Developing Climate Change Downscaling Projection Products over the Malaysia regions

Liew Juneng & Fredolin T. Tangang

Universiti Kebangsaan Malaysia

Outline

- Introduction (General climate simulation activities in Malaysia)
- Downscaling Activities at Climate and Ocean Analysis Laboratory (COAL) UKM.
- Issues on RCM output and bias correction.
- Other climate downscaling studies.
- Currently computing facilities we have access to and on going projects.

Climate simulation (projection) activities in Malaysia

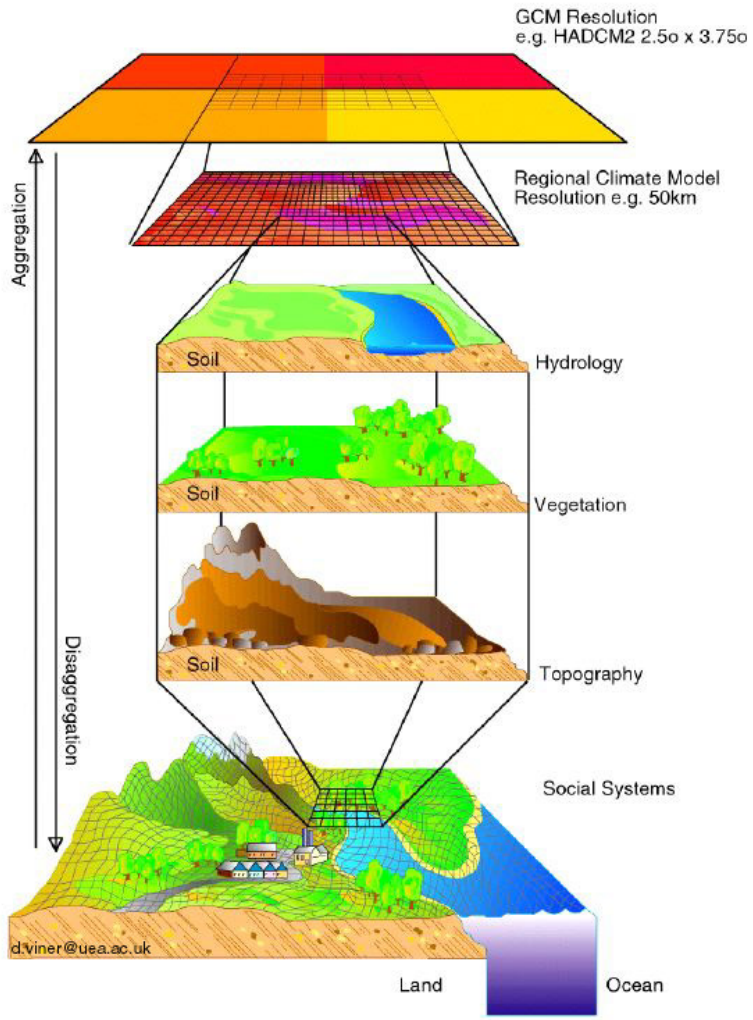
- Malaysian Meteorological Department (MMD)
  - UKMO's PRECIS
- National Hydraulic Research Institute Malaysia (NAHRIM)
  - UKMO's PRECIS
  - RegHCM-PM
- Universiti Kebangsaan Malaysia (UKM)
  - UKMO's PRECIS
  - RegCM4
  - WRF
  - statistical methods.
- University Technology Malaysia
  - statistical approaches

Downscaling Activities at Climate and Ocean Analysis Laboratory (COAL) UKM.

- Two categories of approaches

  (i) dynamical/numerical approaches (Regional Climate Models)

  (ii) statistical/empirical approaches.



Dynamical vs. Statistical Approaches

Statistical	Dynamical
Computationally cheap.	Climate response to physically consistent processes.
Can be used to derive variables not in the RCM.	Fine resolution information anywhere within the model domain.
Required long and reliable observations.	Computationally extensive
Non guaranteed stationary of the predictor-predictand relationship	Strongly dependent on the GCM boundary forcings.
No climate system feedback	RCM climate drift.
Inherit GCM biases.	RCM biases.

Modified from Fowler et al (2007)

- In COAL UKM, we explore both approaches

Numerical/Dynamical methods

- UKMO's PRECIS
- Princeton Ocean Model
- RegCM4 and WRF

Statistical Methods

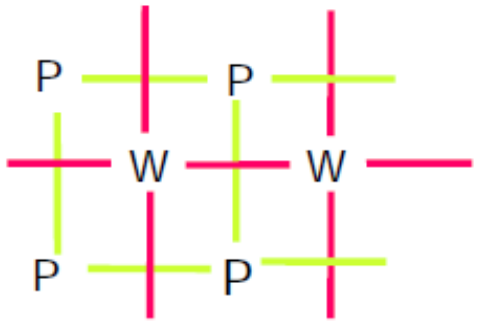
- canonical correlation analysis
- nonhomogenous hidden Markov model

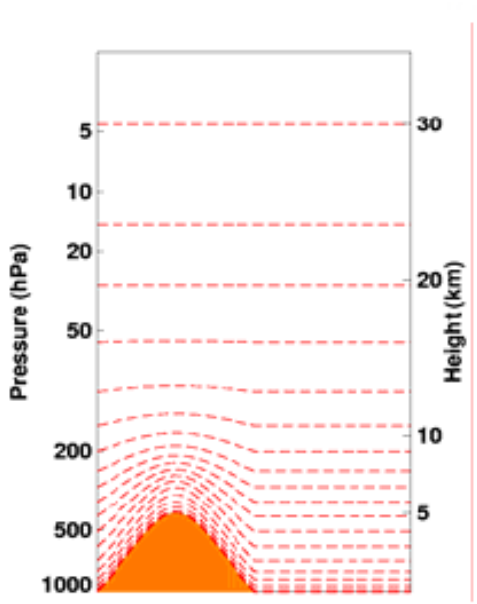
PRECIS

- The RCM used in the PRECIS system – HadRCM3P.
- It has a hydrostatic dynamical core that simulates the advective and thermodynamical evolution of atmospheric prognostic variables.
- Also incorporating effects of various important processes.
  - Radiation
  - Atmospheric aerosol
  - Boundary Layer
  - Gravity wave drag
  - Land surface
  - Clouds and precipitation

Spatial Descritization

- Rotated grid with Mercator projection.
- Horizontal: Arakawa-B.
- Vertical: Hybrid coordinate system
- Time step: ~2.5 minute (for 0.22°×0.22°)





