Hydrospace-GEOGloWS 2021 Seed Questions

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Session 1: Space techniques to measure hydrological surface variables

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Improvement of space techniques

- Is the number/quality of available remote sensing measurements (e.g., satellite altimetry, optical/radar/passive microwave imagery, gravity field, etc.) sufficient for deriving hydrological surface variables with the required accuracies? (Also relevant to session 3)

- What are nowadays limitations in order to derive high-quality hydrological surface variables?
    - Is there a need for improved sensors?
    - Or have methods to be improved for the derivation of products?
    - Or have methods to be improved for the integration of various satellite products (which level?)

- What are the challenges when combining different measurement techniques in order to derive hydrological products, such as storage changes, river discharge, surface water extent?

- Are state-of-art geophysical corrections (e.g., wet troposphere, geoid model) accurate enough in order to derive precise water level time series from satellite altimetry?

- How to consolidate /extend / improve existing climate series of hydrological variables not currently supported, but extensively used?

- What are suited methodologies for validating surface area products from Radar, , passive microwaves or optical imaging sensors? How to bridge complementary low and high spatial resolution products ?

Improvement of space techniques: Future missions

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Needs for science and R&D activities in preparation for the Copernicus Sentinel Expansion Missions

Evolution in ESA's Copernicus Space Component (CSC) is foreseen in the mid-2020s to meet priority user needs not addressed by the existing infrastructure, and/or to reinforce Copernicus services by monitoring capability in the thematic domains of CO2, polar, and agriculture/forestry. This evolution will be synergetic with the enhanced continuity of services for the next generation of ESA's CSC.

See https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Copernicus_expansion_missions

From https://www.dlr.de/content/en/articles/news/2020/03/20200701_rewarding-contracts-copernicus-hpcm.html
Overview of the new missions:

- CO2M (Copernicus Anthropogenic Carbon Dioxide Monitoring) will use infrared instruments to measure the concentrations of carbon dioxide, methane and nitrogen dioxide in the atmosphere, distinguishing between anthropogenic greenhouse gases and natural sources. CO2M will thus help to monitor achievement of the targets set out in the Paris Climate Change Agreement. The Prime Contractor is OHB SE, which has its headquarters in Bremen.

- LSTM (Copernicus Land Surface Temperature Monitoring) will measure the temperature of the land surface. This is of particular interest for agricultural applications, as the surface temperature can be used to determine the amount of evaporation. This supports agricultural applications and large-scale water management, as well as enabling more accurate prediction of droughts and improved counteraction of desertification. Other applications include fire detection and monitoring.

- CRISTAL (Copernicus Polar Ice and Snow Topography Altimeter) is designed to determine the thickness of ice masses in the Arctic and Antarctic and to measure the thickness of the ice layer on the oceans. Among other things, the mission will make an important contribution to predicting changes in sea level. The Prime Contractor is Airbus Friedrichshafen.

- CIMR (Copernicus Imaging Microwave Radiometer) will monitor the ice cover and surface temperature of the oceans. These data will be used in climate research and operational ice services for maritime applications. The most important German industrial partner is HPS GmbH in Munich.

- ROSE-L (Radar Observing System for Europe at L-band), a synthetic aperture radar mission, will classify land surface cover and be able to determine the moisture content of soils as well as soil subsidence. ROSE-L will also be capable of detecting polar ice sheets and the extent of sea ice surfaces. The mission will support applications in agriculture, forestry and maritime services. The main participants in Germany are Airbus in Friedrichshafen and DLR in Oberpfaffenhofen.
- CHIME (Copernicus Hyperspectral Imaging Mission) will perform imaging spectroscopy of the land surface. This will support applications in agriculture – for example, by providing information on plant health or yield forecasts – in environmental protection, and in the extraction of mineral resources. The most important German industrial partner is OHB in Oberpfaffenhofen.

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- What are the synergistic potentials offered by the Copernicus Sentinel Expansion Missions, formerly known as HPCMs (Copernicus High Priority Candidate Missions) also in combination with the set of missions that will fly during the same period (mid-2020s and beyond)… And what R&D is needed today to prepare for this?

- At which product levels, geometries and grids should the products from current missions, Copernicus Sentinel Expansion Missions and future Earth Explorers be merged in order to best benefit from synergies? And what R&D is needed today to prepare for this?

- How do we steer our current and near-future observing strategy to cater for future user community requirements?
    - We know that climate change/human usage pattern shifts cause unforeseen problems with surface water distribution and availability. So, how do we ensure that we are acquiring now those variables and targets that will become crucial later, in order to allow change to be monitored?

