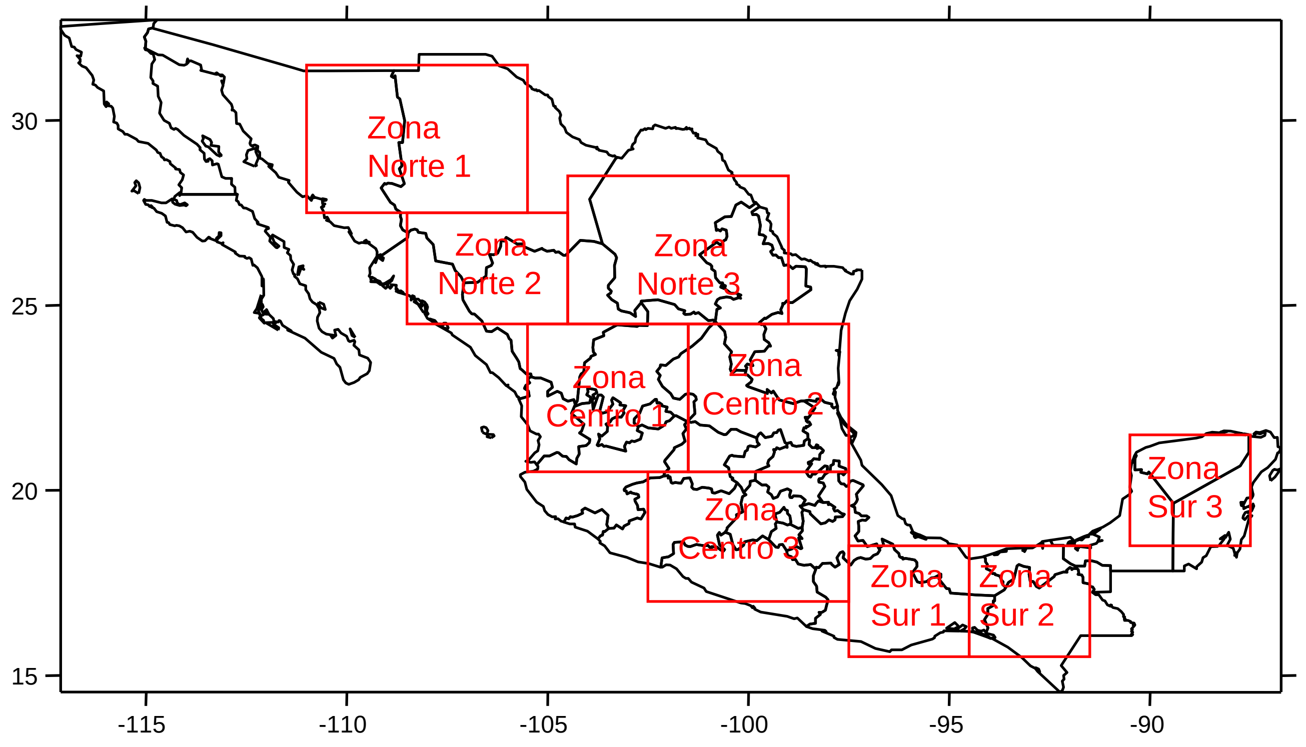
Zonas de validación

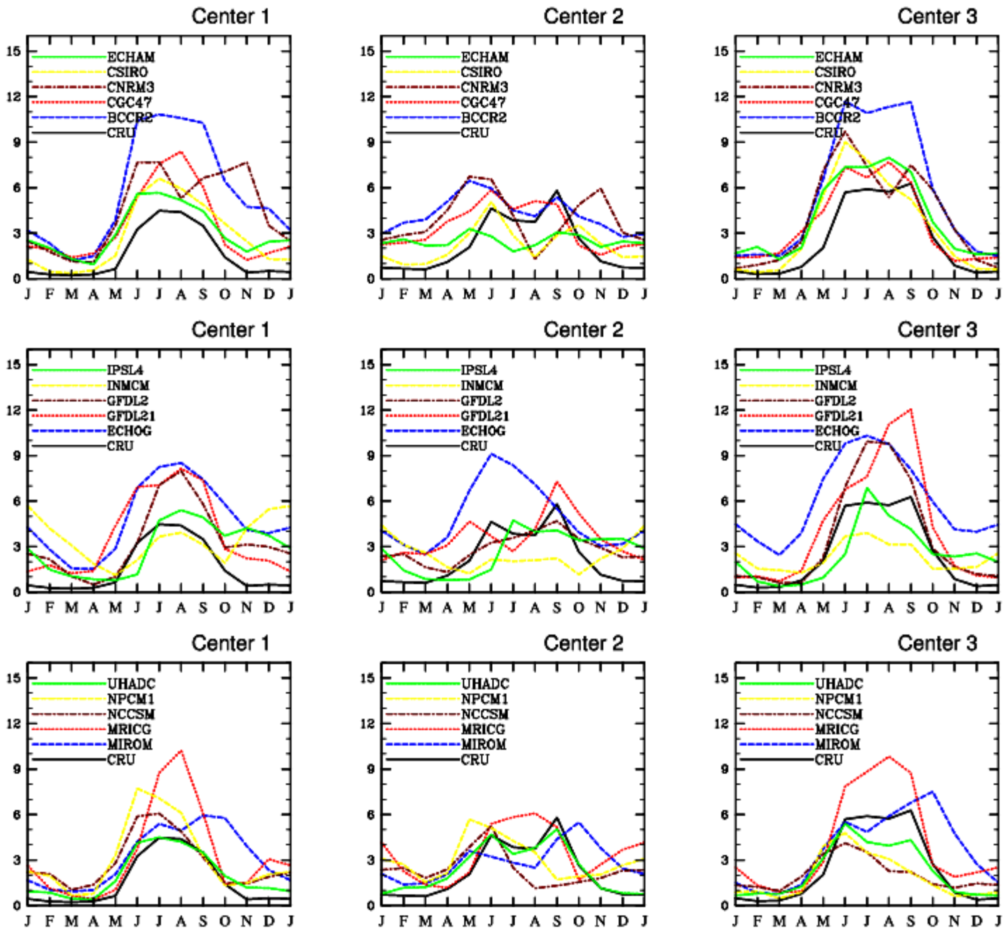


IPCC CGCMs vs CRU (obs)
Precipitación y Temperatura de superficie
Climatologías 1961-90

Precipitación (mm/día)

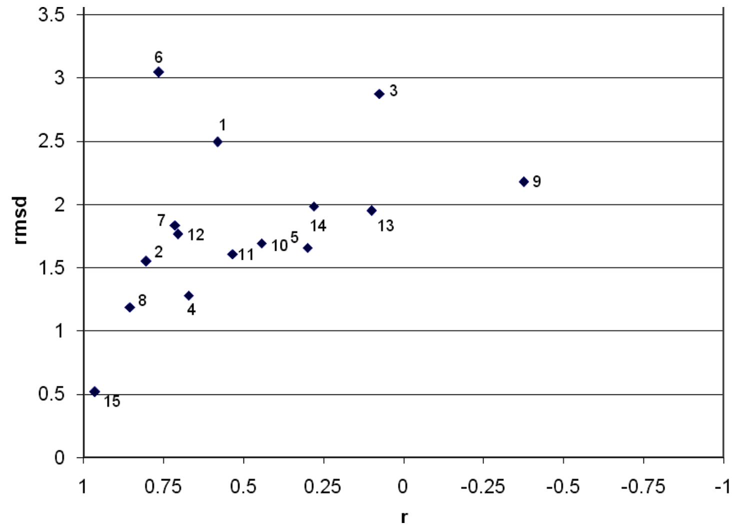
Zonas

C1, C2, C3



Zona C2,

r vs rmsd



Climatología 1961-90

Resultados

Precipitación

#	Model/Zone	N1	N2	N3	C1	C2	C3	S1	S2	S3	Total
1	BCCR_BCM2_0	8	15	8	12	12	8	5	2	4	74
2	**CCCMA_CGCM_3_1**	**9**	**1**	**3**	**4**	**4**	**3**	**7**	**7**	**3**	**41**
3	CNRM_CM3	13	14	13	15	16	14	9	8	10	112
4	CSIRO_MK3_0	3	7	6	2	5	7	14	11	11	66
5	MPI_ECHAM5	4	5	2	5	10	4	4	6	8	48
6	MIUB_ECHO_G	10	3	11	14	11	13	13	9	1	85
7	GFDL_CM2	12	12	7	7	6	11	11	10	15	91
8	GFDL1_CM2_1	14	11	9	8	2	5	1	1	12	63
9	INMCM3_0	16	16	16	16	15	9	8	12	9	117
10	IPSL_ CM4	15	13	12	11	9	10	16	16	16	118
11	MIROC3_2_MEDRES	7	9	4	13	8	16	15	15	14	101
12	MRI_CGCM2_3_2a	2	6	10	10	7	6	3	4	2	50
13	NCAR_CCSM3_0	11	8	14	6	14	15	10	13	13	104
14	NCAR_PCM1	6	10	15	9	13	12	12	14	5	96
15	**UKMO_HADCM3**	**1**	**2**	**1**	**1**	**1**	**2**	**6**	**5**	**6**	**25**
16	**IPCC ens avg**	**5**	**4**	**5**	**3**	**3**	**1**	**2**	**3**	**7**	**33**

Temperatura de superficie

#	Model/Zone	N1	N2	N3	C1	C2	C3	S1	S2	S3	Total
1	BCCR_BCM2_0	11	12	13	16	16	14	7	4	8	101
2	CCCMA_CGCM_3_1	7	7	8	5	10	8	8	7	13	73
3	CNRM_CM3	12	9	10	13	14	11	5	6	12	92
4	CSIRO_MK3_0	13	13	9	6	2	6	9	16	4	78
5	**MPI_ECHAM5**	**2**	**3**	**1**	**2**	**6**	**2**	**4**	**11**	**16**	**47**
6	MIUB_ECHO_G	8	14	5	7	7	7	6	12	15	81
7	GFDL_CM2	14	6	12	12	13	4	1	8	9	79
8	GFDL1_CM2_1	15	10	15	10	9	5	3	15	5	87
9	INMCM3_0	16	15	14	14	11	15	15	5	6	111
10	IPSL_ CM4	5	4	2	4	1	16	16	14	11	73
11	MIROC3_2_MEDRES	4	16	4	11	4	12	12	9	2	74
12	MRI_CGCM2_3_2a	9	11	7	15	5	13	13	3	3	79
13	**NCAR_CCSM3_0**	**1**	**5**	**11**	**3**	**12**	**9**	**11**	**2**	**1**	**55**
14	NCAR_PCM1	10	8	16	8	15	10	14	13	14	108
15	UKMO_HADCM3	6	1	6	9	8	3	10	10	10	63
16	**IPCC ens avg**	**3**	**2**	**3**	**1**	**3**	**1**	**2**	**1**	**7**	**23**

Brief overview on the future changes in climate over Mexico as simulated by the 20km mesh MRI-JMA AGCM

Instituto Mexicano de Tecnología del Agua

Martín Montero
mmontero@tlaloc.imta.mx

11 de marzo de 2010

3er Curso de Primavera sobre Ciclones Tropicales
Hotel Araiza Palmira en La Paz, BCS.

SEMARNAT

Capacity Development for Formulation of Climate Change Adaptation Program in Water and Coastal Management in the Yucatan Peninsula States

Martin Jose Montero-Martinez
Juan Matias Mendez-Perez
David Maximiliano Zermeño-Diaz

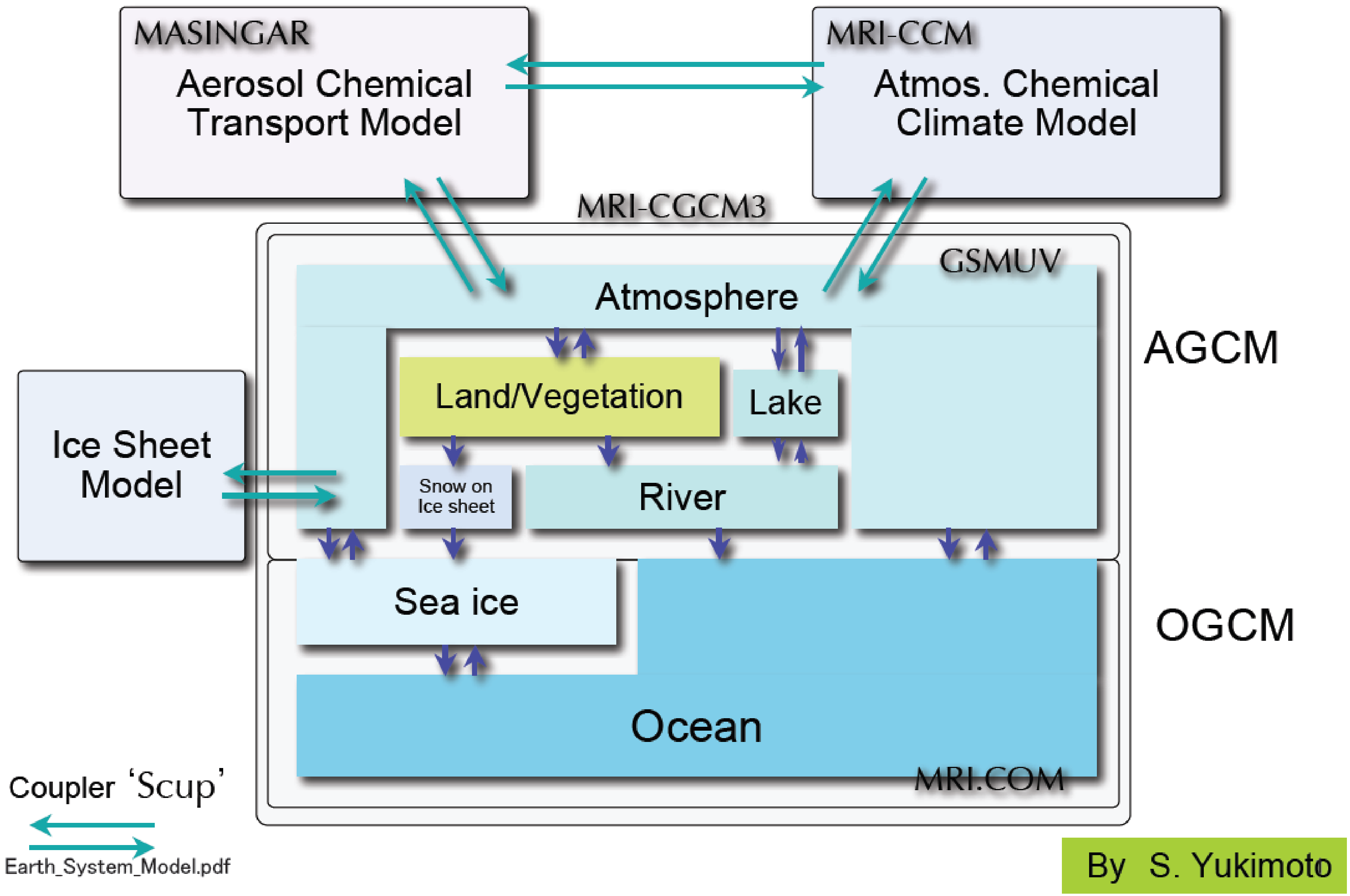
National Autonomous University of Mexico
Mexican Institute of Water Technology

Japan International Coperation Agency (JICA) &
Meteorological Research Institute (MRI)

