Investigations of tropopause dynamics using PV tracers in the COSMO model

Werner Schneider, Andreas Bott

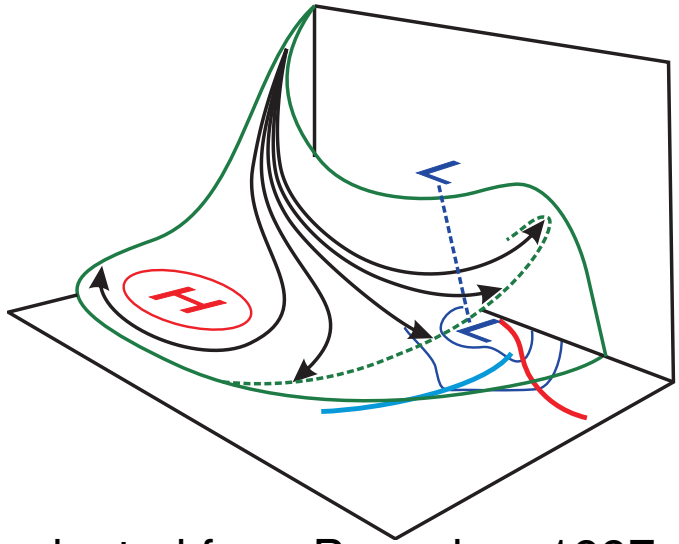
Meteorological Institute, University of Bonn

COSMO User Seminar, March 17-19, 2014

Motivation

Concepts for tropopause dynamics:

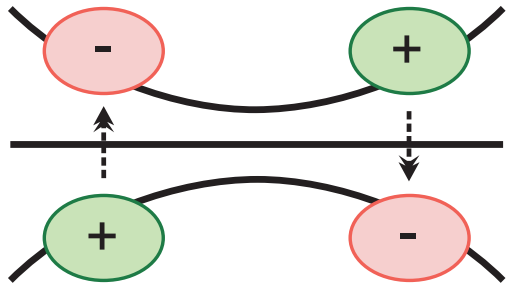
- tropopause break at jet streams
  - → tropopause folds
  - → stratospheric dry intrusions
  - → PV streamer
- PV anomalies



adapted from Browning, 1997

Idealized concepts of jet dynamics:

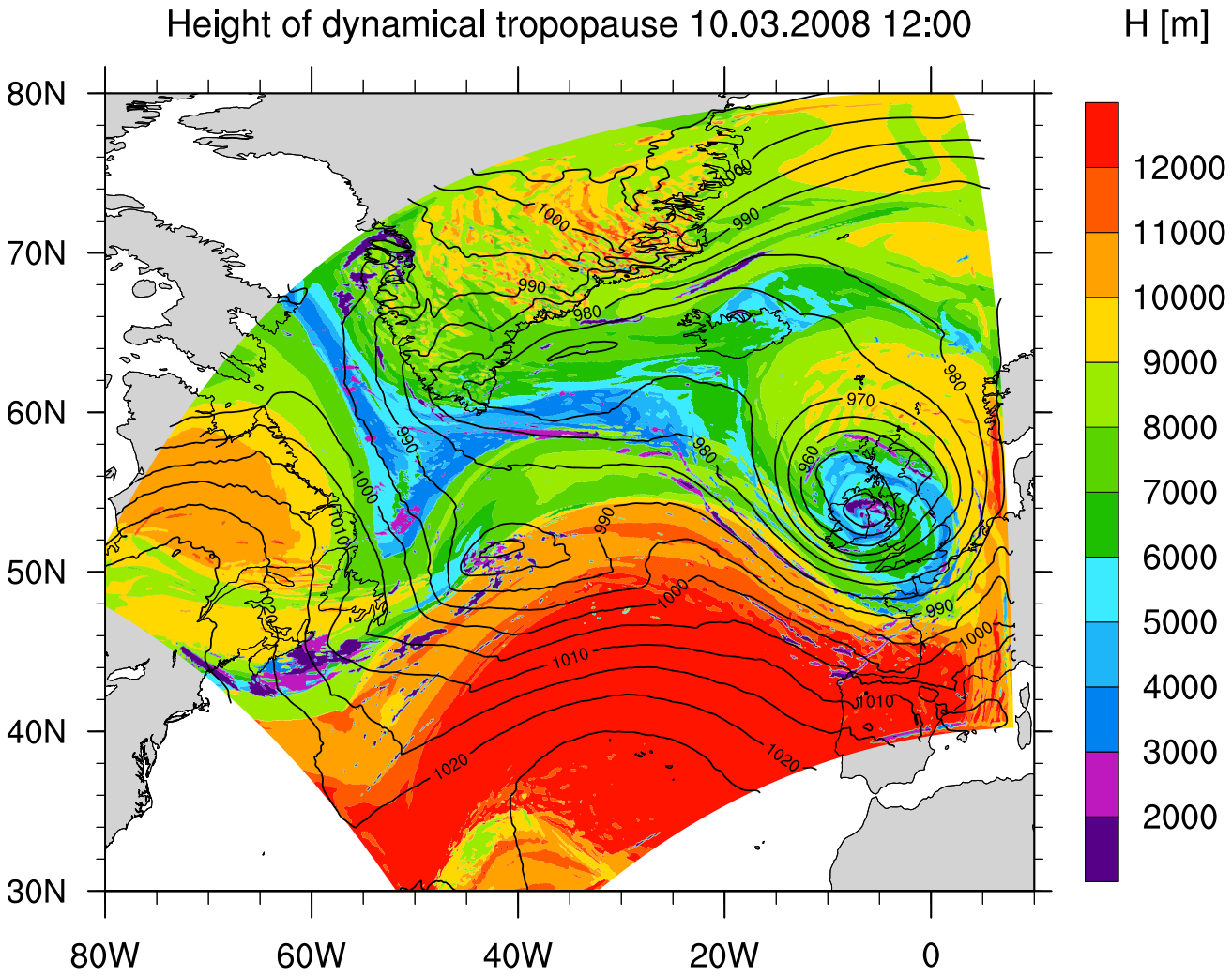
- effects of curvature, latitude, confluence and diffluence
- ageostrophic circulations at fronts



→ **Visualization of realistic tropopause dynamics using tracer studies**

Dynamic Tropopause

Definition with Potential Vorticity (PV = 2 PVU)



Dynamic tropopause

Identification of stratospheric air in the troposphere

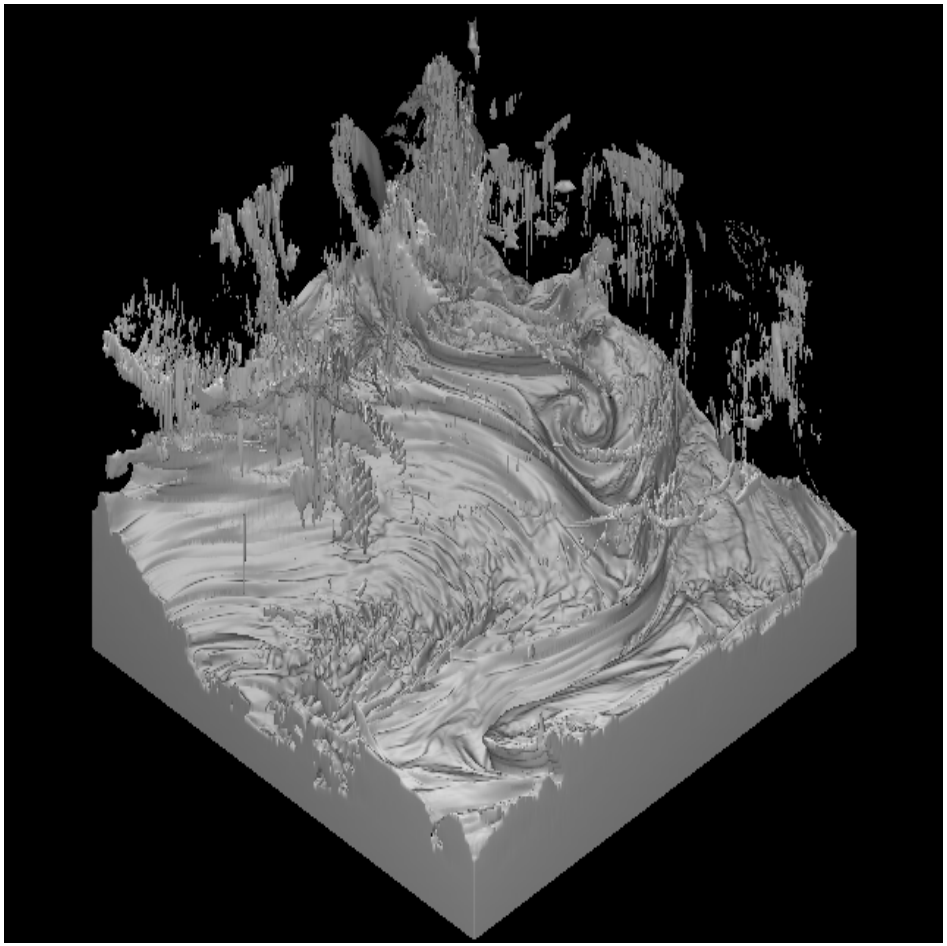
- redistribution and diffusion of PV
- initial PV maxima and minima
  $\rightarrow$ no clear identification of stratospheric air masses

