



World Meteorological Organization

Weather • Climate • Water

WMO Space Programme: anticipated evolution and a Picture of 2040

-- **Development of a Vision of WIGOS
Space-based Component in 2040**

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World Meteorological Organization (WMO)

Value Chain for WMO Space Programme

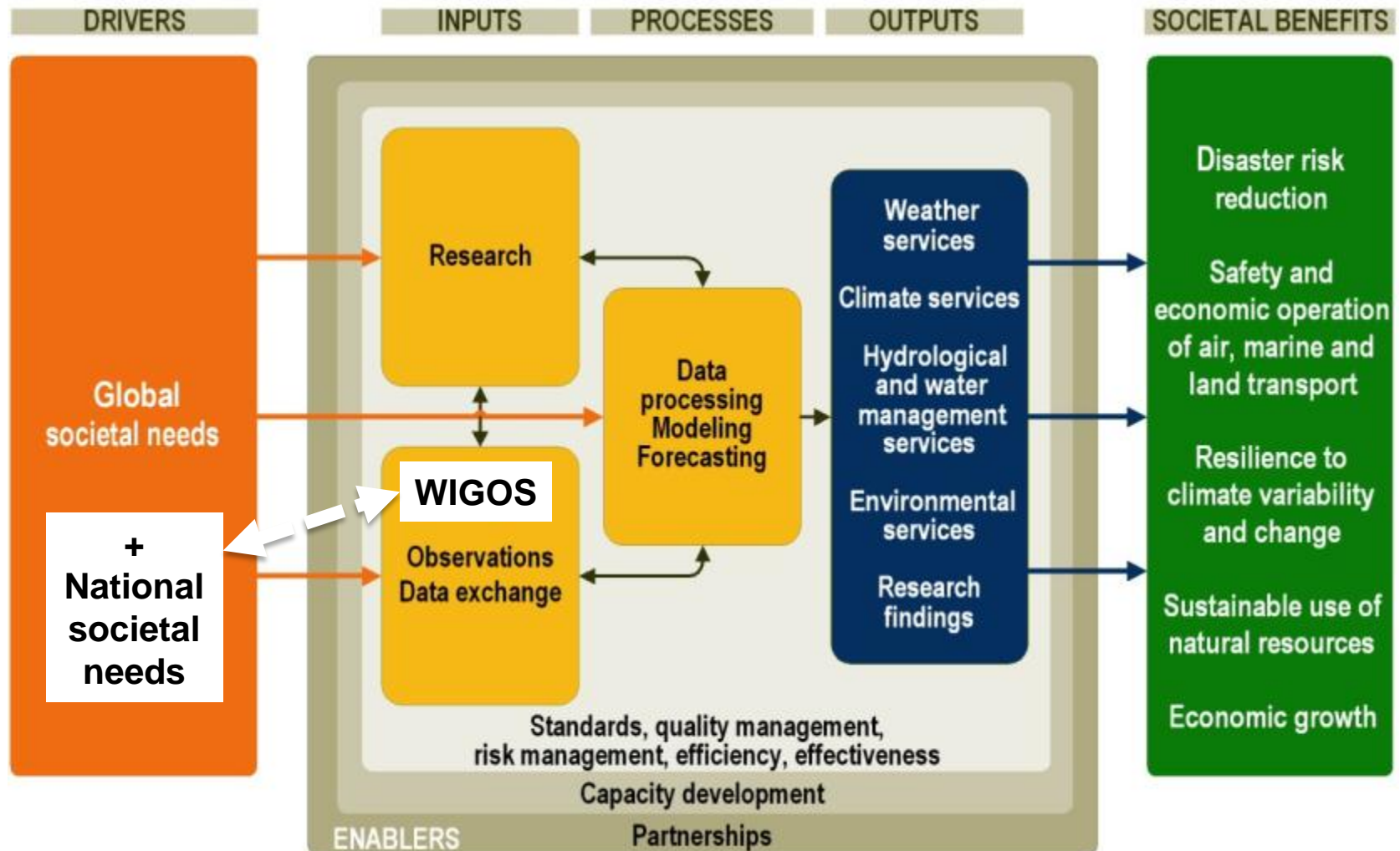




Main drivers for updating the Vision on WMO Global Observing System (GOS)-2025

- Current *Vision of the Global Observing System 2025* played critical role for guiding Members' observing system development.
- However, it needs updating & longer perspective, address new emerging global societal needs, user requirements, and technology advances
 - Global Framework for Climate Services (GFCS), extreme weather & climate events under climate change background, Polar & High Mountain priority, Atmospheric composition & air pollution, hydrology, space weather, etc
- WMO Commission for Basic System (CBS) in 2014 called for a *Vision of WIGOS in 2040*, being developed in 2015-2016.

WMO STRATEGIC PLAN – DRIVEN BY Global Societal Needs



The GFCS initial priority areas

Challenges & opportunities for new partnership to address new observational requirements via user communities

Agriculture



Water



Health

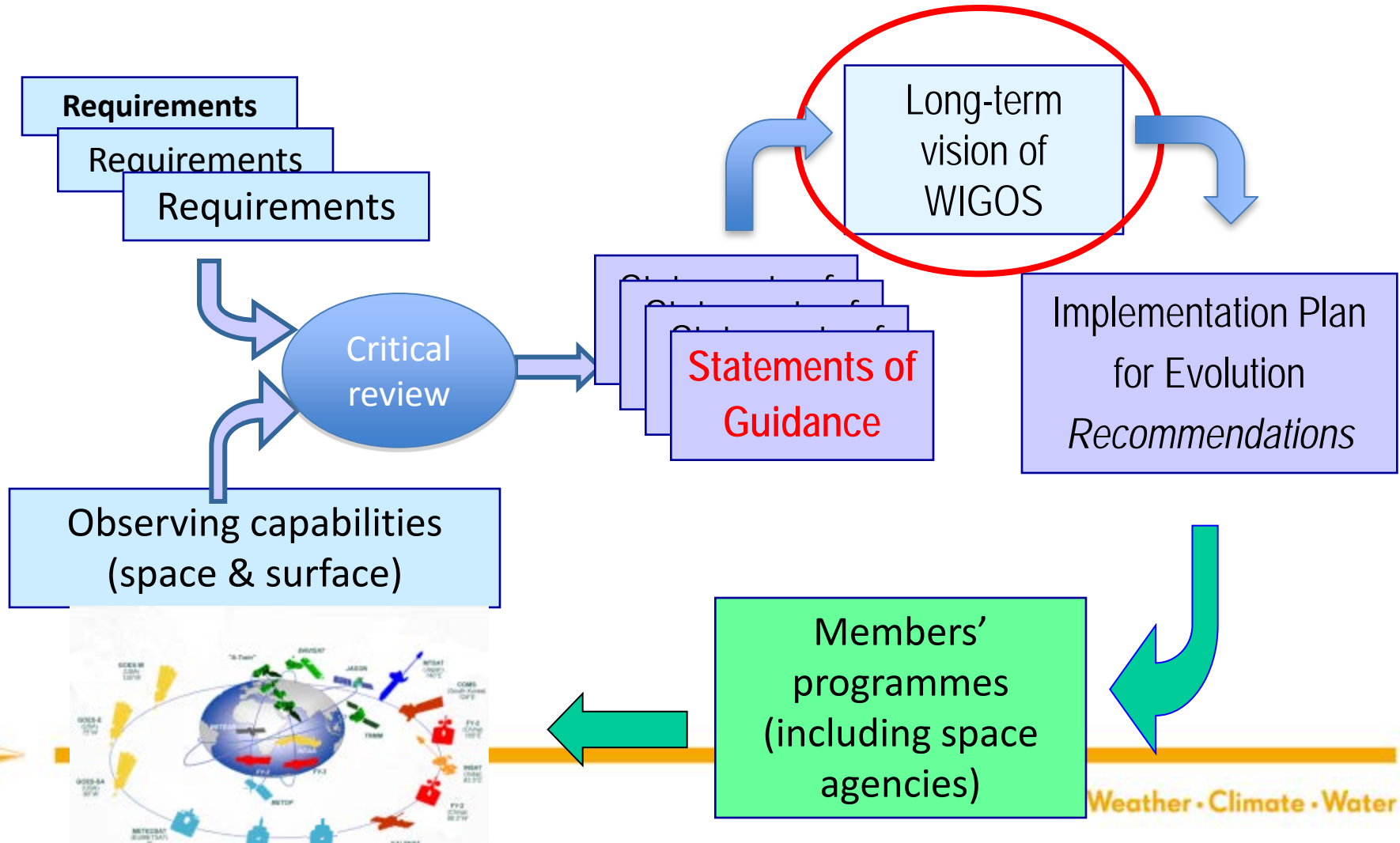


Disaster Risk Reduction



WMO Rolling Review of Requirements (RRR) process drives the Vision development

2. Then from Met **services** 2040 **requirements**, project to anticipated
3. Anticipating advances in **technology** 2040 **capability**, project to **observing requirements** in 2040 - covering all WMO thematic areas with **technical methods or biological services approaches** 2040 (weather, climate, water & environment) user driven approach !





