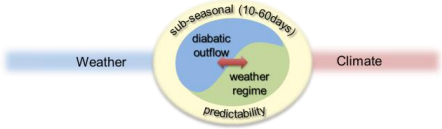
Karlsruhe Institute of Technology

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

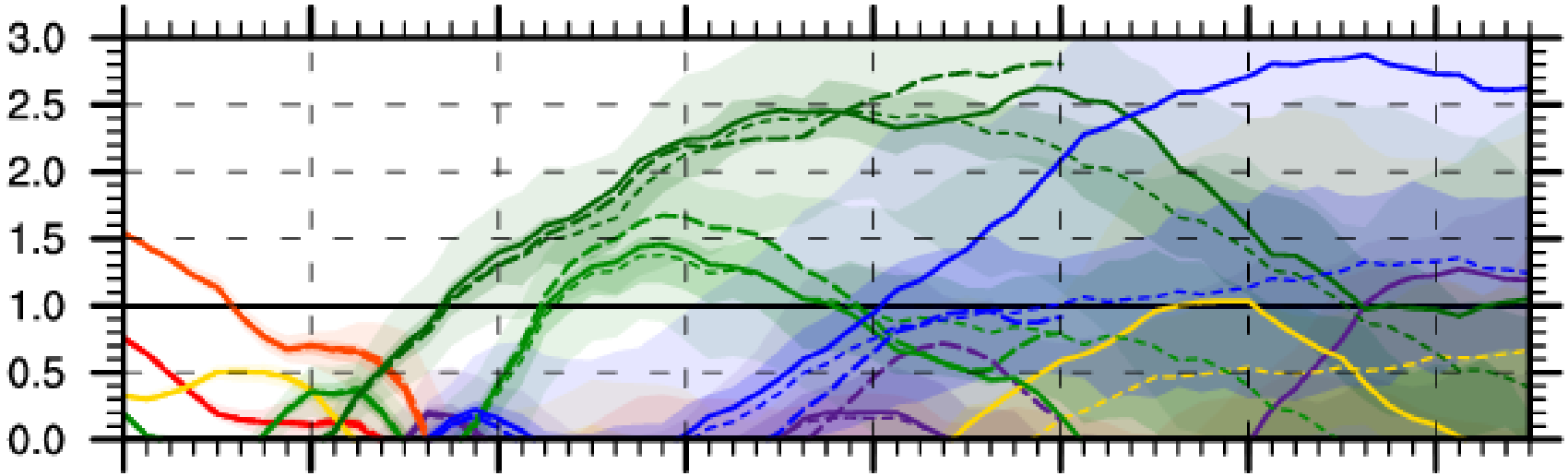


HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

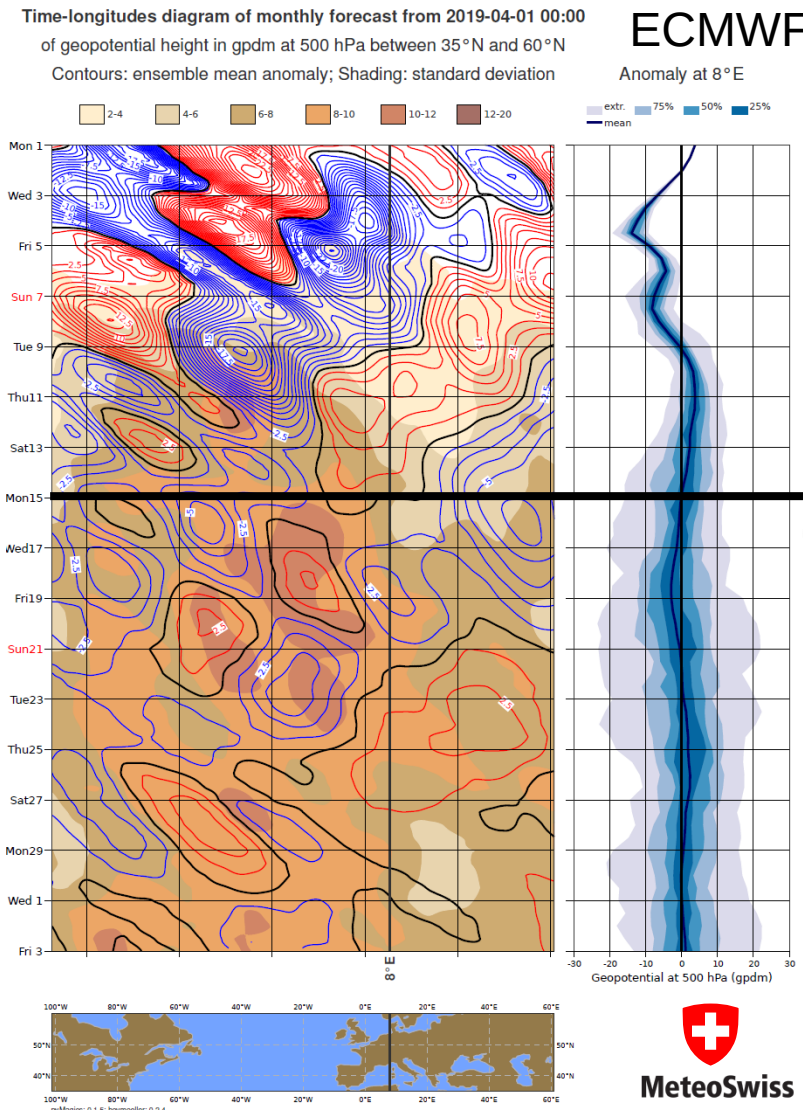
Forecast products for predicting Atlantic-European weather regimes on subseasonal time scales

Christian M. Grams and Jan Wandel
Large-scale Dynamics and Predictability Group

Institute of Meteorology and Climate Research – Department Troposphere Research



Extended-range prediction for the midlatitudes



ECMWF BT 20190401

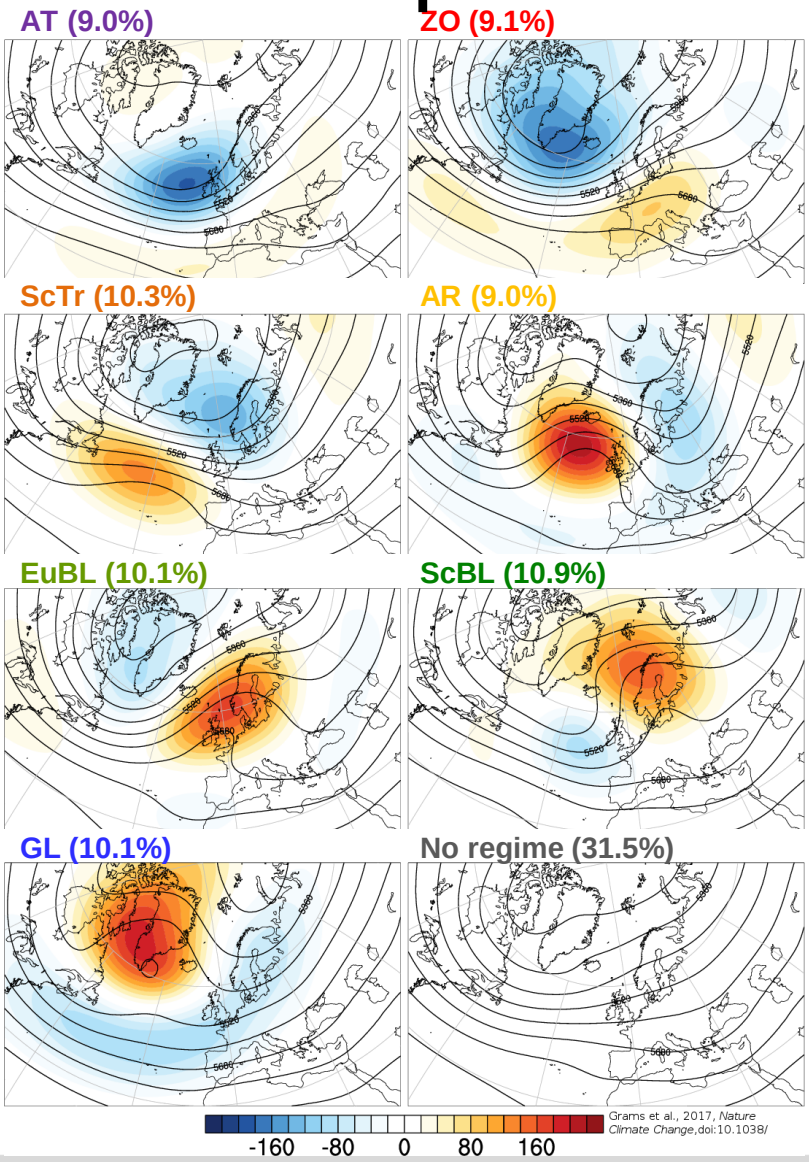
- ensemble mean relaxes towards climatology in week 2
- standard deviation increases

