Climate projections over Central America from CMIP5 GCMs and RCA simulations

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Objectives

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- To assess the skill of CMIP5 GCMs on reproducing the mean features of climate over Central America and Mexico.

- To compare the GCM simulations with CORDEX simulations over the Central American domain performed with the RCA model.

- To evaluate the representation of Tropical Cyclones (TCs) on the RCA simulations.

- To characterize the mean signal of climate change from the ensemble of GCM and RCA projections, as well as the changes on spatial distribution and intensity of TCs.

GCM simulations

List of GCMs

- CanESM2
- CSIRO-Mk3-6-0
- CNRM-CM5
- EC-Earth
- GFDL-ESM2M
- HadGEM2-ES
- IPSL-CM5A-MR
- MIROC5
- MPI-ESM-LR
- NorESM1-M

Forcings:

- Historical simulation.
- RCP8.5 (2.6,4.5,6,8.5)

Mean JJAS surface temperature

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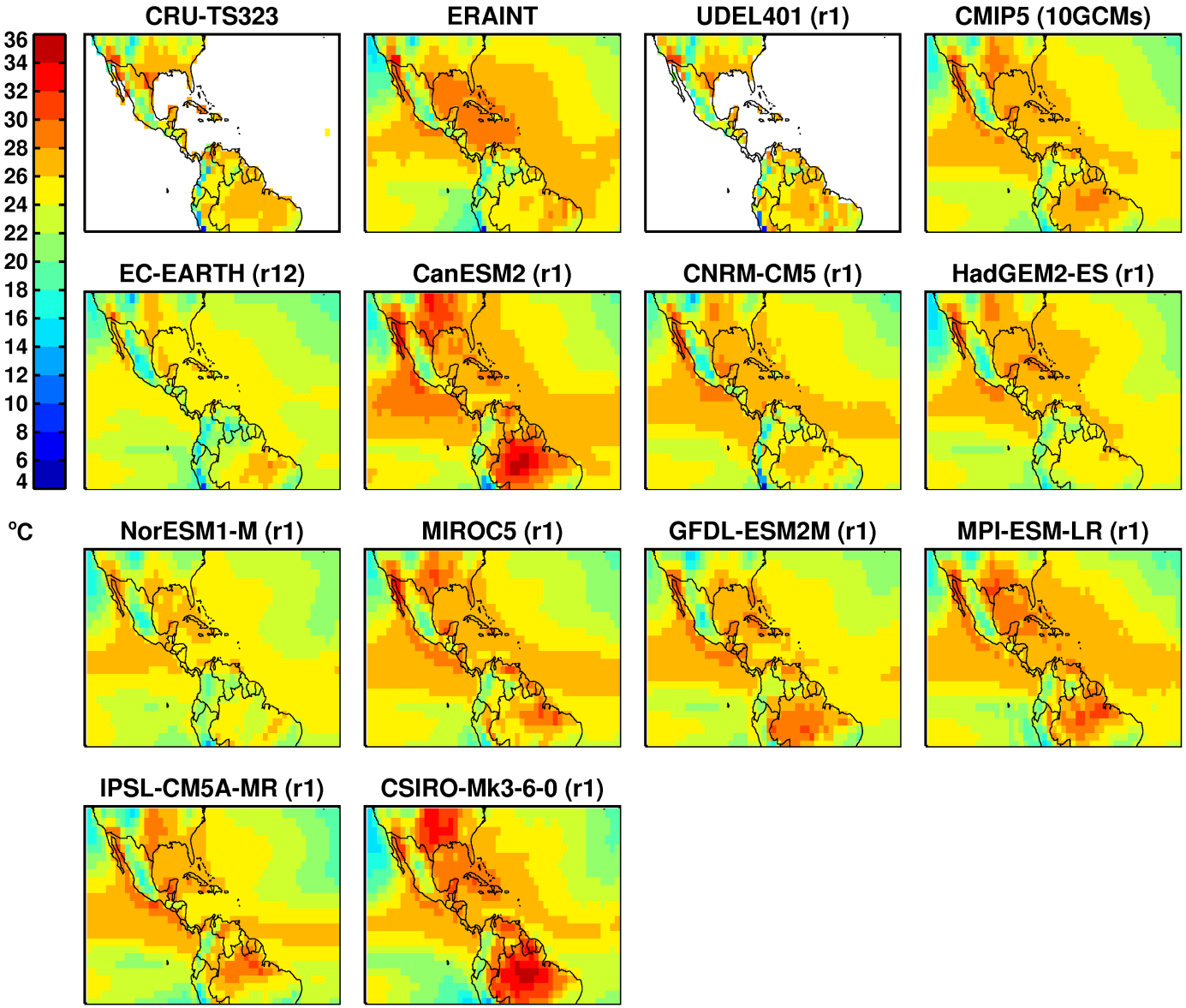
2m Temperature (tas) | JJAS | 1981-2010 | CAM-44



Simulated minus reanalysis surface pressure biases

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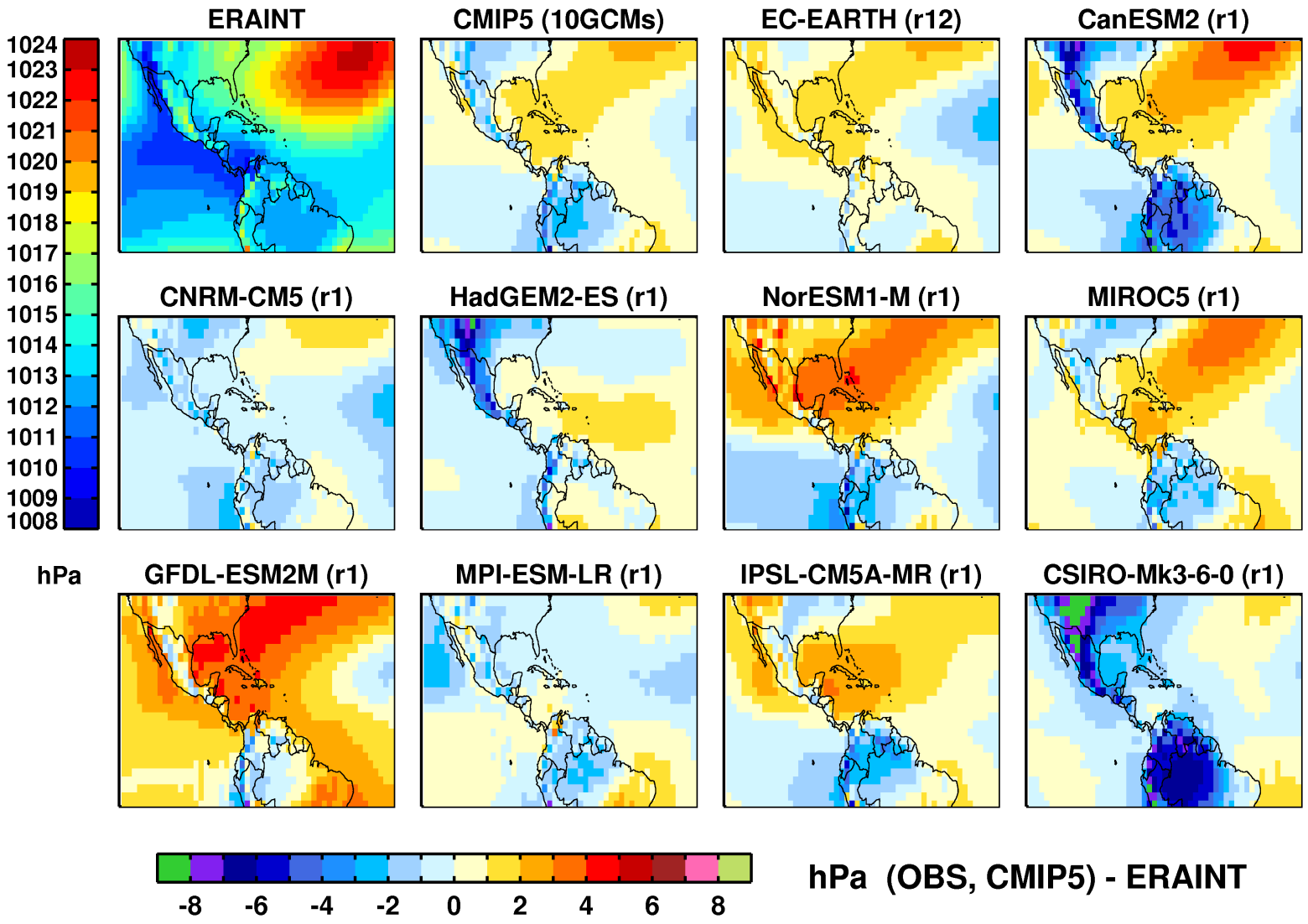

