A CLIMATOLOGICAL STUDY OF JET STREAK ACCELERATION EVENTS AND DOWNSTREAM IMPACTS

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1. INTRODUCTION AND MOTIVATION

Several observational and numerical modeling studies have demonstrated that high-impact weather events can occur downstream from recurving western North Pacific Basin (WNP) tropical cyclones (TC) that undergo extratropical transition (ET) and interact with the midlatitude flow (e.g., Harr et al. 2009; Archambault et al. 2013) . These events, which can occur half a hemisphere away from the TC, are the result of jet streak intensification and downstream wave amplification triggered by the interaction of the TC with the midlatitude flow. Archambault et al. (2013, hereafter A2013) used the magnitude of the negative PV advection by the divergent component of the wind in the TC outflow region, $-V\chi . \nabla_P PV$ as a metric for the strength of the interaction between the TC and the extratropical flow and constructed a climatology of the downstream flow response to these recurving WNP TCs. They also showed that the likelihood of amplified downstream flow was sensitive to the strength of this metric.

Previous studies of high impact weather downstream from TCs interacting strongly with the midlatitude flow have been limited to recurving TCs in the WNP. The present study addresses two new research questions:

- Do similar examples of downstream extratropical flow amplification and intensification occur for TCs undergoing ET in *other* ocean basins?
- Can downstream wave amplification occur more generally in conjunction with episodes of strong negative $-V\chi . \nabla_P PV$ *outside of the TC context*?

2. GLOBAL ANALYSIS OF RECURVING TCs

In this section, the global climatology of TC recurvature is constructed using TC data from the International Best Track Archive for Climate Stewardship (IBTrACS) TC database (Knapp et al. 2010). For each TC, prolonged episodes of strong negative $-V\chi . \nabla_P PV$ at jet level are identified using the methodology of A2013 using gridded data from the 2.5° NCEP-NCAR reanalyses spanning the satellite era, 1979-2015.

Results (Fig. 1) show that 95% of instances of strong negative PV advection occur in WNP basin, with twice as many cases found when the search for strong negative $-V\chi . \nabla_P PV$ is not limited to the recurvature stage of the TC. The downstream response (not shown but similar to Fig. 4 below) is almost identical to A2013.

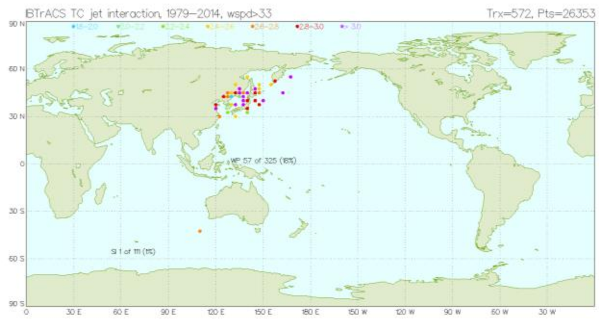

Fig. 1. Global occurrences of strong negative PV advection during ET, for 1979-2015. Instances of 48 h avg $-V\chi . \nabla_P PV <$ -1.8 PVU d^{-1} computed as in A2013 near recurving TCs are shown.

This study has shown that TC-triggered downstream amplification mostly only occurs for TCs in the WNP basin. However, downstream impacts are not limited to the recurvature stage of the TC, as in previous studies.

3. GENERAL CLIMATOLOGY OF $-V\chi . \nabla_P PV$

To determine if prolonged episodes of strong negative $-V\chi . \nabla_P PV$ can occur more generally outside the TC context, ALL $-V\chi . \nabla_P PV$ minima at 200 hPa during 1979-2014 are identified and tracked in the 6-h NCEP reanalyses using the tracking algorithm of Sinclair (1996). From these tracked centers, prolonged episodes of strong negative $-V\chi . \nabla_P PV$ as tracked were identified as in A2013. These episodes are here called jet acceleration events (JAEs).

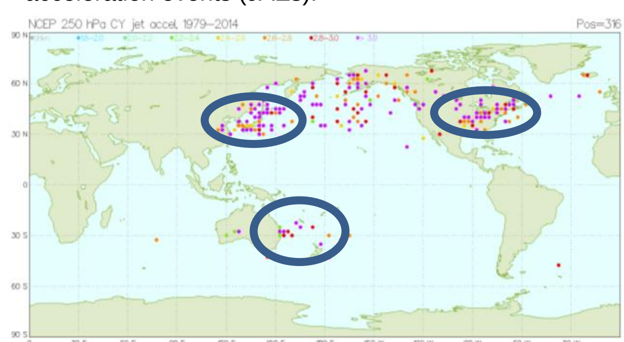

Fig. 2. Global occurrences of strong negative PV advection. Instances of 48 h avg $-V\chi . \nabla_P PV <$ -1.8 PVU d^{-1} are shown.

Results in Fig. 2 show that JAEs are most common in the west and central North Pacific, over the northeast US and east of Australia. Most of these are not TC-related.

