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Automatic gale warning proposals for Swiss lakes and airports

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Motivations

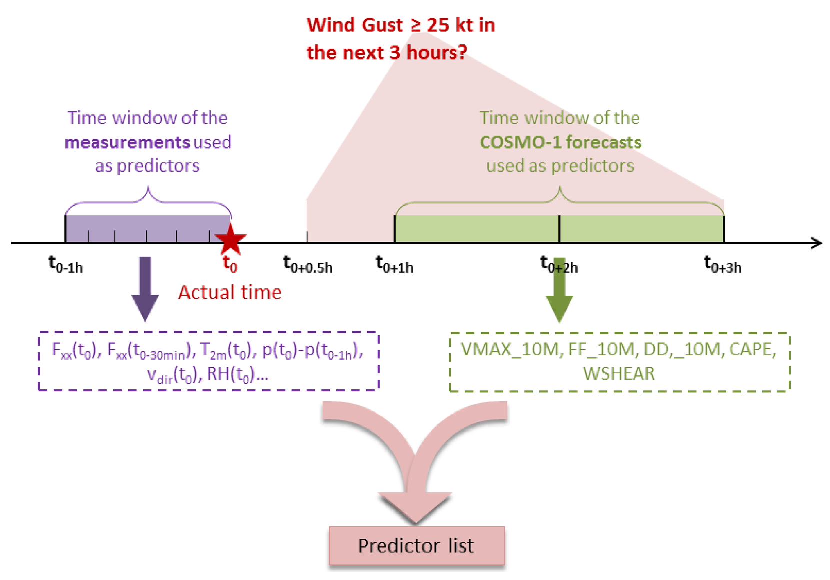
- Improve warnings of gusts exceeding 25 knots for airfields and lakes (also called objects) by increasing the warning hit rate and diminishing false alarms
- Develop a method considering all possible information available including observations and model forecast
- Implement a system working as much as possible automatically, but allowing the intervention of forecasters on duty

Conclusions

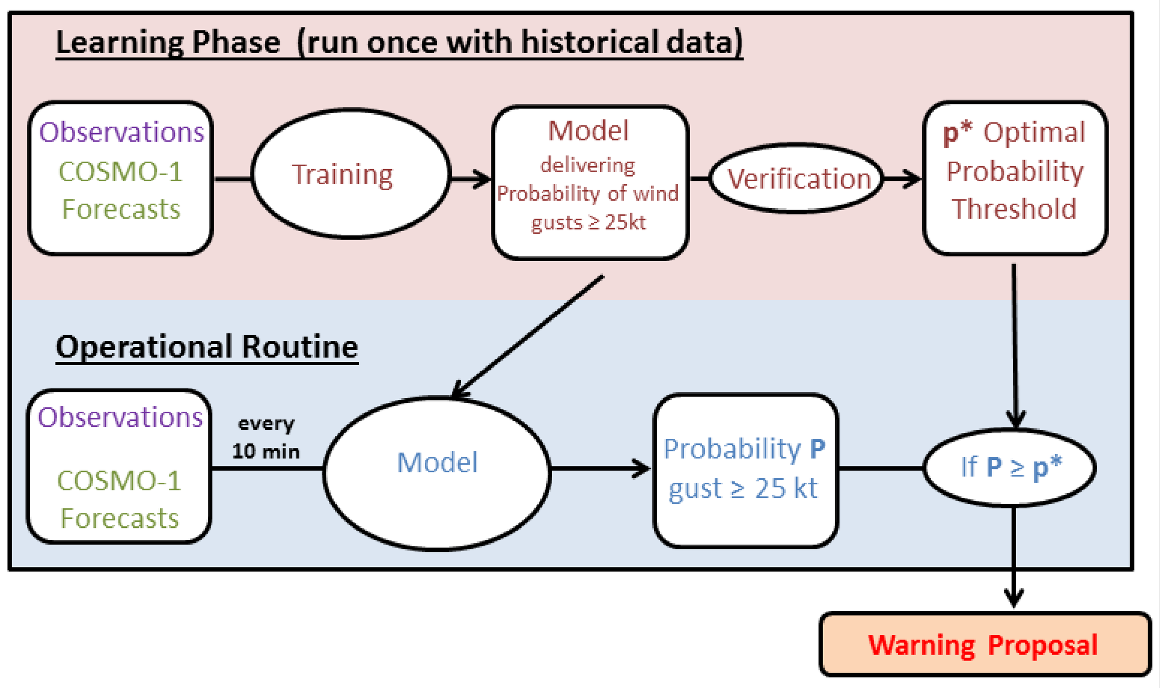
- Overall the automatic gale warning system (**GaleWarn**) obtains significantly higher hit rate than model output or forecaster.
- However **GaleWarn** tends to issue a large proportion of false alarms.
- Forecasters accept or reject the automatic issued **GaleWarn** proposals. Preliminary results show the combination of automatic warnings with forecaster expertise improves the warning system.

