MAIRS and its Role in Regional Climate Change Initiatives

Michael Manton
Chair, MAIRS SSC

CORDEX SEA Workshop, Bangkok, 9-10 June 2014

Objectives of MAIRS

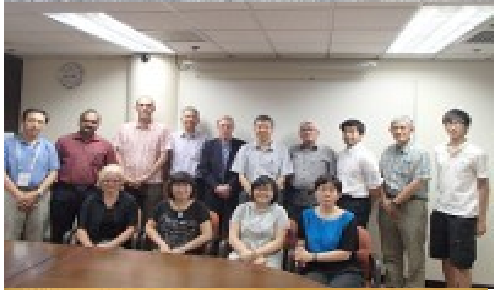
- MAIRS aims to promote integrated regional studies across monsoon Asia, in order
  - To answer science questions on
    - The resilience of the monsoon system to human activities
    - The vulnerability of human societies to environmental change
  - To promote collaboration across disciplines and regions
  - To enhance scientific capacity across the region.

Rationale for MAIRS is Uniqueness of Monsoon Asia

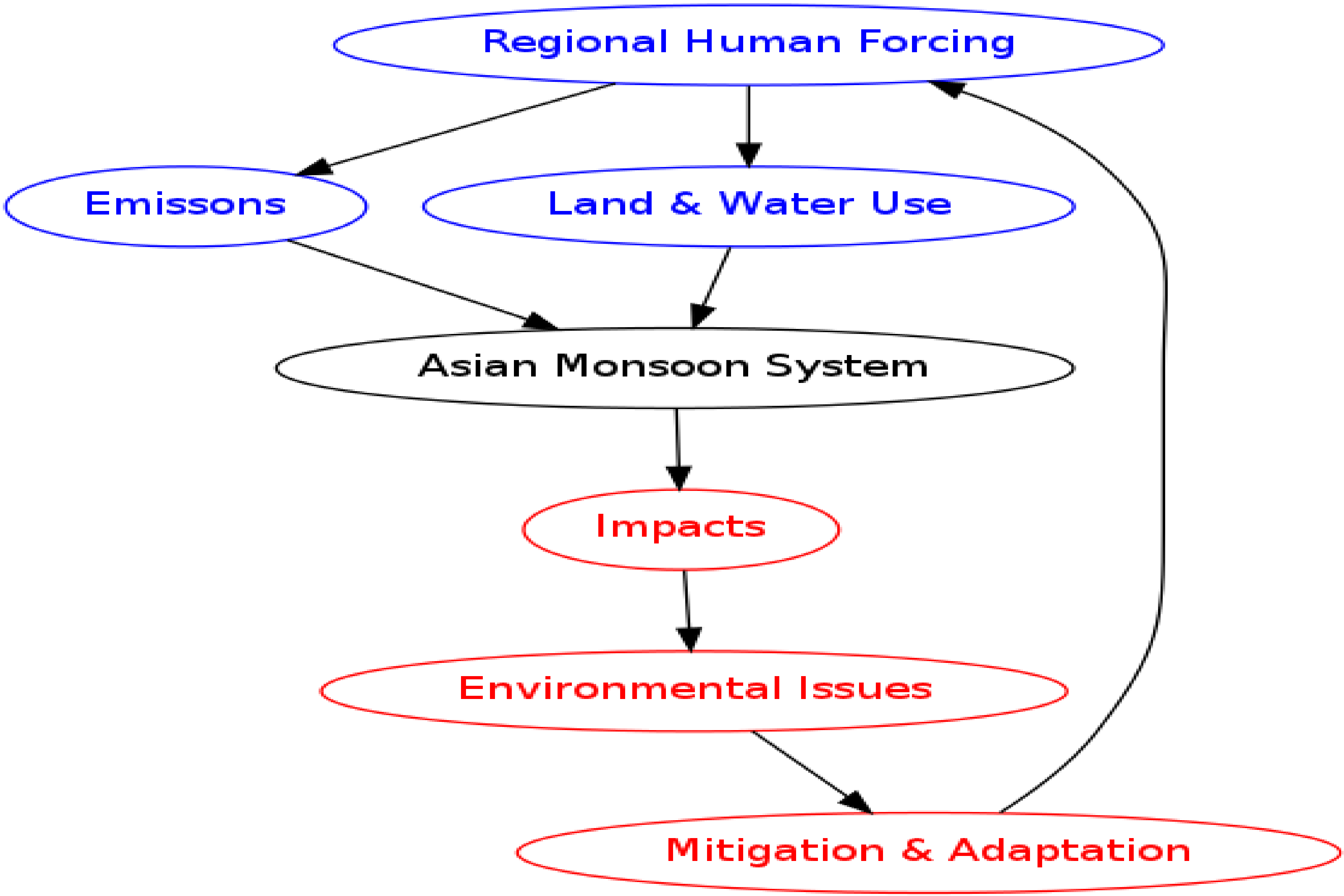
- World's highest mountains
- Heat source of Tibetan Plateau
- Seasonal monsoon affects water and food resources
- Range of natural hazards (TC to GLOF)
- 3.6 billion people
- Anthropogenic aerosols
- Vulnerable coastal development
- Rapid urbanisation and economic growth

