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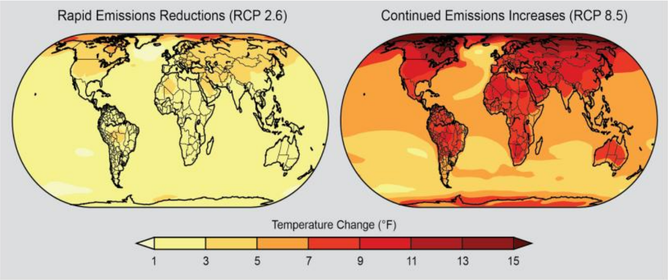
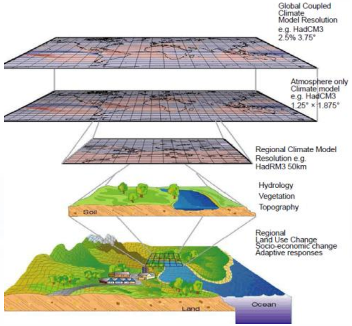
How good have our climate models been so far? A case study from West Africa





Charlene Gaba [1,3], Thomas Poméon[2], Bernd Diekkrueger[3], Ulrich Gaba[4]

1: University of Abomey-Calavi, National Institute of Water, Benin

2: Agrosphere Institute (IBG-3), Forschungszentrum Jülich, Germany

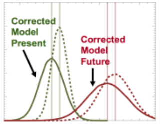
3: University of Bonn, Department of Geography, Germany

4: University of Abomey-Calavi, Institute of Mathematics and Physical Sciences (IMSP), Benin

<u>Key words</u>: Climate model verification, validation, IPCC, West Africa, Climate change

Outline

1 Introduction



2 Methodology

3 Results and Discussion

4 Conclusion

“We do not inherit the Earth from our Ancestors, we borrow it from our Children”

1 Introduction

1- Introduction

- In the last 20-30 years, numerous studies have been undertaken on the impacts of climate change on water resources in West Africa (IPCC, National Communications, Universities, Research institutions, Projects, among others).

- Nevertheless, high uncertainty in model predictions and scenarios (future behavior of society, climate feedback in the face of Greenhouse Gases (GHGs) concentrations, the evolution of land use and land cover) (Wilby and Dessai, 2010).

- Some studies have been undertaken on evaluating the accuracy of past projections but generally they address temperature and sea level rise at a global scale (Hausfather (2017); Kahn (2019); Rahmstorf et al. (2012)).

- Looking back on the performance of past projections might give us some insight for a better planning of the future.

