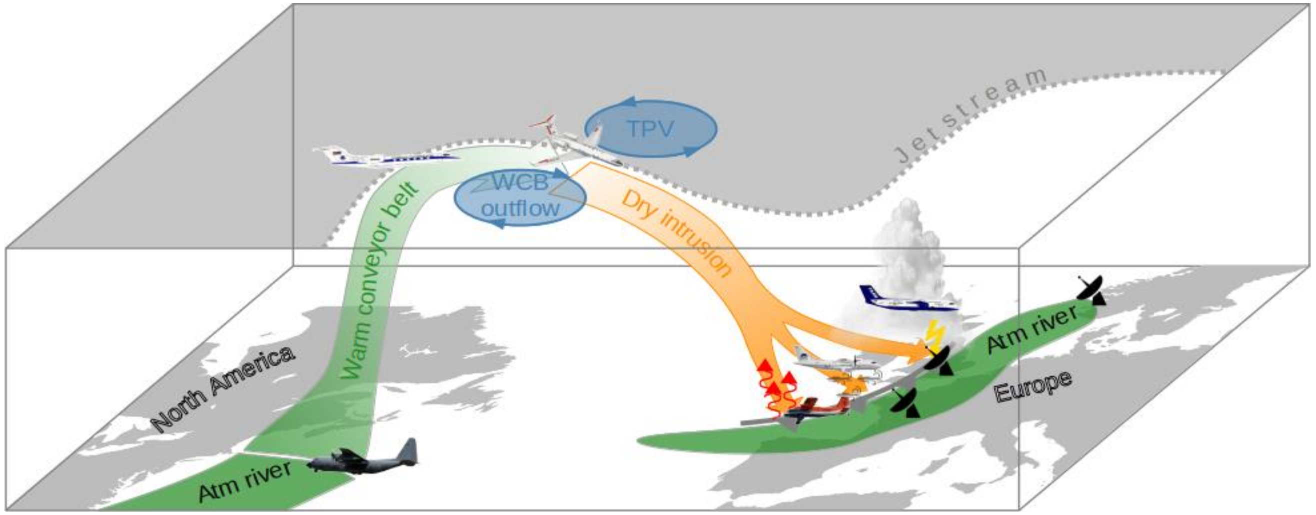
NAWDIC

North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign

NAWDIC Workshop discussing international coordination

30 June 2023 – ECMWF, Reading



Welcome!

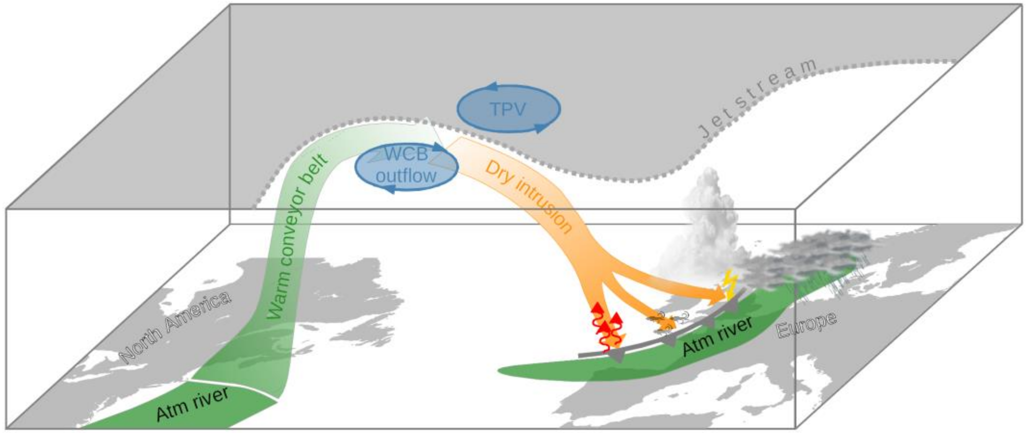
Agenda

9:00-10:50	**Welcome and NAWDIC overview talks**
10:50 – 11:20	*Coffee break*
11:20 – 12:30	**Breakout Groups**
12:30 – 14:00	*Lunch*
14:00 – 15:20	**Case Study**
15:20 – 15:45	**Breakout Group Report and Closing Discussion**

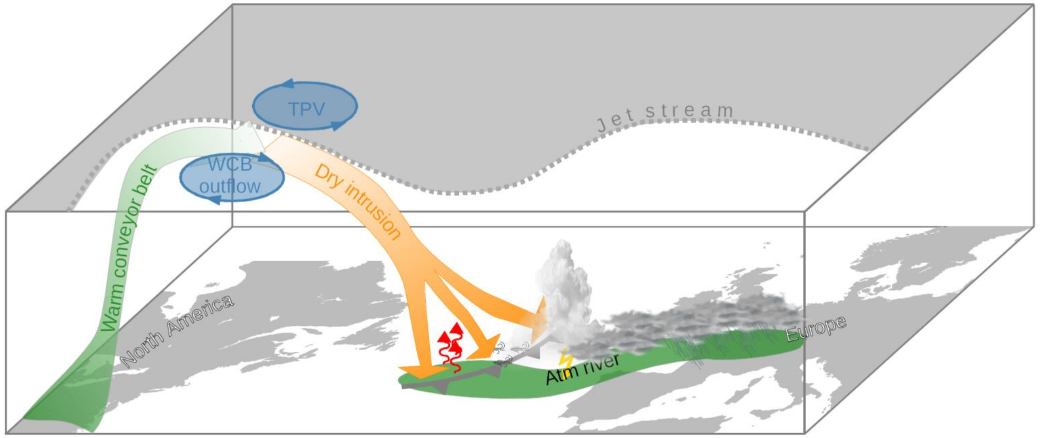
Scientific idea and goals

- Focus on **high-impact weather related to frontal systems of extratropical cyclones** in the North Atlantic – Euro – Mediterranean region in winter

Scenario 1: wind gusts related to cold frontal passage and cold sector



Scenario 2: heavy precipitation related to atmospheric river landfall



NAWDIC North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign

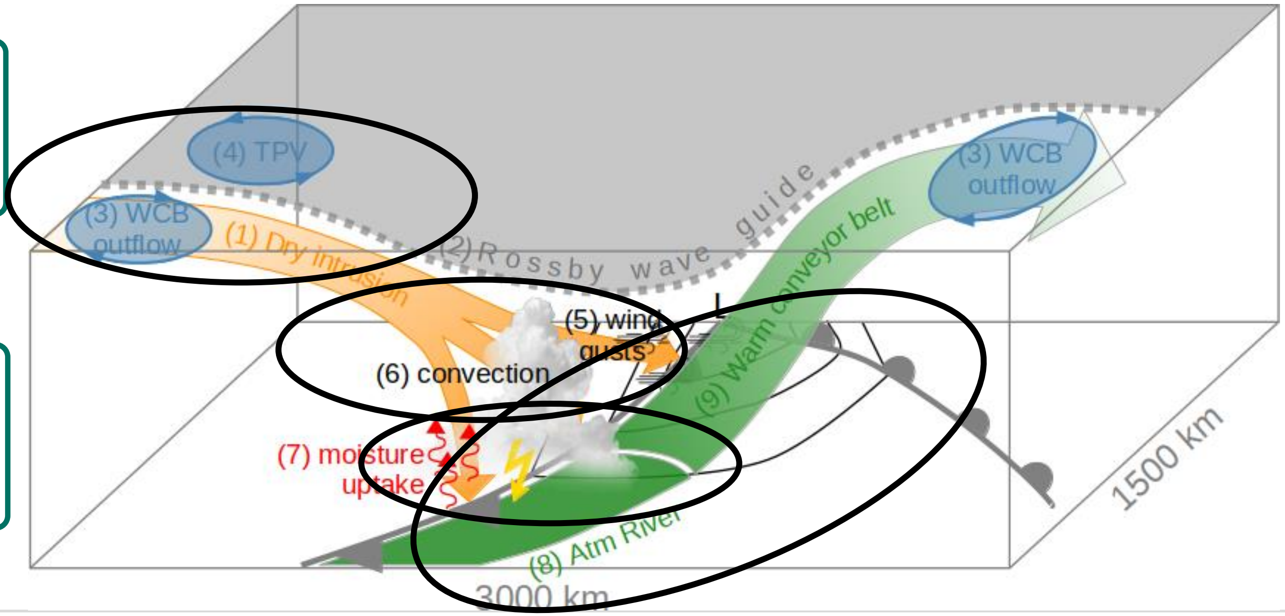
Scientific idea and goals

- Focus on **high-impact weather related to frontal systems of extratropical cyclones** in the North Atlantic – Euro – Mediterranean region in winter

