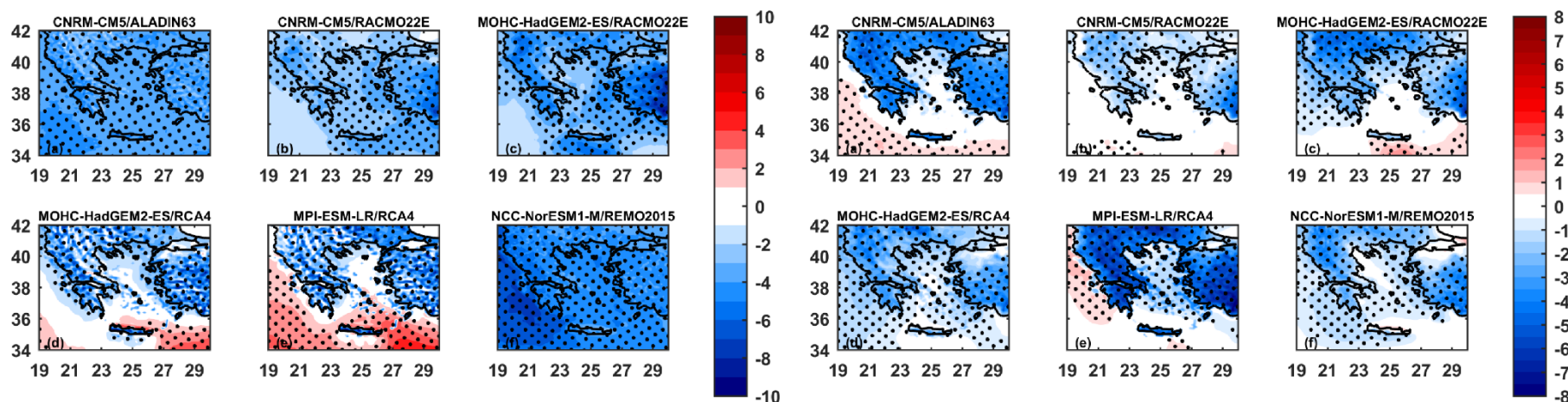




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Future projections of cloud cover and surface relative humidity over Greece during 21st century based on EURO-CORDEX simulations



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Outline

- Introduction.
- Data and Methods.
- Results
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 - Cloud Cover fraction: Annual projections (rcp8.5 scenario wft historical RF).
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 - Cloud Cover fraction: Seasonal (DJF) projections (F3 of rcp's wft historical RF).
- Conclusion.



Greece is located in the heart of one of the most vulnerable regions regarding climate change over the world. The increased severe climate and weather condition over this region turns the Mediterranean to a climate “hot-spot”. Generally, cloud cover variability is considered as a key climatic element because it drastically influences the radiation budget and the transfer of energy affecting the atmospheric circulation and weather. Furthermore, changes in humidity and temperature in ocean - continent systems affect the moist static energy having as a result changes in the dynamic of atmosphere.

The aim of this study is to investigate the projection of cloud cover fraction and surface relative humidity during the period from 1970 to 2099. In this analysis we use six high-resolution regional climate model simulations (RCMs) available from the EURO-CORDEX program.

The main Results show that significant changes are presented during the 2070-2099 period, with respect to a reference period (1976-2005) especially over the continental Greece according to rcp8.5 scenario. Focusing on the winter season, the comparison between future and reference periods shows that cloud cover fraction presents a significant decrease.

Why this study is important? The study of cloud cover and relative humidity are of great importance for the eastern Mediterranean because these climate parameters contribute to the mechanisms of the energy transfer over the atmosphere and precipitation.



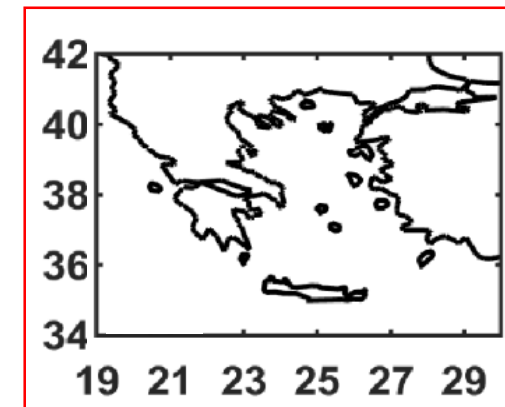
Fig. The topography of the Mediterranean region and the Greek region in the right up corner.



