Investigating low-level jet wind profiles using two different lidars

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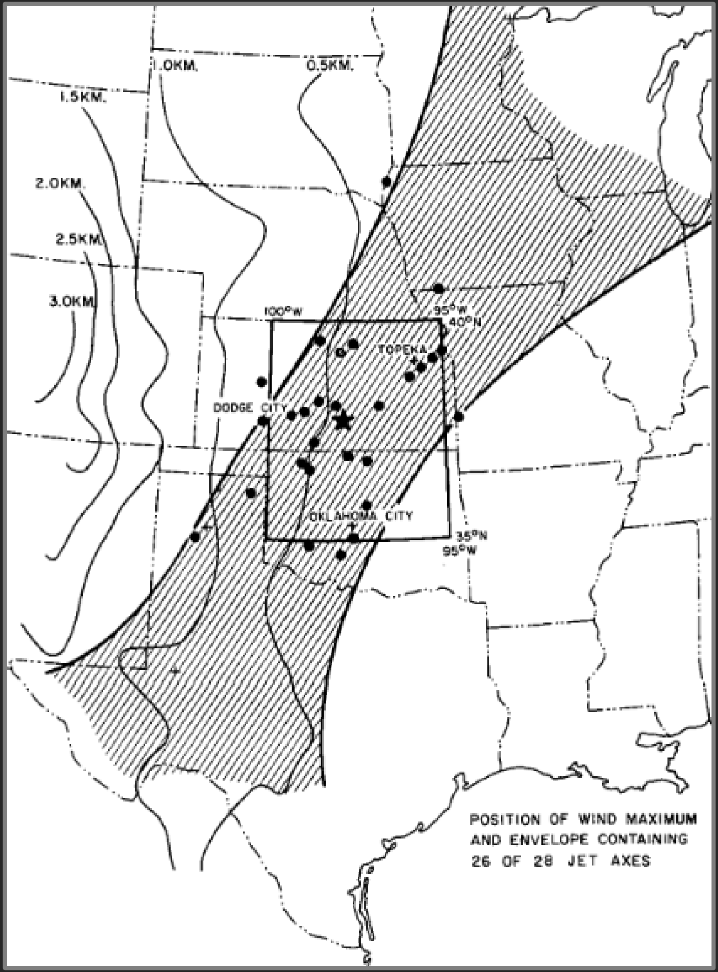
Relevant results of past Great Plains nocturnal low-level jet (NLLJ) studies

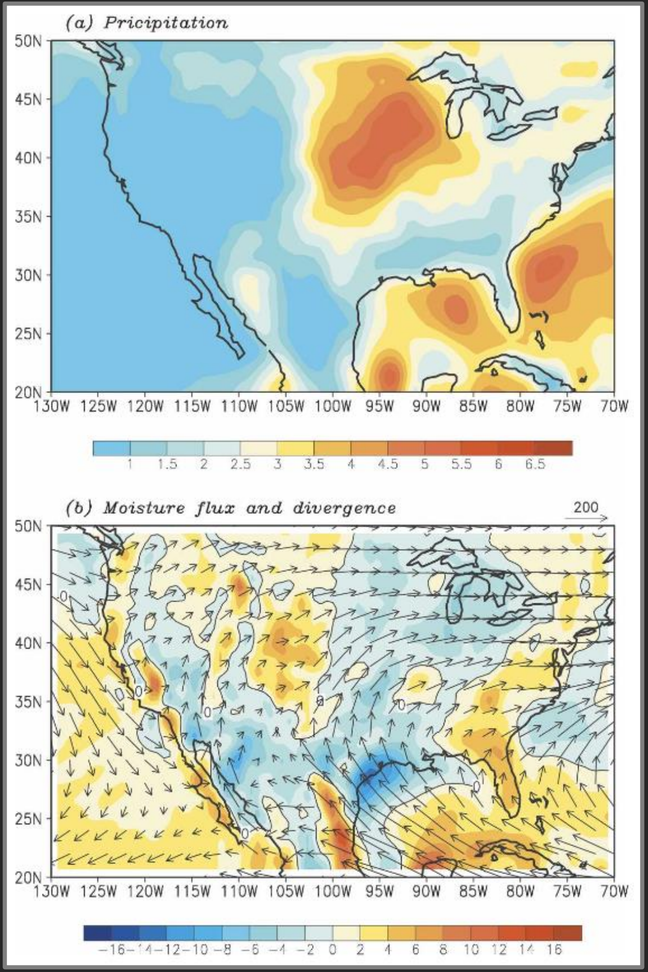
- Summer Great Plains nocturnal jet typically centered over OK/NE
- Produced by inertial oscillation and baroclinicity from sloping terrain



Bonner 1968

Relevant results of past Great Plains nocturnal low-level jet (NLLJ) studies

- Summer Great Plains nocturnal jet typically centered over OK/NE
- Produced by inertial oscillation and baroclinicity from sloping terrain
- NLLJ connected to precipitation and severe weather



Jiang et al. 2007

We examine LLJs in central Iowa during the 2013 Crop Wind Energy Experiment

Data Availability

Leosphere/NRG:

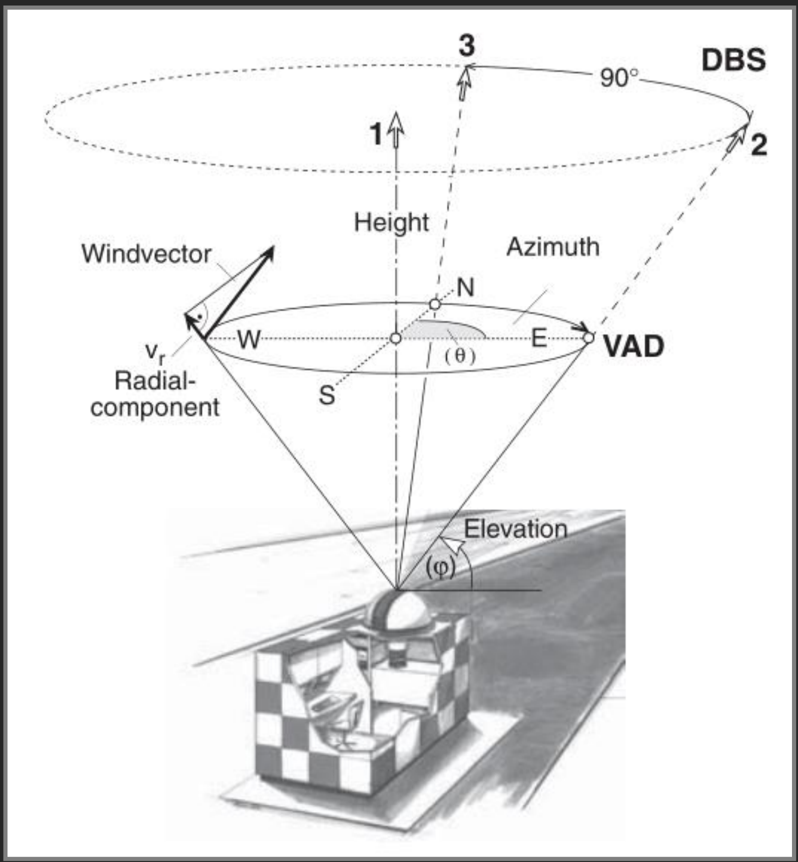
V1 profiling lidar

200S scanning lidar

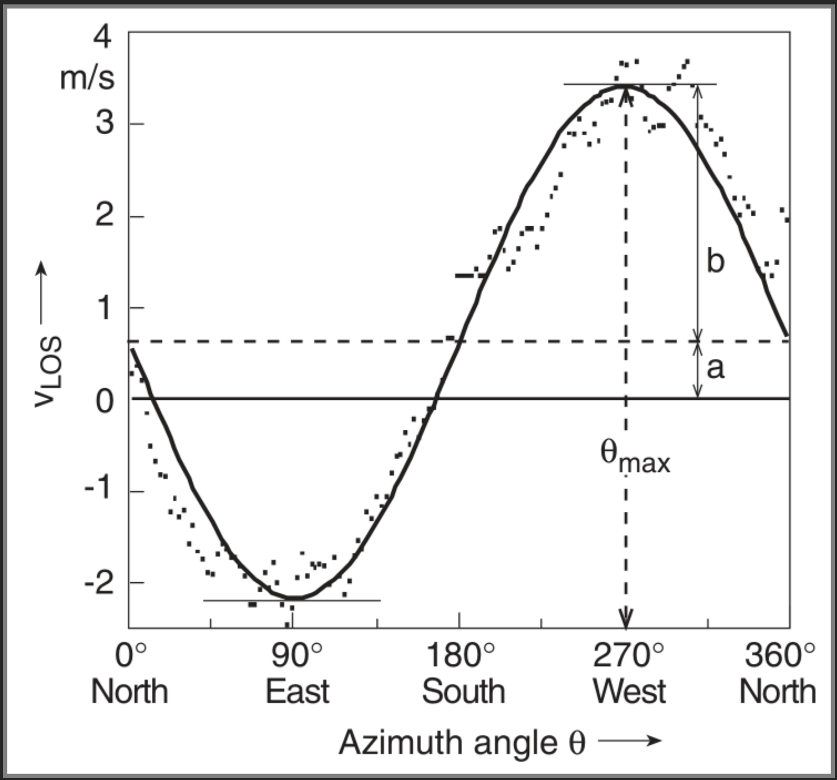
	V1 profiling lidar	200S scanning lidar
Range:	40 up to 220 m	100 up to 5000 m
Output:	3D wind vector	Line-of-sight wind

Two different retrieval techniques are used to obtain profiles from the lidars

V1 lidar (Doppler beam swinging)
- 4 radial wind components
- System of equations gives 3D vector



200S lidar (velocity azimuth display)
- Use least-squares fit of radial winds
- Parameters related to U,W,θ