16 April
(+15 days)

MeteoSwiss

provided by Philipp Meier (MeteoCH)

Atlantic-European weather regimes



- quasi-stationary, persistent, and recurrent large-scale flow patterns
- describe variability on sub-seasonal time scales
- here year-round 7 regimes including a life-cycle definition

Cyclonic regimes:

- **Atlantic trough**
- **Zonal Regime**
- **Scandinavian trough**

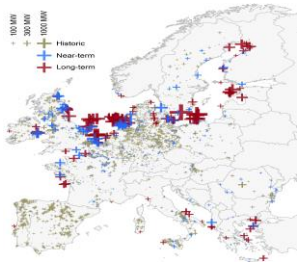
Blocked regimes:

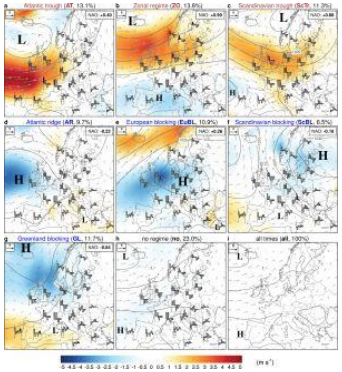
- **Atlantic ridge**
- **European blocking**
- **Scandinavian blocking**
- **Greenland blocking**

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

Why are regimes relevant?

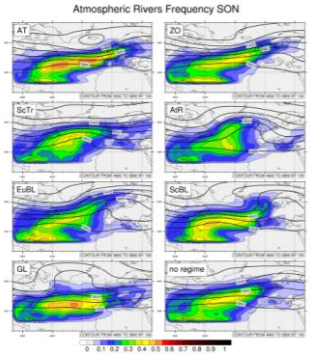
Wind power variability

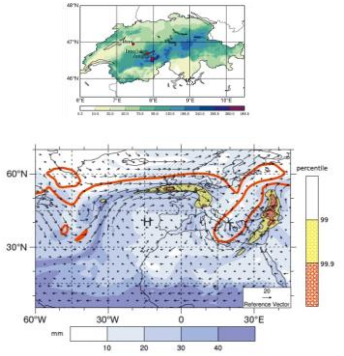




Beerli et al. (2017) 10.1002/qj.3158
Grams et al. (2017) 10.1038/nclimate3338

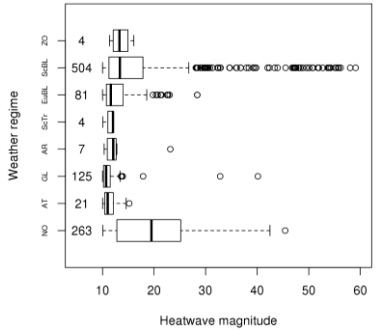
Modulation of heavy precipitation

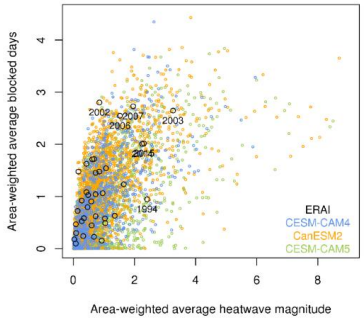




Piaget et al. (2015) 10.1002/qj.2496
Pasquier et al. (2019) 10.1029/2018GL081194

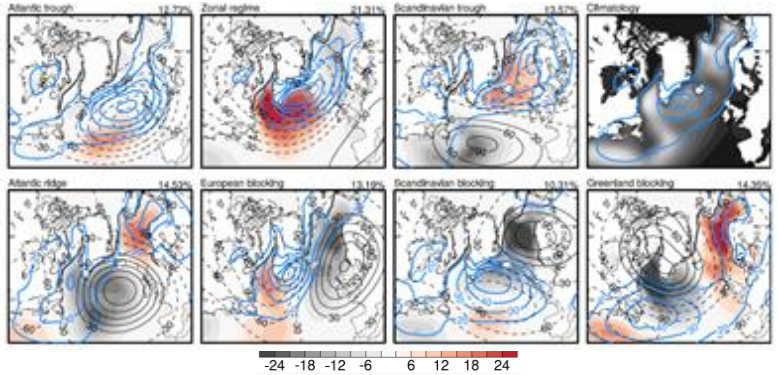
Heat waves





Quinting and Reeder (2017) 10.1175/MWR-D-17-0165.1
Schaller et al. (2018) 10.1088/1748-9326/aaba55