History of MAIRS

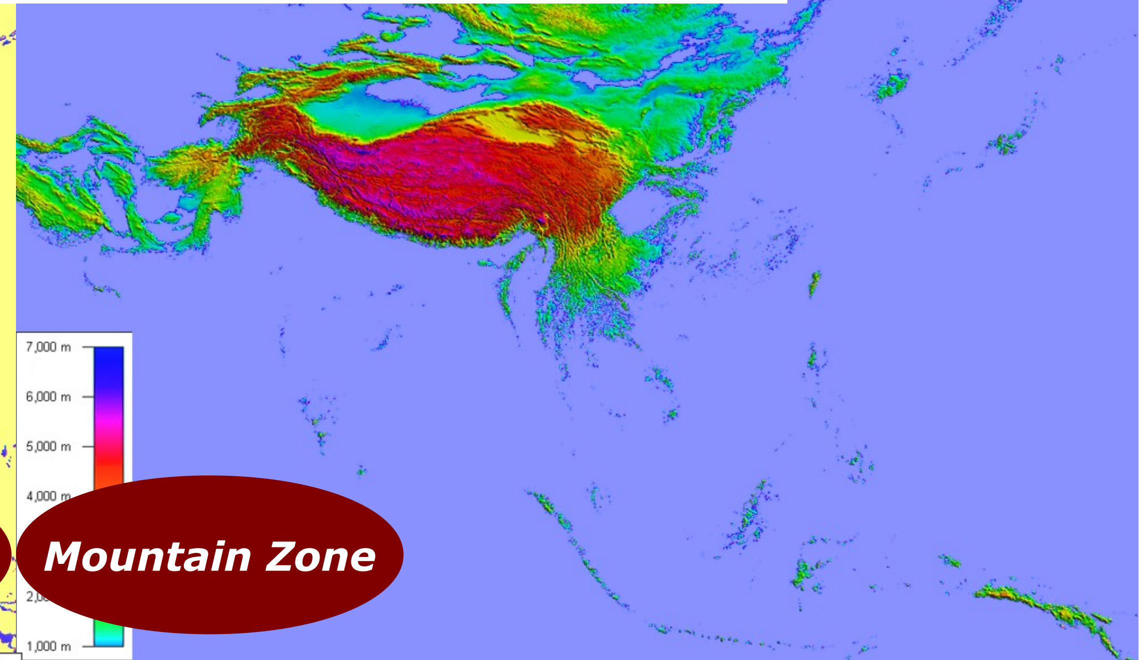
- Planning from 2005 under auspices of START
- Chair SSC
  - Congbin FU (2006-2010) (Phase I)
  - Michael Manton (2011-2014) (Phase II)
- IPO supported by CAS at IAP, Beijing
- Link to Earth System Partnership (ESSP)
- Review in Nov. 2010
- Commence Phase II in 2011
- Link to Future Earth in 2013

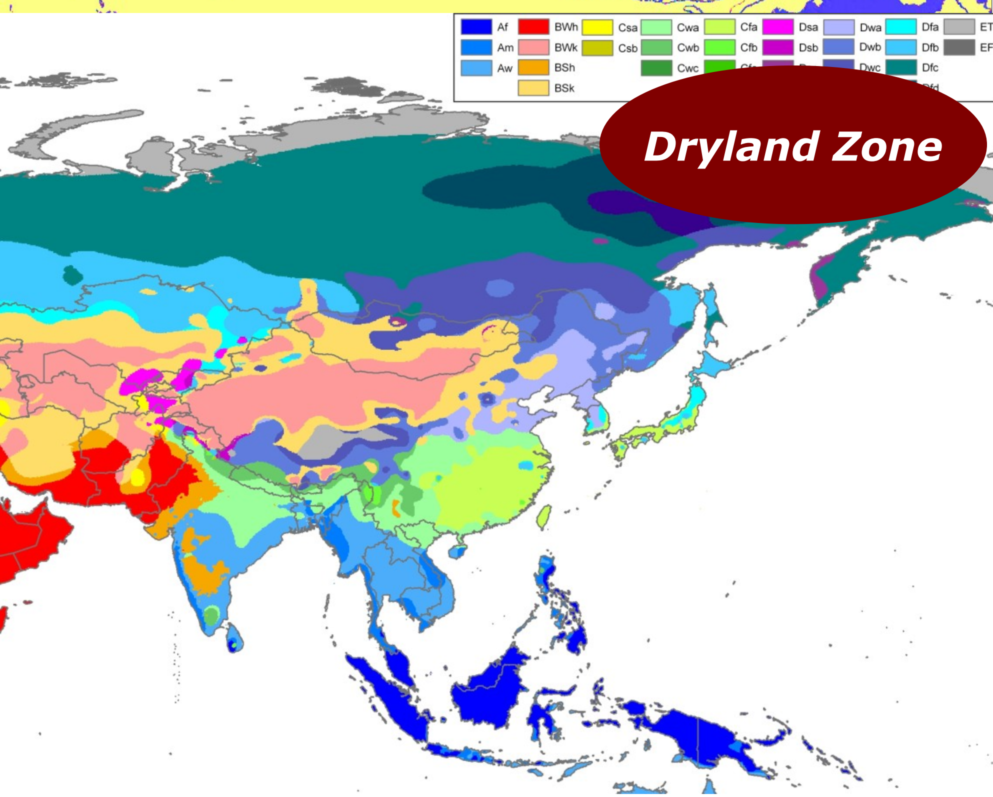


Conceptual Framework



Integration across Vulnerable Zones





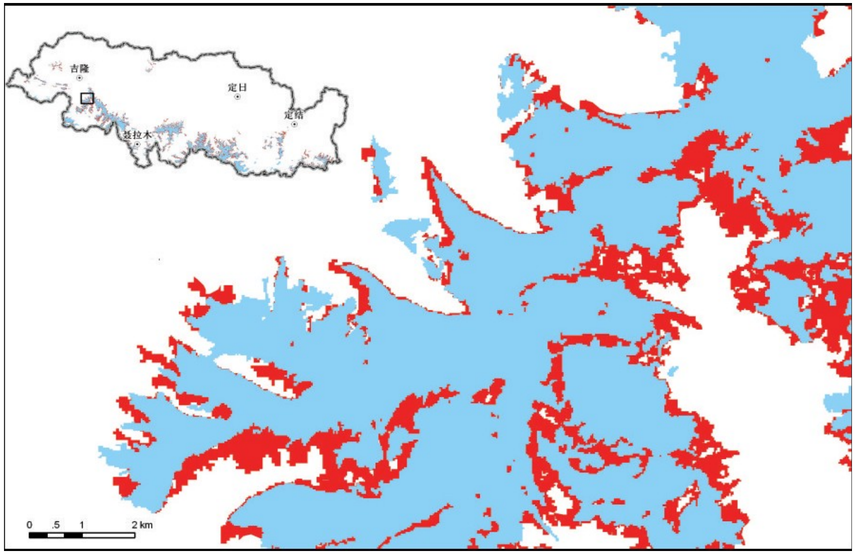
Land Cover Change in Qomolangma National Nature Preserve area (1976-2006)

1) Glacier retreat and expansion of glacier lakes
- Glacier area decrease by 16%
- Glacier lake increase from 57 to 94 sq. km.

