



中国水利水电科学研究院

China Institute of Water Resources and Hydropower Research



FFP1: Seminar on Flash Flood Risk Management

Flash Flood Mitigation Measures for Dense Urban Cities with
short Time of Concentration

Shie-Yui LIONG

Consultant to Tropical Marine Science Institute
(National University of Singapore)

2020.10.29

Content

1

Introduction

2

Flash Flood in Singapore

3

Impacts of Climate Change on
Precipitation in Southeast Asia

4

Summary

- **Flash Flood** is defined as “a flood caused by heavy or excessive rainfall over a short period of time, generally less than 6 hours. (or also due to a levee or dam failure).
- **Singapore (urban island state):** tropical climate; Area= ~750 km²; Topography: flat (highest point 180m above msl); Average annual rainfall: 2,340mm (some wet years: ~3600mm)
- The highest 24-hour rainfall ever recorded: 514mm (2 Dec 1978); 467mm (1969), 366mm (Dec 2006). Note the average monthly rainfall: 100 - 300mm.
- **Time of Concentration: 30 minutes!**
- Singapore is one of the most **water stressed** countries
- Import 250 million gallons of raw water daily from Johor River (Malaysia) as a part of 99 year water agreement (expiring in 2061). This serves about 40% daily water consumption
- The country has built a robust, diversified and sustainable water supply from 4 water sources: (1) Water from local catchments (damming all bays), (2) Imported water, (3) high grade Reclaimed/Recycled water, and (4) Desalinated water. Now it has 5 recycled water plants (55% water need in 2060), 5 desalination plants (~40% water need in 2060).

CHALLENGES:

PRESERVING WATER (ie. Keeping the reservoir water level as HIGH as possible)

VS.

FLOOD PREVENTION (ie. LOWERING reservoir water early before rainfall)

→ **two CONFLICTING objective functions**



16 June 2010, Orchard Road, shopping belt in Singapore, 100mm within 2 hours (=60% of June rainfall), 2 heavy rainfall one after another; conveyance capacity not sufficient as one of the two underground culvert got choked. The inundation subsides in a few hours

- Reduction of **flood prone** areas from **3,200 ha in the 1970s to 30.5 ha in 2016**
- to slow down surface runoff flowing into the drainage system, such as by installing **detention tanks, retention ponds, green roofs or rain gardens** (since **2014**: a compulsory feature for land-development >0.2ha → flood risk reduction)
- **To reduce flood risk**: Rainfall forecasting, Rainfall nowcasting (particularly useful for detecting convective rainfall), heavy rain warning, comprehensive network of sensors (flow level sensors and CCTV), flow simulations, flood warning through sms, flood barriers, etc

3 Impacts of Climate Change on Precipitation in the Southeast Asia

Dynamical Downscaling of Climate Models

DD: Dynamic Downscaling

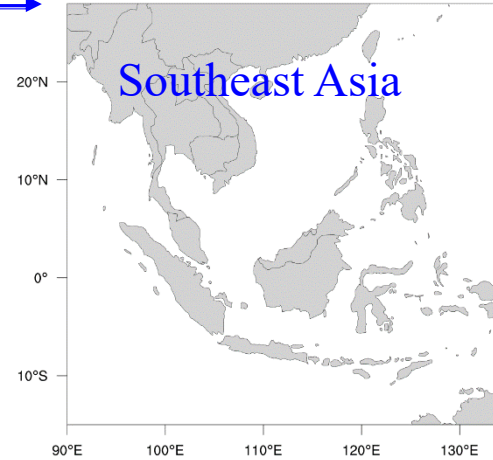


Global (GCM, Global Climate Model)

Spatial Resolution: ~150 - 600 km
Temporal Resolution: ~6 – 24 hours

DD

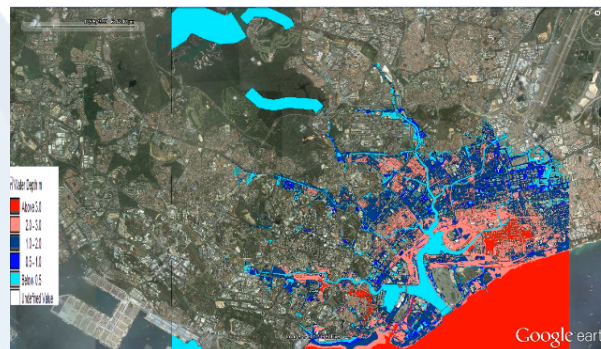
Downscaling



Regional (RCM, Regional Climate Model)

