Aircraft measurements within a warm conveyor belt during the T-NAWDEX-FALCON campaign

Andreas Schäfler[1], Maxi Boettcher[2], Stephan Borrmann[3], Reinhold Busen[1], Andreas Dörnbrack[1], Christian Grams[2], Andrea Hausold[4], Stefan Kaufmann[1,3], Marcus Klingebiel[3], Yannick Lammen[1], Marc Rautenhaus[5], Philipp Reutter[3], Hans Schlager[1], Harald Sodemann[2], Christiane Voigt[1,3], Heini Wernli[2]

[1] Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft und Raumfahrt (DLR)

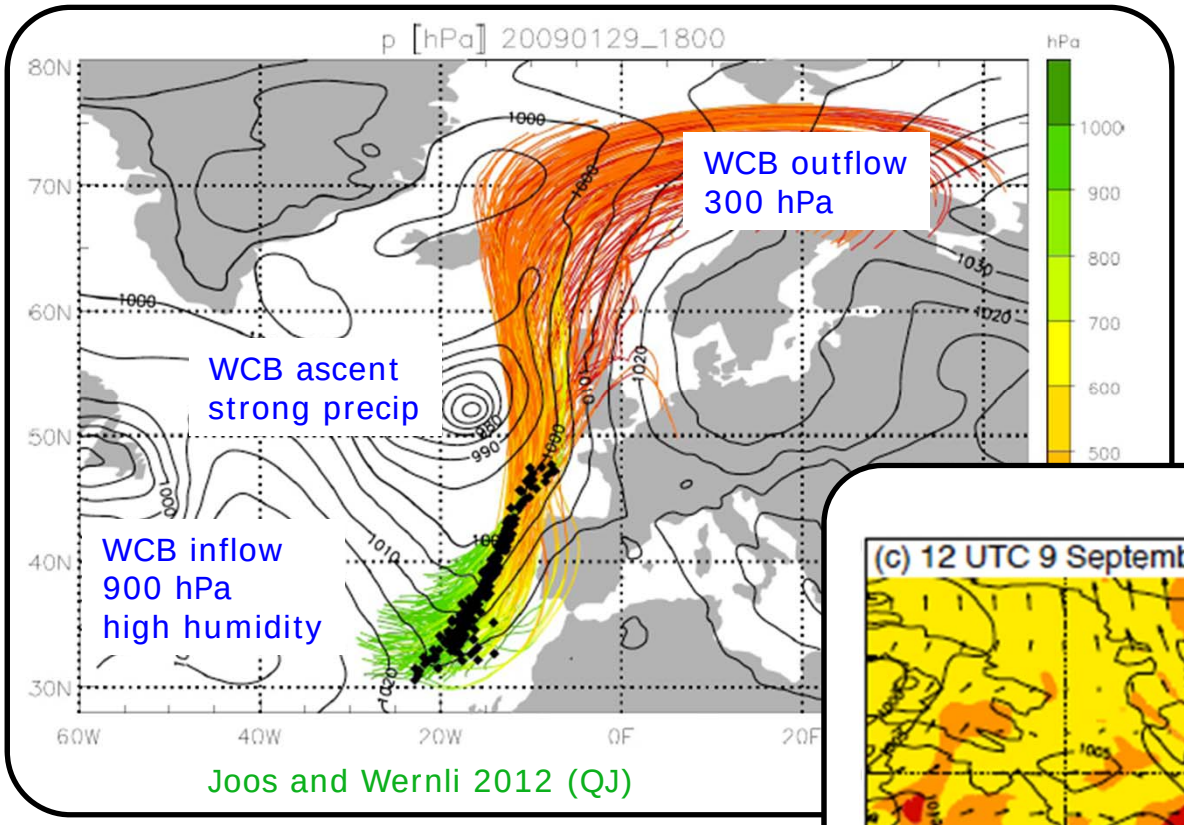
[2] Institute for Atmospheric and Climate Science, ETH Zurich

[3] Institute for Atmospheric Physics, Johannes Gutenberg University Mainz

[4] Flugabteilung, Deutsches Zentrum für Luft und Raumfahrt (DLR)

