Predator – prey behavior of storm tracks

Extratropical cyclones (Fig. 1) are the building blocks of mid-latitude storm tracks. During their growth, cyclones convert potential energy into kinetic energy in a self-amplifying process known as baroclinic conversion. As potential energy is depleted during cyclone growth, conditions become less favorable for subsequent cyclone development until potential energy is restored. This leads to a "predator – prey" behavior between cyclone growth (predator) and baroclinicity (prey). Qualitatively, this behavior can be descripted in a conceptual two-variable model by Ambaum and Novak (2014), which describes a regular oscillatory behavior with slow build-up of potential energy and bursts of cyclone activity that convert it into kinetic energy. In reality, storm tracks indeed exhibit such a cyclic behavior, which, however, also has chaotic features (Fig. 2).

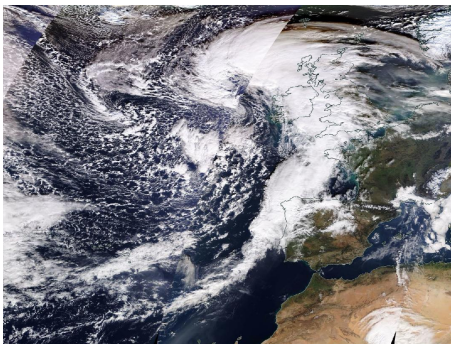

Figure 1: Extratropical cyclone (NASA Worldview)

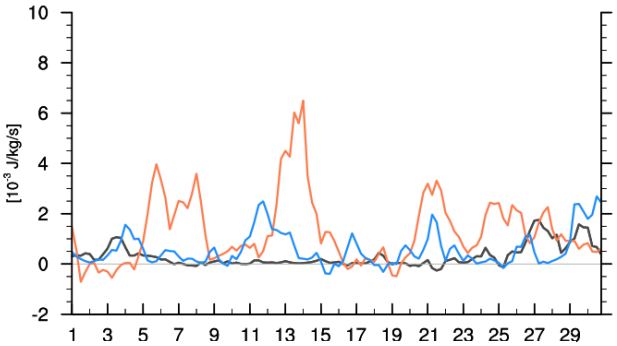

Figure 2: Baroclinic conversion (orange) during January over the North Pacific.

The aims of this thesis are twofold: First, we aim to characterize the predator – prey behavior in observational data sets (eddy kinetic energy, baroclinicity, baroclinic conversion, cyclone counts and growth) for the North Atlantic and North Pacific storm tracks. Second, we aim to investigate the chaotic component of storm track behavior and seek to extend the Ambaum – Novak model by including the effect of moisture and / or a potential energy reservoir in the polar and tropical regions. For that purpose, methods from dynamical systems theory will be employed.

Interests: atmospheric and climate dynamics, interest in analysis of large data sets as well as theoretical work (dynamical systems theory)

Data & tools: ERA-5 reanalysis data, programming with R, Python

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Reference:

Ambaum, M. H. P. and Novak, L. (2014) A nonlinear oscillator describing storm track variability. Quarterly Journal of the Royal Meteorological Society, 140 (685).