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From monitoring to resilience:

Cryosphere information services in Central Asia

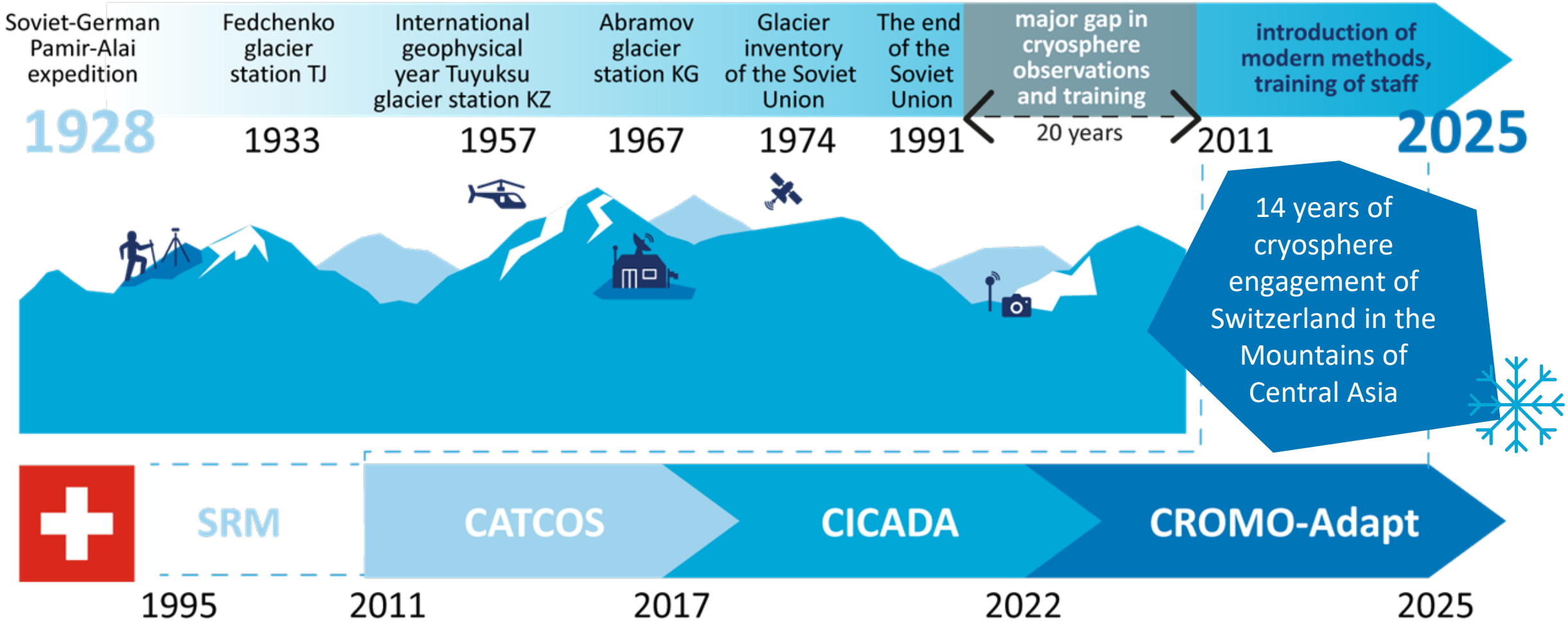
From monitoring to resilience

The cryosphere plays a vital role in Central Asia for communities, economies, and ecosystems, but the effects of climate change – melting glaciers, declining snow cover, and thawing permafrost – are increasing the risks to infrastructure, energy production, water supply, economic activities, and livelihoods. Reliable cryosphere information services are essential for informed decision-making and long-term resilience planning, and strengthening the links between monitoring systems and the decision-making and learning processes of service users is key to building a more resilient future for the region.

This booklet offers an overview of key cryosphere dynamics and future scenarios, explains how cryosphere data can be transformed into actionable information for decision-making, and showcases the results of Switzerland's 15-year engagement in supporting cryosphere monitoring, capacity building, and science-policy dialogue in Central Asia.

Contents

Timeline **100 years** of hydromet and cryosphere observations



Timeline Swiss snow & glacier projects – **past 30 years**

Cryosphere information services - Potential applications

Is the tailing dam stable and not at risk from rock fall due to thawing permafrost?

How much irrigation water can I expect in the upcoming season?

Should we adjust hydropower production based on snowmelt projections?

Will we need to pause or divert the traffic due to high avalanche risk?

Is winter tourism development possible in this area?

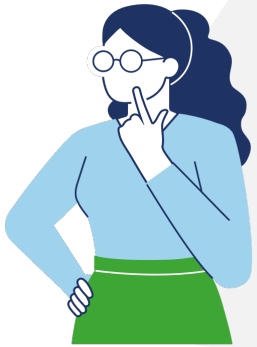
Cryosphere information services – Potential applications

Farmers and pastoralists use information about water availability to adjust farming calendars, grazing routes, or prepare for flooding risks.

Responsible authorities, community leaders and private actors use avalanche data to inform populations of increased avalanche risks.

Spatial planners use avalanche hazard and risk information to guide safe development of winter tourism infrastructure.

Researchers use cryosphere monitoring data to constantly improve their understanding of the current change and future projections.



Water utility providers use snow and glacier melt data and projections to analyze seasonal water availability and plan water supply.

Cryosphere information services – Potential applications

Engineers, architects and builders use permafrost data and projections to assess the stability of the terrain before building roads, pipelines, or infrastructure.

Hydropower managers use cryosphere and hydrological information for the projection of energy production and for the conflict-free management of reservoir vs downstream irrigation needs.

Mining engineers use permafrost monitoring data to assess ground stability for safe geo-exploration and mining infrastructure.

Ski resort managers use snow cover data and projections to analyse future snow reliability to evaluate the economic feasibility of building in specific locations.

