Satellite Data Requirements for Operational Hydrology
A WMO Perspective

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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World Meteorological Organization
Organisation météorologique mondiale

World Meteorological Organization

WMO is the UN specialized agency in the domains of weather, climate and water (hydrology):

- **Worldwide cooperation (observing networks and data centres)**
- **Data and information exchange**
- **Standardization**
- **Application and services**
- **Hydro – Meteo cooperation**
- **Research and training**

World Meteorological Organization
Weather • Climate • Water

WMO HQ in Geneva, Switzerland

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Operational Hydrology: WMO's long term ambitions

1. No one is surprised by a flood
2. Everyone is prepared for drought
3. **Hydro-climate and meteorological data support the food security agenda**
4. **High-quality data supports science**
5. **Science provides a sound basis for operational hydrology**
6. We have a thorough knowledge of the water resources of our world
7. Sustainable development is supported by information covering the full hydrological cycle
8. Water quality is known.

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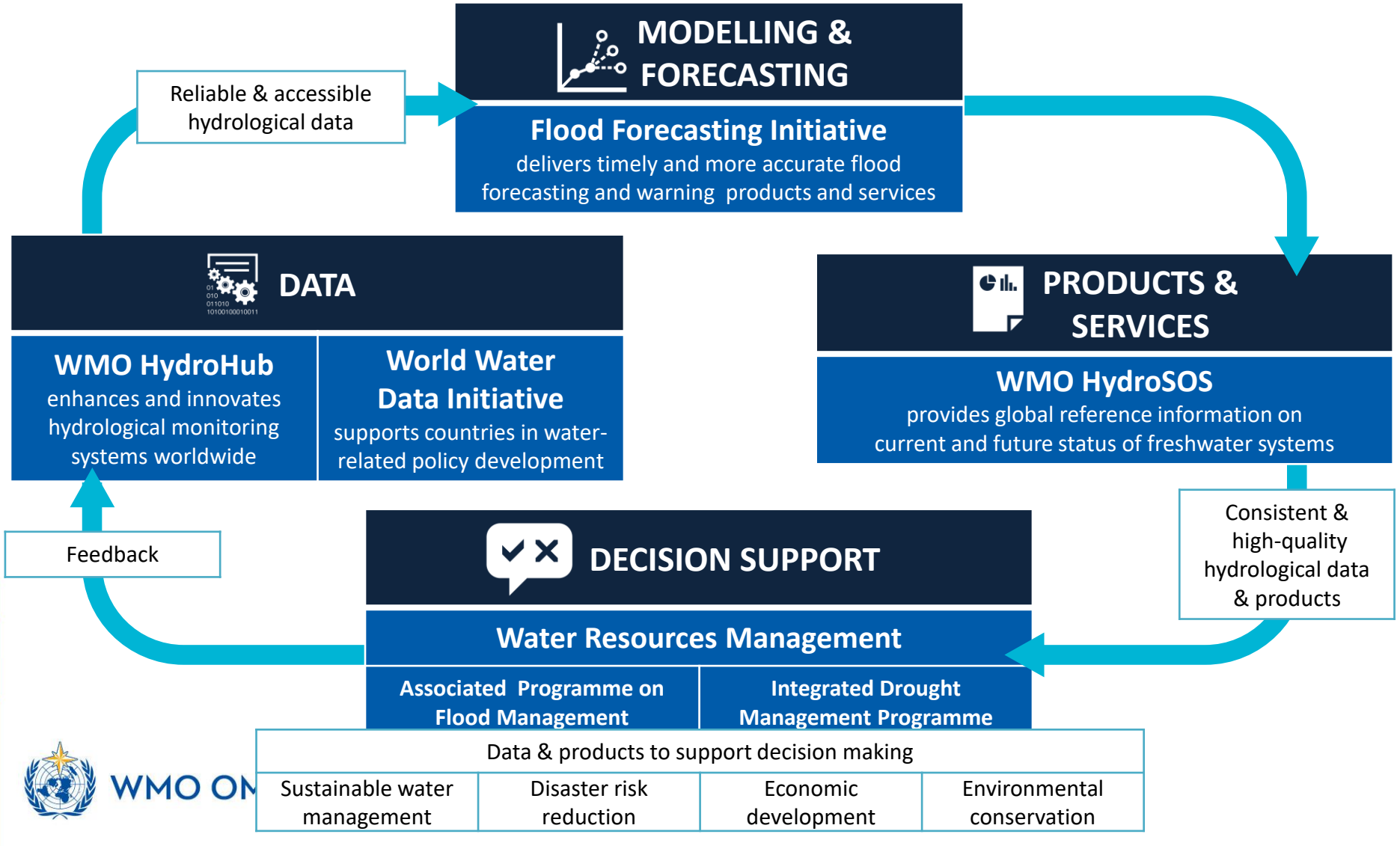
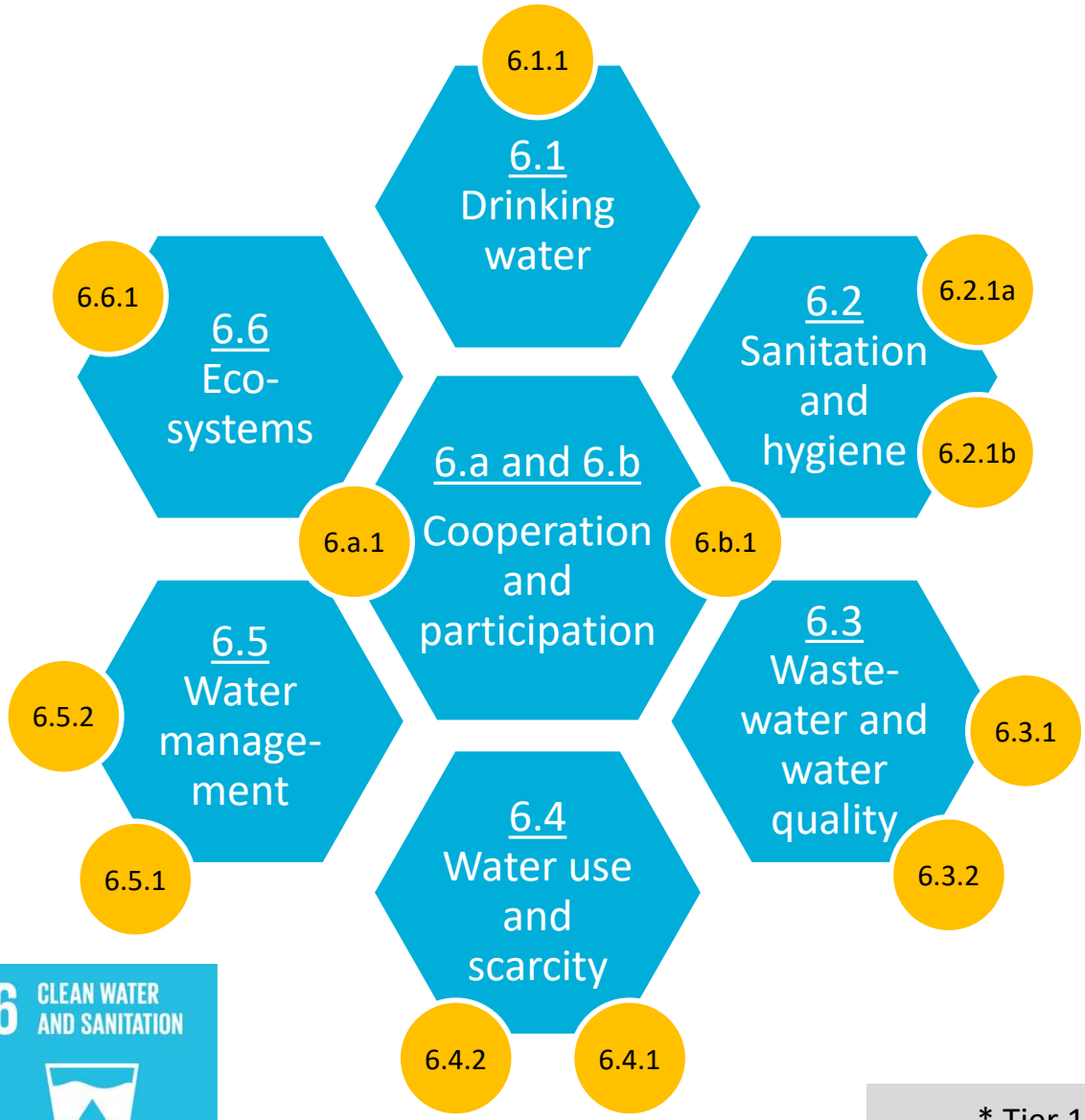
The WMO Hydrological Value Chain Initiatives



