# Far future climate (2060-2100) of the northern Adriatic air-sea heat transfers associated with extreme bora events

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## Abstract

The northernmost part of the Mediterranean Sea, the northern Adriatic shelf, is a complex area where the intensity of dense water formation and the consequent Adriatic-Ionian thermohaline circulation are shaped by a combination of extreme wintertime bora winds and substantial freshwater loads. To better understand the impact of global warming on extreme bora dynamics and the associated sea surface cooling, we applied the Adriatic Sea and Coast (AdriSC) kilometer-scale modelling suite to the far future climate (2060-2100) period. Under both Representative Concentration Pathway (RCP) 4.5 and RCP 8.5 greenhouse emission scenarios, the AdriSC simulations are carried out via the combination of a statistical approach – consisting of an ensemble of 3-day simulations for 22 extreme bora events, and a pseudo-global warning (PGW) methodology – imposing a climatological change to the forcing used to produce the evaluation (present climate) runs. Despite a noteworthy decrease in intensity of the bora winds (by up to 3 m/s), the intensity of the negative latent heat fluxes is simulated to increase (by up to 150 W/m2) due to the reduction in relative humidity in the northern Adriatic (by up to 3%). Consequently, the sea surface cooling associated with severe bora events and preconditioning the dense shelf water formation in the northern Adriatic is projected to not significantly change compared to present climate. Although these results need to be further confirmed, this study thus provides a new view on the future of processes driven by sea surface cooling, such as the dense shelf water formation or the Ionian-Adriatic thermohaline circulation, that were projected to decrease in the future climate by regional climate models an order of magnitude coarser than the AdriSC simulations.

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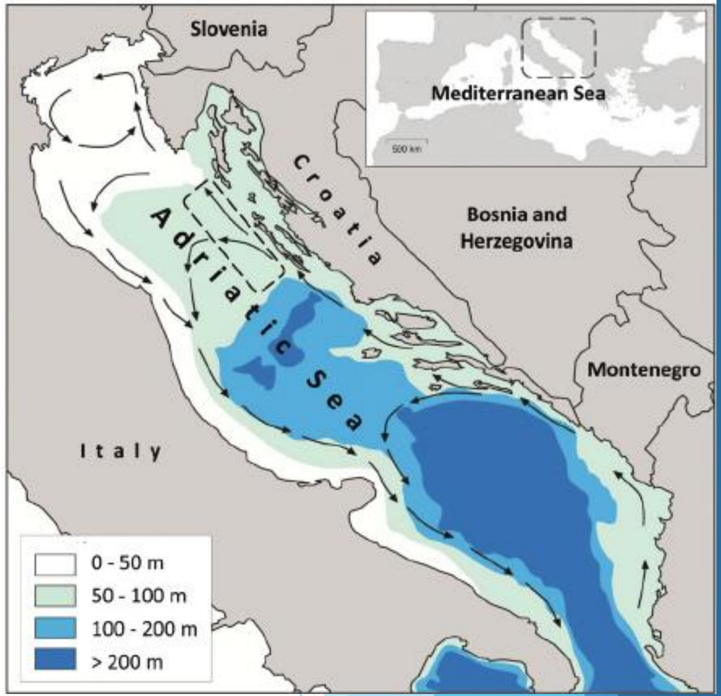



## Motivation:

- ✓ To reproduce climate changes at a kilometre spatial scales (i.e. at scales of dominant local processes, here strong downslope wintertime winds – bora wind – and dense water formation)
- ✓ To overcome need for extensive computer resources needed for „classical” climate projections (eval + hist + scen runs ≈ 180-380 years)

## Methodology:

- ✓ WRF (15 km, 3 km) + ROMS (3 km, 1 km) coupled by SST nudging
- ✓ 22 severe wintertime bora events
- ✓ Pseudo-Global Warming adjustment at boundaries for climate scenarios (RCP 4.5, RCP 8.5)


This work has been done on projects:

ADIOS

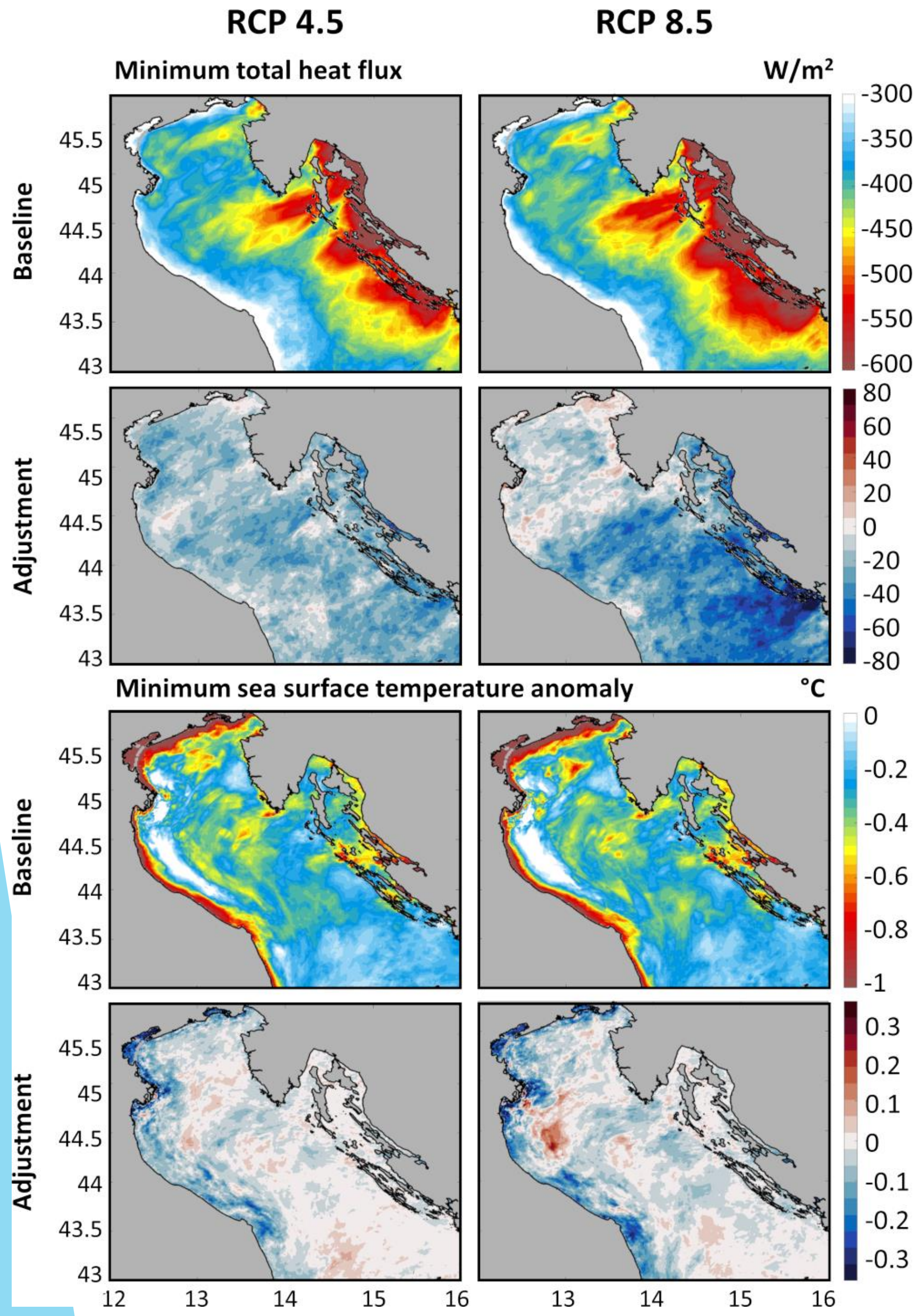
HRZZ Croatian Science Foundation

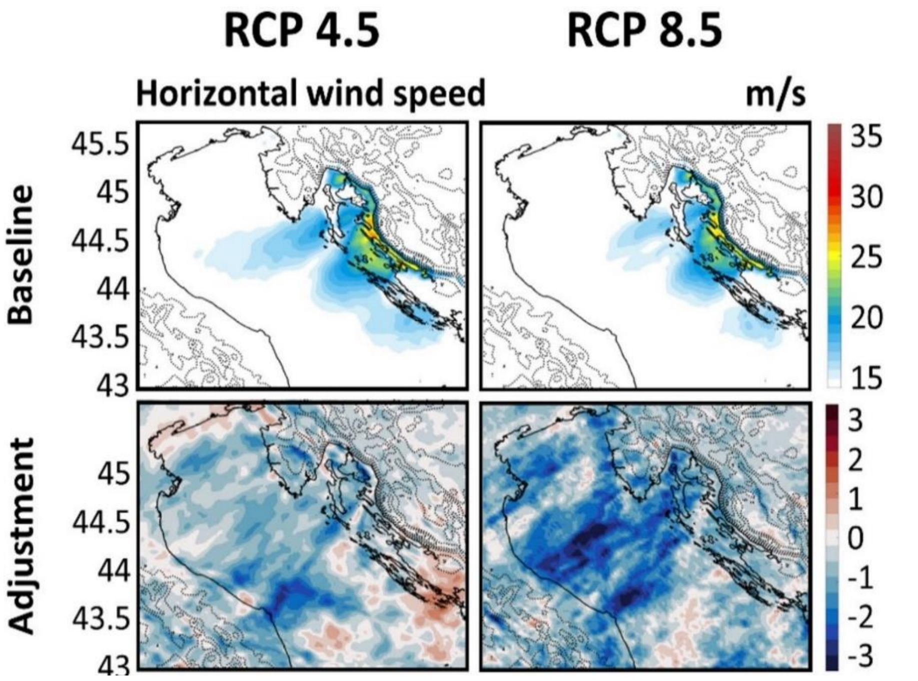
Interreg Italy - Croatia CHANGE WE CARE European Regional Development Fund

