Urban-focused Weather and Climate Services in Hong Kong

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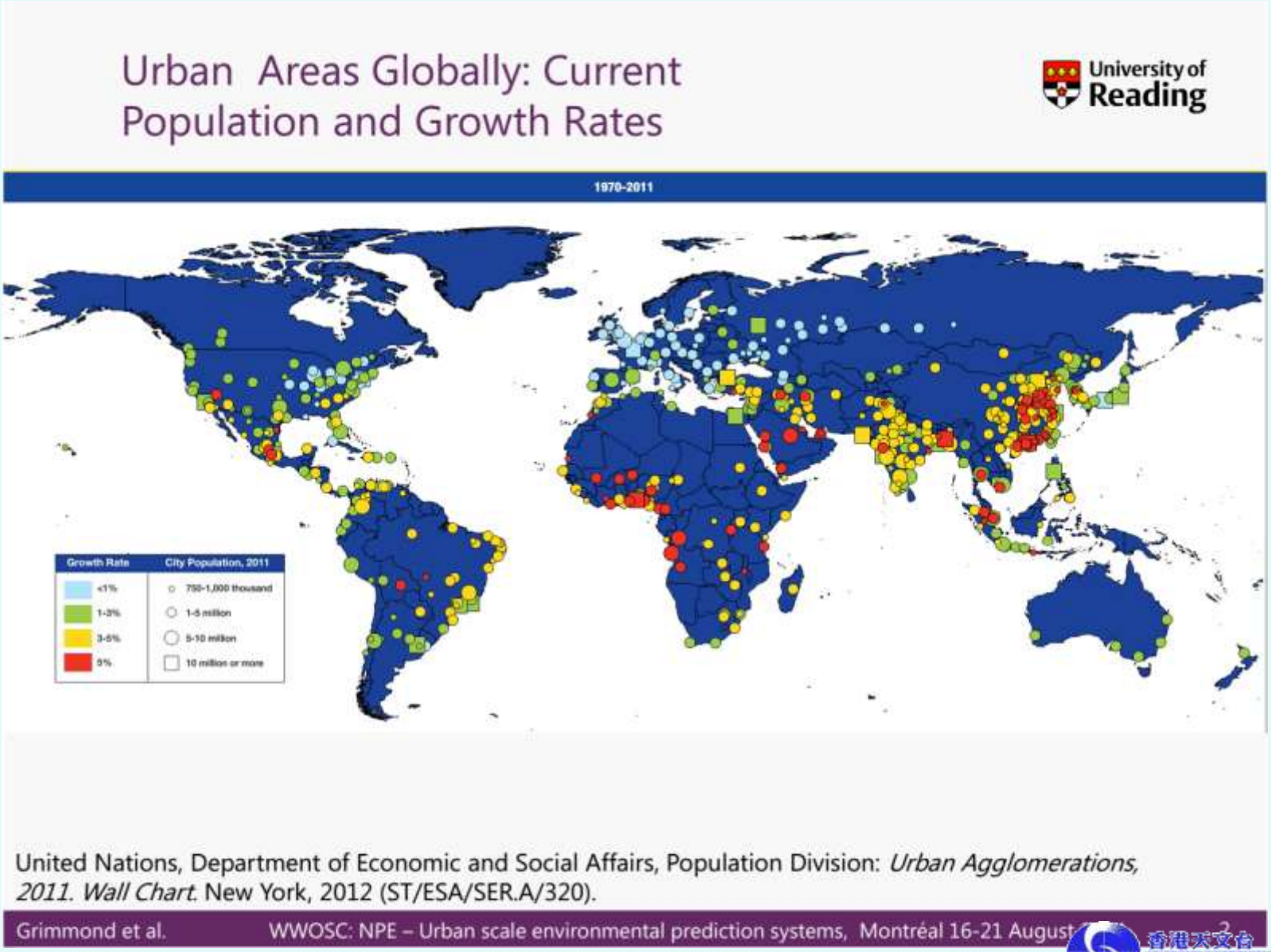
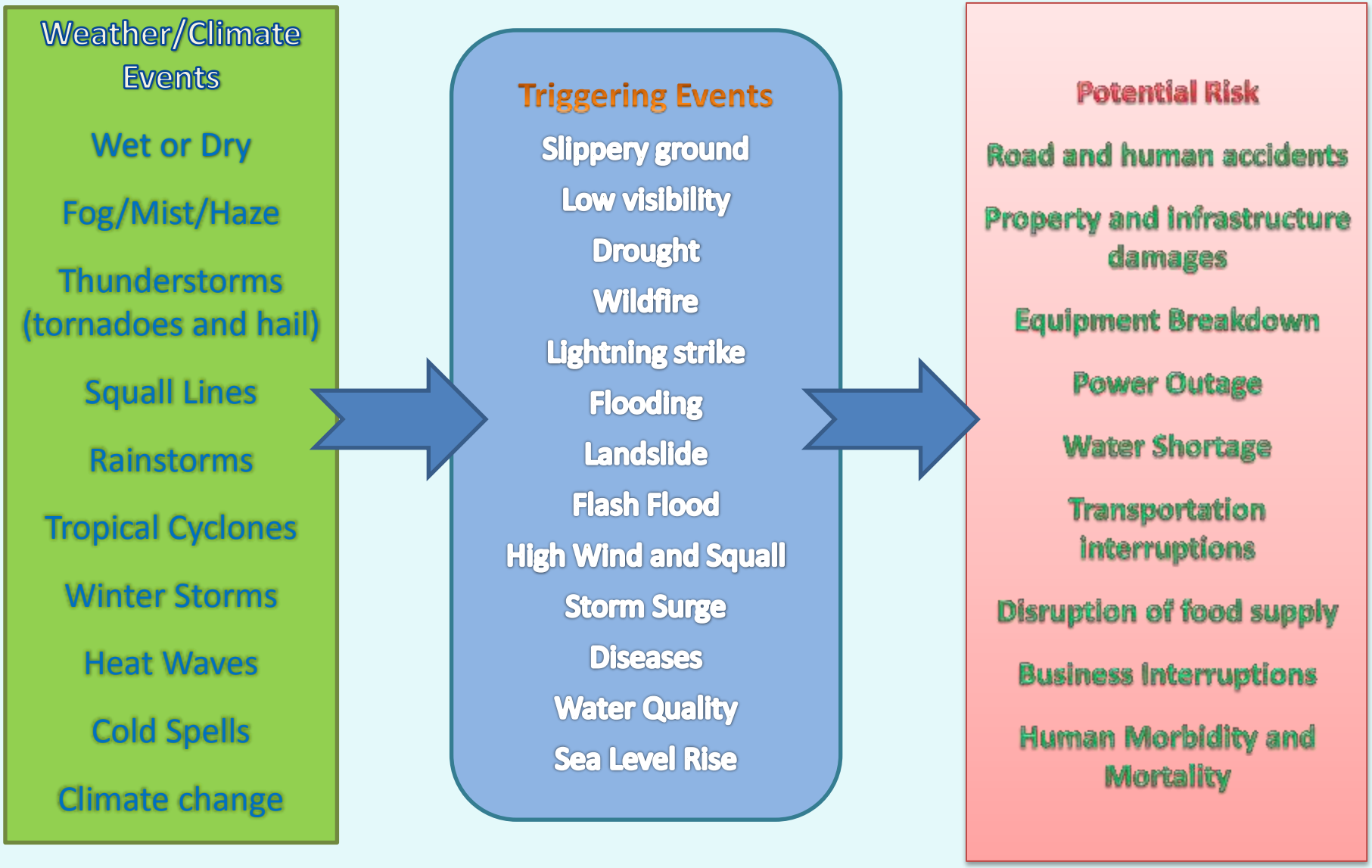
Urbanization in the World

More than half of world's population is now living in urban areas



United Nations, Department of Economic and Social Affairs, Population Division: *Urban Agglomerations, 2011. Wall Chart.* New York, 2012 (ST/ESA/SER.A/320).

Connecting weather / climate events with potential risk of urban complexes



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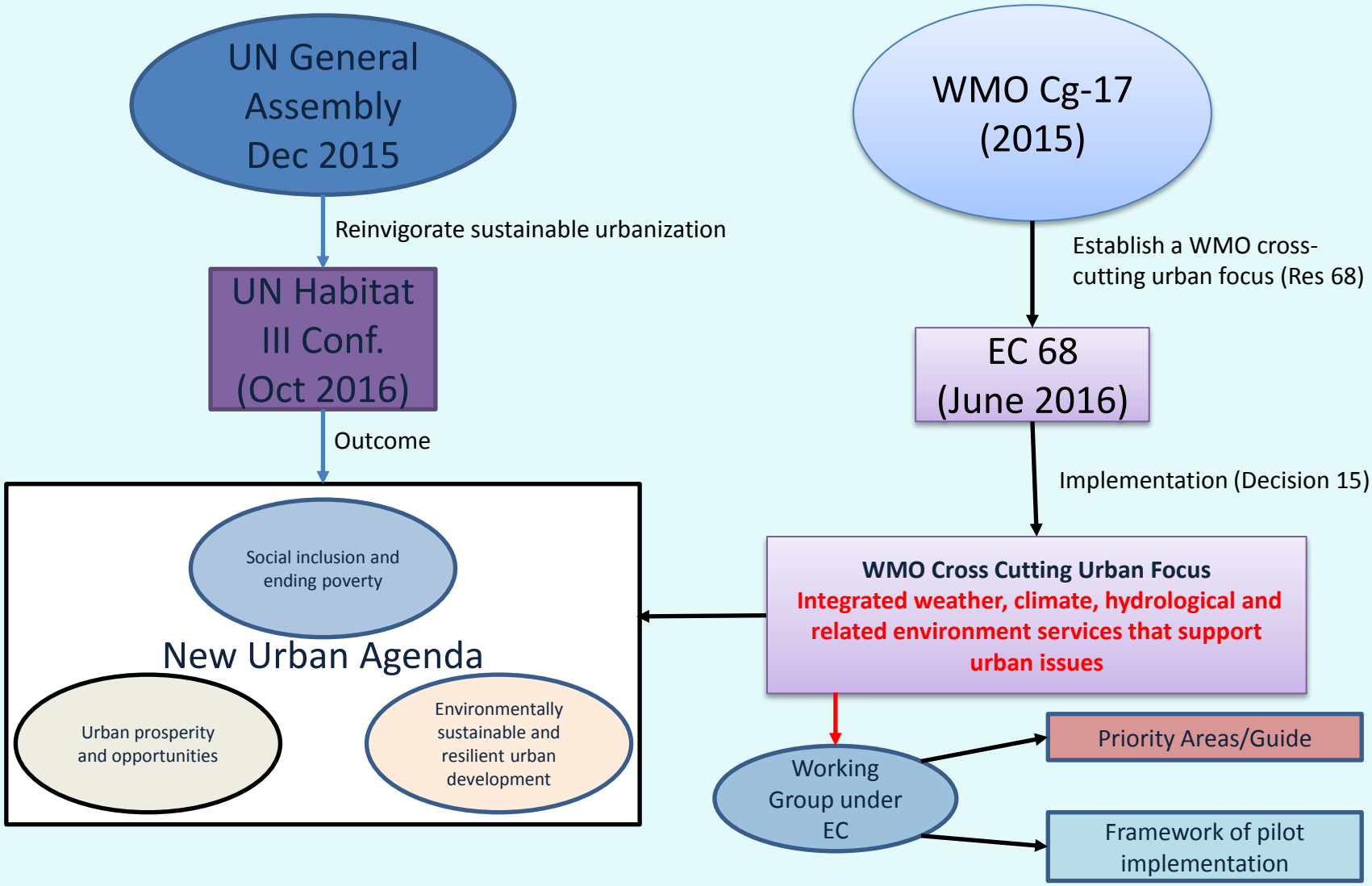
WMO Cross Cutting Urban Focus in response to UN's New Urban Agenda



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WMO "Integrated Weather, Climate and Environmental Services" Initiative

Weather

Weather and climate modeling

Mutli-scale / Seamless weather predictions
(minutes-months-annual & regional to city scale)

High impact weather forecasts

Environmental

Urban environment monitoring
(air quality, chemical constituents, GHG emission and weather elements)

Air pollution modeling and forecasts

Climate

GFCS
(Water, DRR, Energy, Food, Health)

Climate information

Climate change projections (decades to centuries)