- NAWDIC aims to **advance our understanding of the synoptic- to micro-scale dynamical and physical processes** associated with the triggering of **severe wind gusts, heavy precipitation, and cold air outbreaks** in the North Atlantic-Euro-Mediterranean region and of their **representation in NWP models**.

a) Tropopause Structure

d) Dynamics and air mass interactions near the cold front



b) DI influence on PBL

c) Near surface DI and HIW

Karlsruhe Institute of Technology

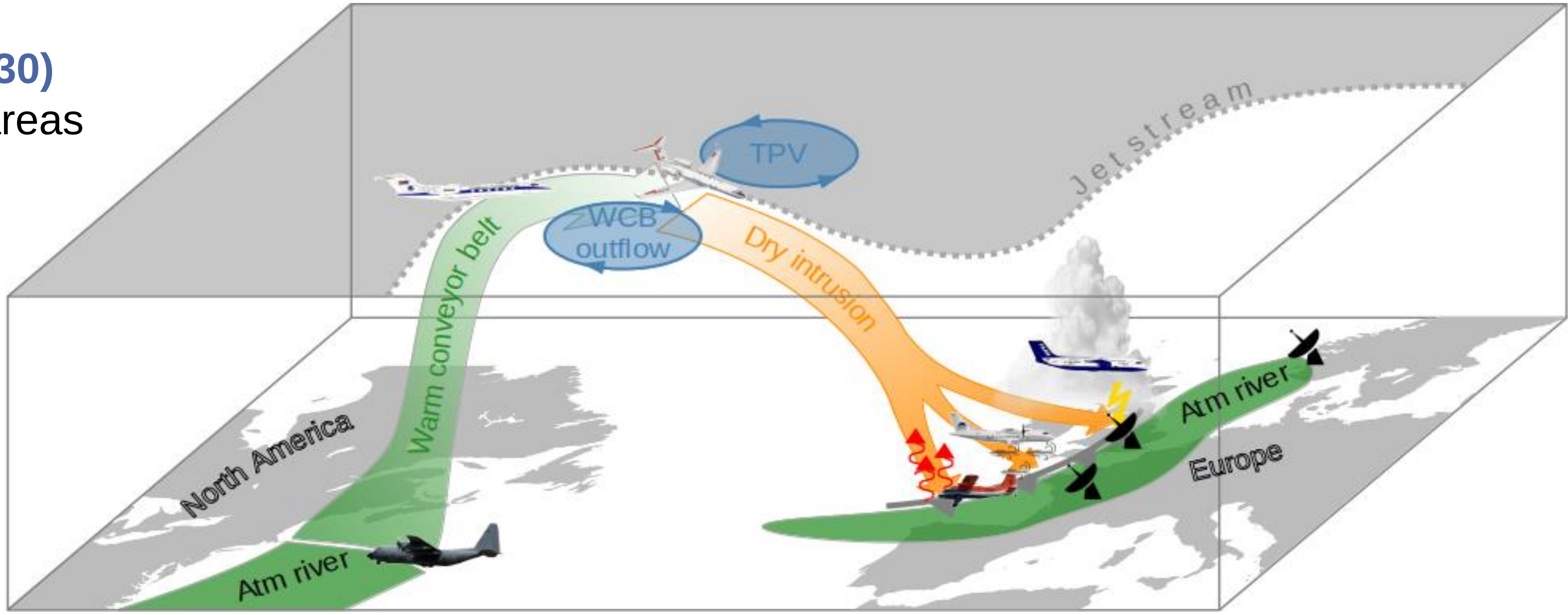
Seamless Observation Strategy – NAWDIC components

- *NAWDIC observations will be made across multiple scales using airborne and ground-based observations complemented by a **seamless modelling component** incl. data assimilation*

Long-range aircraft (HALO / NASA / NOAA?)
Sample tropopause structure, DI-PBL interaction, and moisture uptake & transport with remote sensing instruments/dropsondes

Mid-range aircraft (ATR42/UK FAAM/US-C130)
DI-PBL and ocean-atmosphere interaction in areas related to HIW

Ground-based observations
Dense observation network along the European coastline: **KITcube** supersite + FR mobile radars + UK radars, wind profilers, lidars + NO lidar



NAWDIC-HALO and NAWDIC-KITcube: Seamless observation strategy from synoptic- to micro-scale

Christian M. Grams[1], Julian F. Quinting[1], Annika Oertel[1], Alexandre Ramos[1], Shira Raveh-Rubin[2], Andreas Schäfler[3], Peter Knippertz[1], George Craig[4], and Volkmar Wirth[5]

[1]Karlsruhe Institute of Technology, [2]Weizmann Institute of Science, [3]Deutsches Zentrum für Luft- und Raumfahrt, [4]Ludwig-Maximilians University Munich, [5]Johannes Gutenberg University Mainz

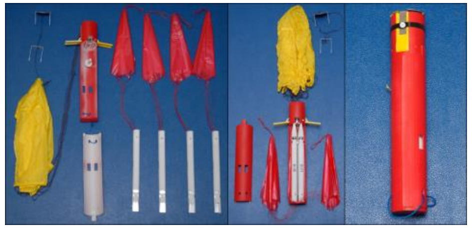
KITcube
integrated atmospheric observation system

Karlsruhe Institute of Technology

NAWDIC-HALO and NAWDIC-KITcube deployment

- local **KITcube** supersite and / or ground array will allow
  - detailed and high-frequent observations of local weather, in particular wind gusts and change of air-mass characteristics during cold frontal / DI passage.
  - realtime high-resolution data assimilation in collaboration with German Weather Service DWD
- Long-range flights with **HALO** will allow
  - **observations of DI-PBL interaction** in the **AR moisture source regions** as well as of the interaction with DIs **affecting HIW** over Europe (→ moisture transport, moisture uptake and winds)
  - detailed observations of the **mesoscale tropopause structure** in remote **DI origin** areas over the North Atlantic and a **quasi-Lagrangian tracking of** the **descending DI** air masses (→ trace gas gradients and wind gradients)

Photo: Andreas Minikin

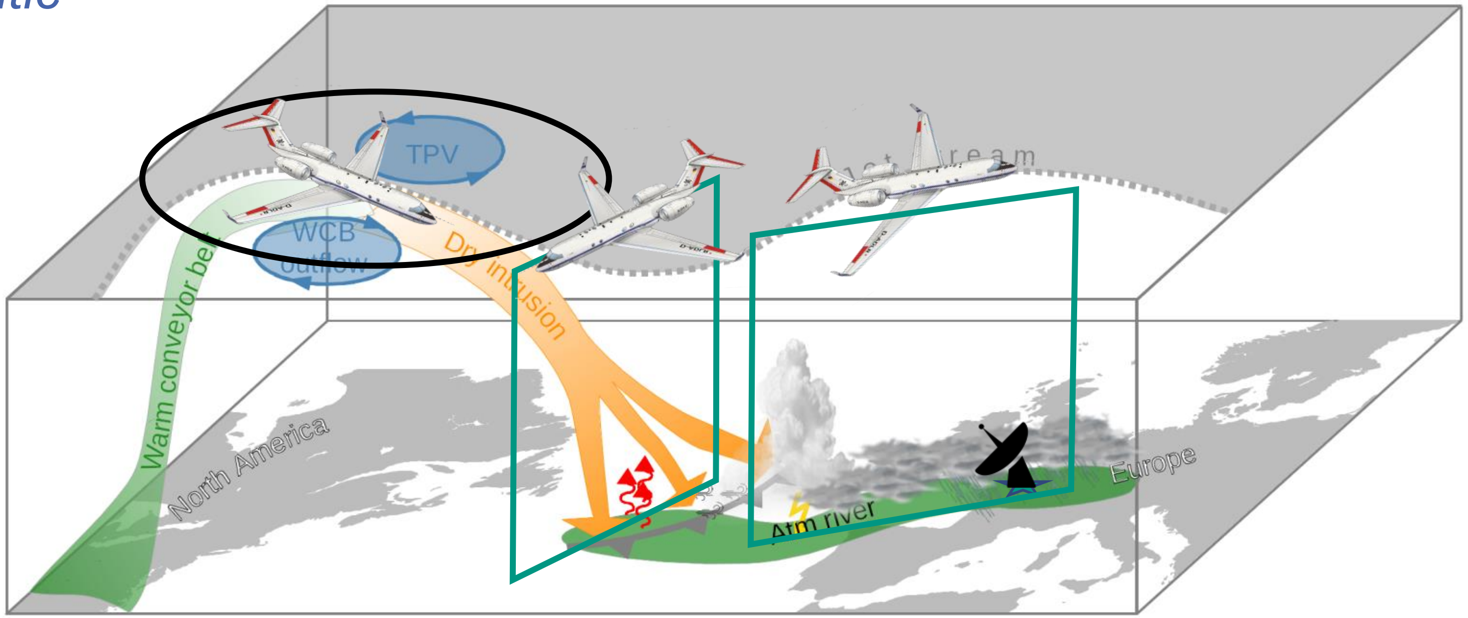


NAWDIC North Atlantic Waveguide, Dry Intrusion, and Downstream Impact Campaign

Karlsruhe Institute of Technology

Seamless observation strategy combining HALO and KITcube

- **HALO Area of Operation:** *North Atlantic*
  - HALO likely based in Ireland
- **KITcube:** *French Coastline*
  - supersite at Atlantic Coast or Mediterranean
  - coordinated with mobile French facilities
- **Time period:** *Winter*
  - 6 weeks in **January – February 2026**
  - storm track activity maximal in winter