[5] Computer Graphics and Visualisation Group, Technische Universität München

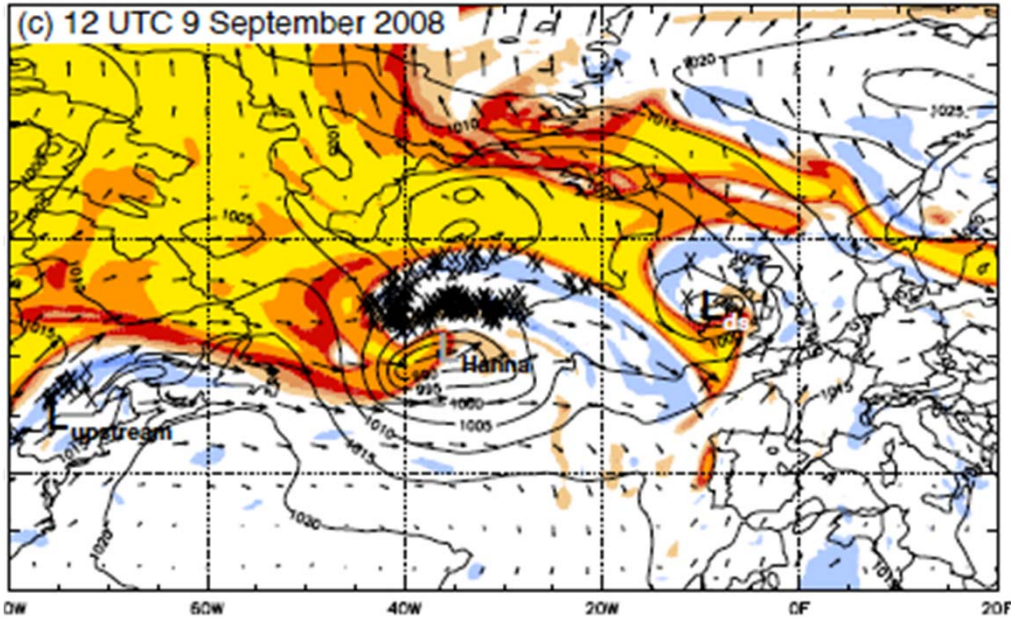
Scientific scope



Joos and Wernli 2012 (QJ)

Latent heating influences
PV distribution along the WCB

PV on 320 K



Grams et al. 2011 (QJ)

WCB outflow (neg. PV anomaly)
intensifies upper-level ridge

Aims

- obtain new insight in the **structure and evolution of WCBs**
- how realistic are **moisture and latent heating** represented along the WCB in NWP models?
- how do diabatic processes modify the **PV structure** of cyclones and upper-level flow?
- investigate importance for the **predictive skill** in the mid-latitudes
- **Lagrangian matching** of flight paths: in-situ measurements during different stages of the WCB

aircraft obs are needed from the boundary layer to the lower stratosphere

The aircraft instrumentation

- in-situ instruments to measure T,u,v,w and p
- 3 instruments to observe both total and gas phase water vapor
- trace gas instrumentation to measure O3, CO, NO/NOY, CH4, CO2, SO2
- dropsondes

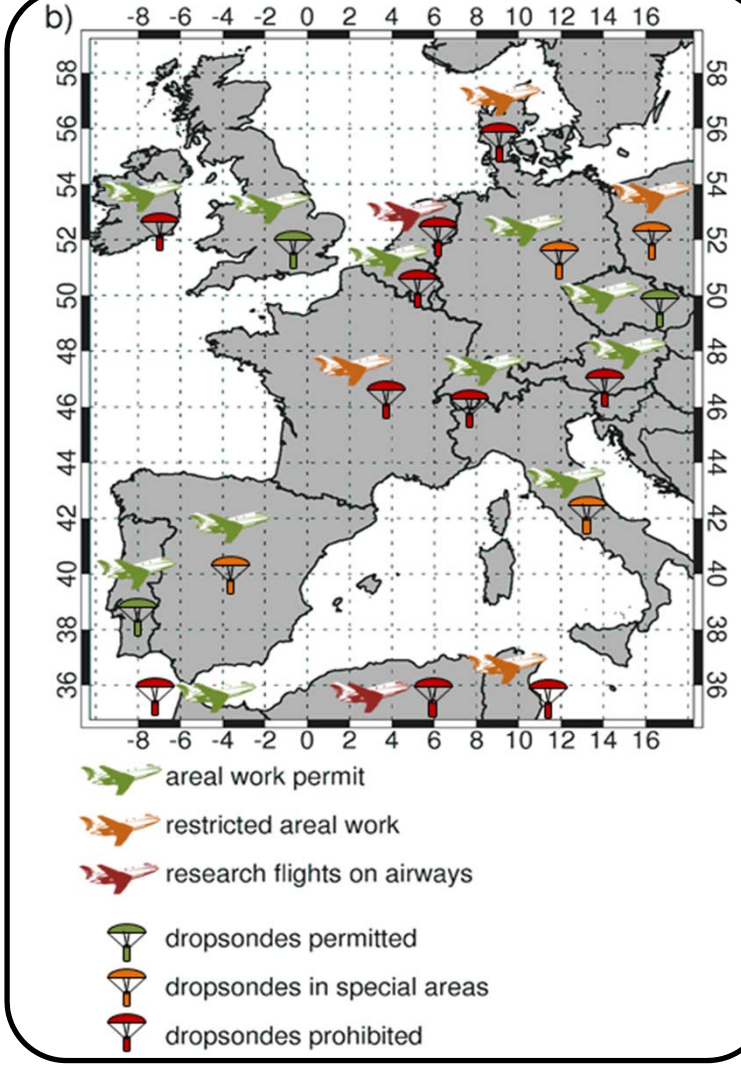
The planning process

Our vision

- fly at various altitudes, leave airways
- drop sondes from high levels
- adapt the flight pattern to the latest forecast runs
- probe the same WCB in a second flight