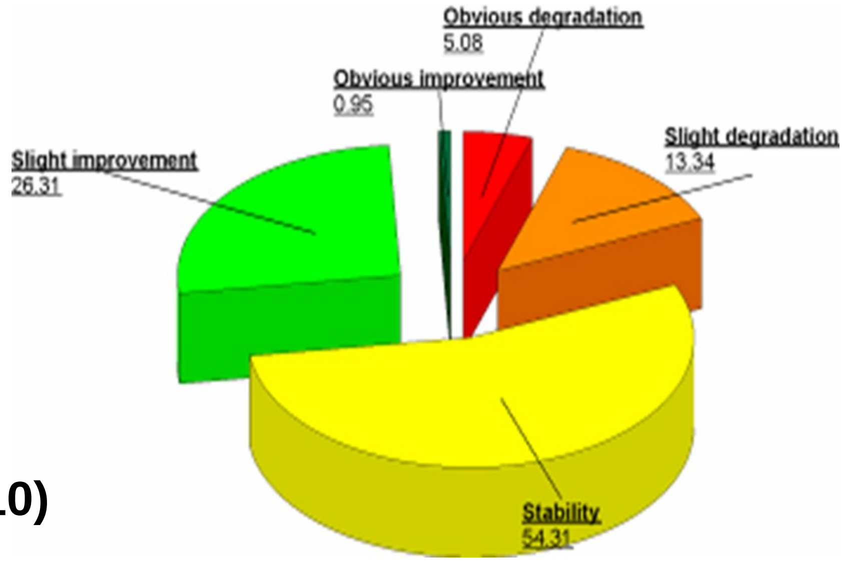
2) Land degradation
- 19% of area degrading
- Wetlands decreasing
- 54% of area stable
- 27% of area improving

3) Drivers of change
- Mainly natural factors
- Degraded areas affected by human activities

Glacier Retreat



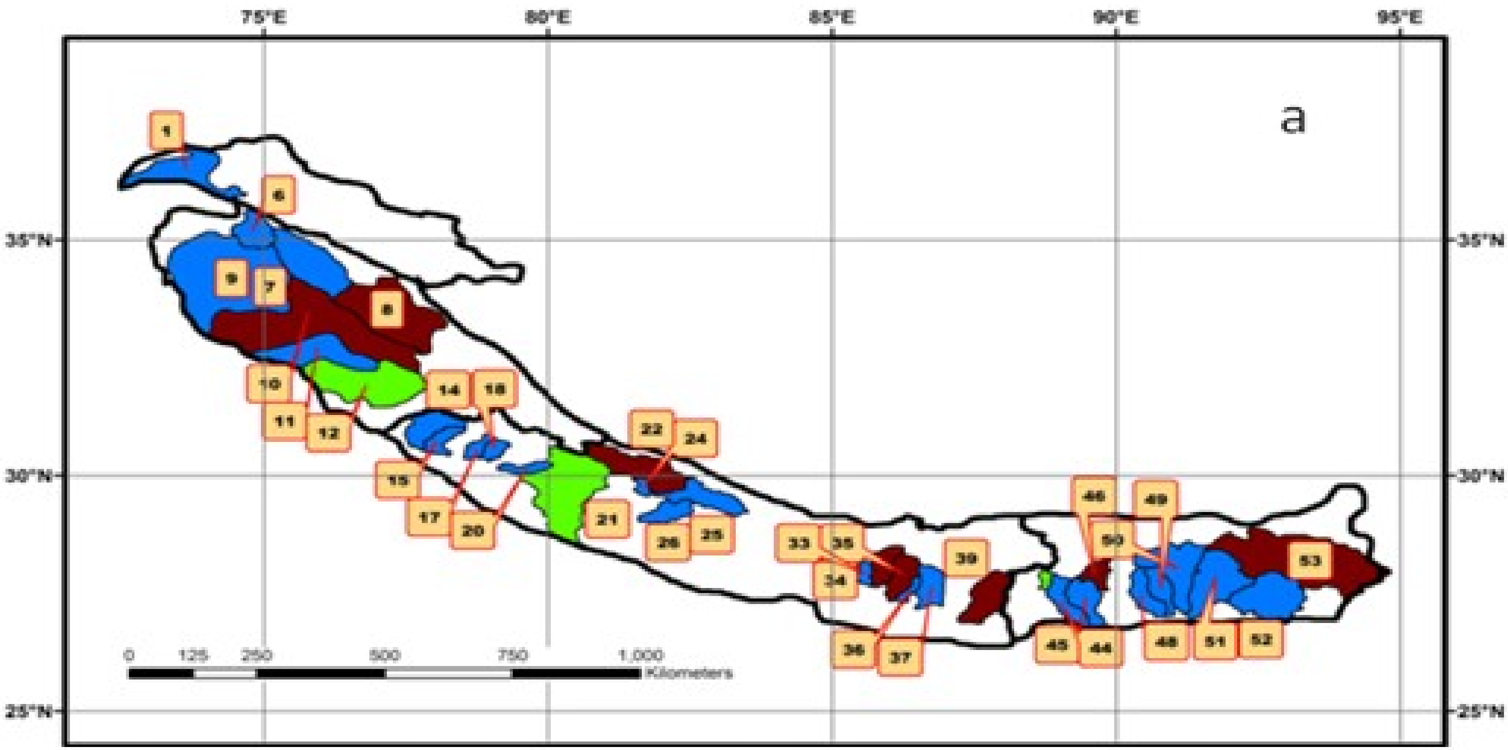
Land Degradation



Zhang, Liu et al. (2010)

