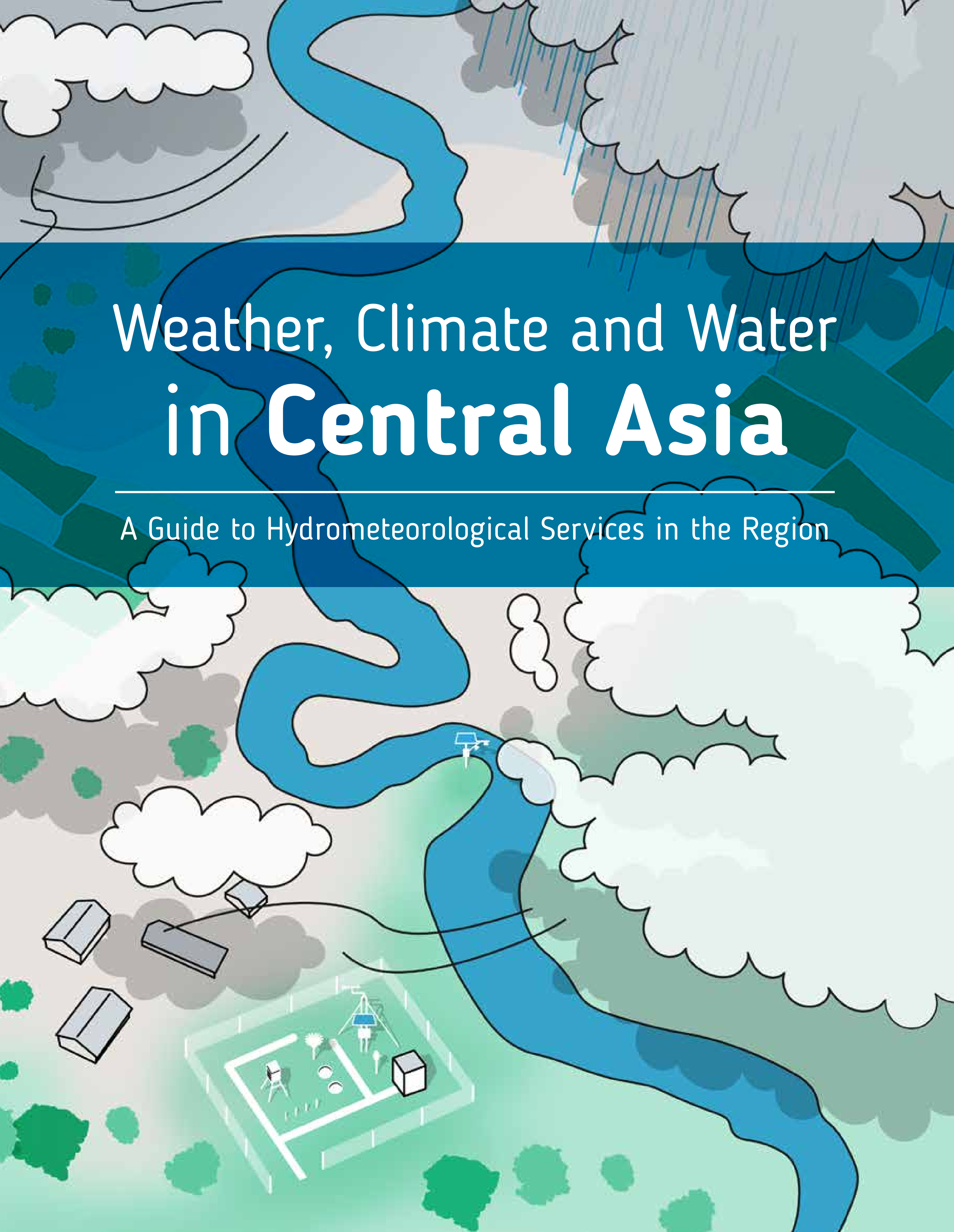
Weather, Climate and Water in **Central Asia**

A Guide to Hydrometeorological Services in the Region



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Foreword

Central Asia has made significant strides in socio-economic development in recent years. However, climate change and weather-related hazards pose significant risks to livelihoods in the region. The World Bank Report *Turn Down the Heat: Confronting the New Climate Normal*, predicts more intense warming in Central Asia than the global average, in a 4°C warmer world. The impacts will be felt in all sectors that are vital to Central Asia's economic growth and development.

Central Asia is also a region where almost 30 percent of the people rely on farming and livestock for their living. For these people, accurate weather and climate information is critical. Forecasting and long-term climate information, for example, can help farmers to grow and protect their crops, and water managers to optimize storage and delivery. Energy producers, transporters, construction companies and tourism/event managers can also optimize the production and security of their services. Finally, good weather information can help reduce disaster risk in locations prone to storms, floods and mudslides, and improve emergency response services.

National Meteorological and Hydrological Services serve as Central Asia's public authorities for weather and river forecasting. While technology is driving rapid evolution in the science of forecasting, computers cannot replace skilled local experts to produce information specific for their countries. The goal is to provide people with timely, reliable and useable information so that they can take appropriate actions to prepare for weather events. The National Meteorological and Hydrological Services are working to provide information through a range of media and in the languages of their users.

With its long-standing support for modernizing the National Meteorological and Hydrological Services of Central Asia and around the world, the World Bank works closely with partners – including with the World Meteorological Organization (WMO) – to strengthen the global weather enterprise. The countries of Central Asia have distinct geographies and climates that require special skills in the National Meteorological and Hydrological Services – for example, weather monitoring and forecasting in both vast deserts and high mountains – and distinct economies with different priority sectors that need specific information on weather, climate and water.

By providing easy-to-understand overviews of the weather and climate in the region, the utility of weather and water information for society, and the role and needs of the National Meteorological and Hydrological Services, this Atlas can be used to inform decision-making, scope possible investments in development, and educate people. It recognizes common interests and specific differences between the climate zones and economic sectors of Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. It also celebrates progress in the modernization of the respective National Meteorological and Hydrological Services and lays out a development path for service-oriented weather, climate and water information services. We sincerely hope that all users, providers, and partners of these services in Central Asia find the Atlas useful.

Sincerely,
Lilia Burunciuc
Regional Director for Central Asia
The World Bank

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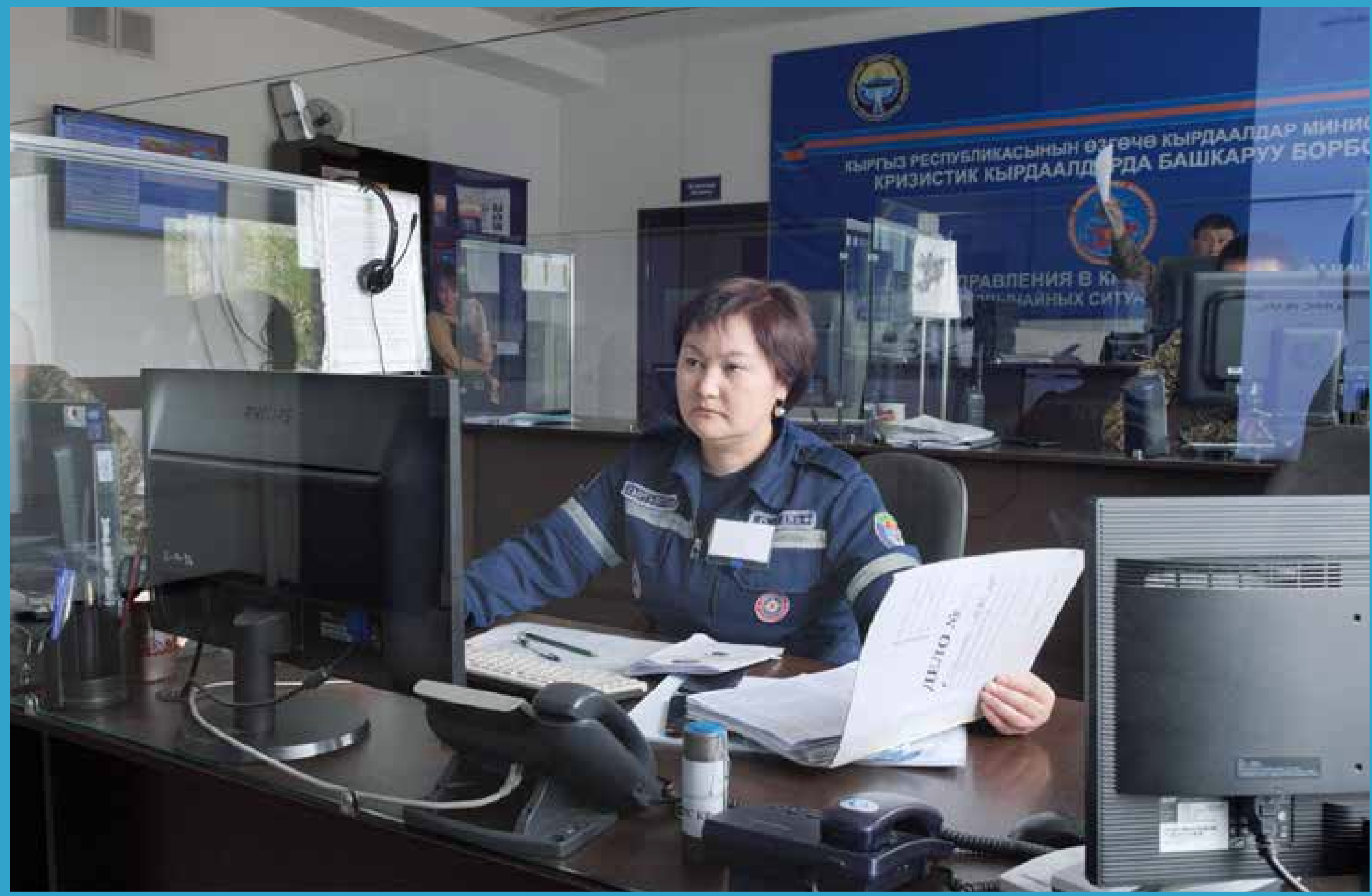
Introduction

Weather is an ever-present part of daily life, and decisions large and small revolve around what the weather is doing and is going to do. The stakes may be fairly low – getting caught in the rain without an umbrella – or extremely high. Hazardous weather conditions can make the transportation of goods and people unsafe, and can put property, livelihoods and lives at risk. Advanced warnings of extreme weather can usually reduce the risks by providing people with the opportunity to take precautionary measures.



Top: Mountain pasture, central Kyrgyz Republic

Bottom: Situation room, Ministry of Emergency Situations of the Kyrgyz Republic

Introduction

In today's world, weather apps are everywhere and when we glance at our devices and decide if we are going to take an umbrella when we leave the house we may be forgiven for taking this twenty-first century, whiz-bang technology for granted and for thinking that weather information comes from our phones. To be sure, weather information is delivered to our phones, but it comes from the collection of an astonishing array of observations and measurements from ground stations, satellites and other remote sensing equipment and from the processing of the data with sophisticated computers, all of which entails the following of rigorous protocols. And the people following those protocols power the entire enterprise with their knowledge, training and professionalism.

This atlas offers insights into the work of the national hydrometeorological services and the global networks that contribute to the information on our screens. It covers the range of weather, water and climate information and services available, and connects that information and those services to the spectrum of users with their own specific needs. As global warming continues to produce more frequent and more intense extreme weather events, interest in the forecasting of these events may be on the rise, and this atlas may serve as an entry point to understanding the methods and limitations of modern practice. Throughout this atlas, the informal term "hydromet" refers to the National Meteorological and Hydrological Services of the Central Asia countries.

The landscape of Central Asia comprises dramatic mountain ranges, high plateaus, deep valleys, steppes and vast desert plains. The Pamirs in Tajikistan and the Tien Shan in the Kyrgyz Republic make those countries the most mountainous in the region, but mountains cover parts of eastern Kazakhstan, southeast Uzbekistan, and Turkmenistan, and extend into Afghanistan and China.

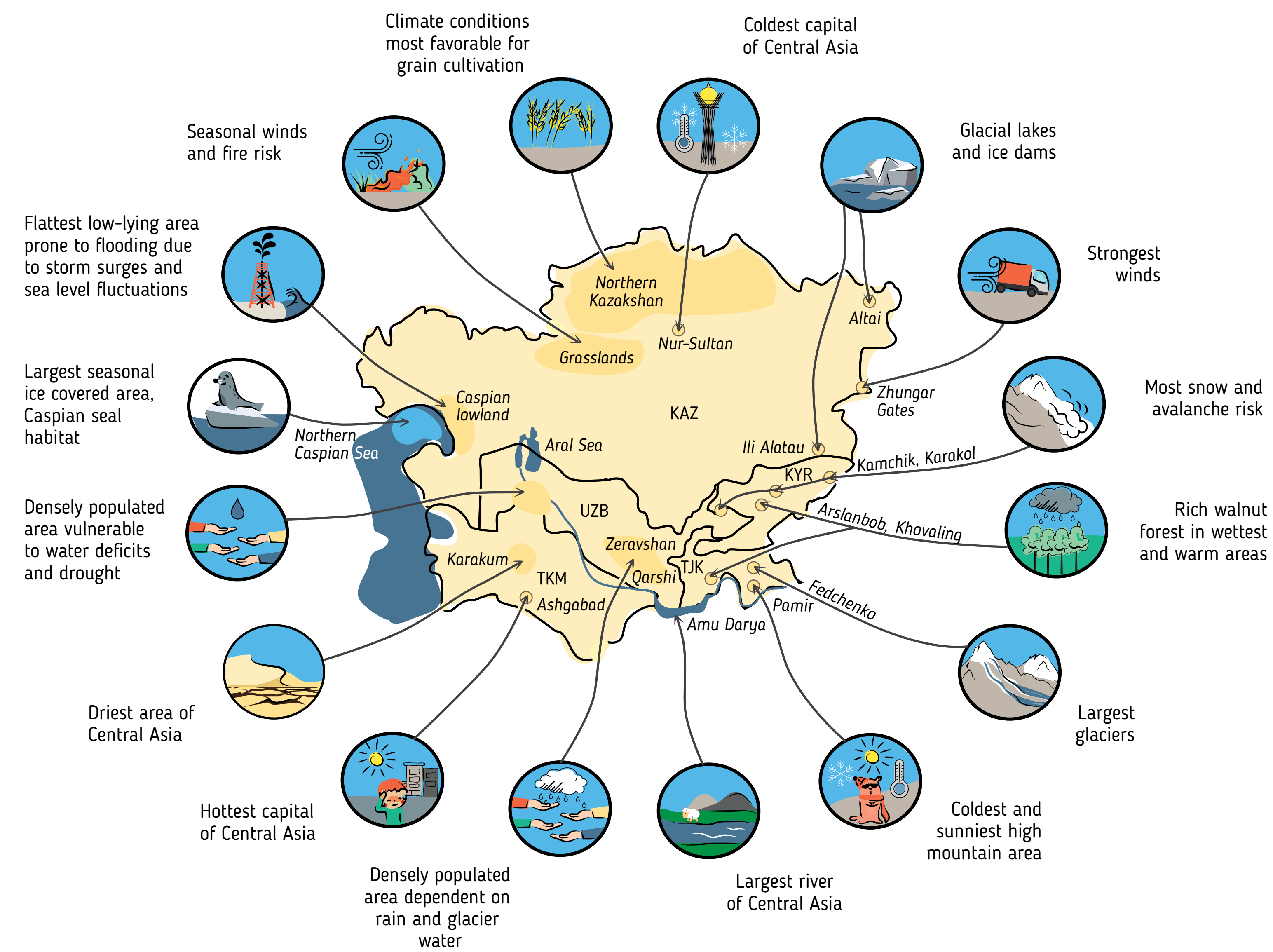
Scientists project that average temperatures in Central Asia will increase by 1°C–3°C by 2050 under likely climate change scenarios, and could rise by 3°C–6°C by the end of the century. Over the last 50–70 years, temperatures have increased by 0.3°C–1.2°C depending on location, and in most places winter warming is more pronounced. Changes in precipitation have varied across the region.

The changes brought by global warming are anything but uniform, and the consequences of climate change vary across landscapes and elevations. Wet areas may become wetter, and dry areas may become drier. By tracking the trends in weather and hydrology, hydromets can assist planners in a range of sectors – transport, agriculture and tourism, to name a few – as they adjust the historical patterns to what is becoming the new normal. The economic stakes related to rising temperatures and changing precipitation patterns are high, and hydromets are at the centre of the development of the new climate knowledge that can guide the sectoral planners and policymakers in the coming years. Hydromets offer summaries of data on temperature, precipitation and other hydrometeorological elements, as well as frequency distributions and average values, and publications on local climate data.

The role of global warming in the hydrological changes in the region extends from the mountains to the lowlands and plays out across the seasons. Mountain glaciers hold vast amounts of water, and tracking the trends in the retreat of glaciers is crucial to the understanding of the downstream effects. Hydropower and agriculture have vital interests in river flows. Planners in these sectors can no longer rely on historical patterns, and the collection and analysis of data are instrumental in the determination of what to expect. Effective water management depends on the sound knowledge and projections provided by hydromets. The products available from hydromets include real-time data and projections on daily, monthly and seasonal water flows by specific river or area, as well as early warnings for flash floods and droughts.

The water that falls as snow and rain in the mountains is stored in glaciers and snowpack before making its way downstream via Central Asia's rivers – the Syr Darya and the Amu Darya along with the Ili, Chu, Talas and Saryjaz, to name the major ones. Some 90 per cent of the population of the region relies on this water from the mountains.

Climate facts of Central Asia



Geography

Map produced by Zoi Environment Network, September 2019

Water formation and use

Weather formation in Central Asia

Thickness of air mass arrows corresponds to the relative occurrence of weather phenomena during the year.

Based on estimates of V. Bugaev

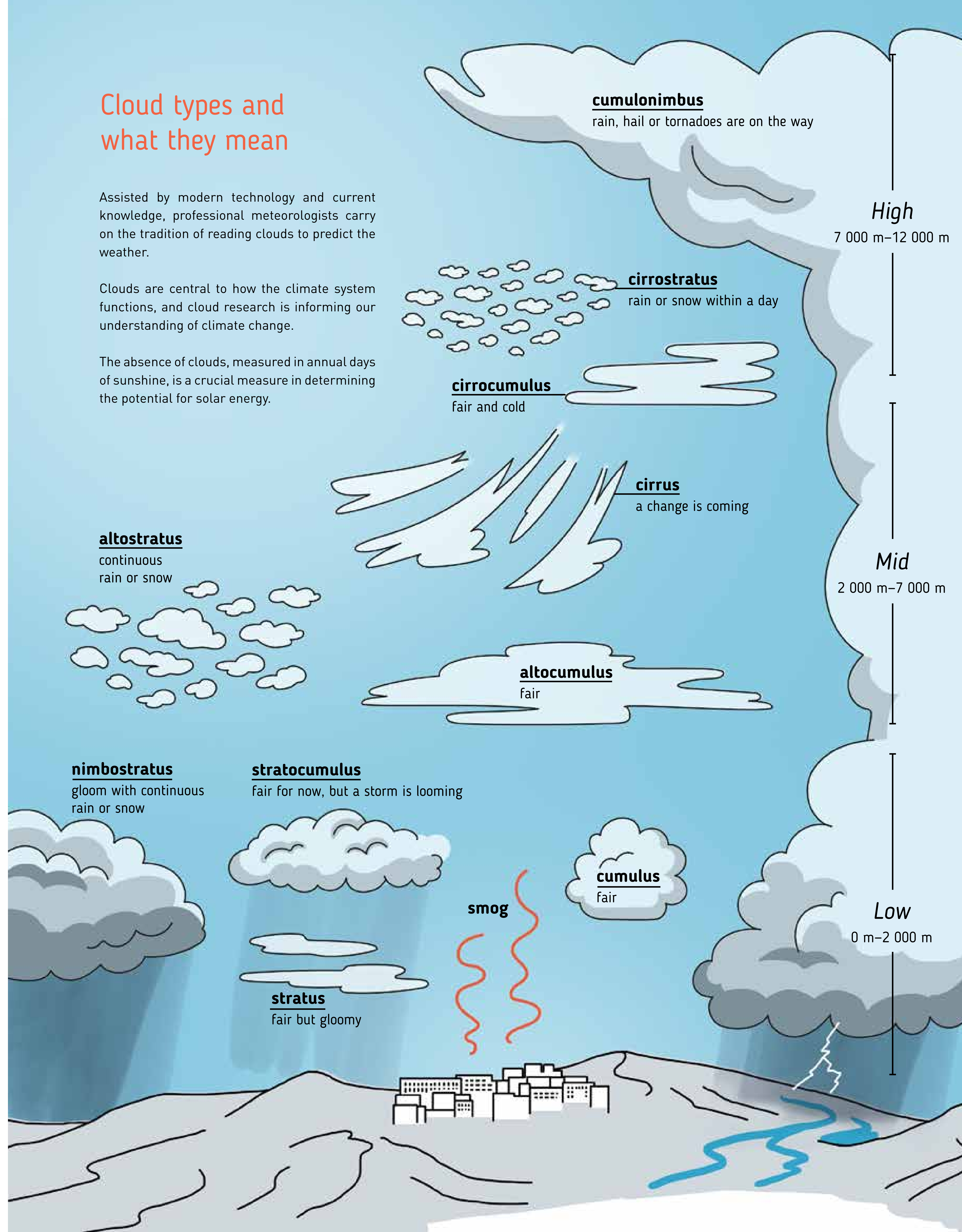
Several large weather patterns affect Central Asia. Warm, subtropical air masses from the south-east can trigger rain and dust storms and unstable weather in the high mountains. Humid air from the west generally brings clouds, rain and cool temperatures, while north-western air flows often bring heavy precipitation to the mountains, and may cause dust storms. Polar air masses can bring sudden dips in temperature and persistent mountain fog, and may trigger dust storms and rain. Siberian high pressure from the north-east usually brings stable, sunny weather, while frontal waves create unstable weather and thunderstorms in the mountains. In the interior of Central Asia, summer thermal depressions – low pressure systems – bring hot temperatures and stable weather.

Cloud types and what they mean

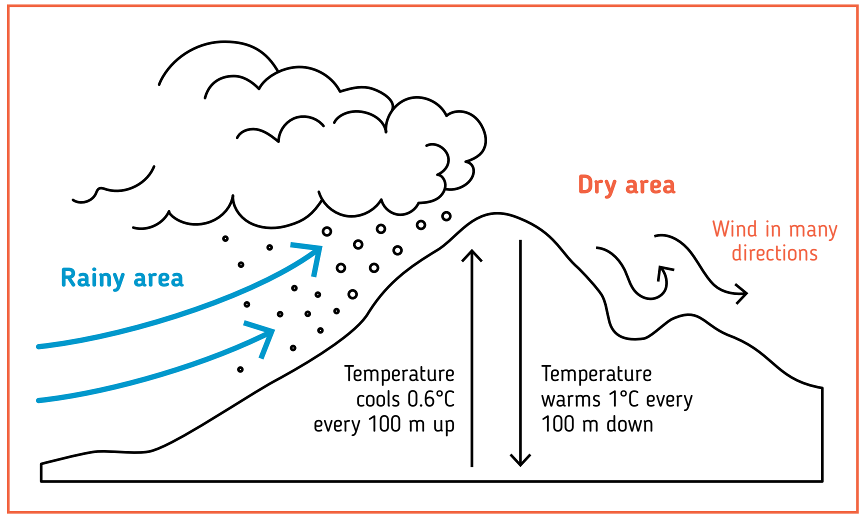
Assisted by modern technology and current knowledge, professional meteorologists carry on the tradition of reading clouds to predict the weather.

Clouds are central to how the climate system functions, and cloud research is informing our understanding of climate change.

The absence of clouds, measured in annual days of sunshine, is a crucial measure in determining the potential for solar energy.

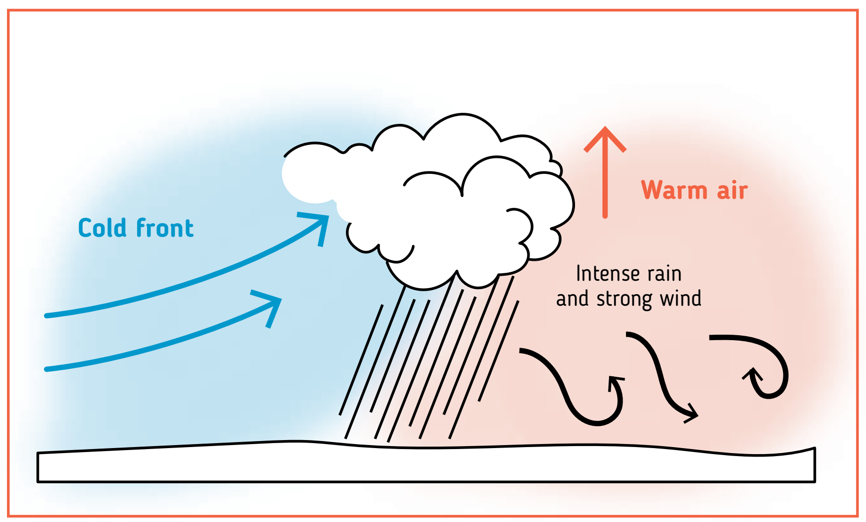


Complex and extreme weather



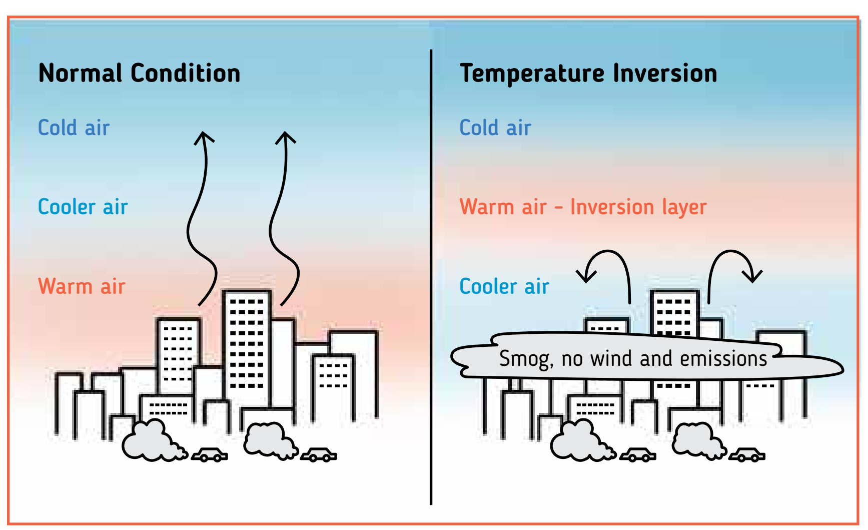
Mountain weather

The many people in Central Asia who live in or near the mountains have experienced close up how the mountains make weather. When moist air flows up the mountains, for example, the wind side generally receives rain and the lee side stays dry. But the specific shapes of the mountains and plateaus contribute to wide variations in precipitation, temperature and wind over relatively small areas. These conditions are challenging to meteorologists, and hydrometeorological observations are scarce and expensive in the mountains.



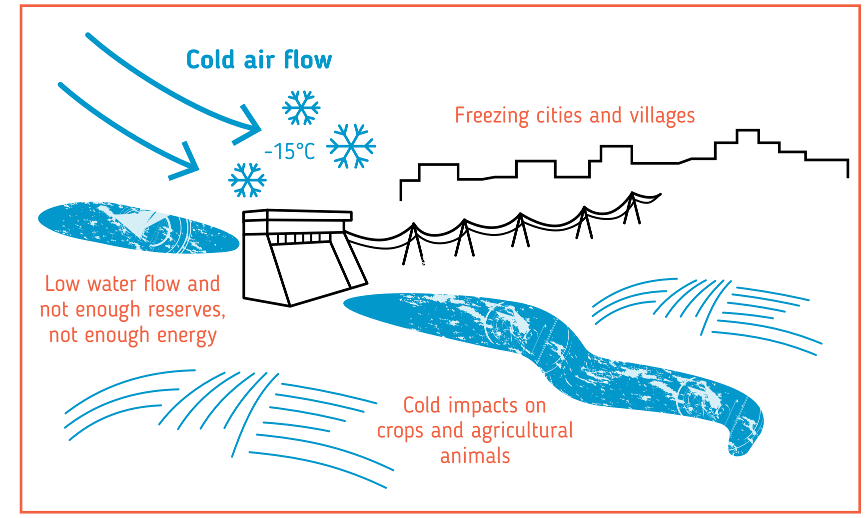
Intense rain and hailstorms

When humid cold air meets warmer air the result can be a quickly developing, highly localized storm with intense rain or hail. Intense rainstorms can flood urban areas, and hail storms can severely damage crops. Hydromets can typically provide only short notice of such storms, and need high-resolution data and expensive instrumentation such as radar.



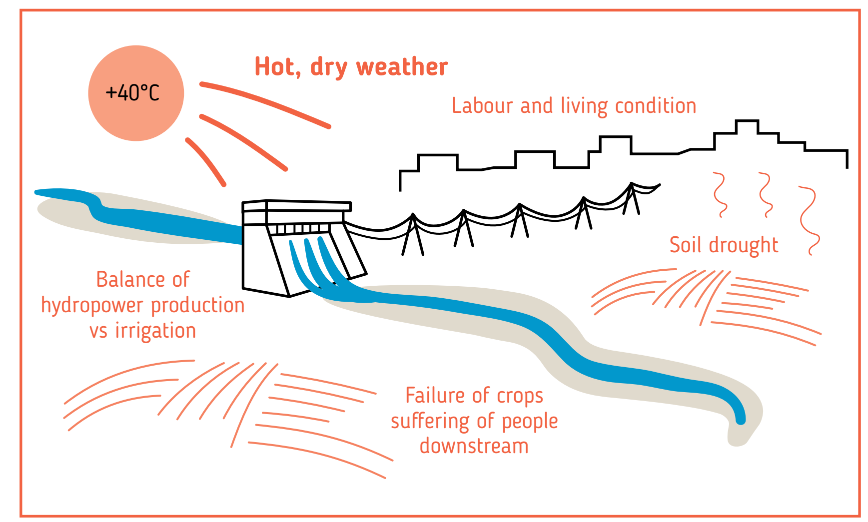
Temperature inversions

Temperature inversions often occur in winter in urban areas, when air temperatures increase rather than cool with altitude. These events trigger air stagnation, accumulation of urban pollutants and the formation of smog. Hydromet forecasts can predict the weather conditions that lead to inversions, and can issue pollution alerts and measure pollution levels.



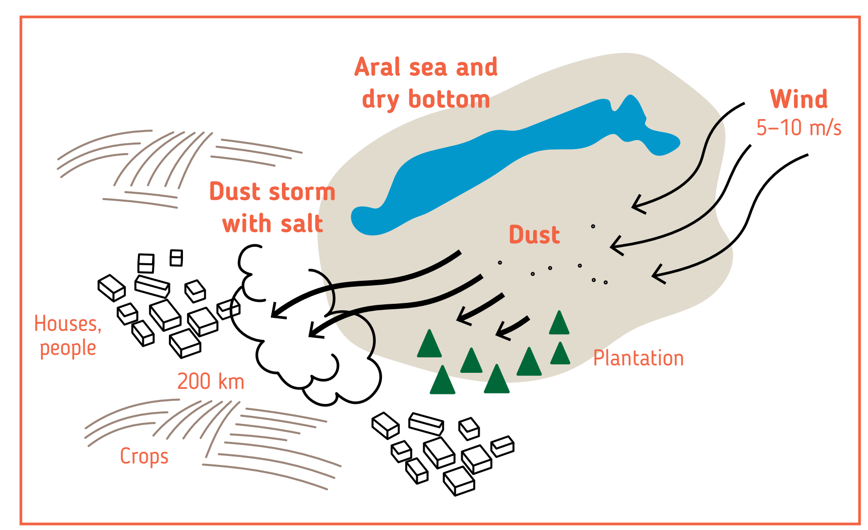
Extreme heat and cold

Heatwaves are periods of several days to several weeks with hot temperatures at least 10 degrees higher than historical averages in a given area. They occur when high-pressure systems force air downwards. The trapped air below has no place to go and keeps getting warmer. Cold waves are sharp near-surface drops in temperature, often accompanied by strengthening winds and icy conditions, and covering a large area. Timely forecasts can save lives and minimize suffering.



Extreme drought

All droughts are the result of an area receiving less precipitation than what is considered normal or average. Meteorological droughts are defined by how dry the air and soil are compared to normal, and by how long the period persists. Hydrological droughts are more closely tied to water levels in rivers and reservoirs. Droughts affect downstream areas more severely than upstream areas, and consecutive year droughts compound the stress. Hydromets can make seasonal forecasts for hydrological droughts based on snowpack and precipitation records, but rainfall deficits can deplete soil moisture quickly.



Dust storm

As a formerly large water body, the Aral Sea influenced the weather in the region, and the shrinking of the sea has changed the local microclimate. What was once the seabed is now exposed dust mixed with salt. Strong winds carry this dust and salt mixture in large storms that can last for a couple of hours that can affect areas up to 300 km from the sea. Hydromets can predict the weather conditions for these storms, but not their size and intensity, so warnings are limited to the alert that the storms are likely to occur. Authorities are planting vegetation around the sea in the attempt to stabilize the ongoing desertification and reduce dust storms.

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Users of weather, water and climate information

Warnings of extreme weather events are crucial across sectors and for the general public. Each sector has its own specific concerns, and hydromets provide important information that allows sector planners and managers to respond to changing weather, climate and water conditions.

Top: Karshi canal, Uzbekistan
Bottom: Cotton field

Users of weather, water and climate information

A well-functioning hydromet service is an essential element in both disaster risk reduction and emergency response. Timely information on hazardous weather conditions and forecasts of extreme events can help public safety officials prepare for and respond to potential disasters effectively. Historical hydromet data provide city planners with the information necessary to design storm water systems, identify evacuation routes and prepare for other disaster contingencies – cooling centres to protect residents during heatwaves, for example. The hydromet products include data summaries and reports on climate normals.

Extreme weather can strike in any season, and can trigger a range of potential consequences, such as avalanches and floods that affect different areas and economic sectors in specific ways, and that require responses specific to the situation. In some cases, the appropriate response may be as simple as the postponement of an event, and in others the response may entail road closures or evacuations. Longer extreme weather events such as droughts, heatwaves and cold spells call for more sustained responses, and forecasts can provide both warnings of coming events and signals of when the weather may change.

Agriculture

No sector has more at stake in the weather and climate conditions than agriculture. Crops, livestock, facilities and infrastructure all are vulnerable to extreme weather events, and the livelihoods of growers depend on their ability to protect their assets from droughts, storms and extreme high or low temperatures. Growers use climate information to help select crops, varieties and species adapted to the changing conditions in specific locations, and rely on weather warnings to alert them to the need to take precautionary measures. Hydromets conduct agrometeorological observations covering soil conditions and vegetation development and provide information that can help farmers predict the health and vigour of crops and natural pastures, and reduce risk of crop damage by diseases and pests. They also produce information crucial for national food security assessments, for scheduling optimal crop watering and harvesting times and for managing commercial gardens and greenhouses.

Construction and cities

The construction sector benefits from a range of hydromet services – historical climate and extreme weather data to inform design and siting criteria, and current forecasts for scheduling and logistics during the course of construction. The marvels of civil engineering such as skyscrapers, sophisticated bridges and sport facilities all require highly detailed climate data to ensure the safety and performance of the structures. Municipal authorities likewise use these data to develop building codes and evacuation plans. Public health and safety agencies and other city officials are on the front lines of emergency response, and they use hydromet forecasts to help them determine when to issue alerts, open cooling centres and take other appropriate measures to protect the population. Hydromets provide data summaries such as temperature frequency distributions, and offer climate data in the form of averages of meteorological measures of temperature, precipitation, frosts and snowfall.

Energy

The systems for generating and transmitting power are vulnerable to certain weather conditions and to numerous projected and actual climate changes. The efficiency and output of power generation decline as temperatures increase, and higher cooling water temperatures at coal and gas-fueled plants are particularly problematic. The power generation and grid infrastructure are threatened by stronger and more frequent storms and high winds that can reduce output and affect energy security. Similarly, the increasing frequency and intensity of droughts, together with changes in precipitation patterns, can reduce hydropower generation as well as the water available for cooling nuclear and thermal power plants.

Climate services help the energy sector build resilience to extreme weather events, climate variability and climate change by providing information the sector can use in planning and operations. Climate data helps planners site a range of facilities, and weather forecasts help managers project demand for energy, estimate load requirements, and determine when to conduct maintenance.

The information that hydromets produce is vital to the development of wind and solar energy. The range of products includes wind speed and solar radiation databases that can help energy planners determine the potential for driving wind turbines and estimate the potential for solar energy. Where wind and solar energy producers have special requirements for services or products, the hydromets may need to develop new information for this important sector.

The planning of hydropower facilities relies on historical hydrology data, and the operation and management of the facilities relies on real-time water flow data and weekly to seasonal water forecasts. Weather and wave forecasts allow managers to schedule the safe servicing of offshore oil rigs by reporting on wind, fog and ice conditions. Hydromets also provide information on measures of expected energy use for heating and cooling, and temperature information that can be used to assess equipment requirements.

Transport

The transportation sector depends on nowcasting and reliable, short- and medium-term weather forecasts to alert schedulers and travellers of current and developing conditions. The aviation sector monitors wind speed and direction at different altitudes as well as potentially hazardous cloud formations for safe take-offs and landings, and uses data on winds aloft to pick the most efficient routes. Ice, snow, rain, fog and wind – and avalanche conditions in the mountains – can affect road and rail transportation of goods and people. Excessive heat and dust storms can damage rail tracks. Historical weather and hydrology data can help planners decide where to site roads and bridges to minimize the chance of flood damage. Marine ports and shippers need information on wind, ice and storm conditions. Among the hydromet products of use to transportation planners are the databases on temperature and precipitation averages and extremes, monthly summaries of daily observations and annual average and extreme values. Hydromets often provide specialized commercial weather services for transport according to specific requirements and standards.

Sports, tourism and outdoor events

Historical hydrometeorological information guides the long-term planning and development of tourism facilities such as skiing and water resorts, and routine weather forecasts help determine maintenance schedules and anticipate the number of visitors. Mountain climbers and alpine sports enthusiasts rely on weather reports for information on avalanche hazards, snow conditions, visibility, winds and approaching storms. Summer hikers can use short-term forecasts to avoid unsafe conditions. Outdoor event planners – who are often civic leaders – seek hourly forecasts so they can prepare for weather contingencies. Hydromets offer reports with historical temperature and precipitation figures, and provide area-specific forecasts.

Climate and water assessments and early warnings of extreme weather

Disasters and livelihoods

Farmers and pastoralists can use weather and agrometeorological information to reduce their risk. Long-term trends can inform traditional practices and land use plans. Early warnings are essential for safety at home, on the road and in the field.

GHG emissions and climate change tracking

Regular inventories of greenhouse gases help evaluate climate policies. The monitoring of climate change consequences, such as the melting of glaciers, informs the assessment of impacts and the development of adaptation plans.

Personal comfort and health

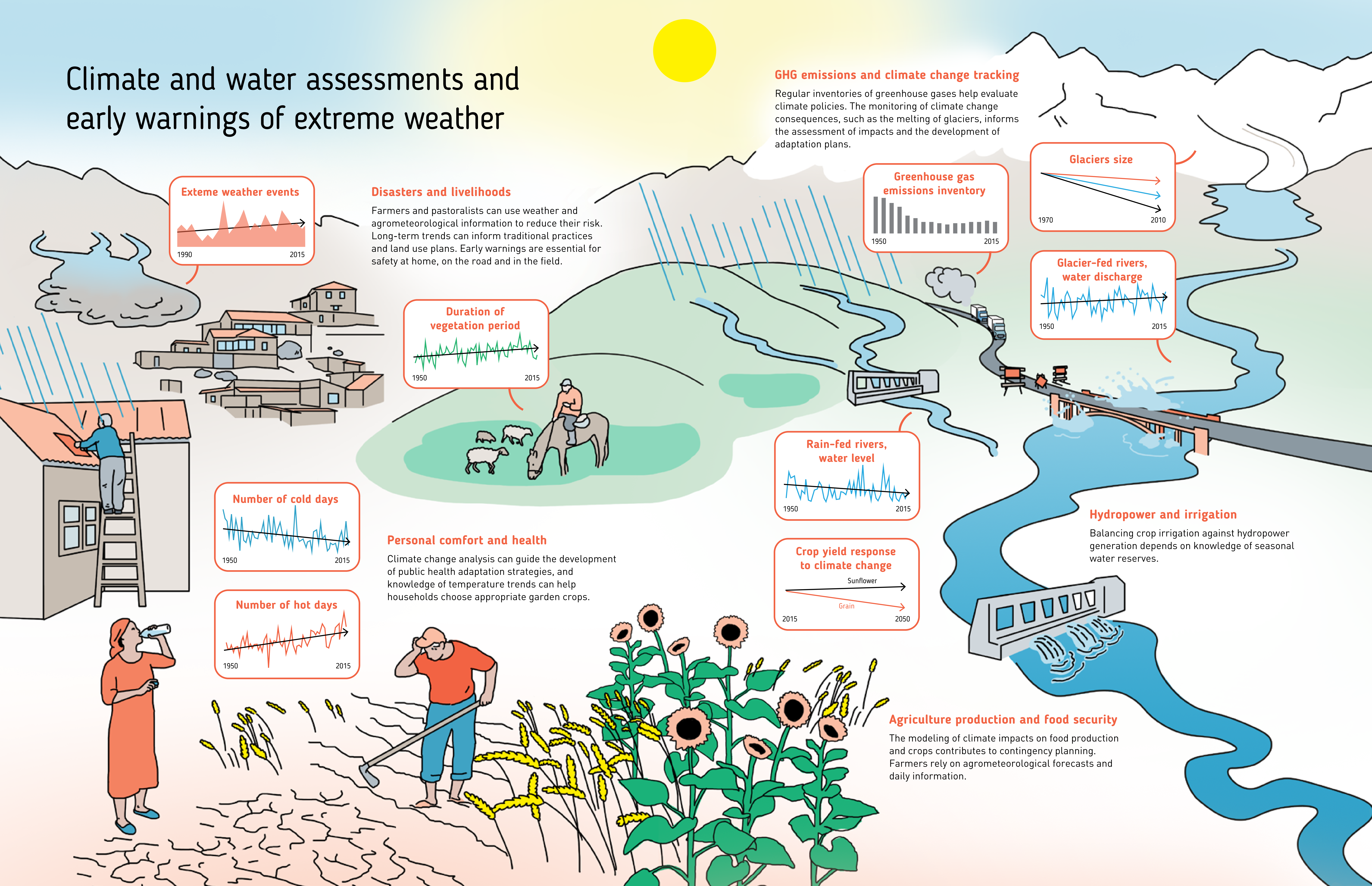
Climate change analysis can guide the development of public health adaptation strategies, and knowledge of temperature trends can help households choose appropriate garden crops.

