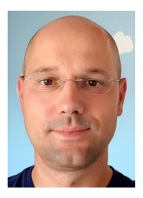
Convection Nowcast for Air Traffic Management Verification



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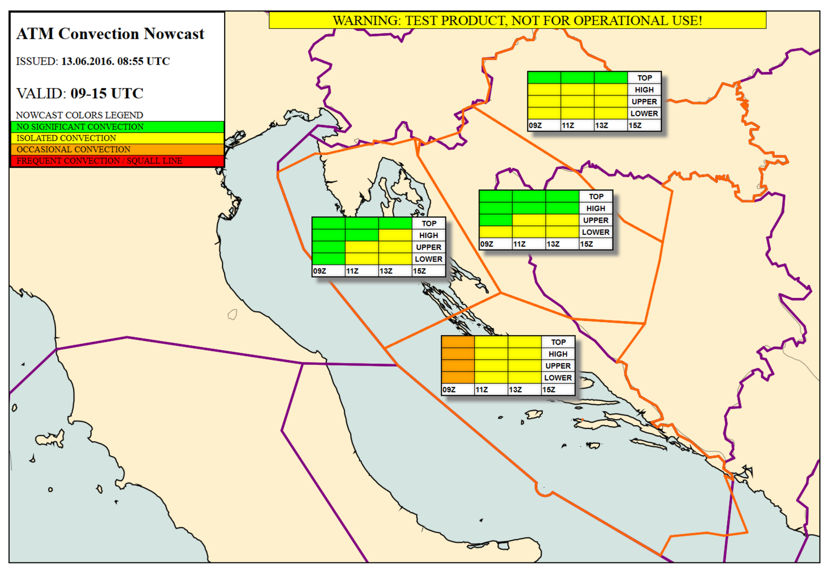
1. Introduction

Widespread convective storms cause large air traffic detours and congestion of airspace, increasing workload on air traffic controllers (ATC). This is why precise convective coverage and cloud top height forecasts are essential for tactical planning and flow planning in Air Traffic Management (ATM). To address these issues, in 2016, Croatia Control meteorological division introduced a new forecast product: **ATM Convection Nowcast**. It is a 6hr nowcast of convective coverage of ATM sectors and levels, manually generated by forecasters, using ingredients-based methodology. The nowcast is generated four times a day and amended as needed.

The main question for verification to answer was: „Are these forecasts good enough to help Air Traffic Management in airspace capacity planning?"



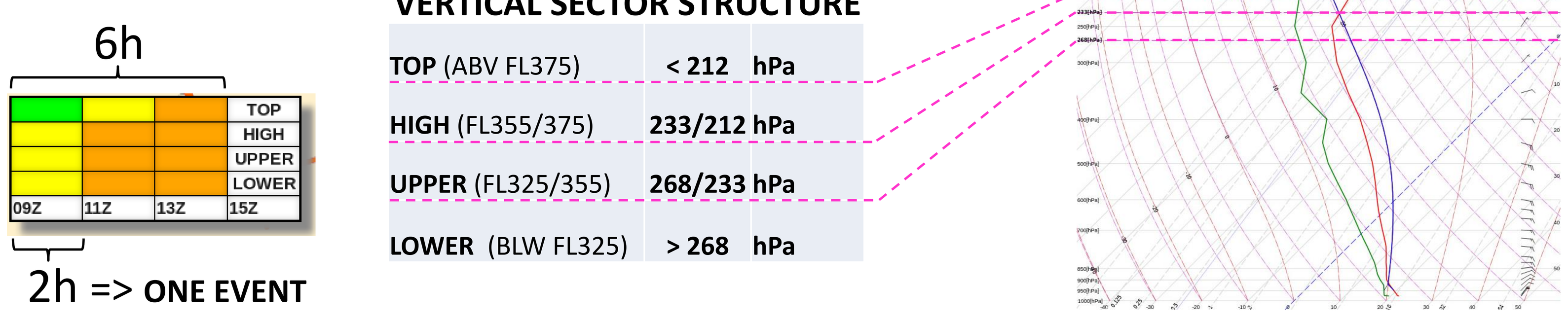


Fig 1. ATM Convection Nowcast product look and visualisation of ATM sectors vertical structure (below).

