Introduction to Climate Projections and Analysis

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www.csiro.au

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ADB

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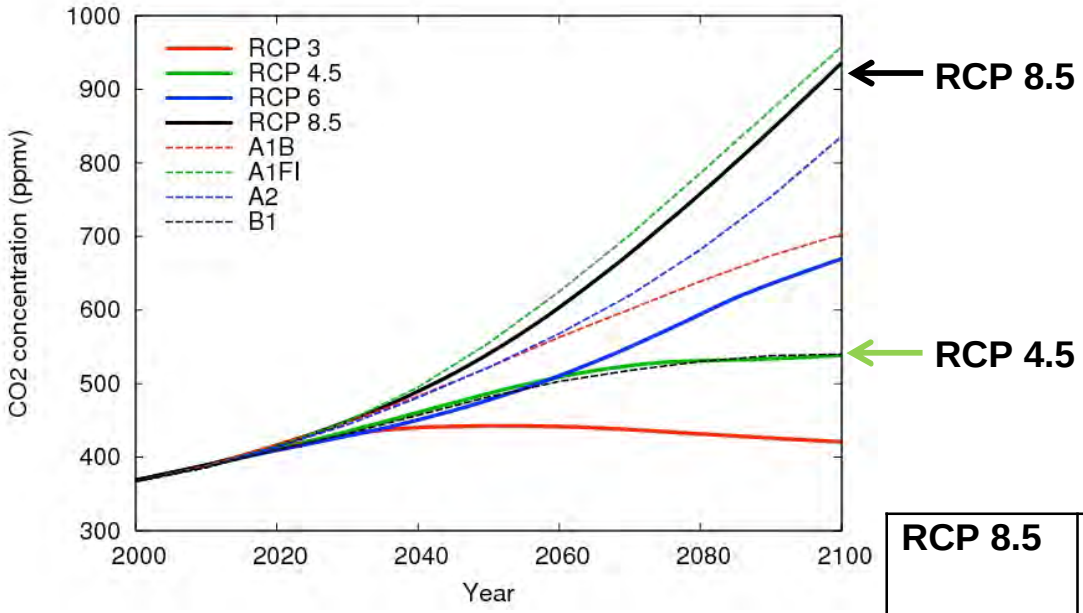
Griffith UNIVERSITY

CSIRO

Outline

- Summary of IPCC AR5
- Summary of dynamical downscaling used for case study
- Example of Climate Guidelines for case study

Comparison of CO_2 concentrations from SRES (A1B, A1FI, A2, B1) and RCPs (3.0, 4.5, 6.0, 8.5) approaches



RCP 8.5

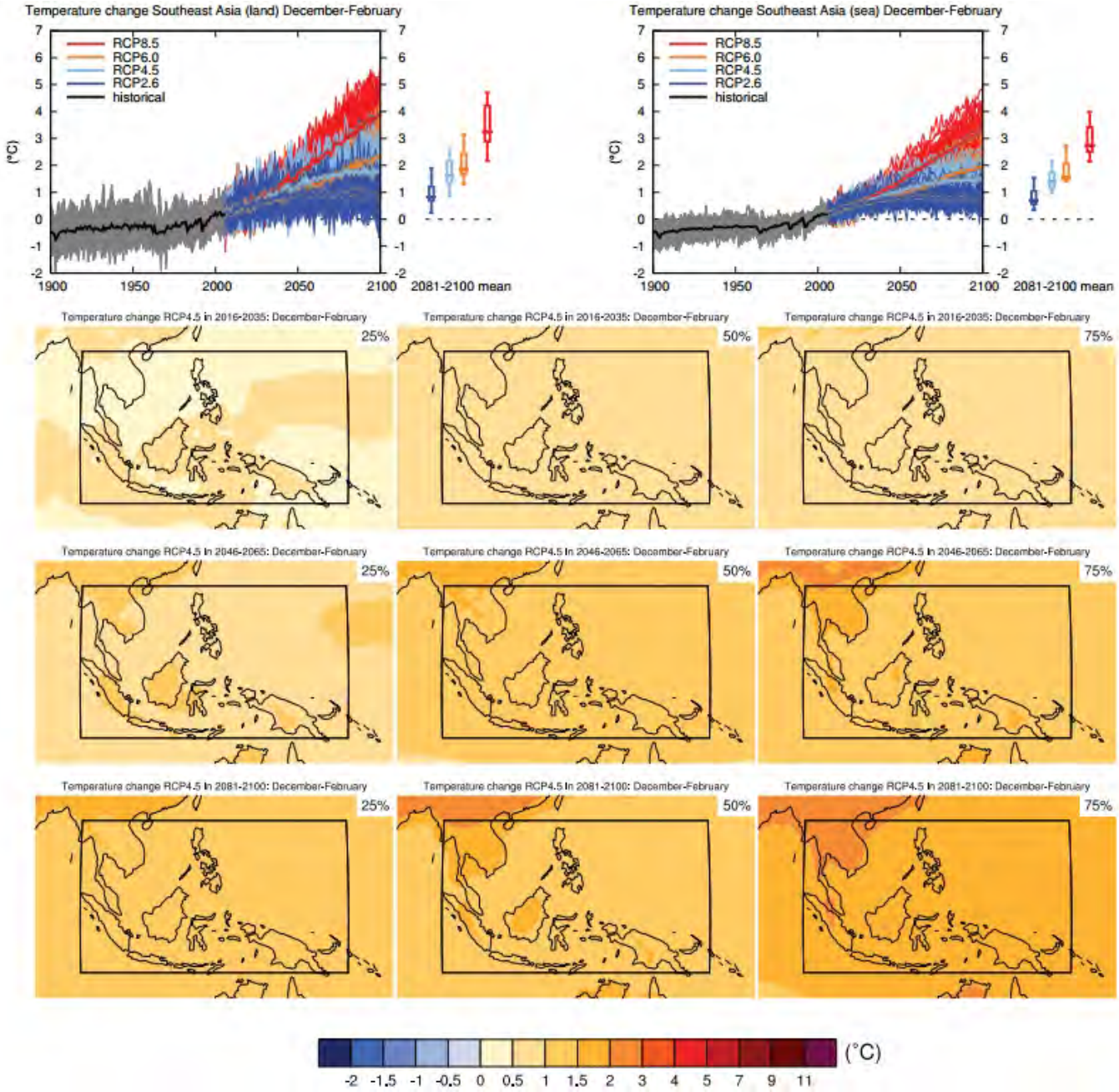
RCP 4.5

RCP 8.5	**Rising radiative forcing pathway leading to 8.5 W/m² in 2100.**
RCP 6	**Stabilization without overshoot pathway to 6 W/m² at stabilization after 2100**
RCP 4.5	**Stabilization without overshoot pathway to 4.5 W/m² at stabilization after 2100**
RCP 2.6	**Peak in radiative forcing at ~ 3 W/m² before 2100 and decline**

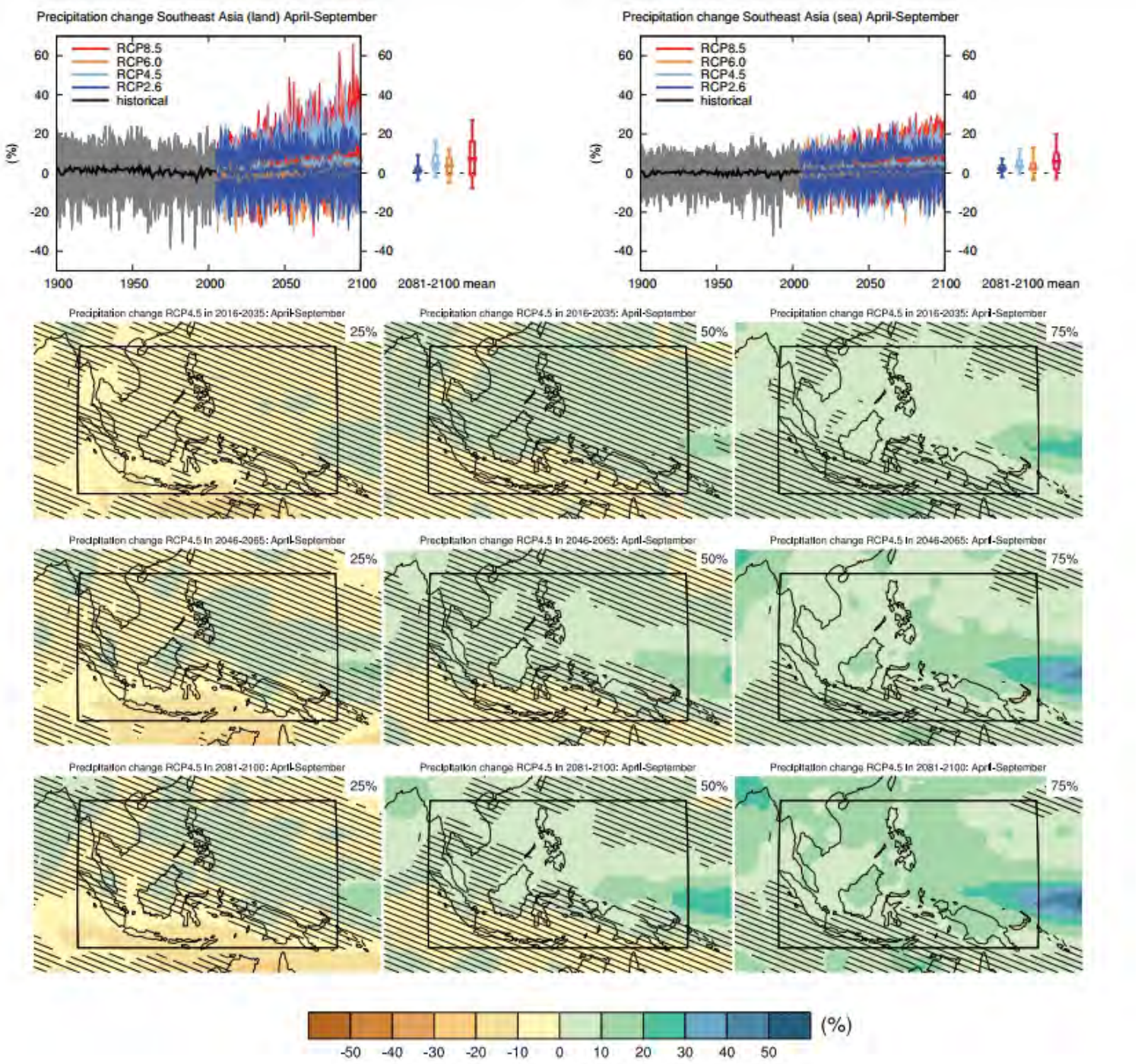
Source: Meinshausen, M. and Coauthors, 2011

DJF Temp.

- Note large spread between scenarios
- Note different probabilities of change signals

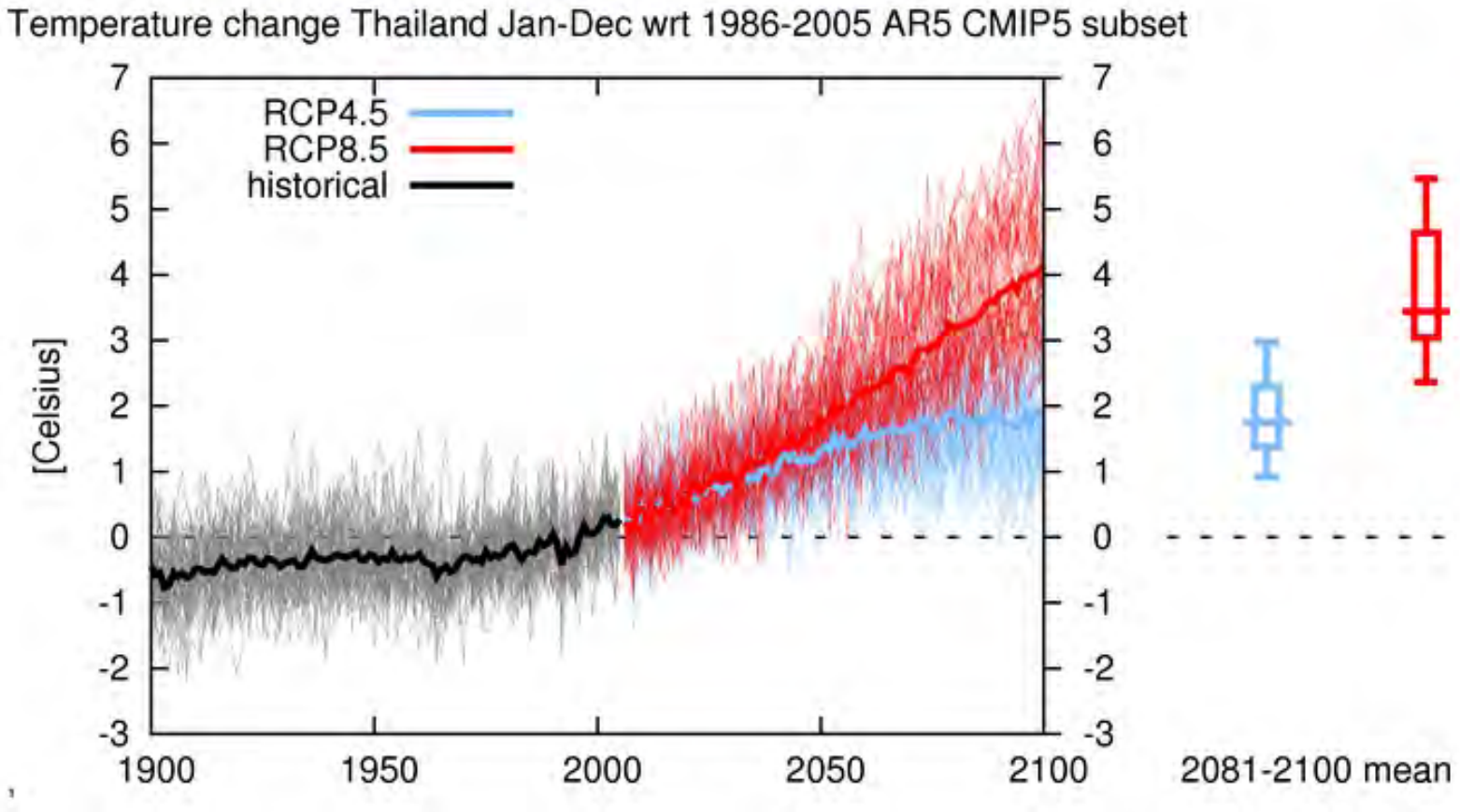


Apr-Sept Rnd


Precipitation change Southeast Asia (land) April-September
RCP8.5
RCP6.0
RCP4.5
RCP2.6
historical
(%)
1900
1950
2000
2050
2100
2081-2100 mean
Precipitation change Southeast Asia (sea) April-September
Precipitation change RCP4.5 in 2016-2035: April-September
25%
50%
75%
Precipitation change RCP4.5 in 2046-2065: April-September
Precipitation change RCP4.5 in 2081-2100: April-September
(%)
-50 -40 -30 -20 -10 0 10 20 30 40 50

