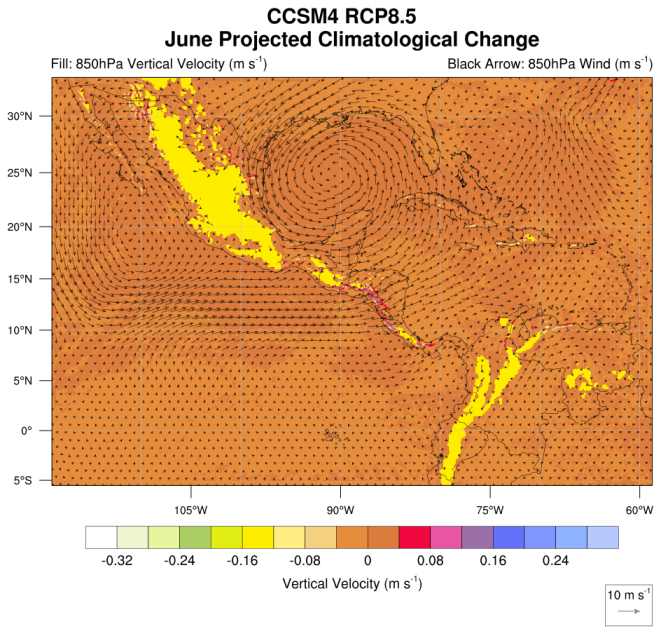
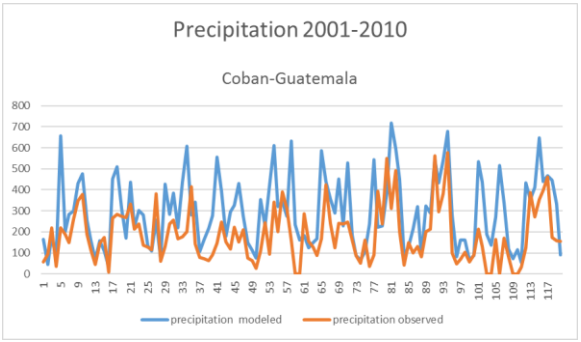
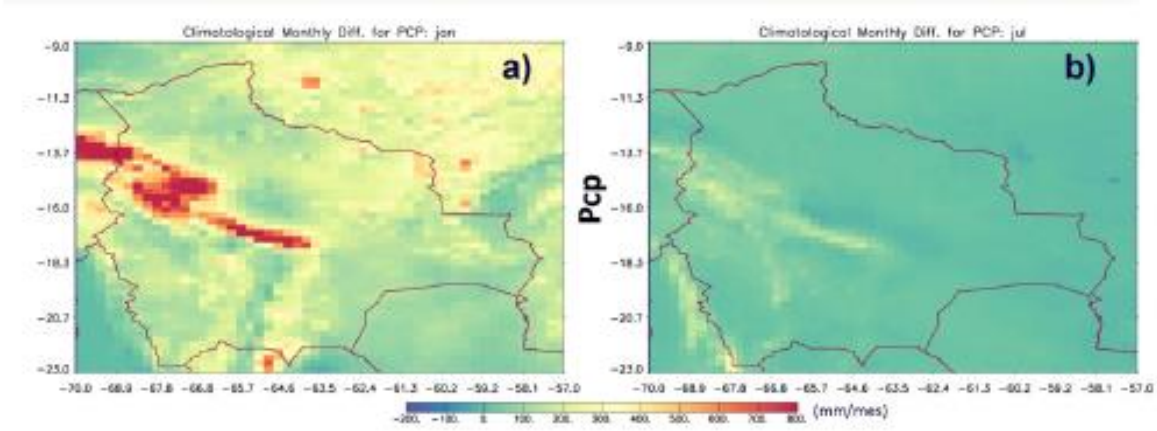
# Strengthening Institutional Capacity to Improve the Assessment of Impacts of Climate Change in Latin America and the Caribbean

## Contract # INE/CCS-RG-T2612-SN1



# Technical Report #3

# Proceedings of the Third Workshop

**prepared by**

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**Lincoln, Nebraska, USA**
**April 2017**

# Contents



## *Appendices*

# Workshop 3: Continuing Regional Climate Change Activities Step 3 (27-30 March 2017)

## *Overview*

The third Consortium workshop was held at the facilities of CATHALAC on the campus of the City of Knowledge in Panama City, Panama from 27-30 March 2017 (see Appendix A for agenda). Eleven representatives from 10 countries were in attendance, and the Workshop was directed by two scientists from the University of Nebraska-Lincoln (see Appendix B for list of participants).

The Workshop was four days in length, and focused primarily on the Working Groups. Each group met to discuss progress and update regional and topical needs, and presented these results regularly through the week to the entire group. Continuing *MapMaker* updates were demonstrated and discussed, and the participants were able to try them out under our guidance, and suggest still further enhancements. Several enhancements and improvements were implemented during the workshop or immediately thereafter. Finally, there was a group assessment and lengthy discussion of project progress to date, and the next steps to take.

## *Workshop Objectives*

The objectives for this third Workshop continued to emphasize putting the 'work' into 'workshop'. That is, the activities focused around the Participants working together, exchanging ideas, learning new methods from us and from each other, and so forth.

1) Meetings of each Working Group to discuss progress and update regional needs. This was a key focus of the Third Workshop.

2) Individual participant discussion of specific country progress and continued needs. This was a key outcome of the Workshop, as they were not shy!

3) Regular reports of each Working Group to all participants (see Appendix D).

4) Update on, demonstration, and discussion of new MapMaker improvements and enhancements

5) Group assessment of progress, and the next steps to take.

A continuing strength of this third Workshop was the frank and open group discussions we had about the scope of the project, what the expectations were, and how best to proceed, both with the workshops and, importantly, between them.

## *Working Groups*

Deliberations by each Group continued much of the day Monday, Tuesday, and Wednesday as well as Thursday morning. This was the focus of the Workshop. As always, the staff from the University of Nebraska circulated among the Groups, answering questions and providing advice and guidance.

On Wednesday afternoon and Thursday morning, each Working Group presented a report that described progress made during the workshop. In addition, each Group discussed their plans until the next workshop, scheduled for this coming July. The presentation slides and other material presented are collected in Appendix C.

We continue to be extremely pleased with the continuing progress each Working Group was able to make both before and during this third Workshop. Each Group has a coherent plan for moving forwarded and, especially once relevant *MapMaker* enhancements are implemented, appear to have the knowledge, capabilities, and resources necessary to carry out their plans.

## *MapMaker Developments*

Participants were again asked to identify and propose any additional capabilities they would like to see added to *MapMaker*. Existing capabilities and proposed additional functionality are summarized in the table below. *MapMaker* development will be on-going during the contract period. In response to participant suggestions at previous workshops, immediately prior to this workshop, a prototype password-protected webpage to allow participants to upload station data for verification against downscaled model results from historical simulations was developed. Participants are working to transform their individual country climate data format into a common, generic format that can be utilized in *MapMaker* applications. During and immediately following the workshop, several improvements and enhancements were added to *MapMaker* applications in response to participant suggestions, including:

- *Download:* return domain limits if user selects out-of-domain point(s) for data selection
- *Download:* daily/monthly dataset selection
- *MapMaker:* added "Change" and "Offset" datasets for Bolivia
- *MapMaker:* added "True winter" option (i.e., DJF, instead of JFD) for seasonal averaging
- *MapMaker:* error message for relative humidity on "Change" and "Offset" runs
- *MapMaker:* allows for user selection of any NCL color table
  - dropdown includes MeteoSwiss colortables plus "default"
  - user can enter text name of any available NCL colormap
- *Verification:* integration of this applications is progressing
    - only scatterplots and times series, at present
    - additional international dataset added – Global Historical Climate Network-Daily (GHCN), with approximately 3× the stations over our domains, compared to Global Summary of Day (GSOD)

## *Group Assessment of Progress*

A continuing strength of this third Workshop was the frank and open group discussions we had about the scope of the project, what the expectations were, and how best to proceed, both with the workshops and importantly during the time in-between them.

The conflicting needs of the Participants were discussed, that is, the requirements of the BID contract funding the project, versus the individual country needs of the participants, which had wide variation and was not always compatible with Working Group objectives.

The need to stay in better contact was also discussed at length. The individual Working Group Skype sessions between the first and second workshops were not well organized (the UNL staff takes full responsibility for this). This meant participation was spotty. Scheduling these sessions at least a month in advance, followed by timely reminders, is therefore a priority. This was a topic of discussion during the Workshop and we mutually agreed that we all need to be more proactive in scheduling these as far in advance as possible and block the time off in our

schedules. This contact will be done via video conferencing, email, and other methods as appropriate. Also, based on Participant suggestions, all Working Group Skypes will be open to all Participants. This is both to ensure continuity and compatibility between the Working Groups, and because the interests of many of the Participants intersect the specific Working Group themes.

Summary of current *MapMaker* suite capabilities and proposed additional functions. Unification of prior capabilities is progressing well (i.e., single version for all projects); enhancements and improvements are being phased in. Green – fully implemented; Blue – partial implementation.

| ***MapMaker* Capabilities – Present & Proposed** | | | | |
|---|---|---|---|---|
| | **Overall** | ***MapMaker*** | **Data Download** | **Verification** |
| **Present capabilities** | | monthly maps | full files only (1 year of monthly data/domain) | GSOD "only" – just WMO stations |
| | | basic variables | netCDF only | pre-processed |
| | | averaging months (2-12) | | 5 variables |
| | | Zoom | | basic statistics table |
| | | change plot parameters | | basic plot types |
| | | change color tables | | |
| | | several graphic formats | | |
| **Proposed additions** | utilize daily data | "get map data" button | sub-setting by time, latitude-longitude box, point, etc. | "country" data & metadata (units, QC, etc.) |
| | add more data (GSOD, "country", other model) for additional time periods | % change for precip | Averaging | ability to select begin/end times for verification (within available data/model times) |
| | statistics (distributions, percentiles, etc.) | cross-model averaging | additional data formats (e.g., CSV) | "get data" button |
| | pre-compute standard climate extreme indices | storage (temporary) of data from other sources for comparison | | |
| | | rename "years" for GCM-driven simulations from nominal years to "model years" to avoid a common source of confusion (e.g., nominal 2006 becomes MY01, nominal 2056 becomes MY51) | | |
| | | custom plot titles | | |
| | | better overlay capability | | |

Assumptions going forward:

- capacity to store all UNL WRF daily data (in place November 2016) and use these to compute requested parameters (e.g., averages, threshold exceedances, dry/wet runs)
    - might be desirable to pre-process and store some standard monthly and climatological parameters (speed vs. storage)
- sufficient processing power to perform some computations "on the fly" (in place November 2016)
- countries will need to provide their data in some simple, standardized format with standardized naming convention (format developed February 2017)
    - metadata (units, QC, etc.) must be provided, as well

## *Workshop Summary*

In summary, the Workshop was a successful continuation to the Regional Consortium. The Participants continued to make considerable progress in the three Working Groups. Each group spent considerable time meeting separately, with the discussions in each case focused on understanding the model downscaled results. The focus was further organized into two themes: 1) The likely impacts for the people and infrastructure involved; and 2) Preparation of a paper reporting on these findings to be submitted to an appropriate scientific journal.

In addition to these separate Working Group meetings, there were also numerous 'plenary' sessions were held with all three groups (i.e., all Participants) meeting together. This led to considerable cross-communication between Working Groups, the need for which had been stressed during our monthly Skype sessions. It is anticipated that at least one joint scientific paper, as well as several crosscutting reports will be a key result.

## *The Next Steps*

The monthly Skype sessions will resume on the first Wednesday of each month. As described above, these will be joint, so as to help ensure communication between Working Groups, and between individual participants.

New features of MapMaker decided upon will be available in the coming months.

The next workshop is scheduled for 10-13 July 2017.

MapMaker is now on **http://rccdp.unl.edu** and this will continue to be developed and enhanced. It is expected that, before the next workshop, integration of prior MapMaker functionality (i.e., single code source for all projects) will be completed and many of the proposed improvements and enhancements will be implemented.

**DATA**

- To include more station data in Mapmaker, as provided by the Participants.
- To include more stations from INSIVUMEH (INETER and other NMHSs, as an example.
- To perform quality control and homogenization process to stations data. This is crucial, but may require a technical person devoted to the effort.

**COORDINATION UPDATE**

- Include all groups into one discussion list to enhance different skills or expertise
- Define short term goals based on country needs or interests
- Skype meetings with all groups
- Discuss a preliminary agenda with the Group prior to the next Workshop.

## Appendix A: Workshop Agenda

# - AGENDA –

# Workshop 3

## *Continuing Regional Climate Change Consortium Activities: Step 3*
## *(27-30 March 2017)*

| **Day 1:** | | |
|---|---|---|
| **Morning** | | |
| 9:00 am | Registration<br>Introduction and Scope of Workshop | |
| 9:30 am | Status reports from each Working Group | (plenary) |
| 10:30 am | ***Break*** | |
| 10:45 am | MapMaker update | (plenary) |
| 11:15 am | Group discussion: MapMaker needs | (plenary) |
| 12:30 pm | ***Lunch*** | |
| **Afternoon** | | |
| 2:00 pm | Working Groups meet | (breakout) |
| 3:30 pm | ***Break*** | |
| 3:45 pm | Working Groups meet | (breakout) |
| 4:30 pm | Group discussion: key themes, ideas, and needs identified so far | (plenary) |
| 5:00 pm | ***Adjourn for the day*** | |

| **Day 2:** ***Working Group Meetings*** | | |
|---|---|---|
| **Morning** | | |
| 8:30 am | Status reports from each Working Group | (plenary) |
| 9:15 am | Working Groups meet | (breakout) |
| 10:30 am | ***Break*** | |
| 11:00 am | Summary of progress to date, half-way through project | (plenary) |
| 12:30 pm | ***Lunch*** | |
| **Afternoon** | | |
| 2:00 pm | Working Groups meet | (breakout) |
| 3:30 pm | ***Break*** | |
| 4:00 pm | Group discussion: key themes, ideas, and needs identified so far | (plenary) |
| 5:00 pm | ***Adjourn for the day*** | |

| **Day 3: *Working Group Meetings*** | | |
|---|---|---|
| **Morning** | | |
| 8:30 am | Status reports from each Working Group | (plenary) |
| 9:15 am | Working Groups meet | (breakout) |
| 10:30 am | ***Break*** | |
| 11:00 am | Working Groups meet | (breakout) |
| 12:30 pm | ***Lunch*** | |
| **Afternoon** | | |
| 2:00 pm | Working Groups meet | (breakout) |
| 3:30 pm | ***Break*** | |
| 4:00 pm | Group discussion: key themes, ideas, and needs identified so far | (plenary) |
| 5:00 pm | ***Adjourn for the day*** | |

| **Day 4: *Workshop Conclusions and Next Steps*** | | |
|---|---|---|
| **Morning** | | |
| 8:30 am | Working Groups finalize plans | (breakout) |
| 10:30 am | ***Break*** | |
| 11:00 am | Working Groups report | (plenary) |
| 12:30 pm | ***Lunch*** | |
| **Afternoon** | | |
| 2:00 pm | What we have accomplished during this workshop | (plenary) |
| 2:30 pm | Key needs moving forward | (plenary) |
| 3:30 pm | ***Break*** | |
| 4:00 pm | Next steps | (plenary) |
| 4:30 pm | Workshop conclusions: Future objectives, tasks, and goals | (plenary) |
| 5:00 pm | ***Adjourn the workshop*** | |

# Appendix B: List of Participants

| | |
|---|---|
| **Nombre del Evento:** | Tercero Taller Regional del Programa "Fortalecimiento de capacidades institucionales para mejorar la evaluación de los impactos del cambio climático en América Latina y el Caribe" |
| **Fechas:** | 27 al 30 march 2017 |
| **Lugar:** | Ciudad de Panamá, Panamá |

| | Nombre | Cargo | Organización | email |
|---|---|---|---|---|
| 1 | Alberto López López | Investigador | Instituto de Investigaciones Eléctricas, México | alopezl@iie.org.mx |
| 2 | Marcos Andrade Flores | Laboratorio de Física de la Atmósfera | Universidad Mayor de San Andrés, Bolivia | mandrade@atmos.umd.edu mandrade@fiumsa.edu.bo |
| 3 | Gabriela Alfaro Marroquín | Directora Interina | Centro de Estudios Ambientales y Biodiversidad, Universidad del Valle de Guatemala | gabyalfaro@yahoo.com |
| 4 | Francisco Javier Argeñal Pinto | Sub Jefe del Centro Nacional de Estudios Atmosféricos, Oceanográficos y Sísmicos | Comisión Permanente de Contingencias (COPECO), Honduras | fjargenal@gmail.com |
| 5 | Juan José Nieto | Jefe de Servicios Climáticos | Centro Internacional para la Investigación del Fenómeno de El Niño (CIIFEN), Ecuador | j.nieto@ciifen.org |
| 6 | Jose Franklyn Ruiz Murcia | Subdirección de Meteorología | Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM), Colombia | jruiz@ideam.gov.co |
| 7 | Alan Gerardo LLacza Rodríguez | Dirección de Meteorología Aplicada | Servicio Nacional de Meteorología e Hidrología (SENAMHI), Perú | allacza@senamhi.gob.pe |
| 8 | Dusstin Barrera Gómez | Encargado de Base de Datos de Meteorología en la Dirección General de Sistemas Geo-Informáticos | Instituto Nicaragüense de Estudios Territoriales | dusstin.barrera@sb.ineter.gob.ni dussbarrera@hotmail.com |

| | Nombre | Cargo | Organización | email |
|---|---|---|---|---|
| 9 | Luis Fernando Alvarado Gamboa | Climatología | Instituto Meteorológico Nacional, Costa Rica | luis@imn.ac.cr |
| 10 | Joel | | CATHALAC | |
| 11 | Marcelo Oyuela | GIS Specialist | CATHALAC | Marcelo.Oyuela@cathalac.int |
| 12 | Robert Oglesby | Professor | University of Nebraska-Lincoln | roglesby2@unl.edu |
| 13 | Clinton Rowe | Professor | University of Nebraska-Lincoln | crowe1@unl.edu |

# Appendix C: Working Group Reports

**Working Group 1: Tropical Systems**

Francisco Argeñal, Alberto López, Jay Campbell, Alejandro del Castillo

This Working Group focuses on weather systems that start as tropical waves and subsequently may develop into tropical storms and possibly then into a hurricane. Both the Atlantic and eastern Pacific basins are considered, as either can affect the LAC, especially Central America, Mexico, and the Caribbean. Because of the large geographic area involved, this group is focused on the region-wide simulations for Mesoamerica and the Caribbean.

# Working Group 1: Tropical Systems

Francisco Argeñal, Alberto López, Jay Campbell, Alejandro del Castillo
al

# Climate Change Impact in Tropical Cyclones for Mesoamerican and Caribbean Regions

1.- Introduction

2.- Objectives

3.- Primary physical parameters discussion for cyclones genesis

4.- Numerical models with WFR

5.- Methodology for the evaluation of climate change impact for Mesoamerican and Caribbean regions

6.- Analysis of results

7.- Commentaries and Conclusions

8.- Annexes of Graphics

# Methodology (from first meeting…)

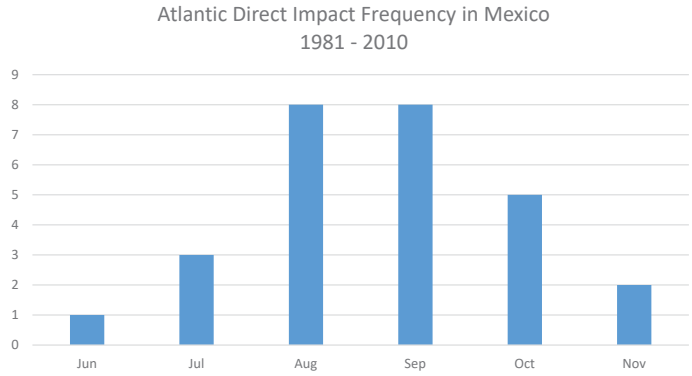
Step 2 Catalogue all Tropical Systems that occurred historically within the domain of interest.

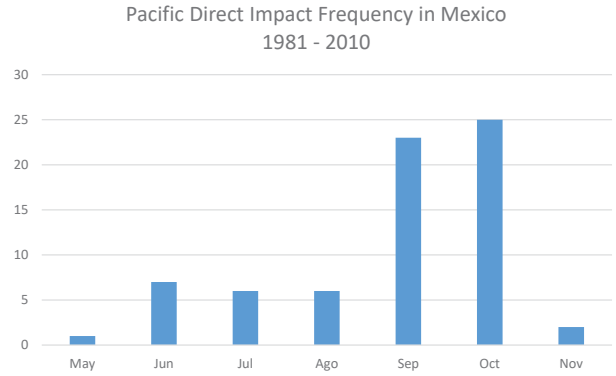
- Sub-divide the storms into Atlantic and Pacific occurrences.
- For each domain
- For each basin (Atlantic and Pacific)
- Select the highest intensity Tropical System for each year of the period of interest.
- To facilitate detection in tropical step 4 the storm must existed within domain of interest for approximately 48 hours.

# Methodology

- Attempt to identify individual TC's identified in Step 2.
- For each Domain. (Gualdi et al. 2008)
- We assume that a model TC is active over a certain gridpoint A if the following conditions are satisfied:
- in A, relative vorticity at 850 hPa is >3 x 10^-5 s^-1 ; there is a relative minimum surface pressure and wind velocity is >14 m s^-1 in an area of **2.25°** around A; **(metric to be adjusted for each domain)**
- the wind velocity at 850 hPa is > wind velocity at 300 hPa;
- the sum of temperature anomalies at 700, 500, and 300 hPa is > 2°K, where the anomalies are defined as the deviation from a spatial mean computed over an area of **13 grid points in the east–west and 2 grid points in the north–south direction**;
- the temperature anomaly at 300 hPa is greater than the temperature anomaly at 850 hPa;
- the above conditions persist for a period longer than 1.5 days.

# Historic Impact of Hurricanes in Atlantic and Pacific Basins

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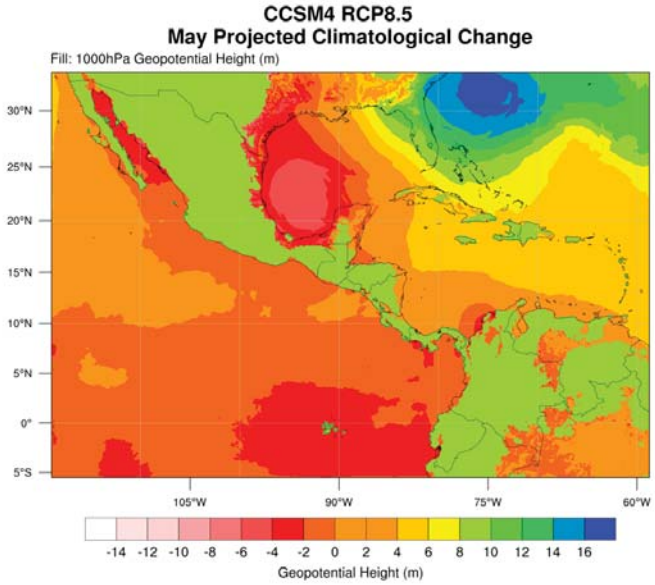
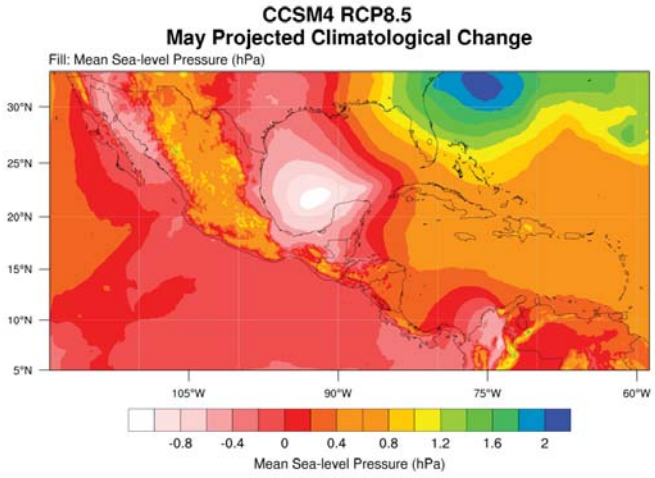
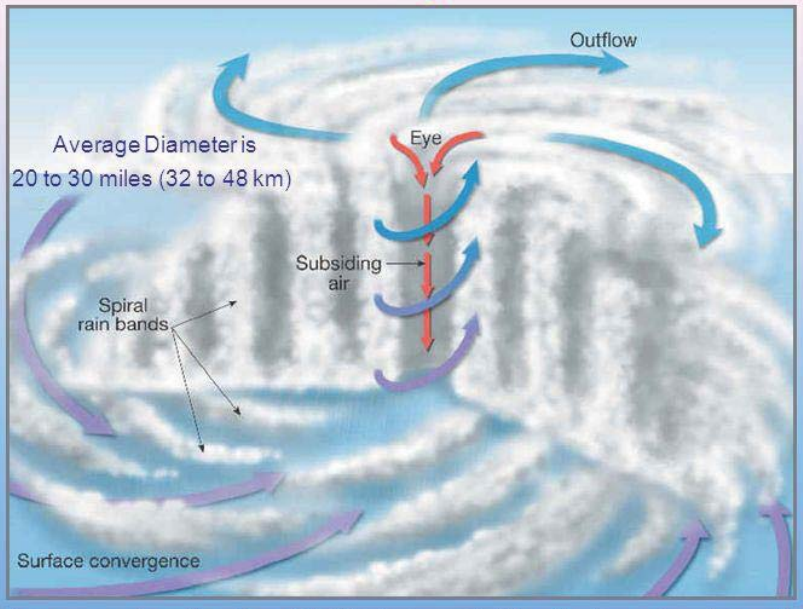


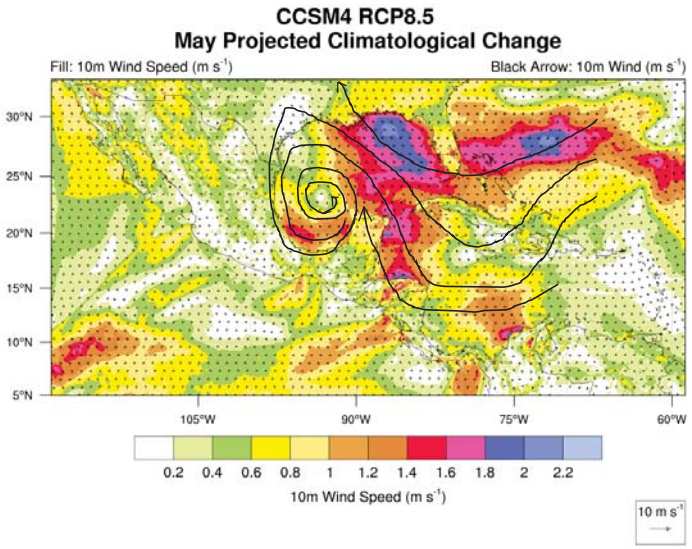



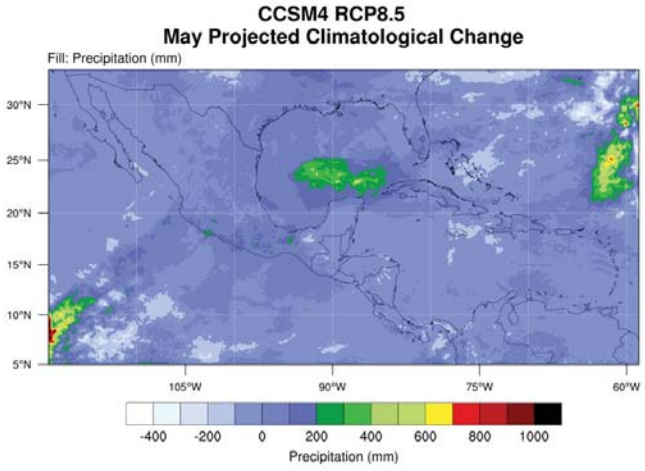
## The Structure of a Hurricane: The Eye




- A quasi-circular or quasi-oval region of light winds and skies that are clear to partly cloudy and free of rain.
- Caused by descending air that heats by compression, making it the warmest region of the storm.