TP structure

DI-PBL interaction moisture uptake

moisture transport / lower level winds

KITcube
integrated atmospheric observation system

https://www.imk-tro.kit.edu/7858.php

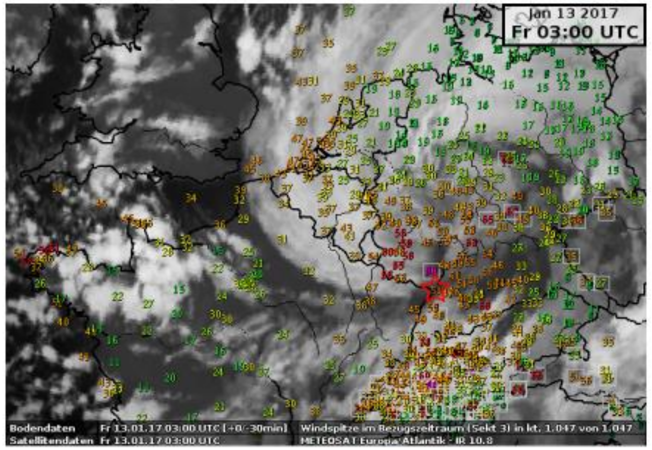
NAWDIC-KITcube - deployment

- **local measurements at a supersite and / or observational array**
- **key instruments:**
  - Cloud, X-, and K-band radars
  - 5 Doppler-Lidars (wind)
  - Microwave radiometers (q, T profiler)
  - Ceilometer, Autolauncher radiosoundings, …
- **area:** *French Coastline*
  - supersite at Atlantic Coast
  - coordinated with mobile French facilities
- **Time period:** *Winter 2025/26*
  - can be operated remotely in extended winter
  - pre-campaign envisioned in winter 2024/25

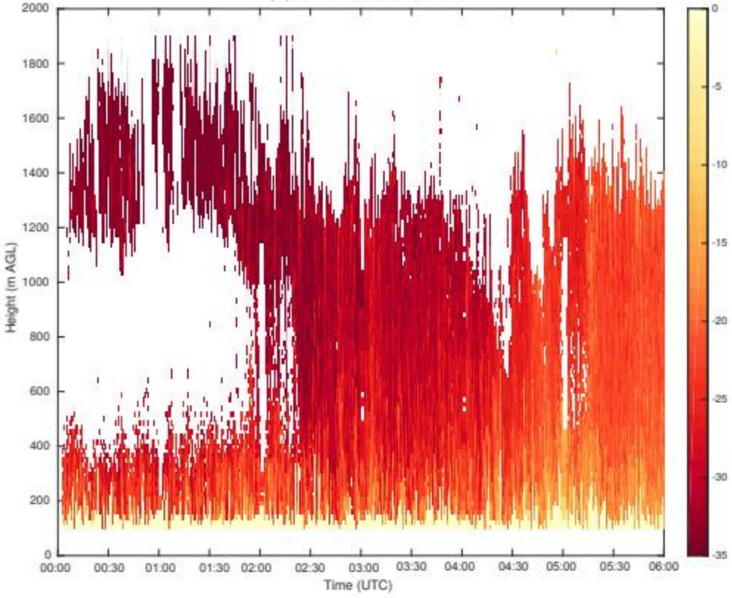
HIW ground-based observations

High wind situations with DI interaction

(a) Satellite and SYNOP observations

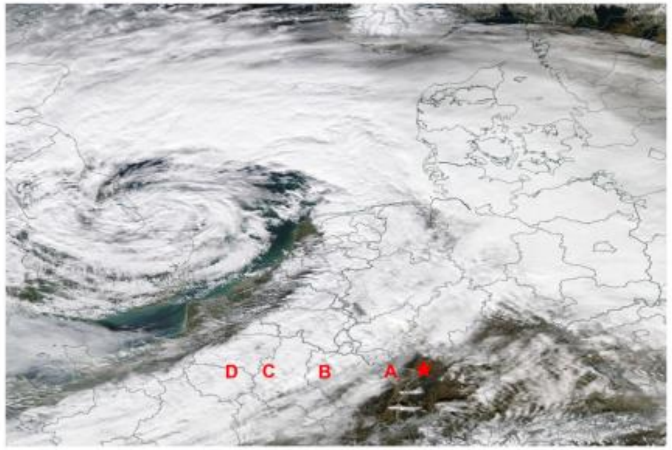


(b) Lidar observations

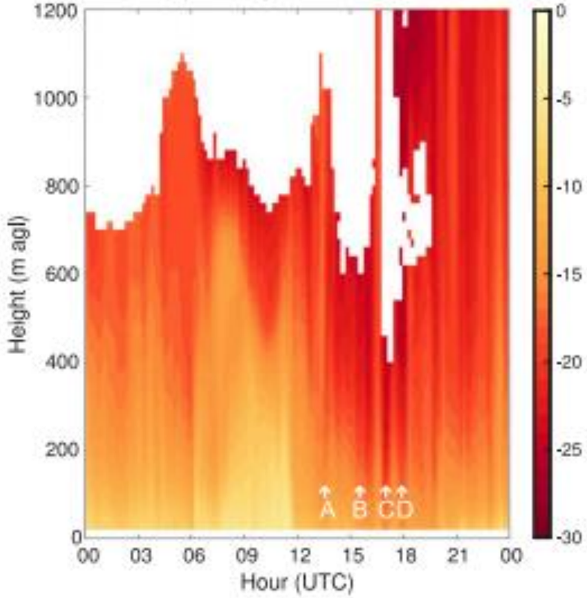


Pantillon et al. 2018, Adv. Sci. Res.,

Heavy precipitation in AR-type flow



(a) Average radial wind



Pantillon et al. 2020, MWR

NAWDIC:

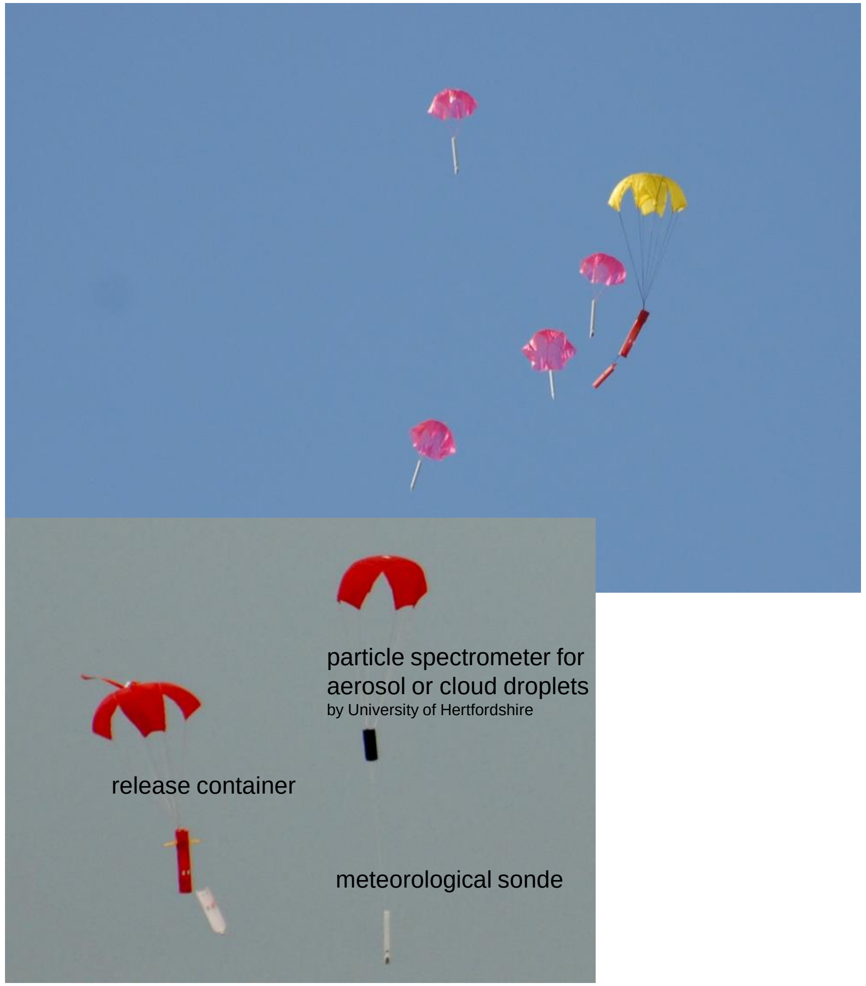
- Validate the PBL structure and mesoscale circulation systems (wind, humidity, moisture transport) and the transition from marine to continental PBL in NWP models
- Flow-dependent impact of meso-scale data assimilation

