**21. Extratropical Transition**

Principal Investigator(s): Sim Aberson

**Links to IFEX:**

* **Goal 1:** Collect observations that span the TC life cycle in a variety of environments for model initialization and evaluation.
* **Goal 3:** Improve understanding of the physical processes important in intensity change for a TC at all stages of its lifecycle.

**Motivation and background:** The poleward movement of a tropical cyclone (TC) initiates complex interactions with the midlatitude environment frequently leading to sharp declines in hemispheric predictive skill. In the Atlantic basin, such interactions frequently result in upstream cyclone development leading to high-impact weather events in the U. S. and Canada, as well as downstream ridge development associated with the TC outflow and the excitation of Rossby waves leading to downstream cyclone development. Such events have been shown to be precursors to extreme events in Europe, the Middle East, and may have led to subsequent TC development in the Pacific and Atlantic basins as the waves progress downstream. During this time, the TC structure begins changing rapidly: the symmetric distributions of winds, clouds, and precipitation concentrated about a mature TC circulation center develop asymmetries that expand. Frontal systems frequently develop, leading to heavy precipitation events, especially along the warm front well ahead of the TC. The asymmetric expansion of areas of high wind speeds and heavy precipitation may cause severe impacts over land without the TC center making landfall. The poleward movement of a TC also may produce large surface wave fields due to the high wind speeds and increased translation speed of the TC that results in a trapped-fetch phenomenon.

During this phase of development, hereafter referred to as extratropical transition (ET), the TC encounters increasing vertical wind shear and decreasing sea surface temperatures, factors that usually lead to weakening of the system. However, transitioning cyclones sometimes undergo explosive cyclogenesis as extratropical cyclones, though this process is poorly forecast. The small scale of the TC and the complex physical processes that occur during the interactions between the TC and the midlatitude environment make it very difficult to forecast the evolution of track, winds, waves, precipitation, and the environment. Due to sparse observations and the inability of numerical models to resolve the structure of the TC undergoing ET, diagnoses of the changes involved in the interaction are often inconclusive without direct observations. Observations obtained during this experiment will be used to assess to what extent improvements to TC structure analyses and the interaction with the midlatitude flow improve numerical forecasts and to develop techniques for forecasting these interactions. Improved understanding of the changes associated with ET will contribute to the development of conceptual and numerical models that will lead to improved warnings associated with these dangerous systems.

**Hypotheses:** ET depends upon the survival of the TC as it penetrates into midlatitudes in regions of increasing vertical wind shear.

**Questions for study:**

* How is the TC vortex maintained in regions of vertical wind shear exceeding 30 ms-1?
* How is the warm core maintained long after the TC encounters vertical wind shear exceeding 30 ms-1?
* How does vertical shear exceeding 30ms-1 alter the distribution of latent heating and rainfall?
* Does vortex resilience depend upon diabatic processes? On subsequent formation of new vortex centers, or by enlisting baroclinic cyclogenesis?
* Does the vertical mass flux increase during ET, as has been shown in numerical simulations?
* Is downstream error growth related to errors in TC structure during ET?
* Is ET sensitive to the sea-surface temperatures?

**Experiment/Module Description:** Two specific targets are to be sampled during each mission, the TC itself, and the interface between the TC and the environmental flow. The systems will be sampled every 12 h from the time it begins the transition to an extratropical cyclone to the time it is out of range of the aircraft, or the system dissipates.

**Analysis Strategy:** Data analysis will occur after the final mission, mainly via case studies based on incorporating the data in a sophisticated data assimilation/model system.

**References:**

Evans, C., K. M. Wood, S. D. Aberson, H. M. Archambault, S. M. Milrad, L. F. Bosart, K. L. Corbosiero, C. A. Davis, J. R. Dias Pinto, J. Doyle, C. Fogarty, T. J. Galarneau, Jr., C. M. Grams, K. S. Griffin, J. Gyakum, R. E. Hart, N. Kitabatake, J. S. Lentink, R. McTaggart-Cowan, W. Perrie, J. F. D. Quinting, C. A. Reynolds, J. Riemer, E. Ritchie, Y. Sun, and F. Zhang, 2017: The Extratropical Transition of Tropical Cyclones. Part I: Cyclone Evolution and Direct Impacts. *Mon. Wea. Rev.*, accepted for publication.