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By Roberto Ranzi

Last 6 August 2021 the Intergovernmental Panel on Climate Change (IPCC), during its 54th Session finalized the first part of the *Sixth Assessment Report (AR6), Climate Change 2021: The Physical Science Basis,* prepared by the Working Group I. The publication of the reports on Impact and Adaptation and on Mitigation is scheduled for spring 2022. The 3949 pages WGI full report is accessible at the www.ipcc.ch web site and it will take time to study it in detail, although browsing the full report and its Summary for Policymakers (SPM) already provides a sound basis for an up-to-date approach for the assessment of the impact and design adaptation measures in water engineering, a topic of high interest for IAHR.

Below is a summary of key conclusions related to water.

The current state of the climate:

It is indisputable that human activities are causing climate change, making extreme climate events, including heat waves, heavy rainfall, and droughts, more frequent and severe.

- The likely range of total human-caused global *surface temperature* increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C.
- Human influence is very likely the main driver of the global *retreat of glaciers* since the 1990s and the decrease in *Arctic sea ice* area between 1979–1988 and 2010–2019. However there has been no significant trend in Antarctic sea ice area from 1979 to 2020 due to regionally opposing trends and large internal variability.
- It can be stated with high confidence that global *mean sea level* increased by 0.20 [0.15 to 0.25] m between 1901 and 2018. The average rate of sea level rise was 1.3 [0.6 to 2.1] mm yr^{-1} between 1901 and 1971, increasing to 1.9 [0.8 to 2.9] mm yr^{-1} between 1971 and 2006, and further increasing to 3.7 [3.2 to 4.2] mm yr^{-1} between 2006 and 2018. Thermal expansion explained 50% of sea level rise during 1971–2018, while ice loss from glaciers contributed 22%, ice sheets 20% and changes in land water storage 8%.
- In 19 out of 45 macroregions of the world an increase of *heavy precipitation* (drawn from one to five days precipitation) is observed, in 8 a low agreement is reached on the type of change and in none of them a decrease is assessed.
- In 12 out of 45 macroregions of the world an increase of *agricultural and ecological drought,* due to increased land evapotranspiration, is observed, in 28 a low agreement is reached on the type of change and just in one of them a decrease is assessed.

Possible climate futures

A set of five new illustrative emissions scenarios (named SSPx-y 'Shared Socio-economic Pathway' differently from the RCPs in the 5th Assessment Report) labelled with x=1,..,5 with radiative forcing, y, set to y=1.9, 2.6, 4.5, 7.0 and 8.5 Wm-2, is considered in AR6.

- In the mid-term (2041-2060) and long term (2081-2100) the very likely range of mean *global surface temperature increase* compared to 1850-1900 ranges from 2.0°C to 2.4°C and 2.7°C to 4.4°C, respectively, according to the SSP3-4.5 and SSP5-8.5 scenarios.
- It is virtually certain that the Arctic will continue to warm more than global surface temperature, with high confidence above two times the rate of global warming. Additional warming is projected to further amplify *permafrost thawing,* and loss of *seasonal snow cover,* of *land ice* and of *Arctic sea ice* (high confidence). There is low confidence in the projected decrease of Antarctic sea ice.
- It is virtually certain that global *mean sea level will continue to rise* over the 21st century. Relative to 1995-2014, the likely (with medium confidence) global mean sea level rise by 2100 is 0.28-0.55 m under the very low GHG emissions scenario (SSP1-1.9), 0.44-0.76 m under the intermediate GHG emissions scenario (SSP2-4.5), and 0.63-1.01 m under the very high GHG emissions scenario (SSP5-8.5).
- *Precipitation* is projected to increase over high latitudes, the equatorial Pacific and parts of the monsoon regions, but decrease over parts of the subtropics and in limited areas of the tropics.
- Increases in frequency and intensity of *hydrological droughts* become larger with increasing global warming in some regions (medium confidence). There will be an increasing occurrence of some extreme events unprecedented in the observational record with additional global warming, even at 1.5°C of global warming.
- It is very likely that *heavy precipitation events* will intensify and become more frequent in most regions with additional global warming. At the global scale, extreme daily precipitation events, with return period of 10 years, are projected to intensify by about 7% for each 1°C of global warming (high confidence).
- There is strengthened evidence since AR5 that the global water cycle will continue to intensify as global temperatures rise (high confidence), with precipitation and *surface water flows* projected to become more variable over most land regions within seasons (high confidence) and from year to year (medium confidence).
- Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO2) and other greenhouse gas emissions occur in the coming decades.

The IPCC AR6 report depicts scenarios consistent with, but, to some extent, even more severe than the AR5 and poses responsibilities to the decision makers on the active measures to be taken to mitigate the effect of the projected global warming.

The water engineering community including IAHR is also challenged in order to properly address the assessment at the regional and local scale the impact of combined climatic and anthropogenic changes in the water cycle and revision of the design and management criteria in the water sector.

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