“New normal” of regional climate under global warming: *the utilization of high-resolution climate modeling*

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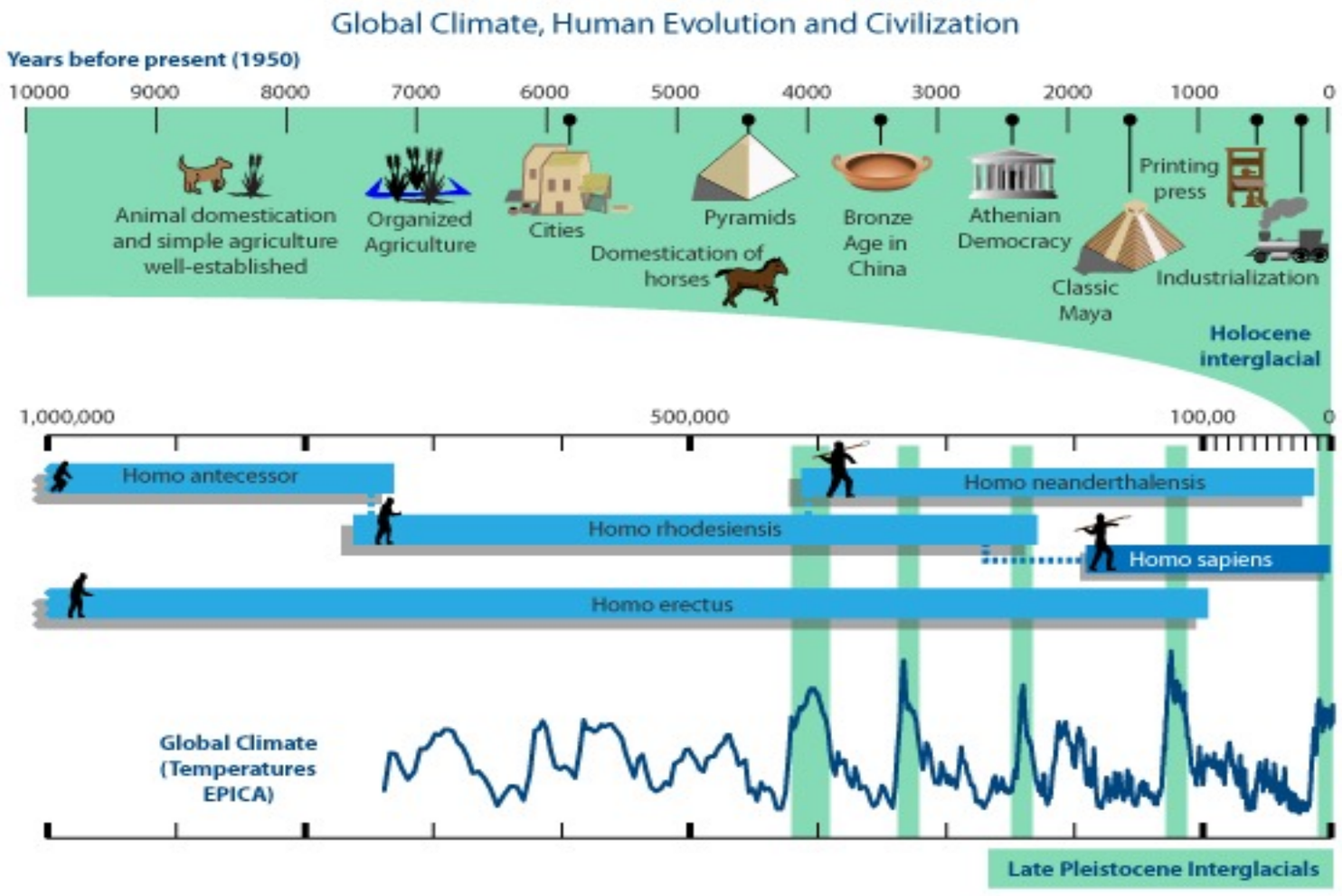
Summer monsson in Las Vegas 2018 (themecloud.co)

Climate is always changing



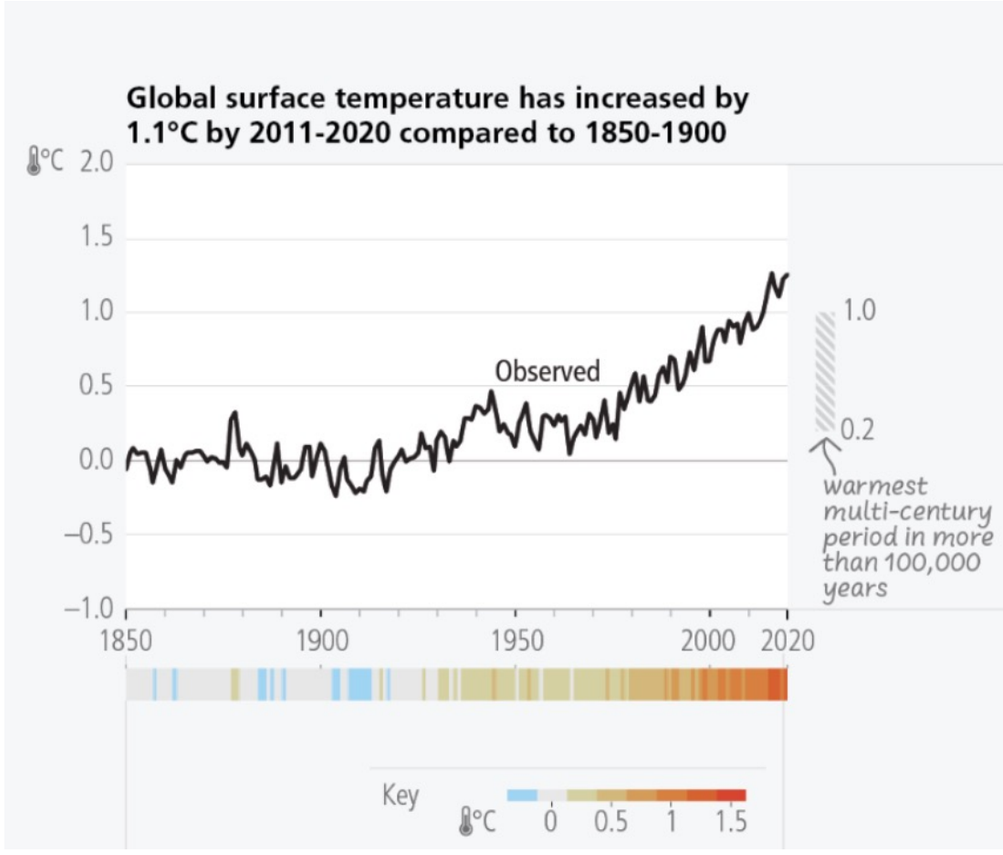
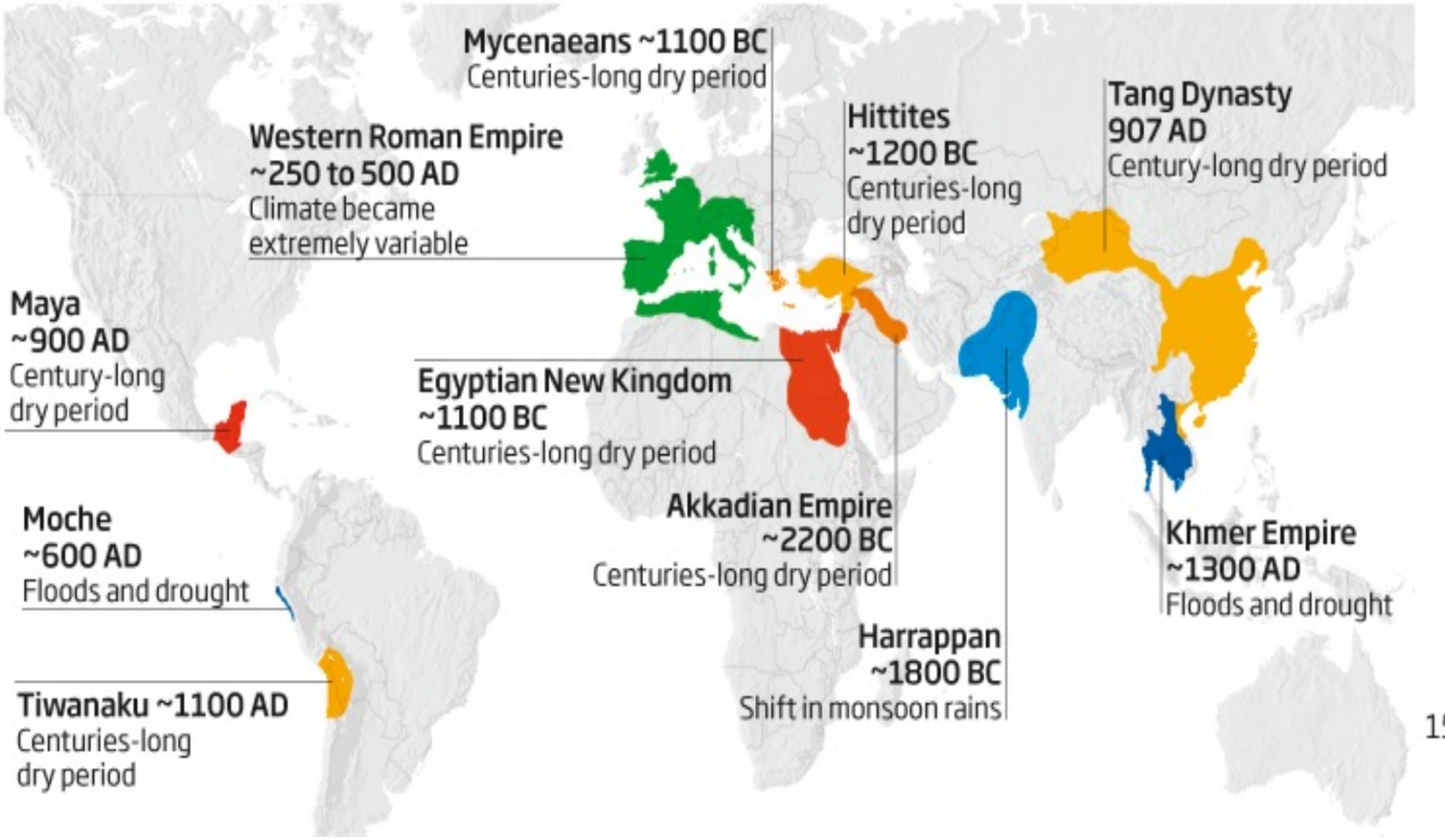


