Bolin Centre for Climate Research

Stockholm University

# Large-scale patterns during Arctic warm events – ongoing work

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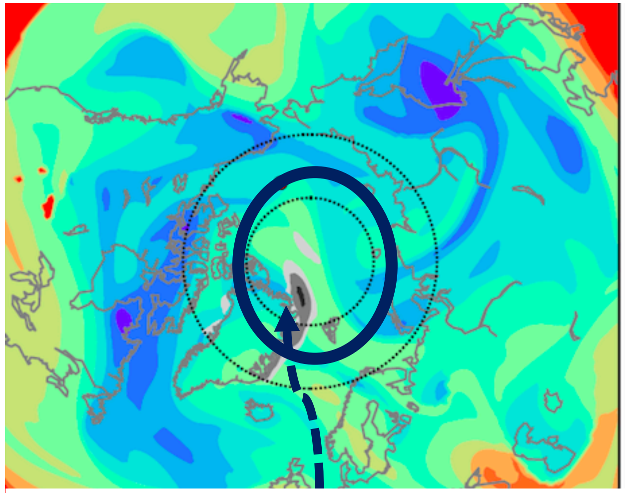
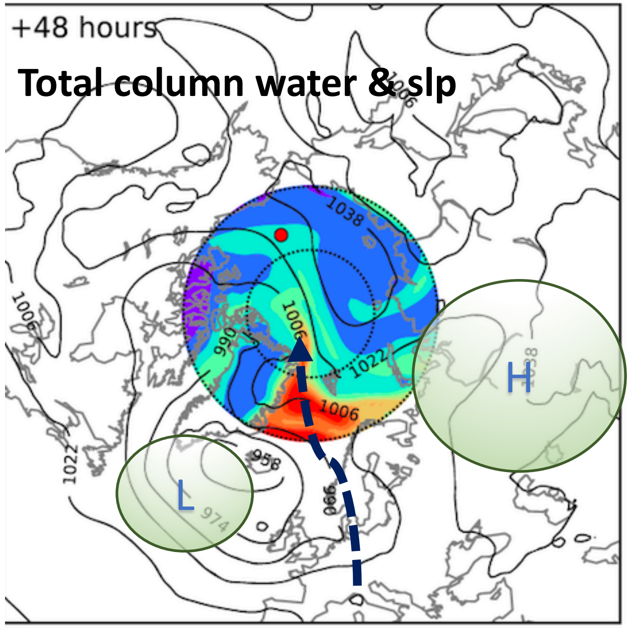
ACAS-project

EGU online session CL4.14,
2020/5/4

Case study: intrusion in Jan 1998[1]



Potential temperature at 2PVU




# Motivation 1: Large-scale circulation patterns during moist intrusions[1]

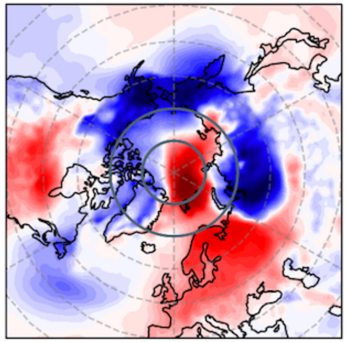
- Poleward moisture transport across 70°N into the Arctic
- Dipole pattern → pathway for southerly flow

  →Blocking east to the sector, intrusion west of the block
- Moisture intrusions correlated with **surface temperatures** in the Arctic

[1]Woods, C., Caballero, R., & Svensson, G. (2013). Large-scale circulation associated with moisture intrusions into the Arctic during winter. *Geophysical Research Letters*, *40*(17), 4717-4721.

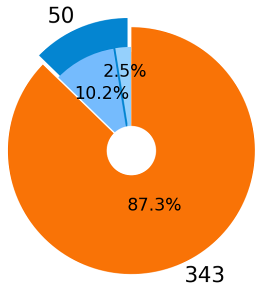
# Motivation 2: Wintertime temperature extremes in the High Arctic → warm events[2]

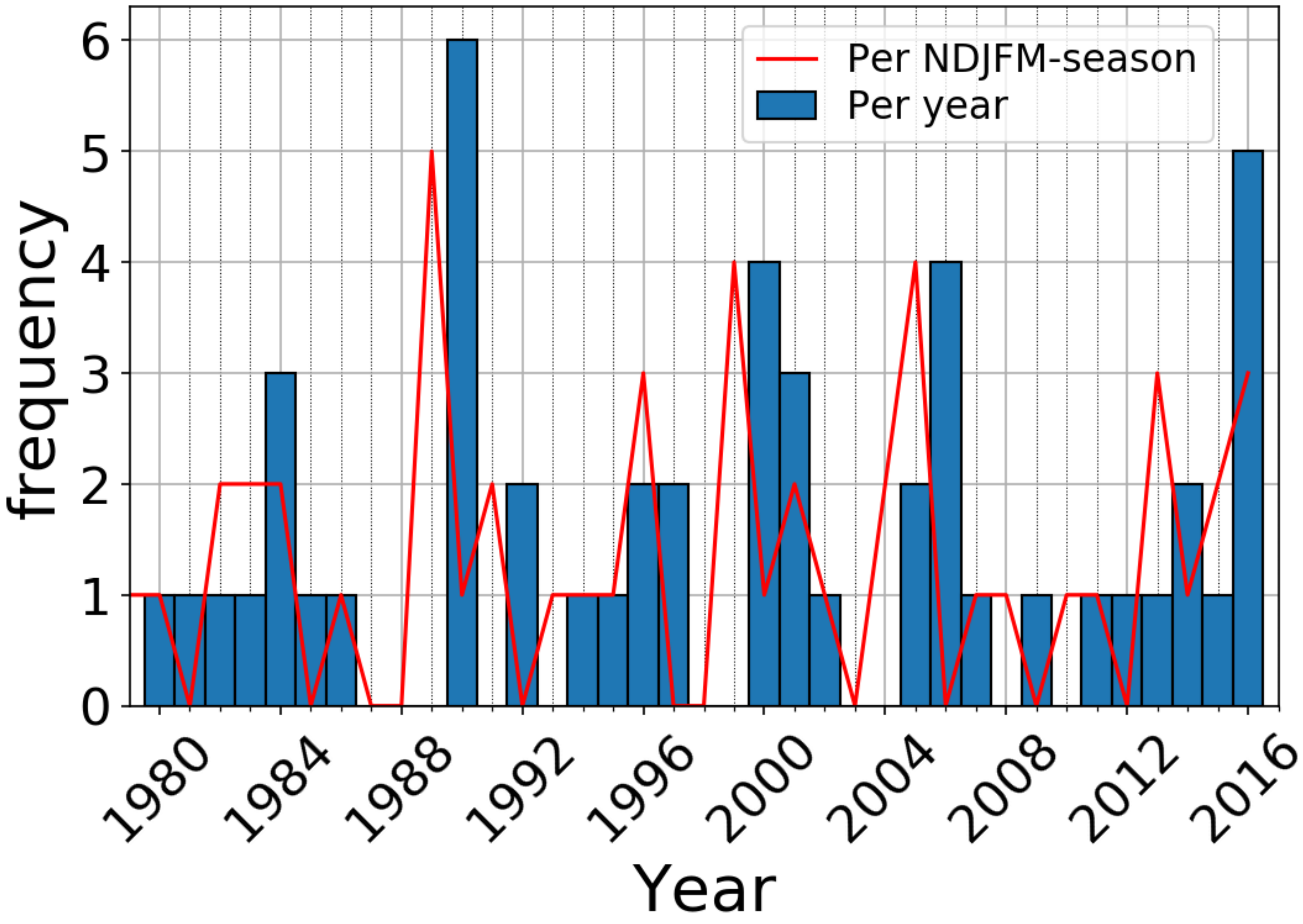
- 50 events of wintertime (**NDJFM**) high Arctic (polar cap north of 80 °N) extreme positive surface temperature anomalies
  - **6-hourly ERAInterim reanalysis data (1979 - 2016),** horizontal resolution: 1° × 1° or 0.75° × 0.75°
  - 5-d running mean over the area weighted and averaged $T_{2m}$ anomalies over the high Arctic
    - Daily climatology computed as 9-y and 21-d running mean
- Many moist intrusions during warm events



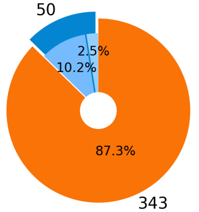

[2]Messori, G., Woods, C., & Caballero, R. (2018). On the drivers of wintertime temperature extremes in the High Arctic. *Journal of Climate*, *31*(4), 1597–1618.

