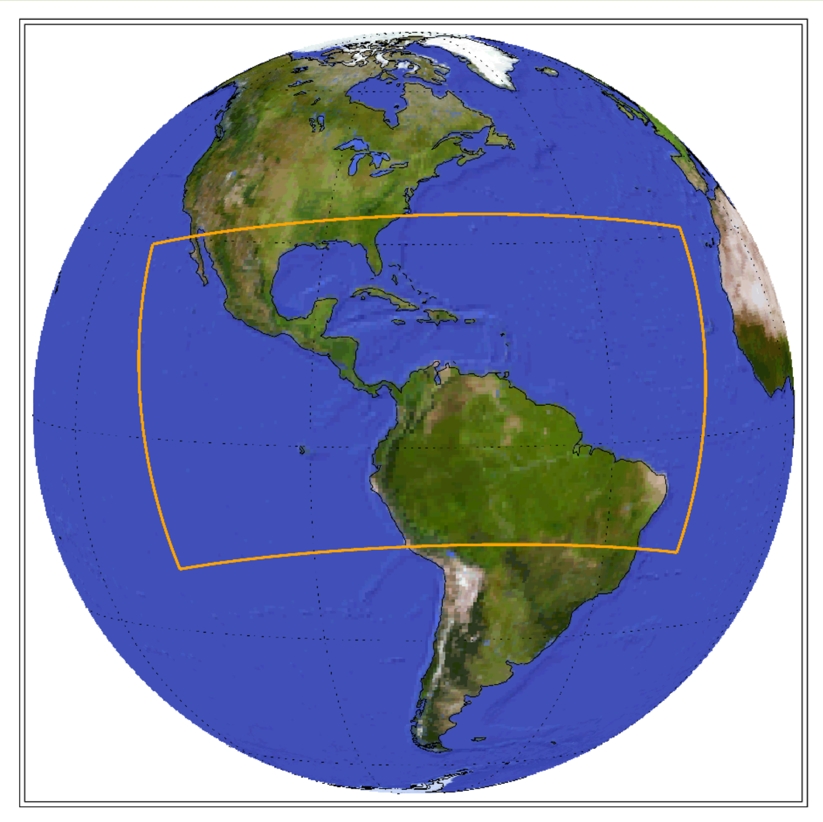
Central America and Mexico CORDEX CAM Studies

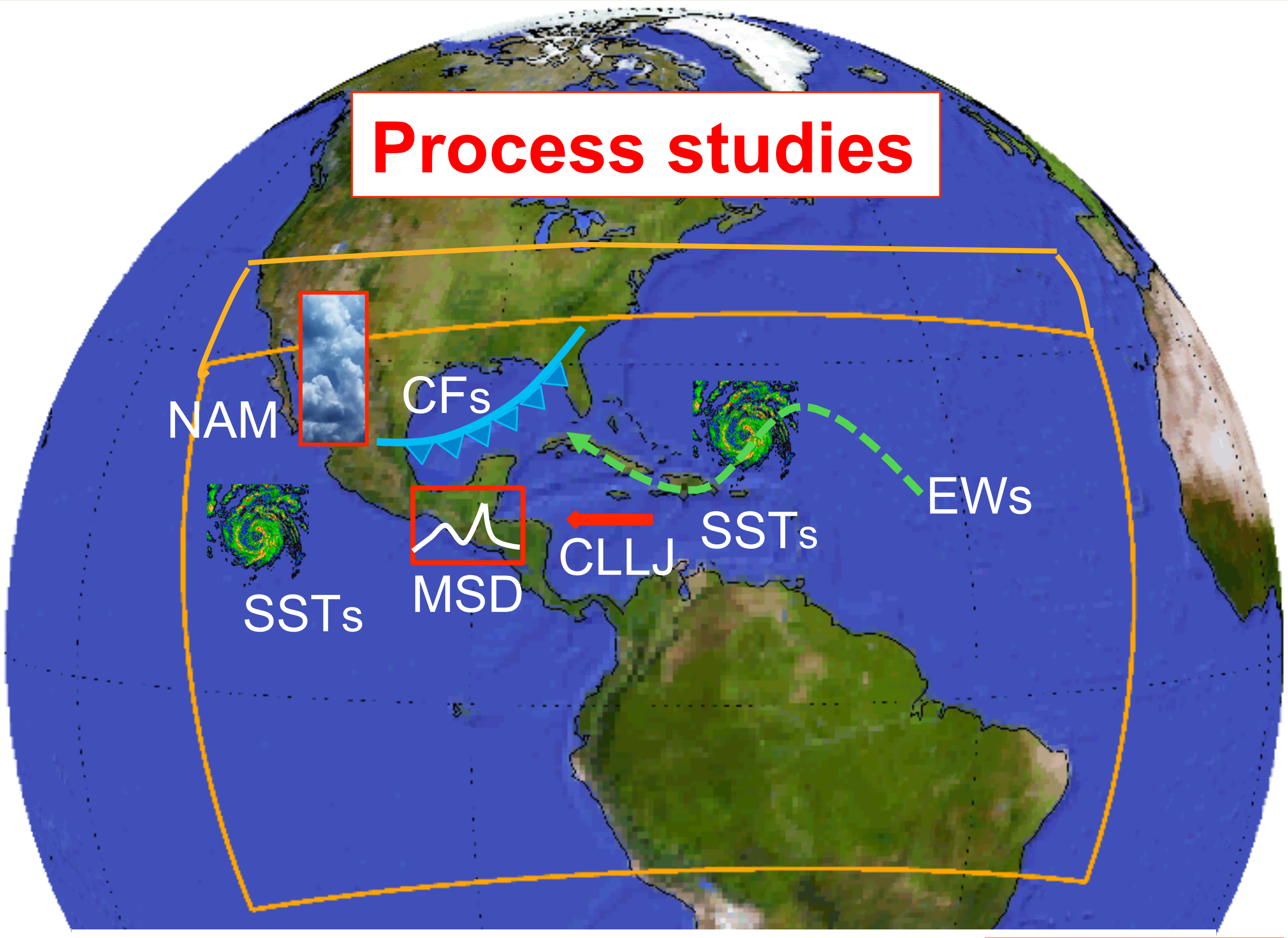


Tereza Cavazos
Dept. of Physical Oceanography
Baja California, Mexico
tcavazos@cicese.mx

CICESE

8^{th} Regional RegCM Workshop
23 May – 4 June 2016, Trieste, Italy

ICTP The Abdus Salam International Centre for Theoretical Physics
www.ictp.it



Sensitivity studies:
- Domain size
- Convective schemes
- Land surface schemes

RCMs:
- RegCM4
- Precis
- REMO
- WRF

Validations and Process Studies

CLLJ, MSD, thermal contrast, sensitivity to SSTs and land-surface schemes

- **PRECIS:** Taylor et al. 2012, 2013
- **RegCM4:** Diro et al. 2012; Fuentes-Franco et al. 2014, 2015
- **REMO:** Martinez et al. (in process)

Diurnal cycle and convection

- **RegCM4:** Diro et al. 2012

Sensitivity to domain size (CLLJ and MSD)

- **PRECIS:** Centella-Artola et al. 2015
- **RegCM4:** Vichot-Llano et al. 2015
- **REMO:** Martinez et al. (in process)

Sensitivity to convective parameterizations and domain size

- **RegCM4:** Arritt 2013 (EGU Assembly)

Tropical cyclones

- **RegCM4:** Diro et al. 2014; Fuentes-Franco et al. 2014, 2016
- **Statistical downscaling of GCMs**: Jones et al. 2016

Published papers

- **Caribbean Group:**

PRECIS - Taylor et al. 2012, *Int. J. Climatol*; Taylor et al. 2013, *BAMS;* Centella-Artola et al. 2015, *Clim Dyn*; Jones et al. 2016, *JGR-Atm.*

RegCM - Vichot-Llano et al. 2014, *Rev. Climatol.*

- **ICTP: RegCM - Fuentes-Franco et al. 2014, 2015, 2016, *Clim Dyn.;* Diro et al. 2012, *Clim. Res;* Diro et al. 2014, *Clim. Change.***

Work in progress

- **Univ. of Edmonton, CA:** **RegCM4 (output) – 4 Master theses**
- **Iowa State University:** **RegCM4 – Ray Arritt**
- **University of Costa Rica:** **RegCM4 and WRF - Rivera and Amador**
- **University of La Habana:** **RegCM4 – Arnoldo B., Daniel, Alejandro**
- **CICESE, IMTA, UNAM, UV:** **RegCM4, RCA, PRECIS, WRF – T. Cavazos, R. Cerezo-Mota, A. Salinas, M. Mendez**
- **UNAM, GERICS, AWI, UAH:** **Coupled Remo – B. Martinez et al.**

Caribbean Group PRECIS-based studies

Scientists from

Barbados, Belize, Cuba, and Jamaica

THE PRECIS CARIBBEAN STORY

Lessons and Legacies

BY MICHAEL A. TAYLOR, ABEL CENTELLA, JOHN CHARLERY, ARNOLDO BEZANILLA, JAYAKA CAMPBELL, ISRAEL BORRAJERO, TANNECIA STEPHENSON, AND RIAD NURMOHAMED

BAMS, 2013

PRECIS-Caribbean Initiative (2003):

Scientists from Barbados, Belize, Cuba, and Jamaica initiated a project to provide dynamically downscaled climate change information for the Caribbean.

GOALS:

- To build regional capacity for the region
- To provide climate information in the shortest possible time frame
- To create a platform for sharing the information

LEGACY AFTER 10 YRS

- Positioned the Caribbean in the international agenda of climate change
- Created a regional template for capacity building
- Expanded regional capacity and cooperation to undertake climate science
- Produced significant body of knowledge on climate change relevant to and at the scale of the Caribbean region.

Why dry? Investigating the future evolution of the Caribbean Low Level Jet (CLLJ) to explain projected Caribbean drying

Michael A. Taylor, Felicia S. Whyte,
Tannecia S. Stephenson, Jayaka D. Campbell
Int. J. Climatol., 2012

PRECIS regional model is used to simulate the end-of-century (2071–2100) manifestation of the CLLJ under two global warming scenarios.

Model Validation: It captures the CLLJ's present-day spatial and temporal characteristics reasonably well.

Future scenarios: Intensification of the CLLJ's core strength from May through November is linked to dry conditions in the Caribbean

In contrast, the boreal winter manifestation of the CLLJ is largely unaltered in the future.

Clim Dyn (2015) 44:1901–1918
DOI 10.1007/s00382-014-2272-8

Clim. Dyn., 2015

Assessing the effect of domain size over the Caribbean region using the PRECIS regional climate model

Abel Centella-Artola · Michael A. Taylor · Arnoldo Bezanilla-Morlot · Daniel Martinez-Castro · Jayaka D. Campbell · Tannecia S. Stephenson · Alejandro Vichot

- PRECIS RCM forced by ERA Interim at 50 km resolution using 3 domains

- The simulations of the CLLJ and the MSD were insensitive to domain size

- Downscaled precipitation showed a systematic dry bias independent of the domain size, especially over land

- Weak hydrologic cycle associated with warm bias of the model, dry soil, and weak evaporation

PRECIS regional climate model

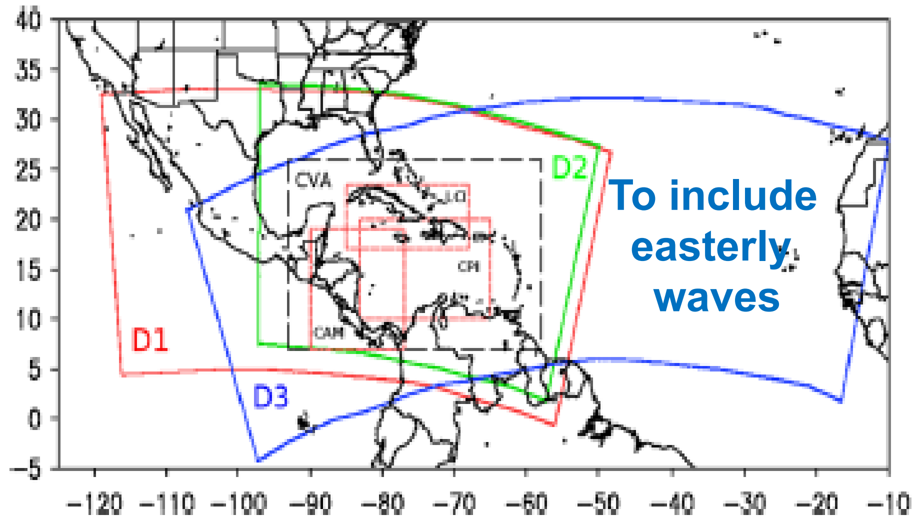


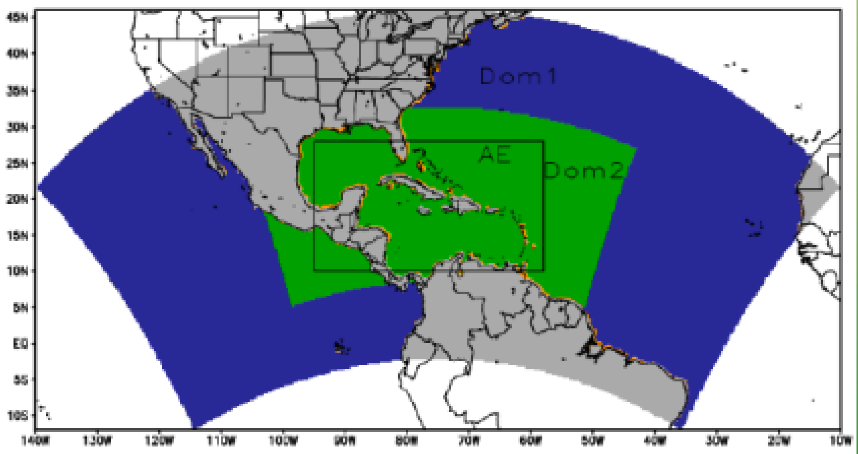
Fig. 1 Domains (excluding the eight point boundary buffer zone) of configurations D1 (*red line*), D2 (*green line*) and D3 (*blue line*) of the regional climate model. The Common Validation Area (CVA) is delimited by *long dash blank line*. *Red boxes* delimit the subregions for which the annual cycle is analyzed-Central America (CAM), Caribbean Precipitation Index (CPI; see the text for definition) and Large Caribbean Islands (LCI)

Revista de Climatología
Vol. 14 (2014): 45-62 ISSN 1578-8768

Sensibilidad al cambio de dominio y resolución de tres configuraciones del modelo climático regional RegCM 4.3 para la región de América Central y el Caribe.

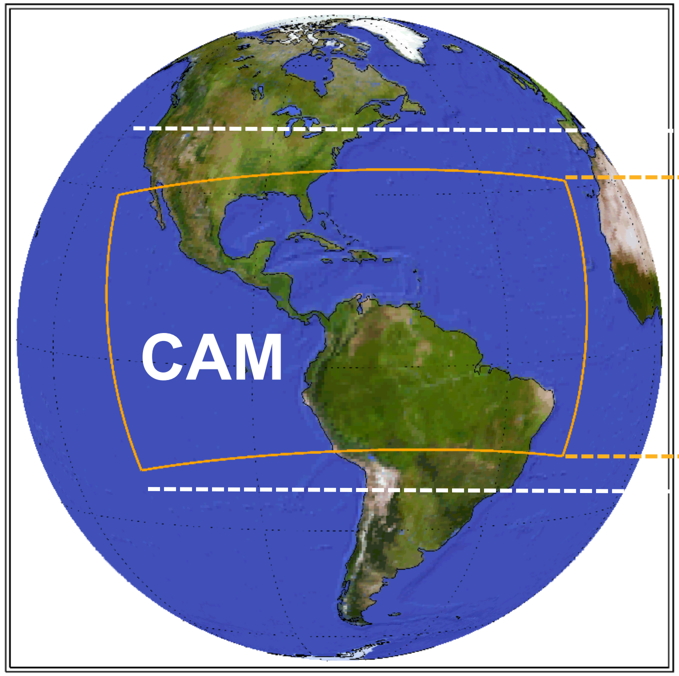
Alejandro Vichot-Llano, Daniel Martínez-Castro, Abel Centella-Artola y Arnoldo Bezanilla-Morlot

RegCM Sensitivity Analysis: Domain, Resol & Conv



Nombre de la simulación	Esquema de convección	Dominio	Resolución horizontal
EM	Emanuel	Dom1	50 km
GE	Grell-Emanuel	Dom1	50 km
TI	Tiedke	Dom1	50 km
EM25	Emanuel	Dom2	25 km
GE25	Grell-Emanuel	Dom2	25 km
TI25	Tiedtke	Dom2	25 km

ICTP Group
RegCM4-based studies



CORDEX CAM Domain

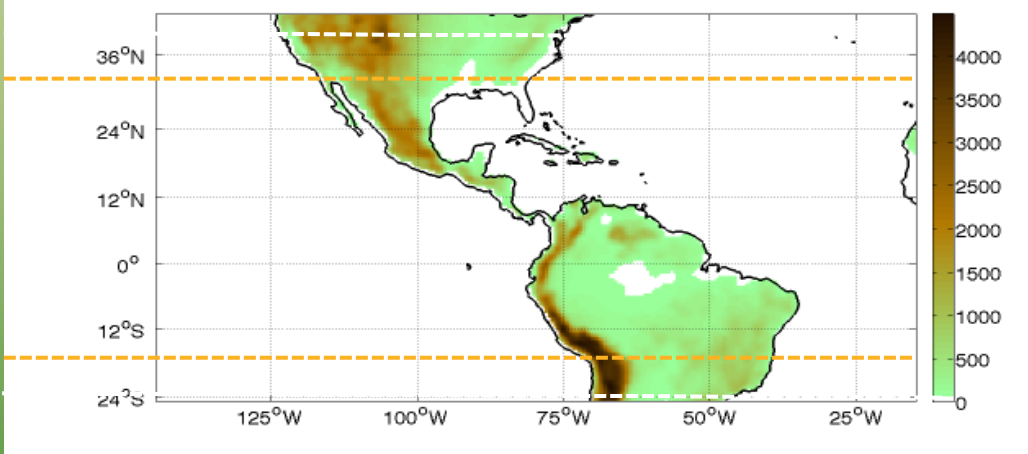


Figure 1. Topography of the Central America CORDEX domain. Colorbar units: meters.