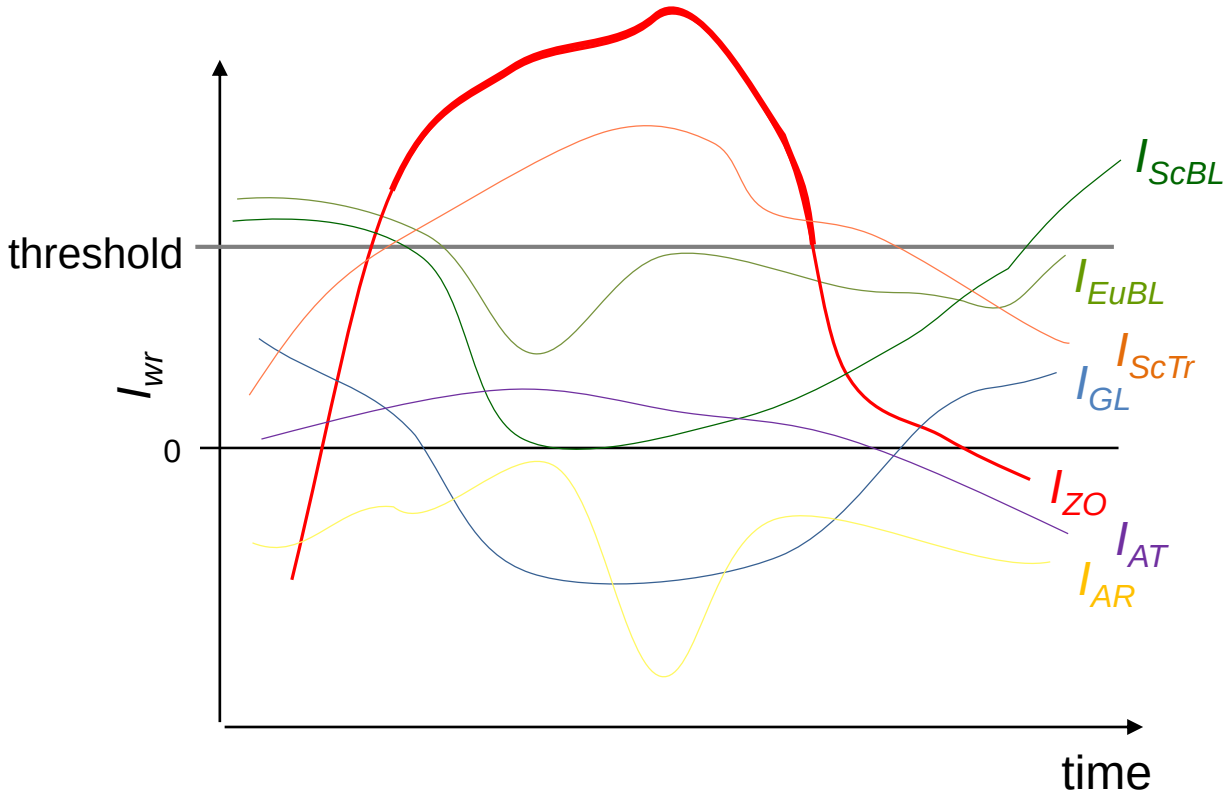
Cold air outbreaks



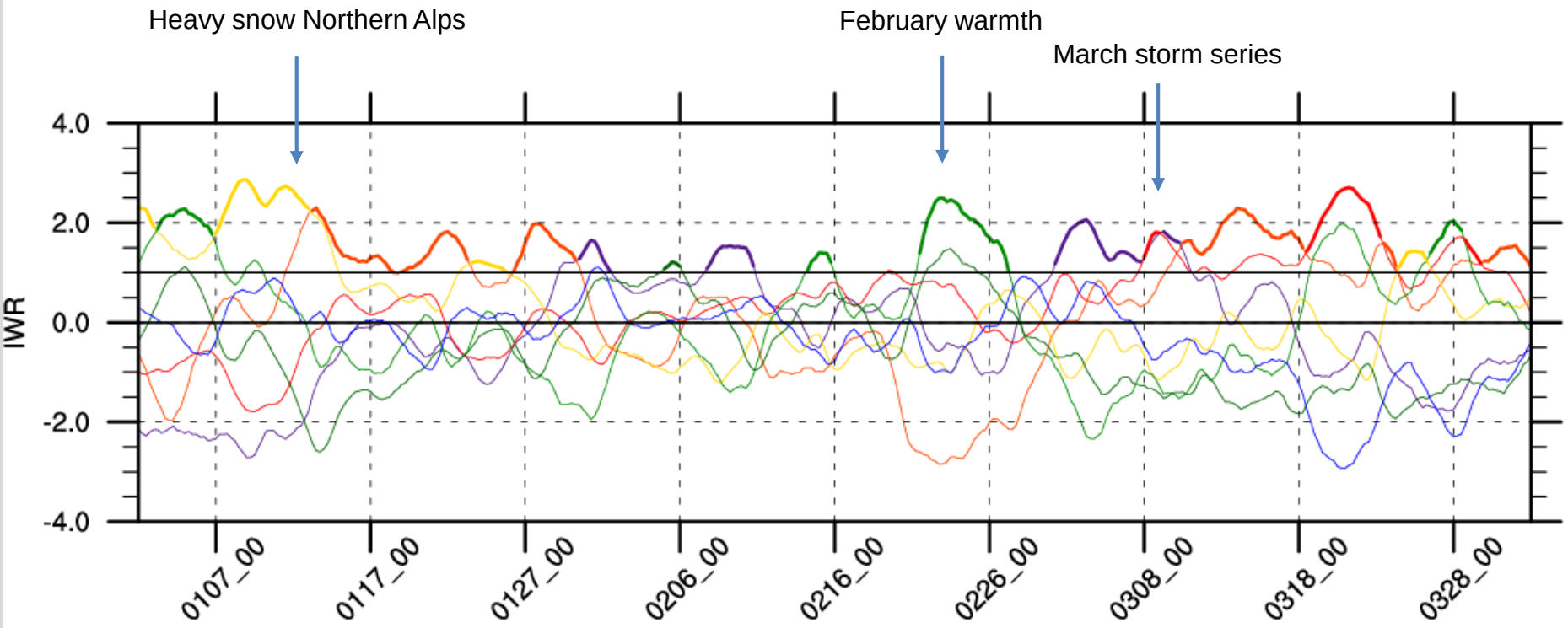
Papritz and Grams (2018) 10.1002/2017GL076921 plot by L. Papritz
Ferranti, Magnusson, Vitart, and Richardson (2018) 10.1002/qj.3341

Weather regime index and life cycles

- Weather regime Index I_{wr} following Michel and Rivière (2011), *JAS* , doi:10.1175/2011JAS3635.1

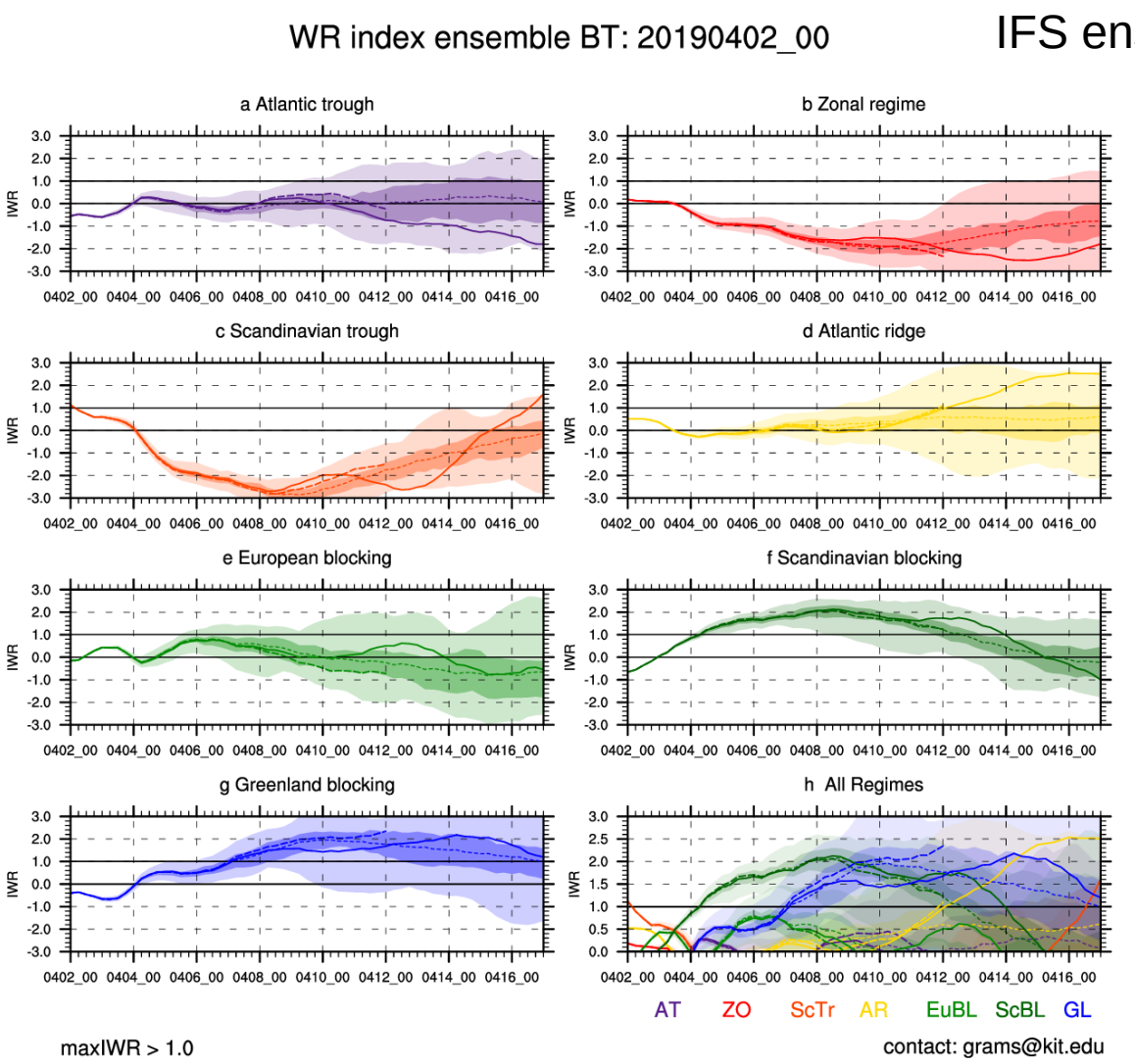


WR Projection during the last 90 days



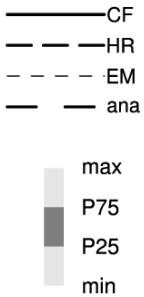
- **Cyclonic regimes**:
  - Atlantic trough (AT)
  - Zonal Regime (ZO)
  - Scandinavian trough (ScTr)
- **Blocked regimes**:
  - Atlantic ridge (AR)
  - European blocking (EuBL)
  - Scandinavian blocking (ScBL)
  - Greenland blocking (GL)

