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
- **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
- **Statistical downscaling of GCMs**: Jones et al. 2016
Published papers

• Caribbean Group:  

• ICTP:  

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, Arnolfo 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.
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
RegCM Sensitivity Analysis: Domain, Resol & Conv
ICTP Group
RegCM4-based studies

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

G. T. Diro¹,*, S. A. Rauscher², F. Giorgi¹, A. M. Tompkins¹


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

CLM 3.5: Comm Land Model ➔ too DRY

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.
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.
**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 TNA tl, which is linked to a stronger CLLJ.
Precipitation and SST in extreme years

\[ \text{TNA} - \text{TNP} = + \quad \rightarrow \quad \text{Wet conditions} \]

Wet years:
Warm TNA and Cold TNP
Weakens the CLLJ
Precipitation vs TNA - TNP SST gradient

Historic ooo  Future ooo

OBS

GCMs

RegCM4

RegCM4
SST Gradient more negative in the RCP8.5 \(\Rightarrow\) Precipitation

CMIP5 GCMs and RegCM4 CORDEX simulations

- OBS
- GCMs
- 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 thermal contrast
- Stronger CLLJ
- Reduced Precip

Several studies:
- Fuentes-Franco et al. 2015
- Cavazos and De Grau 2014
- Martinez-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

Monsoon
<table>
<thead>
<tr>
<th></th>
<th>OBS</th>
<th>HadGEM2</th>
<th>RegCM4_Had</th>
</tr>
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<tbody>
<tr>
<td>DJF</td>
<td>US+CLICOM DIF</td>
<td>HadGEM2 DJF</td>
<td>RegCM4-Had_CAM DJF</td>
</tr>
<tr>
<td>JJA</td>
<td>US+CLICOM JJA</td>
<td>HadGEM2 JJA</td>
<td>RegCM4-Had_CAM JJA</td>
</tr>
</tbody>
</table>

DJF and JJA precipitation (mm/d) 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
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

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

TRMM

KF

BM

GD

(mm/d)
NOAA, 29 OCT 00Z 2010, SFC
Strong Cold front/Norte with LLJ

WRF Td 00Z29OCT2010

WRF CAPE en superficie
00Z29OCT2010

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. Sein², Francisco Álvarez-García¹, Nikolay Koldunov³, Daniela Jacob³
¹University of Alcala, ²Alfred Wegener Institute, ³Climate Service Center

Objective: To explore the CLLJ and MSD using the coupled and uncoupled REMO model under different resolutions
PHYSICALLY MOTIVATED ELECTION OF DOMAINS

Important forcings are provided by the “perfect” reanalysis.

Forcing: ERA-Interim (1980-2012)

- **NAS** ($1/2^\circ$, $1/4^\circ$)
- **MES** ($1/2^\circ$)
- **MEP** ($1/2^\circ$)
- **ME6** ($1/2^\circ$, $1/4^\circ$)
- **NAX** ($1/8^\circ$)

**ME6** is extended
Central American CORDEX

**NAX** postprocessing
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.
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

**Characteristics**
- Resolution: 50 km x 50 km, 6 hs
- Period: 1979-2012
- Vertical levels: 18 (sigma)
3-6 month prediction 2011

OBS
CRU

RegCM4

Dry
Wet

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

Convergencia y debilitamiento de los Alisios a 10N: ITCZ MCG producen vientos del sur/suroeste más intensos
OBS: Mean P95 Thresholds of Precip (mm/d) for DJF and JJA (1979-2005)

- **DJF**
  - P95: 25-30 mm (US+CLICOM P95 DJF)
  - P95: 15-20 mm (NARR P95 DJF)
  - P95: 10 mm (ERA-int P95 DJF)

- **JJA**
  - P95: 15-25 mm (US+CLICOM P95 JJA)
  - P95: 10-15 mm (NARR P95 JJA)
  - P95: 10 mm (ERA-int P95 JJA)

ITCZ: ITCZ region

NAM: NAM region
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

5-15 mm

15 mm ➔ NAM region

ERA-Interim

HadGEM2

MPI

ITCZ

ITCZ

ITCZ

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

DJF

P95: 50 mm
RCA-ERA-Interim

20-30 mm
RCA-HadGEM2

20-40 mm
RCA-MPI

JJA

P95: 20-50 mm
RCA-ERA-Interim

ITCZ??

20-30 mm
RCA-HadGEM2

30-50 mm ➔ NAM region
RCA-MPI
1979-2005
RCA and GCMs: Future changes in the mean Precip in the NAM region (2075-2099 minus 1979-2005)
CORDEX-NA: factors inducing dry/wet years on the North American Monsoon region

Ruth Cerezo-Mota\textsuperscript{a,b,*} Tereza Cavazos\textsuperscript{c} Raymond Arritt\textsuperscript{d} Abraham Torres-Alavez\textsuperscript{e} Kevin Sieck\textsuperscript{f} Grigory Nikulin\textsuperscript{g} Wilfram Moufouma-Okia\textsuperscript{h} and Jose Antonio Salinas-Prieto\textsuperscript{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.
CORDEX-NA: factors inducing dry/wet years on the North American Monsoon region

Ruth Cerezo-Mota,²,³ Tereza Cavazos,⁵ Raymond Arritt,⁴ Abraham Torres-Alavez,⁵ Kevin Sieck,⁷ Grigory Nikulin,⁸ Wilfram Mufouma-Okia⁹ and Jose Antonio Salinas-Prieto¹

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.
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)

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

<table>
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<th>SST</th>
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<th>NATL</th>
<th>Total</th>
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<td>ens_GCM</td>
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1970-2010