CORDEX CAM Domain
http://esg-dn1.nsc.liu.se/search/cordex/

RegCM4 – ICTP : Fuentes-Franco et al.
RCA4 – SMHI : Grigory Nikulin

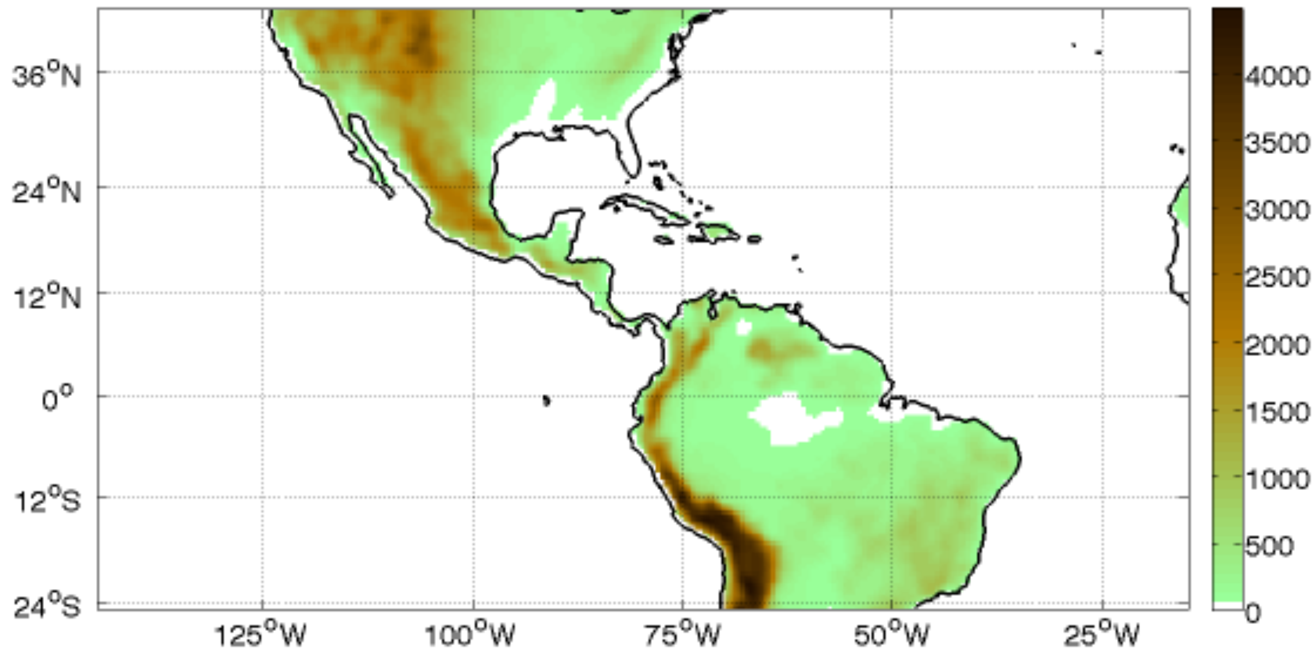


Figure 1. Topography of the Central America CORDEX domain. Colorbar units: meters.

Vol. 52: 31–48, 2012
doi: 10.3354/cr01049

CLIMATE RESEARCH
Clim Res

Published March 22

Contribution to CR Special 29 'The regional climate model RegCM4'

OPEN ACCESS

Sensitivity of seasonal climate and diurnal precipitation over Central America to land and sea surface schemes in RegCM4

G. T. Diro[1,*], S. A. Rauscher[2], F. Giorgi[1], A. M. Tompkins[1]

Clim. Res., 2012

- **RegCM4 driven by ERA-Interim Reanalysis**
- **BATS – Biosphere Atm Transfer Scheme – a more realistic simulation of the precip and of the MSD in southern Mex**
- **Convective parameterizations:**
  Mixed: Emanuel over oceans and Grell over land

JJAS Precipitation: Historical Validations

Obs (mm/d)

BATS Scheme

DCSST: Diurnal Cycle, SST Scheme
➔ Wetter ITCZ

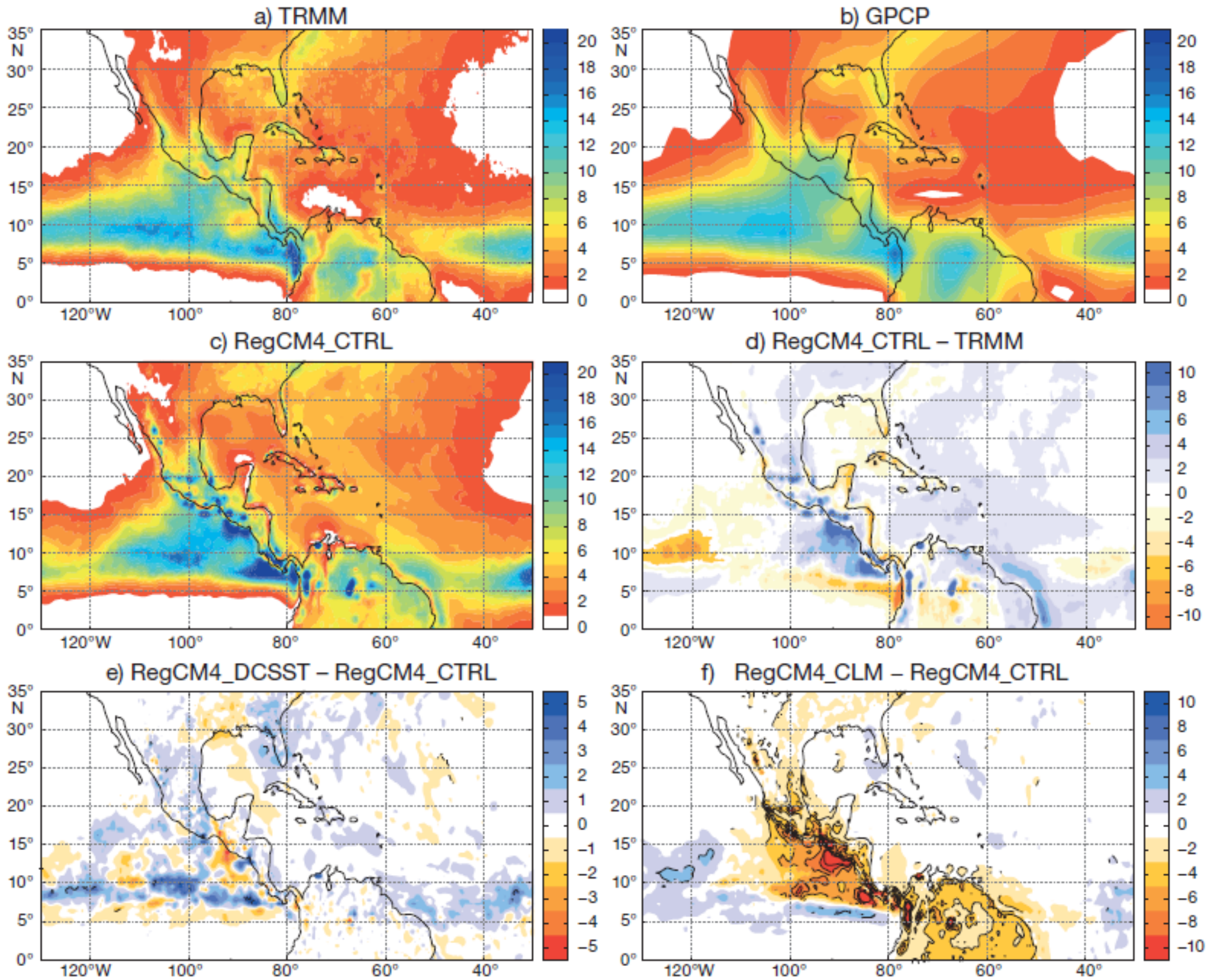
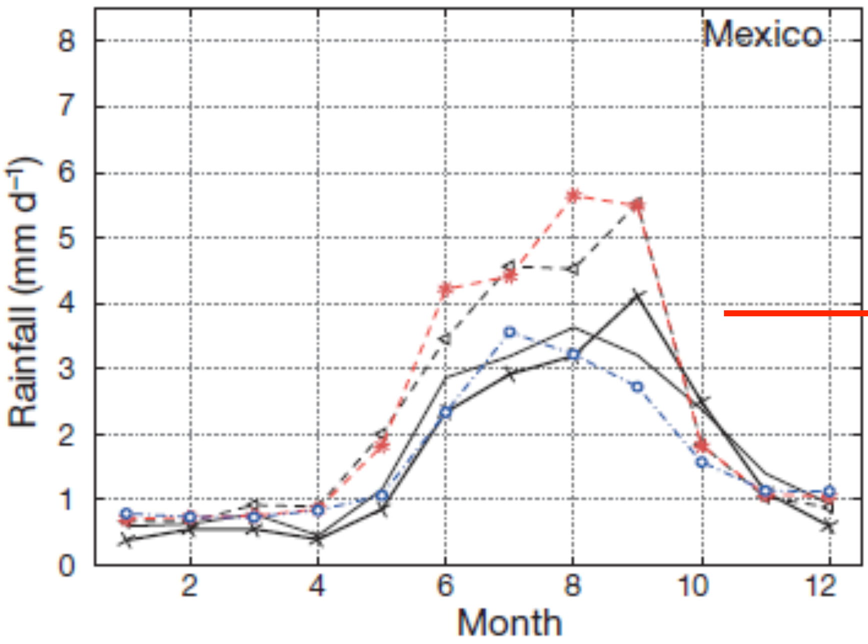


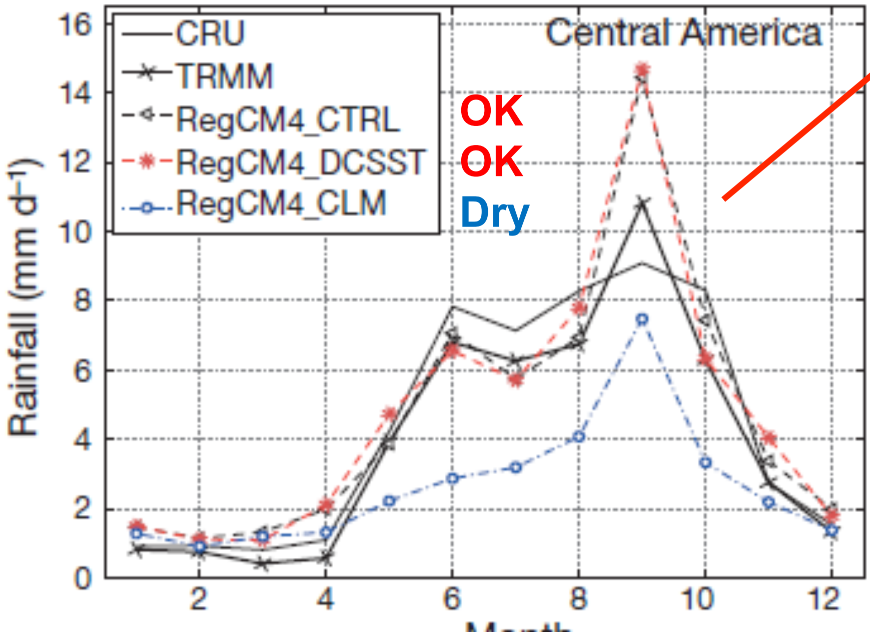
Fig. 2. JJAS mean precipitation (mm d^{-1}) for: (a) TRMM, (b) GPCP, (c) RegCM4_CTRL; and precipitation difference for (d) RegCM4_CTRL minus TRMM; (e) RegCM4_DCSST minus RegCM4_CTRL; and (f) RegCM4_CLM minus RegCM4_CTRL. Contour lines in the bottom-right panel: differences which are statistically significant at the 0.1 level

Mixed Convective Parameter.: Emanuel over oceans, Grell over land

CLM 3.5: Comm Land Model
➔ too DRY

CORDEX CAM





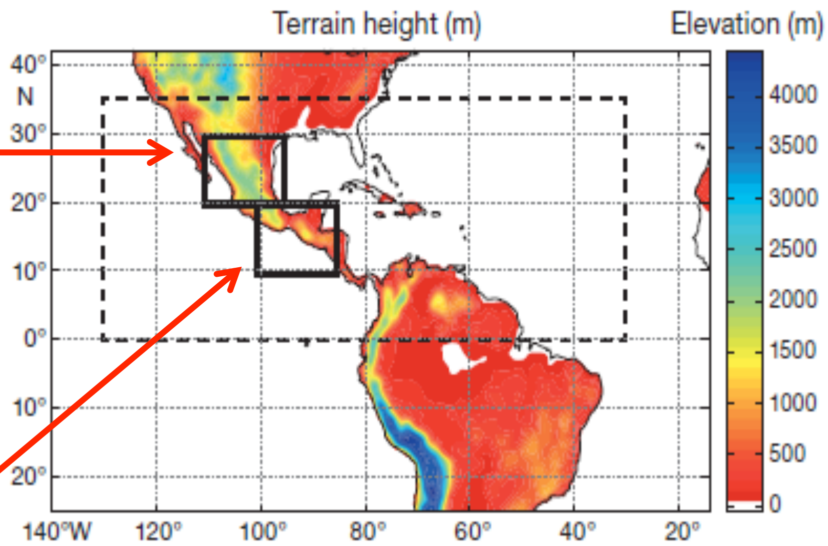


Fig. 1. Model domain and topography of the study region (dashed box). Solid boxes: subregions for which the annual cycle is analyzed — upper: Mexico; lower: Central America

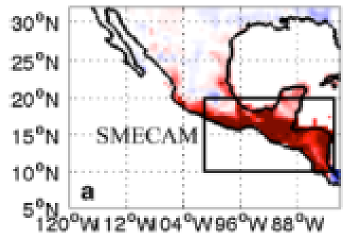
Diro et al. 2012

Clim Dyn (2015) 45:425–440
DOI 10.1007/s00382-014-2258-6

Clim. Dyn., 2015

Inter-annual variability of precipitation over Southern Mexico and Central America and its relationship to sea surface temperature from a set of future projections from CMIP5 GCMs and RegCM4 CORDEX simulations

Ramón Fuentes-Franco · Erika Coppola ·
Filippo Giorgi · Edgar G. Pavia · Gulilat Tefera Diro ·
Federico Graef



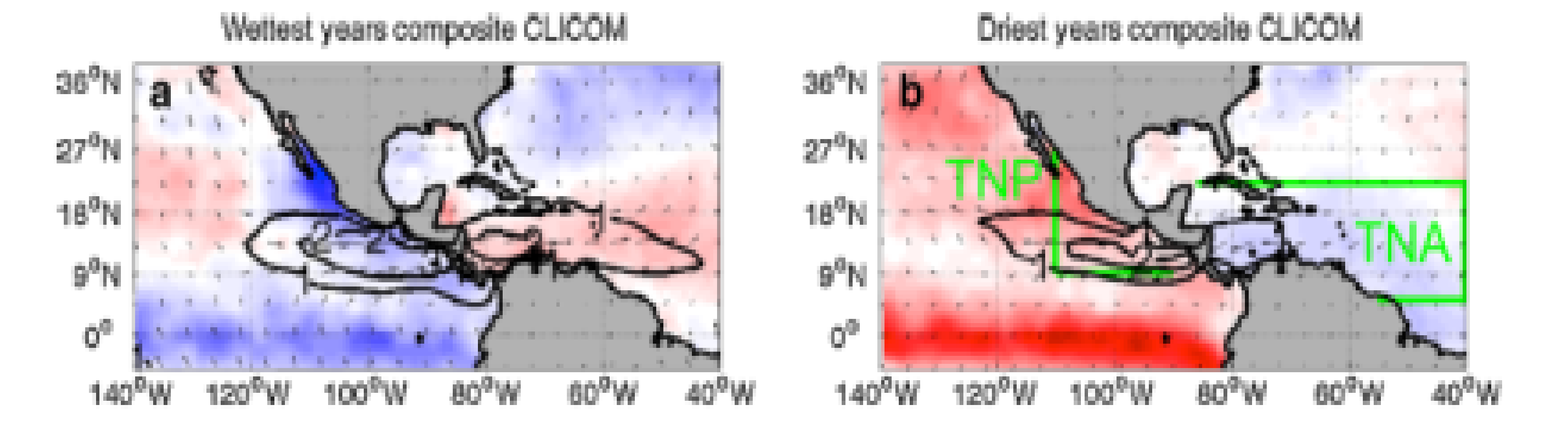
RegCM4 forced by HadGEM and MPI, 1970-2100 under RCP8.5.

Model Validation: It captures the CLLJ's present-day spatial and temporal characteristics reasonably well, as well as the dependence of precipitation on SST gradients. RegCM4 does a better job than the driving models.

Future scenarios: More drier summers linked to greater warming of the TNPac than the TNAtl, which is linked to a stronger CLLJ.

