EVALUATING PERFORMANCE OF CLIMATE MODELS IN REPRODUCING CHARACTERISTICS OF FLORIDA RAINFALL

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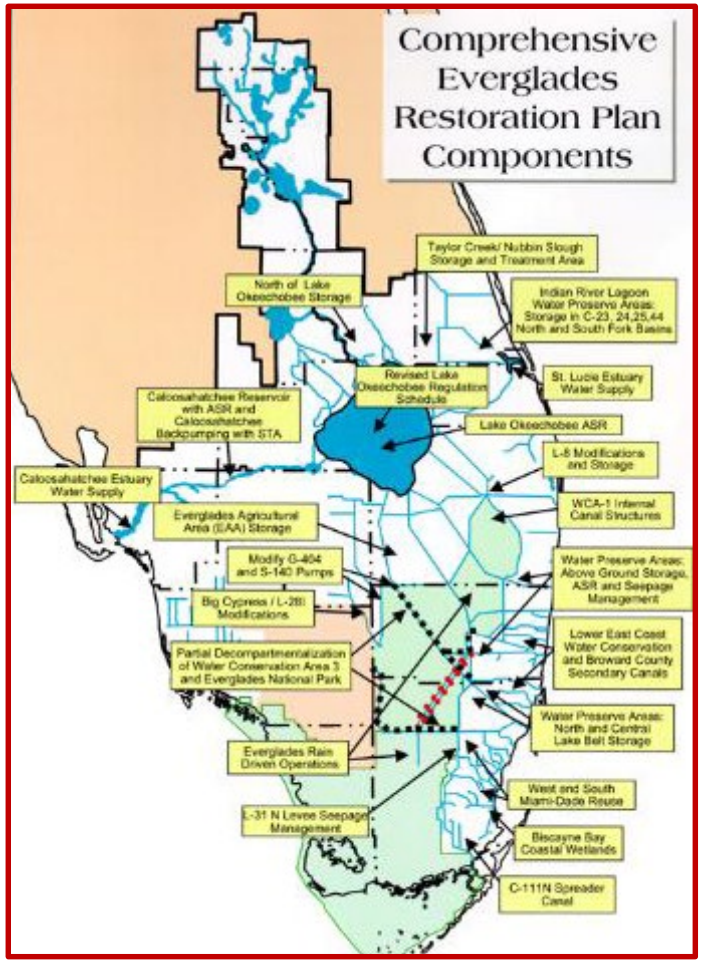
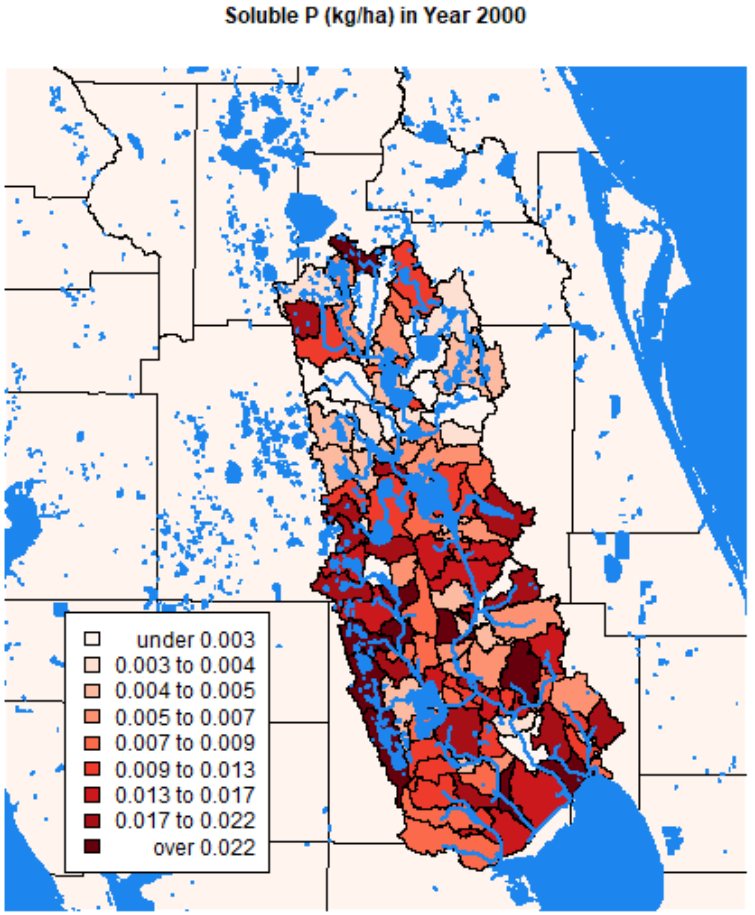
Hydrological Projections

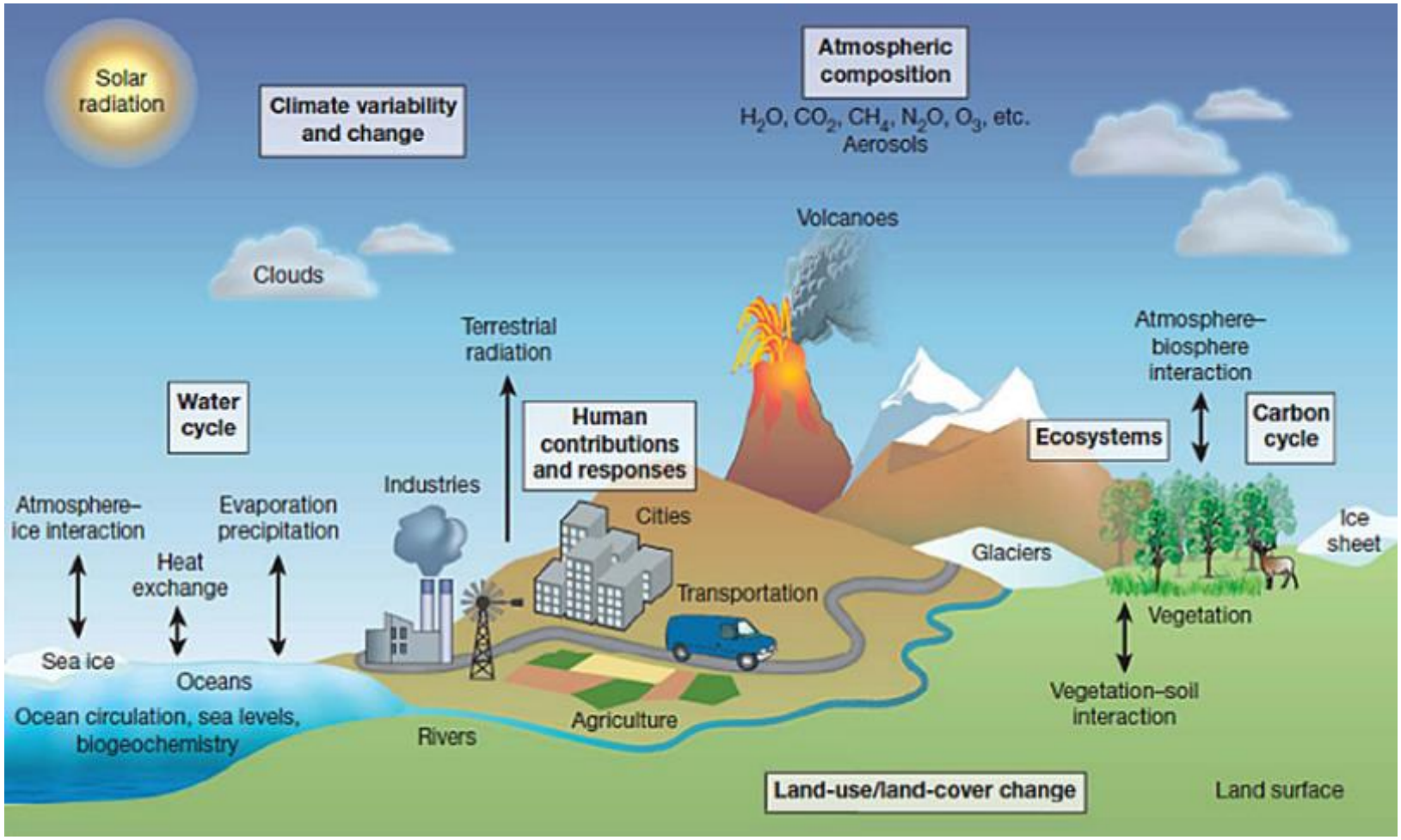


2007 South Florida Environmental Report - Chapter 7A: Comprehensive Everglades Restoration Plan Annual Report



Spatio-temporal variations of soluble P generation simulated by Soil and Water Assessment Tool (SWAT)

