

Annualizing wind statistics from ground-based remote sensing

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Goals of Ground-Based Remote Sensing for Wind Energy

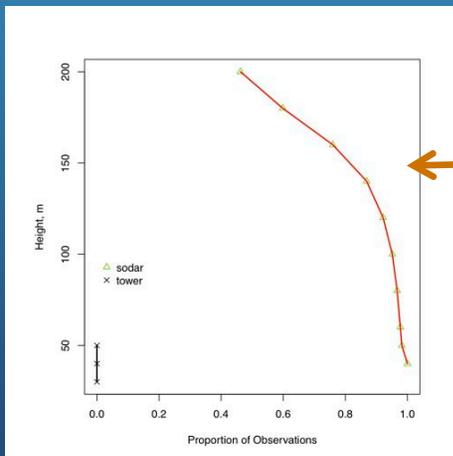
- Wind speed at hub height (80-100 m)
- shear parameter
- Weibull parameters, TAB file (Frequency of U by direction)
- turbulence intensity
- synthetic time series (“8760”) with representative properties (autocorrelation, Weibull, etc..)

**Use in conjunction with tower data, stand-alone, or some combination

***Ultimate goal is “bankable” data which reduce uncertainty

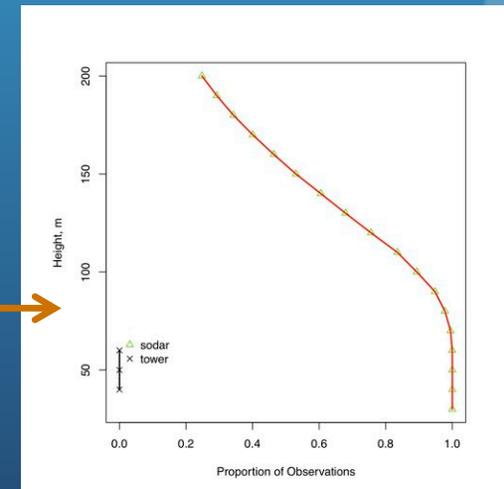
Availability

- Operating continuously?
- Rain/snow
- Altitude performance = $f(\text{hour}, U, RH)$: which observations qualify?
- Filter with tower?



lidar

sodar



Examples

- Sodar near 60-m met. tower for 2 months

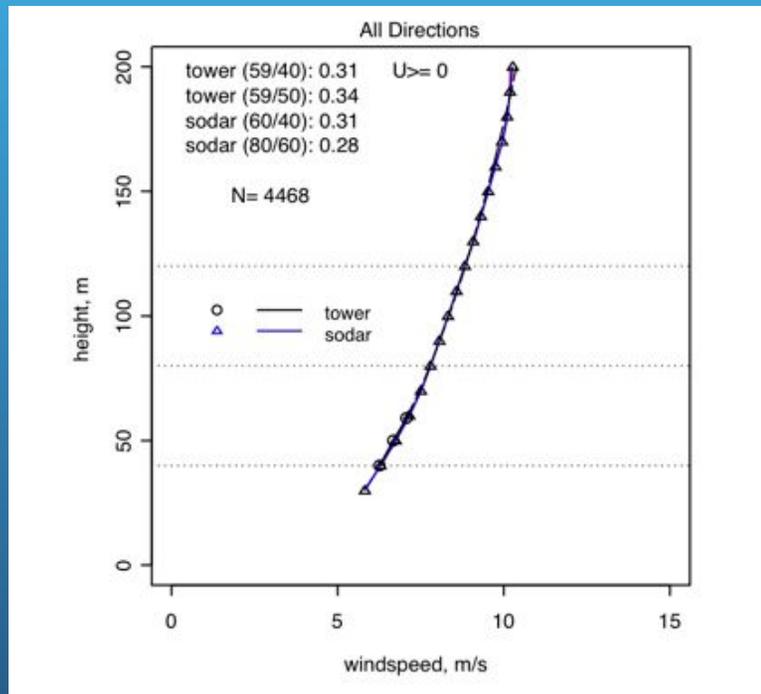


- Sodar at a site 4-5 km from two 60-m met. Towers (~4 months)



- Lidar 14 km from a 50-m met. tower for 1.5 months

Sodar/tower comparison, 2 months



- Availability reflects joint tower/sodar
- Some uncertainty in tower shear is revealed
- Stable estimate of shear above tower top is obtained
- Statistics on how change in shear is related to stability, etc.