Last 3 top layers: pure pressure

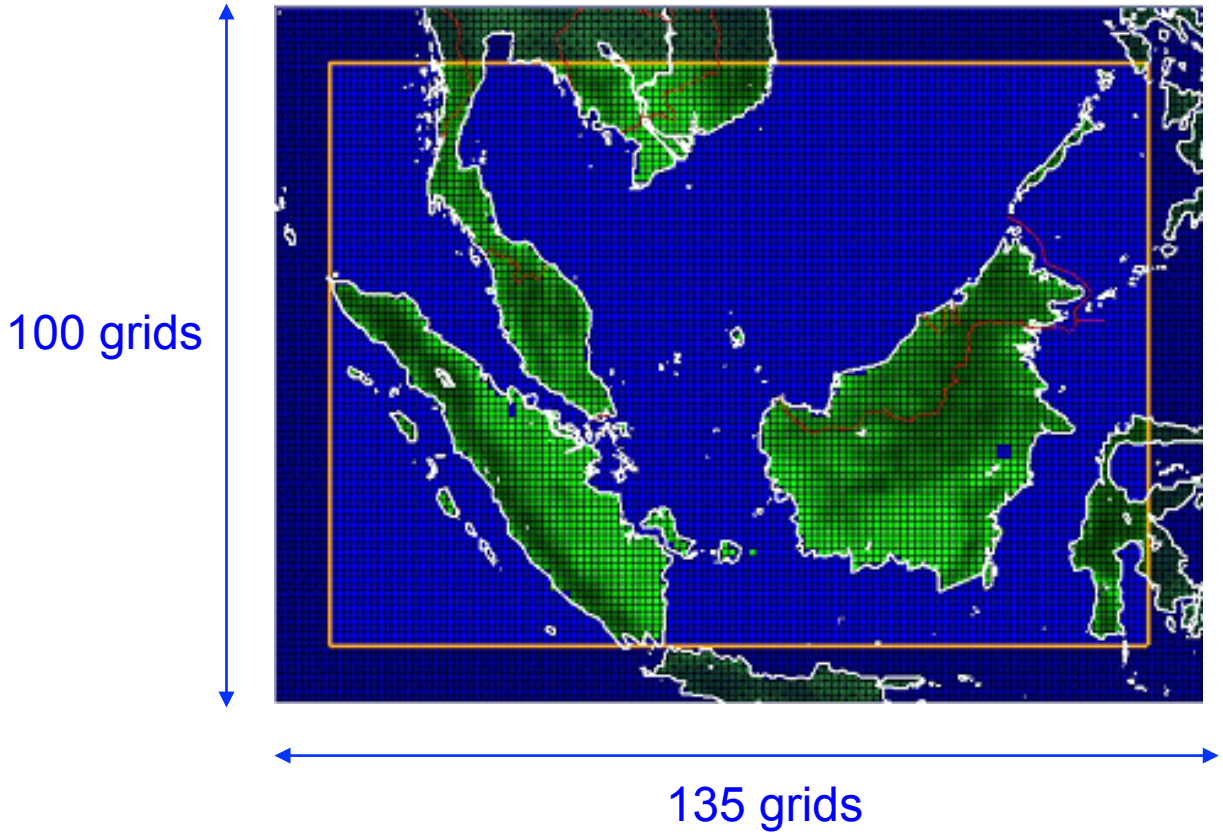
Linear combination of the two

First 4 bottom layers: pure σ

A total of 19 layers

PRECIS Setup

- Domain: ~25x25km, 19 vertical hybrid coordinates.



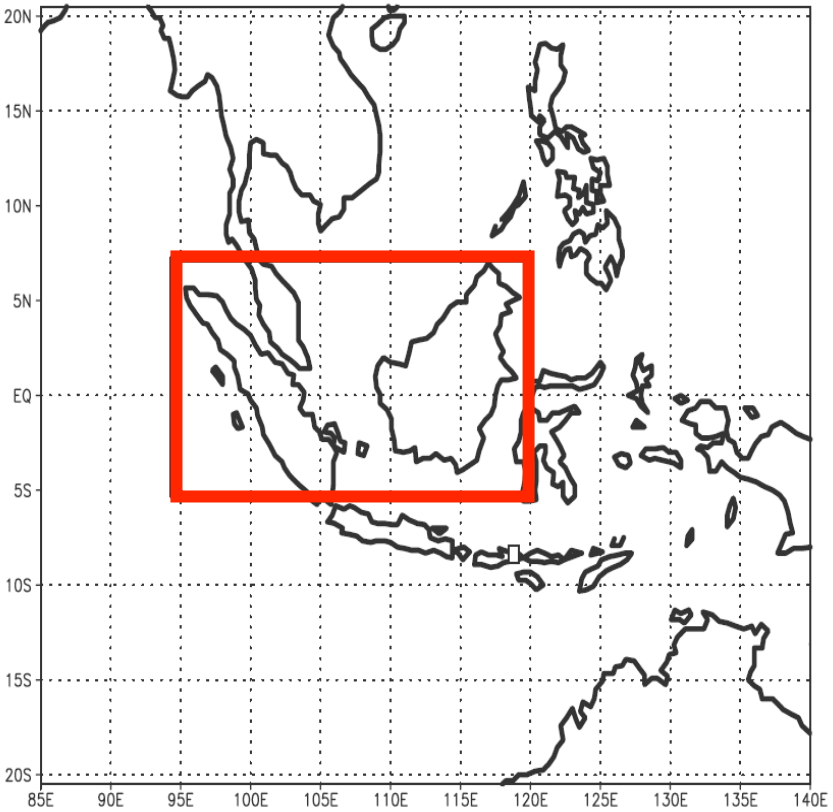
Completed Experiments (Boundary conditions)

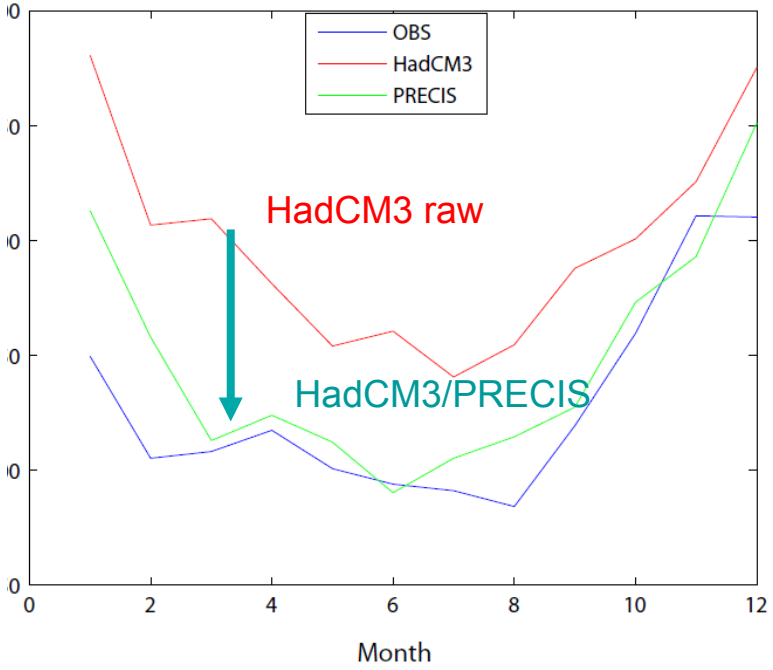
- ERA 40 (1969-2000)
- HadAM3P baseline (1965-1990)
- HadAM3P A2 (2070-2100)
- HadAM3P B2 (2070-2010)
- HadCM3 A1B (1969-2100)
- ECHAM5 A1B (1969-2100)

Analyzed

- Archived output resolutions: Daily/Monthly

PRECIS performance (HadCM3)



