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Corridors of Enhanced Transport and Dispersion: Global Distribution and Characteristics

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Basis for this talk

JOURNAL OF CLIMATE

Global distribution and characteristics of diurnally varying low-level jets

Daran L. Rife, James O. Pinto, Andrew J. Monaghan, Christopher A. Davis, and John R. Hannan

(Manuscript received 04 November 2009, in final form 04 May 2010)

Global precipitation extremes associated with diurnally varying low-level jets

Andrew J. Monaghan, Daran L. Rife, James O. Pinto, Christopher A. Davis, and John R. Hannan

(Manuscript received 04 November 2009, in final form 04 May 2010)

Motivation

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- 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.

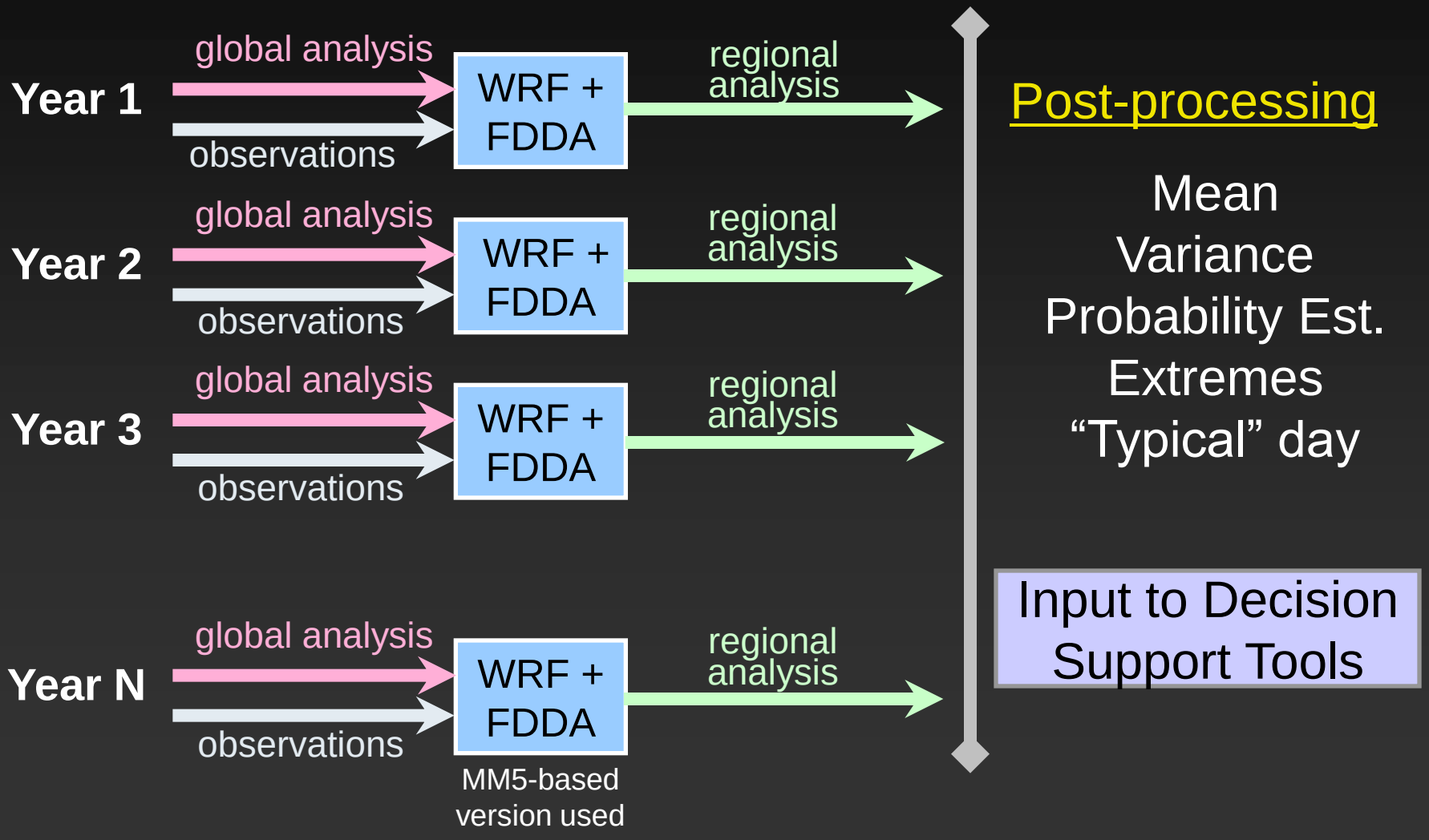
Mechanisms for LLJs

- 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)



