The World Weather Research Programme
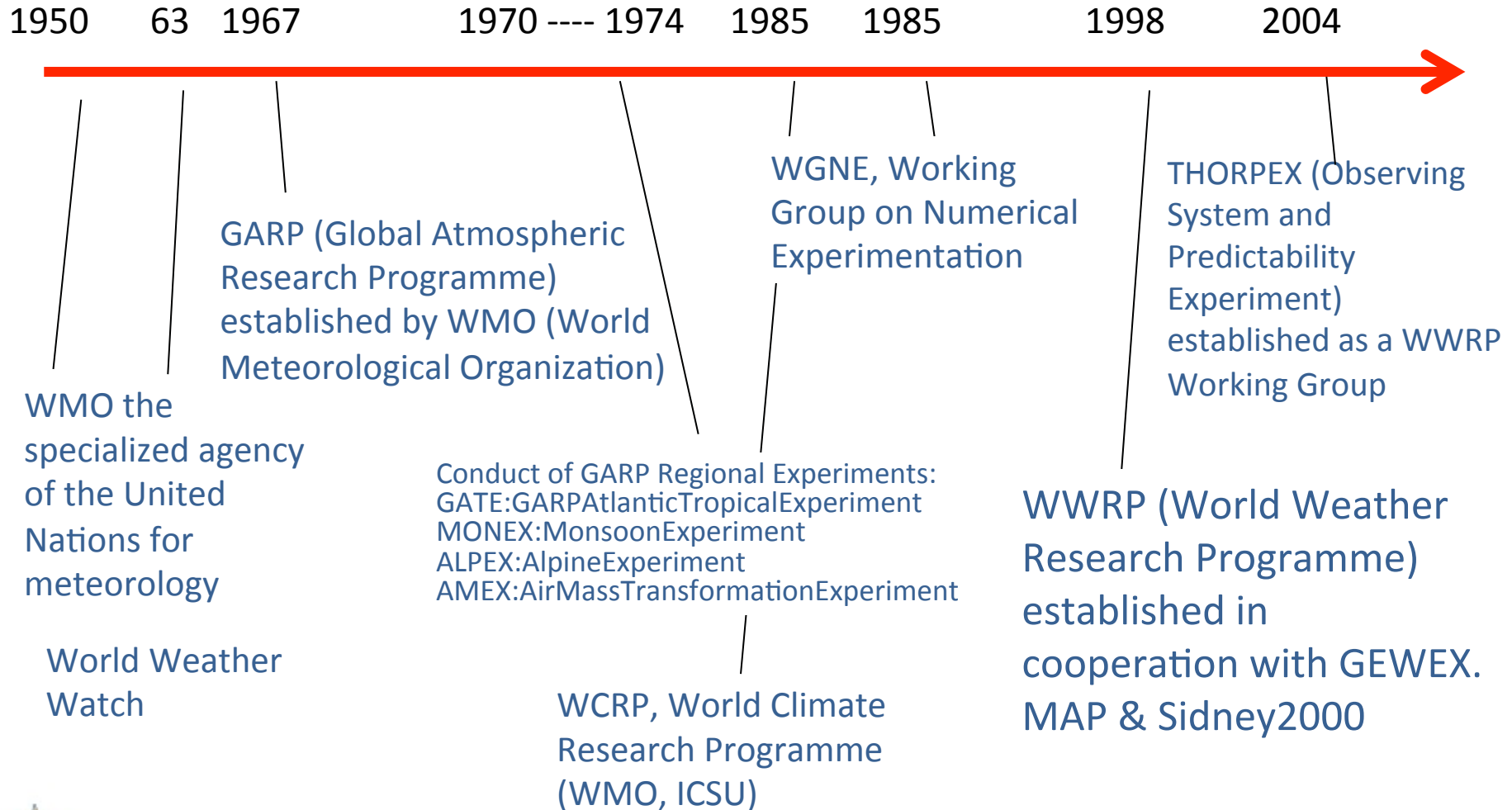
Paolo Ruti, Chief World Weather Research Division
Sarah Jones, Chair Scientific Steering Committee

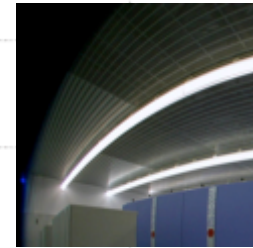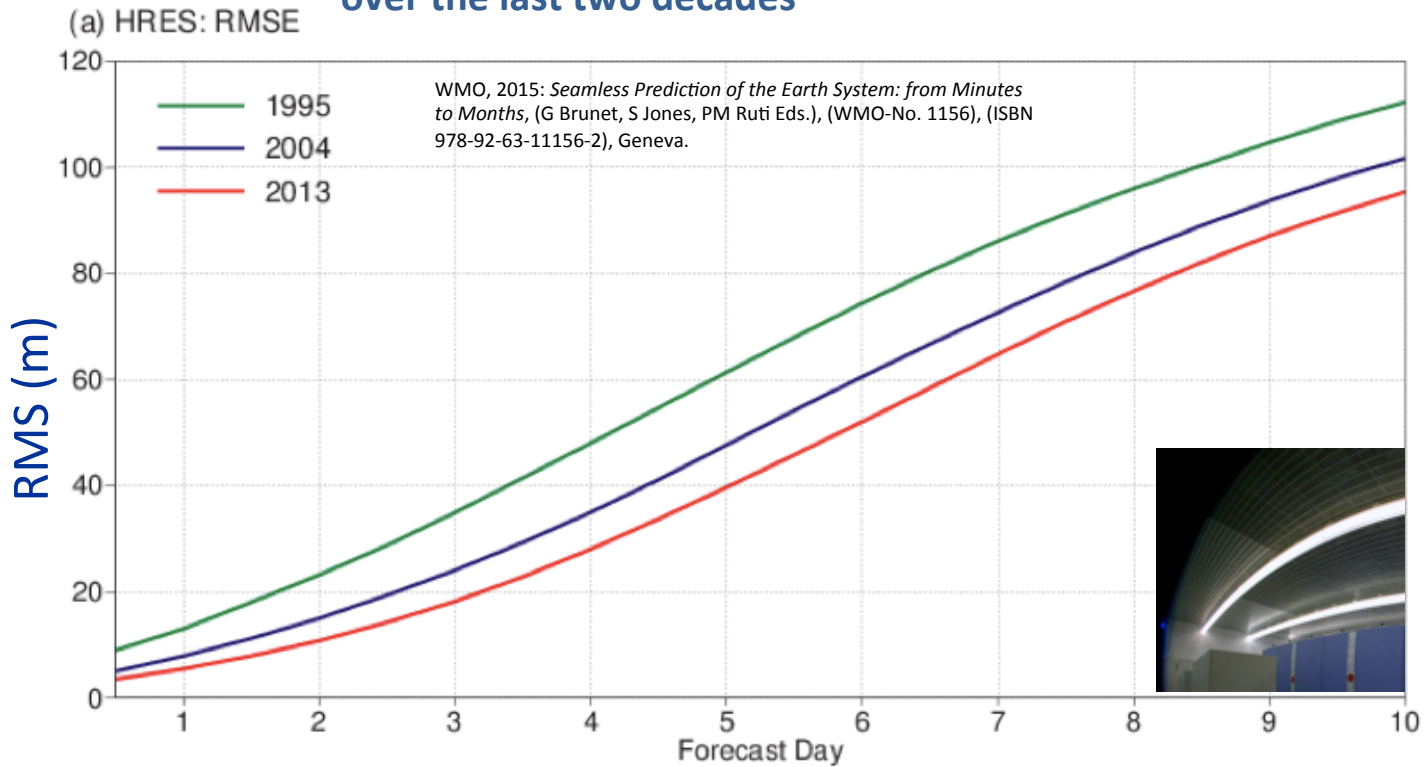WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