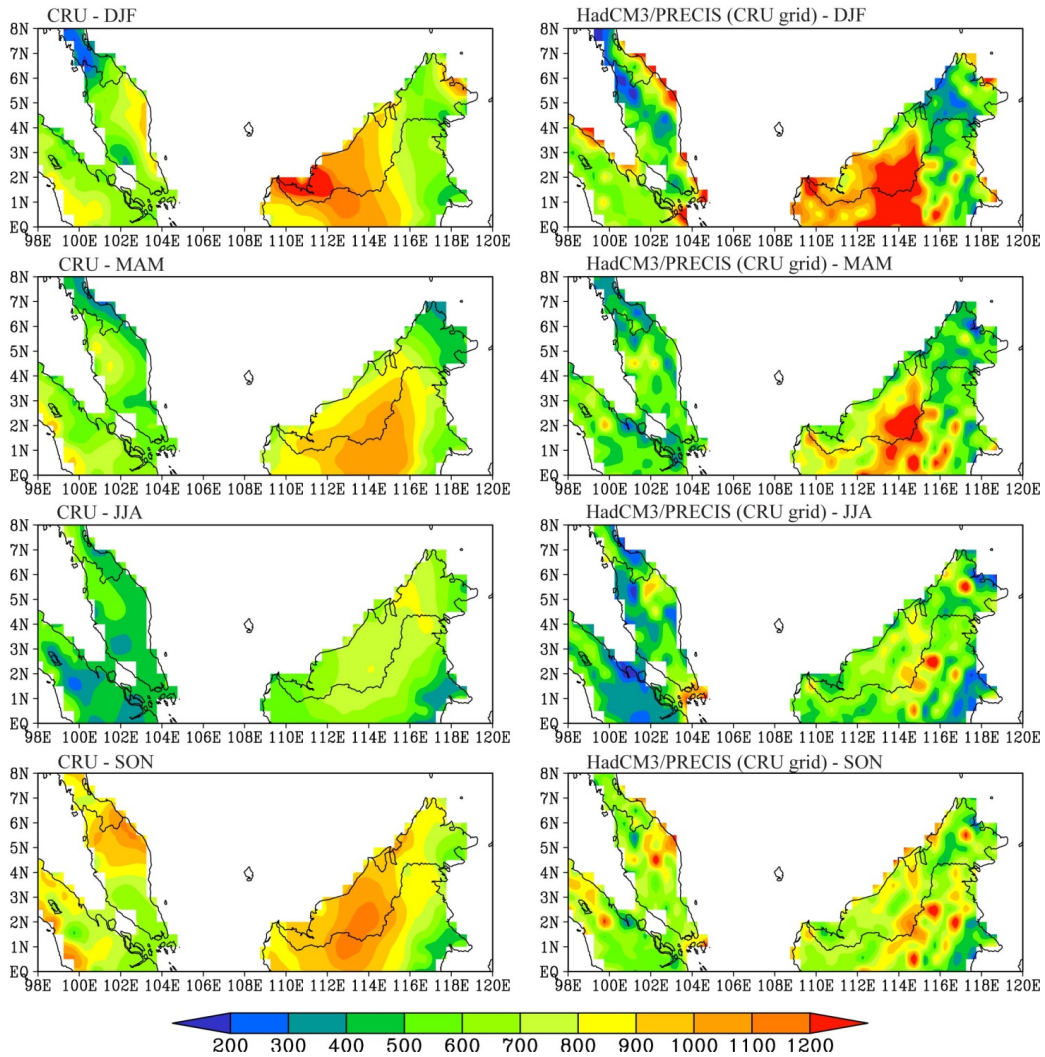


- The downscaling corrected the biases in the GCM simulation.

Spatial/seasonal variations of the simulation performance (historical climate)

Obs. (CRU)