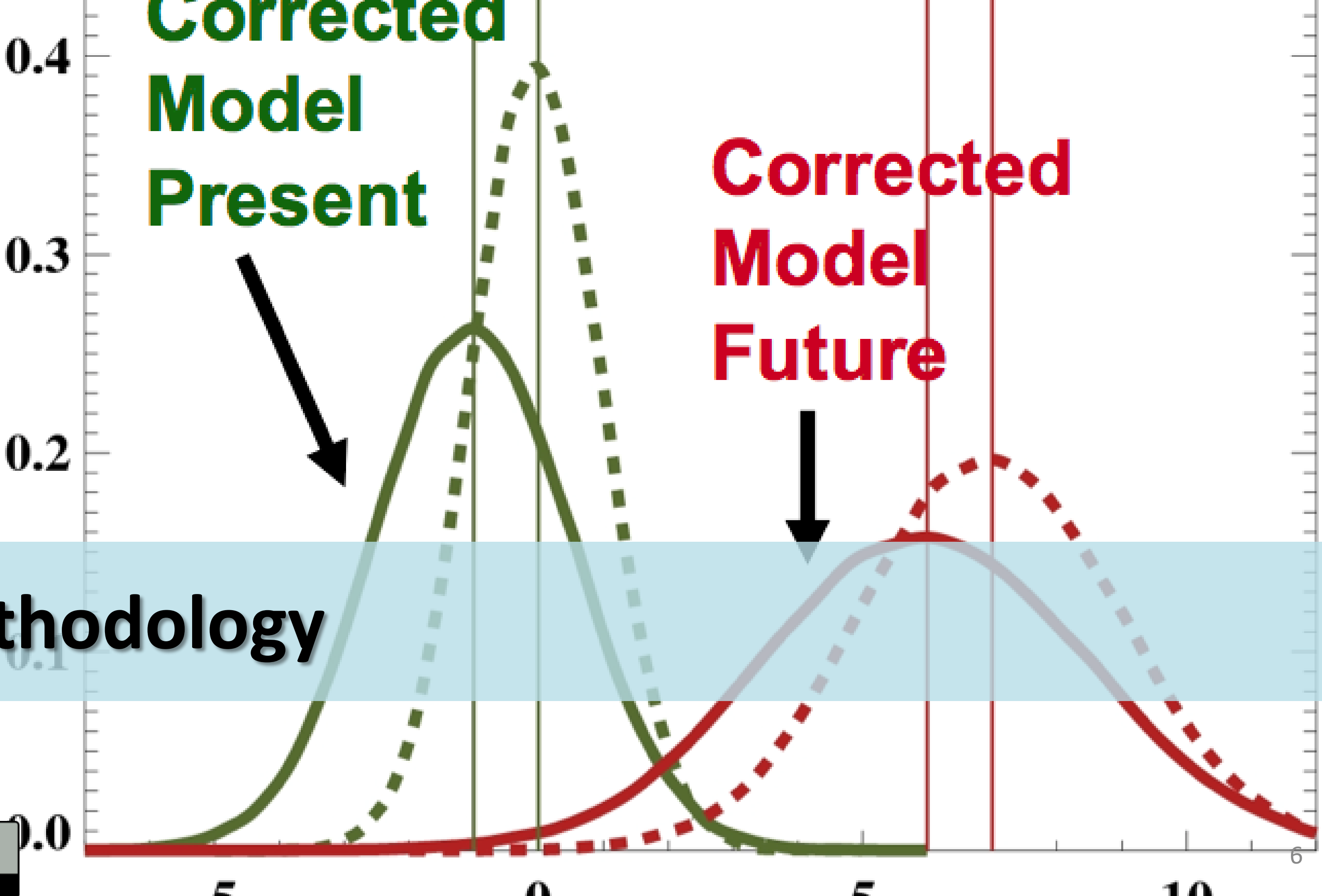
1- Introduction

Research Questions:

- How good have our climate models been so far ? What could be the reasons for similarities / differences ?
- What could be the implications for key development sectors (drinkable water, agriculture, extreme events such as floods or droughts, health, fishing, farming, …) ?
- What could we learn from the past for better projections ?

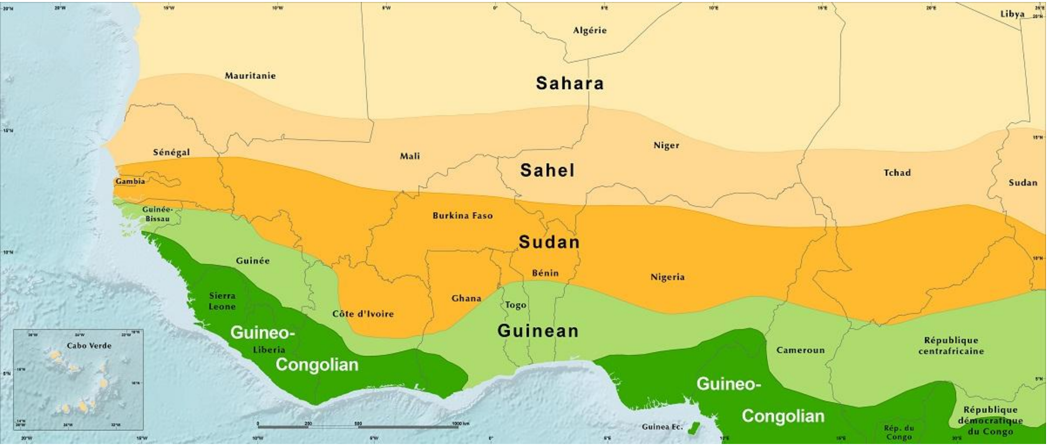
Objective of the study :

"Compare past projections to observations for the period 1995-2018 and learn from the past in order to improve future projections .''