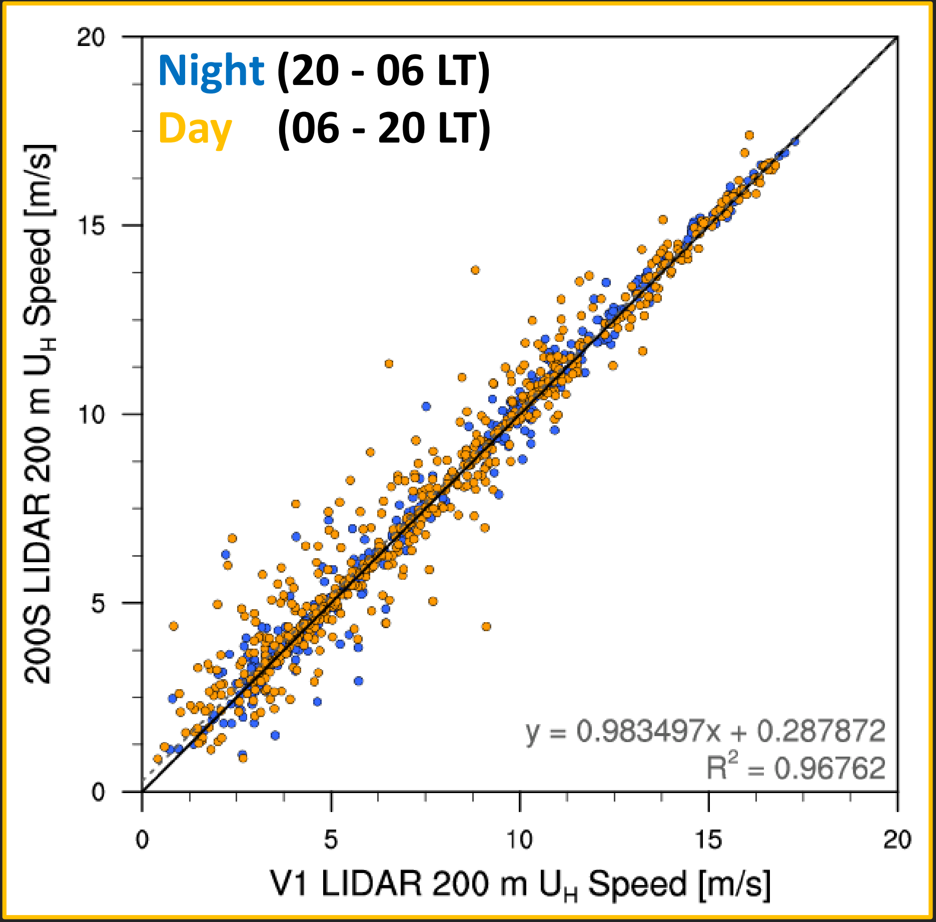


Figures from Weitkamp 2005

Strong agreement in lidar overlap region provided confidence in VAD retrievals

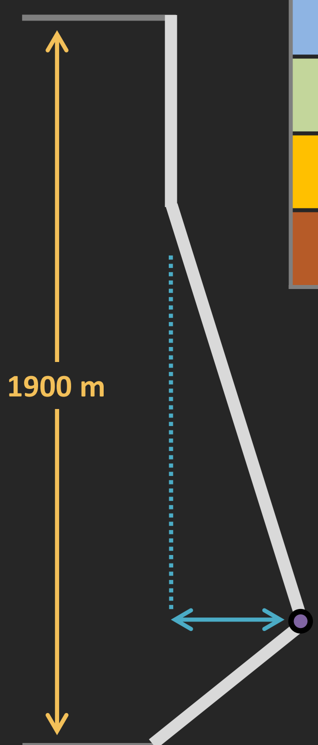
- Sampling times vary between lidars
  - V1: 4 Hz
  - 200S: 3 minutes
- Sampling volumes increase with height above ground level (AGL)

Sampling volume average diameter		
Height AGL	V1 Lidar	200S Lidar
40 m	21 m	N/A
200 m	105 m	54 m
2000 m	N/A	536 m



