Waterborne transport, ports and waterways: A 2021 update of climate change drivers and impacts

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Summary
The initial EnviCom Task Group 3 "Climate Change and Navigation" report (PIANC, TG3, 2008) was based on the assumptions and findings of the 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC AR4, 2007). Since 2008, IPCC has completed several major new reports including the 5th assessment report (IPCC AR5, 2013), the Special Report on Global Warming of 1.5°C (IPCC SR15, 2018), the Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC SROCC, 2019) and the 6th assessment report (IPCC AR6, 2021). This report updates PIANC TG3 (2008) with the improved climate change knowledge beyond IPCC AR4 (2007).

Keywords: climate change, maritime and inland navigation

Introduction and climate science update

This update reviews climate change impacts on maritime and inland navigation including air and water temperature, sea level rise, wind conditions, wave action, tidal and surge propagation and range, ocean circulation, storms, cyclones, coastal hydrodynamics, ice conditions, icing, water supply and quality in inland rivers, extreme hydrological conditions, and coastal, estuarine and river morphology. Notwithstanding the significant improvements in climate science and modelling with each progressive IPCC report, there are still many inherent uncertainties in climate projections, which become much wider when translated into the potential impacts on navigation.

IPCC AR6 (2021) projections for 2100 suggest that the global mean surface and sea surface temperatures will rise by between 1.0 to 4.2°C and 0.8 to 2.9°C relative to the 1986-2005 levels across the range of RCPs from 2.6 to 8.5. Representative Concentration Pathways RCPs are different future scenarios of human emissions of greenhouse gases leading to levels of radiative forcing (in Wm^{-2}) in the year 2100. Four low to very high RCP scenarios (RCP2.6, RCP4.5, RCP6.0, RCP8.5) have been commonly used. Global mean surface and sea surface temperatures can only be held steady or reduced beyond 2100 by the RCP2.6 scenario.

Sea level rise is projected to increase by 0.43 to 0.84m by 2100. As indicated in Figure 1, sea level rise continues beyond 2100 irrespective of the RCP mitigation pathways chosen – this has serious long term implications for maritime and inland navigation.

Relevant associated chemical and biological changes are included (PIANC WG195, 2021). Potential adaptation responses (PIANC WG178, 2020) and measures to strengthen resilience (PIANC TG193 2020) are identified. Navigation contributions to greenhouse gas (GHG) emissions are also summarised, along with opportunities for navigation to contribute to overall decreases in anthropogenic GHG via a framework inclusive of carbon accounting and LCA life cycle analysis (PIANC WG188, 2019).

Figure 2 presents the variation in annual mean temperature change across the world's oceans and land masses for global warming levels 1.5°C, 2°C and 4°C. The IPCC AR6 (2021) best estimate of 2100 future global average temperature is 3°C with a likely range of 2.5°C to 4°C (high confidence). This compares to 1.5°C to 4.5°C in (IPCC AR5, 2013) which did not provide a best estimate. The variability in regions is noteworthy.

Figure 3 presents the variation in annual mean average precipitation across the world's oceans and land masses for global warming levels of 1.5°C, 2°C and 4°C. The variability in regions is noteworthy.
High latitude land masses are likely to experience increased average precipitation due to increased specific humidity and increased transport of water vapour from the tropics; where as many mid-latitude and subtropical regions will likely experience less precipitation and increased risk of drought and desertification. Globally short duration precipitation events will shift with more intense storm events and fewer weak storms being likely as temperatures increase. Over most of the mid latitude land-masses and over wet tropical regions, extreme precipitations events will very likely be more intense and more frequent. These changes resulting in drought, fires and floods are already evident.

Conclusions

Many of the climate-related changes that matter most to ports and waterways are driven by changes in temperature. Rising air and water temperatures will affect worker safety, seasonal precipitation, sea level, wind, waves acidity and other relevant parameters. Even if emissions of greenhouse gases (especially carbon dioxide CO_2) stop today, these changes would continue for many decades and in the case of the sea level rise for centuries

In a survey of international ports by UNCTAD (2017), the impacts of climate change parameters were identified against categories of port assets and operations- noted the impacts of winds, precipitation and storm surge on ship and terminal operations.

References

IPCC AR4 (2007) 4th assessment report
IPCC AR5 (2013) 5th assessment report
IPCC AR6 (2021) 6th assessment report
IPCC SR15 (2018) Special Report on Global Warming of 1.5°C
IPCC SROCC (2019) Special Report on the Ocean and Cryosphere in a Changing Climate
PIANC WG178 (2020); Climate Change Adaptation Planning for Ports and Inland Waterways
PIANC TG3 (2008) Climate Change and Navigation
PIANC WG175 (2019); A Practical Guide to Environmental Risk Management (ERM) for Navigation Infrastructure Projects
PIANC WG188 (2019); Carbon Management for Port and Navigation Infrastructure
PIANC TG193 (2020); Resilience of the Maritime and Inland Waterborne Transport System
PIANC WG195 (2021); An Introduction to Applying Ecosystem Services for Waterborne Transport Infrastructure Projects
UNCTAD (2017) Research Paper 18: Port industry survey on climate change impacts and adaptation: UNCTAD/SER.RP/2017/18/Rev.1: Dec 2017

