What can we know about future precipitation in Africa?

Analysis of the precipitation signal from the CORDEX-Africa RCMs.

Alessandro Dosio
Richard G. Jones
Christopher Jack
Christopher Lennard
Grigory Nikulin
Bruce Hewitson

Dosio et al, 2019. *Clim. Dyn.*

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We used a large ensemble of CORDEX-AFRICA RCM runs (23 GCM-RCM combinations) to address three questions:
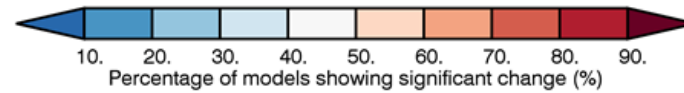
Q1: What can we know about future change in precipitation over Africa?

Q2: Is the message from RCMs similar to that from the driving GCMs?

Q3: Does the message depend on the model ensemble?

Dosio et al, 2019. *Clim. Dyn.*

Data

RCP8.5, 1981-2100

	CanE SM2	CNR M-CM5	CSIR O-MK3	GFDL -ESM2 M	**EC-EART H**	HadG EM2-ES	IPSL-CM5A -MR	MIRO C5	MPI-ESM-LR	Nor-ESM1 -M
CCLM4. 8-17		X			X	X			X	
HIRHA M5					X					X
REMO					X	X	X	X	X	
RACMO 22E					X	X				
RCA4	X	X	X	X	X	X	X	X	X	X

Statistical Significance – KS test
- Reference period (1981–2010)
- Test period(2070–2099)

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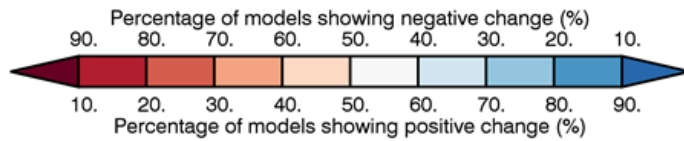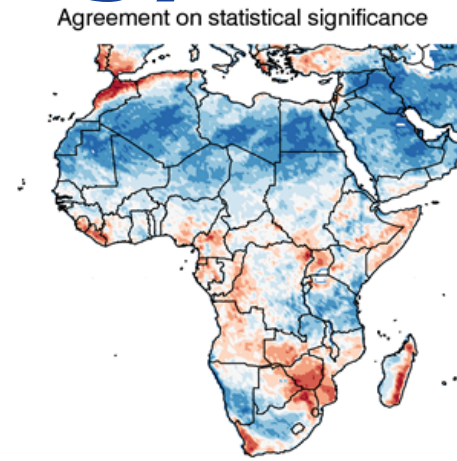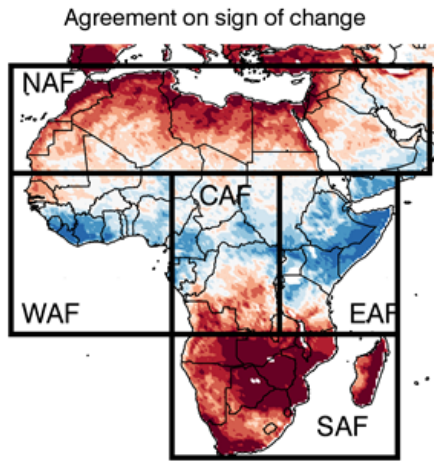# We used a large ensemble of CORDEX-AFRICA RCM runs (23 GCM-RCM combinations) to address three questions:

Q1: What can we know about future change in precipitation over Africa?

Q2: Is the message from RCMs similar to that from the driving GCMs?

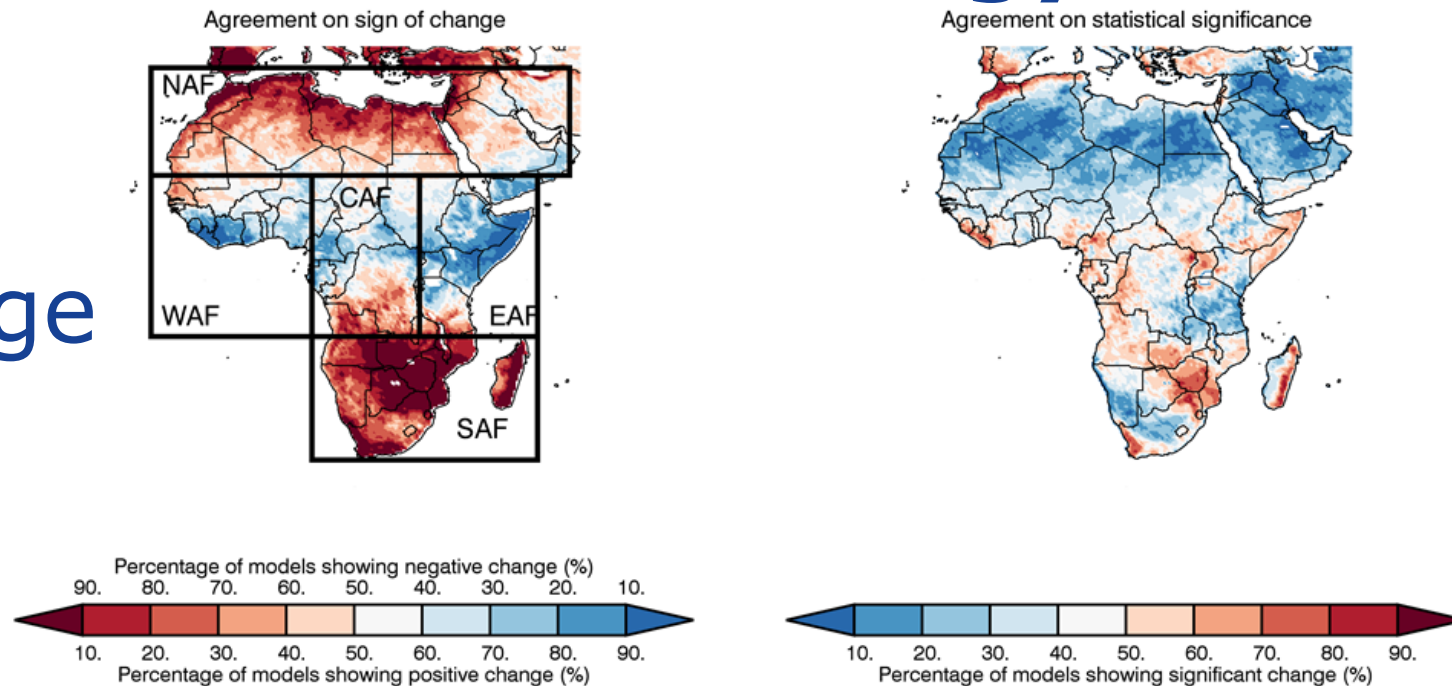**Q3:** Does the message depend on the model ensemble?