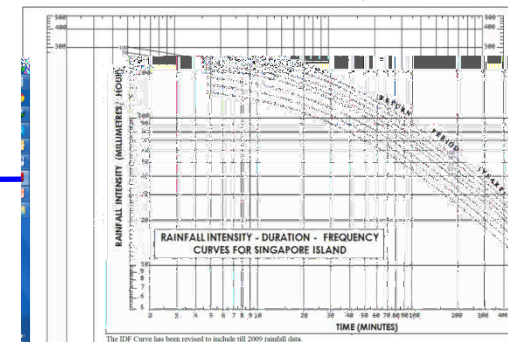
20 km
6 hours

Extreme Rainfall



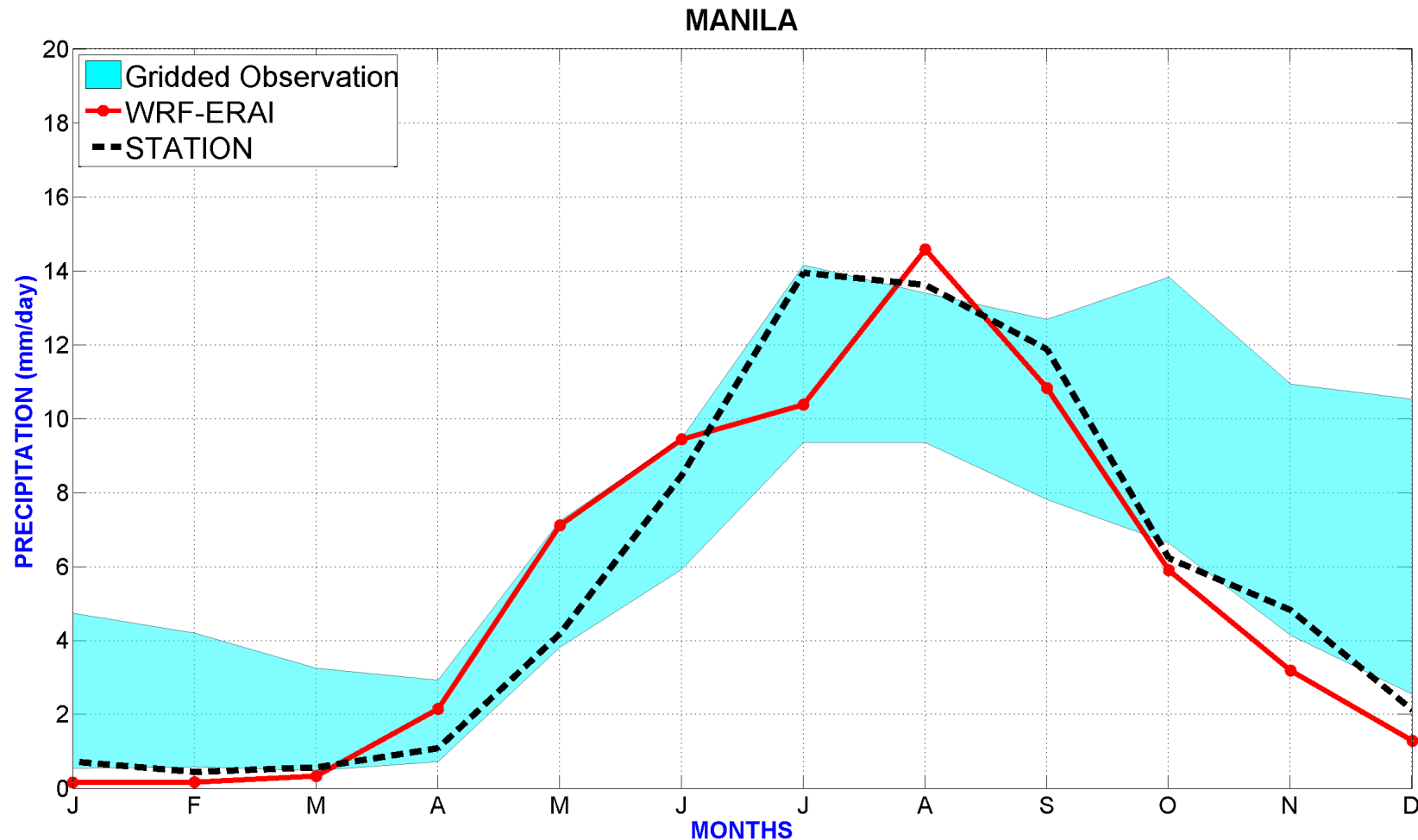
Flood Map

Flood Model



IDF Curves