Sodar: December-April

	After filtering with tower	Sodar only (screened)
U80	7.8 m/s	7.7 m/s
α 80/60	0.22	0.23
α 100/60	0.23	0.23
N	9,495	12,354
N collected	17,495	17,495
Total N poss.	18,496	18,496
Weibull A,k	8.430,1.898	8.435,1.802

- Sodar operated 95% of the time
- 4% of sodar data disqualified due to rain or snow
- Winter operation, so tower icing accounts for another 4.5% loss
- Some bad anemometers
- Altitude performance varies with hour of day, wind speed, humidity (11% didn't reach 100 m)

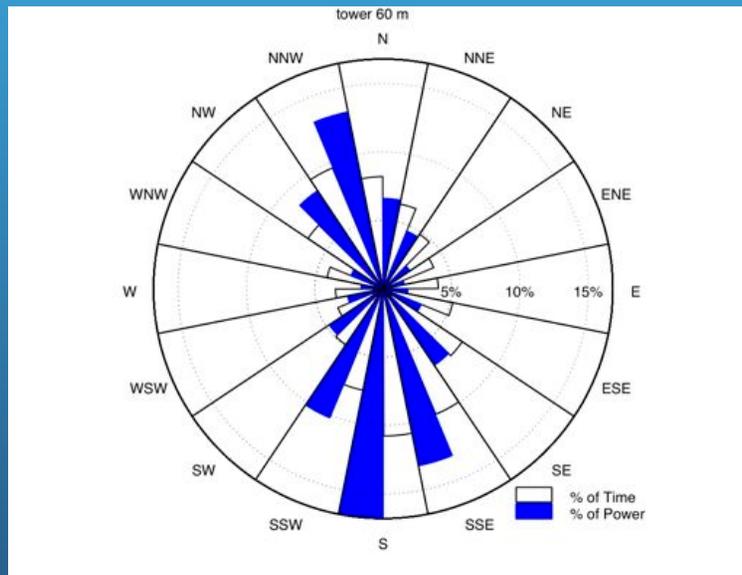
Lidar: 1.5 months (April-May)

	Filtered with tower	Lidar only
U80	6.7 m/s	7.04 m/s
α 80/50	0.26	0.26
α 100/50	0.26	0.25
N	3,836	4,571
N possible	5,953	5,953

- Lidar operated 99% of the time
- Rain (wiper count) disqualified almost 23% of observations
- Reduced altitude performance following cold frontal passage (low signal-to-noise)

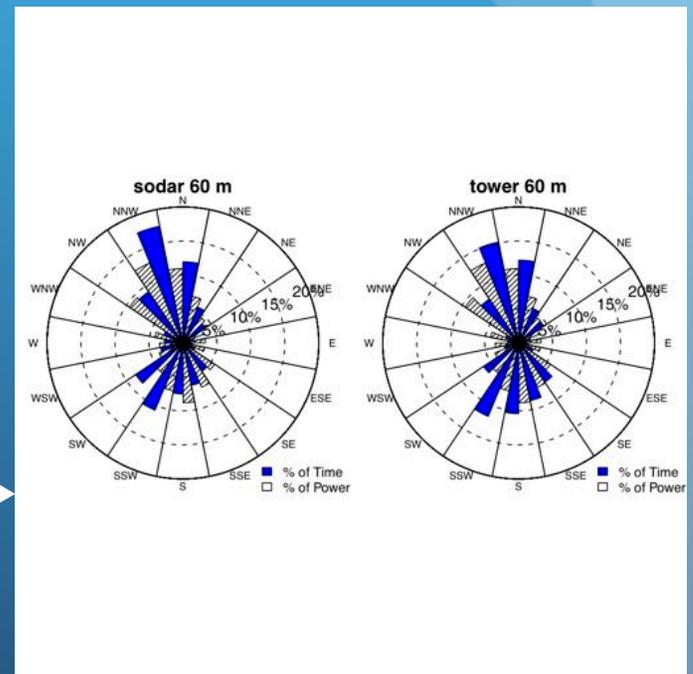
Annualizing Shear

- Average sector-wise shear by annual energy rose (4-month sodar campaign before averaging: 0.22; after: 0.24)



