



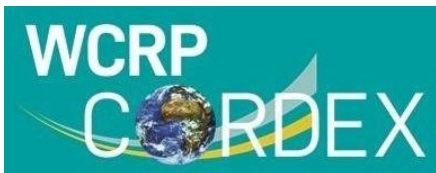
Downscaling climate projections over small islands and territories

The cases of French West Indies and French Guiana

Ali Belmadani – ENM & CNRM, Météo-France, Toulouse

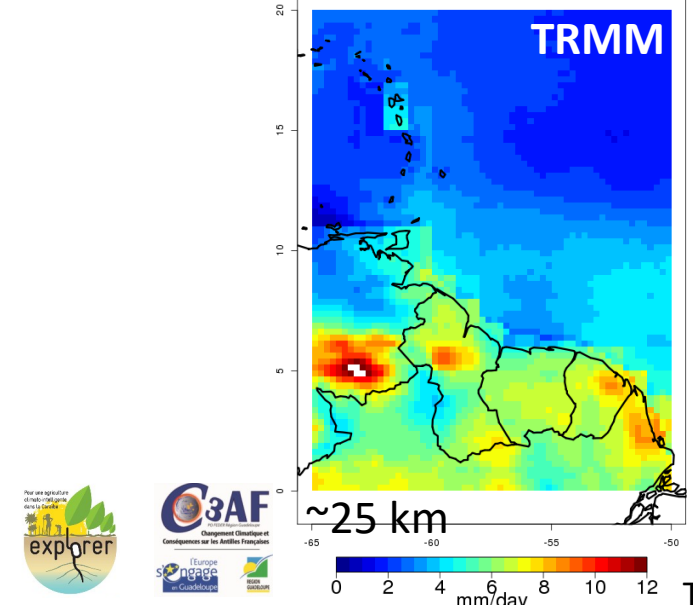
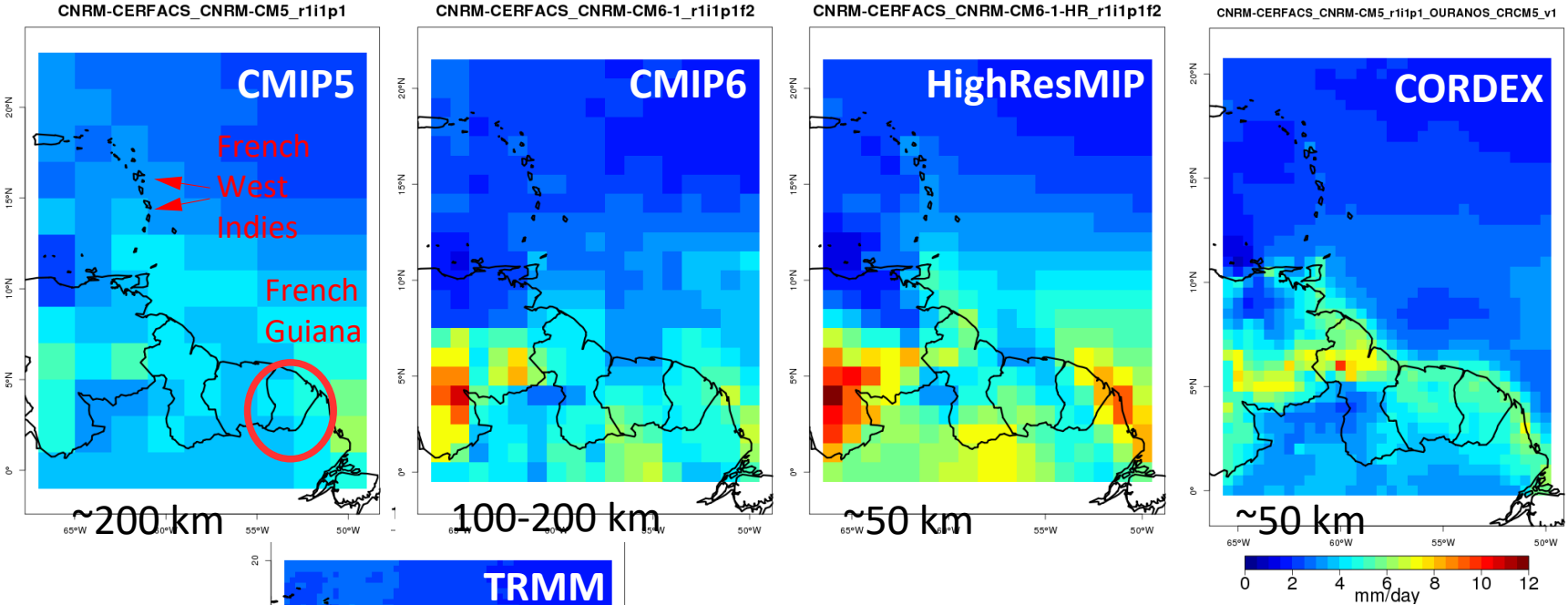
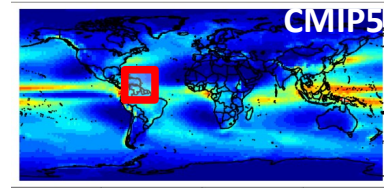
P.C. Dutrieux, P. Cantet, F. Chauvin, B. Suez-Panama-Bouton, C. Decourcelle, A. Dalphinnet, S. Selbonne, J.M. Blazy, F. Longueville, P. Palany

International Conference on Regional Climate, session D3, Trieste, Italy, 28 September 2023



Climate Models & Small Islands

Insufficient horizontal resolution



GCMs & RCMs struggle to represent island-scale rainfall
=> need for dedicated high-resolution models

Current models possibly adequate for French Guiana?

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Trieste, Italy, 28 September 2023

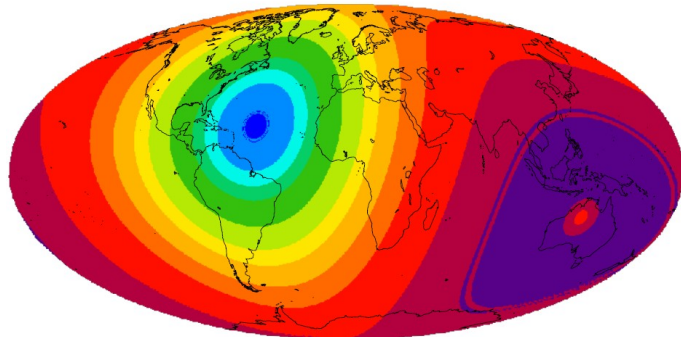


Modelling Framework for French West Indies

Multi-scale atmospheric & wave models

High Resolution Atmospheric GCM

Local Resolution (in kms)