WMO ON

SDG 6 global indicators

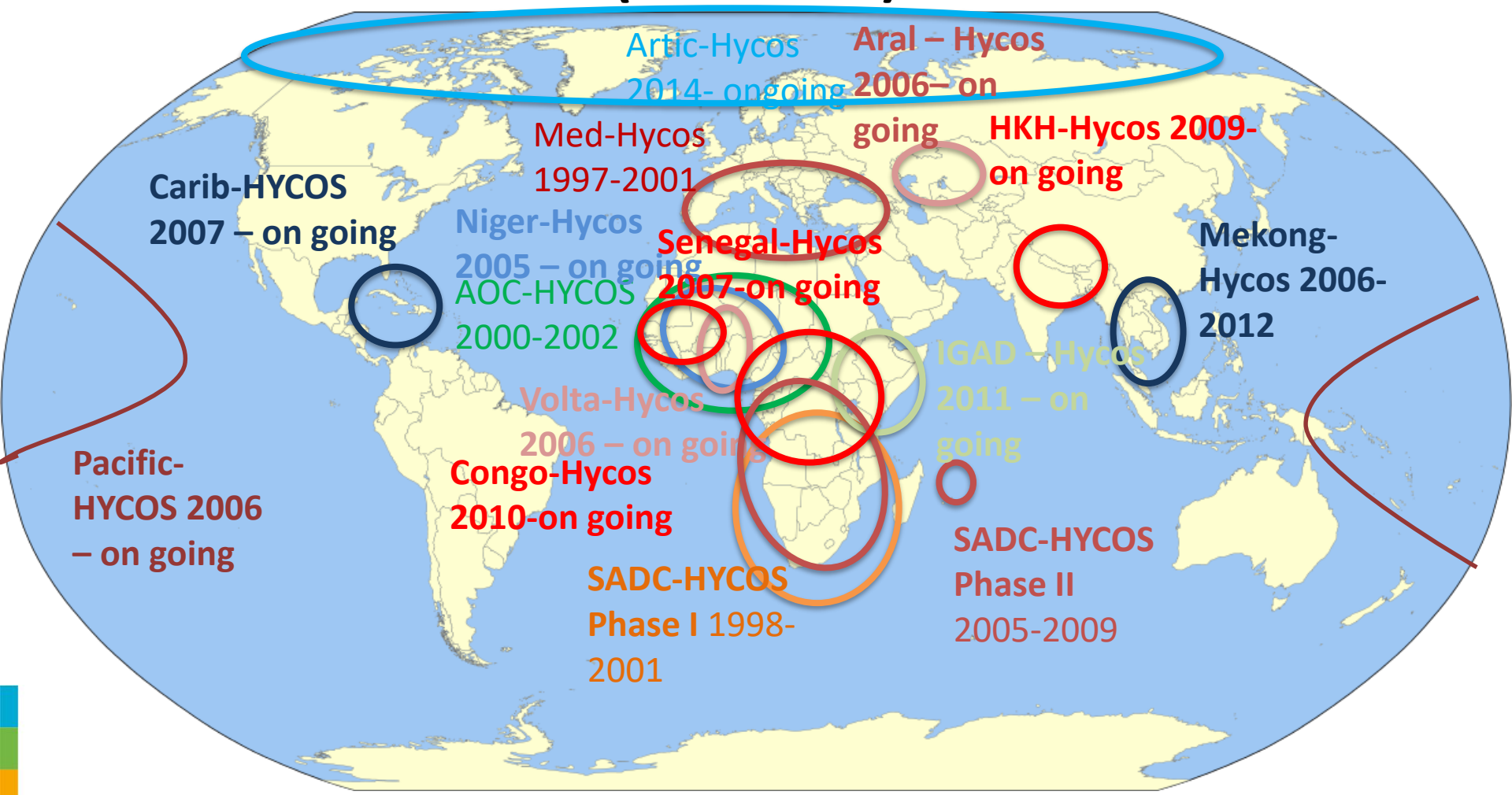


6 CLEAN WATER AND SANITATION

* Tier 1
** Tier 2

6.1.1	Safely managed drinking water services (WHO, UNICEF)**
6.2.1	Safely managed sanitation services and hygiene (WHO, UNICEF)**
6.3.1	Wastewater safely treated (WHO, UN-Habitat, UNSD)**
6.3.2	Good ambient water quality (UNEP)**
6.4.1	Water use efficiency (FAO)**
6.4.2	Level of water stress (FAO)*
6.5.1	Integrated water resources management (UNEP)*
6.5.2	Transboundary basin area with water cooperation (UNECE, UNESCO)*
6.6.1	Water-related ecosystems (UNEP)*
6.a.1	Water- and sanitation-related official development assistance (WHO, OECD)*
6.b.1	Participation of local communities in water and sanitation management (WHO, OECD)*

