Climate predictive drivers for the Mediterranean region

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Overview

Winter

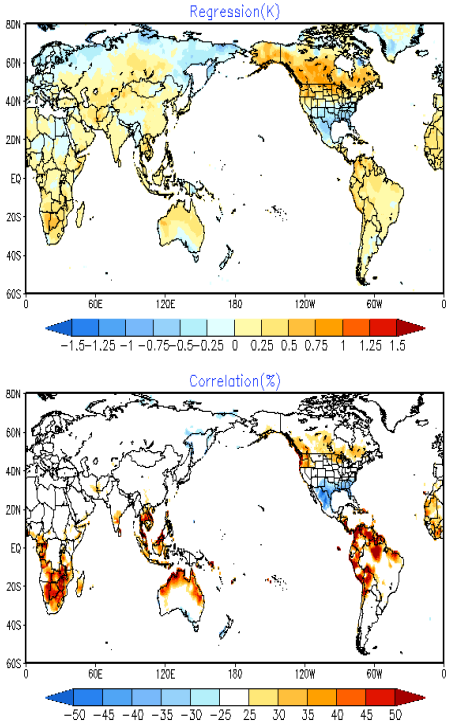
- Internal sources of predictability (predictability due to slower varying conditions at tropospheric boundaries)
  - SSTs
    - Tropical SSTs
      - ✓ ENSO
      - ✓ Tropical Atlantic Variability
    - Decadal variability in oceans (PDO and AMOC)
    - North Atlantic
      - ✓ Lagged SSTs (Previous May SSTs, related to NAO/AO predictability)
  - Previous October/Autumn snow cover (winter NAO/AO related predictability)
  - Arctic Sea ice (winter NAO/AO related predictability)
  - Stratosphere (polar vortex and QBO – NAO/AO related predictability)
- External sources of predictability
  - Global warming (trends)

Summer

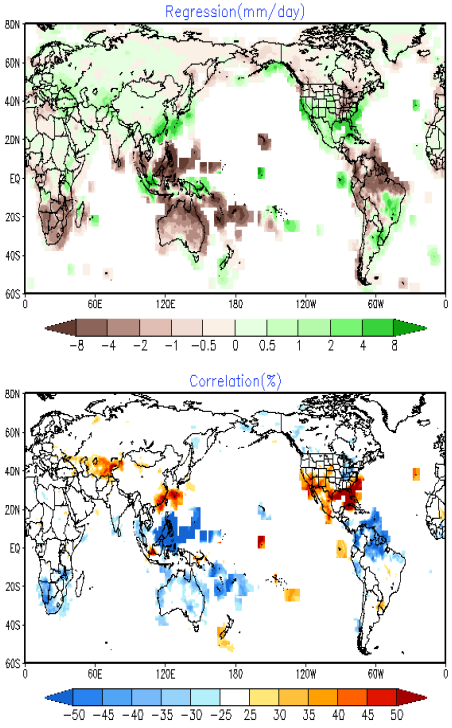
- Internal sources of predictability (predictability due to slower varying conditions at tropospheric boundaries)
  - SSTs
    - Tropical SSTs
      - ✓ ENSO
      - ✓ Tropical Atlantic Variability
    - *Decadal variability in oceans (PDO and AMOC)*
    - No robust signal from extratropical SSTs (e.g. in North Atlantic) for and in the summer.
  - Snow cover in previous cold season (soil moisture related predictability)
  - Summer NAO – related predictability
  - No stratosphere-troposphere connection in summer (due to atmospheric dynamics constraints)
- External sources of predictability
  - Global warming (trends)

