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Climate Change Impact Assessment and Adaptation

Climate Change - Adaptation and Resilience to Minimize Destabilizing Influences
Impact of Climate Change on the water cycle

Observed Greenland Ice Mass Changes after gravimetric GRACE measurements (The Earth Observer, 30 (3), 2018) corresponding to 8 cm/century Sea Level Rise
Melt duration (MD): total number of melting days after passive microwave monitoring
Mean melt duration (MMD): average number of melting days over Greenland
Melt index (MI): number of days of melting times the area detected as melting
Maximum melting surface (MMS): area of the surface presenting melting at least once

Results: Greenland Melting trends

- $\mu_{\text{trend}}^{\text{MD}} = -0.8577 \frac{\text{days}}{\text{year}}$
- $\mu_{\text{trend}}^{\text{MED}} = 0.8782 \frac{\text{days}}{\text{year}}$
- $\mu_{\text{trend}}^{\text{MS}} = 0.3386 \frac{\text{days}}{\text{year}}$
- $\mu_{\text{trend}}^{\text{ELME}} = -0.5985 \frac{\text{days}}{\text{year}}$
- $\mu_{\text{trend}}^{\text{MD} (245K)} = 0.5466 \frac{\text{days}}{\text{year}}$
- $\mu_{\text{trend}}^{\text{MD(MEMS)}} = 0.7841 \frac{\text{days}}{\text{year}}$
- Results consistent with previous works (Tedesco et al., 2007) at 25 km spatial resolution

Tedesco, Colosio, Ranzi, submitted
Impact of Global Warming on the water cycle (1): Flood timing

Fig. 1. Observed trends of river flood timing in Europe, 1960–2010. The color scale indicates earlier or later floods (days per decade). Regions with distinct drivers: Region 1, northeastern Europe (earlier snowmelt); region 2, North Sea (later winter storms); region 3, western Europe along the Atlantic coast (earlier soil moisture maximum); region 4, parts of the Mediterranean coast (stronger Atlantic influence in winter).

Bloeschl et al., Science, 2017
Impact of Global Warming on the water cycle (2): Flood intensity

Fig. 1 | Observed regional trends of river flood discharges in Europe (1960–2010). Blue indicates increasing flood discharges and red denotes decreasing flood discharges (in per cent change of the mean annual flood discharge per decade). Numbers 1–3 indicate regions with distinct drivers. 1, Northwestern Europe: increasing rainfall and soil moisture. 2, Southern Europe: decreasing rainfall and increasing evaporation. 3, Eastern Europe: decreasing and earlier snowmelt. The trends are based on data from $n = 2,370$ hydrometric stations. For uncertainties see Extended Data Fig. 2b.
Impact of Global Warming on the water cycle (3): mean annual riverflow


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Research papers

Long-term trends in global river flow and the causal relationships between river flow and ocean signals

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Data about monthly and annual riverflow of 916 rivers worldwide flowing into the oceans in the period (1948–2004) show that for 120 of them the trends are positive, while for 51 they are negative.

Fig. 3. Spatial distribution of stations with streamflow trends deemed significant by the MK1/MK2/MK3/MK4 tests (5% significance level). Rivers with significant increases in streamflow are represented by dark blue dots; rivers with streamflow increases that were not significant are represented by pale blue dots. Similarly, rivers with significant decreases in streamflow are represented by red dots and rivers with streamflow decreases that were not significant are represented by pink dots. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Adaptation and resilience: structural measures

The Great Acqua Alta of 2-4 November 1966
Observed and projected MSL in Venice (IPCC 2013)

~ 63 cm
Adaptation and Resilience: the engineering ‘hardware’ is completed and now its operation and management will start.
Simulation of storm surge barrage operations under scenarios including climate change: role of hydrodynamic modelling

Courtesy of E. Foti (U Catania)
OBJECTIVE:
Evaluate climate change impacts on Intensity-Duration-Frequency (IDF) curves and develop new regional IDF curves for selected cities in Canada.

KEY CHALLENGES:
- Climate Change Impacts:
  - Downscaling Approaches
  - Non-stationarity Process
- Single-Site and Regional Rainfall Modeling:
  - Multi-site Modeling Methods
  - Regionalization Methods (Ungaged Sites)

Adaption & resilience revision of design criteria in urban drainage

Courtesy of Van Thanh Van Nguyen
Guidelines for Climate Proofing Investment in the Energy Sector
Adaption: non structural measures as land use and agricultural practices and ‘virtual’ water trade

All assessed future socio-economic pathways result in increases in water demand and water scarcity (high confidence)......

Solutions that help adapt to and mitigate climate change while contributing to combating desertification include inter alia: water harvesting and micro-irrigation”
Water-Food Nexus

Examples

Beef (1 kg) 11 m³
Milk (1 liter) 0.8 m³
Wheat (1 kg) 1 m³

Water Footprint

Hoekstra and Chapagain, 2008
Food trade → Virtual water trade

D’Odorico et al., 2014
Global virtual water trade and the hydrological cycle: patterns, drivers and socio-environment impacts
Conclusions

• The impact of CC on the water cycle is evident although regional variability is high
• Discriminating natural and anthropic factors is crucial
• Water engineering and hydro-sciences can help in suggesting structural and non-structural alternatives and solutions to adapt to the challenges climate change is posing to our and next generations
Sea-level rise effects?

Tide gauge at Punta della Salute, Venice

Courtesy of Marco Marani (U Padua) and Enrico Foti (U Catania)