WMO OMM

World Meteorological Organization
Organisation météorologique mondiale

WMO research time line

1950   63   1967   1970 ---- 1974   1985   1985   1998   2004

WMO the specialized agency of the United Nations for meteorology

World Weather Watch

GARP (Global Atmospheric Research Programme) established by WMO (World Meteorological Organization)

Conduct of GARP Regional Experiments:
GATE:GARPAtlanticTropicalExperiment
MONEX:MonsoonExperiment
ALPEX:AlpineExperiment
AMEX:AirMassTransformationExperiment

WCRP, World Climate Research Programme (WMO, ICSU)

WGNE, Working Group on Numerical Experimentation

THORPEX (Observing System and Predictability Experiment) established as a WWRP Working Group

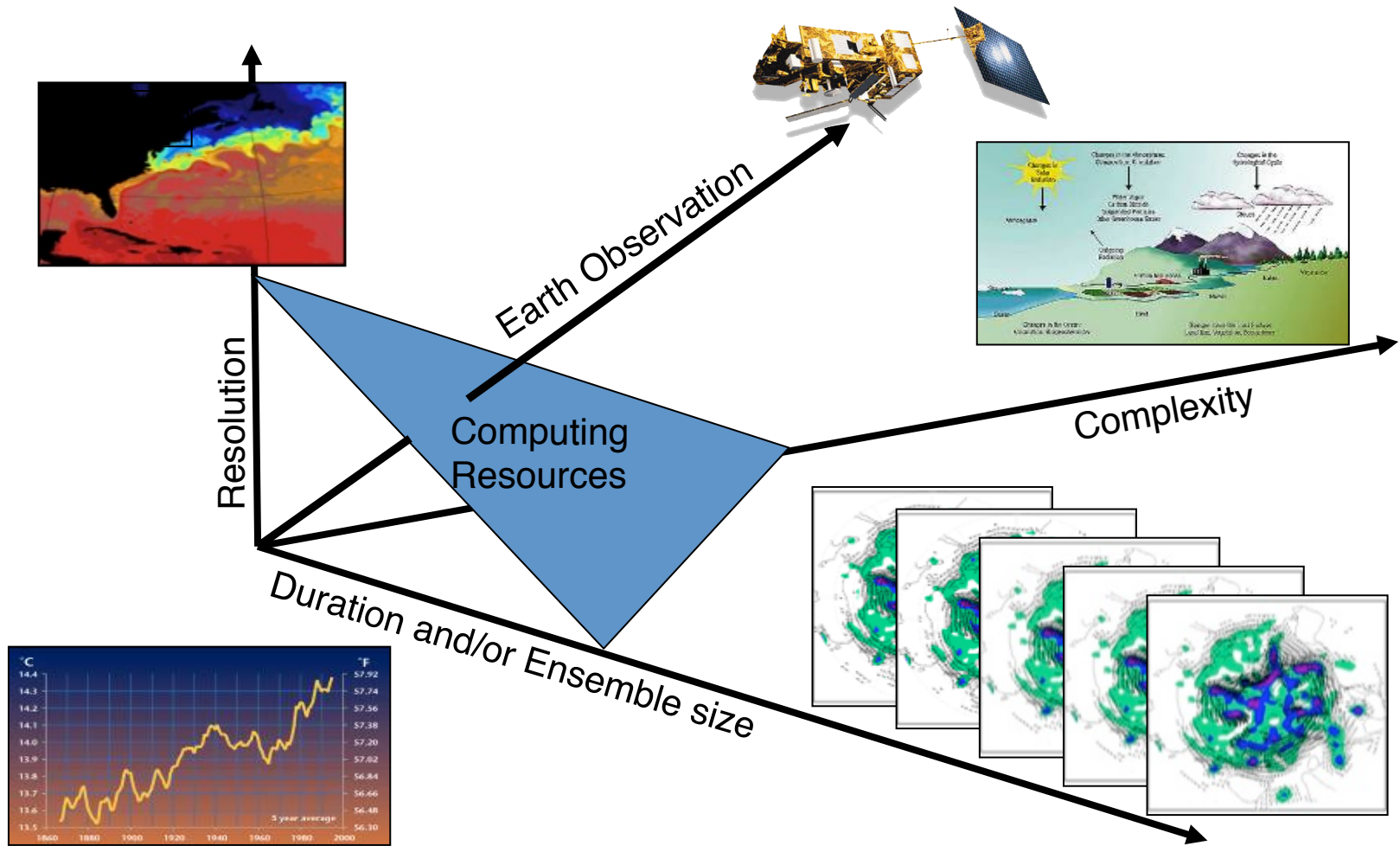WWRP (World Weather Research Programme) established in cooperation with GEWEX. MAP & Sidney2000

