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Sensitivity study on convection schemes in RegCM4.3, in the simulation of climatic features in Central America and the Caribbean, focused on the Greater Antilles.

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Introduction

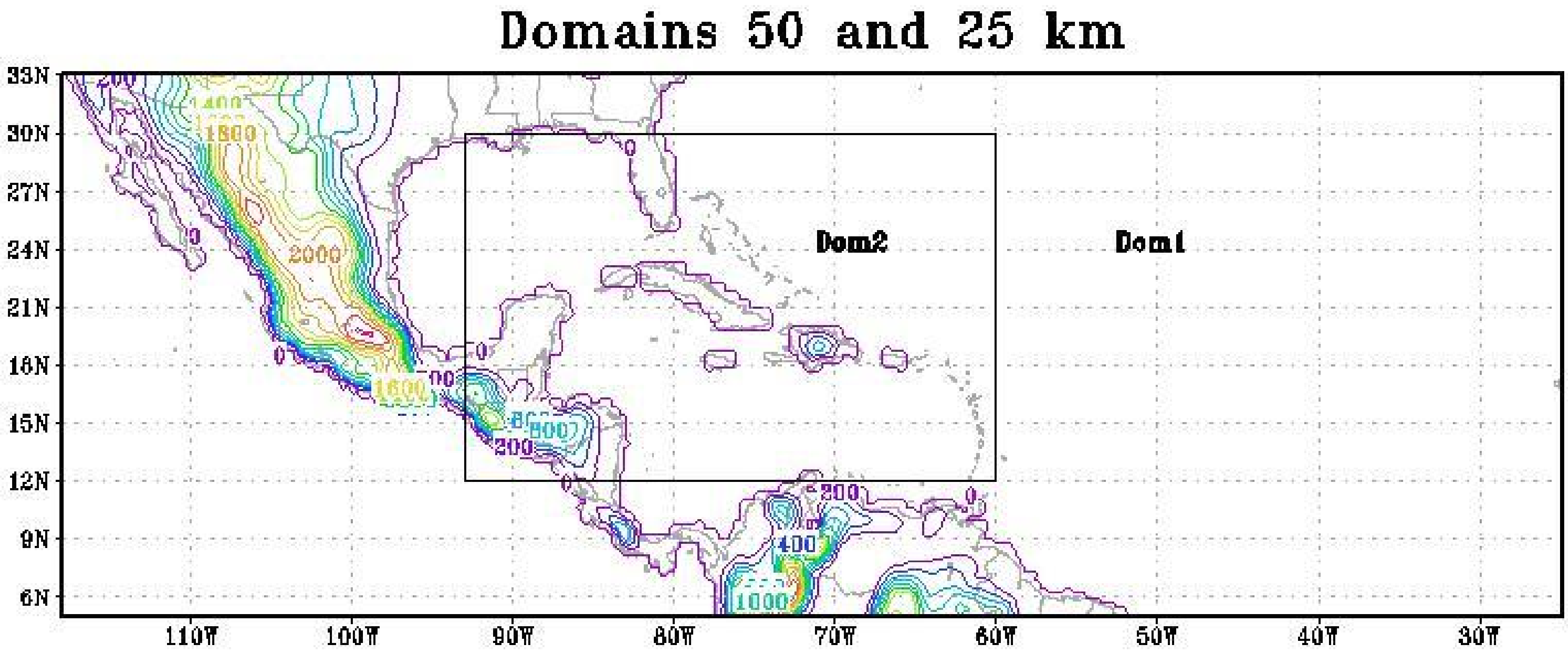
- The region of The Caribbean and central America is a very complex one.
  - Earth-sea interactions
  - Influence of tropical and extra-tropical systems
  - Complex orography
- Outstanding meteorological features and systems
  - Caribbean low level jet
  - Mid-summer drought
  - Easterly waves
  - Tropical cyclones
  - Cold fronts

Model

- Regional climate model RegCM 4.3 (Earth System Section. ICTP)
- Resolution: Horizontal: 50 km and 25 km (only for comparison with local station networks)

  Vertical: 18 σ levels
- Boundary conditions: ERA INTERIM
- Test period: 2000-2001
- Projection: Lambert conformal
- Soil-vegetation-atmosphere interaction processes: BATS (Biosphere-Atmosphere Transfer Scheme
- Ocean-atmosphere fluxes: Zeng scheme
- Convection:
  - Grell (over ground)+Emanuel (over ocean)
  - Emanuel
  - Tiedtke (different combination of parameters)

Domains


Domains 50 and 25 km
Dom2
Dom1
33N
30N
27N
24N
21N
18N
15N
12N
9N
6N
110W
100W
90W
80W
70W
60W
50W
40W
30W
2000
1600
1400
400
800
200
1000
0

Model

Parameter tuning in Tiedtke parameterization

- entr**P**en: Entrainment rate for penetrative convection. Def: 10^{-4}
- entr**M**id: Entrainment rate for midlevel convection. Def: 10^{-4}
- entr**S**cv: Entrainment rate for shallow convection. Def: $3x10^{-4}$
- **C**mtcape: CAPE adjustment timescale parameter. Def: 40
- cprcon (**A**utoconversion): Autoconversion parameter. Def: 10^{-4}

Model

Numerical Experiments

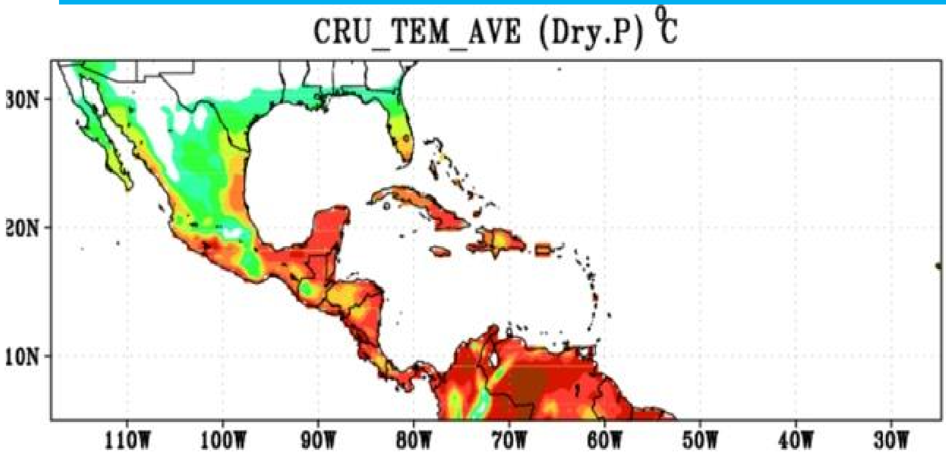
Exp.	Changed default parameters	Horiz. Res. (km)	entrpen	cmtcape	entrmid	entrscv	cprcon
GE	--	50	---------	---------	---------	---------	---------
GE	--	25	---------	---------	---------	---------	---------
EM	--	50	---------	---------	---------	---------	---------
TI	--	50	1.E-04	40	1.E-04	3.E-04	1.E-04
TICPDP	entrPen,cmtCape	50	2.E-04	80	1.E-04	3.E-04	1.E-04
TICPMD	2*(entrPen,entrMid,cmtCape)	50	2.E-04	80	2.E-04	3.E-04	1.E-04
TICD	2*cmtCape	50	1.E-04	80	1.E-04	3.E-04	1.E-04
TICH	½*cmtCape	50	1.E-04	20	1.E-04	3.E-04	1.E-04
TIPD	2*entrPen	50	2.E-04	40	1.E-04	3.E-04	1.E-04
TIPH	½* entrPen	50	5.E-05	40	1.E-04	3.E-04	1.E-04
TIMD	2*entrMid	50	1.E-04	40	2.E-04	3.E-04	1.E-04
TIMH	½*entrMid	50	1.E-04	40	5.E-05	3.E-04	1.E-04
TICMSD	2*(cmtCape, entrMid,),6.6*entrScv	50	1.E-04	80	2.E-04	2.E-03	1.E-04
TICPSD	2*(cmtCape, entrPen,), 6.6*entrScv	50	2.E-04	80	1.E-04	2.E-03	1.E-04

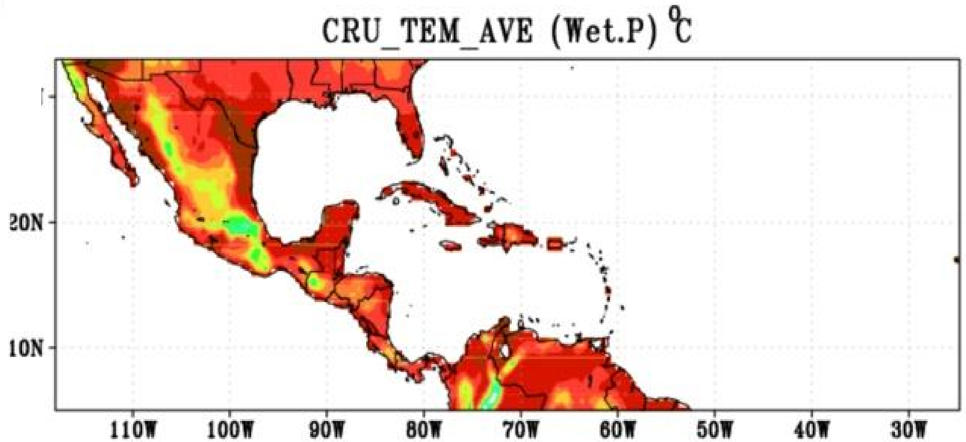
Experiments. Preliminary choice

Å After analyzing the output of 14 experiments, 8 of the 11 combinations of parameters of the previously tested Tiedtke parameterization were discarded for failing to reproduce the precipitation field.

