Met Office

Observed climate extreme/impact trends

These maps show the observed regional trends in 6 types of climate extremes and impacts, with examples of impactful extreme weather events attributable partly or wholly to anthropogenic climate change. Regions experiencing multiple increasing extremes and impacts are highlighted. The maps show regions where recent decades have seen increases in extreme heat, heavy rainfall, agricultural drought, and the length of the fire weather season, as well as changes in river flows, and glacier mass. Regions with decreasing extremes are also shown. Confidence in attribution of trends to human-caused climate change varies between impacts and regions, and information is not available for all impacts. There are numerous other impacts related to human-induced climate change, such as coastal flooding and risks to biodiversity leading to widespread decline in ecosystems, that are also of concern but not shown here.

Met Office

Extreme high temperatures

Observed changes in hot extremes since the 1950s and examples of impactful extreme heat events with severity / likelihood increased by anthropogenic climate change.

Pacific Northwest, North America, June 2021

Record temperature for Canada of 49.6°C.

1,400 excess deaths in USA and Canada. Extensive wildfires, disruption to rail and road infrastructure, flooding due to rapid snowmelt.

Extreme heat at this level is virtually impossible without human-caused climate change.

(Philip et al., 2021)

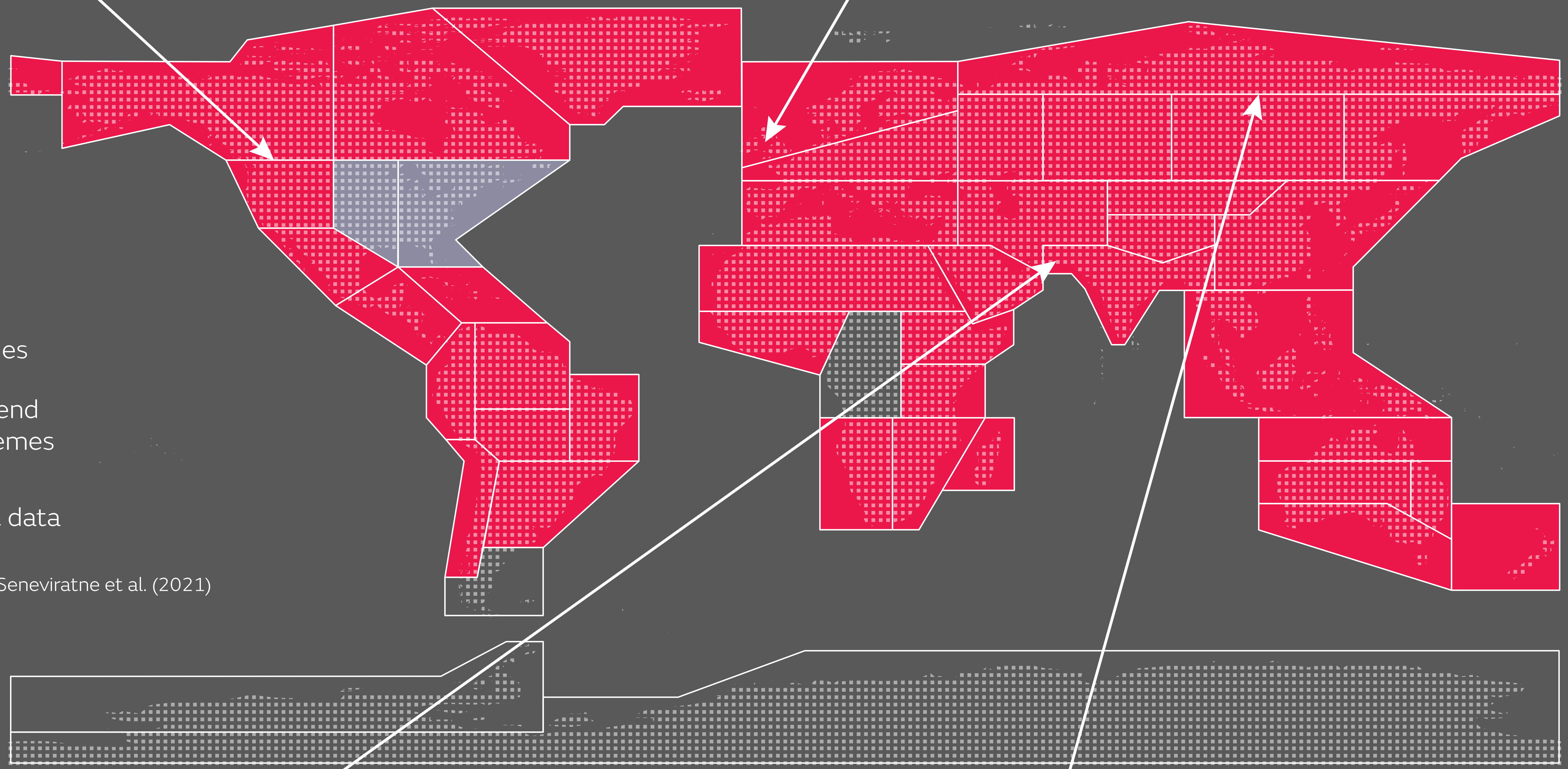
United Kingdom, July 2022

Record high temperatures of over 40°C across wide areas of England.