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1. Anticipated Meteorology Services Needs in 2040
2. Anticipated available Technology meeting needs in 2040

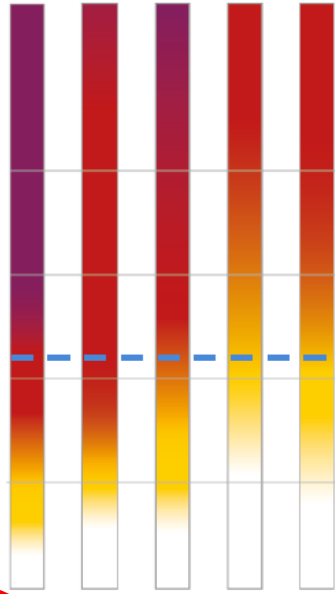
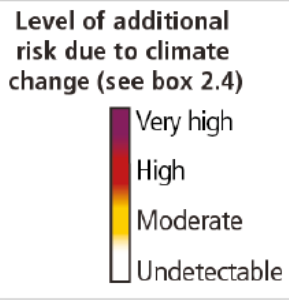


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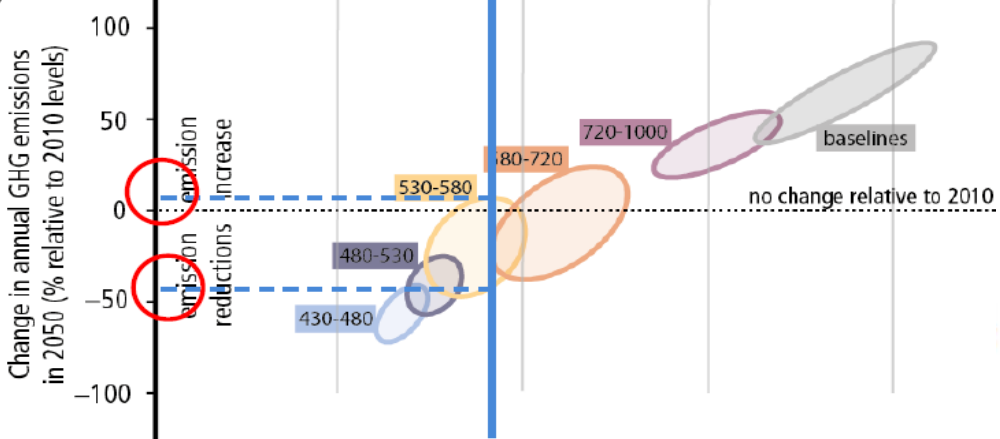
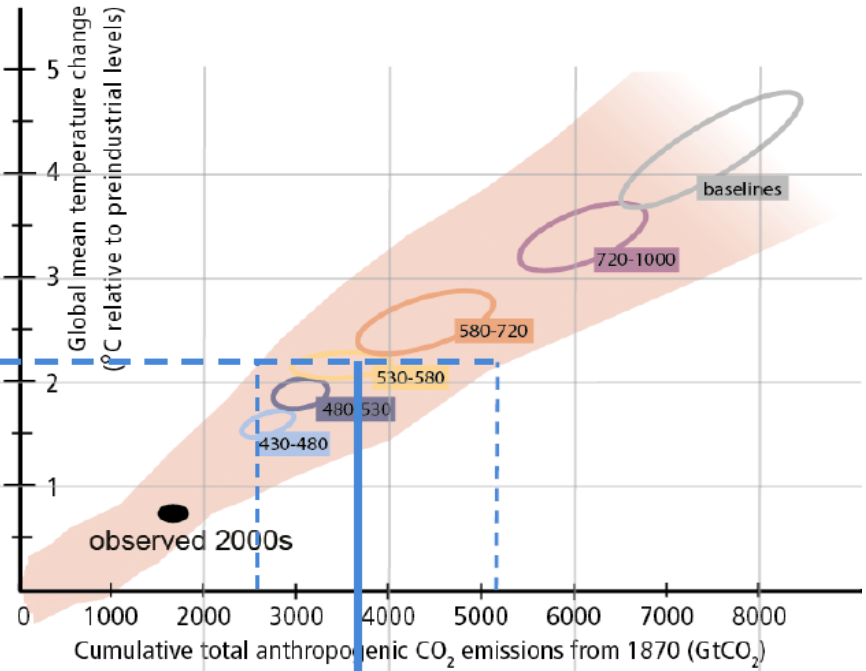
The planet will be warmer, leading to more frequent extreme events--challenges for WMO Members Met Services in 2040



Unique & threatened systems
 Extreme weather events
 Distribution of impacts
 Global aggregate impacts
 Large-scale singular events

Levels of risks can now be connected to GHG emission changes by 2050. Added uncertainty arises from action on non-CO₂ gases, timing of pre-2050 action, and ambition of post-2050

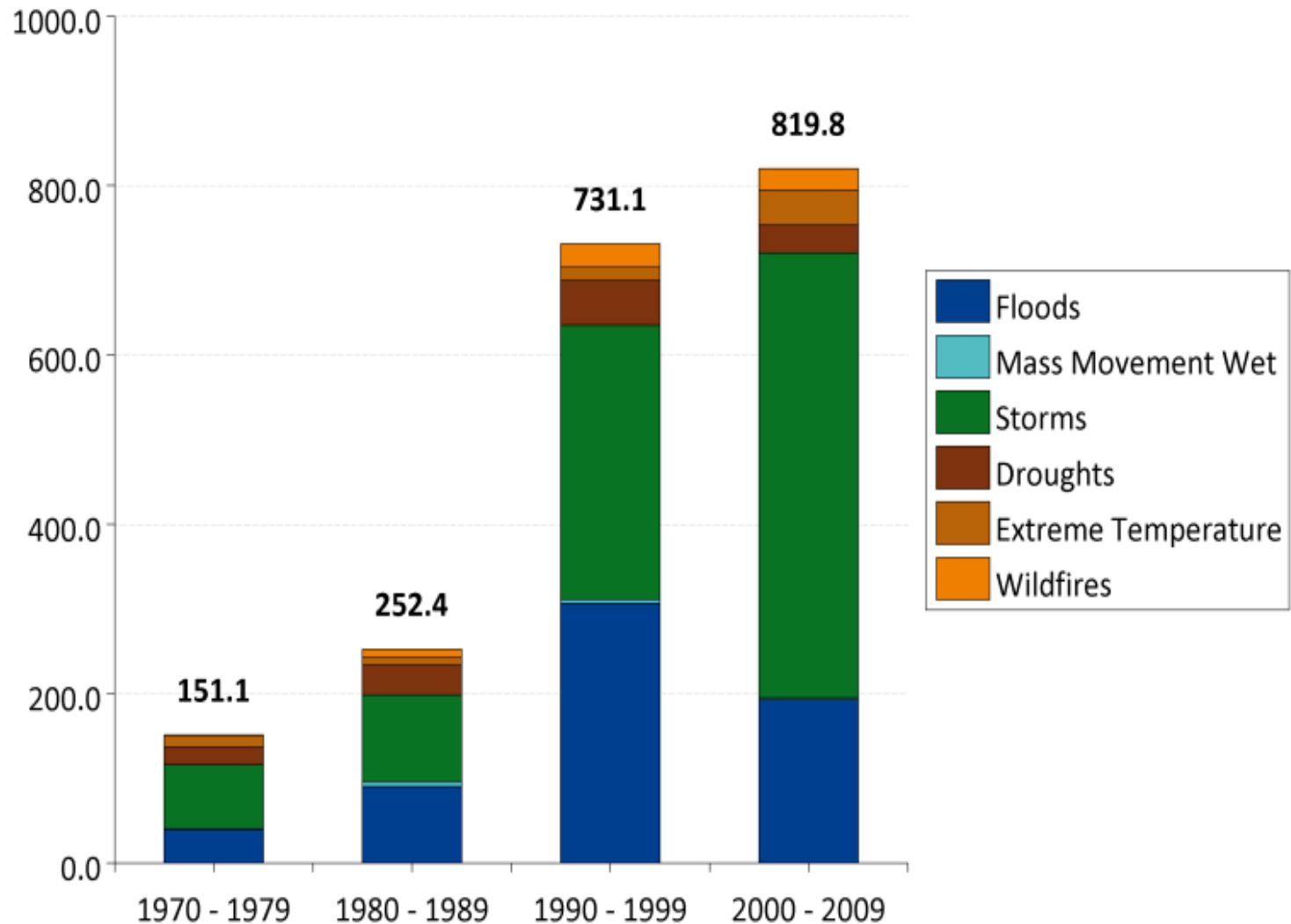
NMHS





World is changing !

- WMO Strategy Plan 2016-2019





Outlook of future in 2040: challenges of WMO Members for meeting anticipation Services Requirements in 2040

- The sea level will continue rising, lead to the coastal regions in a risky area
- Average **tropical cyclone intensity** (maximum wind speed & rainfall) is *likely* to increase
- The frequency of **heavy precipitation** or the proportion of total rainfall from heavy falls will increase in the 21st century over many areas of the globe.