Dosio et al, 2019. *Clim. Dyn.*

Methodology

SON
ppt
change

Agreement on sign of change

Agreement on statistical significance

Dosio et al, 2019. *Clim. Dyn.*

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Methodology

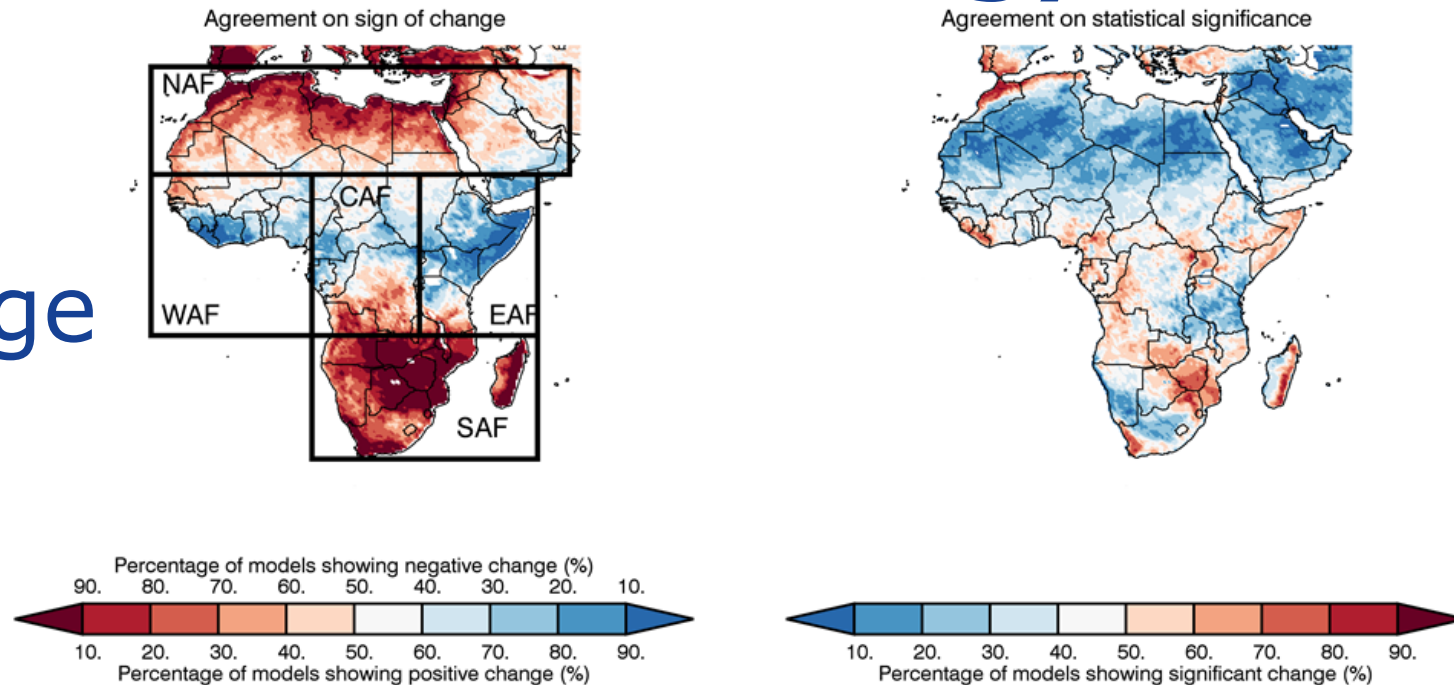SON
ppt
change

What can we say about the robustness of the change signal?
- Use statistical significance and change of sign agreement

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Methodology

SON ppt change

Agreement on sign of change

Agreement on statistical significance

Percentage of models showing negative change (%)
90. 80. 70. 60. 50. 40. 30. 20. 10.

10. 20. 30. 40. 50. 60. 70. 80. 90.
Percentage of models showing positive change (%)

10. 20. 30. 40. 50. 60. 70. 80. 90.
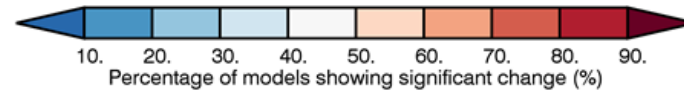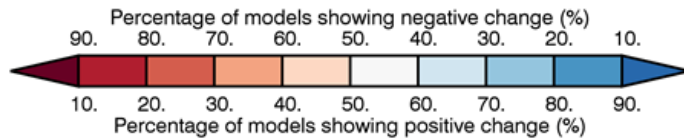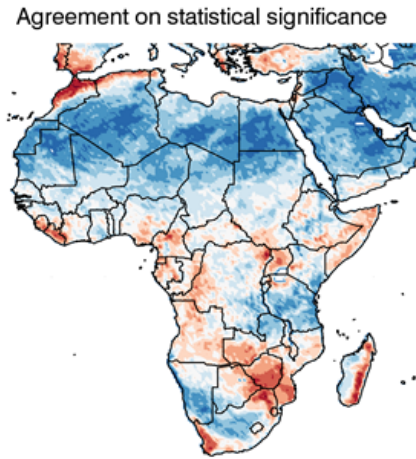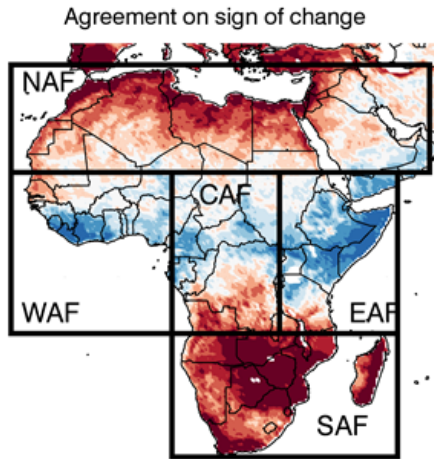Percentage of models showing significant change (%)

