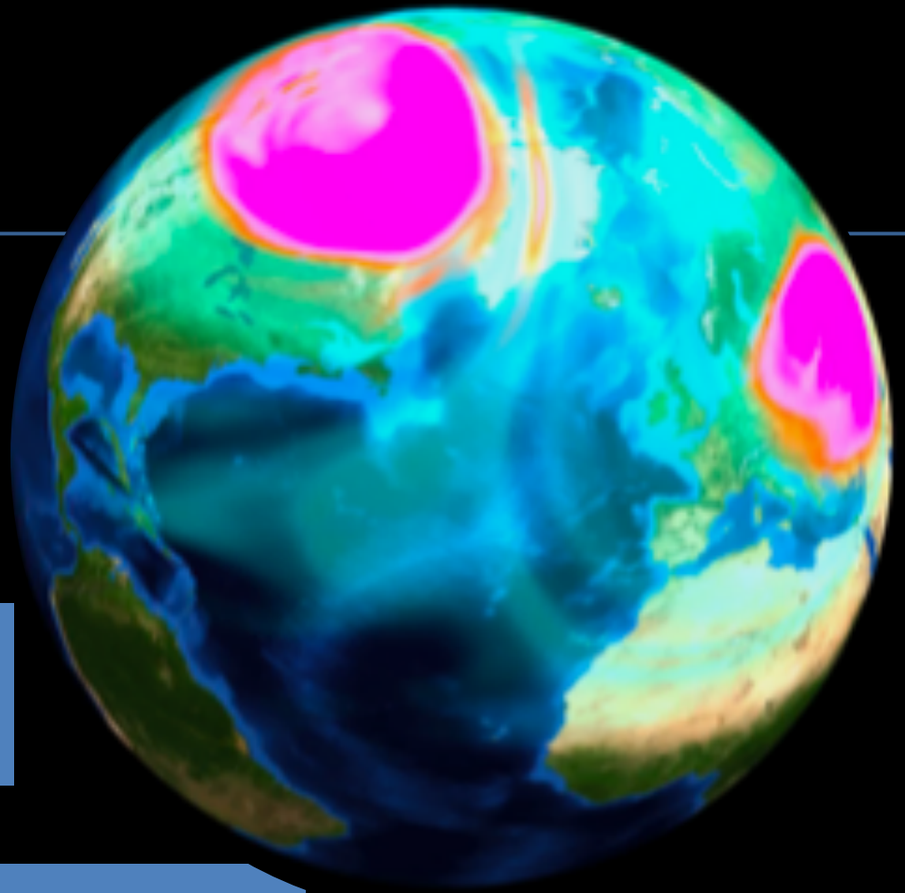
# Prospects for predicting the presence and timing of the surface response after stratospheric events