Precipitation and SST in extreme years

TNA – TNP = + → Wet conditions



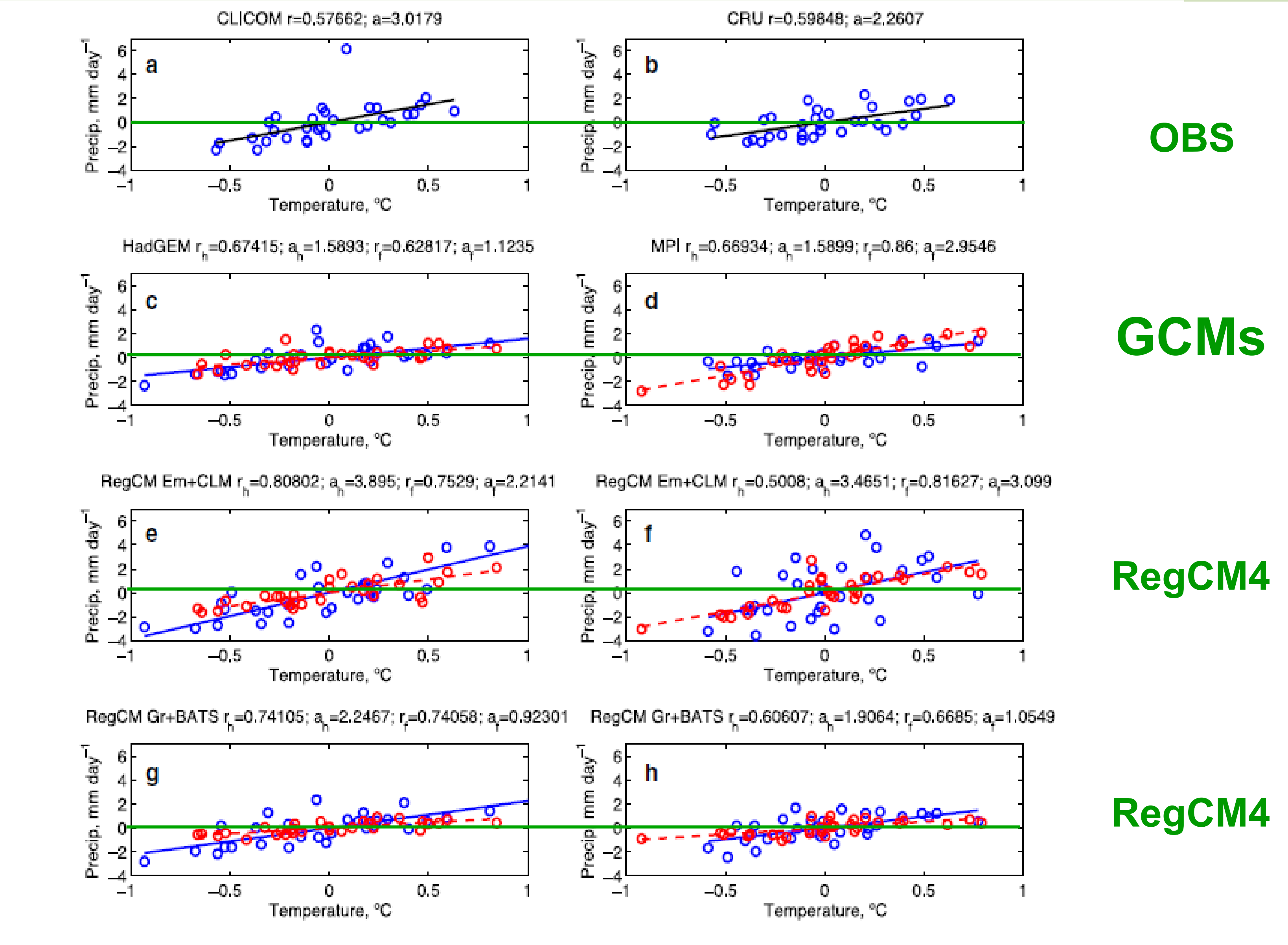
Wet years:

Warm TNA and Cold TNP

Weakens the CLLJ

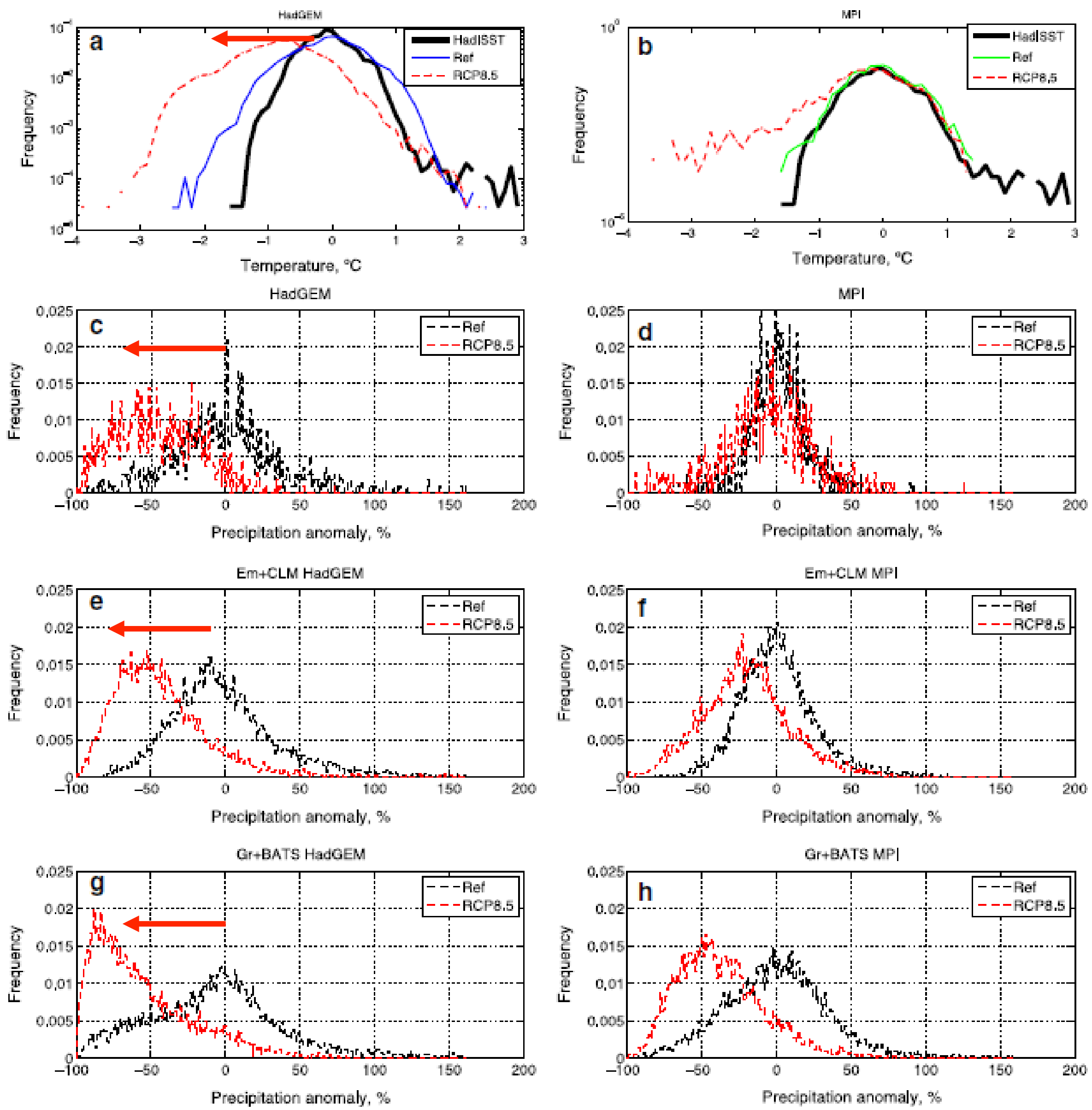
Precipitation vs TNA - TNP SST gradient

Historic ooo Future ooo



SST Gradient more negative in the RCP8.5 ➔ -Precip

CMIP5 GCMs and RegCM4 CORDEX simulations



OBS

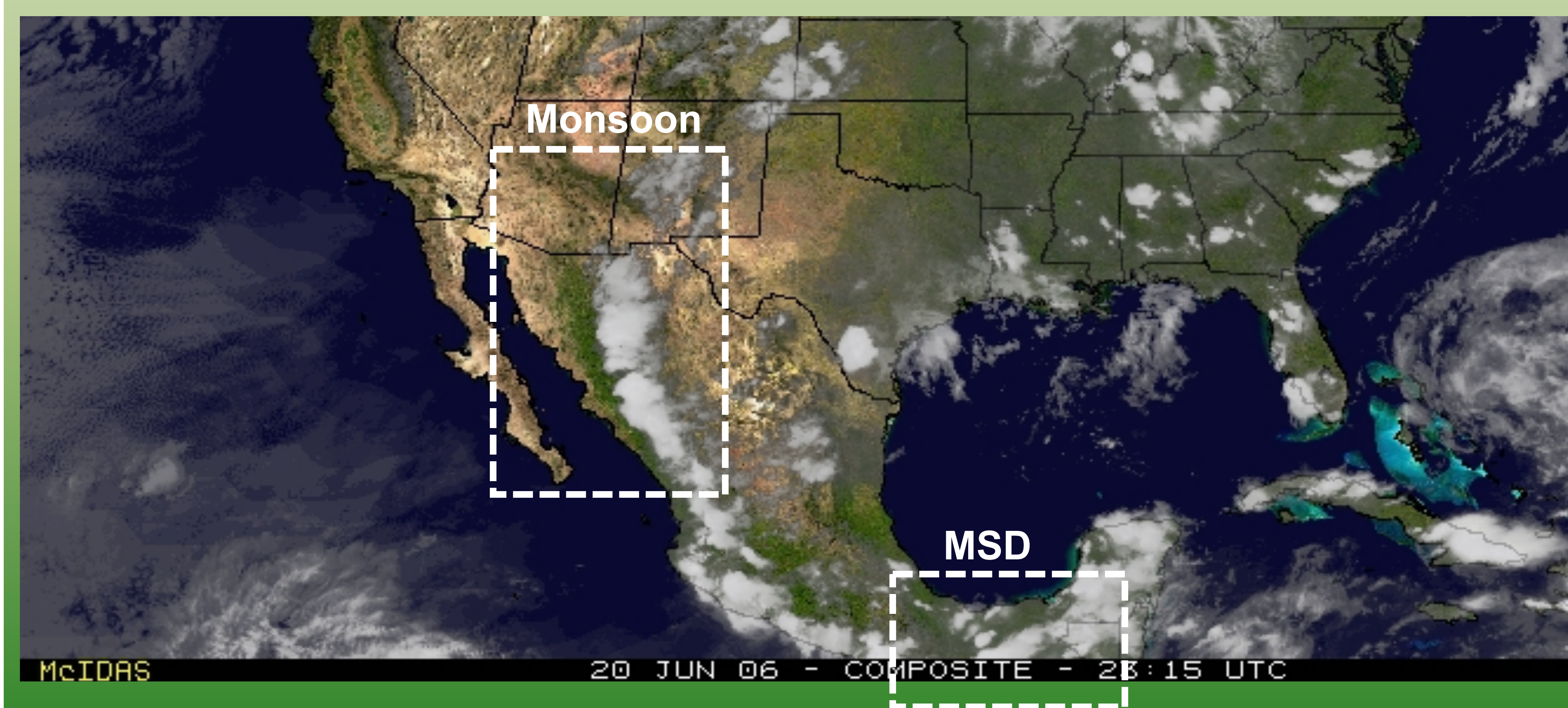
GCMs

RegCM4

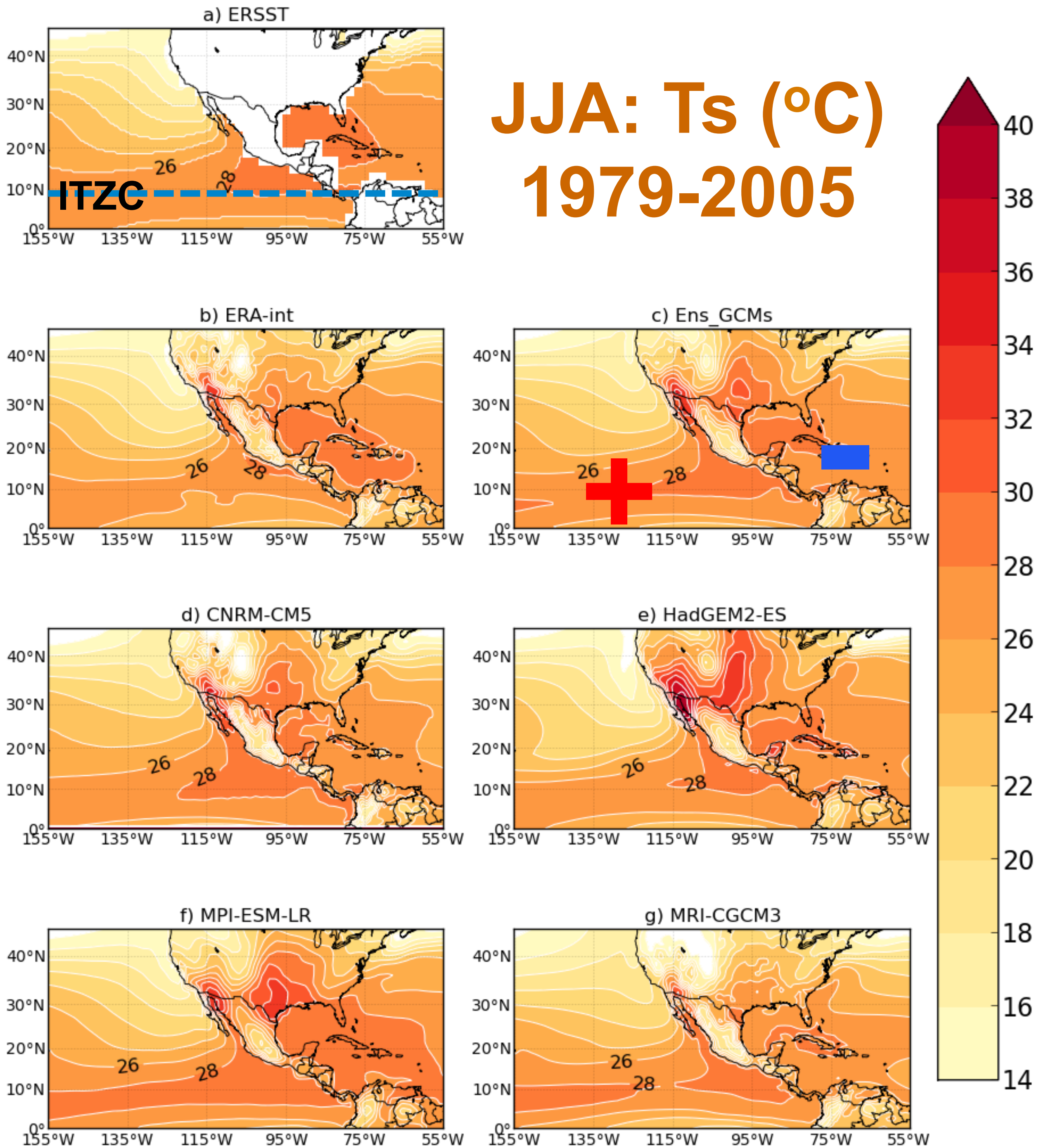
RegCM4

Studies in Progress
RegCM4, RCA, REMO, WRF, PRECIS

Extreme Events in NAM and MSD Intercomparison of Models CICESE Group



JJA: Ts (°C) 1979-2005



Problem with the SSTs in GCMs

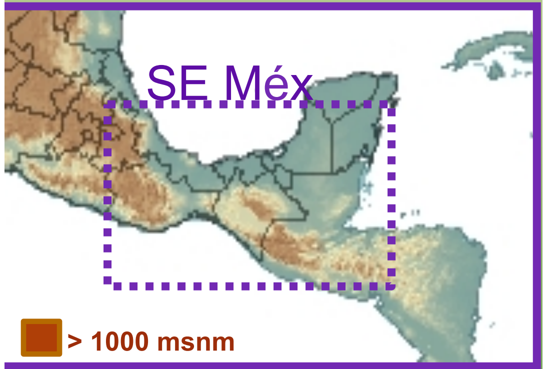
Inverse termal contrast

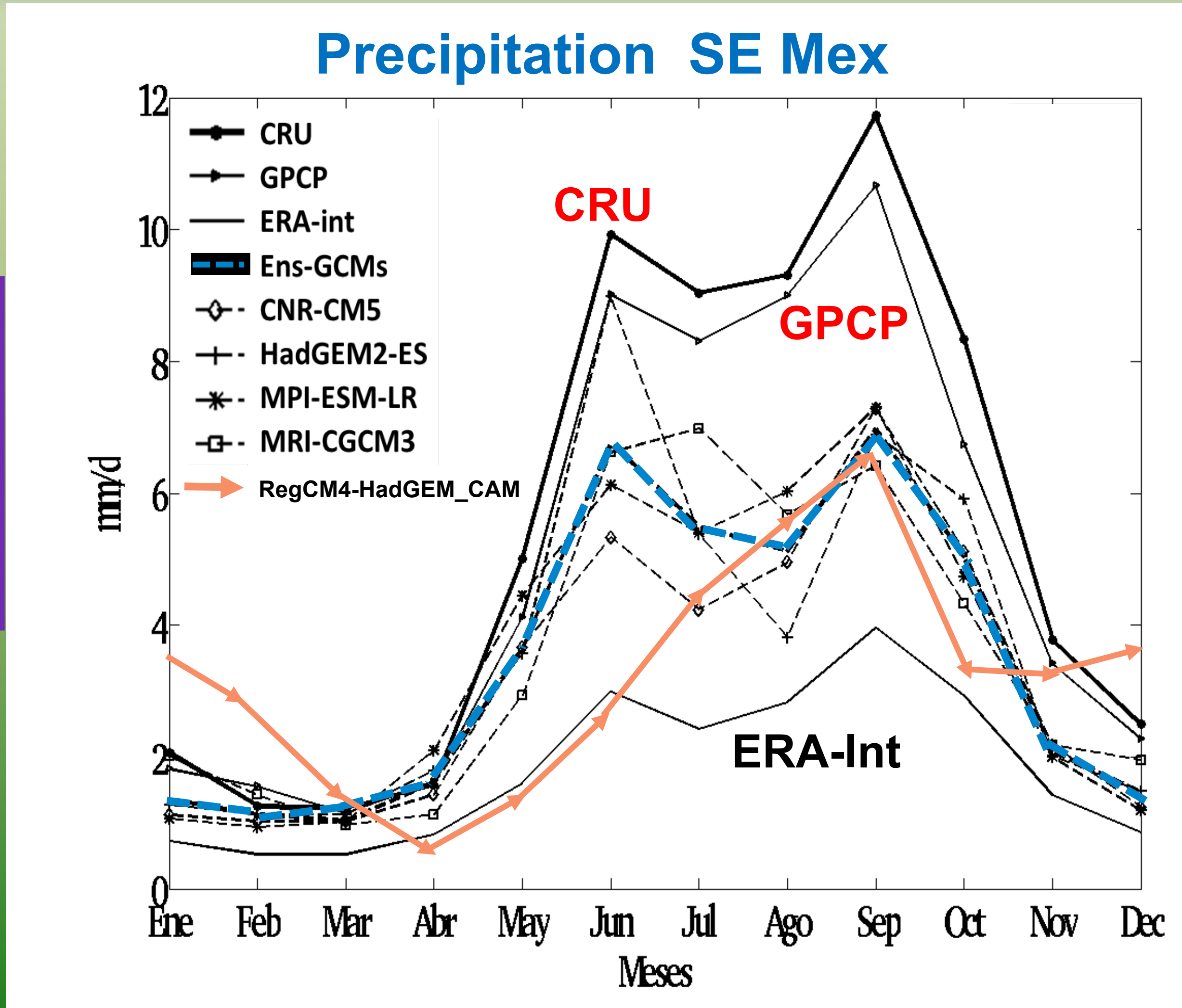
- Stronger CLLJ
- Reduced Precip

Several studies:

- Fuentes-Franco et al. 2015
- Cavazos and De Grau 2014
- Martínez-Sanchez & Cavazos 2014
- Torres-Alavez et al. 2014

SE México (Obs, 4 MCG, and RegCM4): Annual Cycle of Precip (mm/d) 1979-2005



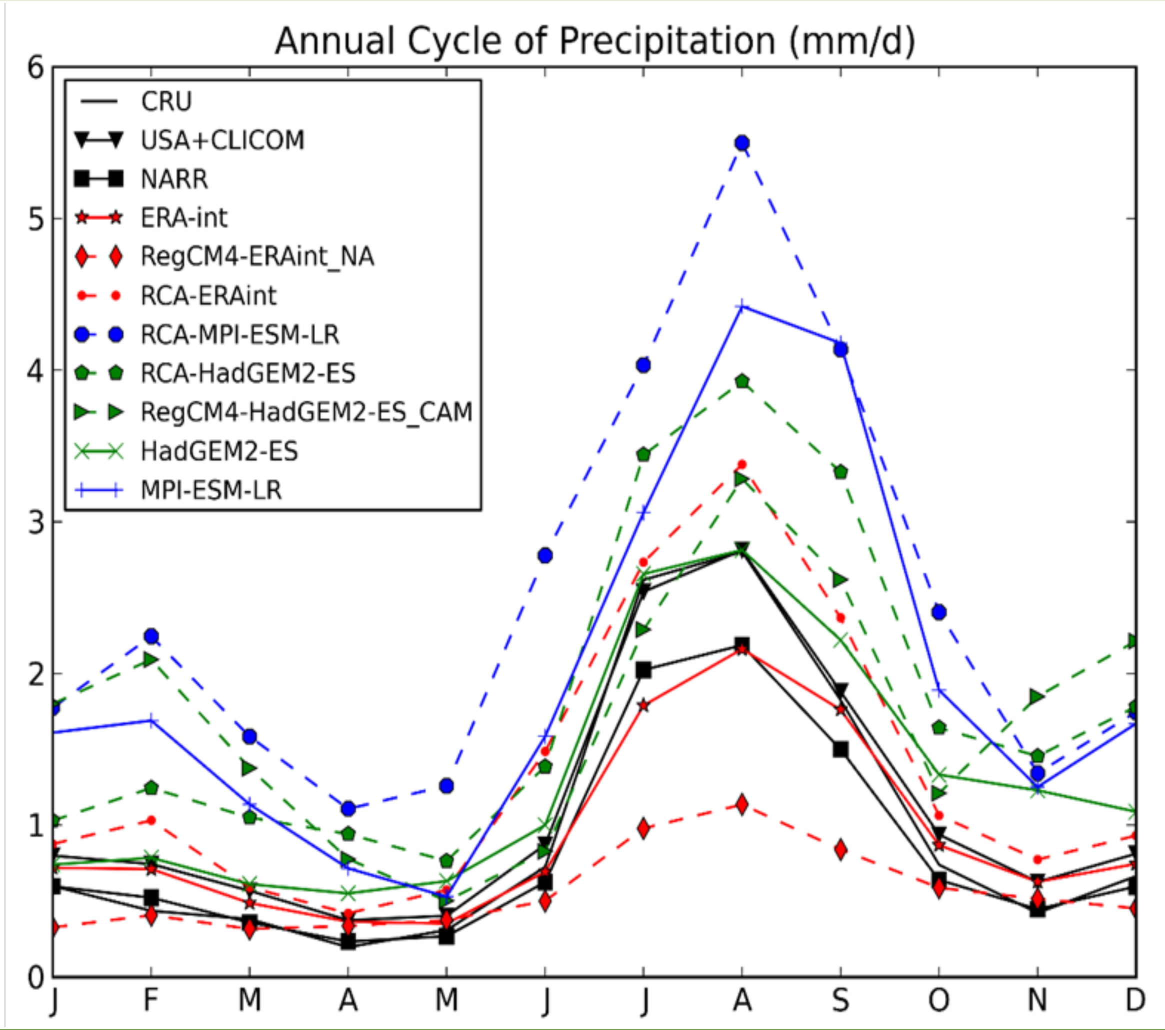


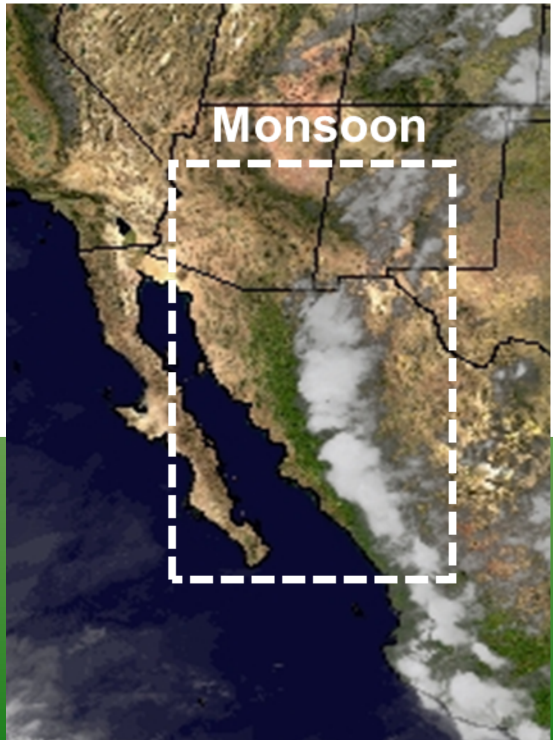
Cavazos and de Grau, 2014

OBS & Reanalysis

Regional Models

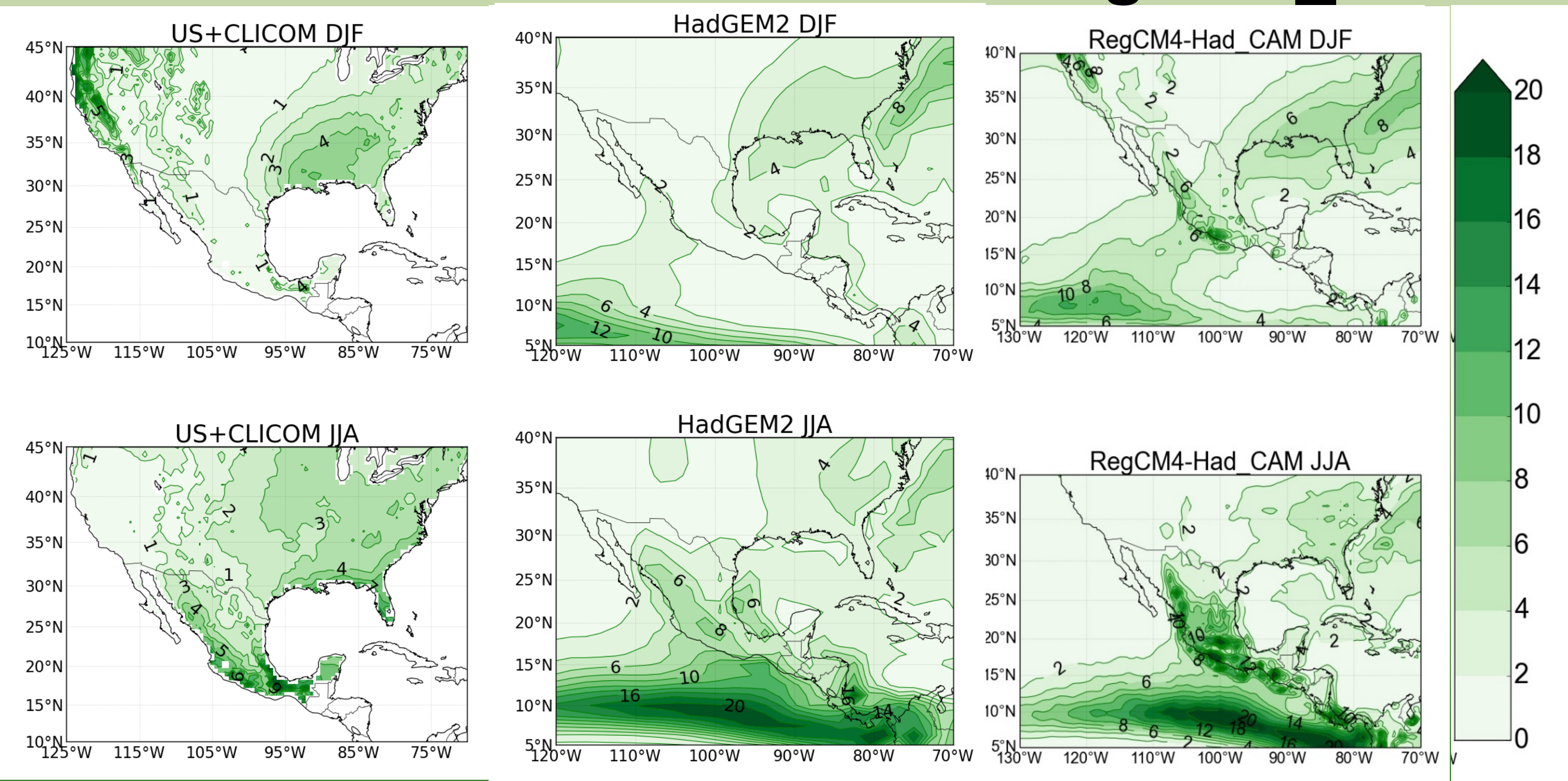
2 GCMs





DJF and JJA precipitation (mm/d) 1979-2005

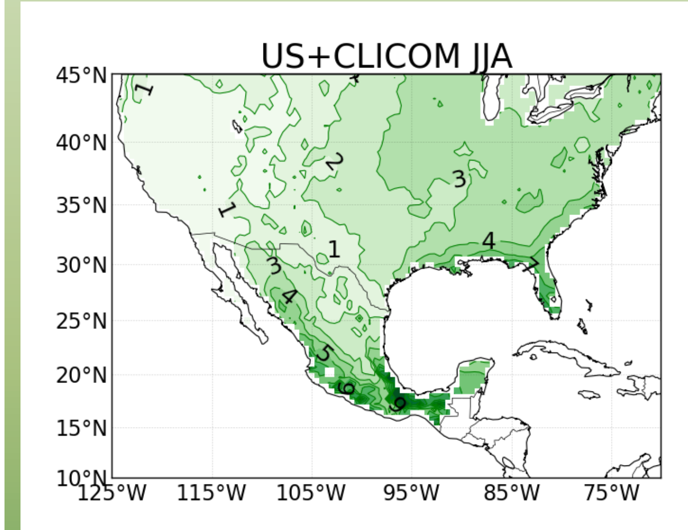
OBS **HadGEM2** **RegCM4_Had**



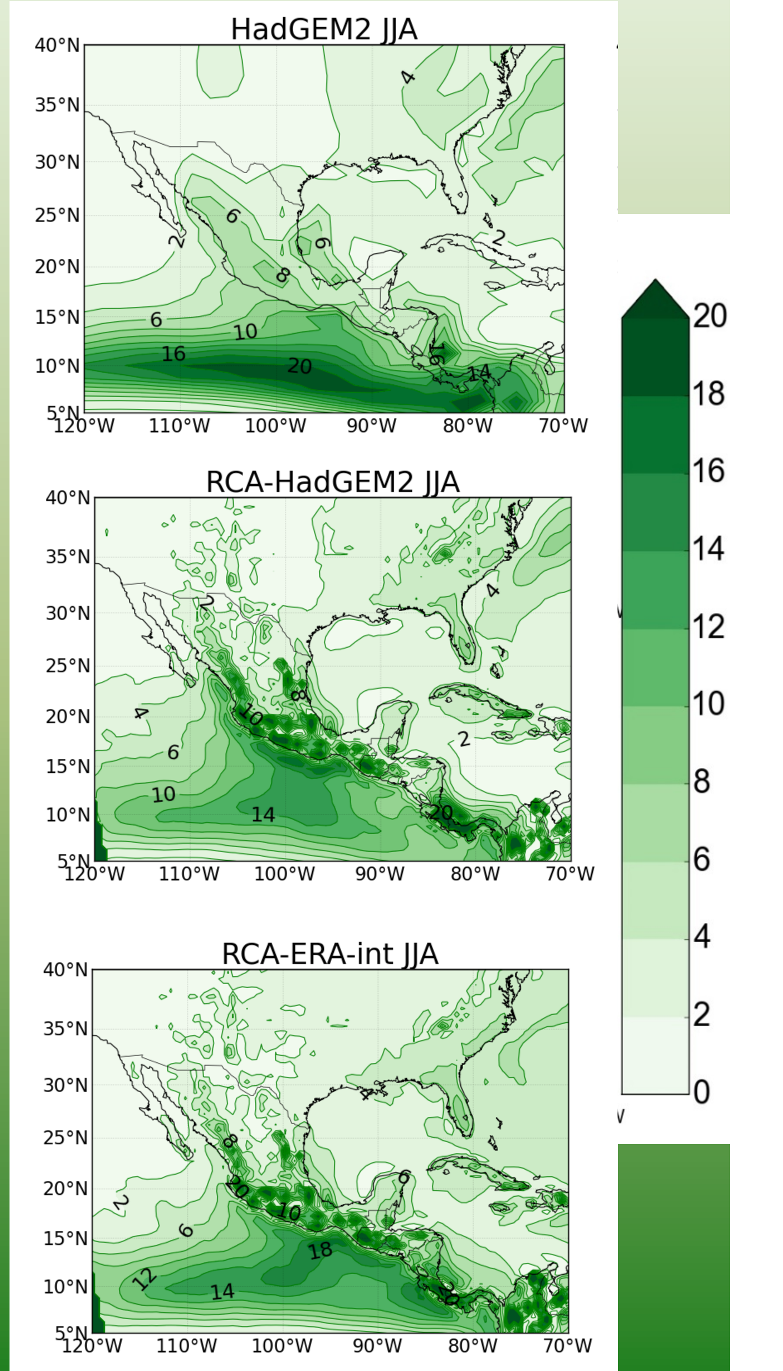
HadGEM2

RCA_Had

RCA_ERA



Obs JJA Precip (1979-2005)



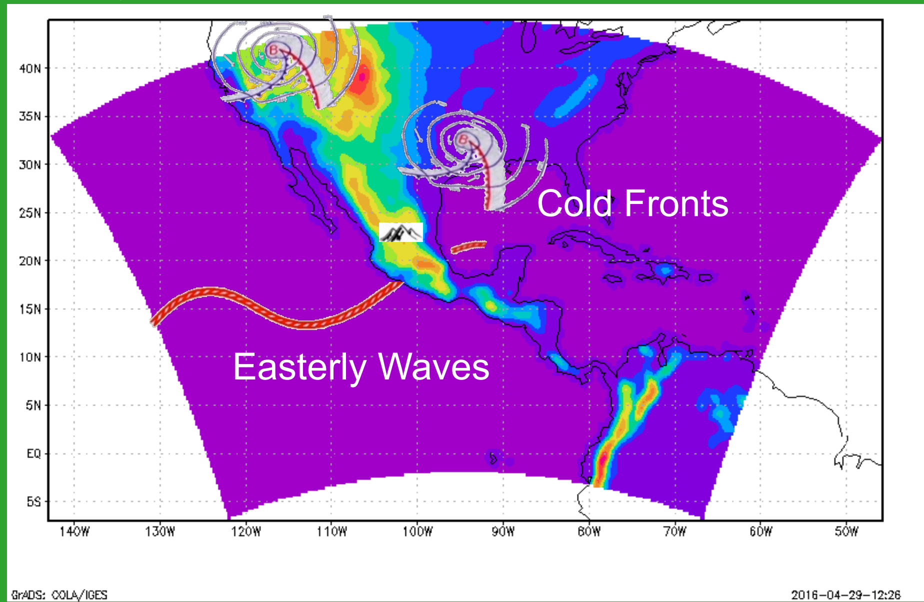
Dynamical Downscaling in Mexico

J. Antonio Salinas, M. Eugenia Maya, Constantina Hernández,
Martín Montero, and David Díaz

IMTA / SEMARNAT, Mexico

Cold Fronts and Easterly Waves

- Historical period: 1979-2005
- Temporal resolution : 6 hrs
- Spatial resolution: 25 km



Forcing GCM

CNRM

1.4°

Regional Models

RegCM4

cWRF

Costa Rica Group
RegCM4 and WRF

Sensitivity of precipitation and atmospheric low-level circulation patterns to domain size in RegCM.v.4.4 over Central America

Erick R. Rivera [1, 2], Jorge A. Amador [1, 2], Fernán Sáenz [2], and Juan J. Vargas [2, 3]

[1] School of Physics, [2] Centre for Geophysical Research, and

[3] School of Computational Sciences and Informatics

University of Costa Rica, 11501 San Jose, Costa Rica

Email: erick.rivera@ucr.ac.cr

Objective: **To test the sensitivity of precipitation distribution and the atmospheric low-level circulation patterns within CCA to domain size and convective parameterizations using RegCM4.**

Domain changes in 10°: increases in all boundaries, increase in north and south limits, and increase in east and west limits.