Over 1000 excess deaths in over-65s. 13 deaths due to drowning. Widespread disruption to railway network. Multiple wildfires, numerous private houses destroyed. London Fire Brigade had busiest day since Second World War.

Event would have been 4°C cooler in pre-industrial times.

(Zaccariah et al., 2022a)



Increased hot extremes

No clear trend in hot extremes

Insufficient data

Source for trends data: Seneviratne et al. (2021)

India and Pakistan, March 2022

At least 90 deaths across India and Pakistan, Glacial Lake Outburst Flood in northern Pakistan, forest fires in India.

10-35% reduction in crop yields in Haryana, Uttar Pradesh, and Punjab.

Extreme heat 30 times more likely due to climate change.

(Zaccariah et al., 2022b)

Siberia, January - June 2020

Record temperature of 38°C north of Arctic Circle.

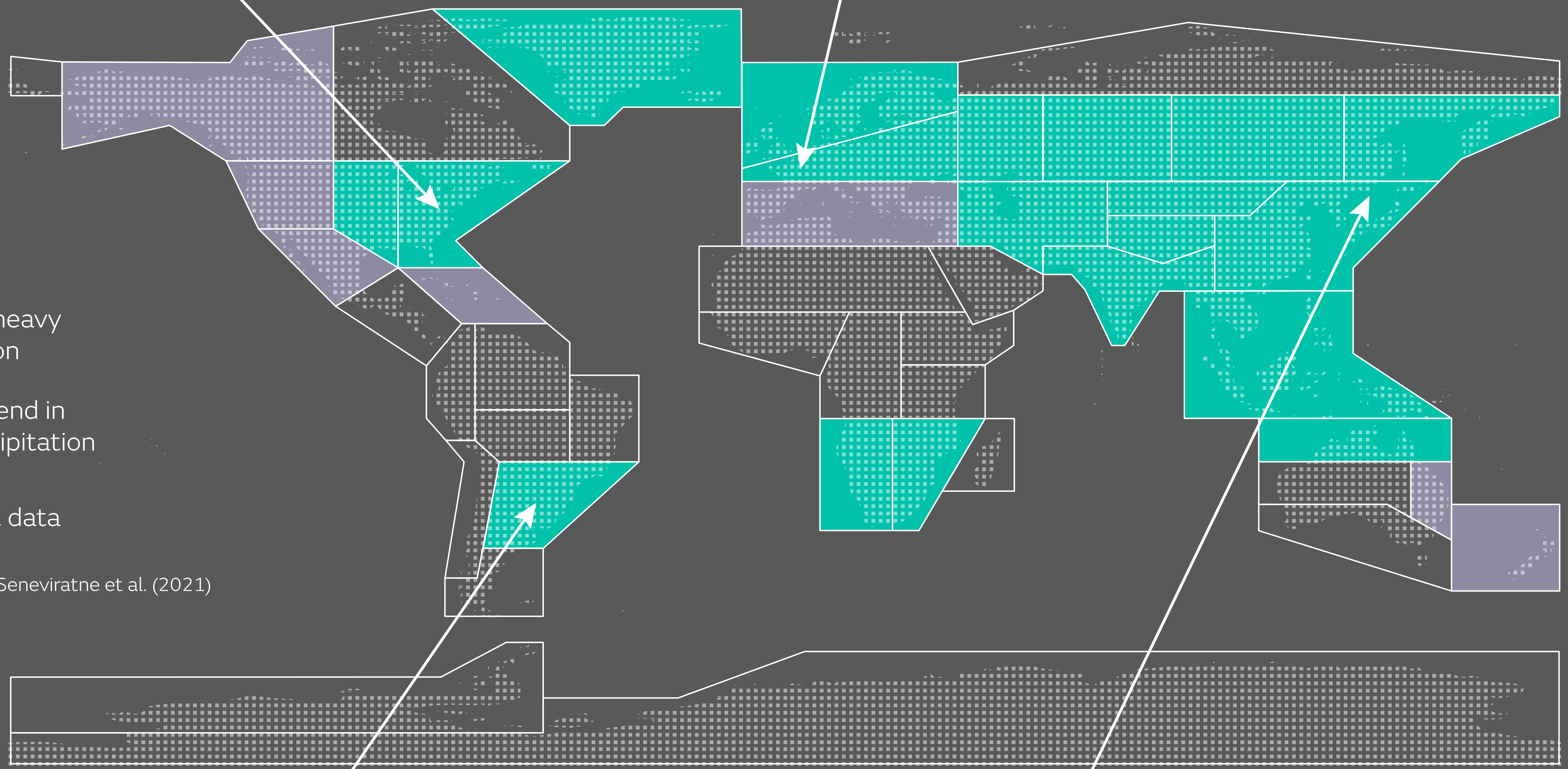
Forest fires affecting hundreds of thousands of hectares, thawing of permafrost, rapid growth of damaging swarms of Siberian silk moth.