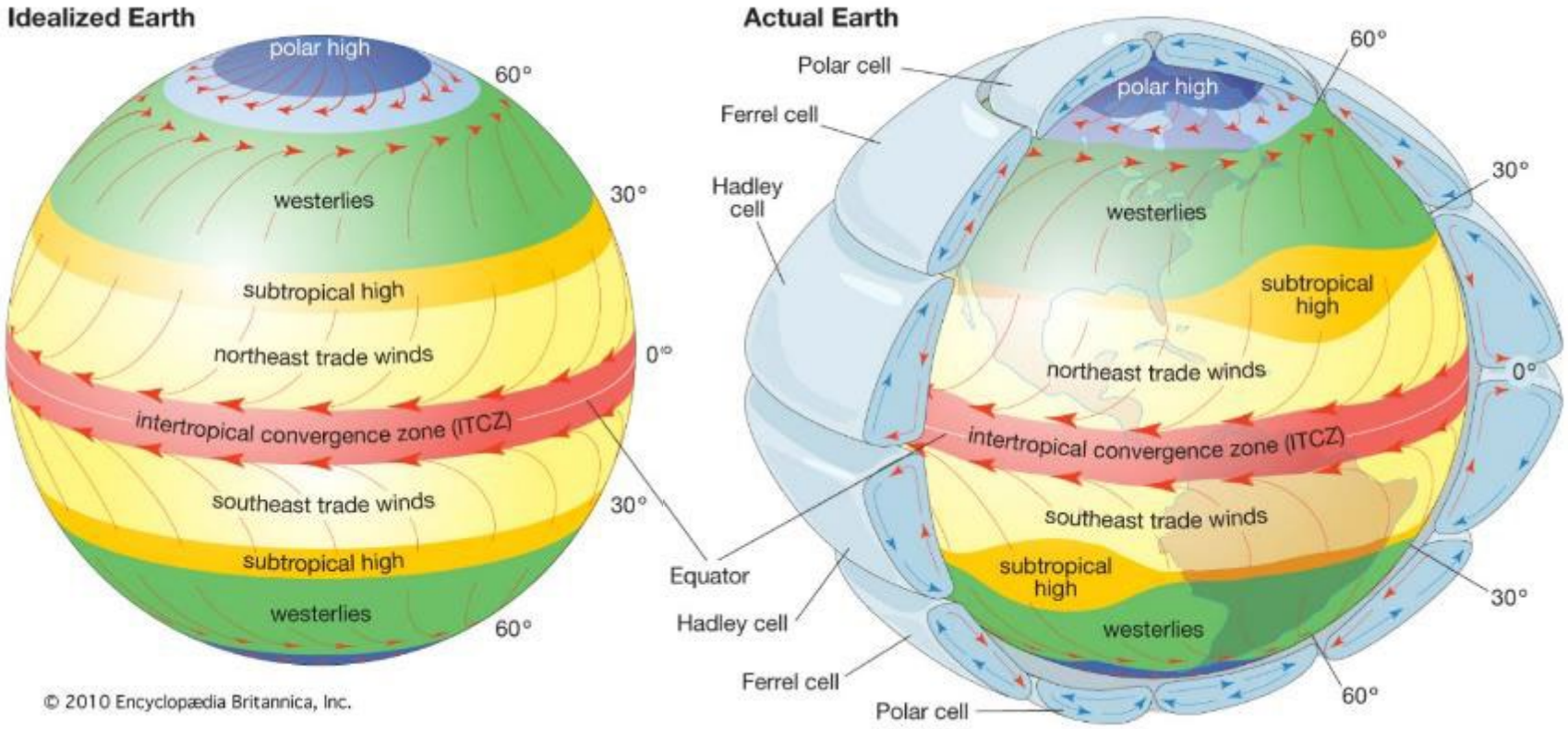
Climate System



Natural and anthropogenic processes in the climate system (NOAA, 2017).

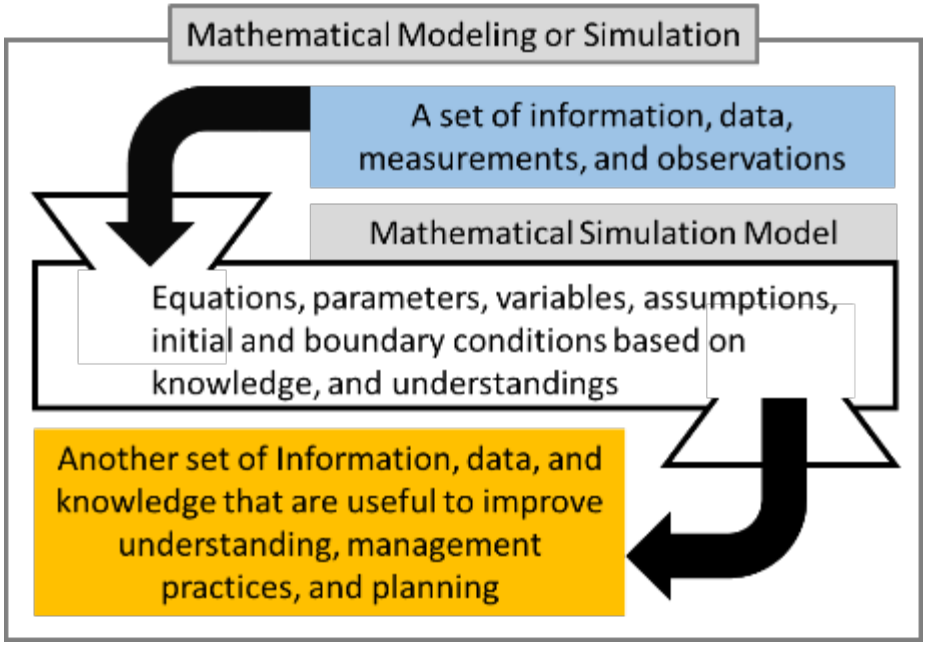
NOAA, 2017, Geophysical Fluid Dynamics Laboratory – Earth System Models: Background, Available: https://www.gfdl.noaa.gov/earth-system-model/.

Climate System



General atmospheric circulation patterns represented in climate models (Encyclopædia Britannica, 2018). Encyclopædia Britannica. 2018. Atmospheric circulation, https://www.britannica.com/science/atmospheric-circulation/media/41463/107938.

Climate Modeling

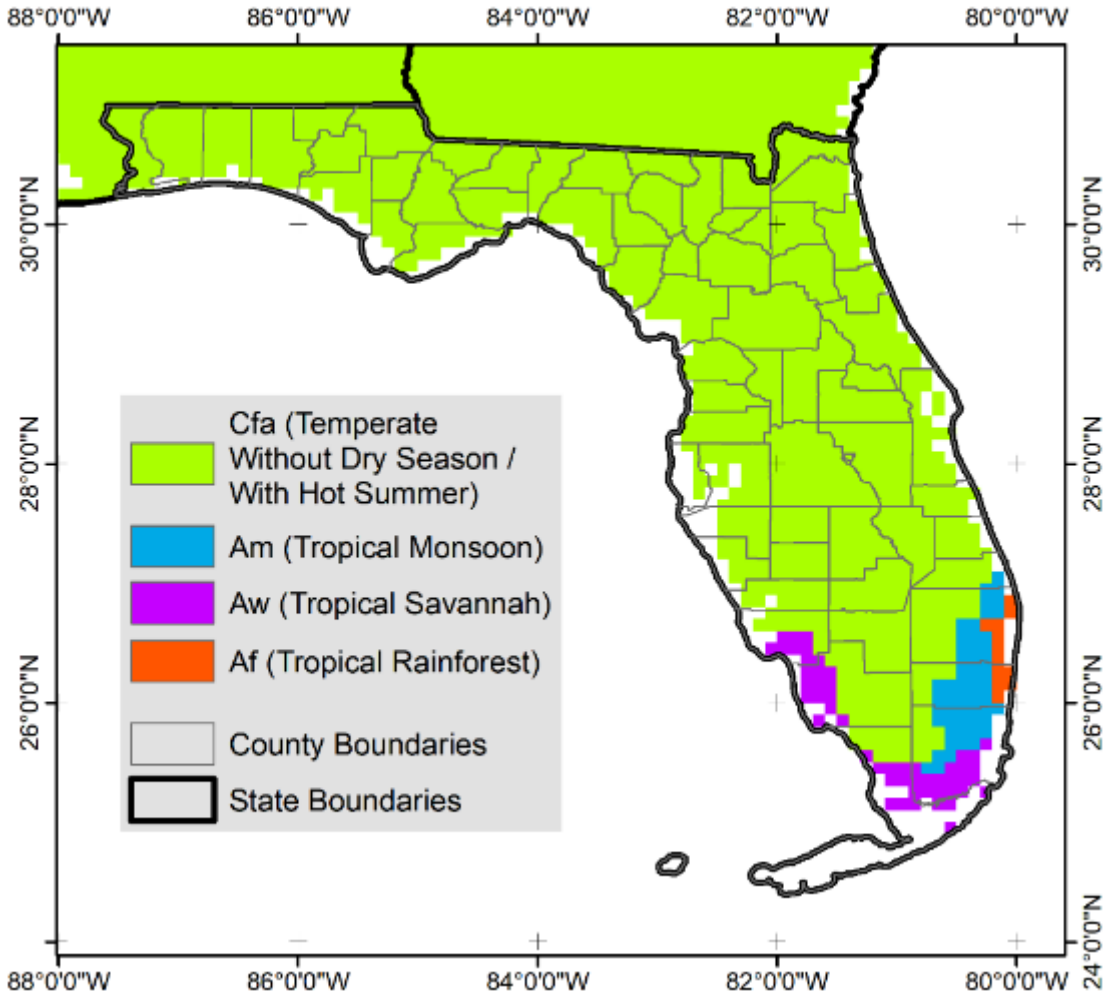


A schematic diagram of a mathematical simulation model.

```
!-----------------------------------------------------------------------
! Calculate light absorption by the plant canopy
!-----------------------------------------------------------------------
      IF (CAN_RAD_MOD == 2) THEN
        CALL ALBPFT(ROW_LENGTH*ROWS,LAND_PTS,                    &
     &                  LAND_INDEX,TILE_INDEX,TILE_PTS,ILAYERS,      &
     &                  ALBSOIL,COS_ZENITH_ANGLE,LAI,ALB_TYPE_DUMMY, &
     &                  FAPAR_DIR,FAPAR_DIF,CAN_RAD_MOD)

      ENDIF


!-----------------------------------------------------------------------
! Loop over Plant Functional Types to calculate the available moisture
! and the values of canopy conductance, the carbon fluxes and the leaf
! turnover rate
!-----------------------------------------------------------------------
      DO N=1,NPFT

        IF (NTILES == 1) THEN
          DO L=1,LAND_PTS
            TSTAR(L) = TSTAR_TILE(L,1)
            Z0(L) = Z0_TILE(L,1)
          ENDDO
        ELSE
          DO L=1,LAND_PTS
            TSTAR(L) = TSTAR_TILE(L,N)
            Z0(L) = Z0_TILE(L,N)
          ENDDO
        ENDIF
```

An example section of code from one of GCMs (https://www.carbonbrief.org/qa-how-do-climate-models-work).

