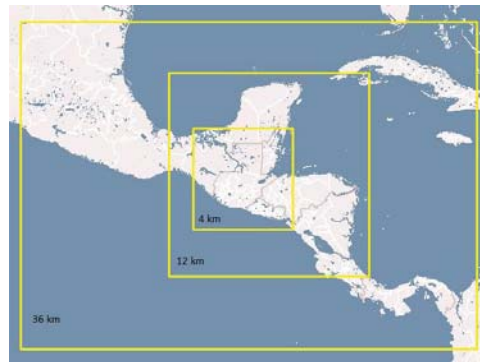


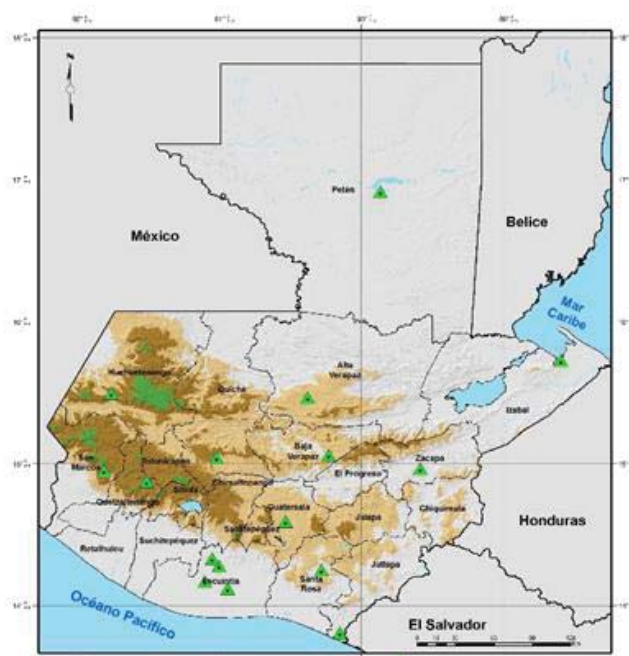
Análisis de los posibles efectos del Cambio Climático en Guatemala, utilizando el modelo CCSM4-WRF.

Alfaro G., Alvarado L., Barrera D., Nieto JJ. y Ruiz, F. 2017.



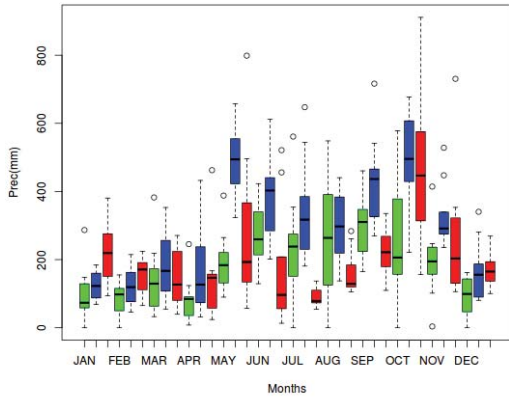
13 de julio 2017

Ubicación de Estaciones Analizadas



Cobán

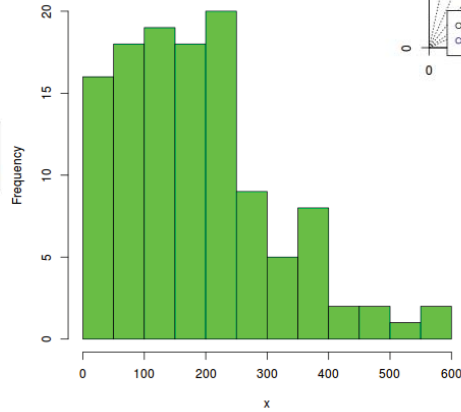
Rainfall's Seasonality for Cobán



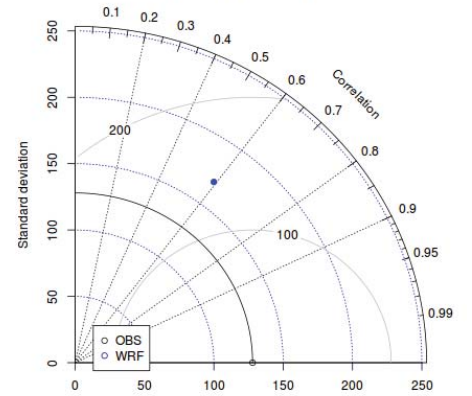
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85



Histogram for Cobán

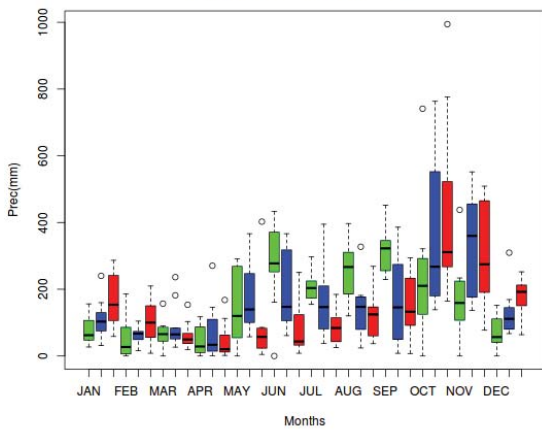


Taylor diagram for Cobán



Flores

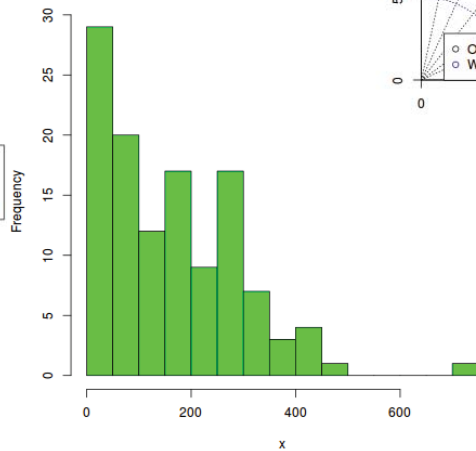
Rainfall's Seasonality for Flores



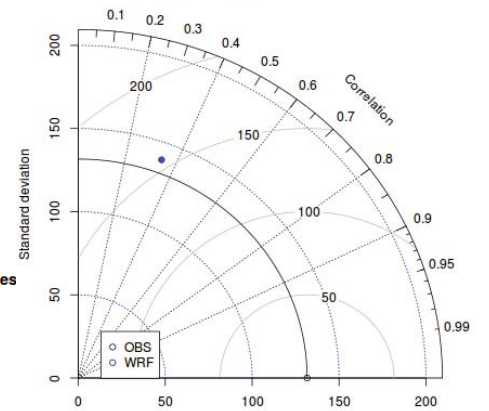
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85



Histogram for Flores



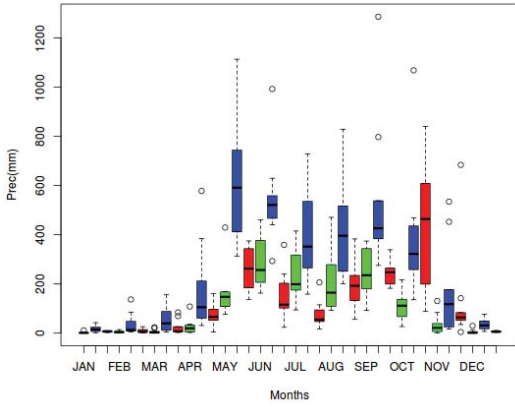
Taylor diagram for Flores



Guatemala Area

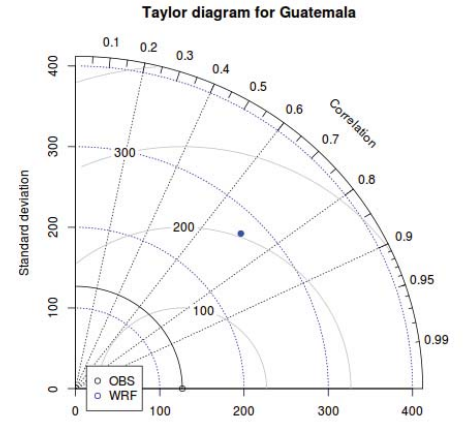
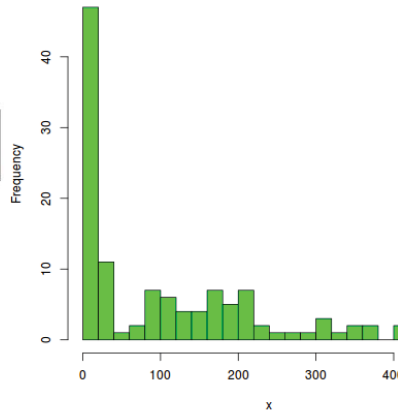


