Downscaling Climate Change Signals to Urban Environments

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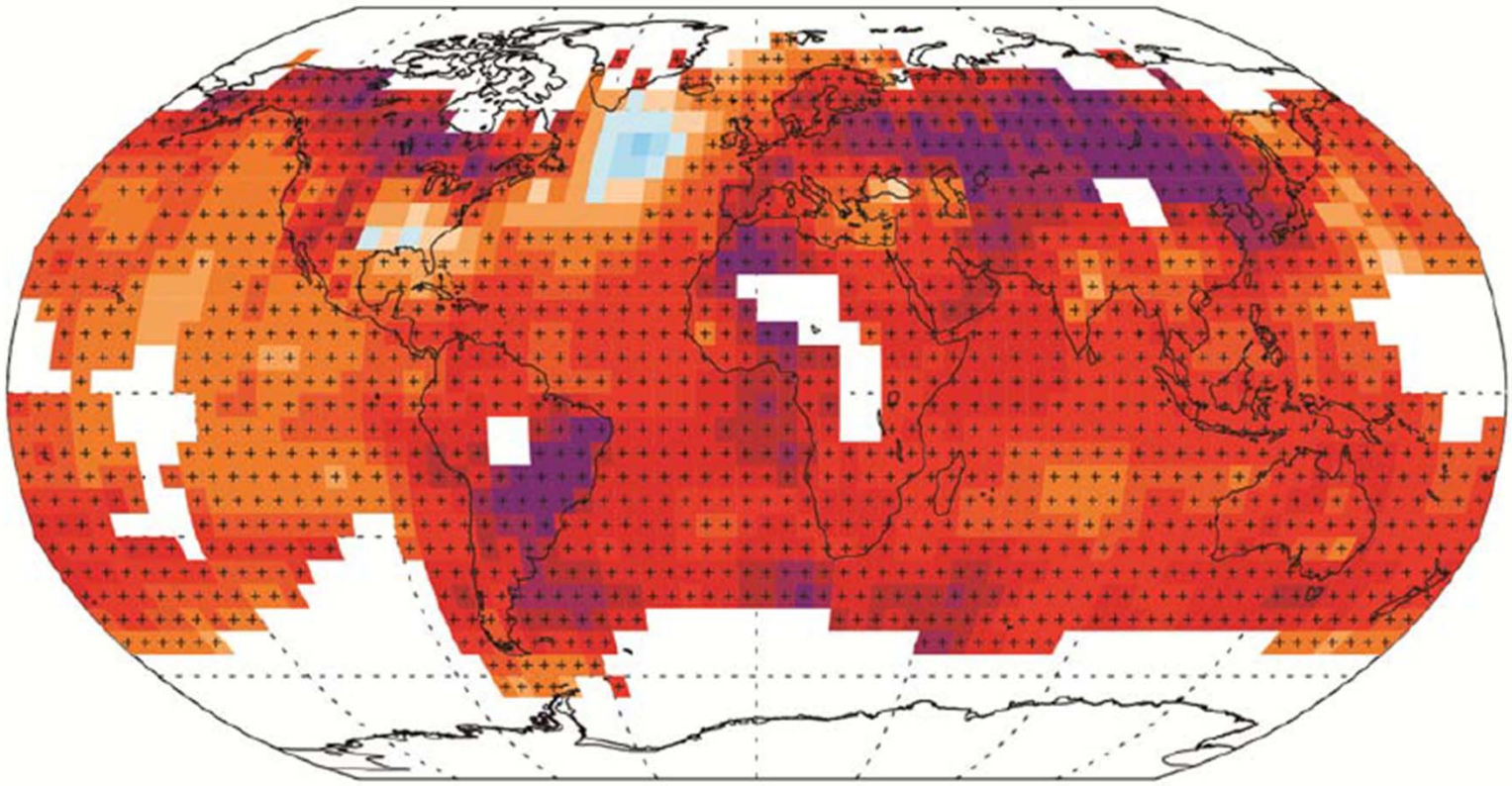
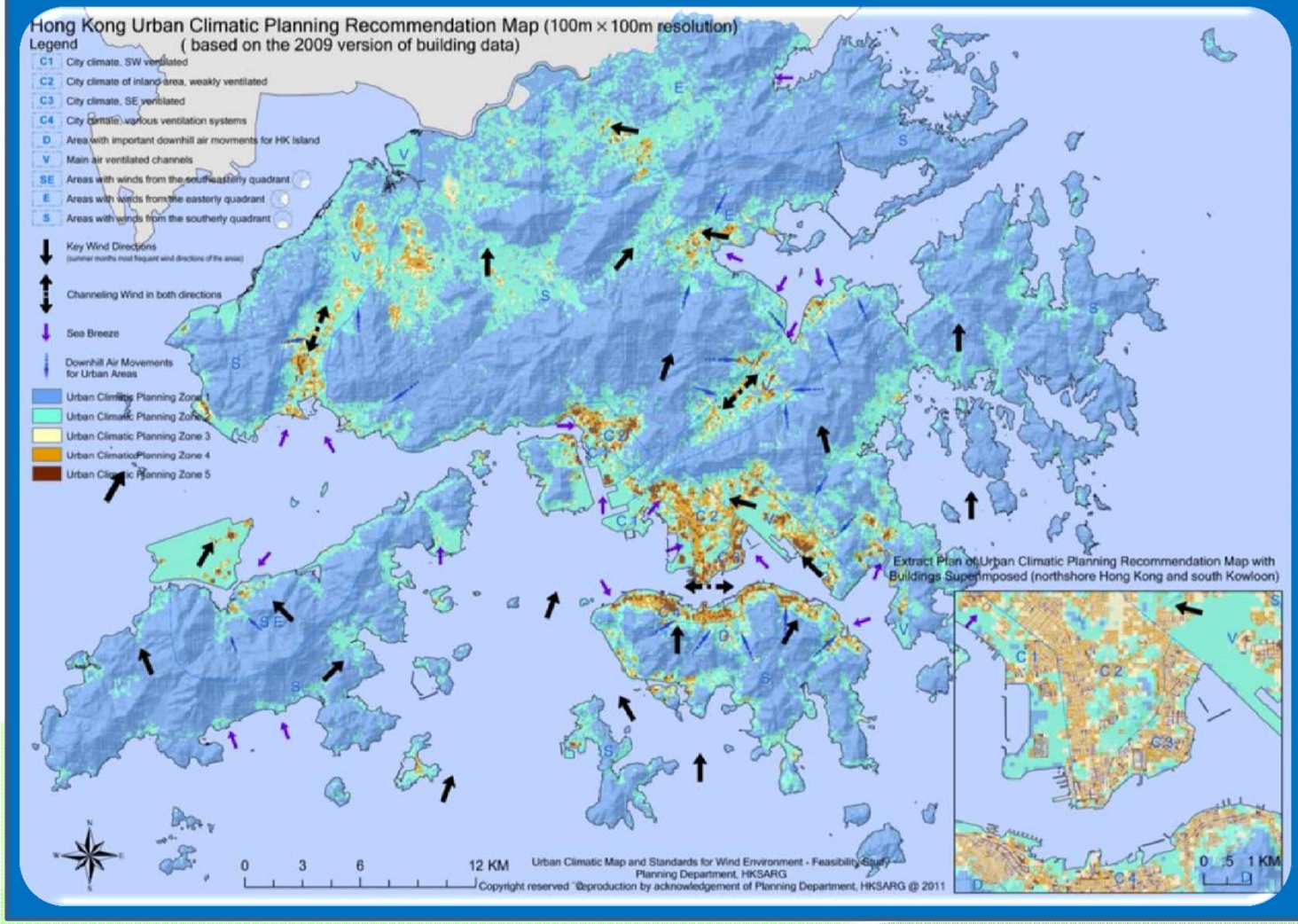
(b) Observed change in average surface temperature 1901–2012