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Data:

- Annual and seasonal (DJF) mean values (calculated from daily data) of **cloud cover fraction** (ccf; in %) and **surface relative humidity** (sRH; in %) (**Table 1**).
- **EURO-CORDEX project**: six RCM simulations in spatial resolution $0.11^{\circ} \times 0.11^{\circ}$ for the period from 1970 to 2099 (*historical period from 1970 to 2005 and, the future period from 2006 to 2099 under the influence of the representative concentration pathway scenarios rcp2.6, rcp4.5 and rcp8.5; rcp's*).



Analysis:

- Composite difference maps of annual and seasonal mean of sRH and ccf are calculated over the Greek region ($19^{\circ}E - 29^{\circ}E, 34^{\circ}N - 42^{\circ}N$).
- The projected changes are investigated comparing three future periods (**F1**:2010-2039, **F2**:2040-2069 and **F3**: 2070-2099) with a reference historical period (**RF**: 1976-2005).

RCM	Driving GCM	Experiment	hist	rcp2.6	rcp4.5	rcp8.5
ALADIN63.v2	CNRM.CNRM-CERFACS-CNRM-CM5	r1i1p1	×	×	×	×
RACMO22E.v2	CNRM.CNRM-CERFACS-CNRM-CM5	r1i1p1	×	×	×	×
RACMO22E.v2	KNMI.MOHC-HadGEM2-ES	r1i1p1	×	×	×	×
RCA4.v1	SMHI.MOHC-HadGEM2-ES	r1i1p1	×	×	×	×
RCA4.v1	SMHI.MPI-M-MPI-ESM-LR	r1i1p1	×	×	×	×
REMO2015.v1	GERICS. NCC-NorESM1-M	r1i1p1	×	×	×	×

Table 1. List of RCMs (EURO-CORDEX) simulations used in this study.



Surface Relative Humidity: Annual projections (rcp8.5 scenario wft historical RF)

A.) Changes of sRH between F1 and RF:

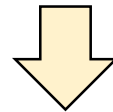
- The sRH decreases (about 2%-3%) mainly over the continental Greece.
- Four out of six simulations show a significant decrease (about 2% to 4%) over northern Greece.
- The majority of simulations present a limited decrease of sRH over Aegean Sea (about 1% to 2%).

B.) Changes of sRH between F2 and RF:

- The sRH decreases mainly over the continental Greece (reduces about 3% to 5%).

C.) Changes of sRH between F3 and RF:

- The sRH reduces compared to the RF over the continental Greece (up to 8%).
- Over the Aegean Sea the simulations show limited changes of sRH about 1% to 1.5%.



Significant changes of sRH over continental Greek region and, limited changes of sRH over sea areas are projected during the future period

