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State and fate of Alpine glaciers

State of Alpine glaciers:

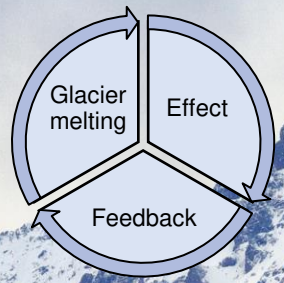
Alpine glaciers are undergoing significant retreat due to global warming, driven by rising temperatures that increase melting and decrease snow accumulation. Over the past century, many glaciers have shrunk, with some losing up to 50% of their volume since the 1850s. Retreat rates have sped up in recent decades, leading to the disappearance of several smaller glaciers. Two main aspects characterize the past development of Alpine glaciers: rapid retreat, primarily due to global warming, and significant loss of volume since the 19th century, affecting length, thickness, and area coverage.

Fate of alpine glaciers:

Projections for Alpine glaciers show continued retreat due to global warming, impacting water resources, ecosystems, and tourism.

- Continued retreat: Climate models predict ongoing shrinkage of Alpine glaciers, with all scenarios indicating significant loss of ice mass, volume, length, thickness, and area coverage.
- Water resource implications: Glacier melt contributes to river flow, affecting water availability for agriculture, hydropower, and ecosystems. Furthermore, glaciers act as a source of potable water in alpine regions, posing unknown problems in the future
- Ecosystem effects: Glacier retreat can disrupt alpine ecosystems, altering habitat availability, species distributions, and ecosystem services, posing challenges for plants and animals adapted to cold conditions.
- Tourism and recreation: Glaciers are vital for tourism, with activities like skiing and mountaineering at risk due to glacier shrinkage.

Main uncertainties: Feedback mechanisms



Albedo feedback:

- Melting glaciers expose darker surfaces (rock, soil etc.)
- Those surfaces absorb more solar radiation than ice
- Increases local temperetures -> further enhancing glacier melt

Atmospheric feedback:

- Glacial melt can influence atmospheric circulation patterns
- Shrinking glaciers may alter temperature and moisture in the local atmosphere
- Regional weather patterns can be affected

Cryospheric feedback:

- Changes in alpine glaciers can affect other cryospheric components (Permafrost, snow cover)
- Retreating glaciers can destabilize slopes, leading to increased rockfall or avalanches
- These can impact glacier dynamics and be hazardous for human settlements and infrastructure

Hydrological feedback:

- Melting contributes to river flow, especially during summer
- Glacial retreat -> less river flow
- Local hydrological systems are influenced
- Altered streamflow, groundwater recharge and water availability

Geological feedback:

- Glacial retreat may expose new terrain previously covered by ice for a long time
- Weathering and erosion can happen
- Changing sediment transport, river morphology and nutrient fluxes
- Downstream changes can influence glacier dynamics and landscape

Call to action!

Dear policy makers and scientists: it is urgent

Adaptation strategies and international cooperation are essential for addressing the impacts of shrinking Alpine glaciers. Adaptation measures may include implementing sustainable water management practices to mitigate the effects of reduced glacier melt on water resources, such as improving water storage and distribution systems. Additionally, promoting diversified tourism offerings beyond glacier-dependent activities can help buffer the economic impacts on local communities. International cooperation plays a crucial role in sharing knowledge, resources, and best practices among countries sharing Alpine regions. Collaborative efforts can involve joint research initiatives, data sharing agreements, and coordinated policies to mitigate climate change and its impacts on glaciers. By working together, nations can enhance resilience to glacier retreat and ensure the long-term sustainability of Alpine ecosystems and economies

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