Drought in a changing climate: AR5 and recent scientific advances

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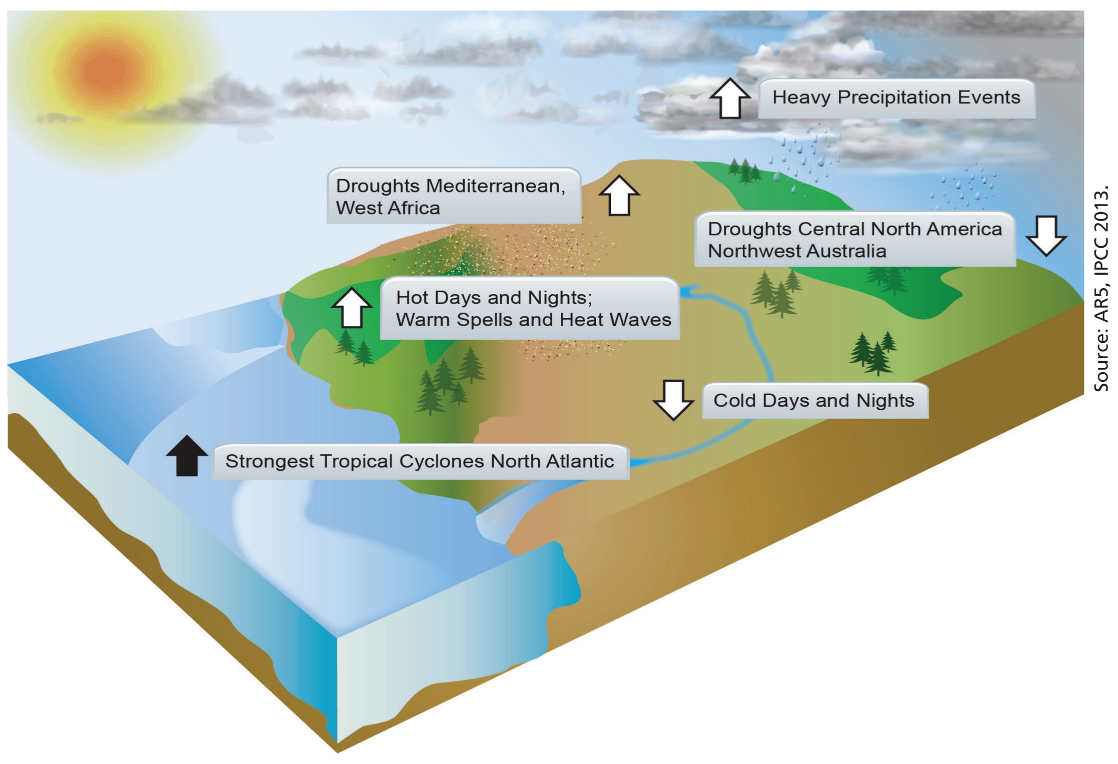
Summary

- Drought is a complex phenomenon affected by changes in the hydrological cycle and producing a web of impacts across many sectors and potentially leading to land degradation and forest dieback ;
- The IPCC AR5 (2013) stressed low confidence in a global-scale observed trend in drought, owing to lack of direct observations, dependencies of inferred trends on the index choice, as well as difficulties in distinguishing long-term climate change from decadal-scale drought variability ;
- Recent years have shown substantial methodological developments to monitor and assess drought in a changing climate.