Simulated minus observed precipitation biases

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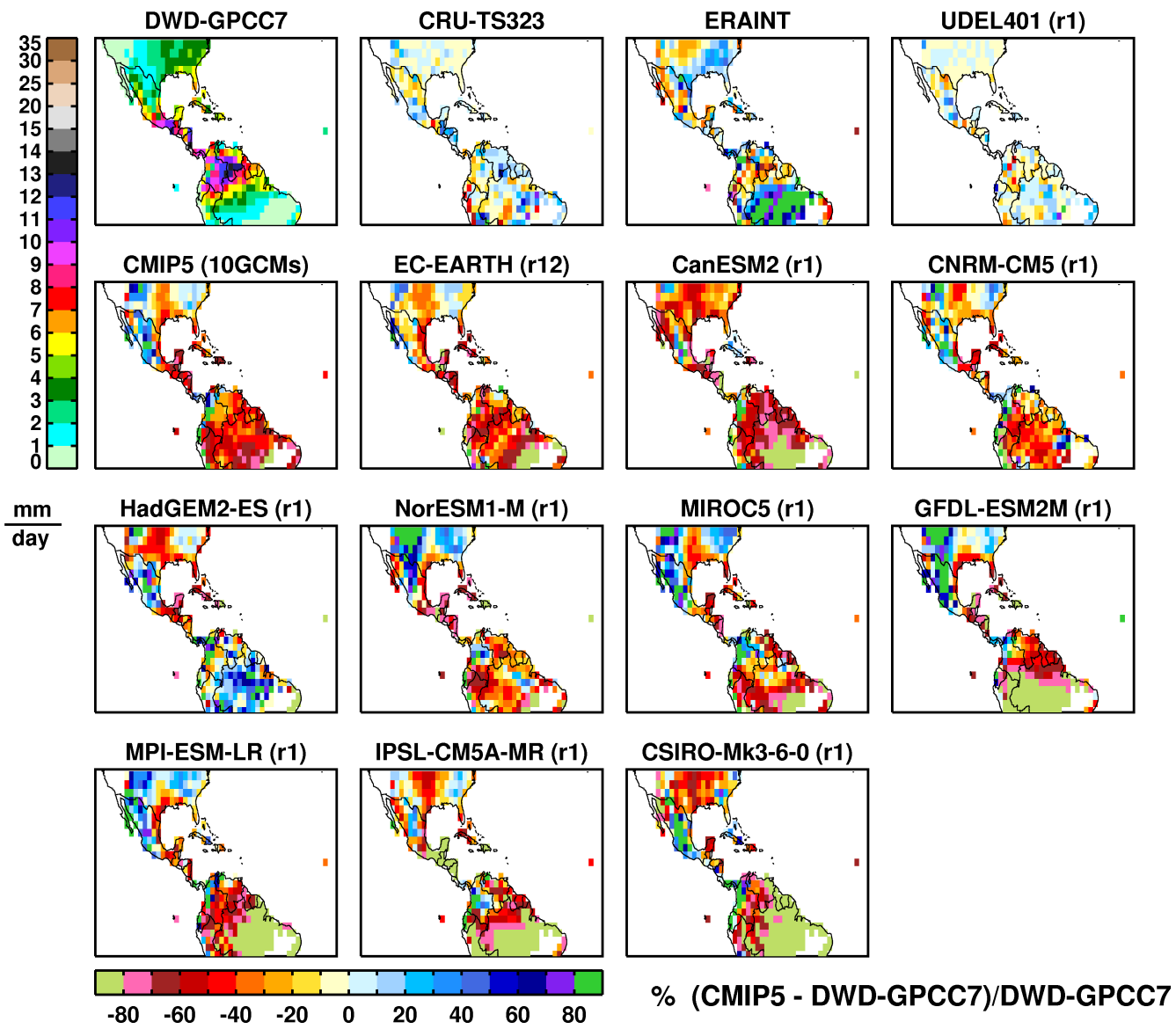

COordinated Regional Downscaling Experiment (CORDEX)

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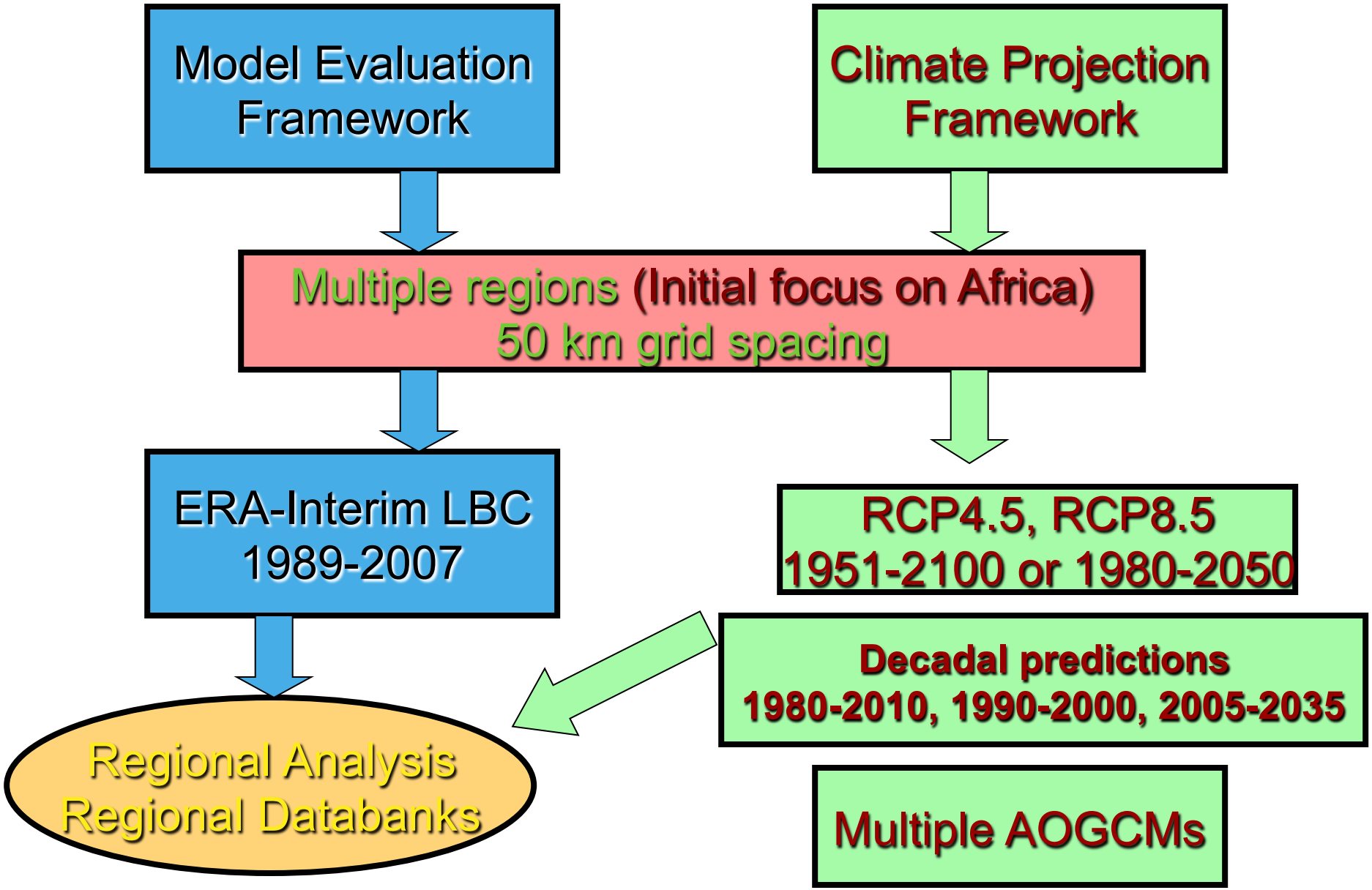
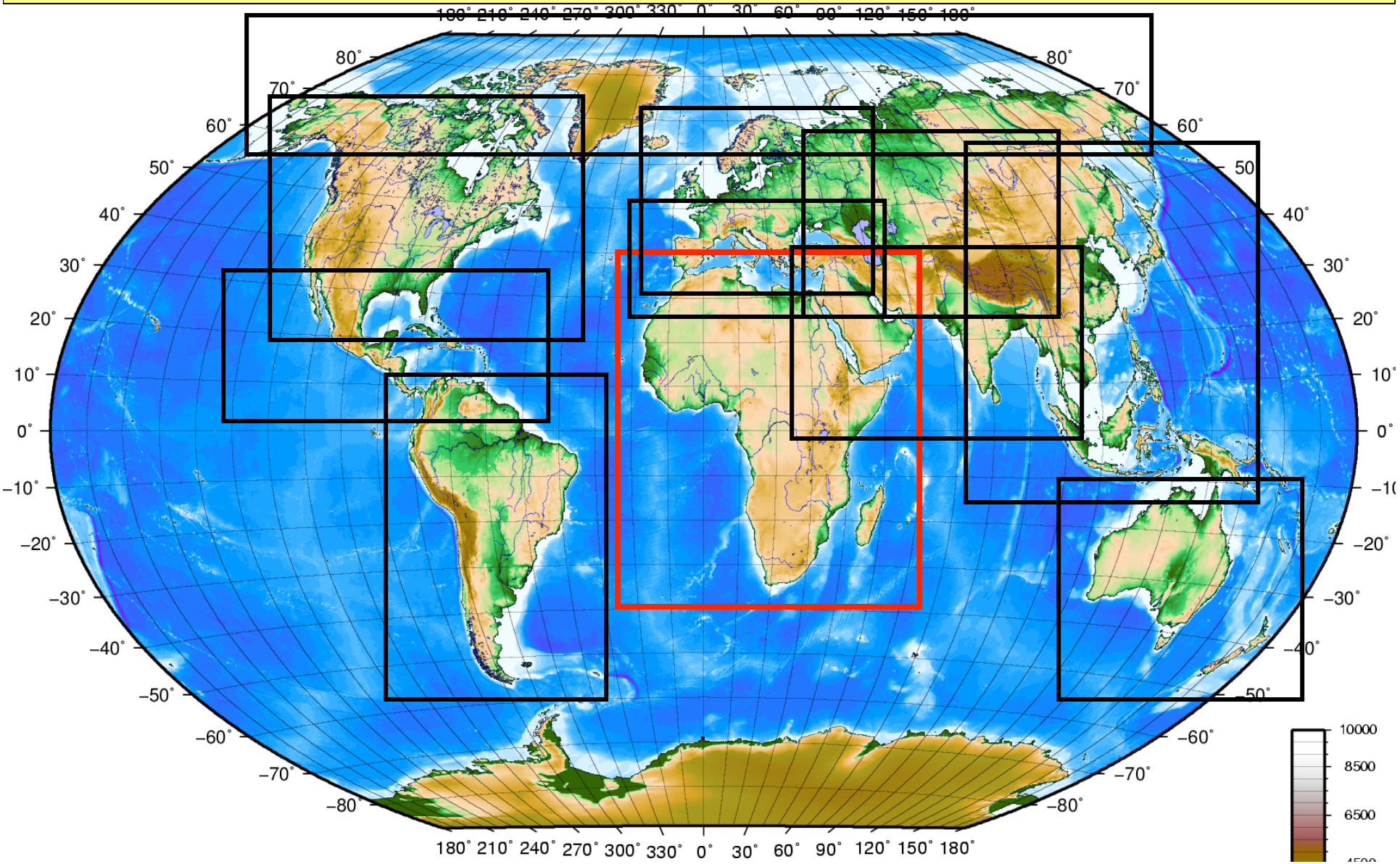
- Modeling framework designed to:
  - Evaluate and improve RCD models and techniques
  - Provide a coordinated set of RCD-based projections/predictions for regions worldwide
  - Facilitate the communication with the IAV community and the involvement of the research community from developing countries

