HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

Young Investigator Group VH-NG-1243:
*"**S**ub-seasonal **PRE**dict**A**bility: understanding the role of **D**iabatic **OUT**flow" (SPREADOUT)*

Karlsruhe Institute of Technology

The role of cloud diabatic processes in the life cycle of Atlantic-European weather regimes

Christian M. Grams

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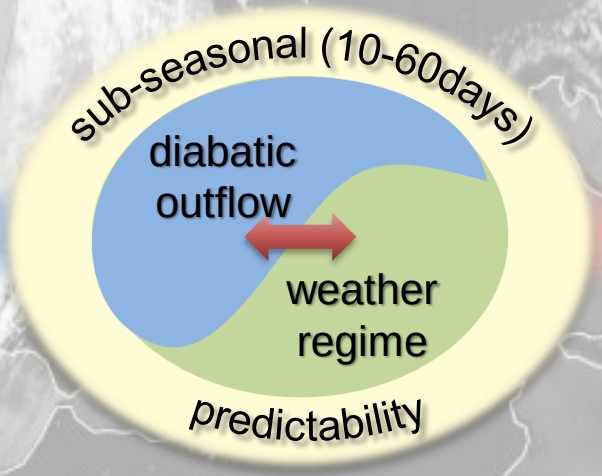
grams@kit.edu



Weather

Climate

FNSNF
FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

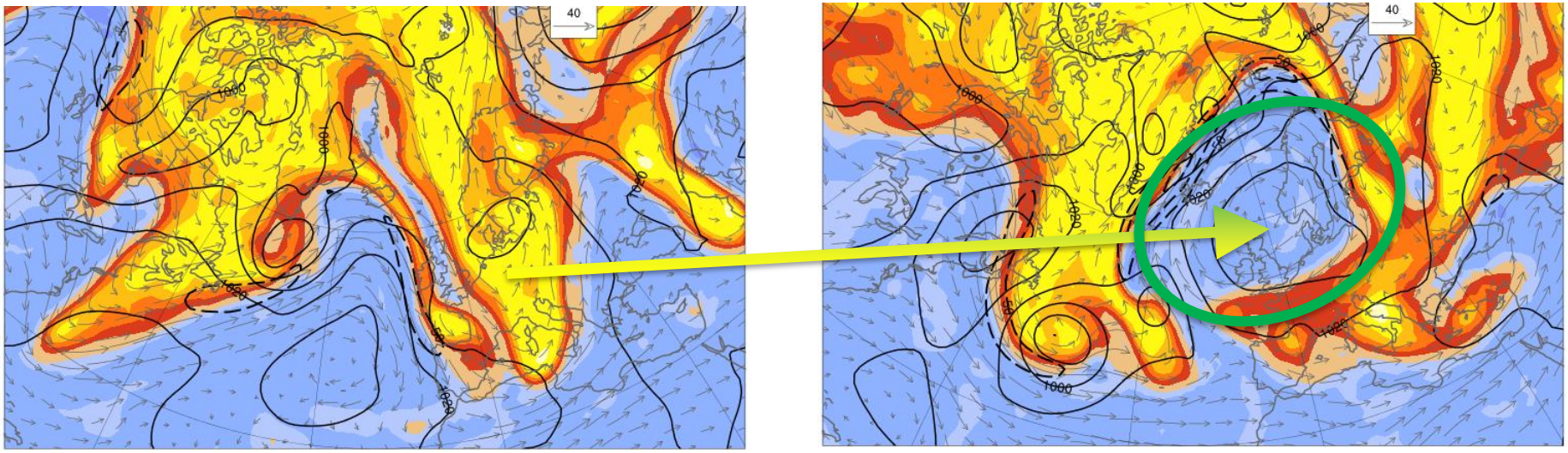
contributions:
Remo Beerli, Maxi Böttcher, Dominik Büeler, Laura Ferranti, Camille Li, Erica Madonna, Linus Magnusson, Lukas Papritz, Stephan Pfahl, Julian Quinting, Michael Sprenger, Daniel Steinfeld, Patrick Suter, Heini Wernli, and others.

A recent forecast bust

Onset of **European Blocking**

ECMWF analysis
20160307_00Z

20160314_12Z



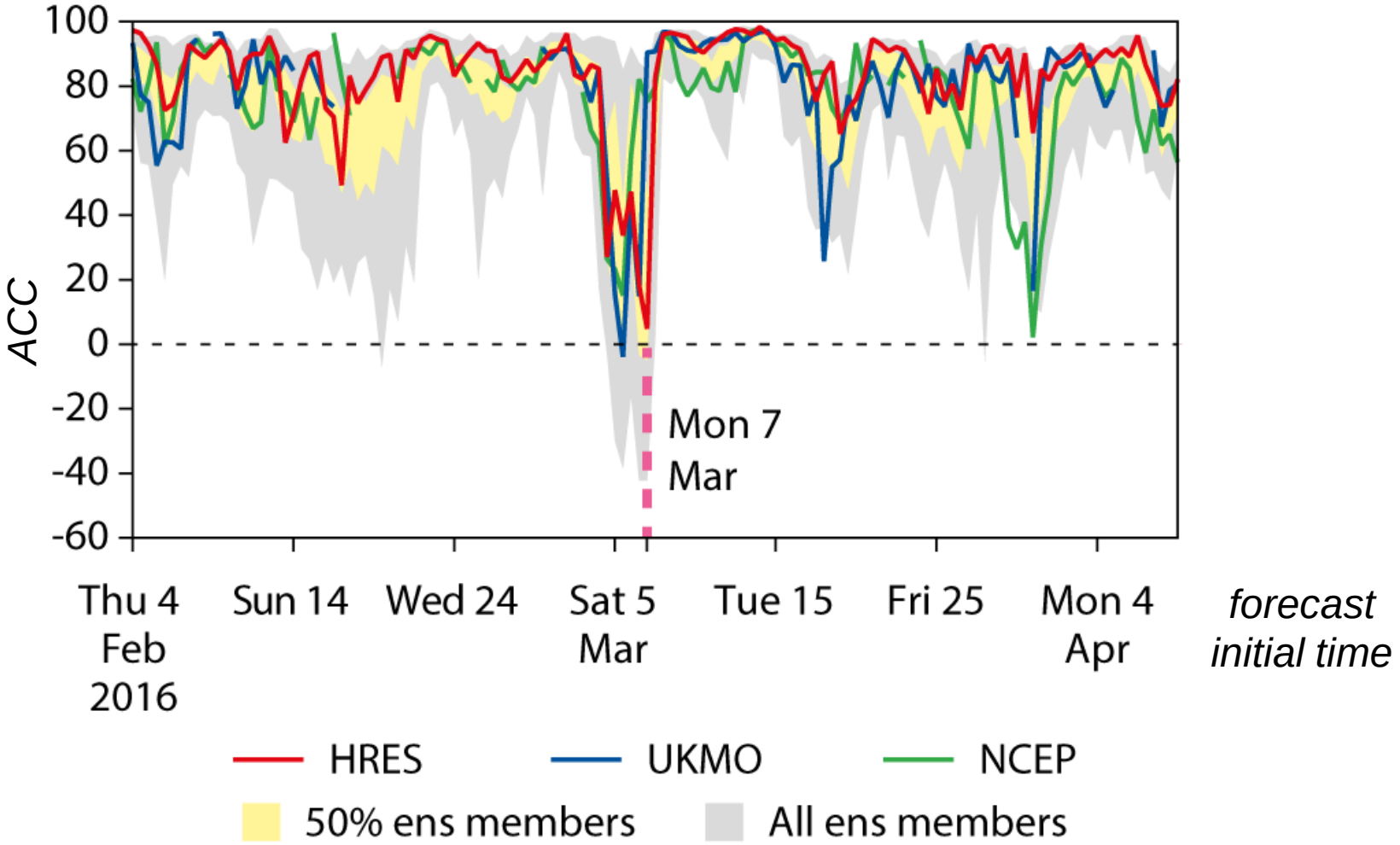
PV@315K, wind@315K, and PMSL

Tue Poster **A2-11** by Julian Quinting
"RWP & blocking in S2S models"

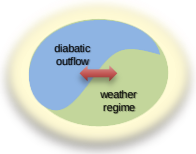
ECMWF Roadmap to 2025: "…we also aim to predict large-scale patterns and regime transitions up to four weeks ahead, …"