CMIP5 GCM model ensemble for Thailand Tave

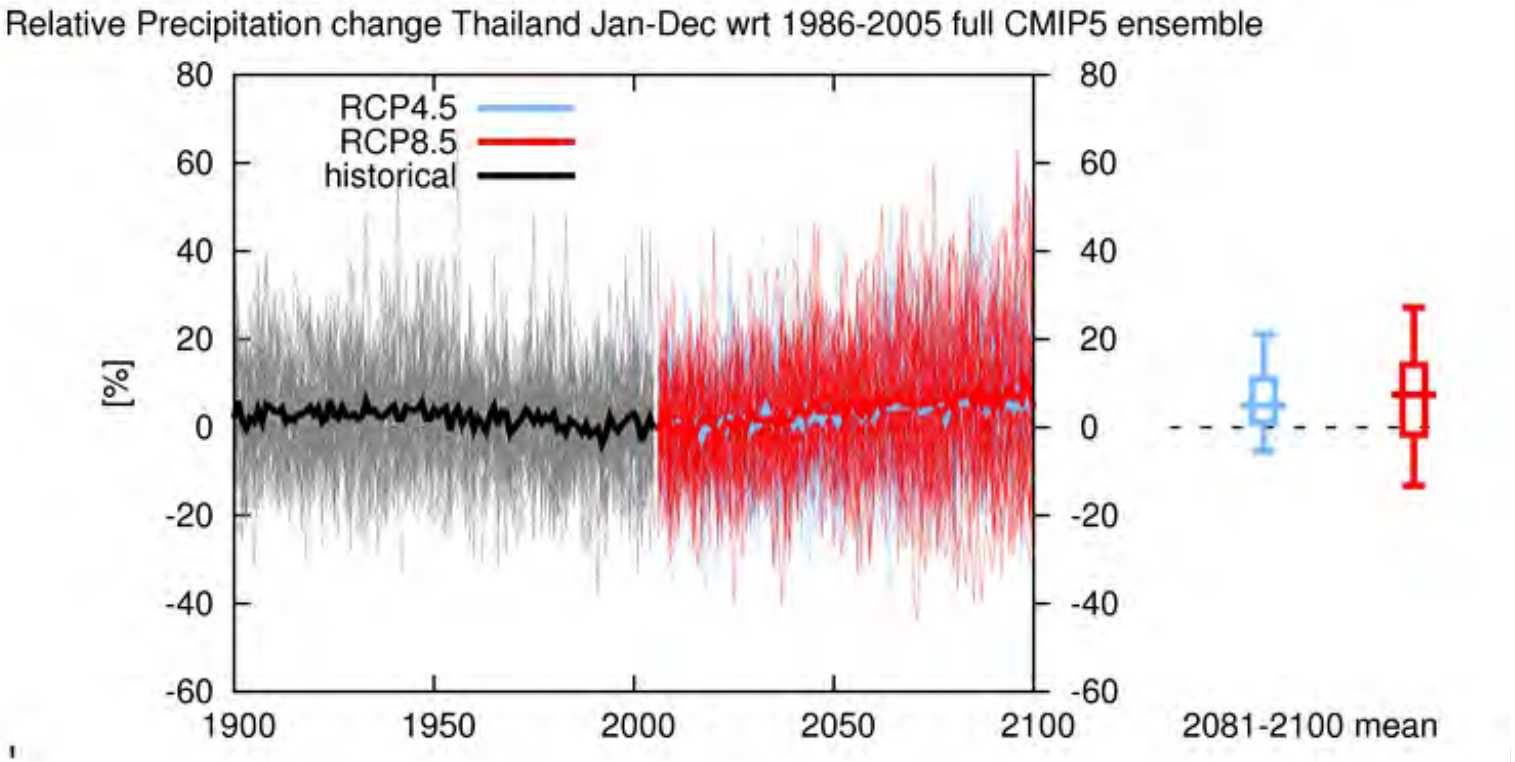
Temperature change Thailand Jan-Dec wrt 1986-2005 AR5 CMIP5 subset. On the left, for each scenario one line per model is shown plus the multi-model mean, on the right percentiles of the whole dataset: the box extends from 25% to 75%, the whiskers from 5% to 95% and the horizontal line denotes the median (50%).(png, eps, pdf, plotscript, all data, means, masks)



https://climexp.knmi.nl/selectfield_cmip5.cgi?id=someone@somewhere

CMIP5 GCM model ensemble for Thailand Rainfall

Relative Precipitation change Thailand Jan-Dec wrt 1986-2005 full CMIP5 ensemble. On the left, for each scenario one line per model is shown plus the multi-model mean, on the right percentiles of the whole dataset: the box extends from 25% to 75%, the whiskers from 5% to 95% and the horizontal line denotes the median (50%).(png, eps, pdf, plotscript, all data, means, masks)



https://climexp.knmi.nl/selectfield_cmip5.cgi?id=someone@somewhere

Regional extreme changes

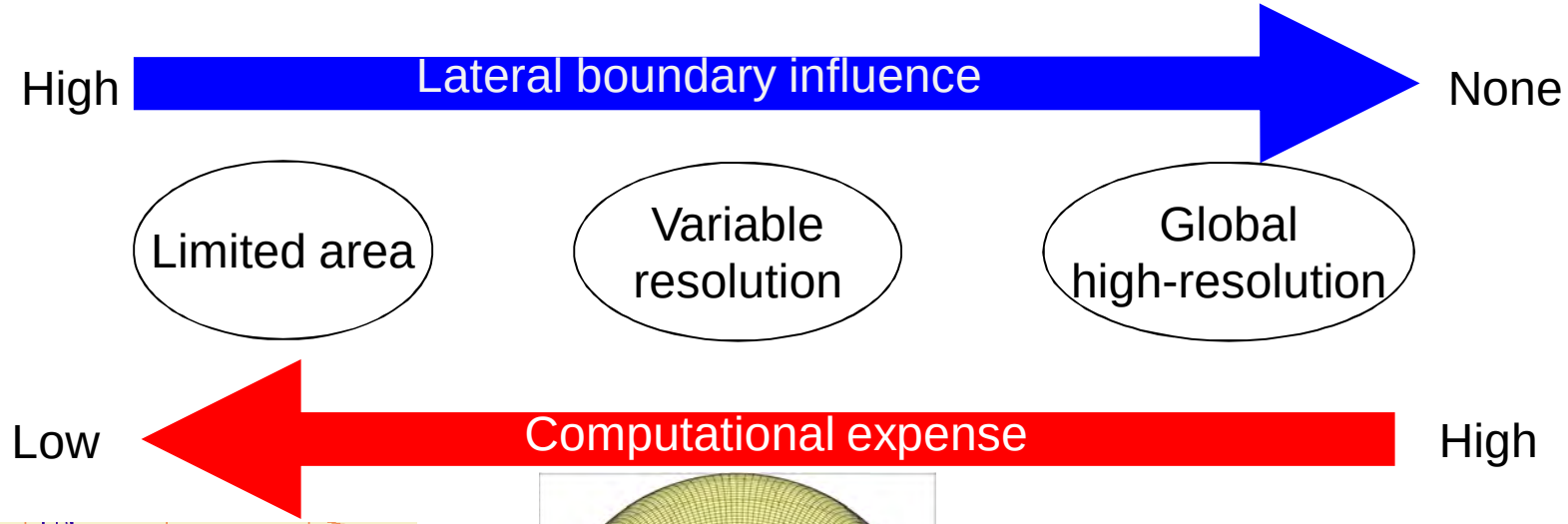
Table 2.13 | Regional observed changes in a range of climate indices since the middle of the 20th century. Assessments are based on a range of 'global' studies and assessments (Groisman et al., 2005; Alexander et al., 2006; Caesar et al., 2006; Sheffield and Wood, 2008; Dai, 2011a, 2011b, 2013; Seneviratne et al., 2012; Sheffield et al., 2012; Donat et al., 2013a, 2013c; van der Schrier et al., 2013) and selected regional studies as indicated. Bold text indicates where the assessment is somewhat different to SREX Table 3-2. In each such case a footnote explains why the assessment is different. See also Figures 2.32 and 2.33.

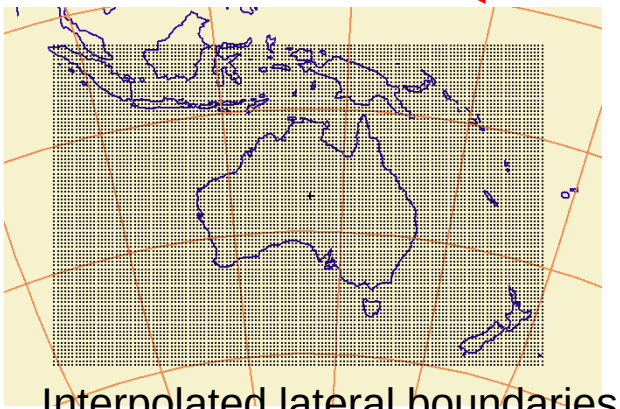
Region	Warm Days (e.g., TX90p[a])	Cold Days (e.g., TX10p[a])	Warm Nights (e.g., TN90p[a], TR[a])	Cold Nights/Frosts (e.g., TN10p[a], FD[a])	Heat Waves / Warm Spells[g]	Extreme Precipitation (e.g., RX1day[a], R95p[a], R99p[a])	Dryness (e.g,. CDD[a]) / Drought[h]
Asia (excluding South-east Asia)	***High confidence***[b,e]: ***Likely*** **overall increase**[27,28,29,30,31,32]	***High confidence***[b,e]: ***Likely*** **overall decrease**[27,28,29,30,31,32]	***High confidence***[b,e]: ***Likely*** **overall increase**[27,28,29,30,31,32]	***High confidence***[b,e]: ***Likely*** **overall increase**[27,28,29,30,31,32]	***Medium confidence***[b,e]: **Spatially varying trends and insufficient data in some regions** ***High confidence***[b,c]: ***Likely*** **more areas of increases than decreases**[3,28,33]	***Low*** **to** ***medium confidence***[b,e]: ***Low confidence*** **due to insufficient evidence or spatially varying trends.** ***Medium confidence***: **increases in more regions than decreases**[5,34,35,36]	***Low*** **to** ***medium confidence***[b,e] ***Medium confidence***: **Increase in eastern Asia**[36,37]
South-east Asia and Oceania	***High confidence***[b,f]: ***Likely*** **overall increase**[27,38,39,40]	***High confidence***[b,f]: ***Likely*** **overall decrease**[27,38,39]	***High confidence***[b,f]: ***Likely*** **overall increase**[27,38,39,40]	***High confidence***[b,f]: ***Likely*** **overall decrease**[27,38,39]	***Low confidence*** **(due lack of literature) to** ***high confidence***[b,f] **depending on region** ***High confidence***[2]: ***Likely*** **overall increase in Australia**[3,14,41]	***Low confidence*** **(lack of literature) to** ***high confidence***[b,f] *High confidence*: *Likely* decrease in southern Australia[42,43] but index and season dependent	***Low*** **to** ***medium confidence***[b,f]: **inconsistent trends between studies in SE Asia. Overall increase in dryness in southern and eastern Australia** ***High confidence***[b]: ***Likely*** **decrease northwest Australia**[25,26,44]

Summary

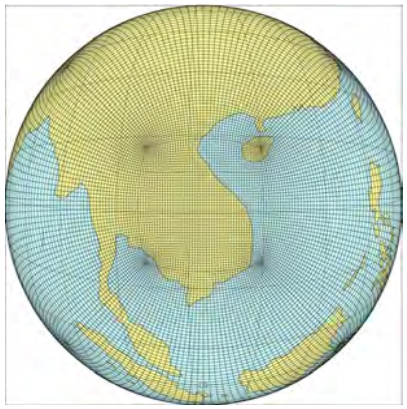
- Some improvement in representation of current climate
- Greater confidence on human impact on observed trends
- New Representational Concentration Pathways
- Some GCMs are more complex (‘earth system models’)

Regional Climate Modelling Approaches





Interpolated lateral boundaries, one-way information



Scale-selective information passed, some 2-way interaction

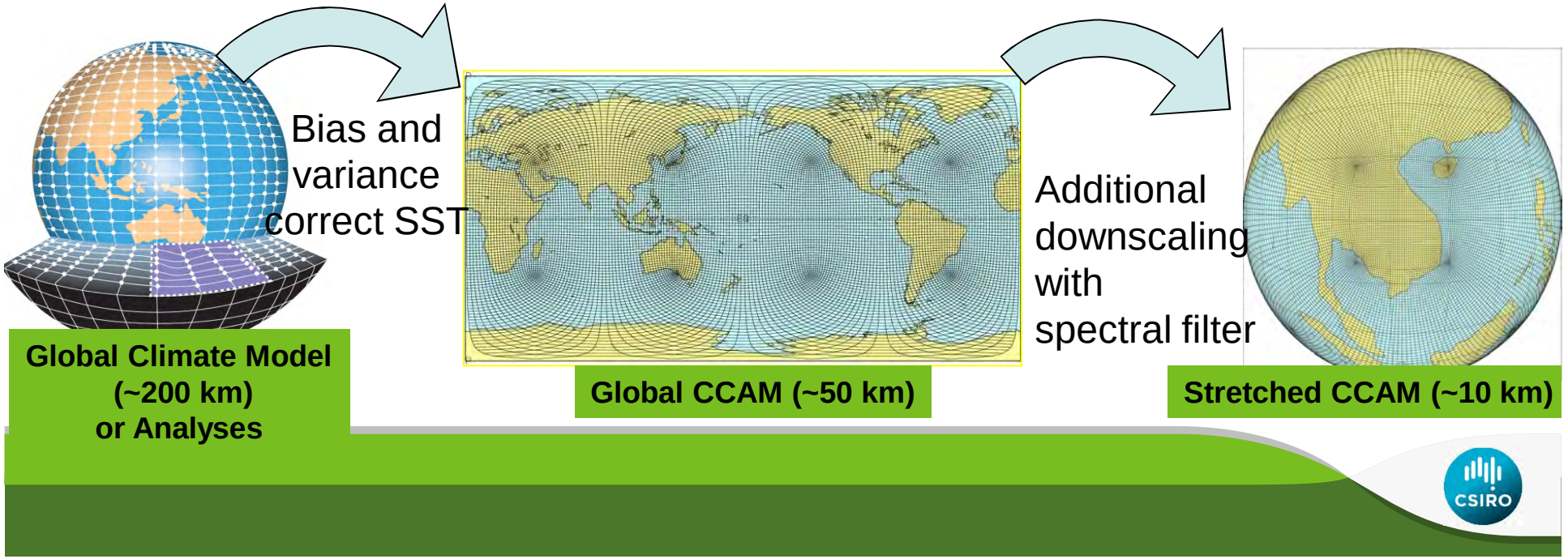
- Also need to consider:
  - Domain size/location
  - Resolution
  - Internal variability

Conformal Cubic Atmospheric Model

- Developed at CSIRO for over 20 years
- First 3D cubic atmospheric model in the world
- CCAM is highly computationally efficient for comparable accuracy. CCAM can run on 25,000+ core supercomputers, or as a 'distributed' system on laptops.