CORDEX Phase I experiment design



CORDEX domains



RCA Configuration

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- Based on Hirlam
- Turbulent Kinetic Energy (TKE) scheme (Lenderink and Holtslag, 2004) into the original CBR (Cuxart et al., 2000) scheme.
- Treatment of convection has been adjusted by switching the deep and shallow convection schemes from the standard Kain-Fritsch scheme (Kain and Fritsch, 1990) to the Bechtold-KF scheme (Bechtold et al., 2001).
- A few additional modifications including a diluted CAPE (Convective Available Potential Energy) profile for calculating the CAPE closure have also been implemented (Jiao and Jones, 2008).
- Cloud formation following Tiedtke (1996).
- Physiography data bases as ECOCLIMAP (Masson et al., 2003) for vegetation,
- Gtopo30 (USGS, 1996) for topography,
- Lake depth (Kourzeneva, 2010)
- Soil carbon density (Global Soil Data Task, 2000).

Surface temperature from GCMs and RCA ensembles

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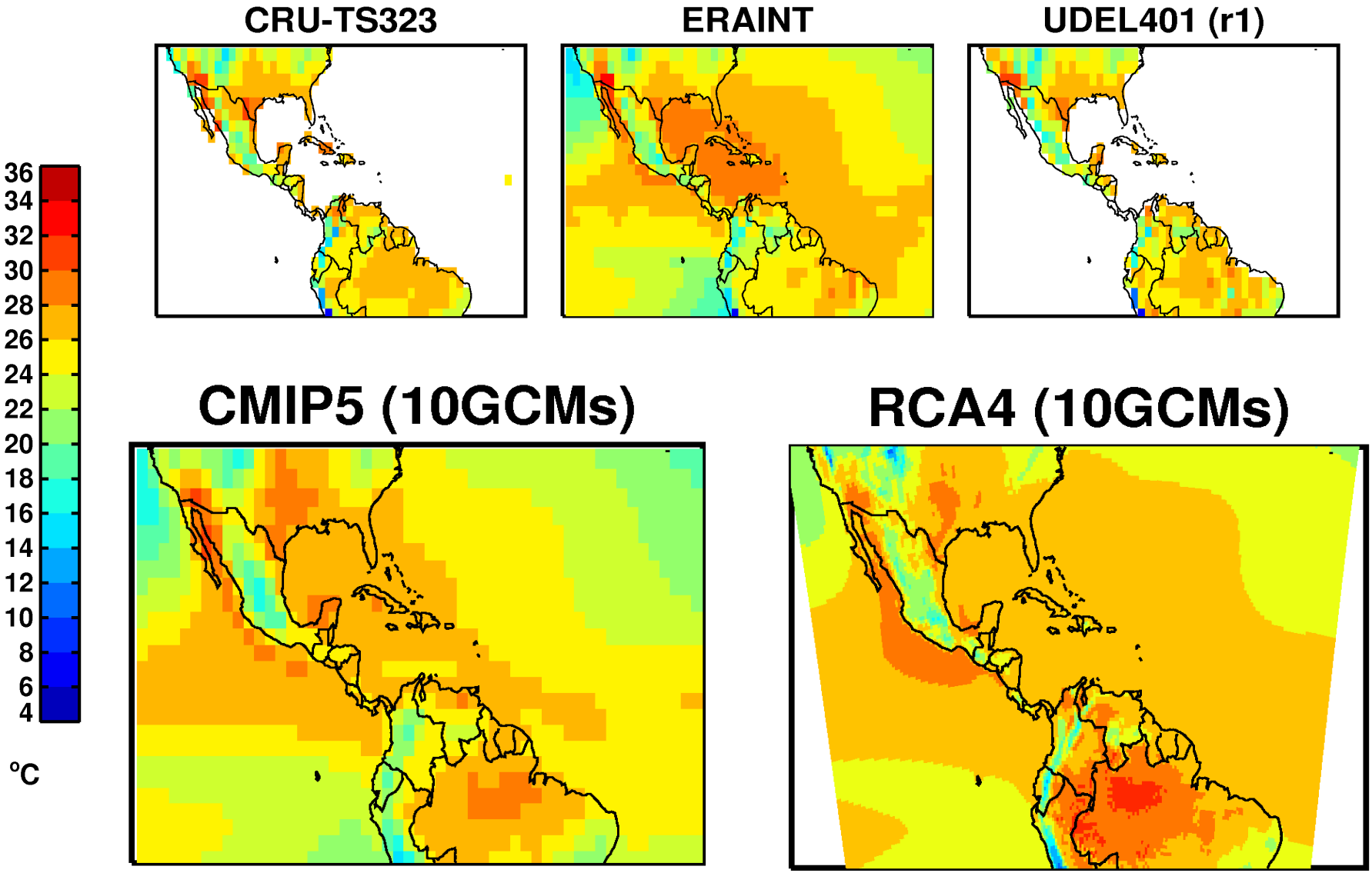

Surface pressure from GCMs and RCA ensembles

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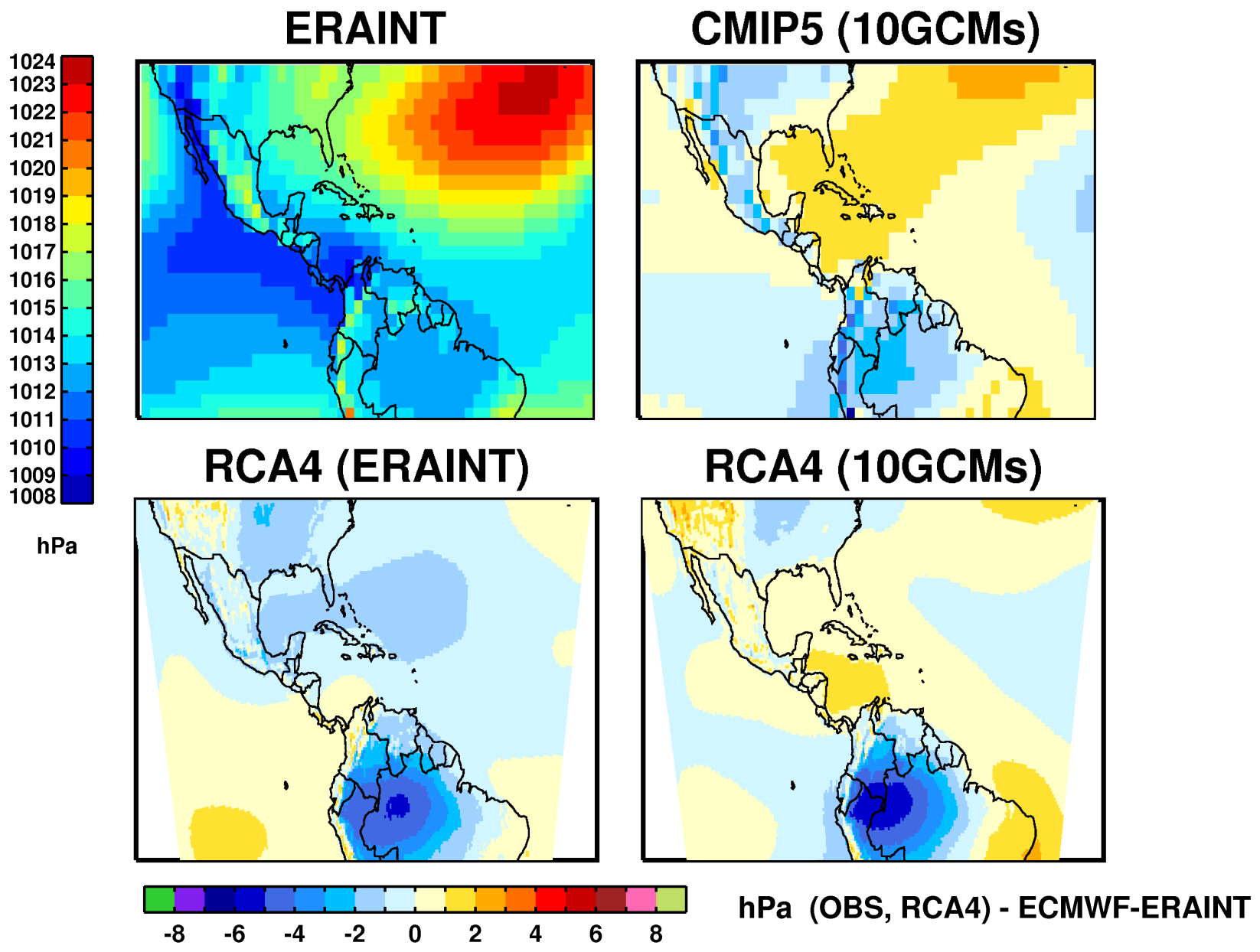