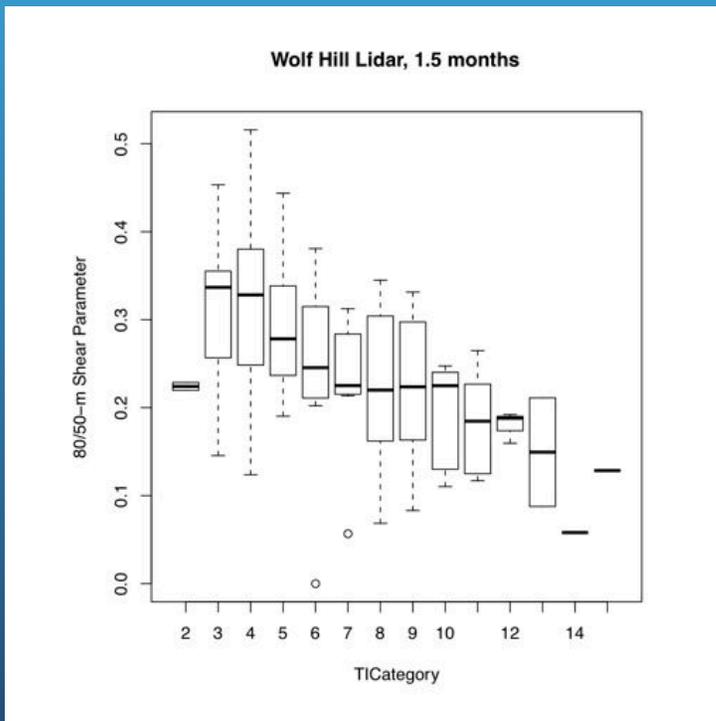
← Annual

Sodar
campaign →



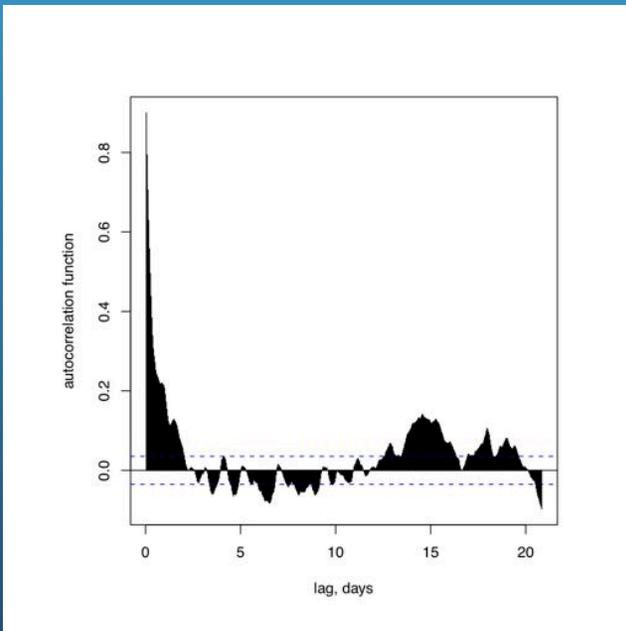
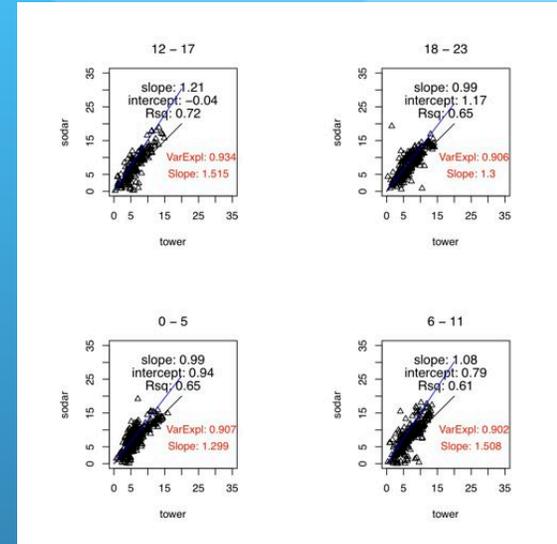
Annualizing shear, cont'd

- Average shear, weighted by annual energy rose and stability category (TI? Surface E-balance?). Lidar before averaging: 0.26; weighted average: 0.15.

