ICO Ingeniería en Construcción

TEC | Tecnológico de Costa Rica

Proyecto VIE 2018-2021

Evaluación del impacto del Cambio Climático futuro sobre cuencas hidrológicas destinadas al abastecimiento de agua potable en Costa Rica

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Escuela de Ingeniería en Construcción. ITCR.

Cambio Climático

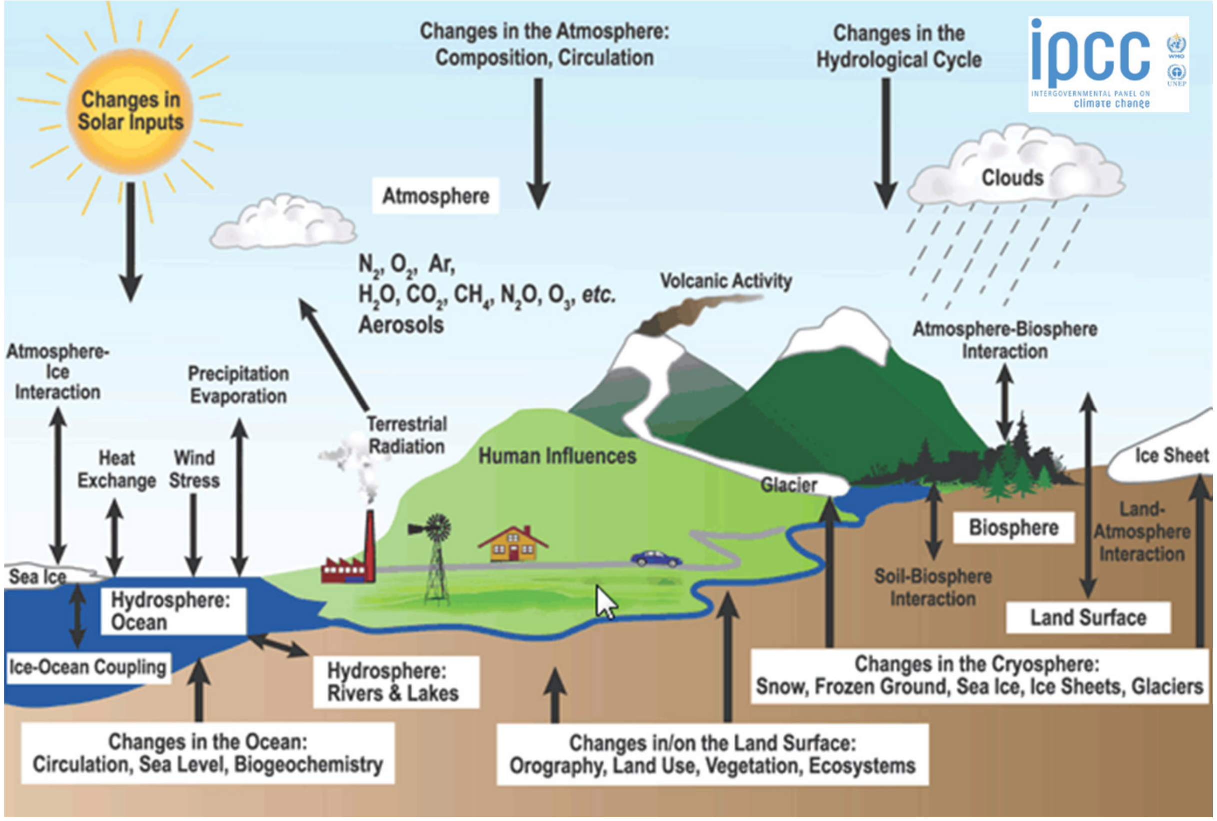
- Se define, como un cambio en el **clima** atribuido directa o indirectamente a la actividad humana que altera la composición del sistema climático global y que se suma a la **variabilidad natural** observada durante períodos comparables (*IPCC, 1992*).

El Sistema Climático

- Cualquier **intento** de **modelar/simular** el clima, debe fundamentarse en la resolución del balance energético a nivel planetario.
- Debe ser capaz de **reproducir** las líneas base de tiempo y debe ser lo suficientemente confiable como para evaluar escenarios futuros con una adecuada resolución espacial y temporal.
- Es un problema matemático basado en sistemas de ecuaciones **altamente** complejas.

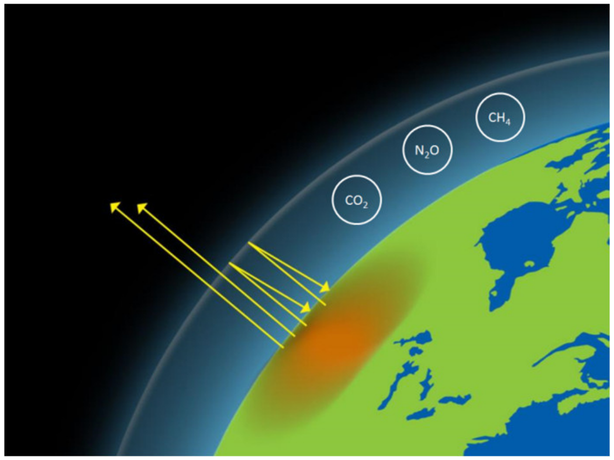
El Sistema Climático

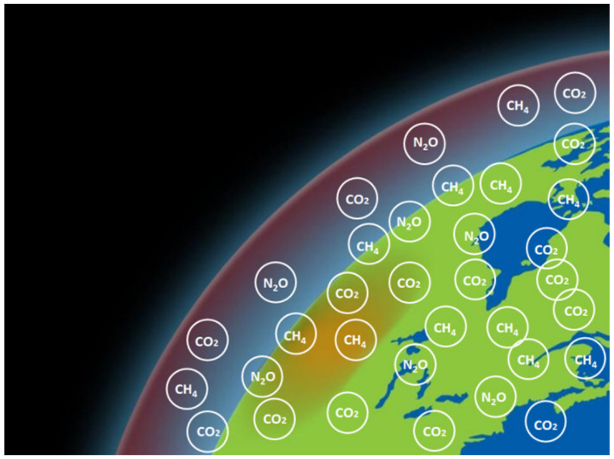
- Se trata de **resolver** un balance **continuo** de flujos.(*energía* + *masa* + *momentum*)


Changes in Solar Inputs
Changes in the Atmosphere: Composition, Circulation
Changes in the Hydrological Cycle
ipcc INTERGOVERNMENTAL PANEL ON climate change
Atmosphere
Clouds
N₂, O₂, Ar, H₂O, CO₂, CH₄, N₂O, O₃, etc. Aerosols
Volcanic Activity
Atmosphere-Biosphere Interaction
Atmosphere-Ice Interaction
Precipitation Evaporation
Terrestrial Radiation
Human Influences
Heat Exchange
Wind Stress
Glacier
Ice Sheet
Biosphere
Land-Atmosphere Interaction
Sea Ice
Hydrosphere: Ocean
Soil-Biosphere Interaction
Land Surface
Ice-Ocean Coupling
Hydrosphere: Rivers & Lakes
Changes in the Cryosphere: Snow, Frozen Ground, Sea Ice, Ice Sheets, Glaciers
Changes in the Ocean: Circulation, Sea Level, Biogeochemistry
Changes in/on the Land Surface: Orography, Land Use, Vegetation, Ecosystems

Cambio Climático

- Un **tercio** de la energía radiada desde el sol es reflejada al espacio. El restante, lo toma la tierra quien la refleja en forma de calor.
- La mayor parte de esta radiación es admitida por los océanos , la tierra y absorbida por la atmósfera, incluyendo las nubes y es re-irradiada.
- Al concentración de los gases que generan el efecto invernadero, la atmósfera retiene más calor.



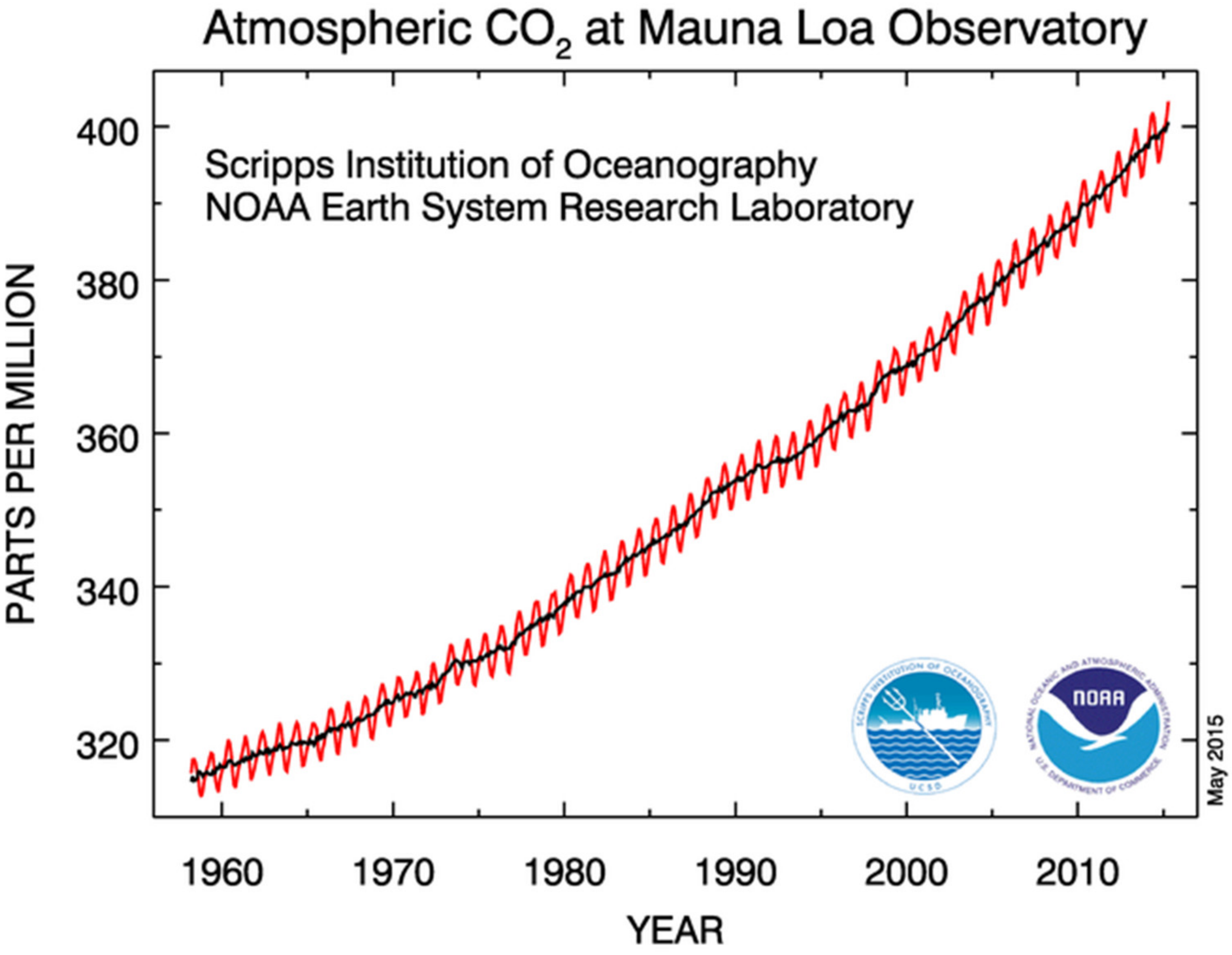


ipcc INTERGOVERNMENTAL PANEL ON climate change WHO UNEP

Evidencias

- La principal autoridad científica sobre el cambio climático es el *Grupo Intergubernamental de Expertos sobre el Cambio Climático de la Naciones Unidas* (*IPCC*).
- "**Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia**" (*AR5-IPCC*).
- Si las temperaturas aumentan más de **2°C**, los efectos pueden ser irreversibles.

Evidencias


Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
400
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1980
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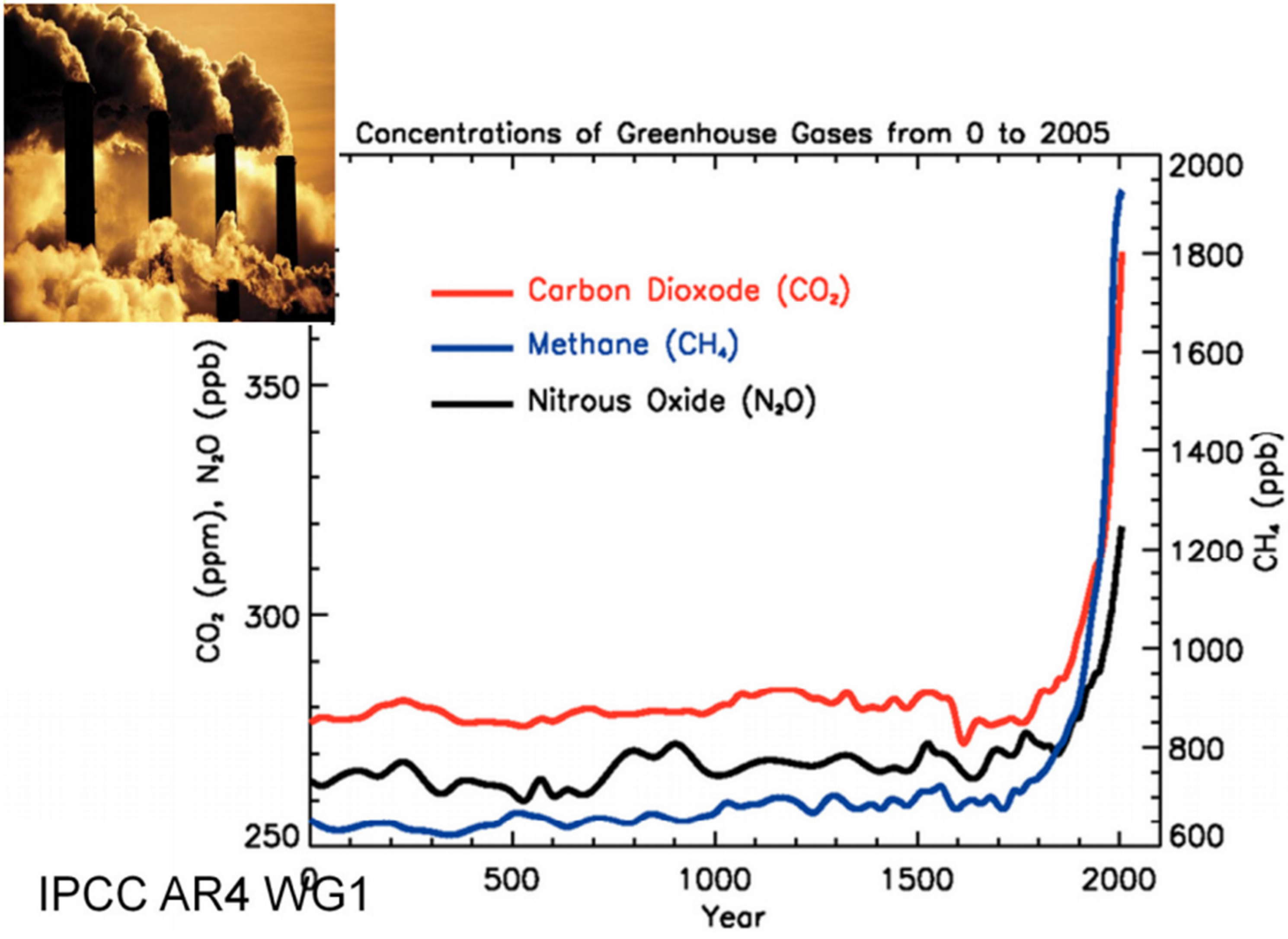
YEAR
May 2015
NOAA

