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Altered NAO - North Atlantic SST Feedback in Mesoscale Resolving Simulations

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Why all this?

- Ocean-atmosphere coupling might be underestimated by climate models 2019, Wills et al. 2019, Simpson et al. 2019, Wills et al. 2019
- A potential solution: high(er)-resolution simulations that are capable of resolving mesoscale circulations
- Getting ocean-atmoshpere feedbacks right is crucial for predictability of the izio et al. 2025 NAO

Coupling:



- Increasing horizontal resolution increases strength of resolved updrafts Jeevanjee & Romps 2016
- This leads to modified transient-eddy fluxes of energy and momentum *Wills et al. 2024*



Do we find a different NAO – SST Feedback in Mesoscale Resolving Simulations?

Mechanisms:



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0.8 **REF** Total • ~0.6 **GRAD** Total WARM Total ва) 0.4 -3 с.2 0 100 120 20 40 60 80 0 Grid Scale (km)

OMEGA SD 850hPa

OMEGA SD 600hPa



Müller et al. (in prep.)

 Differences in the vertical velocity standard deviation highlight regions that might be more prone to respond differently to SST anomalies

NAO forced SST Anomaly:

Data and Figure from NOAA:

https://www.cpc.ncep.noaa.gov/products/precip/C Wlink/pna/norm.nao.monthly.b5001.current.ascii.ta ble





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 NAO index (observational) regressed onto SST and Sea-Ice data (0.1° resolution)



 SST and Sea-Ice anomalies represent the "fast" ocean response to the NAO

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• SST and Sea-Ice anomalies represent the "fast" ocean response to the NAO



Setup:

- CAM6 using the regional refined NATL grid with a regional refinement from 1° to 1/4° or 1/8° in the North Atlantic domain
- For each grid, three experiments are run
 - NAO+ SSTs
 - NAO- SSTs
 - NAO neutral SSTs
- Each experiment and grid combination is run 42 times from mid-November to end of March



Results:

- The results will show the response of the indicated grid to the SST anomaly
- For a better signal to noise ratio, each result is shown against control with control being the combination of all three experiments of each grid respectively



• The differences in mean states between the three grids is not shown



SLP Response:



 NAO+ SSTs cause a weak
NAO- like response in the the two lower resolutions



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simulations







SLP Response:





NAO+ SSTs cause a weak NAO- like response in the the two lower resolution simulations

• NAO+ SSTs cause a stronger NAO+ like response in the the mesoscale resolving simulations









sign of NAO- SST feedback is the same for each grid respectively





Vertical Pressure Veloci























Then alone alone, along along along along along along along along along

Vertical Pressure Veloci





- Warm SST anomalies lead to negative pressure velocity anomalies (stronger ascend!)
- The highest resolution simulations are more sensitive and show a vertical velocity response already for weaker SST anomalies
- The resulting vertical velocity anomalies reach deeper into the troposphere in the highest resolution









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Geopot. Height Respons

















Blue UP





Z300

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15 [....]

- Warm SST anomalies lead to positive geopotential height anomly downstream in line with previous studies (Sun et al. 2025)
- This is strongest in the 1/8° simulations where the effect of SST anomlies reaches deeper into the troposphere

Geopot. Height Response:







Zonal Wind and Heat Flux Response:



Zonal Wind at 300

hPa

Total Heat Flux (Latent + Sensible**)**

- Upper level Zonal Wind anomalies differ strongly between the lower and the highest resolution simulations
- strengthening of zonal winds above the subpolar NA in the highest resolution potentially leads to a positive heat flux anomaly although a negative SST anomly lies underneath



Summary:

- (Fast) NAO NA SST NAO feedback is positive in the 1/8° mesoscale resolving simulations but negative in the lower resolution simulations
- This is due to a more direct and stronger "communication" of anomalous surface signals into the deep troposphere affecting the large-scale circulation
- Increasing the resolution could therefore help to address the signal-to-noise issue of NAO forecasts and increase predictability
- Subpolar Heat Flux response positive despite cold SST underneath due to a potential strong large-scale response caused by GS SST anomalies only in the 14km simulations



Müller et al. (in prep.)





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February

March