Detailed Regime Forecast



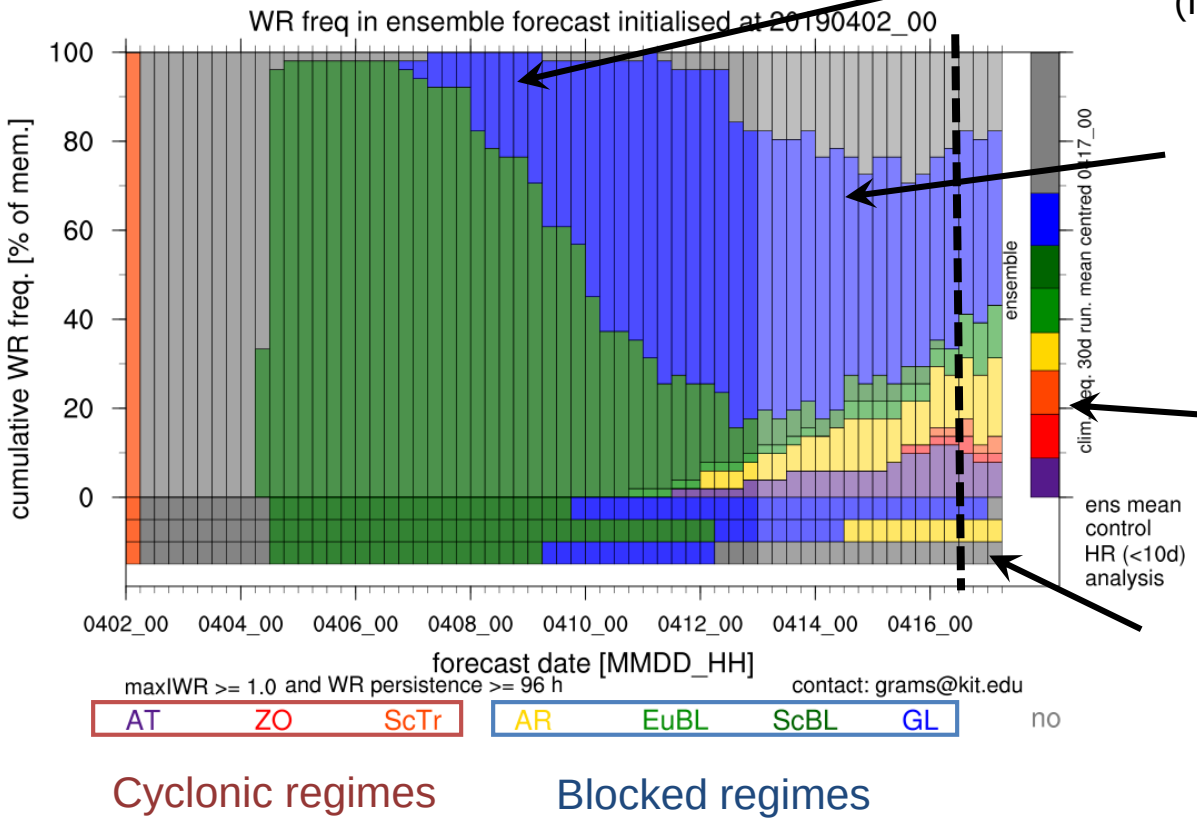
IFS ensemble **BT 20190402_00**

- evolution of IWR in each ensemble member, EM, CF, and HR
- active WRs have maximum IWR and IWR>1.0 for at least 4 days
- „all regime“ plot (h) allows direct comparison of IWRs



Overview regime forecast

IFS ensemble **BT 20190402_00**



0-264h: six-hourly probability in ensemble
(IWR>1.0, persistence of 4 days)

264-360h: six-hourly probability in ensemble
(IWR>1.0, lasting until 360h)

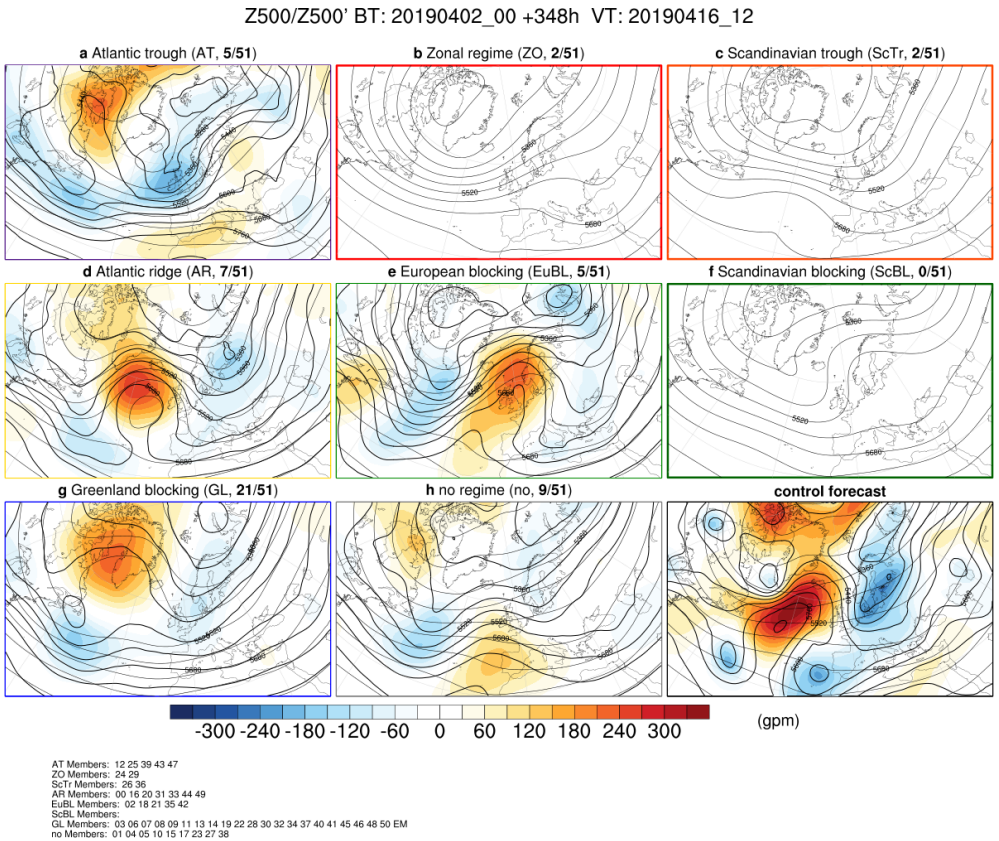
climatological frequency
(full life-cycle, ERA-I)

active WR in ensemble mean, control, and high resolution forecast

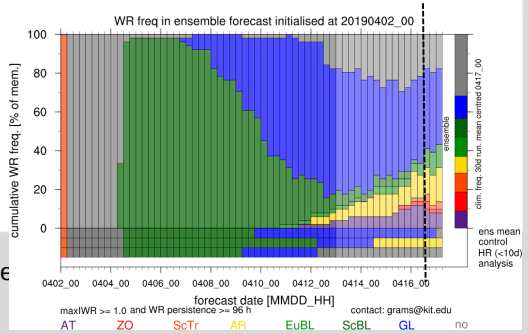
Grams, Magnusson, Madonna (2018), doi:10.1002/qj.3353

Scenario Maps

example: Z500', VT 20190416_12 **(+348h)** IFS ensemble **BT 20190402_00**



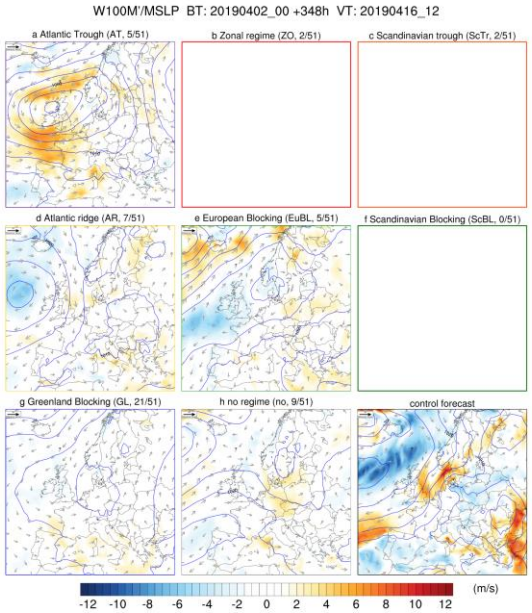
- mean of all members in respective regime (if at least 4 members)
- climatological Z500 (grey)
- highlights current „shape" of the respective regime

