Probabilistic rainy season onset prediction based on long-range ensemble forecasts

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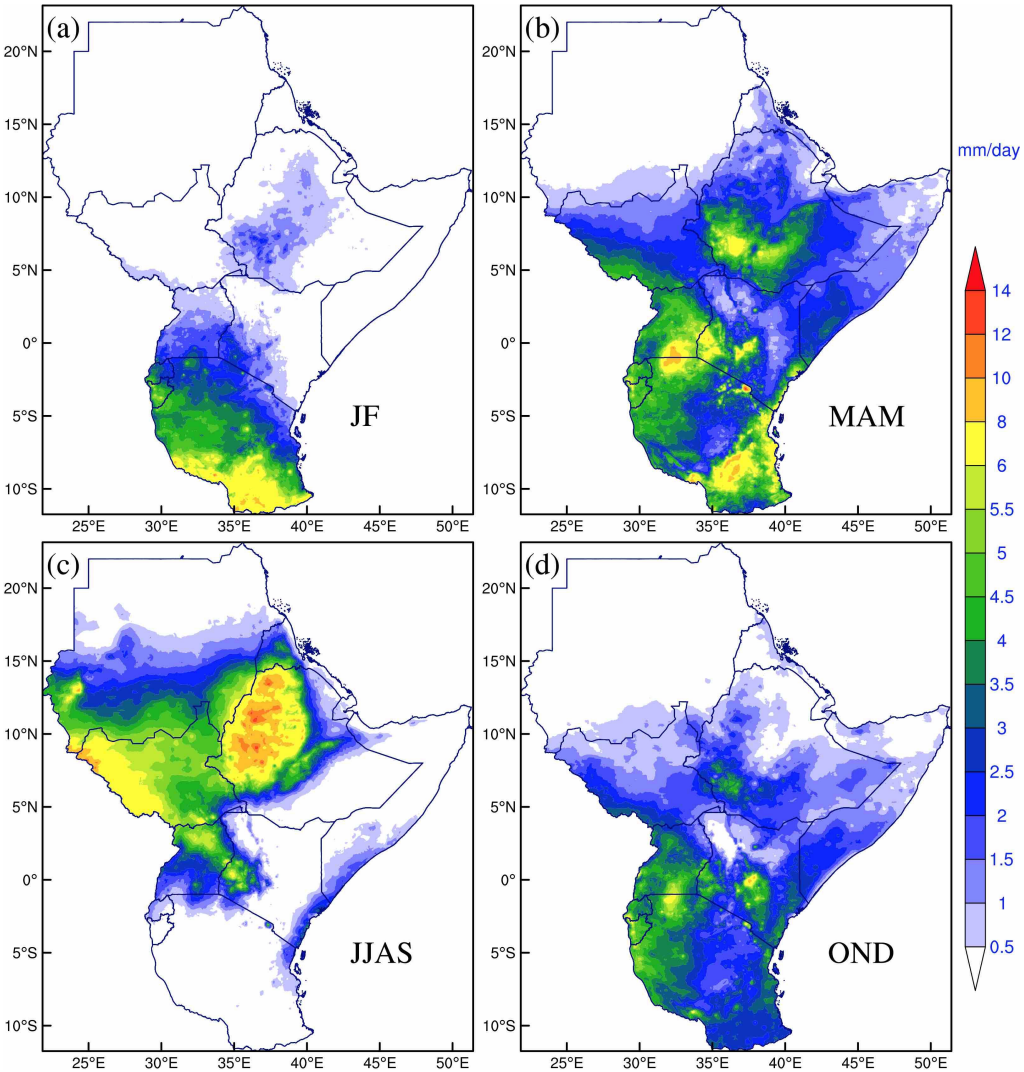
Rainy seasons in the Greater Horn of Africa



The equatorial part of GHA has two rain seasons: 'Long rains' in MAM and 'Short rains' in OND.