Glaciers at the Risk of Terminal Retreat in Himalayans

(Rajiv Kumar Chaturvedi, IIS, Bangalore)



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		

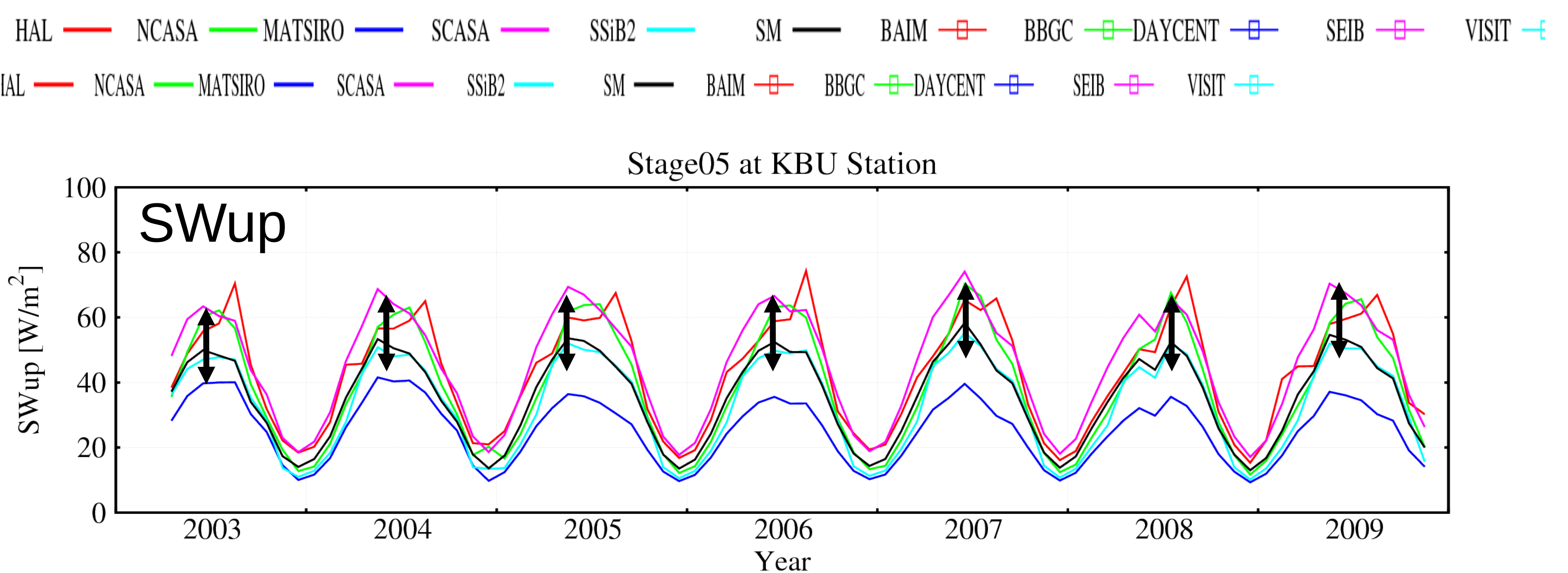
Downscaling of RCP 8.5 scenario:

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

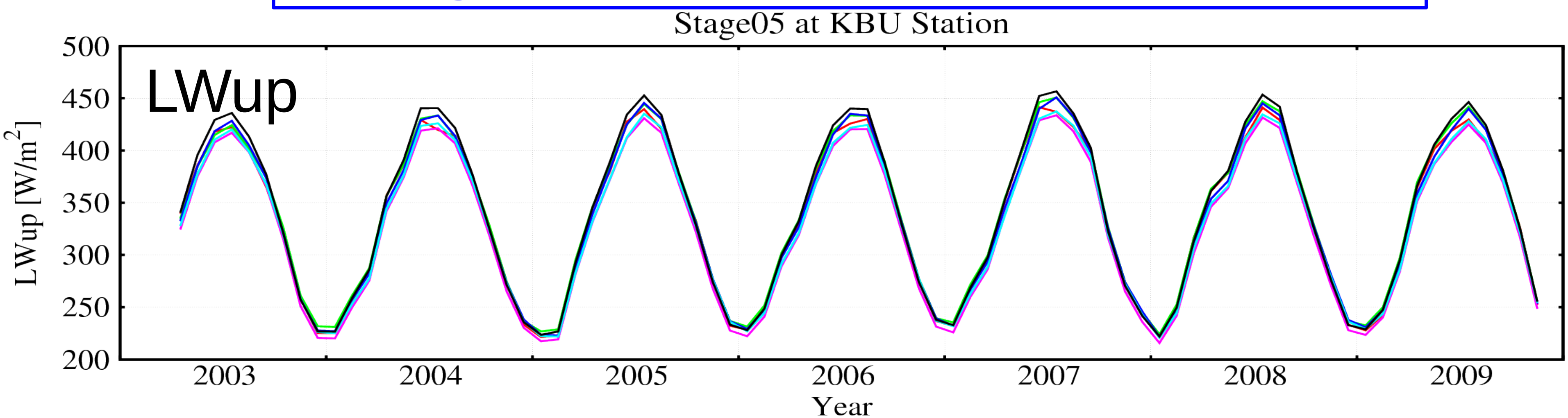
Asian Dryland Model Intercomparison Project (ADMIP)

- Support from APN, MAIRS and MEXT-JSPS
- Few observations and relatively poor performance of LSM in Asian drylands
- Data from sites at Tongyu, China (CEOP), Kherlen Bayan Ulaan, Mongolia (CEOP, AsiaFlux)
- 8 LSMs and 4 TEMs from Japan, China, Korea, USA

