Connections between the Summer NAO and Drying in the Mediterranean Region

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Bladé et al. (2011, Climate Dynamics, in press)

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Summary:

During summers with a positive summer NAO (SNAO), precipitation is enhanced in large parts of the Mediterranean region. This influence of the SNAO, however, is not captured in CMIP3 models. Because many models predict an upward SNAO trend (particularly HADCM3 and GFDL-CM2.1), the error in the models' representation of the influence of the SNAO will impact the projected precipitation trends in the Mediterranean region, where the drying could be less drastic than the models predict.

① Motivating questions:

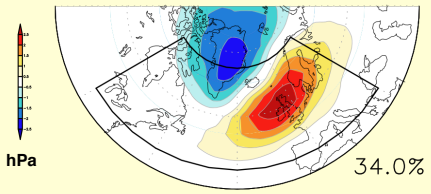
- What is the impact of the summer NAO (SNAO) on precipitation in the Mediterranean region and what is the mechanism involved?
- How well do models reproduce the SNAO influence on summer precipitation in the Mediterranean region?
- What is the role of the SNAO in the projected summer drying in Europe and in the Mediterranean in climate model simulations?

② The summer NAO:

SNAO : leading EOF of July-August SLP in the domain [40°N-70°N; 90°W-30E°] (following Folland et al. 2009)

Results presented here are insensitive to definition of SNAO or dataset used (Trenberth SLP or NCEP)!

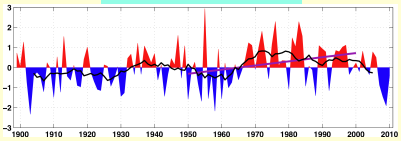
SPATIAL PATTERN



SNAO vs winter NAO:

- weaker and smaller
- displaced northeastward
- explains less variance

TIME EVOLUTION

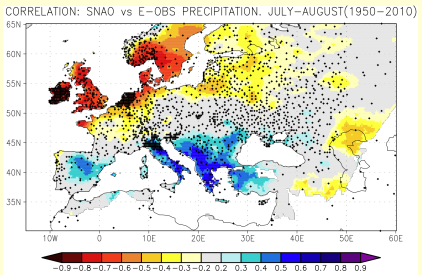


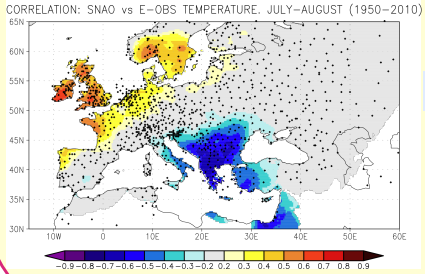
Mostly interannual, but also some multi-decadal variability

Multi-decadal swing from 1967-2005 has been interpreted as "a change towards persistent anticyclonic flow" in northern Europe (Hurell and Folland 2002)

But neither the recent (1950-2010) nor the long-term (1900-2010) trend is statistically significant

③ Impact of SNAO in Mediterranean region:

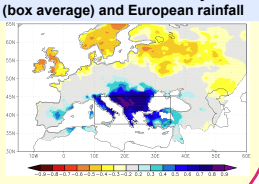




Positive SNAO summers are:

- warm and dry in NW Europe, particularly the British Isles
- cold and wet in southeast Mediterranean (also wet anomalies in Iberia)
- patterns are robust for the 1950-2010 period, but weaker for the 1901-1949 period
- leads to a precipitation see-saw between NW and SE Europe

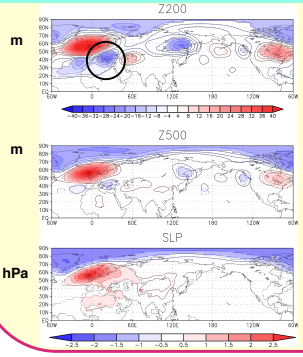
Correlation between Balkan/Italy rainfall (box average) and European rainfall



Enhanced precipitation over SE Mediterranean cannot be directly due to SLP dipole

④ Mechanism for Mediterranean response

SNAO regressions with upper level circulation

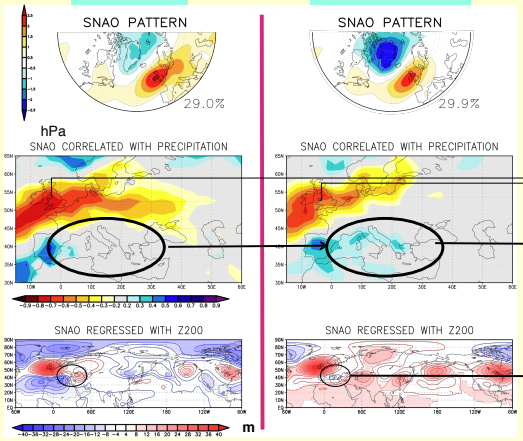


- statistically significant upper-level trough over the Balkans, overlaying the region of positive precipitation anomalies

- trough is part of a hemispheric, equivalent barotropic wavetrain, reminiscent of Branstator's wave-guided circumglobal patterns

- associated mid-level cooling increases potential instability, which (together with moisture supply by warm SSTs + orographic uplifting) favors development of summer convection

⑤ Simulated SNAO impact



spatial pattern of the SNAO is captured by the models

impact in NW Europe correct

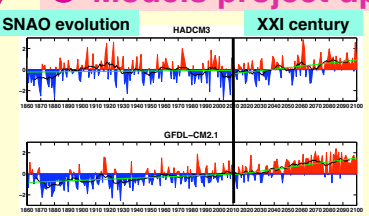
impact in Mediterranean TOO WEAK !

weak or no upper level trough over Balkans

Models reproduce the spatial pattern of the SNAO BUT the impact over the Mediterranean is not well-represented (errors in upper level flow)

⑥ Models project upward SNAO trend

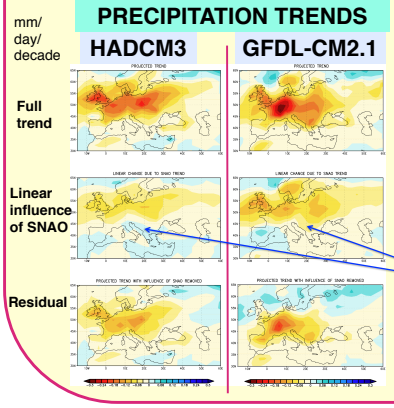
SNAO evolution **XXI century**



The projected upward SNAO trend is common to many CMIP3 models but is particularly strong for HADCM3 and for GFDL-CM2-1, where it is already present in the XXth century. This is not consistent with observations (see ③)

The errors in the representation of the influence of the SNAO will impact the projected precipitation trends

PRECIPITATION TRENDS



The SNAO trend accounts for more than 40% of the projected drying north of 50°N

Observed positive regression of 0.3 mm/day/std of SNAO in the southeast Mediterranean should increase precipitation by 0.5 mm/day, which would partially offset the projected drying due to other processes, but the offset does not occur (only in Iberia)

CONCLUSION:

In at least two CMIP3 models the projected large precipitation decrease in Europe is partly due to a strong projected upward trend in the SNAO. There are two problems with this result. First, the plausibility of this trend cannot be confirmed based on past observations: thus, the intensity of the projected drying becomes uncertain. Second, based on observations, we would expect the SNAO trend to lead to increased precipitation in the eastern Mediterranean, which would offset some of the non-SNAO related drying. This offset, however, does not occur because the influence of the SNAO in this region is not well-captured by the models. Therefore, if the upward SNAO trend is verified, drying should be less drastic over the Med region than the models anticipate.