# Changes in May



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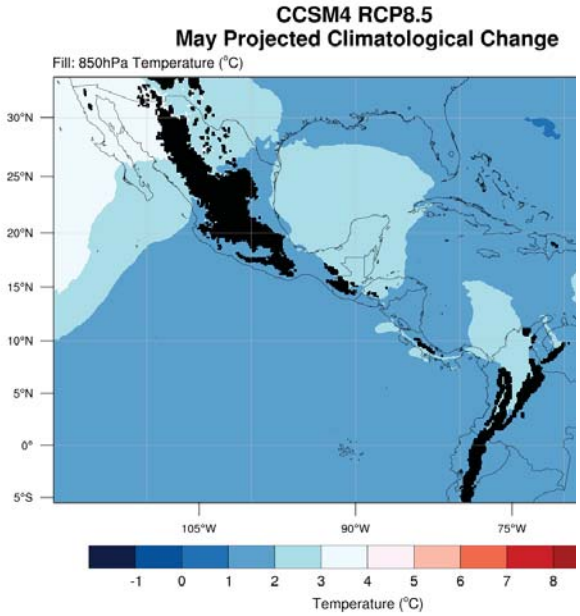


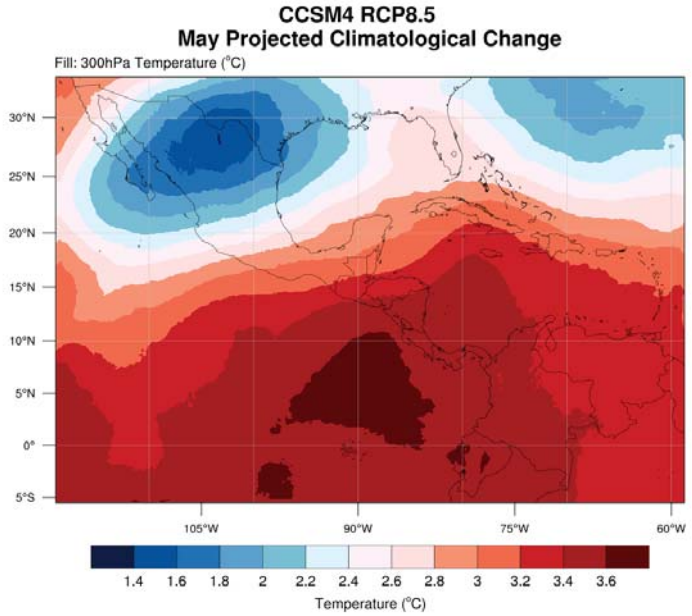


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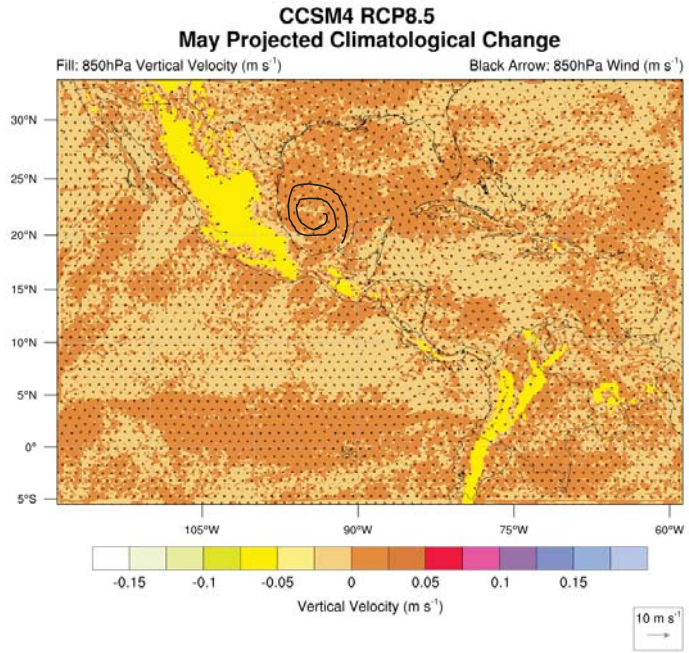


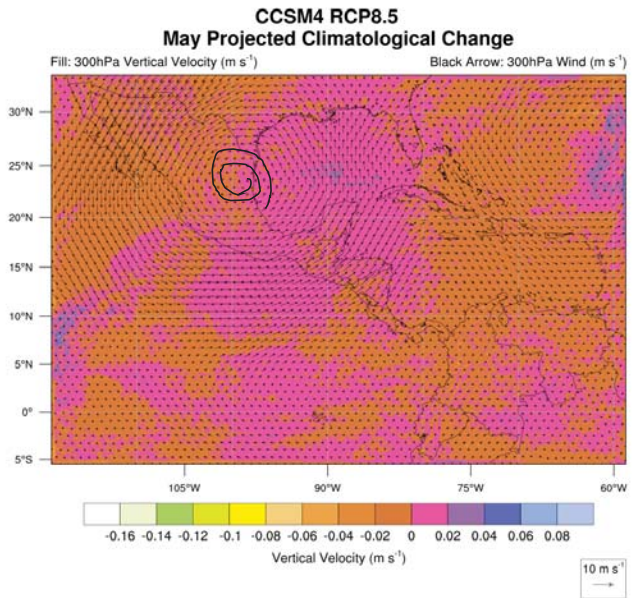

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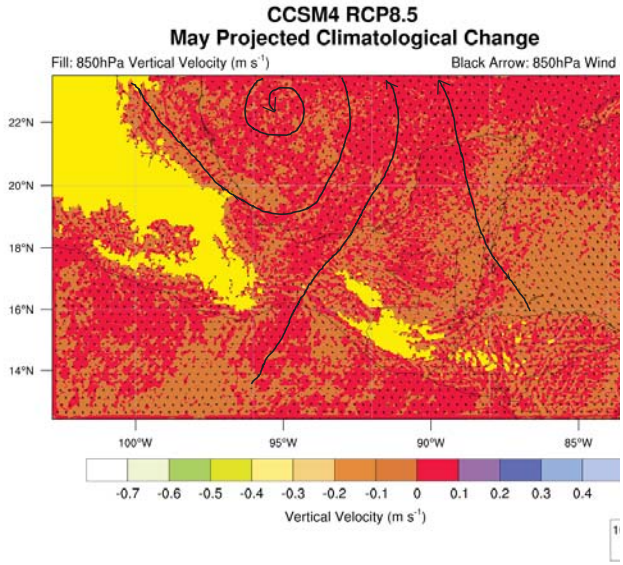


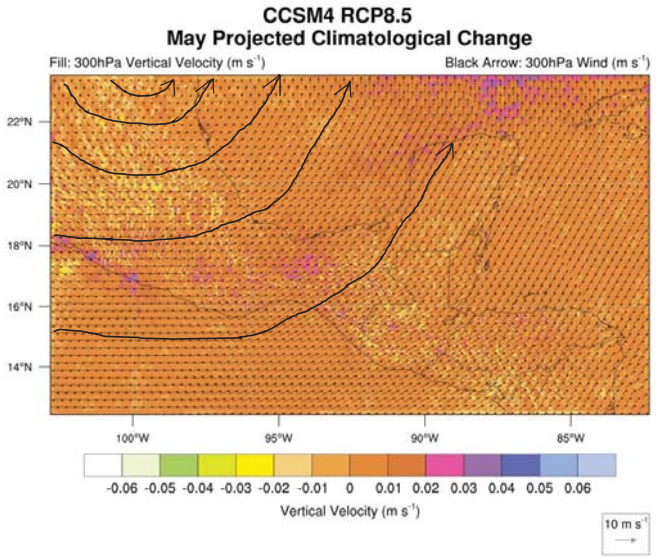


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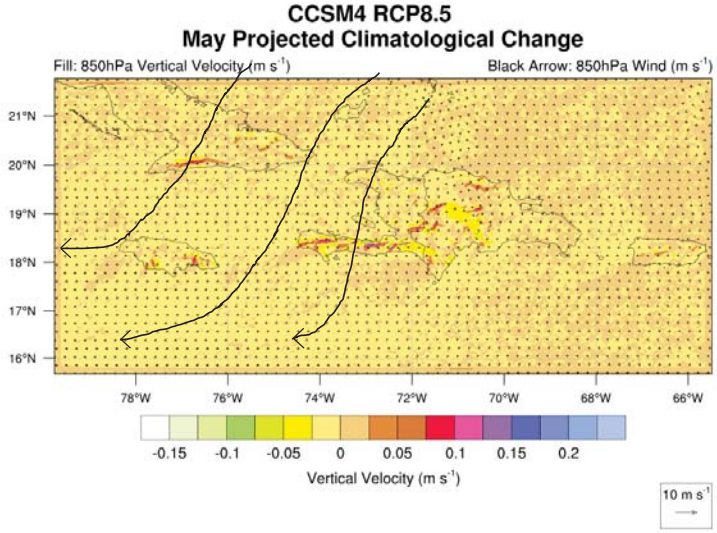


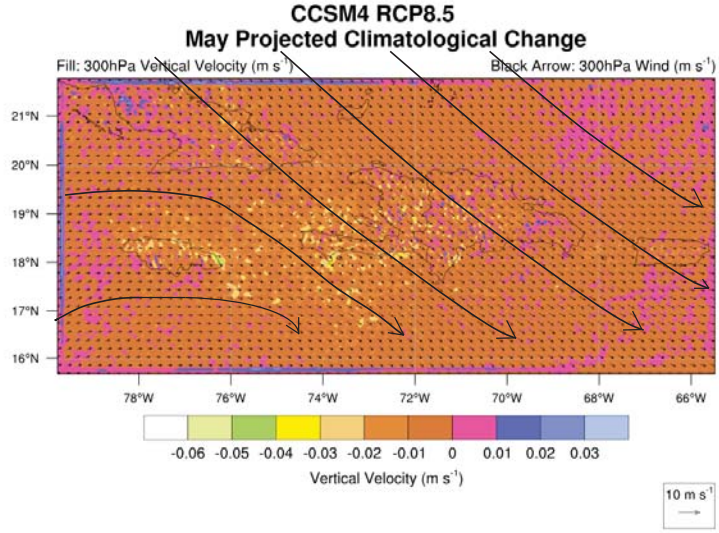

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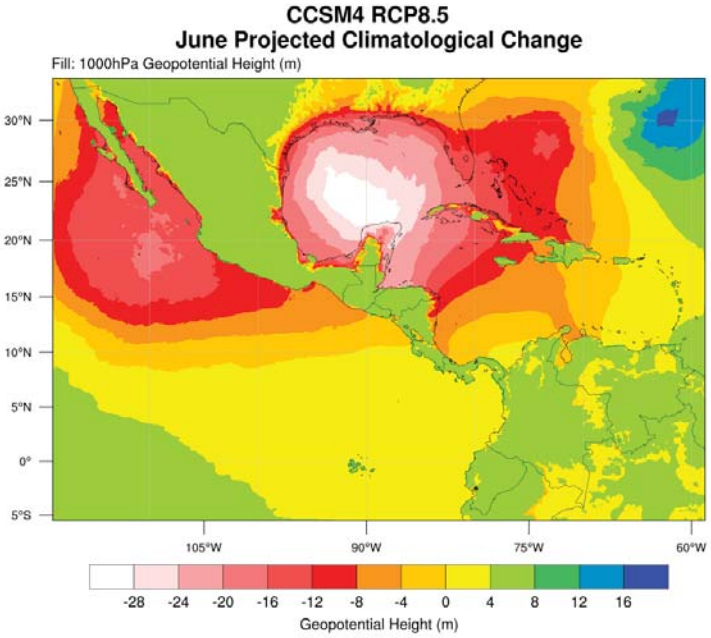


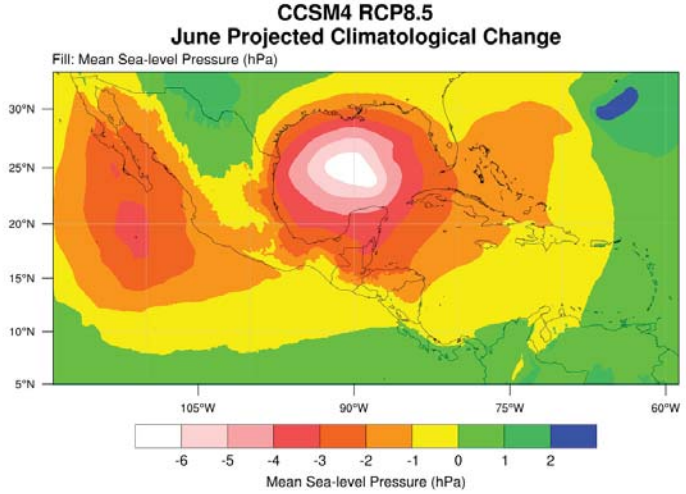


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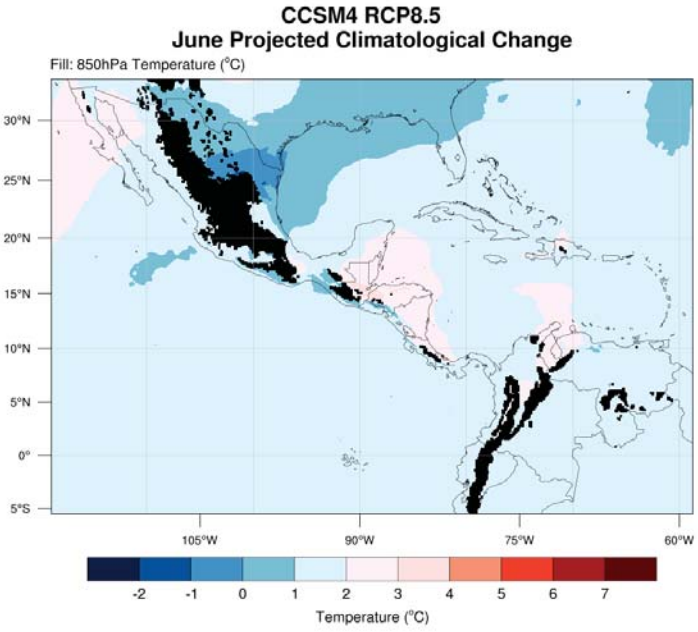


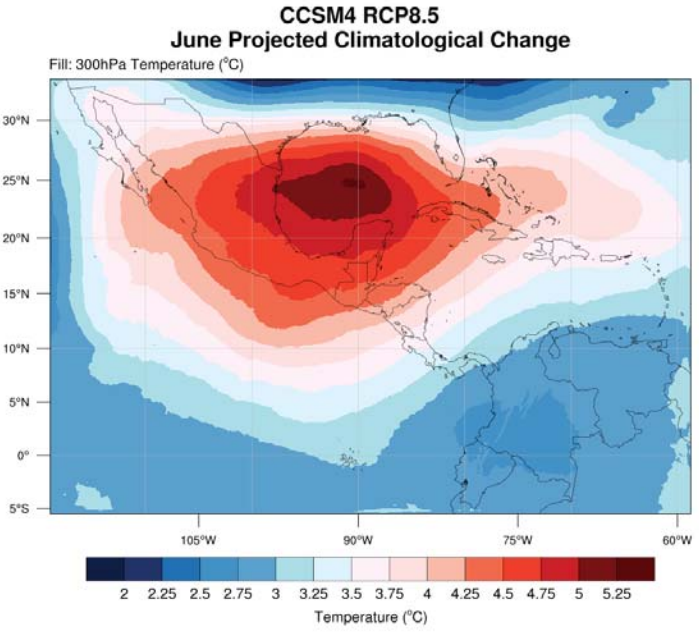

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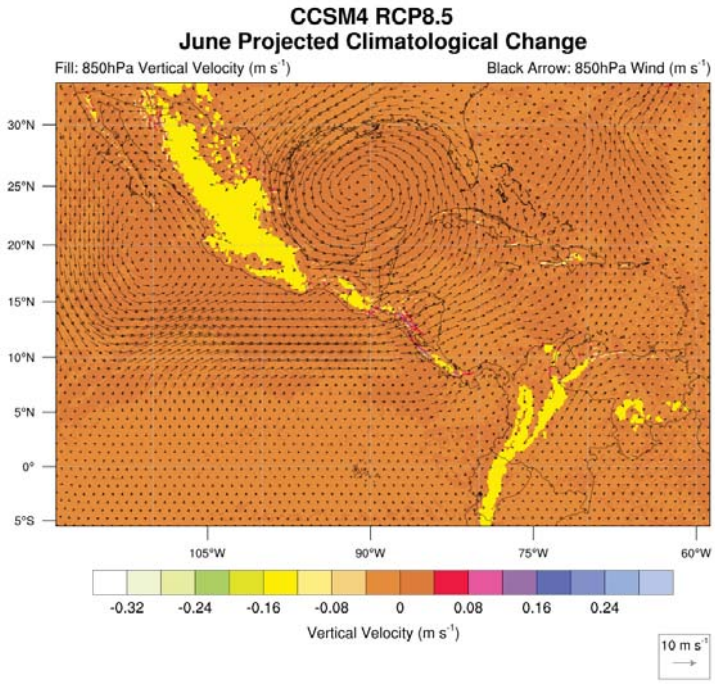
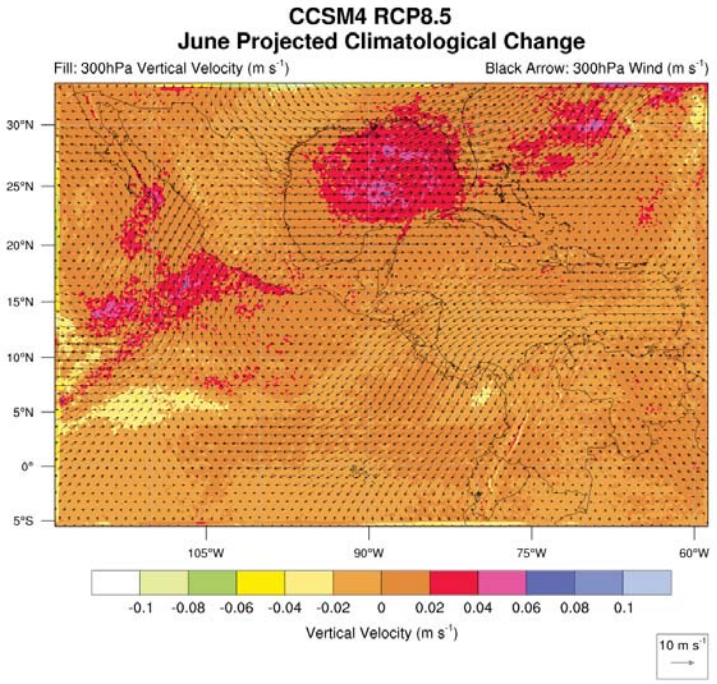
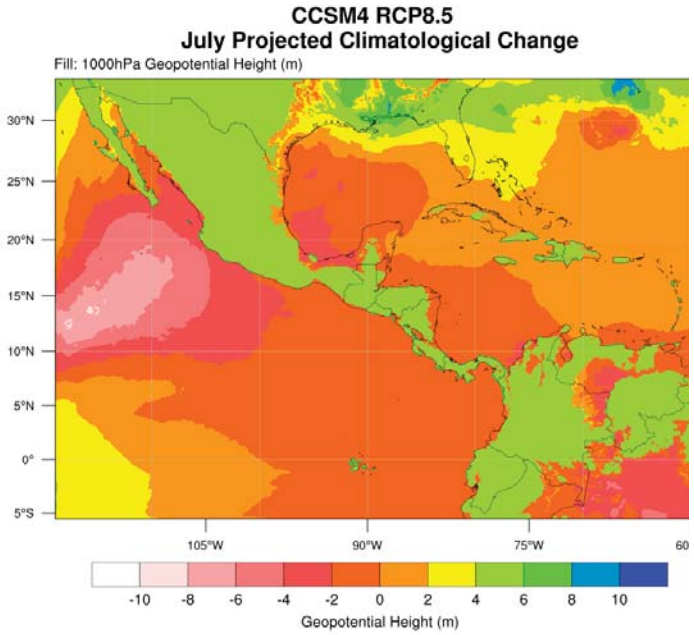
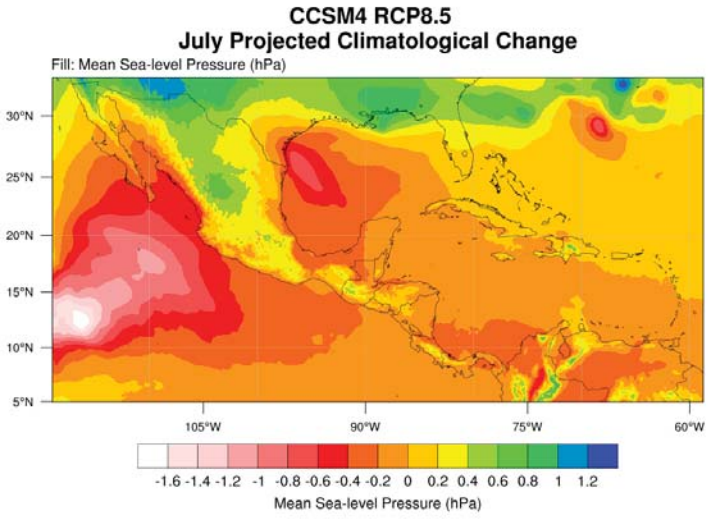



# Changes in July



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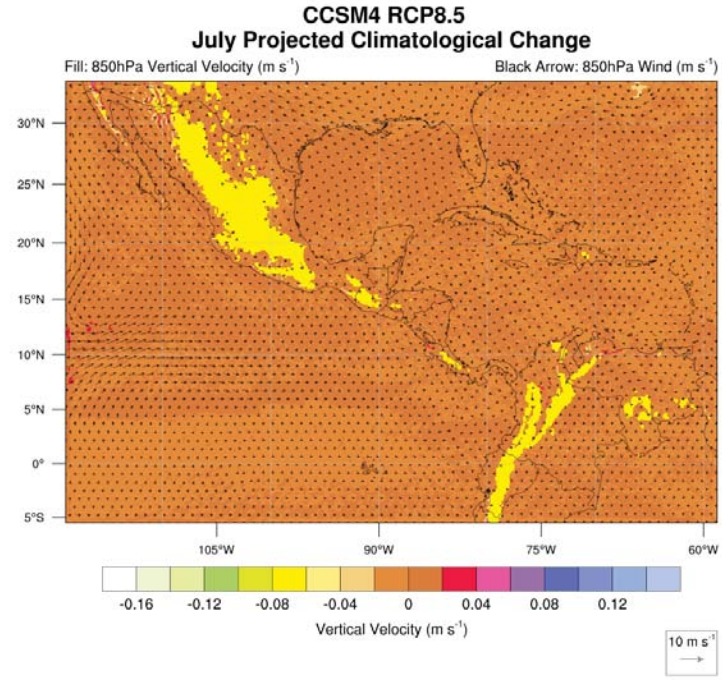


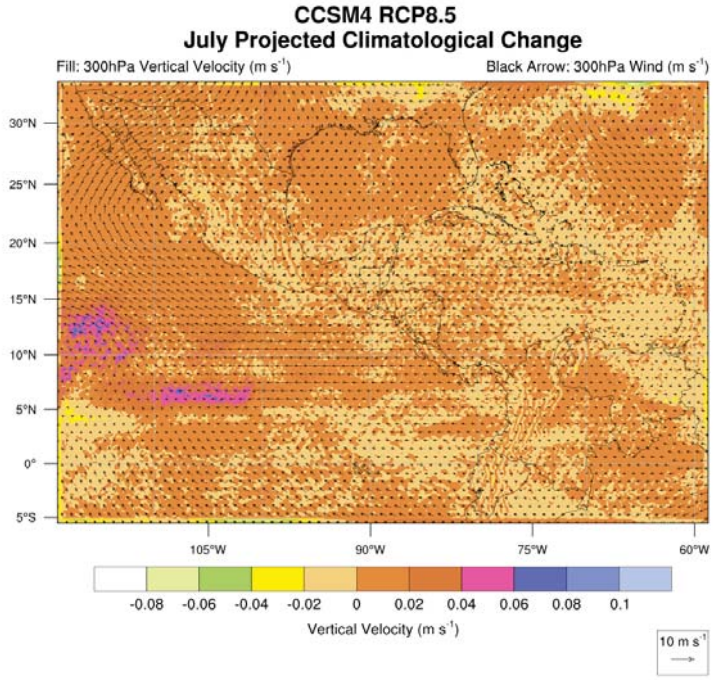


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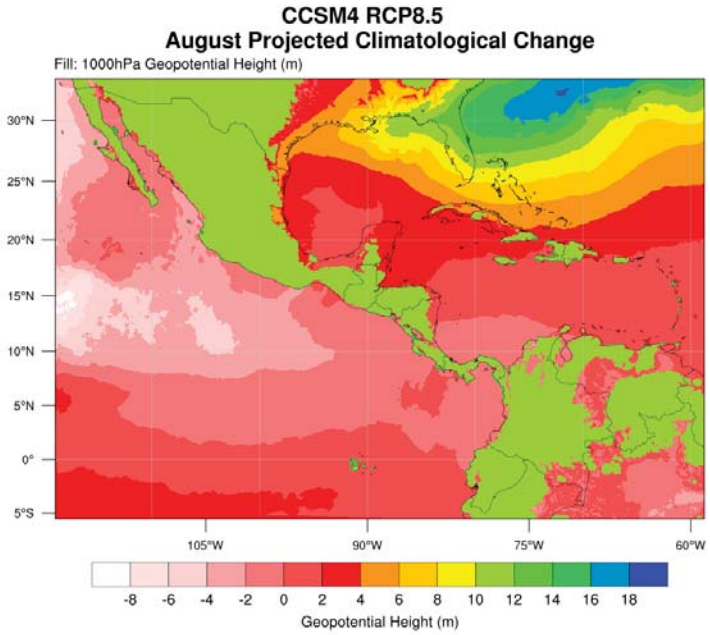