Validation

- We consider satellite data unbiased and reliable and therefore use them to validate in situ measurements, especially in the cases of transboundary waters (when we have no control over in situ data and only remote observations are available)… with calibrated satellite data… With in situ data. This means using a dataset for calibrating another dataset which later will be used to validate the first dataset, which seems scientifically incorrect.
    - What should be done in such cases if there is no option of acquiring neutral ground observations?
    - Can calibration be done at another location (virtual station) where a reliable in situ dataset is available?
    - What similarities (topography, river morphology, others) do we need to ensure between the two locations?

- How to setup network of cal/val instrumentation and field experiments and how to make different sensors inter-calibrated and used in synergy when quality, and resolution are different? What does already exist? What is the role of space agency in order to support such activities?

- how to ensure the quality of the products, and how to make them really useful for different types of users.

- What do you suggest for applying satellite data in data-scarce countries where ground observations are not available for validation purposes?

Data Processing

- In most cases, the reference datums of satellite data and ground observations are not the same (sometimes unknown for in situ data): Any suggestion on how to address this problem?
    - Is there a recommended methodology to merge (unreferenced) in situ with satellite data?

- How to tackle the time difference between the two observations (in-situ and satellite) while comparing them?

- Is the scientific community interested that the SARvatore service (the SAR Altimetry Processor with SAMOSA/+/++ model on ESA-ESRIN GPOD) offers additional requirements to increase the capability (versatility) of SARvatore (more processing options promoted at user level)?

Session 2: Modelling and Assimilation

Chairs: Ayan Fleischmann, Catherine Prigent, Alice Andral, Angelica Gutierrez

- Which model?
  - Global, basin scale, local?
  - At which spatial and temporal resolutions?

- How to make the satellite data usable in models?
  - Assimilation? Data driven Integration before assimilation ?
  - Consistency of the products to be assimilated?
  - Parametrization and calibration of regional models in ungauged basin?
  - Support for prediction?
  - Flood monitoring?
  - Water cycle assessment?
  - We can take the ESA Climate Change Initiative (CCI) as excellent template for such purpose?
  - Can we benefit from the multiplicity of EOs for the same variable (inter-calibration, bias estimation, merging before assimilation)?

- Can the fusion or the combined use of different satellite sensors help to improve the estimation of hydrological variables?
  - Many hydrological variables already available. How consistent are they? Can we improve their consistency?
  - Are there any specific requirements for "auxiliary" data products (topography, vegetation, snow…)?
  - Are the present-day fusion algorithms satisfactory or shall we need to pursue research on data fusion to improve the estimation of hydrological variables?
  - Do we perfectly know the limitation of current satellite missions for hydrological variables, and do we have ideas to implement either new processing method on current data, either propose new idea of instrumentation?
  - Are some data drastically missing that could be obtained from an existing satellite mission or reprocessed data specifically for this application?

- Voice your recommendations regarding Essential Water Variables:
  - Select/define/specify/endorse your choice of Essential Water Variables (EWVs) to meet end-user (research and applications) requirements!
    - Cross-Ref.: Poster#79 - Summary of proposed "EWVs for Water Cycle Research and Water Sustainability Applications" based on the GEOSS Water Strategy Report (WSR), GEOGLOWS, and UN-SDGs among other international frameworks and conventions.

- As the "unit of work" of hydrologists is m^3/s, how do we go from (spatial) altitude at a virtual station to flow/discharge: rating curves, modelling (necessity of rainfall data), other (water slopes...)?

- Are there emerging data assimilation methodologies that are promising?

- What is the potential for alleviating the problem of satellite data coarse resolution in space and time through assimilation? Statistical and AI methods?

- What are the assumptions needed before "perform the bias correction method" can be applied? What problems could cause poor performance of the bias correction?

- Considering that the most commonly used datasets from space observation are providing water level (stage) instead of streamflow (discharge), is it possible to perform bias correction with observed water level?

- Could the Forecast from the GEOGloWS ECMWF Streamflow Services in flood events methodology applied for Drought Events?

Validation

- Considering the most common observed values datasets is water level (stage) instead of streamflow (discharge), with what statistical methods and what accuracy is it possible to validate models with the observed water level?

- Which performance metrics should the community use as a standard in order to ease comparison between studies?
    - E.g., Fit metric for accuracy of flood extent estimation.

- Regarding current hydrodynamic models (from global to regional scale applications),
    - How locally relevant are their estimates? How to define whether a model is 'locally relevant'?
    - Which metric values could be used to assess whether a model prediction can be locally relevant?
        - (E.g., RMSE < 0.4 m for water surface elevation, in the case of flood prediction)
    - What are the biggest challenges to provide useful local-scale estimates by current global to regional models?