WMO OMM

Improving the skill – big resources

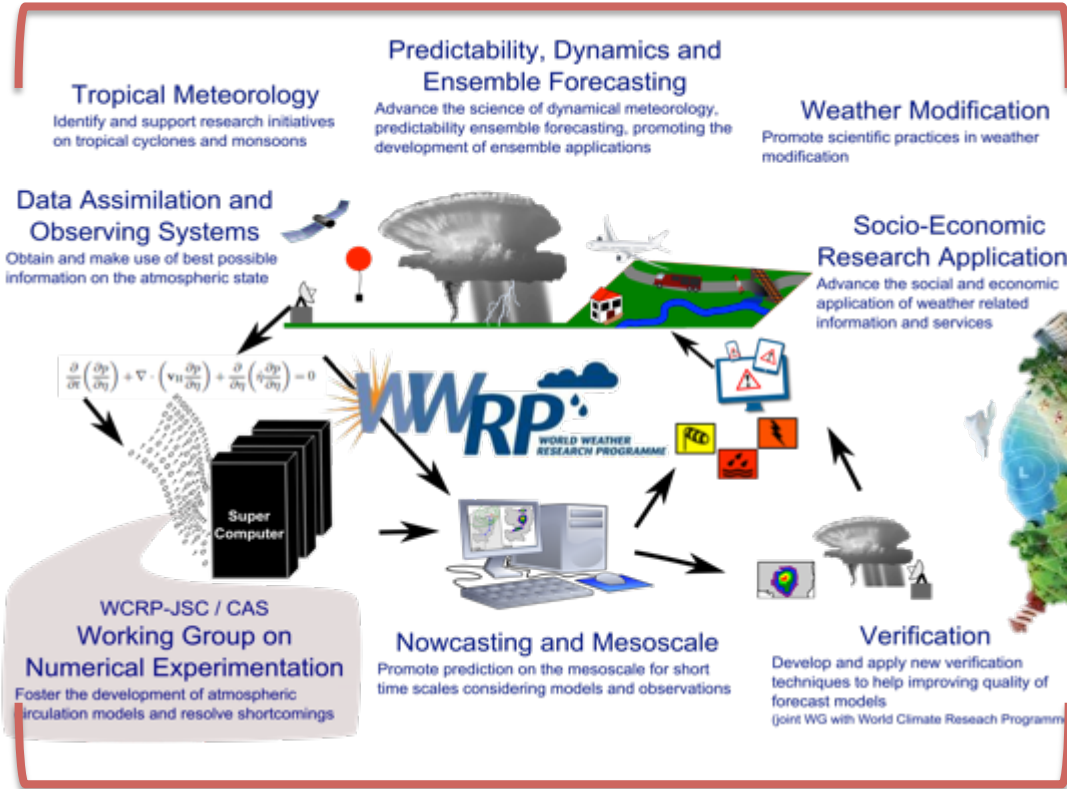**ECMWF's forecast Z500hPa extra-tropical error growth over the last two decades**

(a) HRES: RMSE

WMO, 2015: *Seamless Prediction of the Earth System: from Minutes to Months*, (G Brunet, S Jones, PM Ruti Eds.), (WMO-No. 1156), (ISBN 978-92-63-11156-2), Geneva.

ECMWF

WMO OMM

A seamless approach to predictions

Resolution

Earth Observation

Complexity

Computing Resources

Duration and/or Ensemble size

WMO OMM

WWRP Societal Challenges
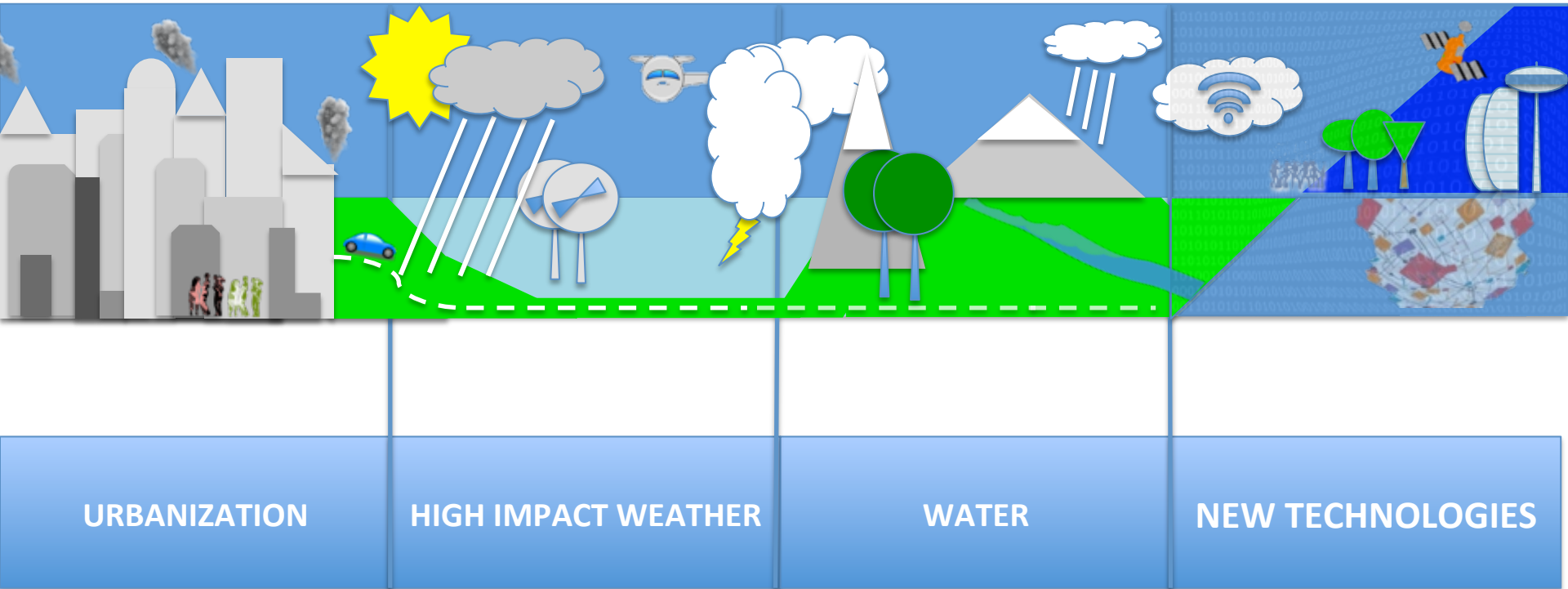
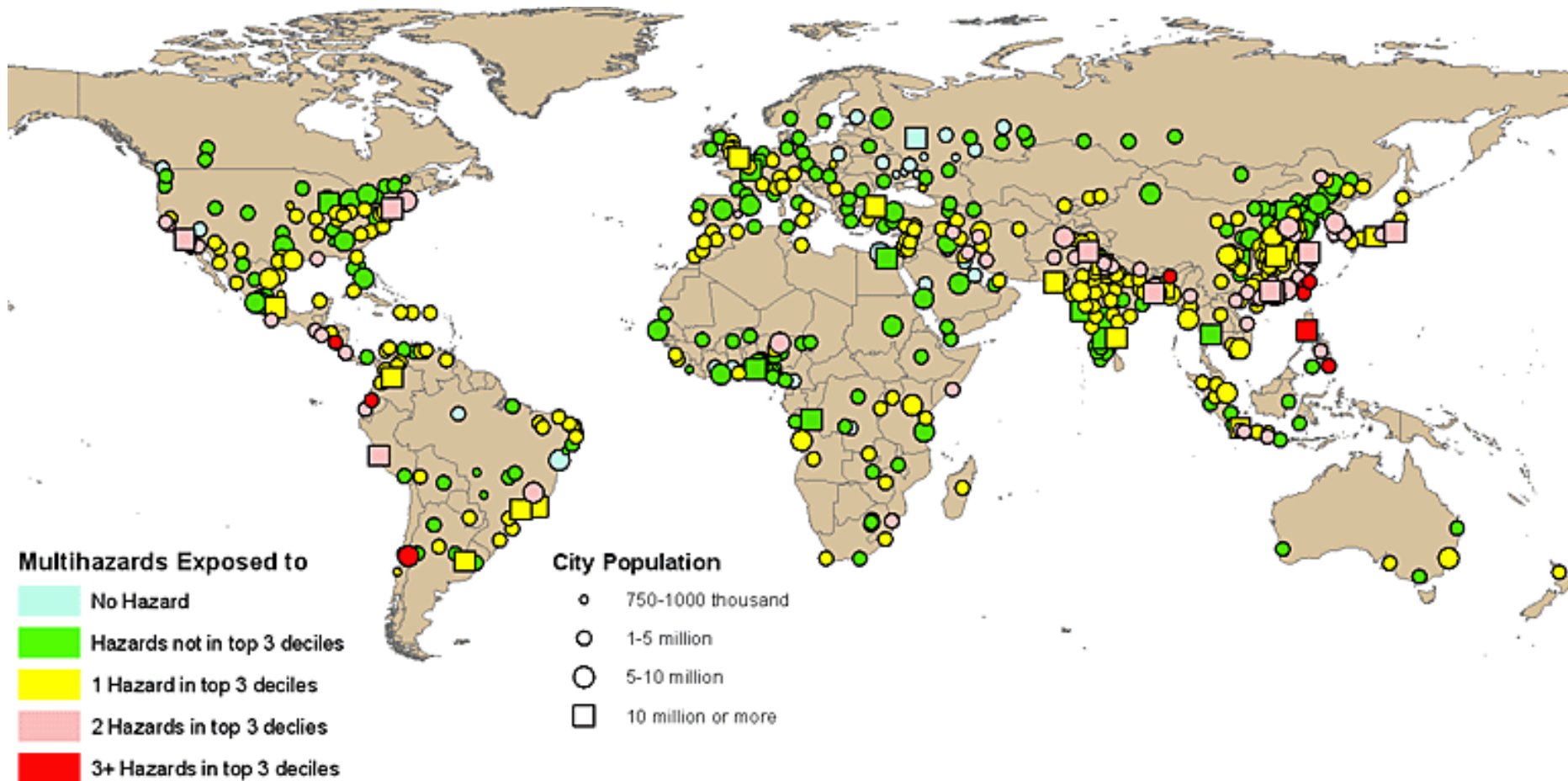| URBANIZATION | HIGH IMPACT WEATHER | WATER | NEW TECHNOLOGIES |