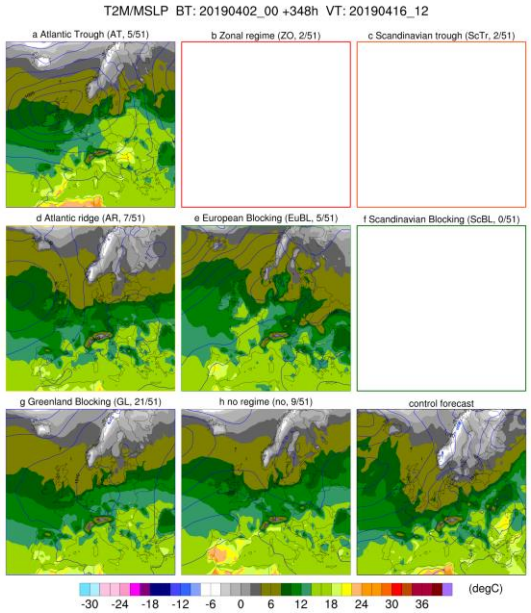


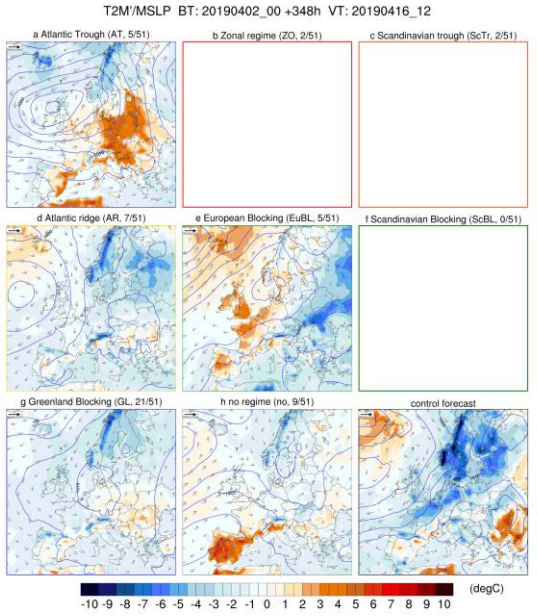
Surface weather

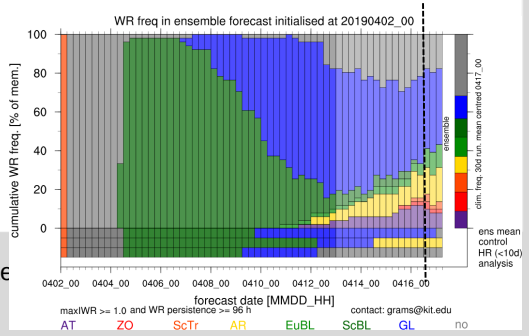
100m wind, 2m temperature, precipitation, cloud cover, mslp, full fields and anomalies

IFS ensemble **BT 20190402_00**
VT 20190416_12 **(+348h)**





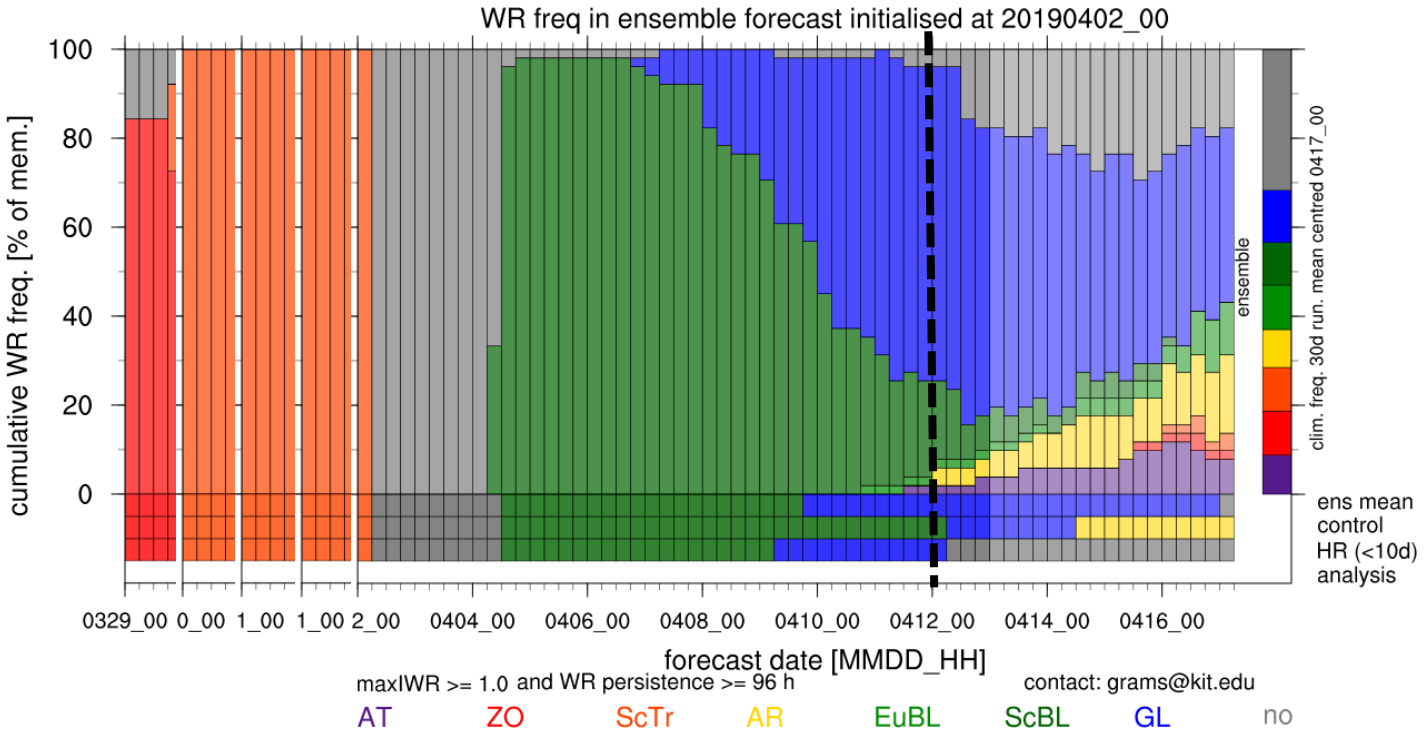




Medium-range regime forecast

IFS ensemble **different initial times**

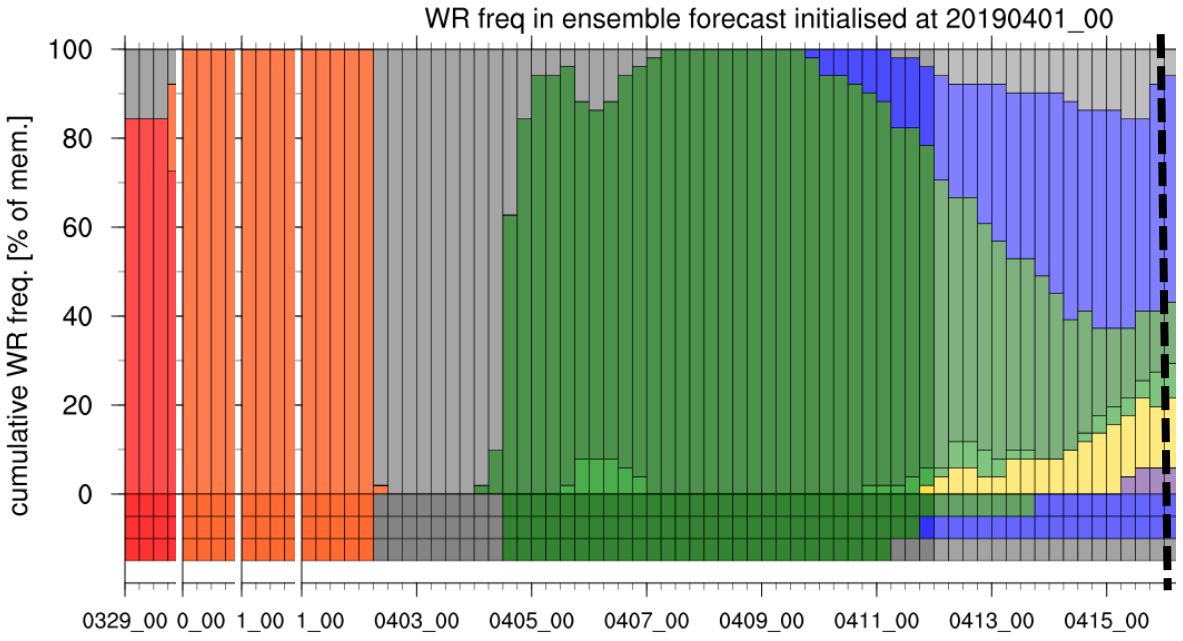
GL from 12 April?



