

2019 International Workshop on Climate Change

Ensemble inundation impact assessment under RCP8.5 Scenario

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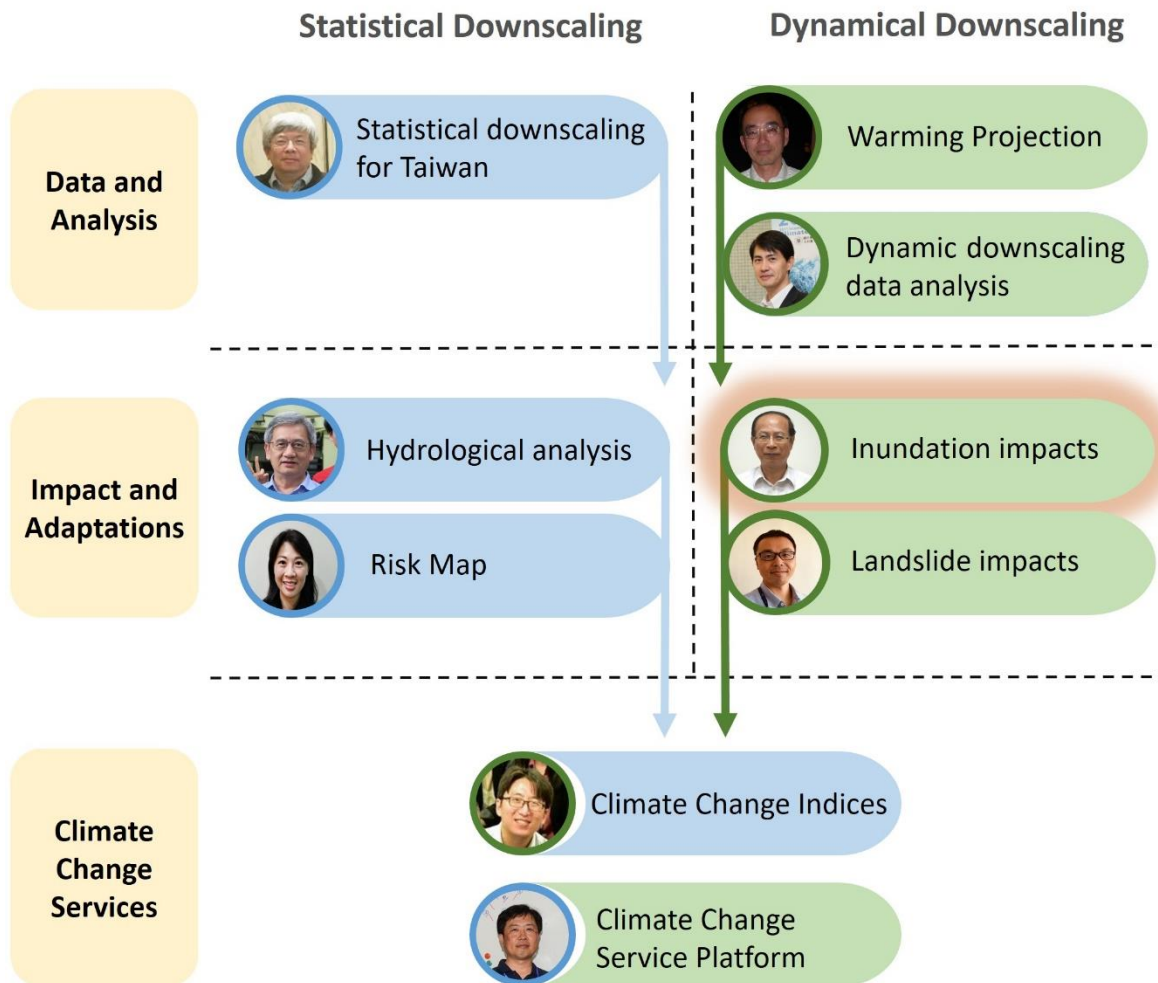
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TCCIP Oral Presentation outline