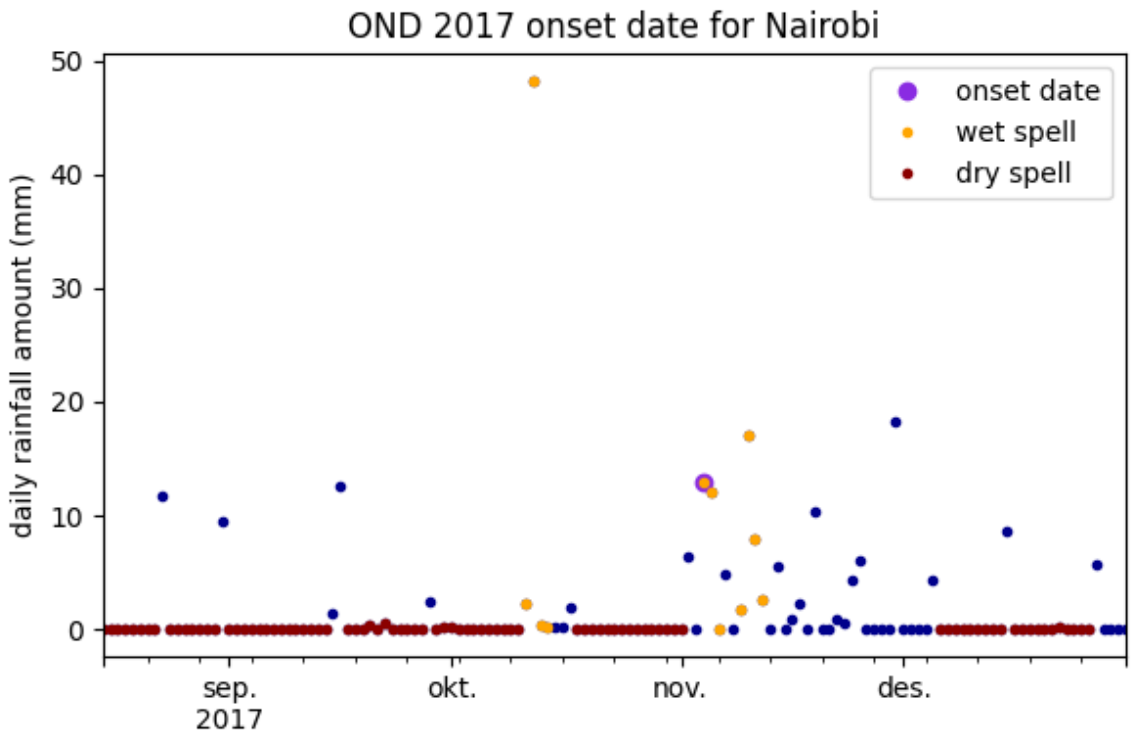
The northern/northwestern parts of GHA have boreal summer monsoon regimes.

Knowledge of the beginning of the rainy season is key for making decisions such as time of planting and the choice of crop.

Definition of the rainy season onset date

ICPAC uses a threshold-based, agronomic definition of the rainy season onset and defines it as the first day of a wet spell that is not followed by a dry spell of at least 7 days within 21 days after onset.

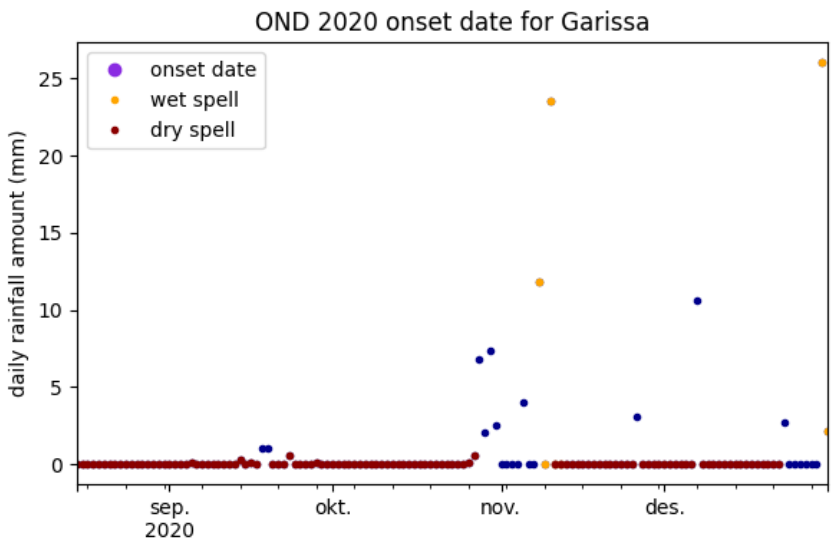
- **wet spell:** at least 20 mm accumulated rainfall within 3 days
- **dry spell:** less than 1 mm accumulated rainfall per day

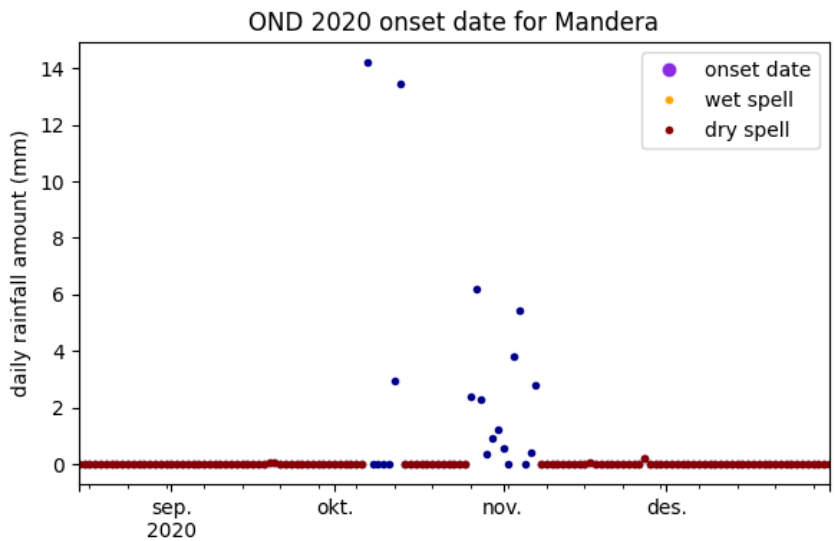


Definition of the rainy season onset date

The threshold-based definition of onset given above is intuitive and can be linked to requirements in agriculture.