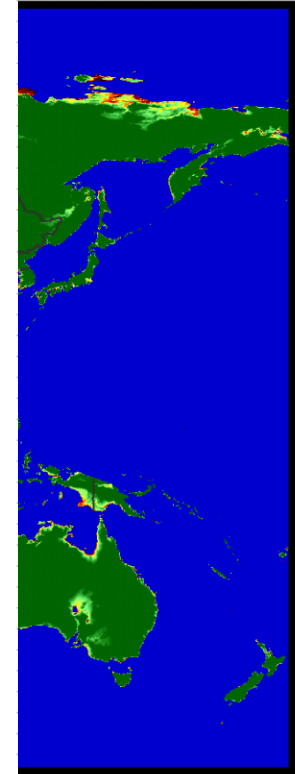
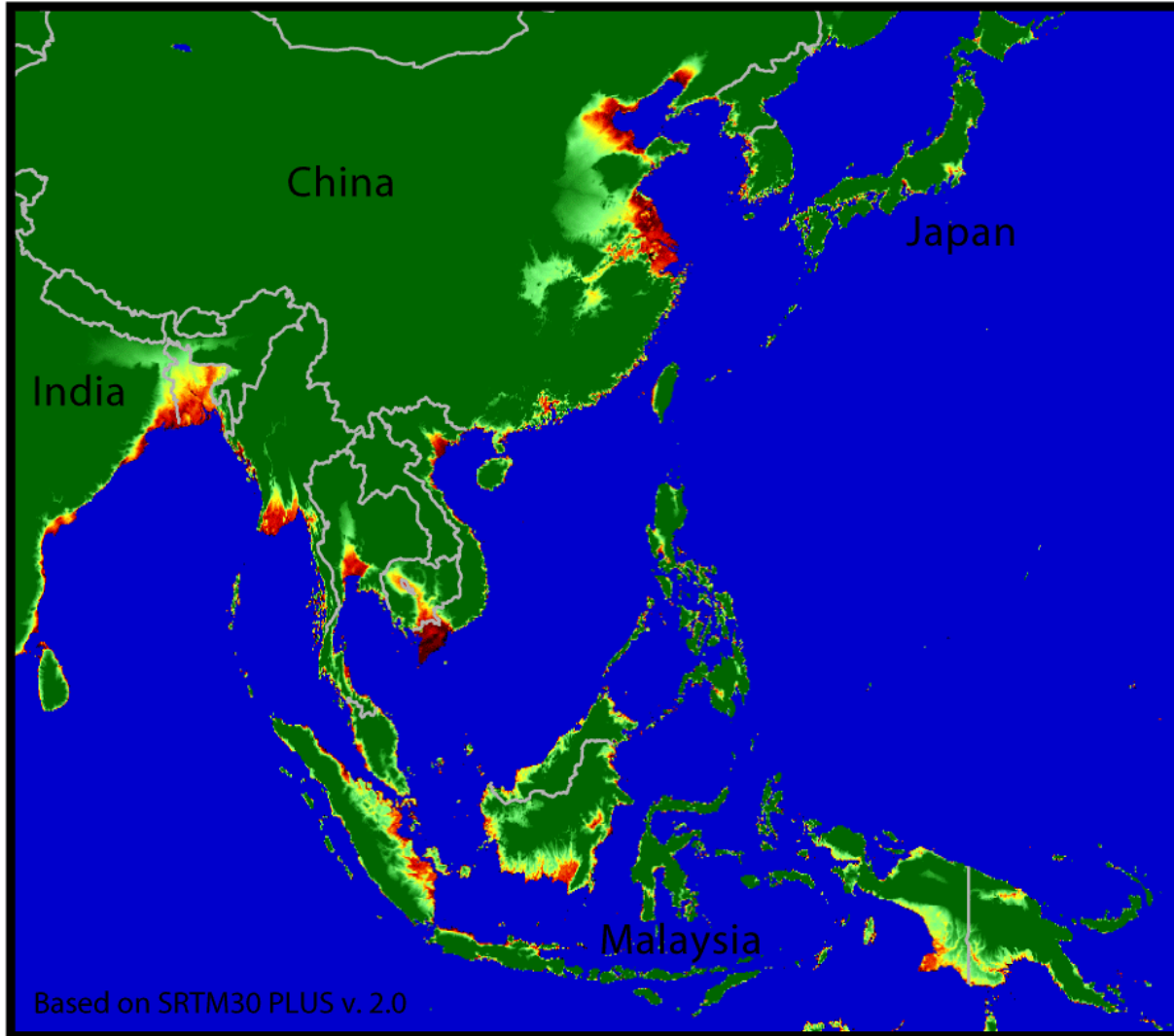