Typhoon inundation in Taiwan



2009 Typhoon Morakot

Annan Dist., Tainan City

2010 Typhoon Fanapi

Niaosong Dist., Kaohsiung City

2016 Typhoon Nepartak

CTV
東森新聞

Kaohsiung City

2017 Typhoon Nesat

Linbian Township, Pingtung County

2017 Typhoon Haitan

Rende Dist., Tainan City

2019 Typhoon Lingling

North Dist., Taichung City

Outlines

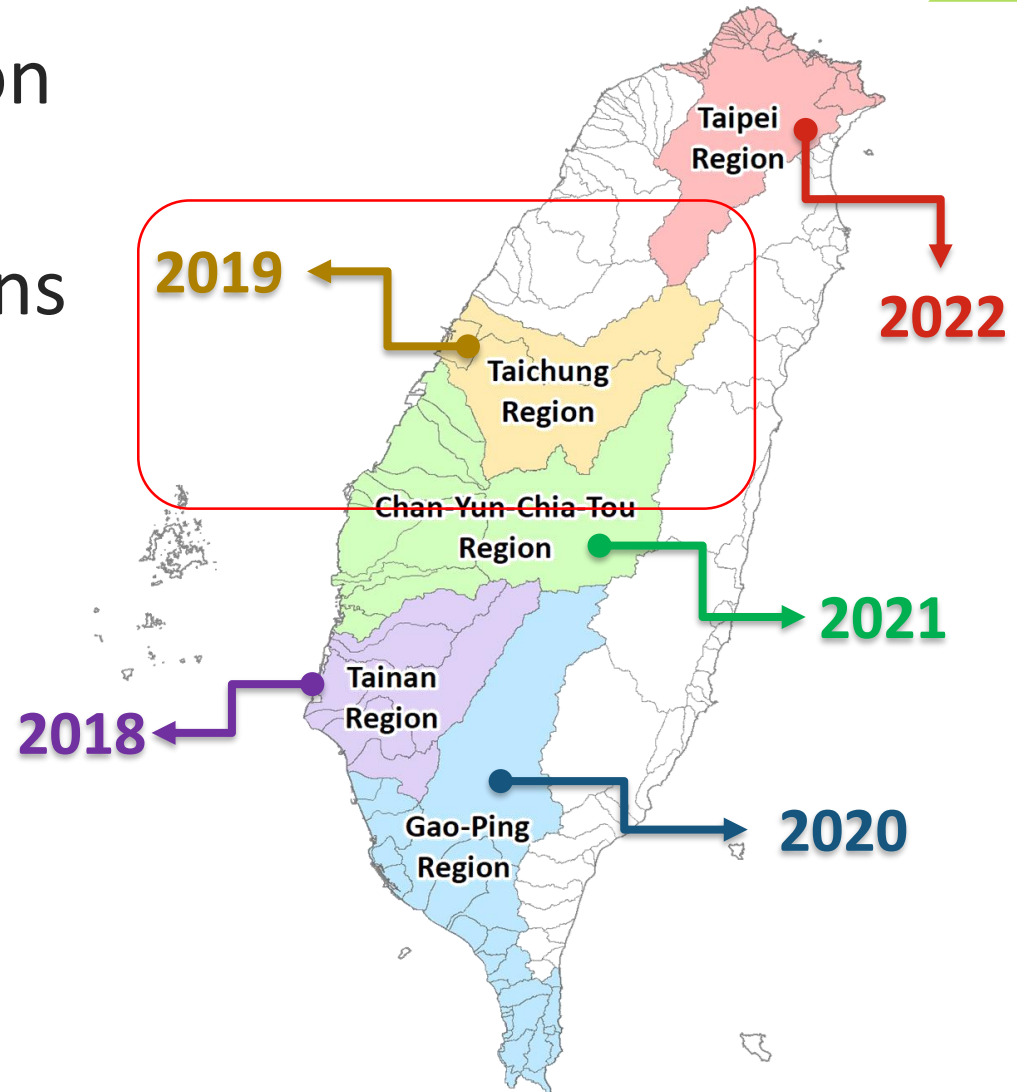


- Inundation impact assessment planning
- Assessment method
- Impact assessment results
- Development path and Future outlook

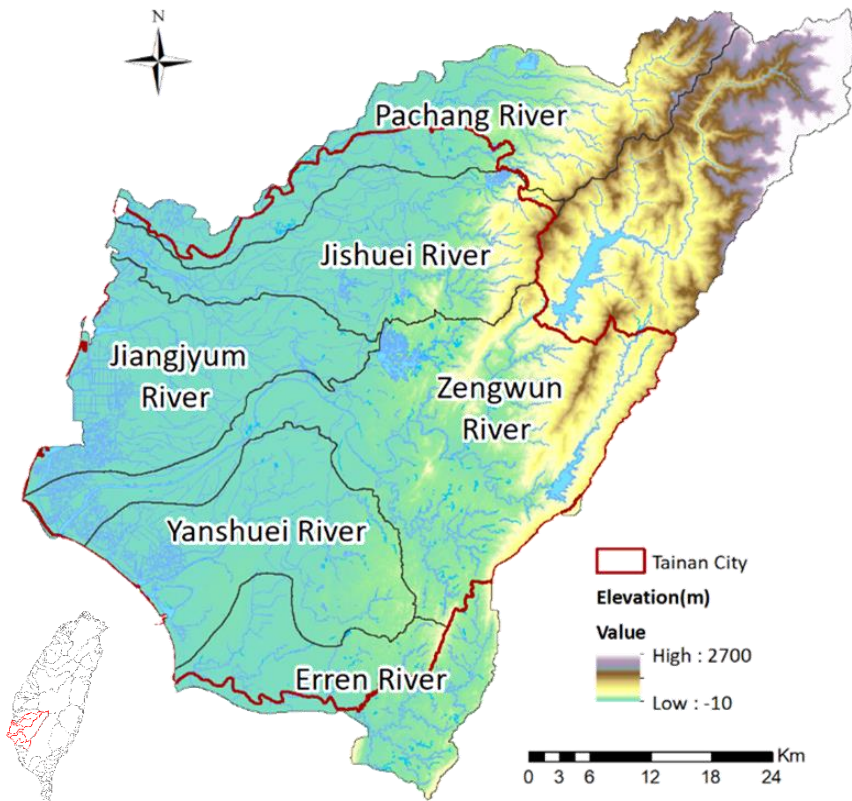
Inundation impact assessment planning



- 5 major inundation regions
- Completion regions
 - Tainan (2018)
 - Taichung (2019)