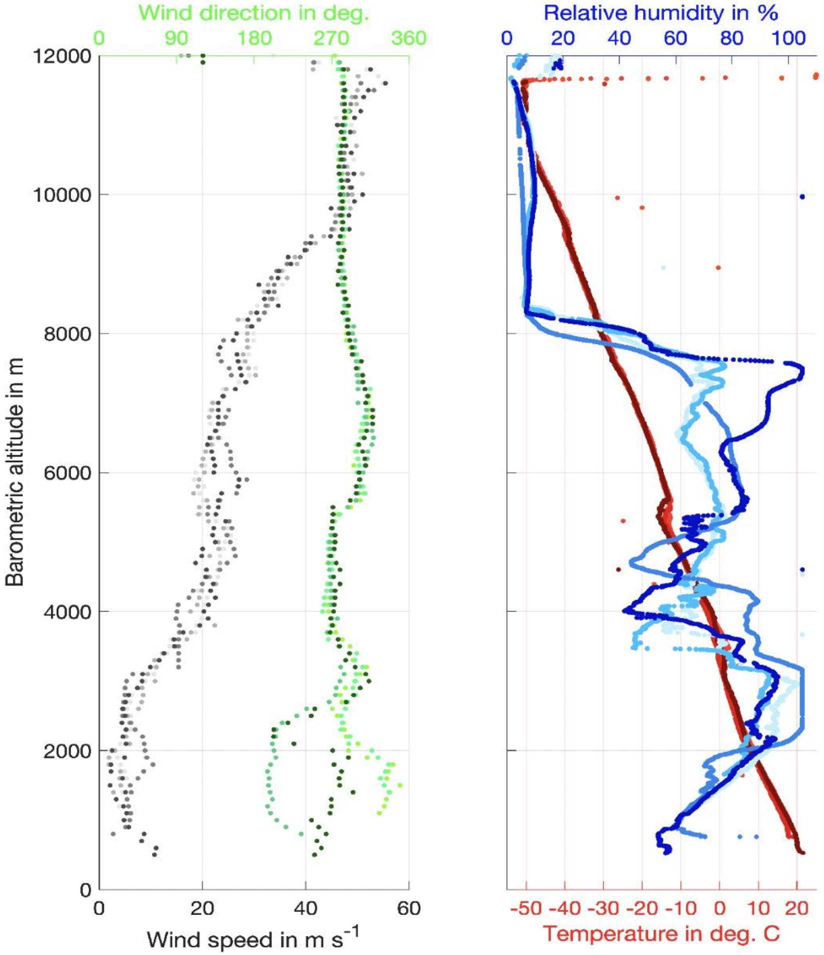
NAWDIC-HALO instrumentation *(in discussion)*

- **In-situ package BAHAMAS**
  - SHARC
  - turbulence
- **Remote sensing**:
  - KITsonde
  - DIAL lidar (WALES)
  - WIND lidar
- **In-situ instruments**
  - SpecMACS
  - UMAQS
  - FISH
  - FAIRO

Instrument	Parameter	Institution	PI
KITsonde	U, V, W, T, RH	KIT	Wieser
WALES	H2O/O3	DLR	Wirth
1.6 mu Wind Lidar	U, V, W	DLR	Witschas
SpecMACS	cloud structure	LMU	Mayer/Zinner
UMAQS	CO, N2O, …	U Mainz	Hoor
FISH	H2O	FZ Jülich	Krämer/Rolf
FAIRO	O3	KIT	Zahn

Interaction of DI with PBL



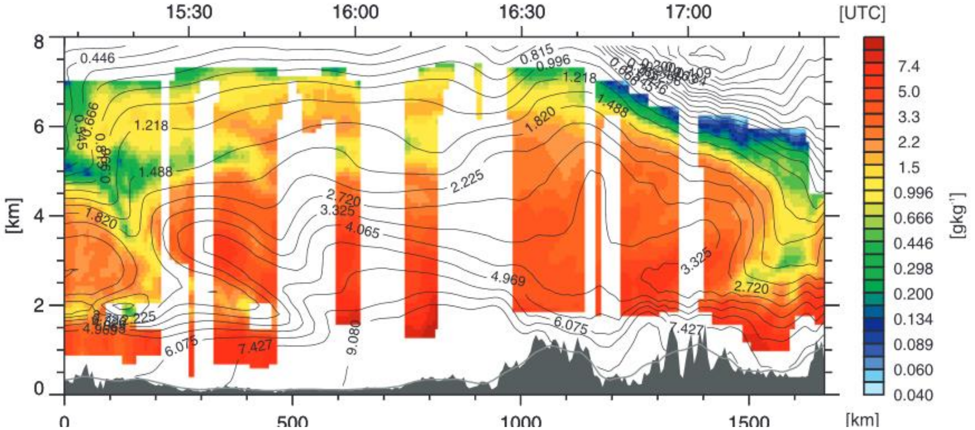


NAWDIC:

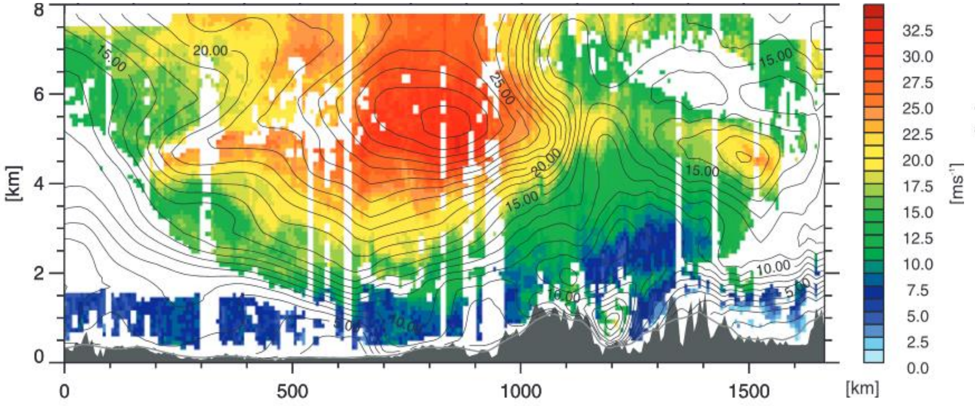
- Mesoscale variability of PBL height
- Validate representation of vertical gradients between DI and PBL
- Study systematic errors through validation and observation impact studies

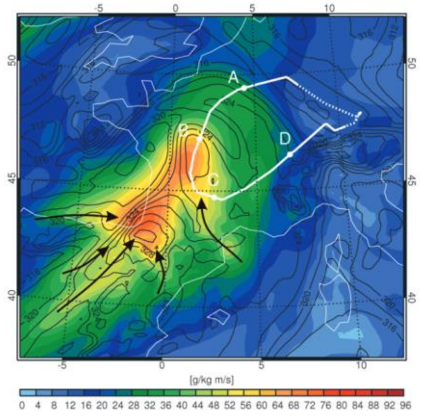
Collocated observations of H_2O and horizontal wind