Precipitation from GCMs and RCM ensembles

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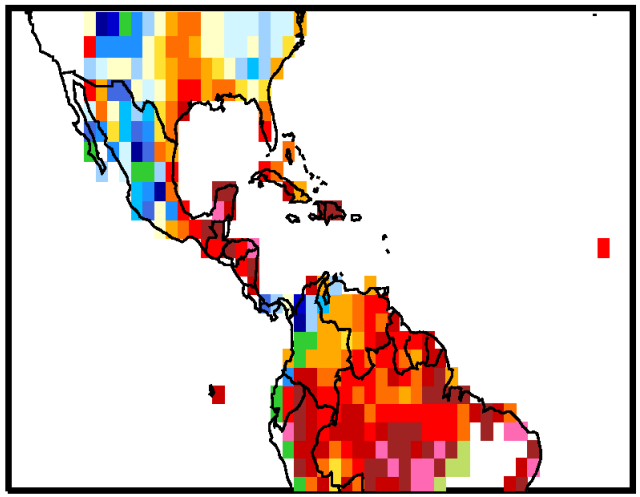
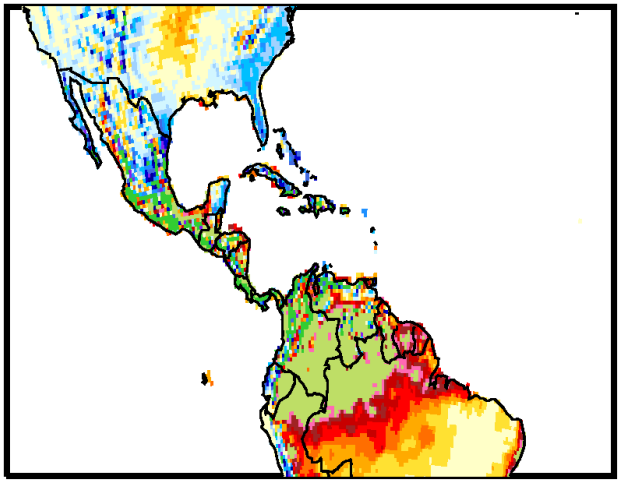
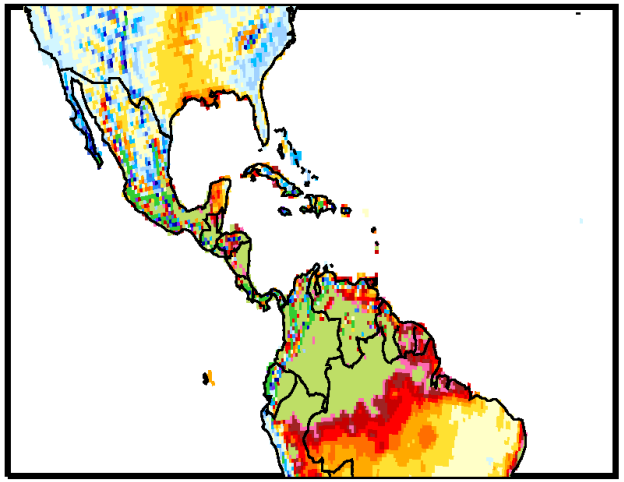
CMIP5 (10GCMs)

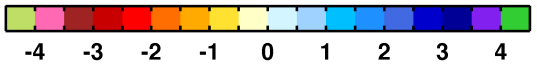


RCA4 (ERAINT)



RCA4 (10GCMs)





mm/day (OBS, RCA4) - GPCC7

TCs detection and tracking

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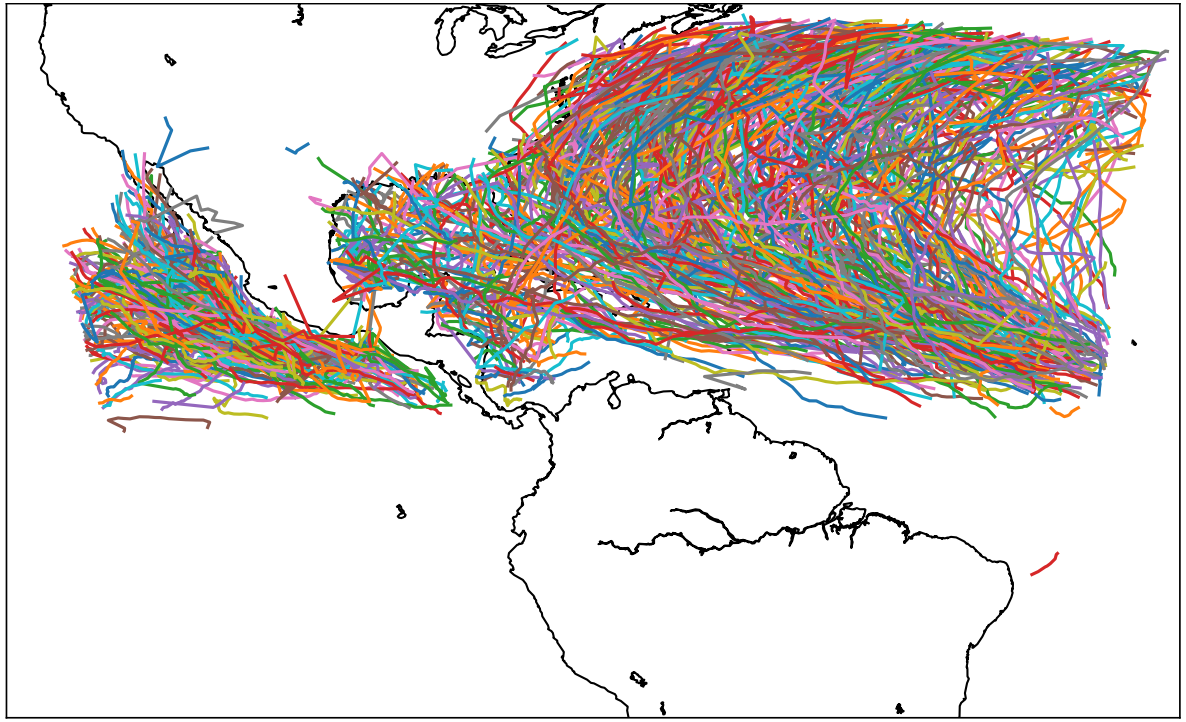

Kyklop: Cyclone's detector and tracker: https://github.com/kyklop-climate/kyklop

Detection thresholds: Wind speed >21 ms^{-1}, SLP<1005 hPa, SST >= 25 C
Tracking algorithm: a check is performed on each three hourly sample to find whether there are cyclones during the next 24 hour period within a radius of 6X6 longitude- latitude grid boxes.
Output: Time, latitude and longitude of centroid of the simulated TC. Maximum windspeed and minimum pressure at the same time step as the input files.

Tropical Cyclones tracker

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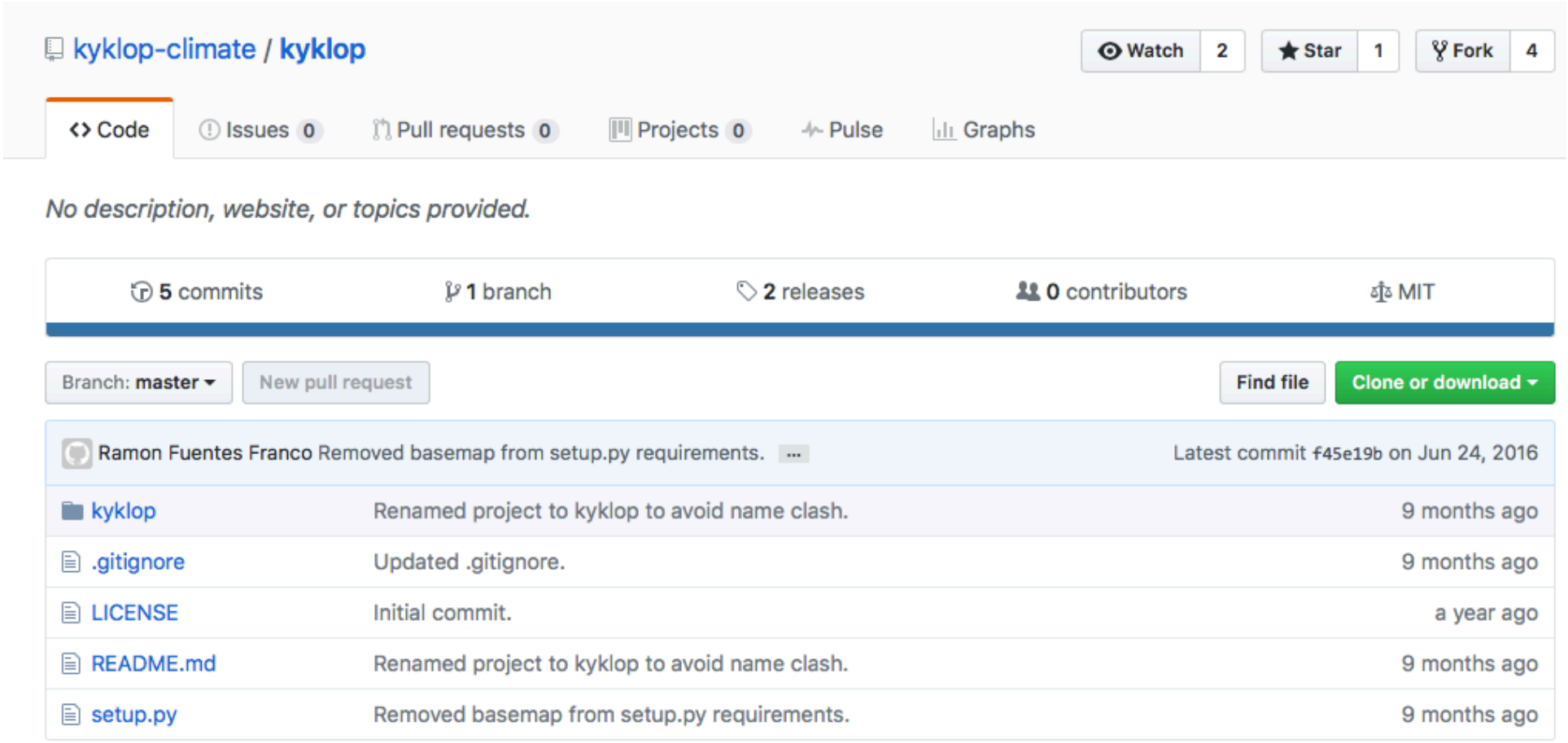