The World Hydrological Cycle Observing System (WHYCOS)



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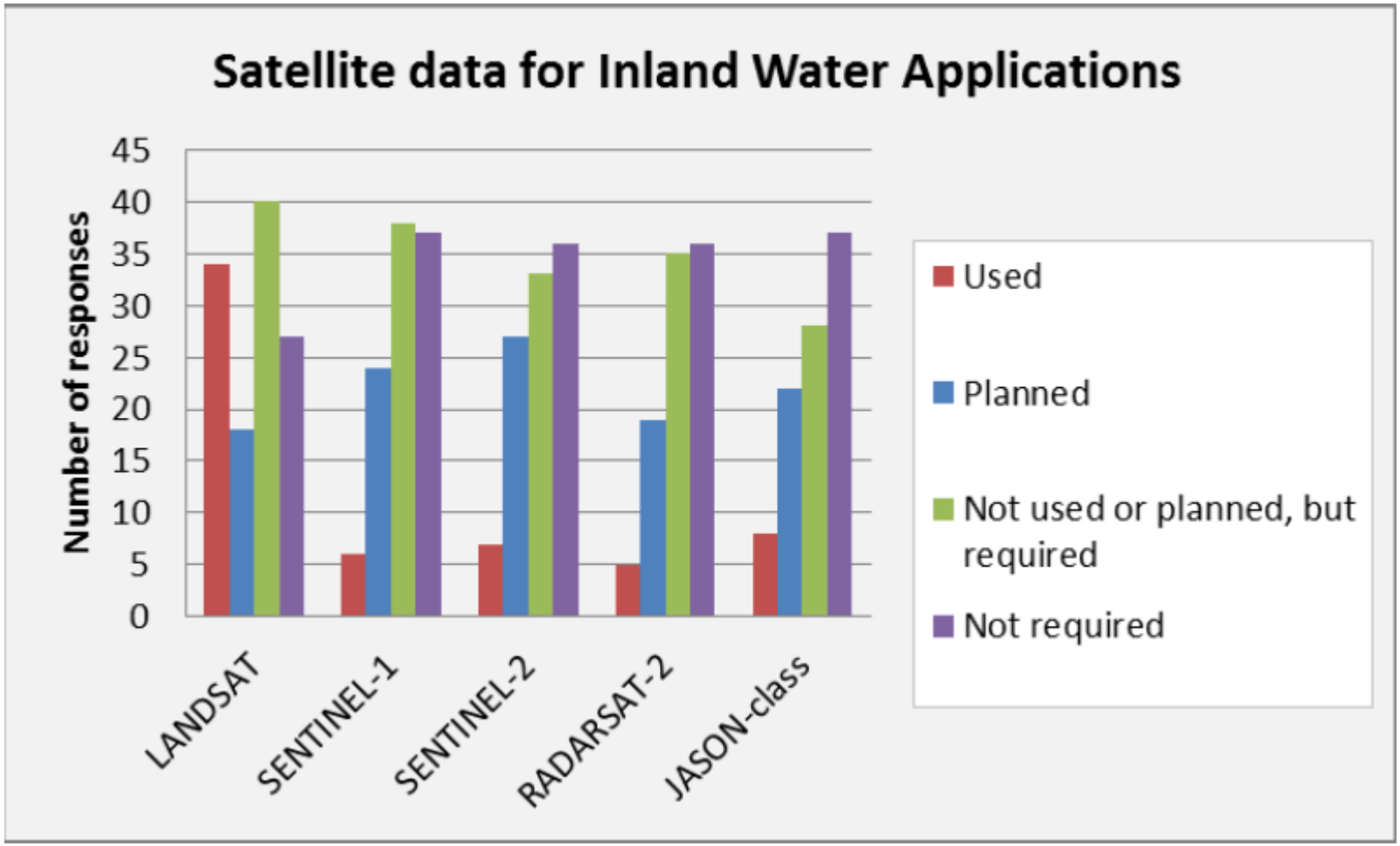
WMO user survey 2017
Satellite data for inland water-related applications



Water challenges require solutions based on sound facts, information and data, but:

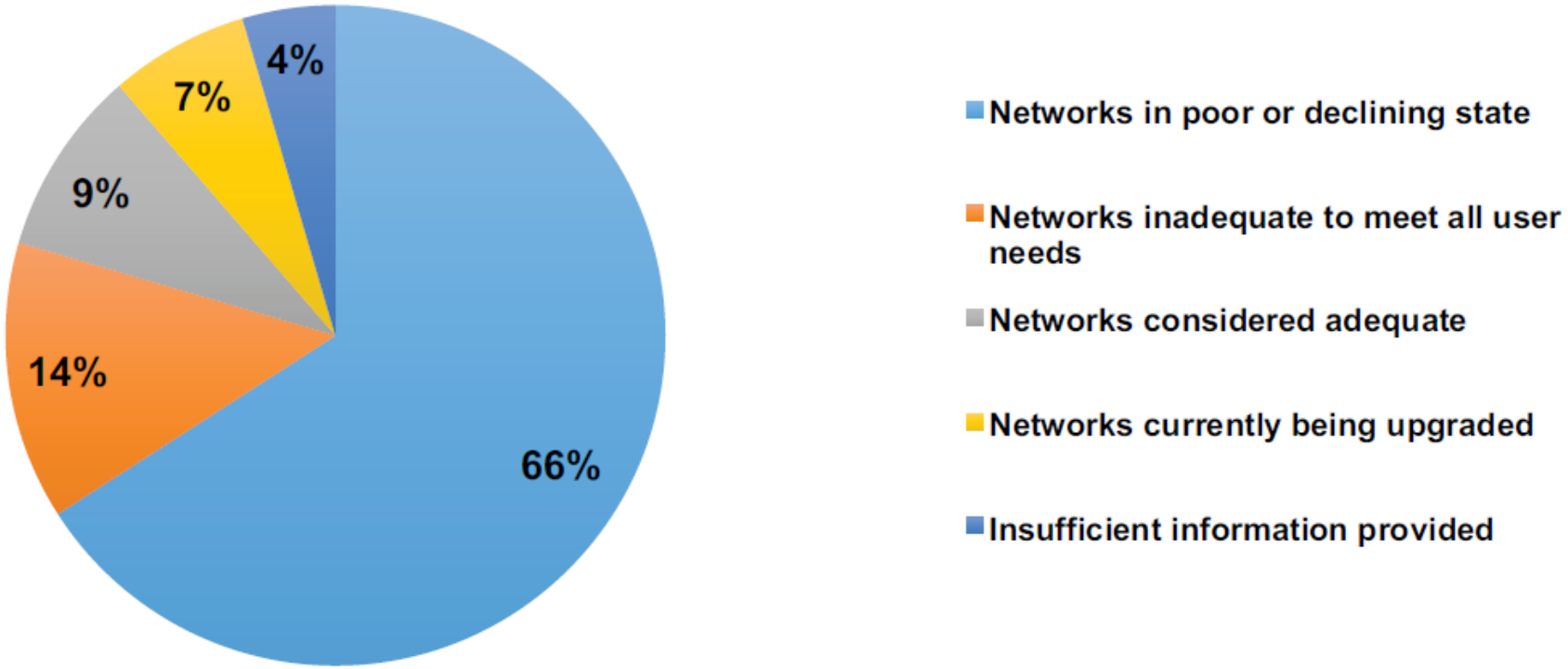
- Insufficient Capacity of current monitoring networks
- Quality of data not always known
- Many data not shared
- Low visibility and recognition of Hydrological Services

