Department of Meteorology

University of Reading

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Urban Climate Services in China: Current capabilities and future needs

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Acknowledgments: all who participated in the survey and talked to us, Met Office, UK-China Research & Innovation Partnership Fund/ Met Office Climate Science for Service Partnership (CSSP) China /Newton Fund.

UN's Global Framework for Climate Services (GFCS)

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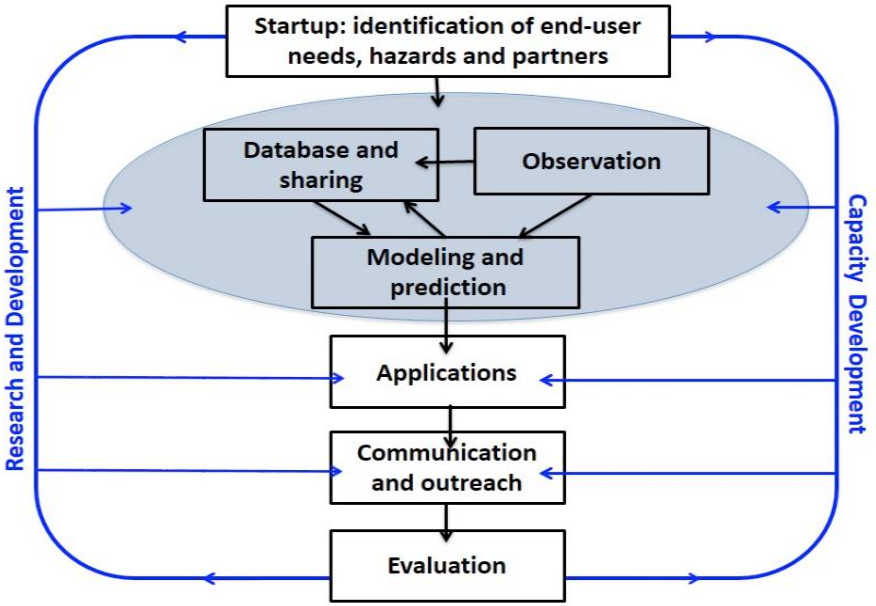
- 5 components for a climate service (*as identified by GFCS)* are:

  www.wmo.int/gfcs/components-of-gfcs

  - User Interface platform
  - Climate services information system
  - Observations and monitoring
  - Research, modelling and prediction
  - Capacity development



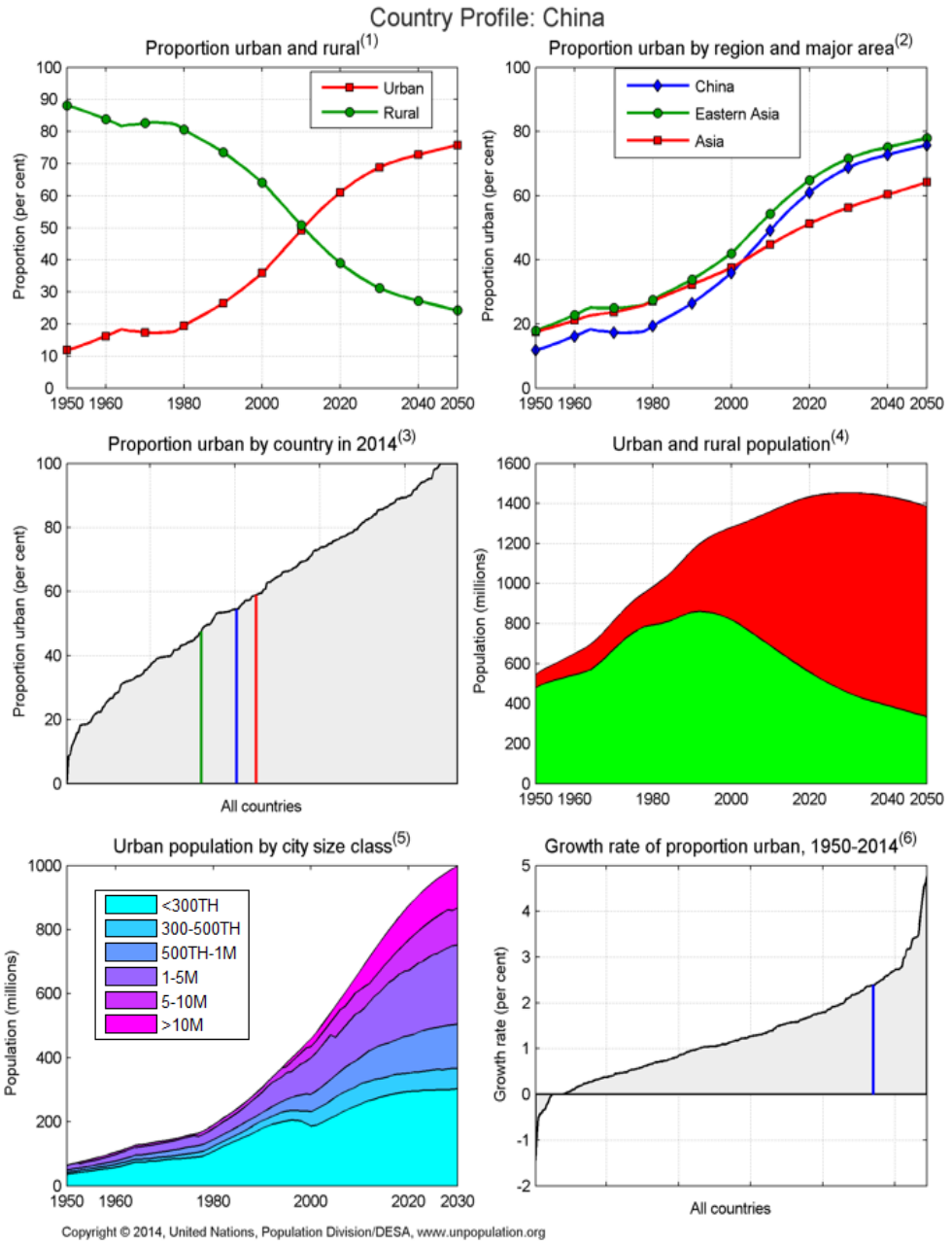
Align closely with those identified in "*Establishing* ***integrated weather, climate, water and related environmental services for megacities and large urban complexes*** *(initial guidance)"*

Grimmond et al. (2014)

www.wmo.int/gfcs/sites/default/files/events/Expert20Workshop//WMO_Megacity_IMP_Plan.pdf

China is urbanizing rapidly

- Rate > global and Asian averages
- Today: 54 % of population
  - 758,360 million people live in urban environments: towns, cities, megacities
- 7/30 largest cities in the world in China
  - Shanghai 3rd
  - Beijing 7th
  - Chongqing 16th
  - Guangzhou-Guangdong 20th
  - Tianjin 24th
  - Shenzhen-Guangdong 26th
  - all >10 million people



- http://esa.un.org/unpd/wup/Country-Profiles/ UN, Dept of Economic and Social Affairs, Population Division (2014): World Urbanization Prospects: The 2014 Revision.

Objective

- To assess current climate services and needs for **cities** in China
  - City based climate services (CBCS)

Methodology

- Data collected: questionnaire
  - Distributed by Shanghai Institute of Meteorological Science (*SIMS*), Chinese Meteorological Administration (*CMA*)
  - To directors and/or experts of provincial level meteorological services across mainland China (*74 responses*) :
    - Weather Centres
    - Climate Centres
    - Institutes of Meteorological Science (IMS) (Research Centres)
    - Service Centres

- *Additional information through visits to 4 centres & within SIMS and Shanghai Meteorological Service (SMS)*

Urban Climate Services Survey: Methodology

Grimmond et al. (2015)

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Respondent: Characteristics	• Person • Cities in the province • Province setting • Meteorological importance

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Climate services & climate/weather elements