Passive PV tracer:

- initialized with 2 TU/kg where PV $>$ 2 PVU
  $\rightarrow$ uniform distribution
  $\rightarrow$ filtering of initial tropospheric PV structures
- background concentration of 1 TU/kg
  $\rightarrow$ direct derivation of mixing ratios for stratospheric air

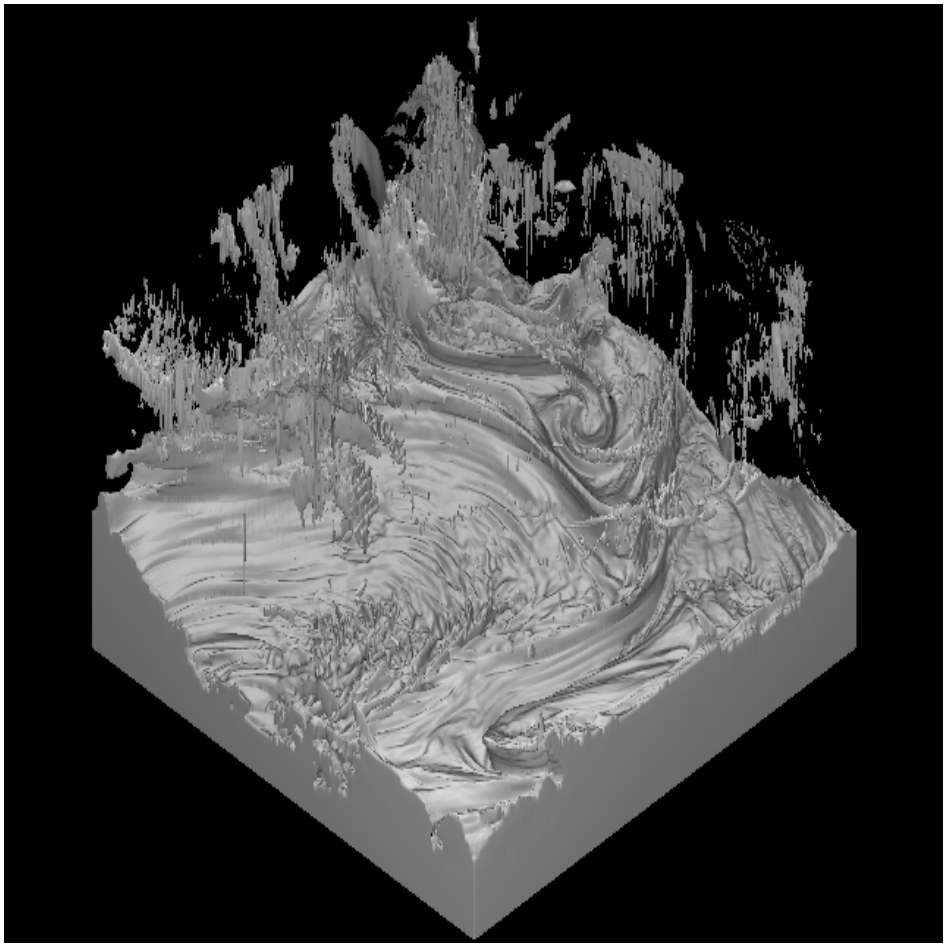
Dynamic tropopause

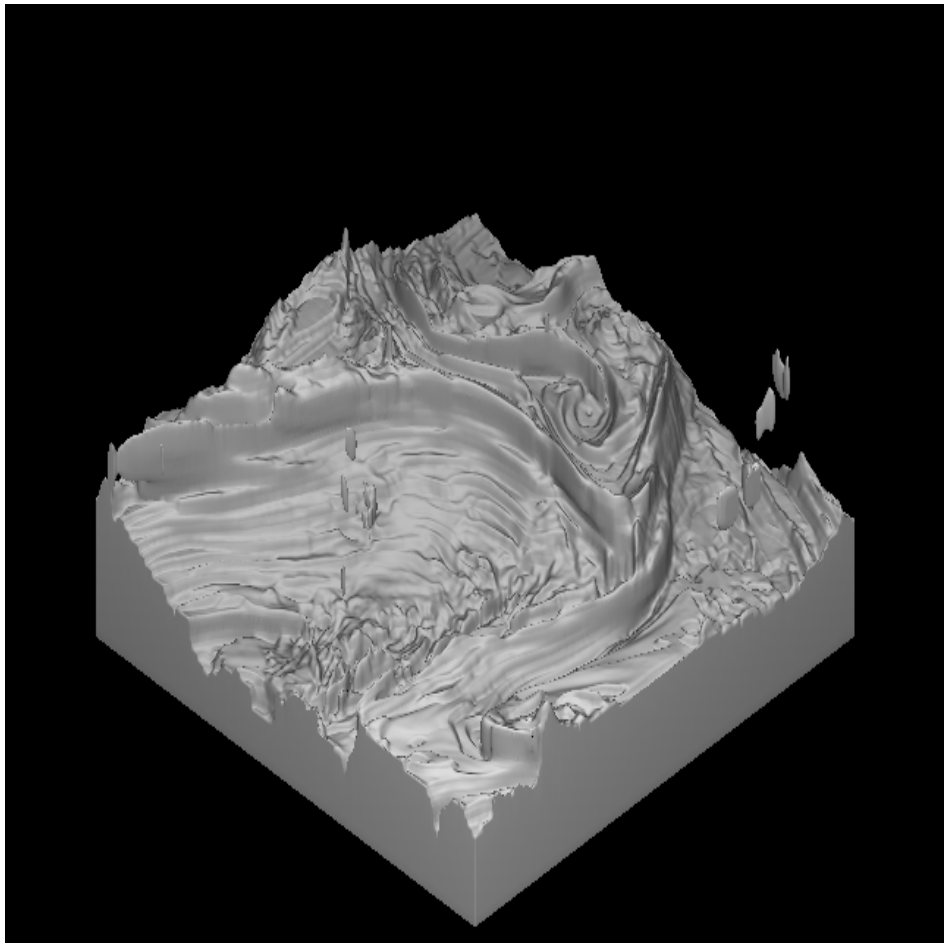
Filtering



Dynamic tropopause