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?
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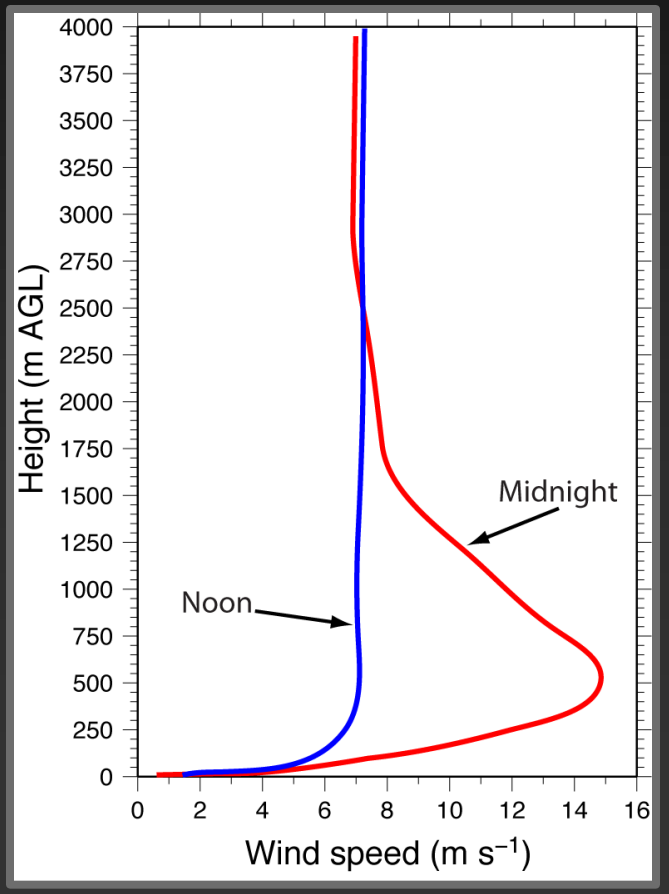

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