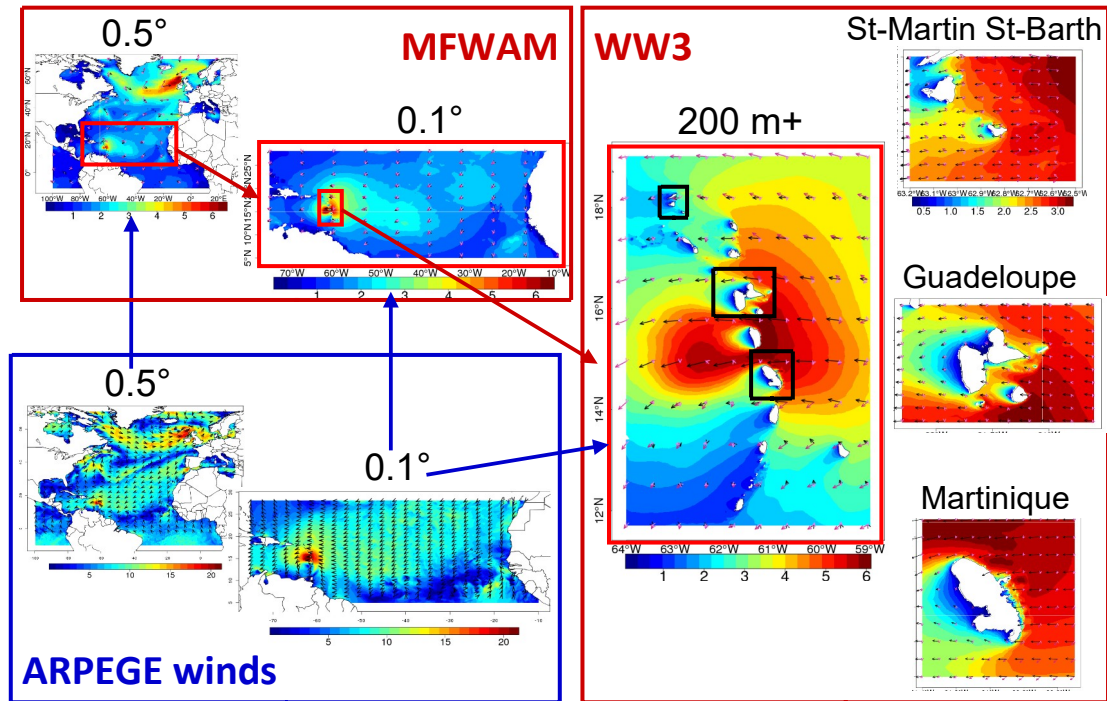
Chauvin et al. 2020 Clim Dyn



ARPEGE-Climat

- 5-member ensemble runs
- RCP8.5 2031-2080 vs. 1965-2013
- Corrected CMIP5 SST (CNRM-CM5)
- CMIP6 Physics (CNRM-CM6)

Nested Spectral Wave Models



ARPEGE winds

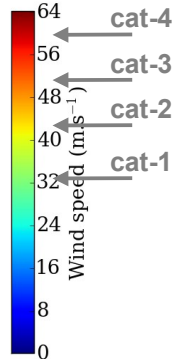
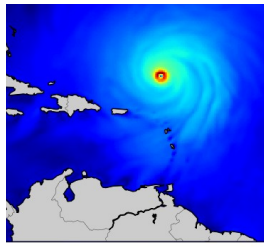
Belmadani et al. 2021 Clim Dyn

- 5-member ensemble runs
- RCP8.5 2051-2080 vs. 1984-2013
- MFWAM runs over *hurricane season* ~Mid-Jul to Early Nov
- WW3 runs over *season peak phase* ~Mid-Aug to Mid-Sep

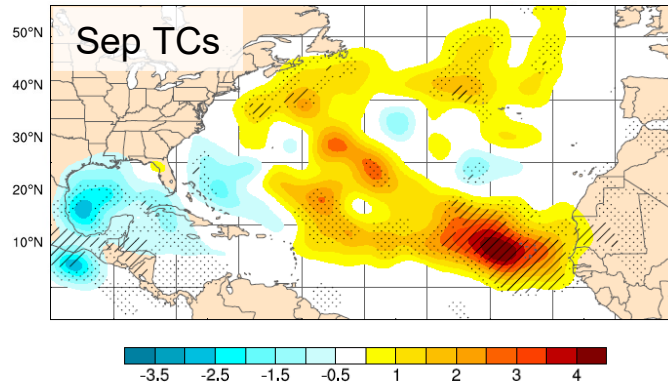
Tropical Cyclones & Storm Waves

Future changes in Atlantic TCs & wave climate

Chauvin et al. 2020 Clim Dyn
Belmadani et al. 2021 Clim Dyn



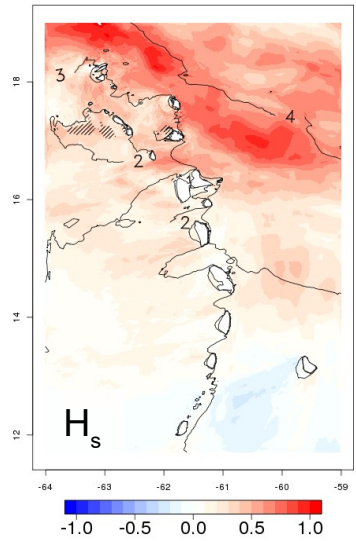
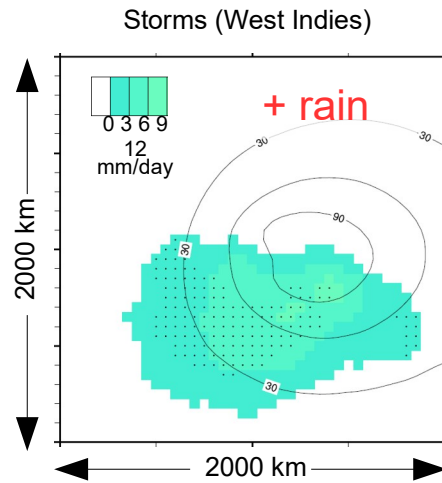
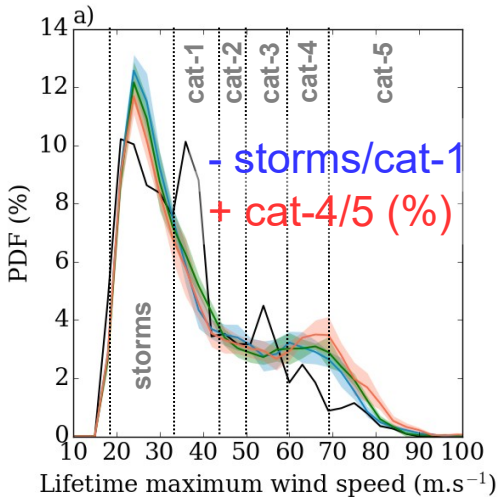
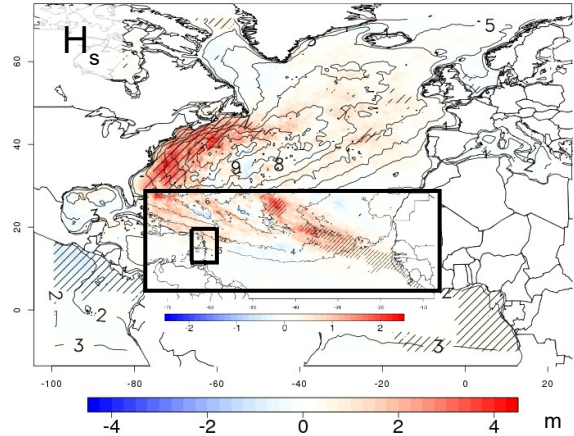
Cat-4 hurricane by ARPEGE



