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Faculty of Geosciences
Physical Geography

The impact of spatial resolution on resolving spatial precipitation patterns in the Himalayas

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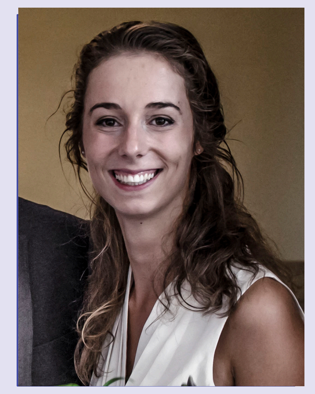

Introduction

Frequently used gridded meteorological datasets poorly represent precipitation in the Himalaya due to their relatively low spatial resolution and the associated representation of the complex topography. Dynamical downscaling using high-resolution weather models may improve the accuracy and quality of the precipitation fields. In this study the WRF (Weather Research and Forecasting) model is used to determine which resolution is required to most accurately simulate monsoon and winter precipitation and 2-meter temperature in the Nepalese Himalayas.

Study area

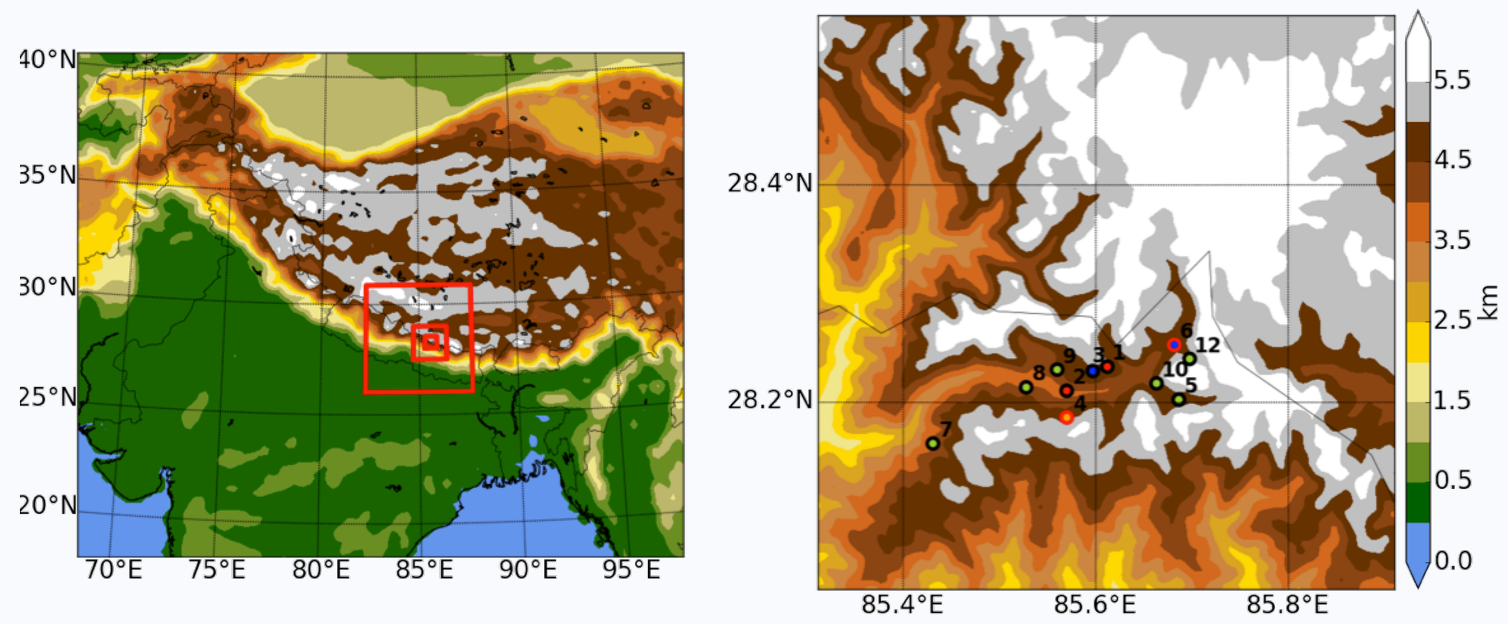

Figure 1: Study area and location of 4 domains (left) and the inner domain with the observation stations. Tipping buckets (green), automatic weather stations (red) and pluvio meters (blue). A black edge means the station is used for both the winter and summer period and a red edge if it is only used in summer period.