WMO OMM

WWRP Structure

Overarching goals

- **Towards Environmental Prediction,** integrating modeling components (hydrology, sea-ice, ocean, atmospheric composition) to improve forecasting systems
  → **Ex. Polar Prediction Project**

- **Towards a seamless predictive capability,** developing a unified approach to advance environmental prediction from minutes to months and seasons, from global to local, for different users
  → **Ex. Sub-seasonal to Seasonal Prediction Project**

- **Towards impacts forecasting,** building community resilience in the face of increasing vulnerability to extreme weather events, through a better understanding of communication and decision-making processes
  → **Ex. High-Impact Weather Project**

WMO OMM

High Impact Weather Project

WMO OMM

Urban vulnerability a challenge for predictions

Multihazards Exposed to

▫	No Hazard
🟩	Hazards not in top 3 deciles
🟨	1 Hazard in top 3 deciles
🟫	2 Hazards in top 3 declies
🟥	3+ Hazards in top 3 deciles

City Population

∘	750-1000 thousand
○	1-5 million
○	5-10 million
□	10 million or more

Urban agglomerations at risk of multiple natural hazards (2025)

WMO OMM

HIWeather targets

Urban Flood: Reducing mortality, morbidity, damage and disruption from flood inundation by intense rain.

Disruptive Winter Weather: Reducing mortality, morbidity, damage and disruption from snow, ice and fog to transport, power & communications infrastructure.

Wildfire: Reducing mortality, morbidity, damage and disruption from wildfires & their smoke.

Urban Heat Waves & Air Pollution: Reducing mortality, morbidity and disruption from extreme heat & pollution in the megacities of the developing and newly developed world.

Extreme Local Wind: Reducing mortality, morbidity, damage and disruption from wind & wind blown debris in tropical & extra-tropical cyclones, downslope windstorms & convective storms, including tornadoes.

Scope defined by a set of hazards
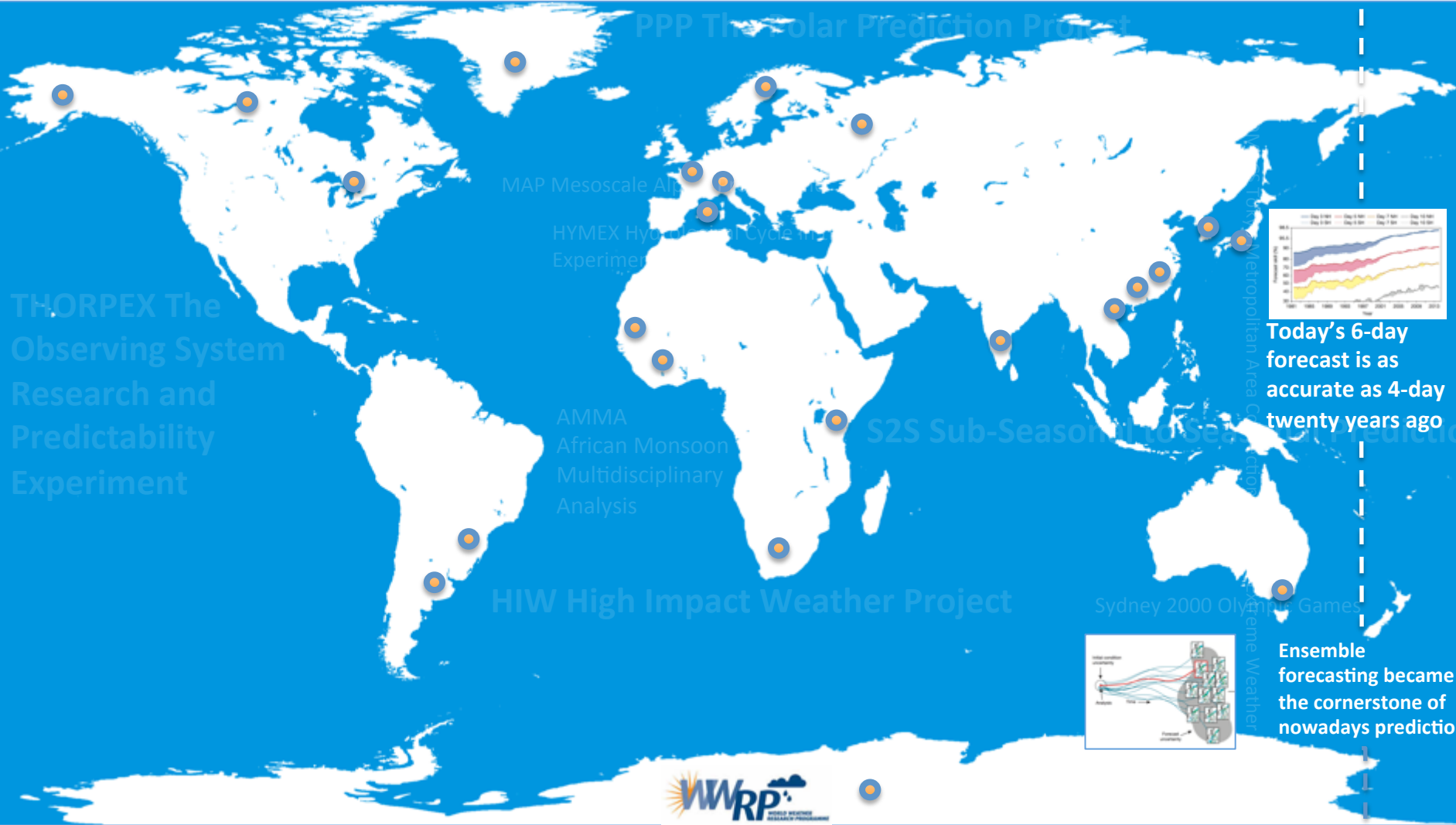
WMO OMM