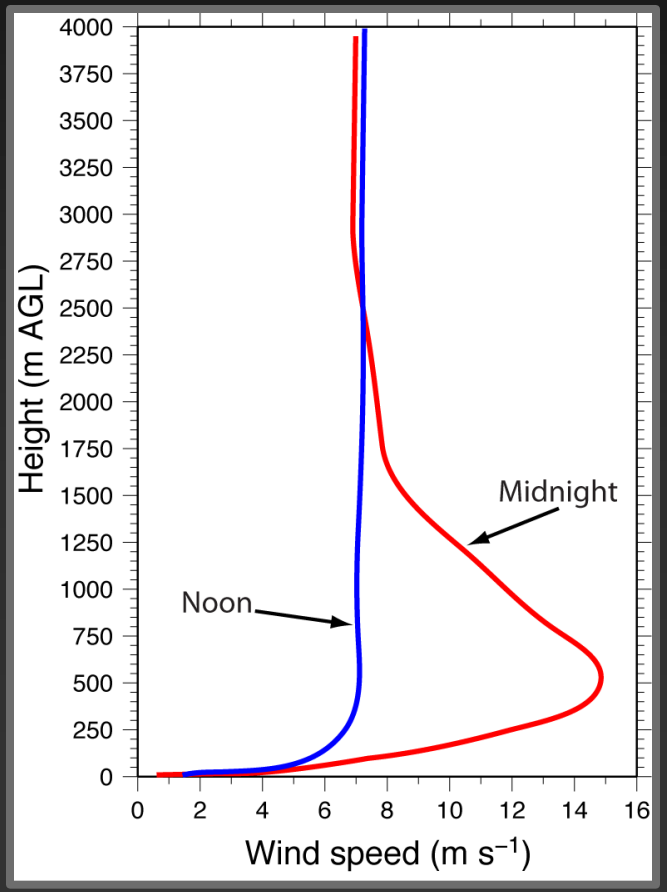
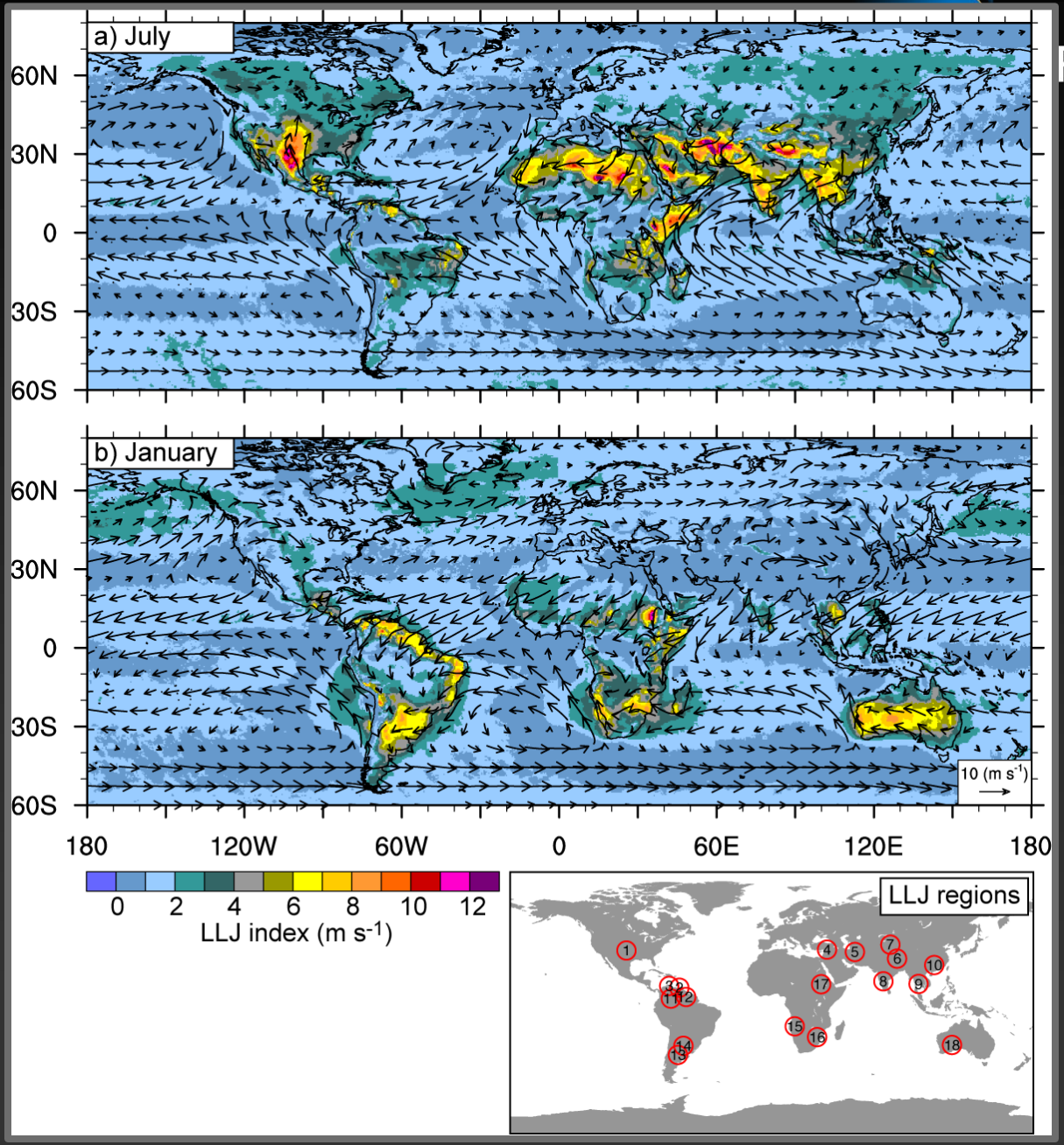
- Result: 21-year database of daily NNLJ index values for every point on globe.