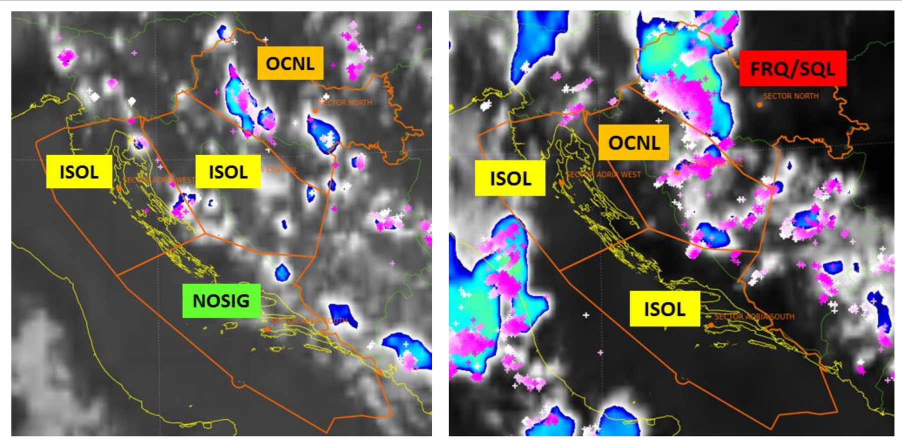


Fig 2. Two examples of observed convective coverage, estimated from IR satellite and lightning detection data.

2. Data and methods

During the testing period in convective season 2018., verification data was generated using IR satellite images and lightning detection data in the same format as original nowcast in order to assess how good are convective coverage, and cloud tops forecasts. Observed cloud top heights were estimated from IR brightness temperature and ALADIN model soundings. Data from LOWER levels were used to verify convective coverage, while cloud tops were traced in such a way to produce flattened data from the highest level containing observed convective coverage (Fig. 4). Besides multi-category verification, by applying realistic criteria of one category difference dichotomous verification was performed and various measures calculated.

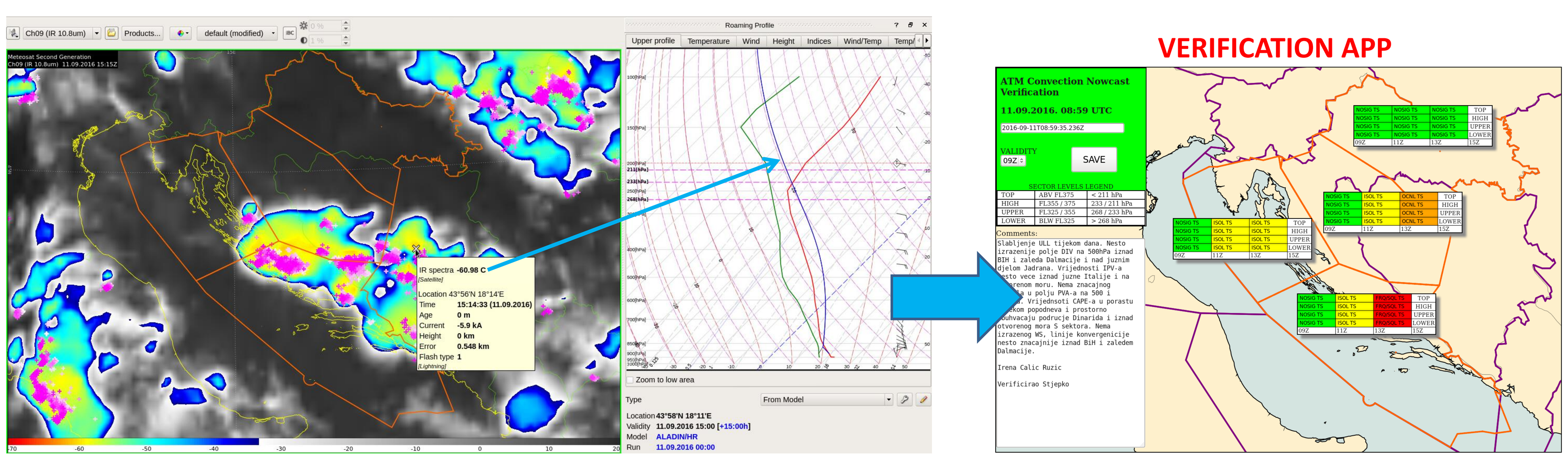
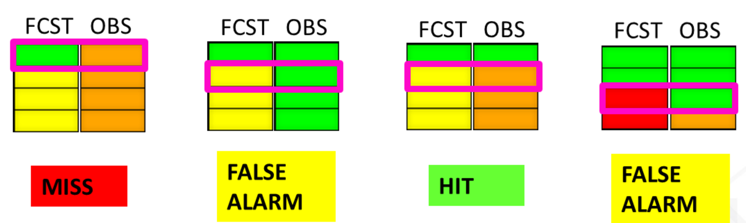
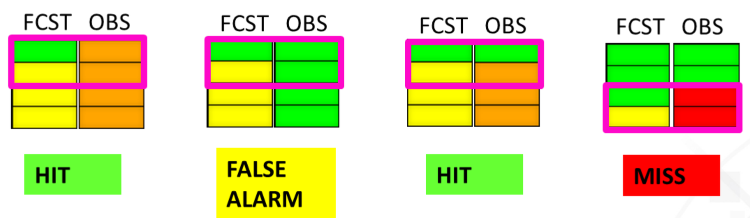


Fig 3. Generation of observation data by estimating convective coverage and cloud top heights .

