# Future decline of the Caspian Sea Level: Does the North Atlantic Oscillation matter?

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Nandini-Weiss, S. D., M. Prange, K. Arpe, U. Merkel, and M. Schulz, 2020: Past and future impact of the winter North Atlantic Oscillation in the Caspian Sea catchment area. *International Journal of Climatology*, 40, 2717-2731.

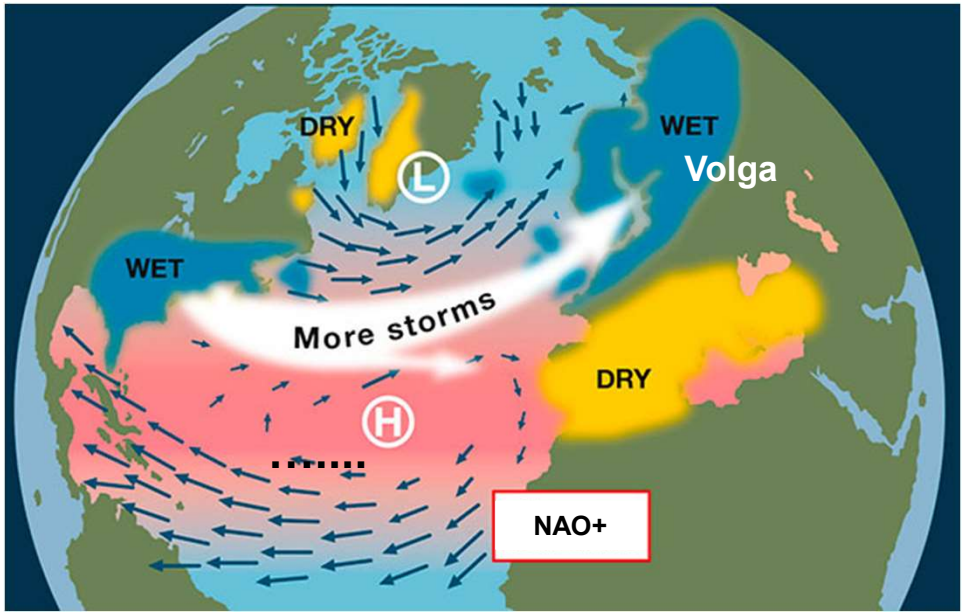
Prange, M., T. Wilke, and F. P. Wesselingh, 2020: The other side of sea level change. *Communications Earth and Environment*, 1, 69.

How does the NAO influence the hydro-climate in the Caspian Sea catchment area in the past and in the future?

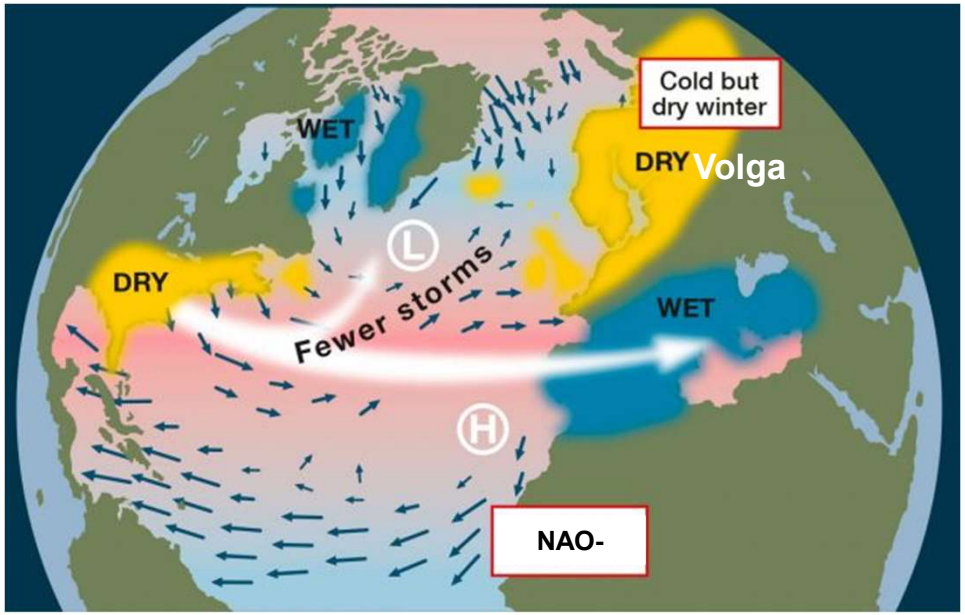
How will the Caspian Sea level change due to future anthropogenic global warming?