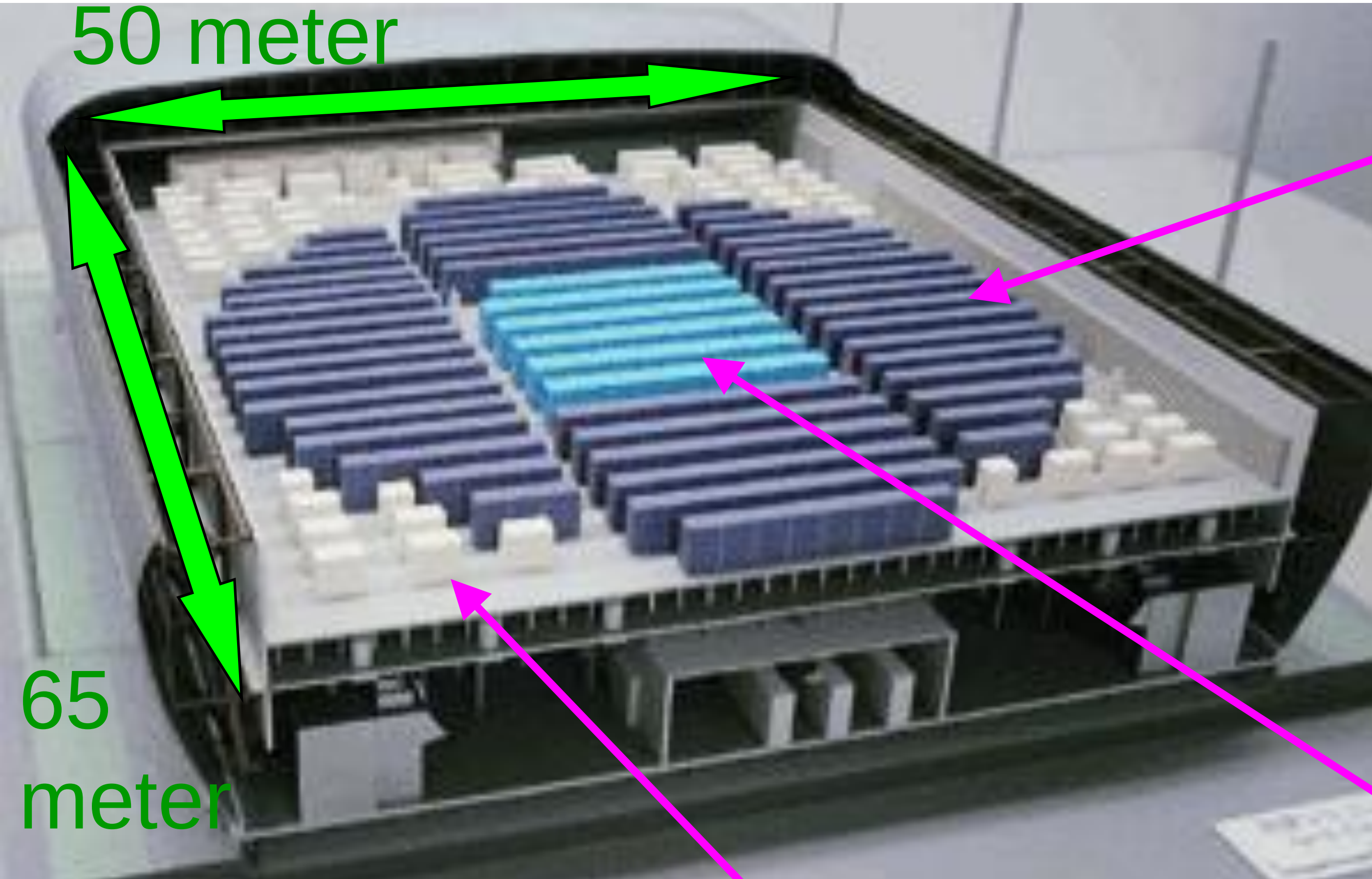
Tsukuba, Japan 28 September -16 October, 2009

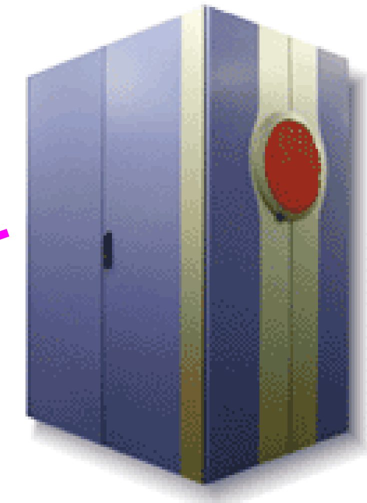
Research with Earth Simulator in Japan

MRI Earth System Model



The Earth Simulator :2002~





Node (8 CPU)

Crossbar switch

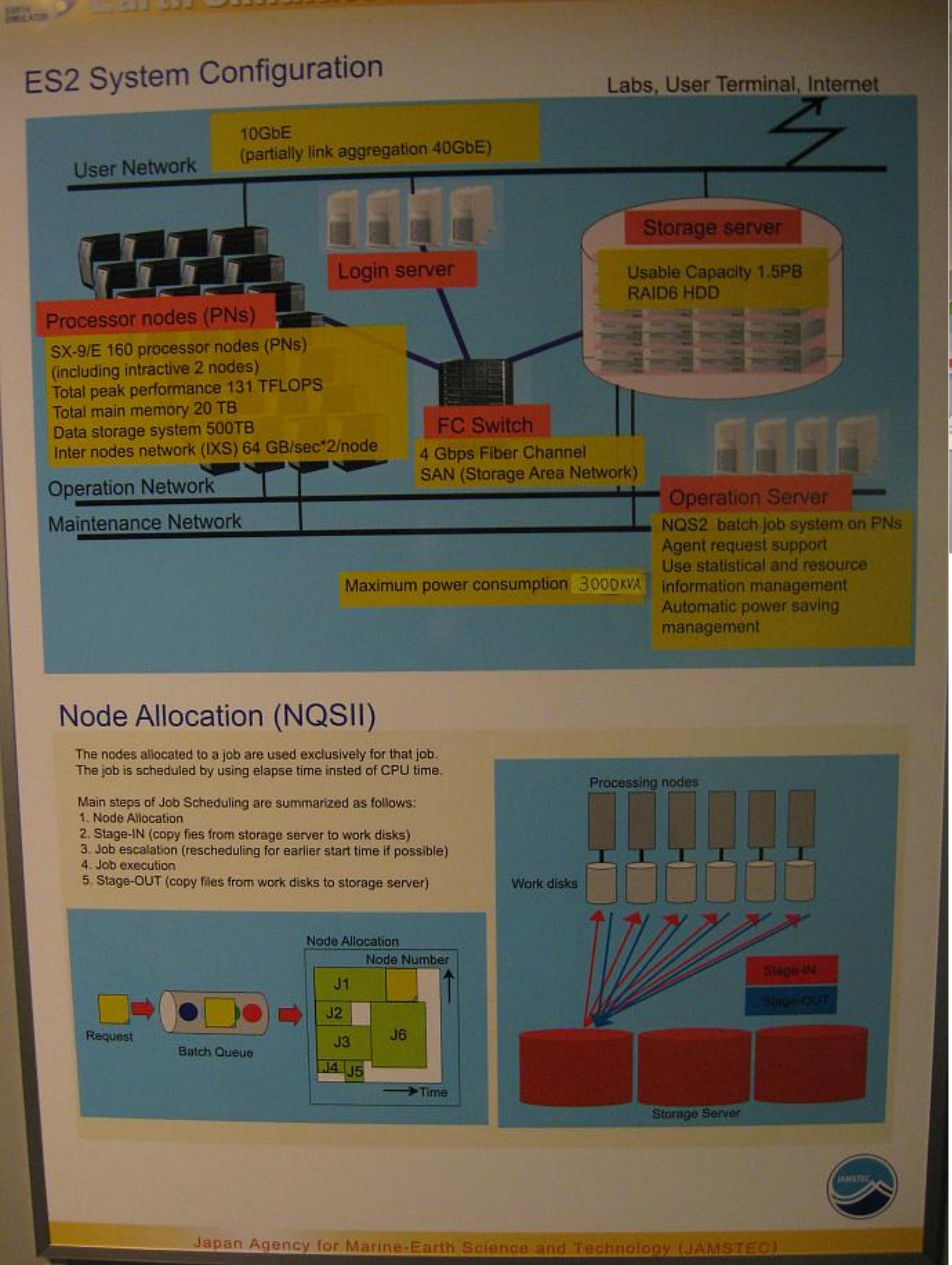
Magnetic Disks

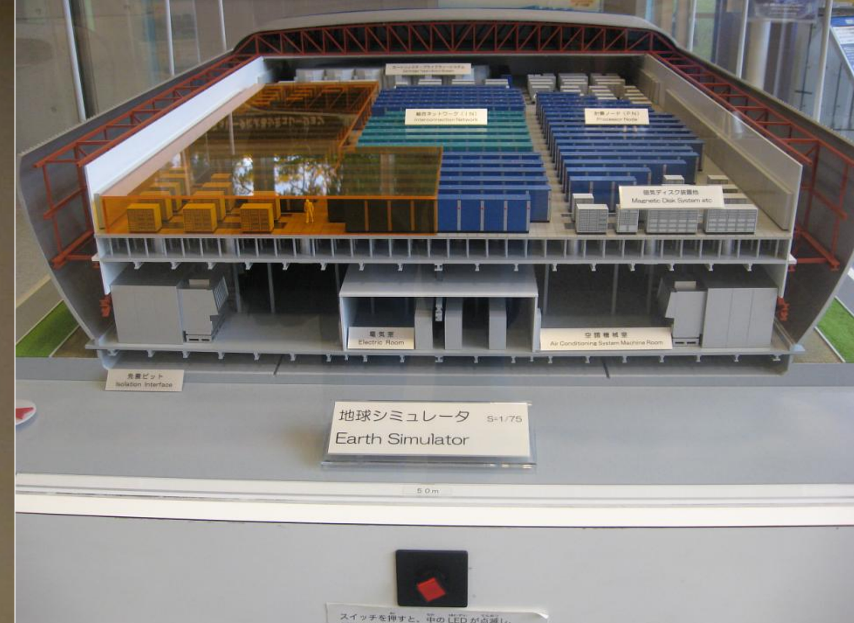
Nodes: 640

CPUs: 5120

Peak performance: 40 Tera flops

http://www.es.jamstec.go.jp/esc/jp/ES/index.html


ES2 System Configuration
Labs, User Terminal, Internet
User Network
10GbE
(partially link aggregation 40GbE)
Login server
Storage server
Usable Capacity 1.5PB
RAID6 HDD
Processor nodes (PNs)
SX-9/E 160 processor nodes (PNs)
(including intractive 2 nodes)
Total peak performance 131 TFLOPS
Total main memory 20 TB
Data storage system 500TB
Inter nodes network (IXS) 64 GB/sec*2/node
FC Switch
4 Gbps Fiber Channel
SAN (Storage Area Network)
Operation Network
Maintenance Network
Operation Server
NQS2 batch job system on PNs
Agent request support
Use statistical and resource
information management
Automatic power saving
management
Maximum power consumption 3000KVA
Node Allocation (NQSII)
The nodes allocated to a job are used exclusively for that job.
The job is scheduled by using elapse time insted of CPU time.
Main steps of Job Scheduling are summarized as follows:
1. Node Allocation
2. Stage-IN (copy fies from storage server to work disks)
3. Job escalation (rescheduling for earlier start time if possible)
4. Job execution
5. Stage-OUT (copy files from work disks to storage server)
Request
Batch Queue
Node Allocation
Node Number
J1
J2
J3
J4
J5
J6
Time
Processing nodes
Work disks
Stage-IN
Stage-OUT
Storage Server
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)


地球シミュレータ S=1/75
Earth Simulator


地球シミュレータ(ES2) 縮尺 1/75
The Earth Simulator(ES2) SCALE 1/75


NEC
SX-9

All Japan climate change research projects using the Earth Simulator

Year 2002-2006

Kyo-sei project --> IPCC AR4 (2007)

Year 2007-2011

KAKUSHIN project --> IPCC AR5 in 2013?

Innovative Program of Climate Change Projection for the 21st century

KAKUSHIN

http://www.kakushin21.jp/eng/index.html

Funded by the Ministry of Education, Culture , Sports, Science and Technology (MEXT).

Program structure

A

Advancing Climate Modeling and Projection

Coordination

Comprehensive Impact Assessment Projects by *Ministry of Environment (MOE)*

Close linkage

B

Quantification and Reduction of Uncertainty

C

Impact assessment on natural disasters

Participating groups and their studies

- ***Long-term global environmental projection***

  with an earth system model

  - Frontier Research Center for Global Change (**FRCGC**) et. al

- ***Near-term climate prediction***

  with a high-resolution coupled ocean-atmosphere GCM: MIROC

  - Center for Climate System Research (**CCSR**) of Tokyo Univ. et. al

- ***Projection of changes in extremes in the future***

  with very-high resolution atmospheric models: 20km mesh AGCM

  - Meteorological Research Institute (**MRI**) et. al

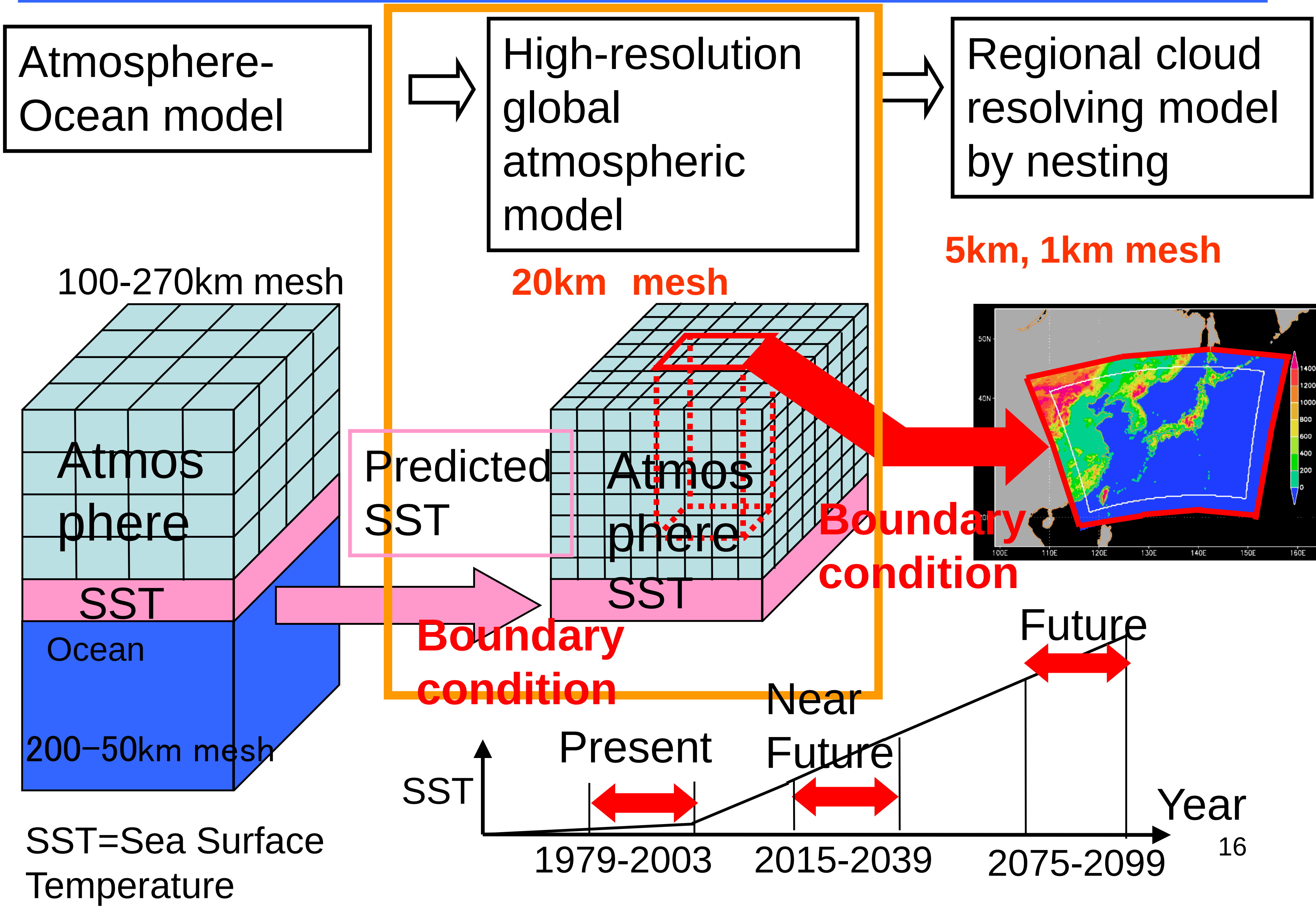
General features of the 20-km AGCM in MRI

20-km global atmospheric model

Item	Content
Basic equation	Hydrostatic, primitive
Horizontal structure	Spherical harmonics (latitude) and Fourie harmonics (longitude)
Horizontal resolution	20 km, TL959
Vertical level	60, top at 0.1 hPa
Time integration	Semi-Lagrangian scheme, Yoshimura (2004)
Shortwave radiation	H20, O3, CO2, O2, Aerosol, Shibata and Uchiyama (1992)
Longwave radiation	H20, O3, CO2, CH4, N2O, Shibata and Aoki (1989)
Cumulus convection	Prognostic of Arakawa-Schubert, Randal and Pan (1993)
Boundary layer	Mellor and Yamada (1974, 1982), level 2 closure
Gravity wave drag	Orographic origin, Iwasaki et al. (1989)
Cloud	Cumulus, Large-scale condensation
Precipitation process	Prognose cloud water content
Land surface	Simple Biosphere (SiB) model, Sato et al. (1989)

From 21 November 2007, the Japan Meteorological Agency is using the 20-km model as an operational global model for deterministic 9-day forecast.

A: Extreme event projection by very high resolution atmospheric models



Sea Surface Temperature (SST)

Present-day climate

Observed historical data by HadISST (Rayner et al. 2003)

Future climate

Observed historical data by HadISST

+

Multi-Model Ensemble (MME) of the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project 3 (CMIP3) including IPCC AR4 CGCMs

Mexican team research in Japan - Results

Objectives

- ❑ To examine high-resolution (20-km mesh) Climate Change Scenario developed on *Earth Simulator* to examine recent climate change experiment constructed with the MRI Earth Simulator to better understand the processes that leads to regional signals of climate change in Mexico.

- ❑ Understanding the regional impacts of “Nortes” and hurricanes as a problem in the analysis of climate change.