Specific humidity

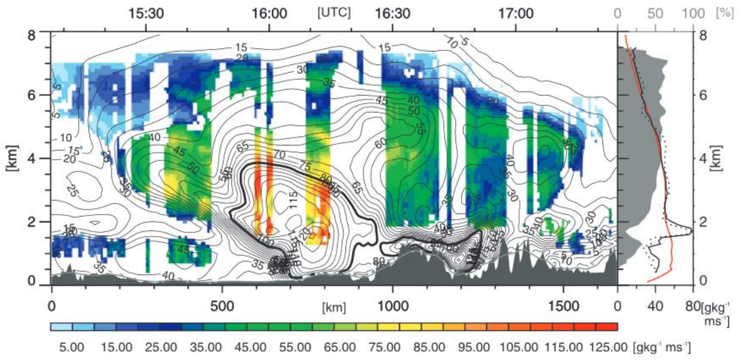


Horizontal wind speed





Horizontal humidity transport

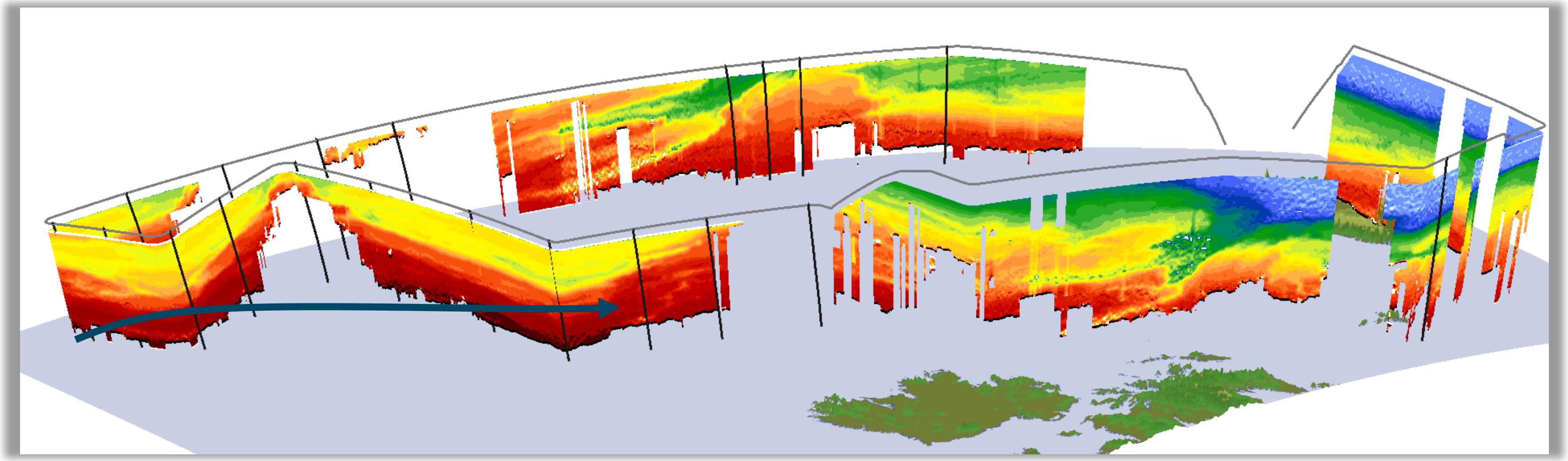


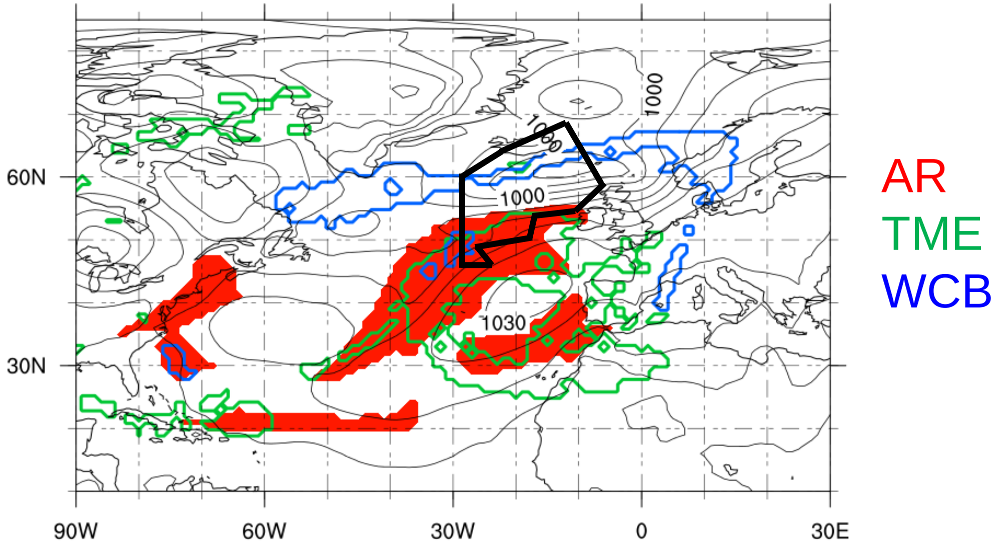
Schäfler et al. 2010, JTECH

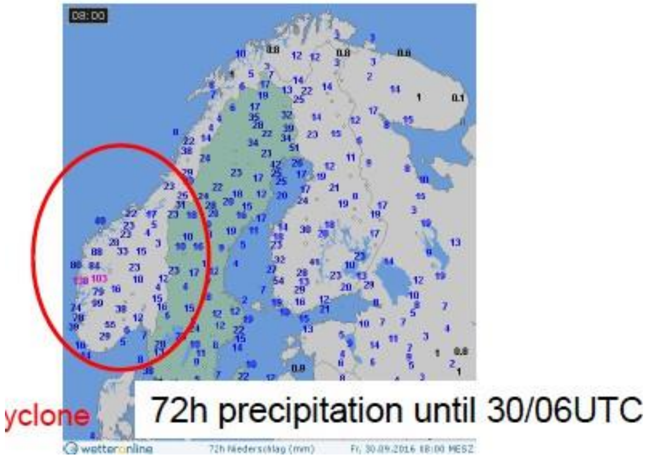
NAWDIC:

- Combined H_2O and wind observations from lidar and dropsondes
- Systematic errors of moisture transport in ARs (Lavers et al. 2018) → uncertainties in low-level winds (Sandu et al. 2020) or moisture?
- Observation impact studies

Collocated observations of H_2O and horizontal wind



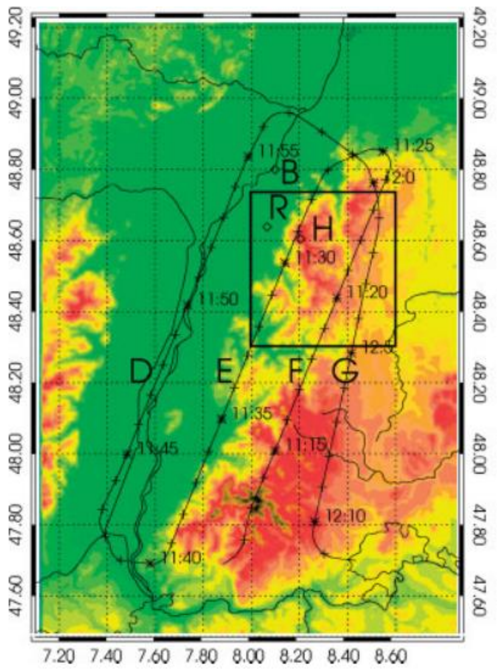


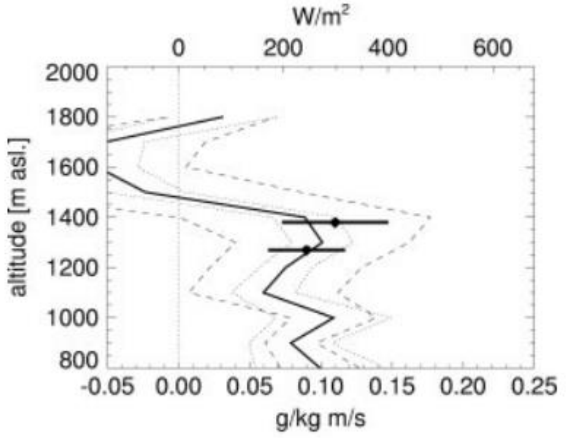


NAWDIC:

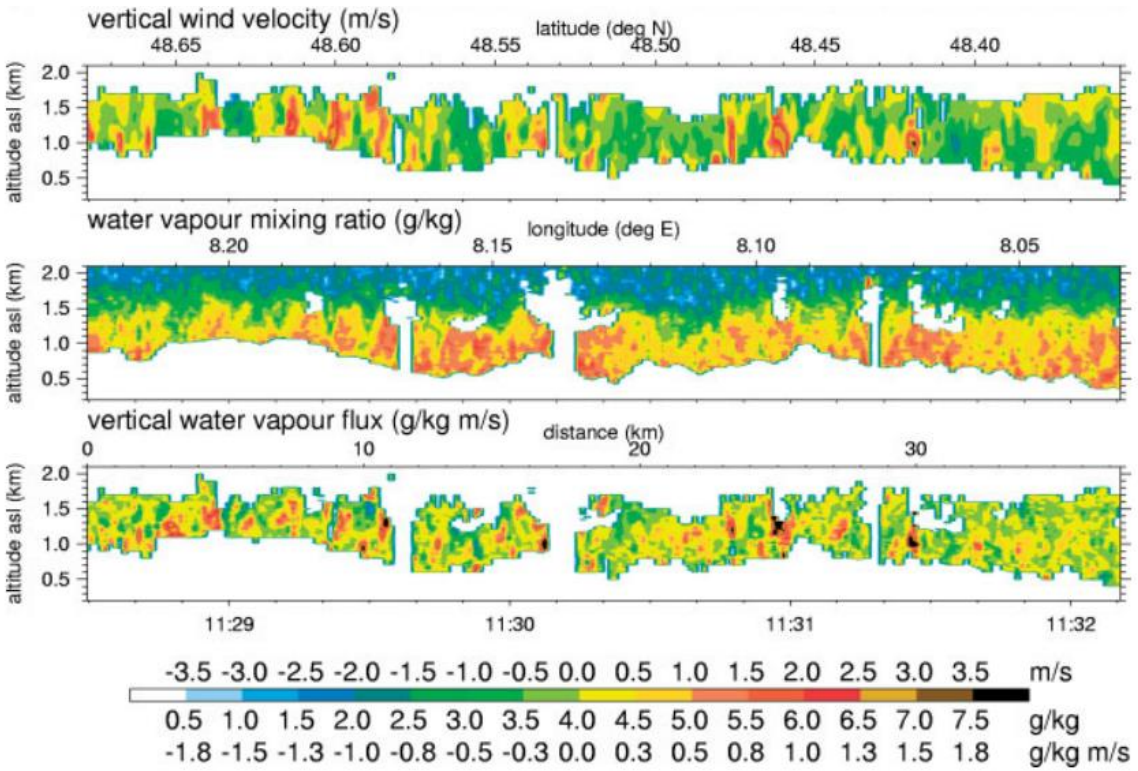
- HALO provides unique capabilities to access regions upstream of HIW events and in moisture source regions
- Study mesoscale variability of moisture transport
- Errors relative to the AR?

Collocated observations of H_2O and vertical wind





re 7. Latent heat flux profile from airborne lidar data of Figure 3 (leg

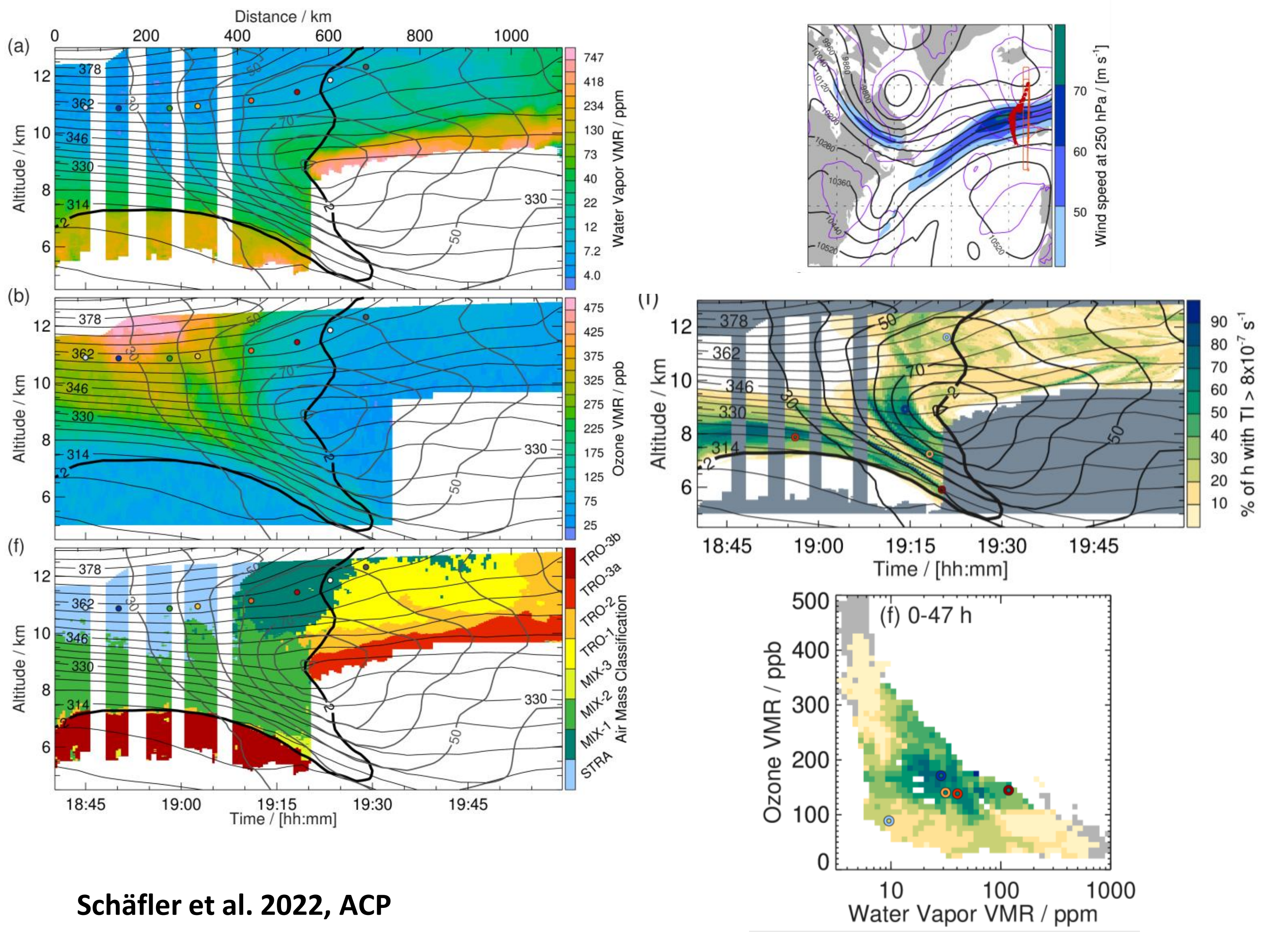


Kiemle et al. 2011, QJ
Kiemle et al. 2007, JTECH

NAWDIC:

- Adapt methods to determine latent heat flux profiles for long range HALO flights legs
- Ideally in cloud-free AR moisture source regions upstream (regions of systematic errors?)
- Study representation of latent heat flux in NWP
- Local fluxes vs. the horizontal transport of moisture?