# North Atlantic Oscillation (NAO): Leading mode of variability

Positive phase




Negative phase




Credit: Maggie Nelson

# NAO and the Caspian Sea Level

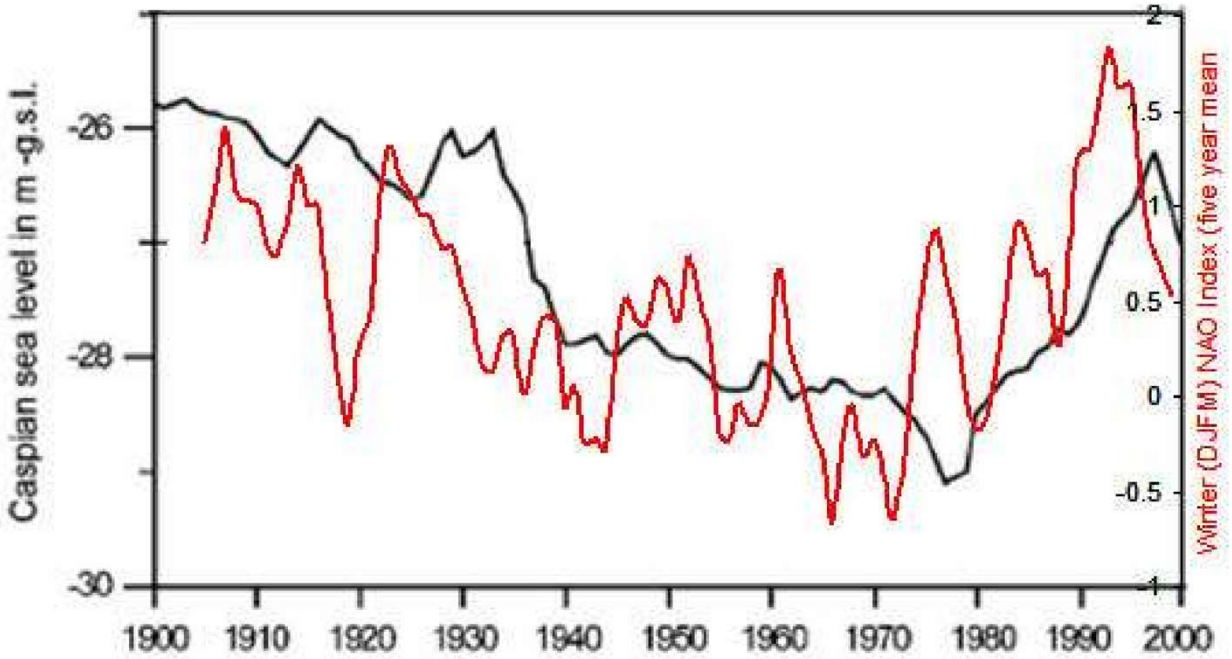


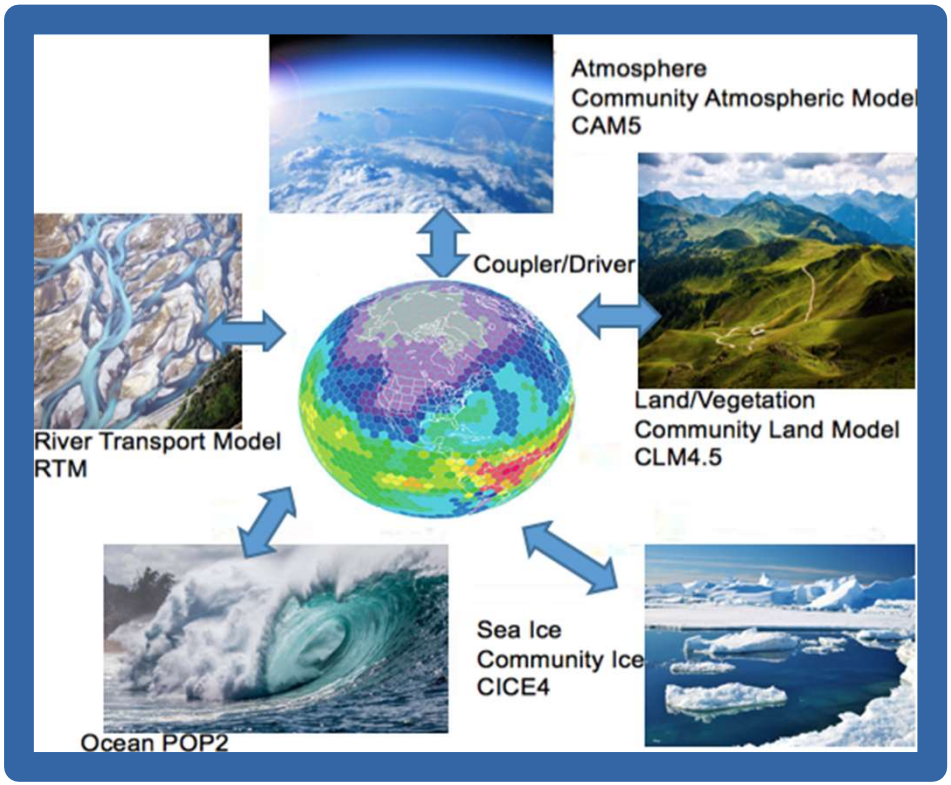

*Figure 7: Observed CSL, 1900-2000 (Hoogendorn 2005, originally from Klige and Myagkov 1992) with superimposed Winter (Dec. Jan. Feb. Mar.) North Atlantic Oscillation Index five year mean in red. (data from Jones et al., 2000)*

Lougheed (2006)

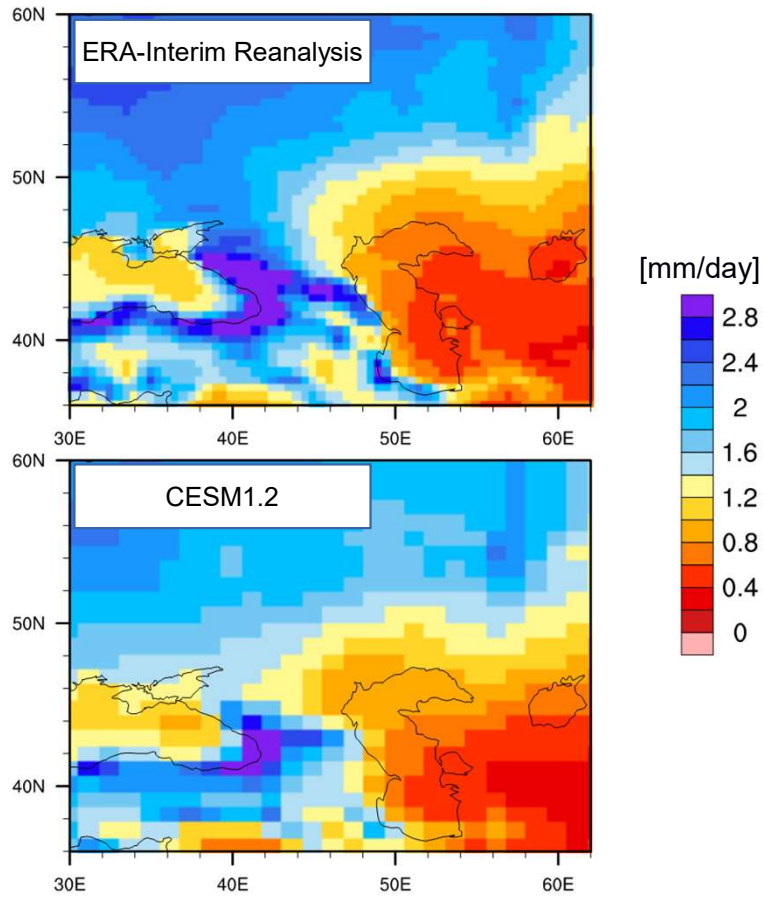
<u>Other studies:</u> Rodionov (1994), Panin and Dianskii (2014), Panin et al. (2015)