The sea level will continue rising, lead to the coastal regions in a risky area

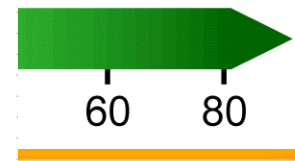
Sea Level Risks - Southeast Asia

Region

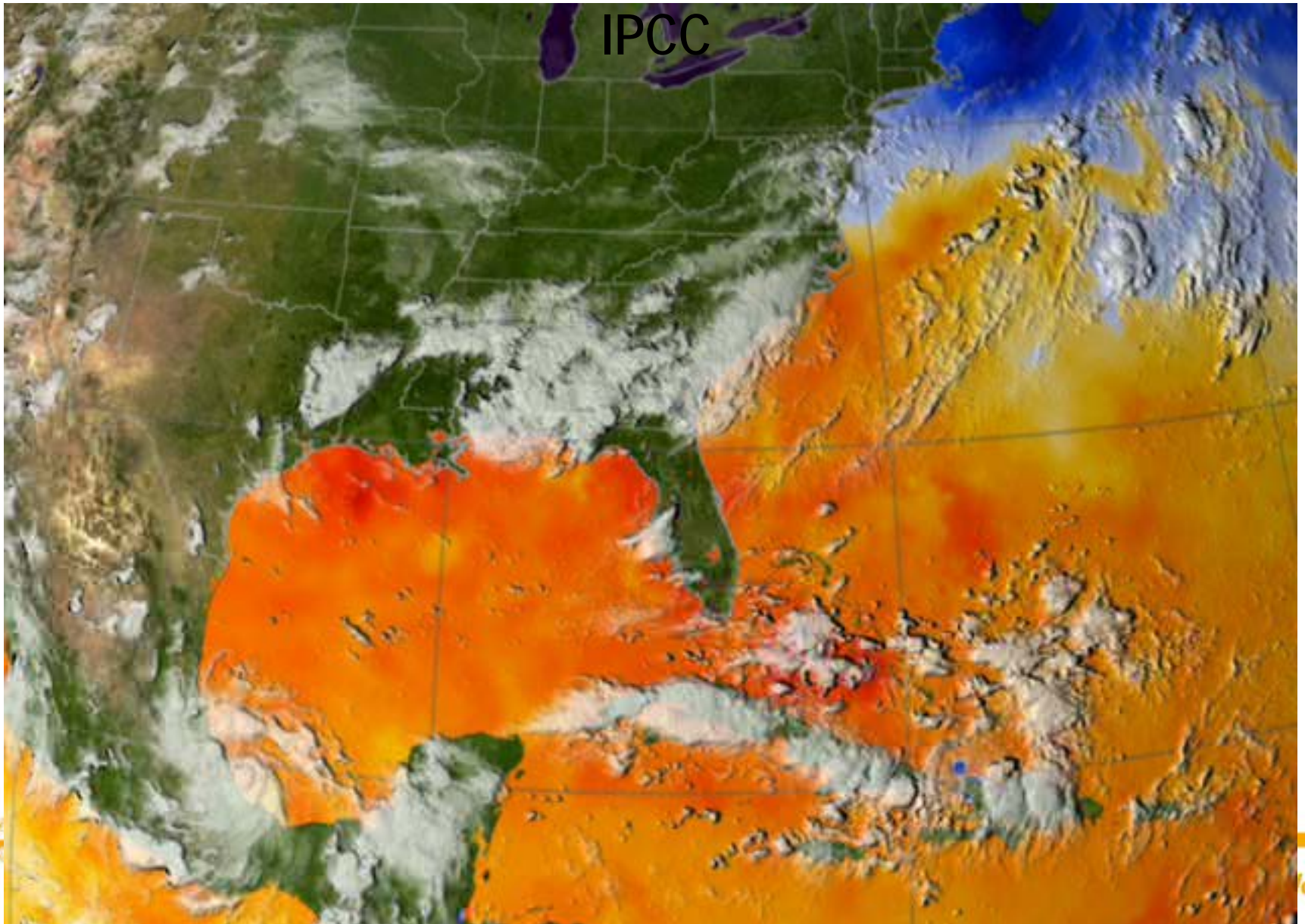
Rise



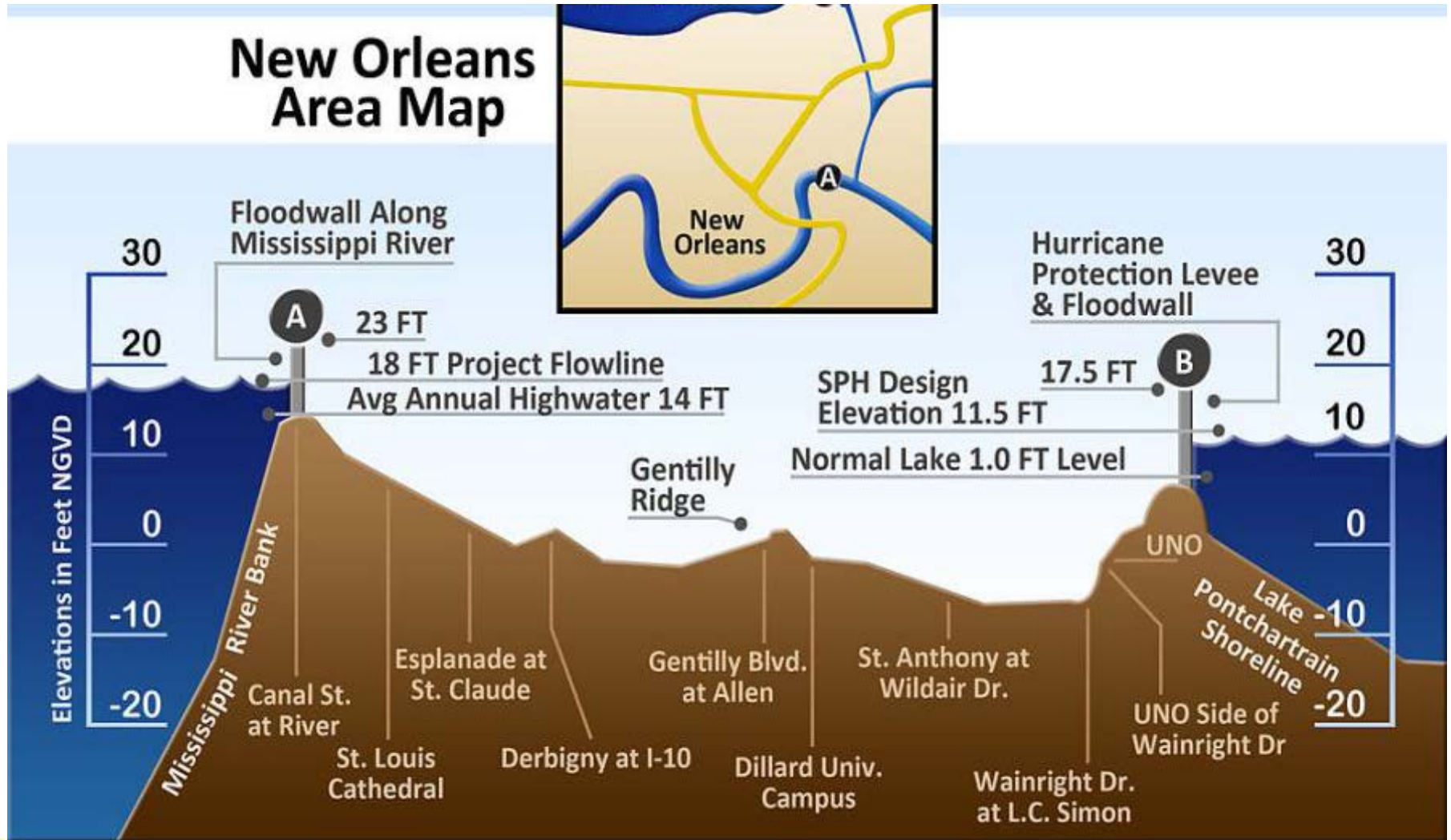
Height Above Sea Level (m)



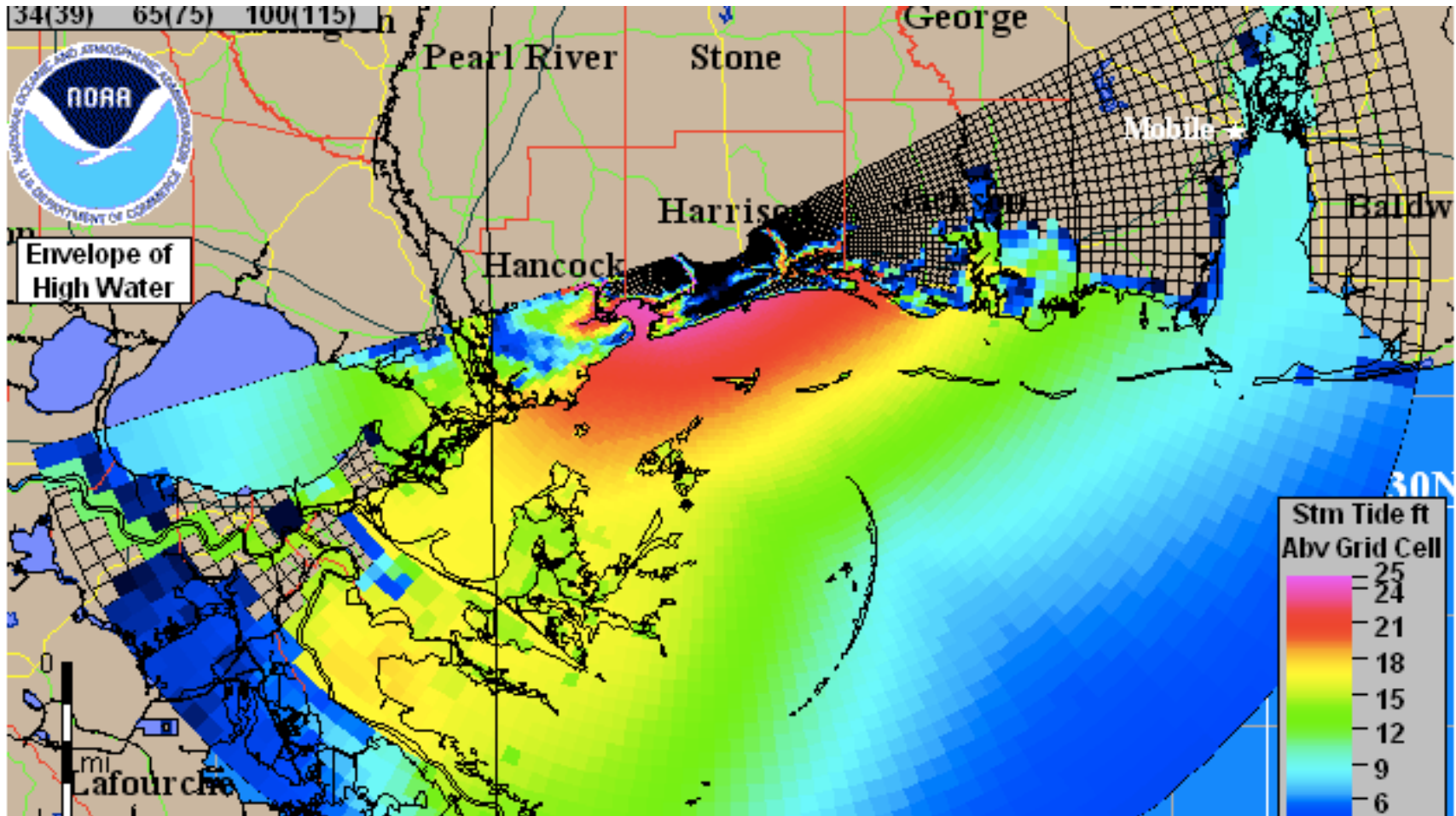
Hurricane Katrina--Average tropical cyclone intensity (maximum wind speed & rainfall) is *likely* to increase-



Storm Surge wave heights higher than 20 feet !



