LIQUIDICE

Milestone 4 Survey of climate data needs from local-scale modellers

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LIQUIDICE: LinkIng and QUantifying the Impacts of climate change on inlanD ICE, snow cover, and permafrost on water resources and society in vulnerable regions.

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Introduction

WP3 aims to advance the land ice representation in a range of global, regional, and local models with a sounder description of hydrological processes. WP3 activities include: i) improving the realism of global simulations by integrating the largest land ice components in global models; and ii) improving regional and local simulations to enhance hindcasts and projections of snow cover, land ice mass balance, and water runoff from glacierized drainage basins. Uncovering the influence of ice sheets on the local scale requires the downscaling of global and regional simulations: this effort is needed to provide the basis for local impact studies.

Within WP3, Task T3.2 “Downscaling Climate Scenarios to the Local Scale of Glacier Basins” is dedicated to bridging the scale mismatch between state-of-the-art global and regional climate model simulations (with spatial resolutions on the order of 100-10 km) and the km-scale typically needed for impact studies. Task T3.2 employs dynamic, statistical, and stochastic downscaling methods to estimate the required kilometer-scale variability (D3.2). This downscaled forcing will drive local models (T3.3, T3.4) and impact studies (WP4) to create a consistent picture of past and projected cryo-hydrological changes.

Within T3.2, CNR-ISAC will downscale the main atmospheric variables used by models employed in T3.3, T3.4 and WP4. Stochastic and statistical methods will be used depending on the specific meteorological variable. The downscaled scenarios will cover the project's supersites at a resolution of a few kilometers in the European Alps, Svalbard, and Greenland.

The present document provides a description of the downscaling strategy which has been agreed with the partners and which CNR-ISAC will follow to produce the downscaled scenarios (Deliverable D3.2).

The downscaling strategy

In LIQUIDICE, downscaled climate forcing is necessary to drive local models (T3.3, T3.4) and impact studies (WP4), to create a consistent picture of past and projected cryo-hydrological changes. The first action taken has been to gather all WP3 and WP4 partners who are involved in climate change impact studies at the local scale and interested in high resolution climate scenarios, to discuss the downscaling strategy, depending on their data needs.

The first meeting took place on May 7th, 2025, online, and aimed to introduce the downscaling methods for generating km-resolution climate scenarios for the LIQUIDICE domains in the European Alps, Svalbard, and Greenland. CNR-ISAC presented stochastic and statistical downscaling methods suitable for the main climate variables (temperature, precipitation, and eventually others) in a dedicated talk. The audience who needs downscaled data have been invited to respond to a survey to define their needs. The survey (an excel file) was shared on the day of the meeting.

A second meeting has been held on June 4th 2025, with a twofold purpose: firstly, to present and discuss the results of the survey of the partners' data needs; secondly, to better define the general strategy for generating km-resolution future projections. The discussed topics included the choice of: 1) the models to be downscaled (either GCMs or RCMs, and which ones); 2) the application of eventual bias-correction methods to the model temperature and precipitation fields, and the reference datasets to adopt for the bias correction; 3) the scenarios to be considered for future projections, 4) the time span to be considered for projections; 5) the downscaling methods to be applied; and 6) the adoption of reference datasets for model validation purposes. The main outcomes of the discussion are summarized here:

1) **Large scale models to downscale**:

ALPS: the CORDEX-CMIP6 simulations performed with RegCM5 regional model at 0.11° resolution over Europe will be downscaled over the Alpine catchments. These simulations are not publicly available yet, but they will be shared within LIQUIDICE by UNESCO-ICTP partners, who are authors of these simulations. The RegCM5 simulation driven by EC-Earth-Veg is already available, while MPI-ESM1-2-HR and NorESM2-MM-driven simulations must be run, and they are expected to become available after the summer 2025.