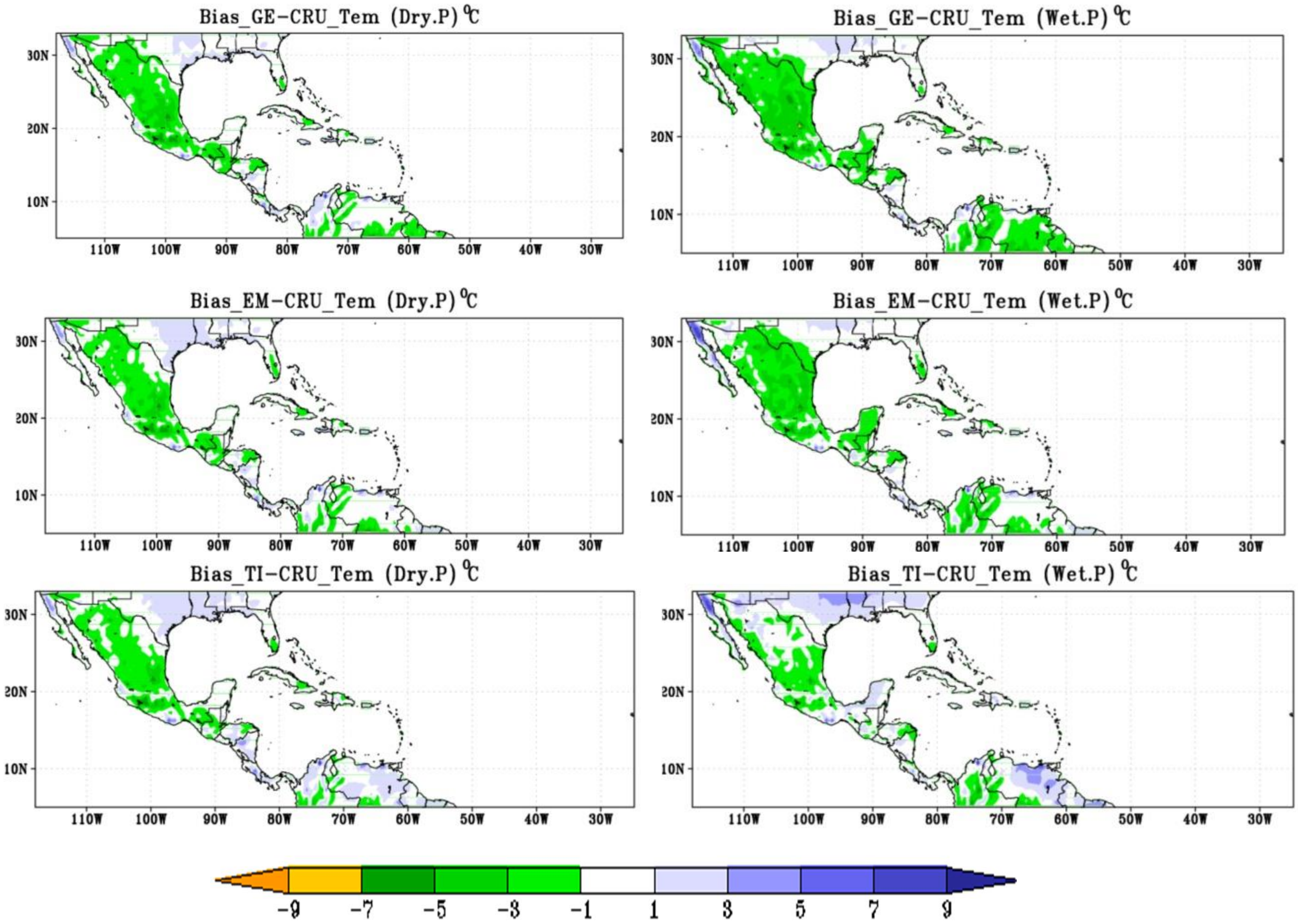
Å The preliminary analysis showed that the parameter of shallow entrainment is very important for the formation of precipitation in the Caribbean, which is related with the moisture intake keeping convection active.