> 20 Global and Regional Research Projects
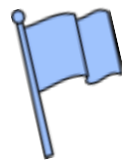
Countries Involved in Research and Capacity Building
50 +

4 Highest Achievements

THORPEX The Observing System Research and Predictability Experiment

PPP The Polar Prediction Project

MAP Mesoscale Alpine

HYMEX Hydrological Cycle Experiment

AMMA African Monsoon Multidisciplinary Analysis

S2S Sub-Seasonal to Seasonal Prediction

HIW High Impact Weather Project

Sydney 2000 Olympic Games

Today's 6-day forecast is as accurate as 4-day twenty years ago

Ensemble forecasting became the cornerstone of nowadays prediction

WWRP WORLD WEATHER RESEARCH PROGRAMME

Innovative solutions in high performance computing and data storage

Unprecedented capacity to integrate millions of daily data in predictions
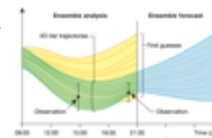
Regional Development Research Projects

- **Southern China Monsoon Rainfall Experiment** (SCMREX) Chinese Academy of Meteorological Sciences (Hong Kong, Japan, Australia, US, Korea). 2013-2018.
- **Beijing Study of Urban-impacts on Rainfall and Fog/haze** (SURF) project. Institute of Urban Meteorology CMA, Beijing (USA, Australia, Japan, Finland) 2014-2017
- **Remote sensing of electrification, lightning and meso-scale / micro-scale processes with adaptive ground observation** (RELAMPAGO) Argentinian Met Service (USA, ...) 2017-2020
- **HIGH impact Weather lAke sYstem** (Highway). WMO, UK, East African Countries. 2017-2020

WMO OMM

Southern China Monsoon Rainfall Experiment

To better understand development of the heavy-rain-producing convective systems in Southern China during early summer, focusing on the roles of:

- **PBL processes and underlying surface;**
- **meso-scale circulations in association with fronts;**
- **microphysical processes**

To improve Quantitative Precipitation Forecast skill by

- **better understanding multi-scale precipitation processes,**
- **assimilating high-resolution observations into numerical models,**
- **convection-permitting (1-3km) ensemble experiments.**

WMO OMM
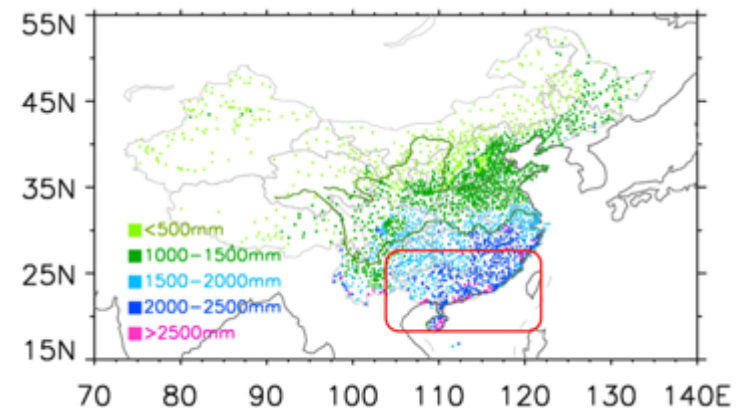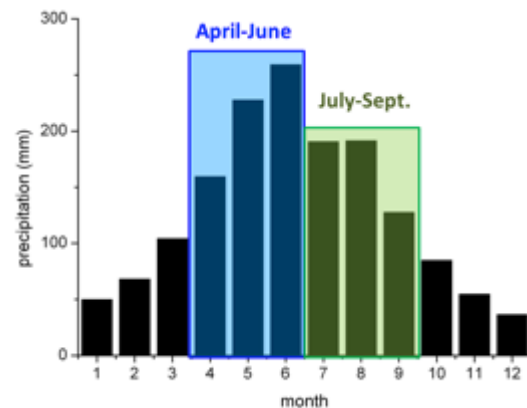
May June Field Campaign: 2014-15-16

Convective scale

Gulf of Tonkin

(110E, 25N)

A Yangjiang Area
B GuangZhou Area

● Sounding
· Surface
▲ DopplerRadar
▲ GPS/MET
— air-borne observation area

(117E, 20N)