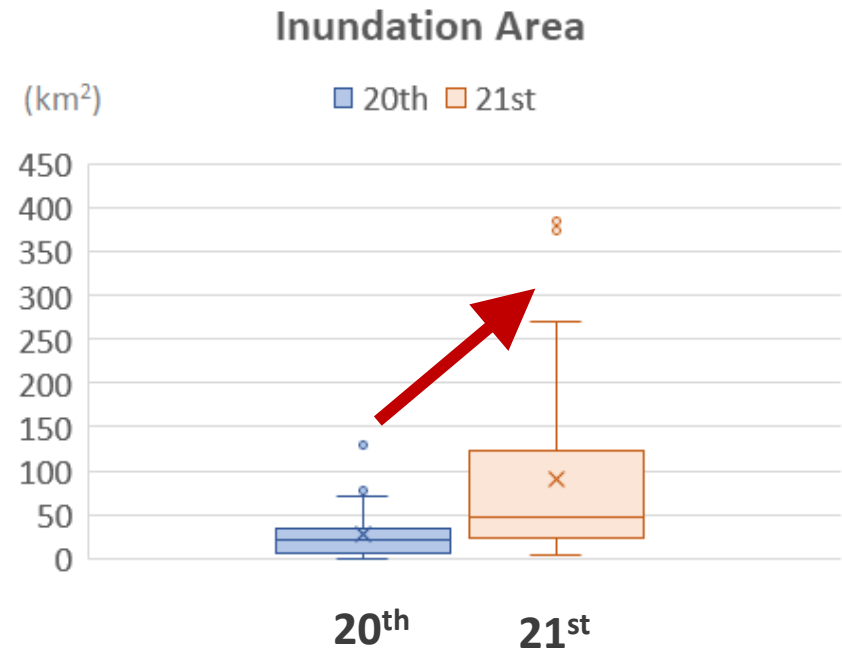


Tainan results overview



Total areas $\approx 2,714\text{km}^2$

Mean inundation areas:
21st is drastic increasing

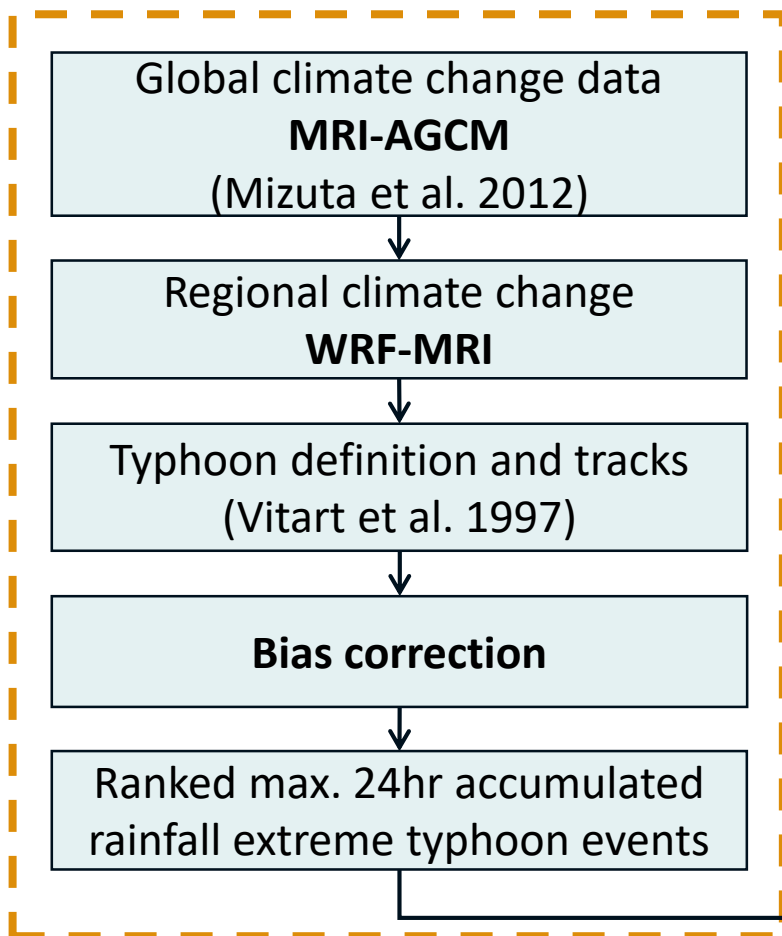


Assessment Method

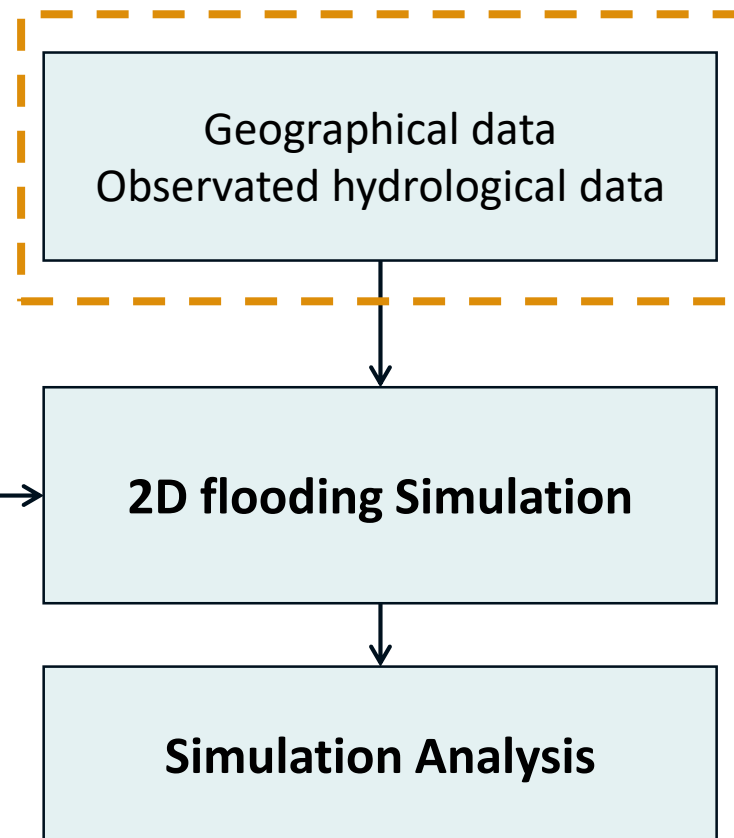
Research framework



Climate Change Data (Team1)



Model Setup Data





[Dynamic Downscaling Data]

- the end of the 20th century (**Base period**) 1979 – 2003yr

	KAKUSHIN	SOUSEI	Total
Typhoon events	82	84	166

- the end of the 21st century (**Future**) 2075 – 2099yr

	WRF-MRI RCP8.5				
4 SST Grouping	c0	c1	c2	c3	Total
Typhoon events	45	23	55	46	169

*SST = Sea Surface Temperature

2D flooding simulation model



● SOBEK

- Developed by WL | Delft Hydraulics in the Netherlands
- Integrates rivers, urban drainage systems and watershed management.