What can we say about the robustness of the change signal?
For each grids cell the change is
- **NON-Significant** - Change is non-significant for over half the models
- **ROBUST** - Change is significant for more than half of the models and 80% of the models the agree on its sign
- **UNCERTAIN** - Change is significant for over half of the models but they do not agree on its sign
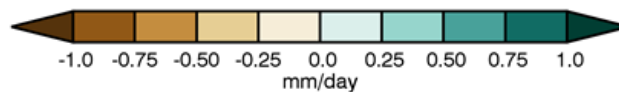
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Methodology

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10. 20. 30. 40. 50. 60. 70. 80. 90.
Percentage of models showing significant change (%)

Precipiation change (median)
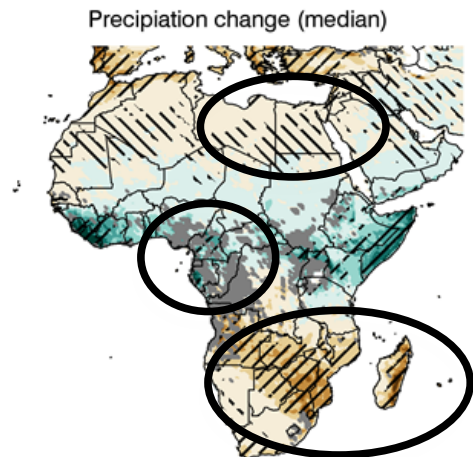
Non-Significant

Uncertain

Robust

-1.0 -0.75 -0.50 -0.25 0.0 0.25 0.50 0.75 1.0
mm/day

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Methodology

Change is non-significant for most of the models

Precipiation change (median)
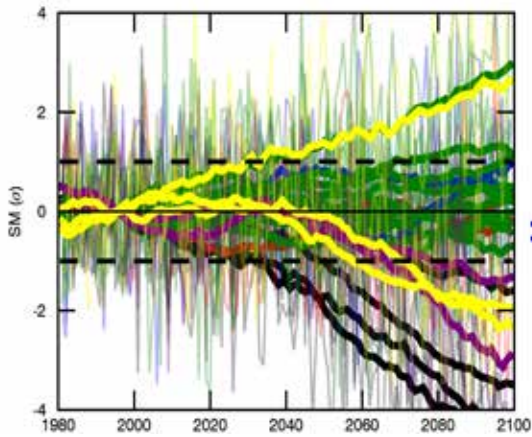
Change is significant for most of the models but they do not agree on its sign
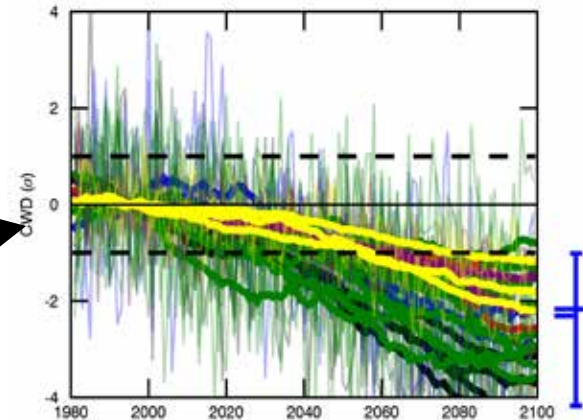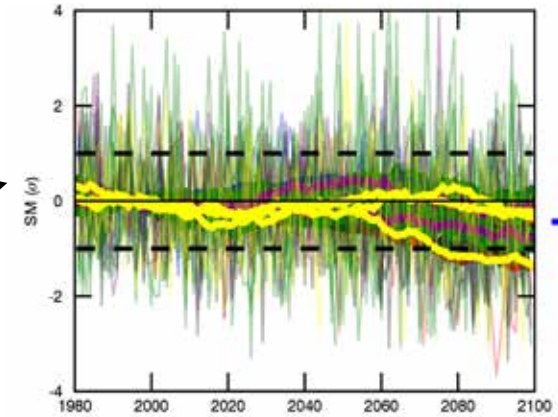
Change is significant for most of the models and the agree on its sign

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Example of results:
Mean vs. frequency vs. intensity

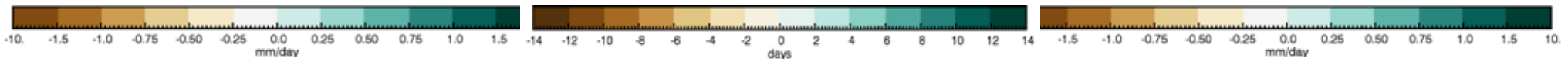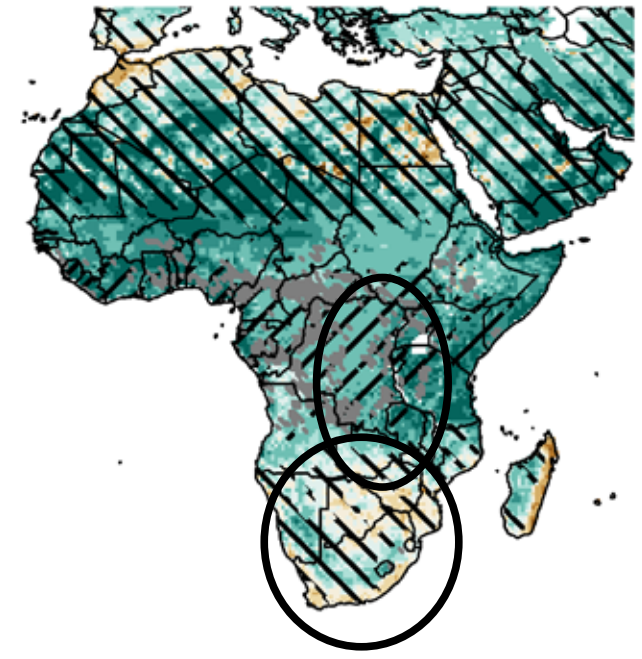**RCMs MEAN CHANGE SM SON**