Mean Temperature field

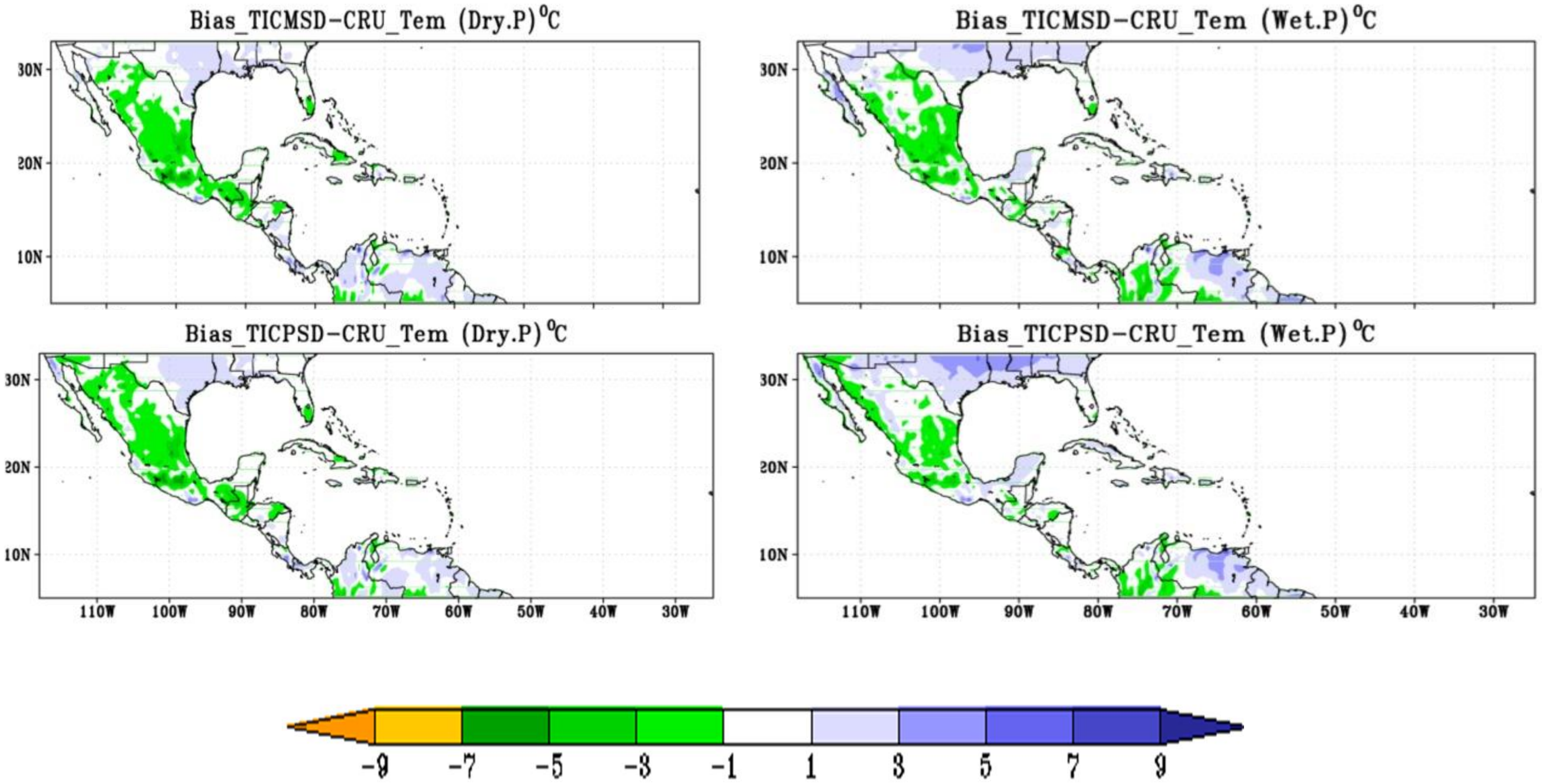




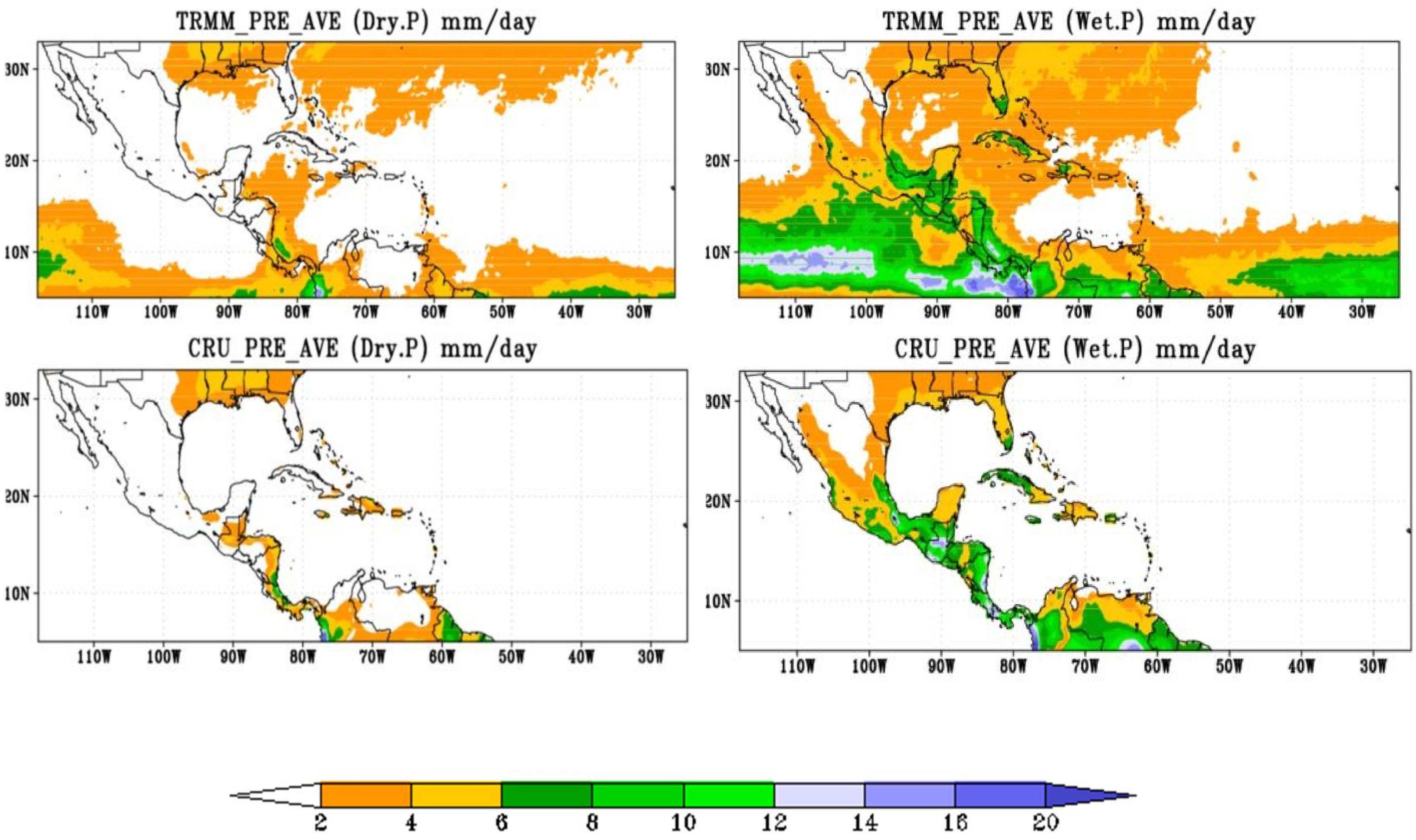
Temperature Bias



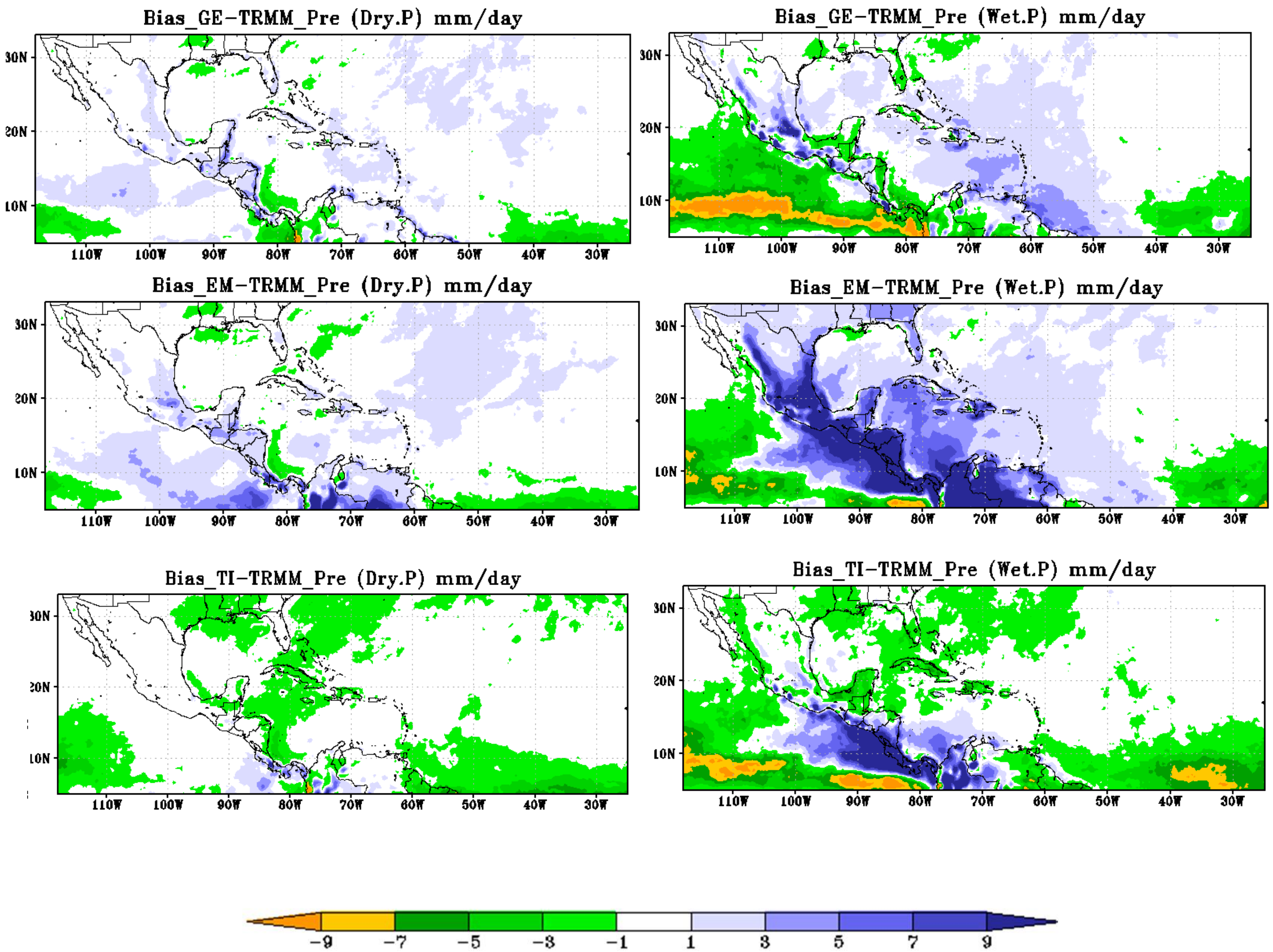
Temperature Bias



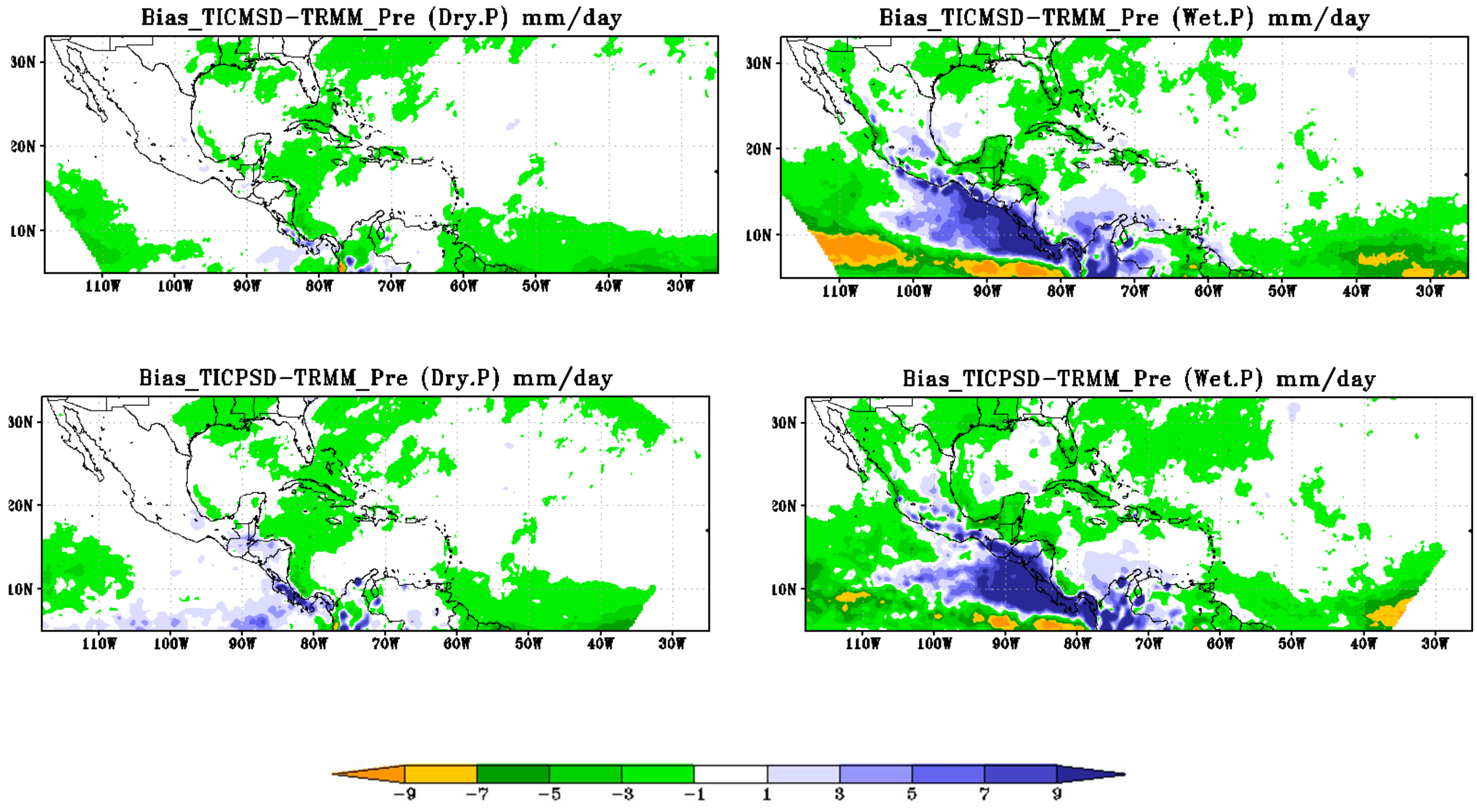
Mean Precipitation field