Continuity Eq.

$$\frac{\partial h}{\partial t} + \frac{\partial(ud)}{\partial x} + \frac{\partial(vd)}{\partial y} = 0$$

Momentum Eq.

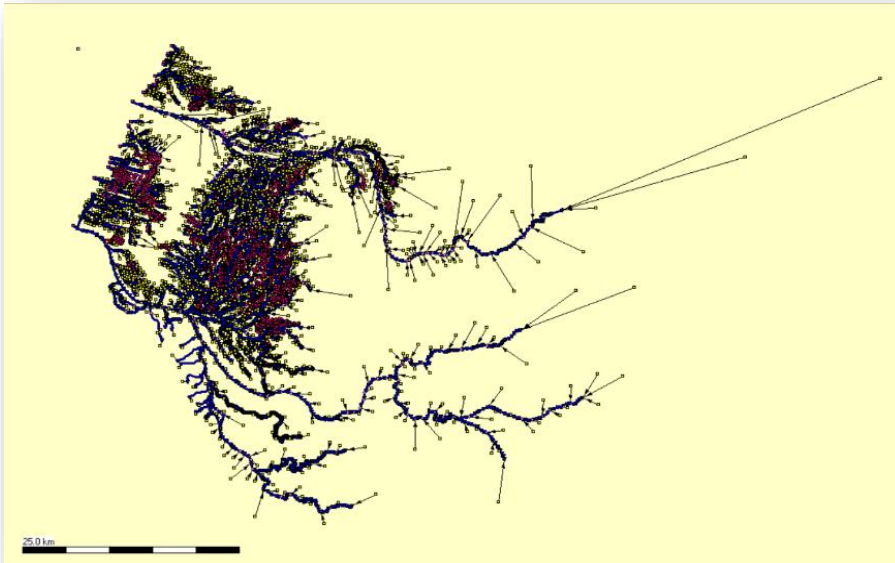
$$\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial v}{\partial y} + g \frac{\partial h}{\partial x} + g \frac{u|V|}{C^2 d} + au|u| = 0$$

$$\frac{\partial v}{\partial t} + u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + g \frac{\partial h}{\partial y} + g \frac{v|V|}{C^2 d} + av|v| = 0$$

Model setup



Taichung SOBEK model



● Model content

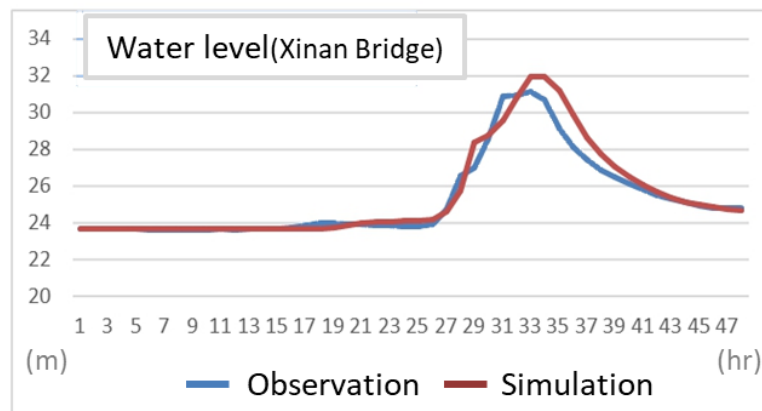
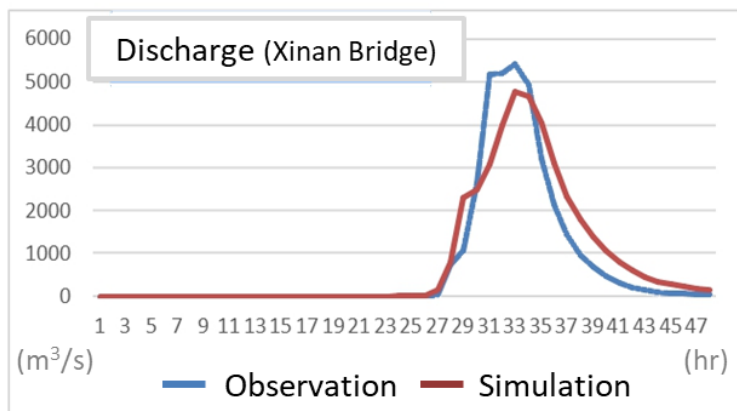
- Rainfall-runoff
- Overland-flow
- Main river's channel-flow
- Regional drainage
- Stormwater sewer
- Manhole
- Detention pond
- Water pumping station
- Tide (boundary condition)

