WCRP CORDEX

14-18 OCTOBER 2019 BEIJING, CHINA

ICRC-CORDEX 2019

International Conference On Regional Climate

Effect of **aerosol-radiation** and **aerosol-cloud** interactions in the simulation of photovoltaic and wind power using regional climate models

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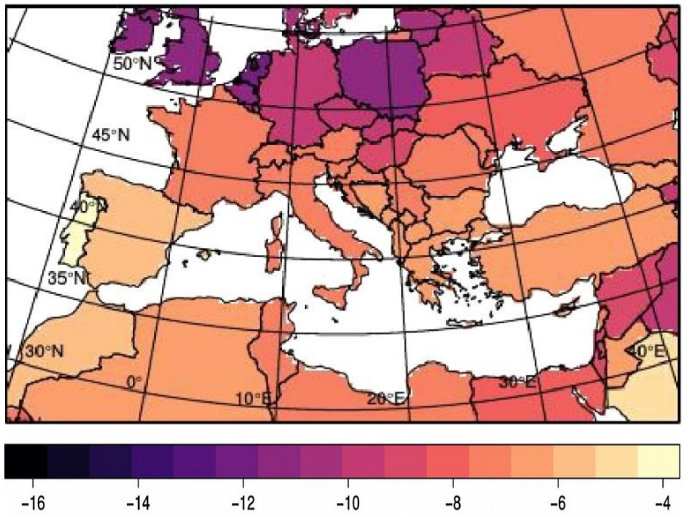
MOTIVATION: previous works

- Increasing use of RCM to evaluate the renewable resource (wind, solar), with previous works indicating a key role of aerosols for such applications.

Differences in PV yearly productivity (in %), averaged by country, for the period 2003–2009 between RCM simulations with and without ARI effects.

►Gutiérrez et al. (2018). Impact of aerosols on the spatiotemporal variability of photovoltaic energy production in the Euro-Mediterranean area. Solar Energy, 174, 1142-1152.



- Discrepancies between GCM and RCM future projections for the solar resource.

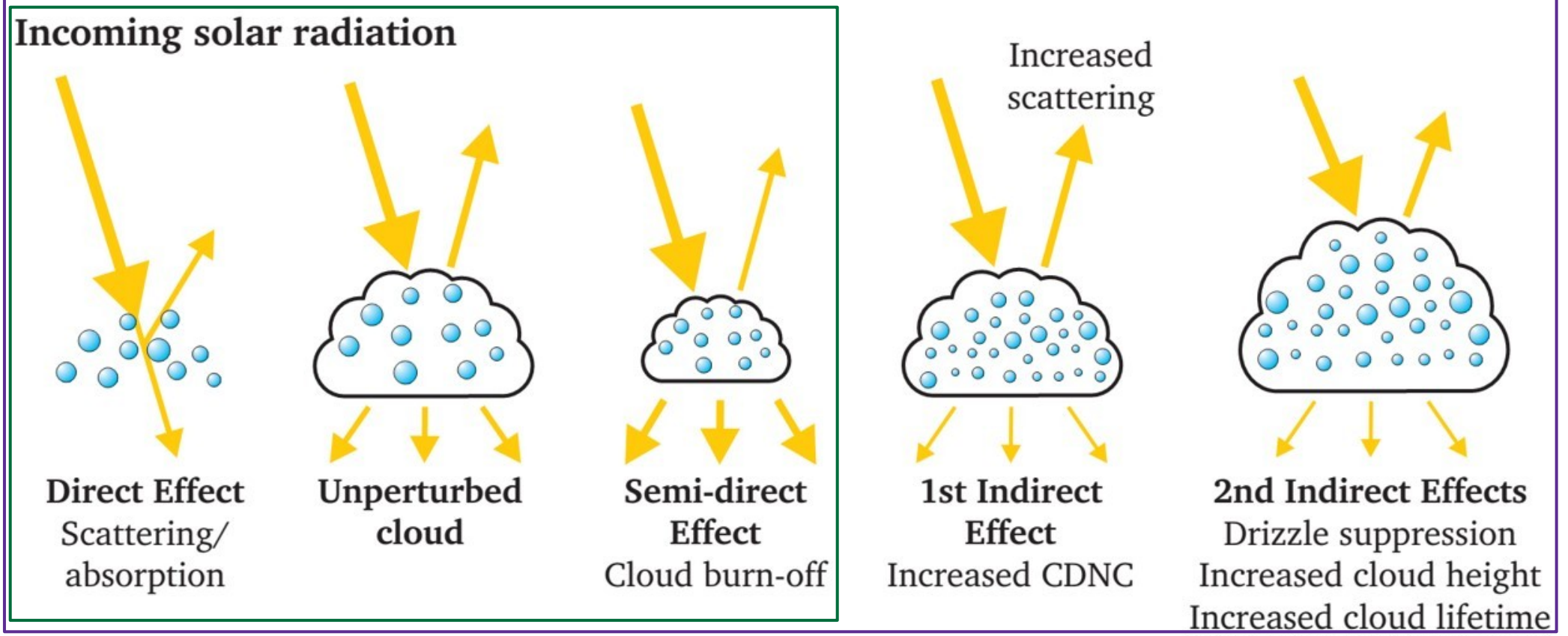
►Jerez et al. (2015). The impact of climate change on photovoltaic power generation in Europe. Nature Communications, 6, 10014.

►Bartók et al. (2017). Projected changes in surface solar radiation in CMIP5 global climate models and in EURO-CORDEX regional climate models for Europe. Climate Dynamics, 49(7-8), 2665-2683.