https://github.com/kyklop-climate/kyklop

TCs in RCA 1976-2005

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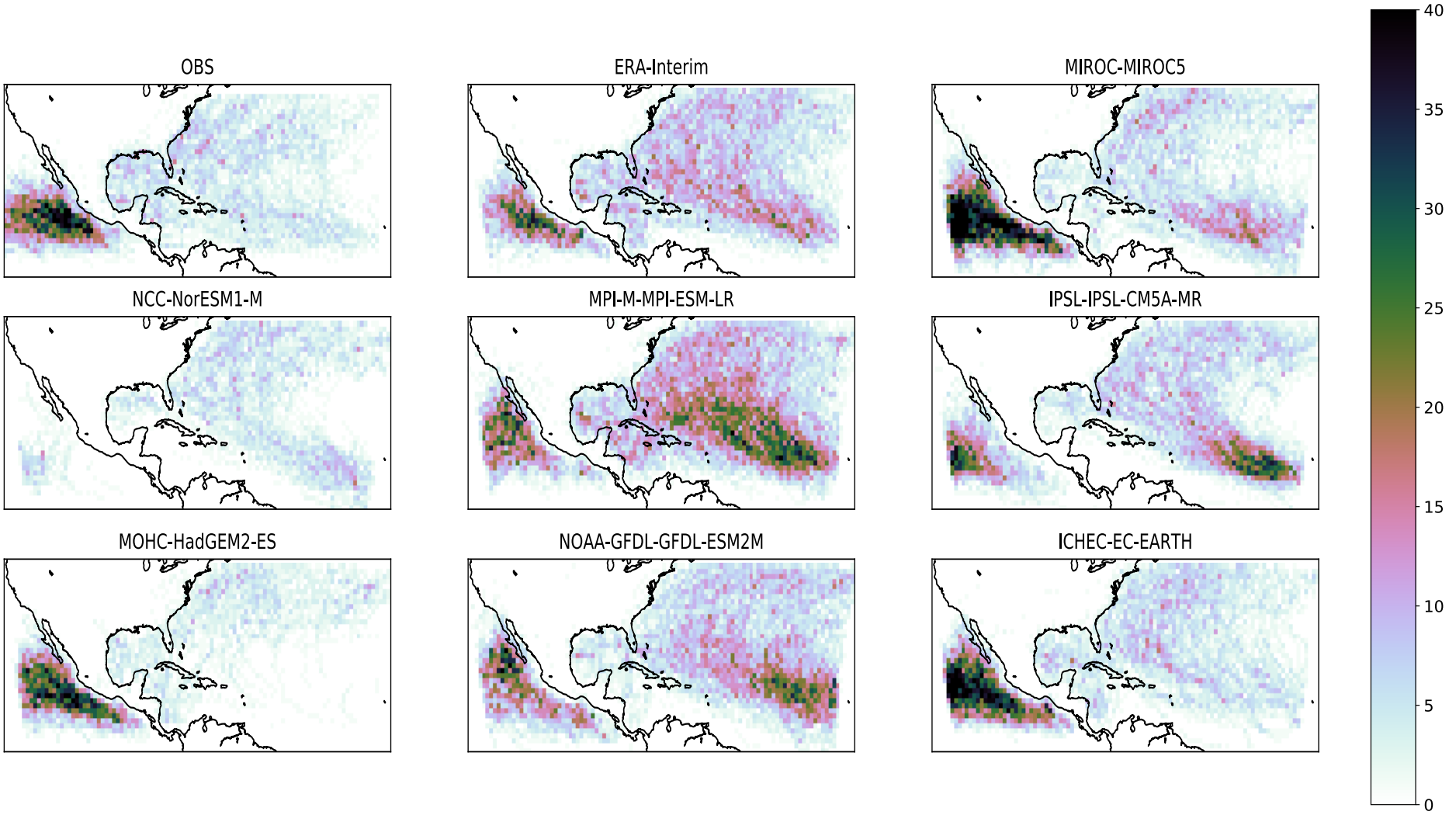

Biases of TCs in RCA compared with observations

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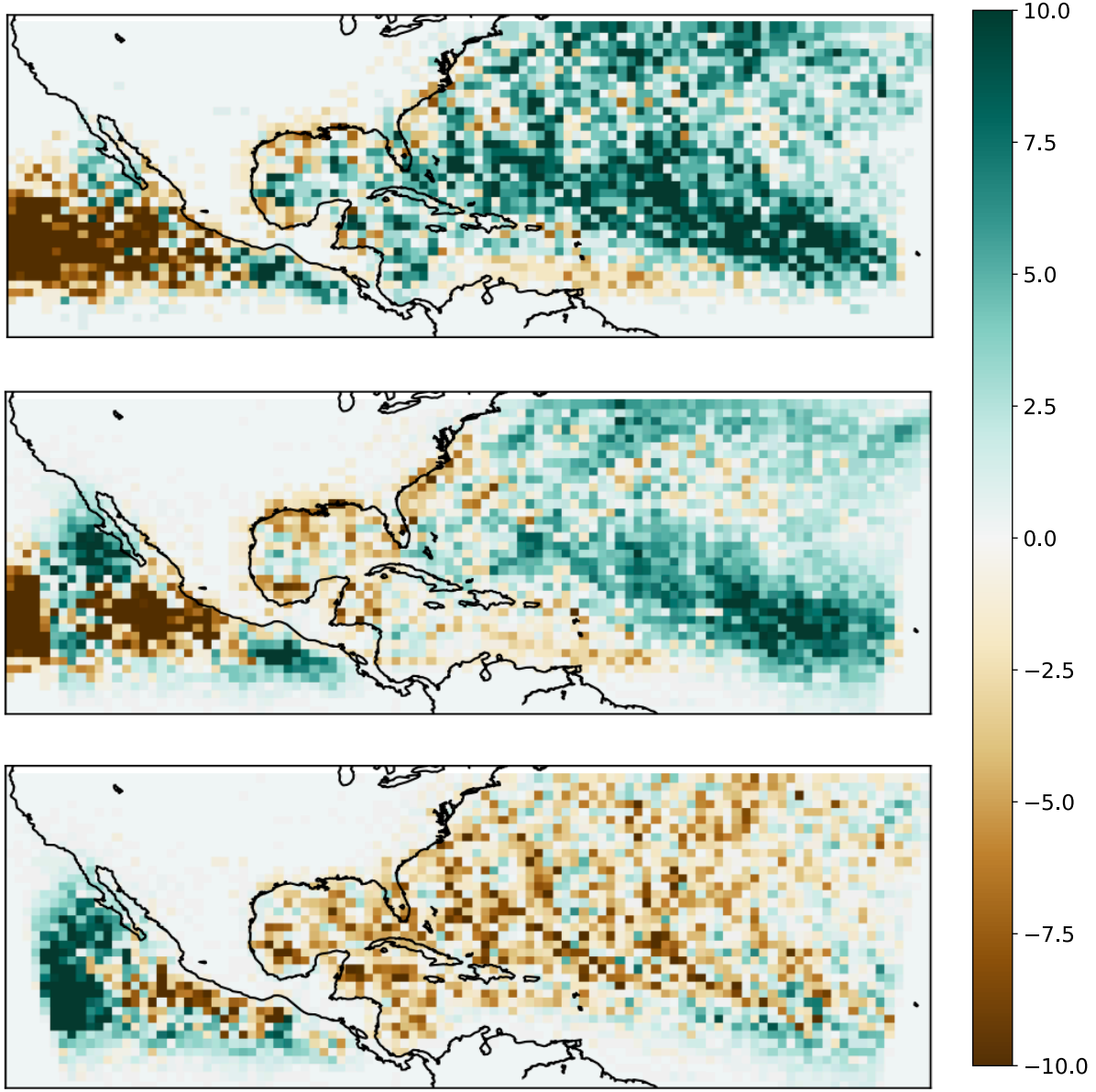
RCA (EIN) - OBS

RCA (ENSEMBLE) - OBS

RCA (ENSEMBLE) – RCA (EIN)



Maximum wind speed reached in TCs (1976-2005) [ms^{-1}]

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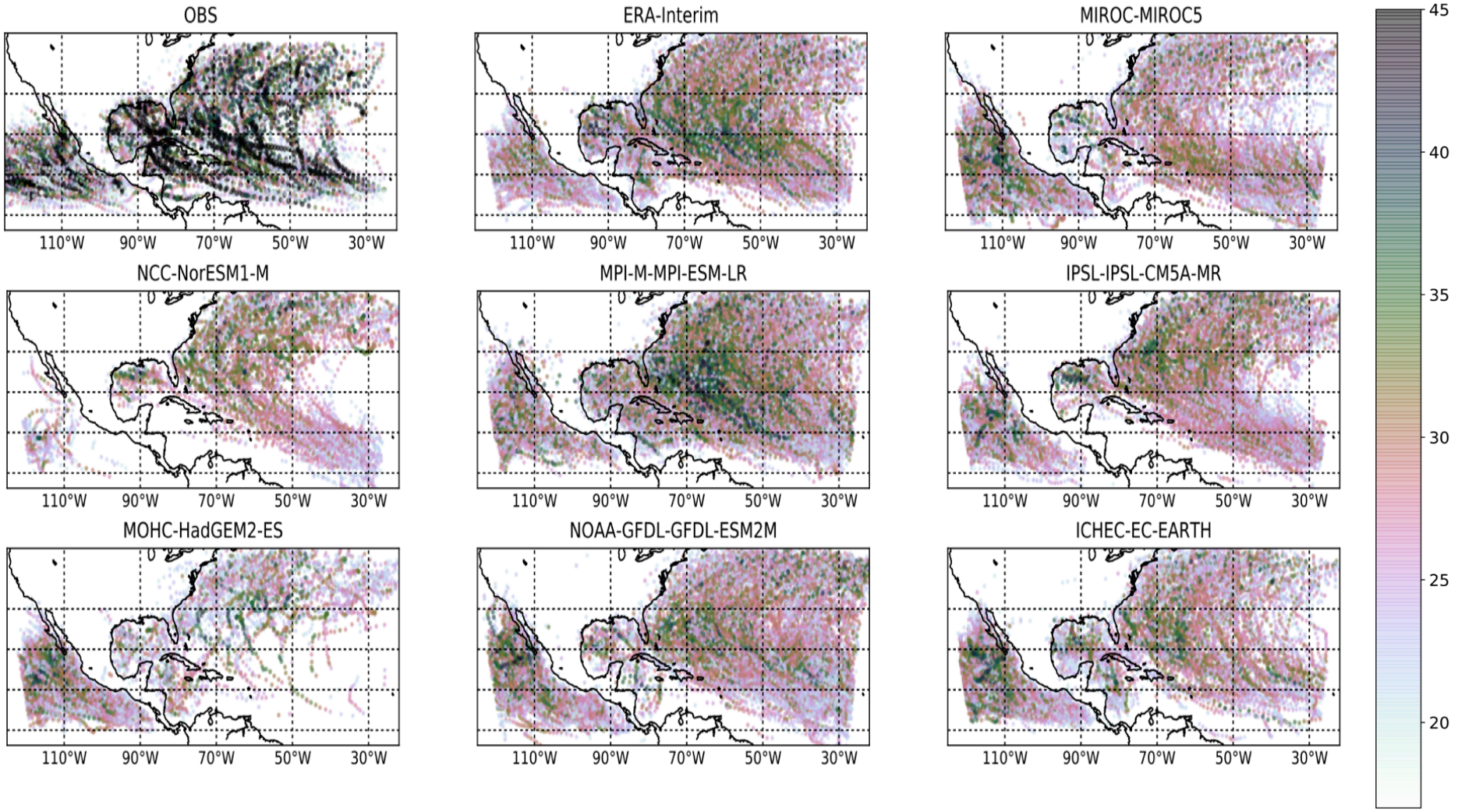