Jun Asanuma, Tsukuba University



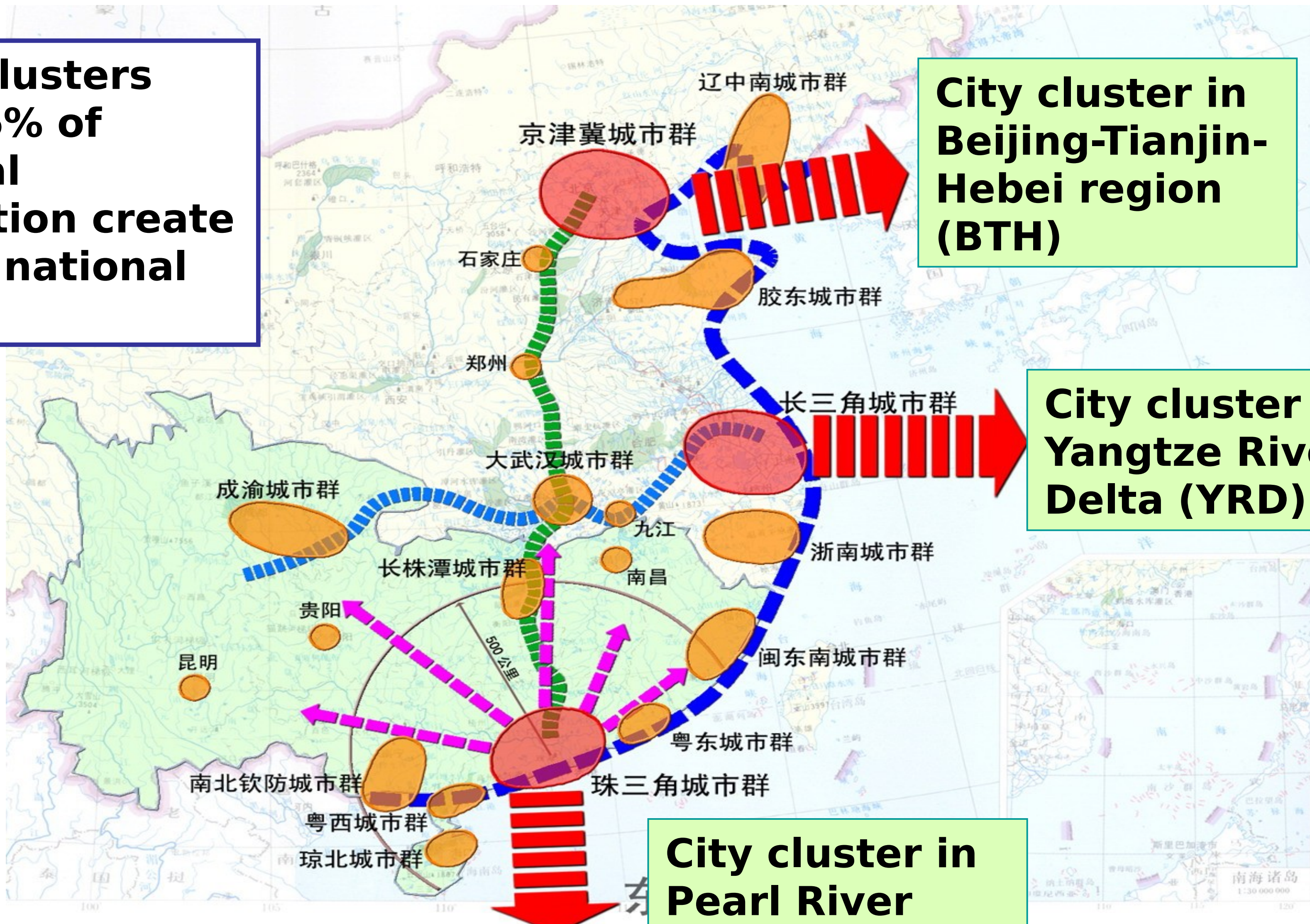
SWup and LWup differences among model results is 10 - 30 W/m2.



Kazuaki Yorozu, Kyoto University

Mega-City Clusters Drive Economic Development

3 city clusters with 26% of national population create 47% of national GDP

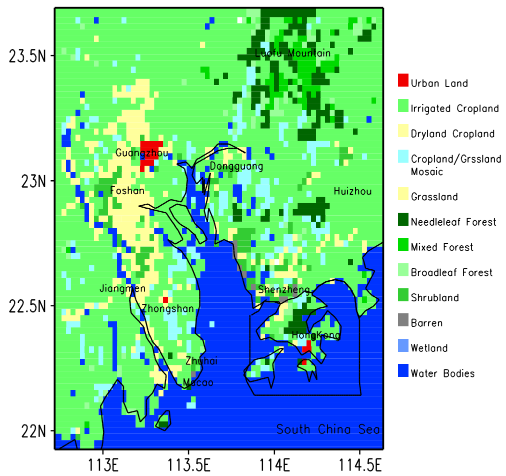


City cluster in Beijing-Tianjin-Hebei region (BTH)

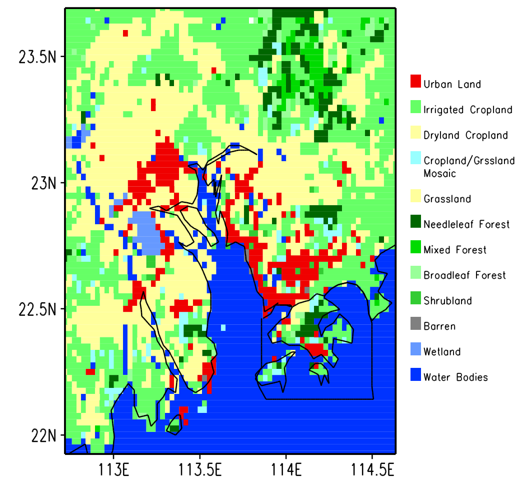
City cluster in Yangtze River Delta (YRD)

City cluster in Pearl River Delta (PRD)