Urban Climatic Maps

UC-AnMap

UC-ReMap



UCPZ 1

UCPZ 2

UCPZ 3

UCPZ 4

UCPZ 5

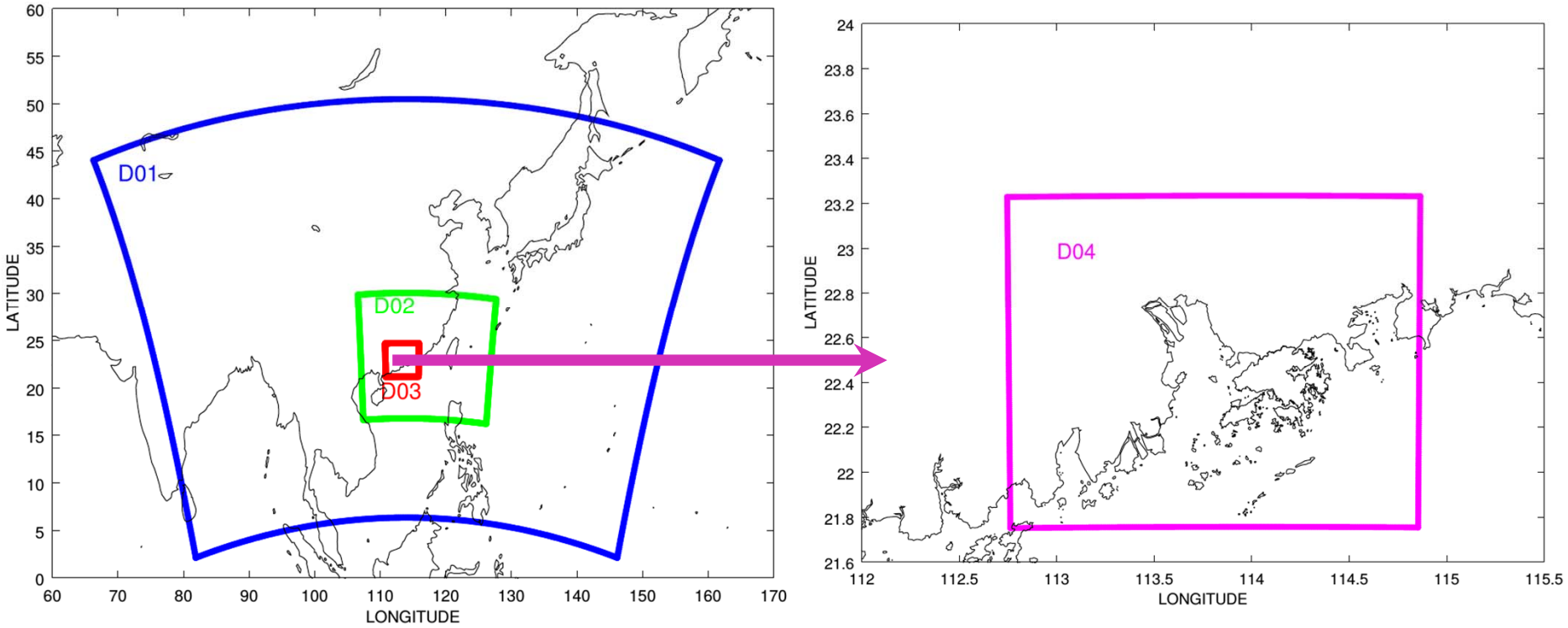
Downscaling

- Dynamical downscaling
  - Using Weather Research and Forecasting Model (WRF) to simulate regional climate based on GCMs and larger scale products
  - Example 1 – Downscaling reanalysis into 1km for Hong Kong region
  - Example 2 – Downscaling reanalysis into 5km for Taiwan region (collaboration with RCEC, TW)

- Statistical downscaling
  - Using statistical methods to predict local scale variables:
    - Climate variable: temperature, humidity, precipitation
    - Variables affecting the urban environment: thermal comfort
  - Mapping large scale climate pattern with local variables

Example 1 – Downscaling reanalysis into 1km for Hong Kong region

(Domains and resolution)



Domain 1: 27 km

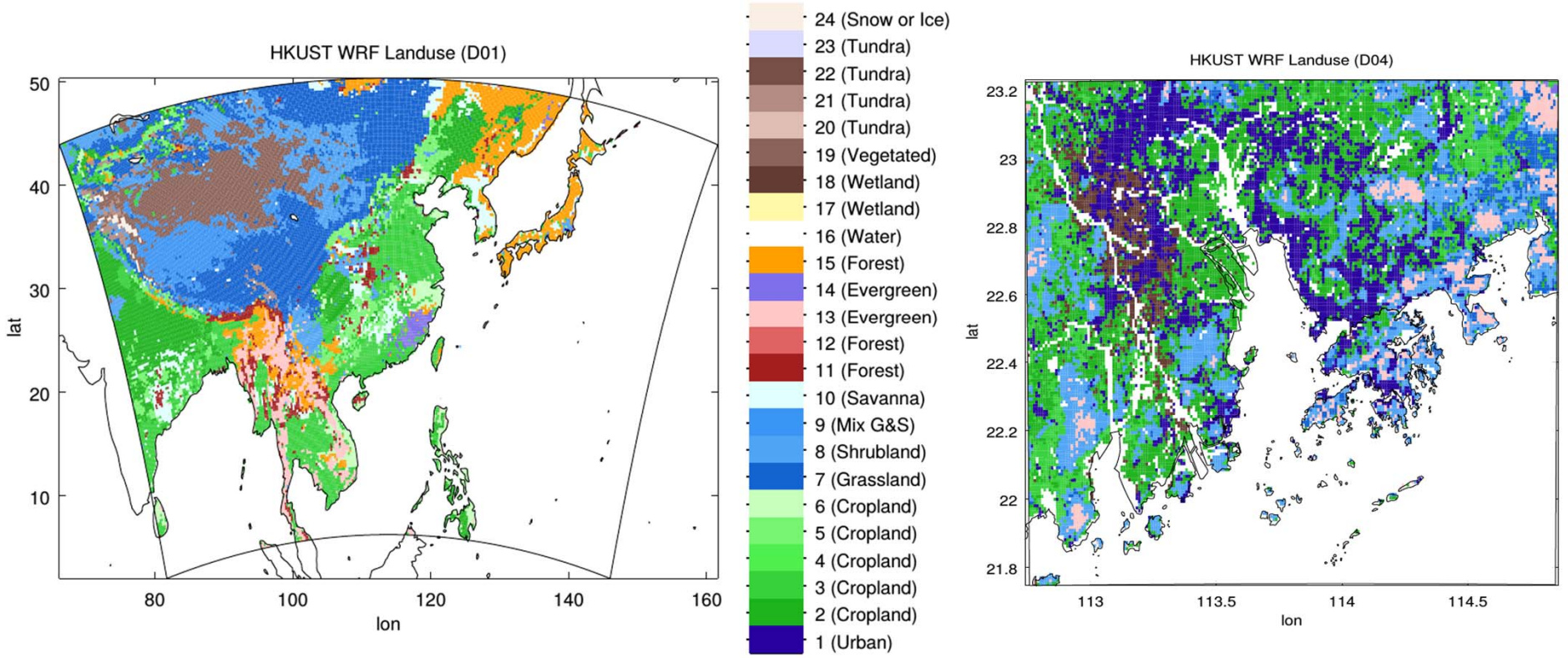
Domain 2: 9 km

Domain 3: 3 km

Domain 4: 1 km

Example 1 – Downscaling reanalysis into 1km for Hong Kong region

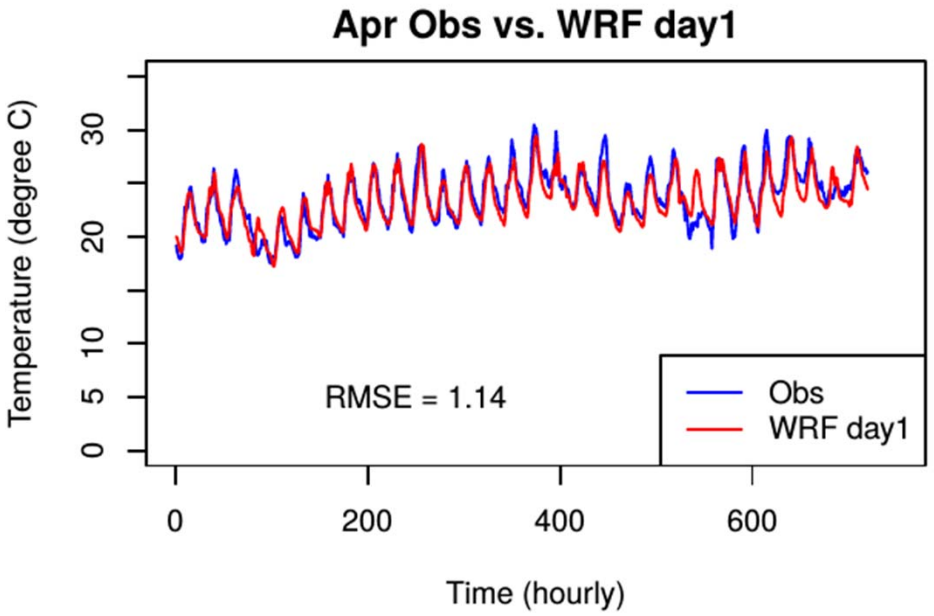
(Land use specification)



