Forecasted Wind Warnings Evaluation (Forecaster vs. Model Output)

Maria Stefania Tesini

23rd COSMO General Meeting

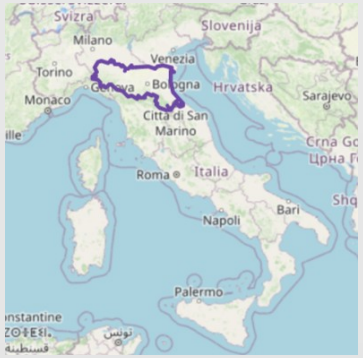
WG5 - Friday 10 September 2021

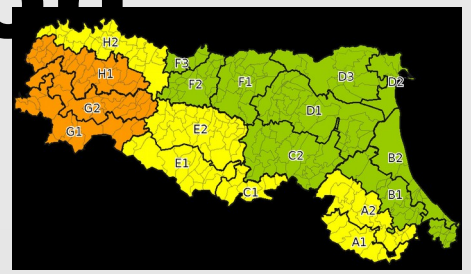
Motivation

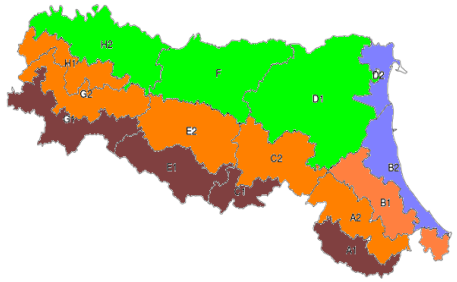
- ARPAE weather service is responsible for issuing warning for strong wind for Civil Protection purposes over the Emilia-Romagna region
- The evaluation of the issued warnings shows a huge numbers of false alarms, so we started to analyze the reasons of that over-forecasting
- One of the problems is related to the definition of the warning thresholds:
  They refer to sustained wind speed, but since most of the (few) reported damages can be related to wind gusts (we exclude thunderstorms gusts since we issue a specific alert for them) the use of maximum wind speed has become commonly used both in the evaluation of observed cases and in forecasting
- Alerts are issued over specific predefined areas, not to a single location, causing problems of forecaster interpretation of how much of the area should be affected by strong wind
- **The comparison of forecaster performance with different “scenario” depicted from models could give some answer to these problems and hopefully provided some guidelines to the use of model forecast**

The warning system of the Emilia-Romagna region

Every day a "green bulletin" or an "alert" is issued for the next day (from 00 to 24) with 3 different warning levels depending on some sustained wind speed conditions on each area *(so for the models verification the second day of forecast is used)*







15 warning areas

- **Mountain**
- **Hill**
- **Plain**
- **Coast**

Green (Verde) no warning

Yellow (Giallo)
Beaufort 8
34 - 39 knots
17.2 -20.7 m/s
for at least 3 consecutive hours throughout the day

Orange (Arancione)
Beaufort 9
40 - 47 knots
20.8 -24.4 m/s
for at least 3 hours throughout the day

Red(Rosso)
Beaufort 10
>47 knots
>24.4 m/s
for at least 3 hours throughout the day

Evaluation of the alert

- After each event an “observed color” is assigned subjectively (from me and some colleagues!) to each warning areas using all the available wind data on each areas (synop, regional network but also from amateur stations on the web)
- We started this job systematically during this year, so the available data set is from Jan 2021 to Aug 2021
- If we apply the rules to determine the color code to 10m observed wind only few days could be considered “yellow” so we decide to relax the rules* and apply them to hourly maximum observed gust imposing anyway a lower threshold on 10m wind:

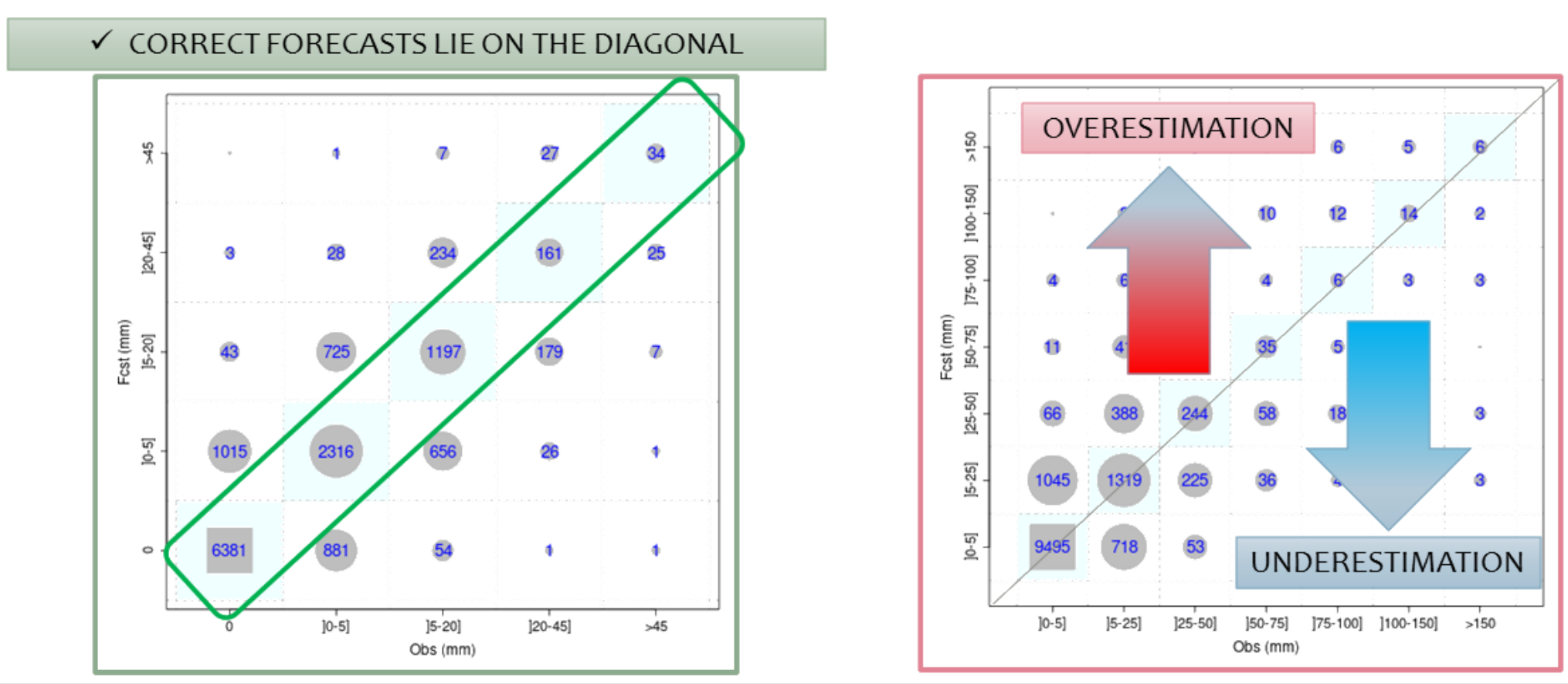
* Maybe the rules had to be changed!!

“RELAXED RULES”

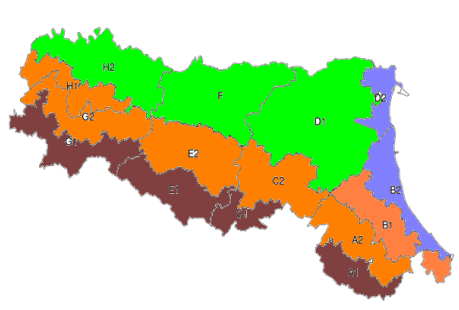
- a day is considered **“YELLOW”** if there are
  3 or more consecutive hours with gust of Beaufort 8
  and a maximum of 10m in the day of Beaufort 6 or higher
- a day is considered **“ORANGE”** if there are
  3 or more hours with gust greater of Beaufort 9
  and a maximum of 10m in the day of Beaufort 8 or higher
- a day is considered **“RED”** if there are
  3 or more hours with gust greater than Beaufort 10

Visual verification with “bubble plots”

- Bubble plot is a sort of the scatter plot, in which the data points are replaced with bubbles. The sizes of the bubbles are determined by the number of events. *(The square symbol is used for the most populated category to preserve the proportions of the other bubbles)*



FORECASTER RESULTS



15 warning areas #

- **Mountain**
- **Hill**
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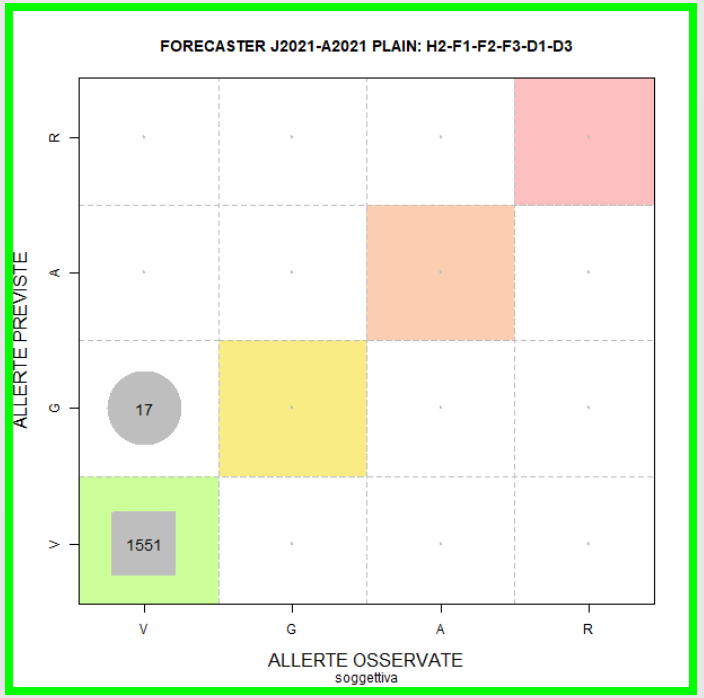
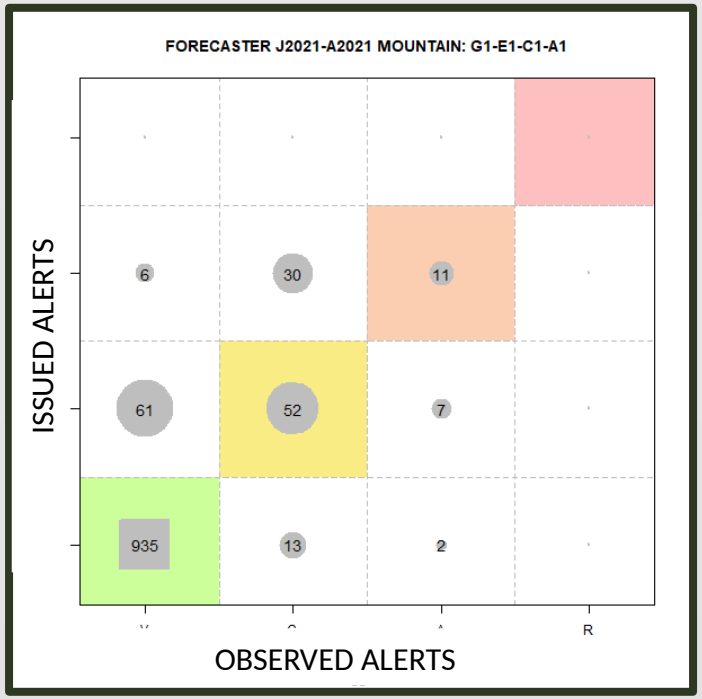
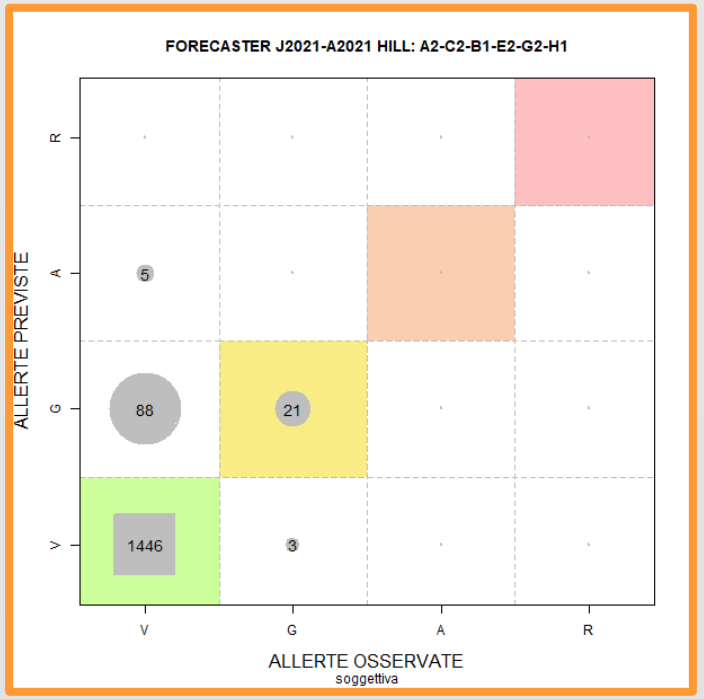
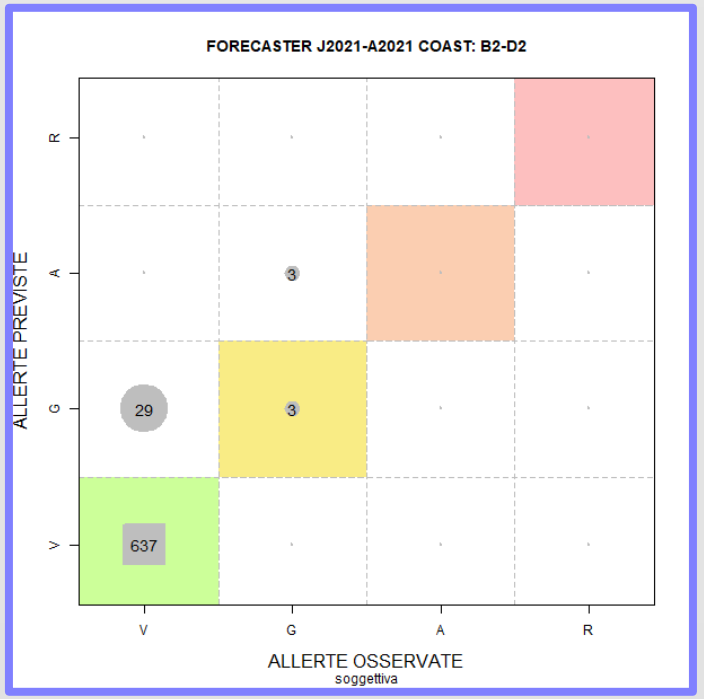
#Plain area are 6 in this case and not 3 because they have internal subdivision but results not change









