# Downscaling for Practical Purposes

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(MAIRS)

Uniqueness of Monsoon Asia

- World's highest mountains
- Heat source of Tibetan Plateau
- Seasonal monsoon affects food, water and energy resources
- Range of natural hazards (TC to GLOF)
- 3.6 billion people
- Anthropogenic aerosols
- Vulnerable coastal development
- Rapid urbanisation and economic growth
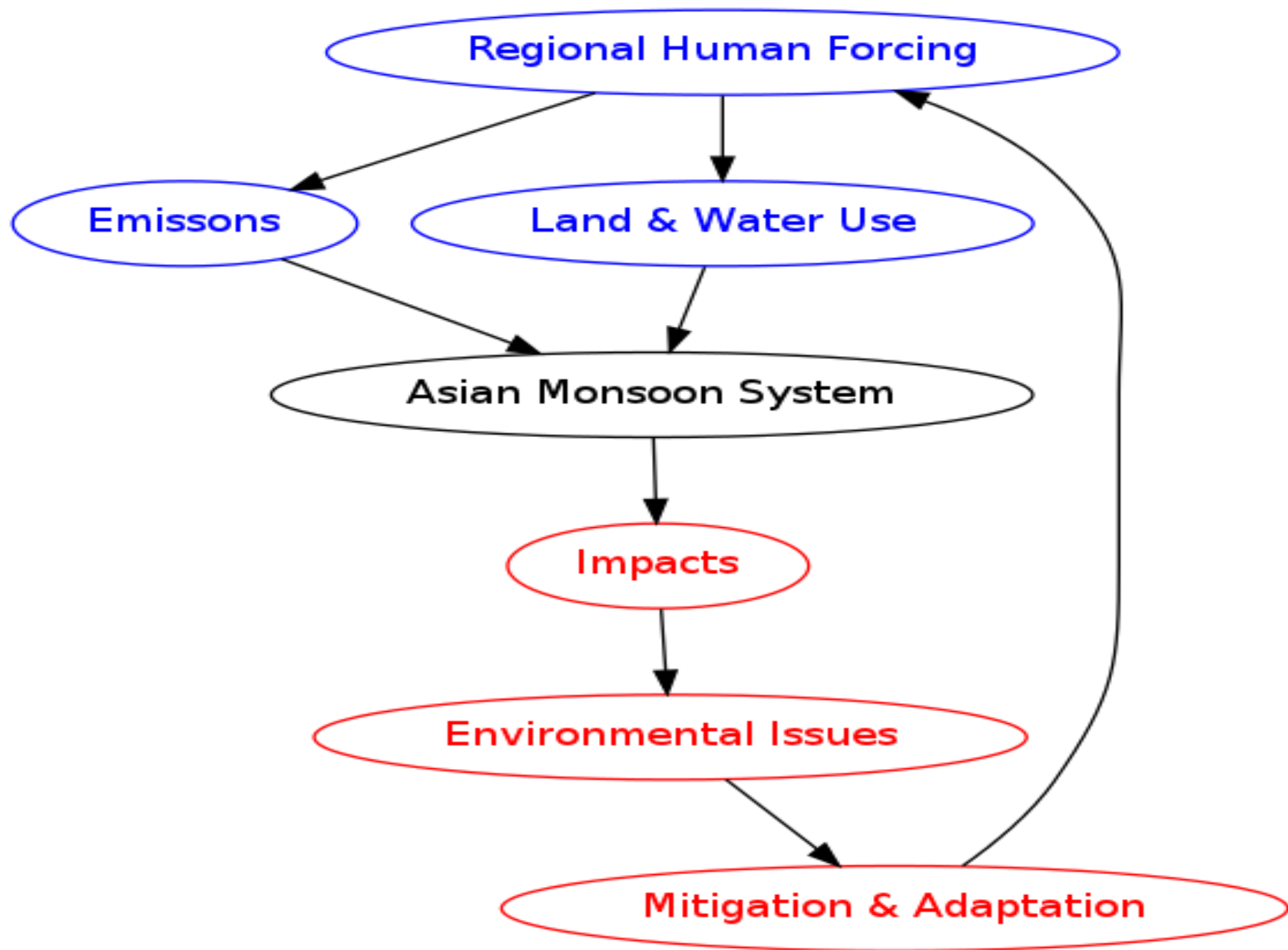
MAIRS Themes

- Multiple stresses in high mountain zones
- Vulnerable systems in dryland zones
- Rapid transformation in coastal zones
- Rapid development of urban zones
- Modelling and observations

Modelling Studies

- Land surface (ecosystem) modelling inter-comparison (ADMIP: Jun Asanuma)

- Regional urban climate modelling project (JST-MOST: Congbin FU and T. Yasunari)

- Regional Modelling Inter-comparison Project (RMIP Asia: Shuyu WANG, Congbin FU)

- Joint activity with WCRP CORDEX across Asia

WCRP
CORDEX

Regional Climate Modelling Inter-comparison Project (RMIP)