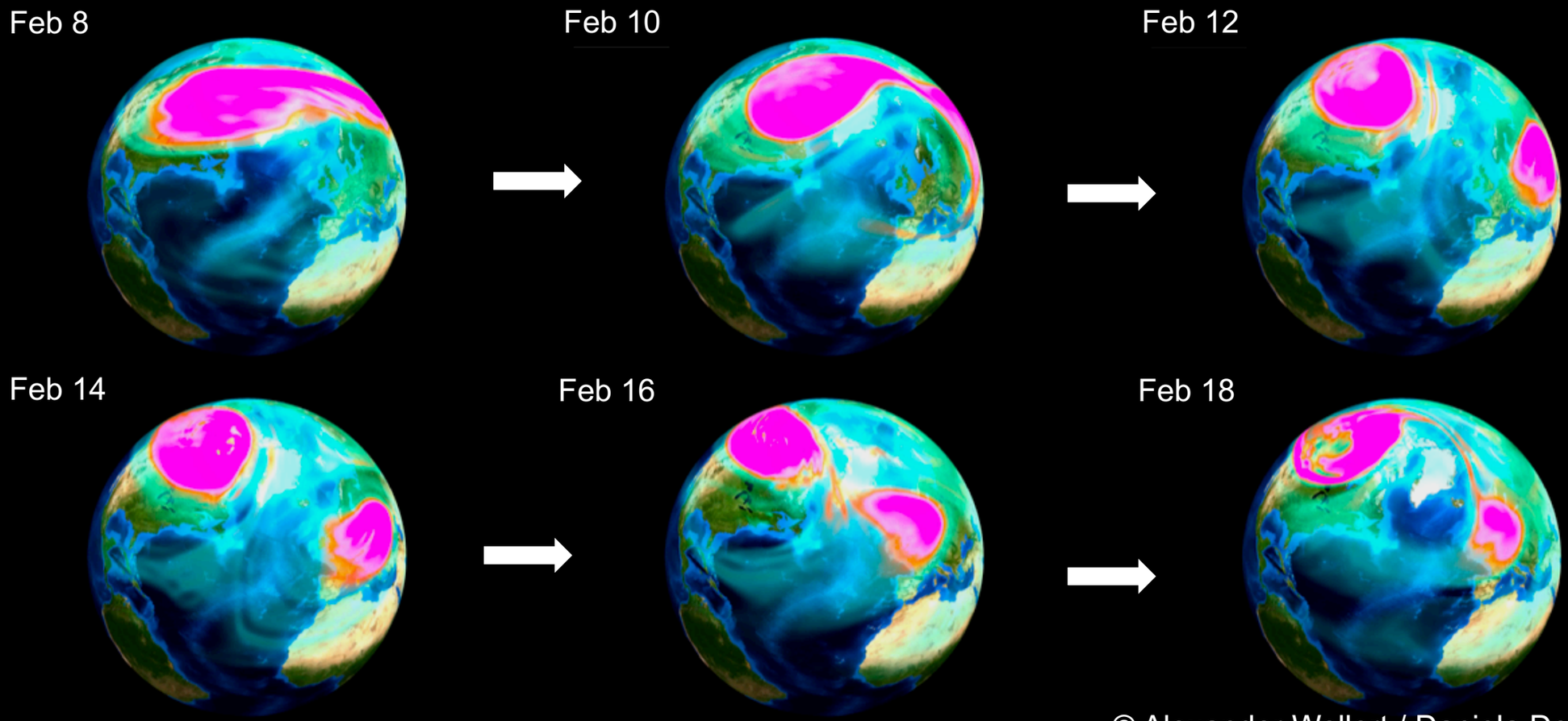


We may be able to better predict the existence, timing, and type of downward impact of sudden stratospheric warming events using several factors including lower stratospheric persistence, Pacific precursors, and tropospheric variability.

**Daniela Domeisen**
**Atmospheric Predictability, ETH Zurich**

with contributions from
Hilla Afargan-Gerstman, Johanna Baehr, Mikhail Dobrynin, Christian Grams, Lukas Papritz, Peter Hitchcock