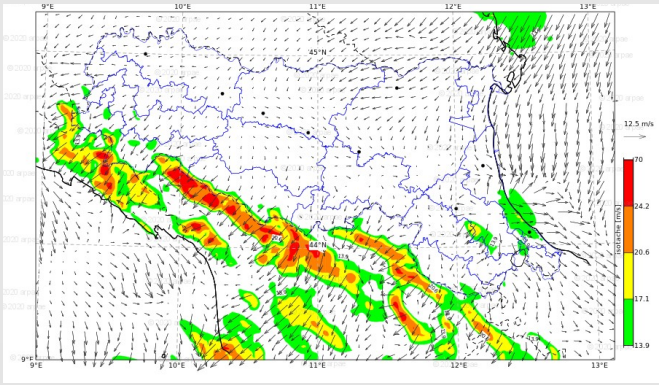
How can we explain the large number of False Alarm?

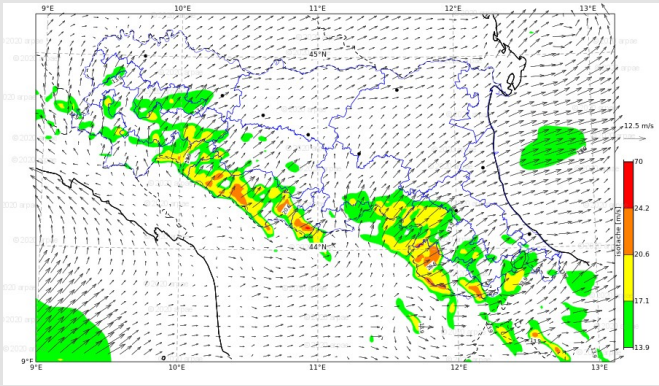
Are models output the reason of this overestimation?

Which is the best wind variable to use? 10m wind speed or wind gust?

Different scenarios have been considered applying the conditions to determine the "color of the alert" to:

- Maximum of 10m wind in the area (at least on point in the area greater than threshold)
- 50th of wind gust distribution over the area (50 % points of the area greater than threshold)
- 75th of wind gust distribution over the area (25 % points of the area greater than threshold)
- 90th of wind gust distribution over the area (10 % points of the area greater than threshold)
- Combination of scenario define by conditions on wind gust and 10m wind speed exceeding a lover threshold (Beaufort 6)

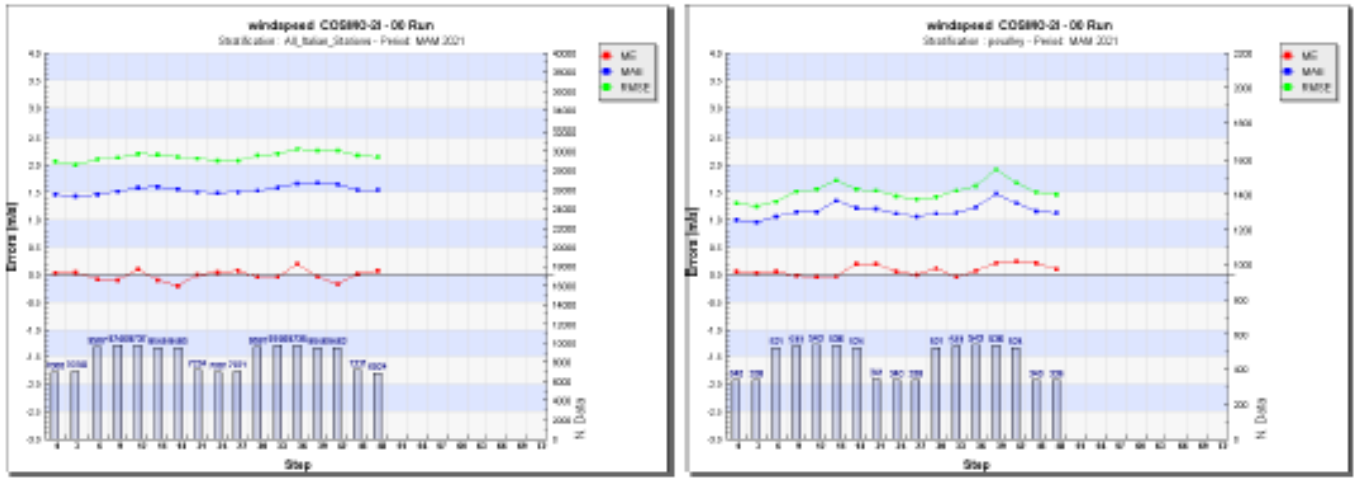




What seasonal standard verification says about 10m ws?

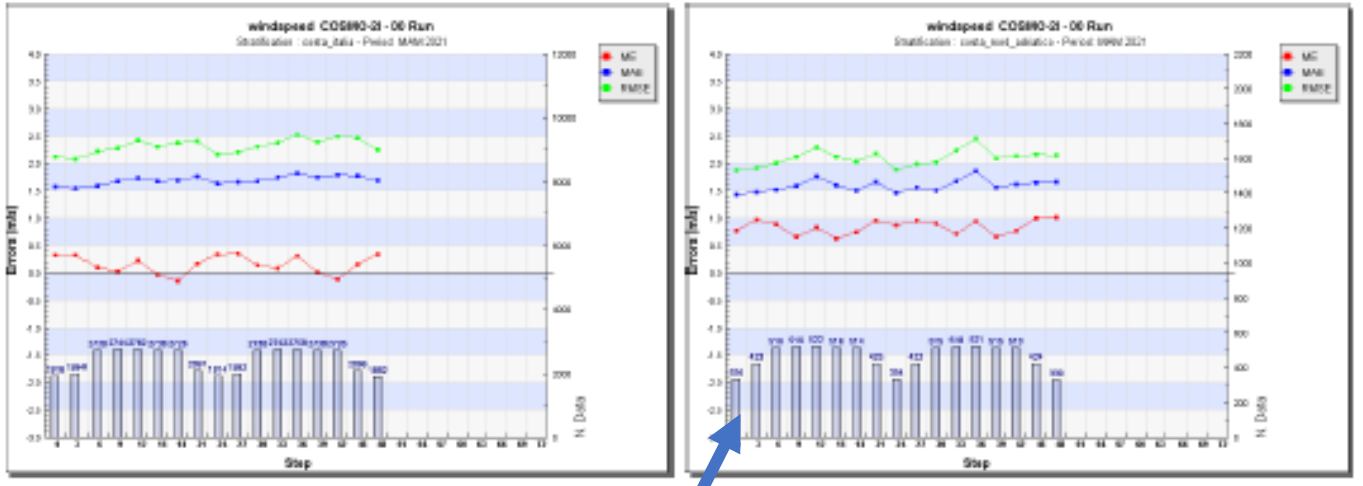
Velocità del vento a 10m: COSMO-2I run 00 UTC

MAM2021



(a) Tutte le stazioni italiane

(b) Stazioni pianura padana



(c) Stazioni costiere

(d) Stazioni Adriatico nord

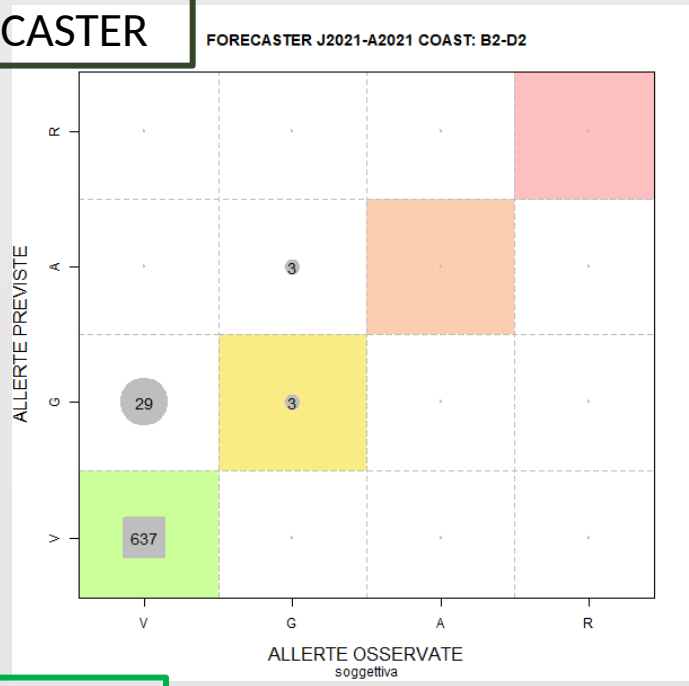
Emilia-Romagna costal stations

Models – costal areas

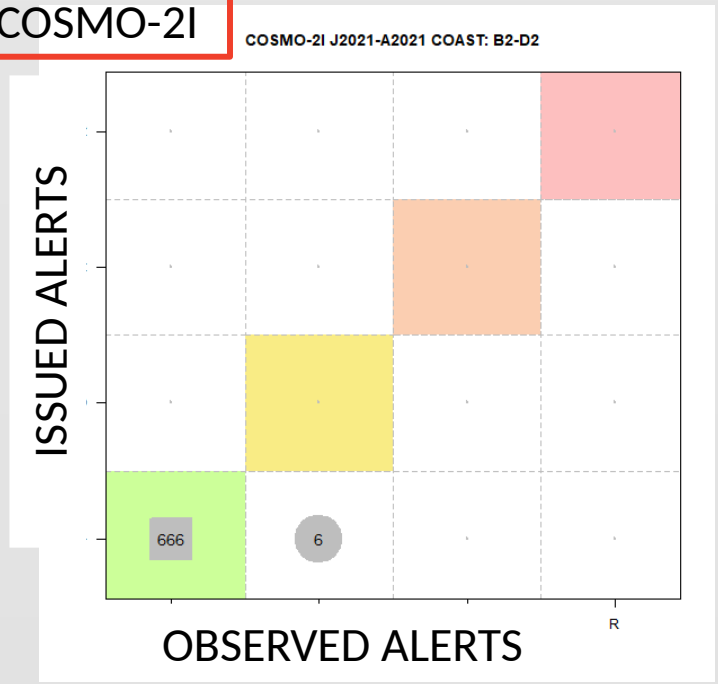
Condition on maximum of 10m wind speed in the area