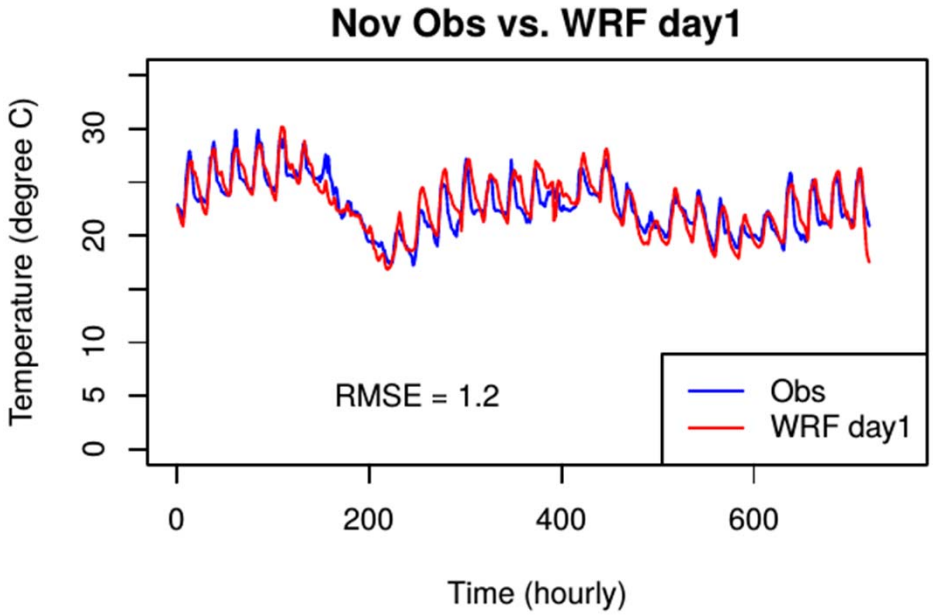
Example 1 – Downscaling reanalysis into 1km for Hong Kong region
(Model output vs. Observation)

Comparison Temperature at 2m (WRF) and surface temperature (Station data)

Hong Kong Airport



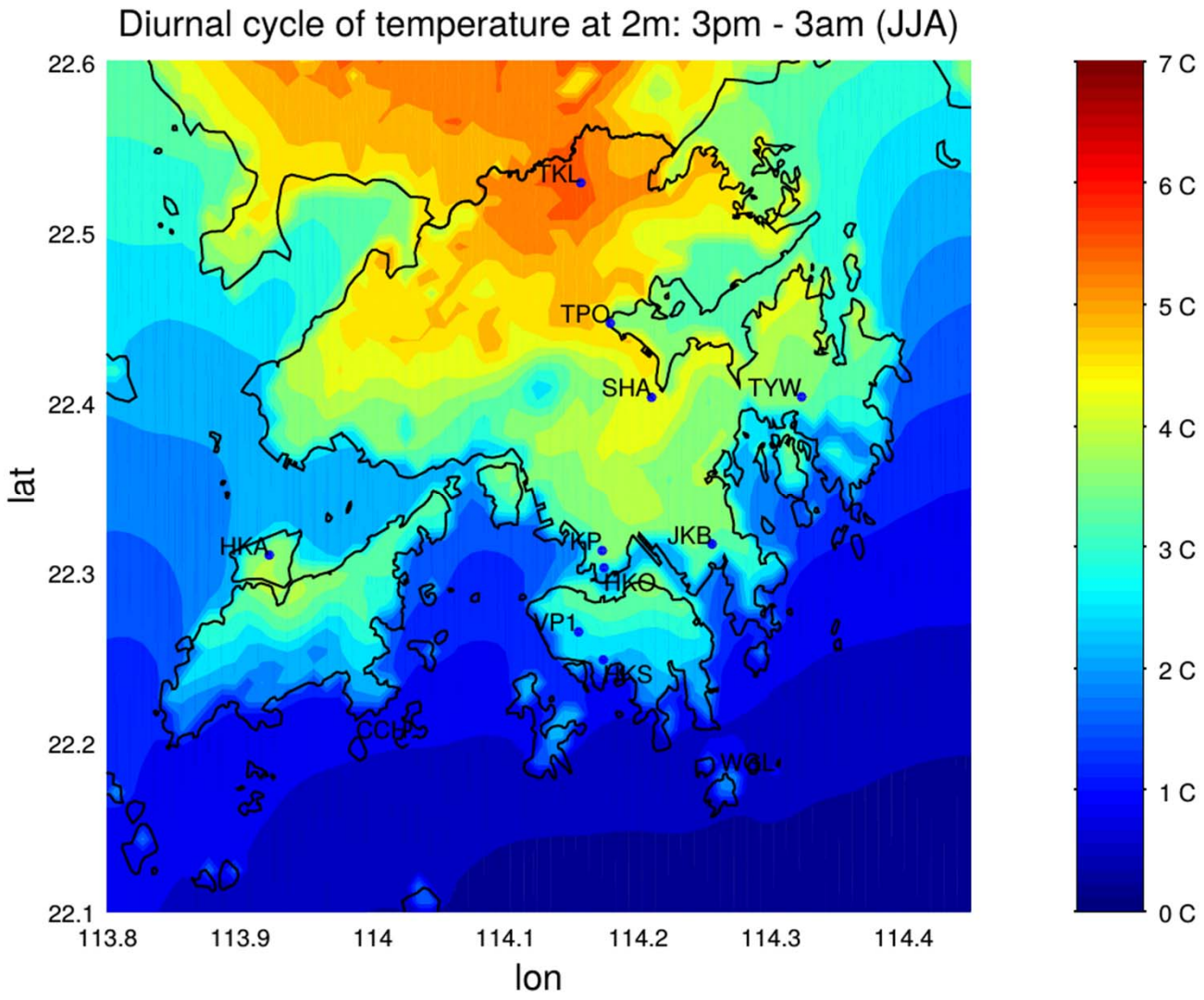
King's Park



(Based on 2011 data)