# Community Earth System Model CESM1.2

1° horizontal grid resolution globally




Annual mean precipitation (1979-1999)



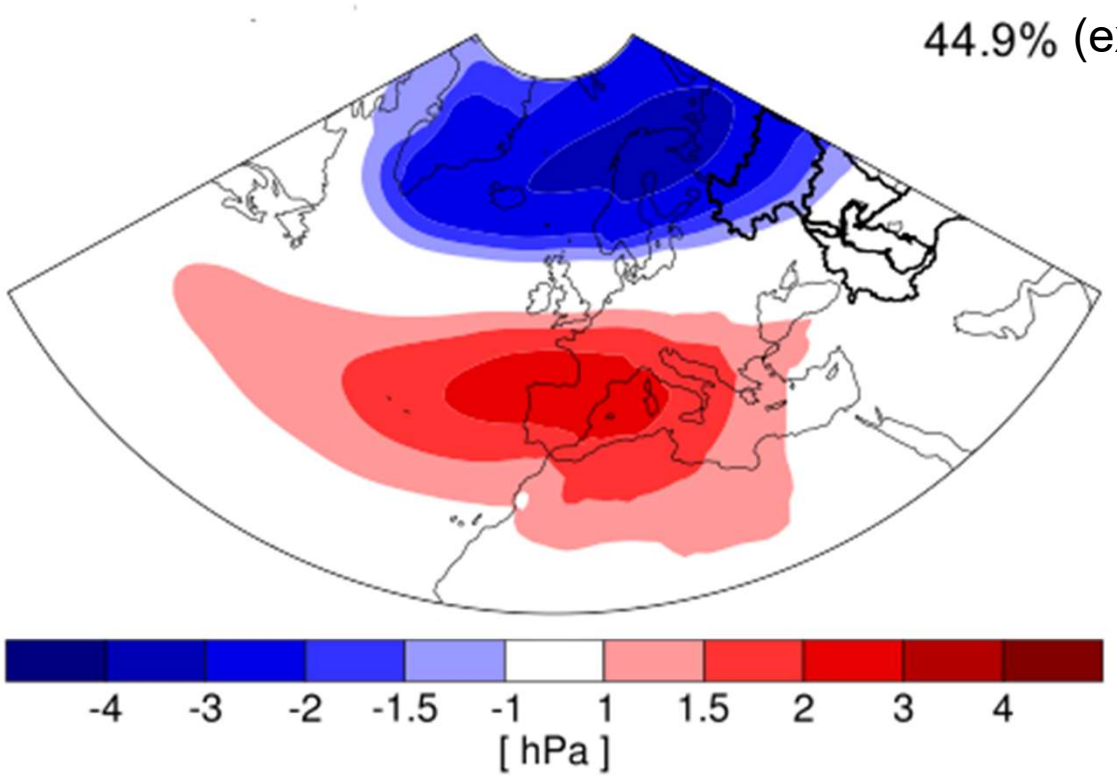
# Simulation of winter NAO in CESM1.2

Leading EOF of winter (Dec-Jan-Feb) Sea Level Pressure (SLP) for 1850-2000

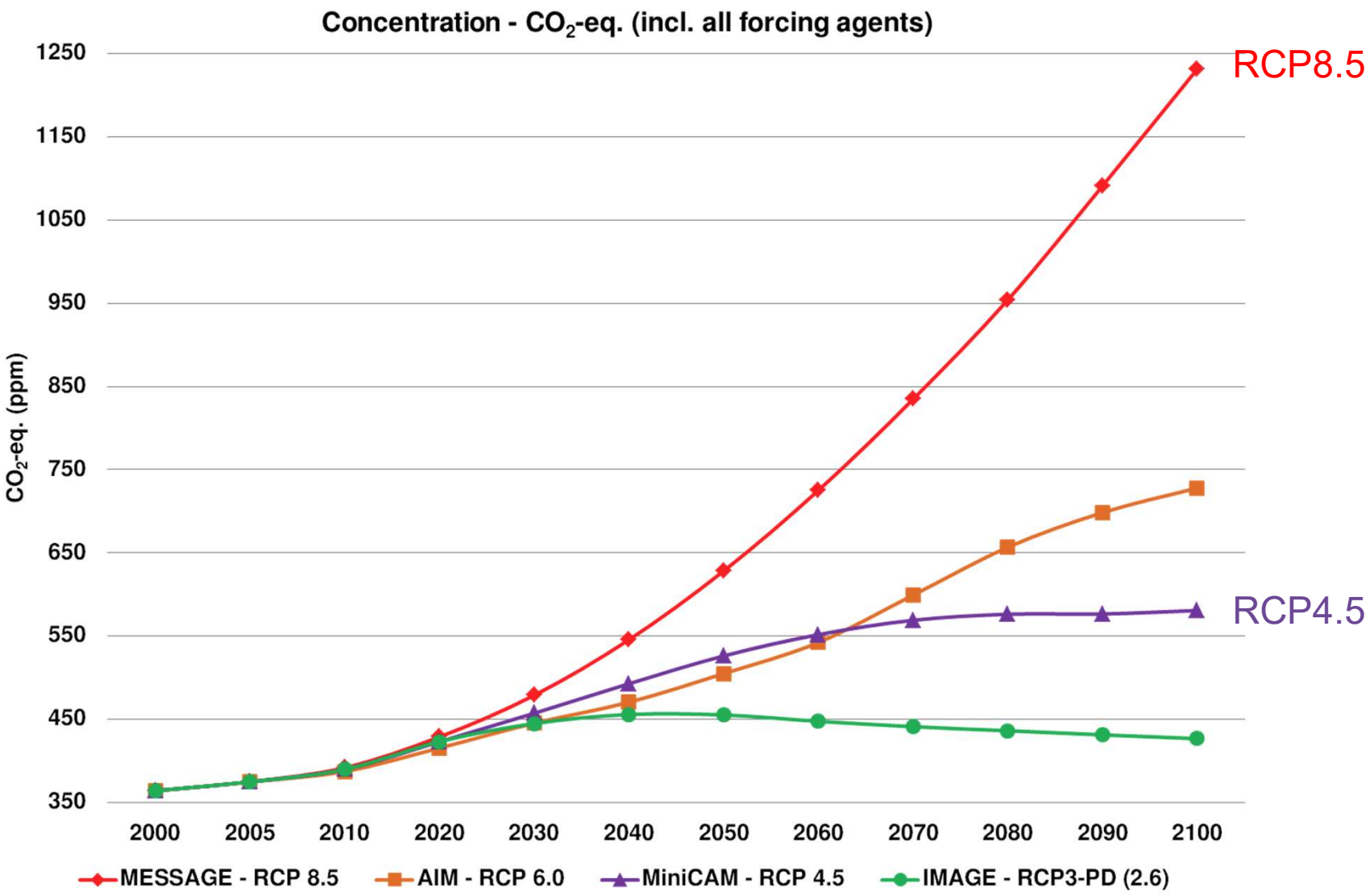
Regression of SLP field onto NAO index (standardized principal component)

44.9% (explained variance)