Medium-range regime forecast

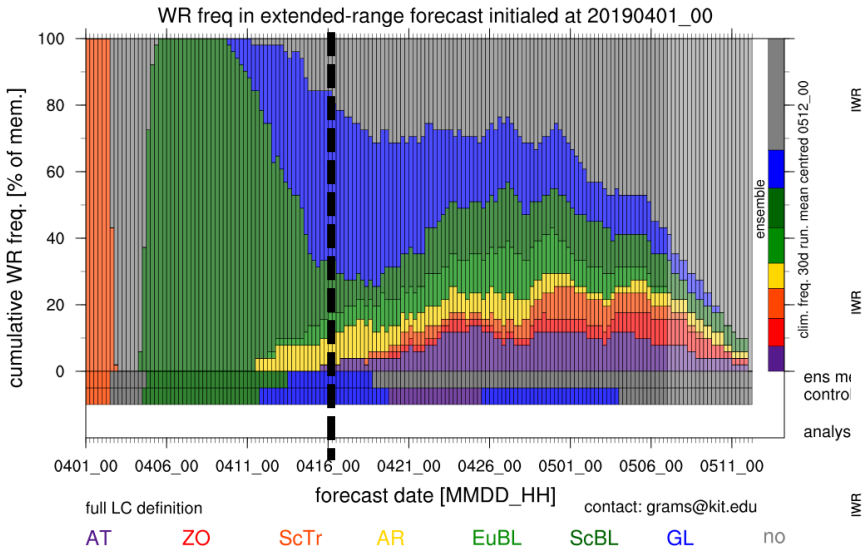
IFS medium-range ensemble **BT 20190401_00**

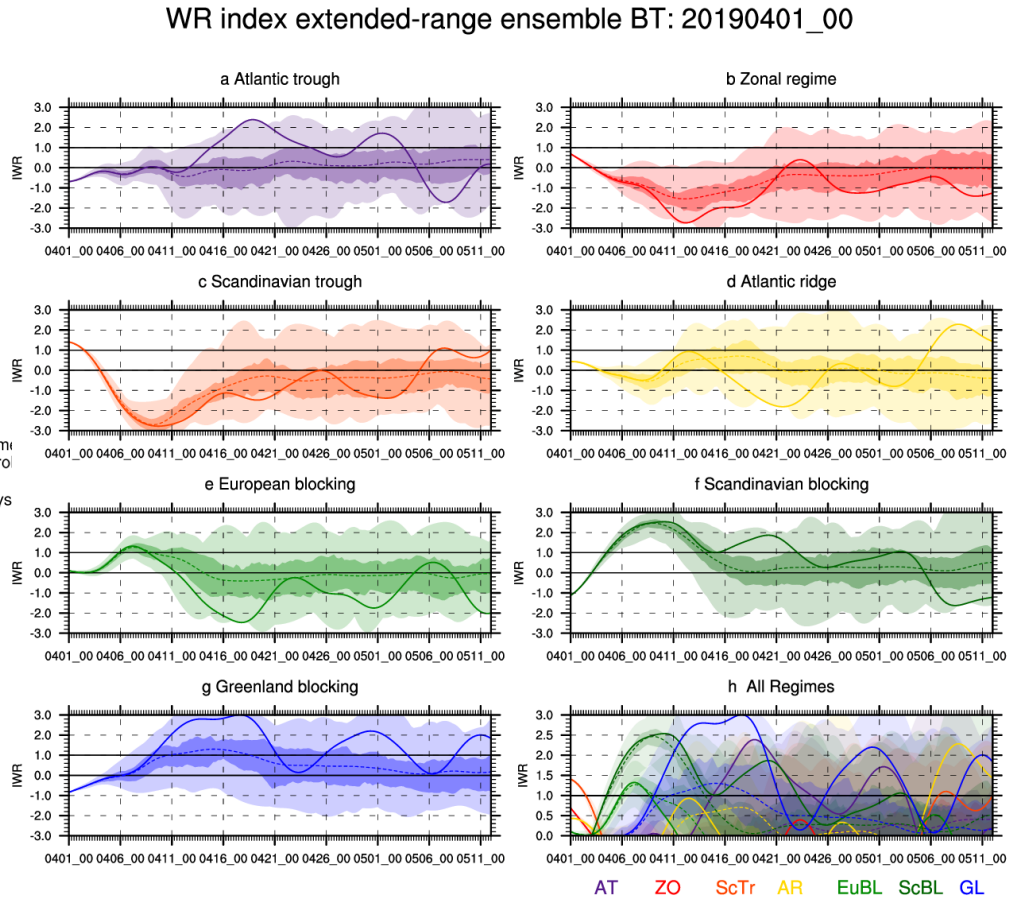
16 April



Extended-range weather regime products

IFS ensemble **BT 20190401_00**

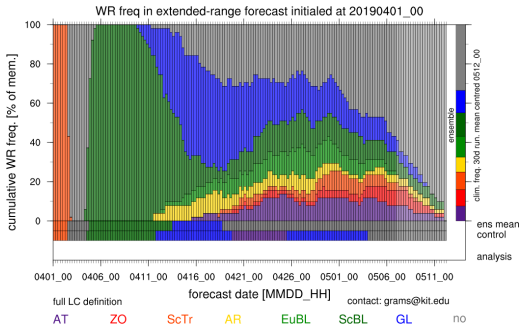


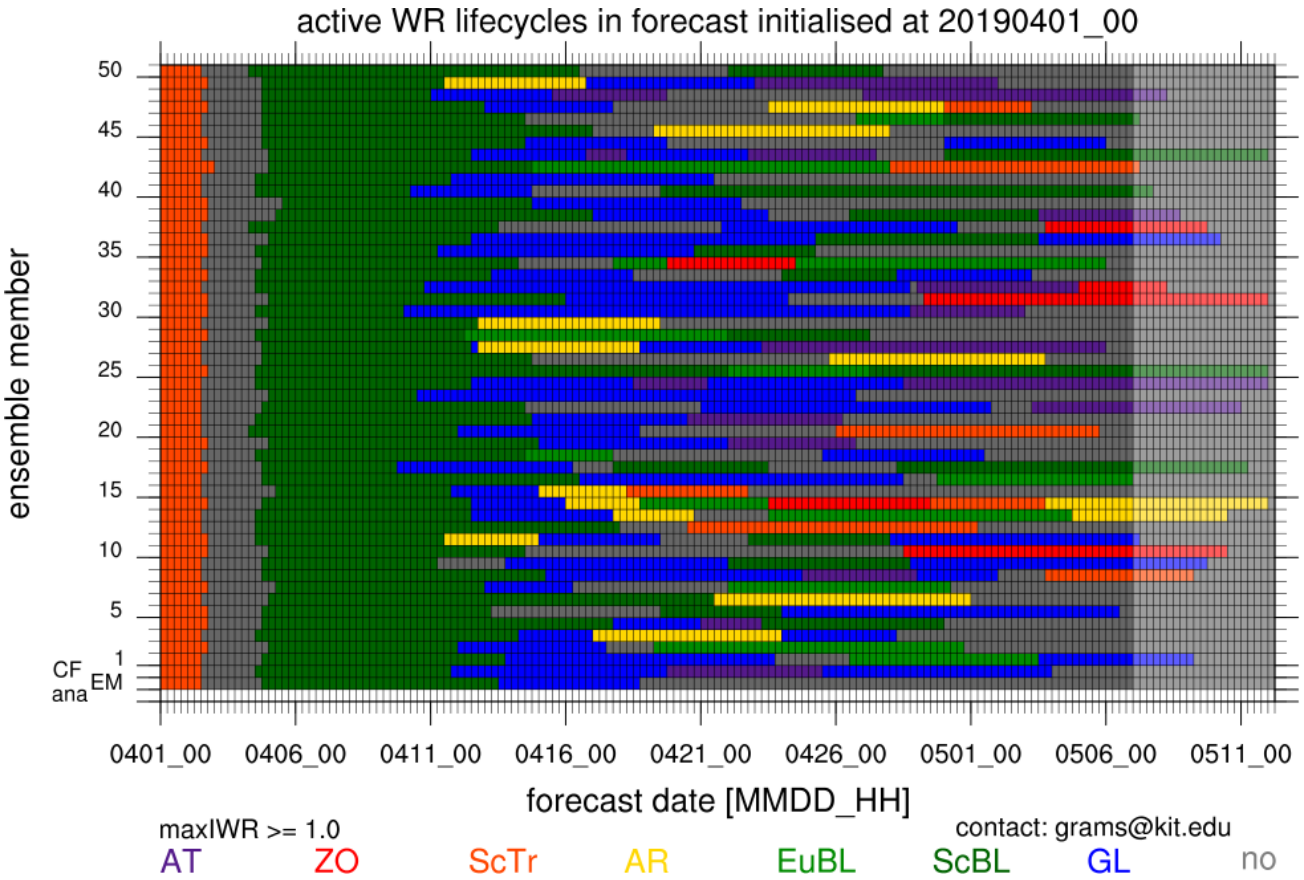


- as for medium-range but full regime life cycle definition
  - 5d low-pass filtered Z500‘
  - 5d persistence
  - …