AR5 assessment of changes in drought

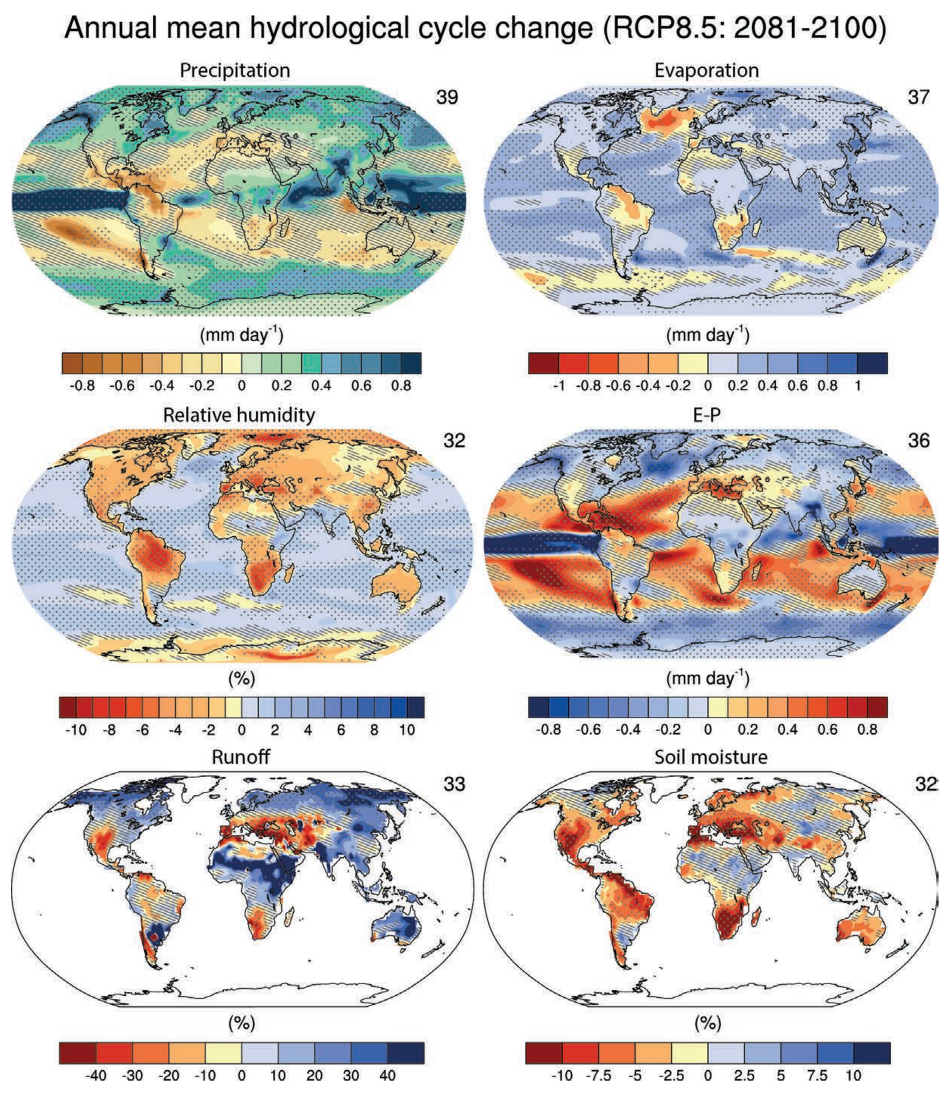
Key findings



- *Low confidence* in an observed global-scale trend in drought or dryness (lack of rainfall) since the 1950s, due to lack of direct observations, methodological uncertainties and choice and geographical inconsistencies in the trends ;
- *High confidence* that the frequency and intensity of drought since 1950 have *likely* increased in the Mediterranean and West Africa (although 1970s Sahel drought dominates the trend) and *likely* decreased in central North America and northwest Australia ;
- *Low confidence* in attributing changes in drought over global land areas since the mid-20th century to human influence owing to observational uncertainties and difficulties in distinguishing decadal-scale variability in drought from long-term trends ;
- *High confidence* for droughts during the last millennium of greater magnitude and longer duration than those observed since the beginning of the 20th century in many regions.

Projections of drought by 2100 in RCP8.5

- Regional to global-scale projected decreases in soil moisture and increased agricultural drought are *likely (medium confidence)* in presently dry regions ;
- Surface drying is *likely* with *high confidence* by the end of the 21st century in the RCP8.5 scenario in the Mediterranean, southwest USA and southern African regions, consistent with projected change in Hadley circulation.