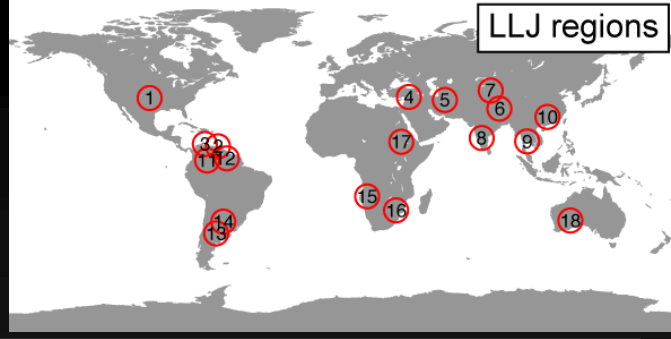
First objective maps of recurring LLJs

Colors = 21-yr mean NLLJ index.

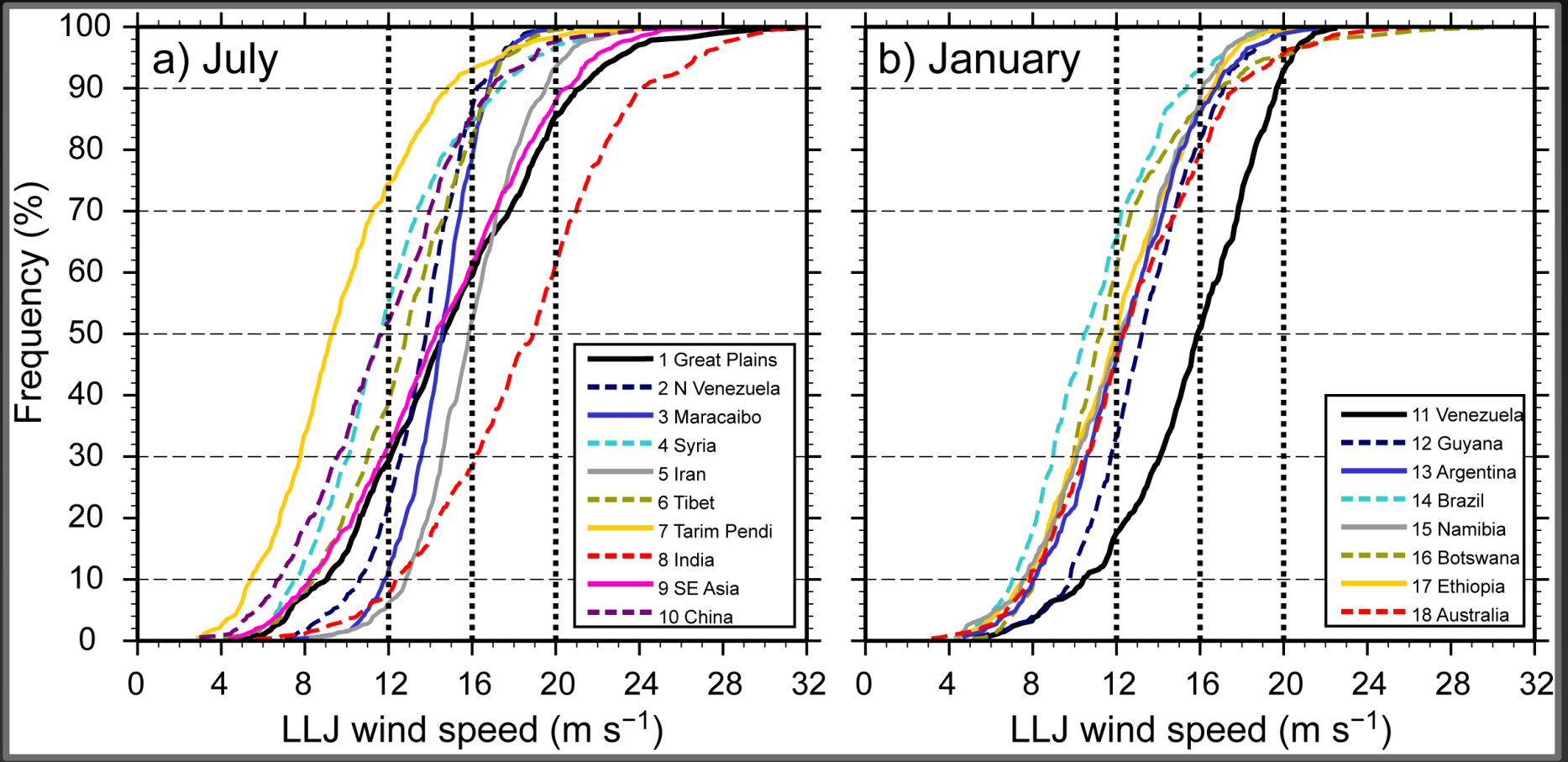
Arrows = Mean 500-m-AGL winds at local midnight, plotted every 20th grid point.