- YELLOW (G): WS> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): WS> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): WS> 24.4 m/s (B10) for at least 3 hours throughout the day

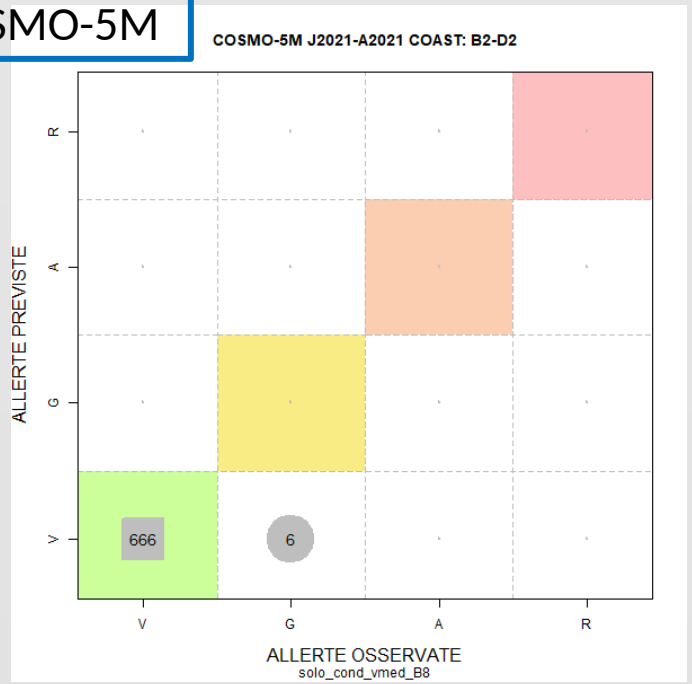
FORECASTER



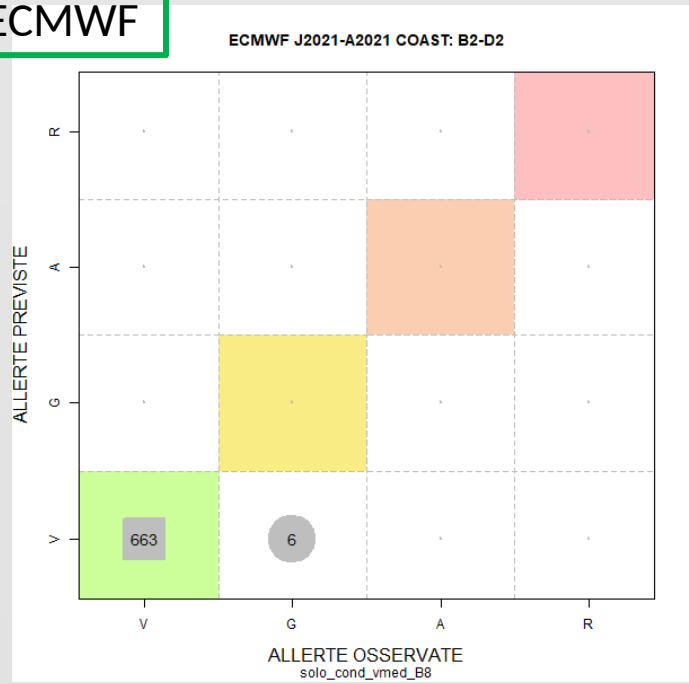
COSMO-2I



COSMO-5M



ECMWF



Models – mountain areas

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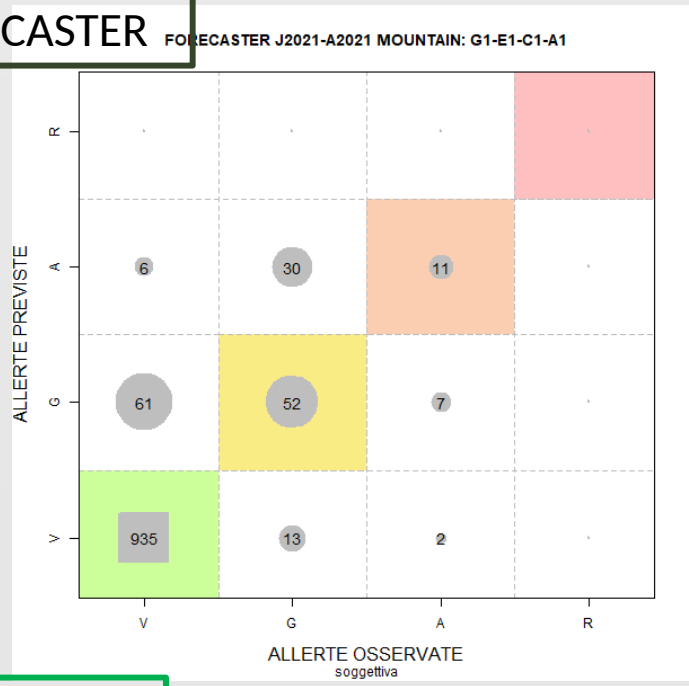

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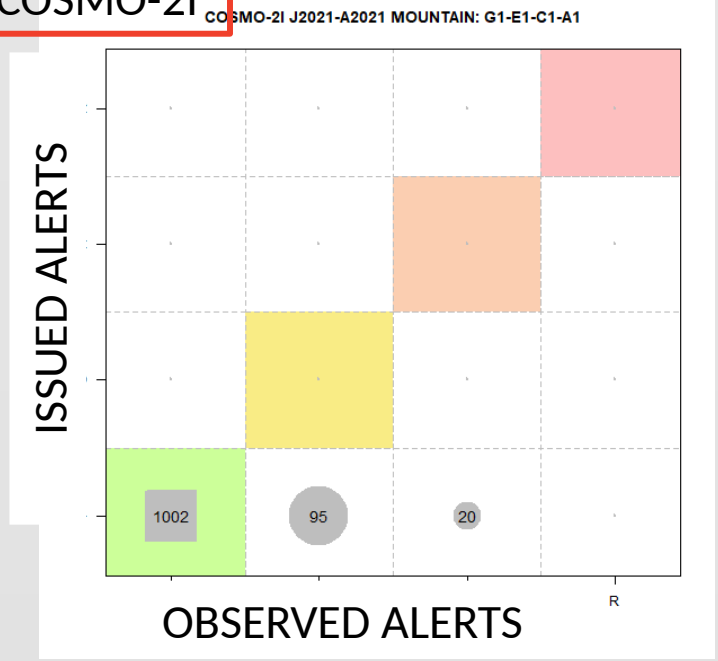

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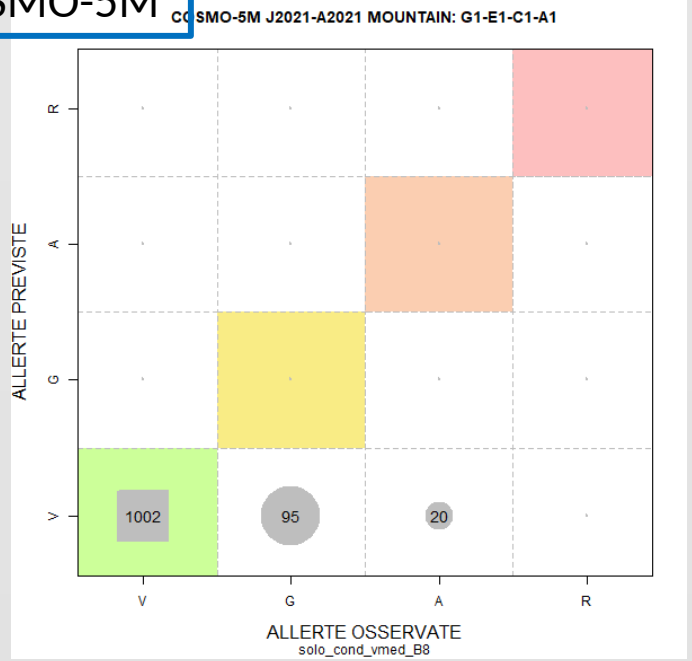

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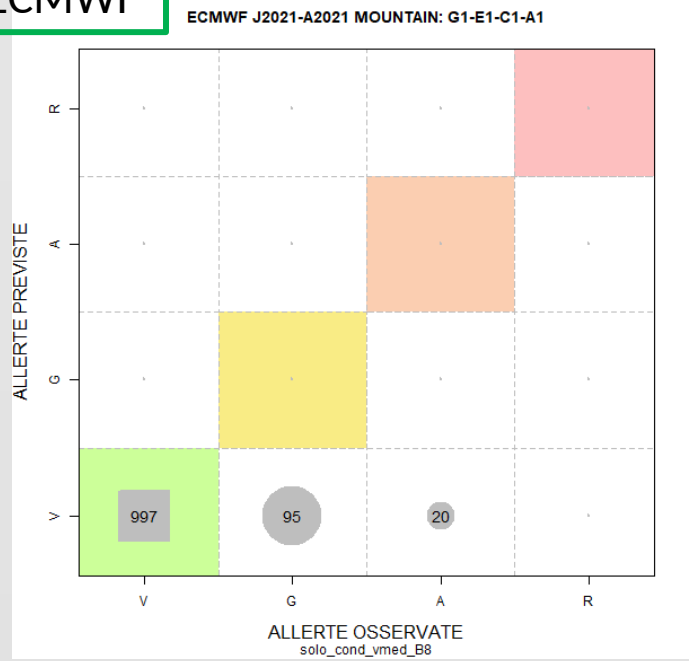

Ongoing outcomes

- WS overestimation in costal stations resulting from standard verification is misleading strong wind are underestimated (but they are few cases in a season)
- Forecasters don’t rely on 10m ws to issue alerts and probably they take into account wind gusts

How can we explain the large number of False Alarm?