A recent forecast bust

+144h Z500 ACC - Europe



Magnusson (2017), *QJRMS*, doi:10.1002/qj.3072
Grams, Magnusson, and Madonna (2018), *QJRMS*, doi:10.1002/qj.3353



Overview

Karlsruhe Institute of Technology

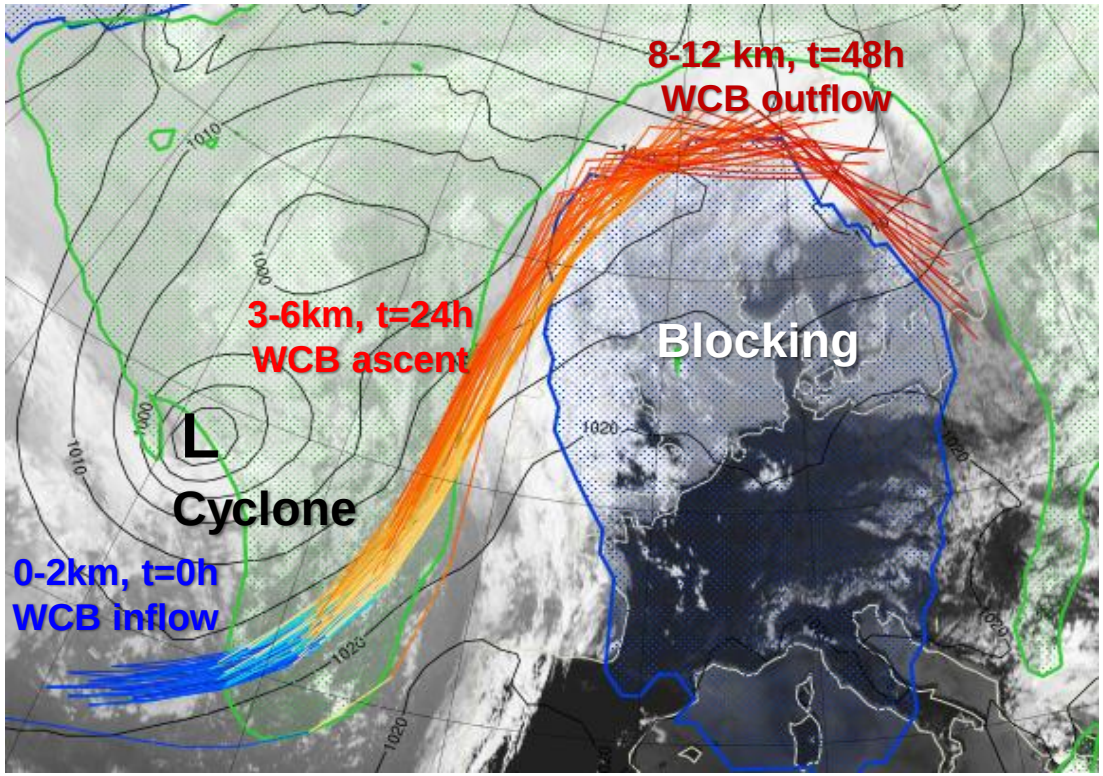
What is the **role of cloud-condensational processes in** the **life cycle of** Atlantic-European **weather regimes?**

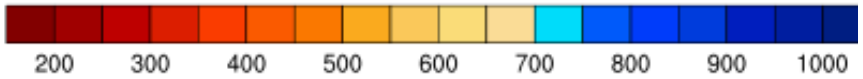
1. Introduction (WCBs, blocking, regimes)
2. WCB activity during regimes and at regime onset
3. Modulation on S2S time scales

Warm conveyor belts & blocking

WCB clim. by Madonna et al. (2014), *JCli,* http://dx.doi.org/10.1175/JCLI-D-12-00720.1

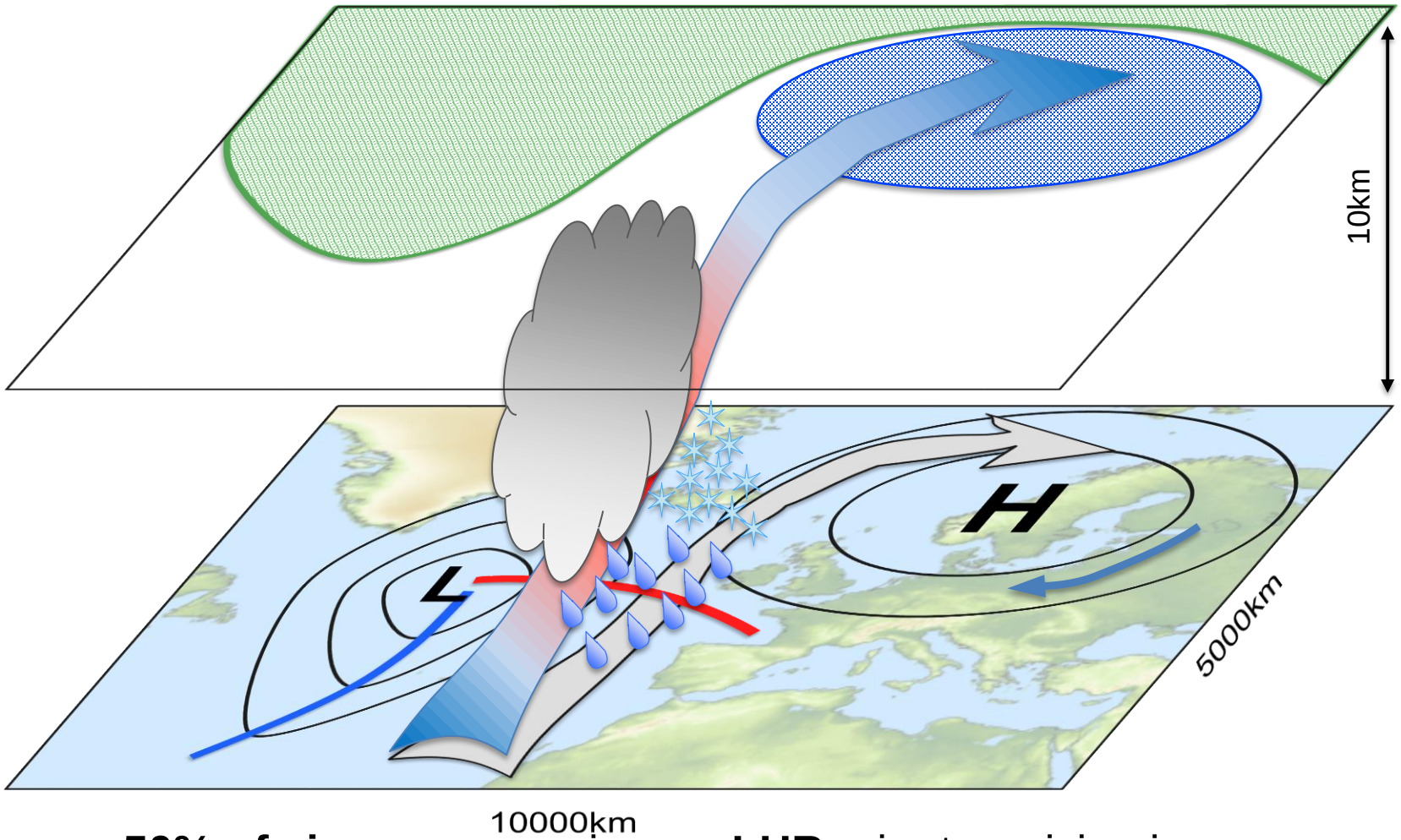
- rapidly ascending air flow (>600hPa/48h) tied to extratropical lows
- Latent heat release due to condensation (about 20K/48h)





pressure height [hPa]

