# The use of the Earth Simulator in climate projections over Amazon

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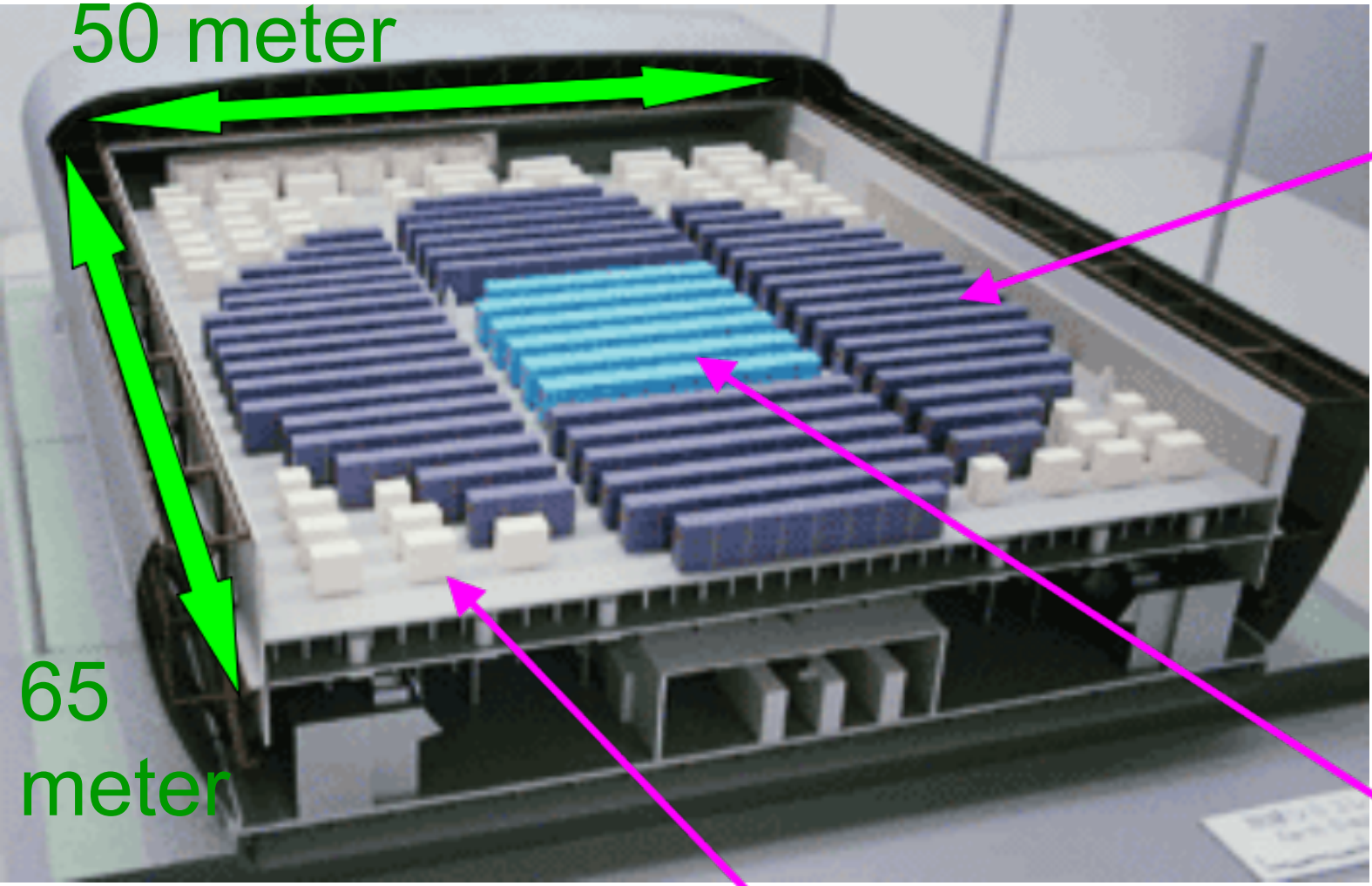
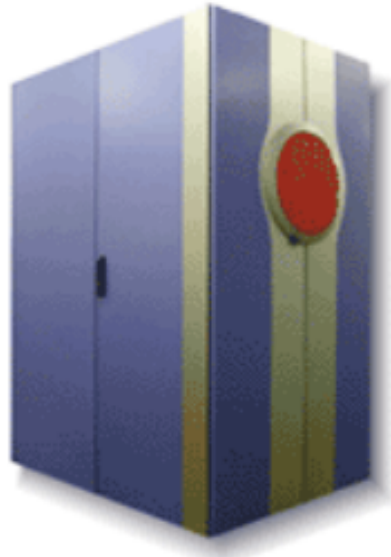
# The Earth Simulator



Node (8 CPU)

Crossbar switch

Magnetic Disks

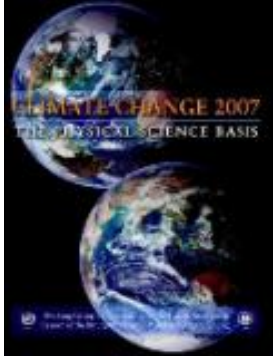
Nodes: 640
CPUs: 5120
Peak performance: 40 Tera flops

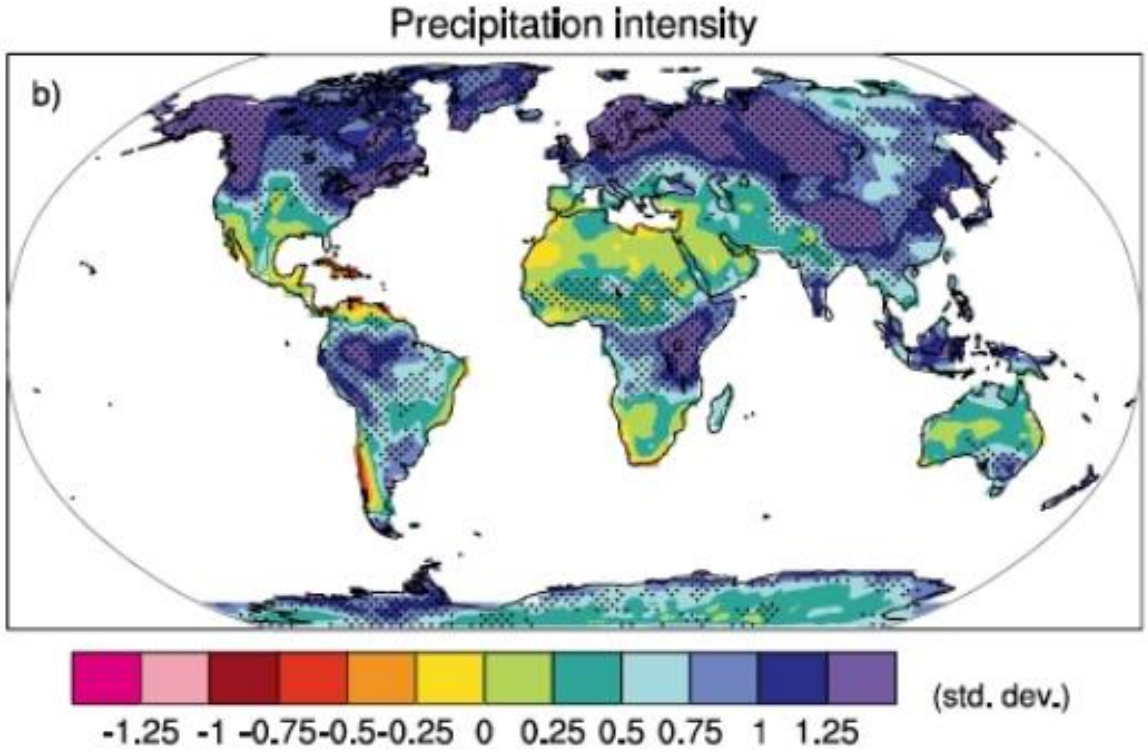
http://www.es.jamstec.go.jp/esc/jp/ES/index.html