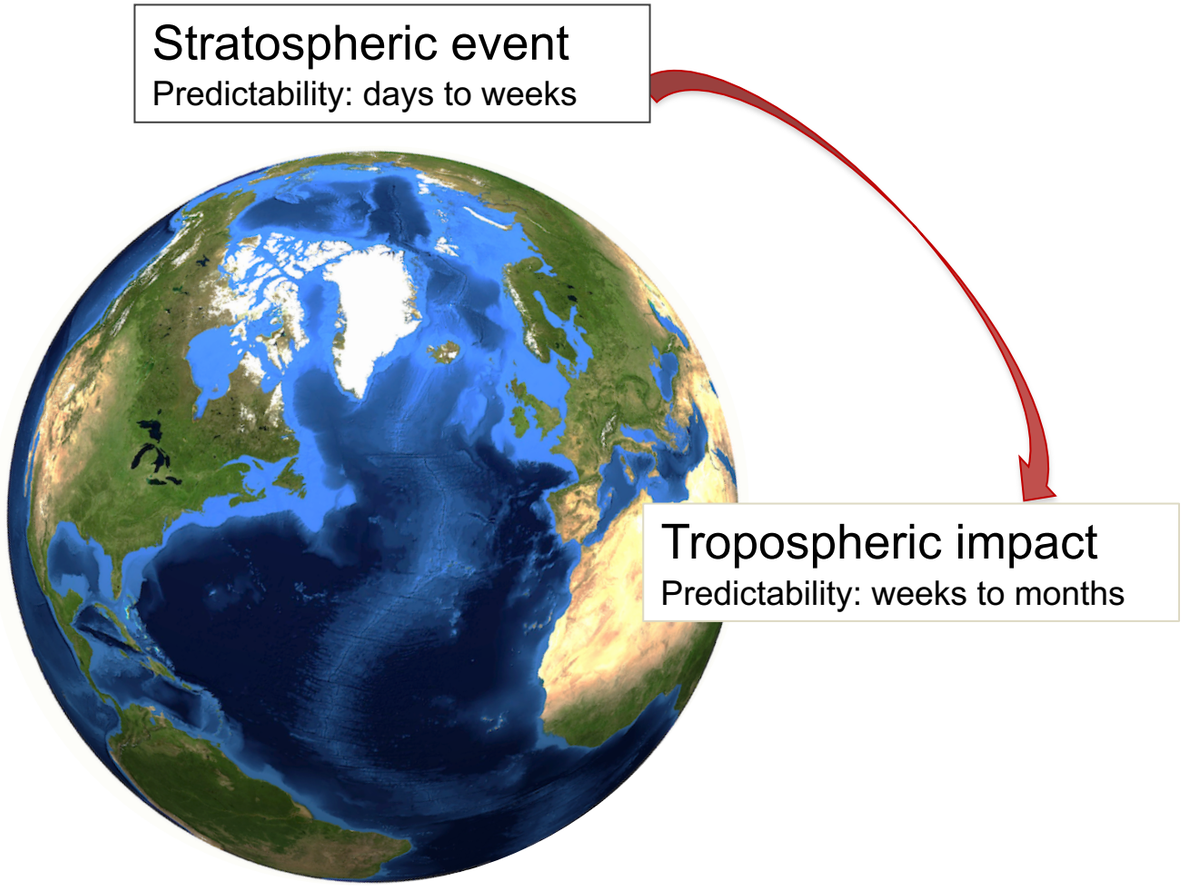
# THE SUDDEN STRATOSPHERIC WARMING EVENT ON FEBRUARY 12, 2018




Figures: potential vorticity at 10hPa during the 2018 SSW event

# THE SURFACE IMPACT OF THE STRATOSPHERE

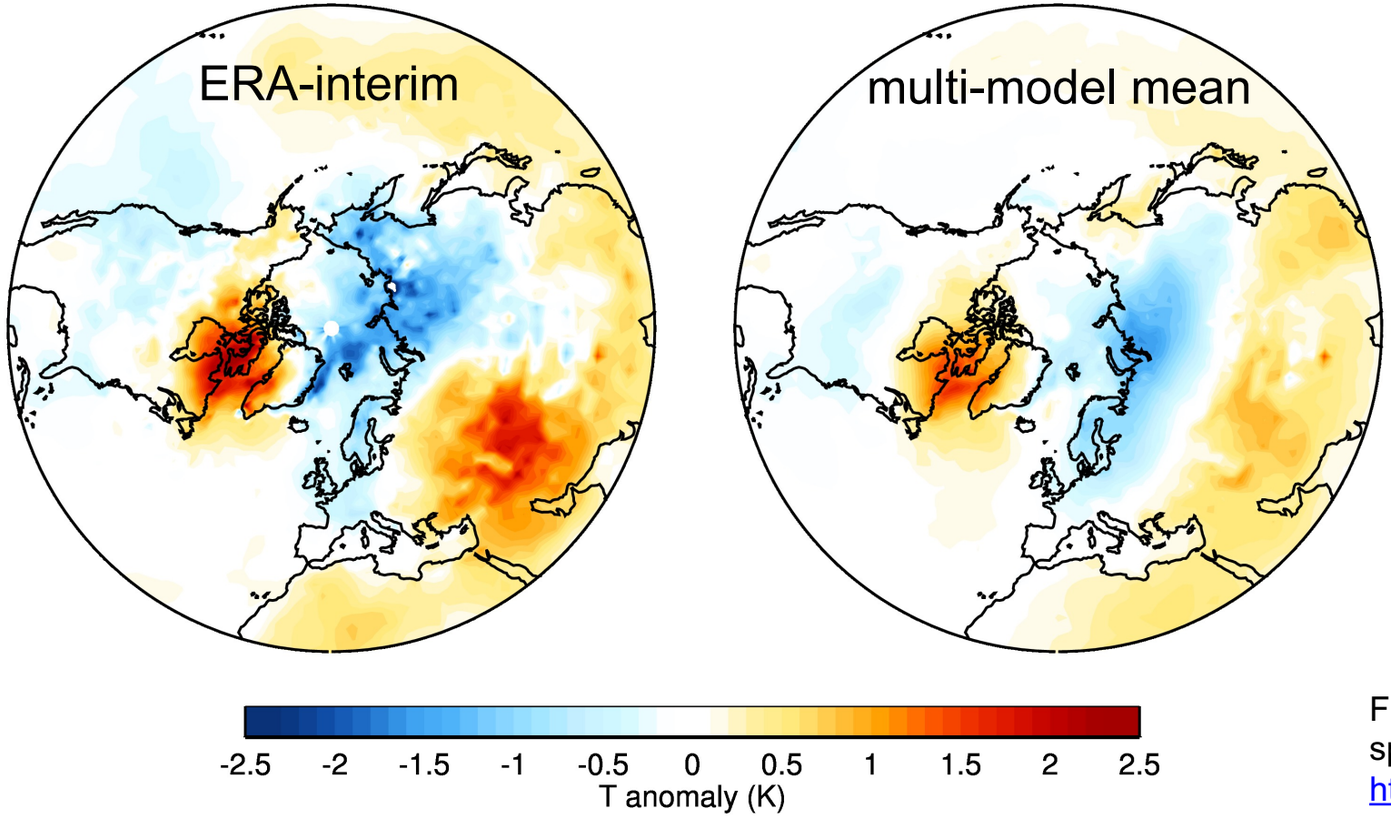
What determines the existence, timing, and persistence of the tropospheric impact of SSW events?



# WE CAN PREDICT THE GENERAL RESPONSE TO STRATOSPHERIC EVENTS

2m temperature anomaly (week 3 + 4) after weak vortex event:

Data: S2S prediction database: Vitart et al. (2017). BAMS. http://doi.org/10.1175/bams-d-16-0017.1




In general, there is a negative NAO response after SSW event.

Models tend to capture this response.

Figure: Domeisen et al., 2019, JGR special issue on S2S prediction. https://doi.org/10.1029/2019JD030923

# THE PERSISTENCE OF NEGATIVE NAO EVENTS INCREASES AFTER SSW EVENTS

Persistent positive NAO phase is suppressed after SSW event, while negative NAO phases tend to become longer

But: less than 25% of persistent NAO events in winter are indeed preceded by SSW events