The cryosphere in Central Asia

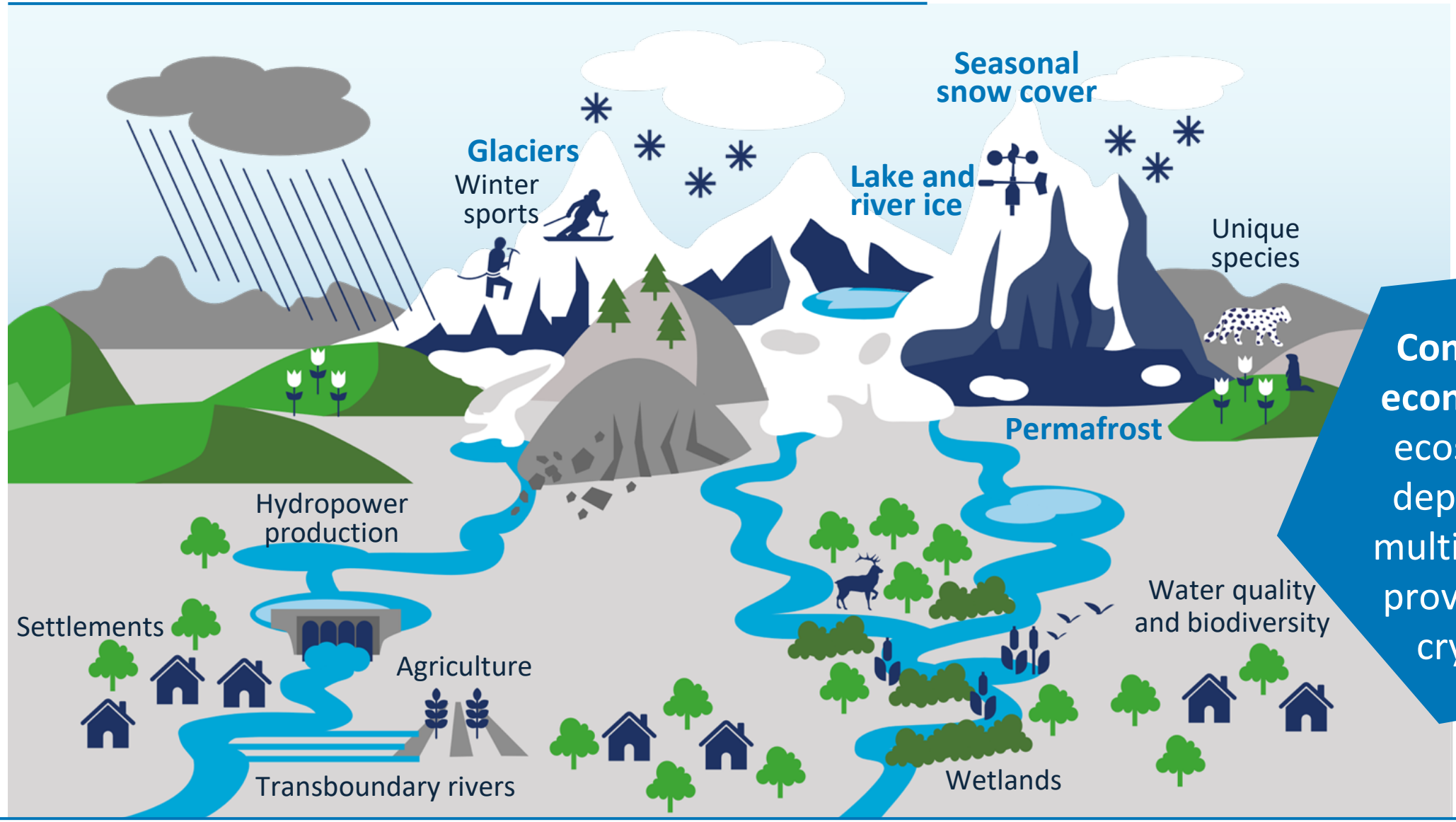
The glaciers of Central Asia contain about 3200 km³ of water reserves.

The CROMO-ADAPT Project supports 16 monitoring sites and 3 boreholes.

The cryosphere in Central Asia

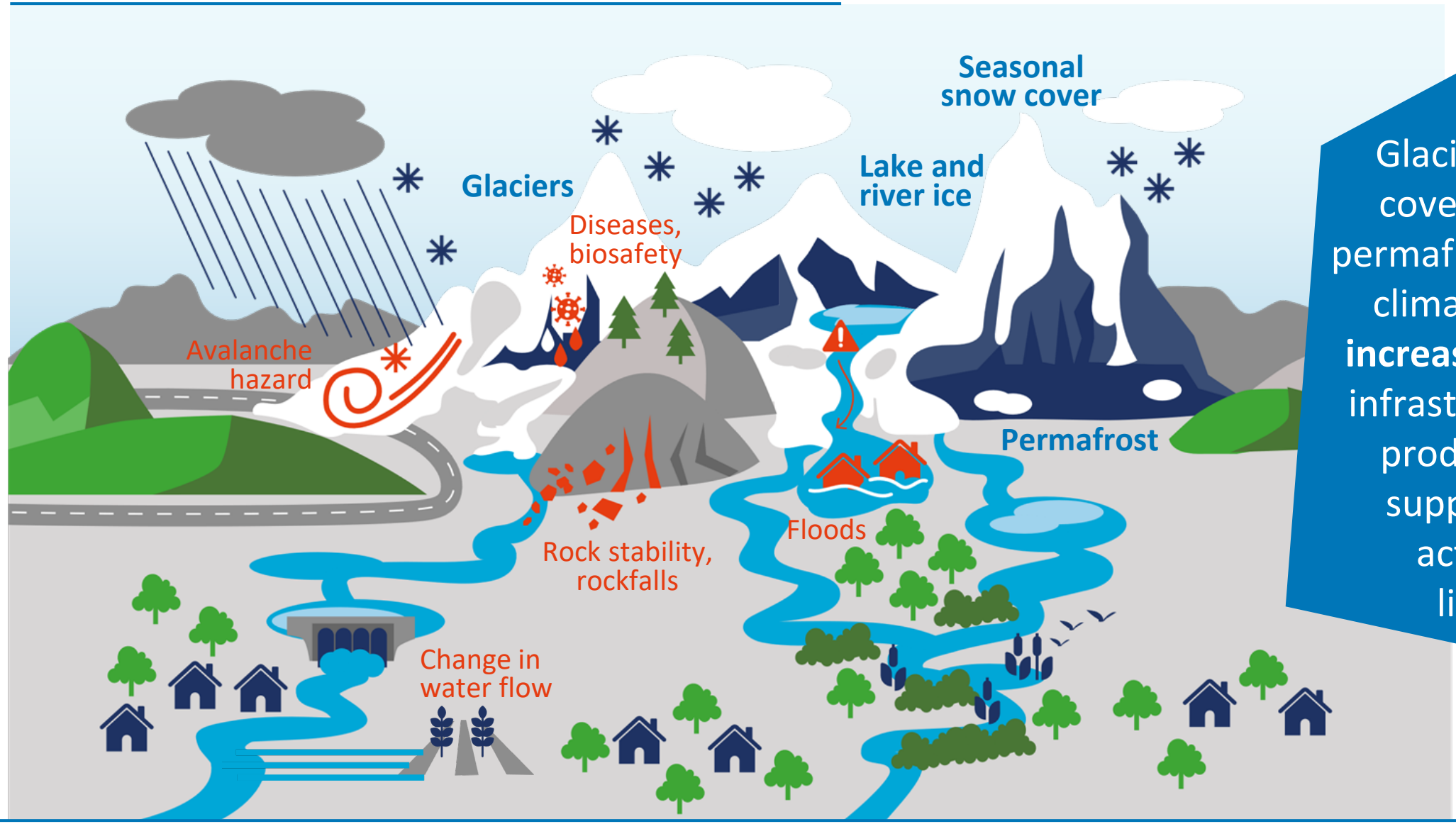
High-elevation hydropower, winter tourism, mining sites and roads, and downstream agriculture are directly dependent on the state of cryosphere.