BIGGER Storm Surge will be a BIG threat to the coastal regions



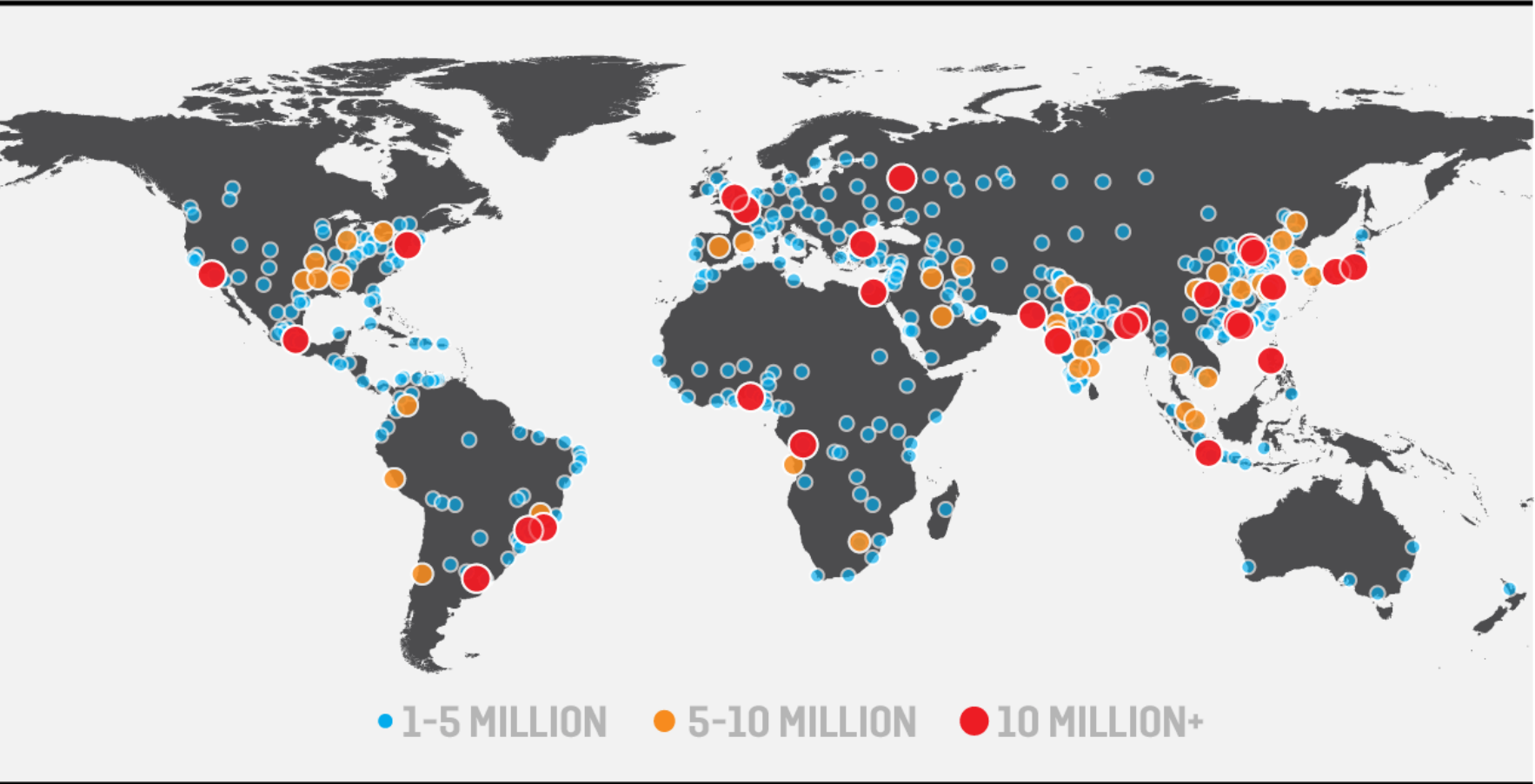
Great lose: 1000 death toll and >100Billion \$



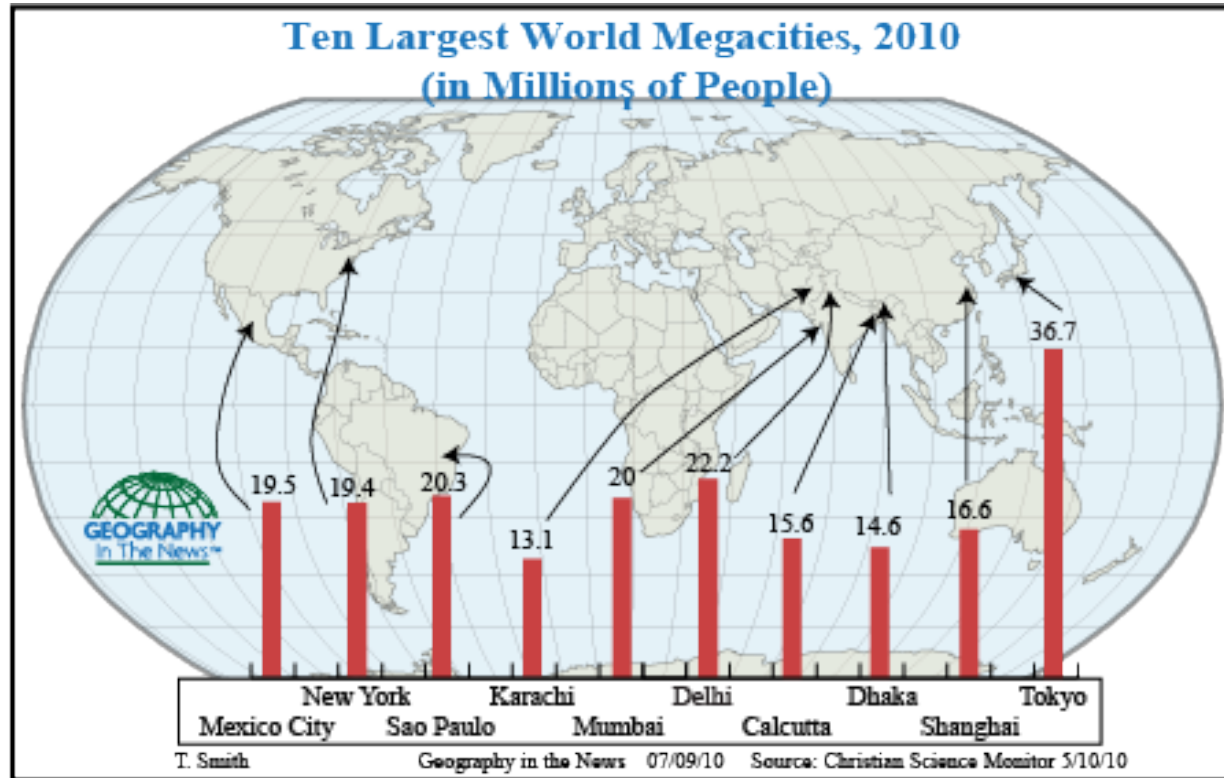


Global risk along the costal Megacities !!

P Distribution of Cities 2014



Lives and Property !!



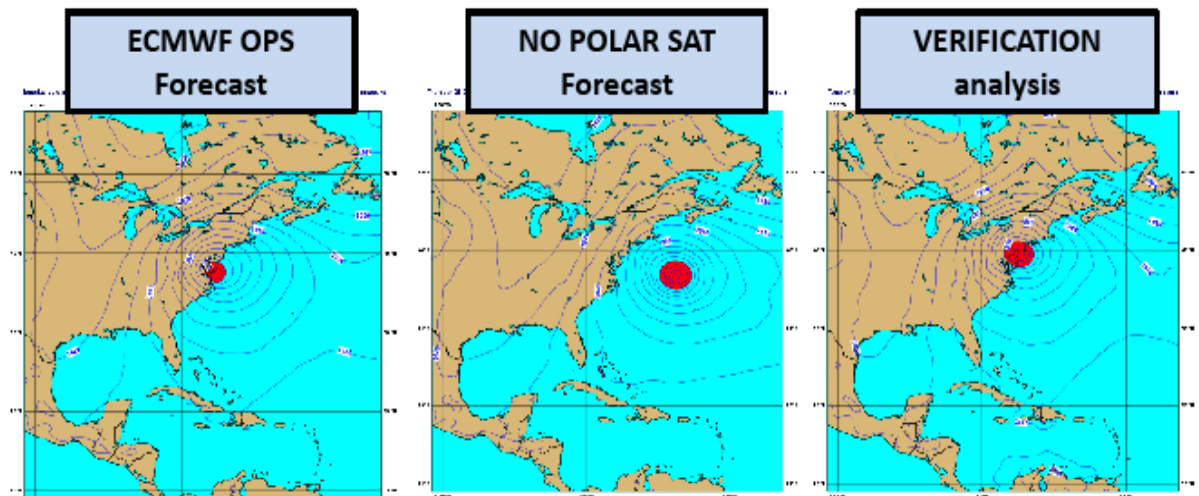
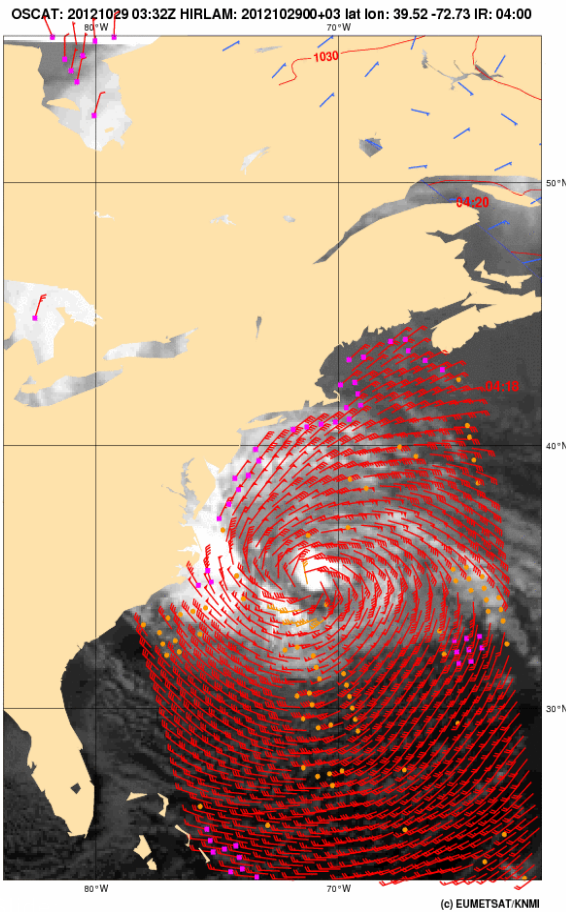
Challenges of space observing capability for meeting severe **Weather** forecast Requirements in 2040 - DRR