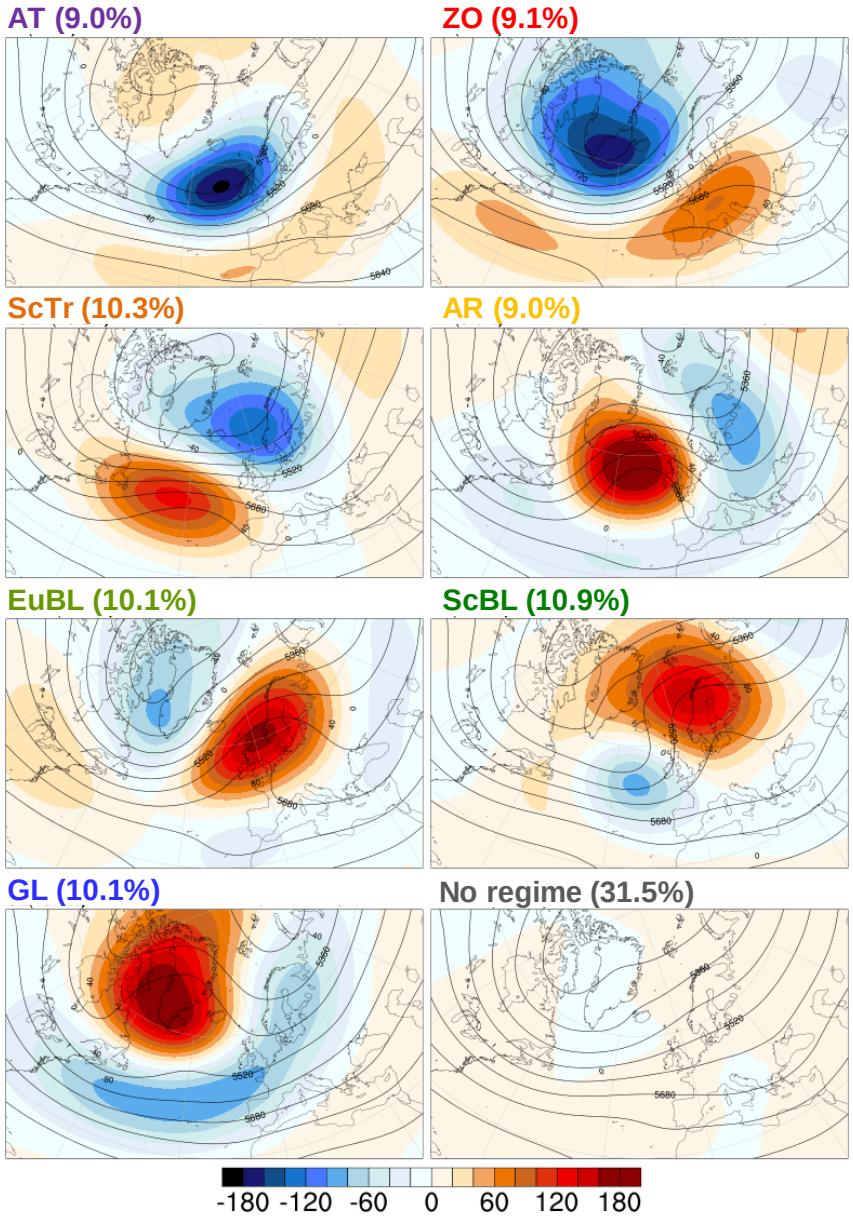
cloud-diabatic processes and blocking



- >**50% of air mass** experiences **LHR** prior to arriving in **blocking anticyclones**

Pfahl et al (2015): *Nature Geosci*, doi:10.1038/ngeo2487.

Year-round weather regimes



- EOF analysis and k-means clustering of 5d low pass-filtered 500hPa geopotential height anomalies
- Normalization to account for seasonality
- **Cyclonic regimes**:
  - **Atlantic trough**
  - **Zonal Regime**
  - **Scandinavian trough**
- **Blocked regimes**:
  - **Atlantic ridge**
  - **European blocking**
  - **Scandinavian blocking**
  - **Greenland blocking**

Grams, C.M., et al. *(2017)*, doi:10.1038/nclimate3338.

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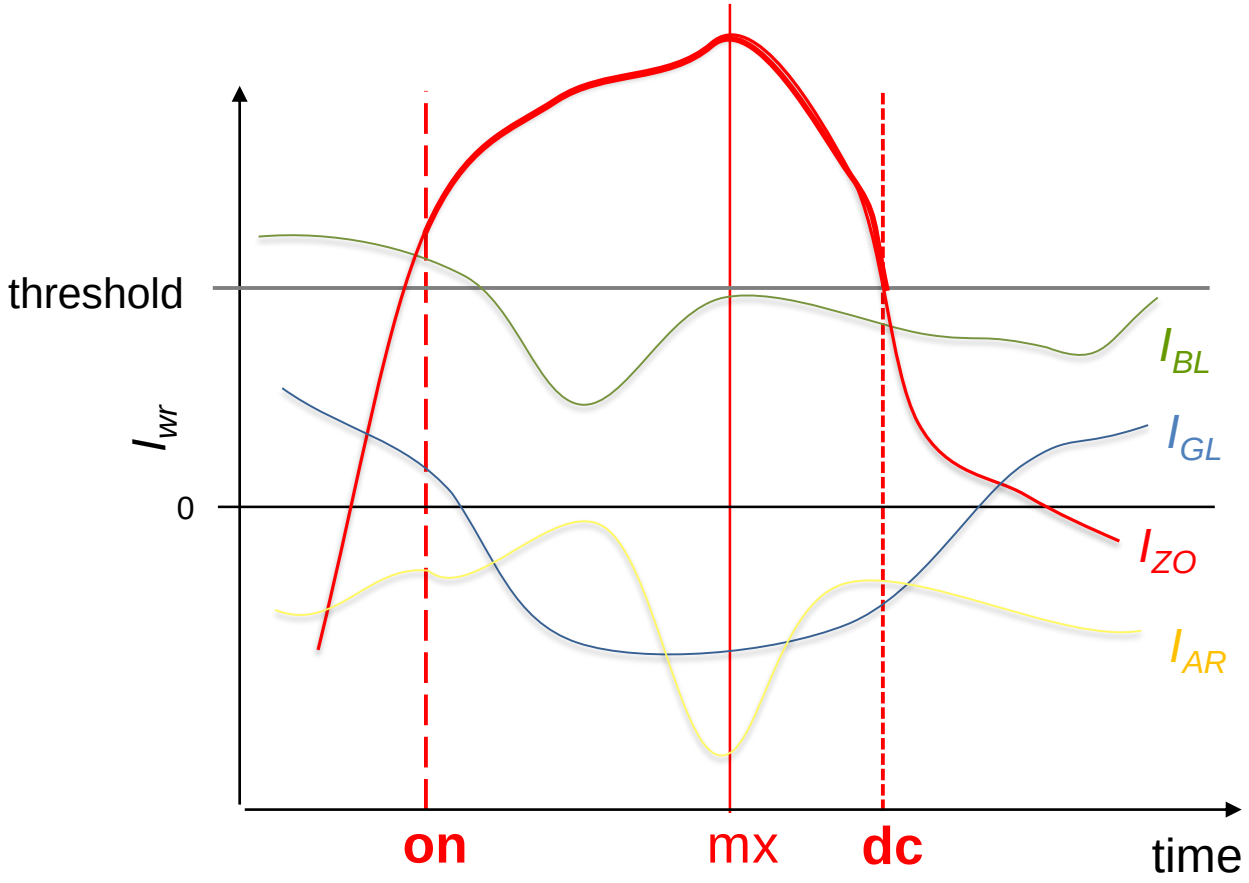
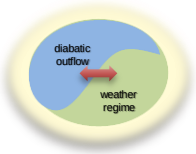
Weather regime life cycles

- Weather **regime Index** I_{wr} (Michel and Rivière, 2011, *JAS* , doi:10.1175/2011JAS3635.1)
- Definition of **onset,** maximum, decay for individual weather regime life cycles