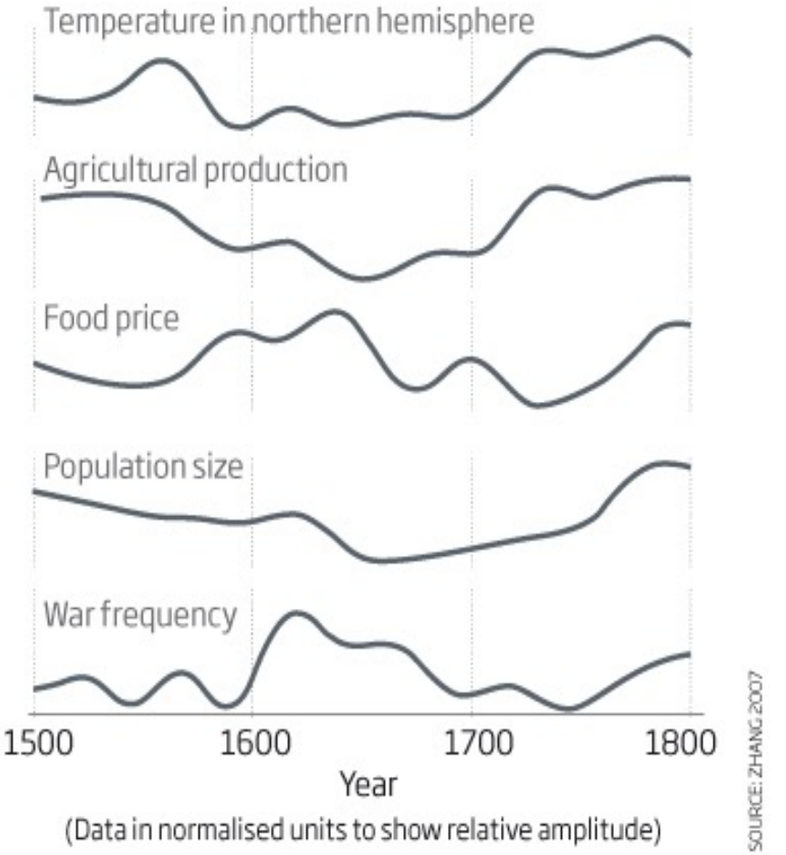
Image by John Garrett (Skepticalscience.com).

IPCC AR6

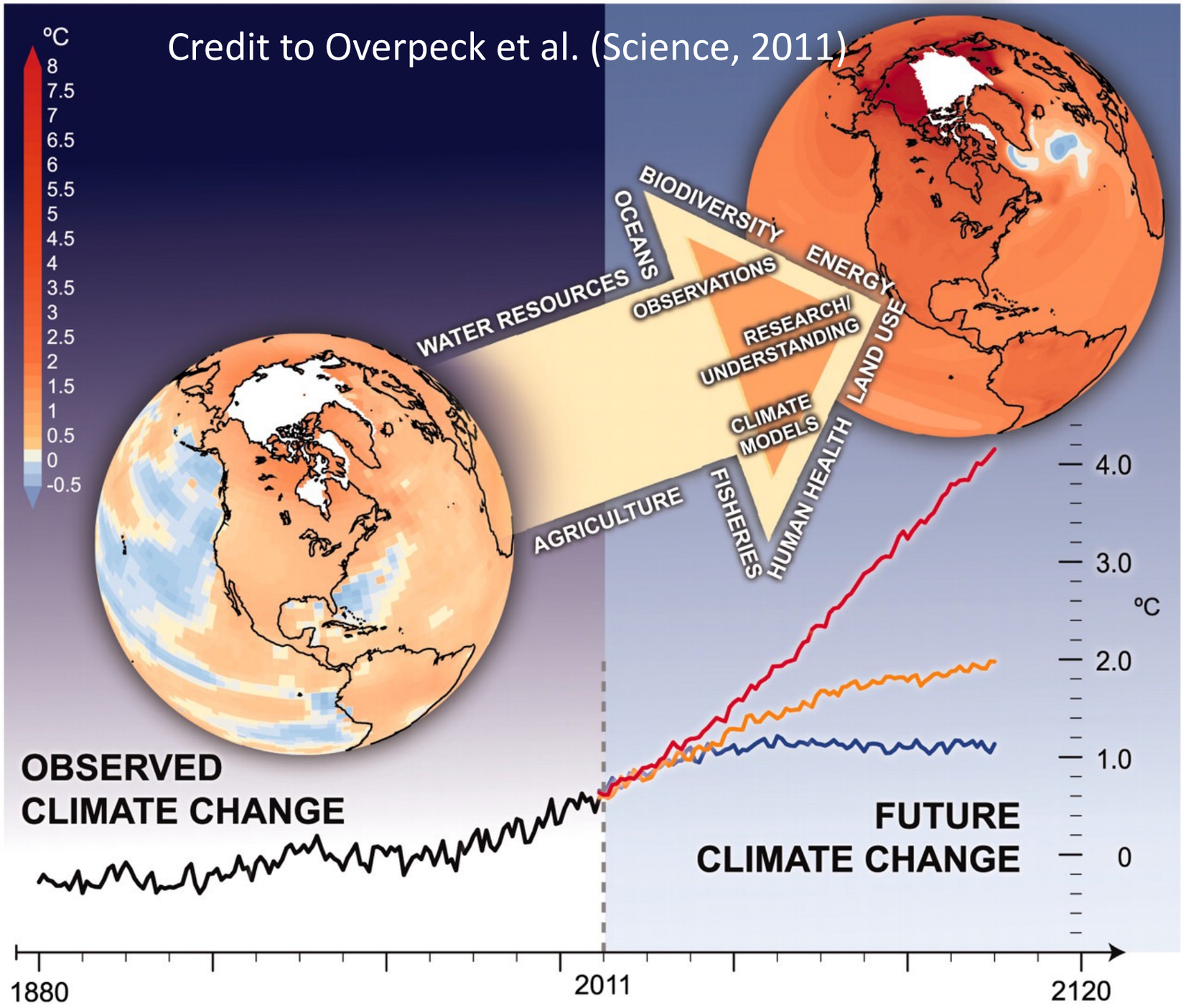
More than coincidence?

The decline and fall of many civilisations coincided with periods of climate change, and there are also correlations between climate change, population size and the frequency of wars, as data from Europe shows (right)





Climate change: The great civilization destroyer? (Michael Marshall, Newscientist)

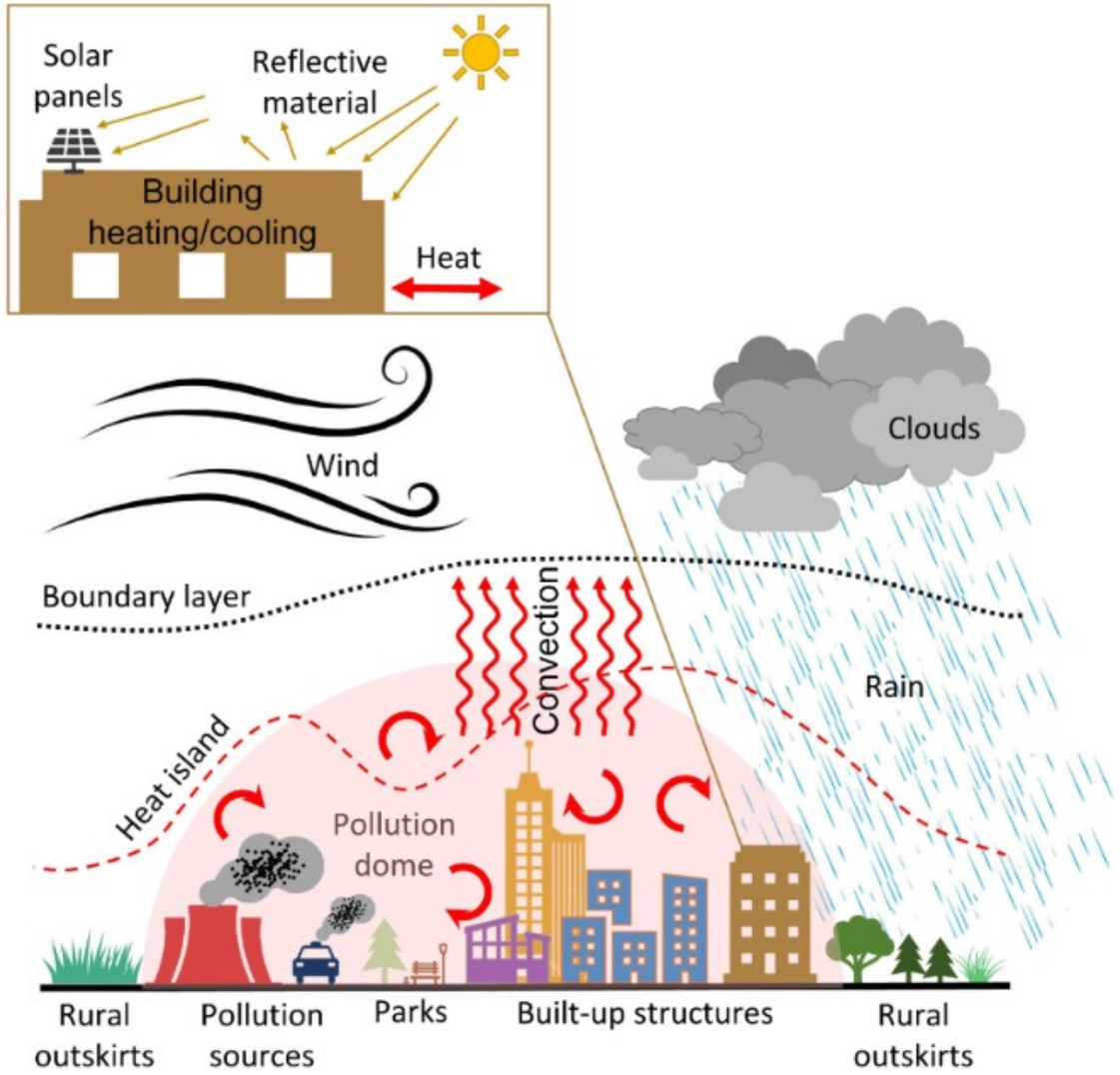


Global climate is shifting to a new normal.