- Regional projections for 2040-2070 with uncertainties

- Data sharing

- Development of integrated assessment tool for urban policy and planning

- High-resolution precipitation events

- High-resolution urban simulations

- High-resolution mountain simulations

Joint Activity with WCRP CORDEX

- Activity funded by APN "Coordinated Regional Climate Downscaling Experiment (CORDEX) in Monsoon Asia" (2013-2016)

- Main Collaborators: KMA, NJU, CMA, IITM, ICIMOD, CSIRO, BMKG, MNU

- CORDEX South Asia workshop, 27-30 Aug 2013, Kathmandu, Nepal

- SEACLID – CORDEX South East Asia workshop, 18-19 November 2013, Jakarta, Indonesia

- CORDEX South East Asia workshop, Nov 2014, Citeko, West Java, Indonesia

- CORDEX East Asia workshop, Nov 2015, Korea or China

CORDEX Issues

- Modelling and evaluation
  - GCMs, RCMs
- Statistical downscaling and evaluation
  - Value-adding to modelling
  - Relate large-scale model output to local climate
- Applications and uncertainties
  - Match method to application
 - Recognise cumulative uncertainties

IPCC AR5 – Model Evaluation - GCMs

- Seasonal cycle of temperature better simulated than precipitation at regional scales

  - *Predictability varies with variable*

- Multi-model mean is closer to observations than individual models

  - *Need to use ensembles*

- Generally small improvements between CMIP3 and CMIP5

  - *Uncertainties remain*

- Inter-model spread remains large, especially with steep orography

  - *Challenge of mountain areas of Asia*

- Model bias increases with decreasing spatial scale

  - *Challenge for local applications*

IPCC AR5 – Model Evaluation - RCMs

- Higher spatial resolution than GCMs
  - Better simulation of locally-forced precipitation
  - Resolved scale greater than grid size
  - Sub-diurnal precipitation limited
  - RCM time-slice is just one realisation
- No ocean feedback in general
  - Local air-sea interactions may be under-estimated
- Driven from GCMs
  - Large-scale bias can propagate from GCM to RCM

UK Winter Precipitation 1961-2000

GCM 300km · RCM 50km · RCM 25km · MetOffice Obs 5km

1 2 3 5 7 10
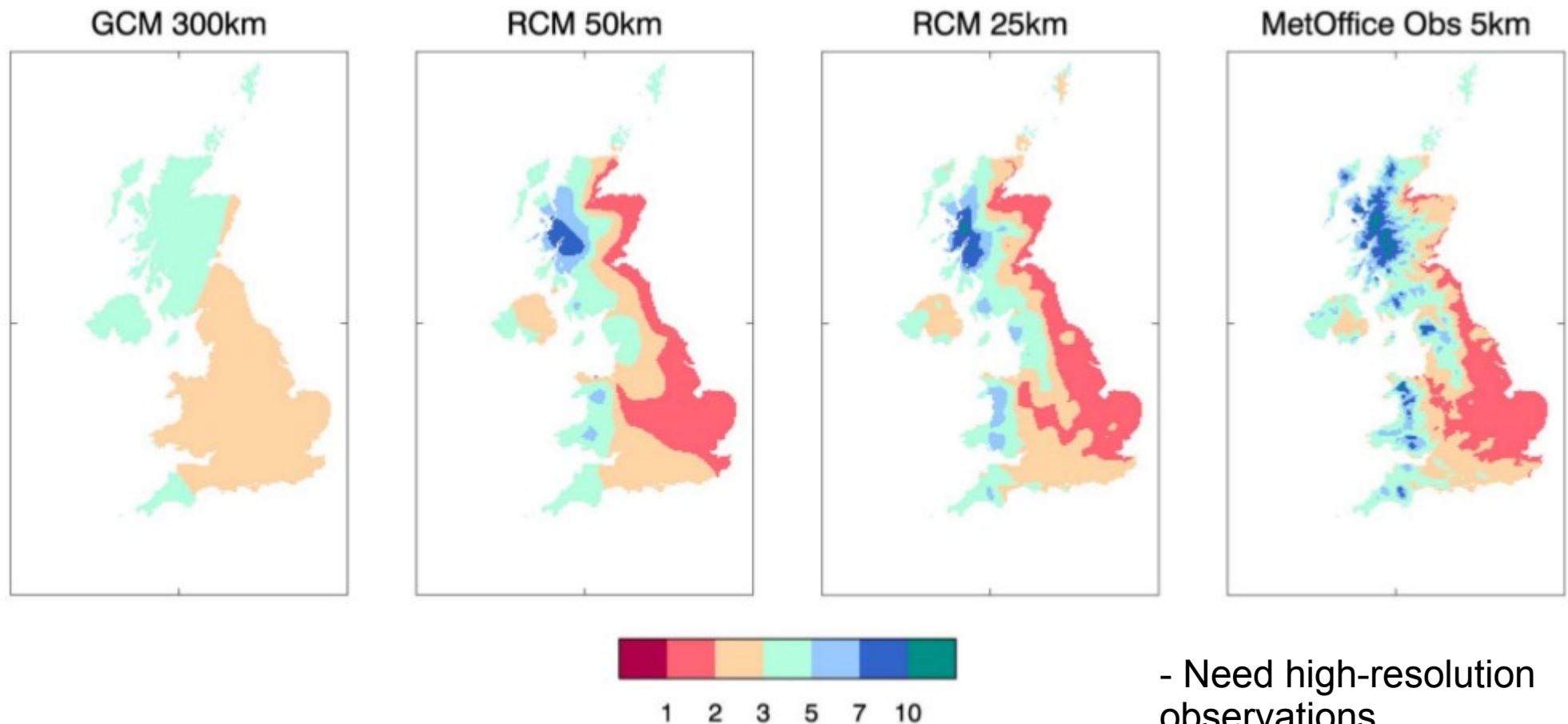
- Need high-resolution observations
- Challenges on and in lee of mountains

