Changes in the Diurnal Timing of the Great Plains Low-Level Jet

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1. Introduction

- Severe convective hazards are among the most impactful and costly weather events annually.
- Much of this convection and the attendant hazards occur nocturnally during the warm season and are associated with the **Great Plains low-level jet (GPLLJ)** (Parish et al. 2020).
- GPLLJs can be **coupled** (driven by synoptic-scale patterns) or **uncoupled** (driven exclusively by terrain and boundary layer effects) (Shapiro et al. 2016; Burrows et al. 2019).
- Prior work found that GPLLJs are becoming *less frequent* but *more intense* (Ferguson 2022).
- Since literature has not addressed changes in diurnal timing of the GPLLJ, our work develops a novel **30-year climatology of diurnal GPLLJ timing**.

2. Research Questions (RQ)

1. Have the **diurnal onset time, duration, and dissipation time** of the GPLLJ changed over the past 30 years (1994-2023)?
2. If so, are these changes **correlated with observed changes in the intensity and location** of the GPLLJ?
3. Are any diurnal changes in the onset time, duration, and dissipation time of the GPLLJ **correlated with upper-level coupling**?

3. Data and Methods

Data: **ERA5 reanalysis** (Carver et al. 2023)

- Hourly isobaric data limited to **extended warm season** (i.e., May-September; MJJAS) over the **most recent 30-year period** (1994-2023) within the Great Plains (GP).
- Domain divided into three subregions: northern (NGP), central (CGP), and southern (SGP)

LLJ Classification:

- 1. LLJs are identified and classified *per hour and subregion* by the following criteria:
  - **Maximum wind (Vmax)** of at least 10 ms^{-1} below the 700 hPa level
  - **Vertical shear (ΔV_z)** of at least 5 ms^{-1} between the height of max speed and 700 hPa level
  - Positive meridional (v) component of wind **(southerly)**
  - **Spatial coverage** of above criteria met **within 25% of grids** in the subregion
- 2. LLJ intensity is defined by the following conventional **Bonner-Whiteman (BW) criteria**:

Classification	V_{max} (ms^{-1})	ΔV_z (ms^{-1})
BW-0	≥ 10	≥ 5
BW-1	≥ 12	≥ 6
BW-2	≥ 16	≥ 8
BW-3	≥ 20	≥ 10

Table 1: *Wind speed and shear criteria for GPLLJ intensity levels from Bonner (1968) and Whiteman et al. (1997)*

- 3. LLJ *events* defined by grouping hours (min of 3 hours)
  - Onset time: first LLJ hour
  - Dissipation time: last LLJ hour
  - Duration: total LLJ hours
  - Max hourly BW intensity
- 4. Upper-level coupling criteria:
  Using **500 hPa height anomalies** (in σ) to the west and over the GP domain (CWA and AWA, respectively)
  1. **Coupled:** CWA ≤ -2.5
  2. **Uncoupled:** AWA ≤ -1
  3. **Coupled:** CWA ≤ -0.75
  4. Otherwise, **uncoupled**

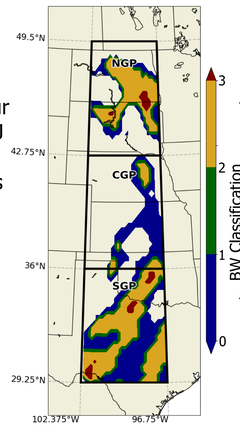


Figure 1: *LLJ intensity over the GP subregions at 0300 UTC May 18, 2019*

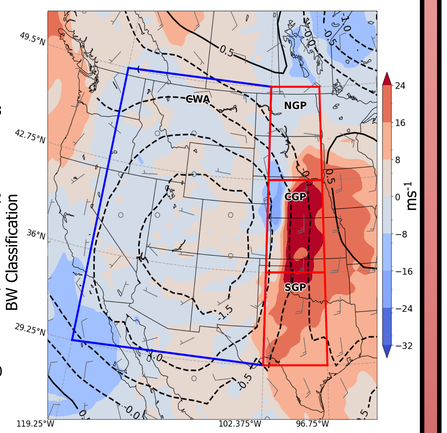


Figure 2 : *Coupling analysis for example in Fig. 1. Positive (negative) height anomalies contoured with a solid (dashed) line. CWA and AWA regions denoted by the red and blue boxes, respectively. Filled contours depict 850 hPa v wind.*

