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Assessing the role of internal variability in Northern Europe winter temperatures at near-term (2020-2040) using a storyline approach

(Liné et al. to be submitted)

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Multi-annual to decadal Climate Predictability in the North Atlantic-Arctic Sector

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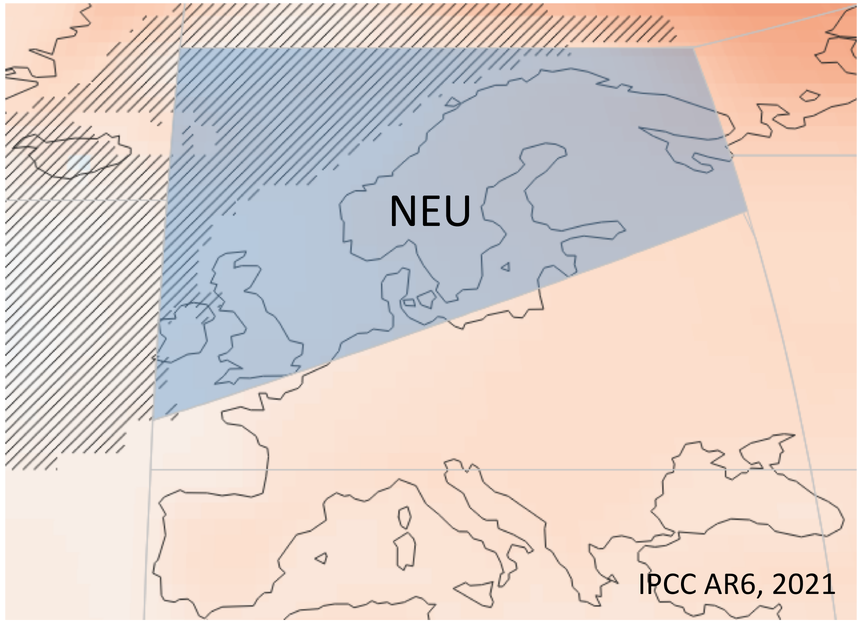
Northern Europe context



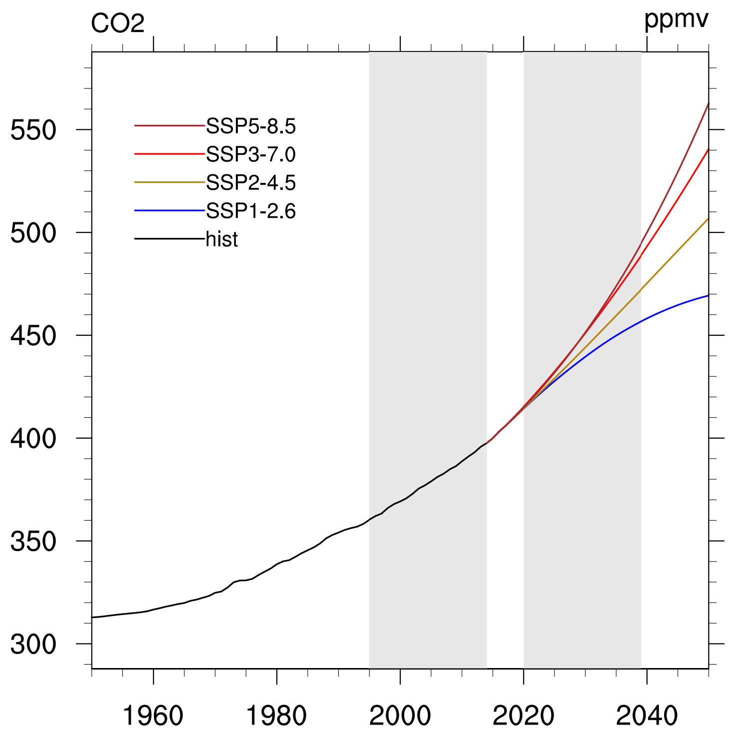
- Over the next 20 years, warming over Northern Europe will continue, with an amplitude of between 0.9 and 1.2°C depending on the anthropogenic forcings scenario (AR6 IPCC, 2021).
- Behind these forced average values (signal) lies a large internal variability (noise). Therefore, it is extremely important to evaluate the full range of outcomes for adaptation to climate change (Deser et al. 2012).
  - *Natural drivers and internal variability will modulate human-caused changes, especially at regional scales and in the near term, with little effect on centennial global warming. These modulations are important to consider in planning for the full range of possible changes.* (AR6 IPCC, SPM, 2021)