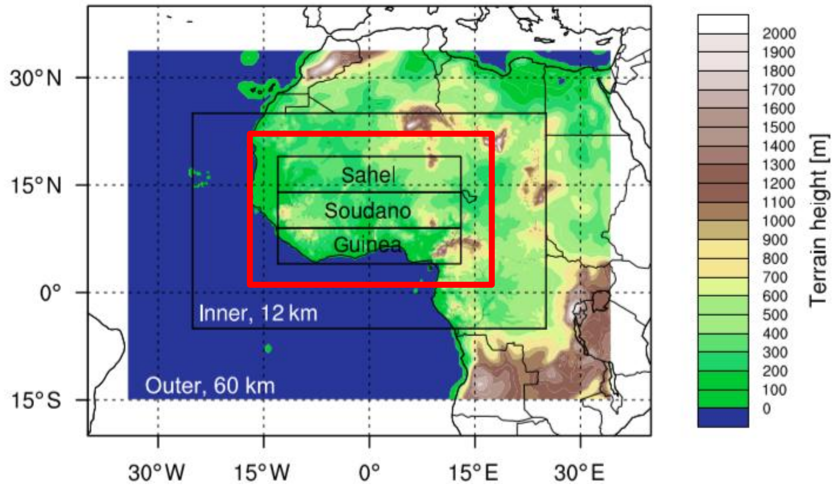


2 Methodology

2- Methodology: Study area



Climatic zones of West –Africa. Source: USGS



West Africa sub-regions: Map from Heinzeller et al. (2018)

West Africa is divided in 3 analysis sub-regions, following a north–south gradient in increasing annual precipitation.

This approximates the 3 dominant agro-climatological regions in West Africa.

Sahel: 14°N - 19°N
Soudano: 9°N - 14°N
Guinea: 4°N - 9°N

Longitude: 13°W - 13°E

2- Methodology: Selection of data

- Total Precipitation, monthly datasets;
- Surface Temperature, monthly datasets;
- Past Projections: 6 datasets for each variable: 2 from AR1, 2 from AR2 and 2 from AR3 (See Table). *Source*: IPCC Data Distribution Centre and German Climate Computing Centre ;
- Observations: 1 dataset for each variable: Gauged –based observations, and satellite products.

Sources:

- Global Precipitation Climatology Centre (GPCC) - German Weather Service (DWD).
- GHCN_CAMS (NOAA) Gridded 2m Temperature.

	IPCC Report	Model	Scenario
1	AR1, 1990	NASA/GISS: NASA Goddard Institute for Space Studies	Scenario A :"Business-as-Usual (BaU)"
2	AR1		Scenario B: the 2060 Low Emissions Scenario.
3	AR2, 1995	GFDL: Geophysical Fluid Dynamics Laboratory, USA	Transient run: CO_2 is increased at the rate of 1% per year (approx. IPCC "business as usual" scenario).
4	AR2	HADCM2: Hadley Centre for Climate Prediction and Research, UK	Transient run: CO_2 is increased, from 1990 to 2100, at the rate of 1% per year (approx. IPCC "business as usual" scenario).
5	AR3, 2001	HADCM3 : Hadley Centre for Climate Prediction and Research - UK Met Office	The Special Report on Emissions Scenarios (SRES); A2 storyline: continuous increasing population together with a slower economic growth and technological change.
6	AR3		The Special Report on Emissions Scenarios (SRES); B2 storyline: emphasis is put on local solutions to economic, social and environmental sustainability. The global population is increasing at a lower rate than A2.

2- Methodology: Processing of data

PRE - PROCESSING OF RAW DATA:
Convert file to netcdf if they are not in that format
Temporal resolution: - Convert the data in monthly totals (P) / monthly means (T) - Extract analysis period 1995-2018 from the complete dataset
Spatial resolution - Remap the dataset to 0.25x0.25 deg (sample grid is **GPCC** 0.25) - Extract West Africa region as defined for our study i.e. [min lon, max lon,min lat, max lat]=[-13,13,4,19] - Sea mask to mask sea points

Tools: cdo, Panoply, Python and R

PROCESSING OF DATA:

Analysis1: Data averaged over time and space for seasonal analysis

Computation of annual cycles over period 24 years (1995-2018) according to each sub-region.