Hurricane Forecast & Monitoring Challenges

Global Polar-orbiting Satellites constellational is critical forecasts

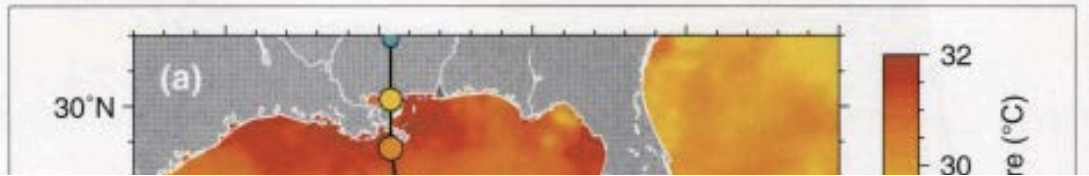
Forecasts of Hurricane Sandy without polar satellites

ECMWF forecasts of Mean Sea Level Pressure, 5 days in advance of the 30th October 2012 for the landfall of Hurricane Sandy. Forecasts from an assimilation system with no polar satellites fail to predict the landfall of the storm on the US east coast.

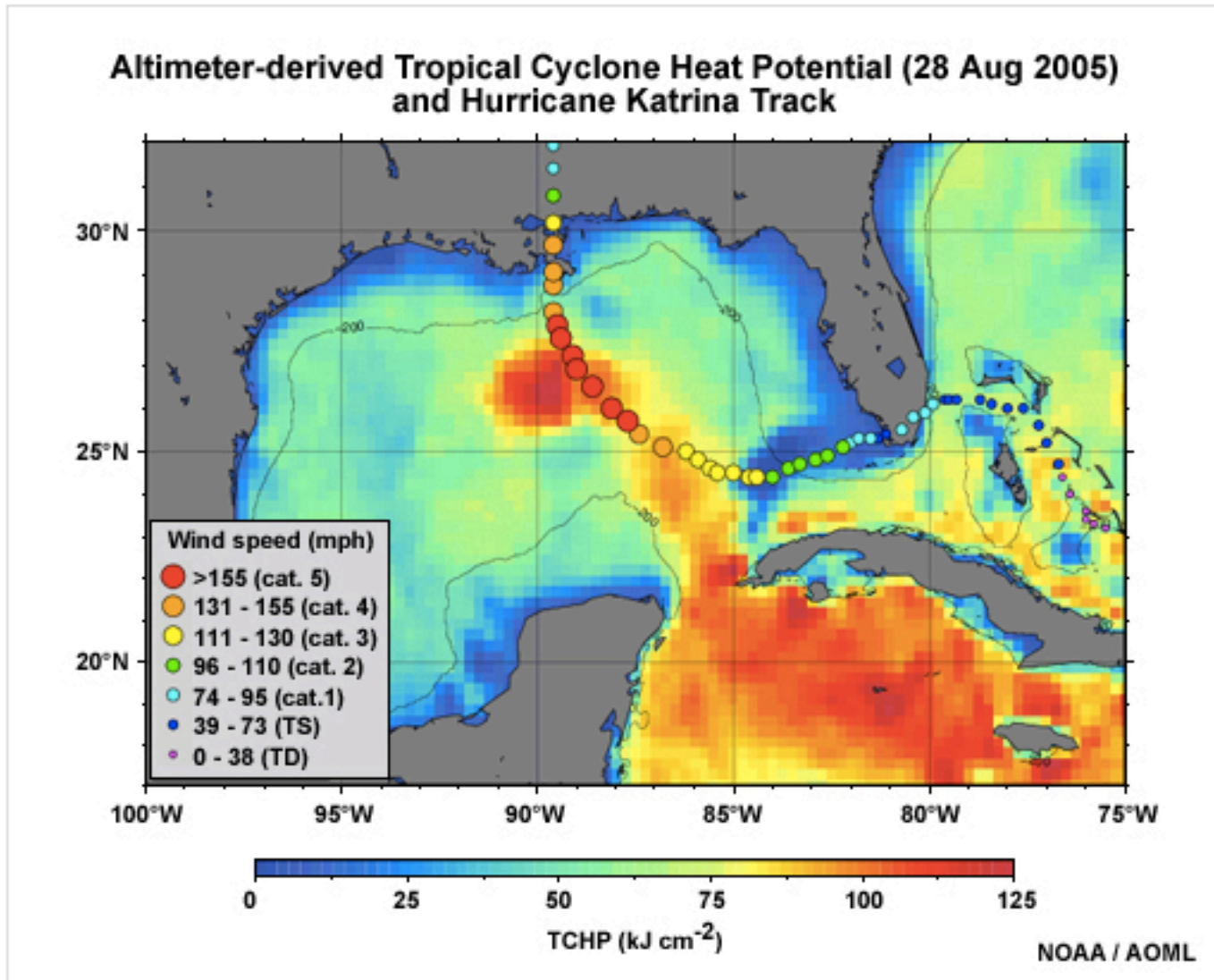


5 day forecast: Base time 2012-10-25-00z Valid Time: 2012-10-30-00z

How



to the



Gulf south of Cuba and exiting south of Florida; the warm-core ring (WCR) is the prominent high shedding from the Loop Current in the center of the Gulf. The crosshair symbols on the storm tracks show the storm position at the times of the three rows of panels in Figure 1.



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Sustain the Altimetry & Ocean Mission !

How space observations support TC monitoring

- **New Gen GeoSats will greatly enhance our monitoring capabilities !**
- **Can we anticipate by 2040 GEO or fleet LEO Microwave instruments to continuously monitoring the internal structure of TC intensity, in addition to VIS/IR Imagers? !**

$$\Delta T_i = T_i - \bar{T}_i \text{ (MV+IR)}$$

From Satellite

MEGI(鲈鱼)

2010-10-18-1755(UTC)

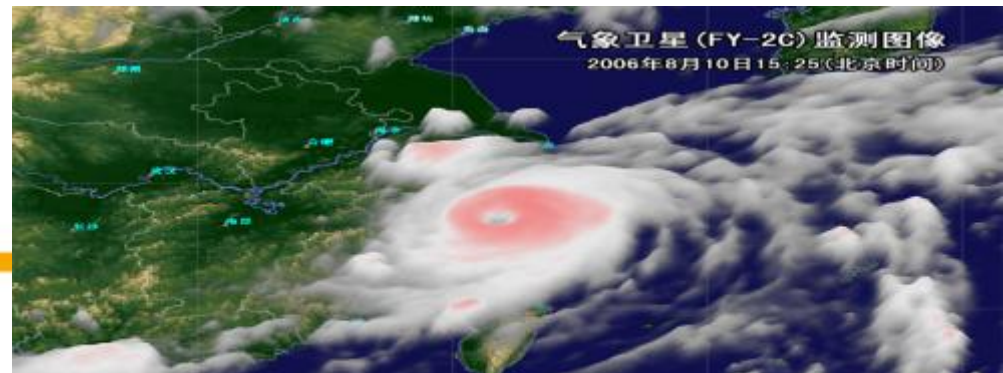
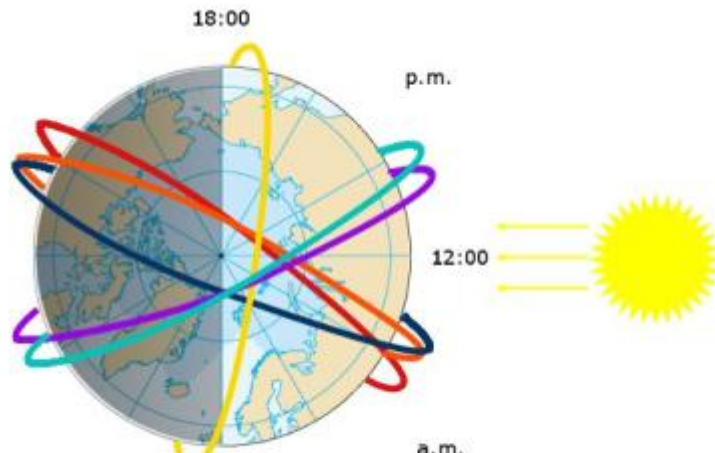
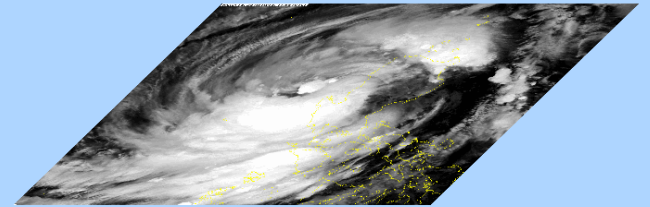
100hPa