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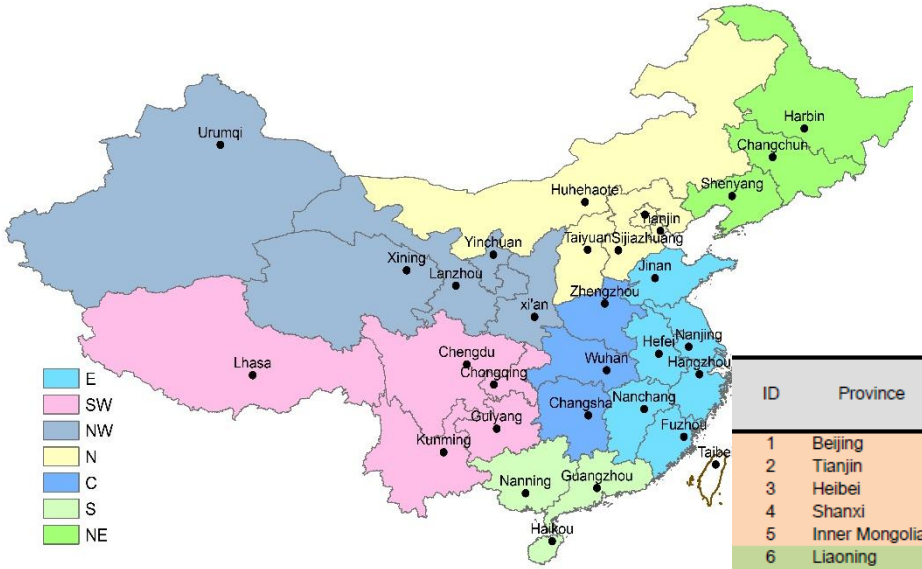
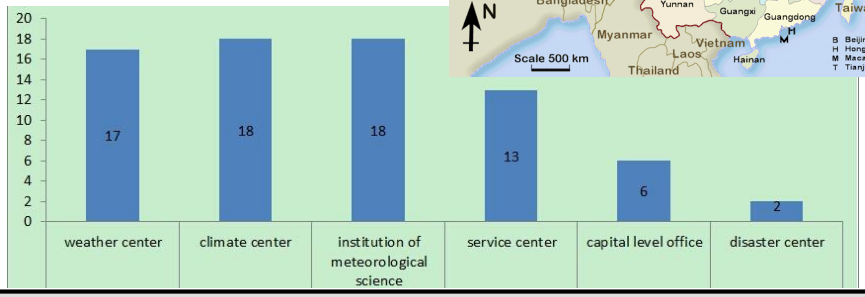
Services for	CBCS needs related to		*Grimmond et al. (2015)*
Disaster Risk Management (DR)	Typhoons Rain storms Snow storms Heat waves	Cold waves Gales Wind warnings Drought	Lightning Hail Fog Frost Other

Respondents: 74, from all provinces

(except Sichuan)





http://www.sacu.org/maps/provmap.png

ID	Province	Capital City	Distinctive features	Region	1.Weather Centre	2.Climate Centre	3.Instit. of Met. Sci.	4.Service Centre	5.Capital Level Office	6.Disaster Centre	Total	
1	Beijing	Beijing	I			1	1	1			3	
2	Tianjin	Tianjin	C		1	1					2	
3	Heibei	Shijiazhuar	C	N	1	1	1	1	2	1	7	16
4	Shanxi	Taiyuan	I,M				1	1			2	
5	Inner Mongolia	Huhhot	I		1	1					2	
6	Liaoning	Shenyang	C		1	1	1				3	
7	Jilin	Changchur	I	NE			1				1	7
8	Heilongjiang	Harbin	I			1		2			3	
9	Shanghai	Shanghai	C				1			1	2	
10	Jiangsu	Nanjing	C		1	1	1		1		4	
11	Zheijiang	Hangzhou	C,M		1		1		1		3	
12	Anhui	Hefei	I	E	1			1	1		3	21
13	Fujian	Fuzhou	C,M			1	1	1			3	
14	Jiangxi	Nanchang	I		1	1					2	
15	Shandong	Jinan	C		1	1	1	1			4	
16	Henan	Zhengzhou	I		1						1	
17	Hubei	Wuhan	I	C			1	1			2	4
18	Hunan	Changsha	I,M			1					1	
19	Guangdong	Guangzhou	C		1	1	1	1			4	
20	Guangxi	Nanning	C	S		1		1	1		3	10
21	Hainan	Haikou	C		1	1	1				3	
22	Chongqing	Chongqing	I,M			1					1	
23	Sichuan	Chengdu	I									
24	Guizhou	Guiyang	I,M	SW			1				1	5
25	Yunnan	Kunming	I,M		1		1				2	
26	The Tibet	Lhasa	I,M				1				1	
27	Shaanxi	Xi'an	I,M		1	1	1	1			4	
28	Gansu	Lanzhou	I		1	1					2	
29	Qinghai	Xining	I,M	NW			1				1	11
30	Ningxia	Yinchuan	I		1						1	
31	Xinjiang	Urumqi	I		1	1		1			3	
Total					17	18	18	13	6	2	74	

Regions *of China (CMA classification)*

- *Major* ***Cities*** *identified by each province*
- *Regional* ***climate influences*** *identified by each province*
  - *C coastal*
  - *I inland*
  - *M mountainous*

Grimmond et al. (2015)

Most important climate elements for CBCS,

ranked by each survey respondent

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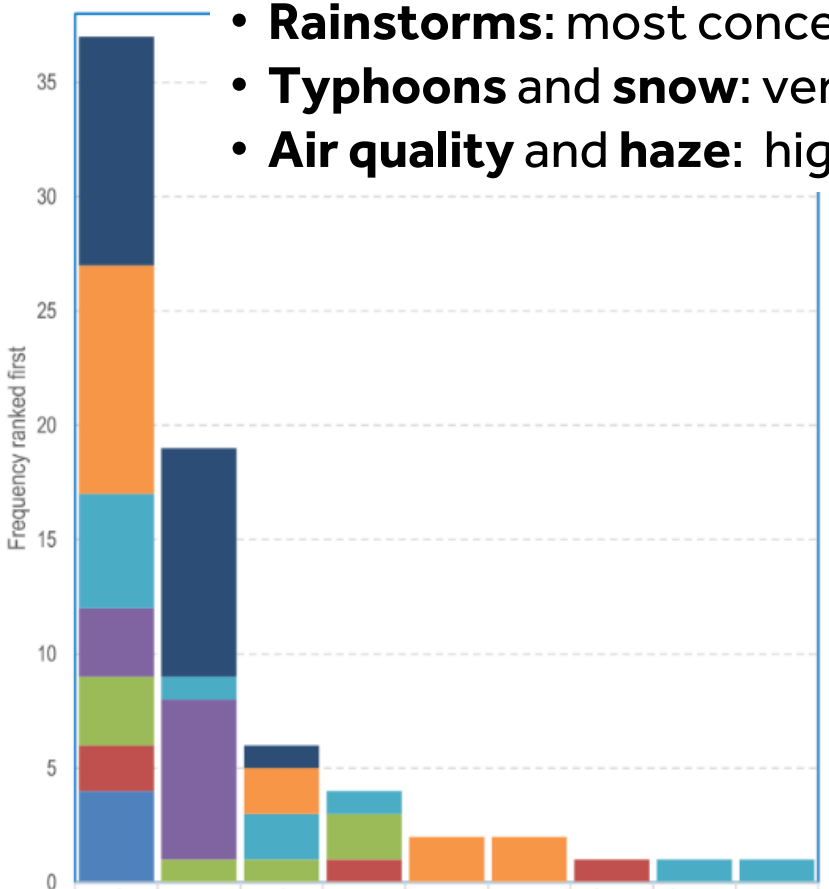
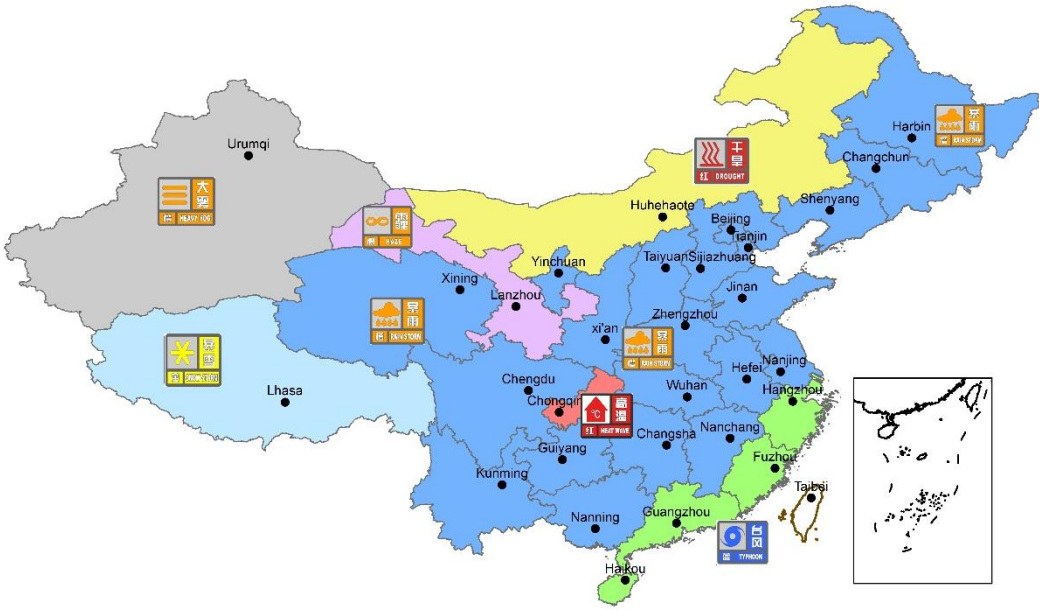
- **Rainstorms**: most concern across all regions
- **Typhoons** and **snow**: very important in some regions
- **Air quality** and **haze**: high priority in the north



	rain storm	typhoons	air quality	snow	haze	drought	heat wave	heavy fog	hail
E	10	10	1	0	0	0	0	0	0
N	10	0	2	0	2	2	0	0	0
NW	5	1	2	1	0	0	0	1	1
S	3	7	0	0	0	0	0	0	0
NE	3	1	1	2	0	0	0	0	0
SW	2	0	0	1	0	0	1	0	0
C	4	0	0	0	0	0	0	0	0