MOTIVATION: ARI vs. ACI and their scarcely studied effect in RCM long-term experiments

Aerosol-cloud interactions (ACI)

Aerosol-radiation interactions (ARI)



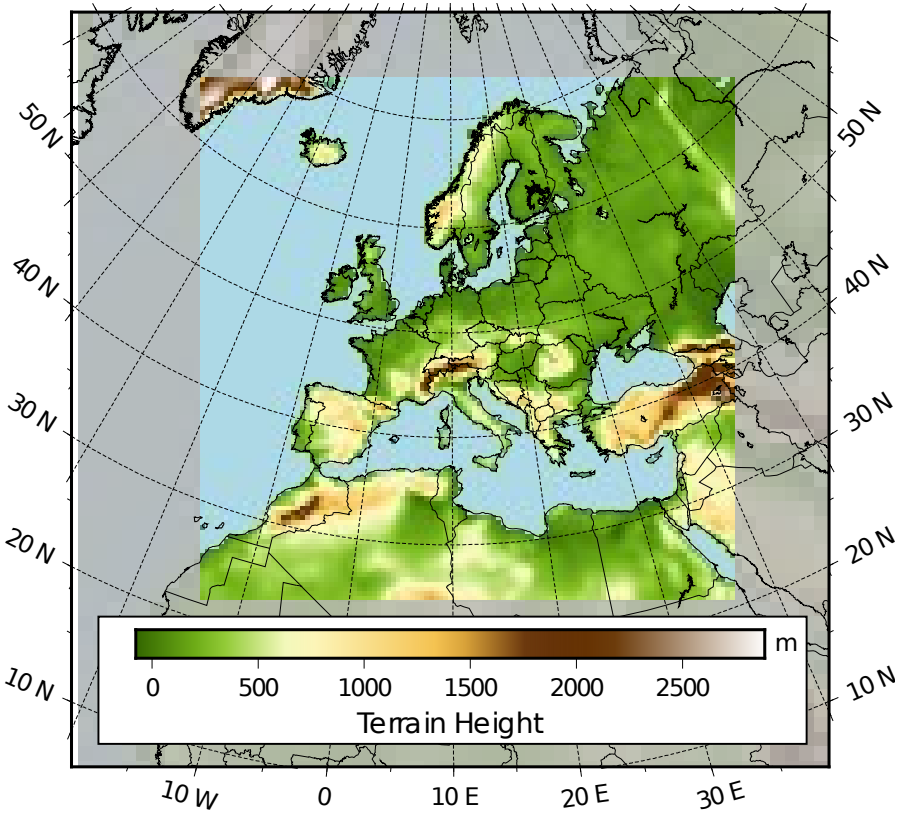
Source: https://allaboutaerosol.com

EXPERIMENTS

WRF-Chem was used to downscale **ERA20C** and the CMIP5 **MPI-ESM-LR**_r1i1p1 historical and **RCP8.5** runs (performed with the global model ECHAM6) for the periods **1991-2010** and **2031-2050** over an **Euro-Cordex** compliant domain with 0.44º resolution.

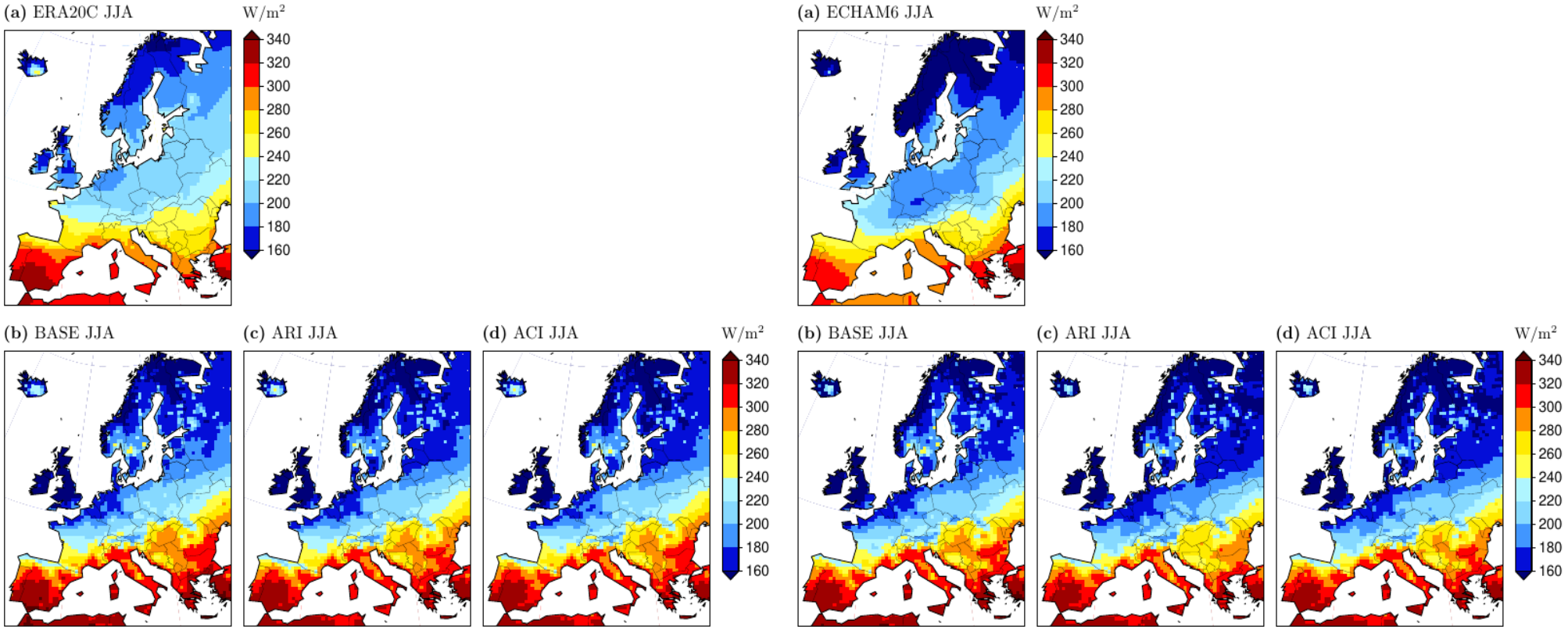
Three sets of simulations were performed:

BASE	constant aerosol concentrations without interactions
ARI	variable (online diagnosed) aerosol concentrations, under constant emissions, with **aerosol-radiation interactions**
ACI	variable (online diagnosed) aerosol concentrations, under constant emissions, with **aerosol-cloud interactions**



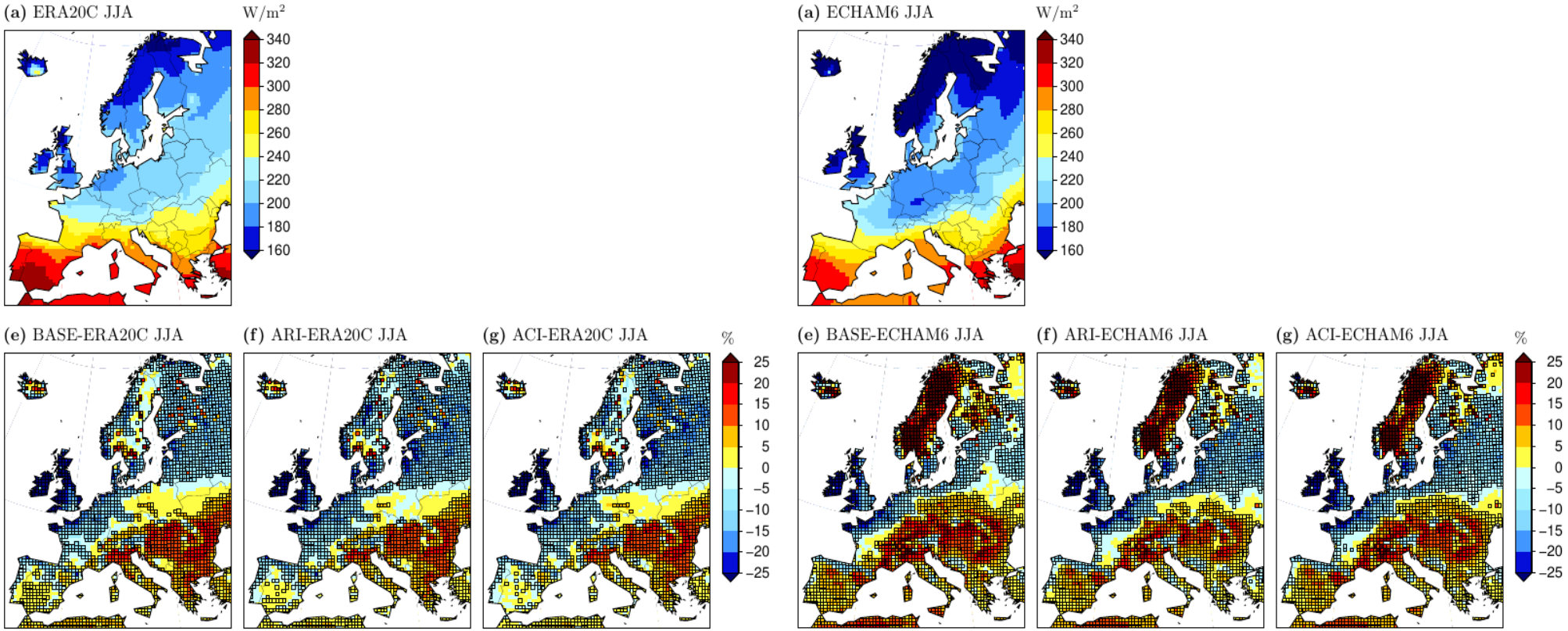
Domain 1 (1.32º) → Saharan dust
Domain 2 (0.44º) → Euro-Cordex

RESULTS: RSDS climatology (JJA 1991-2010)



* RSDS stands for Surface Downward Solar Radiation

RESULTS: RSDS climatology (JJA 1991-2010)