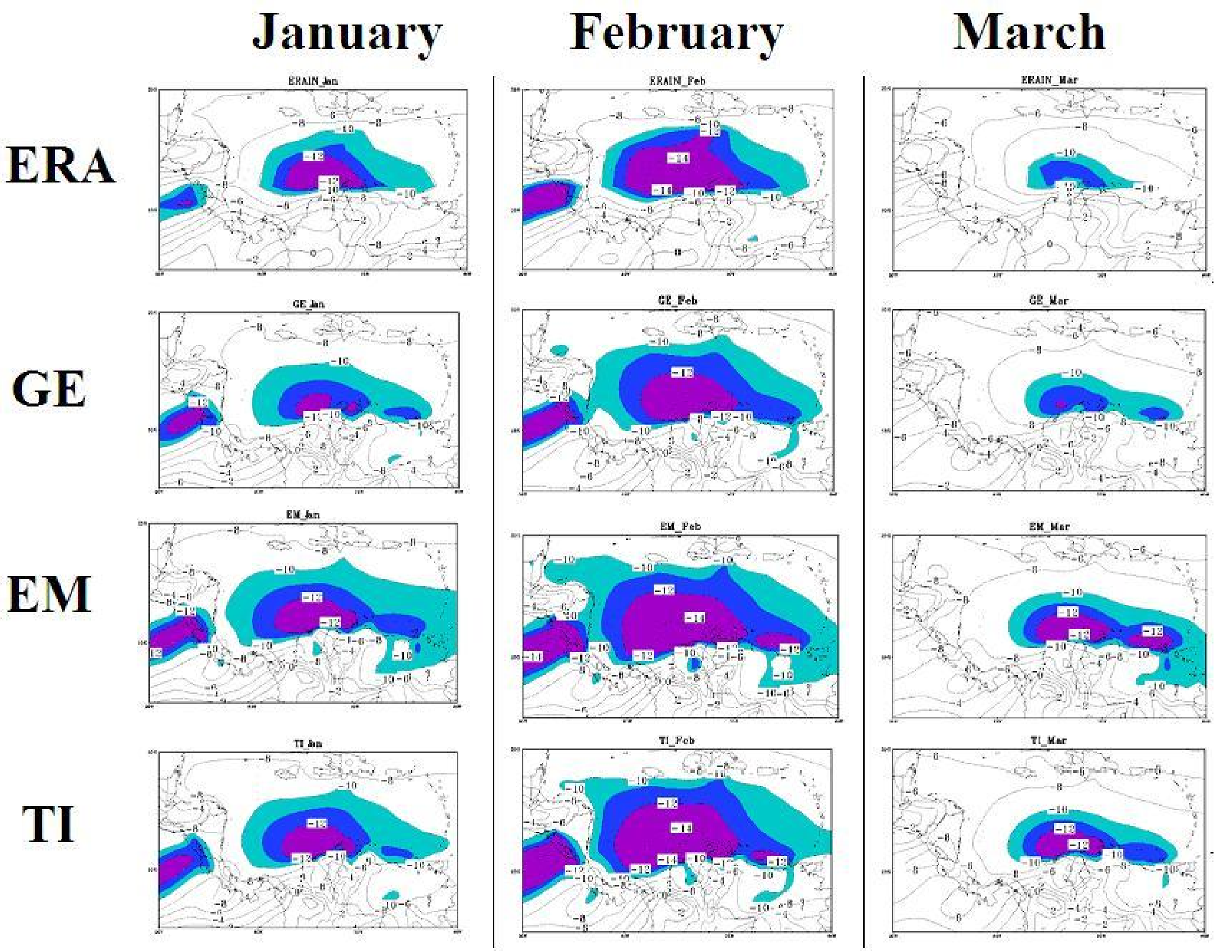
Precipitation Bias



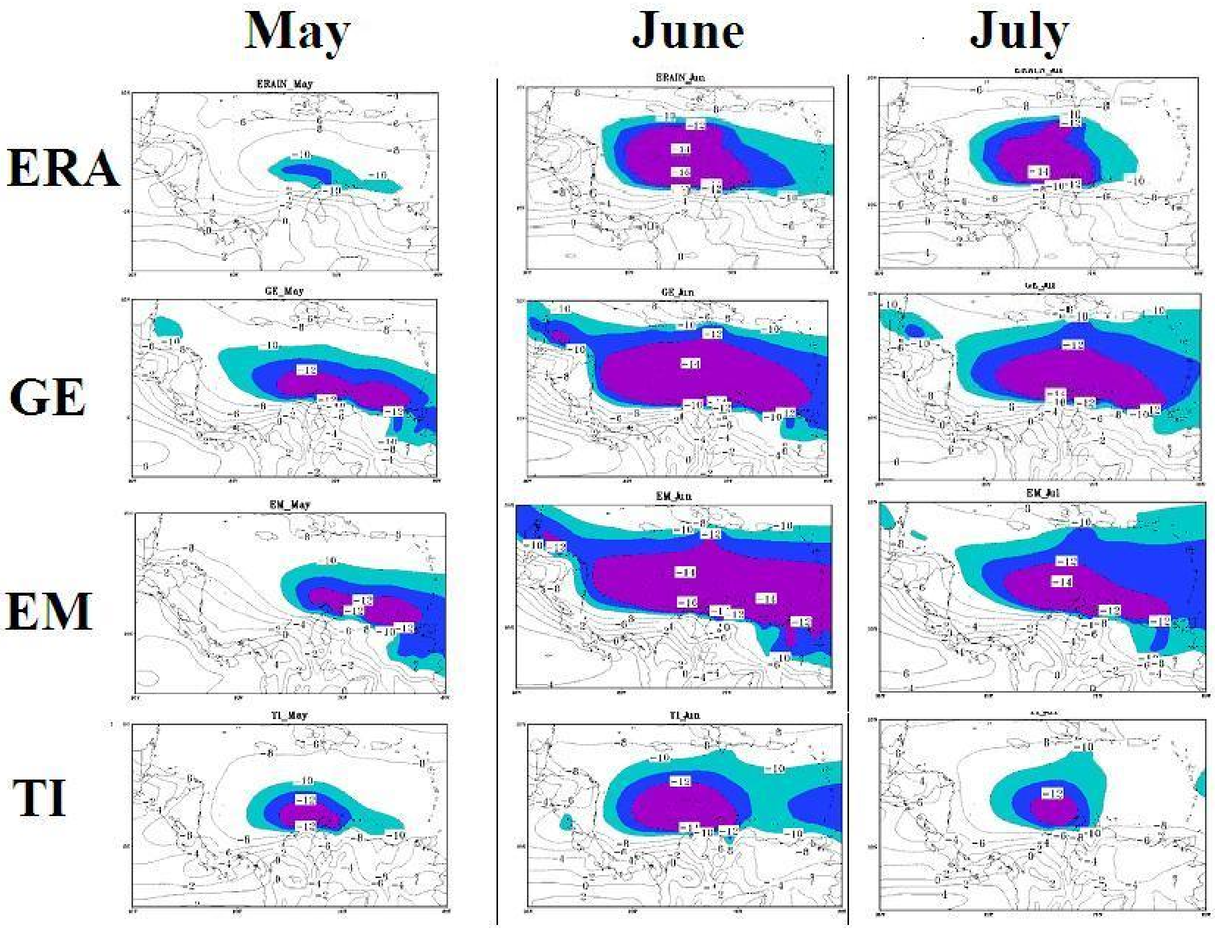
Precipitation Bias



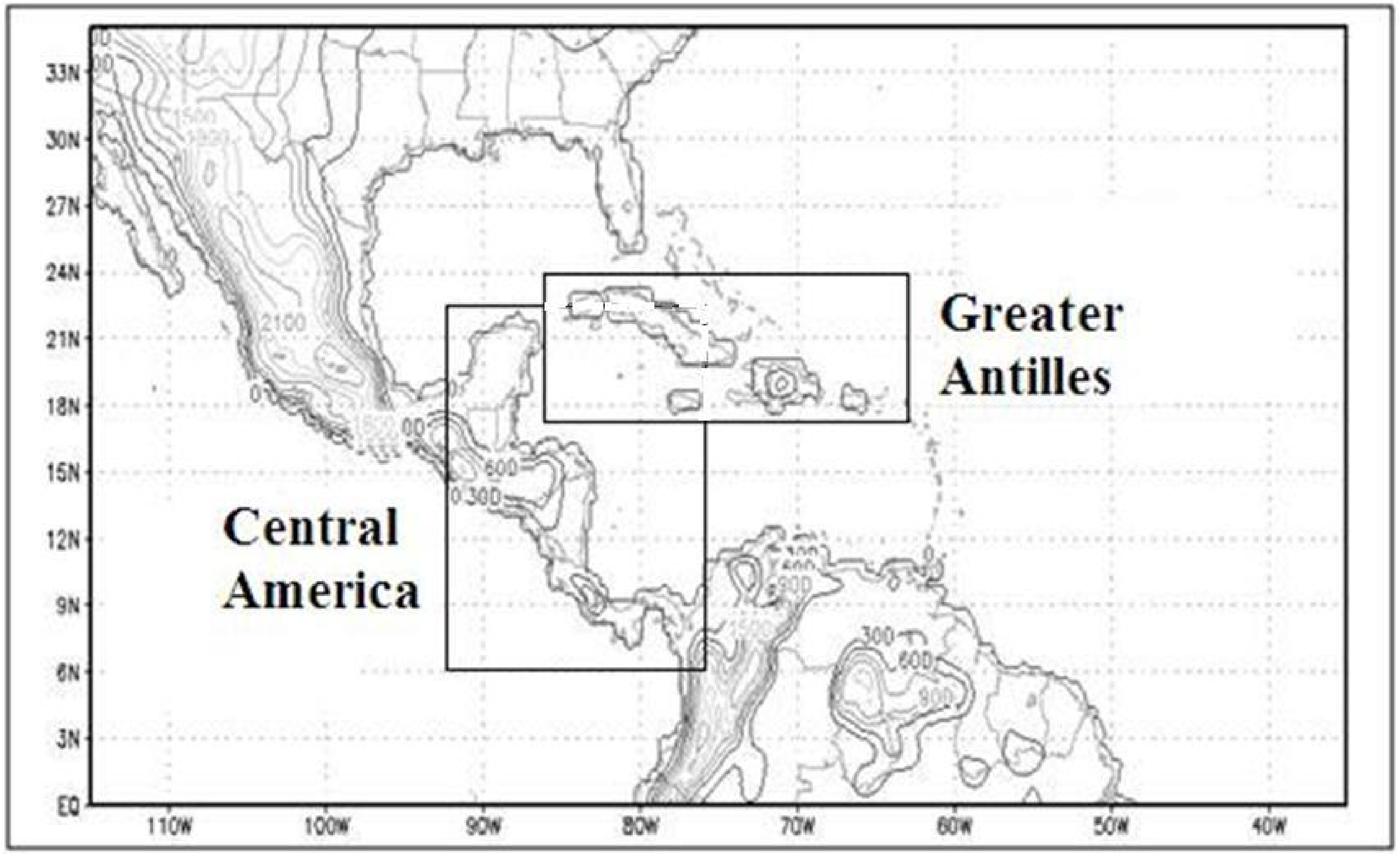
Caribbean Low Level Jet (Dry season)



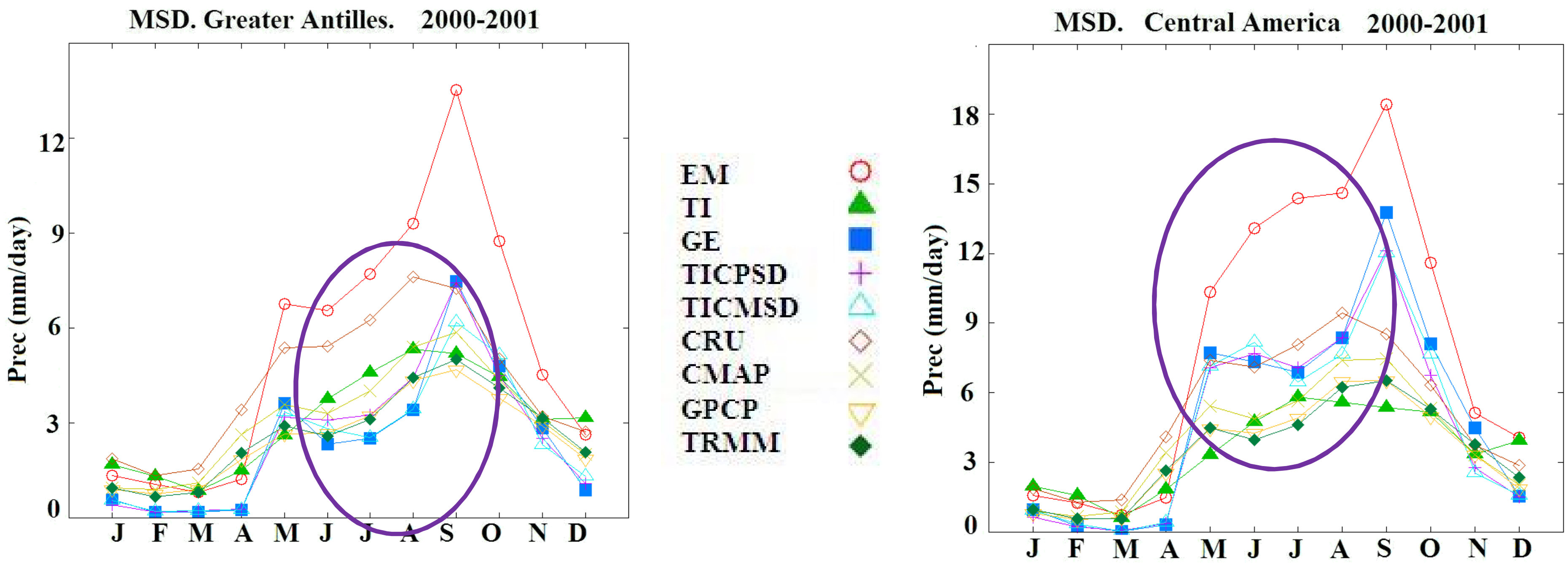
Caribbean Low Level Jet (Wet season)