NAO

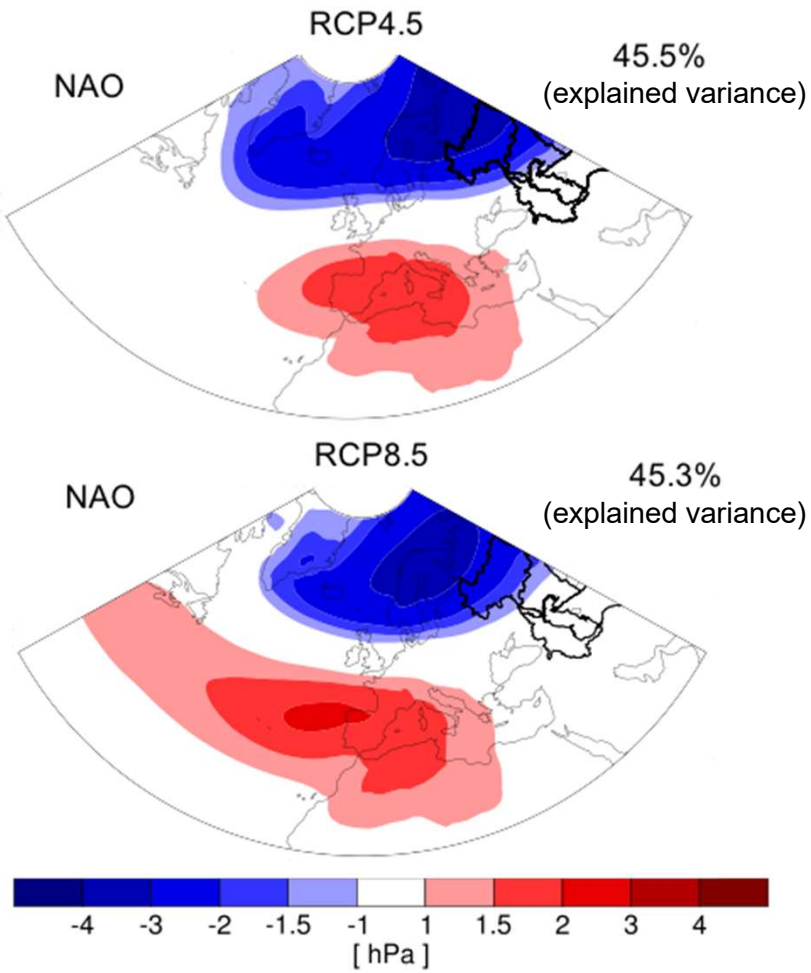


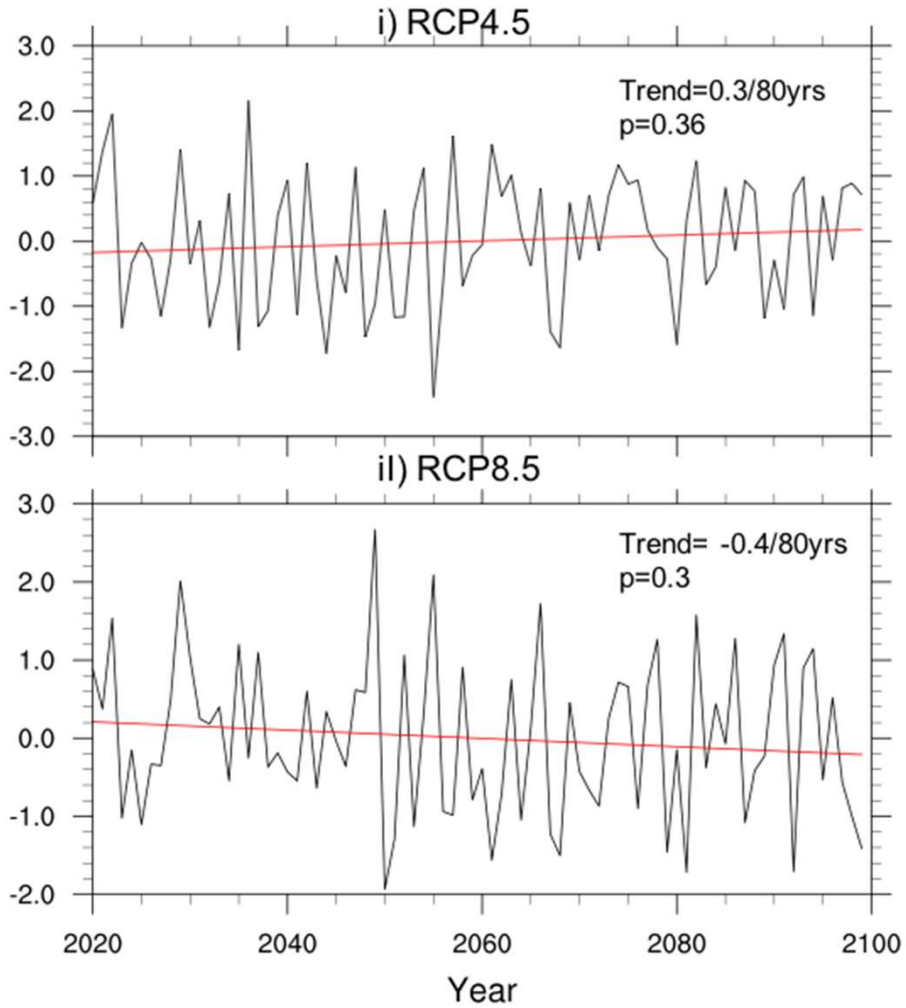
# Future scenarios of the 21st century



# Simulation of future NAO: 2020-2100

Leading EOFs of winter (Dec-Jan-Feb) Sea Level Pressure (SLP)