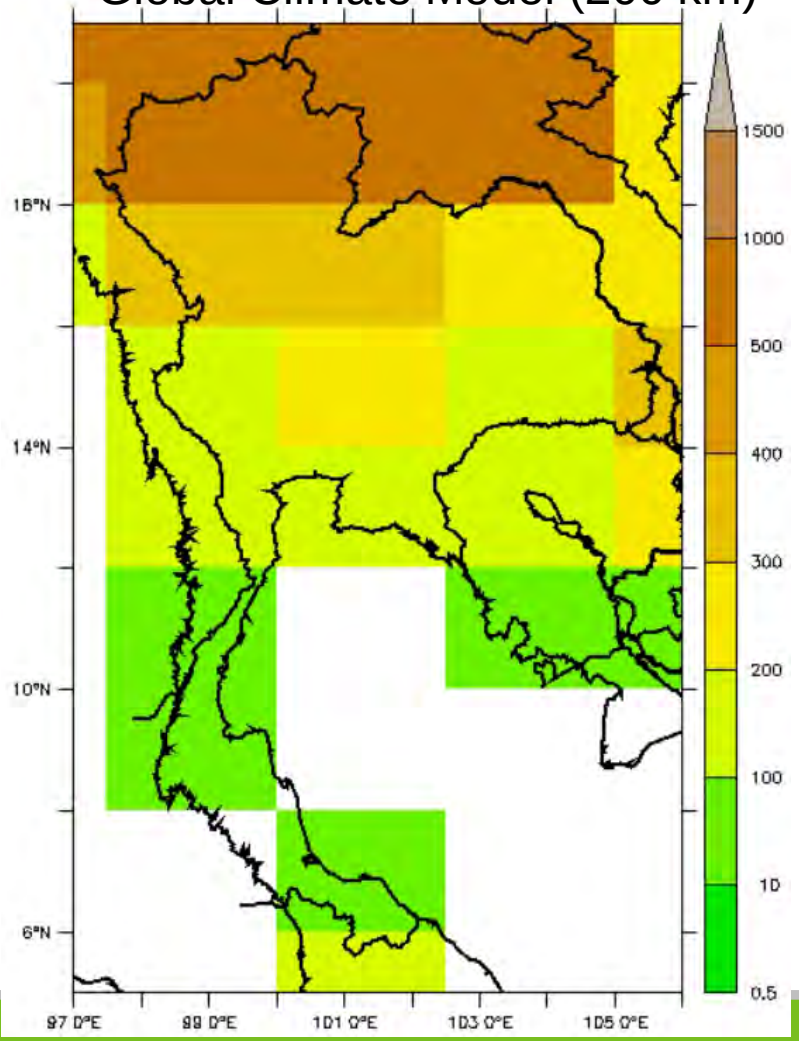
New features

- Urban model
- Parallel IO and improved scaling
- New model: flux form on gnomic grid

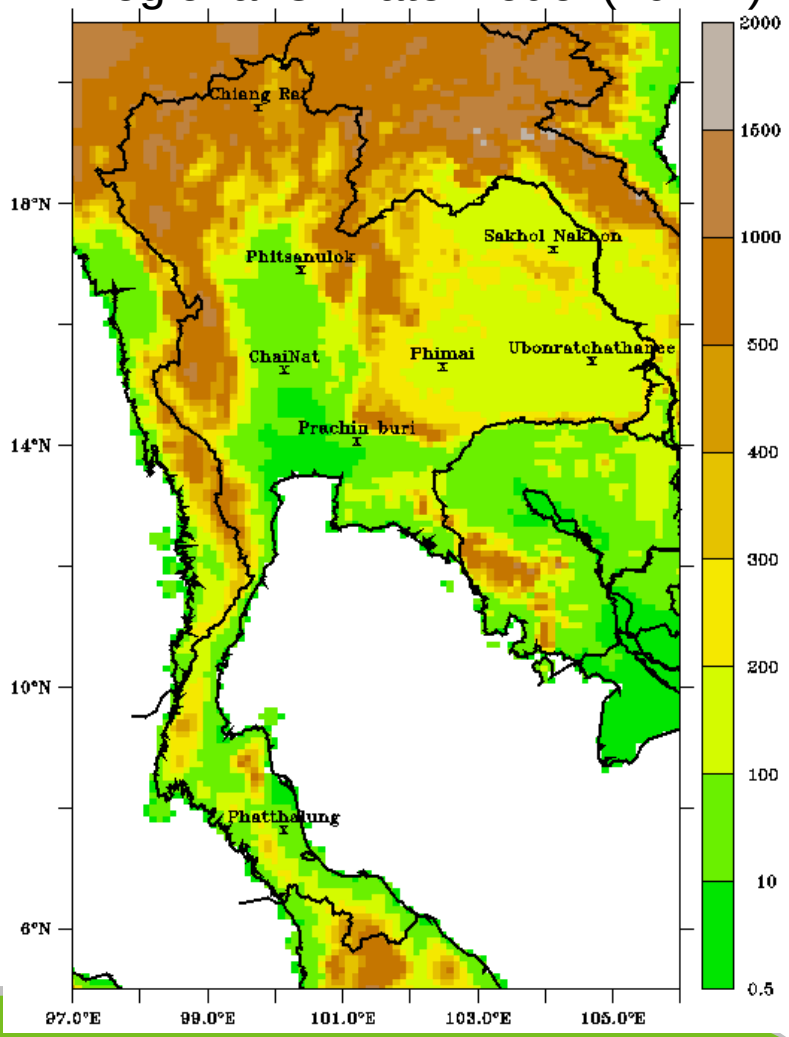


Terrain/land sea mask

Global Climate Model (200 km)



Regional Climate Model (10 km)



GCM Selection

Requirements

- Good performance in present climate
  - Simulation of rainfall, air temperature etc.
  - Reproduce observed trends
- Good SSTs
  - ENSO pattern/frequency
  - SST distribution
- Good spread of climate change signals

- 24 CMIP5 models
- > 20 evaluation studies
- 6 publications with rankings + evaluation

  used within the project
- Peer-reviewed or submitted

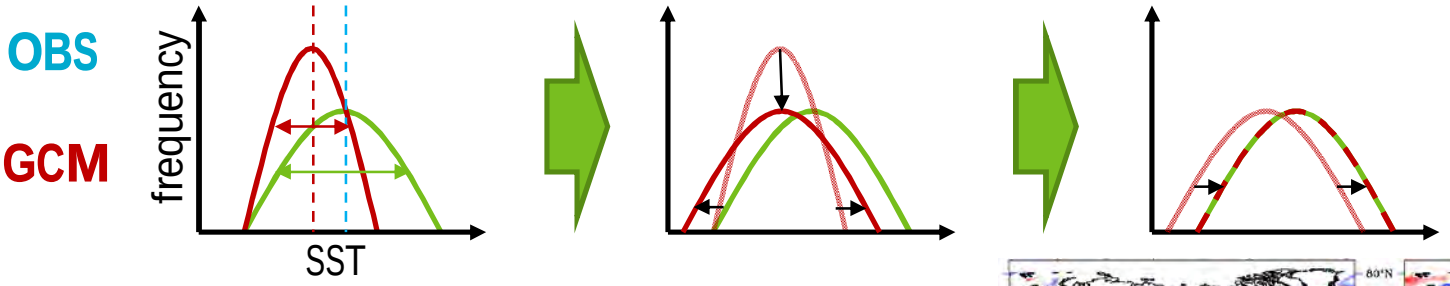
GCM Selection
Final ranking

The rankings of the 6 individual studies are averaged to yield a final ranking of the models.

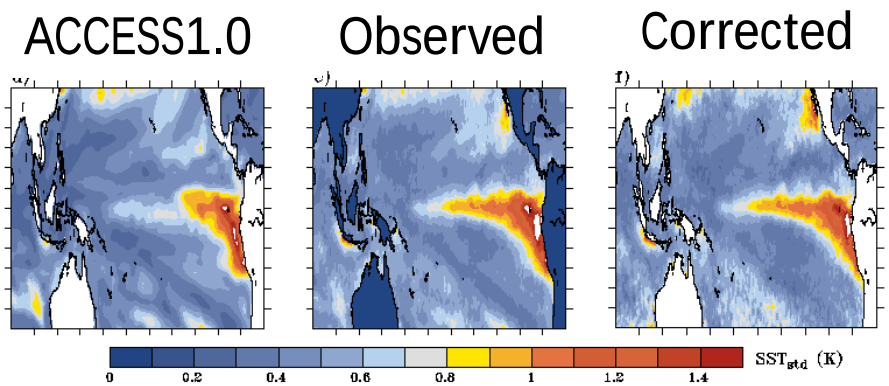
Rank	GCM	Average Score
1	**CNRM-CM5**	**0.31**
2	**CCSM4**	**0.34**
3	ACCESS1.3	0.35
4	**NorESM1-M**	**0.35**
5	**ACCESS1.0**	**0.39**
6	**MPI-ESM-LR**	**0.41**
7	**GFDL-CM3**	**0.42**
8	HadGEM2-CC	0.44
9	MIROC4h	0.46
10	MIROC5	0.47
11	GFDL-ESM2M	0.48
12	MRI-CGCM3	0.51
13	HadCM3	0.53
14	IPSL-CM5A-MR	0.53
15	HadGEM2-ES	0.54
16	FGOALS-g2	0.57
17	CSIRO-Mk3.6.0	0.57
18	inmcm4	0.61
19	CanESM2	0.61
20	MIROC-ESM-CHEM	0.69
21	GISS-ES-H	0.70
22	IPSL-CM5A-LR	0.71
23	FGOALS-s2	0.80
24	MIROC-ESM	0.84

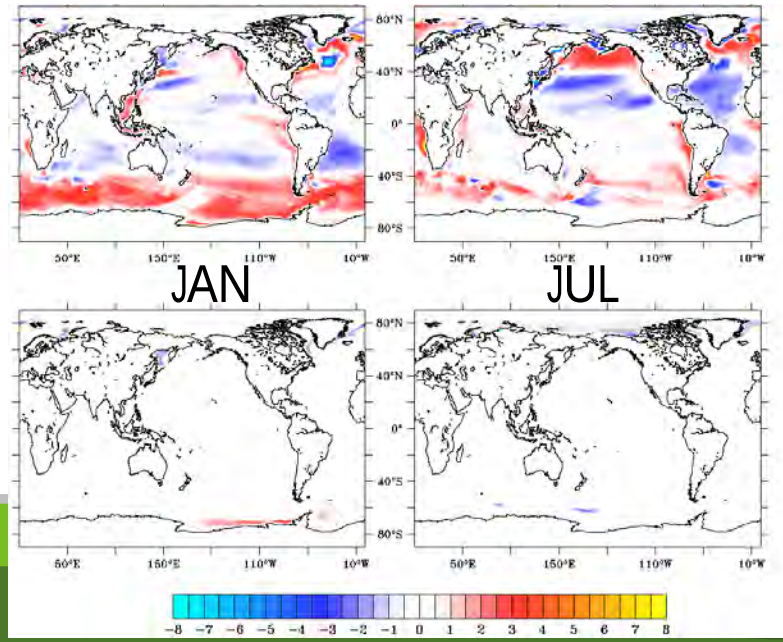
SST Correction Method

- Observations
  - daily optimum interpolation SST & SIC (Reynolds et al., 2007)
  - 1/4° resolution for 1982-2011
- Method



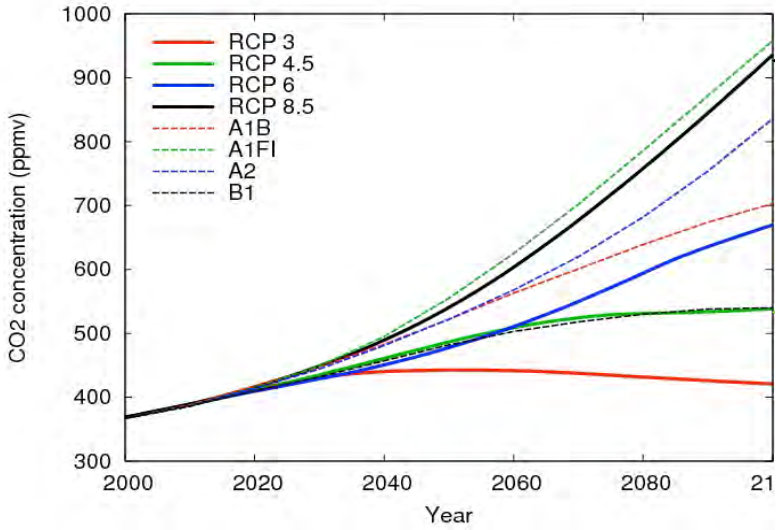
SST variance ACCESS1.0 (January)