Individual 200S profiles are used to detect NLLJs through a 1900 m layer

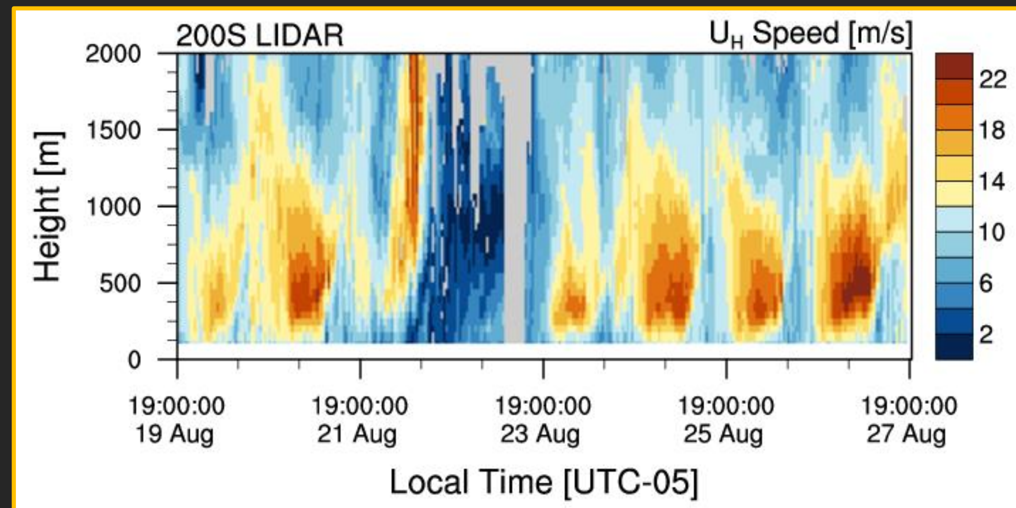
Wind Speed Profile



LLJ	V_{crit}	ΔV_{crit}
0	10	5
1	12	6
2	16	8
3	20	10

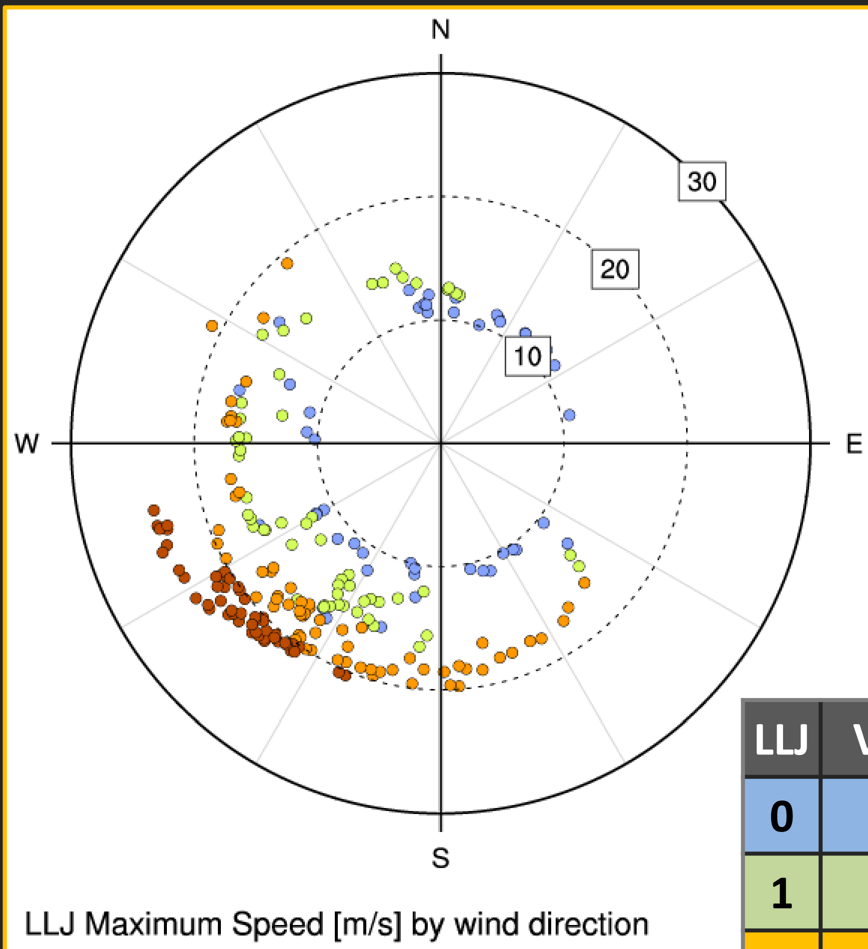
$V_{max} > V_{crit}$

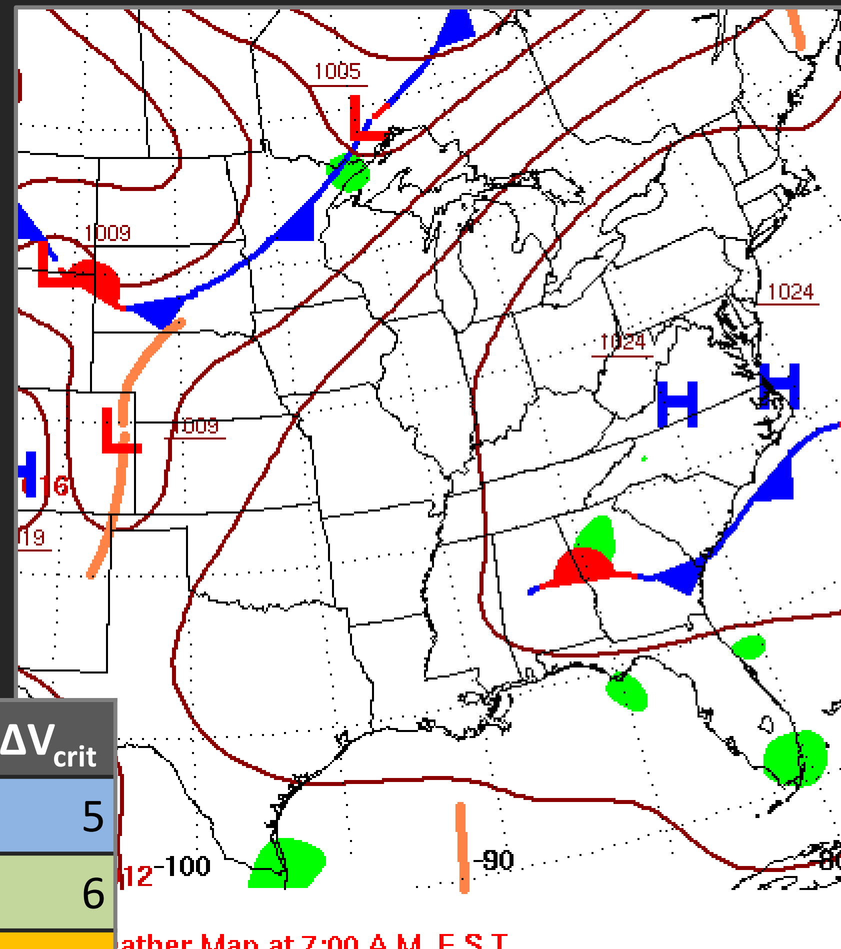
$\Delta V_{max} > \Delta V_{crit}$



We used Whiteman et al. (1997) jet detection scheme, with Song et al. (2006) max height AGL modification