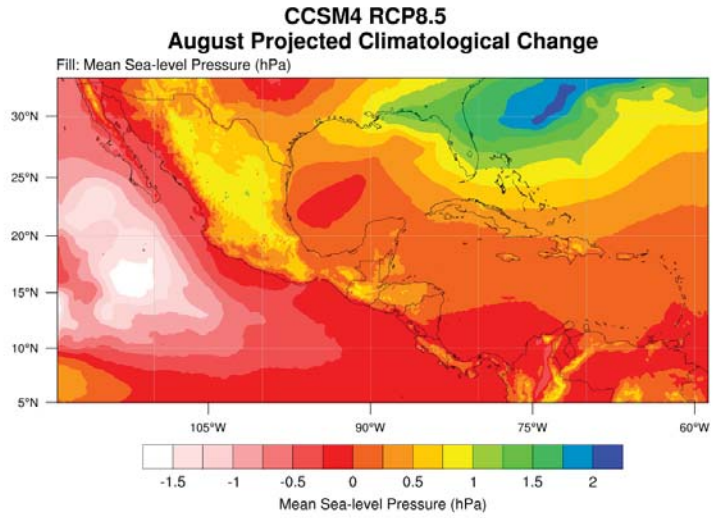

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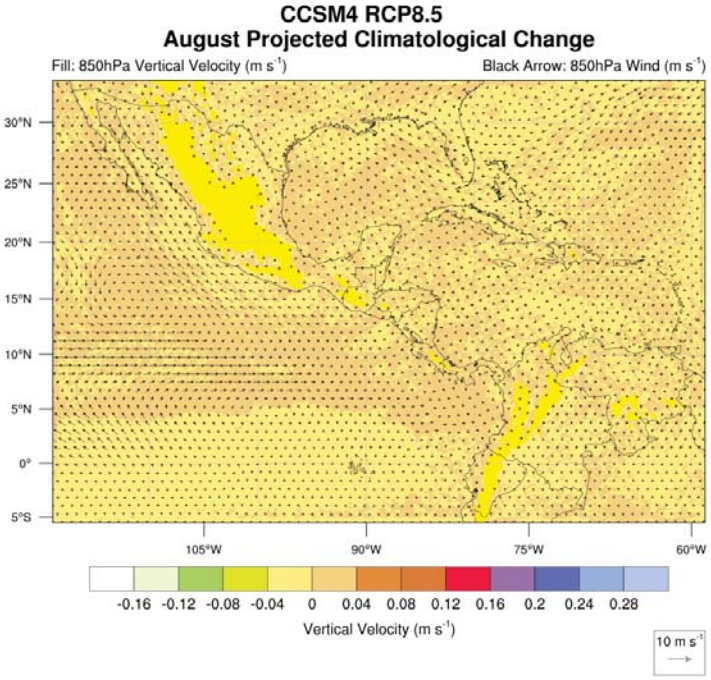


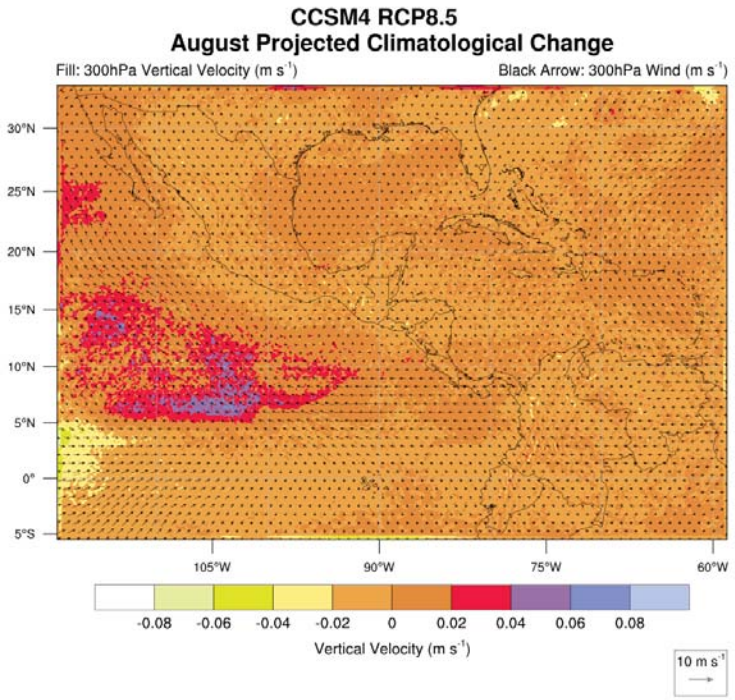


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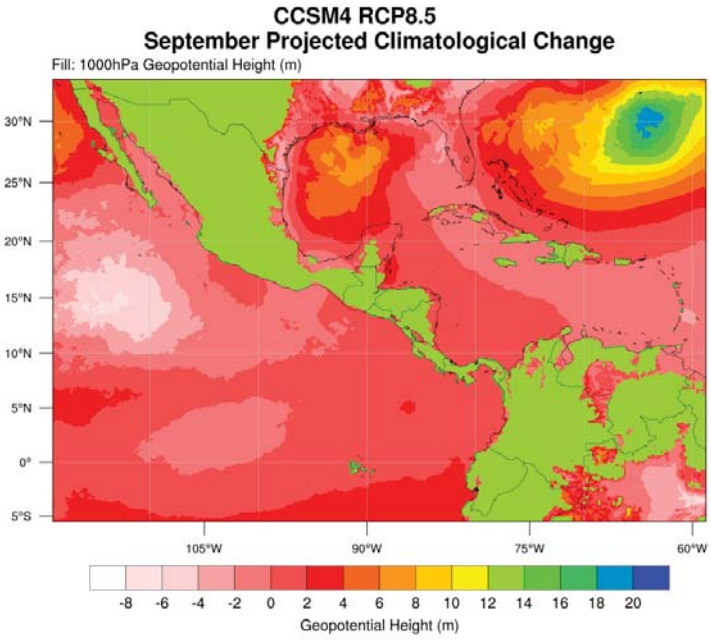


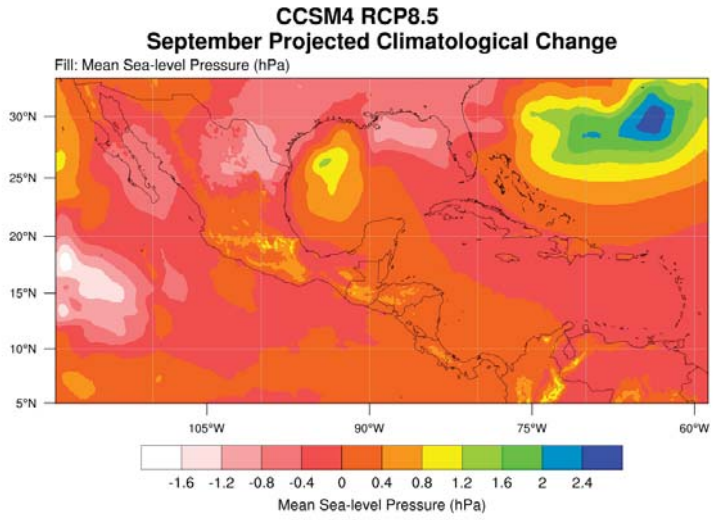

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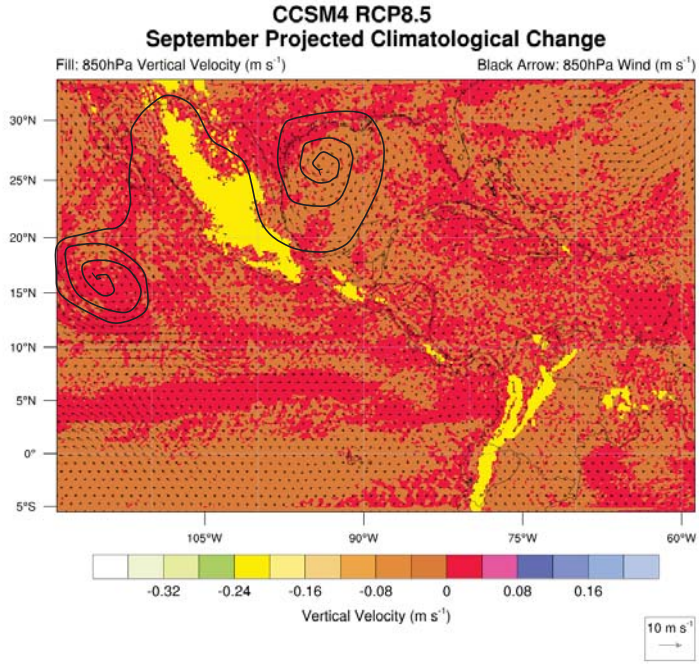


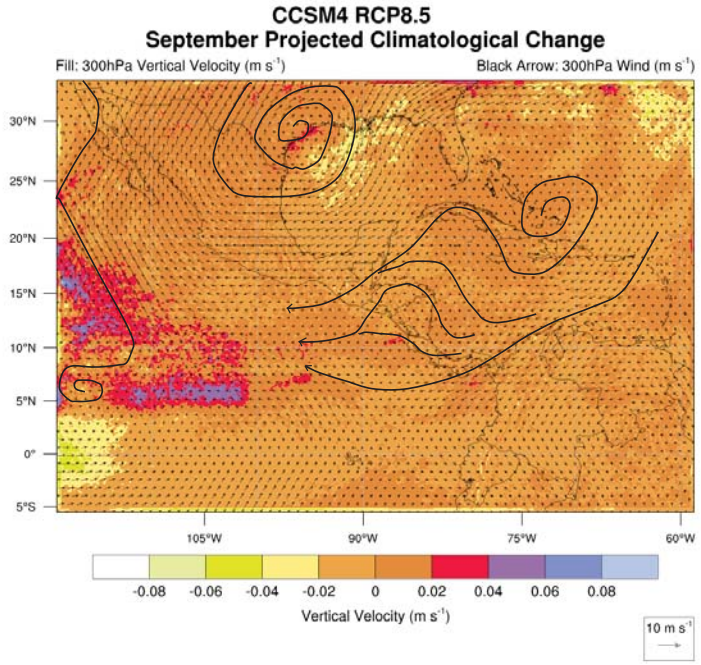


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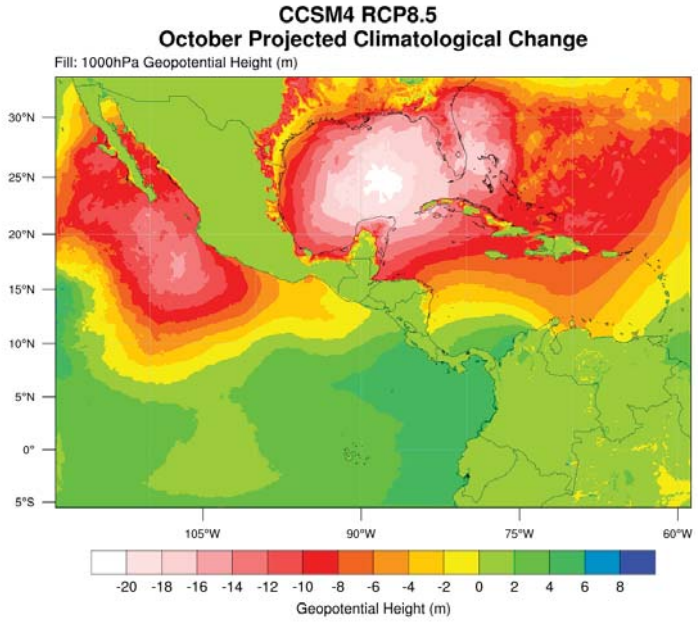


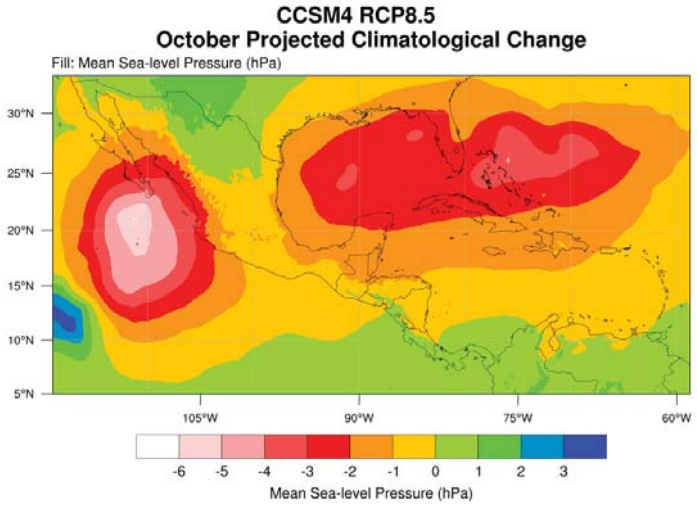

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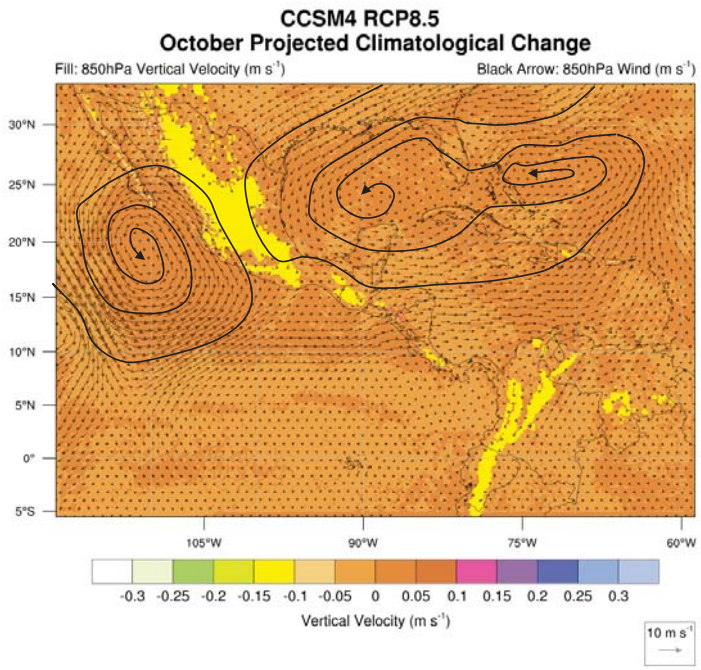
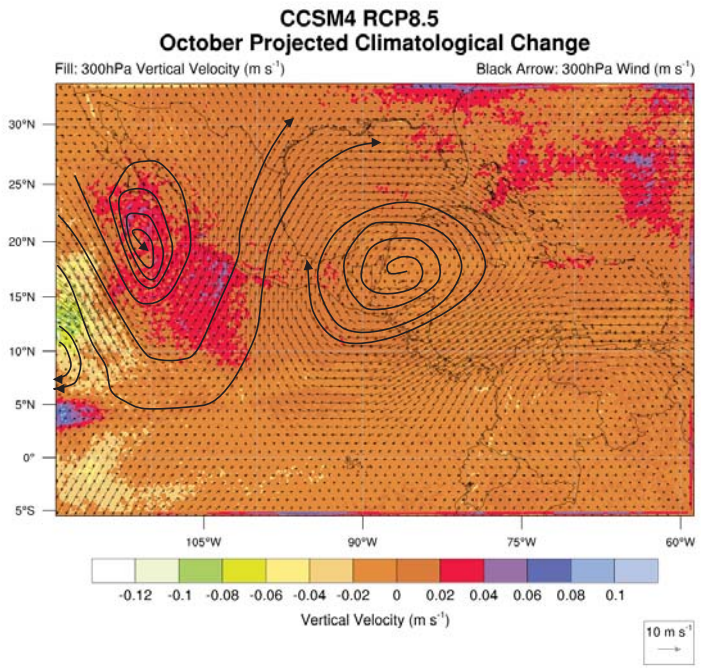



# Recommendations

- Add tropospheric data
- Add SST data and graphics
- Explore the possibility to add Skew T Diagrams
- Recalculate humidity change, there is an error

**Working Group 2: ENSO**

Gabriela Alfaro, Luis Alvarado, Dusstin Barrera, Juan José Nieto, Franklyn Ruiz

This Working Group focuses on El Nino and La Nina events, which can have major impacts on Central America and the Pacific coast of northern South America (Peru, Ecuador, and Colombia. Because of the availability of WRF simulations of sufficient length, at least initially the group is concentrating on Guatemala and surrounding regions.

# Análisis de los posibles efectos del Cambio Climático sobre la Precipitación y la Temperatura en Guatemala, utilizando el modelo CCSM4-WRF

Objetivo General

Analizar el comportamiento de la precipitación y temperatura en clima presente y en el futuro bajo el escenario de cambio climático RCP8.5 de junio a agosto (verano en el Hemisferio Norte).

Objetivos Específicos

- Describir el clima de la región de estudio.
- Verificar los datos modelados contra observados de clima presente (2001- 2010).
- Evaluar la variabilidad climática estacional.
- Analizar las evidencias de Cambio Climático utilizando R-Climdex.
- Cuantificar los cambios futuros (2060) de Precipitación y Temperatura bajo el escenario RCP8.5.

# Plan de Trabajo

**Actividades:**

- Descripción climática de la región de estudio.
  - ✓ Revisar.
- Verificación 2001-2010 (Clima presente)
  - ✓ Ciclo estacional (Faltan trimestrales).
  - ✓ Series de tiempo (Faltan trimestrales).
  - ✓ Histogramas de frecuencia GRS-WRF.
  - ✓ Diagramas de Taylor (Falta trimestral).
  - ✓ Análisis espacial (Map maker) (Faltan trimestrales).

- Variabilidad Climática estacional
  - ✓ Anomalías de temperatura y precipitación.
  - ✓ Correlación con el índice ATSM (El Niño 3.4).
  - ✓ Análisis espacial ENSO.

- ~~Analizar las evidencias de Cambio Climático utilizando R-Climdex.~~
  - ~~✓ R-climdex P10, P90 (extremos).~~
  - ~~✓ Tendencia P/t T/t (Observados).~~

- Cuantificar los cambios futuros (2060) de de Precipitación y Temperatura bajo el escenario RCP8.5.
  - ✓ Estaciones
  - ✓ Análisis espacial (Map Maker).
  - ✓ Distribución estadística.

Preguntas:

1. La variabilidad del futuro se puede asociar con el ENSO?

2. En la corrida del presente, el modelo ve fluctuaciones muy similares a lo observado. Podemos decir si el modelo asocia la señal del ENSO.

Sugerencias para el MAPMAKER:

1. Poder elegir sets estacionales. Por ejemplo: Nov 200 Dic 2000 enero 2001.

2. Además de las descargas CSV y netCDF, descargar gráficas para las coordenadas seleccionadas.
3. Que calcule índices de Cambio Climático.
4. Que genere curvas de distribución entre lo observado, simulado y futuro y su correlación.
5. Incluir “hints” con instrucciones de a qué se refiere cada opción.
6. Hacer el taller en Nebraska o Utila.
7. Que grafique ciclos anuales y series de tiempo específicos.
8. Para corridas largas que pueda calcular tendencias de índices climáticos .

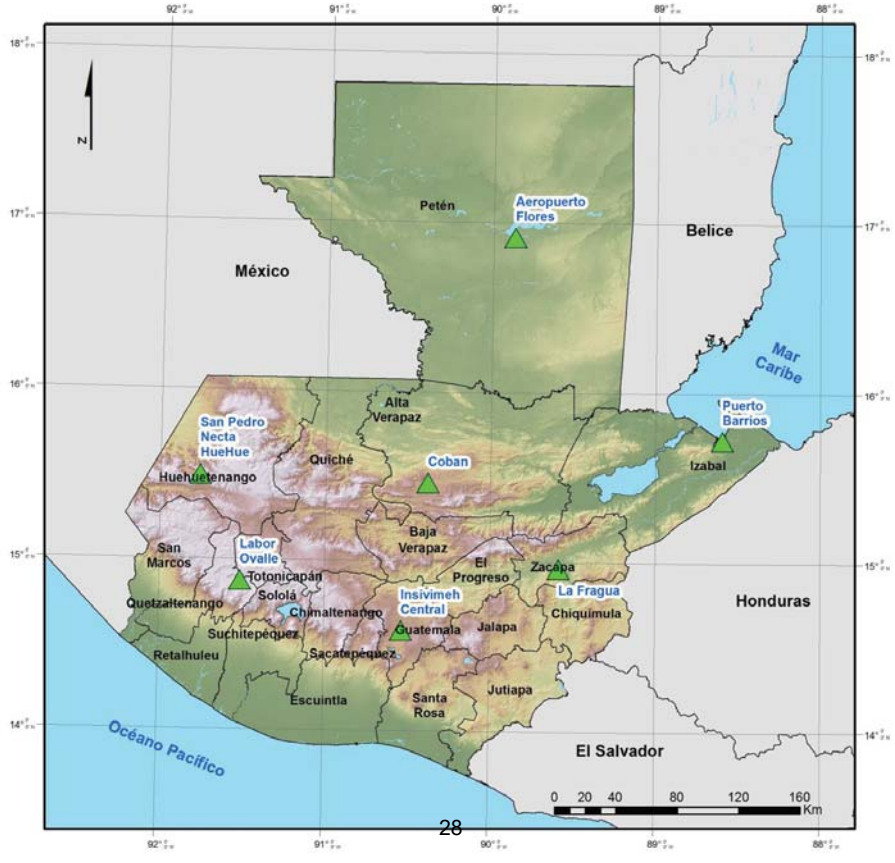
Compromisos Adicionales:

Entregar en formato MapMaker datos de estaciones de Guatemala (Gaby).

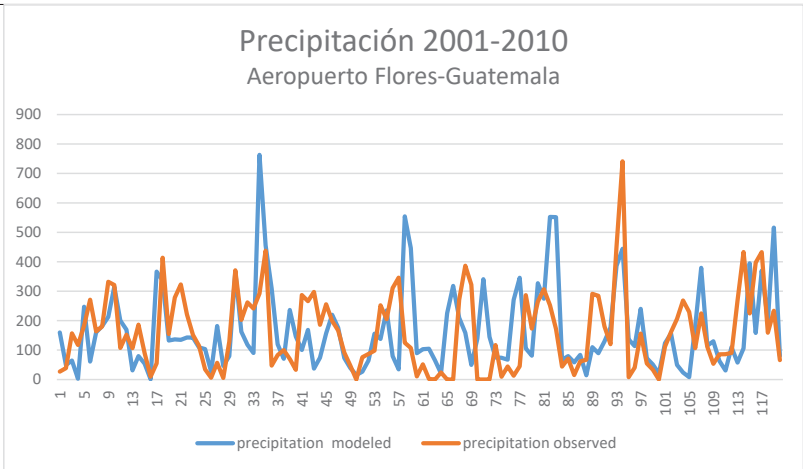
# Análisis de los posibles efectos del Cambio Climático sobre la Precipitación y la Temperatura en Guatemala, utilizando el modelo CCSM4-WRF.

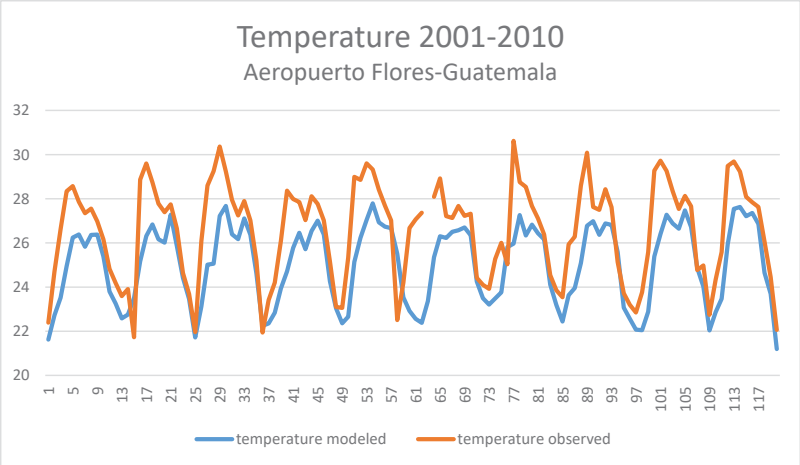
Alfaro G., Alvarado L., Barrera D., Nieto JJ. y Ruiz, F. 2018.