Model validation – 1D

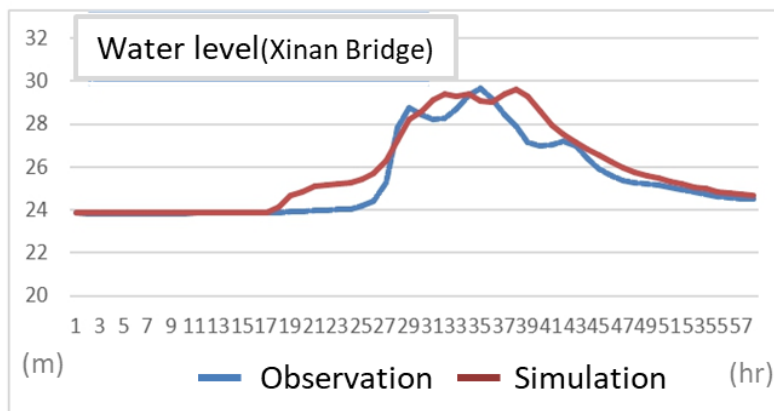
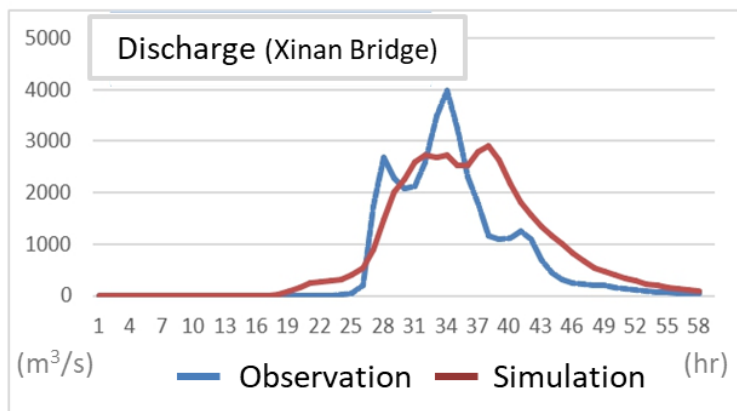


Discharge & Water level

Verification Test –Typhoon Kalmaegi



Verification Test –Typhoon Saola



Model validation – 2D



Inundation area error check

Typhoon Kalmaegi case

Verification Test	Area (m ²)
A_f	1,143
A_o	1,113
A_c	862
A_a	61.8 %

$$A_a(\%) = \frac{A_c}{A_f + A_o - A_c}$$

A_f : observation

A_o : calculation

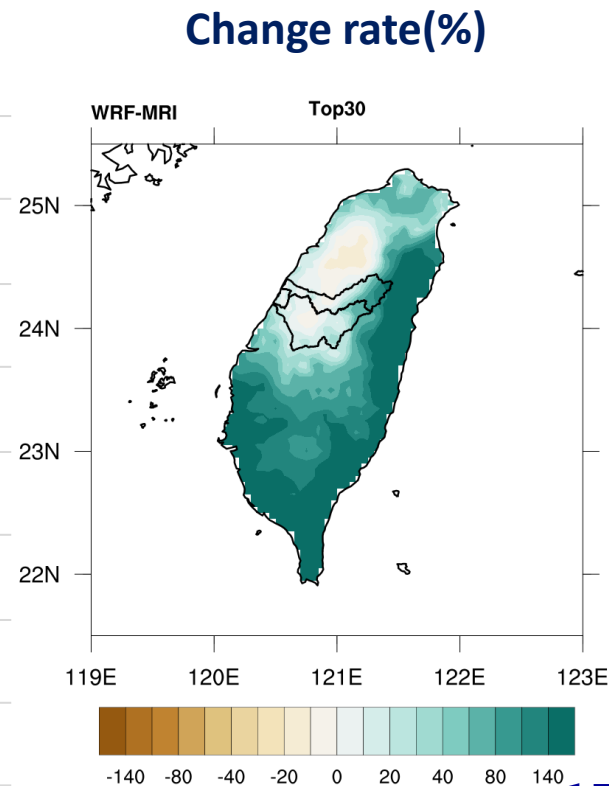
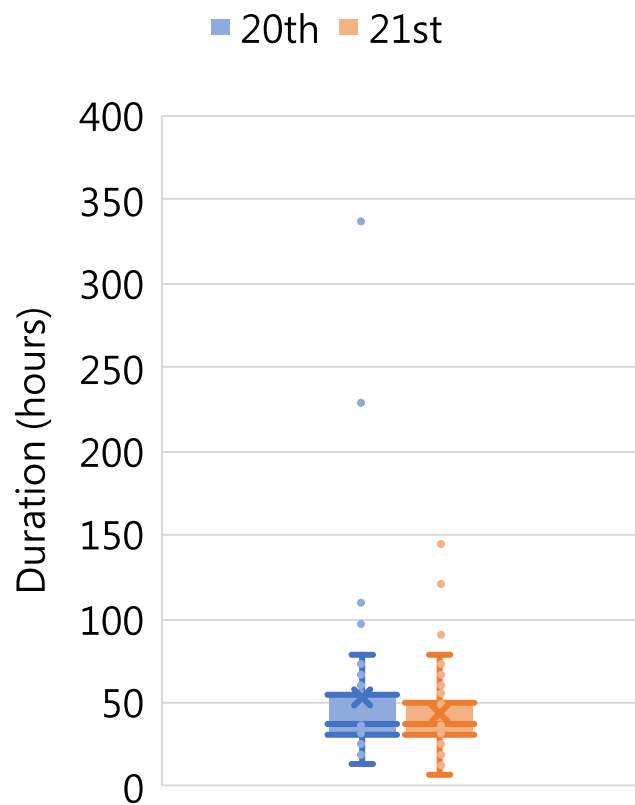
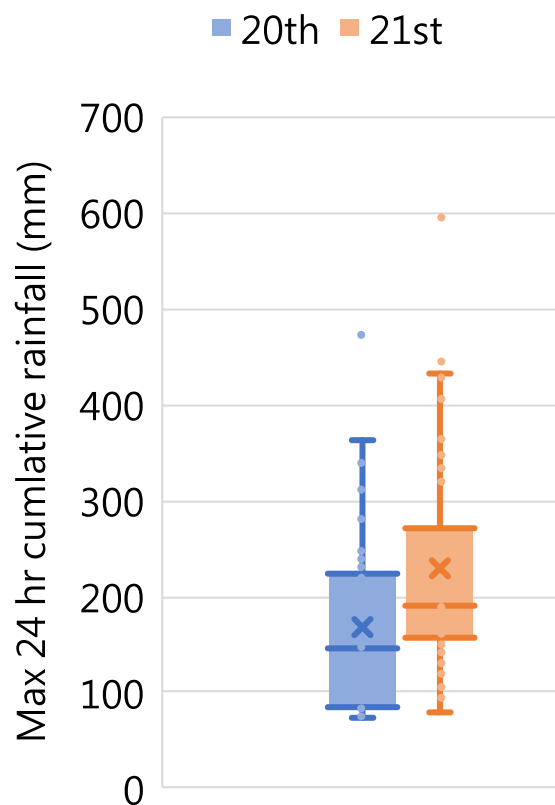
A_c : A_f & A_o overlapping