D. Maraun et al. (2010) Rev Geophys

Ensembles in RMIP – Taylor Diagrams

(KE Taylor (2001) JGR 106, 7183)   Shuyu Wang, NJU
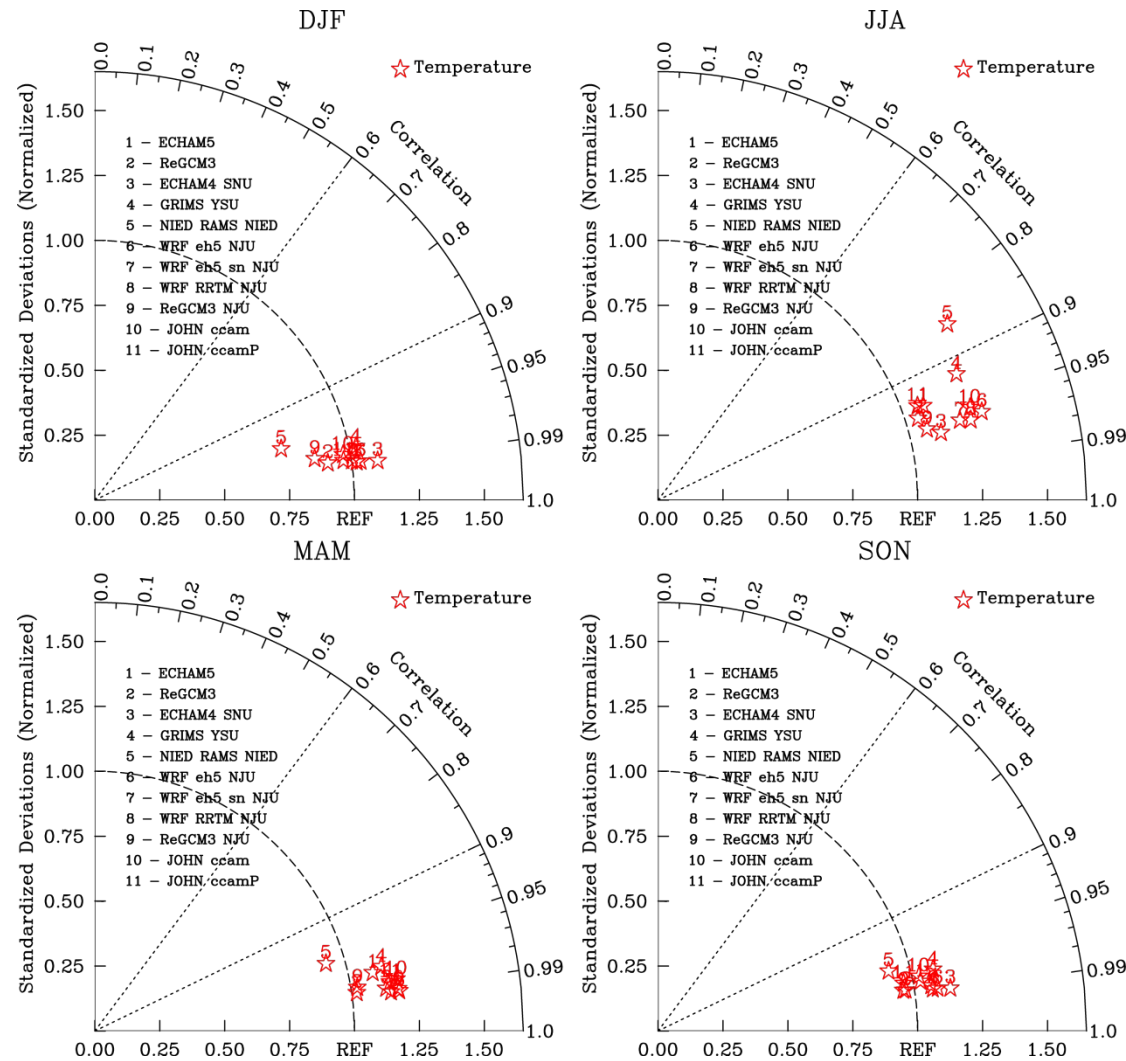
Sources of uncertainty in the simulation of temperature and precipitation change (2071-2100 minus 1961-1990) by the ensemble of PRUDENCE simulations (whole Europe) (Note: the scenario range is about half of the full IPCC range, the GCM range does not cover the full IPCC range) (Adapted from Deque et al. 2006)