Hydropower and irrigation

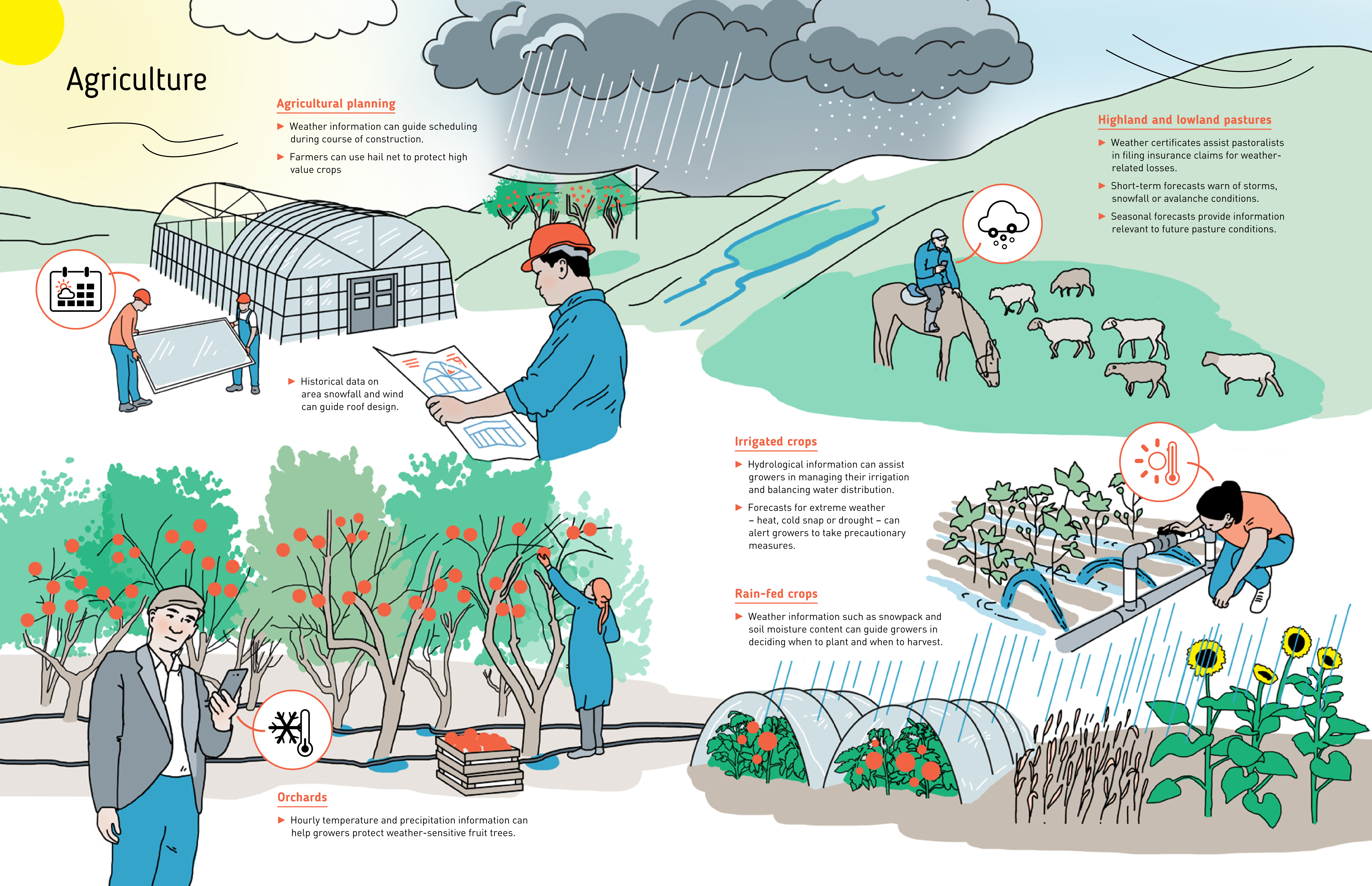
Balancing crop irrigation against hydropower generation depends on knowledge of seasonal water reserves.

Agriculture production and food security

The modeling of climate impacts on food production and crops contributes to contingency planning. Farmers rely on agrometeorological forecasts and daily information.



Agriculture



Agricultural planning

- Weather information can guide scheduling during course of construction.
- Farmers can use hail net to protect high value crops

- Historical data on area snowfall and wind can guide roof design.

Highland and lowland pastures

- Weather certificates assist pastoralists in filing insurance claims for weather-related losses.
- Short-term forecasts warn of storms, snowfall or avalanche conditions.
- Seasonal forecasts provide information relevant to future pasture conditions.

Irrigated crops

- Hydrological information can assist growers in managing their irrigation and balancing water distribution.
- Forecasts for extreme weather – heat, cold snap or drought – can alert growers to take precautionary measures.

Rain-fed crops

- Weather information such as snowpack and soil moisture content can guide growers in deciding when to plant and when to harvest.

Orchards

- Hourly temperature and precipitation information can help growers protect weather-sensitive fruit trees.

Construction and cities

House construction

- Builders and designers can use historical weather data to make good decisions on the siting and orientation of houses, and to determine the level of insulation needed to keep living spaces comfortable and cost-effective to heat and cool.
- Before and during the course of construction, builders can use hydromet services to plan work schedules to optimize safety and efficiency.

Special projects and operation

- Special construction projects – antennas, bridges, mines and other large or complex structures – require special planning.
- Historical data on temperatures and prevailing winds, for example, may inform decisions on material choices and other engineering matters.

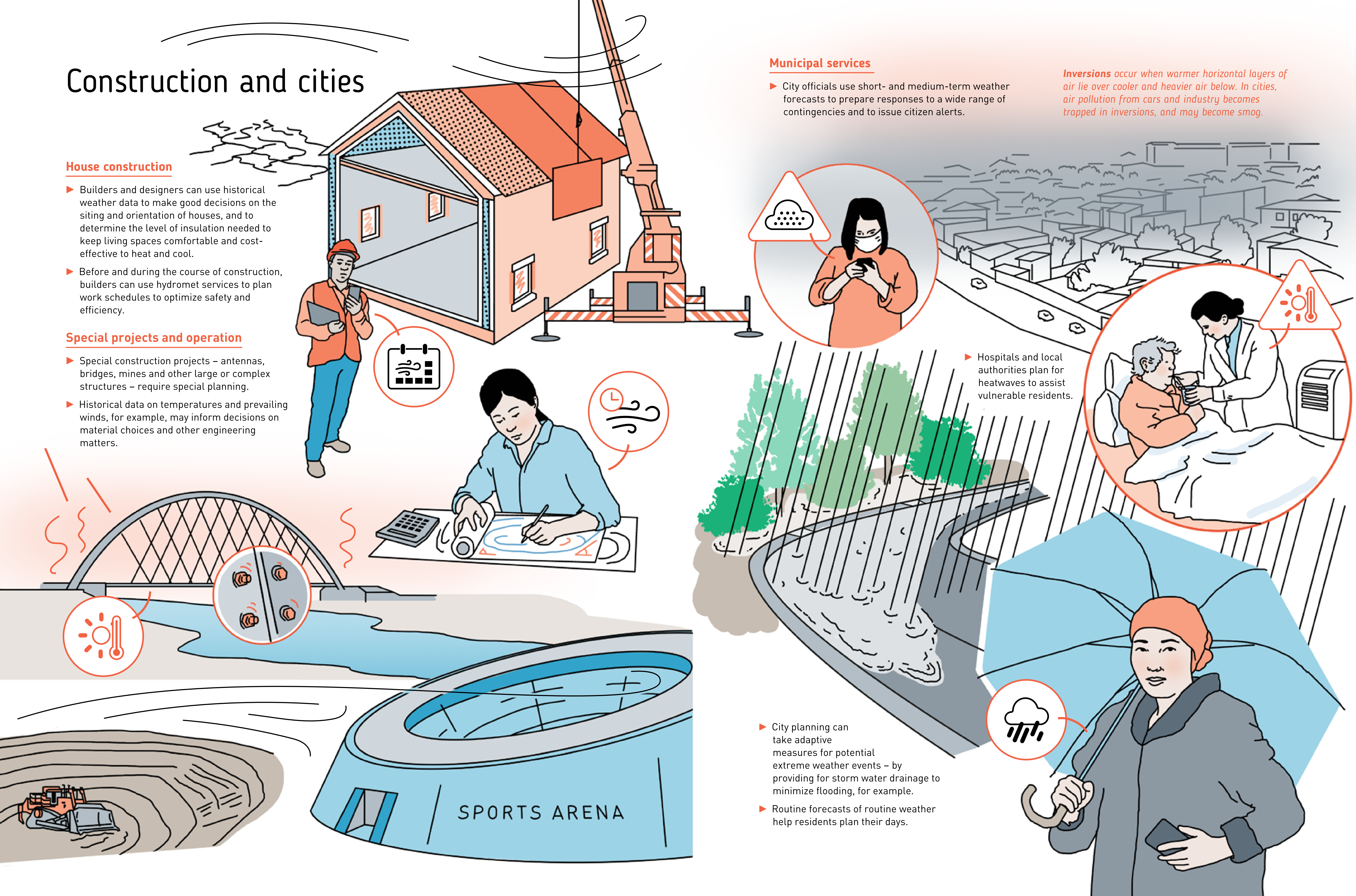
Municipal services

- City officials use short- and medium-term weather forecasts to prepare responses to a wide range of contingencies and to issue citizen alerts.

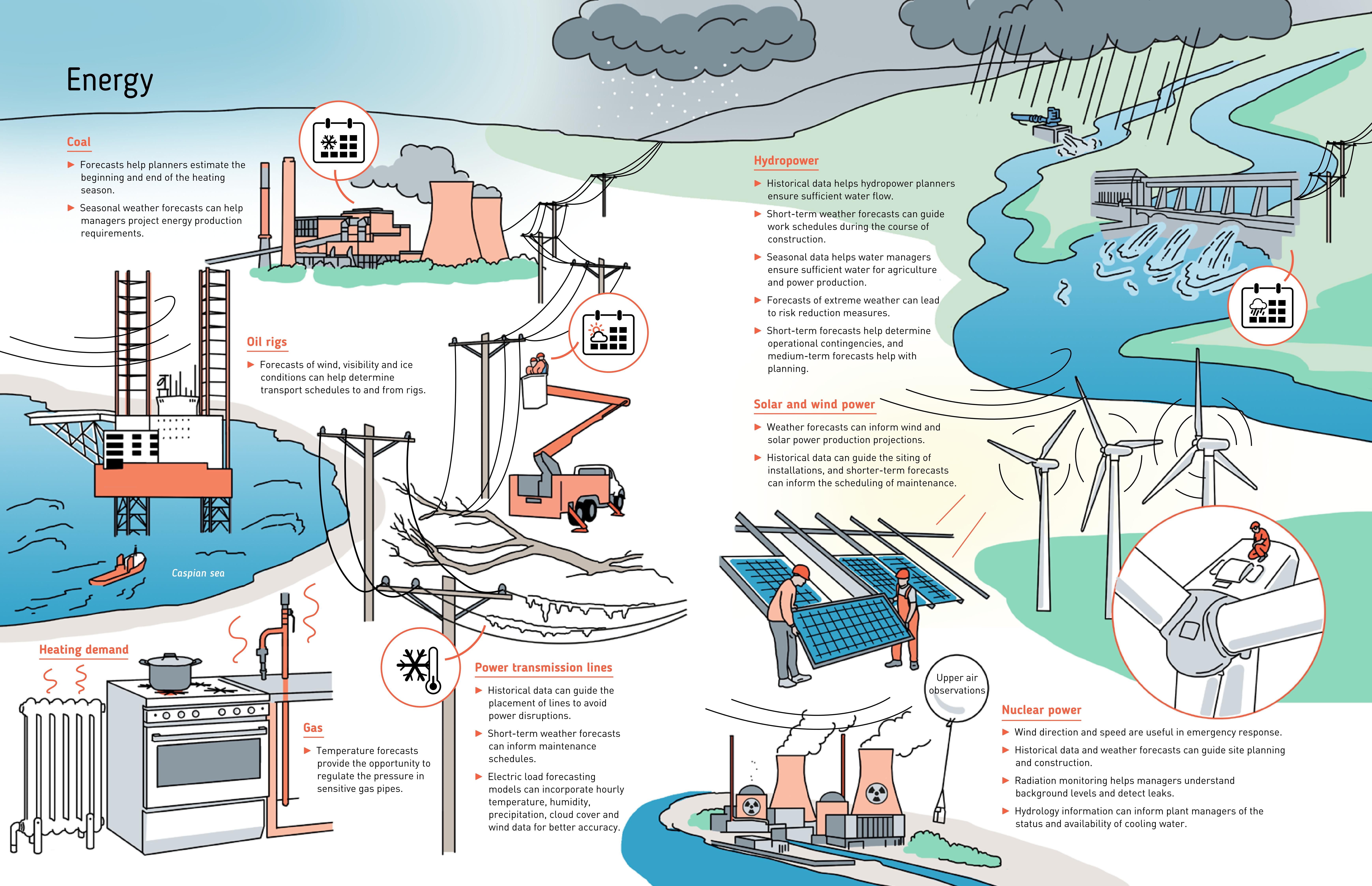
***Inversions** occur when warmer horizontal layers of air lie over cooler and heavier air below. In cities, air pollution from cars and industry becomes trapped in inversions, and may become smog.*

- Hospitals and local authorities plan for heatwaves to assist vulnerable residents.

- City planning can take adaptive measures for potential extreme weather events – by providing for storm water drainage to minimize flooding, for example.
- Routine forecasts of routine weather help residents plan their days.



Energy



Coal

- Forecasts help planners estimate the beginning and end of the heating season.
- Seasonal weather forecasts can help managers project energy production requirements.

Oil rigs

- Forecasts of wind, visibility and ice conditions can help determine transport schedules to and from rigs.

Heating demand

Gas

- Temperature forecasts provide the opportunity to regulate the pressure in sensitive gas pipes.

Power transmission lines

- Historical data can guide the placement of lines to avoid power disruptions.
- Short-term weather forecasts can inform maintenance schedules.
- Electric load forecasting models can incorporate hourly temperature, humidity, precipitation, cloud cover and wind data for better accuracy.

Hydropower

- Historical data helps hydropower planners ensure sufficient water flow.
- Short-term weather forecasts can guide work schedules during the course of construction.
- Seasonal data helps water managers ensure sufficient water for agriculture and power production.
- Forecasts of extreme weather can lead to risk reduction measures.
- Short-term forecasts help determine operational contingencies, and medium-term forecasts help with planning.

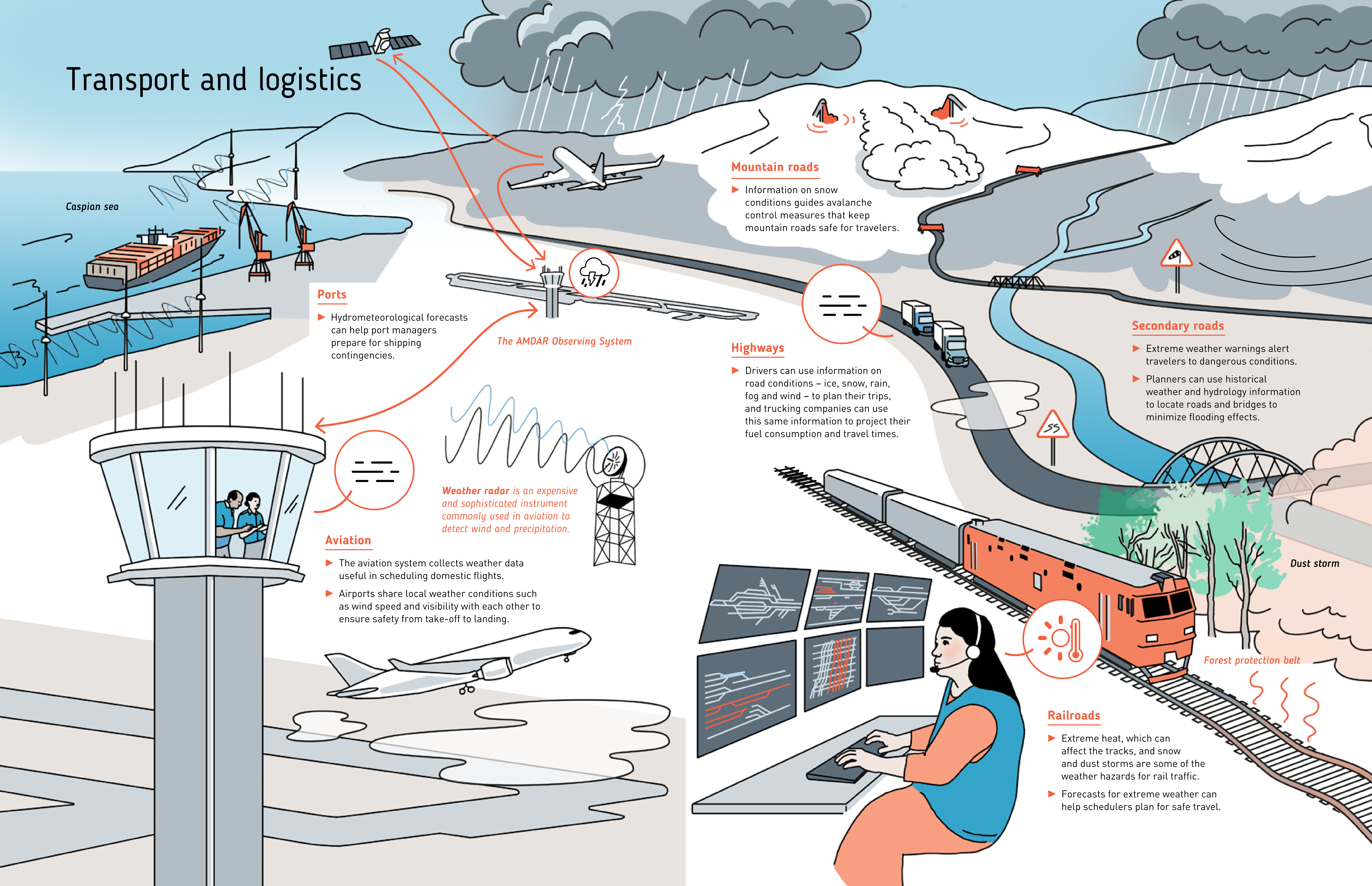
Solar and wind power

- Weather forecasts can inform wind and solar power production projections.
- Historical data can guide the siting of installations, and shorter-term forecasts can inform the scheduling of maintenance.

Nuclear power

- Wind direction and speed are useful in emergency response.
- Historical data and weather forecasts can guide site planning and construction.
- Radiation monitoring helps managers understand background levels and detect leaks.
- Hydrology information can inform plant managers of the status and availability of cooling water.

Transport and logistics



Ports

- Hydrometeorological forecasts can help port managers prepare for shipping contingencies.

***Weather radar** is an expensive and sophisticated instrument commonly used in aviation to detect wind and precipitation.*

Aviation

- The aviation system collects weather data useful in scheduling domestic flights.
- Airports share local weather conditions such as wind speed and visibility with each other to ensure safety from take-off to landing.

Mountain roads

- Information on snow conditions guides avalanche control measures that keep mountain roads safe for travelers.

Highways

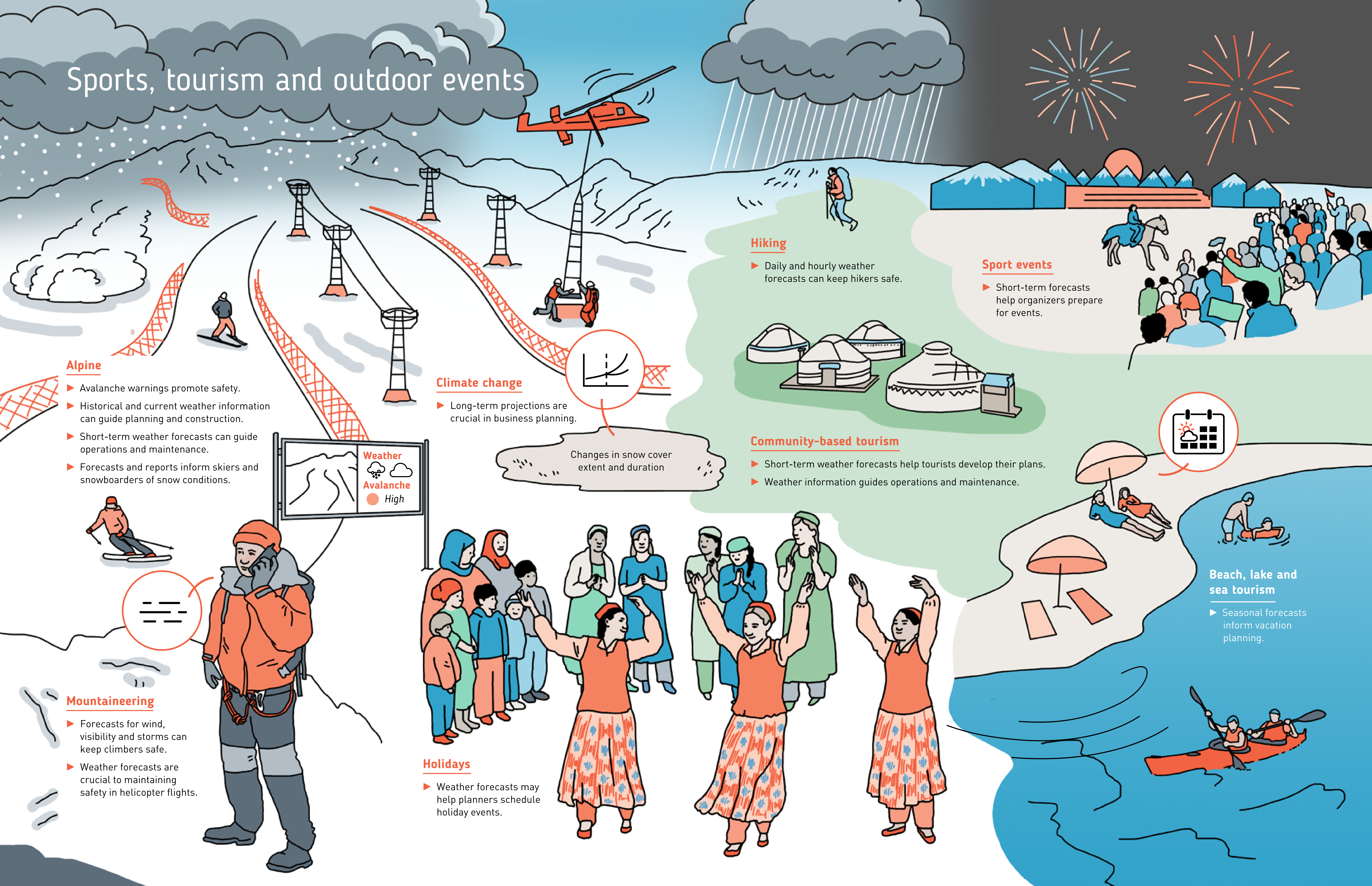
- Drivers can use information on road conditions – ice, snow, rain, fog and wind – to plan their trips, and trucking companies can use this same information to project their fuel consumption and travel times.

Secondary roads

- Extreme weather warnings alert travelers to dangerous conditions.
- Planners can use historical weather and hydrology information to locate roads and bridges to minimize flooding effects.

Railroads

- Extreme heat, which can affect the tracks, and snow and dust storms are some of the weather hazards for rail traffic.
- Forecasts for extreme weather can help schedulers plan for safe travel.


Sports, tourism and outdoor events
Alpine
▶ Avalanche warnings promote safety.
▶ Historical and current weather information can guide planning and construction.
▶ Short-term weather forecasts can guide operations and maintenance.
▶ Forecasts and reports inform skiers and snowboarders of snow conditions.
Weather
Avalanche
High
Mountaineering
▶ Forecasts for wind, visibility and storms can keep climbers safe.
▶ Weather forecasts are crucial to maintaining safety in helicopter flights.
Climate change
▶ Long-term projections are crucial in business planning.
Changes in snow cover extent and duration
Holidays
▶ Weather forecasts may help planners schedule holiday events.
Hiking
▶ Daily and hourly weather forecasts can keep hikers safe.
Community-based tourism
▶ Short-term weather forecasts help tourists develop their plans.
▶ Weather information guides operations and maintenance.
Sport events
▶ Short-term forecasts help organizers prepare for events.
Beach, lake and sea tourism
▶ Seasonal forecasts inform vacation planning.

3

Hydromet information and services

The trend towards automation in weather observations began about 20 years ago, and the countries of Central Asia are starting to catch up. World Bank projects in Tajikistan and the Kyrgyz Republic over the past 10 years have added automated observations at manual stations, and have advanced the integration of the systems.

Automated meteorological station, Sangiston, Tajikistan

Common hydromet information and services

Hydromets' atmosphere and upper air observations include sunshine, cloud cover and type, the atmospheric profile and phenomena, the ozone layer and pollutants. Hazard and special observations range from glaciers, snow reserves and avalanches to flash floods and flood risks. Weather observations near the surface include temperature, wind speed and direction and rainfall, while environmental observations cover air pollution, radiation levels and heatwaves. Surface hydrology observations include water levels and discharge, water phenomena and water quality. Vegetation and soil observations include vegetation phases, soil temperature and moisture content and drought risk. Marine observations include waves, floods and ice events.

The new equipment is more technologically advanced and comes with new maintenance requirements, and the transmission and integration of data need to evolve to ensure smooth operations. The implications for staff remain an open question, but the adoption of a more client-oriented approach – favoured by WMO – may entail local hydromet stations providing direct services, and local staff receiving training in client relations.

The global data system includes data accessible to hydromets through the WMO Information System and through the global telecommunication system, and includes data from satellite systems. Hydromets produce data in their national systems, which also include data produced by other agencies or the private sector or academia. A key requirement for an information and communications system is broad bandwidth access to the Internet for accessing large data volumes from global prediction centers and from satellite and ground-based remote sensing.

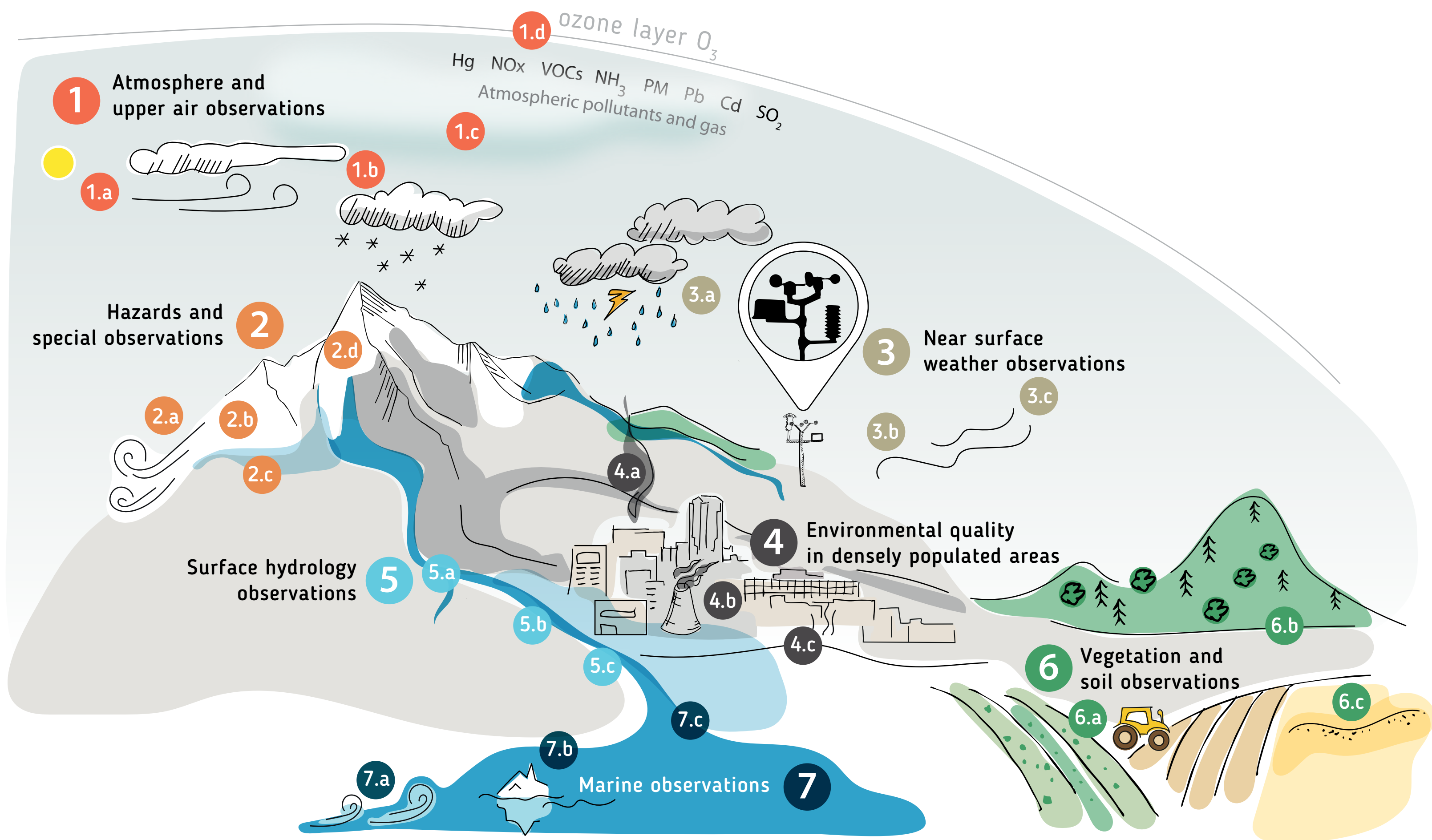
Kaz Hydromet building in Almaty

Checking equipment, Tajikistan

The reliable generation of timely and accurate meteorological and hydrological forecasts calls for the higher resolution numerical guidance increasingly available from the WMO global production centres. The World Bank encourages hydromets to base forecasts on ensemble predictions and to provide users with warnings of the potential impacts and the severity of the risks. To produce and deliver services that are relevant and responsive, hydromets need to understand the kinds of decisions their users make, and how they use hydrometeorological information.

Thermometer housing, Turkmenistan

Collecting observations



1. Atmosphere and upper air observations
   - 1.a sunshine
   - 1.b atmospheric profile and phenomena
   - 1.c cloud type and cover
   - 1.d ozone layer, global pollutants

2. Hazards and special observations
   - 2.a avalanches
   - 2.b snow reserves
   - 2.c flash floods, flood risk
   - 2.d glaciers

3. Near surface weather observations
   - 3.a rainfall
   - 3.b air temperature
   - 3.c wind speed and direction

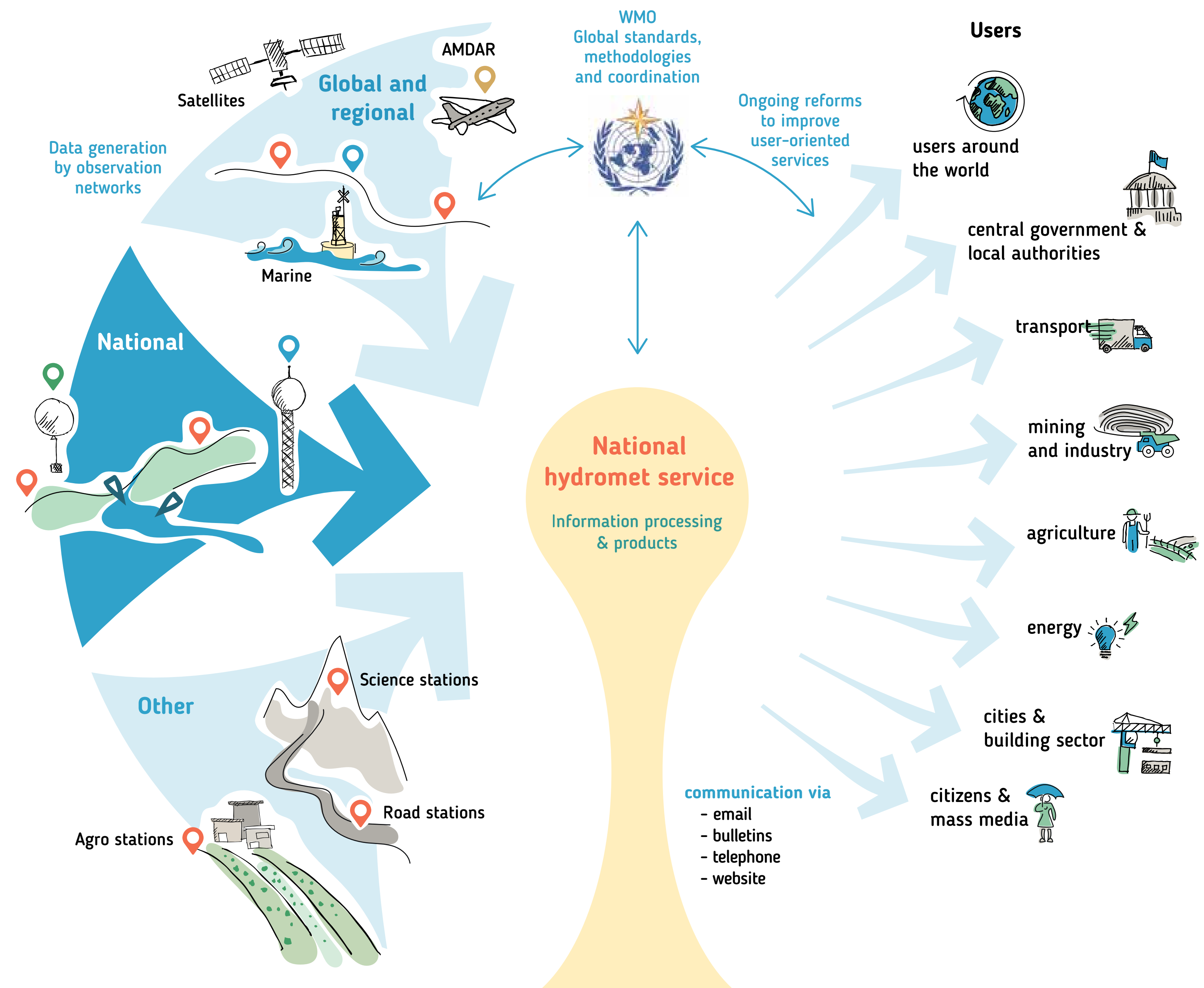
4. Environmental quality in densely populated areas
   - 4.a air pollution
   - 4.b radiation levels
   - 4.c heatwaves

5. Surface hydrology observations
   - 5.a water level and discharge
   - 5.b water phenomena
   - 5.c water quality

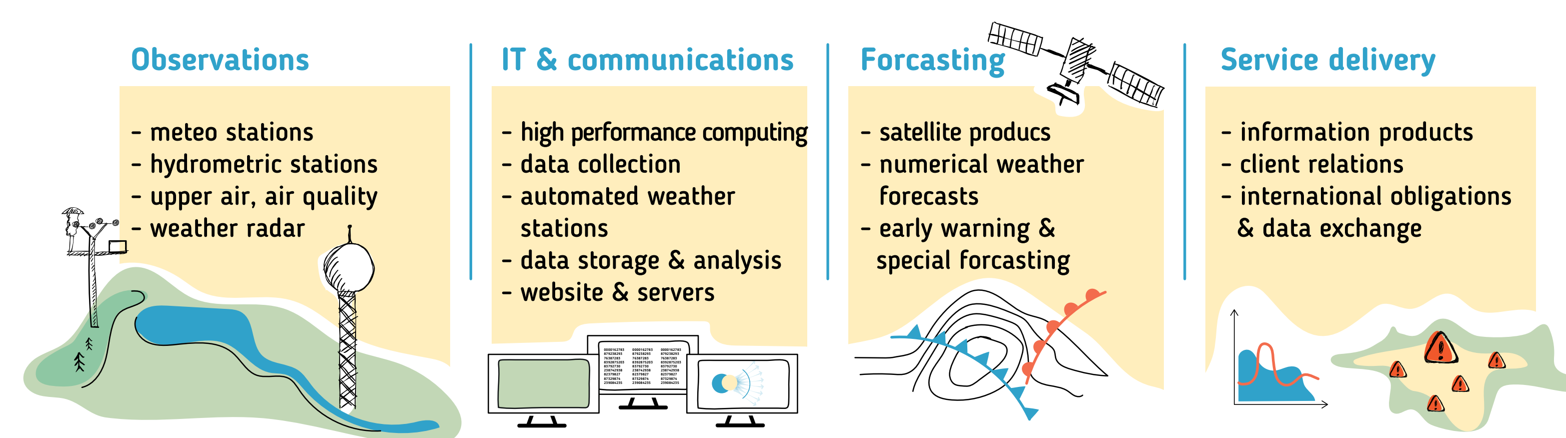
6. Vegetation and soil observations
   - 6.b soil temperature and humidity
   - 6.a vegetation phases
   - 6.c drought risk

7. Marine observations
   - 7.a waves
   - 7.b ice events
   - 7.c sea level

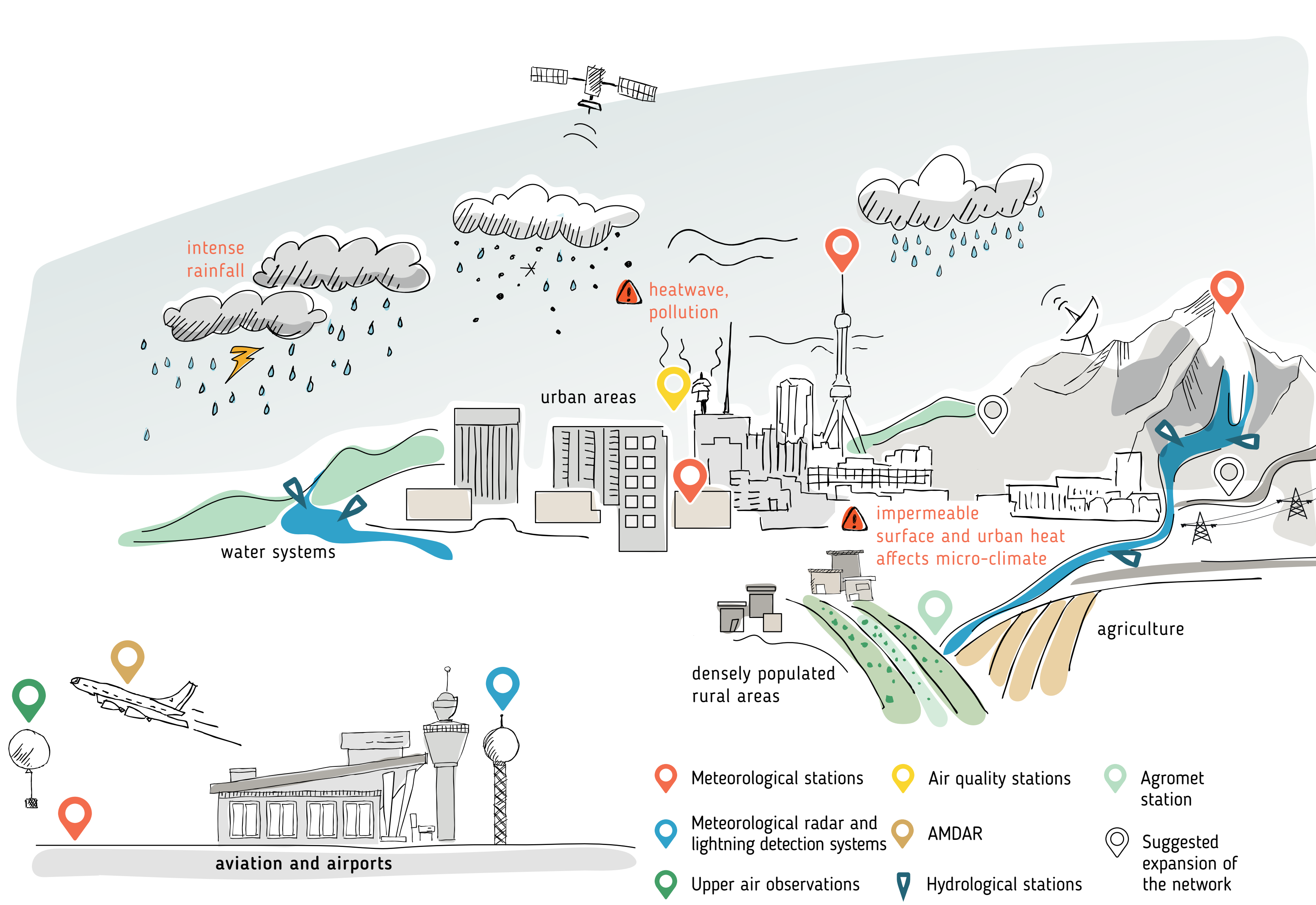
Processing information



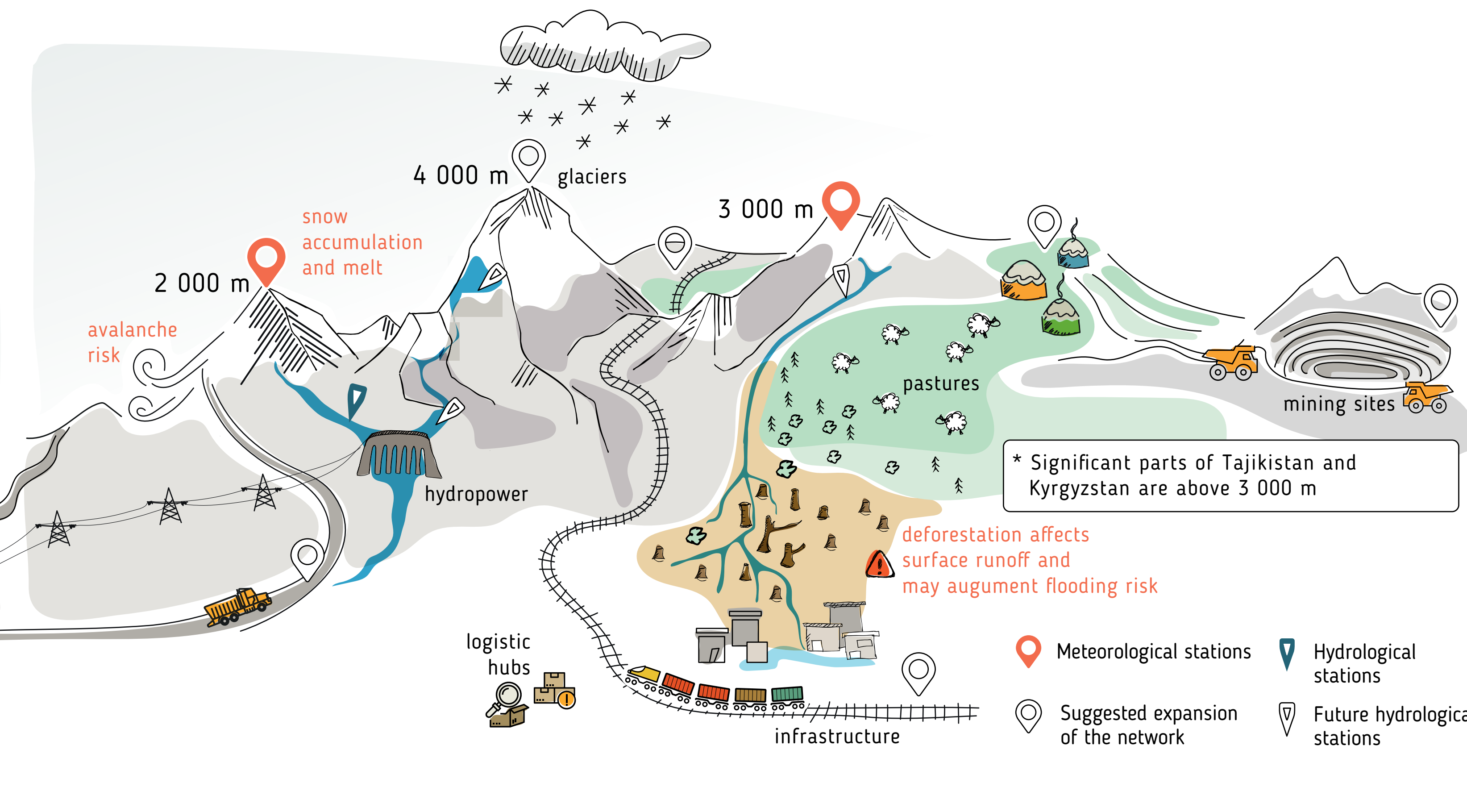
Service production and delivery systems



Densely populated areas

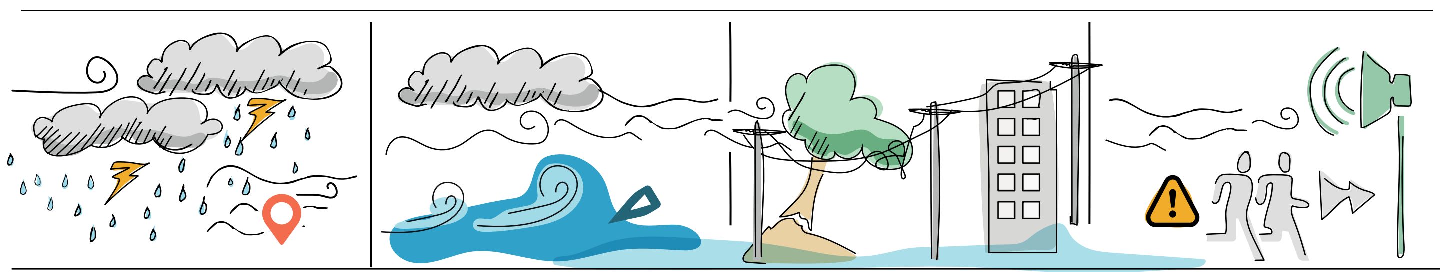


Sparsely populated areas



The participants of a WMO High Mountain Summit (October 2019, Geneva) issued a global call to action to avoid an impending crisis related to mountain weather, climate, snow, ice and water. Their concerns include the scarcity of observations in the mountains, the fragmentation of the available data across organizations and the importance of these observations and data in the development of policy and risk reduction measures. The call for action is global, and recognizes the mountains as a source of global fresh water.