ENSO

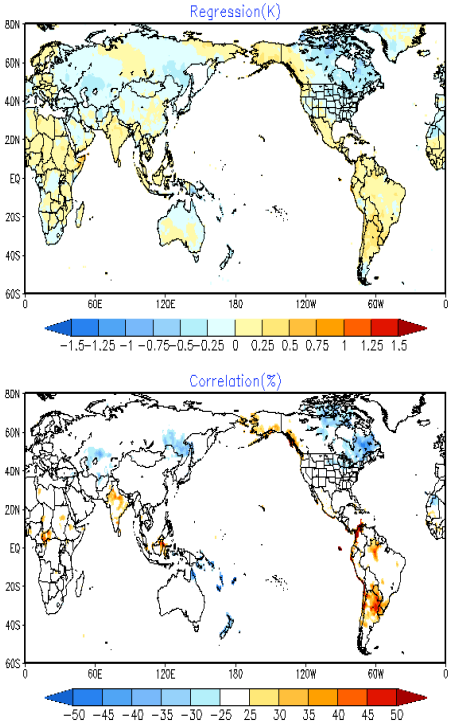
ENSO Teleconnection: JFM Temp



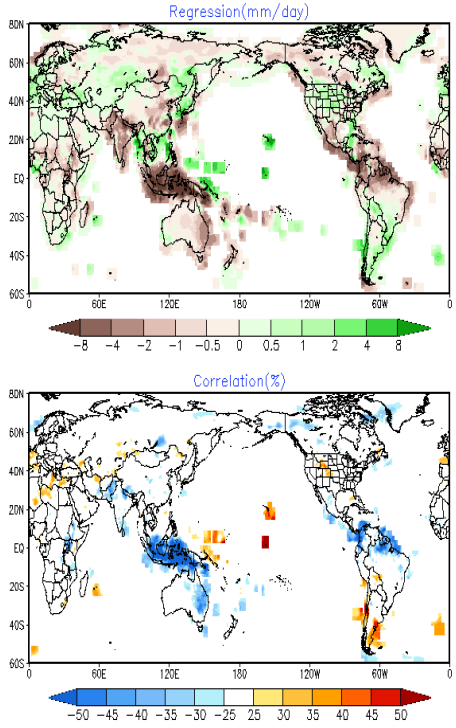
ENSO Teleconnection: JFM Precip



ENSO Teleconnection: JJA Temp



ENSO Teleconnection: JJA Precip

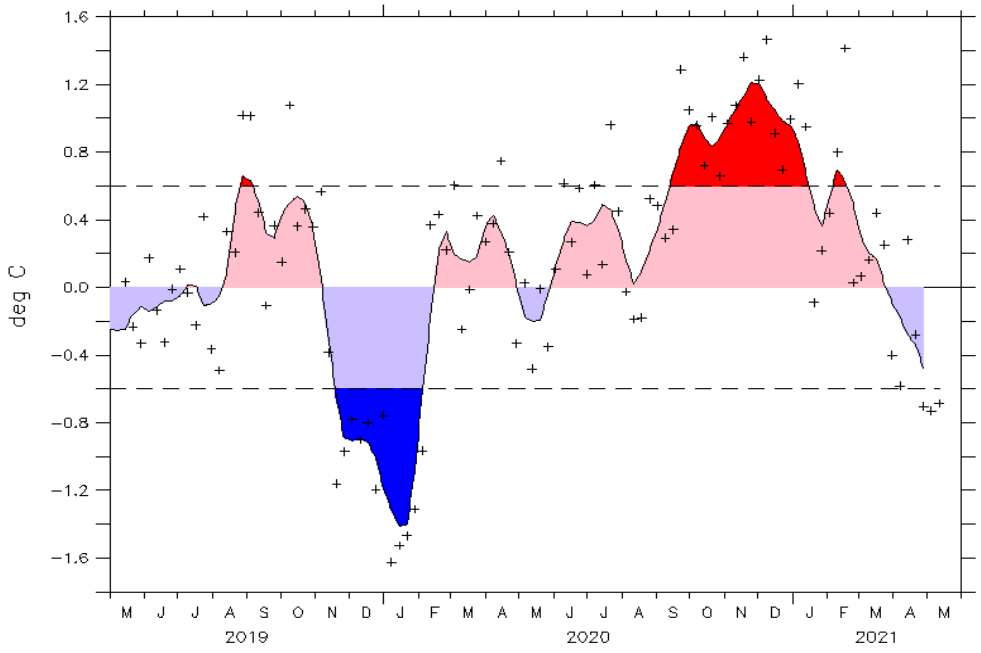


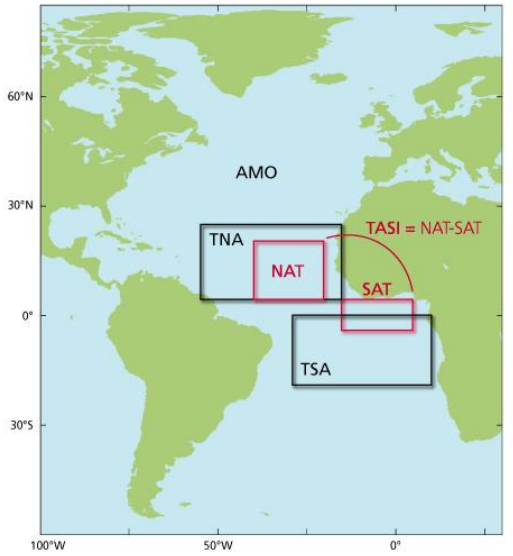
Sources:
https://www.cpc.ncep.noaa.gov/products/precip/CWlink/ENSO/regressions/

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

Tropical Atlantic Variability

The TASI SST anomaly index is an indicator of the meridional surface temperature gradient in the tropical Atlantic Ocean. It is calculated as the difference of the NAT and SAT indices.