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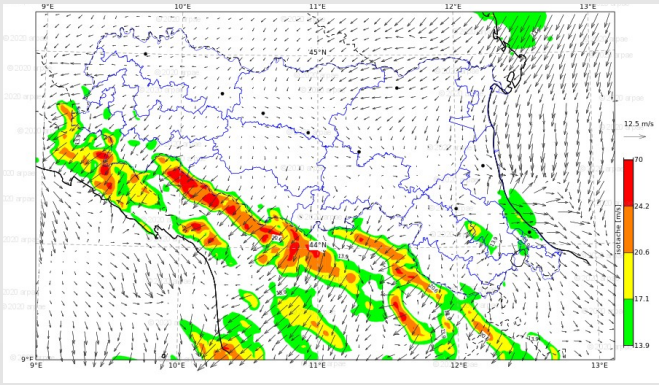

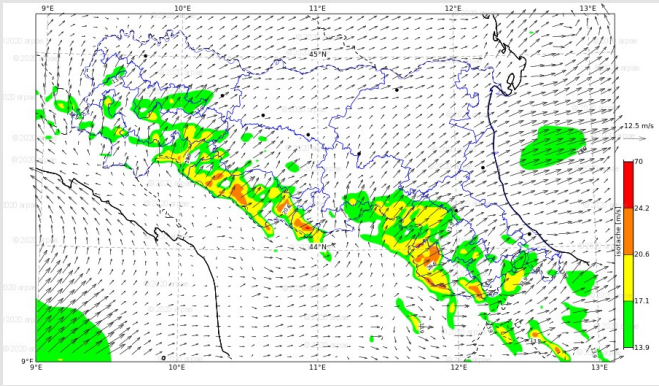

Models – costal areas

Condition on 50th percentile of wind gust in the area

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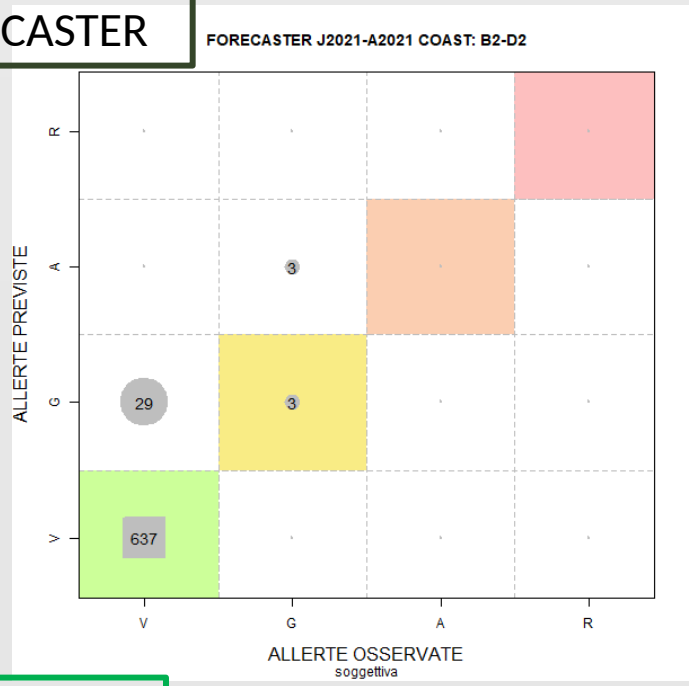
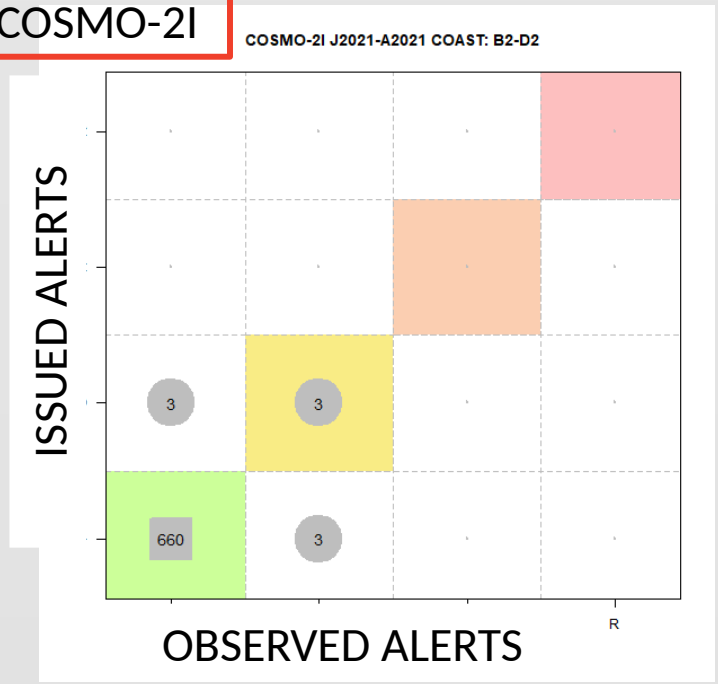
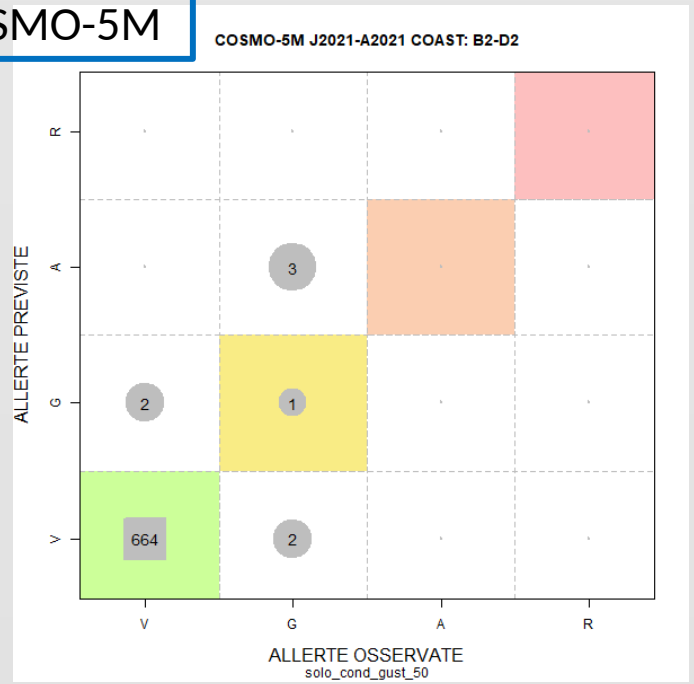
FORECASTER



COSMO-2I



COSMO-5M



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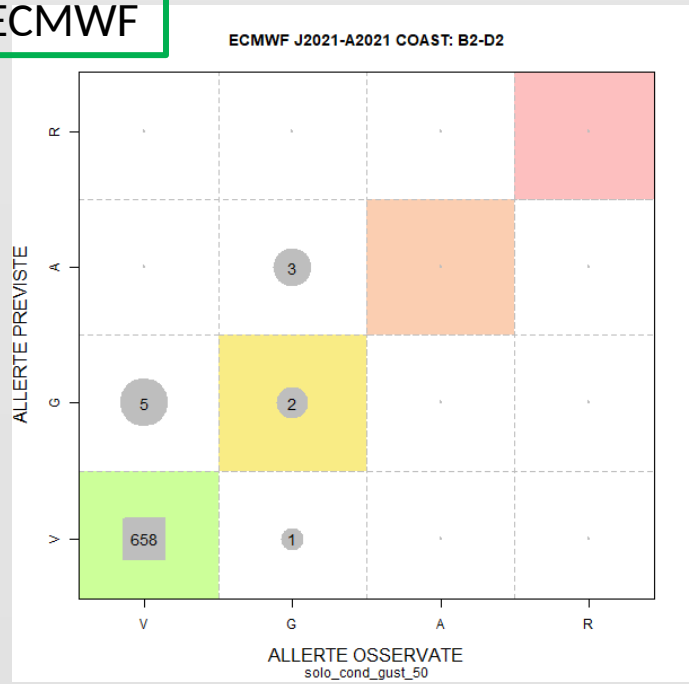

Models – mountain areas

Condition on 50th percentile of wind gust in the area

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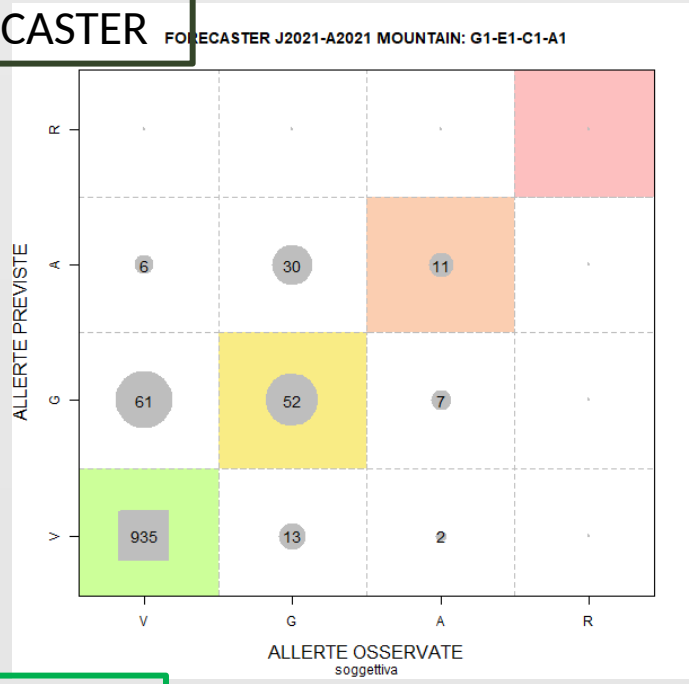
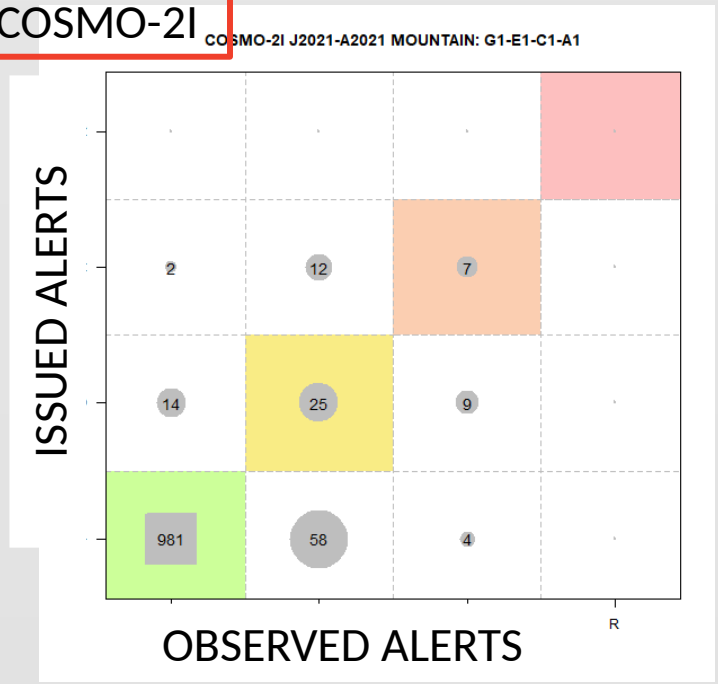
FORECASTER



COSMO-2I



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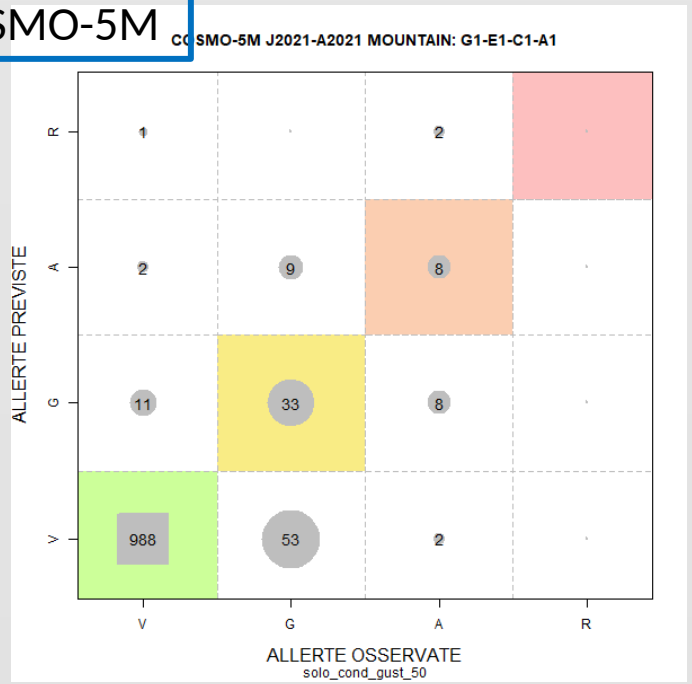