Operation regulations

- dense air traffic over Europe
- a number of authorities need to be contacted for permission to operate away from airways (areal work permit) and to release dropsondes
- first announcement to ATCs already 2-4 days
- military trainings
- airport opening hours and crew duty hours



The planning process

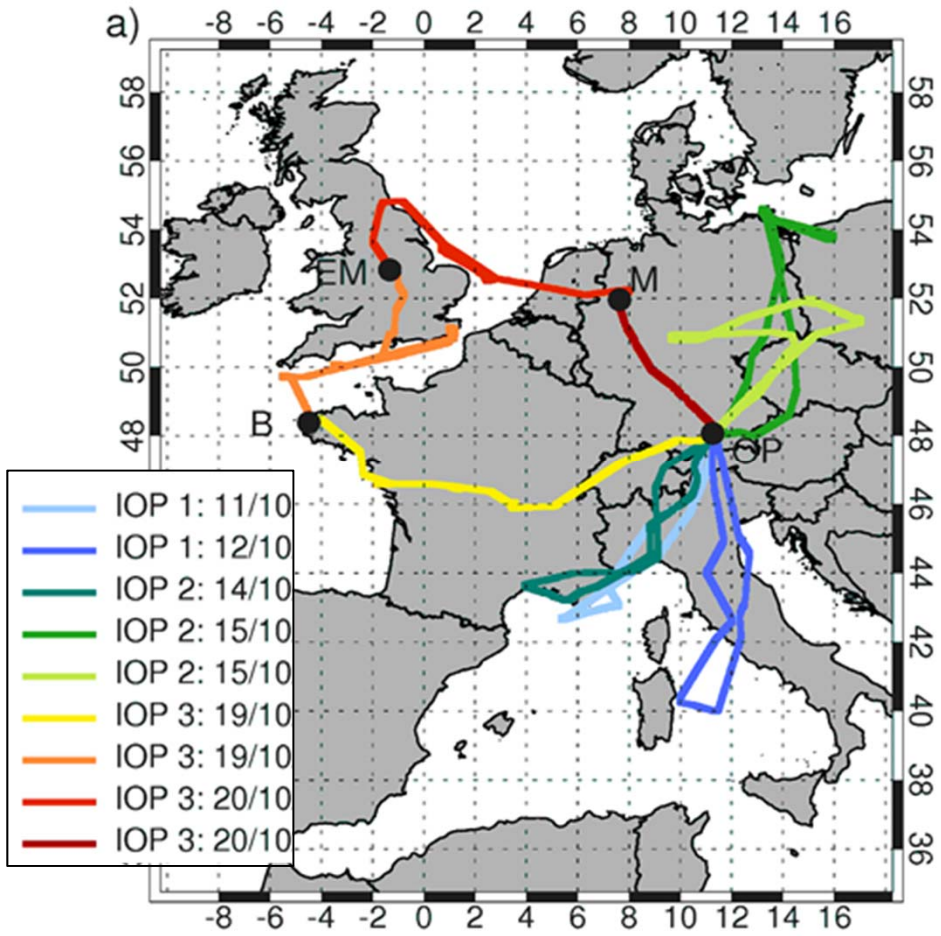
Biggest challenge (beside the op regulations): reduced predictability WCBs and their associated cyclones (which was in turn one of the aims to be investigated).
→ conflicted with the required early planning reliability

For filing meaningful flight plans it was fundamental to have information to answer

- From where and at which altitude does WCB air ascend?
- How much does the air ascend?
- Where is the WCB ascent located relative to the cyclone and its fronts?
- Where is the airmass located after a few hours up to one day?
- Can we expect a Lagrangian matching with the observed airmass during a second flight?
- How reliable are the forecasts of the WCB?

