Towards an Objective Climatology of Frontal Life Cycles

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Summary

- Condensation heating on trailing cold fronts raises baroclinicity and can lead to cyclone clustering.
- A new Front Tracking Algorithm has been developed to track and classify life cycles of fronts in meteorological data
- Fronts are tracked through a watershedding algorithm in space-time

References:

Papritz, L. and Spengler, T. (2015), Analysis of the slope of isentropic surfaces and its tendencies over the North Atlantic. Q.J.R. Meteorol. Soc., 141: 3226-3238. doi:10.1002/qj.2605;

Weijenborg, C., & Spengler, T. (2020). Diabatic heating as a pathway for cyclone clustering encompassing the extreme storm Dagmar. Geophysical Research Letters, 47, e2019GL085777. https://doi.org/10.1029/2019GL085777

Project

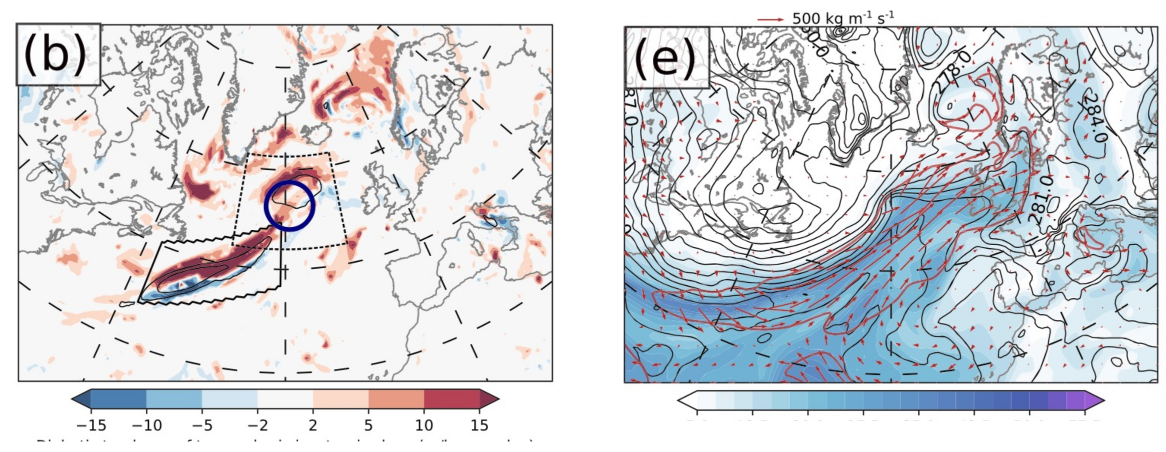
Motivation

A case study on cyclone Dagmar in December 2011 (Weijenborg et Spengler, 2020) showed that sustained diabatic heating through condensation along a trailing cold front can lead to cyclone clustering:
By heating the warm side of the front, baroclinicity is increased such that a secondary baroclinic cyclone development is facilitated.

PhD Project

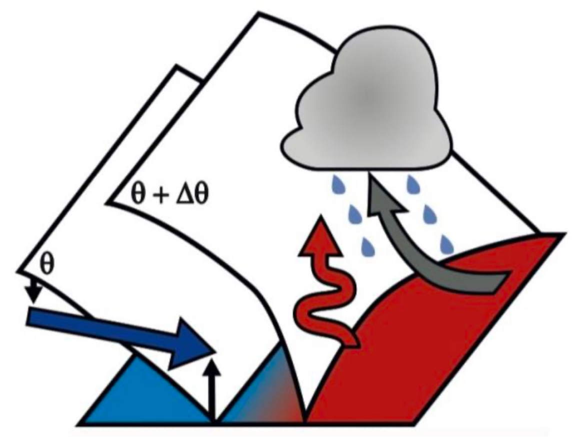
Establish characteristics of life cycles of fronts that lead to secondary cyclogenesis and cyclone clustering

1. **Tracking of fronts in meteorological data along their life cycles**
2. Classification of frontal life cycles
   ➔ Which lead to cyclone clustering?
3. Sensitivity of frontal life cycles to larger-scale forcing



From Weijenborg and Spengler (2020):
b) Increase of baroclinicity (isentropic slope) due to latent heating around Dagmar (blue circle) and in the trailing cold front
e) Corresponding total column water vapour (colours) and fluxes (arrows)

Schematic from Papritz and Spengler (2015):
Balance between increase of baroclinicity (steeper θ surfaces) through condensation heating and decrease of baroclinicity (flatter θ surfaces) by cyclone development



Front Tracking

Input Data

- ERA5 Reanalysis (ECMWF)
- Equivalent-potential temperature θ_e
- Three pressure levels: 700, 800, 925 hPa
- Smoothed (spectrally, T84)