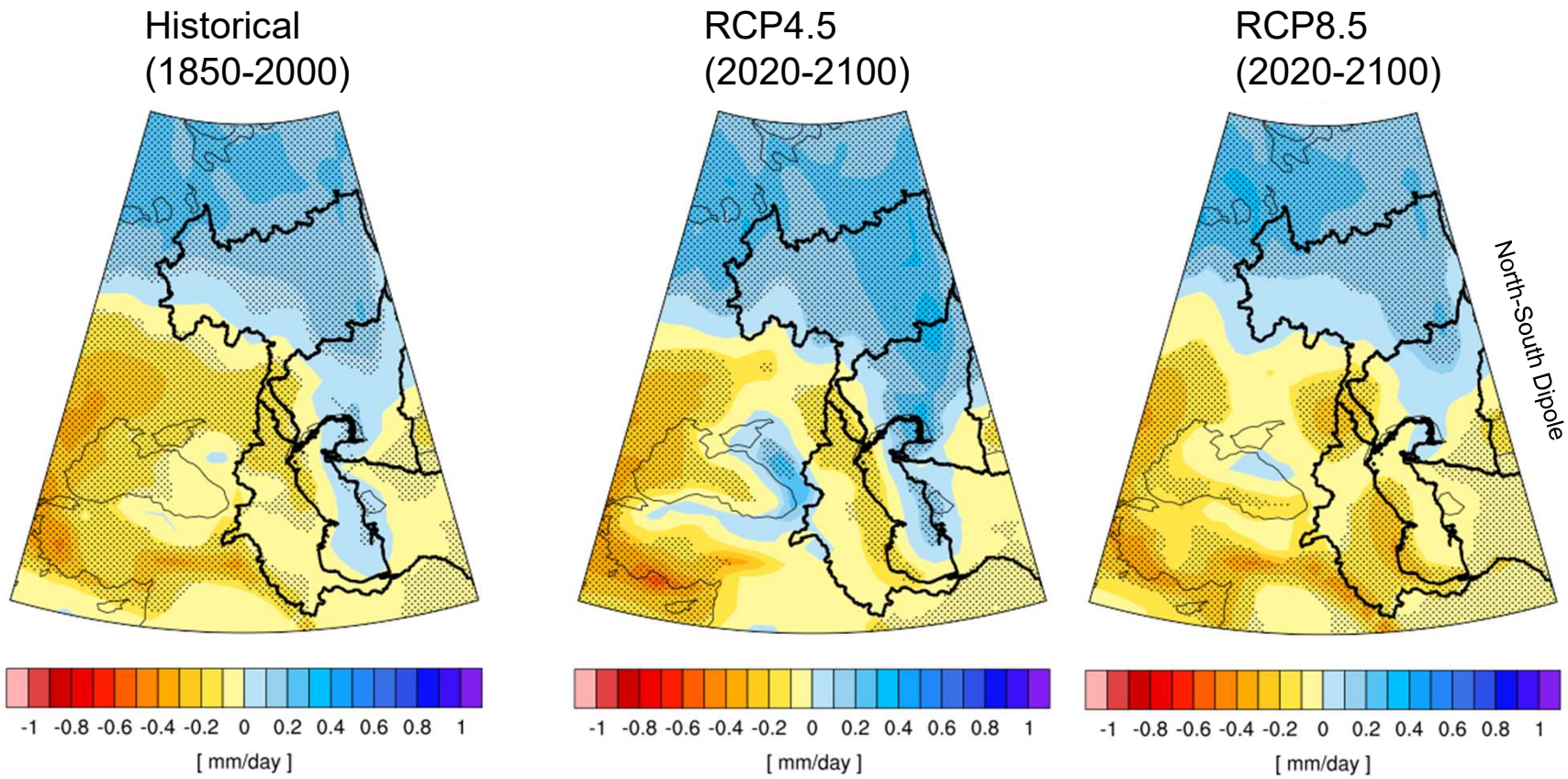



==> No significant trends in the NAO index

# Effect of NAO on Caspian region winter climate in CESM1.2

Regression of detrended winter **P-E** onto NAO index




*Stippling indicates significance at 95% level (Student's t-test)*