Florida Climate



The Köppen-Geiger climate zones of Florida (recreated from Peel et al., 2007).
Peel, M.C., Finlayson, B.L. and McMahon, T.A., 2007. Updated world map of the Köppen-Geiger climate classification. Hydrology and earth system sciences discussions, 4(2), pp.439-473.

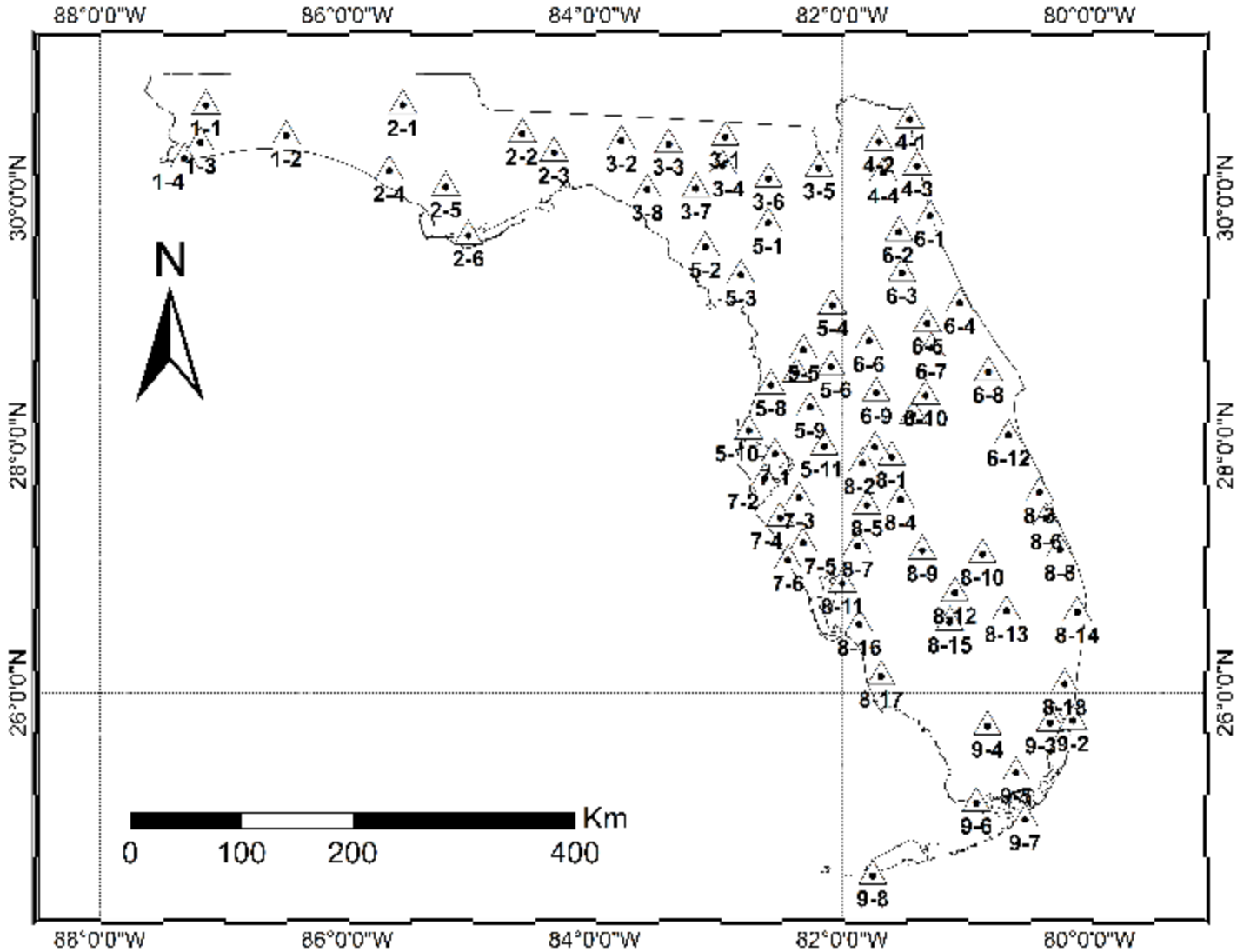
Climate Projections for Florida

- Climate models and projections available

ID	Modeling center	Institution	Model	Res. Lon. ×Lat.
1	NCAR	National Center for Atmospheric Research	CCSM4	1.25° × 0.94°
2	NSF-DOE-NCAR	National Science Foundation, Department of Energy, National Center for Atmospheric Research	CESM1_BGC	1.25° × 0.94°
3			CESM1_CAM5	1.25° × 0.94°
4	CMCC	Centro Euro-Mediterraneo per I Cambiamenti Climatici	CMCC_CM	0.75° × 0.75°
5			CMCC_CMS	1.88° × 1.86°
6	CNRM-CERFACS	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique	CNRM_CM5	1.41° × 1.40°
7	CSIRO-QCCCE	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence	CSIRO_Mk3.6.0	1.88° × 1.86°
8	CCCma	Canadian Centre for Climate Modelling and Analysis	CanESM2	2.81° × 2.79°
9	LASG-CESS	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences; and CESS, Tsinghua University	FGOALS-g2	2.81° × 3.05°
10	LASG-IAP	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences	FGOALS-s2	2.81° × 1.66°
11	NOAAGFDL	Geophysical Fluid Dynamics Laboratory	GFDL-CM3	2.50° × 2.00°
12			GFDL-ESM2G	2.50° × 2.00°
13			GFDL-ESM2M	2.50° × 2.00°
14	NIMR/KMA	National Institute of Meteorological Research/Korea Meteorological Administration	HadGEM2-AO	1.88° × 1.25°
15	MOHC (additional realizations by INPE)	Met Office Hadley Centre (additional HadGEM2-ES realizations contributed by Instituto Nacional de Pesquisas Espaciais)	HadGEM2-CC	1.88° × 1.25°
16			HadGEM2-ES	1.88° × 1.25°
17	IPSL	Institut Pierre-Simon Laplace	IPSL-CM5A-LR	3.75° × 1.89°
18			IPSL-CM5A-MR	2.50° × 1.27°
19			IPSL-CM5B-LR	3.75° × 1.89°
20	MIROC	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC5	1.41° × 1.40°
21			MIROC-ESM	2.81° × 2.79°
22			MIROC-ESM-CHEM	2.81° × 2.79°
23	MPI-M	Max Planck Institute for Meteorology (MPI-M)	MPI-ESM-LR	1.88° × 1.86°
24			MPI-ESM-MR	1.88° × 1.86°
25	MRI	Meteorological Research Institute	MRI-CGCM3	1.13° × 1.12°
26	NCC	Norwegian Climate Centre	NorESM1-M	2.50° × 1.89°
27	BCC	Beijing Climate Center, China Meteorological Administration	BCC-CSM1.1	2.81° × 2.79°
28			BCC-CSM1.1 (m)	1.13° × 1.12°
29	INM	Institute for Numerical Mathematics	INM-CM4	2.00° × 1.50°

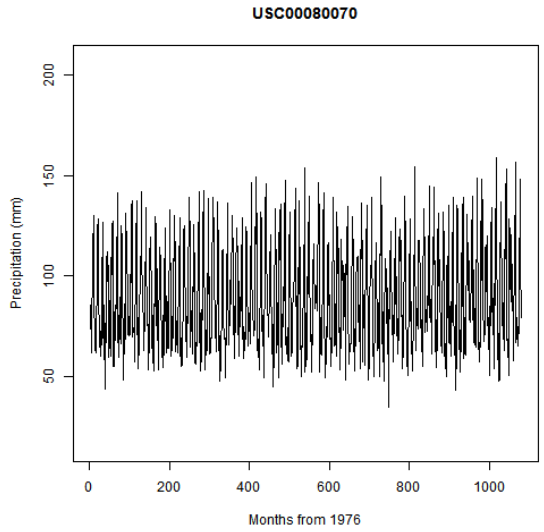
Climate Projections for Florida

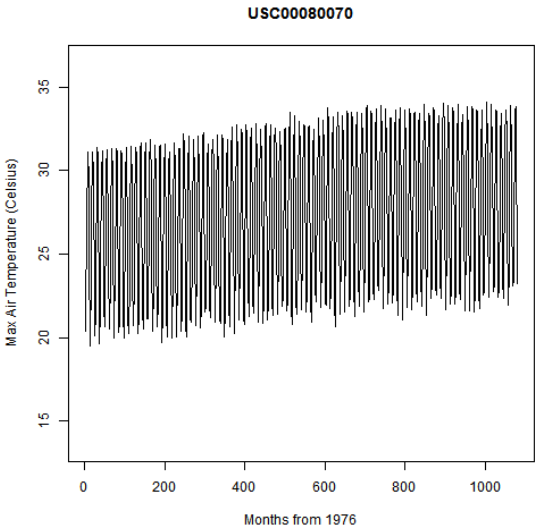
- 29 climate projections for 78 weather stations