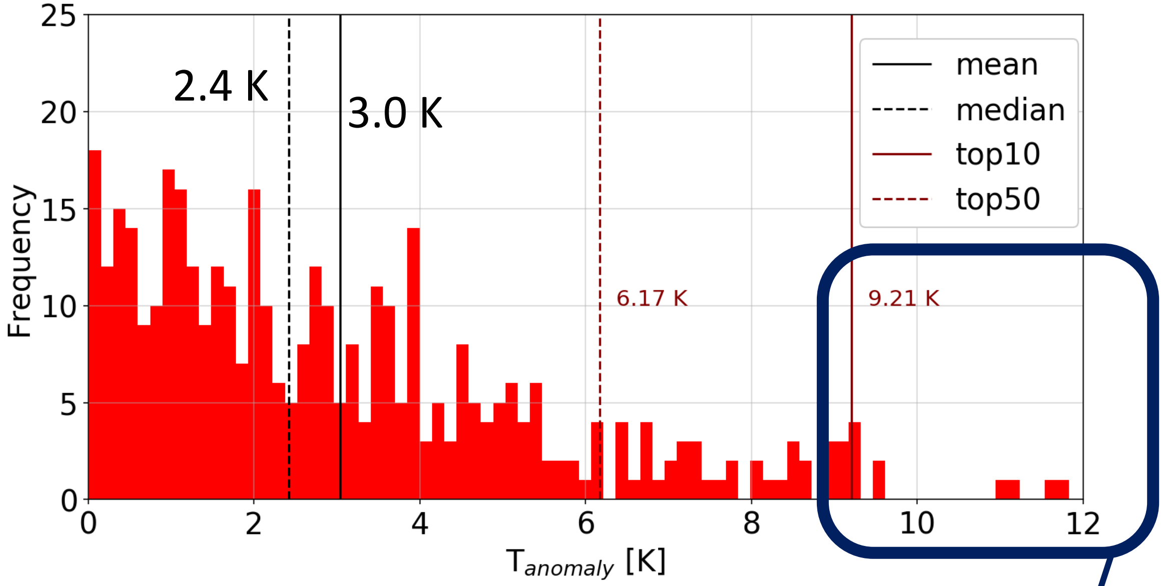
# Overwiew of the 50 warm events

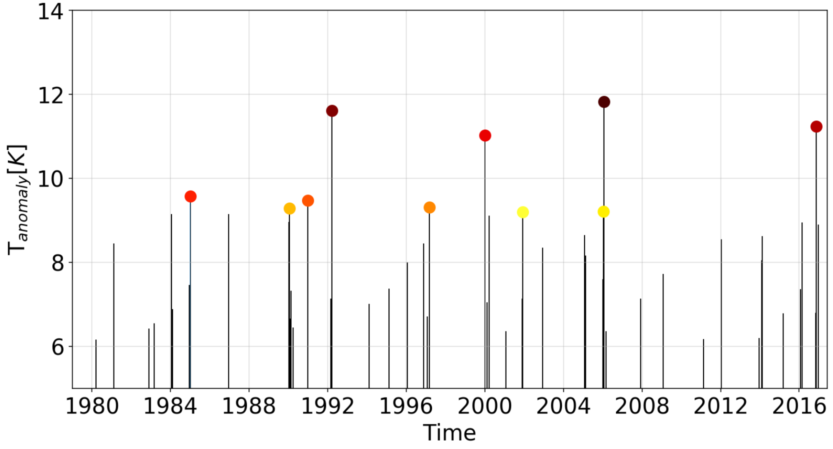


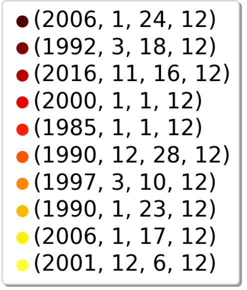



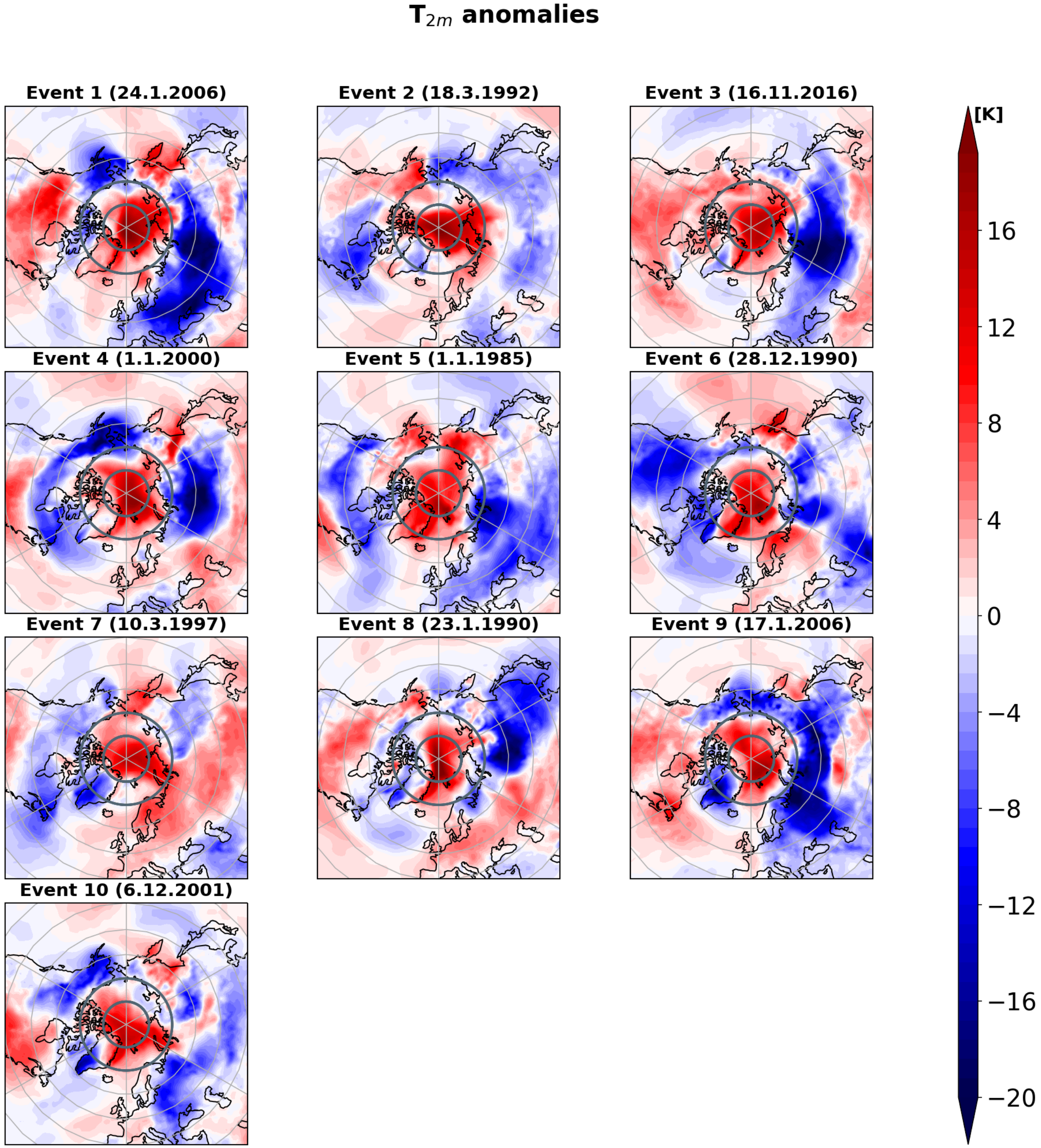
# $T_{surf}$ anomaly



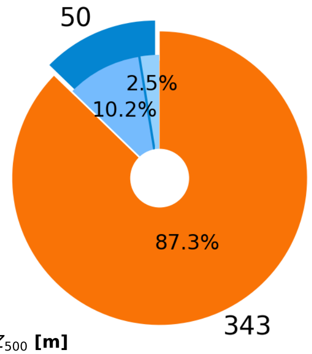



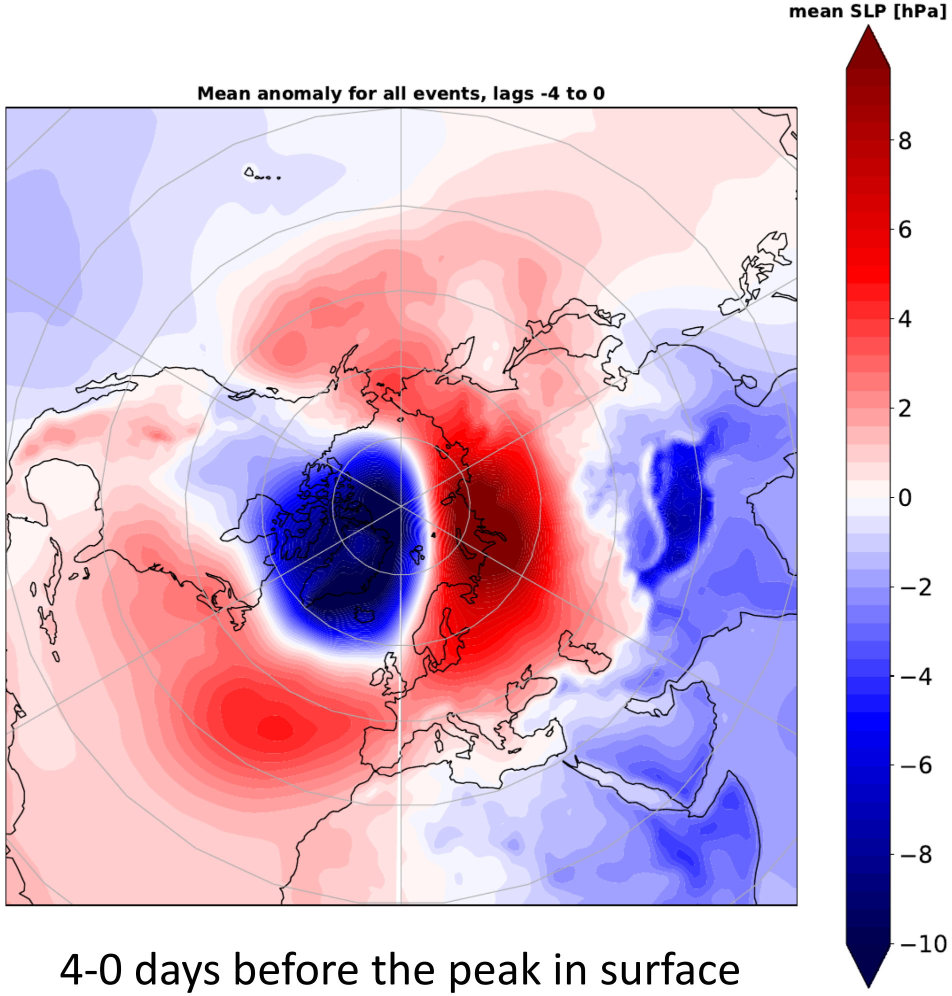



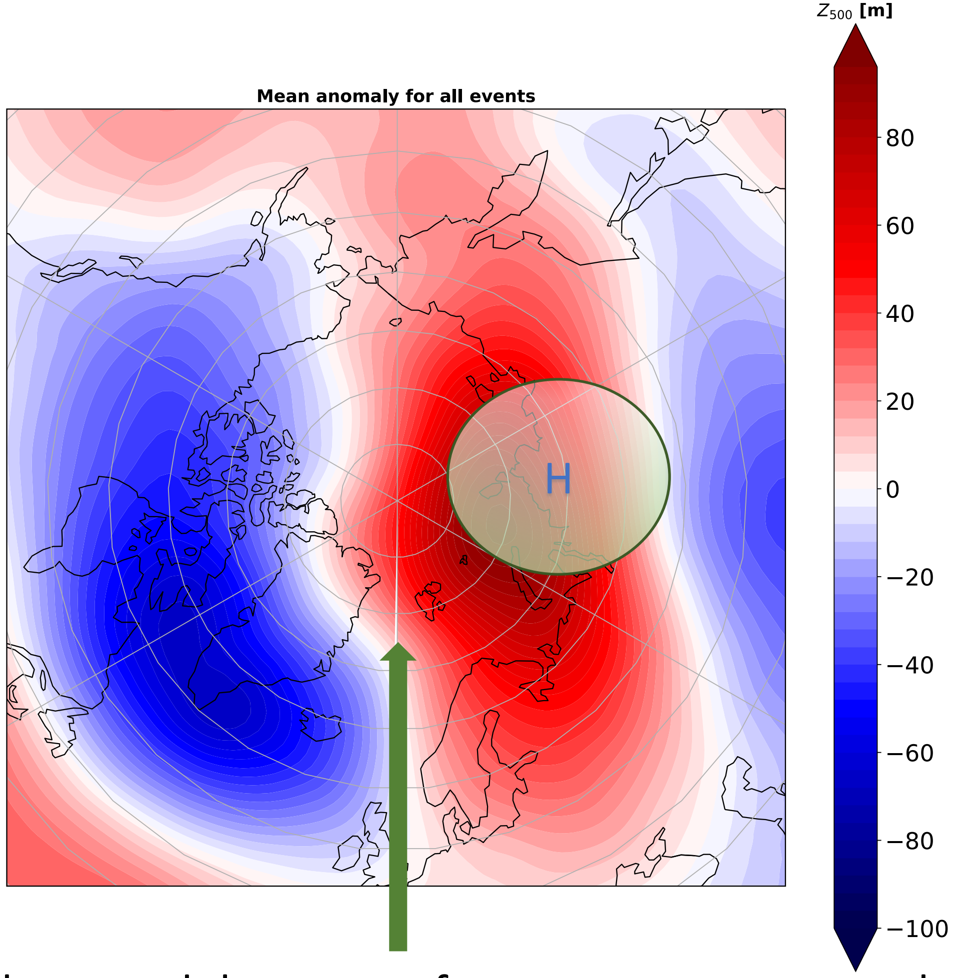
# Mean anomaly in surface level pressure (left) & Geopotential height at 500 hPa (right) during the 50 warm events




(1979-2017)



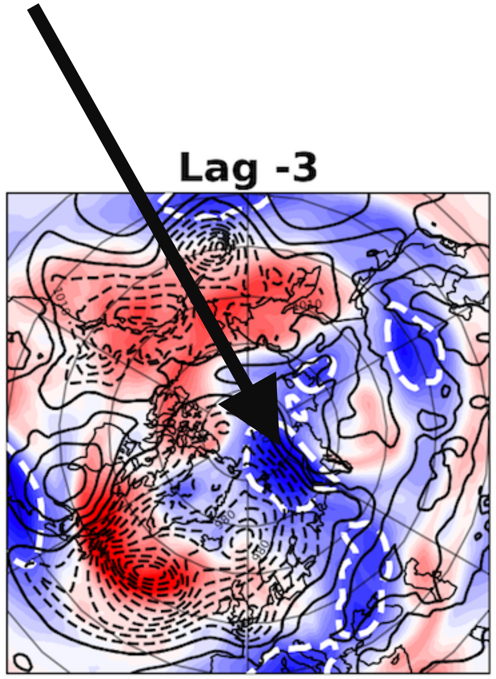

4-0 days before the peak in surface temperature anomaly




2 weeks around the max surface temperature anomaly.