Windspeed/Pressure relationship in TCs

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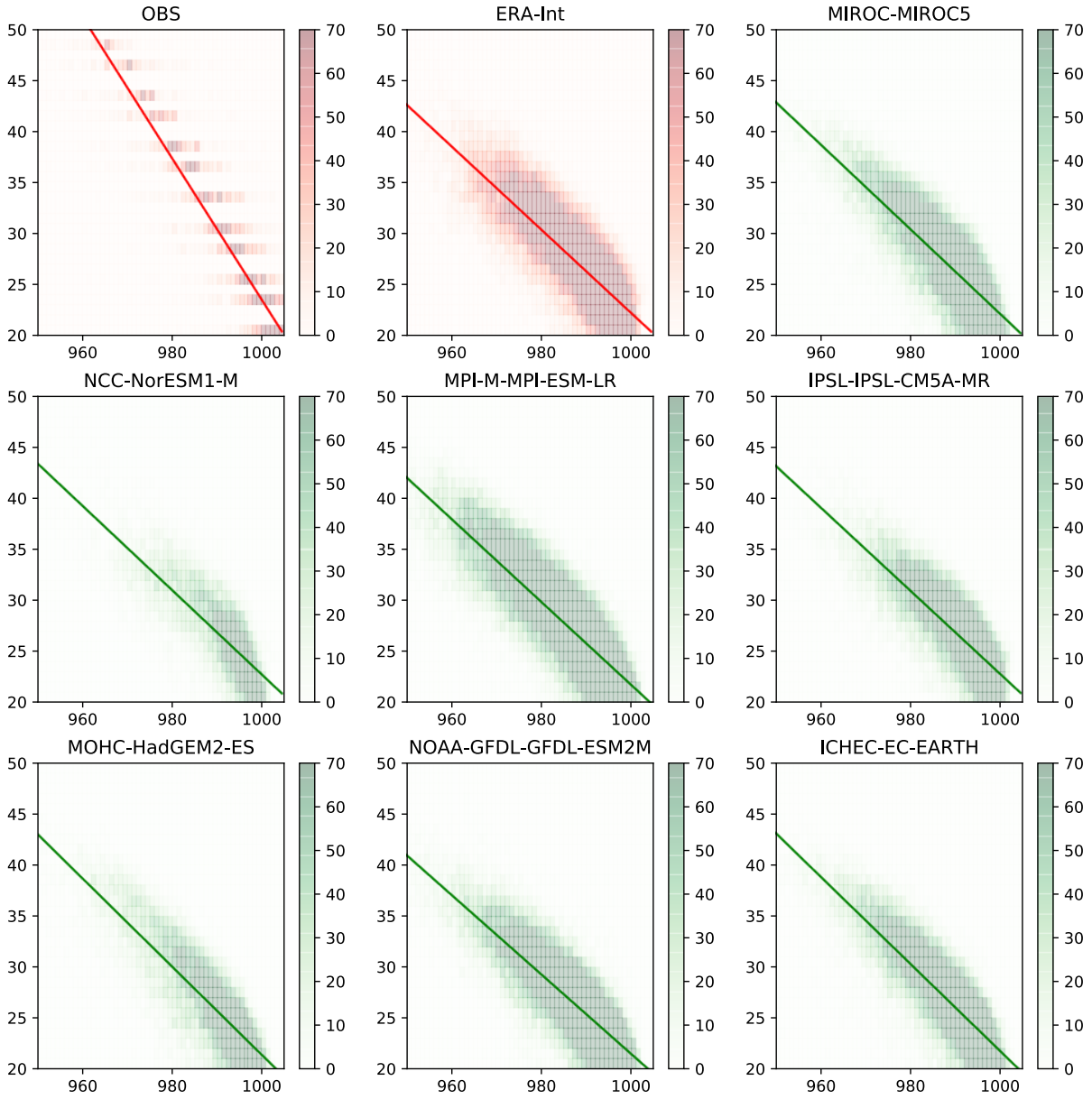

Surface temperature change

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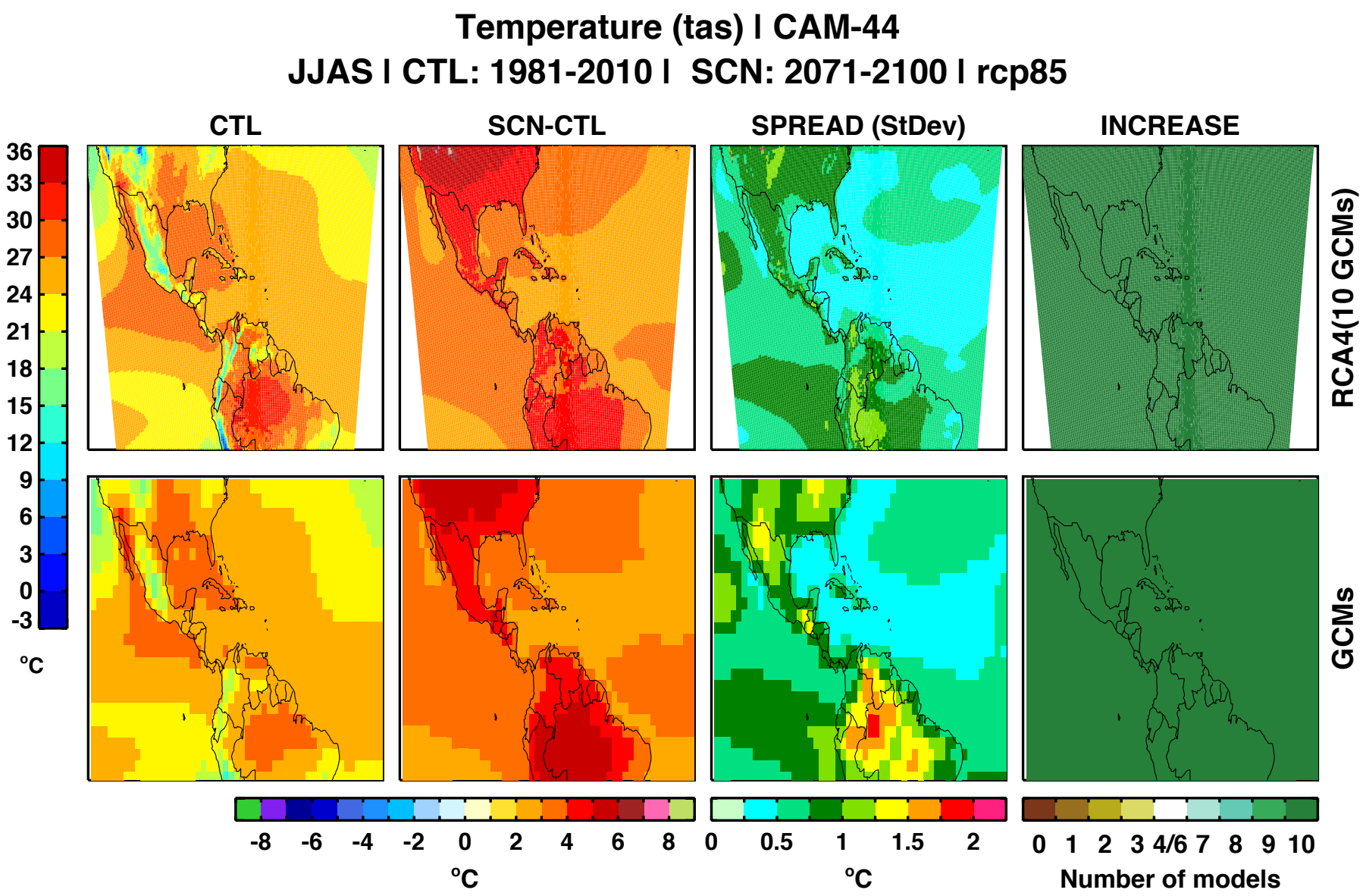

