Displaying the Verification Results of Terminal Aerodrome Forecasts for Thunderstorms and Visibility

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Outline

- Introduction
- Diagnostic purpose
- Displaying Results
  - Thunderstorms
  - Visibility
- Conclusion

Introduction: TAF

- Terminal aerodrome forecast
- Standard ICAO product
- but each country has its own style (Sharpe 2016)
  - „…as agreed by the meteorological authority with the ATS authority and operators concerned”
  - duration 24h (9-32h)
  - Other: standards and recommendations , criteria for groups of changes (and/or AMD)

Introduction: TAF verification

- ICAO Annex 3 attachment B
  - Operationally desirable accuracy of forecasts
  - The same in EASA documents (without changes)
- Several basic approaches
  - Harris (2000), **Mahringer (2008),** Sharpe (2016)
- Other features for TAF verifications:
  - TAF statements are deterministic, probabilistic and temporal
  - Results: scores, contingency tables
  - Rare events
    - forecast for a given point
    - the verification time period is just one hour
    - aviation requirements usually refer to high impact weather
      - Climatological difference

Diagnostic verification

METEOROLOGICAL APPLICATIONS
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Terminal aerodrome forecast verification in Austro Control using time windows and ranges of forecast conditions

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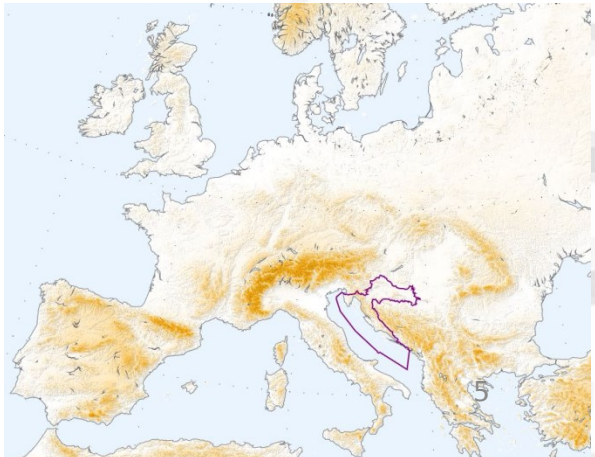
- Basic principles
  - G. Mahringer (2008)
  - Best (FC and OBS) and worse (FC and OBS) conditions are verified
- Diagnostic verification
  - Weakness and strength of forecast
  - Verification of special problems for aviation in Croatia
    - Convection (TS)
    - Fog (reduced visibility)
    - Wind (especially bora events)



Verification

- Verification scores
  - p0, Bias, TCC/PCC (tetrachoric/polychoric correlation coefficient)
  - Juras and Pasarić (2006): Application of tetrachoric and polychoric correlation coefficients to forecast verification (link)
    - Pearson (1900)
    - measure of association in contingency tables
    - TCC=-1, 1, TCC=0 for random
    - TCC/PCC do not depend on bias nor on marginal frequencies => independent information between them
    - TCC/PCC are particularly good for rare events *(fig.2)*

Verification

- Verification of hours with TS
  - FC: „worst conditions”=> all group of changes
  - OBS: METAR 0:00 or 0:30

– Contingency table 2x2

TAF Example hours with observed and forecasted TS hours

Forecasted hours with TSs: Temporary 1-11 UTC, Becoming 20-24

hours(UTC)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
FORECAST																								
OBSERVED																								
Event	d	b	a	a	b	b	b	b	b	b	b	d	d	d	d	d	d	d	d	c	a	a	b	b

Possible events: Hit (a), False alarm (b), Miss (c), Correct rejection (d)

- Frequency of observed hours with TS at airports in Croatia => 0.8-1.5% => rare event
- Relatively large false alarms

TS verification: hit a)

- Analysis of hit event
  - Months
  - Hours
  - Issue time
  - Lead time
  - Chronological
  - Contingency table
  - Forecast expression of TS in TAFs

ANALIZA PROGNOZE GRMLJAVINE (TS)