# Blocking identification method: APV –index[3]

- Individual blocks are identified as upper-level anticyclonic (negative) PV anomalies:
  - Vertically averaged PV (**VAPV**) anomalies between 500 - 150 hPa exceeding *-1.3 pvu*, temporally smoothed with a 2-day running mean.
  - Anomalies calculated with respect to a monthly climatology.
  - *70 %* spatial overlap
  - Temporal persistence: *5* concecutive days
- → Objectively identify air masses in the upper troposphere that are involved in blockings



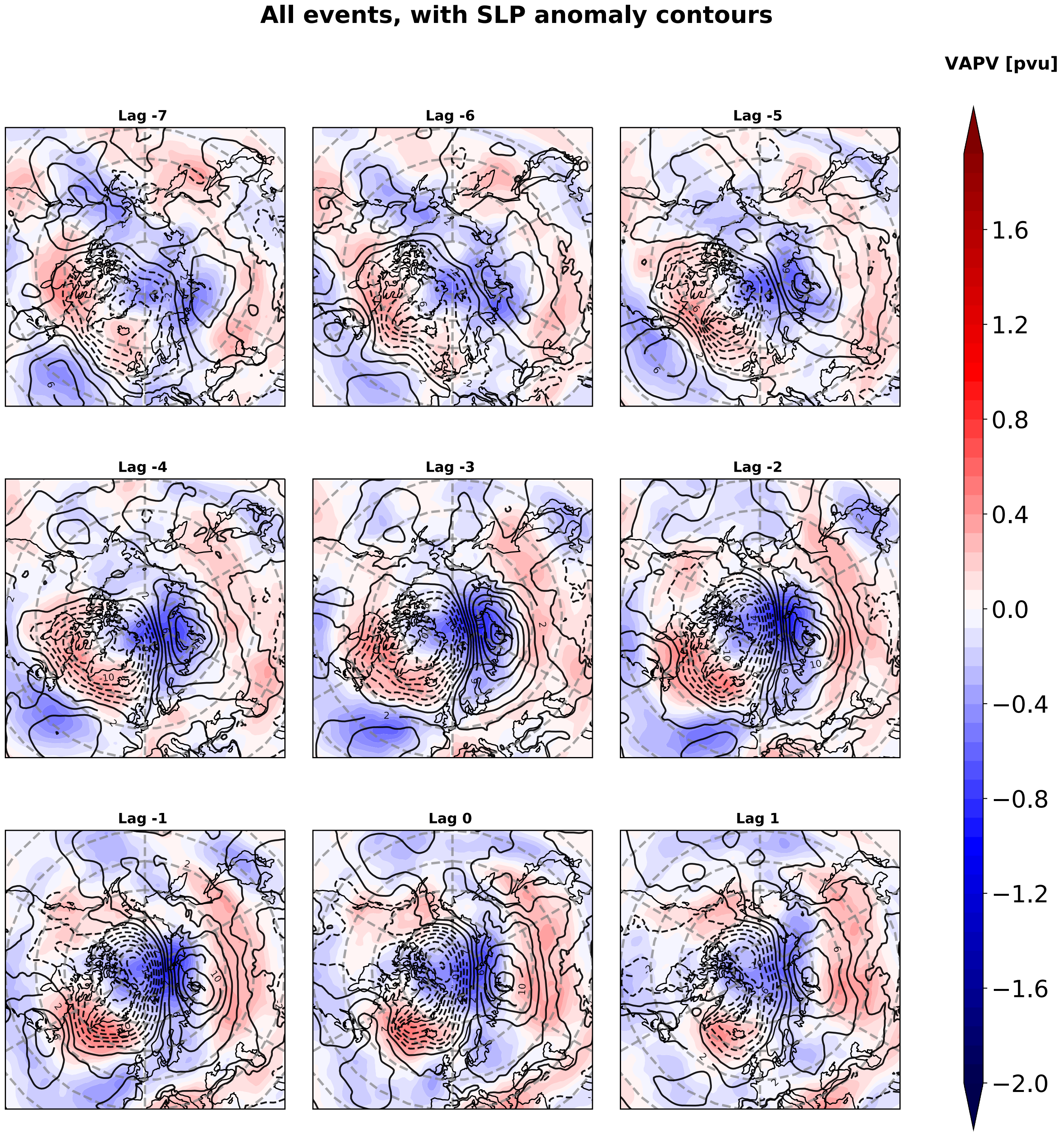

Event 42, SLP contours

(1pvu = $10^{-6}\frac{Km^2}{kgs}$)

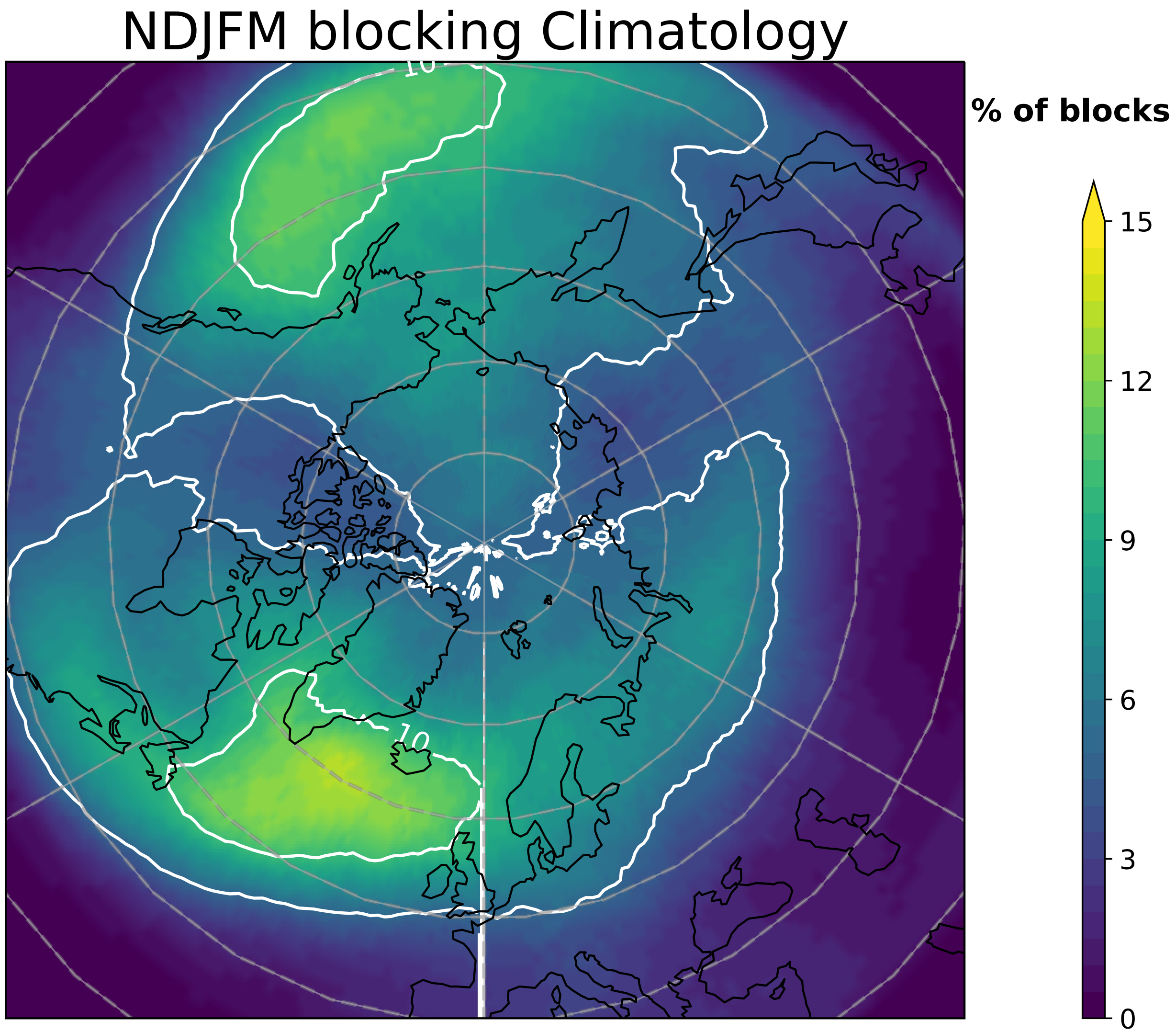
[3]Schwierz, C., Croci-Maspoli, M. & Davies, H. C. Perspicacious indicators of atmospheric blocking. Geophys. Res. Lett. 31, L06125 (2004).

# Lag-composites over all 50 events

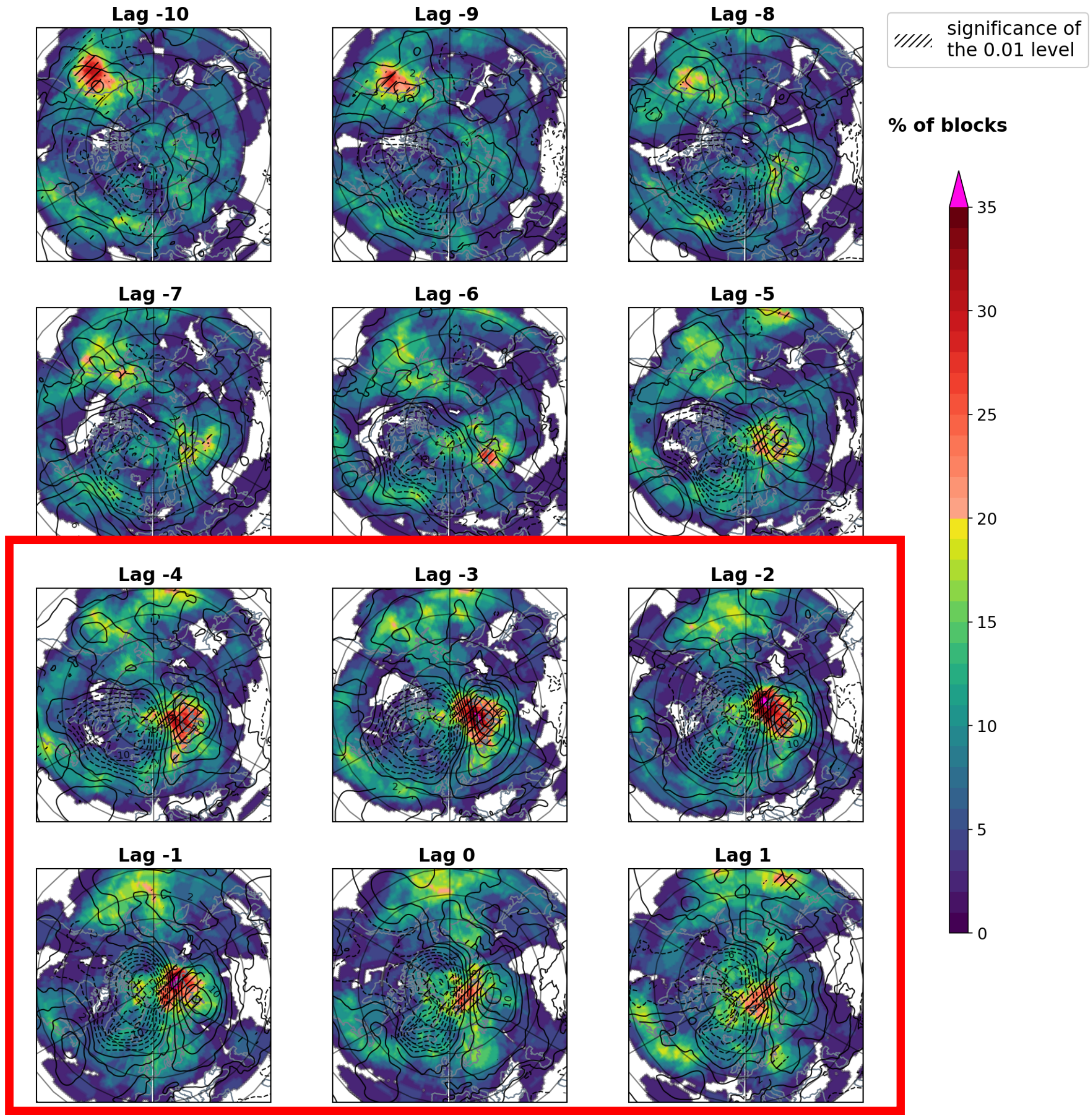
- Slp anomalies (contour) & VAPV-anomalies (color)
- Lag = relative to the day of peak in the positive temperature anomaly



