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Towards automated multi-sensor thunderstorm warning suggestions

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Motivation

⇒ In order to tackle the **considerable damage costs** of thunderstorms, MeteoSwiss developed a multi-sensor thunderstorm severity nowcasting algorithm (Zeder at al. 2018) under the COALITION project,

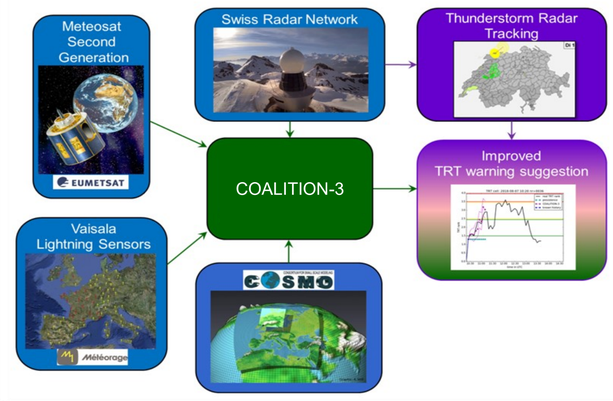
⇒ COALITION uses **radar, satellite, model and lightning** data for **accurate**, **real-time** thunderstorm severity predictions (TRT Rank).

⇒ Through COALITION-3 **strides** have been made towards the **imporvement and automisation** of this algorithm, in order to provide forecasters with r**eliable** thunderstorm warning **suggestions.**

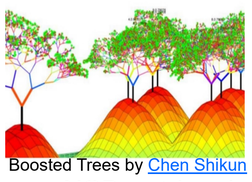
⇒ In such the aims addressed in this poster are **three fold**:

- × ***Improve*** ***the existing warning suggestion algorithm***
- × ***Get prediction intervals to measure trade off between longer prediction time intervals and skill of predictions***
- × ***Validate the algorithm over Switzerland according to the operational implementation***

COALITION Workflow



State of the Algorithm



Boosted Trees by Chen Shikun

⇒ Current algorithm relies on a gradient boosted regression tree method: **XGBoost** alongside **Probability Matching** (Chen & Guestrin 2016).

⇒ XGBoost is relatively quick/cheap and improvable through **hyperparameter optimization**

⇒ R**educed RMSD** by order of magnitude ~0.01.

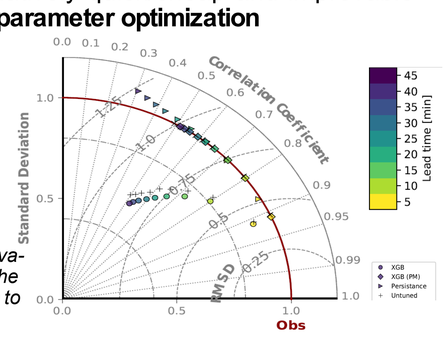


Figure:Taylor Diagram

Interpretable as, the closer values to the red (Obs) line, the more similar the prediction to the observation

TRT Rank Predictions: Direct vs Recipe Technique

Intuition

⇒ The TRT Rank is an **empirical value** describing the **severity** of a **thunderstorm cell.**

⇒ It is given as a single numeric value based on a **weighted summation** of scaled thunderstorm cell attributes (ingredients): VIL, ET45, MaxEcho, area57dBZ.

⇒ **Recipe technique**: rather than directly predicting the TRT Rank, predicting each unscaled ingredient allows knowledge gain on the growth and decay of such chaotic systems.

⇒ **Takes away conditional bias**

Outcome

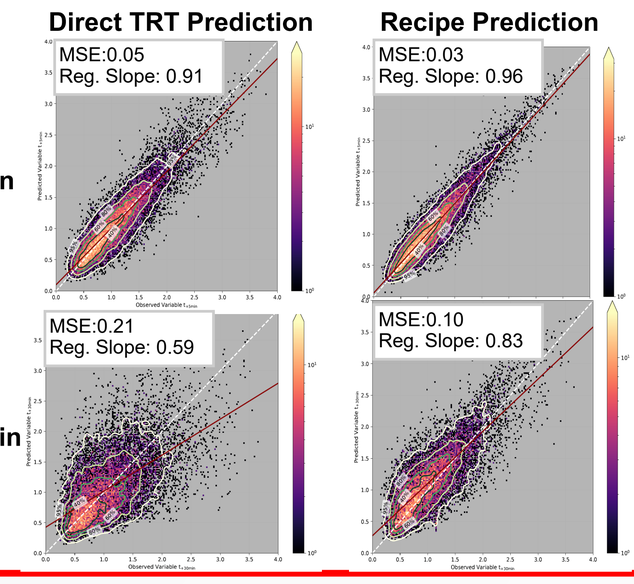


Figure: Observation *(x-axis)* vs Prediction *(y-axis)*

Interpretable as, the closer the values to the one to one line, the better the predictions match the observations.