It may be useful and necessary though to adjust the thresholds to the climatology in drier areas in order to avoid too many outcomes of 'failed onset'.

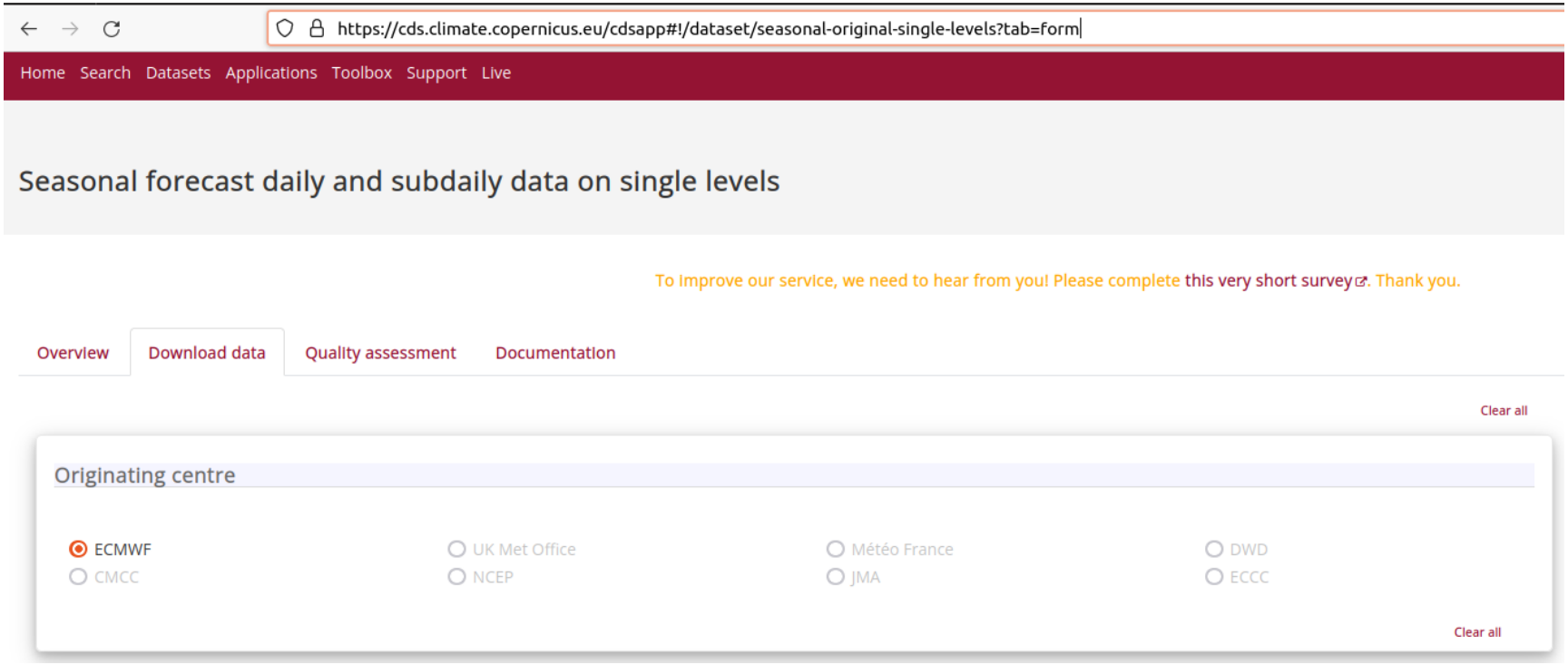




Forecasting the rainy season onset date

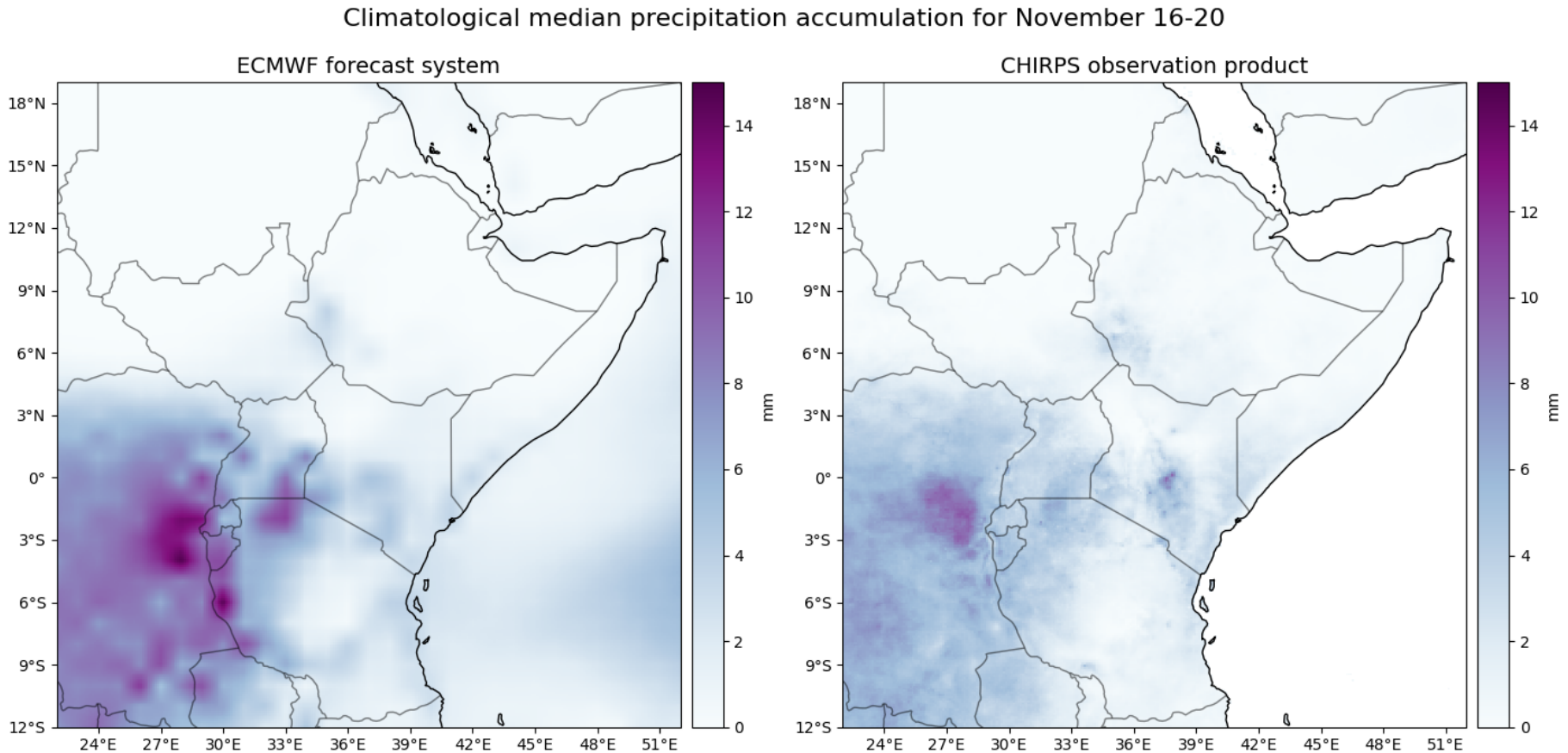