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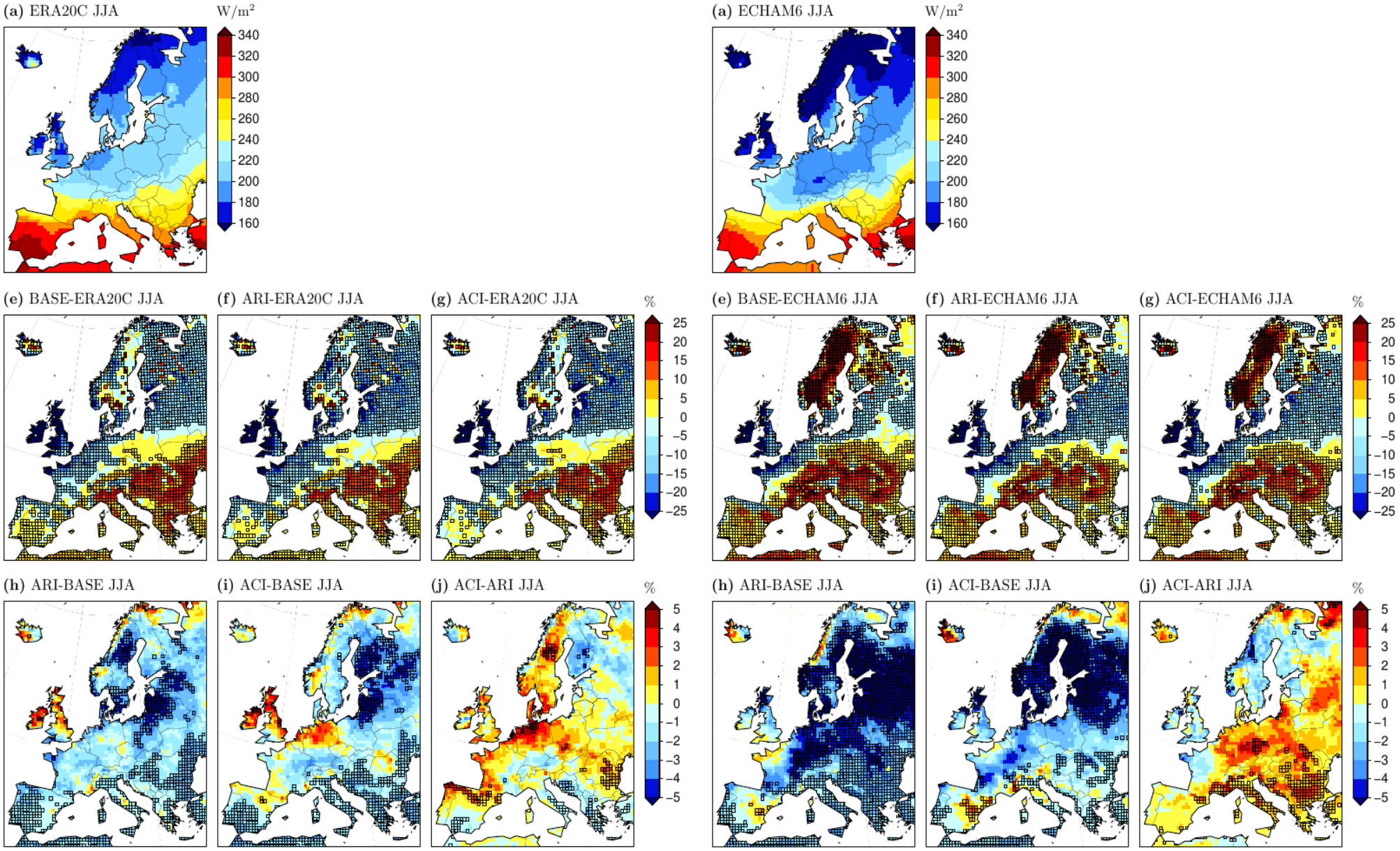

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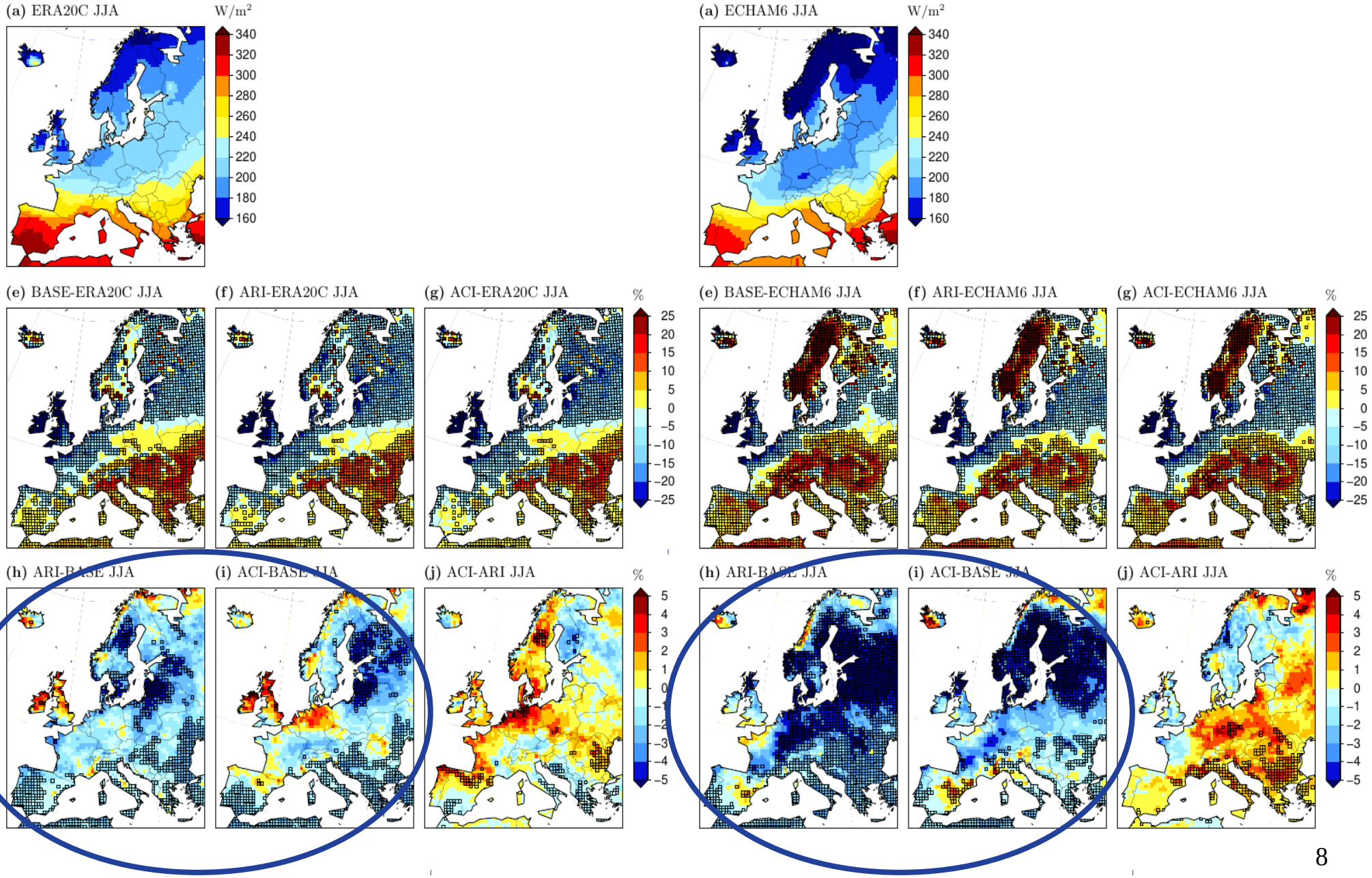