The cryosphere and its benefits



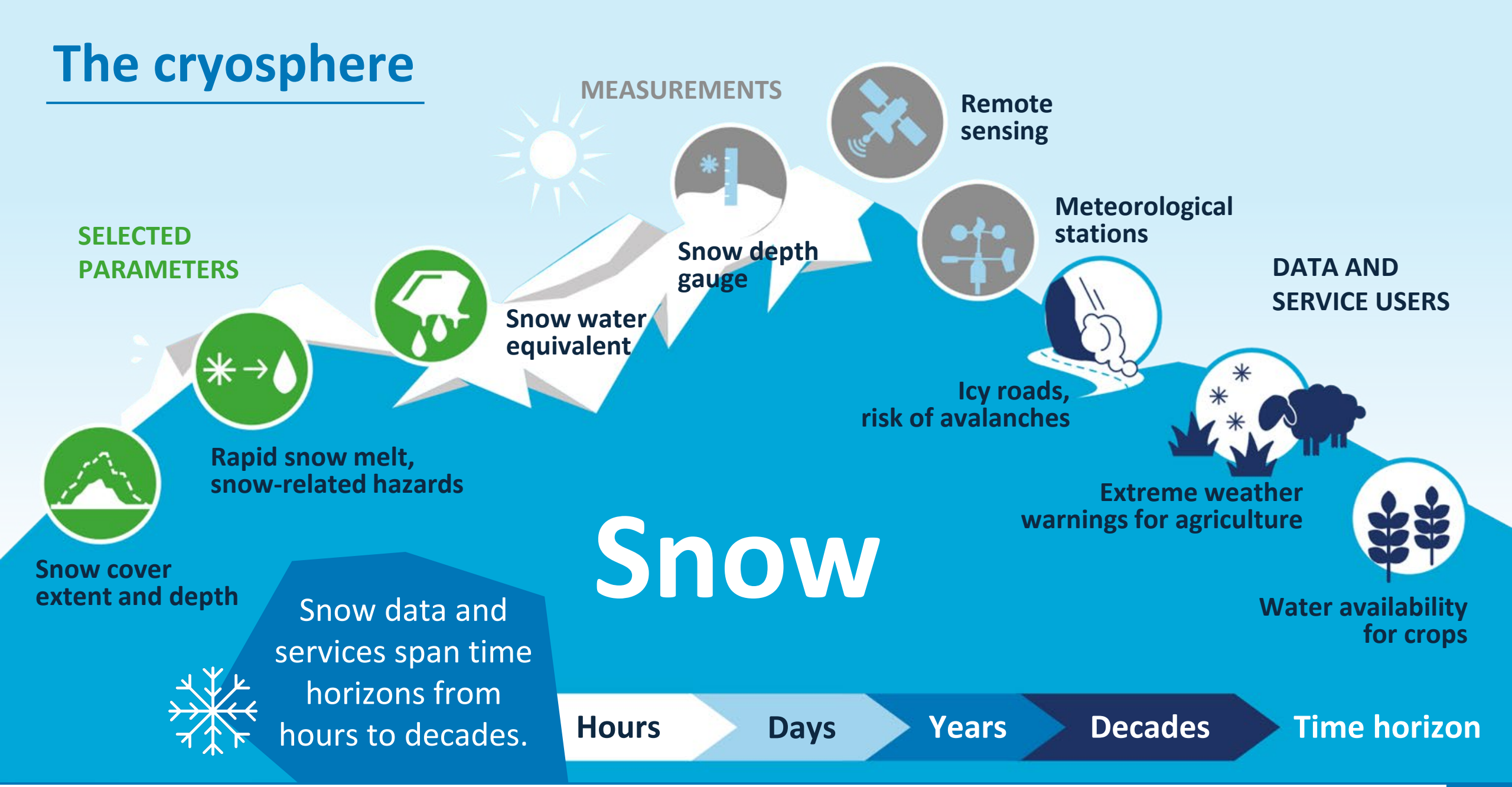
Communities, economies, and ecosystems all depend on the multiple benefits provided by the cryosphere.

