A Novel Wind Atlas Modeling Method

Modeling method refines accuracy of wind resource maps.

Almost every country has created wind resource maps to find potential windy places suitable for building new wind plants. Modelers use a wide range of methods to create these wind resource maps. Yet new methods are needed to capture the detail required to enable dynamic line rating, which could boost transmission and distribution line capacity by 10 to 40 percent.

Idaho National Laboratory researchers are working with the simulation company WindSim to develop a new wind atlas method using specialized software. The new approach supports dynamic line rating modeling and simulation that can expand over hundreds of miles. To be as accurate as possible, the method combines wind speed and wind direction data from smaller simulation areas, and it is based on scaling against measurements where available.

MANY MODELING METHODS

To create these wind resource maps, scientists have many modeling options to choose from, including mesoscale modeling, linear methods and computational fluid dynamics (CFD).

Using mesoscale models has the advantage that an entire area of interest can be fully covered by one model, while using other approaches requires that several simulation areas be combined afterwards. However, mesoscale modeling does not reach the horizontal resolution necessary for a reliable wind resource map.

For example, mesoscale models reach their limits in rough terrain because the approximately 1-km resolution is too coarse and forces oversimplified orography. By comparison, CFD can simulate the wind flow with a horizontal resolution of 10 meters, or even 1 m with specialized data collection. As a result, the CFD approach can better predict the flow pattern within smaller valleys and in very difficult terrain.

For that reason, it has become common to use CFD to generate wind resource maps of smaller areas, and then combine the different simulation areas in the end to see the big picture.

A NEW MODELING APPROACH

INL researchers are working with software developers at WindSim to evaluate different approaches for combining the CFD results obtained for every simulated area:

- Combining the already weighted wind resource maps. This approach has the advantage that those

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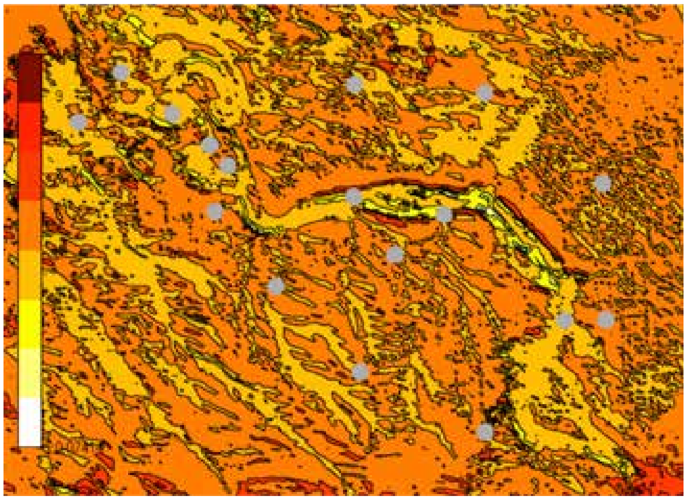
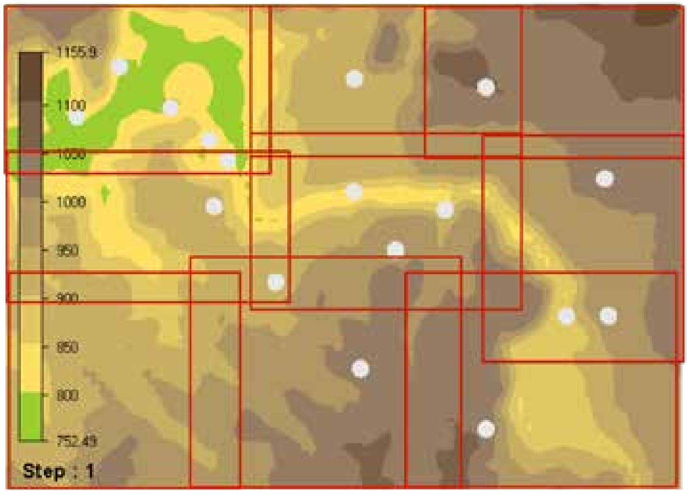
maps can be created for every project individually. As a result, the processing is simplified, as weighting against the measurements is done before combining the maps. One drawback is that differences between maps covering the same area can be large because each map is weighted against different measurements.

- Combining the wind fields of the individual areas. This approach is physically more precise because the simulated wind fields are combined before they are weighted by any measurements. The approach compiles several WindSim CFD models, then combines up to 36 sectors with differing atmospheric stability using a 3D CFD wind flow model. Direction-dependent interpolation combines all results into a single map, then results are scaled with measurements that are weighted according to distance and representativeness.

INL researchers validated the more precise method by applying it to a real project. The process revealed the need to have sufficient quality measurements throughout the area. Without them, mesoscale model results must be incorporated as virtual climatologies. Also, the boundary area of each domain must be large enough to allow boundary effects to be discarded.



Wind speed for entire domain, including the weather stations that are used to weight the results.



Example of a WindSim CFD model — each red section is one simulation area.

Researchers also discovered that the roughness and terrain data for all areas should be provided from the same data source and should be checked for consistency against the entire area of interest. INL scientists note it is important that CFD boundary conditions describing behavior on the top of the domain guarantee that the wind flow is maintained throughout the area, since this function is usually completed by the geostrophic wind for large areas. Finally, a clever interpolation and decision technique must be used to ensure smooth transitions at the borders between one area and the next.

FOR MORE INFORMATION

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