Prediction Intervals

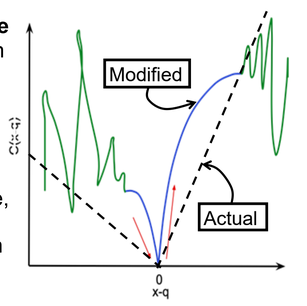
Given x with **unknown distribution**, a quantile q can be found by **minimizing** the following w.r.t q

$$C(x-q) = argmin_q \begin{cases} -(1-\alpha)|x-q| & if\ x < q \\ \alpha|x-q| & if\ x > q \end{cases}$$

Modified Quantile Cost Function

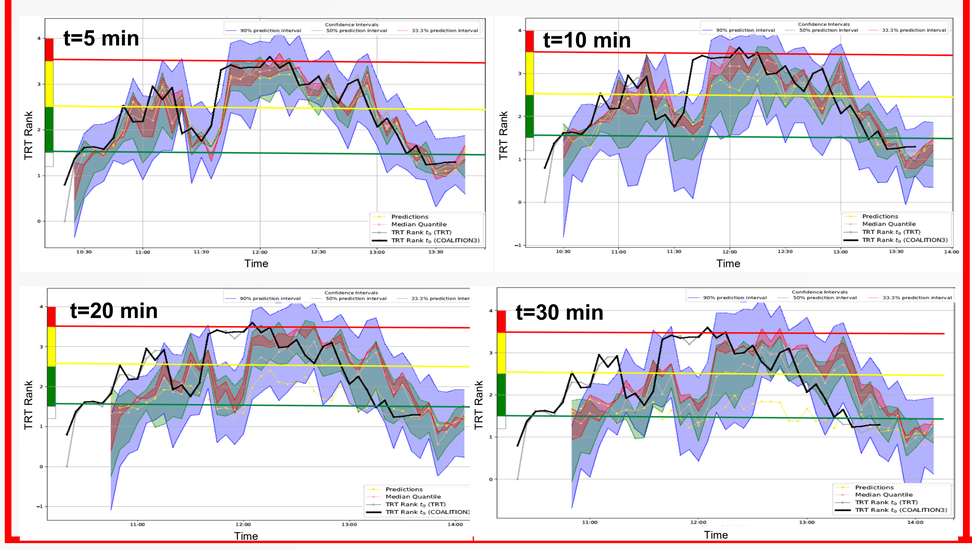
⇒ **Speed Up Convergence** to true value when within the neighbourhod (red arrows)

⇒ If prediction is too far away from the true value, create a **random split** to **reset** by randomisation (green)



Disclaimer: This figure is merely for illustrative purposes and may contain over-exaggerations

Case study: 10 UTC 07 August 2018



Reliability Diagrams

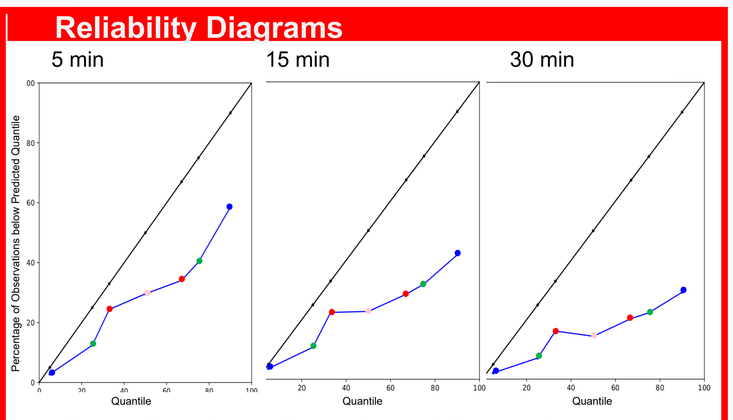
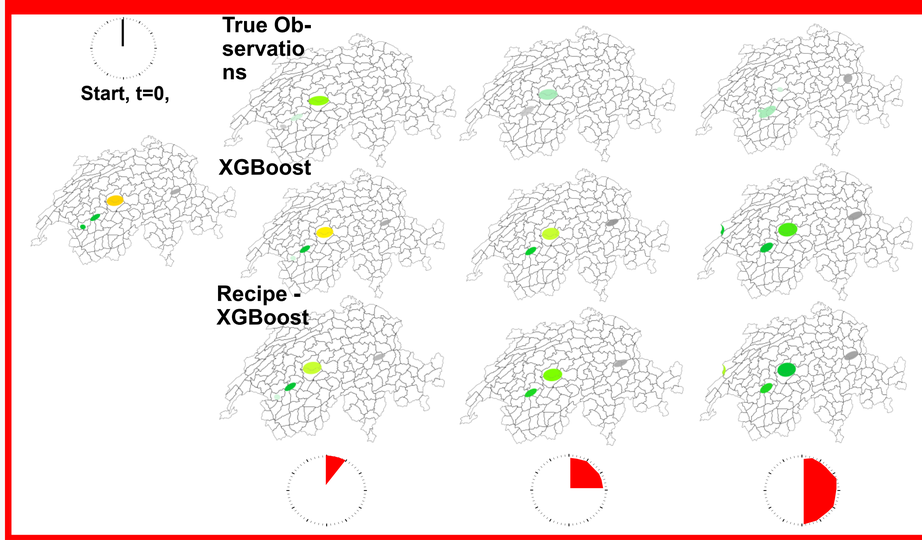