Impact-based forecasting: extreme weather preparedness



Weather and climate extremes
Size and intensity

Forecasters project likely development of severe thunderstorms with intense rain and gusting winds. Meteorological network provides observation data in near real time.

Weather-linked hazards
Inundation and strong winds

Flood is likely to result from intense rain that could be aggravated by a storm surge and wind damage. Hydrological stations detect rising water levels.

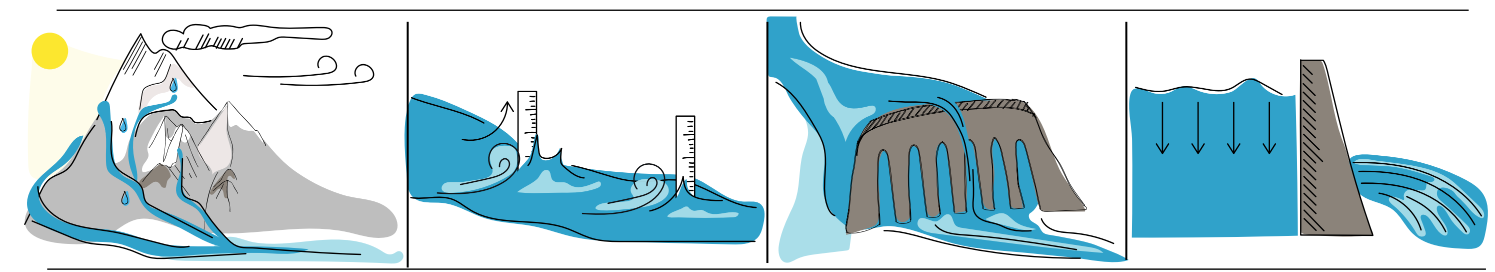
Impact estimation
Disruption of services, affected population

Specific parts of a city likely to be affected – flooding of roads, and wind damage to power systems is likely.

Risk reduction and response
Evacuation, recovery

Residents get timely and clear warnings and advice on how to respond.

Impact-based forecasting: sound water and energy management



Weather and climate extremes
Size and intensity

Forecasters project heatwave. Hydrologists report high snow reserves in the mountains. This combination may cause rapid snow melt over an extensive area even at high elevations.

Weather-linked hazards
High water levels

Rapid increase in river flow is likely, with possible glacial lake formation posing risk of floods.

Impact estimation
Dam overflow risk

Reservoirs behind hydropower dams are likely to fill quickly and, if operators do not take measures, the dam may overflow.

Risk reduction and response
Controlled release of water

Power operators and dam engineers get timely and clear warning and respond with risk mitigation measures.

Automated meteorological station at the Barkrak Glacier, Uz Hydromet

Densely populated areas

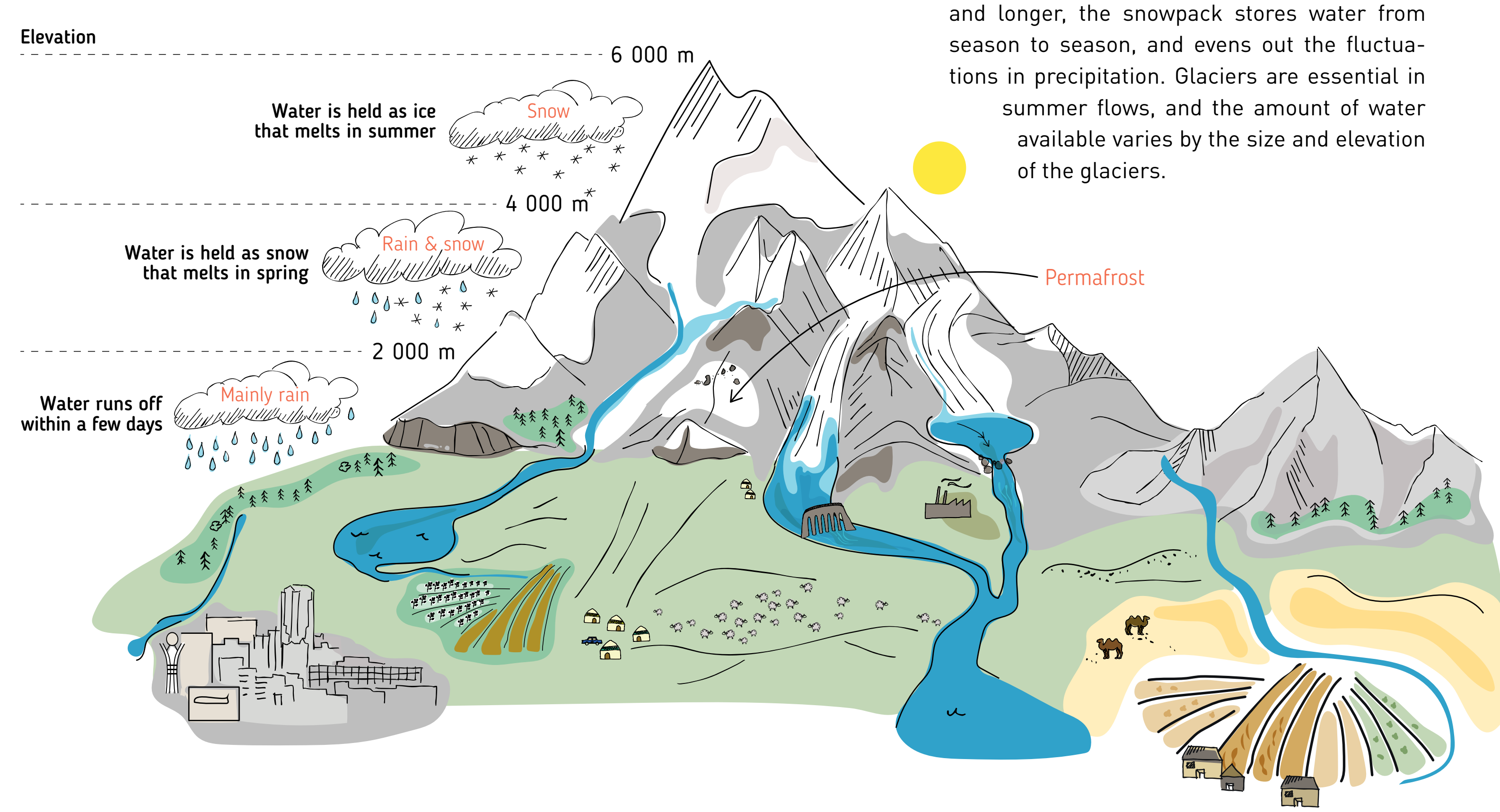
The users of hydromet services in densely populated areas include – in addition to the general public – officials responsible for public health and safety, air quality, water supply and quality, and nearby farmers. The observation networks in these areas collect data from a range of sources – airports, weather balloons, upstream hydro stations, and air quality monitors. These networks are easier to maintain than remote stations, but the expectations of users continue to grow. Cities that cover large geographic areas are interested in hourly and location-specific forecasts. These growing demands imply a need for a more extensive network of stations and for the integration of other sources of information into the system.

Sparsely populated areas

The region's sparsely populated steppes and deserts are vast, and the relatively few observations currently collected are sufficient for hydromet purposes. Population density in the mountains is also low, but the weather here affects more than the local residents. Water reserves for the region form in the mountains, and water forecasting for the region requires mountain information. In addition, people in the mountains face particular weather-related hazards and highly specific local conditions. The variations in weather caused by the mountains themselves render models less accurate, and while remote sensing helps, ground observations remain essential. Current coverage up to 2000 metres in elevation is generally sufficient, but blank areas remain where hydromet stations do not report. Mining operations, which are often located above 3000 metres, need better information.

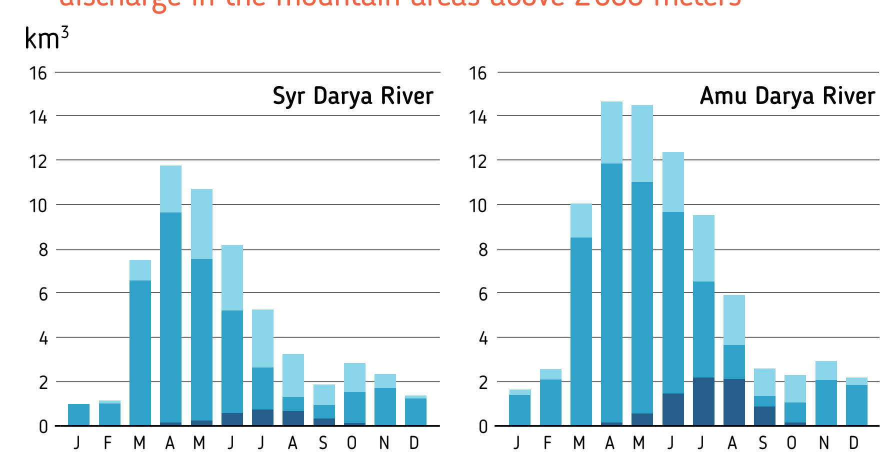
Areas of special focus in Central Asia

Weather and water in the mountains



The spring and summer run-off provide water for agricultural use, and can offset the consequences of reduced precipitation in low water years. While glaciers store water over decades and longer, the snowpack stores water from season to season, and evens out the fluctuations in precipitation. Glaciers are essential in summer flows, and the amount of water available varies by the size and elevation of the glaciers.

Contribution of rainfall, snow and glacier melt to river discharge in the mountain areas above 2000 meters



Source: Armstrong et al 2019 in *Regional environmental change*, Vol 19, Issue 5.
Runoff from glacier ice and seasonal snow in High Asia: separating melt water sources in river flow

Monthly contribution to river flow:

- Rainfall
- Melt water from snow on land
- Melt water from snow on ice and glacier ice

Hydromet services are of crucial importance in developing information related to river flow. Snow melt and glacier melt from the Pamir, Hindu Kush and Tien Shan mountain ranges supply the Syr Darya and Amu Darya rivers – the main water sources in Central Asia. Snow accumulation in the winter is a key factor in river flow, and the melt water reaches maximum flow in the summer.

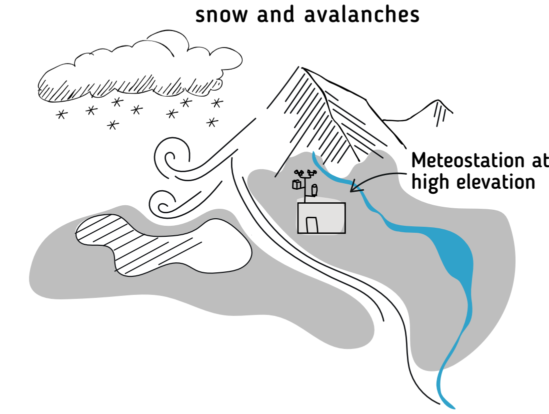
Glacier observations in the Pamirs, Tajikistan

Glacier observations in the mountains

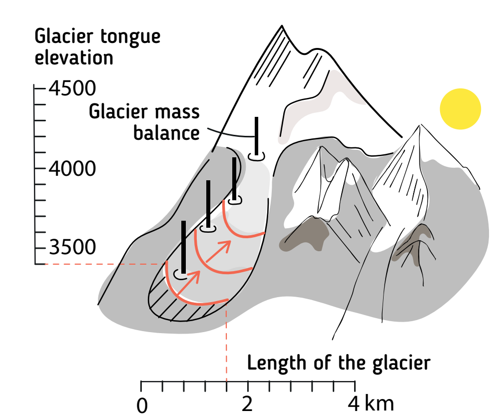
As visual indicators of climate change, glaciers are easy to understand – as global warming progresses, glaciers shrink in length and mass. And because of the importance of glaciers in water resources, hydromets and scientists are interested in the changes in glaciers and the effects on river flows. Remote sensing and continuous on-site monitoring of glaciers and snow cover are necessary to close the gaps in understanding of the effects of global warming on the cryosphere in Central Asia, and hydromets in the region need to increase the range and depth of their data collection. The current glacier measurements and data on changes in run-off cannot sufficiently reduce the uncertainties associated with the interactions between climate and the cryosphere. Close monitoring of changes in glacier mass and length is essential to the making of accurate water resources projections, and the monitoring of permafrost will be increasingly important. Fortunately, progress is underway, and hydrologists, meteorologists and climate scientists in the region are starting to close the gaps and build hydromet capacity.

Snow and ice observations in the mountains

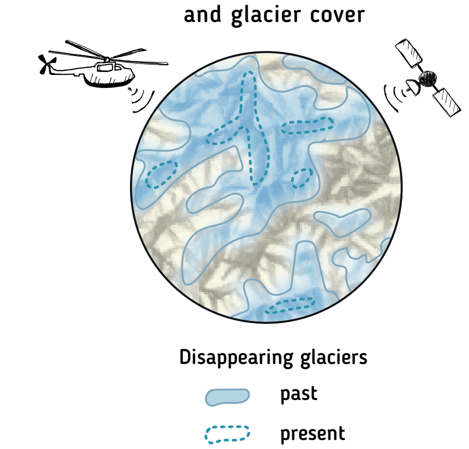
Ground observations of snow and avalanches



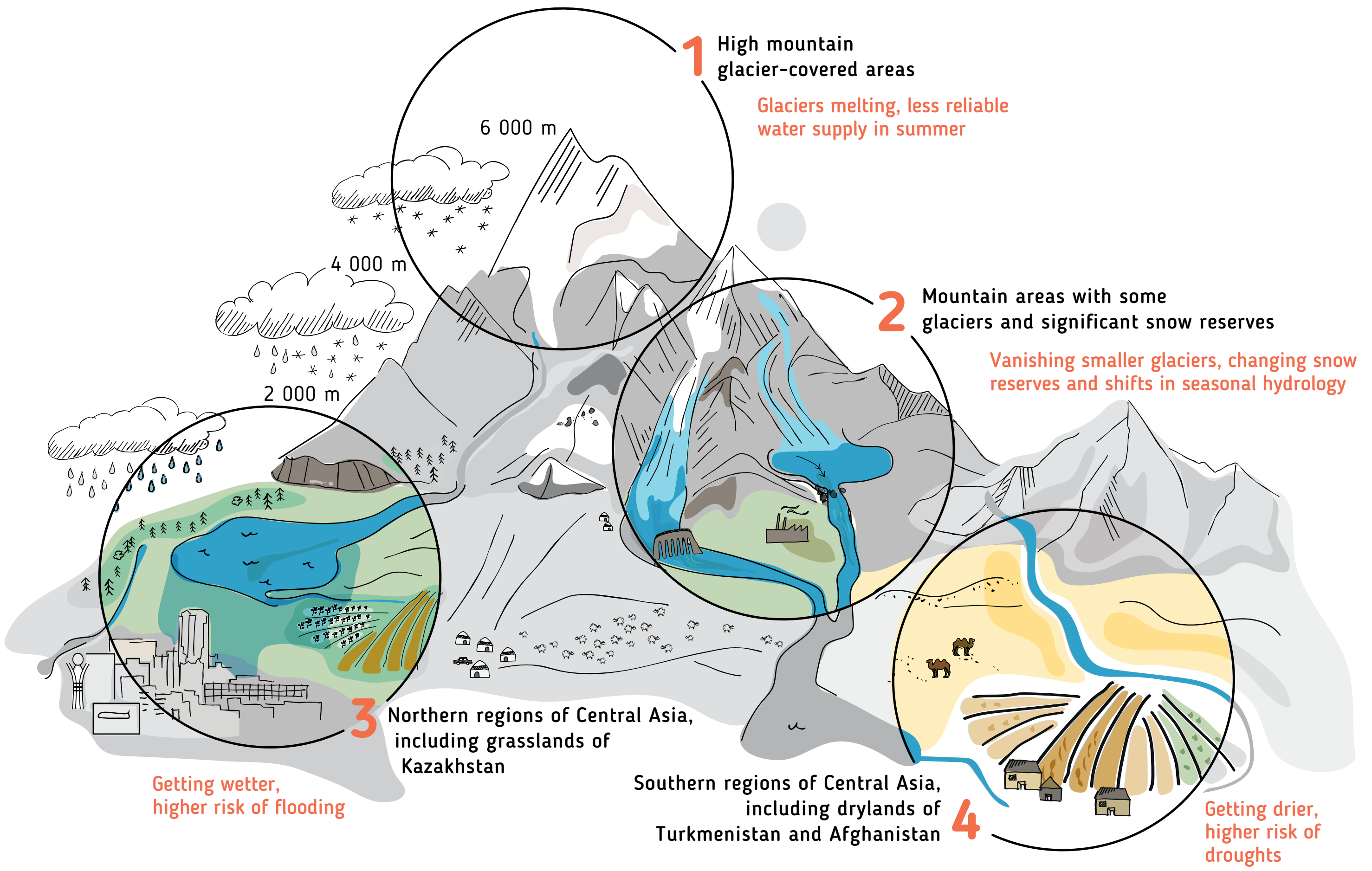
Ground observation of glaciers



Remote sensing of snow and glacier cover

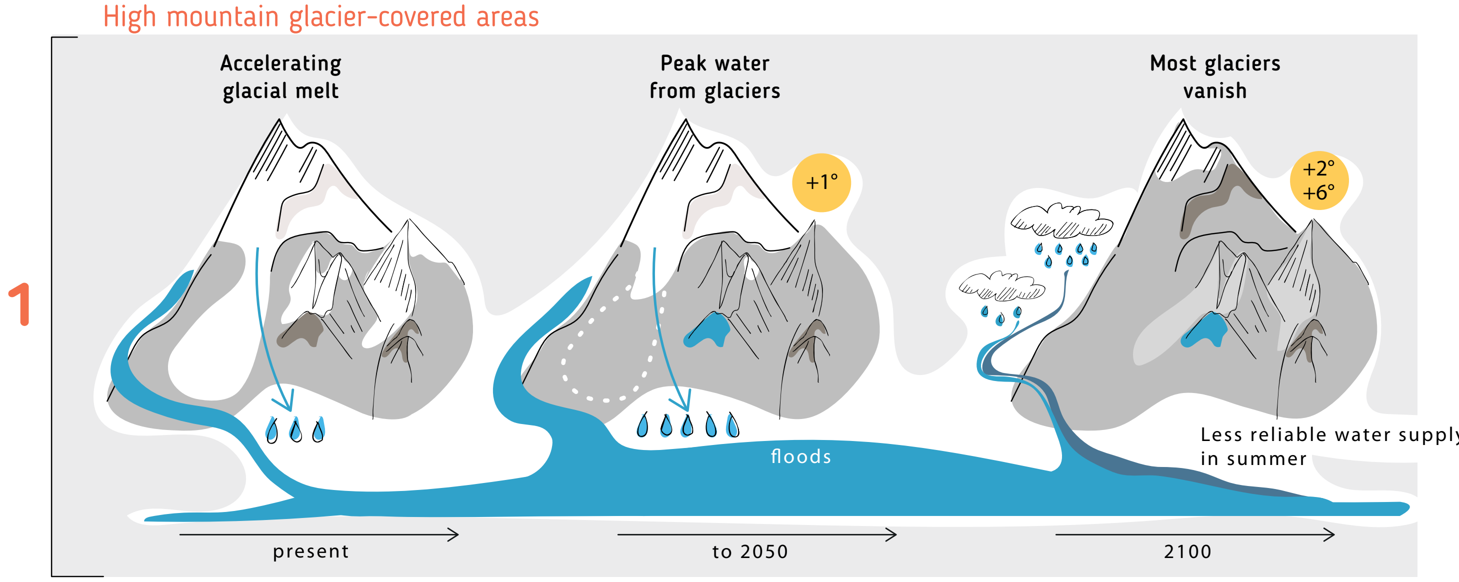


Climate change impacts on water resources

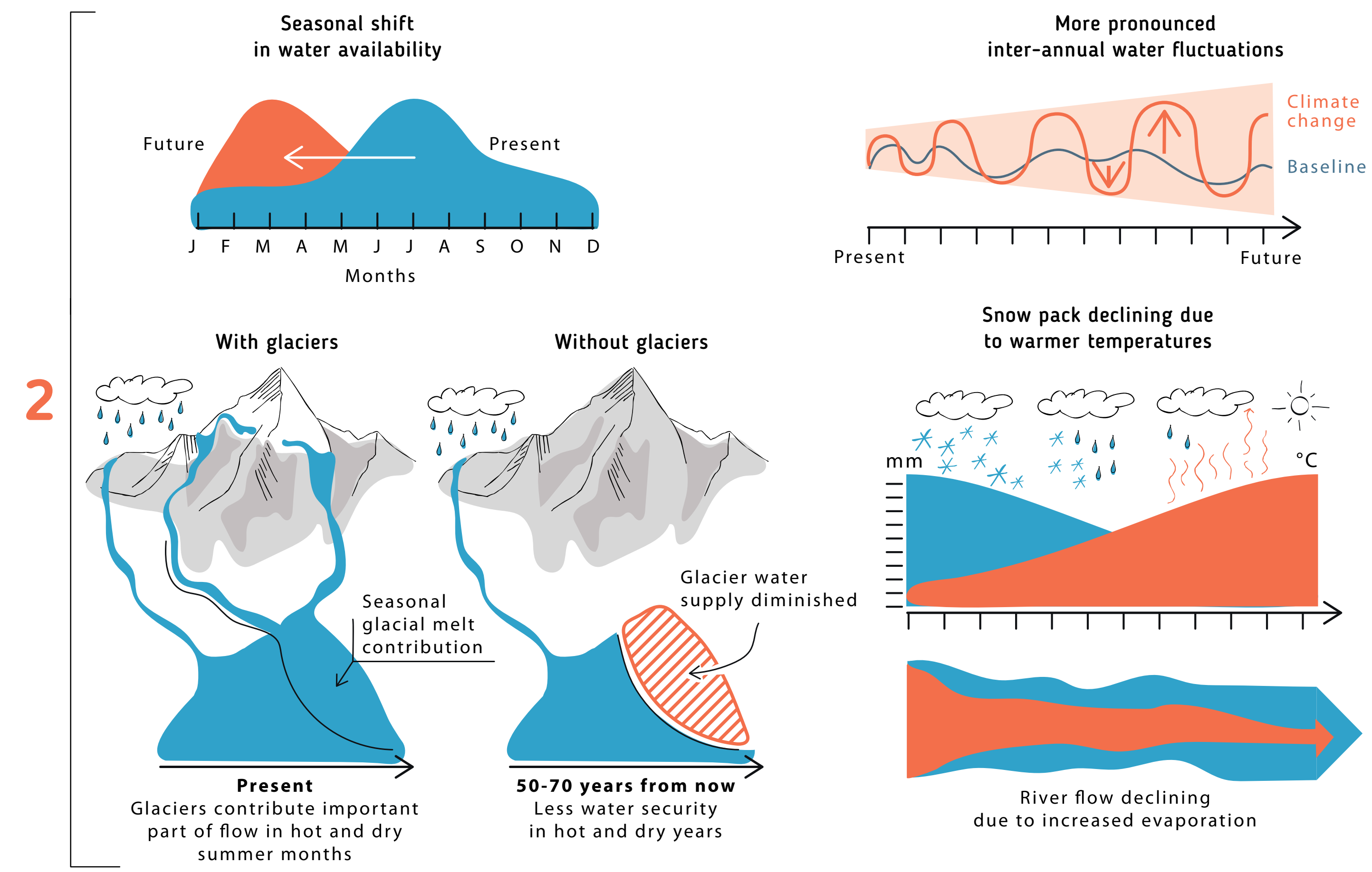


Concerns about the future climate change effects on water in Central Asia will play out in four separate scenarios. In the first – highly glacierized basins – the changes in the timing and seasonality of run-off from the mountains will reach peak water in the next 20–30 years, and water flows later in the century will diminish.

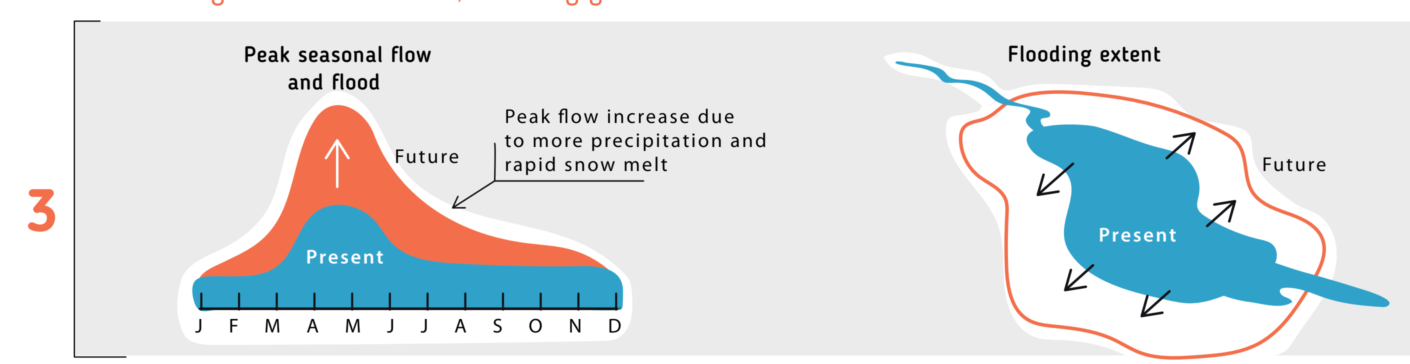
High mountain glacier-covered areas



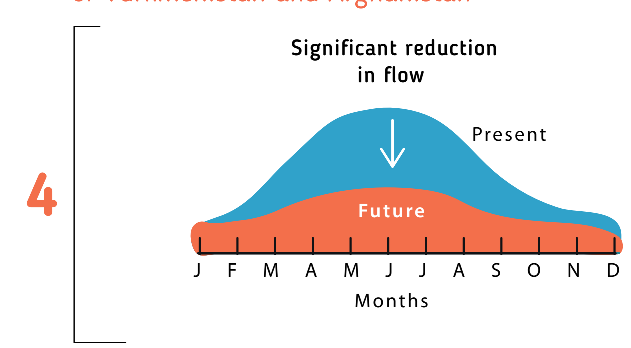
Mountain areas with some glaciers and significant snow reserves



Northern regions of Central Asia, including grasslands of Kazakhstan



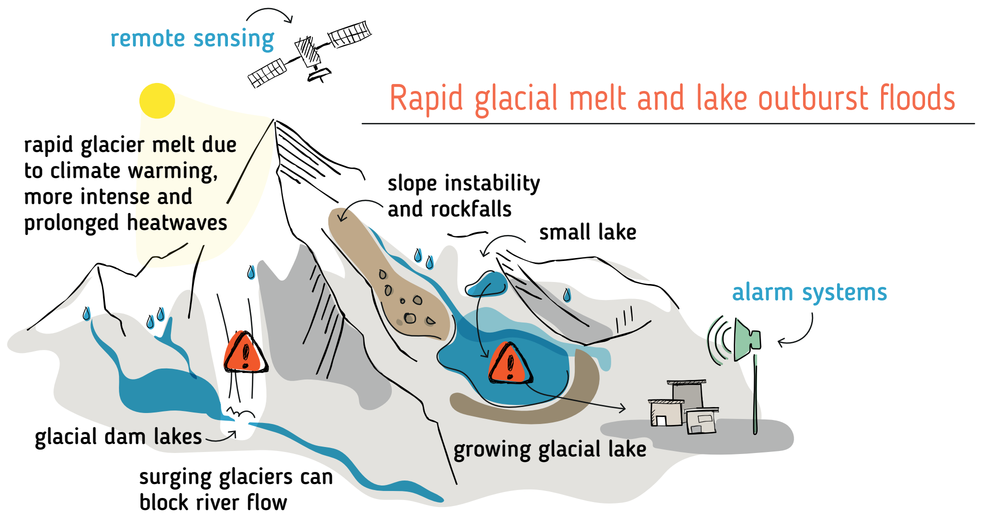
Southern regions of Central Asia, including drylands of Turkmenistan and Afghanistan



In the second scenario – medium glacierization at lower elevations – warming temperatures will reduce the snowpack, the glaciers will lose mass and flows will decline over time. Toward the end of the century, as less water is available from glaciers, water insecurity may be compromised in hot, dry seasons. In the northern parts of the region where there are no glaciers – the third scenario – rising temperatures will result in more precipitation falling as rain instead of snow, and in reduced snow cover and rapid snow melt. This will increase both peak flow and the extent of flooding. The dry southern parts of the region with no glaciers – the fourth scenario – can expect reductions in flow. In all cases, the hydromets can play a crucial role in tracking the changes in temperature, precipitation and glaciers, and in measuring the flow of rivers.

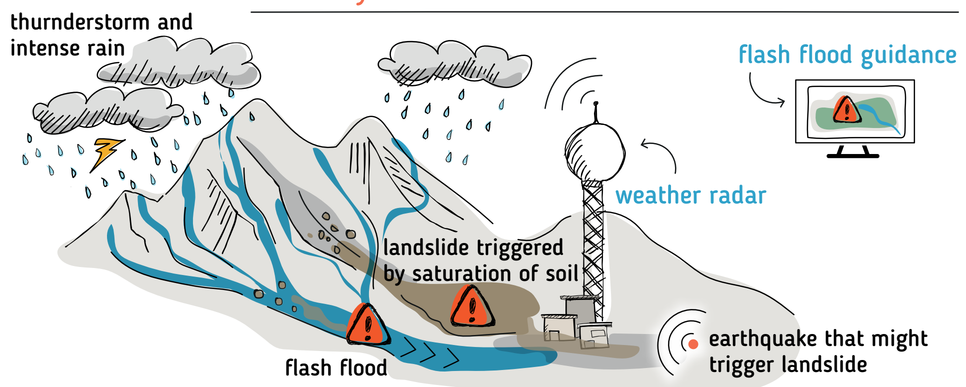
Flood risk

Rapid glacial melt and lake outburst floods



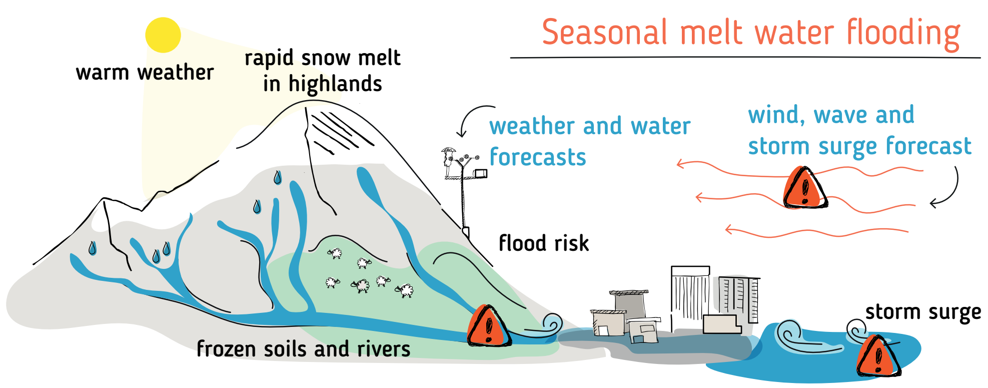
Glaciers erode the land and form depressions that fill with water as the glaciers melt. Climate change is accelerating the melting of glaciers and increasing the rate of glacial retreat. The number of glacial lakes may increase, and the ice dams may give way in sudden releases known as glacial lake outburst floods. These events tend to build in power and scale as they move downstream collecting sediments, unconsolidated rocks and debris.

Heavy rain causes flash floods and landslides



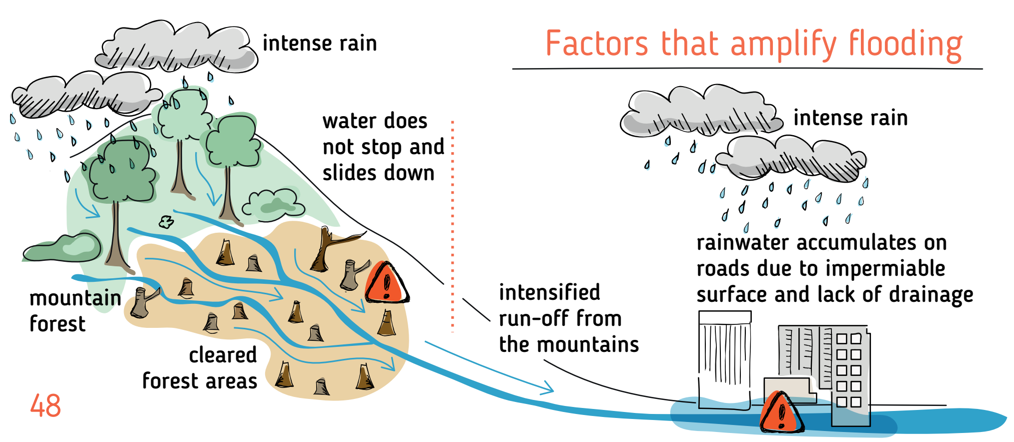
Heavy rains can trigger flash floods and landslides, especially in mountain areas where slopes are cleared of vegetation. Without the root systems of trees and shrubs to hold the soil in place, these slopes can give way as sheets of rainwater sweep downhill. Weather forecasts for heavy rains can provide some warning for downstream communities, but hydromets have little role in improving slope stability.

Seasonal melt water flooding



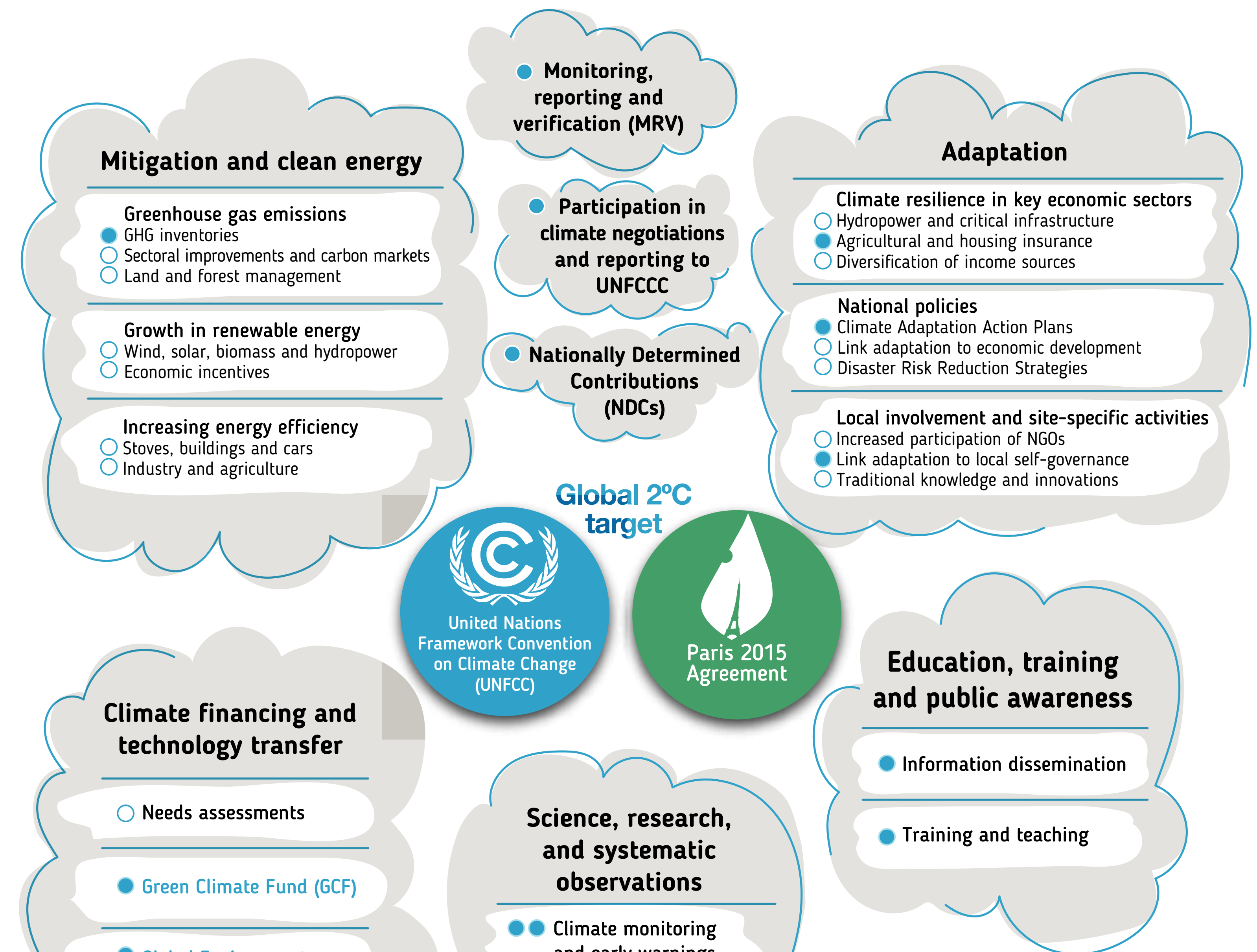
Flatland rivers and streams are subject to springtime flooding when sudden warming melts snow faster than the ice in rivers. Frozen soil channels the melt water into the rivers, and floods can develop rapidly as the melt water flows over the river ice. The timing and scale of these events are hard to predict, but hydromet forecasts of quickly rising temperatures along with weekly hydrological forecasts can provide some warning.