Fig 4. Two methods for comparing forecast and observed cloud tops. In first method (a) Cb tops were traced by taking the highest level with observed convection and comparing it with forecast for that level. This way cloud top data were flattened, simplifying verification problem. Since vertical dimensions of sector levels are relatively small (~600m), verification was also performed by using second method (b), where block flattening was used. Levels were divided in just two blocks (LOWER+UPPER / HIGH+TOP) and the highest coverage level was taken from the two levels.



a) Examples of precise Cb top tracing



b) Examples of block Cb top tracing

3. Results

OBS vs FCST events for LOWER levels

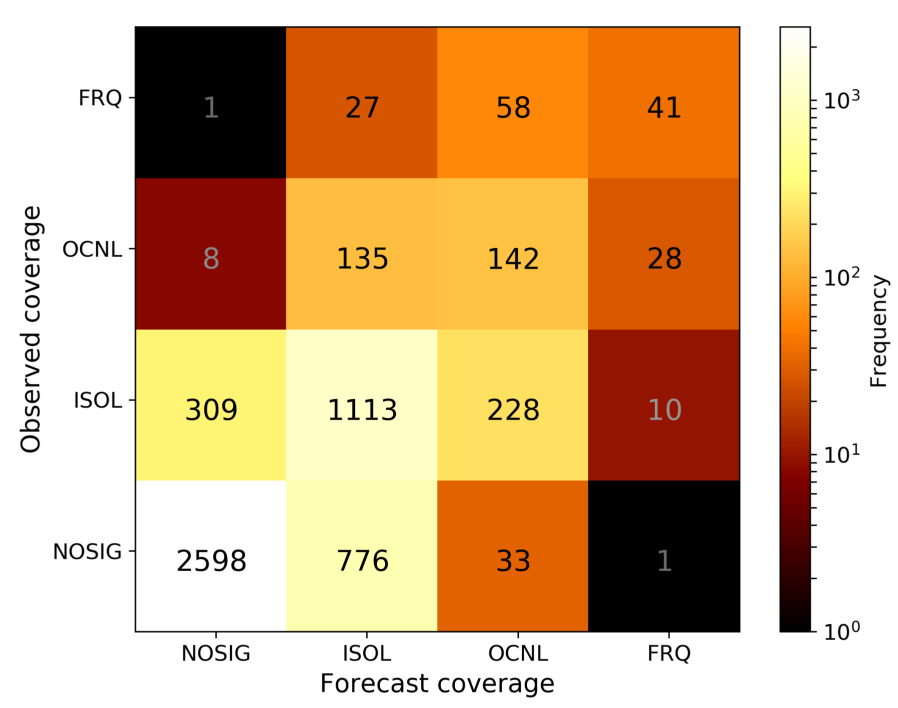


Fig 5. Multi-category contingency table for conv. coverage forecasts (all sectors). Extreme (FRQ coverage) misses and over forecasting are obviously rare, but FRQ coverage is most frequently forecast as occasional (OCNL).

Multi-category coverage forecast verification measures:
PC (accuracy) = **0.71**
Gerrity score = **0.49**

Table 1. Contingency table for translation of multi-category (4x4) coverage forecast into dichotomous (2x2) coverage forecast verification (with reduced criteria, allowing one category difference).

	OBS NOSIG	OBS ISOL	OBS OCNL	OBS FRQ
FC NOSIG	NOSIG HIT	TS MISS	TS MISS	TS MISS
FC ISOL	FALSE ALARM	TS HIT	TS HIT	TS MISS
FC OCNL	FALSE ALARM	TS HIT	TS HIT	TS HIT
FC FRQ	FALSE ALARM	FALSE ALARM	TS HIT	TS HIT

Table 2. Dichotomous coverage forecast verification results for all levels.