extended range weather regime products

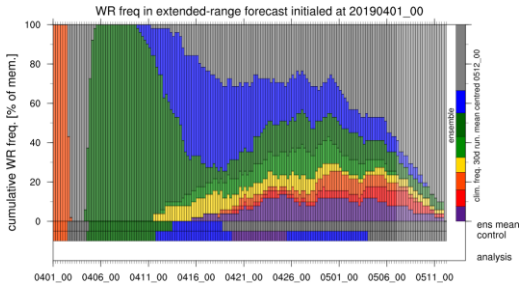
IFS ensemble **BT 20190401_00**





- maximum active WR life cycle in each member
- actual WR sequence

- Weather regimes …
  - describe large-scale flow variability,
  - characterize surface weather for several weeks

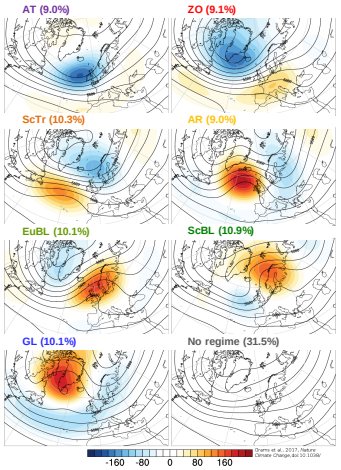


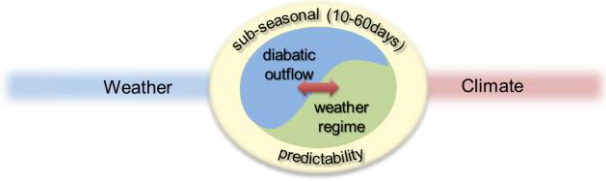
→ extended-range forecast opportunity

- Tailored regime forecast products help assessing large-scale flow evolution in medium-range (0-15d) and extended-range (15-45d)

- Correct prediction of WR life cycles key challenge in NWP
  - synoptic processes affect life cycles
  - modulation by climate modes on S2S time scales

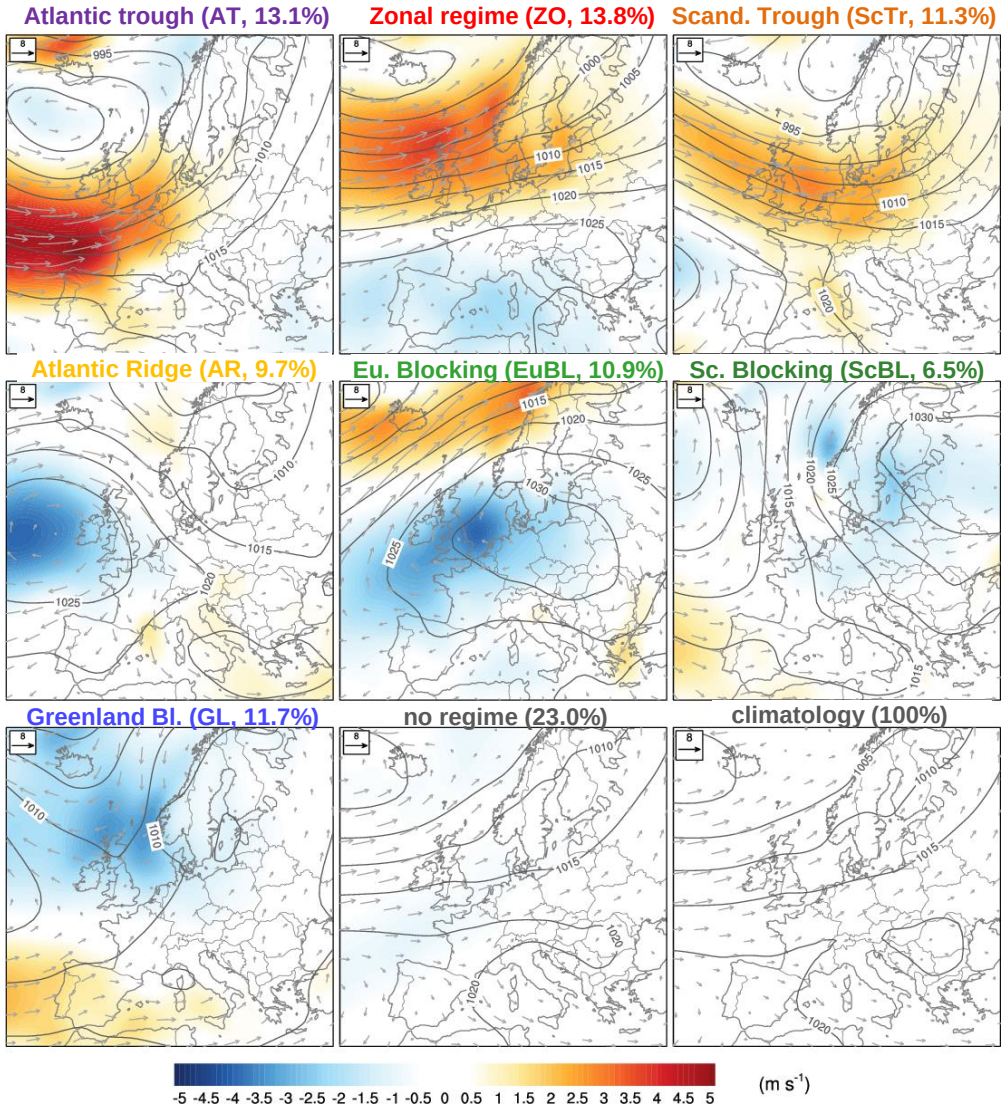
→ fundamental research needed





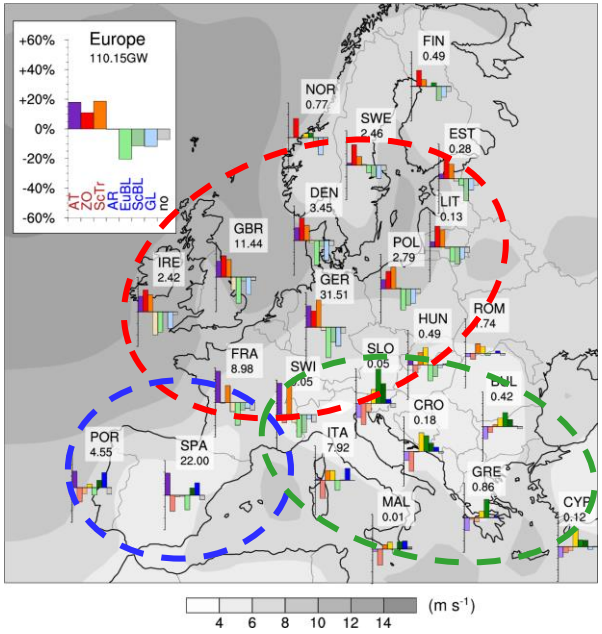
Young Investigator Group VH-NG-1243 ***SPREADOUT****: "****S****ub-seasonal* ***PRE****dict****A****bility: understanding the role of* ***D****iabatic* ***OUT****flow"*

