The Wind Above Us: Studies of The Great Plains Low-Level Jet

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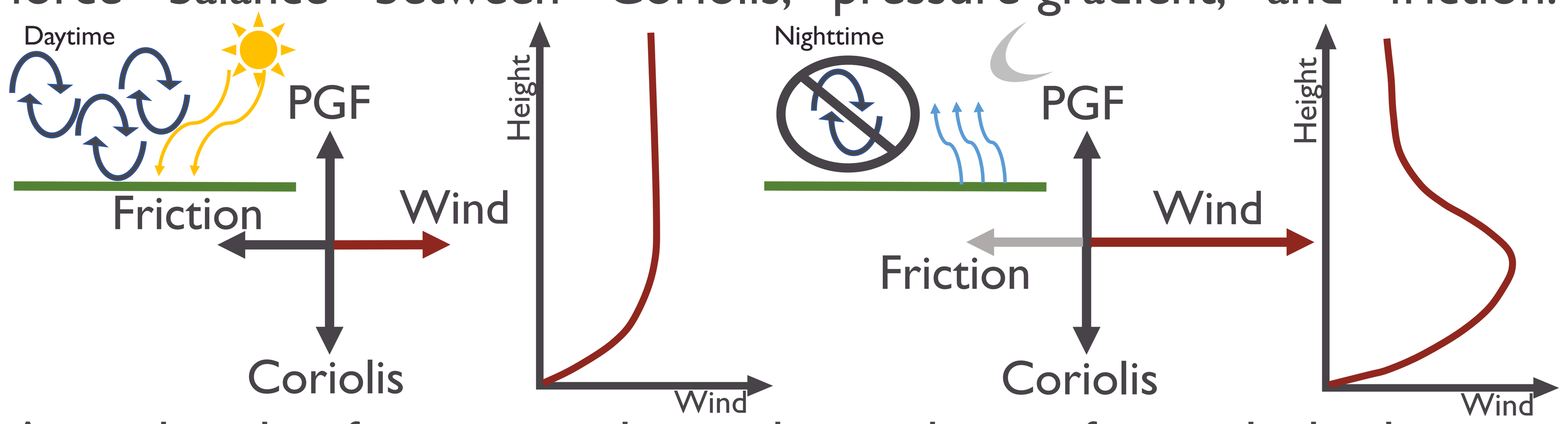
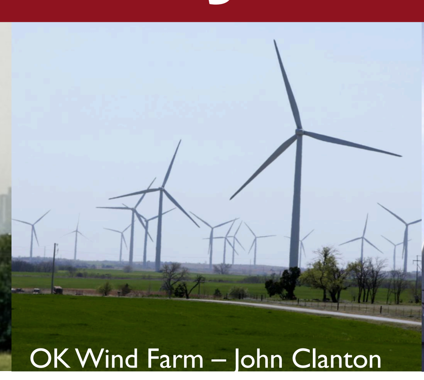
What is a low-level jet?

Wind maxima called nocturnal low-level jets (NLLJs) often occur during the night in the lowest kilometer of the atmosphere. In the most general sense, the NLLJ is the result of the disrupted daytime force balance between Coriolis, pressure-gradient, and friction.



At night, the friction weakens above the surface, which destroys balance and leads to increased wind speed in the boundary layer.

Why do NLLJs matter?



NLLJ winds can transport pollutants, moisture, and impact convection and several important industries such as wind energy and aviation.