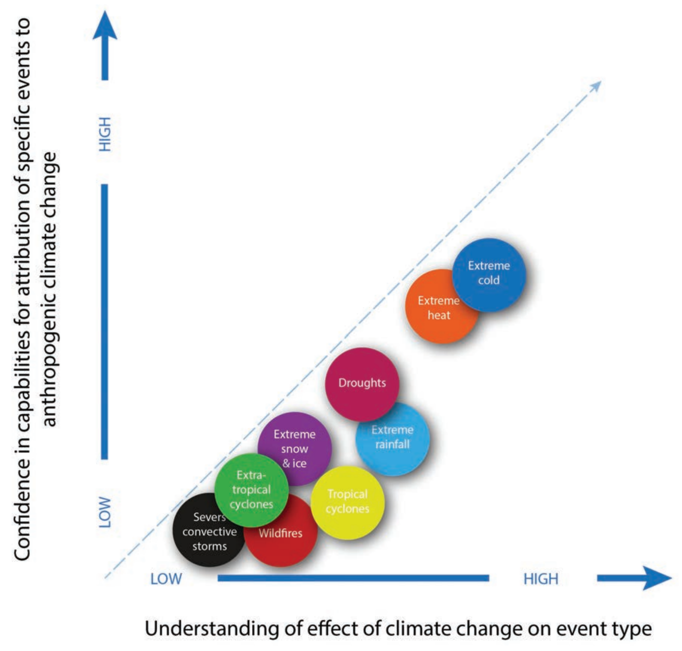


Source: AR5, IPCC 2013.

Emerging areas of research

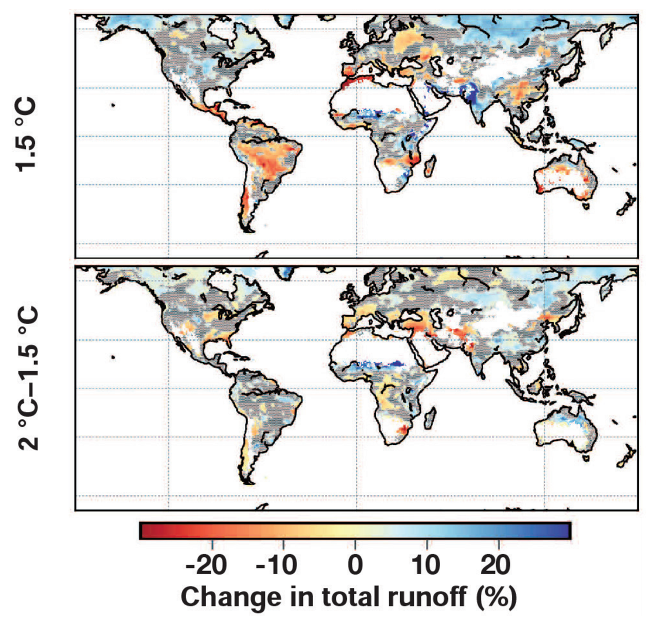
Internal variability versus anthropogenic forcing

- California: rainfall deficit linked to natural variability, water stress enhanced by warming trend *(Griffin et al, GRL, 2014 ; Williams et al, GRL 2015 ; Diffenbaugh et al, PNAS, 2015 ; Cheng et al.,2016, J Clim)* ;
- Levant region: drought twice more likely due to human influence on drying and warming trend *(Bergaoui et al., 2015, BAMS ; Cook et al, JGR, 2016, Kelley et al, PNAS, 2015)* ;
- Australia: human influence on large scale drivers *(Cai et al., 2014, J. Clim)* ;
- Sahel rainfall recovery since the 1980s: role of greenhouse-gas and aerosol forcing *(Dong and Sutton, Nature Climate Change, 2015)*.



Source: NAS Report, Attribution of extreme events, 2016.