Source: https://stateoftheocean.osmc.noaa.gov/sur/atl/tasi.php

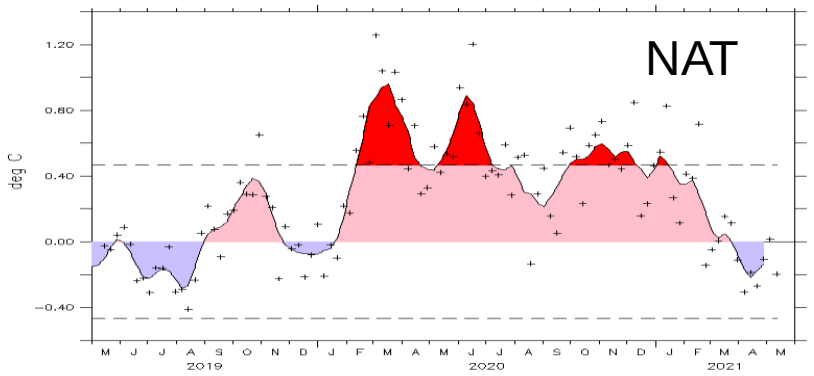
NAT and TNA phase

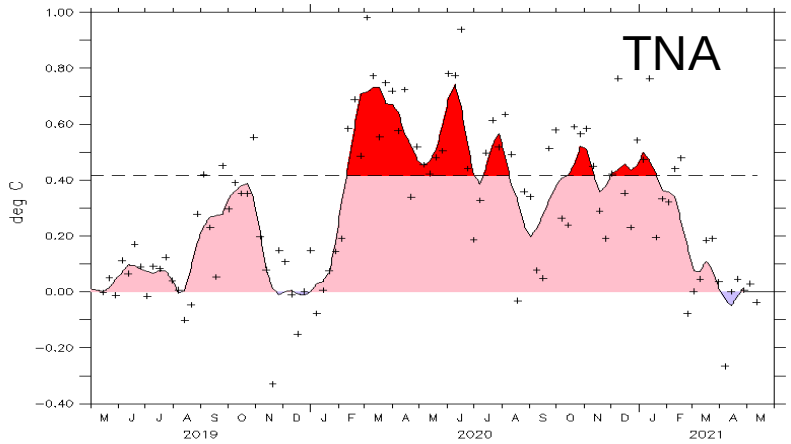
The TNA and TSA indices were defined in a paper by Enfield et al. (JGR, 1999), where dipolar patterns across the tropical Atlantic were found with a periodicity of 8-12 years for the boreal winter-spring, and 2.3 years for the boreal summer-fall.

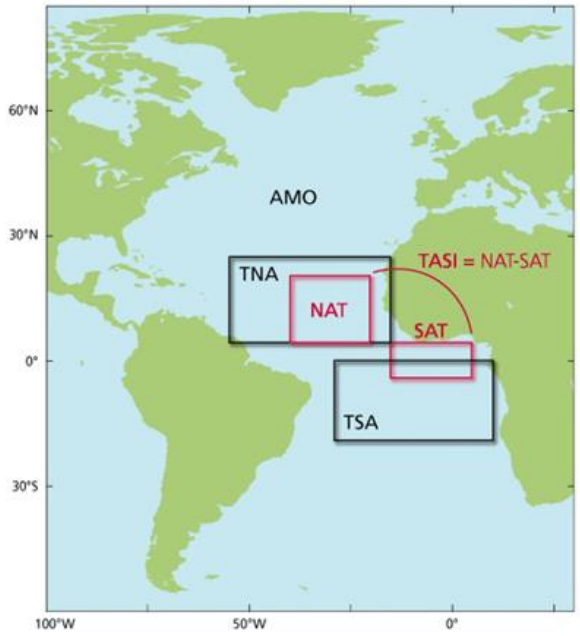
Enfield et al., Journal of Geophysical Research Atmospheres ,1999, DOI: 10.1029/1998JC900109

The NAT and SAT indices were defined in a paper by Chang, Ji, and Li (Nature, 1997), where they were associated with a potential decadal 'dipole' mode of coupled variability in the tropical Atlantic

Chang et al., Nature, 1997, https://doi.org/10.1038/385516a0



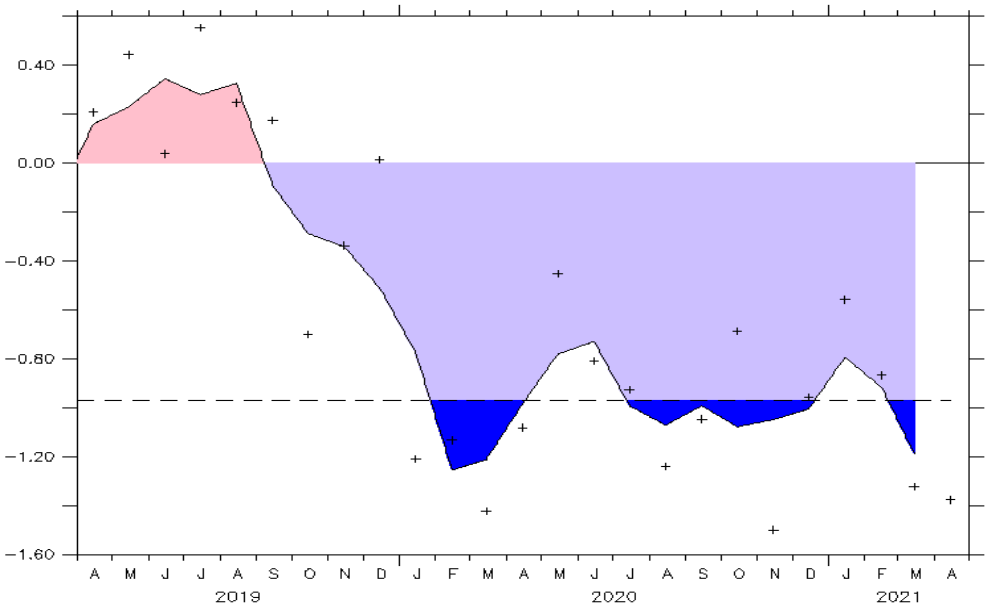




Source: https://stateoftheocean.osmc.noaa.gov/sur/atl/nat.php
https://stateoftheocean.osmc.noaa.gov/sur/atl/tna.php