Partnership and Stakeholder Engagement

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Applications

Multi-hazard Early Warning Systems

Emergency Preparedness

Disaster Risk Reduction

Climate Change Mitigation and Adaptation

Sustainable Development

Urban Planning

Infrastructure & Building Design

User Routine Operations / Planning

Research Development

Big Data and Smart City

Outreaching and Public Education

Urbanization in Hong Kong over the last century

c.1880s

(Source : CO 1069-447-53 National Archives UK https://www.flickr.com/photos/nationalarchives/7838570400/)

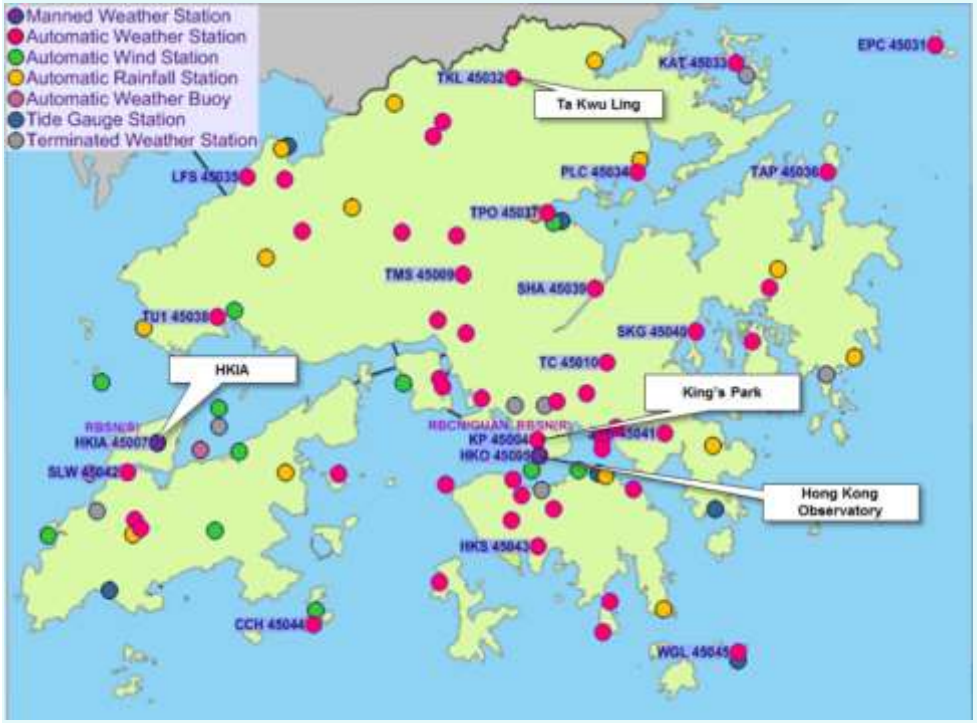
2014

Weather and climate monitoring

- provides valuable information and scientific basis for research and various weather and climate services in support of the everyday operations and sustainable development of the city.

Weather and climate monitoring in Hong Kong

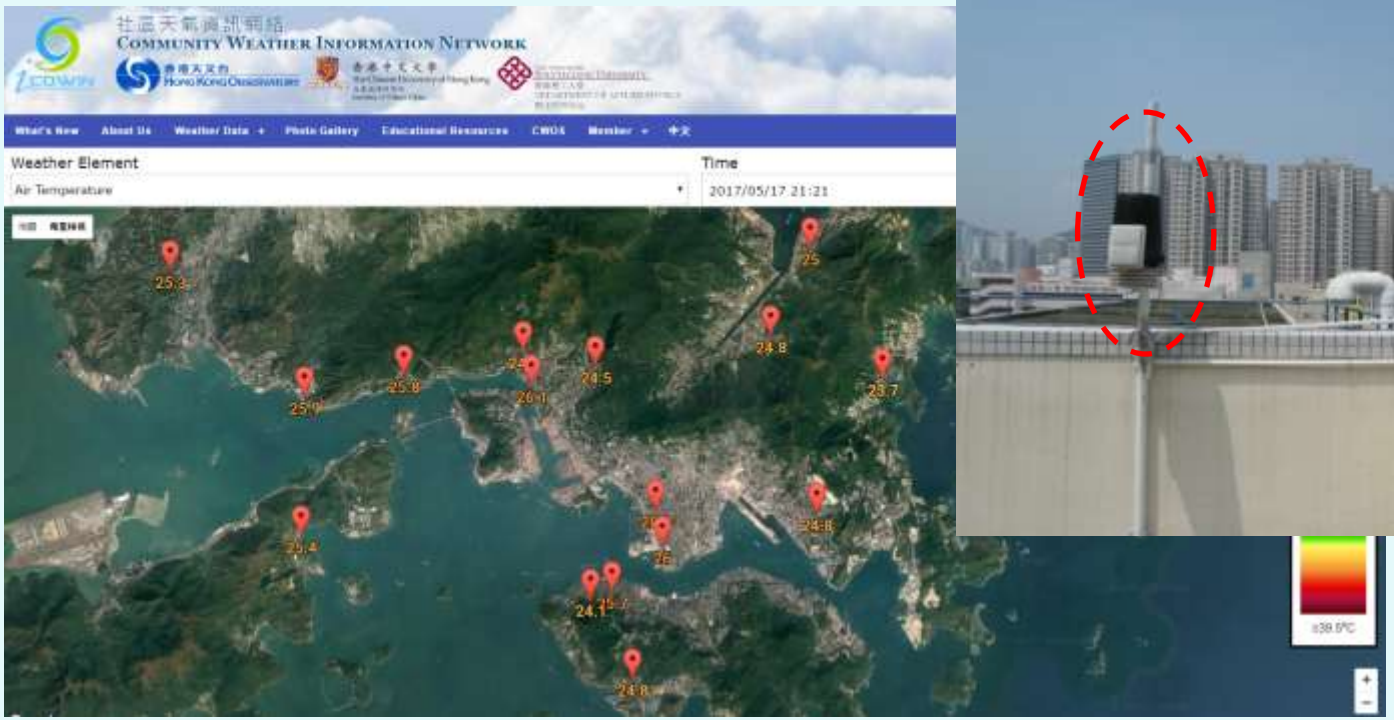
- Long term meteorological observations at Hong Kong Observatory (HKO) headquarters since 1884
- Upper air sounding at King's Park (KP) since 1950s
- Dense automatic weather station and raingauge networks over Hong Kong since 1985 (including those operated by Drainage Services Department and Geotechnical Engineering Office)
- Other remote sensing systems (e.g. radar, lightning location network, wind profilers, lidars, etc.)



Community weather observations

Established in 2007, the Community Weather Information Network (Co-WIN) is a joint public education initiative between the Hong Kong Observatory (HKO), the Hong Kong Polytechnic University (PolyU) and the Chinese University of Hong Kong (CUHK).

Co-WIN aims to assist schools and other organizations in setting up automatic weather stations to promote weather education, and to provide the public with comprehensive weather information covering a wide area to the community level. Up to early 2017, 160+ schools or organizations have joined Co-WIN

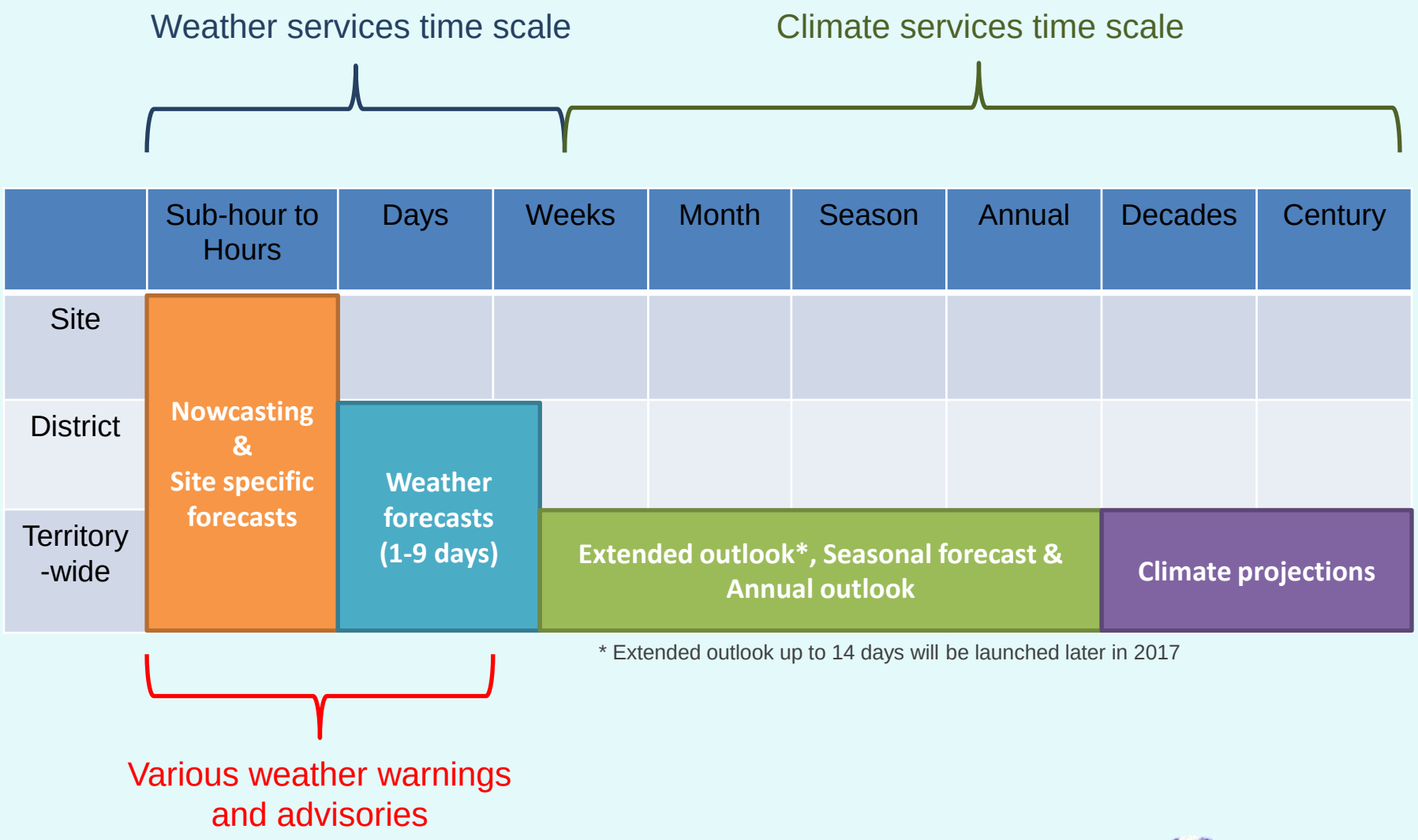


Urban focused weather and climate services

- under the relentless pace of population growth and urban development, HKO continuously enhances its wide range of weather and climate services with an increasing focus on the delivery of tailored information to meet the needs of special users and various sectors in the community.

- Besides various meteorological observations, the weather and climate forecasting and warning services of Hong Kong are fully supported by state-of-the-art numerical weather prediction (NWP) and nowcasting products.