The cryosphere and its risks

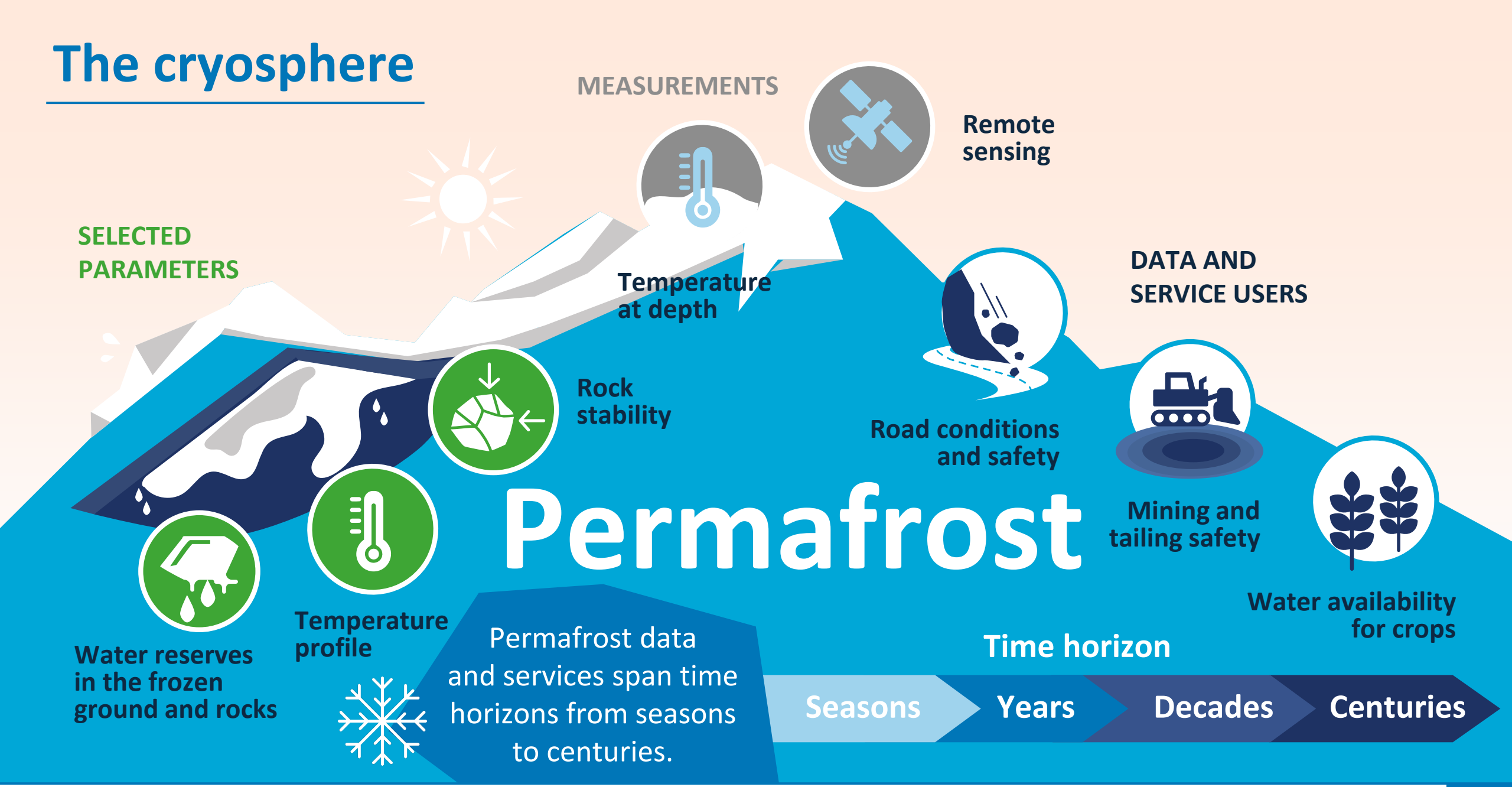


Glacier melt, snow cover decline, and permafrost thaw due to climate change are **increasing the risks** to infrastructure, energy production, water supply, economic activities, and livelihoods.