RCM
VARIABILITY
GCM
SCENARIO

T-DJF   T-JJA   P-DJF   P-JJA

(F. Giorgi, 2008)
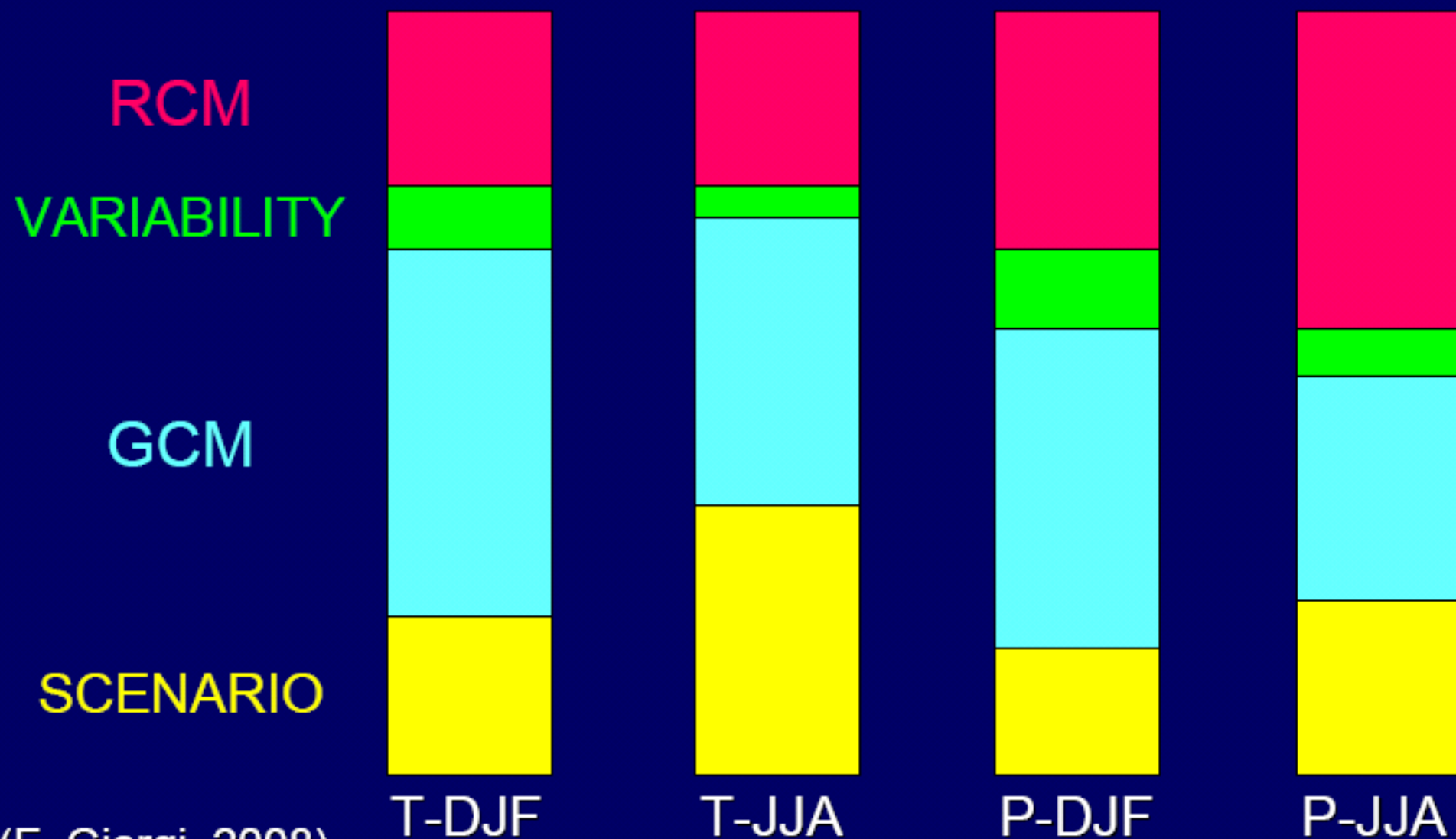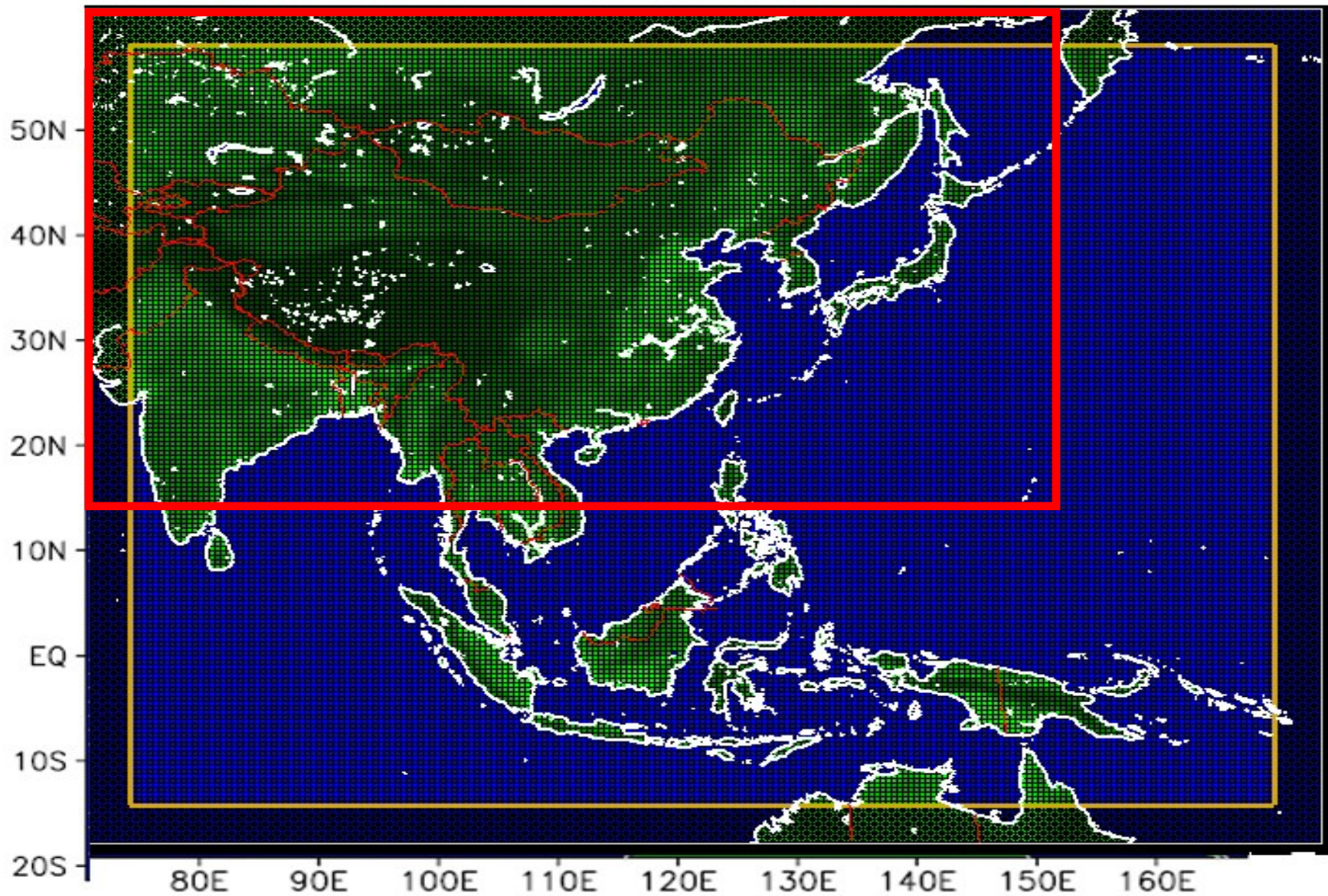
Original EA domain (yellow) and the proposed NEW EA domain (red)