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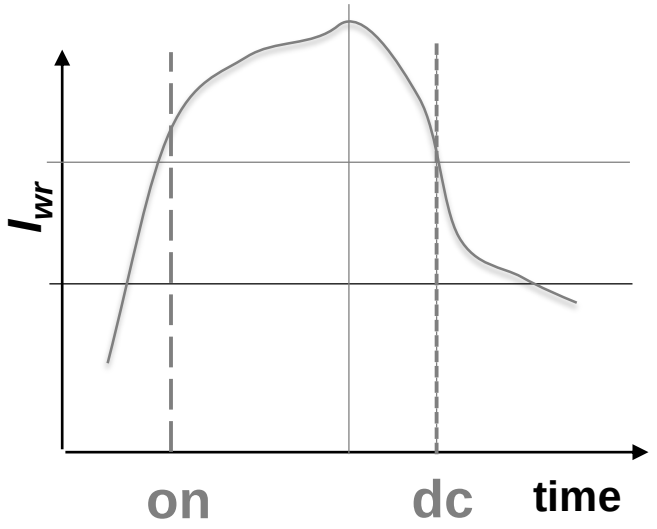
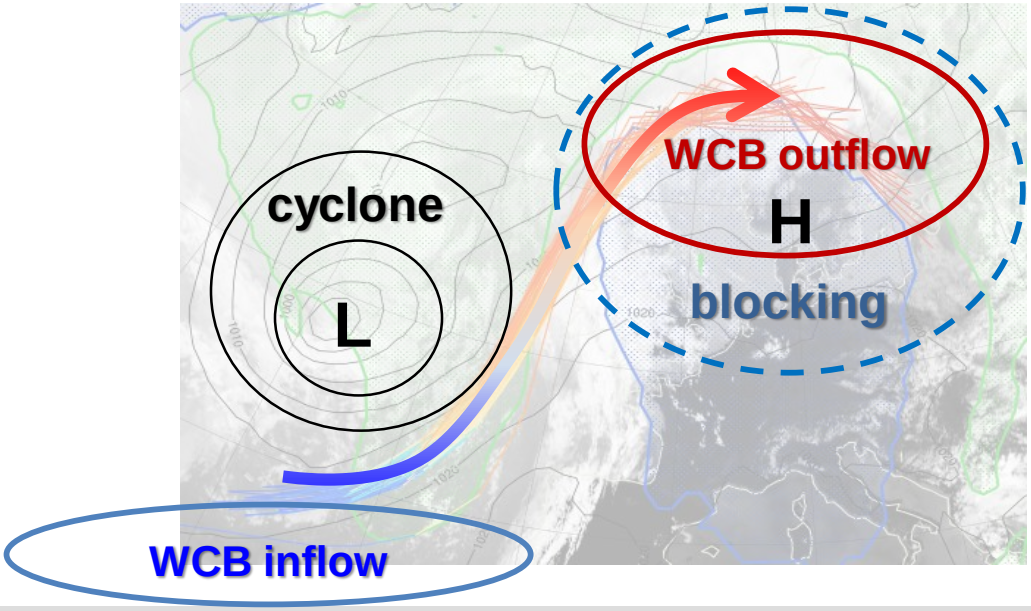
WCB activity during WR

→ cyclone, **WCB inflow & outflow,** and **blocking** frequency anomalies **during weather regime** life cycle

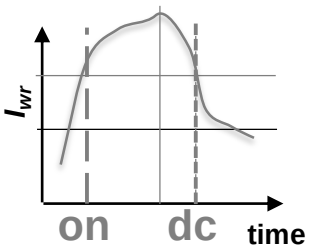
→ lagged composites in period **around onset**

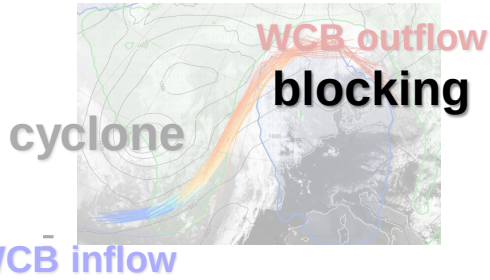




Blocking during WR

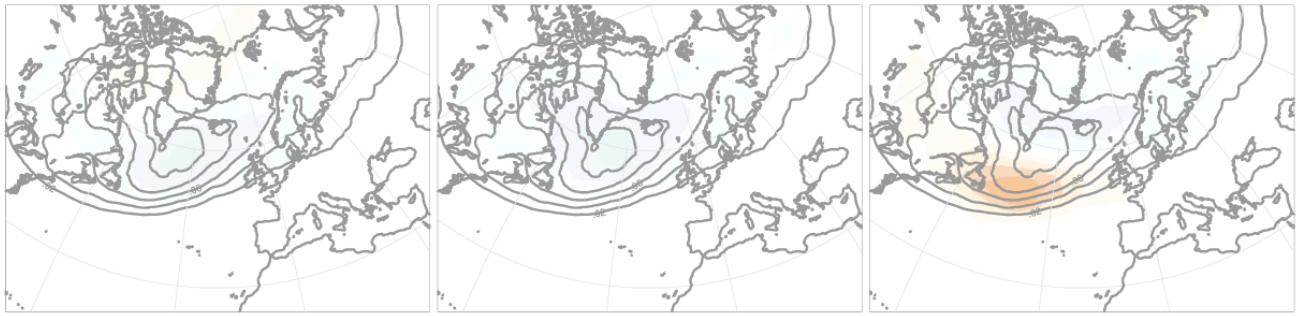
Blocking frequency anomaly during active weather regime life cycles
(Schwierz et al., 2004)





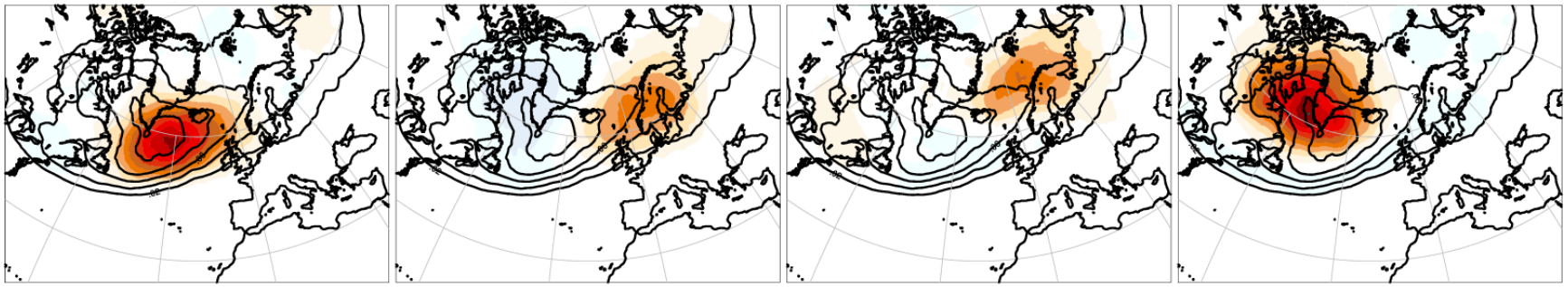
cyclonic

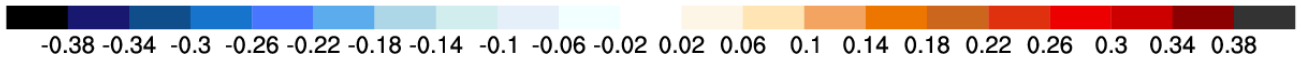
AT (13.1%) ZO (13.8%) ScTr (11.3%)



blocked

AR (9.7%) EuBL (10.9%) ScBL (6.5%) GL (11.7%)

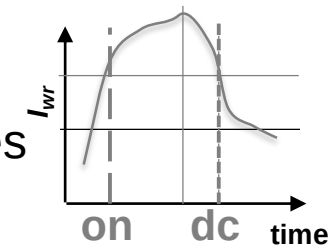


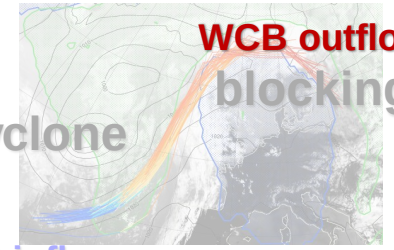


Black contours: DJF mean frequency (contours every 0.02).
Shading: anomaly during active weather regime life cycle (onset to decay).