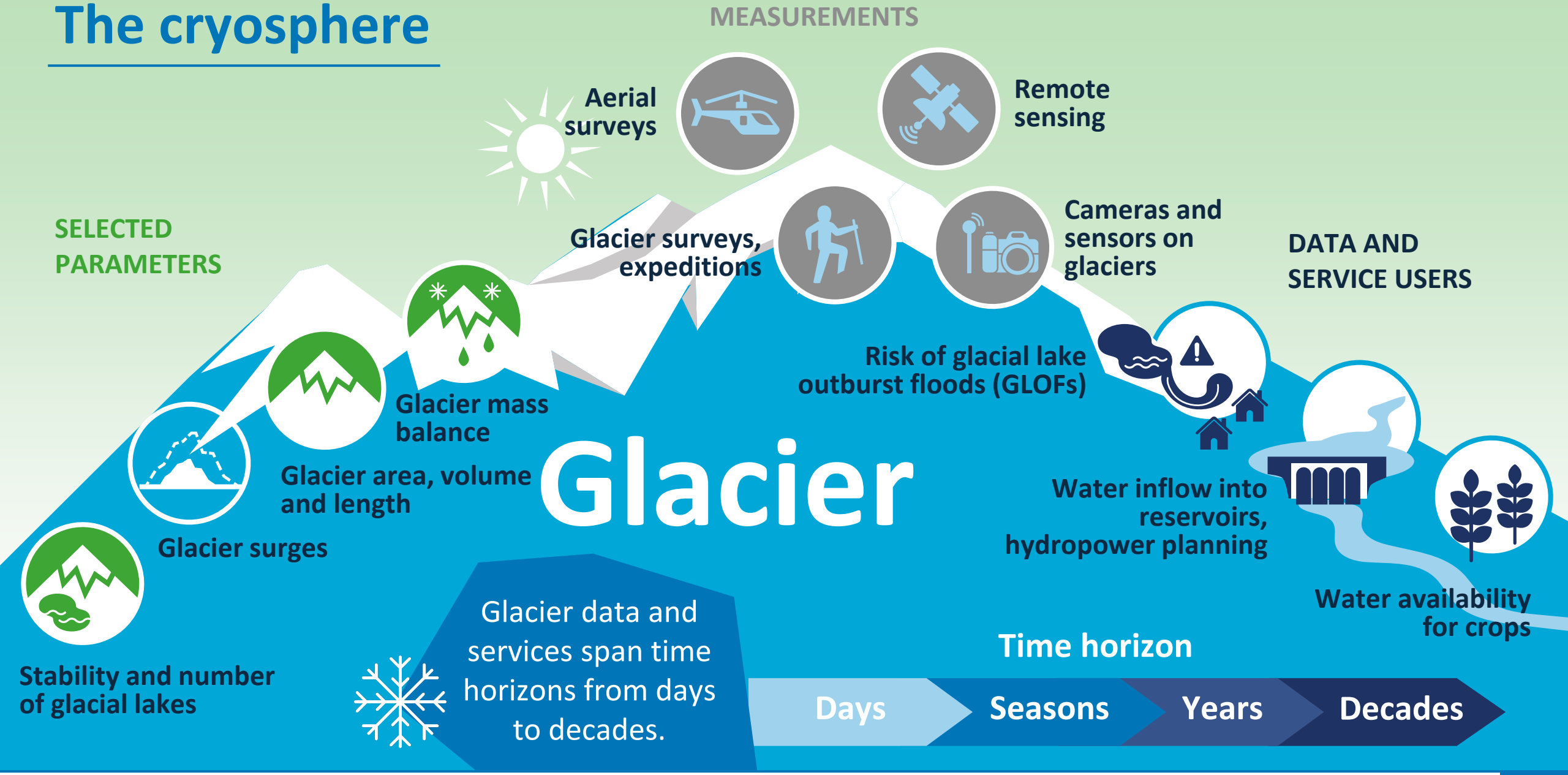
The cryosphere



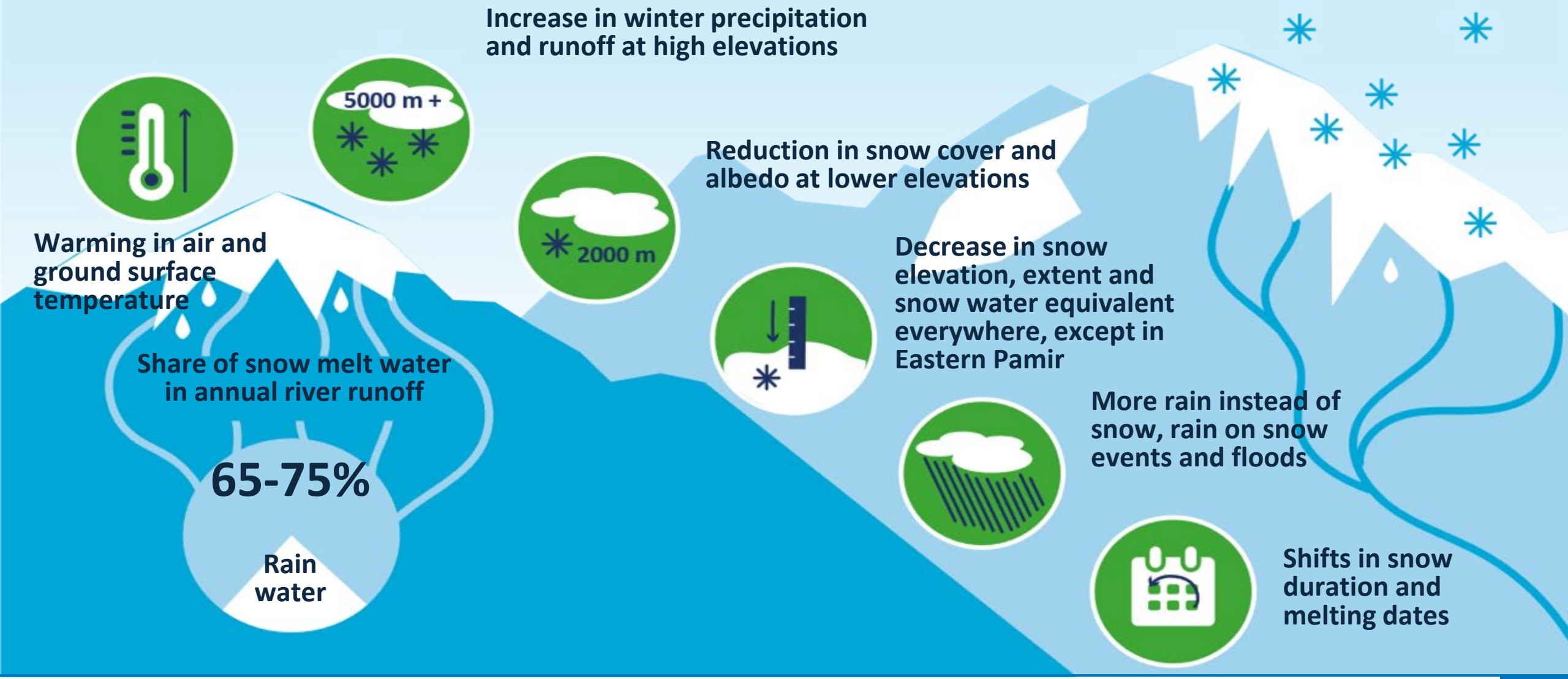
The cryosphere



The cryosphere

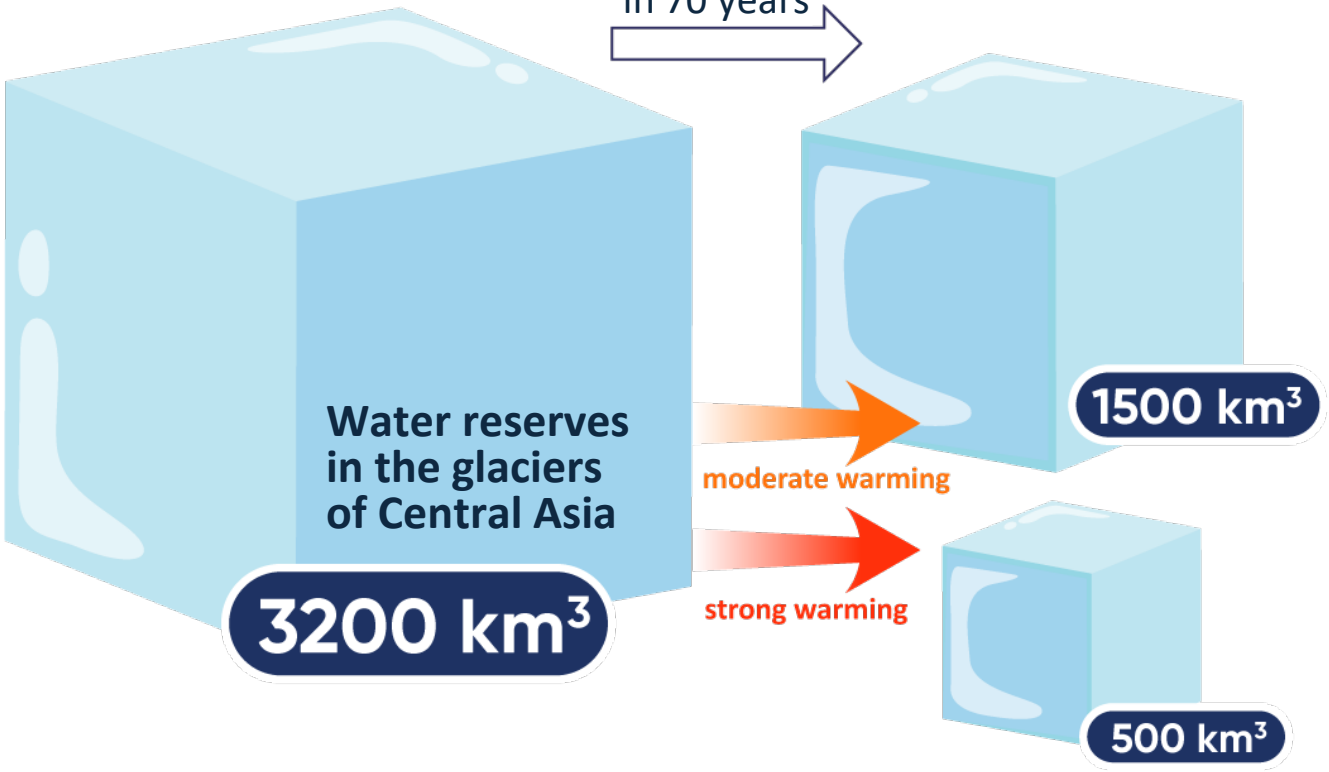


Scenarios for snow

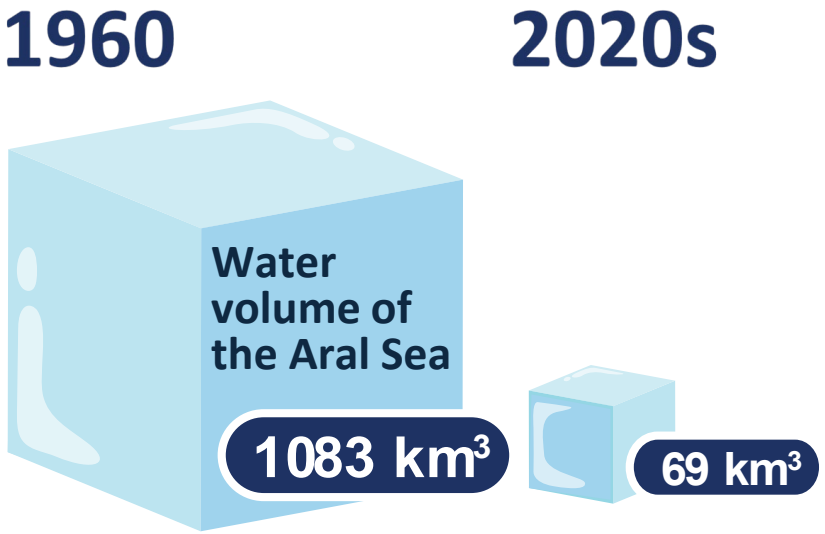