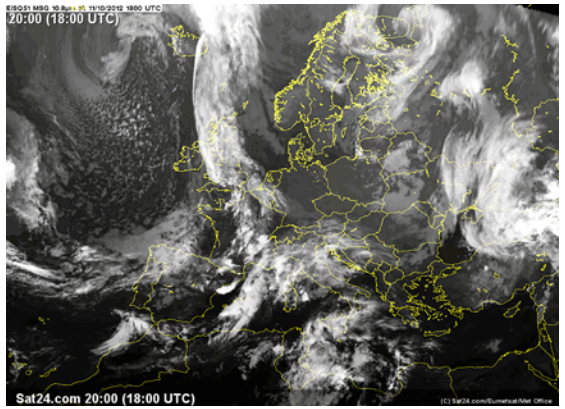
October climatologically very promising month - small chance remained for no WCB

Overview

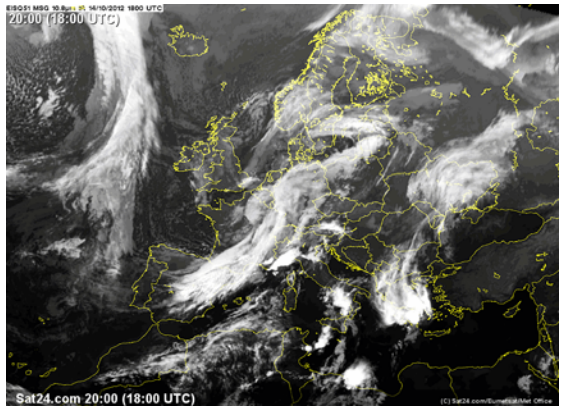


- **32 flight hours** in eight scientific missions
- **three WCBs**

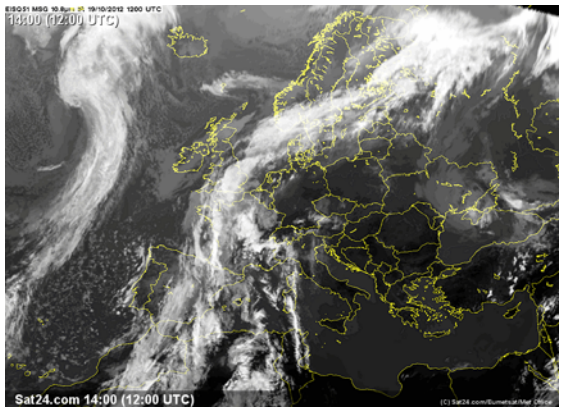
IOP 1: 11 – 12 Oct



IOP 2: 14 – 15 Oct