Convective schemes: Grell over land and Emanuel over ocean

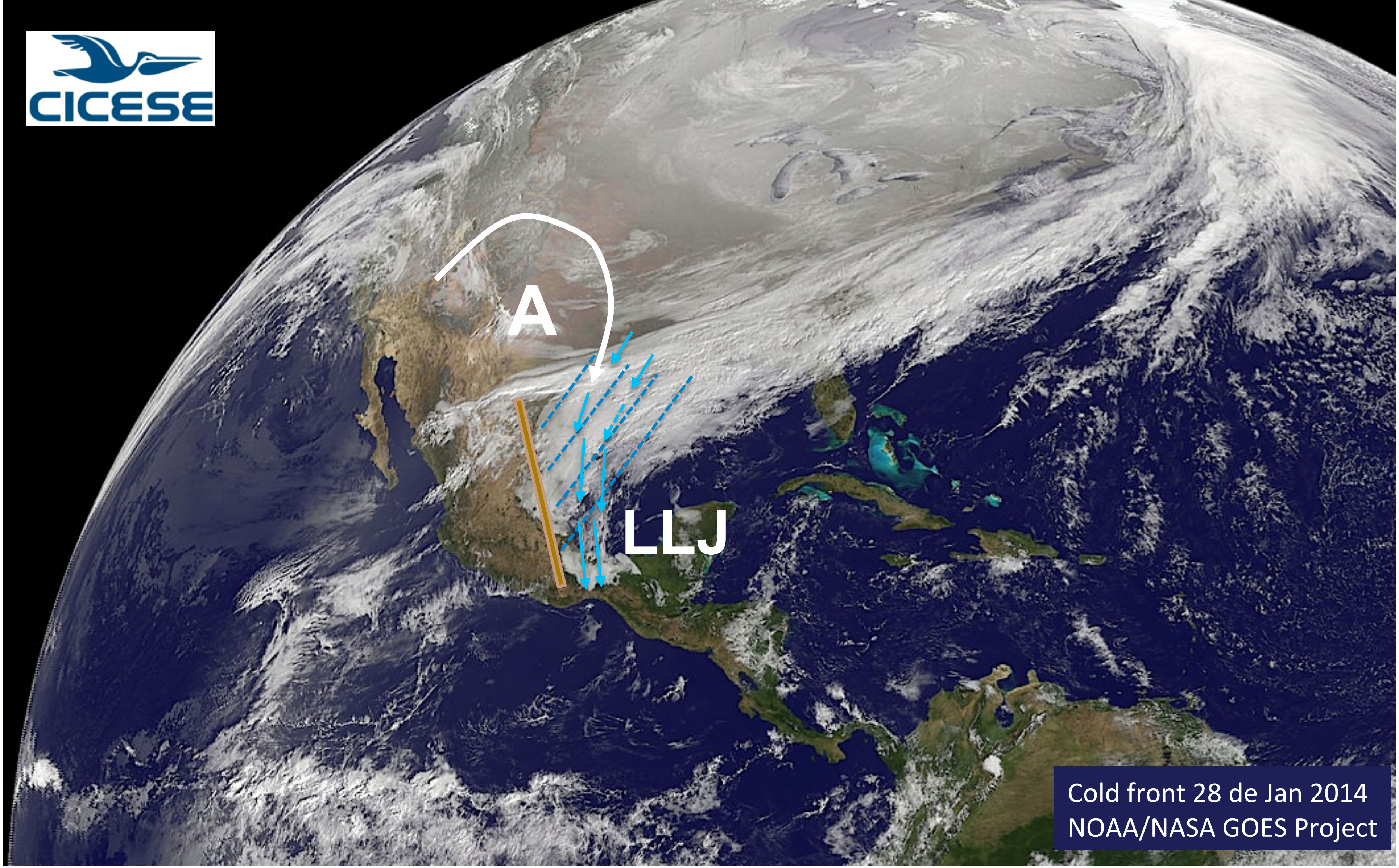
Forced with Era-Interim during 7 years

Validation of processes: Precipitation, CLLJ, Choco Jet.

Thermodynamical Evolution of Cold Fronts/Nortes Using Regional Models (WRF and RegCM4)

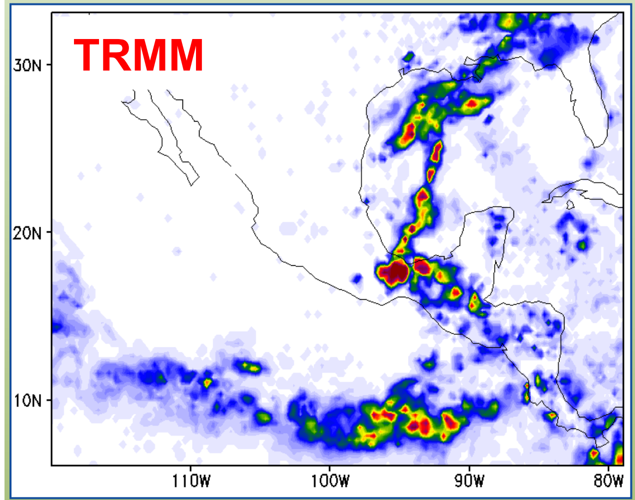
Rosa B. Luna and Tereza Cavazos

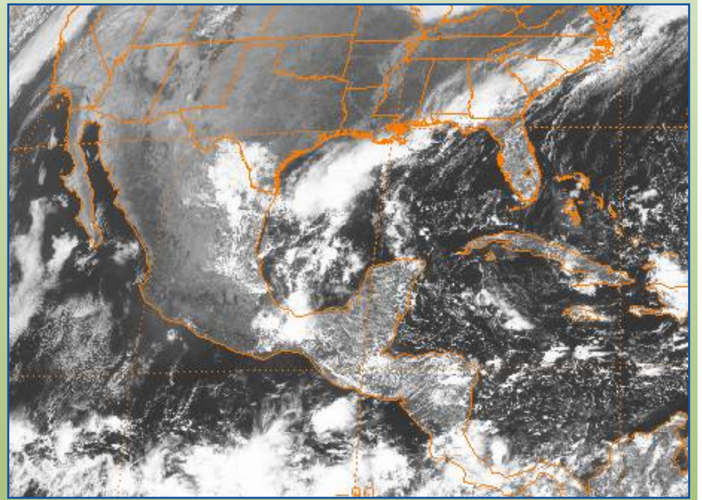
CICESE



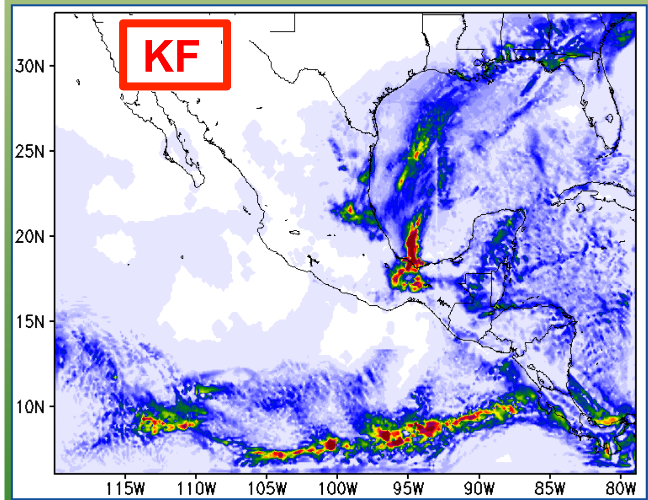
Cold front 28 de Jan 2014
NOAA/NASA GOES Project

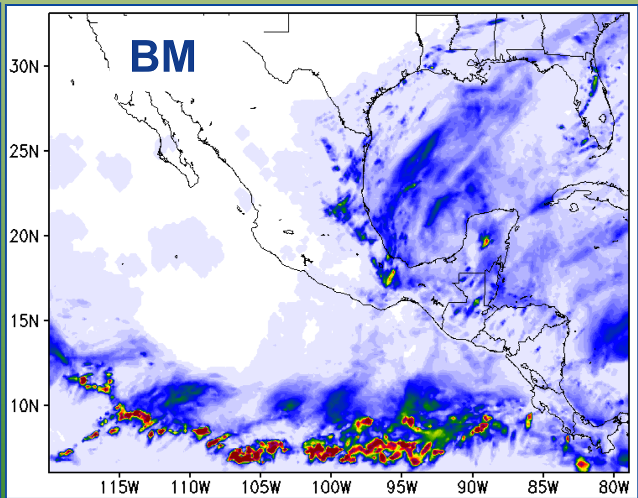
Observed Precipitation vs WRF forced by CFSR
36 and 12 Km Resolution, 28 de Oct de 2010

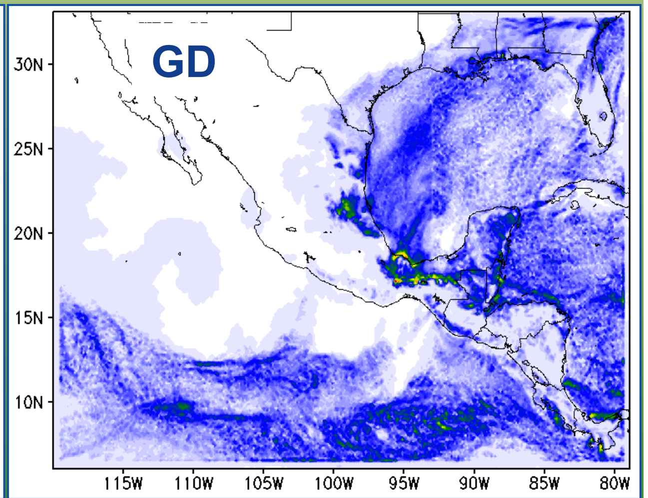


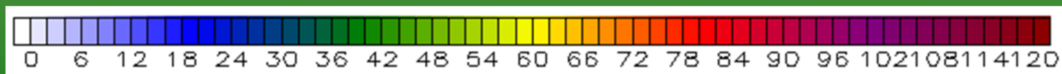


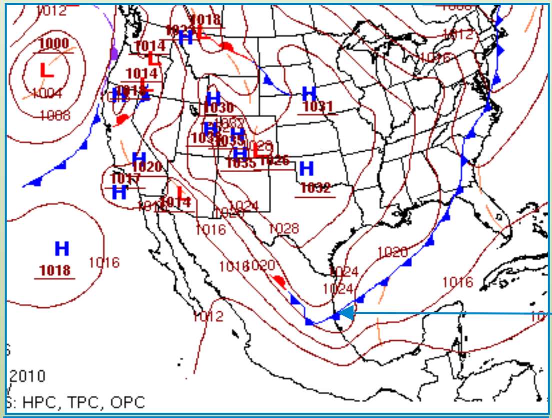
Testing Convective Parameterizations



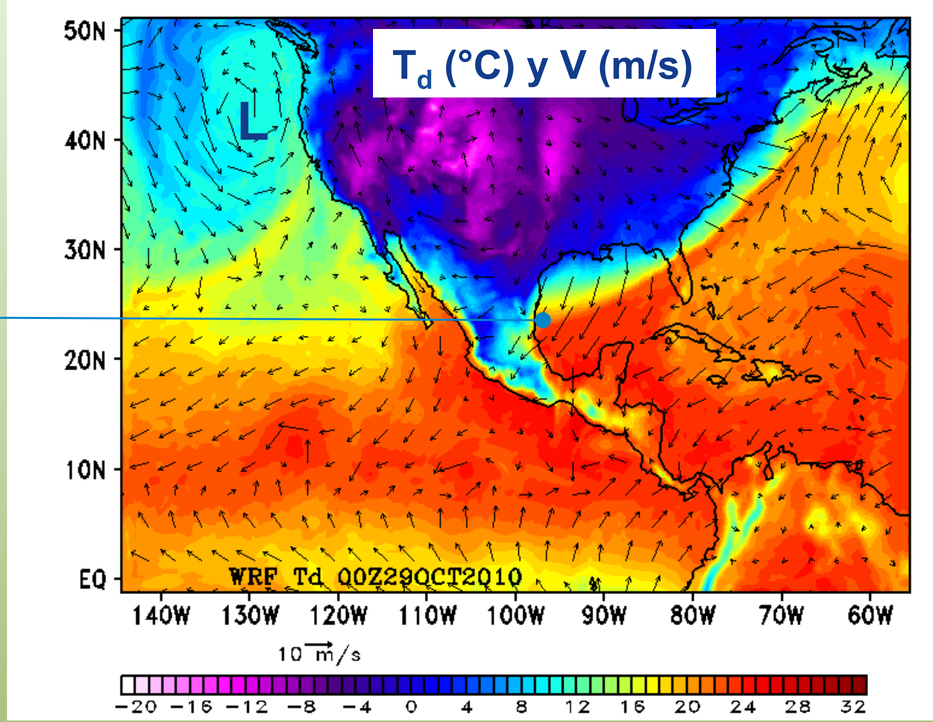


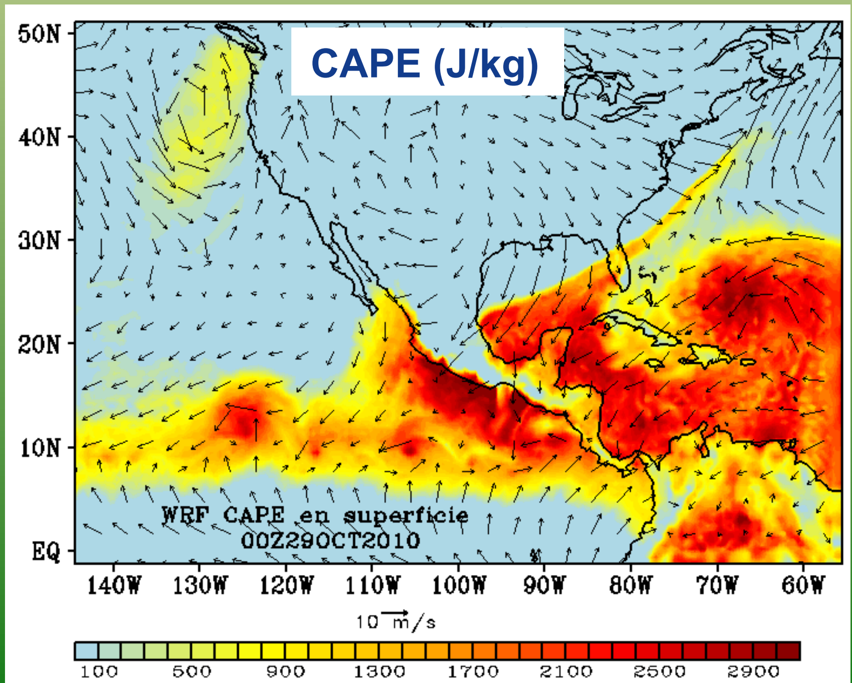




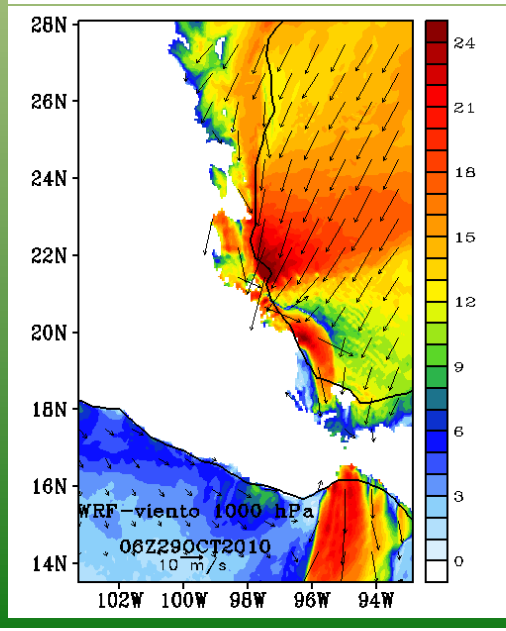


NOAA, 29 OCT 00Z 2010, SFC
Strong Cold front/Norte with LLJ





Sfc winds (m/s): 29 OCT 06Z



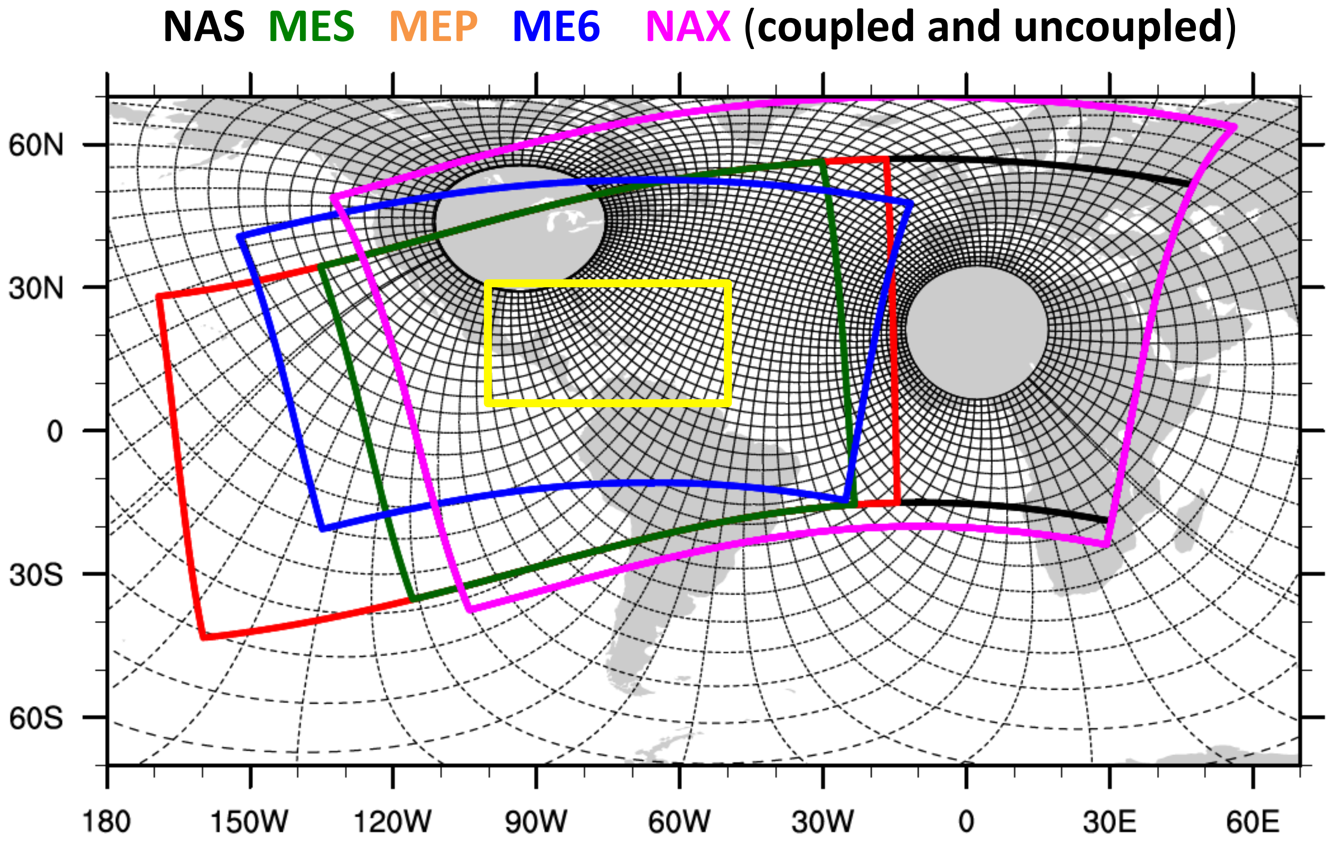
The role of internal and external variability in the simulated Caribbean climate using REMO