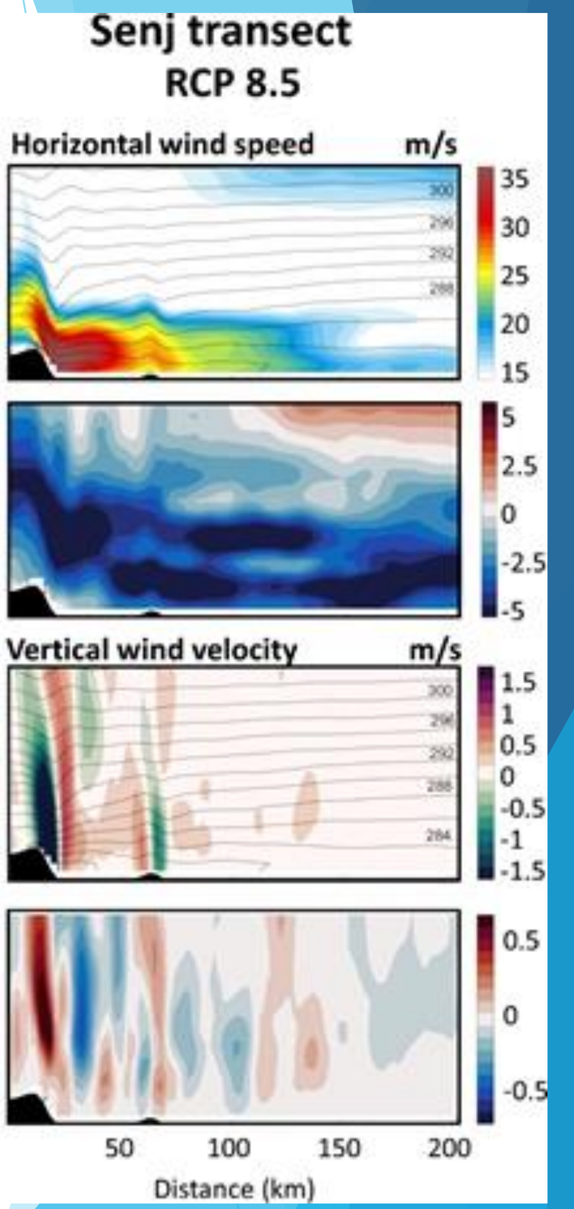
EUROPEAN UNION

BivACME

ECMWF



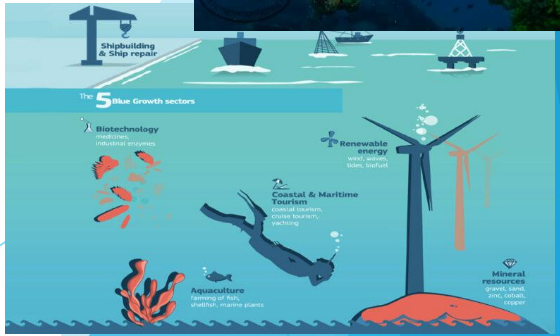




- ✓ Bora will weaken in the future climate (both RCP 4.5 and RCP 8.5)
- ✓ The main bora features are expected to remain similar
- ✓ The cooling remains the same due to decrease in bora humidity (→ the increase in the latent heat losses)
- ✓ Cooling of the surface and therefore dense water formation (→ then the Adriatic thermohaline circulation) would not significantly change

# Conclusions and perspectives

- ✓ A substantial progress in climate modelling of the Adriatic Sea, going down by an order of magnitude higher resolutions – 1 to 3 km vs. 10 to 20 km (in RegCMs)
- ✓ New methodology (pseudo-global warming, PGW) applied in assessment of future climate of extreme events
- ✓ Bora will weaken in the future climate, but surface cooling and therefore dense water formation would not significantly change → ventilation of deep layers will remain, says PGW simulations → relevance for benthic life and demersal fisheries
- ✓ Long-term high-resolution climate runs (1987-2017 → finished, PGW RCP 8.5 2070-2100 → ongoing) to confirm the findings
- ✓ High-resolution climate modelling should be the tool used by decision-makers and policy-makers in shaping the future of the small-scale (like Adriatic) regions, coastal areas and sea resources




## Further reading:


- ✓ Denamiel et al., 2020. *Climate Dynamics*, https://doi.org/10.1007/s00382-020-05397-x
- ✓ Denamiel et al., 2020. *Climate Dynamics*, https://doi.org/10.1007/s00382-020-05435-8
- ✓ Denamiel et al., 2019. *Ocean Modelling*, https://doi.org/10.1016/j.ocemod.2019.02.003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