Evidencias



IPCC AR4 WG1

Consecuencias

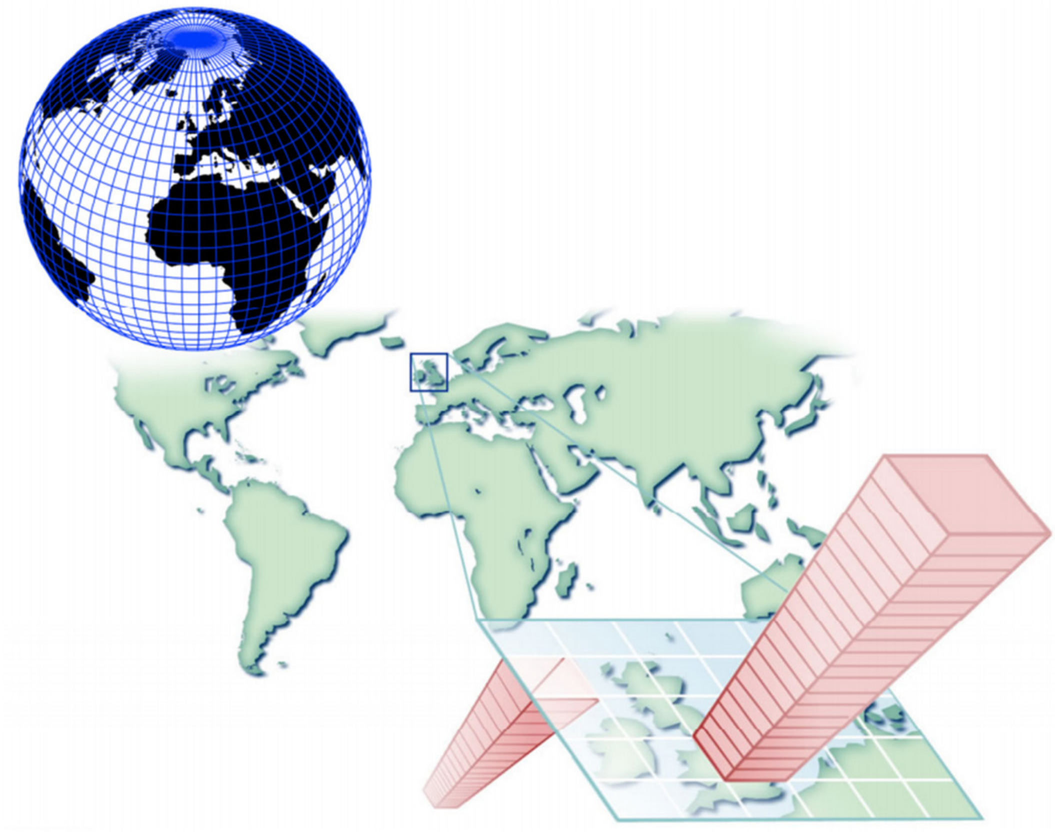
- Fenómenos meteorológicos extremos, incluyendo tormentas, inundaciones, sequías y olas de calor de mayor intensidad que los históricos.
- Perdidas de las capas glaciares y polares.
- Aumento del nivel del mar.
- Desplazamiento de poblaciones costeras.
- Susceptibilidad de la infraestructura civil y productiva.
- Impacto general sobre el ecosistema y pérdida de biodiversidad.
- Erosión de los suelos.
- Menor rendimiento de cultivos.
- Acidificación de los océanos y lagos.
- **Disrupción del Sistema Climático Global**.

Modelos de Clima

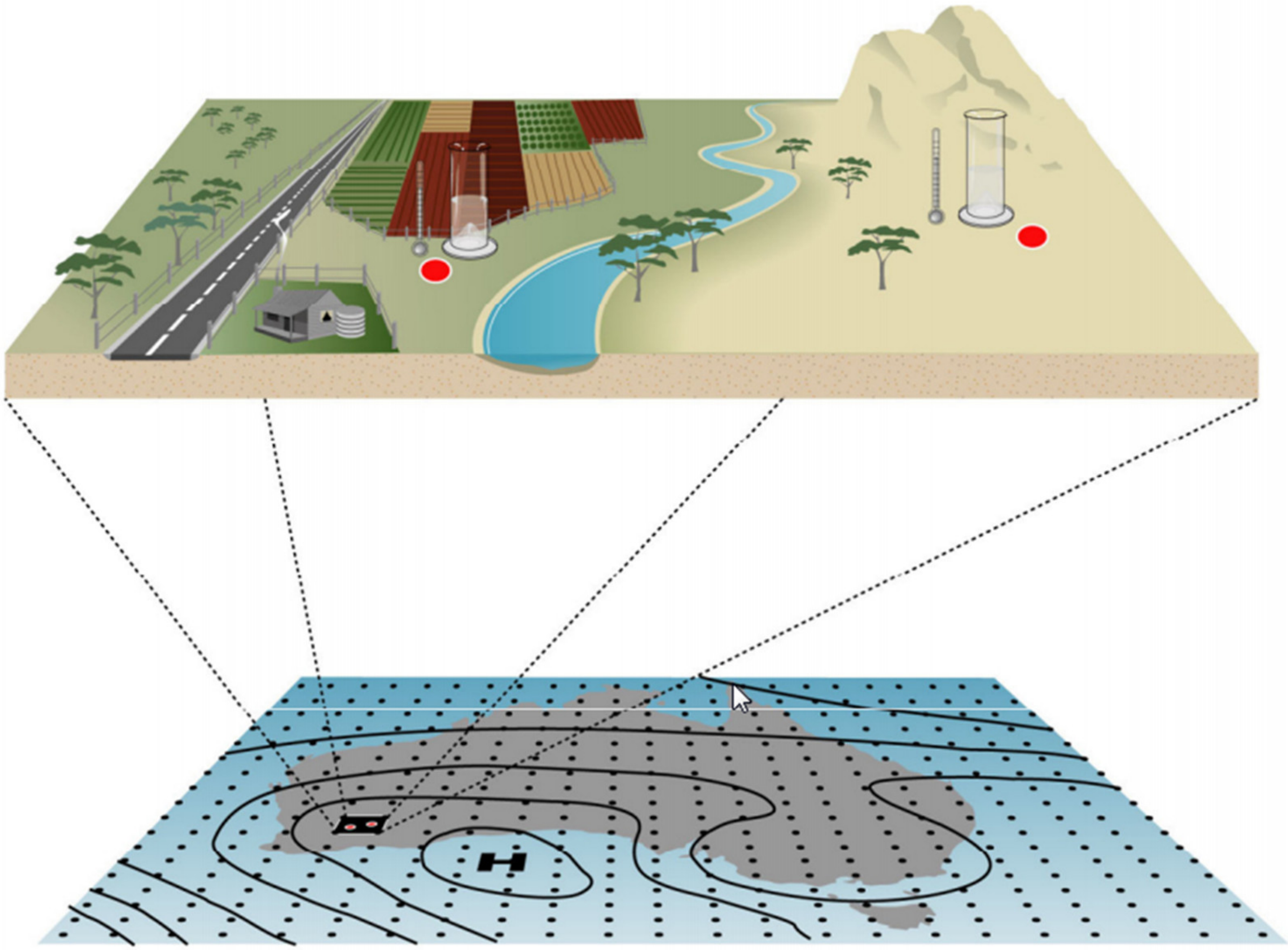
- Los modelos de clima juegan un papel importante en la investigación del sistema climático.
- Mejoran nuestra **capacidad para entender** los patrones del clima presente y pasado.
- Proporcionan información cuantitativa sobre el curso futuro.
- General Circulation Models (**GCMs**) **250** km2.
- Regional Climate Models (**RCMs**) **< 25** km2.

Modelos de Clima

- Discretización del dominio (*volúmenes finitos*).
- Computational fluid dynamics (*CFD*).
- Resolución espacial y temporal.



Modelos de Clima



Forzamiento(RCPs)

- Set of scenarios, the Representative Concentration Pathways (**RCPs**), used for the new climate model simulations carried out under the framework of the Coupled Model Intercomparison Project Phase 5 (**CMIP5**) of the World Climate Research Programme.

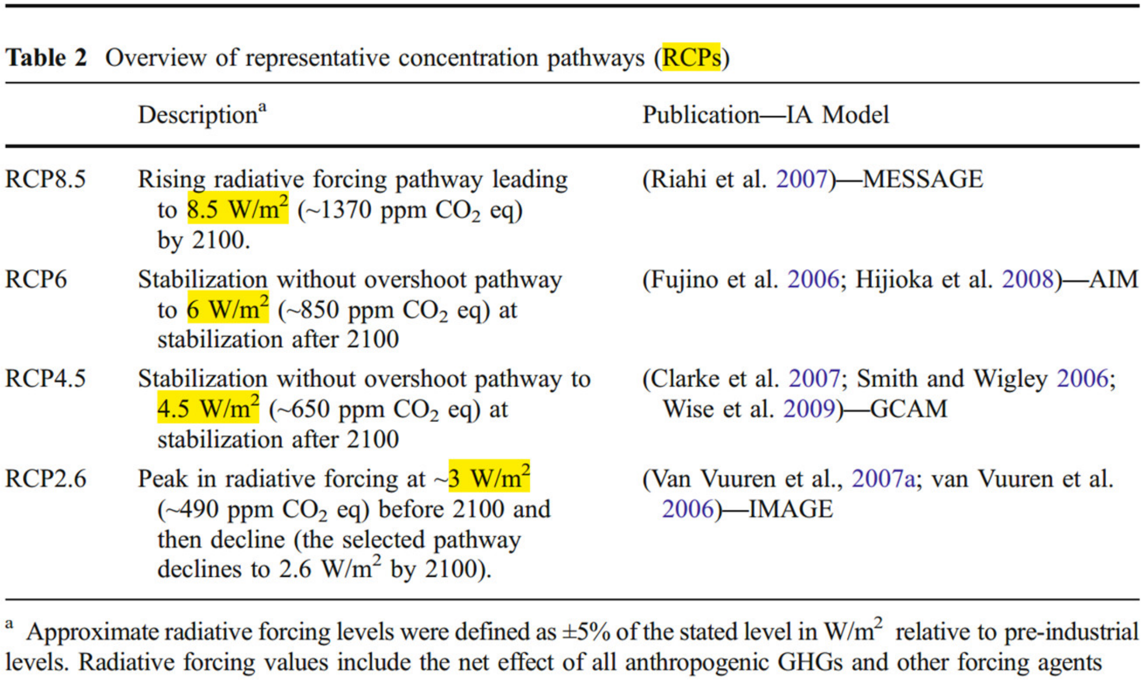


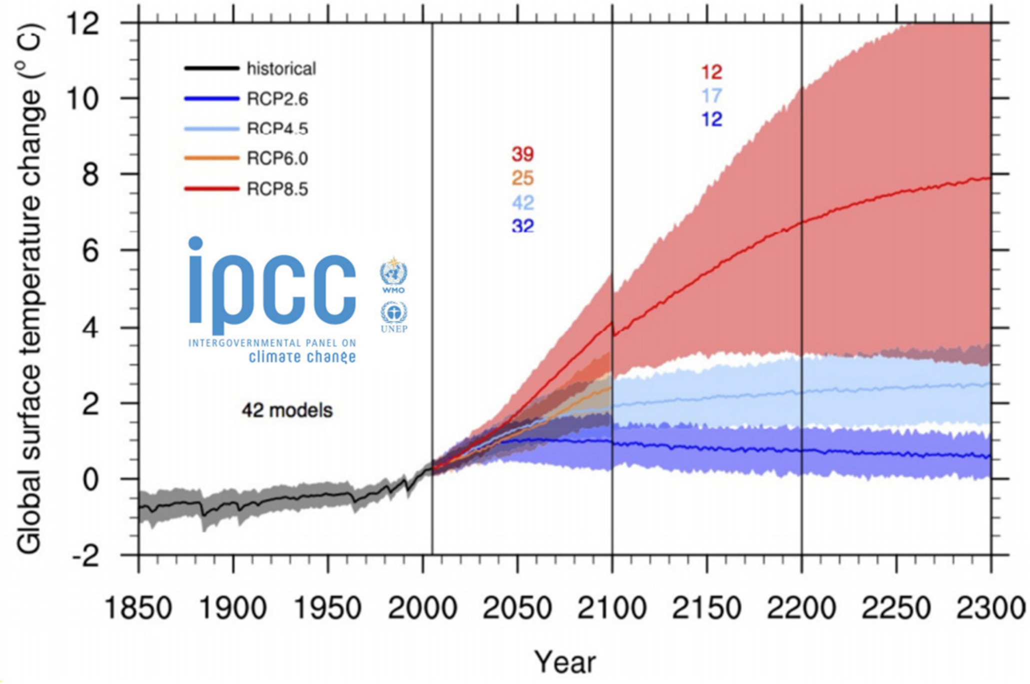
Table 2 Overview of representative concentration pathways (RCPs)

	Description[a]	Publication—IA Model
RCP8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 (~1370 ppm CO_2 eq) by 2100.	(Riahi et al. 2007)—MESSAGE
RCP6	Stabilization without overshoot pathway to 6 W/m^2 (~850 ppm CO_2 eq) at stabilization after 2100	(Fujino et al. 2006; Hijioka et al. 2008)—AIM
RCP4.5	Stabilization without overshoot pathway to 4.5 W/m^2 (~650 ppm CO_2 eq) at stabilization after 2100	(Clarke et al. 2007; Smith and Wigley 2006; Wise et al. 2009)—GCAM
RCP2.6	Peak in radiative forcing at ~3 W/m^2 (~490 ppm CO_2 eq) before 2100 and then decline (the selected pathway declines to 2.6 W/m^2 by 2100).	(Van Vuuren et al., 2007a; van Vuuren et al. 2006)—IMAGE

[a] Approximate radiative forcing levels were defined as ±5% of the stated level in W/m^2 relative to pre-industrial levels. Radiative forcing values include the net effect of all anthropogenic GHGs and other forcing agents