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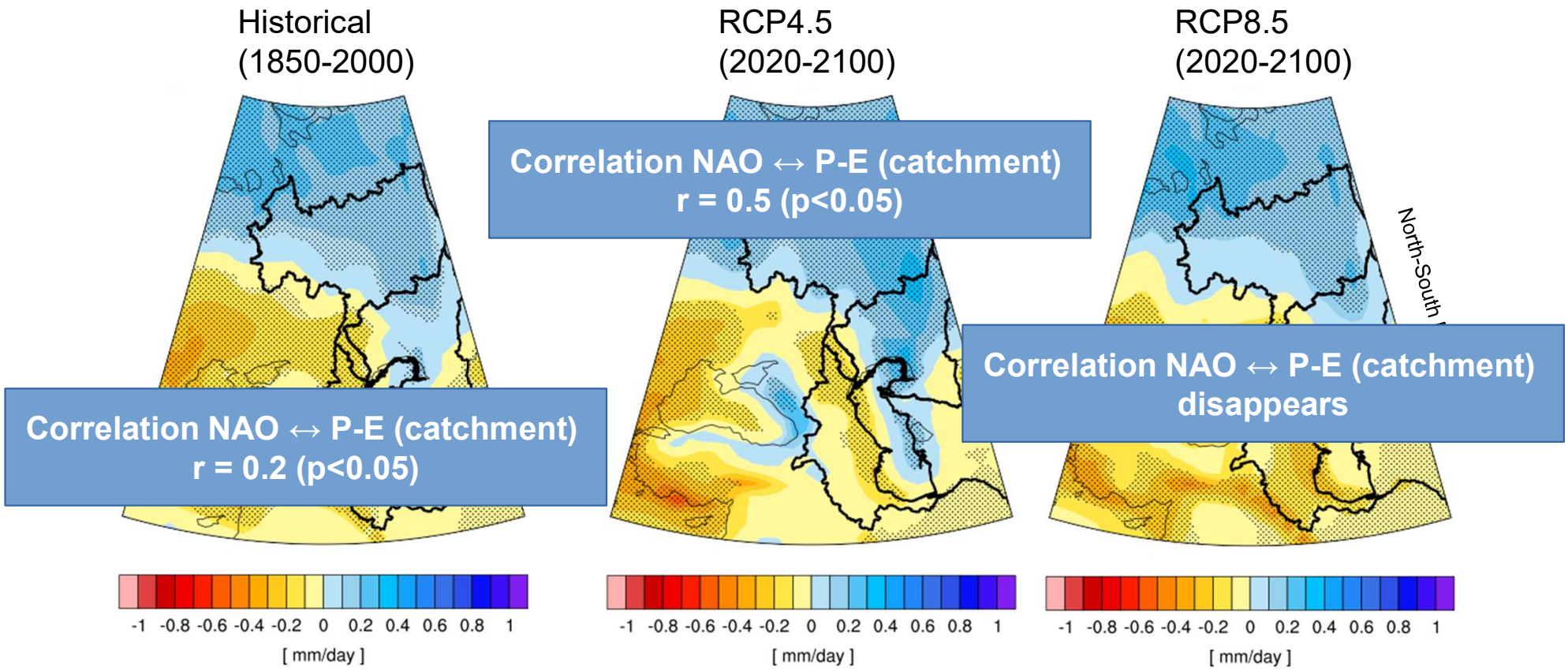


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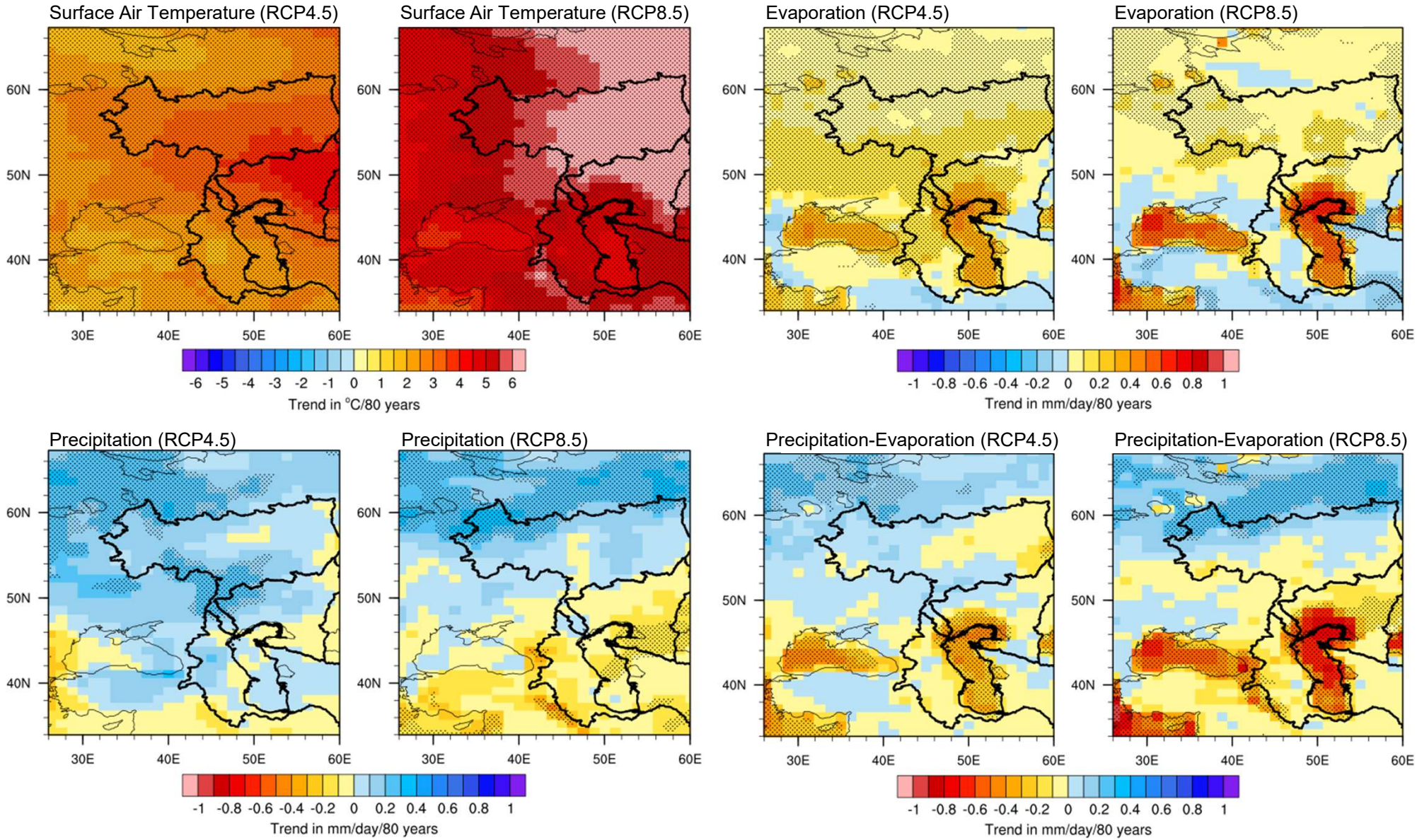
# Future climate trends in the Caspian region as simulated by CESM1.2
(2020-2100)