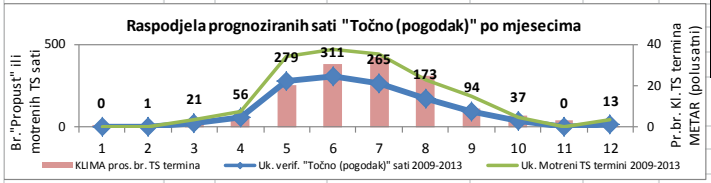
Termini prognozirani: **a = Točno (pogodak)**

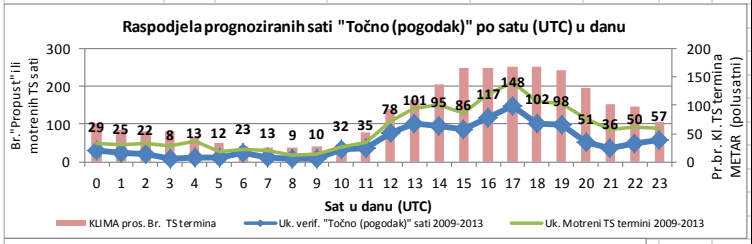
(Prognozirano: DA Motreno: DA)

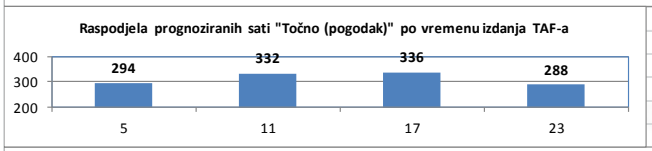
Zračna Luka: LDZA Razdoblje: 2009-2013

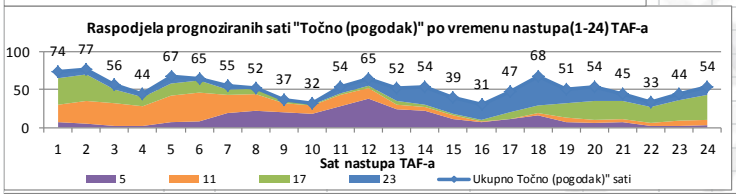
HKZP-SZM (interno)

	Motreno		
Prognozirano	Da	Ne	Ukupno
Da	**a= 1062**	b= 8059	9121
Ne	c= 820	d= 164308	165128
Ukupno	1882	172367	174249