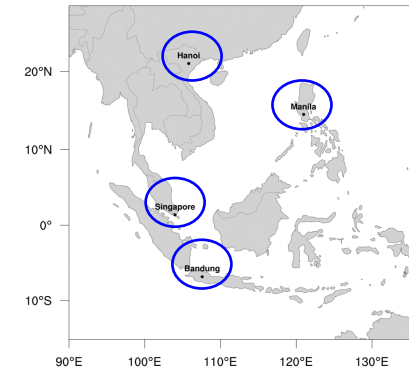
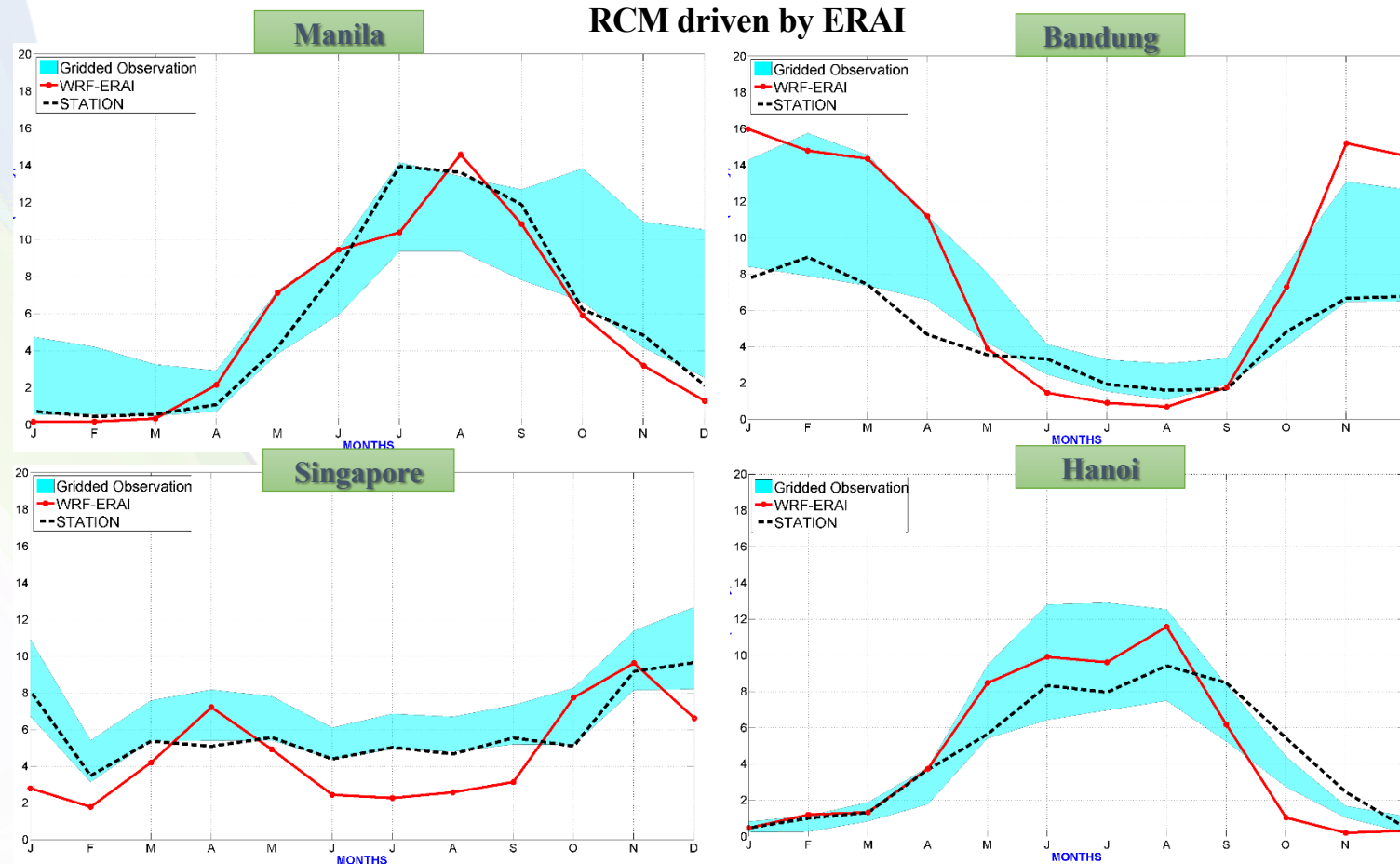
Annual Cycle of Manila Gridded Observation Data (Daily Precipitation)