Mean precipitation change

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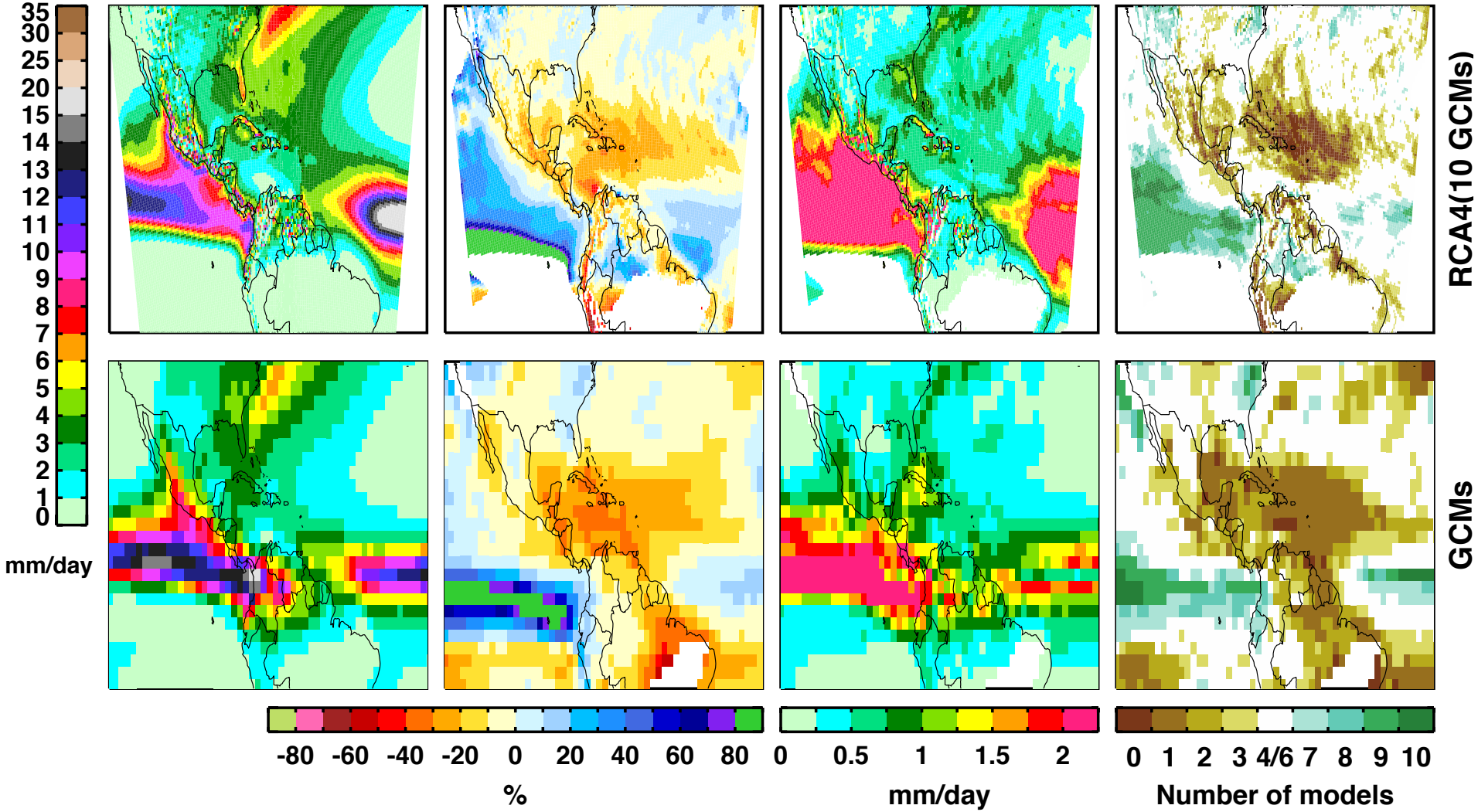
Precipitation (pr) | CAM-44

JJAS | CTL: 1981-2010 | SCN: 2071-2100 | rcp85



Change on density of TC
Future(2071-2100)- Hist (1976-2005)

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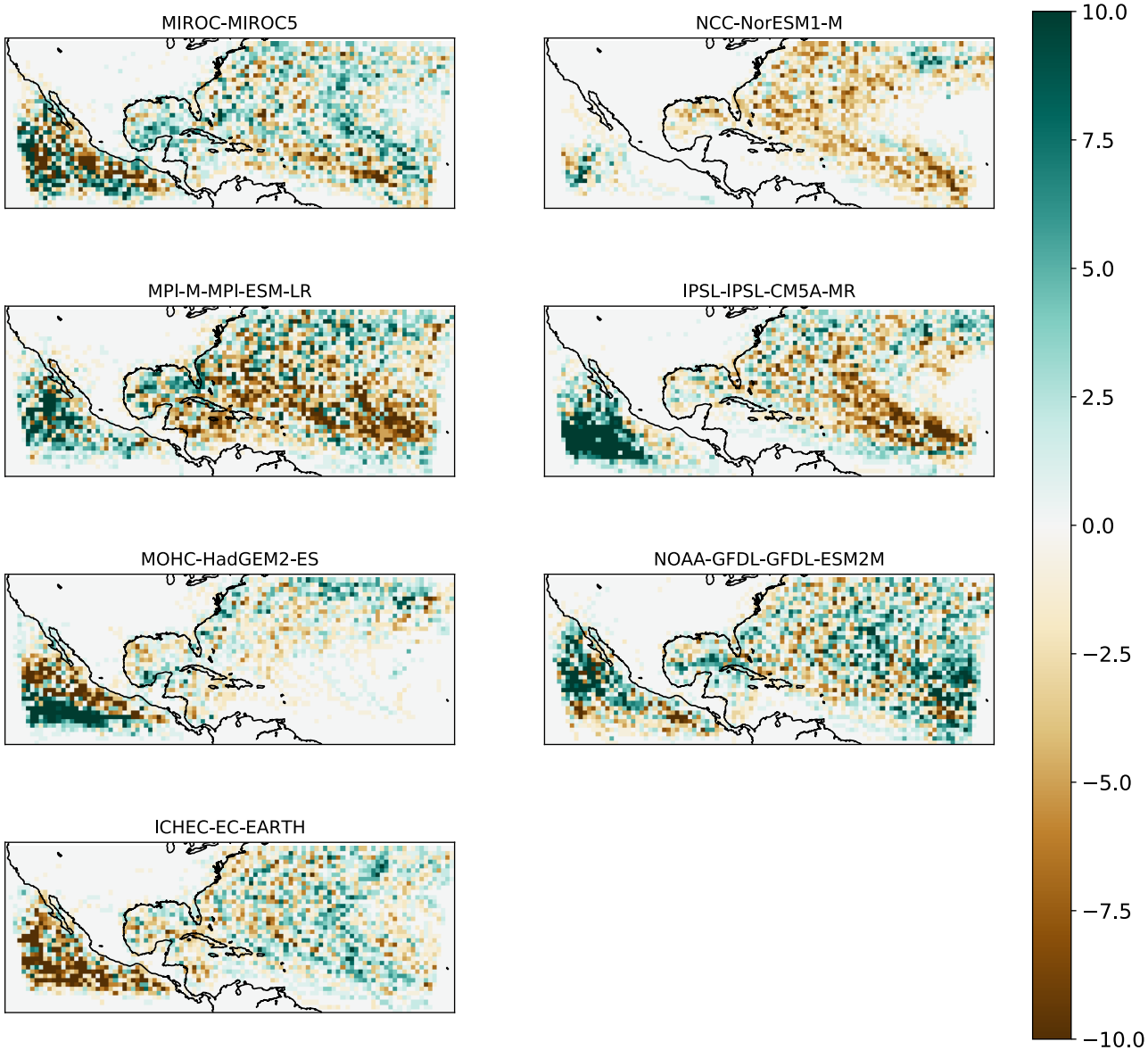

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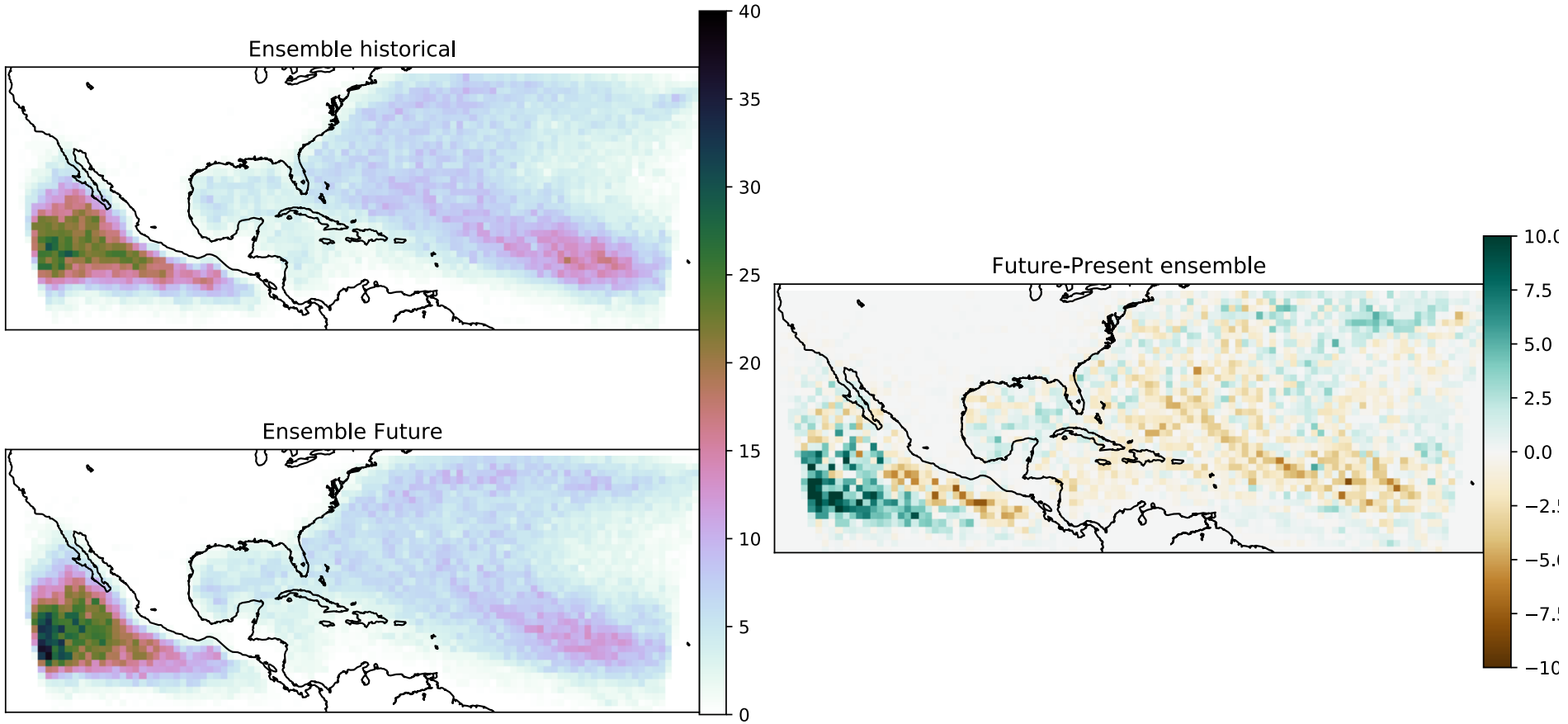