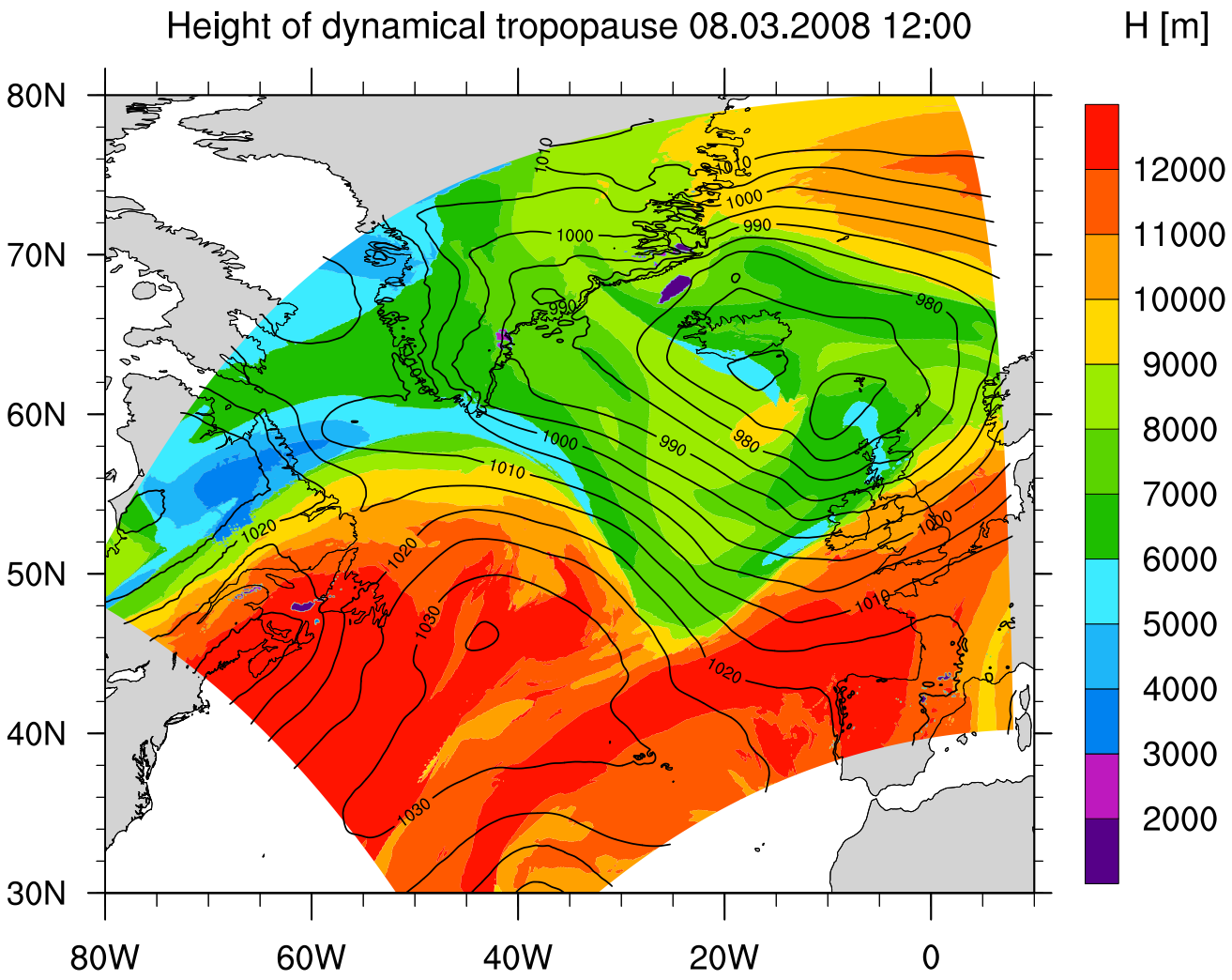
Filtering





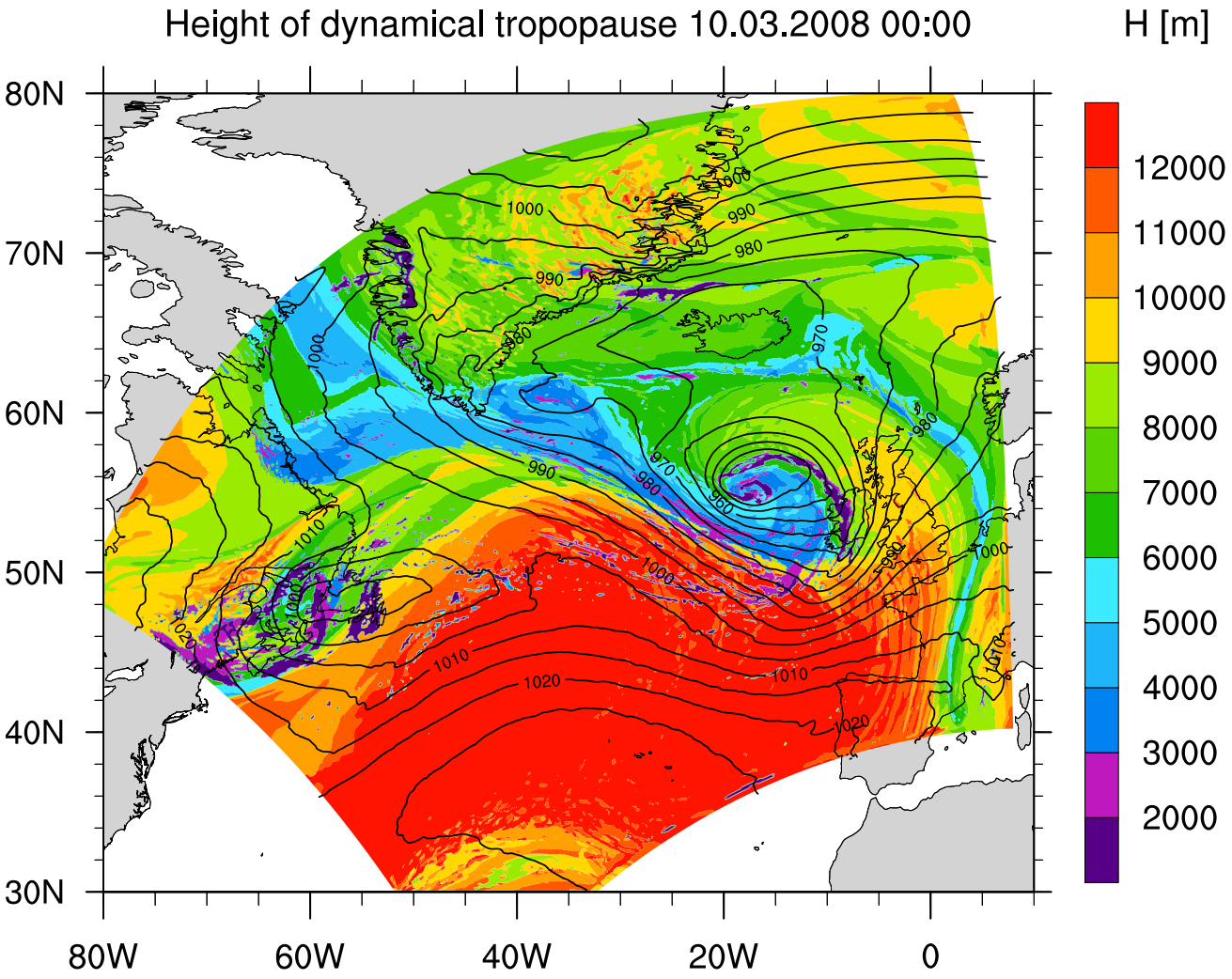
Results

Case study: March 8-10, 2008

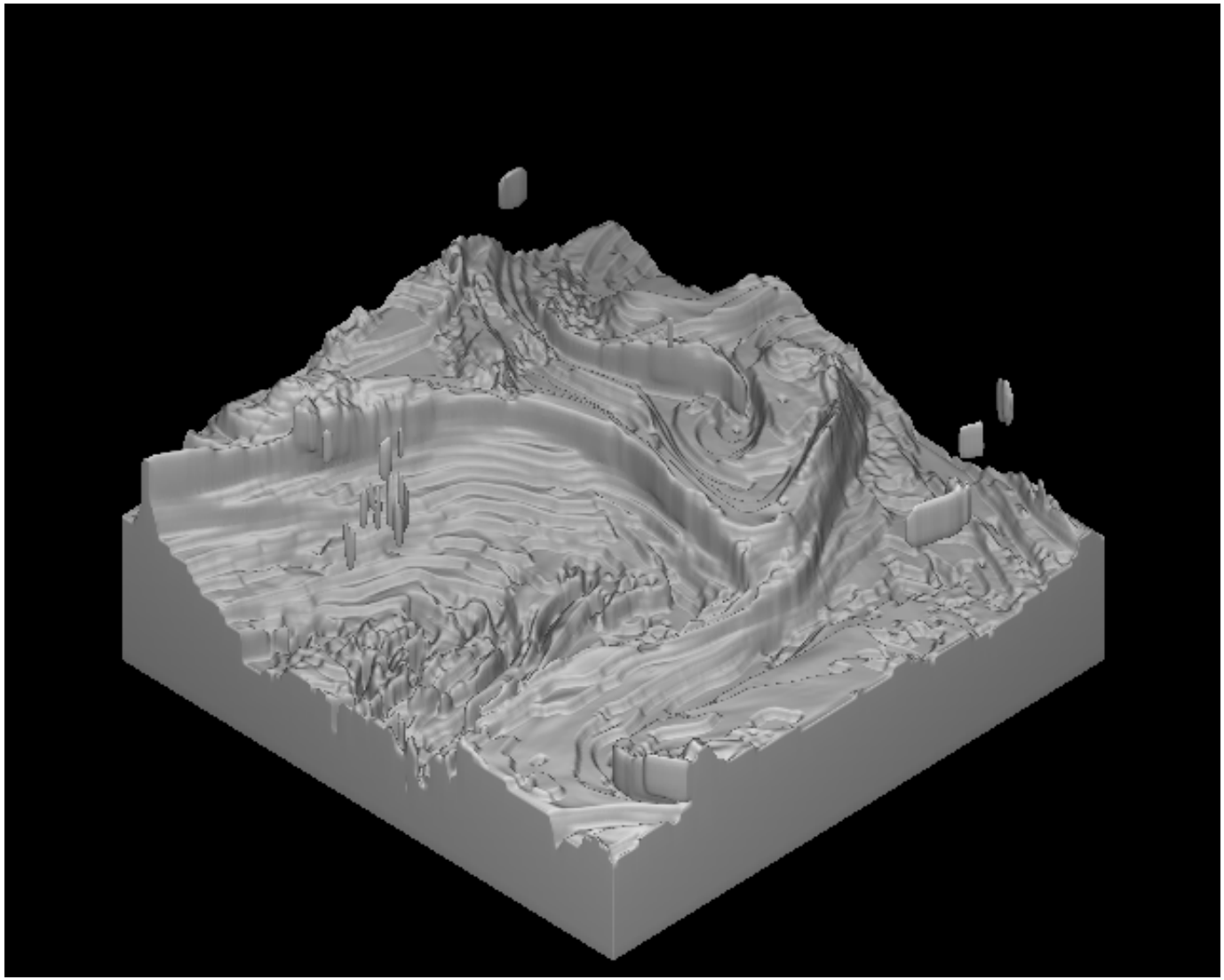


Results

Case study: March 8-10, 2008