Sub-domains G. Antilles and Central America



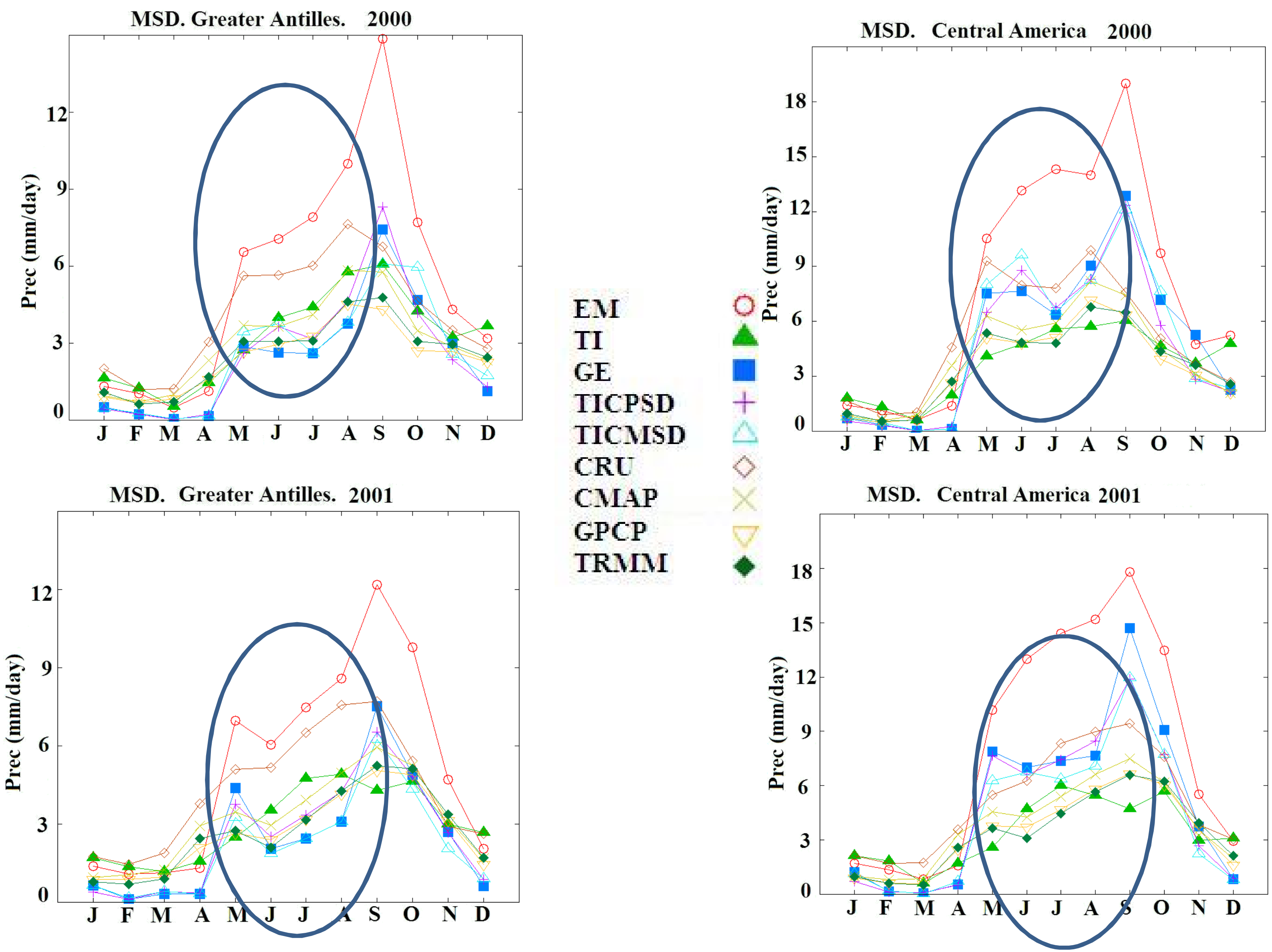
G. Antilles and Central American Midsummer Drought



GE underestimates prec.
EM overestimates prec.
Both Reproduce MSD in June
Data evidence slight minimum in June

GE slightly underestimates prec.
EM overestimates prec.
Both Reproduce MSD in July, but data evidence minimum in June

G. Antilles and Central American Midsummer Drought



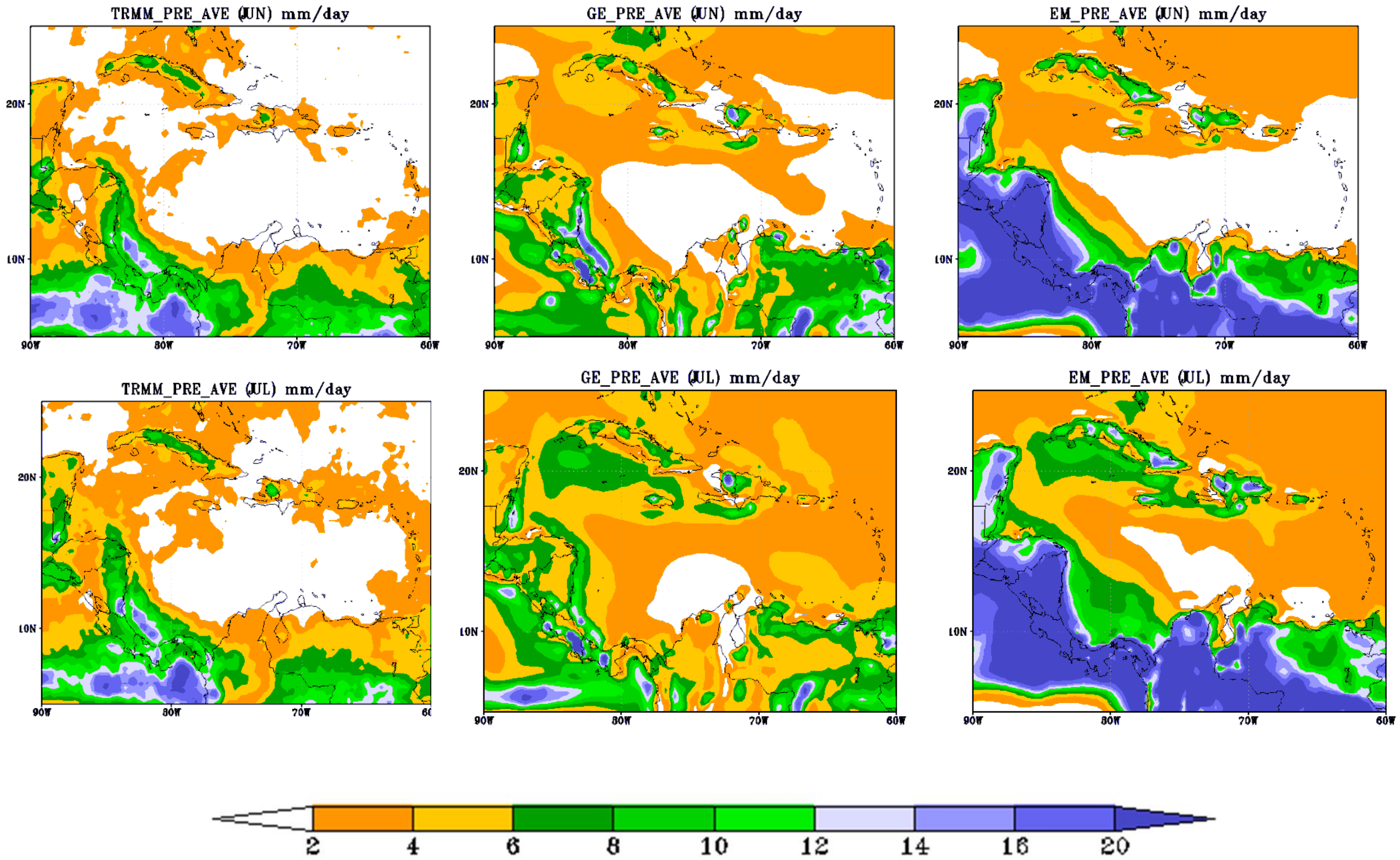
G. Antilles and Central American Midsummer Drought

2000→ MSD The MSD is extended to June and July. Precipitation similar in the two months and minimum in the year.