Meso-scale

Synoptic scale

South China Sea
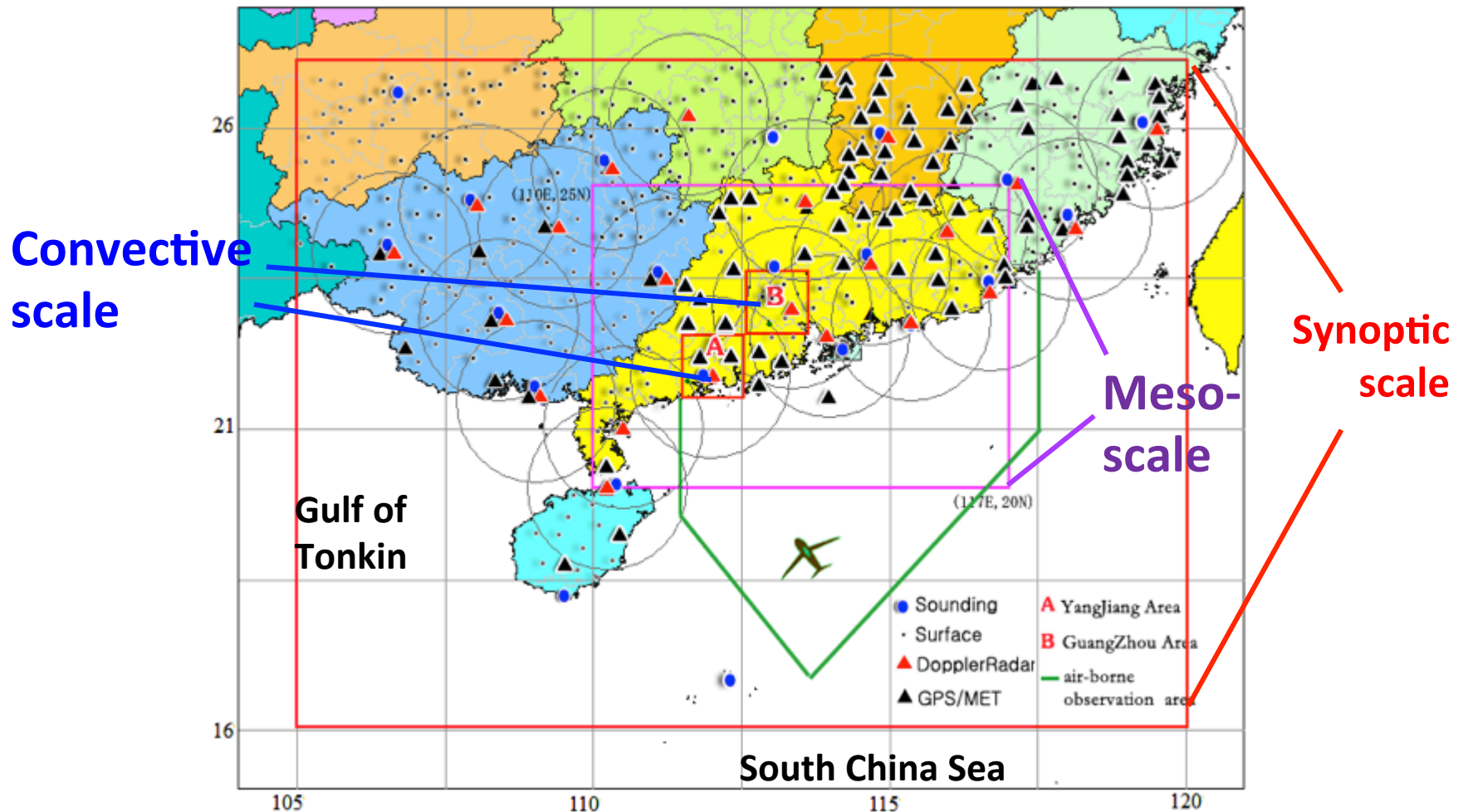
● **Radiosonde sounding station** (23)
▲ GPS/MET water vapor station (85)
national-level AWSs (366)

• **wind-profiling radar (21 operational, 2 portable)**
• **air-borne observations**

WMO

Beijing Study of Urban-impacts on Rainfall and Fog/haze

- **Evaluate & improve high-resolution (~1 km resolution) numerical urban-weather forecast-models**
- **Enhance the applications of urban weather forecasts of stakeholders/end users for societal and economic developments**
- **Specific objectives of Summer heavy rainfall & Winter-aerosol field studies: Better understand Beijing urban, terrain, convection & aerosol interactions convection-permitting (1-3km) ensemble experiments.**

Beijing 2012

Beijing 2013

WMO OMM

2016 Summer Campaign (Ongoing)

King Air

Mobile lidar
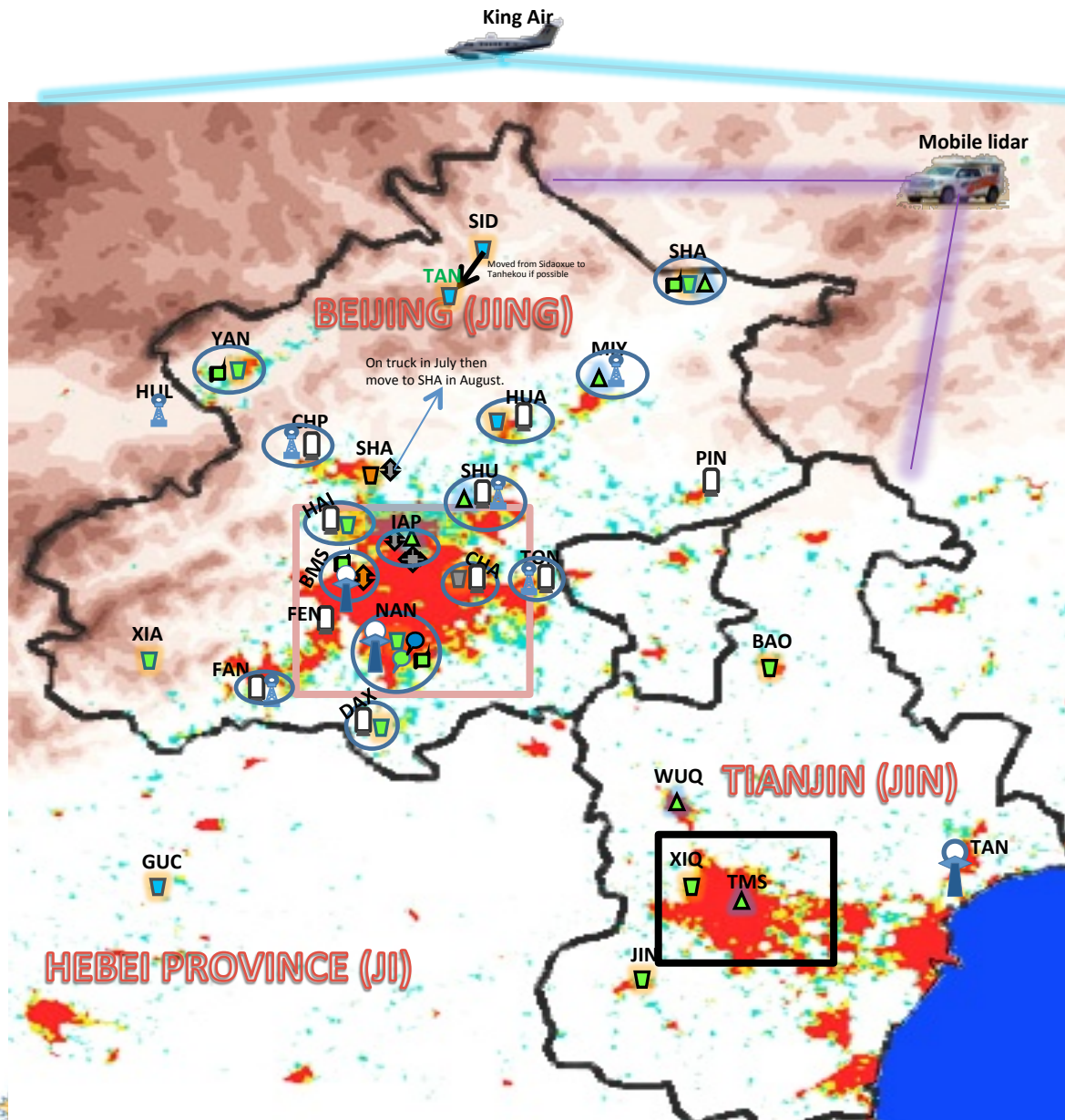
Legend:
- Wind profiler (S)
- Wind profiler (O)
- Wind profiler (R)
- Wind profiler (I)
- Flux tower (O)
- Flux tower (I)
- Radiometer (O)
- Aerosol lidar (I)
- Doppler lidar (I)
- Radiosonde (O)
- GPS Radiosonde (IOP only)
- S/C Band radar (O)
- X-band radar (O)
- Ceilometer (O)