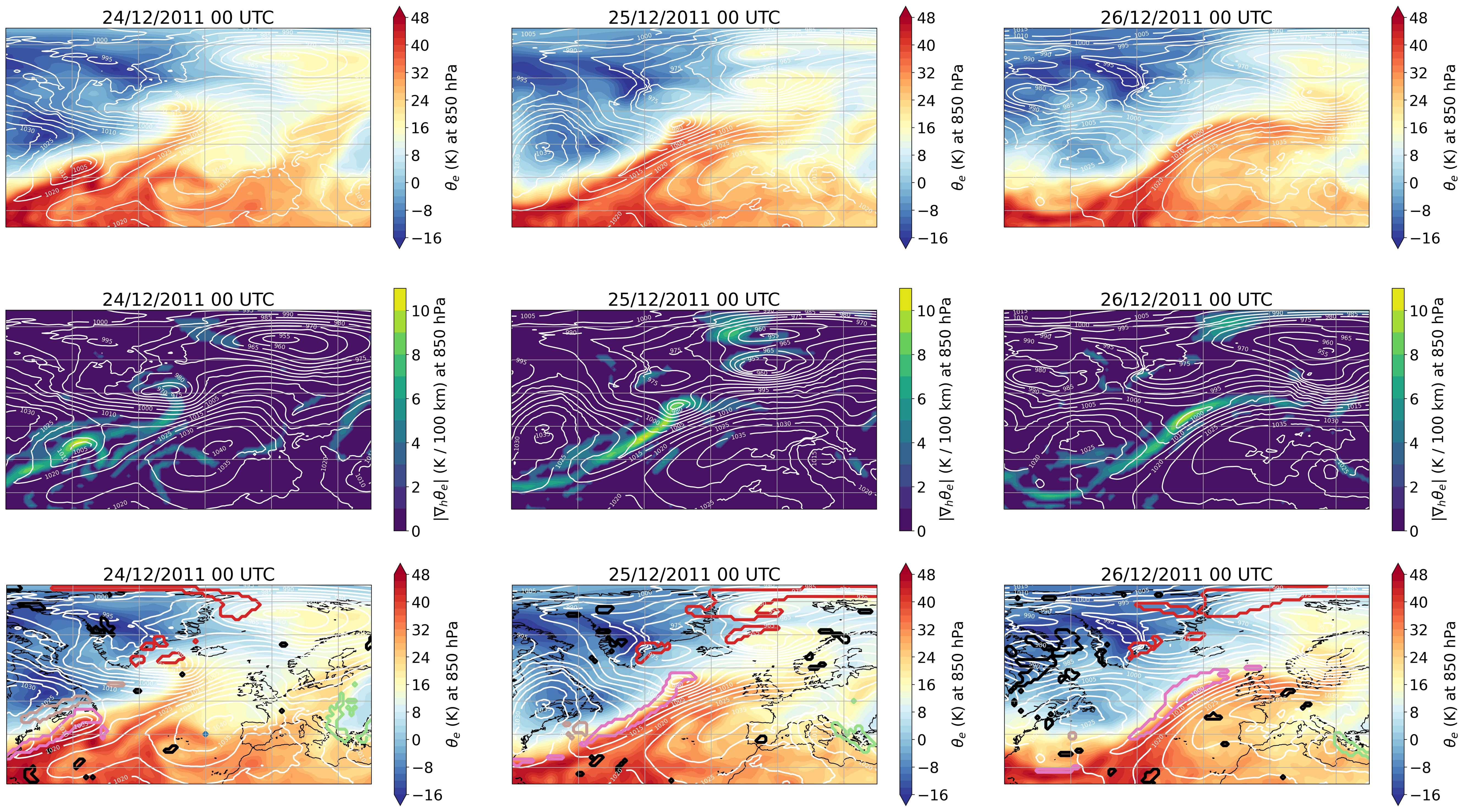
Gradient Field

- Centred Differences
- Magnitude (Euclidian Norm)
- Omit all points where $|\nabla\theta_e| < 3\ \mathrm{K/100\ km}$

Front Tracking

- Sort all points by $|\nabla\theta_e|$
- ***Watershedding Algorithm***
- Keep all major front objects (prominence $> 5\ \mathrm{K/100\ km}$)

➔ Frontal Life Cycles



Watershedding Algorithm

1. **Iterate all points from strongest to weakest gradient magnitude $|\nabla\theta_e|$**
2. **Local Maxima in space-time are nuclei for new objects**
3. **Small objects are incorporated in larger objects at meeting**
4. **Major objects stop growing at meeting**