WCB outflow during WR

WCB outflow frequency anomaly during active weather regime life cycles
(Madonna et al. 2014, Sprenger et al. 2017)



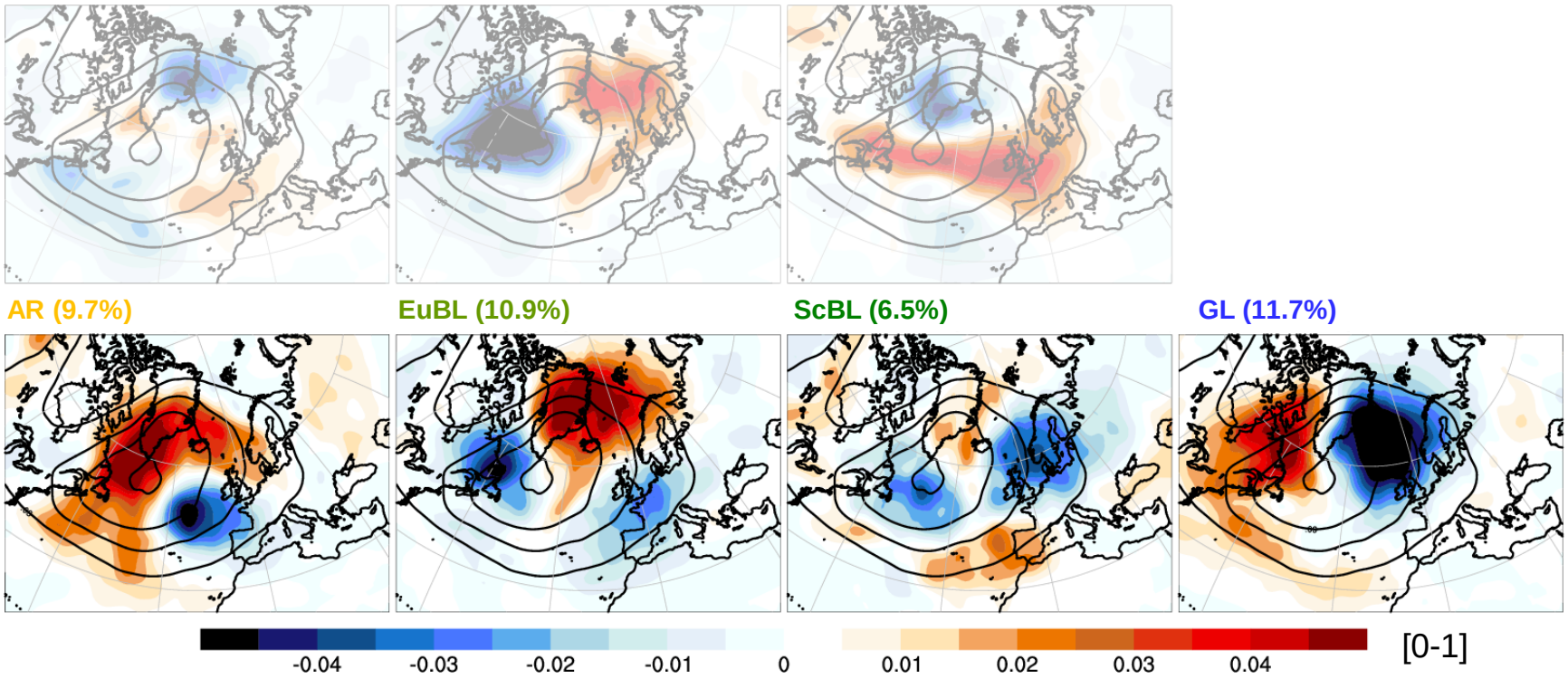


cyclonic

AT (13.1%) ZO (13.8%) ScTr (11.3%)

blocked

AR (9.7%) EuBL (10.9%) ScBL (6.5%) GL (11.7%)

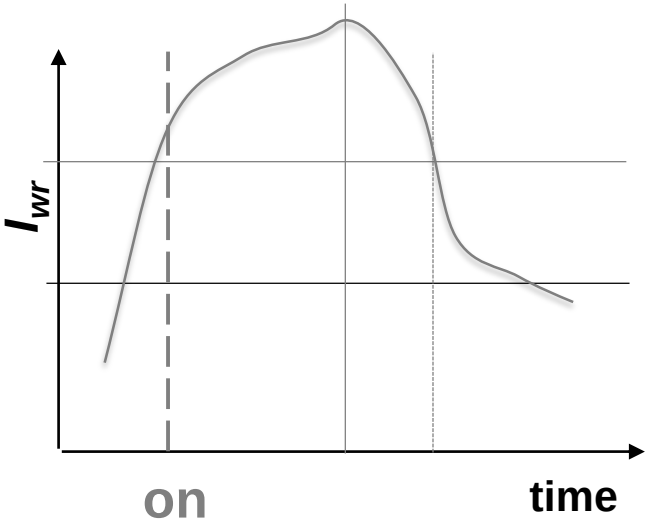


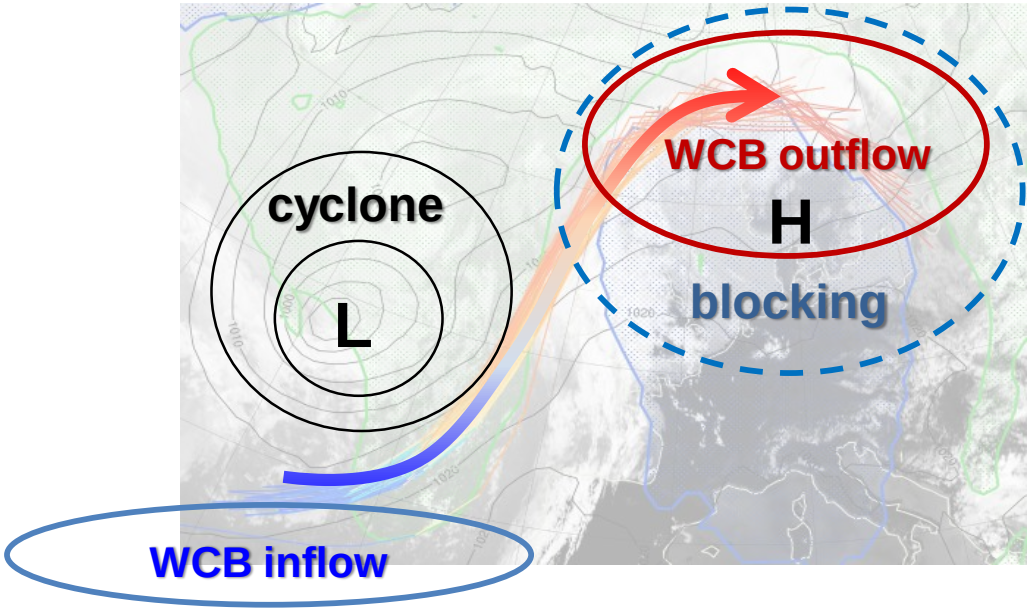
Black contours: DJF mean frequency (contours every 0.03).
Shading: anomaly during active weather regime life cycle (onset to decay).