Methods

►***Fig 1:*** *Basic setup. All information available at time step t_0 including measurements of the last hour and the latest model output forecasts provided by the high resolution model COSMO-1 build a predictor list used to develop algorithms predicting the probability of occurrence for gusts exceeding 25 kt at a specific location within 30 minutes to 3 hours.*



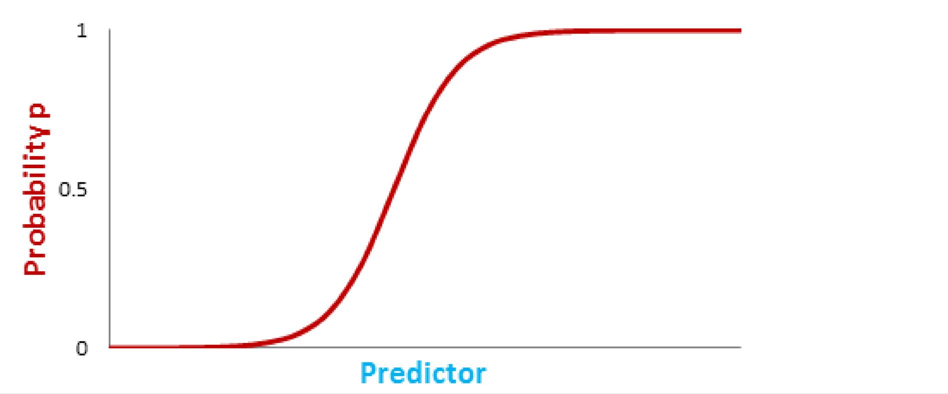
►***Fig 2 :*** *Development of algorithms for each object. During the learning phase, a 4-year set of predictors is used to compute a statistical model for each object based on a* ***logistic regression*** *(fig. 3). The optimal probability threshold* ***p**** *is obtained with historical data (fig. 4a and 4b). In daily operations each specific statistical model delivers the probability* ***P*** *that gusts will reach 25 kt or more in the next 30 minutes to 3 hours using the actual measurements and model forecasts. A warning proposal is issued when the computed probability* ***P*** *is greater than the optimal probability* ***p**** *threshold defined with historical data during the learning phase.*



Probability p for gust > 25 kt

$$p = \frac{1}{1 + exp(-(\beta_0 + \beta_1 x_1 + \cdots + \beta_K x_K))}$$

with predictors $x_1, \ldots, x_K$ and coefficients $\beta_0, \ldots, \beta_K$



◄ ***Fig 3:*** *Logistic regression. This statistical method estimates the relation between a categorical variable (probability* ***p****) and a set of independent variables (predictors x_i). The result is a sigmoid curve delivering the probability for an event to occur in the present case the probability of wind gust ≥ 25 kt.*

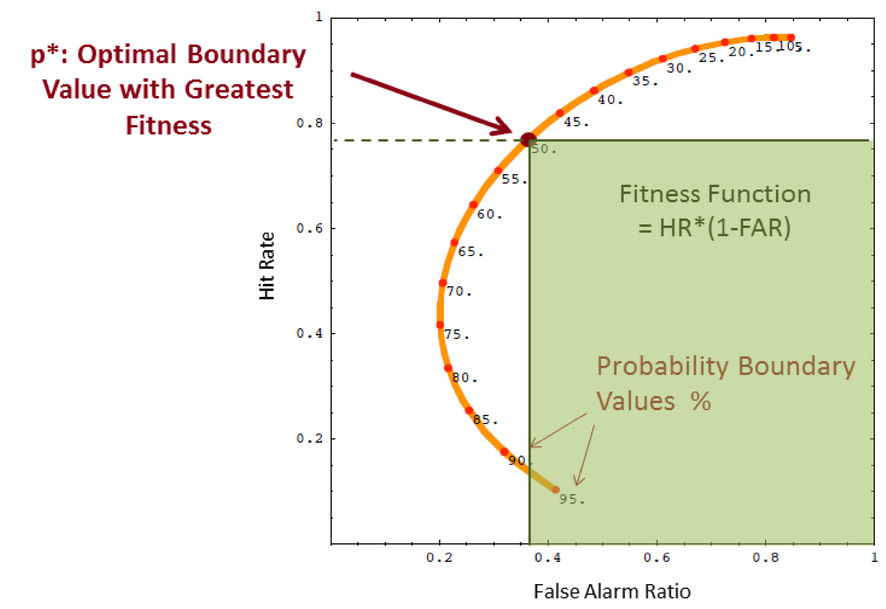
Hosmer D. W., Lemeshow S., Sturdivant R.X. (2013) Applied Logistic Regression. Wiley