What are implications for regional climates, ecosystem, bio- and social environment?

Make sense of regional climate change information and build future climate knowledge, actions

Urban effects on regional climate

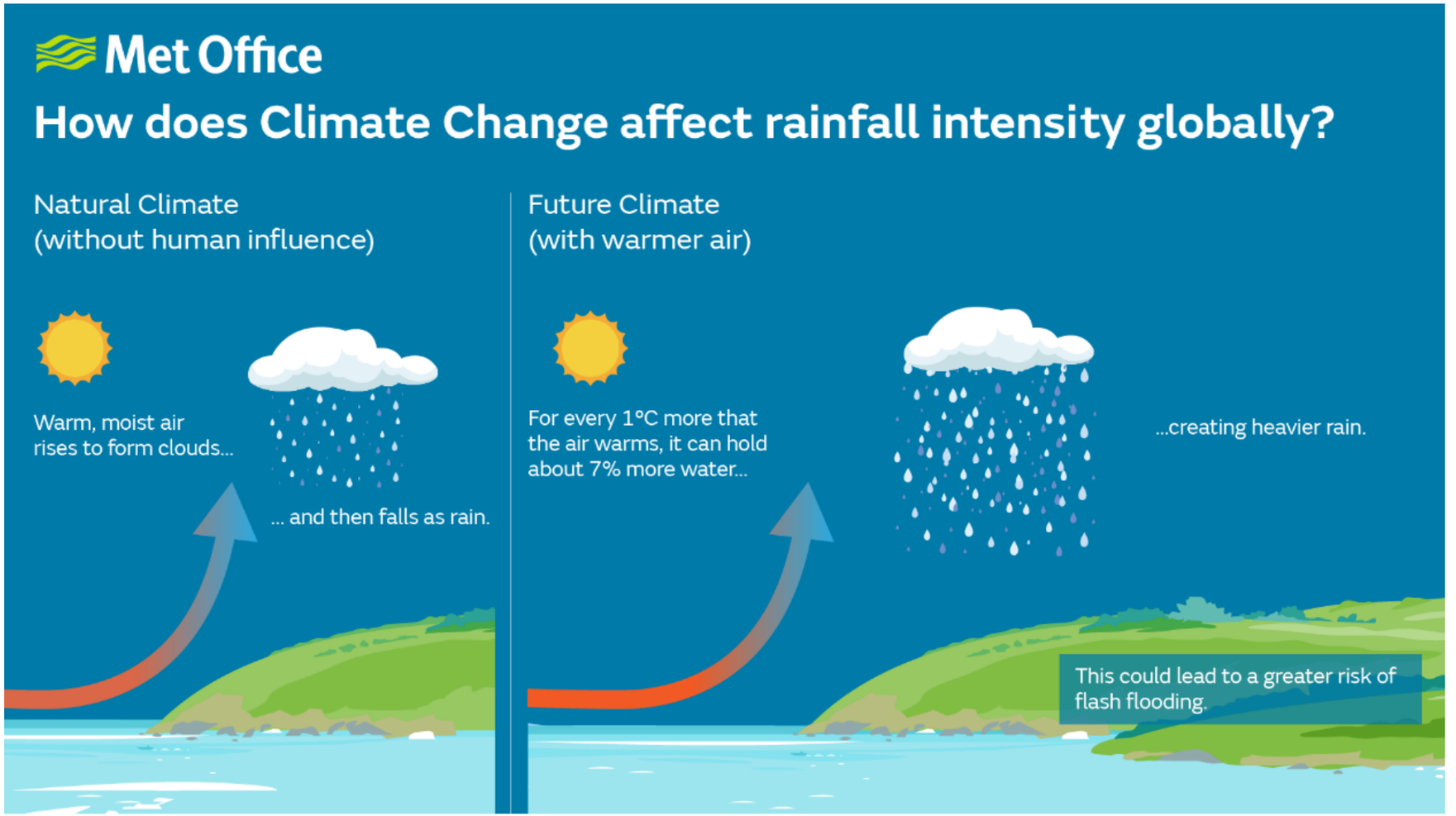


Climate's "old-normal" based knowledge will be the same in the future?

Credit to Qian et al., 2022, Advances in Atmos Sci

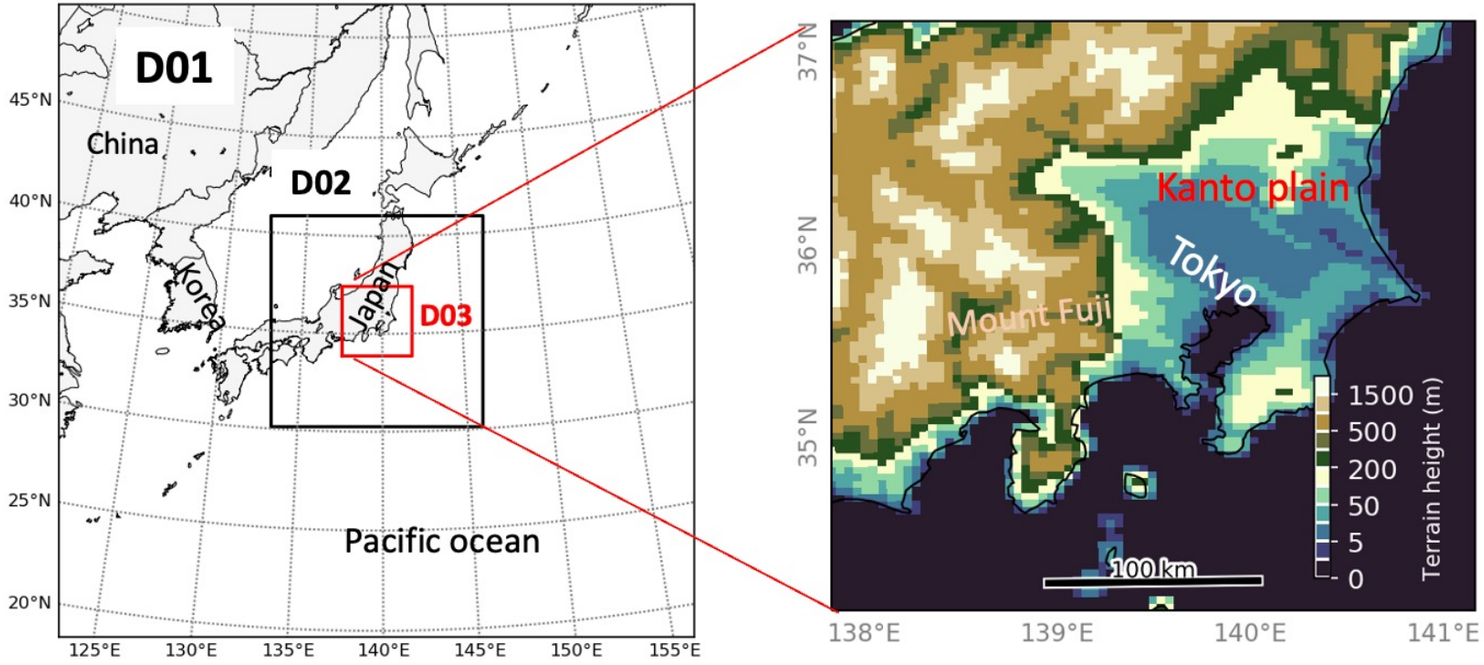
Urban precipitation, why it does matter?