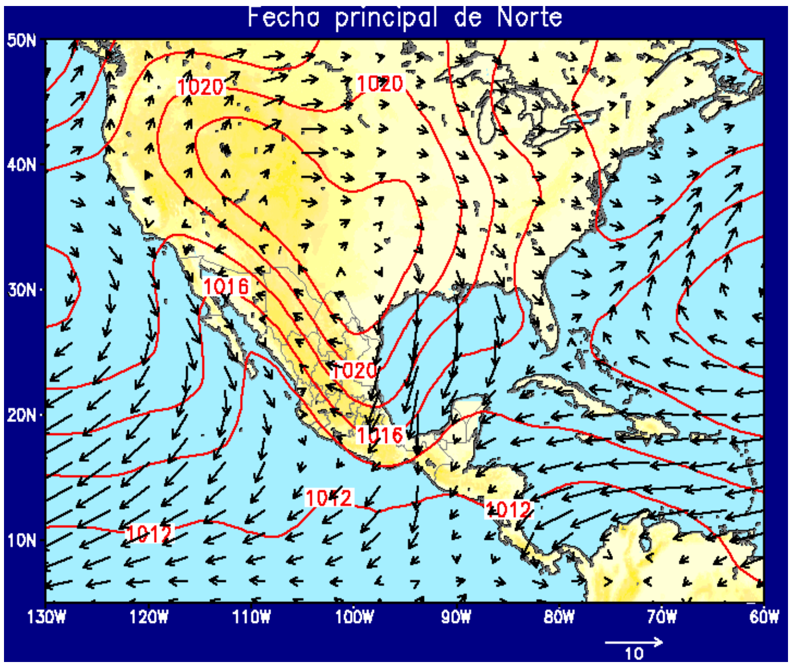
- ❑ To analize changes of occurrence of extreme meteorological events, of great relevance in the potential impacts of regional climate change.

- ❑ To validate MRI model output through trends analysis.

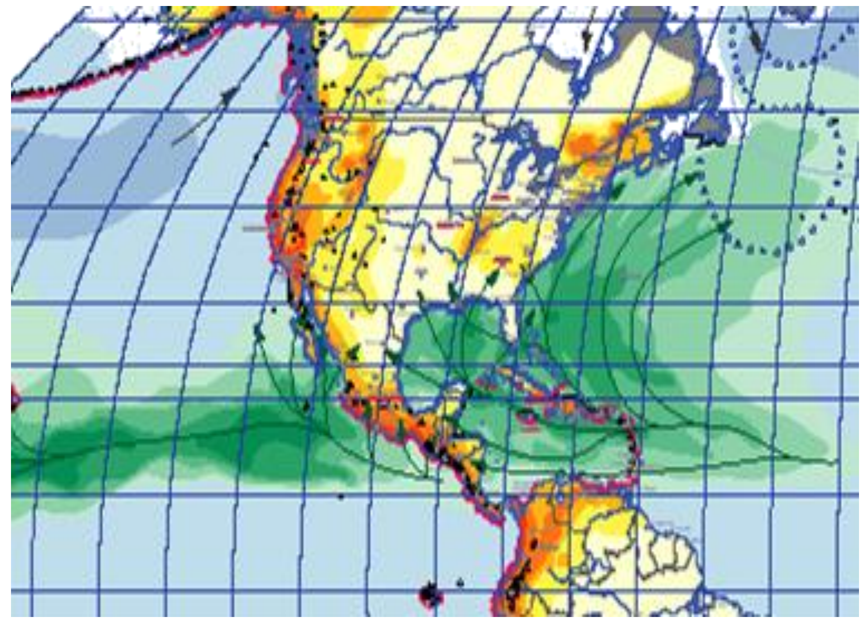
- ❑ To quantify uncertainty in climate change scenarios.

Elements of the Climate of Mexico

Because of its geographical location, Mexico is affected by mid-latitude systems in winter (cold fronts, ‘Nortes’) and by tropical systems (easterly waves, hurricanes) during summer.



Cold Frontal activity



Tropical Cyclones,
Easterly Waves, ITCZ

Validation Study in the Mexican Neighborhood

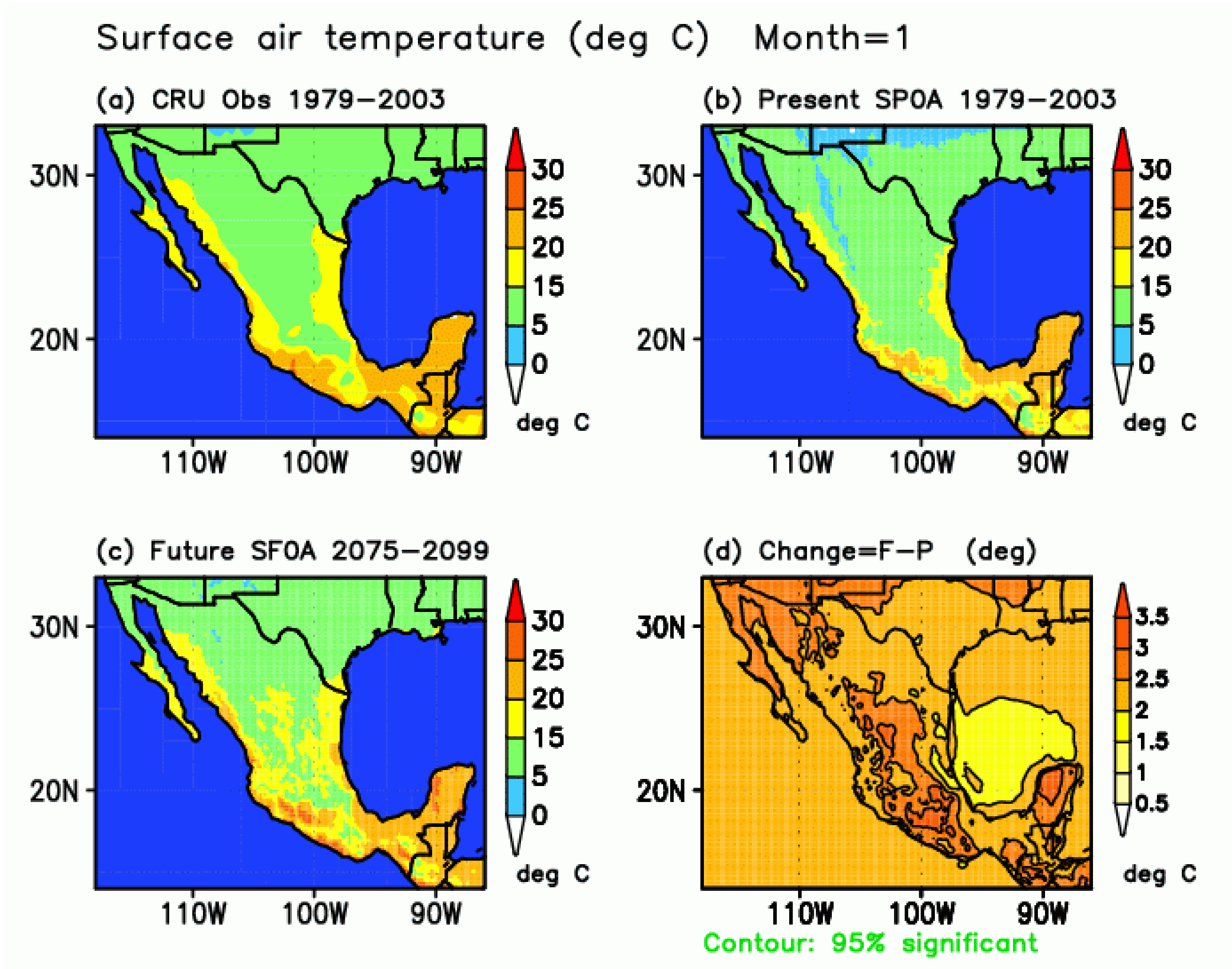
Model simulations used here are:

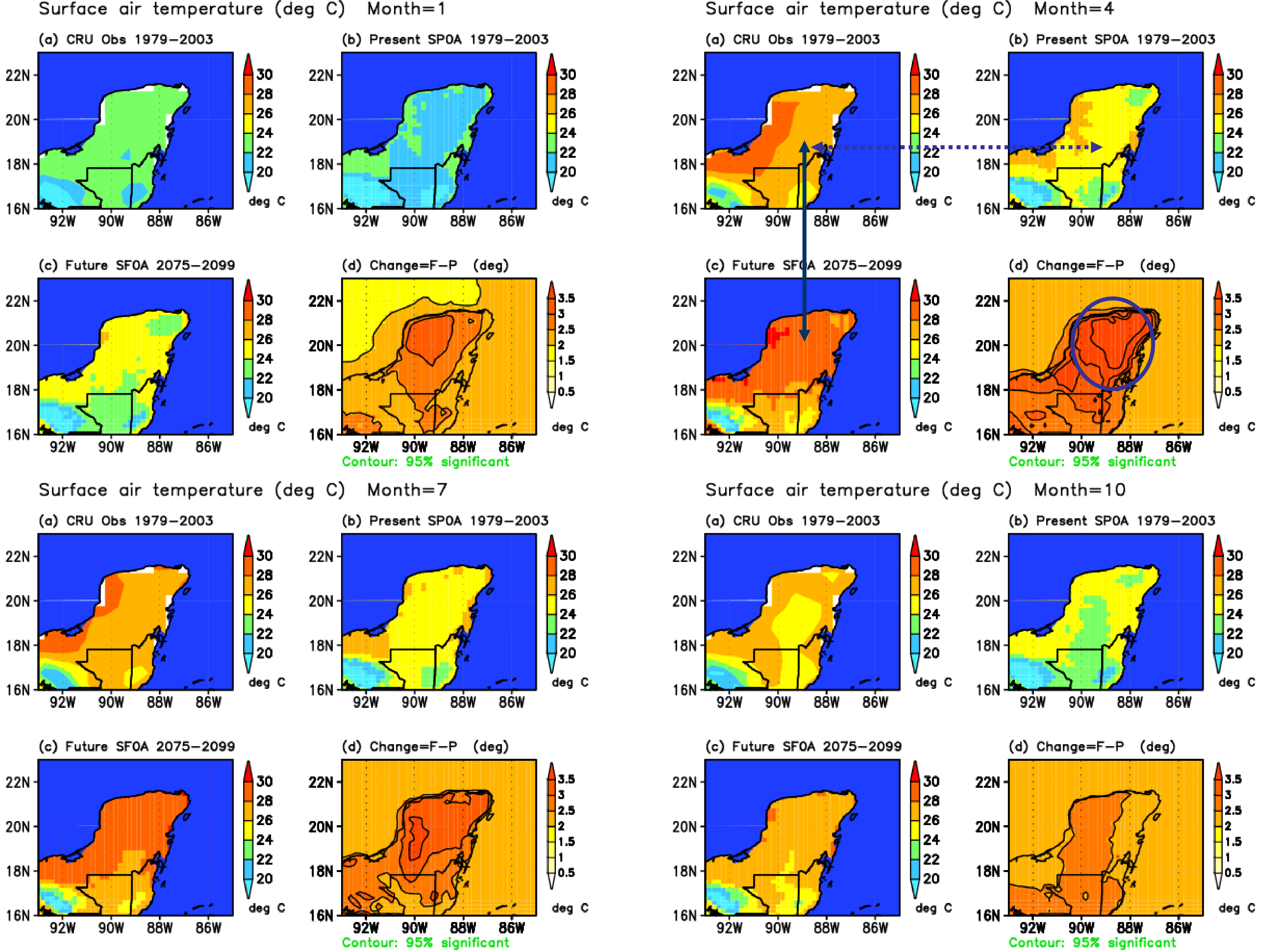
Model		Target period		
Grid size	Specification	Present-day 1979-2003	Near future 2015-2039	End of 21st century
20 km*	TL959L60	SP0A	SN0A	SF0A
60 km*	TL319L60	HP0A	HN0A	HF0A
120 km	TL159L40	MP0C	MN0A	MF0A
180 km	TL095L40	LP0A	LN0A	LF0A

* 20km , 60km model uses the Earth Simulator

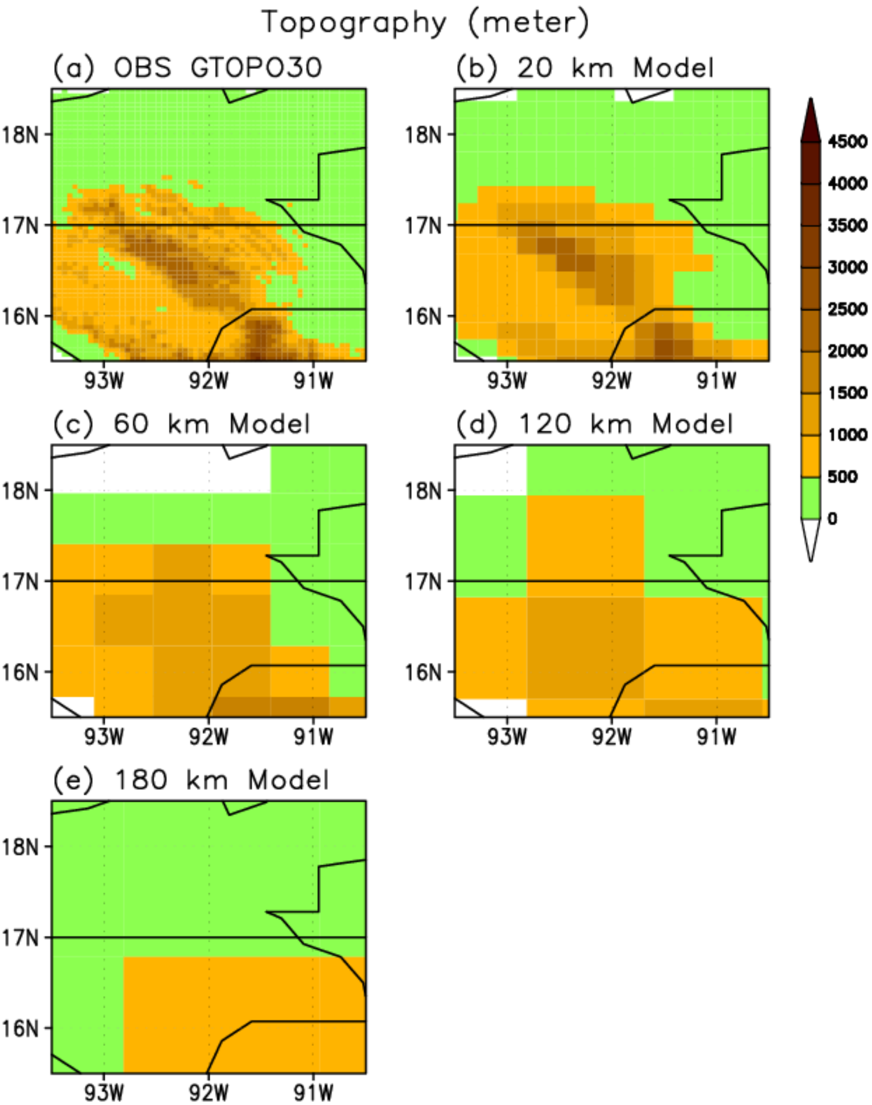
Observations taken from:

- CRU (precipitation & surface temperature)
- TRMM (standard deviation precipitation)
- NARR (climate indices)


Surface air temperature (deg C) Month=1
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=F–P (deg)
30N
20N
110W
100W
90W
30
25
20
15
5
0
deg C
3.5
3
2.5
2
1.5
1
0.5
Contour: 95% significant



Surface air temperature (deg C) Month=1
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=F–P (deg)
Contour: 95% significant
Surface air temperature (deg C) Month=4
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=F–P (deg)
Contour: 95% significant
Surface air temperature (deg C) Month=7
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=F–P (deg)
Contour: 95% significant
Surface air temperature (deg C) Month=10
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=F–P (deg)
Contour: 95% significant
deg C



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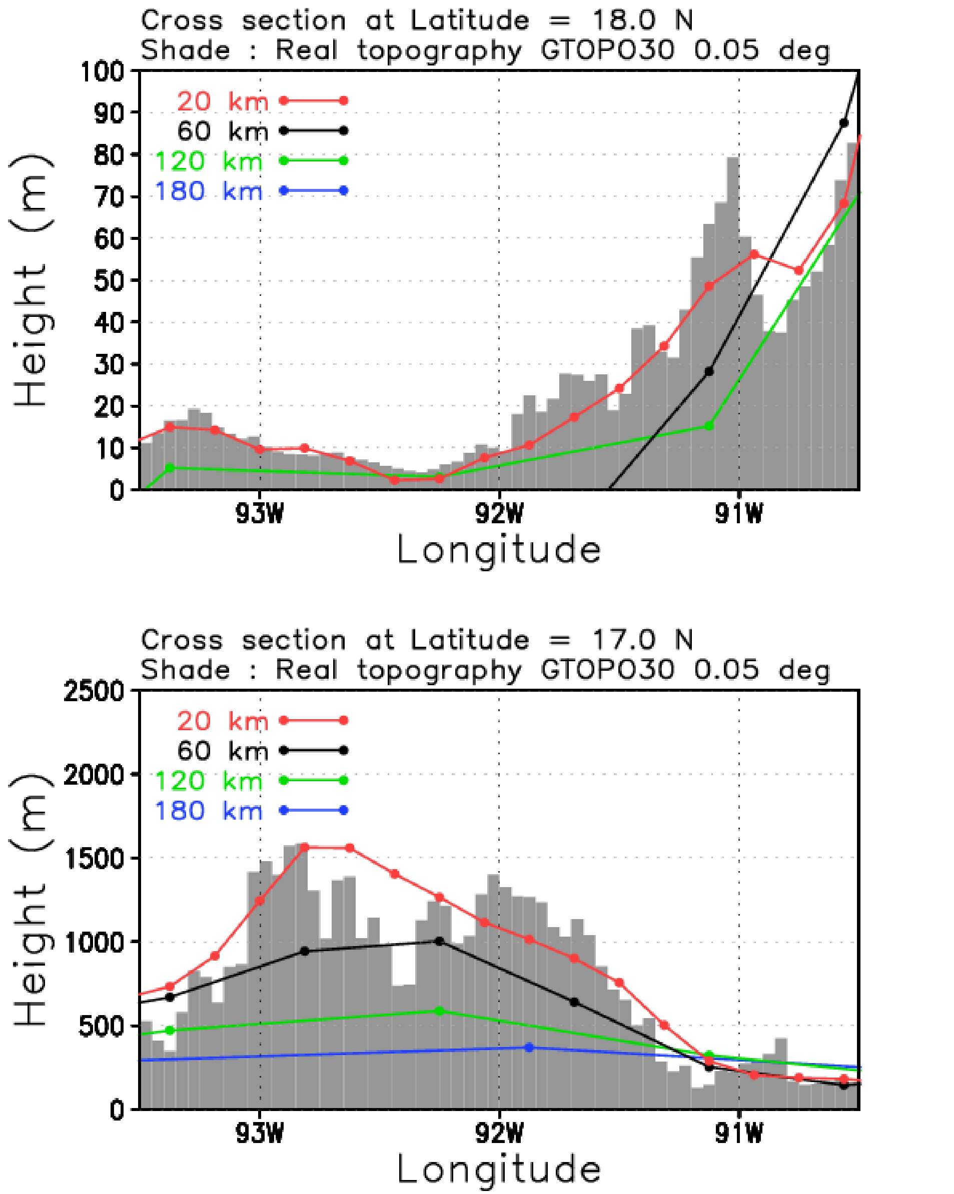