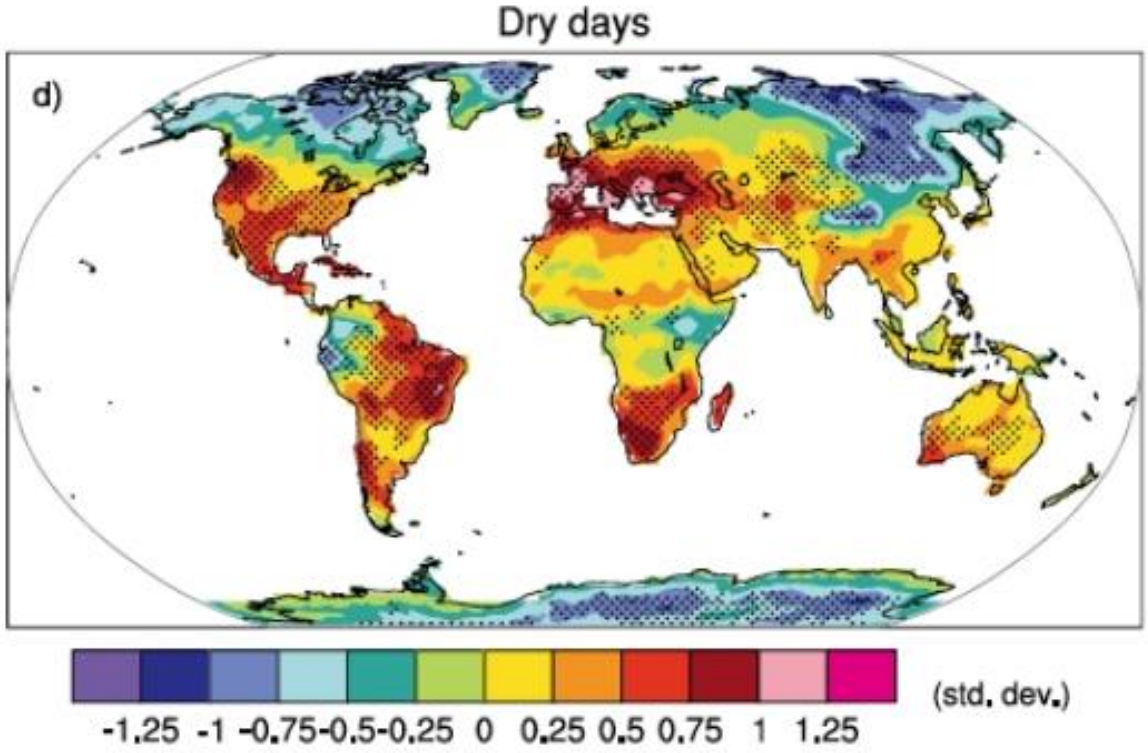
# Using the Earth Simulator

- Peak performance: 8 GFLOPS x 8 cpu x 640 nodes = 40 TFLOPS
- 4.3 %/year (~240,000 node hour) is allocated to the MRI group
- Costs: 380 Million Yen/year in my project
- MRI/JMA 20-km mesh AGCM
  - TL959(20km) with 60 layers
  - Uses 30 nodes of Earth Simulator
  - DT = 6 min
- Turnaround time integration:

IPCC AR4




# Projected changes extremes

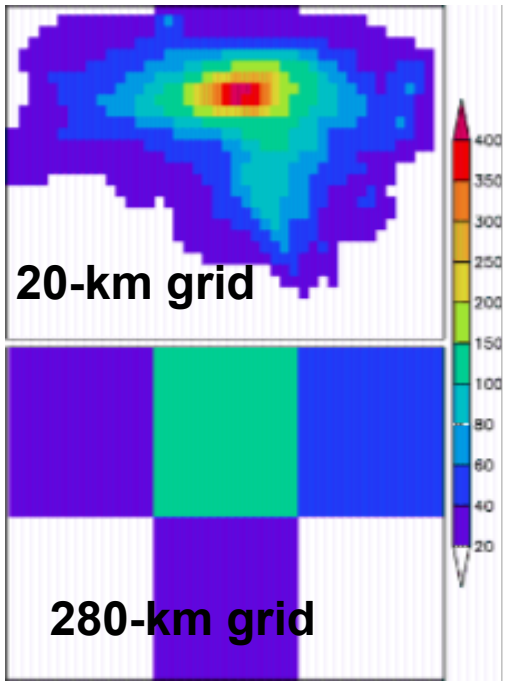
**Warming of day and night extreme temperatures is** virtually certain **.**

**It is** very likely **that heat waves and heavy precipitation events will continue to become more frequent.**

**Based on a range of models, it is** likely **that future tropical cyclones**

# Needs for High-Resolution Model

**Daily precipitation amount on certain day (mm/day)**




Extreme events are highly local phenomena

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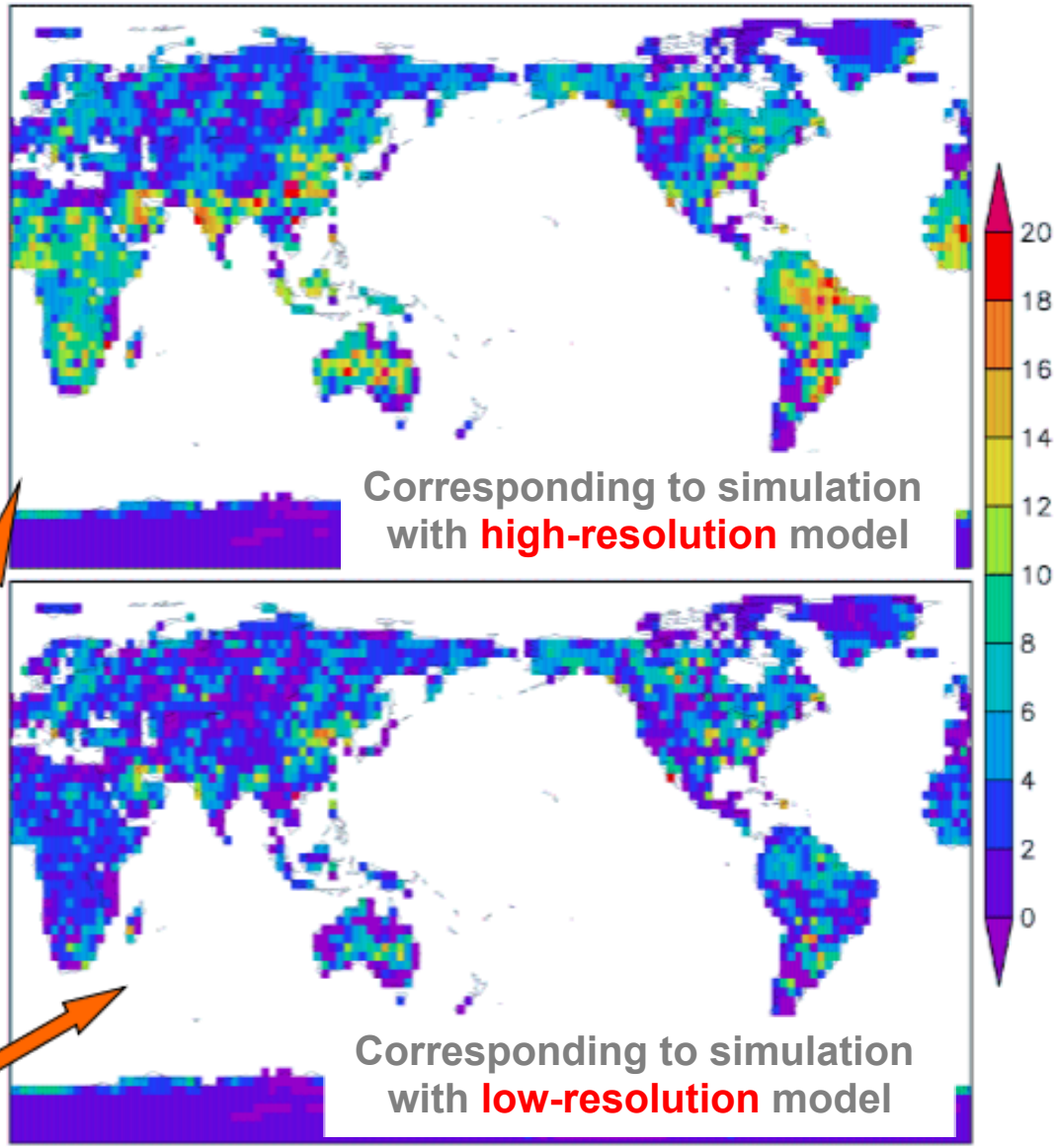
In the low-resolution model, heavy rain is smoothed out

**Future Change in the Annual Maximum Precipitation**
**Future – Present (mm/day)**



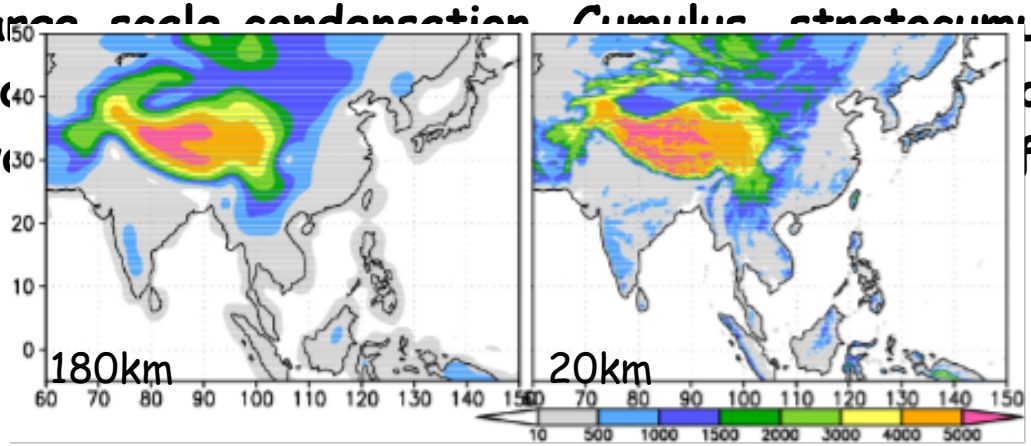

**Right upper** The annual maximum rain calculated by original 20-km mesh daily rain
To compare with the lower figure, the annual maximum rain is regridded to low resolution (280-km) grid

**Right lower** The annual maximum rain calculated by regridded daily rain, which is interpolated to 280-km gird from original 20-km grid
This can be considered as a proxy of low resolution model

**Change in precipitation extremes can not be captured well by low-resolution model**

# MRI/JMA Atmospheric GCM

- JMA : Operational global NWP model since Nov 2007
- MRI : Next generation climate model
- Resolution: TL959(20km) with 60 layers
- Time integration: Semi-Lagrangian Scheme (Yoshimura, 2004)
  2 days/1 year integration with DT=6 min and
  30 nodes of Earth Simulator (ES has total 640 nodes)
- Physics
  - SW radiation: Shibata & Uchiyama (1992)
  - LW radiation: Shibata & Aoki (1989)
  - Cumulus convection: Prognostic Arakawa-Schubert (Randall and Pan, 1993)
  - Land hydrology: MJ-SiB: SiB with 4 soil-layers and 3 snow-layers
  - Clouds: lar[illegible] [illegible] Cumulus, stratocumulus
  - PBL: Mell[illegible]
  - Gravity w[illegible]




This model will be used in MRI-CGCM3 and MRI-ESM after introducing additional physics and tuning.