Grimmond et al. (2015)

Top 3 most **important** climate elements for CBCS, ranked by each survey respondent

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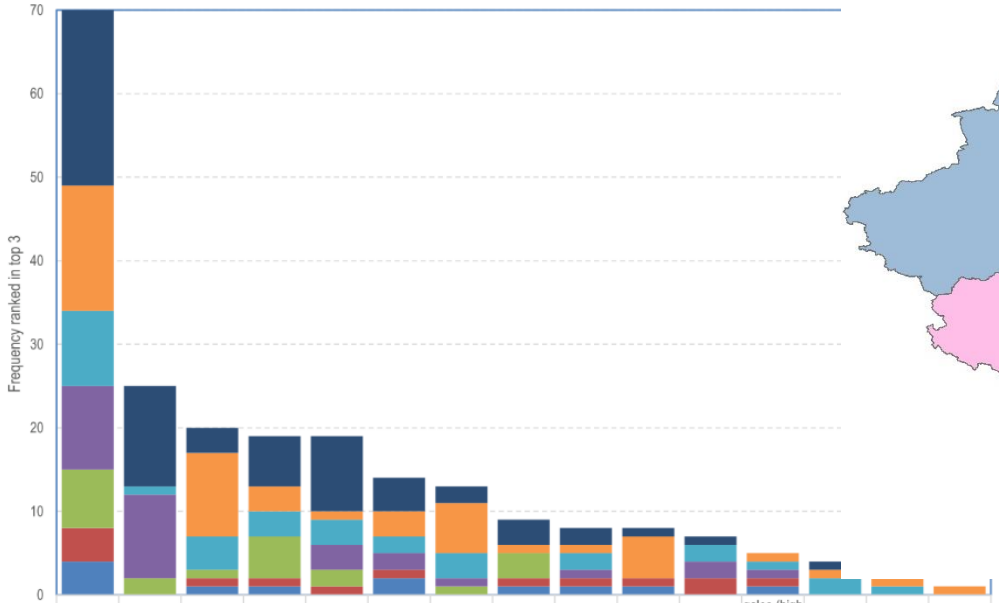
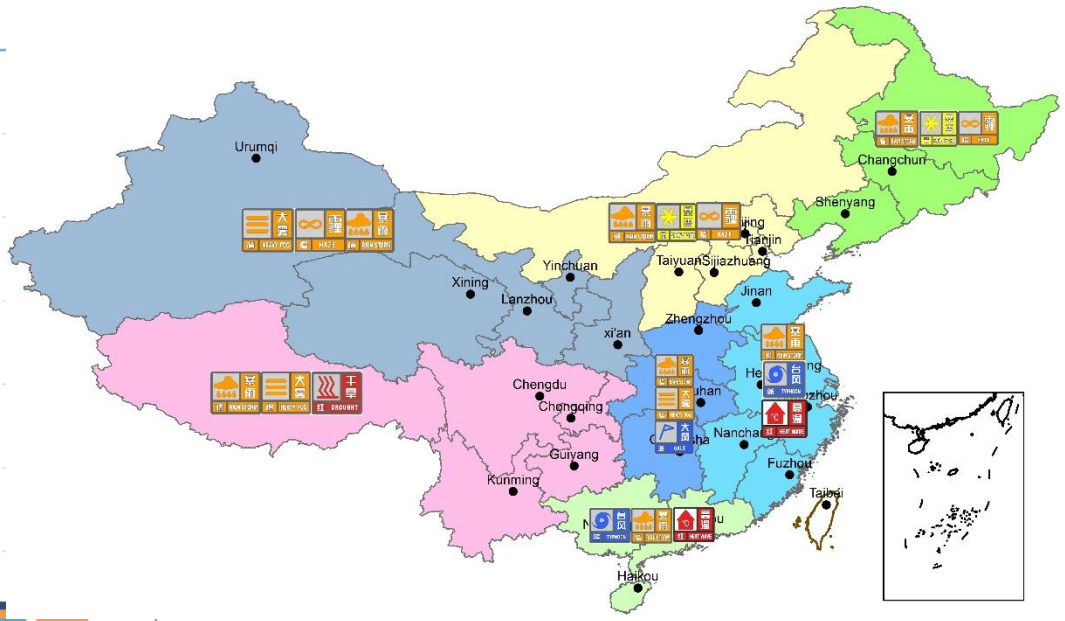
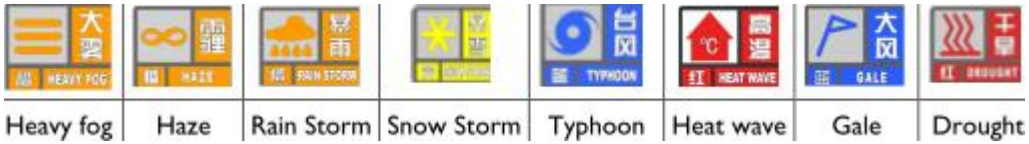
- Strong regional dependence



	rain storm	typhoons	air quality	snow	lightning	heat wave	haze	road icing	heavy fog	drought	cold-wave	gales (high winds)	hail	sand storm	frost
E	21	12	3	6	9	4	2	3	2	1	1	0	1	0	0
N	15	0	10	3	1	3	6	1	1	5	0	1	1	1	1
NW	9	1	4	3	3	2	3	0	2	0	2	1	2	1	0
S	10	10	0	0	3	2	1	0	1	0	2	1	0	0	0
NE	7	2	1	5	2	0	1	3	0	0	0	0	0	0	0
SW	4	0	1	1	1	1	0	1	1	1	2	1	0	0	0
C	4	0	1	1	0	2	0	1	1	1	0	1	0	0	0





Number **CBCS currently delivered**:

by type and number (N) of respondents (SR) and timescale

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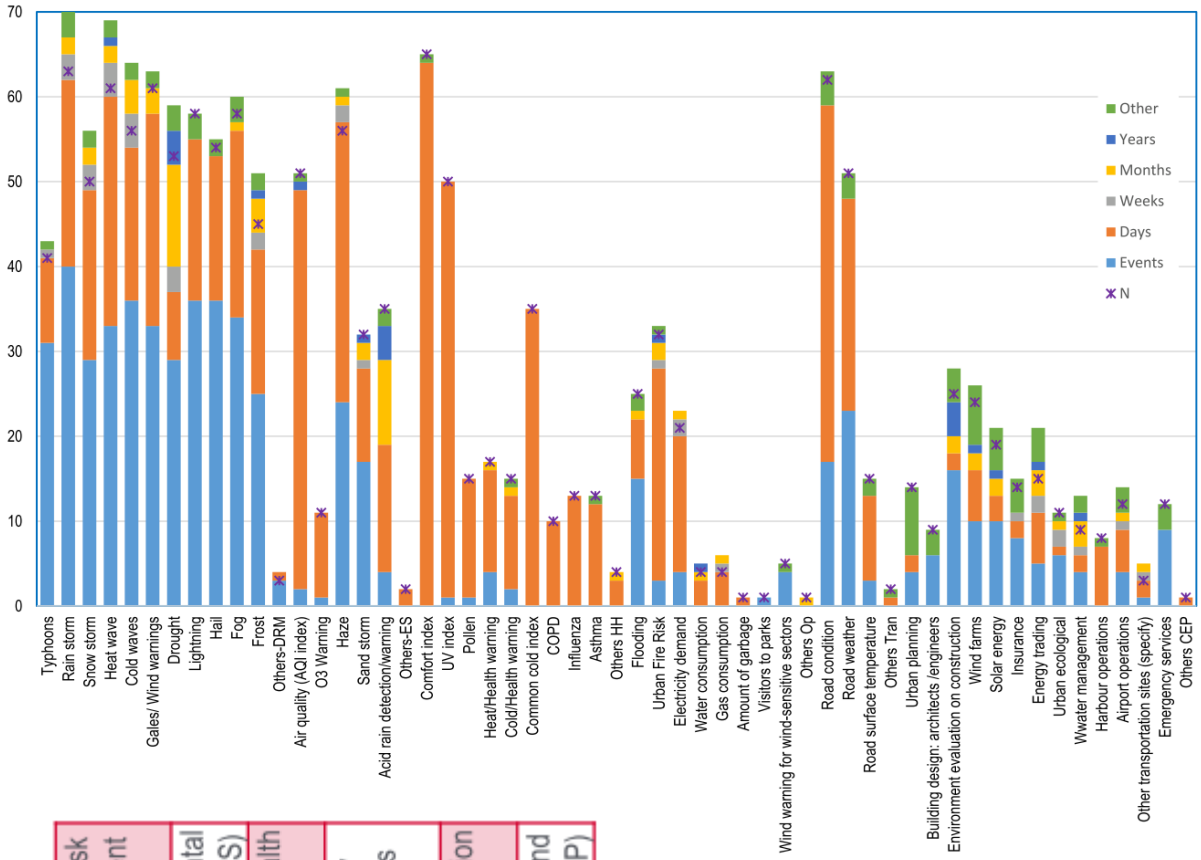