HadCM3/PRECIS

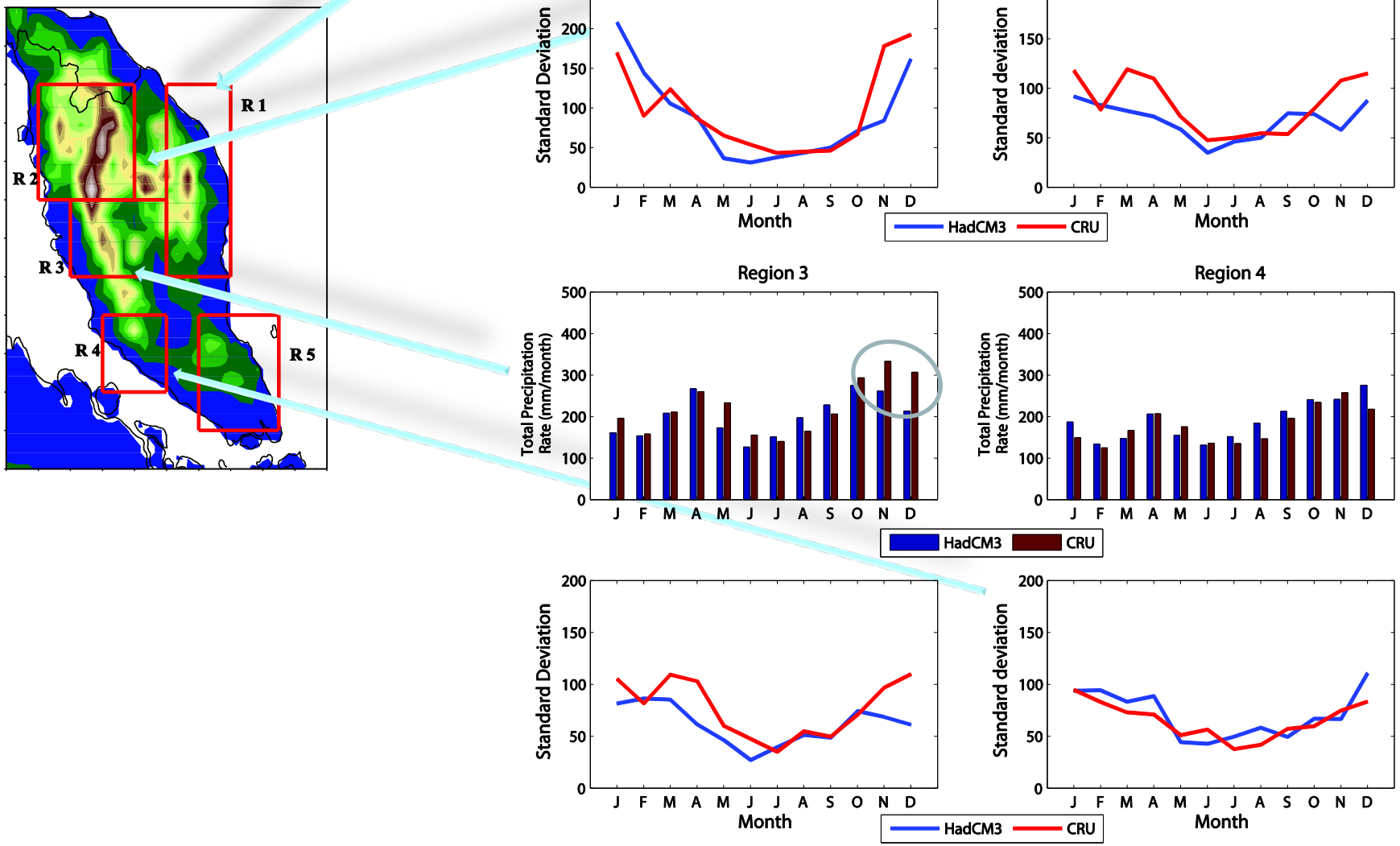


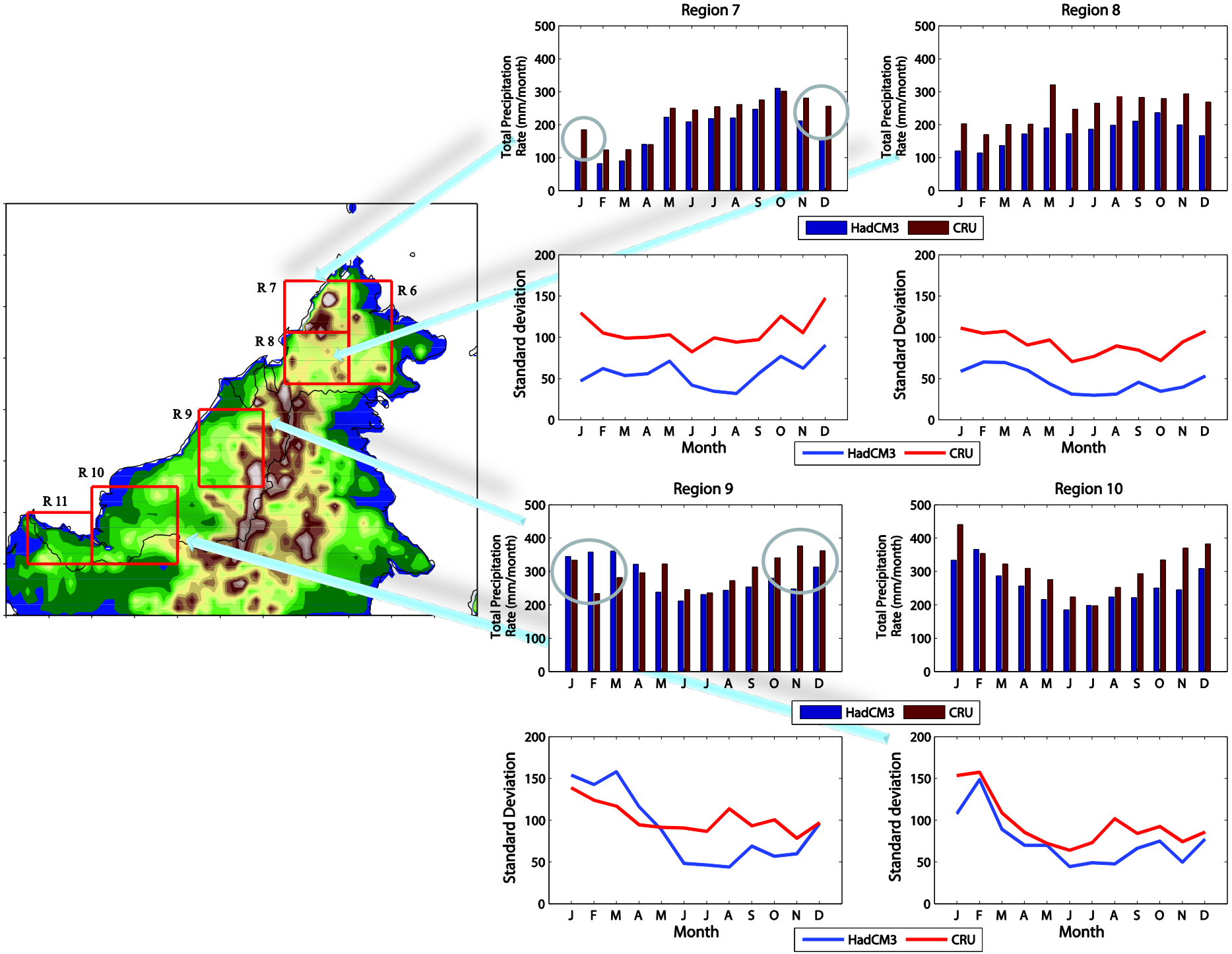
Dec-Jan-Feb

Mar-Apr-May

Jun-Jul-Aug

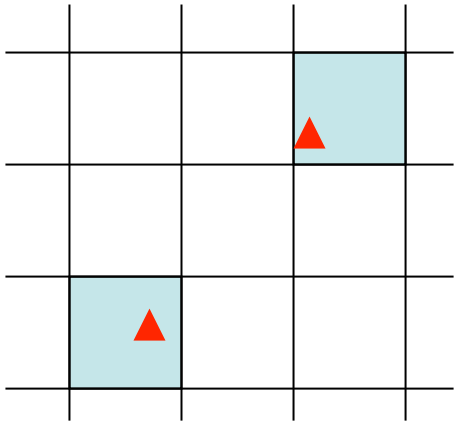
Sep-Oct-Nov


R 1
R 2
R 3
R 4
R 5
Region 1
Region 2
Region 3
Region 4
Total Precipitation Rate (mm/month)
Standard Deviation
Standard deviation
Month
J F M A M J J A S O N D
HadCM3
CRU

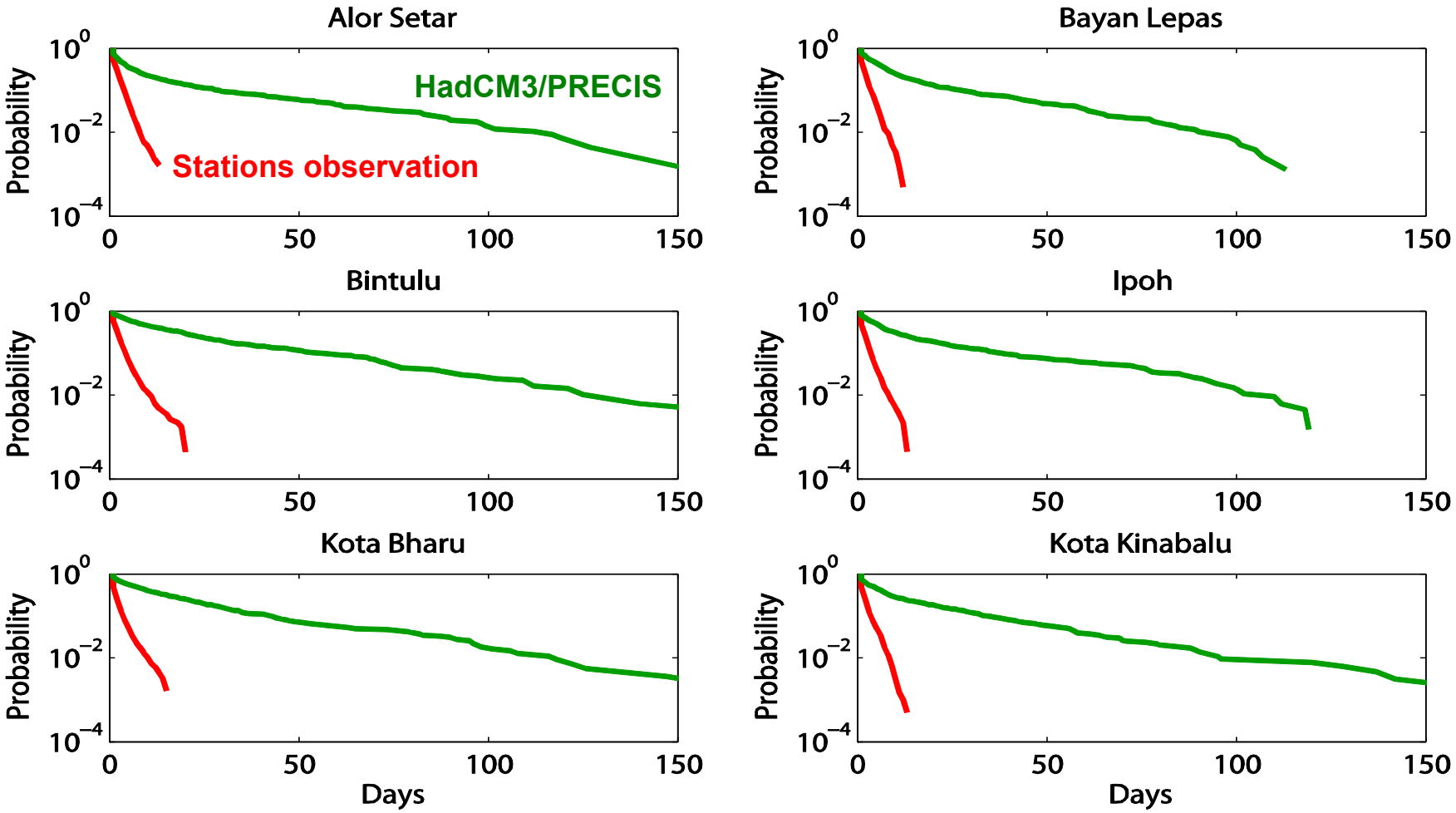

R 7
R 6
R 8
R 9
R 10
R 11
Region 7
Region 8
Region 9
Region 10
Total Precipitation Rate (mm/month)
Standard deviation
Standard Deviation
Month
J F M A M J J A S O N D
0 100 200 300 400 500
0 50 100 150 200
HadCM3
CRU

