A Climatological Study of Jet Streak Acceleration Events and Downstream Impacts

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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) found that prolonged episodes of strong negative $-V_x$, $F_p$, $PV$ 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 cold air outbreak over the US three days later (from A2013, their Fig. 1).

• 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 outside of the recurring TC context?

2. Recurring TCs – global analysis

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

Fig. 3. Global climatology of TC recurring, defined as western-most position of TCs that continue into extratropics. Most recurvatures in WNP and NH basins.

Fig. 4. Global occurrences of strong negative PV advection during ET. Instances of 48 h avg $-V_x$, $F_p$, PV $< -1.8$ PVU d$^{-1}$ near recurring 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 $-V_x$, $F_p$, $PV$

• Globally identify ALL $-V_x$, $F_p$, $PV$ 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 $-V_x$, $F_p$, $PV$ as tracked.
• Most of these are non-TC related.

Fig. 5. Global occurrences of 48 h avg $-V_x$, $F_p$, PV $< -1.8$ PVU during 1979-2014.

Fig. 6. Occurrence by month of strong negative $-V_x$, $F_p$, PV.
• These episodes of strong negative $-V_x$, $F_p$, 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 $-V_x$, $F_p$, 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 $(v - u)$, b-n-a 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 $-V_x$, $F_p$, $PV$ (black) and standardized anomaly of H 925 (blue), for 18Z 21 Jan 2010.

Large negative $-V_x$, $F_p$, PV persisted over the North Pacific during the preceding 3 days.
The 925-hPa height was $< 7$ at’s below normal at this time.

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 $-V_x$, $F_p$, PV may have wider utility as a diagnostic for anticipating high impact downstream weather.

References