- **Bar:** cumulative sum of the CBCS delivered for all the different **time periods**
- x = *number of respondents N*
- **bar > N** CBCS is delivered for more than one time period (*event, day, week etc.*)

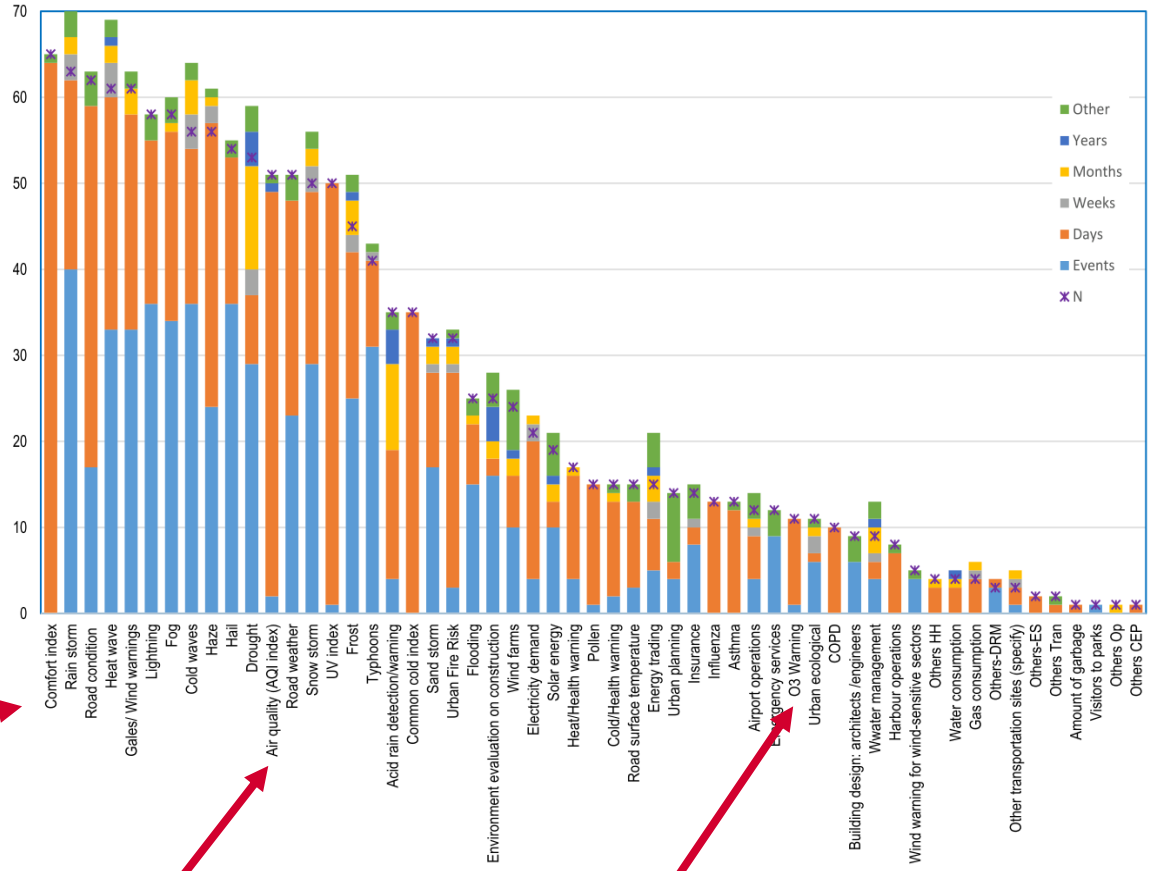
Disaster Risk Management (DR)	Environmental Services (ES)	Human Health (HH)	Daily City Operations (DO)	Transportation (Tr)	Economy and planning (EP)

- Most CBCS are for **events** or **days**
  - some for longer periods: weeks, months, years
- Disaster risk management: mainly for events

Grimmond et al. (2015)

Number **CBCS currently delivered:**

by number (N) of respondents (SR)



Most Common CBCS

- Comfort index
- Rainstorms
- *Regionally*:
  - human health in East China *(esp. Beijing, Shanghai, Guangzhou and Nanjing)*
  - sand storms: north China
- most provinces: air quality (or haze) CBCS delivered
- CBCS for ozone: largest cities *e.g. Beijing, Shanghai*

Grimmond et al. (2015)

CBCS currently delivered

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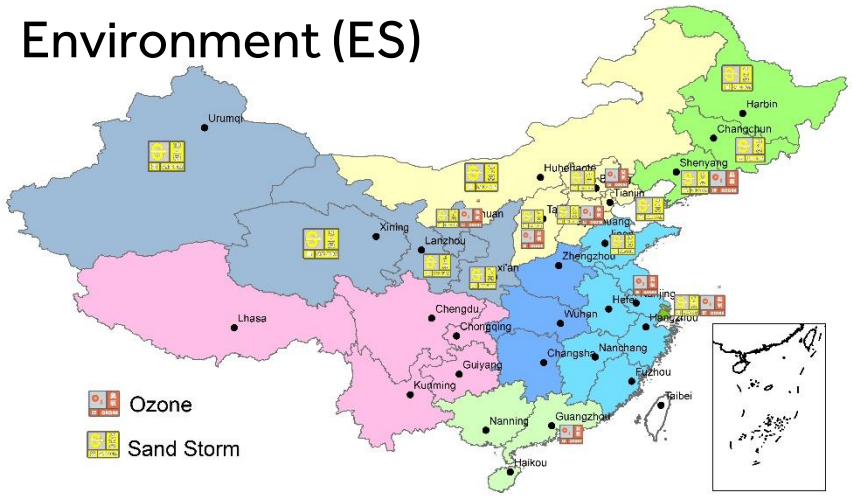
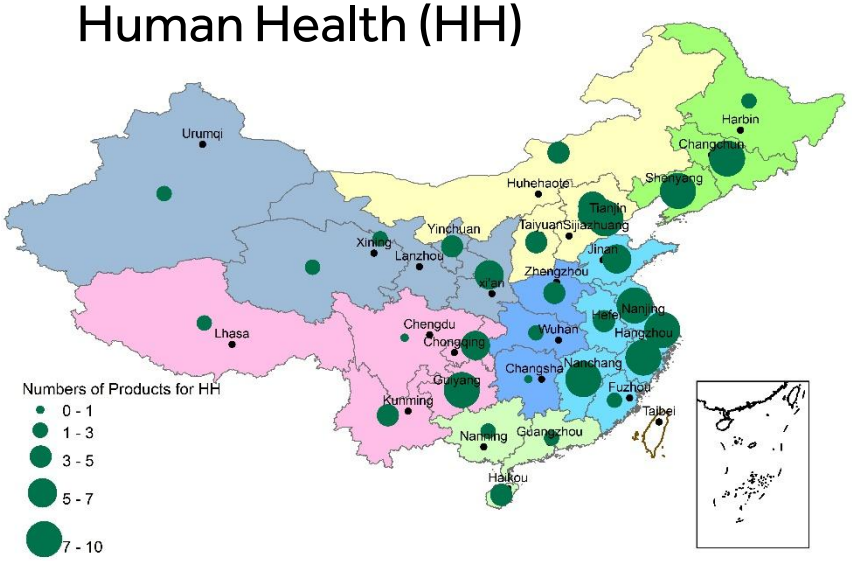
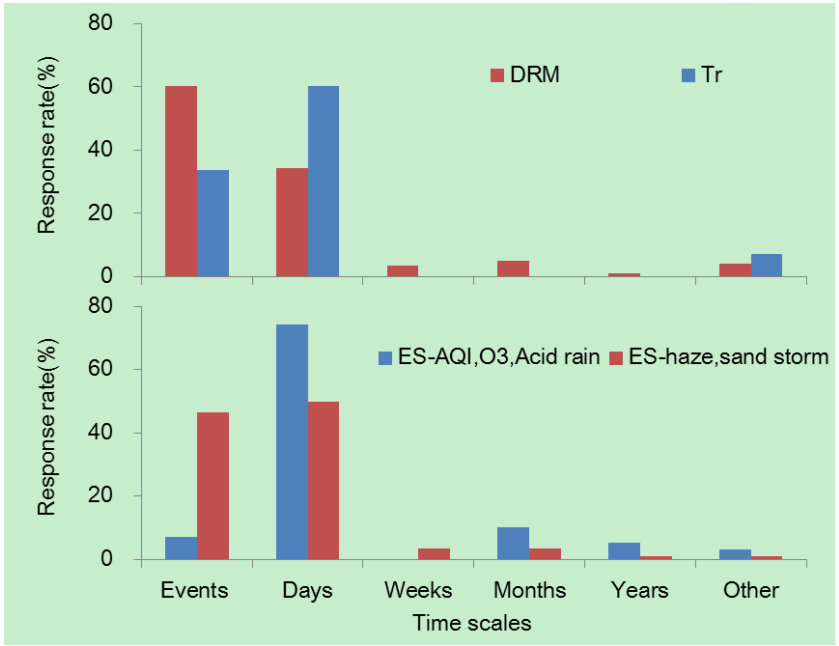
Environment (ES)

