

Inferring glacial meteorology from physical modeling and remote sensing



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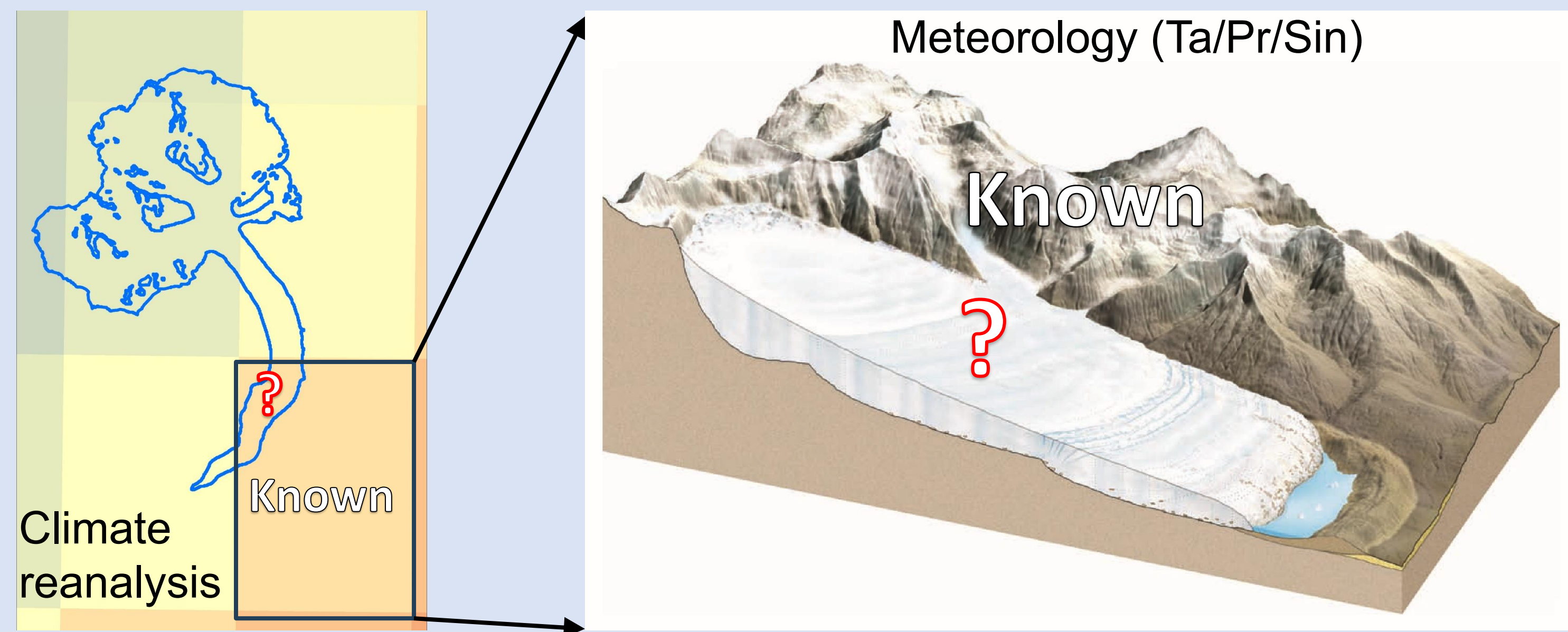
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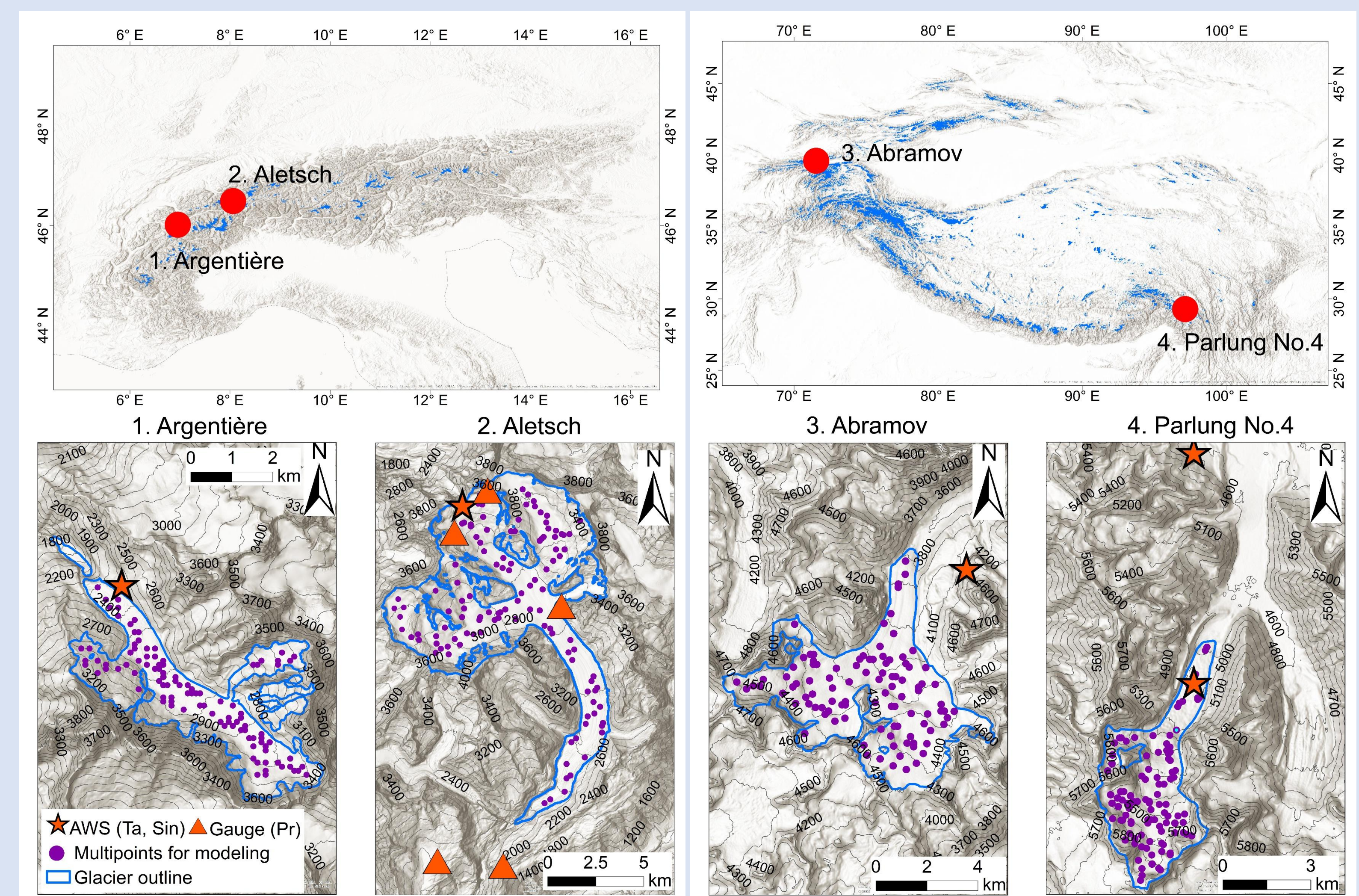
1. INTRODUCTION