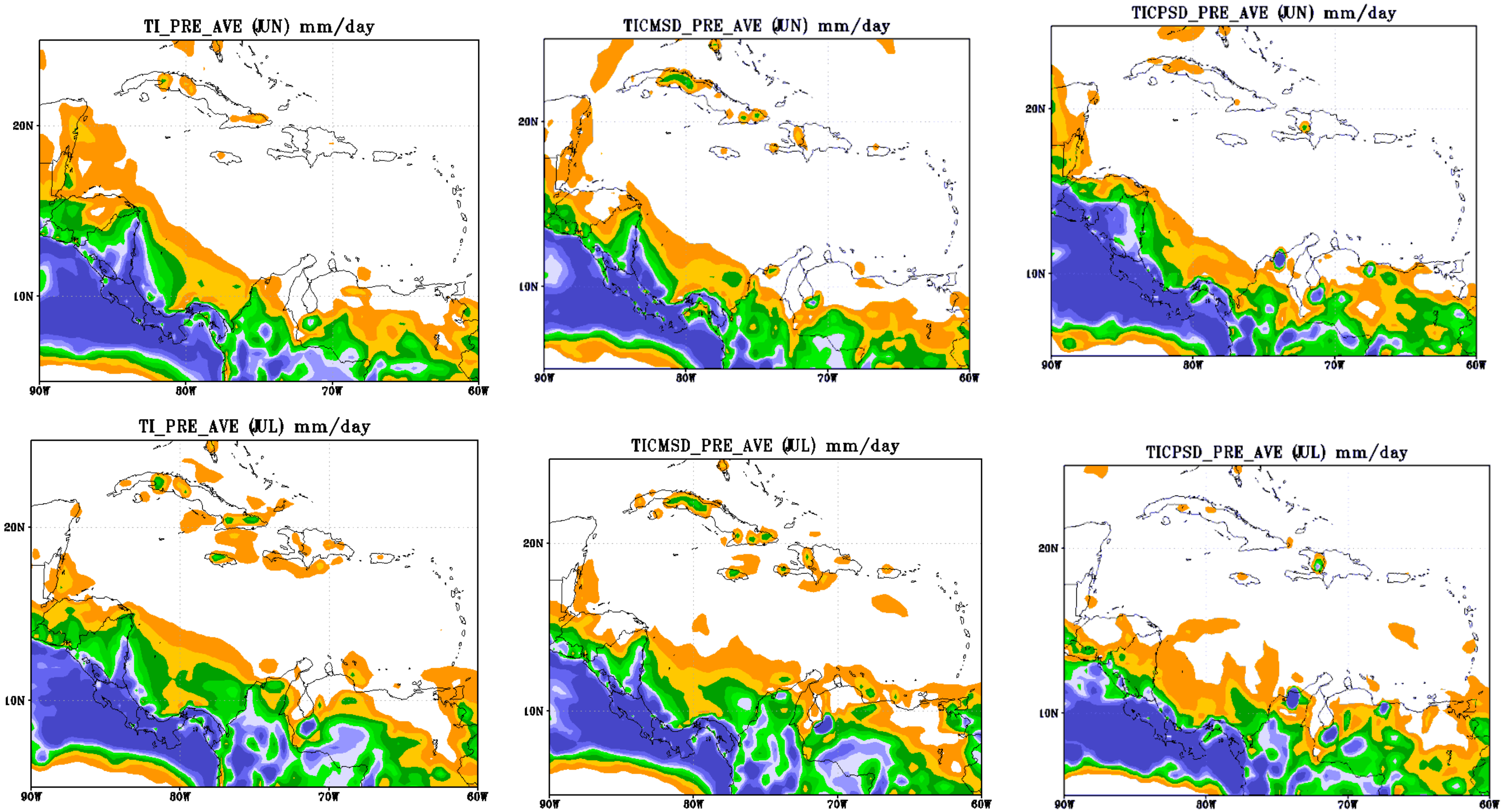
2001. MSD in June with well defined minimum in June

2000-2001→ The MSD is extended to June and July, with a minimum in June. Best defined by databases including precipitation over ocean. The general situation is well simulated by GE and TICPSD. EM and TI fail to capture this feature

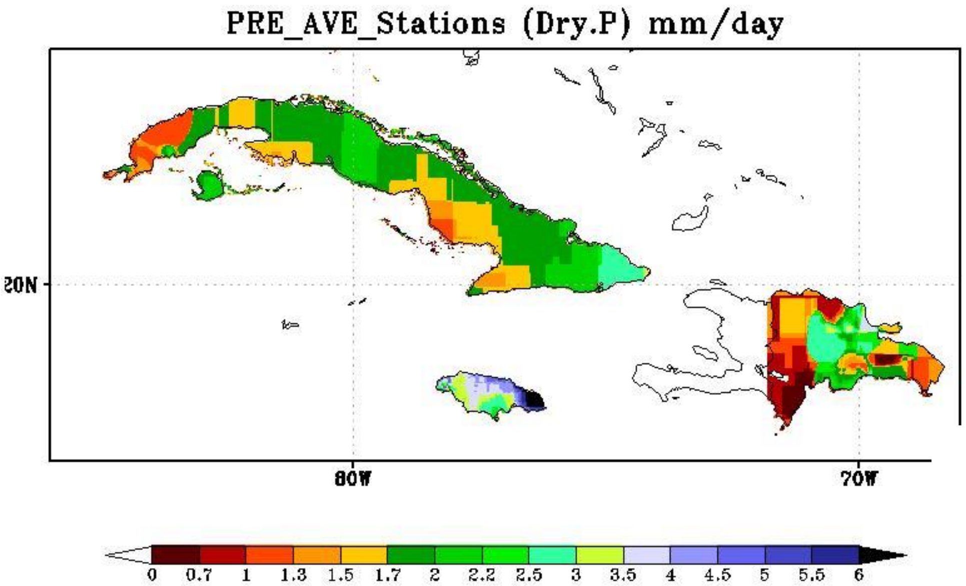
G. Antilles and Central American Midsummer Drought Comparison June-July (2000-2001). Data and models



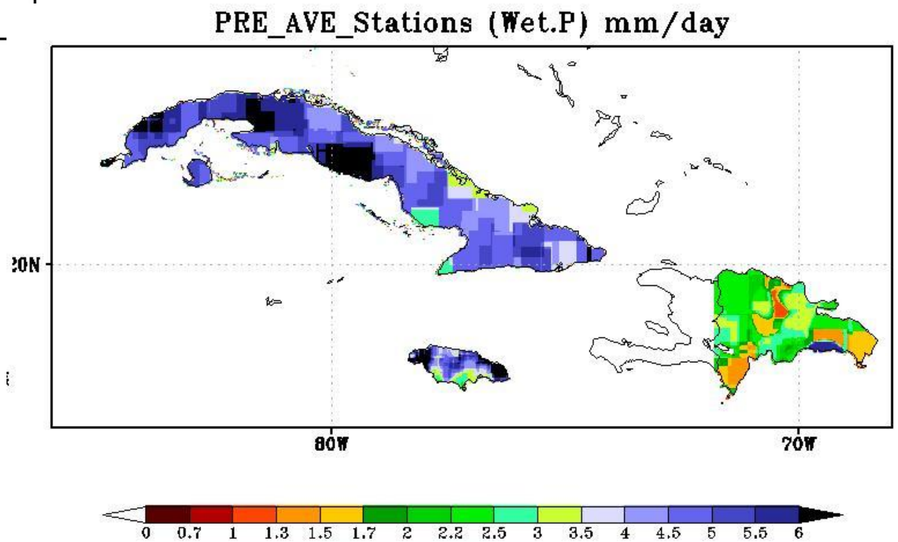
G. Antilles and Central American Midsummer Drought Comparison June-July (2000-2001). Data and models



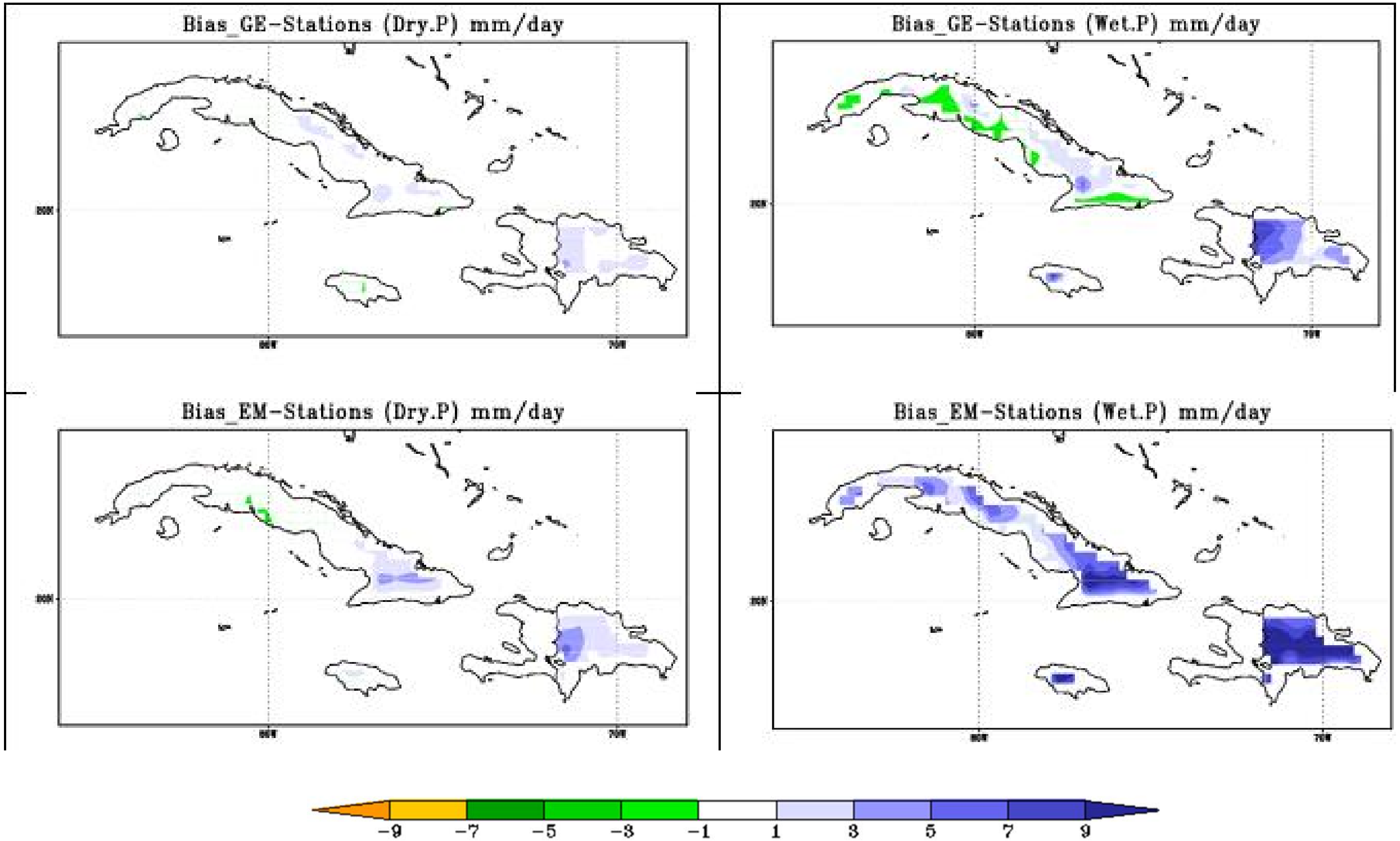
Precipitation
Cuba-Jamaica-Dominican Rep.
Surface Stations Network



Cuba: 67 meteorological stations
Dominican R.: 40 met. Stations
Jamaica: 239 raingauges



Comparison of model precipitation (50km) with Greater Antilles Surface Station Networks