Impact assessment results

Top1 – 30 sorting by Max24hr rainfall



- Max24hr rainfall: $21^{\text{st}} = 1.24 * 20^{\text{th}}$
- Duration: $21^{\text{st}} = 0.88 * 20^{\text{th}}$
- Rainfall focuses on middle-southern & eastern TW



Different Inundation Depth Assessment



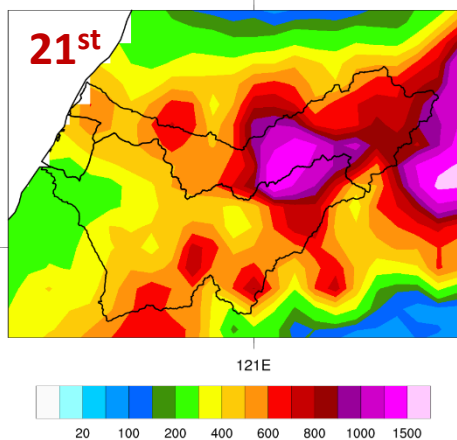
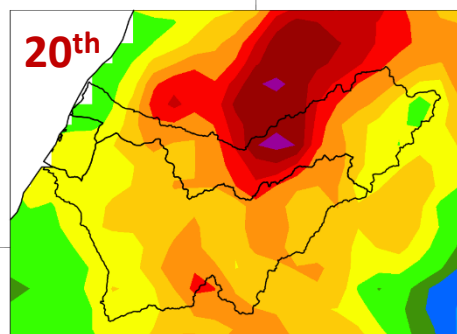
- Inundation depth contracts on $< 1\text{m}$
- 21st inundation areas are obvious greater than 20th

Mean area (km ²)	20 th	21 st	Times (21 st /20 th)
$< 0.5\text{m}$	2.51	4.58	1.82
0.5m~1m	2.38	5.11	2.15
1m~2m	0.8	2.72	3.40
2m~3m	0.14	0.66	4.71
$> 3\text{m}$	0.18	1.30	7.22

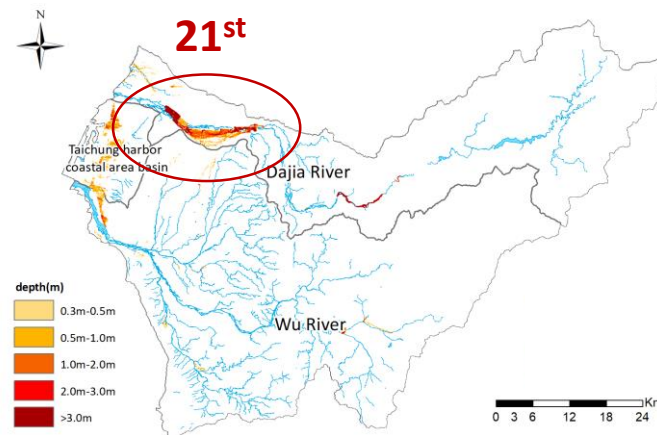
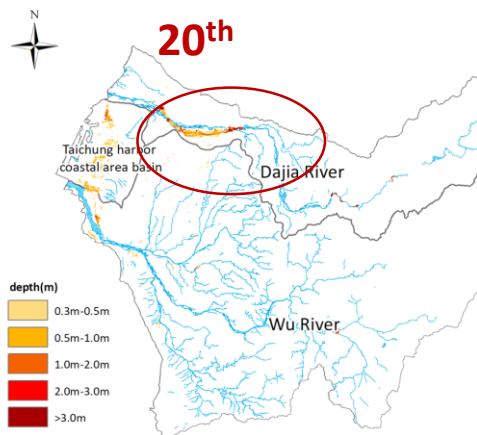
Worst case – TOP1



Max24hr cumulative rainfall (mm)