To predict the rainy season onset several weeks in advance, we need long range ensemble forecasts like those from the ECMWF-SEAS5 system.

Those can be downloaded at `https://cds.climate.copernicus.eu/cdsapp#!/dataset/seasonal-original-single-levels?tab=form`



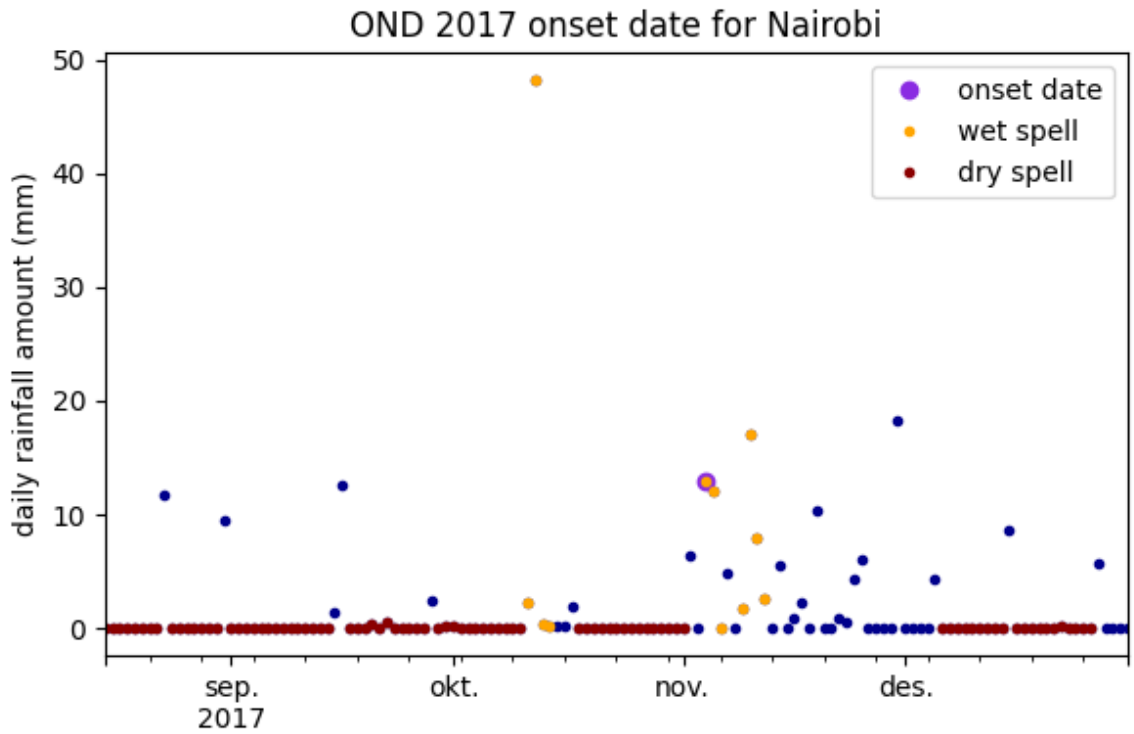
Bias correction of the long-range ensemble forecasts