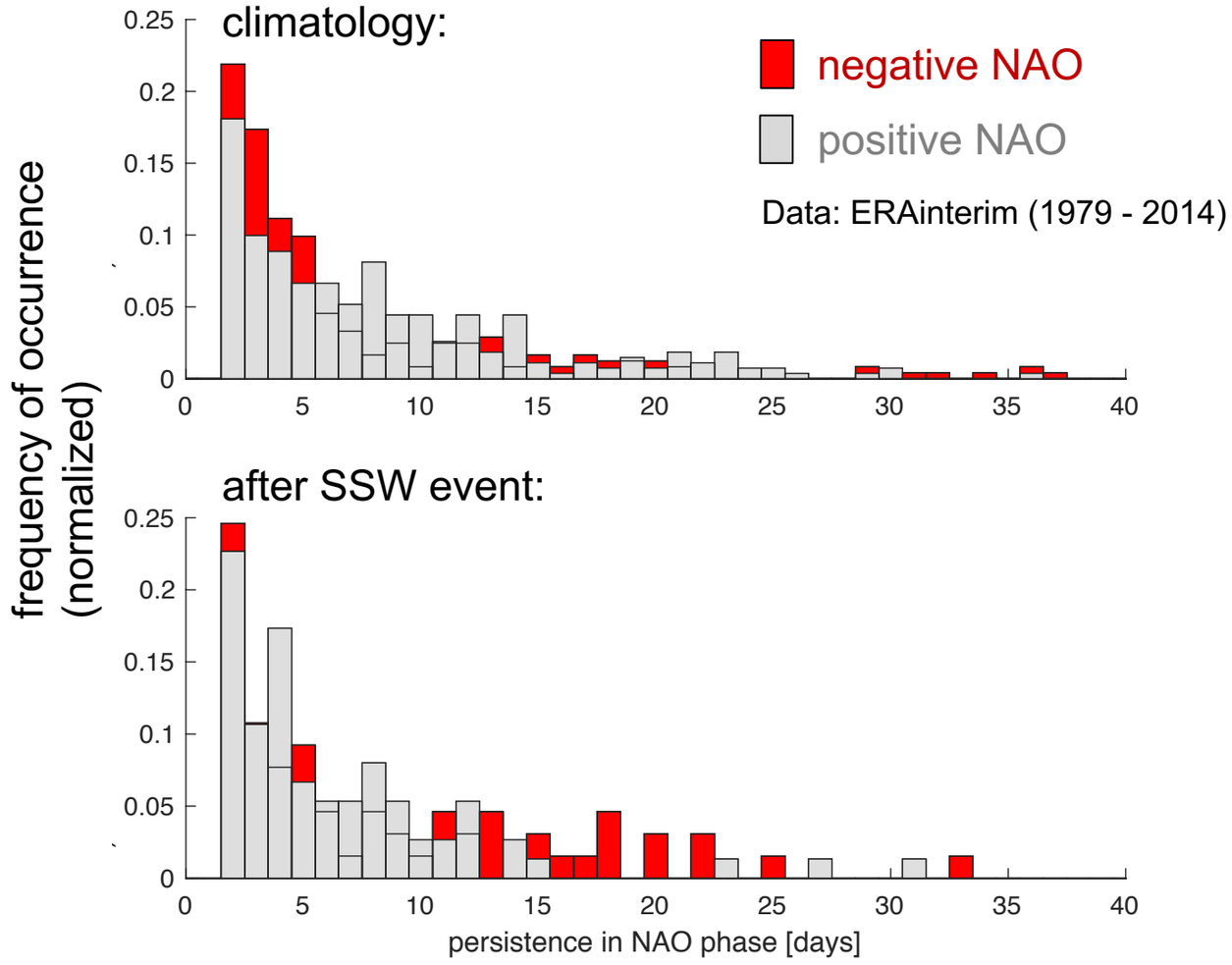



Figure: Domeisen, 2019. JGR-Atmospheres. https://doi.org/10.1029/2018JD030077

see also: Charlton-Perez et al (2018). *QJRMS*, http://doi.org/10.1002/qj.3280

# BUT NOT ALL SSW EVENTS EXHIBIT A “DOWNWARD IMPACT”

days 8 to 52 after SSW event

all SSW (24 events)

SSW followed by persistent NAO (14 events)

“downward impact”

SSW not followed by persistent NAO or switch to negative NAO (8 events)

“no downward impact”

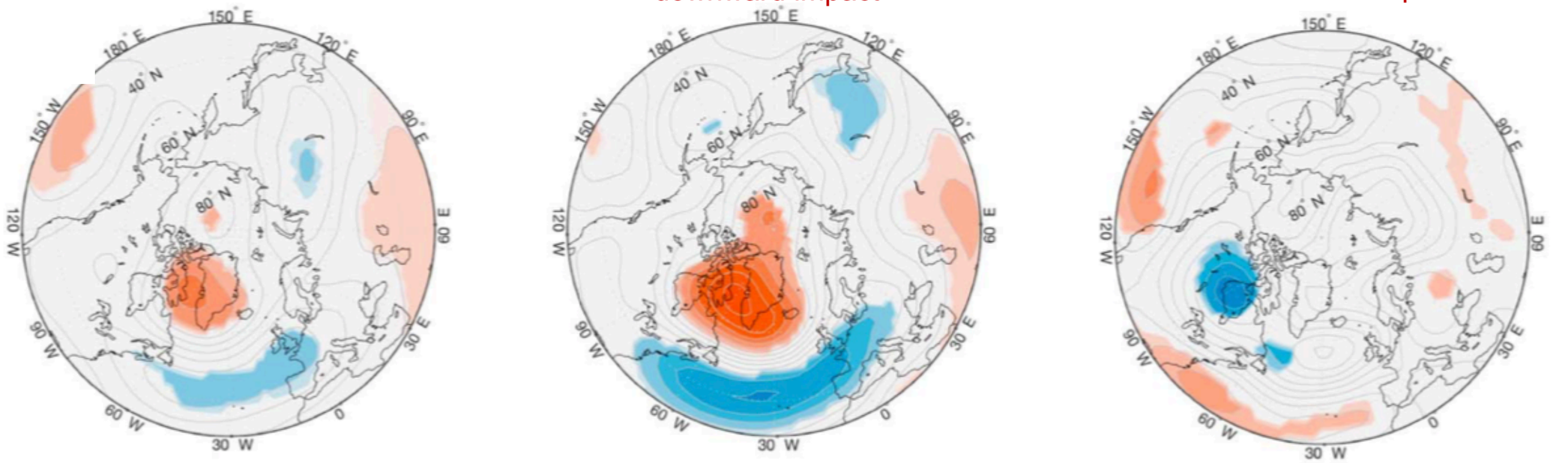



Figure: Domeisen, 2019. JGR-Atmospheres. https://doi.org/10.1029/2018JD030077

see also: Karpechko et al (2017). *QJRMS*, http://doi.org/10.1002/qj.3017

Contours: all anomalies
Shading: values significant at $p < 0.05$ level.