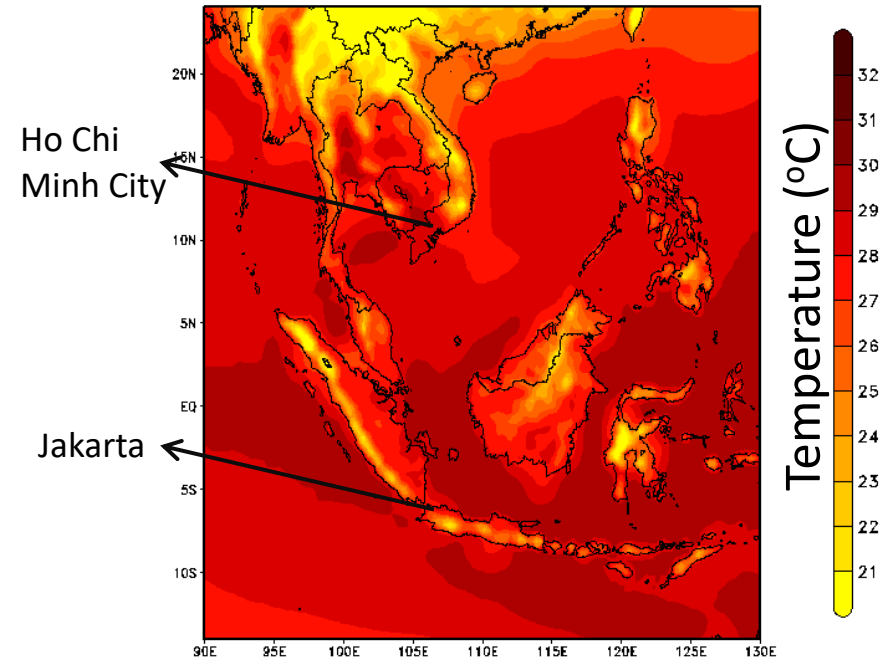
Station data from National Centers for Environmental Information (NCEI)