Number of TC days per 20 years per 5x5 degrees square

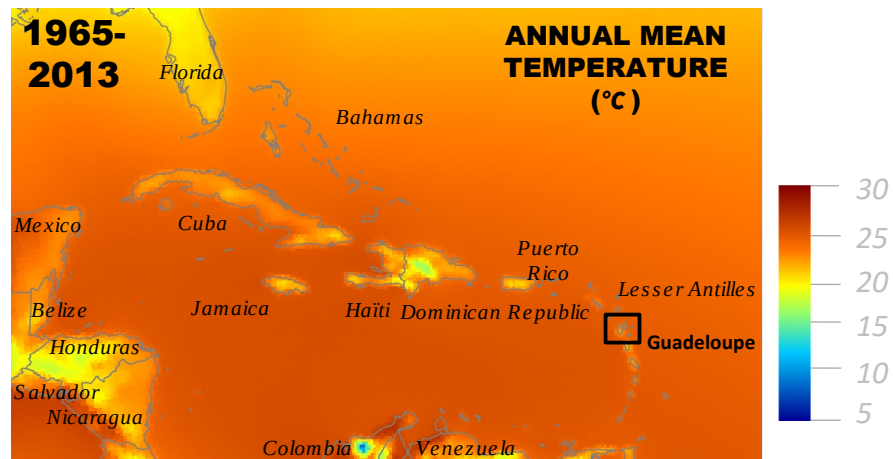
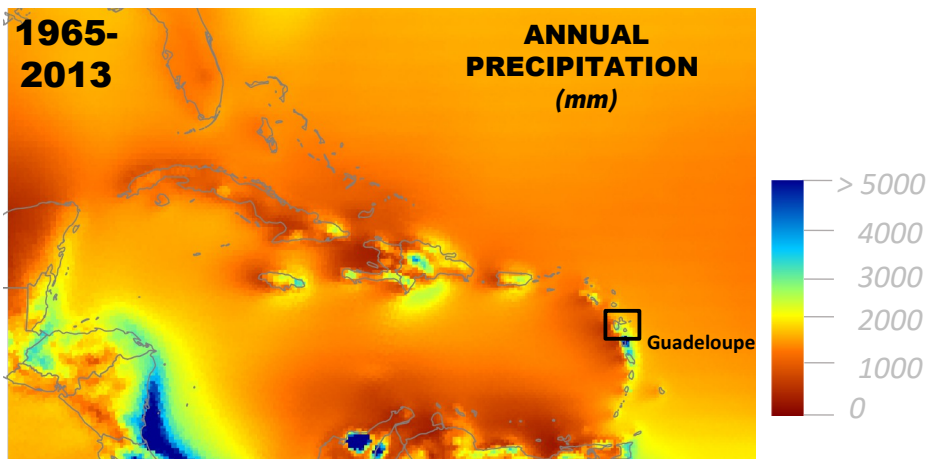
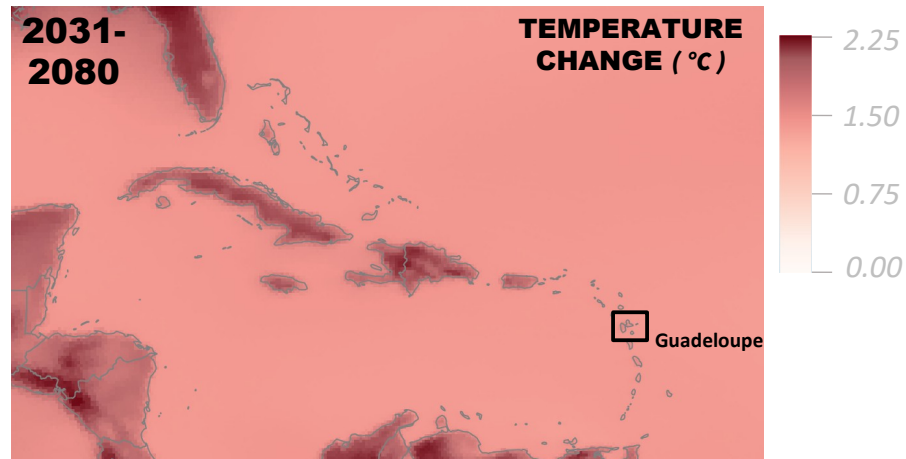
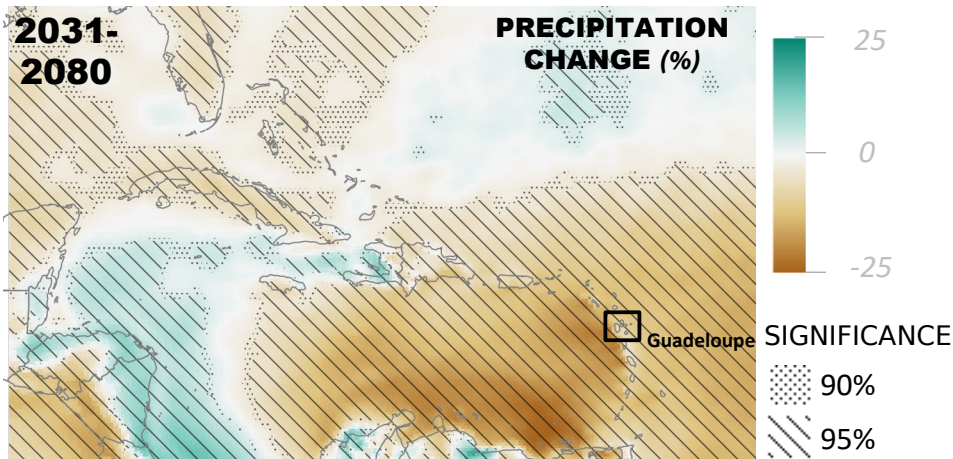
TC extremes, peak phase

2051-2080: Change in 90th percentile Significant wave height (m) MFWAM 0.5° - ARPEGE



Regional Climate

Projections of Caribbean temperature & precipitation

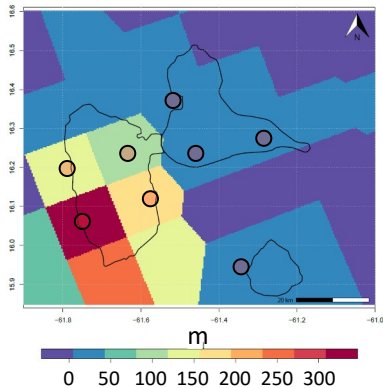


=> Regional **warming** & **drying**

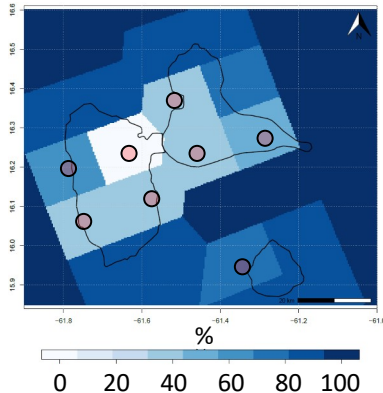
Island Climate

Model climate & projections for Guadeloupe

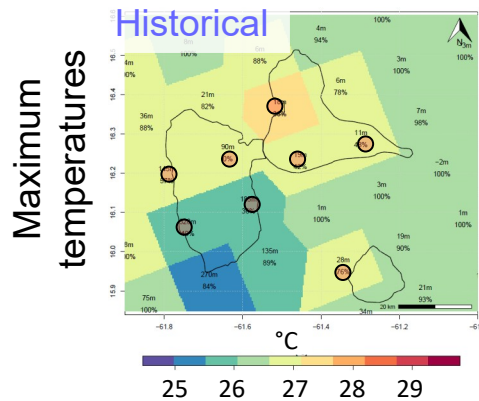
Orography



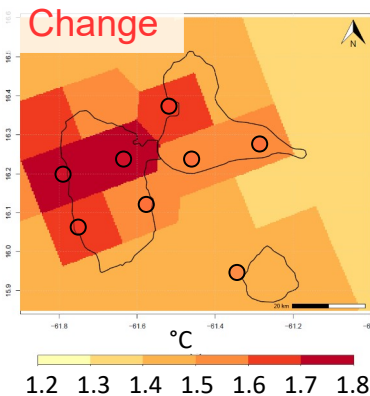
Land-sea fraction



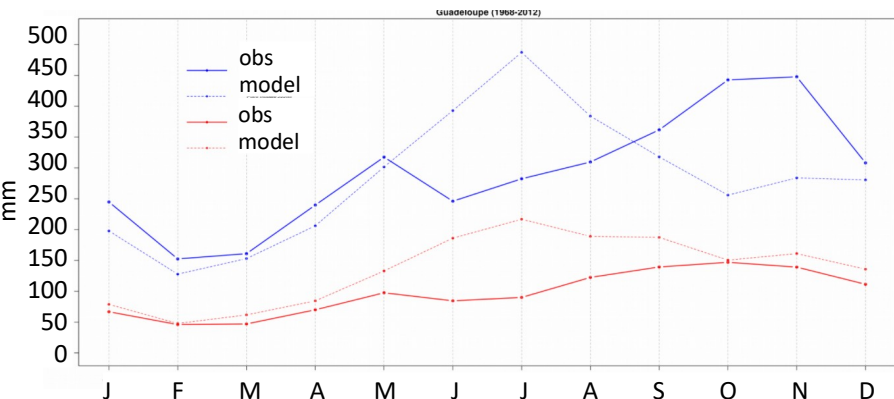
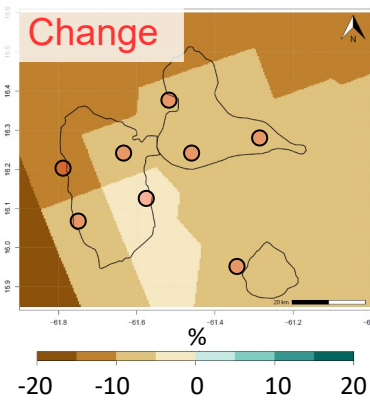
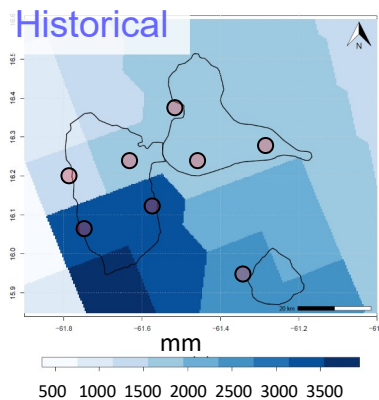
1965-2013