Example 1 – Downscaling reanalysis into 1km for Hong Kong region

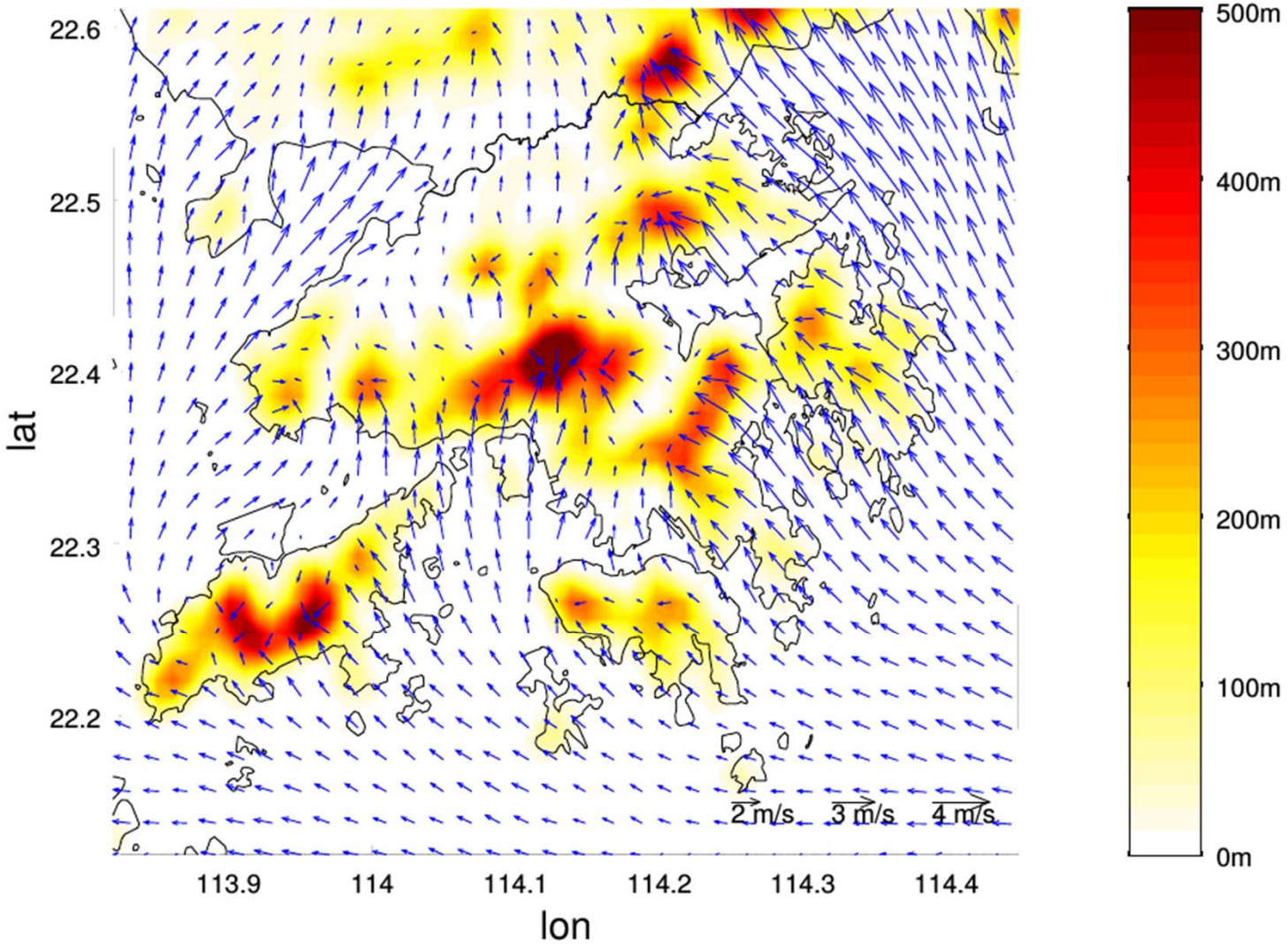
(Diurnal cycle studies 1 - Tempature)



Station	T2 @ 3pm-3am
HKO	2.9 °C
SHA	3.2 °C
TKL	5.7 °C
HKS	2.9 °C
WGL	2.1 °C
JKB	3.8 °C
CCH	3.4 °C
KP	3.0 °C
TYW	6.1 °C
HKA	3.1 °C
TPO	3.5 °C
VP1	2.4 °C

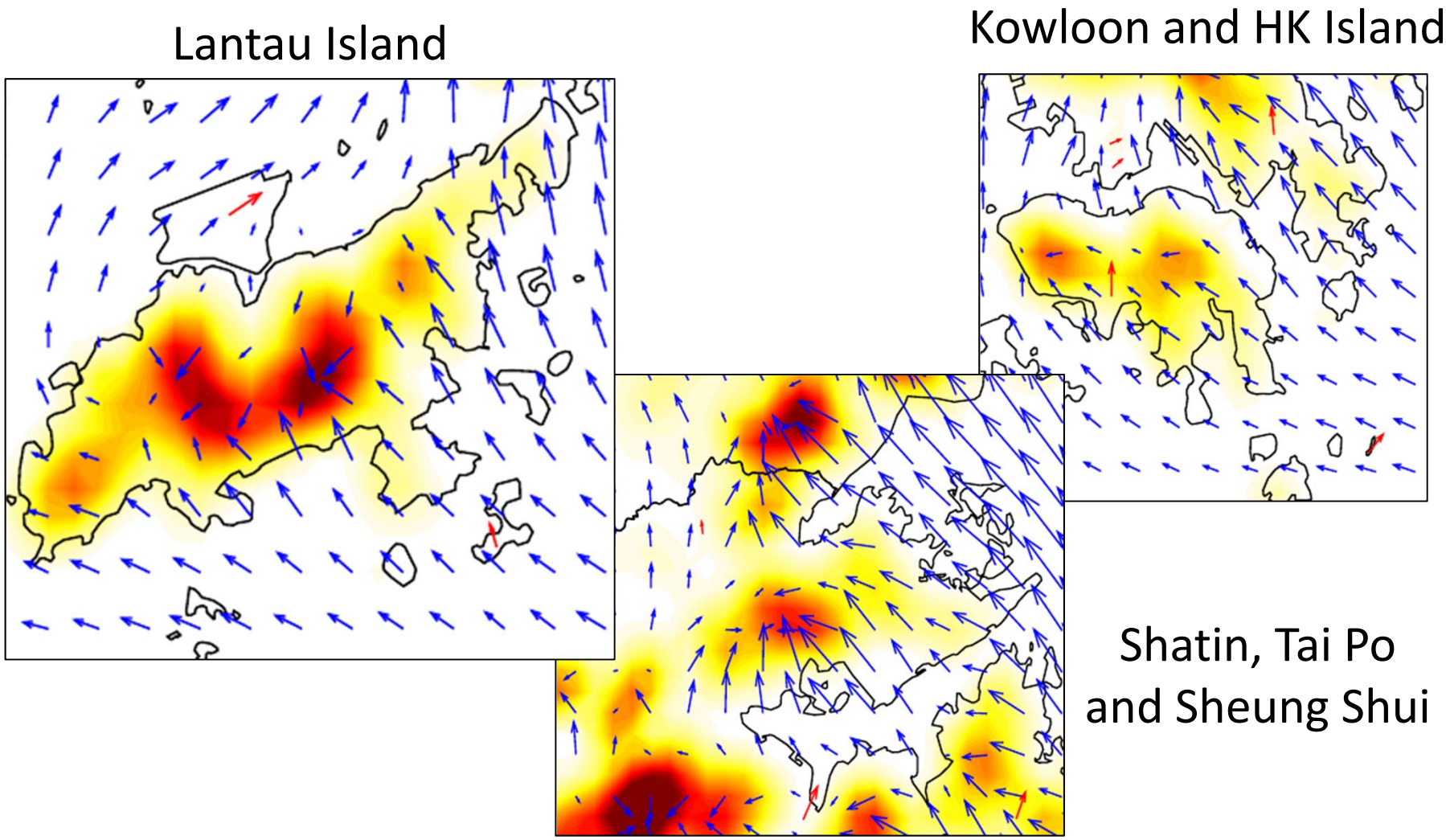
Example 1 – Downscaling reanalysis into 1km for Hong Kong region

(Diurnal cycle studies 2 – wind fields affected by terrain height)