Chicken and egg problem

Blocking ↔ WCB

→ Lagged composites in period **around onset**



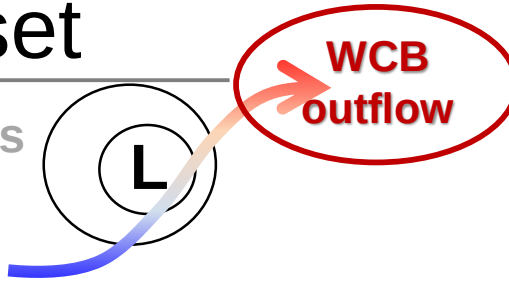


WCB outflow at EuBL onset

- lags wrt. **onset**

European blocking

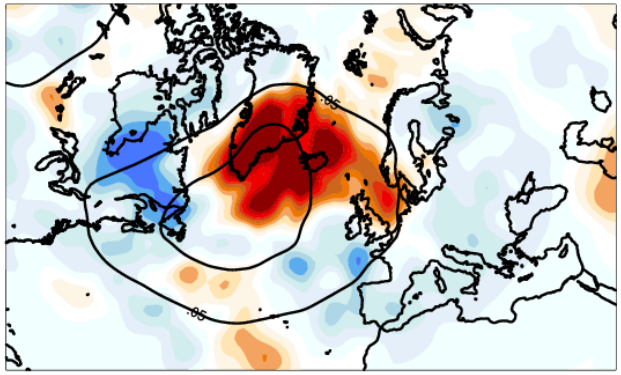
cyclones



-6d to -4d

-4d to -2d

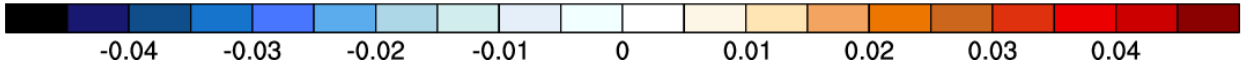
-2d to **onset**



onset to +2d

+2d to +4d

+4d to +6d



less frequent WCB outflow

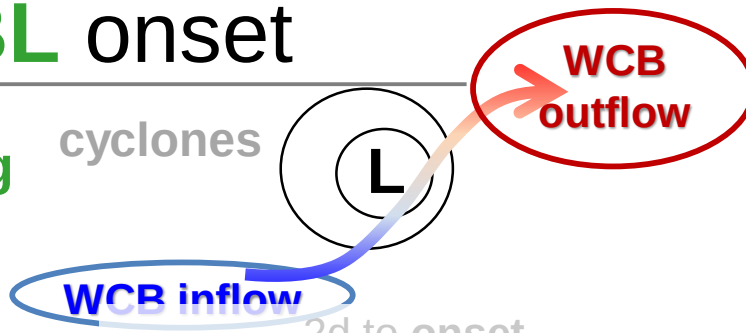
more frequent WCB outflow

WCB inflow at EuBL onset

- lags wrt. **onset**

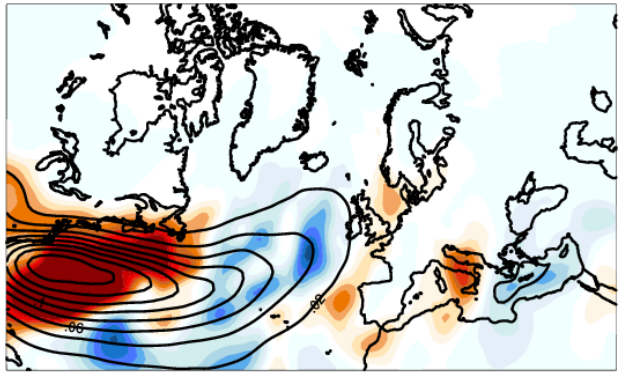
European blocking

cyclones



-6d to -4d

-4d to -2d

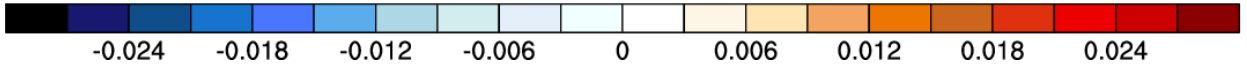


-2d to **onset**

onset to +2d

+2d to +4d

+4d to +6d

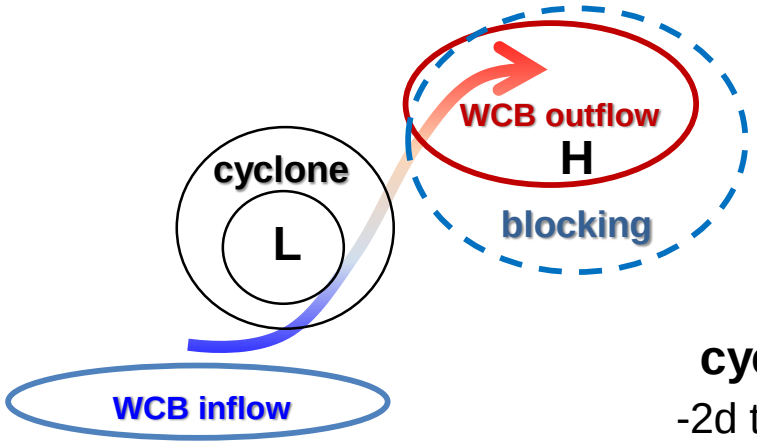


[0-1]