150hPa

250hPa

500hPa

850hPa





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Climate



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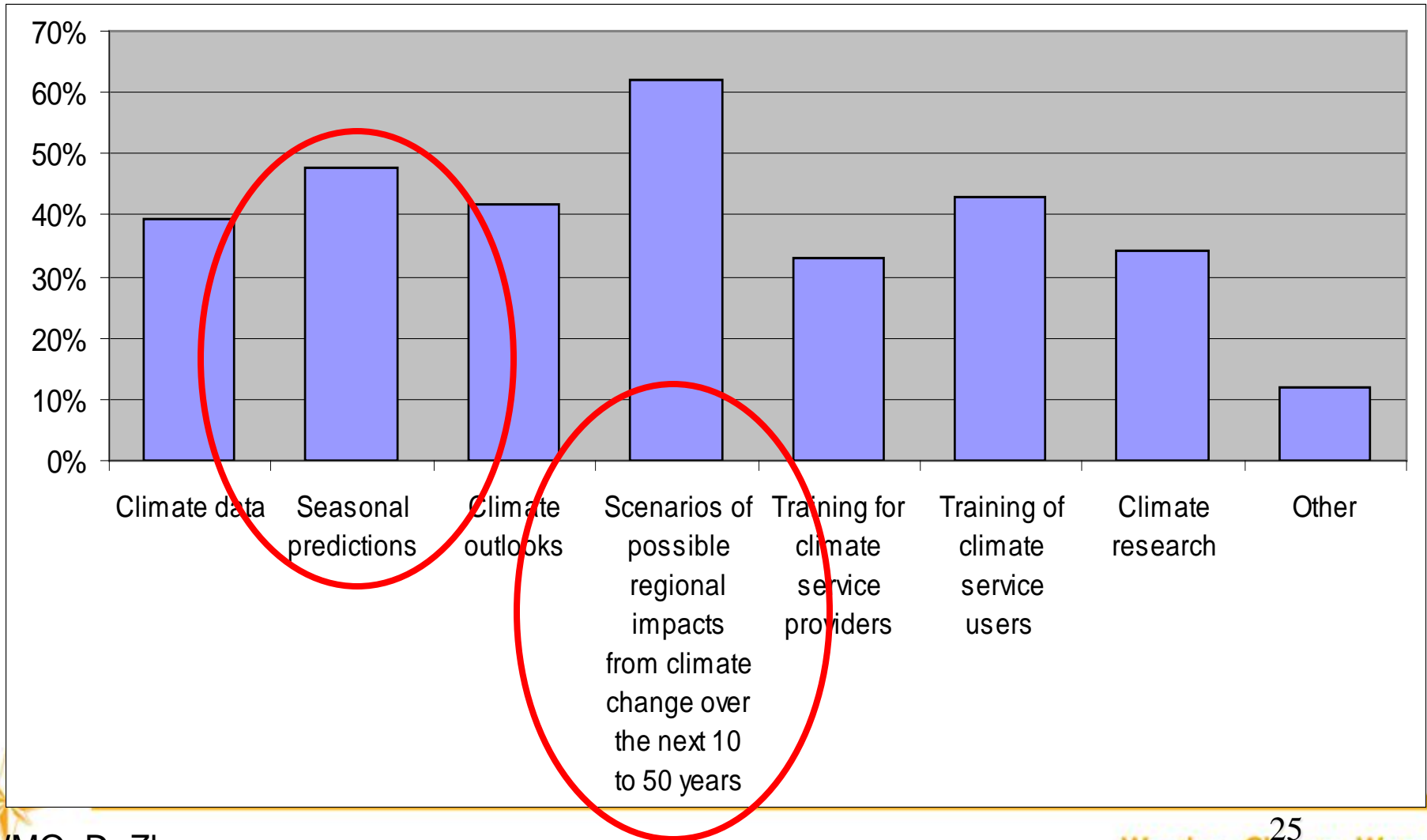
Health



Disaster Risk Reduction

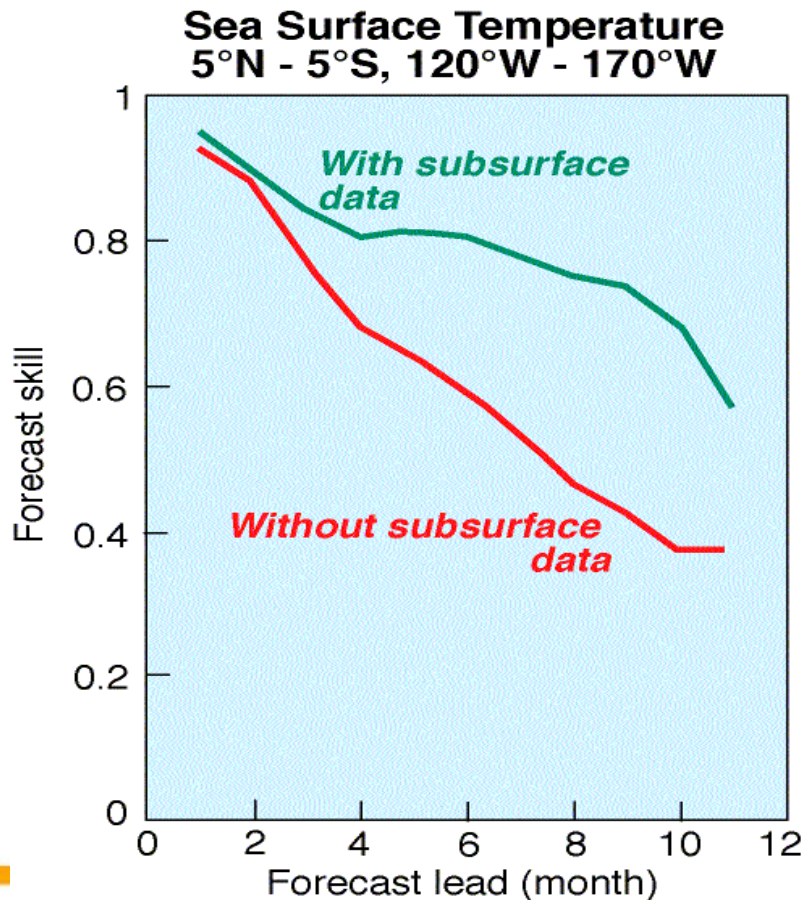
Questionnaire:

Which climate services do you need but are currently unable to obtain ?

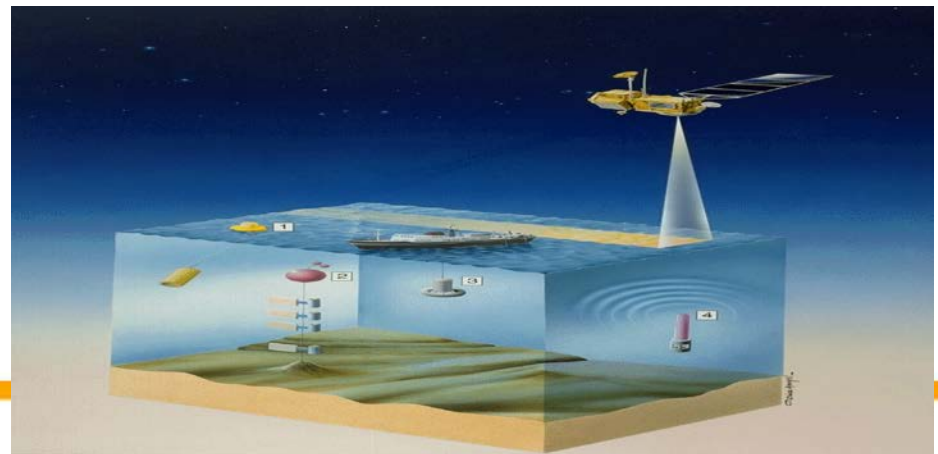


New observations for ocean subsurface are important

- The predictability of ENSO



- Seasonal climate predictions require information **below the surface for many tens of metres depth,**
- For decadal climate prediction, information from the full depth of the ocean may be needed.





Then the measurements needs...