2031-2080



Guadeloupe archipelago seen by ARPEGE



Model/obs rainfall seasonal cycle for 2 stations

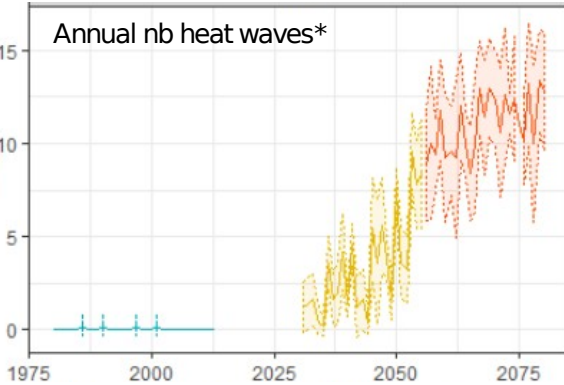
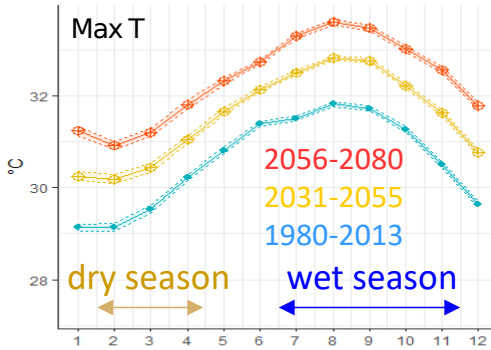
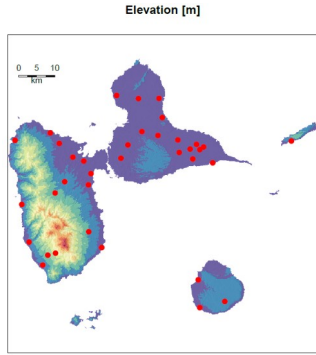
Annual change in max temperatures & accumulated rainfall

Island Climate

Bias-corrected projections for Guadeloupe

- * 3+ consecutive warm days (32°C+) & nights (25°C+)
- ** 3+ consecutive days with RR < 1 mm
- *** daily RR > 30 mm

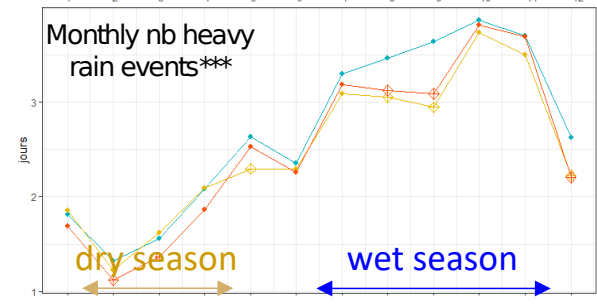
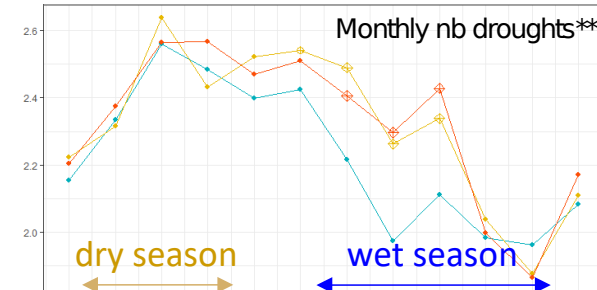
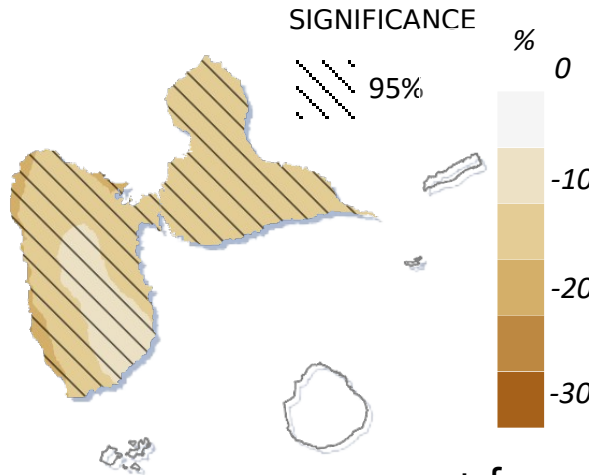
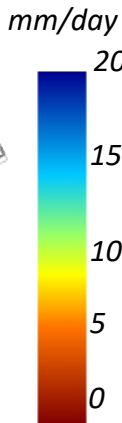
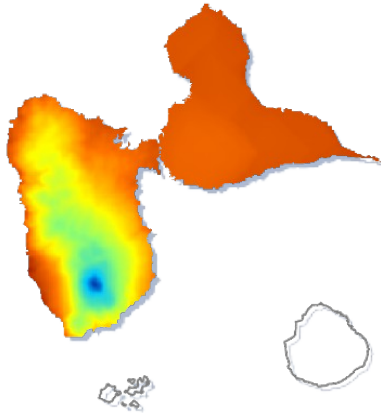
Quantile-quantile corrections with long daily station data (*Cantet et al. 2021 Int J Climatol*)



1980-2013

2056-80 change

Wet season RR



Cantet 2015
Theor Appl Clim

year-round **warming** & wet-season **drying** everywhere

- + frequent & longer **heat waves**
- + frequent wet-season **droughts**
- frequent wet-season **heavy rain**



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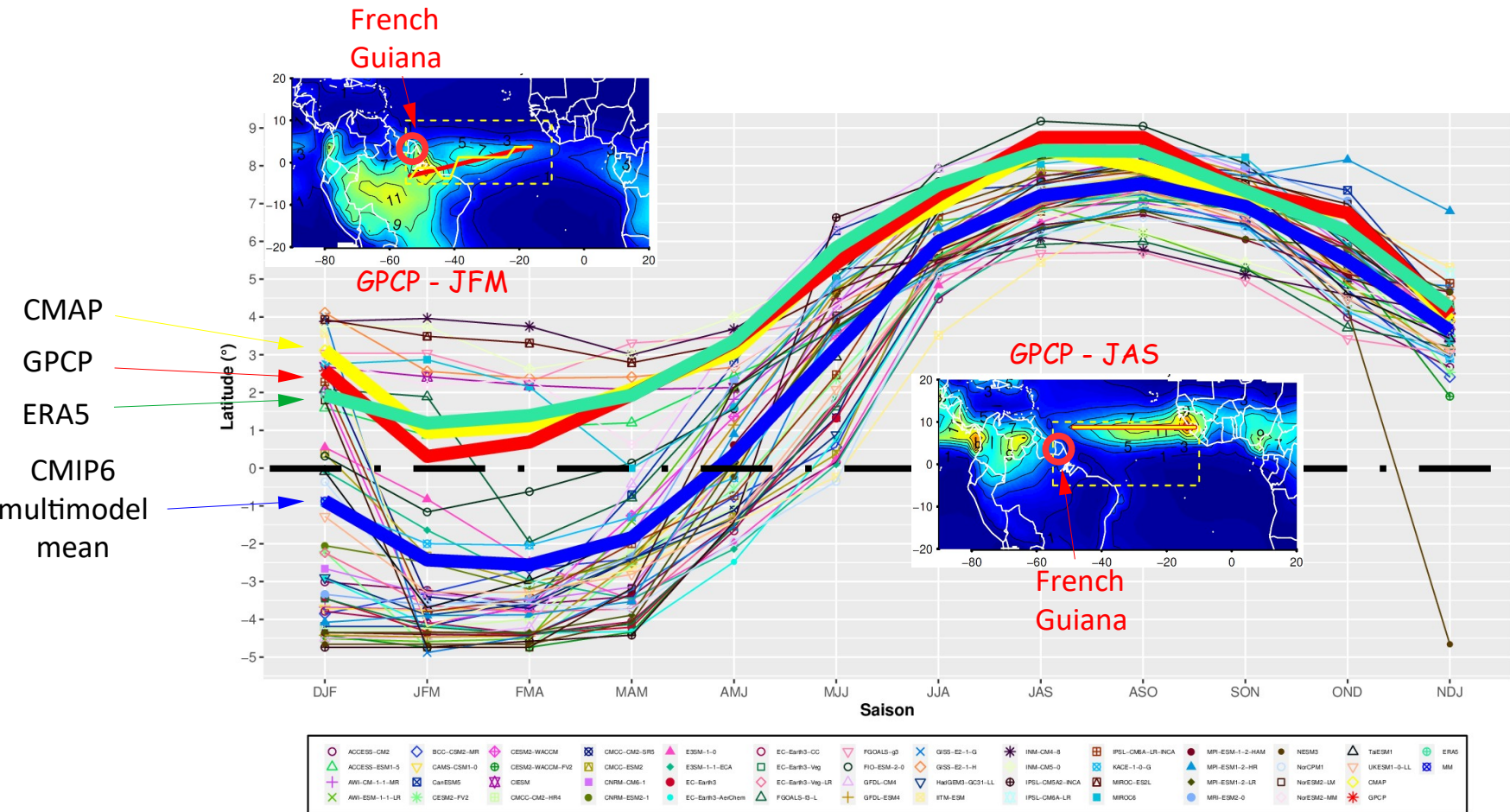
Trieste, Italy, 28 September 2023