# Results: Blocking climatology




- NDJFM 1979-2016
- Monte Carlo method

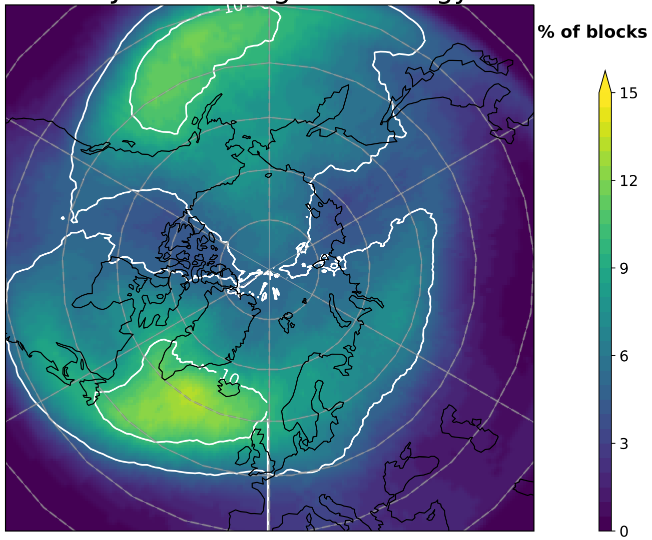



# Blocking frequency during Arctic warm events

- Lag = relative to the day of peak in the positive temperature anomaly

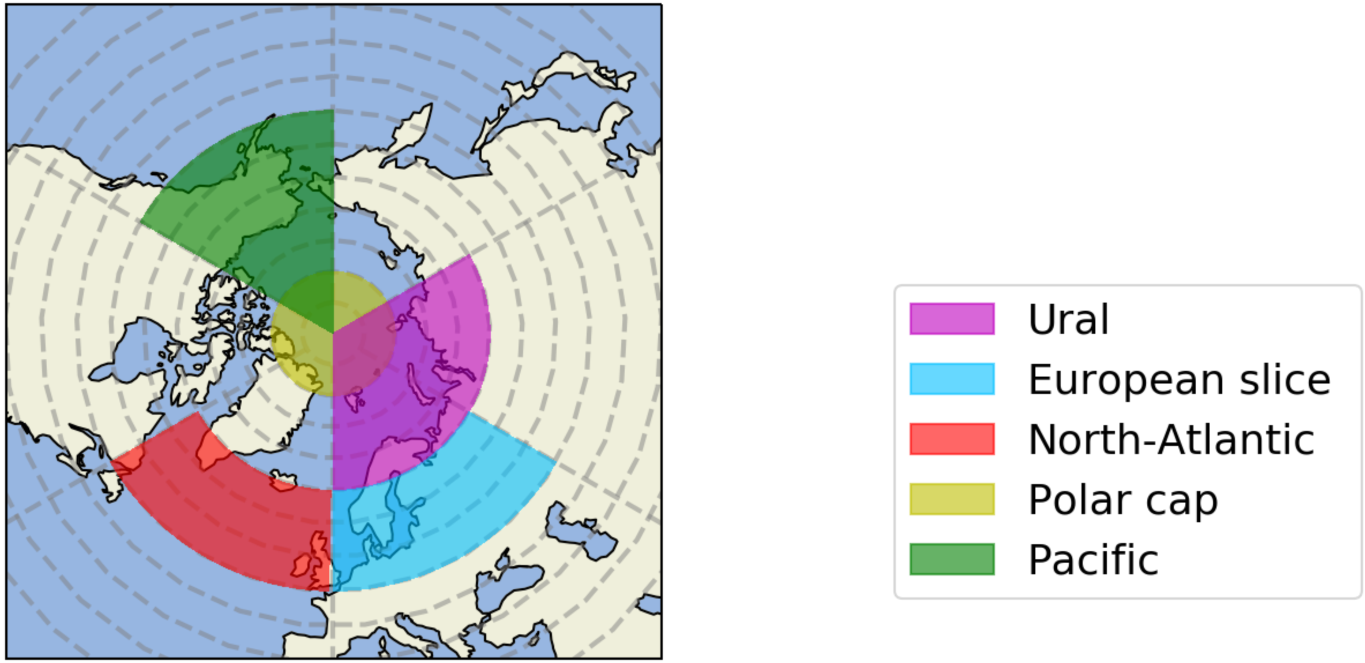
APV – index:
Treshold = -1.3 pvu
Persistence = 5 days
Overlapping = 70 %

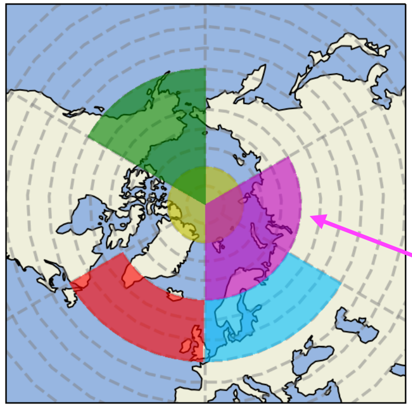
NDJFM blocking Climatology



# Sector division → Sector averaged blocking frequency

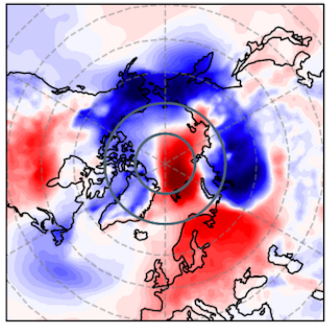
- ”Ural” sector = 65 - 90 °N, 0 - 120 °E
  - Over Barents – Kara seas
  - Northward shift of the Ural blockings important for extreme warm events in the Arctic!
- → Daily mean blocking area fractions for the study period





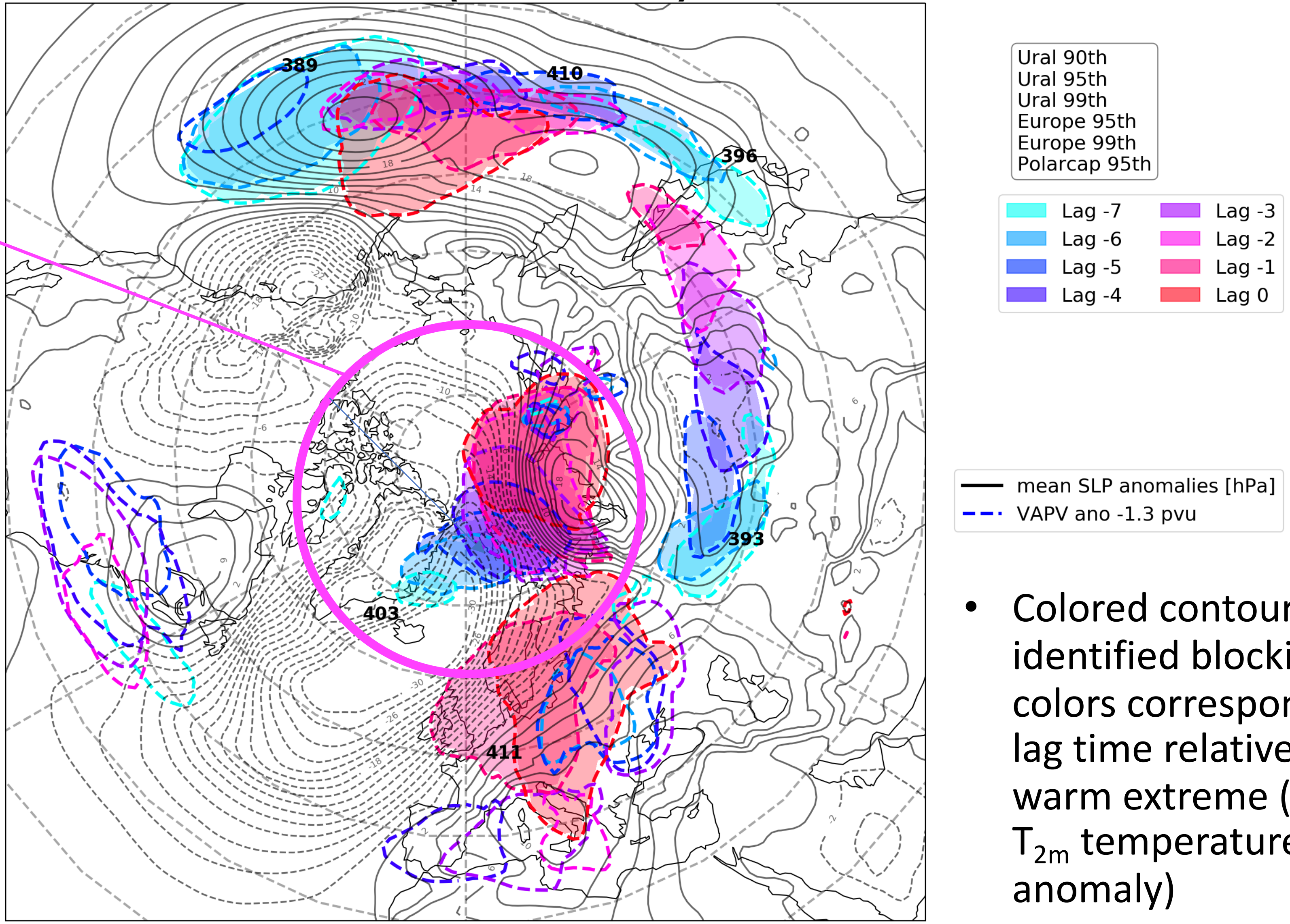
Sector division

Event 42 (6.2.1990)