Ubicación de Estaciones
Guatemala

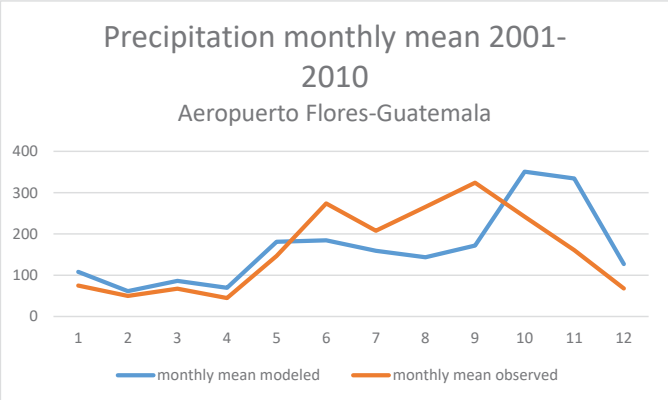


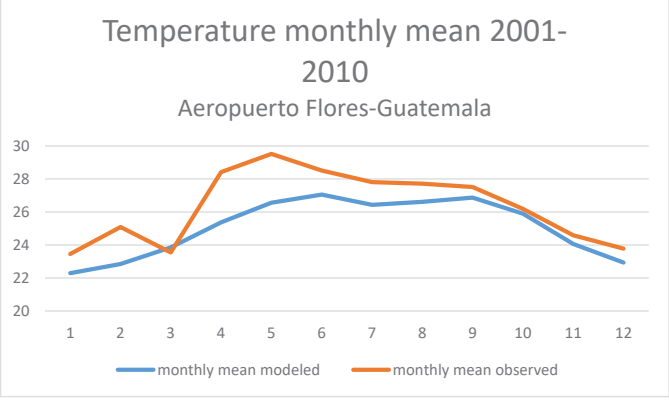
**Series de tiempo Modelo vs Observado Areopuerto Flores**



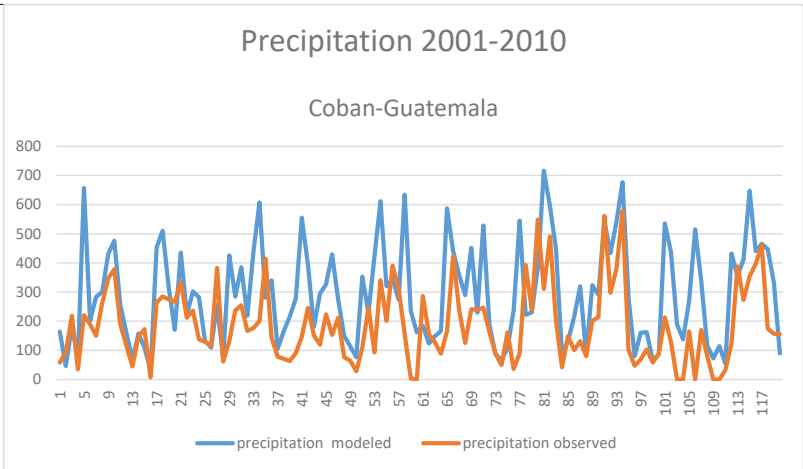



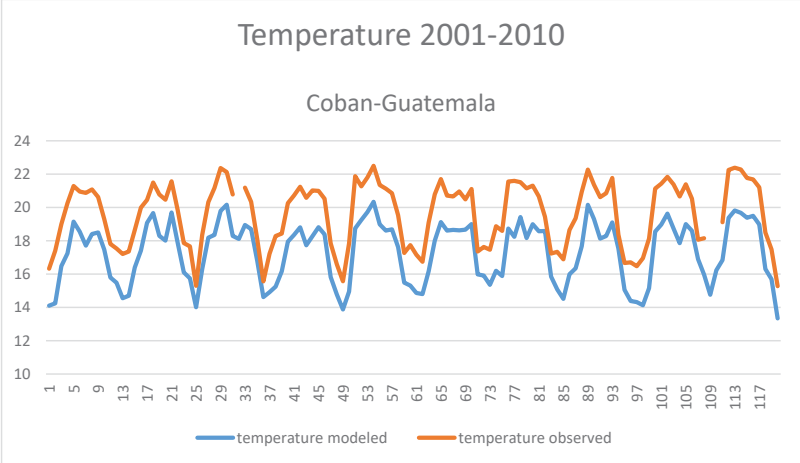

**Series de tiempo Modelo vs Observado Aereopuerto Flores**



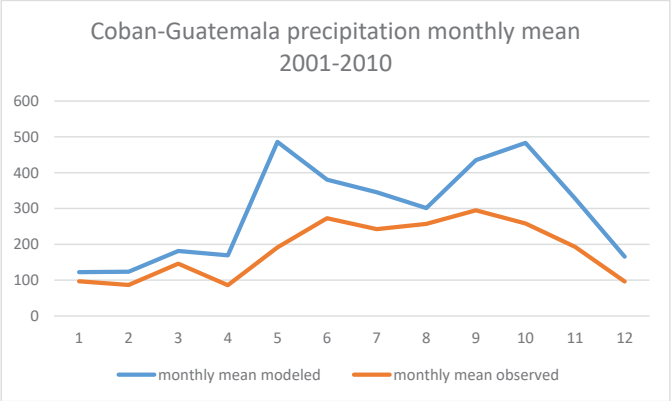



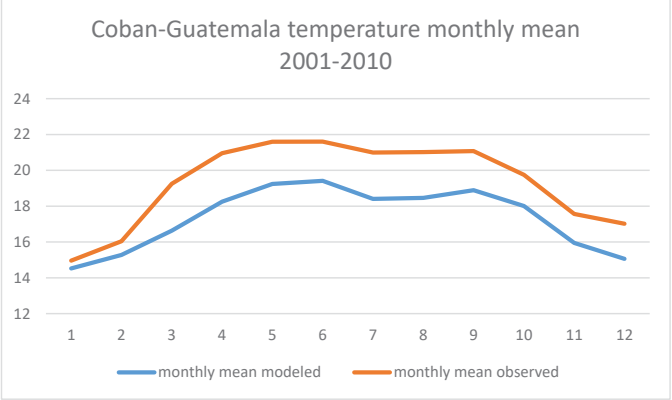
**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Cobán**



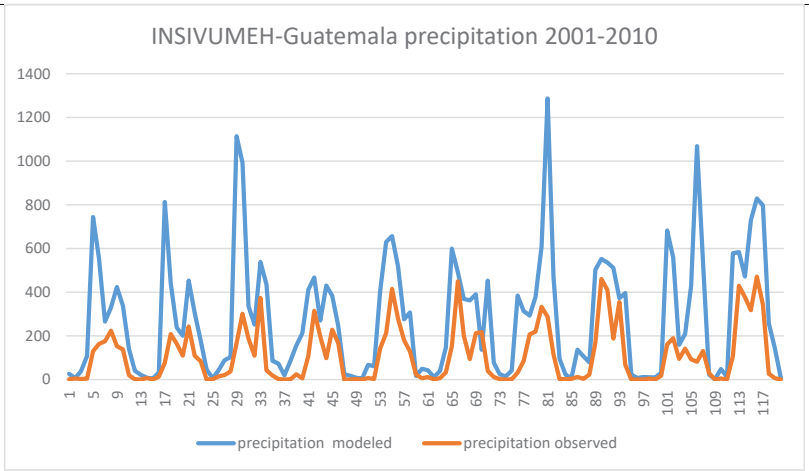



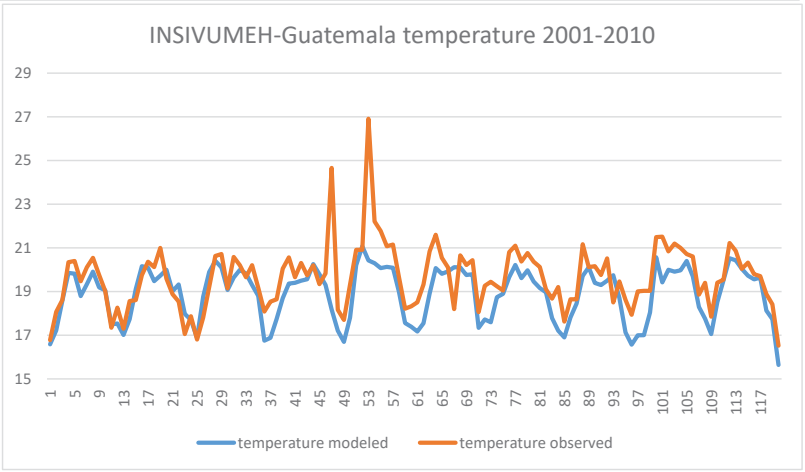

**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Cobán**



**Series de tiempo**
**Modelo**
**vs**
**Observado**
**INSIVUMEH**

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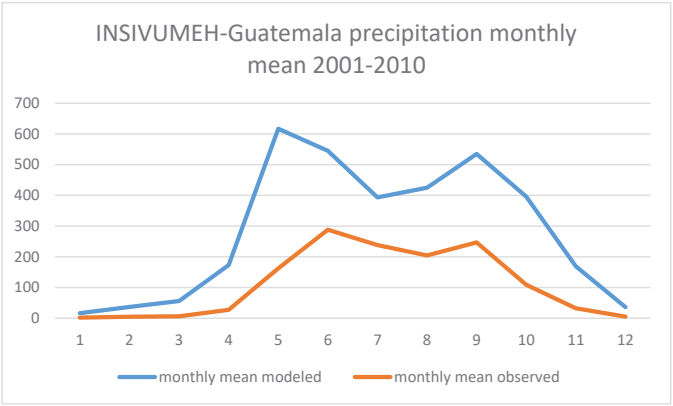
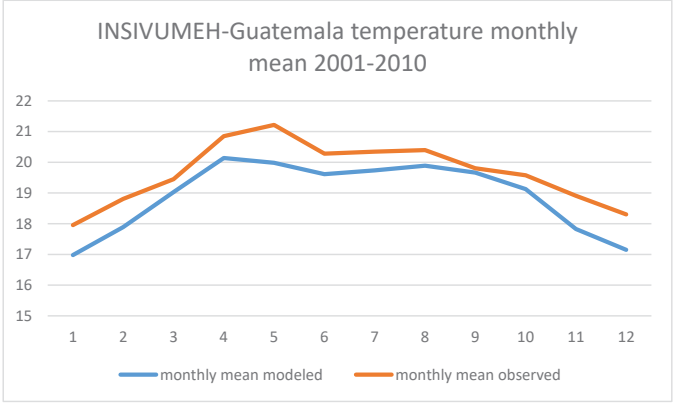
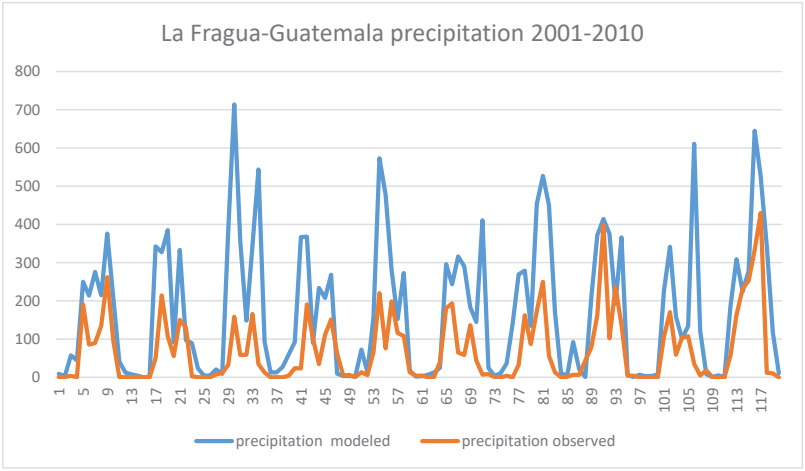
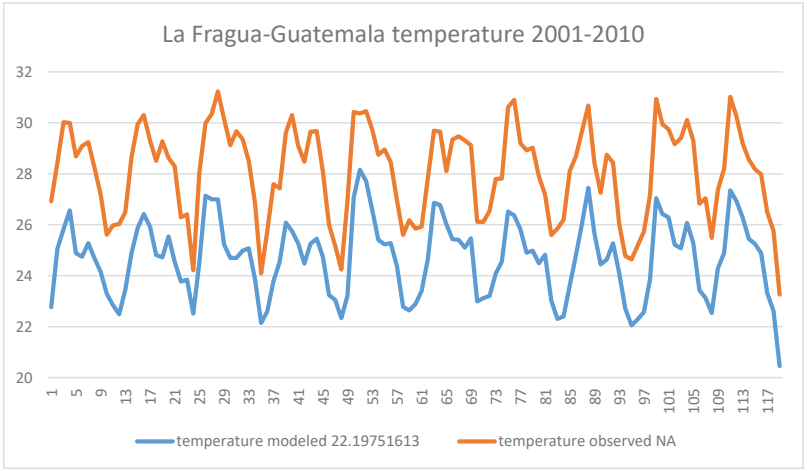
**Modelo**
**vs**
**Observado**
**INSIVUMEH**



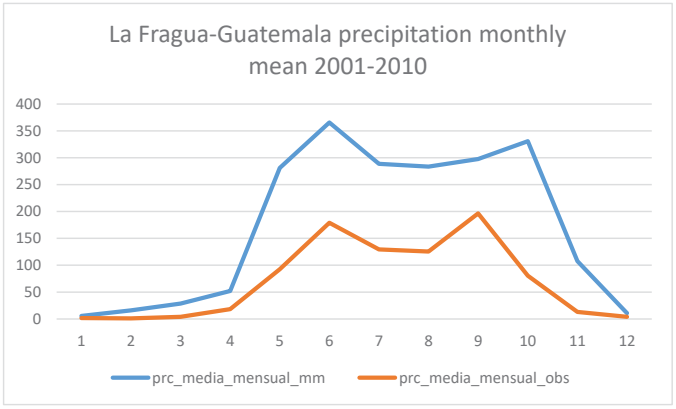



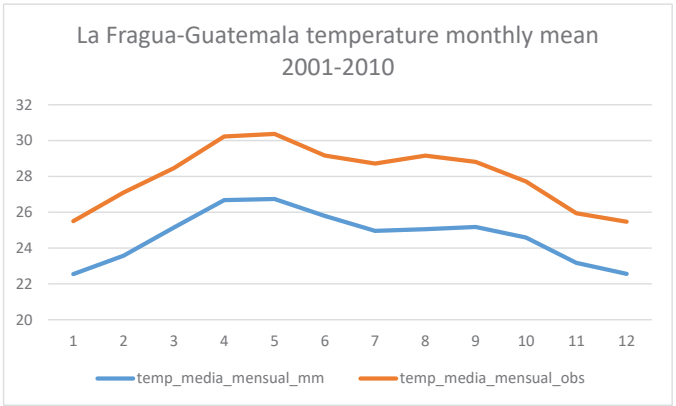
**Series de tiempo**
**Modelo**
**vs**
**Observado**
**La Fragua**



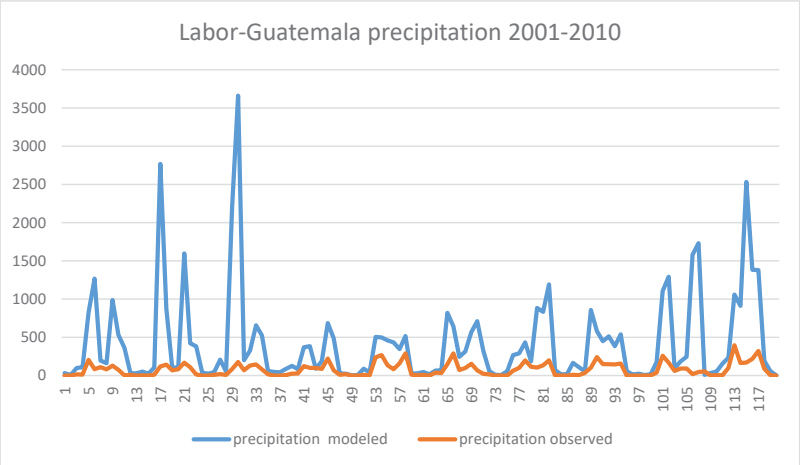



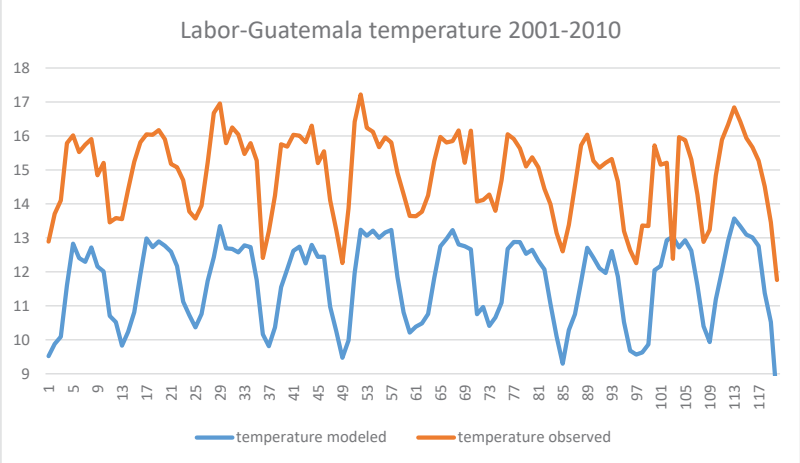

**Series de tiempo**
**Modelo**
**vs**
**Observado**
**La Fragua**



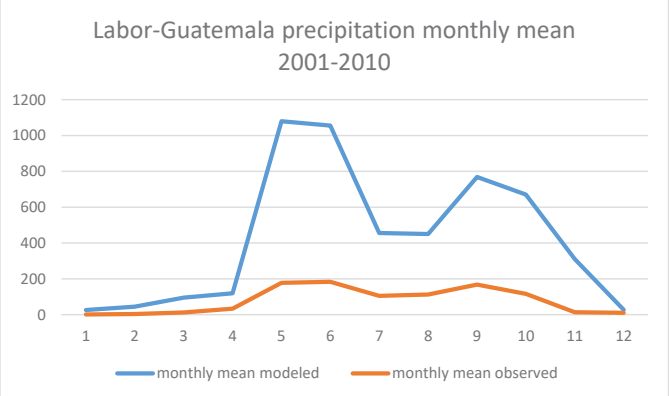



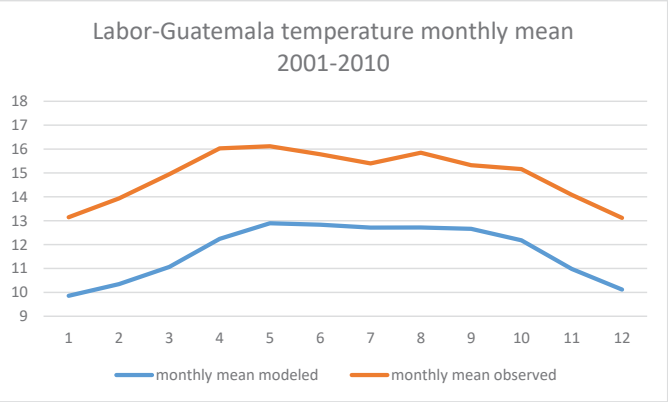
**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Labor**



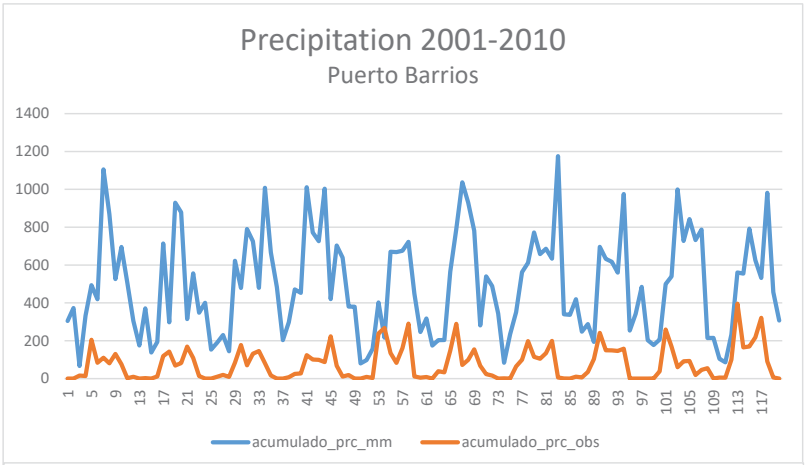



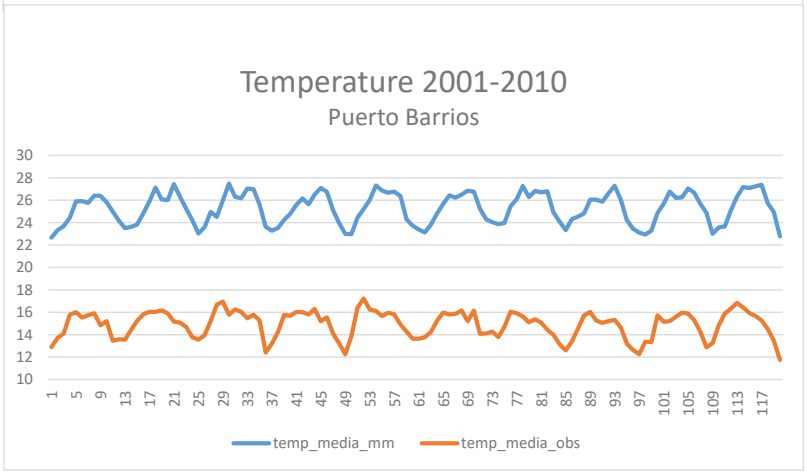

**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Labor**



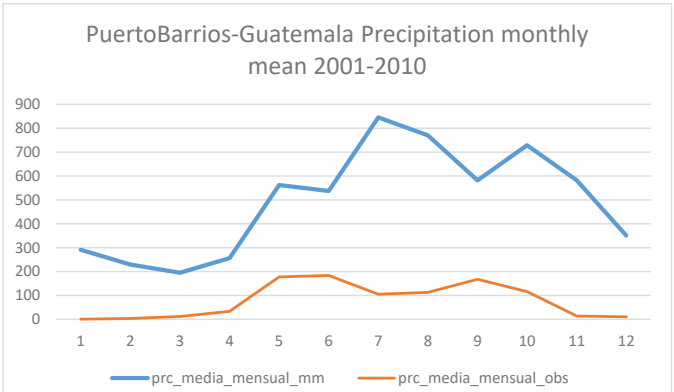



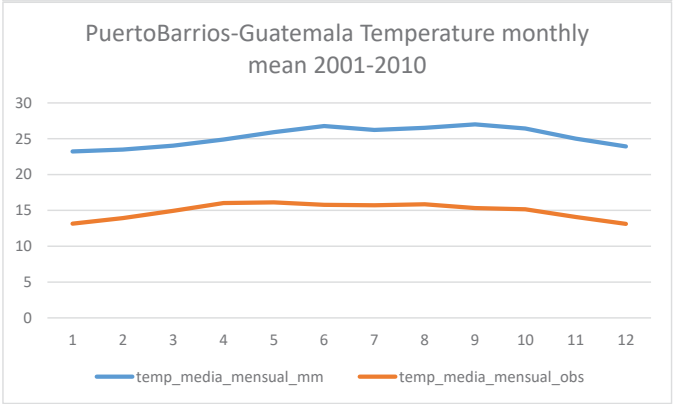
**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Puerto Barrios**



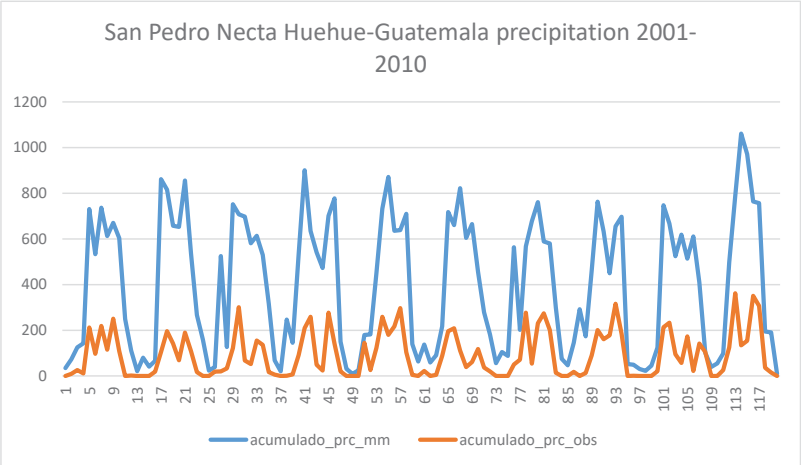



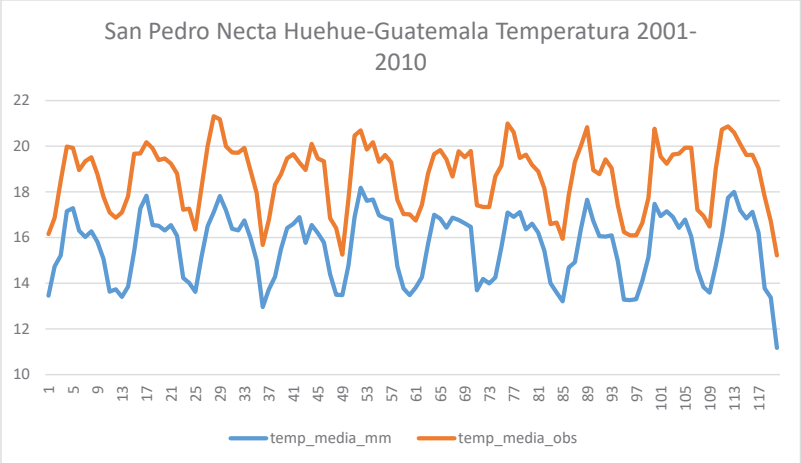

**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Puerto Barrios**



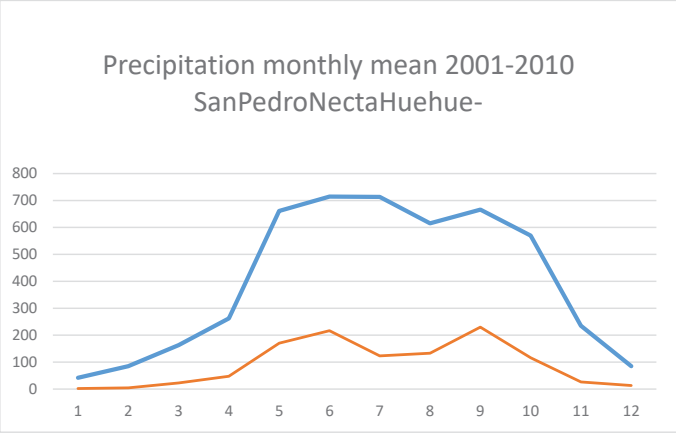



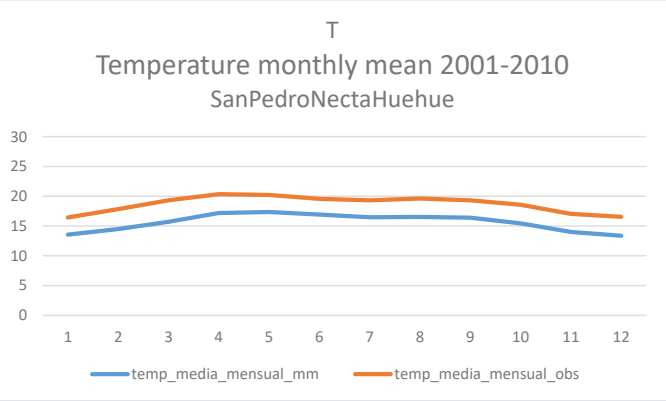
**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Huehuetenango**