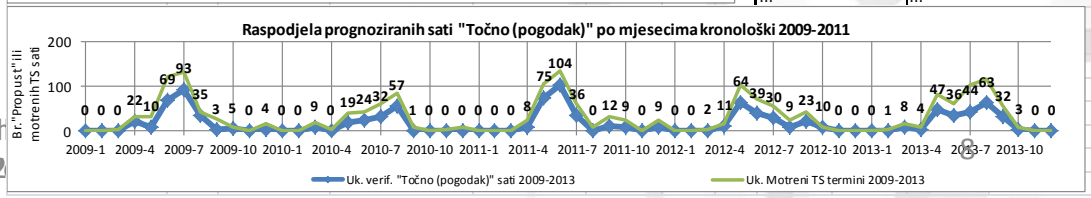








Načini i i izvještavanje za događaje "a" LDZA	
METAR	**TAF**
70 TS	183 NSW TE SHRA P40 TSRA
41 TSRETS	99 NSW TE TSRA
41 TS TS	86 NSW P40 TSRA
25 TS	78 NSW TE SHRA P30 TSRA
22 -TSRARETS -RA	57 NSW P30 TSRA
20 -TSRA -TSRA	27 NSW TE TSRA P30 TSGR
19 -TSRA TS	12 RA TE TSRA
15 TSRA TSRA	10 NSW TE SHRA TE TSRA
15 TSRETS	9 NSW P40 SHRA P30 TSRA
15 VCTS	6 NSW TE RA P30 TSRA
14 -TSRA TSRA	6 NSW TE TSRA BE RA
12 -TSRA -RA	5 NSW TE TSRA P40 TSGR
12 TS TSRETS	4 NSW TE SHRA P40 TSRA BE RA BR
11 -TSRA	4 NSW TE RA P40 TSRA
9 -TSRARETS	4 RA P30 TSRA
8 RARETS RA	4 BR P40 BCFG P30 TSRA
8 RETS	3 NSW BE TSRA
8 -TSRARETSRA	3 NSW P40 TS
8 TS -TSRA	3 NSW TE SHRA P40 TSRA BE RA
6 TSRARERA	3 NSW TE TSRA P30 TSRAGR
6 TSRARETS RA	3 NSW TE SHRA TE TSRA P30 TSGR
6 -TSRA -TSRARETS	2 NSW FM RA TE SHRA P30 TSRA
6 TSRA -TSRARETS	2 TSRA
5 -TSRARERA -TSRARERA	2 NSW TE TSRA P30 TSRA
5 TSRARETS	2 NSW BE RA P30 TSRA
5 -TSRA TSRARERA	2 NSW P40 SHRA TE TSRA
5 TSRETS RETS	
4 +TSRARESHRA -TSRA	
4 -RA -RARETS	
...	...



Bias / TCC display

Example of contingeny tables for different bias and TCC

Example: frequency (a+c) of hours with TS je 1.3%

a	b
c	d

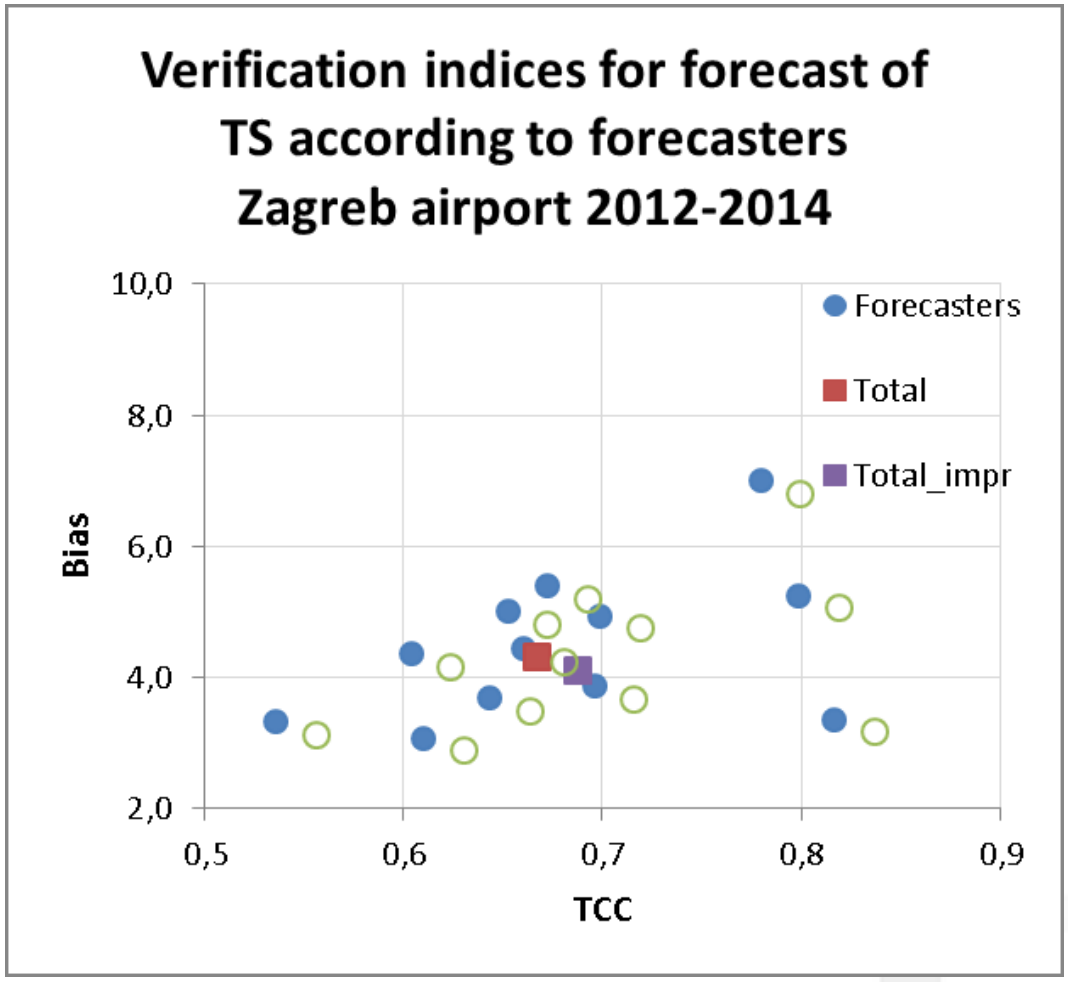
a	Hit
b	False alarm
c	Miss
d	Correct rejection