Figure: Quantile vs Percentage of Observations Under Quantile

Interpretable as, the closer (the blue line) to the one to one (black) line the better the quantile estimate

Validation Framework



⇒ Implemented in python (geopandas) for **quick, easy validation** under **different** algorithm **modifications**.

⇒ Usual operational implementation **tracks** thunderstorm **cells** moving across different **warning regions** (black borders) in Switzerland.

⇒ The cell's **TRT Rank** and number of **pixels intersecting** a **warning region** are considered before issuing a warning suggestion.

Probability Integral Transform Histogram

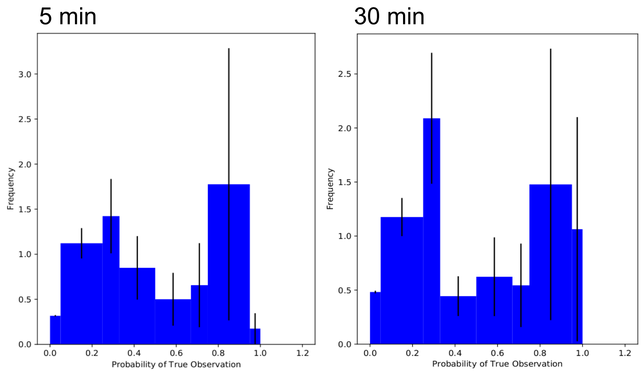


Figure: Histogram of probabilities of true observations as interpolated from their predicted quantile distributions. Black error bars are provided by considering each probability bin as having a binomial distribution.

Interpretable by considering probability integral transform theory where a variable, Y, defined from the cumulative distribution function of a continuous random variable, X, has a uniform distribution. Hence the flatter the histogram the less overconfident the predictions.

Conclusions and Outlook:

⇒ The XGBoost Nowcasting algorithm outperforms a usual persistence assumption for thunderstorm severity (empirically defined under the TRT Rank) prediction.

⇒ By only predicting the separate ingredients (recipe method) of the TRT Rank, skill of predictions was drastically improved (a 30 min recipe method prediction has half the MSE of a 30 min direct prediction).

⇒ Quantile regression provides further opportunity to investigate the trade off between prediction time and skill => higher prediction times show higher prediction uncertainty as proportion of observations below a given quantile decreases i.e. prediction is nearing as good as random.

References

- Hering, A. M., U. Germann, M. Boscacci, and S. Sénési, 2008: Operational nowcasting of thunderstorms in the Alps during MAP D-PHASE. In *Proceedings of 5th European Conference on Radar in Meteorology and Hydrology (ERAD)*, 30 June–4 July 2008, Helsinki, Finland. pp. 5. Copernicus: Goettingen, Germany.
- Zeder, J., et al. "Comparison of thunderstorm characteristics as seen by SEVIRI and radar regarding lightning and hail initiation." *EUMETSAT conference, Tallinn, Estonia*. 2018.
- Chen, T., & Guestrin, C. (2016, August). Xgboost: A scalable tree boosting system. In *Proceedings of the 22nd acm sigkdd international conference on knowledge discovery and data mining* (pp. 785-794). ACM.
- Shikun, C. (2018) An Overview of Boosted Trees. http://cican17.com/an-overview-of-boosted-trees/

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