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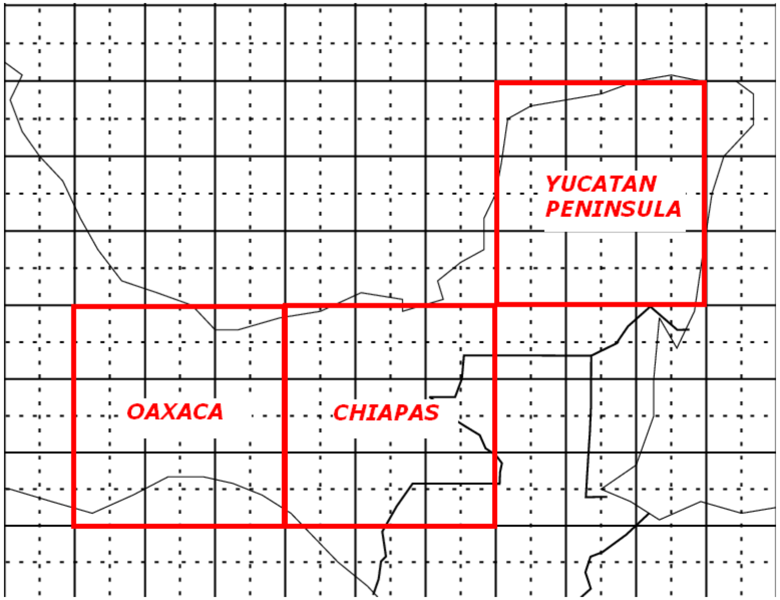
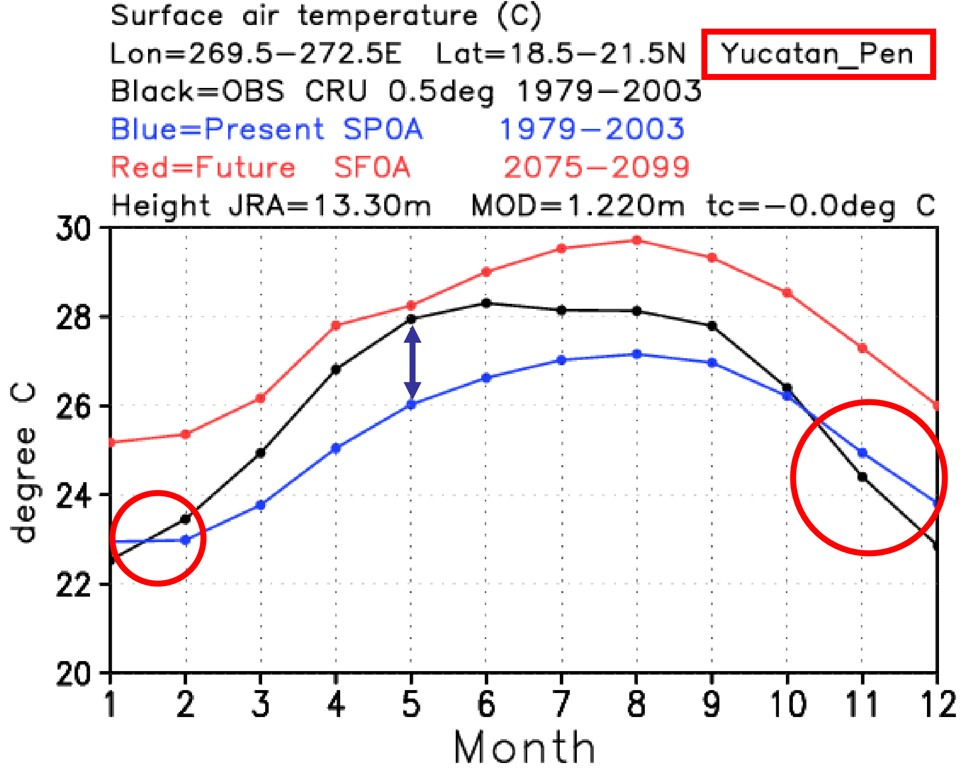
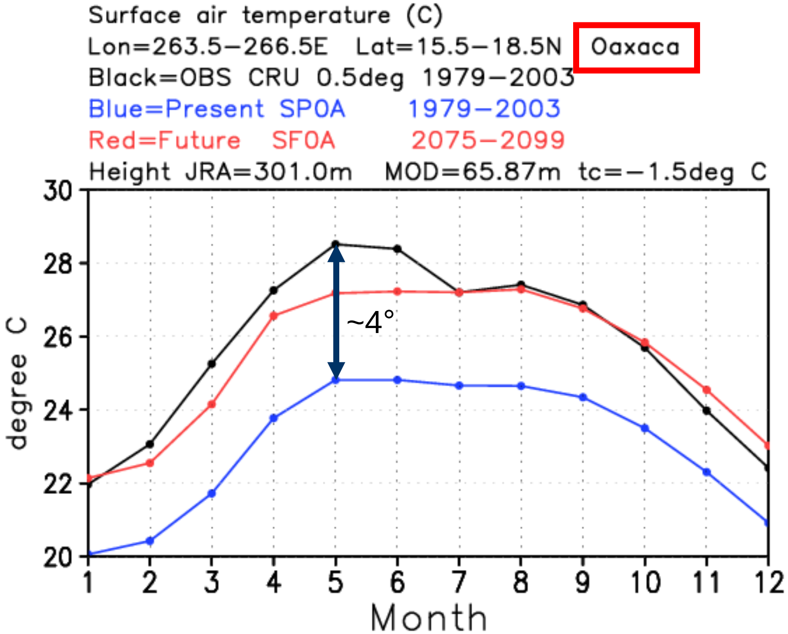
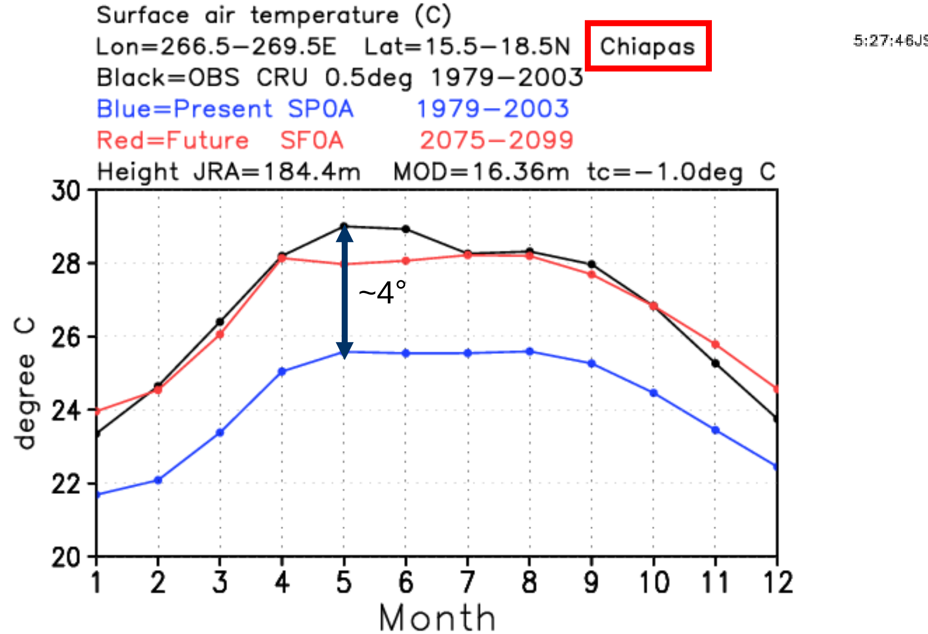
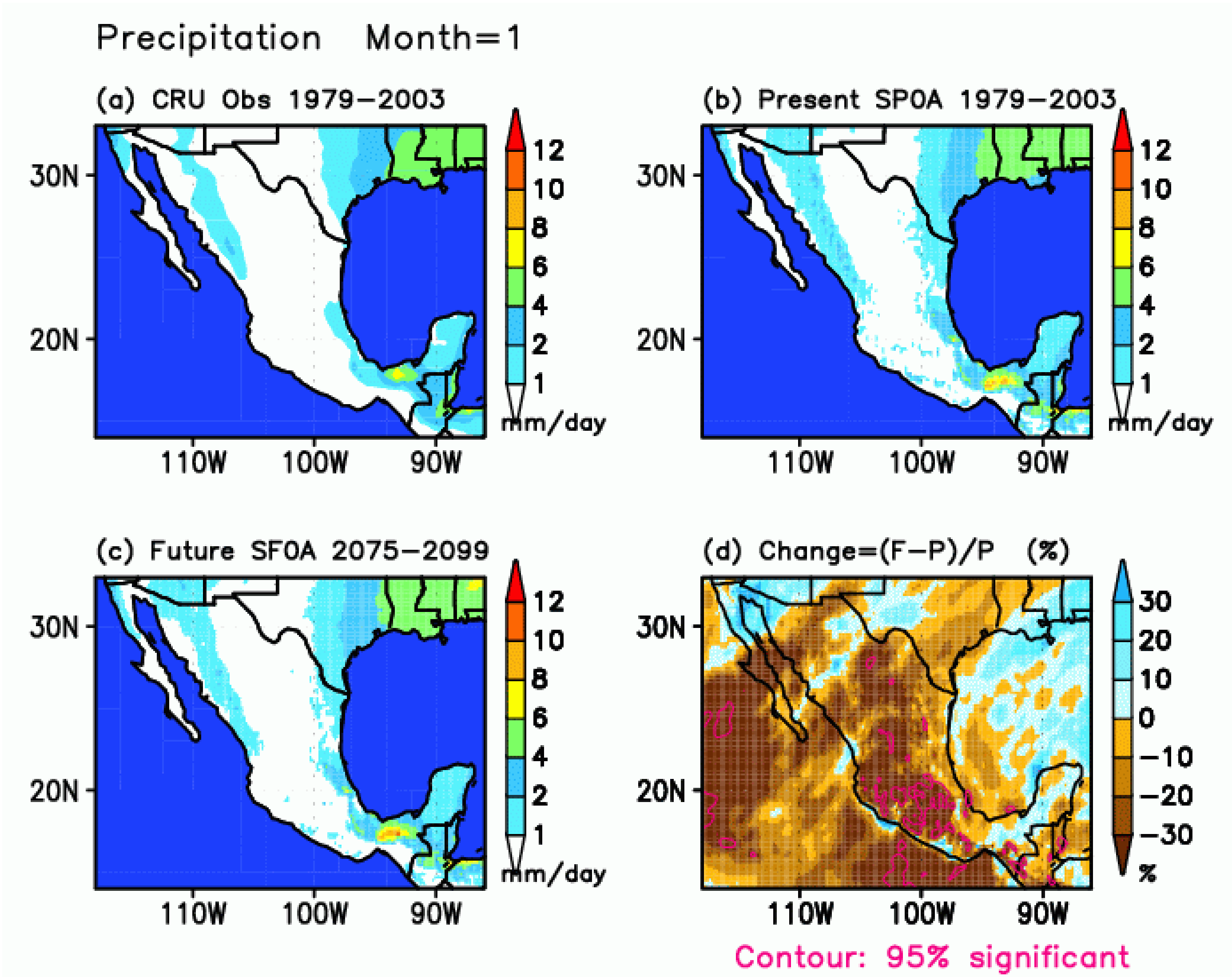

YUCATAN
PENINSULA
OAXACA
CHIAPAS

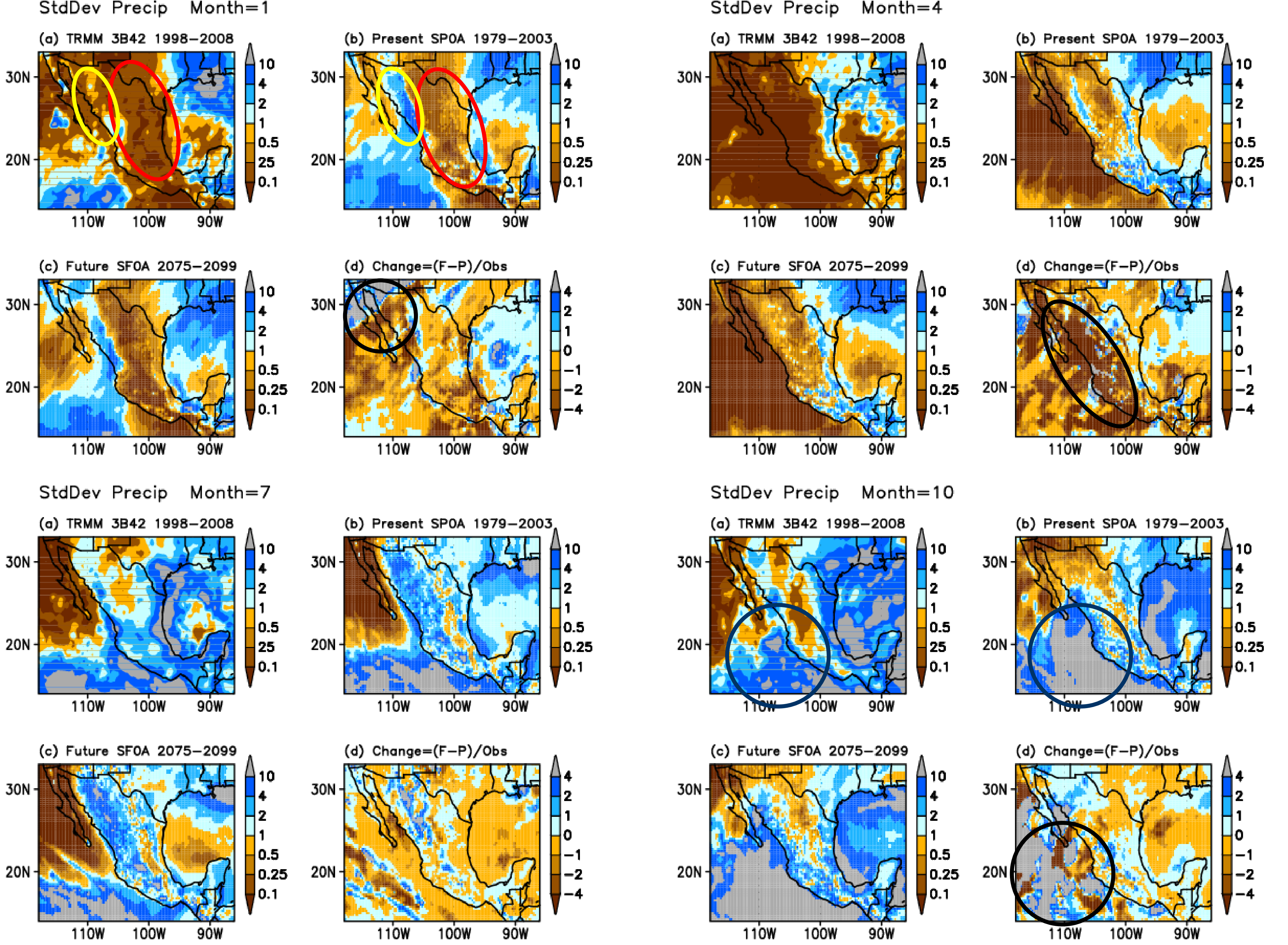

Surface air temperature (C)
Lon=269.5−272.5E Lat=18.5−21.5N
Yucatan_Pen
Black=OBS CRU 0.5deg 1979−2003
Blue=Present SP0A 1979−2003
Red=Future SF0A 2075−2099
Height JRA=13.30m MOD=1.220m tc=−0.0deg C
degree C
Month