Analysis2: Spatial analysis of the data. Here the data are averaged over time

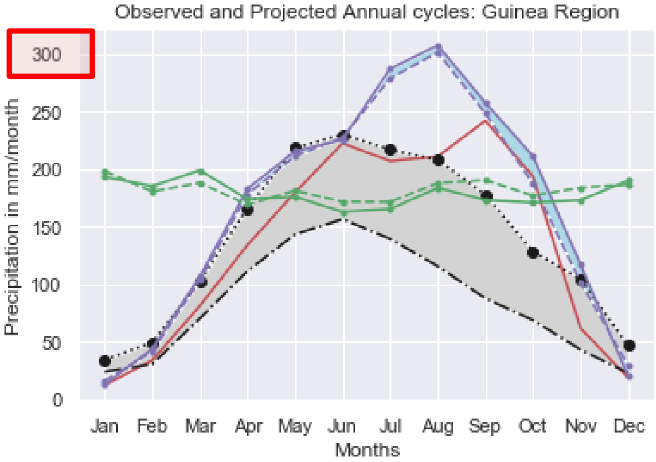
Computation of annual mean (for Total Precipitation) and Time mean (for Temperature) over 24 years (1995-2018) :

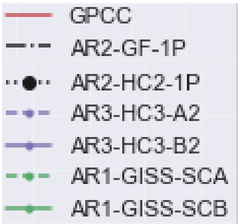
- Computation of the annual mean of **P** over the 24 years and the percentage of difference for each projection dataset by comparison to observation. Display as a map.

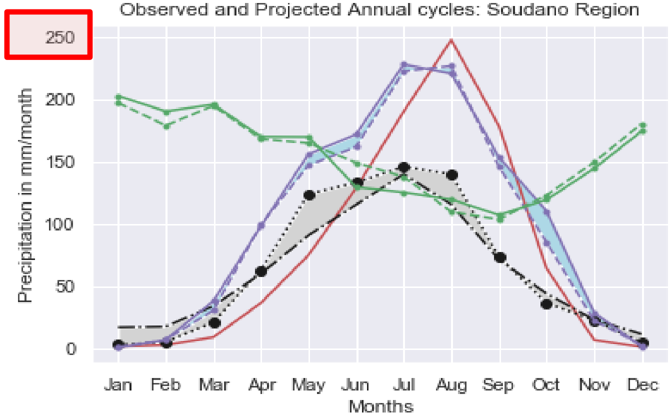
- Computation of the time mean of **T** over the 24 years and the percentage of difference for each projection dataset by comparison to each observation. Display as a map.