Objective

Better understand and possibly constrain
the uncertainty associated with internal variability

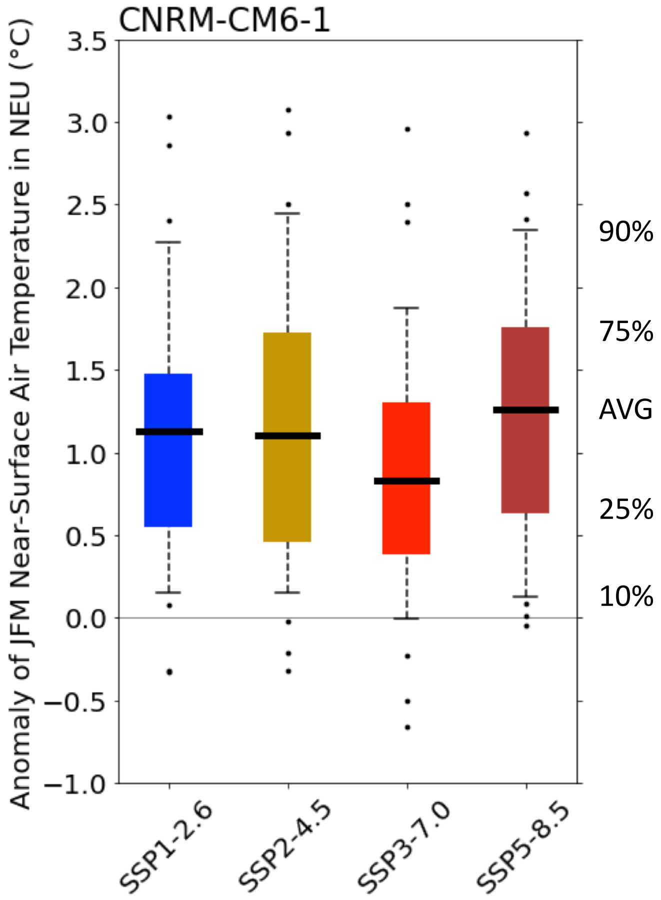
Tools and framework

- Numerical simulation
  - 1 model: CNRM-CM6-1 (Voldoire et al., 2019),
  - 4 scenarios: Tier 1 SSP (O'Neill et al., 2016),
  - 30 members per set
- The focus is on winter, as it is the season where internal variability has the highest weight over Northern Europe
- Near-term (2020-2039) is compared to present days (1995-2014)



Global concentration of carbon dioxide, during the common historical period (black), then according to the scenario (colours)