Strongest jets mostly coincide with southwesterly mean flow





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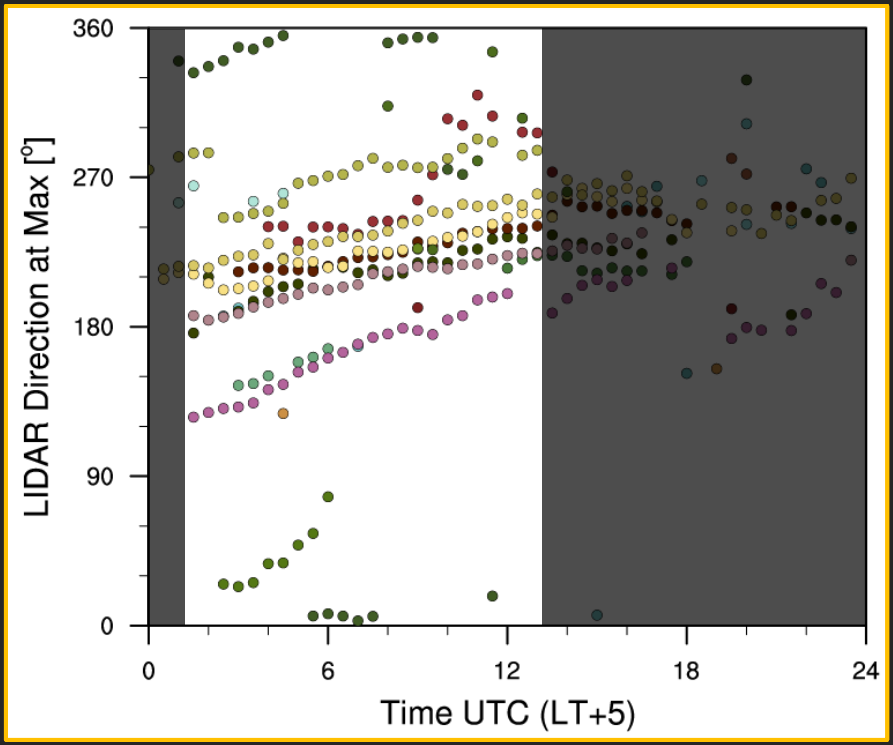