NLLJ characteristics



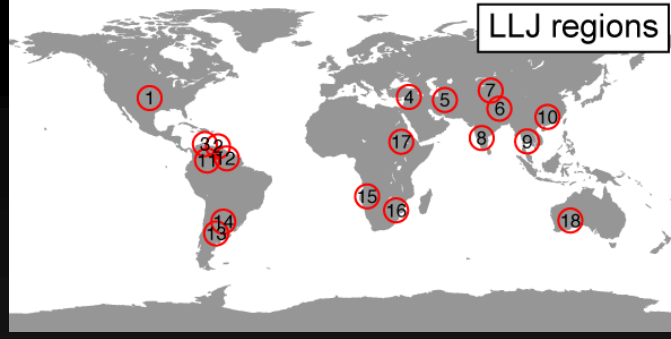
1985-2005

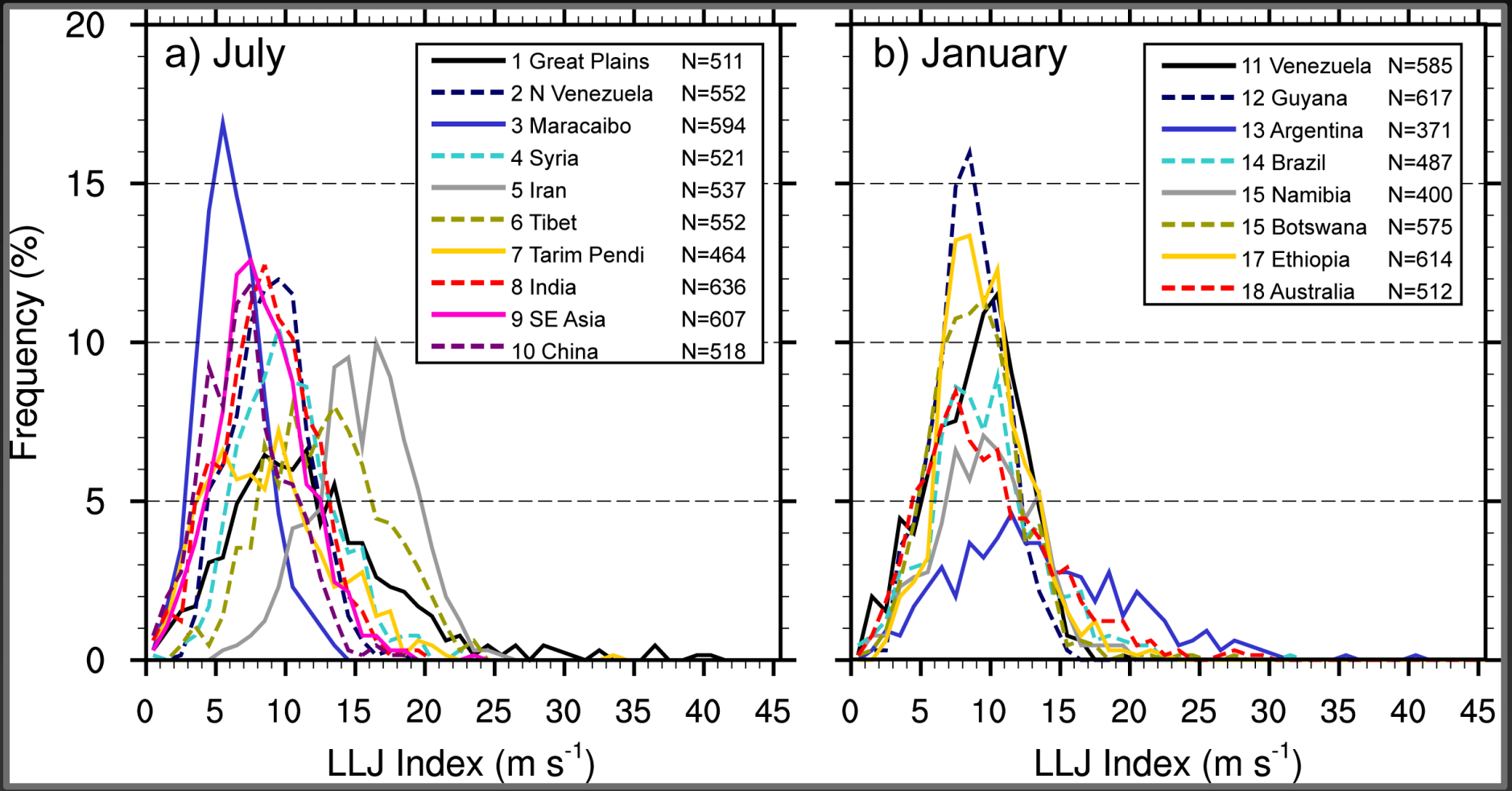


Vertical, dotted black lines mark Bonner (1968) wind speed classes.