NLLJ field observations

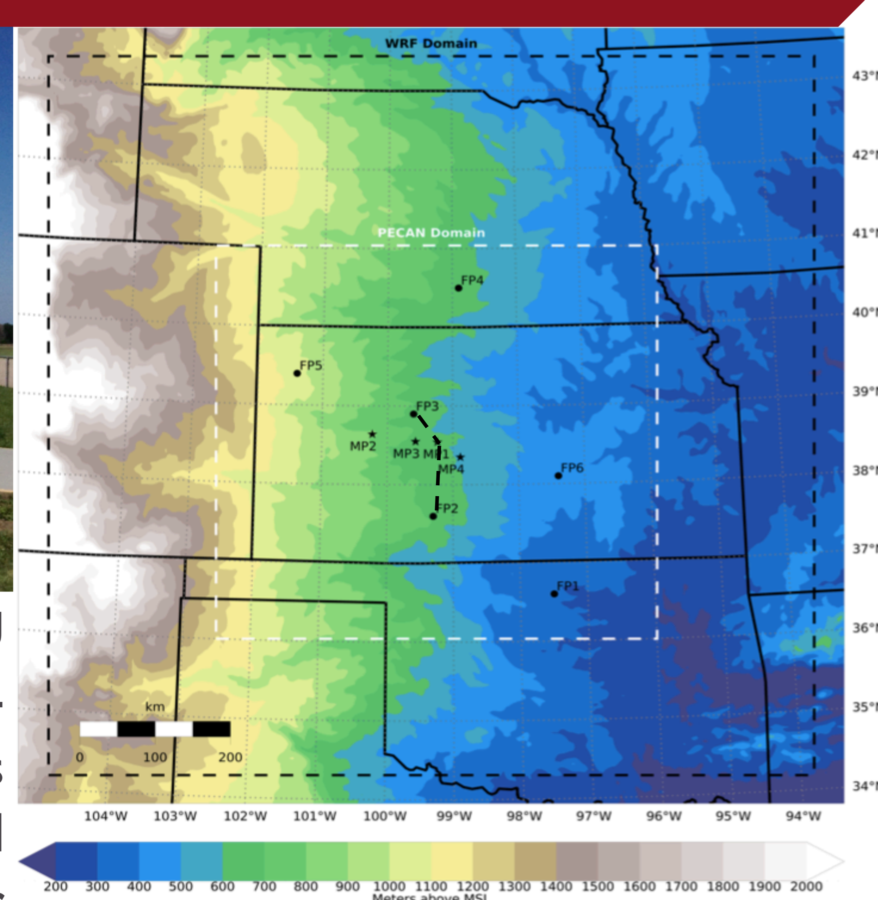


Figure 1. PECAN domain, simulation domain, and terrain height.

CLAMPS is maintained by OU and NSSL and uses state-of-the-art profiling instruments including Doppler lidar for wind observations and AERI for thermodynamic observations. The Plains Elevated Convection At Night (PECAN) campaign used CLAMPS and similar platforms to collect NLLJ observations with high spatial *and* temporal resolution during summer 2015. Such an observation set for NLLJ analyses is uncommon. These data will be used alongside mesoscale model output for NLLJ studies.

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References:

Gebauer, J. G. , A. Shapiro, E. Fedorovich, and P. M. Klein, 2018: Convection initiation caused by heterogeneous low-level jets over the Great Plains. Mon. Wea. Rev., 146, 2615-2637.

Smith, E. N., J. A. Gibbs, E. Fedorovich, and P. M. Klein, 2018: WRF model study of the Great Plains low-level jet: effects of grid spacing and boundary layer parameterization. J. Appl. Meteor. Climatol., in press.