RCMs MEAN CHANGE RR1 SON
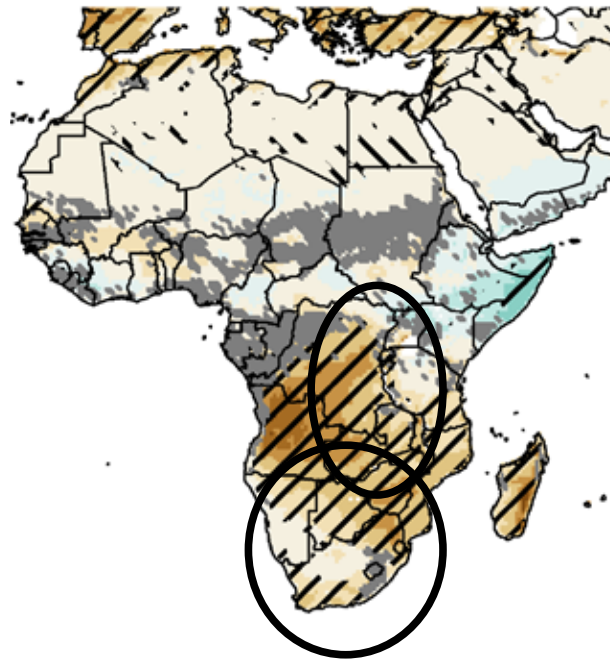
RCMs MEAN CHANGE SDII SON

Mean does not change

Mean decreases
(robust change)

It rains less frequently
(robust change)

It rains less frequently
(robust change)

It rains more intensely
(robust change)

Intensity stays the same
(non significant change)

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Mean vs. frequency vs. intensity

RCMs MEAN CHANGE SM JJA   RCMs MEAN CHANGE CWD JJA   RCMs MEAN CHANGE CDD JJA
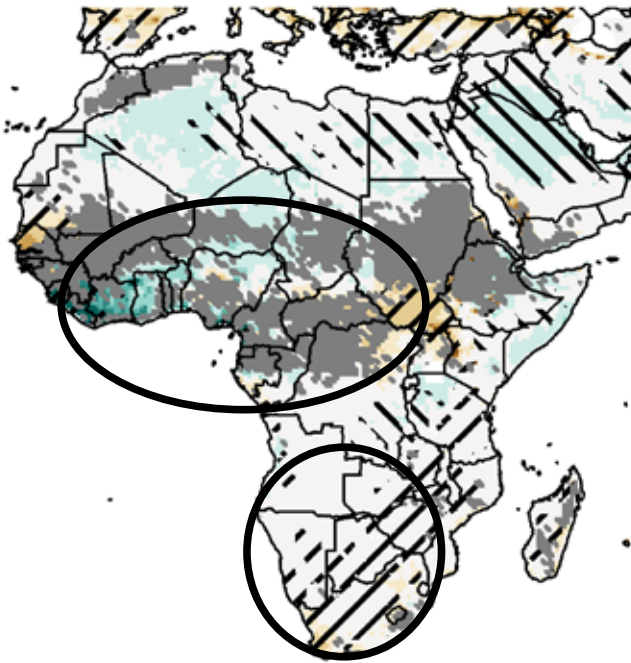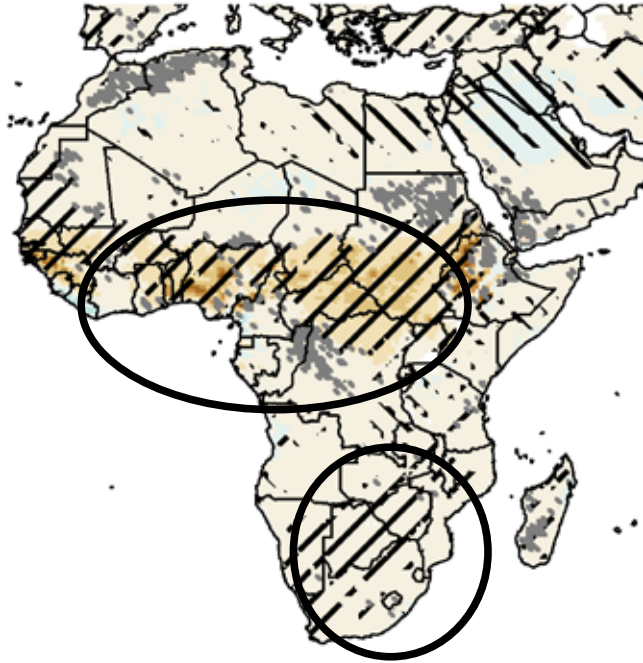
Mean is uncertain   Less CWDs   More CDDs

Mean decreases   Less CWDs   More CDDs

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Lesson learnt (1)

Q1: What can we know about future change in precipitation over Africa?