WMO WB survey of hydro network

- Fragmented and myopic policy environments;
- Insufficient budgets;
- Inability to attract, train, and retain qualified staff;
- **Limited and often declining hydrometeorological monitoring networks;**
- **Insufficient maintenance of hydrological infrastructure;**
- Inadequate data management systems;
- Insufficient integration between hydrological and meteorological services;
- Poor connection with users;
- Inability to develop and provide hydrological products; and
- Unsatisfactory service delivery.

WMO WB survey of hydro network

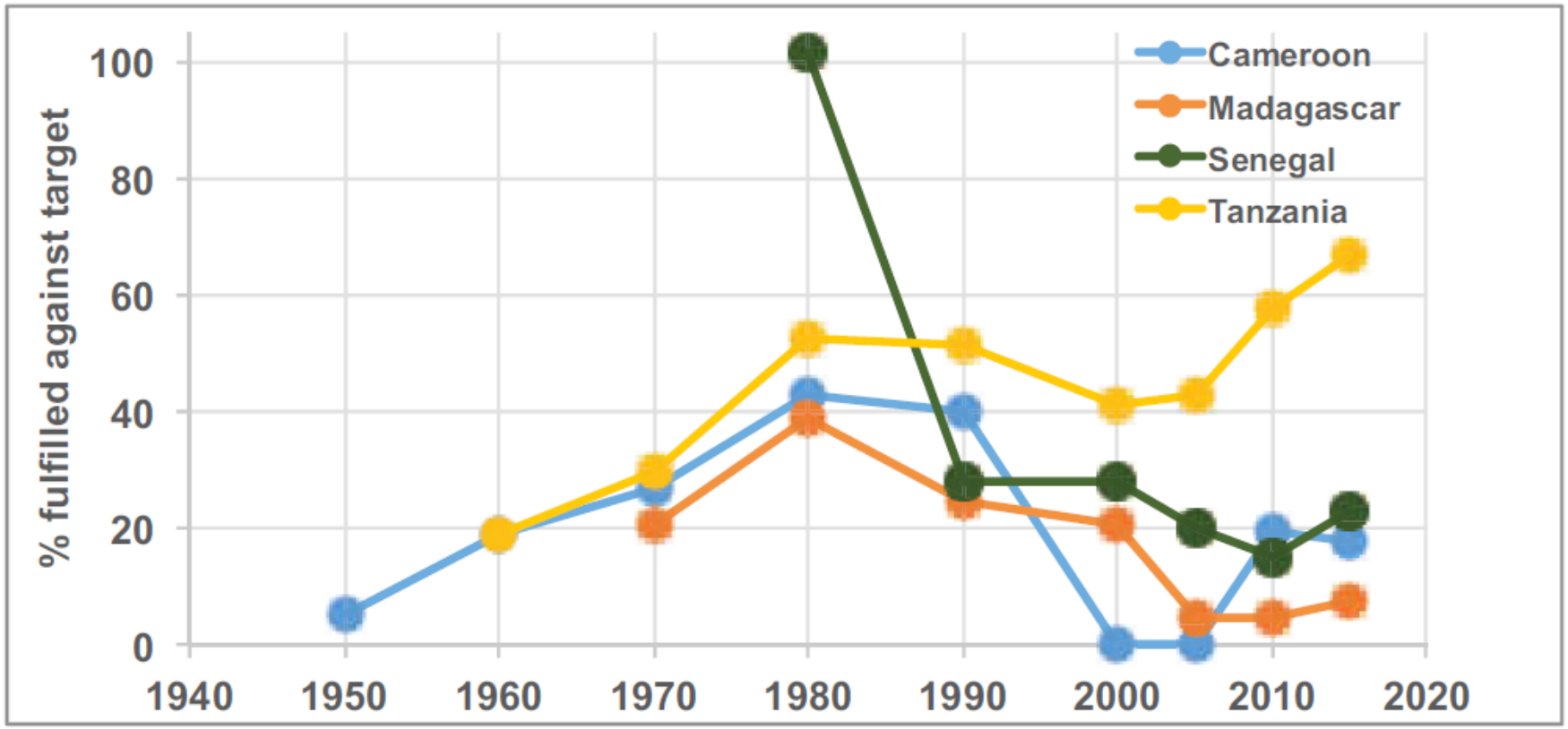
FIGURE 3 • **Status of Hydrometeorological Observation Networks in Developing Countries**



Source: World Bank Group based on all listed references (2018).

WMO WB survey of hydro network

FIGURE 4 • **Trends in Hydrological Observation Network Size in Four African Countries, as Compared to WMO Minimum Guidelines**



Source: World Bank and Water4Life (2016).