Remarks

- PRECIS/HadCM3 - good performance in simulating the seasonal rainfall (with identified negative biases during winter monsoon).
- How about other aspects of rainfall?
  - Extreme rainfall characteristics
  - Rainfall intensity
  - Dry/Well spell characteristics.
- Most RCM has difficulties in getting the daily values correct – large implication in downstream hydrological applications.
  - RCM produces grid averaged values.

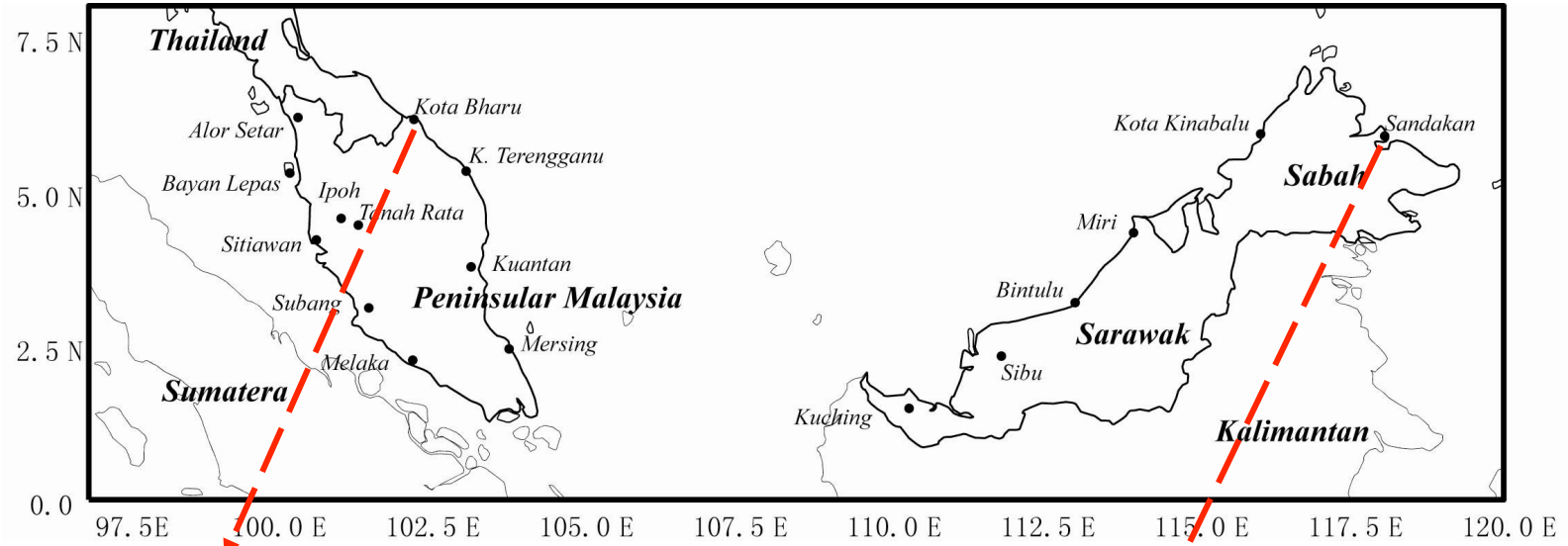


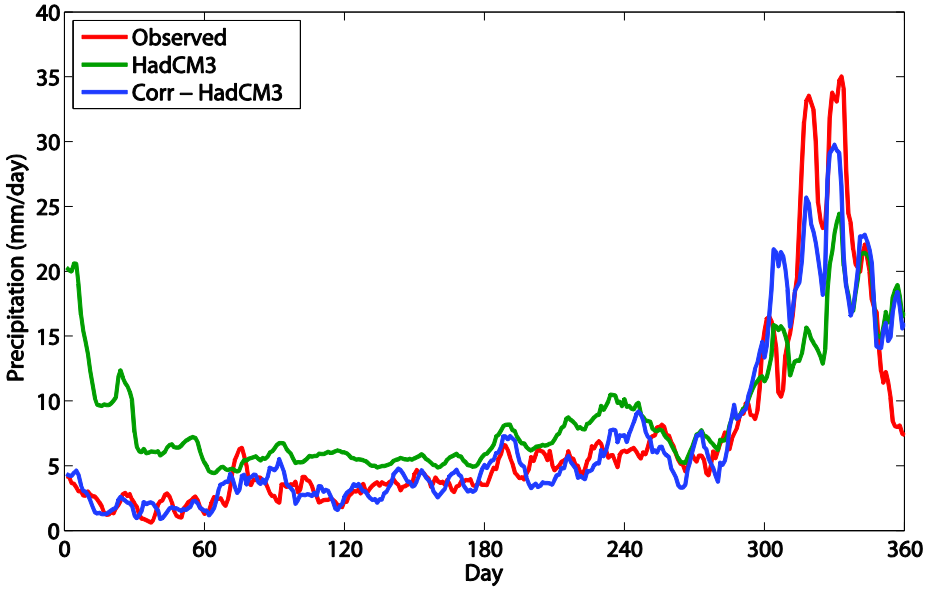
- RCM gridded simulation values are incomparable to station data.
- Always produces lesser daily rainfall but more rain days.
- Examples:

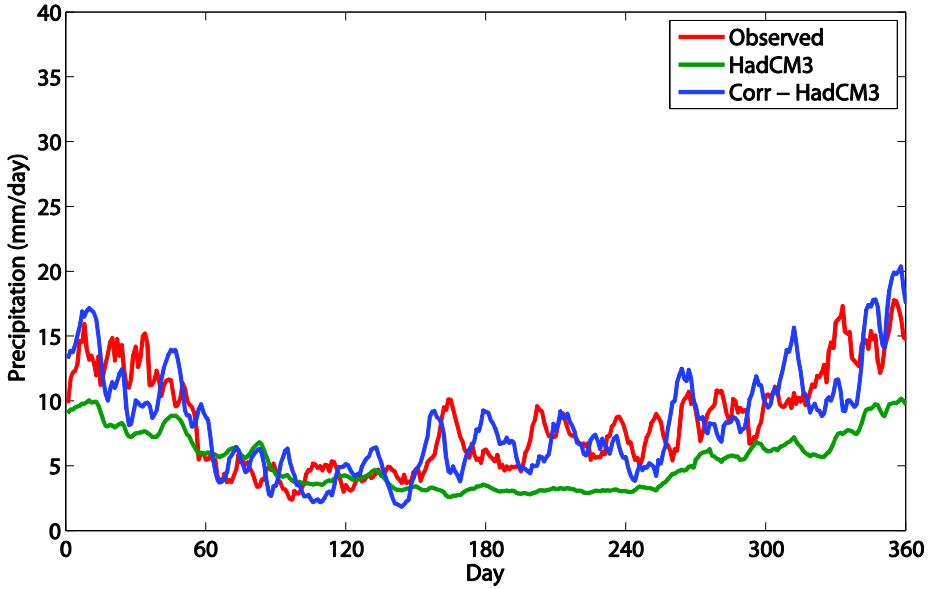


Probability of wet spell longer than n days
(HadCM3/PRECIS vs. stations data)