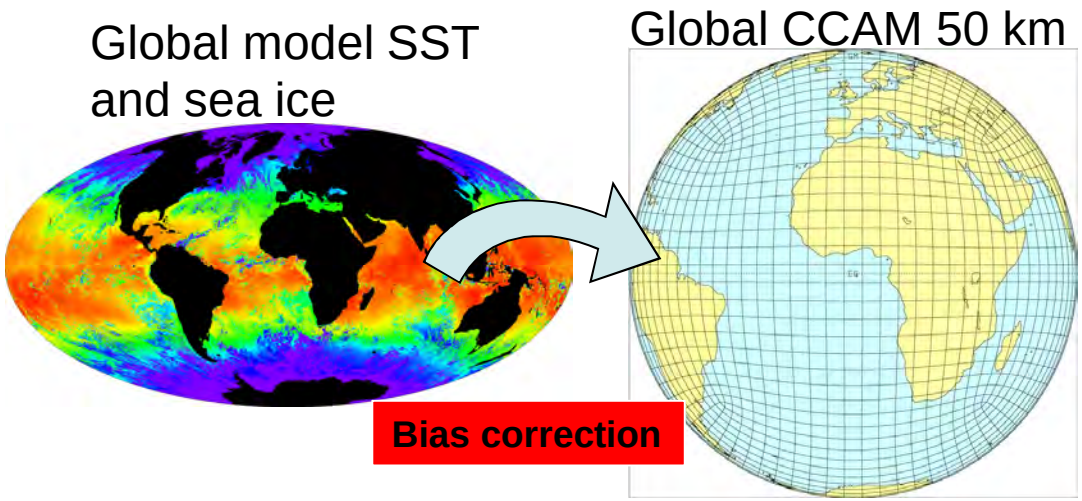




Dynamical Downscaling

- Start with Global Climate Models
- Select 6 global models and 2 scenarios
  - lower: RCP4.5 and higher: RCP8.5
- Simulations from 1970-2099
- Drive regional models with bias-corrected sea surface temperatures (SST) and sea ice



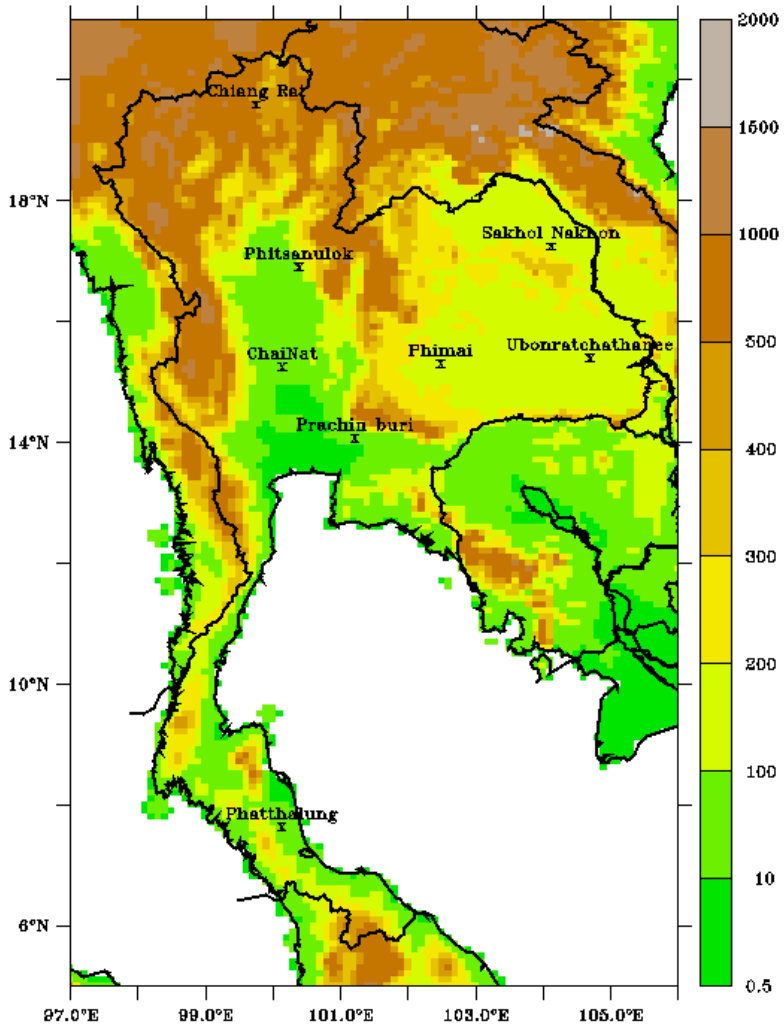


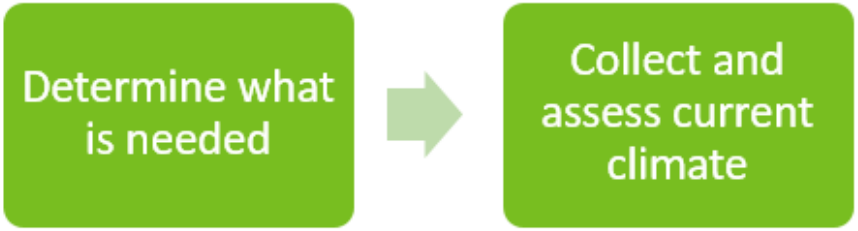
Overall guidelines for using climate information/projections

- Decide **what is needed/important** for assessment
- Collect and **evaluate current climate** information
  - Assess the **natural variability**
- Decide on **time and space scales** needed for projections
- Collect and **evaluate current climate** simulations
- Use **range of** climate projection **scenarios**
  - Ideally assess a ‘median’, ‘best-case’ and ‘worst-case’ projection
- Do we need to **application-ready** projections?
- **Assess confidence and uncertainty of projections**

Determine what is needed

Rice Model needs daily:
Tmax,
Tmin,
Rainfall and
Solar Radiation




Determine what is needed
Collect and assess current climate

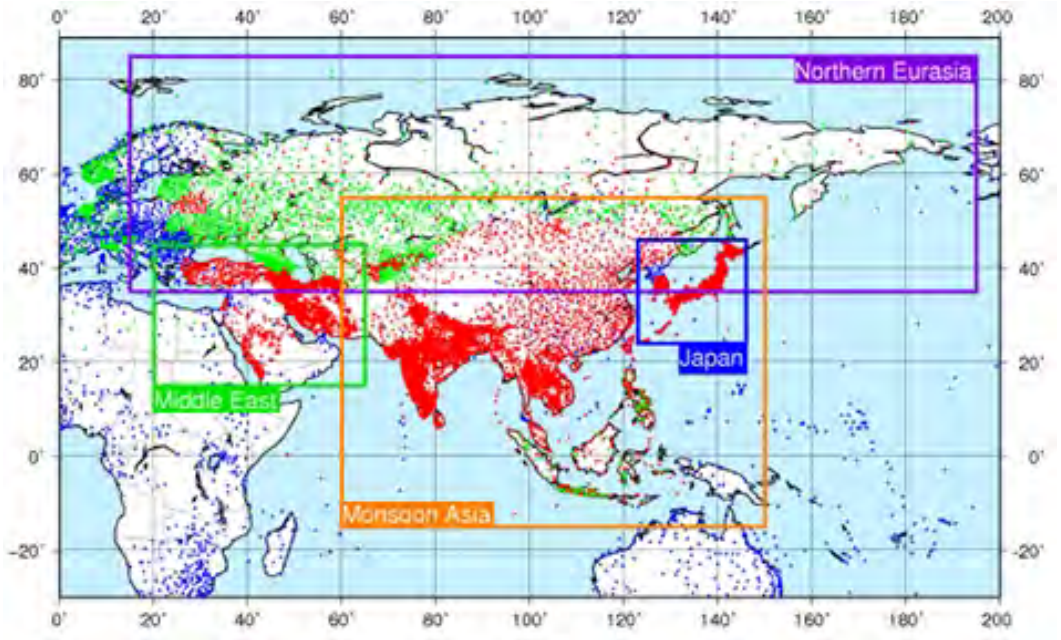
Example of gridded data

APHRODITE: Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources

Years of Record: 1951/01 to 2007/12

Type of data product: Gridded rainfall and temperature from obs

Institution and PI: University of Tsukuba, Japan Meteorological Agency/ Akiyo Yatagai



Cuurent version: V1101 Download »Readme

Name	Domain	Resolution	Period
Monsoon Asia (MA)	60°E-150°E, 15°S-55°N	0.5° and 0.25°, daily	1951-2007
Middle East (ME)	20°E-65°E, 15°N-45°N		
Russia (RU)	15°E-165°W, 34°N-84°N		

Current version, with Rain/Snow discrimination: V1101R2 Download »Readme

Name	Domain	Resolution	Period
Monsoon Asia (MA)	60°E-150°E, 15°S-55°N	0.5° and 0.25°, daily	1961-2007

AphroTemp Current version: V1204R1 Download »Readme

Name	Domain	Resolution	Period
Monsoon Asia (MA)	60°E-150°E, 15°S-55°N	0.5° and 0.25°, daily	1961-2007

APHRO_JP Current version: V1207 Download »Readme

Name	Domain	Resolution	Period
Japan (JP) (Kamiguchi et al. 2010, 2011)	123°E-146°E, 24°N-46°N	0.05°, daily	1900-2011

http://www.chikyu.ac.jp/precip/index.html

APHRODITE evaluation

https://climatedataguide.ucar.edu)

Key Strengths:

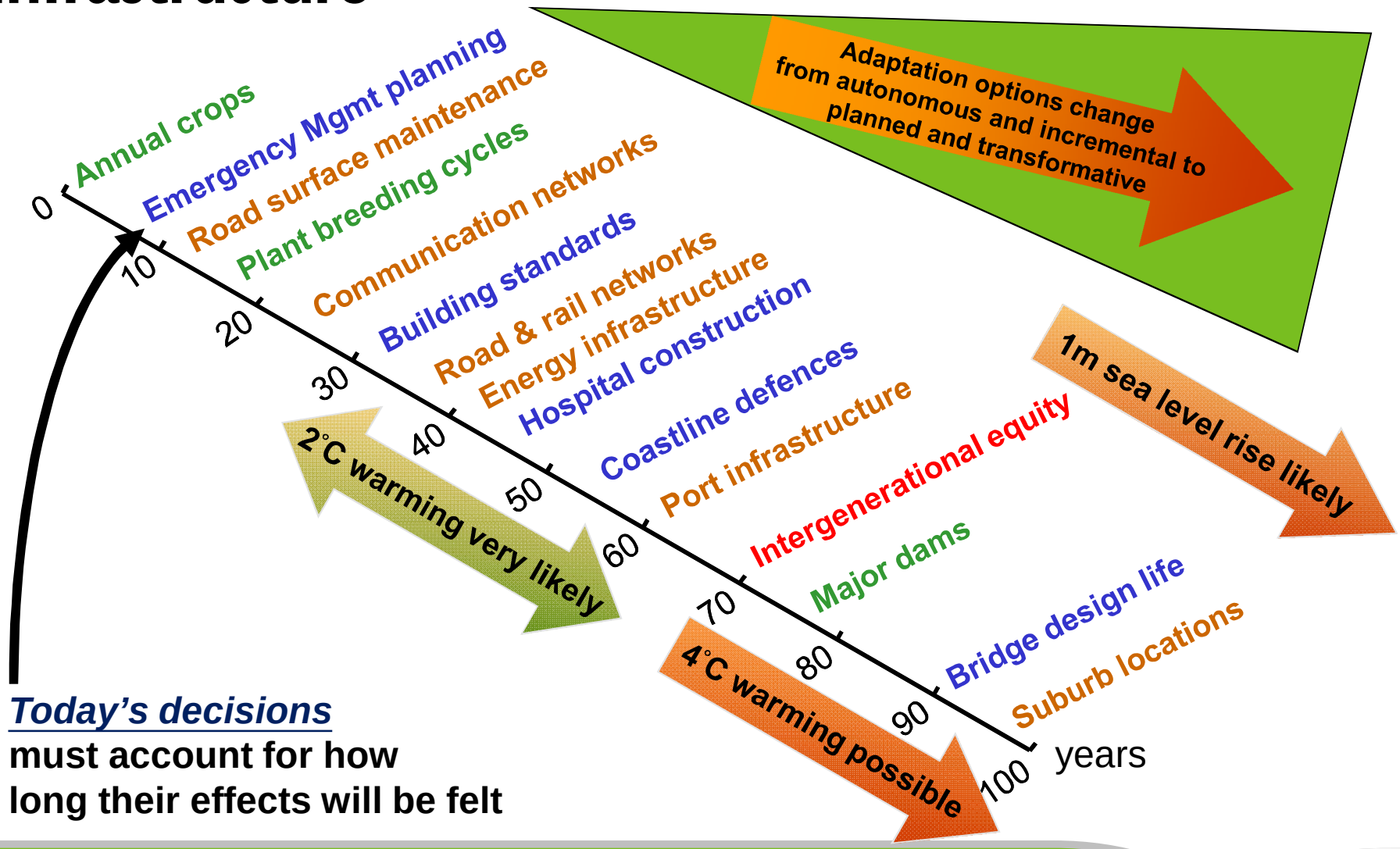
- High density and quality station network.