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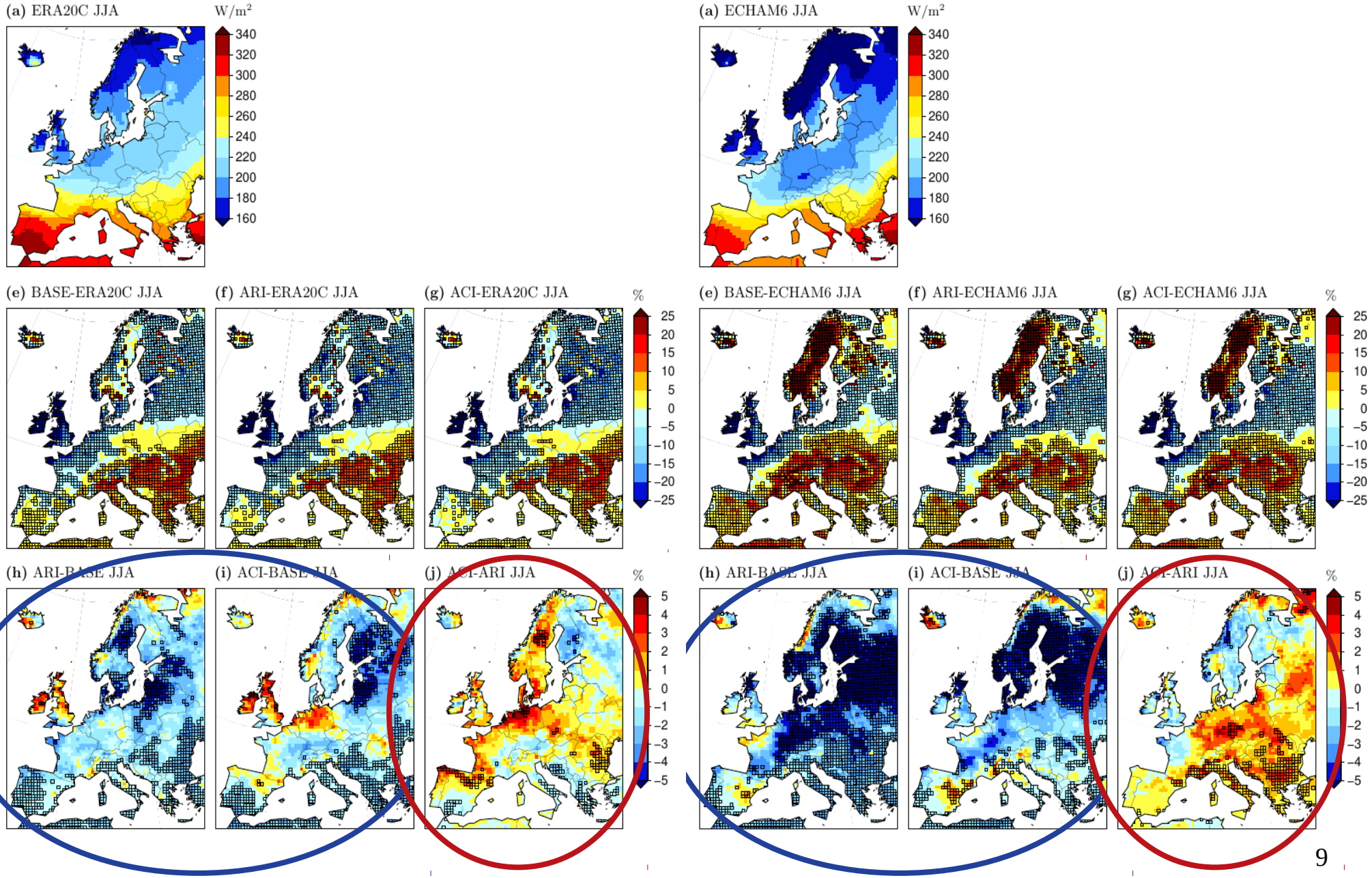

