Corridors of Enhanced Transport and Dispersion: Global Distribution and Characteristics

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Global distribution and characteristics of diurnally varying low-level jets

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Global precipitation extremes associated with diurnally varying low-level jets

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Motivation

• Low-level jets (LLJs) strongly impact distribution of atmospheric constituents originating from Earth’s surface and human activity.
• Document phenomenology of low-level jets in various environments.
Mechanisms for LLJs

• Diurnally varying eddy viscosity driven by changes in solar heating.
• Changes in horizontal baroclinicity arising from spatial contrasts in heating.
Global mesoscale analysis

- 21-year global downscaled reanalysis
  - 1985-2005
  - 40 km grid.
  - 12 vertical layers in lowest 1.5 km AGL.
  - Hourly three-dimensional output to fully resolve diurnal cycle.
- Performed with MM5- and WRF-based climate downscaling system.
- Assimilated high-quality observational datasets.
NCAR Climate FDDA system (ClimoFDDA)

Year 1
- Global analysis
- Observations
- WRF + FDDA
- Regional analysis

Year 2
- Global analysis
- Observations
- WRF + FDDA
- Regional analysis

Year 3
- Global analysis
- Observations
- WRF + FDDA
- Regional analysis

Year N
- Global analysis
- Observations
- WRF + FDDA
- Regional analysis

Post-processing
- Input to Decision Support Tools
- MM5-based version used
- Mean
- Variance
- Probability Est.
- Extremes
- “Typical” day
Mapping corridors of enhanced T&D

• Each hourly output assigned the local time within each 15° longitudinal strip on the globe.
  — Example: 100°W at 0600 UTC assigned time of 0000 LT.
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- NLLJ index based on diurnal change in wind’s vertical profile.
  — Do winds conform to a jet-like profile?
    - Jet level winds (500 m AGL) at midnight stronger than those aloft (4 km AGL).
  — Is jet nocturnal?
    - Jet level winds (500 m AGL) at midnight stronger than at noon.
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• Result: 21-year database of daily NNLJ index values for every point on globe.
First objective maps of recurring LLJs

Colors = 21-yr mean NLLJ index.

Arrows = Mean 500-m-AGL winds at local midnight, plotted every 20th grid point.
NLLJ characteristics

1985-2005

Vertical, dotted black lines mark Bonner (1968) wind speed classes.
Diurnal variations in NLLJs

1985-2005

a) July

b) January
Detailed study: Tarim Pendi NLLJ

**Strongest 10% LLJ events 1985-2005.**

Occurs in boreal summer; very episodic.

Forms following cold frontal passages around Tian Shan mountains to the north.
Strongest 10% LLJ events 1985-2005.

One of only three that occur in winter.

Results from formation of a cyclonic lee vortex on the west side of the Ethiopian Highlands.
Summary and commentary

• NLLJs are ubiquitous within world’s land covered areas and strongly drive the regional T&D.
  — Mesoscale through synoptic-scale in extent.
  — Produce coherent transport over hundreds of kilometers.

• Remain a fundamental challenge to global weather and climate modeling of atmospheric constituents.
  — Shallow and intense.
  — Arise partly from variations in turbulence.
Independent verification of re-analysis: Diurnal and vertical structure of PBL

None of the 36 stations assimilated by ClimoFDDA or driving NCEP-DOE Reanalysis

Composite 5 stations along the climatographic axis of the North American low level jet (LLJ).

Neligh, NE
Fairbury, NE
Hillsboro, KS
Lamont, OK
Purcell, OK
Mean time-height of meridional winds for Great Plains LLJ

Oranges = southward
Blues = northward

From Rife et al. (2010), Journal of Climate