Key Limitations:

- Station network changes with time and season.
- We do not homogenize the observed time series of temperature data. Changes in gauges, location of the stations, and many other factors might cause discontinuity of observation data.
- Lack of observation data (in India, Indonesia and Papua New Guinea)

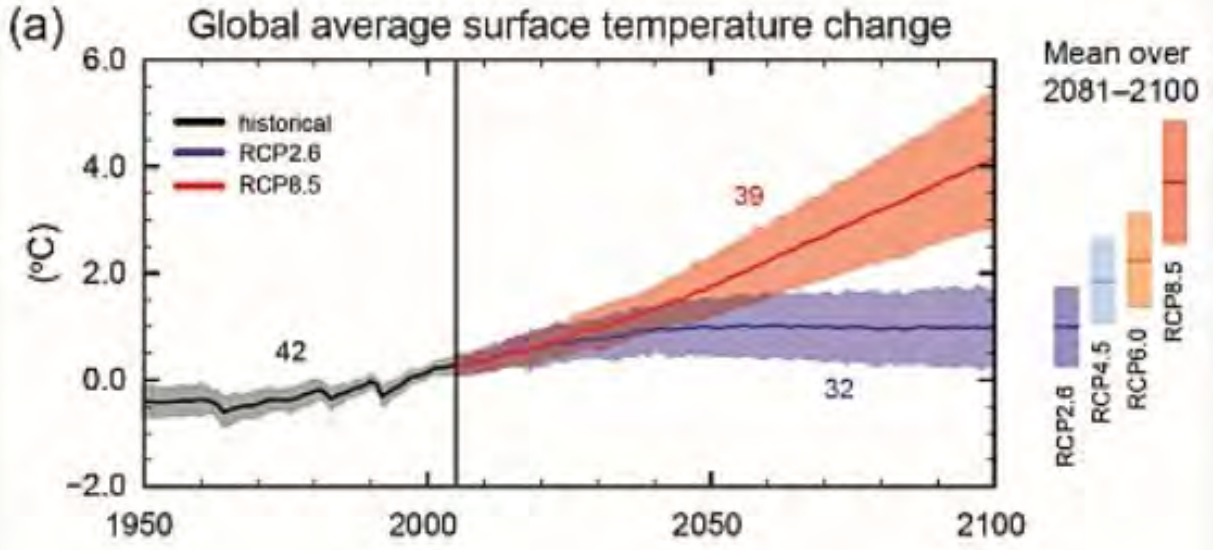

Determine what is needed
Collect and assess current climate
Decide on space and timescale required

Timescales for detailed adaptation planning for infrastructure



Stafford Smith et al, *PhilTransRoySoc* 2011 (after Jones & McInnes 2004)

Determine what is needed → Collect and assess current climate → Decide on space and timescale required → Select scenario



CMIP5 multi-model simulated time series from 1950 to 2100 for change in global annual mean surface temperature relative to 1986–2005. SOURCE: IPCC 2013

Determine what is needed → Collect and assess current climate → Decide on space and timescale required → Select scenario

Select scenario → Source projections data

Determine what is needed

Collect and assess current climate

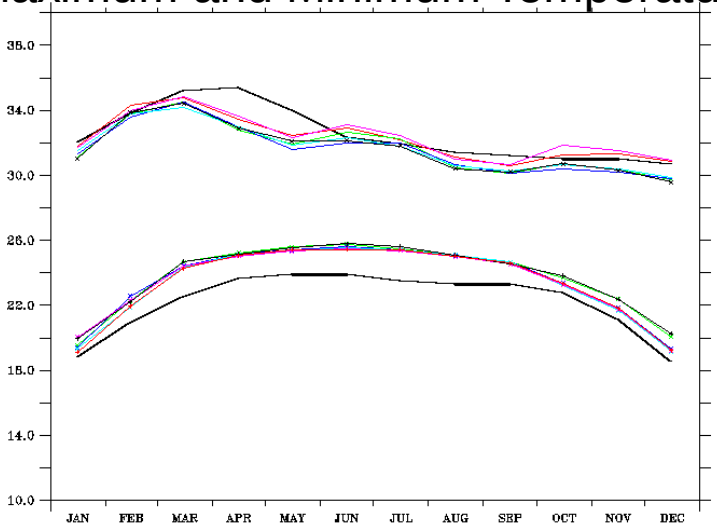
Decide on space and timescale required

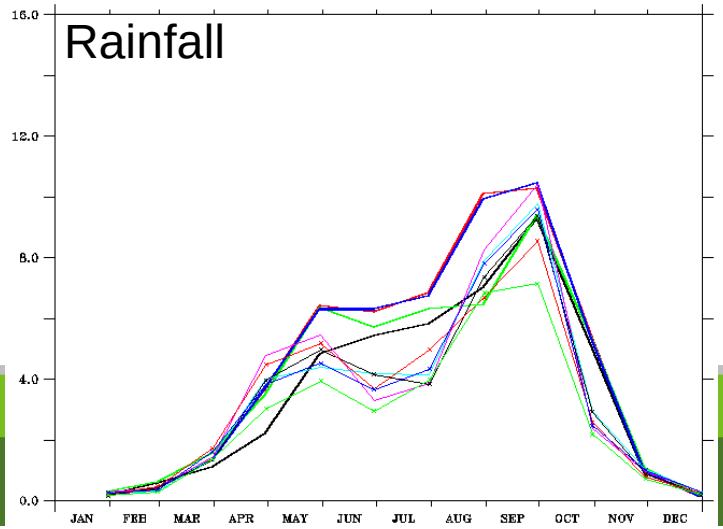
Select scenario

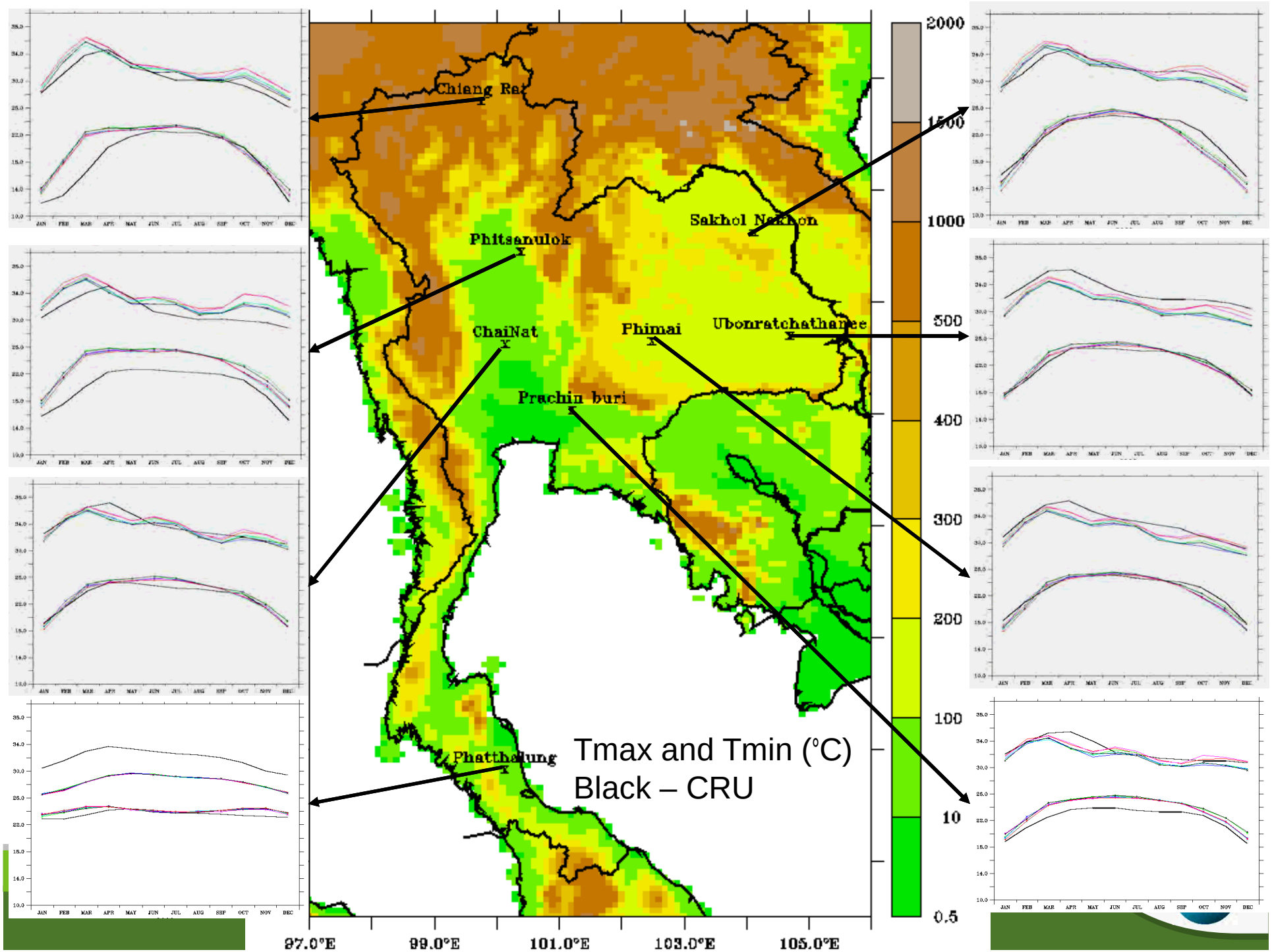
Source projections data

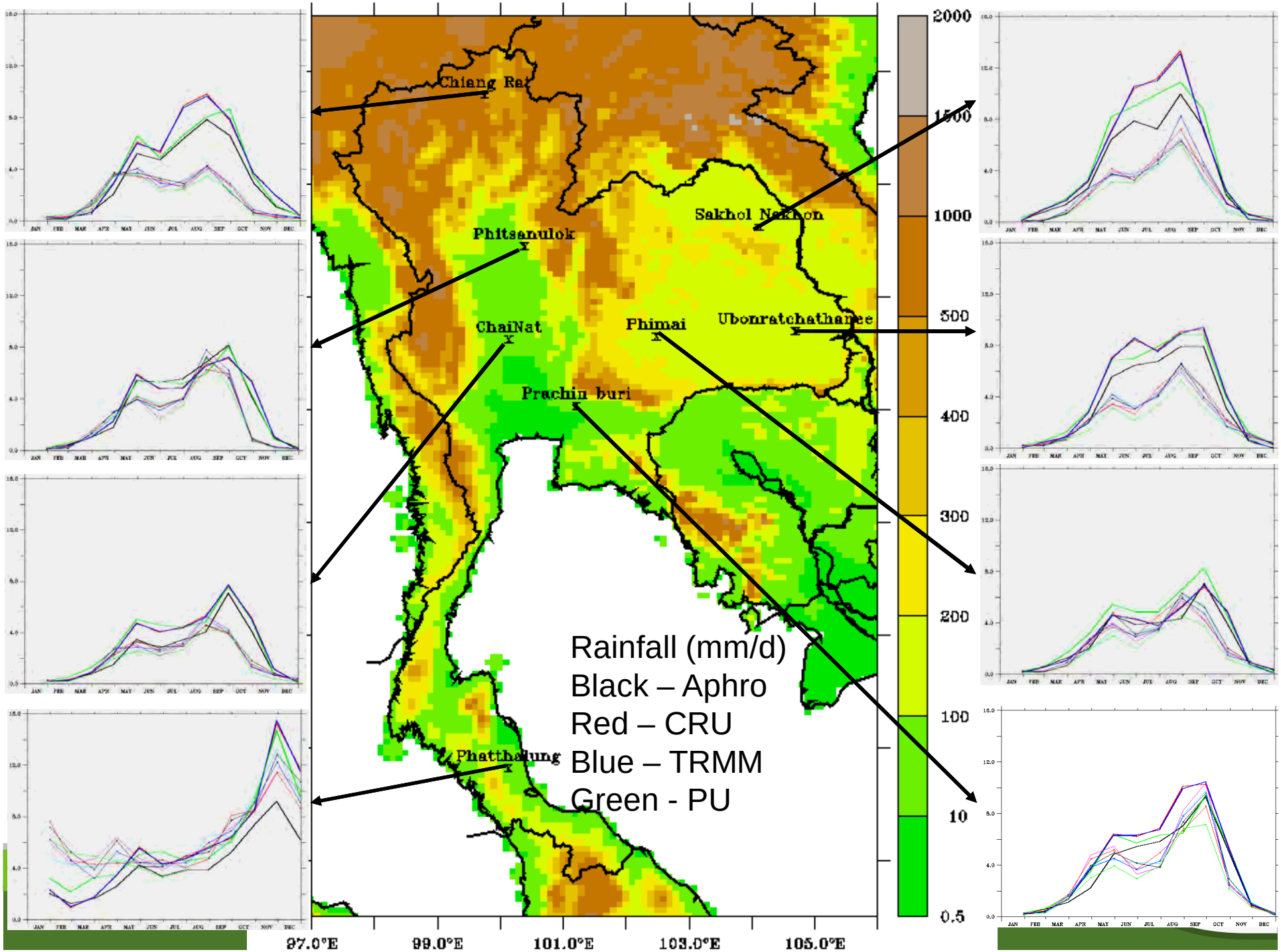
Evaluate simulations for current climate