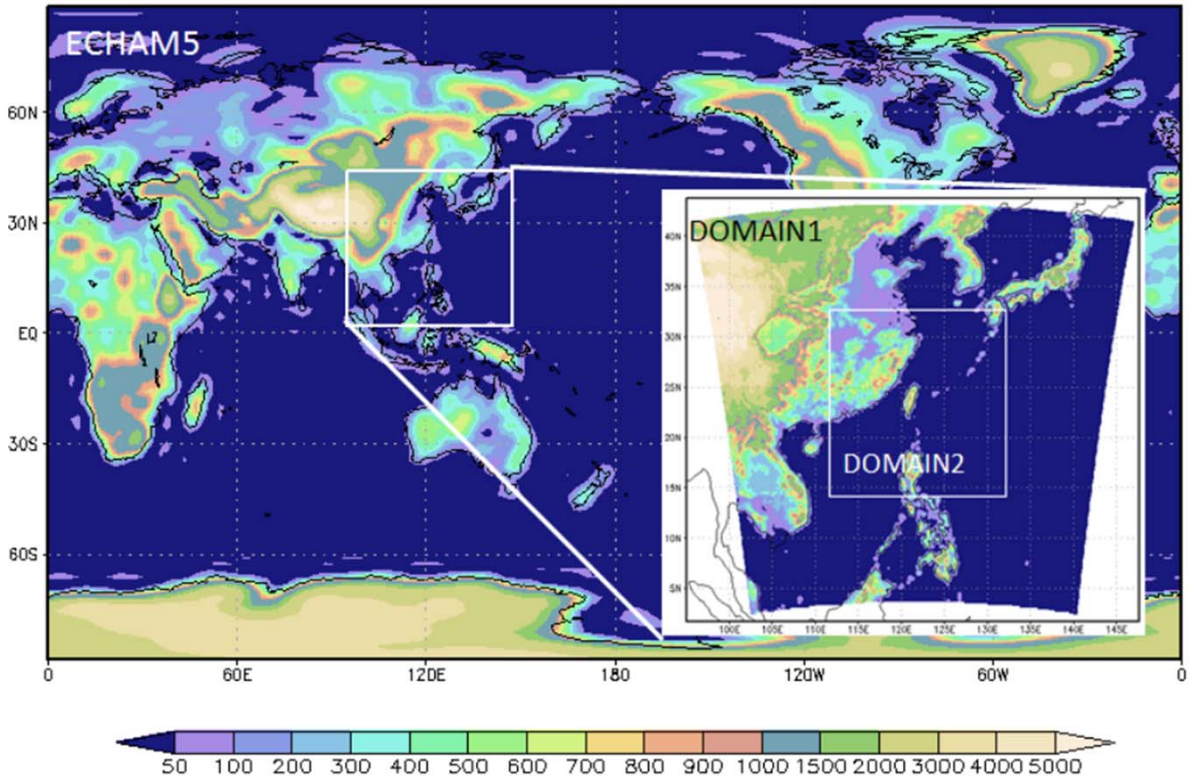
Example 1 – Downscaling reanalysis into 1km for Hong Kong region

(Diurnal cycle studies 2 – wind fields affected by terrain height)



Example 2 – Downscaling reanalysis into 5km for Taiwan region

(collaboration with RCEC, TW)



WRF system run by RCEC:

Domain 1: 15 km
Domain 2: 5 km (Cover Hong Kong region and most region in Pearl River Delta)

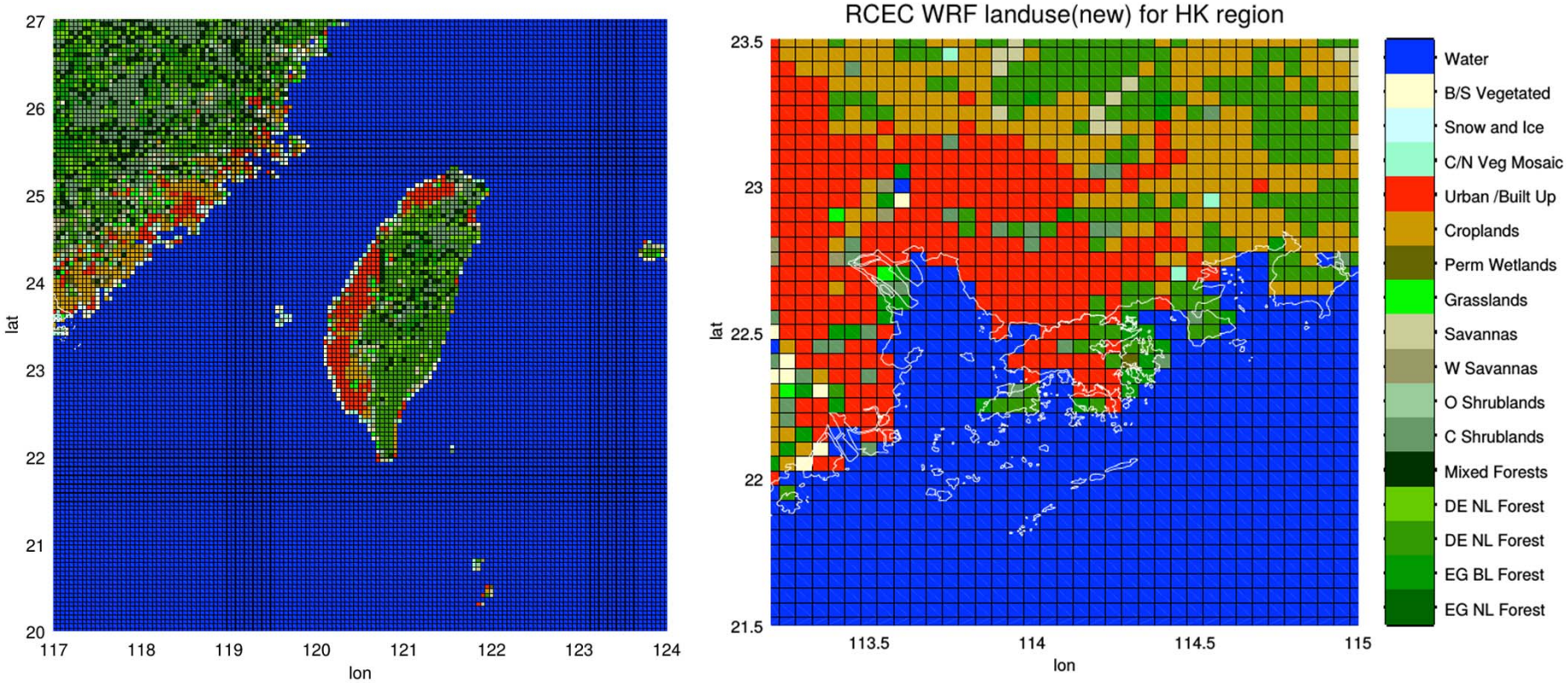
4 sets of downscaled data:

1. 1979 to 2003 (CFSR)
2. 1979 to 2003 (20C3M)
3. 2015 to 2039 (A1B)
4. 2075 to 2099 (A1B)

2, 3 & 4 are IPCC scenarios run by ECHAM5 GCM

Example 2 – Downscaling reanalysis into 5km for Taiwan region

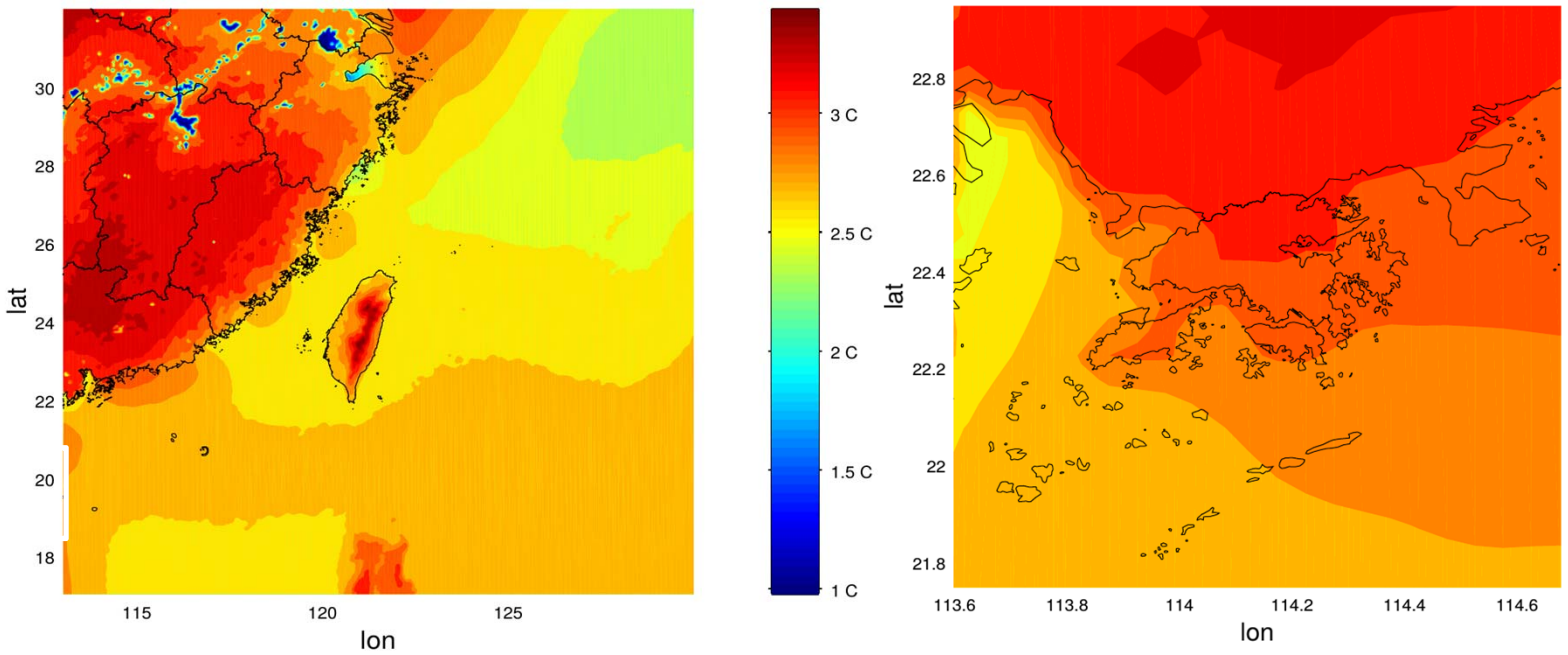
(Land use specification)