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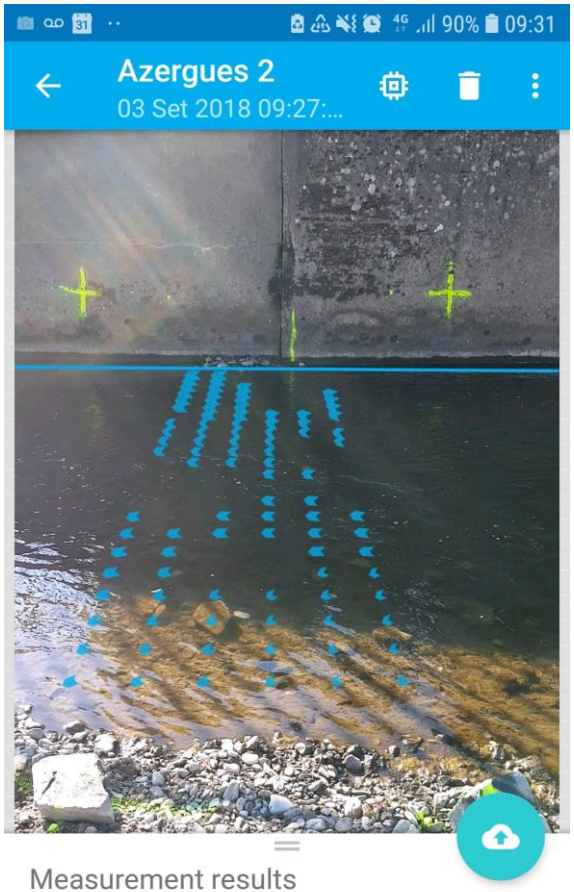
World Water Data Initiative

- The accompanying societal challenge is to foster the improved use of water data and information as a basis for enlightened management of water resources, to protect life and property from effects of extremes in the water cycle

INNOVATIVE MEASUREMENT



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FFGS

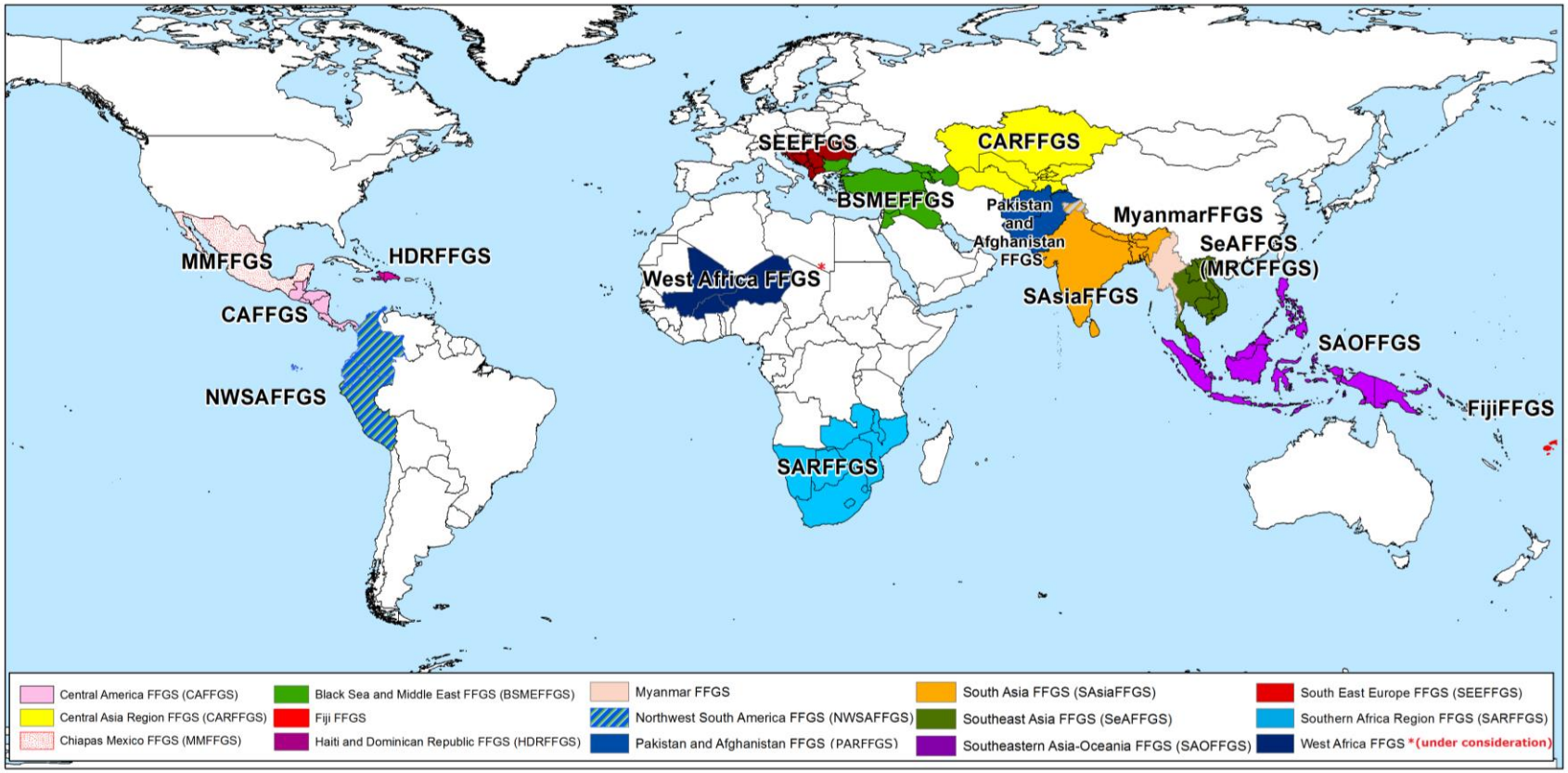
WORLD METEOROLOGICAL ORGANIZATION

USAID FROM THE AMERICAN PEOPLE

Environment and Climate Change Canada
Environnement et Changement climatique Canada

