Variable / Process / Extreme	Process-based expectations	Observed changes	Projected changes	LOSU	Uncertainties in key-processes
		Unless otherwise indicated, the majority of the observed / projected changes discussed apply to Switzerland (or the Alpine region).		*Level of scientific understanding*	

General uncertainties and remarks on the past and projected future evolution

Meteorological variables, especially precipitation and extremes, exhibit substantial **natural and decadal variability**, which can obscure long-term anthropogenic trends. This masking effect is less evident for temperature, where significant warming is detectable, but it is more pronounced for precipitation, its extremes, and for rare or **poorly observed** processes.	Climate projections are affected by several sources of uncertainty, which vary in importance depending on the time scale and the variable considered; additionally, **some processes are not**, or only approximately, **represented in current climate models**. (1) **Emission scenario uncertainty** refers to the uncertainty of future greenhouse gas emissions and socio-economic developments (important in the long-term). (2) **Model uncertainty** refers to differences in climate projections caused by how various models represent physical processes, such as clouds, ocean currents, or land-atmosphere interactions. (3) **Natural variability** is the natural fluctuation of the climate system that occurs independently of changes in external forcing (important in the near-term).

Temperature					*in addition to general uncertainties (see above)*
Temperature (mean)	Temperature increases as a result of global warming caused by anthropogenic greenhouse gas emissions. Amplified warming over land-areas (and high elevations).	The Swiss mean temperature has increased by 2.9°C since the pre-industrial period, with strongest warming rates in summer. (SR Section 3.2.1)	Continued warming with respect to present-day (1991-2020), depending on emission scenario / global warming of 0.9°C for GWL1.5, 1.6 for GWL2.0 and 2.9° for GWL3.0, with strongest warming rates in summer (SR Section 3.2). Hot and cold extremes warm more than the mean. (SR Section 3.2.2 & 4.2.2, 4.2.4)	Very high	Urban heat island effects, soil moisture–temperature feedbacks, and land-use changes, including irrigation, which are often simplified or not fully represented in current climate models. Influence of changes in radiation and wind. Large-scale circulation changes, such as persistent anticyclones, winter blocking events, and potential impacts of Arctic amplification and sea ice loss on midlatitude weather patterns. Model limitations in capturing key processes, including precipitation and cloud dynamics, and the strength of land–atmosphere interactions.
Hot days and warm nights in summer	More frequent and warmer hot days and warm nights as a result of mean summer warming, strongest increase at low and medium elevations.	More hot days, summer days, warm nights and tropical nights. (SR Section 3.2.1)	Continuation of increase in summer days and tropical nights, and strong increase in hot days and tropical nights, especially for GWL3.0. Occurrence of tropical nights and hot days becomes the norm, even in regions not experiencing such events in today's climate (SR Section 3.2.1)	Very high	
Hot extremes, summer heat waves	Increasing intensity of heat extremes and more frequent and longer lasting heatwaves along with summer warming and enhanced variability/amplification due to drying of soils. Amplification of heat-stress in urban areas due to urban heat island (UHI) effect.	The hottest days (warmest nights) per year have warmed by ~3.5° (~4.5°). Generally increasing maximum temperatures and increasing frequency of events and periods with heat stress. Amplified heat stress in urban areas. (SR Section 3.3.1 & 4.2.1)	Hot tempeature extremes continue to warm stronger than the mean. Increasing frequency, intensity and duration of heat waves and heat stress conditions. (SR Section 4.2.2)	High	
Heat stress (combination of temperature and humidity)	Specific humidity increases despite a weak reduction in relative humidity, accompanied by increasing hot extremes	More frequent and intense heat stress due to rising temperature and higher specific humidity (SR Section 4.2). Amplified heat stress in urban areas (SR Section 3.3)	Heat stress will continue to increase and become more severe at higher GWLs (SR Section 4.2). Amplified heat-stress in urban areas (SR Section 3.3).	High	
Cold days and nights in winter	Fewer and warmer cold days and nights as a result of mean winter warming, strongest frequency reduction at high elevations and areas of enhanced snow melt or shortening snow seasons	Fewer and warmer cold days and nights in winter, fewer frost days and ice days, rising zero degree line (SR Section 3.2.2)	Continued decrease in frequency of cold days and nights, incuding frost and ice days. (SR Section 3.2.2)	Very high	
Cold extremes / winter cold waves	General decrease along with winter warming, potentially amplified by snow albedo feedback and pronounced warming in source regions of cold air advection	Decreasing frequency and duration (SR Section 4.2.3)	Cold extremes warm more than mean temperature. Frequency/intensity/duration of cold waves decline, but cold waves will still occur. (SR Section 4.2.4)	High	
Zero-degree line	Warming leads to an increase in the zero-degree line	The zero-degree line has increased substantially over the last decades (SR BOX 3.2). In winter (DJF) from about 675m to 900m (1961-90 vs. 1991-2020)	Under further warming conditions, the zero-degree line is expected to further increase by +550m (+190/+325) for GWL3.0 (GWL1.5/GWL2.0). (SR BOX 3.2)	Very high	
Precipitation					*In addition to general uncertainties (see above)*
Precipitation (mean)	Acceleration of hydrological cycle as consequence of global warming leads to increasing water-uptake capacity of the air intensifying extreme precipitation; changes in circulation and weather types as well as stratification changes can all influence total (mean) precipitaiton amounts.	No clear changes at the annual scale, but apparent seasonal features. Large inter-annual variability, but tendency towards increase in winter precipitation (*also more liquid precipitation at the cost of snowfall*) and slight reduction in summer precipitation. (SR Section 3.4.1)	Increase in winter (*distinctly more liquid precipitation at the cost of snowfall, especially at lower elevations*), slight decrease in summer (associated with large model spread). No clear signal for the full-year (seasonal signals compensate each other) (SR Sections 3.4.1 & 4.4.2)	Medium	