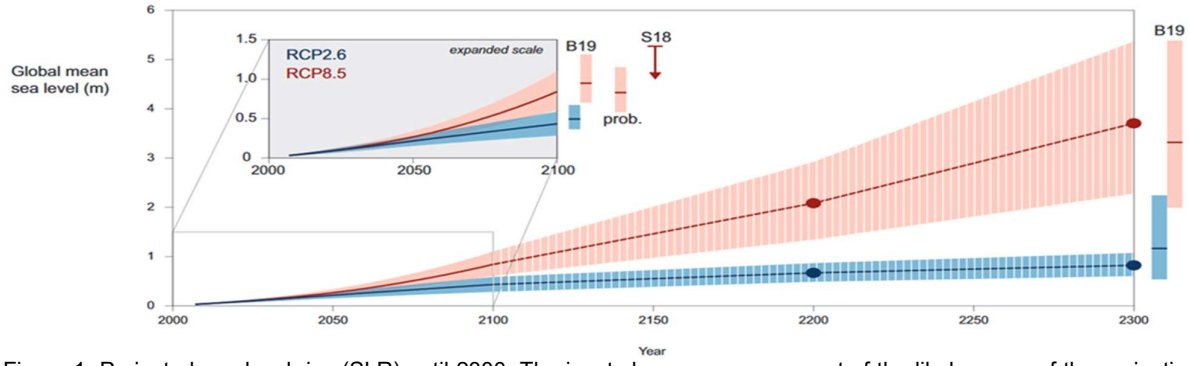

Figure 1: Projected sea level rise (SLR) until 2300. The inset shows an assessment of the likely range of the projections for RCP2.6 (0.43m) and RCP8.5 (0.84m) up to 2100 (medium confidence). Projections for longer time scales are highly uncertain but a range is provided (low confidence). Reproduced from IPCC AR6 2021 Figure 4.2

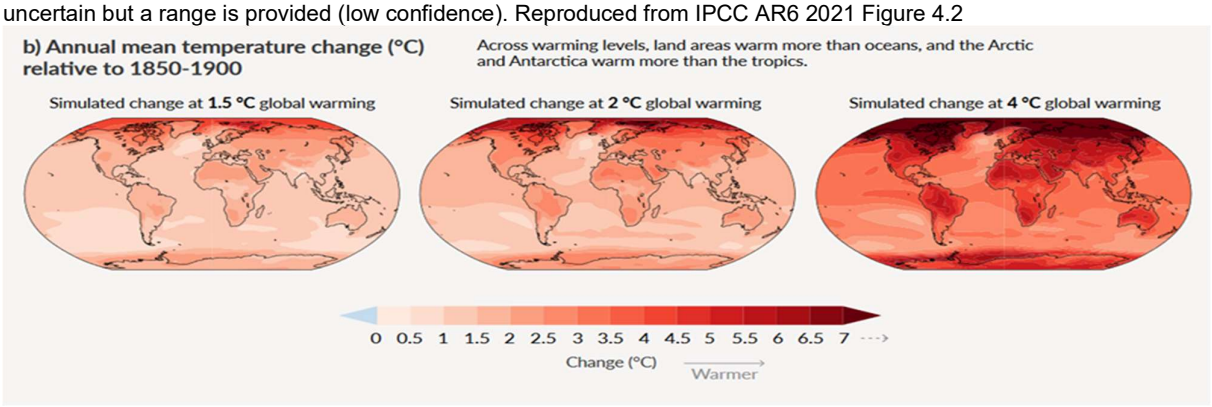

Figure 2: Simulated annual mean temperature change (°C) at global warming levels of 1.5°C, 2°C and 4°C (20-yr mean global surface temperature change relative to 1850–1900) - Reproduced from IPCC AR6 2021 Figure SPM.5b

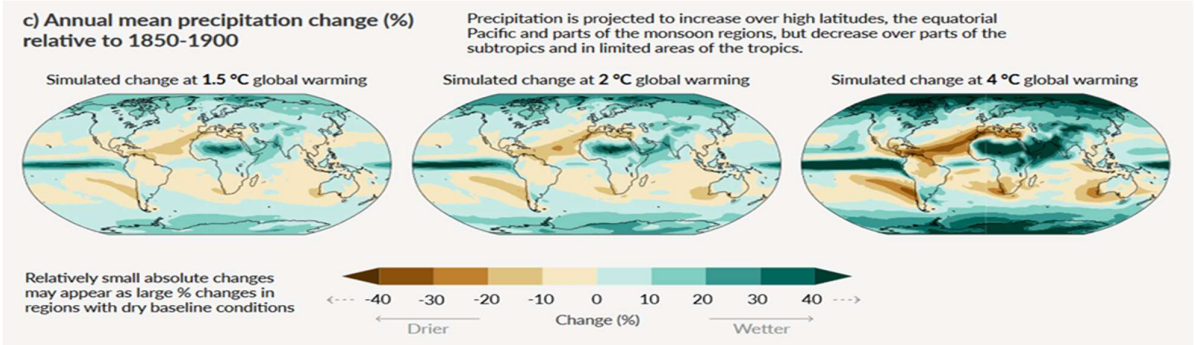

Figure 0: Simulated annual mean precipitation change (%) at global warming levels of 1.5°C, 2°C and 4°C (20-yr 0). - reproduced from IPCC AR6 (2021) Figure SPM.5c.