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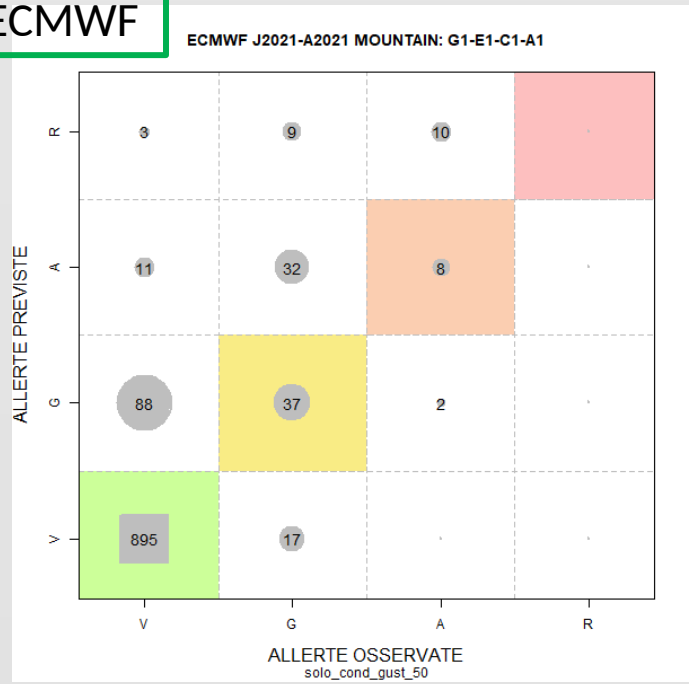

Models – hill areas

Condition on 50th percentile of wind gust in the area

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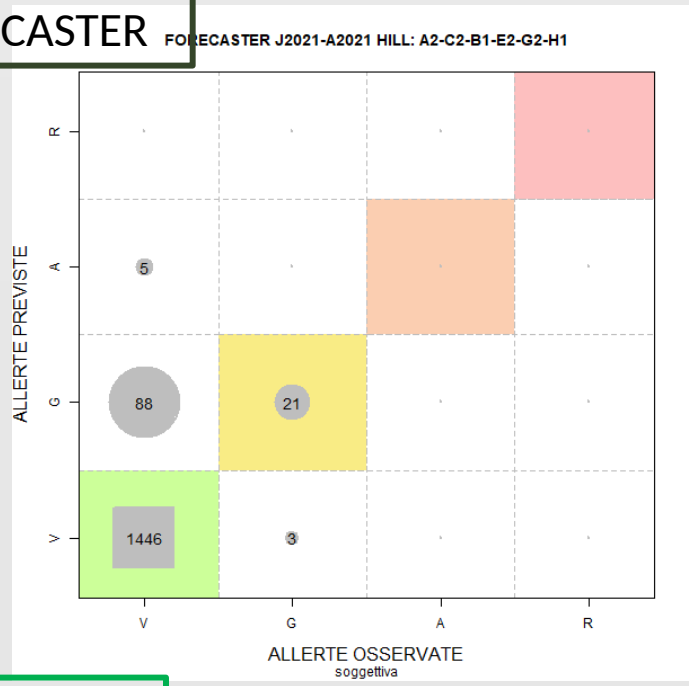

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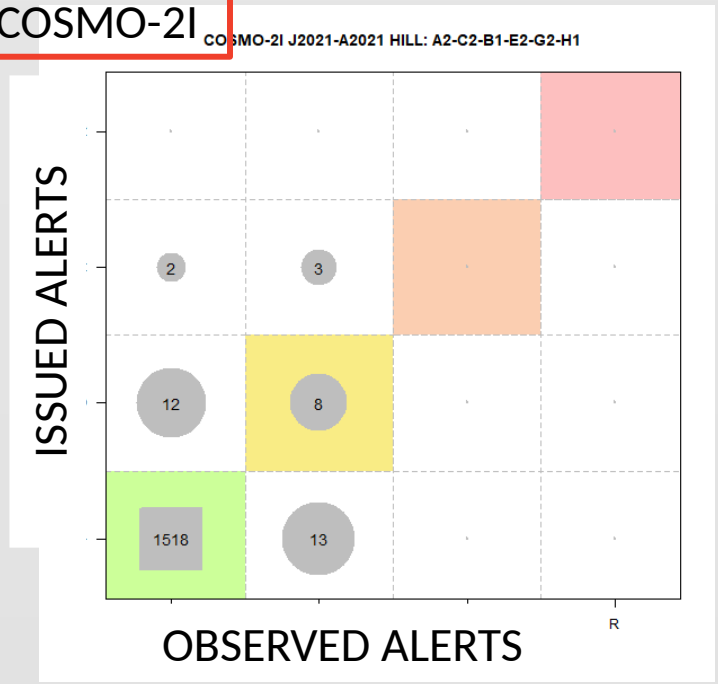

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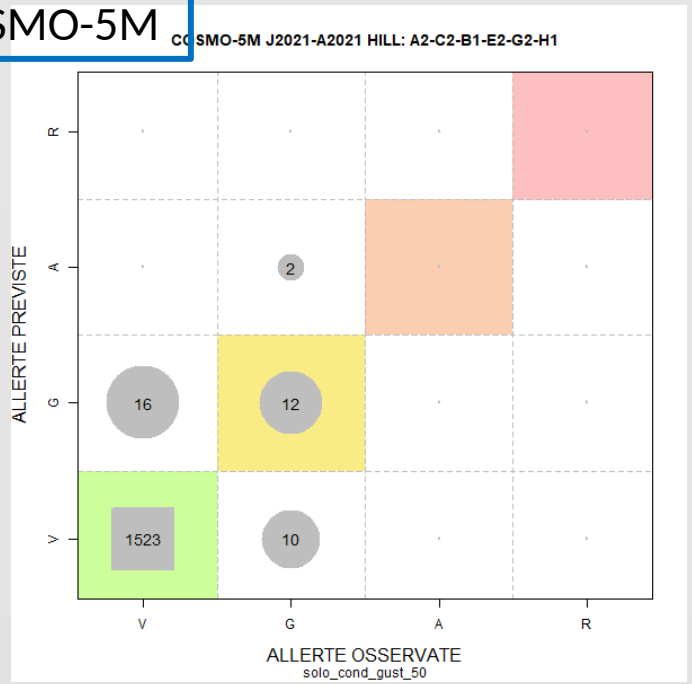

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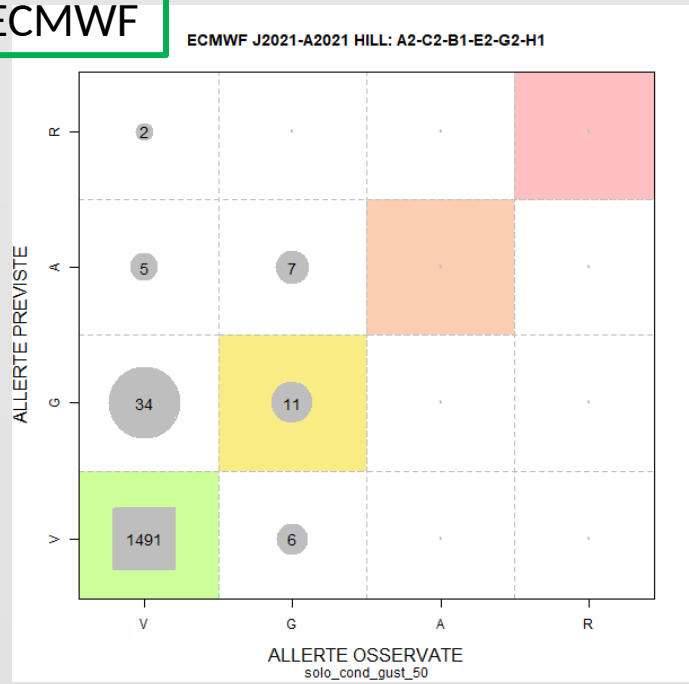

Models – plain areas

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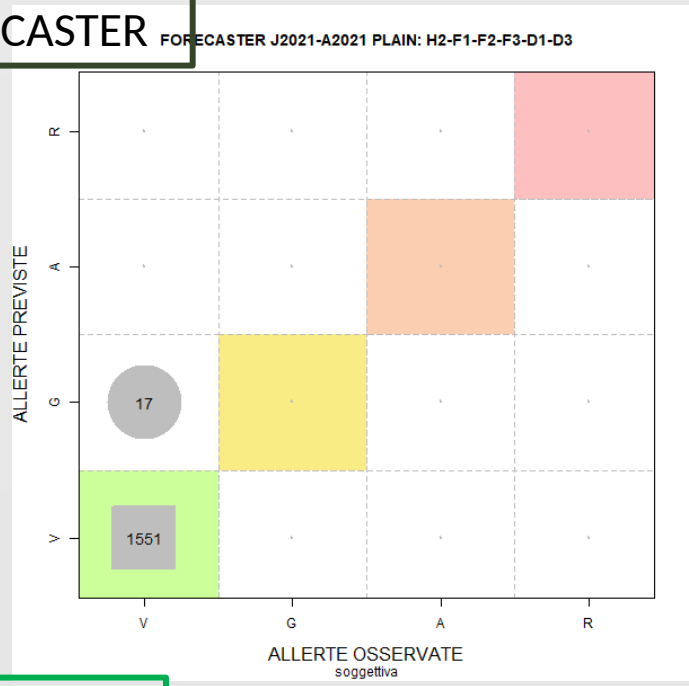

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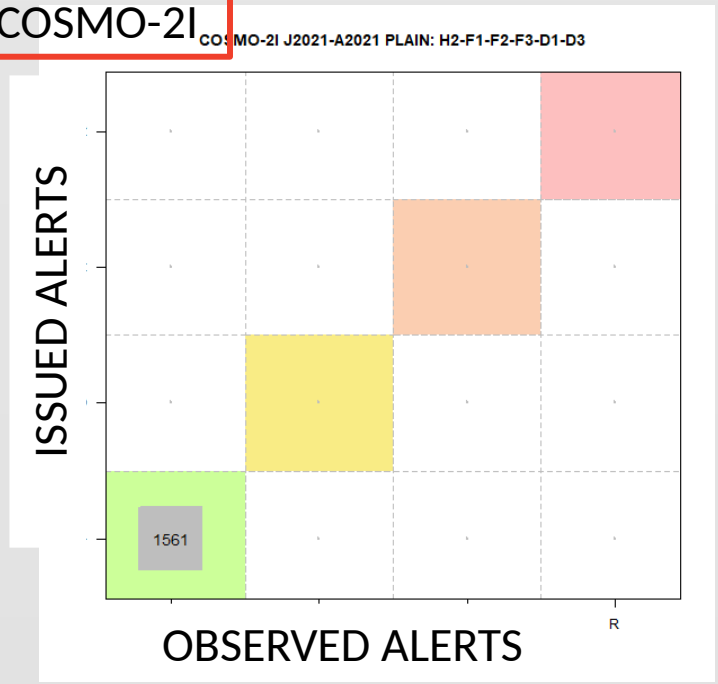
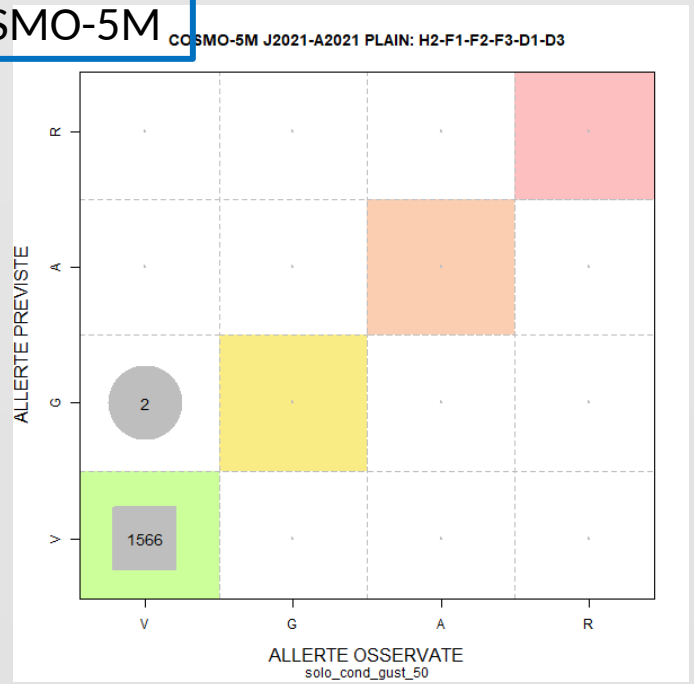


