent long-term conditions; stations with periods of record of less than one year are not considered.

[1] Manobianco, J., J. W. Zack and G.E. Taylor, 1996: Workstation-based real-time mesoscale modeling designed for weather support to operations at the Kennedy Space Center and Cape Canaveral Air Station. Bull. Amer. Meteor. Soc., 77, 653-672. Embedded equations are described in Zack, J., et al., 1995: MASS Version 5.6 Reference Manual. MESO, Inc., Troy, NY.

[2] Brower, M.C., 1999: Validation of the WindMap Model and Development of MesoMap, Proc. of Windpower 1999, American Wind Energy Association, Washington, DC.

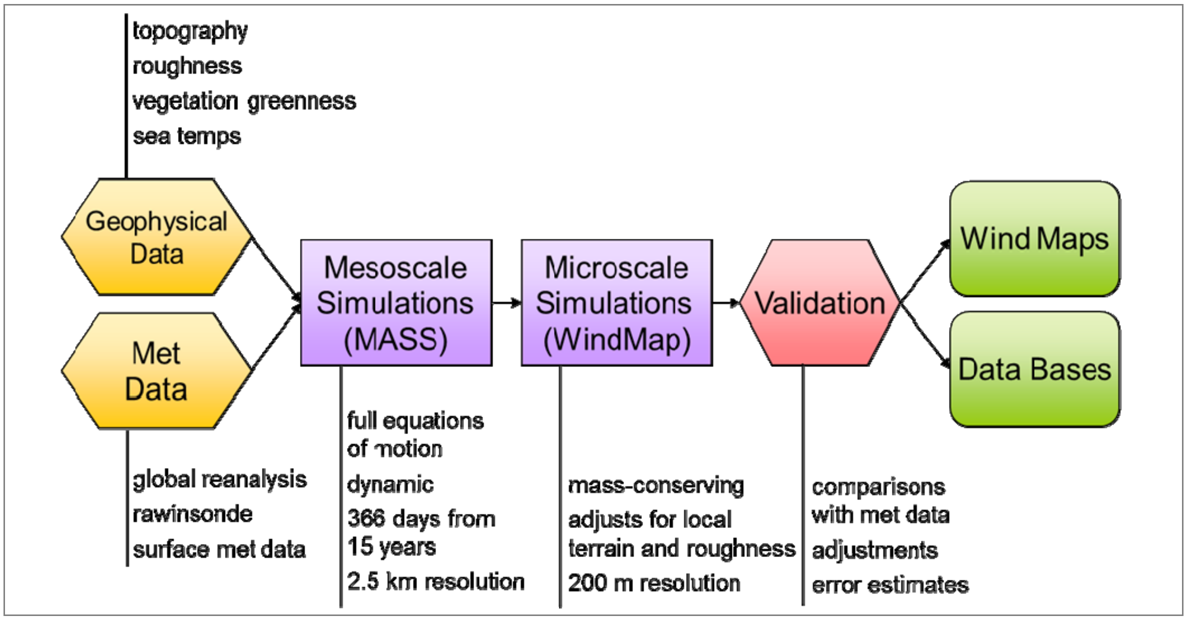


**Figure 1. Schematic of the *MesoMap* process.**

For each station, the mean speed is projected to the map height using either the observed wind shear exponent (where available), an exponent derived from modeling, or an exponent estimated from regional experience and local land cover and topography. A bias is then calculated between the raw (unadjusted) wind map and the extrapolated-observed speed for each station.

Finally, a software program developed by AWS Truepower interprets the biases to create a bias-correction map, and applies the correction to create the final wind map. This process does not eliminate the bias at every station, as this could produce unreasonable adjustments in some areas. Instead, it is designed to eliminate spatially correlated biases affecting regions of a significant size (roughly the mean spacing between stations, about 50-100 km).

## Wind Resource Distributions and Virtual Met Masts

In addition to wind maps, the Wind Site Assessment Dashboard provides access to wind resource distribution data and virtual met masts (VMMs). Both types of data are generated from AWS Truepower's database of weather conditions.

The database of weather conditions is created in two stages. First, the MASS model is run in a sequence of two-week simulations from 1997 to the present. As in the *MesoMap* system, the simulations are initialized from NNGR data, and rawinsonde data are assimilated every 12 hours to control model drift. To accommodate the multi-year simulations, however, the grid resolution is 20 km rather than 2.5 km. In addition, the rawinsonde stations are carefully selected to ensure that wind and other weather trends are consistent through time. In the second stage, the WindMap model is applied to correct for local topographic and land cover influences, and the resulting speeds are scaled so that the mean speed matches the wind resource map.

The result is a time series of hourly wind speed, direction, temperature, and pressure values for a selected location and height above ground. From this VMM, frequencies by speed and direction are derived, along with mean speeds by time of day and time of year. Other statistics, such as interannual variability, wind power density, and maximum speeds, are also calculated.

# VALIDATION

## Wind Resource Maps

To produce an objective estimate of the map accuracy, each station in AWS Truepower's database is withheld in turn from the fine-tuning procedure and the difference between the map speed and the observed speed at that station is determined. Then all the deviations are analyzed and error statistics are derived.

Based on this procedure, the mean bias of the high-resolution wind maps is found to be very small or virtually zero for most regions.  Errors tend to be largest where the terrain and vegetation cover are more complex. The mean bias, standard error, and uncertainty estimate for each region currently available in the Wind Site Assessment dashboard are presented in Table 1.

In all cases, AWS Truepower recommends that the wind resource be measured on-site before committing funds to a wind energy project of a substantial size.

**Table 1. Validation statistics and uncertainty estimates in meters / second, for the adjusted 80 m wind maps.**

| Region | Validation Points | Mean | Std Dev | Uncertainty |
|---|---|---|---|---|
| **Alaska** | 139 | 0.27 | 0.62 | 0.8 |
| **Canada** | 368 | -0.01 | 0.41 | 0.35 |
| **Caribbean** | 32 | 0.04 | 1.04 | 0.8 |
| **Europe** | 433 | -0.08 | 0.56 | 0.5 |
| **Hawaii** | 107 | -0.31 | 0.94 | 0.8 |
| **India** | 116 | -0.02 | 0.44 | 0.5 |
| **Mexico / Central America** | 75 | 0.00 | 0.41 | 0.5 |
| **South America** | 170 | -0.03 | 0.45 | 0.5 |
| **United States** | 1625 | 0.00 | 0.42 | 0.35 |