Status and Change of the HKH Cryosphere

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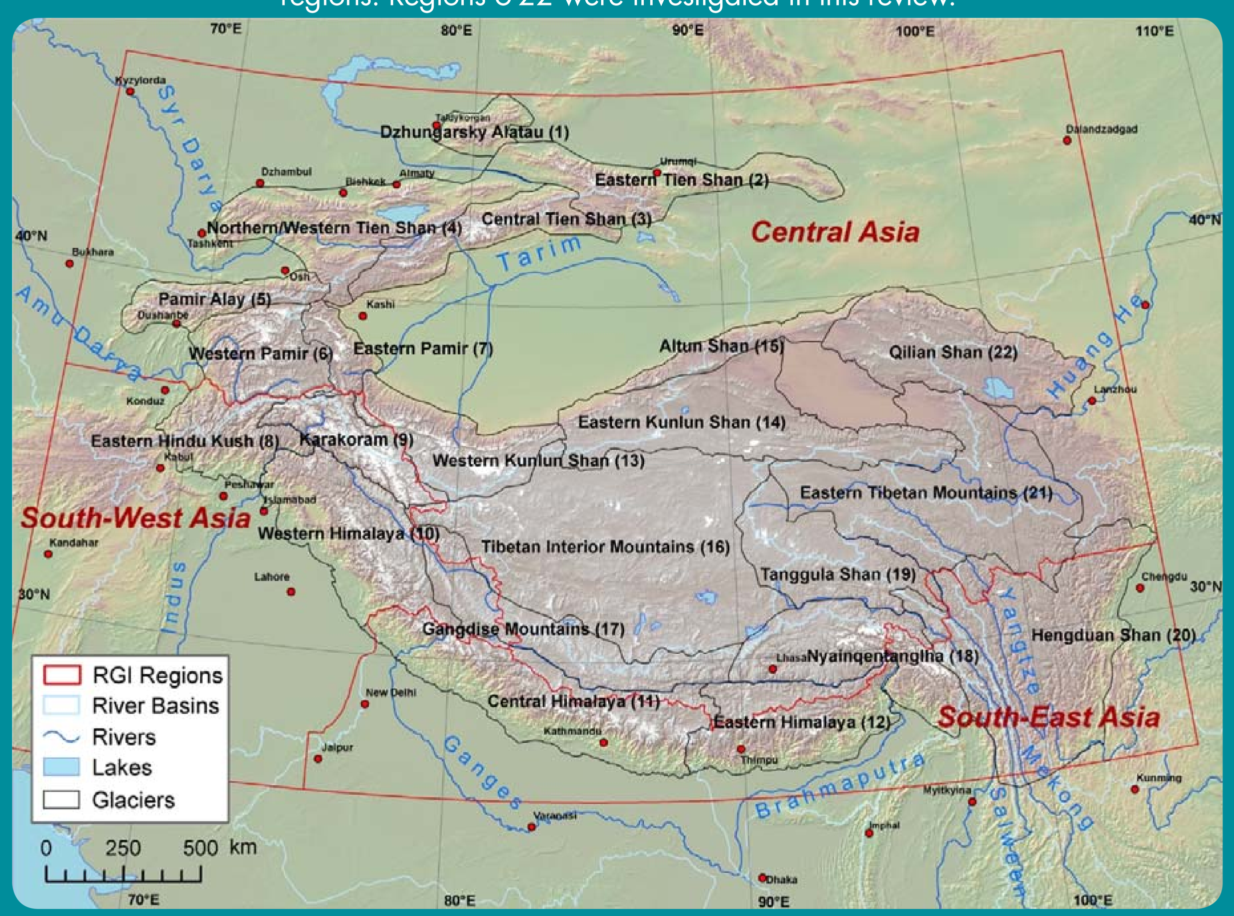
Why is the cryosphere important?

The cryosphere—snow, ice, and permafrost—is an important part of the water supply in the Hindu Kush Himalaya and Tibetan Plateau-Pamir (HKH-TP) region, driving changes in other spheres (hydrological, biological, geophysical) and sectors (hydroelectricity, agriculture, tourism, disasters).

The cryosphere helps to buffer against changes in streamflows due to climate change and monsoon variability. Agriculture, industry, and power generation in the region rely to varying degrees on water generated from snow and ice melt.

Figure 1: High Mountain Asia with defined subregions and the Randolph Glacier Inventory (RGI) regions. Regions 6-22 were investigated in this review.