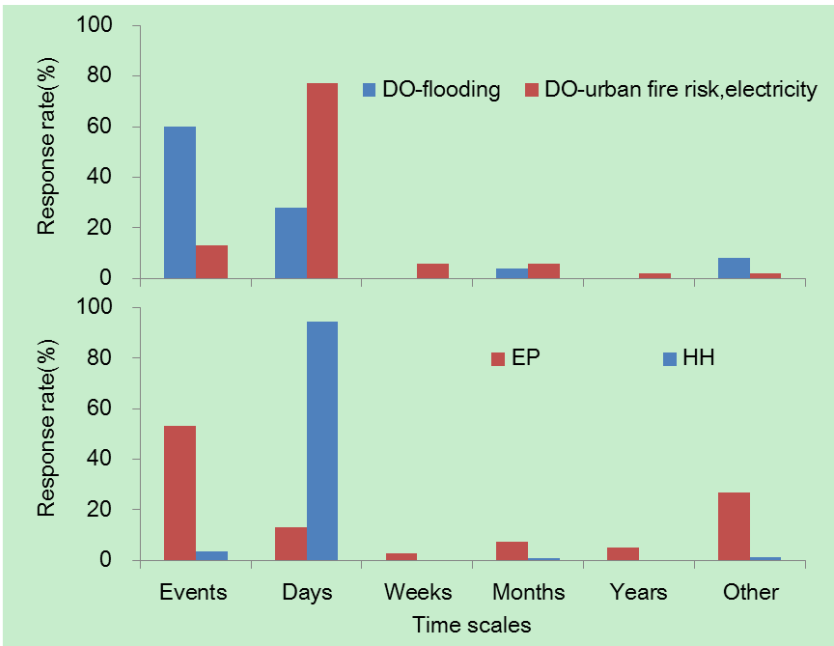


Human Health (HH)

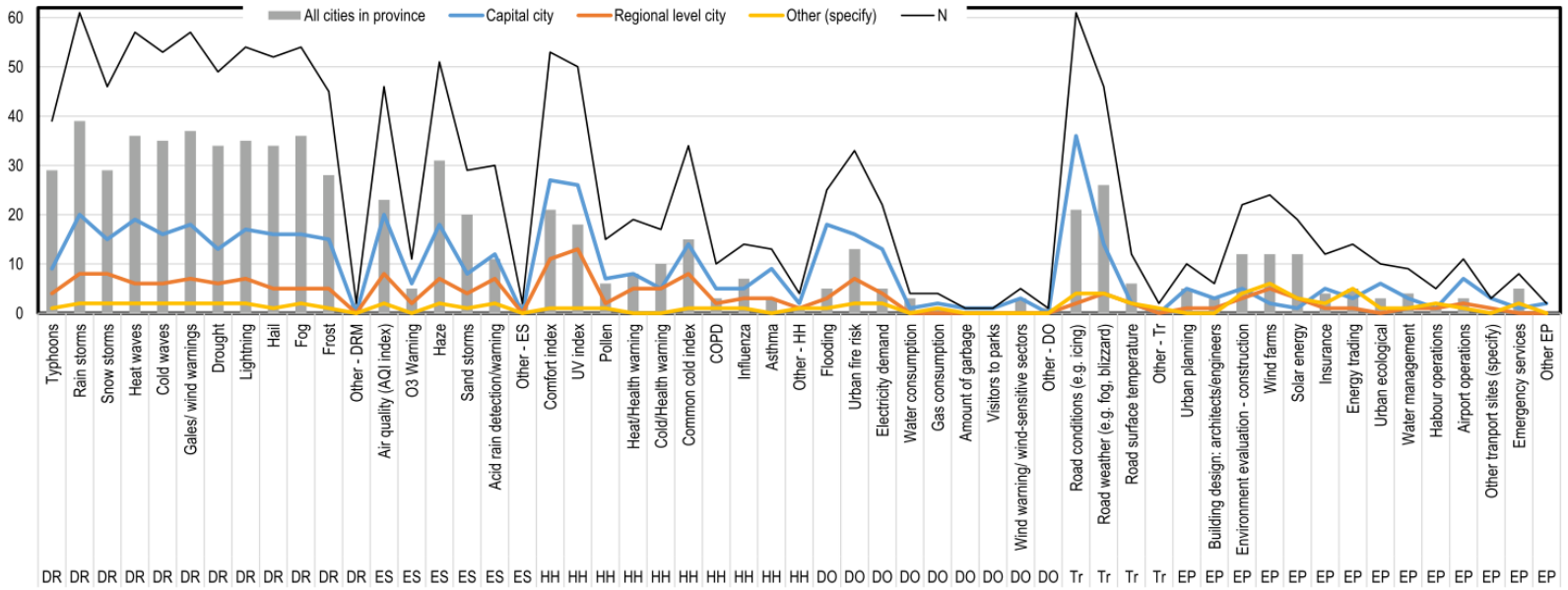


Disaster Risk Management (DR)
Environmental Services (ES)
Human Health (HH)
Daily City Operations (DO)
Transportation (Tr)
Economy and planning (EP)