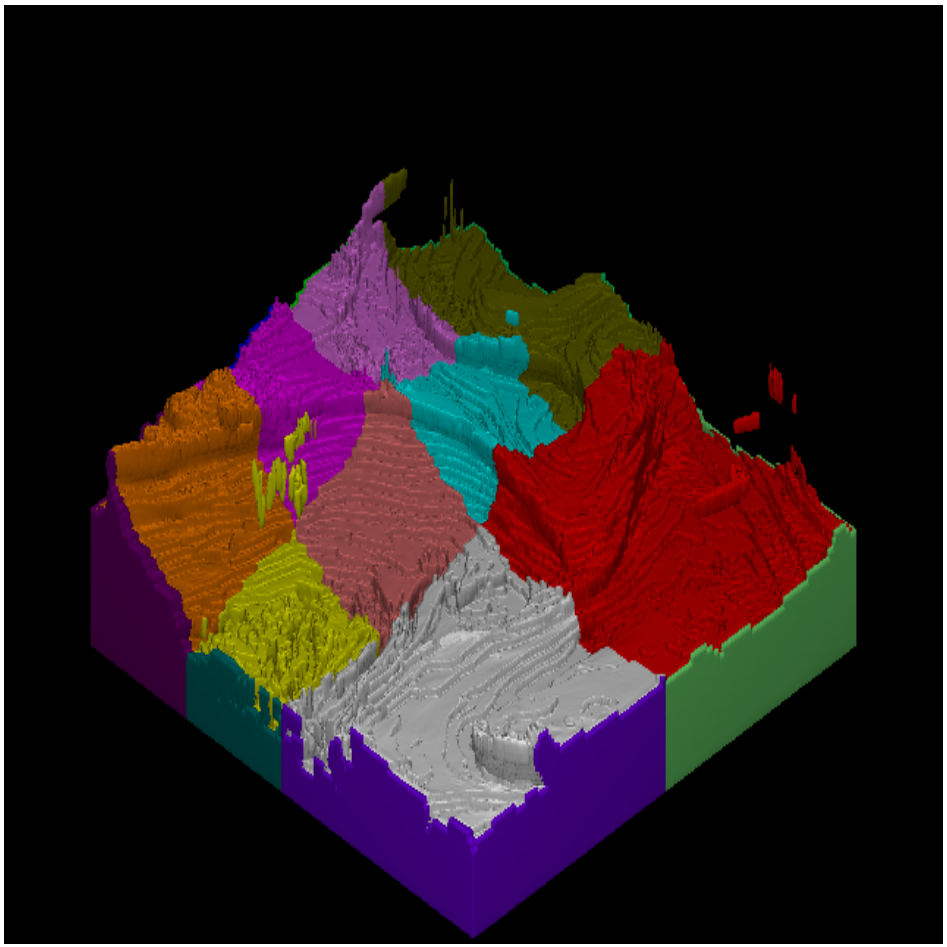


Results



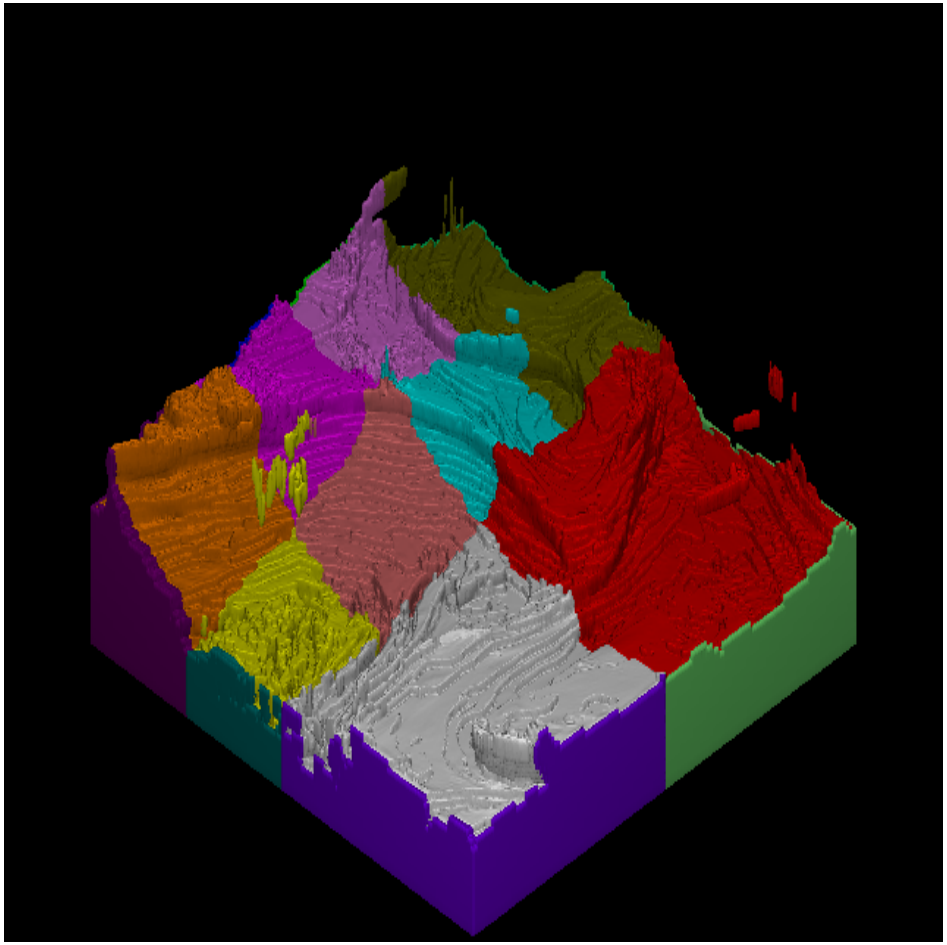
Results

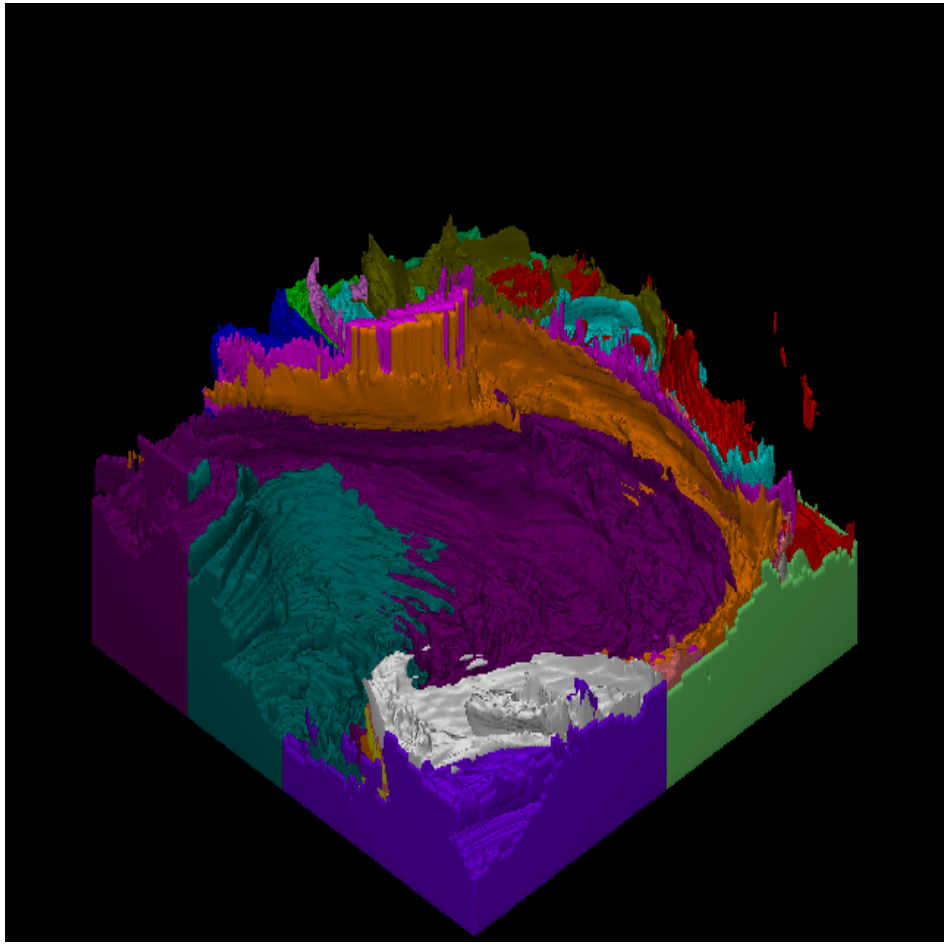
Tracking of source region



Results

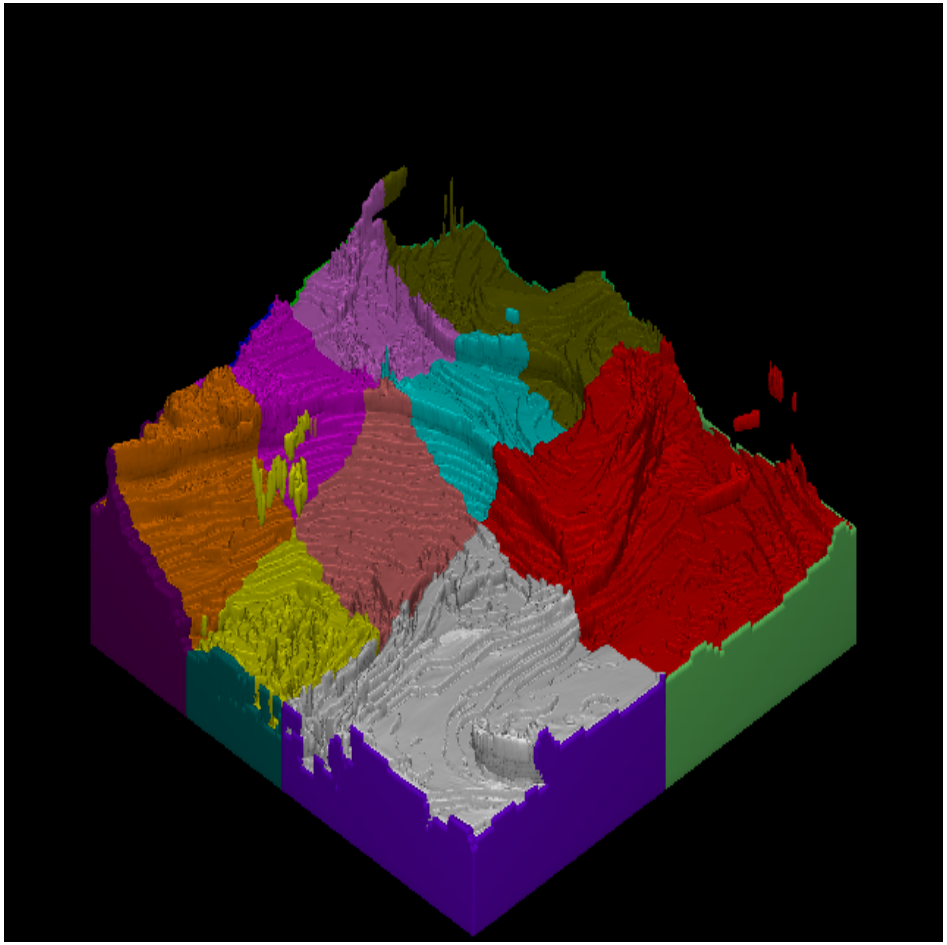