Near-term Northern Europe winter temperature change



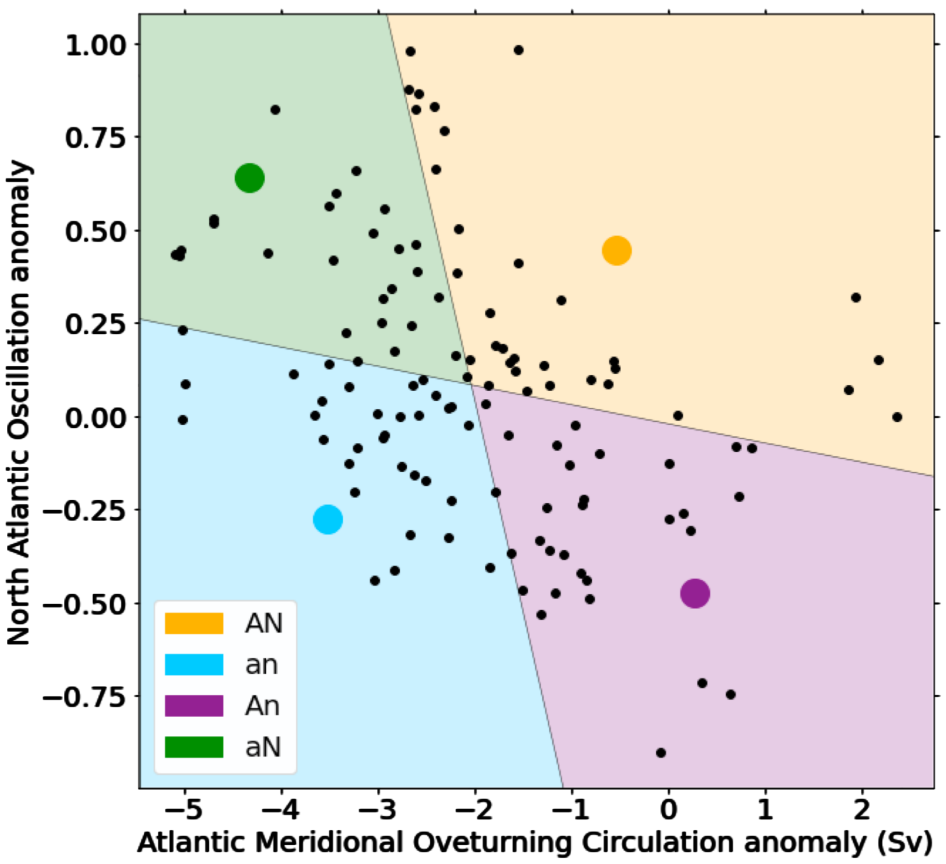
Distribution of anomalies (2020-2039 – 1995-2014) of NEU TAS in JFM as a function of scenario

Scenario	Warming	SNR
SSP1-2.6	+1.1°C [0.15 : 2.27]	0.54
SSP2-4.5	+1.1°C [0.15 : 2.45]	0.55
SSP3-7.0	+0.8°C [-0.00 : 1.87]	0.42
SSP5-8.5	+1.3°C [0.13 : 2.34]	0.64

Can drivers of internal variability help to understand this uncertainty?

Construction of storyline families based on internal variability drivers

Anomalies of NAO according to anomalies of AMOC for the 120 members



Drivers of internal variability of winter temperature in Northern Europe:

- Atlantic Meridional Overturning Circulation, AMOC (Tietsche et al., 2020)
- North Atlantic Oscillation, NAO (Wang et al., 2017)

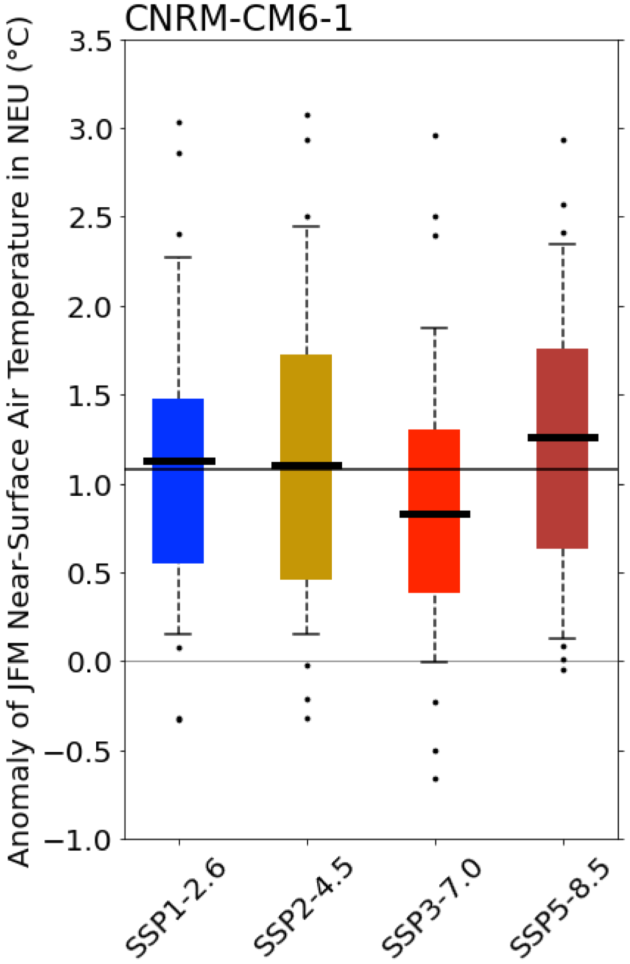
Identification of 4 physical trajectories:

- AN: AMOC remains stable — positive NAO
- an: AMOC declines — negative NAO
- An: AMOC remains stable — negative NAO
- aN: AMOC declines — positive NAO

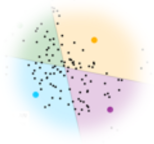
What are the warming levels associated to these families?

