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Dynamical Statistical Forecast of Alpine Snow Amounts

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INTRODUCTION

Affected:
- public transport
- winter tourism
- outdoor sportsmen
- residents & infrastructure

Forecasts needed for:
- risk assessments
- public warning
- road/railroad maintenance
- $+12h$ to few days in advance

Challenges of rain/snow forecasting in complex terrain:
- depends on various scales (global circulation $\rightarrow$ micro physics)
- strongly modulated by local orography
- even high resolution NWP models do not resolve all important processes
- minor station density at high altitudes

OBSERVATIONAL DATA SET

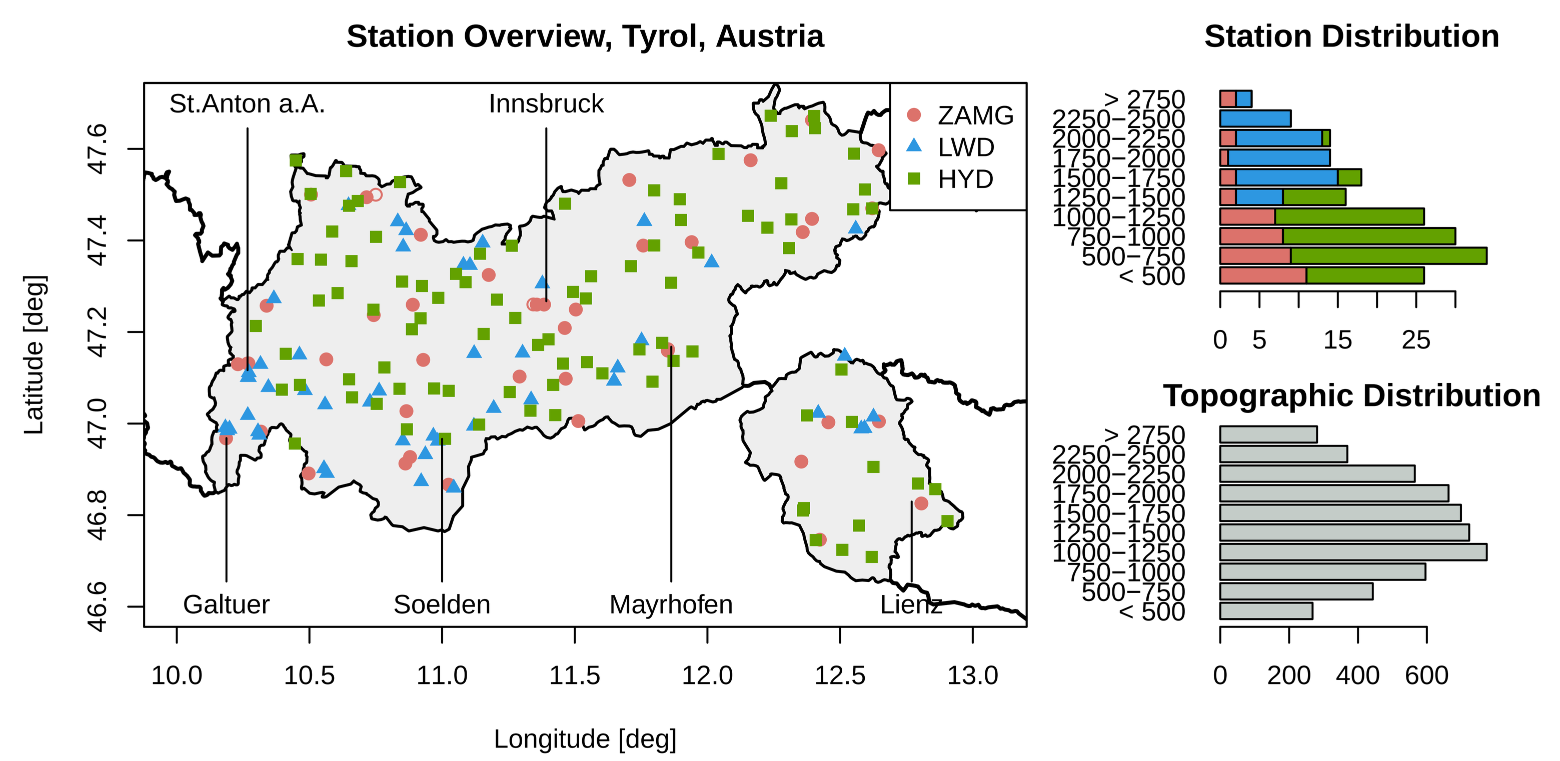

Figure 1 : Overview of all precipitation observation stations in Tyrol. Left panel: spatial distribution; Right panel: station and topographic elevation distribution.

