# GHP cross-cutting project proposal

# MOUNTerrain: GEWEX Mountainous Terrain Rainfall project

# Proposers/Contacts

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# Motivation

*This section should provide the scientific rationale/motivation for the project, along with relevant institutional context. It should answer questions like: Why is this project important scientifically and to GHP? How does this project build on past studies/knowledge and take advantage of expertise and observations supported by GEWEX/GHP? What will this project contribute to the field and the GHP community if successful? How will this project contribute to the GEWEX imperatives?*

**This proposal is designed to address the mismatch between the strong need for, but poor availability of, high-quality observational data sets of precipitation in mountain regions.** Mountains and high-elevation topography play a critical role in regional weather and climate, and help shape the global circulation of the atmosphere. In particular, the interaction of mountainous topography and the atmospheric circulation strongly shapes the distribution of precipitation in many parts of the world (e.g., Wratt et al. 1996, Isotta et al. 2014). The windward slopes of many mountain ranges experience very heavy precipitation and mountain precipitation contributes very significantly to water resources in many regions of the globe. Mountain precipitation is a key source of the water in several major rivers worldwide. Much precipitation over high-elevation topography falls as snow and contributes to the mass accumulation of glaciers and ice caps, thus playing an important role in the cryosphere and modulating the seasonality of river flows and water resources. Heavy rainfall events associated with orographic precipitation can result in flash flood events (e.g., Costa et al. 1978, Panziera et al. 2014), with significant risk to human life, to ecosystems, and to built infrastructure.

Climate change-related shifts in the nature, amount and seasonality of mountain precipitation have the potential to significantly affect water resource availability in many parts of the globe. With warming, the atmosphere can hold more moisture and there are prospects for heavier snows in the cold season in mountains, although the snow season is apt to become shorter at either end. Rain is likely to replace snow at some times of year. There is an urgent need to understand changes in precipitation in these areas. Accurate observations of precipitation in high-elevation regions are critical for understanding the current state and the future of water resources, especially for planning and risk management.

Despite the clear need for comprehensive observations of precipitation in high-elevation terrain, ground-based observation density is often poorest in mountainous regions. The reasons include low population densities, inaccessibility of appropriate observational locations, and harshness of high-elevation climates and the high cost of maintaining observing platforms in mountainous regions. Hence, there is a clear disconnect between the need for observations of mountain and high terrain precipitation and the availability of such observations. Moreover, rainfall over mountainous terrain exhibits strong variability and a high degree of intermittency in space and time (see Fig. 1), thus making understanding and prediction challenging (Poveda et al., 2005, Hurtado and Poveda 2009, Poveda 2011).



Figure 1. An intense storm over the city of Medellin in the central Andes of Colombia.

There are a variety of remote-sensing techniques available to supplement or substitute for ground-based measurements. Radar observations provide high-resolution estimates, but radar signals are often confounded by ground clutter and signal blockage by topography. Space-based estimates also face difficulties with high topography and complex surface emissivities although recent advances brought about by use of high frequency microwave channels have shown considerable potential in capturing precipitation over complex terrain (e.g., Levizzani et al. 2013). Yet newer space-based observations from the Global Precipitation Measurement (GPM) mission should provide a basis for improved estimates but there is a critical need for ground truth.

MOUNTerrain builds upon and is related to many former and current programs such as TRMM, GPCP, CMAP, APHRODITE, and MAHASRI. It naturally falls under the GEWEX High Elevations (HE) project and has strong links to the GEWEX cross-cutting study on extremes. It will feed in to the GPM and supporting projects, such as OLYMPEX. It is something of a follow-on to the WMO-SPICE intercomparison and will draw on the findings of earlier programmes and experiments such as MAP and SALPEX.

MOUNTerrain will contribute new and improved data sets, deeper understanding of mountain precipitation processes, and will lead to improvements in numerical weather prediction models, climate models, and models of surface runoff and hydrology of average and extreme events (low flows and floods). As such, MOUNTerrain will contribute directly to the GEWEX Imperative on Data Sets, and will provide observational data sets to feed into the Imperatives on Analysis, Processes, and Modeling.

A reason for this initiative now is two-fold. One is the need for ground truth related to GPM. However, another is to take advantage of a number of specialized, often research, precipitation measurements and mesonets that have been established in mountainous areas. Many observations are believed to be available but they era not distributed and not in global datasets such as GPCC or GPCP. However, there will be challenges in how to best utilize these data and fill in gaps in space and time in complex terrain, and this is where shared techniques and successful projects can be extremely useful. Developments of the observational data base in the context of mesoscale modeling is one expected development.