Scenarios for glaciers

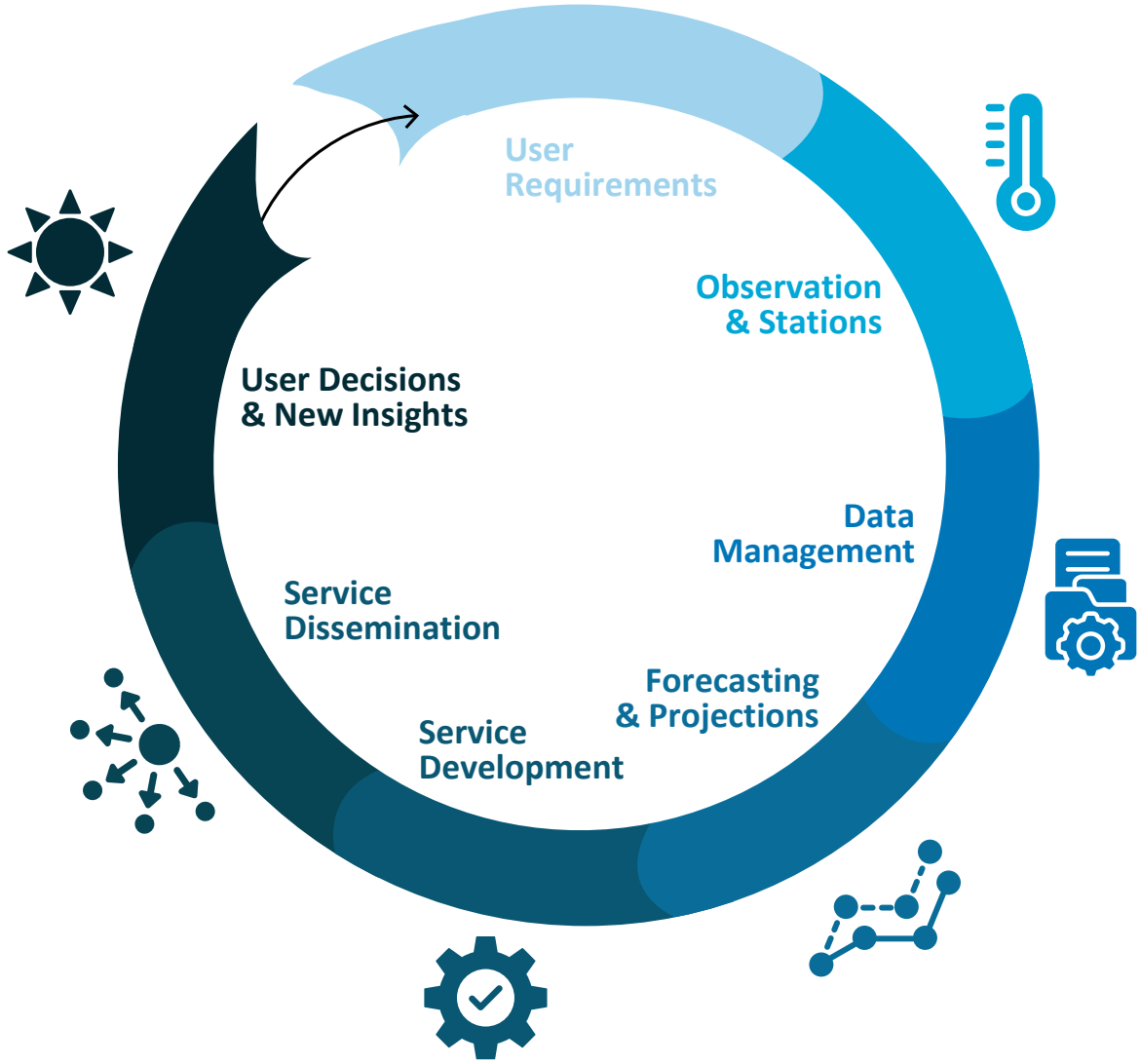
Projected reduction in 70 years



The projected reduction of water resources in the glaciers of Central Asia is immense and can be compared to the decline in the water volume of the Aral Sea.