Xuejie Gao, CMA

- Large domain → 25 km
- Smaller domain → 50 km
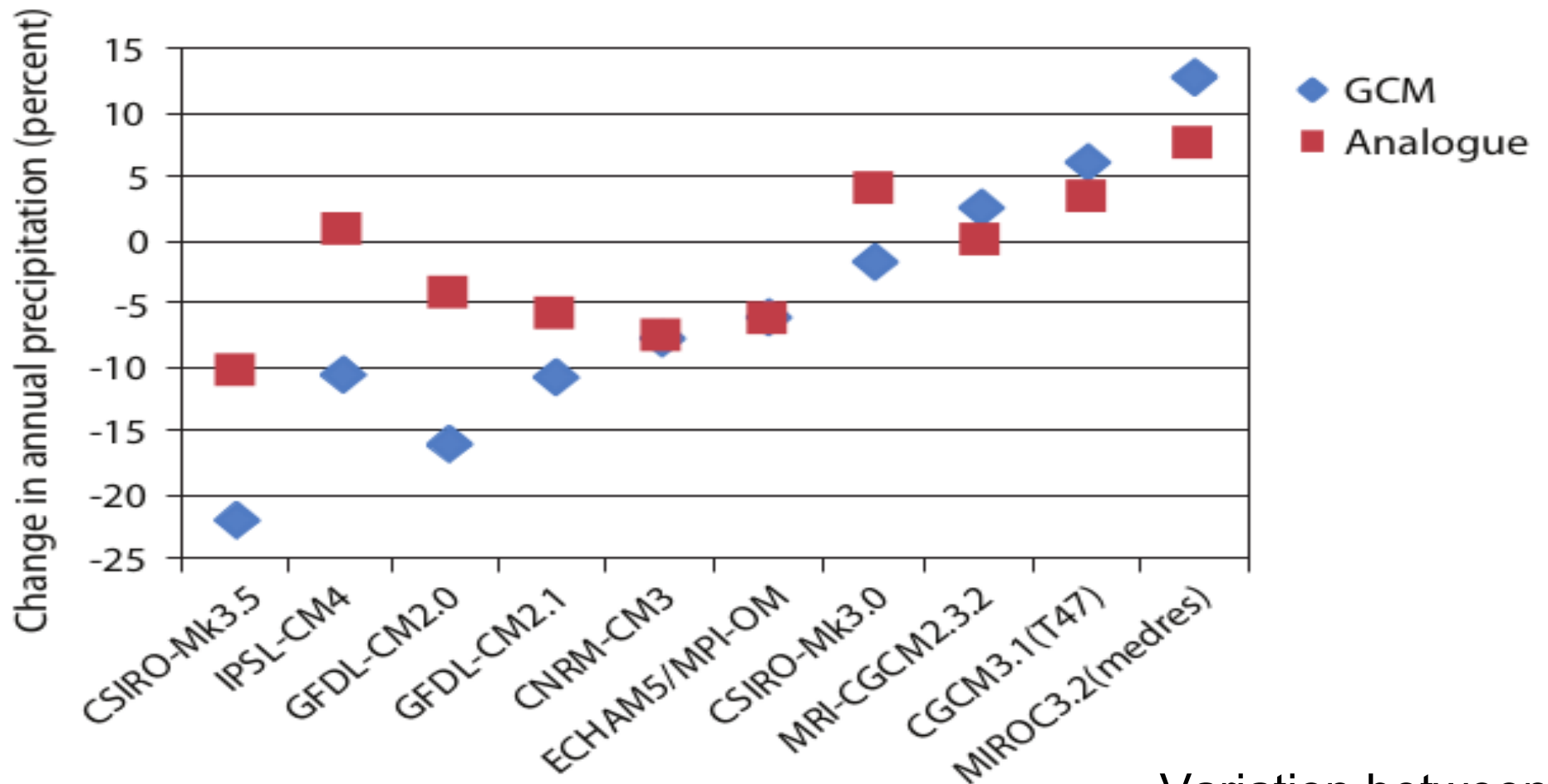- Interaction of large-scale systems