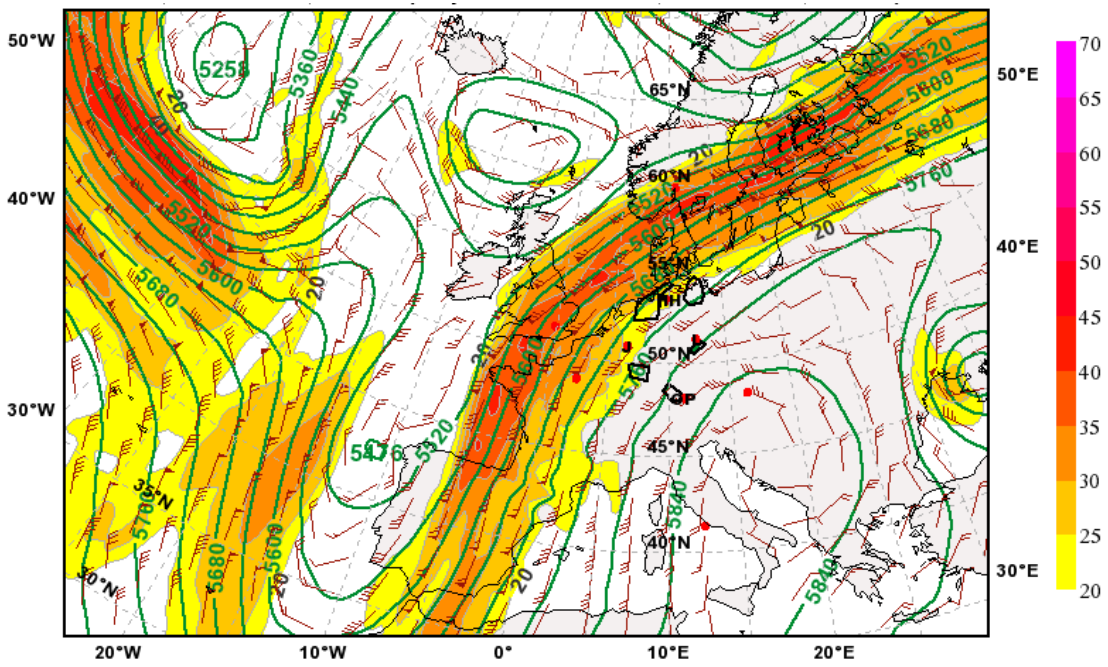


IOP 3: 19 – 20 Oct

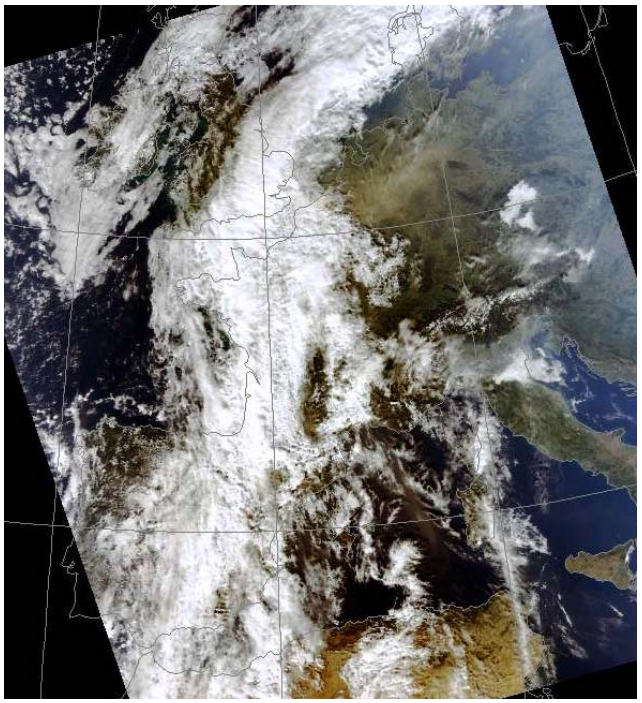


Planning of IOP 3 (19 October 2012)

500 hPa Geopot. height (m) and wind speed (m s^{-1})
19 October 2012, 12 UTC



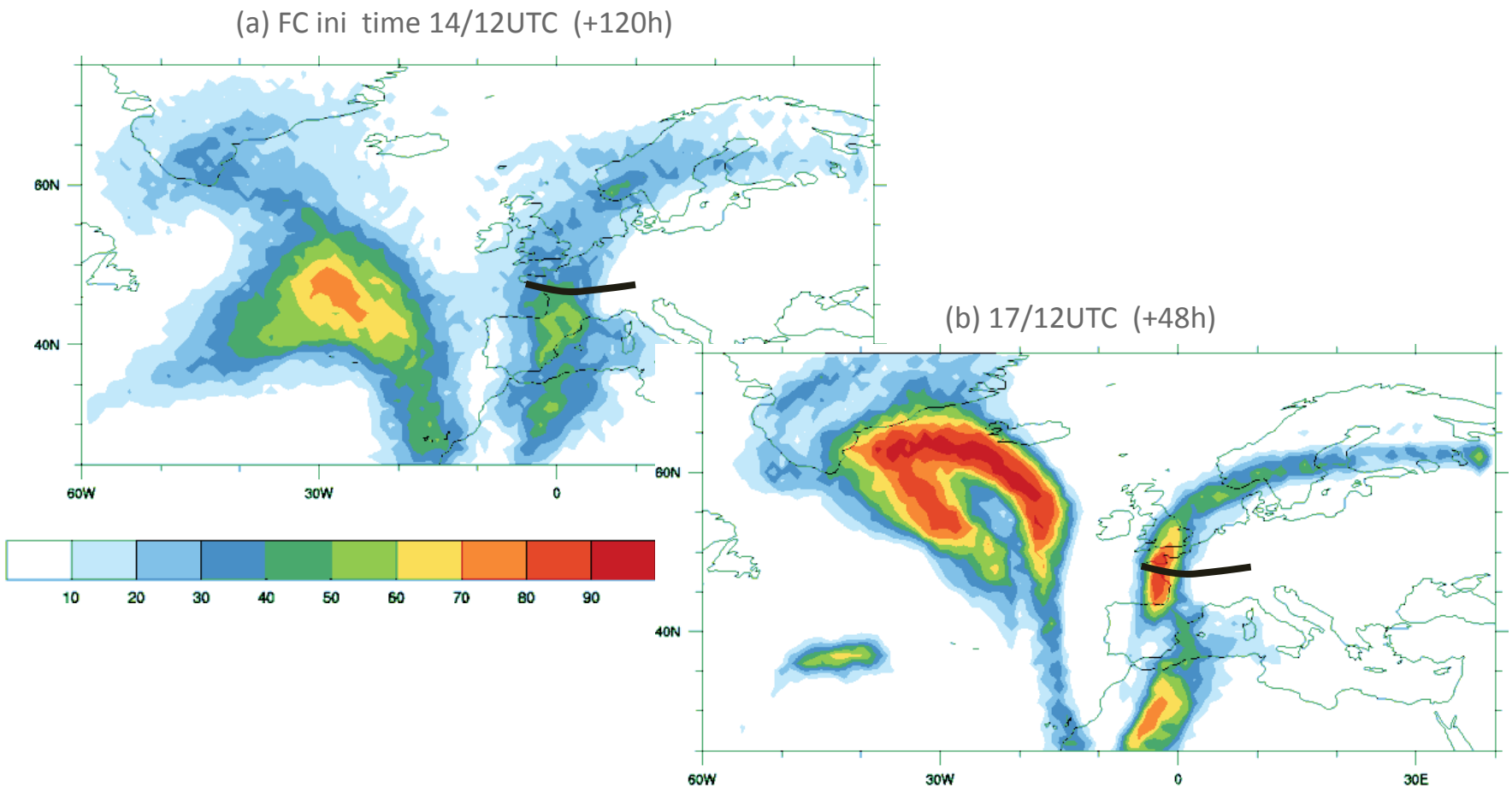
RGB MODIS image of the AQUA overpass at 1251 UTC