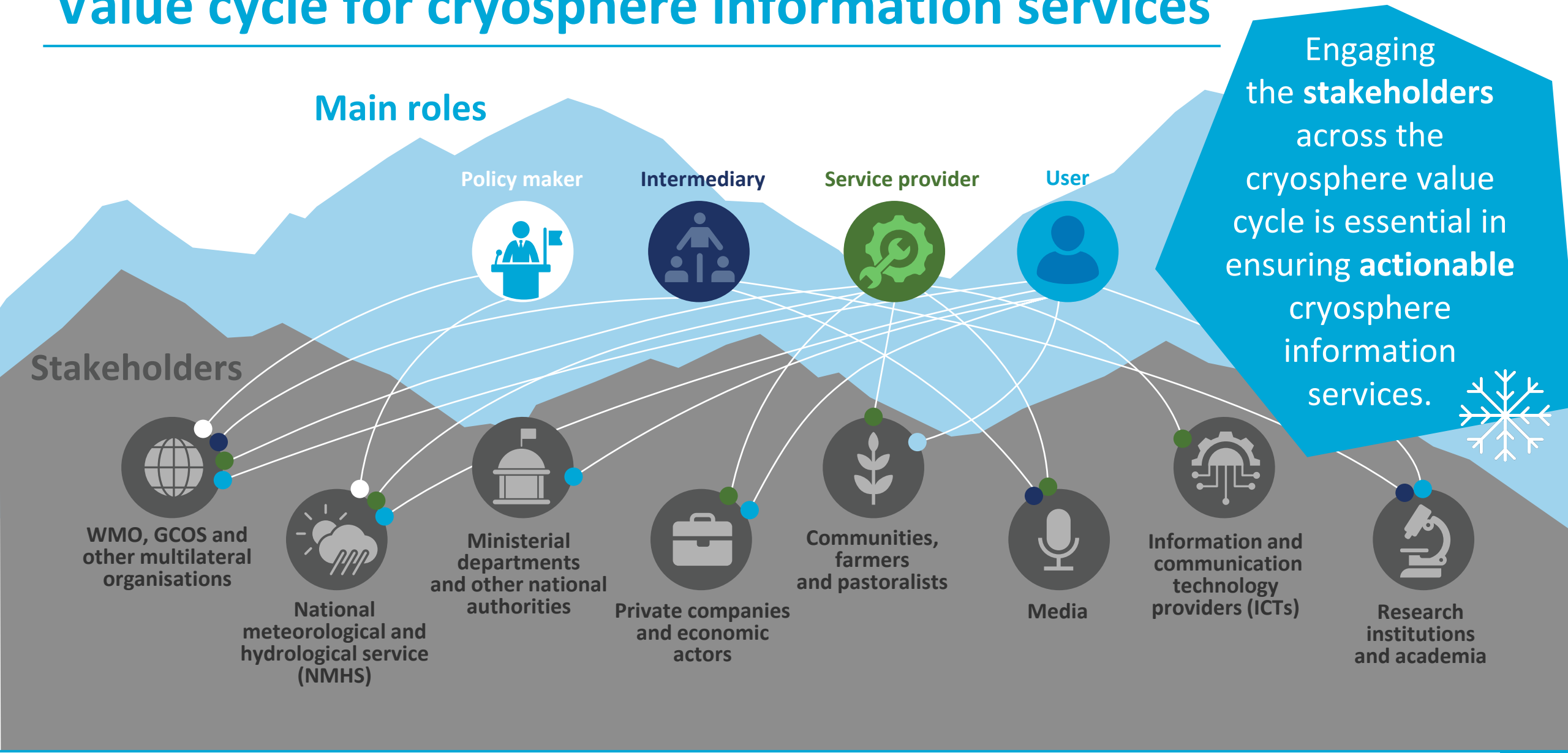


Value cycle for cryosphere information services



Cryosphere information services depend on interconnected activities that create a **benefit for end users** provided the cycle is closed.