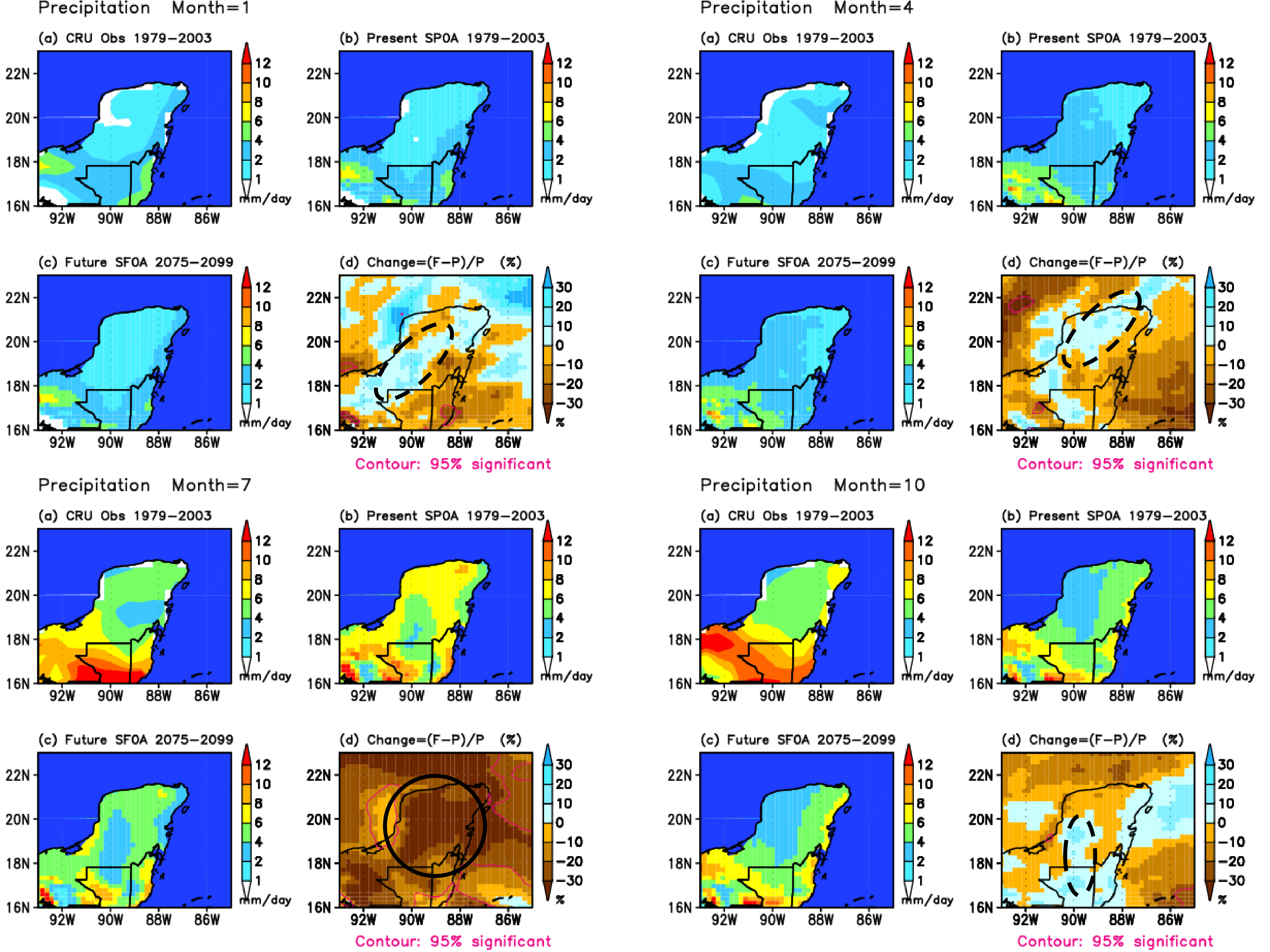

Surface air temperature (C)
Lon=263.5−266.5E Lat=15.5−18.5N
Oaxaca
Black=OBS CRU 0.5deg 1979−2003
Blue=Present SP0A 1979−2003
Red=Future SF0A 2075−2099
Height JRA=301.0m MOD=65.87m tc=−1.5deg C
~4°
degree C
Month


Surface air temperature (C)
Lon=266.5−269.5E Lat=15.5−18.5N
Chiapas
Black=OBS CRU 0.5deg 1979−2003
Blue=Present SP0A 1979−2003
Red=Future SF0A 2075−2099
Height JRA=184.4m MOD=16.36m tc=−1.0deg C
~4°
degree C
Month
5:27:46JST

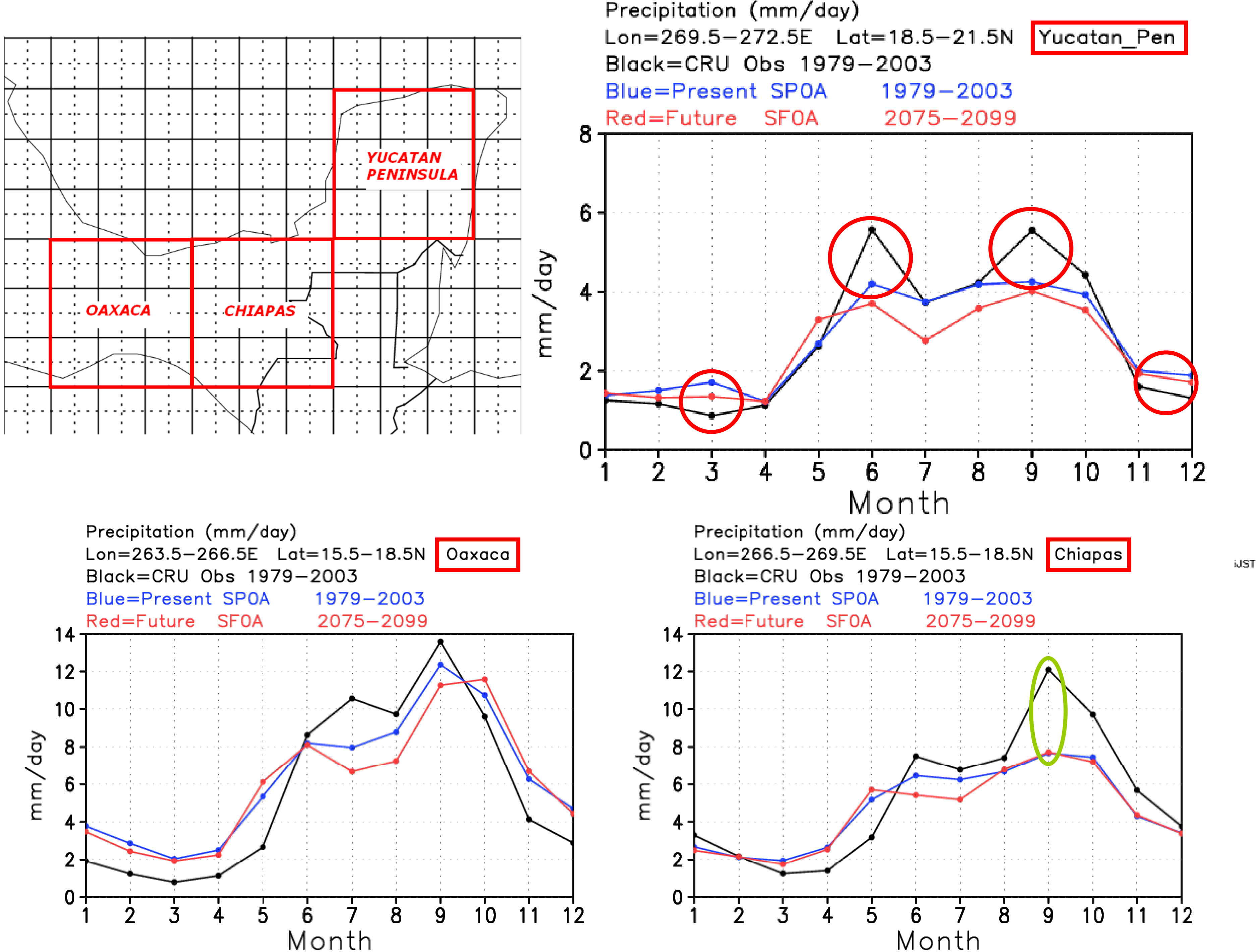


Precipitation Month=1
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/P (%)
30N
20N
110W
100W
90W
12
10
8
6
4
2
1
mm/day
30
20
10
0
–10
–20
–30
%
Contour: 95% significant

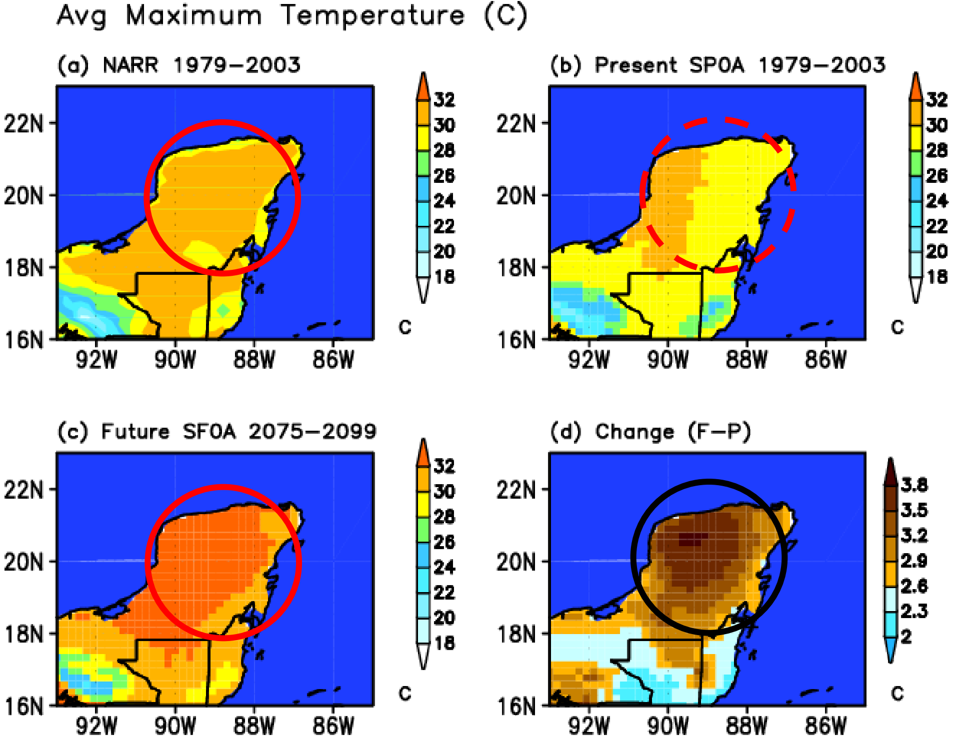

StdDev Precip Month=1
(a) TRMM 3B42 1998–2008
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/Obs
StdDev Precip Month=4
(a) TRMM 3B42 1998–2008
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/Obs
StdDev Precip Month=7
(a) TRMM 3B42 1998–2008
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/Obs
StdDev Precip Month=10
(a) TRMM 3B42 1998–2008
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/Obs
30N
20N
110W
100W
90W
10
4
2
1
0.5
0.25
0.1
0
–1
–2
–4

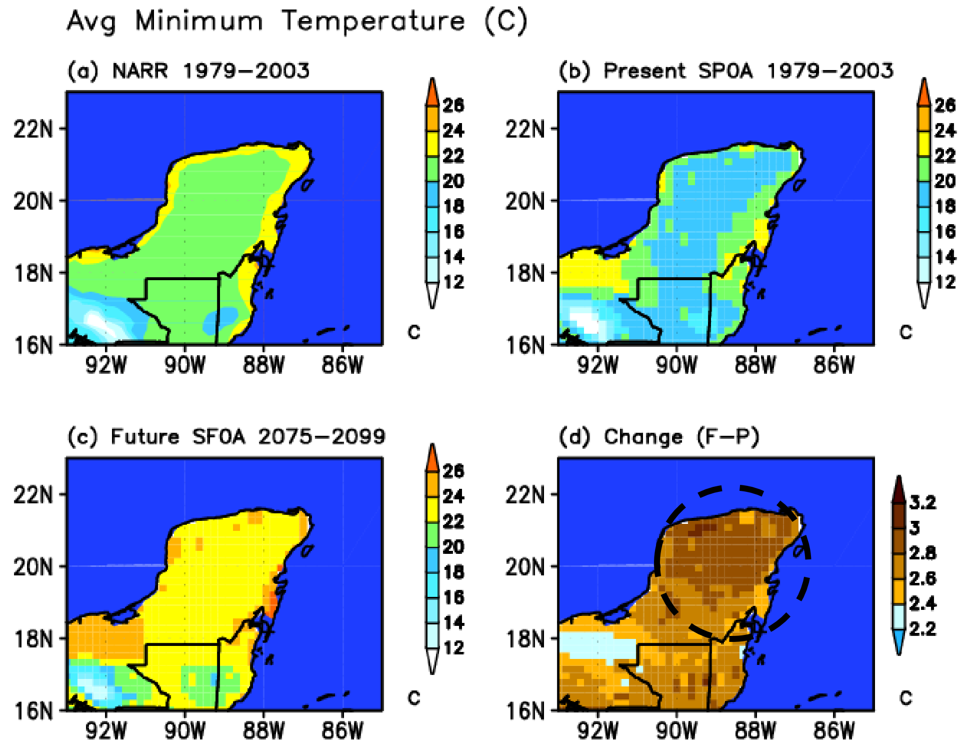


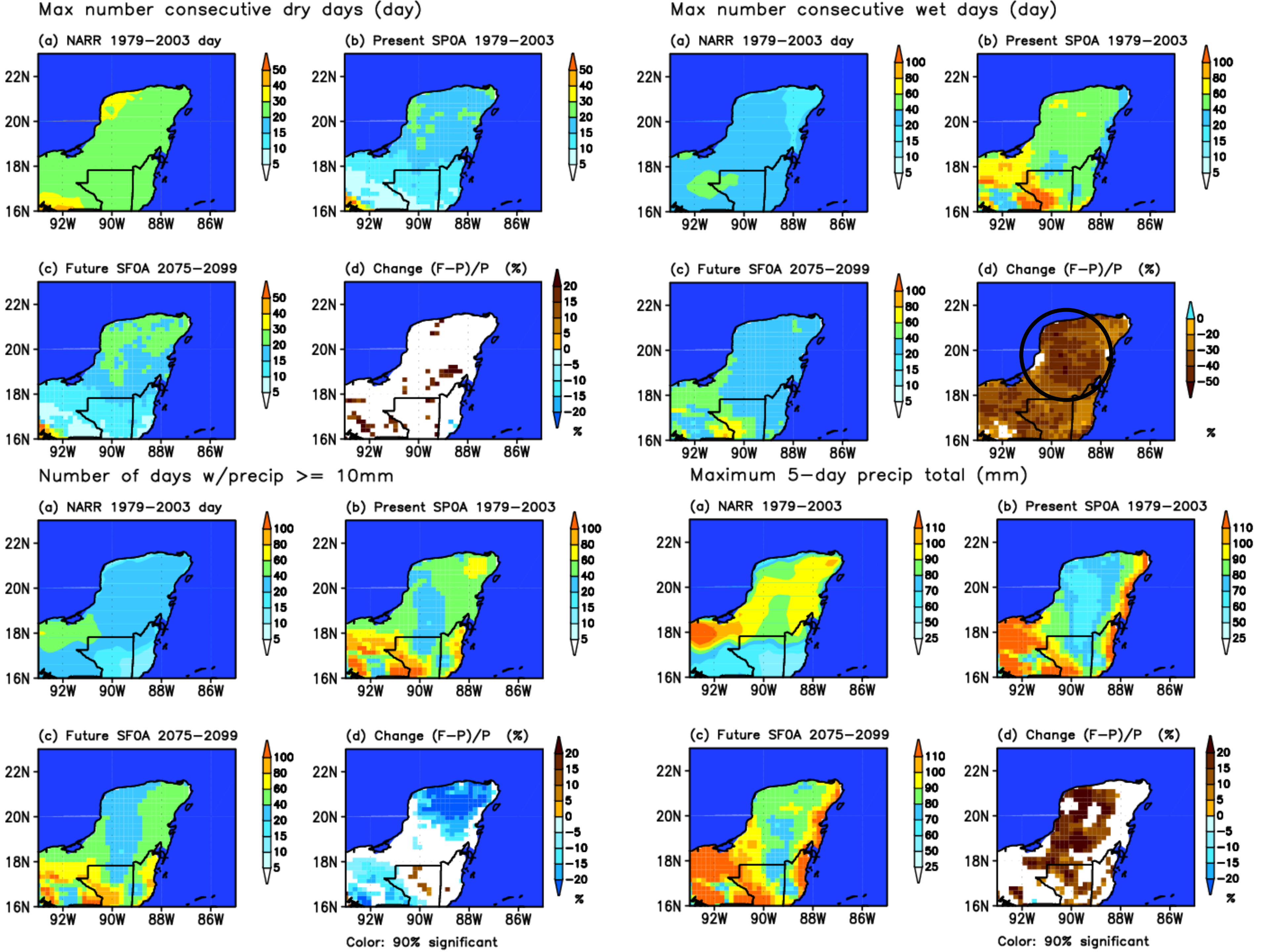
Precipitation Month=1
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/P (%)
Contour: 95% significant
Precipitation Month=4
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/P (%)
Contour: 95% significant
Precipitation Month=7
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/P (%)
Contour: 95% significant
Precipitation Month=10
(a) CRU Obs 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change=(F–P)/P (%)
Contour: 95% significant
mm/day
%
22N
20N
18N
16N
92W
90W
88W
86W