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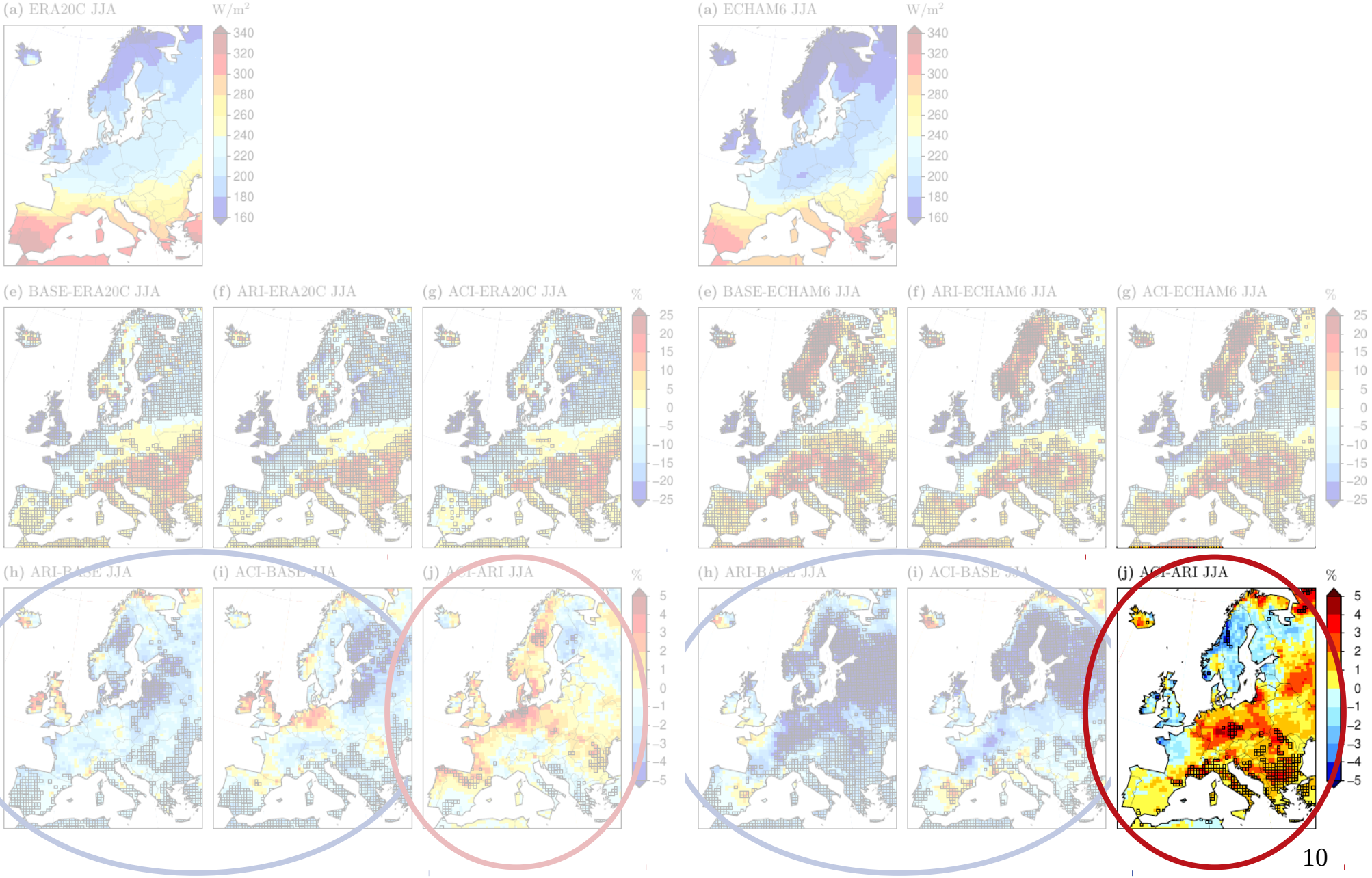
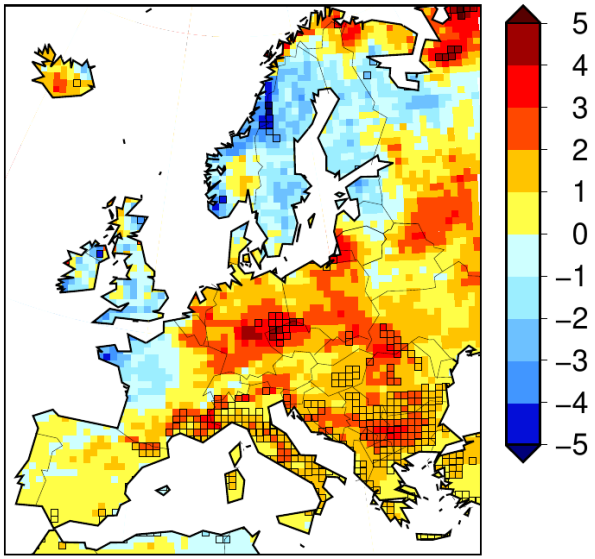


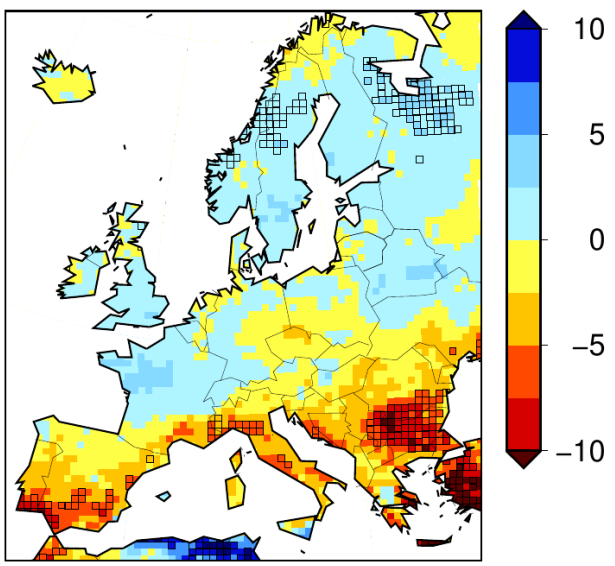
RESULTS: RSDS climatology (JJA 1991-2010)

ACI vs. ARI: matching the different aerosol effects on radiation, cloud cover and aerosol optical depth

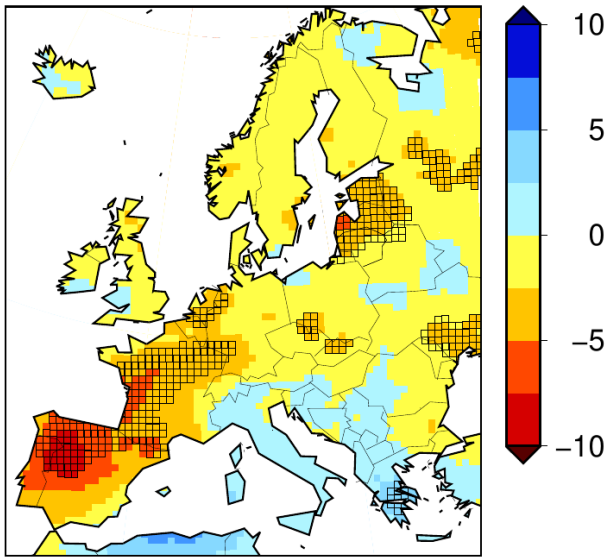
(a) RSDS ACI-ARI (JJA)