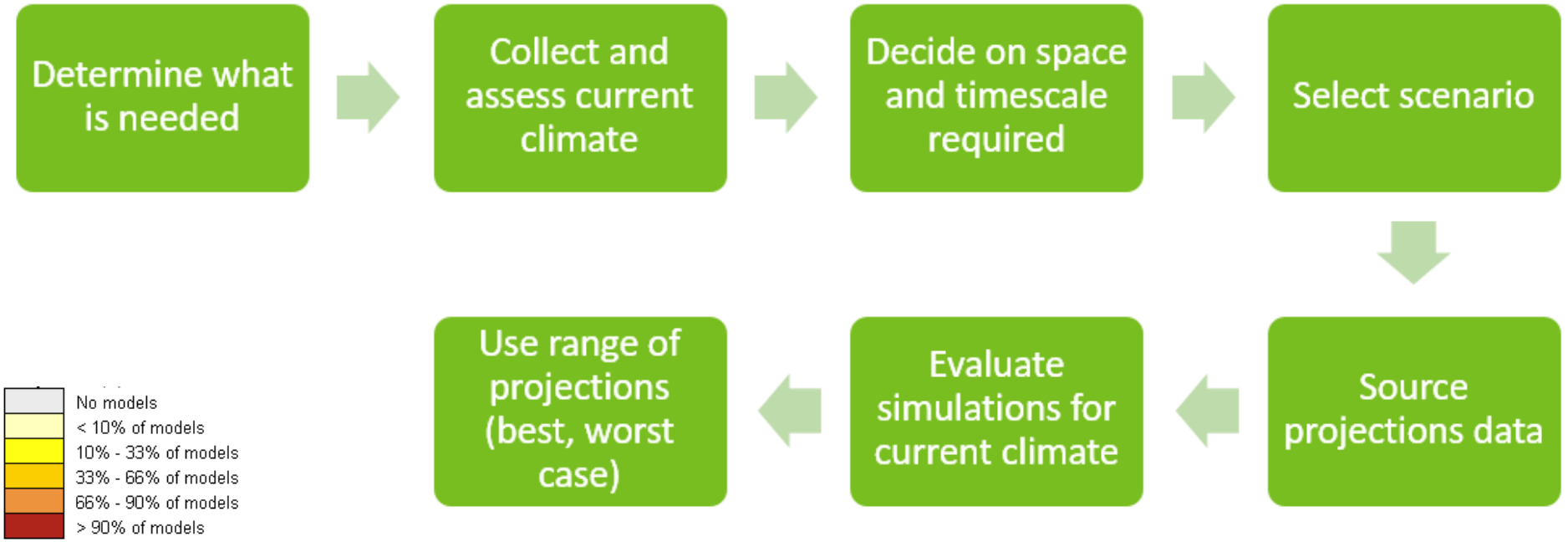
Maximum and Minimum Temperatures



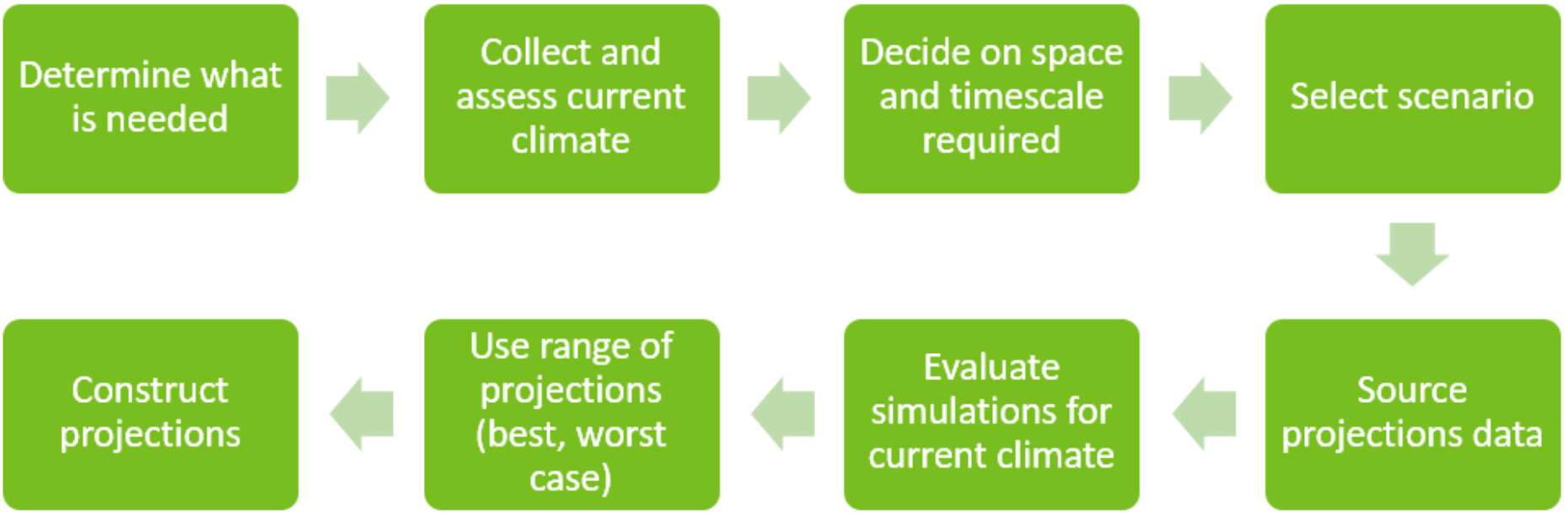



Chiang Rai
Phitsanulok
Sakhol Nakhon
ChaiNat
Phimai
Ubonratchathanee
Prachin buri
Phatthalung
Tmax and Tmin (°C)
Black – CRU
2000
1500
1000
500
400
300
200
100
10
0.5
97.0°E
99.0°E
101.0°E
103.0°E
105.0°E


Chiang Rai
Phitsanulok
Sakhol Nakhon
ChaiNat
Phimai
Ubonratchathanee
Prachin buri
Phatthalung
Rainfall (mm/d)
Black – Aphro
Red – CRU
Blue – TRMM
Green - PU
2000
1500
1000
500
400
300
200
100
10
0.5
97.0°E
99.0°E
101.0°E
103.0°E
105.0°E



		Surface Temperature - Annual (° C)			
		Slightly Warmer < 0.50	Warmer 0.50 to 1.50	Hotter 1.50 to 3.00	Much Hotter > 3.00
Rainfall - Annual (% change)	Much Drier < -15.00			Likelihood: 12 of 24 models (50%) Most Likely	Likelihood: 1 of 24 models (4%) Worst case
	Drier -15.00 to -5.00			Likelihood: 6 of 24 models (25%)	Likelihood: 2 of 24 models (8%)
	Little Change -5.00 to 5.00		Likelihood: 1 of 24 models (4%)	Likelihood: 1 of 24 models (4%)	
	Wetter 5.00 to 15.00			Likelihood: 1 of 24 models (4%) Best case	
	Much Wetter > 15.00				



Need to consider

1) Format
2) Calculate indices

Determine what is needed

Collect and assess current climate

Decide on space and timescale required

Select scenario

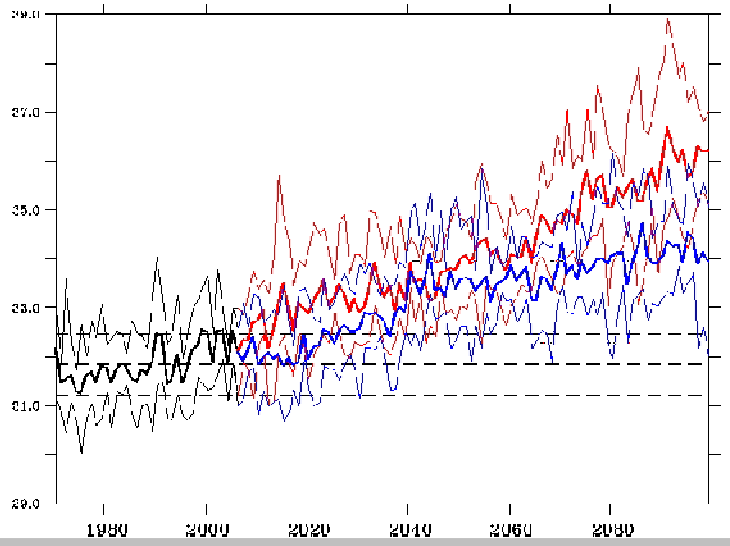
Source projections data

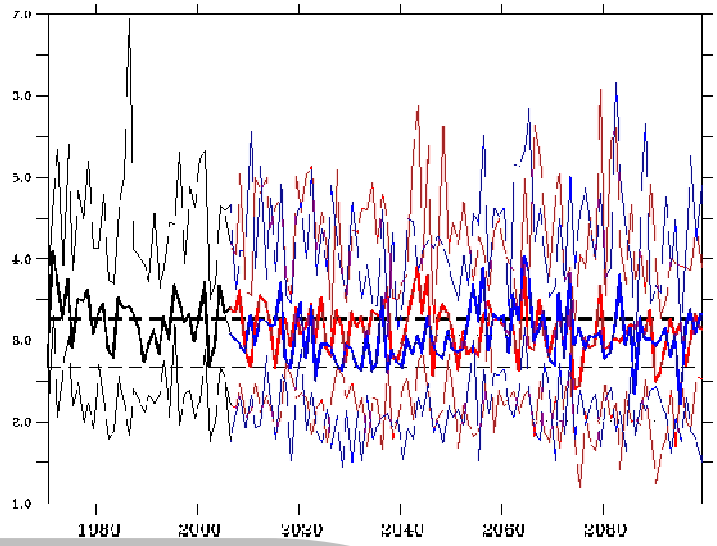
Evaluate simulations for current climate

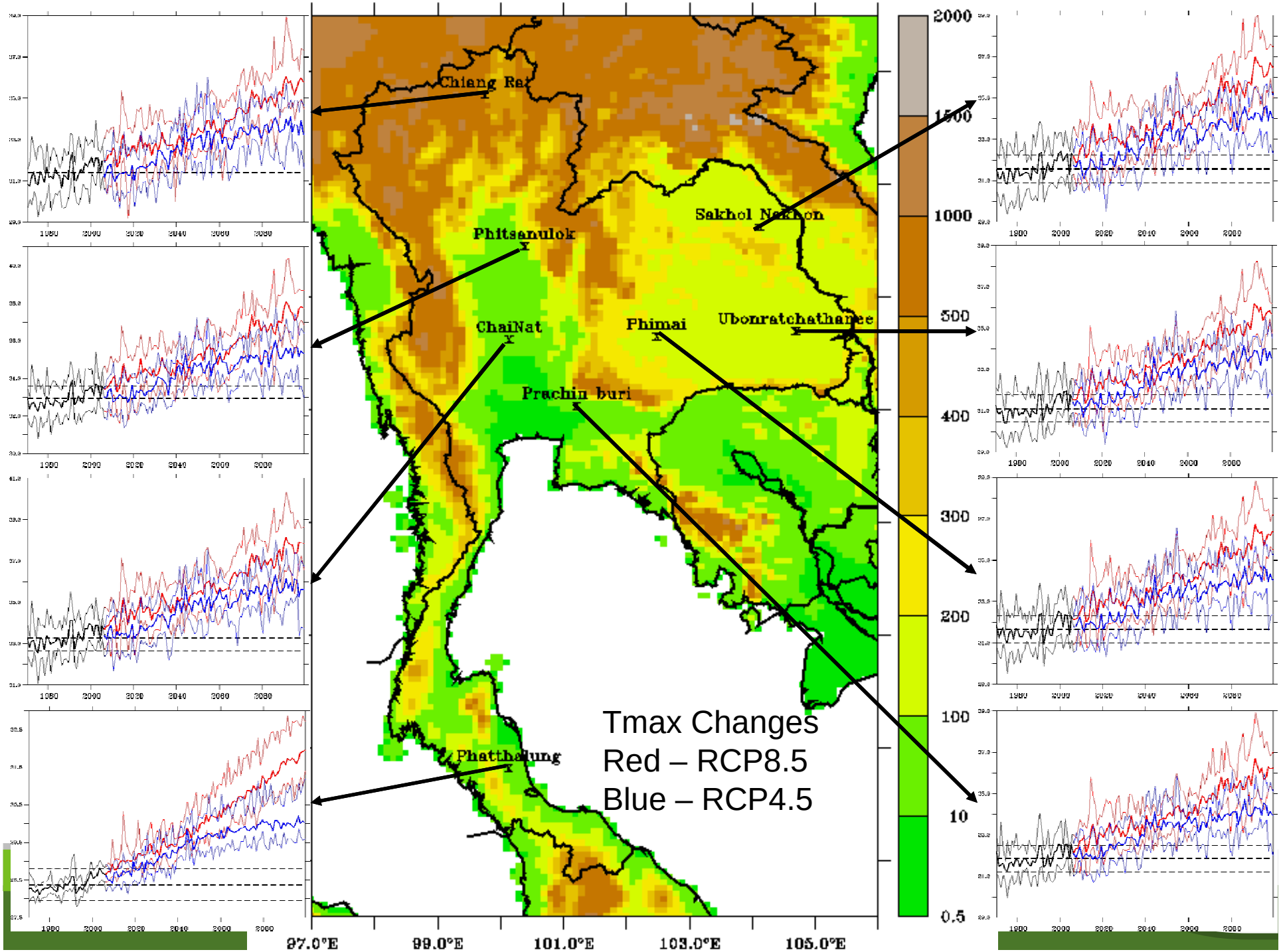
Use range of projections (best, worst case)