# Time-slice experiments

Atmosphere-Ocean Couple Model, A1B Scenario

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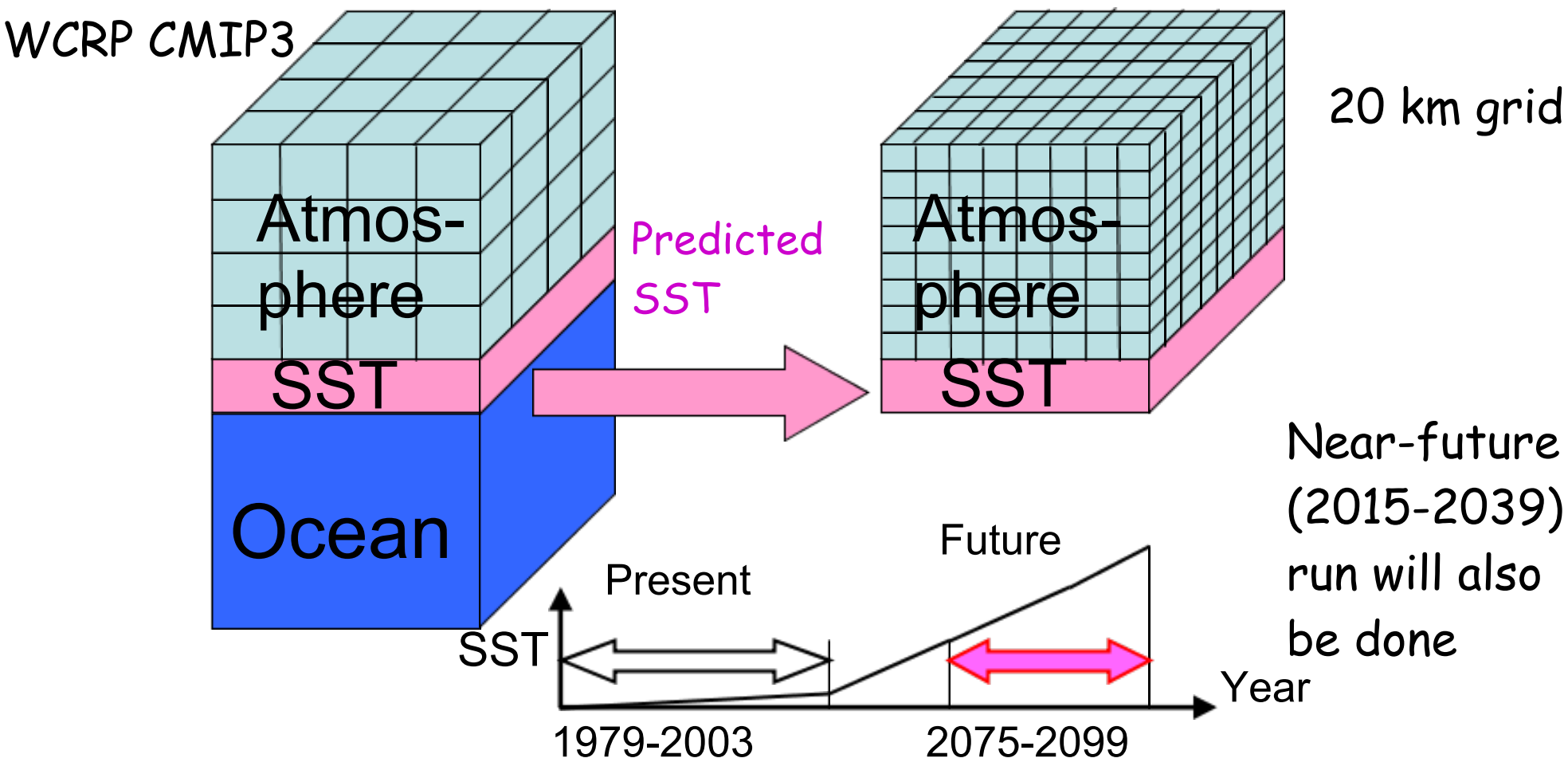
High resolution Atmosphere model experiment