CREWS CLIMATE RISK & EARLY WARNING SYSTEMS

FLASH FLOOD GUIDANCE SYSTEM WITH GLOBAL COVERAGE



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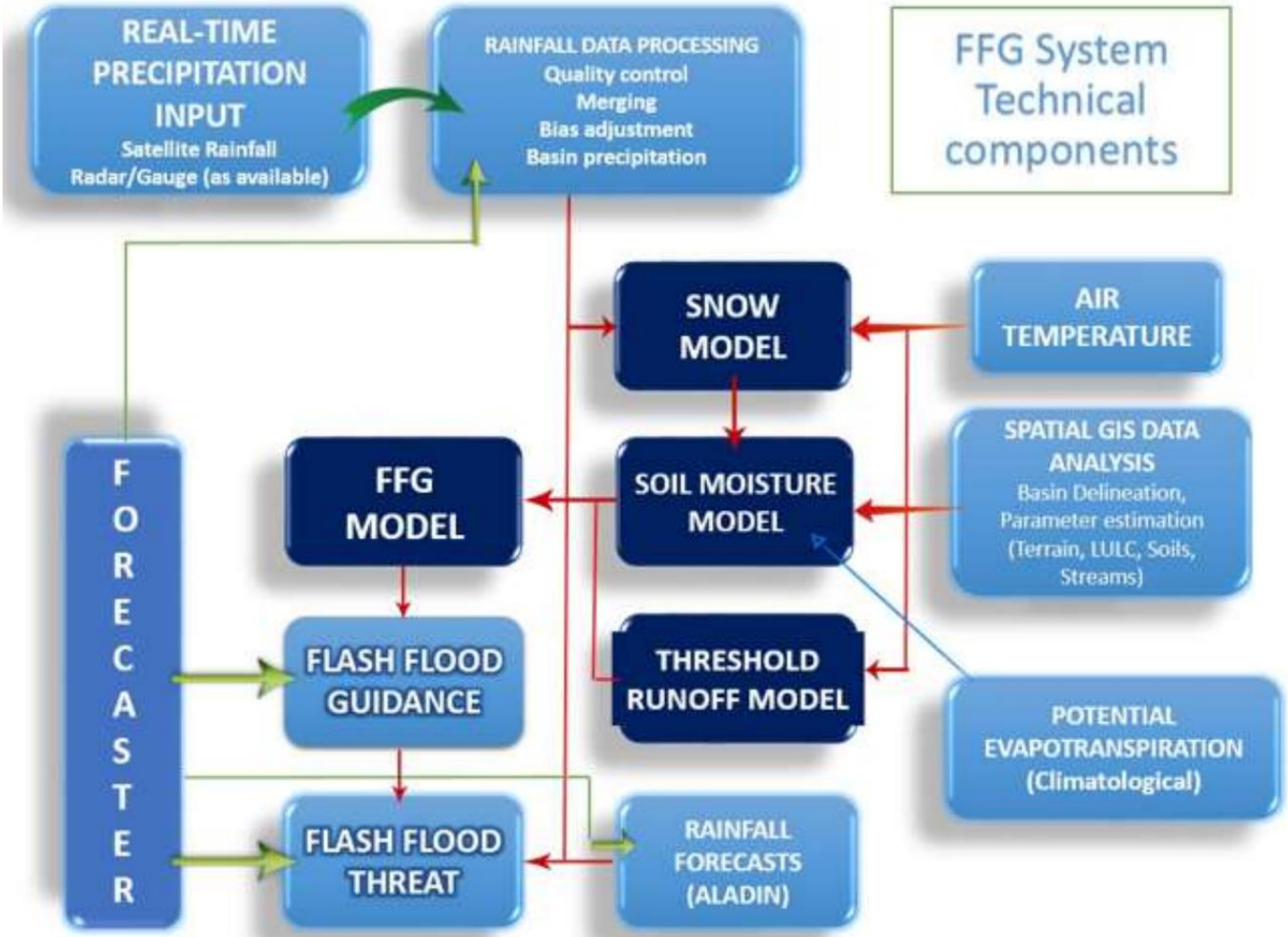
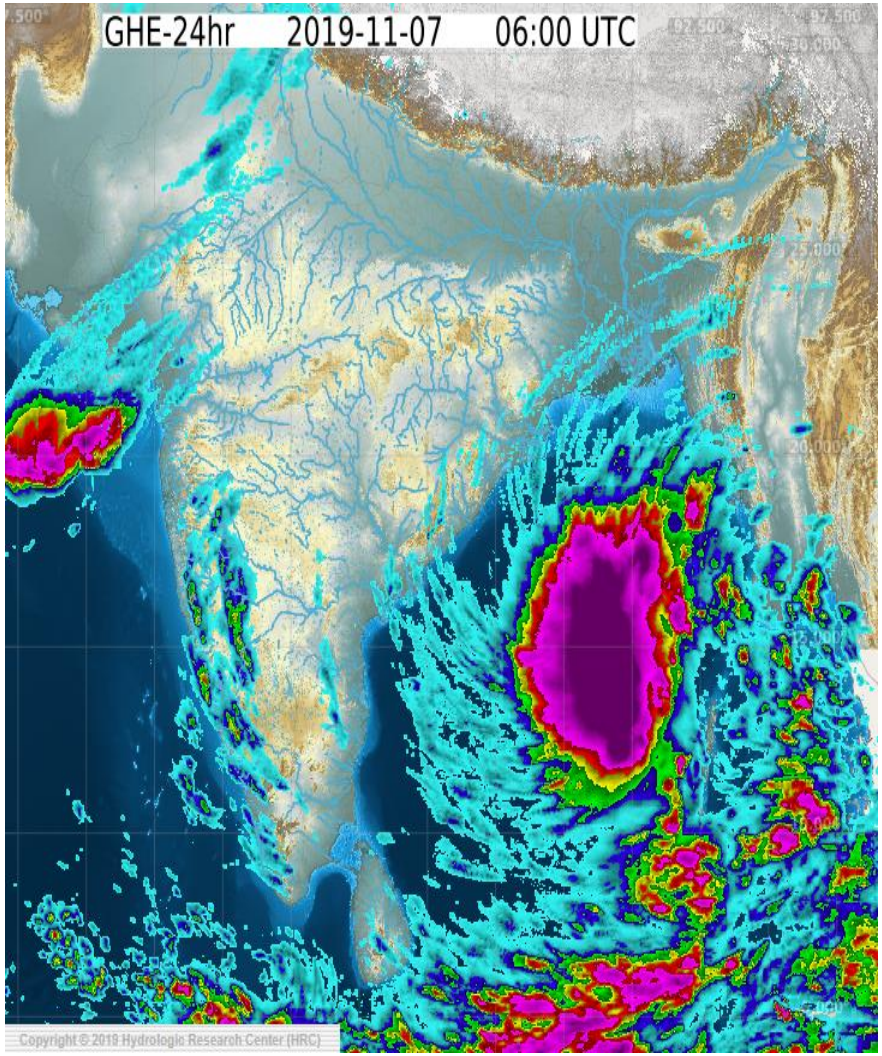
FFGS How?