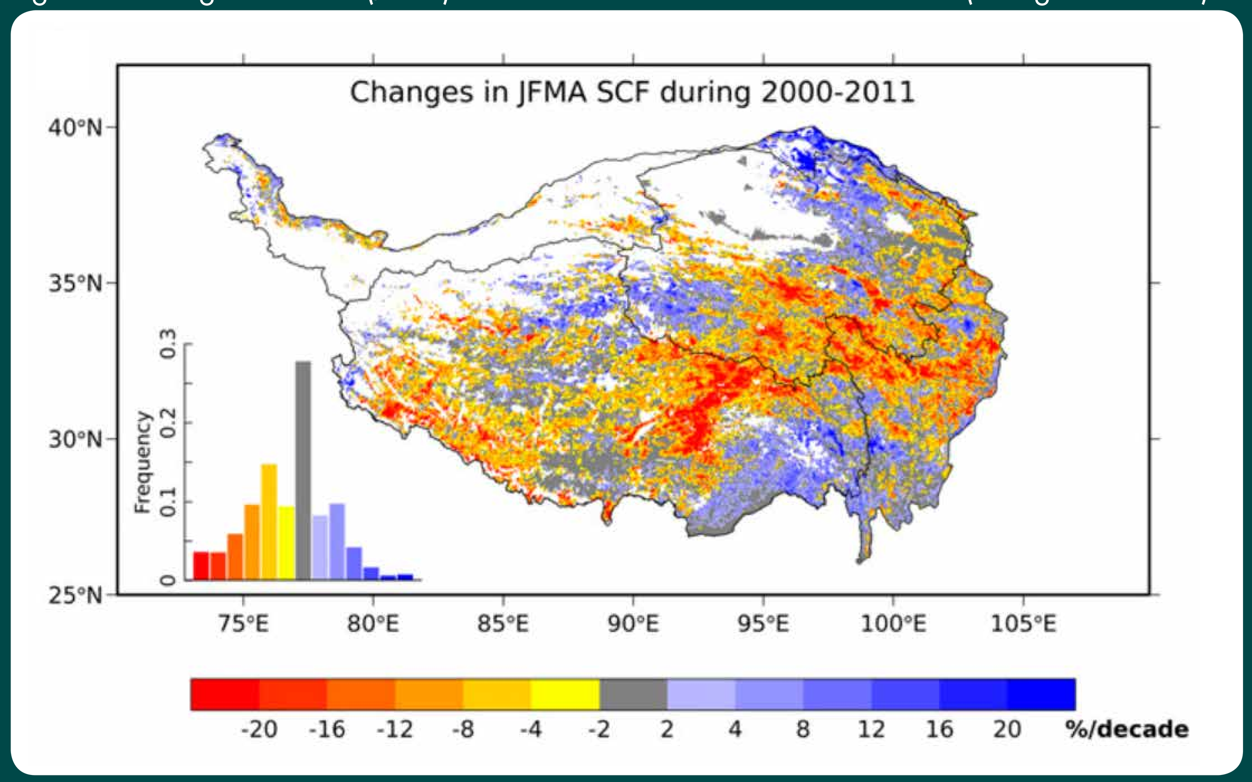


Snow

There is high confidence that snow covered areas and snow volumes will decrease over the coming decades in response to increased temperatures, and that snowline elevations will rise.

Regions with higher mean annual temperatures will be most sensitive to changes in snowfall, and changes in snow volumes and snowline elevations will affect mountain streamflow. It can be expected that the snow melt induced run-off peak will be stronger and occur earlier in the year.

Figure 2: Changes in winter (JFMA) snow cover fraction from 2000 to 2011 (Wang et al. 2013)



Glaciers

In most parts of the region, glaciers are thinning, retreating, and losing mass—a trend that is projected to continue, with possibly large changes in the timing and magnitude of glacier melt runoff.

Glacier volumes are projected to decline substantially through the 21st century as snowfalls decrease and melt rates increase. Lower emission pathways should, however, lessen the total volume loss. The highest mass loss occurred in the South Eastern region of High Asia while glaciers in Central Karakoram, Eastern Pamir and Western Kunlun showed only slight mass loss of even stability during the last decades.

Figure 3: Glacier area (left) and mass (right) change rates for different regions in the HKH-TP.