YUCATAN PENINSULA
OAXACA
CHIAPAS
Precipitation (mm/day)
Lon=269.5–272.5E Lat=18.5–21.5N
Yucatan_Pen
Black=CRU Obs 1979–2003
Blue=Present SP0A 1979–2003
Red=Future SF0A 2075–2099
mm/day
Month
Precipitation (mm/day)
Lon=263.5–266.5E Lat=15.5–18.5N
Oaxaca
Black=CRU Obs 1979–2003
Blue=Present SP0A 1979–2003
Red=Future SF0A 2075–2099
mm/day
Month
Precipitation (mm/day)
Lon=266.5–269.5E Lat=15.5–18.5N
Chiapas
Black=CRU Obs 1979–2003
Blue=Present SP0A 1979–2003
Red=Future SF0A 2075–2099
mm/day
Month
iJST

Climate Indices






Max number consecutive dry days (day)
(a) NARR 1979–2003 day
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change (F–P)/P (%)
Max number consecutive wet days (day)
(a) NARR 1979–2003 day
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change (F–P)/P (%)
Number of days w/precip >= 10mm
(a) NARR 1979–2003 day
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change (F–P)/P (%)
Color: 90% significant
Maximum 5–day precip total (mm)
(a) NARR 1979–2003
(b) Present SP0A 1979–2003
(c) Future SF0A 2075–2099
(d) Change (F–P)/P (%)
Color: 90% significant

Summary

- Temperature:
  - MRI-20km res model catches very well the general aspects of the temperature mean monthly climatology for most of the regions in Mexico.
  - There is a bias of about -2 to -3 C at least for the southern part of Mexico. For the Yucatan Peninsula (YP) region, the bias is shown especially for the spring and summer season, having a minimum (bias) during winter. The origin of the bias seems to be due to the model physics not to topographical issues as shown in the T vs time figures.
  - MRI-20km res simulations have the potential to be used as a good high-res estimation of climate changes for the YP, after a model-bias correction technique applied to them.
  - The model estimates a change in temperature for the future of about +2 to +3.5 C with more higher values and confidence levels in the central part of the peninsula.

- Precipitation:
  - MRI-20km res model catches very well the general aspects of the precip mean monthly climatology for most of the regions in Mexico (monsoon season and mid-summer drought).
  - For the YP region the model catches very well the observed mid-summer drought shown in the southeast region of Mexico. However, in all of the three analyzed regions the model tends to underestimate summer precipitation and overestimate winter precipitation. This figure has been shown in previous analysis for most of the GCMs that reported to the last IPCC-AR4.
  - MRI-20km model estimates significant future changes in precipitation (around 20% decrease) in the study region (YP) from June to August; on the other times the estimated changes are smaller. It is notable that for all of the seasons (except summer) there are several regions with a positive anomaly for the future.
  - The standard deviation precipitation (SDP) analysis shows that most of the time the model SDP is larger compared to that of the observations (according to TRMM). Even though, it is found that the future changes could be more significant around the western part of Mexico.

Changes in the future compared to the present estimated by the model

- Climate indices:
  - Avg Maximum Temperature
    - Maximum increase around +3.5 C for the north-central and north-western part of the YP.
  - Avg Minimum Temperature
    - Similar behavior than avg max temperature but with a lesser increase, around +3 C.
  - Max Number of Consecutive Dry Days
    - Practically without significant changes.
  - Max Number of Consecutive Dry Days
    - A strong decrease of about 40% in the central and northwestern part of the YP.
  - Number of Days with Precip ≥ 10 mm
    - A significant decrease of about 20% in the north-central part of the YP.
  - Max 5-day Precipitation Total
    - A significant increase of about 15-20% in the western part of the YP.

Tropical Cyclones activity over Mexico region: Preliminary Results

Objective

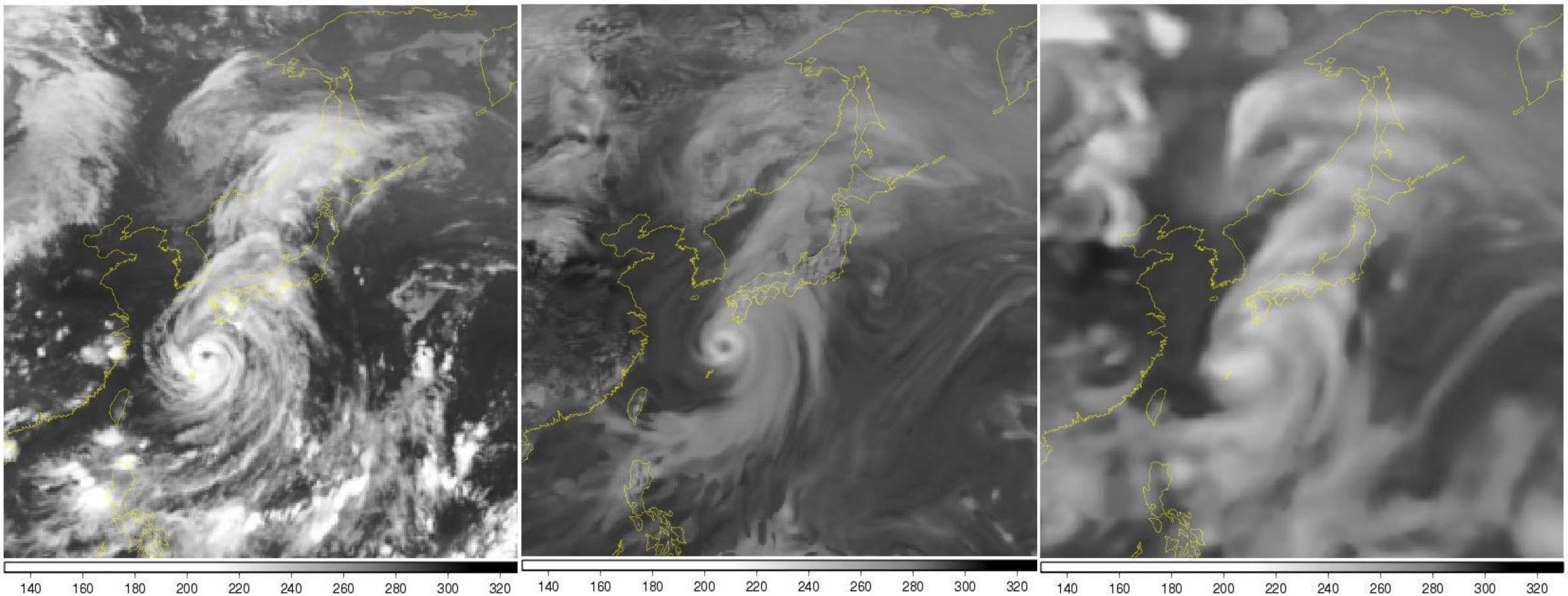
- To examine high-resolution (20-km mesh) Climate Change Scenario developed on *Earth Simulator* to examine regional climate change of tropical cyclones activity.

Infrared brightness temperature:36 hour forecast

Satellite observation

20-km model

55-km model for short-range weather forecast



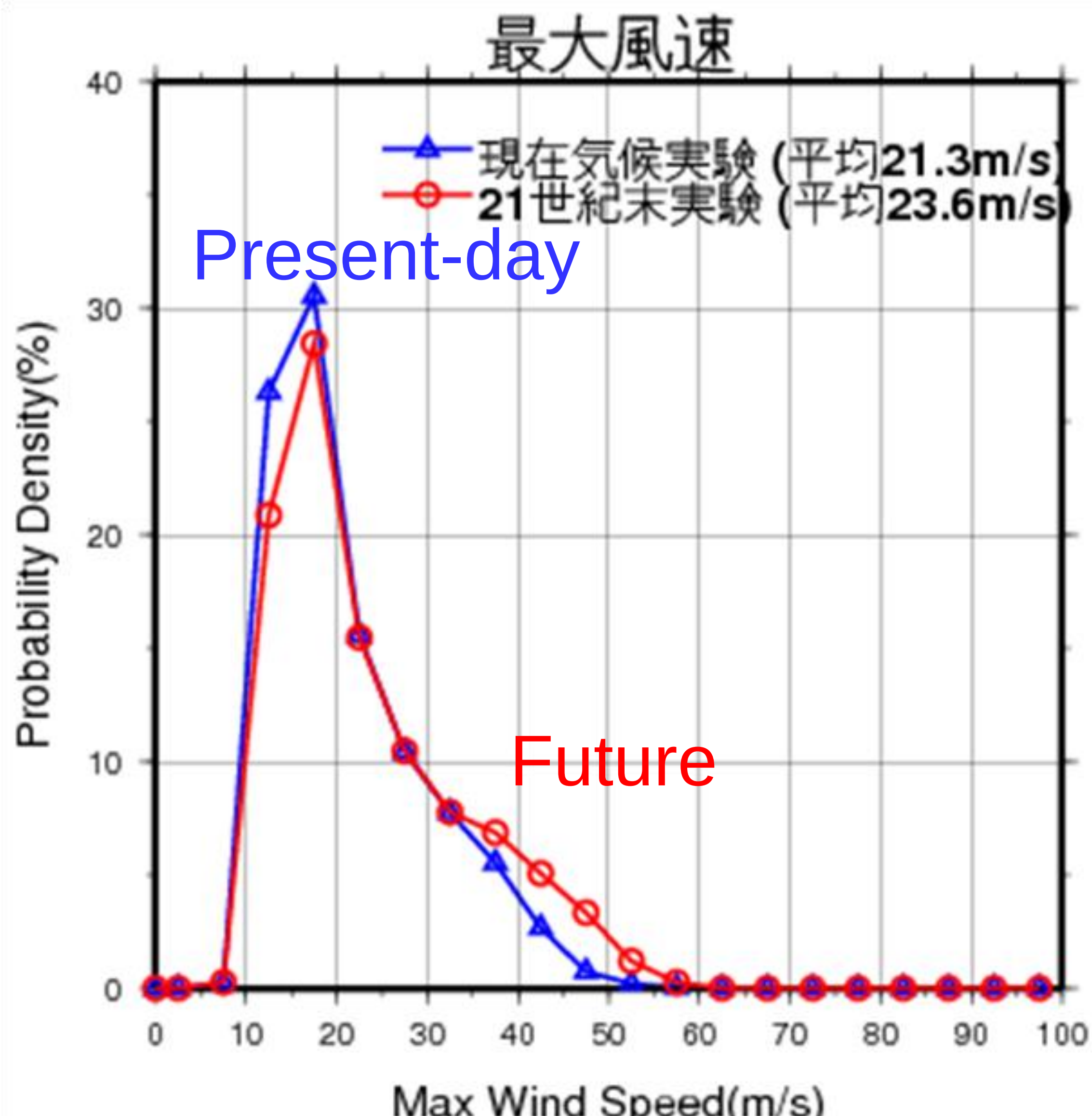
Typhoon 2003-10

Initial time:00UTC 6 Aug. 2003

Valid time:12UTC 7 Aug. 2003

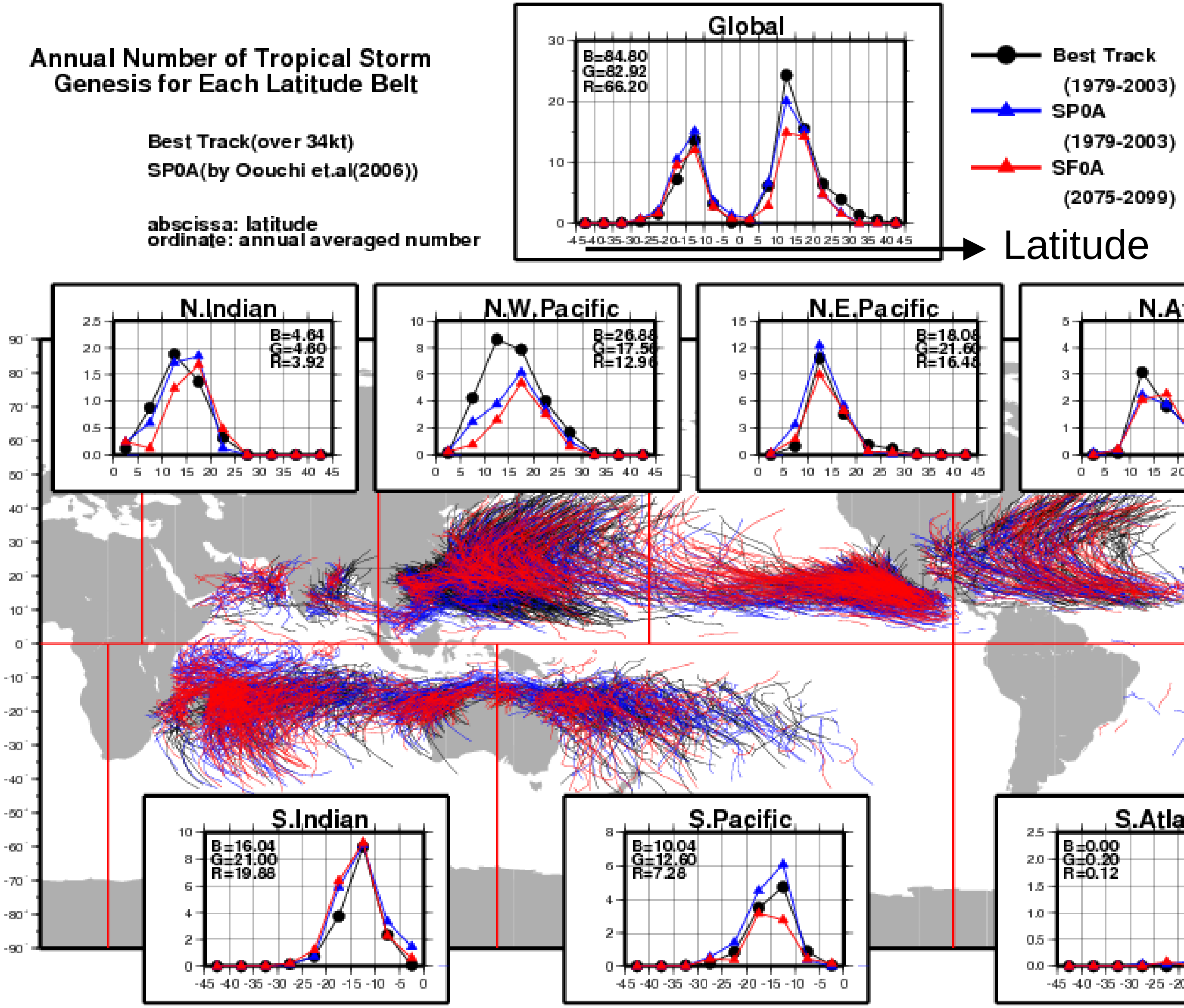
Murakami, H. (2005)

Intensity change of TC



Strong TC increases

Change in the number of TC



Observation

Present-day

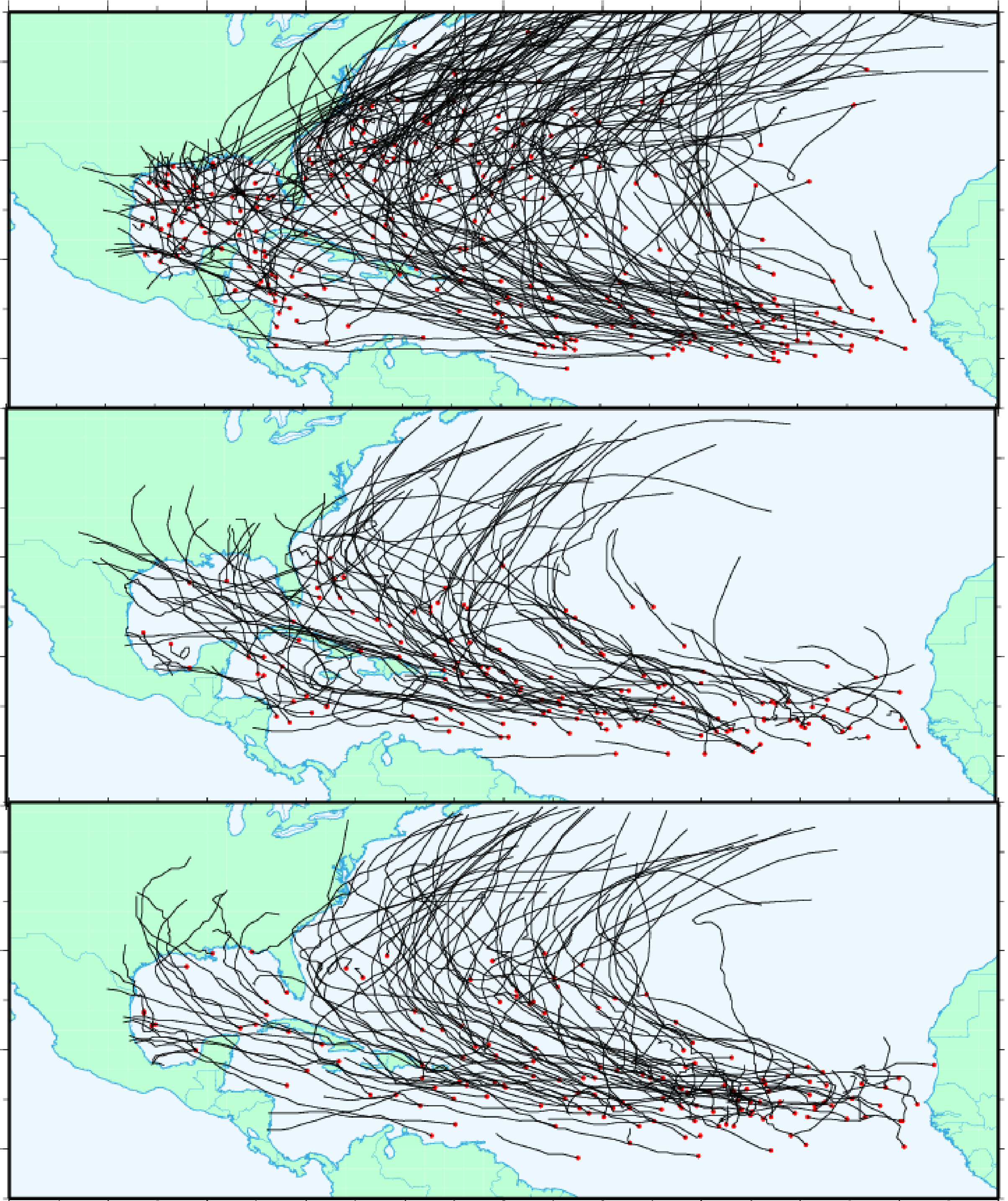
Future

TC decreases globally

Local change is different

Identification of Tropical Cyclones

Identification of tropical cyclones following method and criteria according (Oouchi et al. 2006).