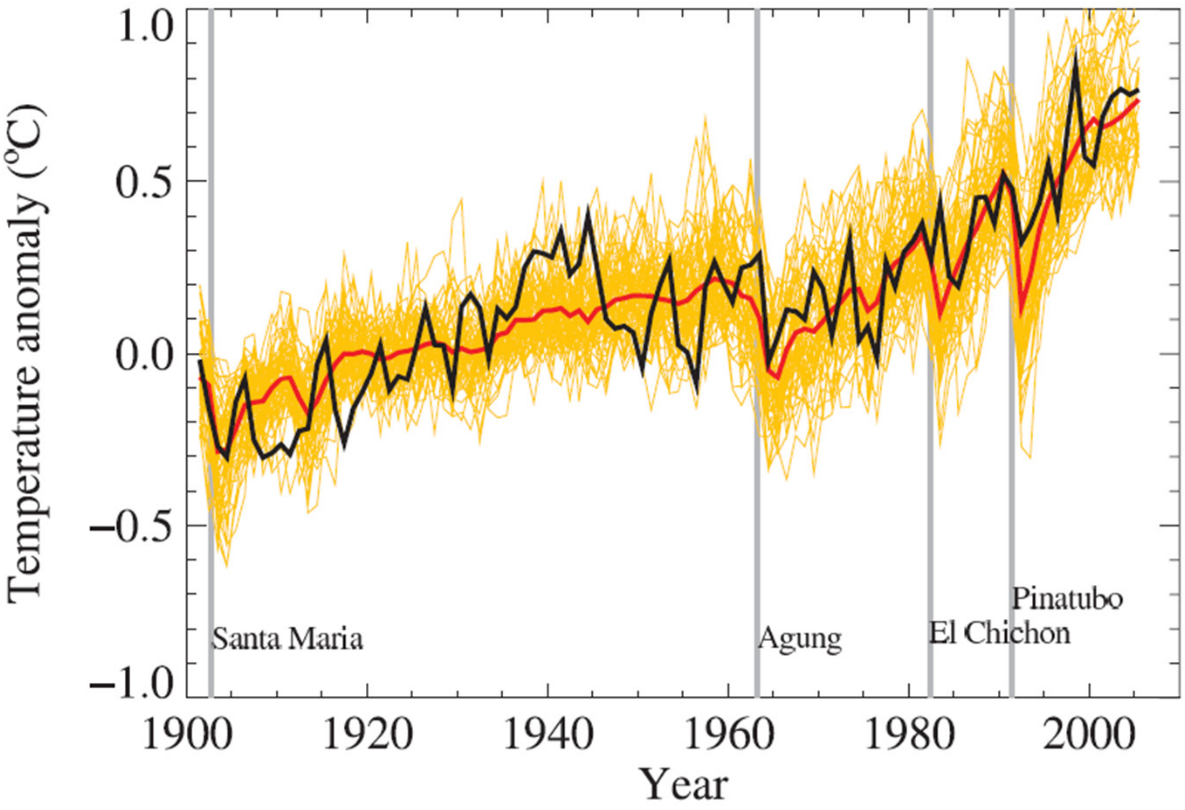
Forzamiento(RCPs)

- La confianza en la utilización de modelos de clima depende de una cuidadosa evaluación del desempeño del modelo, haciendo uso de bases de datos de observación y actividades de inter-comparación de modelos (*CPTEC, Brazil*).



Forzamiento(RCPs)

- 14 GCMs, 58 simulaciones (**BIAS**).



Escenarios CC Costa Rica

- Objetivo General: *Contribuir a disminuir la incertidumbre asociada al impacto del Cambio Climático futuro sobre cuencas hidrológicas destinadas al abastecimiento de agua potable en Costa Rica*.

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Instituto Meteorológico Nacional
Fundado en 1888

AyA
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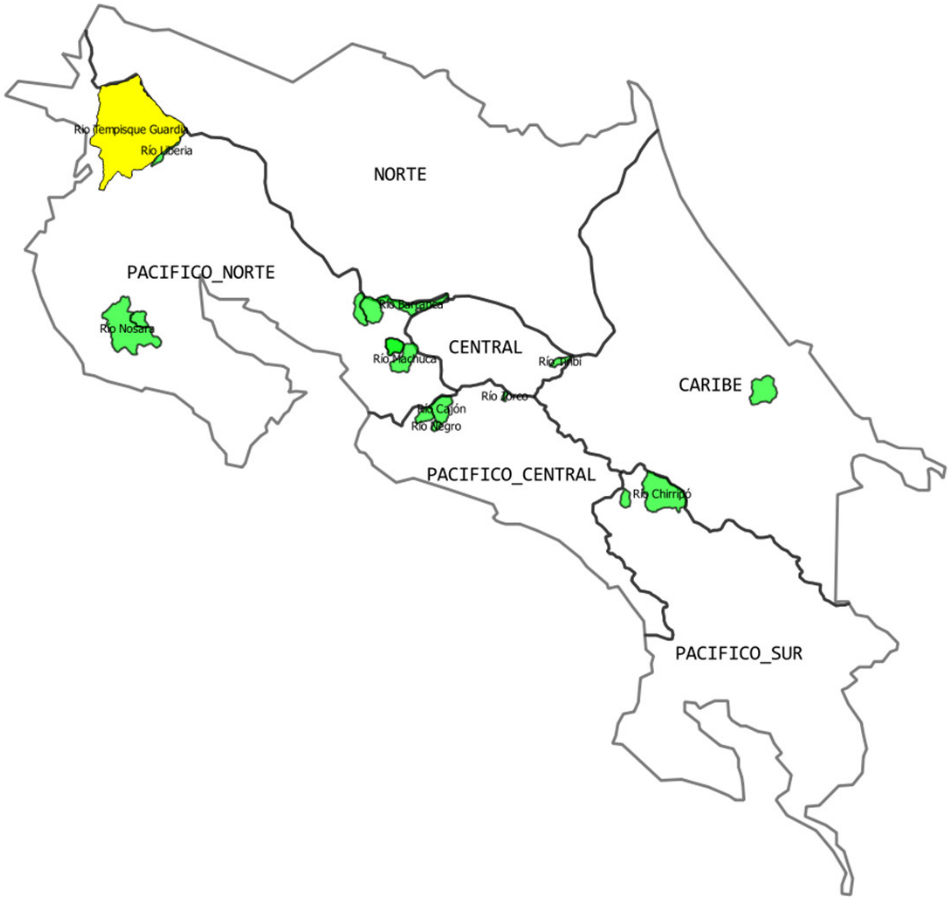
ACUEDUCTOS Y ALCANTARILLADOS

UNIVERSITY
OF TWENTE.

CR-CC (AyA Aplicación)

- Proyecciones-Futuras, resolución mensual, 25x25 km.
- *Precipitación, Temperatura, ET0*.
- RCPs **26**, **45**, **85**.
- 2011-2040, 2041-2070, 2071-2100.
- 6 Regiones Climáticas CR, estacionales **DFJ**, **MAM**, **JJA**, **SON**.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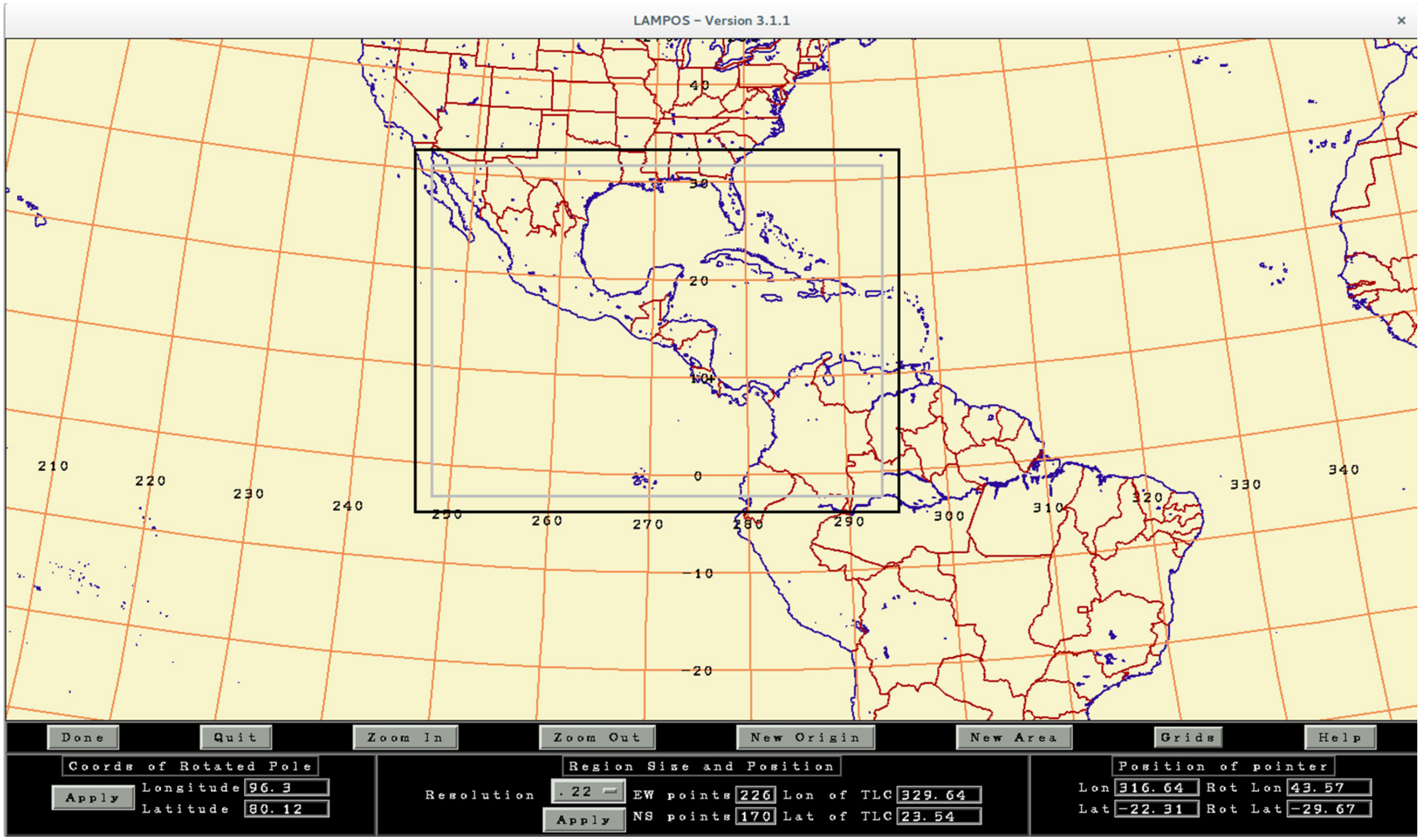
PACIFICO_SUR

CR-CC (Dominio)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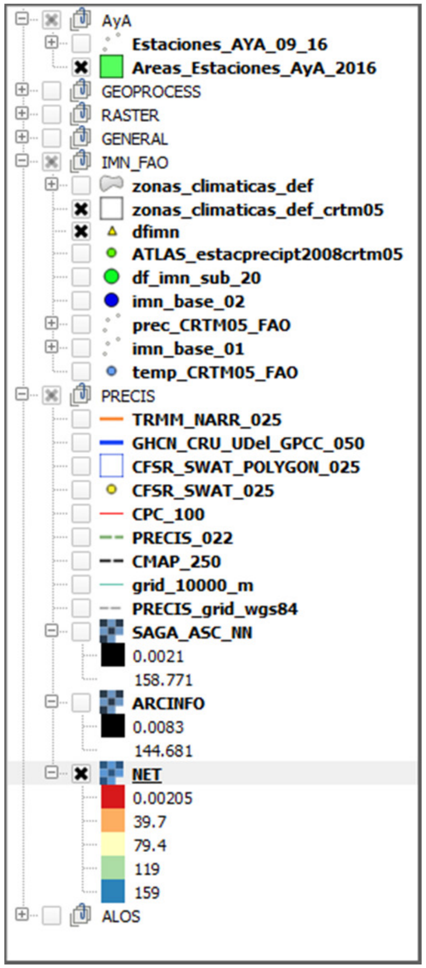
Coords of Rotated Pole
Longitude 96.3
Latitude 80.12

Region Size and Position
Resolution .22
EW points 226
NS points 170
Lon of TLC 329.64
Lat of TLC 23.54

Position of pointer
Lon 316.64
Lat -22.31
Rot Lon 43.57
Rot Lat -29.67

CR-CC (Dominio)