(Ciavarella et al., 2020)

Met Office

Heavy rainfall and flooding

Observed changes in heavy precipitation since the 1950s and examples of major flooding events with severity / likelihood increased by anthropogenic climate change.



Increased heavy precipitation

No clear trend in heavy precipitation

Insufficient data

Source for trends data: Seneviratne et al. (2021)

Ottawa, Canada, Spring 2019

Flooding fed by a month of above-average rainfall. Thousands of people evacuated, extended states of emergency, $200 million in insured losses.

30-day rainfall at this level 2 to 3 times more likely with anthropogenic forcing.

(Kirchmeier-Young et al., 2021)

Western Europe, July 2021

Flooding due to very heavy rainfall over 1-2 days. At least 243 deaths.

Daily rainfall increased by up to 19% by climate change.

(Kreienkamp et al., 2021)

Uruguay and Brazil, April-May 2017

Flooding caused direct economic loss in Brazil of US$102 million and displacement of more than 3,500 people in Uruguay.

Fivefold increase in likelihood of extreme rainfall levels due to anthropogenic climate change.

(de Abreu et al., 2019)

Japan, July 2018

237 fatalities, more than 6,000 buildings destroyed by floods and landslides.

Rainfall increased by 7% by recent rapid warming.

(Kawase et al., 2020)

Met Office

River flows

Observed changes in river flows influenced by climate change, between 1971 and 2010.

Declining flows in Colorado river

Increased evapotranspiration due to warming has caused a a 13% decrease in flows in the Colorado River.

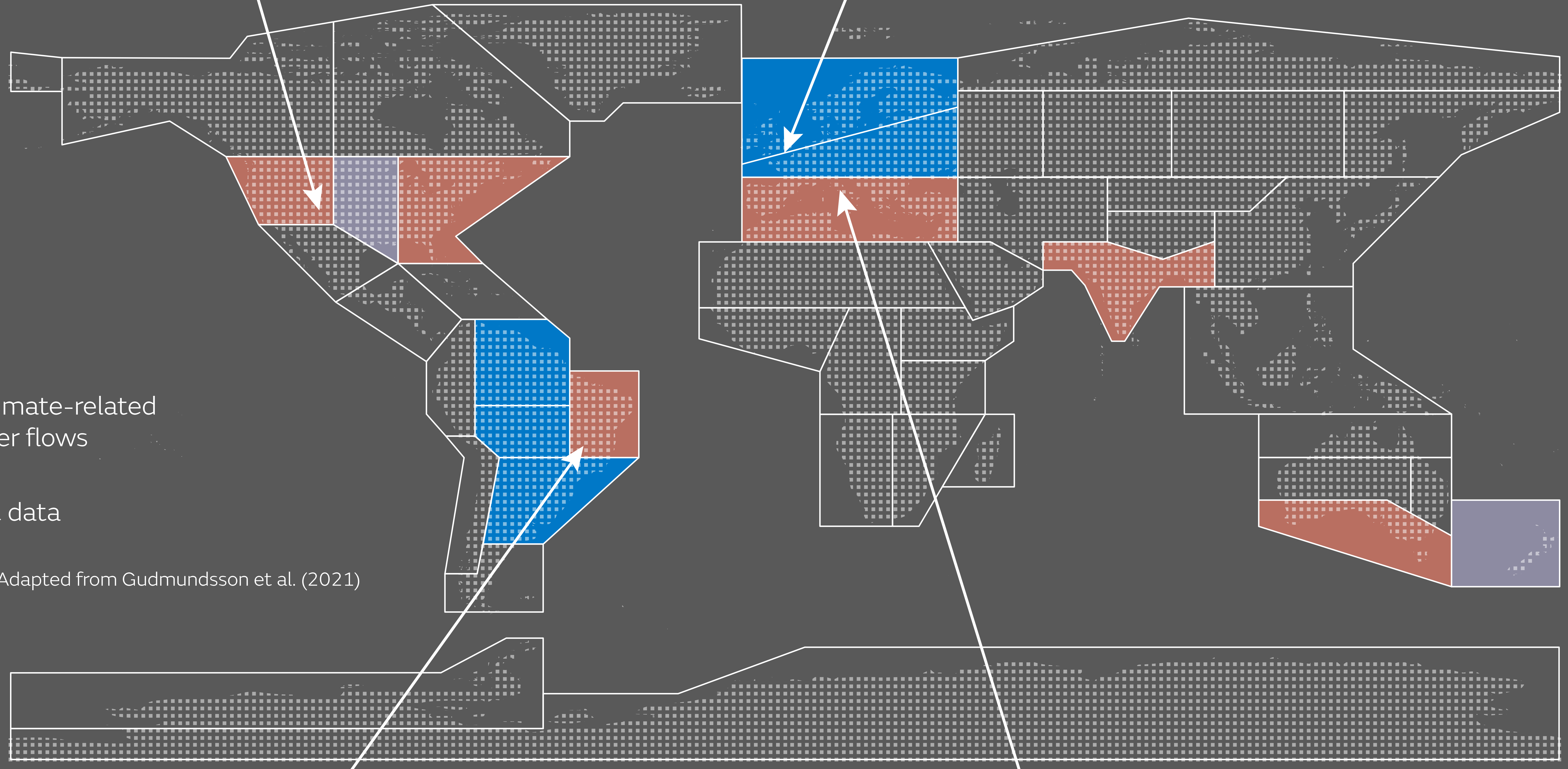
Tier-1 water shortage declared for the first time ever in 2021, restricting water extractions.