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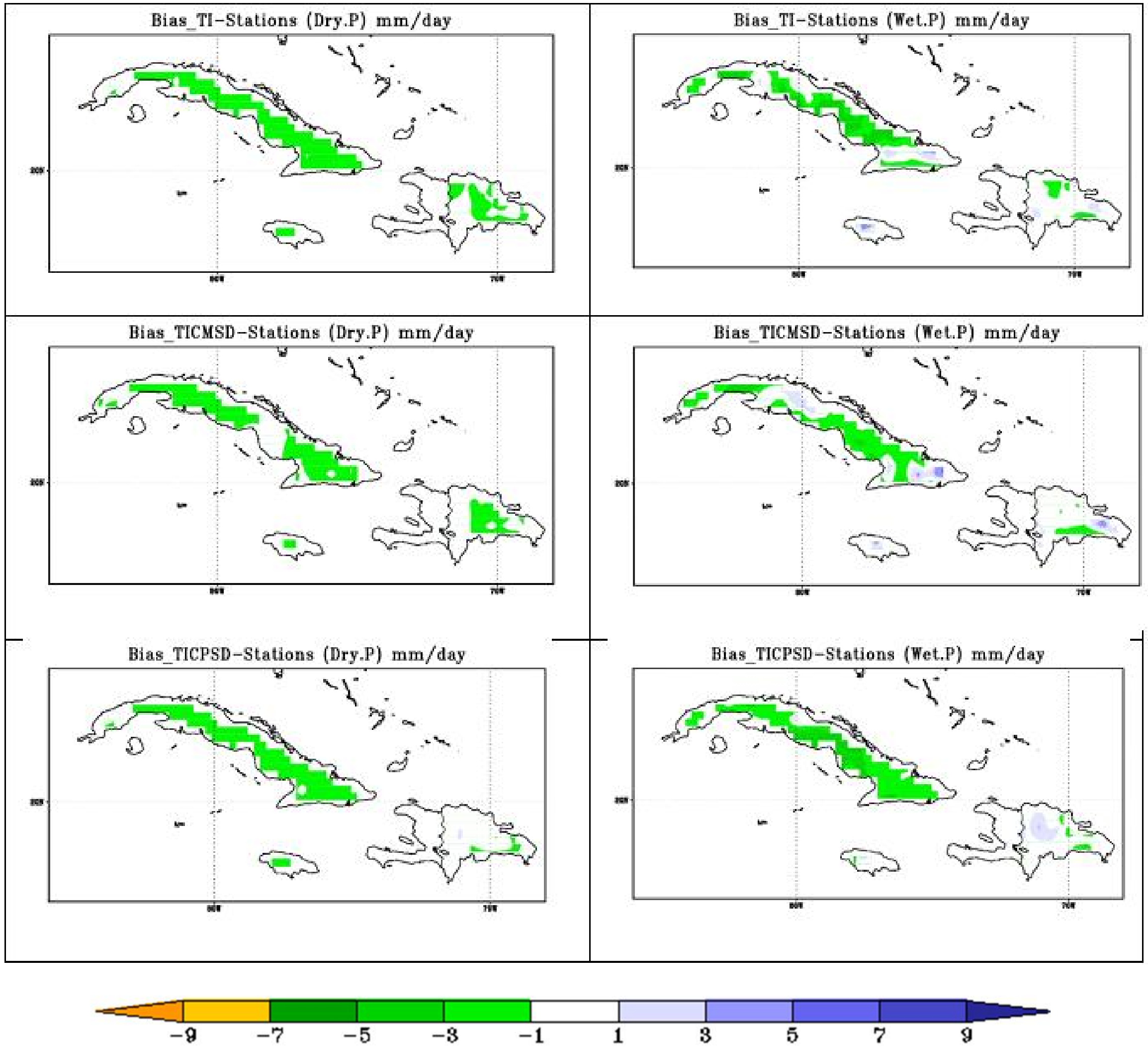
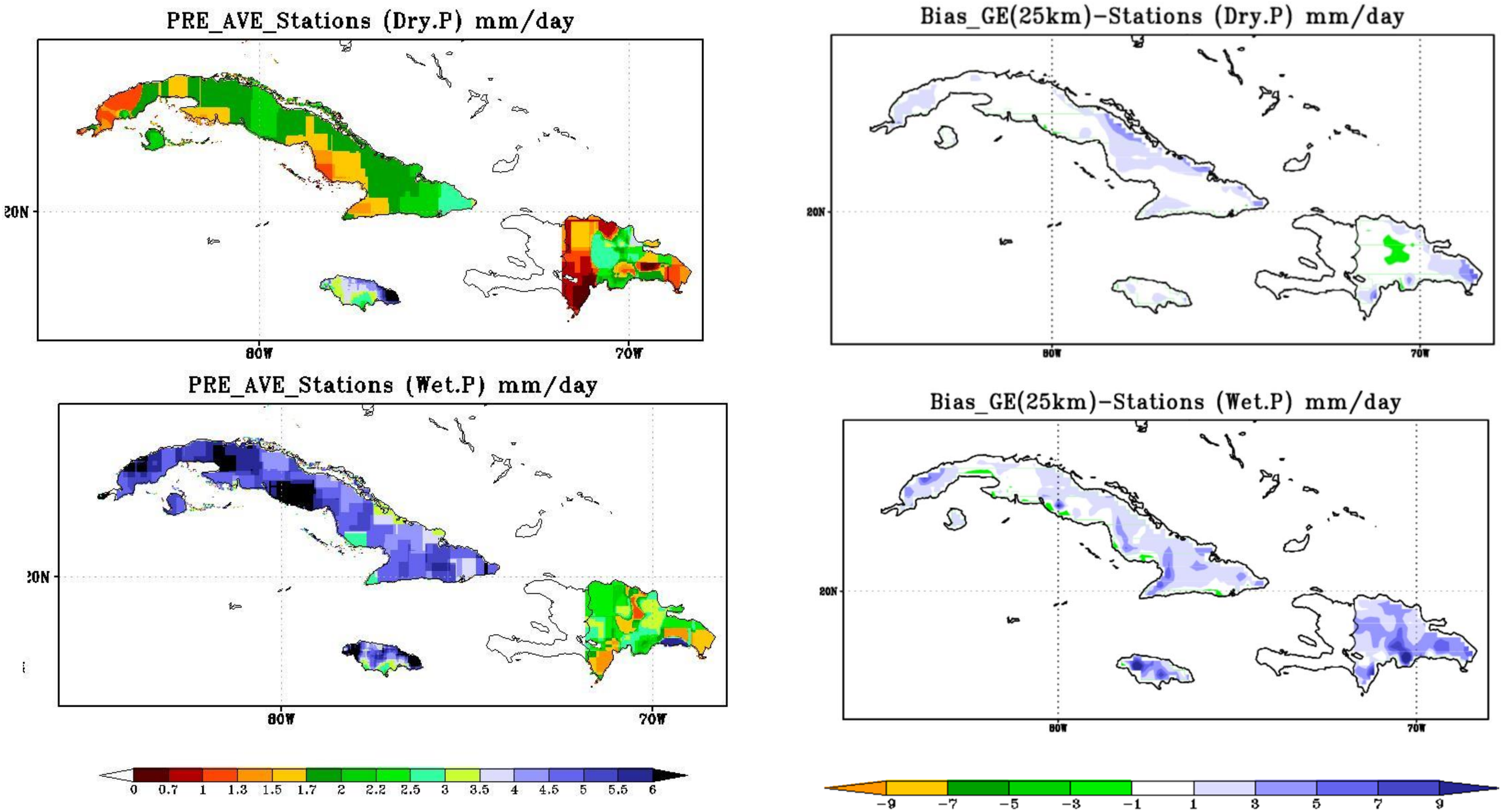
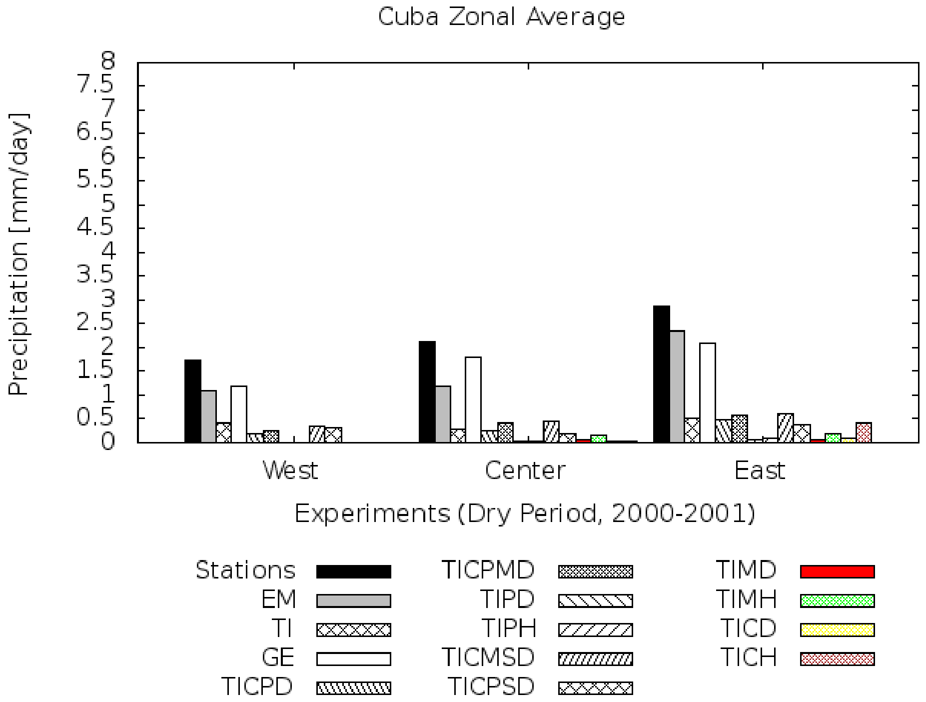
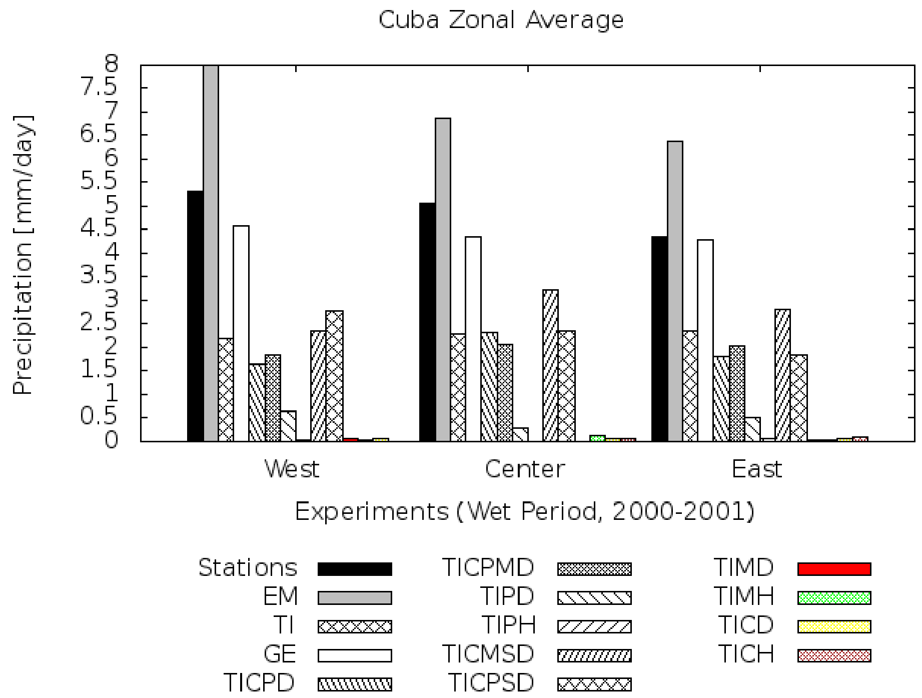