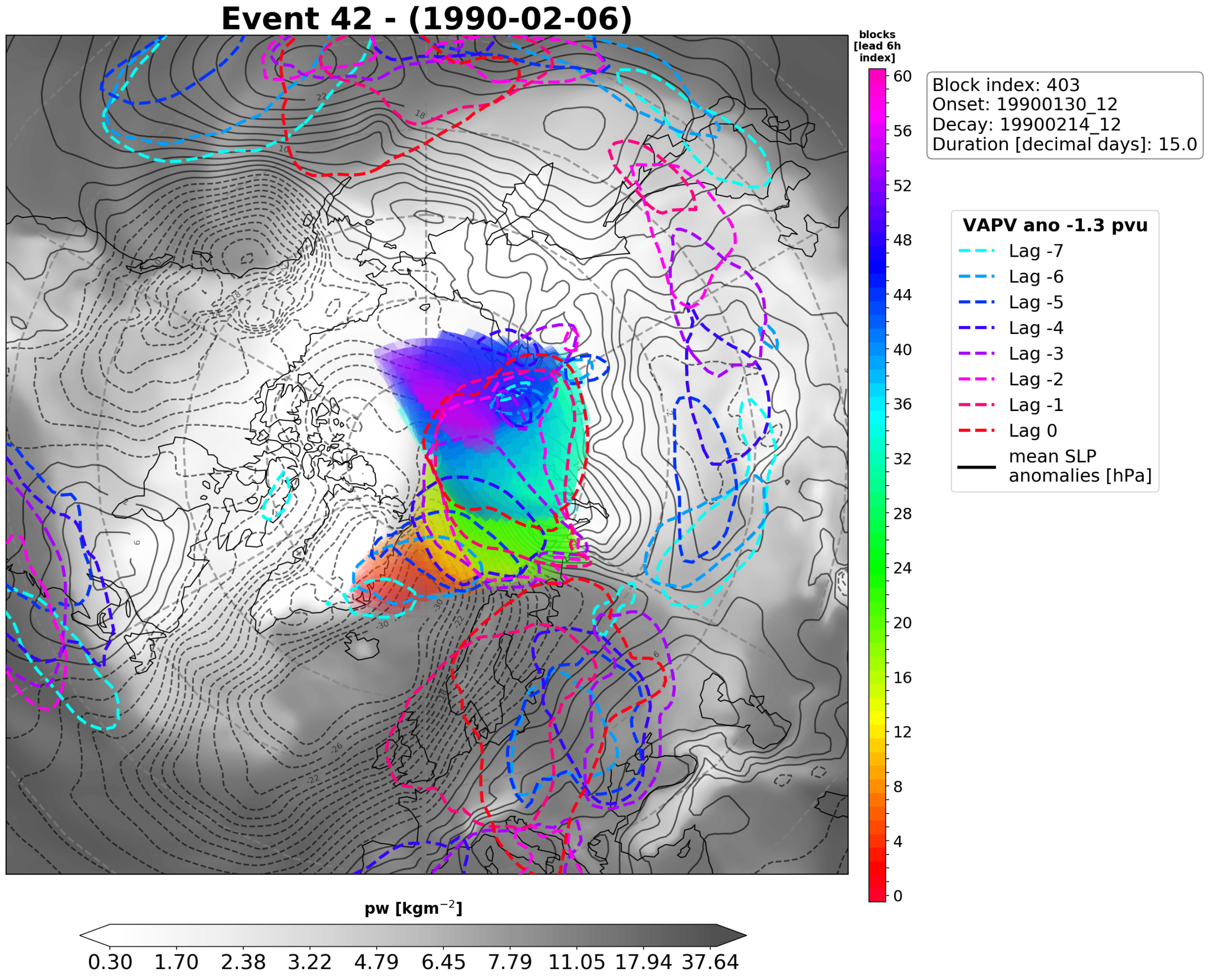
Temperature anomaly

**Event 42 - (1990-02-06)**

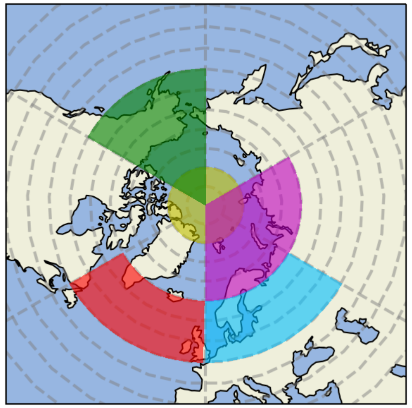



- Colored contours are identified blockings, colors correspond with lag time relative to the warm extreme (high $T_{2m}$ temperature anomaly)

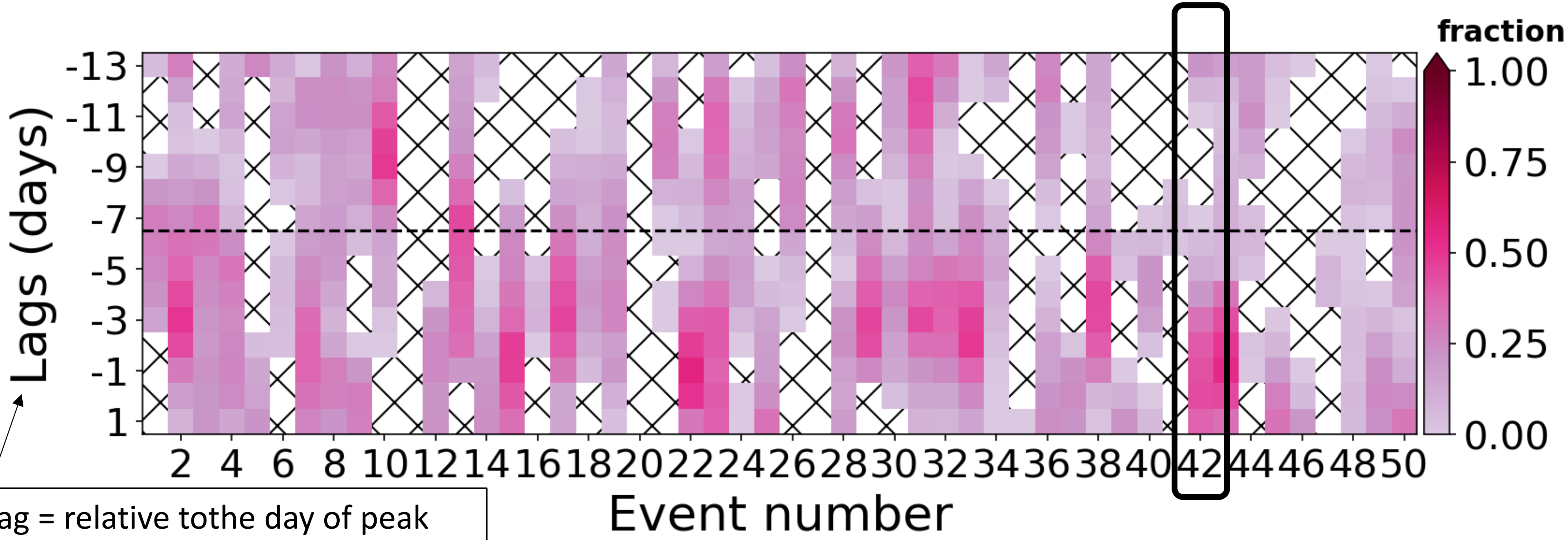
# Lifetime of the block with ID 403 over Urals




- Colored contours are identified blockings, colors correspond with lag time relative to the warm extreme (high $T_{2m}$ temperature anomaly)
- Filled color of the block = block lifetime (in 6-h time steps)
- Gray shading: total column water