(Overpeck and Udall, 2020; Schlageter, 2021)

Increasing river flood hazards in Western Europe

Increasing precipitation raised river flood hazards in western central Europe and the UK by 11% per decade from 1960 to 2010. The last three decades saw the highest number of floods in the past 500 years.

(Bednar-Friedl et al., 2022)



Increased river flows

Decreased river flows

No clear climate-related trend in river flows

Insufficient data

Source for trends data: Adapted from Gudmundsson et al. (2021)

Reduced hydropower generation in North-East Brazil

30% decrease in streamflows at Sobradinho Dam causing reduced hydropower generation.

(Santos et al., 2022)

Reduced groundwater recharge in southern Europe

Low recharge rates combined with high levels of abstraction are depleting of groundwater resources in parts of southern Europe, increasing water scarcity and threatening environmental flow limits.

(Bednar-Friedl et al., 2022)

Met Office

Agricultural drought

Observed changes in agricultural (soil moisture) drought since the 1950s, and examples of major drought events with severity / likelihood increased by anthropogenic climate change.

Washington State, USA, 2015

$335 million loss for the agricultural industry.

Drought emergency declared in May following several months of snowpack drought resulting from exceedingly high temperatures despite normal precipitation.

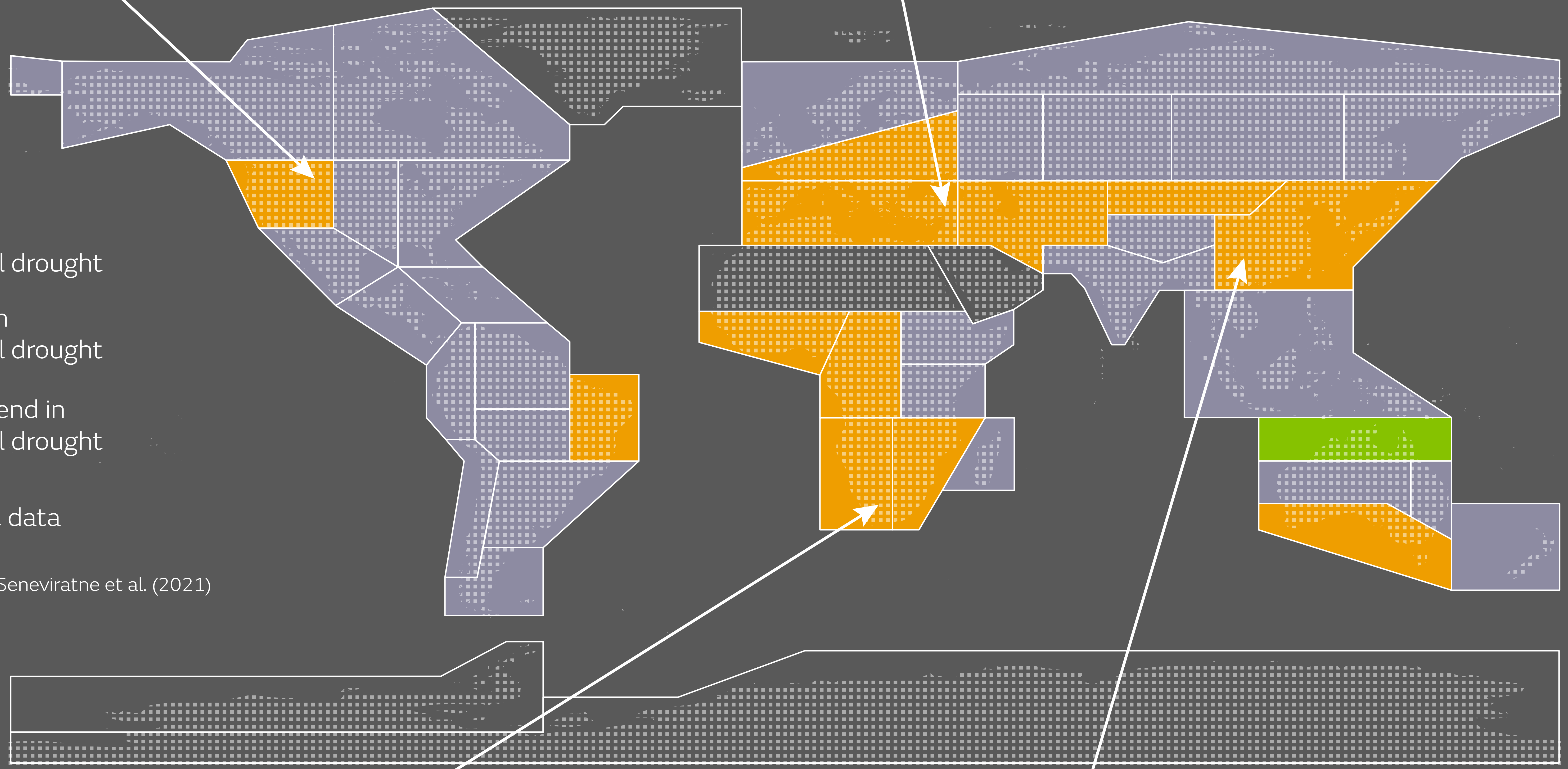
(Fosu et al., 2016)