	Total
Wind profiler	16
Radiometer	3
Aerosol lidar	2
Doppler lidar	1
Flux tower	6
Ceilometer	10
Weather radar	4
X-band radar	6

Map labels: SID, TAN, Moved from Sidaoxue to Tanhekou if possible, SHA, BEIJING (JING), YAN, HUL, MIY, On truck in July then move to SHA in August., CHP, SHA, HUA, PIN, SHU, HAI, IAP, BMS, CHA, TON, FEN, NAN, XIA, FAN, DAX, BAO, WUQ, TIANJIN (JIN), GUC, XIQ, TMS, TAN, JIN, HEBEI PROVINCE (JI)

S: data **S**haring site
O: **O**perational site
R: **R**ental instruments
I: **I**UM's instruments

WMO OMM

Remote sensing of electrification, lightning and meso-scale / micro-scale processes with adaptive ground observation

Argentina

- **Has one of the highest frequencies of lightning in the world**
- **Extreme flooding**
- **Produces some of the largest hail in the world**

RELAMPAGO Field experiment to understand:

- **Convection initiation processes**
- **Intensification and upscale growth of convection**
- **Generation of hazardous weather**
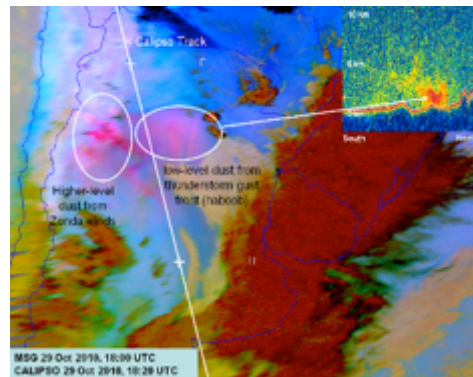
Remote sensing of electrification, lightning and meso-scale / micro-scale processes with adaptive ground observation

WMO OMM
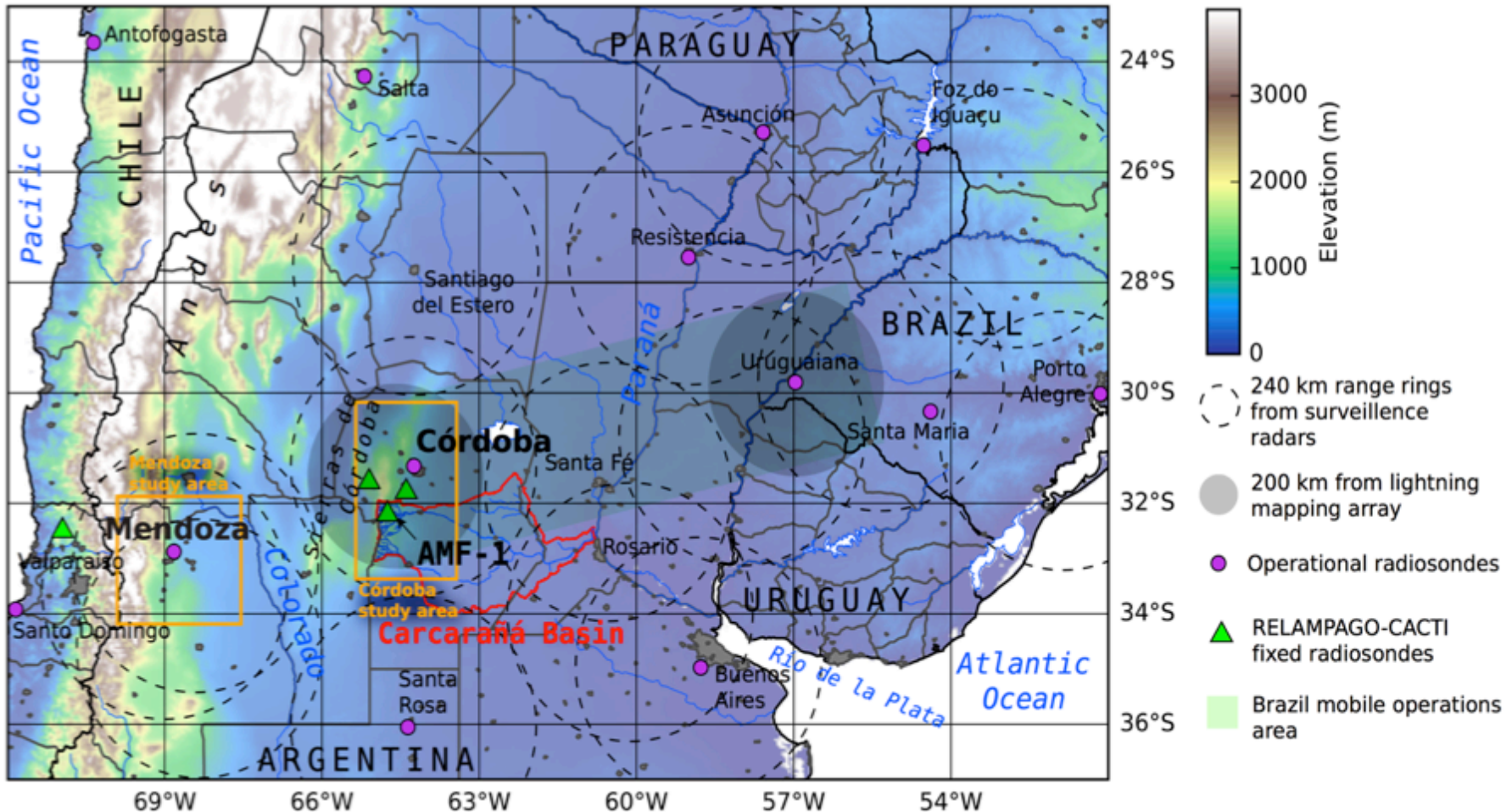
HIGH WAY Principles

HIGH WAY

HIGH impact
Weather
lAke
sYstem

- **Nowcasting** capacity enhancement (observational network enhancement)
- **Improving the local capacity to receive and handle with high-frequency satellite information and high-resolution modelling** (4 km)
- **Pilot projects** with end-users (i.e. Rescue, Aviation)
- **Capacity building** infrastructural component, … enhancement through fellowship, improved links with local universities (key topics, verification services, tailoring products)

WMO OMM

Suggested Field campaign phased approach
some ideas (adapted from other field campaigns, e.g. AMMA)...