Rainfall's Seasonality for Guatemala



Legend
 — OBS
 — NNRP
 — CCSM4_rcp85

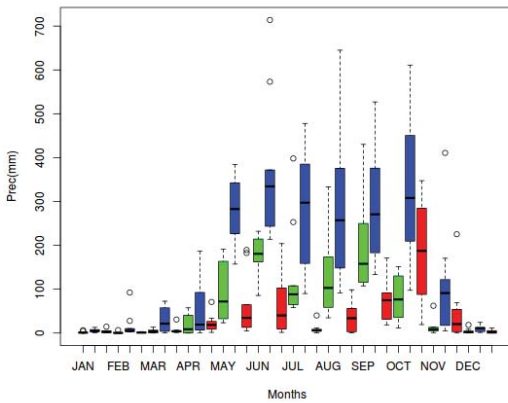
Histogram for Guatemala



La Fragua

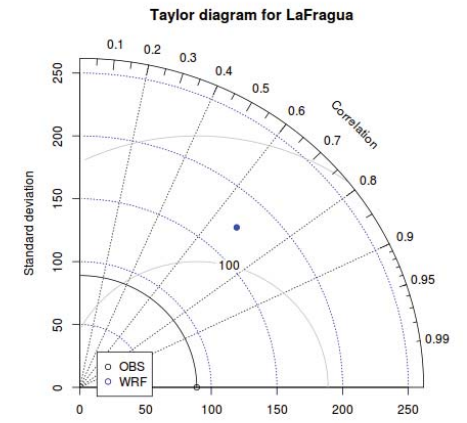
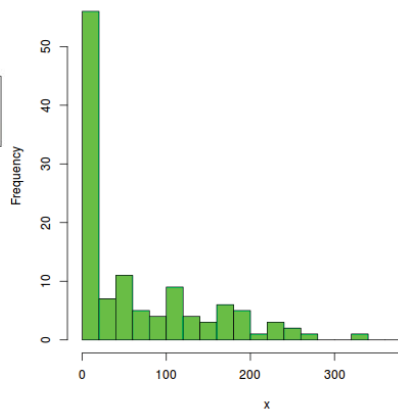


Rainfall's Seasonality for LaFragua



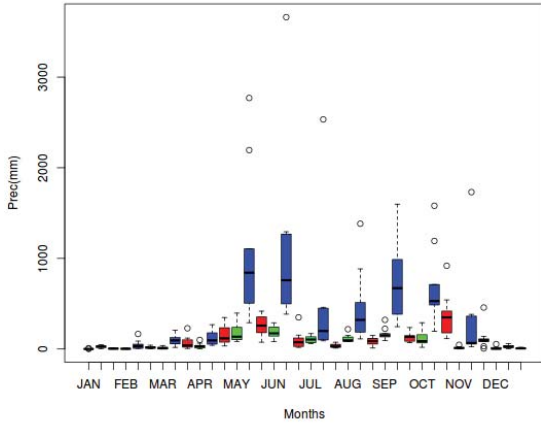
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85

Histogram for LaFragua



Ovalle

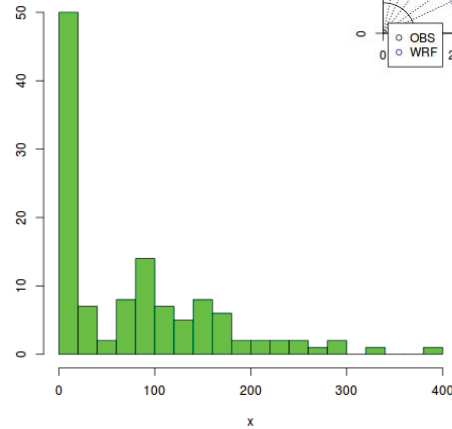
Rainfall's Seasonality for Ovalle



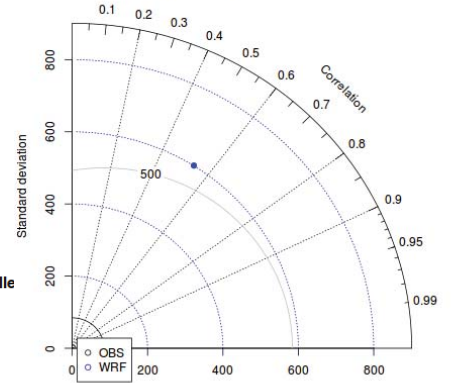
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85



Histogram for Ovalle

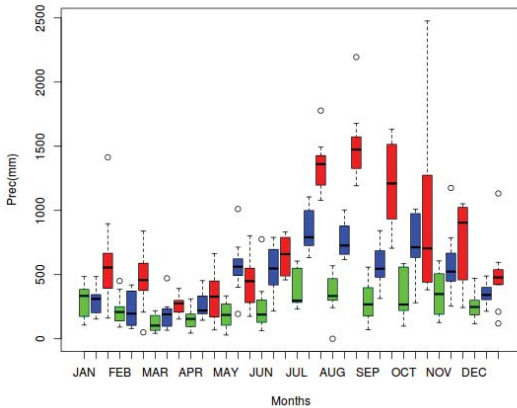


Taylor diagram for Ovalle



Puerto Barrios

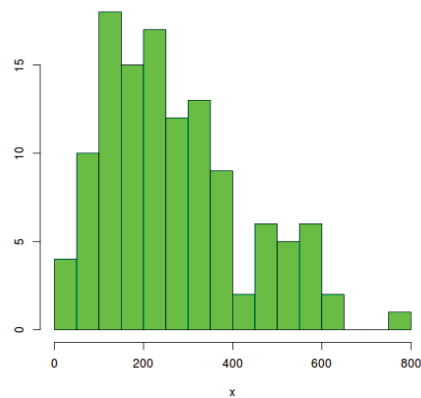
Rainfall's Seasonality for PtoBarrios



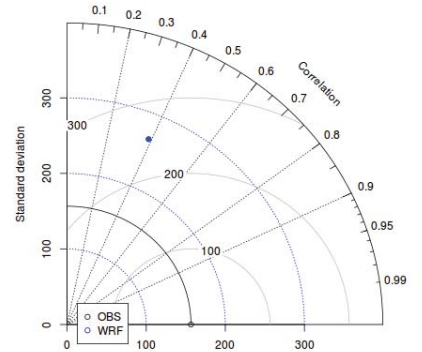
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85



Histogram for PtoBarrios

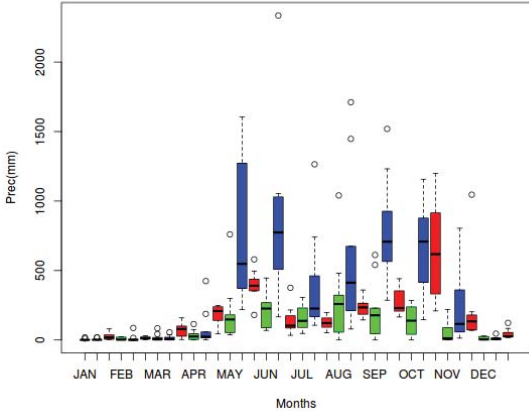


Taylor diagram for PtoBarrios



Bouganvilia

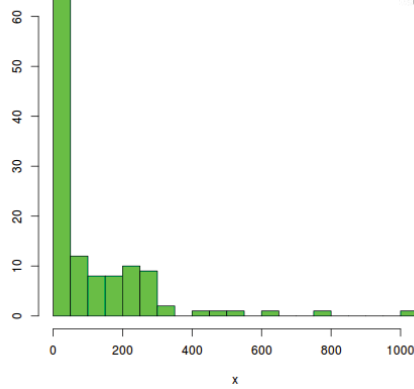
Rainfall's Seasonality for Bouganvilia



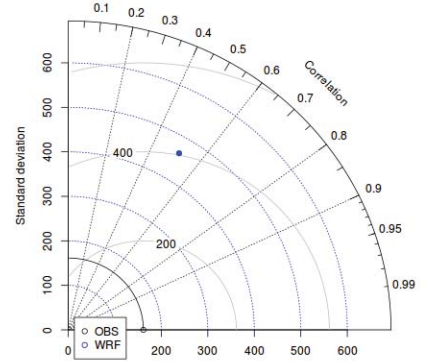
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85