Weather and climate services in Hong Kong - spatial and temporal coverage



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Severe weather and corresponding warning services in Hong Kong

High winds

TC warning signals
No. 1, 3, 8, 9 & 10

Strong Monsoon Signal

Heavy rain

Color rainstorm
warning signals

Landslide warning

Special Announcement on
Flooding in the Northern NT

Thunderstorm warning

Extreme temperatures

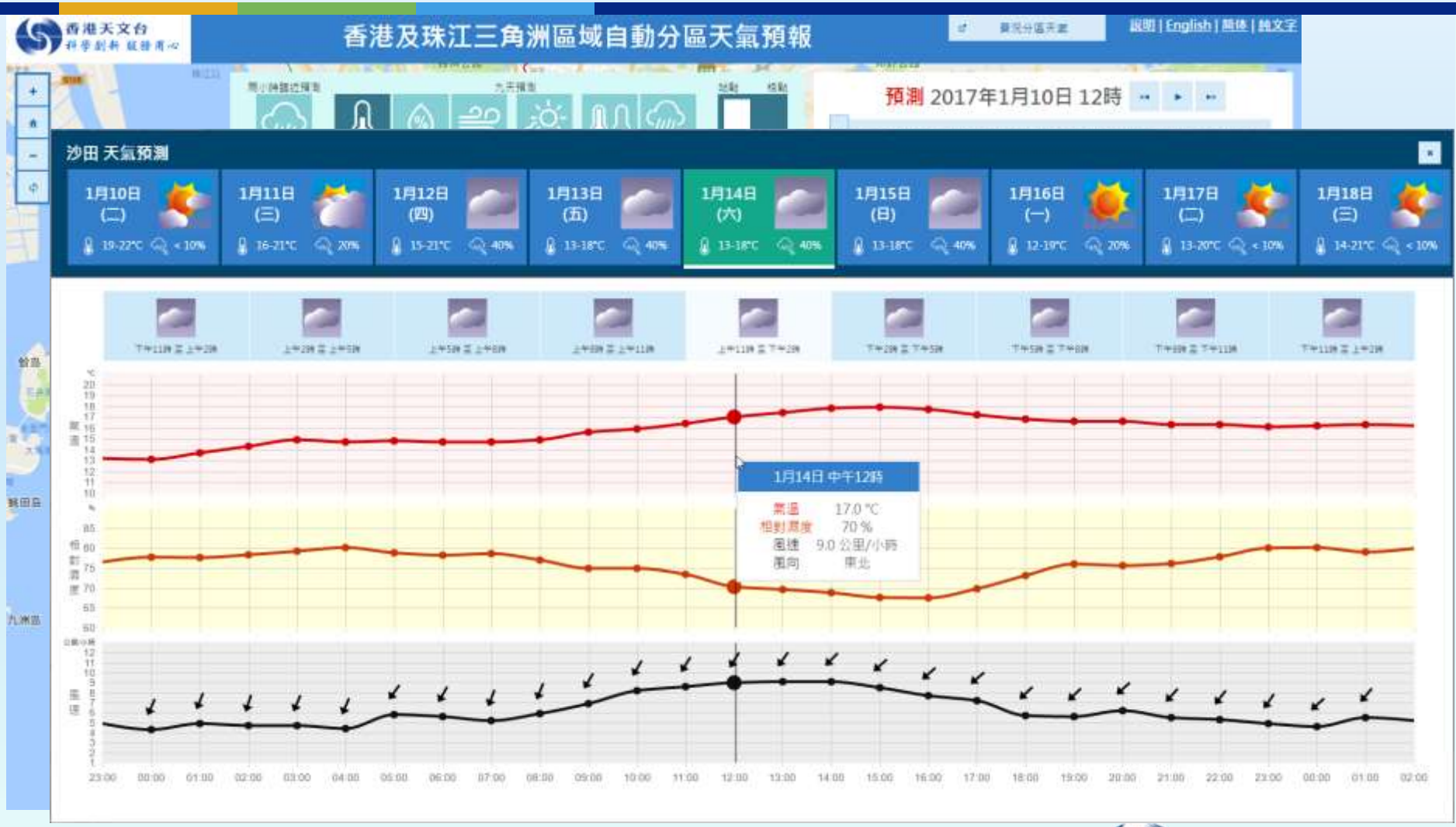
Cold and Very Hot
warning

Frost warnings

Dry conditions

Color fire danger warnings

Digital Weather Forecast at Your Fingertips



http://maps.weather.gov.hk/ocf/

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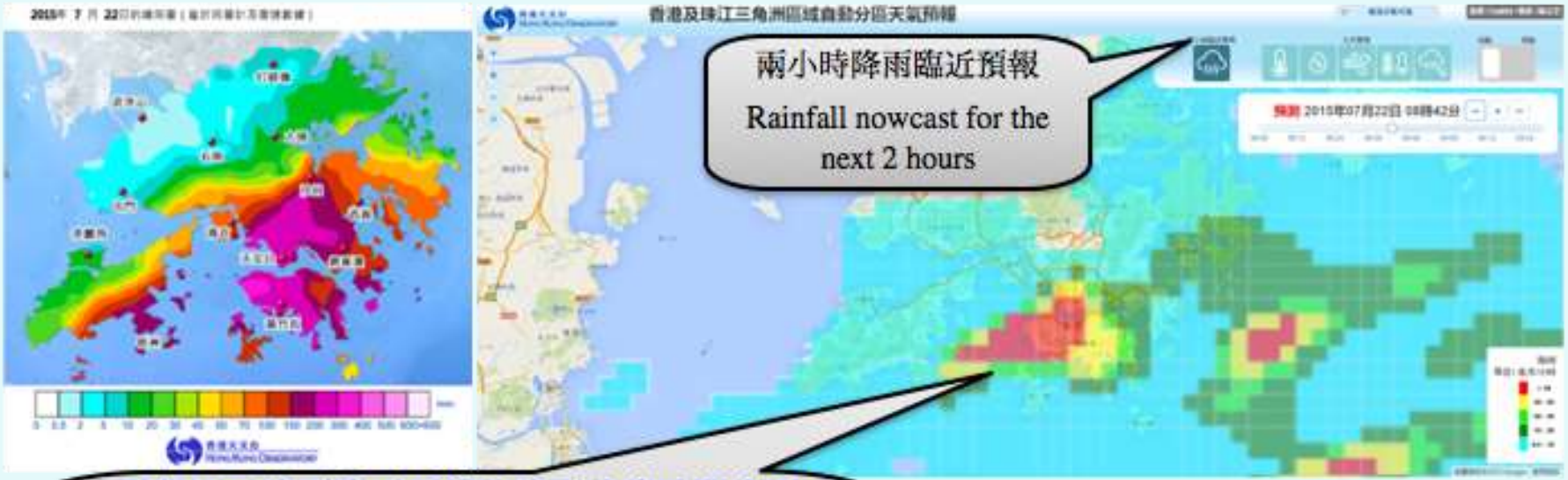
Nowcasting of severe weather

未來兩小時香港與珠三角的預測降雨分佈和動畫

Depicts rainfall forecast in Hong Kong and Pearl River Delta Region in the next 2 hours in the form of an animation of forecast rainfall maps.



今年 7 月 22 日，天文台發出黃色暴雨警告接近 12 小時，而山泥傾瀉警告亦生效超過 6 小時。強降雨區在早上一段長時間幾乎停留在香港南部。

On 22 July this year, the Amber Rainstorm Warning Signal issued by the Observatory lasted for nearly 12 hours and the Landslip Warning was also in force for more than 6 hours. The area of intense rain remained almost stationary over the southern part of Hong Kong for a prolonged period in the morning

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Re-definition of service models and information dissemination

Traditional

Internet website

Mobile platform

- Limited information
- Text/Audio format
- Spoon-fed with data

- Attractive and detailed
- Interactively “poll” the required information
- Multimedia
- Anytime and anywhere
- Personalized location service

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Mobile App - MyObservatory

A personalized location-based weather service

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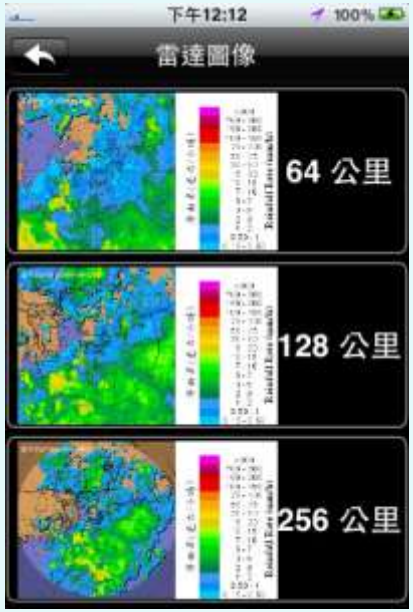
A complete suite of weather service via App

Getting WX Information Anywhere & Anytime

- Weather forecasts and warnings
- Observations
- Radar and satellite images
- Lightning location
- Location-specific rainfall and lightning nowcast
- Tropical cyclone track
- UV Index
- Astronomy and tide information
- World major cities forecast
- .....

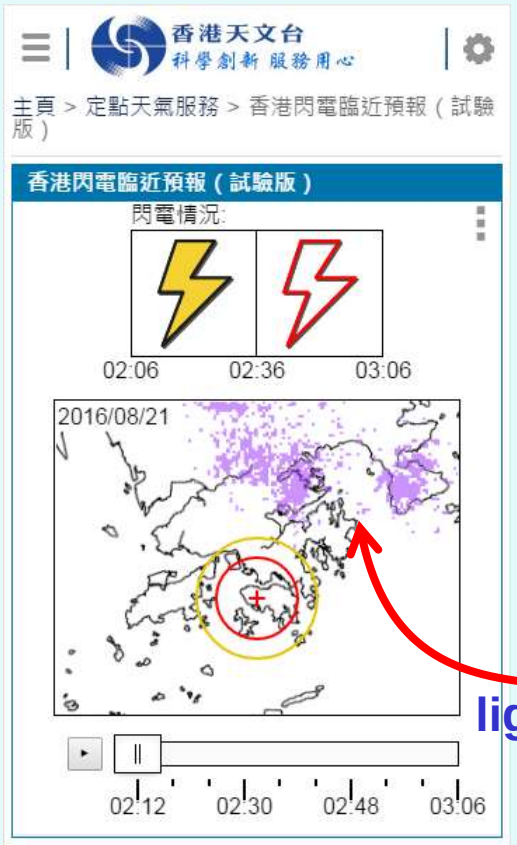


First-hand warning information to prepare for and avoid hazardous heather

Special Weather Tips (Web & App)

Location specific lightning nowcast services

http://www.weather.gov.hk/m/nowcast/lightning/hk_lightning_nowcast.htm



1-h Lightning nowcast at selected location

Forecast lightning Map

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WMO's WWIS and SWIC + "MyWorldWeather" app

Authoritative world city weather forecasts and severe weather information for Urban Dwellers and Travelers

http://worldweather.wmo.int/en/home.html

Developed and maintained on behalf of WMO by HKO

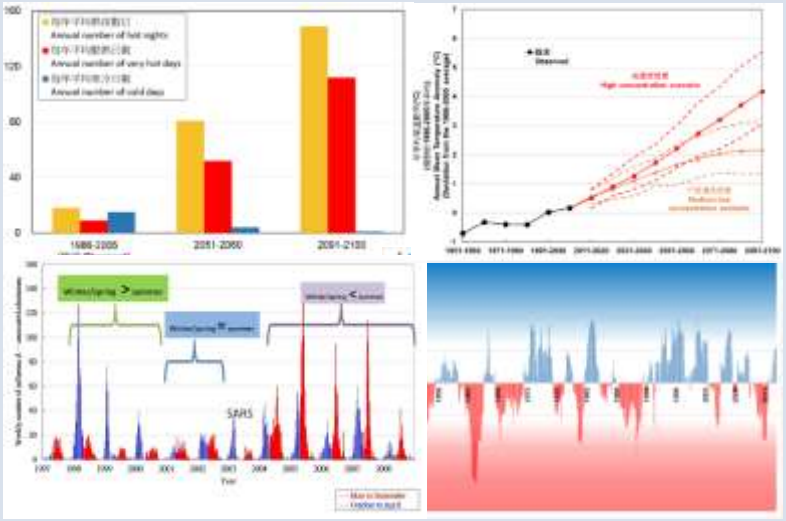
http://severe.worldweather.wmo.int/

Application of Century-long Climate Information

Infrastructure design and city planning

(Sea Wall Design, Port Work, Drainage Design, Water Resource Management, etc.)

Climate research



(Climate Change, Climate Projection, Climate and Health, Water Resource, etc.)

Climate partnership

(Health sector, Academia, Farming Community, Energy Sector, etc.)