Observed BestTrack (1979-2003)

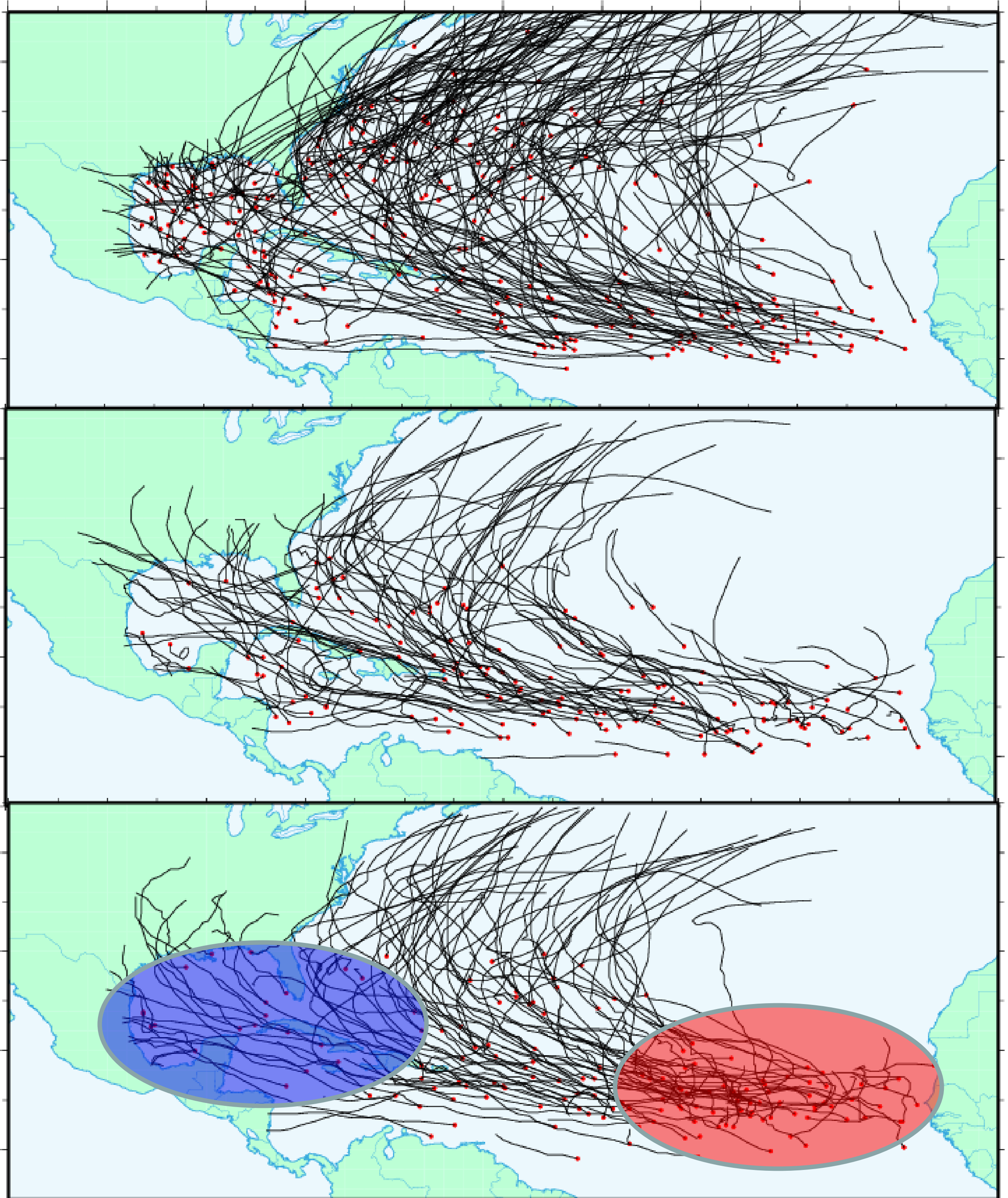
10.72

Present Climate (1979-2003)

5.72

Future Climate (2075-2099)

6.12



Observed BestTrack
(1979-2003)

10.72

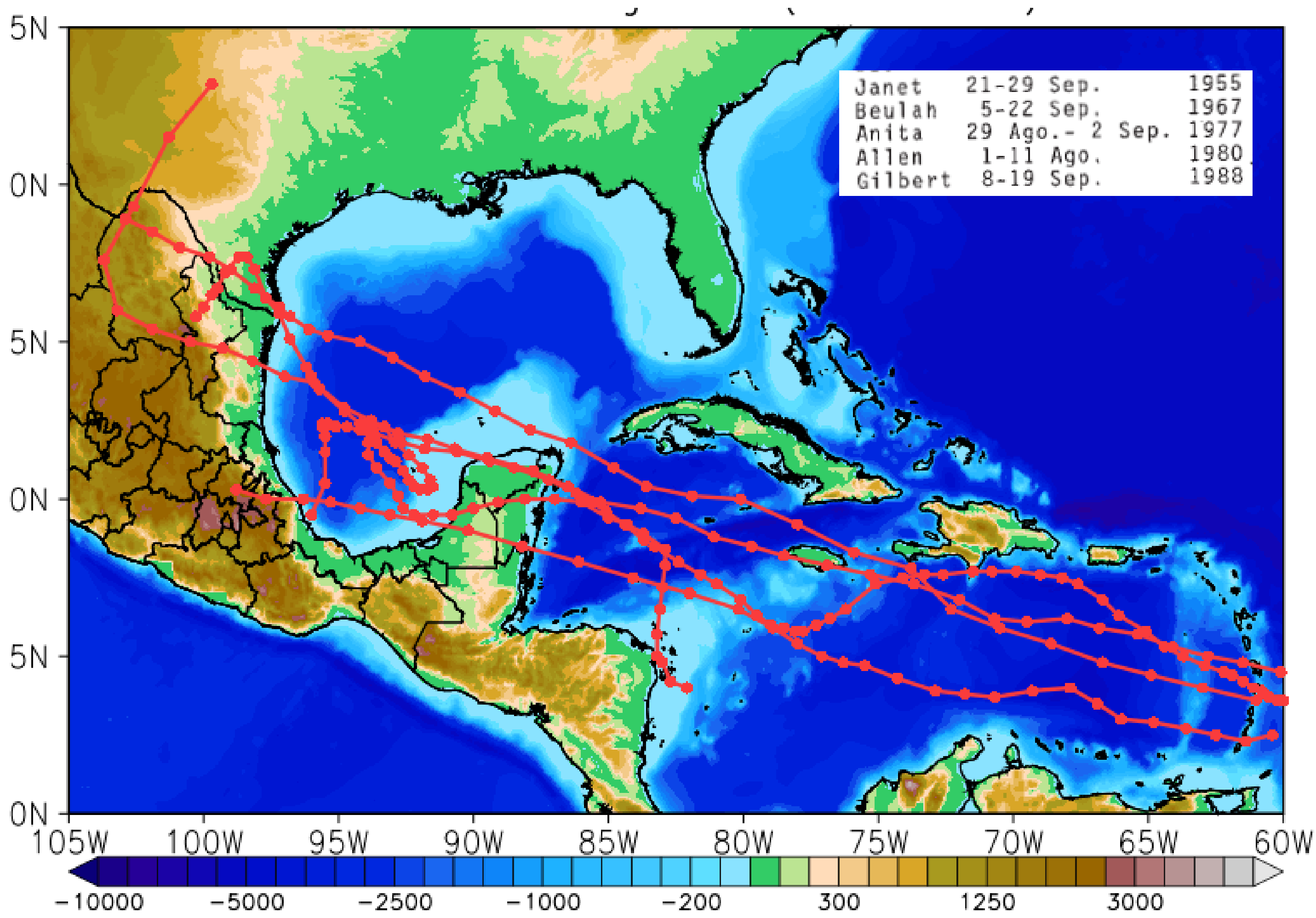
Present Climate
(1979-2003)

5.72

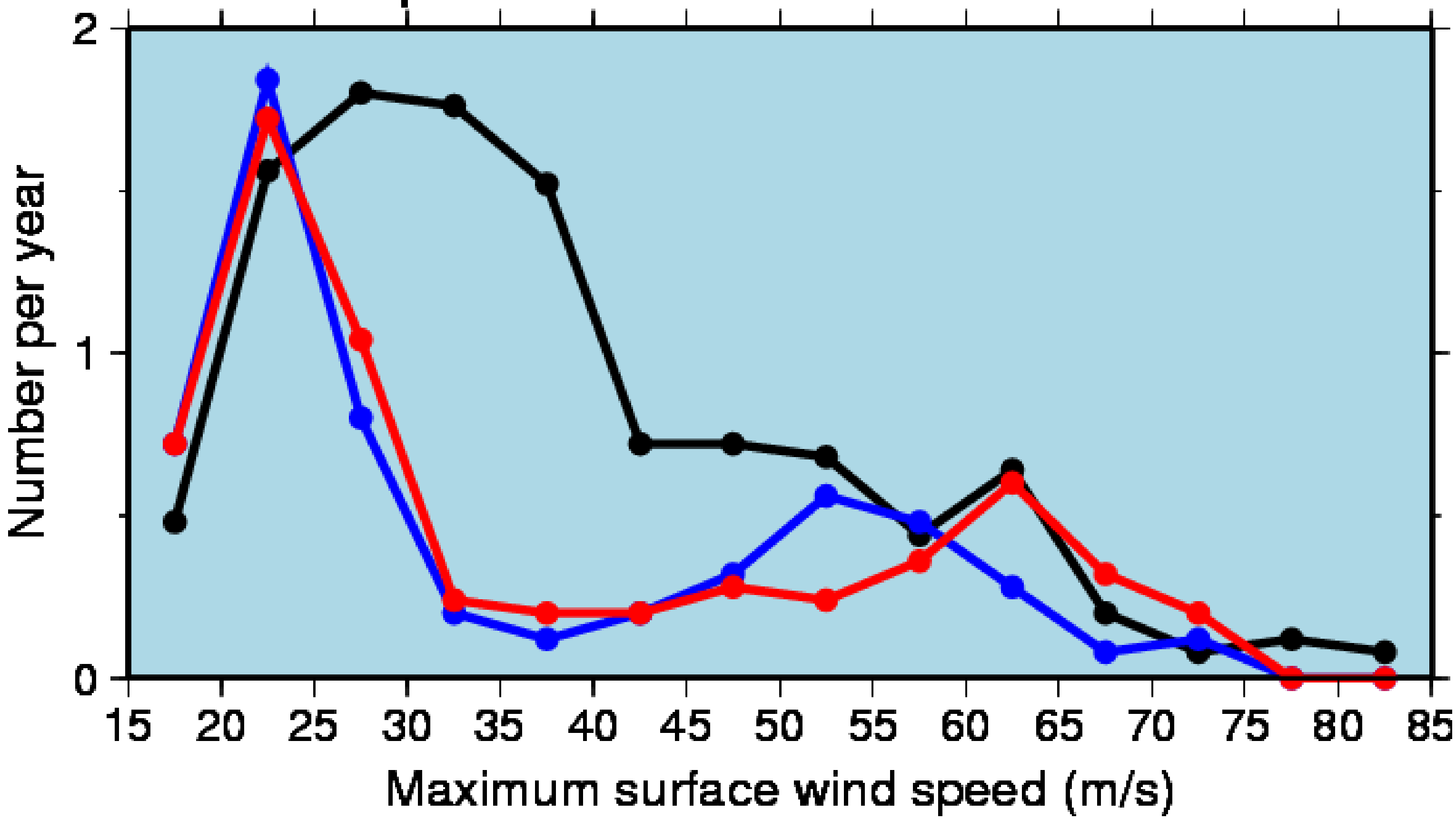
Future Climate
(2075-2099)

6.12

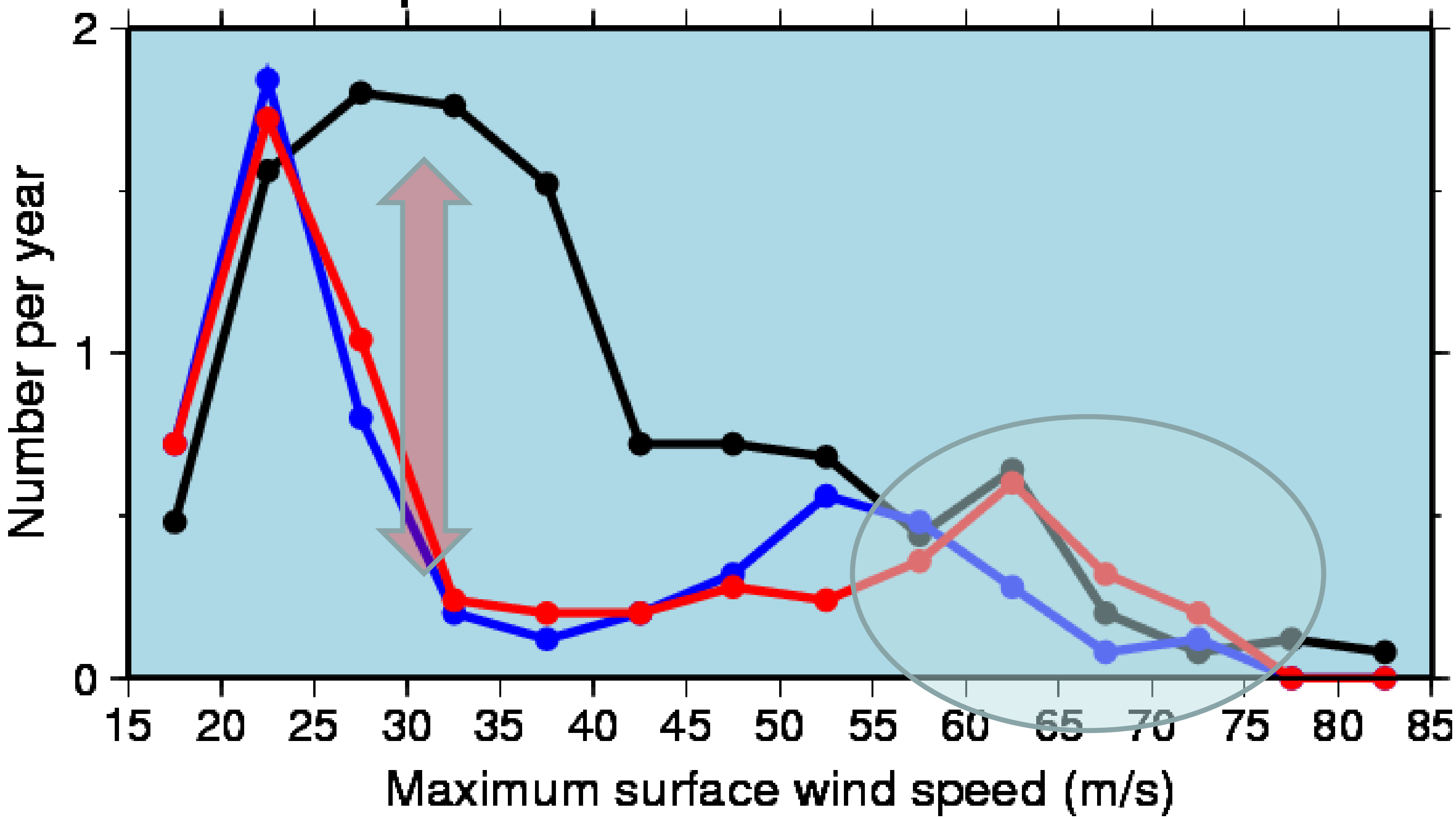
Hurricanes category 5 (1950-2000)



Annual mean frequency of maximum surface wind speed in North Atlantic



Annual mean frequency of maximum surface wind speed in North Atlantic



Conclusions

The model has skill to reproduce typical spatial pattern of Nortes and tropical cyclones.