NLLJ Case Study – PECAN observations and WRF model simulations

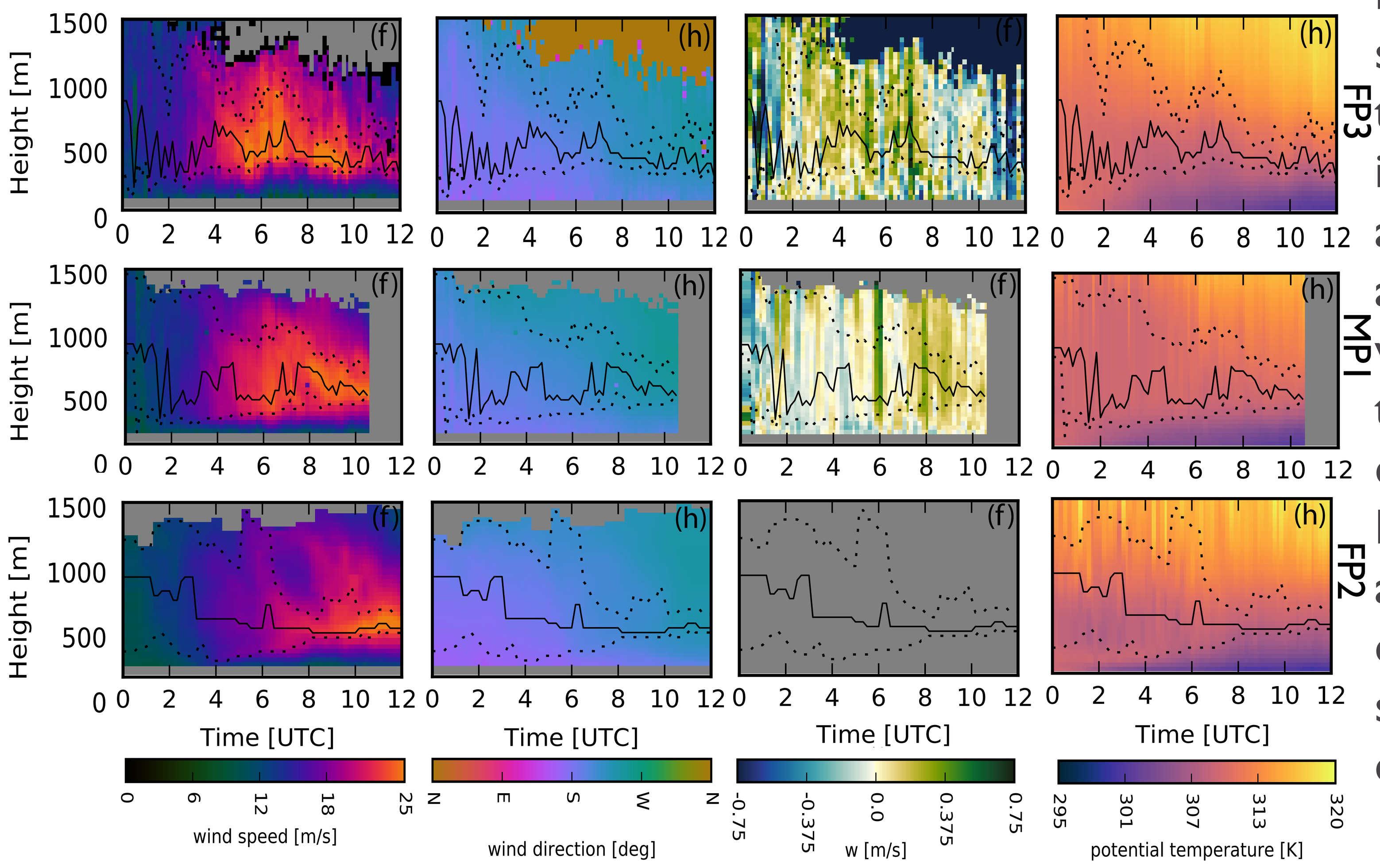

Figure 2. PECAN observations at FP3, MP1 (CLAMPS), and FP2 (see Fig. 1).

Plan-view analyses of WRF (Smith et al. 2018 defined relevant settings) modeled wind speed and moisture fields (Fig. 3) show the NLLJ moved W to E down the slope associated with an increased westerly component. This strong westerly component advects warm and dry air from W to E. Vertical cross-sections across the slope of the Great Plains (Fig. 4) show that NLLJ winds veer in time *and* height. The westerly component first increases at the top of the NLLJ and gradually descends. This veering can explain the diagonal striation feature in the wind field (Fig 5). Heterogeneity of the NLLJ with respect to its depth, wind speed, and wind direction was identified as a potential source of localized convergence and associated vertical motion. With sufficient saturation, this mechanism could be important for nocturnal convection initiation as explained in Gebauer et al. (2018).