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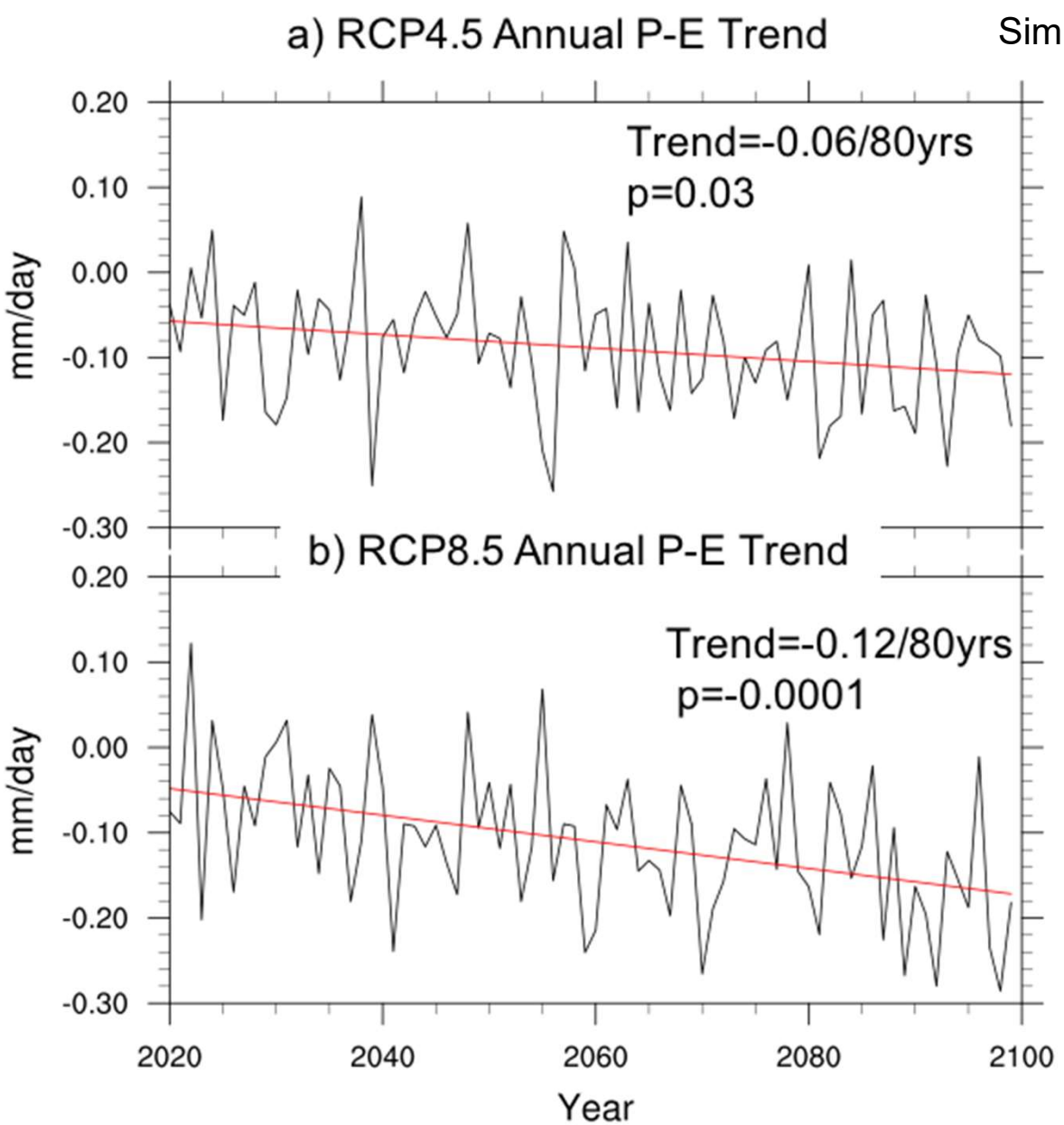
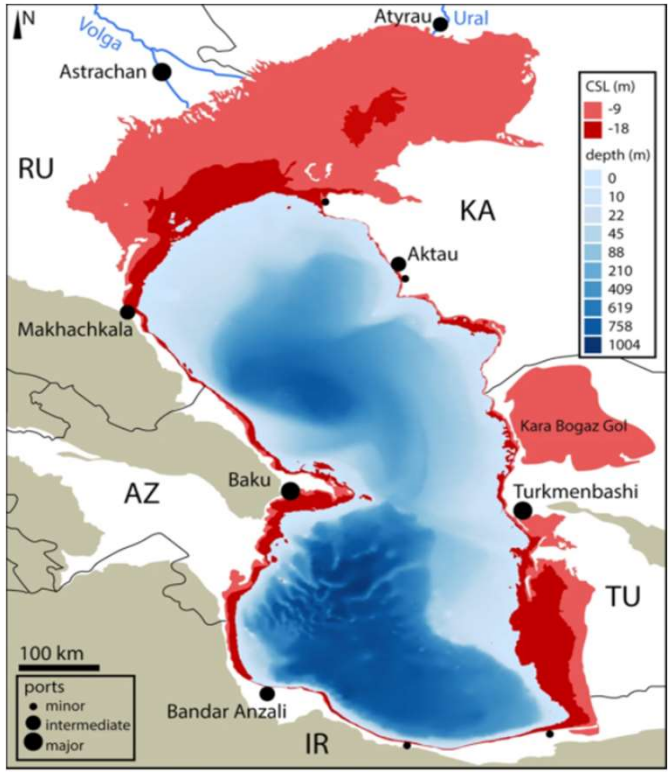
# Future trends in Caspian Sea Level based on Precipitation-Evaporation averaged over the total Caspian catchment area