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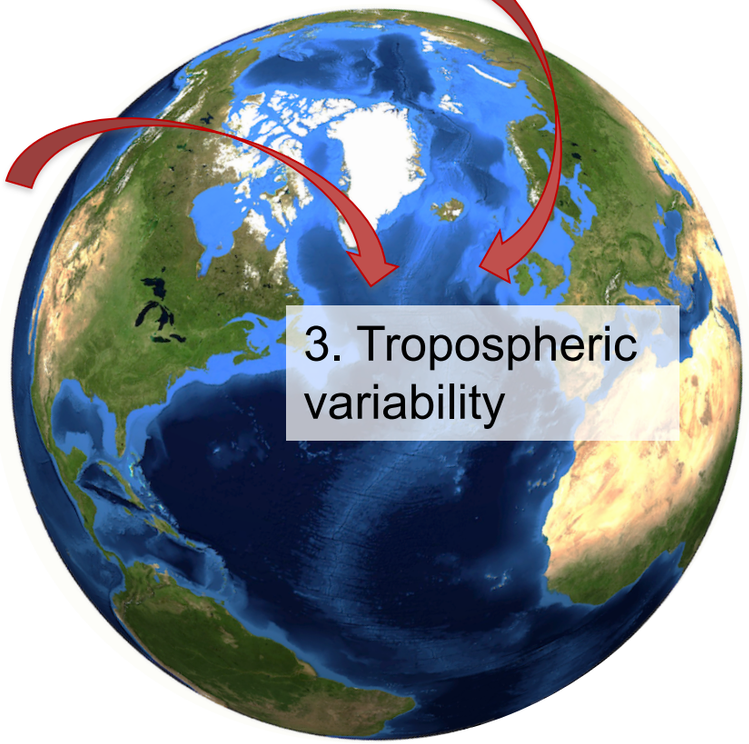
# WHAT MIGHT BE THE REASONS FOR THE VARIABILITY IN THE DOWNWARD IMPACT?

Considering 3 factors:

1. Lower stratospheric persistence

2. East Pacific forcing



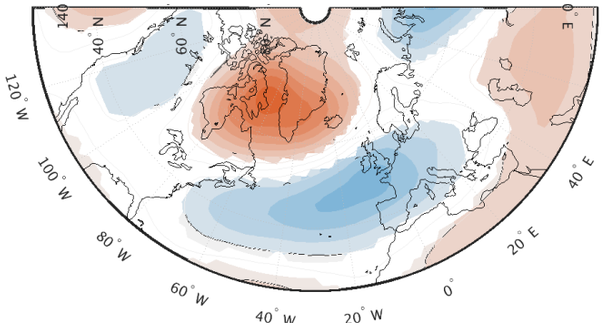
3. Tropospheric variability

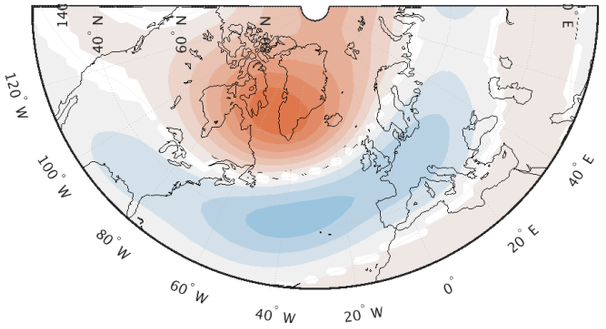
# 1. THE TROPOSPHERIC RESPONSE IS STRONGER AND MORE PERSISTENT FOR A PERSISTENT LOWER STRATOSPHERIC SIGNAL

**ERAinterim**
(32 SSW events)

**MPI-ESM seasonal prediction system**
(894 SSW events)

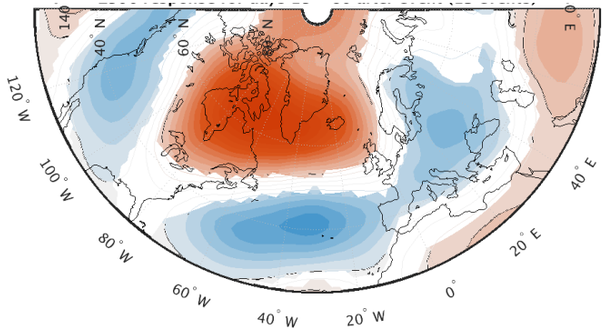
all SSW events



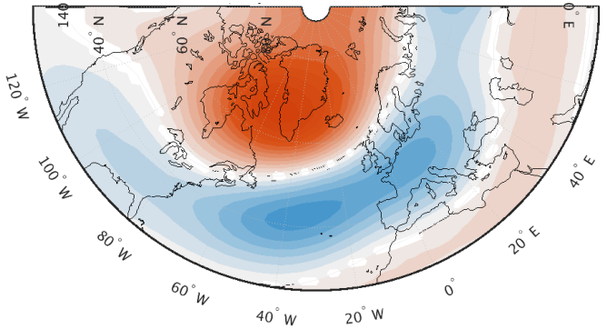


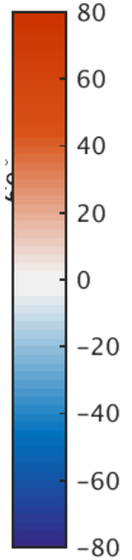
SSW events associated with a persistent lower stratospheric response

(13 persistent SSW events)



(403 persistent SSW events)






[m]

500hPa geopotential height anomaly for days 15 – 60 after an SSW event

Data: MPI-ESM seasonal prediction model: Baehr et al (2015). *Climate Dynamics*. http://doi.org/10.1007/s00382-014-2399-7

Figure: Domeisen, Hitchcock et al, in prep.