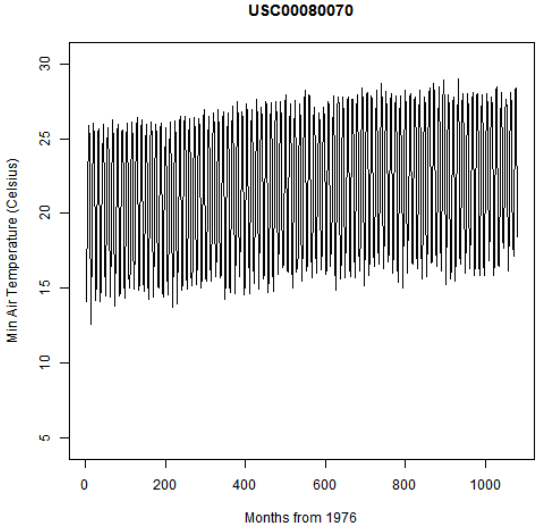


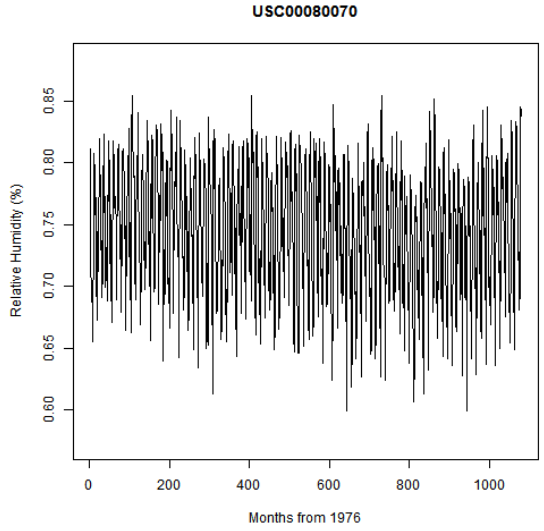
Climate Projections for Florida

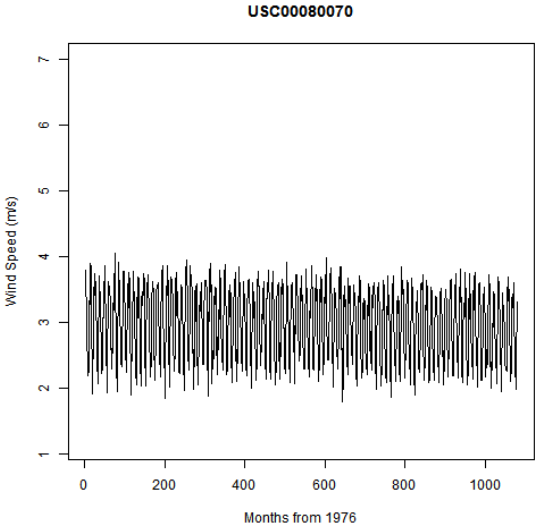
- Bias-corrected daily weather projections