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Climate Predictions

- **Annual outlook**
  - Annual rainfall in tercile category
  - No. of tropical cyclones within 500 km of HK, onset of tropical cyclone season
  - Probability of annual temperature reaching top 10 positions

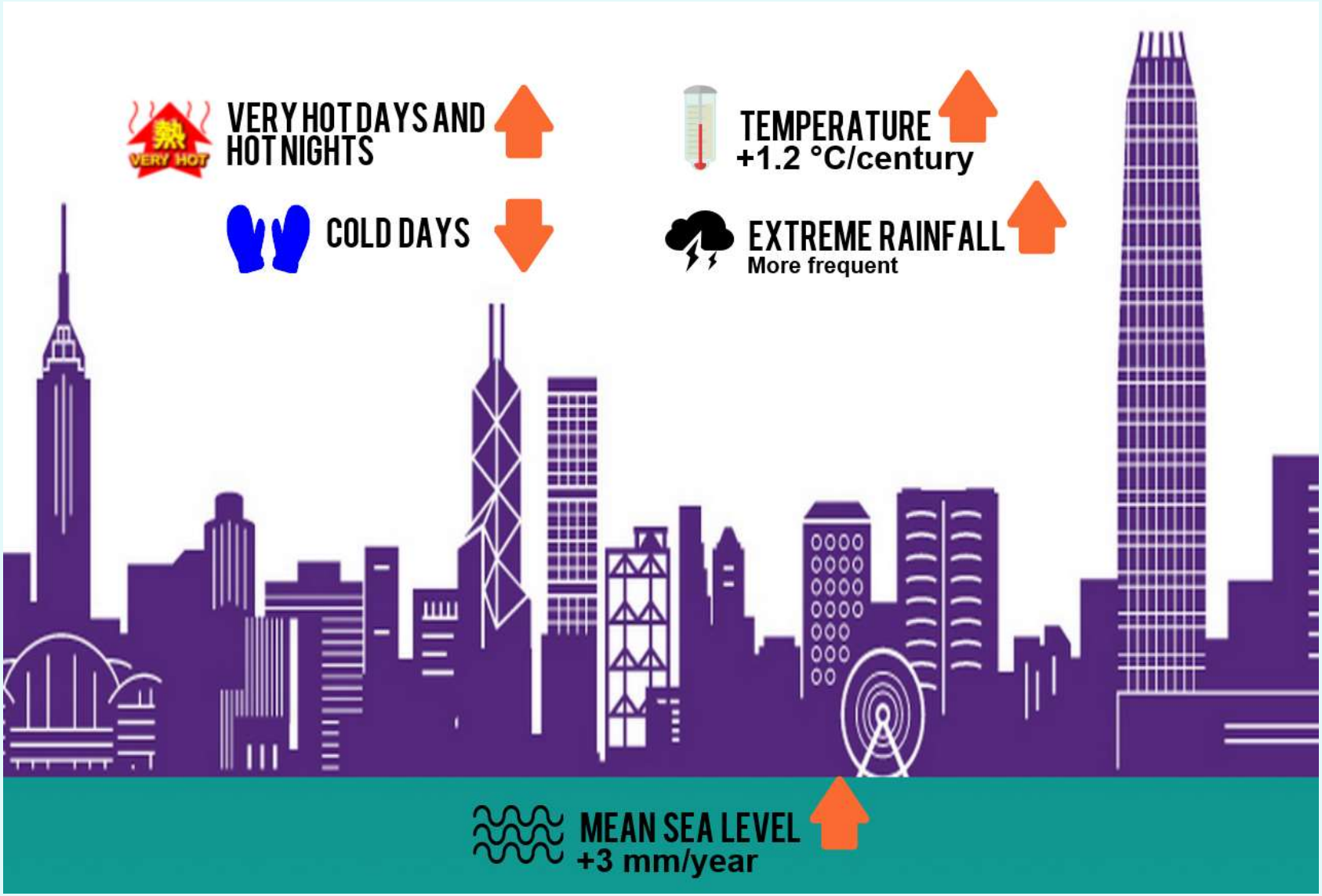
- **Seasonal forecast**
  - Average seasonal temperature and total rainfall in tercile category

- **Experimental monthly forecast** (internal ref., special users)
  - Monthly temp. and rainfall in quantitative terms
  - No. of cold surges
  - TC activities in South China Sea / within 500 km of HK

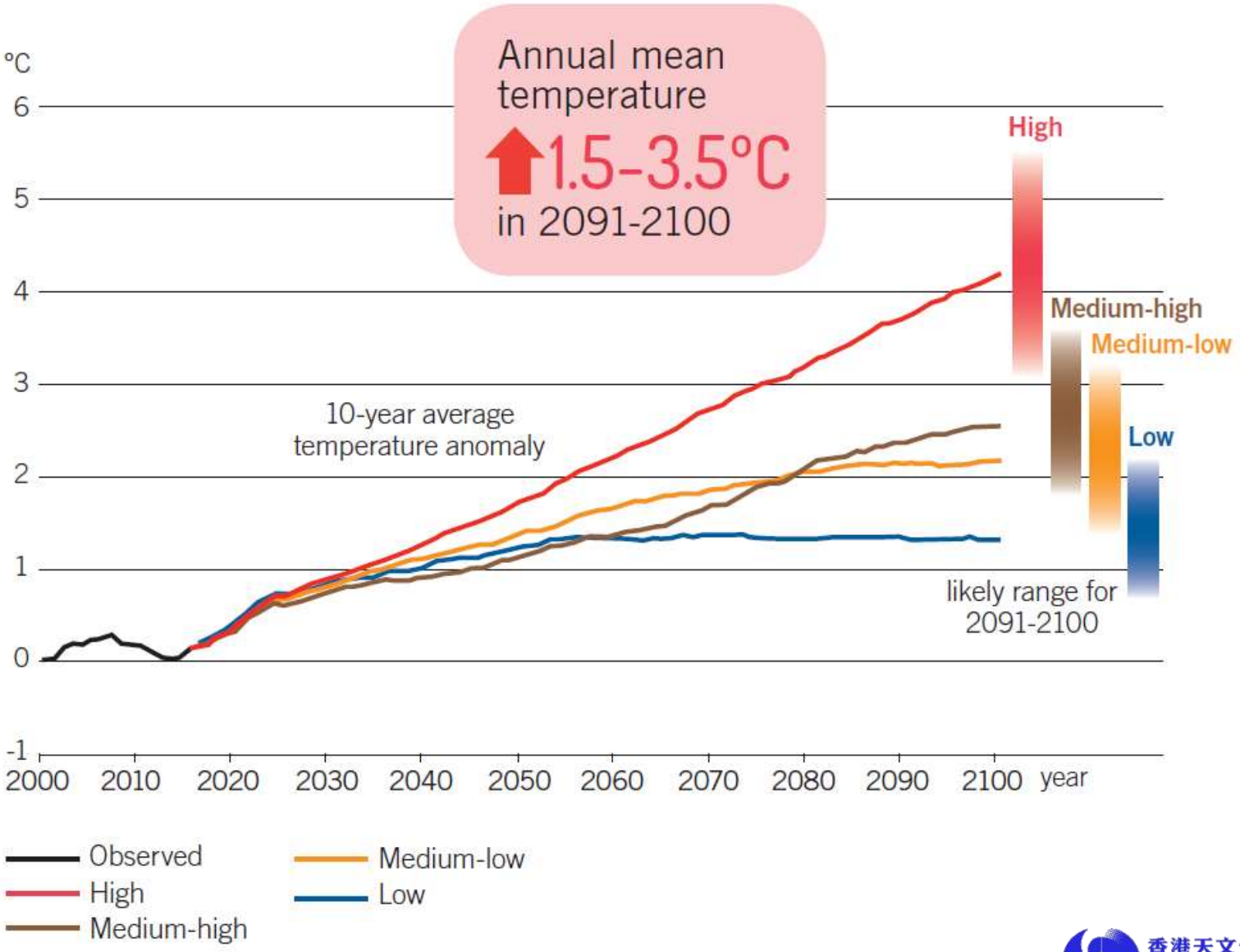
- **Experimental 3-week forecast** (internal ref., special users)
  - Forecast range: 2nd, 3rd, 4th week
  - Weekly temperature and rainfall

Climate Change Monitoring and Research

Observed climate change in Hong Kong over the last century



Projected changes in the annual temperature of Hong Kong under different greenhouse gas concentration scenarios relative to 1986-2005



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Urban focused weather and climate services in Hong Kong

Weather

Weather forecasts
Weather forecast (9 days)
Regional (city district scale) forecasts
Special client services (e.g. festivals, sports events)

Warning and advisories for high impact weather
Tropical cyclone
Thunderstorm and lightning
Thermal Stress (hot and cold)
Heavy rain, flooding and landslide

Numerical modeling
Nowcasting (QPE and QPF)
Mesoscale and fine-scale models

Climate

Climate information services
One-stop shop information webpage
Data provision, extreme statistics and publications

Climate services for GFCS priorities
Water – water resource management
Energy – energy saving and management
DRR – infrastructure standard and code of practices
Health – communicable diseases and thermal stress

Climate prediction and projections
Annual outlook
Monthly and seasonal forecasts
Climate change and sea level rise projections

Communications

HKO Webpage
TV/Radio/Newspaper
Social media platforms
MyObservatory mobile app
Partnership and stakeholder engagement

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Applications

- User routine operations / planning
- Emergency preparedness
- Disaster risk reduction

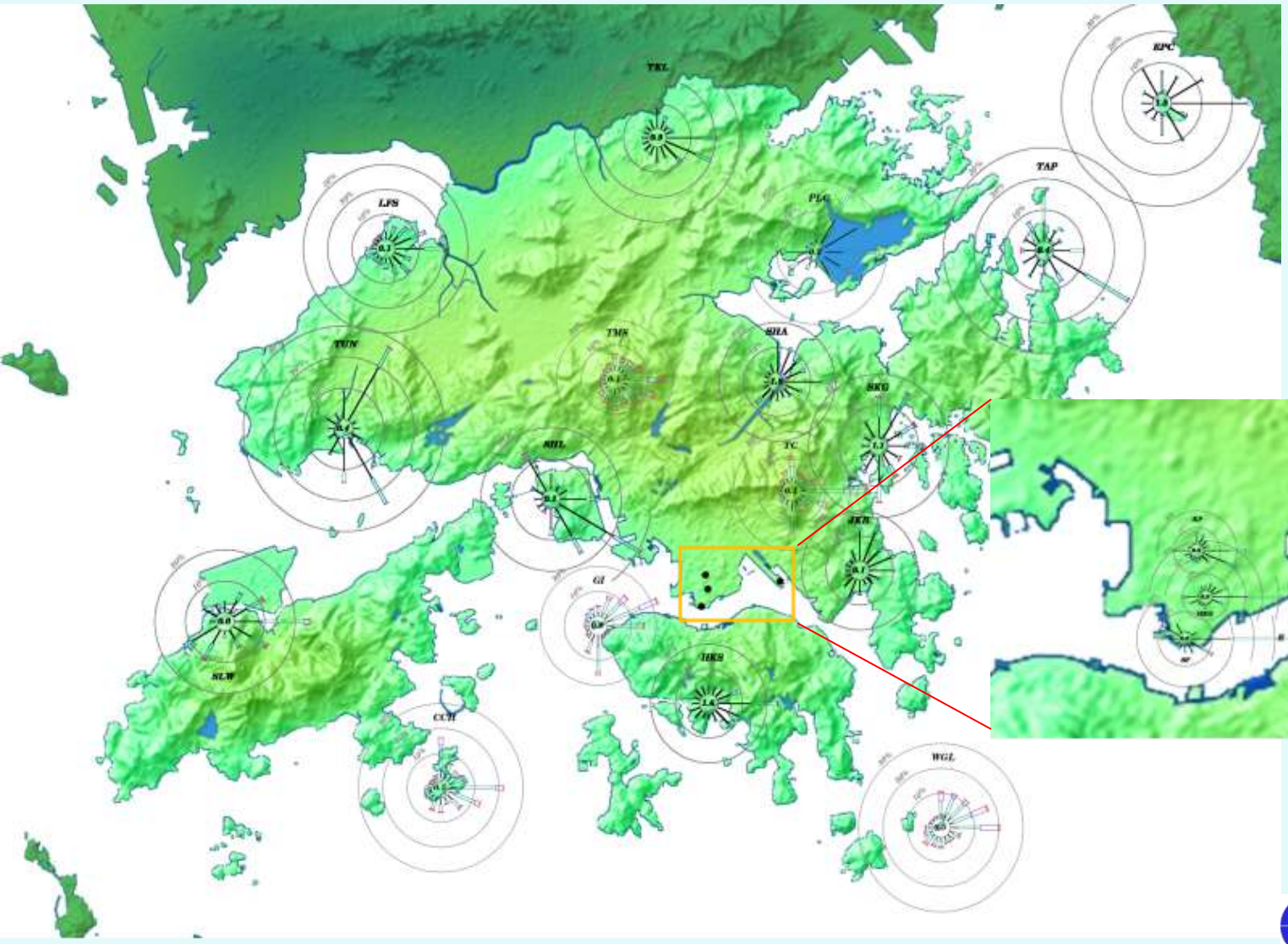
- Climate change mitigation and adaptation
- Sustainable development
- Urban planning
- Infrastructure & building design