▼***Fig 4a and 4b:*** *The optimal probability threshold is computed in 2 steps. First the logistic model is applied on a set of independent historical data for every probability level in 5% steps. In a second step the optimal threshold is obtained by searching for the maximum of the fitness function* ***Hit Rate * (1 - False Alarm Ratio).***

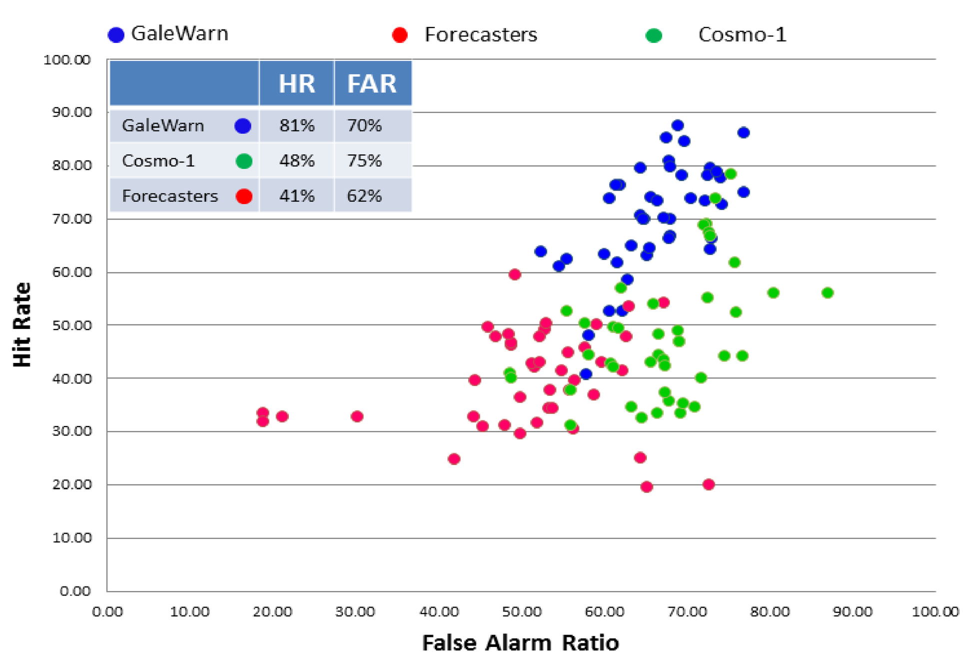
Event: v_{max} ≥ 25 kt		Observed Event: Yes	Observed Event: No
Forecasted Event	Yes	A	B
Forecasted Event	No	C	D

