Low-Level Jets and Mixing Layer Heights in the Plains Elevated Convection at Night (PECAN) Campaign

Brian Carroll¹, Belay Demoz², Timothy Bonin², Ruben Delgado¹, Kevin Vermeesch¹, David Whiteman³

¹University of Maryland, Baltimore County; ²Cooperative Institute for Research in Environmental Sciences; ³NASA Goddard Space Flight Center

Nocturnal warm season thunderstorms are a common phenomenon in the Great Plains region of the United States. These storms have a crucial impact on the local agriculture and everyday life, and yet the forecasting of these events and their quantitative rainfall remains a difficult task. PECAN was designed to study Great Plains nocturnal rainfall and related phenomena with unprecedented temporal and spatial coverage.

• Focused on nocturnal convection with a stable boundary layer (SBL), low-level jet, and largest convectively available potential energy (CAPE) above the SBL.
• Domain: southern Great Plains from June 1 – July 15, 2015
• 200+ scientists from multiple agencies and universities
• 6 fixed sites (FPs), 4 mobile sites, and 3 aircraft

Low-Level Jets and Moisture Transport

The Warm Season Great Plains Nocturnal LLJ
• Typically forms around sunset (~1 UTC) with dissipation of constraining boundary layer turbulence, and often persists until sunrise. Wind speed maximum in early morning hours.
• Characteristic southerly flow from the Gulf of Mexico
• Most common in Oklahoma and Kansas but can reach Canada
• Moisture and momentum can feed into mesoscale convective systems

Objectives
• The broad array of instrumentation operating during PECAN will be used for a statistical study characterizing moisture transport and jet wind structure and evolution with unprecedented detail.
• Data from the PECAN site FP2 along with other fixed sites and aircraft will be utilized to examine mesoscale spatial variations.

LLJ Statistics from PECAN FP2

<table>
<thead>
<tr>
<th>LLJ category</th>
<th>Vmax (m/s)</th>
<th>σ (σ)</th>
<th>Count in PECAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>No jet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLJ 0</td>
<td>≥ 10</td>
<td>≥ 5</td>
<td>5</td>
</tr>
<tr>
<td>LLJ 1</td>
<td>≥ 12</td>
<td>≥ 6</td>
<td>6</td>
</tr>
<tr>
<td>LLJ 2</td>
<td>≥ 16</td>
<td>≥ 8</td>
<td>4</td>
</tr>
<tr>
<td>LLJ 3</td>
<td>≥ 20</td>
<td>≥ 10</td>
<td>17</td>
</tr>
</tbody>
</table>

Vmax is the maximum wind speed at jet nose. σ is the difference between Vmax and the minimum speed above nose.

What’s Next?

This research will improve our understanding of the atmospheric phenomena related to Great Plains rainfall, opening the door for better models and weather forecasts.

• Intercomparison of high-resolution moisture and wind profiles for the 33 LLJ events observed at FP2. Calculate Richardson numbers.
• Expand some case studies to the entire PECAN domain of data; report on spatial variation of LLJ moisture transport
• Incorporate airborne instrument flyer data
• Continue validation and fine-tuning of MLH algorithm
• Examine nighttime busts of mixing using MLH algorithm in conjunction with other profiling and surface instruments
• Utilize MLH algorithm and individual products to explore turbulence above and below LLJ noise

Mixing Layer Heights from Doppler Lidar: A New Algorithm

1) Detect and remove effects of gravity waves and large scale, non-turbulent motions
2) Find turbulent layer via velocity variance of all useful scans: \( a_{\sigma^2} \) from each VAD scan \( a_{\sigma^2} \) from vertical scans

Combine using fuzzy logic for a first guess of the MLH
3) Find nearby proxies for mixing:
   - Peaks in wind shear and SNR variance, large gradients in SNR
   - If locations of these proxies are within 15% of the first guess MLH, combine them with first guess to determine final MLH
4) Flag the final estimate of the MLH:
   - Is MLH estimate near max or min of measurement range?
   - Is MLH cloud-topped?
   - Is MLH estimate near max or min of measurement range?

Applications to PECAN
• Relate daytime convective boundary layer heights to evening/night phenomena
• Examine MLH before and after bore wave passage
• Nocturnal bursts of mixing

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