LOCAL STATION (DAILY PRECIPITATION)

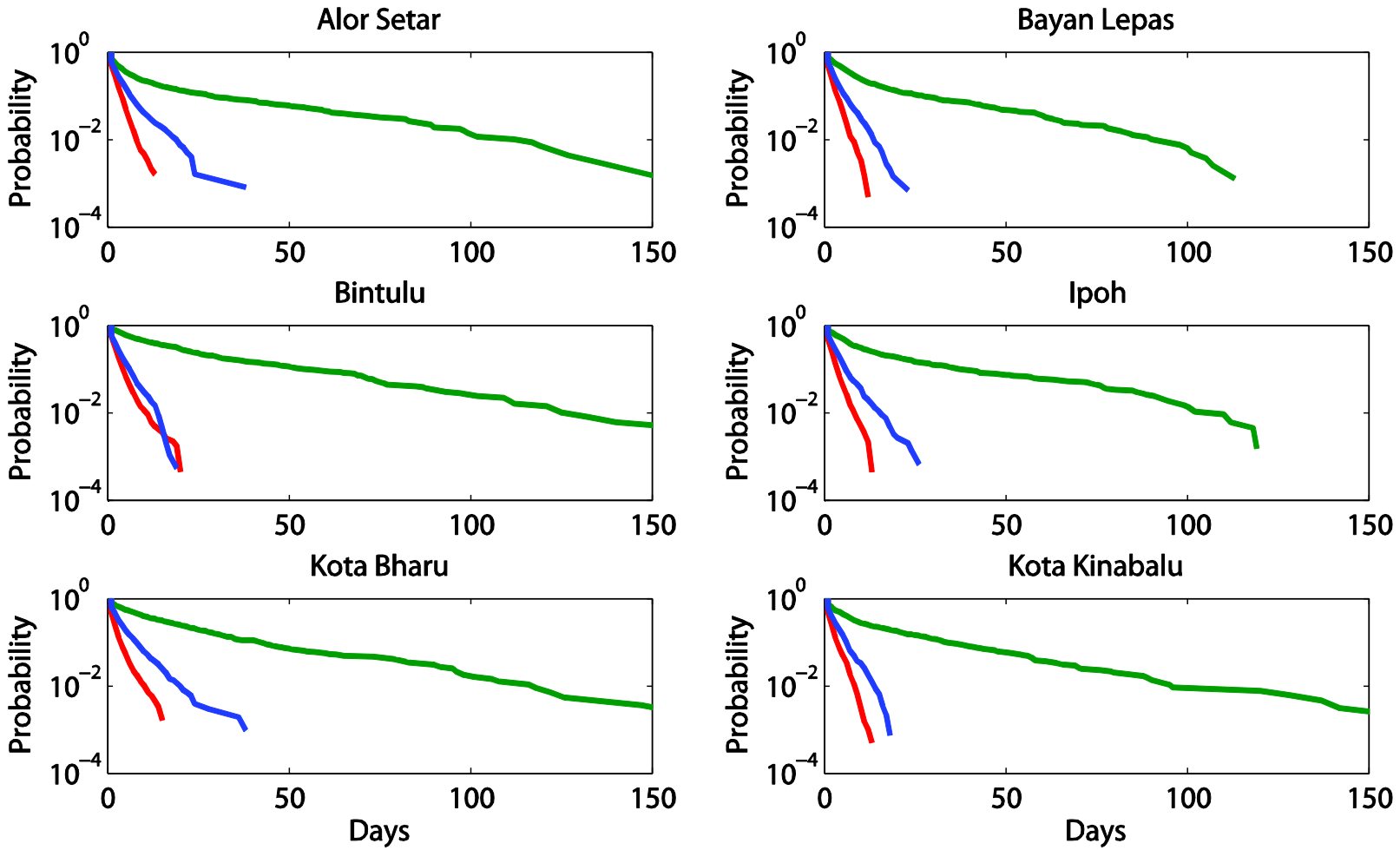






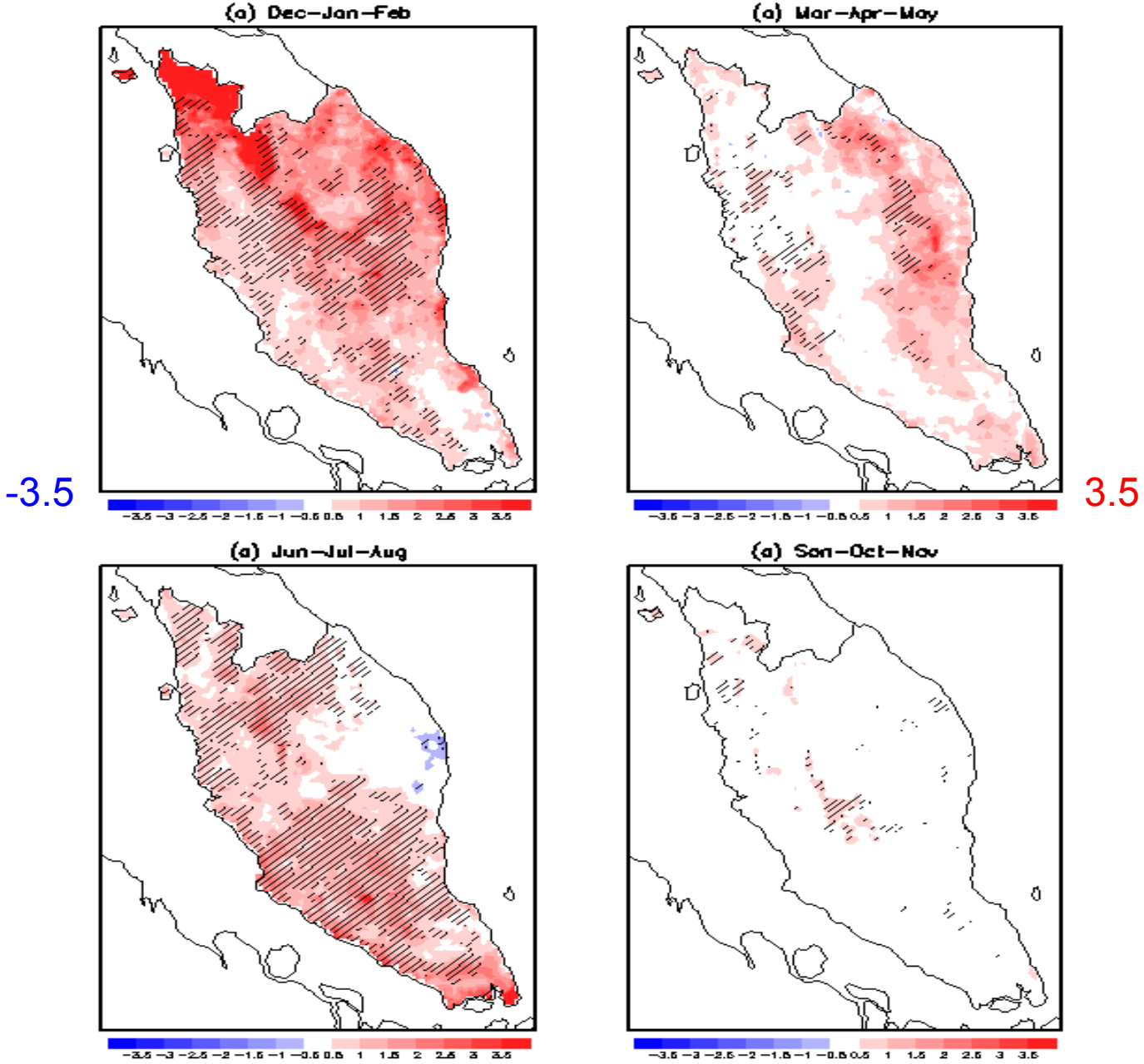
- Daily annual rainfall (mean for 1970-1999)

