SEI Stockholm Environment Institute

GMET in Bolivia: building gridded climate datasets for water resource studies

SEI brief
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Highlights:

- **A common challenge in water resource studies is finding continuous spatial coverage of precipitation data, due to the sparse and often uneven distribution of meteorological stations.**
- **The Gridded Meteorological Ensemble Tool (GMET) uses station data to create a continuous, gridded product – and unlike other tools, it incorporates data and prediction errors into its analysis.**
- **SEI worked with Bolivian scientists and the National Center for Atmospheric Research (NCAR) to apply GMET to a country outside of the US for the first time.**
- **The project provided a window into how GMET works in data-sparse regions, revealing both strengths and weaknesses.**
- **The resulting tool is open-source and is now accessible to a broader community.[1]**
- **This project included a technology transfer, with SEI working with government partners to train local experts on how to use and update the tool.**

Hydrologic applications for water planning and water balances require datasets for climate parameters, such as precipitation and temperature, that cover a territory on a continuous basis. However, meteorological stations are often unevenly distributed.

Water managers thus use a variety of methods to generate the necessary continuous dataset from station observations. These methods typically do not recognize the gaps and errors in local observations, leading to uncertainty. This is a more acute problem in mountainous areas and other regions where meteorological stations are sparse and where the topography is complex.

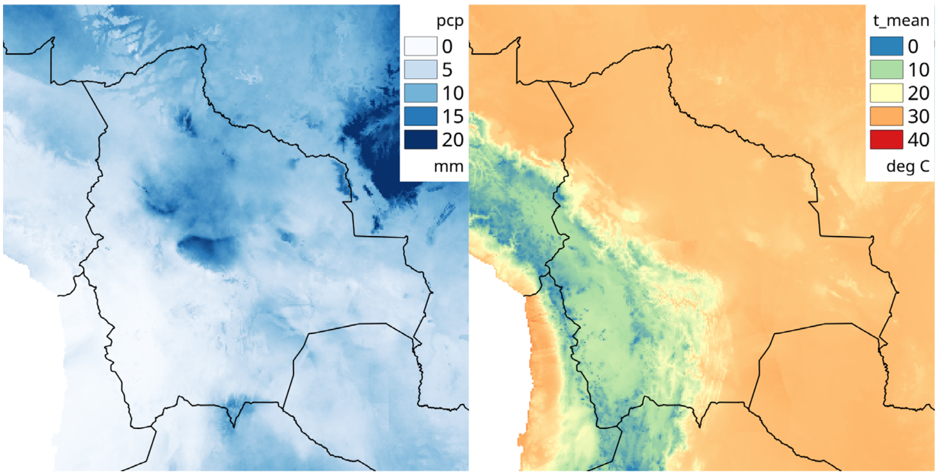
The Gridded Meteorological Ensemble Tool (GMET) enables water managers to use station data to generate historic climate grids for an area, along with statistical information that can provide an estimate of the level of uncertainty. Over the past few years, the National Center for Atmospheric Research (NCAR) developed GMET in collaboration with researchers from the US Army Corps of Engineers and the University of Washington.[2] An early application used 12,000 stations to generate a daily climate grid for the continental United States, which was applied in hydrologic modelling studies, climate forecasts and other applications.

This brief describes SEI's effort to use GMET in Bolivia, as a key input for the country's water balance study. The study consisted of a comprehensive model of water availability in its rivers, lakes and streams. This marked the first time the tool has been applied outside of the United States.

1 http://gmet.sei-us.org/
2 The scientific foundation of GMET is described in a paper by the main authors of the tool, Andrew Newman et. al. (2015). Building on the work of Clark and Slater (2006) they developed a station-based, ensemble dataset of precipitation and temperature for the contiguous United States. The current project is the first application of the tool outside of the United States.

Photo (above):

Figure 1. An example of GMET gridded precipitation and temperature for a single day in Bolivia



A first for GMET

In recent years, researchers from SEI have worked closely with the government of Bolivia, local academics and NCAR to apply and develop an application of GMET for Bolivia and parts of neighbouring countries (Peru, Brazil, Paraguay, Argentina and Chile). In support of this project, a database of over 400 stations was assembled and used to generate daily climate grids for the period between 1980 and 2016.

Bolivia has a wide variety of terrain — from the Andes Mountains to the Amazon lowlands — and its data availability is much sparser than it is in the US. Our application of GMET in these conditions revealed both strengths and weaknesses. A major strength is the fact that GMET provides gridded values, accompanied by statistical metrics that represent the level of uncertainty in the data. In areas with sufficient station density, GMET realistically represented both quantity and spatial patterns of precipitation and temperatures. However, in data-sparse regions, additional (satellite-based) data was required to fill gaps and close water balance calculations. SEI's future development of the GMET tool will focus on the fusion of satellite data to improve its performance in data-sparse regions.

While creating the model, SEI and Bolivian officials prioritized building local capacities; local climate experts were trained to run the GMET software and update its results for future water balance studies. Working with the Linux operating system, we made GMET available using open-source software libraries, so it could be shared freely with this new community of end-users. A local academic institution — the Laboratory of Atmospheric Physics (LFA) — supported a series of workshops that guided the local experts through using R software for data processing and analysis, running GMET using Linux, and evaluating GMET outputs of error and correlations. The entire modelling effort — from database compilation to generating the GMET outputs — was documented in English and Spanish.

Outcomes and next steps

A group of local experts are now capable and responsible for updating GMET in Bolivia. As new and improved data becomes available, they will be able to regularly make the necessary adjustments and thus improve the water balance results.

Water planners and experts in other countries also now have access to a tool that outperforms other existing methods when building a water model, particularly in regions with meteorological stations that are sparse and not evenly distributed. GMET's algorithm allows the production of results that acknowledge the error associated with low density metrological networks. Building on this work, other regions and countries could explore GMET applications for multiple purposes.

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