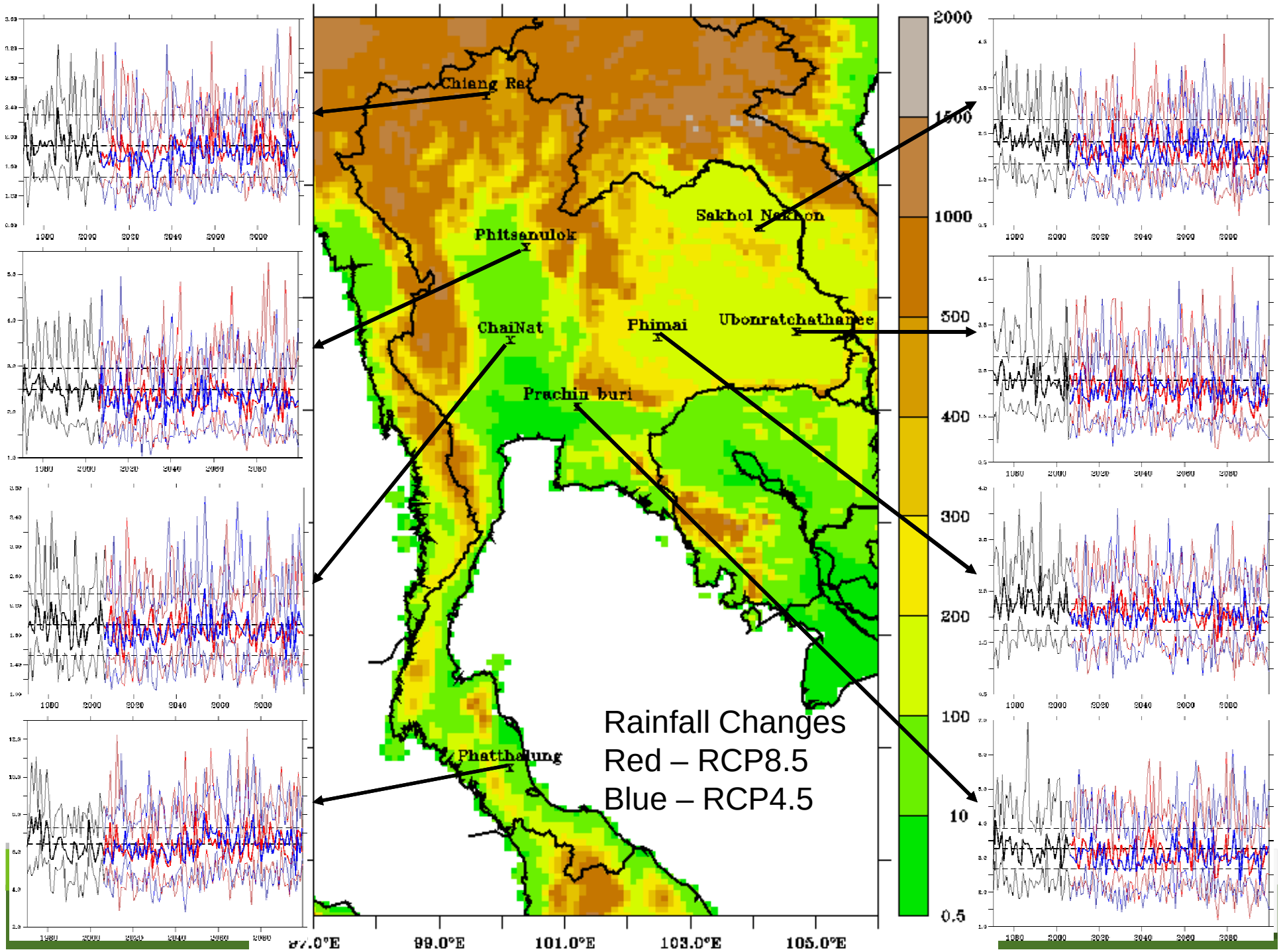
Construct projections

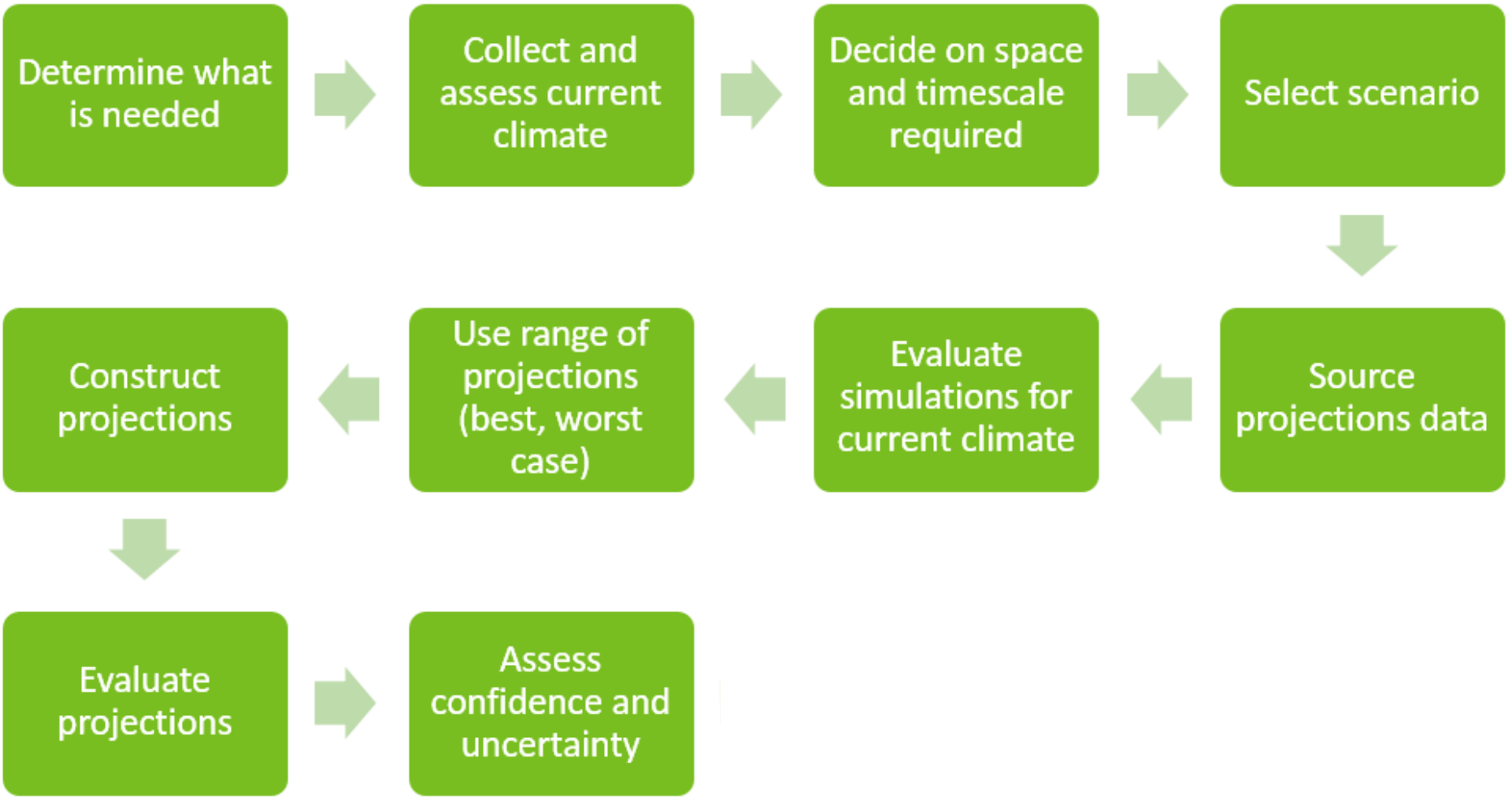
Evaluate projections



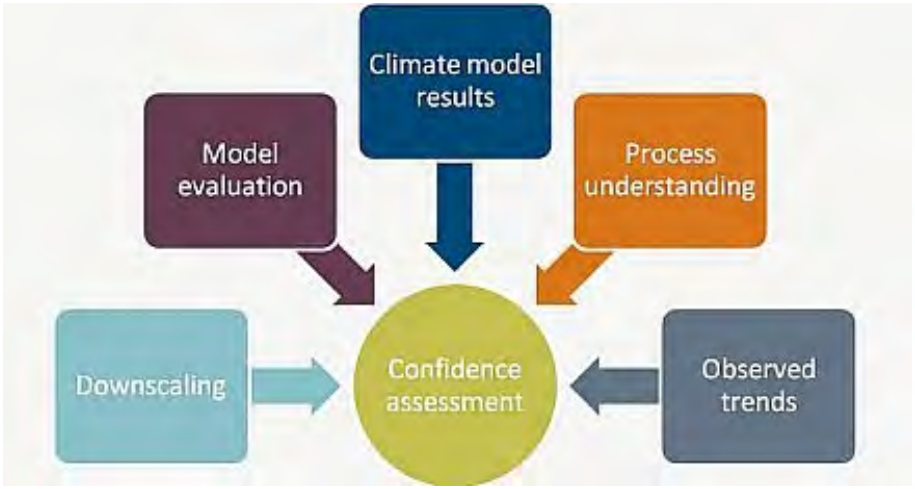


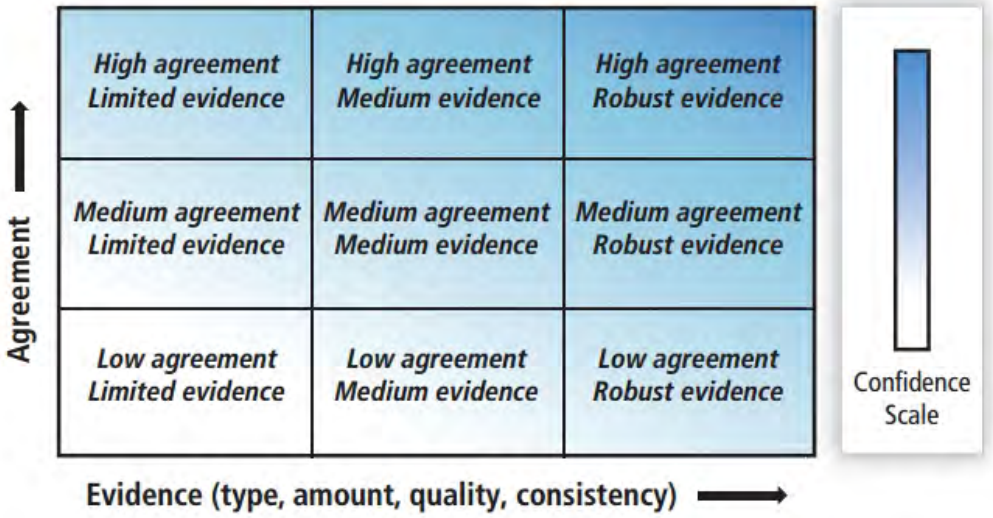

Chiang Rai
Phitsanulok
Sakhol Nakhon
ChaiNat
Phimai
Ubonratchathanee
Prachin buri
Phatthalung
Tmax Changes
Red – RCP8.5
Blue – RCP4.5
2000
1500
1000
500
400
300
200
100
10
0.5
97.0°E
99.0°E
101.0°E
103.0°E
105.0°E


Chiang Rai
Phitsanulok
Sakhol Nakhon
ChaiNat
Phimai
Ubonratchathanee
Prachin buri
Phatthalung
Rainfall Changes
Red – RCP8.5
Blue – RCP4.5
99.0°E
101.0°E
103.0°E
105.0°E
2000
1500
1000
500
400
300
200
100
10
0.5


Determine what is needed
Collect and assess current climate
Decide on space and timescale required
Select scenario
Source projections data
Evaluate simulations for current climate
Use range of projections (best, worst case)
Construct projections
Evaluate projections
Assess confidence and uncertainty

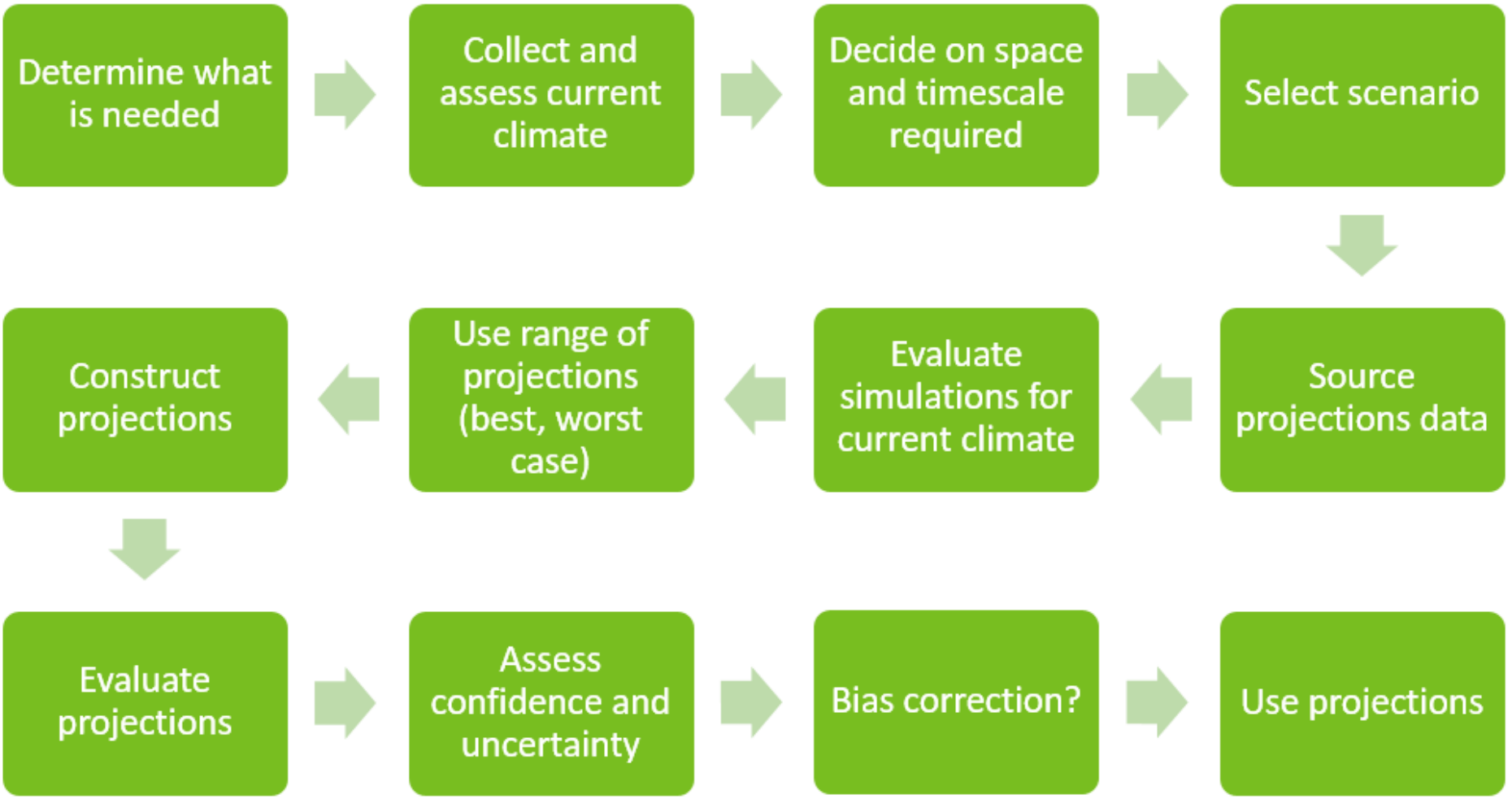
Uncertainty and confidence in projections





Five lines of evidence to consider when assessing confidence in projections

IPCC


Determine what is needed
Collect and assess current climate
Decide on space and timescale required
Select scenario
Source projections data
Evaluate simulations for current climate
Use range of projections (best, worst case)
Construct projections
Evaluate projections
Assess confidence and uncertainty
Bias correction?
Use projections

Data preparation

Weather data file format:

*WEATHER DATA :Prachin Buri Meteorology Station,THAILAND (WMO Index Number: 48430)

@ INSI	LAT	LONG	ELEV	TAV	AMP	REFHT	WNDHT
RDPC	14.050	101.370	2.0	29.1	2.7	2.0	2.0

@DATE	SRAD	TMAX	TMIN	RAIN	DEWP	WIND	PAR
09001	10.72	29.2	22.4	0.0	-99	-99	-99

ELEV = Elevation of the weather station in meter above mean sea level
TAV = Temperature average (°C) for whole year
AMP = Temperature amplitude (°C), monthly averages
REFHT = Reference height for data in meter above ground level
WNDHT = Reference height for wind speed in meter above ground level
SRAD = Daily solar radiation in MJ m^{-2} day^{-1} (total radiation).
RAIN = Daily rainfall (incl. snow) in mm day^{-1}
DEWP, WIND, PAR not used

```
var=rnd24
  cdo -O outputf,%5.1f $var.nc > $var.txt

var=tmaxscr
  cdo -O subc,273.16 $var.nc txc.nc
  cdo -O outputf,%5.1f txc.nc > txc.txt

var=tminscr
  cdo -O subc,273.16 $var.nc tnc.nc
  cdo -O outputf,%5.1f tnc.nc > tnc.txt

# convert radiation from w/m2 to MJ/m2/d
cdo -O divc,$conv sgdn_ave.nc srad.nc
cdo -O outputf,%5.1f srad.nc > srad.txt

ofile=$odir/${INSI}$yy$en.WTH

echo "*WEATHER  DATA : $name,THAILAND(gcm=$gcm,rcp=$rcp)" > $ofile
echo "@ INSI      LAT     LONG    ELEV   TAV   AMP REFHT WNDHT" >>  $ofile
echo "  $INSI $lat $lon   $elev $tav $amp   2.0  10.0" >>  $ofile
echo "@DATE  SRAD  TMAX  TMIN  RAIN  DEWP  WIND   PAR" >>  $ofile
paste -d " " date.txt srad.txt txc.txt tnc.txt rnd24.txt dewpt.txt u10.txt 99.txt >>  $ofile

rm -f date.txt srad.txt txc.txt tnc.txt rnd24.txt dewpt.txt u10.txt 99.txt

sed 's/$/\r/g' $ofile > $$.txt;mv $$.txt $ofile # to get msdos format correct
```

-- Filename must follow the 8.3 format, CR017001.WTH
CR = Chiang Rai
01 = Zone one
70 = last two digits of the year, 1970
01 = station no of Zone one.
Extension name must be WTH.