Statistical Downscaling

- Account for scale difference between model and local climate

- Assume $P = fn(X)$ where P is local climate variable and X is vector of large-scale model variables

- Assume model estimates X better than P

- Use observations of P (and perhaps X) to determine parameters in function
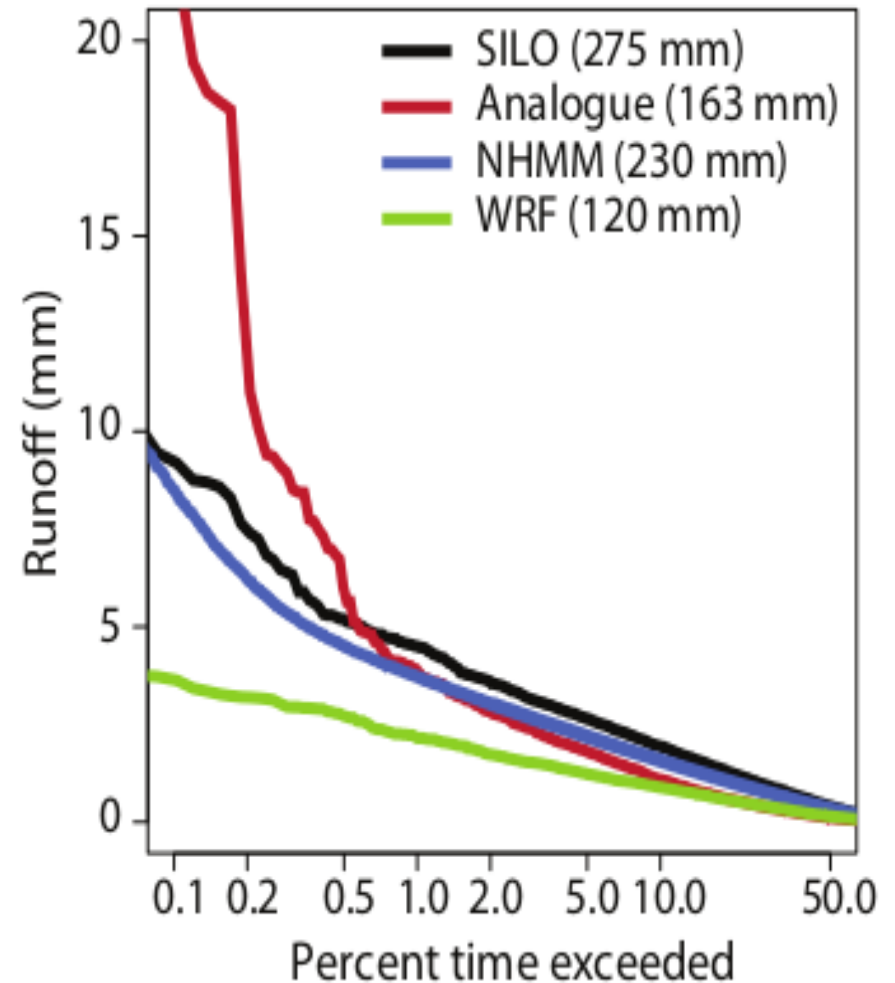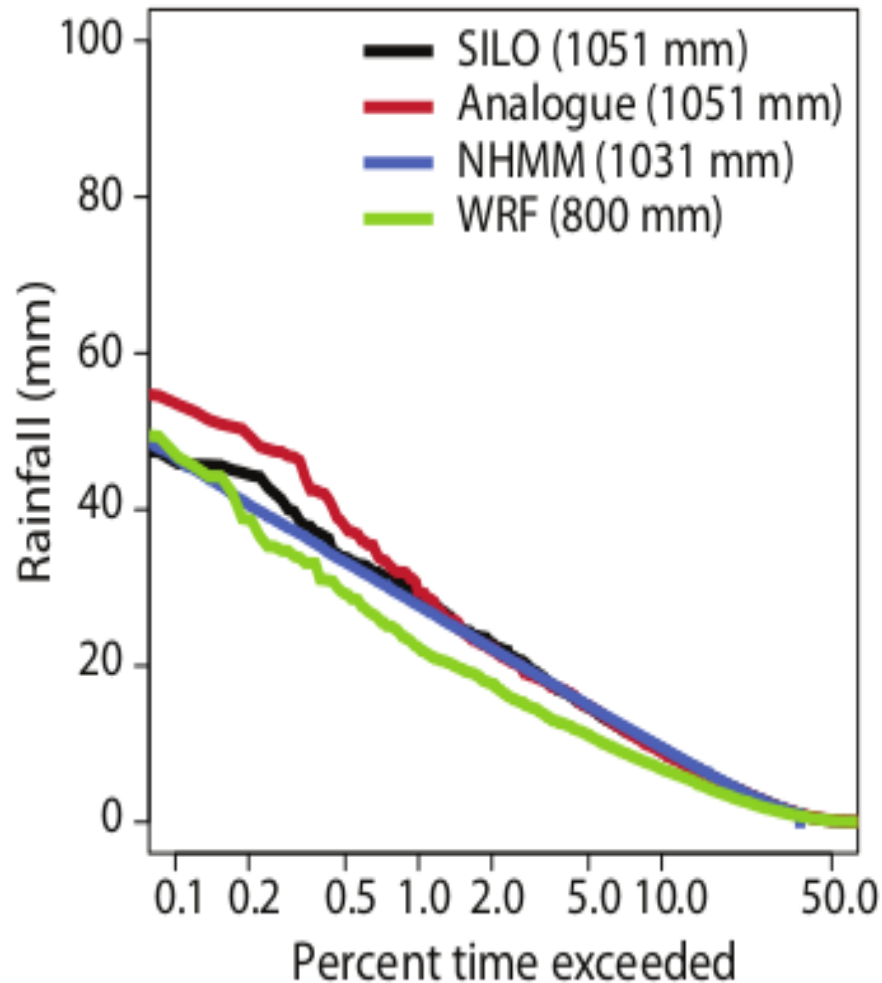
- Downscale from GCM or RCM