French Guiana Climate Driver

Systematic biases in the ITCZ latitude...

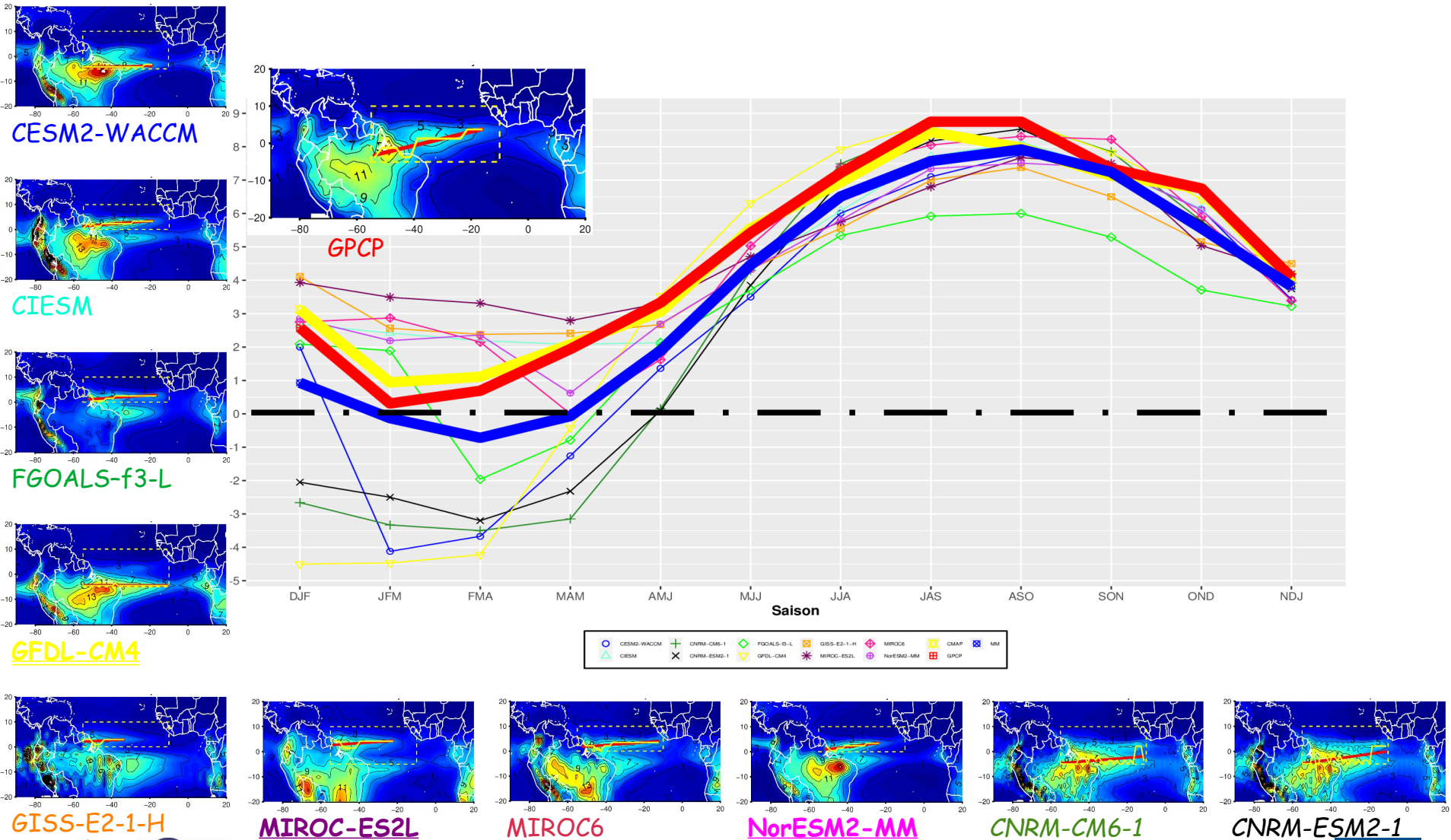
Belmadani et al. in prep



French Guiana Climate Driver

...markedly reduced in a subset of 8 GCMs

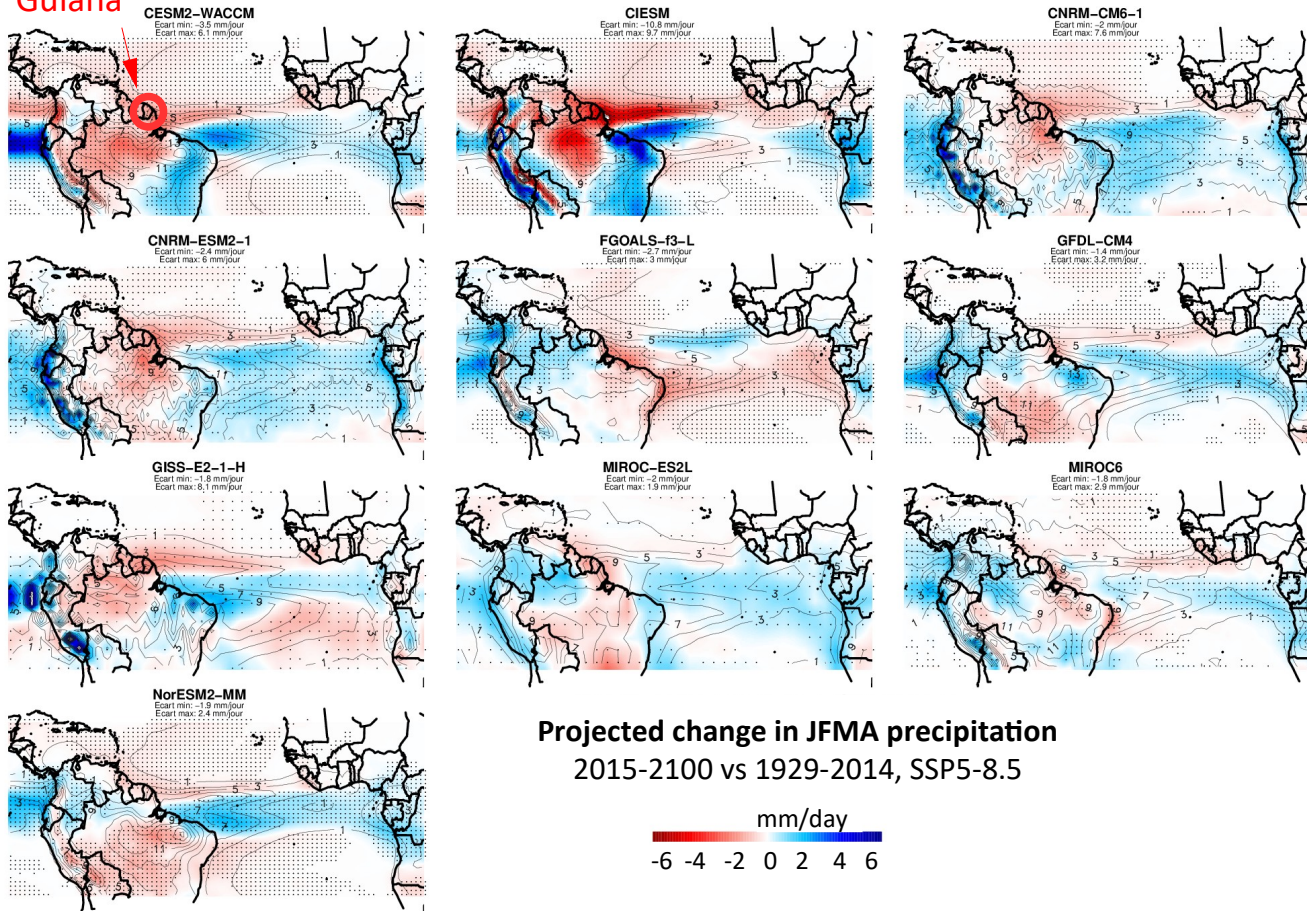
Belmadani et al. in prep



Projected Southward ITCZ Displacement and reduced rainfall over French Guiana