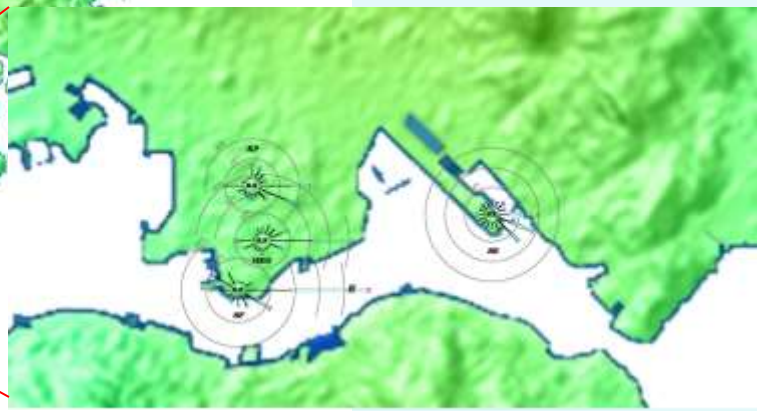
- Big Data analytics
- Smart city development

- Research development
- Public education

The Wind Climate of Hong Kong

Wind observations in the past decades provide useful information of the wind climate of different parts of Hong Kong and the long term changes





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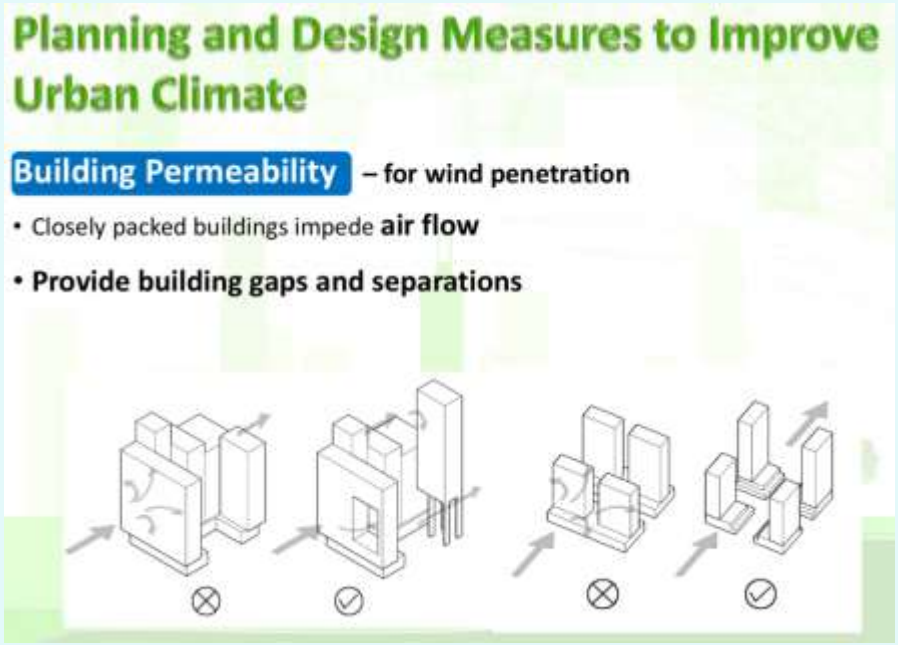
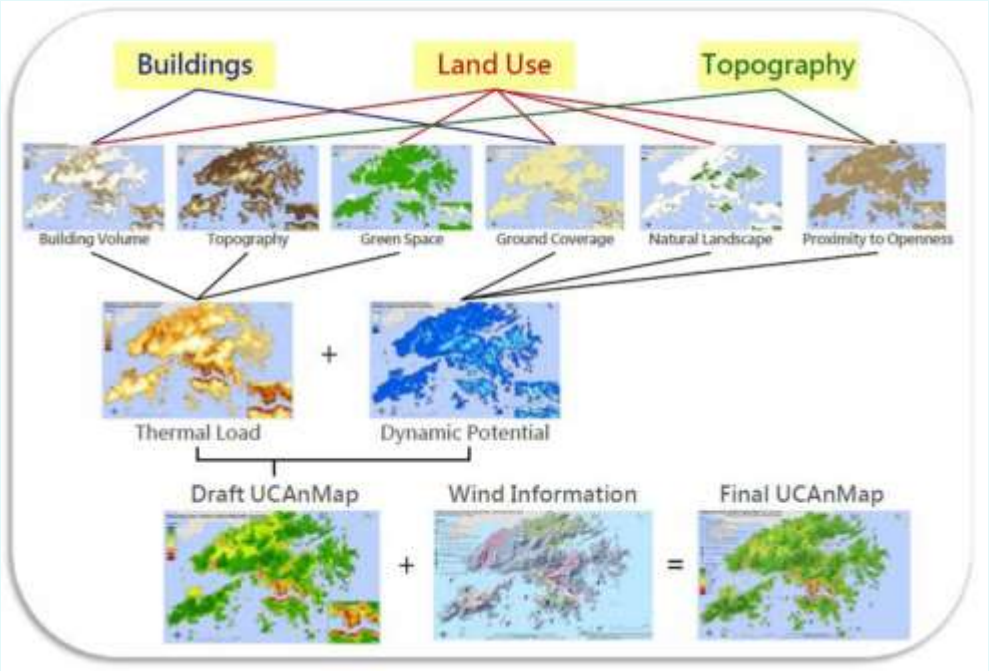
Air Ventilation and Urban Planning



Help assess and regulate the impact of potential city, community and building developments on local air ventilation



By analysing and evaluating climate wind data together with different geometric and urban development data (e.g. land use, greening, building density, topography), "Urban Climatic Maps" by the CUHK divides the territory into different urban climate zones, each with recommended planning and development actions

(courtesy by Planning Department)
Source : http://www.pland.gov.hk/pland_en/p_study/prog_s/ucmapweb/ucmap_project/content/content.html

Climate and Health Studies

The Observatory has been collaborating with tertiary institutions and relevant government departments to study the impacts of climate/weather on human health in Hong Kong in recent years, including thermal stress, infectious disease and vector-borne disease

Thermal Stress

- The impact of cold and hot weather on senior citizens in Hong Kong (HKO and Senior Citizen Home Safety Association)
- Development of Hong Kong Heat Index (HKO and JC School of Public Health and Primary Care, Chinese University of Hong Kong (CUHK))

Infectious Disease (HKO and Department of Microbiology, CUHK)

- Seasonal influenza activity in Hong Kong and its association with meteorological variations
- Rotavirus Activity and Meteorological Variations
- Seasonality of Common Respiratory Viruses in Hong Kong

Vector-borne Disease (HKO and Food and Environmental Hygiene Department)

- A climate model for predicting the abundance of Aedes mosquitoes in Hong Kong

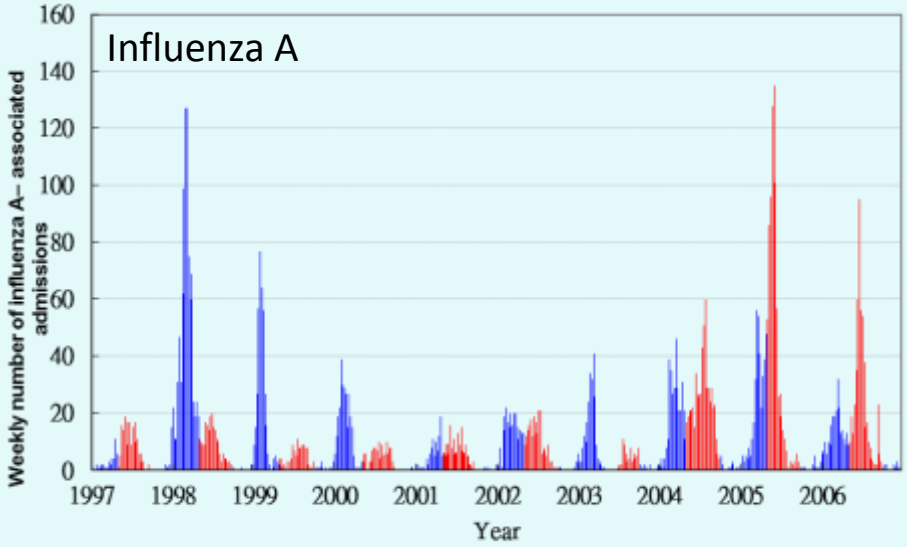
Papers published can be found at : http://www.hko.gov.hk/climate_change/publication_hko_e.htm

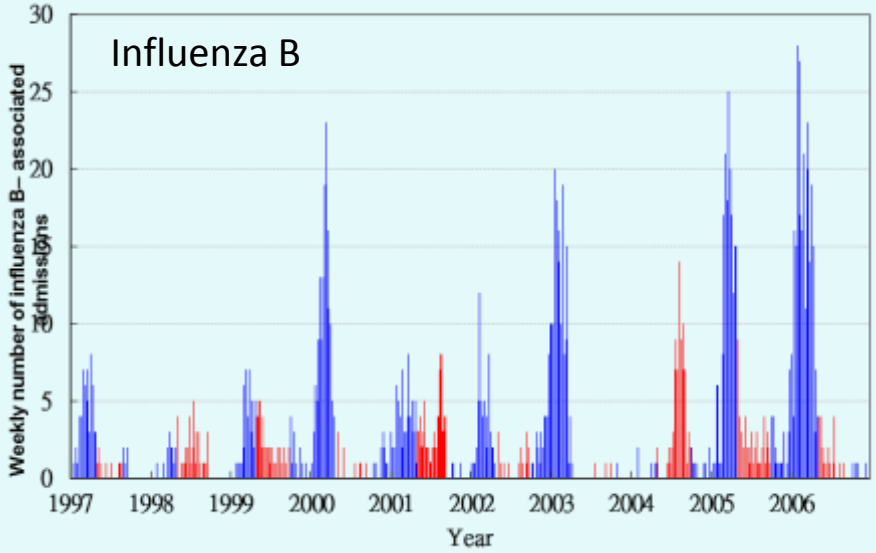
HKO + Microbiology Department of CUHK

Seasonal variations of Influenza in Hong Kong

- jointly conducted a study on influenza and climate in Hong Kong.

- The daily number of laboratory-confirmed influenza A and B cases admitted to the Prince of Wales Hospital and the weather data recorded at the Observatory's automatic weather station at Shatin from 1997 to 2006 were used for the study.





- **2 peaks for influenza A**
- **Winter/spring peak - Feb / Mar**
- **Summer peak – Jun / July**

- **1 (2 in some yrs) peak for influenza B**
- **Major: Winter/spring peak - Feb / Mar**
- **Minor, less consistent: Summer peak – 4 out of 10 yr**