William Cabos [1], Dmitry V. Sein[2], Francisco Álvarez-García[1], Nikolay Koldunov[3], Daniela Jacob[3]
[1]University of Alcala, [2]Alfred Wegener Institute, [3]Climate Service Center

Objective: To explore the CLLJ and MSD using the **coupled and uncoupled REMO** model under different resolutions

PHYSICALY MOTIVATED ELECTION OF DOMAINS

Important forcings are provided by the "perfect" reanalysis



ME6 is extended Central American CORDEX

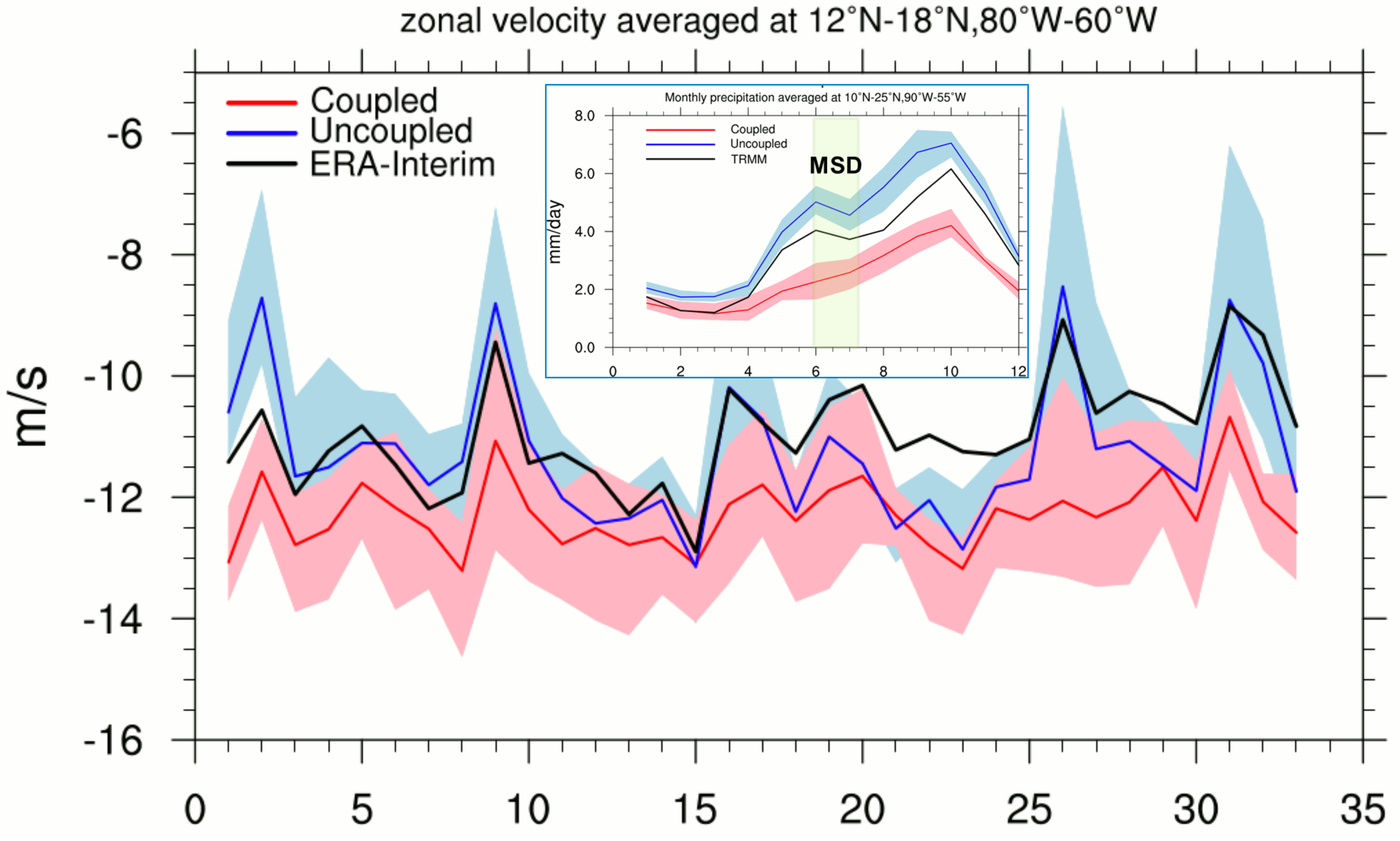
NAX postprocessing

Forcing: ERA-Interim (1980-2012)

NAS (1/2°, 1/4°), **MES** (1/2°), **MEP** (1/2°), **ME6** (1/2°, 1/4°), **NAX** (1/8°)

Interannual variability of the JJA Mean CLLJ

Stronger CLLJ with coupled model



University of Alberta
Edmonton, Canada

Marissa Castro M., MSc Student

Thesis: Spatial modeling of water availability for ecosystem services in the tropical dry forest of Santa Rosa National Park at Costa Rica

Objective: To evaluate the natural variability and possible implications of climate change in water availability using CORDEX CAM model outputs

3 Other students: Working with drought, forest structure, land use and soils at the same area. They also have to analyze climate change implications on their respective works.

Linear and nonlinear sensitivity to convective parameterization and resolution in simulations over Central America

R. Arritt, Iowa State University

EGU Abstract

Objectives: To examine the effect of 4 convective parameterizations and resolution in precipitation

Resolution and Period: CORDEX standard **50 km grid spacing and at 25 km spacing**; 1989-2008

Convective Parameterizations: Kuo-Anthes scheme; 2 Grell versions, and the Emanuel scheme.

Results: Kuo-Anthes scheme and Grell scheme with quasi-equilibrium closure are too dry, while the Emanuel scheme is more realistic over South America, but it is too wet in Central America.

The results vary with resolution !

Implementation of RegCM4 for seasonal climate prediction in Mexico

Raúl Méndez, **Bachelor Thesis**, Advisor: Matías Méndez
Universidad Veracruzana, Xalapa, Mexico

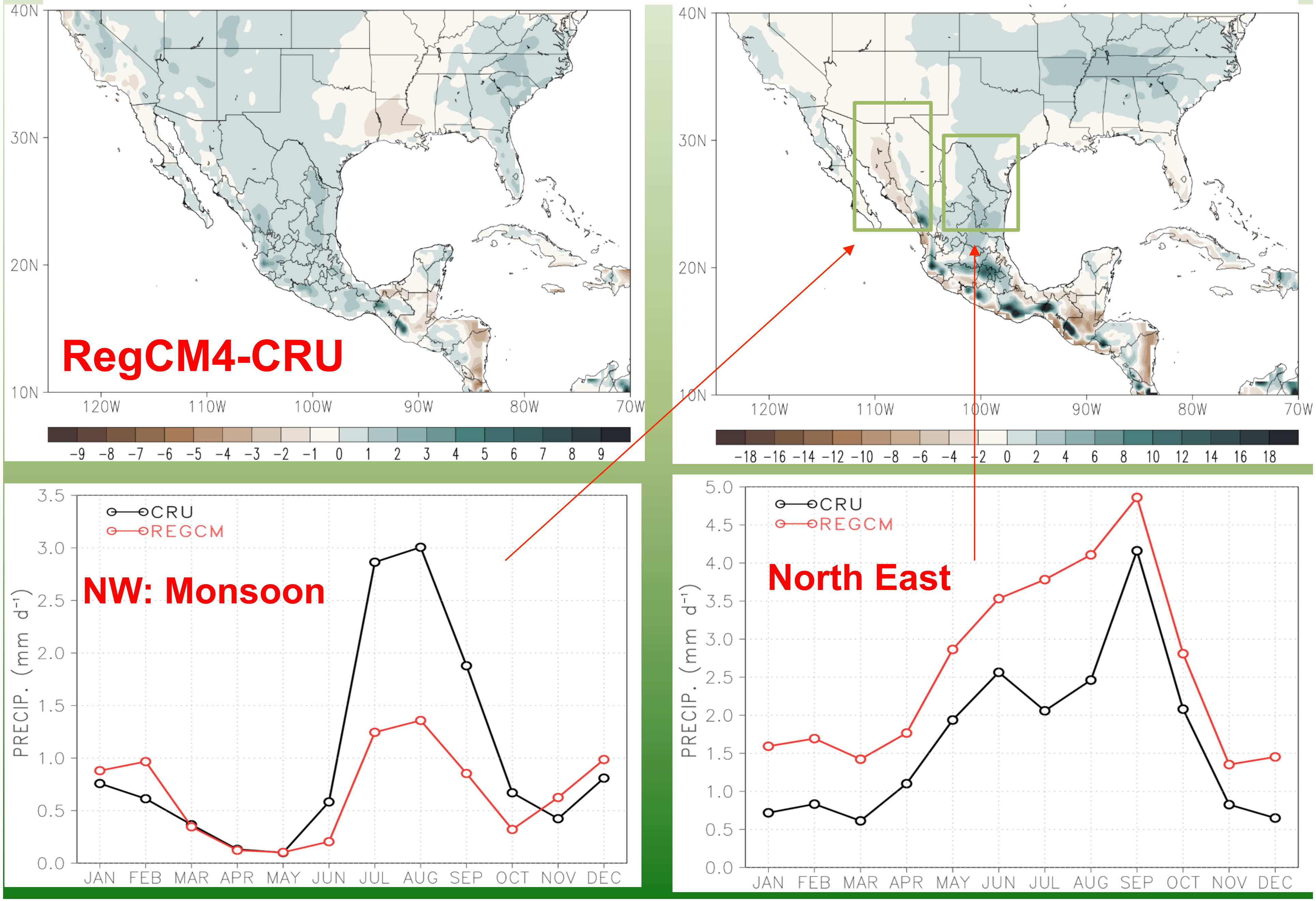
RegCM4 configuration used by Diro et al. (2012), forced by ERA-Interim

Caracteristics

- Resolution: **50 km x 50 km, 6 hs**
- Period: **1979-2012**
- Vertical levels: **18 (sigma)**

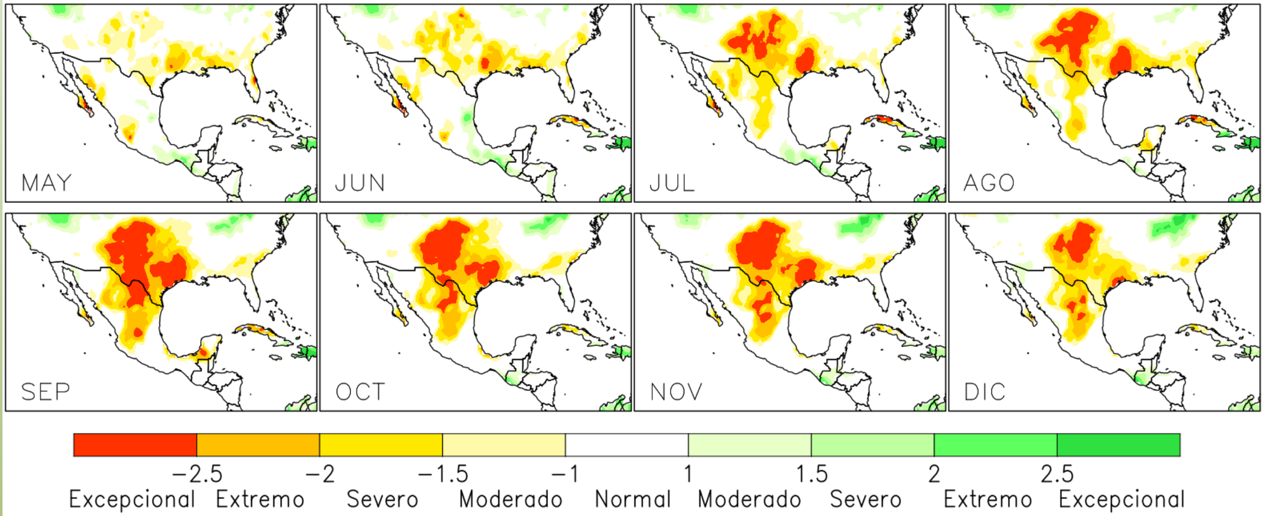
DJF Precip anom (mm/d)

JJA Precip anom (mm/d)



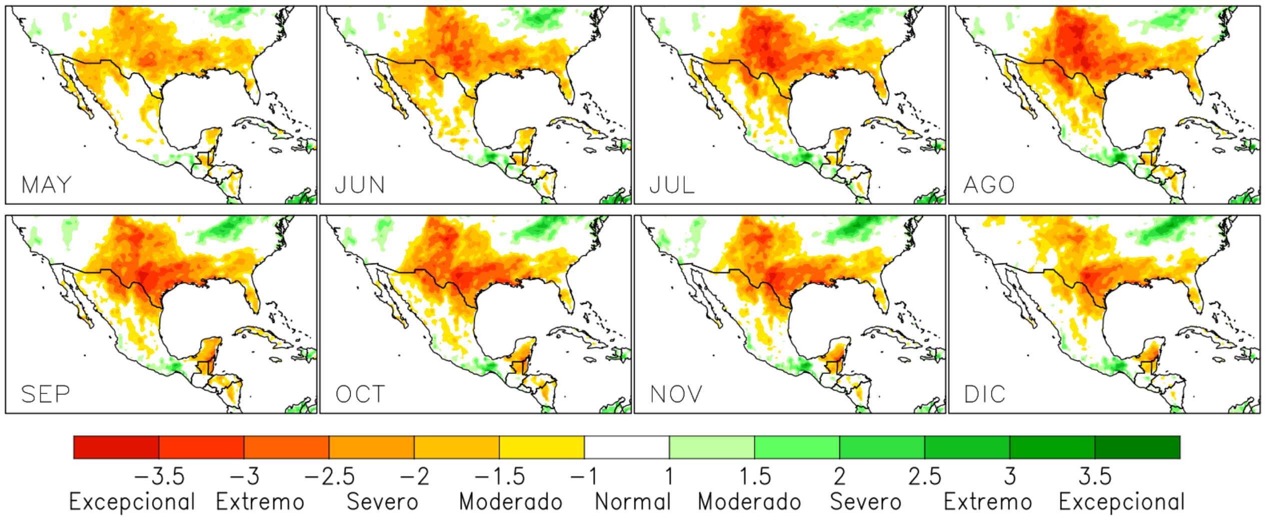
3-6 month prediction 2011

OBS
CRU



Dry Wet

RegCM4

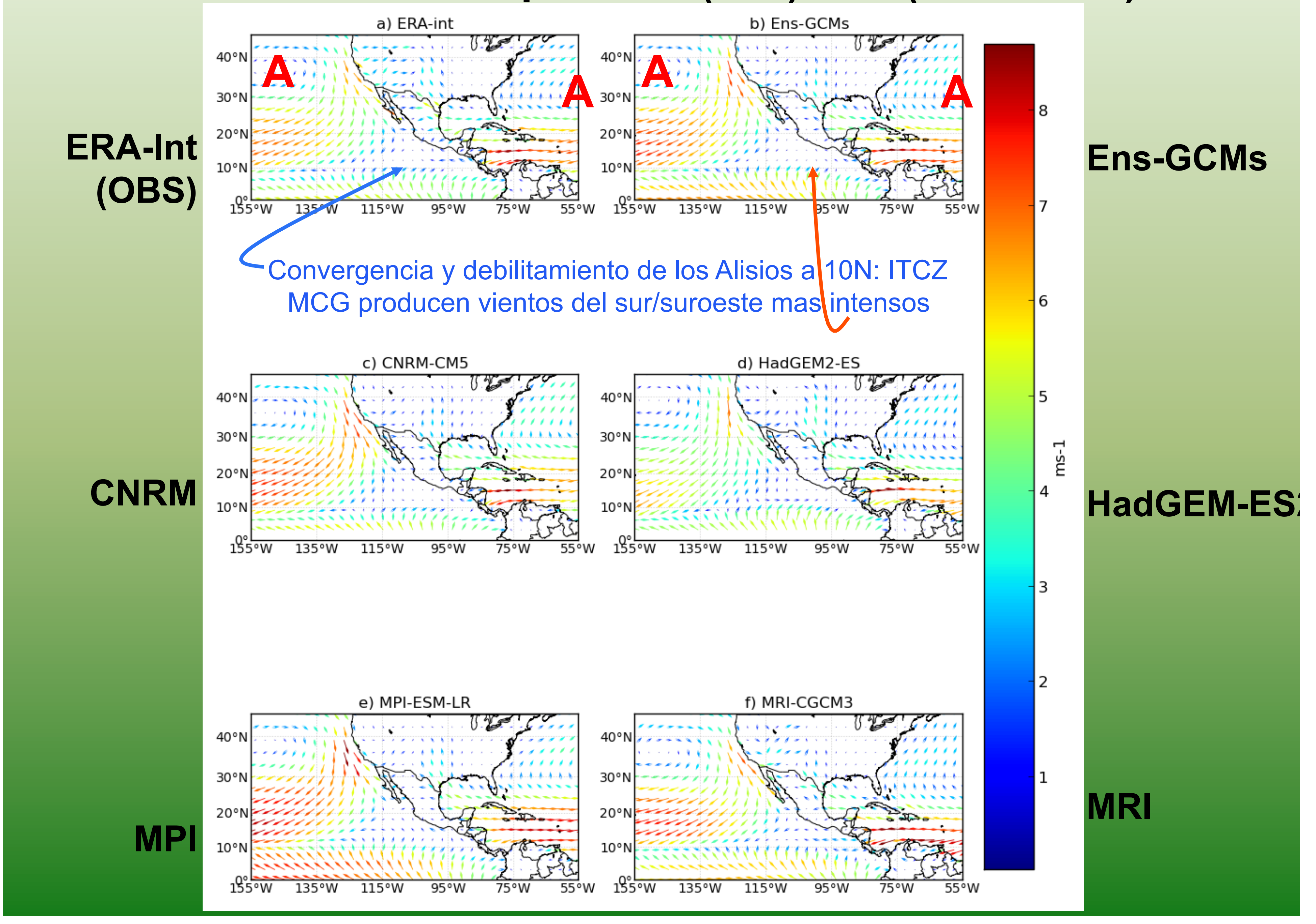


Too Dry

OK

Dry Wet

Vector de viento superficial (m/s) JJA (1979-2005)