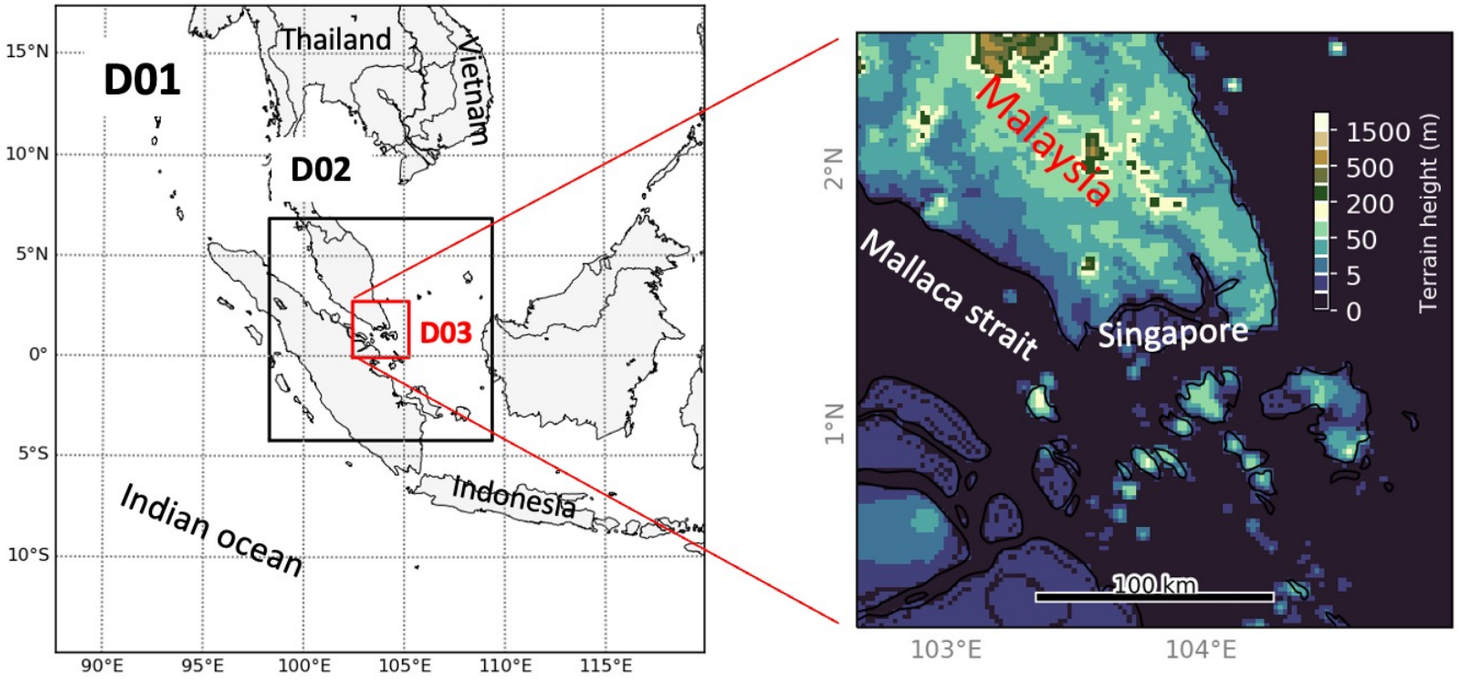
- Urban Flooding
- Water supply
- Water quality
- Climate change



Climate change at the urban scale

A tale of two cities





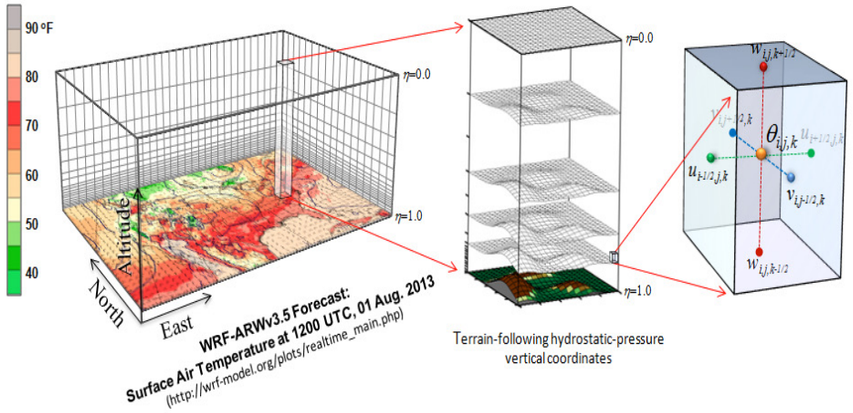
- Tokyo and Singapore
- Pseudo global warming with WRF

- BC:Baseline Climate

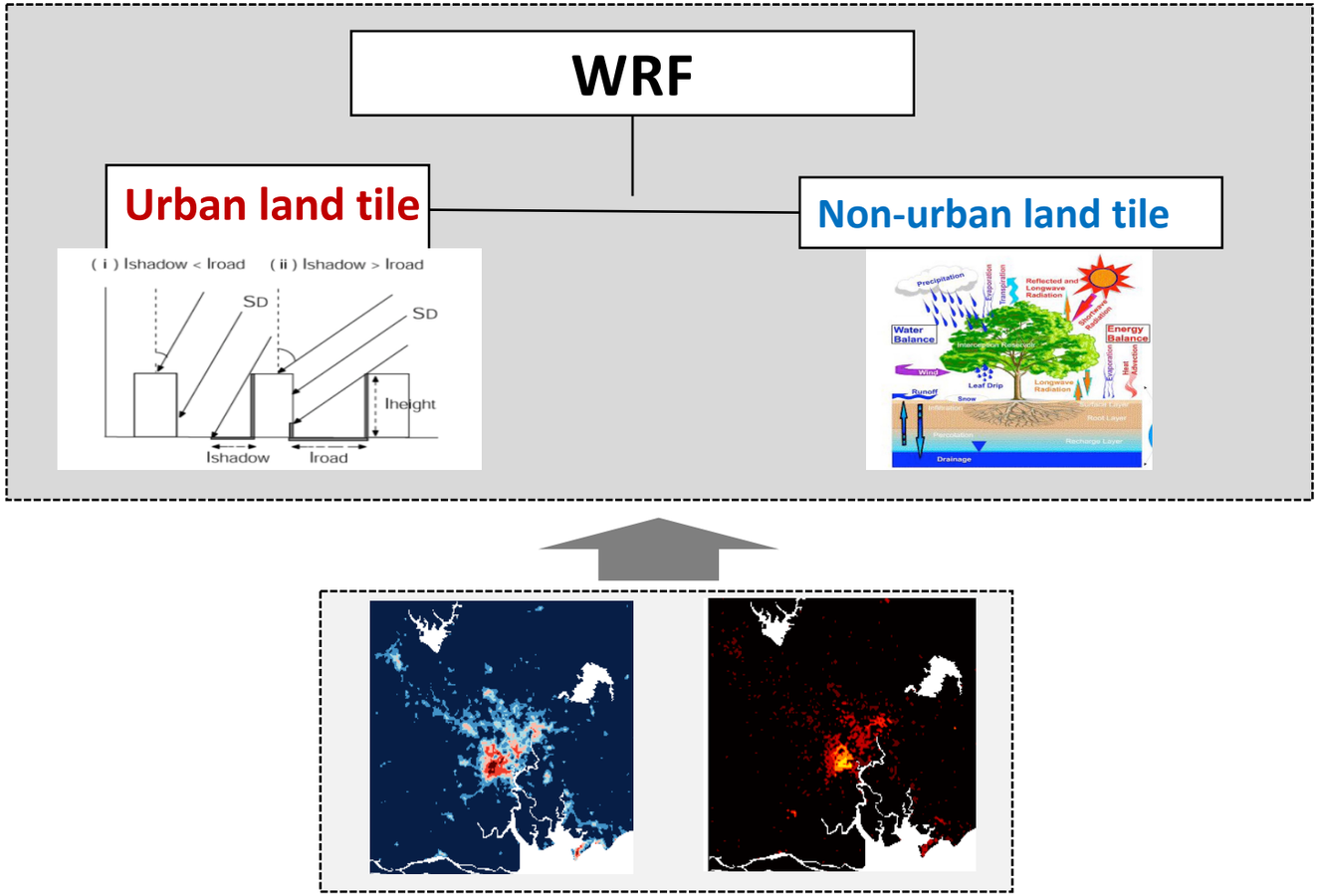
(Tokyo:Aug; Singapore:Nov, 2005 – 2014)

- FC: Future Climate (2050s, 2090s, CMIP5 RCP8.5, RCP4.5)