bias

bias	TCC 0,5	TCC 0,65	TCC 0,8
7	0,65% 9,10% 0,65% 89,60% 1,30% 98,70%	0,90% 9,10% 0,40% 89,60% 1,30% 98,70%	1,15% 9,10% 0,15% 89,60% 1,30% 98,70%
5	0,55% 6,50% 0,75% 92,20% 1,30% 98,70%	0,79% 6,50% 0,51% 92,20% 1,30% 98,70%	1,09% 6,50% 0,21% 92,20% 1,30% 98,70%
3	0,41% 3,90% 0,89% 94,80% 1,3% 98,7%	0,64% 3,90% 0,66% 94,80% 1,3% 98,7%	0,90% 3,90% 0,40% 94,80% 1,3% 98,7%

TCC

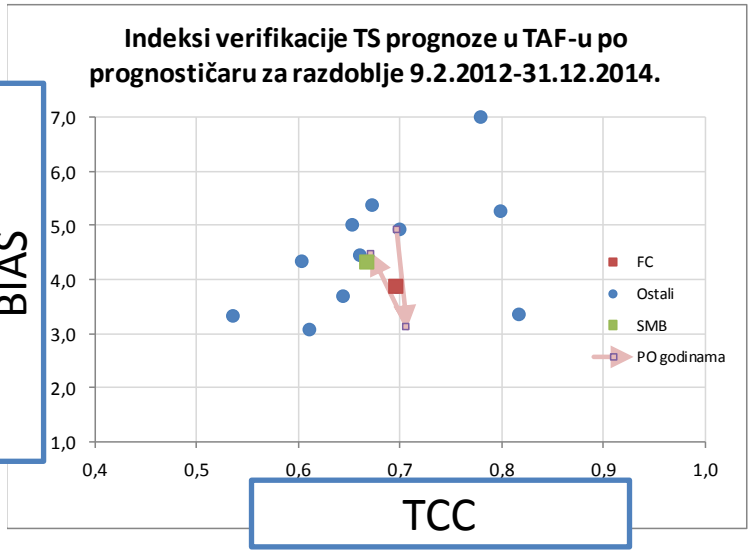
Bias / TCC display example 2

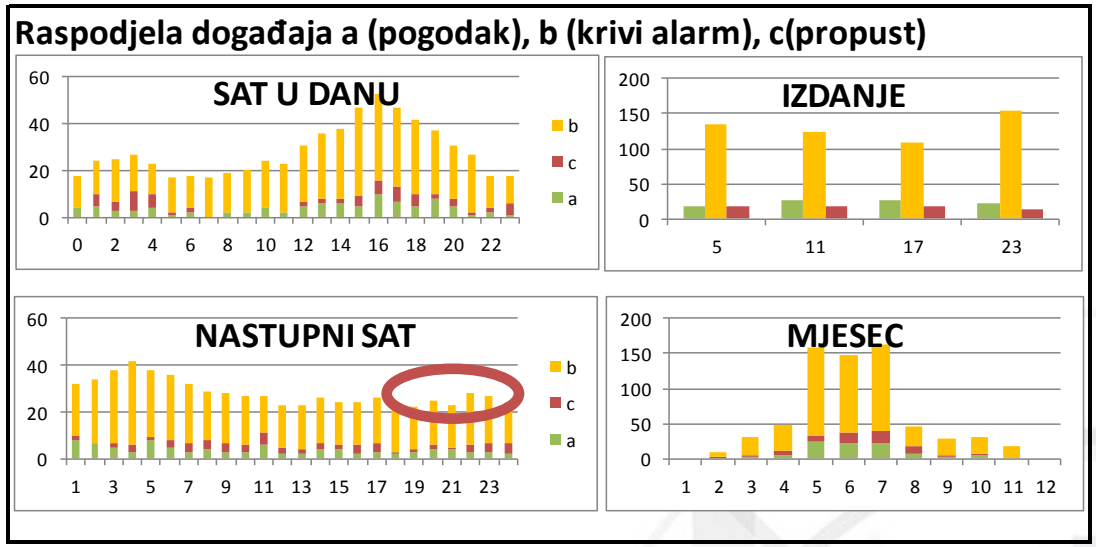


Dispersive results are expected

TS verification: forecaster LDZA

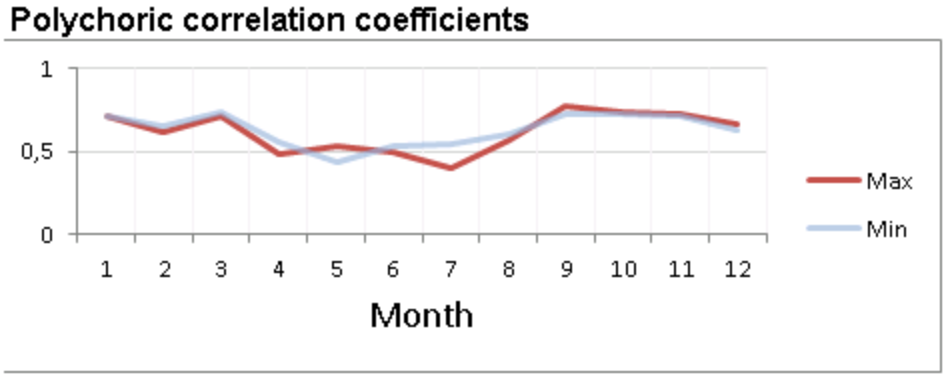
		Tablica kontningencije				Tablica kontningencije					Verifikacijski indeksi		Ostali pomoćni pokazatelji								
Razdoblje: 9.2.2012-31.12.2014.	Broj	Aspolutne čestine [sat]				Relativne čestine [%]					Točnost	Pristranost	Motreni		Pa+Pb	Pa+Pc	a/(a+c)	a/(a+b)	a/(a+b+c)	(PSS+HSS)/2	
Ime_EERS	TAFova	a	b	c	d	Pa	Pb	Pc	Pd		TCC	Bias	TS sati	a-c/(a+c)	Pfc	Pobs	POD	pTSfc	CSI	KPI	
XY	480	93	521	66	10756	0,8%	4,6%	0,6%	94,1%		0,70	3,9	159	0,17	5,4%	1,4%	0,58	0,15	0,14	0,26	
SMB	*4111*	*703*	*4684*	*549*	*92366*	*0,7%*	4,8%	0,6%	94,0%		*0,67*	*4,3*		*0,12*	*5,6%*	*1,3%*	*0,56*	*0,13*	*0,12*	*0,25*	