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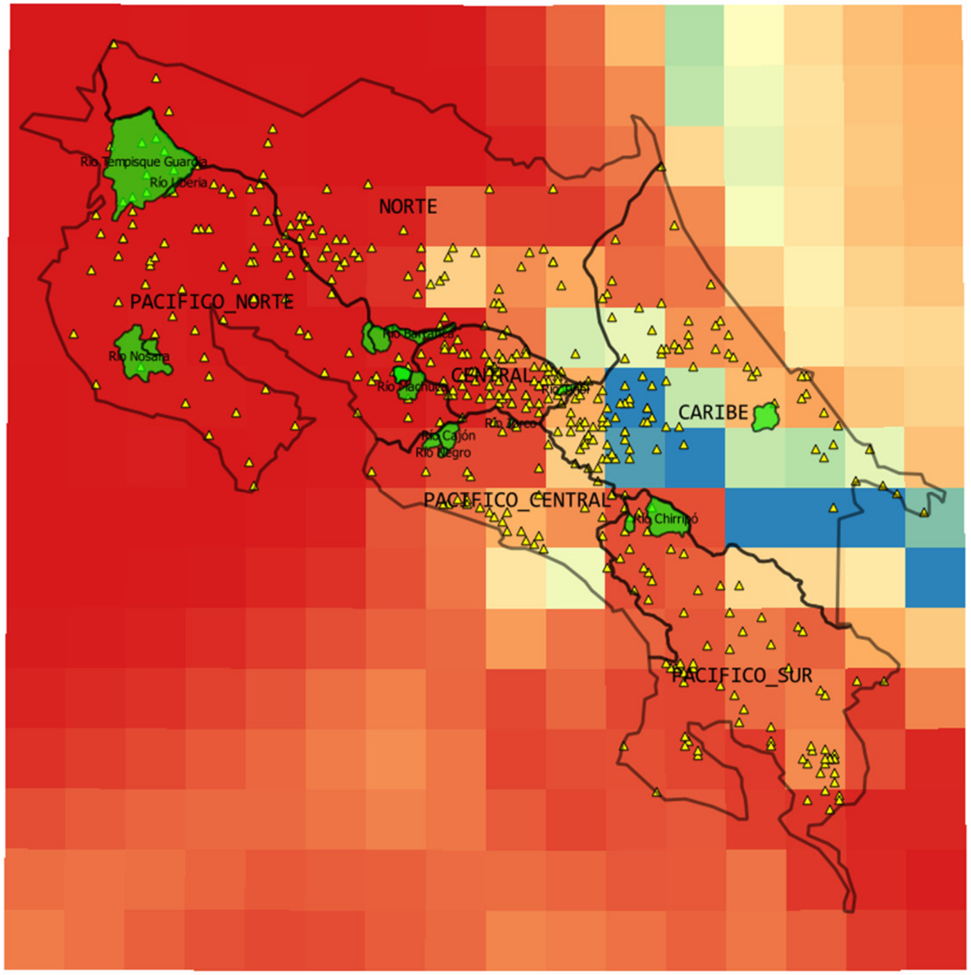
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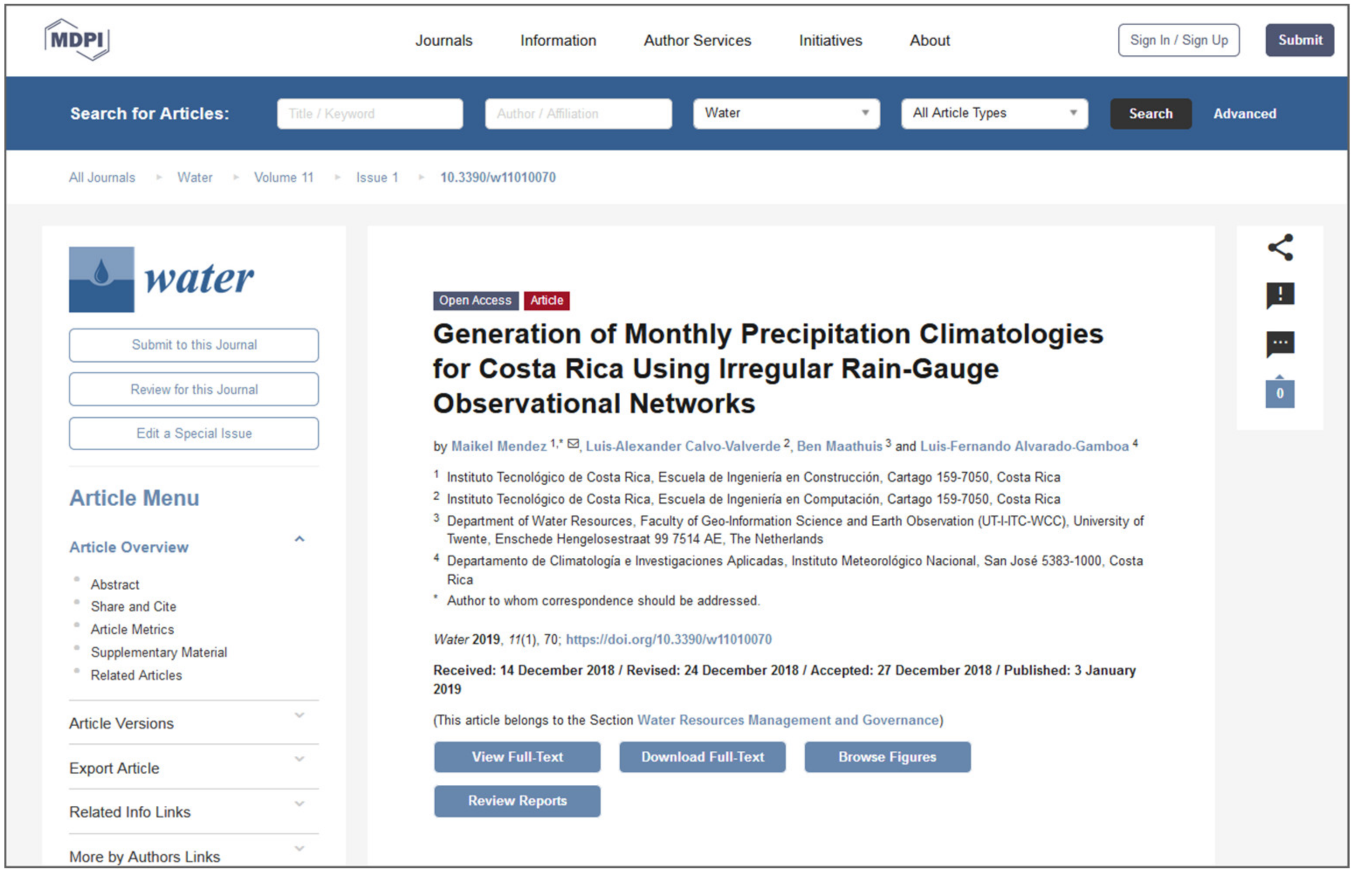
Río Negro
PACIFICO_CENTRAL
Río Chirripó
PACIFICO_SUR

CR-CC (Modelos)

- *HadGEM2* GCM gridded, downscaled by **HadRM3P** (MetOffice-ITCR) (0.22° x 0.22°).
- GCMs gridded downscaled by **RCA4** (CORDEX) [**HadGEM2, EARTH, MIROC, and CanESM2**] (0.44° x 0.44°).
- Bias respecto de la línea base, asociada a: GCM-RCM parameterización, estructura interna y supuestos matemáticos, RCPs.
- **Evaluación de Bias-Correction-Methods**.
- **Proyecciones futuras**.

CR-CC (Modelos)

- Climatología Base Prec-Temp 1x1 km, (1951-1995) (1961-1990), (1951-1980), (1981-1995).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Generation of Monthly Precipitation Climatologies for Costa Rica Using Irregular Rain-Gauge Observational Networks

by Maikel Mendez [1,*], Luis-Alexander Calvo-Valverde [2], Ben Maathuis [3] and Luis-Fernando Alvarado-Gamboa [4]

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[2] Instituto Tecnológico de Costa Rica, Escuela de Ingeniería en Computación, Cartago 159-7050, Costa Rica
[3] Department of Water Resources, Faculty of Geo-Information Science and Earth Observation (UT-I-ITC-WCC), University of Twente, Enschede Hengelosestraat 99 7514 AE, The Netherlands
[4] Departamento de Climatología e Investigaciones Aplicadas, Instituto Meteorológico Nacional, San José 5383-1000, Costa Rica
* Author to whom correspondence should be addressed.

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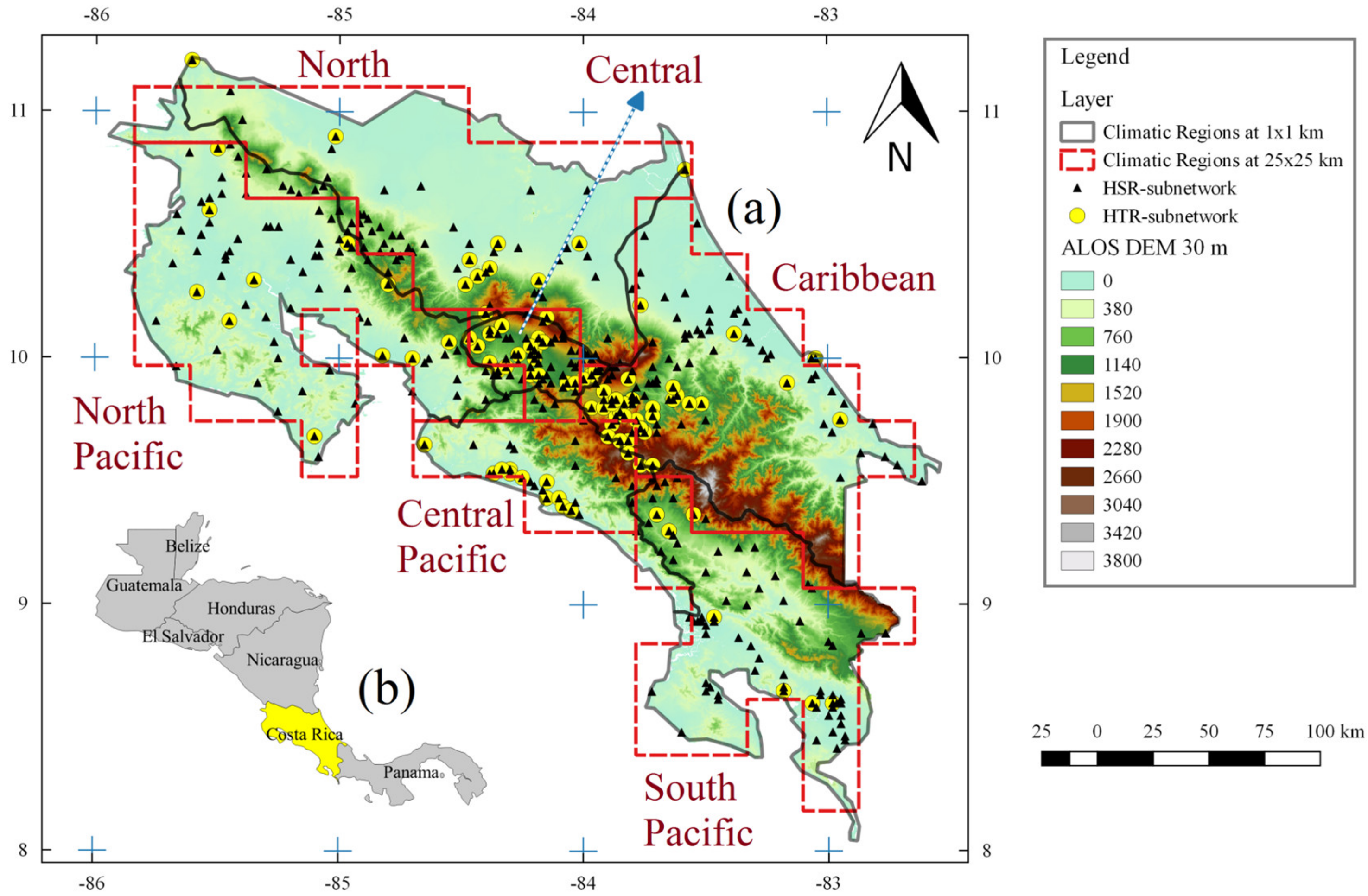
CR-CC (Modelos)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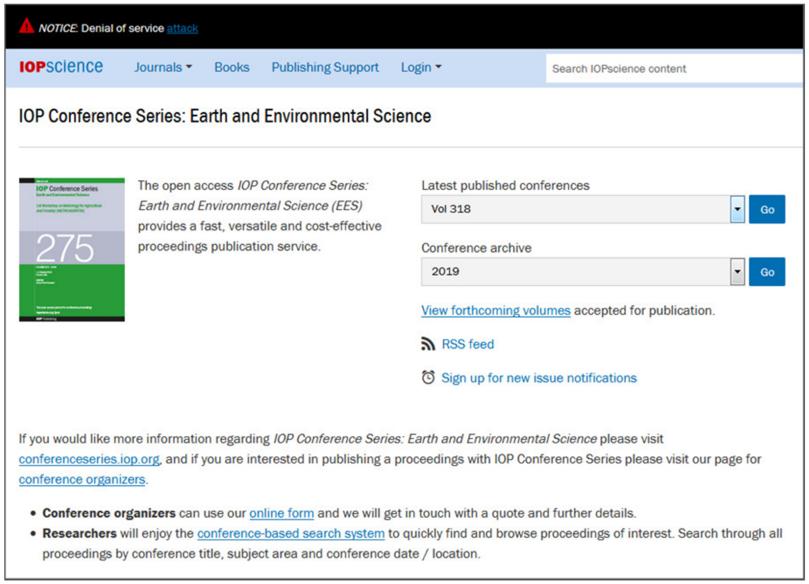
CR-CC (Modelos)

- Climatología Base Prec-Temp 1x1 km, (1951-1995) (1961-1990), (1951-1980), (1981-1995).



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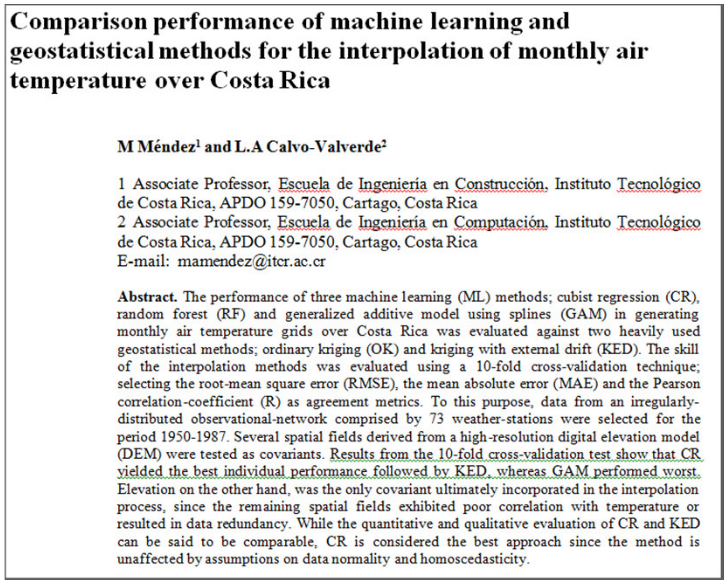

Comparison performance of machine learning and geostatistical methods for the interpolation of monthly air temperature over Costa Rica

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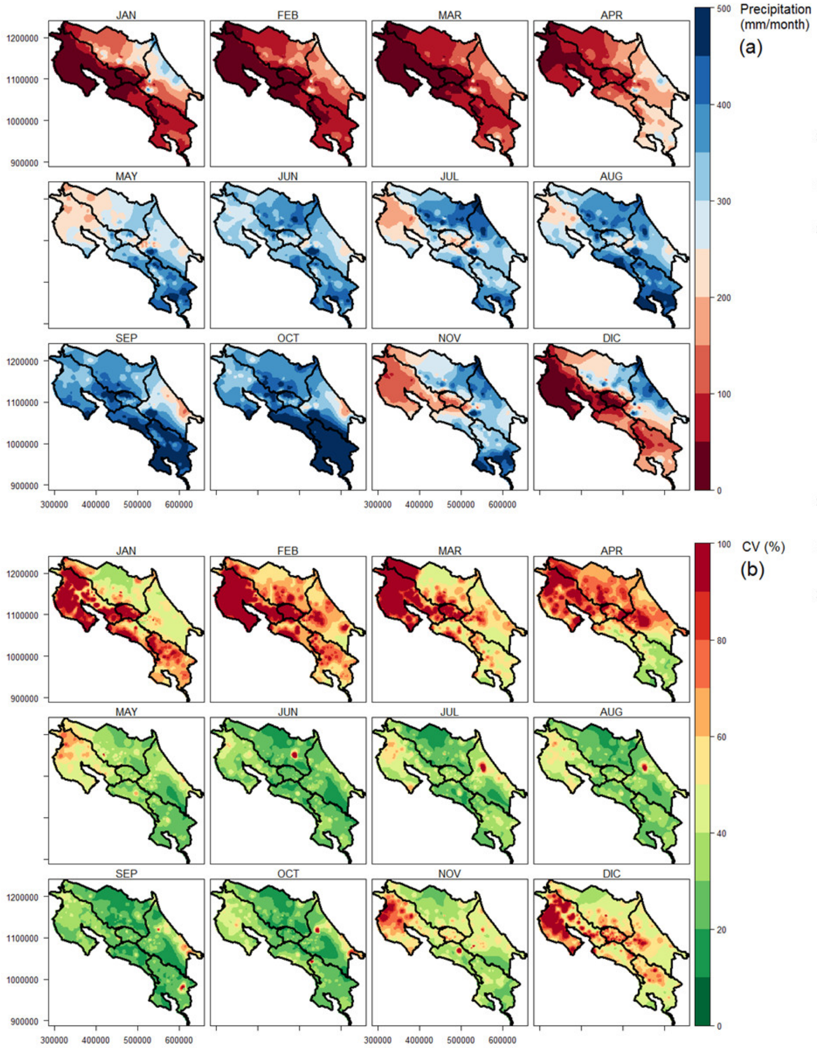
E-mail: mamendez@itcr.ac.cr

Abstract. The performance of three machine learning (ML) methods; cubist regression (CR), random forest (RF) and generalized additive model using splines (GAM) in generating monthly air temperature grids over Costa Rica was evaluated against two heavily used geostatistical methods; ordinary kriging (OK) and kriging with external drift (KED). The skill of the interpolation methods was evaluated using a 10-fold cross-validation technique; selecting the root-mean square error (RMSE), the mean absolute error (MAE) and the Pearson correlation-coefficient (R) as agreement metrics. To this purpose, data from an irregularly-distributed observational-network comprised by 73 weather-stations were selected for the period 1950-1987. Several spatial fields derived from a high-resolution digital elevation model (DEM) were tested as covariants. Results from the 10-fold cross-validation test show that CR yielded the best individual performance followed by KED, whereas GAM performed worst. Elevation on the other hand, was the only covariant ultimately incorporated in the interpolation process, since the remaining spatial fields exhibited poor correlation with temperature or resulted in data redundancy. While the quantitative and qualitative evaluation of CR and KED can be said to be comparable, CR is considered the best approach since the method is unaffected by assumptions on data normality and homoscedasticity.