Weather Research and Forecasting for Cities



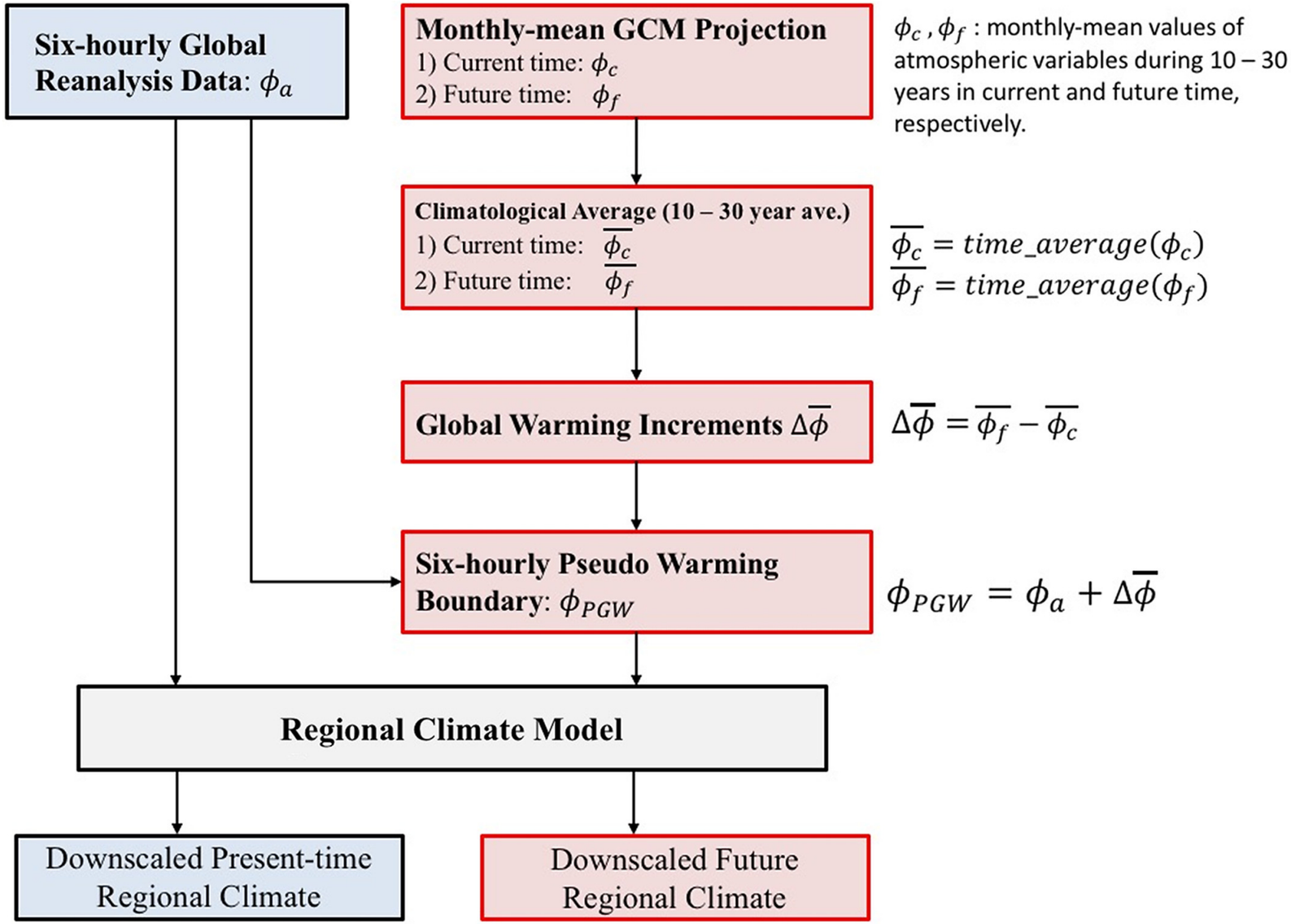
WRF model, source: BioEarth, WSU



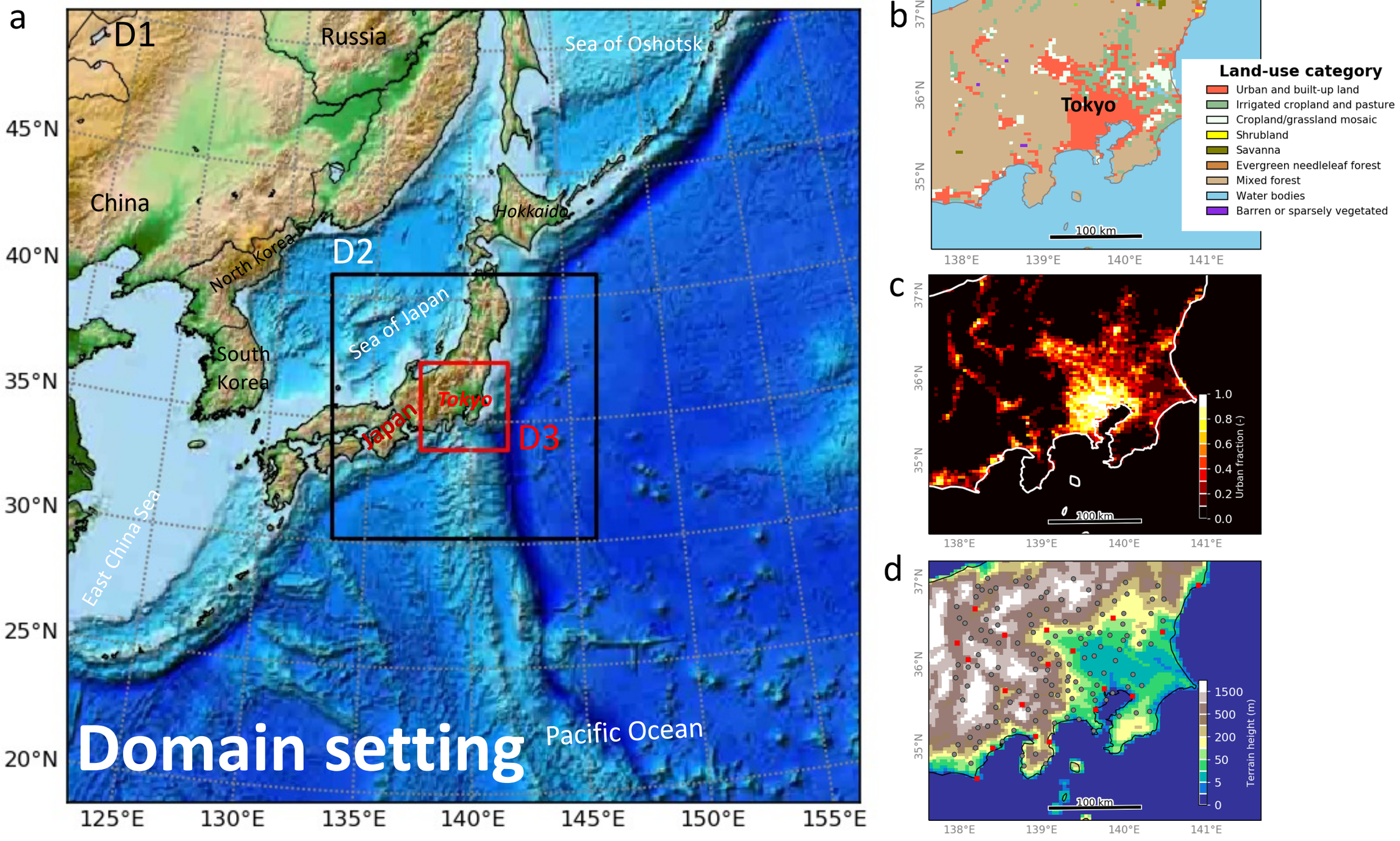
(Doan et al. 2016, Doan et al., 2019; Gu et al. 2019)

Pseudo-Global Warming Downscaling

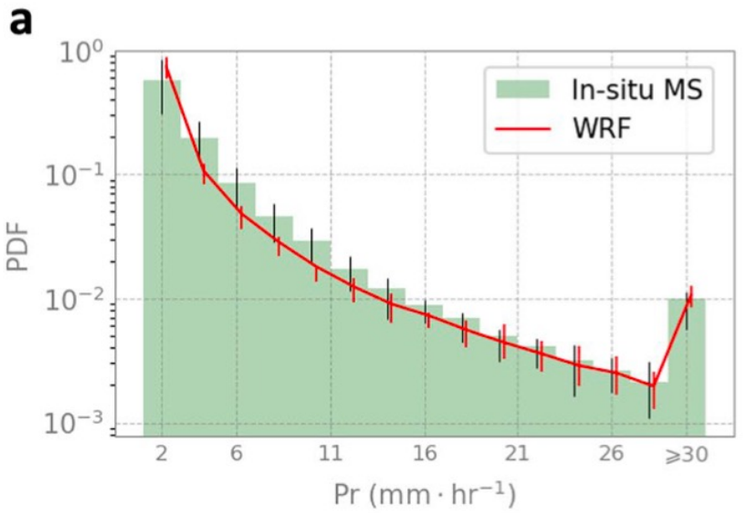
To isolate the impact of “primary mode” of global warming

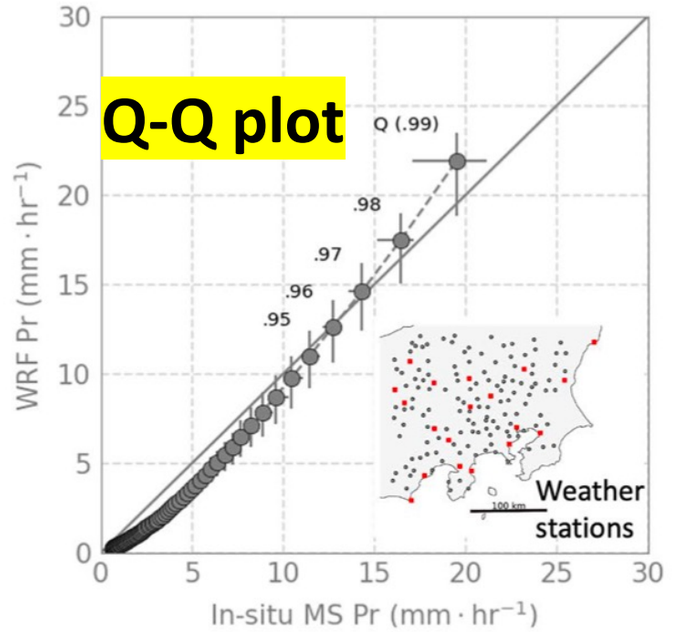


Credit to Doan & Kusaka (IJoC, 2018)

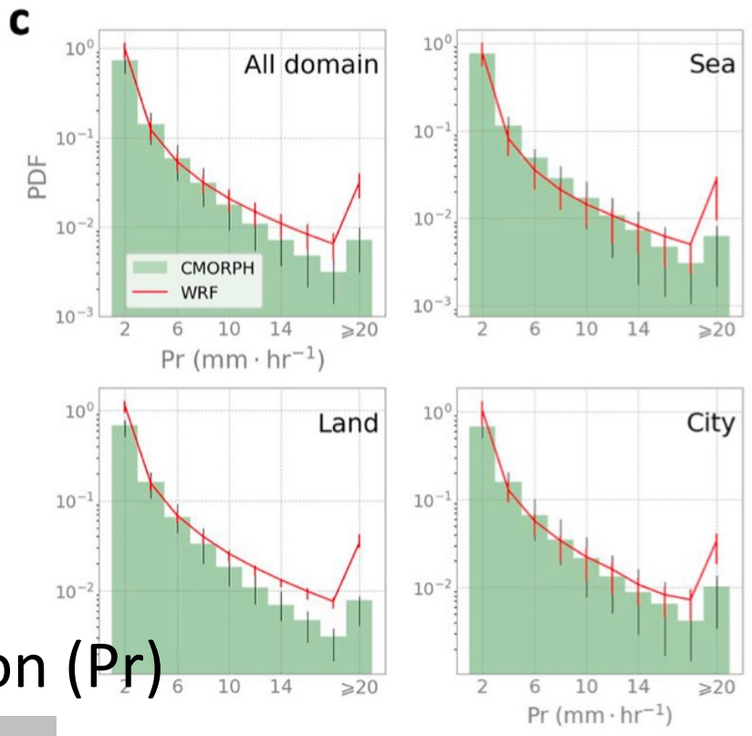

a
D1
Russia
Sea of Oshotsk
China
Hokkaido
D2
North Korea
Sea of Japan
South Korea
Tokyo
Japan
D3
East China Sea
Pacific Ocean
Domain setting
45°N
40°N
35°N
30°N
25°N
20°N
125°E
130°E
135°E
140°E
145°E
150°E
155°E
b
Tokyo
100 km
Land-use category
Urban and built-up land
Irrigated cropland and pasture
Cropland/grassland mosaic
Shrubland
Savanna
Evergreen needleleaf forest
Mixed forest
Water bodies
Barren or sparsely vegetated
37°N
36°N
35°N
138°E
139°E
140°E
141°E
c
100 km
1.0
0.8
0.6
0.4
0.2
0.0
Urban fraction (-)
d
100 km
1500
500
200
50
5
0
Terrain height (m)