- What are the hydrodynamic variables (e.g., river discharge, river width, water surface elevation, flood extent) mostly assessed with hydrodynamic models by the hydrologic community today, and what are the actual variables that end users expect to have? e.g., many local civil defenses rely on water surface elevation instead of river discharges, which can be a variable of difficult understanding for some operational people...

- Which hydrodynamic variables have been poorly addressed by the hydrologic community, and deserve more attention?
    - E.g., Surface water storage (in contrast to more typical variables as river discharges, water surface elevation and flood extent)

- How to improve hydrodynamic models' predictions? In which input data (e.g., boundary conditions, river cross sections, floodplain topography, distributed roughness values) should we put more effort on?

- Are the currently available flood extent data suitable to be used as model validation data?
    - It is still very difficult to validate flood models' predictions at local scales, especially in areas with quick hydrographs, or in densely vegetated floodplains. In tropical areas as the Amazon and Congo, it's still a great challenge to find flood validation data for some floodplains, given high cloud over and vegetation density - even more on upstream rivers as in the Andes mountains, with quick hydrographs

- How to compare different flood models (e.g., rainfall-runoff, hydrodynamic models, statistical approaches), in order to obtain a cost-efficiency analysis that could guide us on model selection?

Session 3: From products to applications

Chairs: Christophe Brachet, Hyongki Lee, Andreas Güntner, Huilin Gao, Zaidi Arjumand, Cédric David

Final User Analysis-Ready Products

- The hydrological communities and flood management authorities are primarily interested in **daily measurements of inland waters.** The main drawback is coarser temporal resolutions of altimetry missions, which are not suited for flood monitoring:
  - Any suggestion to convince these communities of the usefulness of satellite radar altimetry for flood monitoring?

- How to deal with **user needs**, regarding temporal and spatial resolution of final user analysis-ready products and their distribution tools?
  - Are there spatial and/or temporal sampling limitations hindering adoption of remote sensing for applied hydrology? If so, can these be overcome?

- What is the **degree of expertise of final users** needed to exploit data products?
  - What are the most critical knowledge/expertise barriers to broad use of remote sensing for water management?
  - Shall they access the same products as remote sensing specialist or are simplified products required?
  - How does one improve access and discoverability of remote sensing data?

- What are the needs of final users that is **not yet fulfilled**?
  - Are specific tools required to be developed to ease the use of satellite data products?

Requirements for Future Missions, Products and Applications

- The national adaptation plans (NAP)[1] process enables Parties/countries to formulate and implement national adaptation plans (NAPs) as a means of identifying medium- and long-term adaptation needs and developing and implementing strategies and programmes to address those needs.
  - Is there a plan within the satellite community to look at the NAPs to set criteria for future satellite missions?

- Regarding the development of applications:
  - What are some of the key success factors for applications?
  - What were the biggest challenges in the development of your respective applications? You can touch on scientific, programmatic, technical, practical, or legal challenges, for example. What did you learn that surprised you?
  - What are key pain points in the life cycle, the ingredients for failure and what can we do better?

[1] https://unfccc.int/topics/adaptation-and-resilience/workstreams/national-adaptation-plans

  - What kinds of “bad” assumptions do application developers frequently make?
  - What is your advice to both new and established applications developers?

- Is there a prospect for **adoption of your methodology** by a water management organisations (local, regional, national, international)?

- What is the **respective role of scientists and decision makers** in helping transition research to applications?

- What are the **requirements from stakeholders** for future hydrologic remote sensing applications? Daily discharge? Field scale soil moisture? Weekly snow pack? Deep groundwater? All of the above? More?

- The SDG monitoring guidelines for water-related ecosystems recognise the unique value of EO datasets to measure the changes in extent in lakes & rivers, reservoirs and wetlands.
  - What is needed to increase the uptake of satellite observations in other areas: to monitor the changes in lake and reservoir volumes, the changes in river flows in particular in ungauged rivers, the changes in ground water volumes?

- It is widely recognised that an efficient monitoring of surface waters globally must be based on different satellite observing systems (e.g., radar, optical, microwave imagers, altimetry) to overcome the limitations of single sensors.
  - What would be the improvements that the R&D community should further implement to fully address the policy needs, also keeping in mind the future new generation of satellite observing systems?

- The scientific community has made significant advances in the assimilation of surface water observations from Space into hydraulic and hydrological modelling.
  - What is needed to improve the acceptance of EO-based models in water policies and related operational water resource management practices (e.g., Water Framework Directive, Sustainable Development Goal #6, Integrated Water Resources Management)?