Link with global temperature target



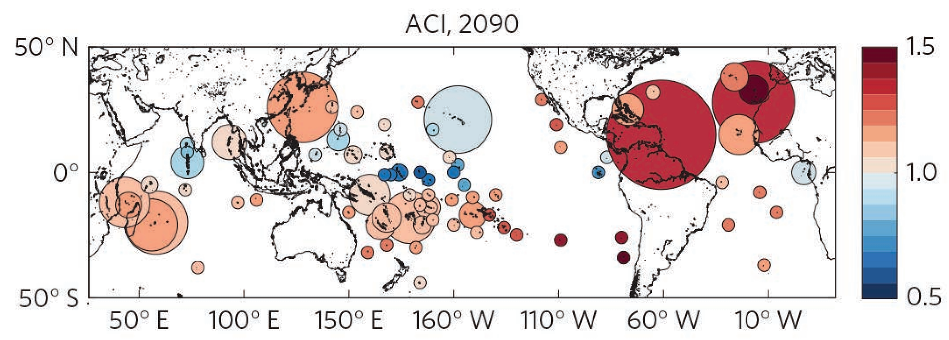
Source: Schleussner et al, Earth Syst. Dynam., 2016.

- Increased reduction in annual water availability projected in the Mediterranean region (from 9 % to 17 %), Central America, South Africa for 2°C compared to 1.5°C above 1850-1900 (ISI-MIP).

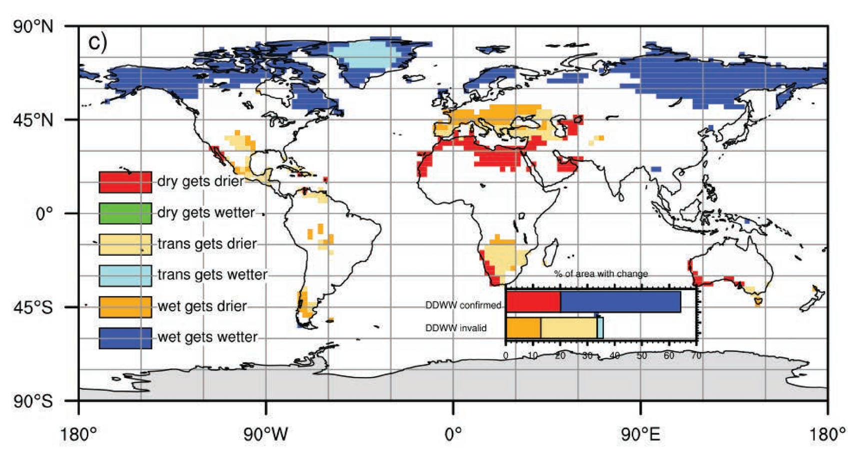
Fresh water stress in small islands

- Robust yet spatially variable tendency towards increasing aridity for 73 % of island groups by 2050 (RCP8.5, 22 models).

Figure: aridity change index (ratio of change in potential evaporation to fractional change in precipitation) compared to 1981-1999. Area of bubble proportional to the population. From Karnauskas et al., 2016, Nature Climate Change.



Paradigm of « Wet regions get wetter and dry regions get drier »



Source: Greve and Seneviratne, GRL, 2015.

- Discrepancies explained by the role of internal variability and water limitation in dry regions, greater detectability of wet regions *(Kumar et al, GRL, 2015, WRR 2016)* ;
- Large uncertainities in projected change in water availability *(Greve and Seneviratne, GRL, 2015, Sedlacek and Knutti, ERL, 2014)*.

Expanding AR5 findings

- Role of drought on inter-annual variability in semi-arid ecosystem net primary production: affecting the global carbon cycle *(Huang et al, Nature Scientific Reports, 2016)* ;
- Expansion of global drylands observed since 1950 and projected under RCP8.5 warming climate: controversy on calculations of aridity indices based on evaporative demand *(Sherwood and Fu, Science, 2014; Roderick et al, WRR, 2015, McEnvoy et al., J. Hydromet, 2016)*. Drying in SW N. America, Mediterranean area, S. Africa, Australia *(Feng and Fu, ACP, 2013; Spinoni et al, Int. J. Clim, 2015)*, central America and the Amazon *(Cook et al, J. Clim., 2015)* ;
- Lessons from large climate model ensembles for projected change in river runoff: robust between-ensemble agreement in regional drying (e.g., southern Africa and southern Europe) and wetting trends (e.g., northeastern United States) *(Boehlert etal., J. Clim, 2015)* ;
- Gridded centennial hydroclimate reconstruction for the northern hemisphere land: similar patterns of spatio-temporal variability as observed in the instrumental period *(Ljungqvist et al, Nature, 2016)*.

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