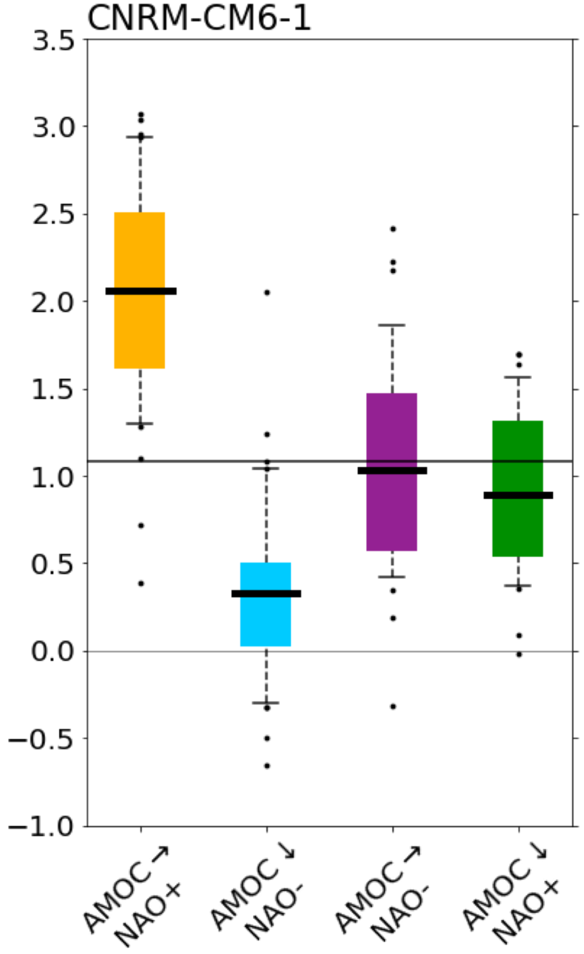
Method adapted from Zappa and Shepherd, 2017