Histogram for Bouganvilia

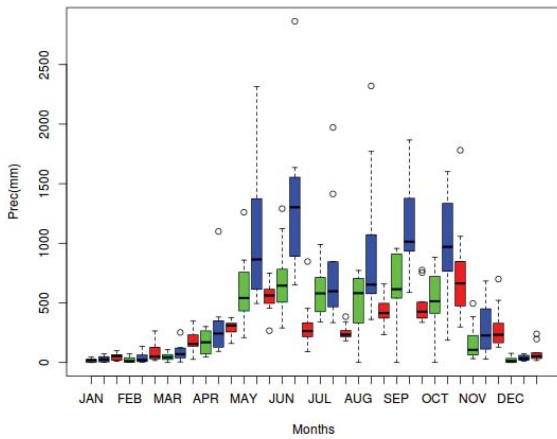


Taylor diagram for Bouganvilia



Cengicaña

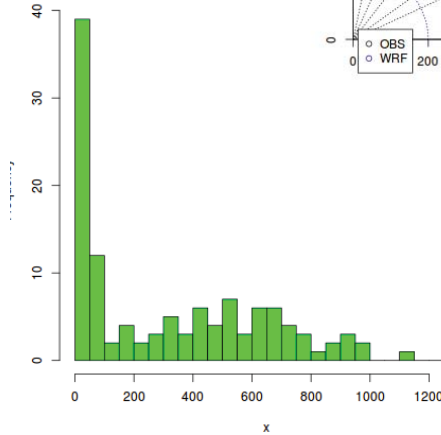
Rainfall's Seasonality for Cengicana



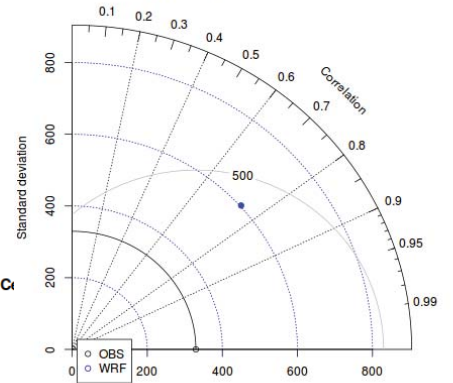
Legend
 — OBS
 — NNRP
 — CCSM4_rcp85



Histogram for Cengicana

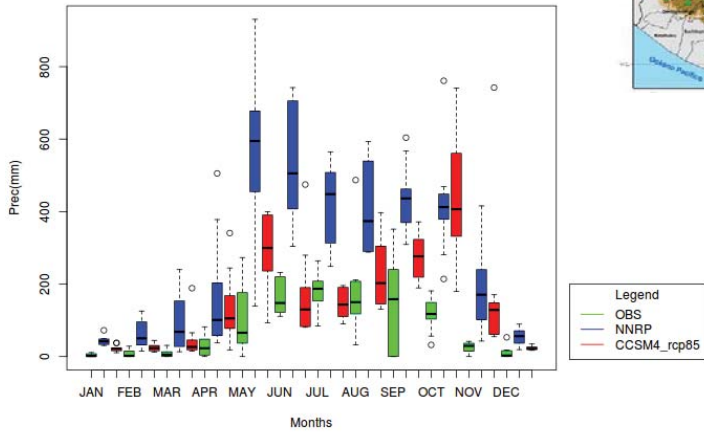


Taylor diagram for Cengicana

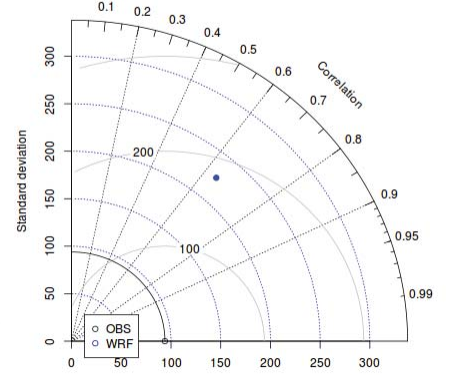


Chinique

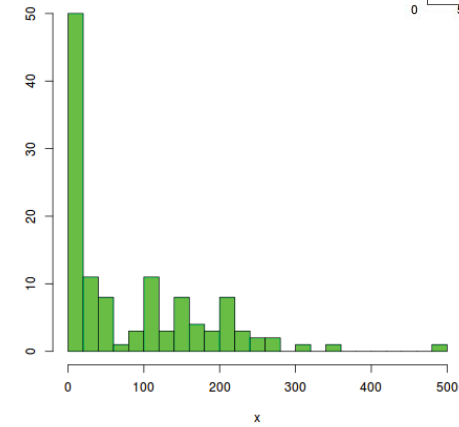
Rainfall's Seasonality for Chinique



Taylor diagram for Chinique

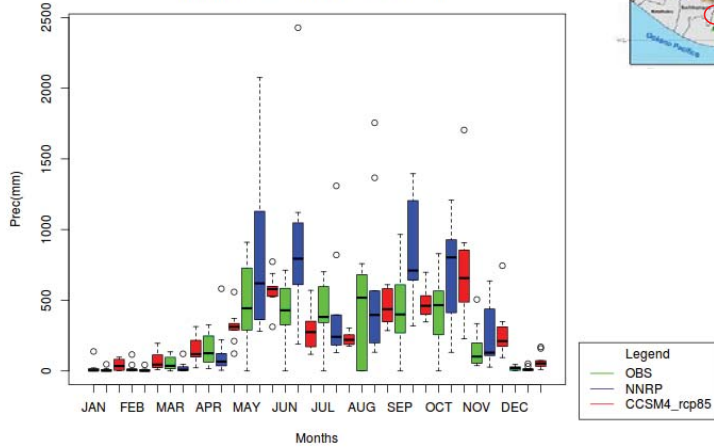


Histogram for Chinique

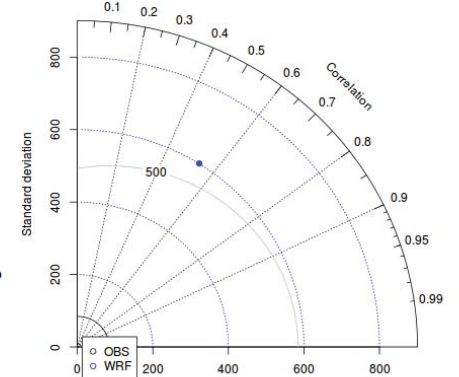


El Bálsamo

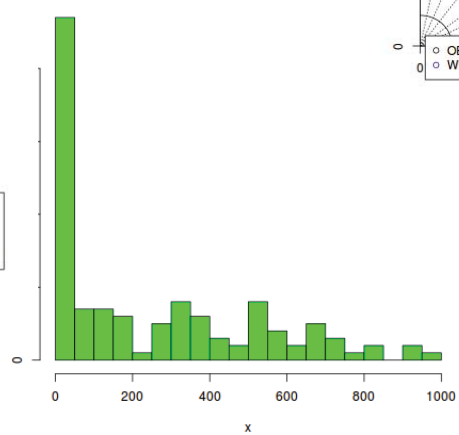
Rainfall's Seasonality for El_balsamo



Taylor diagram for Ovale

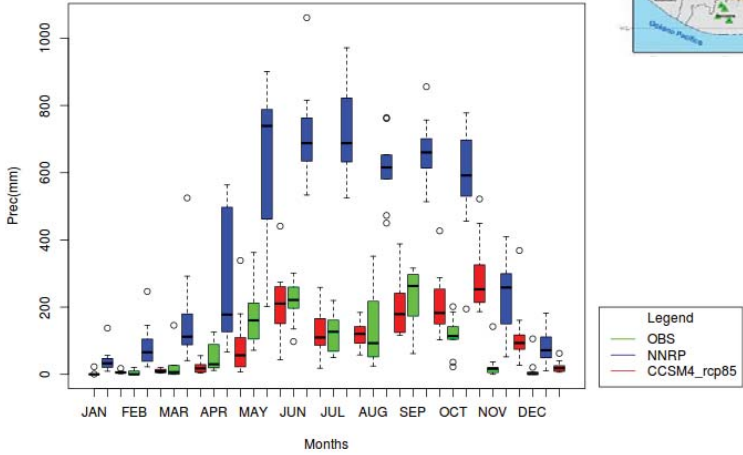


Histogram for El_balsamo

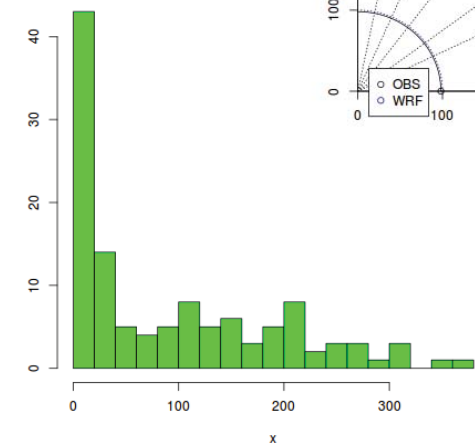


Huehuetenango

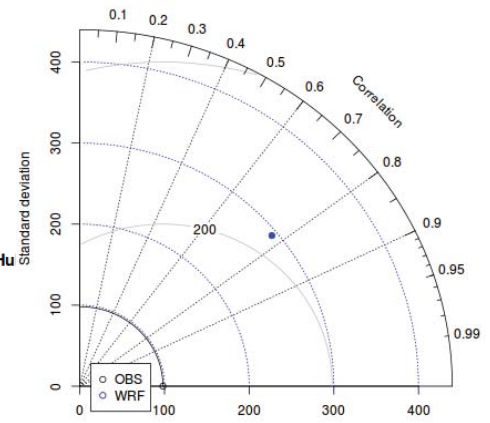
Rainfall's Seasonality for Huehuetenango