	LOWER	UPPER	HIGH	TOP
Bias (B)	1,23	1,43	1,46	1,28
Proportion Correct (PC)	0,79	0,78	0,79	0,81
Probability Of Detection (POD)	0,83	0,86	0,83	0,72
Frequency of Misses (FOM)	0,17	0,14	0,17	0,28
False Alarm Ratio (FAR)	0,32	0,40	0,43	0,43
Critical Success Index (CSI) [0..1]	**0,60**	**0,55**	**0,51**	**0,47**
Heidke Skill Score (HSS) [-1..1]	**0,57**	**0,54**	**0,52**	**0,51**
Peirce Skill Score (PSS) [-1..1]	**0,60**	**0,60**	**0,60**	**0,56**

OBS vs FCST events for traced CB top levels

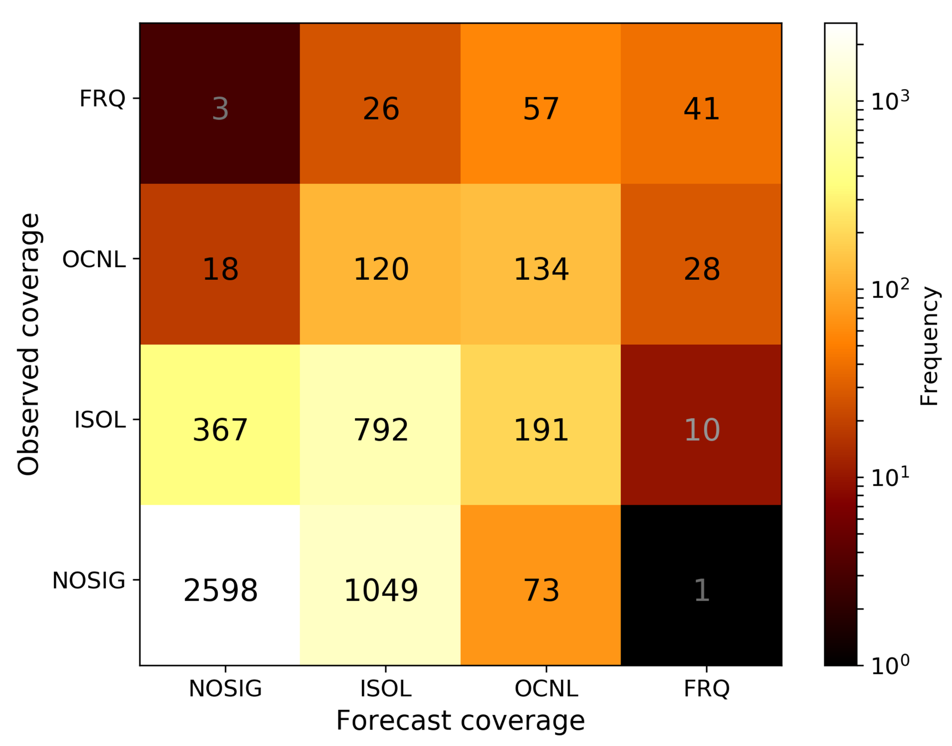


Fig 6. Multi-category contingency table for coverage forecasts at block traced Cb tops.

Table 3. Multi-category Cb top forecast verification measures:

Cb top tracing	precise	block
PC (accuracy)	**0.60**	**0.65**
Gerrity score	**0.37**	**0.45**

4. Discussion

Multi-category contingency table for convective coverage (Fig. 5) shows some spread around diagonal, but extreme misses and over forecasting are very rare. It also shows that frequent (FRQ) coverage is most frequently forecast as occasional (OCNL). Calculated accuracy for coverage (0.75) and Gerrity score (0.47) indicate good performance of such forecast. Dichotomous coverage forecast for different levels also indicate good performance, but with some over forecasting (Bias > 1 and FAR up to 0.5). Multi-category verification results of Cb top forecasts with precise top tracing are not as good, which was expected considering vertical level dimensions (HIGH ~600m thick). Block tracing gave better results (Table 3). In Cb tops verification, coverage difference at cloud top level was also considered (with allowed one category difference), which also contributed to lower verification measure values.

5. Conclusion

- **Verification results indicate good convective coverage forecasts.**
- **Cb top forecasts within required sector heights proved more challenging.**
- **Verification of Cb top forecasts with different criteria (block tracing) gives better results, implying that such forecasts can still give valuable information about convection penetrating highest flight levels.**

References:
Jolliffe, I.T. and Stephenson, D.B. eds., 2012: *Forecast Verification: A Practitioner's Guide in Atmospheric Science, 2nd Edition*. Wiley.
Wilks, D. S., 2006: *Statistical methods in the atmospheric sciences*. 2nd edn. Academic Press, San Diego, 627 pp.