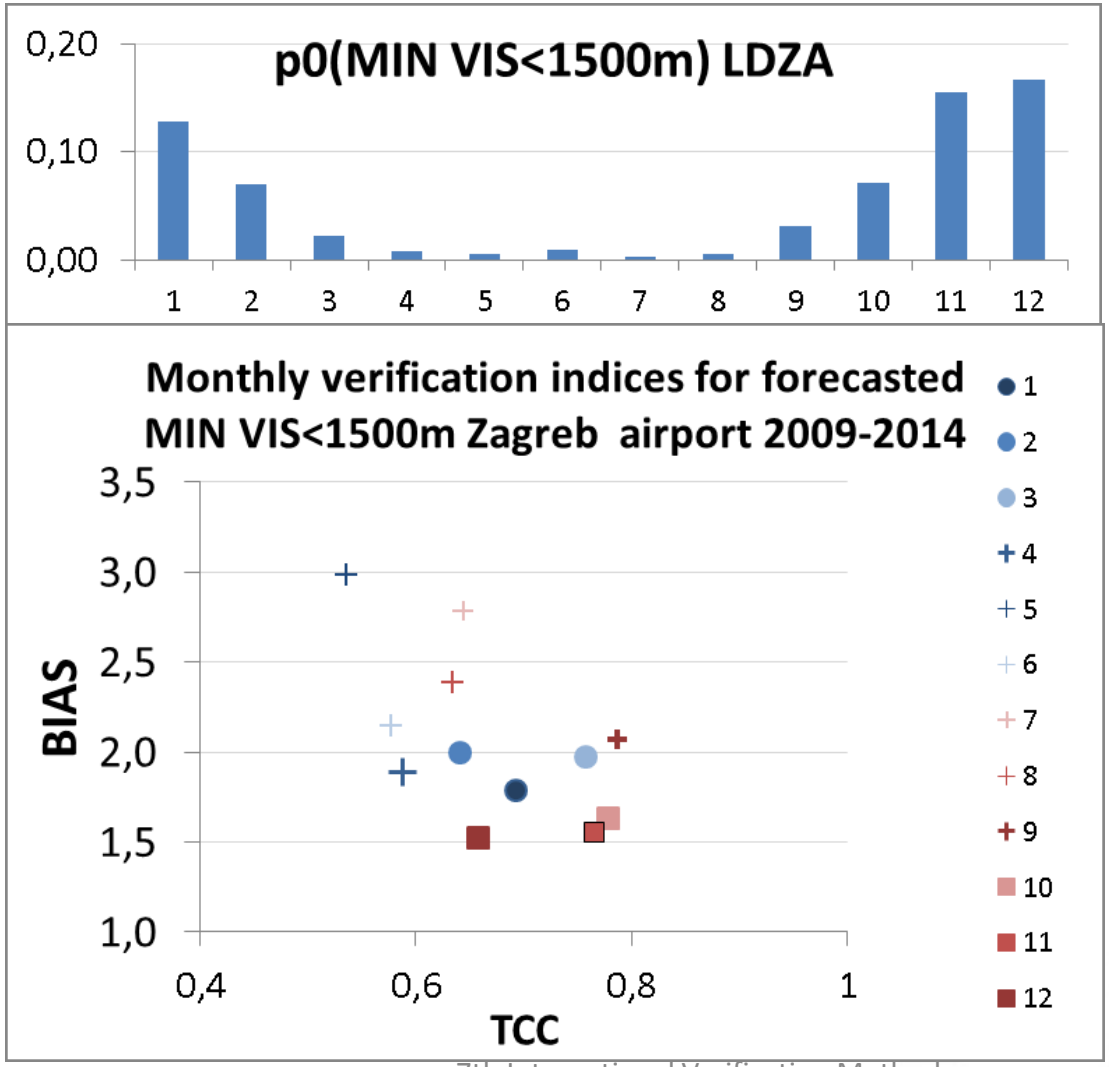


Bias / TCC display example 3

- Verification of visibility
  - According to categories with limits 150, 350, 600, 800, 1500, 3000 and 5000m
  - Best (FC and OBS) and worse (FC and OBS) conditions are verified
  - 2 contingency tables NxN: polyhoric correlation coefficient is used



Bias / TCC display example 4



Better results when p0 is higher

Bias is larger

- p0 smaller

Conclusions

- Diagnostic verification
  - Based on approach by Mahringer (2008)
- Verified elements in TAFs are rather rare
- Displayed results are used with triplet
  - marginal frequency, bias and tetrachoric coefficient (Juras and Pasarić 2006)
  - Bias and TCC represents forecast
  - 4 examples for thunderstorms and visibility
- Additional conclusion : verification results depend on
  - climatology (frequency of an event)
  - forecaster

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