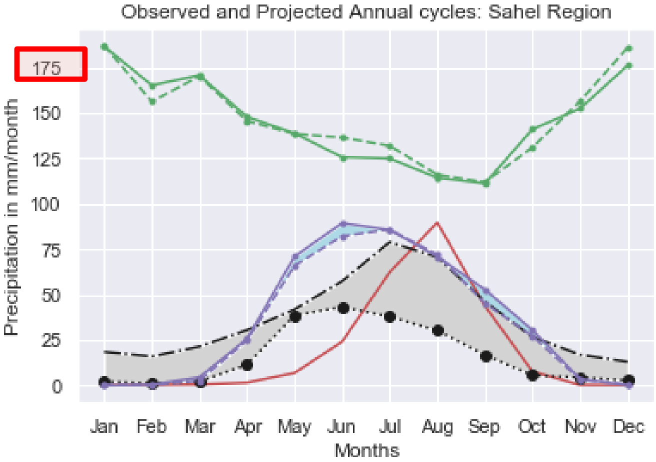
3 Results and Discussion

3- Results and Discussion: Precipitation annual cycles for each sub-region







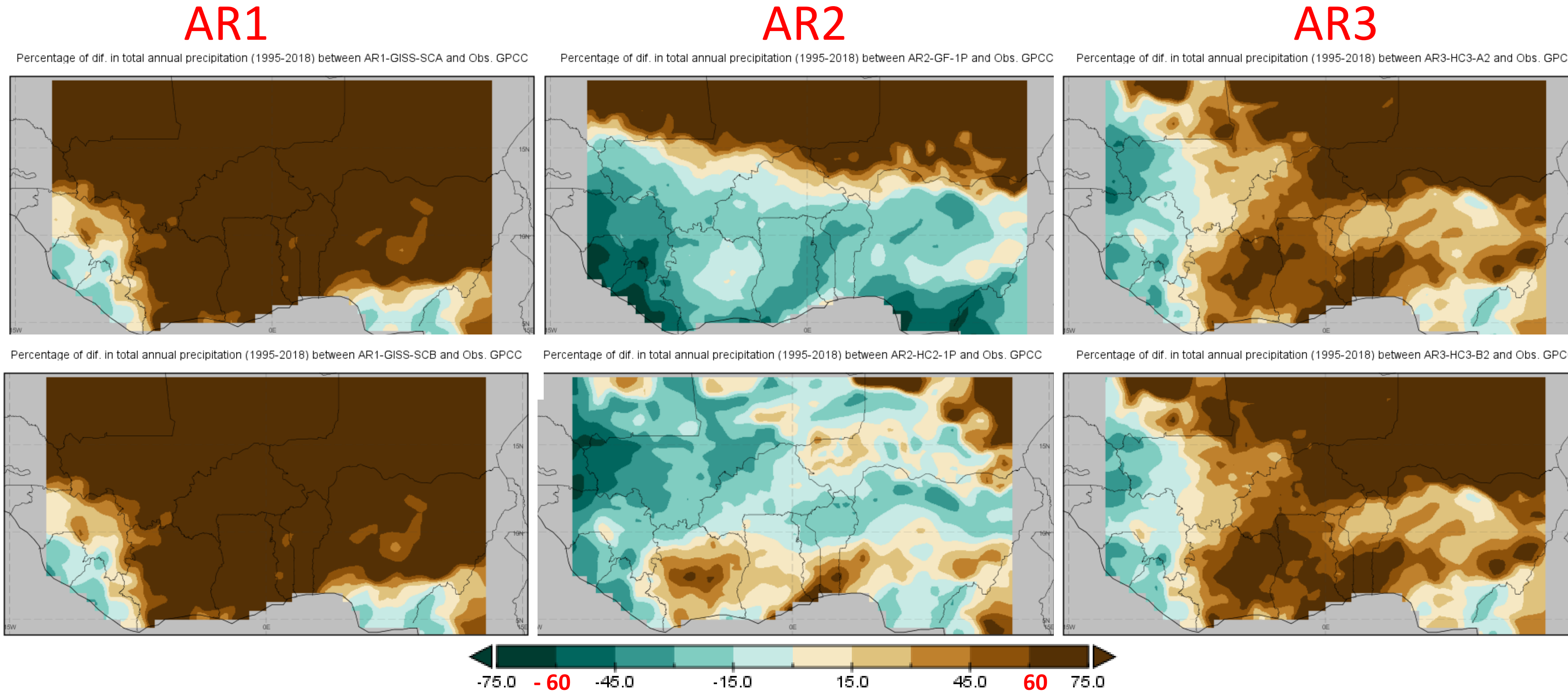


Guinea: All projections are unable to capture the 2nd season, but AR2 and AR3 well captured the first one in timing. AR2-GF underestimate. AR3 captured well season Sept-Dec. AR1 does not catch the seasonality.

Soudano: The seasonal pattern (one season) is well captured but not the timing: the peak of the season is projected to arrive 1 month earlier than obs. Intensity is underestimated by AR2 and slightly overestimated by AR3. AR1 does not catch the seasonality.

Sahel: The seasonal pattern (one season) is well captured but not the timing (1 to 4 months ahead). AR1 is completely out of the range of the data.

Percentage of diff. in total annual precipitation (1995-2018) between Proj. and Obs. GPCC



- Green colours indicate areas which were wetter than projected;
- Brown colours indicate areas which were drier than projected.
- The more intensive the colour, the greater the difference with observations. Threshold=60%

3- Results and Discussion : Precipitation

- Results depend on the choice of observations products (Sylla et al., 2013; Poméon et al., 2017)

- Maps were plotted considering a threshold of **60%** of difference (for example) between projections and observations. Maximum values generally go beyond that threshold. This allows us to easily locate areas where this threshold is not reached.

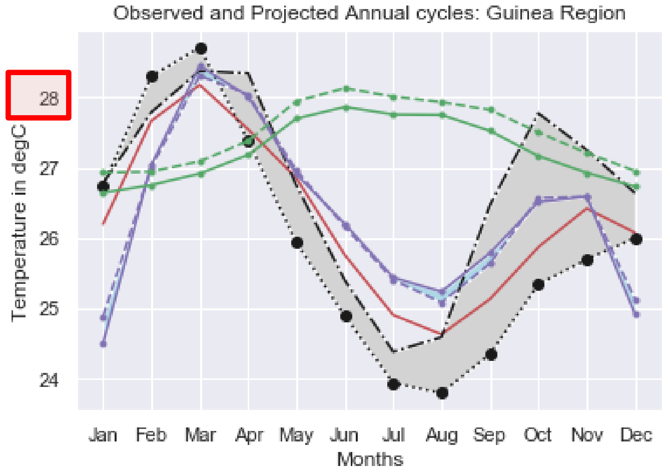
- There is a greater percentage of difference in higher latitudes (drier areas).