In some areas and for some seasons we are confident that **precipitation characteristics will change** (e.g. Southern Africa is the region showing the more consistent trend towards drier future conditions.)
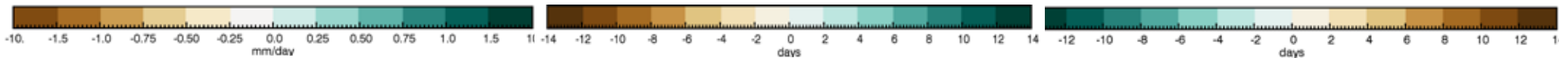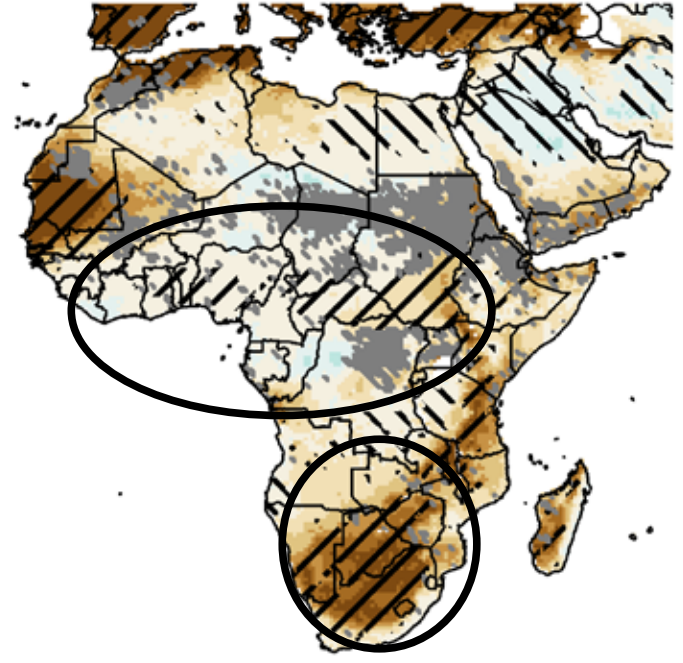
In some areas and for some seasons **we are confident that they will not change** (E.g. North Africa, where precipitation characteristics, especially the precipitation intensity, are projected to not change significantly).

In some **areas we still cannot say much** (model's results uncertain); however, even if e.g. mean precipitation signal is uncertain, other characteristics (such as frequency and intensity) may show a robust change. (e.g. West Africa)

Dosio et al, 2019. *Clim. Dyn.*

Q2: Is the message from RCMs similar to that of the driving GCMs?

We have compared the changes in precipitation characteristics of the RCM ensemble to those of the driving GCMs.

Dosio et al, 2019. *Clim. Dyn.*

When the Robust change is compared, GCMs and RCMs give a very consistent message

RCMS
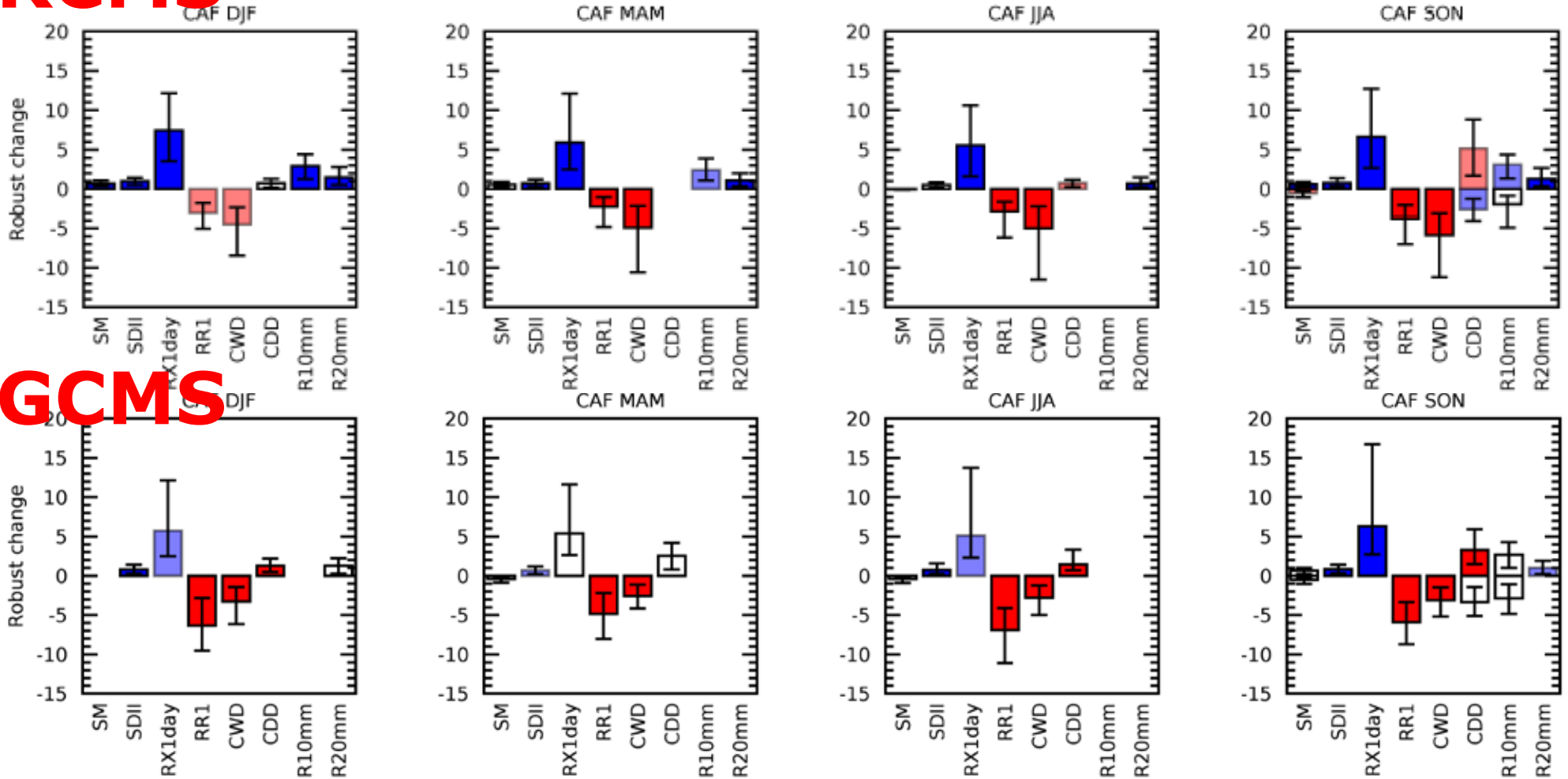
GCMS
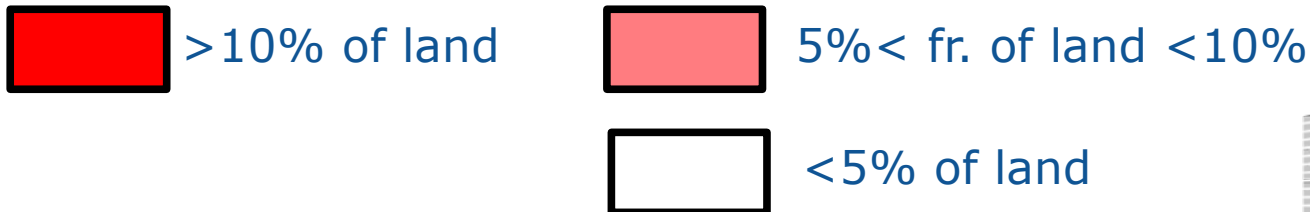
Legend:
- **>10% of land** (red)
- **5%< fr. of land <10%** (pink)
- **<5% of land** (white)