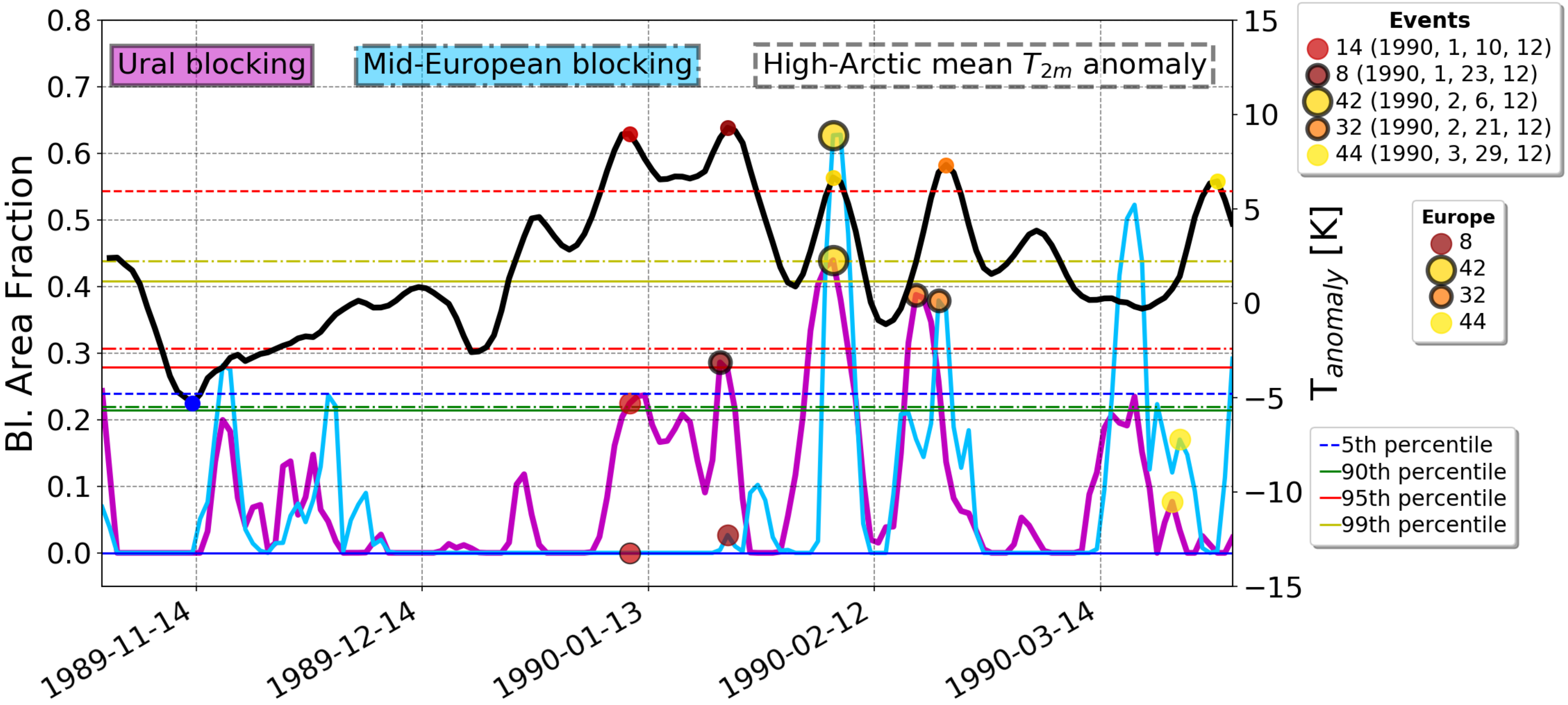


# "Ural"-sector area weighted blocking frequency / occurence

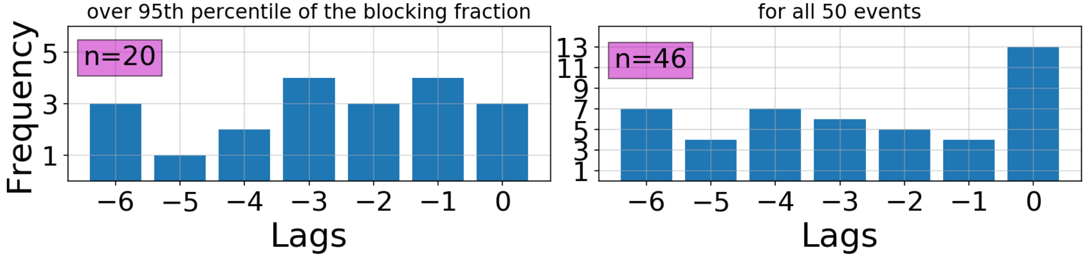



Lag = relative tothe day of peak in the positive temperature anomaly

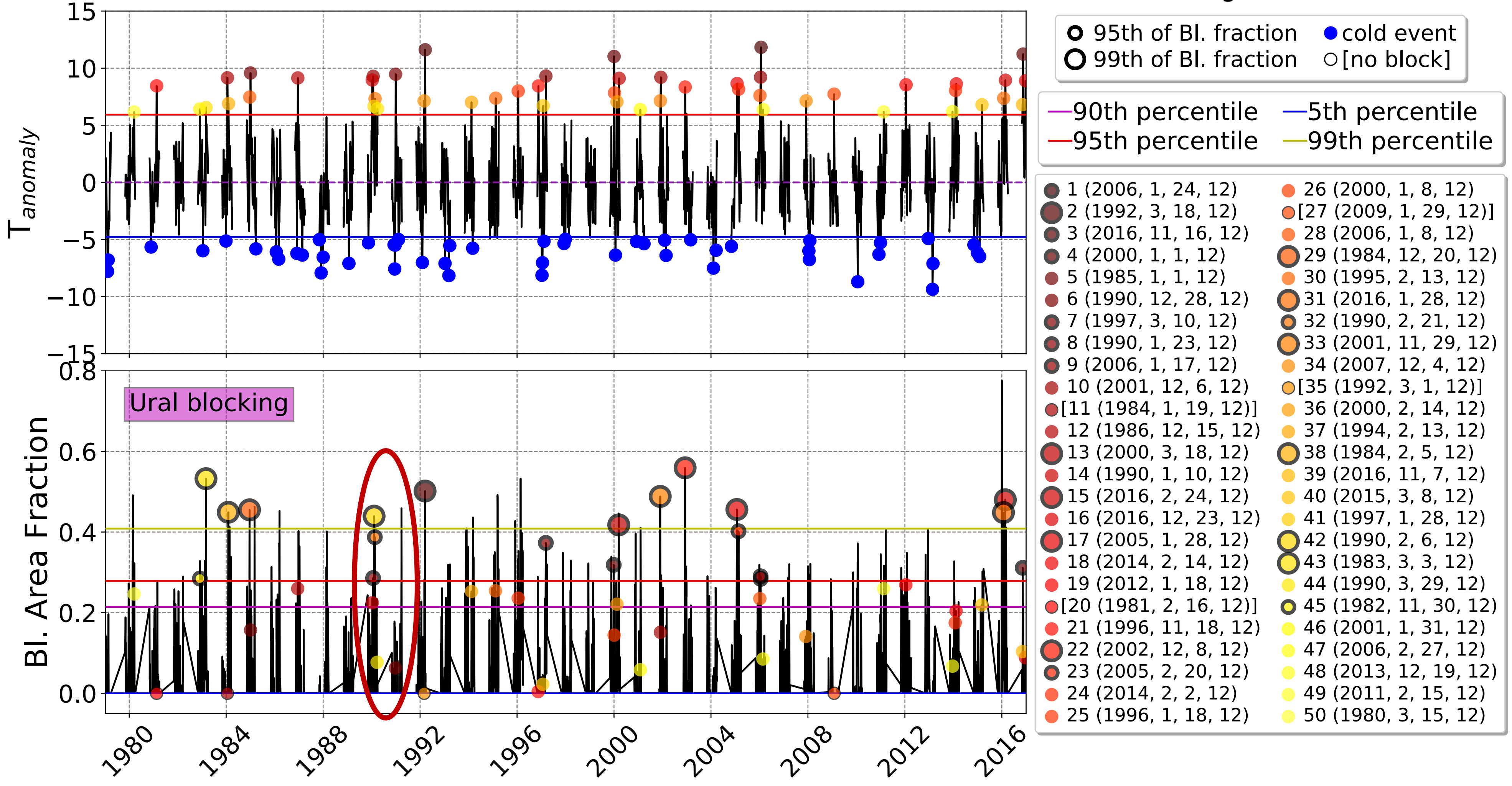
# Snapshot: Locate the max blocking fraction up to 6 days before the warm event



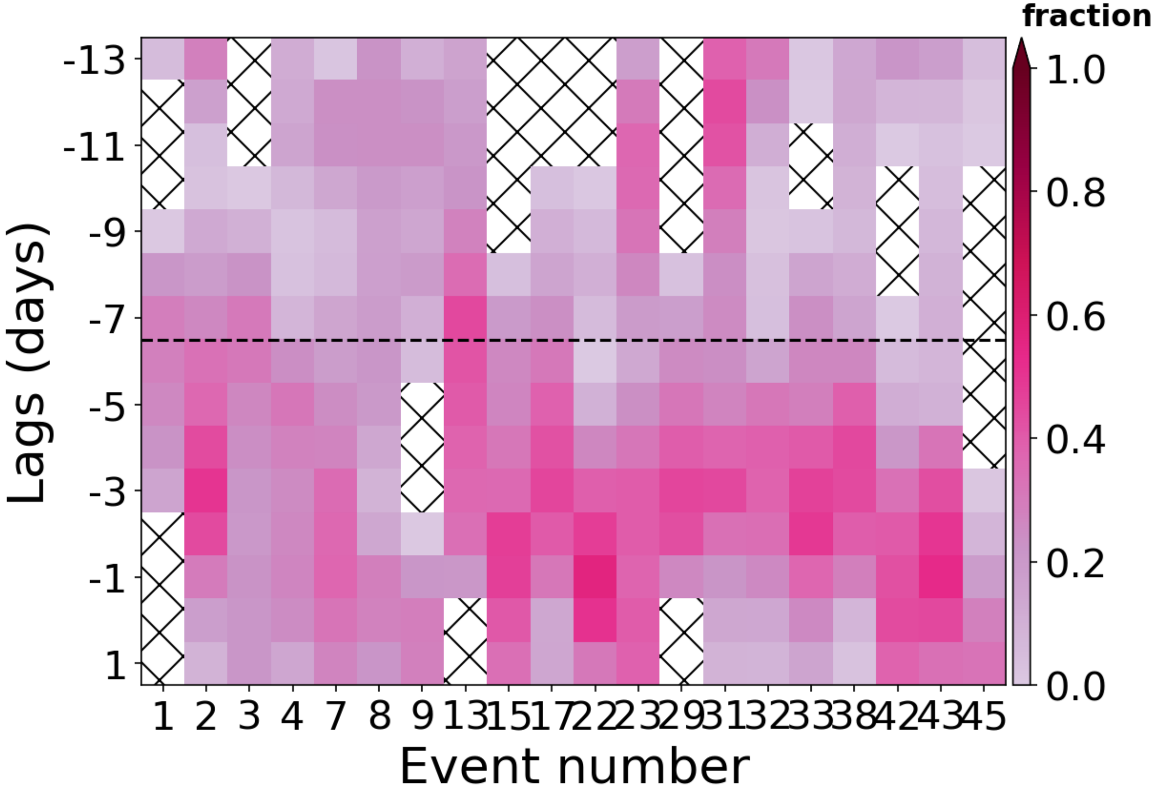
# Locate the max blocking fraction up to 6 days before the warm event




Lag = relative to the day of peak in the positive temperature anomaly



# Ural sector - 95th percentile




- 99th percentile: 25 days > 5d apart
  --> 11 of 25 (44%) "blocking events" are related to the warm events

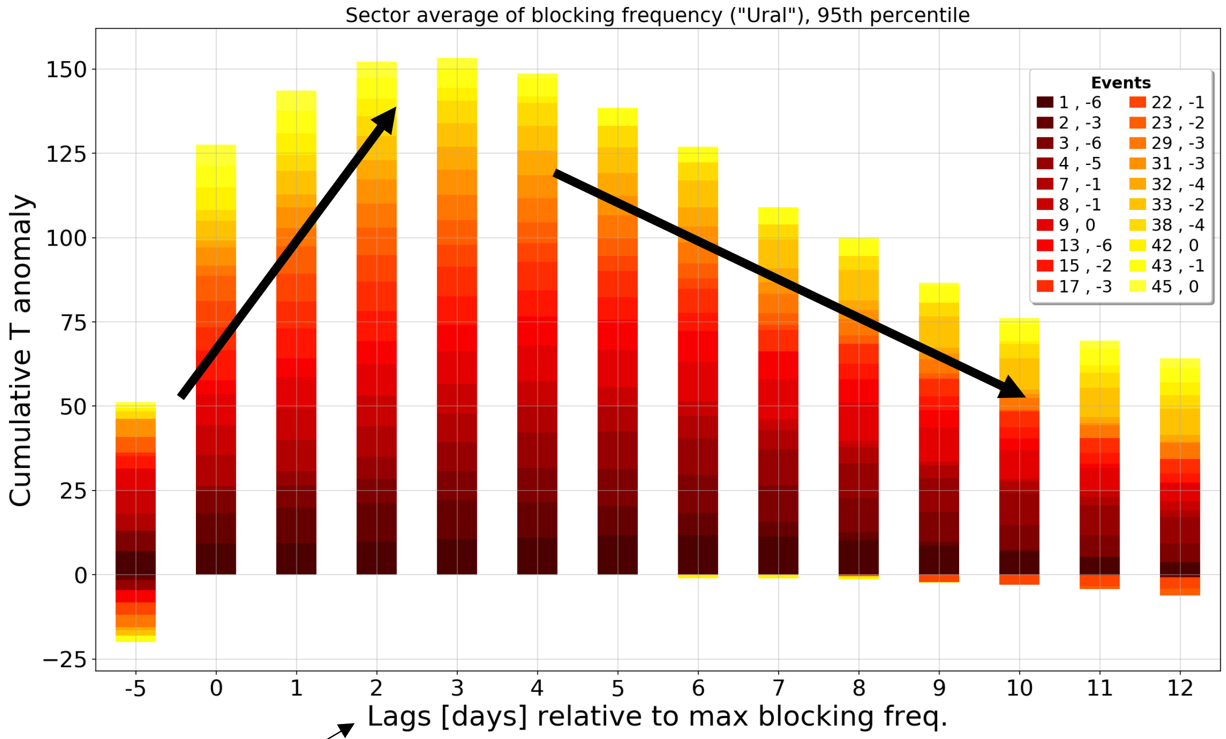
- Other days including the 99th percentile (33) are within 5 consecutive days

| Percentile | Fraction limit | Total days | Events included (of 50) |
|---|---|---|---|
| 90th | 0.21 | 575 | 31 |
| 95th | 0.28 | 288 | 20 |
| 99th | 0.41 | 58 | 11 |