PDO phase

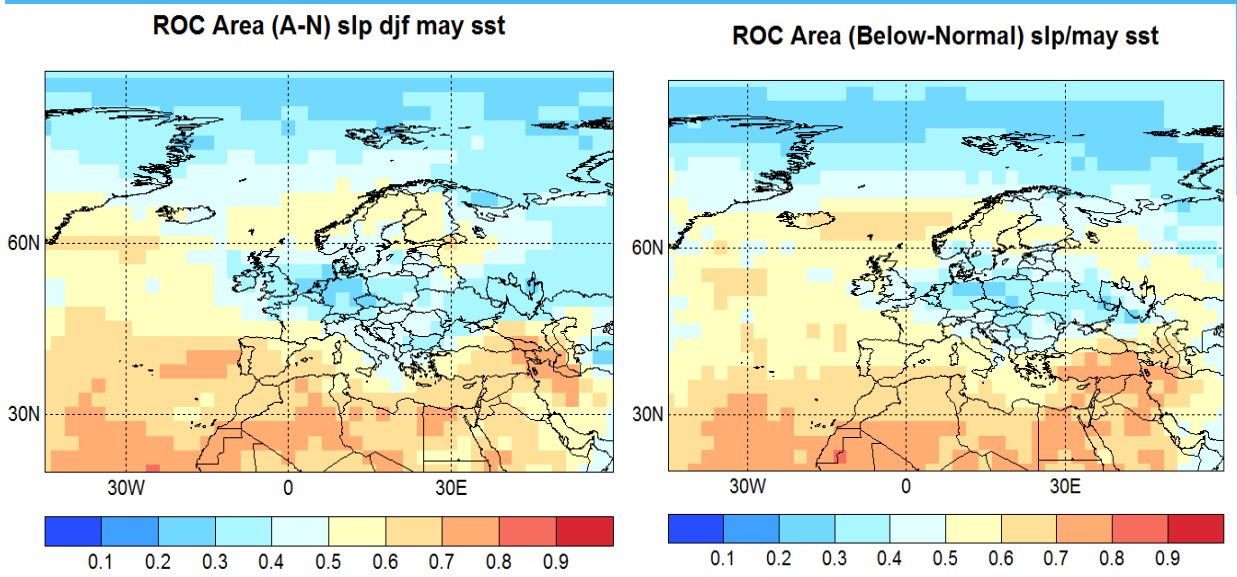
The Pacific Decadal Oscillation is a pattern of climate variability with a similar expression to El Niño, but acting on a longer time scale, and with a pattern most clearly expressed in the North Pacific/North American sector – related to PNA pattern which can be also linked with atmospheric variability over North Atlantic (related to AO/NAO). The way in which ENSO connects to extratropics (e.g. via PDO) and how extratropics players (comprised of the North Atlantic/Arctic Oscillation - NAO/AO, Stratospheric Polar Vortex, and the Pacific Decadal Oscillation - PDO) (nonlineary) interact define the weather we experience especially in the winter.



Source: http://stateoftheocean.osmc.noaa.gov/atm/pdo.php

Lagged SSTs (May SSTs)

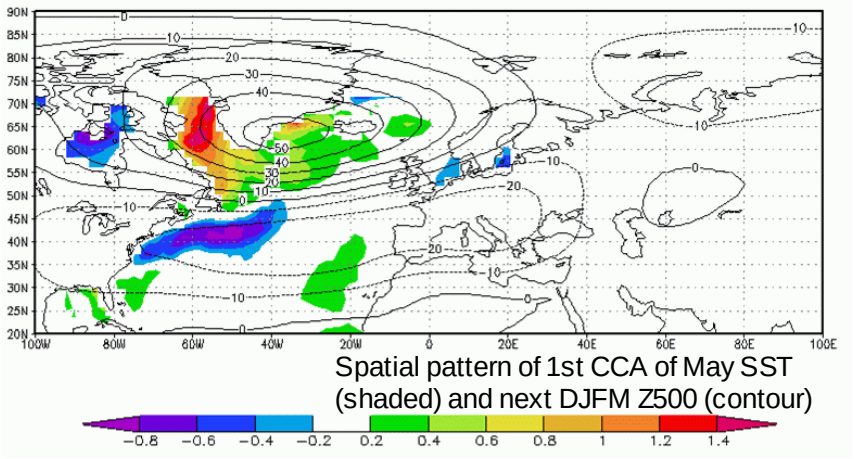
Predictabily especially from subtropical SSTs –NAT and TNA might be involved.



References:

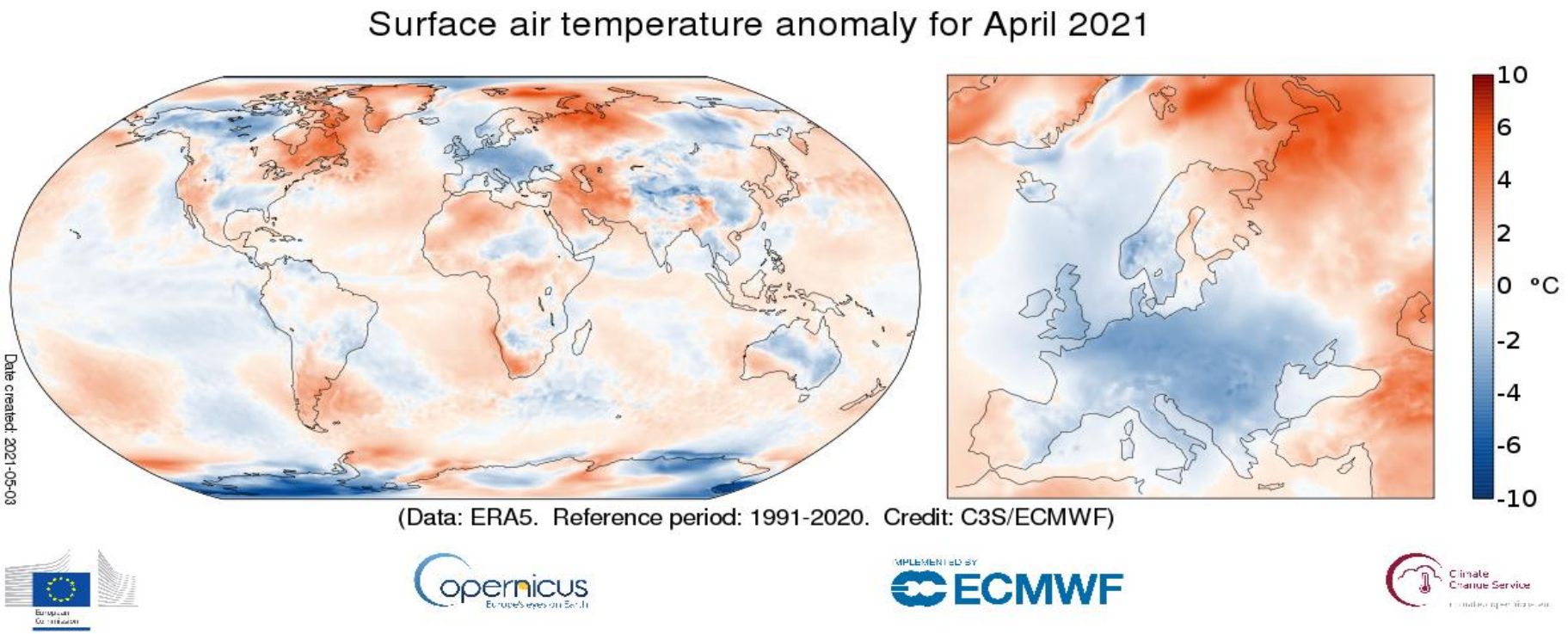
Rodwell, M. J., D. P. Rowell, and C. K. Folland, 1999: Oceanic forcing of the wintertime North Atlantic oscillation and European climate. Nature, 398, 320-323.

Bojariu, R., L.Gimeno, 2003: Predictability and numerical modelling of the North Atlantic Oscillation. Earth Science Reviews, Vol 63/1-2, 145-168.



Spatial pattern of 1st CCA of May SST (shaded) and next DJFM Z500 (contour)

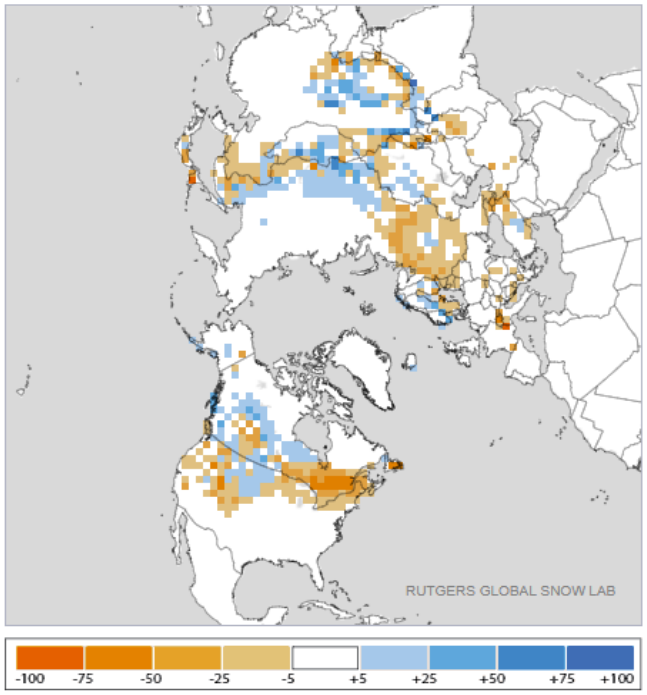
Global warming



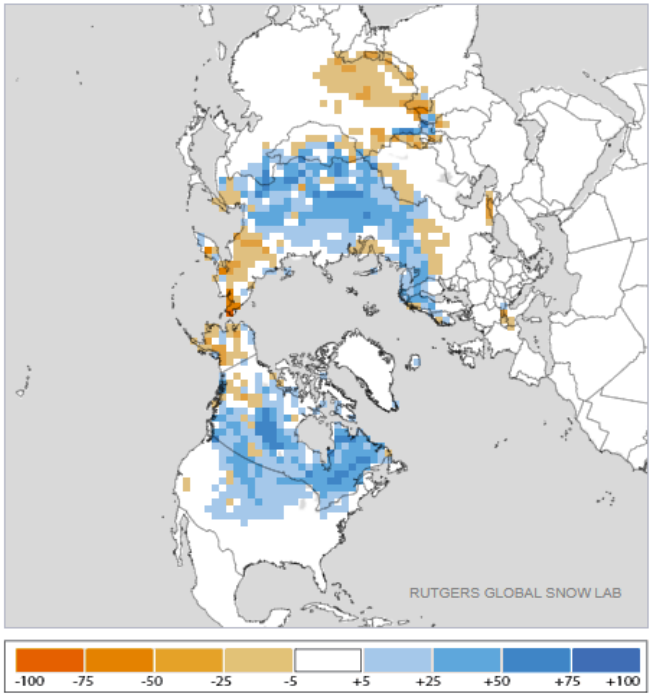
https://climate.copernicus.eu/surface-air-temperature-april-2021

