EMS Annual Meeting Abstracts
Vol. 8, EMS2011-108, 2011
11th EMS / 10th ECAM

Forecasting the weather
- ensemble techniques
in probabilistic weather prediction

Does the weather stop the traffic?

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Natural hazards in Norway, the most important being avalanches, landslides, and floods, are often triggered by extreme weather events (EWEs). According to recent studies winter precipitation in Norway has increased by 5-25% between the two 30-year periods 1961-90 and 1979-2008. Climate models indicate that this trend will continue in the future, and EWEs are expected to become more frequent and intense. These changes are likely to threaten important infrastructure that are designed along the guidelines based on known historical precedence.

The current study is carried out under the Norwegian project InfraRisk (Module A) which aims to improve the understanding of past and future variability of EWEs in Norway and its connection to natural hazards affecting Norwegian transport infrastructure. The focus is on major roads, railways and related buildings. The main objectives are to identify EWEs that are most relevant in the triggering of natural hazards, and to analyze past and future changes in frequency and intensity of these events, as well as their spatial distribution. In this study we have assessed changes in the past, between 1961 and 2010, with particular focus on climate elements relevant in the triggering of avalanches. Among the climate variables studied are intense and/or prolonged precipitation events, episodes of heavy snowfall, especially those followed by strong winds, and freeze-thaw events known to cause instability in the snow pack and triggering rock fall.

The Mann-Kendall trend test is applied to compute trends for different time periods and evaluate these for statistical significance. Since observations are limited in many areas, especially in higher elevations, data are extracted from the climate grids presented at www.seNorge.no. These are daily values of temperature, precipitation and different snow parameters on a 1x1 km^2 grid for the period 1957 until today. Wind with $\sim$11km resolution is extracted from a high-resolution hindcast of wind (the Hindcast archive), which consists of regional downscaling of ERA40 reanalysis.

For precipitation we find that long-duration events have more obvious trends than short-duration events. Trends for the entire period 1961-2010 are positive in the southwest and along the northern coast, while weakly negative in the southeast and in central Norway. Annual maximum snow depth reveals positive trends in cold areas, explained by increased winter precipitation, and negative trends in warm areas, explained by increased winter temperatures. For snowfall we do not see such strong trends, however patterns are similar. Events of snowfall combined with wind above the specified thresholds only occur a few places along the coast, and trends here were generally negative. This is most likely due to changes in snowfall rather than changes in wind speed. The number of freeze-thaw events obviously depends on the winter temperature in any location. There are mainly positive trends in the entire country except near the coast in Southern-Norway. Trends are stronger in cold areas, which can be explained by the recent warming forcing temperatures closer to zero and creating more favorable conditions for freeze-thaw events to occur.