- Local meteorology in high mountains is key for understanding glacier change, but challenge to obtain;
- Reanalysis climate data is an option, but is too coarse resolution and has large inherent biases.

Goal: Developing a **general method to optimize glacier meteorology** from physical modeling and remote sensing observations using a Monte Carlo approach and Bayesian Inference.



2. STUDY SITES

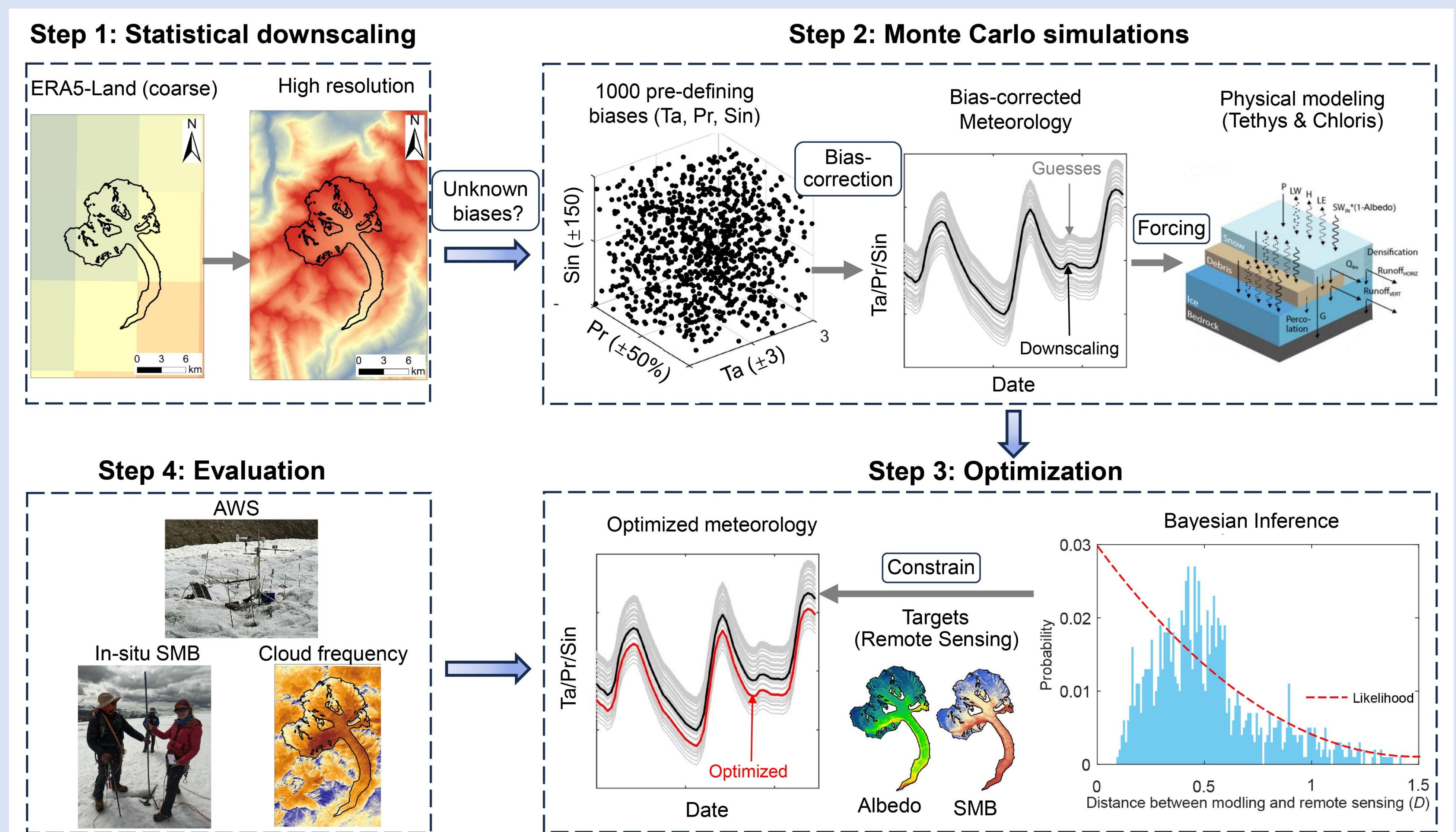


3. DATASETS

- ① **Forcing data:** ERA5-Land climate reanalysis
- ② **Remote sensing data:**
 - Glacier albedo (Sentinel-2 and Landsat-8/9)
 - Resolved surface mass balance from ASTER¹