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# 2. EAST PACIFIC FORCING CAN MODIFY THE RESPONSE TO SSW EVENTS IN THE NORTH ATLANTIC

The opposite SSW responses in the North Atlantic storm track also exhibit opposite "precursors" in the eastern North Pacific.

The troposphere can have a strong impact on the manifestation of the downward response to SSWs.

see also: Garfinkel et al 2013, Chan & Plumb, 2009

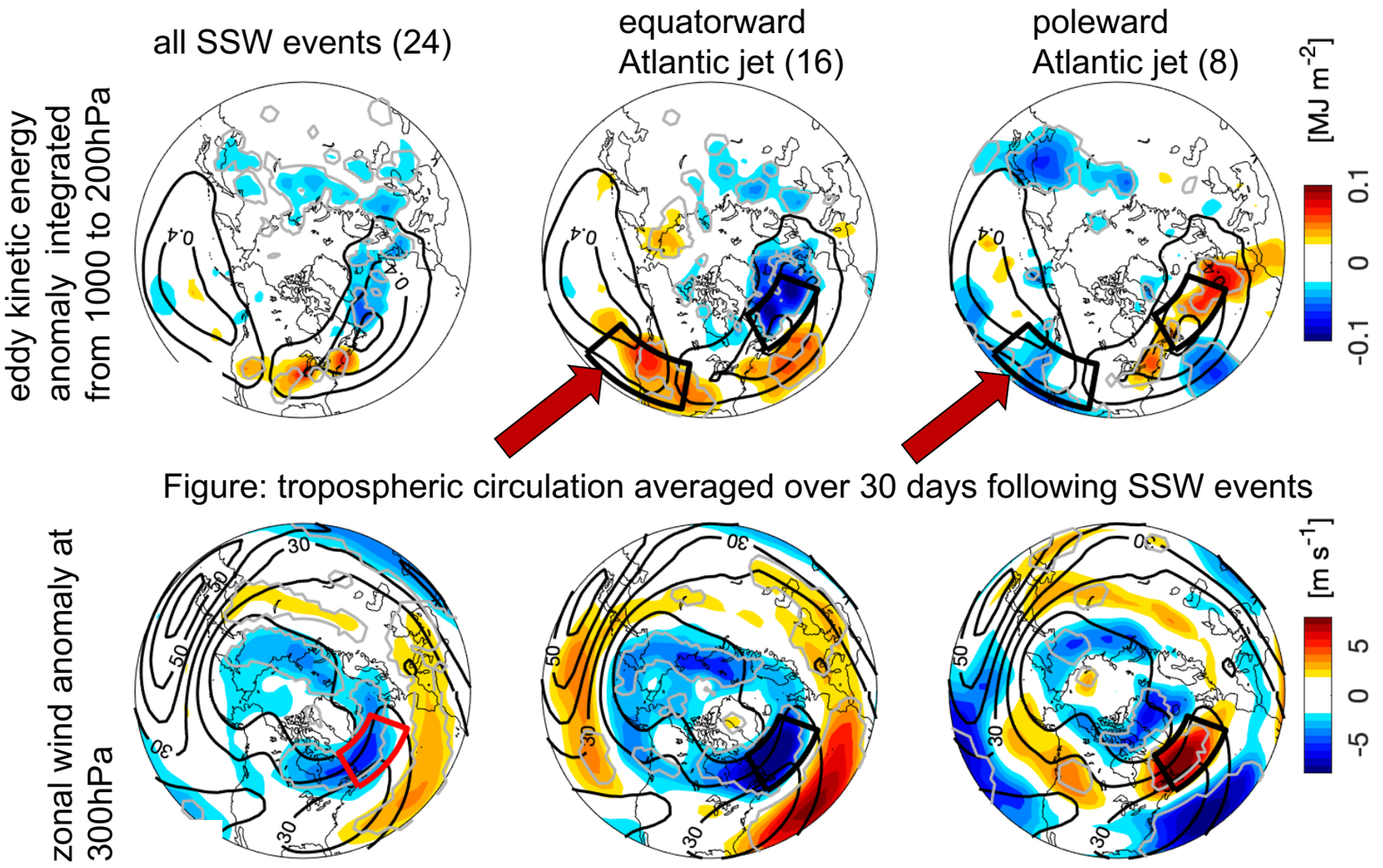


Figure: tropospheric circulation averaged over 30 days following SSW events

Fig: Afargan-Gerstman & Domeisen, GRL,2020.
https://doi.org/10.1029/2019GL085007



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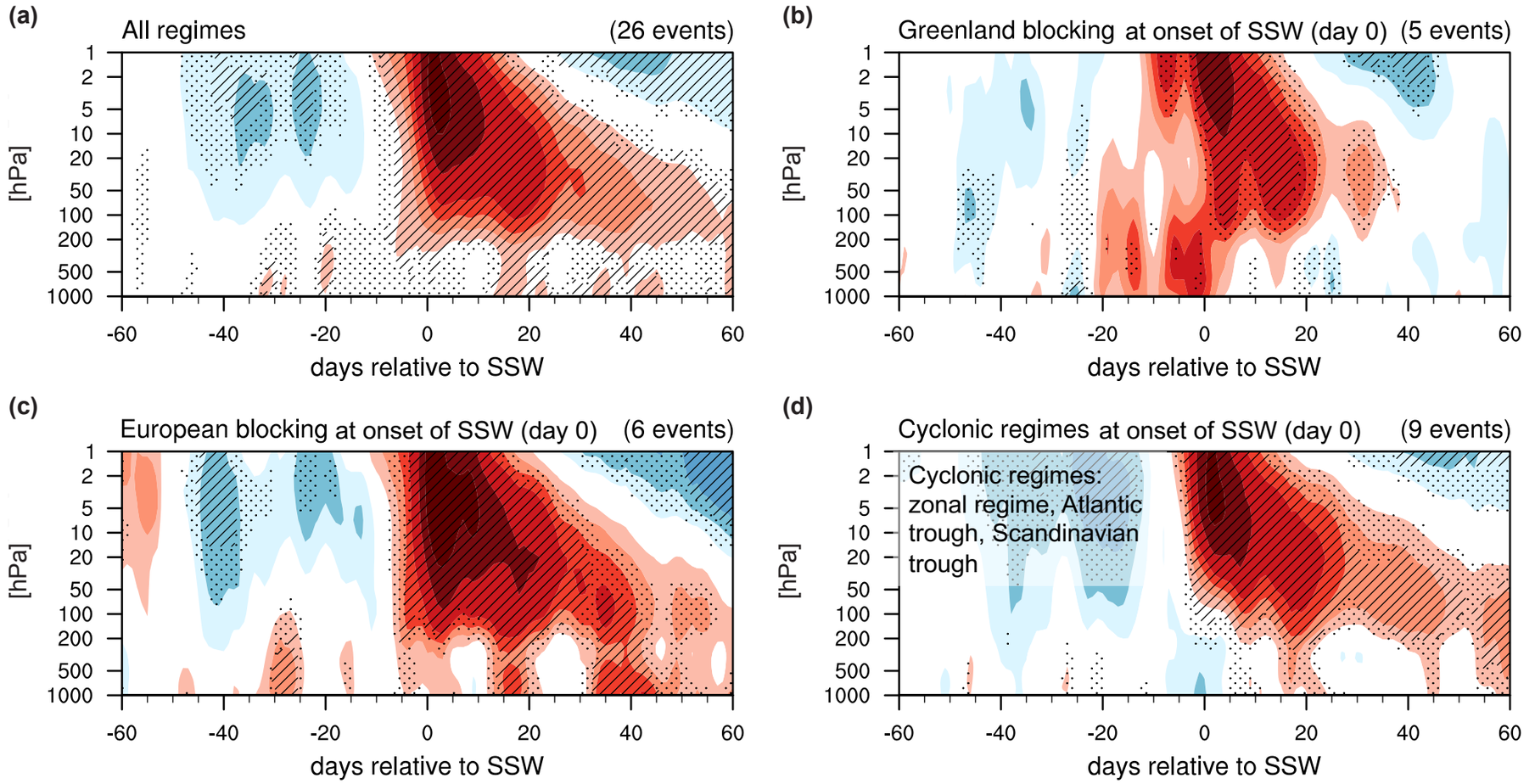
# 3. THE SURFACE IMPACT OF SSWS MAY DEPEND ON THE STATE OF THE TROPOSPHERE AT SST ONSET

description of weather regimes: see appendix