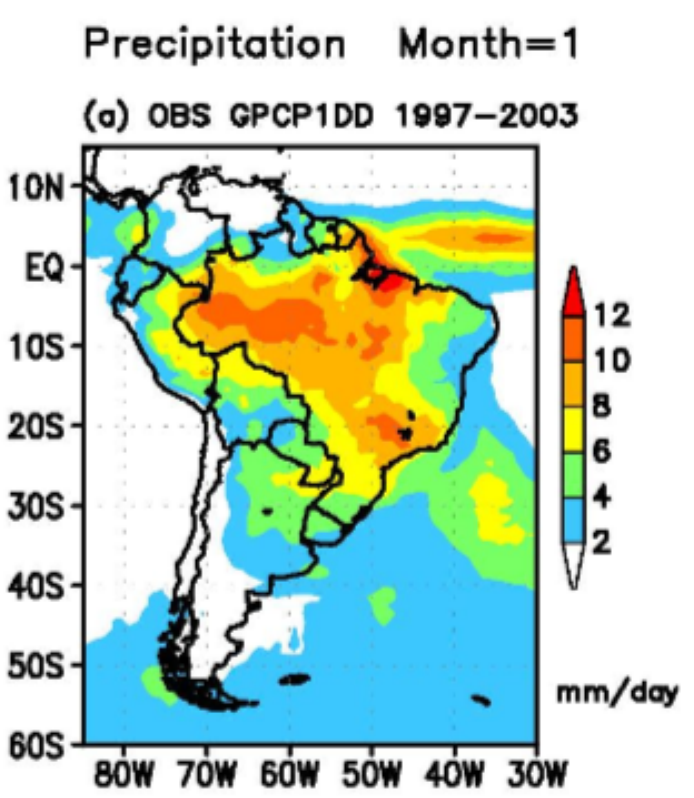
# Precip

## January

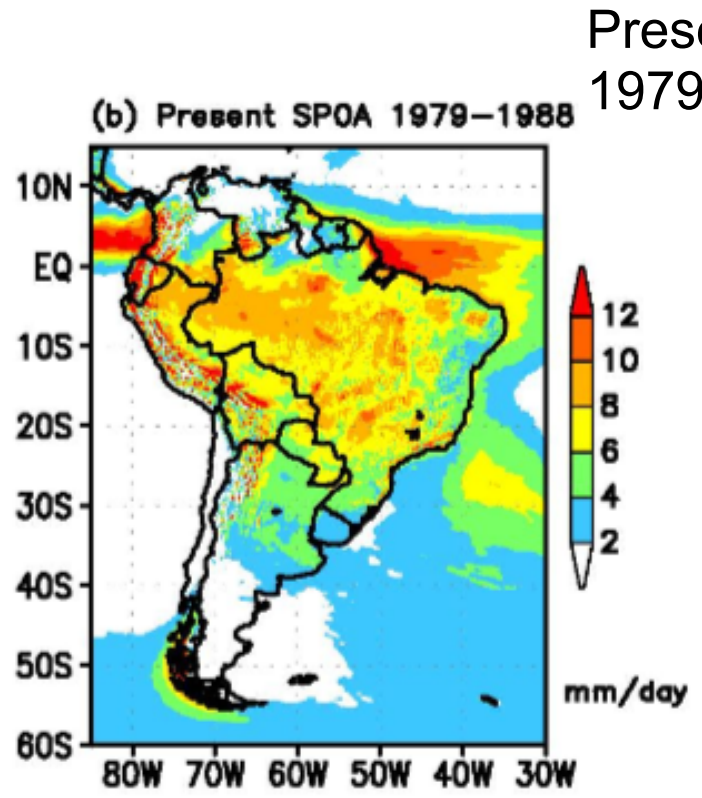
GPCP1.0
1997-2003

Future
2075-2084

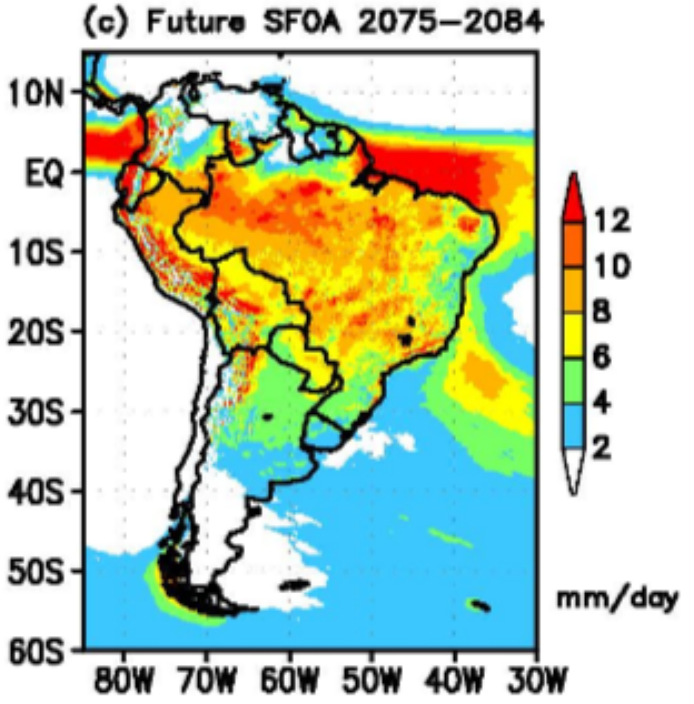
20km
model

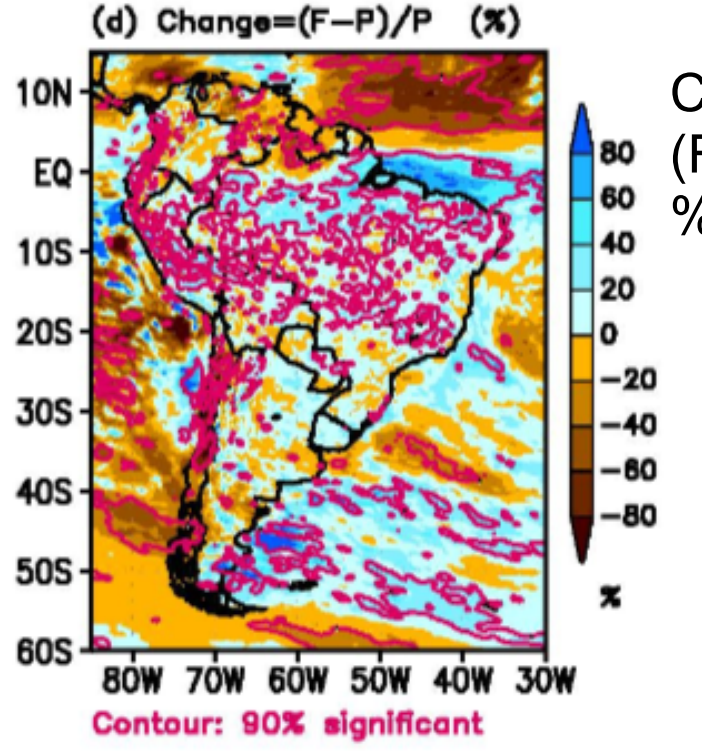



Present
1979-1988




20km
model




Change
(F-P)/P
%

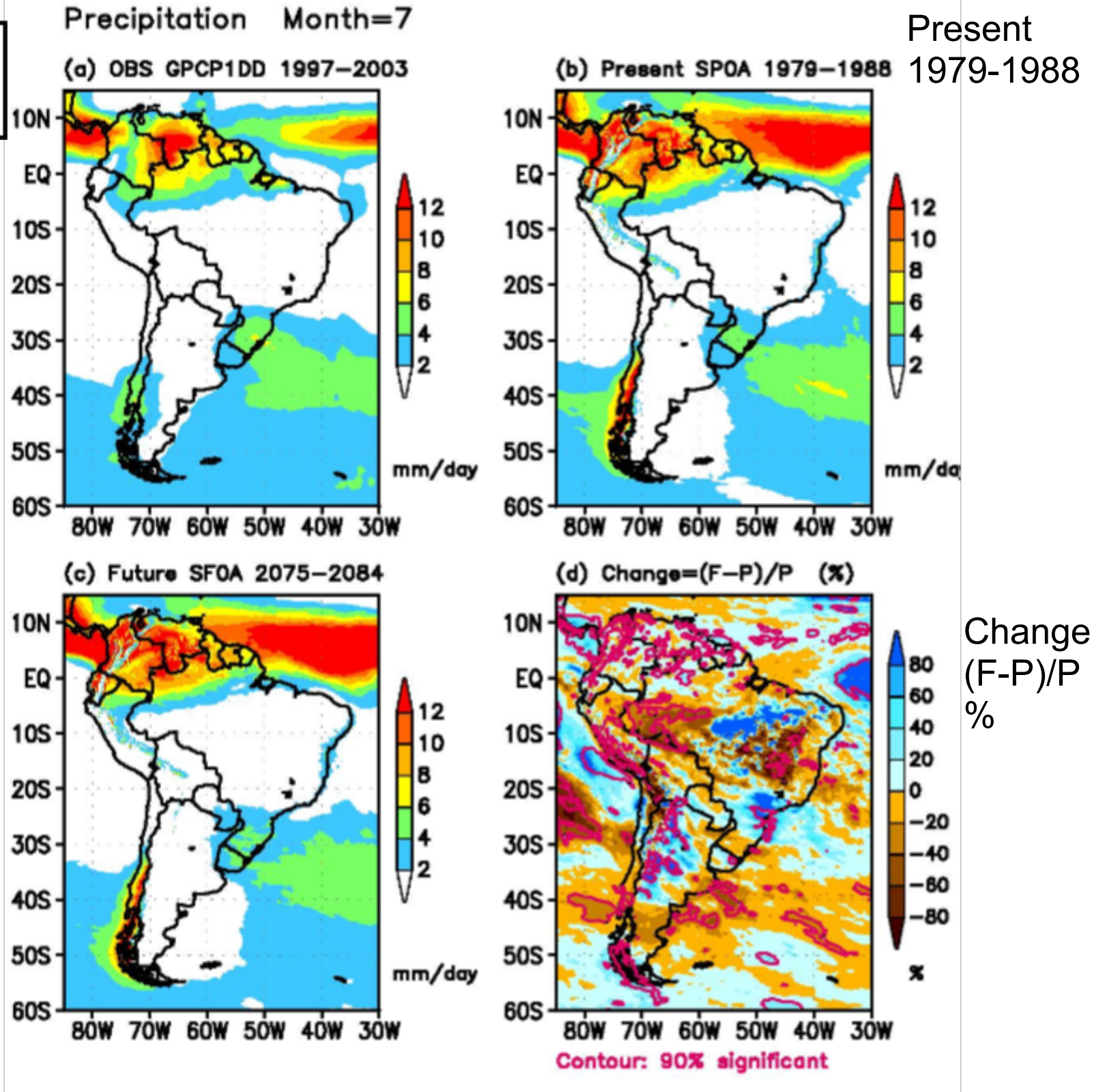
20km
model

# Precip

## July

GPCP1.0
1997-2003

Future
2075-2084




Present
1979-1988

Change
(F-P)/P
%

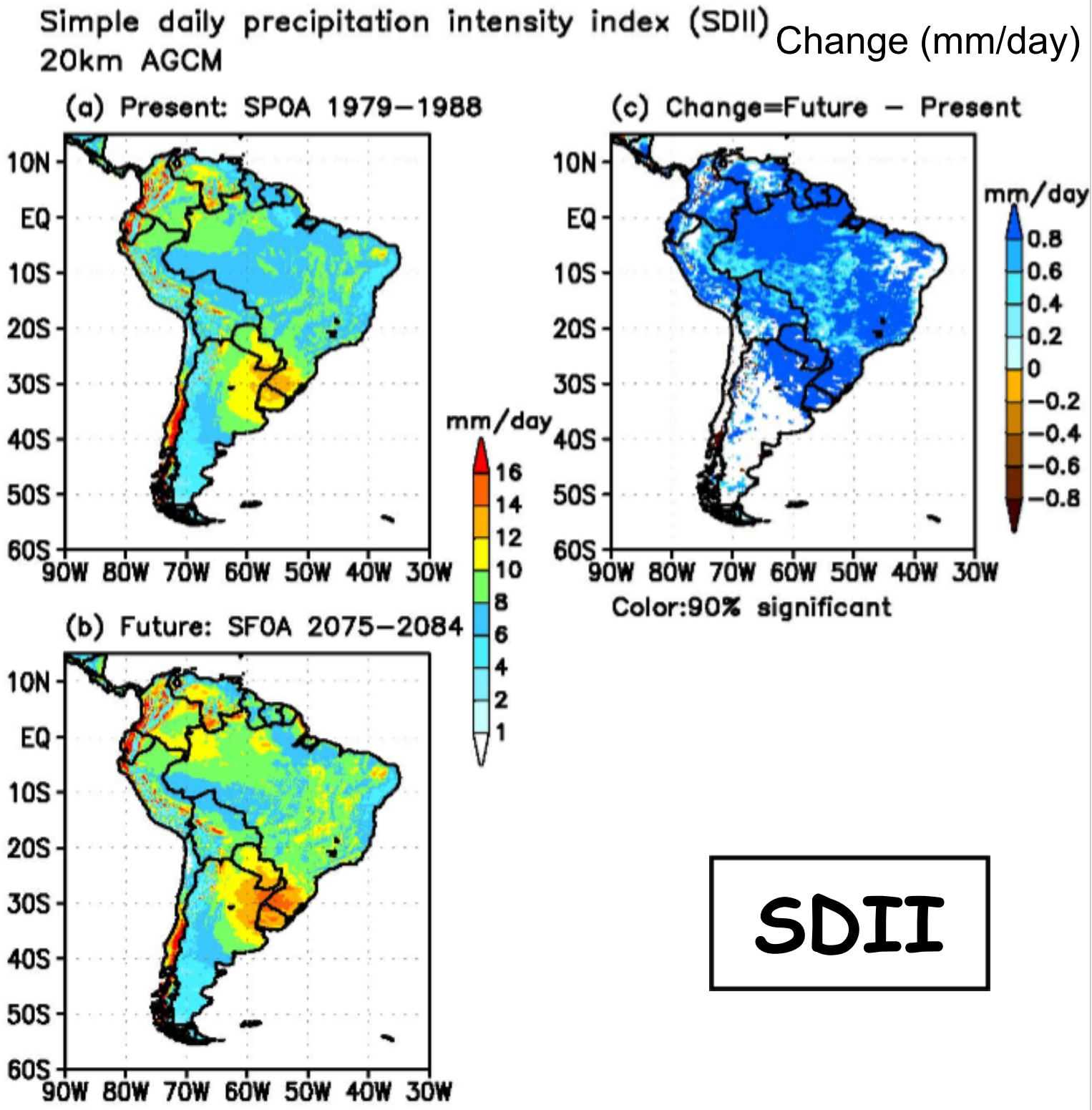
# Simple daily precipitation intensity index (SDII)