CR-CC (Modelos)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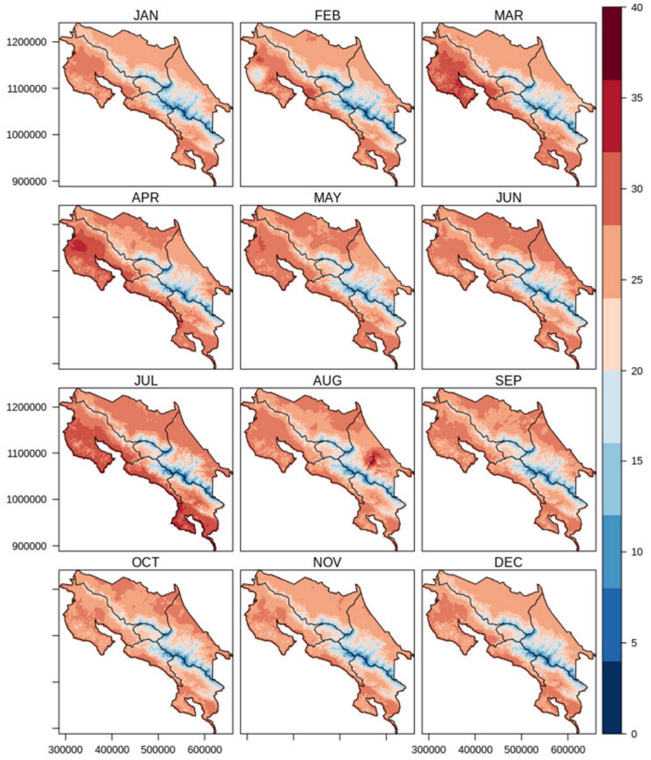
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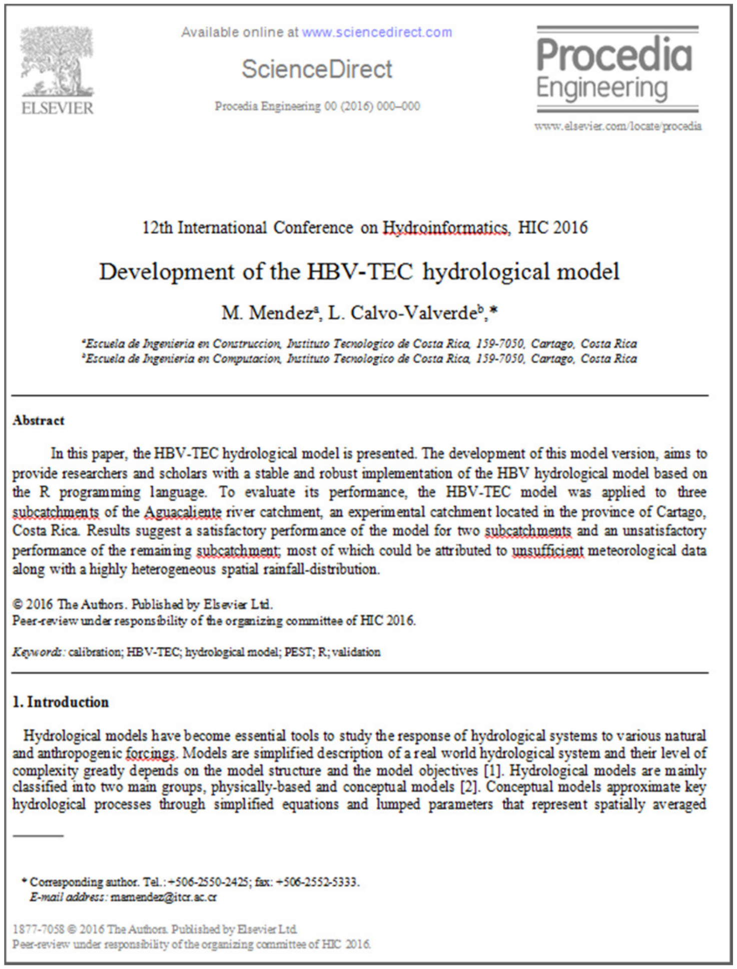

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12th International Conference on Hydroinformatics, HIC 2016

Development of the HBV-TEC hydrological model

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[b]*Escuela de Ingenieria en Computacion, Instituto Tecnologico de Costa Rica, 159-7050, Cartago, Costa Rica*

Abstract

In this paper, the HBV-TEC hydrological model is presented. The development of this model version, aims to provide researchers and scholars with a stable and robust implementation of the HBV hydrological model based on the R programming language. To evaluate its performance, the HBV-TEC model was applied to three subcatchments of the Aguacaliente river catchment, an experimental catchment located in the province of Cartago, Costa Rica. Results suggest a satisfactory performance of the model for two subcatchments and an unsatisfactory performance of the remaining subcatchment; most of which could be attributed to unsufficient meteorological data along with a highly heterogeneous spatial rainfall-distribution.

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Keywords: calibration; HBV-TEC; hydrological model; PEST; R; validation

1. Introduction

Hydrological models have become essential tools to study the response of hydrological systems to various natural and anthropogenic forcings. Models are simplified description of a real world hydrological system and their level of complexity greatly depends on the model structure and the model objectives [1]. Hydrological models are mainly classified into two main groups, physically-based and conceptual models [2]. Conceptual models approximate key hydrological processes through simplified equations and lumped parameters that represent spatially averaged

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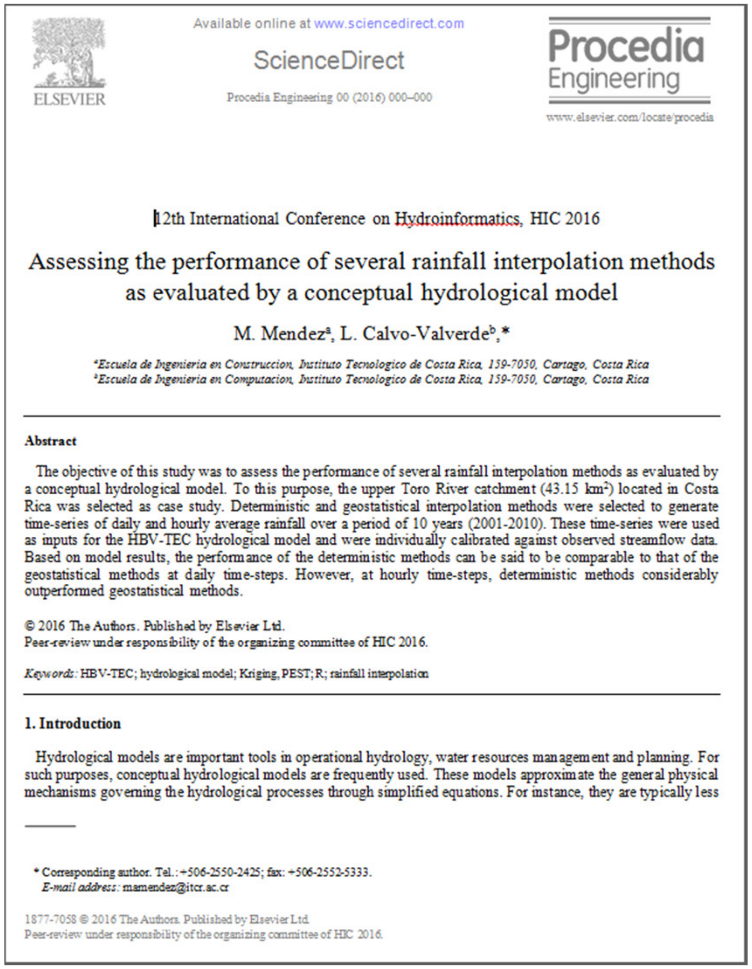

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12th International Conference on Hydroinformatics, HIC 2016

Assessing the performance of several rainfall interpolation methods as evaluated by a conceptual hydrological model

M. Mendez[a], L. Calvo-Valverde[b],*

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[b]*Escuela de Ingenieria en Computacion, Instituto Tecnologico de Costa Rica, 159-7050, Cartago, Costa Rica*

Abstract

The objective of this study was to assess the performance of several rainfall interpolation methods as evaluated by a conceptual hydrological model. To this purpose, the upper Toro River catchment (43.15 km^2) located in Costa Rica was selected as case study. Deterministic and geostatistical interpolation methods were selected to generate time-series of daily and hourly average rainfall over a period of 10 years (2001-2010). These time-series were used as inputs for the HBV-TEC hydrological model and were individually calibrated against observed streamflow data. Based on model results, the performance of the deterministic methods can be said to be comparable to that of the geostatistical methods at daily time-steps. However, at hourly time-steps, deterministic methods considerably outperformed geostatistical methods.

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Keywords: HBV-TEC; hydrological model; Kriging, PEST; R; rainfall interpolation

1. Introduction

Hydrological models are important tools in operational hydrology, water resources management and planning. For such purposes, conceptual hydrological models are frequently used. These models approximate the general physical mechanisms governing the hydrological processes through simplified equations. For instance, they are typically less

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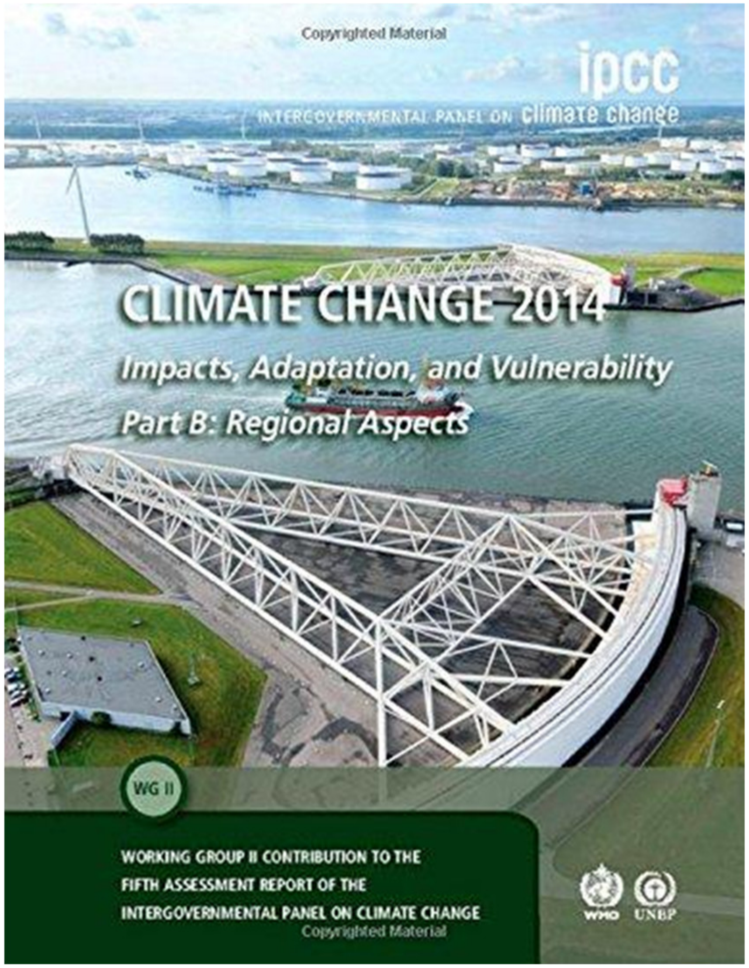
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INTERGOVERNMENTAL PANEL ON climate change
CLIMATE CHANGE 2014
Impacts, Adaptation, and Vulnerability
Part B: Regional Aspects
WG II
WORKING GROUP II CONTRIBUTION TO THE
FIFTH ASSESSMENT REPORT OF THE
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27