- horizontally and vertically well distributed
- 44 stations from the national weather service (ZAMG) [(a)]
- 54 stations the local avalanche service (LWD) [(b)]
- 93 stations from the national hydrographical service (HYD) [(a,c)]
- Station density approximately 1.5 stations per $10 \times 10\ km^2$

Measuring (*a*) precipitation and new snow water equivalent, (*b*) total snow depth, and/or (*c*) new snow depth. Most stations measure 12 or 24 hourly sums.

CURRENT APPROACH

Basic concept:
use anomalies to eliminate station dependence

$$\underbrace{obs - obs_{clim}}_{\text{Observed anomalies}} = \beta_0 + \beta_1 \cdot (\underbrace{ens - ens_{clim}}_{\text{Forecast anomalies}}) + \epsilon \qquad (1)$$

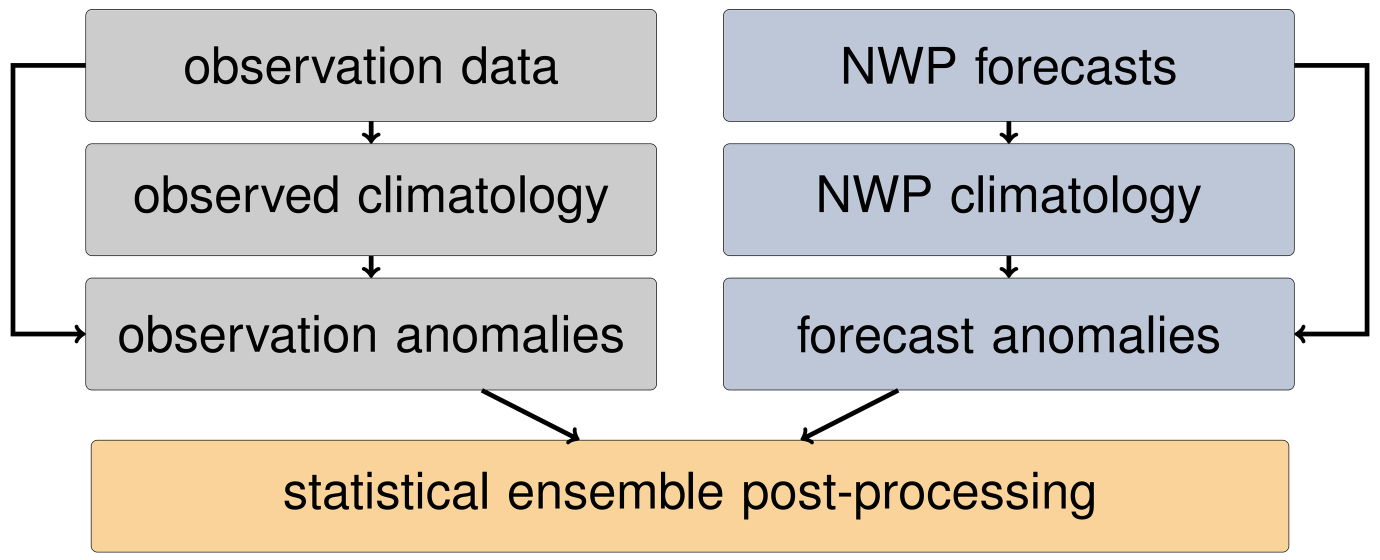

Figure 2 : Simplified process chart of one of the applied models. The idea is based on Scheuerer and Büermann (2014) but has to be modified for precipitation forecast.