$$SDII = \frac{\text{Annual total precipitation}}{\text{Number of rain day}}$$

where "rain day": day of precipitation $\geqq$ 1 mm/day

Present
1979-1988

Future
2075-2084

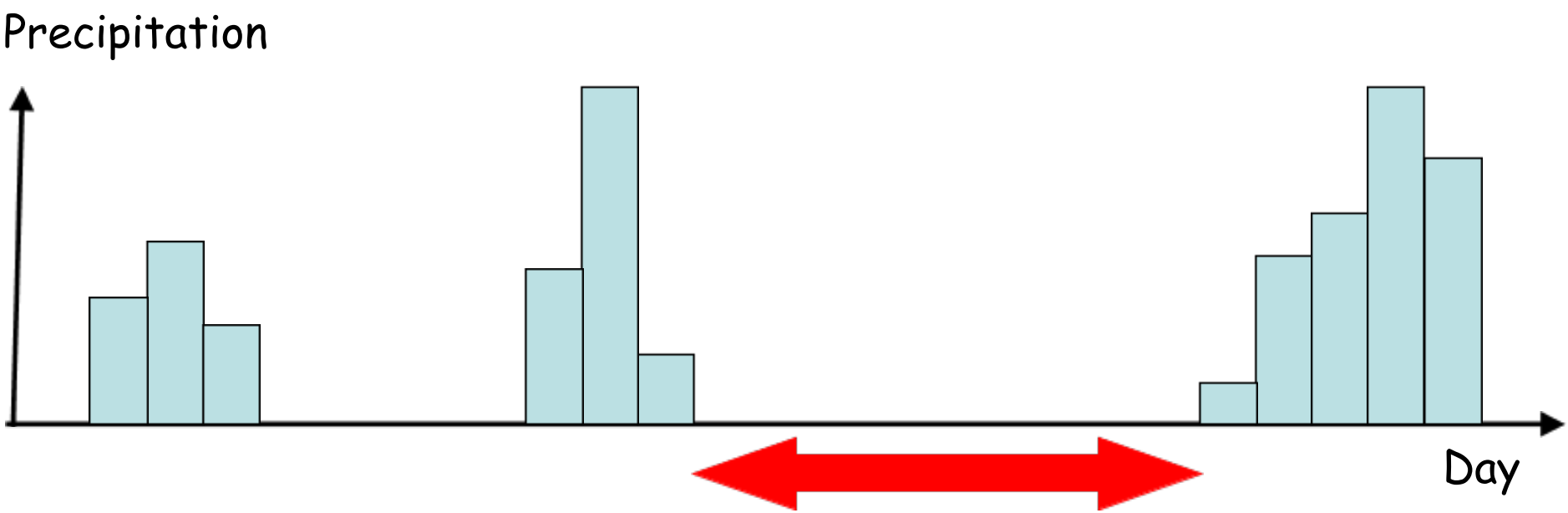



**SDII**

# Drought index

## Maximum number of consecutive dry days (CDD)

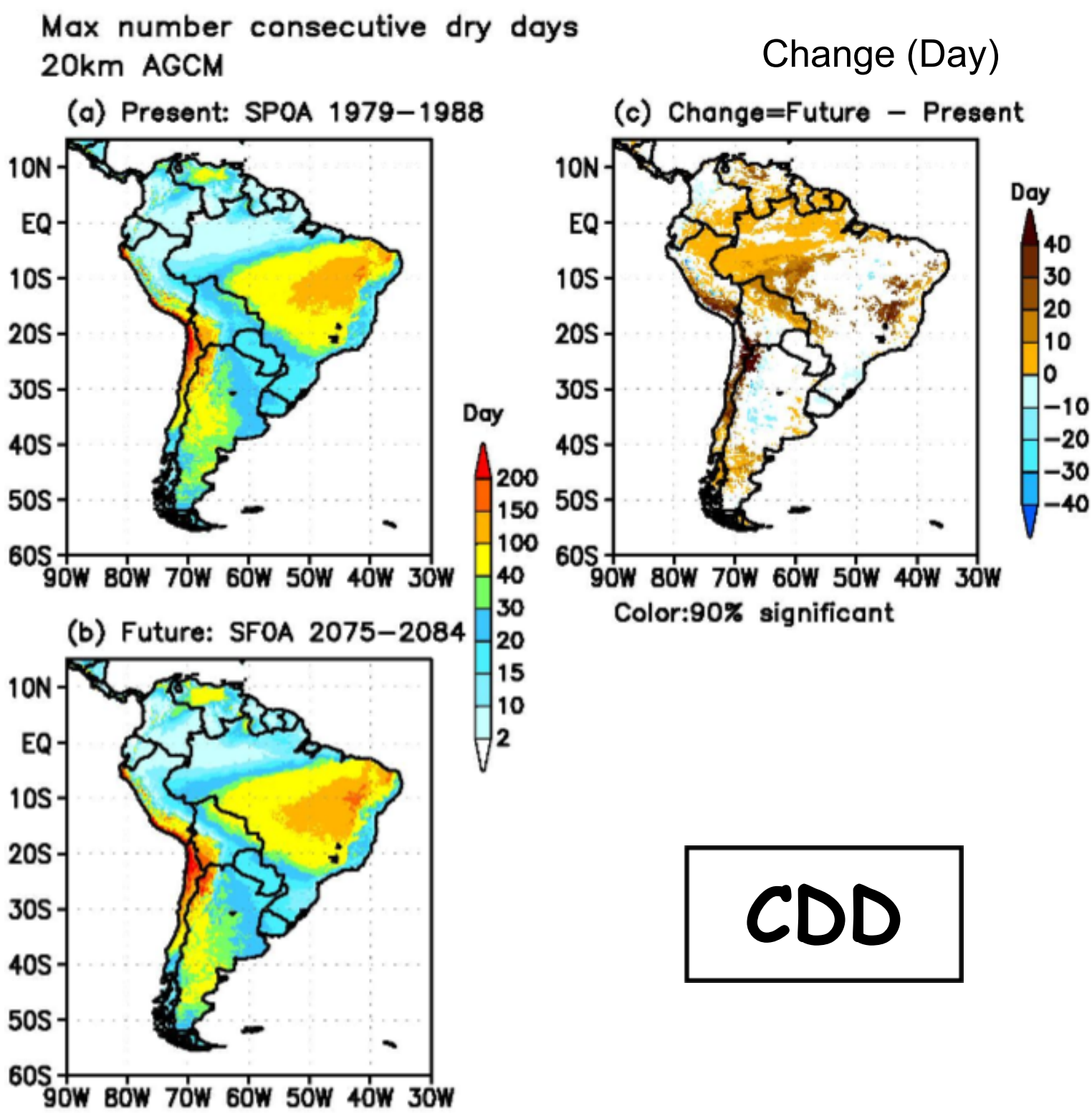
where "dry day": day of precipitation < 1 mm/day