Inundation distribution

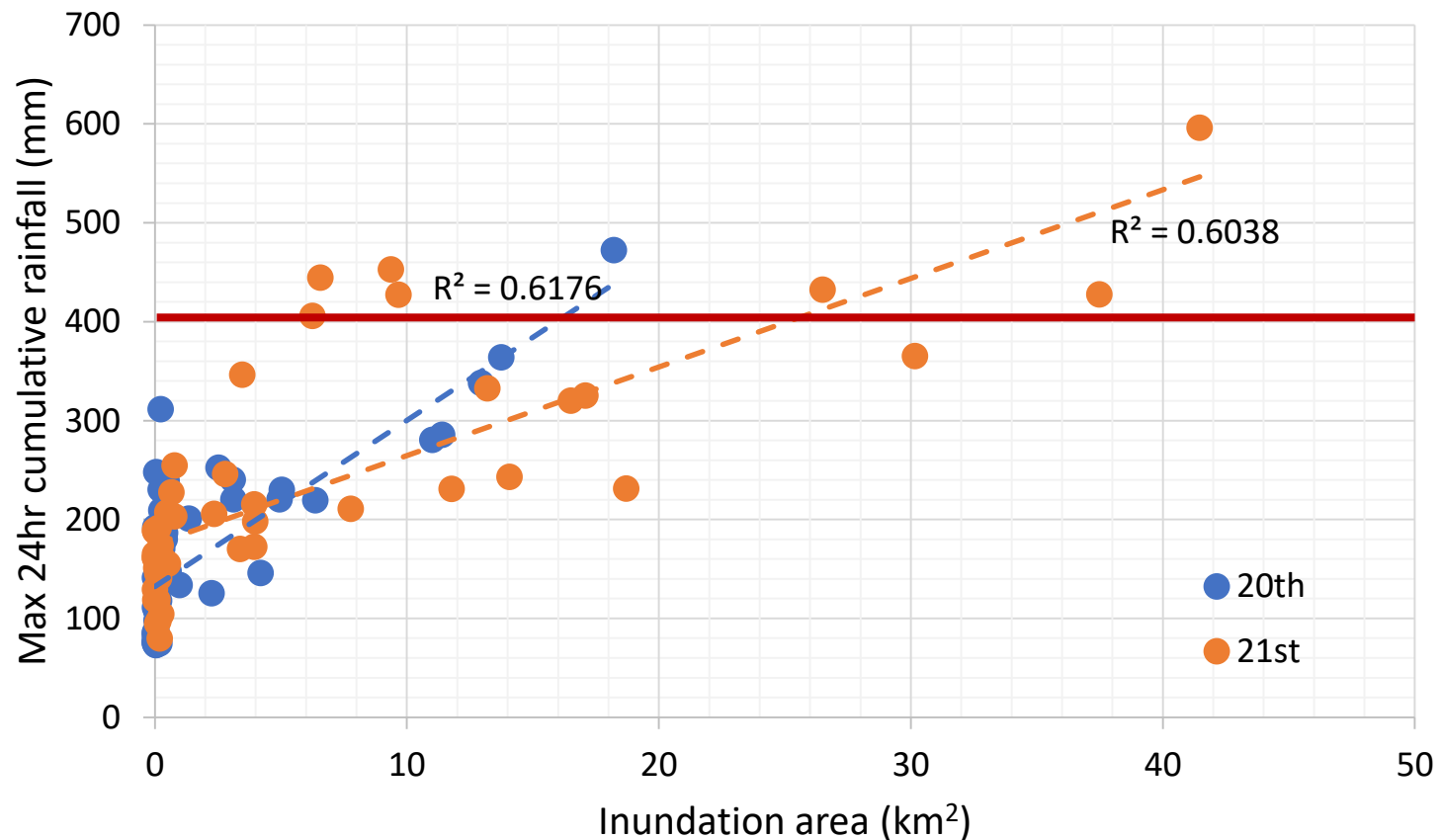


	20 th TOP1	21 st TOP1
Max 24hr	472.38 mm	596.24 mm
Total rainfall	551.40 mm	855.07 mm
Duration	37 hr	73 hr
Inundation area	18.21 km ²	41.46 km ²

Rainfall & Inundation relationship



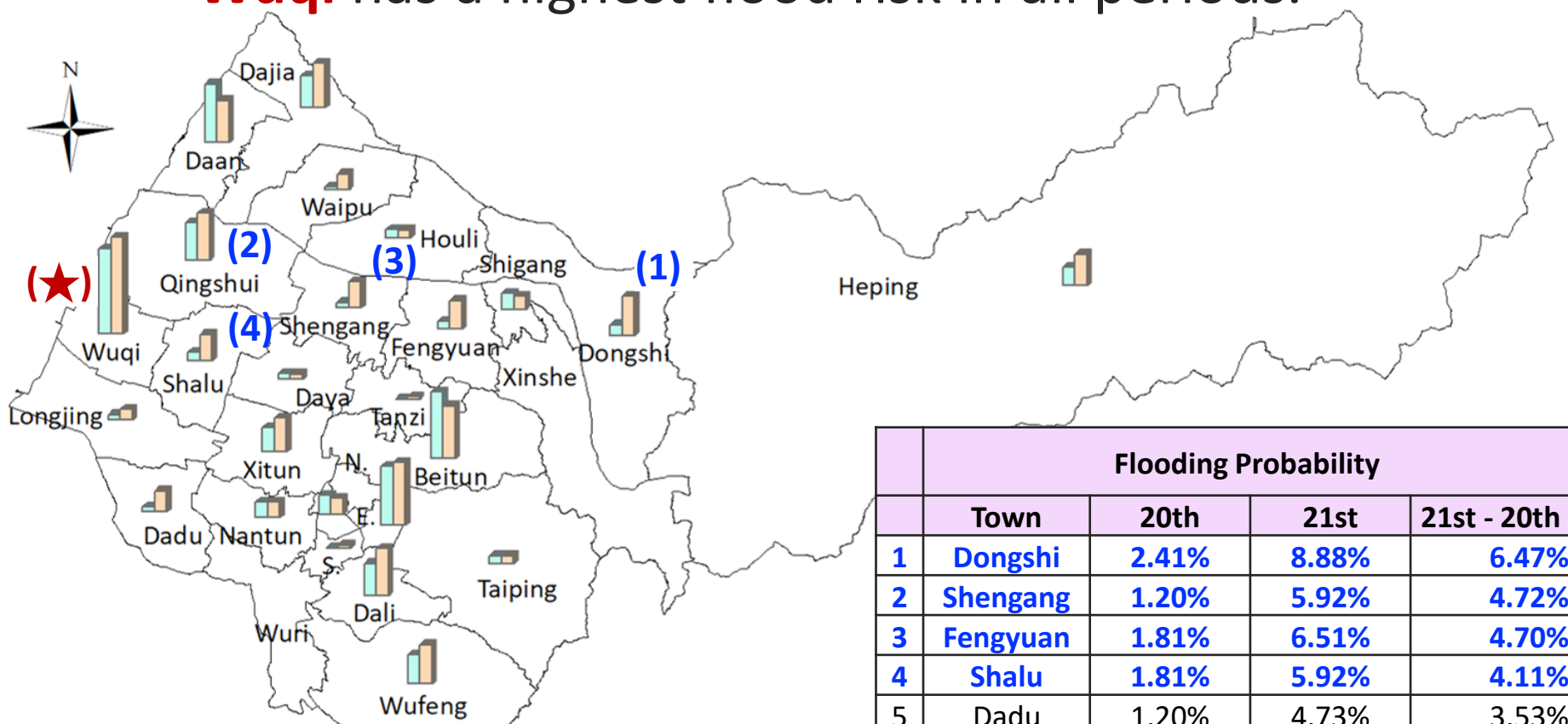
- 21st inundation impact will be drastic increased than 20th as the same rainfall.