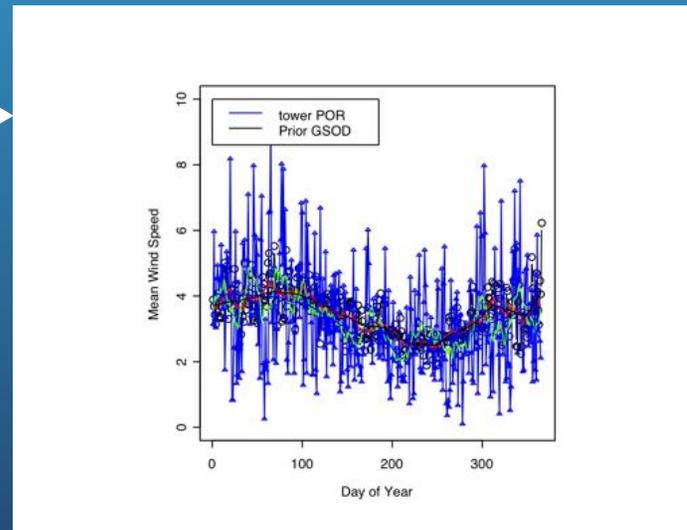


Annualizing Wind Speed

- PCA 
- (as in MCP) hour of day is important:
- Stochastic modeling with ARIMA

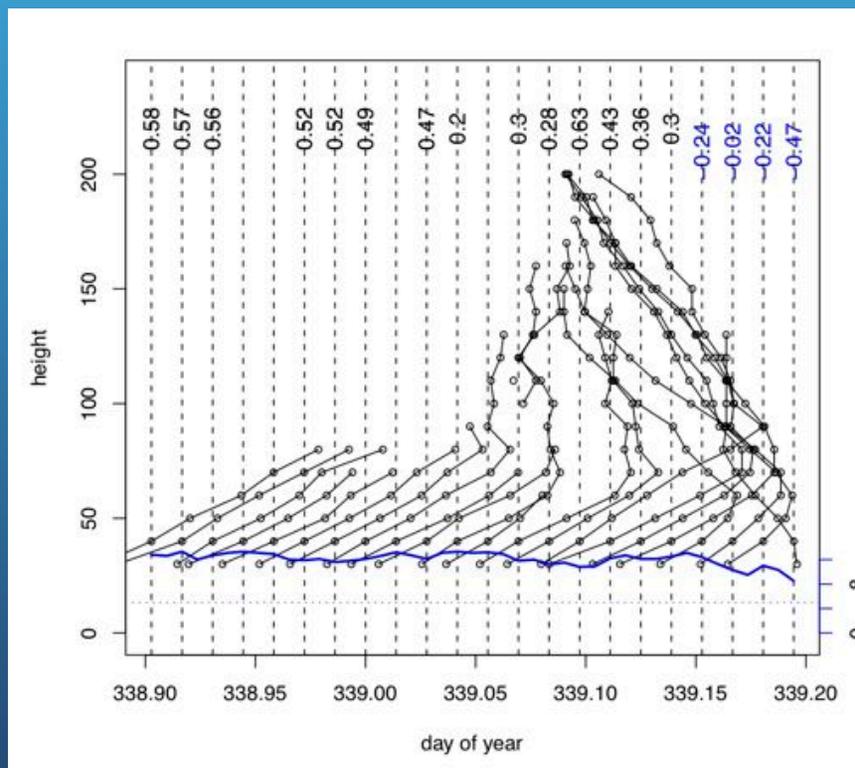


Seasonal:



Extreme/Unusual Events

LLJ, ramps, extreme shear occurrences complicate the characterization of time series. Diagnosing, forecasting, etc.



Recommended Practices

- IEA Recommended Practices document:
- Calibration & testing, instrument verification, operating requirements, siting and noise, data collection & handling, *complex terrain*, uncertainty
- Decide what the purpose is, and what the desired parameters are (shear, U_{80} etc.)
- What degree of uncertainty is acceptable? How should availability be assessed? What is the impact of availability on bias, uncertainty?

Thank You!

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