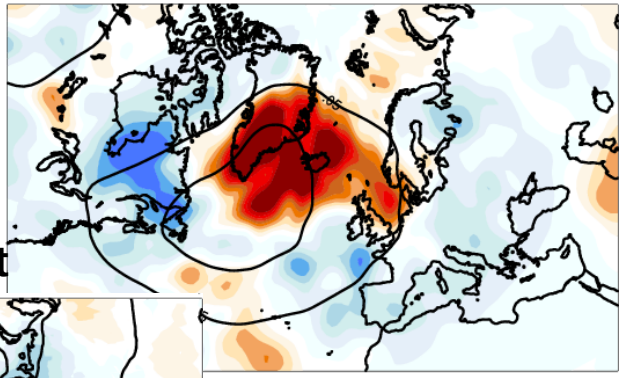
less frequent WCB inflow

more frequent WCB inflow

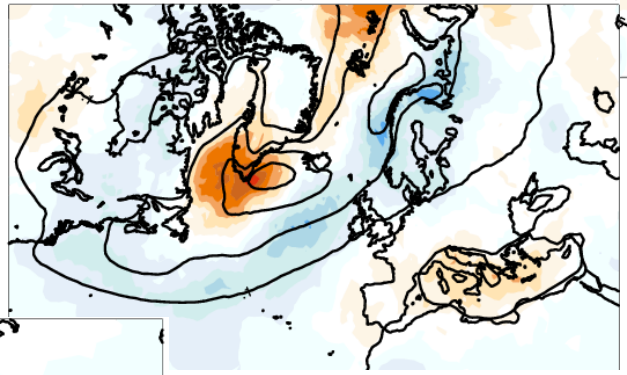
Summary EuBL onset



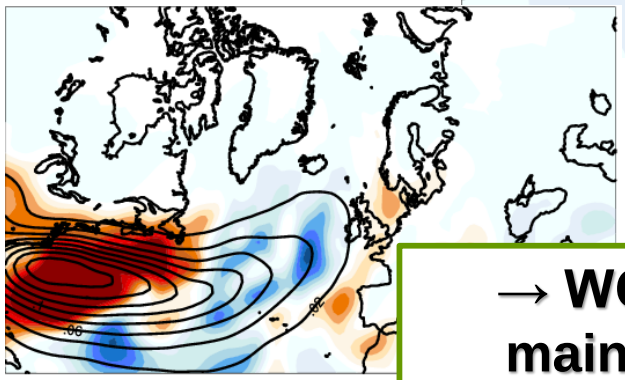
WCB outflow
-2d to **onset**



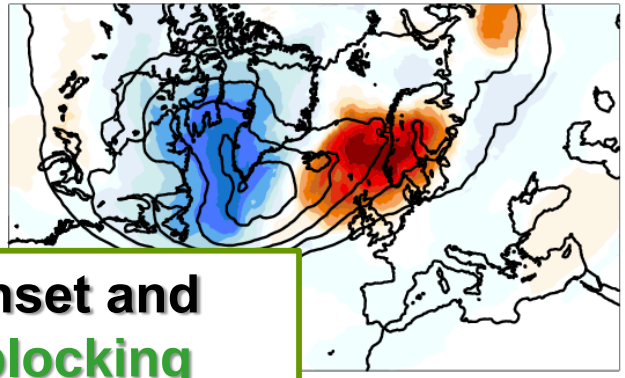
cyclones
-2d to **onset**



WCB inflow
-4d to -2d



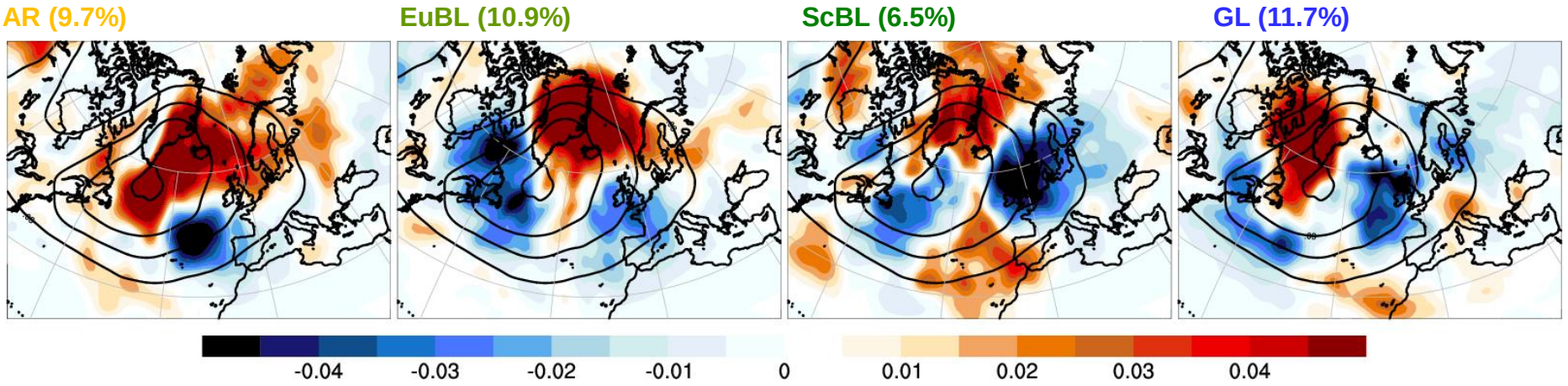
blocking
onset to +2d



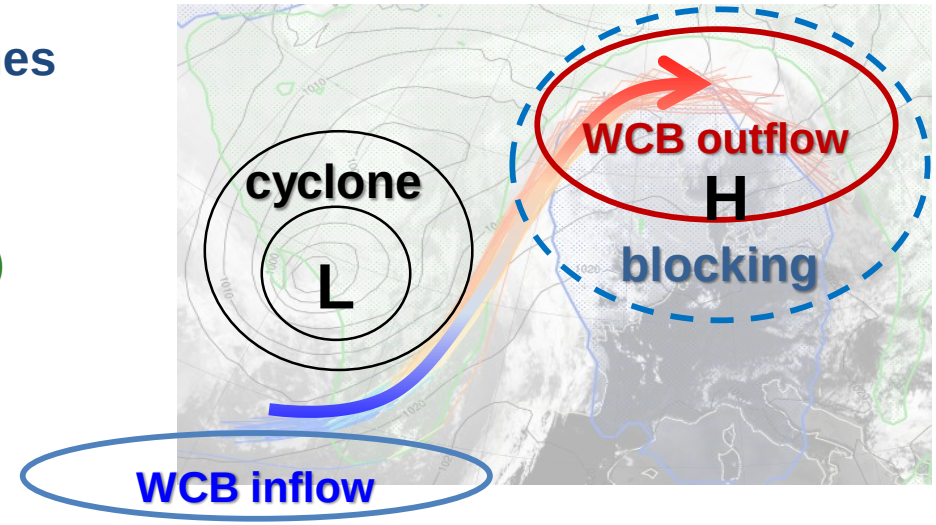
→ **WCB activity supports onset and maintenance of European blocking**

Other blocked regimes

WCB outflow variability at onset of **blocked regimes** **onset to +2d**



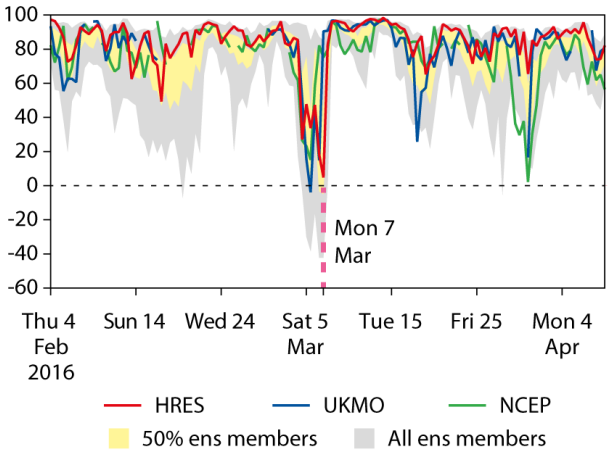
- WCB activity during **onset** and **maintenance** of **blocked regimes**
  - **Atlantic ridge (AR)**
  - **European blocking (EuBL)**
  - **Scandinavian blocking (ScBL)**
  - **Greenland blocking (GL)**
- Consistent with Pfahl et al. (2015), *Nature Geosci*, doi:10.1038/ngeo2487



Grams (2018), *in preparation*

A recent forecast bust

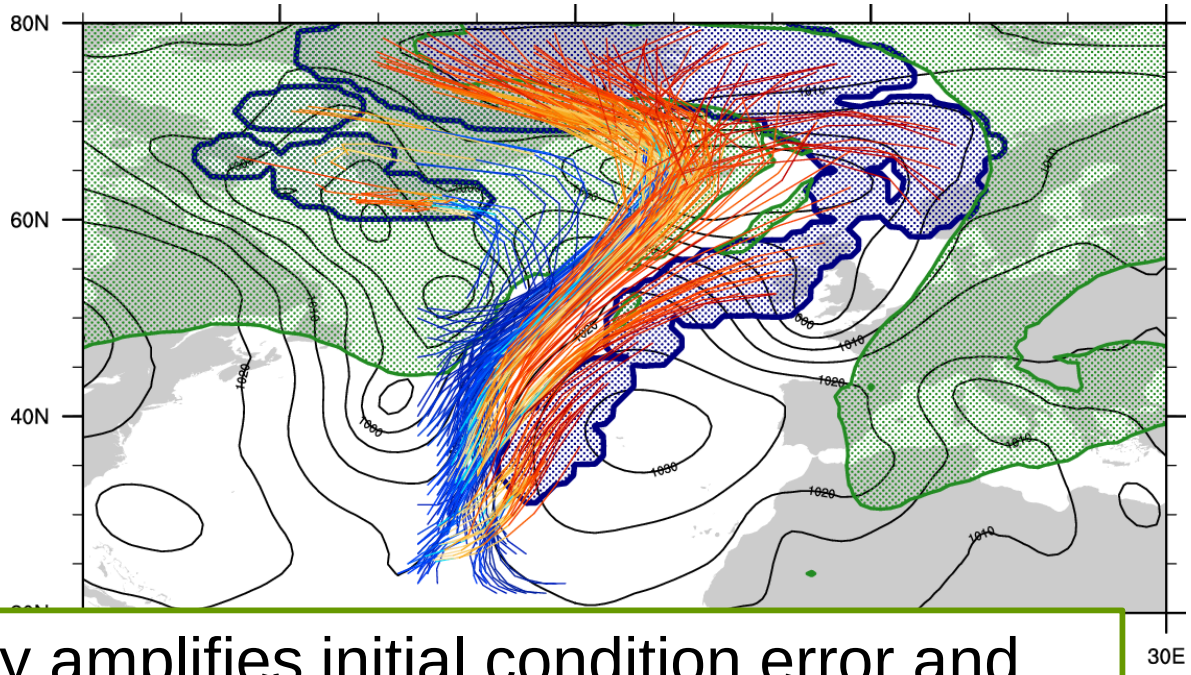
Warm conveyor belt activity during **EuBL** onset



ECMWF analysis

tra starting & pmsl 20160309_00

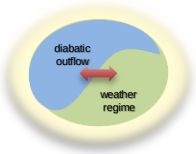
tra ending & 2PVU@315K 20160311_00



→ WCB activity amplifies initial condition error and projects it on the large-scale extratropical circulation