Delivery

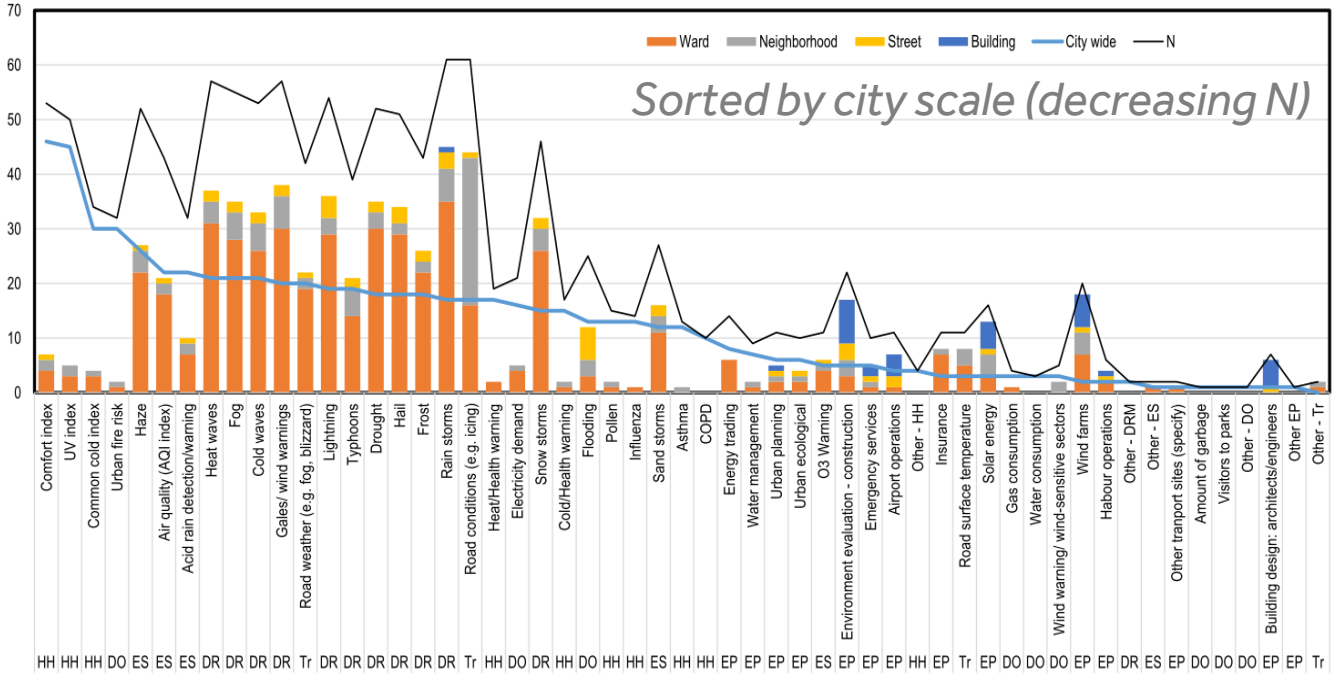


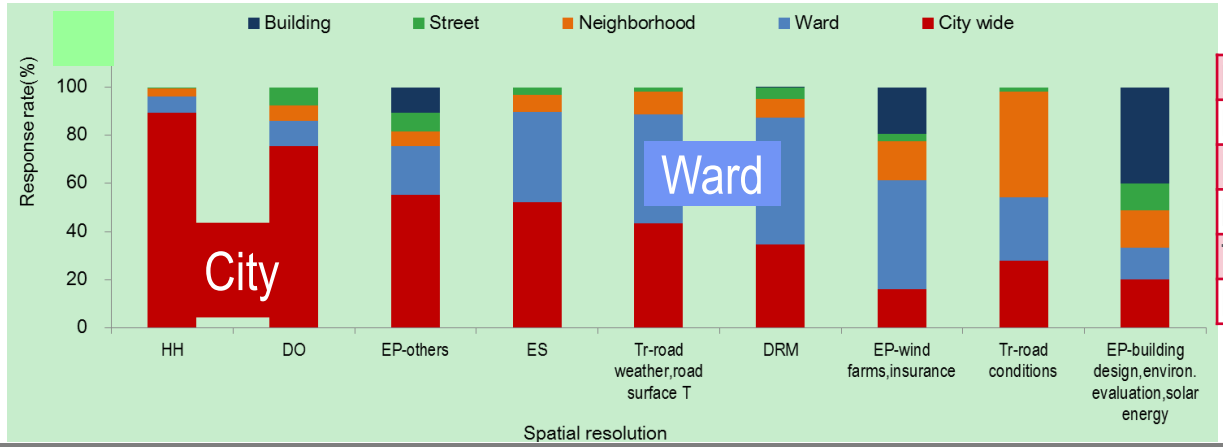
- Capital cities: better served than regional or other cities
  - except for services related to wind farms

	Service	Products	Capital city	Regional level city	All cities in province	Other (specify)
Disaster Risk Management	DRM	All	94.4%	75.5%	65.6%	69.0%
Environmental Services	ES	All	91.6%	70.1%	53.9%	58.1%
Human Health	HH	All	86.2%	63.6%		
Daily City Operations	DO	Flooding, urban fire risk, electricity demand	83.8%			
		Others	A few of cities provide these services, but methods used are various			
Transportation	Tr	All	86.6%	51.3%		51.3%
Economy and planning	EP	Wind farms, solar energy, energy trading	61.4%	66.7%	50.9%	75.4%
		Others	80.0%	53.8%		53.8%

Delivery: Smallest spatial scale

- CBCS are delivered at a range of spatial scales:
  - City, ward (*particularly for disaster response*) and buildings

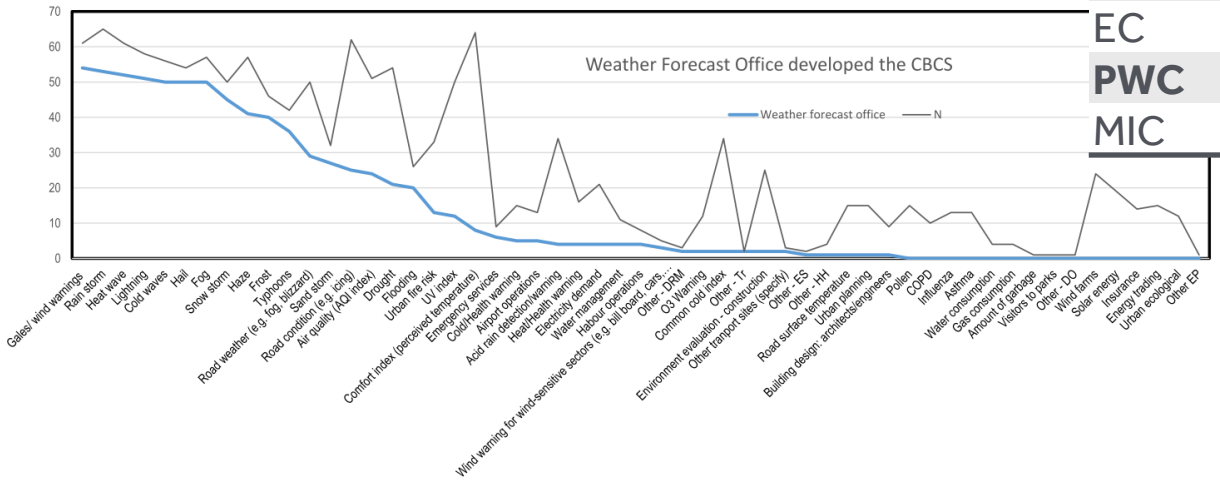




- Disaster Risk Management (DR)
- Environmental Services (ES)
- Human Health (HH)
- Daily City Operations (DO)
- Transportation (Tr)
- Economy and planning (EP)

Involvement in the development

WFO	**Weather Forecast Office**
CC	**Climate Centre**
IMS	Institute of Meteorological Science
EC	Environment Centre
PWC	**Public Weather Centre**
MIC	Meteorological Information Centre



%	Products	WFO	CC	IMS or EC	PWC	MIC	University	Other
Disaster Risk Management (DR)	all but drought	**87.6**	11.5	11.5	14.2	1.6	0.0	0.9
	drought	**38.9**	**59.3**	13.0	9.3	1.9	0.0	3.7
Environmental Services (ES)	all	**53.0**	10.3	38.9	9.2	2.7	0.5	3.2
Human Health (HH)	all	13.5	0.9	22.2	**68.7**	1.7	0.0	0.0
Daily City Operations (DO)	all	**46.3**	7.5	7.5	**48.8**	2.5	0.0	1.3
Transportation (Tr)	all	**43.3**	2.4	7.9	**62.2**	0.0	0.0	0.0
Economy and planning (EP)	all	13.2	**50.6**	6.9	30.5	0.6	4.0	2.3

Methods used within the CBCS

Method	Description	Examples
Numerical Model	Physically based model	*CFD model analysis to determine likely impacts of different billboard designs* *Climate model and air quality model (WRF-Chem).* *NWP: Global Spectral Model(TL839L60), Meso Scale Model (GRAPES_Meso), 10 day Ensemble (T213L31),* *Typhoon deterministic & Ensemble forecast, SMS-WARMS, etc.*
Statistical Model	Time series analysis, regression analysis, etc.	*Heat Health watch system in Shanghai (Tan et al. 2004)*
Threshold	Warnings given when reach certain threshold	*Heat wave: 35°C* *Gale: 13.9 m s^{-1}* *Haze: visibility <3000 m and RH<80%, or $PM_{2.5}$ > 150 μg m^{-3}*
Index		*Heat index, UV index, etc.*
Synoptic Method	Based on the synoptic chart	*Rainstorm, typhoon, sandstorm, etc. forecast.*
Climatic Method	Climatic statistics	*Climate atlas*
Observation	Service depends on observed data	*Lightning for lightning warning* *Acid rain detection* *Pollen sampling, etc.*
GIS Mapping	GIS technique used for service	*Road thermal mapping, urban waterlogging*
Analytical Input	Different approaches used to produce an analytical report	*Environmental evaluation, climate based design suggestion for construction (buildings, project, etc.)*

- commonly used
  - statistical
  - synoptic methods
  - Observations

What are the challenges?

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- Engaging with **individual** end-users more challenging than with organisations
  - Particularly an issue for health related CBCS

- Challenges with **organisations**
  - lack of resources to allow personnel to be involved
  - perception that the organisations do not have anything to offer

- Survey only obtained responses from within CMA
  - broader range of stakeholders would provide additional important insights
  - Within CMA:
    - recognise key role of specific government departments, city planners and social scientists to better understanding how the services are being used

Benefits of the CBCS

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- Understood to be multiple
  - varying between the different services (as expected):
    - reduction of accidents
    - better allocation of resources
    - advanced warnings
    - improved health of vulnerable (young and elderly) populations
    - urban safety

Greatest challenges in development of services

- Spatial/temporal scale of forecasts
- Data availability
  - meteorological
  - land surface

Performance of the CBCS

- 80% respondents – current performance:
  - satisfactory but would benefit from improvements

- Strong sense that the CBCS have correct **temporal** scale
  - not always the correct **spatial** scale