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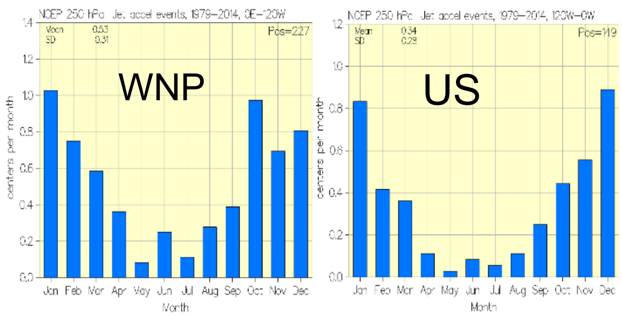

Fig. 3. Northern hemisphere JAE occurrence by month

Figure 3 shows that northern hemisphere JAEs are most common in fall and winter months. Southern hemisphere JAEs (not shown) are most common in the austral winter and spring months.

4. DOWNSTREAM RESPONSE

To determine the downstream response of these (mostly) non-TC JAEs, we determined the composite domain-averaged 250-hPa windspeed and the meridional index, obtained as the domain average 250-hPa |***V***| over a moveable domain between latitudes 20 and 70 extending 90° longitude east of each episode of negative $-V\chi . \nabla_P PV$.

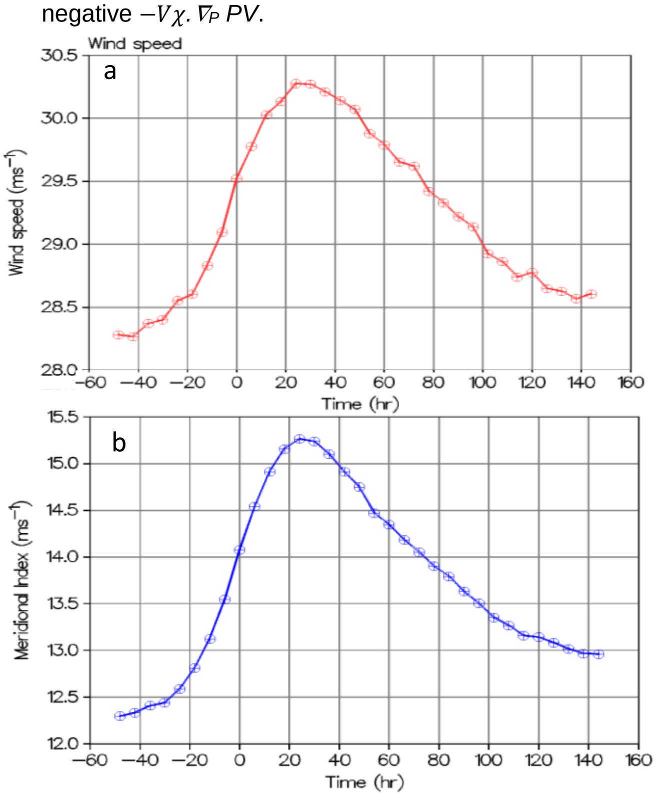

Fig. 4. Composite downstream response for all JAEs, from 48-h before maximum JAE index to 144-h after. a) Domain-averaged 250-hPa windspeed, b) meridional index, obtained as the domain average 250-hPa |*v*|. 0-h is the time of maximum JAE.

Figure 4 reveals that the maximum downstream response occurs 24 h after JAE maximum and that a downstream response is already underway at the time of maximum JAE (0-h). These results are similar to those obtained by A2013 for WNP TCs.

5. WINTER EXAMPLE

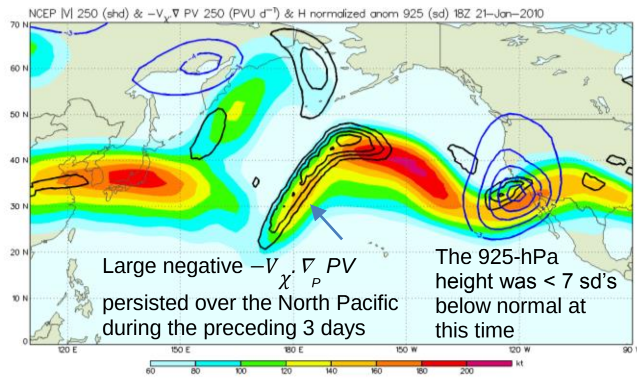

Fig. 5. 250-hPa isotachs (shaded), negative $-V\chi . \nabla_P PV$ (black) and standardized anomaly of H 925 (blue), for 18Z 21 Jan 2010.

This example shows strong downstream impacts following a JAE in the central Pacific in January, 2010. This storm produced flooding in AZ and record low MSL pressure near CA.

6. CONCLUSIONS

Prolonged episodes of strong upper tropospheric negative PV advection (JAEs) during the ET of TCs are rare outside of WNP basin. However, JAEs are found more generally 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. This study suggests that prolonged episodes of strong negative $-V\chi . \nabla_P PV$ may have wider utility as a diagnostic for anticipating high impact downstream weather at any time of year.

7. REFERENCES

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