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ECRA Collaborative Programme

Changes in the Hydrological Cycle

Changes in the hydrological cycle and vulnerable regions

The global hydrological cycle is composed of many different and interconnected elements, which include evaporation from water surfaces and bare soil, evapotranspiration from vegetated land, transport of water vapour in the atmosphere, cloud droplet formation and cloud dynamics, liquid and solid precipitation, glaciers and snow cover dynamics, surface and river runoff, and subsurface processes such as root dynamics in vegetation and groundwater flow. The different components of the hydrological cycle react in complex, dynamic and often non-linear ways to climate change, sometimes leading to an amplification of the initial change, sometimes giving rise to negative feedbacks. While hydrological impacts of climate change – such as spatial and temporal alterations in water balance, streamflow and extreme events (floods, droughts) – typically occur at regional or local scales, they can initiate modifications that lead to larger-scale or even global changes in the water cycle. All scales are interconnected.

This Collaborative Programme fosters the study of changes in the hydrological cycle and its impacts at global and regional scales and generally aims at improving the scientific understanding of hydrological processes under modified climatic boundary conditions. It places a focus on regions with an already experienced or expected vulnerability to climate variability and change, such as the Mediterranean and mountain areas, and addresses the ecological and socioeconomic challenges that are related thereto.

Key topics for ECRA – Changes in the Hydrological Cycle

- *Performance and limitations of numerical models*
- *Representation of processes in the models and their process-oriented evaluation*
- *Uncertainty in precipitation, one of the most difficult variables of the water cycle to observe and model*
- *Societal challenges related to studying impacts of changes in components of the hydrological cycle*
- *Identification of climate hotspot regions, such as the Mediterranean and the global mountains*

Recommendations for research priorities in H2020 and beyond

- *Focus on climate-hydro interface*
  In the last decades, the impact of climate change on the water cycle has been increasingly studied, owing to new modelling frameworks operating in downscaling and upscaling modes. These have the **capability of addressing scaling issues and coupling feedback mechanisms operating at multiple scales**. Some technical questions arising at the climate and hydrology interface include: the role of observations and reference data, the appropriate downscaling approach for the variable at hand, bias-correction methods, the quantification of uncertainties across different scales and methodologies to reduce them.

- *New key topics: the Earth's Critical Zone*
  One of the less studied aspects of the water cycle concerns the **Earth's Critical Zone (ECZ), the veneer of our planet from the top of the tree canopy to the bottom of drinkable water aquifers where most life supporting processes occur.** Research on ECZ is perforce multi-sectoral and requires interdisciplinarity. It includes the potential influence of paleo-evolution on ECZ ecosystem functions, the response of the ECZ to perturbations such as climate and land use changes, possible benefits of integrating new sensing technology and models for the simulation of essential terrestrial variables, and safeguarding and managing ECZ services.

- *Impact-oriented research*
  A lack of water for drinking, agriculture, industry and energy production can impose risks for civil security. Therefore, it is important to assess and predict possible changes in water availability, distribution, and quality. Research needs to be impact-oriented in order to respond to crucial **societal challenges resulting from changes in different components the hydrological cycle and to support adaptation and risk mitigation strategies.** The appropriate context for adopting this approach is one of collaboration between scientists including hydrologists, social scientists and economists.

- *Modelling framework: a downscaling chain and related uncertainties*
  A scale mismatch still exists between the typical spatial resolution of global (70-100 km) and regional (10-40 km) climate models as well as eco-hydrological and impact models (mostly well below 1 km) to represent the response of a given variable to climatic forcing or atmosphere-surface interactions. The scale gap can be bridged through statistical and/or stochastic downscaling methods. While the reliability of both models and downscaling techniques has considerably improved, **the cascade of uncertainty from climate to impact and hydrological modelling has not been systematically accounted for. The uncertainty quantification and reduction and its correct communication to the target audience are of primary importance** for better understanding and predicting changes in the hydrological cycle and possible impacts on water resources.

- *Focus on specific regions/ecosystems/natural laboratories*
  Regions that respond more rapidly and intensely to climatic changes and anthropogenic pressures often provide essential goods to human societies. Therefore, **it is crucial to focus research efforts on vulnerable areas (mountain regions, coastal areas, natural parks, etc.) because their degradation can cause serious threats to ecosystems, habitat degradation, risk of collapse and loss of ecosystem services**.

Coordinators

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