Collocated observations of H_2O / O_3 - UTLS and mixing

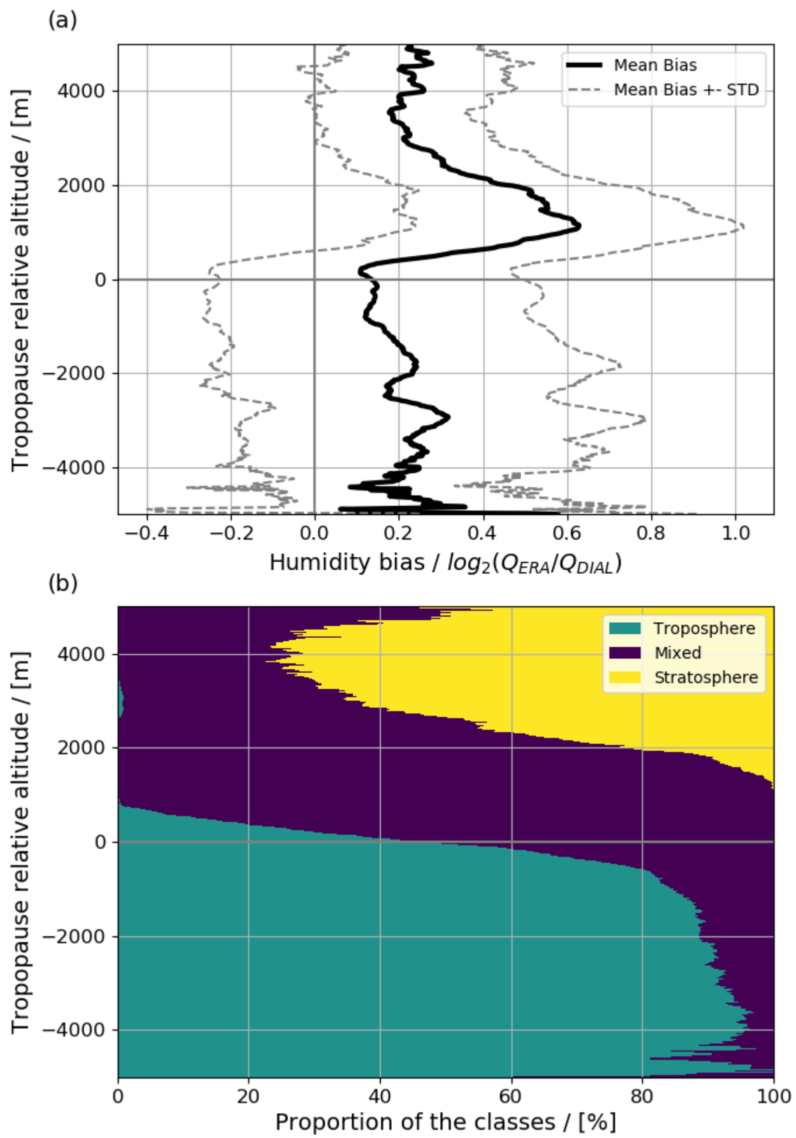


Schäfler et al. 2022, ACP

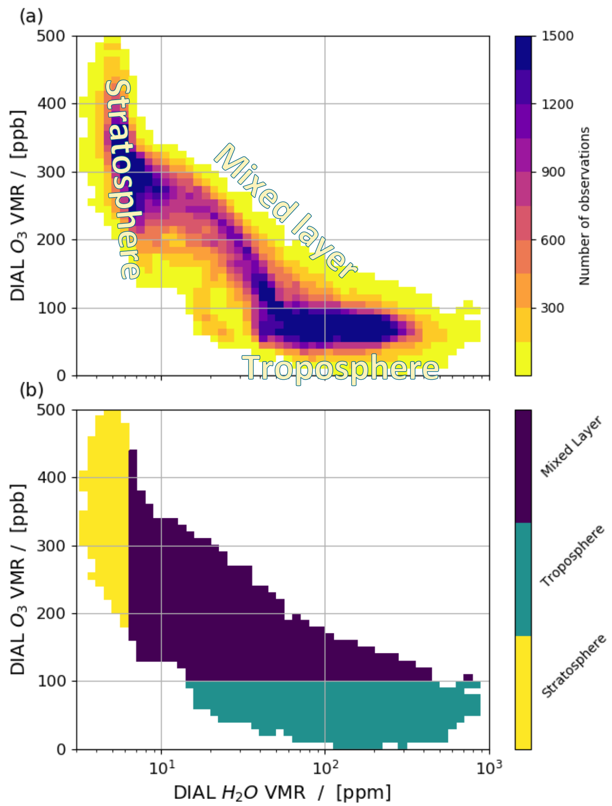
NAWDIC:

- Combined in situ and DIAL H_2O/O_3 observations across the jet stream
- Role of tropospheric processes for UTLS
- Extend data base: different dynamical situations with differing transport pathways and mixing processes (WCBs)

Collocated observations of H_2O / O_3 - LS moist bias



- Co-located H_2O/O_3 DIAL obs
- So far only 4 flights during WISE 2017



Krüger et al. 2022, ACP

NAWDIC:

- Extend data base of combined in situ and DIAL H_2O/O_3 observations across the jet stream
- Focus on different dynamical situations, mixing processes

Near-tropopause wind speed biases

- few observational evidence of wind speed near tropopause, unclear connection of tropopause uncertainties to downstream weather

tropopause windspeed error in short-range IFS forecasts during NAWDEX

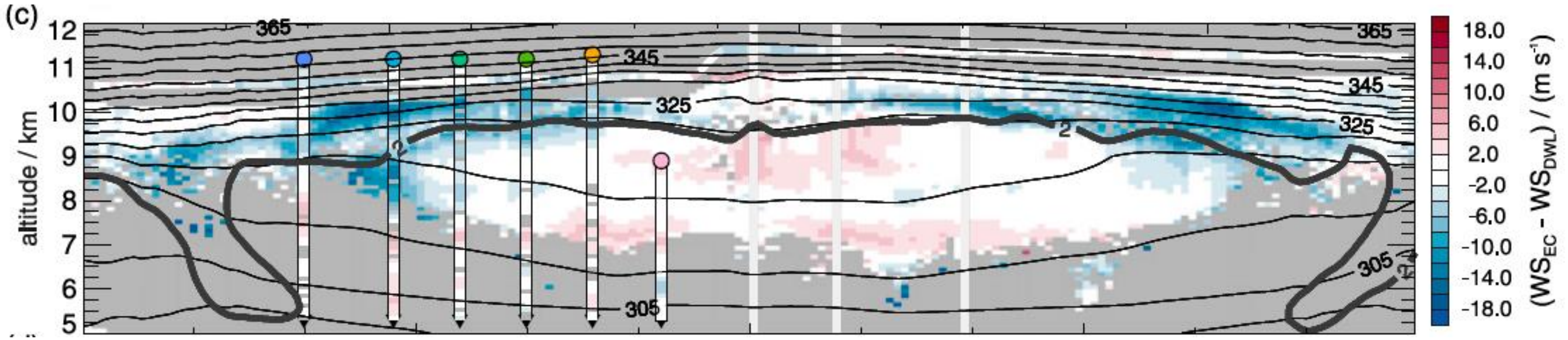
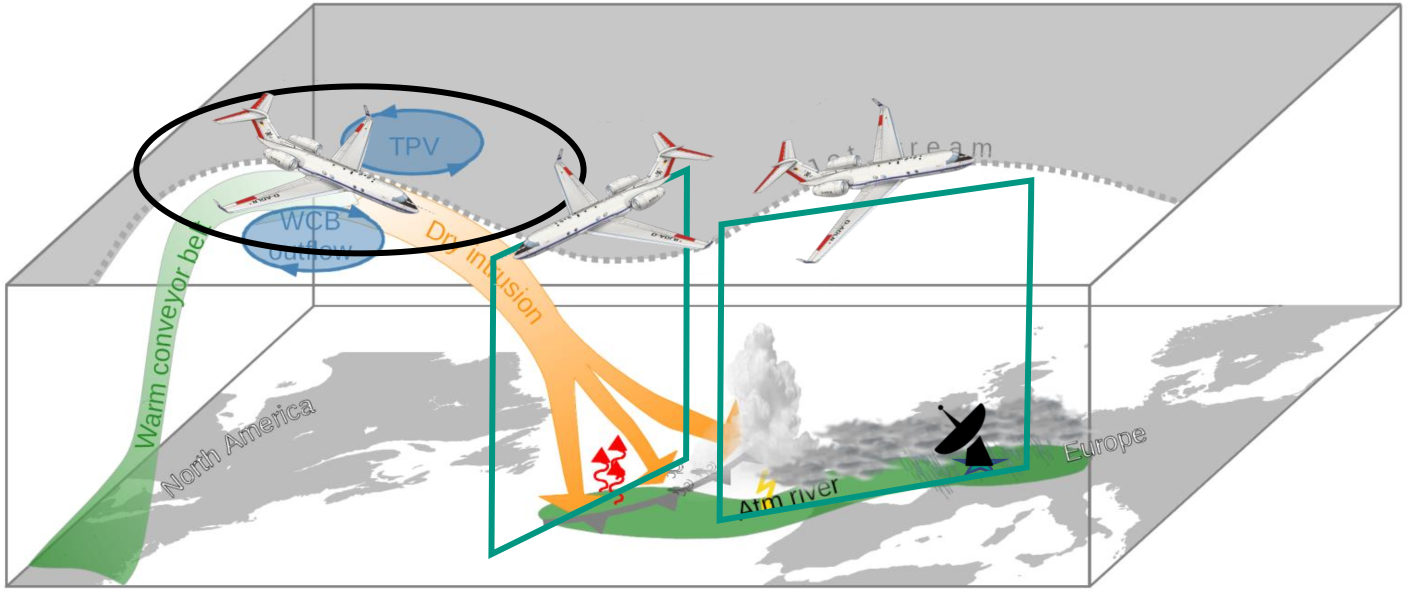