Southern Levant, Syria, 2014

Drought amplified an already complex water and food situation in a war-affected region with a refugee crisis.

Persistent drought in the 2014 rainy season was unprecedented for the critical January–February period in the observational record, and was made about 45% more likely by anthropogenic climate change.

(Bergaoui et al., 2015)



- Increase in agricultural drought
- Decrease in agricultural drought
- No clear trend in agricultural drought
- Insufficient data

Source for trends data: Seneviratne et al. (2021)

Western Cape, South Africa, 2015-2019

Water supply was reduced to 20% of capacity in January 2018. Agricultural yields in 2019 declined by 25%.

Anthropogenic greenhouse forcing at least doubled the likelihood of drought levels seen in 2015-2019 with possible offsetting effects by anthropogenic aerosols.

(Kam et al., 2021)

South-western China, May-June 2019

- Over 640,100 hectares of crops damaged
- Over 100 rivers and 180 reservoirs dried out
- Over 824,000 people and 566,000 head of livestock faced severe lack of drinking water
- Direct economic loss of 2.81 billion Yuan ($400 million)

The low precipitation levels were 1.4 to 6 times more likely due to human-caused climate change.

(Lu et al, 2021)

Met Office

Fire weather

Change in length of fire weather season between 1979 and 2019 from reanalysis, and examples of major fire events with severity / likelihood increased by anthropogenic climate change.

Northern Great Plains, USA, May-July 2017

"Billion-dollar disaster" one of Montana's worst wildfire seasons on record. Agricultural losses of $2.5 billion.

1.5 times more likely due to increased evapotranspiration (minimal anthropogenic impact on rainfall).