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However, there are regions where RCMs and GCMs give different (opposite) signals (Potential added value of downscaling)

GCMs SM MAM

-1.0 -0.75 -0.50 -0.25 0.0 0.25 0.50 0.75 1.0
mm/day

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However, there are regions where RCMs and GCMs give different (opposite) signals (Potential added value of downscaling)

RCM SM MAM

GCMs SM MAM

-1.0   -0.75   -0.50   -0.25   0.0   0.25   0.50   0.75   1.0
mm/day

Dosio et al, 2019. *Clim. Dyn.*

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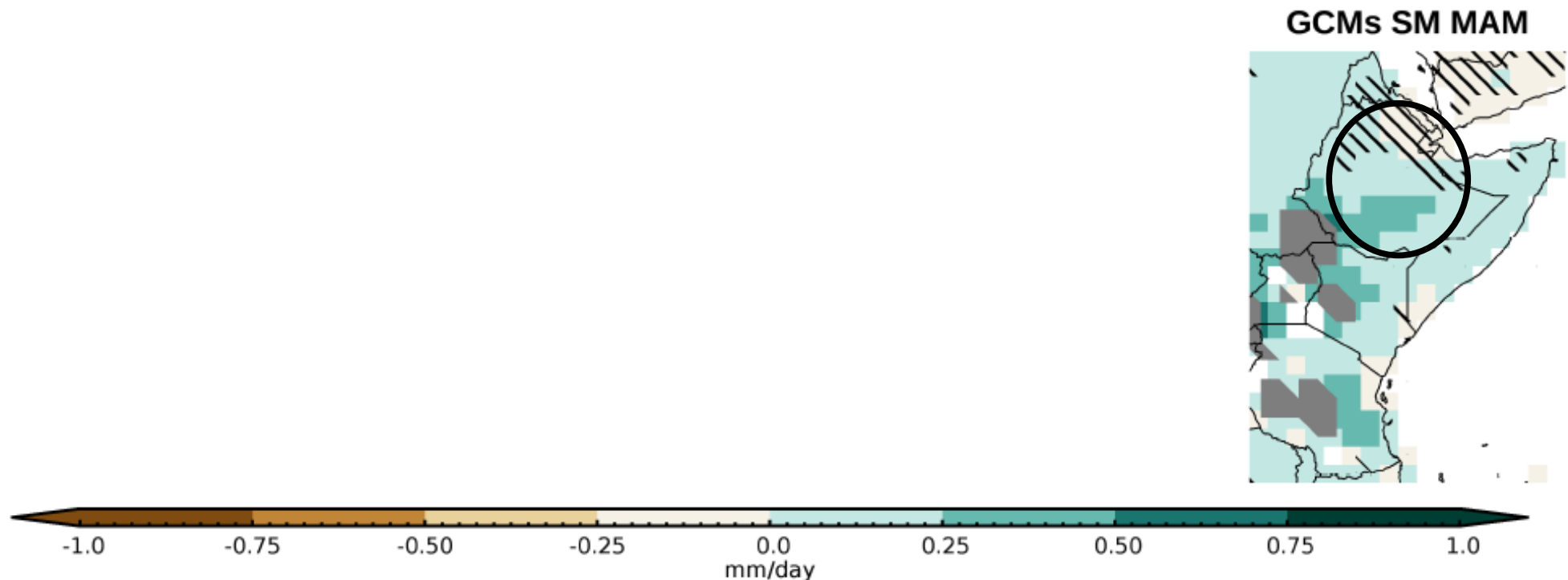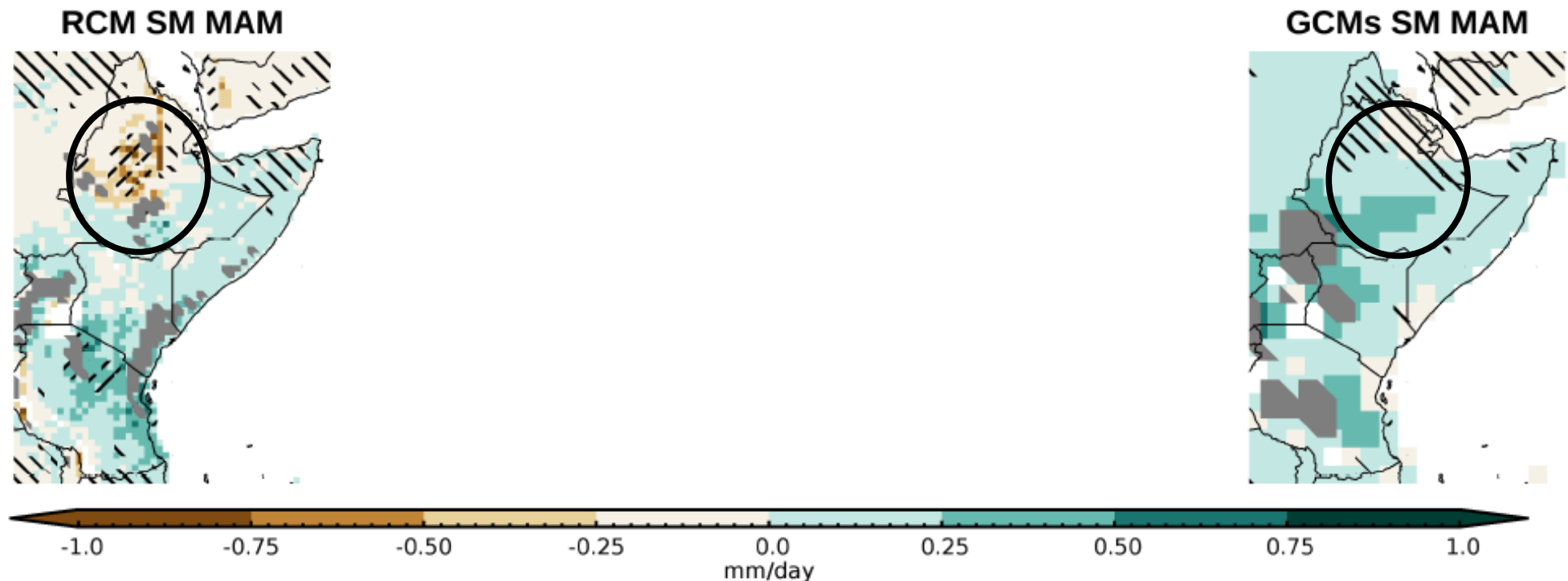
However, there are regions where RCMs and GCMs give different (opposite) signals (Potential added value of downscaling)
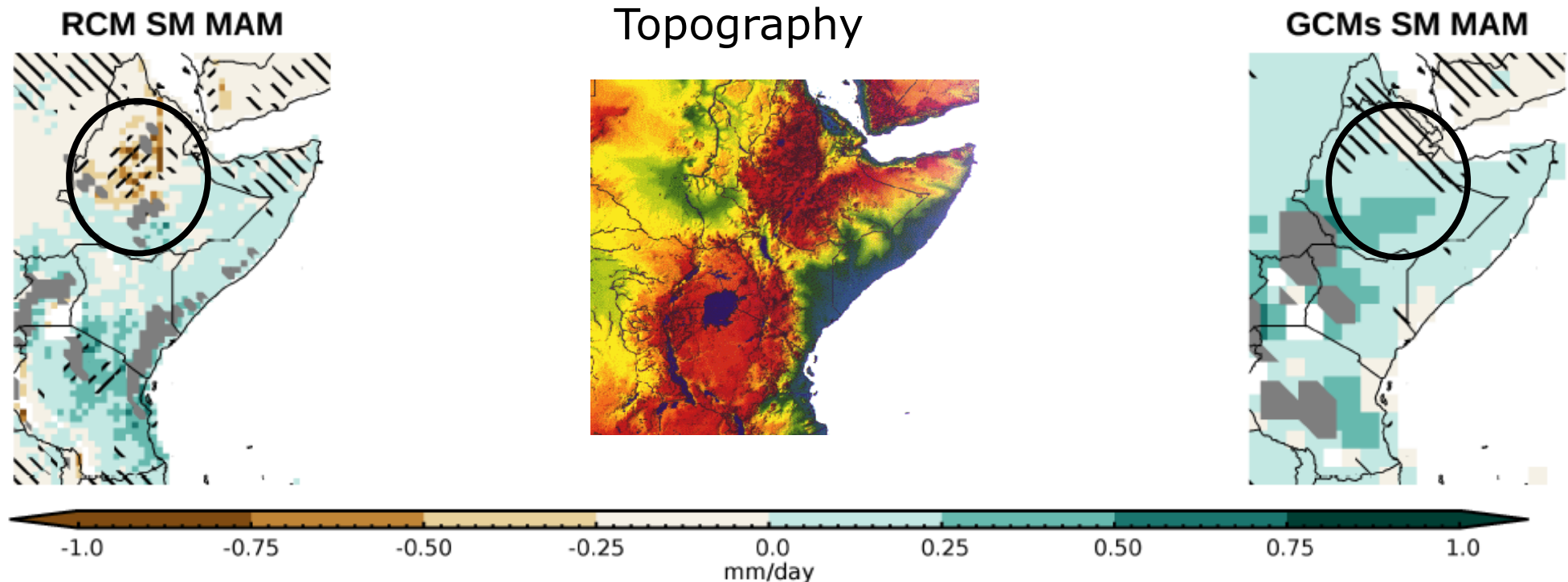