Snow-cover signal

Departure from Normal - April 2021

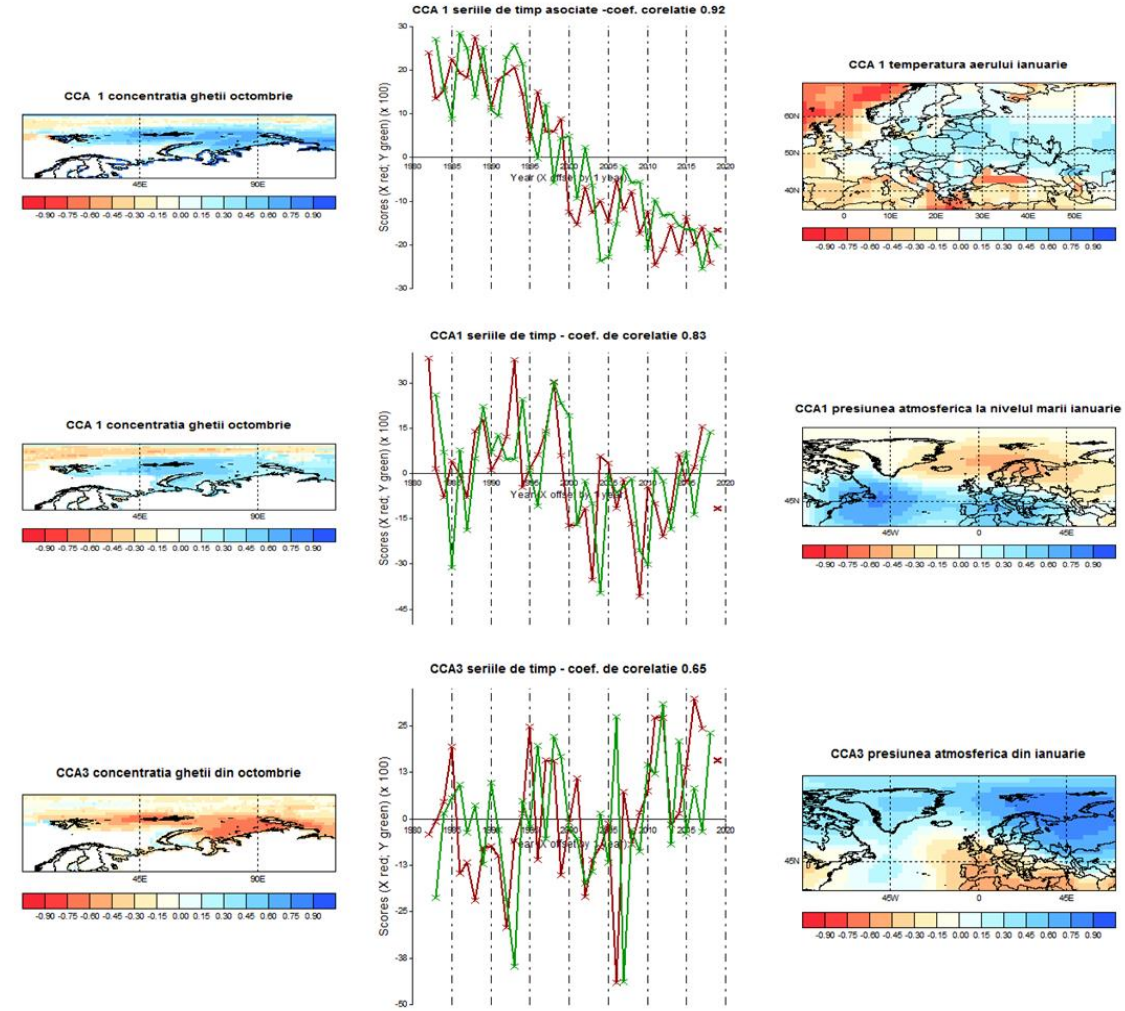


Departure from Normal - October 2020



Source: Rutgers University (USA)
http://climate.rutgers.edu/snowcover

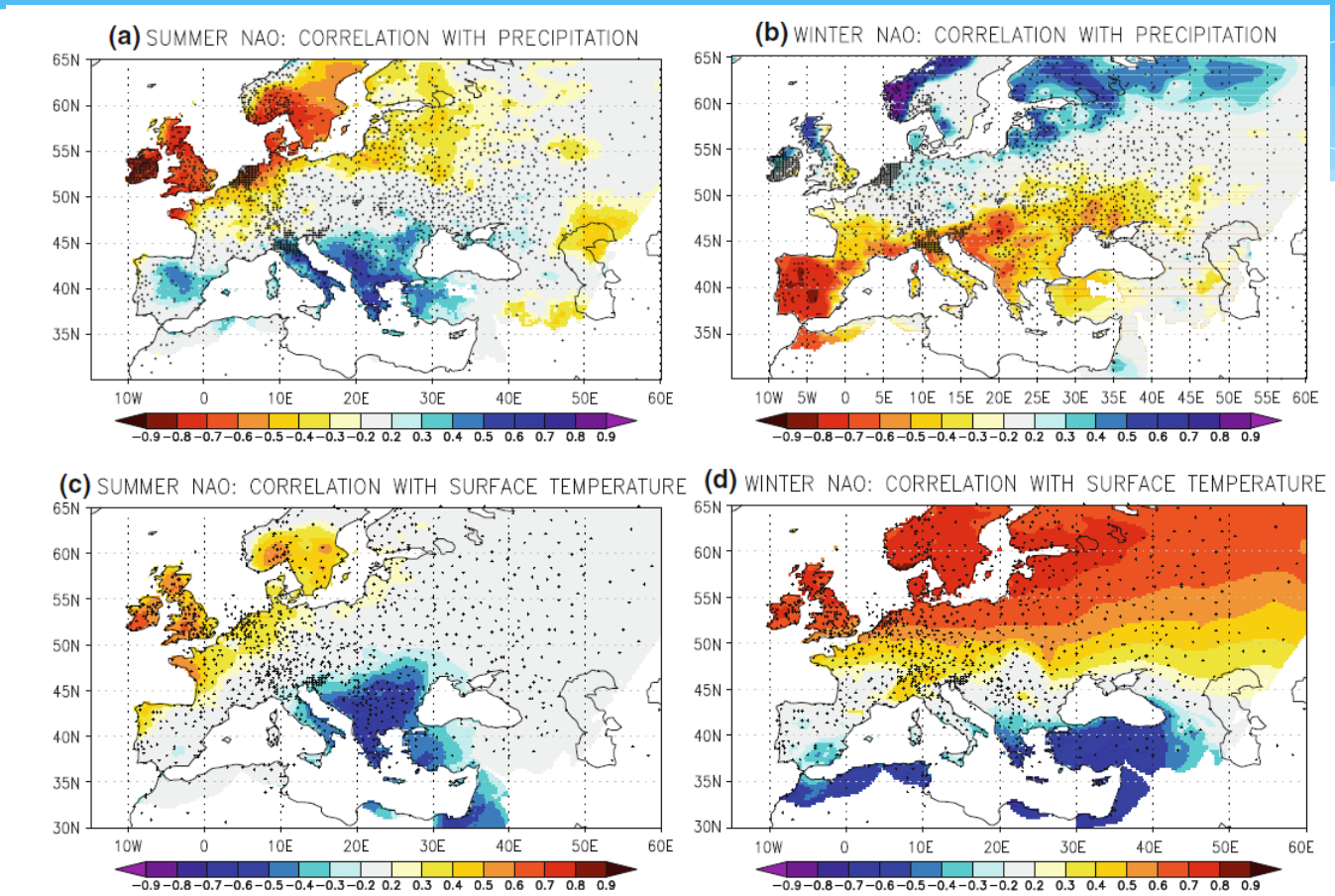
Predictive signal of October sea ice concentration in Barents and Kara seas and temperature and SLP over Europe in next January (CCA spatial and temporal patterns)