# Principal research questions to be addressed

*This section should contain the principal research questions that embody the aims/objectives of this project. It should distill the science focus in a clear and concise fashion.*

How useful are (and how best do we utilize) remotely-sensed and gridded data sets such as TRMM, GPCP, and reanalyses for characterizing high-elevation precipitation?

How well are we measuring solid precipitation in mountain areas and how representative are the available datasets?

What are the statistics of high-elevation precipitation around the globe – means, extremes, seasonal cycle, spatial distribution, trends at different space and time scales?

What are the key processes involved in features of high-elevation precipitation – spillover, orographic lifting, slope effects, spatial gradients, location of the pluviometric optimum, phase and amplitude of the diurnal cycles?

How well is high-elevation precipitation modeled, and what advances are needed to improve model performance (e.g., orographic enhancement, convective initiation, …)?

What are the effects of climate variability and climate change on the characteristics and features discussed in the previous questions?

MOUNTerrain addresses all four areas identified in the GEWEX Science Questions[[1]](#footnote-1), particularly Question 1: Observations and Predictions of Precipitation, and Question 2: Global water resource systems, by developing improved observations of precipitation in mountainous terrain and associated effects upon water resources and the cryosphere.

# Data requirements

*What observational or model data will be required to address the research questions? What data will be needed and how will they be obtained (open repositories, direct contact …) ? Of these data, which are available through accessible data repositories (e.g. satellite data, CORDEX)? And which need to be sourced through local or regional institutions/contacts? How will the RHPs contribute?*

This project has the development of observational data sets as a central activity. On that basis, the project should seek to act as a portal or clearing-house for all available mountainous precipitation data sets, both observed and modeled. In particular, MOUNTerrain will focus on:

* Collation of available digitized observational data for high-elevation precipitation along orographic gradients.
* Data rescue of high-elevation precipitation records, such as un-digitized meteorological station records, non-conventional written records from ski fields, alpine clubs, etc.
* Global and regional reanalysis products. The existing and future in-situ data sets must serve as a ground truth for validation of reanalysis products.
* CMIP5 (CMIPx) model output

# Project methodology

*This section should present the proposed experiment design and analysis techniques. It could include information on data quality control, required model simulations, and data analysis to be performed. The experiment and data analysis should be connected to the research questions above. Enough detail should be included to foster discussion of the most appropriate techniques or potentially the requirement for development of new techniques.*

**Data quality control**

In association with any data rescue activities, quality control against existing digital records, and reanalyses and gridded products, will be critical. Any relevant observational data sets that have not been analyzed will need to be tested for homogeneity, using standard approaches (e.g., Alexander et al. 2005).

**Project methodology**

Project-related research can take many forms. There are three major areas envisaged –

1. Sharing of software and methodologies for analysis of precipitation in complex terrain.
2. *Intercomparison studies*: Comparing gridded precipitation data sets (and reanalyses) both with station records and through cross-comparison. Development of best-estimate integrated, gridded data sets of mountain precipitation for all major high-elevation terrain regions of the globe.
3. *Model validation and model experiments*: Validating global and regional climate model output against gridded data sets developed under (1). Development of coordinated model experiments to guide process studies and model development – “MtnPrecMIP”?
4. Development of proposals for Integrated Observing Periods/Programmes in identified areas, on the basis of (1) and (2).
5. Interactions with GPCP (GDAP).

# Collaboration Mechanisms

*How will scientists collaborate in this project and interact with other GHP groups? Is there a need of collaboration with other GEWEX panels or WCRP groups? If so, what mechanisms are foreseen? Will there be a website? Email list? Workshops? Is there a plan for an initial workshop? When? Where?*

A first task is to collate and make available all known mountain precipitation data sets, though a GEWEX-hosted web portal.

A start-up workshop for interested parties is desirable. Depending on timing of project approval, this could be held at the 2014 AGU Fall Meeting (Dec 2014), or perhaps at the 2015 IUGG conference in Prague (June 2015), or somewhere in between those dates. Subsequent to that workshop, MOUNTerrain sessions can be promoted over coming years at international conferences – EGU, AGU, AMS, etc.

A review paper on the state of knowledge of high-elevation precipitation and identifying research and observational gaps would be one useful way to publicize the issue. The MOUNTerrain project can be cross-linked on the GEWEX and WCRP web pages. Interaction with the scientific community, especially early-career scientists and those from emerging economies, can come through a dedicated Facebook page and Twitter feed and a MOUNTerrain blog site – in addition to the web portal for data access.

# References

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1. <http://www.gewex.org/pdfs/GEWEX_Science_Questions_final.pdf> [↑](#footnote-ref-1)