COSMO-5M



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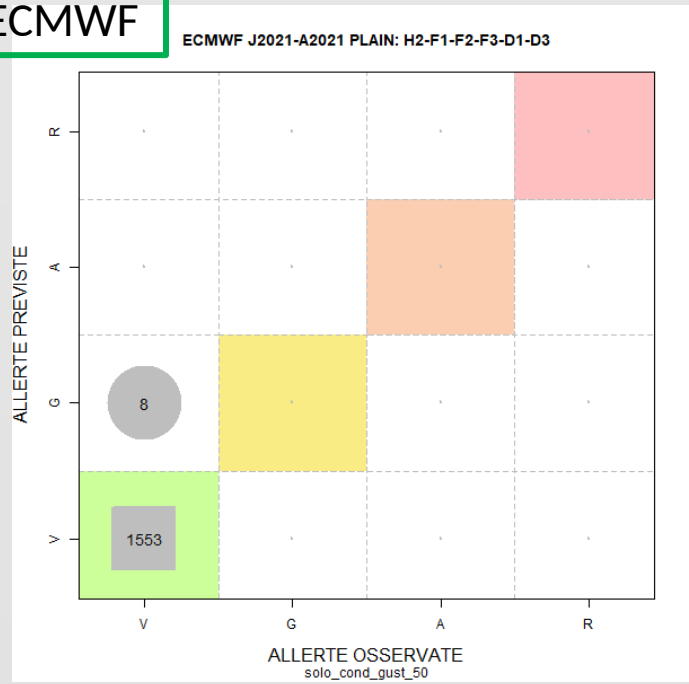

Ongoing outcomes

- WS overestimation in costal stations resulting from standard verification is misleading strong wind are underestimated (but they are few cases in a season)
- Forecasters don’t rely on 10m ws to issue alerts
- Considering the 50% of coverage of points with gust over the thresholds reduce the number of false alarm but hits are also reduced with an increase of misses (not for ECMWF in mountain areas)

How can we explain the large number of False Alarm?

Are models output the reason of this overestimation?

Which is the best wind variable to use? 10m wind speed or wind gust?

Different scenarios have been considered applying the conditions to determine the "color of the alert" to:

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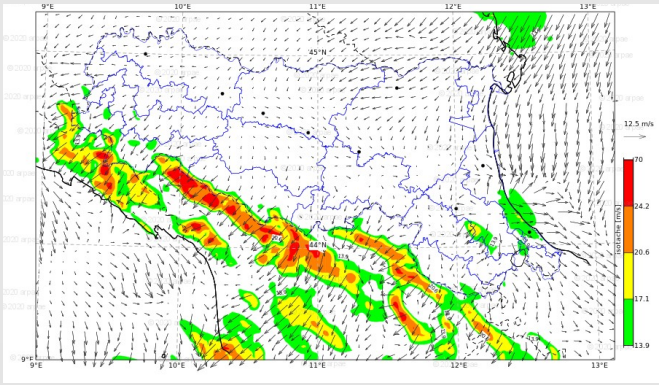
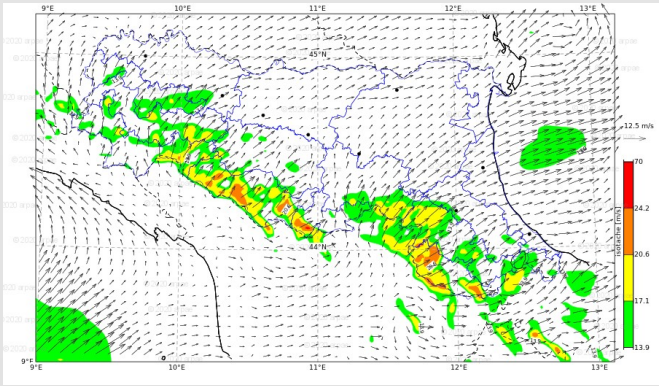
- Combination of scenario define by conditions on wind gust and 10m wind speed exceeding a lover threshold (Beaufort 6)



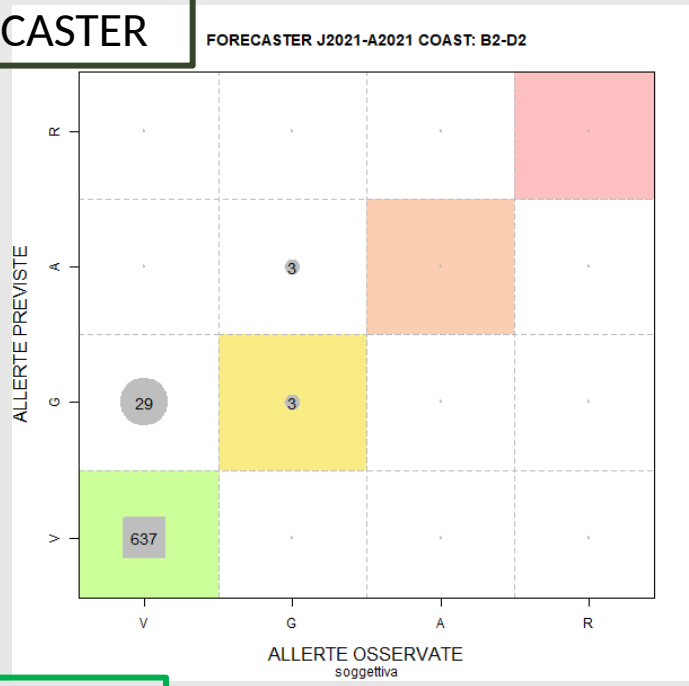


Models – costal areas

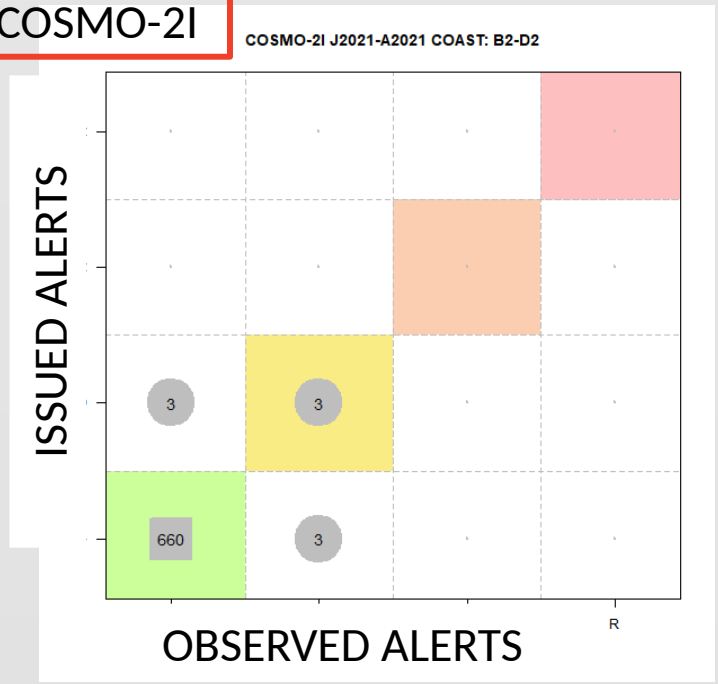
Condition on 50th percentile of wind gust in the area

- YELLOW (G): Wg50> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg50> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg50> 24.4 m/s (B10) for at least 3 hours throughout the day

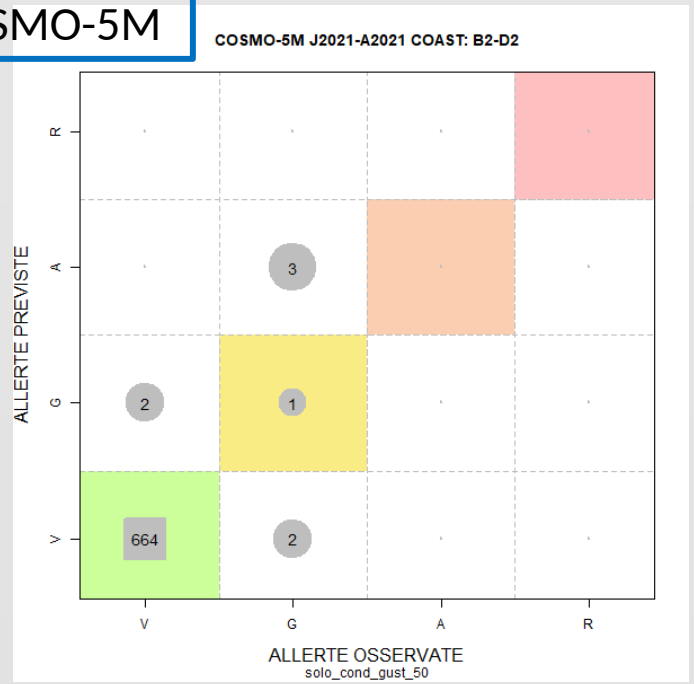
FORECASTER



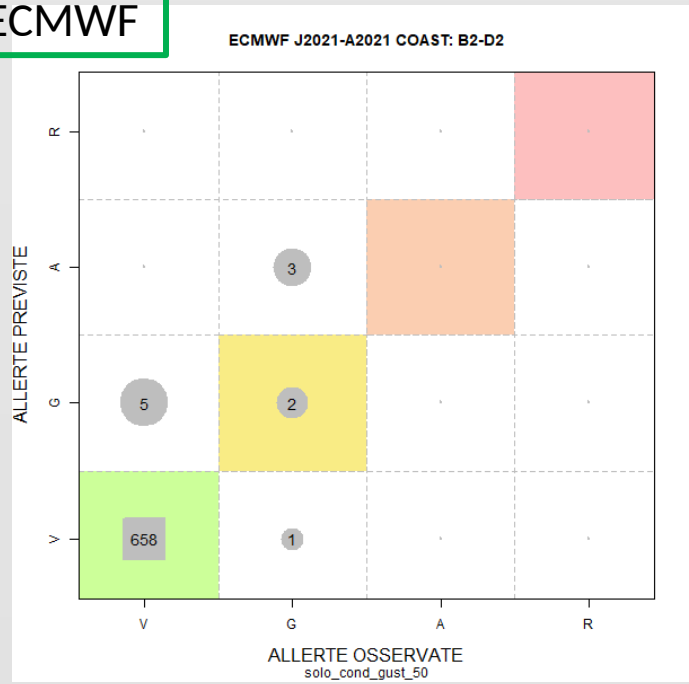
COSMO-2I



COSMO-5M



ECMWF

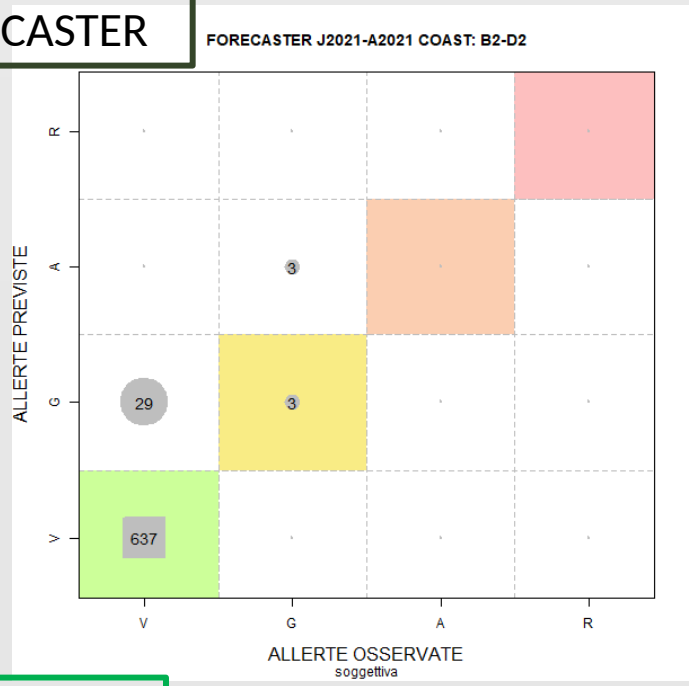


Models – costal areas

Condition on 75th percentile of wind gust in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg75> 24.4 m/s (10) for at least 3 hours throughout the day