Histogram for Hu

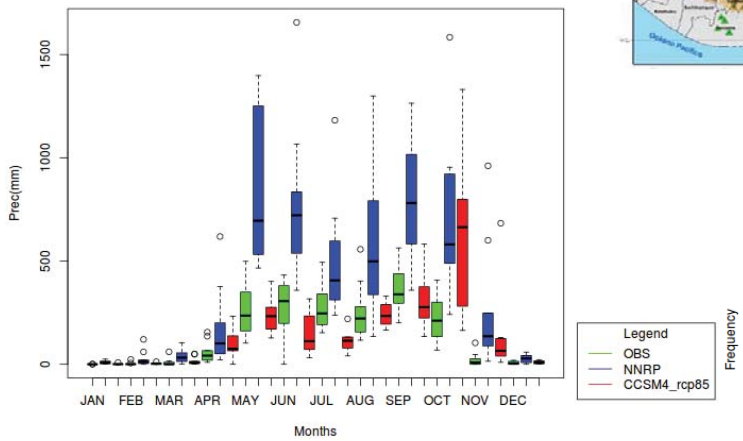


Taylor diagram for Huehuetenango

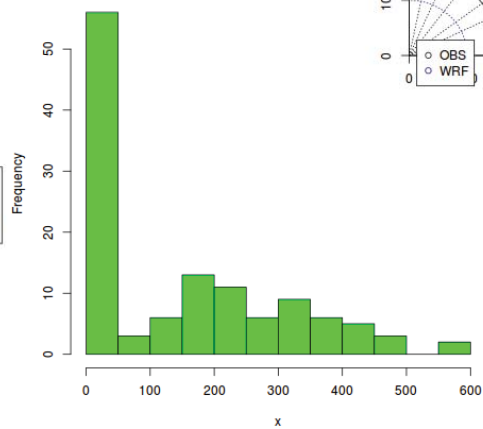


Los Esclavos

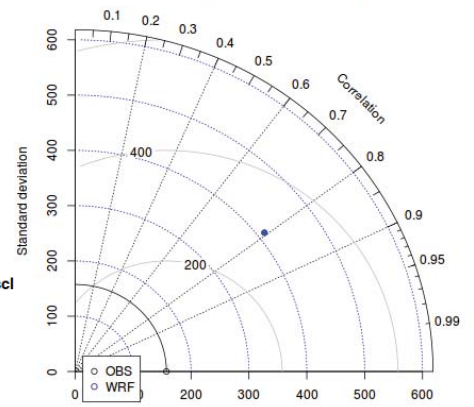
Rainfall's Seasonality for Los_Esclavos



Histogram for Los_Escl

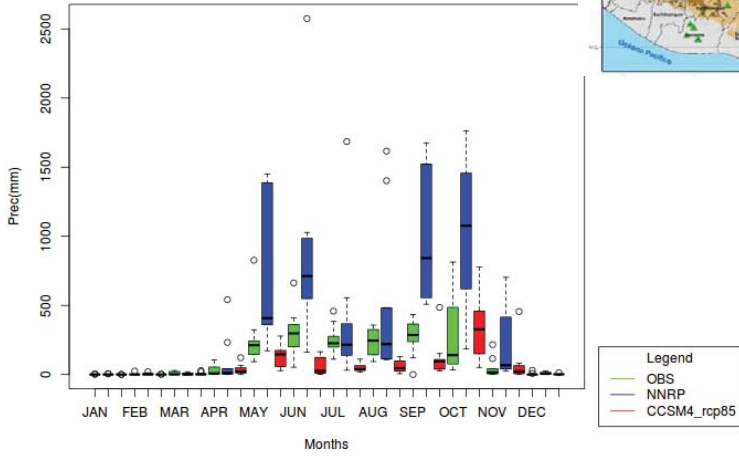


Taylor diagram for Los_Esclavos

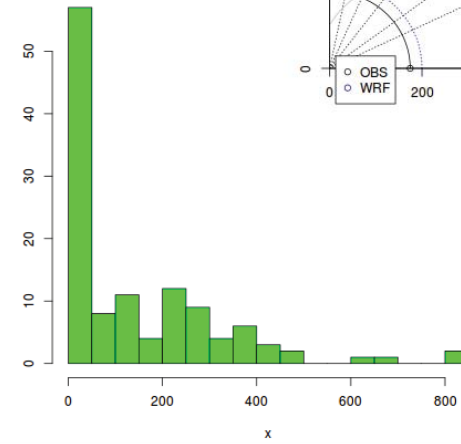


Montufar

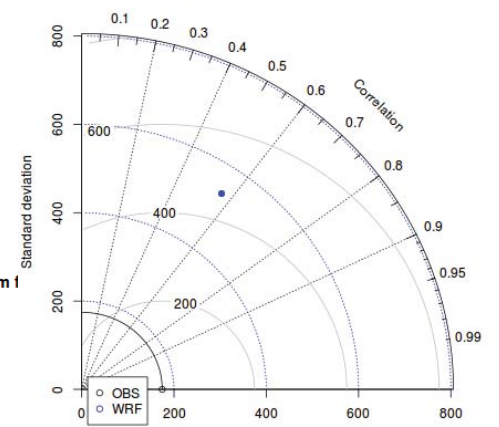
Rainfall's Seasonality for Montufar



Histogram 1

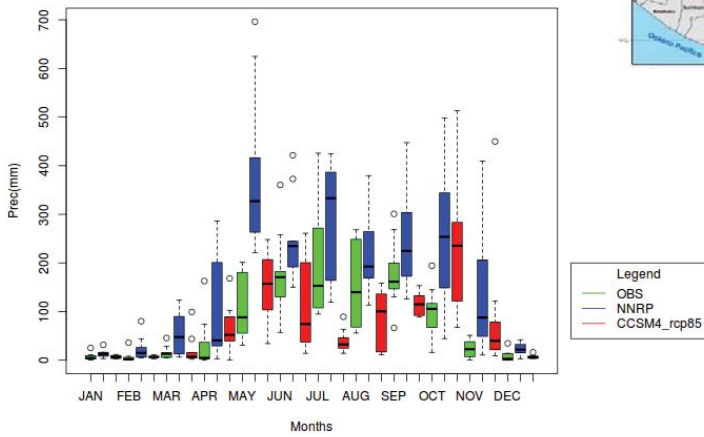


Taylor diagram for Montufar

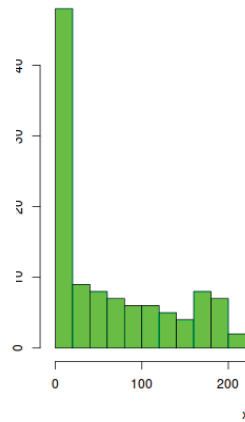


San Jerónimo

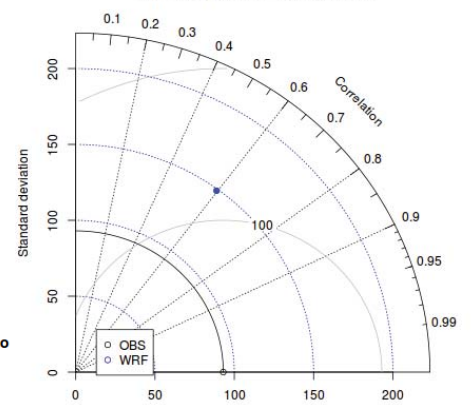
Rainfall's Seasonality for SanJerónimo



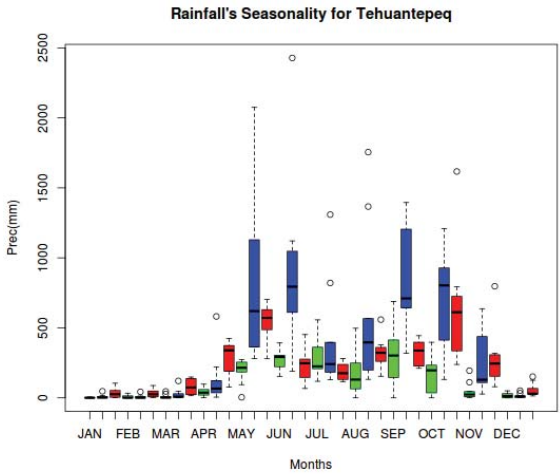
Histogram for SanJerónimo



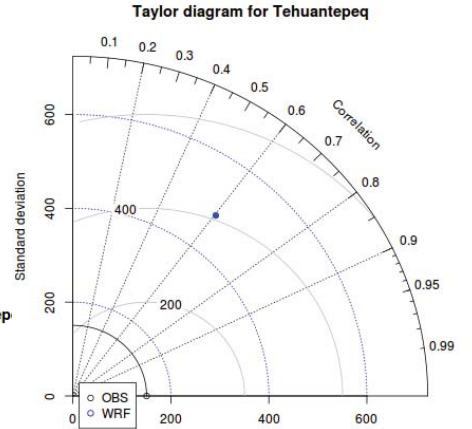
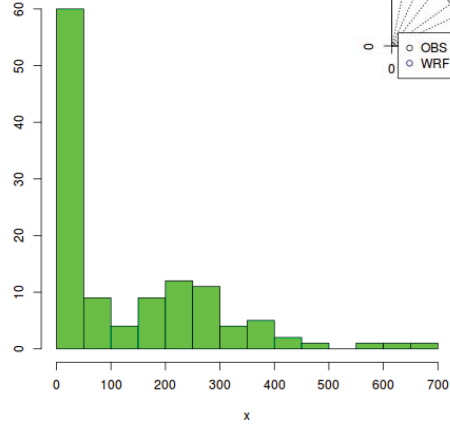