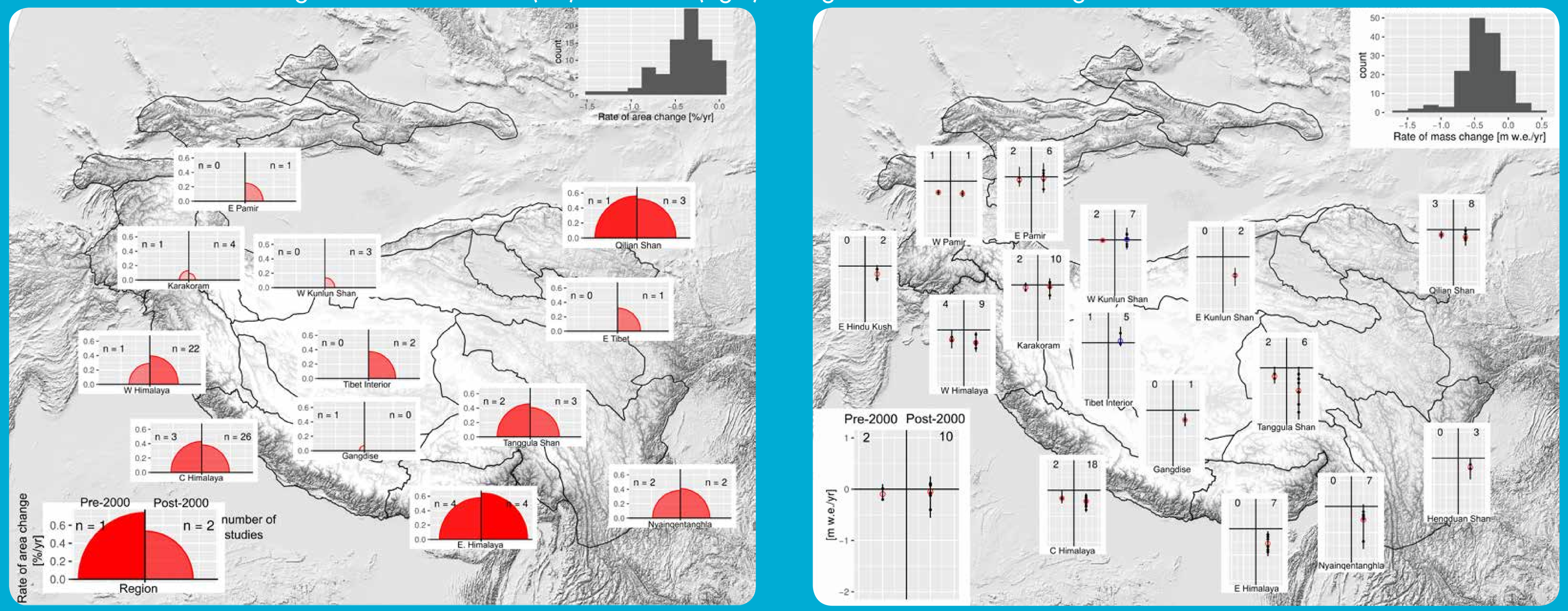


Figure 4: Regional glacier volume change projections (left) and projected changes in ELA (right).