The number of Nortes over Gulf of Mexico will slightly increase.

There is no significant changes in the number of tropical cyclones over North Atlantic Ocean.

Intensity of maximum surface winds of tropical cyclone is understimated

Trends and quantitative model uncertainty in anomaly projections: Preliminary Results

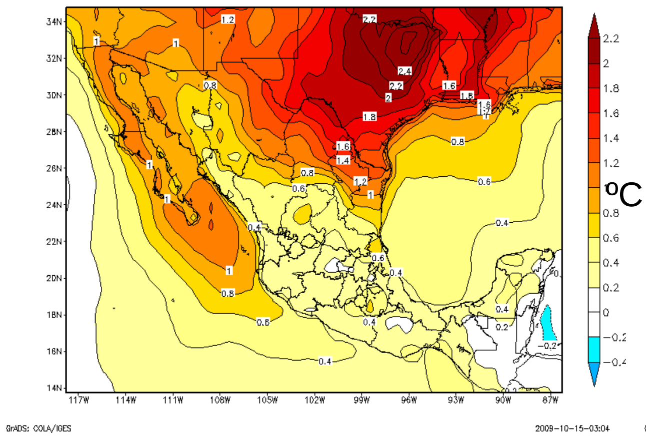
Validation: simulation of observed trends

- Climate Change Experiments challenge GCM to simulate the observed trend
- It’s necessary to validate GCM output in a historical period in order to make sure that it’s capable of reproducing the historic trend in regional scales: Peninsula of Yucatan

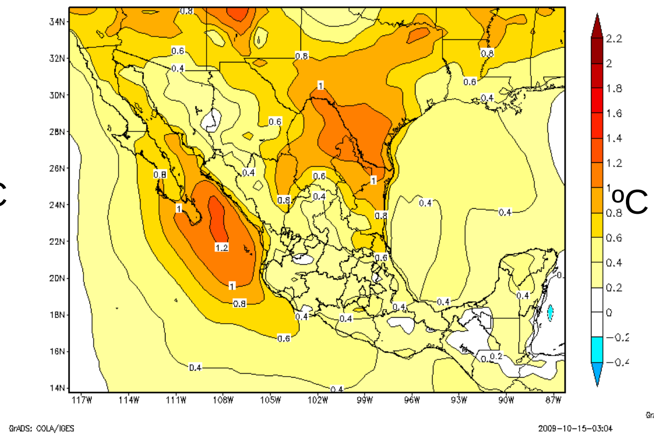
Trend Analysis, 1979-2003 period
Ensemble Approach

Temperature

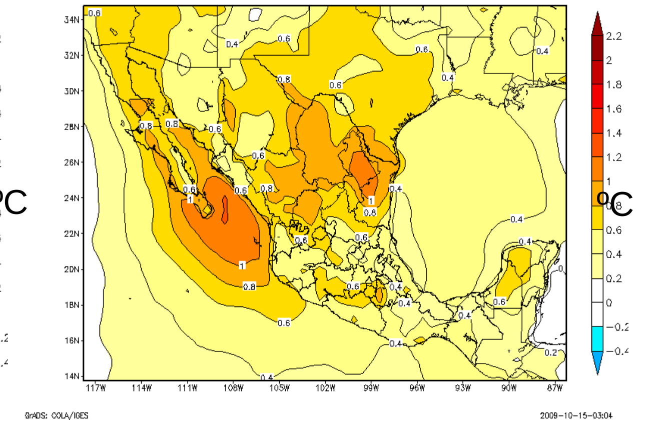
experiment 01



experiment 02

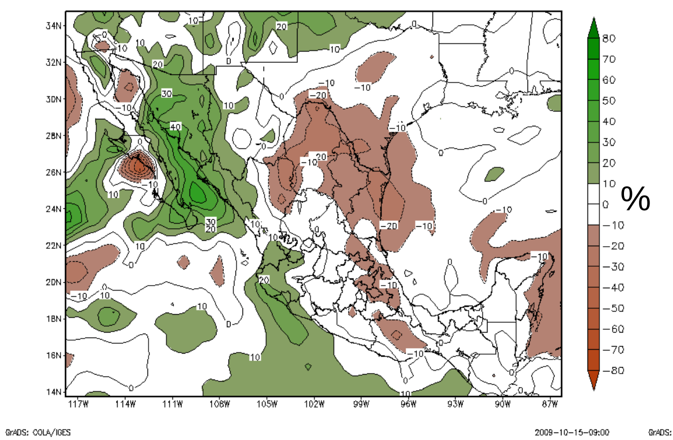


experiment 03

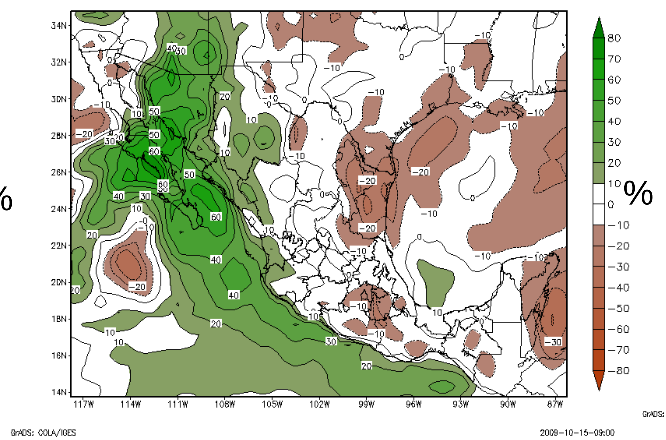


Precipitation

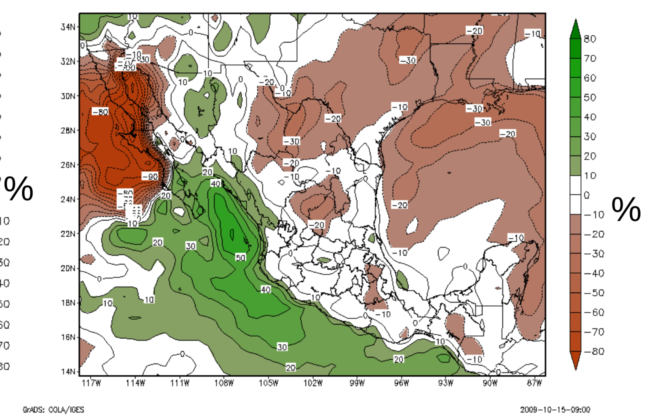
experiment 01



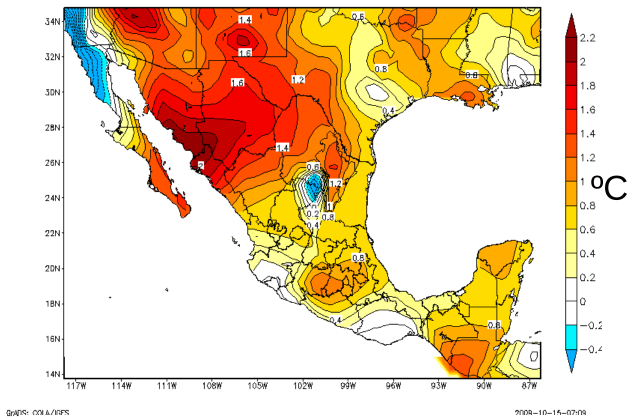
experiment 02



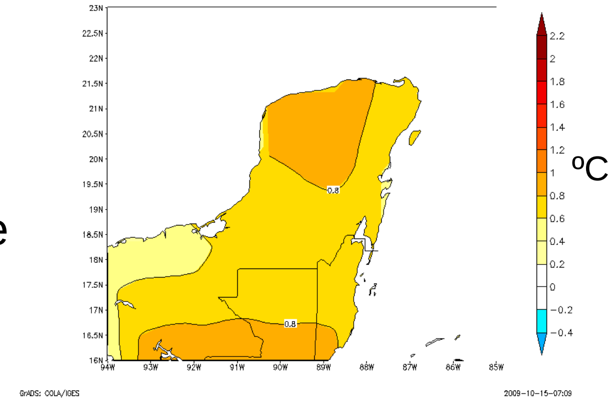
experiment 03

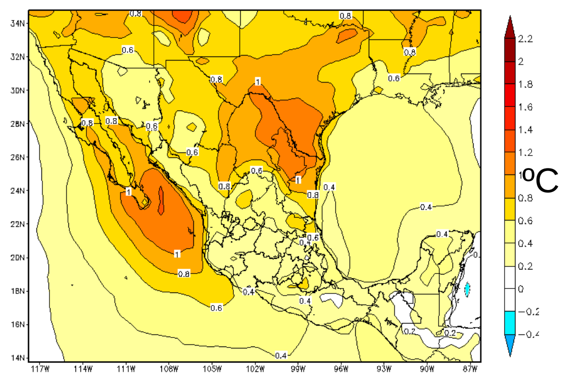


Trends in annual mean temperature, 1979-2003 period

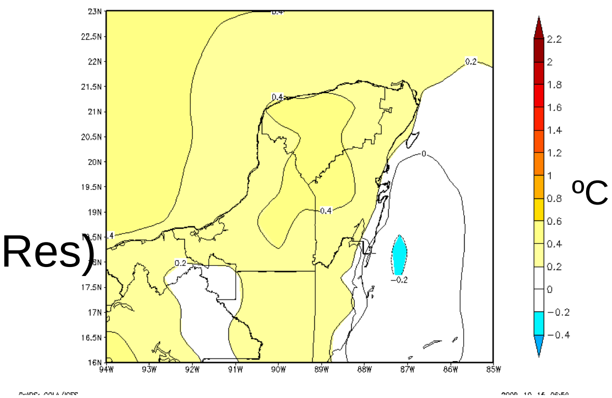


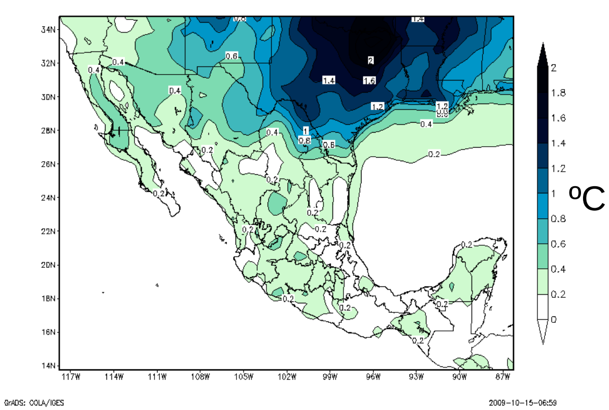
Observed
CRU database



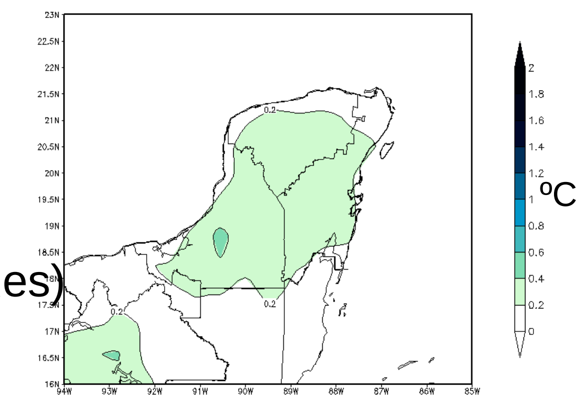


MRI Model
3 experiments
Median
(CMIP SST, High Res)

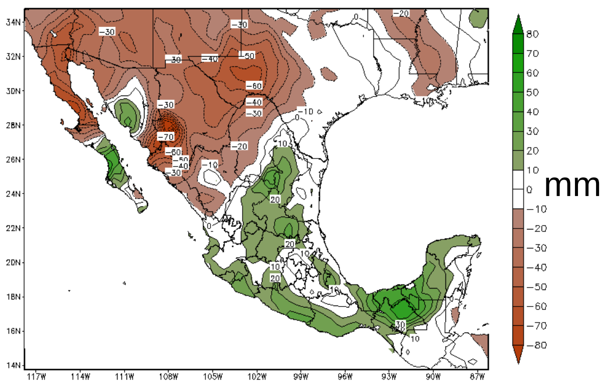




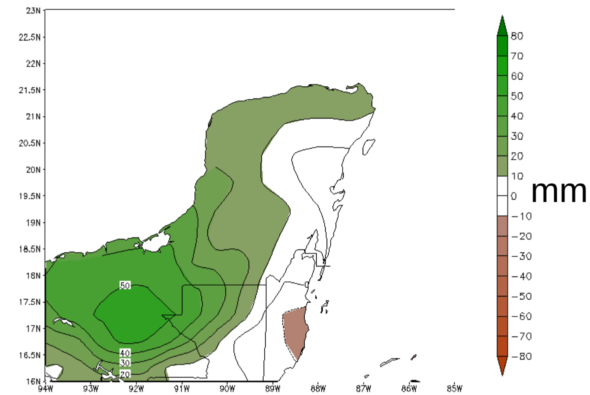
MRI Model
3 experiments
range
(CMIP SST, High Res)

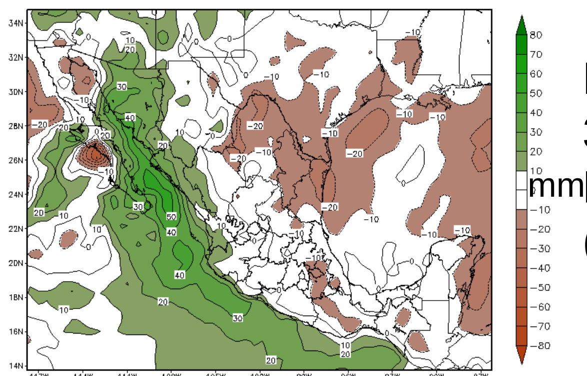


Trends in annual accumulated precipitation (percentage), 1979-2003 period

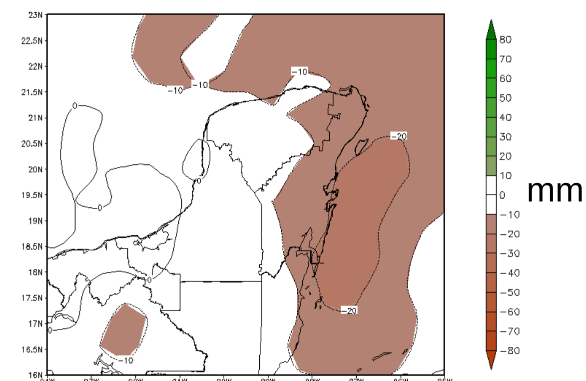


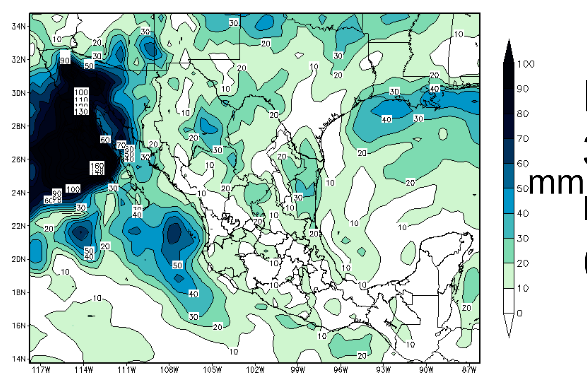
Observed
CRU database



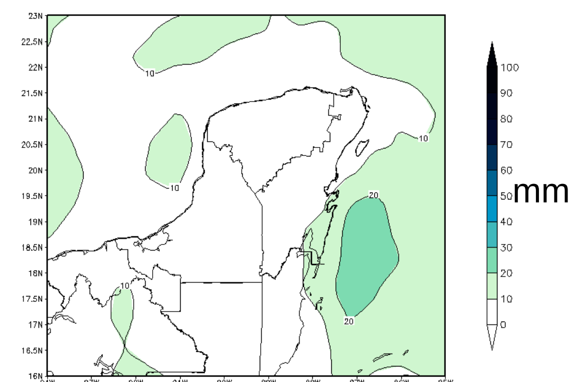


MRI Model
3 experiments
Median
(CMIP SST, High Res)





MRI Model
3 experiments
range
(CMIP SST, High Res)



What is needed in climate change scenarios in a risk management context

- Climate Change scenarios has been developed as "breeches" between GCM output and those studying its potential impacts, so climate change scenarios must be:
  - Detailed enough to be used in impact studies
  - A quantitative uncertainty in the climate projections must be involved as every risk management problem requires
  - Relevant for socioeconomic sectors and designed to the user necessities
  - Designed to feed making decision schemes

Action plan

- Near Future Work:
  - Hydrological variables
  - Extreme climate indices (wind speed, humidity, vegetation, etc.)
  - Changes in daily Probability density function: Variability changes
- Future Work:
  - Easterly waves analysis
  - Local impacts in precipitation associated with the change in hurricane tracks and intensity
  - Changes in sea level*

Acknowledgment

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