As we have seen yesterday, the climatology of the (interpolated) forecasts differs from the CHIRPS climatology use here as 'truth'. These biases are also a problem for rainy season onset prediction and have to be removed.



Bias correction of the long-range ensemble forecasts

Consider, for example, the 2017 OND onset in Nairobi:

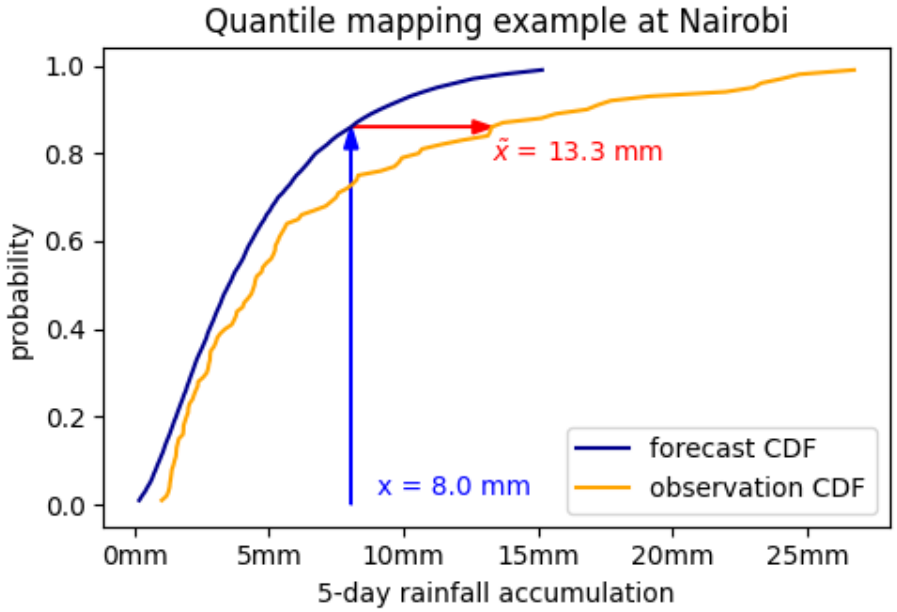


If the ECMWF model underforecasts 3-day rainfall amounts, the daily November rainfall amounts seen above may fall short of reaching 20 mm within 3 days as required to fulfill the wet spell criterion.

Quantile mapping thresholds instead of rainfall forecasts

Yesterday, we discussed how a bias-corrected version $\tilde{x}$ of a forecast x can be obtained via

$$\tilde{x} = F_{obs}^{-1}\big(F_{fcst}(x)\big)$$



Now, however, we only want to know whether $\tilde{x}$ exceeds 1 mm per day or 20 mm in 3 days, and with some algebra we get:

$$\tilde{x} > 1\ mm \quad \Longleftrightarrow \quad x > F_{fcst}^{-1}(F_{obs}(1\ mm)) \qquad \text{(likewise for 20 mm)}$$

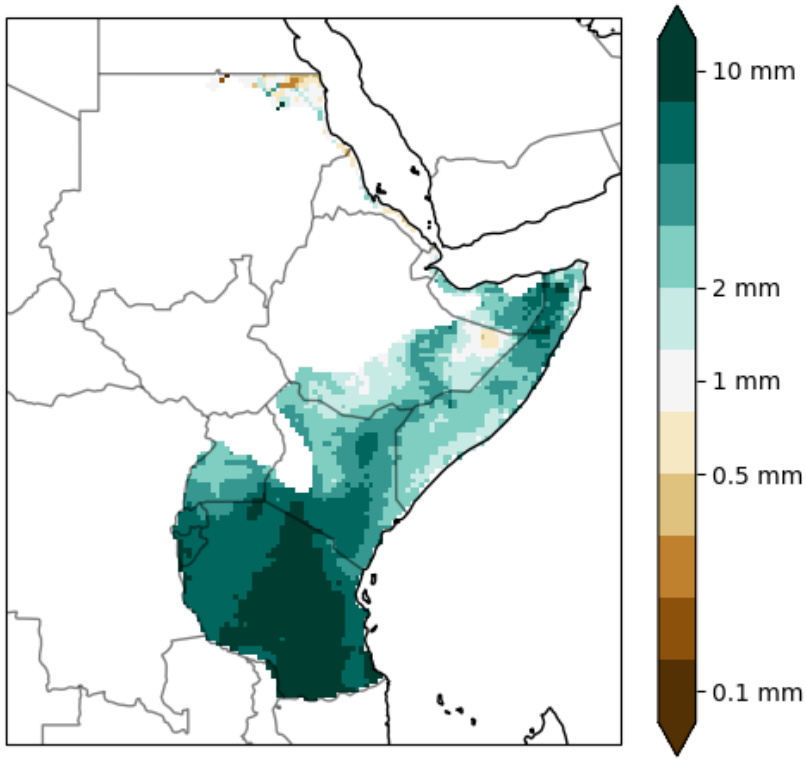
i.e., instead of bias-correcting the ECMWF rainfall amounts we can bias-correct the thresholds in the onset definition.