Methodology

- Model 10-day summer and winter period with WRF (Weather and Research Forecast) model
- First sub-kilometer evaluation with WRF in Himalayas
- Compare to 14 observation stations for precipitation and temperature
- Correct for under-catch of snow for wind speed (Theriault, 2012)

Challenges

Higher resolution is preferred however:

- Constraints in parameterizations (dx<500m)
- Higher computational cost
- At least 1 km grid spacing is required for capturing meteorological variability (Collier and Immerzeel, 2015)
- Under-catch of precipitation makes model validation hard

Figure 2: Showing complex topography in Langtang catchment (Photos Inka Koch).

Results

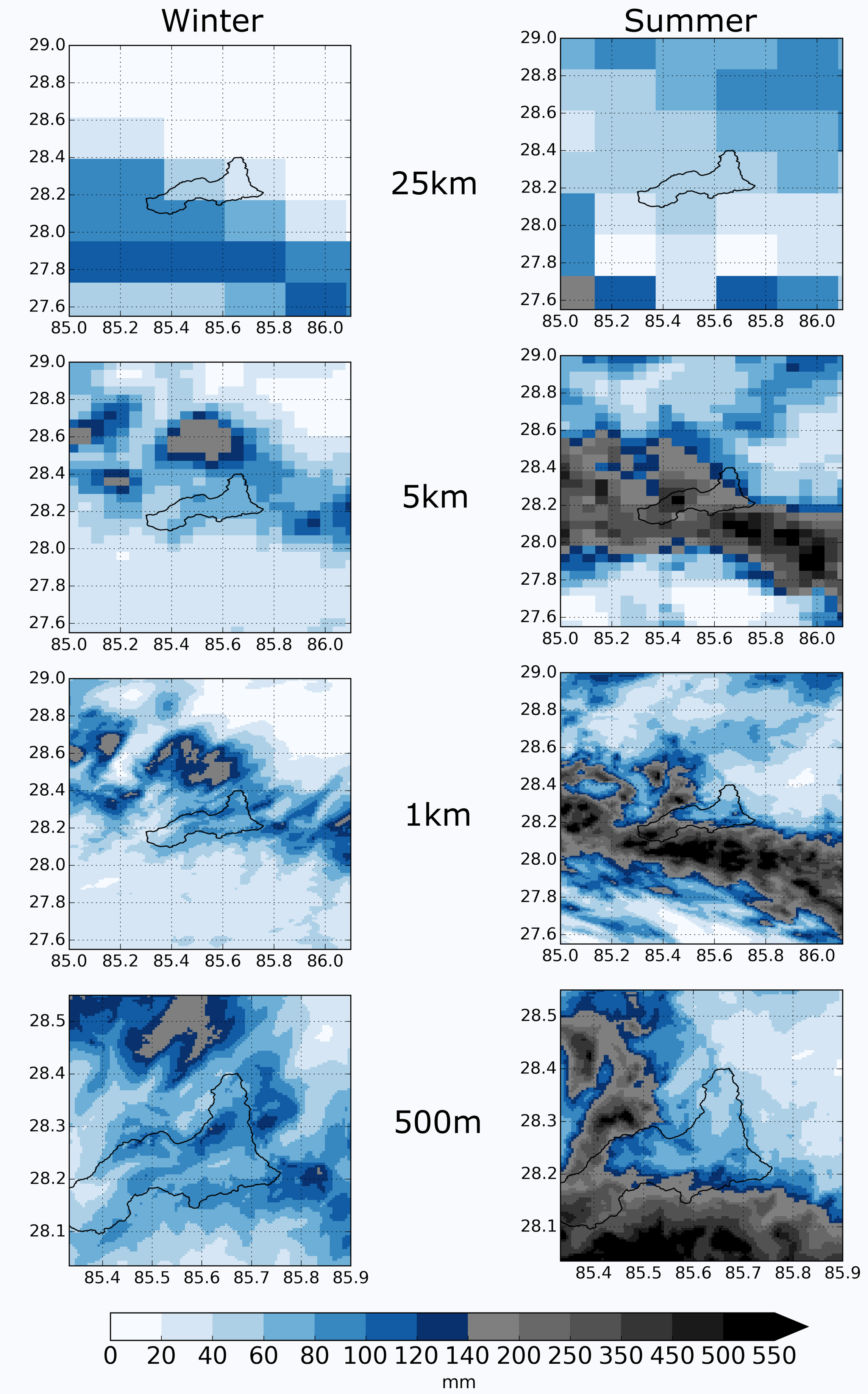

Figure 3: Total accumulated precipitation for 4 different grid sizes (25, 5, 1, 0.5 km from top to bottom) for the 10-day winter (left panels) and summer period (right panels).

500m resolution best match with observations, because:

- Better resolved topography and glaciers
- Intensified orographic forced precipitation by better resolved updrafts
- More detailed precipitation patterns revealed in valley

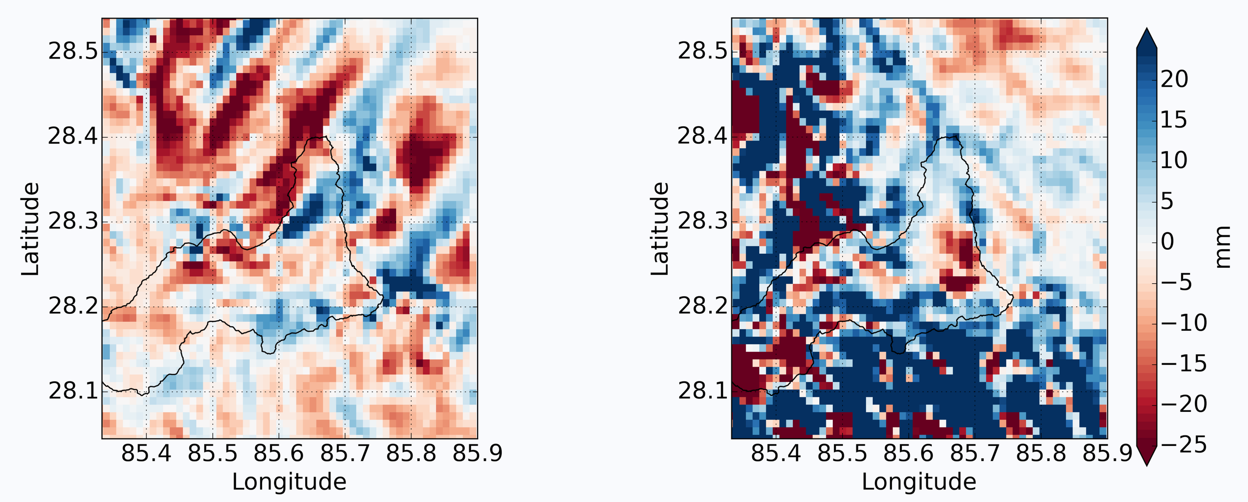

Figure 4: Difference in precipitation (dx=1km minus dx=0.5km) for the winter (left) and summer period (right). Data of 0.5km-domain is regridded to 1km-domain.