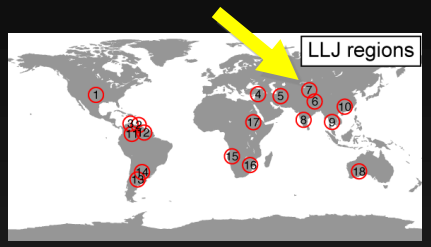
Diurnal variations in NLLJs

1985-2005





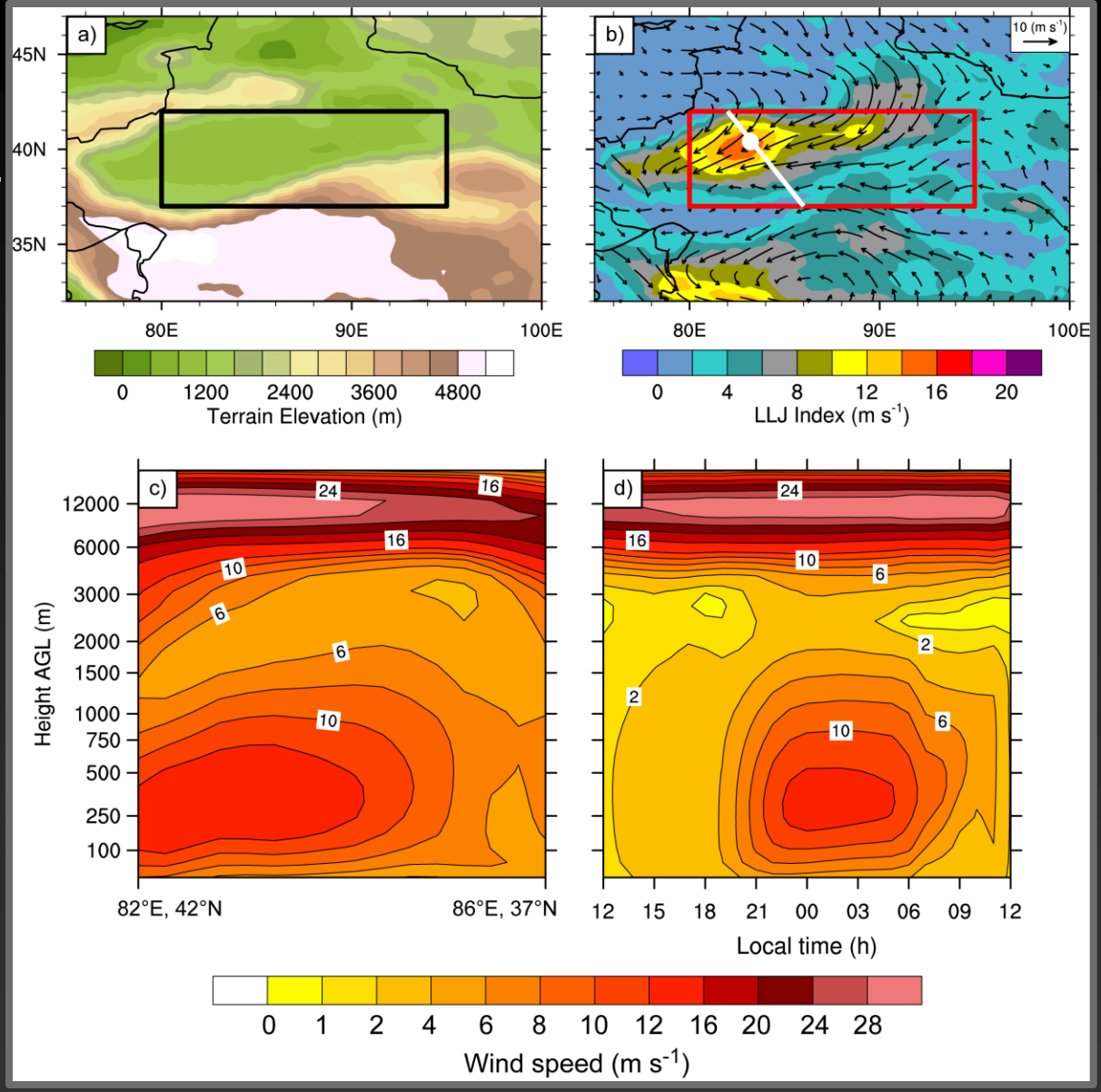
Detailed study: Tarim Pendi NLLJ



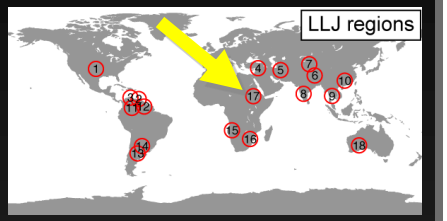
Strongest 10% LLJ events 1985-2005.

Occurs in boreal summer; very episodic.

Forms following cold frontal passages around Tian Shan mountains to the north.