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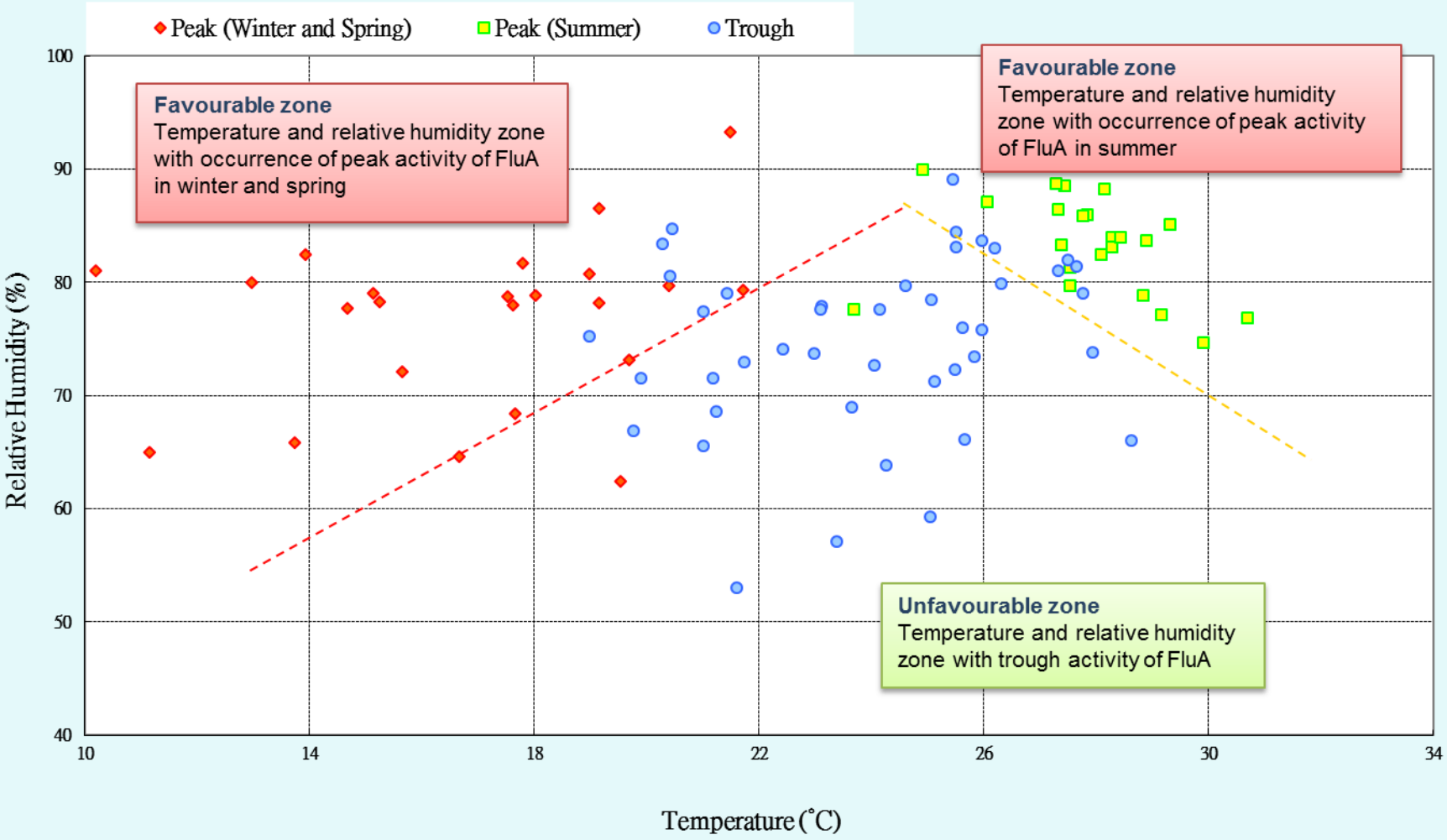
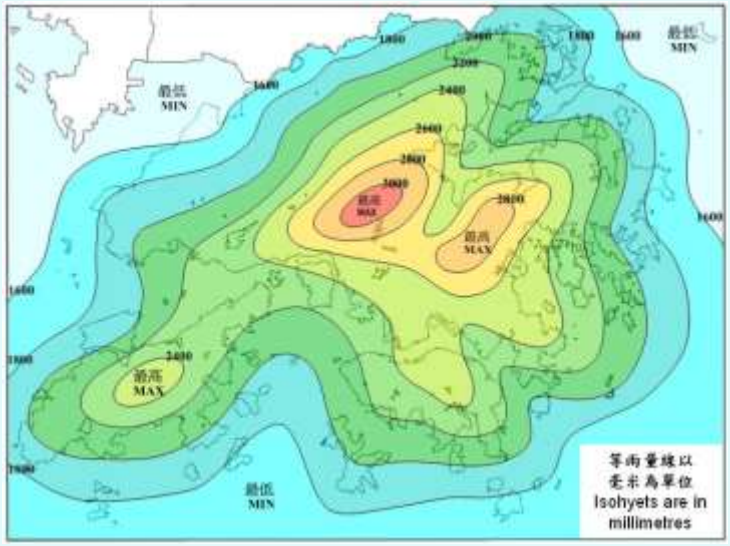
Favourable climatic zones for influenza A



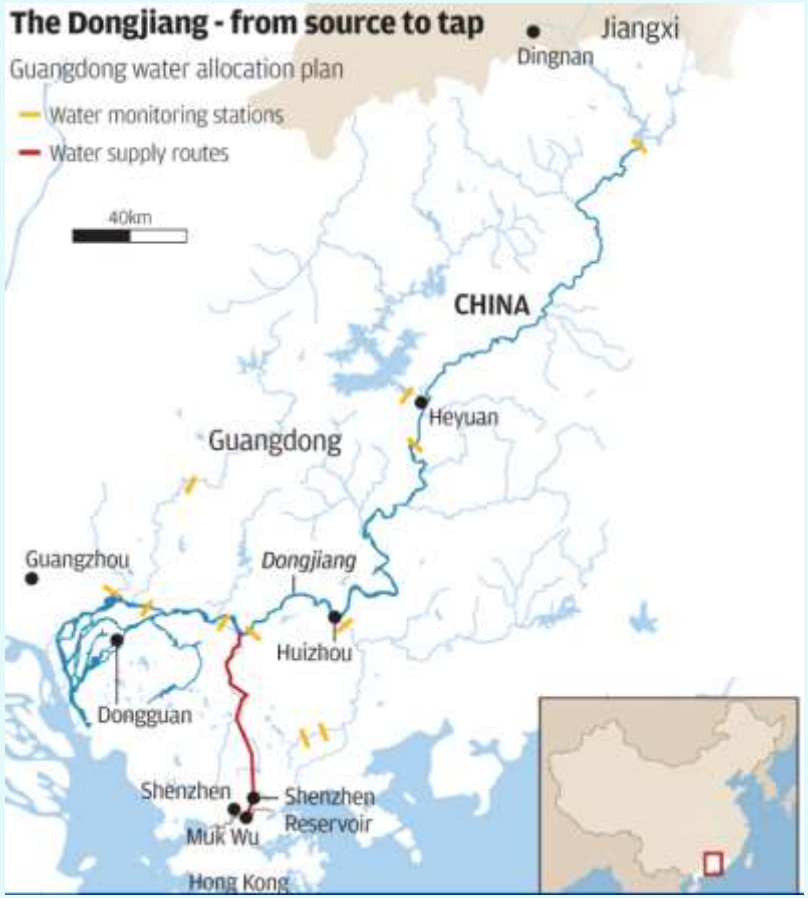
(Ref : Chan, Paul K.S., H.Y. Mok, T.C. Lee, Ida M.T. Chu, W.Y. Lam and Joseph J.Y. Sung, 2009 : Seasonal Influenza Activity in Hong Kong and its Association With Meteorological Variation, Journal of Medical Virology 81:1797–1806)

Rainfall and Water Resource Management

Rainfall data collected in Hong Kong and nearby areas are useful in various aspects of water resource management. In recent years, about 80 percent of the fresh water demands of Hong Kong are supplied from the Dongjiang River Basin.



Rainfall distribution in Hong Kong (1981-2010)



(Courtesy of SCMP, http://www.scmp.com/news/hong-kong/health-environment/article/1838499/turning-tide-could-leave-hong-kong-deep-water)

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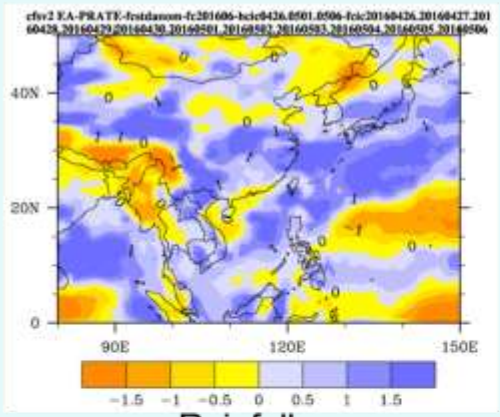
HKO + Water Supplies Department (WSD)

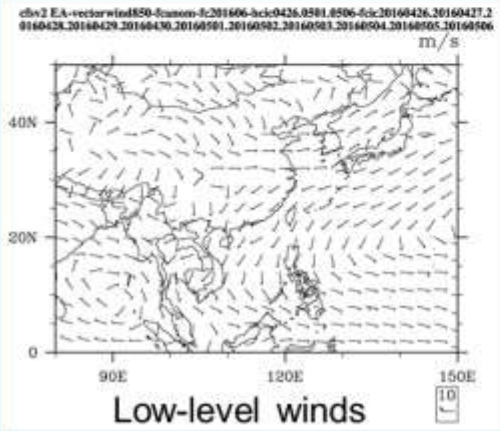
Reservoir yield prediction

Provide reference for WSD to assess the quantity of water to be imported from Dongjiang

Climate models' output



Rainfall



Low-level winds

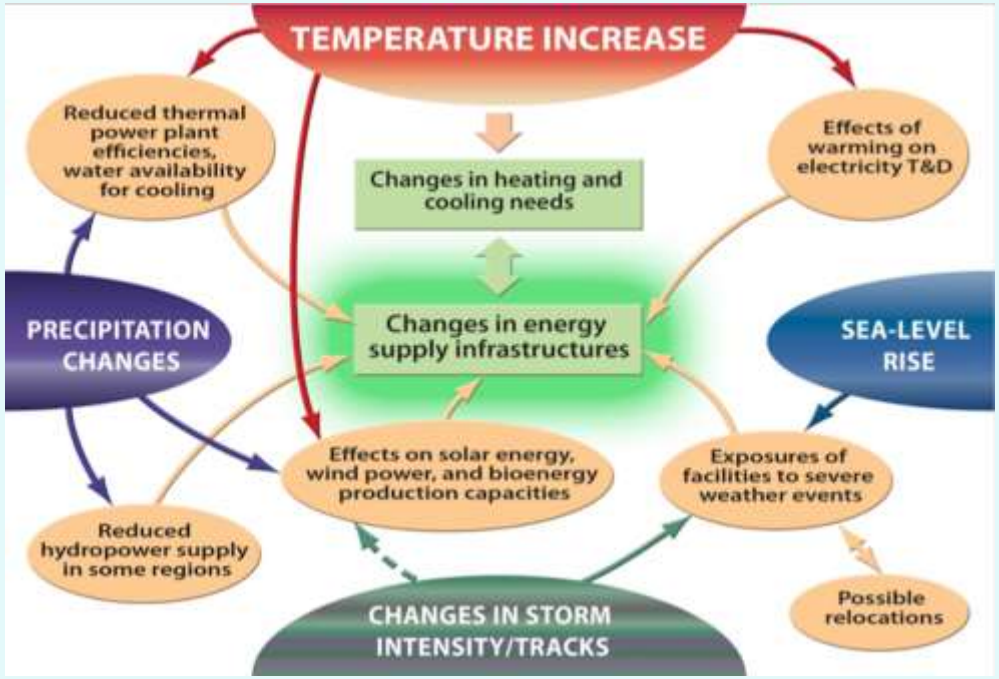
Calibration, statistical methods, expert judgement:

2016 JUN	Yield (RMSE)			
	JMA	NCEP	ECMWF	GRAND
QQMapping	66014 (46150)	53912 (44679)	61405 (47869)	- (-)
Std Anomaly Mapping	65416 (46843)	51918 (45094)	62446 (48541)	- (-)
Regression-Gamma-Yld	66973 (46599)	63519 (48793)	67352 (47047)	- (-)
Grand-Calib	66135 (46082)	56450 (45995)	63734 (46889)	62377 (45925)
81-10 Clim Mean	68415			
Clim RMSE	43844	43480	43844	43466

Climate Services for the Energy Sector: A New GFCS Priority Area

Development and application of targeted climate products and services through the GFCS can help improve efficiency and reduce risk associated with hydro-meteorological hazards affecting energy systems, in particular to support:

- Greater climate resilience and adaptation across the sector;
- Efficiency and reduction of energy consumption; and
- The growing renewables sub-sector.



(Reference : http://public.wmo.int/en/resources/bulletin/climate-services-energy-sector-new-priority-area-gfcs)

HKO + CLP Power

Saving Energy through Weather Watch

Climate data and user energy consumption data >> CLP's energy consumption forecast model for each high consumption client

9-day weather forecast >> consumption forecast model >> 9-day "Energy Consumption Forecast" in CLP's Meter Online Services*

Timely energy-saving measures could be taken in response to early alerts of high consumption days under hot weather situations for high energy consumption clients.

Peak loading

Forecast daily consumption

Date	05.10.2015 Monday	06.10.2015 Tuesday	07.10.2015 Wednesday	08.10.2015 Thursday	09.10.2015 Friday	10.10.2015 Saturday	11.10.2015 Sunday	12.10.2015 Monday	13.10.2015 Tuesday
Weather Outlook									
Forecast Temperature	28 °C	27 °C	28 °C	28 °C	27 °C	26 °C	24 °C	24 °C	25 °C
Forecast Humidity	81 %	81 %	79 %	76 %	72 %	67 %	60 %	63 %	65 %
Forecast Max. kVA	6,221 @ 13h 6,119 @ 12h 6,083 @ 15h	6,162 @ 13h 6,052 @ 15h 6,048 @ 12h	6,070 @ 13h 5,958 @ 14h 5,947 @ 15h	6,014 @ 13h 5,926 @ 14h 5,915 @ 15h	5,721 @ 13h 5,634 @ 14h 5,615 @ 15h	4,616 @ 11h 4,578 @ 13h 4,568 @ 12h	3,160 @ 15h 3,151 @ 16h 3,151 @ 14h	4,871 @ 13h 4,837 @ 14h 4,768 @ 12h	5,022 @ 13h 4,968 @ 14h 4,919 @ 12h
Forecast Consumption (kWh)	84,502	83,401	82,176	81,029	77,611	64,031	52,607	65,447	67,644
Forecast - Historical Average Consumption (Same month last year) (kWh)	8,340	7,239	6,014	4,867	1,449	-3,437	-12,043	-10,715	-8,518

*Figures highlighted in red are higher than the historical average of same month last year. You may want to implement your energy saving measures.