Taylor diagram for SanJerónimo



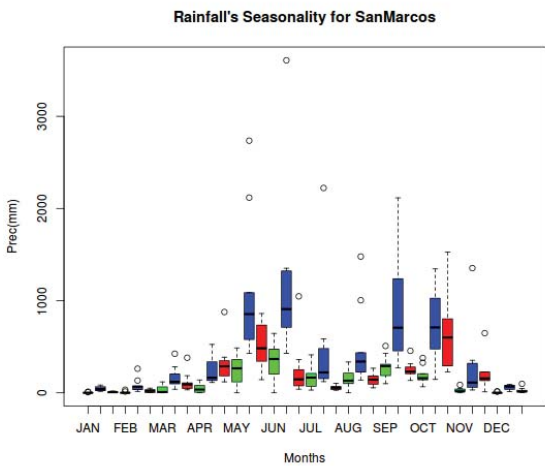
Tehuantepeq



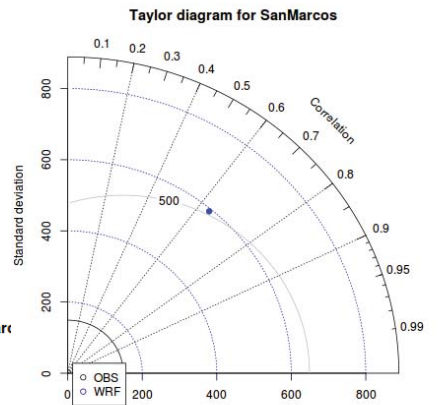
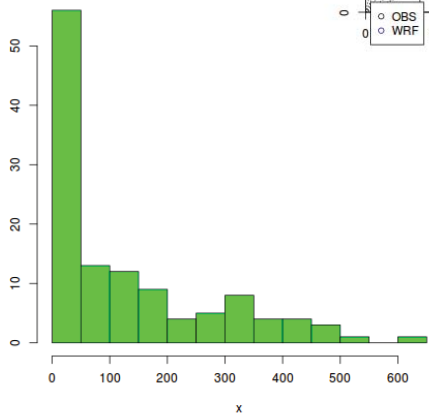
Histogram for Tehuantepeq



San Marcos



Histogram for SanMar



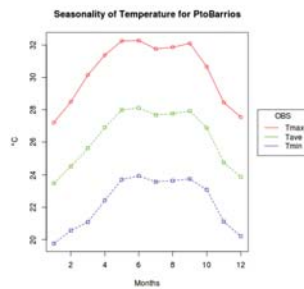
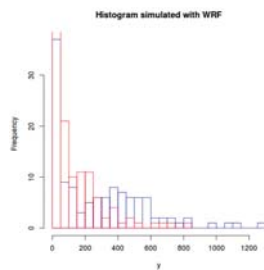
CHG Climate Hazards Group

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DATA CHIRPS

Pending

What is CHIRPS?
Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) is a 30+ year quasi-global rainfall dataset. Spanning 50°S-50°N (and all longitudes), starting in 1981 to near-present, CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. As of February 12th, 2015, version 2.0 of CHIRPS is complete and available to the public. For detailed information on CHIRPS, please refer to our [Scientific Data](#).