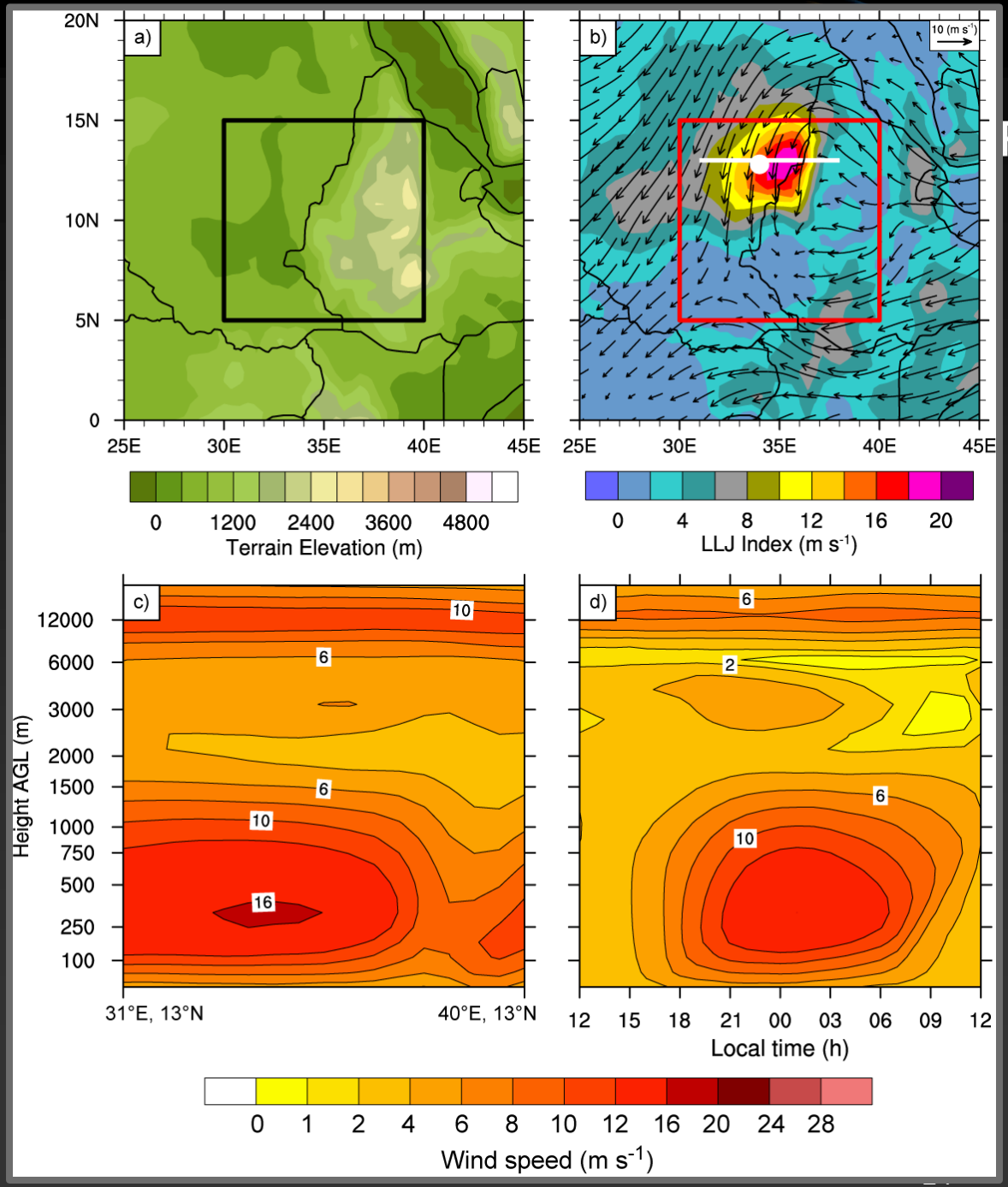
Detailed study: Ethiopia NLLJ



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.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Independent verification of re-analysis: Diurnal and vertical structure of PBL

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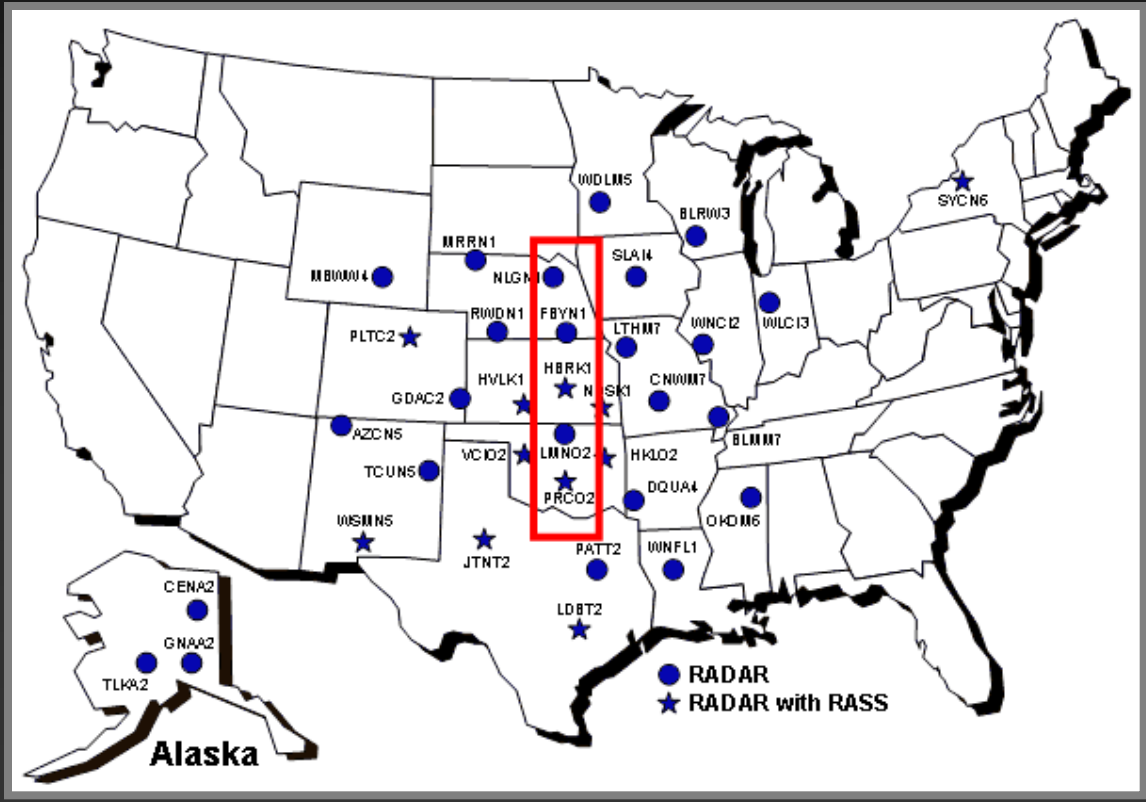
None of the 36 stations assimilated by ClimoFDDA or driving NCEP-DOE Reanalysis