Corrected forecast:

$$\hat{y} = obs_{clim} + \beta_0 + \beta_1 \cdot (ens - ens_{clim}) \qquad (2)$$

Description of terms

- obs: observations
- obs_{clim}: climatology of observations
- ens: ensemble forecasts from an NWP model
- ens_{clim}: climatology of past ensemble forecasts
- $\hat{y}$: estimated, spatially corrected forecasts
- ϵ: statistical (unexplained) error

PRELIMINARY RESULT

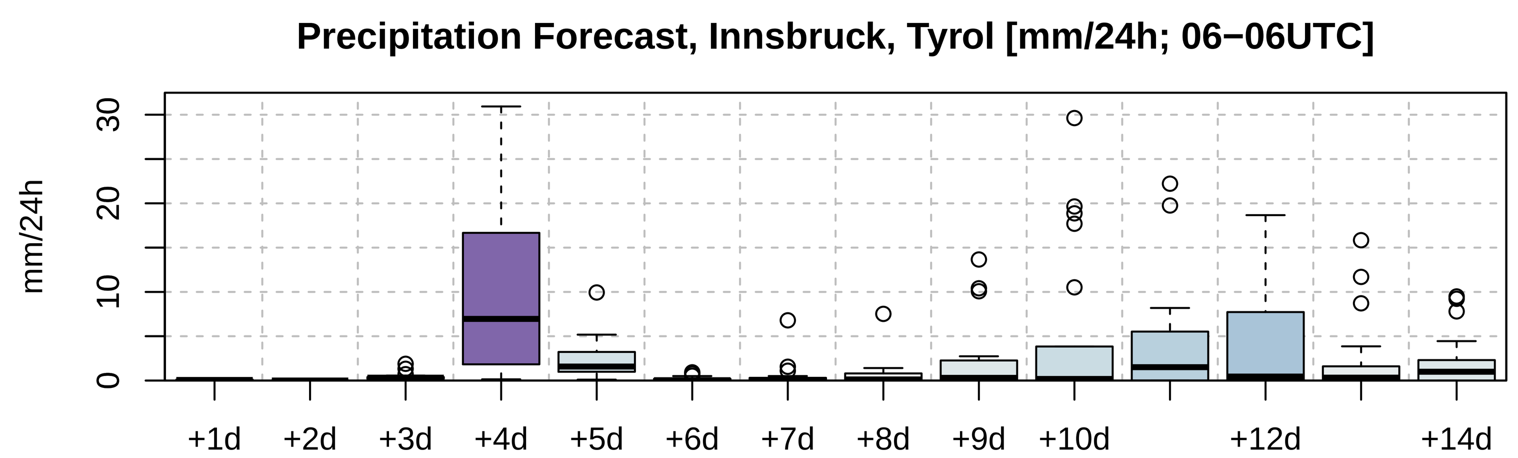

Figure 3 : Example of probabilistic $+14$ days forecast. The boxplot shows $24h$ sums of accumulated precipitation. Forecasts based on the ensemble of the European Center for Medium-Range Forecasts (ECMWF).