Inundation Probability (IP)



- **4 Town** IP will increase **over 4%** in future.
- **Wuqi** has a highest flood risk in all periods.



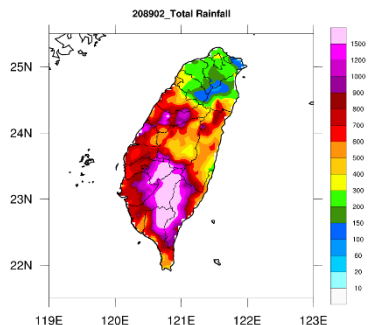
Flooding Probability				
	Town	20th	21st	21st - 20th
1	Dongshi	2.41%	8.88%	6.47%
2	Shengang	1.20%	5.92%	4.72%
3	Fengyuan	1.81%	6.51%	4.70%
4	Shalu	1.81%	5.92%	4.11%
5	Dadu	1.20%	4.73%	3.53%
★	Wuqi	19.28%	21.89%	2.61%

$$Probability(\%) = \frac{\text{Inundation events}}{\text{Total events}} \times 100\%$$

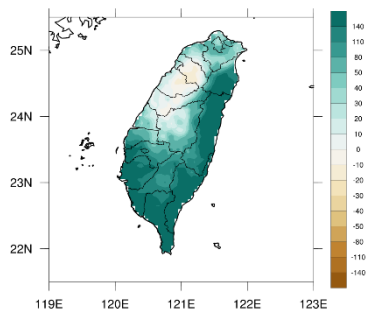
Development path and Future outlook



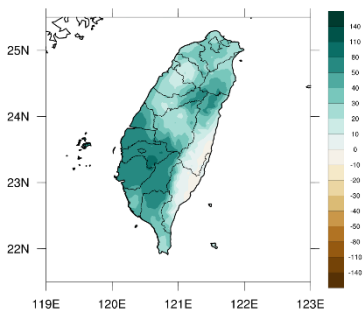
Total cumulative rainfall (mm)



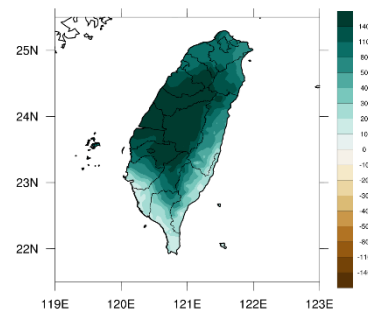
Change rate (%)



Change rate (%)



Change rate (%)



TOP1

I

TOP1-5

II

Over 100
events

III

Over 1000
or more

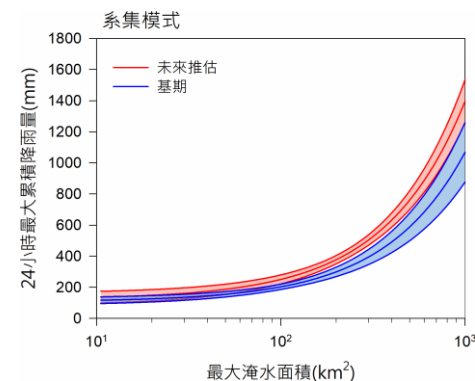
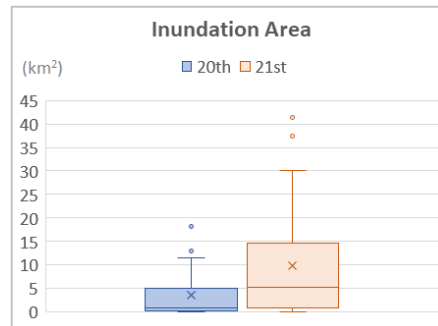
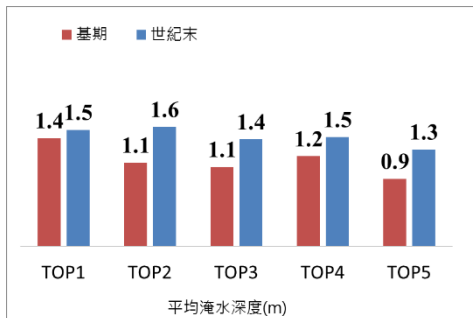
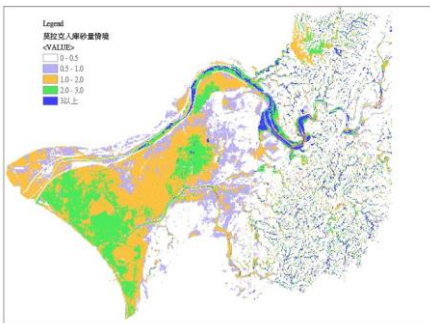


2011-2015

2015-2018

2018-Now

Future





Thank you