Quantile mapping thresholds instead of rainfall forecasts

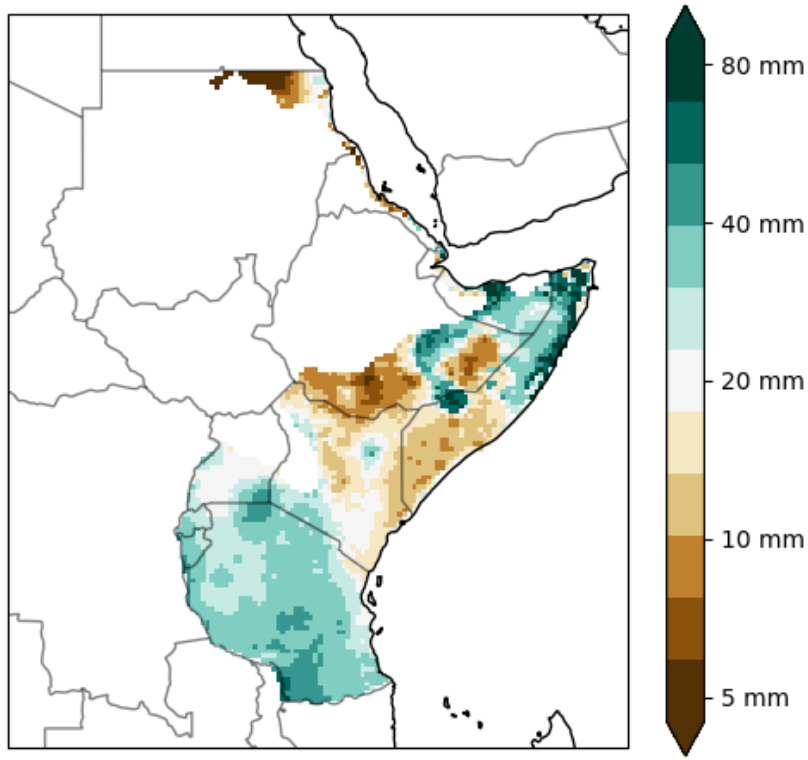
The adjustment of the thresholds is equivalent to a bias correction of predicted rainfall amounts:

- if the forecast has a dry bias, the threshold is lowered
- if the forecast has a wet bias, the threshold is increased