ARCTIC: the CORDEX-CMIP6 simulations for the Arctic region are not public yet, and thus they are unavailable. We will rely instead on CMIP6 HighResMIP global simulations at the global scale at 0.25° resolution. A search in the ESGF archive (https://esgf-node.ipsl.upmc.fr/search/cmip6-ipsl/, accessed on June 4th, 2025) showed that the only model providing daily data for the main climate variables over the historical period and future scenario is MRI-AGCM3-2-S (1). HiRAM-SIT-HR (1) has a rather complete dataset, but surface pressure is missing. Subdaily datasets (6h and 3h frequency) are incomplete as models provide some variables and not others: if subdaily data are critically needed by LIQUIDICE partners we could look for lower resolution GCM simulations (50-100 km) providing them. Additional high-resolution global simulations, generated with Earth System Models within Task 3.1, are expected to become available by M24. These simulations will be downscaled too, but necessarily after M24, so they will not be included in the Deliverable D3.2 due on M24.

2) **Application of bias correction schemes prior to downscaling**. Climate models often have a bias (e.g., a cold and wet bias in the mountain regions in winter is commonly found in both state-of-the-art GCMs and RCMs). For the Alpine domain, a few datasets have been suggested as a reference for the bias correction, namely EMO-1 (Gomes et al., 2020), EURO4M-APGD (Isotta et al., 2013) and the station-based E-OBS datasets (Cornes et al., 2018). For the Arctic, the C3S Arctic Regional Reanalysis (CARRA, Schyberg et al., 2020) at 2.5 km resolutions has been proposed and identified as the most suitable. Bias correction is expected to be carried out on the long-term climatology, pixel by pixel.

3) **Selection of future scenarios**: the CMIP6 and CORDEX communities agreed on putting the focus on high-impact scenarios, but with slightly different flavors. The CORDEX experiment protocol identified the SSP3-7.0 as the main scenario to be produced (CORDEX, 2025), while HighResMIP provides the SSP5-8.5 scenario (Haarsma et al., 2016). We will downscale the available scenarios.

4) **Time span for downscaled scenarios**: the full period of availability of CORDEX and HighResMIP simulations has been requested by the partners.

5) **Downscaling of the temperature and precipitation variables at the km resolution**. The most appropriate downscaling solution depends on the variable and on the temporal scale of interest, as well as on the needs for a specific application. A temperature downscaling based on the orographic correction (using the atmospheric temperature lapse rate) and a stochastic downscaling method for precipitation, also

considering orography, were proposed to achieve spatial scales up to 1 km. Other variables will be downscaled with the bilinear interpolation method.

6) **Reference datasets for the evaluation of downscaled data.** A first quality check of the downscaled data will be applied using the main observational gridded datasets as a reference. However, an in-depth evaluation of the quality of the downscaled data would require knowledge of the local climate at the km scale, for example from in-situ station data. This work is left to the data users, who know the local climate conditions with a higher level of detail.

The discussion highlighted that downscaled data for East Asia domains, originally not included in this task, could be useful for example for the evaluation of new high resolution climate simulations. To this regard, the downscaling of HighResMIP simulations over small pilot domains in East Asia will be explored. As the final point of the online meeting, the participants have been invited to check again the accuracy and completeness of their data requests in the excel file.

The final list of data requests is summarized in Table 1.

TABLE 1. Data requests from LIQUIDICE partners. Variables: 2mT=2meter air temperature, TP=total precipitation, 2mH=2meter humidity,10mU(V)=10meter component of U (V) wind velocity, SSRD(STRD)=surface solar (thermal) radiation downwards.