(from NERC Satellite Receiving Station, Dundee University, Scotland, http://www.sat.dundee.ac.uk).

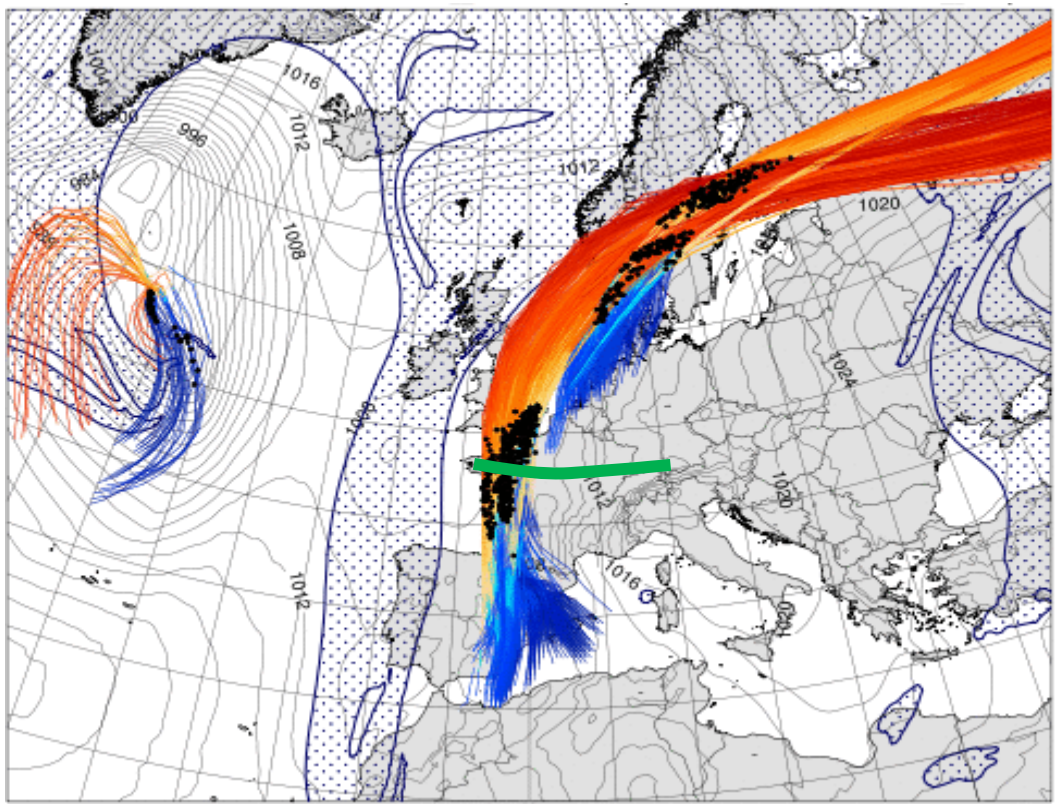
Planning of IOP 3 (19 October 2012)

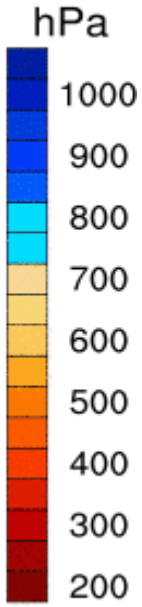
WCB ensemble probability of occurrence (in % shaded) valid time is 12 UTC, 19 Oct



Planning of IOP 3 (19 October 2012)

WCB trajectories and positions valid at 12 UTC 19 Oct based on the **deterministic forecast** (12 UTC, 17 Oct). WCB trajectories started at 18 UTC, 18 Oct.