Maximum wind speed (2071-2100)

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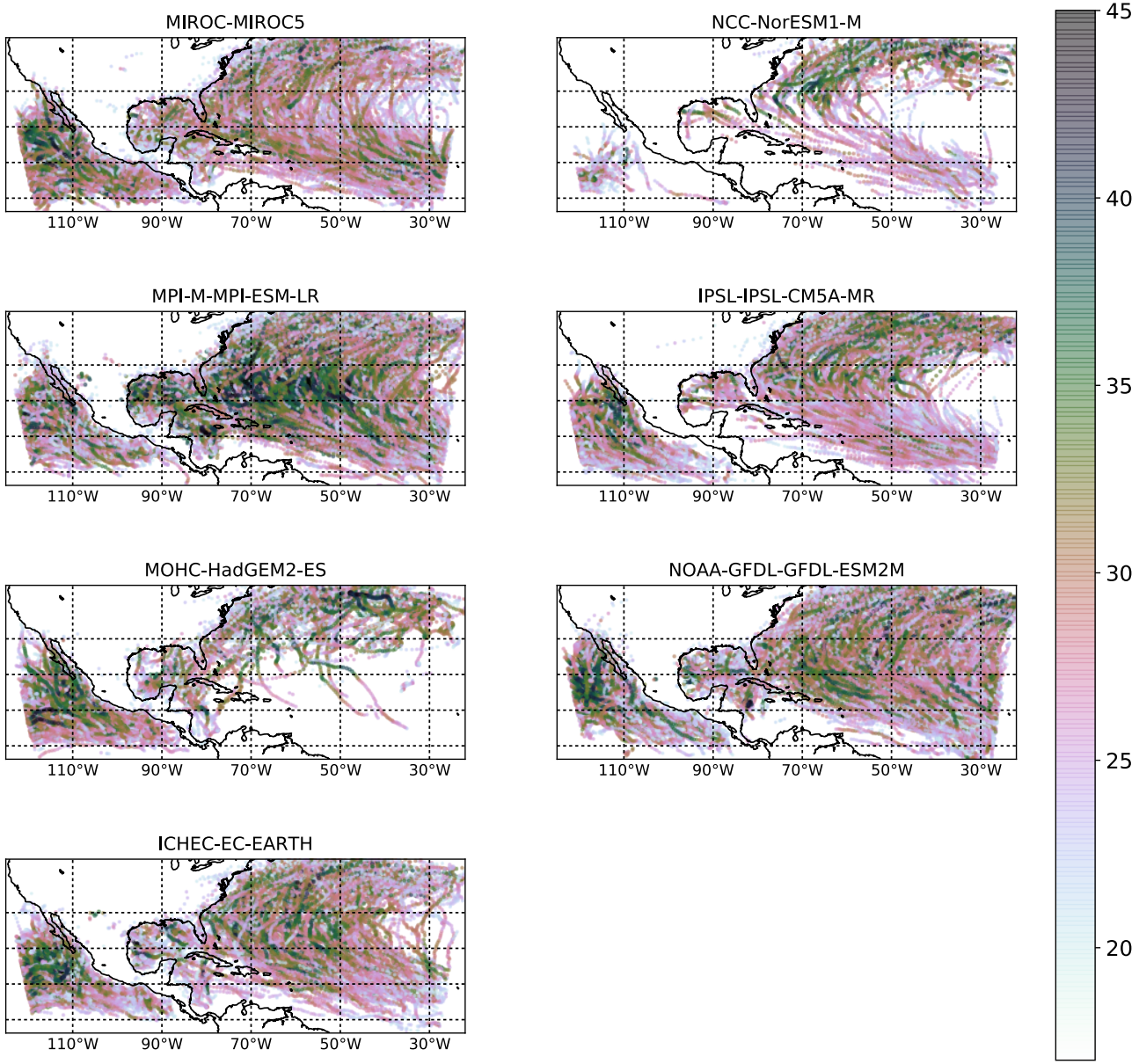

TC intensity

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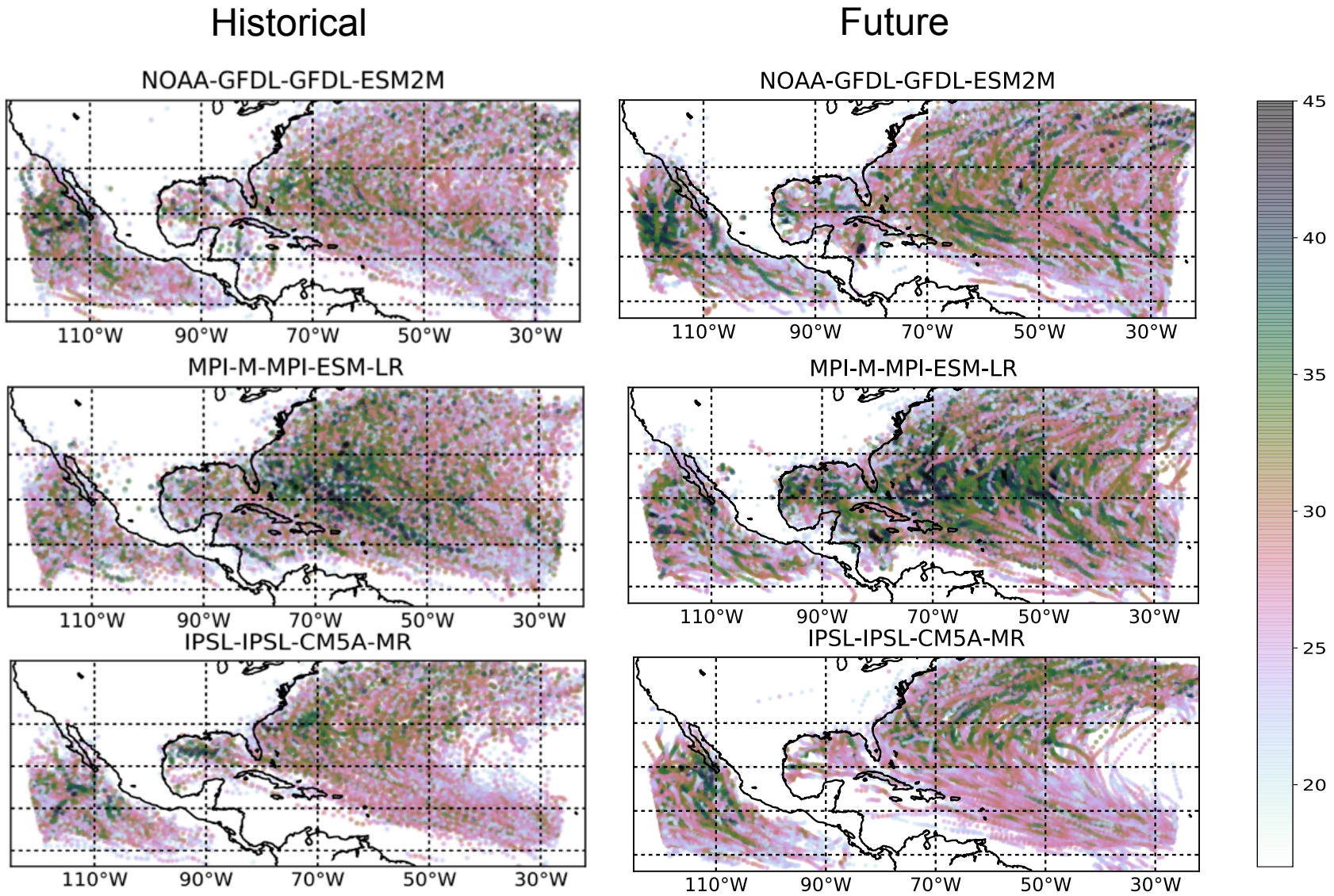

Preliminary conclusions

- In the historical period the GCMs ensemble show a stronger High Pressure Center (Azores-Bermudas).

- This intensification, causes stronger trade winds, which together with the lack of skill to resolve precipitation over complex terrain due to coarse resolution, might influence drier conditions over Southern Mexico, Central America, and the Caribbean islands.

- The RCA ensemble improves the large scale signal, by showing a SLP pattern more similar to observations. The precipitation over the region is improved compared with the GCMs ensemble.

- During the historical period, the RCA model overestimates the TCs over the Atlantic ocean, while over the Pacific is underestimated only when is forced by ERA-Interim. This behavior is systematic across regional models since this is the same case in RegCM simulations.

Preliminary conclusions

- For the future period, the GCMs ensemble shows a warmer eastern tropical Pacific ocean compared to the tropical north Atlantic. This is in-line with previous studies.

- The GCMs scenario ensemble shows a decrease of precipitation over Southern Mexico and Central America, which is robust across ensemble members (8/10). This decrease appears to be due to a more intense easterly winds over the Caribbean.

- The ensemble of RCA projections follows the sign of the GCMs ensemble, however it reproduces a more intense drying pattern.

- The density of TCs in the future show a change towards a higher concentration towards the North subtropical Atlantic ocean, and a decrease over the Tropical Atlantic. Similarly it is found a higher concentration away from the Mexican coasts and a decrease of TCs concentration close to coastal regions.