FORECASTER



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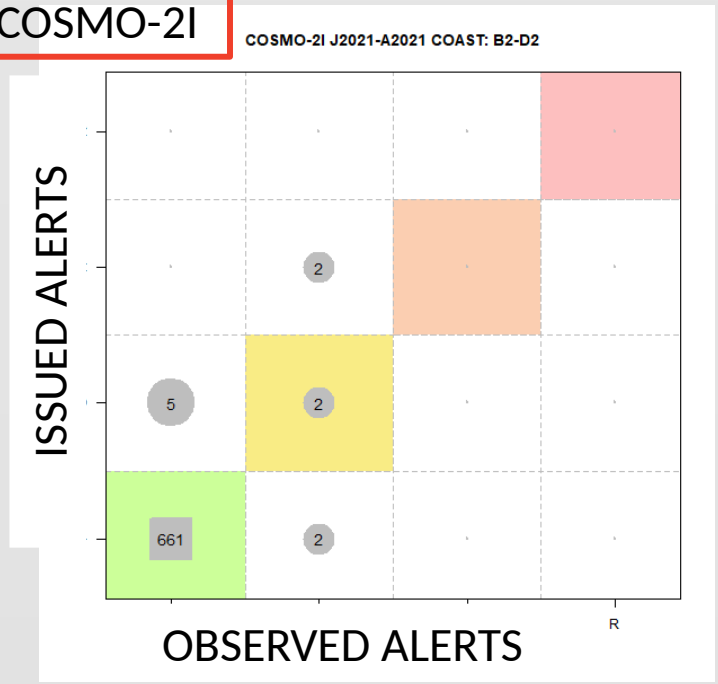

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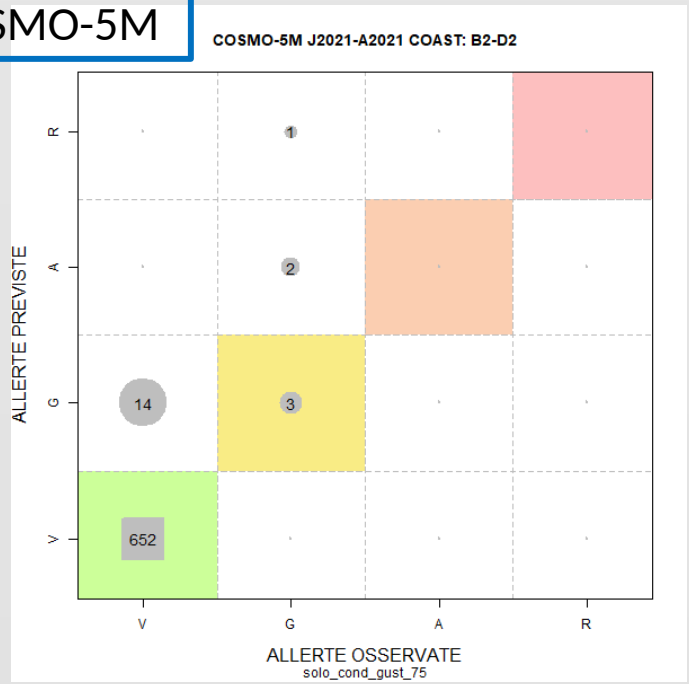

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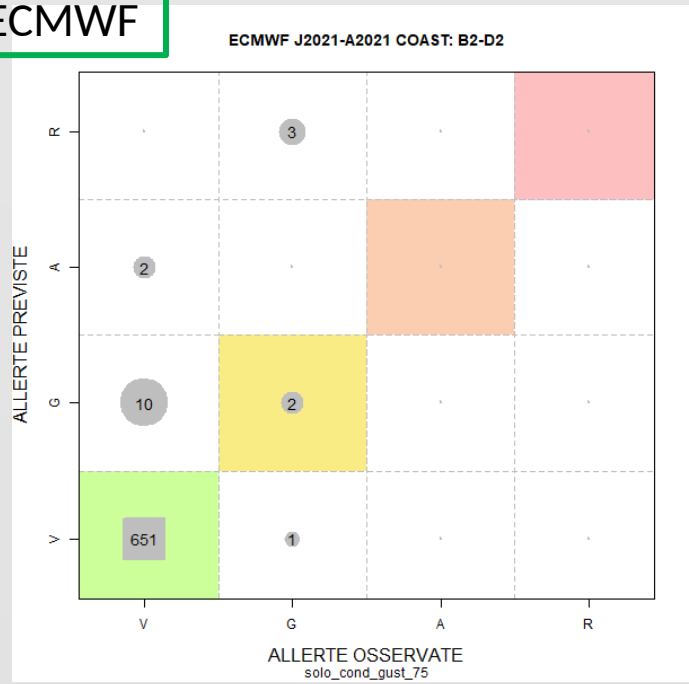

Models – costal areas

Condition on 90th percentile of wind gust in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
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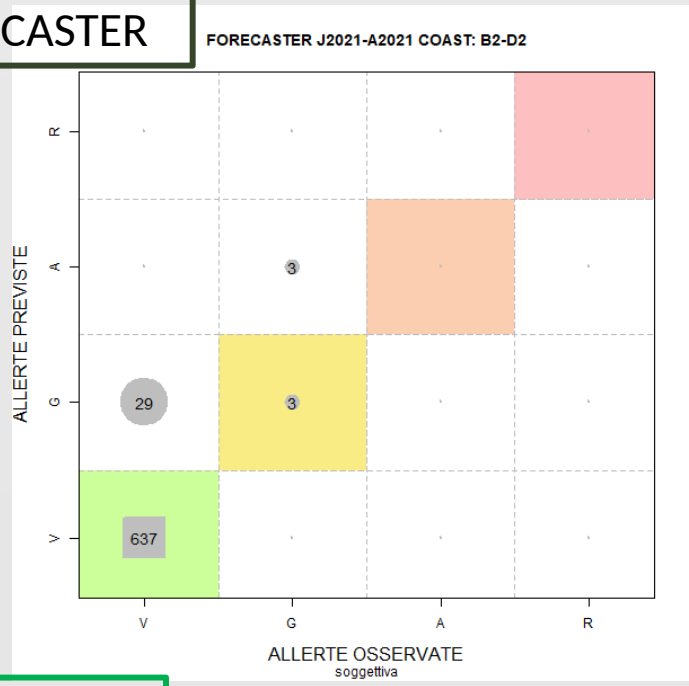
- RED(R): Wg90>24.4 m/s (B10) for at least 3 hours throughout the day

FORECASTER



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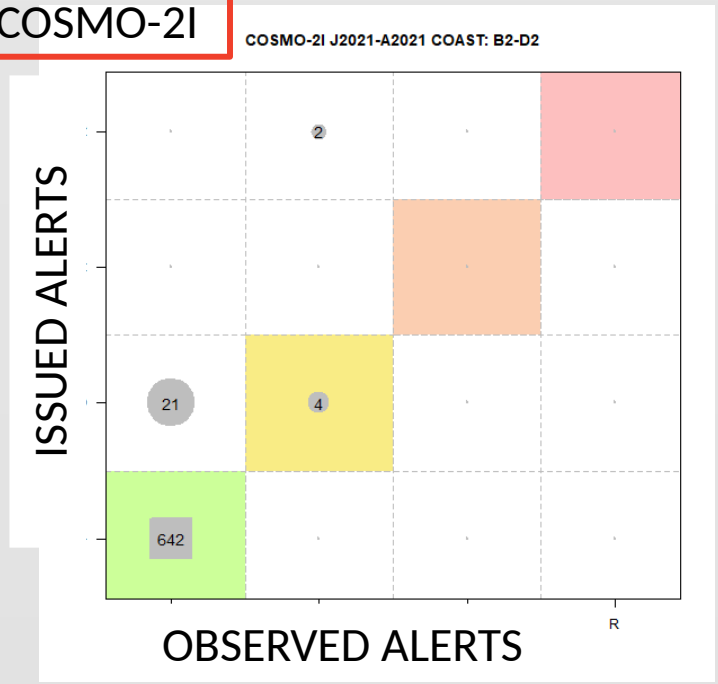
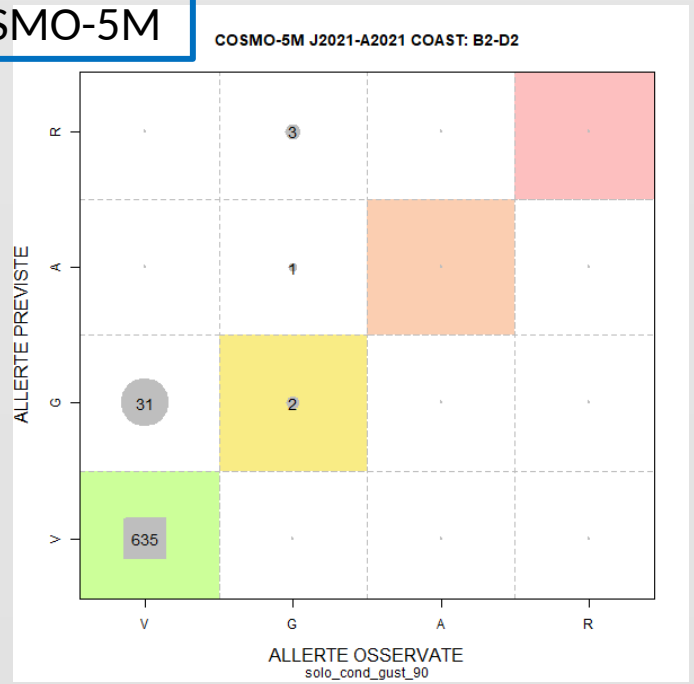


COSMO-5M



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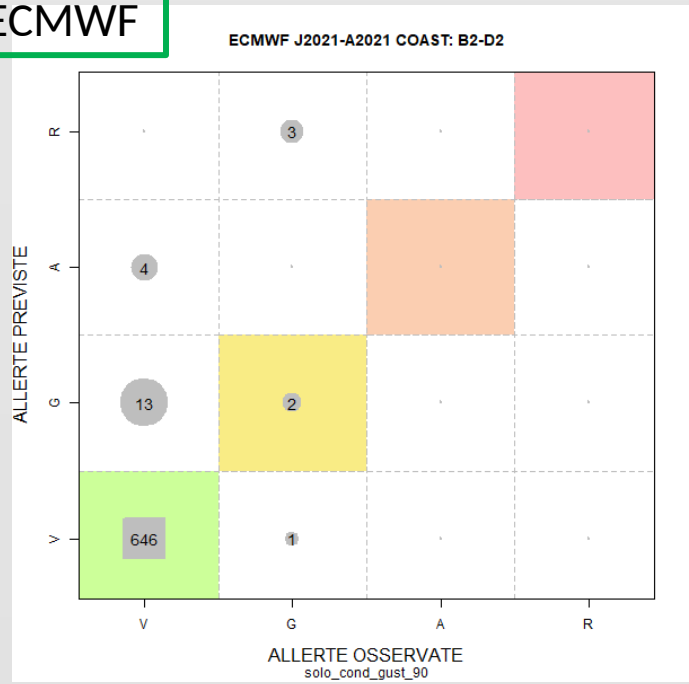