Tracking of source region

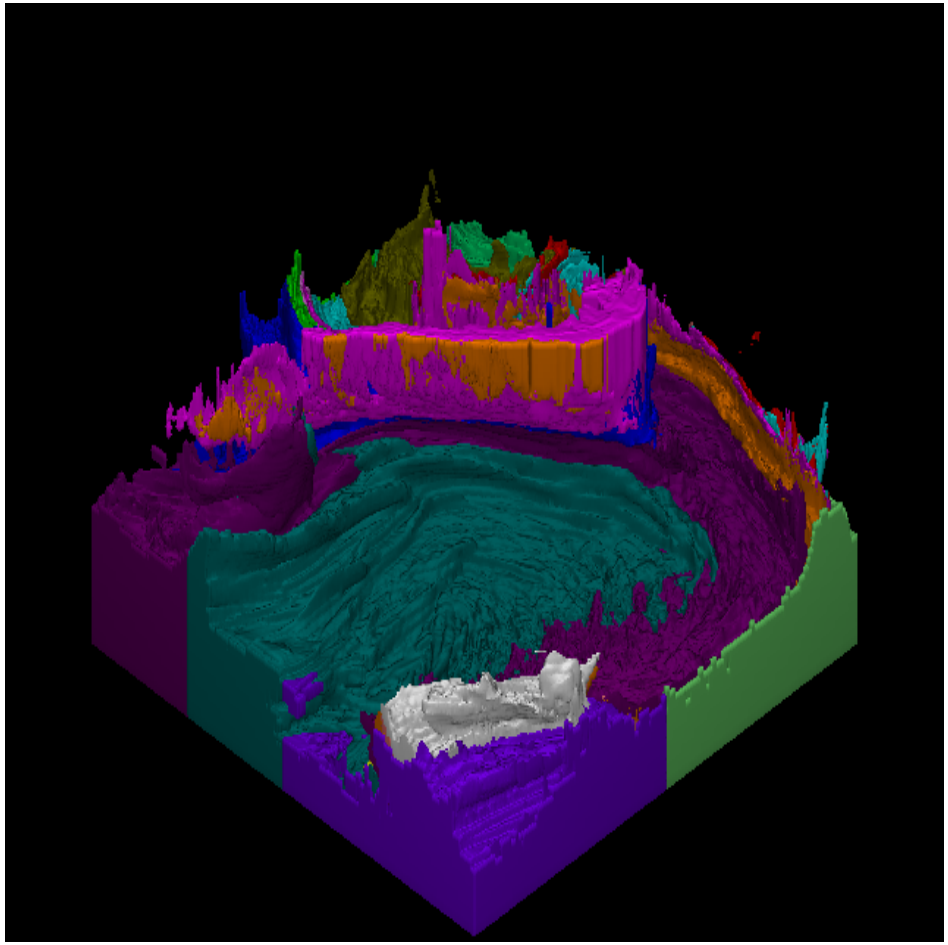




Results

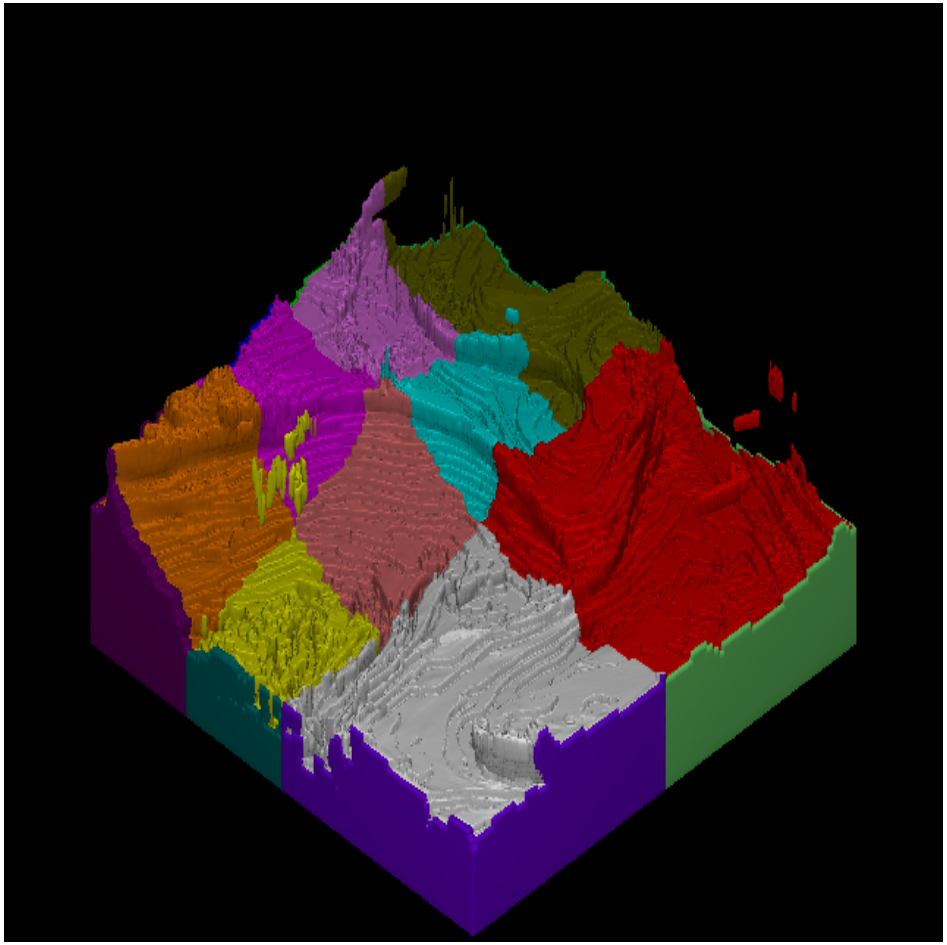
Tracking of source region

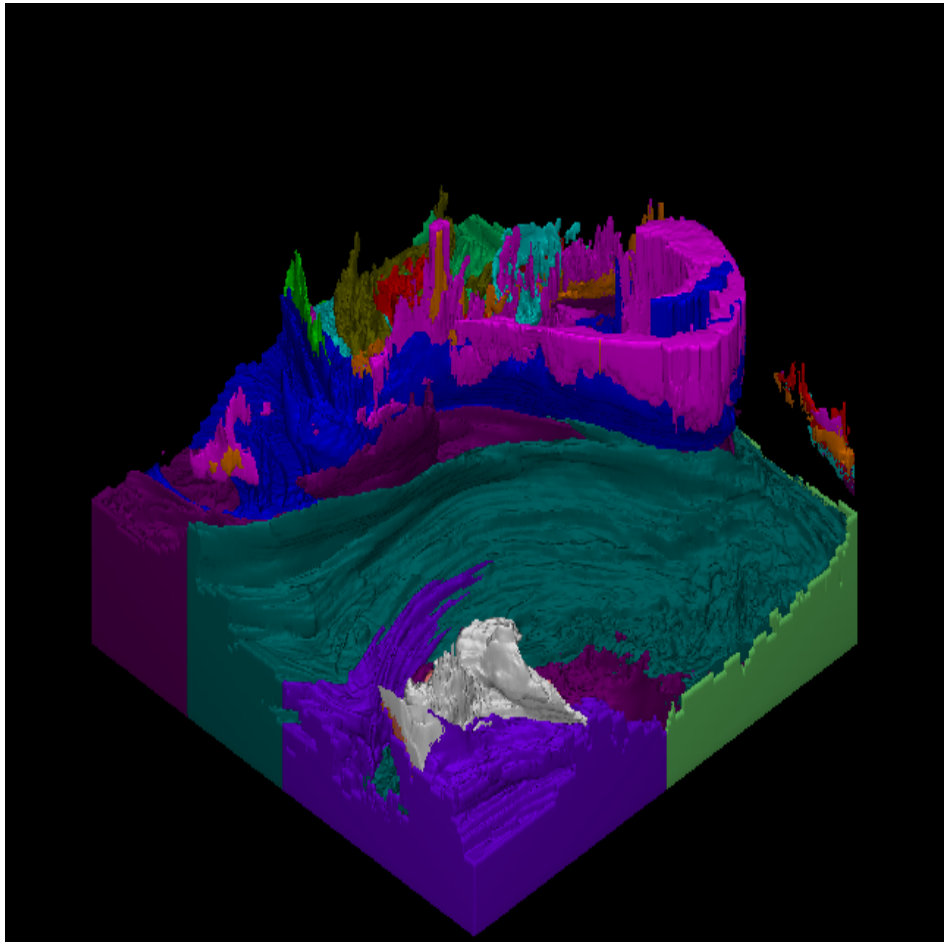




Results