Belmadani et al. in prep

French Guiana

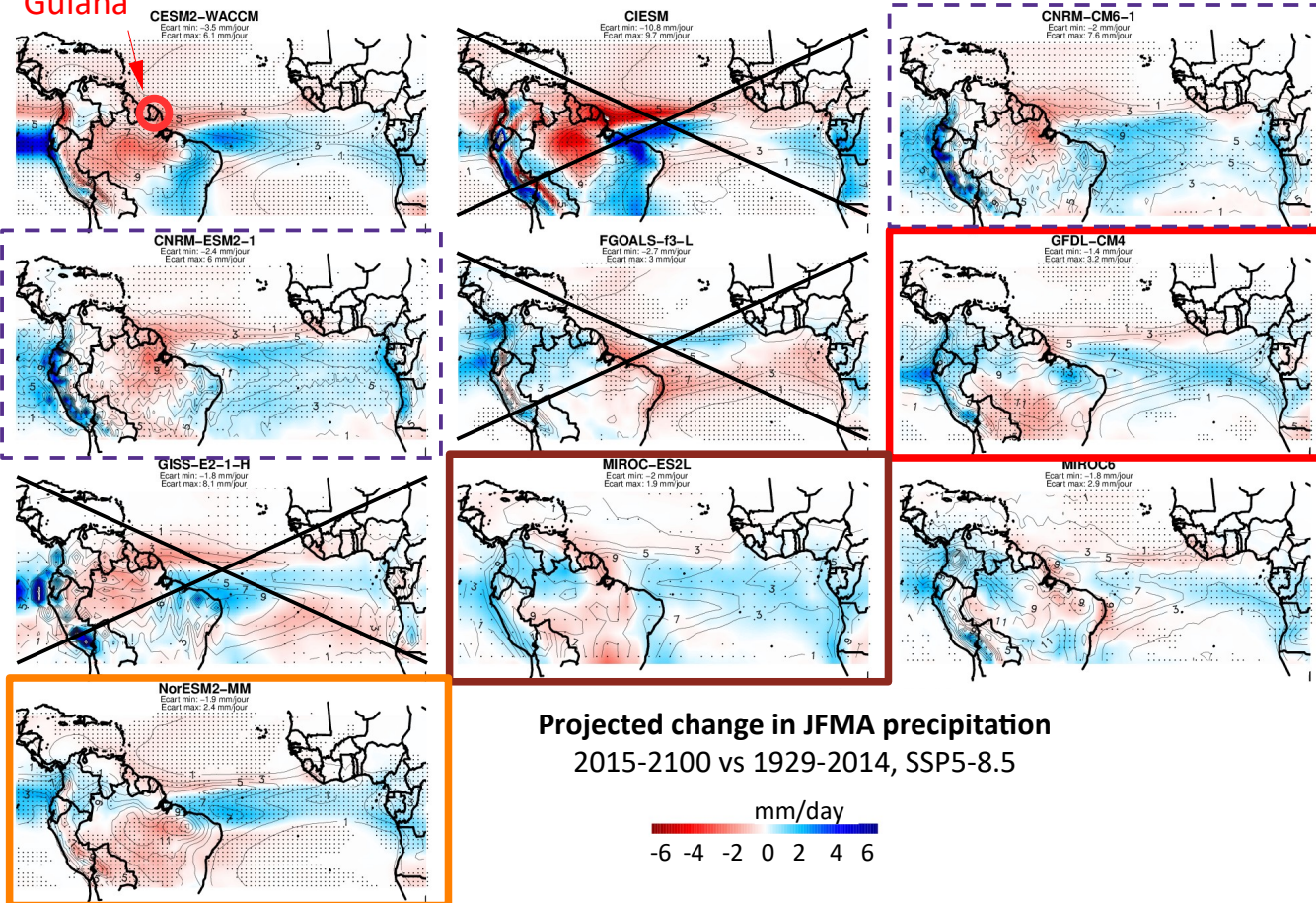


Selection of final GCM subset

3 GCMs with contrasted future changes

Belmadani et al. in prep

French
Guiana



- **GFDL-CM4** : stronger annual warming
- **MIROC-ES2L** : stronger reduction in rainfall
- **NorESM2-MM** : weaker annual warming
- **CNRM-XXX-1** : very strong warming