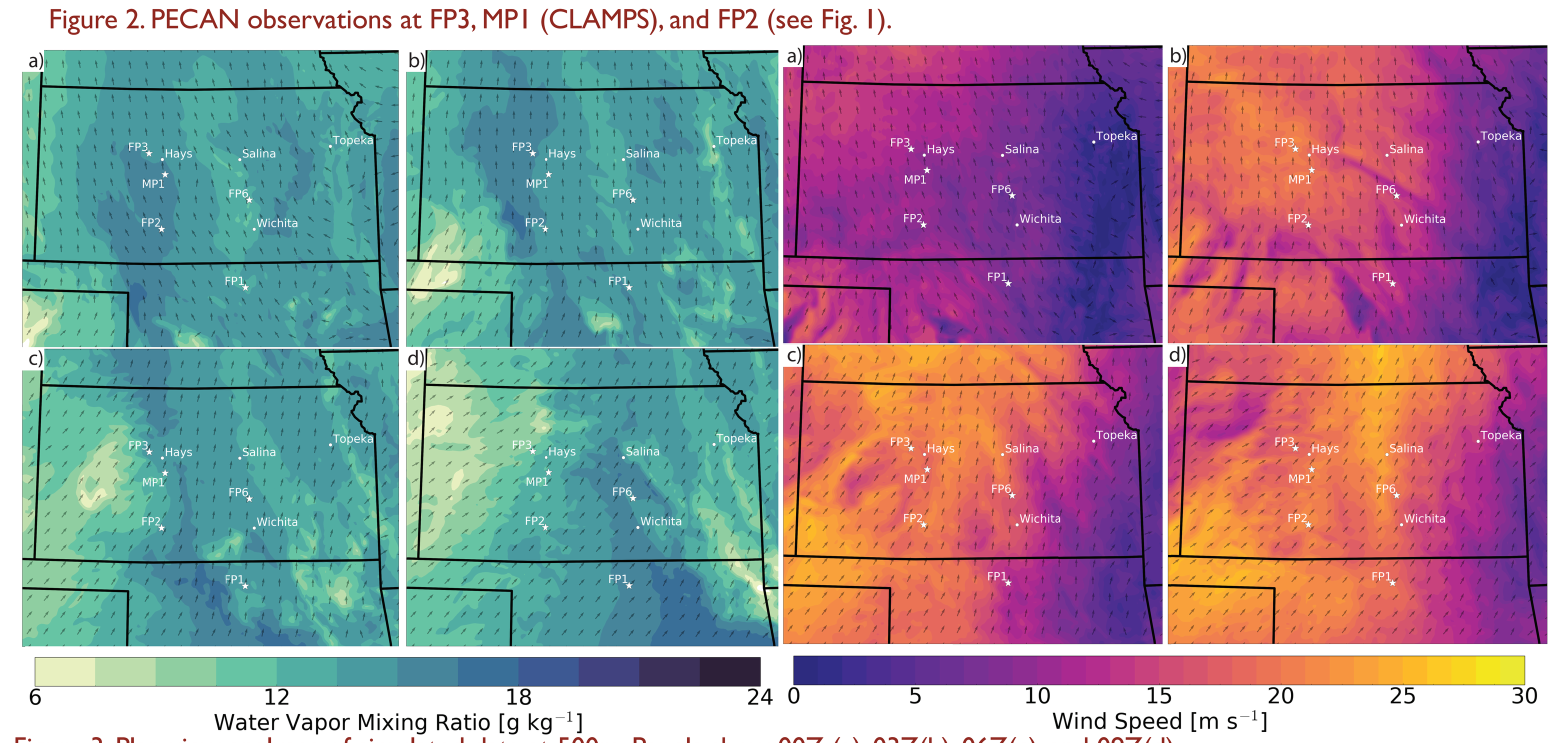

Figure 3. Plan view analyses of simulated data at 500m. Panels show 00Z (a), 03Z(b), 06Z(c), and 09Z(d).