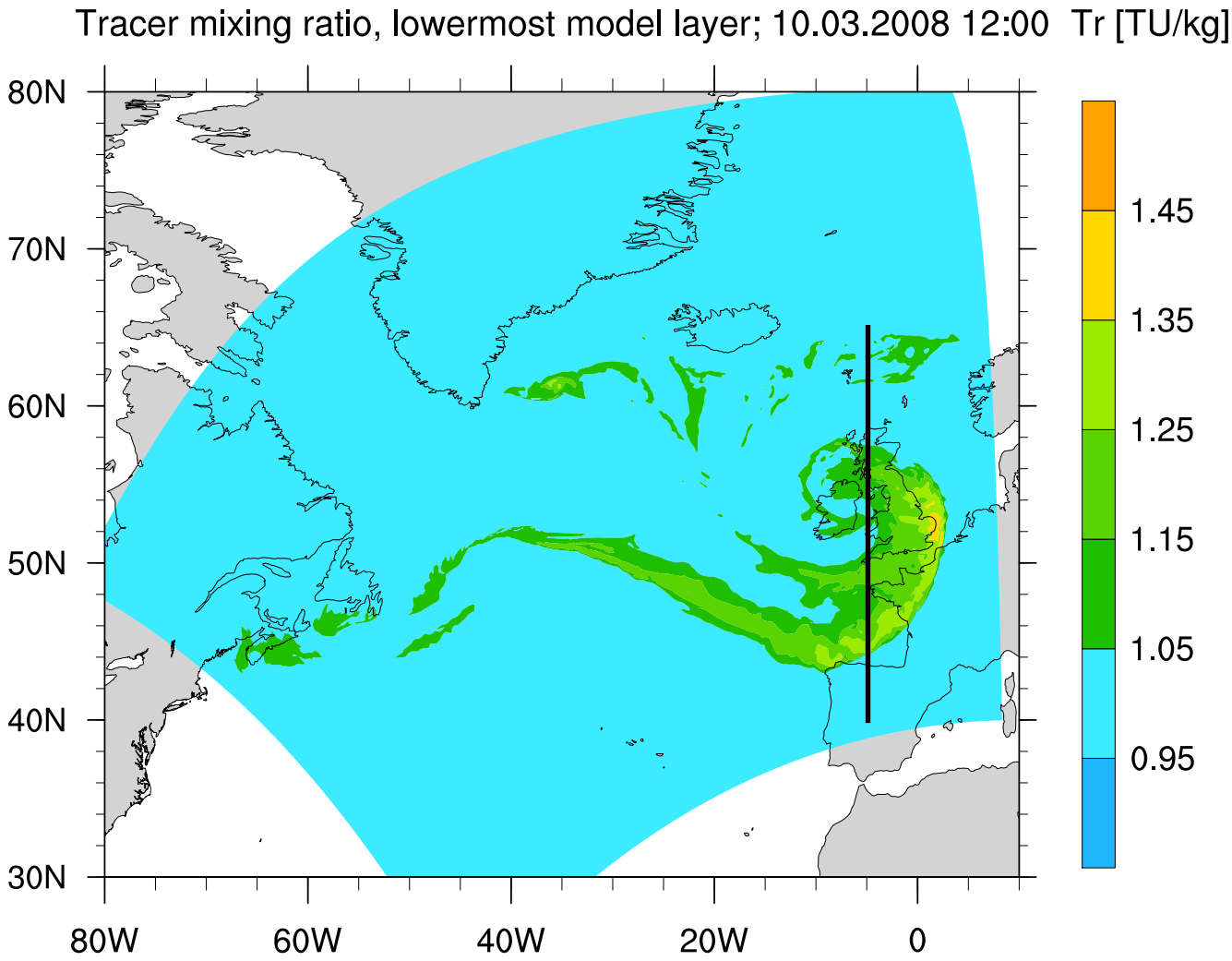
Tracking of source region



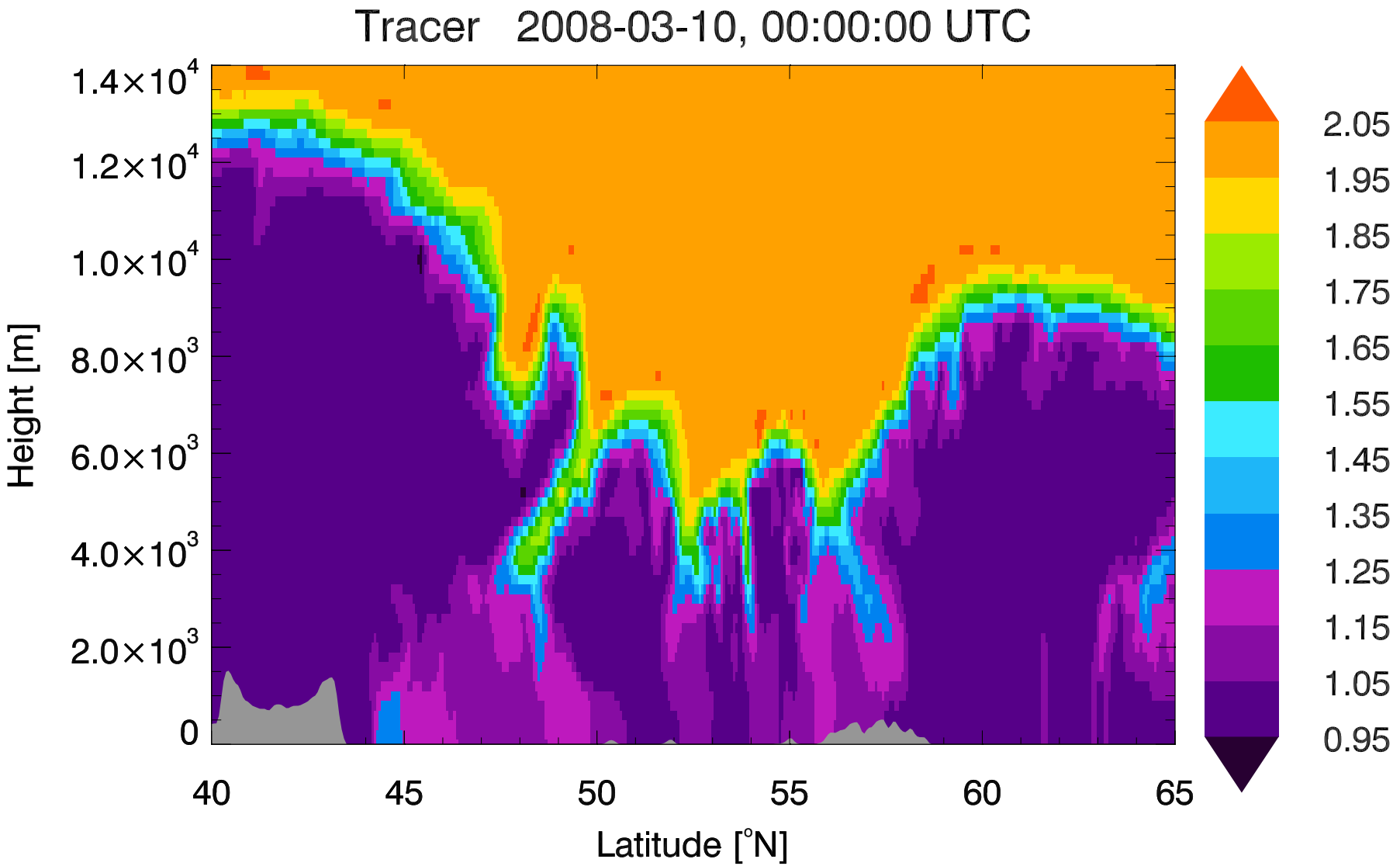


Results

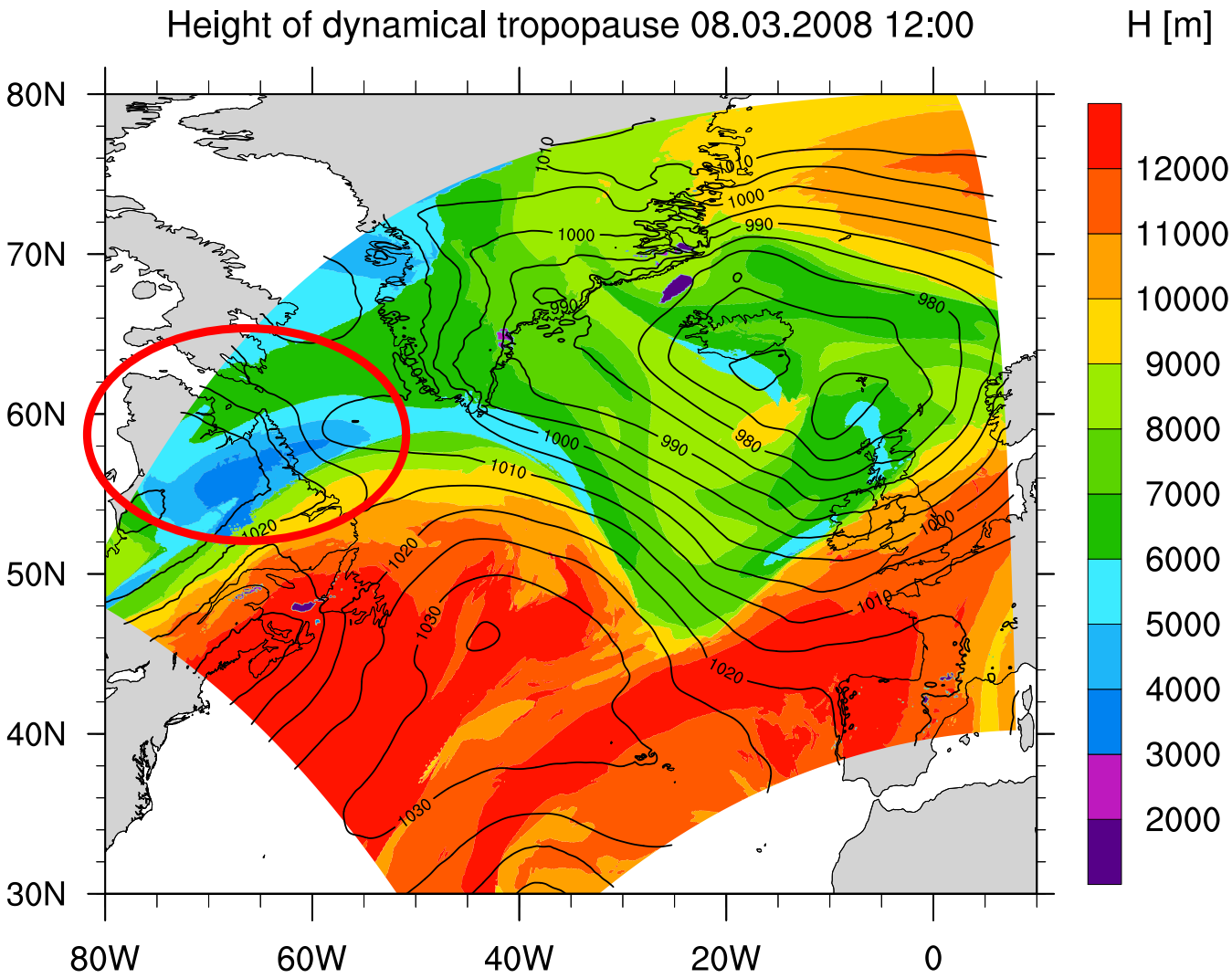
Stratospheric air streamers in the planetary boundary layer