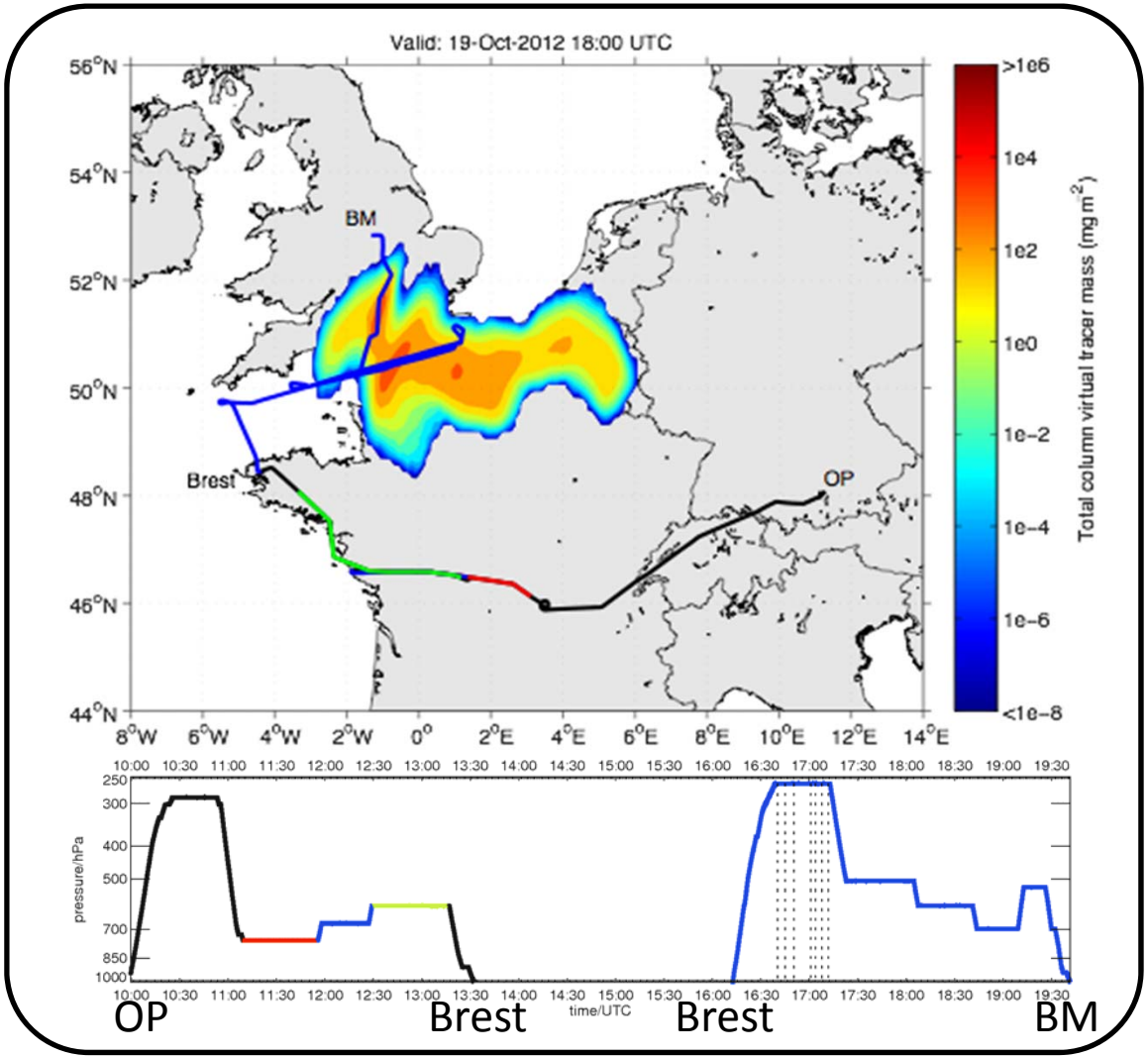
WCB trajectories
Δp_{48h} > 600 hPa

SLP (Gray lines))

PV > 2 PVU at 325K
(blue stippled)

Planning of IOP 3 (19 October 2012)

Virtual tracer plume simulated by FLEXPART

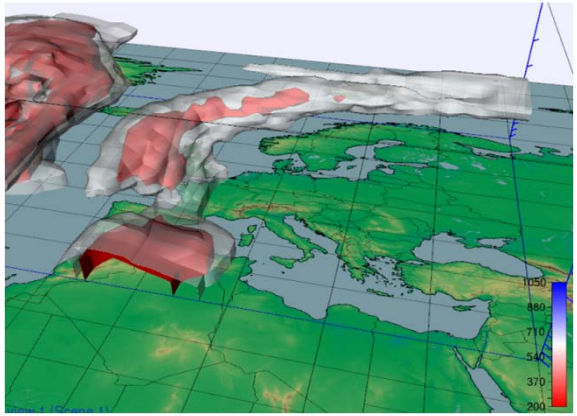


Outlook

Suitable synoptic pattern and a novel chain of forecasts products and WCB diagnostics allowed to obtain a dataset of 3 WCB events.