(Photo courtesy of CLP Power)

* CLP Meter Online services.
https://www.clponline.com.hk/MyBusiness/CustomerService/MeterOnline/Documents/CLP_MeterOnlineLeaflet.pdf

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Future directions

(i) Partner with researchers and collaborators in designing and developing a new set of compact and mobile sensors for enhancing weather and environmental monitoring in the high density urban environment.

(ii) Conduct studies to integrate the collected data in high resolution weather, air quality, urban climate models and other related forecasting systems in support of multi-hazard impact-based forecasts and warnings for the city.

(iii) Establish a data sharing platform in support of Big Data analytics and smart city development, as well as research and development for other weather or climate sensitive operations, applications and services in collaboration with relevant stakeholders.

Some preliminary ideas about the "Integrated weather and environmental monitoring network" in the high density urban environment

Phase I

- Enhance existing Co-WIN stations with new generation multi-functional weather and environmental sensors.
- Explore synergy between HKO, Co-WIN and other departments and stakeholders

Phase II

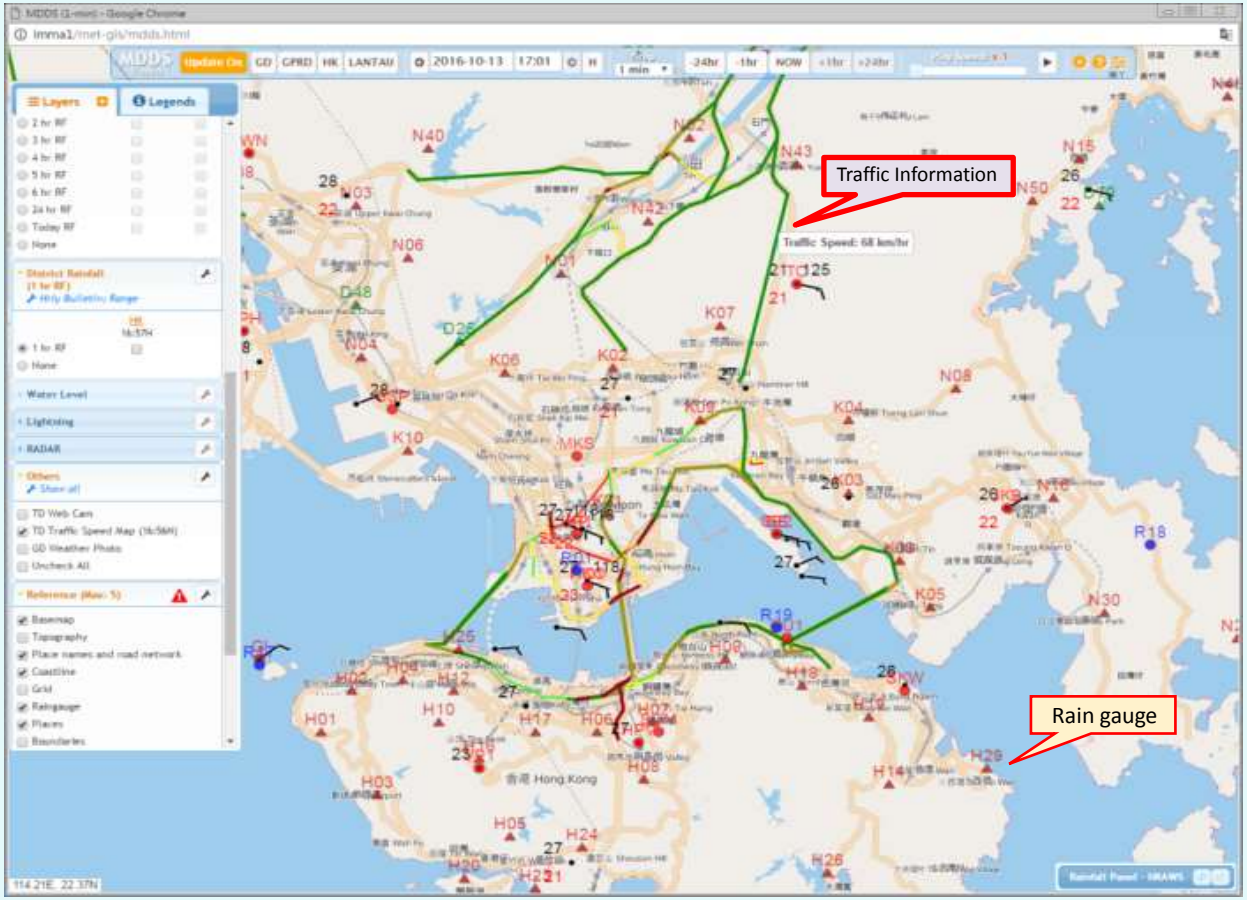
- Design and develop a new set of compact and mobile sensors for "street level" weather and environmental measurements
- Pilot project for a targeted area

Phase III

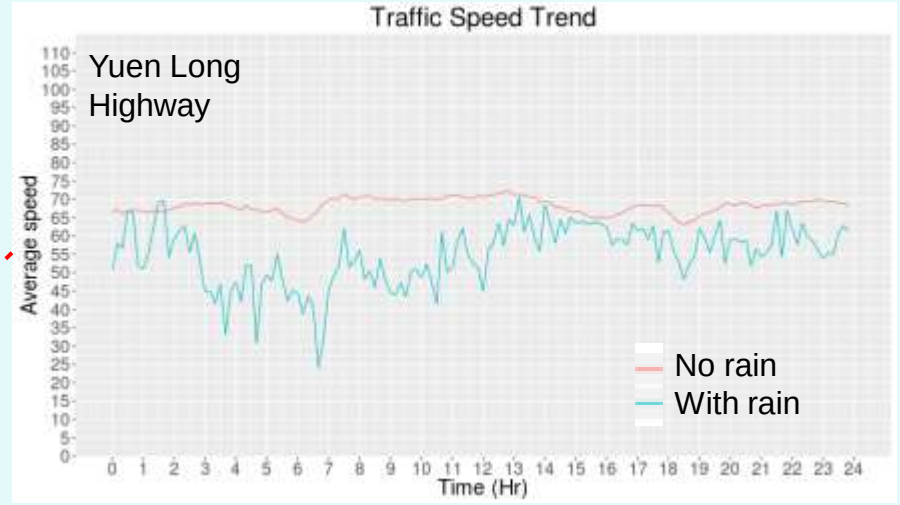
- Set up data sharing platform (may be expanded based on existing version of Co-WIN website)

Weather Impact on Road Traffic

- Traffic congestion a commonplace in HK, and can become even worse in rainy days
- Study launched in collaboration with other government departments using big data analytics

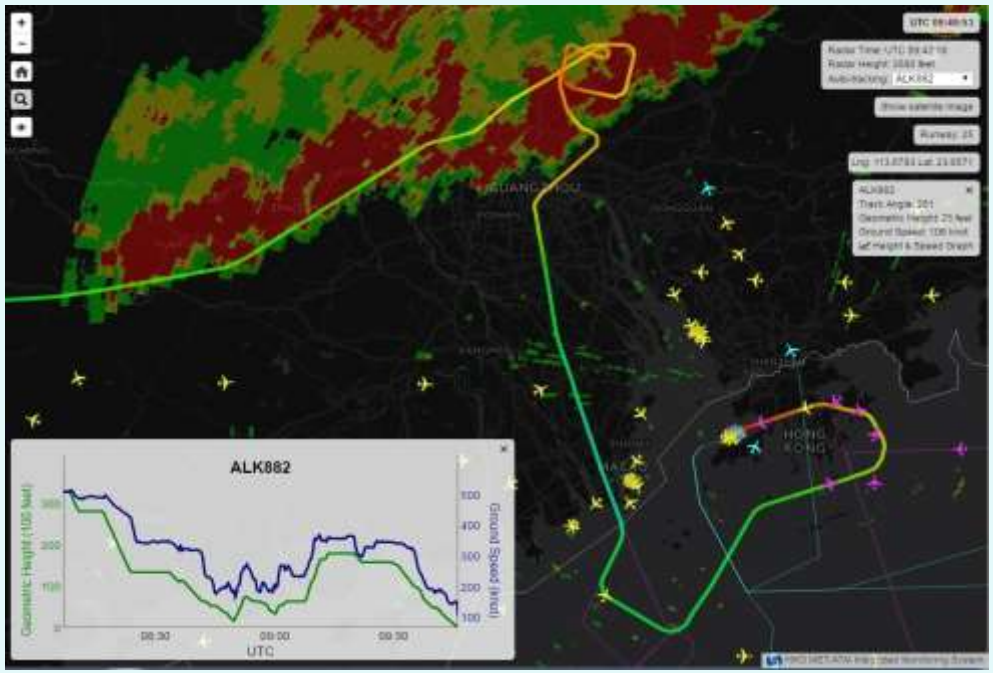


- Study the correlation between rainfall amount and traffic speed
- Aim at predicting impact on road traffic due to rain



Aircraft Surveillance × Weather

- Weather also a crucial factor for air traffic
- Avoidance of significant weather for safety concern
  -> increase in fuel consumption, flight delays & reduction of airport capacity
- Research project embarked to uncover the hidden relationship between meteorological, aircraft & air traffic data
- To enable automatic nowcast of weather impact on airport & nearby airspace for safer & more efficient air traffic operations



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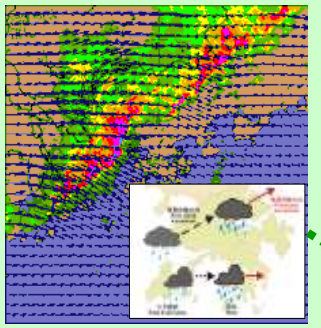
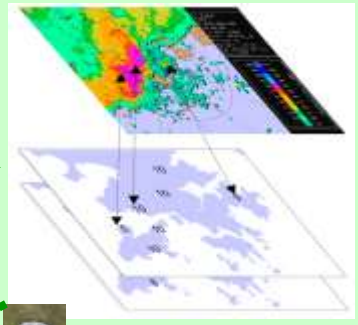
HKO Nowcasting System for Rainstorms - SWIRLS

雷達追蹤、分析及預測
Radar Tracking, Analysis and Forecast

「小渦旋」臨近預報系統
SWIRLS Nowcasting System

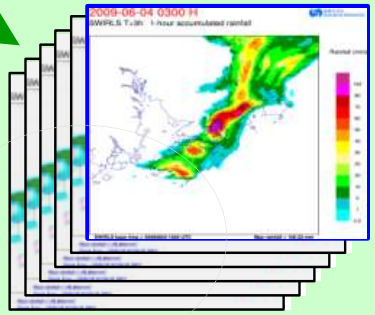
利用雷達自動追蹤及估計雨帶的移動路徑
Automatic tracking and prediction of rainband movement from radar





利用密集的雨量站數據，實時訂正雷達探測降雨率
Real-time calibration of radar-detected rainfall rate using the dense raingauge network