- Easily downscale model ensemble

Maraun et al (2010) Res Geophys

Comparison of SD and RCM

	Statistical downscaling	Dynamical downscaling
Advantages	• Comparatively cheap and computationally efficient • Can provide point-scale climatic variables from GCM-scale output • Can be used to derive variables not available from RCMs • Easily transferable to other regions • Based on standard and accepted statistical procedures • Able to directly incorporate observations into method	• Produces responses based on physically consistent processes • Produces finer resolution information from GCM-scale output that can resolve atmospheric processes on a smaller scale
Disadvantages	• Require long and reliable observed historical data series for calibration • Dependent upon choice of predictors • Non-stationarity in the predictor-predictand relationship • Climate system feedbacks not included • Dependent on GCM boundary forcing; affected by biases in underlying GCM • Domain size, climatic region and season affects downscaling skill	• Computationally intensive • Limited number of scenario ensembles available • Strongly dependent on GCM boundary forcing

HJ Fowler et al (2007) Int J Climatol

Impact of SD on Model Differences

SEACI Synthesis Report (2012)

- Variation between estimates reduced by statistical downscaling

Evaluation for Hydrology

SEACI Synthesis Report (2012)

- Need care in applying statistical downscaling

Impact and Vulnerability Studies

- Local climate variables are input to impact model; e.g. crop or hydrological models
  - Evaluate climate model variables from observations
  - Evaluate impact model from observations
- Recognise cascade of uncertainties
  - Ensemble of future climates
  - Consider sensitivity studies rather than forecasts
- Downscaling linked to user needs
  - Daily, monthly or seasonal frequency

Examples of RCM for Climate Change Studies in Asia

- Yinling Xu, CAAS, Beijing
  - Adaptation planning in Ningxia
  - Projections from PRECIS drive crop models
  - Linked to social and economic analysis
- Motaleb Hossain Sarker, CEGIS, Bangladesh
  - Impact assessment for rice crops across Bangladesh
  - Projections from PRECIS for water availability
  - Hydrological and crop modelling
  - Develop adaptation strategies