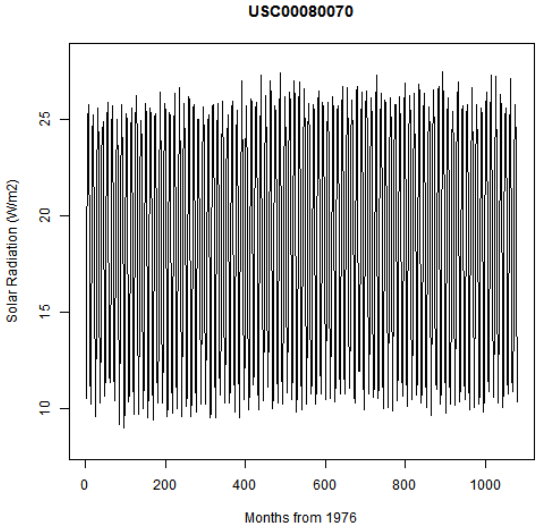






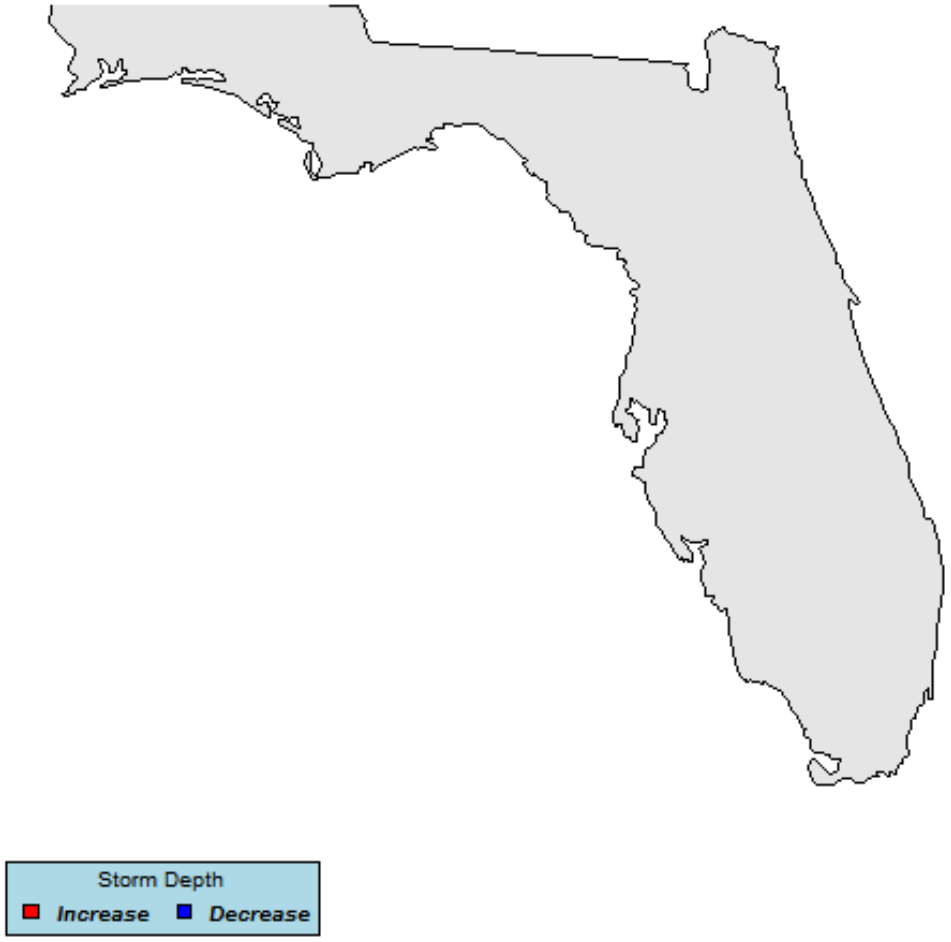






Climate Projections for Florida

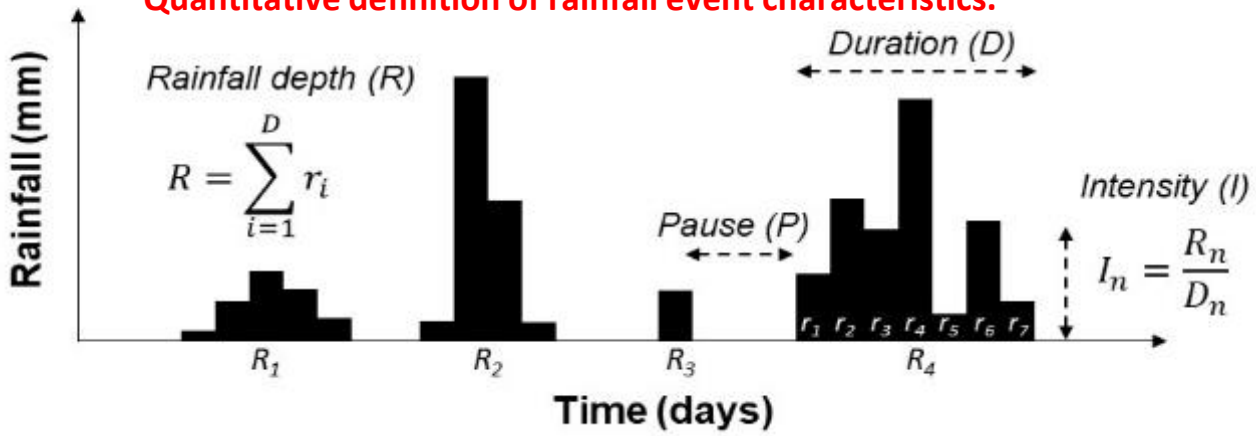
- Rainfall depth projections

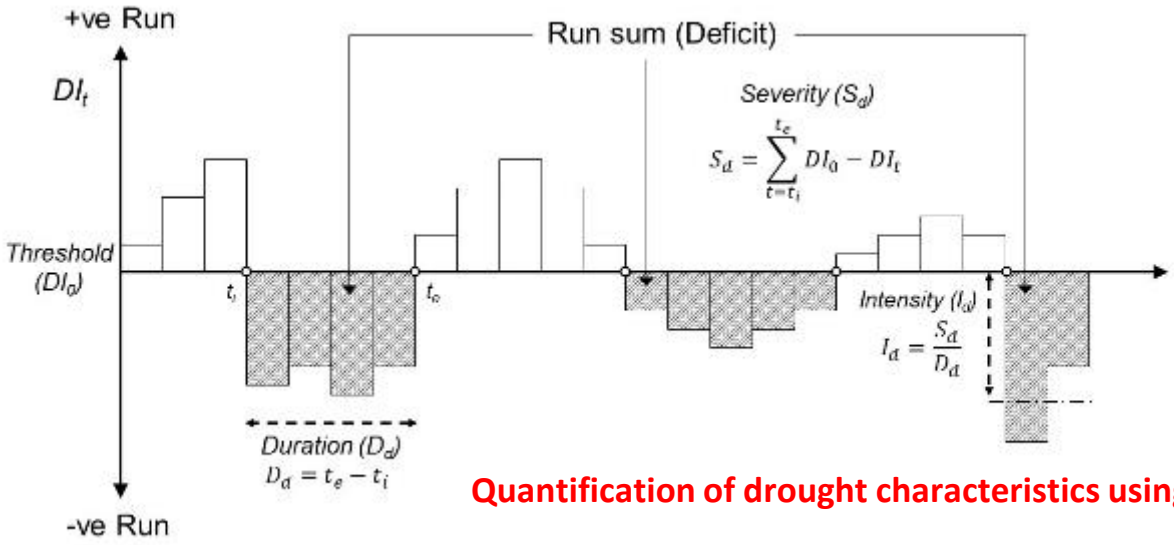


Characterization

- Rainfall event and drought

Quantitative definition of rainfall event characteristics.

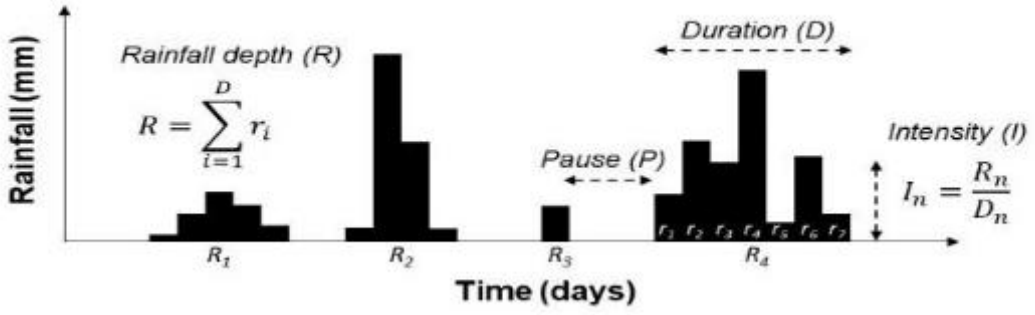




Quantification of drought characteristics using the run theory.