Value cycle for cryosphere information services



Engaging the **stakeholders** across the cryosphere value cycle is essential in ensuring **actionable** cryosphere information services.

Human connections and capacity building

Engaging in cryosphere information services has co-benefits.

Skills development and strengthening of local expertise

Enhance capacity through training, higher education, knowledge transfer, and hands-on involvement in monitoring, modeling, data interpretation and service delivery.

Linkages to international cooperation and international initiatives

Open opportunities for collaboration with global scientific networks, climate adaptation initiatives, and policy frameworks (e.g. UNFCCC, WMO).

National to regional network strengthening

Fosters collaboration and data and knowledge exchange across countries and institutions.

Human connections and capacity building

400+ Local scientists trained: Equipping scientists with the skills to perform high-quality monitoring.

20+ PhD students co-supervised: Ensuring that the next generation of cryosphere experts is well prepared.

30+ Cryosphere Monitoring sites: Providing comprehensive baseline data in all climate regions.

20+ Study visits to Switzerland: Providing students with international exposure and advanced training.

50+ Women participating in "Adventure of science: Women and glaciers in Central Asia": Ensuring that women have a strong voice and active role in cryosphere research and exploration.

18 Modelling tools and services developed: Providing access to cutting edge technology.

200+ Participants in Summer Schools and Workshops: Offering students hands-on learning experiences.

Key results of CROMO-ADAPT and previous projects

Annual Regular GTN-G (WGMS), GTNP & WMO submissions: Ensuring global visibility and access.

Policy recommendations

1. To address the growing impacts of cryosphere loss on water availability, ecosystems, and hazards, it is essential to **improve cryosphere information services by aligning them with user needs and by making use of cost-efficient and robust technology**. Enhancing mutual understanding between users and providers, establishing supportive legal and institutional frameworks, and investing in low-maintenance monitoring and service dissemination solutions are all critical for achieving this.

2. To enable accurate forecasting and projections, it is crucial to **improve data exchange by establishing data-sharing mechanisms among countries and sectors**. Supporting interoperability across platforms, and promoting open access policies that ensure timely, transparent, and coordinated use of cryosphere data are important to achieve this.

3. To ensure that research continues beyond the lifespan of external projects, it is essential to **strengthen local and national expertise in cryosphere research and secure funding** through the development of training programmes, the promotion of citizen science, smart investments, and multi-stakeholder partnerships.

4. To address the evolving climate change adaptation needs that vary across regions, it is essential to **develop and implement demand-driven and demand-triggering projects through ongoing engagement with users and by designing modular projects** that can be adjusted based on emerging needs and that contribute to **National Adaptation Plans**.

Potential applications for end users

1. **Hydropower and irrigation**
   - Check forecasts on seasonal water availability and contribution of meltwater from snow and glaciers
   - Plan hydropower operation based on sub-daily resolution forecasts
   - Consider slope stability and long-term changes in water flow for strategic and long-term planning

2. **Roads and transport**
   - Check forecasts on severe weather (including visibility) and snow avalanche risk
   - Monitor rock stability and permafrost at high altitude sections and consider these in road planning and safety

3. **Mining at altitude**
   - Use data on timing, extent and depth of snow cover, risk of avalanches
   - Monitor ice and rock stability and permafrost and consider these in industrial safety
   - Model long-term stability of sites for safe tailings operation and waste management

4. **Mountain tourism**
   - Use data on timing and depth of snow cover, risk of avalanches
   - Ask site-specific long-term snow and cryosphere modelling to plan or modify ski resorts and infrastructure
   - Check forecasts and warnings on severe weather
   - Check data on glaciers and glacial flood risk

5. **Disaster risk reduction (DRR) and National Adaptation Plan (NAP) processes**
   - Use risk and impact scenarios for DRR and for National Adaptation Plan process
   - Use sectorally relevant data for line ministries and other agencies

Links

National hydromet services (NHMS) sites:

- Kazakhstan: kazhydromet.kz
- Kyrgyzstan: meteo.kg
- Tajikistan: meteo.tj
- Uzbekistan: hydromet.uz

National and regional cryosphere websites:

- Kazakhstan and Central Asia (Regional glacier centre): cargc.org
- Tajikistan: cryosphere.tj

SnowMapper – Snow situation in Central Asia

- Central Asia Mountains dashboard: snowmapper.ch
- Tajikistan: taj.snowmapper.ch

Adventure of Science: Women and glaciers in Central Asia: inspiringgirls.org/central-asia-en
World Glacier Monitoring Service WGMS: wgms.ch
Global Cryosphere Watch: globalcryospherewatch.org

Links

Further resources and projects:

- UN World Water Development Report 2025, Mountains and glaciers, Water towers: https://www.unwater.org/publications/un-world-water-development-report-2025
- Central Asia Hydromet atlas: https://zoinet.org/product/hydromet-atlas
- Knowledge products from GLOFCA – Glacier lake outburst floods in Central Asia UNESCO-AF project: https://glofca.org/resources-for-science-and-policy
- PAMIR project — From ice to microorganisms and humans: Toward an interdisciplinary understanding of climate change impacts on the Third Pole: https://pamir-project.ch

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About the Swiss engagement on cryosphere in Central Asia:
Switzerland supports several initiatives to enhance resilience to climate change impacts on the cryosphere in Central Asia through research, capacity building, and science-policy dialogue. This engagement is carried out in collaboration with local partners and international initiatives.

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