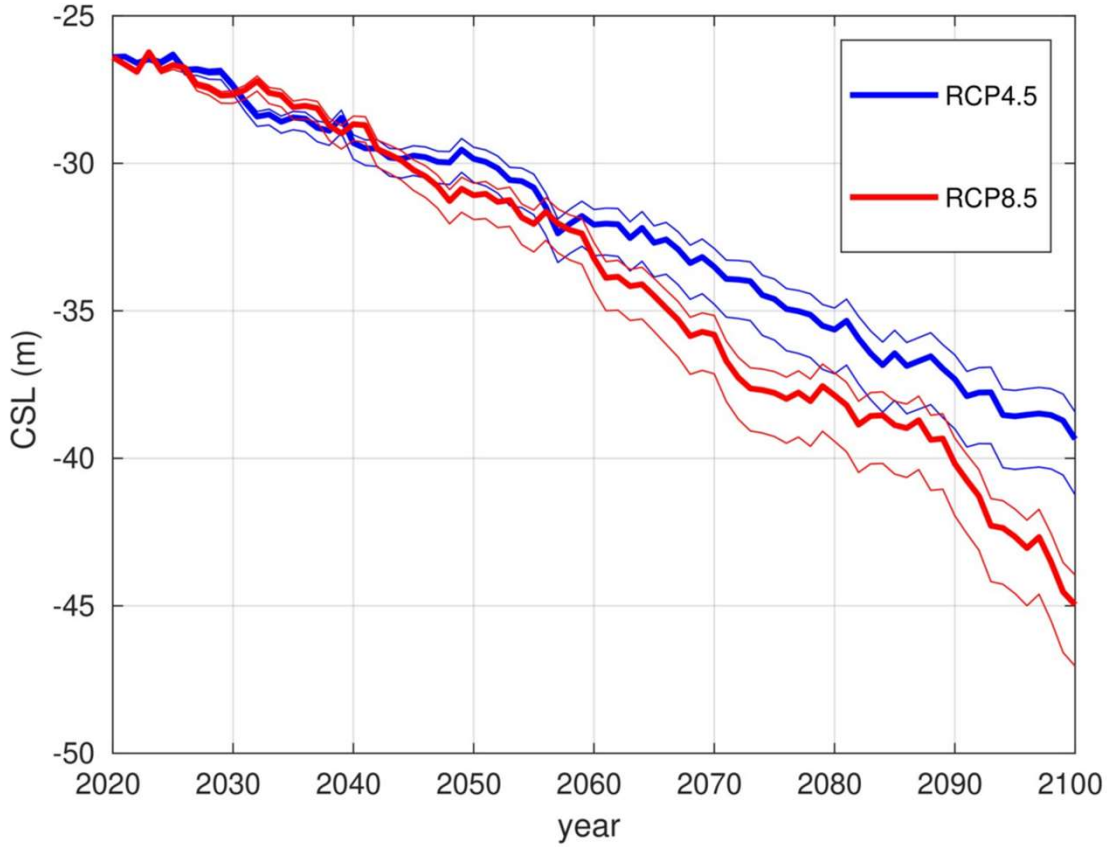

Simple "bathtub" model: $\frac{\partial CSL}{\partial t} = \int R + \int (P - E)$

==> CSL will fall by ~9 m
by the end of this century (RCP4.5)




==> CSL will fall by ~18 m
by the end of this century (RCP8.5)

# Future trends in Caspian Sea Level based on Precipitation-Evaporation taking surface area changes into account




==> CSL will fall by ~13 m
by the end of this century (RCP4.5)

==> CSL will fall by ~19 m
by the end of this century (RCP4.5)

$$\frac{d}{dt}\mathrm{CSL} = \frac{1}{A_S}[(A_L + A_S)\cdot(1-f)P - A_L \cdot E_L - A_S \cdot E_S)],$$

with $A_S = A_S(\mathrm{CSL}), A_L = A_L(\mathrm{CSL}),$

$0.027 \leq f \leq 0.036$

## Summary and Conclusions:

- Over the historical period (1850-2000) a weakly positive correlation (r=0.2) was found between catchment-integrated P-E and the NAO in the CESM1.2 climate model

- This correlation is not stable and depends on the background climate; it may increase (RCP4.5) or disappear (RCP8.5) in the future

- Increasing evaporation over the Caspian Sea surface in a warming climate may lead to a CSL decrease in the order of 10-20 m by the end of the 21st century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