Domain Name	Country	Coordinates of the Domain				Variables	Temporal resolution	Spatial resolution
		Lon_min	Lon_max	Lat_min	Lat_max			
Sabine Land	Svalbard	17.54ºE	18.37ºE	78.06ºN	78.26º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Wedel Jarlsberg South	Svalbard	15.00ºE	15.81ºE	76.98ºN	77.20º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Wedel Jarlsberg North	Svalbard	14.13ºE	15.52ºE	77.32ºN	77.58º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Nordelskiold Land	Svalbard	13.87ºE	15.25ºE	77.75ºN	78.00º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Brogger Peninsula	Svalbard	11.50ºE	12.64ºE	78.50ºN	79.00º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Fuglebekken and Ariebekken	Svalbard	15.44°E	15.53°E	76.99°N	77.03°N	2mT,TP,2mH,10mU,10mV,SSRD,STRD	3/6 hourly	1 km or less
Freya Glacier	East Greenland	20.46º	20.96º	74.35ºN	74.48º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
AP Olsen Ice Cap	East Greenland	21.25º	21.72º	74.60ºN	74.70º	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Evancon/Lys	Italy	7.5°E	8.0°E	45.5°N	46.0°N	2mT,TP,2mH,10mU,10mV,SSRD,STRD	Daily	1 km
Monte Rosa	Italy	7.67°E	8.31°E	45.69°S	46.04°N	2mT,TP,2mH,10mU,10mV	daily	1 km
ISTA, Kangerlussuaq, Pakitsoq	West Greenland	37°E	53°E	63°N	72°N	2mT,TP,2mH,10mU,10mV,SSRD,STRD	monthly	1 km

References

CORDEX, (2025). CORDEX experiment design for dynamical downscaling of CMIP6 (Version v2). Zenodo. https://doi.org/10.5281/zenodo.15268192

Cornes, R., G. van der Schrier, E.J.M. van den Besselaar, and P.D. Jones. 2018: An Ensemble Version of the E-OBS Temperature and Precipitation Datasets, J. Geophys. Res. Atmos., 123. doi:10.1029/2017JD028200

Gomes, Goncalo; Thiemig, Vera; Skøien, Jon Olav; Ziese, Markus; Rauthe-Schöch, Armin; Rustemeier, Elke; Rehfeldt, Kira; Walawender, Jakub; Kolbe, Christine; Pichon, Damien; Schweim, Christoph; Salamon, Peter (2020): EMO: A high-resolution multi-variable gridded meteorological data set for Europe. European Commission, Joint Research Centre (JRC) [Dataset] doi: 10.2905/0BD84BE4-CEC8-4180-97A6-8B3ADAAC4D26 PID: http://data.europa.eu/89h/0bd84be4-cec8-4180-97a6-8b3adaac4d26

Haarsma, R. J., Roberts, M. J., Vidale, P. L., Senior, C. A., Bellucci, A., Bao, Q., Chang, P., Corti, S., Fučkar, N. S., Guemas, V., von Hardenberg, J., Hazeleger, W., Kodama, C., Koenigk, T., Leung, L. R., Lu, J., Luo, J.-J., Mao, J., Mizielinski, M. S., Mizuta, R., Nobre, P., Satoh, M., Scoccimarro, E., Semmler, T., Small, J., and von Storch, J.-S.: High Resolution Model Intercomparison Project (HighResMIP v1.0) for CMIP6, Geosci. Model Dev., 9, 4185–4208, https://doi.org/10.5194/gmd-9-4185-2016, 2016.

Isotta, Francesco A., et al. "The climate of daily precipitation in the Alps: development and analysis of a high-resolution grid dataset from pan-Alpine rain-gauge data." International Journal of Climatology 34.5 (2014): 1657-1675.

Schyberg H., Yang X., Køltzow M.A.Ø., Amstrup B., Bakketun Å., Bazile E., Bojarova J., Box J. E., Dahlgren P., Hagelin S., Homleid M., Horányi A., Høyer J., Johansson Å., Killie M.A., Körnich H., Le Moigne P., Lindskog M., Manninen T., Nielsen Englyst P., Nielsen K.P., Olsson E., Palmason B., Peralta Aros C., Randriamampianina R., Samuelsson P., Stappers R., Støylen E., Thorsteinsson S., Valkonen T., Wang Z.Q., (2020): Arctic regional reanalysis on single levels from 1991 to present. Copernicus Climate Change Service (C3S) Climate Data Store (CDS). DOI: 10.24381/cds.713858f6 (Accessed on 17-Jun-2025).