Comparison of model precipitation (GE-25km) with Greater Antilles Surface Station Networks

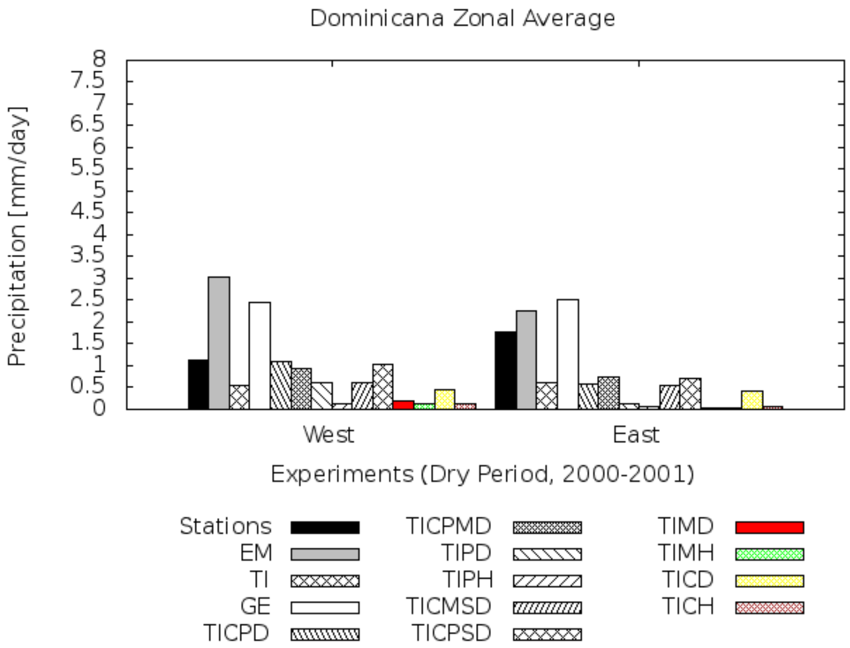


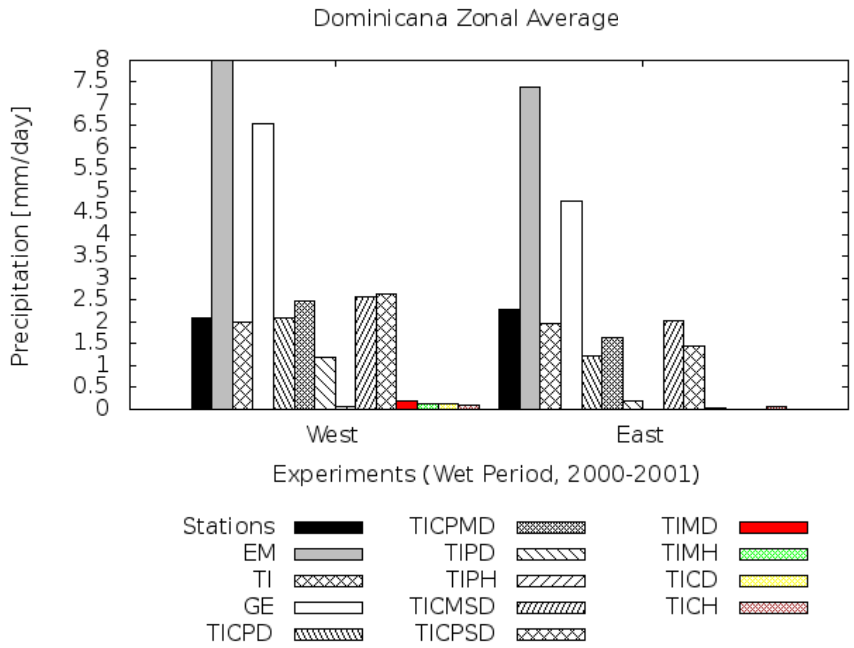
Precipitation in Cuba. Zonal average.
SSN and model



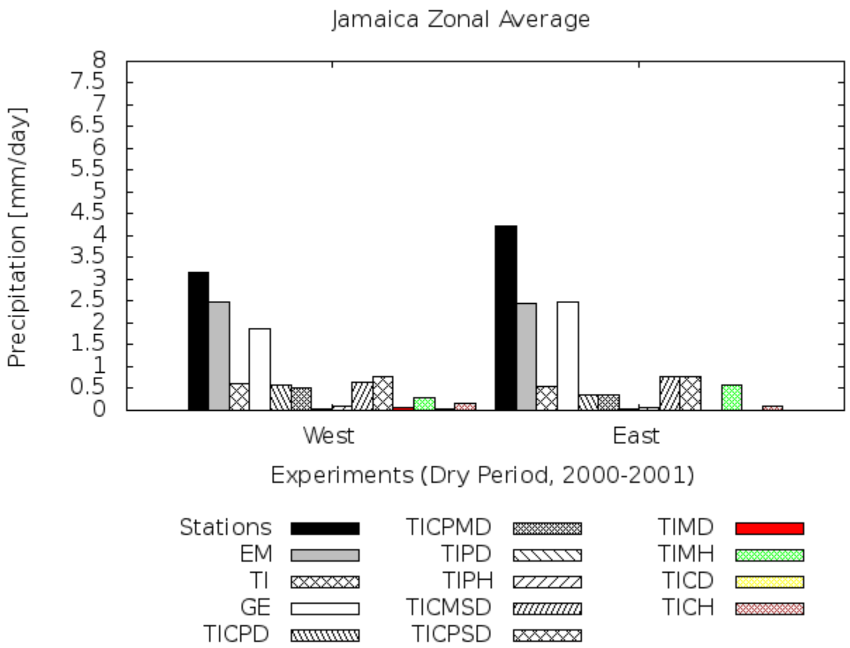


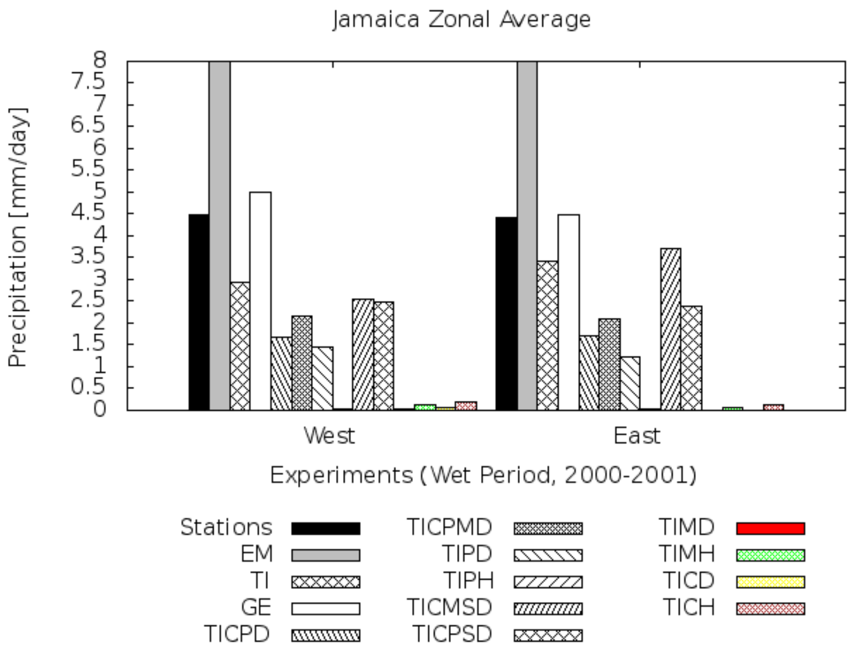
Precipitation in R. Dominicana. Zonal average. SSN and model





Precipitation in Jamaica. Zonal average. SSN and model





Summary

Å GE is the best scheme to reproduce the precipitation field in the wet season

Å EM overestimates wet season precipitation practically the whole domain.

Å For most combinations of parameters, the Tiedtke scheme seriously underestimated wet season precipitation in the Caribbean and the Atlantic, but increasing the shallow convection entrainment rate, the precipitation field was greatly improved. However, the scheme still overestimates precipitation in the Pacific coast of Central America.

Å For the dry season, the pattern is well reproduced by the GE and the EM schemes, but TI scheme produces extremely low precipitation.

Å Temperature fields were acceptably well reproduced by all parameterizations, with small bias for most of the islands, though negative bias was observed, mainly for continental mountainous areas and a positive bias for some flat continental areas.

Summary

- In general, the model estimations are best for the Caribbean islands than for the continent.
- The CLLJ is well reproduced by the different configurations, but best by the Tiedtke scheme
- The Caribbean MSD is well reproduced by GE, TICMSD and TICPSD, but not by EM nor TI.
- A special comparison was made for simulated precipitation on Cuba, Jamaica and Dominican R., using local meteorological networks, showing that the GE produces acceptably small bias for the different seasons and regions . EM produces relatively small bias in the dry season, but a high overestimation for the wet season. TI, TICMSD and TICPSD underestimate precipitation both for the dry and wet season, but the bias is under 2 mm/day.
- The experiment using GE with a resolution of 25 km showed that the precipitation bias over the Greater Antilles is reduced

Work to be done

- Work must still be done in optimizing the autoconversion and shallow entrainment parameters in the Tiedtke scheme to produce an ensemble of configurations of RegCM4.3 to be applied to climate change projections.
- Testing the model for the inner Caribbean domain with a 25 km grid for the selected configurations
- Producing climate projections for the CORDEX Central American-Caribbean domain using 50 km grid and for the inner Caribbean domain using 25 km.