Relevant reference: Kolstad, E. W., & Screen, J. A. (2019).Nonstationary relationship betweenautumn Arctic sea ice and the winterNorth Atlantic oscillation. GeophysicalResearch Letters, 46, 7583–7591. https://doi.org/10.1029/2019GL083059

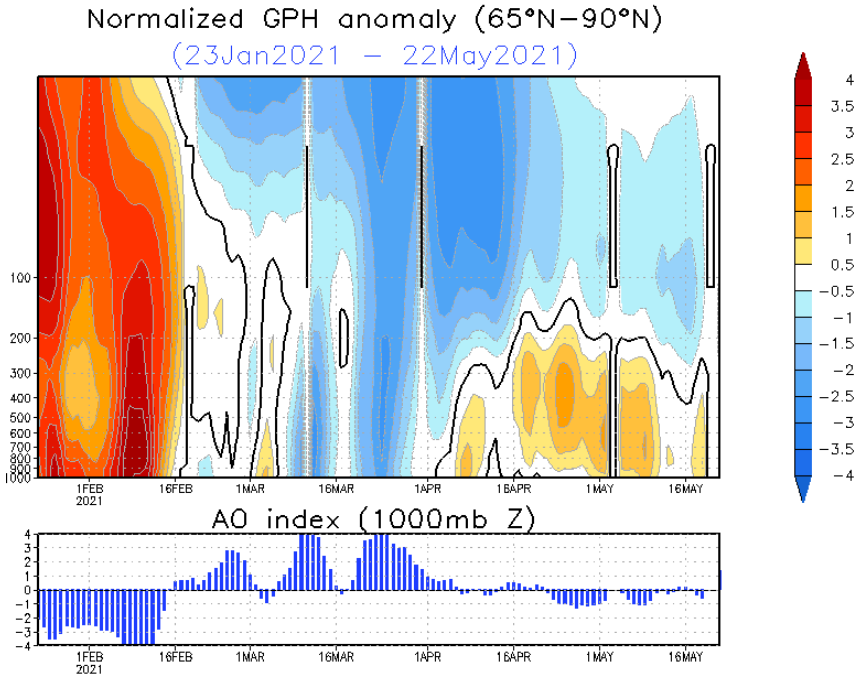
Negative anomalies in the ice extent over Arctic regions are usually related to favorable conditions for atmospheric blockings in the Northern Hemisphere.