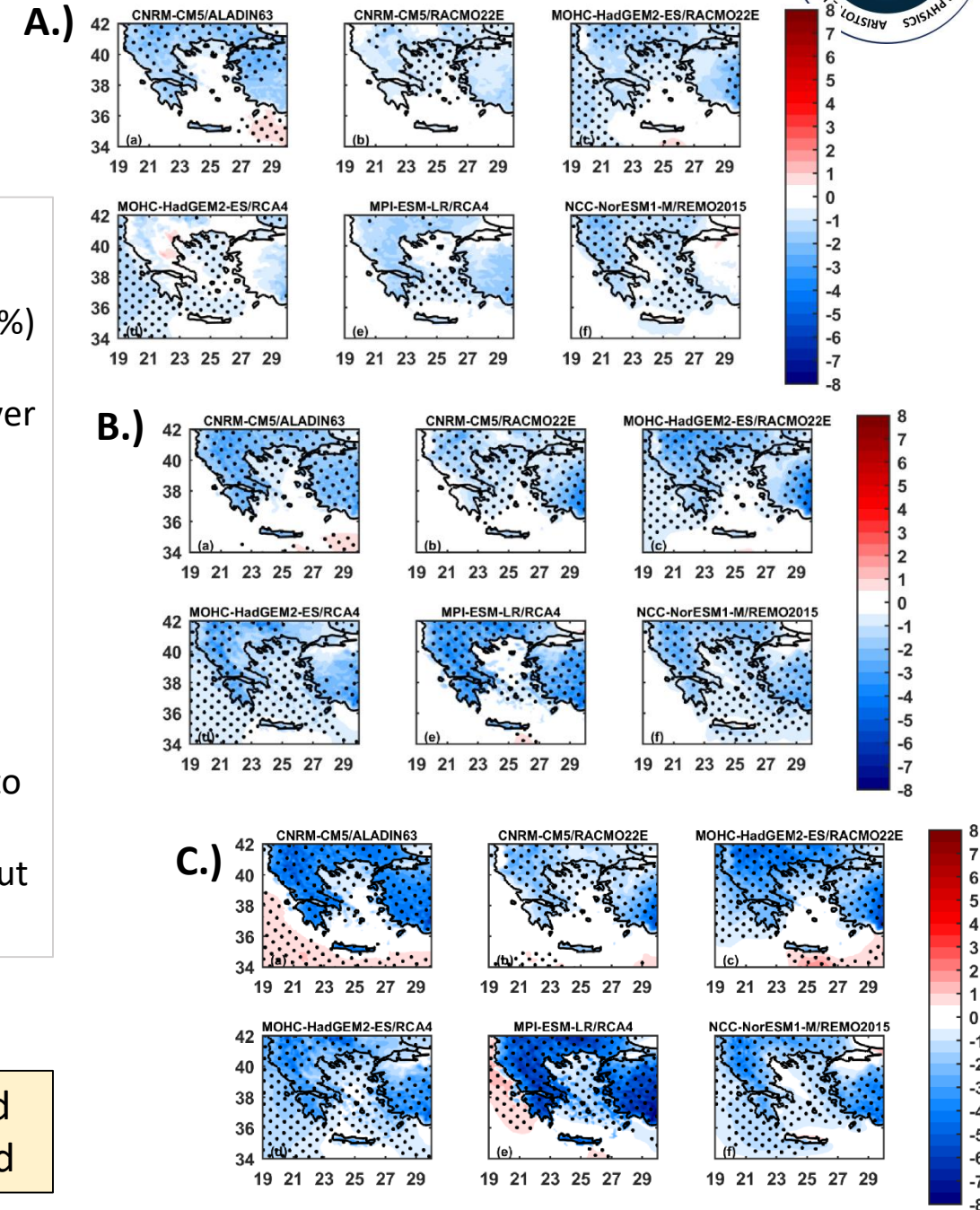