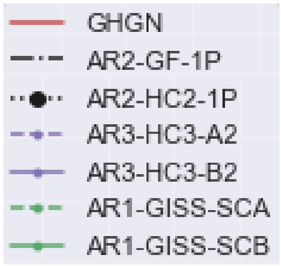
- Along some coastal areas (Liberia/Sierra-Leone and Nigeria/Cameroon), there is a systematic underestimation. When analyzing the map of West –Africa climatic zones, these coastal areas match with the Guineo-congolian climate.

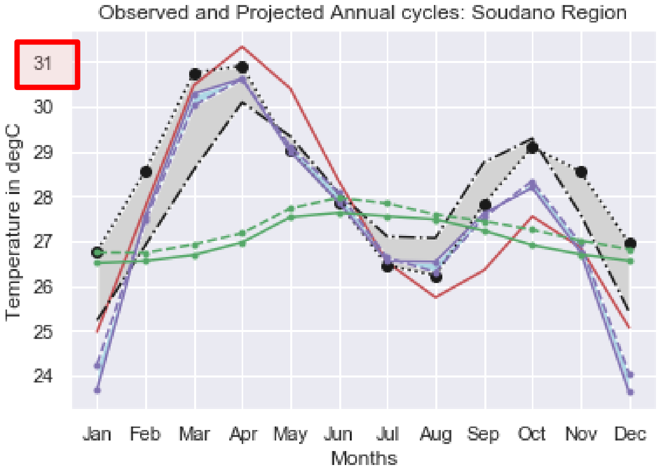
- We notice that when using the same model (AR1-GISS or AR3-HC3), there is not much difference from one scenario to another.

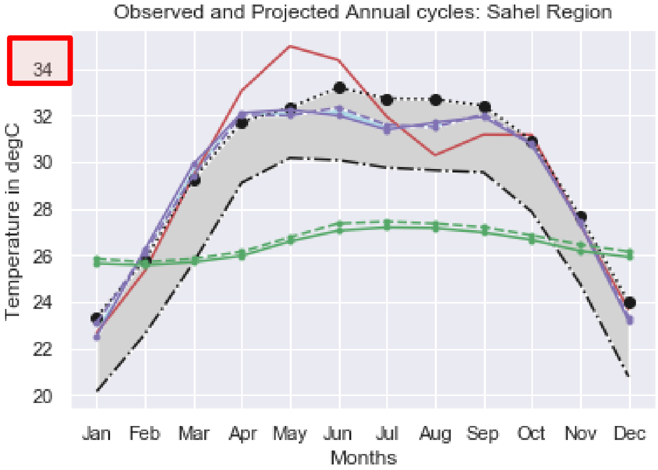
- HC version 2 seems to show a better performance than HC version 3; this might be linked to the formulation of scenarios.