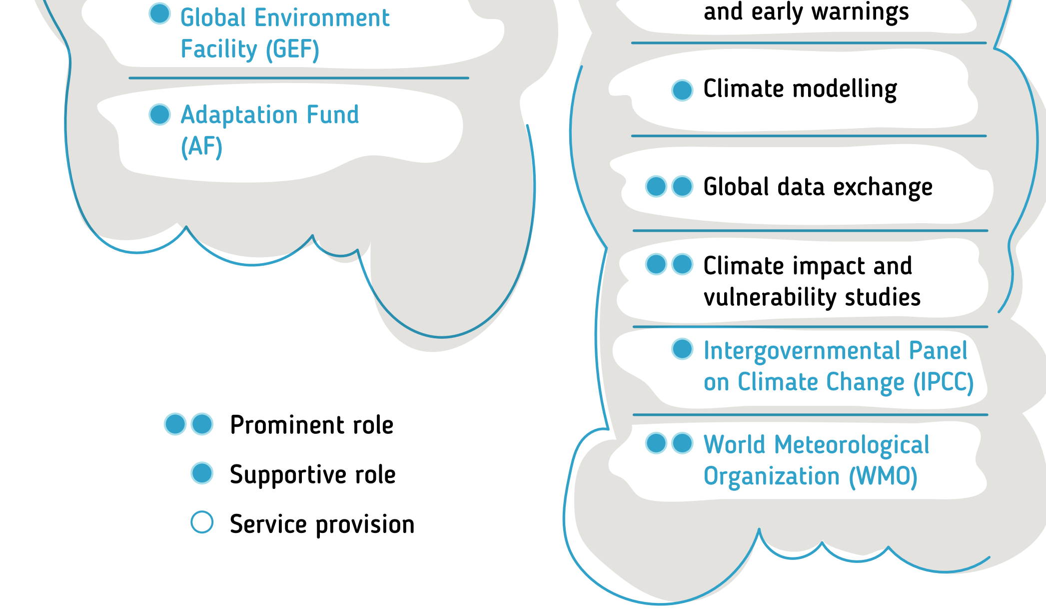
Factors that amplify flooding



Impermeable surfaces in urban areas and the absence of vegetation on slopes in rural areas contribute to flooding by accelerating the downhill course of water. Inadequate drainage in built-up areas contributes to this run-off problem.

Climate change responses



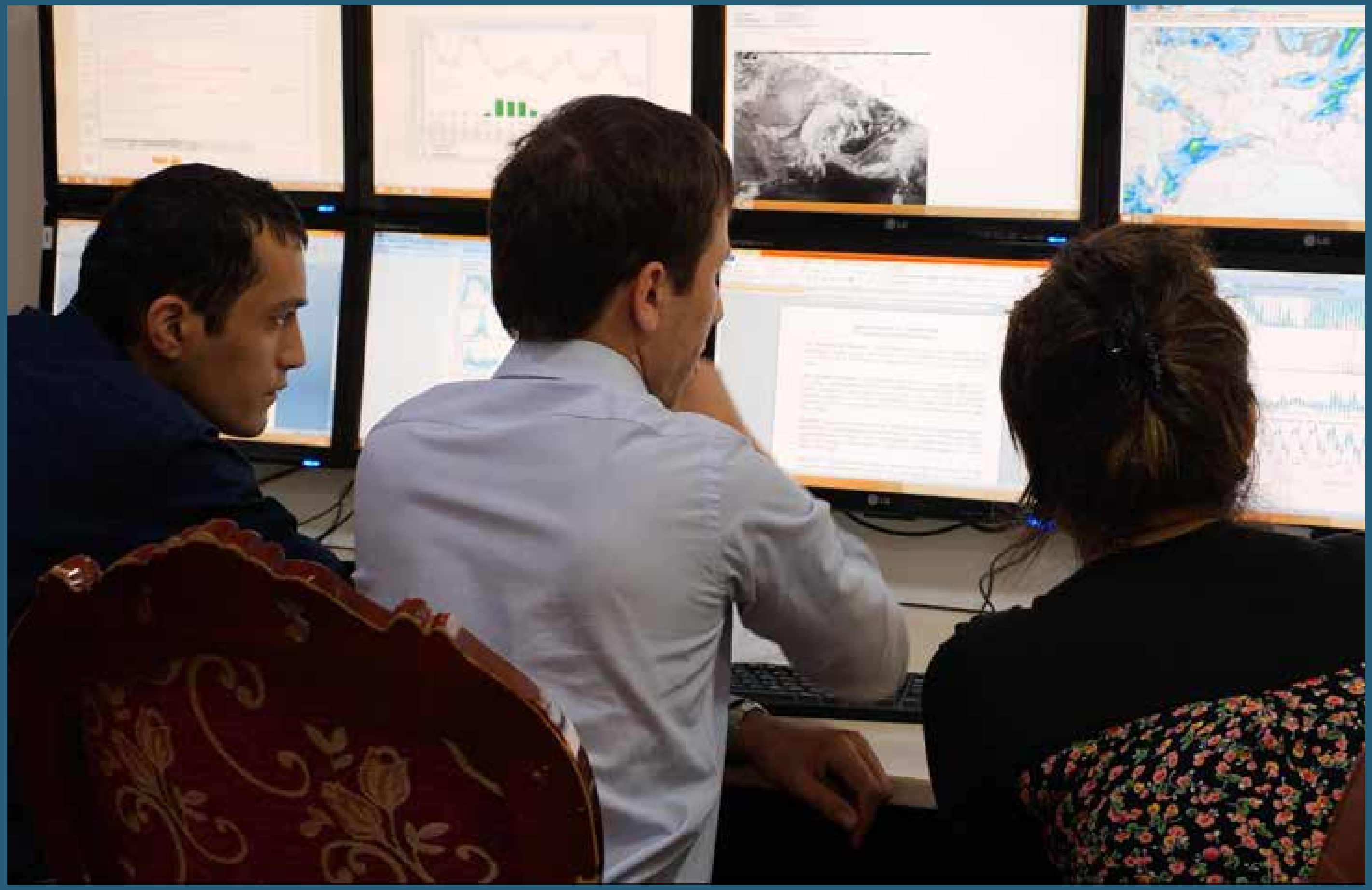


In Central Asia, hydromets play a larger role in climate change than hydromets in other areas. Their involvement often extends to the compiling of greenhouse gas inventories, national reporting to the UNFCC, acting as focal points, participating and even leading delegations to international climate change conferences, and coordinating national climate change policy. As more agencies and ministries become engaged in climate issues, and as climate change knowledge and expertise become established throughout a range of sectors, hydromets are likely to occupy a less prominent role.

4

How hydromets function

Basic weather forecasting builds on a foundation of observations and measurements taken remotely from satellites and balloons, and from an array of ground stations, many of which are automated and many still manual. These activities generate huge amounts of data that need to be transmitted, processed and analysed, and the global weather enterprise now relies on cloud computing for the capacity required. National and regional hydromet centres work together with the global weather and climate data centres to generate information for weather forecasts and early warnings and for analysts and managers in climate services, agrometeorology and hydrology. Hydrological information is of particular importance in Central Asia, where densely populated areas depend on irrigated agriculture, and the energy security of the mountain countries rests on the reliability of water flow information and forecasts.



Top: Automated river gauge, Yezgand, Tajikistan

Bottom: Forecasters' room, Tajikistan

How hydromets function

Most of the labour force in hydromet services is occupied with manual observations in stations typically staffed with 3–4 people providing around-the-clock coverage. The transition from manual to automated observations entails a four- to five-year period of parallel observations. Cross-border data sharing among hydromets improves the reliability of forecasts, and radar and numerical forecasts, which are more expensive, increase the accuracy of short-term forecasts. The hydromet situation rooms, where forecasters use multiscreen displays to handle information from several sources, are migrating to all-in-one stations that allow the forecasters to overlay the separate displays.

The climate services function prepares analyses and tracks trends in temperature and precipitation and other hydrometeorological data, produces information for key economic sectors and policymakers, and reports to the United Nations Framework Convention on Climate Change. As the Central Asia hydromets approach their 100th anniversaries, they have enormous amounts of historical data that may be useful in climate change analyses, but not all the data are digitized, and even those data that are digitized can be difficult to retrieve.

Agrometeorology takes basic climate information and collects supplemental information of interest to agriculturists – pasture conditions, soil moisture content, and phenology – and provides forecasts and analyses to government officials and farmers. The agrometeorology products rely on remote sensing for collecting information on vegetation and land use.

The hydrology function mirrors weather forecasting in its range of remote and ground-based collection of observations, and in its processing and analysis of the data. Climate trends in precipitation patterns and the cryosphere inform the projections of river flows, and help water managers adjust their plans to the changing parameters. Hydropower operators in particular need hydrology forecasts so they can balance power production against downstream water user needs. Public health and safety officials rely on the combination of weather and hydrology forecasts to prepare for drought and heat stress on the one hand and flooding on the other.

Climate records archives, Kyrgyz Hydromet

Installation of new equipment, Tajikistan

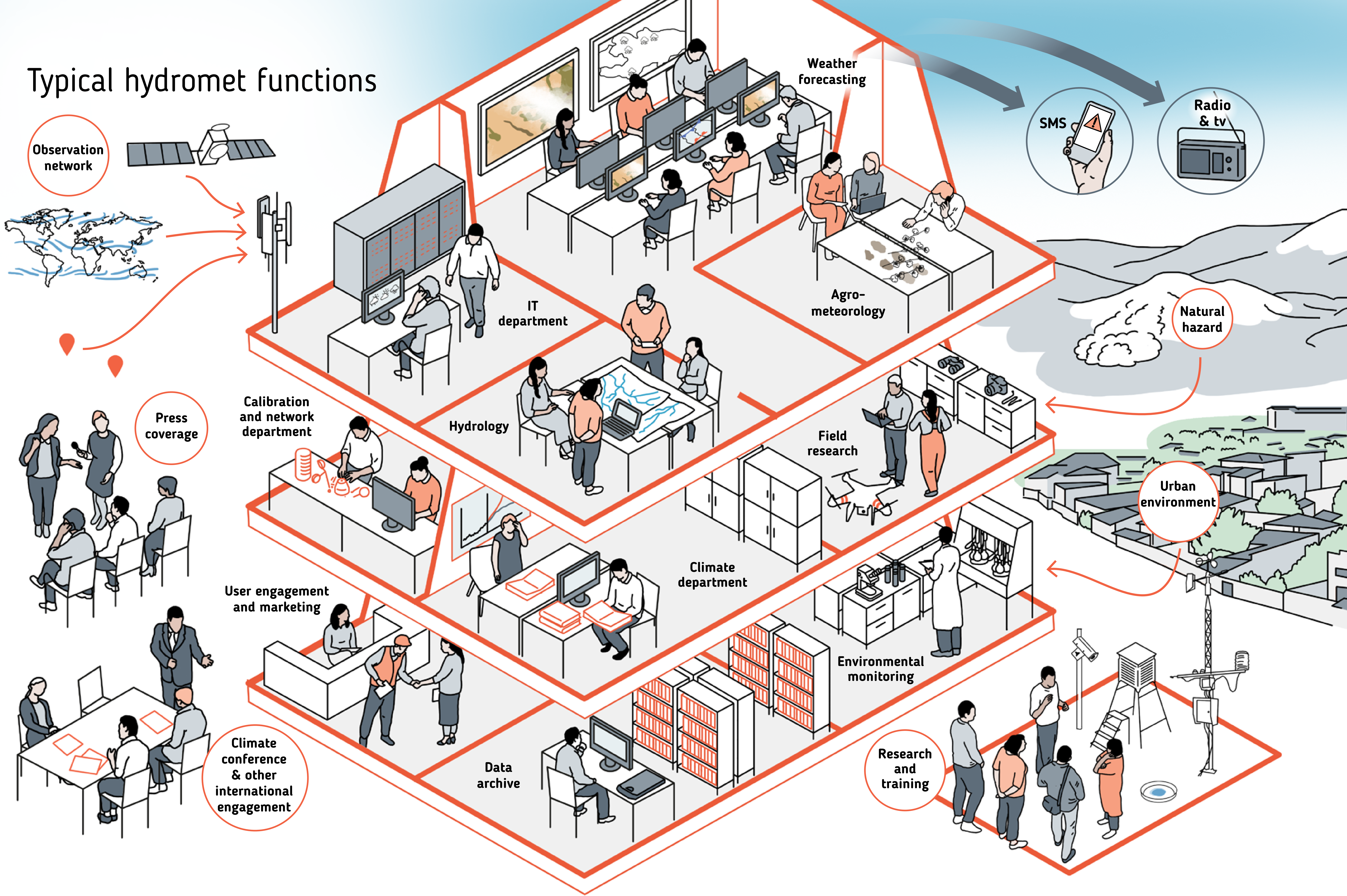
In most regions of the world, meteorological and hydrological functions are separate, but they have always been together in Central Asia – a model that WMO wants more countries to follow. Hydrology services are less well known than weather services, but the importance of water for Central Asia hydropower and irrigation is so great that some national hydromets in the region have more hydro stations than weather stations. The hydromets track snowpack, rivers, lakes and the Caspian Sea and reservoirs behind hydropower dams, but do not track dam discharges or water diversions to canals. These diversions of unknown quantities of water compromise the ability of analysts to make downstream projections.

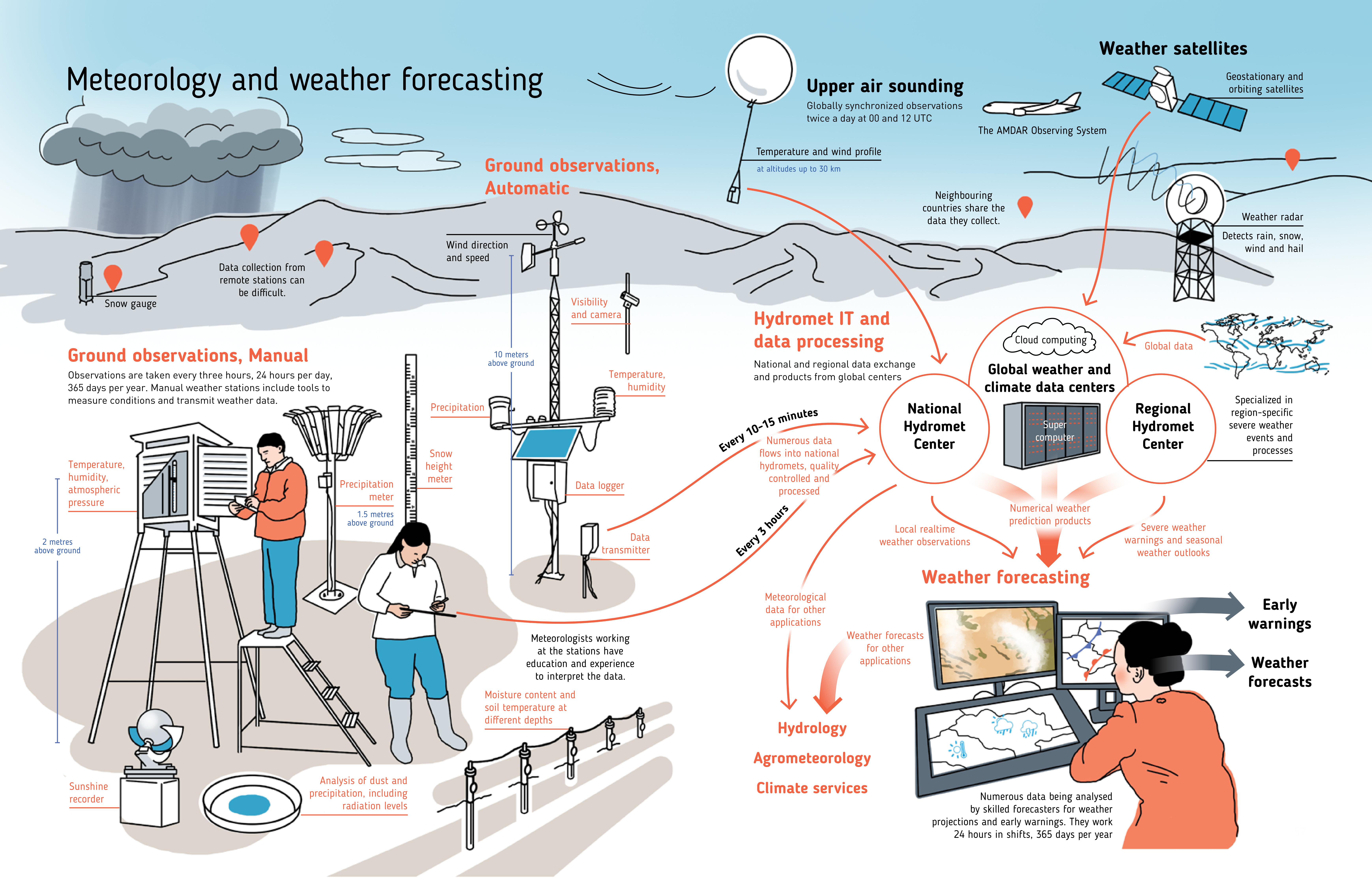
Transport safety on roads and waterways depends on weather and hydrology forecasts, and on specialized observations that alert officials to the risk of avalanche, icy conditions, landslides and glacial lake outburst floods. These observations come from fixed sensors and cameras, manual stations, snow gauges and mobile radar on the ground, and from drones, helicopters and satellites. Specialized observations are typically related to seasonal occurrences – with avalanche monitoring being the most common – or to specific research.

Environmental monitoring is another type of specialized observation, and includes air, water and soil sampling and analysis as well as radiation monitoring, which benefits from a robust network dating from the Cold War era of nuclear testing and later applied to nuclear power. Lab testing produces findings for reports on pollution and radiation levels.

Many hydromets have all their functions under one roof – sometimes as part of larger ministry – but do not necessarily integrate all their data. User engagement is a developing dimension in hydromet services, but for research and development, the hydromets generally rely on outside expertise, a situation that can mean that local knowledge plays little or no role. Professional education for hydrologists and meteorologists is limited in the region.

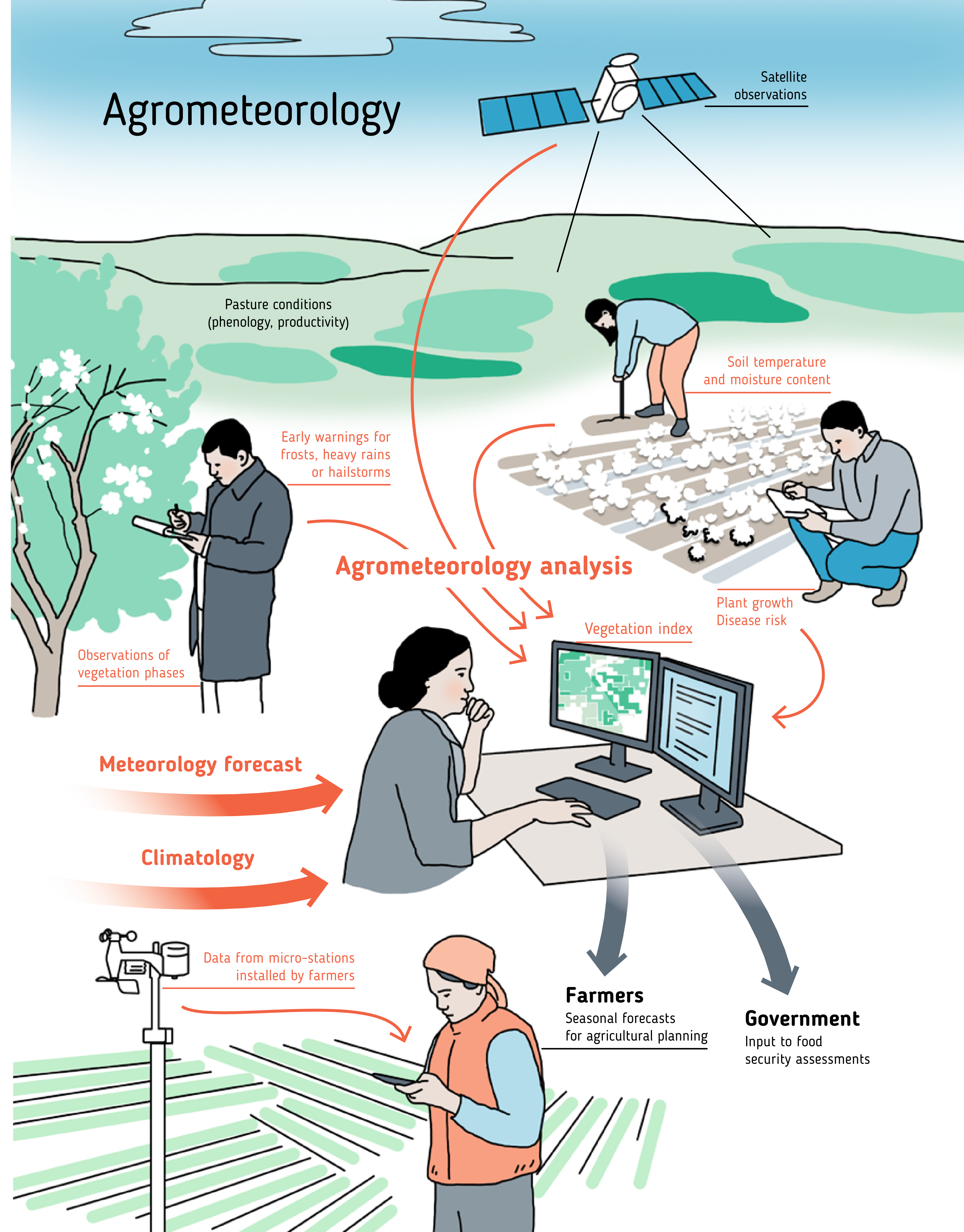
Typical hydromet functions

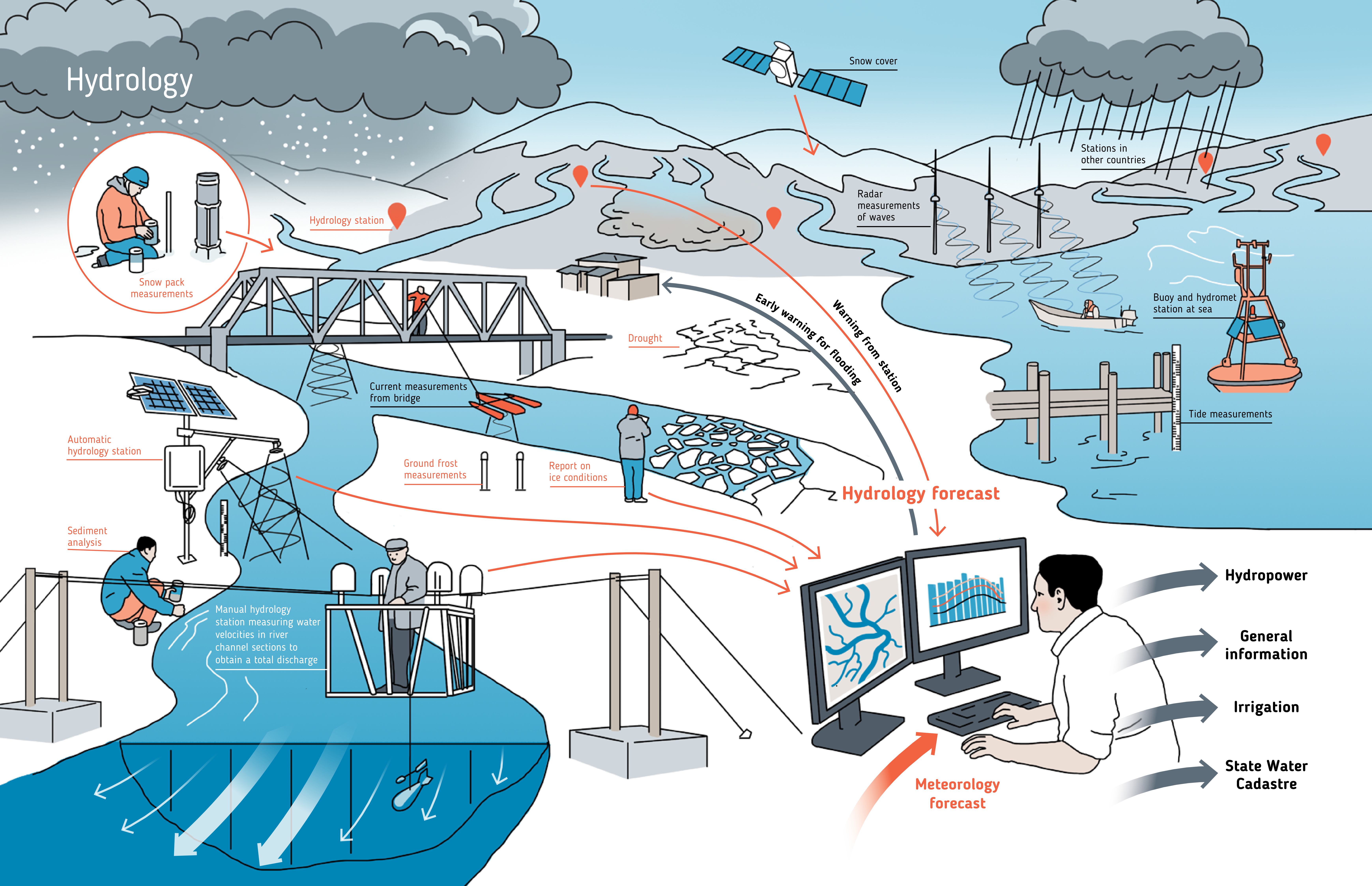




Meteorology and weather forecasting
Upper air sounding
Globally synchronized observations twice a day at 00 and 12 UTC
Temperature and wind profile
at altitudes up to 30 km
Weather satellites
Geostationary and orbiting satellites
The AMDAR Observing System
Neighbouring countries share the data they collect.
Weather radar
Detects rain, snow, wind and hail
Ground observations, Automatic
Wind direction and speed
Visibility and camera
10 meters above ground
Temperature, humidity
Precipitation
Snow height meter
Data logger
Data transmitter
Snow gauge
Data collection from remote stations can be difficult.
Ground observations, Manual
Observations are taken every three hours, 24 hours per day, 365 days per year. Manual weather stations include tools to measure conditions and transmit weather data.
Temperature, humidity, atmospheric pressure
2 metres above ground
Precipitation meter
1.5 metres above ground
Sunshine recorder
Analysis of dust and precipitation, including radiation levels
Moisture content and soil temperature at different depths
Meteorologists working at the stations have education and experience to interpret the data.
Hydromet IT and data processing
National and regional data exchange and products from global centers
Every 10-15 minutes
Every 3 hours
Numerous data flows into national hydromets, quality controlled and processed
Cloud computing
Global weather and climate data centers
Global data
National Hydromet Center
Super computer
Regional Hydromet Center
Specialized in region-specific severe weather events and processes
Local realtime weather observations
Numerical weather prediction products
Severe weather warnings and seasonal weather outlooks
Weather forecasting
Meteorological data for other applications
Weather forecasts for other applications
Hydrology
Agrometeorology
Climate services
Early warnings
Weather forecasts
Numerous data being analysed by skilled forecasters for weather projections and early warnings. They work 24 hours in shifts, 365 days per year


Climate services
Past
Digital and hard copy archives of climate data
Future
Global climate change model
Climate data analysis and products
Downscaling
Present
Farmer asking for advice
CLIMATE BULLETIN
UNFCCC
Climate yearbooks and bulletins
International reporting on climate change

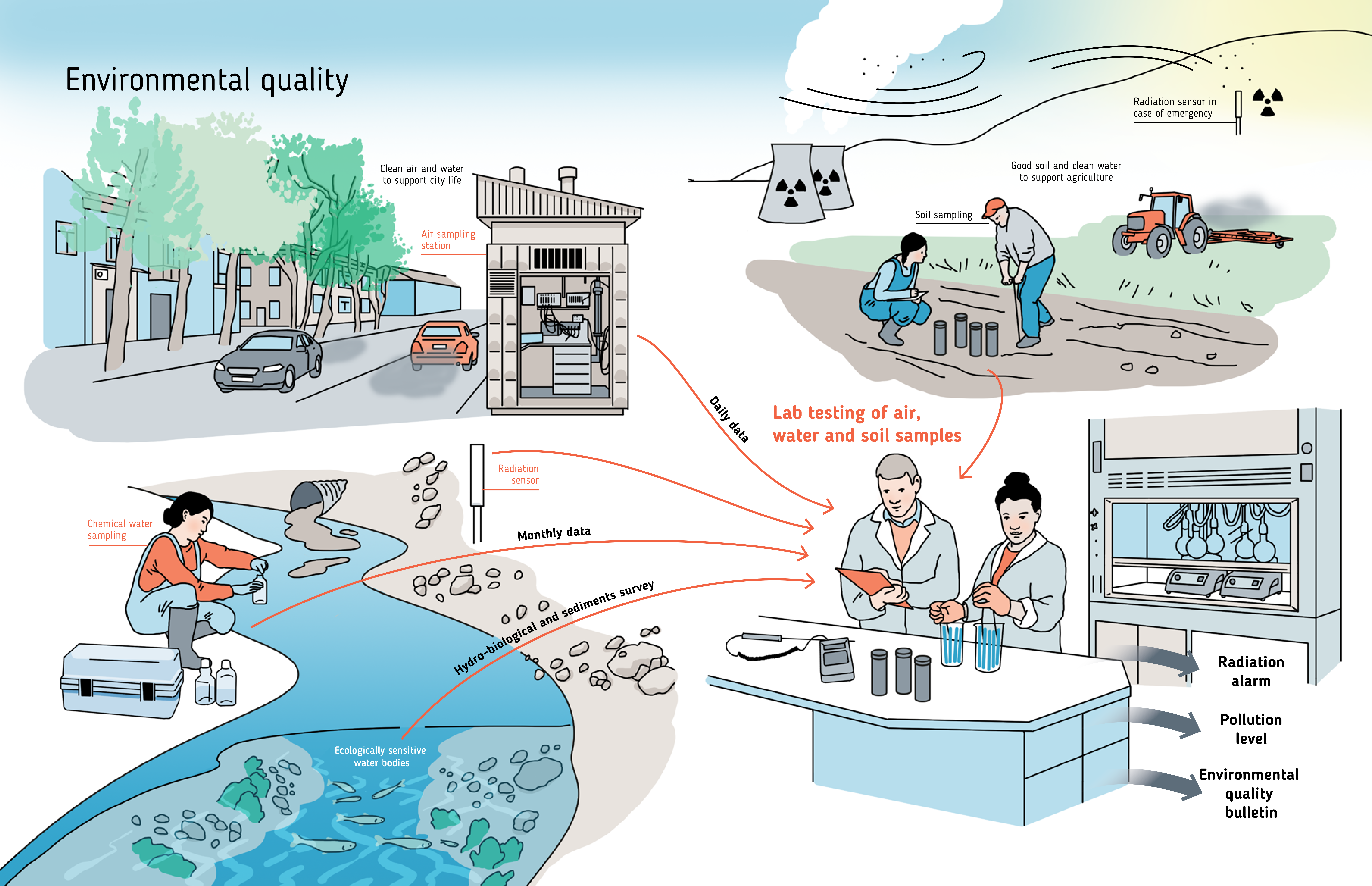

Agrometeorology
Satellite observations
Pasture conditions (phenology, productivity)
Soil temperature and moisture content
Early warnings for frosts, heavy rains or hailstorms
Agrometeorology analysis
Plant growth
Disease risk
Vegetation index
Observations of vegetation phases
Meteorology forecast
Climatology
Data from micro-stations installed by farmers
Farmers
Seasonal forecasts for agricultural planning
Government
Input to food security assessments



Hydrology
Snow pack measurements
Hydrology station
Snow cover
Stations in other countries
Radar measurements of waves
Buoy and hydromet station at sea
Drought
Early warning for flooding
Warning from station
Current measurements from bridge
Tide measurements
Automatic hydrology station
Ground frost measurements
Report on ice conditions
Hydrology forecast
Sediment analysis
Manual hydrology station measuring water velocities in river channel sections to obtain a total discharge
Hydropower
General information
Irrigation
State Water Cadastre
Meteorology forecast

Specialized observations

Environmental quality



Forecast accuracy

Weather forecasts for 1–3 days or one week are easier to make than hourly forecasts, and tend to be more accurate, while the one-month forecasts are less precise. Projections for one month or for a season are based on current information, historical probabilities and professional experience, and are indicative of what to expect relative to the long-term average.

Hourly hydrological forecasts rely on information on rainfall and on soil and ice conditions in watersheds, and typically relate to warnings of flash flooding. Water flow forecasts for up to a week out use data on snow cover, precipitation and river conditions. Monthly and seasonal forecasts rely on modelling.

Wind gusts, heavy rains and flash floods are highly influenced by geography and can develop in minutes or hours. Issuing early warnings for a particular time and place for these events is challenging, but radar and high-resolution numerical weather prediction models are improving the accuracy of forecasts. For cold spells, heatwaves and droughts, forecasters provide reasonably accurate predictions over longer periods.

How to get hydromet information

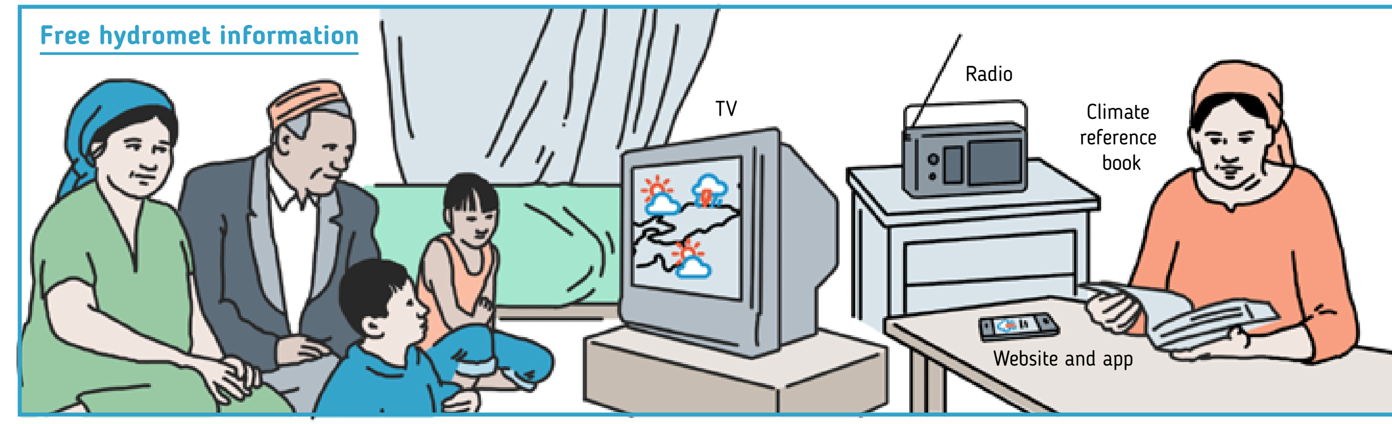
The basic products of all hydromets are weather forecasts and early warnings, which are always free and widely distributed. In Central Asia, like in many other parts of the world, the national hydrometeorological services were established as production organizations charged with collecting observations, managing data and making weather forecasts. Client service was not part of their work, and providing additional information to users exceeded the original mandate. Consequently, the hydromets developed the practice of charging fees based on units of data requested. As the practice evolved, hydromets began working to provide high quality data that meets the complicated requirements of users, and to provide advice on what information users might need. Now, some subscription services are available, and hydromets can calibrate equipment and participate in contractual assignments for special purposes or major projects. As hydromets transition to a digital environment, they may develop a more sophisticated way to provide customized services and set fees.

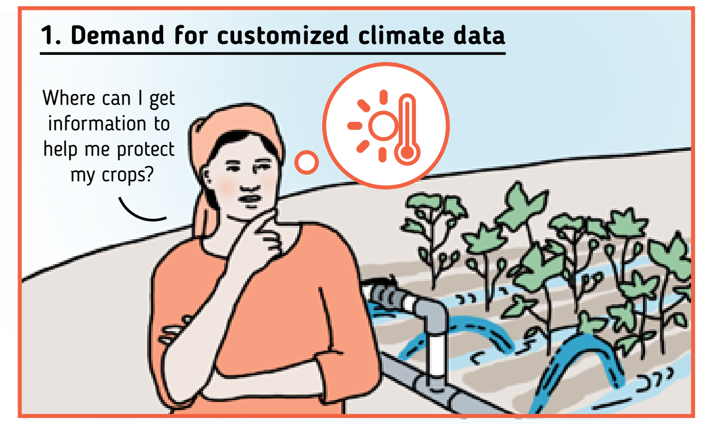
Forecast accuracy

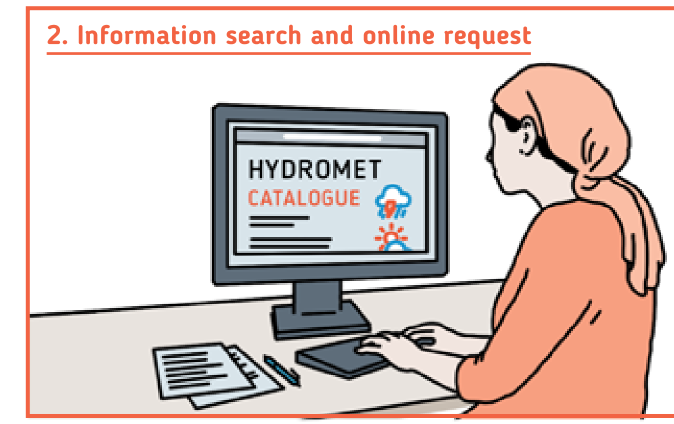
	Specific data forecast: **1-12 hours**	*Specific data forecast:* **1-3 days and one week out**	*Above or below average* **Outlook: 1 month**	*Above or below average* **Projection: seasonal**
Weather	●●●○○	●●●●◐	●●●○○	●●◐○○
Water	●●●○○	●●●◐○	●●●○○	Well studied rivers ●●●●○ Complex rivers ●●◐○○
Extreme events	Flash flood ●●●◐○ Heavy rain ●●●●○ Temperature fluctuations ●●●●○	Local events ●●●○○ Regional events (cold snap) ●●●◐○	Local events ●●○○○ Regional events (heat wave) ●●◐○○	Local events ○○○○○ Regional events (drought) ●●◐○○

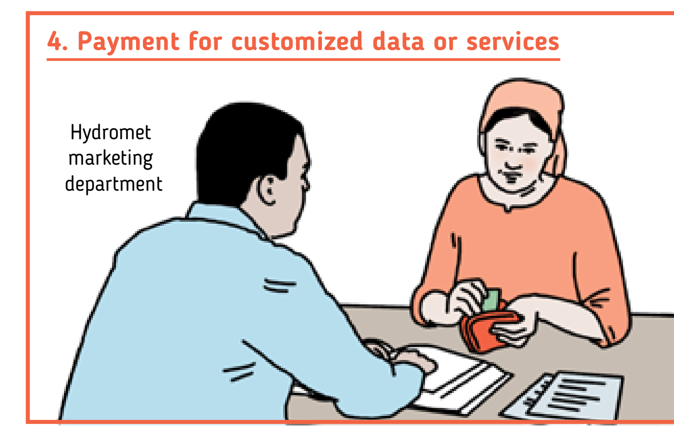
Each dot represents 20% accuracy   Less accuracy ← ○○○○○ → More accuracy

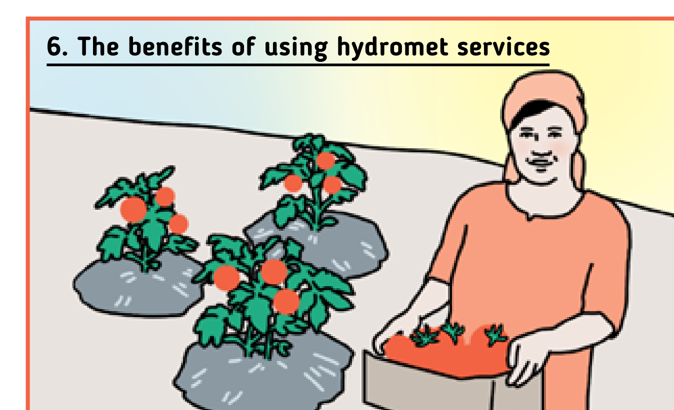
How to get hydromet information





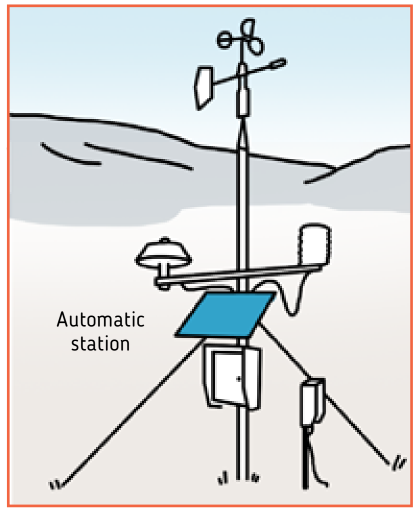




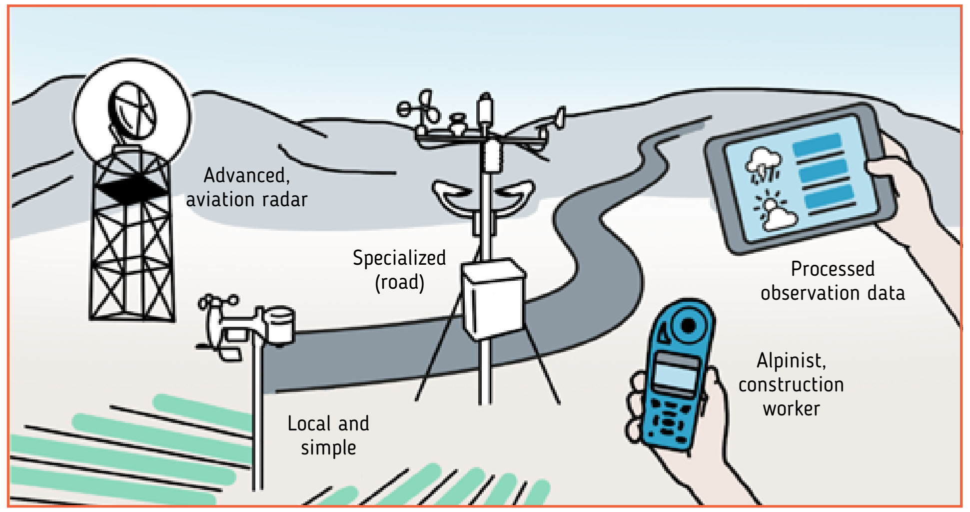


Diverse sources of weather information

Official stations



Other observation



Hydromets follow World Meteorological Organization standards in making observations, collecting and analysing data and preparing forecasts. They collect their data for specific hydromet purposes, but others also collect observations and conduct analyses and hydromets and their users may benefit from some data-sharing arrangements.