Present
1979-1988

Future
2075-2084

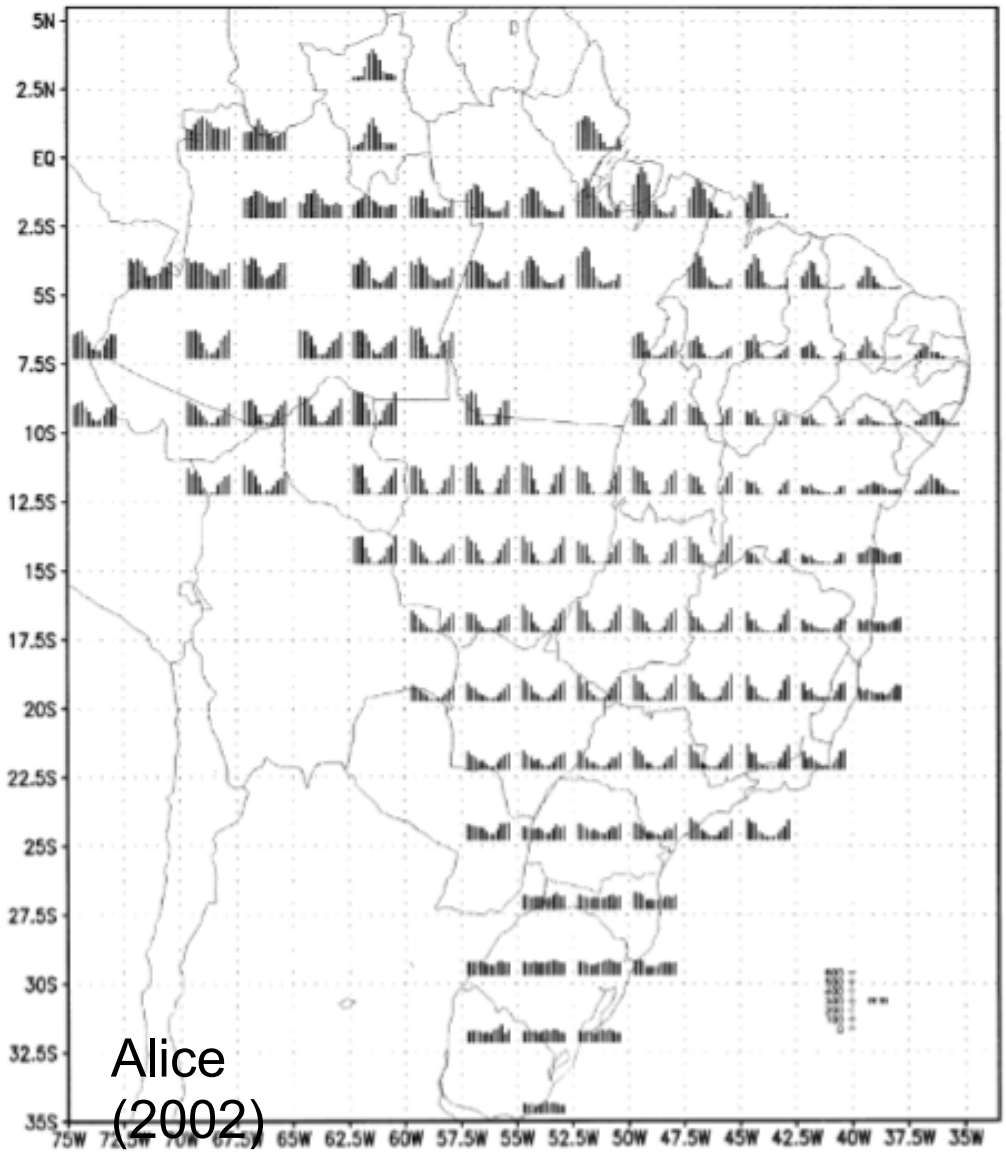
Change (Day)




CDD

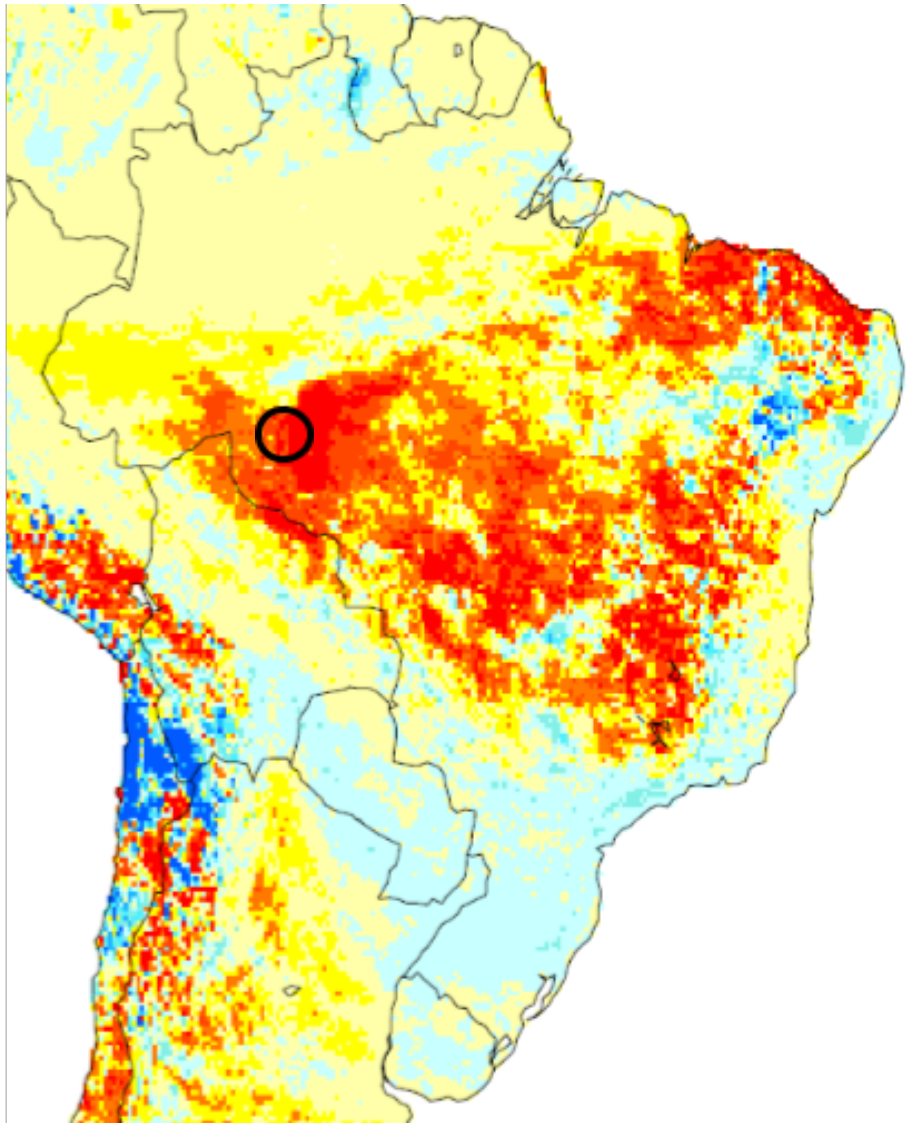
# Large CDD change over the central and western Amazon

Annual precipitation cycle, averaged 2.5x2.5 boxes, for the period 1956-1992



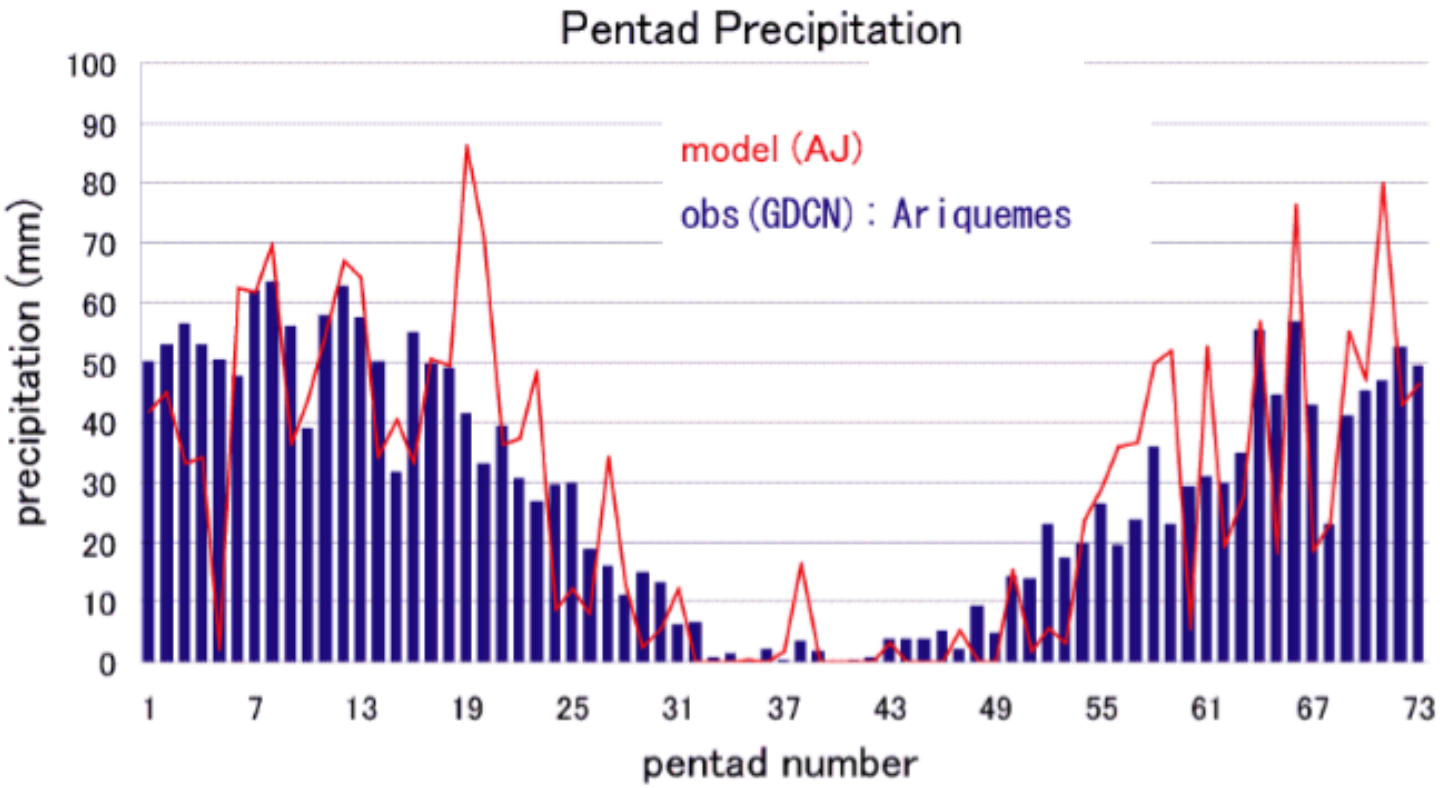

Alice (2002)

CDD change (F-P)