Variable / Process / Extreme	Process-based expectations	Observed changes	Projected changes	LOSU	Uncertainties in key-processes
Frequency (of rainy days)	Changes in circulation / weather types as well as stratification / atmospheric stability can alter frequency of wet events	No clear change, but indications for reduction in frequency of wet events (*less rainy days*) in summer.	Reduction in summertime frequency (*less rainy days*) and slight increase (*more rainy days*) in winter frequency. (SR Sections 3.4.2 & 4.4.2)		Large-scale circulation changes, changes in atmospheric stratification / stability and wind, small-scale convective processes
Intensity (of rainy days)	Increased moisture uptake capacity of warmer air results in an intensification of precipitation, changes in stratification / atmospheric stability can suppress or enhance (convective) precipitation formation	Intensification of precipitation *(more precipitation during wet days)*	Further intensification of precipitation events in all seasons, especially in winter. (SR Section 4.4.2)	Medium-High	
Heavy precipitation (moderate events that occur every year and can be classified as the heaviest events per year)	Increased moisture uptake capacity of warmer air results in an intensification, especially of heavy and extreme events and short duration rainfall events	Majority of stations across Switzerland with trends to more frequent and intense heavy rainfall. (SR Section 4.4.1)	More intense and frequent heavy rainfall events in all seasons and for all temporal aggregation periods (daily and multi-day), in particularly in the cold season, higher increase for more intense event categories and shorter aggregations (e.g. 1-day) increasing stronger than multi-day (3- and 5-day) events. (SR Section 4.4.2-5)		
Extreme precipitation (rare events that generate large impacts, associated with return periods larger than approx. 5 years)	Increased moisture uptake capacity of warmer air results in an intensification, amplification of increase for high return periods and short duration rainfall.	Intensification of events in all seasons. Short duration events (e.g. hourly and 10-min) intensify at stronger rates than daily events, particularly in summer.	Intensification, especially for sub-daily events. Stronger intensification for short-duration events as compared to prolonged rainfall. Changes scale close to C-C scaling (~7% per degree local warming), especially for short-term extremes. (SR Section 4.4.2-5)		
Drought					*In addition to general uncertainties (see above)*
Dry spells and drought	Enhanced evapotranspiration and reduced (summer) precipitation increase the probability of summer droughts and dry spells, earlier snow melt and vegetation onset leads to soil drying and potentially more dry days	No robust and significant trend in summer mean precipitation (SR Section 3.4), but indications of more frequent and intense drought conditions (SR Section 4.3), increase in evapotranspiration.	More frequent soil moisture droughts (SR Section 4.3), tendency to more and longer dry spells and less summer precipitation for strong warming scenarios (meteorological drought) (SR Sections 3.4 & 4.4).	Medium-High	Large-scale circulation changes and persistence of anticyclones/atmospheric blockings, changes in the character and amount of precipitation, strength of land-surface-atmosphere feedbacks
Other Processes					*In addition to general uncertainties (see above)*
Mean Windspeed	Changes in circulation and occurrence of weather types can lead to changes in mean wind-speed.	No robust trend detected and large natural / decadal variability (SR Section 3.8.3)	Climate model projections provide no clear evidence for changes (SR Section 3.8)	Low	Large-scale circulation and weather type changes, urbanization in sub-urban areas.
Föhn	Changes in circulation and weather types favoring Föhn conditions can lead to changes in the frequency and intensity of Föhn events.	No observational evidence for changes	Climate model projections provide no evidence for changes, relevant processes not resolved in GCMs/RCMs		Large-scale circulation and weather type changes, underresolved small-scale proceses
Bise	Changes in circulation and weather types favoring Bise conditions can lead to changes in the frequency and intensity of Bise events.	No observational evidence for changes	Climate model projections provide no evidence for changes, relevant processes not resolved in GCMs/RCMs		
Winter storms	Intensification of cyclones due to latent heat release, changes in latitudinal temperature gradient affecting storm tracks	No robust trend detected and large natural / decadal variability	Climate model projections provide no evidence for changes		Large-scale circulation changes affecting regional frequency, intensity and track of cyclones
Convective storms (Thunderstorms) **and associated wind gusts**	More severe convective events lead to increased occurrence and intensity of extreme wind gusts. Increase in low-level buoyancy (CAPE) causes more severe convection.	No observational evidence for changes.	Indications for an increase in severe convective storms and supercells that can potentially lead to downbursts and strong wind gusts (SR Section 4.5)	Low	Changes in stratification and circulation (frequency of weather types favoring convective initiation), increasing low-level warm and moist air,associated with an increase in CAPE.
Hail	Increasing occurrence and intensity of thunderstorms can lead to more frequent hail, increase in low-level buoyancy (CAPE), changes in atmospheric stability and vertical velocity	Indication for an increasing frequency of hail. (SR Section 4.5)	First studies indicate a further increase of hail frequency in the Alpine region (SR Section 4.5)	Very low	Small-scale convective processes
Tornadoes	Sign not clear, competing effects of decreasing wind shear, and moistening / warming of boundary layer	Only few documented cases and no evidence for changes	Climate model projections provide no evidence for changes. Process not resolved by climate models.		Vertical wind shear, change in convective available energy, storm initiation
Snow (snow cover and snowfall)	Higher temperatures and an increasing zero-degree line lead to a higher fraction of liquid precipitation and a decrease of snowfall sums, potentially partly offset by a general increase of total winter precipitation. Snow cover decreases as a consequence. Earlier springtime snowmelt in a warmer climate, leading to shortening of snow season especially at low to medium elevations.	Decrease of mean snow depth, accompanied by a shortening of the natural snow season, particularly at low to medium elevations. Changes in maximum snow depth are more uncertain. Step-like decline in snow cover in the late 1980s (reflecting combined influence of long-term warming and natural climate variability). Strong variability of total number of snowfall days and only minor long term changes (apart from step-like reduction in the late 1980s).	Number of snowfall days and mean snow depth are expected to decrease in a warmer climate. Duration of natural snow season will shorten. Maximum snow depths may decline, although less consistent evidence. (SR Section 3.5)	High	Low network density at high elevations and high spatial variability of snow cover. Considerable uncertainties of projected changes in in high-elevation winter precipitation (snow accumulation). Analysis of climate-model simulated snow cover has to be carefully designed and typically models have to be excluded due to unrealistic snow accumulation at high elevations.
Heavy Snowfall Events	Frequency decrease of heavy snowfall events at low to medium elevations due to shortening of the snowfall season following temperature increases. However, due to a higher water holding capacity of warmer air, heavy snowfall events might increase in magnitude especially at high elevations.	No observational evidence for changes.	General decrease of the frequency of heavy snowfall events, but intensification of events possible especially at high elevations and in the core winter season.	Medium	Fractionation of total precipitation into rainfall and snowfall is only poorly constrained in climate models and is complex (involves cloud microphysics). Large uncertainties due to high natural variability of extreme snowfall.