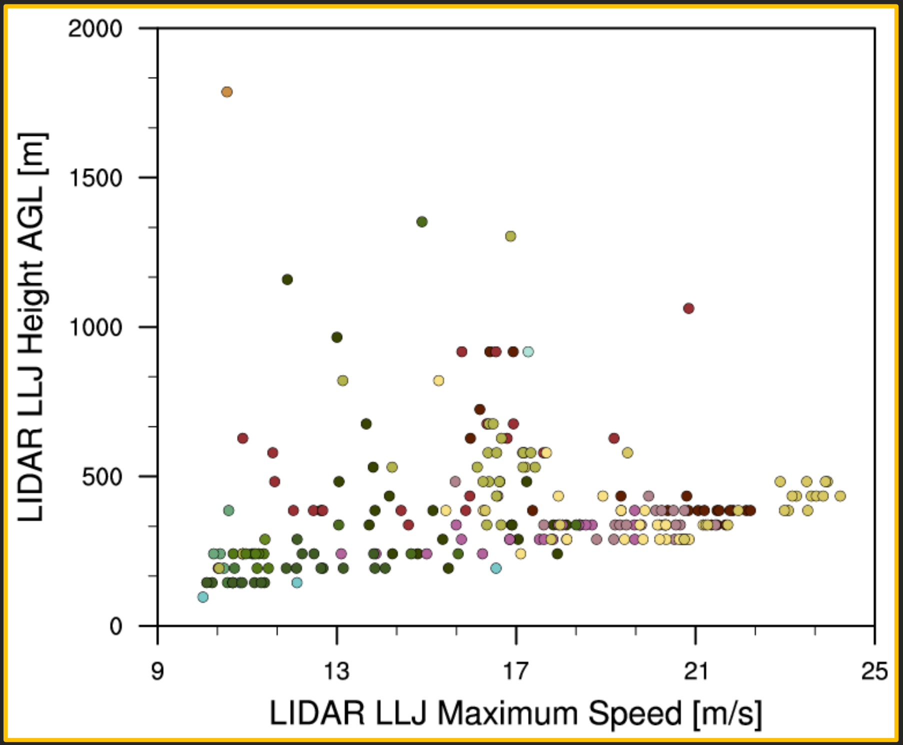
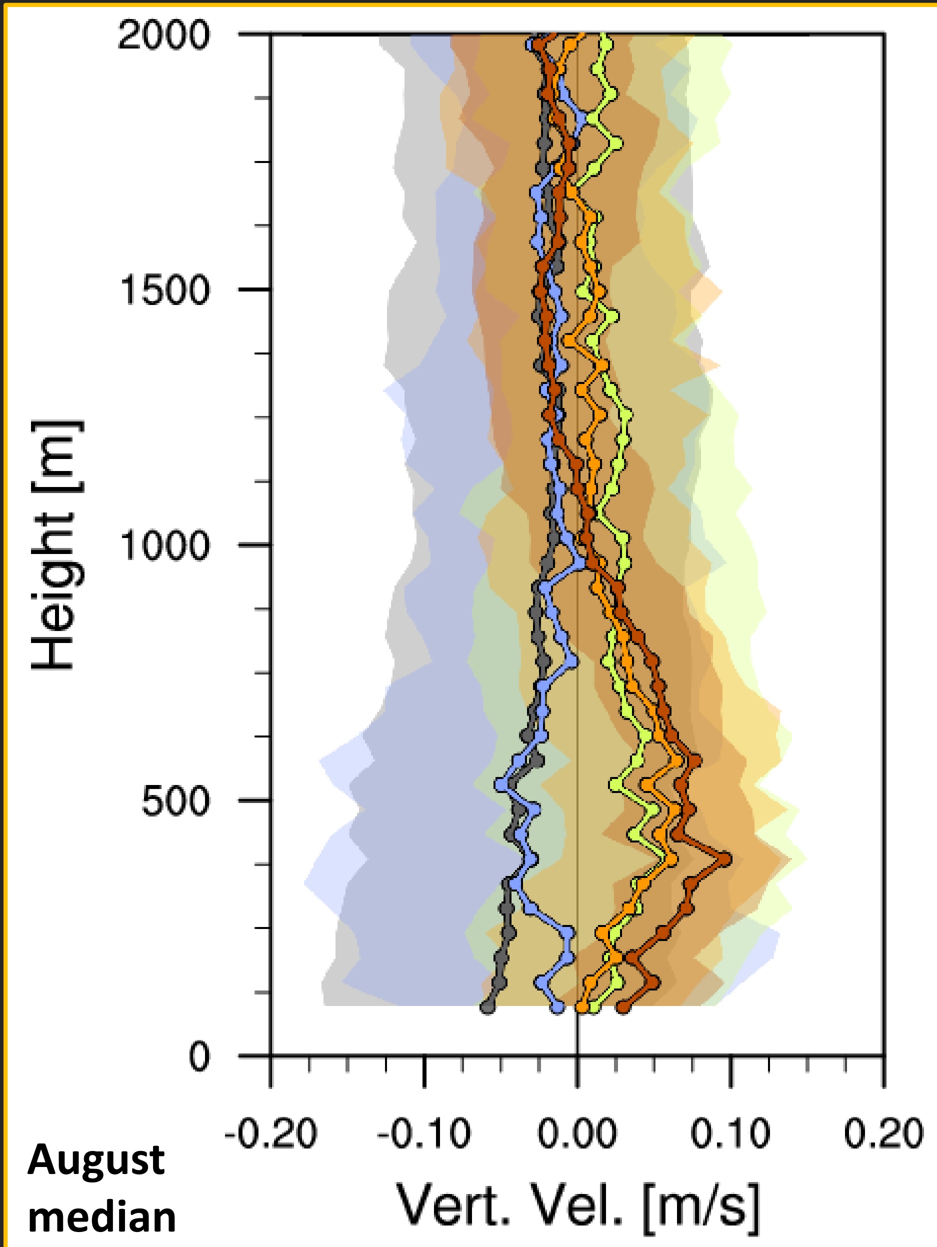
NLLJ winds exhibit dependence on time and height of jet observation