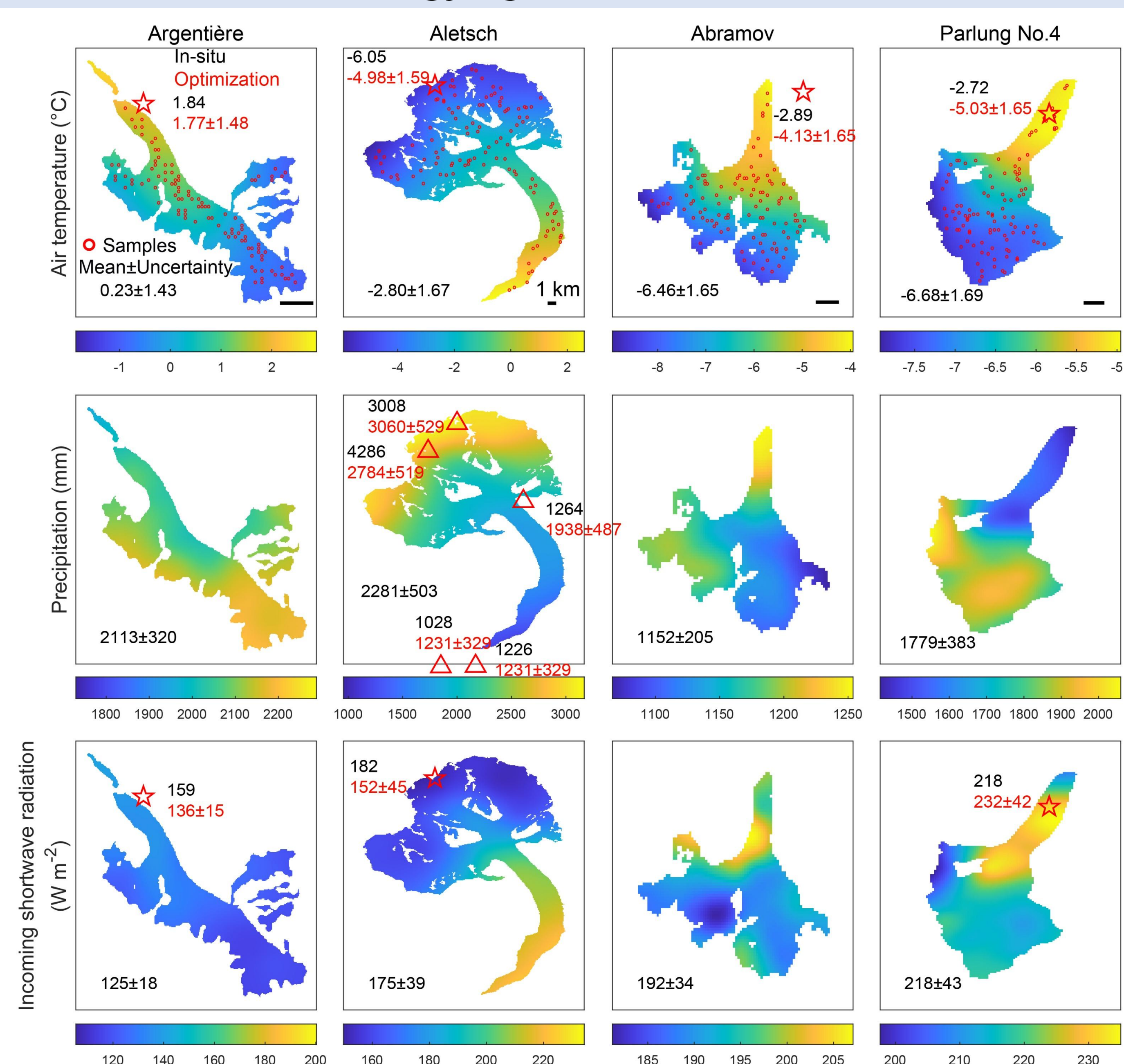
4. METHODOLOGY

- ① **Statistical downscaling of ERA5-Land²**
- ② **Monte Carlo simulations with a land surface model**
1000 runs with Air temperature: $\pm 3^\circ\text{C}$; Precipitation: $\pm 50\%$; Incoming shortwave radiation: $\pm 150\text{ W m}^{-2}$
- ③ **Multiparameter optimization by Bayesian Inference**
$$p(\theta|y) = p(\theta)p(y|\theta)/p(y)$$
where θ is combination of three meteorological variables; y is remote sensed surface mass balance and glacier albedo, $p(\theta|y)$ is posterior; $p(\theta)$ is prior distribution for θ and is a constant due to its uniform distribution, $p(y|\theta)$ is the distribution of the data at a given θ (likelihood), $p(y)$ is the marginal distribution of the.