Regional Climate Change due to Land Use Change in PRD



1993

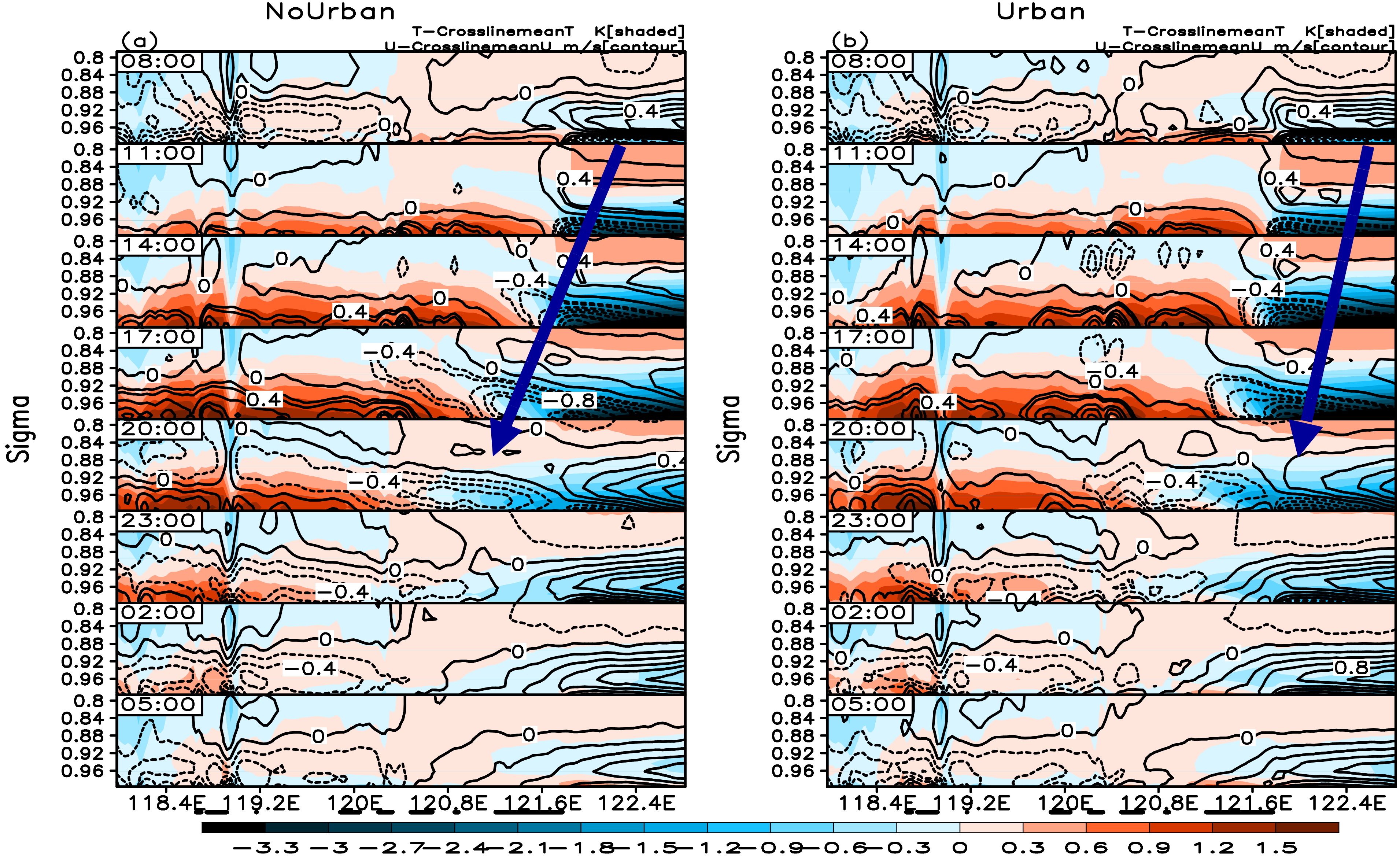


2000

	No Urban	Urban
• Surface temperature:	+0.09°C	+0.37°C
• Relative Humidity:	-0.36 %	-0.80 %

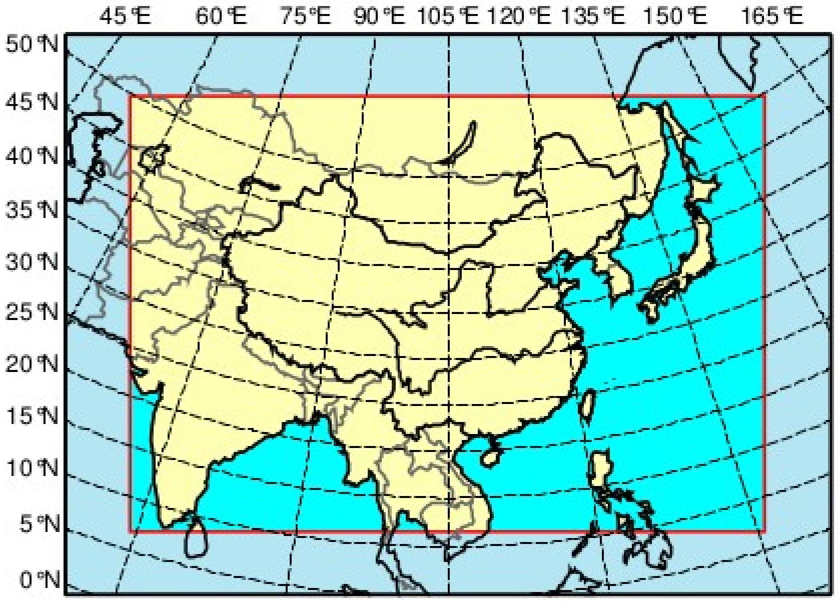
Wenshi LIN (2011)