○ Ariquemes; 63W, 10S

# Pentad precipitation over Amazon (Ariquemes 63W 10S)

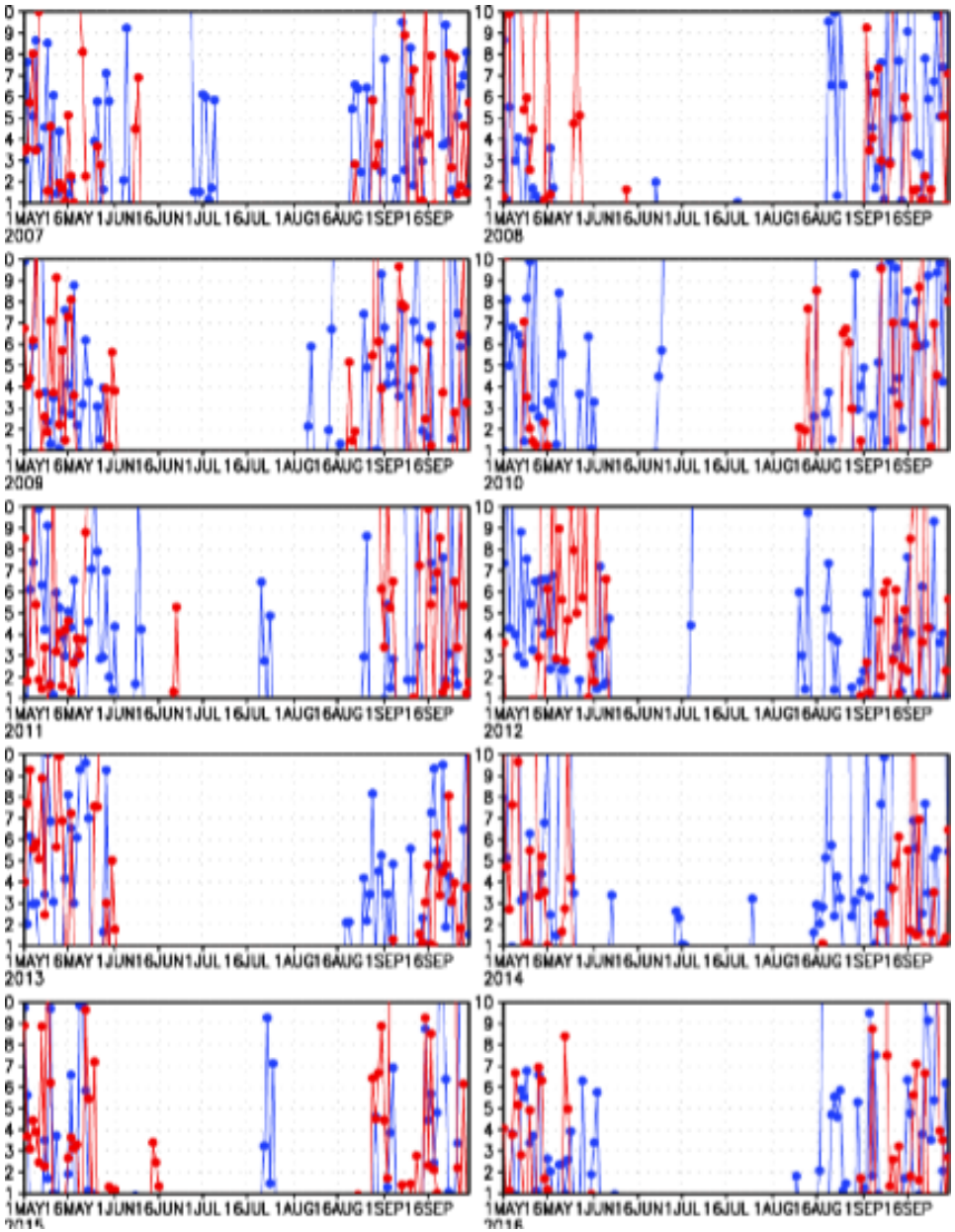



- 10-year model average for the present-day simulation
- GDCN 23-year average for 1975-1997

- Some rain in dry season both in observation and GCM

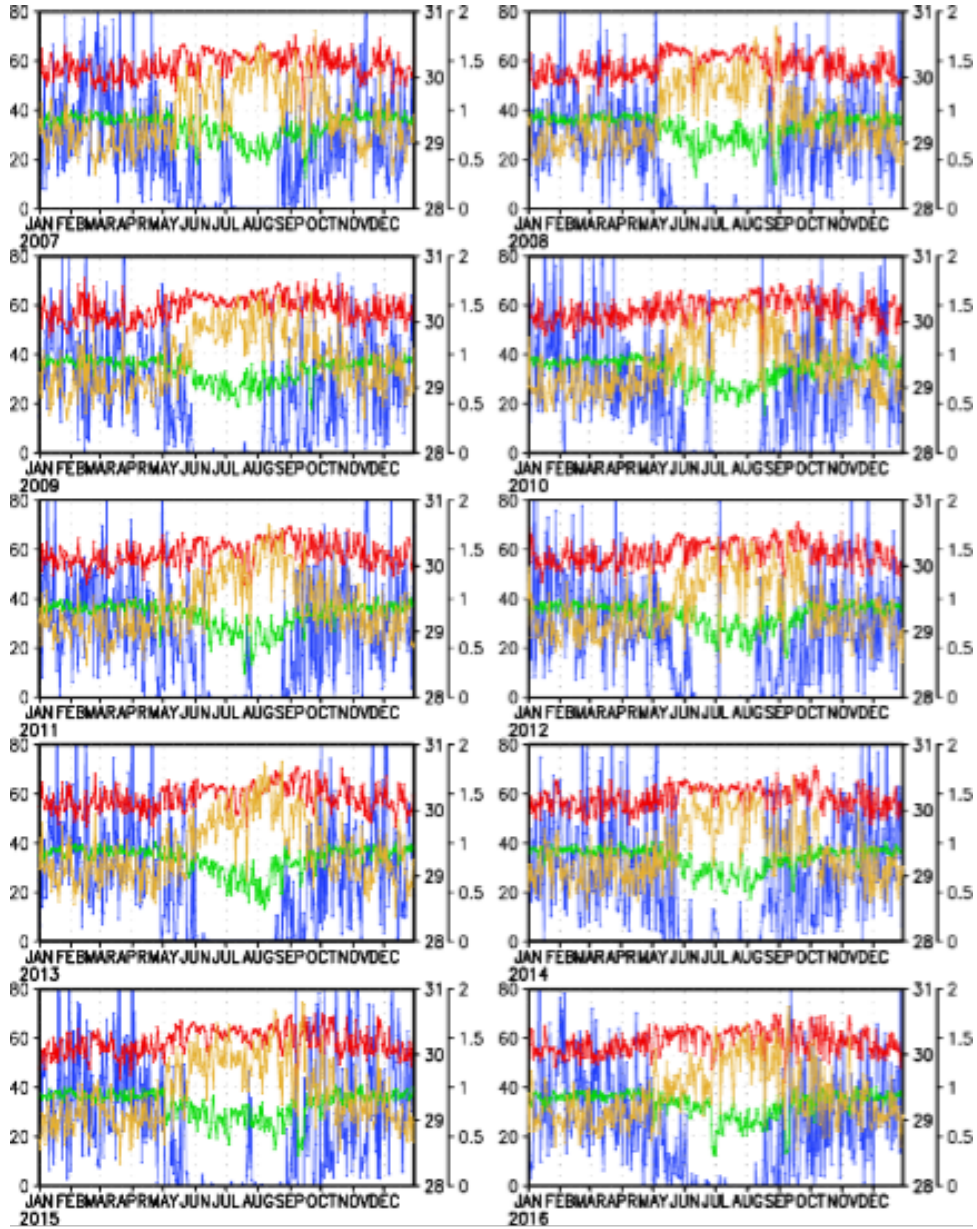
# 10-year data over Amzaon (Ariquemes)

Daily precipitation: present vs future




Present-day simulation

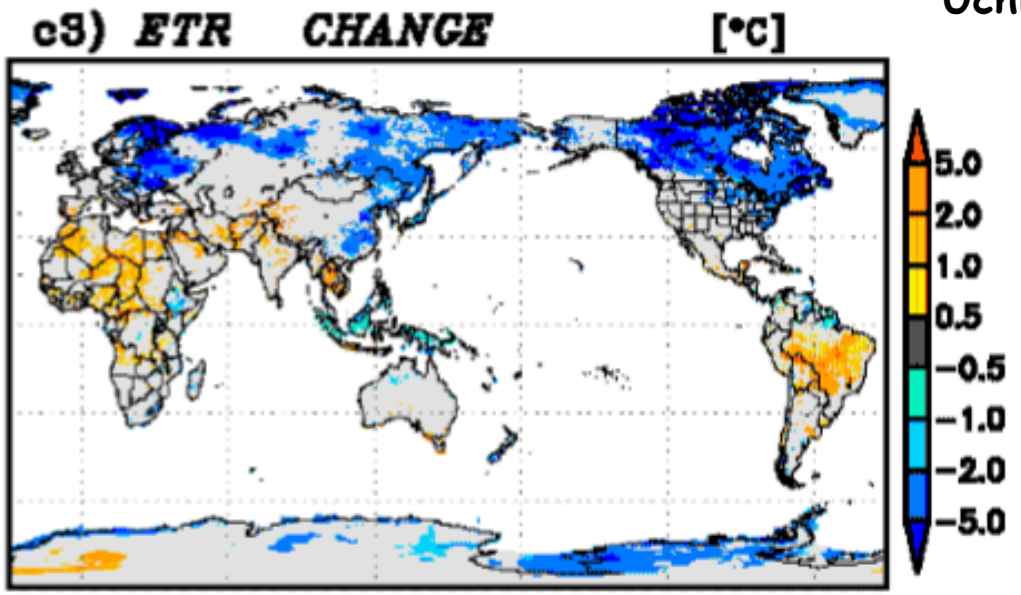
Daily precipitation maximum temperature minimum temperature diurnal temperature range