RCM SM MAM

Topography

GCMs SM MAM

-1.0 -0.75 -0.50 -0.25 0.0 0.25 0.50 0.75 1.0
mm/day

Dosio et al, 2019. *Clim. Dyn.*

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Lesson learnt (2)

Q2: Is the message from RCMs better/more robust/more informative (chose words at will) than the GCMs' one?

When comparing ensemble mean results, GCMs and RCMs may differ. However, if we focus on regions where the change is robust, **RCMs and GCMs give consistent and similar results** (although the fraction of land with robust signal can differ between GCMs and RCMs).

It is assumed that RCMs simulate more realistic climate than driving GCMs because they simulate small-scale climate processes that are absent in the coarser resolution simulation. **Strong local effects of e.g. topography and coasts** are found on mean and second order statistics (extremes) (Added Value is expected there).

However there are still **large uncertainties in RCMs' projections and differences with driving GCMs**. These need to be investigated further.

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Q3: Do the results depend on the RCM/GCM?

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Q3: Do the results depend on the RCM/GCM?

	CanESM 2	CNRM-CM5	CSIRO-MK3	GFDL-ESM2M	EC-EARTH	HadGEM2-ES	IPSL-CM5A-MR	MIROC5	MPI-ESM-LR	Nor-ESM1-M
CCLM4.8-17		X			X	X			X	
HIRHAM5					X					X
REMO					X	X	X	X	X	
RACMO22E					X	X				
RCA4	X	X	X	X	X	X	X	X	X	X