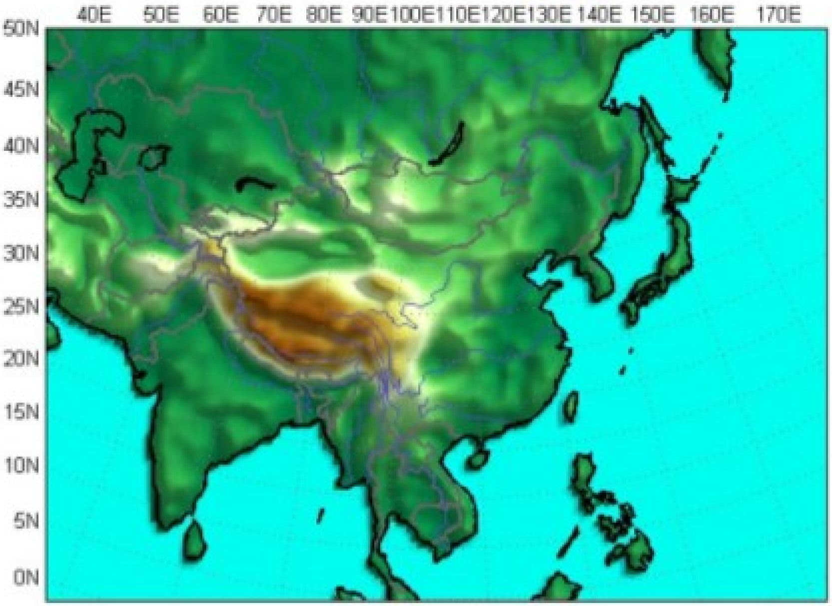
Urban Heat Island impact on Sea Breeze in YRD



Tang JP (2011)

RMIP Simulation Design





- **Integration Domain: (45-165E, 0-45N)**
- **Resolution: 60KM (for whole area, downscaling to 30KM in some key areas)**
- **Participating Countries: China, Japan, Korea, Australia, US**
- **Regional Models: 6 models in RMIP II, and 11 models in RMIP III**
- **Global models: 2 GCM outputs as driving fields**
- **Simulation Periods: 1978-2000 for control, 2038-2070 for projection, A 2-year spin-up time is applied to both control and projection runs**

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
- SEACLID – CORDEX South East Asia workshop, 9-10 June 2013, Bangkok, Thailand
- 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