Regional Climate Model: Daily precipitation on 4 cities

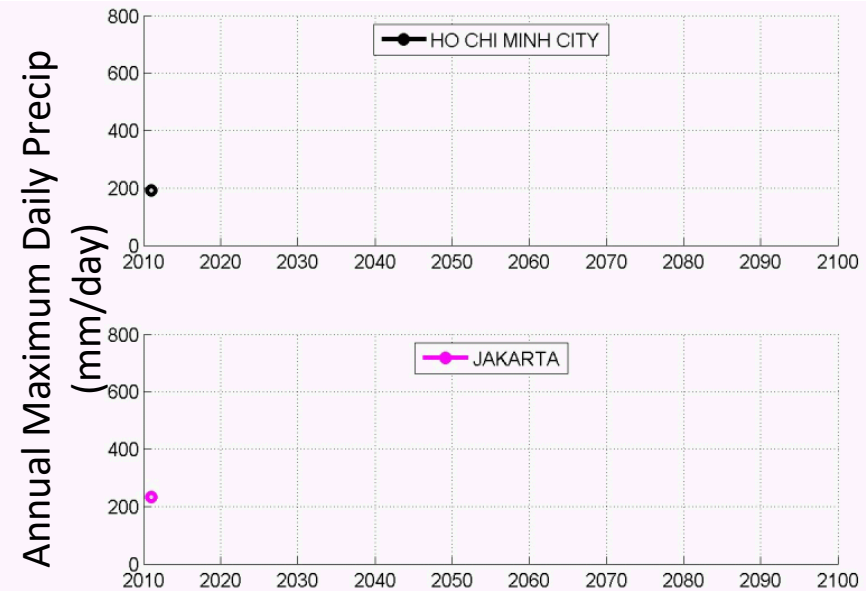
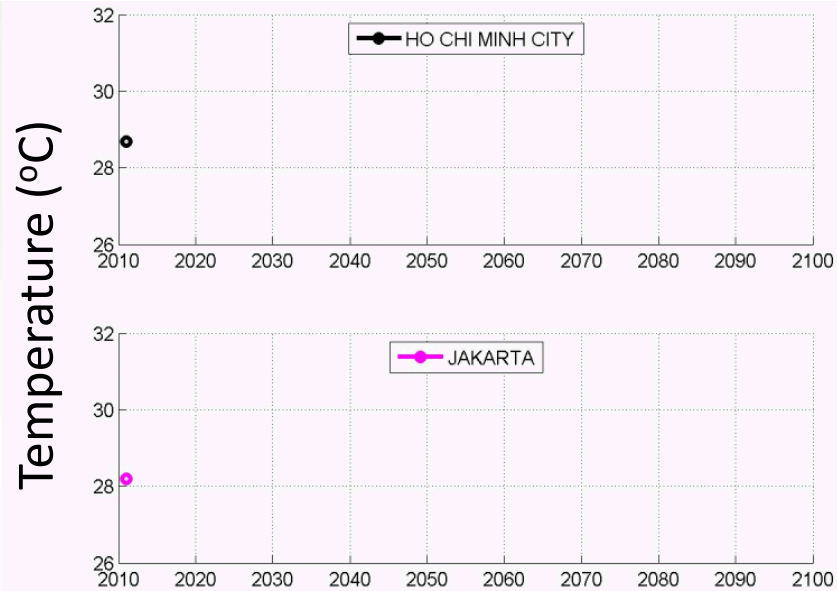
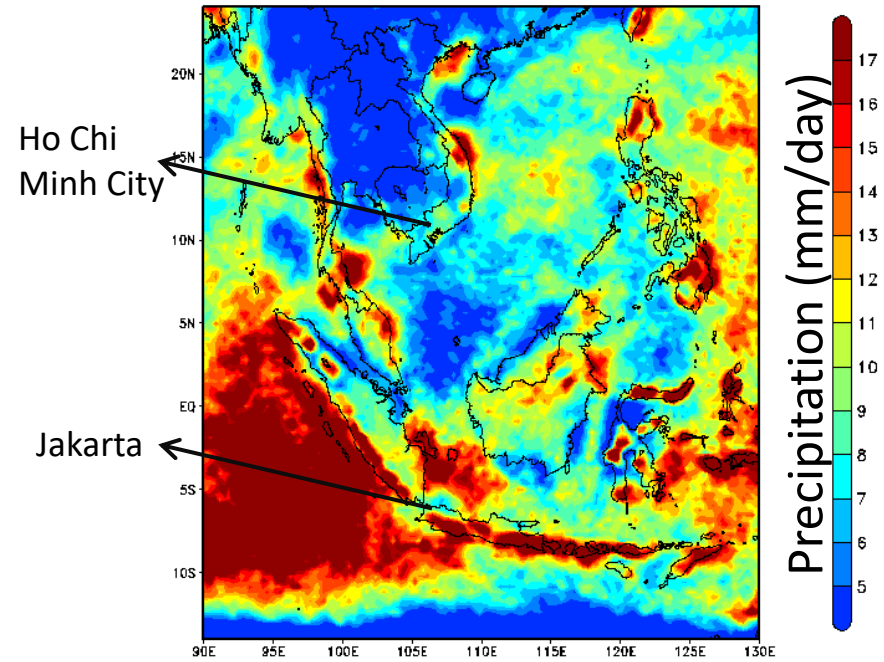
Precipitation (mm/day)