Central and South America

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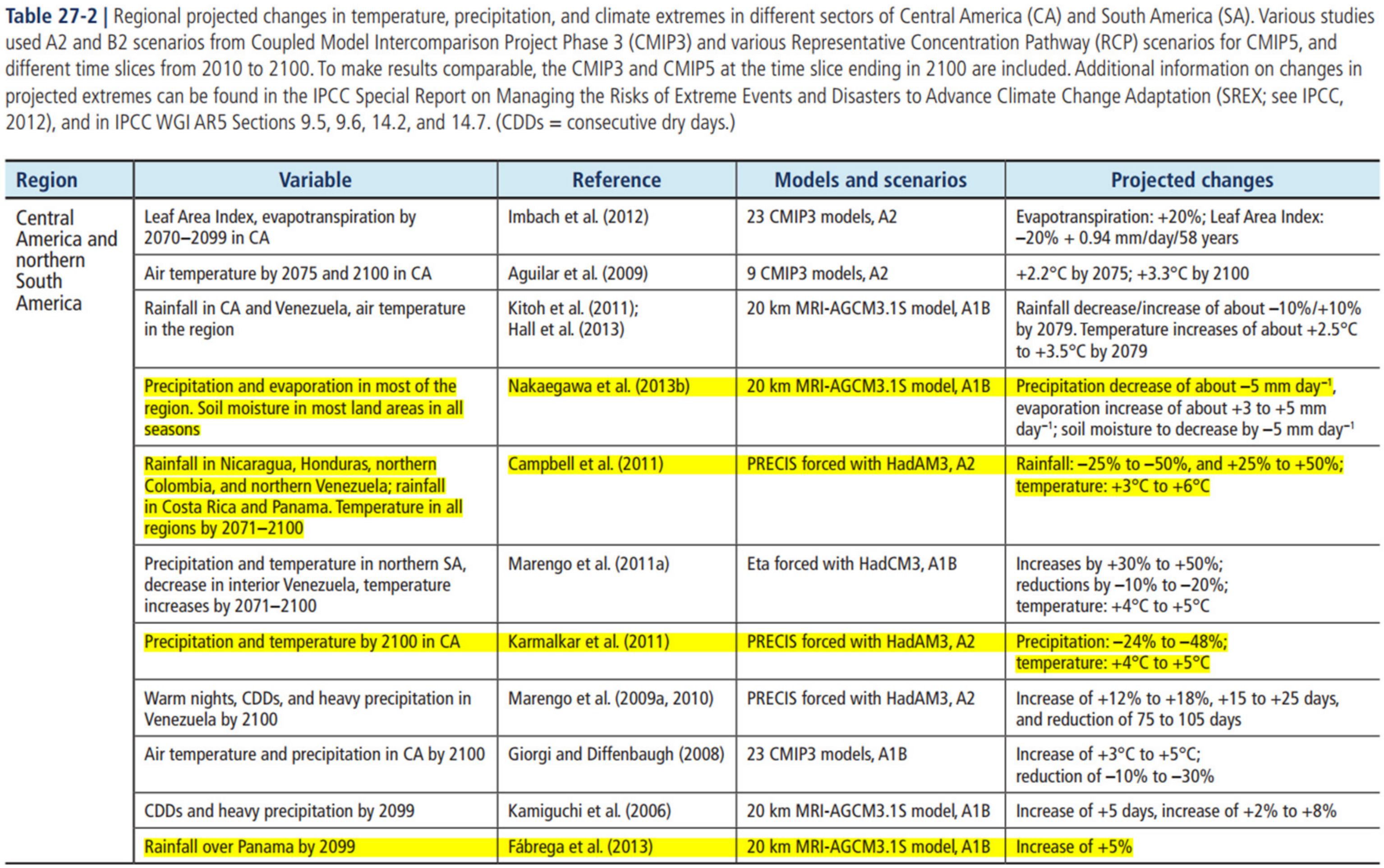

Table 27-2 | Regional projected changes in temperature, precipitation, and climate extremes in different sectors of Central America (CA) and South America (SA). Various studies used A2 and B2 scenarios from Coupled Model Intercomparison Project Phase 3 (CMIP3) and various Representative Concentration Pathway (RCP) scenarios for CMIP5, and different time slices from 2010 to 2100. To make results comparable, the CMIP3 and CMIP5 at the time slice ending in 2100 are included. Additional information on changes in projected extremes can be found in the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX; see IPCC, 2012), and in IPCC WGI AR5 Sections 9.5, 9.6, 14.2, and 14.7. (CDDs = consecutive dry days.)

Region	Variable	Reference	Models and scenarios	Projected changes
Central America and northern South America	Leaf Area Index, evapotranspiration by 2070–2099 in CA	Imbach et al. (2012)	23 CMIP3 models, A2	Evapotranspiration: +20%; Leaf Area Index: –20% + 0.94 mm/day/58 years
	Air temperature by 2075 and 2100 in CA	Aguilar et al. (2009)	9 CMIP3 models, A2	+2.2°C by 2075; +3.3°C by 2100
	Rainfall in CA and Venezuela, air temperature in the region	Kitoh et al. (2011); Hall et al. (2013)	20 km MRI-AGCM3.1S model, A1B	Rainfall decrease/increase of about –10%/+10% by 2079. Temperature increases of about +2.5°C to +3.5°C by 2079
	Precipitation and evaporation in most of the region. Soil moisture in most land areas in all seasons	Nakaegawa et al. (2013b)	20 km MRI-AGCM3.1S model, A1B	Precipitation decrease of about –5 mm day^{-1}, evaporation increase of about +3 to +5 mm day^{-1}; soil moisture to decrease by –5 mm day^{-1}
	Rainfall in Nicaragua, Honduras, northern Colombia, and northern Venezuela; rainfall in Costa Rica and Panama. Temperature in all regions by 2071–2100	Campbell et al. (2011)	PRECIS forced with HadAM3, A2	Rainfall: –25% to –50%, and +25% to +50%; temperature: +3°C to +6°C
	Precipitation and temperature in northern SA, decrease in interior Venezuela, temperature increases by 2071–2100	Marengo et al. (2011a)	Eta forced with HadCM3, A1B	Increases by +30% to +50%; reductions by –10% to –20%; temperature: +4°C to +5°C
	Precipitation and temperature by 2100 in CA	Karmalkar et al. (2011)	PRECIS forced with HadAM3, A2	Precipitation: –24% to –48%; temperature: +4°C to +5°C
	Warm nights, CDDs, and heavy precipitation in Venezuela by 2100	Marengo et al. (2009a, 2010)	PRECIS forced with HadAM3, A2	Increase of +12% to +18%, +15 to +25 days, and reduction of 75 to 105 days
	Air temperature and precipitation in CA by 2100	Giorgi and Diffenbaugh (2008)	23 CMIP3 models, A1B	Increase of +3°C to +5°C; reduction of –10% to –30%
	CDDs and heavy precipitation by 2099	Kamiguchi et al. (2006)	20 km MRI-AGCM3.1S model, A1B	Increase of +5 days, increase of +2% to +8%
	Rainfall over Panama by 2099	Fábrega et al. (2013)	20 km MRI-AGCM3.1S model, A1B	Increase of +5%

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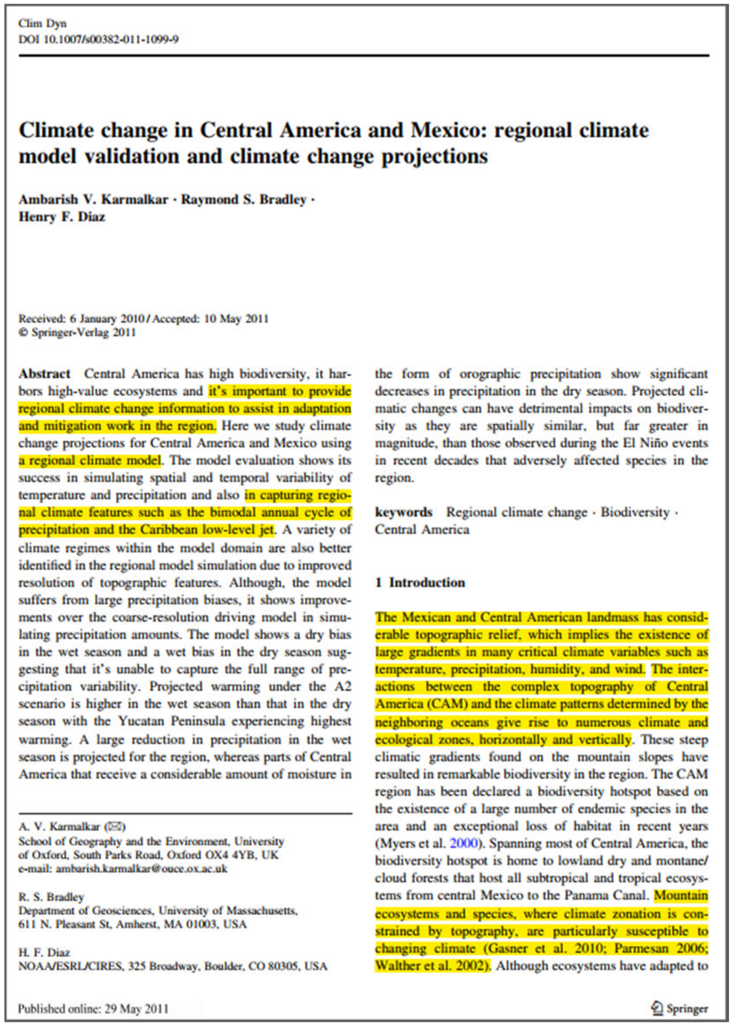

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DOI 10.1007/s00382-011-1099-9

Climate change in Central America and Mexico: regional climate model validation and climate change projections

Ambarish V. Karmalkar · Raymond S. Bradley · Henry F. Diaz

Received: 6 January 2010 / Accepted: 10 May 2011
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Abstract Central America has high biodiversity, it harbors high-value ecosystems and it's important to provide regional climate change information to assist in adaptation and mitigation work in the region. Here we study climate change projections for Central America and Mexico using a regional climate model. The model evaluation shows its success in simulating spatial and temporal variability of temperature and precipitation and also in capturing regional climate features such as the bimodal annual cycle of precipitation and the Caribbean low-level jet. A variety of climate regimes within the model domain are also better identified in the regional model simulation due to improved resolution of topographic features. Although, the model suffers from large precipitation biases, it shows improvements over the coarse-resolution driving model in simulating precipitation amounts. The model shows a dry bias in the wet season and a wet bias in the dry season suggesting that it's unable to capture the full range of precipitation variability. Projected warming under the A2 scenario is higher in the wet season than that in the dry season with the Yucatan Peninsula experiencing highest warming. A large reduction in precipitation in the wet season is projected for the region, whereas parts of Central America that receive a considerable amount of moisture in the form of orographic precipitation show significant decreases in precipitation in the dry season. Projected climatic changes can have detrimental impacts on biodiversity as they are spatially similar, but far greater in magnitude, than those observed during the El Niño events in recent decades that adversely affected species in the region.

keywords Regional climate change · Biodiversity · Central America

1 Introduction

The Mexican and Central American landmass has considerable topographic relief, which implies the existence of large gradients in many critical climate variables such as temperature, precipitation, humidity, and wind. The interactions between the complex topography of Central America (CAM) and the climate patterns determined by the neighboring oceans give rise to numerous climate and ecological zones, horizontally and vertically. These steep climatic gradients found on the mountain slopes have resulted in remarkable biodiversity in the region. The CAM region has been declared a biodiversity hotspot based on the existence of a large number of endemic species in the area and an exceptional loss of habitat in recent years (Myers et al. 2000). Spanning most of Central America, the biodiversity hotspot is home to lowland dry and montane/cloud forests that host all subtropical and tropical ecosystems from central Mexico to the Panama Canal. Mountain ecosystems and species, where climate zonation is constrained by topography, are particularly susceptible to changing climate (Gasner et al. 2010; Parmesan 2006; Walther et al. 2002). Although ecosystems have adapted to

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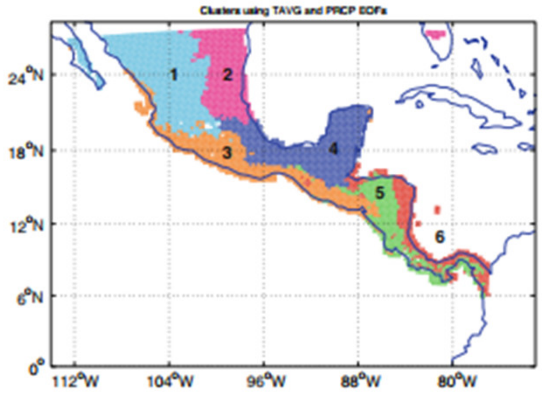

Fig. 7 Regional model domain divided into six regions using EOF and cluster analyses on simulated mean annual SAT and PRCP data

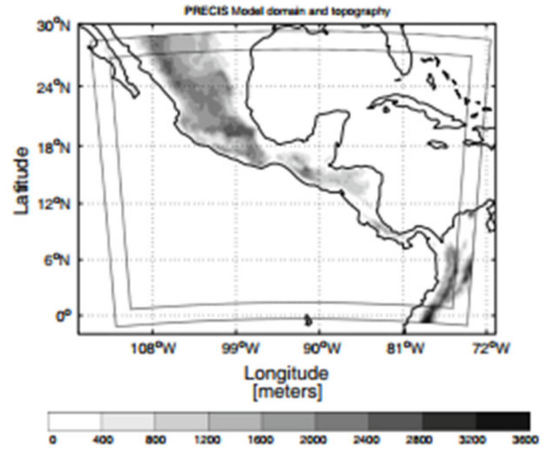

Fig. 1 PRECIS RCM model domain and the elevation map. The area between the outer rectangle and the inner rectangle is the buffer zone, where the boundary conditions data interacts with the RCM data. The model output for the area within the inner rectangle is included in the analysis

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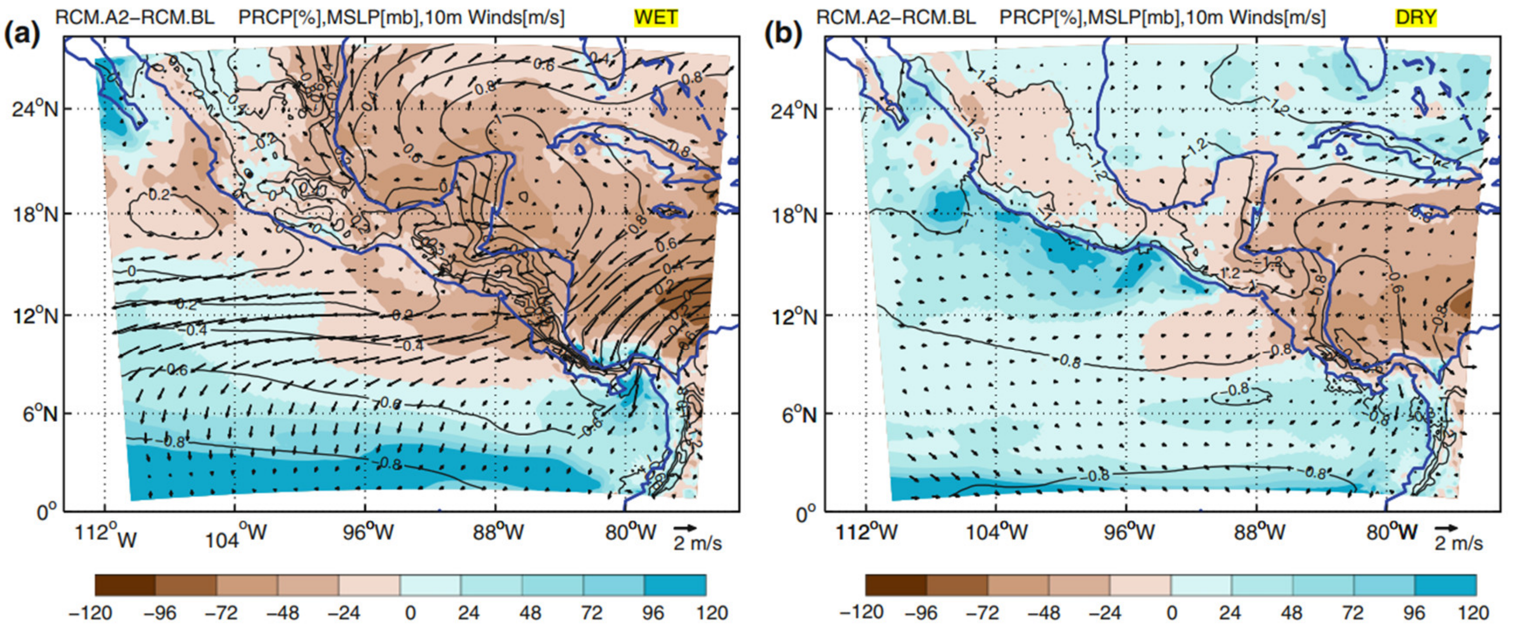
(a)
RCM.A2–RCM.BL PRCP[%],MSLP[mb],10m Winds[m/s]
WET
(b)
RCM.A2–RCM.BL PRCP[%],MSLP[mb],10m Winds[m/s]
DRY
24°N
18°N
12°N
6°N
0°
112°W
104°W
96°W
88°W
80°W
2 m/s
−120
−96
−72
−48
−24
0
24
48
72
96
120