**Series de tiempo**
**Modelo**
**vs**
**Observado**
**Huehuetenango**

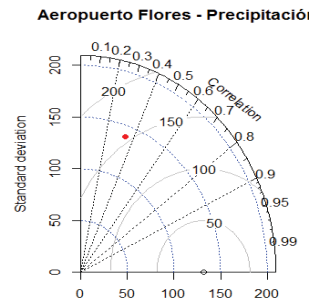


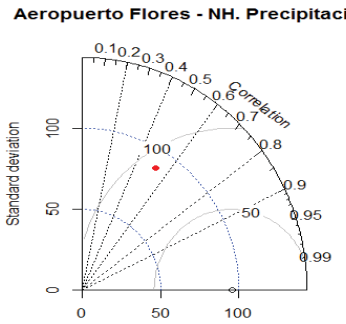



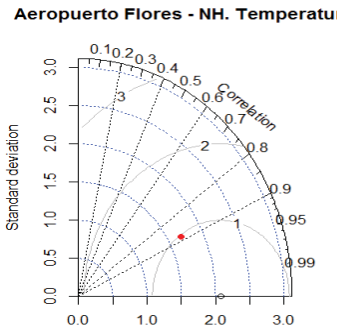
# Diagramas de Taylor

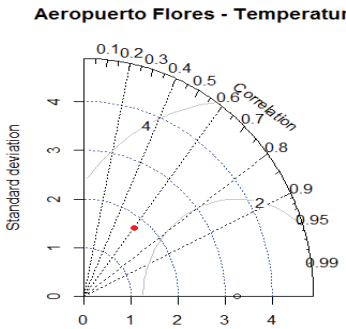
Datos observados vs Datos modelados

# Estación: Aeropuerto Flores

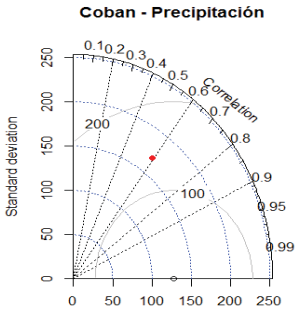


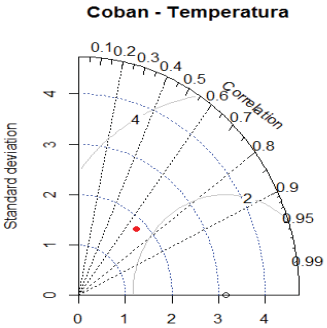



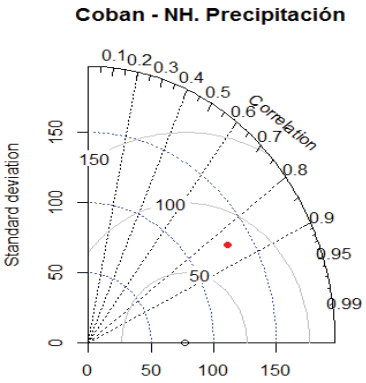



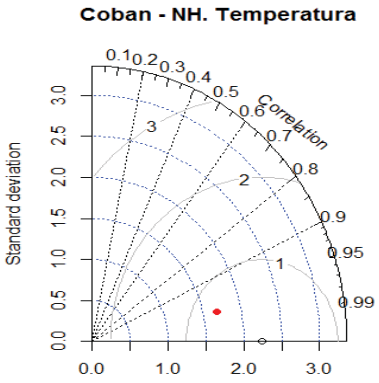



# Estación: Cobán

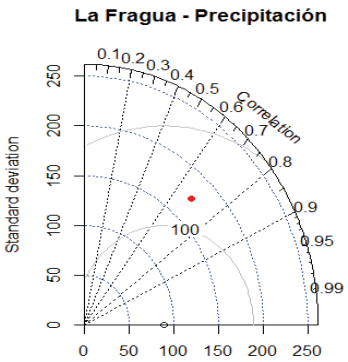


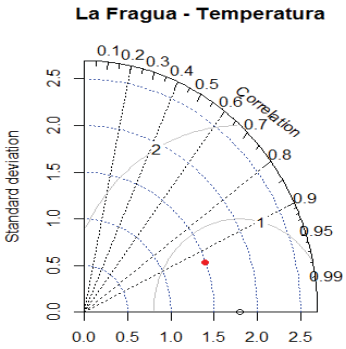



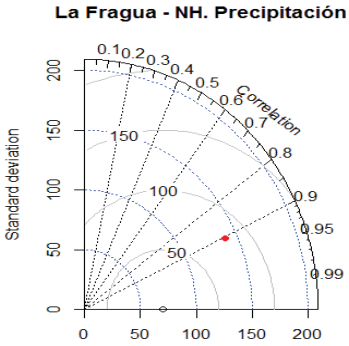



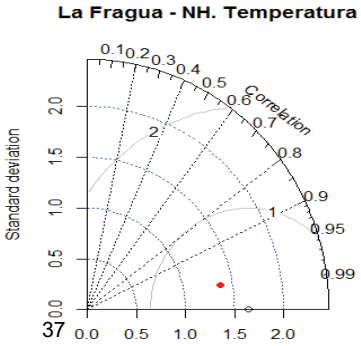




# Estación: La Fragua

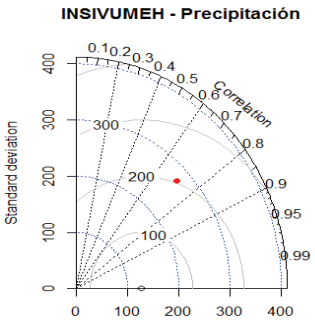


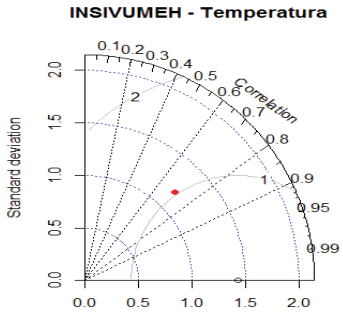



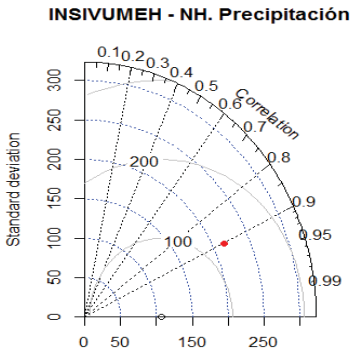



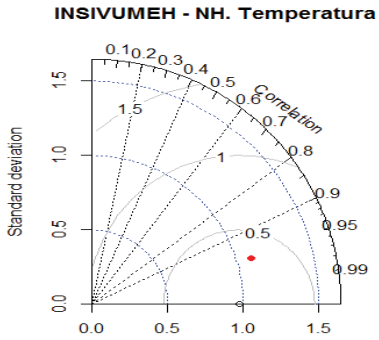



# Estación: INSIVUMEH

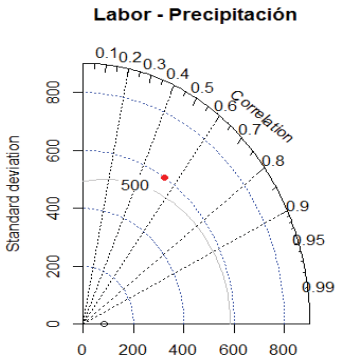


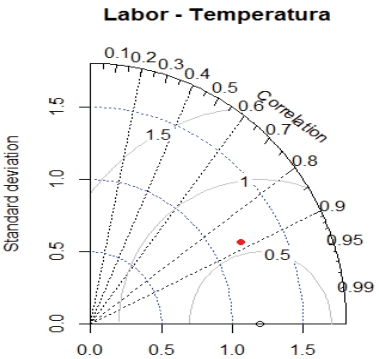



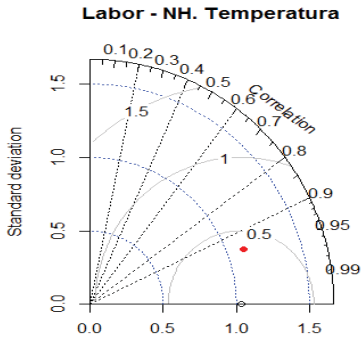



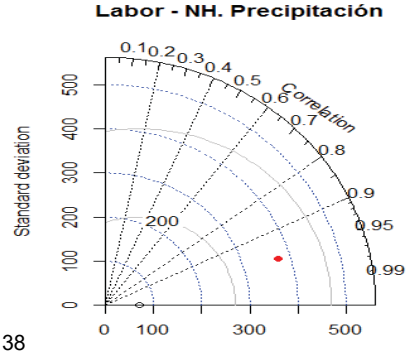




# Estación: Labor



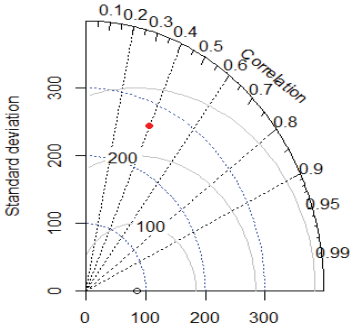



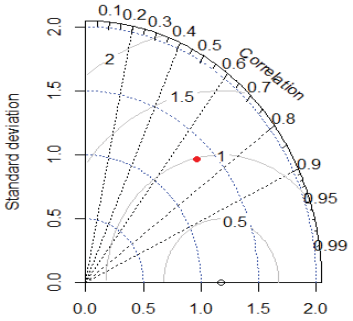



# Estación: Puerto Barrios

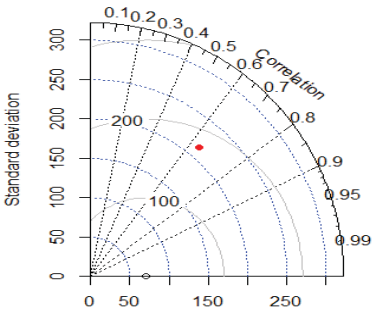
**Puerto Barrios - Precipitación**



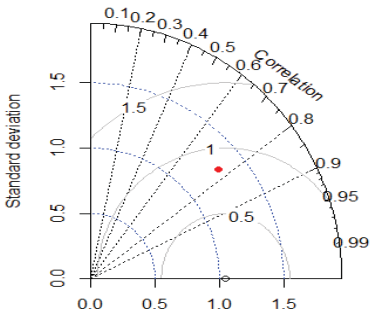

**Puerto Barrios - Temperatura**




**Puerto Barrios - NH. Precipitación**

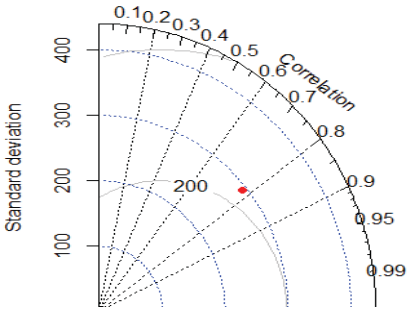



**Puerto Barrios - NH. Temperatura**

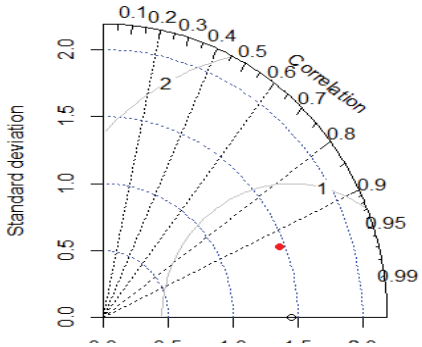



# Estación: San Pe

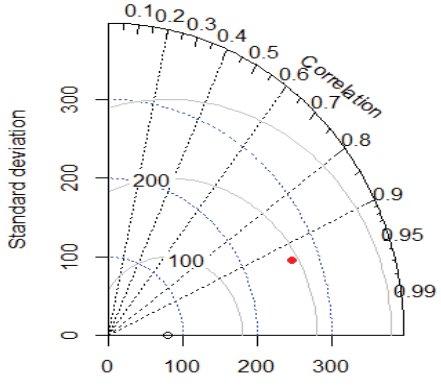
**San Pedro - Precipitación**



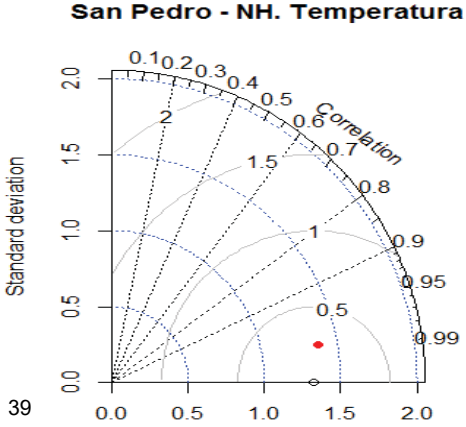

**San Pedro - Temperatura**




**San Pedro - NH. Precipitación**




**San Pedro - NH. Temperatura**



# EVENTOS NIÑO y NIÑA

| HS1 (1971 - 1980) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Niña | | | | Niño | | |
| | I | F | M.I. | | I | F | M.I. |
| 1 | Jul(1970) | Feb(1972) | -1.3 | | | | |
| 2 | | | | | May(1972) | Mar(1973) | 2 |
| 3 | Jun(1973) | Mar(1976) | -1.9 | | | | |
| 4 | | | | | Set(1976) | Feb(1977) | 0.8 |
| 5 | | | | | Set(1977) | Ene(1978) | 0.8 |
| 6 | | | | | Oct(1979) | Feb(1980) | 0.6 |

**Nota:**

| | |
|---|---|
| Jul= | Jun-Jul-Ago |
| I= | inicio |
| F= | final |
| HS1 = | 1971-1980 |
| HS2 = | 2001-2010 |

| HS1 (1971 - 1980) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Niña | | | | Niño | | |
| | I | F | M.I. | | I | F | M.I. |
| 1 | Ene(2000) | Feb(2001) | -1.6 | | | | |
| 2 | | | | | Jun(2002) | Feb(2003) | 1.2 |
| 3 | | | | | Jul(2004) | Abr(2005) | 0.7 |
| 4 | | | | | Set(2006) | Ene(2007) | 0.9 |
| 5 | Ago(2007) | Jun(2008) | -1.4 | | | | |
| 6 | | | | | Jul(2009) | Abr(2010) | 1.3 |

| BL (2011-2016) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Niña | | | | Niño | | |
| | I | F | M.I. | | I | F | M.I. |
| 1 | Jul(2010) | Abr(2011) | -1.5 | | | | |
| 2 | Ago(2011) | Feb(2012) | -1 | | | | |
| 3 | | | | | Nov(2014) | May(2016) | 2.3 |
| 4 | Ago(2016) | Nov(2016) | -0.8 | | | | |

Proyecto: Guatemala

Escenario: Histórico

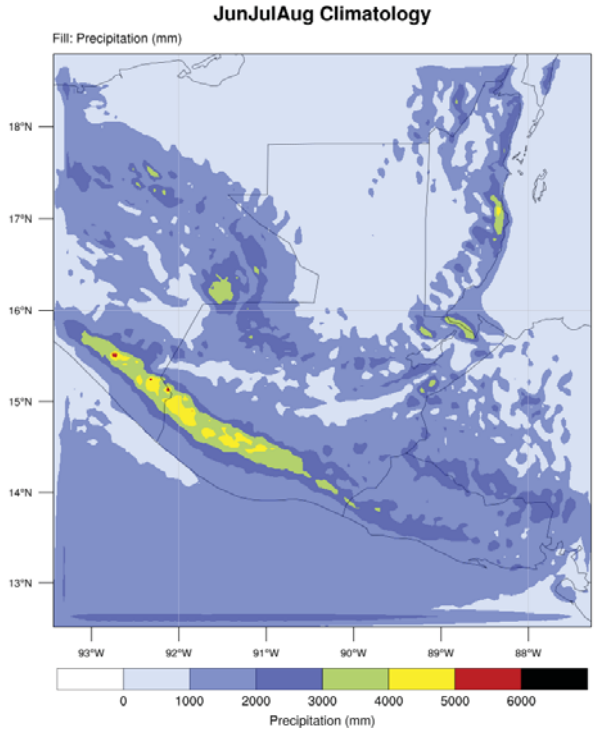
Dominio: D03 Guatemala (4 km)

## Corrida: NNRP: 1971-1980

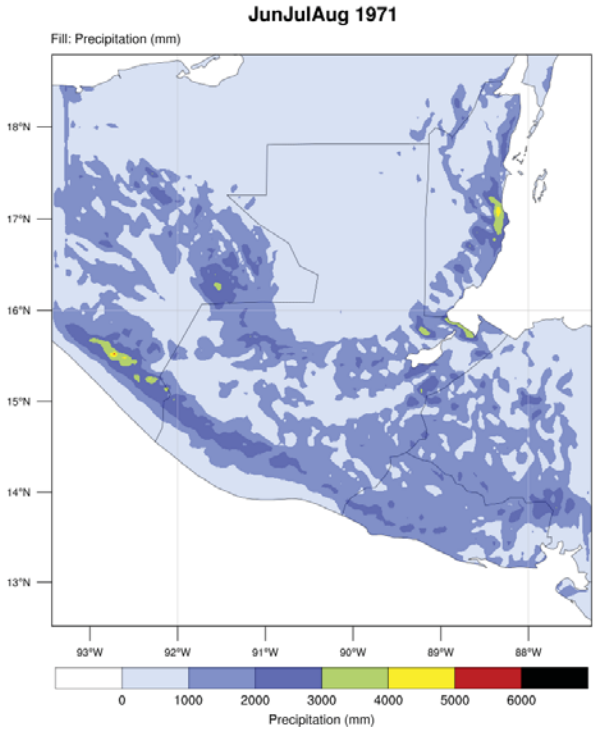
## Temporada : verano (junio-agosto)

## Variable: lluvia (mm)

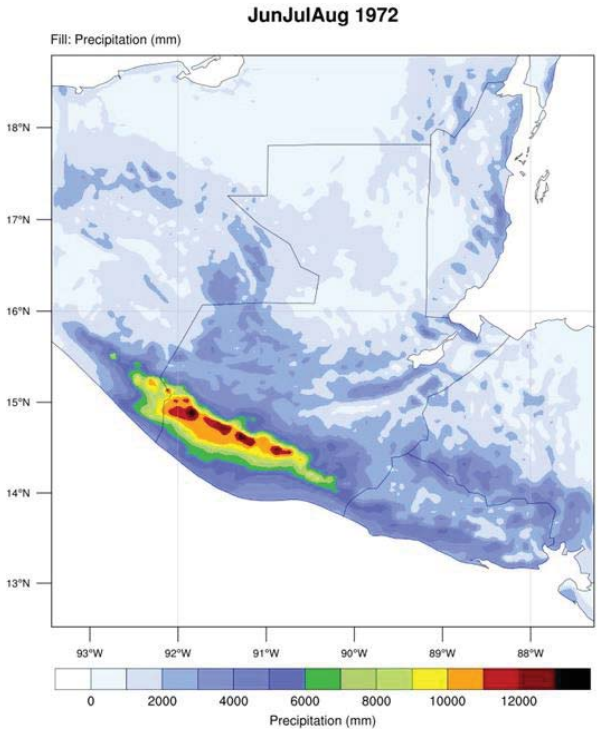
## CLIMATOLOGIA
## (1971-1980)



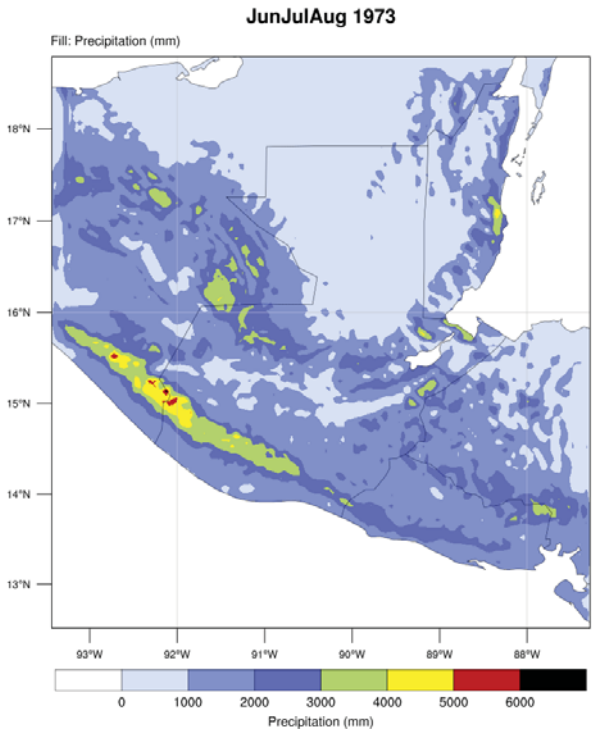

## EVENTO: LA NIÑA 1971



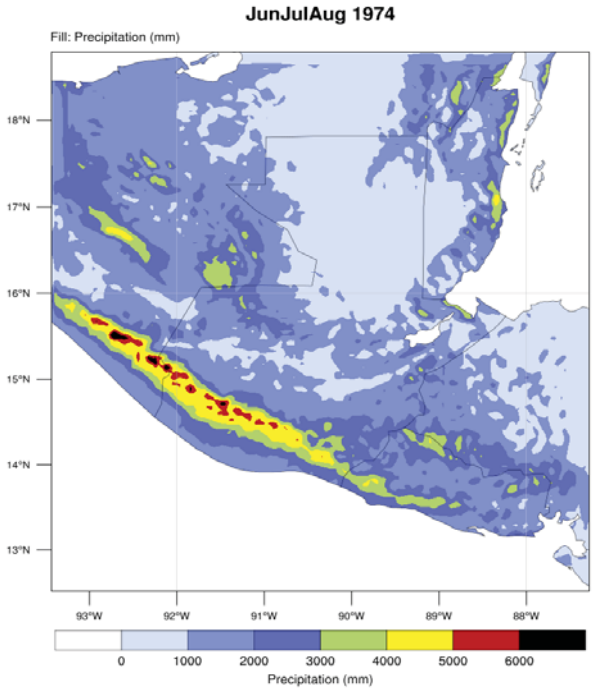

## EVENTO: EL NIÑO 1972



## EVENTO: LA NIÑA 1973




## EVENTO: LA NIÑA 1974




Proyecto: Guatemala

Escenario: Histórico

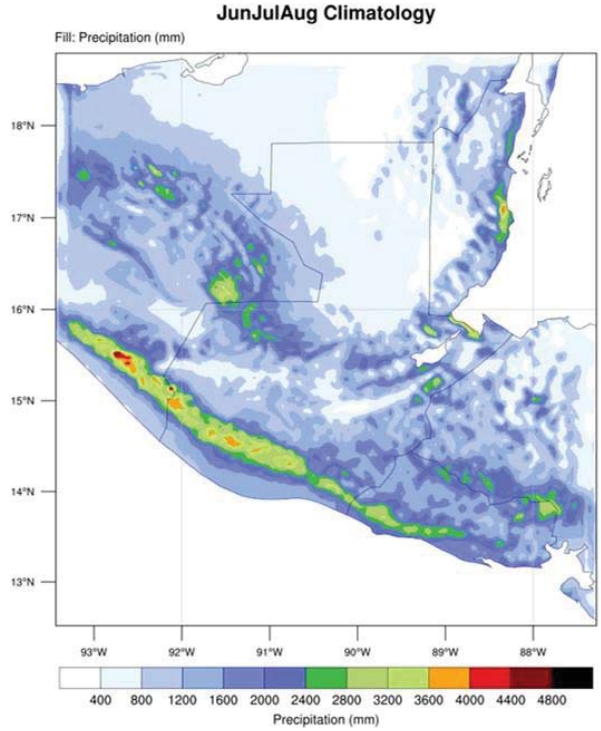
Dominio: D03 Guatemala (4 km)

Corrida: NNRP: 2001-2010

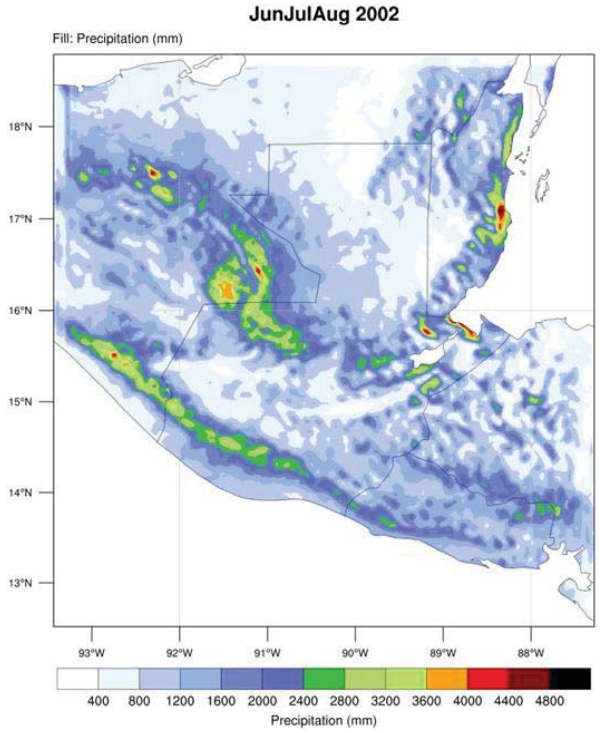
Temporada : verano (junio-agosto)

Variable: lluvia (mm)

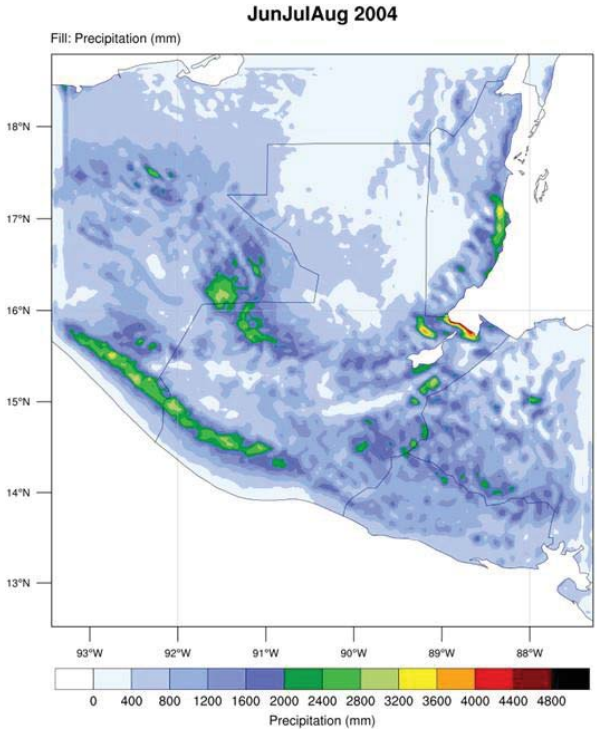
## CLIMATOLOGIA
## (2001-2010)



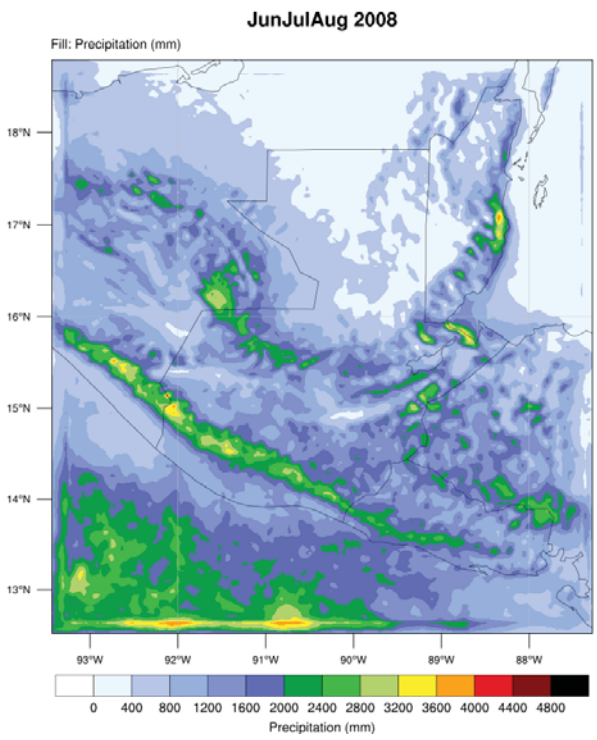

## EVENTO: EL NIÑO 2002



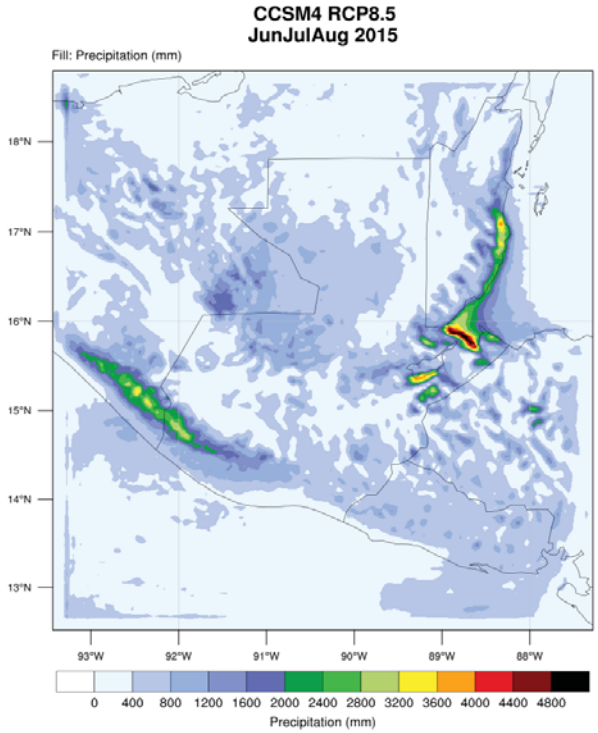

## EVENTO: EL NIÑO 2004



**EVENTO: LA NIÑA 2008**




**EVENTO: EL NIÑO 2015**




Proyecto: Guatemala

Escenario: Histórico

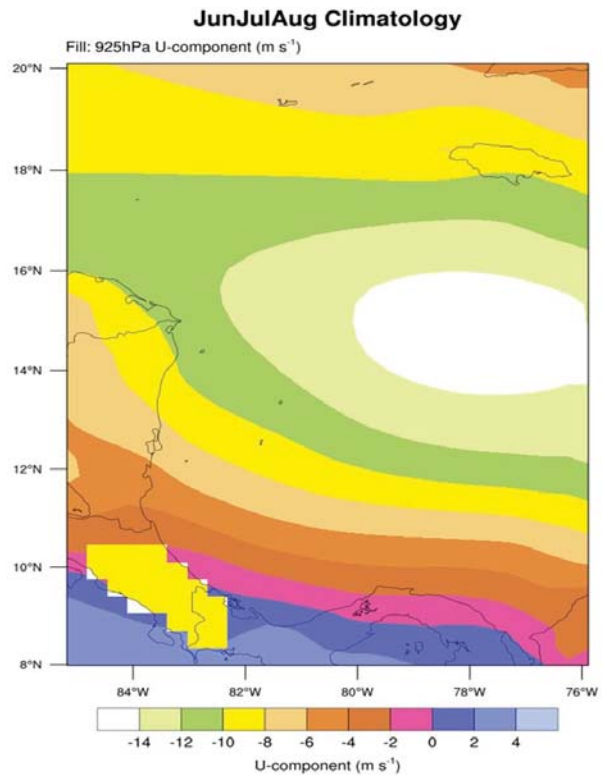
Dominio: D01 Guatemala (36 km)