Magnusson (2017), *QJRMS*, doi:10.1002/qj.3072

Grams, Magnusson, and Madonna (2018), *QJRMS*, doi:10.1002/qj.3353



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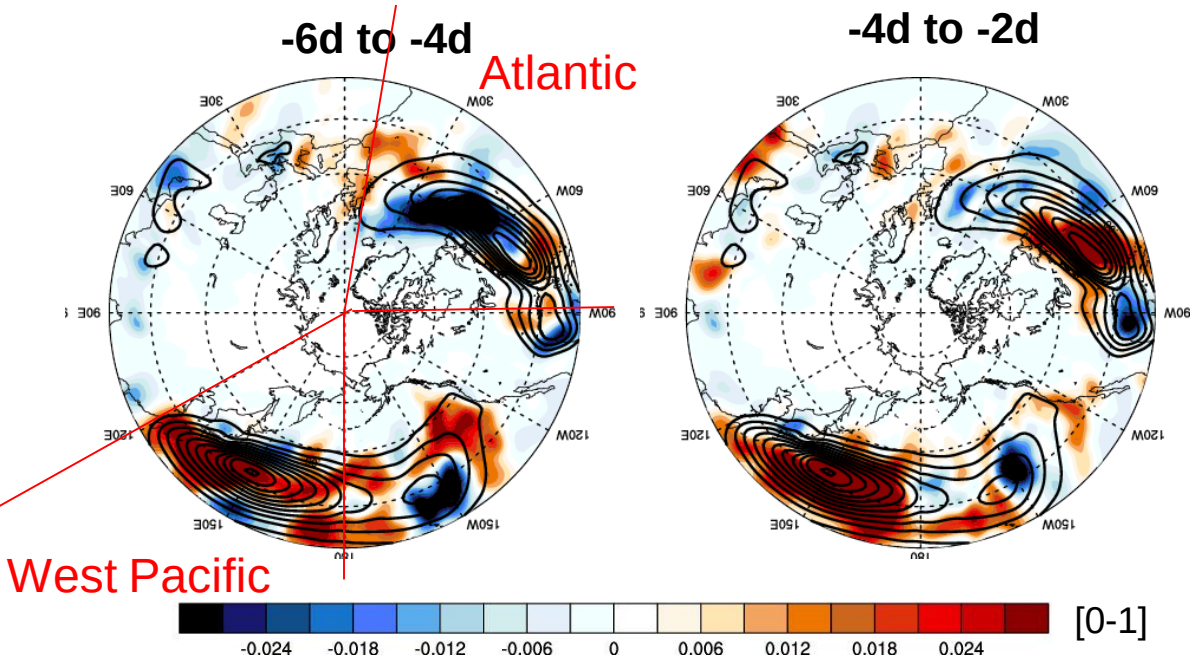
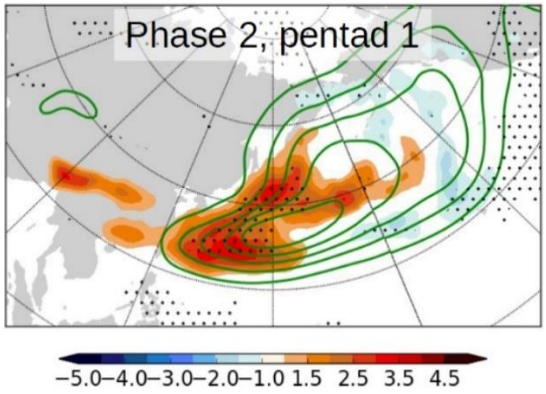
MJO-WCB influence on EuBL?

WCB inflow anomly prior to **onset**



Cassou (2008): European blocking more likely following **MJO Phase 2/3**

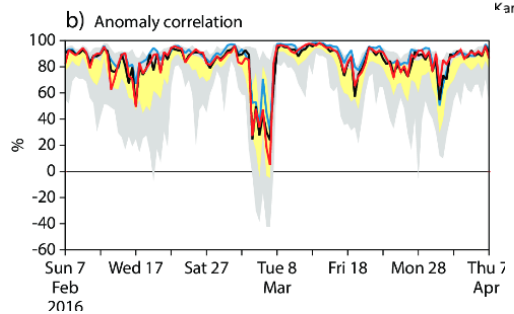
Total WCB anomly
5-10days after MJO Ph2



West Pacific

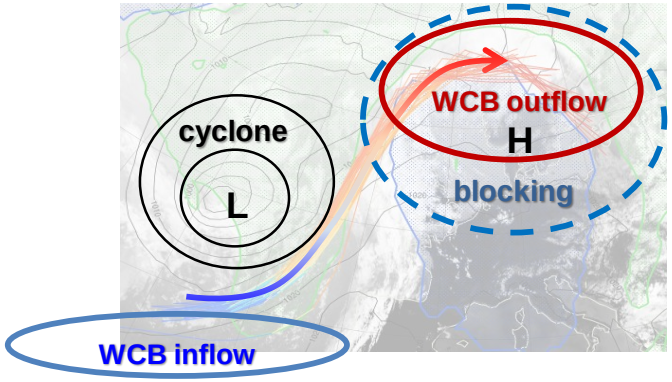
Mon Poster A1-22 by Julian Quinting
"WCB & MJO teleconnections"

Outlook



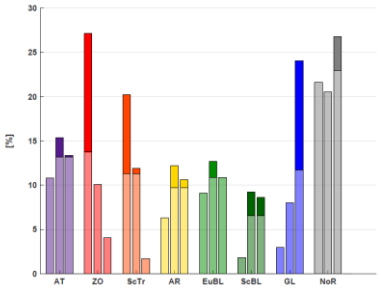
Summary

- Correct depiction of weather regime life cycle challenge for NWP
- Diabatic WCB outflow supports blocked regime onset



Outlook

- weather regimes and diabatic outflow in S2S models
- Impact of stratosphere and other climate modes
- Modulation of surface weather and renewable energies



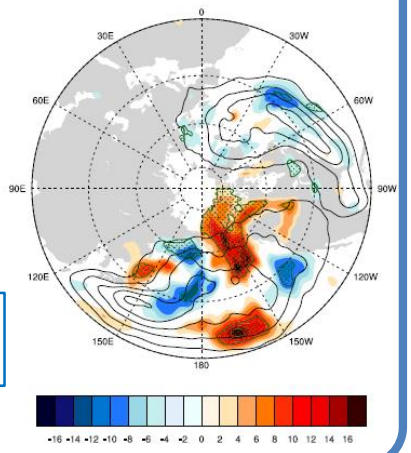
Wed. Talk A4-05 Beerli & Büeler
Poster A4-03 Grams et al.

Extra slides

Stratospheric impact & Applications

WCB activity prior to SSW 2009

- Consistent with MJO 7/8 during LaNina

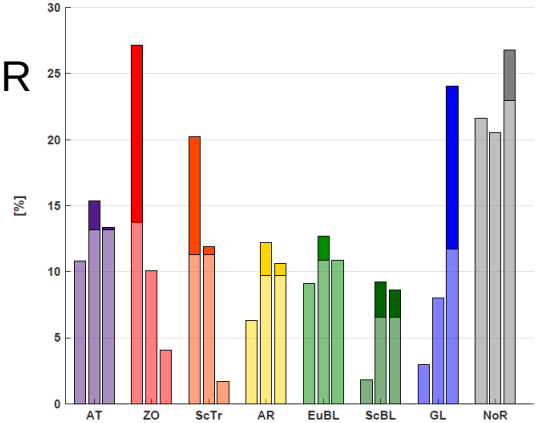


Schneidereit et al. (2017) doi:10.1175/MWR-D-16-0242.1

Stratospheric modulation of WR frequency

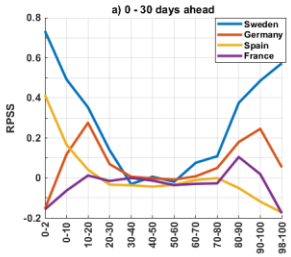
- NAO-related WR affected
- Others robust

PhD Remo Beerli (2017) ETH Zurich, Beerli et al. *in preparation*

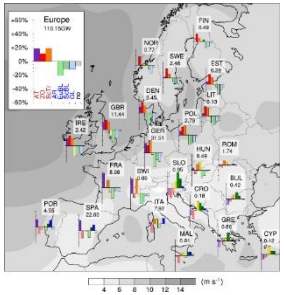


NAO: +0.40 **+0.99** **+0.88** -0.22 +0.26 -0.18 **-0.84**

Modulation of European wind power



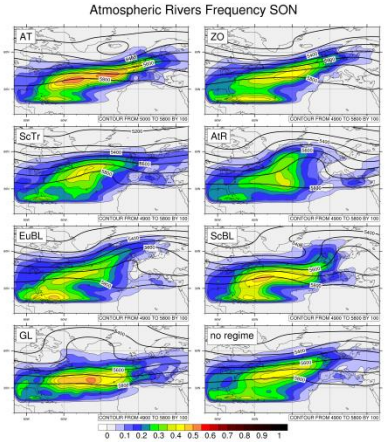
Stratospheric state and WR affect wind power output

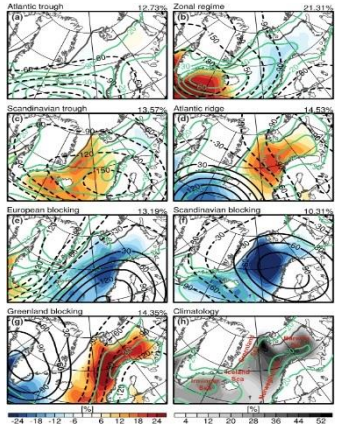


Wed. Talk A4-05 Beerli & Büeler
Poster A4-03 Grams et al.

Beerli et al. (2017) doi:10.1002/qj.3158
Grams et al. (2017) doi:10.1038/nclimate3338

Modulation of Atm. Riv. / Cold Air Outb.





Pasquier et al. (2018) *in revision for GRL*
Papritz and Grams (2018). doi:10.1002/2017GL076921