Advanced

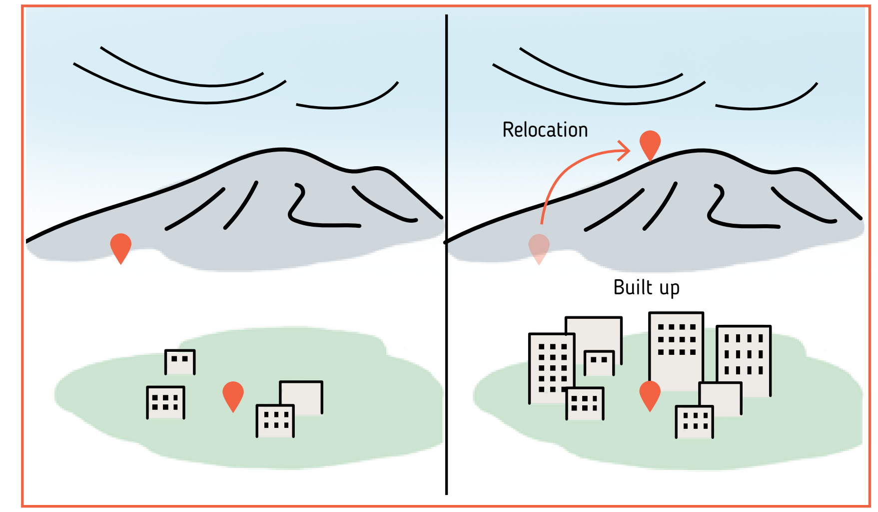
Scientists conducting glacier research have installed many expensive, technologically advanced stations that provide reliable data. An exchange of data with hydromets data could benefit both parties. Similarly, airports operate expensive weather radar that collects the high-quality observations necessary for aviation safety, and while the sector cooperates with hydromets, not all aviation data are integrated into forecasts. The development of a weather radar network would require new institutional and technological arrangements, but would less expensive than duplicating the radar installations and would improve short-term forecasting.

Basic

As small farms in the region replaced industrial operations, many more individual growers now need weather and climate data that is specific to their location and crops. While some farmers subscribe to remote sensing services for information on local conditions, other growers set up their own mini-stations, and collect and use basic data. Many more farmers are now among the hydromets' clientele, and opportunities exist for data sharing and closer client relations.

Sector-specific

Some organizations gather specific information to fill their data gaps through the installation of their own narrowly focused stations that collect those few observations that fill in missing pieces in the hydromet coverage. The linking of the observations from these stations with the hydromet observations may benefit both parties, and in the longer term the exchange of data may lead to deeper cooperation and mutual adjustments of equipment and measurements.

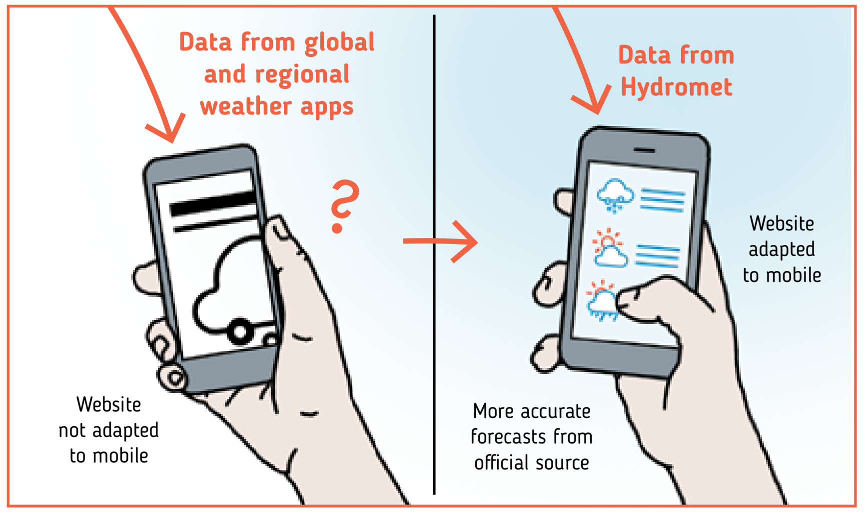


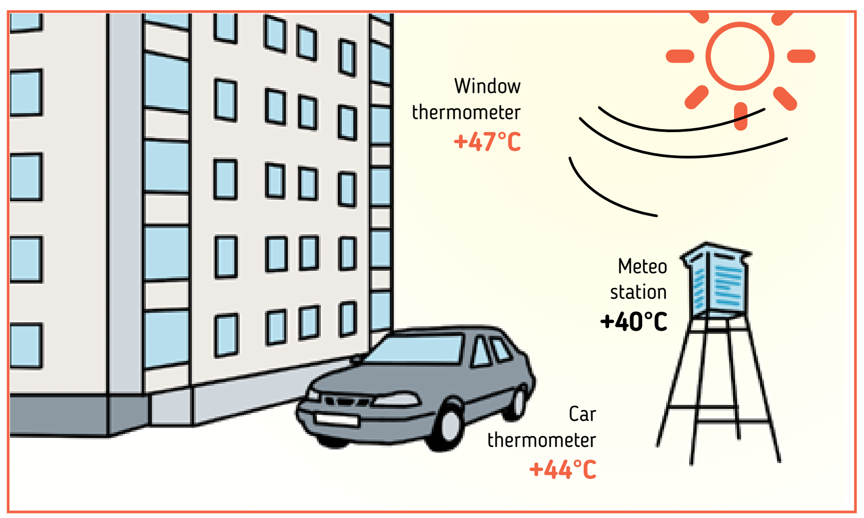
Relocation of stations

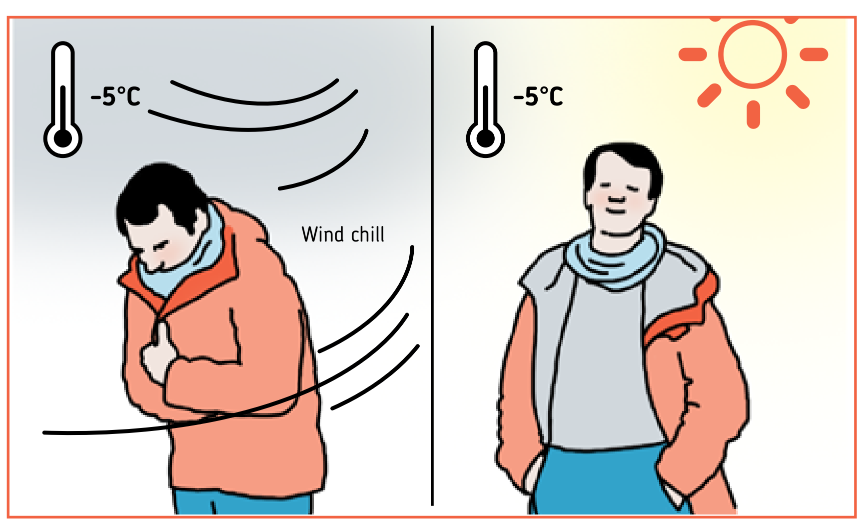
On occasion, a hydromet station needs to be relocated in response to new conditions in its vicinity. Longstanding urban stations may have cities grow up around them as large buildings replace open spaces, and over time the microclimate around the station changes and affects the observations. Remote stations may have to give way to road or mining developments or to changes in property rights. Where such stations have been collecting data in long time series, the relocation can disrupt the series, even in short-distance moves. From the perspective of the data, these are new stations, and the long-term continuity of the original station may be lost, in which case analysts may have to reconcile the new with the old.

Development near the Almaty meteorological station

Diverse sources of weather information







International weather apps

Twenty years ago, official hydromet forecasts were the sole source of weather information in the region, and most people got these reports via television or radio. Now mobile weather apps are available on many media, and accessibility matters more to some users than the reliability of the information. Hydromets in Central Asia maintain official weather websites, but do not yet offer mobile apps. The Meteo Swiss app is a fine example of how to present integrated information on multiple parameters in an easy-to-understand format, and Central Asian countries are interested in learning how to emulate the Swiss success with their own weather apps to reach their users more directly.

Citizen observations vs. official reports

Hydromets throughout Central Asia follow WMO guidelines, and use standardized equipment and procedures for observations and measurements. The protocols for these measurements are well developed, and are professionally implemented. Now that car and window thermometers and personal air quality monitors have become so popular, members of the general public feel empowered to take issue with any official reports that fail to agree with their own measurements, notwithstanding the vast differences in the quality of the instruments and the rigour of the protocols. With their credibility at stake, hydromets may want to consider how to help the public understand the differences and the nuances.

Heat index and wind chill

The way we experience colder temperatures depends on the wind, and the way we experience hotter temperatures depends on the humidity. The differences in what we experience and what the thermometer says are expressed as "wind chill" and "heat index". When the temperature is -5°C, for example, and the wind speed is 40 kilometres per hour, we experience the temperature as -14°C. Similarly, when the temperature is 32°C and the relative humidity is 80 per cent, we experience the temperature as 44°C.

Hydromet public information products

5

Country profiles

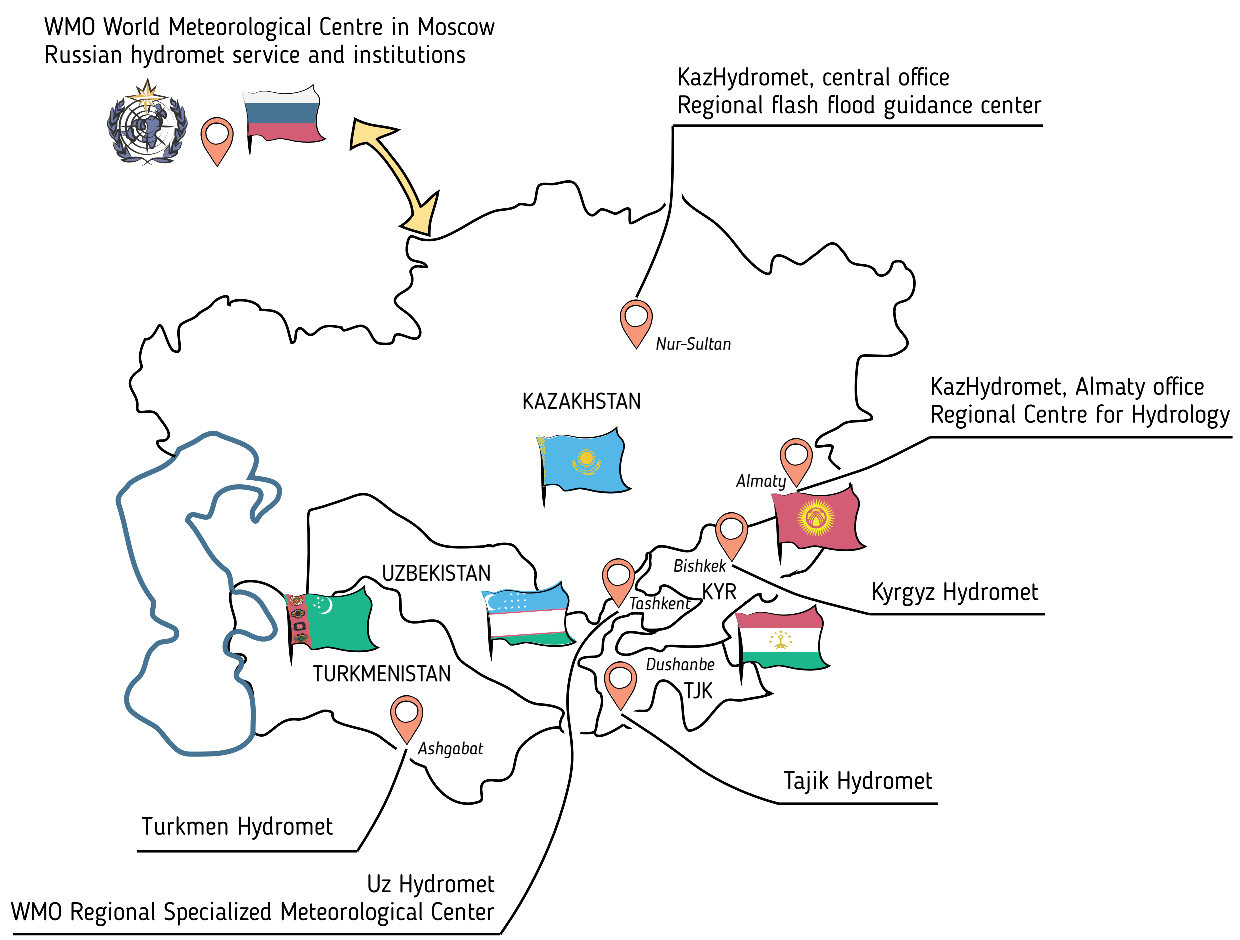
The national hydrometeorological services of Central Asia provide hydrometeorological information for the common and specific needs of their countries and key sectors. Central offices of all national hydrometeorological services are located in the capitals.

Top: Oil pump, Kazakhstan

Bottom: Pomegranate farmer, Tajikistan

Country profiles

National and regional centres



Tashkent

Regional specialized Meteorological Center under the World Meteorological Organization

Main functions and areas of expertise:

- Numerical weather forecasting, support regional access and downscaling of weather products
- Regional severe weather forecasting
- Quality control of observation data and global / regional data exchange

Almaty

Regional Center for Hydrology under the Interstate Foundation for the Aral Sea

Main functions and areas of expertise:

- Research, studies and expeditions on glaciers and water resources
- Support best practices and training on hydrology and its applications
- Coordination and implementation of the international projects on climate and hydrometeorology

The national hydromets in Central Asia all benefit from their common legacy from the Soviet era when the hydromets combined meteorology, hydrology and environmental observations in an integrated, well-funded approach. This organizing principle distinguishes hydromets in the region from those in many other countries where the services are segregated. After independence, some of the countries could not maintain the same level of funding, and the quality of the stations and equipment declined, while others managed to maintain their networks.

Tashkent, once the scientific and communication hub for all Central Asian hydromets, has transitioned to serving as the WMO Regional specialized meteorological centre (RSMC), which will feature prominently on the regional scene when the new numerical prediction models and could-based data exchange for Central Asia become fully operational. The regional center on hydrology (RCH) is supporting hydrometeorology modernization projects and promotes experience exchange. Among the current regional needs are glacier monitoring, regional climate outlooks and assessments, reliable seasonal water assessments for cross-border rivers, and the forecasting and early warnings for droughts and dust storms at the regional scale.

Meteorological station, Almaty

Kazakhstan

The State Enterprise Kaz Hydromet is organized to accommodate the scale of the country and the diverse climate conditions. Under the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, Kaz Hydromet includes branches in all 15 provincial capitals as well as central and science offices in Nur-Sultan and Almaty. Founded in 1922, the national hydrometeorological service of Kazakhstan has grown over the years into a sophisticated network consisting of 328 meteorological stations and 310 river and lake gauges, many of which report daily to the global observation systems of the World Meteorological Organization. Several meteorological stations of Kazakhstan have conducted continuous observations for 100–150 years or more.

More than 3300 people are employed and most observations are still taken manually by field-based staff. The state-funded hydromet modernization programme is investing in the expansion and upgrade of the network of meteorological radar, automated stations and new methods and technologies of weather and water forecasting, all of which result in greater accuracy.

Kaz Hydromet stands out in Central Asia in online availability of the basic information, including via mobile applications and text messaging, and provides early warnings, environmental quality monitoring and weather data. It publishes annual climate overviews, and runs its own climate models. An agrometeorological network of more than 200 stations supports farmers at all stages of crop planning and production, including forecasts of wheat yields, monitoring of soil moisture and assessments of damages caused by severe weather events. These assessments are mandatory for agricultural insurance.

Hydrological bulletins and forecasts appear on Kaz Hydromet website daily. Data from six Kaz Hydromet maritime stations on the Caspian Sea are published weekly. A national magazine on hydrometeorology and ecology is published quarterly.

National hydrometeorological service of Kazakhstan in numbers

3 300
People employed

Nur-Sultan
Central office

328
Meteorological stations, including automated
88 Agrometeo posts

3 100 m to -27 m
Elevation range of hydromet observations

100
Meteorological and hydrological stations report internationally

10
Meteorological and marine radar units

2
Snow avalanche monitoring stations

9
Upper air (aerological) weather stations

310
Hydrological gauges, including automated

25
Snow monitoring routes and glaciers regularly monitored

500
Environmental quality monitoring locations, including air sampling stations

Forecast accuracy in meteorology:
90-95% 1-7 days

kazhydromet.kz
Official website and online services

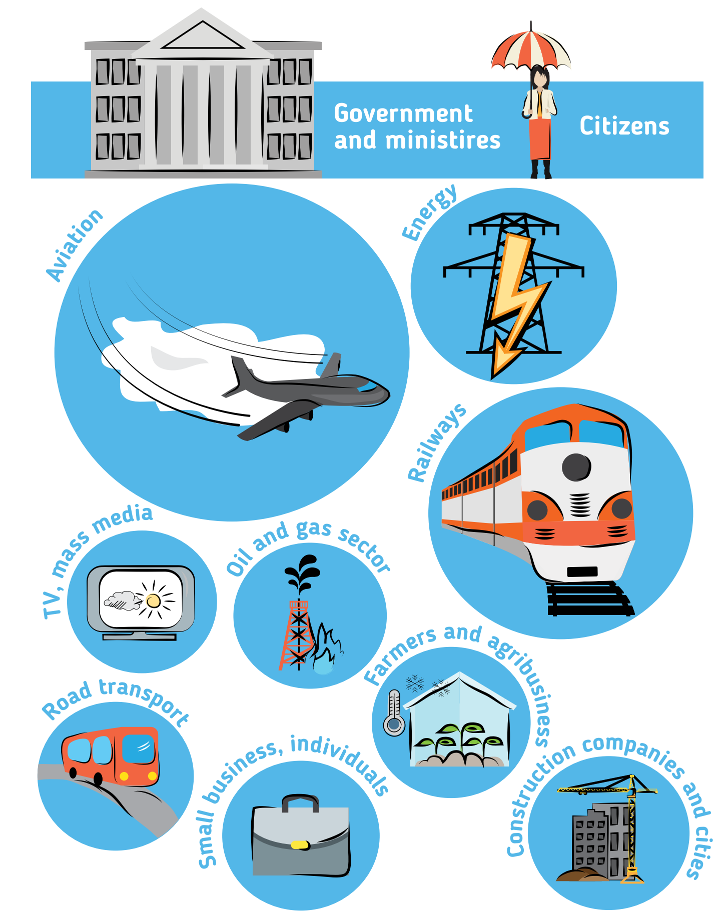
Forecast accuracy in hydrology:
84-90%
seasonal water flow

Data for November 2019

Governmental agencies, local authorities and the general public receive free basic weather and water information, early warnings and notifications about pollution levels and environmental quality on a daily basis. The economic sectors with the highest demand for hydromet services in Kazakhstan are aviation, transport, energy and agriculture. TV and other mass media are also interested in official Kaz Hydromet forecasts.

Domestic and international aviation is a key commercial Kaz Hydromet client. Aviation relies on localized and customized meteorological information, especially for upper air and radar observations. The rail and road transport and energy sectors need data on extreme events in specific locations as well as monthly and seasonal outlooks to plan heating demand and logistical connections and to ensure safety. As a major transit country in the region and with the increasing connections between Kazakhstan and China, Europe and the Middle East, the importance of hydrometeorological services for international transport and transit. The private-public partnership on the automated meteorological stations along international roads is an important step in that direction. The agricultural sector is an important producer of wheat and other cereal grains, and the country's complicated hydrology calls for reporting and forecasts specific to local conditions.

Main clients of general and customized hydrometeorological information in Kazakhstan



Recipients of the basic and free information, such as weather warnings and forecasts

Recipients of the customized sector-specific fee-based services and information

The bigger the size of sector circle, the larger the relative share or value of the commercial hydromet services

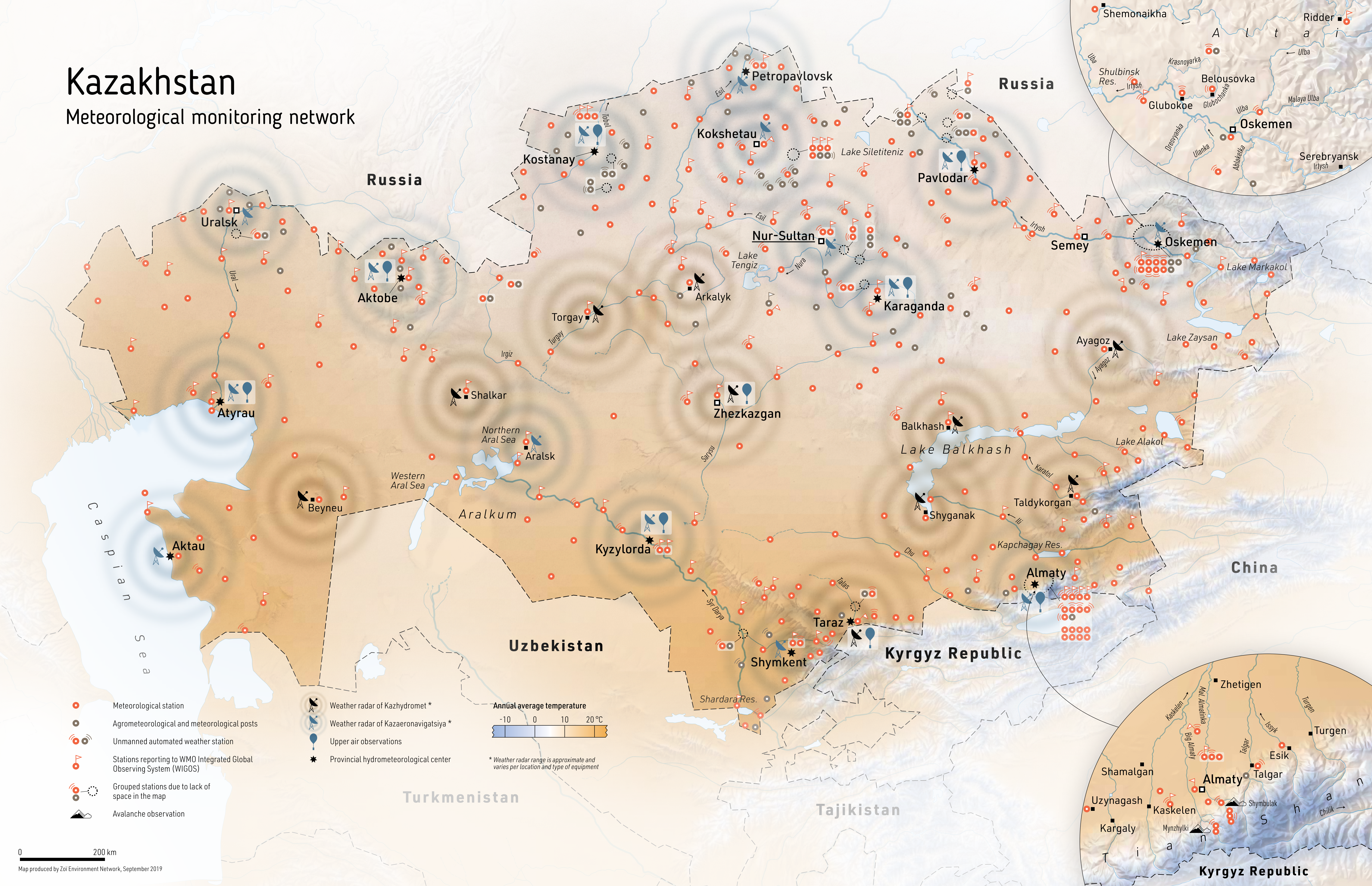
Kazakhstan

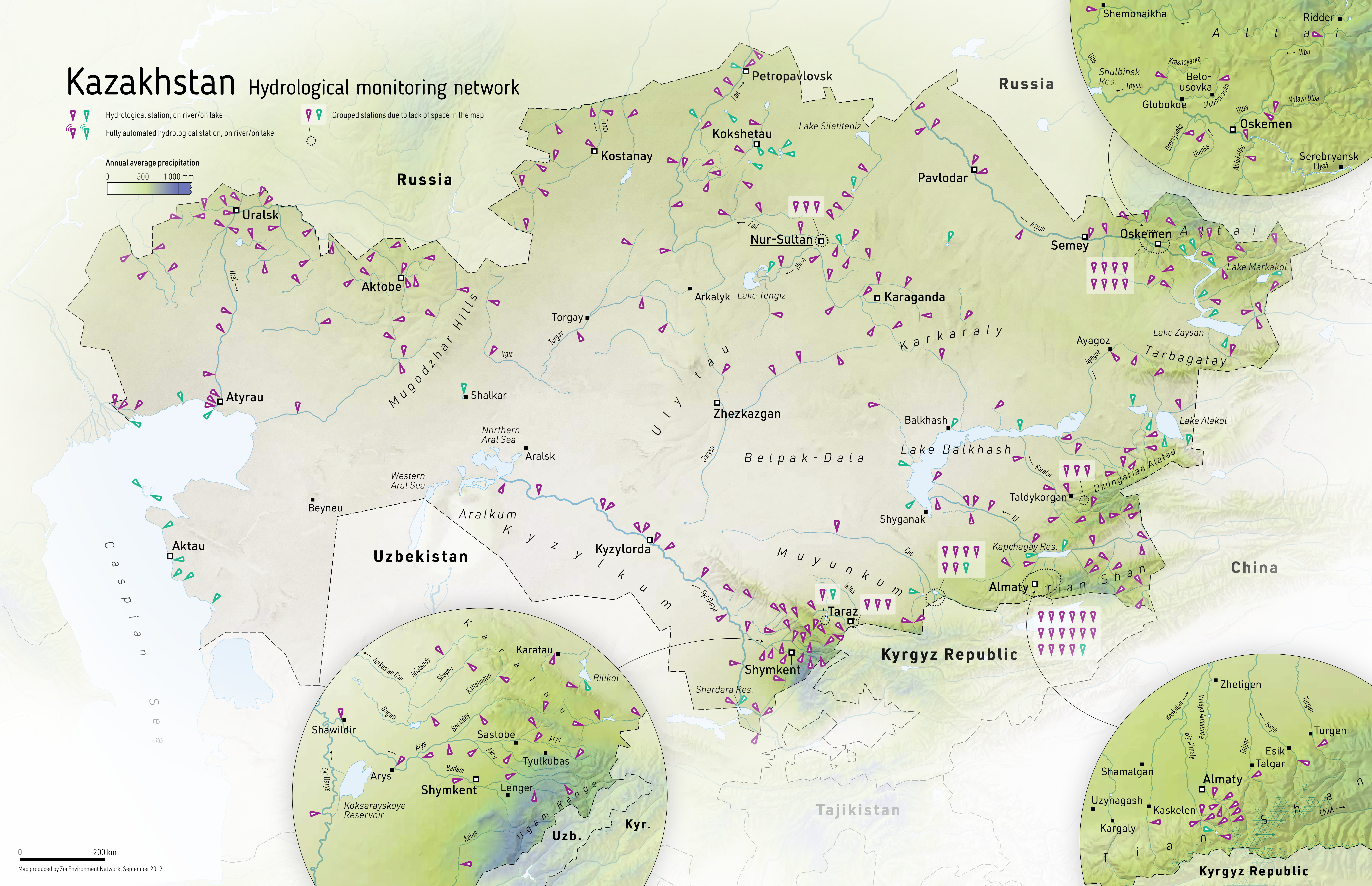
Land cover and features

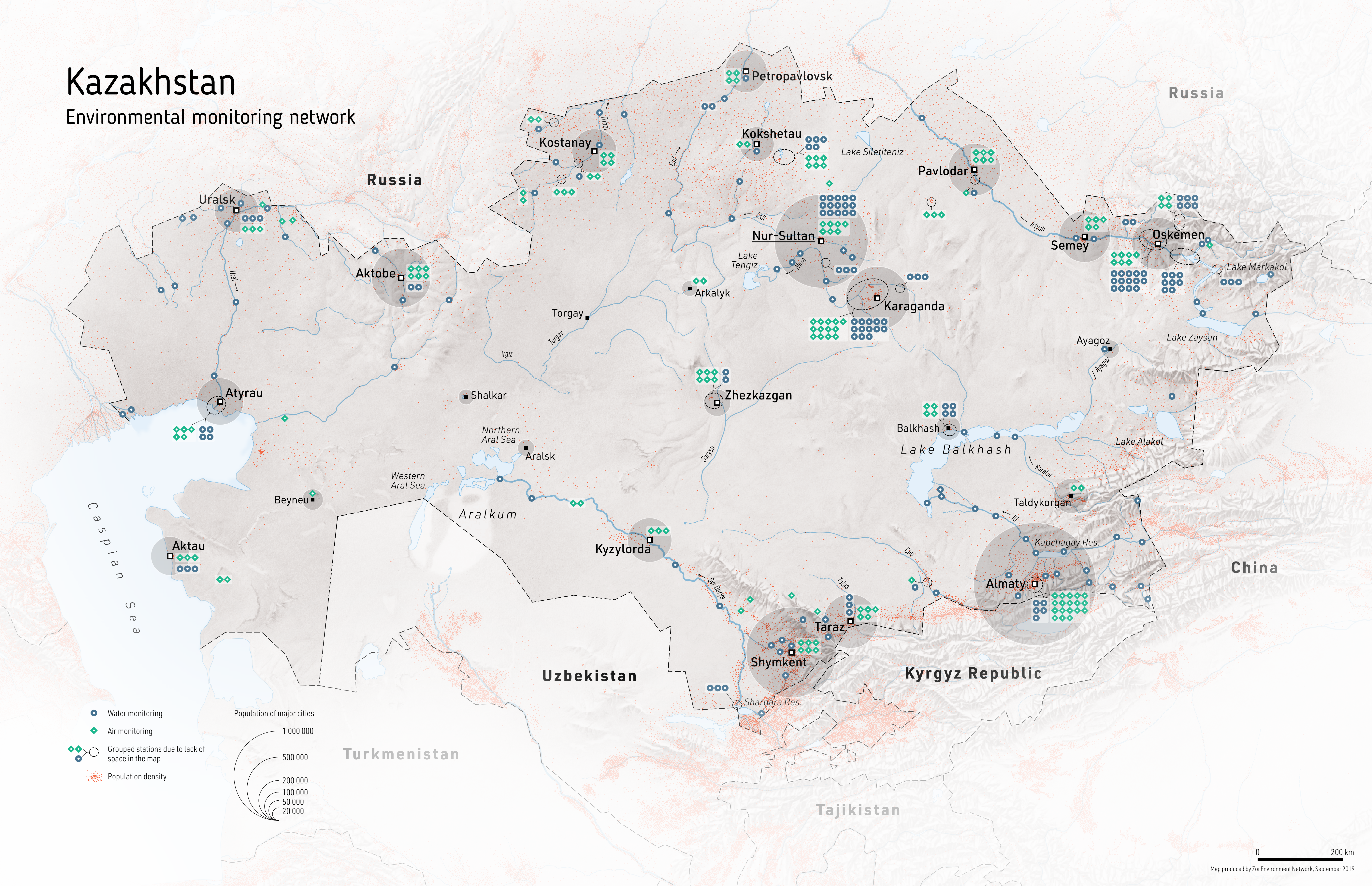
Windy, cold Kazakhstan covers some 2.7 million square kilometres, and its unevenly distributed population lives mostly in the steppes and highlands. Its geographic features include the shallow northern Caspian Sea, vast wind-swept steppes, sandy and stony deserts and the magnificent Altai, Jungar and Tien Shan Mountains. All of Kazakhstan's main rivers – Syr Darya, Ural, Irtysh, Ili, Chu and Talas are cross-boundary and originate outside of the country. Seasons are well defined with harsh and snowy winters and hot and dry summers. Droughts, floods, strong winds and storm surges, cold snaps and avalanches are among the weather hazards affecting Kazakhstan. Climate warming is evident across the country and has already resulted in intense glacier melting and loss, which in turn changes the timing and magnitude of floods and leads to a multitude of future impacts. With its cold climate and high reliance on coal for energy, Kazakhstan emits more greenhouse gases than other countries of Central Asia, but the country is increasingly tapping its great potential for clean renewable energy – solar, wind and hydropower.

0 200 km

Map produced by Zoï Environment Network, September 2019


Kazakhstan
Meteorological monitoring network
Russia
Russia
China
Uzbekistan
Kyrgyz Republic
Turkmenistan
Tajikistan
Caspian Sea
Uralsk
Aktobe
Atyrau
Aktau
Beyneu
Shalkar
Northern Aral Sea
Aralsk
Western Aral Sea
Aralkum
Kyzylorda
Kostanay
Torgay
Irgiz
Petropavlovsk
Kokshetau
Lake Siletiteniz
Pavlodar
Nur-Sultan
Lake Tengiz
Arkalyk
Karaganda
Zhezkazgan
Balkhash
Lake Balkhash
Semey
Oskemen
Lake Markakol
Lake Zaysan
Ayagoz
Lake Alakol
Taldykorgan
Shyganak
Kapchagay Res.
Almaty
Taraz
Shymkent
Shardara Res.
Syr Darya
Sarysu
Chu
Talas
Ili
Karatal
Irtysh
Esil
Nura
Tobol
Turgay
Ural
Shemonaikha
Ridder
Altai
Shulbinsk Res.
Belousovka
Glubokoe
Oskemen
Serebryansk
Zhetigen
Turgen
Esik
Talgar
Shamalgan
Almaty
Uzynagash
Kaskelen
Kargaly
Shymbulak
Mynzhylki
Tian Shan
Kyrgyz Republic
Meteorological station
Agrometeorological and meteorological posts
Unmanned automated weather station
Stations reporting to WMO Integrated Global Observing System (WIGOS)
Grouped stations due to lack of space in the map
Avalanche observation
Weather radar of Kazhydromet *
Weather radar of Kazaeronavigatsiya *
Upper air observations
Provincial hydrometeorological center
Annual average temperature
-10 0 10 20 °C
* Weather radar range is approximate and varies per location and type of equipment
0 200 km
Map produced by Zoï Environment Network, September 2019


Kazakhstan Hydrological monitoring network
Hydrological station, on river/on lake
Fully automated hydrological station, on river/on lake
Grouped stations due to lack of space in the map
Annual average precipitation
0
500
1 000 mm
Russia
Russia
China
Uzbekistan
Kyrgyz Republic
Tajikistan
Uzb.
Kyr.
Petropavlovsk
Kostanay
Kokshetau
Lake Siletiteniz
Pavlodar
Uralsk
Aktobe
Nur-Sultan
Arkalyk
Lake Tengiz
Karaganda
Torgay
Semey
Oskemen
Lake Markakol
Lake Zaysan
Ayagoz
Tarbagatay
Karkaraly
Ulytau
Mugodzhar Hills
Shalkar
Atyrau
Zhezkazgan
Balkhash
Lake Alakol
Northern Aral Sea
Aralsk
Lake Balkhash
Betpak-Dala
Western Aral Sea
Beyneu
Aralkum
Kyzylkum
Taldykorgan
Dzungarian Alatau
Shyganak
Kapchagay Res.
Aktau
Caspian Sea
Kyzylorda
Muyunkum
Almaty
Tian Shan
Taraz
Shymkent
Shardara Res.
Esil
Tobol
Ural
Irgiz
Turgay
Nura
Sarysu
Syr Darya
Chu
Talas
Ili
Karatal
Ayagoz
Irtysh
Altai
Shemonaikha
Ridder
Ulba
Krasnoyarka
Shulbinsk Res.
Irtysh
Belo-usovka
Glubokoe
Glubochanka
Malaya Ulba
Ulba
Oskemen
Oravyanka
Ulanka
Ablaketka
Serebryansk
Irtysh
Karatau
Turkestan Can
Arystandy
Shayan
Kattabugun
Bilikol
Bugun
Boralday
Shawildir
Sastobe
Arys
Arys
Aksu
Tyulkubas
Badam
Syr Darya
Shymkent
Lenger
Koksarayskoye Reservoir
Keles
Ugam Range
Zhetigen
Kaskelen
Malaya Almatinka
Big Almaty
Issyk
Turgen
Turgen
Talgar
Esik
Talgar
Shamalgan
Almaty
Uzynagash
Kaskelen
Kargaly
Chilik
Tian Shan
Kyrgyz Republic
0
200 km
Map produced by Zoï Environment Network, September 2019


Kazakhstan
Environmental monitoring network
Russia
Petropavlovsk
Kostanay
Tobol
Kokshetau
Lake Siletiteniz
Pavlodar
Esil
Uralsk
Ural
Aktobe
Nur-Sultan
Lake Tengiz
Nura
Irtysh
Semey
Oskemen
Lake Markakol
Arkalyk
Karaganda
Torgay
Turgay
Irgiz
Lake Zaysan
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Atyrau
Shalkar
Zhezkazgan
Balkhash
Lake Balkhash
Lake Alakol
Northern Aral Sea
Aralsk
Sarysu
Karatal
Western Aral Sea
Aralkum
Beyneu
Taldykorgan
Ili
Caspian Sea
Aktau
Kyzylorda
Kapchagay Res.
Chu
Syr Darya
Talas
Almaty
China
Taraz
Shymkent
Uzbekistan
Kyrgyz Republic
Shardara Res.
Water monitoring
Air monitoring
Grouped stations due to lack of space in the map
Population density
Population of major cities
1 000 000
500 000
200 000
100 000
50 000
20 000
Turkmenistan
Tajikistan
0
200 km
Map produced by Zoi Environment Network, September 2019

The Kyrgyz Republic

The Agency on Hydrometeorology (Kyrgyz Hydromet) under the Ministry of Emergency Situations of the Kyrgyz Republic has its roots in the national hydrometeorological service established in 1926. The oldest weather station – Asksu, on the northern coast of Issyk-Kul Lake – began its observations in 1856. Three other stations – Naryn, Baitik and Pacha-Ata – have climate records for more than 100 years. The high mountain stations at altitude of 3 000 metres and above include Teo-Ashuu, Sary-Tash and Tien Shan with records of 60–90 years.

Today's country observation network covers 55 meteorological stations, including 3 operational snow and avalanche stations. Two more avalanche stations will be established soon to improve public safety at strategic mountain roads. In addition to meteorology, half of weather stations monitor radiation levels. Supported by the World Bank hydromet modernization project, automated weather stations were installed at many manned stations and at remote sites to improve weather data coverage and forecasting. Currently 78 river and lake gauges are operational, but the level of automation in hydrology remains low.

In addition to the observation network upgrade, the hydromet modernization project invested in enhanced data management systems, numerical weather forecasting methods, a calibration laboratory, and distance learning centres in Bishkek, Osh and Cholpon-Ata. Digitalization of the massive historical data sets is progressing. Future plans include installation of early warning systems for glacial lakes, and upgrades of weather and water forecasting methods and technologies for higher accuracy. User engagement and outreach will be growing. Considering the complex mountain weather and inaccessibility of many remote parts of the Kyrgyz Republic, the national hydrometeorological service intends to expand its own network and to increase cooperation with other networks from scientists to key sector actors such as road and hydropower operators to provide better service and more complete geographical coverage.

National hydrometeorological service of the Kyrgyz Republic in numbers

530 People employed

Bishkek Central office

55 Meteorological stations, including automated
10 Agrometeo posts

3 600 m to 500 m Elevation range of hydromet observations

20 Meteorological and hydrological stations report internationally

0 Meteorological radar units

3 Snow avalanche monitoring stations

0 Upper air (aerological) weather stations

78 Hydrological gauges, including automated

5 Snow monitoring routes and glaciers regularly monitored

40 Environmental quality monitoring locations, including air sampling stations

Forecast accuracy in meteorology: **90–95%** 1-7 days

meteo.kg Official website and online services

Forecast accuracy in hydrology: **80–90%** seasonal water flow

Data for November 2019

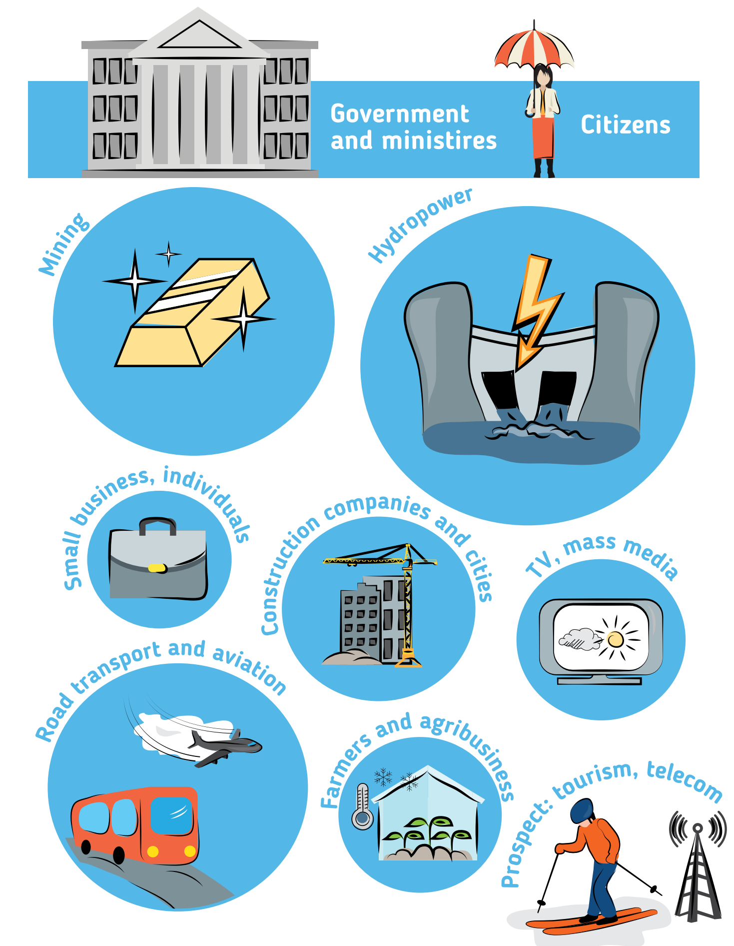
Kyrgyz Hydromet performs its functions according to the international WMO standards and recommendations, and provides governmental authorities, the general public and key economic sectors with weather forecasts and early warnings, and conducts environmental monitoring. The energy, mining, transport, agriculture and tourism sectors all rely on Kyrgyz Hydromet information and services.

The mountains of the Kyrgyz Republic play a special role in water formation for greater Central Asia, and hydropower stations here are crucial elements in managing water resources for downstream users and for the production of electricity for domestic purposes. The hydropower and mining sectors – both operating in the high mountains – use specialized hydrometeorological information for planning business operations, ensuring industrial safety and anticipating production peaks and lows. Mining sites are scattered across the country, and climate services are an increasingly important part of planning for safety and for conducting impact assessments.