Corrida: NNRP: 1971-1980

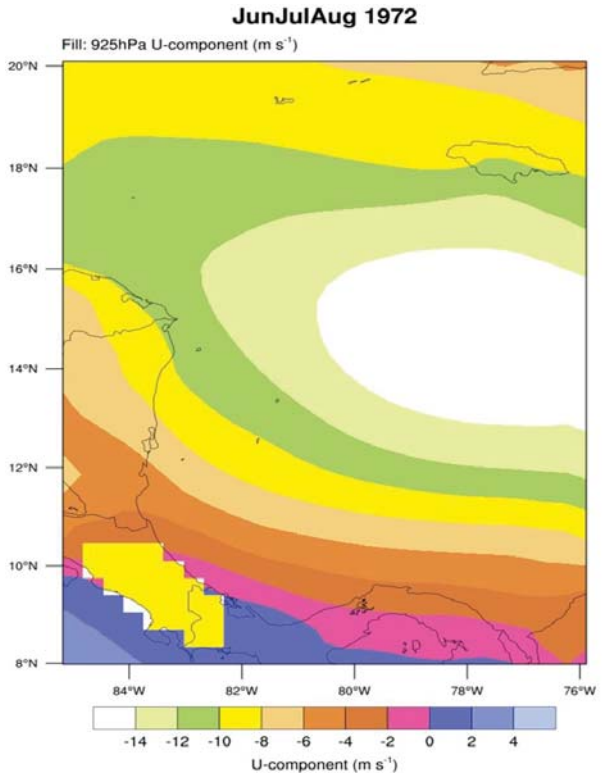
Temporada : verano (junio-agosto)

Variable: U-925 (m/s)

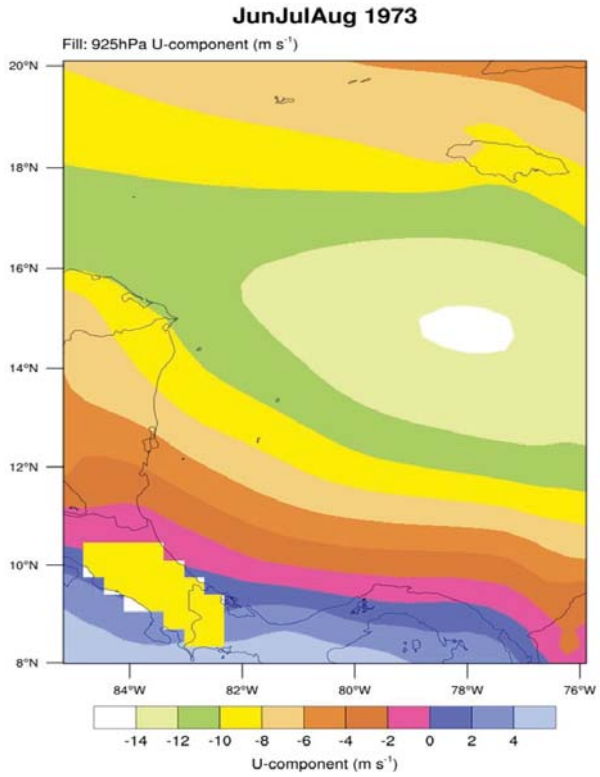
**“Corriente en chorro del Caribe”**




## EVENTO: EL NIÑO 1972




## EVENTO: LA NIÑA 1973



Proyecto: Guatemala

Escenario: Histórico

Dominio: D03 Guatemala (4 km)

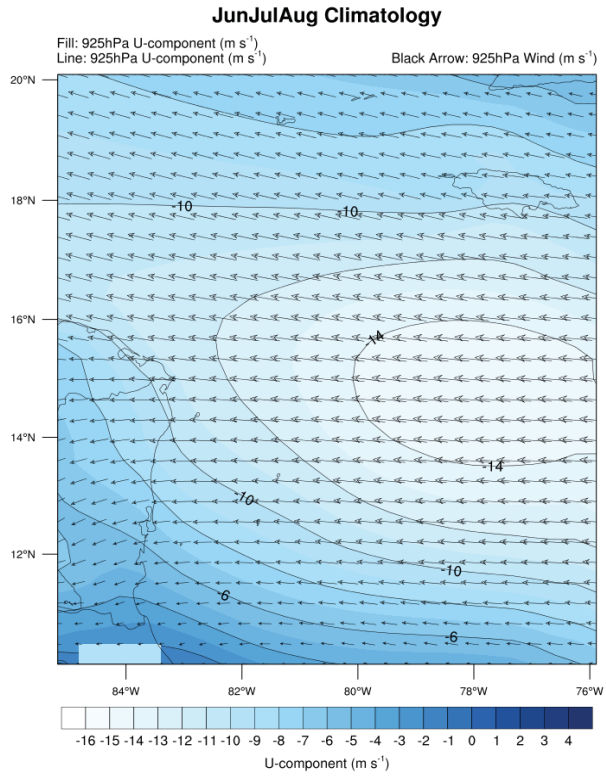
Corrida: NNRP: 1971-1980

Temporada : verano (junio-agosto)

Variable: U-925 (m/s)

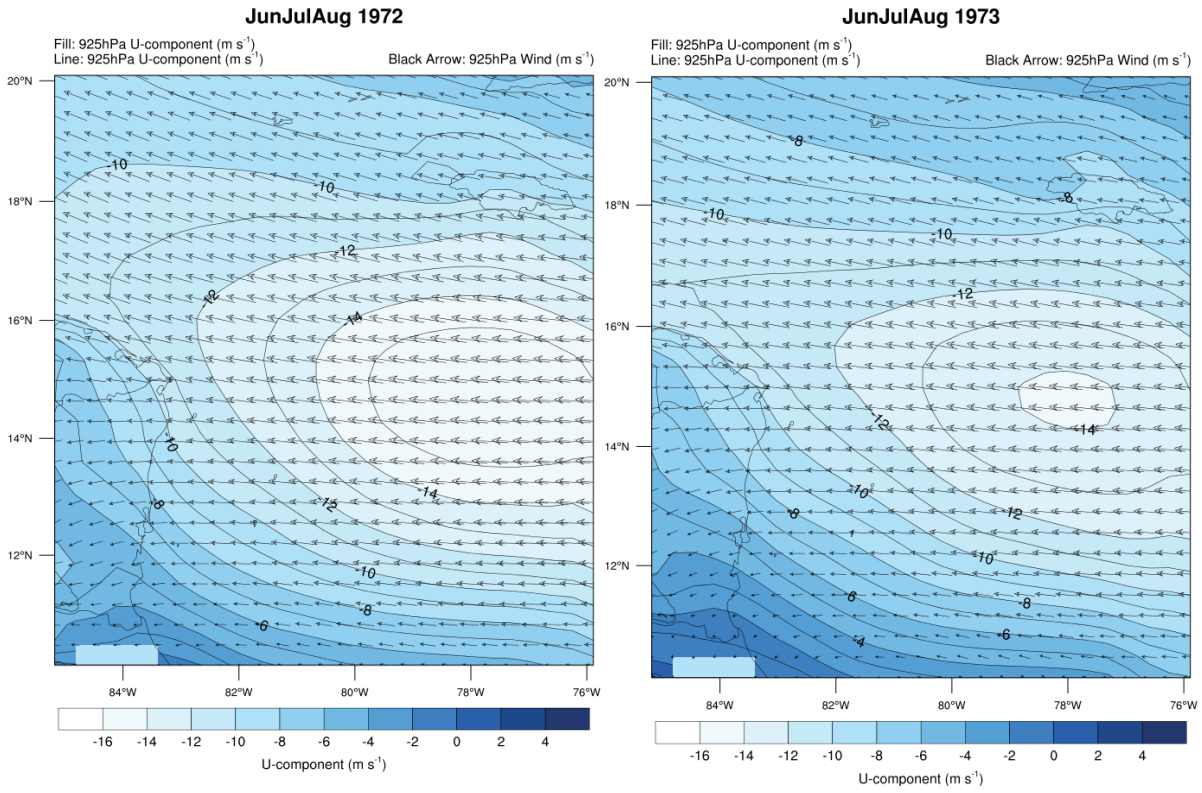
**“Corriente en chorro del Caribe”**

**CLIMATOLOGIA**
**(1971-1980)**



**EVENTO: EL NIÑO 1972**

**EVENTO: LA NIÑA 1973**




Proyecto: Guatemala

Escenario: Histórico

Dominio: D03 Guatemala (4 km)

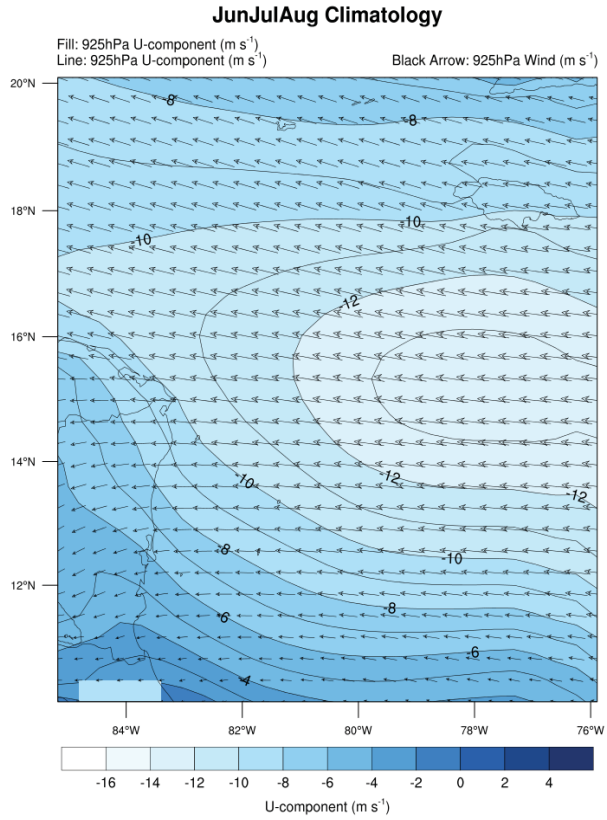
Corrida: NNRP: 2001-2010

Temporada : verano (junio-agosto)

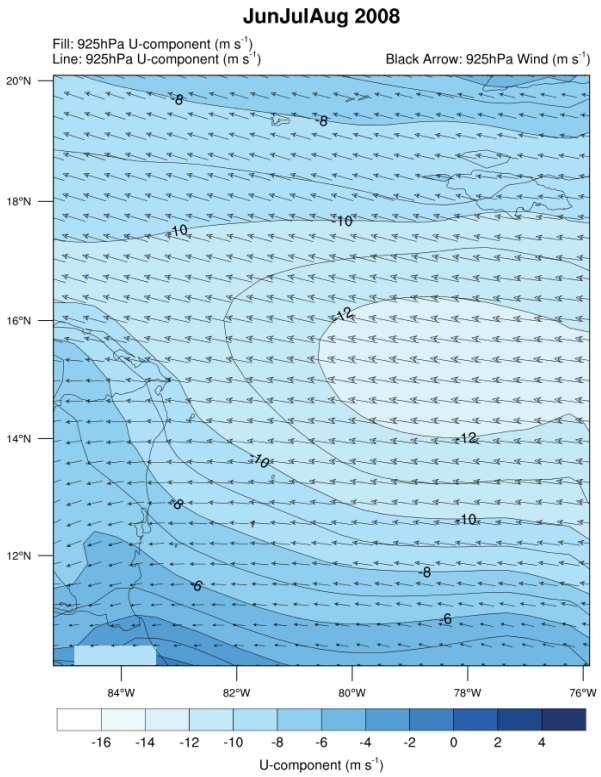
Variable: U-925 (m/s)

**"Corriente en chorro del Caribe"**

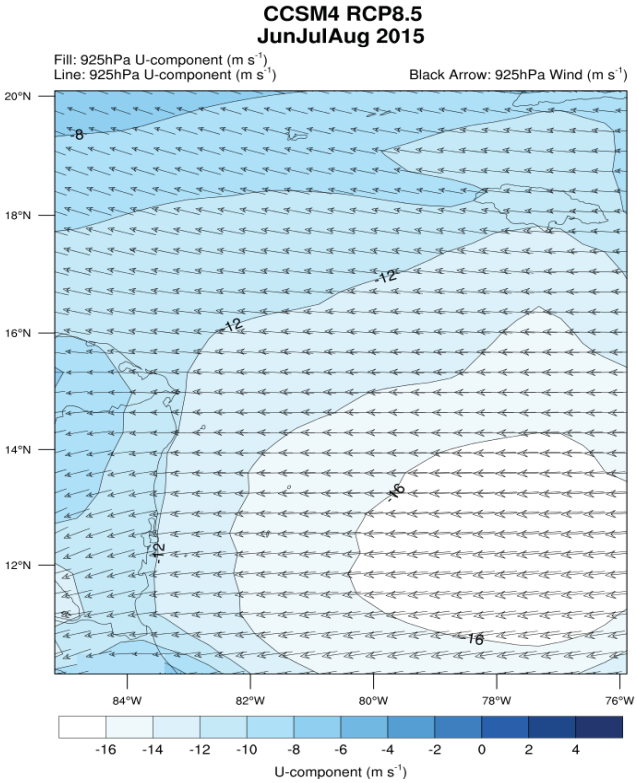
# CLIMATOLOGIA
# (2001-2010)

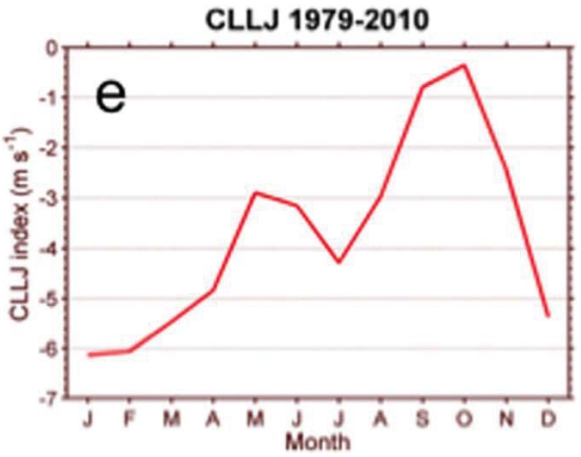


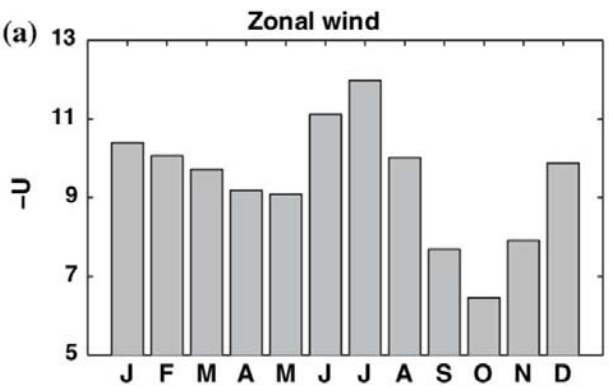

## EVENTO: LA NIÑA 2008

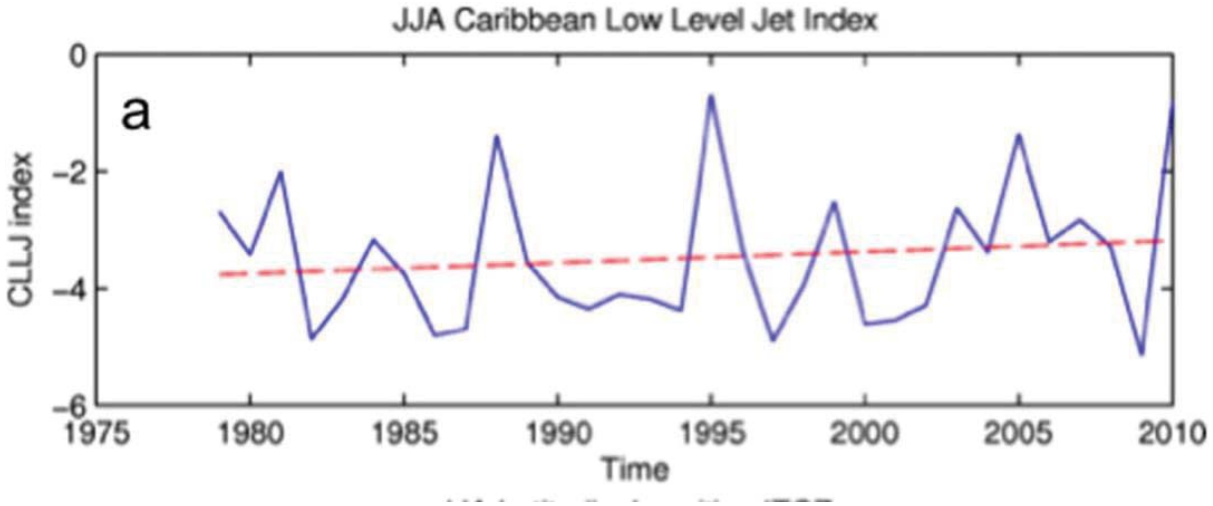


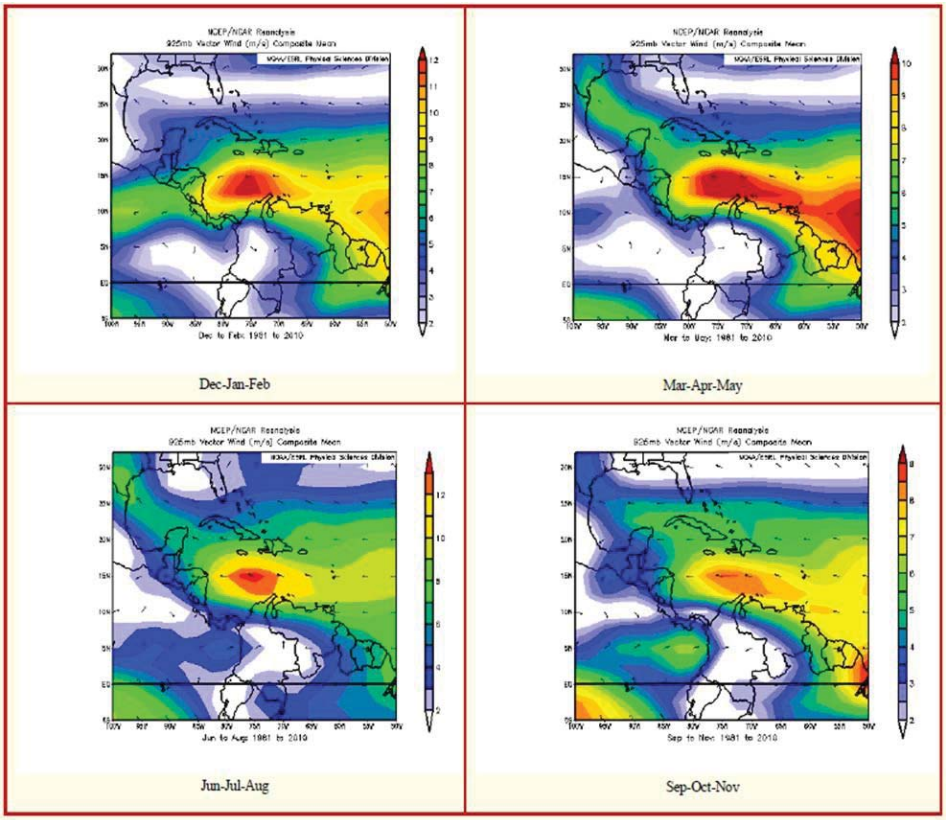

## EVENTO: EL NIÑO 2015
## (BL, rcp8.5, D01)





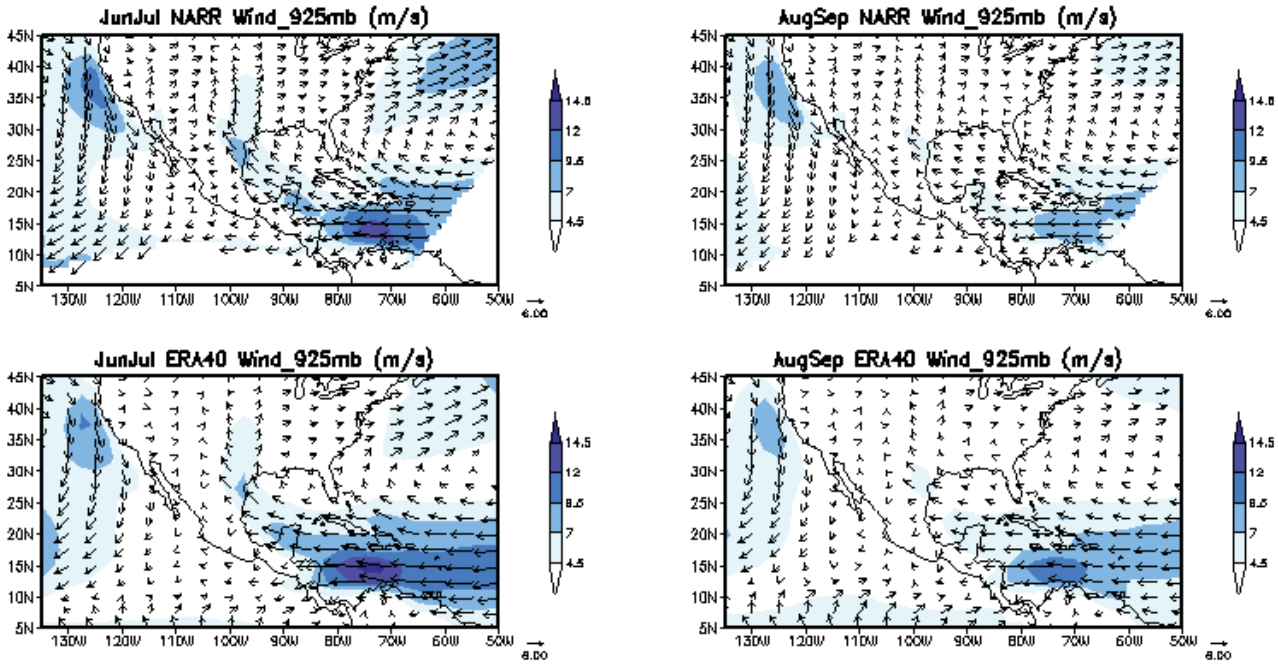



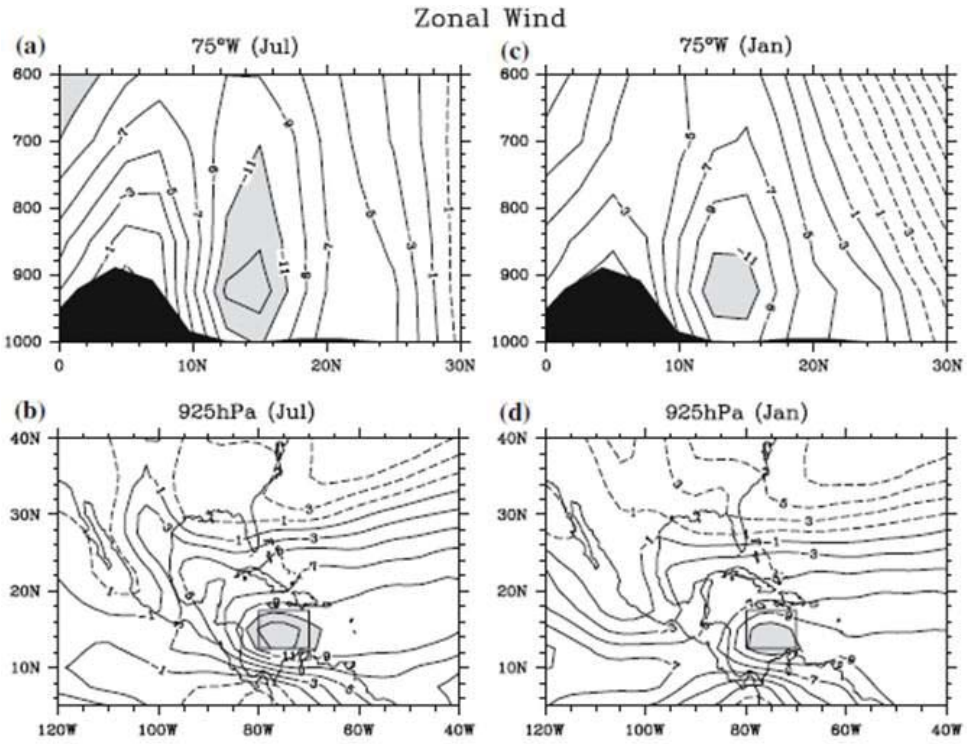




*Vectors winds to 925 hPa.*

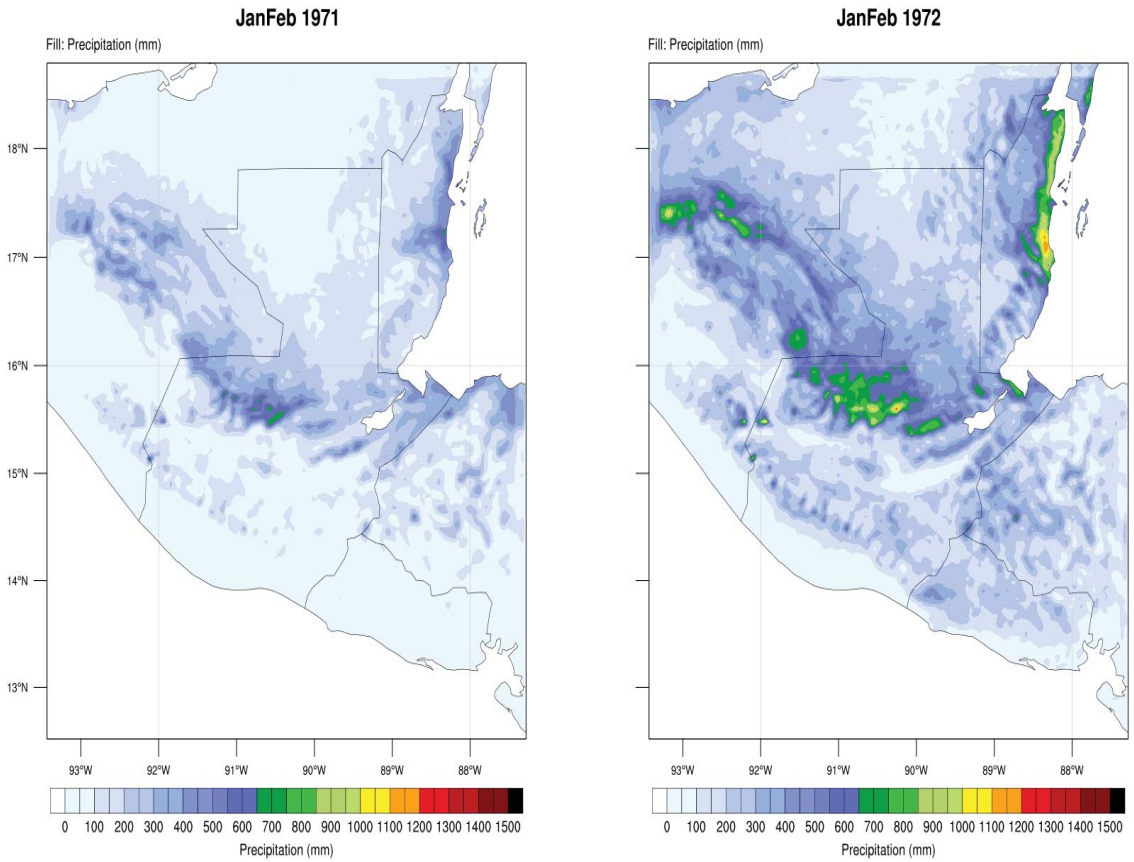
# JunJul & AugSep averages of 925 mb wind