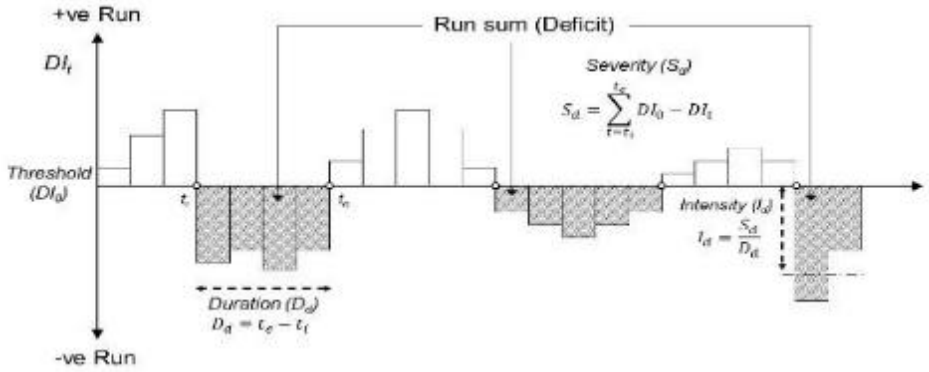
Performance Assessment

- Rainfall event and drought



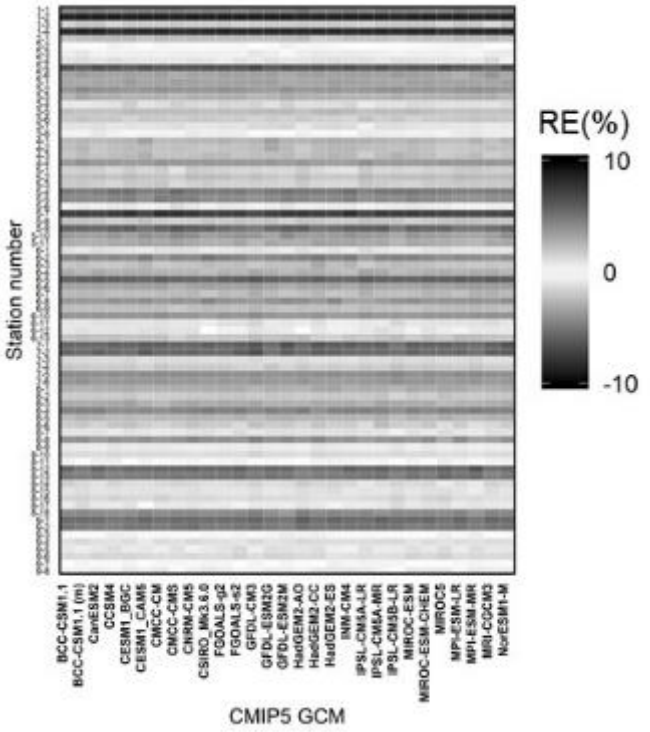
Observed vs. Predicted Characteristics

1976 **2005**

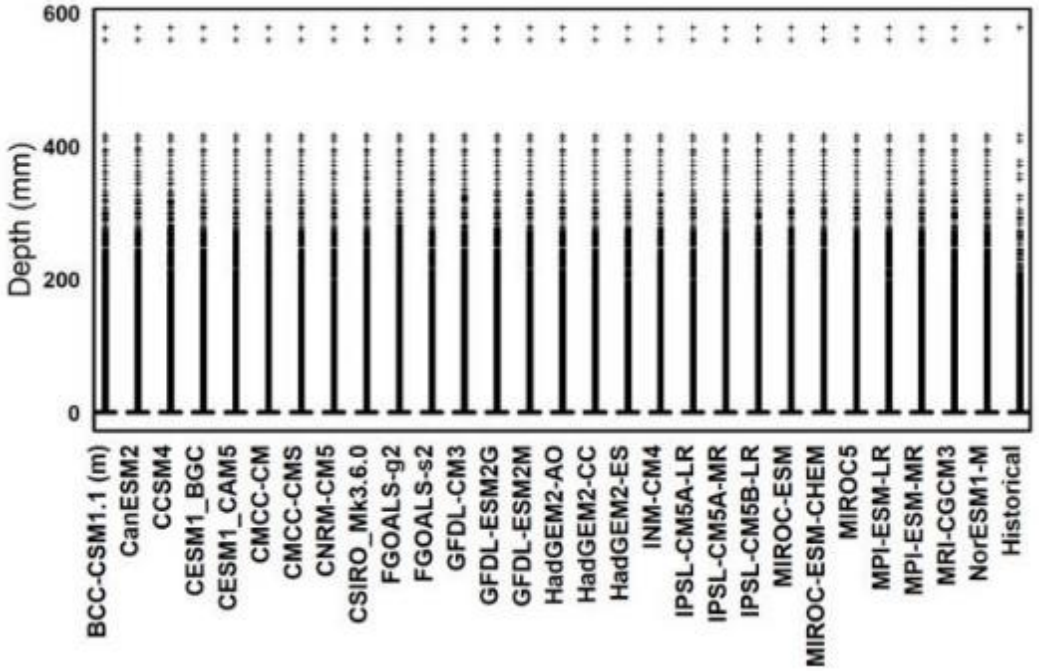


Performance Assessment

- Daily rainfall
  - Relative error < 10 % at an annual scale



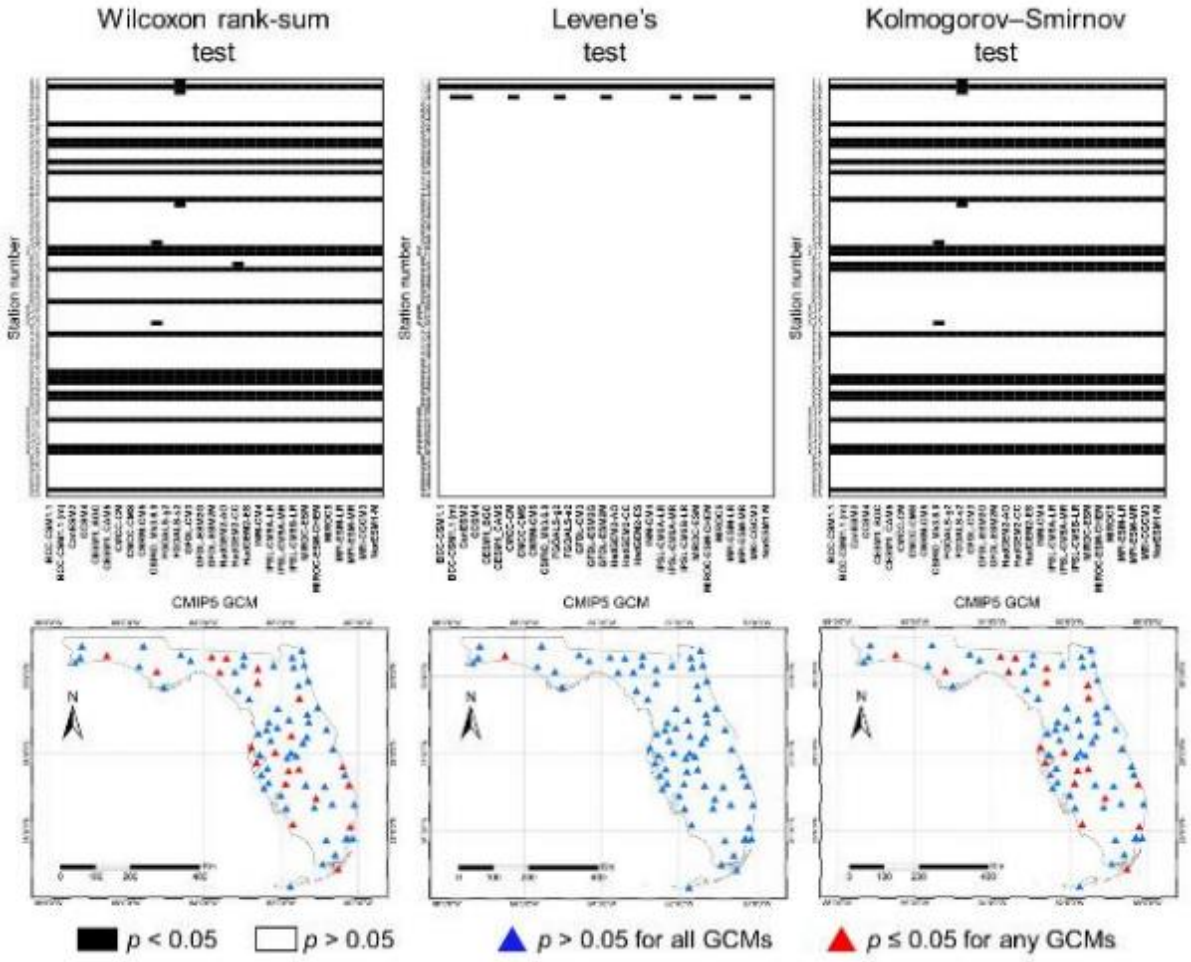
Comparison between relative errors of annual rainfall depth observed and projected using the 29 GCMs at the 78 rainfall stations



Comparison between the distributions of observed and projected daily rainfall depths using the 29 GCMs at the 78 rainfall stations.

Performance Assessment

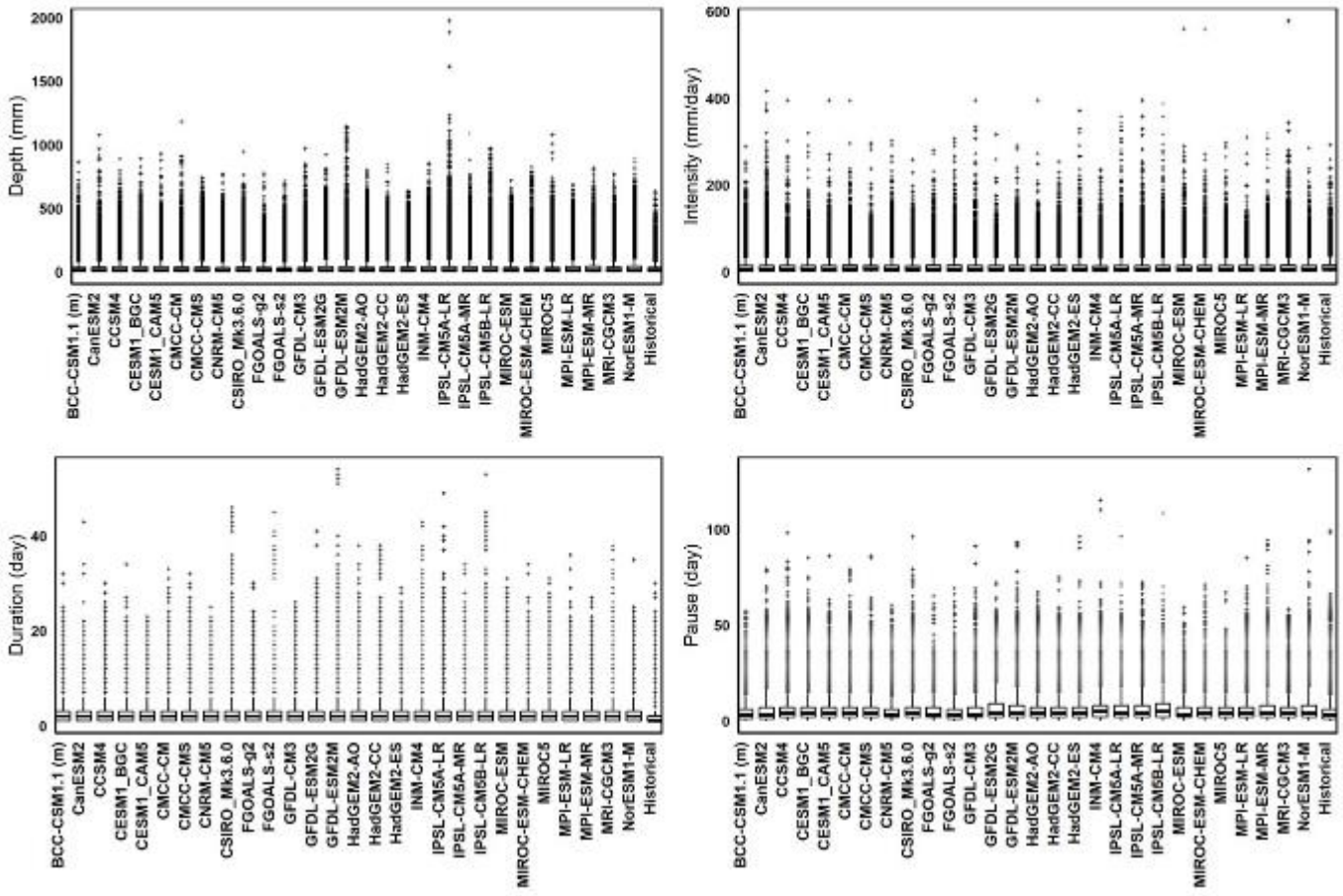
- Daily rainfall



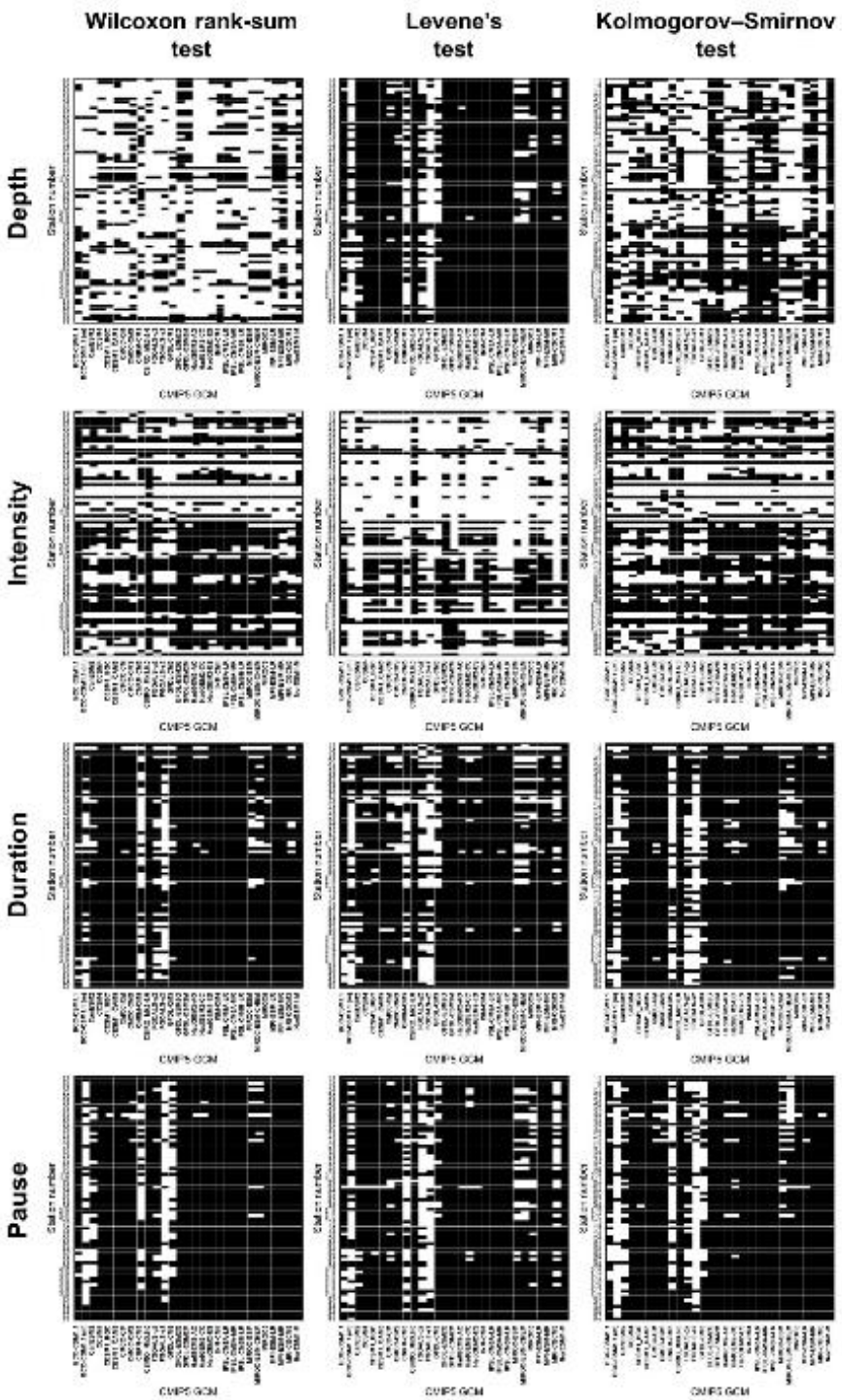
Results of the statistical tests for the significance of the differences between the median, variance, and distributions of projected and observed daily rainfall depths for the 78 rainfall stations in Florida.