Road expansion is booming in the Kyrgyz Republic, and surface and air transport connects the country's regions. Climate and water information is essential for planning, and the reliability and safety of transport operations are directly related to weather conditions and early warnings of the risk of mudflows, avalanches and wind gusts.

Emerging new forms of agriculture such as greenhouses, drip irrigation systems and intense orchards require specialized and localized weather data. Their profitability depends on weather and climate. Farmers and herders benefit significantly from agrometeorological and climate services. Tourism is an emerging sector with its own needs for hydromet services related to snowfall and mountain safety.

Main clients of general and customized hydro–meteorological information in the Kyrgyz Republic



Recipients of the basic and free information, such as weather warnings and forecasts

Recipients of the customized sector-specific fee-based services and information

The bigger the size of sector circle, the larger the relative share or value of the commercial hydromet services

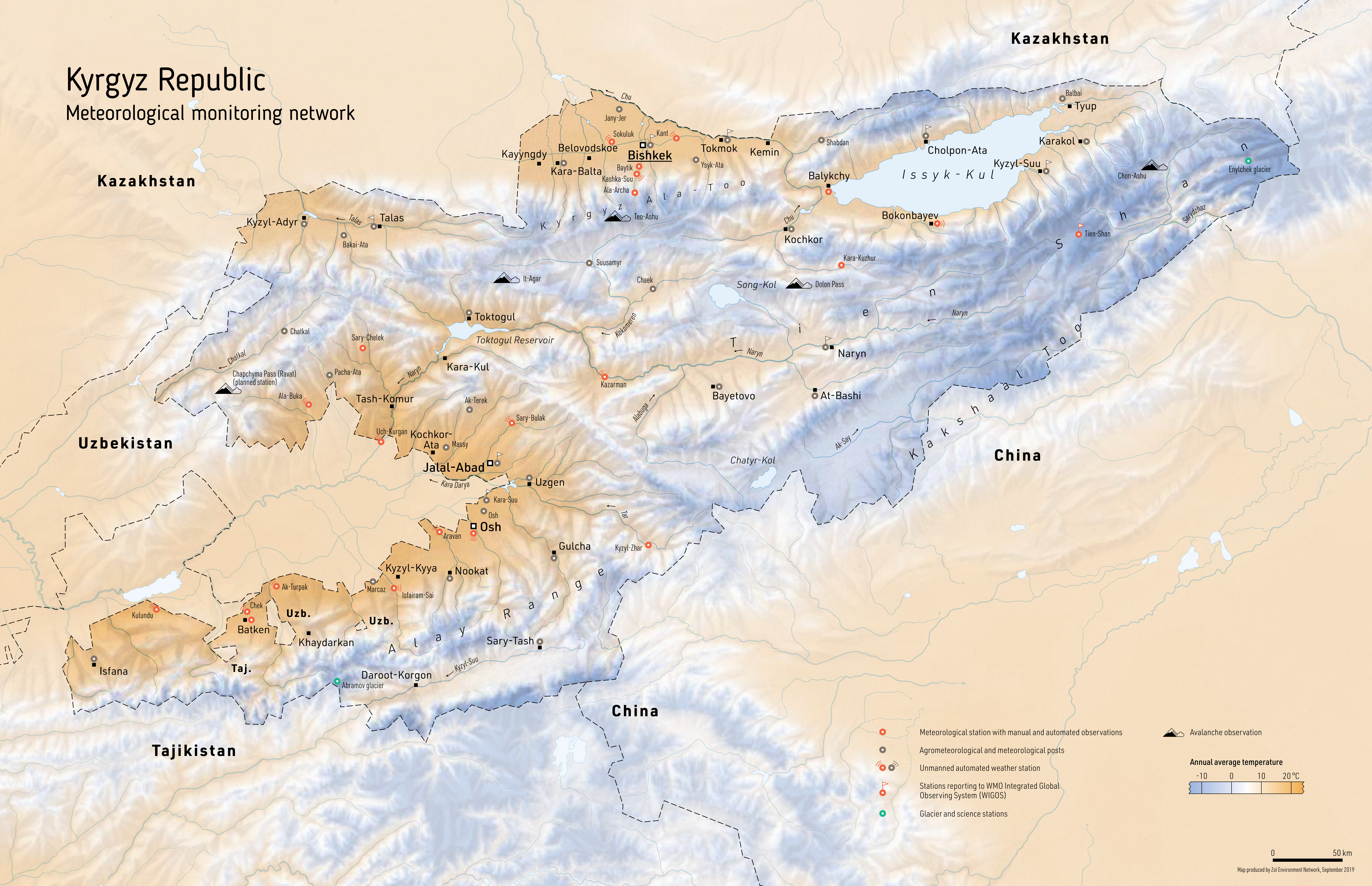
Kyrgyz Republic

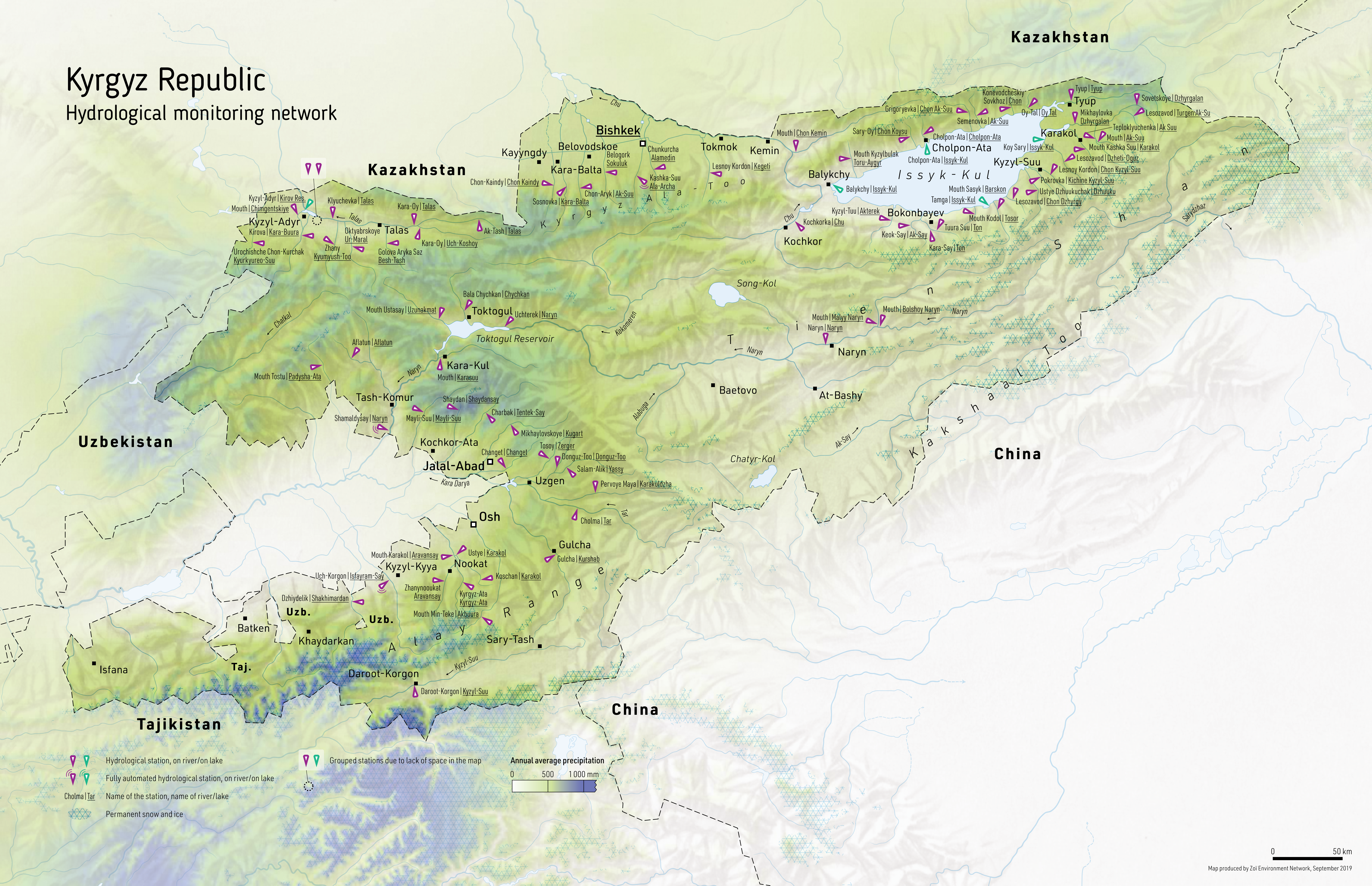
Land cover and features

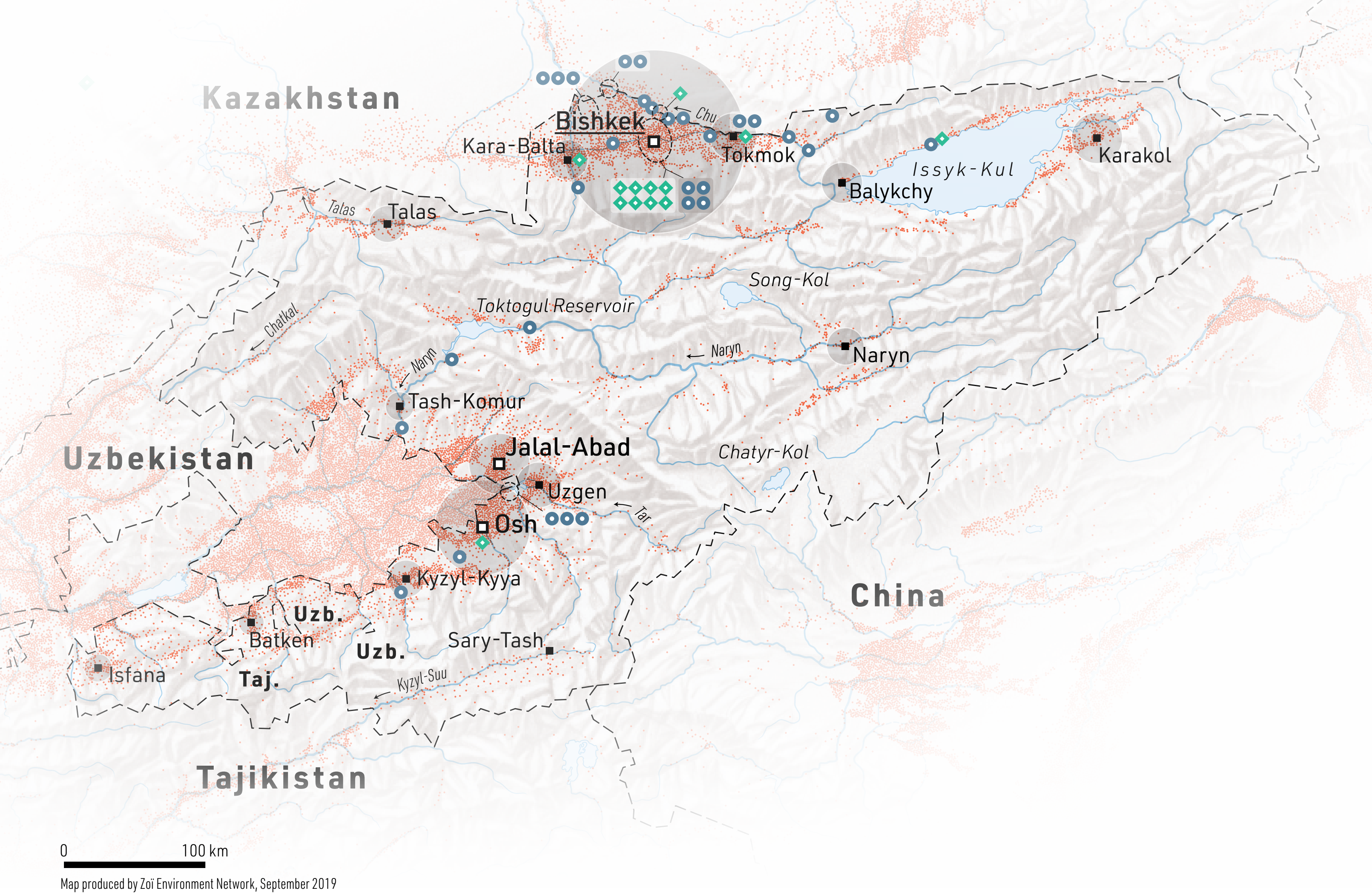
The complex atmospheric, geographic and topographic conditions in the small mountain country of the Kyrgyz Republic create distinct regional climates – in the Ferghana Valley, around the capital city of Bishkek, in the high elevations, and at Issyk-Kul Lake.

In the south, the Ferghana Valley features favorable conditions for agriculture, with a warm climate and natural protection against cold air. The central part of the country consists of high mountain plateaus, peaks and glaciers, and can be bitterly cold with quickly changing weather conditions. To the east, encircled by spectacular mountains, Issyk-Kul Lake exhibits a unique climate where one side of the lake is the driest area of the country and the other side receives the highest annual snowfall. In winter, the plentiful powdery snow is a key asset for the famous ski resorts, and in summer, more than a million visitors, local residents and international tourists alike, come to Issyk-Kul for swimming and hiking.

Map produced by Zoi Environment Network, September 2019


Kyrgyz Republic
Meteorological monitoring network
Kazakhstan
Kazakhstan
Uzbekistan
China
China
Tajikistan
Uzb.
Uzb.
Taj.
Chu
Jany-Jer
Sokuluk
Kant
Bishkek
Belovodskoe
Kayyngdy
Kara-Balta
Baytik
Kashka-Suu
Ala-Archa
Tokmok
Ysyk-Ata
Kemin
Shabdan
Balykchy
Cholpon-Ata
Issyk-Kul
Balbai
Tyup
Karakol
Kyzyl-Suu
Chon-Ashu
Enylchek glacier
Bokonbayev
Tien-Shan
Sarydzhaz
Kyrgyz Ala-Too
Teo-Ashu
Talas
Kyzyl-Adyr
Bakai-Ata
Talas
Chu
Kochkor
Kara-Kuzhur
Susamyr
It-Agar
Chaek
Song-Kol
Dolon Pass
Tien Shan
Naryn
Kokomeren
Toktogul
Toktogul Reservoir
Chatkal
Chatkal
Sary-Chelek
Pacha-Ata
Chapchyma Pass (Ravat) (planned station)
Ala-Buka
Naryn
Kara-Kul
Tash-Komur
Naryn
Naryn
Kazarman
Bayetovo
At-Bashi
Alabuga
Ak-Terek
Sary-Bulak
Uch-Kurgan
Kochkor-Ata
Massy
Jalal-Abad
Kara Darya
Uzgen
Ak-Say
Kakshaal Too
Chatyr-Kol
Kara-Suu
Osh
Osh
Tar
Aravan
Gulcha
Kyzyl-Zhar
Kyzyl-Kyya
Nookat
Marcaz
Isfairam-Sai
Ak-Turpak
Chek
Kulundu
Batken
Khaydarkan
Alay Range
Sary-Tash
Isfana
Daroot-Korgon
Kyzyl-Suu
Abramov glacier
Meteorological station with manual and automated observations
Agrometeorological and meteorological posts
Unmanned automated weather station
Stations reporting to WMO Integrated Global Observing System (WIGOS)
Glacier and science stations
Avalanche observation
Annual average temperature
-10
0
10
20 °C
0
50 km
Map produced by Zoï Environment Network, September 2019


Kyrgyz Republic
Hydrological monitoring network
Kazakhstan
Uzbekistan
Tajikistan
China
Uzb.
Taj.
Bishkek
Kayyngdy
Belovodskoe
Kara-Balta
Tokmok
Kemin
Balykchy
Cholpon-Ata
Tyup
Karakol
Kyzyl-Suu
Bokonbayev
Kochkor
Issyk-Kul
Song-Kol
Naryn
At-Bashy
Baetovo
Chatyr-Kol
Talas
Kyzyl-Adyr
Toktogul
Toktogul Reservoir
Kara-Kul
Tash-Komur
Kochkor-Ata
Jalal-Abad
Uzgen
Osh
Gulcha
Nookat
Kyzyl-Kyya
Sary-Tash
Daroot-Korgon
Khaydarkan
Batken
Isfana
Kyrgyz Ala-Too
Alay Range
Kakshaal-Too
Teskey Ala-Too
Chu
Talas
Naryn
Kokomeren
Chatkal
Kara Darya
Alabuga
Ak-Say
Tar
Kyzyl-Suu
Sarydzhaz
Kyzyl-Adyr | Kirov Res.
Mouth | Chimgentskiye
Kirova | Kara-Buura
Urochishche Chon-Kurchak
Kyurkyureo-Suu
Zhany Kyumysh-Too
Oktyabrskoye Ur-Maral
Klyuchevka | Talas
Kara-Oy | Talas
Golova Aryka Saz Besh-Tash
Kara-Oy | Uch-Koshoy
Ak-Tash | Talas
Chon-Kaindy | Chon Kaindy
Sosnovka | Kara-Balta
Chon-Aryk | Ak-Suu
Belogork Sokuluk
Chunkurcha Alamedin
Kashka-Suu Ala-Archa
Lesnoy Kordon | Kegeti
Mouth | Chon Kemin
Grigoryevka | Chon Ak-Suu
Konevodcheskiy Sovkhoz | Chon
Semenovka | Ak-Suu
Oy-Tal | Oy Tal
Tyup | Tyup
Mikhaylovka Dzhyrgalan
Sovetskoye | Dzhyrgalan
Lesozavod | Turgen Ak-Su
Teploklyuchenka | Ak Suu
Mouth | Ak-Suu
Mouth Kashka Suu | Karakol
Lesozavod | Dzheti-Oguz
Lesnoy Kordon | Chon Kyzyl-Suu
Pokrovka | Kichine Kyzyl-Suu
Ustye Dzhuukuchak | Dzhuuku
Lesozavod | Chon Dzhyrgy
Sary-Oy | Chon Koysu
Cholpon-Ata | Cholpon-Ata
Cholpon-Ata | Issyk-Kul
Koy Sary | Issyk-Kul
Mouth Kyzylbulak Toru-Aygyr
Balykchy | Issyk-Kul
Mouth Sasyk | Barskon
Tamga | Issyk-Kul
Mouth Kodol | Tosor
Tuura Suu | Ton
Kyzyl-Tuu | Akterek
Kochkorka | Chu
Keok-Say | Ak-Say
Kara-Say | Ton
Mouth | Malyy Naryn
Naryn | Naryn
Mouth | Bolshoy Naryn
Bala Chychkan | Chychkan
Mouth Ustasay | Uzunakmat
Uchterek | Naryn
Aflatun | Aflatun
Mouth Tostu | Padysha-Ata
Mouth | Karasuu
Shaydan | Shaydansay
Shamaldysay | Naryn
Mayli-Suu | Mayli-Suu
Charbak | Tentek-Say
Mikhaylovskoye | Kugart
Changet | Changet
Tosoy | Zerger
Donguz-Too | Donguz-Too
Salam-Alik | Yassy
Pervoye Maya | Karakuldzha
Cholma | Tar
Gulcha | Kurshab
Ustye | Karakol
Mouth Karakol | Aravansay
Koschan | Karakol
Uch-Korgon | Isfayram-Say
Zhanynoouknat Aravansay
Kyrgyz-Ata Kyrgyz-Ata
Dzhiydelik | Shakhimardan
Mouth Min-Teke | Akbuura
Daroot-Korgon | Kyzyl-Suu
Hydrological station, on river/on lake
Fully automated hydrological station, on river/on lake
Cholma | Tar
Name of the station, name of river/lake
Permanent snow and ice
Grouped stations due to lack of space in the map
Annual average precipitation
0
500
1 000 mm
0
50 km
Map produced by Zoï Environment Network, September 2019



Kyrgyz Republic
Environmental monitoring network

- Water monitoring
- Air monitoring
- Grouped stations due to lack of space in the map
- Population density

Population of major cities

1 000 000
500 000
200 000
100 000
50 000
20 000

Climate change impacts and adaptation in the Chu and the Talas river basins

Projected temperature change

2050s compared to 1961 – 1990 (° Celsius)

-2 +2 +4

Projected precipitation change

2050s compared to 1961 – 1990 (%)

+10% -10%

+5% -5%

- Melting and/or disappearing of glaciers due to climate change
- Farmland: shortage of water resources by 2050 for agriculture
- Decrease of productivity of forests
- Decrease of productivity of pastures
- Border of the basin
- State borders

Range of river flow projections 2100

- Weak climate change (+1.5 °C / +10% precipitation): same flow as in current conditions
- Strong climate change (+6.4 °C / -10% precipitation): flow reduction by 45 – 50%

4 2 1 km³/year

In 2006 Kazakhstan and the Kyrgyz Republic established the commission on the use of water management facilities in the Chu and Talas transboundary river basins. A joint board determines allocations and has considered climate change impacts and adaptation measures in its recent sessions and activities. The countries' hydromets play a prominent role in the commission's work by conducting and coordinating water quality and quantity surveys and coordinating efforts on climate modelling using the methodologies and experience of the United Nations Economic Commission for Europe and the Water Convention. The hydromets also prepare and share with water planners monthly and seasonal water forecasts.

Tajikistan

Tajikistan's State Agency for Hydrometeorology of the Committee of Environmental Protection (Tajik Hydromet) is a key player in country's climate, water and weather observations. Ten weather stations in Tajikistan are more than 100 years old, and four date from the 1800s – Khujand (1866), Ura-Teppa (1873), Murgab (1892) and Khorog (1898). The peak density of the observation network was achieved in the 1970s–1980s with 70–75 meteorological stations and 136 river gauging stations. But many of those stations were in the remote mountains and expensive to maintain. The meteorological station at the Fedchenko glacier is at an elevation of 4 169 metres. It was manned and functioning between 1933 and 1995, and required helicopter deliveries of food and fuel supplies. Currently it operates as an automated weather station.

The current observation network in Tajikistan consists of 54 manned and automated (same location) weather stations and 96 hydrological stations. Many stations are being automated with support of the international hydromet modernization projects. Tajik Hydromet employs about 700 people, but there is shortage of a skilled personnel and young staff. Professional training and higher education has improved access to numerical weather products and the quality of forecasts and early warnings. A higher level of automation of the observation network and better links with remote stations have increased data availability.

With support of international donors, Tajikistan plans to build a new Tajik Hydromet central office building, rehabilitate stations for better working conditions, introduce robust links to all remote stations, and improve access to regional numerical weather models. New tools and technologies for remote sensing can help in water forecasts, glacier research and agrometeorological monitoring, while better user relations and better quality and diversity of Tajik Hydromet products will increase the applications of – and resulting benefits from – hydrometeorological information.

National hydrometeorological service of Tajikistan in numbers

700
People employed

Dushanbe
Central office

56
Meteorological stations, including automated

24 Agrometeo posts

4 200 m to 300 m
Elevation range of hydromet observations

30
Meteorological and hydrological stations report internationally

0
Meteorological radar units

1
Snow avalanche monitoring stations

0
Upper air (aerological) weather stations

96
Hydrological gauges, including automated

3
Snow monitoring routes and glaciers regularly monitored

40
Environmental quality monitoring locations, including air sampling stations

Forecast accuracy in meteorology:
85-90% 1-7 days

meteo.tj
Official website and online services

Forecast accuracy in hydrology:
75-90%*
seasonal water flow

Planned in 2020: 5 new meteorological stations, 10 new hydrological gauges
*Hydrological forecasts do not cover the Panj Rover – the largest river of Tajikistan

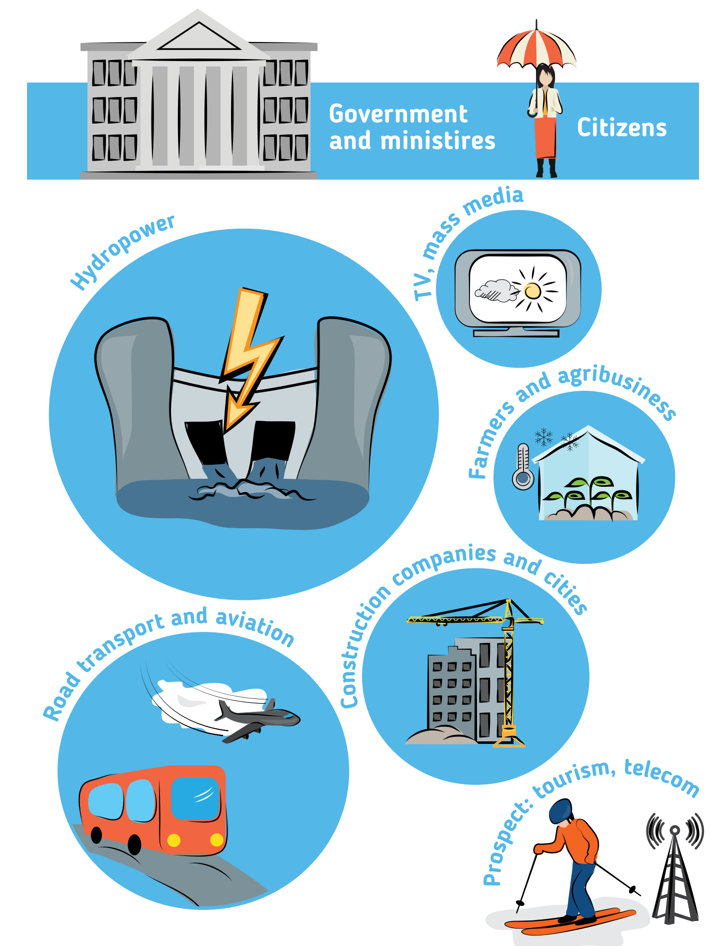
Data for November 2019

Governments at all levels, emergency response authorities and the general public are the basic users of weather information and notifications of extreme events. The number one client for specialized hydrometeorological information is hydropower. Others include the aviation and transport sectors, and construction, tourism, telecommunications and agriculture are all poised to become users of specialized hydromet information and services.

Hydropower generation is highly sensitive to weather and water conditions and relies on forecasts for safe operations and good performance, and Tajikistan produces almost 95 per cent of electricity at hydropower plants on the Vakhsh and Syr Darya rivers. Several power plants – large and small – are under construction. The hydromet service supports the hydropower sector and provides weather warnings of extreme events to the responsible authorities at all governmental levels with offices in every province.

For the transport sector, the ridged mountain terrain of Tajikistan poses many challenges to road safety – avalanches and icy roads in winter, flash floods in spring, high temperatures and dust storms in summer. Booming construction, tourism and telecommunication sectors can all benefit from hydromet information, as can farmers, many of whom are not yet familiar with the benefits of weather information and agrometeorological services. Through intentional user engagement, Tajik Hydromet may raise their knowledge and awareness, and bring them in as clients.

Main clients of general and customized hydrometeorological information in Tajikistan



Recipients of the basic and free information, such as weather warnings and forecasts

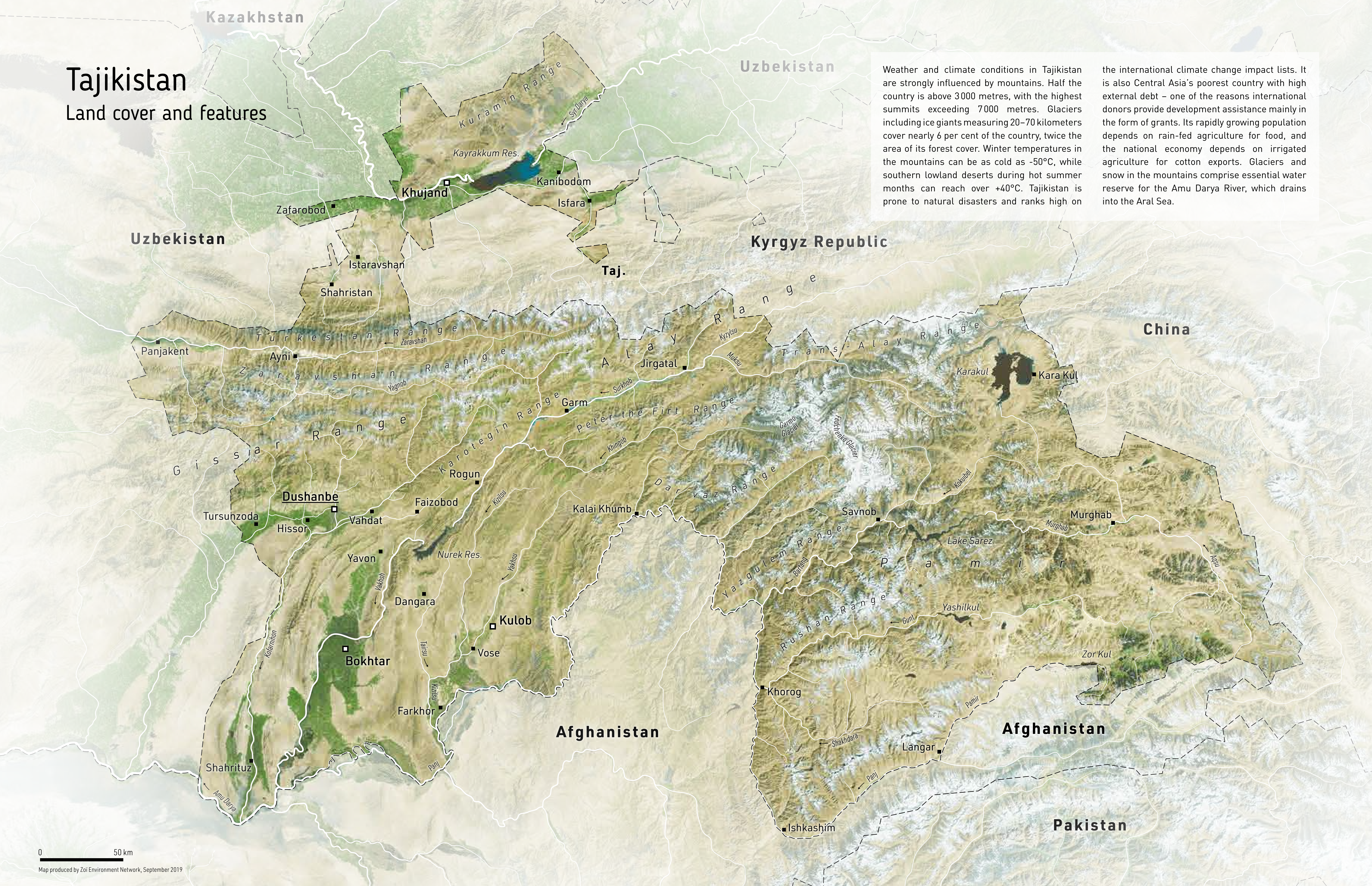
Recipients of the customized sector-specific fee-based services and information

The bigger the size of sector circle, the larger the relative share or value of the commercial hydromet services

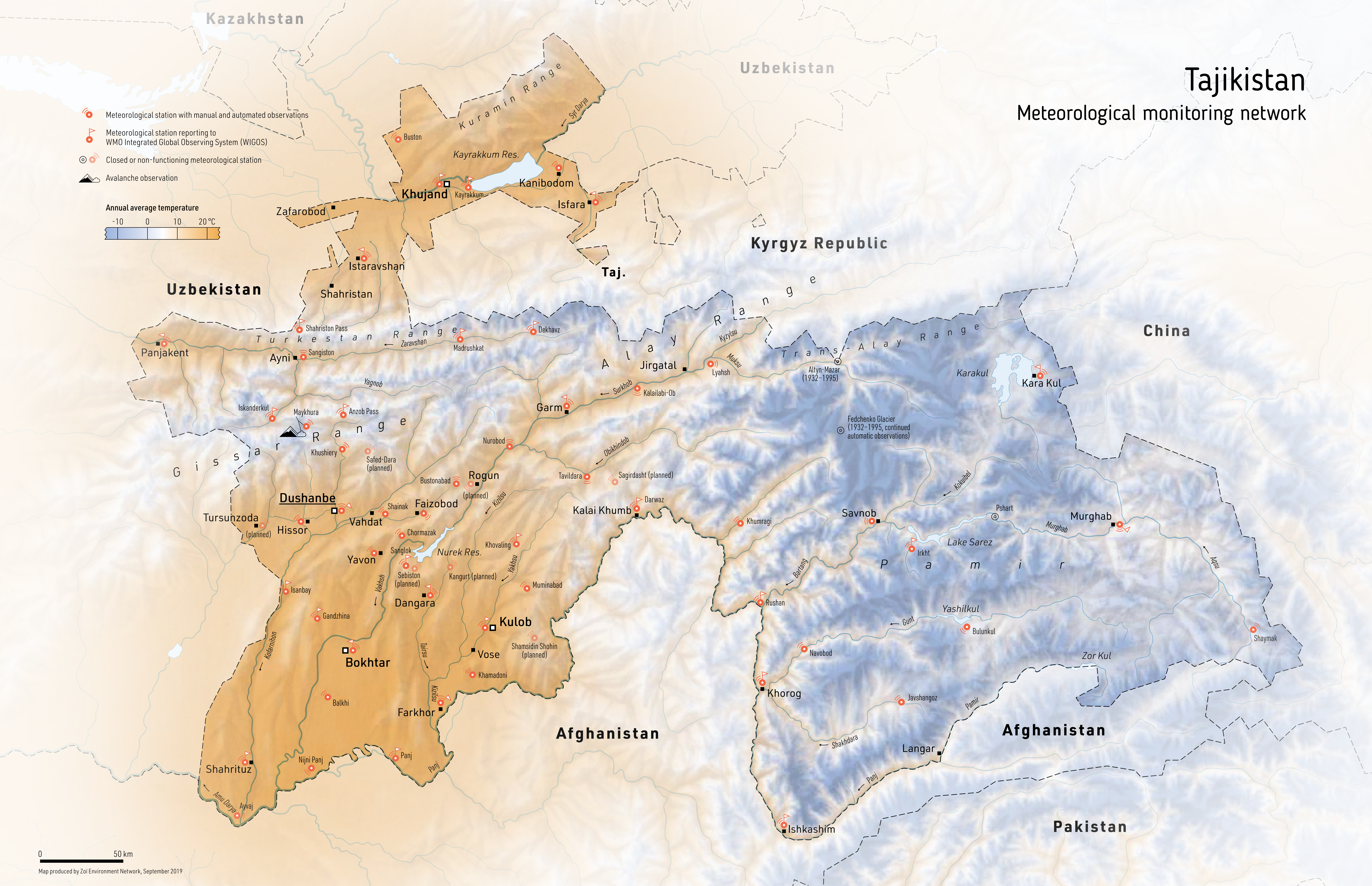
Tajikistan

Land cover and features

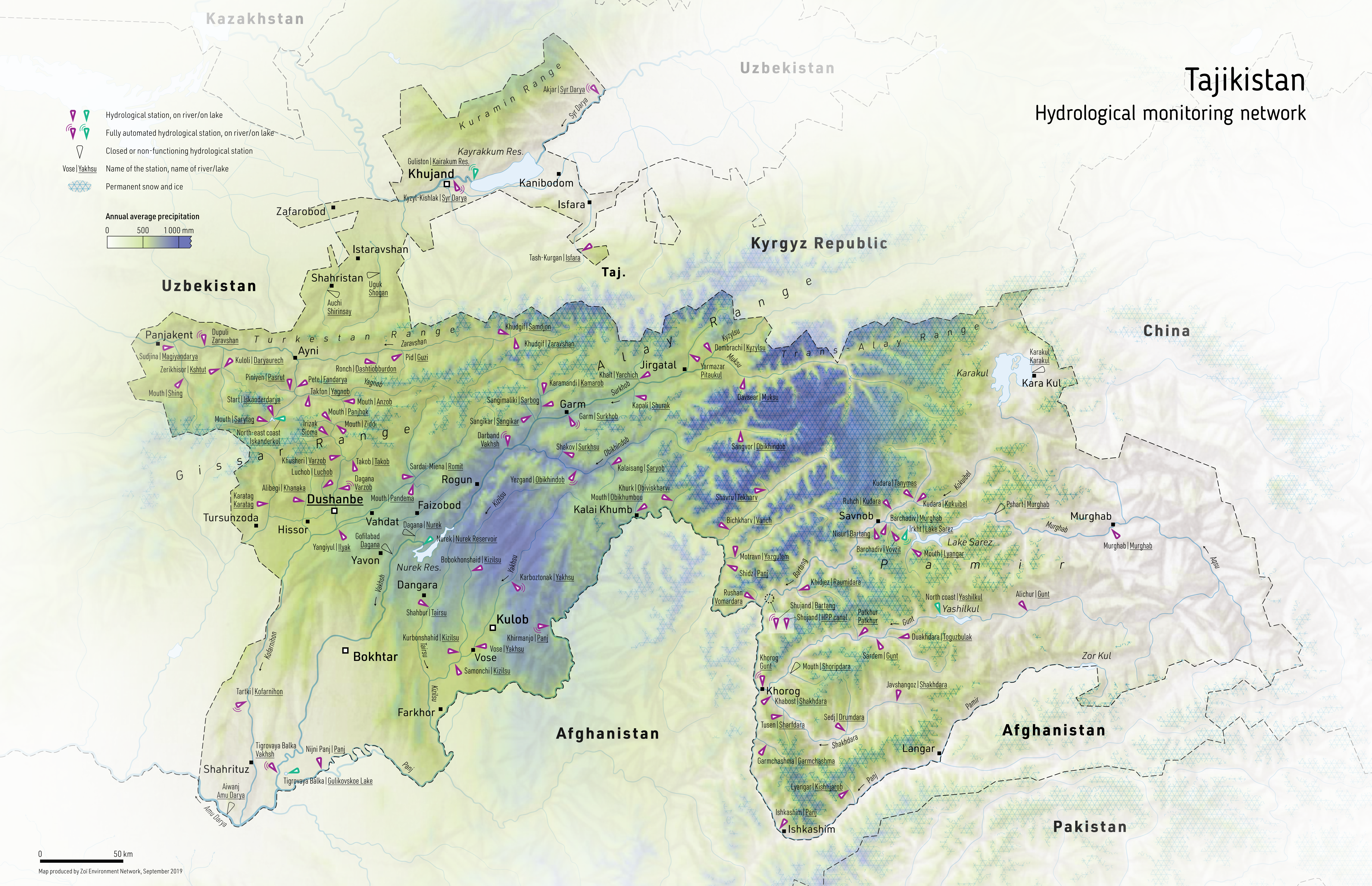
Weather and climate conditions in Tajikistan are strongly influenced by mountains. Half the country is above 3 000 metres, with the highest summits exceeding 7 000 metres. Glaciers including ice giants measuring 20–70 kilometers cover nearly 6 per cent of the country, twice the area of its forest cover. Winter temperatures in the mountains can be as cold as -50°C, while southern lowland deserts during hot summer months can reach over +40°C. Tajikistan is prone to natural disasters and ranks high on the international climate change impact lists. It is also Central Asia's poorest country with high external debt – one of the reasons international donors provide development assistance mainly in the form of grants. Its rapidly growing population depends on rain-fed agriculture for food, and the national economy depends on irrigated agriculture for cotton exports. Glaciers and snow in the mountains comprise essential water reserve for the Amu Darya River, which drains into the Aral Sea.