Example 2 – Downscaling reanalysis into 5km for Taiwan region
(future climate projections)

Future - Past, for JJA seasonal mean temperature at 2 m

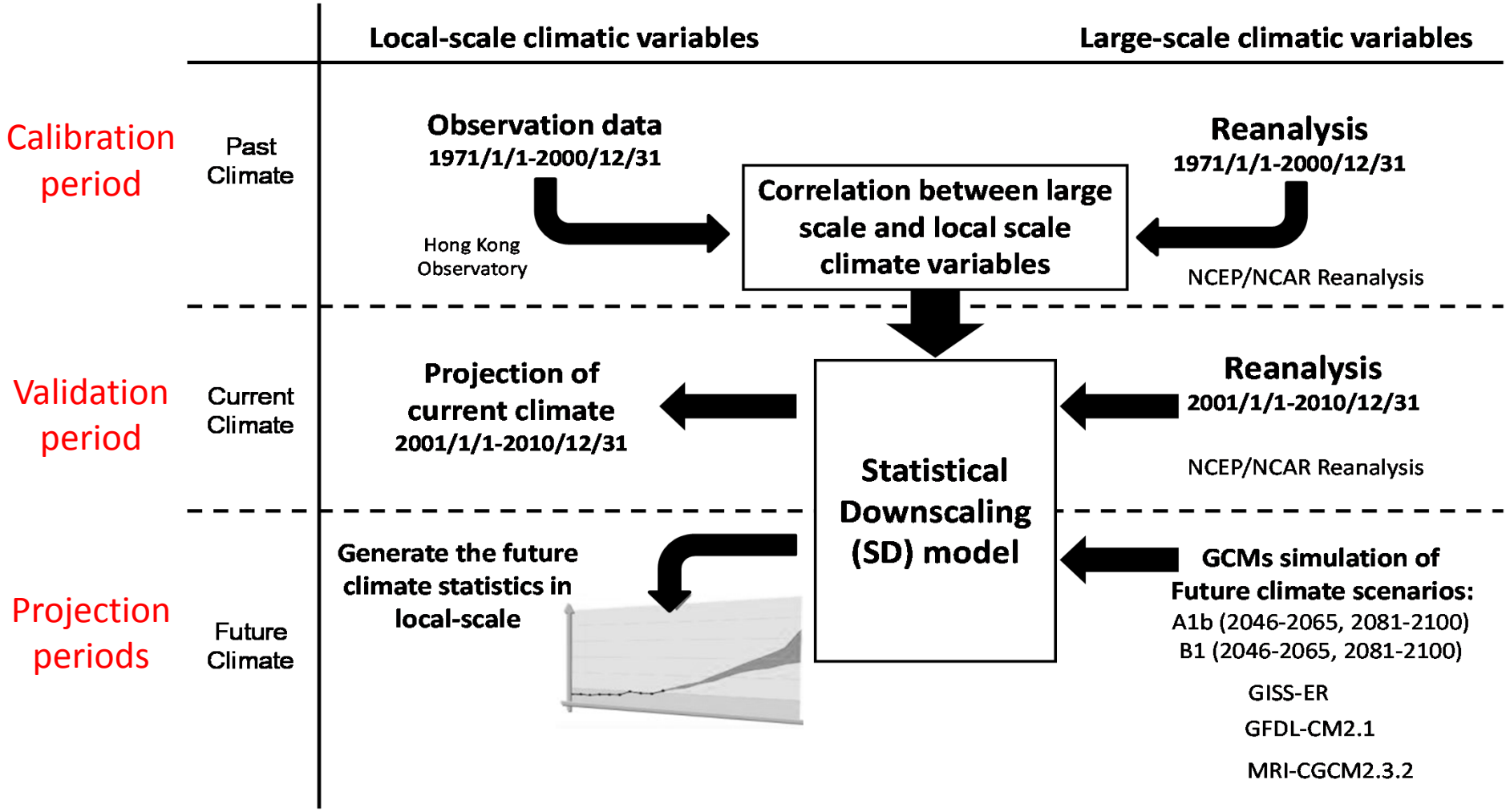
Future: A1B 2075 -2099 Past: 1979 2003



- Climate change signal provide by the model
- Extreme events such as heat waves, cold surge and precipitation
- To understand the ability and limitations of the model

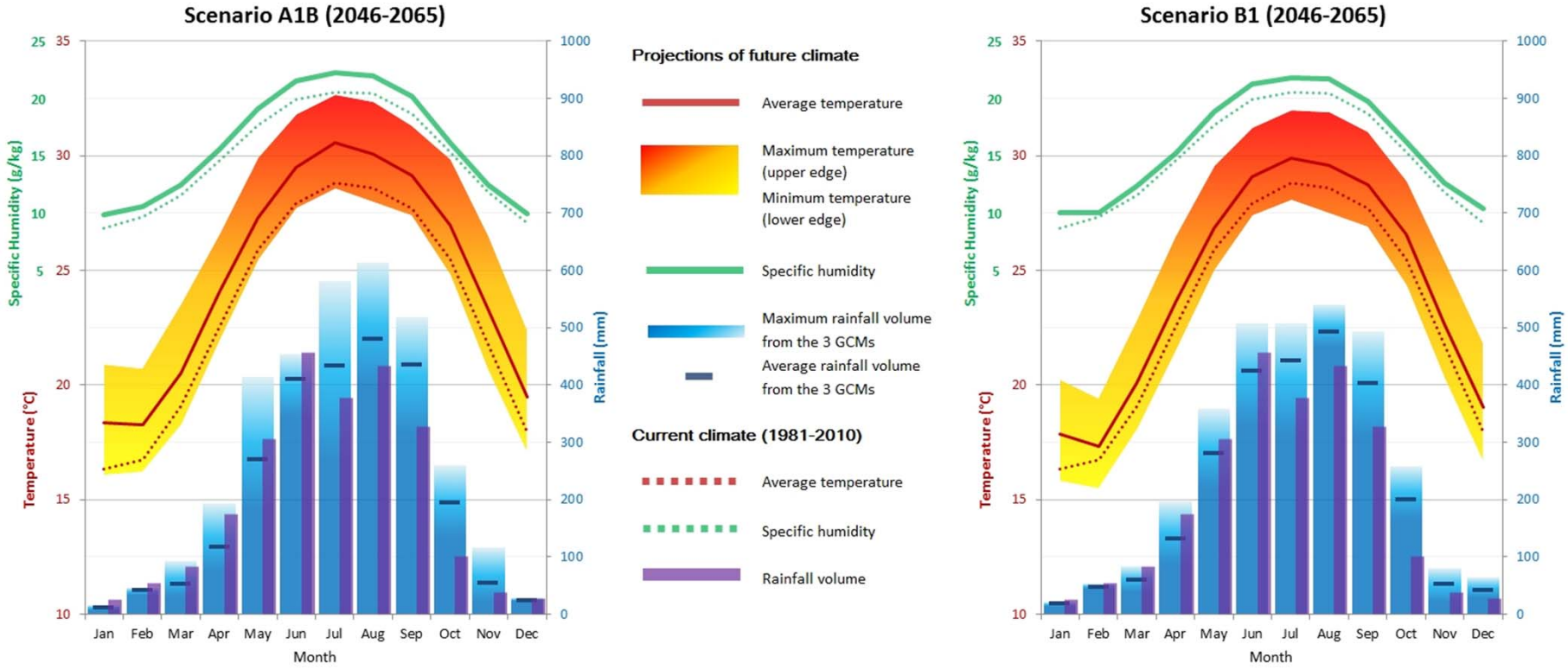
Statistical downscaling of local climate variables