Variable / Process / Extreme	Process-based expectations	Observed changes	Projected changes	LOSU	Uncertainties in key-processes
Fog and low stratus	Decreased air pollution leading to less fog, changes in circulation and weather types that favor the initiation of fog and / or inversions.	Less fog in the Mittelland, in line with "brightening" and air quality measures over the last decades	Climate model projections provide no evidence for changes, relevant processes not resolved in GCMs/RCMs or subject to large uncertainties	Low-Medium	Changes in atmospheric circulation, air-quality measures and regional/local-scale changes in circulation (i.e. inversions)
Sunshine and Insolation	Changes in circulation and weather types, (air quality measures and less fog)	Increasing sunshine duration over the last decades, in particular in summer and as a consequence of less fog in winter.	Climate model projections provide no clear evidence for changes, but tend to a slight increase (rather uncertain). (SR Section 3.6)	Low	Changes in atmospheric circulation, (weather types and fog), changes in cloud cover
Circulation & Weather Types	Shift of sub-tropical high pressure belts to the north (especially in summer) leading to more high-pressure, shift of the North Atlantic trajectories of low pressure systems.	No clear evidence of observed changes while natural variability is high. (SR Section 3.8.3)	Climate model projections provide no clear evidence for changes but natural variability remains high. (SR Section 3.8.)	Low	Large-scale circulation changes and global-scale feedback mechanisms
Fire weather (combination of temperature precipitation, humidity and wind)	Rise in temperature increases fire weather due to increase in evaporation, combined with drier summers and longer periods of drought (and local winds in mountain areas)	Increase in fire weather over last decades. Positive trends mostly in spring and in summer with temperature as main driver. (SR Box 3.3)	Increase in fire weather as a consequence of warming, increasing evapotranspiration and summer drying. Especially pronounced increase in fire weather in summer and fall, and in southern Switzerland and Rhone Valley (SR Box 3.3)	Medium-High	Similar to heat extremes, with local winds (not resolved by RCMs) of particular relevance