3- Results and Discussion: Temperature annual cycles for each sub-region







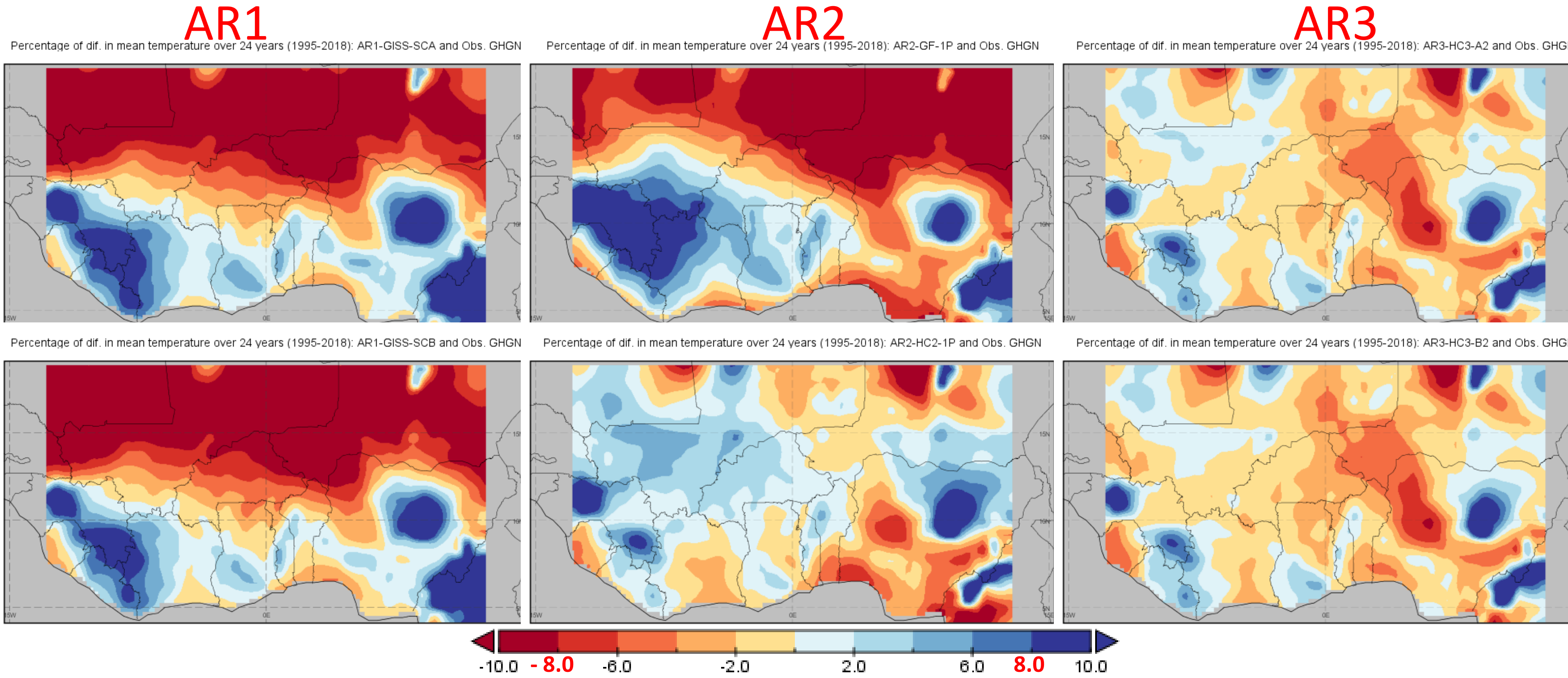


Guinea: All projections are able to capture the seasonality except AR1. AR3 is good at catching the timing. During Jan-Mar, AR2 overestimates while AR3 underestimates.

Soudano: The seasonal pattern is well captured except for AR1. From Jan-Jul, projections tend to underestimate the obs while from Aug-Dec, they tend to overestimate it.

Sahel: The seasonal pattern of Apr-May is not well captured; but for the rest of the year AR2-HC2 and AR3 follow quite good the obs. AR2 completely underestimates the obs. AR1 is giving almost the same temperature all over the year.

Percentage of diff. in mean temperature over 24 years (1995-2018): Proj. and Obs. GHCN



- Blue colours indicate areas which were cooler than projected;
- Red colours indicate areas which were warmer than projected.
- The more intensive the colour, the greater the difference with observations. T= 8%

3- Results and Discussion : Temperature

- Results depend on the choice of the observation product.

- Maps were plotted considering a threshold of **8%** of difference (for example) between projections and observations. Maximum values generally go beyond that threshold. This allows us to easily locate areas where this threshold is not reached.

- There is a greater percentage of difference in higher latitudes (hotter areas).

- For AR1 and AR2 GF, there seems to be a systematic underestimation in the north and overestimation in the South. AR2-HC2 and AR3 show a general good agreement with observations.