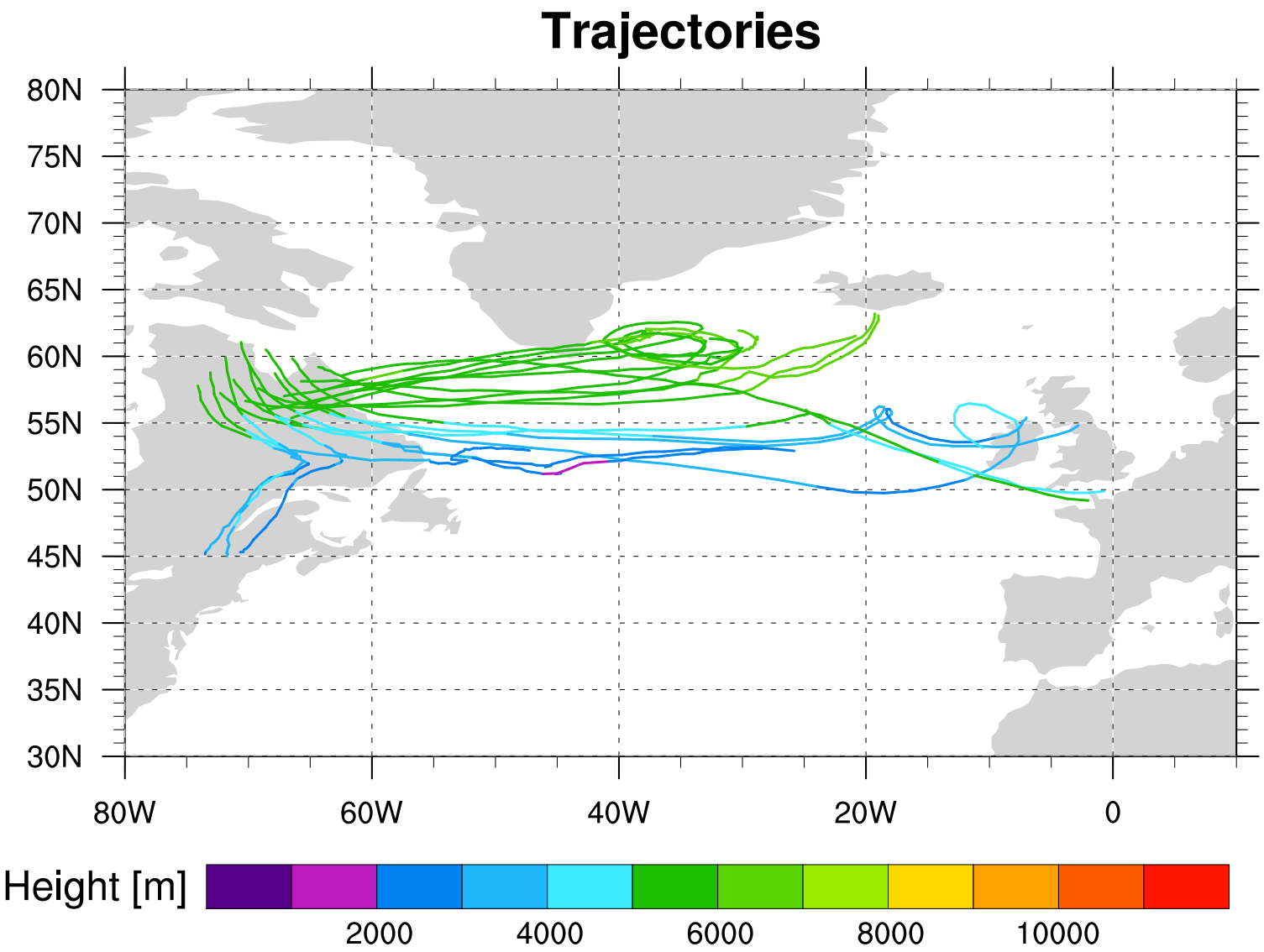
Results


Tracer 2008-03-10, 00:00:00 UTC
Height [m]
1.4×10^4
1.2×10^4
1.0×10^4
8.0×10^3
6.0×10^3
4.0×10^3
2.0×10^3
0
40
45
50
55
60
65
Latitude [°N]
2.05
1.95
1.85
1.75
1.65
1.55
1.45
1.35
1.25
1.15
1.05
0.95

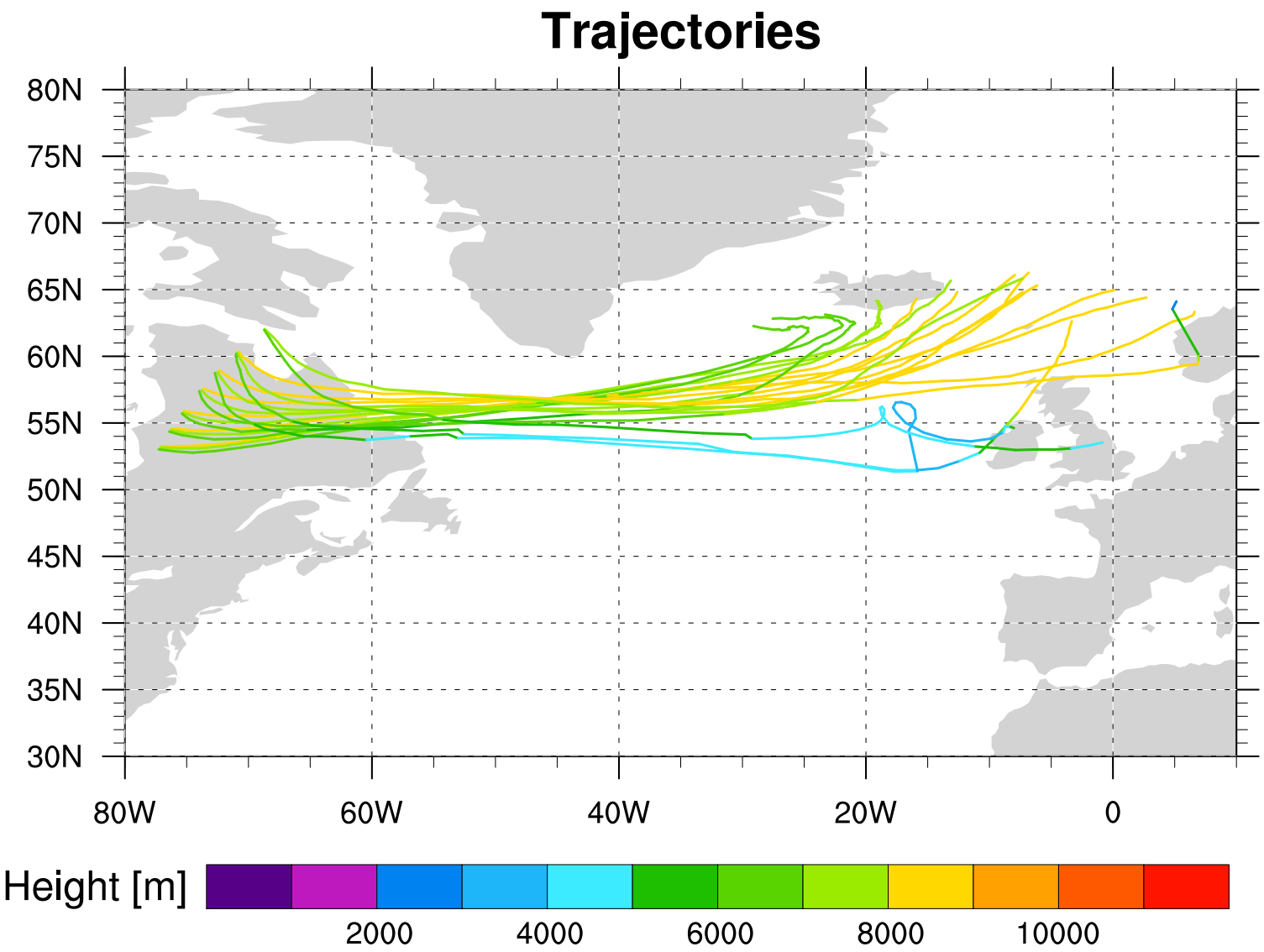
Source region



Trajectories



Trajectories



Case Summary

Concept of dry intrusion:

- dry intrusion can be visualized with PV tracers
- structure similar to idealized concepts
- PV streamer in boundary layer

Additional observations:

- sinking starting from existing PV anomaly in about 5 km height
- only air from lowermost stratospheric layers reaches planetary boundary layer

$\rightarrow$ Pre-conditioning of tropopause structure before cyclogenesis

Outlook

Tracer analyses allow deep insight into mesoscale dynamics in NWP-models.

First results:

- dry intrusions need to be analyzed over longer time scales
- pre-conditioning and large scale PV-anomalies play distinct role
- formation not only during single cyclogenesis


Thank you for your attention!