NOAA Hydro estimator – IMS - HRC

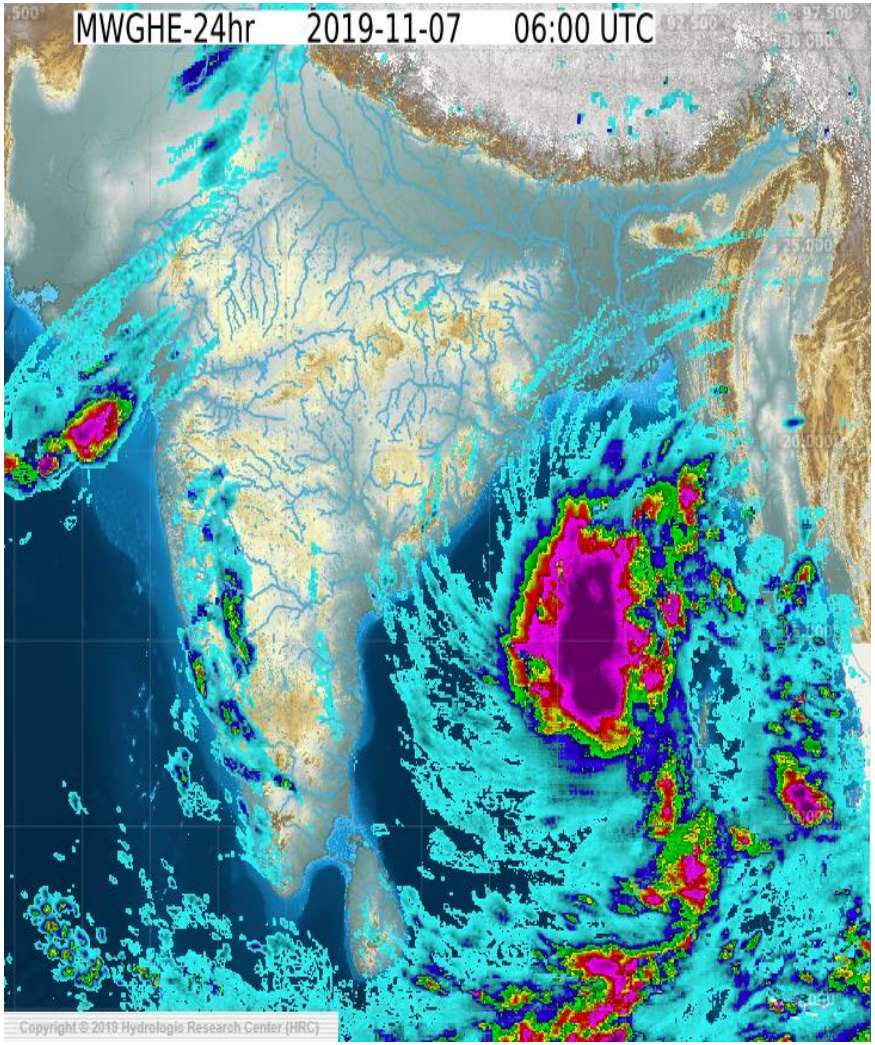


Global HydroEstimator (GHE)
Satellite-based Precipitation Estimates



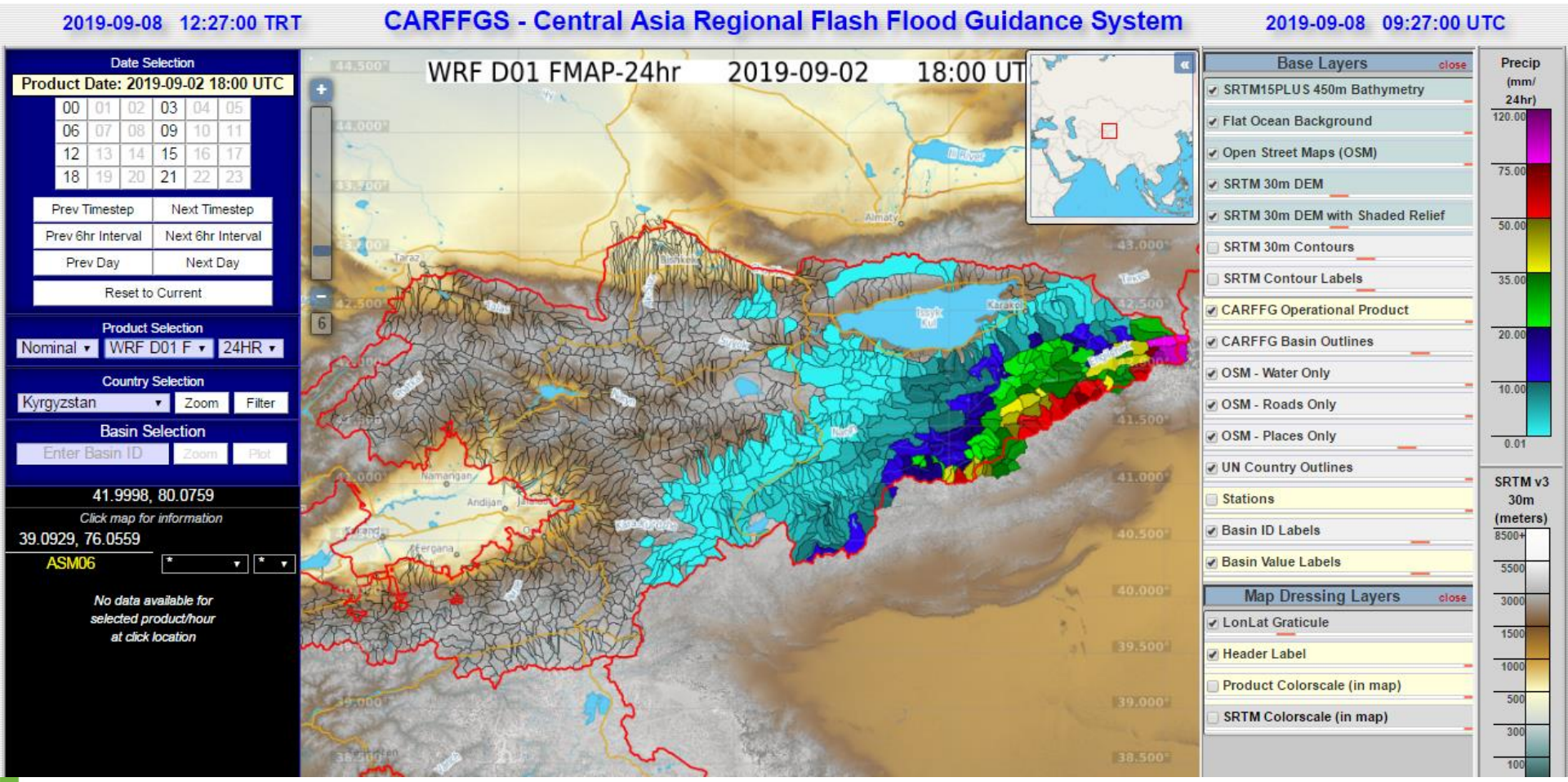
Global HydroEstimator (GHE) provides gridded accumulations of satellite-based rainfall estimates (mm) from the NOAA-NESDIS operational HydroEstimator. The data products are updated every hour with a latency of approximately 25 minutes with resolution of approximately 4 km by 4 km at the equator.