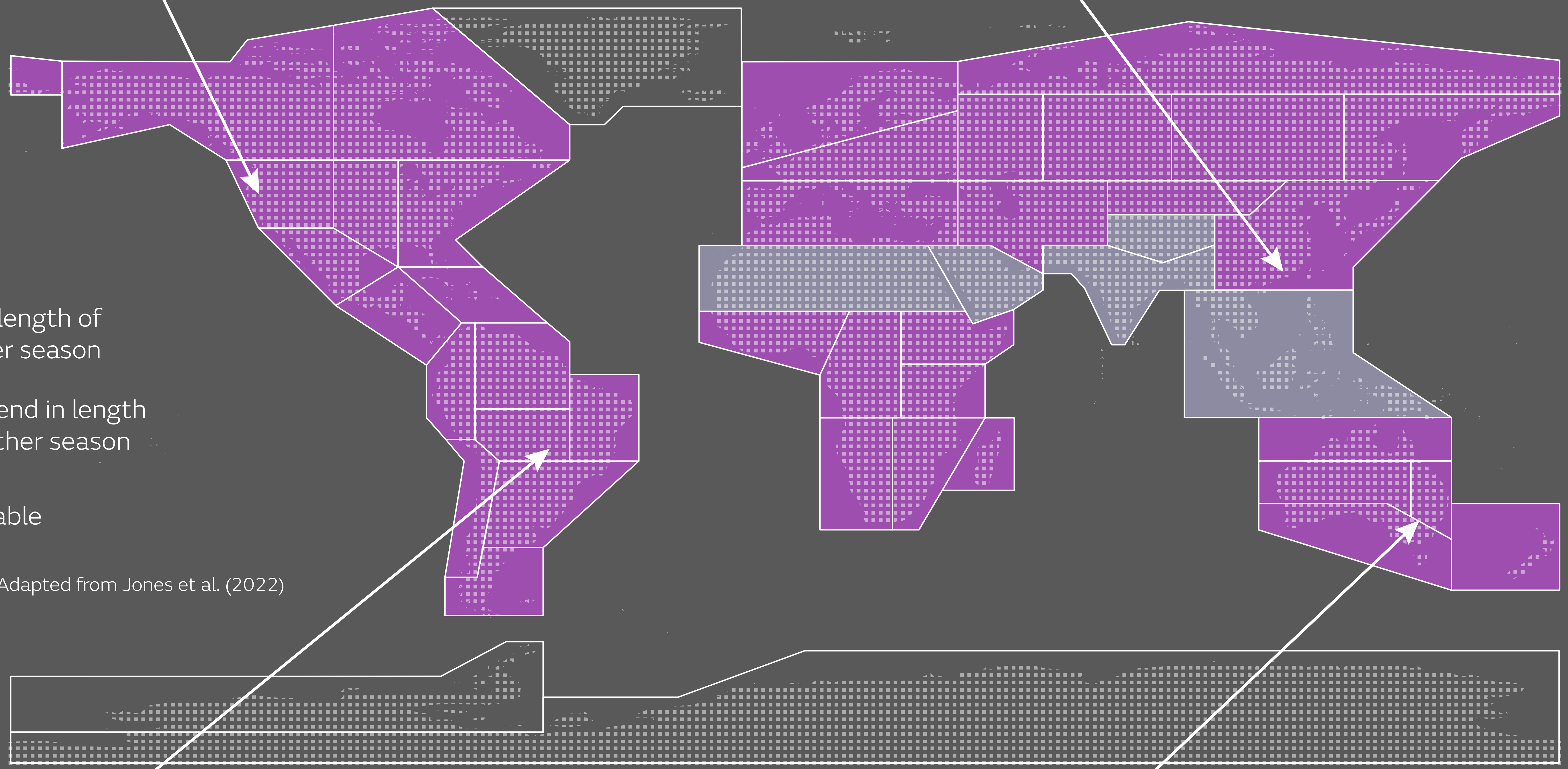
(Hoell et al., 2019)

South China, April 2019

A lightning-caused forest fire in Muli County killed 31 people and burned about 30 ha of forest.

Anthropogenic global warming increased the weather-related risk of extreme wildfire by 7.2 times. In addition, the El Niño event increased risk by 3.6 times.

(Du et al., 2021)



Increasing length of fire weather season

No clear trend in length of fire weather season

Not applicable

Source for trends data: Adapted from Jones et al. (2022)

Amazonia, 2015-16

Burned forest area of 3,993 km^2 in 2015 and 5,253 km^2 in 2016, increases of 51% and 99% relative to average of non-drought years in 2006-2016. 242 Tg CO_2 emitted.

Anthropogenic climate change quadrupled the risk of the severe drought event.

(Silva Junior et al., 2019; Ribeiro Neto et al, 2021)

Southern and eastern Australia, 2019-2020

~97,000 km^2 burnt, 34 human deaths; millions affected by hazardous air quality; 5900 buildings destroyed; 0.5 - 1.5 billion wild animals and tens of thousands of livestock killed; at least 30% of habitat affected for seventy taxa.

Fuel was dried by extreme high temperatures made at least twice as likely by long-term warming trend. Likelihood of severe levels of Fire Weather Index increased by at least 30% despite no attributable increase in meteorological (precipitation) drought.

(Haque et al., 2021; Ward et al., 2020; van Oldenborgh et al., 2021)