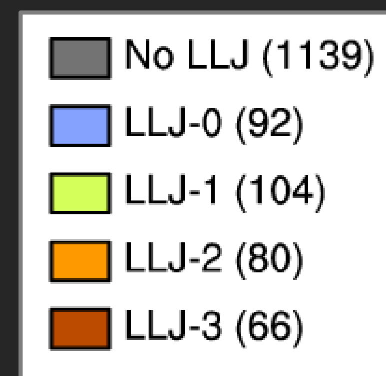


Most jets experience inertial oscillation veering throughout the night

Larger jet wind speeds generally occur at higher altitudes

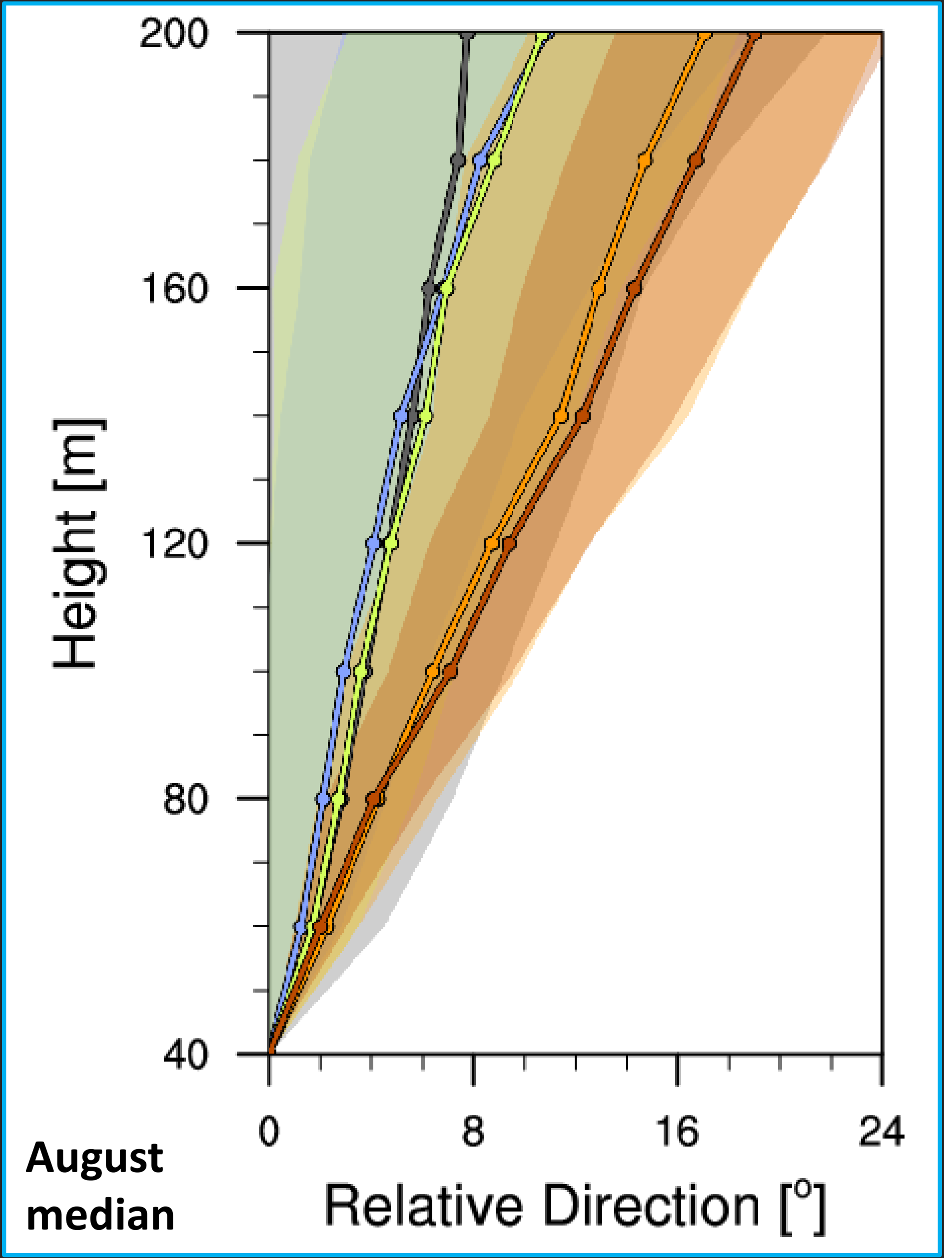


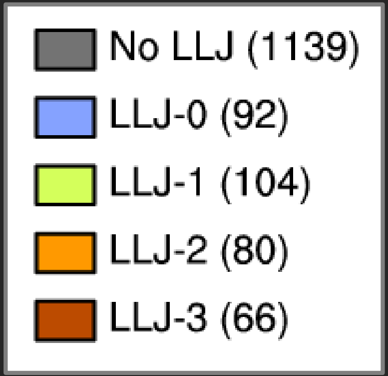
Rising motion seen in strong jets as anticipated by Midwest nocturnal precipitation theories



Layer with positive upward velocity similar to that of wind speed acceleration

V1 lidar shows strong NLLJs cause increased wind veer with height below the jet max