(Temperature, humidity, precipitation)



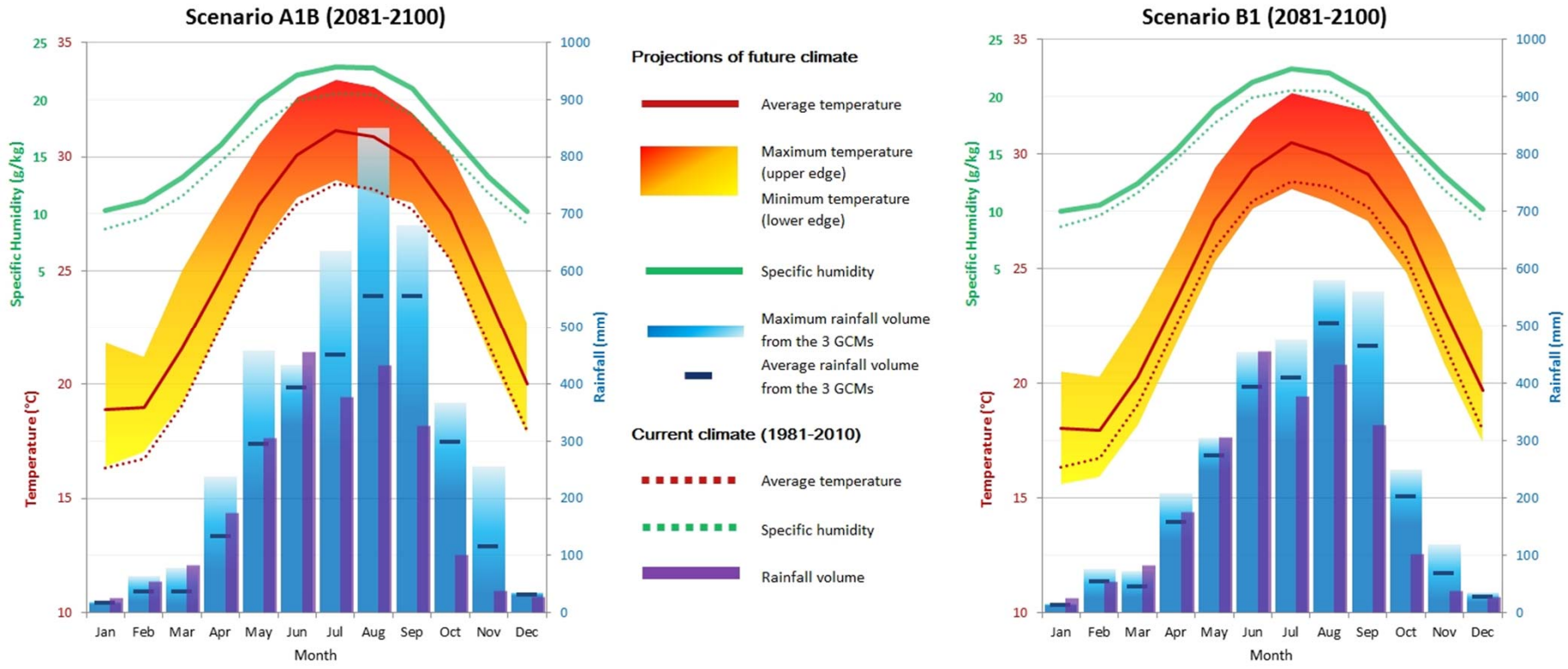
Statistical downscaling of local climate variables

(Climate chart of Hong Kong in 2046 - 2065)



Statistical downscaling of local climate variables

(Climate chart of Hong Kong in 2081 - 2100)



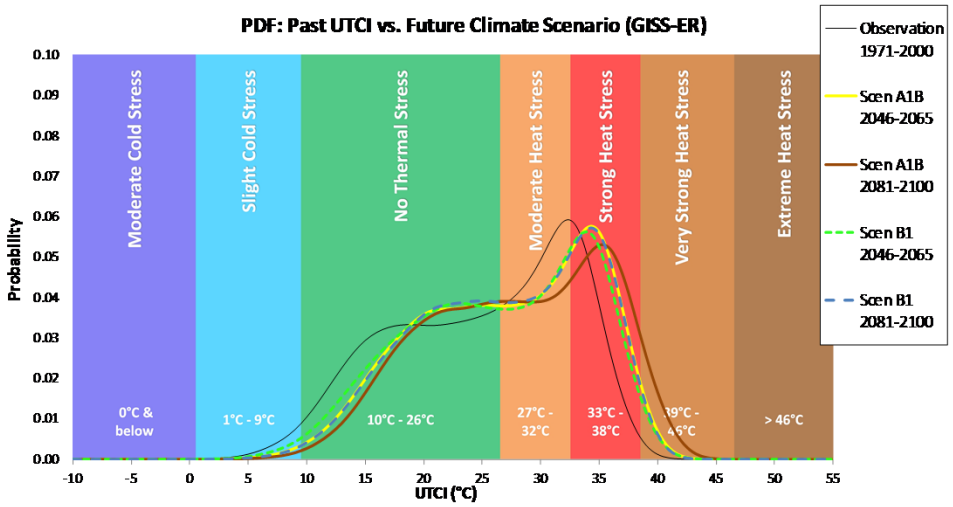
Statistical downscaling of local climate variables
(Projection of thermal comfort)

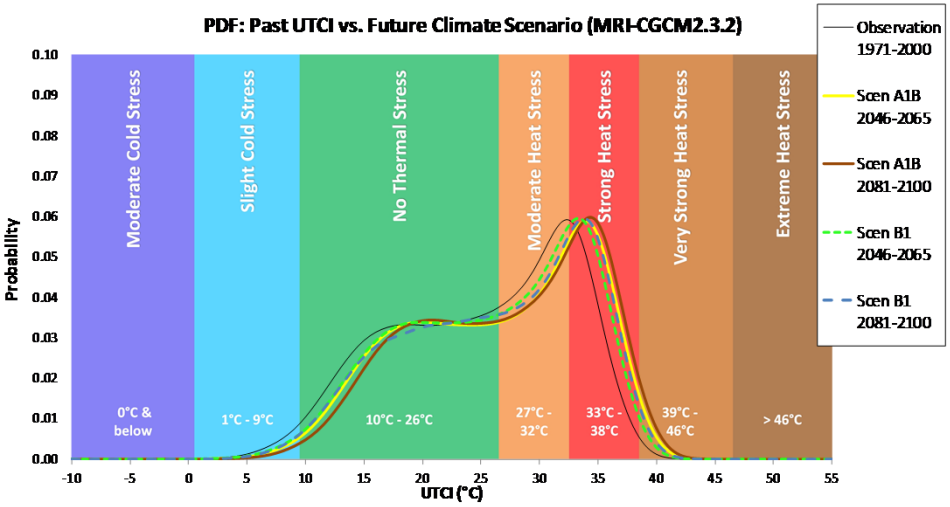
- Universal Thermal Climate Index (UTCI) - measuring thermal comfort, both hot and cold, for short and long term outdoor exposure
- Simulate by RayMan model, inputting average daily values of:
  - Temperature (downscaled variable)
  - Relative humidity (downscaled variable)
  - Wind speed (downscaled variable)
  - solar radiation
  - site characteristics (such as location and sky view factor)
- Stress category