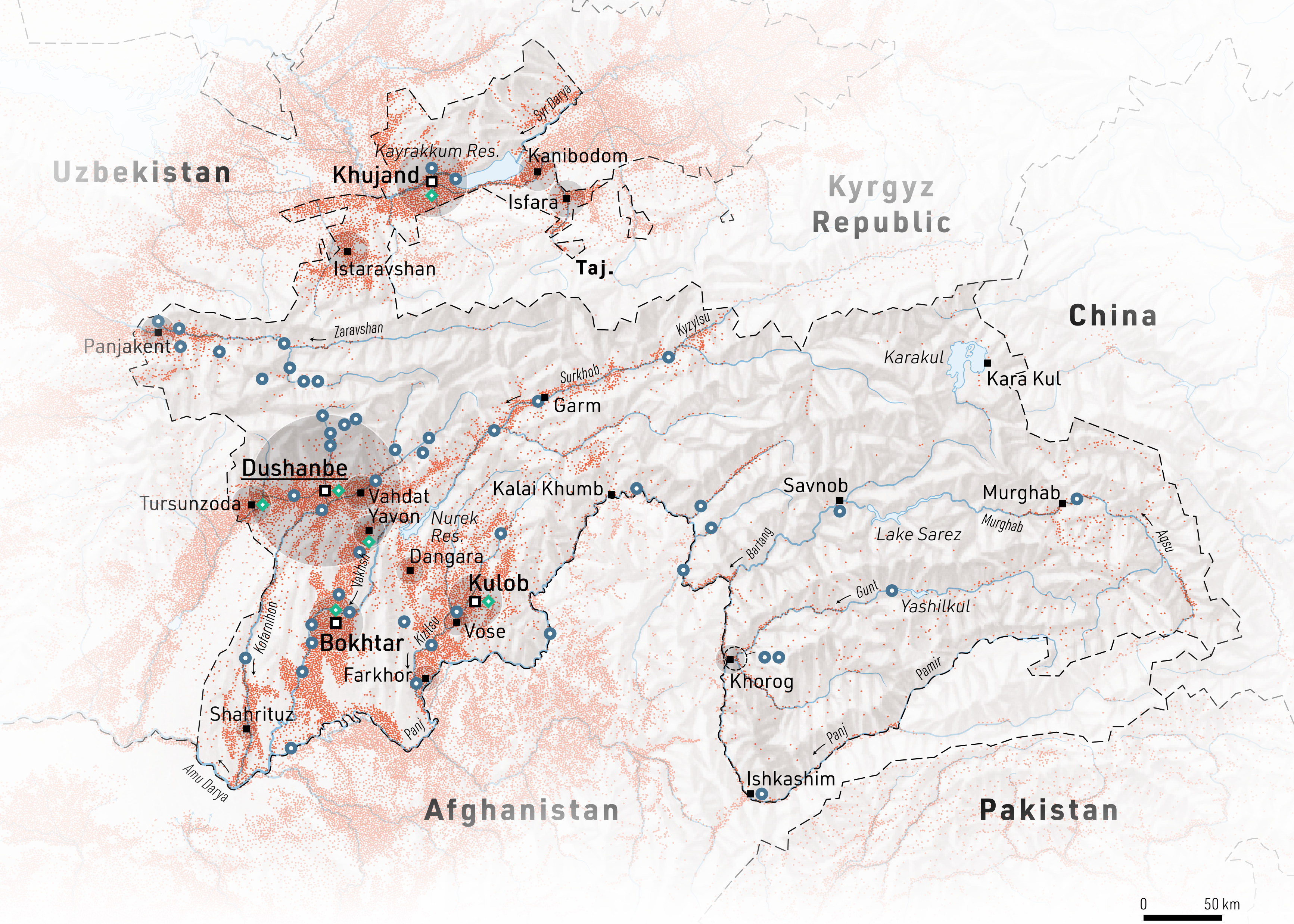


Map produced by Zoï Environment Network, September 2019


Tajikistan
Meteorological monitoring network
Meteorological station with manual and automated observations
Meteorological station reporting to WMO Integrated Global Observing System (WIGOS)
Closed or non-functioning meteorological station
Avalanche observation
Annual average temperature
-10 0 10 20 °C
Kazakhstan
Uzbekistan
Uzbekistan
Kyrgyz Republic
China
Afghanistan
Afghanistan
Pakistan
Taj.
Kuramin Range
Syr Darya
Kayrakkum Res.
Buston
Khujand
Kayrakkum
Kanibodom
Isfara
Zafarobod
Istaravshan
Shahristan
Shahriston Pass
Turkestan Range
Zaravshan
Panjakent
Ayni
Sangiston
Madrushkat
Dekhavz
Yagnob
Alay Range
Trans-Alay Range
Jirgatal
Kyzylsu
Muksu
Lyahsh
Altyn-Mazar (1932-1995)
Karakul
Kara Kul
Surkhob
Kalailabi-Ob
Garm
Iskanderkul
Maykhura
Anzob Pass
Gissar Range
Khushiery
Safed-Dara (planned)
Nurobod
Fedchenko Glacier (1932-1995, continued automatic observations)
Obikhingob
Tavildara
Sagirdasht (planned)
Bustonabad
Rogun
(planned)
Kizilsu
Kokuibel
Dushanbe
Tursunzoda
(planned)
Hissor
Vahdat
Shainak
Faizobod
Darwaz
Kalai Khumb
Khumragi
Savnob
Pshart
Murghab
Murghab
Chormazak
Nurek Res.
Khovaling
Lake Sarez
Irkht
Yavon
Sanglok
Sebiston (planned)
Kangurt (planned)
Vakhsh
Vakhsh
Muminabad
Bartang
Pamir
Aksu
Isanbay
Dangara
Rushan
Yashilkul
Gunt
Bulunkul
Shaymak
Gandzhina
Kulob
Kofarnihon
Shamsidin Shohin (planned)
Bokhtar
Taírsu
Vose
Navobod
Zor Kul
Khamadoni
Khorog
Balkhi
Kizilsu
Farkhor
Javshangoz
Pamir
Panj
Panj
Shakhdara
Langar
Shahrituz
Nijni Panj
Amu Darya
Aywaj
Panj
Ishkashim
0 50 km
Map produced by Zoi Environment Network, September 2019

Tajikistan
Hydrological monitoring network





Map produced by Zoï Environment Network, September 2019

Tajikistan
Environmental monitoring network

Water monitoring

Air monitoring

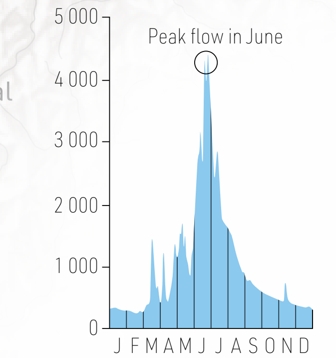
Grouped stations due to lack of space in the map

Population density

Population of major cities

1 000 000
500 000
200 000
100 000
50 000
20 000

Map produced by Zoï Environment Network, September 2019



Hydrograph of the Panj River in 2005

Flow in Khamadoni district, Tajikistan
Water discharge (m³/s)

The upper Amu Darya river basin and hydrology cooperation

Scale of average annual flow (m³/s)

200 400 600 800 1 000

River regime

Glacier-snow feeding

Snow-glacier feeding

Snow-rain feeding

Hydrological station on transboundary river

563 Average annual flow (m³/s)

The Amu Darya River forms most of the border between Afghanistan and Tajikistan, and is the longest, most complex river in Central Asia. The accuracy of hydrological forecasts for the Amu Darya depends upon the collection of many observations on its tributaries. Normal border security issues – plus the occasional gunfire – have limited the opportunities for observers to conduct their work safely, and reliable forecasts are rare. An agreement between the two countries for the exchange of hydrological data on the shared river has contributed to improved information and awareness about the river, but data flow is still limited and irregular. The ongoing cooperation between the countries with support of the international community is exploring options for more robust hydrological observations and forecasting methods. The Upper Amu Darya is subject to seasonal flooding and flash floods, and Tajikistan's cooperation with its upstream neighbour can improve flood risk forecasting and prevention.

Turkmenistan

The Hydrometeorological Service of Turkmenistan (Turkmen Hydromet) was established in 1926, and several of its meteorological stations have climate observation records going back 100 years. Until recently, Turkmen Hydromet operated as an independent structure under the Cabinet of Ministers of Turkmenistan. In 2019 it merged with the Ministry of agriculture and environmental protection of Turkmenistan. Turkmen Hydromet is fully financed from the governmental budget, and its paid and contractual services are minor. All basic information is provided to governmental and local authorities and the population free of charge.

The Government of Turkmenistan recognizes the importance of its hydrometeorological service, and invests in modernization. The new building of Turkmen Hydromet quickly became one of Ashgabat's landmarks thanks to its large screen with a national weather map and official forecasts. The national hydrometeorological service employs more than 600 people to operate a network of almost 100 stations spread across the country and involved in disciplines from weather forecasting and marine observations to agrometeorological and hydrological surveys and climate data management. Most observations are manual, but increasingly weather stations are being automated. Climate research is an emerging area for Turkmen Hydromet as the country is vulnerable to climate change impacts such as the growing number of hot days, water deficits, flash floods in the mountains, and Caspian Sea level fluctuations.

Accurate weather forecasts and early warnings depend on technical equipment, the density of the meteorological network, the skills of forecasters and numerical weather prediction. Under the Central Asia Hydromet Modernization Project, specialists from Turkmen Hydromet benefited from training, experience exchange and improved access to the regional weather prediction products. In 2014 Turkmenistan signed an agreement on cooperation in hydrometeorology for the Caspian Sea region. Six marine stations and three marine radar installations monitor the Turkmen coast of the Caspian Sea.

National hydrometeorological service of Turkmenistan in numbers

600 People employed

Ashgabat Central office

58 Meteorological stations, including automated

5 Agrometeo posts

2 200 m to -27 m Elevation range of hydromet observations

20 Meteorological and hydrological stations report internationally

5 Meteorological and marine radar units

0 Snow avalanche monitoring stations

1 Upper air (aerological) weather stations

33 Hydrological gauges, including automated

0 Snow monitoring routes and glaciers regularly monitored

40 Environmental quality monitoring locations, including air sampling stations

Forecast accuracy in meteorology: **85-90%** 1-7 days

Official website and online services

Forecast accuracy in hydrology: **80-90%** seasonal water flow

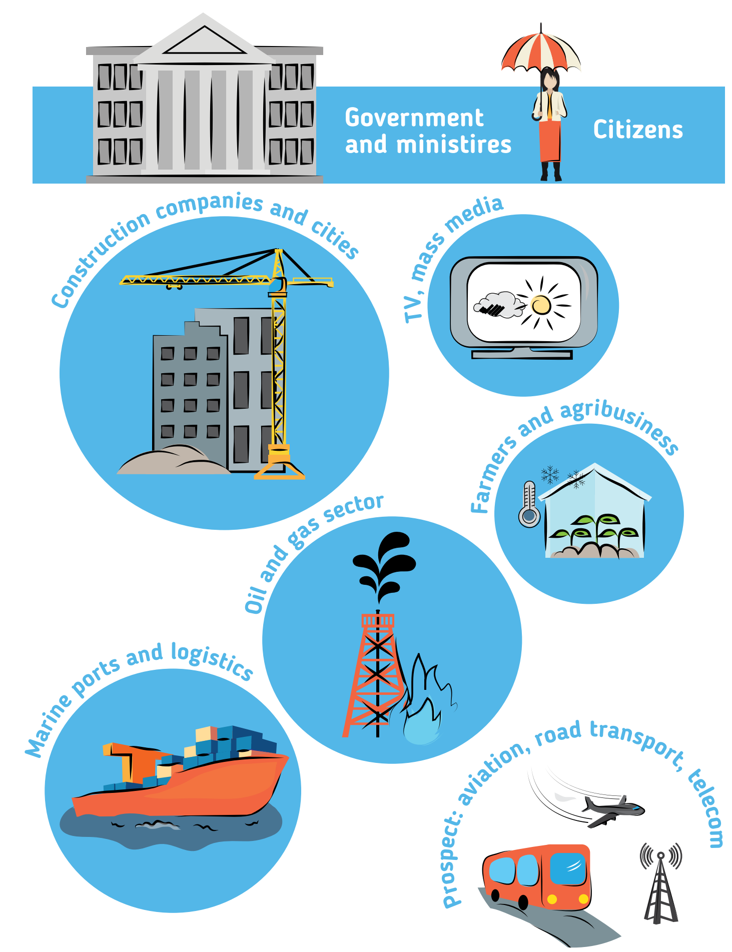
Data for November 2019

The typical consumers of hydrometeorological information in Turkmenistan, in addition to the key users among governmental ministries and the general public, are the construction firms, transport and energy companies, and farmers.

Booming housing and commercial construction drive demand for climate information in the building sector, while oil and gas and transport companies are regular clients of the Turkmen Hydromet for specialized hydrometeorological data and services to ensure safety of their operations on the land, at sea and in the air. Airports and air carriers of Turkmenistan receive specialized services on the basis of agreements on mutually beneficial cooperation.

A central concern of the agricultural sector is the availability of water for the irrigation of cotton, wheat, fruits and vegetables. Upstream users generally receive enough water, but shortages are common near the Aral Sea. A small but growing private segment of the sector is planting new crops, and seeks hydromet information specific to their needs including localized and specific weather data and early warnings of extreme weather, such as heat waves, frost and dust storms that can affect crops and animals. Turkmen Hydromet is providing climate data based on individual requests from farmers and produces agrometeorological forecasts and bulletins useful for agricultural enterprises.

Main clients of general and customized hydrometeorological information in Turkmenistan



Recipients of the basic and free information, such as weather warnings and forecasts

Recipients of the customized sector-specific fee-based services and information

The bigger the size of sector circle, the larger the relative share or value of the commercial hydromet services

Turkmenistan

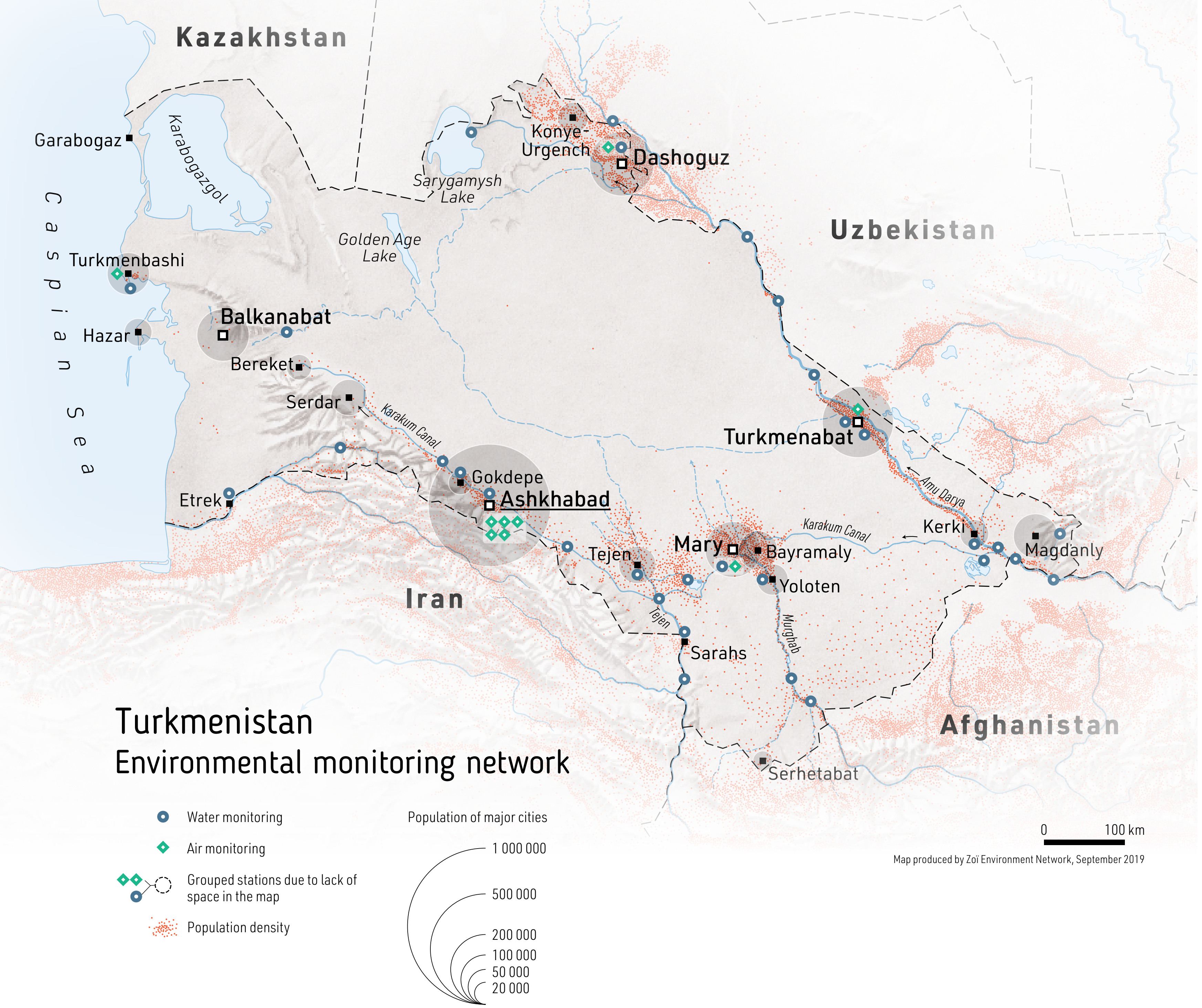
Land cover and features

With its southernmost location in Central Asia and its vast sandy deserts, Turkmenistan is hot and dry. The country is sparsely populated with concentrations along the base of the mountains, on the Amu Darya River and near the Caspian Sea. The largest desert is Karakum, covering 350 000 km² – twice the size of Tajikistan. Rainfall is scarce, with an annual average 100 mm in central parts of the country. In mountain areas precipitation is higher – up to 400 mm per year – where rainfall can trigger destructive flas floods. Summer temperatures in Ashgabat, the hottest capital city in Central Asia, reach +40°C, and can soar +50°C in the Repetek reserve. Winter is mild, but intrusions of cold Arctic air can lower air temperatures to -30°C.

Map produced by Zoi Environment Network, September 2019


Turkmenistan
Meteorological monitoring network
Meteorological station
Agrometeorological and meteorological posts
Unmanned automated weather station
Stations reporting to WMO Integrated Global Observing System (WIGOS)
Grouped stations due to lack of space in the map
Weather radar for aviation *
Upper air observations
Provincial hydrometeorological center
Annual average temperature
-10
0
10
20 °C
* Weather radar range is approximate and varies per location and type of equipment
Kazakhstan
Uzbekistan
Iran
Afghanistan
Caspian Sea
Karabogazgol
Khwarazm
Karakum
Kopetdag
Sarygamysh Lake
Golden Age Lake
Great Balkhan Range
Koytendag Range
Dashoguz Collector
Great Turkmen Collector
Karakum Canal
Amu Darya
Uzboy
Etrek
Tejen
Murghab
Garabogaz
Duzlybogaz
Gowlymayak
Turkmenbashi
Awaza
Hazar
Ogurjaly
Balkanabat
Bereket
Serdar
Bugdayly
Bekibent
Ekerem
Etrek
Esenguly
Cagyl
Yasga
Dawaly
Derweze
Ekezhe
Sasenem
S. Turkmenbashy
Konye-Urgench
Akdepe
Boldumsaz
Gubadag
Dashoguz
Gurbansoltan Eje
Gorogly
Akmolla
Yerbent
Bokurdak
Magtymguly
Aydere
Nohur
Duzlydepe
Garawul
Konekesir
Baherden
Akdepe
Gokdepe
Dusak-Erek dag
Ashkhabad
Arcabil
Yaslyk
Artyk
Kaka
Tejen
Babadayhan
Altyn Asyr
Oguzhan
Denizhan
Sarahs
Pesanaly
Garagum
Sakarcage
Mary
Bayramaly
Murgap
Turkmengala
Yoloten
Dowletli
Saryyazy
Tagtabazar
Serhetabat
Lekker
Margiana
Bagtyyarlyk
Darganata
Seydi
Danew
Turkmenabat
Sakar
Sayat
Repetek
Garabekewul
Gunorta
Burdalyk
Halac
Kerki
Magdanly
Koytendag
Garlyk
0
100 km
Map produced by Zoi Environment Network, September 2019


Turkmenistan
Hydrological monitoring network
Hydrological station, on river/on lake
Cat | Etrek
Name of the station, name of river/lake
Sea radar
Annual average precipitation
0
500
1 000 mm
Kazakhstan
Uzbekistan
Iran
Afghanistan
Caspian Sea
Karabogazgol
Khwarazm
Karakum
Kopetdag
Garabogaz | Caspian Sea
Garabogaz
Duzlybogaz | Caspian Sea
Guwlymayak | Caspian Sea
Turkmenbashi
Awaza
Turkmenbashi | Caspian Sea
Great Balkhan Range
Hazar
Balkanabat
Ogurjaly | Caspian Sea
Ekerem
Etrek | Etrek
Etrek
Cat | Etrek
Gyzylbayyr | Sumbar
Magtymguly | Sumbar
Duzly-Depe | Sumbar
Ipaygala | Arwaz
Sekizyap | Sekizyap
Altyyap | Altyyap
Arcabil | Firjuzinka
Gokdepe
Ashkhabad
Bereket
Serdar
Garagum 969 km | Karakum Canal
Karakum Canal
Yasga | Lake Yasga
Uzboy
Golden Age Lake
Sarygamysh Lake
Dashoguz Collector
Konye-Urgench
Dashoguz
Darganata | Amu Darya
Turkmenabat
Gjunorta | Gyzyl Burun Collector
Great Turkmen Collector
Gunorta | Janubiy Collector
Gundogar | Amu Darya
Amu Darya
Kerki | Amu Darya
Kerki
Magdanly
Basgatly Amu Darya
Koytendag Range
Koyten | Kugitang
Zeyid | Zeyid Res.
Mukry | Amu Darya
Kelif | Amu Darya
Zahmet | Karakum Canal
Karakum Canal
Mary
Bayramaly
Yoloten
Tejen
Denizhan | Hanhowuz Res.
Garagum 475 km | Karakum Canal
Tejen
Sarahs
Saryyazy | Saryyaz Reservoir
Murghab
Tagtabazar | Murghab
Soyunaly | Murghab
Gulja | Kashan
Kushka
Pullyhatyn | Tejen
Serhetabat
Etrek
0
100 km
Map produced by Zoi Environment Network, September 2019



Caspian Sea coastline, Turkmenistan

Caspian seal, Turkmenistan

Uzbekistan

The Hydrometeorological Service of Uzbekistan (Uz Hydromet) was established in May 1921. The first meteorological station – Tashkent Observatory – has conducted observations since 1867. In the Soviet period Tashkent city hosting Uz Hydromet was the hydrometeorological center for all the republics of Central Asia. Since independence, Uz Hydromet has served as WMO's Regional Specialized Meteorological Centre for Central Asia, and has the capacity to run numerical weather prediction models and undertake research and training activities, and make climate change projections. Its scientific research institute NIGMI is conducting various hydrometeorological assessments and environmental studies. Its hydrometeorological college trains professional observers and junior specialists.

Uz Hydromet operates an extensive network of 85 meteorological stations, 34 agrometeorological monitoring sites and 132 hydrological gauges. The service employs more than 2 200 people. The ongoing state-funded hydromet modernization programme is aiming to improve the working conditions at meteorological stations and central offices, increase the level of automation and introduce more advanced methods for weather and water forecasting. International donors are supporting Uz Hydromet modernization through procurement of automated weather stations and environmental sampling equipment.

Environmental monitoring is conducted in 25 urban areas (air quality) at 60 sampling points, at 60 rivers and lakes at 100 sampling points (water quality) and at 40 meteorological stations (radiation). Hydro-biological studies focus on 10 locations of the Tashkent province. One station is tracking global and regional air pollutants at the remote Chatkal nature reserve.

National hydrometeorological service of Uzbekistan in numbers

2 200
People employed

Tashkent
Central office

85
Meteorological stations, including automated
34 Agrometeo posts

3 000 m to 50 m
Elevation range of hydromet observations

30
Meteorological and hydrological stations report internationally

3
Meteorological radar units

3
Snow avalanche monitoring stations

1
Upper air (aerological) weather stations

132
Hydrological gauges, including automated

5
Snow monitoring routes and glaciers regularly monitored

150
Environmental quality monitoring locations, including air sampling stations

Forecast accuracy in meteorology:
90-95% 1-7 days

meteo.uz
Official website and online services

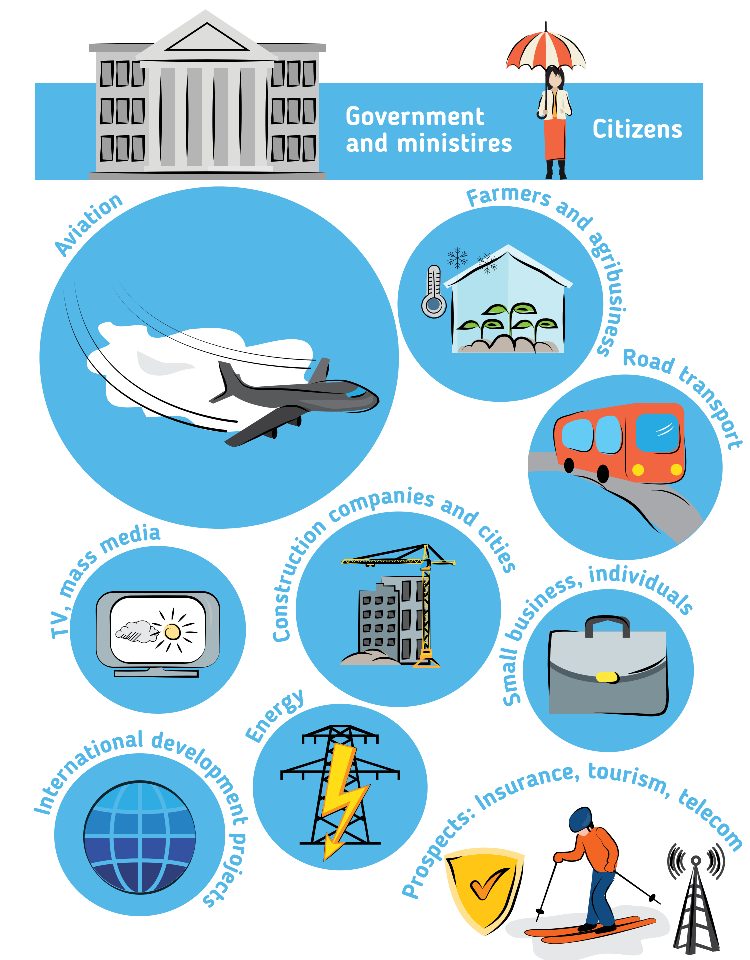
Forecast accuracy in hydrology:
80-90%
seasonal water flow

Data for November 2019

Uz Hydromet maintains a website with basic user-friendly real time weather data and forecasts, environmental quality reviews and agrometeorological bulletins for governmental and public use. The most active commercial user of the specialized hydrometeorological information in Uzbekistan is aviation. Construction, energy and road transport are other users.

Considering that half of Uzbekistan's population live in rural areas and are involved in agriculture, weather and agrometeorological information is of vital importance to their food and water security and their comfort. Commercial greenhouses, orchards, and plantations are booming in the country to serve both export and domestic markets, and farmers increasingly ask for localized and crop-specific weather data. Uz Hydromet is keen to respond to the growing demand and is seeking to further improve agrometeorological coverage.

Main clients of general and customized hydrometeorological information in Uzbekistan



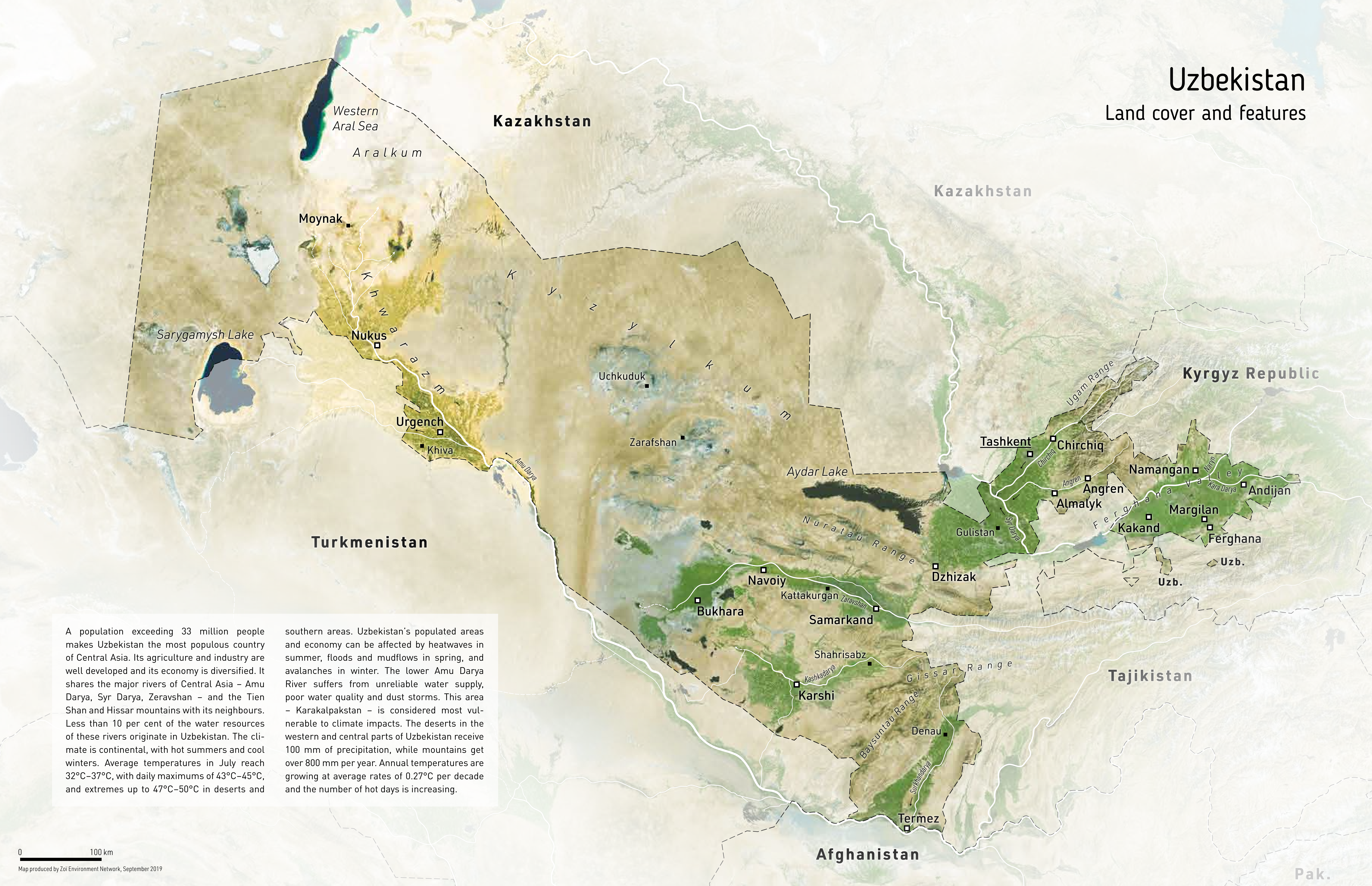
Recipients of the basic and free information, such as weather warnings and forecasts

Recipients of the customized sector-specific fee-based services and information

The bigger the size of sector circle, the larger the relative share or value of the commercial hydromet services

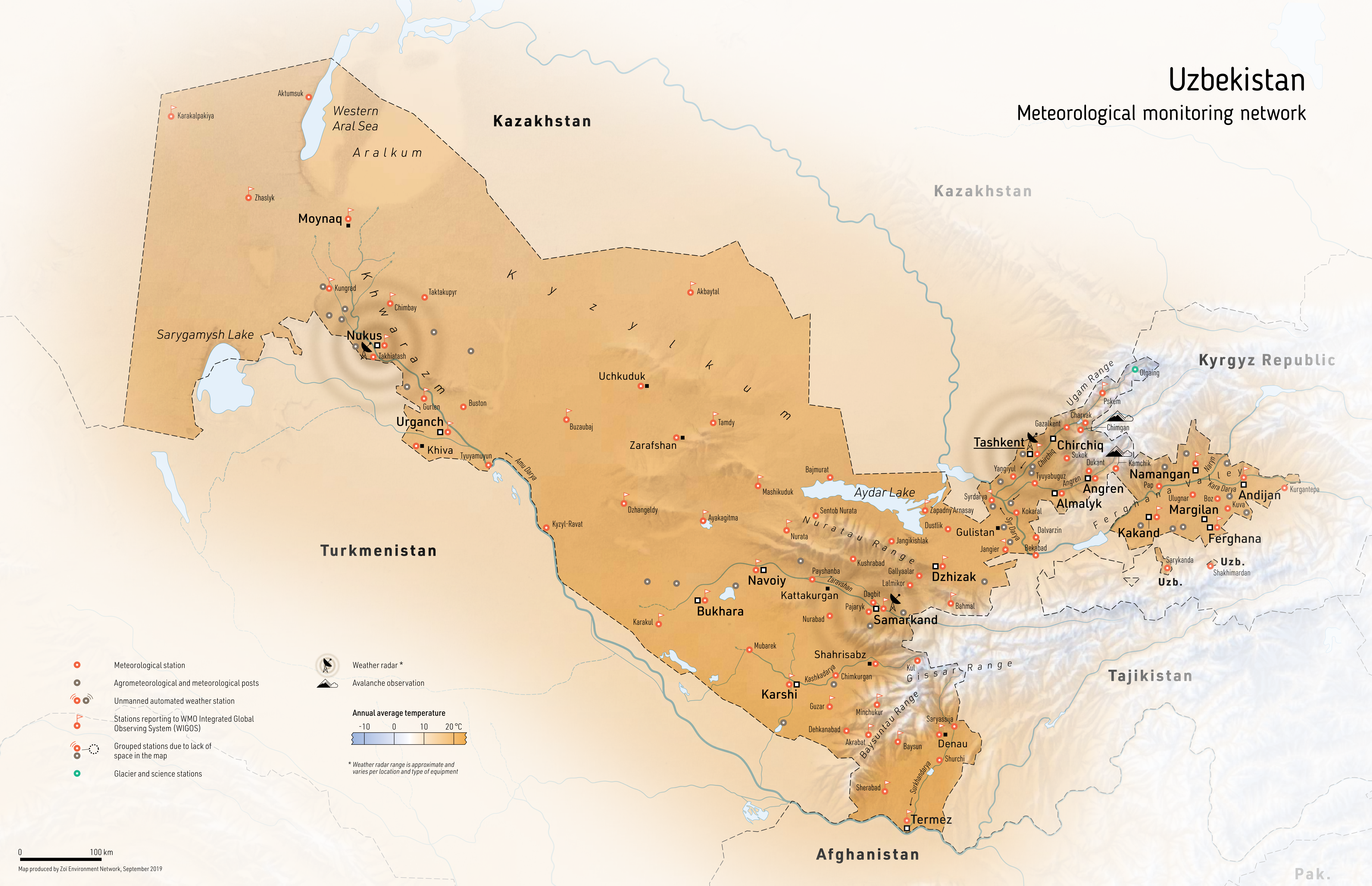
Uzbekistan

Land cover and features

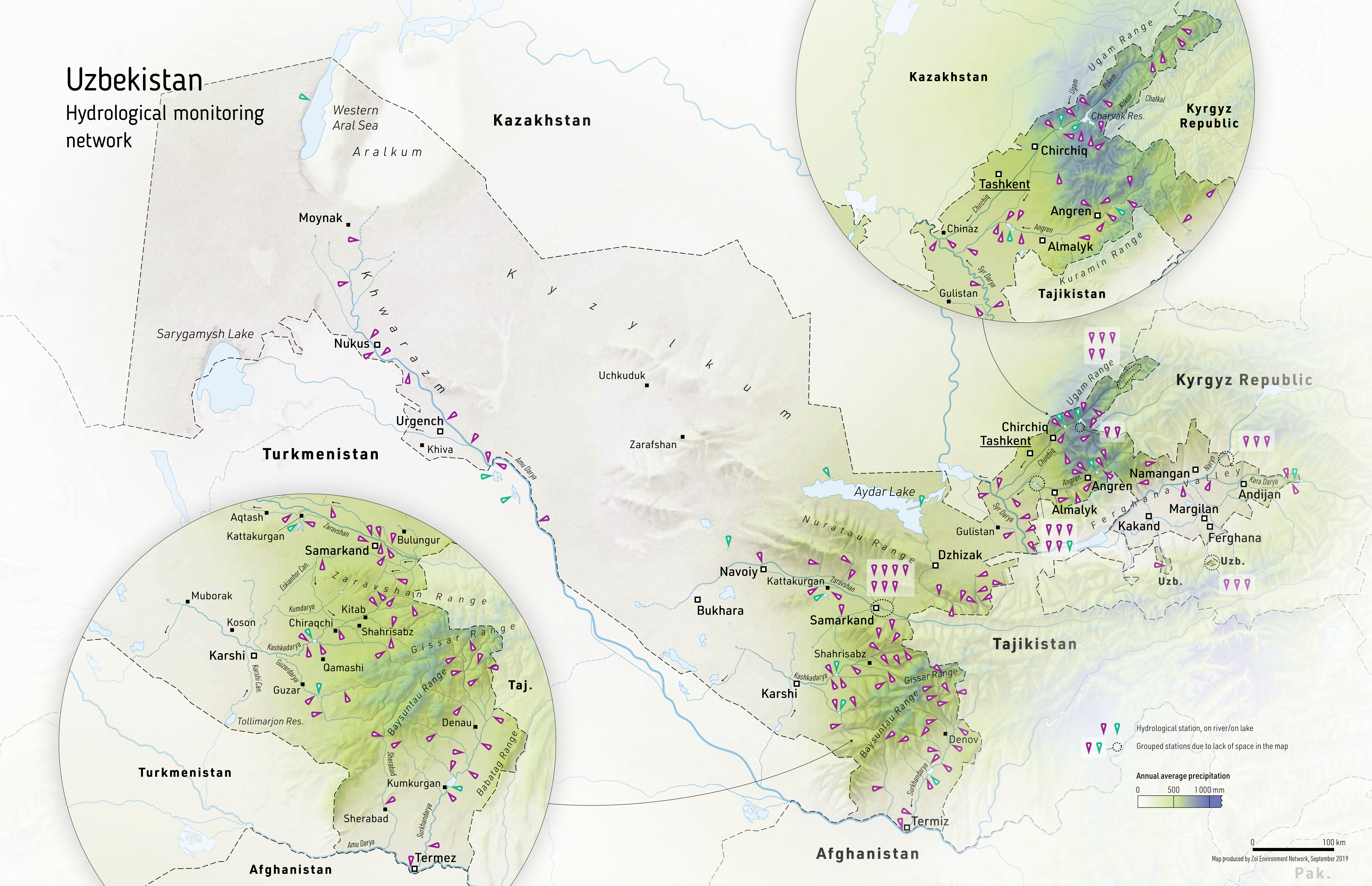


A population exceeding 33 million people makes Uzbekistan the most populous country of Central Asia. Its agriculture and industry are well developed and its economy is diversified. It shares the major rivers of Central Asia – Amu Darya, Syr Darya, Zeravshan – and the Tien Shan and Hissar mountains with its neighbours. Less than 10 per cent of the water resources of these rivers originate in Uzbekistan. The climate is continental, with hot summers and cool winters. Average temperatures in July reach 32°C–37°C, with daily maximums of 43°C–45°C, and extremes up to 47°C–50°C in deserts and southern areas. Uzbekistan's populated areas and economy can be affected by heatwaves in summer, floods and mudflows in spring, and avalanches in winter. The lower Amu Darya River suffers from unreliable water supply, poor water quality and dust storms. This area – Karakalpakstan – is considered most vulnerable to climate impacts. The deserts in the western and central parts of Uzbekistan receive 100 mm of precipitation, while mountains get over 800 mm per year. Annual temperatures are growing at average rates of 0.27°C per decade and the number of hot days is increasing.

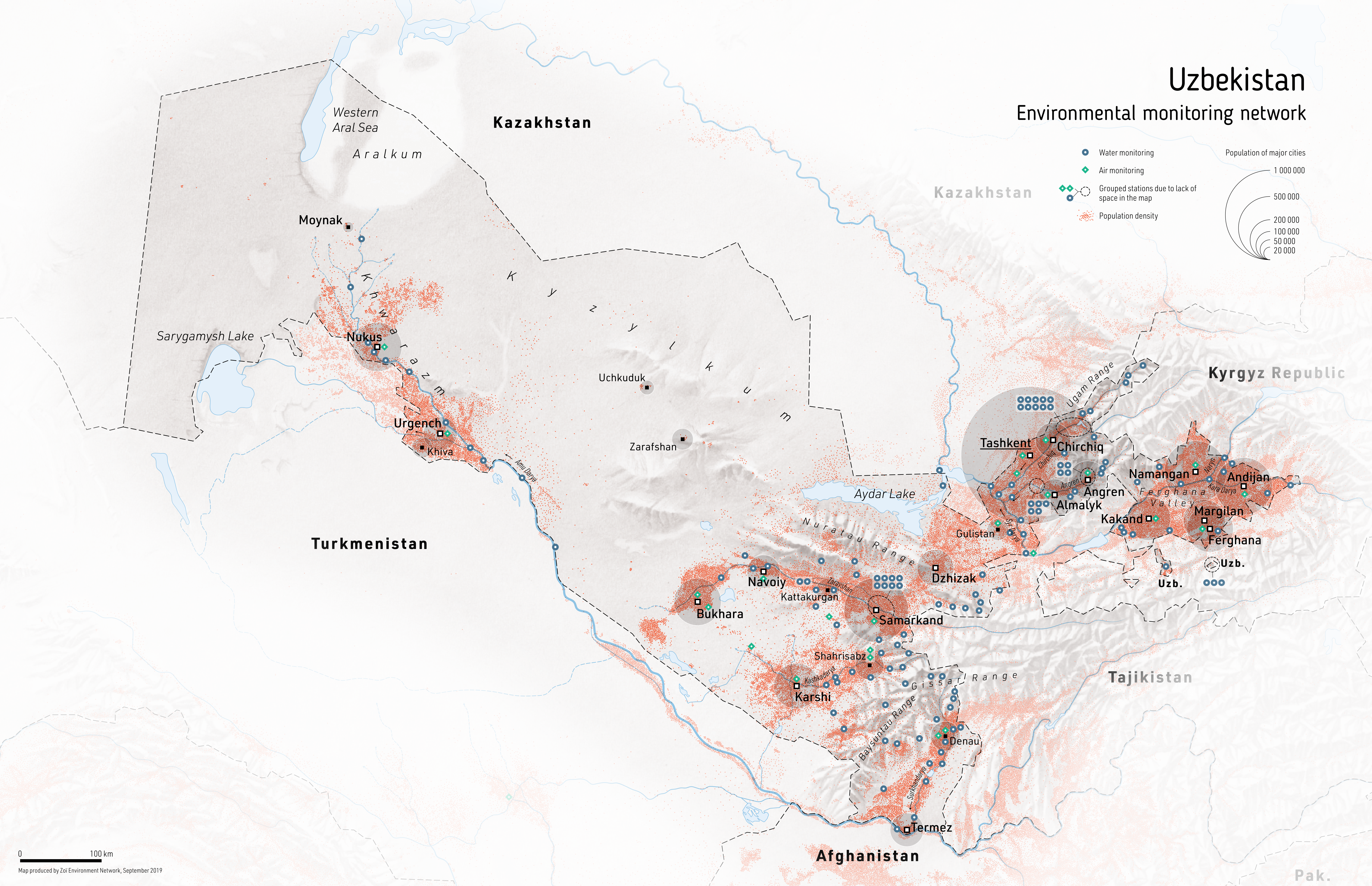
Map produced by Zoï Environment Network, September 2019



Uzbekistan
Meteorological monitoring network
Kazakhstan
Kazakhstan
Kyrgyz Republic
Tajikistan
Turkmenistan
Afghanistan
Pak.
Uzb.
Uzb.
Western Aral Sea
Aralkum
Kyzylkum
Khwarazm
Sarygamysh Lake
Aydar Lake
Nuratau Range
Gissar Range
Baysuntau Range
Ugam Range
Fergana Valley
Amu Darya
Syr Darya
Zarafshan
Kashkadarya
Surkhandarya
Chirchiq
Angren
Naryn
Kara Darya
Aktumsuk
Karakalpakiya
Zhaslyk
Moynaq
Kungrad
Chimbay
Taktakupyr
Nukus
Takhiatash
Gurlen
Buston
Urganch
Khiva
Tyuyamuyun
Akbaytal
Uchkuduk
Buzaubaj
Zarafshan
Tamdy
Kyzyl-Ravat
Dzhangeldy
Mashikuduk
Bajmurat
Ayakagitma
Sentob Nurata
Nurata
Zapadny Arnasay
Dustlik
Gulistan
Jangier
Syrdarya
Yangiyul
Tashkent
Chirchiq
Sukok
Gazalkent
Charvak
Pskem
Chimgan
Oigaing
Tyuyabuguz
Angren
Almalyk
Dukant
Kokaral
Dalvarzin
Bekabad
Kamchik
Namangan
Pap
Ulugnar
Boz
Kuva
Andijan
Kurgantepa
Margilan
Kakand
Ferghana
Sarykanda
Shakhimardan
Jangikishlak
Kushrabad
Gallyaalar
Dzhizak
Lalmikor
Bahmal
Dagbit
Pajaryk
Samarkand
Payshanba
Navoiy
Kattakurgan
Bukhara
Karakul
Nurabad
Mubarek
Shahrisabz
Kul
Chimkurgan
Karshi
Guzar
Minchukur
Dehkanabad
Akrabat
Baysun
Saryassija
Denau
Shurchi
Sherabad
Termez
Meteorological station
Agrometeorological and meteorological posts
Unmanned automated weather station
Stations reporting to WMO Integrated Global Observing System (WIGOS)
Grouped stations due to lack of space in the map
Glacier and science stations
Weather radar *
Avalanche observation
Annual average temperature
-10
0
10
20 °C
* Weather radar range is approximate and varies per location and type of equipment
0
100 km
Map produced by Zoï Environment Network, September 2019



Uzbekistan
Hydrological monitoring network
Western Aral Sea
Aralkum
Kazakhstan
Moynak
Khwarazm
Kyzylkum
Sarygamysh Lake
Nukus
Uchkuduk
Urgench
Khiva
Turkmenistan
Amu Darya
Zarafshan
Aydar Lake
Nuratau Range
Navoiy
Kattakurgan
Bukhara
Samarkand
Dzhizak
Shahrisabz
Karshi
Gissar Range
Baysuntau Range
Denov
Termiz
Afghanistan
Tajikistan
Kyrgyz Republic
Ugam Range
Chirchiq
Tashkent
Angren
Almalyk
Gulistan
Namangan
Margilan
Kakand
Ferghana
Andijan
Fergana Valley
Uzb.
Kazakhstan
Kyrgyz Republic
Charvak Res.
Chinaz
Kuramin Range
Tajikistan
Aqtash
Kattakurgan
Bulungur
Samarkand
Zaravshan Range
Muborak
Koson
Kitab
Chiraqchi
Shahrisabz
Karshi
Qamashi
Guzar
Tollimarjon Res.
Denau
Kumkurgan
Sherabad
Babatag Range
Termez
Taj.
Turkmenistan
Afghanistan
Hydrological station, on river/on lake
Grouped stations due to lack of space in the map
Annual average precipitation
0 500 1 000 mm
0 100 km
Map produced by Zoi Environment Network, September 2019


Uzbekistan
Environmental monitoring network
Water monitoring
Air monitoring
Grouped stations due to lack of space in the map
Population density
Population of major cities
1 000 000
500 000
200 000
100 000
50 000
20 000
Kazakhstan
Kazakhstan
Kyrgyz Republic
Tajikistan
Turkmenistan
Afghanistan
Pak.
Western Aral Sea
Aralkum
Kyzylkum
Khwarazm
Sarygamysh Lake
Aydar Lake
Nuratau Range
Ugam Range
Gissar Range
Baysuntau Range
Ferghana Valley
Amu Darya
Zarafshan
Kashkadarya
Surkhandarya
Syr Darya
Chirchiq
Angren
Naryn
Kara Darya
Moynak
Nukus
Urgench
Khiva
Uchkuduk
Zarafshan
Bukhara
Navoiy
Kattakurgan
Samarkand
Dzhizak
Gulistan
Tashkent
Chirchiq
Angren
Almalyk
Namangan
Andijan
Kakand
Margilan
Ferghana
Uzb.
Uzb.
Shahrisabz
Karshi
Denau
Termez
0
100 km
Map produced by Zoï Environment Network, September 2019

Modernization of hydrometeorological stations, Tajikistan

6

Towards improved hydromet services

The users of hydrometeorological services face an array of increasing meteorological and hydrological challenges, and hydromet services are responding to the changing needs of users by working to provide the information required for action, and by taking a more service-oriented approach.