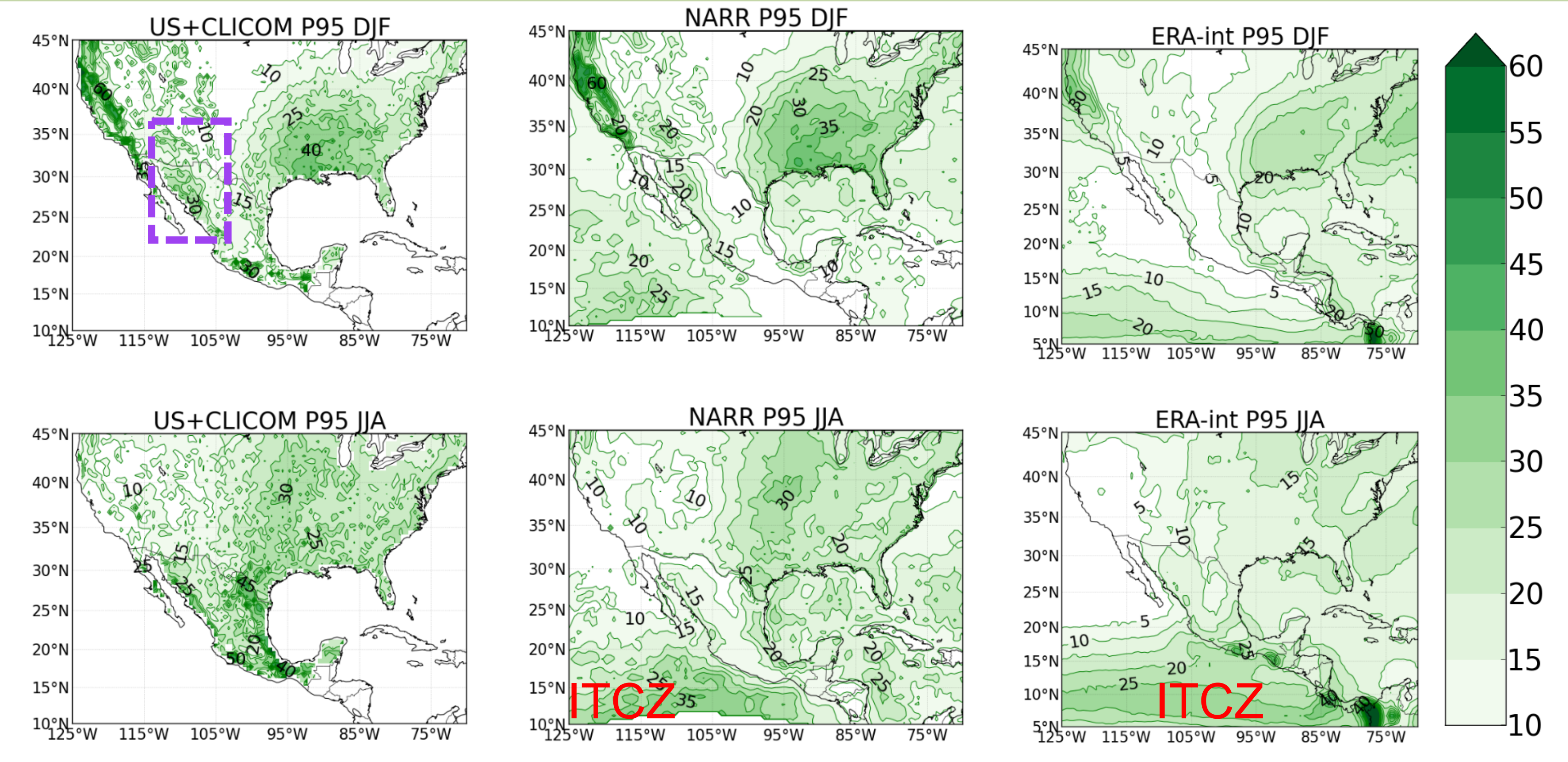


OBS: Mean P95 Thresholds of Precip (mm/d) for DJF and JJA (1979-2005)

P95: 25-30 mm | 15-20 mm | 10 mm ➔ NAM region

DJF

JJA



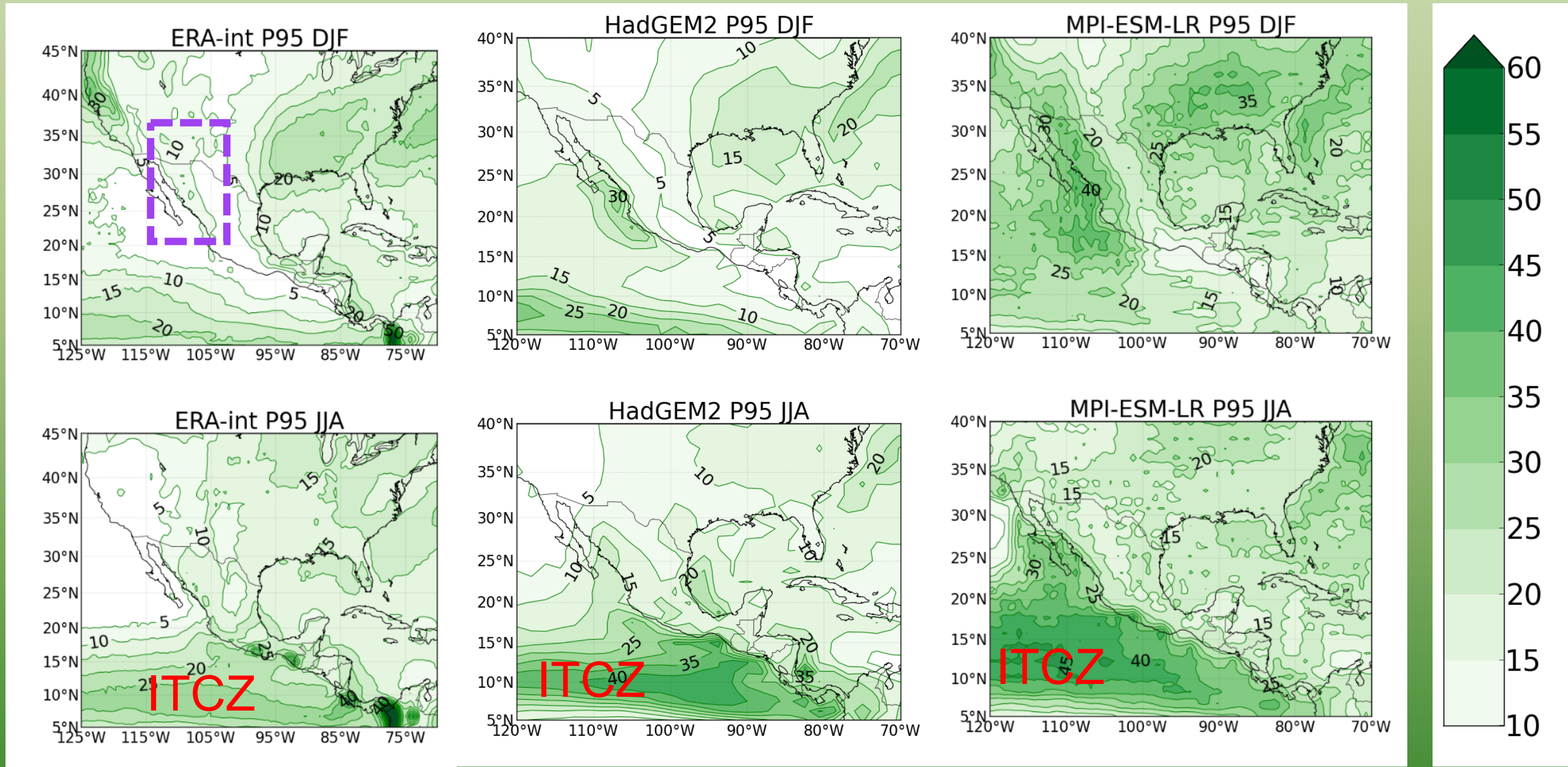
P95: 15-25 mm US+CLICOM | 10-15 mm NARR | 10 mm ➔ NAM región ERA-Interim

GCMs: Mean P95 Thresholds of Precip (mm/d) For DJF and JJA (1979-2005)

P95: 10 mm   5-30 mm   20-40 mm

DJF

JJA



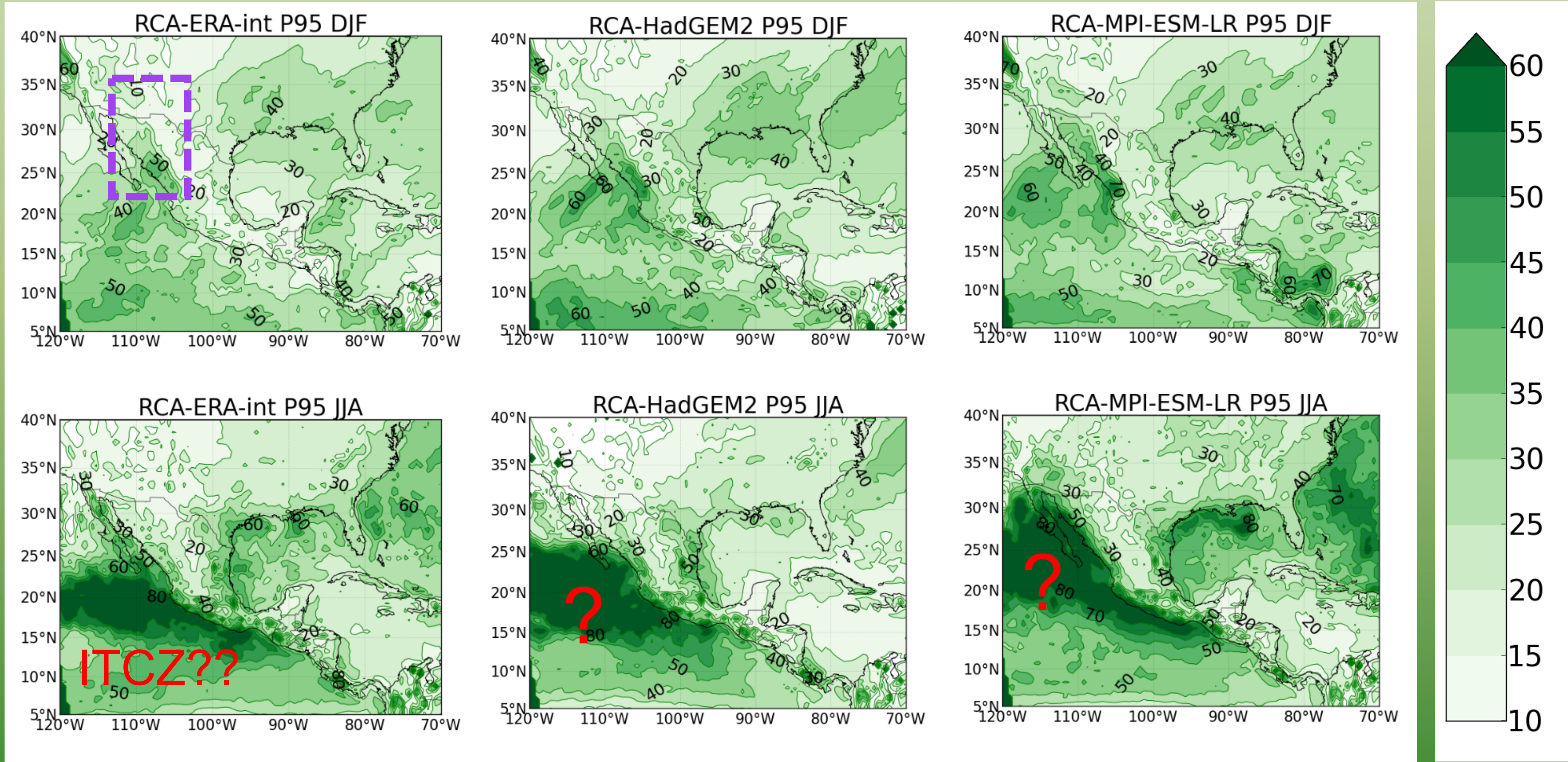
P95: 5-10 mm ERA-Interim   5-15 mm HadGEM2   15 mm MPI ➔ NAM region

RCA: Mean P95 Thresholds of Precip (mm/d) for DJF and JJA (1979-2005)

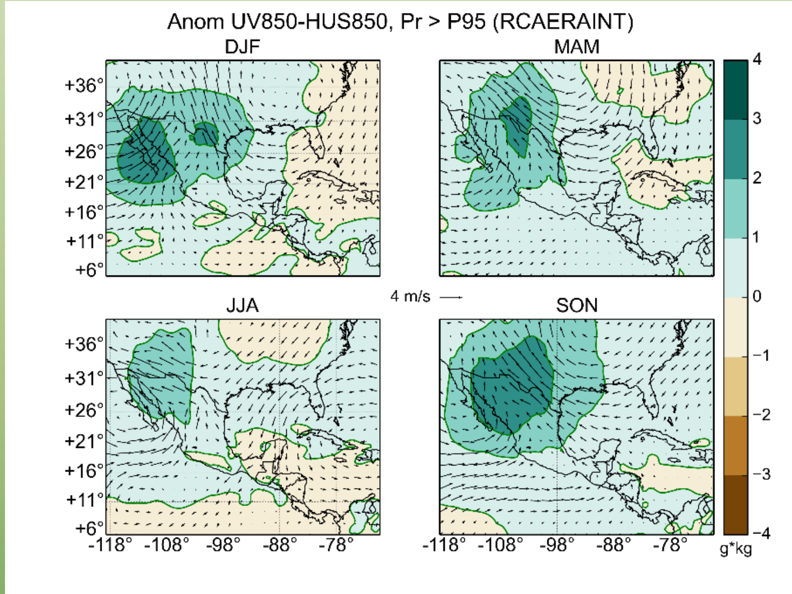
P95: 50 mm | 20-30 mm | 20-40 mm

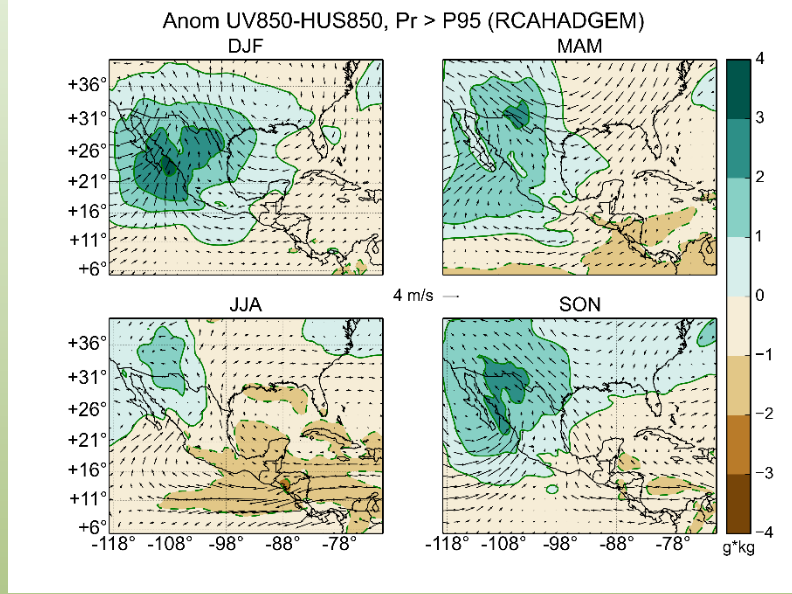
DJF

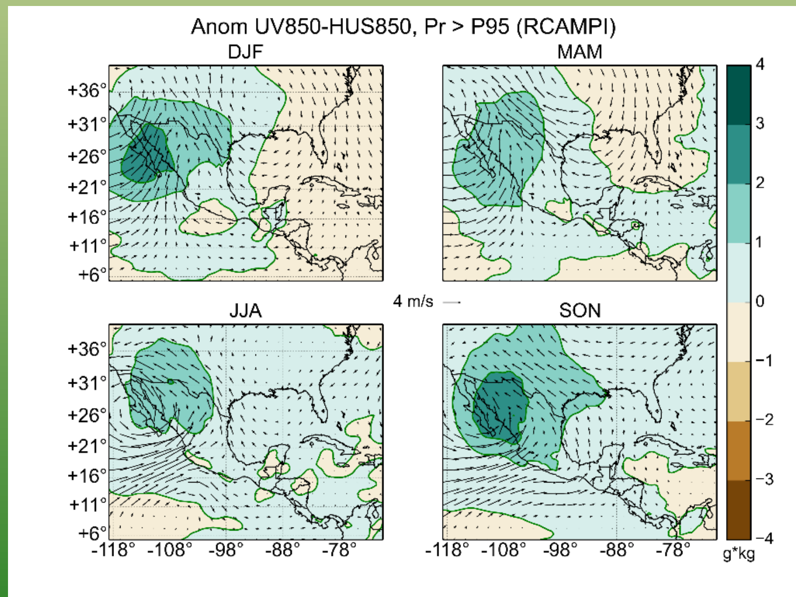
JJA



P95: 20-50 mm RCA-ERA-Interim | 20-30 mm RCA-HadGEM2 | 30-50 mm RCA-MPI → NAM region