Microwave-adjusted Global HydroEstimator (MWGHE) Satellite-based Precipitation Estimates



Microwave-adjusted Global HydroEstimator (MWGHE) provides gridded accumulations of satellite-based rainfall estimates (mm) from the NOAA-NESDIS Global HydroEstimator (infrared-based) and adjusted by the NOAA-CPC CMORPH microwave-based satellite rainfall product. The MWGHE data products are updated every hour.

Map Server Interface – Kyrgyz Hydromet



Likelihood of the landslide occurrence

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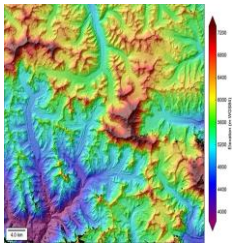
High Mountains: Progress

- Ice caps, glaciers, snow and permafrost
- Combining optical/radar imaging, altimetry and gravimetry; and DEM differencing from stereo optical data.
- Snow extent and glacier mapping still largely dependent on optical ~10 metre res. global, decadal and freely/openly accessible datasets from Landsat, ASTER and Sentinel-2, complemented by high spatial res. (<10m), limited coverage optical images (and stereo data) from SPOT, Pleiades, Cartosat-I etc.
- Snow melt mapping developing based on SAR image data at intervals of several days. Terrain flattening required to remove shadowing effects in mountains (dependent on digital elevation models)
- Multi-agency coordination or satellite constellations required to achieve revisit frequency to meet needs of snow-melt runoff operational services
- Preparation for SAR snow-depth mapping using Interferometric L-band data from SAOCOM-1A and combined L- and S-band data from NISAR (in development by NASA/ISRO)

High Mountains: Gaps



- Consolidated user requirements needed – to refocus of strategic goals.
- Spatio-temporal resolution - user requirements
- Combination of satellite data with in-situ data and Models fundamental to bridge sampling issues
- Lack of operational product capturing SWE satisfactorily at appropriate spatial scales
- Global, freely available, standard DEM (with 10-30m goal) critically needed to facilitate orthometric rectification of images – and to be able to extract hypsometric information from image data
- Regular refresh of DEM data needed to correctly assess mass balance changes in dynamic HM regions
- Future Laser altimetry / Interferometric Swath Altimetry for vertical registration of glacier images, for mass balance estimates
- Current imaging capability unsuitable for monitoring of rock glaciers in mountain permafrost

Ice sheets, Glaciers and Ice Caps: Gaps

- Consolidated glacier user requirements needed – for refocusing of strategic goals
- Need for Left-looking InSAR coverage in central Antarctica – planned to be fulfilled by NASA/ISRO NISAR (L-band SAR) in future
- Gap in continuity of gravimetric ice sheet mass-balance timeseries - now continued by GRACE-FO
- Operational successor of CryoSat-2 sought as part of evolution in Copernicus (CRISTAL ice and snow topography mission) for ice surface elevation at > 82° lat.
- Consolidated computation of ice shelf calving/iceberg flux
- Regular refresh of ice sheet DEMs in dynamic regions (TBD interval)
- Most significant residual source of uncertainty in SLR is Antarctic peninsula

Snow: Gaps

- Integration of multi-temporal, multi-sensor data to achieve products suitable for most regional snow/hydrology services
- Provide combined “all-weather” snow covered area/fractional coverage and snow melt products
- Optimal SWE satellite mission concepts in which to invest in the future.
- L-band InSAR methods still to be tested for snow depth retrieval potential (e.g. using NISAR, SAOCOM)

Permafrost: Gaps

- Obtain contiguous, seasonal, cloud-free high-res. optical coastline images (of coastal permafrost) – to enable mosaicking of shoreline retreat
- Challenge to obtain continuous, multi-sat timeseries over all cold spots
- Consistent InSAR acquisitions in high resolution modes for terrain change
- Seasonal high res. data needed for process understanding : Thaw slumps; Rock glaciers; Ice wedges (small ponds)
- No suitable tool for monitoring rock glaciers in permafrost

Possible areas for collaboration

- Data Collection: water level, soil moisture, Groundwater
- Data platform and centers:
  - WHOS will be contributing to UNOOSA – Space4Water
  - HYDROLARE
- Projects: HydroSOS (global, regional and national hydrological situation – Today and in the Future), will combine in situ and satellite information
- Other collaborations: COPERNICUS (exploratory discussions), CEOS-Water, International Network of Basin Organization, …

Conclusions

- Water is a complex system: no good decision without good information: data are central
- All data sources must be combined
- WMO paves the way to innovative water monitoring (HydroHub) and to information on possible water related problems (HydroSOS)
- Needs for satellite information for water are growing
- Only a few NMHSs a effectively using satellite information
- Cooperation a key!

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Thank you
Merci

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Summary

- Growth in cryosphere applications/service needs (particularly for non-polar cryosphere) not matched by growth in new member Agency engagement or observing system capacity designed specifically for cryosphere
  - Addition of new member Agencies needed to bring new/additional satellite capacity/resources
  - Revised strategic priorities must be established in response to the new WMO strategic plan
- WMO active stimulus of new agency engagement in PSTG needed to supplement existing available satellite resources and to make coordinated progress towards meeting user needs for frequency of revisit, particularly in low latitude HM cryosphere regions
- Balanced engagement of R&D and Operational agencies mandatory to stimulate research to operations transition
- Restricted mandate of operational space agencies means there is limited advocacy for operational satellite capabilities beyond the traditional atmospheric/meteorological/ice service domain
  - Operational advocacy needed for gravimetry based operational capability for cryosphere/hydrology/water users in the future (critical component of GGOS and unified height system)
  - Non-commercial global digital elevation/terrain model standards required for common interpretation
  - Free/open access to date products a requirement to stimulate development of new pilot products and operational services