A Climatological Study of Jet Streak Acceleration Events and Downstream Impacts

Mark R. Sinclair

Email: sinclam@erau.edu

Department of Applied Aviation Sciences, College of Aviation, Embry-Riddle Aeronautical University, Prescott, AZ

1. Motivation and Research Objective

- It is known that recurving western North Pacific (WNP) TCs undergoing extratropical transition (ET) can initiate amplification of the downstream extratropical flow, resulting in high-impact weather events thousands of miles downstream.
- Archambault et al. (2013) (A2013) found that prolonged episodes of strong negative $-V_\chi . \nabla_P PV$ PV associated with recurving WNP TCs excited downstream jet streak acceleration & Rossby wave amplification, as illustrated below

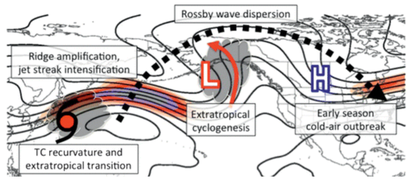

Fig. 1. Schematic diagram illustrating key processes that link the recurvature and extratropical transition of WNP TC Oscar during 15-18 Sep 1995 to a cold air outbreak over the US three days later (from A2013, their Fig. 1).

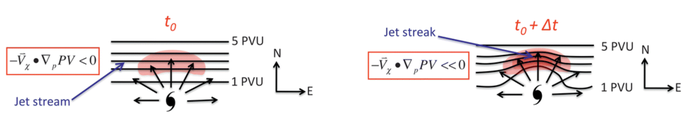

Fig. 2. Schematic representation of ridge amplification and jet streak intensification associated with the divergent outflow of a TC impinging on an upper-tropospheric jet (from A2013, their Fig. 4).

- The present study addresses two new research questions:

1. Do prolonged episodes of negative PV advection during ET excite downstream jet streak acceleration & Rossby wave amplification in other TC basins?
2. Can prolonged episodes of negative PV advection excite downstream jet streak acceleration & Rossby wave amplification <u>*outside*</u> of the recurving TC context?

2. Recurving TCs – global analysis

- Use IBTrACS global TC database and NCEP-NCAR 2.5º reanalysis dataset (1979-2014), determine global climatology for TC. recurvature for all TC basins
- Identify prolonged episodes of large negative $-V_\chi . \nabla_P PV$ near time of recurvature using methodology of A2013 (reverse sign for SH).

Results

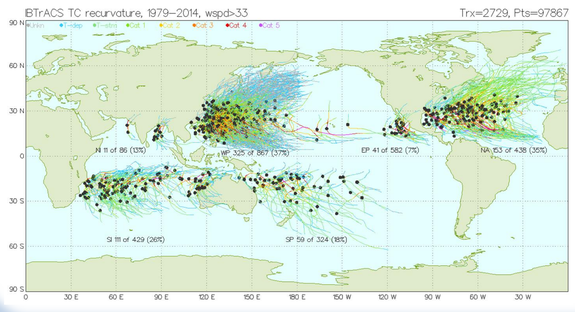

Fig. 3. Global climatology of TC recurvature, defined as western-most position of TCs that continue into extratropics.

Most recurvatures in WNP and NA basins.

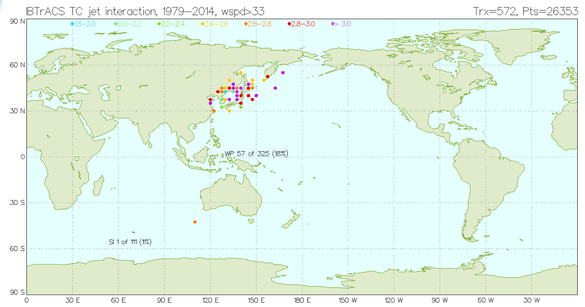

Fig. 4. Global occurrences of strong negative PV advection during ET. Instances of 48 h avg $-V_\chi . \nabla_P PV$ < -1.8 PVU d^{-1} near recurving TCs are shown.

- 95% of instances of negative PV advection during ET occur in WNP basin
- Twice as many cases found when search for strong interaction made at ANY stage of the TC (not just recurvature)
- Downstream response (not shown) almost identical to A2013

3. General Climatology of $-V_\chi . \nabla_P PV$

- Globally identify ALL $-V_\chi . \nabla_P PV$ minima & track these in the 6-h NCEP. reanalyses during 1979-2014 using the tracking algorithm of Sinclair (1996).
- Identify prolonged episodes of large negative $-V_\chi . \nabla_P PV$ as tracked.
- Most of these are non-TC related.