Conclusions

- Detailed risk assessments need projections from individual climate models to ensure **internal consistency** across multiple climate variables
- Using all climate models is very resource intensive
- Need to consider **range of scenarios**
- **No "one size fits all",** so climate projections need to be purpose-built
- For region-specific projections, select of a small number of can be models for use in risk assessment: **median case, 'worst' case and 'best' case** (not just downscaled results)

Thank you

FOR MORE INFORMATION CONTACT:

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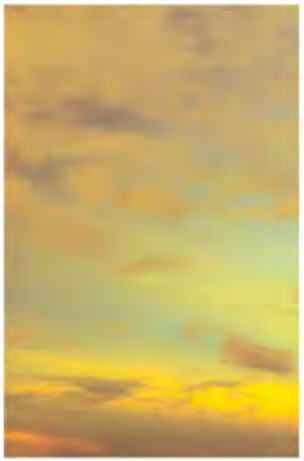
Regional Climate Projections Consortium and Data Facility for Asia and the Pacific

Use of climate services in Asia and the Pacific is challenged by limited reliable climate information, insufficient capacity to interpret and use climate information, and limited technical and financial resources.

The Regional Climate Projections Consortium and Data Facility (RCCDF) will develop a community of practice to provide this in a cost-effective and sustainable manner through capacity building. The RCCDF project[1] will address these challenges by providing:

1. Access to climate information.



2. Guidelines and examples for conducting impacts and vulnerability assessments.

3. Knowledge sharing and learning.

RCCDF GOALS:

- Adopt best practices for adaptation planning
- Support learning by doing
- Develop in-country capacity for using climate information in impacts and vulnerability assessments
- Implement and support the portal (an online resource with links to data and information)
- Increase collaboration on assessment of common regional climate impacts

THE RCCDF WILL PROVIDE ACCESS TO:

- Available current and future climate information
- Guidelines on how to develop, interpret and use climate information
- An online web interface (portal) to provide access to the guidelines, learning materials and other related services.

[1] The project is being implemented by the Asian Development Bank through the technical assistance for Regional Climate Projections Consortium and Data Facility in Asia and the Pacific (TA 8359-REG) financed by the Japan Fund for Poverty Reduction.

Types of projection data

Application-ready data

- Some impact assessments require future weather and climate data that have a format similar to historical data, including natural variability.

- Sensitivity analysis
- Delta change or perturbation method
- Climate analogues
- Weather generation
- Statistical downscaling
- Dynamical downscaling

SACA&D

Southeast Asian Climate Assessment & Dataset

http://sacad.database.bmkg.go.id/

Home FAQ Daily data Indices of extremes Project info

See also: ICA&D KNMI Climate Explorer

Home

Home

Welcome to the website of the Southeast Asian Climate Assessment & Dataset (SACA&D) project. Presented is information on changes in weather and climate extremes, as well as the daily dataset needed to monitor and analyse these extremes.

What's new?

The database is updated until: Dec 30, 2014.
March 2011 - Website online.
January 2011 - Logo included and website colours updated.
All news items

Participants and data

Today, SACA&D is receiving data from 24 participants for 15 countries and the SACA dataset contains 6477 series of observations for 10 elements at 4090 meteorological stations throughout Southeast Asia. 31% of these series is public, which means downloadable from this website for non-commercial research (see Daily data > Data dictionary for an overview of all available series). Participation to SACA&D is open to anyone maintaining daily station data. If you want to join please contact us. See our Data Policy for more details.

DiDaH project

DIDAH project

SACA&D is developed as part of the Digitisasi Data Historis (Didah) project. This project is focusing on the digitization and use of high-resolution historical climate data from Indonesia and other Southeast Asian countries. Didah is a joint project between the National Meteorological Services of Indonesia (BMKG) and the Netherlands (KNMI).

The results on this website contribute to the work of the Asian Pacific Network for climate extremes (APN).

Contact us

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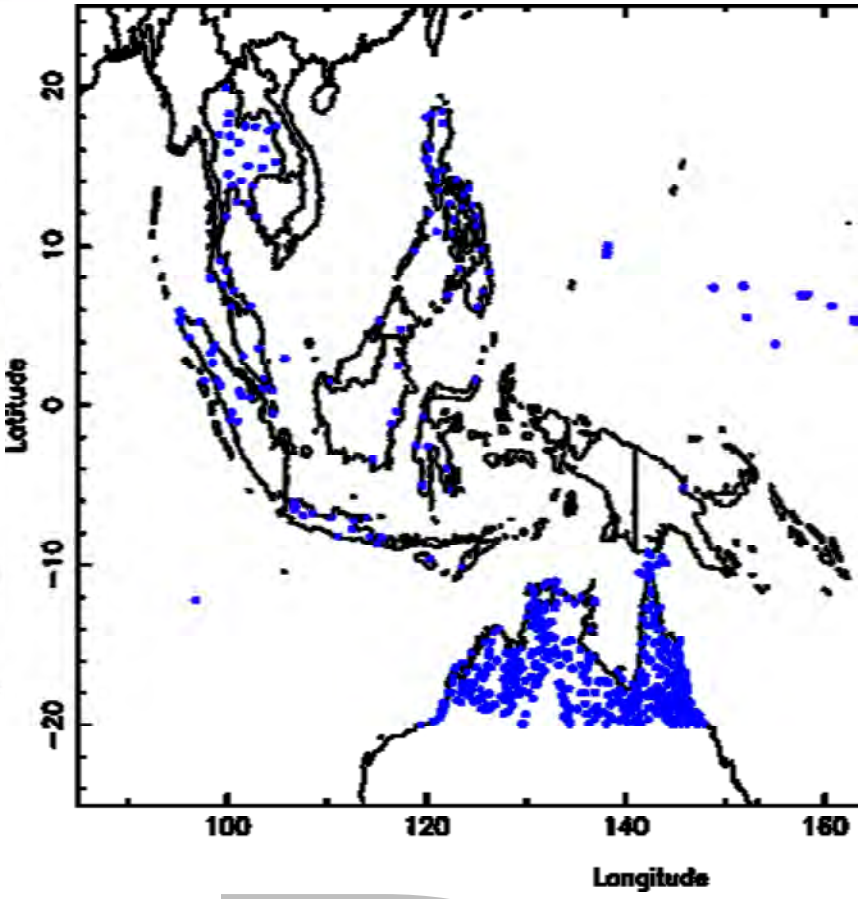
Rudmer Jilderda (KNMI)
Richard Rothe (KNMI)
Gerard van der Schrier (KNMI)



CSIRO

Atmosphere

- Overview of current reanalyses
  - Comparison Table
  - EURO4M
  - References
- How to obtain/plot/analyze data
- Comparison
- Tools
- Diagnostic Studies: Climate Variability
- Diagnostic Studies: Weather Variability
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    - Observation and Reanalysis Studies
      - Diurnal variation of upper tropospheric

Home ▸ Atmosphere ▸ Overview of current atmospheric reanalyses

Overview of current atmospheric reanalyses

Last edited by michael.bosilovich on Tue, 10/27/2015 - 10:37

Current / State-of-the-art:
ASR | ERA-20C | ERA-20CM | ERA-Interim | JRA-55 | MERRA-2 | NCEP CFSR | NOAA-CIRES 20CRv2c

Possible issues: Consider other datasets for use in new research projects: NCEP/DOE II | NCEP/NCAR | NCEP NARR
Superseded / Caution use for new research projects: ERA-40 | ERA-15 | JRA-25

Model Change: NCEP CFSR (2011 and after)

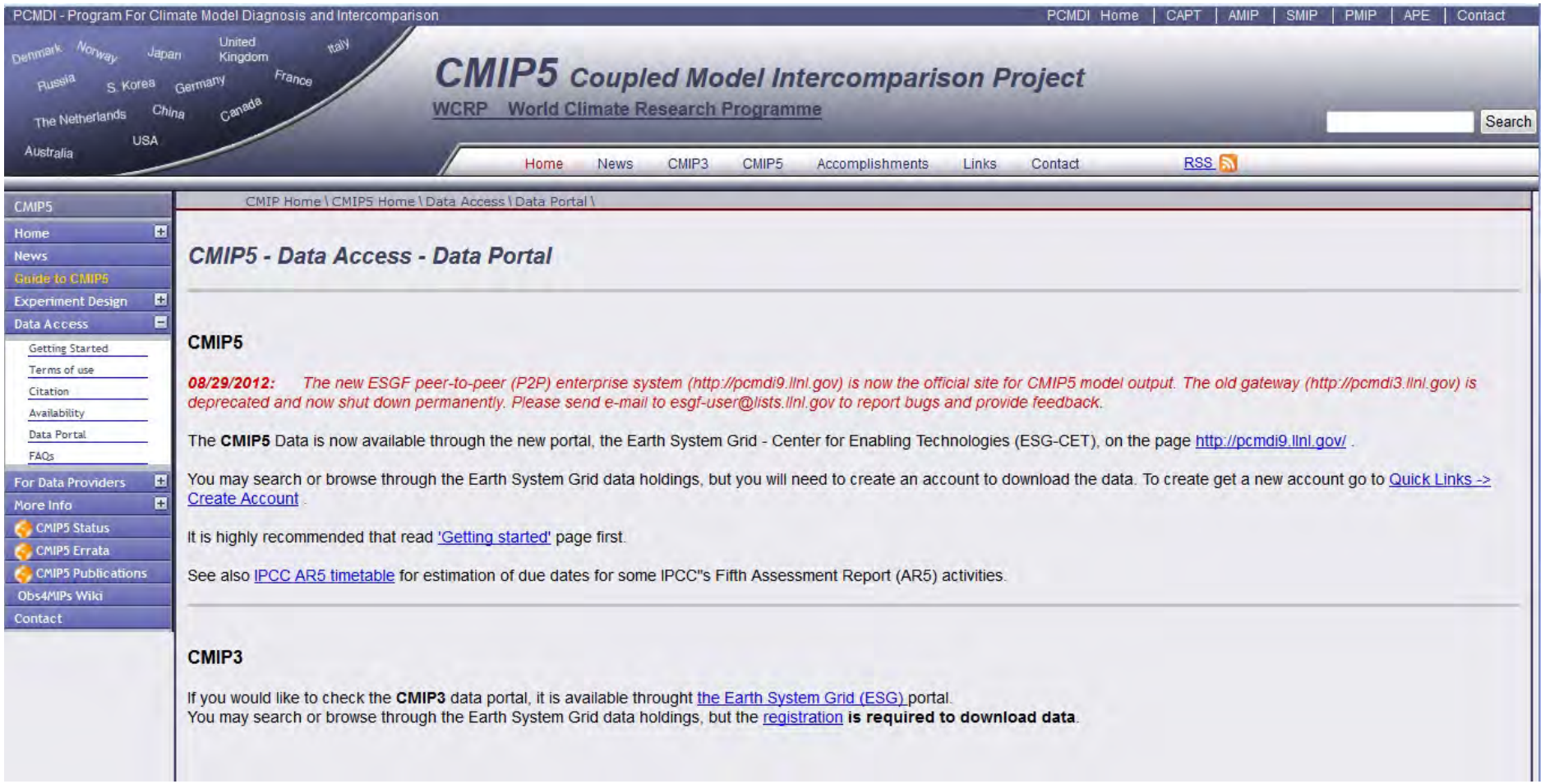
Updated in real-time for public use (days behind): NCEP/DOE II | NCEP/NCAR | NCEP NARR | NCEP CFSR?
Updated in near real-time for public use (months behind): ERA-Interim | JRA-55 | MERRA-2
Updated irregularly for public use (years behind): ERA-20C | ERA-20CM | NOAA-CIRES 20CR | NOAA-CIRES 20CRv2c | NASA MERRA

Arctic System Reanalysis (ASR): 2000-2011

The Arctic System Reanalysis (ASR), which can be viewed as a blend of modeling and observations, will provide a high resolution description in space (10-30 km) and time (3 hourly) of the atmosphere-sea ice-land surface system of the Arctic. There are two versions of ASR:

Arctic System Reanalysis-Interim (ASR-int)
Source: The Ohio State University, Byrd Polar Research Center, Polar Meteorology Group
Time Range: 2000-2010
Assimilation: WRFDA-3DVAR
Model Resolution: 30 km, 71 sigma levels
Model Output Resolution: 30 km
Publicly Available Dataset Resolution: 30 km
Dataset Output Times and Time Averaging: 3-hourly for surface and upper air fields
Monthly means of selected variables
Here is the dataset location: http://rda.ucar.edu/datasets/ds631.4/
A new version is expected late 2012.

Arctic System Reanalysis-Final (ASR-fnl)
Source: The Ohio State University, Byrd Polar Research Center, Polar Meteorology Group
Time Range: 2000-2011
Assimilation: WRFDA-3DVAR
Model Resolution: 10 km, 71 sigma levels
Model Output Resolution: 10 km
Publicly Available Dataset Resolution: 10 km
Dataset Output Times and Time Averaging: 3-hourly for surface and upper air fields



http://cmip-pcmdi.llnl.gov/cmip5/data_portal.html