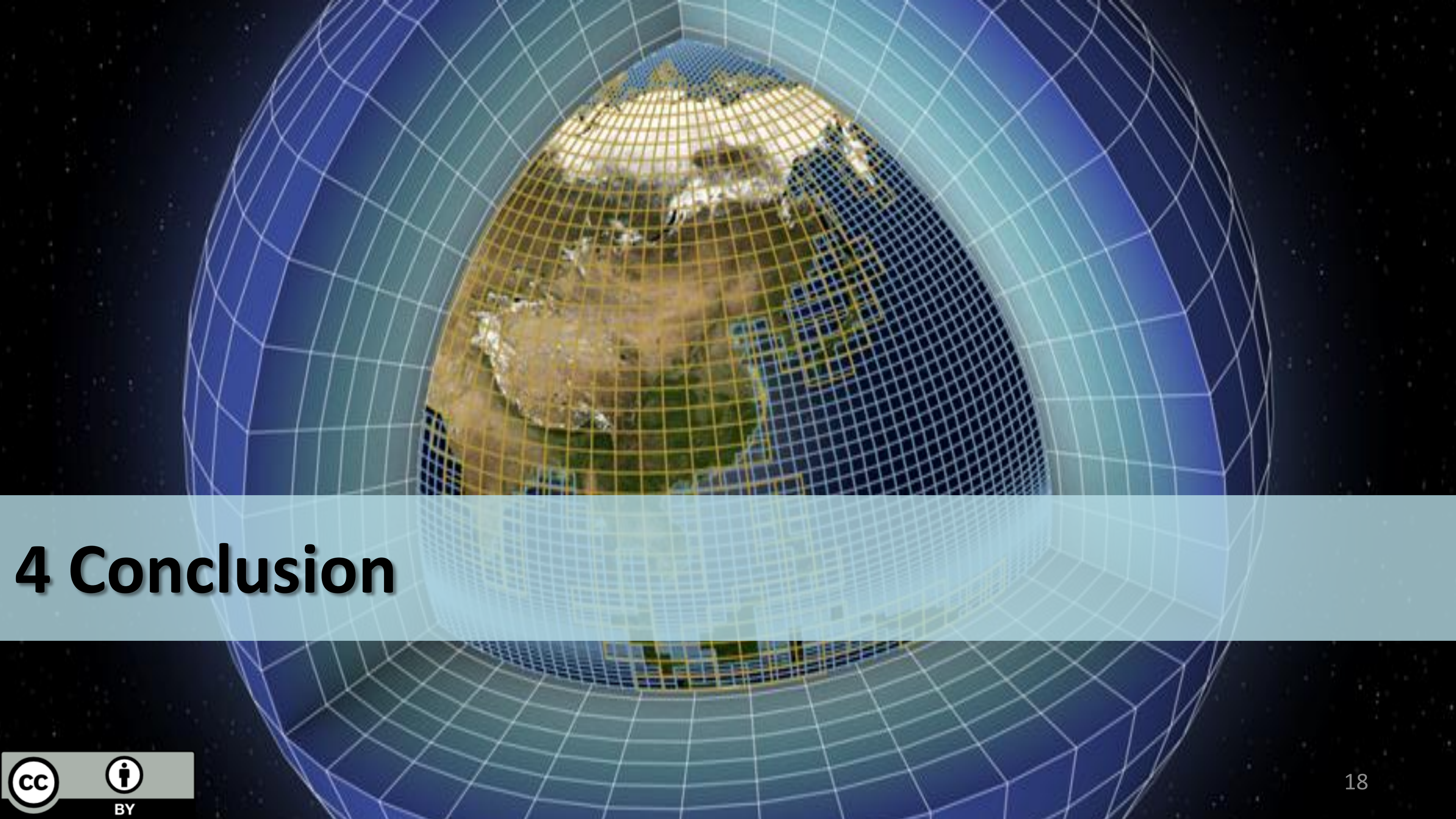
- We notice that when using the same model (AR1-GISS or AR3-HC3), there is not much difference from one scenario to another.

3- Results and Discussion

Linking the results to various key development sectors:

- **Water resources availability**: underestimation in P is preferable for managing purposes than an overestimation , but of course it would be best if the result was as accurate as possible;
- **Extreme events** (Floods, Droughts): overestimation in P is desirable for floods prediction; underestimation in P is desirable for droughts prediction;
- **Agriculture**: analysis of seasonal cycle, timing, intensity may be relevant for agriculture;
- **Ecology**: analysis of seasonal cycle, timing of P and T may be relevant for ecology;
- **Health** : analysis of seasonal cycle, timing and intensity of T may be relevant for predicting occurrence of certain deseases linked to weater like malaria;
- **Farming, Fishery, Mobility**.

Further steps could be to use more projection datasets in the analysis and determine to which extend the observed difference is acceptable depending on the sector and the country.



4 Conclusion

4- Conclusion

The research proposes an approach that intends to learn from the recent past in order to be better prepared for the near future.

We have a number of interesting results, we have a better insight on how past models and scenarios were able to catch various characteristics of today's climate.

The results could be further analyzed in order to be valued for prediction of Precipitation and Temperature for the next 20-30 years.

We think this approach can become complementary to current climate impacts assessments studies.

We expect to communicate with stakeholders and policy makers in West Africa via regional and national research and governmental institutions, NGOs and possibly the private sector.

4- Conclusion

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4- Conclusion: References

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THANK YOU FOR YOUR ATTENTION

MERCI POUR VOTRE ATTENTION

GRACIAS POR SU ATENCIÓN