**JunJul** **AugSep**

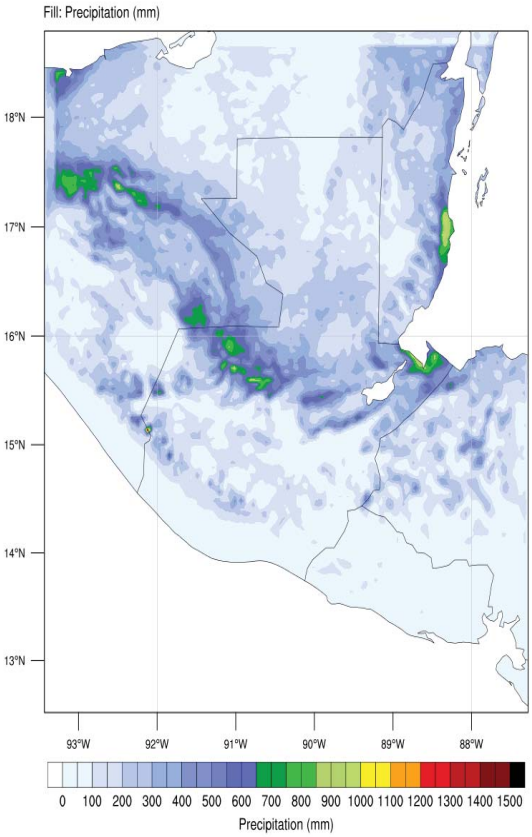


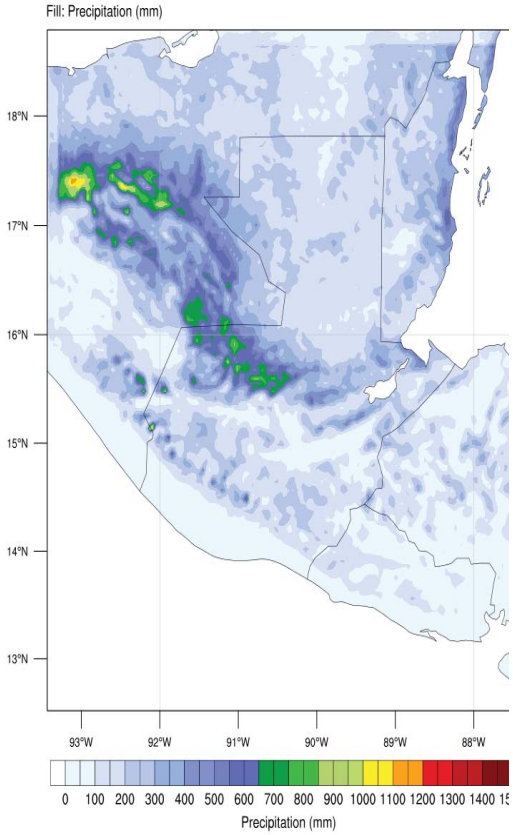
# Eventos La Niña



**JanFeb 1974**




**JanFeb 1975**

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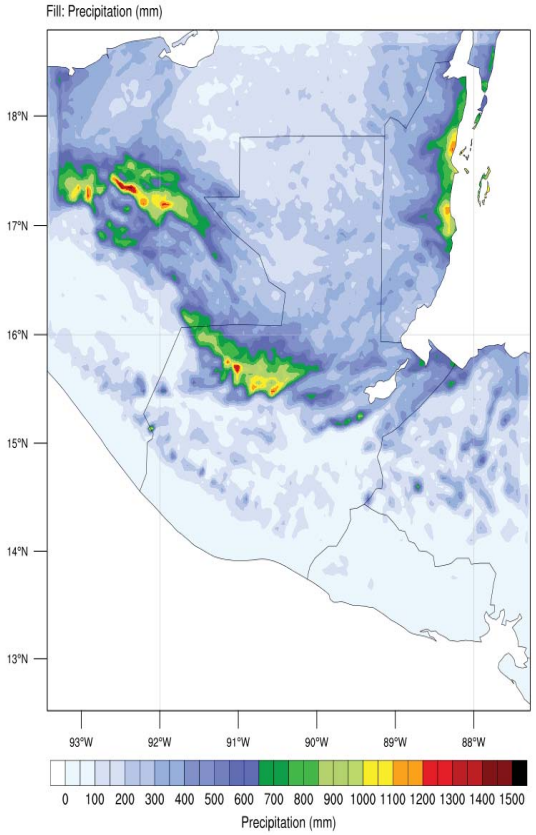

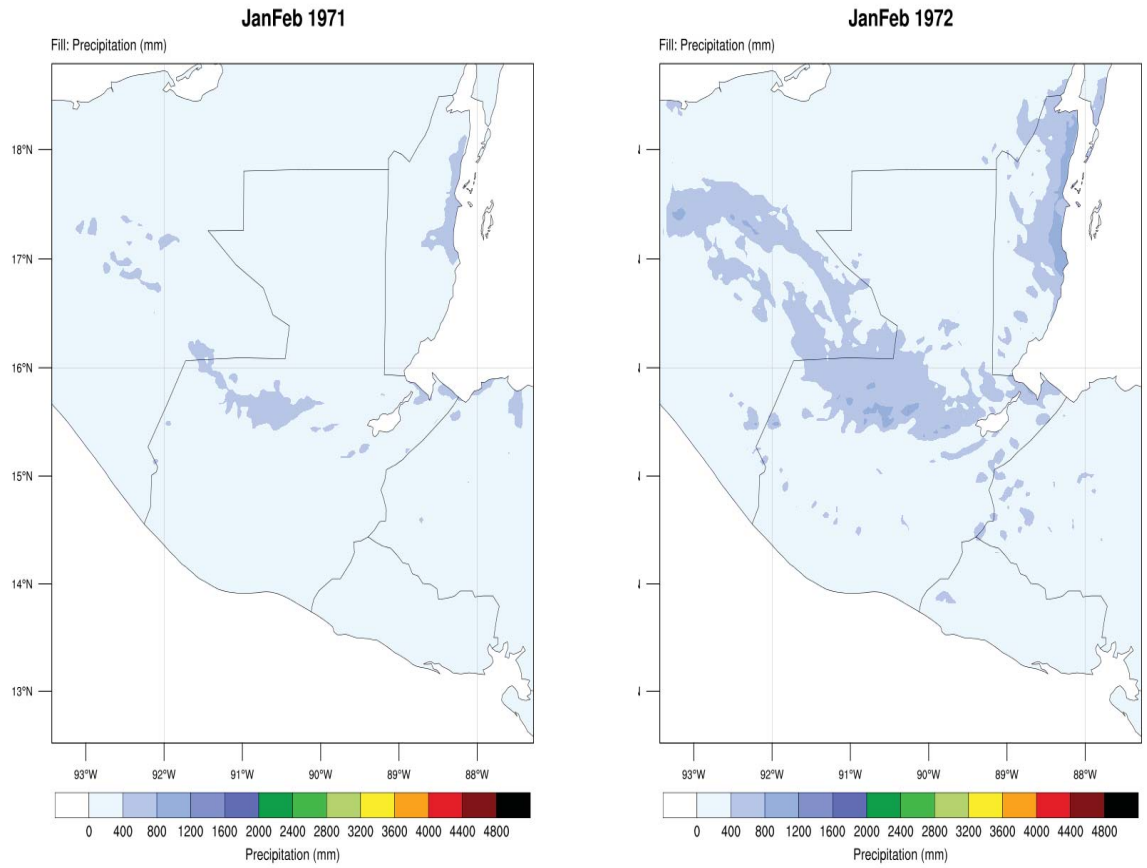
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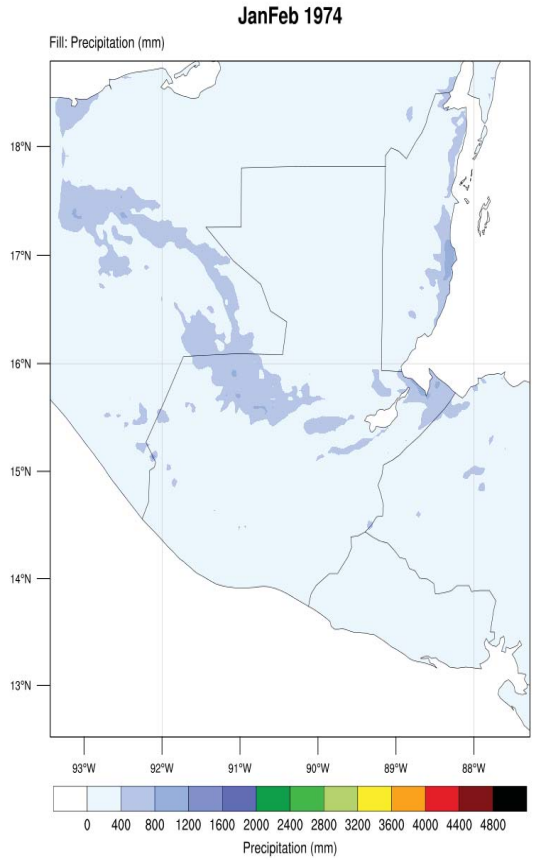
18°N
17°N
16°N
15°N
14°N
13°N
93°W
92°W
91°W
90°W
89°W
88°W
0 400 800 1200 1600 2000 2400 2800 3200 3600 4000 4400 4800
Precipitation (mm)
JanFeb 1972
Fill: Precipitation (mm)
93°W
92°W
91°W
90°W
89°W
88°W
0 400 800 1200 1600 2000 2400 2800 3200 3600 4000 4400 4800
Precipitation (mm)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91°W
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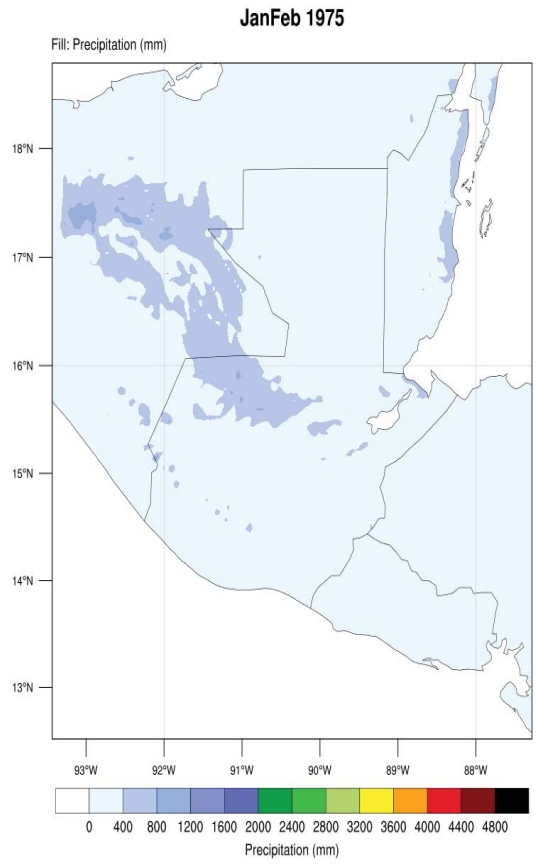
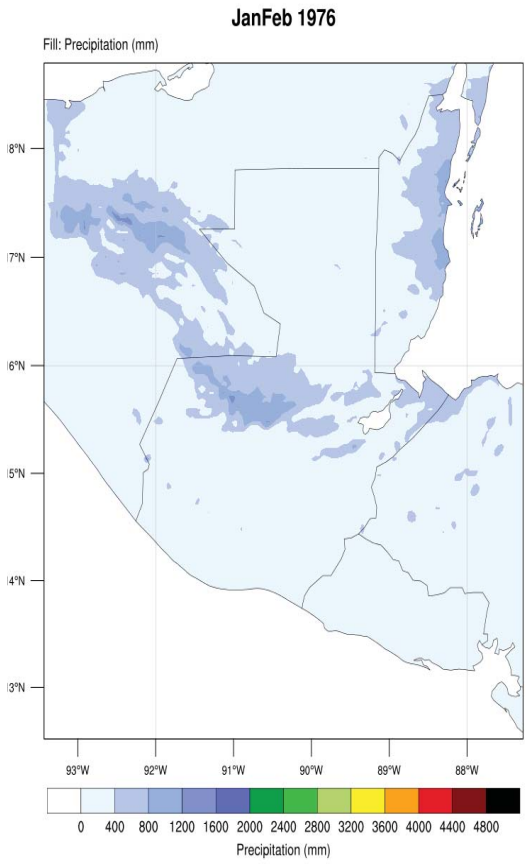
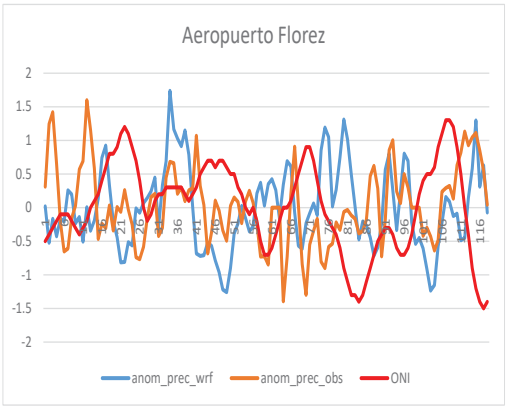
Precipitation (mm)




# Variabilidad Climática (Presente 2001-2010)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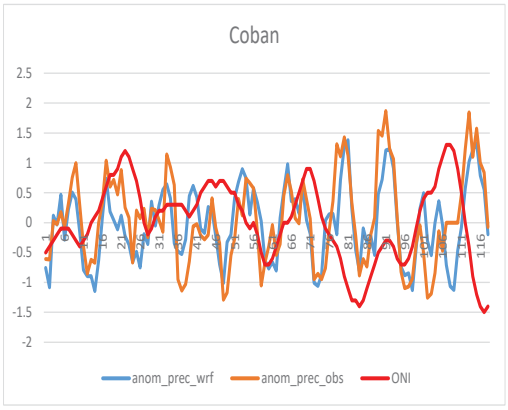
anom_prec_obs
ONI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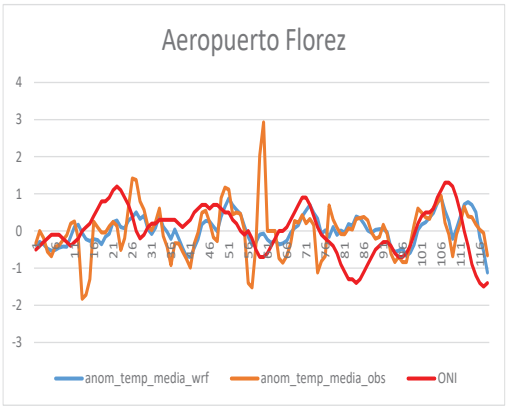
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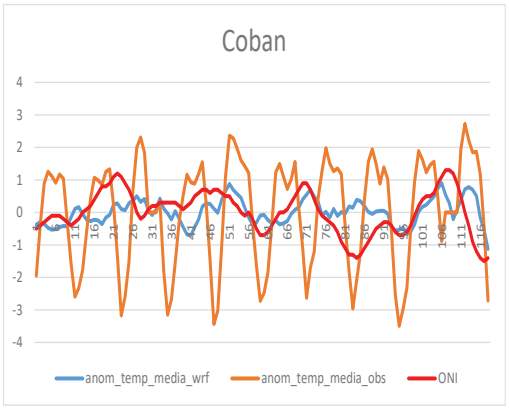
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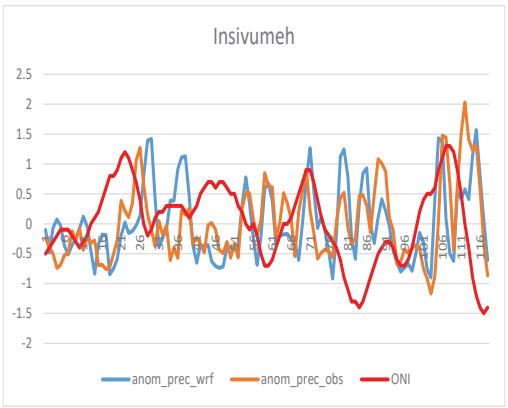
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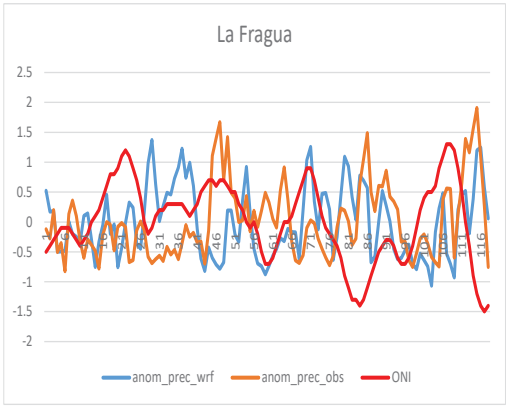
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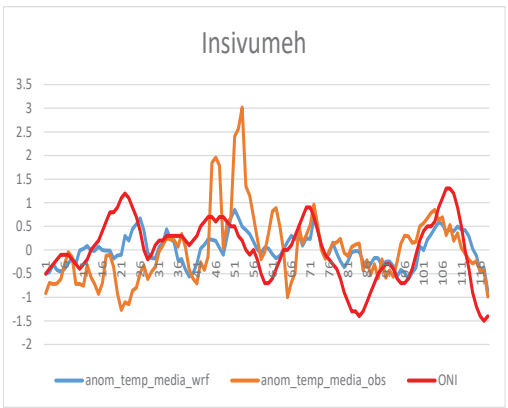
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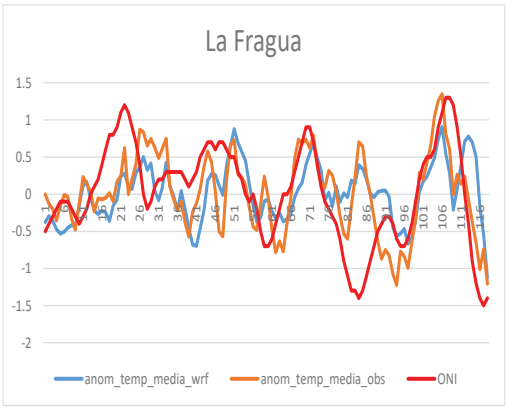
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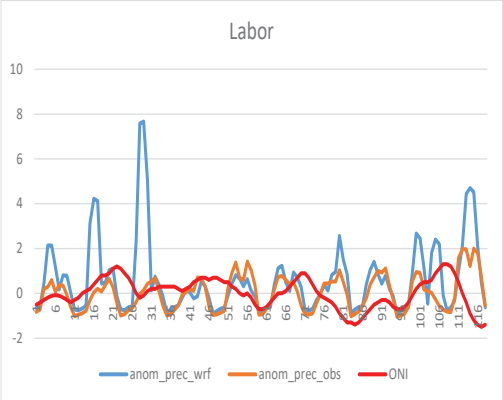
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anom_prec_obs
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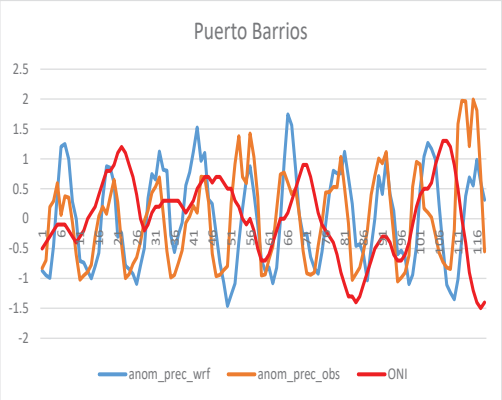
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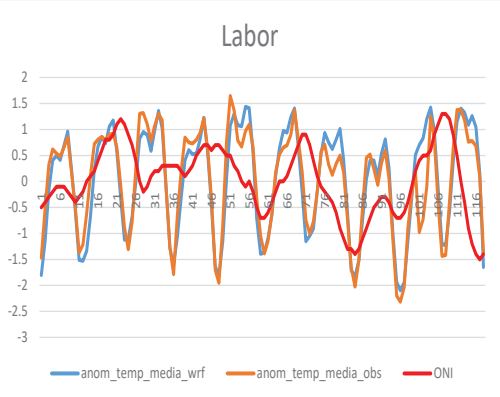
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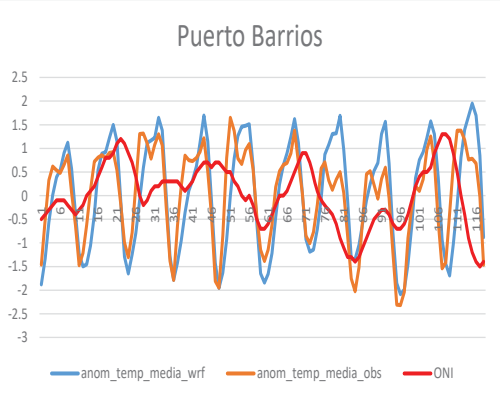
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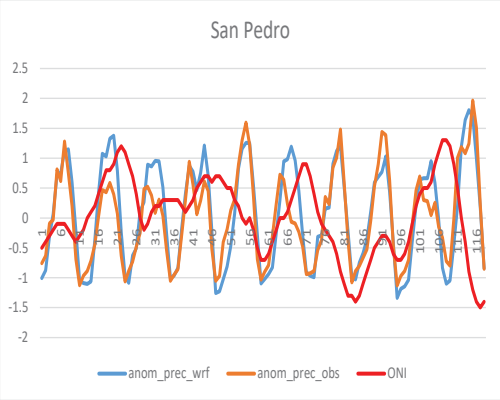
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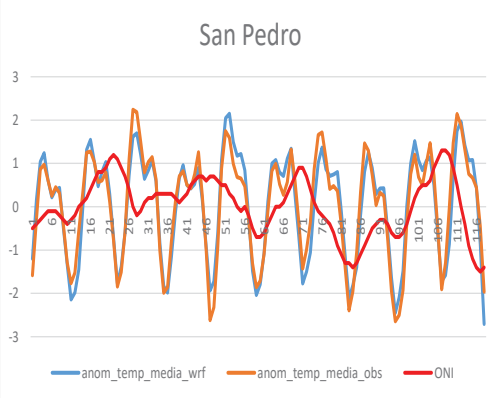
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ONI

**Working Group 3: Mountain Precipitation and Glaciers**

Marcos Andrade, Alan LLacza

This Working Group focuses on precipitation in the very mountainous terrain that comprises much of the region. In Central America, this is primarily rainfall, but in the northern Andes of Bolivia, Peru, and Ecuador snowfall and the resultant impacts on mountain glaciers is also extremely important. At least initially the group is concentrating on Bolivia (and surrounding regions) because of the availability of a catalog of long and relevant simulations with WRF.