Obs

now

EOP

EOP

EOP

Special Observation Period
SOP

LOP

Long Observation period
Includes investment in obs
networks rather than
temporary equipment

> 10 yrs

Number of pilot phases or 'Extra Observation
periods'. Tests equipment, small deployment/
quick start, builds logistical relationships

Time
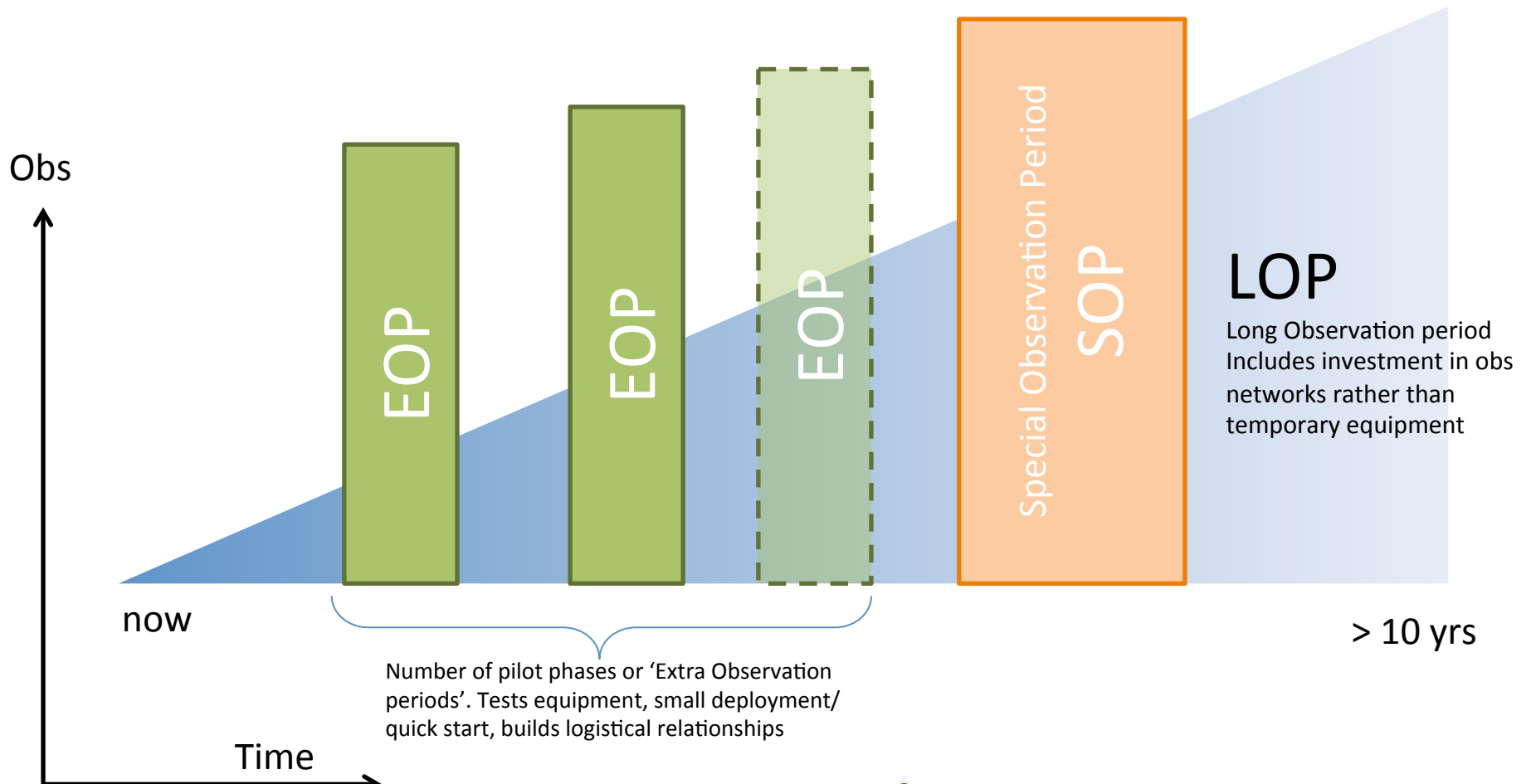
WISER PRINCIPLE → A learning programme

WMO OMM

Key Messages
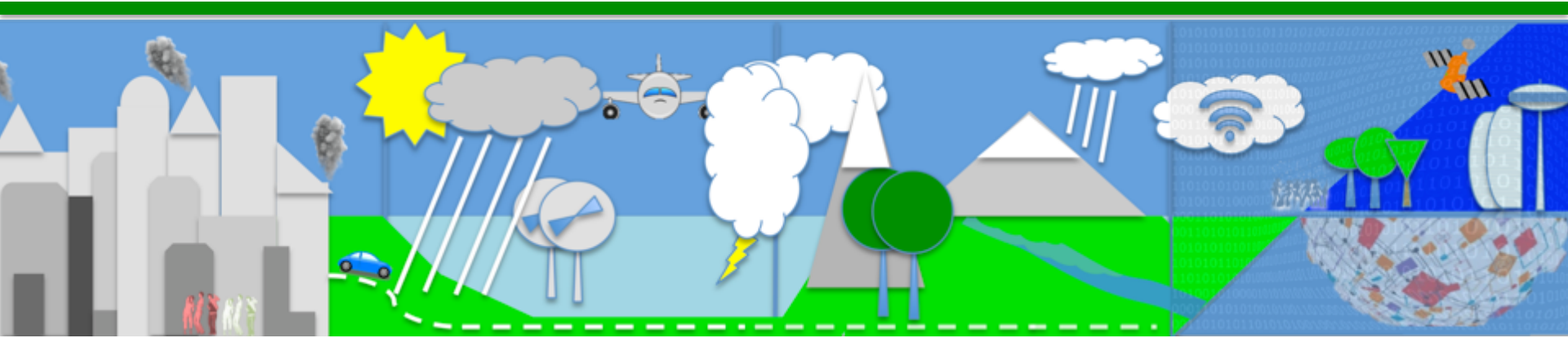
HIGH IMPACT WEATHER – GEWEX EXTREME GC
CATALOGUING EXTREMES
LINKING EXTREME VALUE ANALYSIS TO WEATHER EVENTS
HINDCAST AND FORENSIC ANALYISIS
WEATHER/CLIMATE EXTREMES & COMMUNICATION

REGIONAL DEVELOPMENT– REGIONAL HYDROCLIMATE PROJECTS
A SEAMLESS APPROACH TO REGIONAL SCALE
INVOLVING GLOBAL ATMOSPHERIC SYSTEM STUDIES & GLOBAL LAND
ATMOSPHERE SYSTEM STUDY
COORDINATION WHERE/WHEN POSSIBLE (HYMEX EX …)
SYNERGIES WITH DONORS

WMO OMM

What successful people read before bed?

Google: seamless prediction WMO
https://www.wmo.int/media/content/seamless-prediction-minutes-months

WMO OMM