Hit Rate= $HR = \frac{A}{A+C}$ False Alarm Ratio = $FAR = \frac{B}{A+B}$

Fitness Function = $HR * (1 - FAR)$



Results

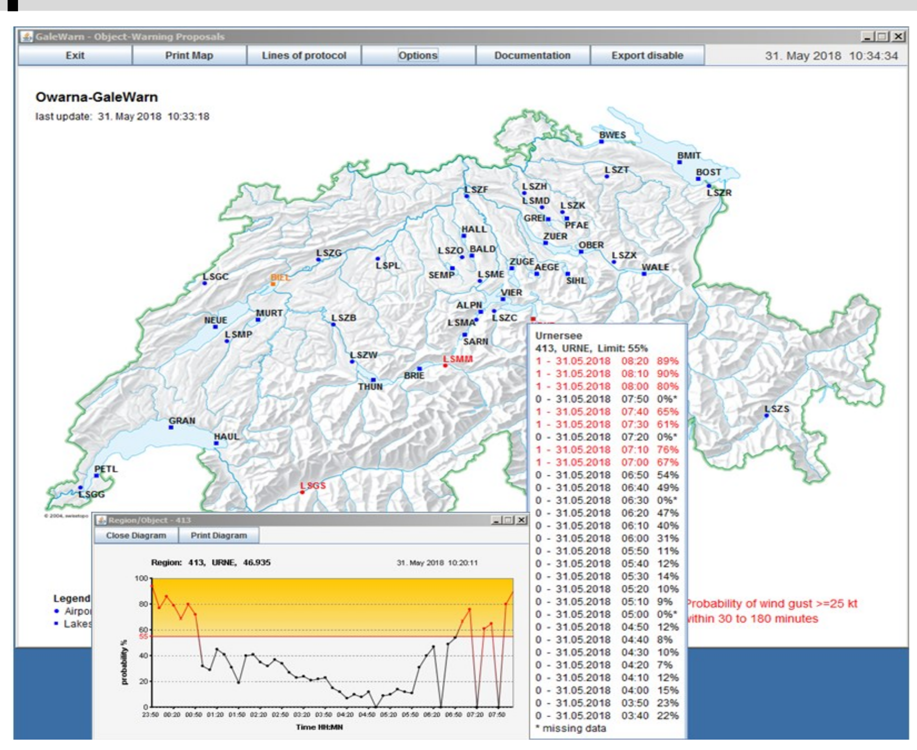


◄ ***Fig 5:*** *Results obtained during the development phase of* ***GaleWarn****:*

- *The Hit Rate (HR) obtained with the automatic* ***GaleWarn*** *(HR: 81%) is significantly higher than the HR of both forecasters (HR: 41%) and direct model output of Cosmo-1 (HR: 48%).*
- ***GaleWarn*** *as well as Cosmo-1 tend to produce to many false alarms.*
- *The forecasters false alarm ratio is slightly, but significantly better than both* ***GaleWarn*** *and Cosmo-1*
- *The system has been operationally introduced during 2017 and improved in the beginning of 2018. First qualitative results show that the forecasters seem to improve the* ***GaleWarn*** *performance by reducing the number of false alarms. However this qualitative observations must be confirmed with quantitative data.*
- *The performance of* ***GaleWarn*** *strongly depends on the specific object (lake or airfield).*
- *One of the benefit of* ***GaleWarn*** *is to react very sensitively and to issue warning proposal in a very early stage before a storm event takes place, focusing the attention of forecasters on the coming warn situation.*

Operational Setup

►***Fig 6:*** *The probabilities of wind gusts ≥ 25 kt for about 50 lakes and airfields are computed every 10 minutes. The visualization allows to distinguish between locations where the probability threshold have been outreached (in red) or where at least 80% of the threshold have been reached (orange dots and fonts). At each location a list of the probabilities calculated in the last 1 to 8 hours can be displayed as popup windows either as list or time series. In case of missing values from one of the predictors the calculation for the specific object and time step is not done.*



▼ ***Fig 7:*** *In daily forecast operations warning proposals issued by* ***GaleWarn*** *are automatically displayed by* ***NinJo****, the workstation system used for processing and displaying meteorological data and warnings at* ***MeteoSwiss****, on which forecasters can decide to either confirm or reject the warning proposals. An example of warning proposals as they appear automatically in* ***NinJo*** *is shown below. Buttons to* ***accept*** *(****Annehmen****) or* ***reject*** *(****Abweisen****) the proposals are on the left. By accepting a proposal, a form containing the automatic warning information will open allowing the forecaster to edit it before sending. The incoming warning proposals are signalled by an acoustic signal. The forecasters have 3 minutes to decide to accept the warning proposals. After 3 minutes the proposals are automatically discarded, and no action takes place. If an object (lake or airfield) is warned, no further warning proposals will be shown. The forecasters have also the possibility to issue warnings without automatic proposals.*

Annehmen	Abweisen	Timer	Wahrscheinli...	Warntyp	Warnereig...	Warnkate...	Warnereignis	RZ	Höhenbereich	Ausgabe...	Gültig von	Gültig bis
		00:00:39	98 %				Starkwindwarnun...	Vorschläge ...	Alle Höhens...	23.05. 15:5...	23.05. 16:...	23.05. 22:...
		00:00:38	80 %				Starkwindwarnun...	Vorschläge ...	Alle Höhens...	23.05. 15:4...	23.05. 16:...	23.05. 22:...
		00:00:39	100 %				Starkwindwarnun...	Vorschläge ...	Alle Höhens...	23.05. 15:4...	23.05. 16:...	23.05. 22:...

Further information:
Mayoraz L, Ambühl J : 2016, Automatic Gale Warning Proposals for Swiss Lakes and Regional. Aerodromes, Scientific Report MeteoSwiss, 102
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