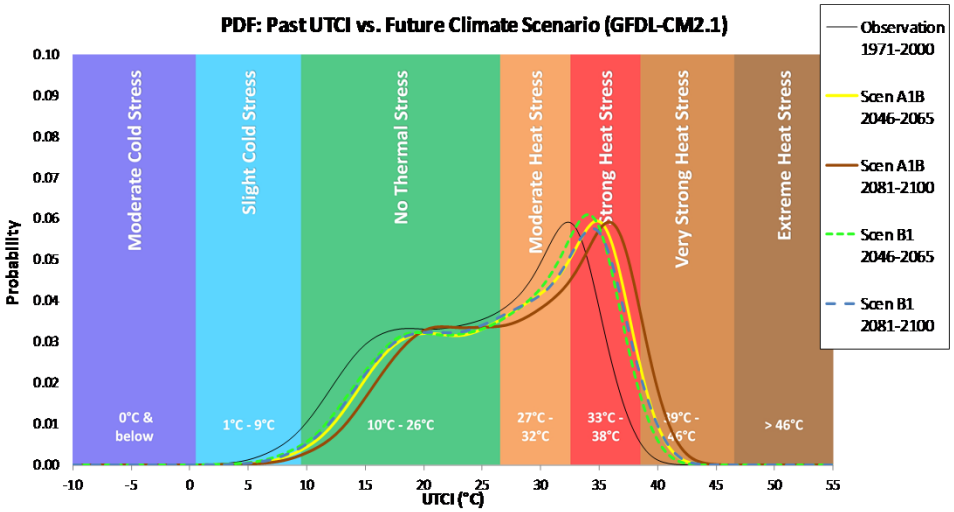
UTCI (°C)	Stress Category	UTCI (°C)	Stress Category
> 46	Extreme heat stress	1 to 9	Slight cold stress
39 to 46	Very strong heat stress	-12 to 0	Moderate cold stress
33 to 38	Strong heat stress	-26 to -13	Strong cold stress
27 to 32	Moderate heat stress	-39 to -27	Very strong cold stress
10 to 26	No thermal stress	≤ -40	Extreme cold stress

Statistical downscaling of local climate variables

(Projection of thermal comfort)







- **Shifting from no thermal stress to more heat stress**
- **Higher occur of very hot heat stress**
- **Less cold stress.**
- **Scenario A1B has the most severe change, especially in 2081 to 2100**

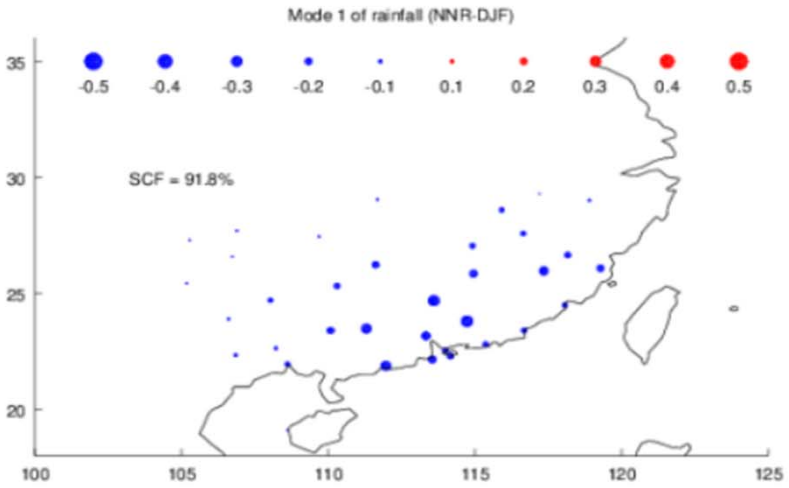
Cheung & Hart (2014). Climate change and thermal comfort in Hong Kong. IJB.

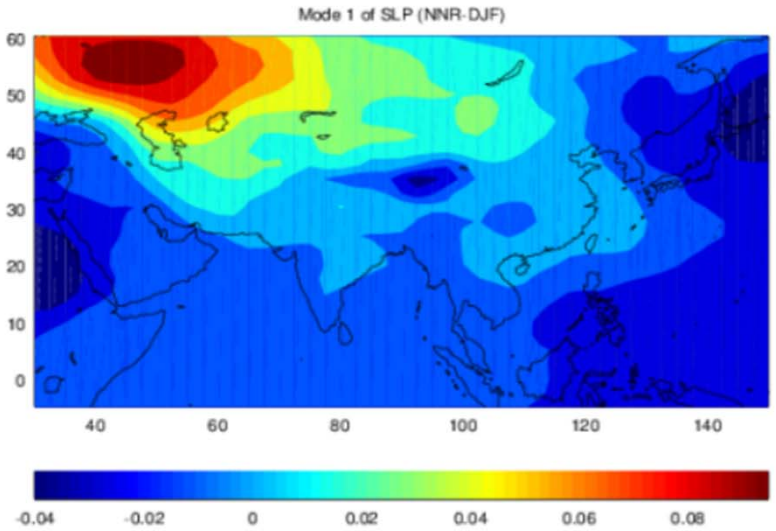
Statistical downscaling using climate pattern
(Prediction of precipitation)

- Southeast China (SEC) rainfall is affected by a number of climate systems, such as moonsoon, PDO, IOD, ENSO etc.
- Important to check whether GCM can reproduce co-variability between SEC rainfall and large scale circulation
- If such linkage is found, then ultimately circulation variables such as sea level pressure (SLP) and geopotential height, can be used as predictors for statistical downscaling.

Statistical downscaling using climate pattern

(Prediction of precipitation)



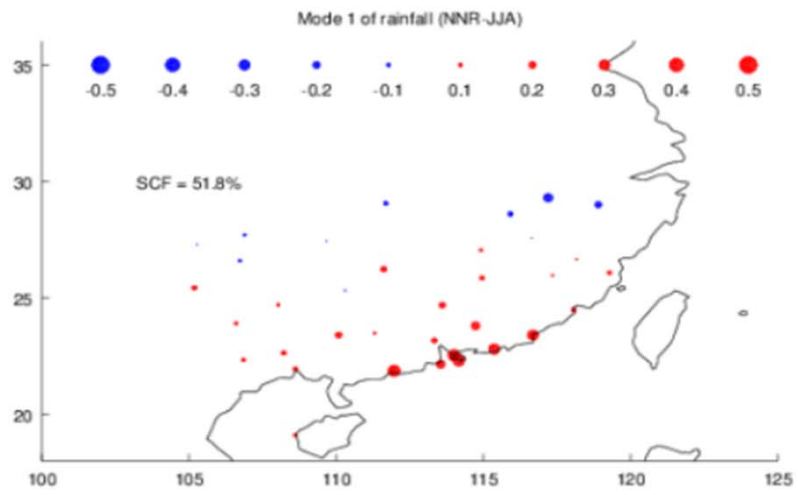


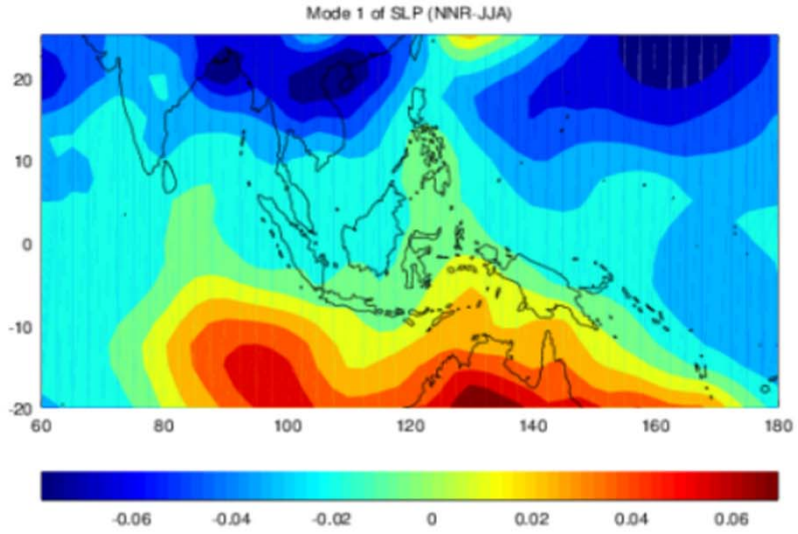
Winter rainfall

- Suppressed rainfall in Southeast China (SEC) associated with large scale positive sea level pressure (SLP) anomaly
- Strong SLP gradient → stronger northerly surface wind (stronger winter monsoon)
- Enhanced northerly flow → brings cold and dry continental air to SEC
- Reduced amount of precipitation in SEC

Statistical downscaling using climate pattern

(Prediction of precipitation)





Summer rainfall

- Negative anomaly SLP covering Indochina to SEC is associated with enhanced rainfall in the region
- Lower than normal SLP conducive of occurrence of rainfall in SEC

Thank You

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