

Simulating the seasonal variation of rainfall in East Africa and its potential future change in the CORDEX-CORE experiments – ELLIIT Focus Period

WILHELM MAY CENTRE FOR ENVIRONMENTAL AND CLIMATE SCIENCE

Smallholder farming in East Africa

Smallholder farming (typically 1-2 ha) accounts for about **75% of the agricultural production** and more than **75% of the employment** in East Africa (in 2010)

Smallholder farming plays a very important role for **food security** in many households



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Smallholder farming in East Africa is **rainfed** and, thus, synchronized with the **rainy seasons**

Smallholder farming is, thus, vulnerable to climate variability and change

UPSCALE project

Upscaling the benefits of **Push-Pull Technology** for sustainable agricultural intensification in East Africa



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Upscaling the benefits of **Push-Pull Technology** for sustainable agricultural intensification in East Africa

... By determining the factors influencing push-pull success across scales, we will enable targeted implementation and prediction of **push-pull effectiveness and resilience under current and future climate conditions.**

Seasonal variation of rainfall



March – April – May

June – July – August

September – October – December – January – November February

Alahacoon et al (2022)

Characteristics of rainy seasons

For each grid point and data set

- 1. Compute the climatological annual cycle of daily rainfall
- 2. Perform a **spectral analysis** of the climatological annual cycle
- 3. Estimate the **contributions** of the first six harmonics **to the variance** associated with the climatological annual cycle
- Determine the onset and cessation date(s) of the rainy seasons(s) for the grid points, where one of the first two harmonics is dominating

CORDEX-CORE experiment

- CORDEX: COordinated Regional Downscaling EXperiment
- **CORE:** Coordinated Output for Regional Evaluations
- Provides a **homogenous set of projections for 9 domains** at a resolution of \approx 25 km
- Three Regional Climate Models (RCMs) driven by three Global Climate Models (GCMs) for two climate scenarios

CORDEX-CORE experiment



Evaluation simulation: driven with ERA-Interim for the observed period **Historical simulations**: driven with simulations from the three GCMs for the historical period

Scenario simulations: driven with the two scenario simulations (RCP2.6 and RCP8.5) from the three GCMs for the future period

Study region – orography

Eritrea

Ethiopia*

Djibouti

Somalia

Kenya*

Tanzania*

Uganda*

Rwanda*

Burundi

*part of UPSCALE



Rainy seasons(s) – observations Onset Cessation Length 19N 19N 19N **One rainy** 16N 16N 16N season 12N 12N 12N 8N 8N 8N **4**N 4N 4N EQ EQ EQ **4**S **4**S 4S 85 85 85 [Julian day] [day] [Julian day] 12S 12S 12S 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 48E 52E 44E 28E 32E 36E 40E 44E 48E 52E 18. 54. 90. 126. 162. 198. 234. 270. 306. 342. 9. 27. 45. 63. 81. 99. 117. 135. 153. 171.

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Rainy seasons(s) – observations Cessation Length Onset 19N · 19N 19N First of two 16N 16N 16N rainy 12N 12N 12N seasons 8N 8N 8N 4N 4N 4N EQ -EQ -EQ 4S 4S 4S 85 -85 **8**S [Julian day] [day] [Julian day] 12S 12S 12S 32E 36E 40E 44E 48E 52E 32E 36E 40E 44E 48E 52E 32E 36E 40E 44E 48E 28E 28E 28E 52E 18. 54. 90. 126. 162. 198. 234. 270. 306. 342. 9. 27. 45. 63. 81. 99. 117. 135. 153. 171. Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Rainy seasons(s) – observations Cessation Length Onset 19N 19N 19N Second of 16N 16N -16N two rainy 12N 12N -12N seasons 8N 8N 8N 4N 4N 4N EQ -EQ -EQ 4S -4S -4S 85 85 -85 -[Julian day] [day] [Julian day] 12S -12S 12S 28E 32E 36E 40E 44E 48E 52E 32E 36E 44E 48E 52E 28E 32E 36E 40E 44E 48E 28E 40E 52E 18. 54. 90. 126. 162. 198. 234. 270. 306. 342. 9. 27. 45. 63. 81. 99. 117. 135. 153. 171. Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Rainy seasons(s) – evaluation simulation vs. observations

Onset



Cessation

19N

16N

12N

8N

4N

EQ

4S

85

12S

28E

Length





32E 36E 40E

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Rainy seasons(s) – evaluation simulation vs. observations

Onset



Cessation

19N

16N

12N -

8N

4N

EQ ·

4S

85 -

12S

28E

32E

36E

Length



First of two rainy seasons

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

40E

44F

Rainy seasons(s) – evaluation simulation vs. observations

Onset



Cessation

19N

16N

12N -

8N

4N

EQ ·

4S

85 -

12S

28E

32E

Length



Second of two rainy seasons

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

40E

44F

36E

Onset



Cessation

19N

8N

4N

EQ ·

4S

85

12S

28E

32E



4S

85

12S

28E

32E

36E

40E

44F

[day]