Met Office

Glaciers

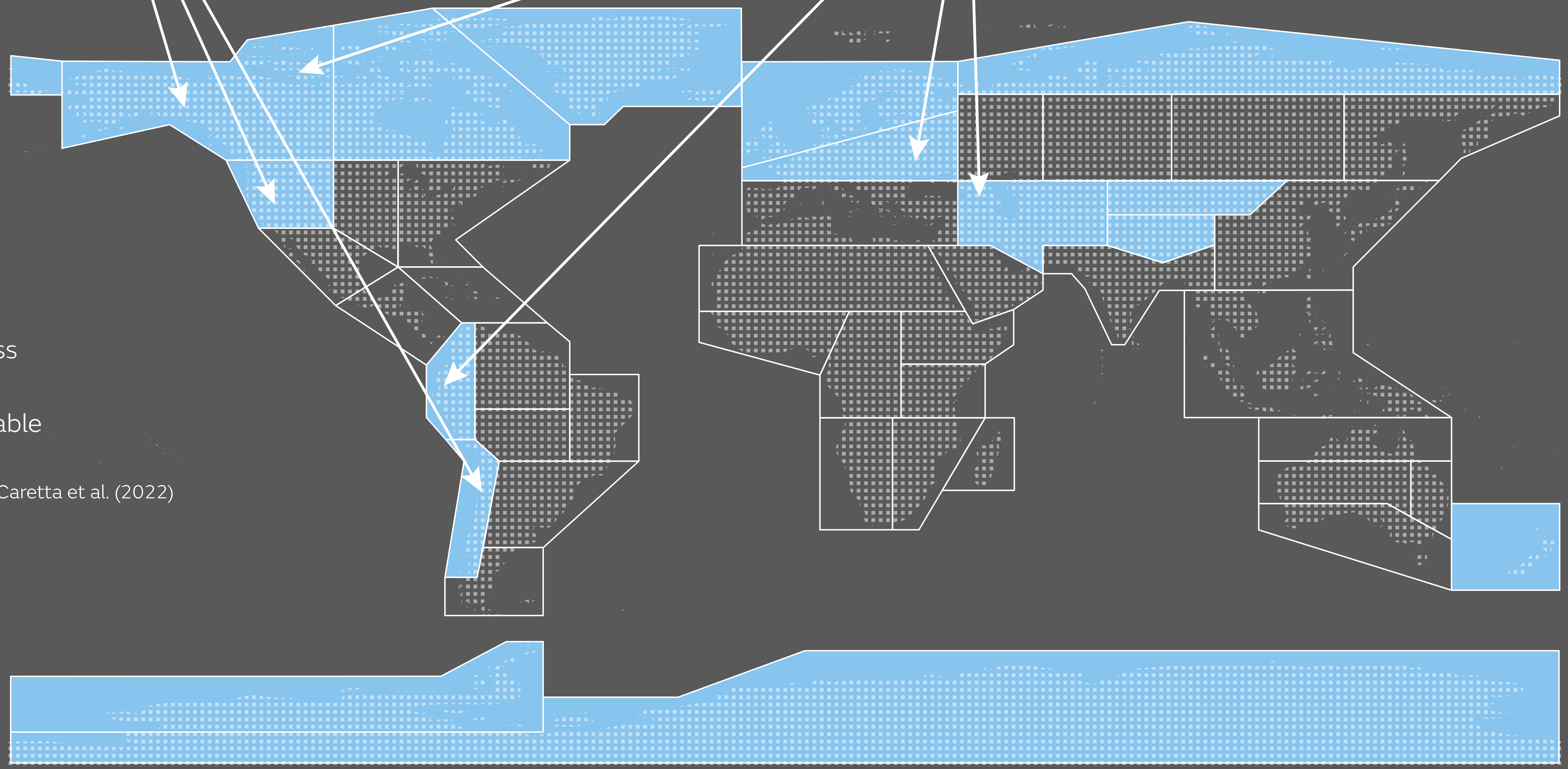
Observed change in glacier mass 2000 - 2019.

Glacier mass loss accelerated after 1990, especially in western Canada, the USA, and the southern Andes.

(World Glacier Monitoring Service, 2017)

Reduced glacier runoff in regions where the glaciers have already passed their peak water stage, e.g. in Canadian Rocky Mountains, Swiss Alps, tropical Andes and North Caucasus.

(Hock et al., 2019; Rets et al., 2020)



Decline in glacier mass

Not applicable

Source for trends data: Caretta et al. (2022)

Worldwide growth in the number, total area and total volume of glacial lakes by around 50% between 1990 to 2018 due to the global increase in glacier melt rate, potentially increasing future risks of Glacial Lake Outburst Floods.