Result has implications for wind turbine power production and fatigue

We also performed a 20-28 August case study using the WRF model

Data Availability

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WRF case study

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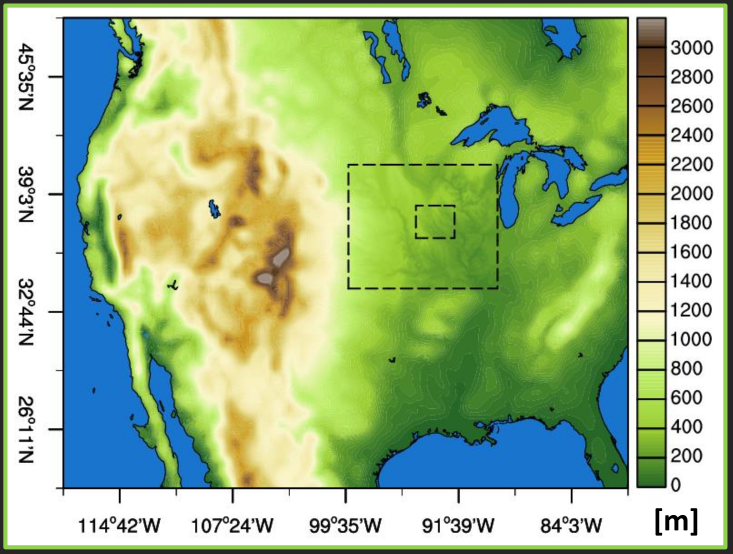
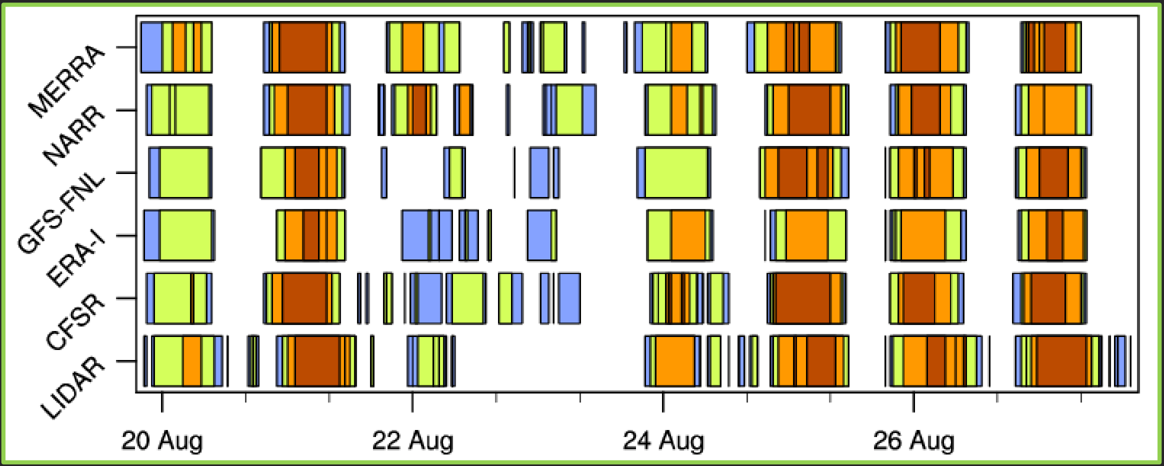


WRF V3.4.1

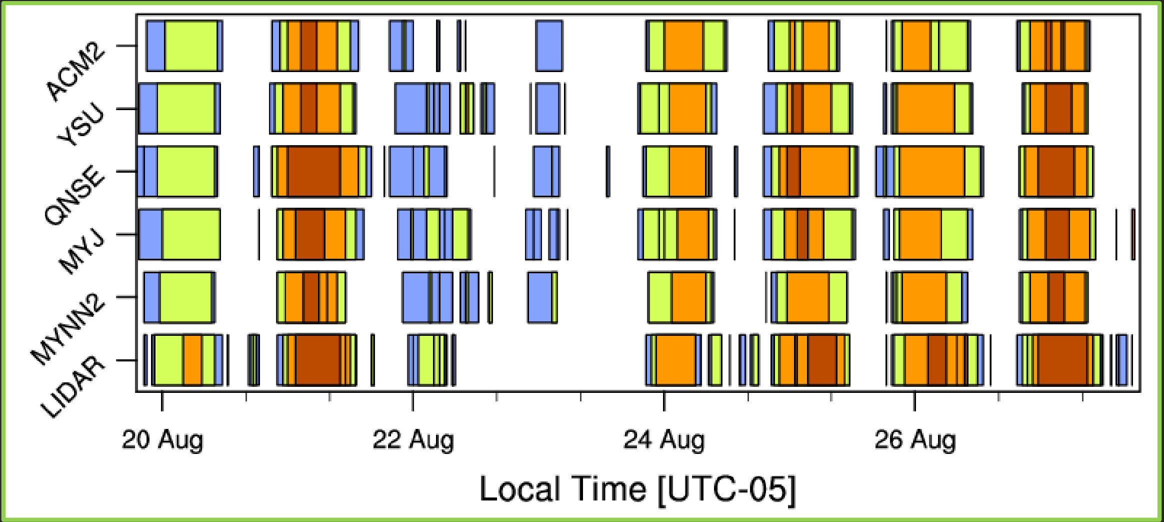
- 3 domains
- 1-way nesting
- 1.1 km horizontal resolution (finest)

WRF case study indicates simulated NLLJ sensitivity to input data

Input data (boundary and initial conditions)



Planetary Boundary Layer (PBL) scheme



- WRF captures overall recurring NLLJ pattern

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- Less variation among PBL schemes

Summary: new generation of profiling lidars a powerful tool for LLJ analysis

- Observed NLLJs in Iowa exhibit similarities to Great Plains LLJ
  - SW wind direction dominant
  - Mostly occur below 1000 m
- Stronger NLLJs tend to be higher
- WRF jets sensitive to input data
  - May impact storm forecasts in Iowa

More from CWEX 2013 at BLT

- *Wednesday, 11 June in Palm Court*

  *Poster - Coupling a Mesoscale NWP model with Large-Eddy-Simulation CFD for realistic wind-plant aerodynamics simulations (**67**)*

- *Thursday, 12 June in Queens Ballroom*

  *1:30 PM - Lidar observations of the variation of wind turbine wakes with inflow conditions in an onshore wind farm (**16A.1**)*

  *1:45 PM - Could crop roughness impact the wind resource at agriculturally productive wind farm sites? (**16A.2**)*

Thank you for your attention!

Any questions?