4. Jet Duration and Frequency

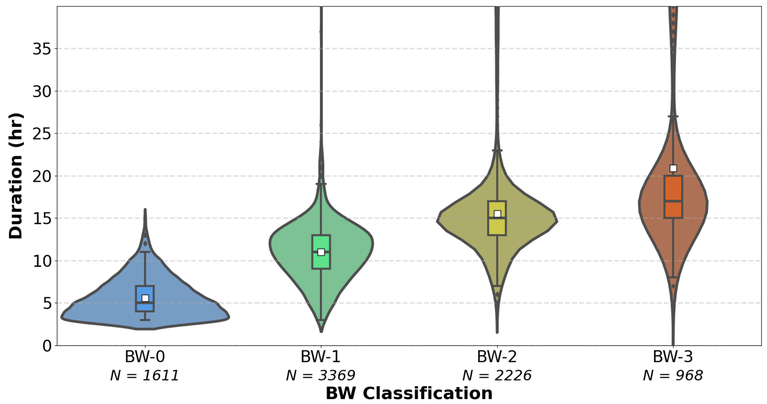


Figure 3: *GPLLJ event duration by BW classification*

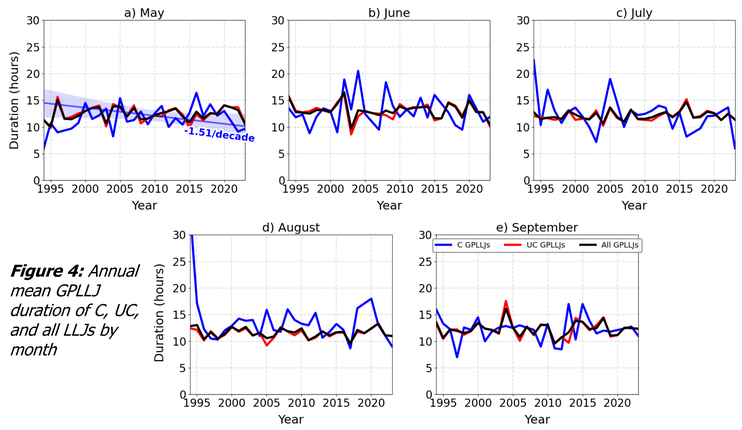


Figure 4: *Annual mean GPLLJ duration of C, UC, and all LLJs by month*

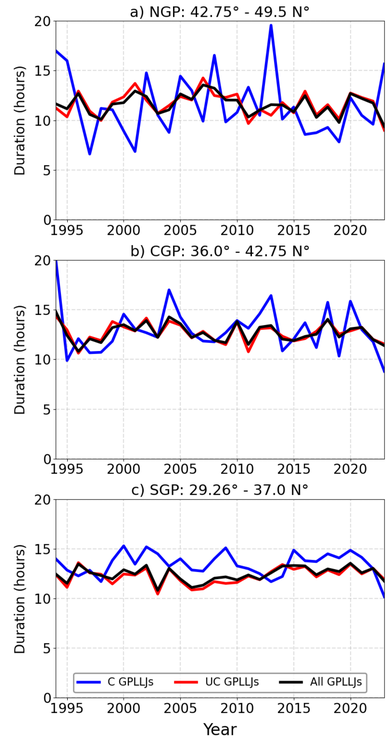


Figure 5: *Annual mean GPLLJ duration of C, UC, and all LLJs by subregion*

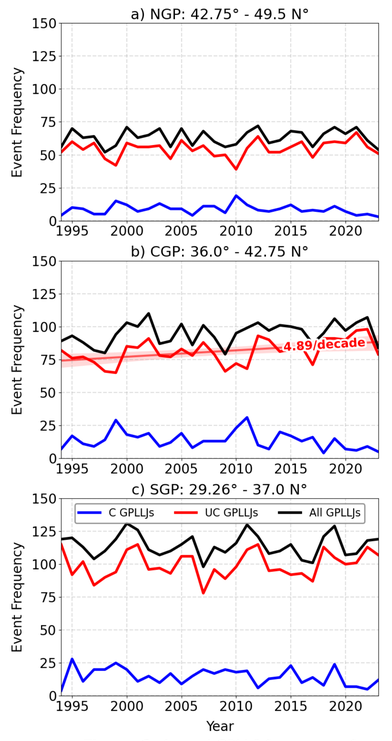


Figure 6: *Annual GPLLJ frequency of C, UC, and all LLJs by subregion*

5. Jet Onset and Dissipation Time

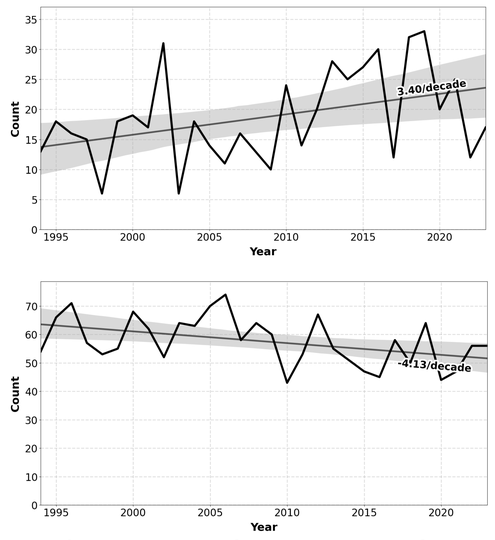


Figure 7: *Time series of GPLLJ event onset time frequency between 21-23Z (top) and 04-06Z (bottom)*

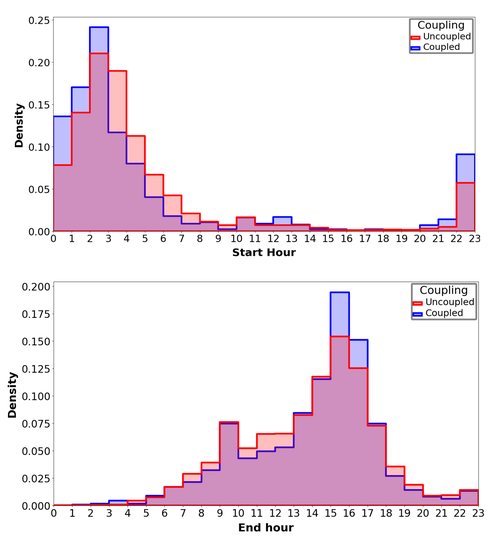


Figure 8: *Distribution of GPLLJ event start hour (top) and end hour (bottom) by upper-level coupling*

6. Conclusions

RQ1:

- The mean annual **duration** of GPLLJs has not changed over the past 30 years across all subregions and months.
- Overall, GPLLJs are **starting and peaking earlier** in the day (18-23Z).
  - Primarily within the CGP and during the early evening hours (21-23Z)
- There is a corresponding decrease in onset time later in the night (4-6Z), but not in dissipation time.

RQ2:

- We **could not replicate observed trends** in GPLLJ frequency and intensity by subregion or month from prior literature.
- Our findings **do not correlate** with changes in the intensity or location of the jet.

RQ3:

- While there is a slight increase in UC LLJs in the CGP, there are **no significant coupling trends.**

Climatology:

- More intense GPLLJs last longer than weaker GPLLJs
- **Coupled LLJs** tend to **start earlier** and are **more variable** in duration than **UC LLJs**

References