Local Climate

Bias-corrected projections for French Guiana

Belmadani et al. in prep

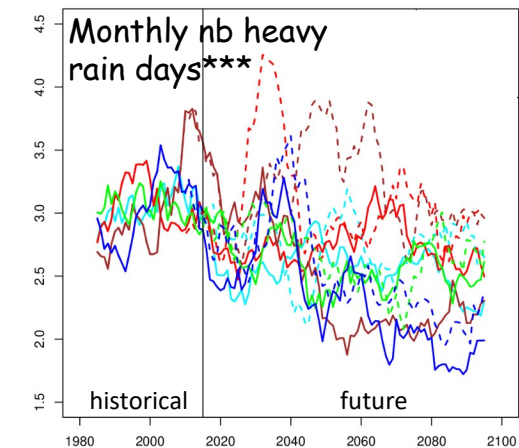
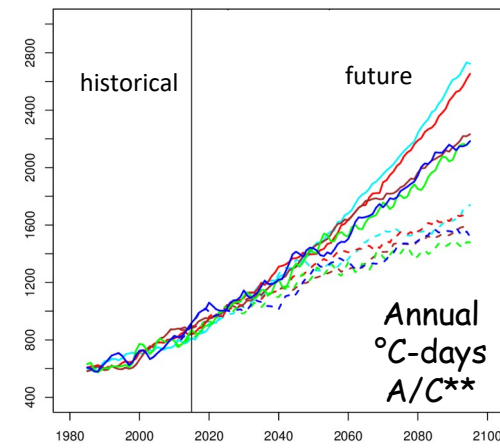
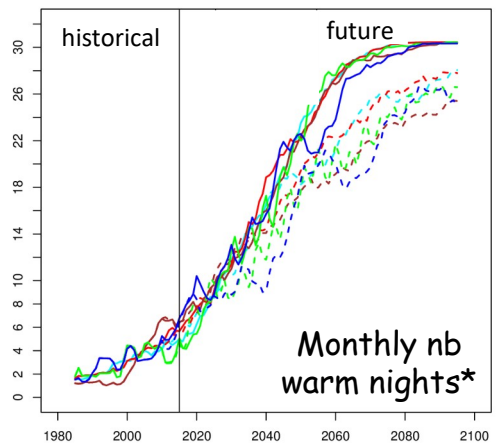
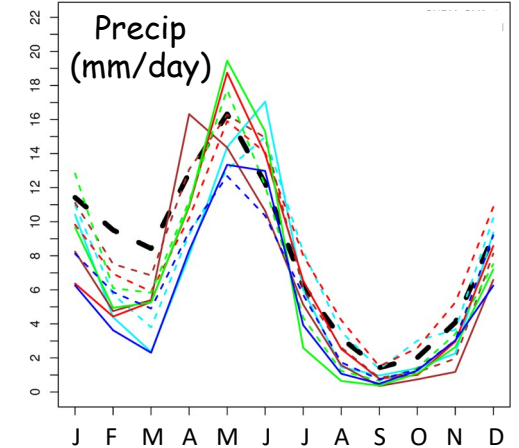
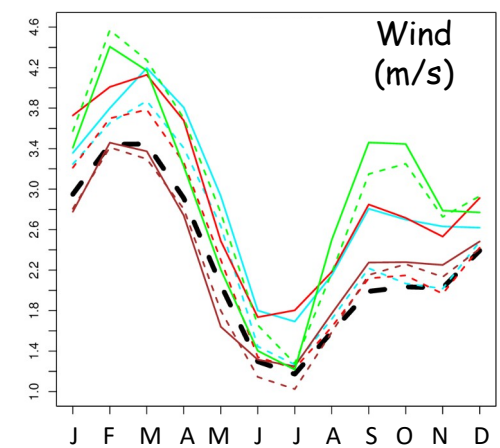
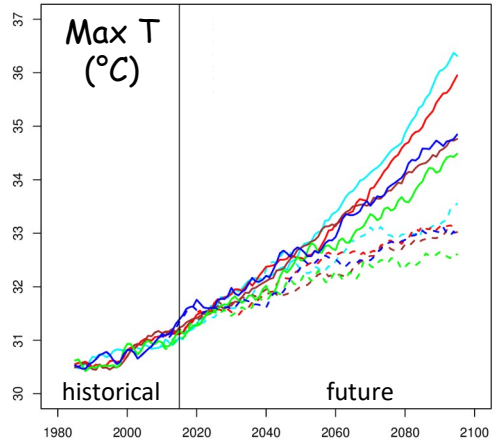
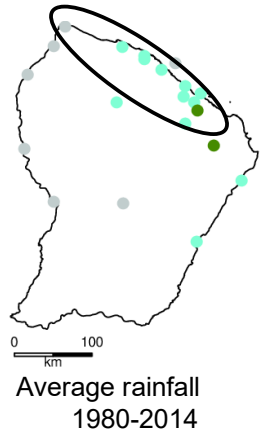
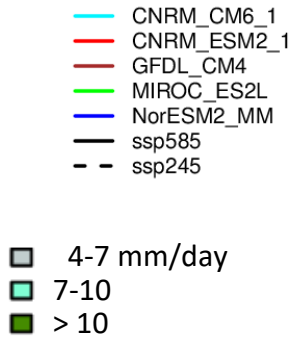
* Tmin > 90th percentile

** threshold for Tmean : 25°C

*** daily RR > 90th percentile

Quantile-quantile corrections with long daily station data

2071-2100 vs. 1980-2014



Conclusion



- *French West Indies*

Dynamical downscaling of a CMIP5 GCM : ARPEGE-Climat HR atmospheric GCM with refined grid = 15-20 km over the islands. Explicit island masses + reasonable island rainfall climatology & basin-scale tropical cyclone activity including storm waves.

- **Statistical downscaling** of ARPEGE-Climat : quantile-quantile bias correction with long daily island station temperature & precipitation data. Strong year-round warming, wet-season drying, ↑ heat waves & droughts, ↓ heavy rain events => impacts on e.g. water resource & agriculture.



- *French Guiana*

Subsetting the CMIP6 GCM ensemble : from 50 to 8 with smaller bias in the Atlantic ITCZ latitude, down to 3 GCMs with contrasted future changes & available daily data => storyline approach.

Statistical downscaling of 3 GCMs : quantile-quantile for temperature, precipitation, wind. Consistent warming & drying, increased windspeed or no change, climate impacts including increased energy demand for A/C.





Thanks for your attention!

<http://c3af.univ-montp3.fr>

ali.belmadani@meteo.fr



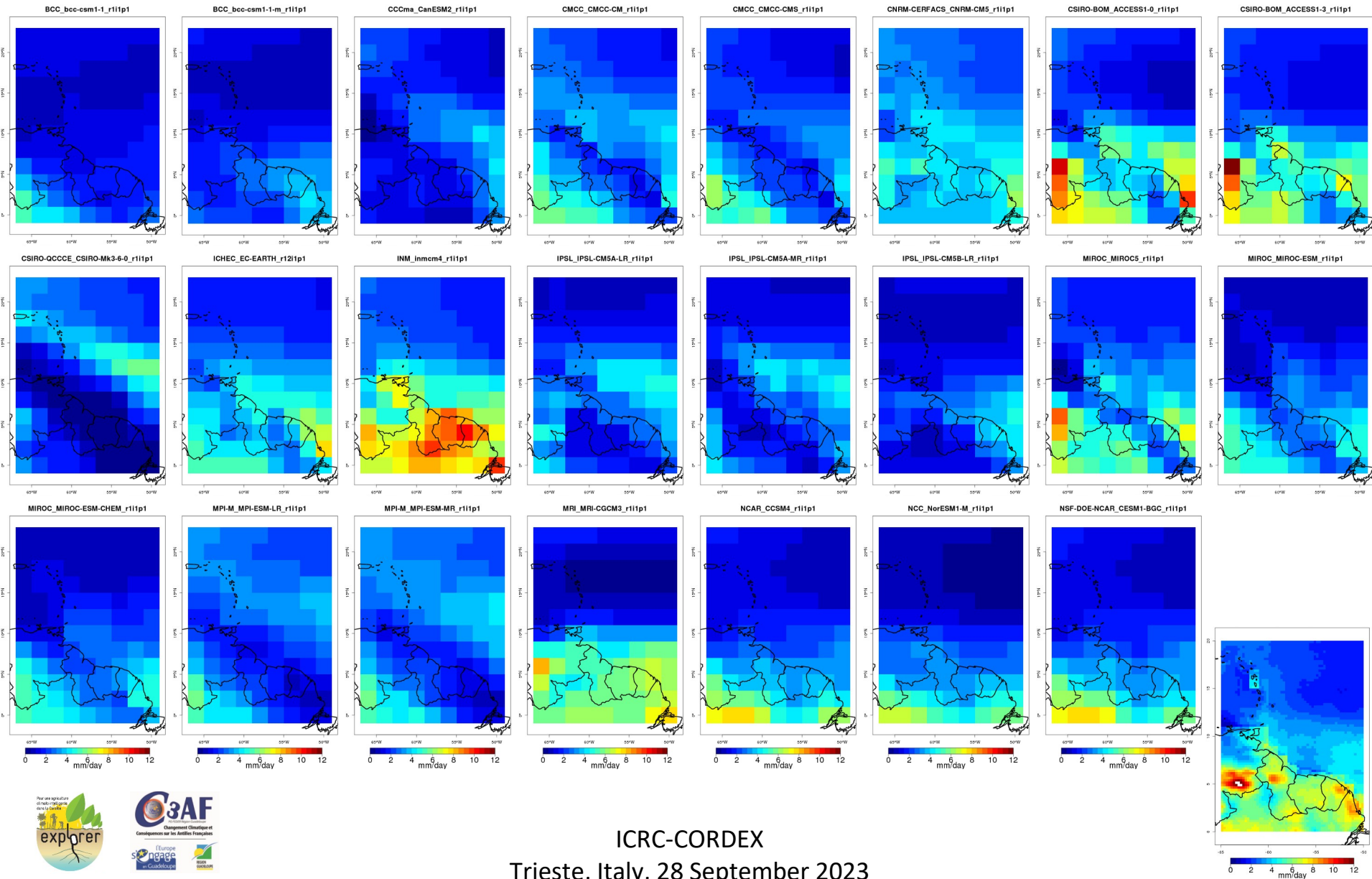
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Climate Models & Small Islands