We compare ensemble mean results vs. those averaged across RCMs and GCMs

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Example: Central Africa JJA
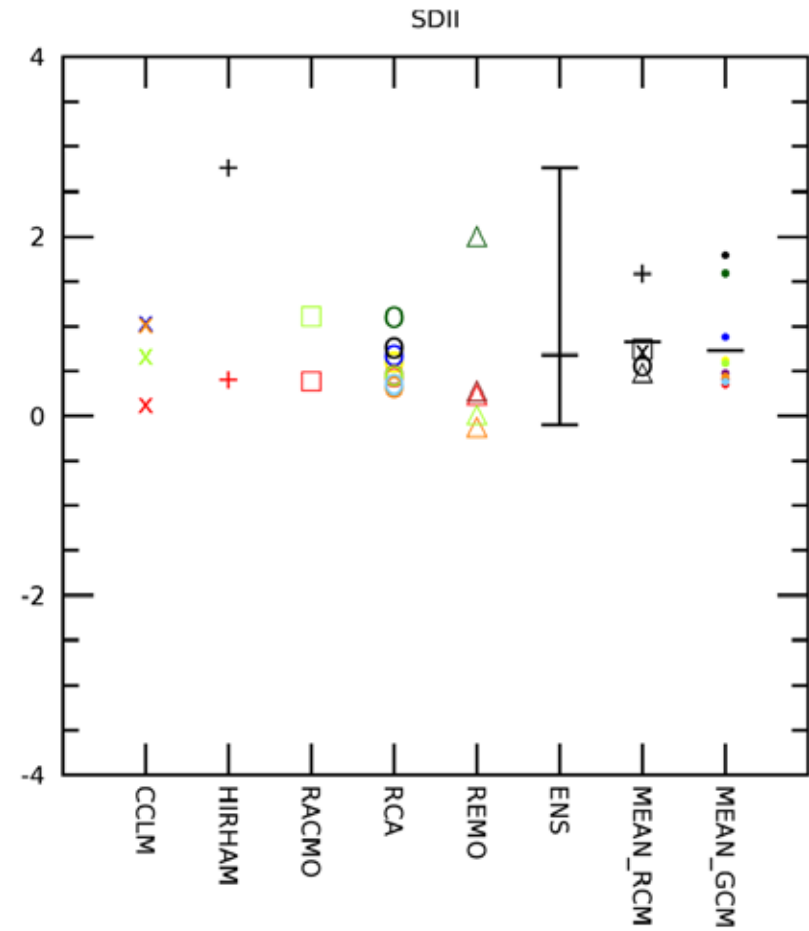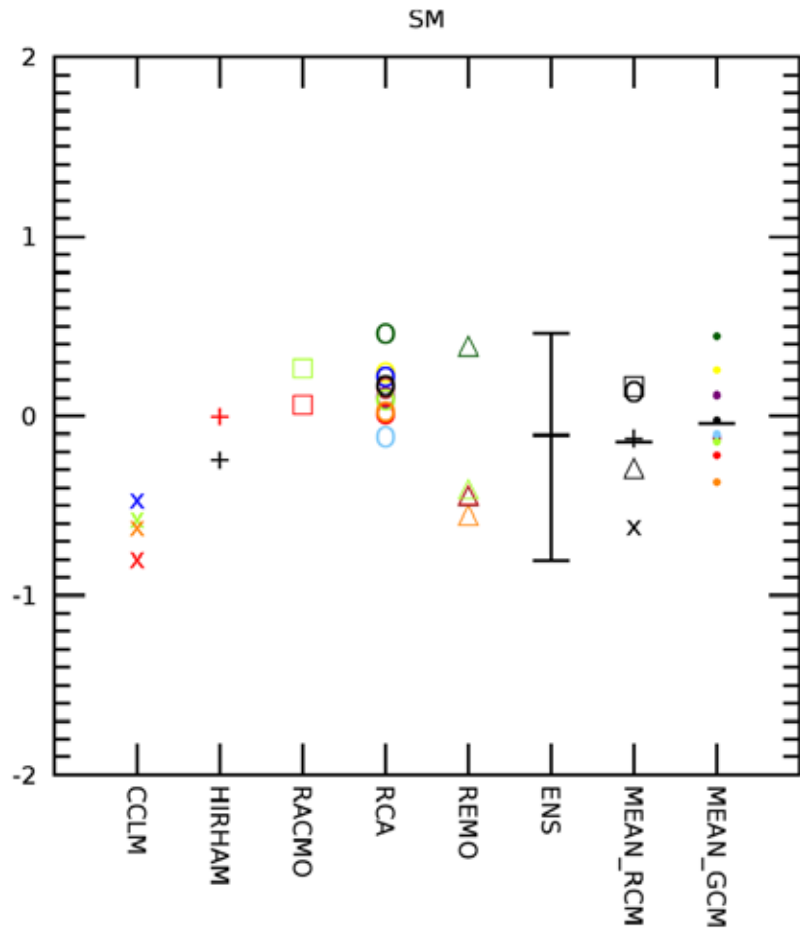
Lesson learnt (3)

Q3: Since our RCM/GCM matrix is very sparse, do results depend on the choice of the model and/or a subsampling of the ensemble?

We showed that **results are often robust (or non-significant) regardless of the choice of the specific RCMs or GCMs.**

Where the **results are uncertain**, however, and clearly clustered according to the RCM, we showed that a **simple subsampling** based on averaging according the RCM and/or the GCM, is **not able to reduce significantly the uncertainty** nor the value of the mean change.

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Conclusions:

Q1: What can we know about future change in precipitation over Africa?

- There are regions where there is robust message of change, but others where we cannot say anything yet

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Conclusions:

Q1: What can we know about future change in precipitation over Africa?

- There are regions where there is robust message of change, but others where we cannot say anything yet

Q2: Is the message from RCMs similar to that from the driving GCMs?

- Where RCM message is robust, yes.
- In some regions (topography), messages can be different

Dosio et al, 2019. *Clim. Dyn.*

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Conclusions:

Q1: What can we know about future change in precipitation over Africa?

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Q2: Is the message from RCMs similar to that from the driving GCMs?

- Where RCM message is robust, yes.
- In some regions (topography), messages can be different

Q3: Does the message depend on the model ensemble?

- Not where the message is robust

Dosio et al, 2019. *Clim. Dyn.*

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Many more info can be found here

What can we know about future precipitation in Africa? Robustness, significance and added value of projections from a large ensemble of regional climate models

Alessandro Dosio[1] · Richard G. Jones[2,3] · Christopher Jack[4] · Christopher Lennard[4] · Grigory Nikulin[5] · Bruce Hewitson[4]

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Alternatively, please contact Alessandro.dosio@ec.europa.eu

Thank you!