T-NAWDEX-Falcon cases are now investigated:

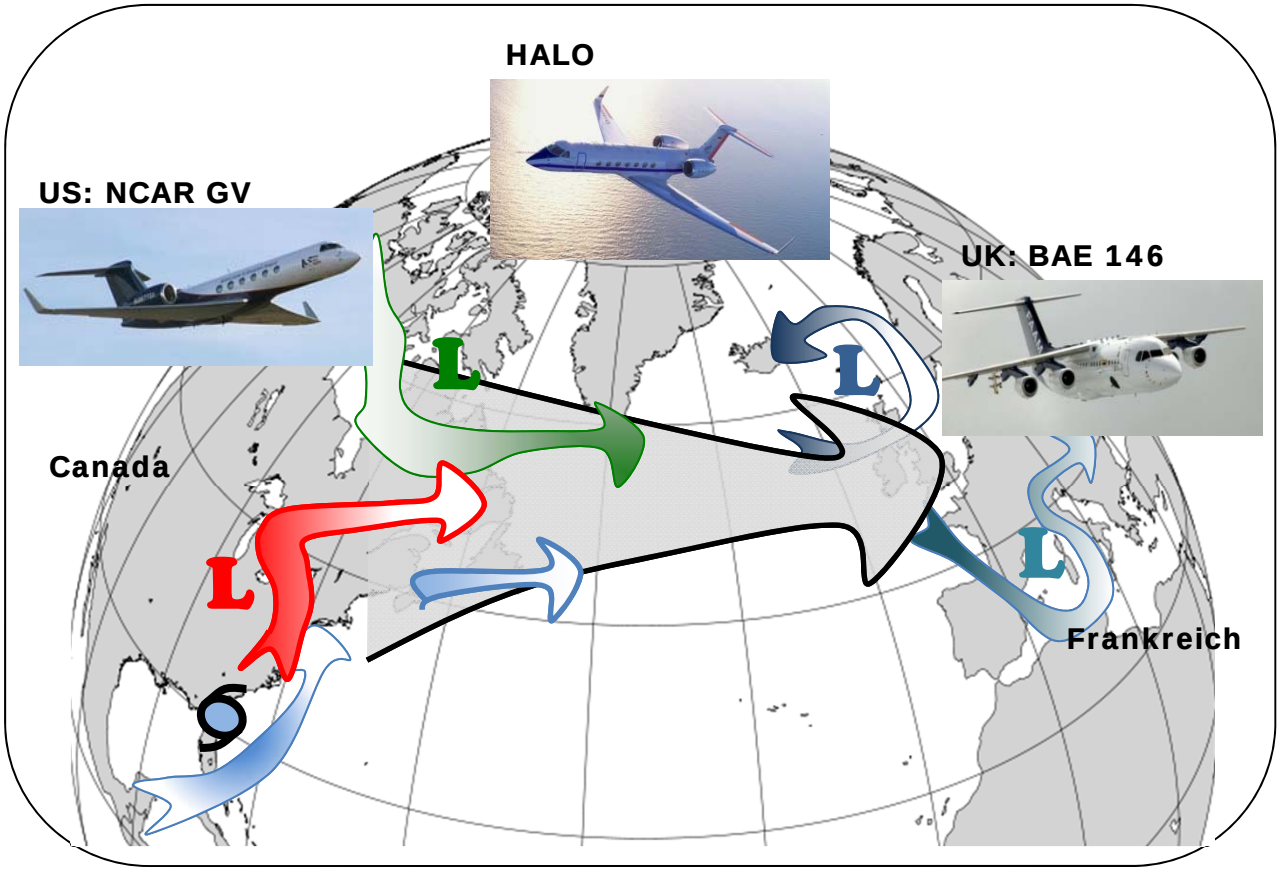
- Mesoscale structures of WCBs and their representation in NWP models
- Analysis of Lagrangian matches of airmasses
- Analysis of cloud types: compare with NWP cloud microphysics
- Predictability investigation of WCB forecasts
- Research in Ensemble Forecast
  Visualization for Flight Planning
  (Thu, 11 Apr 13:45, R14, M. Rautenhaus)



Outlook

T-NAWDEX (THORPEX-North Atlantic Waveguide and Downstream Impact Experiment)

- scheduled for 2016
- internationally coordinated



Overarching hypothesis:

There are systematic errors in model representation of waveguide perturbations that are attributable to diabatic processes . Errors are manifested as errors in PV distribution that correspond to errors in the jet stream → forecast errors of high-impact weather downstream