3.2.1. The Delta change method

By assuming that the relative changes obtained from the GCMs are more representative than the absolute ones, the simple Delta method maintains the temporal structure of the projected series, hence does not consider changes in variability. The future daily rainfall ($P_{Fut,d}$) is obtained by multiplying the observed daily series ($P_{Obs,d}$) by the ratio of the mean monthly rainfall value for the GCM scenario series ($P_{Sce,m}$) to the control series ($P_{Con,m}$).

$$P_{Fut,d} [mm / day] = P_{Obs,d} \times \frac{P_{Sce,m}}{P_{Con,m}} \quad (3)$$

The advantages of the Delta method are:

- it is simple to apply
- it preserves the observed pattern of temporal and spatial variability

The disadvantages of the Delta method include the following:

- it only accounts for the changes in mean; this is done while ignoring other possible changes in the distribution of the variables
- changes in the length of dry or wet spells are not taken into consideration
- it is not suitable for extreme events
- it requires data to be normally distributed

EVENTOS NIÑO y NIÑA

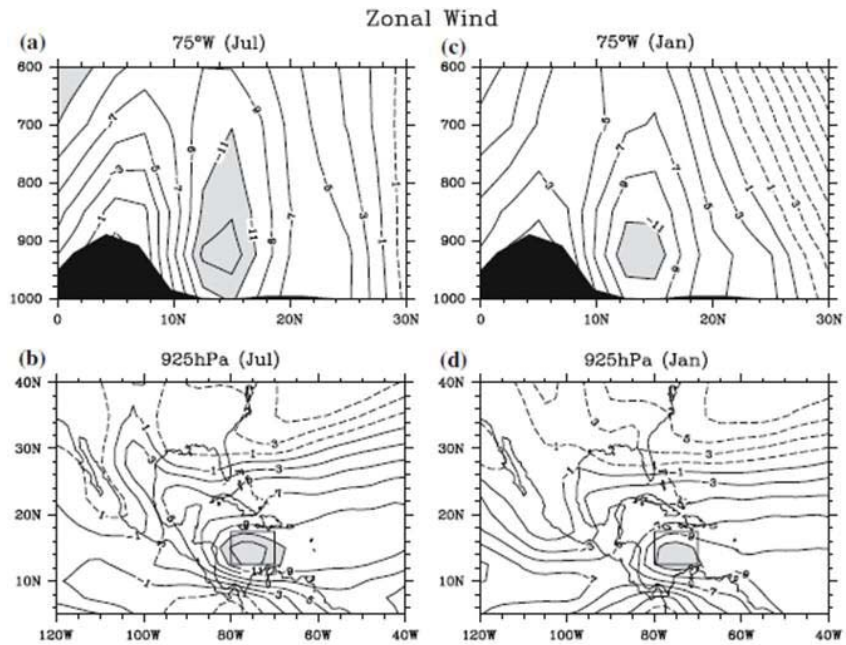
| Year | DJF | JFM | FMA | MAM | AMJ | MJJ | JJA | JAS | ASO | SON | OND | NDJ |
|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2000 | -1.6 | -1.4 | -1.1 | -0.9 | -0.7 | -0.7 | -0.6 | -0.5 | -0.6 | -0.7 | -0.8 | -0.8 |
| 2001 | -0.7 | -0.5 | -0.4 | -0.3 | -0.2 | -0.1 | -0.1 | -0.1 | -0.2 | -0.3 | -0.4 | -0.3 |
| 2002 | -0.2 | 0.0 | 0.1 | 0.2 | 0.4 | 0.6 | 0.8 | 0.8 | 0.9 | 1.1 | 1.2 | 1.1 |
| 2003 | 0.9 | 0.7 | 0.4 | 0 | -0.2 | -0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 |
| 2004 | 0.3 | 0.3 | 0.2 | 0.1 | 0.2 | 0.3 | 0.5 | 0.6 | 0.7 | 0.7 | 0.6 | 0.7 |
| 2005 | 0.7 | 0.6 | 0.5 | 0.5 | 0.3 | 0.2 | 0 | -0.1 | 0 | -0.2 | -0.5 | -0.7 |
| 2006 | -0.7 | -0.6 | -0.4 | -0.2 | 0.0 | 0.0 | 0.1 | 0.3 | 0.5 | 0.7 | 0.9 | 0.9 |
| 2007 | 0.7 | 0.4 | 0.1 | -0.1 | -0.2 | -0.3 | -0.4 | -0.6 | -0.9 | -1.1 | -1.3 | -1.3 |
| 2008 | -1.4 | -1.3 | -1.1 | -0.9 | -0.7 | -0.5 | -0.4 | -0.3 | -0.3 | -0.4 | -0.6 | -0.7 |
| 2009 | -0.7 | -0.6 | -0.4 | -0.1 | 0.2 | 0.4 | 0.5 | 0.5 | 0.6 | 0.9 | 1.1 | 1.3 |
| 2010 | 1.3 | 1.2 | 0.9 | 0.5 | 0.0 | -0.4 | -0.9 | -1.2 | -1.4 | -1.5 | -1.4 | -1.4 |
| 2011 | -1.3 | -1.0 | -0.7 | -0.5 | -0.4 | -0.3 | -0.3 | -0.6 | -0.8 | -0.9 | -1.0 | -0.9 |
| 2012 | -0.7 | -0.5 | -0.4 | -0.4 | -0.3 | -0.1 | 0.1 | 0.3 | 0.3 | 0.3 | 0.1 | -0.2 |
| 2013 | -0.4 | -0.4 | -0.3 | -0.2 | -0.2 | -0.2 | -0.3 | -0.3 | -0.2 | -0.3 | -0.3 | -0.3 |
| 2014 | -0.5 | -0.5 | -0.4 | -0.2 | -0.1 | 0.0 | -0.1 | 0.0 | 0.1 | 0.4 | 0.5 | 0.6 |
| 2015 | 0.6 | 0.5 | 0.6 | 0.7 | 0.8 | 1.0 | 1.2 | 1.4 | 1.7 | 2.0 | 2.2 | 2.3 |
| 2016 | 2.2 | 2.0 | 1.6 | 1.1 | 0.6 | 0.1 | -0.3 | -0.6 | -0.8 | -0.8 | -0.8 | -0.7 |
| 2017 | -0.4 | -0.1 | 0.2 | 0.4 | 0.5 | | | | | | | |

| 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 |

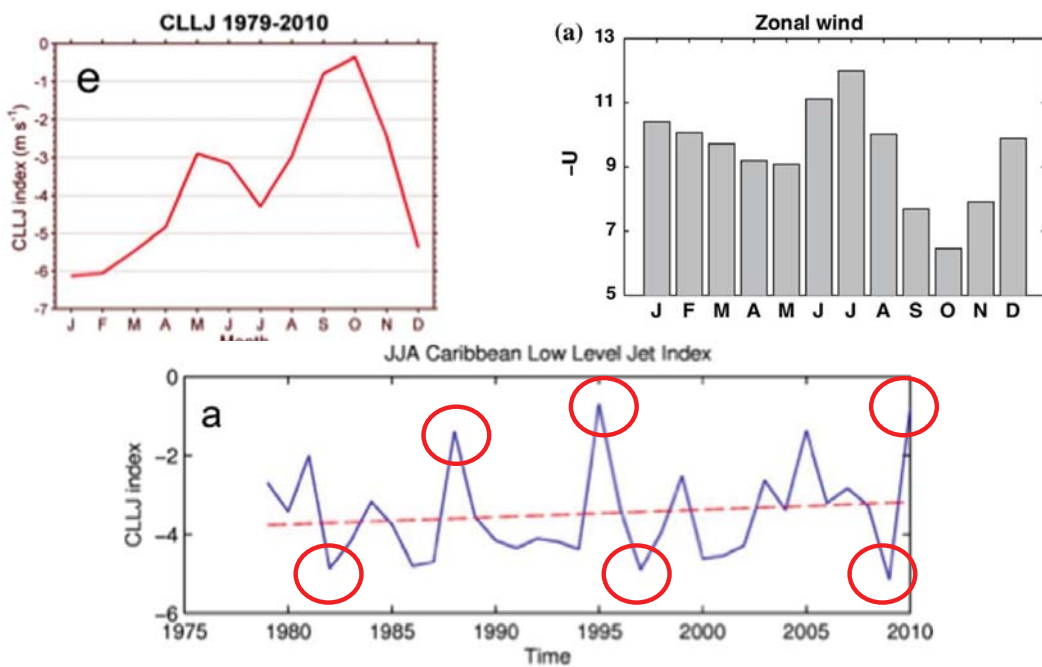
| HS2 (2001 - 2010) | | | | | | | |
|-------------------|-----------|-----------|------|-----------|-----------|---|------|
| Niña | | | Niño | | | | |
| | I | F | M.I. | | I | F | M.I. |
| 1 | Ene(2000) | Feb(2001) | -1.6 | | | | |
| 2 | | | | Jun(2002) | Feb(2003) | | 1.2 |
| 3 | | | | Jul(2004) | 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 (2011-2020) | | | | | | | |
|----------------|-----------|-----------|------|-----------|-----------|---|------|
| 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 | | | | |