Measurement Needs — Short-Term Climate

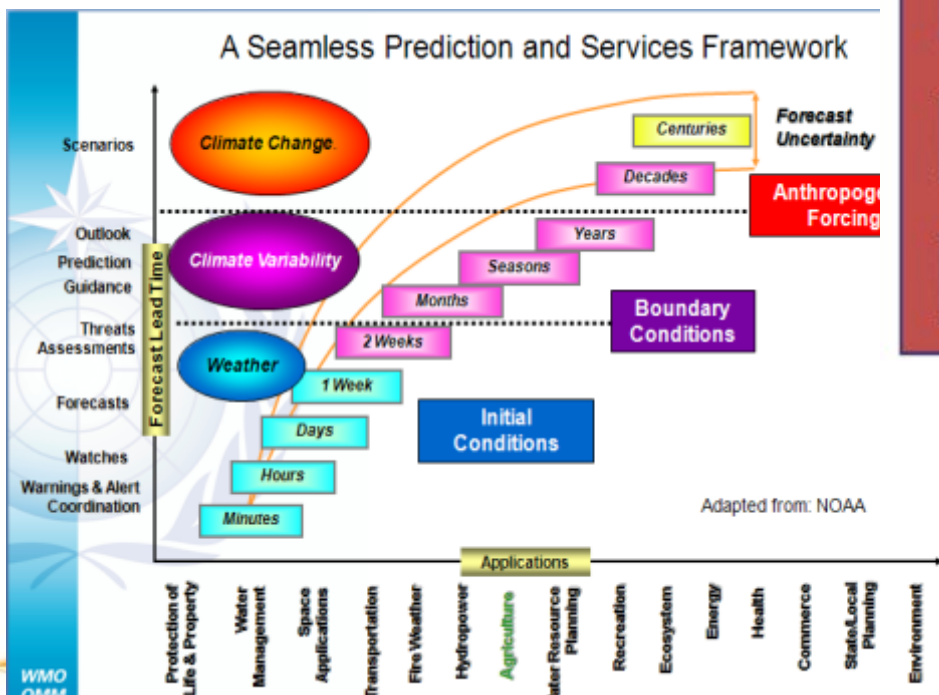
Measurements	Frequency	Horizontal Resolution	Precision/Accuracy
Ocean evaporation rate	Daily	10 km	5 %
Ocean mixed layer depth	Weekly	10 km	10 %
Sea Ice thickness	Monthly	5 km	5 cm
Soil Moisture	Daily	< 1 km	10 %
Soil properties (carbon stocks, nutrient availability, hydrologic properties)	Monthly To Weekly	< 1 km	NA
Stream flow	Daily	NA	10 %
Aerosol distribution and absorption properties	Hourly	< 1 km	10 %
Atmospheric ozone	Hourly	1 km (vertical)	5 %
Carbon dioxide and methane	Hourly	1 km (horizontal)	1 % (column)
Atmospheric gases	Hourly	1 km (H & V)	1-10 %

Sixteenth World Meteorological Congress (2011) decided to Implement WIGOS

WMO INTEGRATED GLOBAL OBSERVING SYSTEM

The whole is more than the sum of the parts—Aristotle

WIGOS: A future observing framework for WMO



WIGOS-Space needs to meet weather, climate, water and related environmental services requirements



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Anticipated Advances in technology
to meet requirements. –
technology driven !

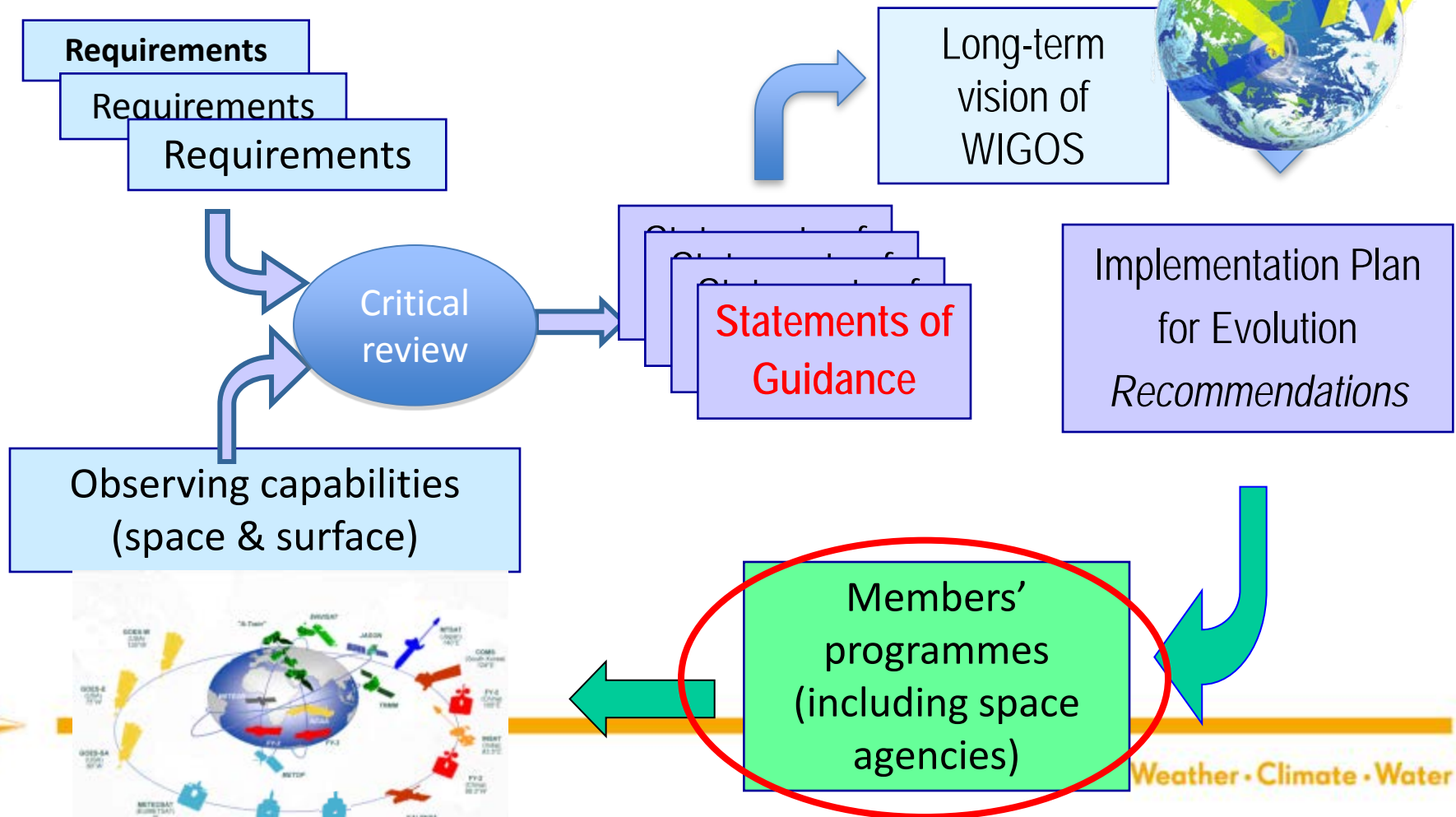
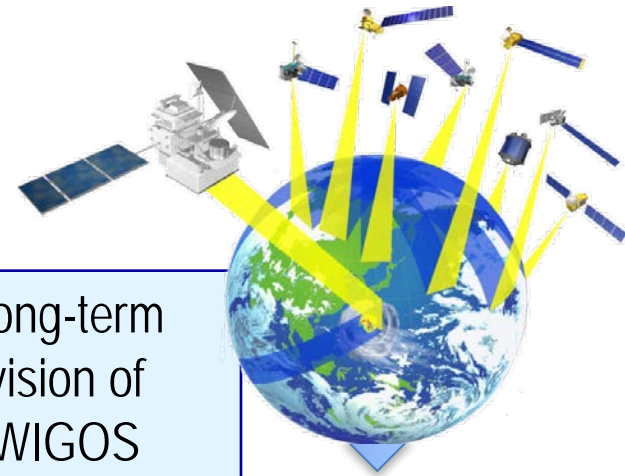
Technology advances for satellite systems

- More satellite providers, allowing more diverse orbits
 - HEO-GEO-MEO-LEO (inclined or sun-sync) and lower platforms
- Backbone system
 - Geostationary ring
 - LEO sun-synchronous in 3 planes (am/pm/earlymorning)
 - Sun-Synch. Satellites at various ECT for better time sampling
 - Missions on inclined orbits (altimetry, precipitation & soil moisture missions)
 - HEO missions for improved Arctic coverage
 - **How the successful R/D missions be added to the baseline 2040 ?**
- In-orbit measurement reference standards for calibration, traceability
 - would leverage the value of the whole constellation of satellites
- Other, novel concepts
 - Nanosatellites ready to serve as gap fillers for contingency
 - Use of the International Space Station for demonstration missions,....



Vision of WIGOS in the Rolling Review of Requirements (RRR)

WIGOS Vision in 2040 – Key challenges
Can we go beyond coordination to start
International Planning & implementation ?





Need interaction with applications

- Difficulty to anticipate the user needs 25 years ahead
- Users unaware of potential future capabilities
- Space agencies need to better understand the user needs
- Direct interaction needed to stimulate a prospective view
- Dialogue is planned at a «WIGOS Space 2040 workshop»
 - Geneva, 18-20 November 2015 (important dialogue)
 - Leads or representatives of the major user communities and space agencies involved in the Vision development
 - A panel of representative users of WMO applications (NWP, NWC, GAW, GCW, Ocean, Hydrology..)
 - With invitation to all important & interested agencies



Major **References**

- WMO Strategic Plan 2016-2019, *Synthesis Report of the UN SG on the post-2015 sustainable development agenda*
- EUMETSAT Strategy
- NASA *Earth Science Vision 2030*, ESA & other space agency reports
- Dr. Kathryn Sullivan: AMS 2015 Annual Meeting Presidential Forum Keynote: [Anticipating Meteorology in 2040](#)
- ET-SAT-9 (12-14 Nov. 2014) Final Report (Chair: Jack Kaye (NASA),) with participation of major space agencies

Thank you for your attention!

Your feedback is welcome

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