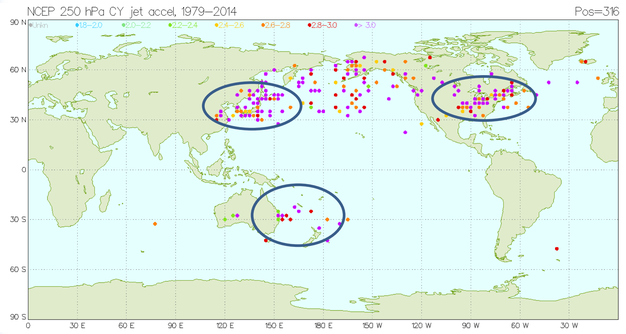

Fig. 5. Global occurrences of 48 h avg $-V_\chi . \nabla_P PV$ < -1.8 PVU during 1979-2014.

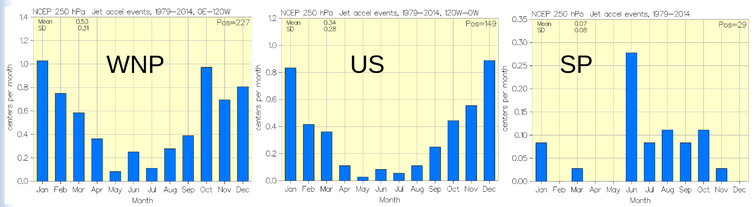

Fig. 6. Occurrence by month of strong negative $-V_\chi . \nabla_P PV$.

- These episodes of strong negative $-V_\chi . \nabla_P PV$ (here called jet acceleration events, JAE) are found in three regions – west and central North Pacific, over the northeast US and east of Australia.
- NH JAE events occur mostly during fall and winter.

4. Downstream Response

- Do these (mostly) non-TC JAE events excite a similar downstream response to that associated with TC recurvature as reported in A2013?
- Examine downstream response in a moveable domain between latitudes 20 and 70 extending 90° longitude east of each episode of negative $-V_\chi . \nabla_P PV$.

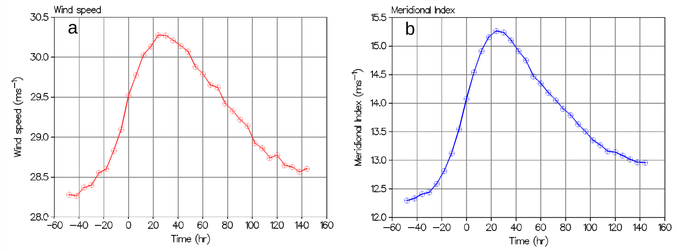

Fig. 7. Composite downstream response for all JAEs, from 48-h before maximum JAE index to 144-h after. a) Domain-averaged 250-hPa windspeed, b) meridional index, obtained as the domain average 250-hPa |*v*|. 0-h is the time of maximum JAE

Results

- Maximum downstream response occurs 24 h after JAE maximum.
- Results similar to those obtained by A2013 for WNP TCs
- Downstream response already underway at time of max JAE (0-h),

5. Winter example

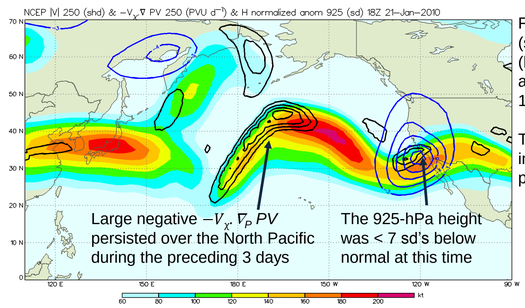

Fig. 8. 250-hPa isotachs (shaded), negative $-V_\chi . \nabla_P PV$ (black) and standardized anomaly of H 925 (blue), for 18Z 21 Jan 2010.

This storm produced flooding in AZ & record low MSL pressure near CA.

6. Conclusions

- Prolonged episodes of strong upper tropospheric negative PV advection (JAEs) during ET are rare outside of WNP basin.
- JAE episodes with downstream impacts can occur at any stage of the TC, not just near the time of TC recurvature.
- JAEs are found in other parts of the globe at any time of year.
- These mostly non-TC JAEs excite downstream jet streak acceleration & Rossby wave amplification similar to their WNP TC counterparts.
- Prolonged episodes of strong negative $-V_\chi . \nabla_P PV$ may have wider utility as a diagnostic for anticipating high impact downstream weather.

References

Archambault, H. M., L. F. Bosart, D. Keyser, and J. M. Cordeira, 2013: A climatological analysis of the extratropical flow response to recurving western North Pacific tropical cyclones. *Mon. Wea. Rev.*, **141**, 2325–2346.

Sinclair, M.R.,1997: Objective identification of cyclones and their circulation intensity, and climatology. *Wea. Forecasting*, **12**, 591–608.