(b) CLT ACI-ARI (JJA)



(c) AOD ACI-ARI (JJA)

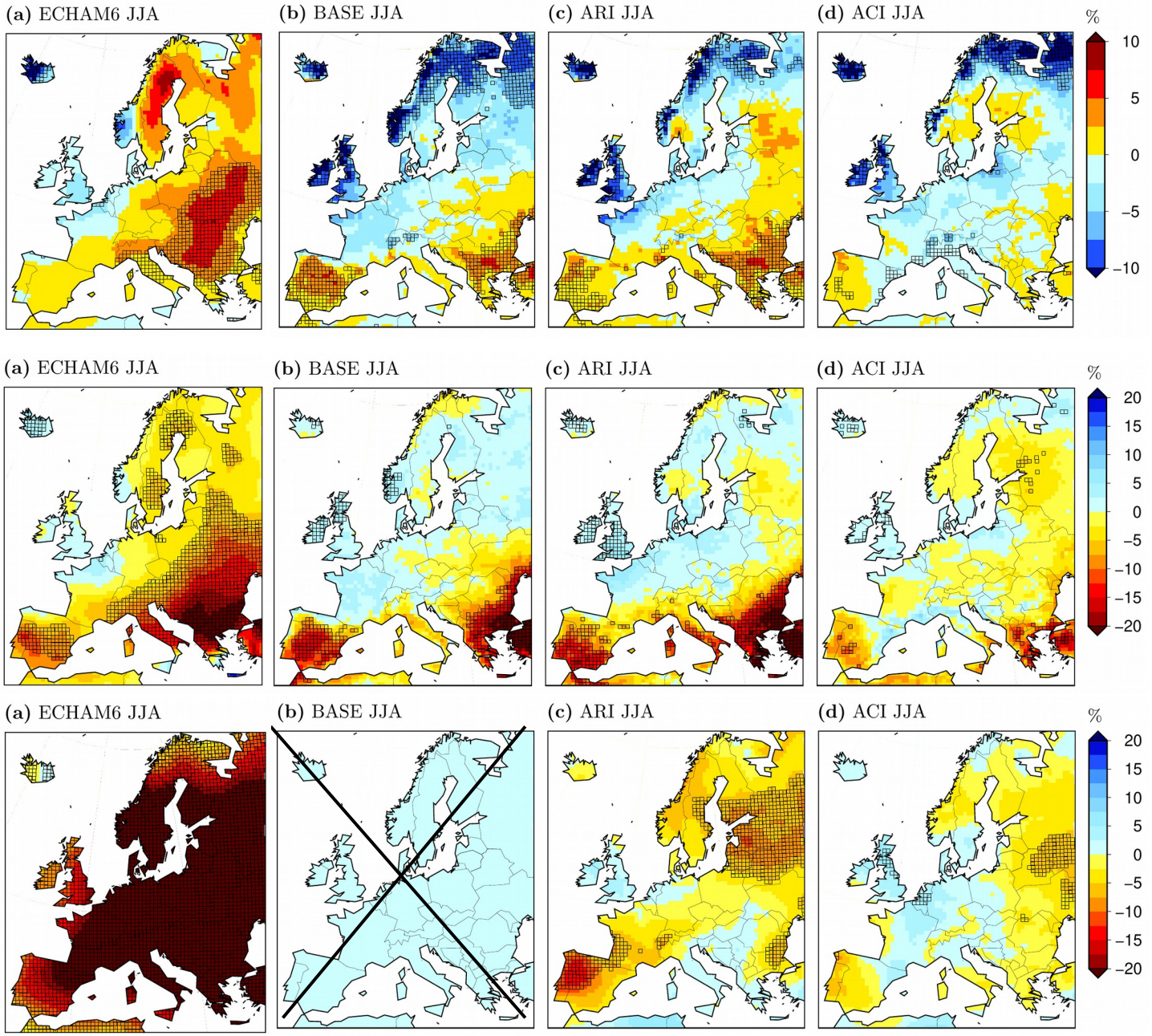


RESULTS: RSDS change (JJA 2031-2050 vs. 1991-2010)