# Temperature anomaly response relative to maximum blocking frequency (Ural)

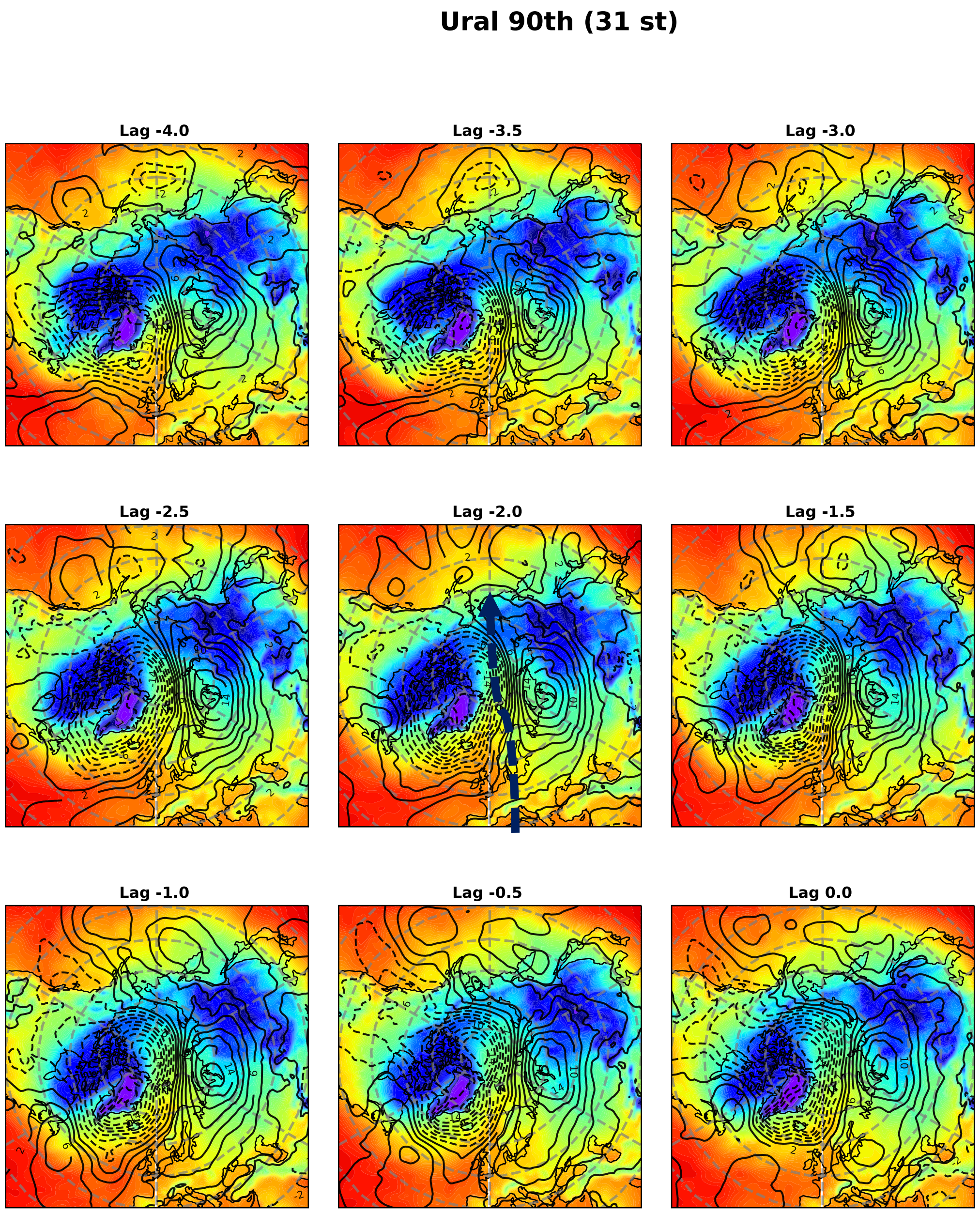
| Events \ Lags [days] | -5 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.06 | 9.34 | 9.4 | 9.73 | 10.52 | 11.05 | 11.72 | **11.83** | 11.4 | 10.26 | 8.65 | 6.94 | 5.33 | 3.76 |
| **2** | -1.53 | 8.93 | 10.52 | 11.6 | **11.61** | 10.4 | 8.59 | 6.46 | 4.2 | 2.32 | 1.14 | 0.45 | -0.1 | -0.67 |
| 3 | 6.05 | 6.34 | 6.47 | 7.13 | 8.52 | 10.13 | 11.09 | **11.23** | 10.94 | 10.15 | 8.8 | 7.33 | 6.3 | 5.42 |
| 4 | -2.97 | 1.79 | 4.27 | 6.49 | 8.69 | 10.6 | **11.03** | 10.82 | 10.67 | 10.42 | 9.99 | 9.65 | 8.97 | 7.84 |
| 7 | 4.98 | 9.17 | **9.31** | 9.05 | 8.69 | 8.2 | 7.5 | 6.66 | 5.7 | 4.66 | 3.85 | 3.18 | 2.56 | 2.11 |
| 8 | 6.7 | 8.75 | **9.29** | 9.13 | 8.49 | 7.07 | 5.71 | 4.44 | 3.2 | 1.9 | 1.09 | 0.88 | 1.53 | 2.75 |
| 9 | 6.78 | **9.21** | 9.34 | 9.4 | 9.73 | 10.52 | 11.05 | 11.72 | 11.83 | 11.4 | 10.26 | 8.65 | 6.94 | 5.33 |
| **13** | -3.76 | 4.18 | 5.55 | 6.77 | 7.85 | 8.57 | 8.96 | **9.11** | 8.36 | 6.85 | 5.09 | 3.22 | 1.36 | 0.14 |
| **15** | 3.52 | 8.9 | 8.94 | **8.95** | 8.6 | 7.78 | 6.64 | 5.49 | | 4.61 | 4.09 | 3.49 | 3.12 | 2.76 |
| **17** | 1.14 | 6.87 | 7.88 | 8.65 | **8.66** | 8.42 | 7.86 | 7.15 | 6.37 | 5.86 | 5.22 | 4.66 | 4.44 | 4.28 |
| **22** | -3.63 | 7.73 | **8.35** | 7.88 | 6.52 | 5.54 | 4.39 | 3.02 | 1.41 | -0.42 | -2.12 | -3.02 | -3.32 | -3.41 |
| 23 | 4.61 | 7.51 | 8.04 | **8.16** | 7.32 | 6.29 | 5.43 | 4.35 | 3.49 | 2.61 | 1.58 | 0.46 | -0.74 | -2.05 |
| **29** | -3.61 | 3.0 | 5.46 | 7.15 | **7.47** | 7.17 | 6.56 | 6.27 | 5.63 | 4.81 | 4.05 | 3.47 | 3.74 | 4.79 |
| **31** | 5.37 | 5.32 | 6.22 | 7.22 | **7.36** | 6.8 | 5.76 | 4.64 | 3.52 | 2.7 | 1.77 | 1.13 | 0.65 | 0.2 |
| 32 | -0.91 | 2.16 | 3.8 | 5.57 | 6.93 | **7.32** | 6.91 | 5.72 | 4.16 | 2.77 | 1.86 | 1.54 | 1.73 | 2.06 |
| **33** | -1.7 | 5.88 | 6.9 | **7.14** | 7.02 | 7.21 | 7.56 | 7.93 | 8.51 | 9.02 | 9.21 | 9.08 | 8.74 | 7.87 |
| **38** | 2.28 | 3.07 | 4.79 | 5.98 | 6.57 | **6.89** | 6.36 | 5.4 | 4.52 | 4.18 | 4.11 | 4.37 | 4.5 | 3.91 |
| **42** | 0.88 | **6.66** | 6.4 | 5.25 | 3.81 | 1.89 | 0.04 | -0.91 | -1.12 | -0.9 | -0.28 | 0.82 | 2.16 | 3.8 |
| **43** | -1.79 | 6.33 | **6.55** | 6.1 | 6.05 | 5.45 | 5.03 | 4.75 | 5.06 | 4.9 | 4.9 | 5.09 | 5.0 | 4.33 |
| 45 | 1.8 | **6.42** | 6.16 | 4.83 | 2.93 | 1.3 | 0.31 | -0.14 | 0.04 | 0.49 | 1.01 | 1.73 | 2.32 | 2.85 |

$T_{anomaly}$ [K]




Lag = relative to the day of maximum blocking frequency

- **Bold event numbers** are within 99th percentile, others are 95th percentile
- White bold temperatures values represent the day of the peak of the positive temperature anomalies

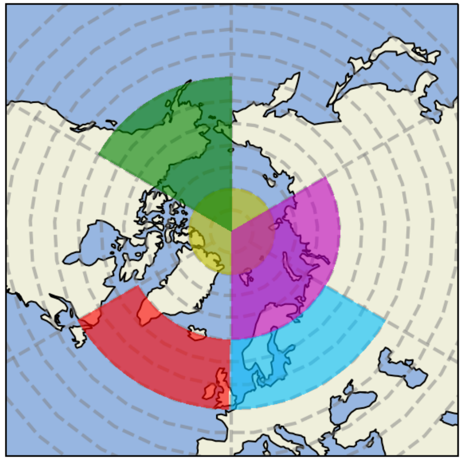


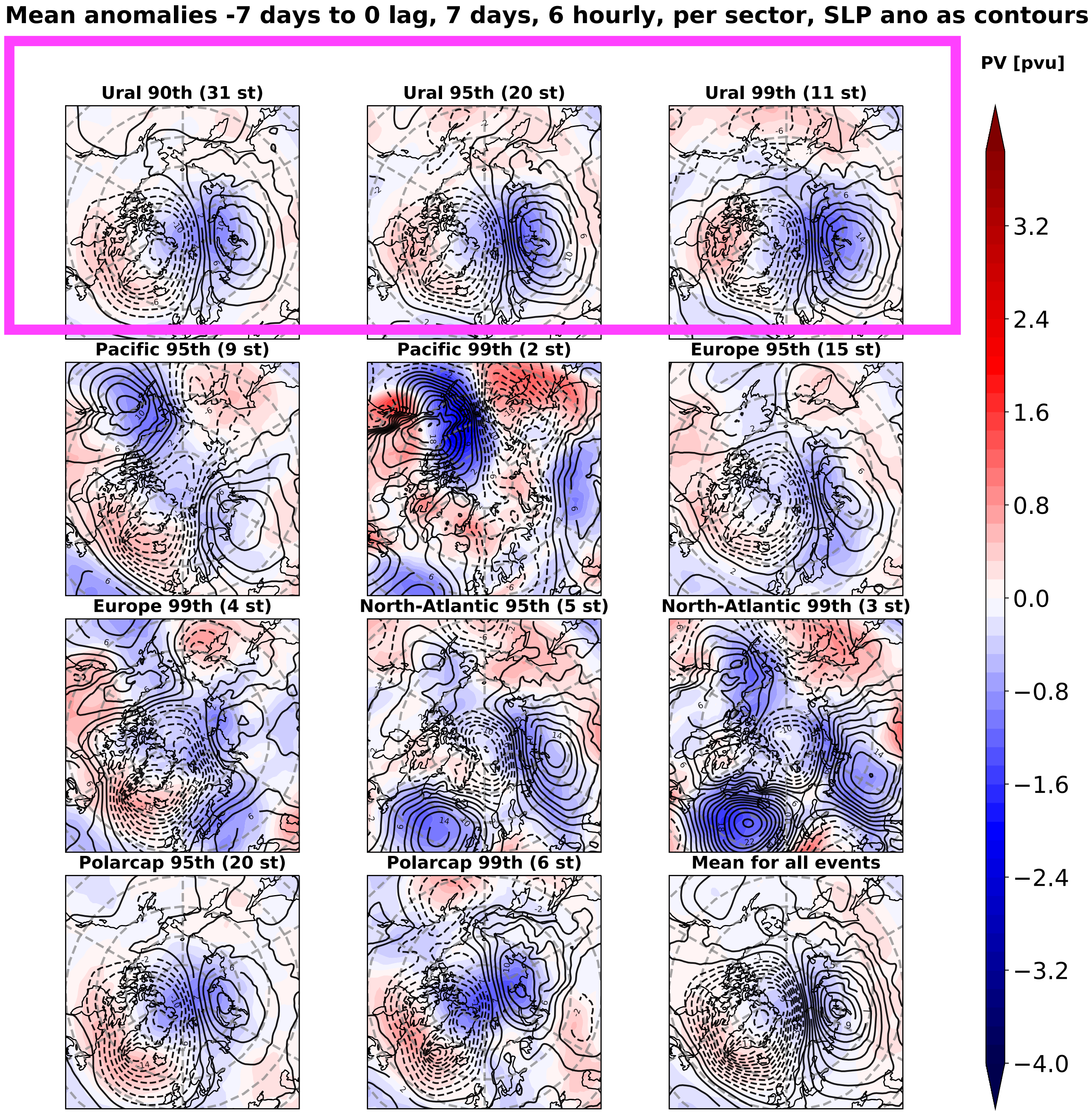

# Composites over total column water and slp anomalies for Ural 90th sector

- Dipole pressure field
- Narrow ”moist river” directed northwards by the pressure difference