Glaciers at the Risk of Terminal Retreat in Himalayans
(Rajiv Kumar Chaturvedi, IIS, Bangalore)
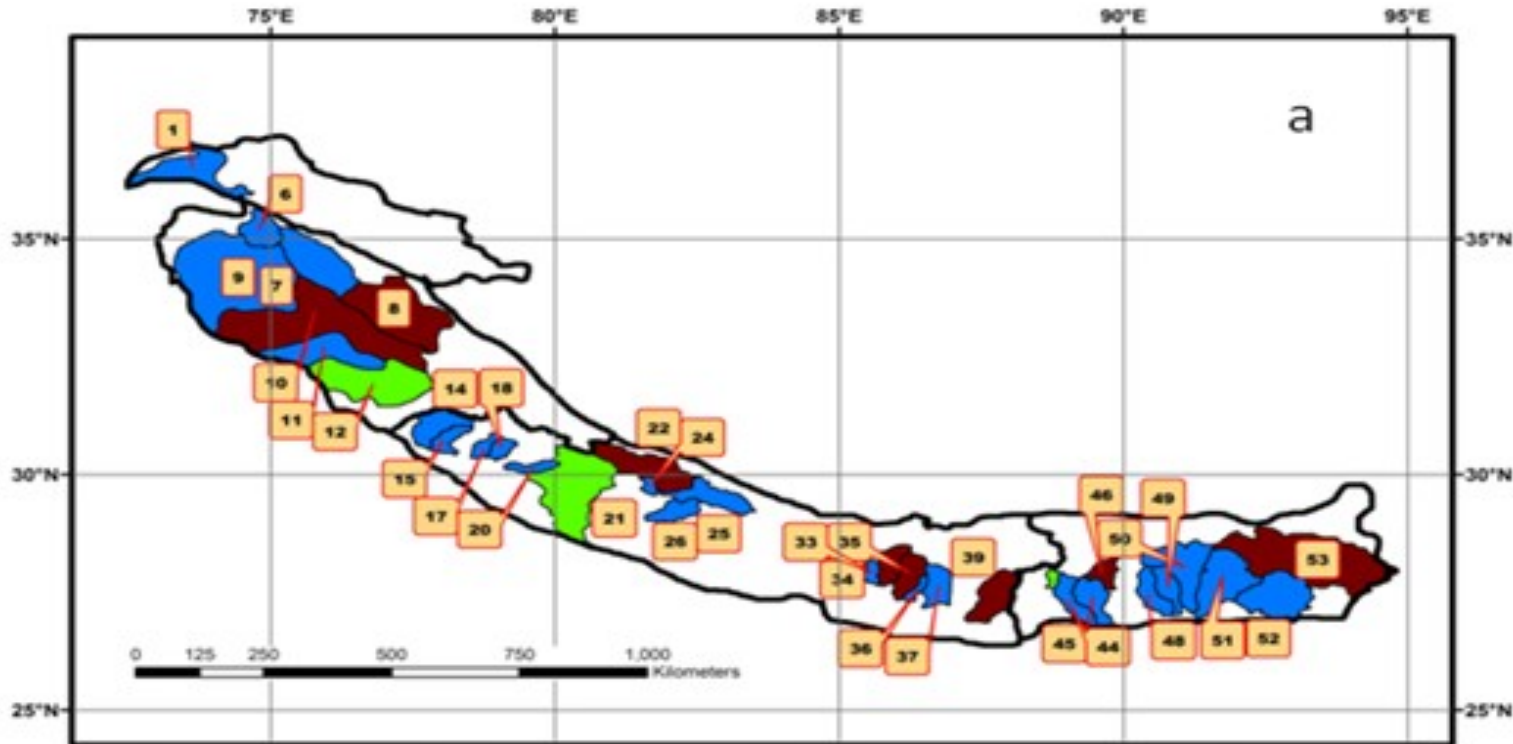
Downscaling of RCP 8.5 scenario:

Basins showing negative mass balance by 2030s are shown in **blue**, by 2050s in **green** and by 2080s in **brown**.

#	Name	#	Name	#	Name	#	Name
1	Gilgit	16	Bhagirathi	31	Budhi Gandaki	46	Mo
2	Hunza	17	Bhilanga	32	Trishuli	47	Pho
3	Shigar	18	Mandakini	33	Indrawati	48	Mangde
4	Shyok	19	Alaknanda	34	Sun Koshi	49	Chamkhar
5	Upper Indus	20	Pindar	35	Tama Koshi	50	Kuri
6	Astor	21	Kali	36	Likhu	51	Dangme
7	Shingo	22	Humla	37	Dudh Koshi	52	Kameng
8	Zanskar	23	West Seti	38	Arun	53	Subansiri
9	Jhelum	24	Kawari	39	Tamor		
10	Chenab	25	Mugu	40	East Rathong		
11	Ravi	26	Tila	41	Talung		
12	Beas	27	Bheri	42	Zemu		
13	Satlaj	28	Kali Gandaki	43	Chngme		
14	Tons	29	Seti	44	Amo		
15	Upper Yamuna	30	Marsyangdi	45	Wang		

Conclusions

- MAIRS promotes links between research groups across Asia

- MAIRS promoting CORDEX across Asia

- Modelling is important capability to support climate research and applications

- CORDEX involves evaluation and application of RCM and SD to support impact and vulnerability studies

- Need to recognise

  - Value-adding of SD to modelling

  - Cascade of uncertainties

  - Essential role of local observations