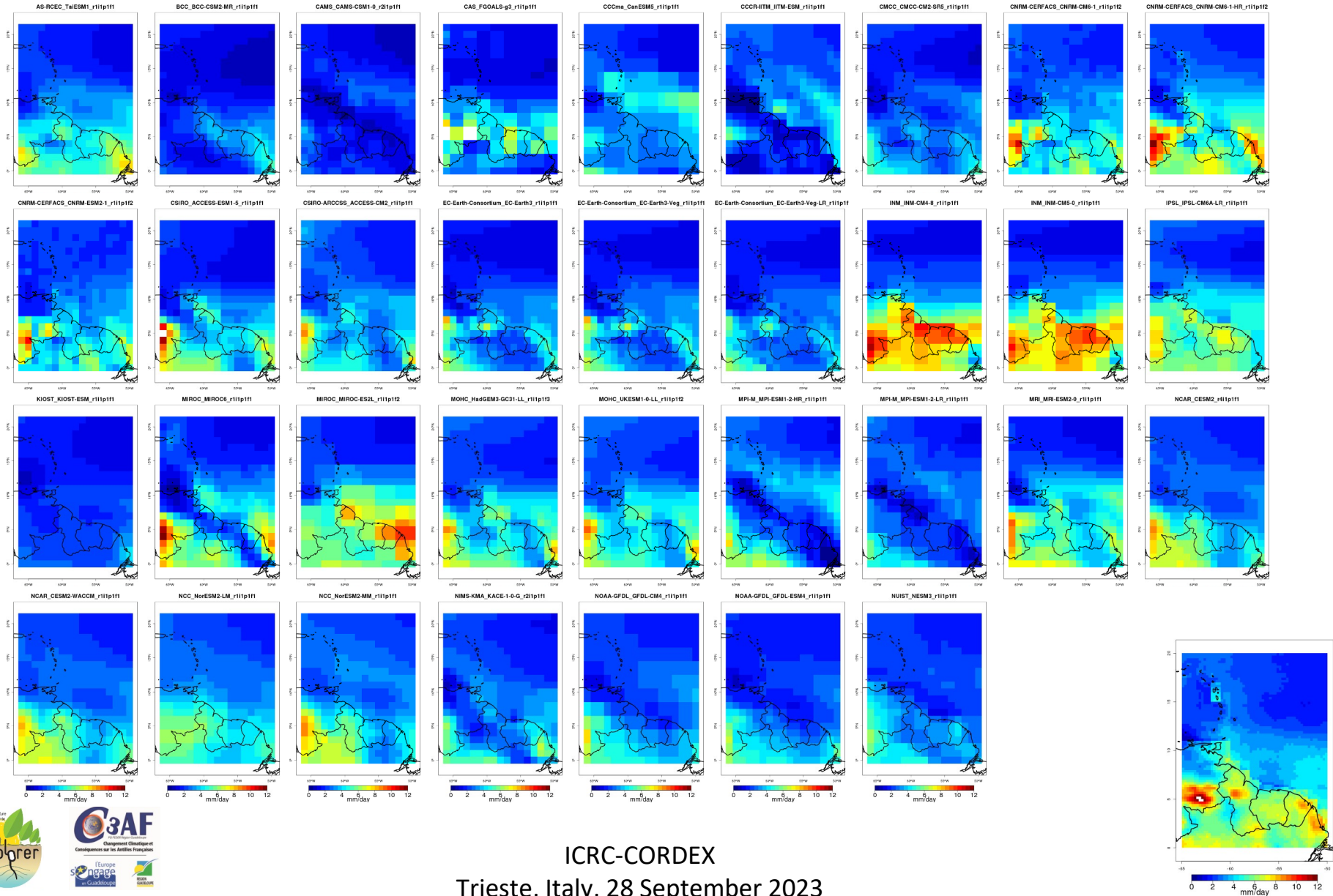
CMIP5



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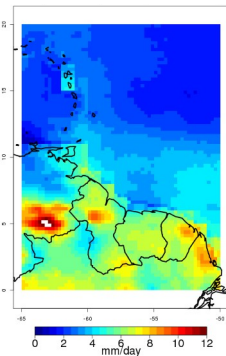
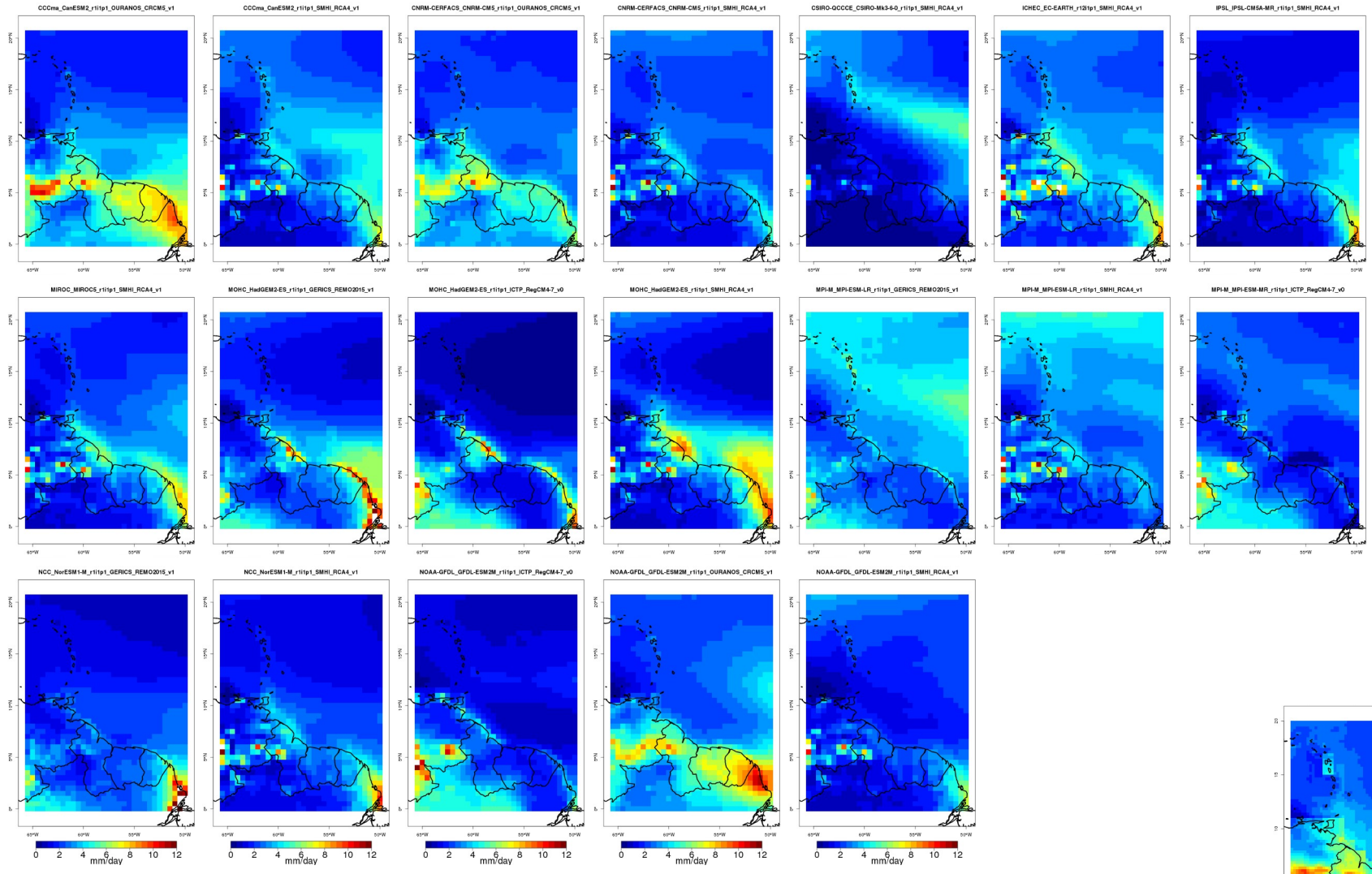
Climate Models & Small Islands

CMIP6



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