Fig 5c from Schäfler et al. 2020, doi: 10.1175/MWR-D-19-0229.1

Summary



TP structure

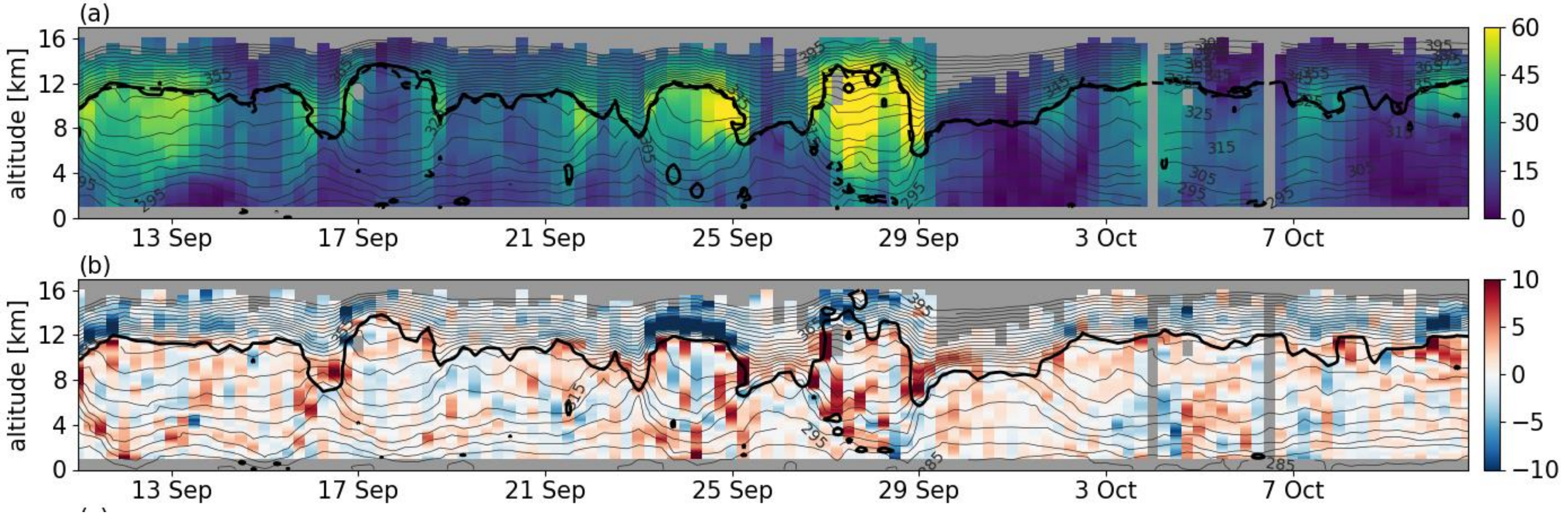
DI-PBL interaction moisture uptake

moisture transport / lower level winds

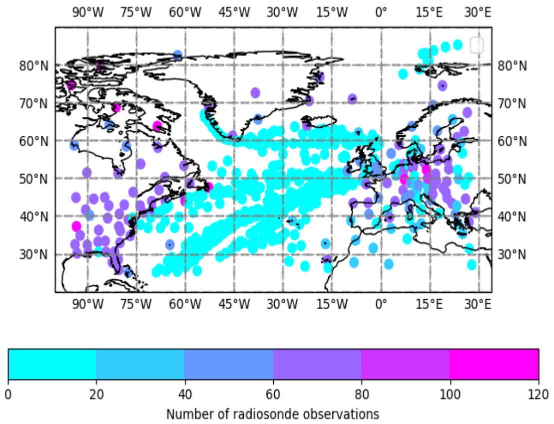
- **KITcube:** air-mass transformation at coast during cold-front and DI passage
  - characterization of landfalling AR at the microscale
- **HALO:** mutual benefits from remote sensing and in-situ payload
  - air mass characterisation, mixing processes near the tropopause
  - jet stream wind biases
  - mid- and low-level horizontal moisture transport and vertical water vapour fluxes
- Lagrangian storyline connects UTLS and lower troposphere region
  - upstream HALO observation
  - DI-PBL interaction
  - HIW downstream

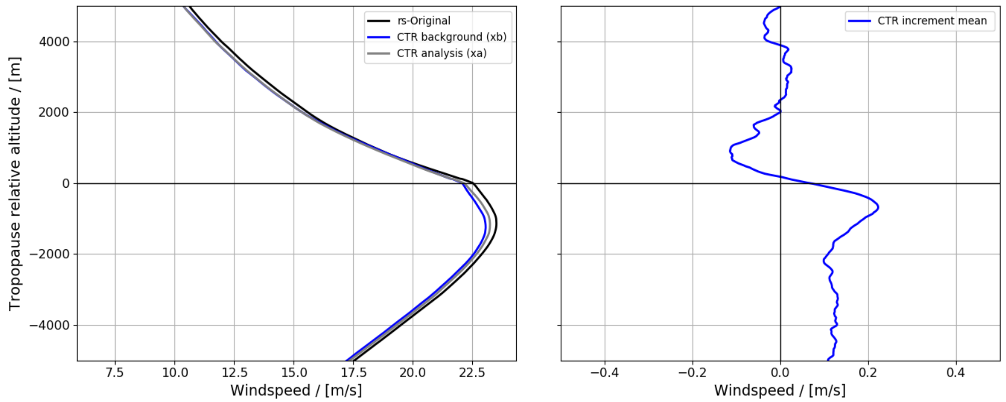
additional slides

Jet stream winds



Schäfler et al. 2020, MWR, South Uist Profiler





Krüger et al. 2023, in prep.

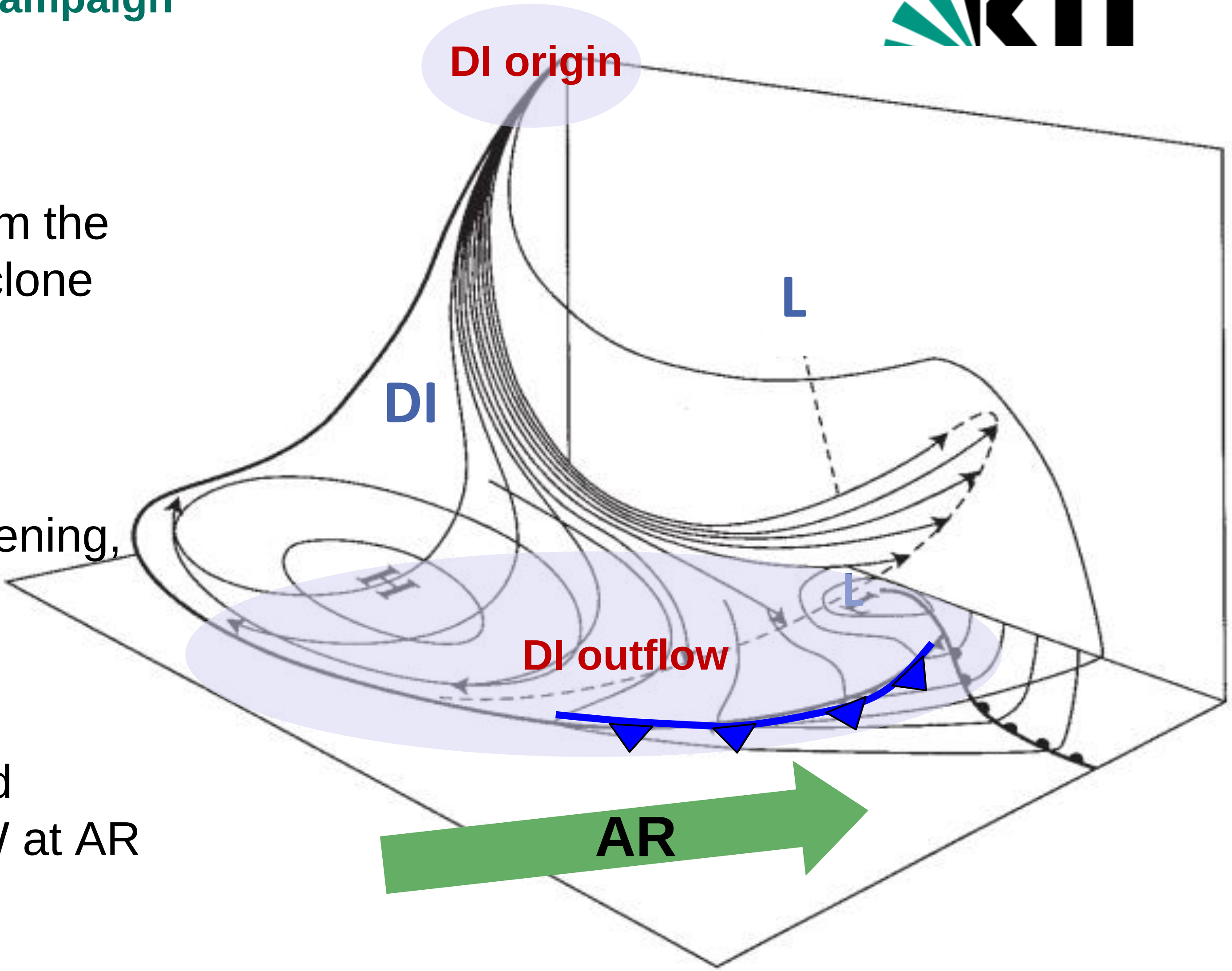
NAWDIC:

- Wind errors in a post-Aeolus phase
- Systematic analysis of jet stream transects from high altitudes
- Vertical motion related to mesoscale circulations in the jet stream

Dry air intrusions (DIs)

- DIs: synoptic-scale slantwise **descent** from the upper troposphere equatorward to the cyclone cold sector

- DIs affect:
  - PBL (destabilization from above, deepening, mixing, evaporation)
  - front intensity and associated impact (precipitation, wind gusts)
  - AR structure, AR moisture sources and moisture transport and associated HIW at AR landfall



Danielsen (1964)