Better understanding of uncertainty via the storyline classification



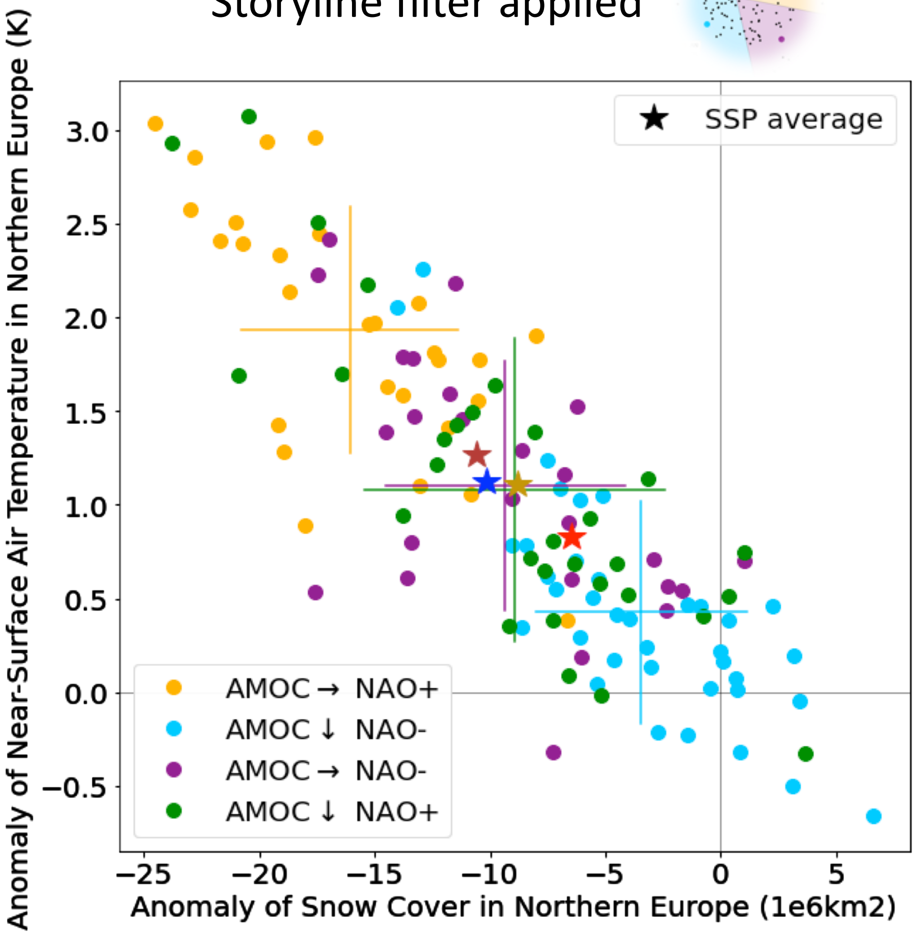
Storyline filter





Snow cover anomalies in our storylines

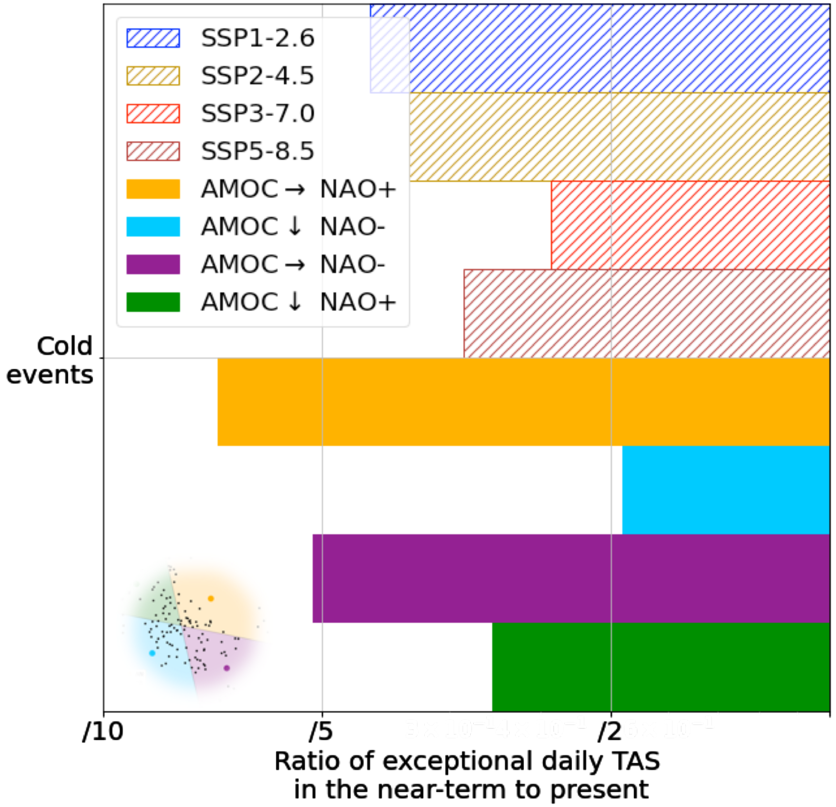
Storyline filter applied



- High correlation between temperature and snow cover in Northern Europe
- The storyline filter again allows a better differentiation of climates than the 4 scenarios

Sensitivity of extreme events frequency

Changes in frequency of extreme daily cold events
as a function of scenario and storyline



Exceptional cold event: 1st percentile of daily temperature in January-February-March (defined during the present-day period)

- The scenarios become discriminating when it comes to differentiating the extremes
- But families are even more discriminating

Conclusion

The storyline classification of members from the grand ensembles allowed a better partition of the temperature uncertainty at near-term

- While the scenarios have common average warming and high uncertainty, the storyline families have distinct warming with less uncertainty
- The storyline filter allows to have several physical climate trajectories, where, in addition to studying temperature changes, one can study the links with other quantities (snow, precipitation, wind)
- The different trajectories result in some very marked changes in extreme events, far from the averages of the large SSP ensembles

Therefore, it is absolutely essential to take internal variability into account in impact assessments in order to adapt to local climate change in the coming decades

Perspectives

- Use of other models to test the model uncertainty
- Use of observations to constrain storylines: probabilise them to provide a forecast