# Working Group 3: Mountain precipitation and Glaciers
## (no glaciers for the moment)

Marcos Andrade: Universidad Mayor de San Andrés, Bolivia
Alan Llacza: Servicio Nacional de Meteorología e Hidrología del Perú

**Tentative title:** **Results from a regional high-resolution model for evaluating possible climate changes at the Central Andean region**

**Resultados de un modelo regional de alta resolución espacial para la evaluación de posibles cambios del clima en los Andes centrales**

**Outline**

1. Introduction
2. Data
3. Methodology
4. Results and discussion
5. Conclusions
6. References
7. Acknowledments
8. Annex

*The regions with glaciers (above 4500 masl) have not been considered in this study. Solid precipitation has some problems and time series for those stations have not been QA/QC checked. In addition not too many stations are available for a long period*

## 2. Description of the data

2.1. Regional model WRF

2.2. Surface data: QA/QC ok from a DECADE project (Univ. Of Bern MetoSwiss, SENAMHI's Peru and Bolivia, and UMSA)

2.3. Gridded data for precipitation (either PISCO, produced by SENAMHI-Peru, or CHIRPS already discussed in the literature) and temperature (AgMERRA)

2.4. Winds at 200 mb from the ERA-Interim reanalysis: Aim -> moisture transport

## 3. Methodology

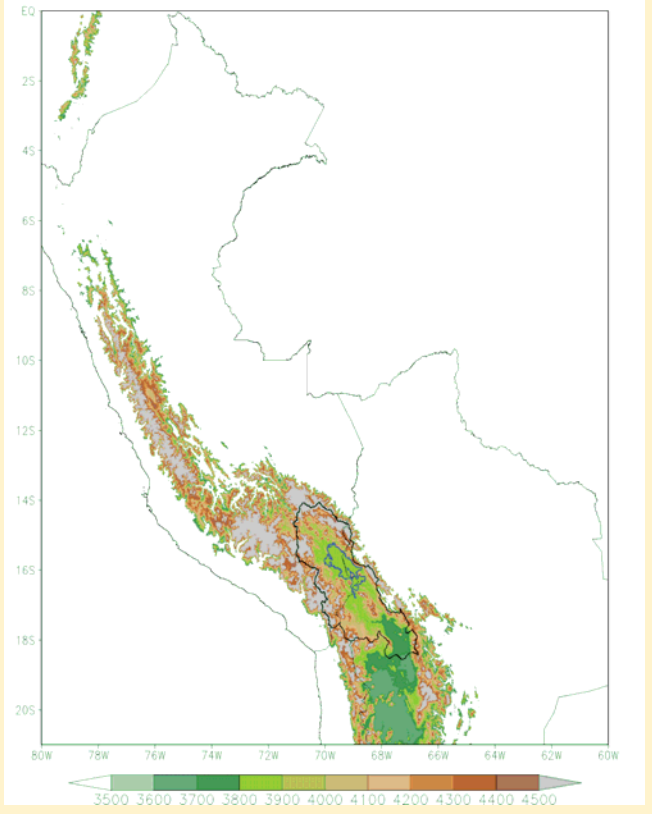
### 3.1. Evaluation of the model

3.1.1. Selection of the region of interest:

- Central Andes, the South American Altiplano
- There are previous works for the region,
- Other projects interested in the region
- Bi-national interest
- Observations of good quality available for the region

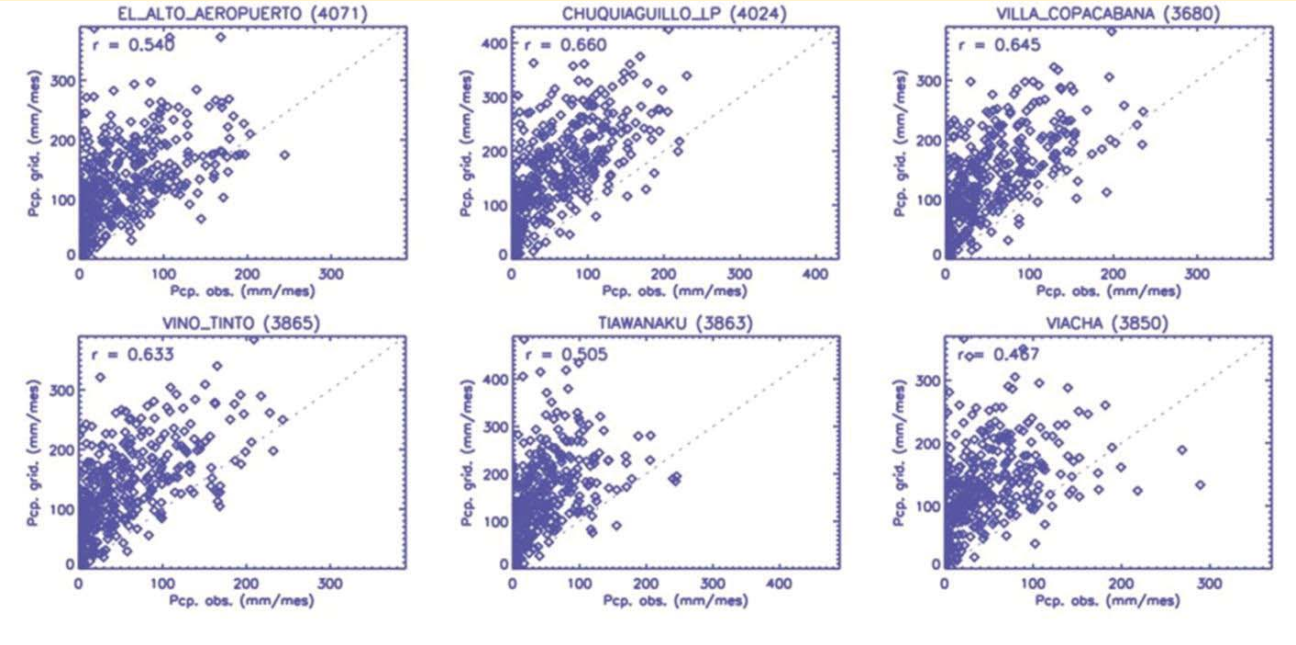
3.1.2 Selected period: 1981-2010

- Observational and model data available for this period



### 3.1.3 Comparison observations vs model outputs

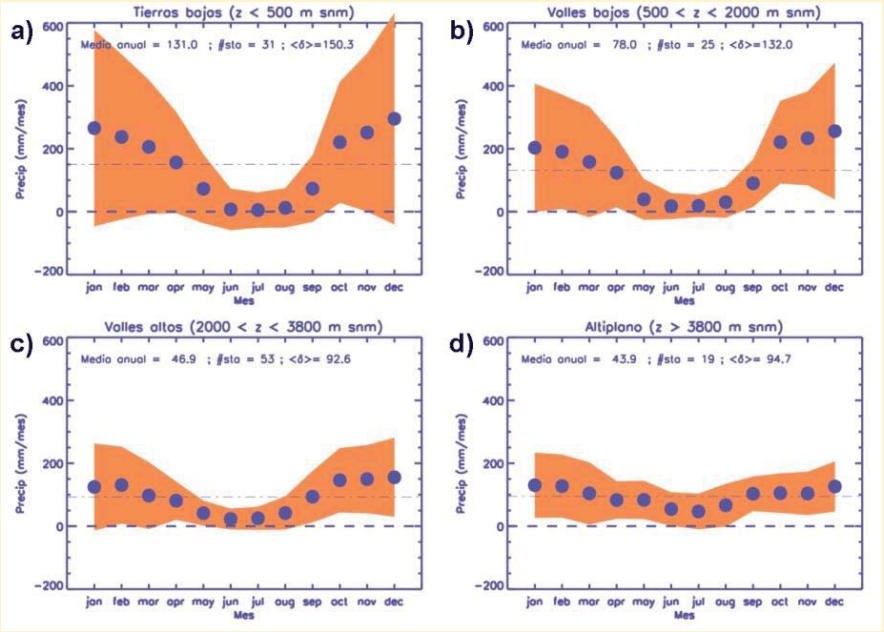
3.1.3.1 Dispersion plots for temperature and precipitation




3. Methodology (cont)

### 3.1.3 Comparison observations vs model outputs

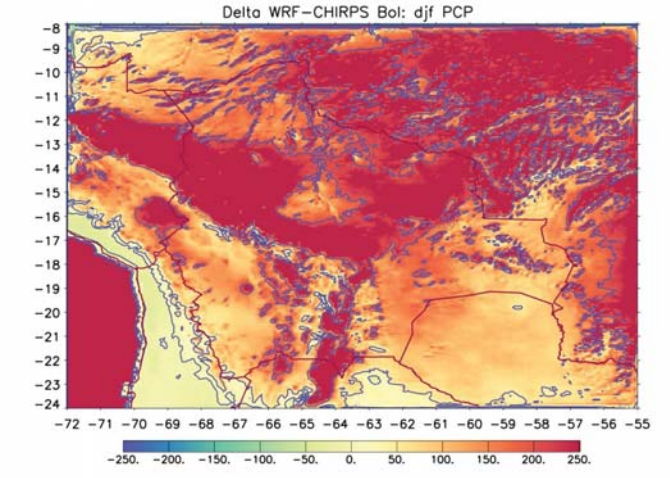
3.1.3.2 Monthly mean differences model-observations

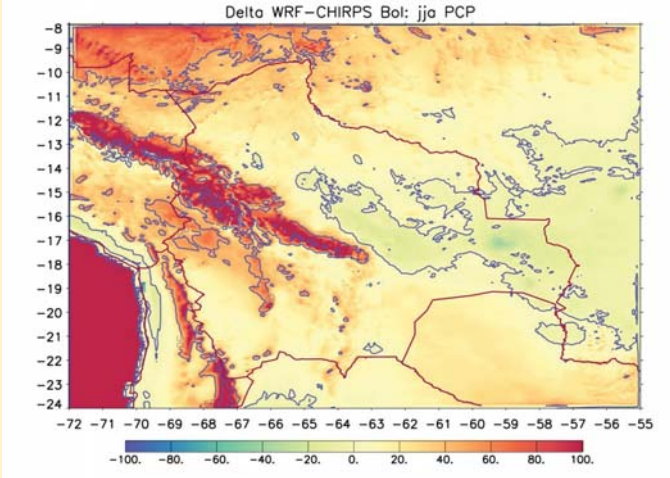



**PCP**

### 3.1.3 Comparison observations vs. model outputs

3.1.3.3 Maps of differences model-observations: monthly and by season (wet and dry)



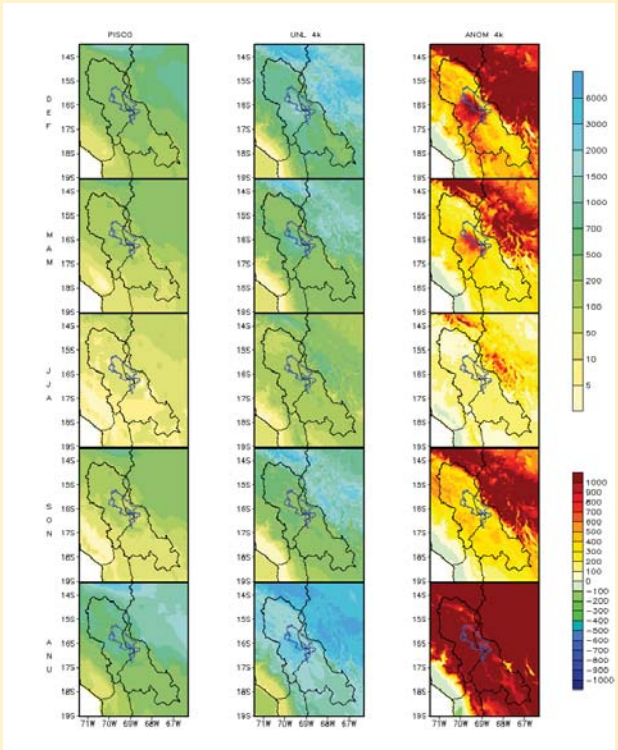




**PCP**

3. Methodology (cont)

3.1.3 Comparison observations vs. model outputs

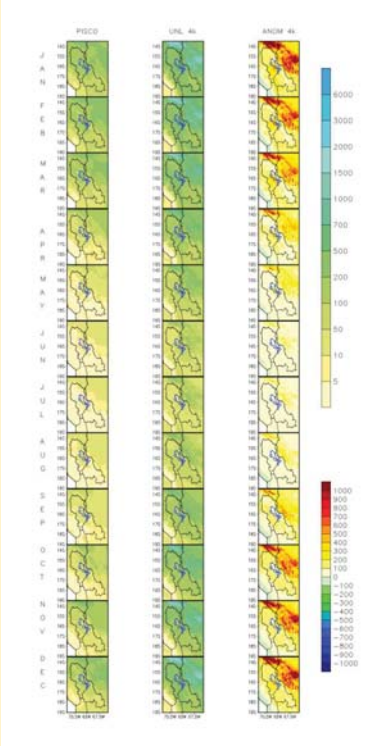
3.1.3.3 Maps of differences model-observations: monthly and by season (wet and dry)




PCP

### 3.1.3 Comparison observations vs. model outputs

3.1.3.3 Maps of differences model-observations: monthly and by season (wet and dry)

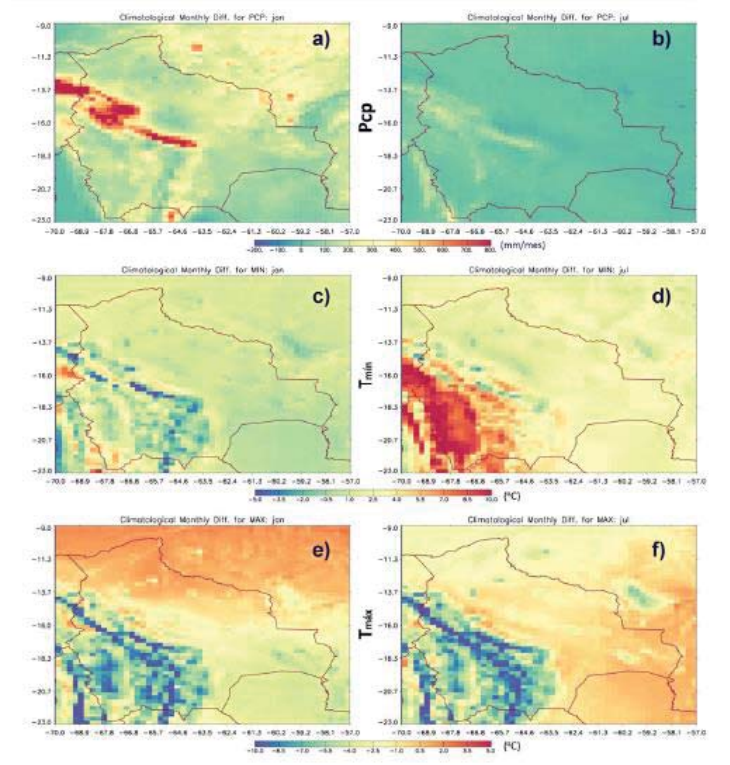


PCP

3. Methodology (cont)

### 3.1.3 Comparison observations vs. model outputs

3.1.3.3 Maps of differences model-observations: monthly and by season (wet and dry)



**3.1.3 Comparison observations vs model outputs**

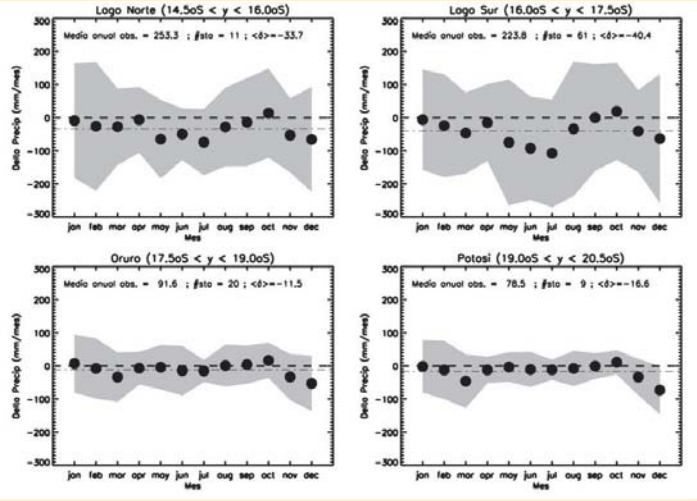
3.1.3.4. Maps of differences for winds at 200 mb

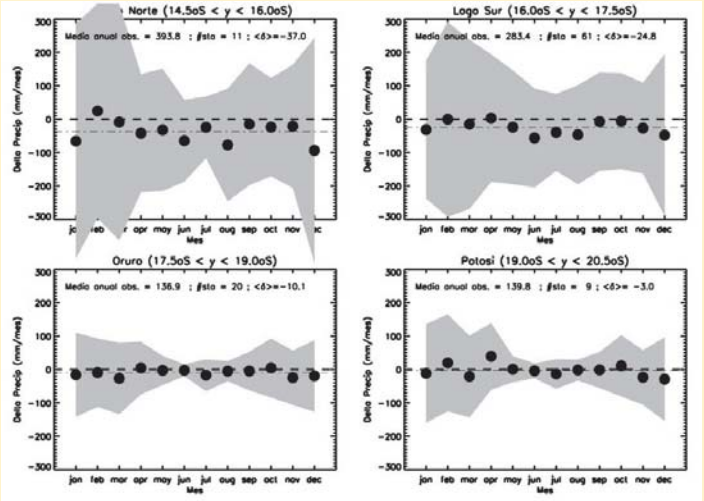
3.1.3.5. Moisture either integrated or at different levels (?)



**3.2 Projected changes: RCP8.5 on main text (but RCP4.5 & RCP2.6 in annex)**

3.2.1. Annual evolution of monthly changes FUTURE-PRESENT (both absolute and relative for TMP and PCP respectively)

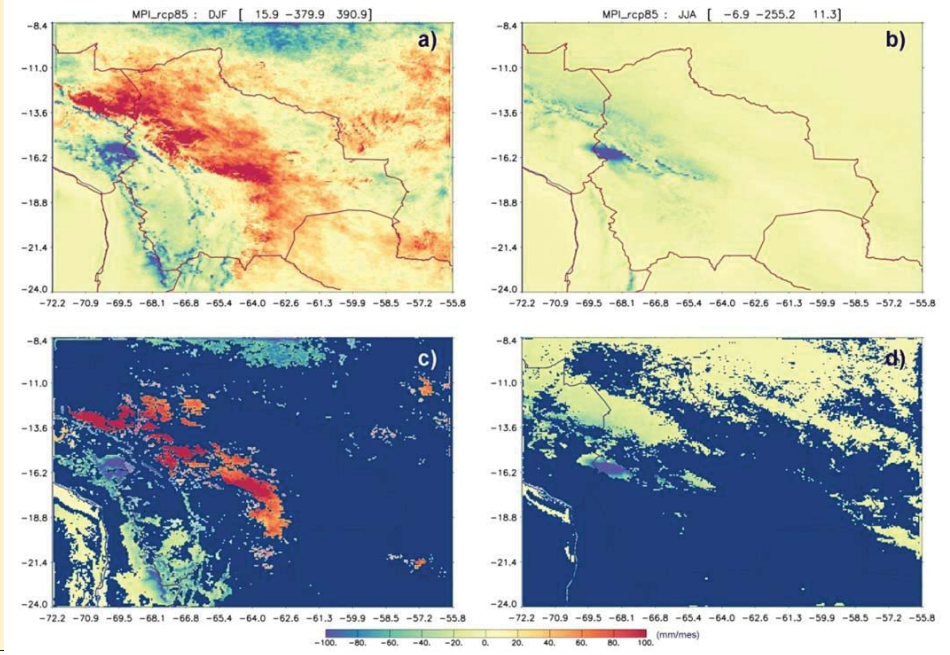



**MPI** **CCSM4**

### 3.2 Projected changes: RCP8.5 on main text (but RCP4.5 & RCP2.6 in annex)

3.2.2 Maps of change both in PCP and TMP with statistical significance




## 4. Results and discussion

4.1. Evaluation

4.2. Differences future-present: implications

4.3. Uncertainties

**Tabla 3.** Valores de cambio entre futuro y presente (en mm) y en porcentaje por franja latitudinal para cada GCM forzante de WRF. Se colocan los valores promedio 9en %) por modelo o por franja.

| MODELO | Lago Norte | | | Lago Sur | | | Oruro | | | Potosí | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | δ | Media Pres | Cambio % | δ | Media Pres | Cambio % | δ | Media Pres | Cambio % | δ | Media Pres | Cambio % | |
| MPI | -33.7 | 253.3 | -13.3 | -40.4 | 223.8 | -18.1 | -11.5 | 91.6 | -12.6 | -16.6 | 78.5 | -21.1 | -16.3 |
| MIROC | -46.9 | 187 | -25.1 | -19.6 | 120 | -16.3 | -12.9 | 56 | -23.0 | -20.5 | 80.2 | -25.6 | -22.5 |
| CCSM4 | -37 | 393.8 | -9.4 | -24.8 | 283.4 | -8.8 | -10.1 | 136.9 | -7.4 | -3 | 139.8 | -2.1 | -6.9 |
| | | | -15.9 | | | -14.4 | | | -14.3 | | | -16.3 | |

| | RCP2.6 | RCP4.5 | RCP8.5 |
|---|---|---|---|
| MPI | | | |
| CCSM4 | | | |
| MIROC | | | |

## 5. Conclusions

## 6. References

## 7. Annex

Results for RCP2.6 and RCP4.5

## Working Group 3: Mountain precipitation and Glacier

Marcos Andrade: Universidad Mayor de San Andres
Alan Llacza: Servicio Nacional de Meteorologia e Hidrologia del Peru

**Resultados de un modelo regional de alta resolución espacial para la evaluación de posibles cambios del clima en los Andes centrales.**

**Índice**



NOTA: En el presente estudio no se considera los glaciares debido a que no hay información confiable de precipitación y/o no se dispone de pocos años para alturas mayores a 4500 msnm

## 2. Datos utilizados

2.1. Modelo regional WRF [UNL]

2.2. Datos de superficie de precipitación y temperatura [MARCOS]

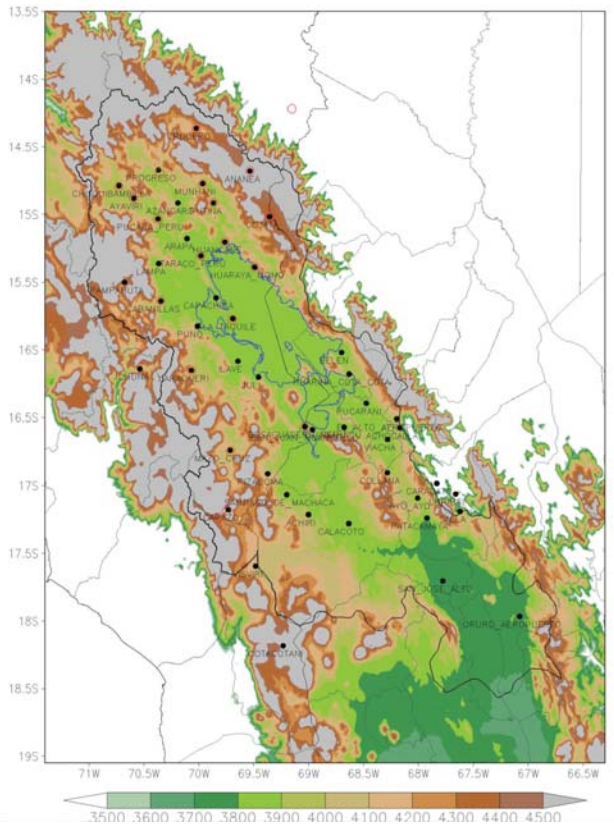
2.3. Datos en malla para precipitación (PISCO) y temperatura (AgMERRA). [ALAN]

2.4. Datos de viento del reanálisis ERA-Interim. [ALAN]

## 3. Metodología

3.1. Validación a escala mensual [1981-2010]

3.1.1. Selección del área de estudio (proyecto DECADE, características topográficas, etc.) [MARCOS]



## 3. Metodología

3.1. Validación a escala mensual [1981-2010]

3.1.1. Selección del área de estudio (proyecto DECADE, características topográficas, etc.) [MARCOS]

3.1.2. Diagramas de dispersión de la precipitación y temperatura [Observado y WRF-UNL] [MARCOS]

3.1.3. Evolución anual de las diferencias mensuales. [MARCOS]

3.1.4. Mapas de las diferencias climáticas mensuales y/o trimestrales [PISCO/AgMERRA y WRF-UNL]. [ALAN]

3.1.4. Mapas de diferencias de la climatología de viento [Viento zonal a 200hPa] [ALAN]

3.1.5. Mapas de la humedad (por decidir)

3.2. Cambios a futuro [RCP 8.5]

3.2.1. Mapas trimestrales de los cambios de precipitación y temperatura [con significancia estadística] [ALAN]

3.2.2. Evolución anual de los cambios a futuros. [MARCOS]

## 4. Resultados y discusión

4.1. Resultados de la validación.

4.2. Diferencias entre modelos y escenarios de emisión.

4.3. Incertidumbres “total”

## 5. Anexos

Evaluación de cambios para RCP2.6 y RCP 4.5 [Incertidumbre].

**Workshop 3**

A continuación, se presentan preguntas y/o comentarios acerca de la web interactiva MapMaker, los cuales son importantes resolverlos en el taller, para desarrollar mejor el documento técnico de cada grupo.

http://rccdp.unl.edu/portal/maps/uberMapMaker.html

**1. Página de descarga de datos:**

1.1. Para el dominio Bolivia (4 km), hay problemas al descargar el dominio completo. Además, al seleccionar un área más pequeña da un mensaje de error. **¿Es posible que la selección del área de forma visual?**

Ejemplo:

RPTA: Se puede hacer, pero es un problema de tiempo, lo que podria hacer es unas notas sobre los limites de los dominios.

1.2. ¿Es posible añadir la opción de descarga de data diaria o mensual?

RPTA: No se podria por el tiempo.

1.3. ¿Es posible añadir las variables de superficie Humedad relativa y Radiación solar?

RPTA: Si

1.4. ¿Es posible colocar en la misma página de descarga la referencia cual periodo es el disponible en la descarga como los límites de los dominios?

**2. Página de visualización de datos:**

2.1. En el dominio Bolivia, al elegir un modelo del CMIP5, debería aparecer la opción del mapa de cambios a futuro**. ¿Es posible que solo exista la opción de medias climáticas y cambios?**

**RPTA: Es posible.**

2.2. ¿Por qué no hay una opción de poder seleccionar el promedio o acumulado de una variable?

RPTA: De la precipitacion es acumilado, de las demas variables es promedio.

2.3. Hay problemas al graficar: Categoría de uso de suelo y vegetación dominante con otra variable. **¿Es posible modificarlo?**

2.4. En la selección de la tabla de colores debería aparecer los colores y no los nombres. **¿Es posible cambiar esto?**

**RPTA: Hay un prototipo, que luego se mostrara.**

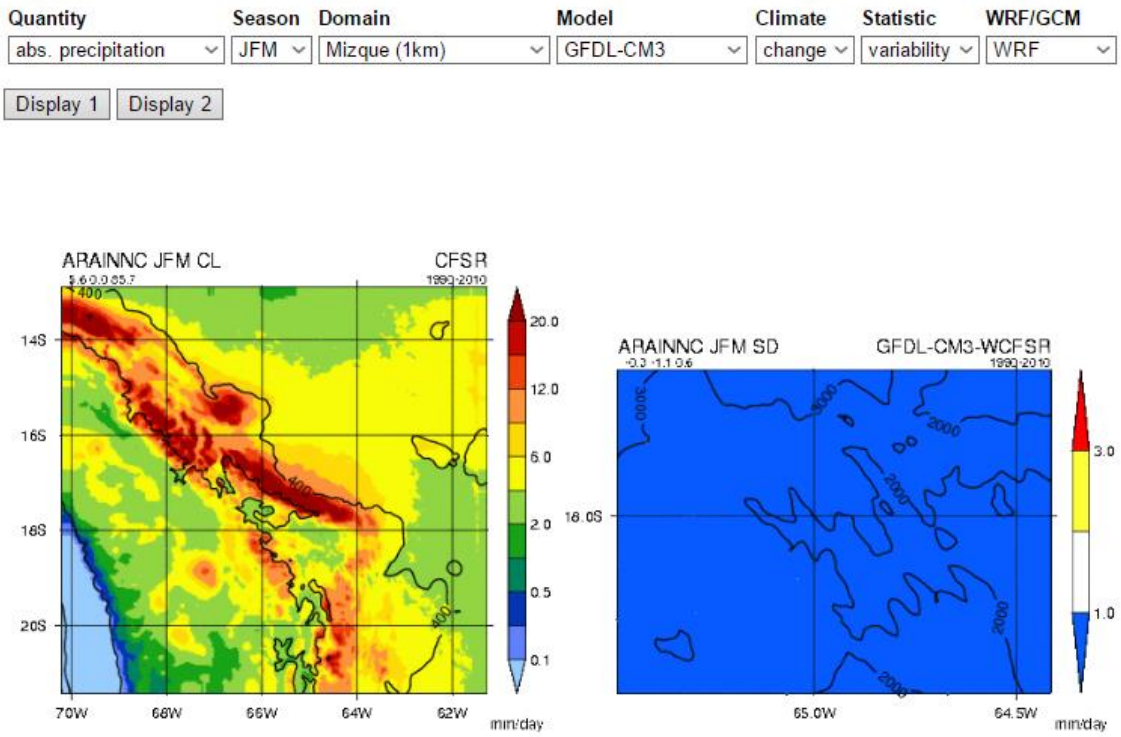
2.5. ¿Puede ser la selección del dominio a graficar de manera visual?

2.6. ¿Por qué no se encuentra en la misma página web las opciones de selección y visualización?

2.7. Debido a que se disponen de varios modelos del CMIP5 regionalizados, es más practico tener la opción de poder visualizarlos todos o algunos de ellos, y/o el promedio de ellos. ¿Por qué no se ha añadido esa opción?

Ejemplo: http://www.inscc.utah.edu/~reichler/BOLIVIA/Explorer.shtml?

3. El periodo de las simulaciones futuras es diferente por cada modelo **¿Por qué?**




**4. Sobre resultados:**

4.1. Para el dominio Bolivia. **¿Cuál es la confiabilidad de los cambios a futuro, si en la simulación presente difiere respecto a las observaciones (sobre/sub estimación)?**

**4.2. Los mapas de humedad relativa en superficie y en niveles no muestran una escala correcta**

**RPTA: se va a volver a recalcular los datos.**

**PARA MESOAMERICA:**

**Tener analisis para periodos 2000 – 2005 y 2011-2015**

**NOTAS DE LA SIMULACION:**

La simulación utiliza la TSM del modelo global y lao actualiza.