The events with a strong "downward impact" are dominated European blocking at the onset of the SSW.
These events favor a transitioning into Greenland blocking, the "canonical response" to SSWs.

Units: Standard deviation of geopotential height anomalies for Atlantic sector. Hatching (stippling): confidence intervals and the random distributions overlap by less than 25% (10%).

Figure: Domeisen, Grams, Papritz, Weather and Climate Dynamics Discussions. https://www.weather-clim-dynam-discuss.net/wcd-2019-16/wcd-2019-16.pdf



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# SUMMARY

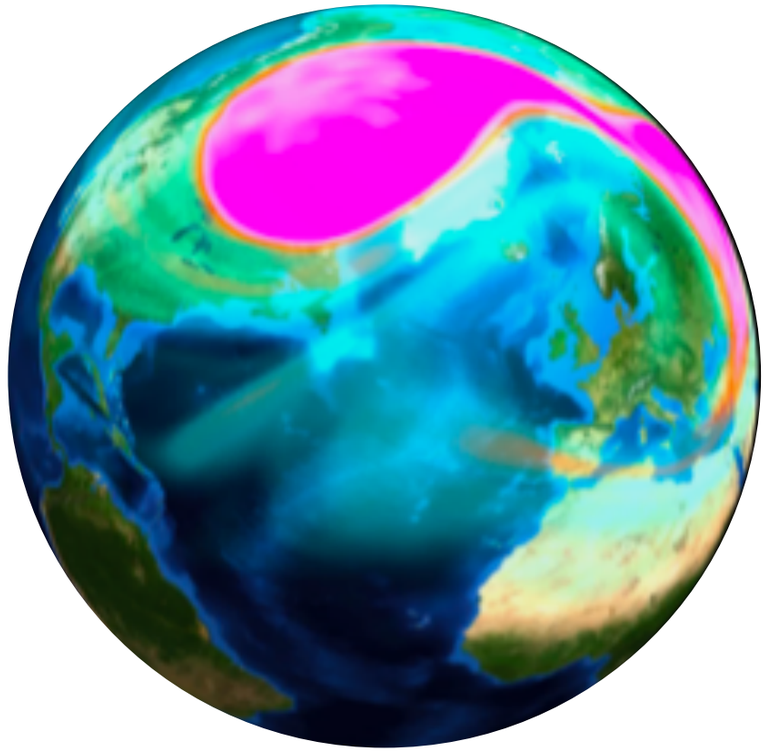
Not all stratospheric events have the same surface impact:

- About two thirds are followed by a negative NAO response and an equatorward shift of the jet over the North Atlantic.
- About one third of events show a poleward jet shift and a positive NAO response.