Greatest needs identified for CBCS improvement

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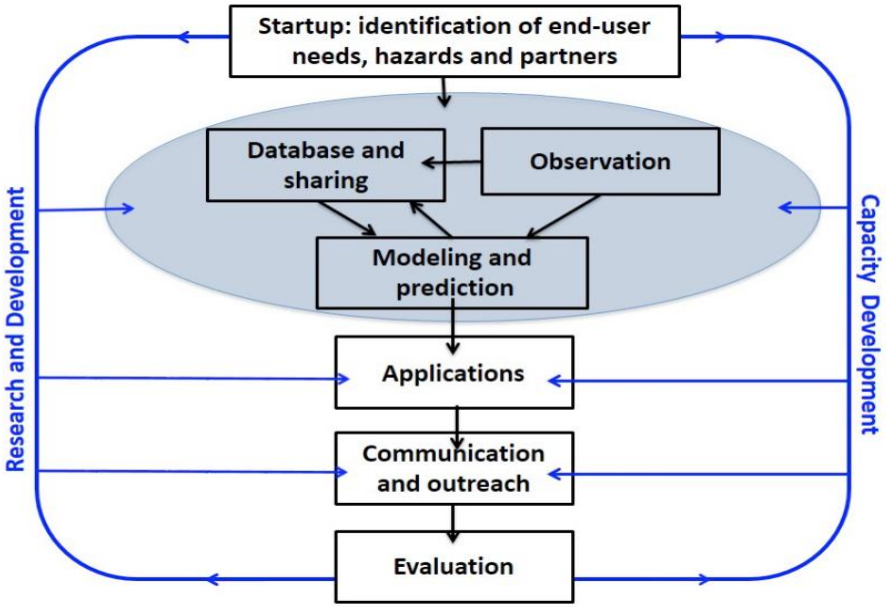
- Forecasting of rainfall and flooding, particularly high intensity events
  - refined rainfall forecasts and warning services, time resolution: 0 ~3 h
  - enhanced services on rainstorm intensity
  - flood warnings at block-scales

- Short-term prediction products:
  - disaster weather lightning hail fog
  - road icing heat waves cold waves drought

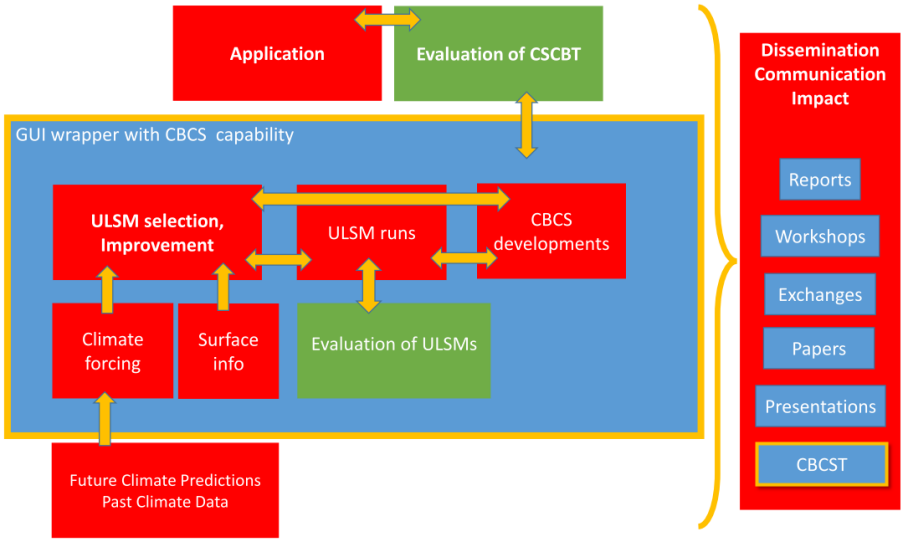
- Haze: better insights when and where developing, detection and forecasting
- PM_{10} and $PM_{2.5}$
- Composite indices of meteorology and health

Next stage: Development of a pilot CBCS

- UMEP (Friday: Lindberg et al.) – User Interface
- ULSM
  - e.g. SUEWS – Friday (Ward et al.; Järvi et al.)
- Observations - Thursday *Tan et al.* (BAMS 2015)
  - Posters: Ao et al., Peng et al., Tang et al.



Grimmond et al. 2014



Grimmond et al. 2015

Final Comments

- China's cities experience: wide range of climatic & meteorological conditions
- Conditions of particular concern in one city (*flooding, haze, windstorms etc*.) may not have the same importance in another
- Strong regional dependence:
  - what climatic elements of most concern to different branches of CMA
  - pattern of CBCS have been developed
- CBCS in China: well developed, range of different time scales appropriate for different applications (warnings, forecasts, operations)
- City based climate services (CBCS) needed for:
  - day-to-day operations of cities *e.g. for public health, transport operations, management of energy demand and water supply), for emergency response, and to inform urban design and development*
  - wide range of temporal *(events to decades)* and spatial scales *(cities, small and large; neighbourhoods/ subdivisions; buildings)*
  - fundamental to the economic prosperity of China
  - wellbeing of the majority of the Chinese population
- *Report: contains wide database of CBCS information –for China*

Urban Climate Services Survey: Methodology

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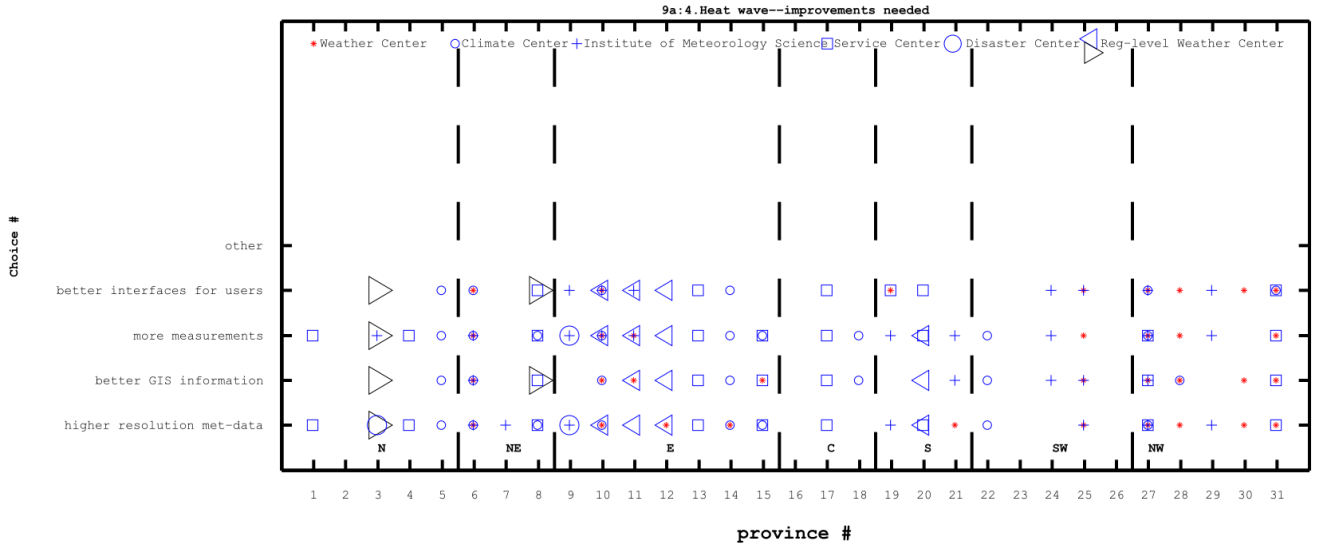
- Visited CMA offices in 3 Provinces
  - Shanghai: Shanghai IMS (collaborators)
  - Zhejiang: ZIMS, Hangzhou Meteorological Bureau
  - Jiangsu: Suzhou Meteorological Bureau

  - Discussed: approaches taken to services, structure of development and delivery of services

Example: What improvements are needed?

- (Choose and add appropriate comments below. If more than one response, Please rank it according to the priority?)
    1. higher resolution meteorological input data
    2. better GIS/surface information
    3. more/different measurements
    4. better interfaces for users
    5. other - please specify



- Response for all sectors and processes

What are the specific elements of the climate of particular concern for the major cities in your