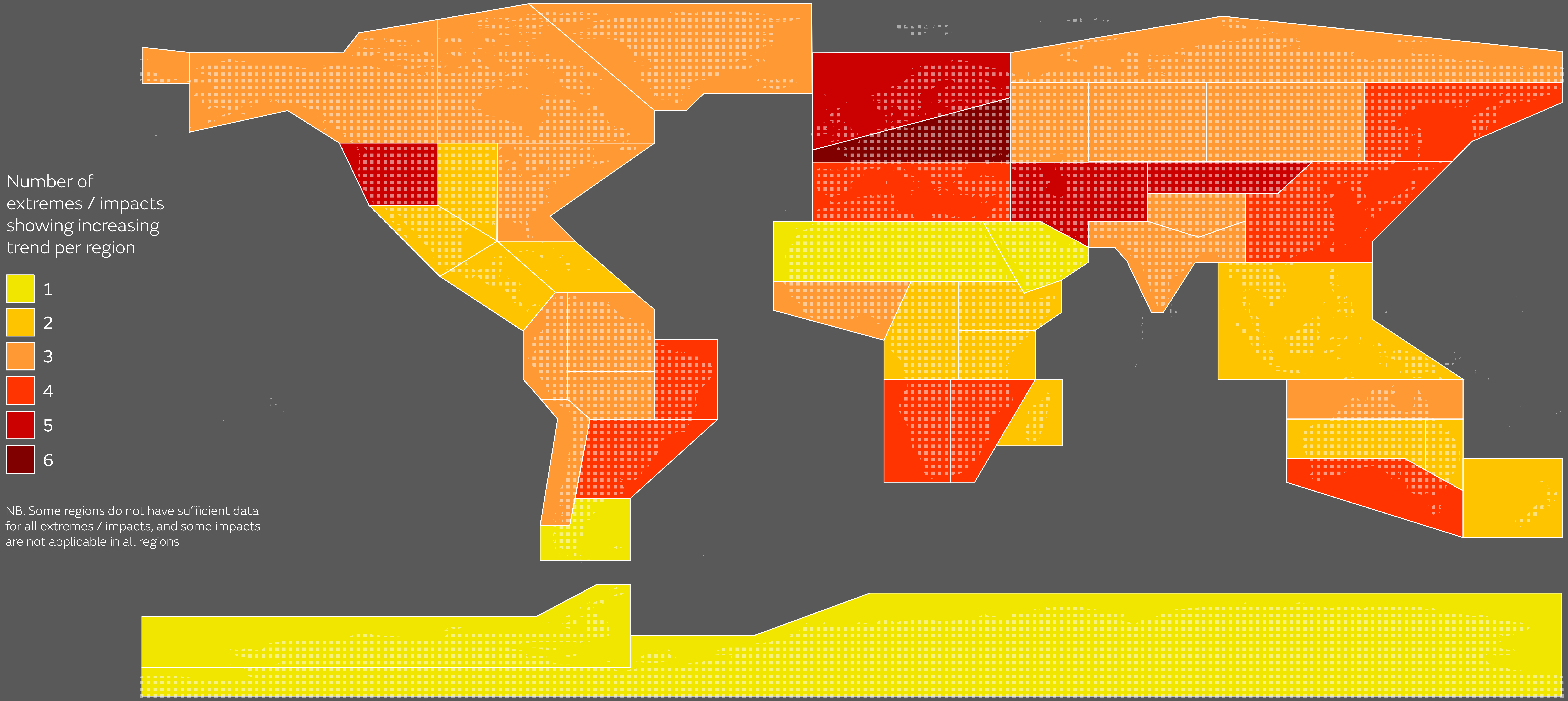
(Shugar et al., 2020; Harrison et al., 2018)

Glacier retreat or reduced snow cover has led to reduced water availability for irrigation of crops and declining agricultural yields in several mountain areas.

(Hock et al., 2019)

Met Office

Multiple changes in weather extremes and climate impacts



NB. Some regions do not have sufficient data for all extremes / impacts, and some impacts are not applicable in all regions

Met Office

Footnotes

Observed trends are shown at the scale of climate regions as defined in the IPCC 6th Assessment Working Group 1 Report, Chapter 1 (Chen et al., 2021). Trends are not necessarily seen at all locations within a region.

Observed changes in hot extremes, heavy precipitation and agricultural drought are from syntheses of multiple studies in the IPCC 6th Assessment Working Group 1 Report. Further details including level of confidence in attribution to human-caused climate change are given by Seneviratne et al. (2021).

Agricultural drought refers to periods with abnormally low soil moisture due to both a shortage of rainfall and excess evapotranspiration, and during the growing season impinges on crop production or ecosystem function. Other drought metrics which are not shown here include meteorological drought (a period with abnormally low rainfall) and hydrological drought (a period with abnormally low water in rivers, lakes and reservoirs).

Observed changes in river flows are from gauging station data. The map shows regional-scale river flow changes consistent with observed regional climate trends, which in all cases except South Australia are found to be consistent with human-caused climate trends in a limited set of climate models (Gudmundsson et al., (2021); flow changes inconsistent with climate trends are not shown.

Fire weather refers to weather conditions conducive to the spread of fire should one be ignited, and the fire weather season length (FWSL) is the period of time with fire-conducive weather conditions (Jones et al., 2022). Actual fire occurrence and spread also depends on ignition and other factors such as vegetation cover and land use – these factors are not included in FWSL.

Observed changes in glacier mass are from a synthesis of multiple sources (Caretta et al., 2022).

The absence of data of long-term observation data availability means it is not possible to assess an observed trend for some regions (shown in dark grey). This does not necessarily mean a trend is not present for these areas.

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