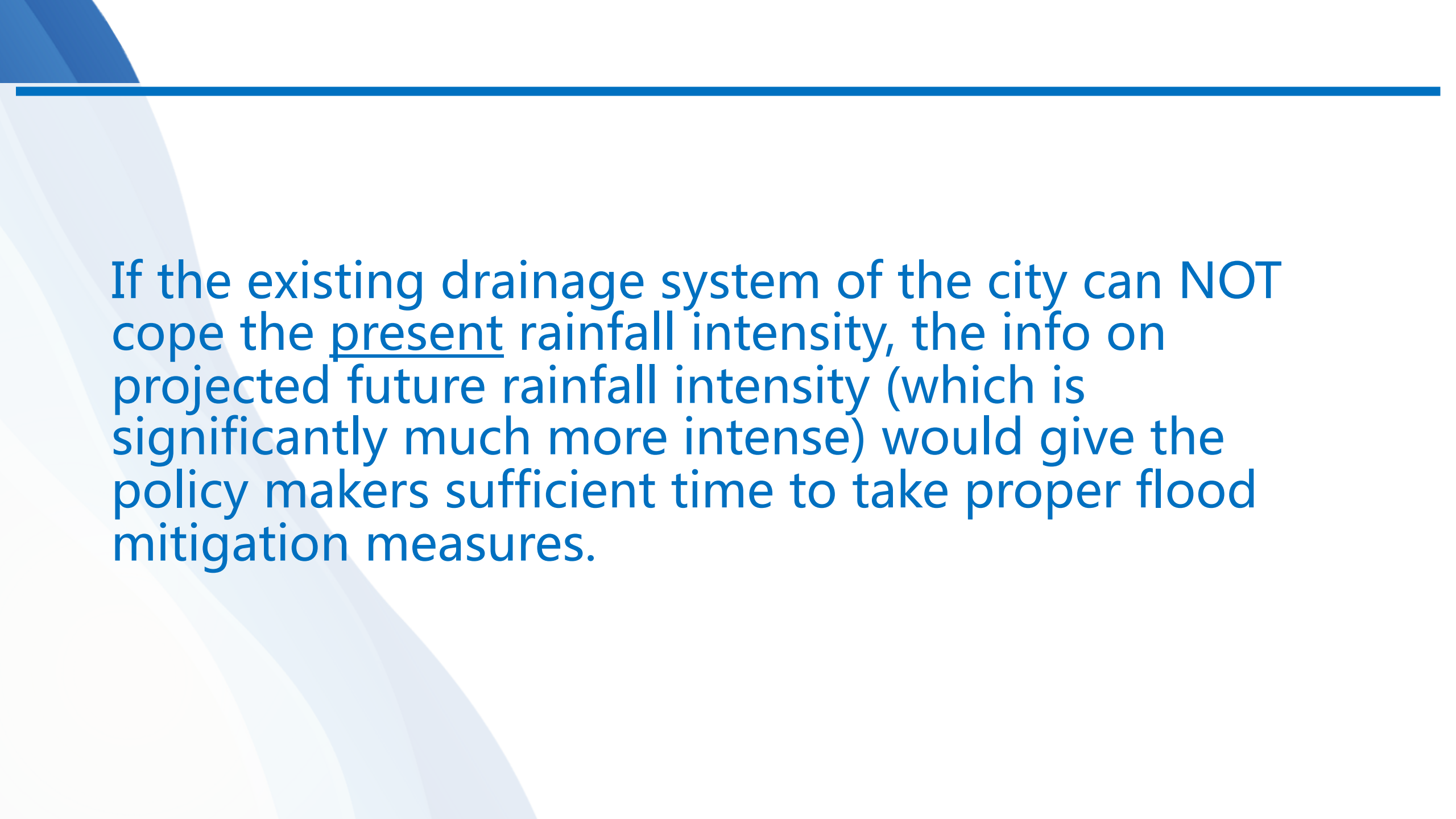


Projected Temperature
T2 WRF/ECHAM A2 2011



Projected Precipitation
PRECIP WRF/ECHAM A2 2011





If the existing drainage system of the city can NOT cope the present rainfall intensity, the info on projected future rainfall intensity (which is significantly much more intense) would give the policy makers sufficient time to take proper flood mitigation measures.

An integrated flood detection, mitigation and prevention system is of significant importance to minimize flash-flood risk.



中国水利水电科学研究院

China Institute of Water Resources and Hydropower Research

Thank you!