□□□□□□□
Raingauge data



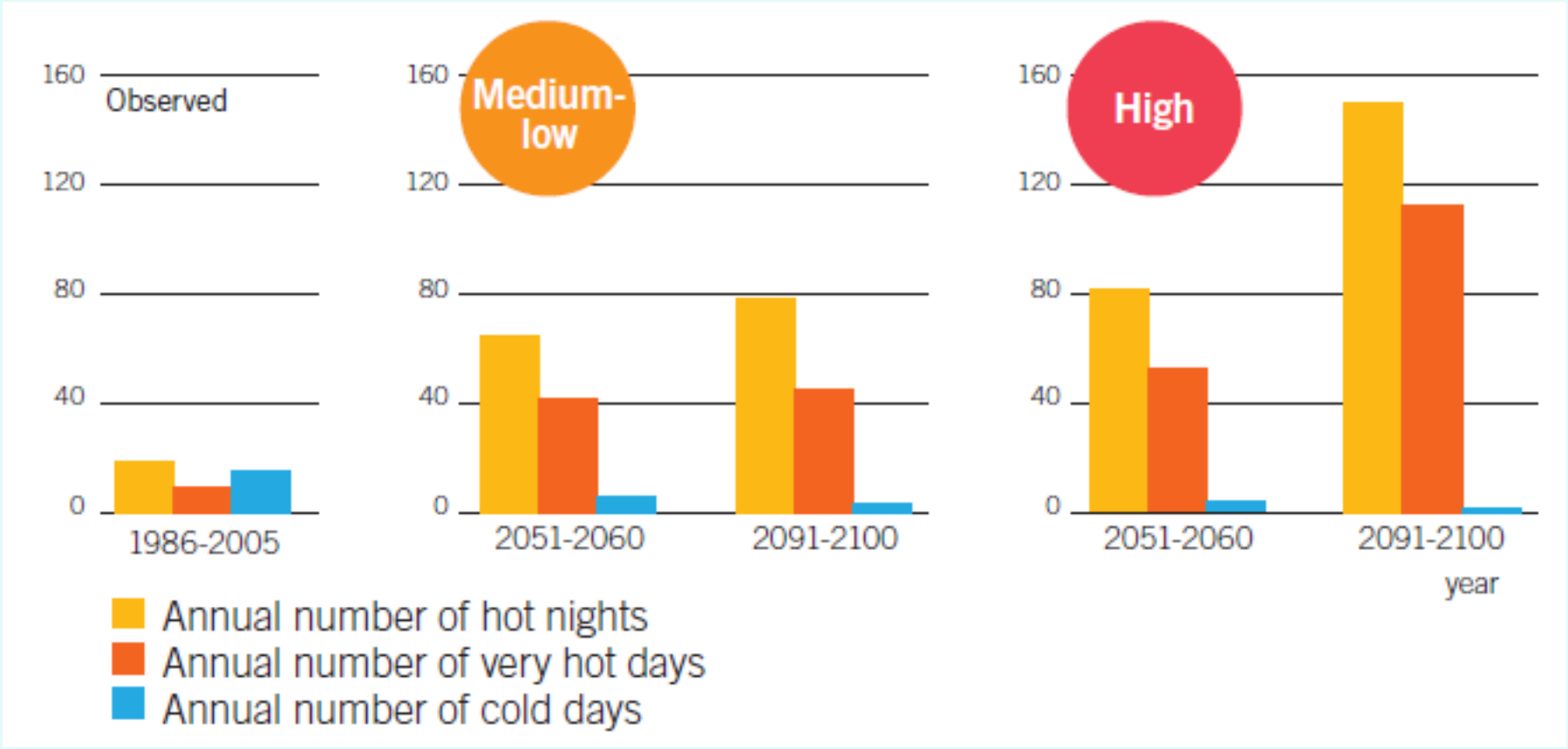
電腦製作未來1至6小時的雷達降雨預測圖
Computer-generated forecast rainfall maps up to 6 hours ahead based on radar

Supporting related warning systems

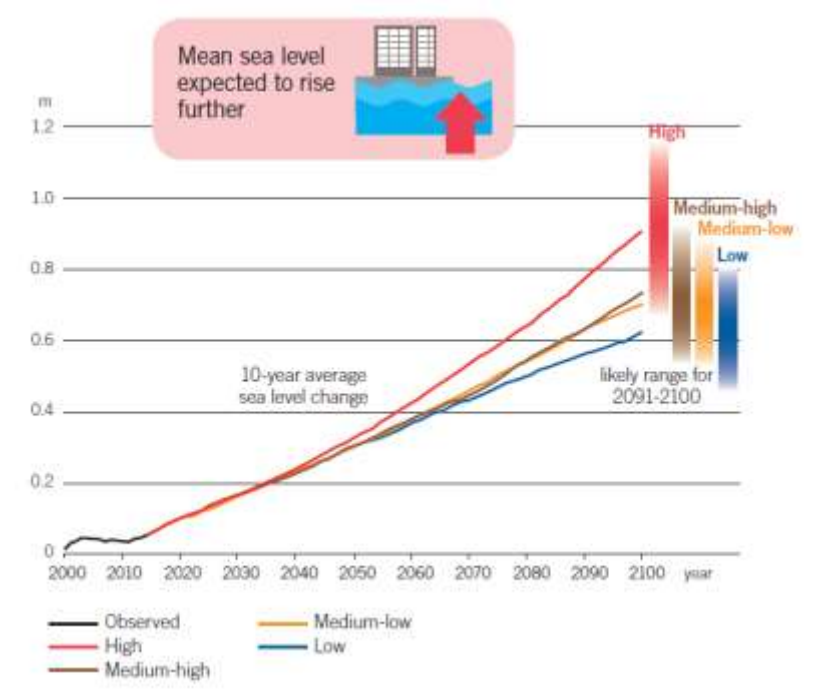
Integration of Weather Information with Geographic Information System (GIS)

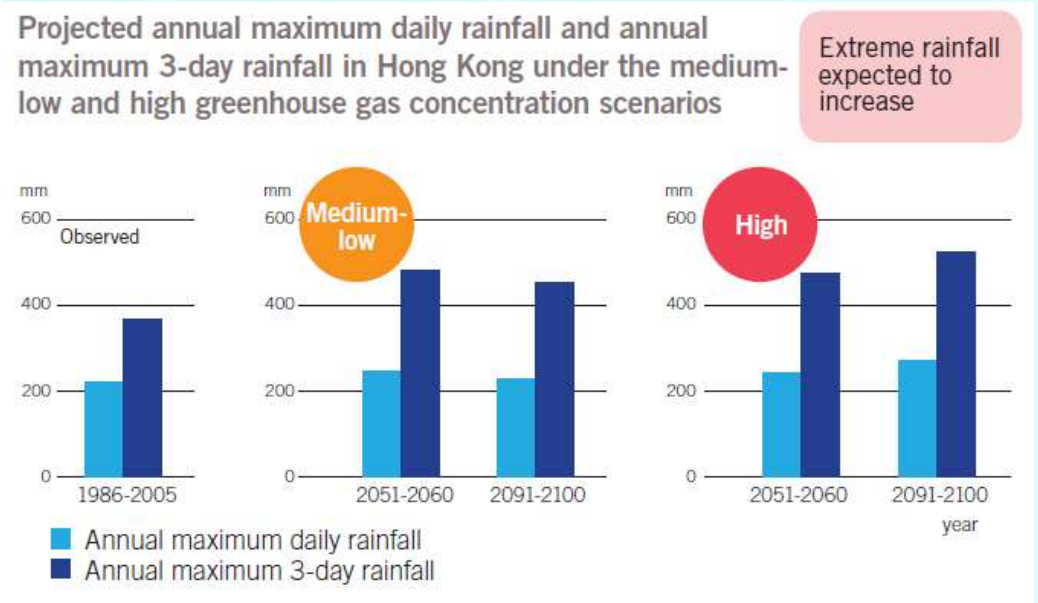
GIS Regional Weather in Hong Kong web page (http://maps.weather.gov.hk)

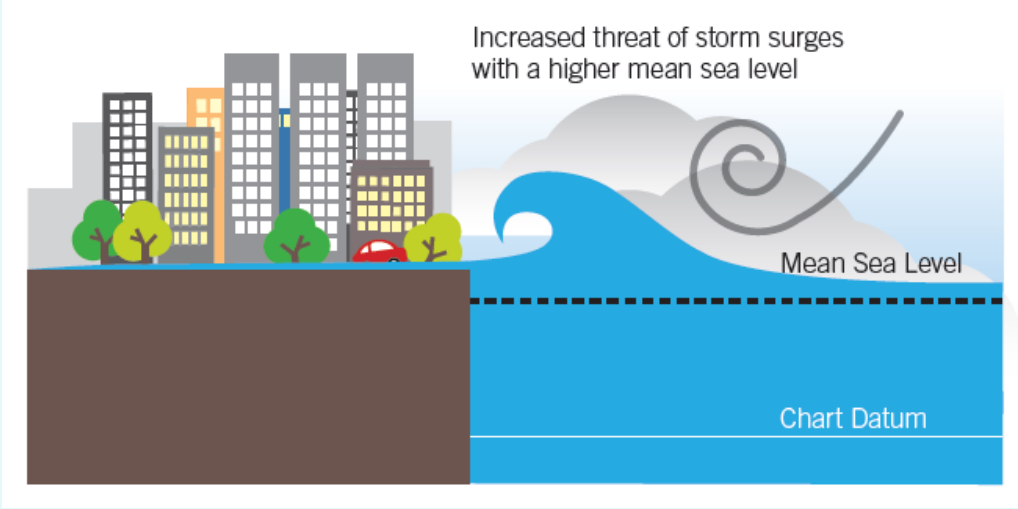
Projected annual number of hot nights, very hot days and cold days in Hong Kong under the medium-low and high greenhouse gas concentration scenarios



Climate change will also bring about higher sea level, more extreme rainfall and increased threat of storm surge in the future







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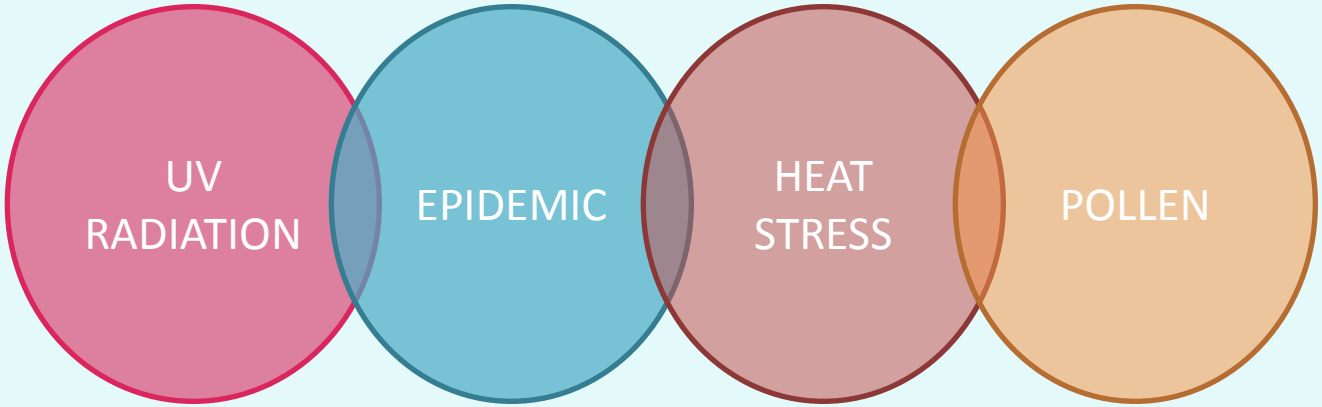
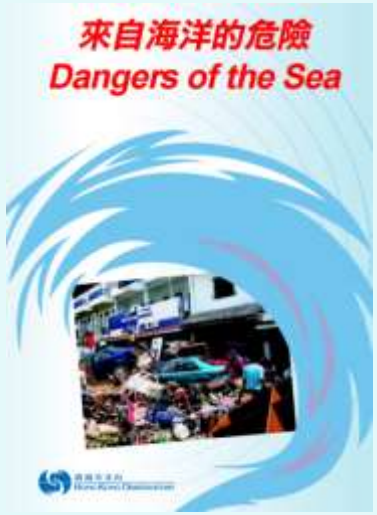
Health × Weather

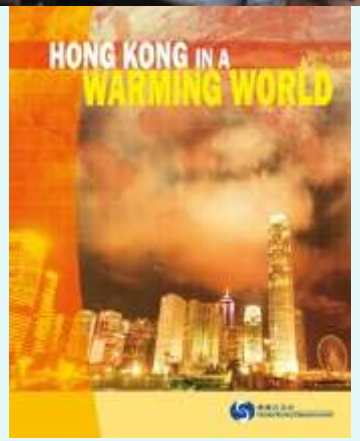
- Extreme weather & climate change pose genuine threat to public health
- Big data analytics on health data, e.g. heart rate and prevailing weather conditions may help generate personalized advice for users
- Partnership to be explored with relevant authorities/private sectors to collect & study health data taking due consideration of privacy issue



Promoting Awareness on Climate Change and Extreme Weather

- **Educational TV programme**
- **Cool Met Stuff (regular TV programme)**
- **Pamphlet**
- **Open day**
- **Blogs**
- **School and public talks**
  (with partners from the engineering sector and other gov. depts)





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