Weather impact – 100m wind



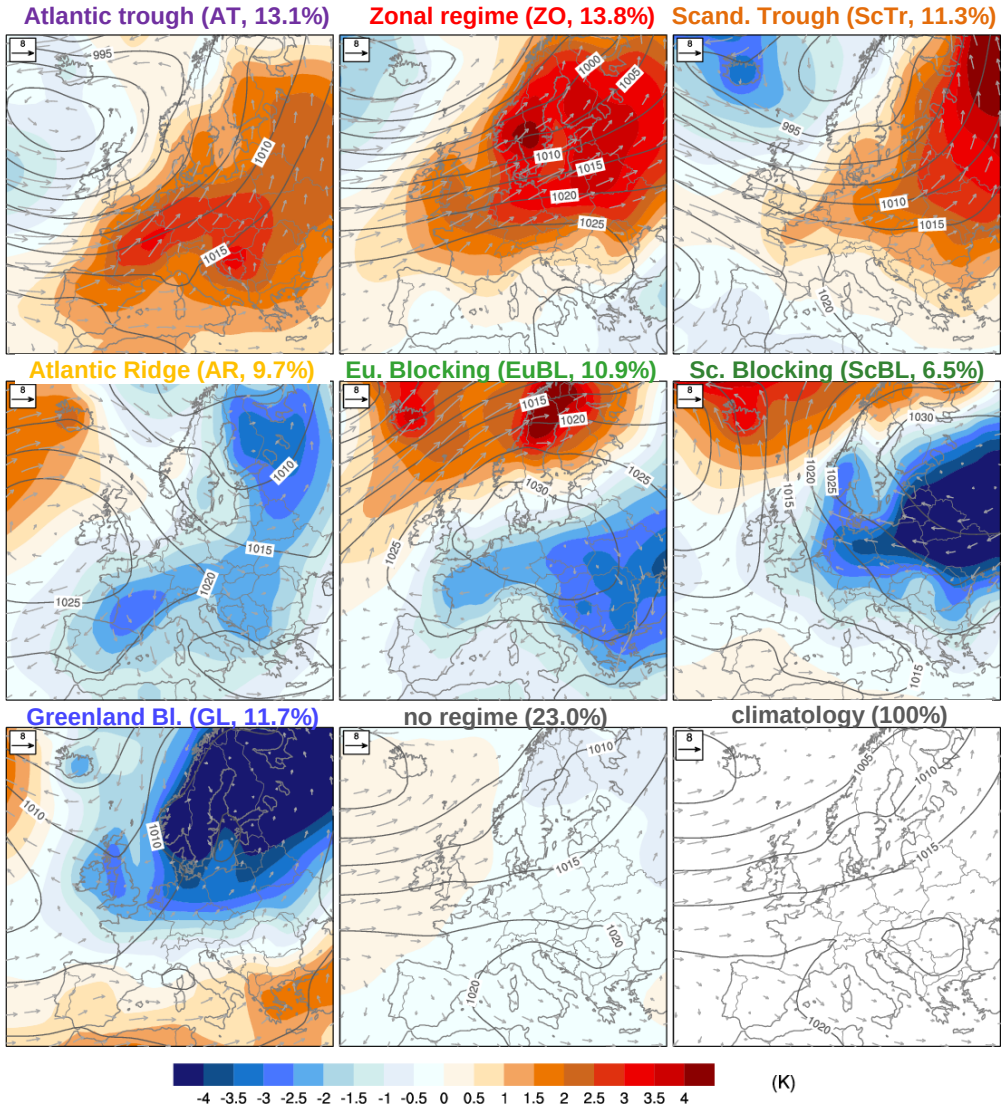
100m wind anomaly [m s^{-1}] (winter DJF)

- regimes modulate European wind power output



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

Weather impact – 2m temperature

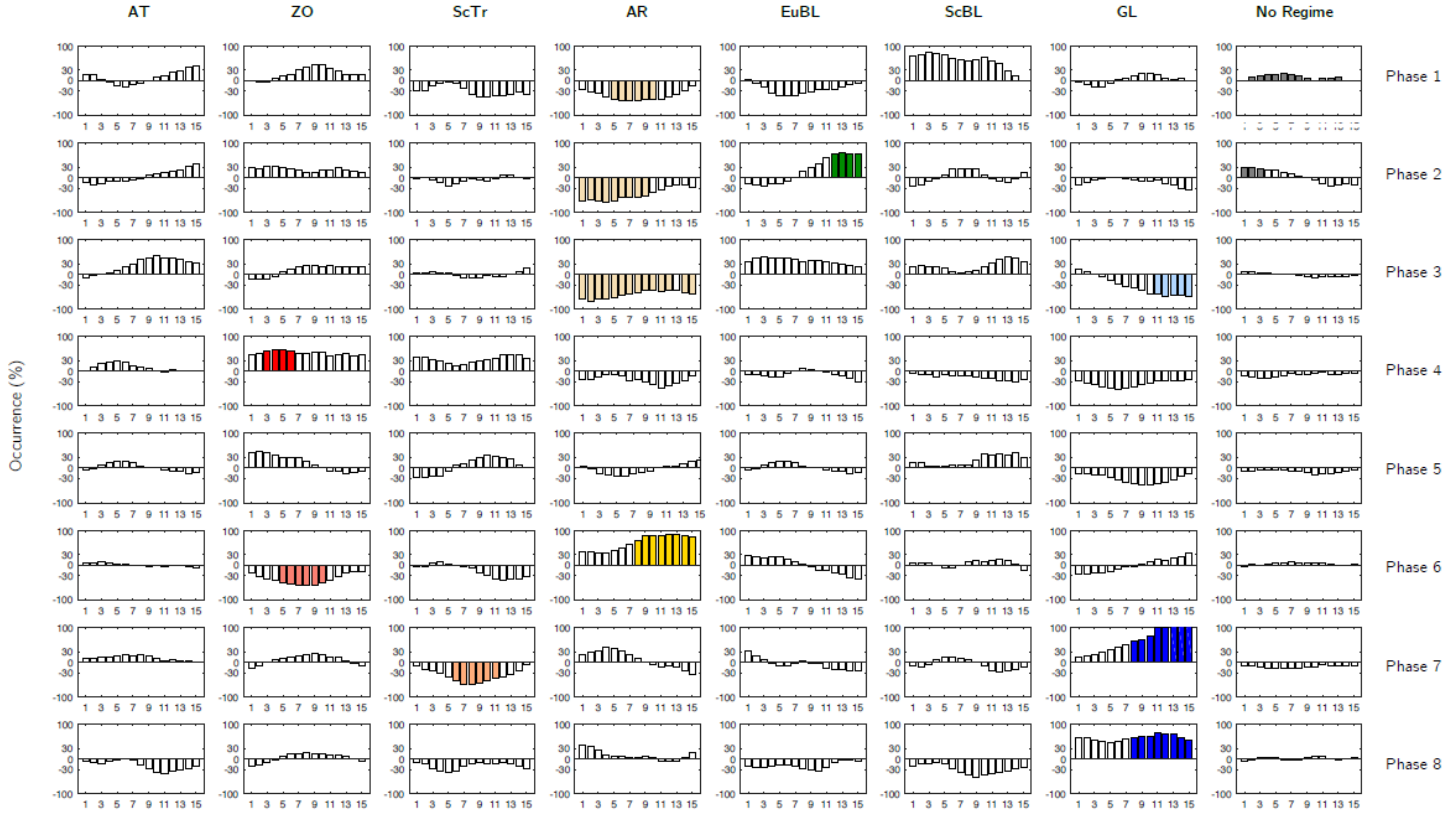


2m temperature anomaly [K]
(winter DJF)

- regimes strongly modulate surface temperature
- potential impact on energy demand

Modulation of Regimes on S2S time scales

Change in regime frequency ***after active MJO phases***



- some active MJO phases strongly favour specific regimes
- 5-15d after **MJO** phase 6 **AR**, 10-30d after phase 7/8 **GL** more likely

MSc thesis **Seraina Klaus ETH Zurich** [10.3929/ethz-b-000238793](https://doi.org/10.3929/ethz-b-000238793) following Cassou (2008), [10.1038/nature07286](https://doi.org/10.1038/nature07286)
supervised by R. Beerli and C.M. Grams

WR in members BT 20190402_00