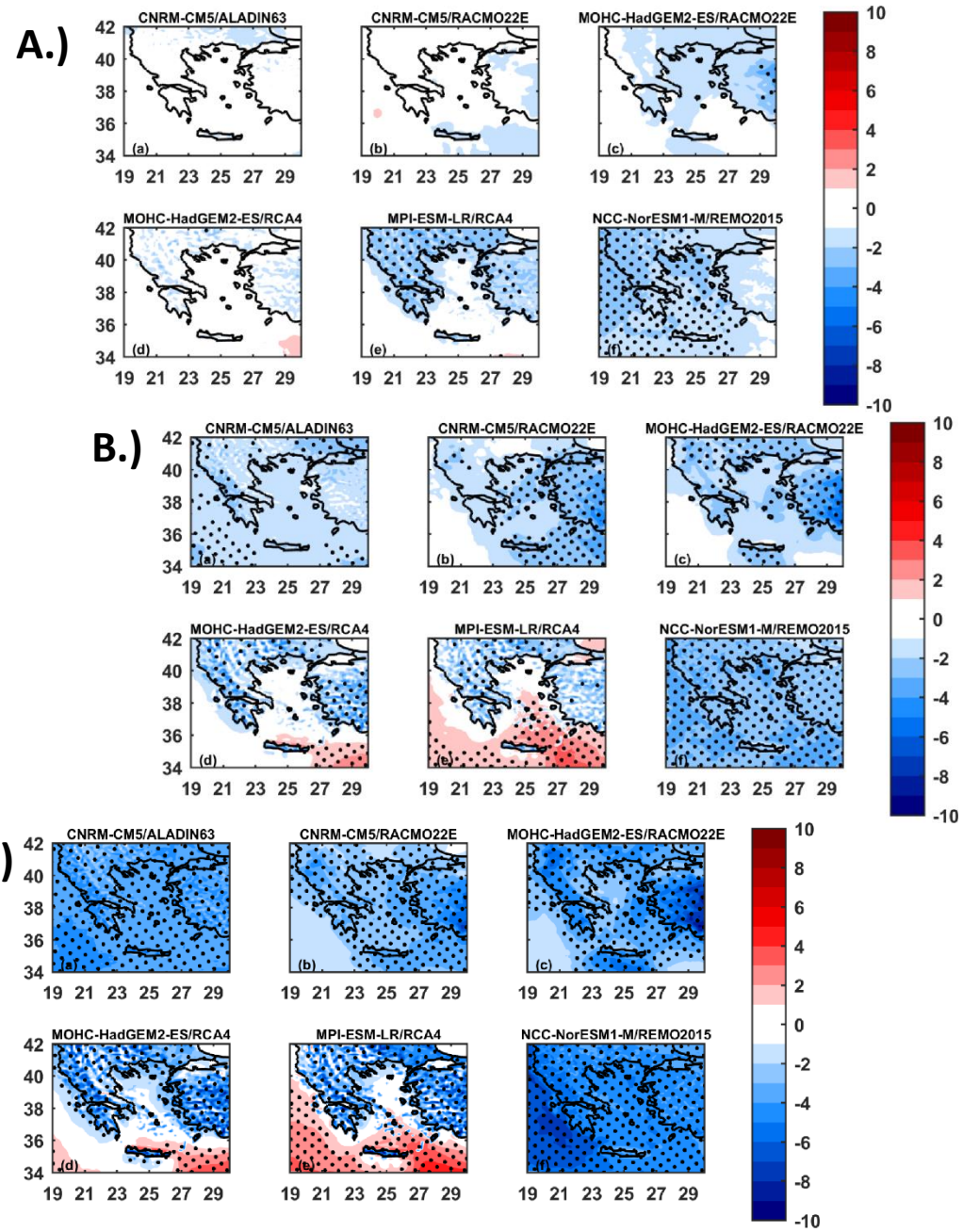