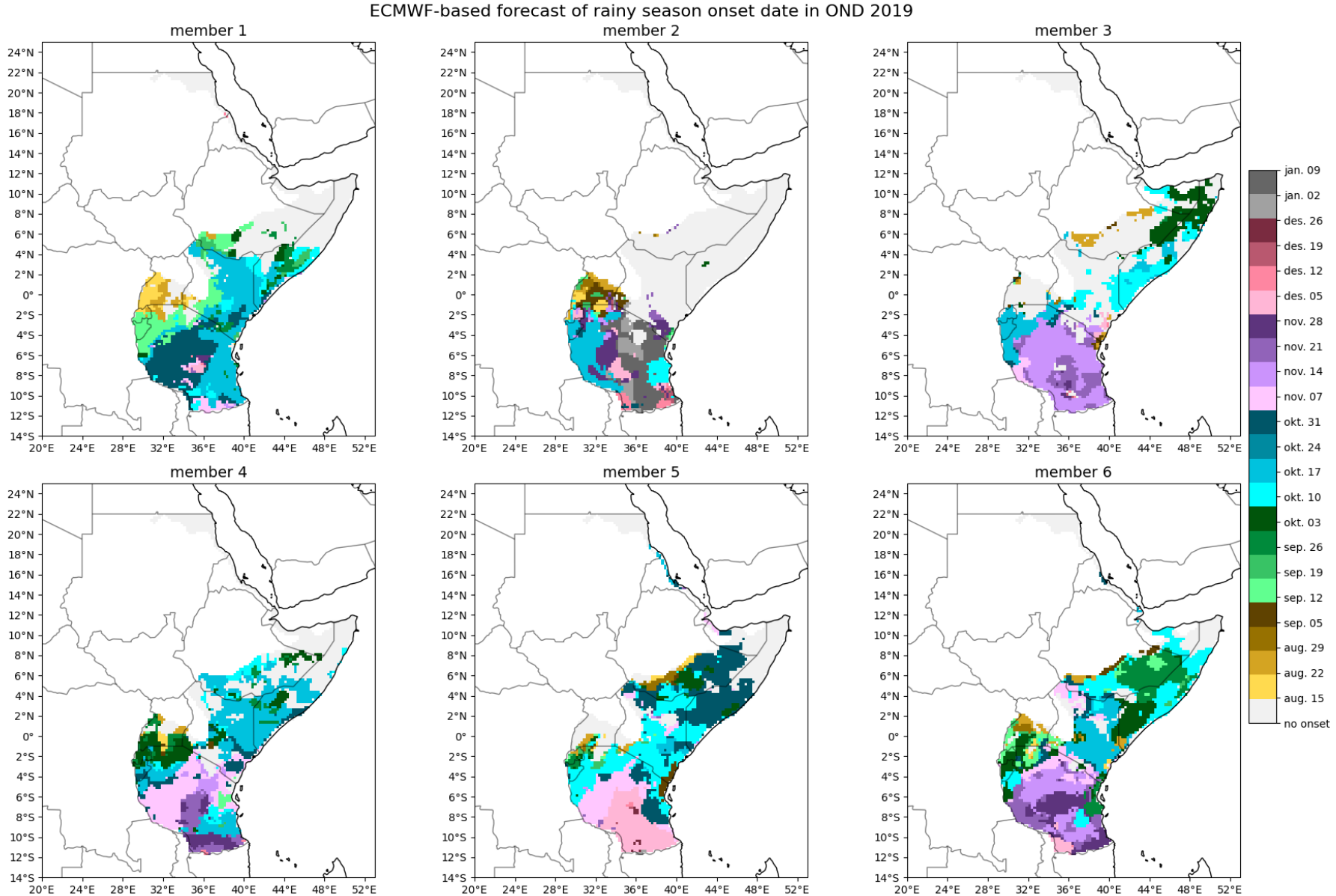
Adjusted 1 mm threshold for ECMWF, Nov 16



Adjusted 20 mm threshold for ECMWF, Nov 16

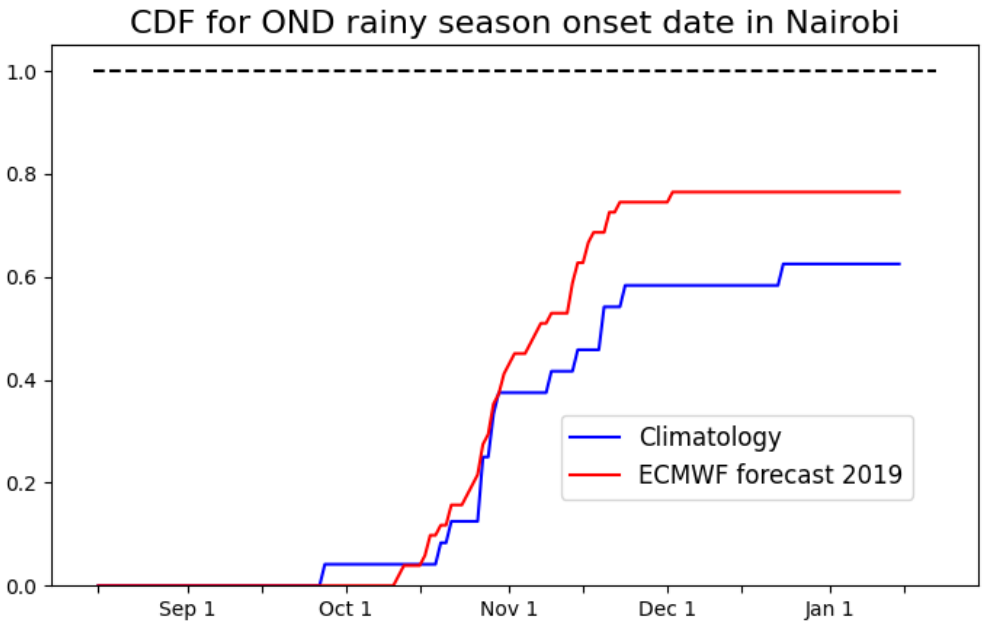


Probabilistic forecasting



Probabilistic forecasting

At individual locations, the ensemble of onset dates can be summarized through a cumulative distribution function (CDF) that showing the relative frequency of members predicting onset no later than a given date:

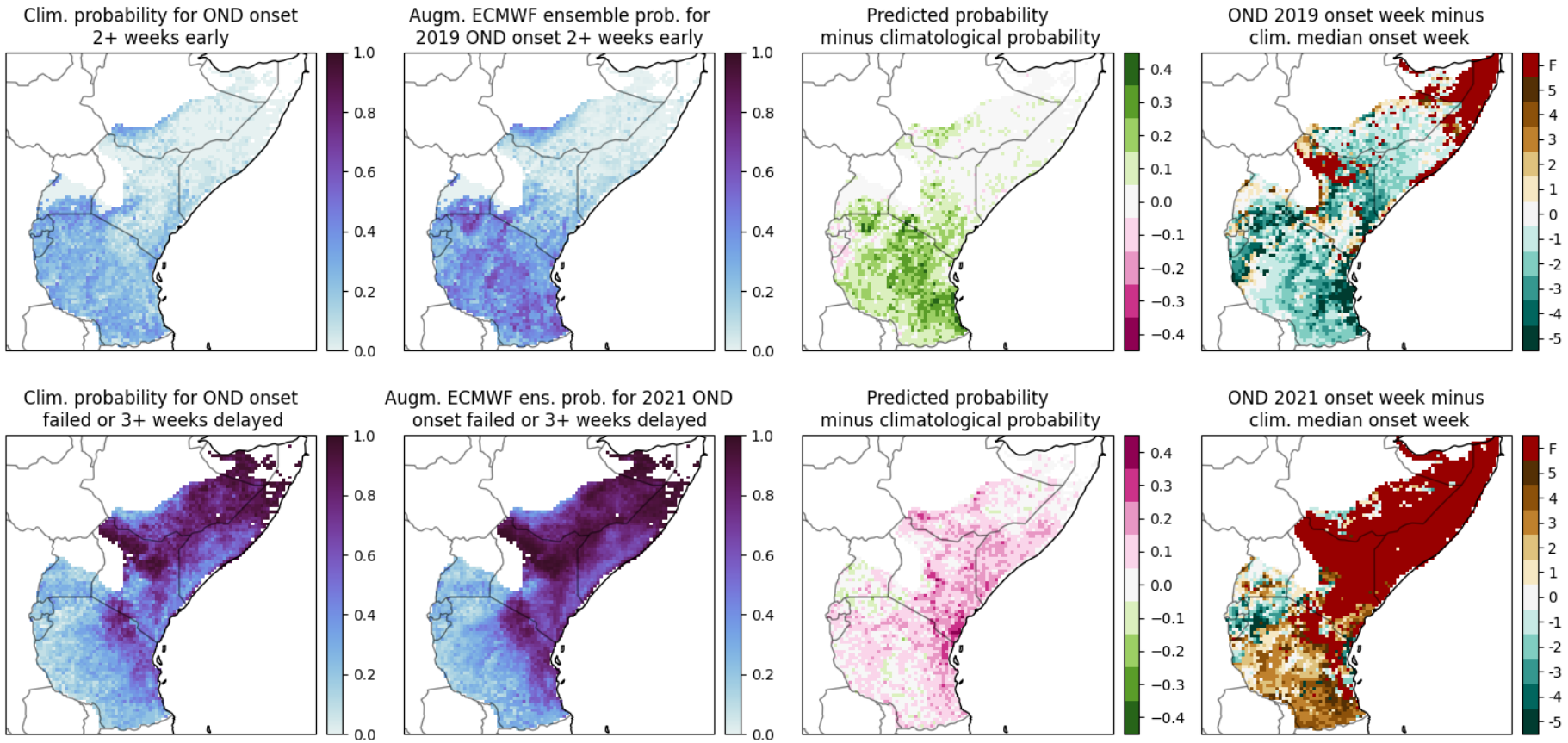


Normally, a CDF reaches probability 1 eventually, but since there is a chance of a failed onset, a gap can remain at the end of the search period.

Comparison with a CDF of historical onset dates (climatology) can reveal probabilistic shifts towards an earlier/later onset that usual.

Probabilistic forecasting

Another way of depicting probabilistic information is to focus on specific events like ‘onset is at least two weeks early’ or ‘onset failed or is at least 3 weeks delayed’, and showing probabilities for this event as a map:



Summary

- Rainy season onset forecast can be produced based on long-range ensemble forecasts, but those need to be bias-corrected before they can be used in connection with a threshold-based onset definition.
- In this context, however, the quantile mapping procedure can be applied to adjust the thresholds instead of adjusting the predicted daily precipitation amounts.
- We ultimately get and ensemble of onset dates, which can be depicted as a CDF at individucal locations and compared with a CDF of historical onset dates.
- Or, the ensemble can be visualized via probability maps of specific events like 'onset failed or is at least 3 weeks delayed'.
- Regional adjustment of the onset definition is recommended.

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- Or, the ensemble can be visualized via probability maps of specific events like 'onset failed or is at least 3 weeks delayed'.
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Thanks for listening!

Exercises

You are now ready to make your own rainy season onset forecasts.

Exercises can be found at

`https://github.com/ScheuererNR/FoundationalTraining-2023/tree/main`

If the scripts have not already been downloaded to your account, go to your home directory and type

git clone `https://github.com/ScheuererNR/FoundationalTraining-2023.git`

You can either use a Jupyter Notebook 'onset_exercise.ipynb', or work with 'onset_exercise.py' in a standard Python programming environment.

In either case, you will need several Python libraries to run the scripts: standard libraries like numpy, pandas, matplotlib, etc., and the more special libraries xarray and cartopy, introduced in the Python session.