Climatología del Chorro de bajo nivel del Caribe (CLLJ)



Climatología del Chorro de bajo nivel del Caribe (CLLJ)



Climatología del CLLJ e importancia para Guatemala

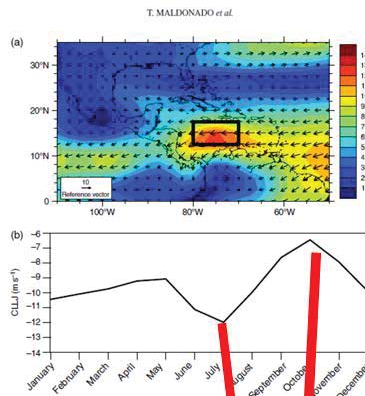


Figure 1. (a) February mean horizontal wind at 925 hPa for the 1950-2010 period using the NCEP-NCAR reanalysis. Contour lines are spaced 1 m s^{-1} apart and represent the wind magnitude. Arrows show the mean wind direction and magnitude. The CLLJ index is defined as the February monthly anomalies of the zonal wind in the area enclosed by the black square. Latitude and longitude coordinates are in degrees. (b) Annual cycle of the CLLJ monthly means (m/s).

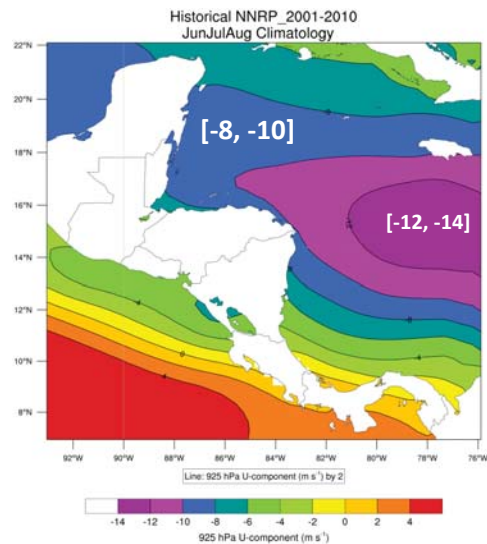
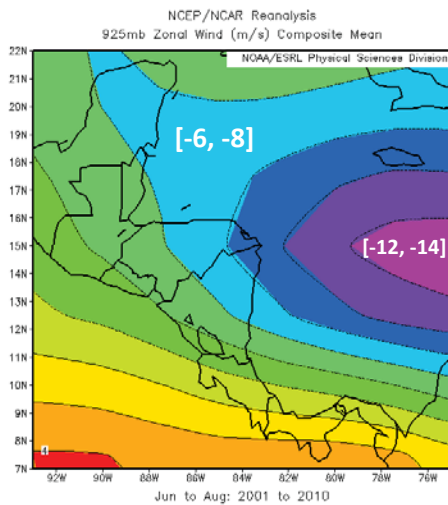


Figure 1. Ciclo anual de la lluvia en Ciudad de Guatemala para el periodo de línea base (2001-2010). Datos del downscaling.org del modelo WRF con el forzamiento del reanálisis NCEP/NCAR (NNRP).

Resultados WRF: chorro de bajo nivel del Caribe (CLLJ)

Reanálisis NNRP (BL)

WRF-NNRP (BL)



El modelo WRF presenta un sesgo (bias) negativo respecto a u-925 hpa: el viento del este es más alto en el WRF.

Resultados WRF: chorro de bajo nivel del Caribe (CLLJ)

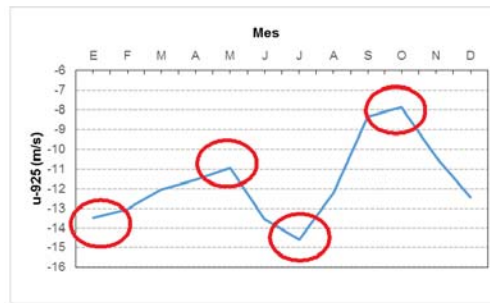


Figura 2. Ciclo anual medio del periodo 2001-2010 de la componente zonal (u, m/s) del viento para el nivel de 925 hPa en las coordenadas 15°N, 78°O.

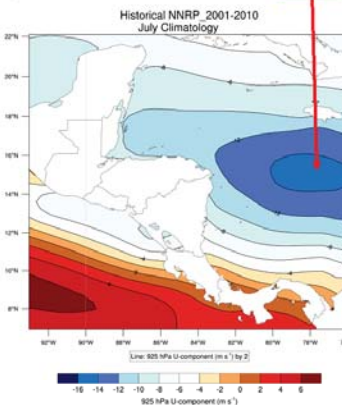


Figura 3. Variación horizontal de la componente zonal media del viento en 925 en julio en el periodo histórico (HS).

Resultados WRF: chorro de bajo nivel del Caribe (CLLJ)

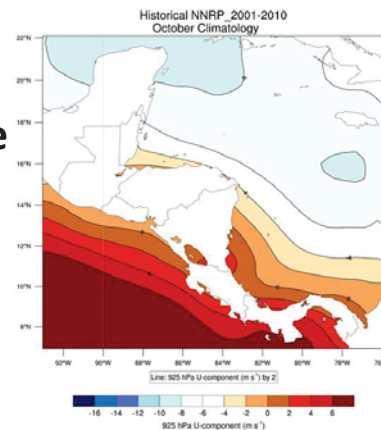


Figura 4. Lo mismo anterior pero para octubre.

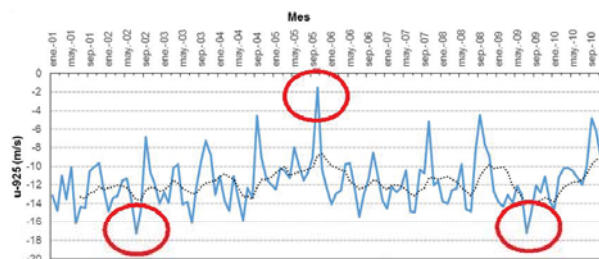


Figura 5. Variación mensual del viento zonal en 925 hPa en el periodo histórico (HS).

Resultados WRF: chorro de bajo nivel del Caribe (CLLJ)

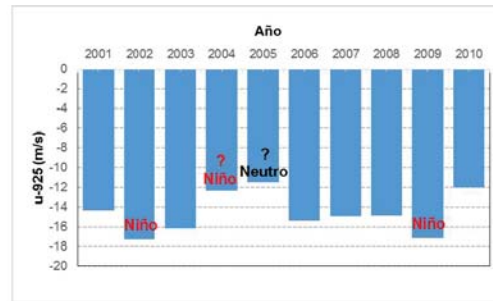


Figura 6. Variación interanual de la componente zonal del viento en julio y en 925 hPa.

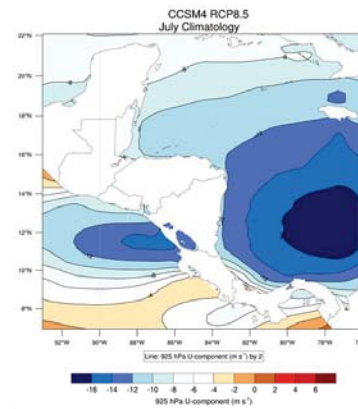


Figura 7. Variación horizontal de la componente zonal media del viento en 925 hPa en el mes de julio del periodo de línea base (BL, 2011-2020).

Resultados WRF: chorro de bajo nivel del Caribe (CLLJ)

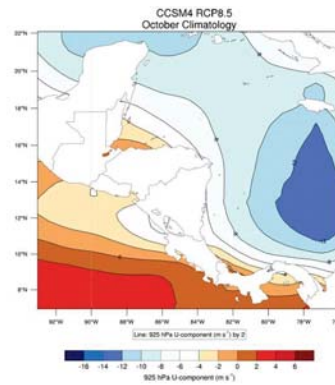


Figura 8. Lo mismo anterior pero para el mes de octubre (BL).