Fig. Annual mean sRH composite difference according to rcp8.5 scenario of A.) F1 and RF B.) F2 and RF and C.) F3 and RF for each simulation (please note that the percentage values are absolute differences). The dotted points denote statistical significance at 95%.



**Cloud Cover fraction: Annual projections
(rcp8.5 scenario wft historical RF)**

A.) Changes of sRH between F1 and RF:

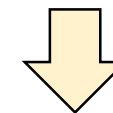
- Only two out of six simulations show that the ccf reduces about 1% to 3%.

B.) Changes of sRH between F2 and RF:

- The ccf reduction varies from 1% to 5%.
- In two out of six simulations, the ccf increases over the south sea area (about 1% to 3%).

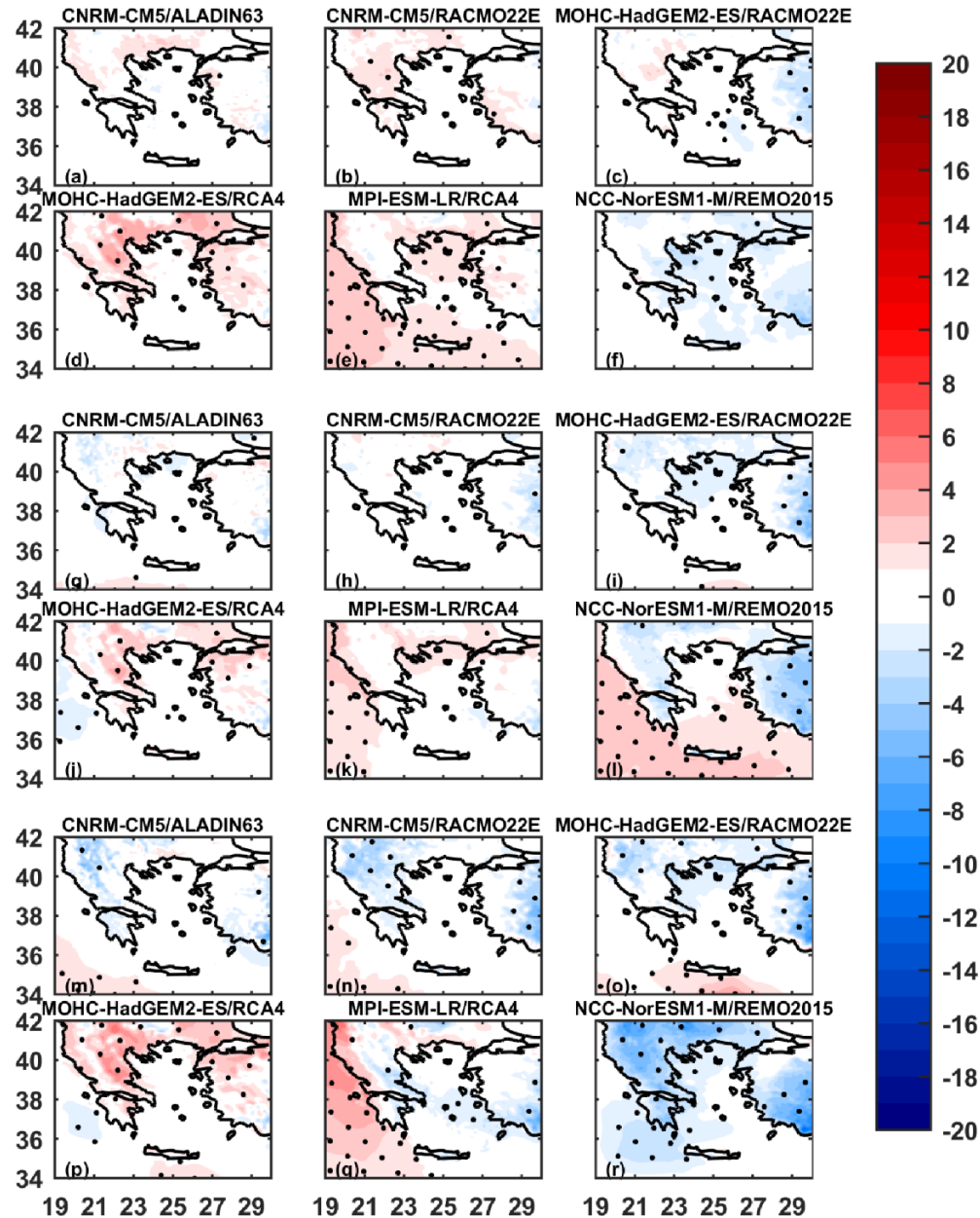
C.) Changes of sRH between F3 and RF:

- The ccf reduction varies from 1% to 8%.
- In two out of six simulations, the ccf increases over the south sea area (about 2% to 5%).



The ccf reduces especially over the continental Greek area.

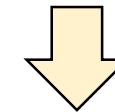
Fig. Annual mean ccf composite difference according to rcp8.5 scenario of **A.)** F1 and RF **B.)** F2 and RF and **C.)** F3 and RF for each simulation (please note that the percentage values are absolute differences). The dotted points denote statistical significance at 95%.



Surface Relative Humidity: Seasonal (DJF) projections (F3 of rcp's wft historical RF)

➤ winter (DJF) is the season with the maximum ccf and sRH in the Greek region.

- The changes of sRH are insignificant for rcp2.6 and rcp4.5 scenarios.
- Some limited changes are found over the northwest continental Greece in the rcp8.5 scenarios.



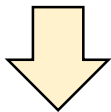
Some limited changes are shown in continental Greece according to the rcp8.5 scenario.

Fig. Winter (DJF) season relative composite difference (%) of sRH of F3 according to (a-i) rcp2.6, (g-l) rcp4.5 and (m-r) rcp8.5 scenarios with respect to RF. The dotted points denote a statistical significance at 95%.



Cloud Cover fraction: Seasonal (DJF) projections (F3 of rcp's wft historical RF)

- According to the rcp2.6 scenario, the simulations show insignificant changes.
- For the moderate scenario (rcp4.5), the ccf (in three out of six simulations) shows a relative decrease (about 4% to 8%) especially over the sea area of Greek region.
- The main changes are presented in the rcp8.5 scenario (relative reduction about 10% to 20% over the Greek domain).



The ccf reduces in future. The reduction is shown mainly according to the rcp8.5 scenario.