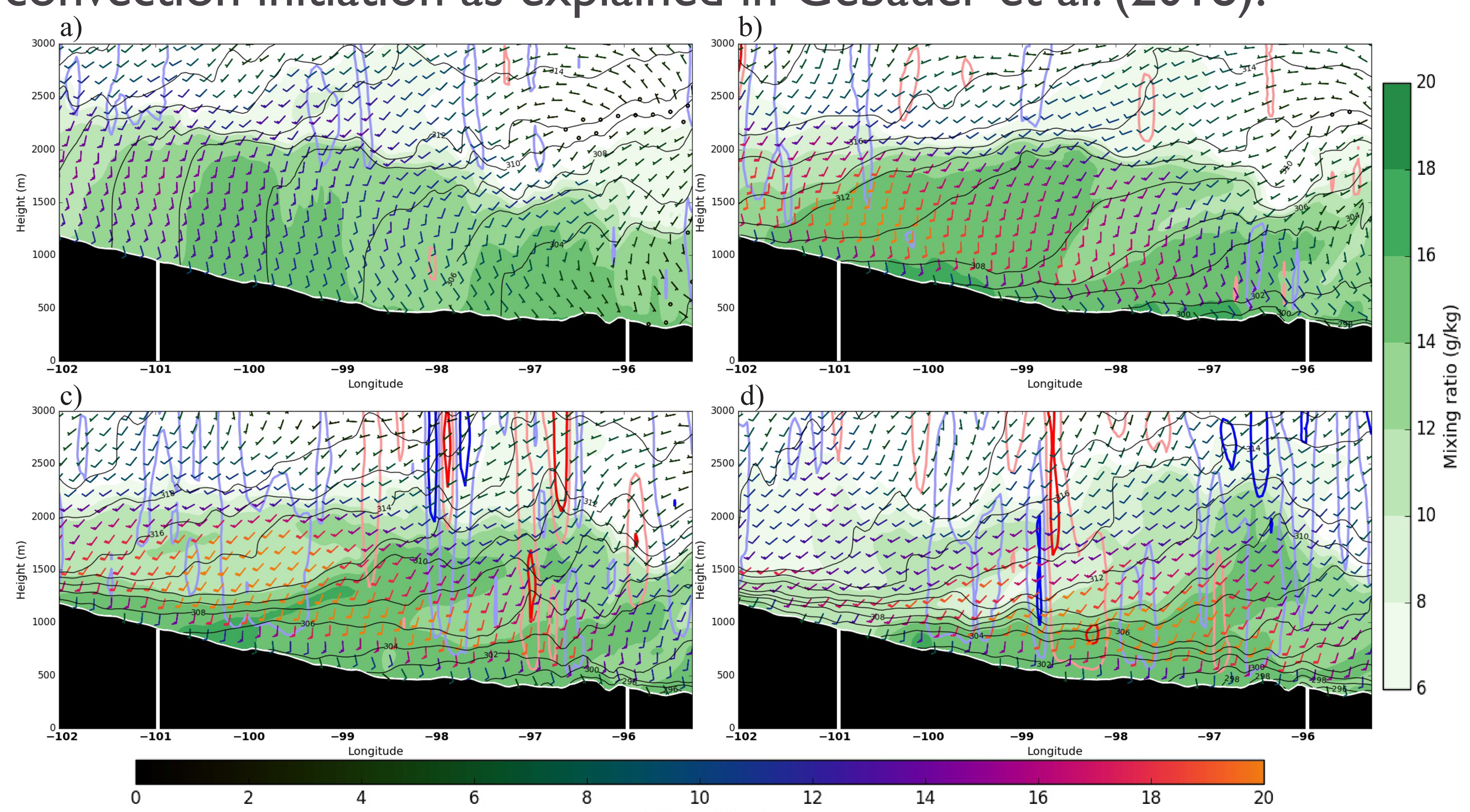

Figure 4. Cross sections along the Great Plains slope. Contours of vertical velocity (red-up, blue-down).

Observations at FP3, MP1, and FP2 (Fig. 2, 20 June 2015) suggest NLLJ spatial evolution via diagonal striations in wind with coincident rising motion and warm advection aloft.

Summary

Previous studies of the NLLJ have often focused on connecting locally defined boundary layer features to NLLJ characteristics and evolution. This approach was natural since most boundary layer observations have been limited to single or few points at or near the surface only. The development and application of modern observations and simulations have allowed for a new perspective on the relationship between the boundary layer and the NLLJ.