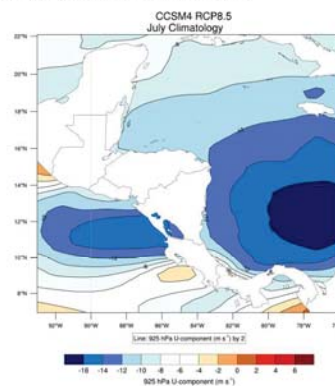


Figura 9. Lo mismo que la figura 6 pero para el periodo de futuro (FT, 2061-2070) según el escenario de emisiones RCP8.5

Resultados WRF: chorro de bajo nivel del Caribe (CLLJ)

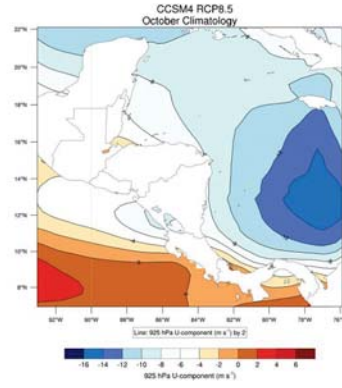


Figura 10. Lo mismo que la figura 8 pero para el periodo de futuro (FT, 2061-2070) con el forzamiento del modelo global NCAR_CCSM4 y el escenario de emisiones RCP8.5

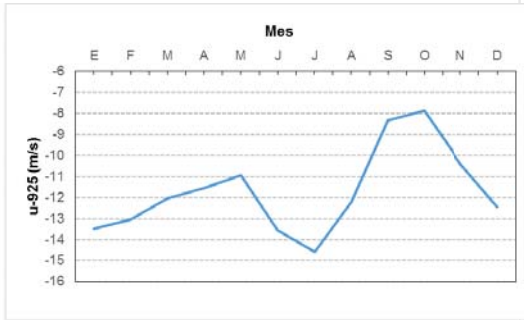
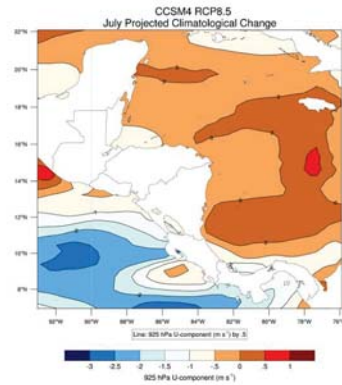
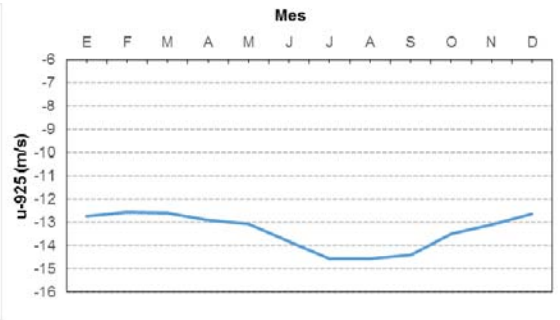


Figura 2. Ciclo anual medio del periodo 2001-2010 de la componente zonal (u, m/s) del viento para el nivel de 925 hPa en las coordenadas 15°N, 78°O.



u-925 (FT, 2061-2070), 15°N, 78°O.



Cambio u-925 (FT-BL), 15°N, 78°O.

Proyecto: Guatemala

Escenario: Histórico

Dominio: D03 Guatemala (4 km)

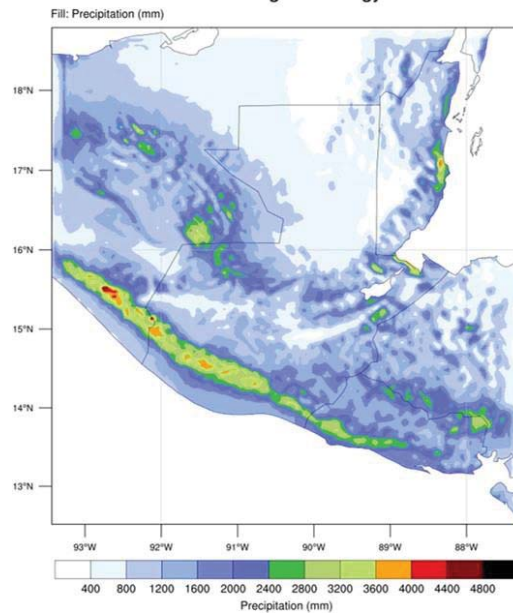
Corrida: NNRP: 2001-2010

Temporada : verano (junio-agosto)

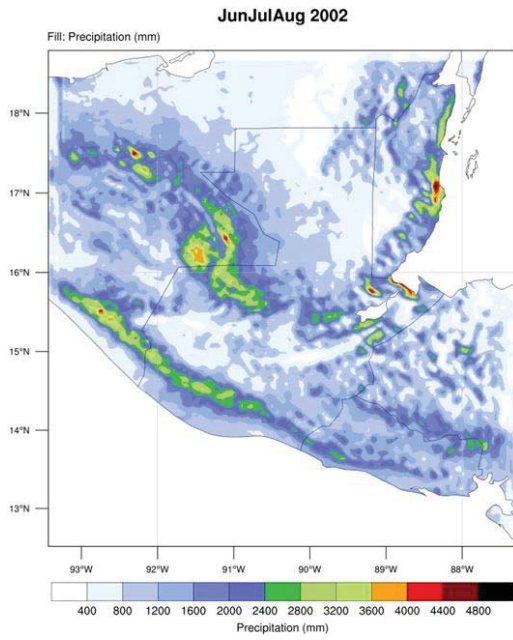
Variable: lluvia (mm)

CLIMATOLOGIA (2001-2010)

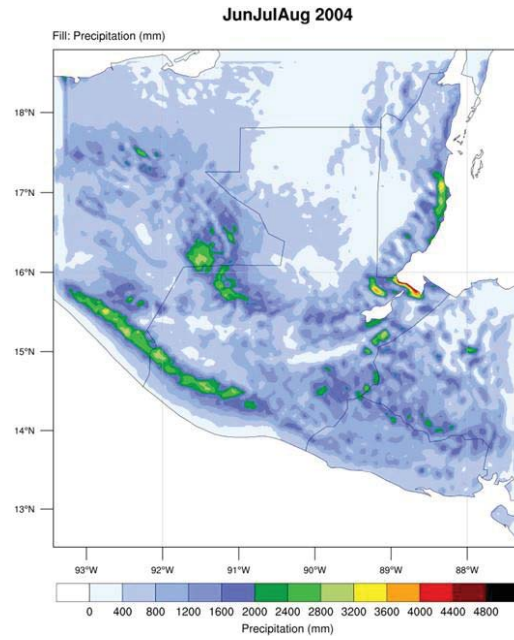
JunJulAug Climatology



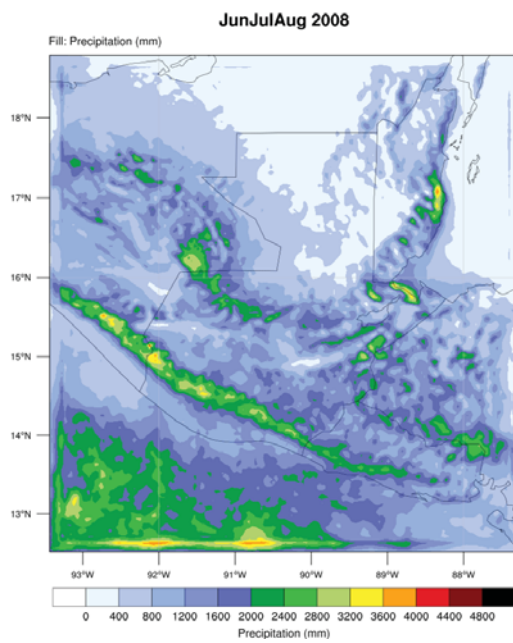
EVENTO: EL NIÑO 2002



EVENTO: EL NIÑO 2004



EVENTO: LA NIÑA 2008



EVENTO: EL NIÑO 2015