- Consecutive Wet Days (> 1 mm/day)
  - Reduces the biases of the number of rainy days



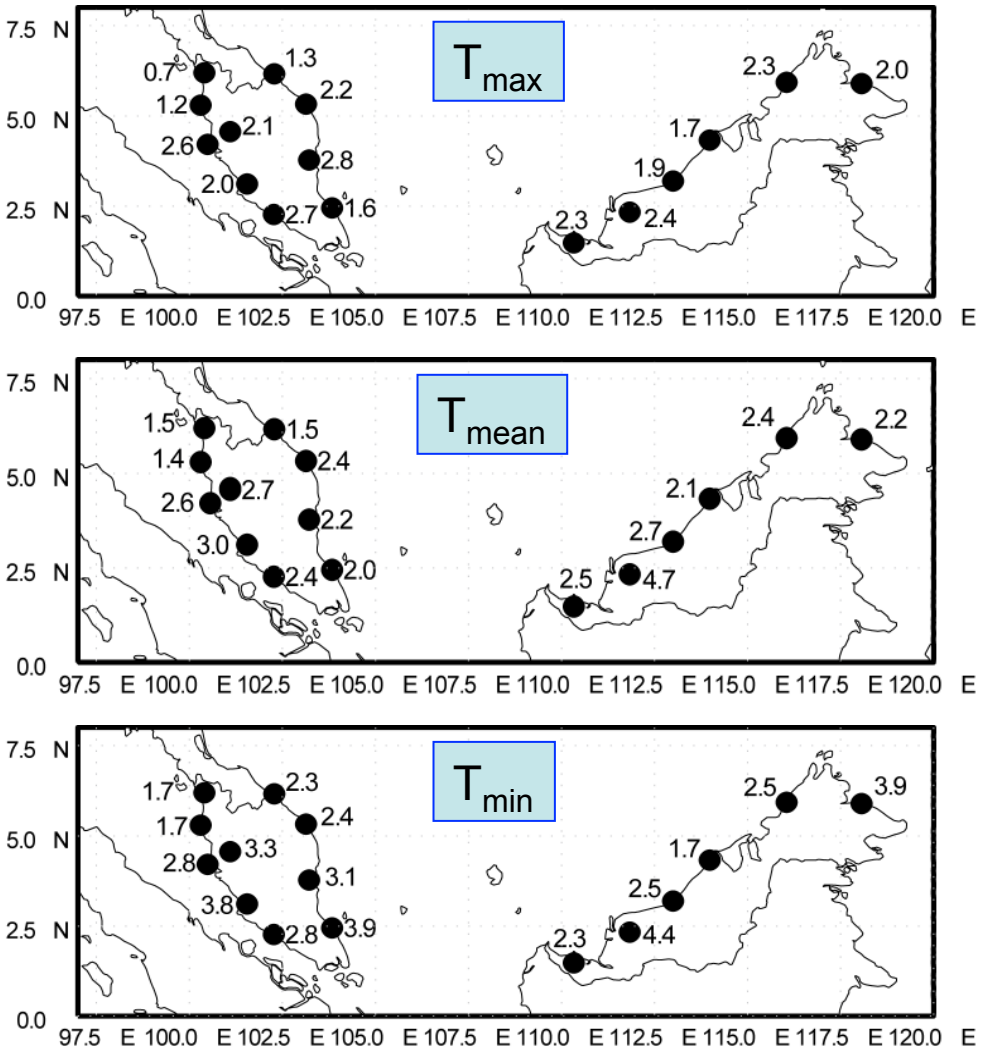
- Probability of getting consecutive wet days (> 1 mm/day)

Example applications: Changes in the seasonal mean dry spell at 5km x 5km grids

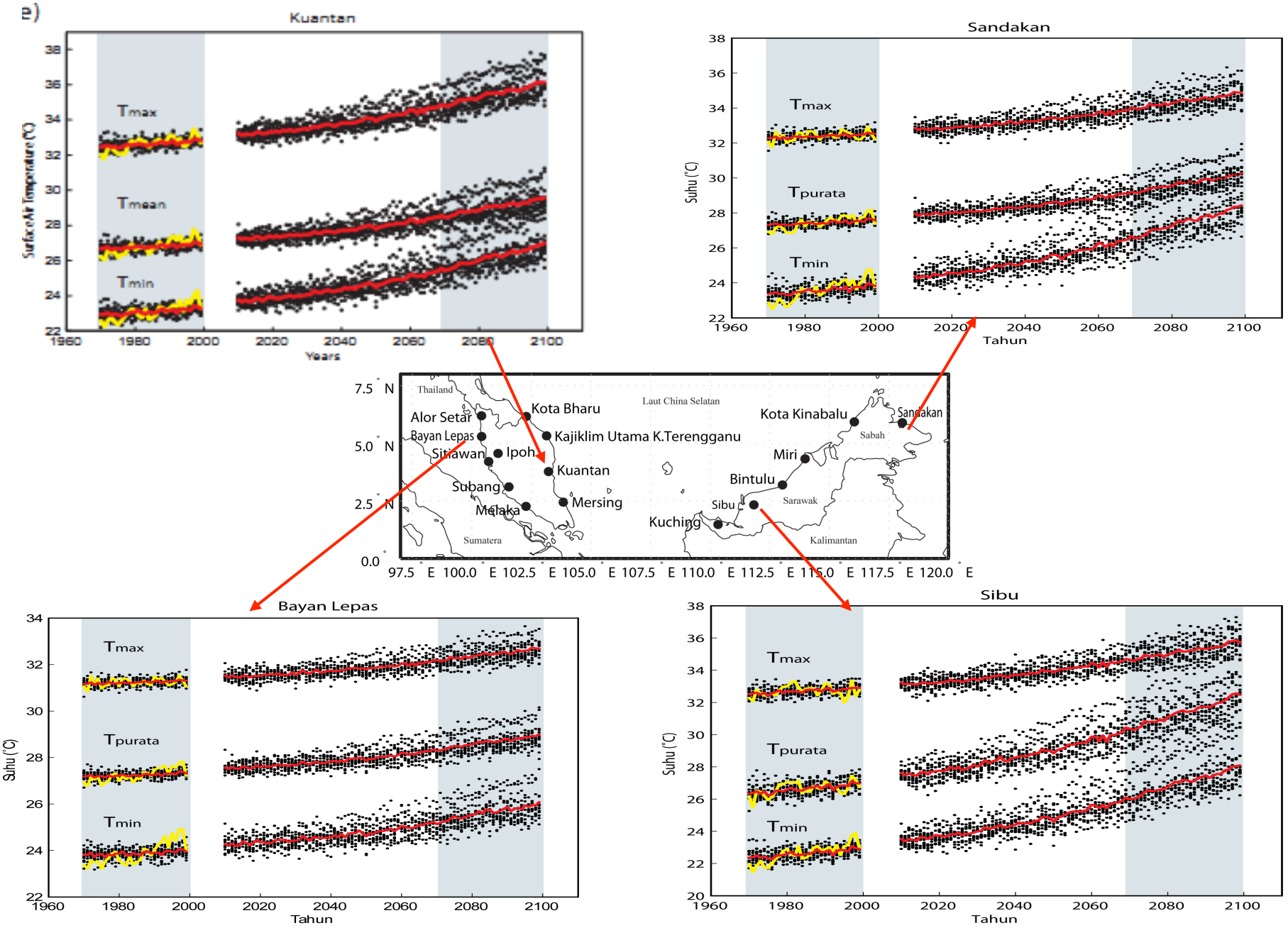


Other climate downscaling studies

Temperature Changes (SRES A2) at the end of 21st century (2070-2100 minus 1970-2000) using canonical correlation analysis.