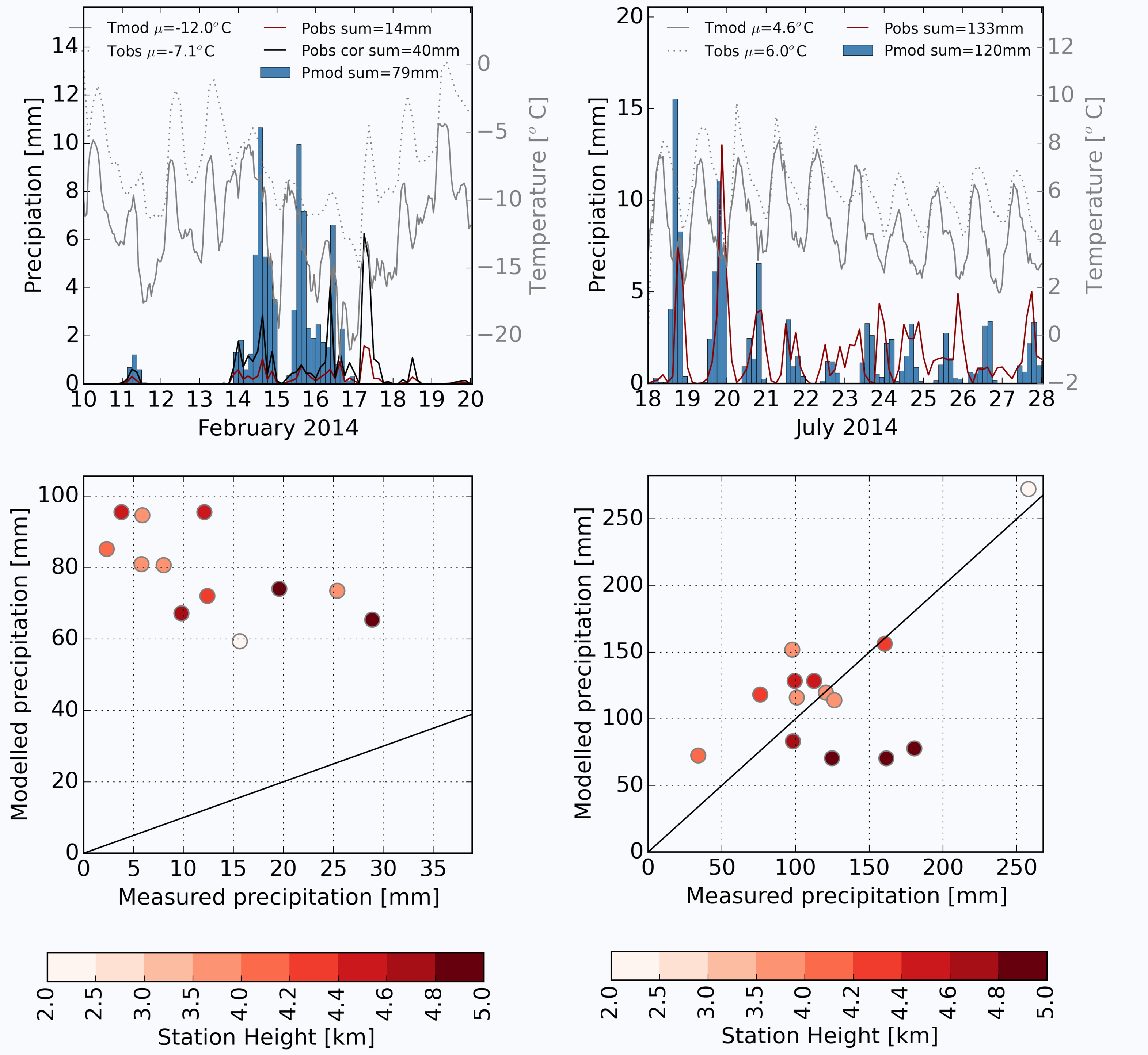

Figure 5: Averaged modelled (blue bars) and measured (red) precipitation and modelled (solid grey) and measured (dashed grey) temperature over the stations for summer (left) and winter (right) period (upper panels) for 500 meter resolution. Lower panels show the total accumulated precipitation for each station for the summer (left) and winter (right) period. Points are colored by altitude.

High altitude stations (>4600 m) under (over) estimated in summer (winter) by 57 % (330%), because:

- Under-catch of snow up to factor 5
- Cold temperature bias, which could potentially lead to more snow (positive feedback)

Conclusions

- Sub-kilometer modelling has benefits in complex terrain to accurately resolve meteorological variability
- Our results increase confidence in the performance of WRF at high resolution
- Computationally feasible to run multi-year WRF simulations at 500 meter resolution
- LES modelling recommended to understand sub-scale processes

References:

- Collier, E., and W. W. Immerzeel (2015), High-resolution modeling of atmospheric dynamics in the Nepalese Himalaya, J. Geophys. Res. Atmos., 120, 9882–9896, doi:10.1002/2015JD023266
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