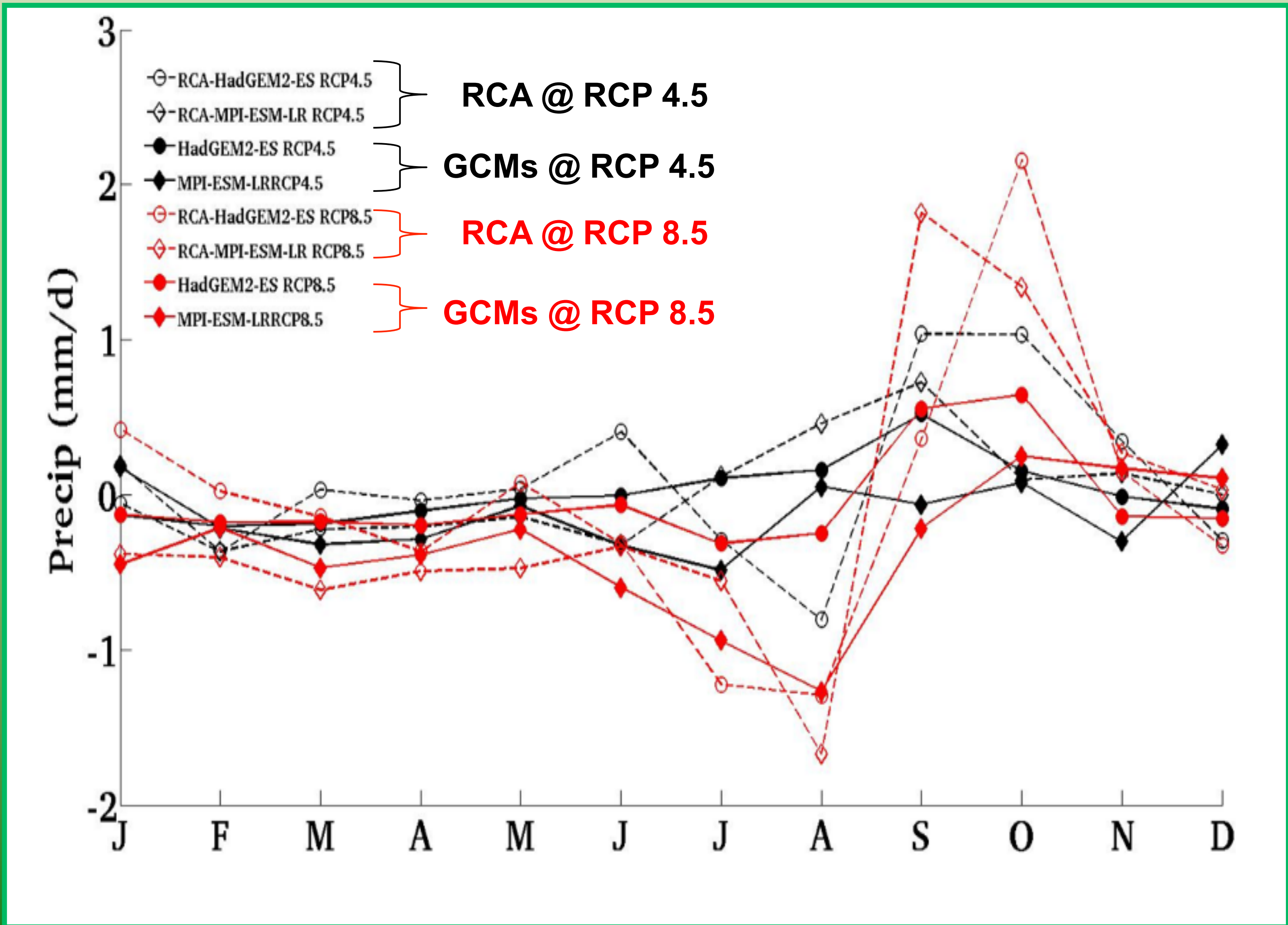

Anom UV850-HUS850, Pr > P95 (RCAERAINT)
DJF
MAM
JJA
SON
+36°
+31°
+26°
+21°
+16°
+11°
+6°
-118° -108° -98° -88° -78°
4 m/s
4
3
2
1
0
-1
-2
-3
-4
g*kg


Anom UV850-HUS850, Pr > P95 (RCAHADGEM)
DJF
MAM
JJA
SON
+36°
+31°
+26°
+21°
+16°
+11°
+6°
-118° -108° -98° -88° -78°
4 m/s
4
3
2
1
0
-1
-2
-3
-4
g*kg


Anom UV850-HUS850, Pr > P95 (RCAMPI)
DJF
MAM
JJA
SON
+36°
+31°
+26°
+21°
+16°
+11°
+6°
-118° -108° -98° -88° -78°
4 m/s
4
3
2
1
0
-1
-2
-3
-4
g*kg

1979-2005

RCA and GCMs: Future changes in the mean Precip in the NAM region (2075-2099 minus 1979-2005)



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CORDEX-NA: factors inducing dry/wet years on the North American Monsoon region

Ruth Cerezo-Mota,[a,b]* Tereza Cavazos,[c] Raymond Arritt,[d] Abraham Torres-Alavez,[e]
Kevin Sieck,[f] Grigory Nikulin,[g] Wilfram Moufouma-Okia[h] and Jose Antonio Salinas-Prieto[i]

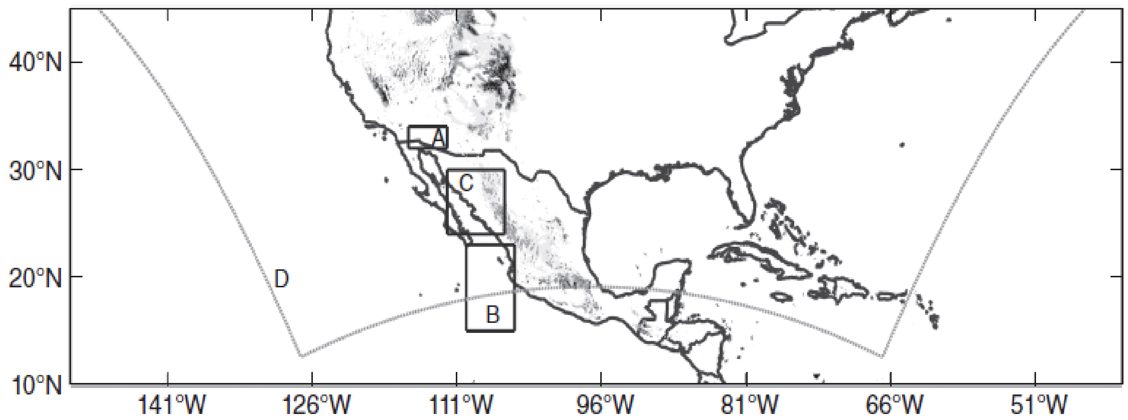

Figure 1. Region as defined for CORDEX-North America (D box); A and B boxes indicate the areas over the continent and ocean, respectively, used for the LSTC. C box indicates the NAM core region. Topography (from etopo1, Amante and Eakins, 2009) higher than 2000 m is shaded. Note that the full CORDEX-NA domain goes up to 60°N.

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CORDEX-NA: factors inducing dry/wet years on the North American Monsoon region

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ABSTRACT: The output of four regional climate models (RCMs) from the Coordinated Regional Climate Downscaling Experiment (CORDEX)-North America (NA) region was analysed for the 1990–2008 period, with particular interest on the mechanisms associated with wet and dry years over the North American Monsoon (NAM) core region. All RCMs (RCA3.5, HadGEM3-RA, REMO, and RegCM4) were forced by the ERA-Interim reanalysis. Model precipitation was compared against several observational gridded data sets at different time scales. Most RCMs capture well the annual cycle of precipitation and outperform ERA-Interim, which is drier than the observations. RCMs underestimate (overestimate) the precipitation over the coastal plains (mountains) and have some problems to reproduce the interannual variability of the monsoon. To further investigate this, two extreme summers that showed the largest consistency among observations and RCMs were chosen: one wet (1990) and one dry (2005). The impact of the passage of tropical cyclones, the size of the Western Hemisphere Warm Pool (WHWP), the Intertropical Convergence Zone (ITCZ) position, and the initial intensity of the land–sea thermal contrast (LSTC) were analysed. During the wet year, the LSTC was stronger than the 2005 dry monsoon season and there were a larger number of hurricanes near the Gulf of California, the WHWP was more extended, and the ITCZ was located in a more northerly position than in 2005. All these processes contributed to a wetter NAM season. During the dry year, the LSTC was weaker, with a later onset, probably due to a previous very wet winter. The inverse precipitation relationship between winter and summer in the monsoon region was well captured by most of the RCMs. RegCM4 showed the largest biases and HadGEM3-RA the smallest ones.

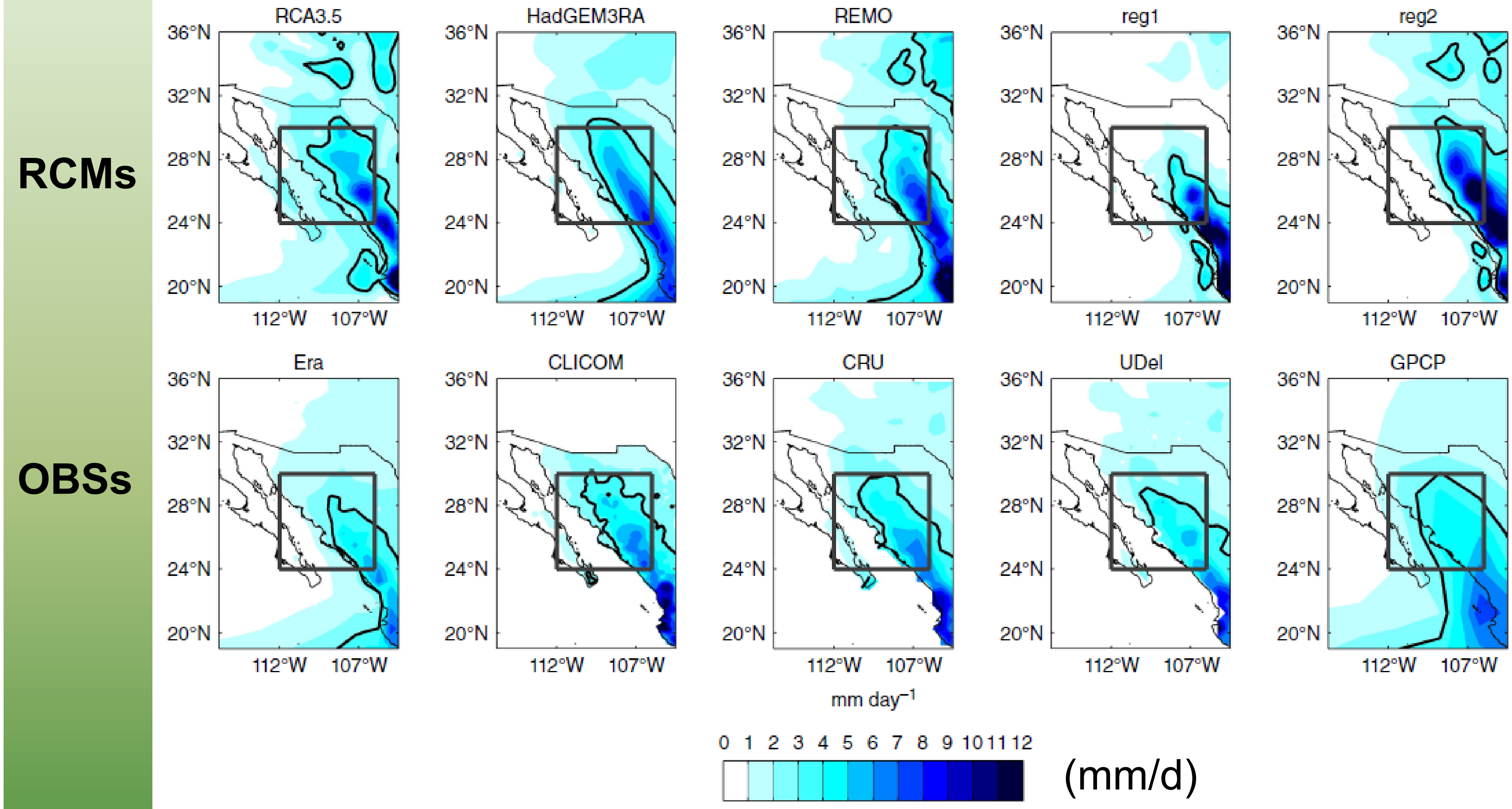

Figure 3. Mean JJAS precipitation (mm day^{-1}) during 1990–2008 for the regional models and the observational data sets. The 3 mm day^{-1} contour is highlighted. The square shows the core monsoon region.

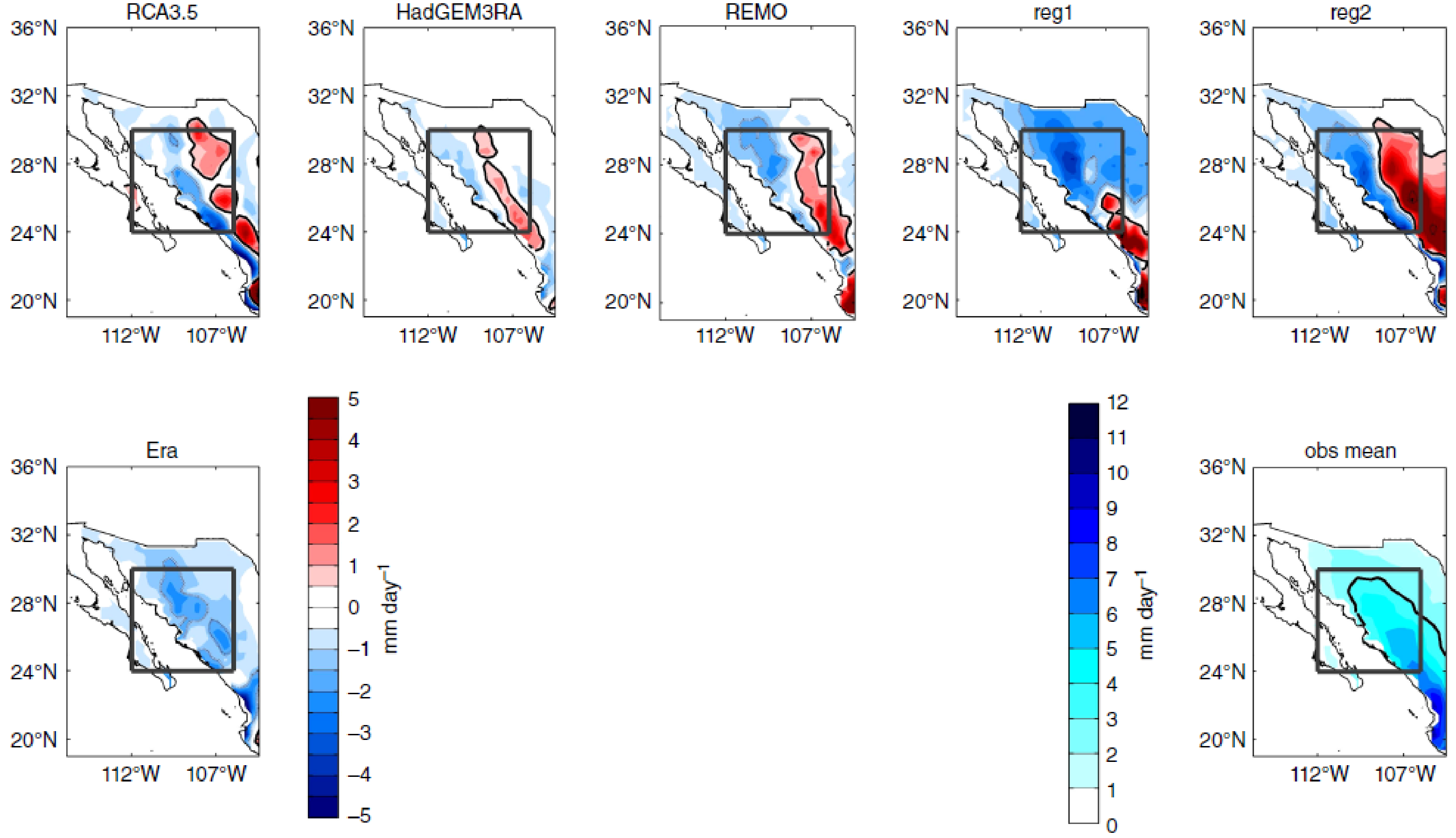

Figure 4. RCMs bias (model minus mean of the observations) for JJAS precipitation (mm day^{-1}) for the 1990–2008 period. Contours of 1 mm day^{-1} (dark continuous line) and -1 mm day^{-1} (grey discontinuous line) are highlighted. The mean of the observation used for this calculation is shown in the last panel.

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Eastern Tropical Pacific hurricane variability and landfalls on Mexican coasts

Julio N. Martinez-Sanchez, Tereza Cavazos*

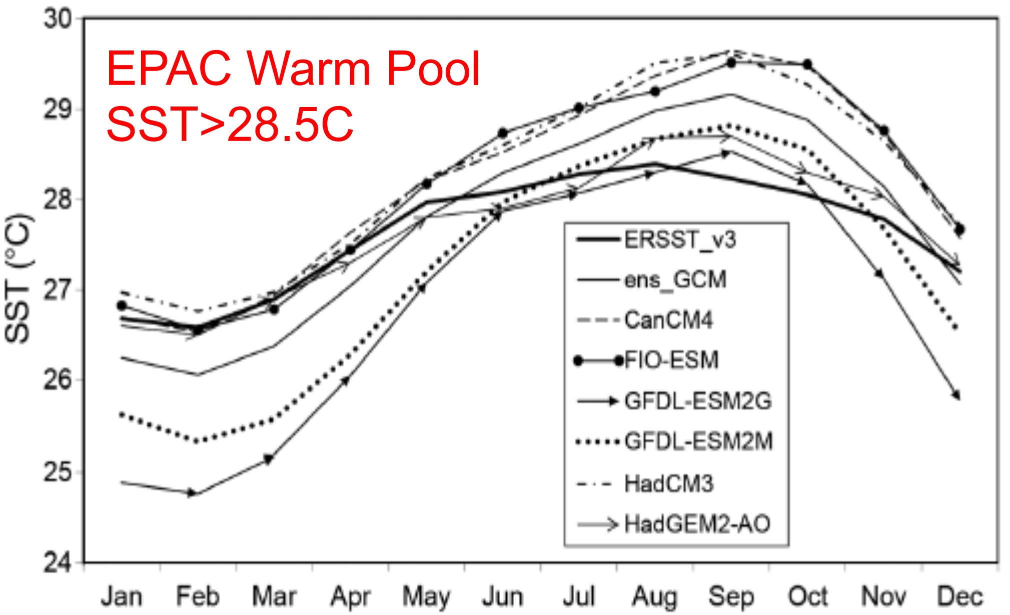

Fig. 8. Mean annual cycle of sea surface temperature (SST) averaged over the main development region of the Eastern Tropical Pacific during 1961–2000 for the observed NOAA Extended Reconstructed SST v3b (ERSST_v3) and the historical simulations of 6 general circulation models (GCMs; see Table 1) and their mean ensemble (ens_GCM)

Size of EPAC and NATL Warm Pools

Table 7. Same as Table 6, but for the average size ($\times 10^6$ km^2) of the Western Hemisphere Warm Pool in the Eastern Tropical Pacific (EPAC) and North Atlantic (NATL) basins according to observed NOAA Extended Reconstructed SST v3b (ERSST_v3) and the mean ensemble (ens_GCM) of the 6 general circulation models (GCMs) in Table 1 for the historical period 1961–2000. SST: sea surface temperature

SST	EPAC	NATL	Total
ERSST_v3	2.1	4.2	6.3
ens_GCM	3.4	2	5.4

1970-2010

Event	EPAC	NATL	Total
La Niña	1.4	6.3	7.7
Neutral	1.8	5.4	7.2
El Niño	2.4	4.6	7.0
Average	1.9	5.4	7.3