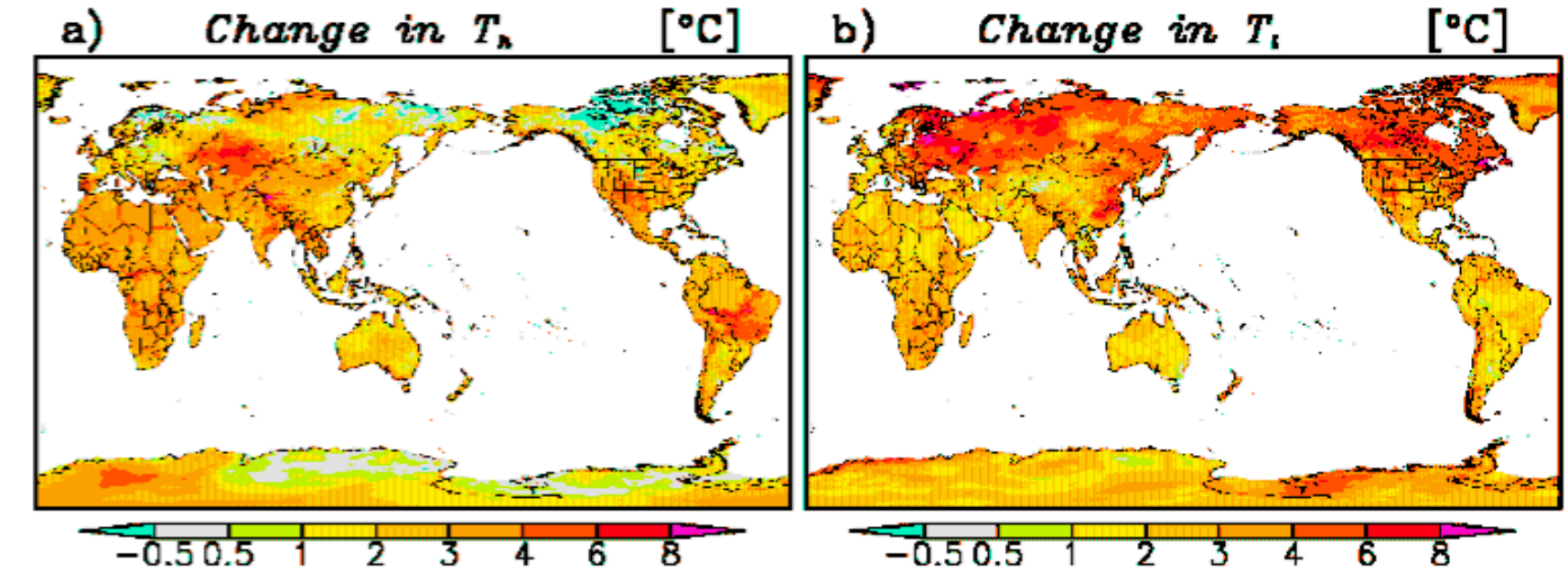

Intermittent rain in dry season stops in the future climate

# Extremes indices on temperature

**Uchiyama et al. (2006) SOLA**

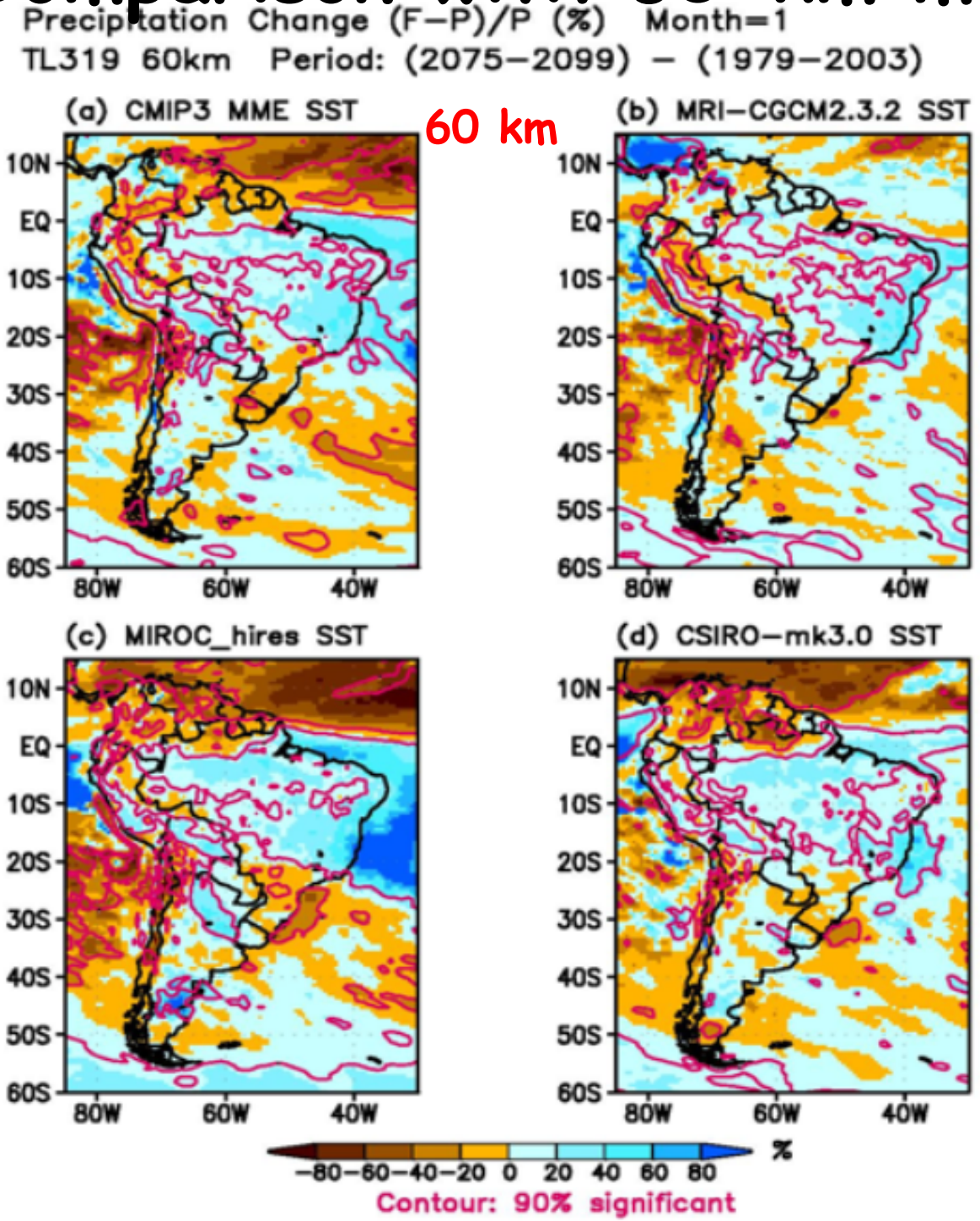


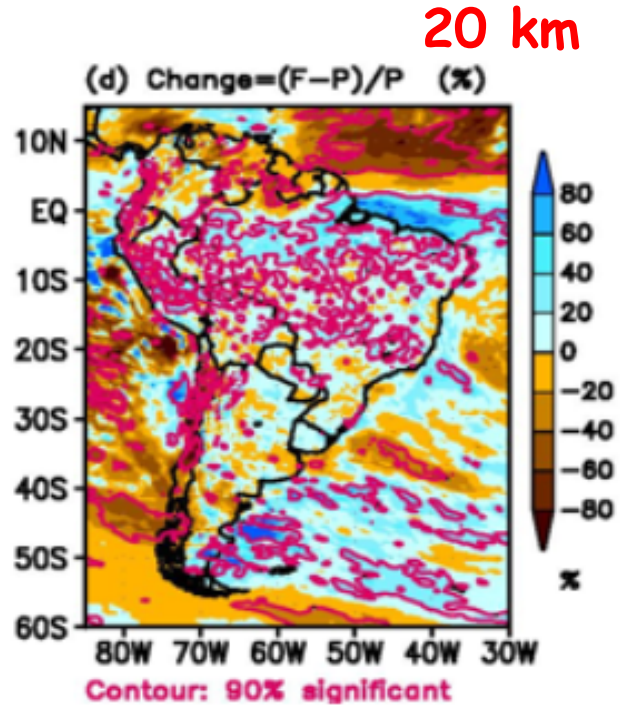

ETR
(Intra-annual extreme temperature range)




ETR increases over Amazon due to increase in Tmax

# Comparison with 60-km mesh model results




- consistent between 20km and 60km models
- robust among different SSTs used

> to be used for quantifying uncertainty

# Acknowledgements


This study was conducted as a part of research theme "Projection of the change in the future weather extremes using super-high-resolution atmospheric models" under the framework of the Innovative Program of Climate Change Projection for the 21st Century (KAKUSHIN), funded by the Ministry of Education, Culture , Sports, Science and Technology (MEXT). The KAKUSHIN program is a 5-year research program started in April 2007. This is also a part of collaboration work between MRI and World Bank.