48E 52E

One rainy season MOHC

[day]

48E

52E



44E

36E 40E

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Onset



Cessation

19N

8N

4N

EQ

4S

85

12S

28E

Length



44E

32E 36E 40E

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Onset



Cessation

8N

4N

EQ ·

4S

85

12S

28E

Length



One rainy season NCC



44E

32E 36E 40E

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

MOHC



NCC



Length of one rainy season

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Onset



Cessation

19N

16N

12N -

8N

4N

EQ

4S

85 -

12S

28E

Length



First of two rainy seasons MOHC

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

40E

44F

36E

32E

Onset





19N

16N

12N

8N

4N

EQ -

4S -

85 -

12S

28E

32E

36E

Length



First of two rainy seasons MPI

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Onset



Cessation

19N

16N

12N -

8N

4N

EQ

4S

85 -

12S

28E

Length



First of two rainy seasons NCC

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

40E

44F

36E

32E

MOHC



NCC

Length of

seasons



-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Rainy seasons(s) – future changes Onset Cessation Length 19 N 19 N 19N **One rainy** 16N 16N 16N season 12N 12N 12N MOHC 8N 8N 8N 4N 4N 4N EQ EQ EQ 4S 4S **4**S **8**S **8**S **8**S [day] [day] [day] 12S 12S 125 28E 32E 36E 40E 44E 48E 52E 32E 36E 40E 48E 52E 28E 44E 28E 32E 36E 40E 44E 48E 52E

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Rainy seasons(s) – future changes Onset Cessation Length 19 N 19 N 19N **One rainy** 16N 16N 16N season 12N 12N 12N MPI 8N 8N 8N 4N 4N 4NEQ EQ EQ 4S **4**S **4**S **8**S **8**S **8**S [day] [day] [day] 12S 12S 125 ----32E 36E 40E 44E 48E 52E 32E 36E 48E 52E 28E 28E 40E 44E 28E 32E 36E 40E 44E 48E 52E

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Rainy seasons(s) – future changes Onset Cessation Length 19 N 19 N 19N **One rainy** 16N 16N 16N season 12N 12N NCC 12N 8N 8N 8N 4N 4N 4NEQ EQ EQ 4S 4S **4**S **8**S 8S **8**S [day] [day] [day] 12S 12S 12S 32E 36E 40E 48E 52E 32E 36E 48E 52E 28E 44E 28E 40E 44E 28E 32E 36E 40E 44E 48E 52E

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Rainy seasons(s) – future changes

19N 19N -16N 16N -12N 12N -8N 4N 4N EQ 4S **8**S [day] 12S 12S 28E 32E 36E 40E 44E 48E 52E

MOHC



MPI





Length of one rainy season



Rainy seasons(s) – future changes Onset Cessation Length 19N 19N -19N First of two 16N 16N 16N rainy 12N 12N -12N seasons **MOHC** 8N 8N -8N 4N 4N 4N EQ EQ EQ 4S 4S **4**S **8**S 8S -**8**S [day] [day] [day] 12S 12S 12S 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 44E 48E 52E

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Rainy seasons(s) – future changes Onset Cessation Length 19N 19N -19N First of two 16N 16N 16N rainy 12N 12N -12N seasons MPI 8N 8N -8N 4N 4N 4N EQ EQ -EQ 4S 4S **4**S 85 8S -**8**S [day] [day] [day] 12S 12S 12S 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 44E 48E 52E

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Rainy seasons(s) – future changes Cessation Length Onset 19N 19N -19N First of two 16N 16N 16N rainy 12N 12N -12N seasons NCC 8N 8N -8N 4N 4N 4NEQ EQ -EQ 4S 4S **4**S 85 8S -**8**S [day] [day] [day] 12S 12S 12S 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 44E 48E 52E 28E 32E 36E 40E 44E 48E 52E

-54. -42. -30. -18. -6. 6. 18. 30. 42. 54.

Rainy seasons(s) – future changes

19N 16N 12N 8N 4N EQ 4S **8**S [day] 12S 28E 32E 36E 40E 44E 48E 52E

MOHC





32E 36E 40E 44E

Length of the first of two rainy seasons

[day]

52E

48E



Conclusions

- All three selected RCMs simulate the seasonal variation of rainfall in East Africa realistically when forded with ERA-Interim
- All three RCMs show some regional deviations from observations specific to each RCM
- For all three RCMs the characteristics of the three driving GCMs govern the representation of the dominating rainy seasons in the RCMs, with one GCM giving much more realistic simulations for the regions with two rainy seasons
- The future climate changes simulated by the three driving GCMs govern the future changes of the dominating rainy seasons simulated by the three RCMs, resulting in a large uncertainty of the projected climatic changes

And what about Machine Learning?

Advancing bias correction of climate model output

- * What is feasible; can biases in the timing of the rainy seasons be corrected based on the coupling to certain features of the largescale circulation (that the GCM may not represent properly)?
- What is a valid way to go; would such a correction also be valid for a different climate state, and would such a correction constrain the simulation too much?