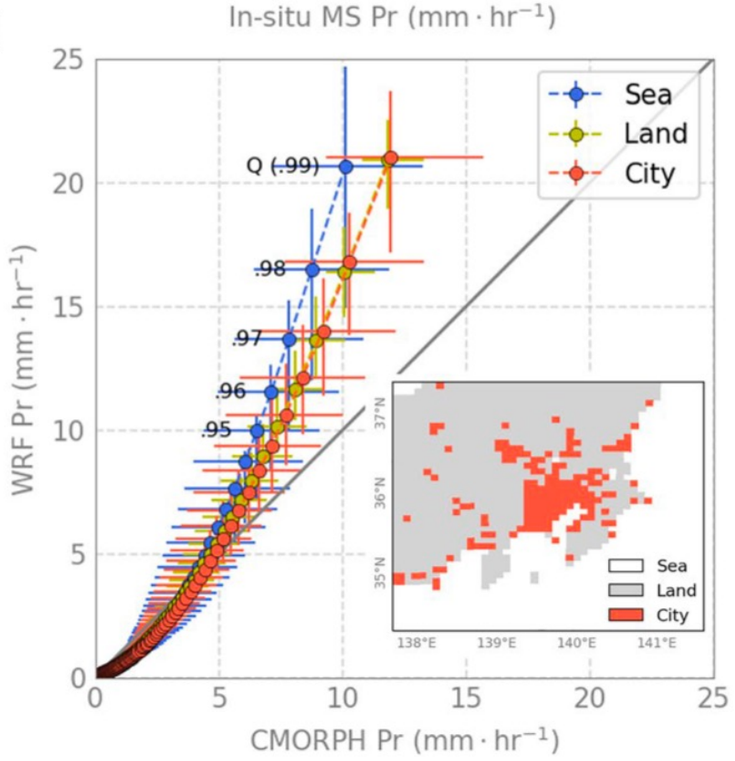
Model performance on insitu observation and satelite product





Probability Density Function (PDF)



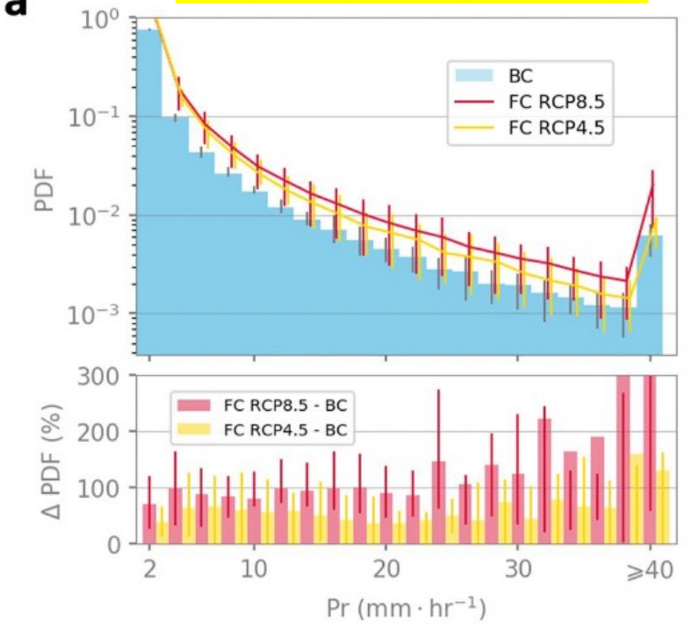


Precipitation (Pr)

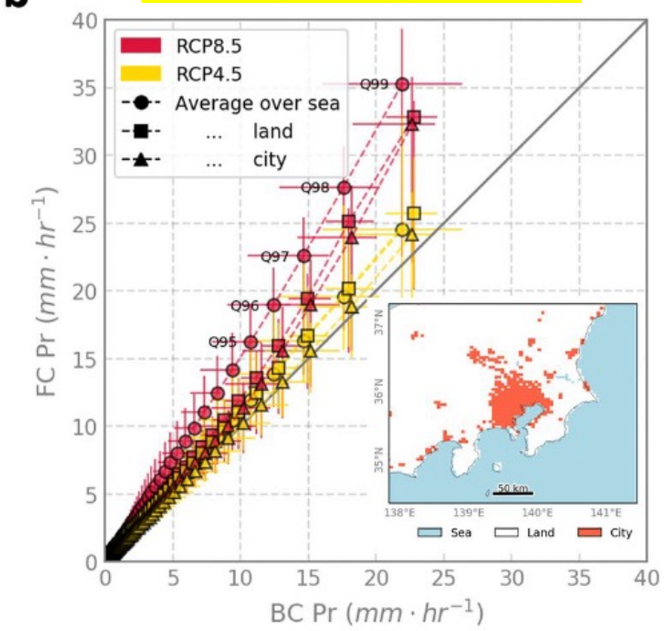
Results for Tokyo

Local precipitation's climatic responses to global warming

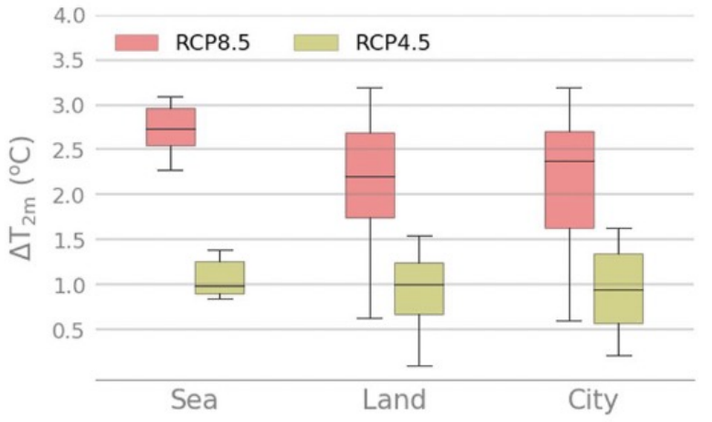
Frequency change (Precip)

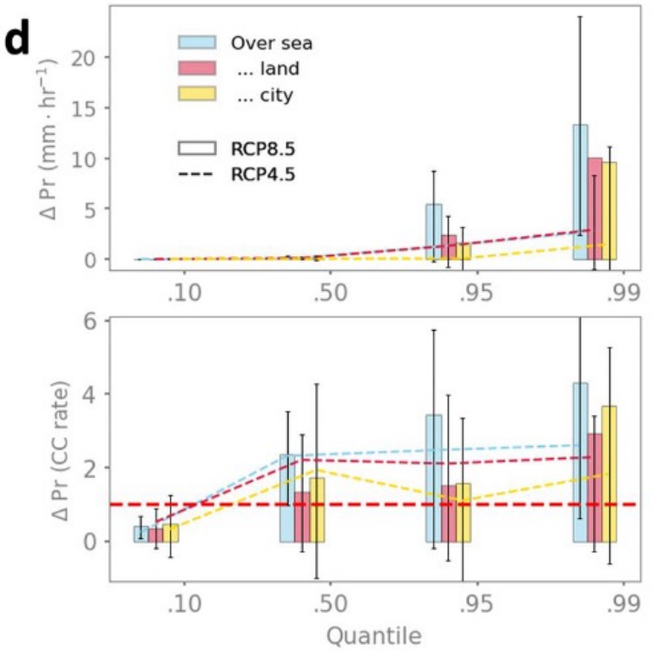


Intensity change (Precip)



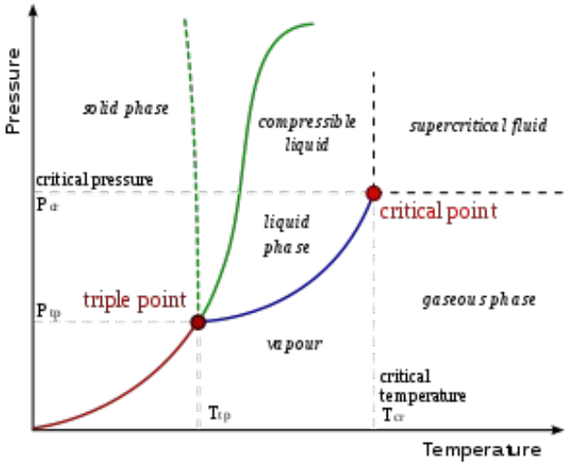
Warming (Temp)