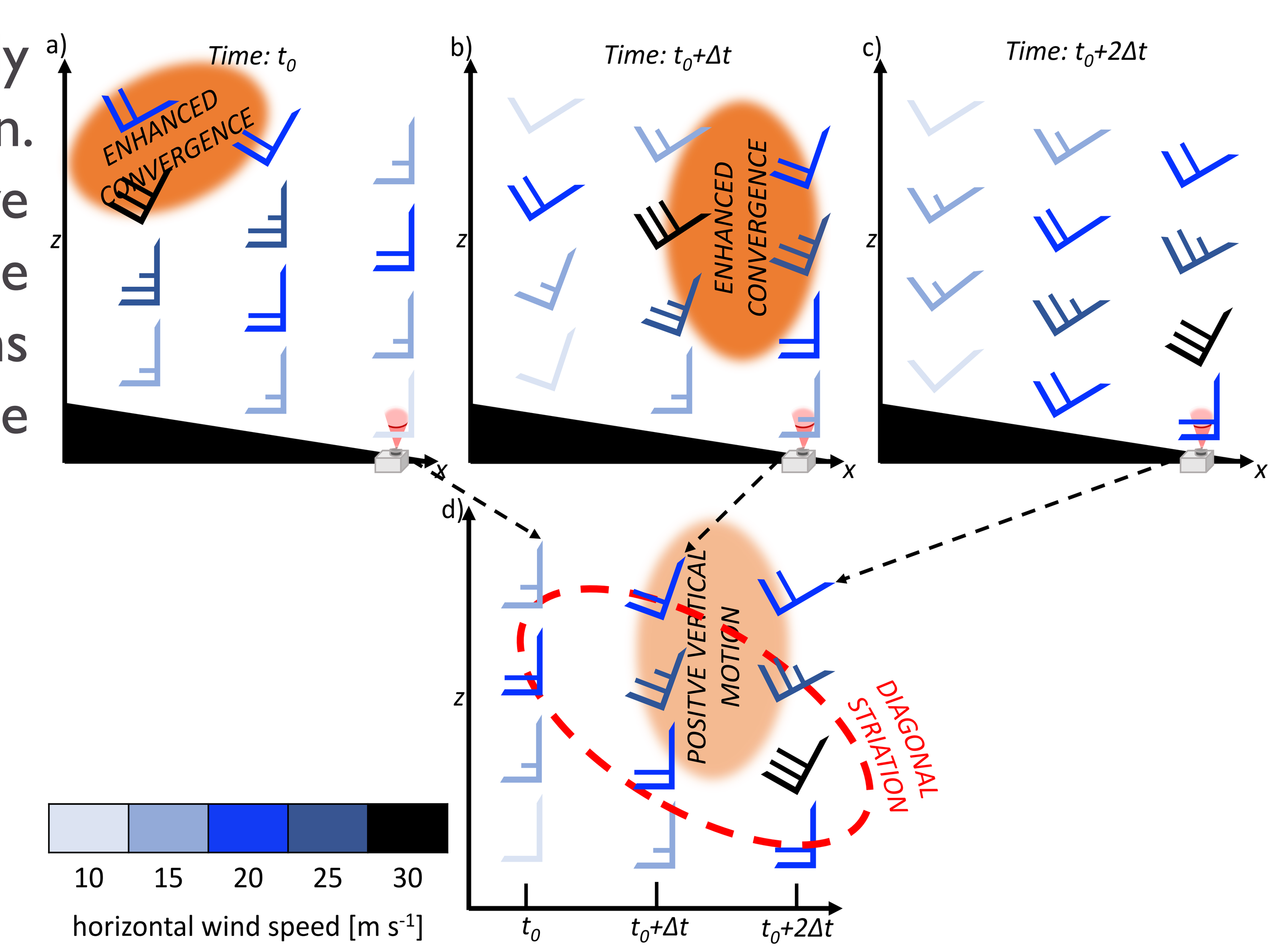

Figure 5. Schematic of spatial-temporal NLLJ evolution.

This study demonstrated the following:

- Using high-resolution observations in tandem with carefully configured simulations can allow for more robust analyses than either dataset alone.
- The Great Plains NLLJ is typically heterogeneous in depth, wind speed, and wind direction
- The heterogeneous NLLJ was shown to move across the slope of the Great Plains through the night
- Spatial and temporal characteristics of the Great Plains NLLJ are deeply connected (Fig. 5) and should not be considered independently.

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