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User-centred Evaluation of Cold Wave Forecasts for Disaster Risk Reduction in Lesotho

Katherine Egan[a,*], Calum Baugh [a], Rebecca Emerton[a], Christel Prudhomme[a], Daniele Castellana [b], Sebongile Hlubi [c]

[a] *ECMWF, The United Kingdom, Katherine Egan - katherine.egan@ecmwf.int, Calum Baugh - calum.baugh@ecmwf.int, Rebecca Emerton - rebecca.emerton@ecmwf.int, Christel Prudhomme - christel.prudhomme@ecmwf.int*
[b] *510 The Netherlands Red Cross, The Netherlands, Daniele Castellana - dcastellana@redcross.nl*
[c] *The Lesotho Red Cross Society, Lesotho, Sebongile Hlubi - shlubi@redcross.org.ls*

* Corresponding author

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Abstract:

In the real world, people must decide how to act in the build-up to hazardous weather or climate events. Forecasts should be a fundamental component of timely and appropriate decision making. However, relevant services do not always exist or, if they do, may be overlooked because they are not tailored to the user's needs or considered 'good enough' to justify action. The I-CISK project (Innovating Climate services through Integrating Scientific and Local knowledge) aims to create a 'next generation' of climate or forecasting services that directly support users' needs.

Performance evaluation of these climate and forecasting services is fundamental to their success and can also contribute to their development. Prior knowledge of a service's strengths and weaknesses when predicting parameters and values that are used for decision-making can help users assess how best to incorporate it (or not!) into their operational procedures. Standard statistical verification, whist integral to model development, can be difficult to understand and apply to operational problems where action is imperative. 'User-centred' evaluation differs from this classical approach by considering the context in which forecast data is used and by ensuring results are relevant and understandable for end-users.

Here we present an adaptable process for user-centred evaluation and demonstrate its application to cold wave forecasting for disaster risk reduction in Lesotho, one of seven I-CISK 'Living Laboratories'. Lesotho is a mountainous country in southern Africa whose population is vulnerable to cold waves. In the past such events have caused fatalities, loss of livestock and damage to livelihood, and necessitated rescue operations because communities have been cut off or substantial transport disruption has occurred. We evaluate ECMWF temperature and snow forecasts in the context of the Lesotho Red Cross Society's draft Early Action Protocol (also known as an Anticipatory Action Plan) for cold wave disaster risk reduction.

In the first part of the evaluation process, historical cold wave events are identified, and the severity of the impacts is categorized. Events are then characterised in the ECMWF 'model world' by assessing temperature and snow reanalysis data (ERA5 Land; Figure 1). The results are used both to tailor the 'action trigger thresholds' defined in the Early Action Protocol (these are the forecast values at which the Red Cross will start to take actions to mitigate the impact of a potential event) for use with ECMWF forecasts, and to derive operationally useful information on their ability to identify historical events. This is used as an example of how evaluation can not only assess performance, but also be used to tailor a service to the users' needs.

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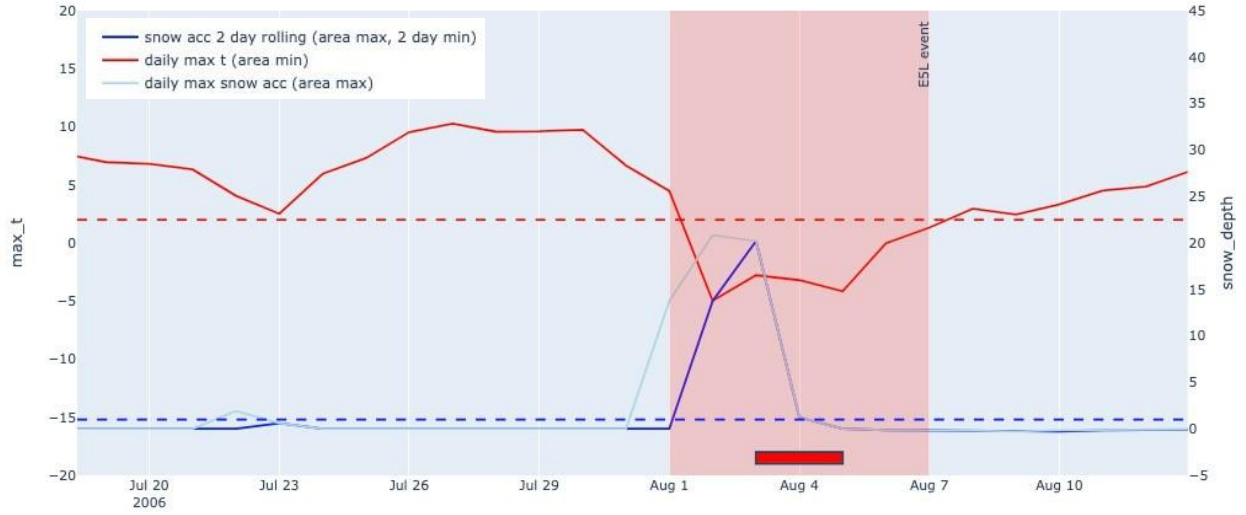

Figure 1. ERA5-Land temperature and snow accumulation during a cold wave event that caused severe impacts in August 2006, showing trigger thresholds and the dates of recorded impacts. Red line = Daily maximum temperature, Light blue line = Daily accumulated snow depth, Dark blue line = 2 day running minimum of accumulated snow depth. Red dashed line = 2 C threshold, Dark Blue dashed line = 1 cm accumulation threshold. Red shading = event as identified in ERA5 Land using the tailored Early Action Protocol threshold in the Lesotho highlands. Red Bar = impact dates recorded in the historical impactful events database.

Forecast exceedances of temperature (and potentially snow) thresholds, as outlined in the Early Action Protocol, will be used to guide anticipatory action by the Lesotho Red Cross Society, so it is important to know how well models can detect events defined by those thresholds. In the second part of the evaluation process, we assess deterministic ECMWF temperature and snow re-forecast performance at the tailored action trigger thresholds, employing a user-centred, event-based approach to the standard contingency table. We focus primarily on two operational questions ‘How well is the event start date predicted?’ and ‘At what lead time can the forecast first be relied upon?’.

Our results show that the primary action trigger threshold, when tailored using ERA5 land data, effectively detects higher impact events. ECMWF deterministic forecasts show good ability to identify the start of an event to within +-1 day at a lead time of 4-6 days, however, false alarm rates were found to be relatively high. The forecast is less effective at predicting the exact start date of an event. High instances of false alarms are likely linked to over-forecasting of the number of instances of temperature below the trigger threshold, and snow accumulation above the threshold, on high ground. We find that over-forecasting is worse in spring than in autumn or winter. These findings could be used to help forecasters and decision makers interpret ECMWF forecasts in the build-up to future events. However, evaluating probabilistic (ensemble) cold wave event forecasts, and understanding whether using a relevant probability threshold could reduce false alarm rates, is a key area for future research.

This work highlights the valuable, operationally relevant information that can be gained through user-centred evaluation, which should form an integral part of any forecast or climate service.

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