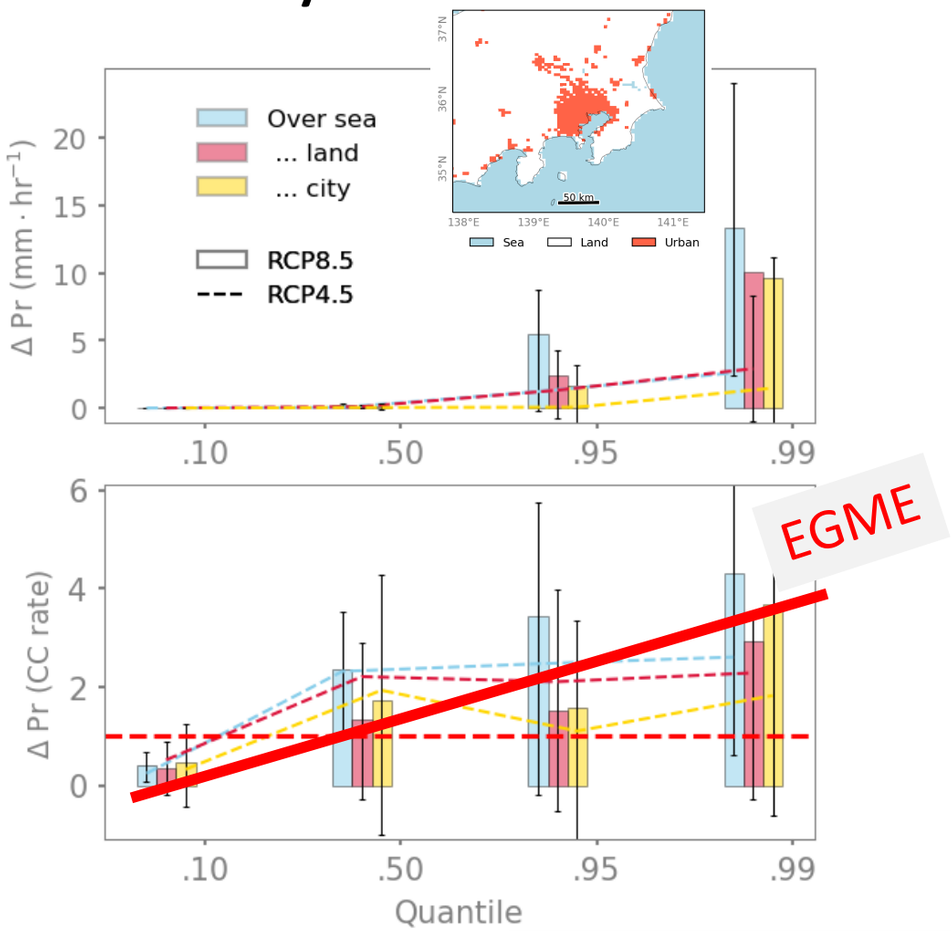
Results for Tokyo

Extreme gets more extreme (EGME)

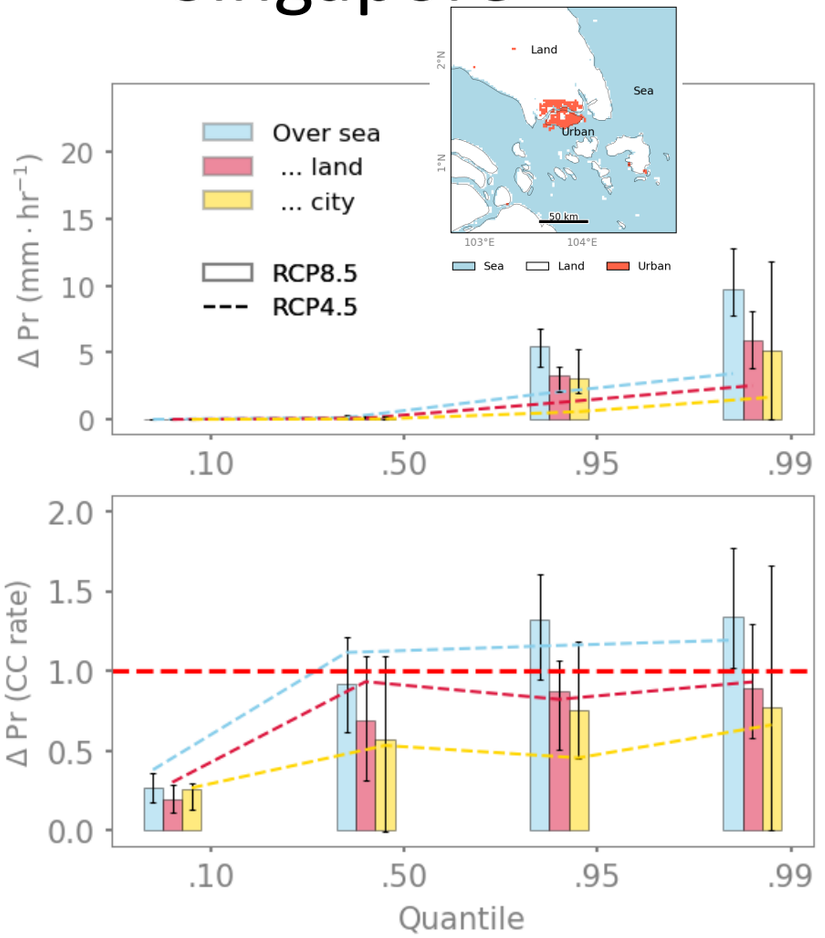


1 CC is about
7% increase of atmospheric moisture per one K warming

Tokyo



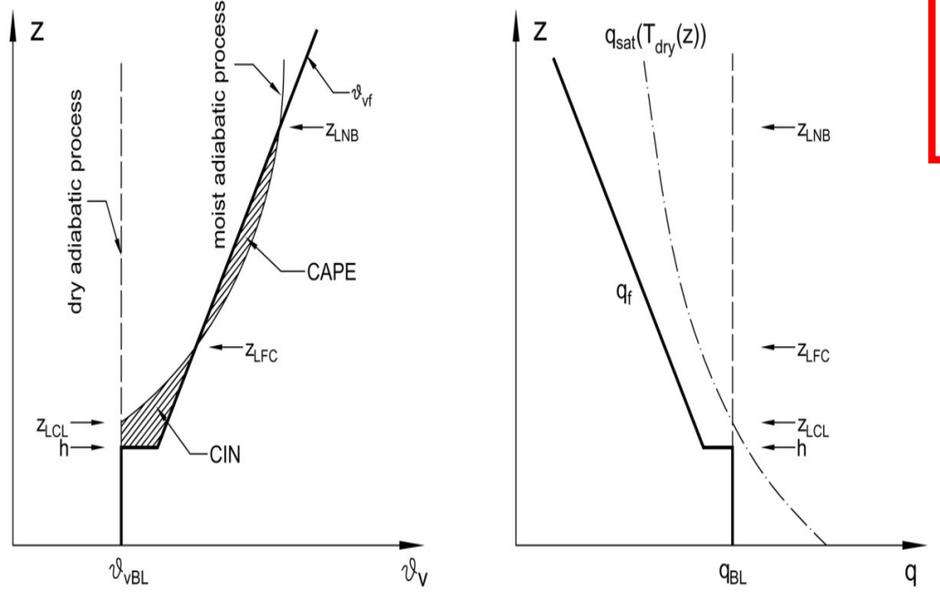
Singapore

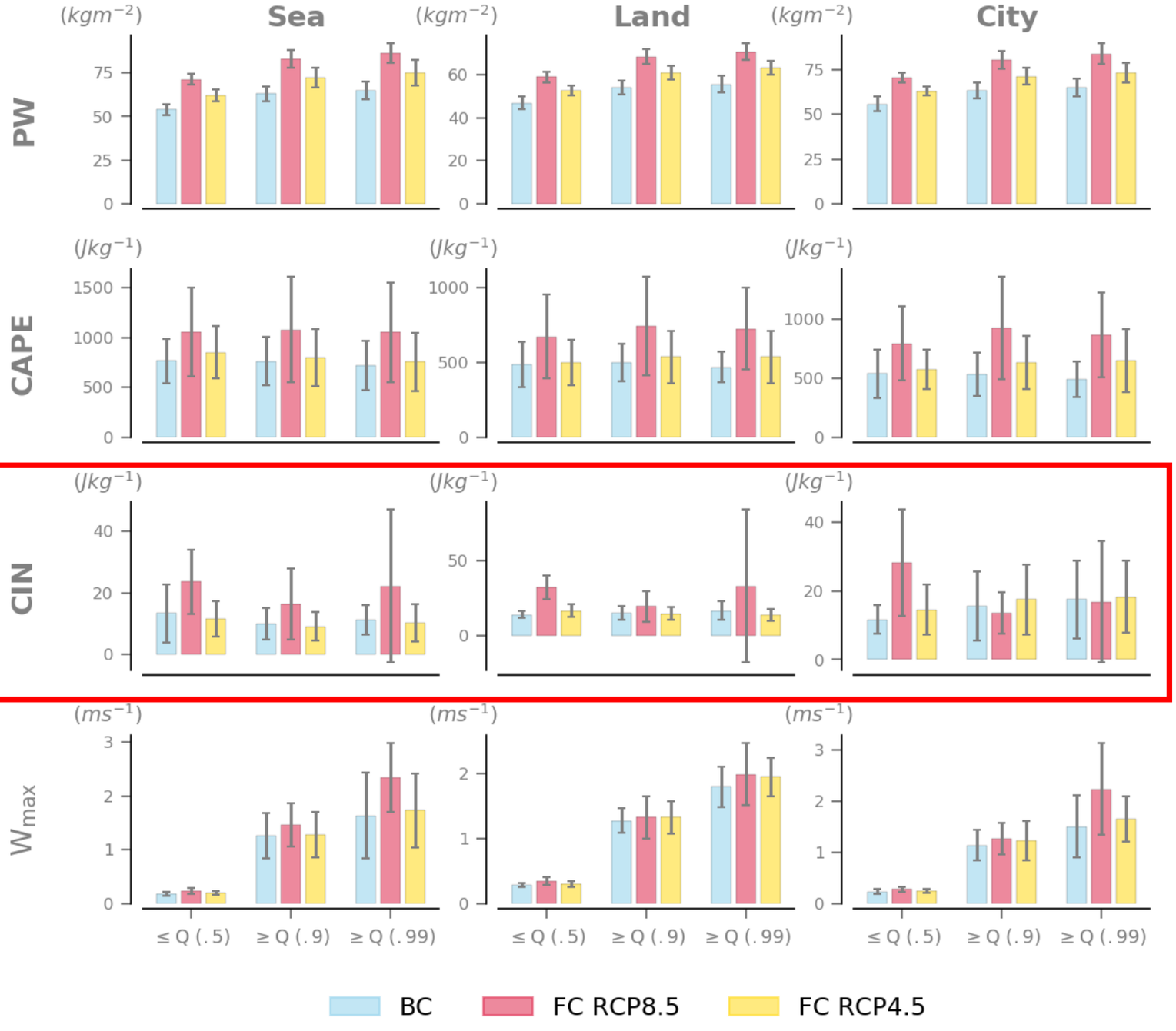


CC: Clausius Clapeyron scaling

Weak convection is suppressed for strong one to grow

PW: precipitable water
CAPE: Convective available potential energy
CIN: Convective inhibition
Wmax: maximum vertical velocity