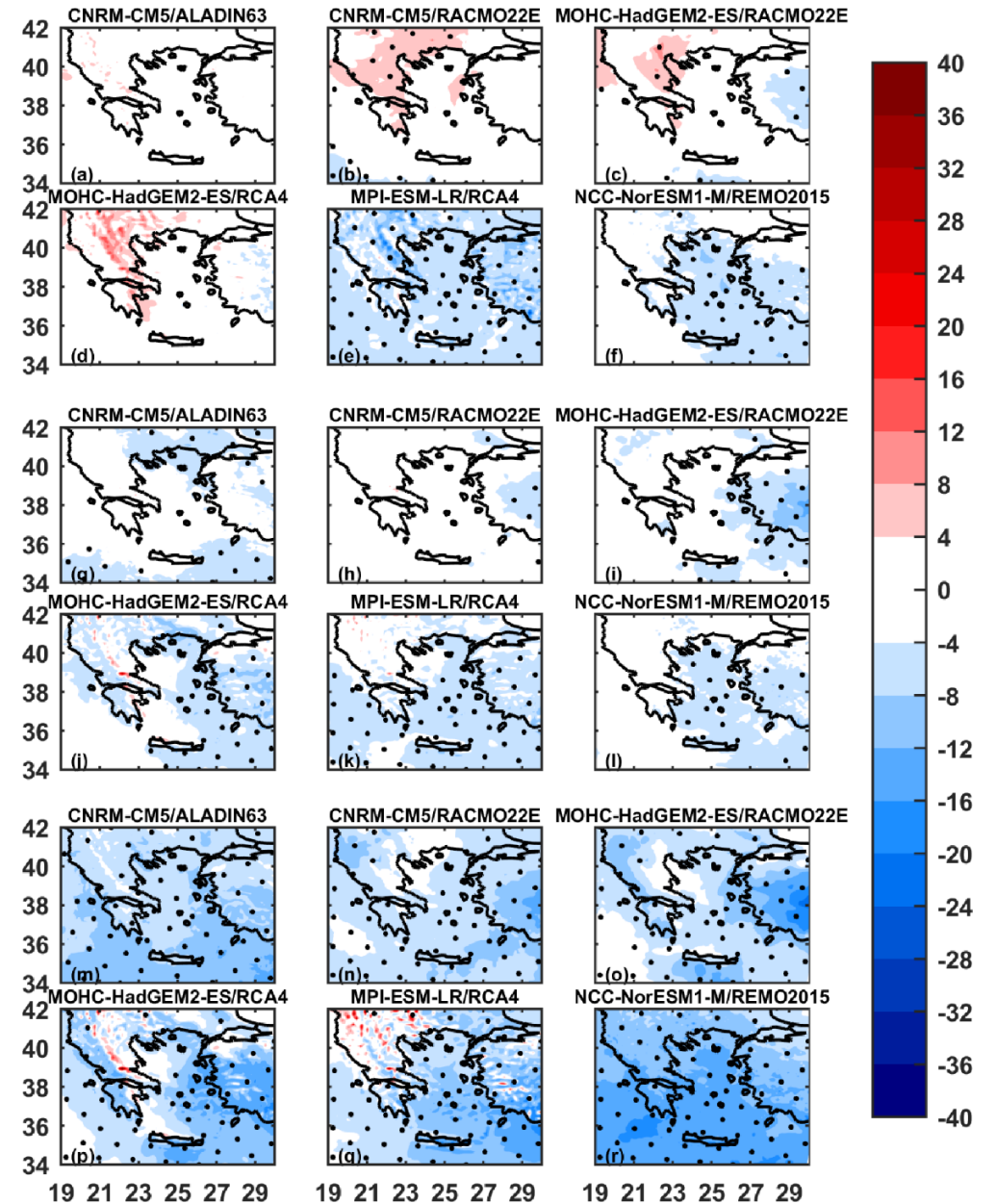


Fig. Winter (DJF) season relative composite difference (%) of ccf of F3 according to (a-i) rcp2.6, (g-l) rcp4.5 and (m-r) rcp8.5 scenarios with respect to RF. The dotted points denote a statistical significance at 95%.



Introduction	Data and Methods	Results	<u>Conclusion</u>
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- **Significant changes of ccf and sRH are found mainly in the rcp8.5 scenario and during the last period of 21st century.**
 - The sRH decreases about 5% to 8% during 2070-2099 with respect to the reference period and ccf decreases about 4% to 6%, respectively.
 - The main changes are found over the continental Greece.
 - In some cases the simulations show a different sign of change.
- **For the winter period (DJF) the main changes are found during the end of 21st century both for sRH and ccf.**
 - Generally, the simulations show a different sign of sRH changes over Greece.
 - The majority of simulations presents a little relative reduction of sRH over northwestern Greece.
 - The ccf shows a relative reduction about 10% to 20% compared to the reference period over the Greek domain.

Thank you



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