Temperature, precipitation and SLP over Europe in summer - summer NAO



Bladé, I., Liebmann, B., Fortuny, D. et al. Observed and simulated impacts of the summer NAO in Europe: implications for projected drying in the Mediterranean region. Clim Dyn 39, 709–727 (2012). https://doi.org/10.1007/s00382-011-1195-x

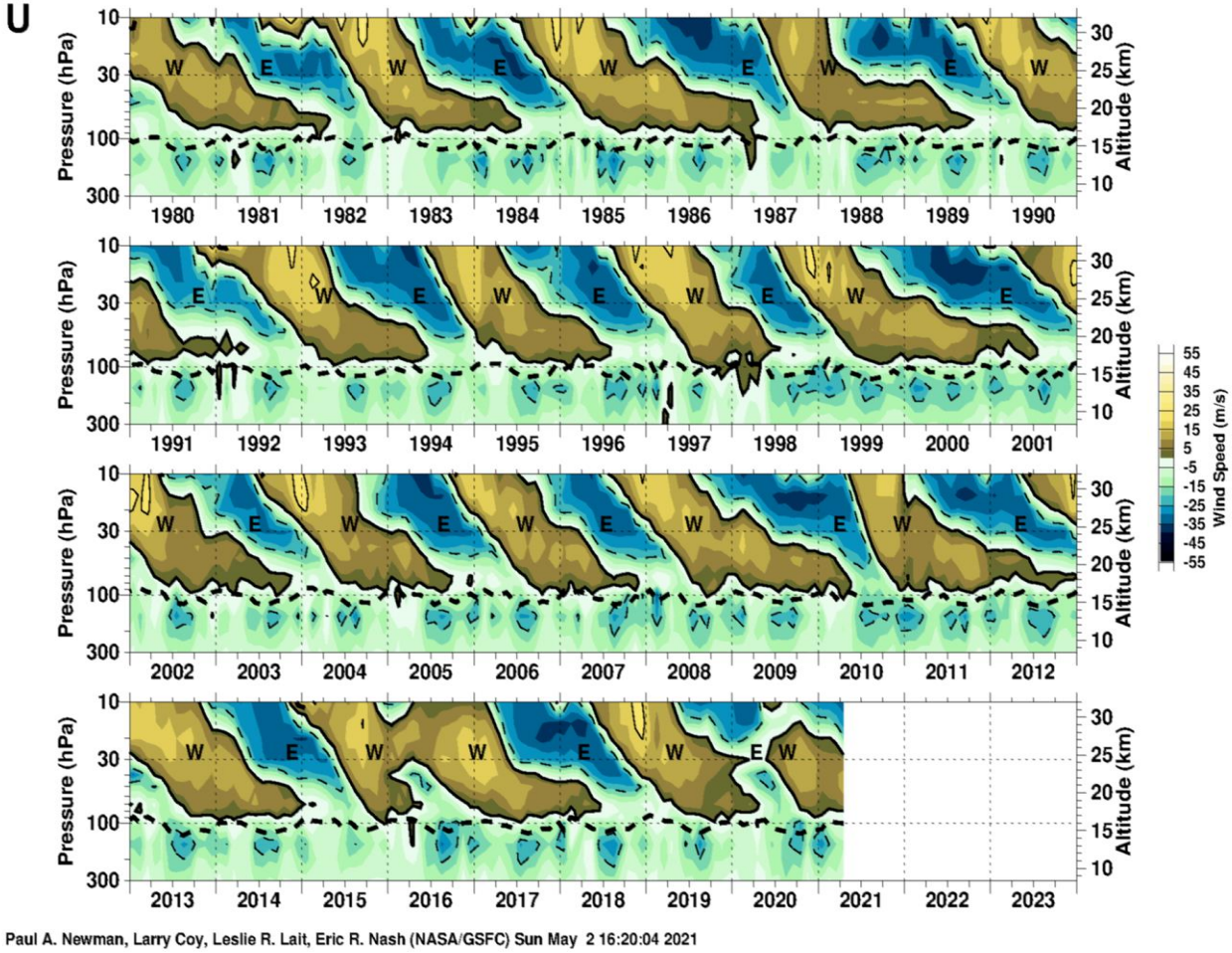
Conditions in the stratosphere

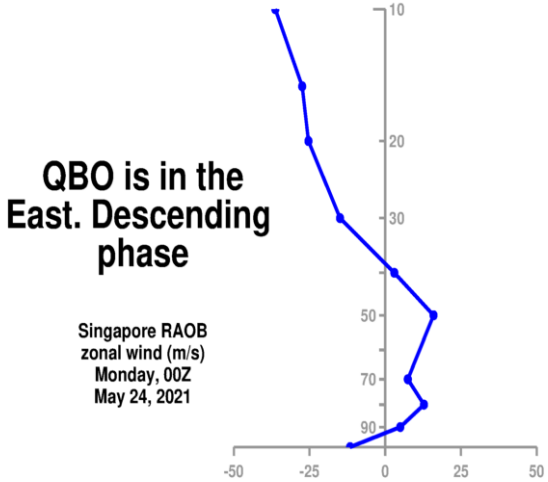


Source: CPC (USA)
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/hgt.shtml

Stronger (weaker) polar vortex is consistent with zonal (meridianal) circulation prelevance in the NH in winter (i.e. mild (severe) winter conditions over Europe).

Conditions in the stratosphere





Source: https://acd-ext.gsfc.nasa.gov/Data_services/met/qbo/qbo.html

Easterly QBO (from the zonal average of the 30mb zonal wind at the equator) is consistent with blocking circulation prelevance over the NH in winter (e.g. severe winter conditions over regions in Europe).

Conclusions

- There are multiple sources of predictability specific for summer and winter and their net effect have to be estimated.
- Linear (robust) predictive signals are rather exceptions.
- Climate models that capture all the signals might give the overall estimate of net effect of multiple predictability signals improving climate outlook scores.