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

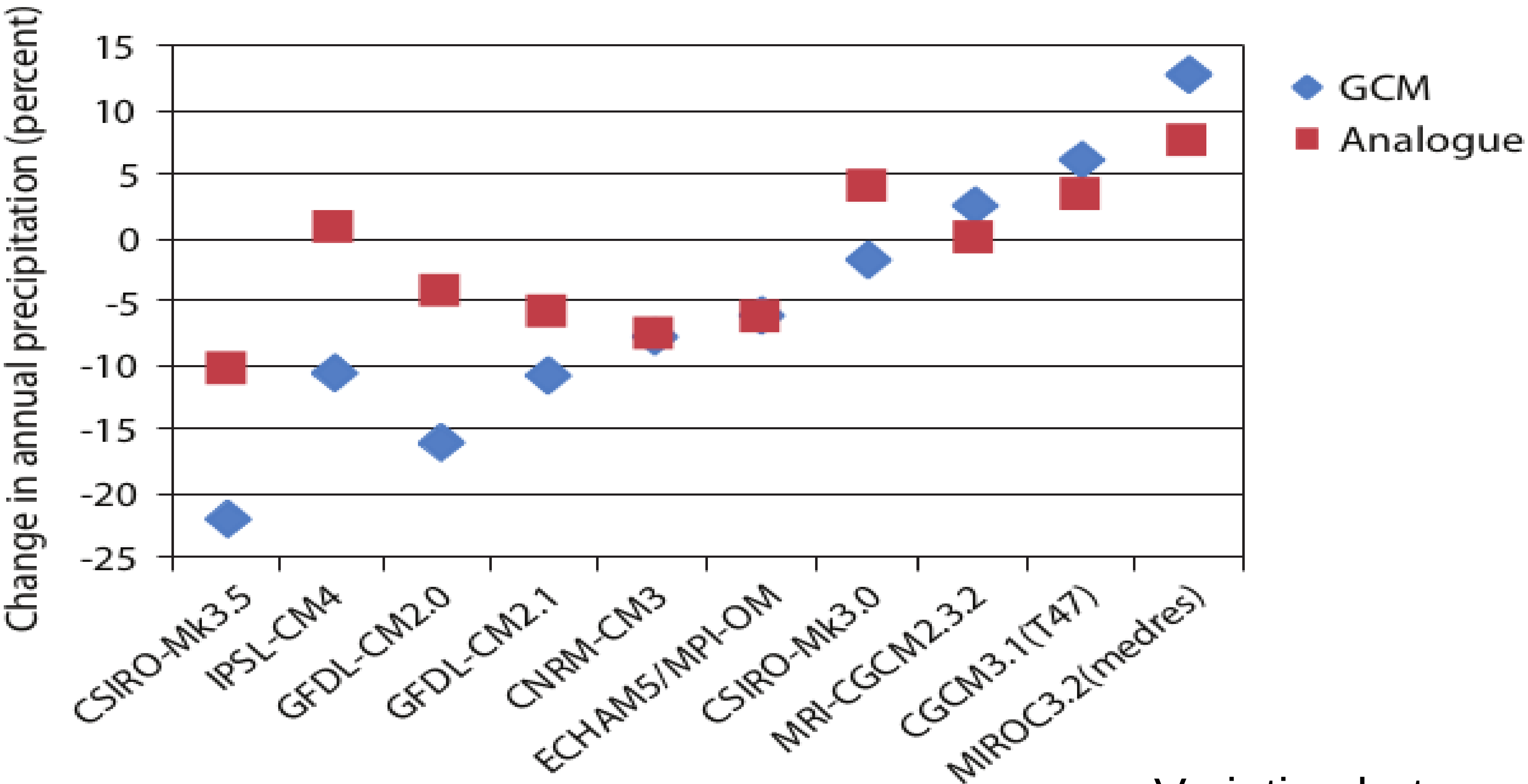
Maraun et al (2010) Res Geophys

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

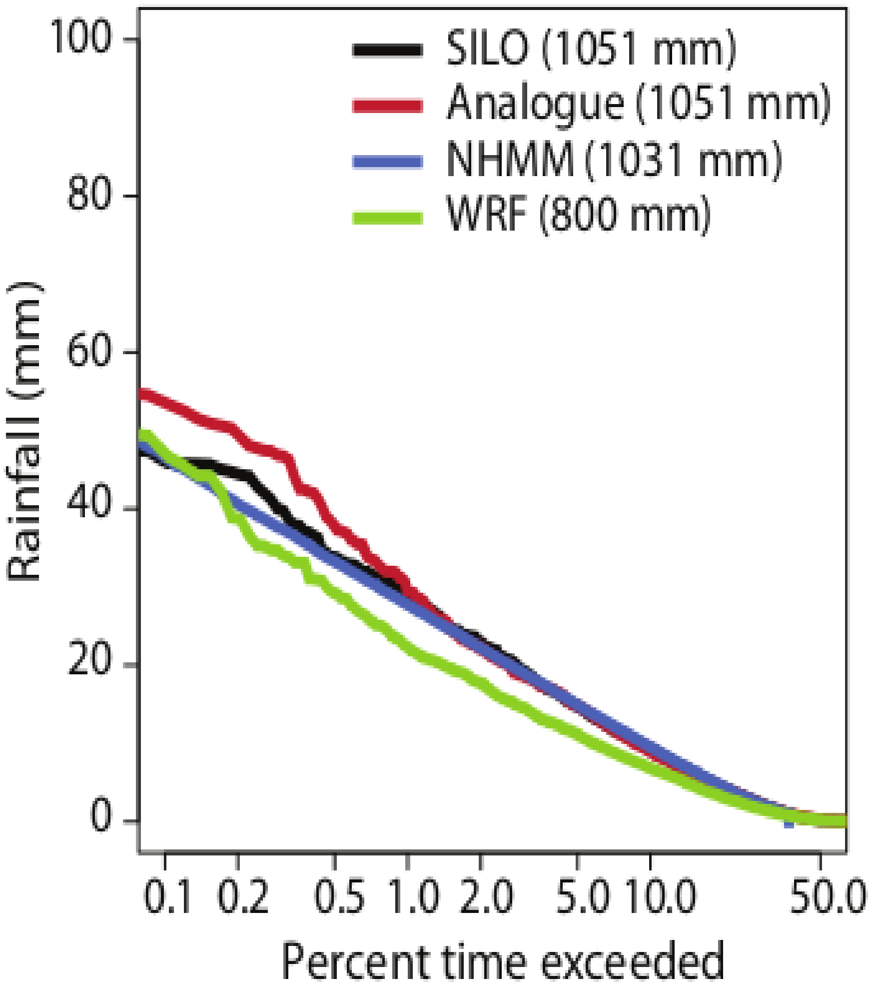
Impact of SD on Model Differences

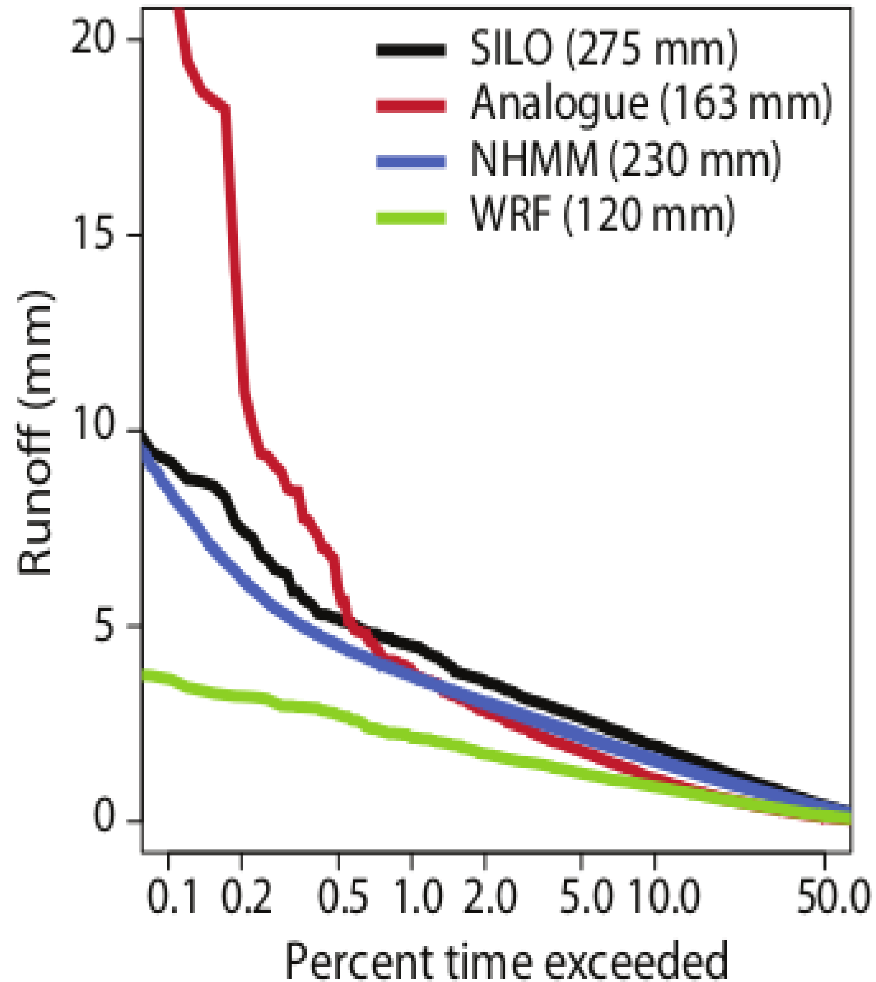


- Variation between estimates reduced by statistical downscaling

SEACI Synthesis Report (2012)

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

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