Fig. 16 Projected change in PRCP (*colors*, % change with respect to RCM.BL), MSLP (*contours* in mb) and 10 m winds (m/s). Percentage change within ±20% is not significant at the 95% significance level

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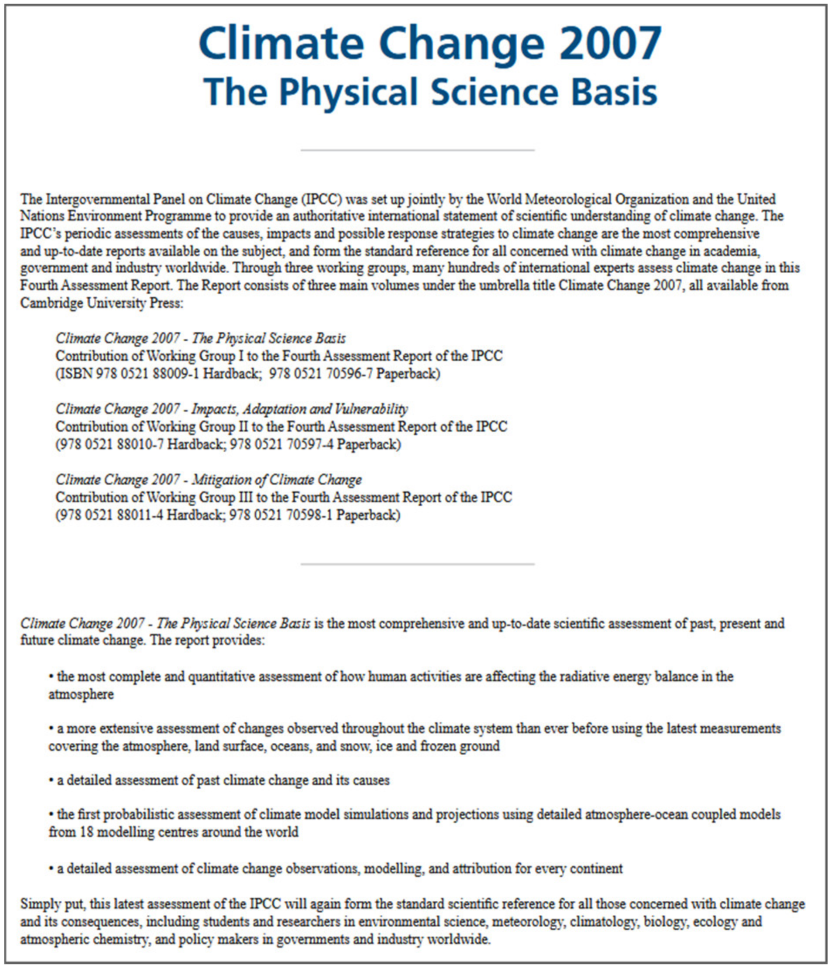

Climate Change 2007
The Physical Science Basis

The Intergovernmental Panel on Climate Change (IPCC) was set up jointly by the World Meteorological Organization and the United Nations Environment Programme to provide an authoritative international statement of scientific understanding of climate change. The IPCC's periodic assessments of the causes, impacts and possible response strategies to climate change are the most comprehensive and up-to-date reports available on the subject, and form the standard reference for all concerned with climate change in academia, government and industry worldwide. Through three working groups, many hundreds of international experts assess climate change in this Fourth Assessment Report. The Report consists of three main volumes under the umbrella title Climate Change 2007, all available from Cambridge University Press:

Climate Change 2007 - The Physical Science Basis
Contribution of Working Group I to the Fourth Assessment Report of the IPCC
(ISBN 978 0521 88009-1 Hardback; 978 0521 70596-7 Paperback)

Climate Change 2007 - Impacts, Adaptation and Vulnerability
Contribution of Working Group II to the Fourth Assessment Report of the IPCC
(978 0521 88010-7 Hardback; 978 0521 70597-4 Paperback)

Climate Change 2007 - Mitigation of Climate Change
Contribution of Working Group III to the Fourth Assessment Report of the IPCC
(978 0521 88011-4 Hardback; 978 0521 70598-1 Paperback)

Climate Change 2007 - The Physical Science Basis is the most comprehensive and up-to-date scientific assessment of past, present and future climate change. The report provides:

- the most complete and quantitative assessment of how human activities are affecting the radiative energy balance in the atmosphere
- a more extensive assessment of changes observed throughout the climate system than ever before using the latest measurements covering the atmosphere, land surface, oceans, and snow, ice and frozen ground
- a detailed assessment of past climate change and its causes
- the first probabilistic assessment of climate model simulations and projections using detailed atmosphere-ocean coupled models from 18 modelling centres around the world
- a detailed assessment of climate change observations, modelling, and attribution for every continent

Simply put, this latest assessment of the IPCC will again form the standard scientific reference for all those concerned with climate change and its consequences, including students and researchers in environmental science, meteorology, climatology, biology, ecology and atmospheric chemistry, and policy makers in governments and industry worldwide.

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- The annual mean warming between 1980 to 1999 and 2080 to 2099 varies in the CAM region from 1.8 C to 5.0 C (Christensen et al. 2007).
- For Central America, 19 (out of 21) GCMs agree on the direction of change in precipitation, predicting a decrease in precipitation under the A1B scenario. The full range of IPCC projections for the area range from -48 to 9% change in mean precipitation with half the models between -16 to -5% (Christensen et al. 2007).

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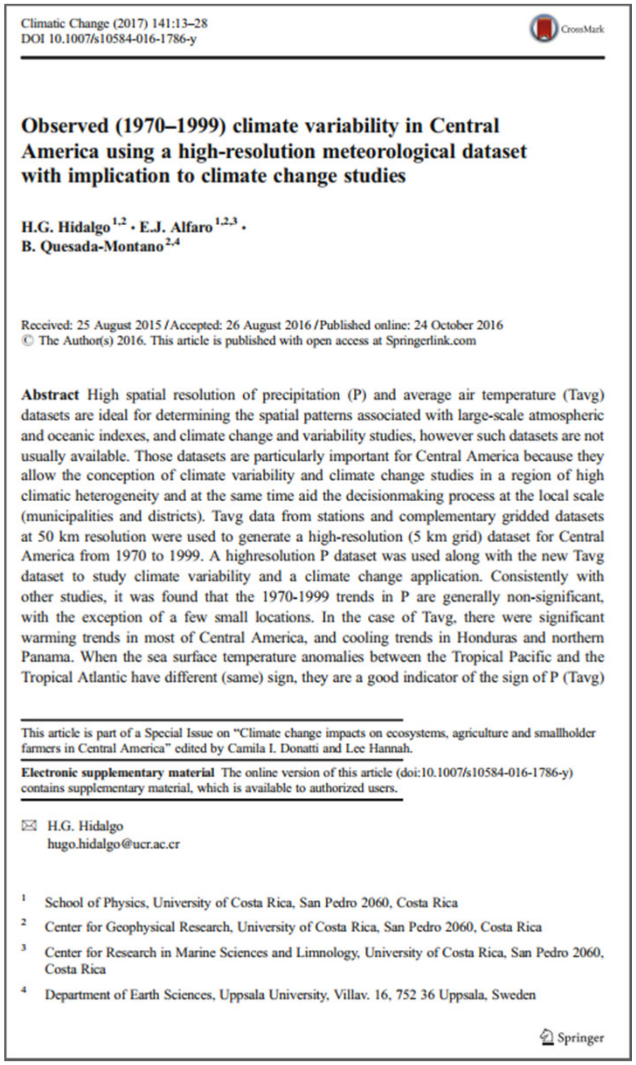

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DOI 10.1007/s10584-016-1786-y

Observed (1970–1999) climate variability in Central America using a high-resolution meteorological dataset with implication to climate change studies

H.G. Hidalgo[1,2] · E.J. Alfaro[1,2,3] ·
B. Quesada-Montano[2,4]

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Abstract High spatial resolution of precipitation (P) and average air temperature (Tavg) datasets are ideal for determining the spatial patterns associated with large-scale atmospheric and oceanic indexes, and climate change and variability studies, however such datasets are not usually available. Those datasets are particularly important for Central America because they allow the conception of climate variability and climate change studies in a region of high climatic heterogeneity and at the same time aid the decisionmaking process at the local scale (municipalities and districts). Tavg data from stations and complementary gridded datasets at 50 km resolution were used to generate a high-resolution (5 km grid) dataset for Central America from 1970 to 1999. A highresolution P dataset was used along with the new Tavg dataset to study climate variability and a climate change application. Consistently with other studies, it was found that the 1970-1999 trends in P are generally non-significant, with the exception of a few small locations. In the case of Tavg, there were significant warming trends in most of Central America, and cooling trends in Honduras and northern Panama. When the sea surface temperature anomalies between the Tropical Pacific and the Tropical Atlantic have different (same) sign, they are a good indicator of the sign of P (Tavg)

This article is part of a Special Issue on "Climate change impacts on ecosystems, agriculture and smallholder farmers in Central America" edited by Camila I. Donatti and Lee Hannah.

Electronic supplementary material The online version of this article (doi:10.1007/s10584-016-1786-y) contains supplementary material, which is available to authorized users.

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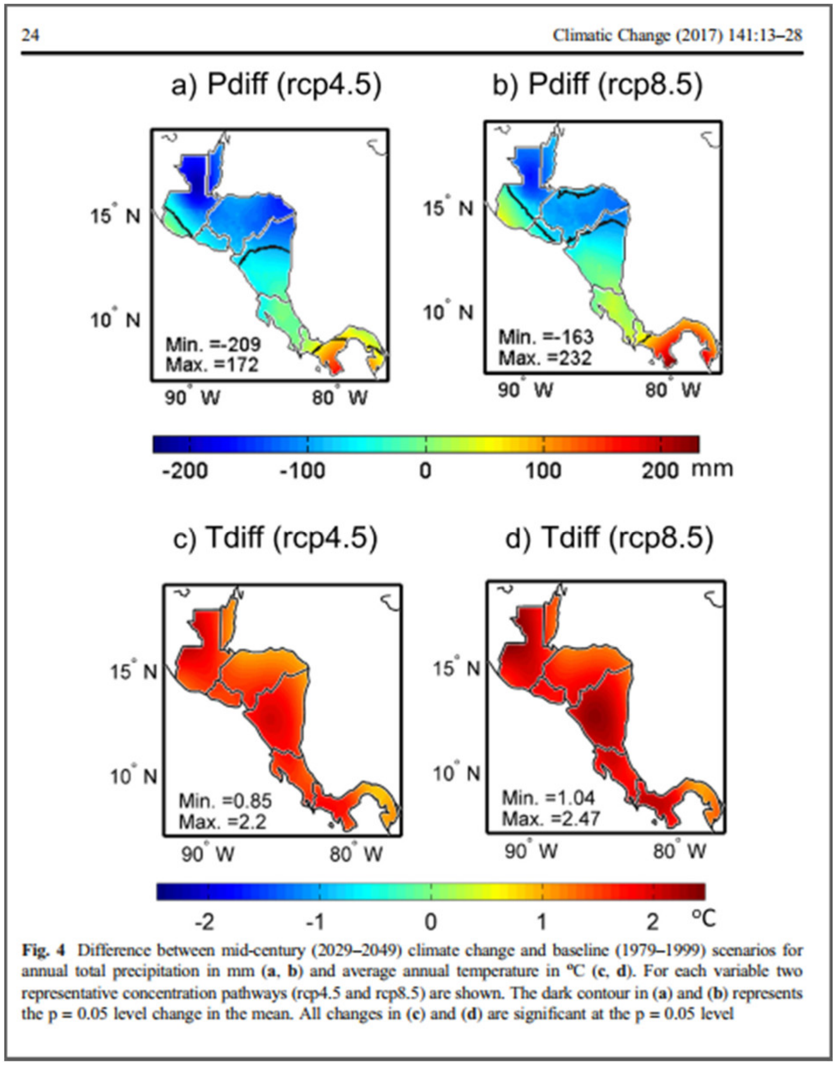

Fig. 4 Difference between mid-century (2029–2049) climate change and baseline (1979–1999) scenarios for annual total precipitation in mm (**a**, **b**) and average annual temperature in °C (**c**, **d**). For each variable two representative concentration pathways (rcp4.5 and rcp8.5) are shown. The dark contour in (**a**) and (**b**) represents the p = 0.05 level change in the mean. All changes in (**c**) and (**d**) are significant at the p = 0.05 level