- ④ **Evaluation with independent datasets**

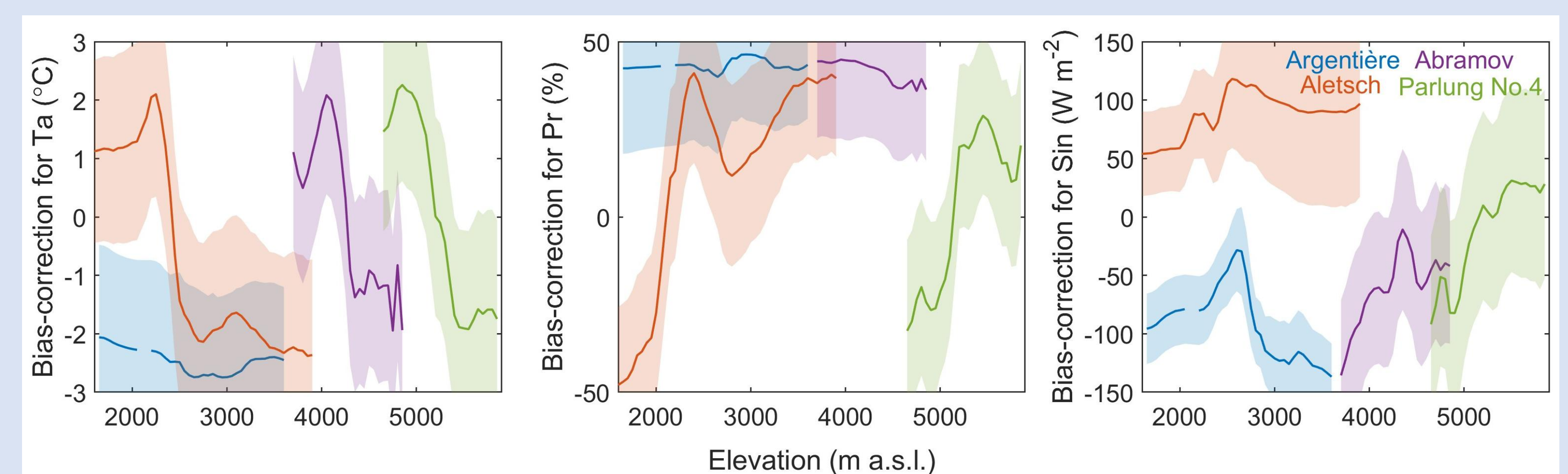


5. RESULTS AND CONCLUSIONS

Inferred meteorology against in-situ observations



- Estimated accuracy: $<1^\circ\text{C}$ for Ta; $<20\text{ W m}^{-2}$ for Sin; similar pattern for Pr;
- Glacier meteorology is **highly spatially variable** over the glacier;



- **Spatial bias-corrections** for ERA5-Land are necessary.

Discussion:

- More direct evaluations are needed;**
- Large scale and long-term applications** are still changing due to high computing cost and absence of high-quality remote sensing data.

Main references:

1. Miles et al. (2021), Nature Communication; 2. Machguth et al. (2009), JGR

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