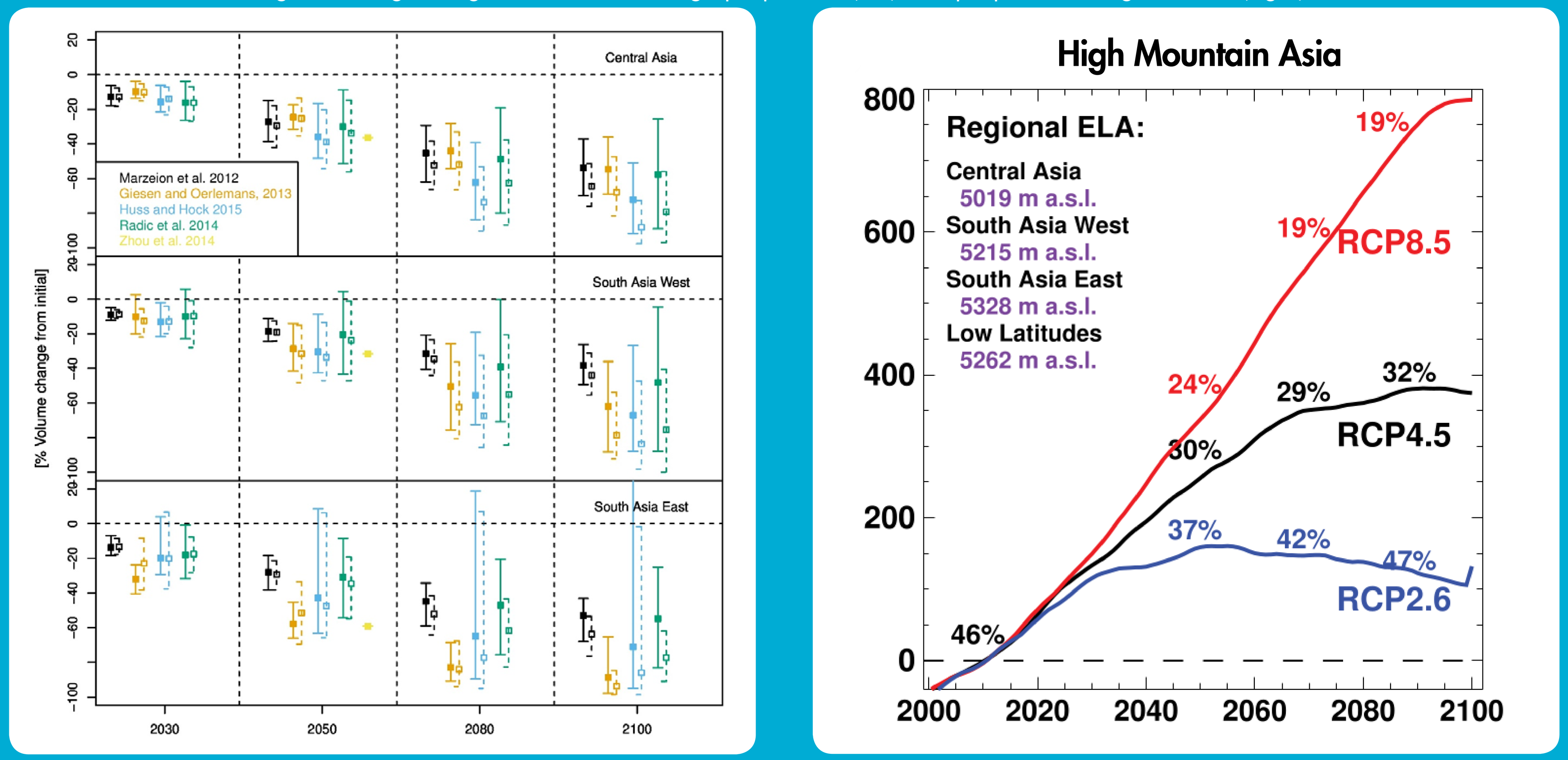
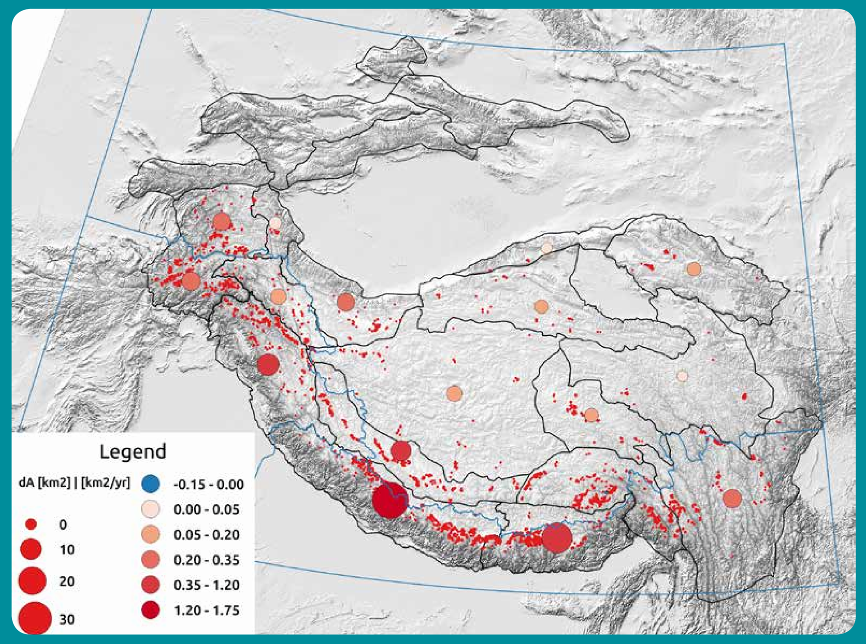


Figure 5: 2010 distribution of glacier lakes in the HKH-TP region, with change in total lake area as both absolute (km², area of centroids) and relative (%, colour of centroid) in each subregion between 1990 and 2010.