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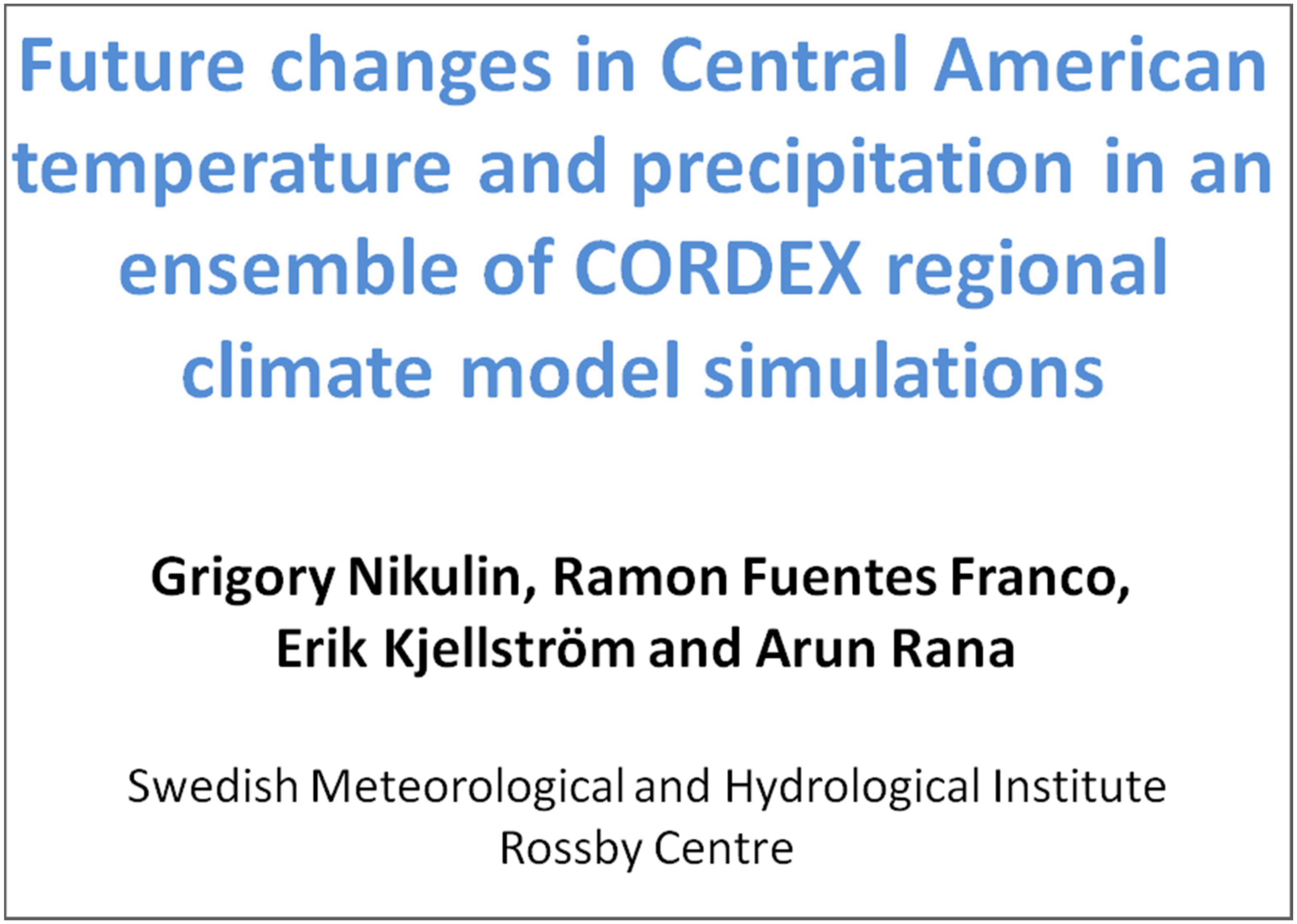

Future changes in Central American temperature and precipitation in an ensemble of CORDEX regional climate model simulations

Grigory Nikulin, Ramon Fuentes Franco, Erik Kjellström and Arun Rana

Swedish Meteorological and Hydrological Institute
Rossby Centre

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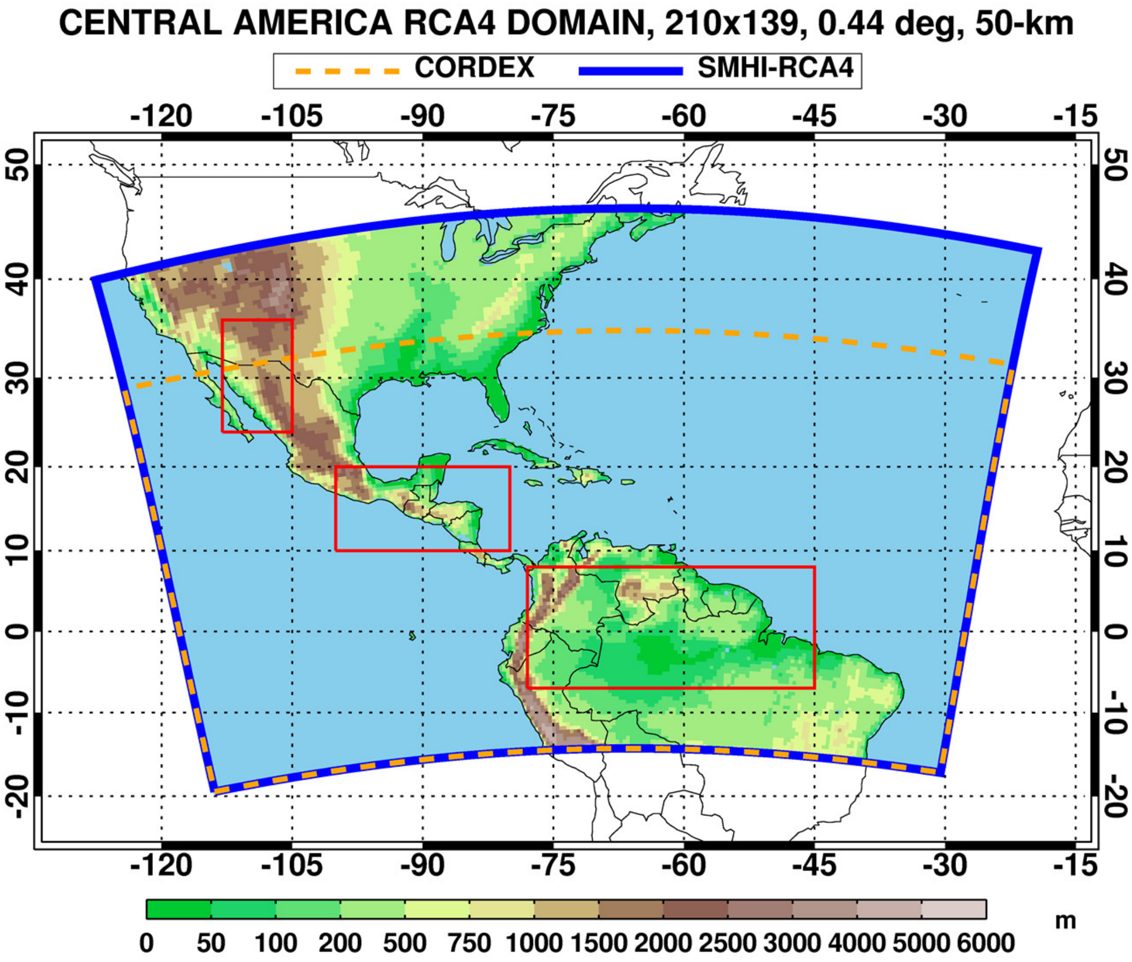
CENTRAL AMERICA RCA4 DOMAIN, 210x139, 0.44 deg, 50-km
CORDEX
SMHI-RCA4
-120
-105
-90
-75
-60
-45
-30
-15
50
40
30
20
10
0
-10
-20
0
50
100
200
500
750
1000
1500
2000
2500
3000
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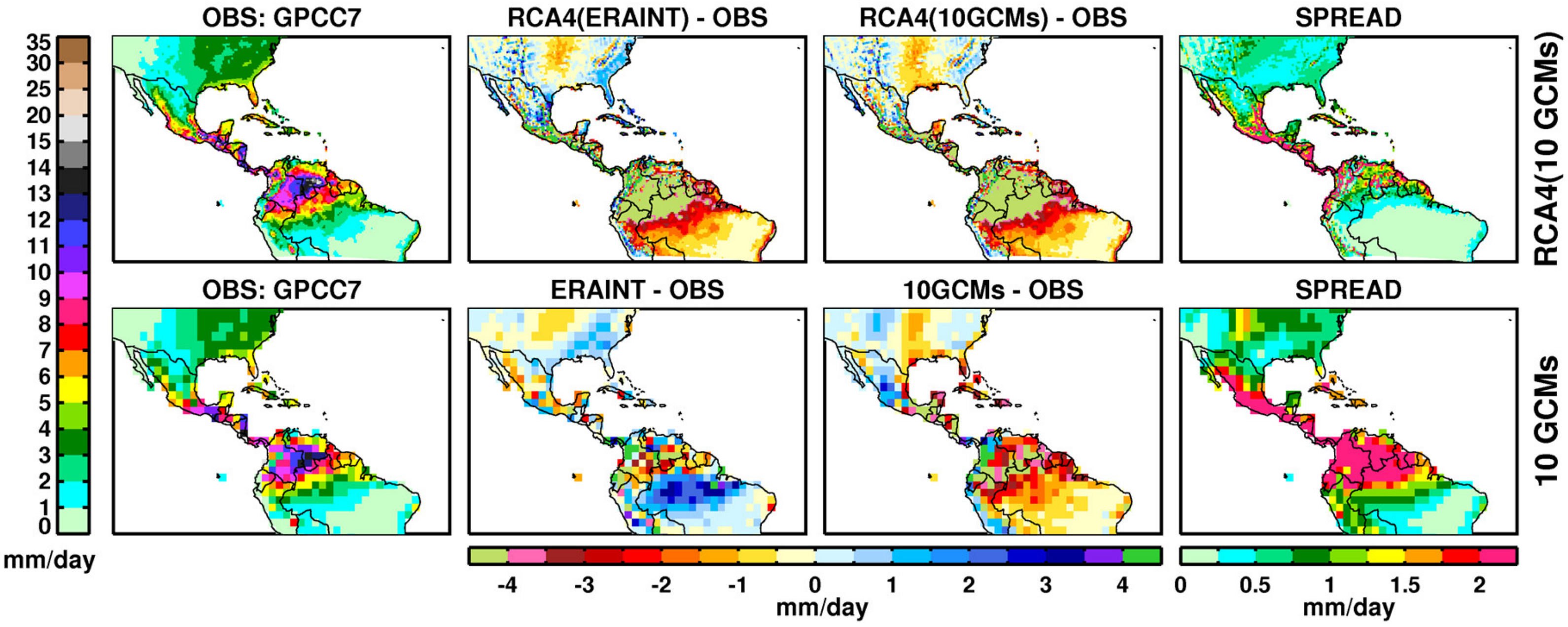
OBS: GPCC7
RCA4(ERAINT) - OBS
RCA4(10GCMs) - OBS
SPREAD
RCA4(10 GCMs)
OBS: GPCC7
ERAINT - OBS
10GCMs - OBS
SPREAD
10 GCMs
35 30 25 20 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
mm/day
-4 -3 -2 -1 0 1 2 3 4
mm/day
0 0.5 1 1.5 2
mm/day

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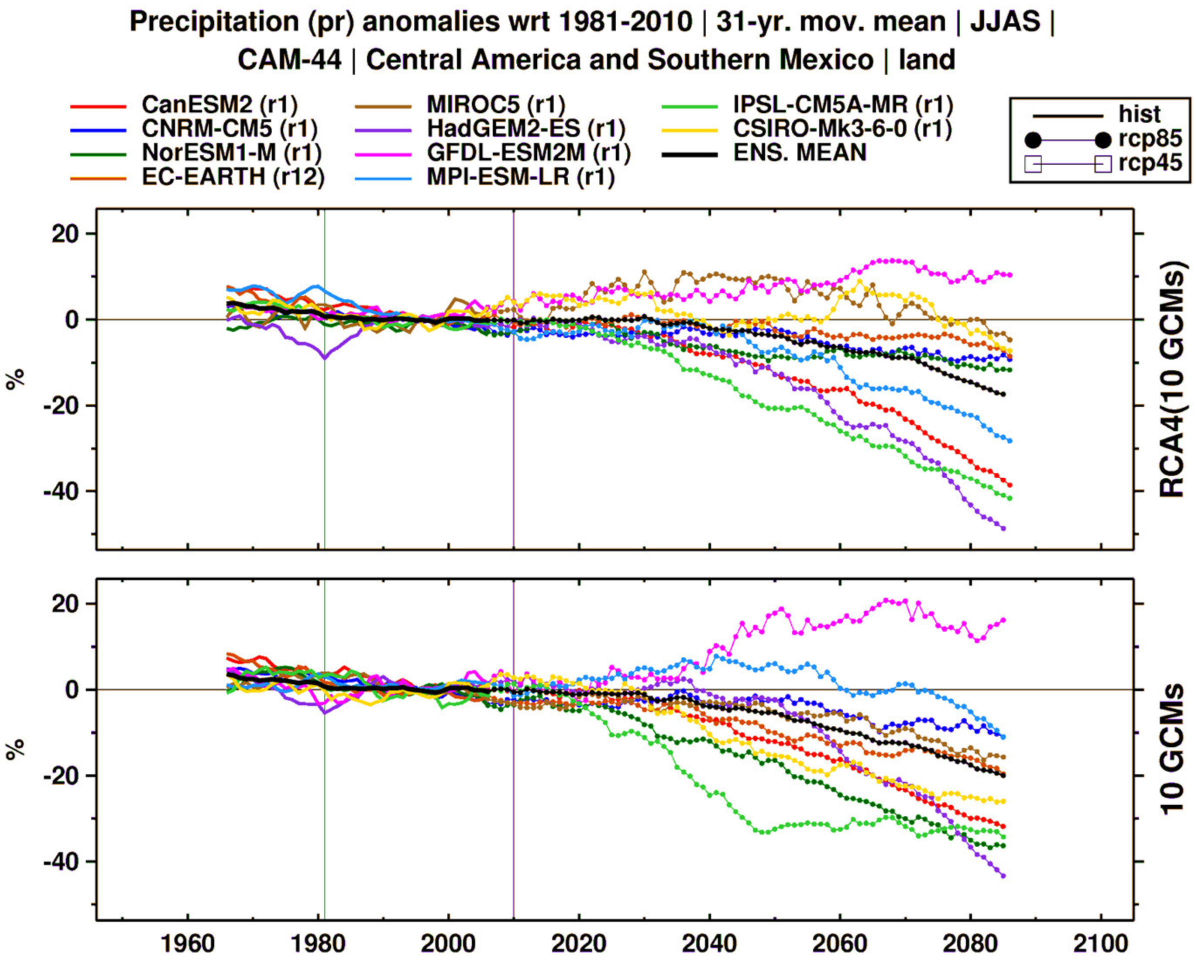

Precipitation (pr) anomalies wrt 1981-2010 | 31-yr. mov. mean | JJAS | CAM-44 | Central America and Southern Mexico | land

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- Aumento de resolución espacial a 0.11° x 0.11° (12 x 12 km) (***RCA4, RegCM4***).
- Disminuir la incertidumbre (BIAS).
- Super Optimización de **HadGEM2** sobre la línea base.
- Aplicación de nuevos BC-Methods.
- Aplicación a nivel de Estaciones Puntuales.
- Reconstrucción de registros de temperatura.
- Compensación curvas IDFs.

Fin de la presentación

- Preguntas?