Performance Assessment

- Rainfall event characteristics



Comparison of the distribution of observed and projected rainfall event depth, intensity, duration, and pause period.

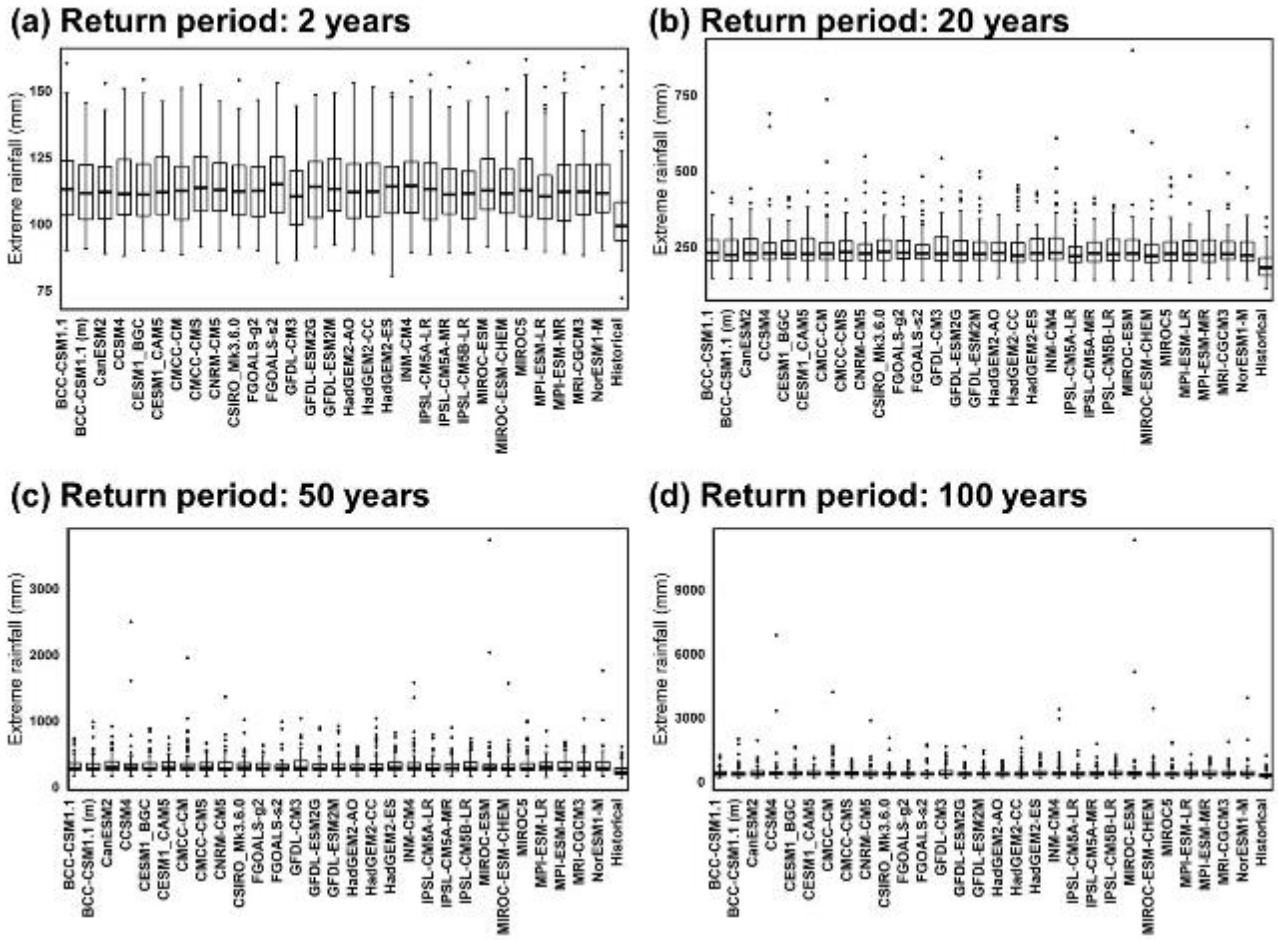


Results of statistical tests for the significance of the differences between observed and projected rainfall event characteristics of 78 Florida weather stations.

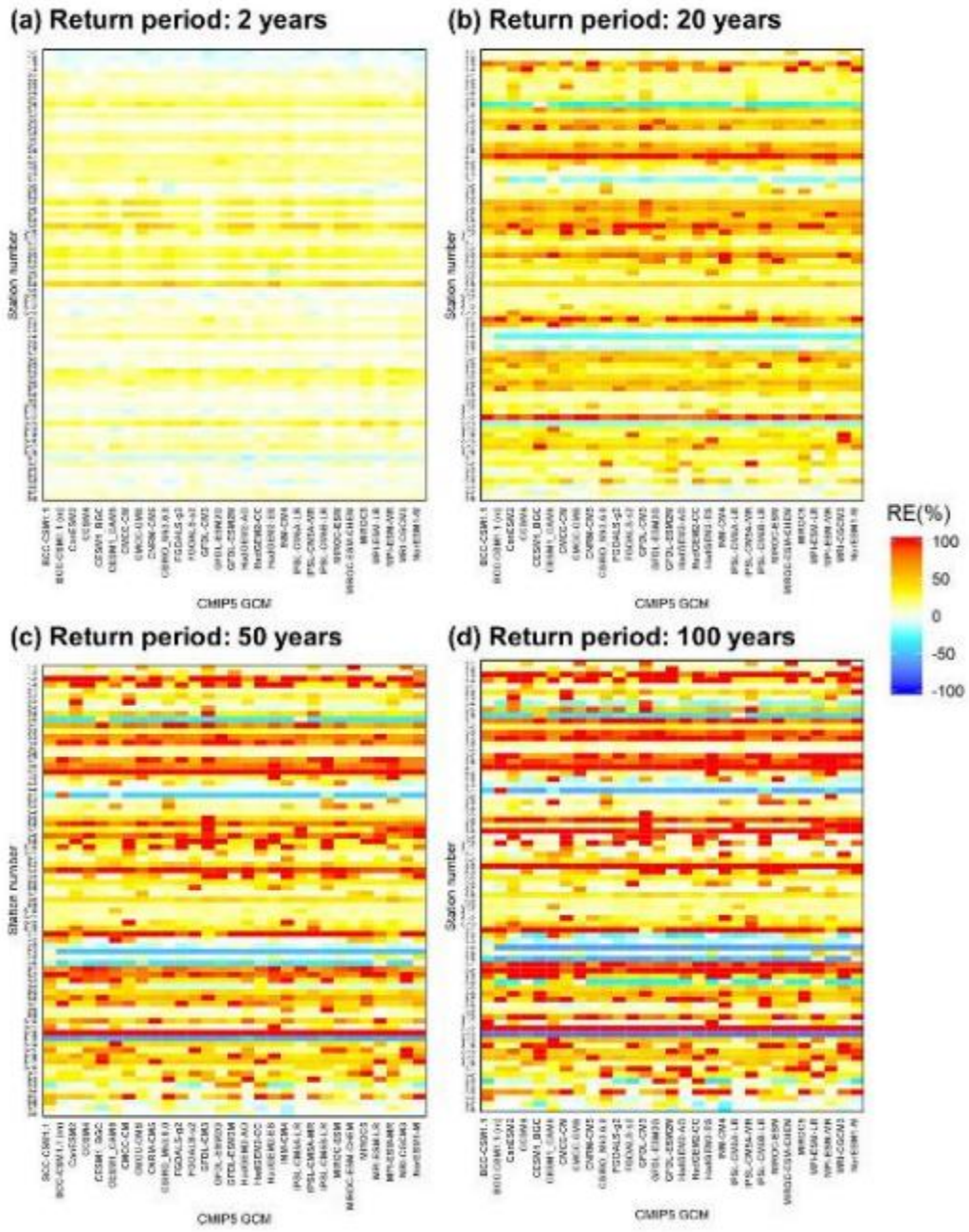
Average: Wilcoxon Rank-sum Test
Variance: Levene's Test
Distribution: Kolmogorov-Smirnov Test