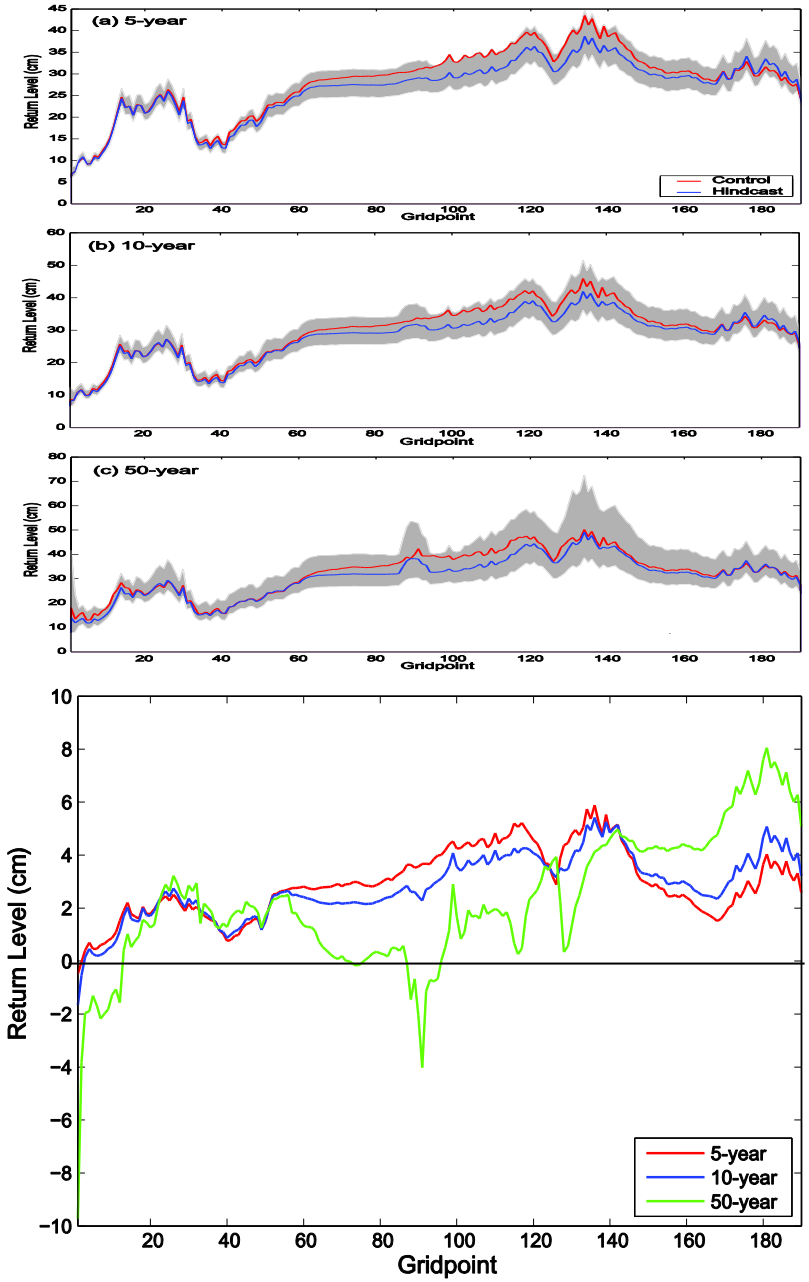


- Less warming projection for northern Peninsular.
- T_{min} warms more.
- Changes: ~1- 4˚C.

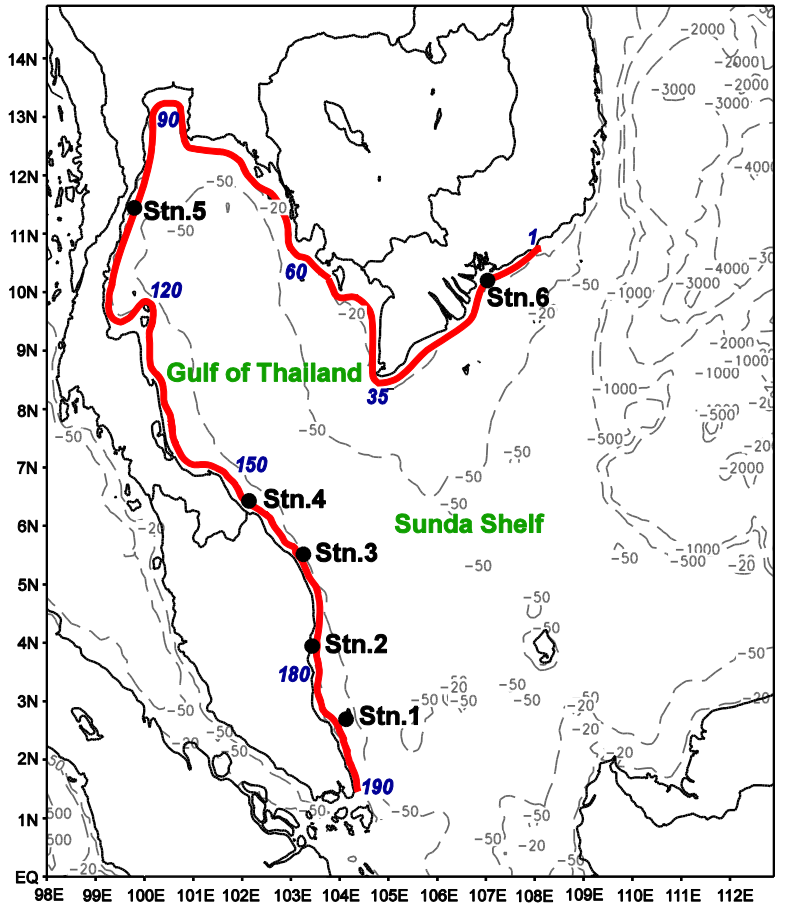


Temperature projection time series

Changes of SSH using ocean model (SRES A2)



- Return levels for 5-year, 10-year and 50-year return period based GEV distribution.
- As a reference to compute the future changes.



Current Computing Facilities at COAL UKM

- 12 nodes cluster
  - 8 cores per node
  - 2 x Intel Xeon E56xx series processors.
  - RAM 1 GB per core = 8 GB per node
  - separate 20TB NAS storage.
- Several Intel Xeon E3 (4GB RAM) workstations.
- Running apps: MM5, WRF3.4, RegCM4 and POM.
- SGI Altix 4700 (computing time offered by MGI)

Associate ongoing Projects

- 2 Malaysia government funded projects:

Downscaling projection of Malaysia climate based on the latest AR5's RCP emission scenario (RCP4.5 and RCP 8.5) (RCM: RegCM4, PRECIS, WRF)

Downscaling projection of marine climate over the South China Sea.

Thank you