A Mass-Conserving Wind Field Model Run Directly From Tower Observations

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Motivation

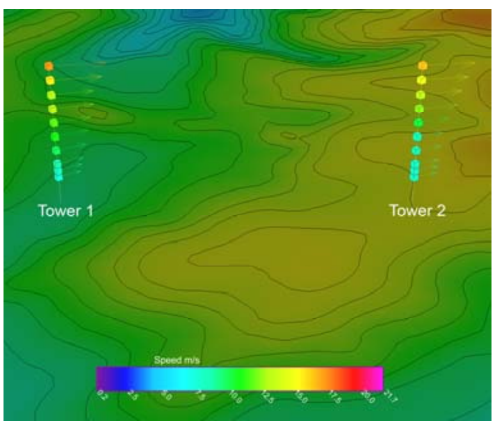
The process of performing wind resource assessments with a mass-conserving wind field model has, until now, involved running the MM5[1] mesoscale meteorological model, then using the meteorological model gridded output as input to the wind field model. The resulting wind field is adjusted, using tower data, to correct any biases. This process, known as MMA[2], is quite accurate, but is also computationally expensive.

WAsP[3] is a well-known resource assessment tool that has become popular because it is a very fast-running program and uses tower data as input. However, it does not incorporate multiple tower observations simultaneously and thereby omits information about the local flow field.

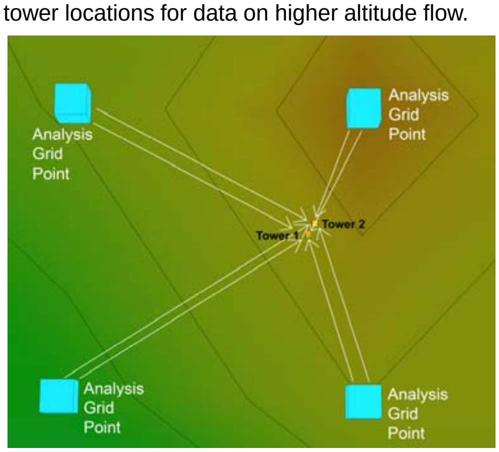
We propose here an intermediate method, known as "Towers to Swift" (TTS), that accepts tower data directly into the wind field model, saving considerable computational expense. It also incorporates all tower data simultaneously, taking full advantage of the additional flow field information that multiple towers provide.

Input Data

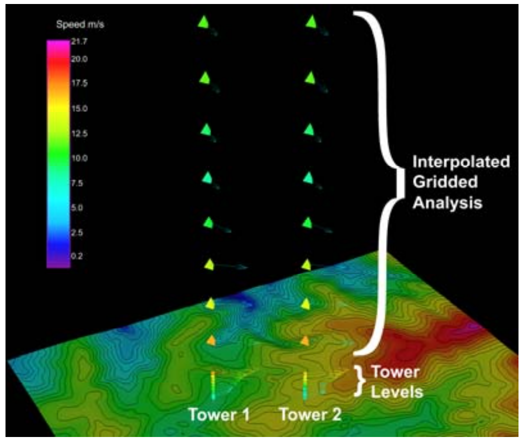
Step A: Use ***ALL*** available levels from ***ALL*** available towers at a site.



Step B: Interpolate gridded model analyses to tower locations for data on higher altitude flow.



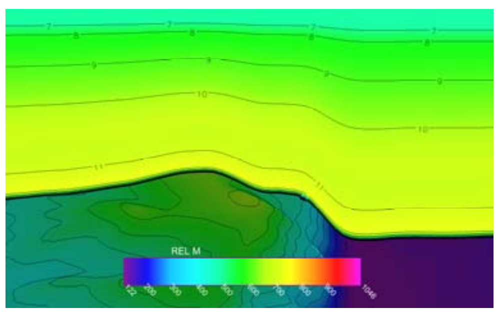
Resulting Input: Columns of combined input data.



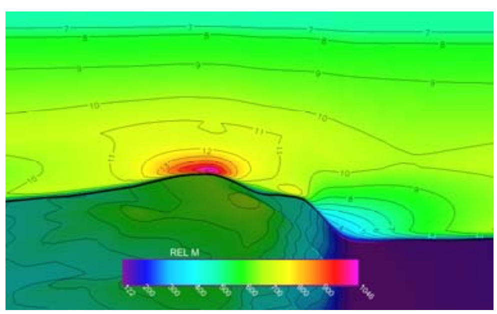
The Model

The model is based on **nSwift**[4], a mass-conserving wind field model developed by ARIA Technologies.

Step C: Interpolate the tower observations onto the model grid.



Step D: Mass conservation is used to adjust the interpolated wind field. Atmospheric stability influences the speedup of wind flow over hills.



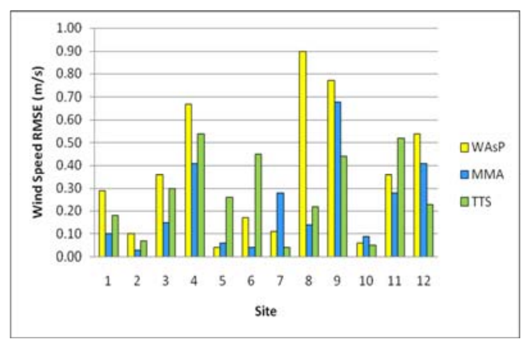
Because met tower siting is typically biased toward higher terrain, the model includes an option to make a terrain-based correction to the tower observations when interpolating to lower terrain locations on the grid. The output can then be compared to tower observations, and vector corrections made (Natural Neighbor interpolation method, followed by a second mass-based adjustment) to remove bias.

Testing Procedure

We selected twelve sites around North America, representing a variety of wind regimes in both simple and complex terrain, in order to provide the most rigorous test of the methodology and to examine its applicability with respect to wind resource assessment. We compared root mean square error (RMSE) of TTS against MMA and WAsP. The errors were calculated by withholding tower data, in a sequential manner, from the input and using those towers as locations to evaluate the respective wind field model values.

Test Results

	RMSE (m/s)		
Site	**WAsP**	**MMA**	**TTS**
1	0.29	**0.10**	0.18
2	0.10	**0.03**	0.07
3	0.36	**0.15**	0.30
4	0.67	**0.41**	0.54
5	**0.04**	0.06	0.26
6	0.17	**0.04**	0.45
7	0.11	0.28	**0.04**
8	0.90	**0.14**	0.22
9	0.77	0.68	**0.44**
10	0.06	0.09	**0.05**
11	0.36	**0.28**	0.52
12	0.54	0.41	**0.23**
Average	**0.36**	**0.22**	**0.28**



Conclusions

The TTS approach represents a significant advancement in wind resource assessment methods. As shown in this study, superior accuracy relative to WAsP is achieved without the computational (and run-time) requirements of mesoscale meteorological modeling.

References

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3. Mortensen, N. G., L. Landberg, I. Troen, and E. L. Petersen, 1993: *Getting started. Vol. 1, Wind Analysis and Application Program (WASP), User's Guide*, Risø-I-666 (EN), Risoe National Laboratory, Roskilde, Denmark, 30 pp.
4. Geai, P. 1987: *Méthode d'interpolation et de reconstitution tridimensionnelle d'un champ de vent : le code d'analyse objective SWIFT*. Paris: EDF-DER (Ref. HE 34-87.03).