Glacier Lakes

Glacier lakes – lakes which are in direct contact with glaciers or in close vicinity – are common in HMA. Glacier retreat caused proglacial lakes to form and to increase.

Projected future glacier retreat will cause glacier lakes to expand in area and volume.

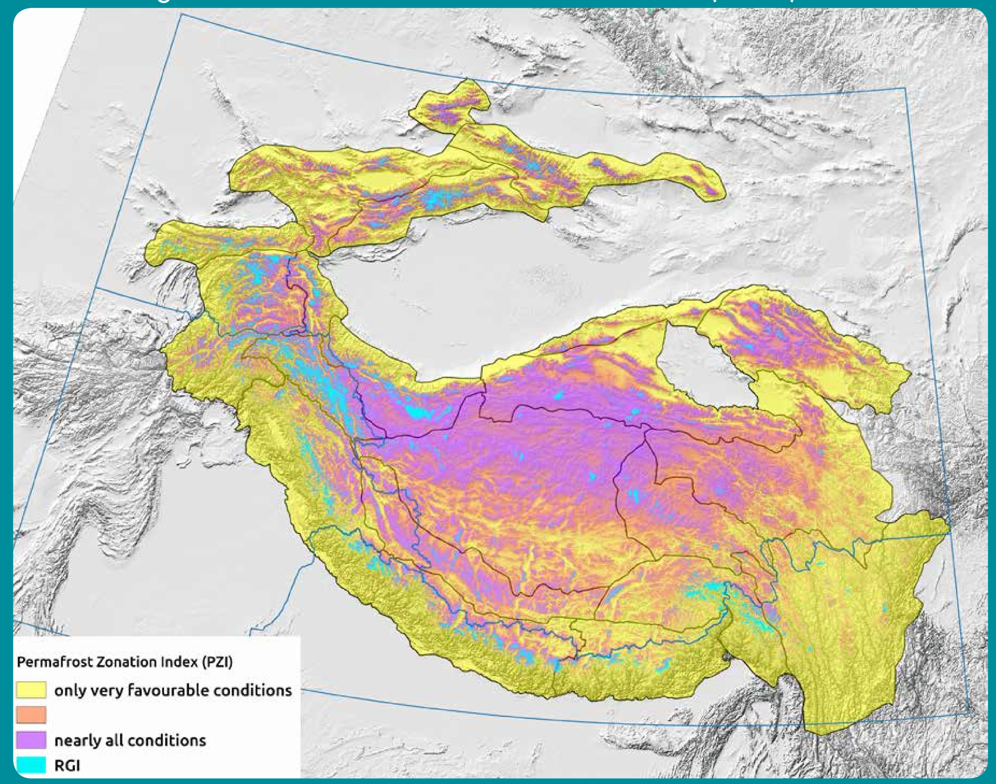
Permafrost

Permafrost is ground that is frozen for more than two consecutive years. It occurs in large parts of HMA. Measurements are rare but indicate that active layer (the unfrozen ground above the permafrost layer insummer) thickness has increased and permafrost area declined.

Projected future temperature increase will lead to further permafrost thaw, affect local water resources, and endanger infrastructure.

Permafrost degradation will destabilize slopes, lead to local changes in hydrology, and threaten transportation infrastructure.

Figure 6: Permafrost extent based on Gruber (2012)



Impacts on water resources

Observed and projected changes in the cryosphere will affect the timing and magnitude of streamflows across the region, with proportionally greater impacts upstream.

Glacier melt is most important in Western HMA, e.g. the Indus Basin, where precipitation during summer is lower due to less influence of the monsoon.

Total annual streamflow in larger river systems will probably not change significantly in response to cryospheric change, but will continue to be a function of monsoon variability. Hence, snow and ice melt provide important and reliable baseflow and are of special importance in years with low monsoon precipitation.

Policy implications

To better monitor and model cryospheric change, expanded observational networks and data-sharing agreements are critically needed. Open access to ground-based meteorological, hydrological, and glaciological data from the entire region will facilitate the development and testing of models of cryospheric change.

To help reduce the magnitude and rate of cryospheric change, international agreements must mitigate climate change through emission reductions. Lower emission pathways will reduce overall cryospheric change, and reduce secondary impacts on water resources from mountain headwaters.

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