PRELIMINARY RESULT

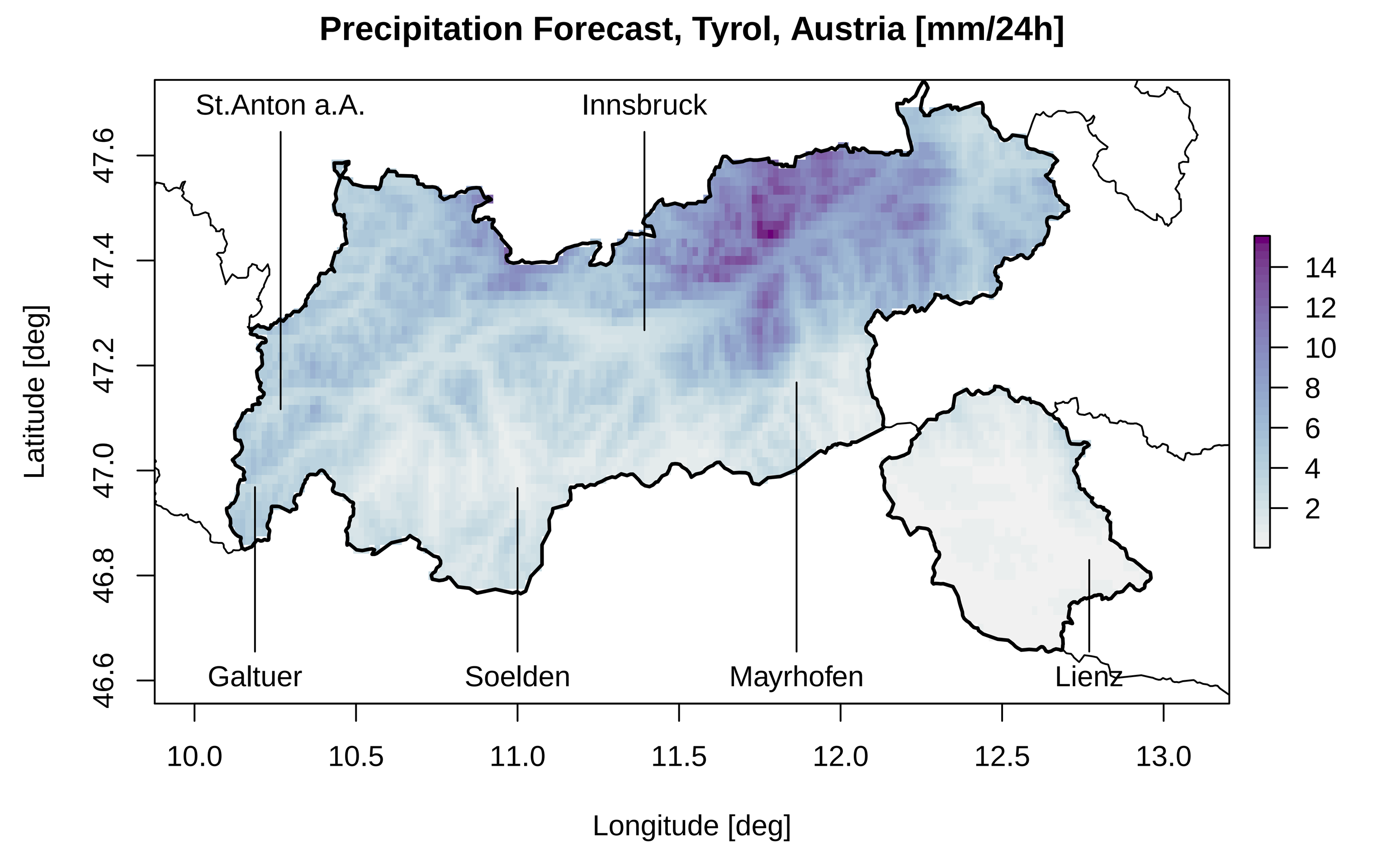

Figure 4 : Example forecast based on an adapted version of the Scheuerer and Büermann (2014) model. The plotted field corresponds to $\hat{y}$ for one random day in 2014, precipitation sum from $+6$ to $+30h$ in advance.

PROJECT GOALS & CHALLENGES

- combining different observations: liquid water, new snow amount, and total snow depth
- including high resolution digital elevation model and local orographic properties
- extending the concept shown in figure 2 to precipitation
- flexible spatio-temporal additive models to create forecast and observation climatologies (obs_{clim}, ens_{clim})

References:
Scheuerer, M. and L. Büermann, 2014: Spatially adaptive post-processing of ensemble forecasts for temperature. Journal of the Royal Statistical Society: Series C (Applied Statistics), 63, 405–422.

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