A reliable prediction of the downward response is currently only possible in a statistical sense but not for individual events.

The response depends on the state of the troposphere at the time of the stratospheric event, the persistence of the signal in the lower stratosphere, and the upstream forcing in the East Pacific.

A better understanding of these factors will allow for improved predictions on sub-seasonal to seasonal timescales.



# APPENDIX: WEATHER REGIMES

Cyclonic regimes: the Zonal regime (ZO), the Atlantic Trough (AT) regime with cyclonic activity shifted towards western Europe, and the Scandinavian Trough (ScTr) regime.

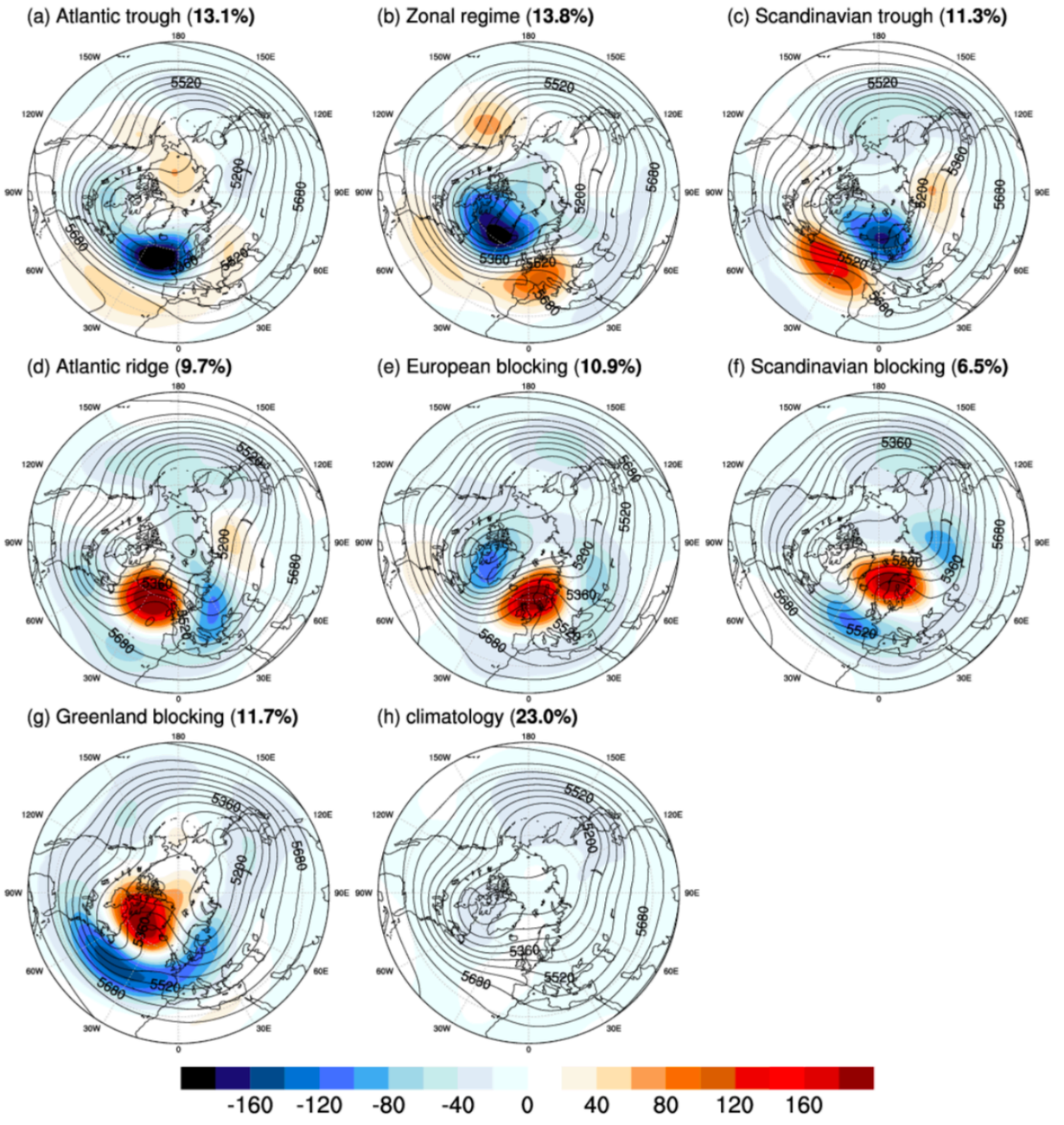



Figure: Domeisen, Grams, Papritz,
Weather and Climate Dynamics Discussions.
https://www.weather-clim-dynam-discuss.net/wcd-2019-16/wcd-2019-16.pdf