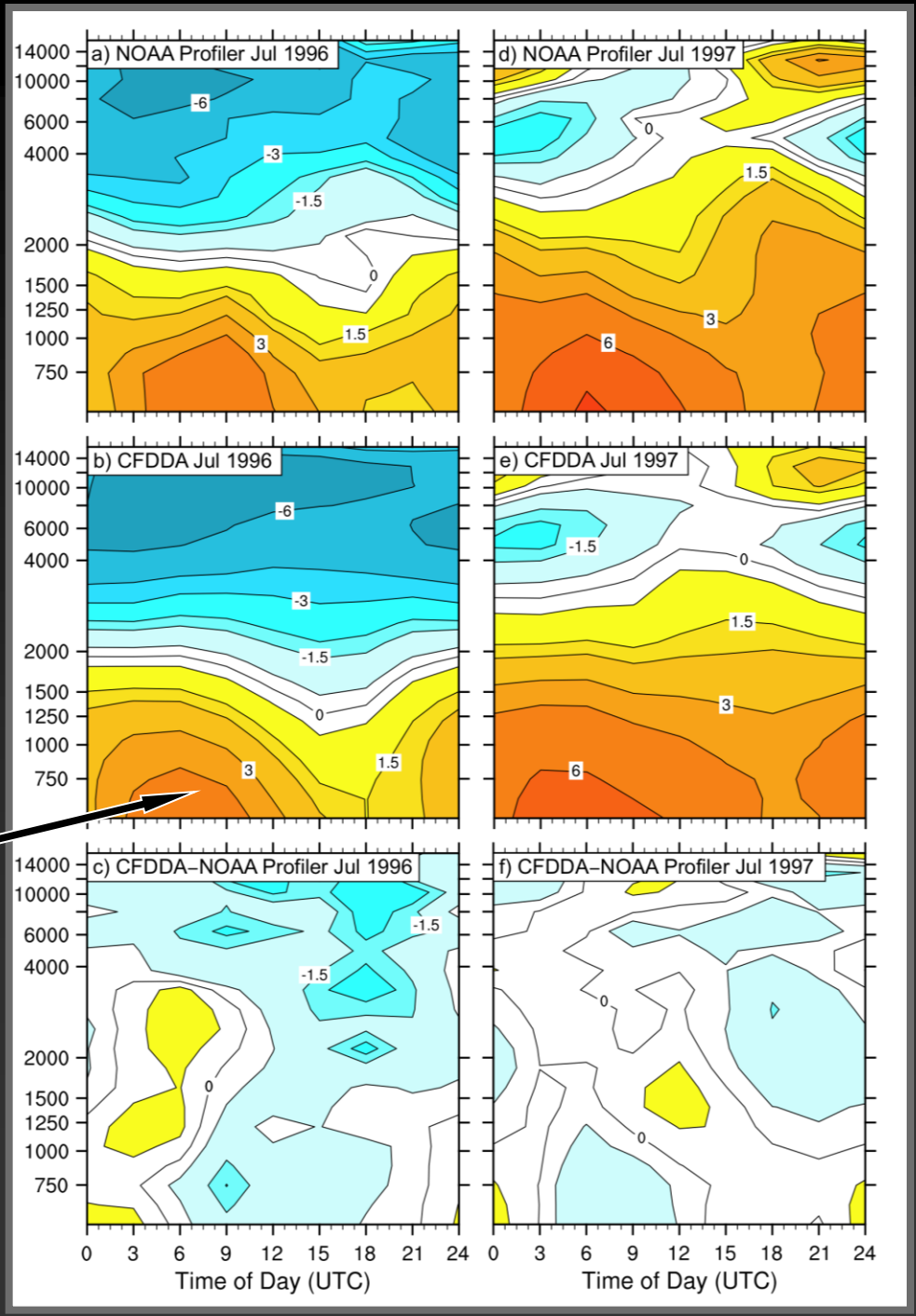
Neligh, NE
Fairbury, NE
Hillsboro, KS
Lamont, OK
Purcell, OK



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

Mean time-height of meridional winds for Great Plains LLJ

Oranges = southward
Blues = northward



LLJ

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