The core business of hydromets is weather forecasting, and if the weather is a moving target, so too is the rapidly evolving field of forecasting. Modern hydromets process and integrate massive amounts of data from sophisticated ground measurement instruments, satellites, and meteorological radar, and incorporate their findings into their weather reports. Global and regional climate data centres employ cloud computing and prepare numerical forecasts that supplement, but cannot replace, the qualified forecasters whose interpretations of complex information and professional judgment inform their reports.

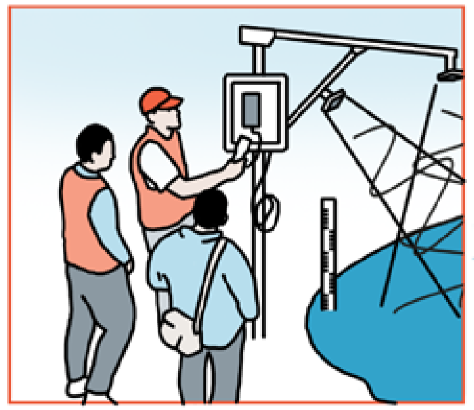
As in any field with relentless advancements in technology and knowledge, ongoing professional development is crucial to ongoing success. To keep up with advances in IT, remote sensing and modelling, forecasters need to attend conferences and workshops and get regular training.

Modernization accomplishments and plans

Human resources

Before modernization

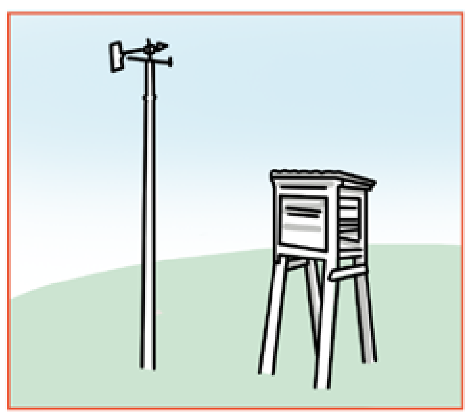
After modernization



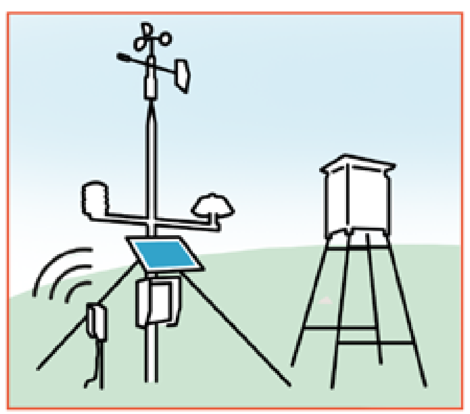
For years, the staff of hydromet services collected manual observations, and received little or no professional development training. Recent modernization efforts have included the specialist training at national and international workshops and the publication of manuals for use in the observation networks and specialized services. Training centres provide well-equipped classrooms, and offer on-site and online education and training. Field staff have received training and special clothing.

Observation network

Before modernization



After modernization

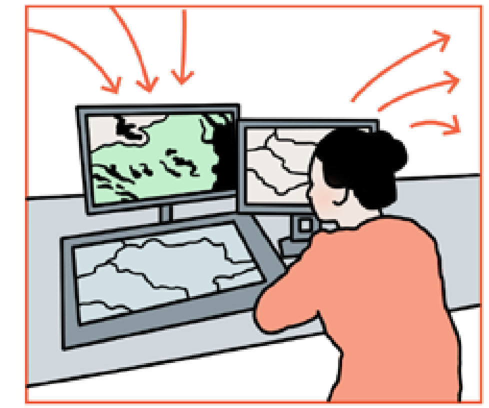


Prior to modernization, the observation networks relied on basic manual devices that were becoming obsolete. Now the networks include automated meteorological and hydrological stations that improve hydrometeorological observations and strengthen the collection of data related to potential hazards. Other improvements include the restoration of key manual stations and the installation of new monitoring equipment – flow meters, water thermometers and devices for monitoring evaporation. The avalanche service added cross-country vehicles.

Accuracy of forecasts

Before modernization

After modernization

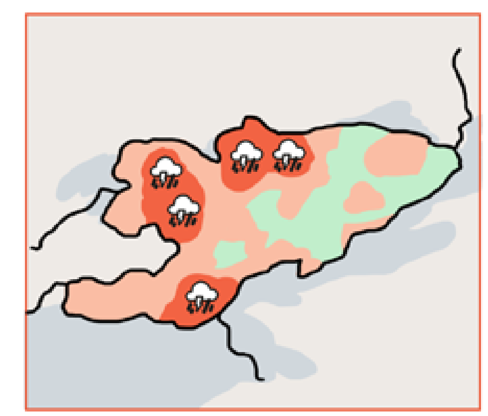


The manual, paper-based approach to integrating data into a forecast is giving way to modern methods. A data centre and communication system receives hydrometeorological data from the field and distributes the data to the appropriate departments for processing and analysis. Laboratories house modern calibration equipment and measuring devices. The climate service has new software, and upgraded systems and databases. A new web portal contains products for the general public, economic sectors, and other hydromet users, and for hydromet staff.

Severe weather warnings

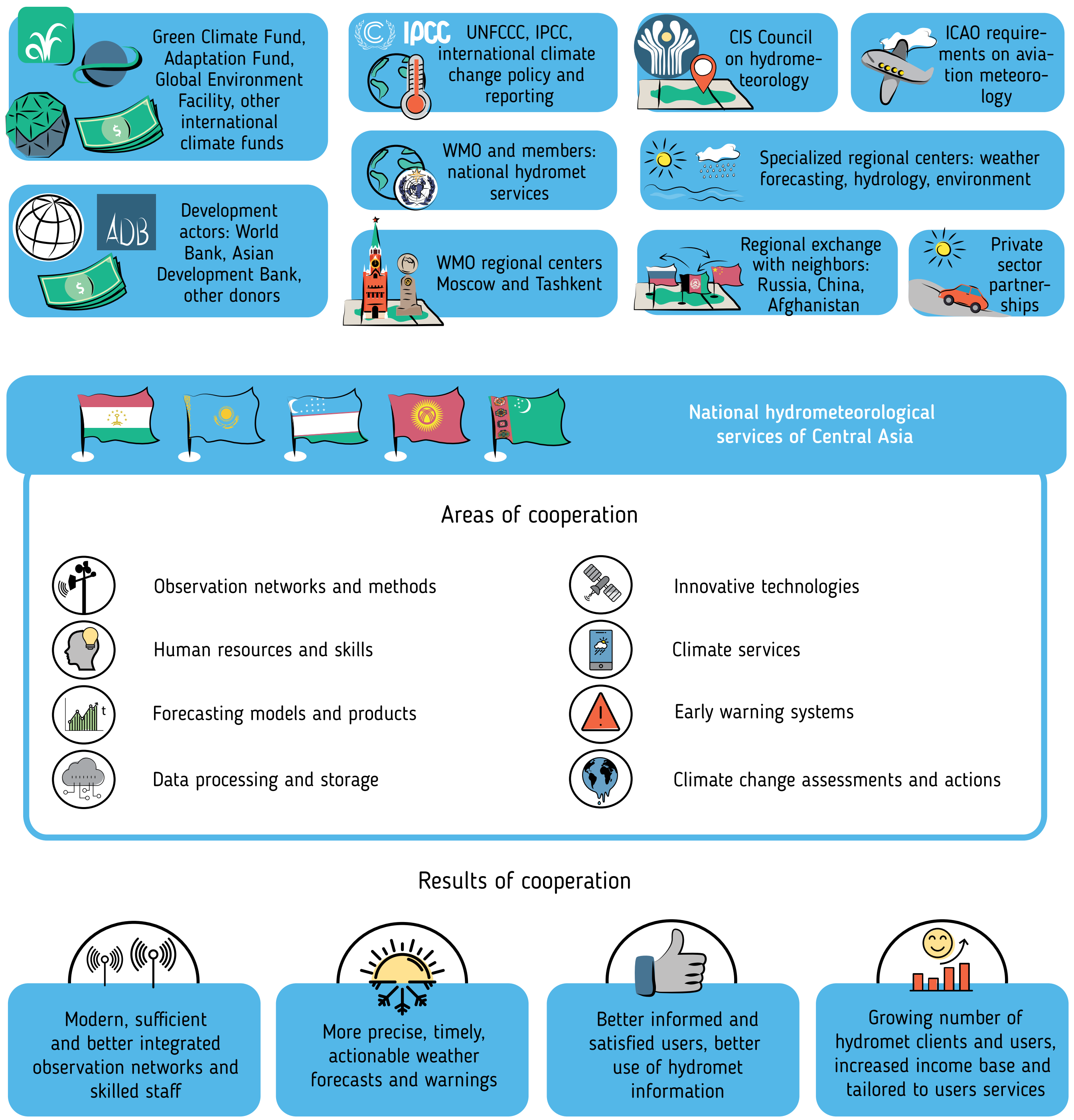
Before modernization

After modernization



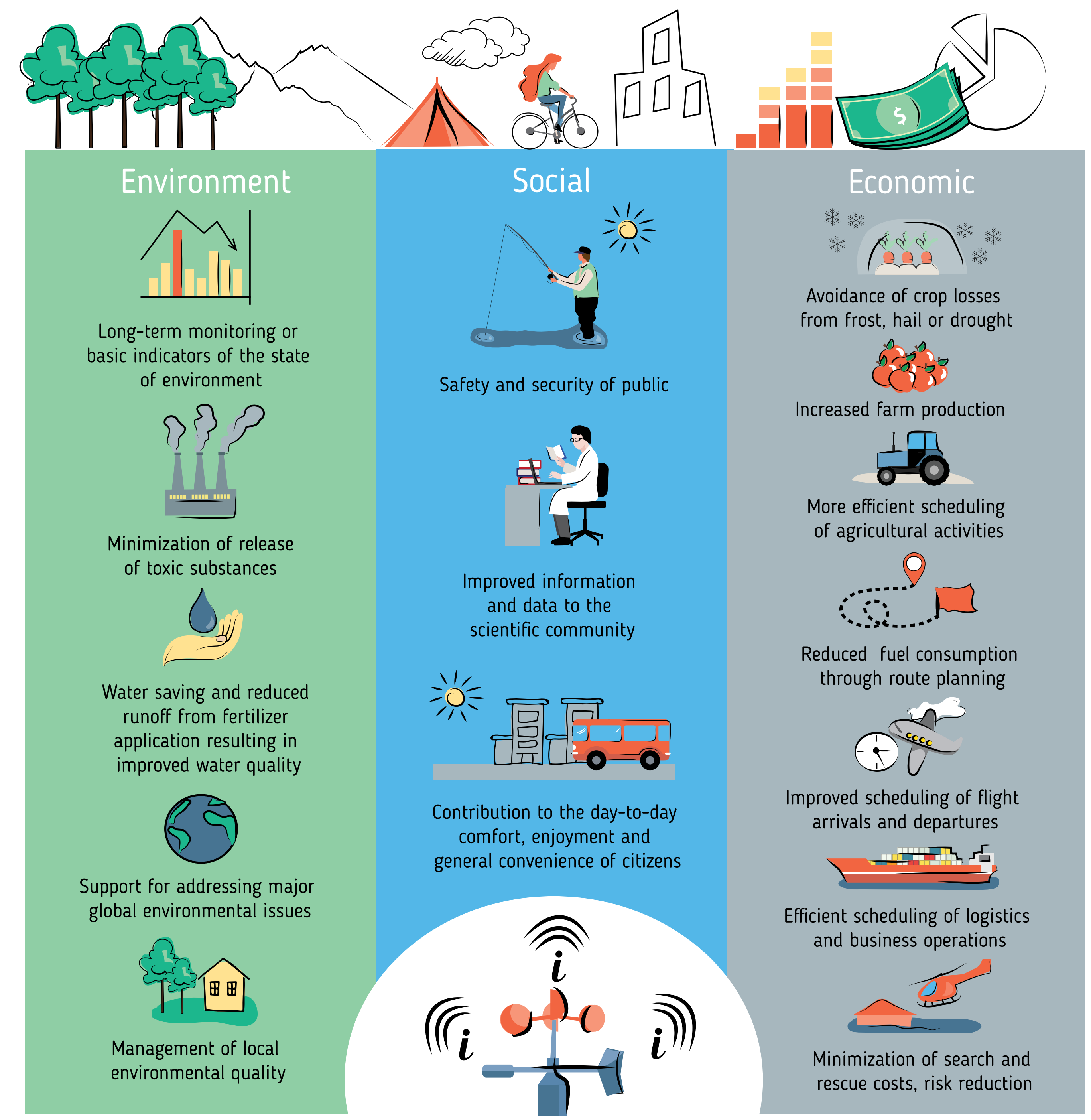
With a limited number of stations to provide coverage and a lack of software and prediction products, forecasters had inadequate tools for making accurate and timely severe weather warnings. With modernization, forecasters now have the ability to provide better spatial accuracy and more practical warnings supported by visuals that users can understand. False alarms have decreased, and the warnings are better integrated into the mass media for wide dissemination.

Regional and international cooperation



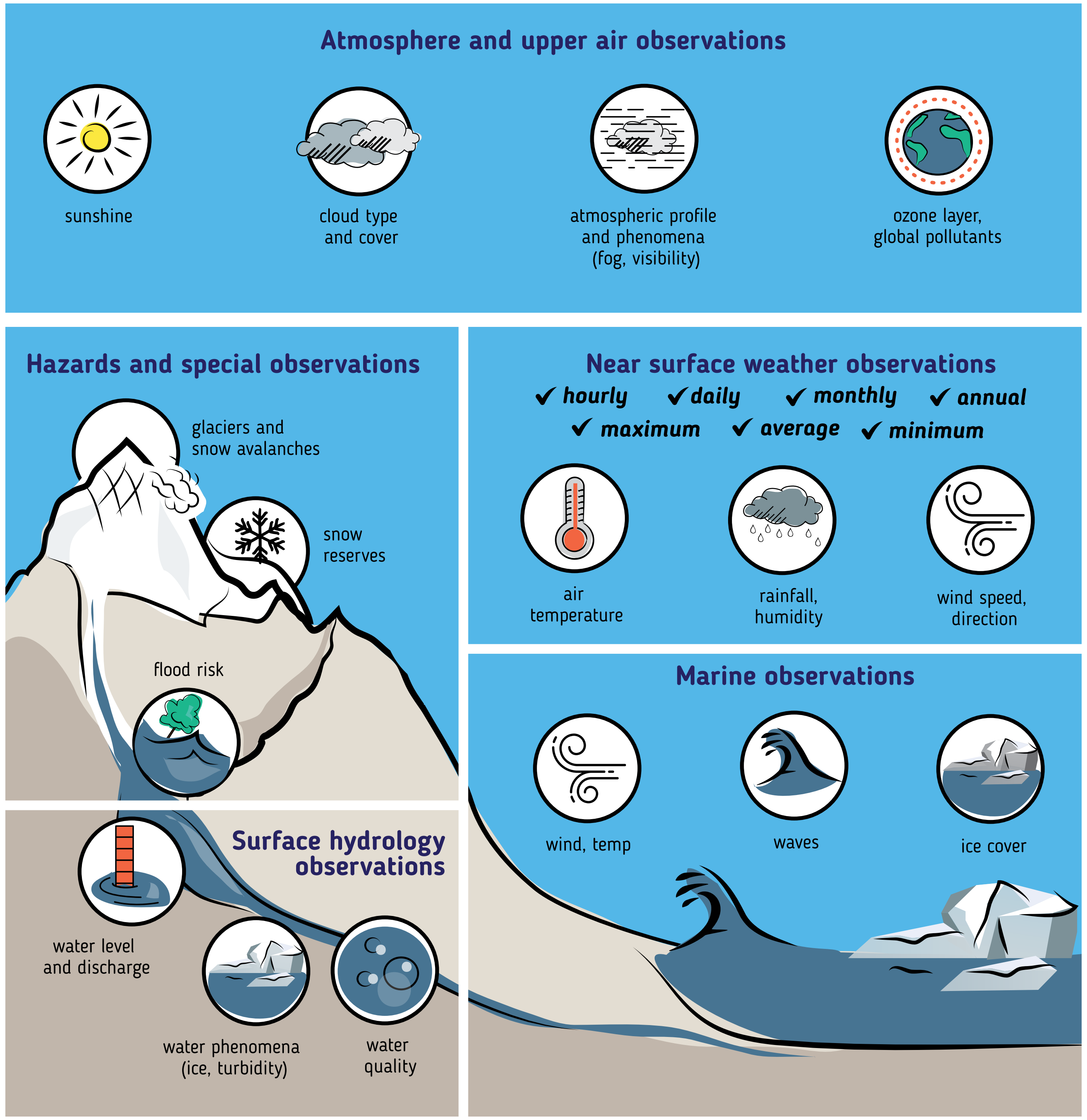
National hydromets in the region have a range of opportunities for cooperation with each other, with neighbouring states and with regional and international organizations. Cooperation on the development and use of analytical tools may extend to observation networks and methods, forecasting models and products, data processing and storage, and climate change assessments. Other areas include human resources and skills, innovative technologies, climate services, and early warning systems.

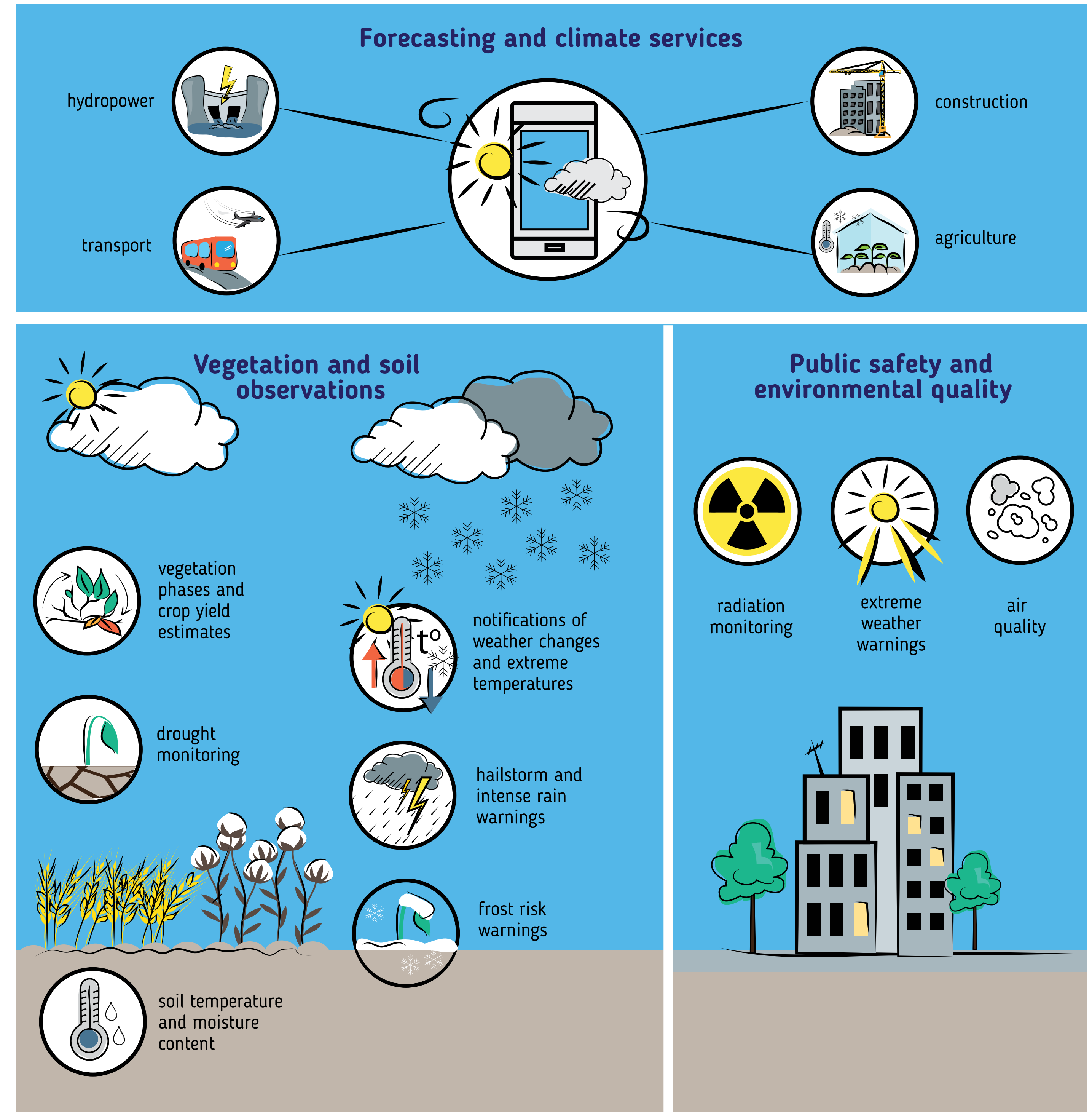
Benefits of hydrometeorological information



The users of hydrometeorological information include the general public and managers, planners and analysts in environmental, social and economic endeavours. The application of the information results in benefits across this spectrum. Hydromet information is used for environmental indicators and informs a range of environmental management strategies. The social benefits include public safety, security and comfort, and the contributions to scientific research. The economic benefits extend to applications in such sectors as agriculture, transport and emergency response.

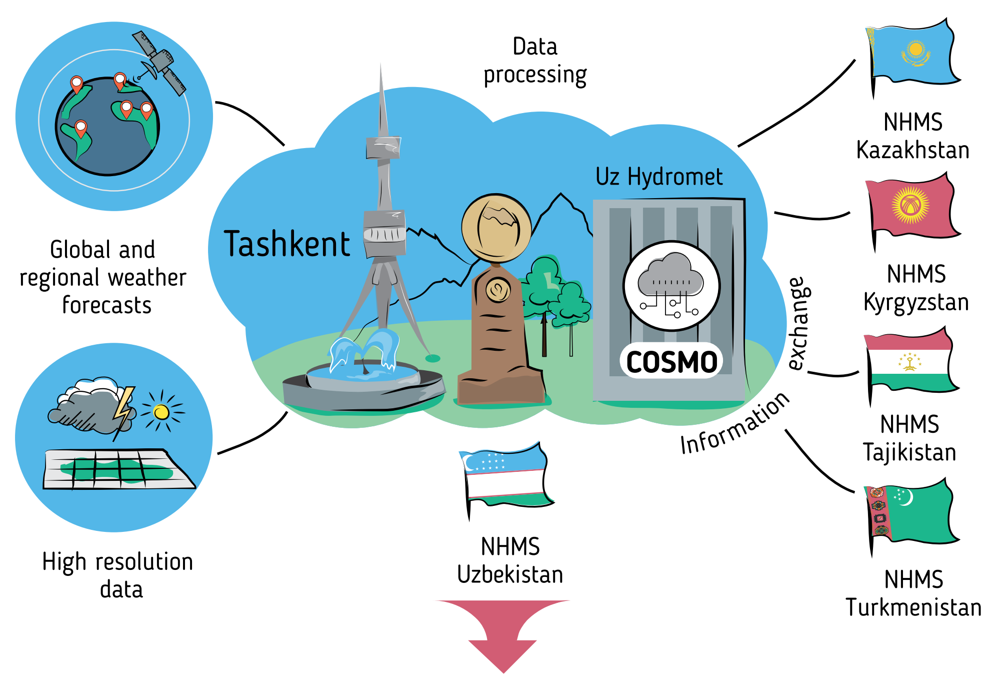
Summary of hydromet observations and services





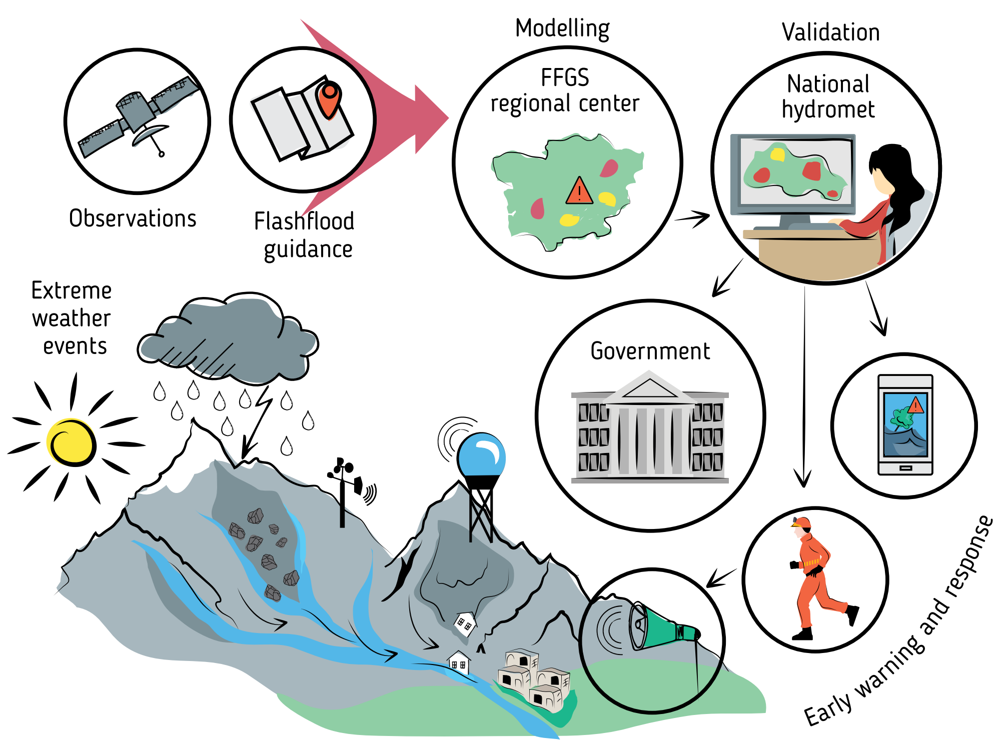
Hydromet innovations expected in Central Asia in 2020 and beyond

Numerical weather prediction and cloud computing



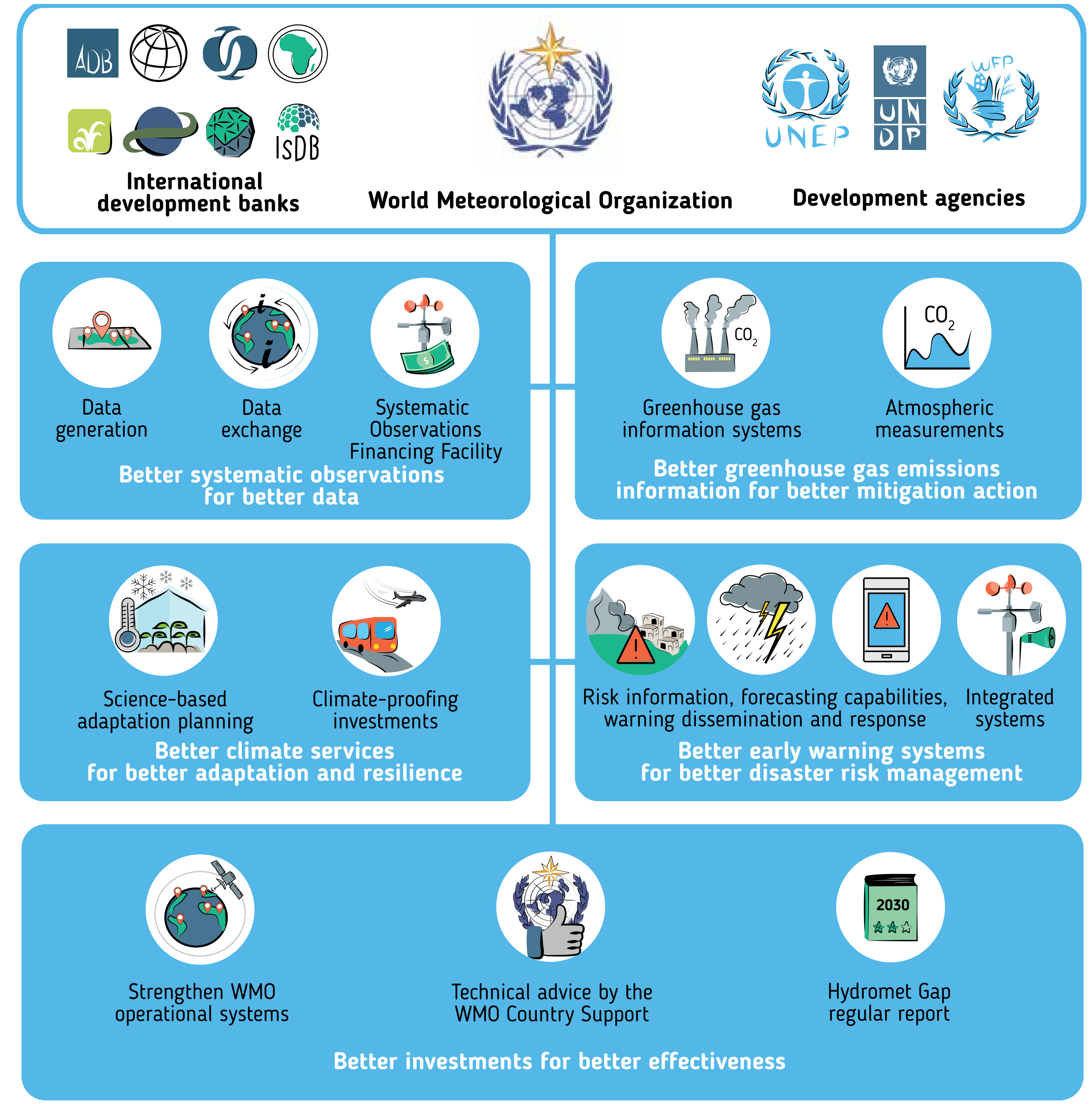
Within the next year, enhancements in numerical weather resolution to 6 x 6 km for all of Central Asia and 2 x 2 km for the high mountain areas will improve the spatial accuracy of numerical forecasts in the region. This higher-resolution tool still needs to be tested, but is expected to produce better local forecasting. Internet speed in the region may be too slow for the data transfer needed for numerical forecasting, but the advent of cloud computing will allow hydromets in Central Asia to connect to the data at their own Internet speed. Cloud computing has the additional benefit of providing better security against cyber attacks.

Improved flashflood guidance and flow forecasting



The specific local occurrence of flash floods makes them difficult to forecast, and they remain a major threat especially in the mountains. Advances in numerical forecasting combined with flash flood guidance systems are beginning to improve the forecasts, and an upgraded version of the system is now available in Central Asia with improved accuracy of flash flood warnings for periods of 3 hours up to 36 hours, and possibly longer.

Alliance for Hydromet Development



An initiative driven by WMO and the World Bank – the Alliance for Hydromet Development – is an effort to achieve consistency and coordination among hydromet services, and to close the gap between developed and developing countries in their capacity to respond to weather, water and climate risks. Twelve international organizations – the Adaptation Fund, African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Global Environment Facility, Green Climate Fund, Islamic Development Bank, United Nations Development Programme, United Nations Environment Programme, World Bank, World Food Programme and World Meteorological Organization – launched the Alliance for Hydromet Development in December 2019.

The global outlook

WMO service delivery strategy

The World Meteorological Organization is implementing a service delivery strategy designed to assist National Meteorological and Hydrological Services improve their services to the general public and decision makers. The strategy comprises the following six elements:

- Evaluate user needs and decisions
- Link service development and delivery to user needs
- Evaluate and monitor service performance and outcomes
- Sustain improved service delivery
- Develop skills needed to sustain service delivery
- Share best practices and knowledge

The underlying idea of the strategy is to move hydromet services toward a more service-oriented culture, and these six elements provide a framework for hydromets to follow in the pursuit of that end.

World Bank approach to modernization

The World Bank approach to modernization of hydromet services emphasizes the relationships between the public and private sectors and between service providers and users, and builds on the WMO service delivery strategy. According to the World Bank, effective services must be available and timely, dependable and reliable, useable, useful, credible, responsive and flexible, sustainable, and expandable. The drivers for effective service delivery include a shift toward open data, a greater need for efficiency, social and technological changes, evolving national policies on disaster risk reduction, the need for cost recovery for some services, and new service markets.

In addition to service delivery systems, the World Bank considers production systems and support systems as part of what it calls a "System of Systems". Production systems include monitoring and observations, modelling, forecasting, and warnings. Support systems include information and communications technology, quality management, research and development, and capacity-building.

The World Bank rationale for modernizing hydromets starts with the observation that high-income countries have demonstrated the benefits of providing accurate, actionable weather, climate, and hydrological information that mitigates the impacts of extreme weather events by affording authorities the opportunity to take timely steps based on timely warnings. These countries owe their success to investment in public hydromet services and in research and development, and to the encouragement of complementary private services.

In response to the increase in meteorological and hydrological hazards, the needs of hydromet users are changing. Hydromet services, in turn, need to respond to these changes, and provide actionable information. In terms of developing and maintaining the human resources necessary to meet these challenges, the World Bank approach relies on its long experience with capacity-building through business development and through the training of hydromet staff, stakeholders, and end users.

The World Bank finds that on-the-job training is the most effective approach, and that external training should be used only to develop trainers who can then conduct national training. The national hydromet staffs need training in not only the core disciplines and global weather enterprise skills but also in business practices, social media, and information and communications technology.

The adoption of new business models is a particular concern for hydromets that need to modernize rapidly to accommodate new demands for services. Two critical elements in this institutional modernization are a strategic plan that lays out hydromet goals and the means by which to achieve them, and an operational concept.

The modernization of infrastructure extends to systems for monitoring and observing, modelling, forecasting, and information and communications technology. This short list of systems disguises a long list of specific needs – from improvements in remote sensing and ground observations to the introduction of communications equipment that meets WMO standards to the rehabilitation and upgrading of offices and facilities.

References

Climate change data and trends

Sources: National Communications to the UNFCCC → https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/national-communications-and-biennial-update-reports-non-annex-i-parties/national-communication-submissions-from-non-annex-i-parties and North Eurasian Climate Centre → http://seakc.meteoinfo.ru/climatemonitoring/climatmonitr

Satellite images (maps)

Esri, Digital Globe, Earthstar Geographics, CNES/Airbus DS, Geo Eye, USDA FSA, USGS, Aerogrid, IGN, IGP

Annual precipitation and temperature (maps)

Source: WorldClim (→ www.worldclim.org Fick, S.E. and R.J. Hijmans, 2017, 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology); complimented with national climate data

Meteorological and hydrological stations and environmental monitoring points (maps)

Sources: National Hydrometeorological Service of Kazakhstan (http://www.kazhydromet.kz/ru and http://maps.hydromet.kz/), National Hydrometeorological Service of the Kyrgyz Republic (http://meteo.kg/), National Hydrometeorological Service of Tajikistan (http://meteo.tj/), National Hydrometeorological Service of Turkmenistan (http://meteo.gov.tm/tm/), National Hydrometeorological Service of Uzbekistan (https://www.meteo.uz/)

Annual river flow (maps)

Source: Global Runoff Data Center → https://www.bafg.de/GRDC; complimented with national hydrology data

Country chapters are informed by expert interviews, data and maps collected during Zoi country visits and discussions with the central offices of the national hydrometeorological services: Turkmenistan – November 2018, Uzbekistan, Kazakhstan, Tajikistan, Kyrgyz Republic – December 2018.

Useful links:

Global Facility for Disaster Risk Reduction (GFDRR) → https://www.gfdrr.org/en

World Bank's Central Asia Hydromet Modernization Project materials, background and progress reports → https://projects.worldbank.org/en/projects-operations/project-detail/P164780?lang=en

World Bank, 2019. Weathering the Change: How to Improve Hydromet Services in Developing Countries?

World Meteorological Organization, 2014. The WMO Strategy for Service Delivery and Its Implementation Plan

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World Meteorological Organization (WMO) → http://www.wmo.int

US National Oceanic and Atmospheric Administration, National Climatic Data Center (NCDC NOAA) → http://www.ncdc.noaa.gov and NOAA weather and atmosphere education resources → https://www.noaa.gov/education/resource-collections/weather-atmosphere-education-resources

Photo credits

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p. 19: Karshi canal, Uzbekistan © V. Novikov

p. 19: Cotton field © M. Mergili (www.mergili.at)

p. 35: Automated meteorological station, Sangiston, Tajikistan © Tajik Hydromet for the World Bank

p. 36: Kaz Hydromet building in Almaty © Z. Gainulina for "Vlast" online magazine

p. 37: Checking equipment, Tajikistan © C. Stuhlberger for the World Bank

p. 37: Thermometer housing, Turkmenistan © M. Libert

p. 42: Automated meteorological station at the Bartrak Glacier © Uz Hydromet

p. 44: Glacier observations in the Pamirs, Tajikistan © M. Mergili (www.mergili.at) and Tajik Hydromet

p. 51: Automated river gauge, Yezgand, Tajikistan © Tajik Hydromet for the World Bank

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p. 52: Climate records archives, Kyrgyz Republic © C. Stuhlberger for the World Bank

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p. 115: Caspian Sea coastline, Turkmenistan © V. Novikov

p. 115: Caspian seal, Turkmenistan © Institute of deserts, flora, and fauna of Turkmenistan

p. 127: Modernization of hydrometeorological stations, Tajikistan © Tajik Hydromet for the World Bank

Acknowledgements

Preparation and production of this guide involved direct and remote consultations with the staff of national hydrometeorological services of Central Asia and key users of hydrometeorological and climate information, as well as the review of a broad range of information sources, including World Bank and World Meteorological Organization materials and guidelines. It would not have been possible to gather the wealth of information for the guide without the input of almost 50 contributors.

Presentations and other materials from the national meetings and national atlases, WMO and hydromet databases, and other data have been used extensively in the preparation of this guide.

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In today's world, weather apps are everywhere and when we glance at our devices and decide if we are going to take an umbrella when we leave the house we may be forgiven for taking this twenty-first century, whiz-bang technology for granted and for thinking that weather information comes from our phones. To be sure, weather information is delivered to our phones, but it comes from the collection of an astonishing array of observations and measurements from ground stations, satellites and other remote sensing equipment and from the processing of the data with sophisticated computers, all of which entails the following of rigorous protocols. And the people following those protocols power the entire enterprise with their knowledge, training and professionalism.

This atlas offers insights into the work of the national hydrometeorological services and the global networks that contribute to the information on our screens. It covers the range of weather, water and climate information and services available, and connects that information and those services to the spectrum of users with their own specific needs. As global warming continues to produce more frequent and more intense extreme weather events, interest in the forecasting of these events may be on the rise, and this atlas may serve as an entry point to understanding the methods and limitations of modern practice. This guide to the hydromet services in Central Asia may serve as both an example of how to communicate weather, water and climate information and as a catalyst for renewing interest in these increasingly important areas and for clarifying the need for climate adaptation strategies.