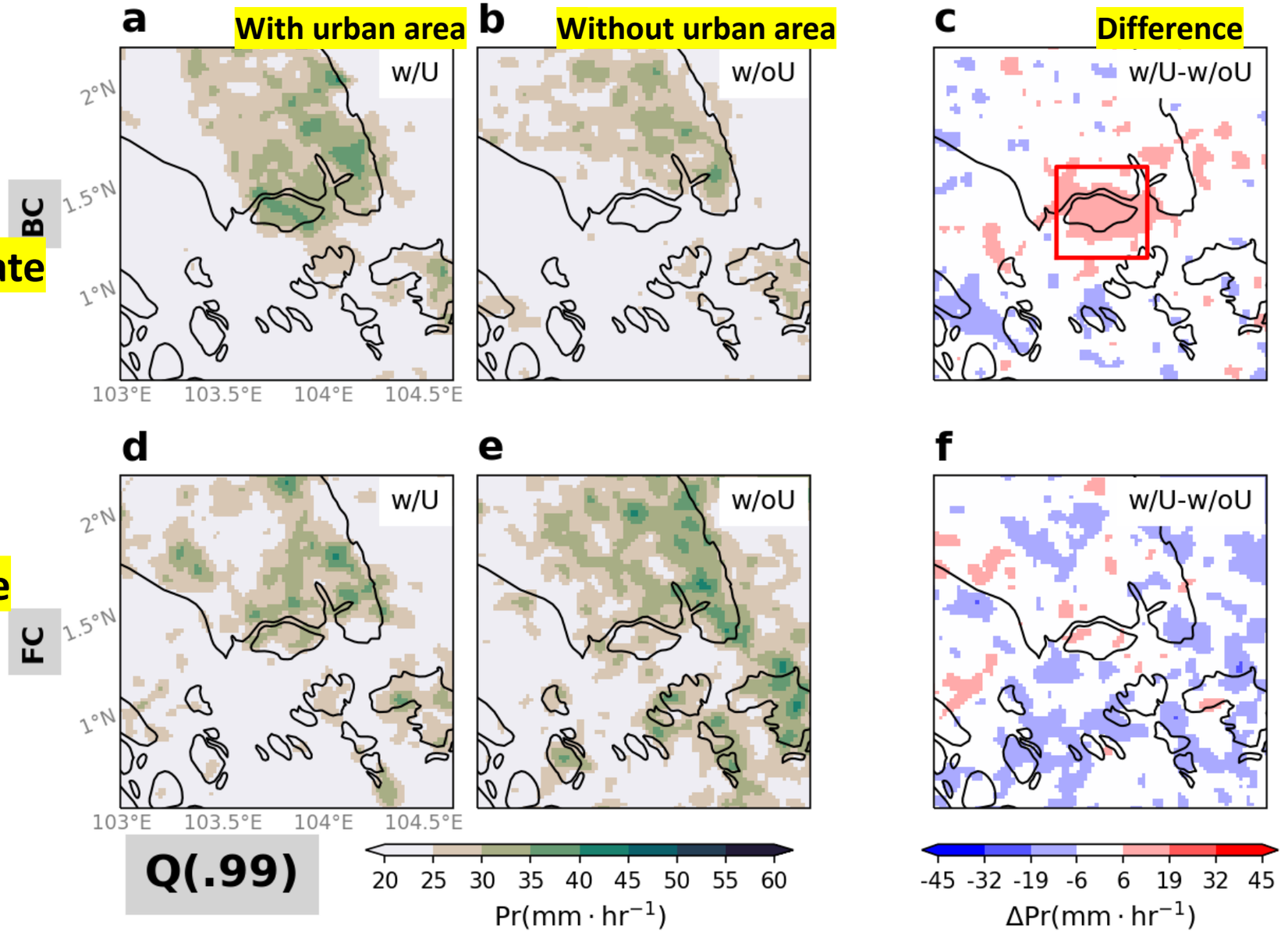




Urban footprint disappears ?

Baseline climate

Future climate



Urban footprint changes under different climate regimes?

Key points

- Importance of HPC in investigating how and why urban climate changes under the “new normal” of the global climate system.
- Extreme gets more extreme (EGME).
- Weak convection is suppressed for a stronger one to grow.
- Urban footprint on extreme precipitation in the tropics will disappear?
- Mid-latitude responds more sensitively to warming stimulations. Mechanisms need to be discovered.

Thank you!

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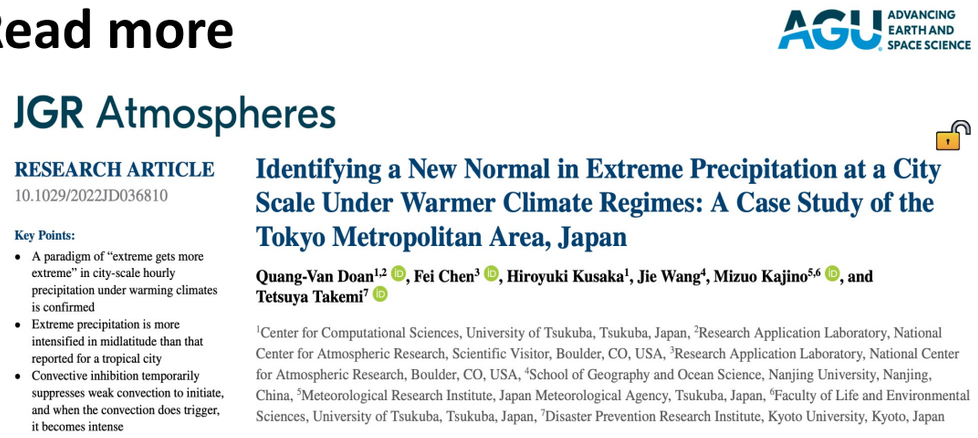
Thank co-authors from U of Kyoto, MRI (Japan), NCAR, U of Texas at Austin (USA), U of Nanjing (China) for great contributions to this study

Read more



JGR Atmospheres

RESEARCH ARTICLE
10.1029/2022JD036810

Identifying a New Normal in Extreme Precipitation at a City Scale Under Warmer Climate Regimes: A Case Study of the Tokyo Metropolitan Area, Japan

Key Points:
- A paradigm of "extreme gets more extreme" in city-scale hourly precipitation under warming climates is confirmed
- Extreme precipitation is more intensified in midlatitude than that reported for a tropical city
- Convective inhibition temporarily suppresses weak convection to initiate, and when the convection does trigger, it becomes intense

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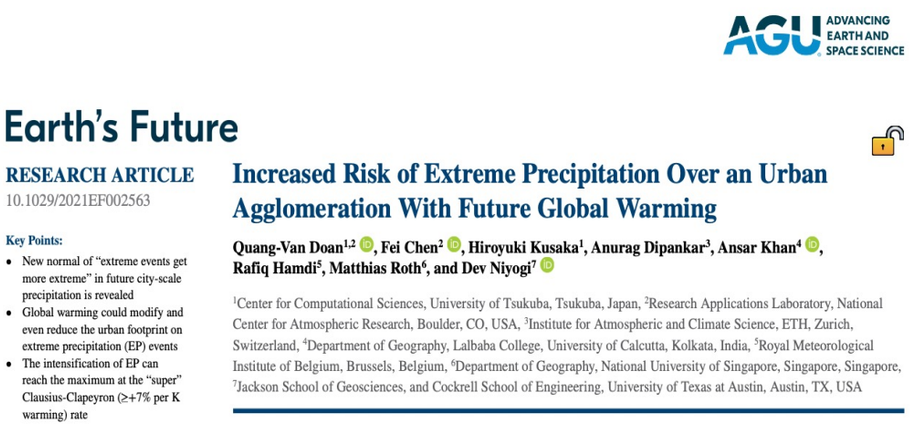

Earth's Future

RESEARCH ARTICLE
10.1029/2021EF002563

Increased Risk of Extreme Precipitation Over an Urban Agglomeration With Future Global Warming

Key Points:
- New normal of "extreme events get more extreme" in future city-scale precipitation is revealed
- Global warming could modify and even reduce the urban footprint on extreme precipitation (EP) events
- The intensification of EP can reach the maximum at the "super" Clausius-Clapeyron (≥+7% per K warming) rate

Quang-Van Doan[1,2], Fei Chen[2], Hiroyuki Kusaka[1], Anurag Dipankar[3], Ansar Khan[4], Rafiq Hamdi[5], Matthias Roth[6], and Dev Niyogi[7]

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