RSDS

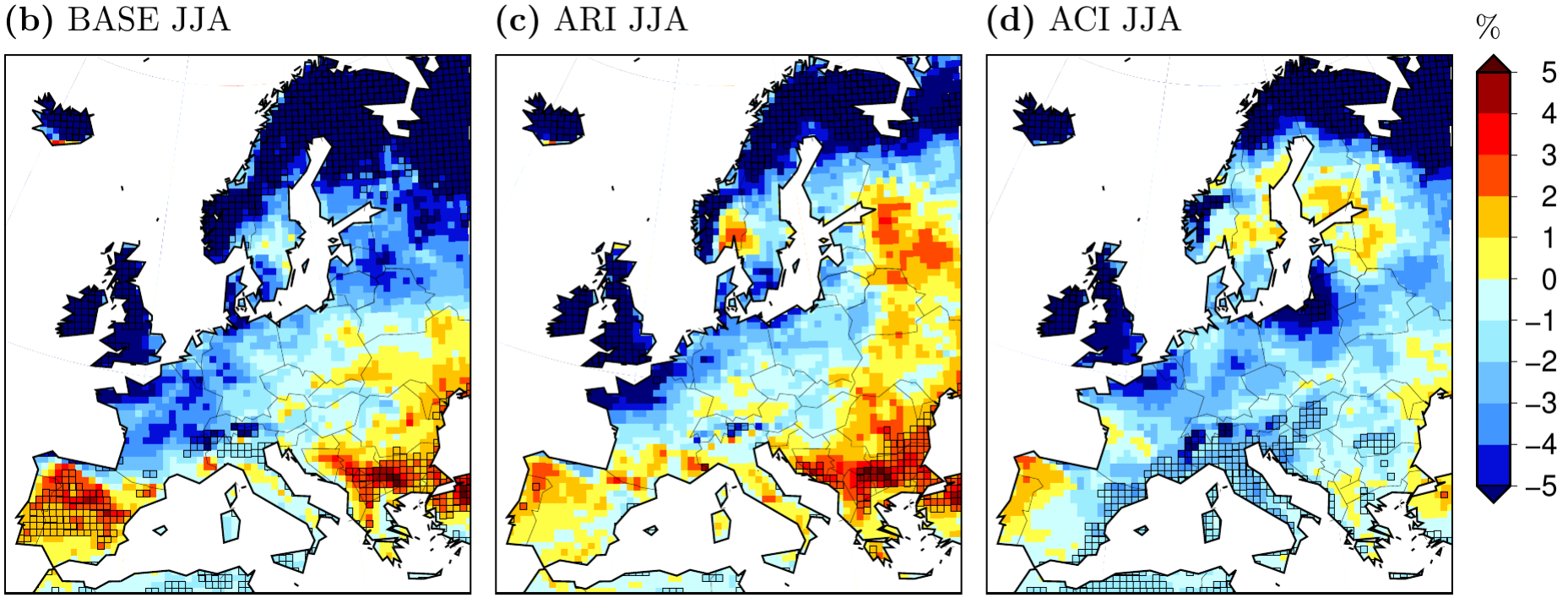
CLT

AOD



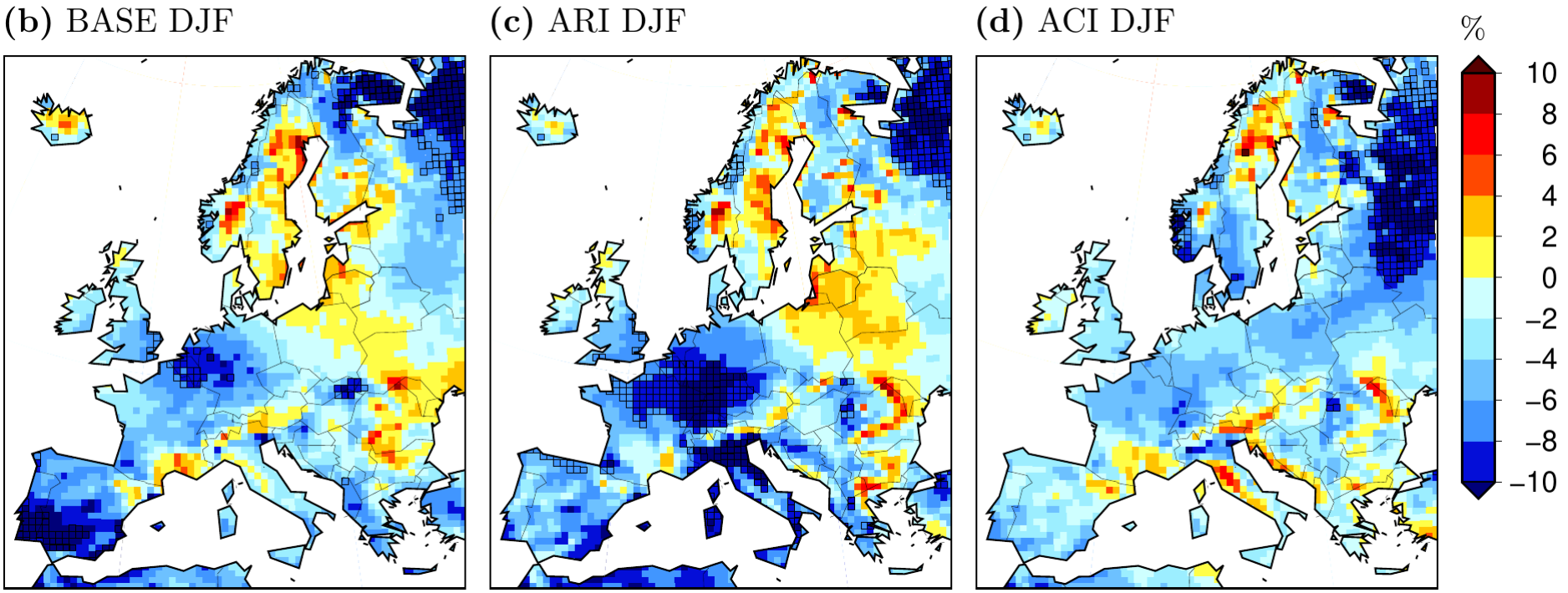
RESULTS: Implications for Solar Power

Solar power productivity change (JJA 2031-2050 vs. 1991-2010)



RESULTS: Implications for Wind Power

Wind power productivity change (DJF 2031-2050 vs. 1991-2010)



CONCLUSIONS

In present-day simulations, **aerosols interactions reduce the amount of solar radiation reaching the surface**, both ARI and ACI.

⇨ The reduction is smaller when ACI are included in the RCM execution, because we got less cloud coverage and less AOD as compared to the ARI experiment, so **ACI partly counteracts the ARI effects**.

In terms of future changes, BASE and ARI projections are the most similar between them, with the ARI patterns being the most similar to the patterns retrived from the driving global simulation. So **ARI certainly reduce the discrepancy between GCM and RCM projections**.

⇨ Again, **the inclusion of ACI counteracts the ARI effects**, not only in the projections for the solar resource, but also for the solar and wind power productivity. As much as that **ARI and ACI projections provide change signals of different sign** in some cases.

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Thank you for your attention!

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