Performance Assessment

- Design storm (or rainfall event)



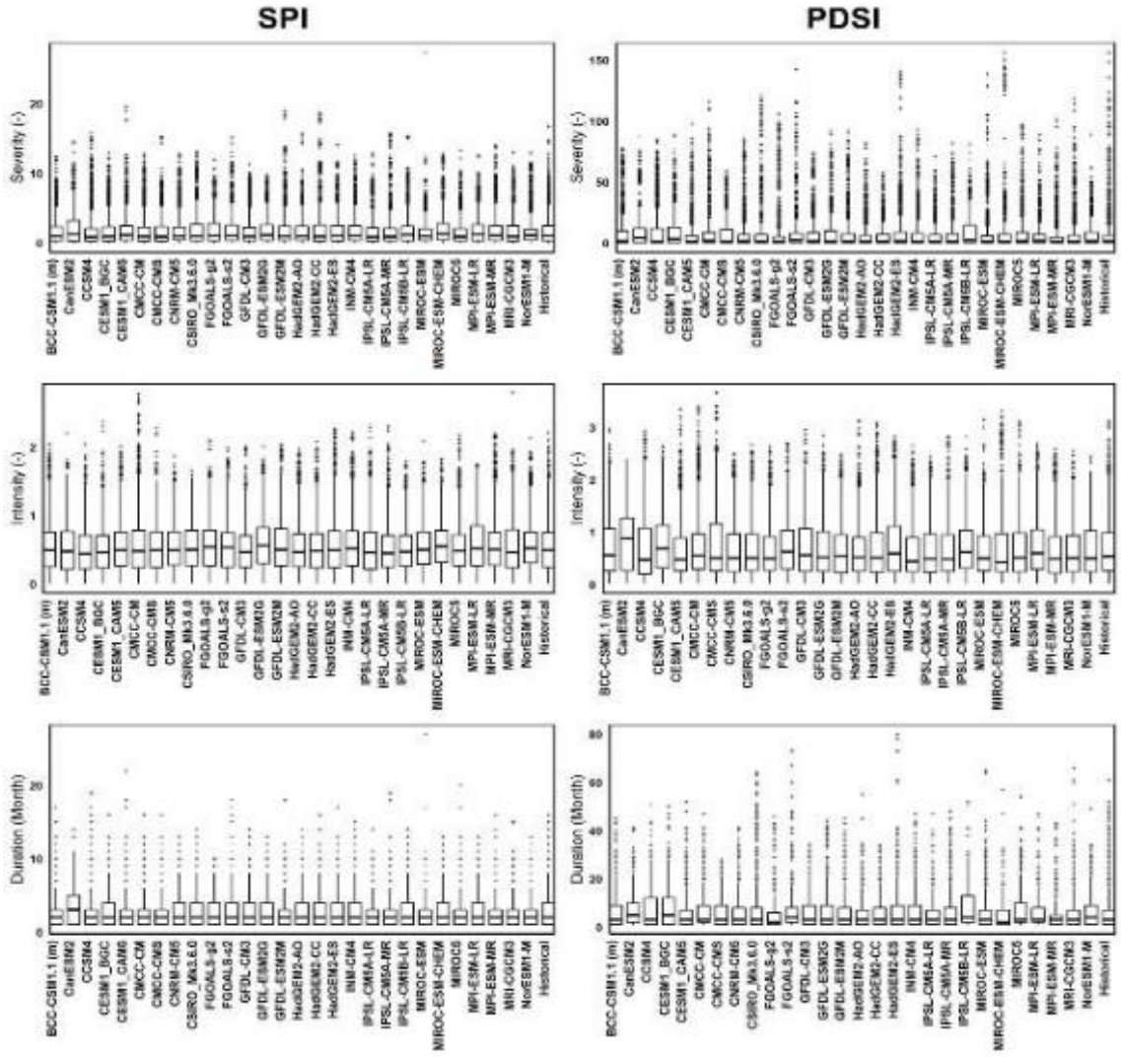
Comparison of the design storm sizes calculated using the observed and projected rainfall events.



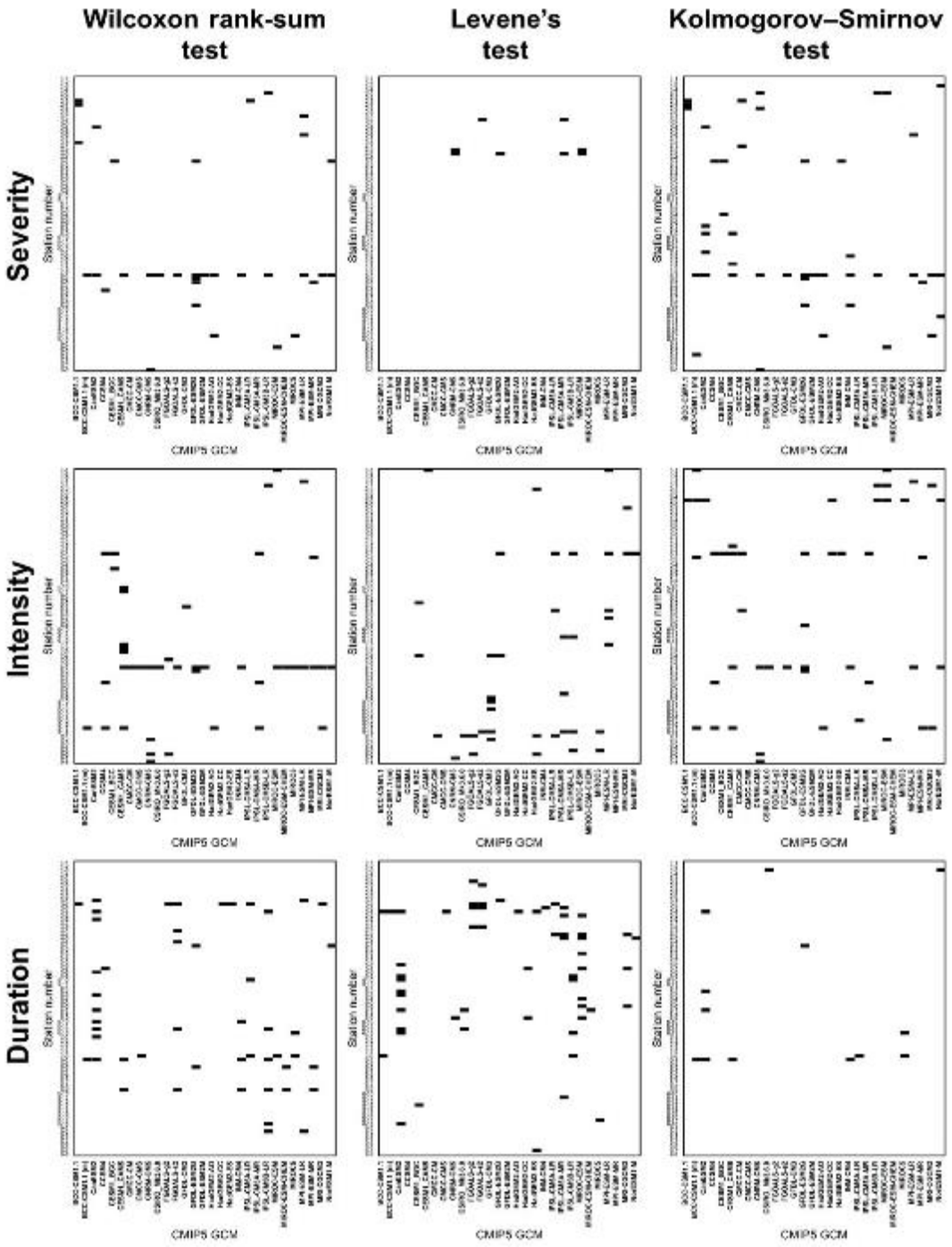
Relative errors performance of 29GCMS in reproducing 24-hr extreme rainfall in 78 Florida weather stations.

Performance Assessment

- Drought indices (SPI & PDSI)



Comparison of the distribution of drought severity, intensity, and duration calculated using the observed and projected rainfall and temperature.



Results of statistical tests for the significance of the differences between observed and projected SPI drought characteristics of 78 Florida weather stations.

Average:
Wilcoxon Rank-sum Test

Variance:
Levene's Test

Distribution:
Kolmogorov-Smirnov Test

Findings

- All GCMs were good at reproducing the statistical characteristics of “daily” rainfall and drought indices
- Only a few GCMs successfully intimated the rainfall “event” characteristics
  - Depth: BCC-CSM1.1 (m) and FGOALS-s2
  - Intensity: MRI-CGCM3
- Overestimated design storm sizes
- Performed better in the northwestern than southeastern part of Florida
  - Higher temporal variability

Thank you!

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