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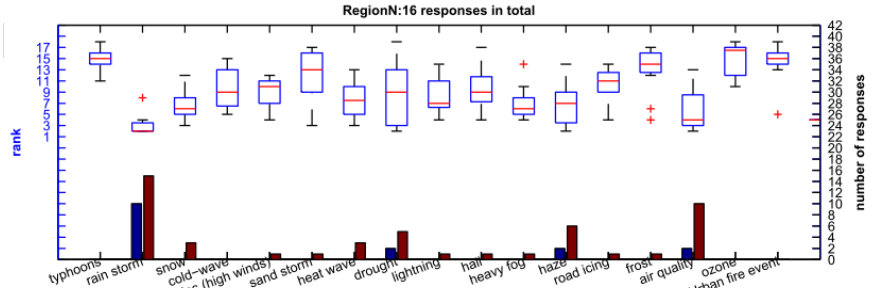
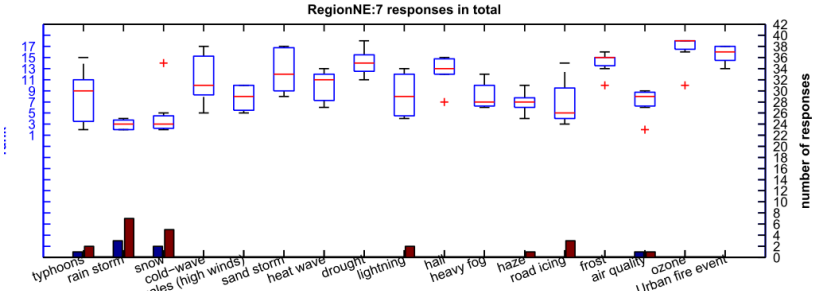
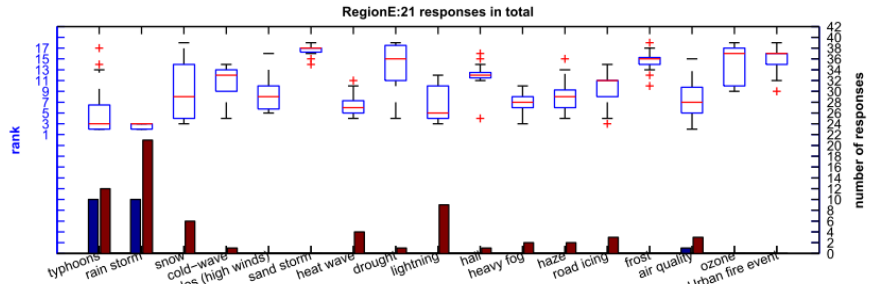
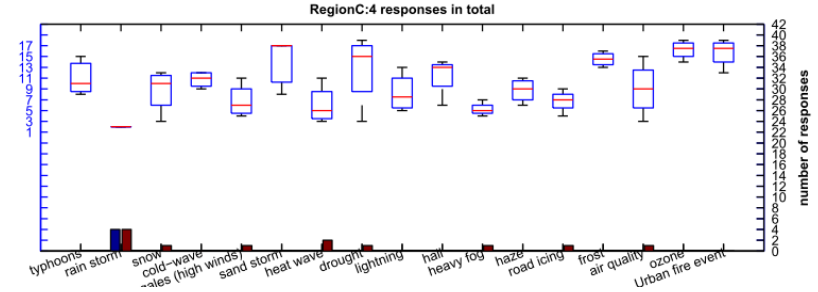
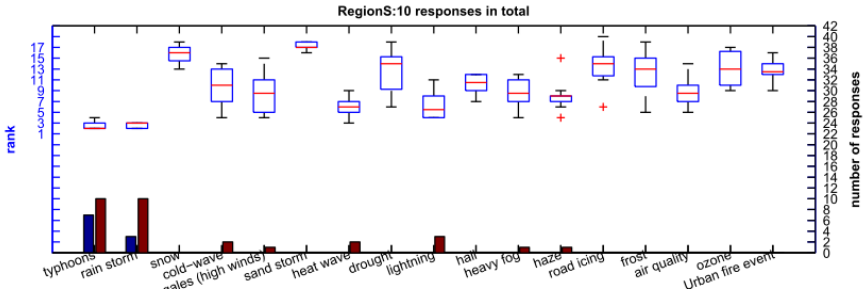
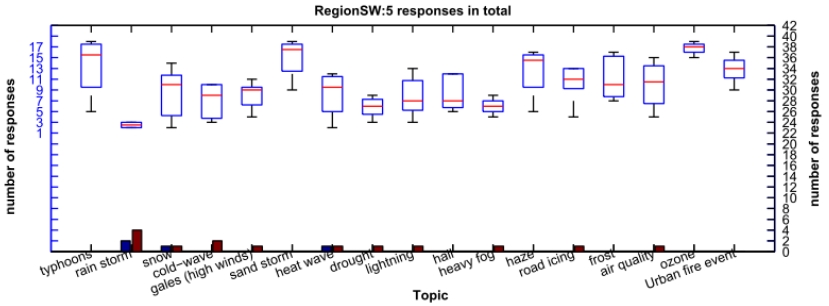


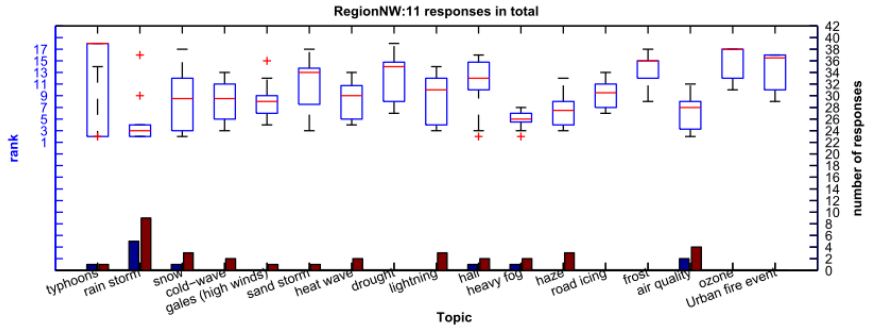




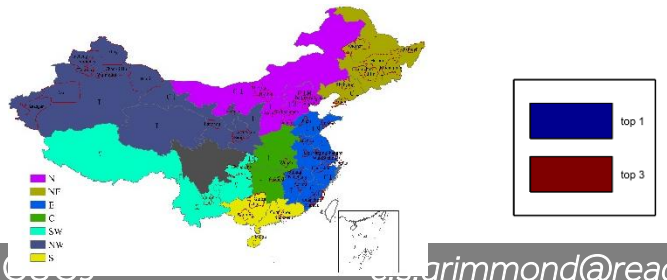






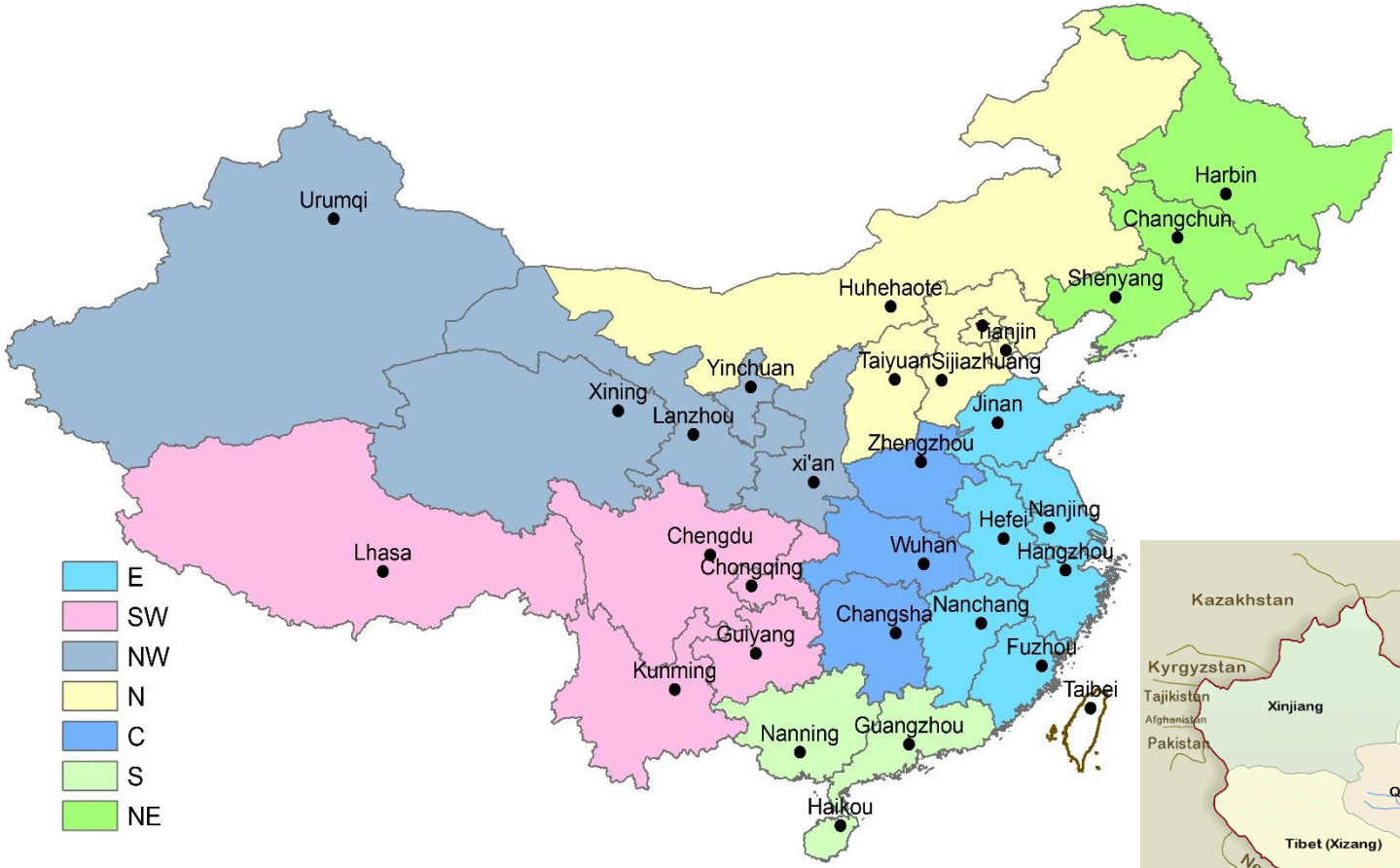


Asked to rank what was their major concern



China

- Provincial Capitals
- Regions



http://www.sacu.org/maps/provmap.png *[last accessed January 2015]*