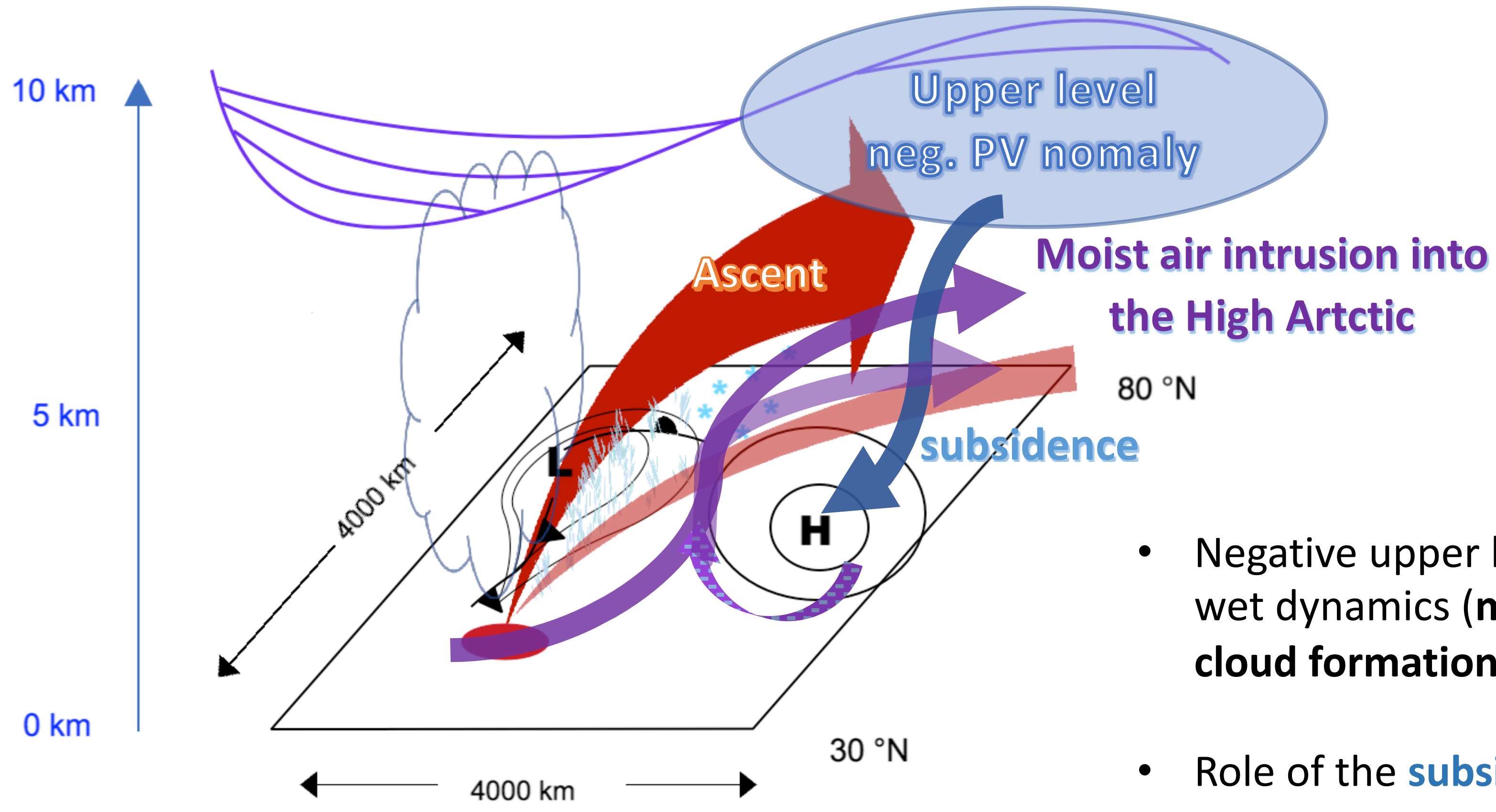
# General large-scale patterns – composites of VAPV and slp-anomalies – divided into sectors

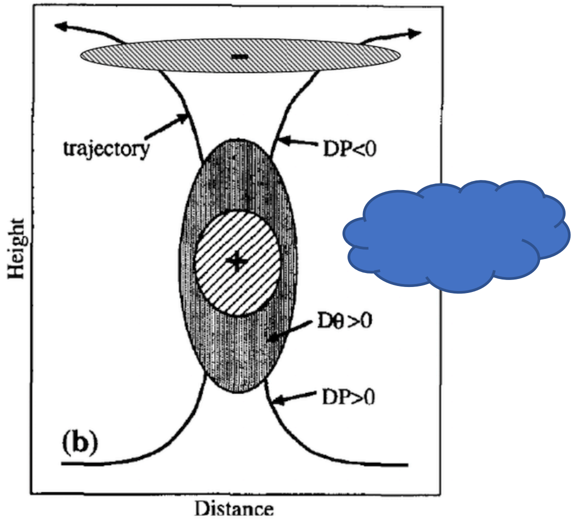
- Mean up to 7 days prior to the warming





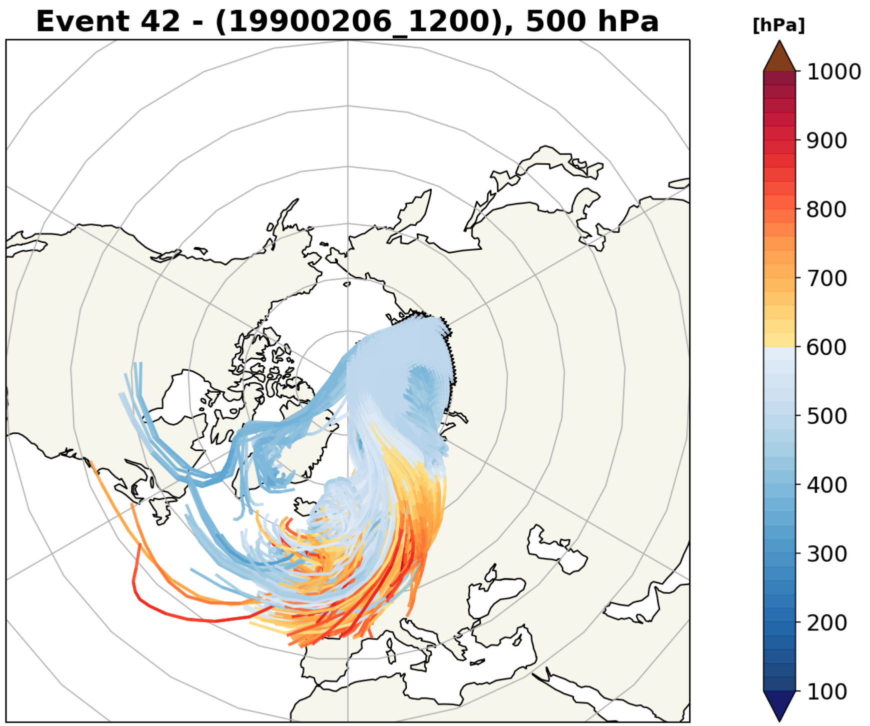
# Next step/Outlook: Dynamical drivers of the warm events




- Negative upper level PV-anomalies due to wet dynamics (**moist-diabatic processes in cloud formation by ascending air**)?
- Role of the **subsidence** in the block?
- → Contribution of blockings to warm extremes? → **moist intrusions**

# Outlook…




Block ID 403 over Urals, lag = 0

- Backward trajectories from the "Ural blocks"

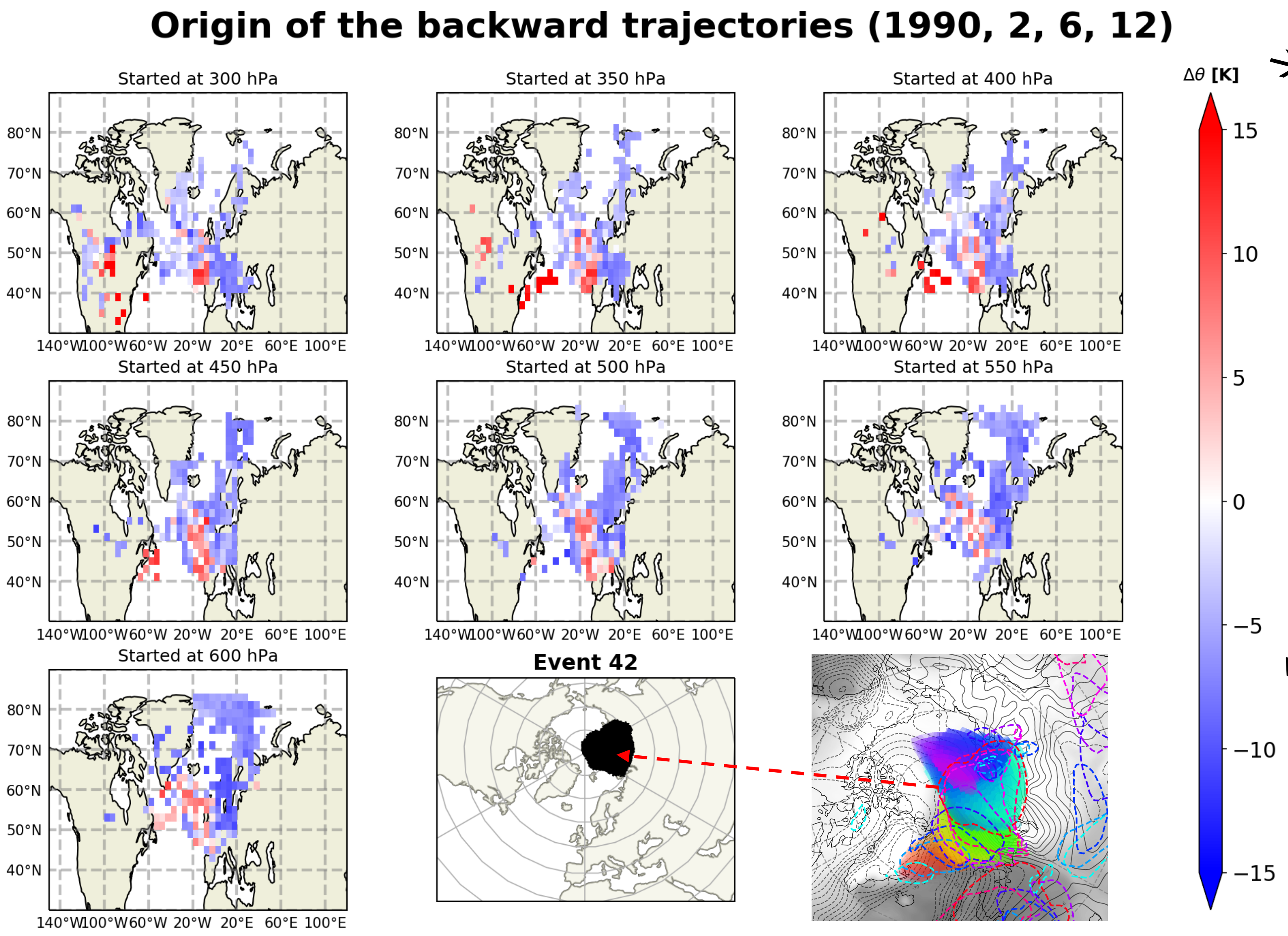
→ **Investigate the origin to and the processes involved in polar anticyclones during Arctic warm events**

→ which processes and mechanisms are contributing to the blocking formation and maintenance during the warm events?

- Trace meteorological variables along the trajectories…

# Trace meteorological variables along the trajectories

Outlook




→ What is the contribution of blocks to the warm temperature extremes?

→ Which processes (local vs remote) are involved?

→ What are the preconditions for warm events to occur?

# Thank you for your attention!

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I am greatful for feedback, ideas and comments!

Longyearbyen, Svalbard, autumn 2016