Models – mountain areas

Condition on 50th percentile of wind gust in the area

- YELLOW (G): Wg50> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
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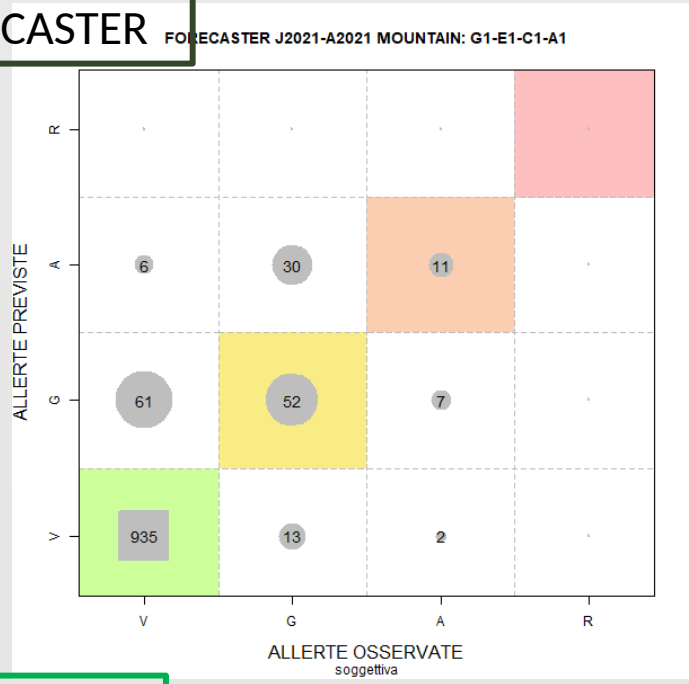
- RED(R): Wg50> 24.4 m/s (B10) for at least 3 hours throughout the day

FORECASTER



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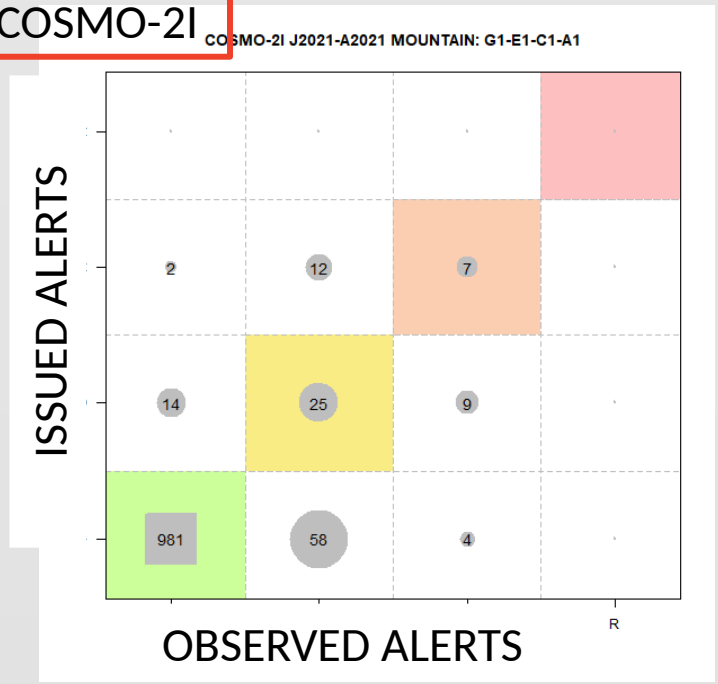

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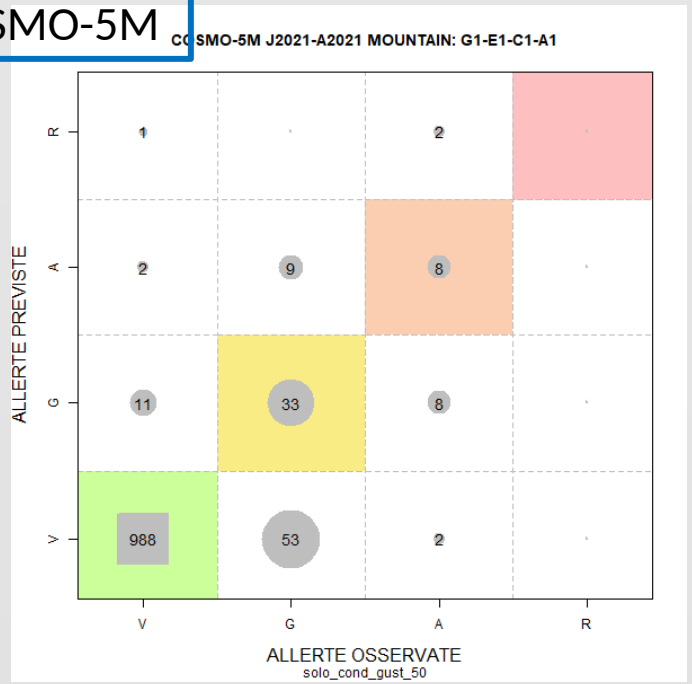

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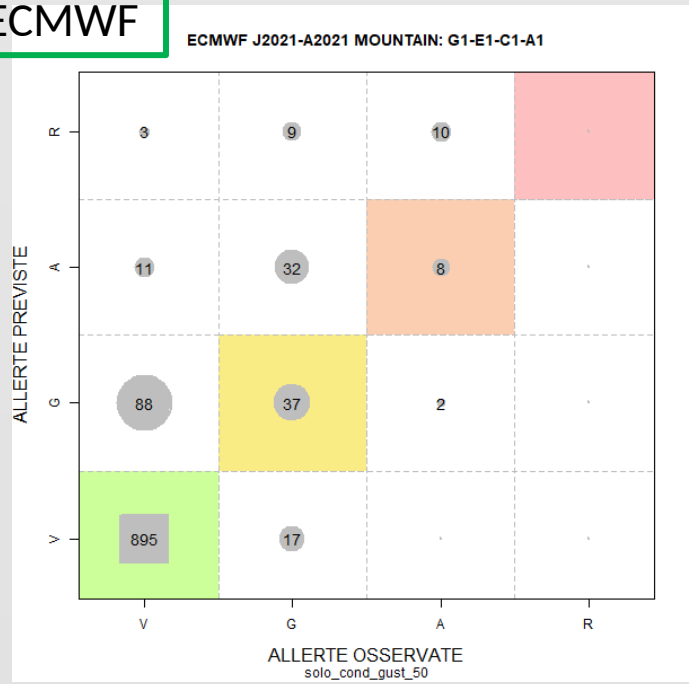

Models – mountain areas

Condition on 75th percentile of wind gust in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
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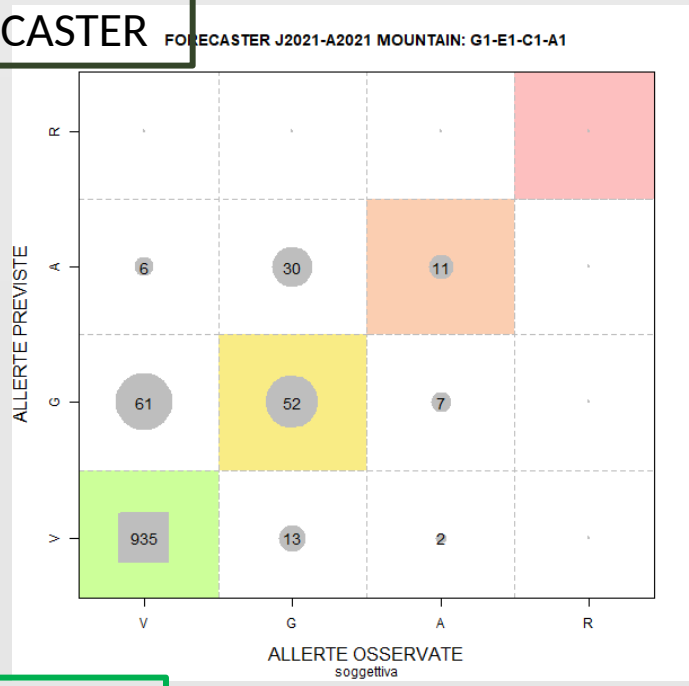
- RED(R): Wg75> 24.4 m/s (10) for at least 3 hours throughout the day

FORECASTER



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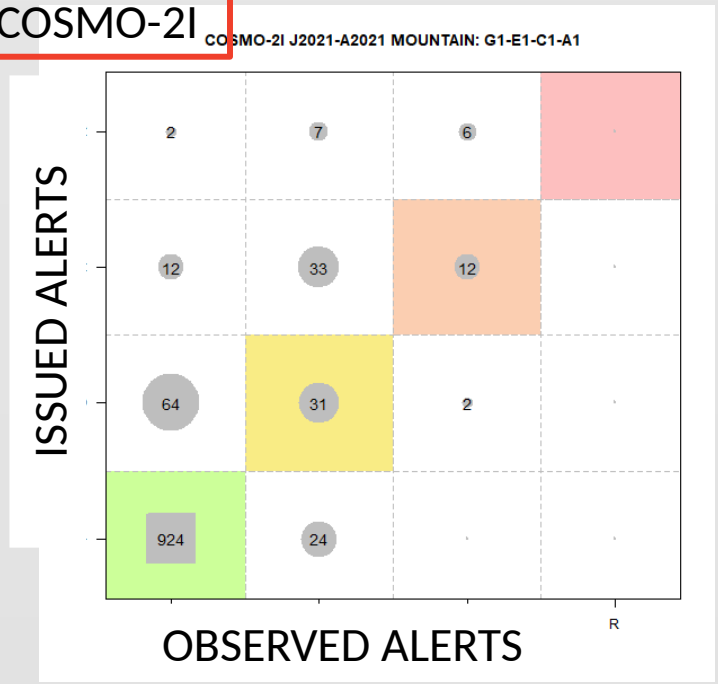

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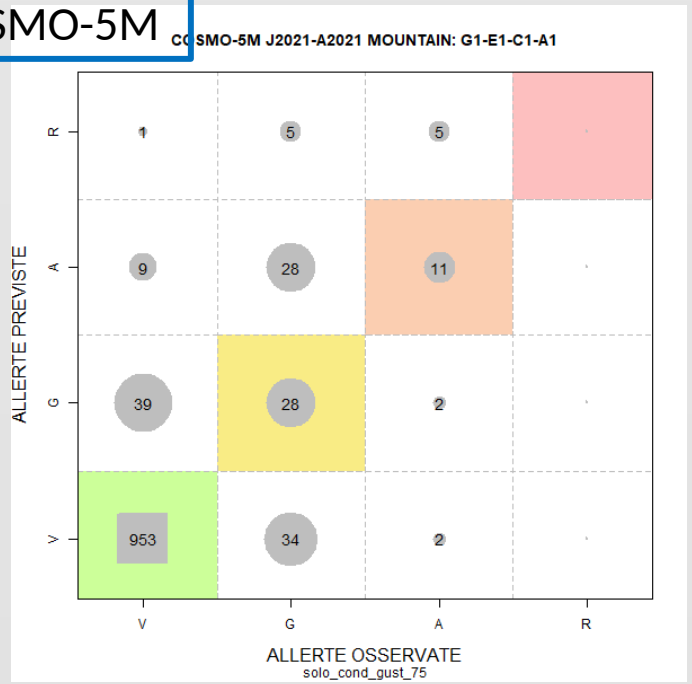

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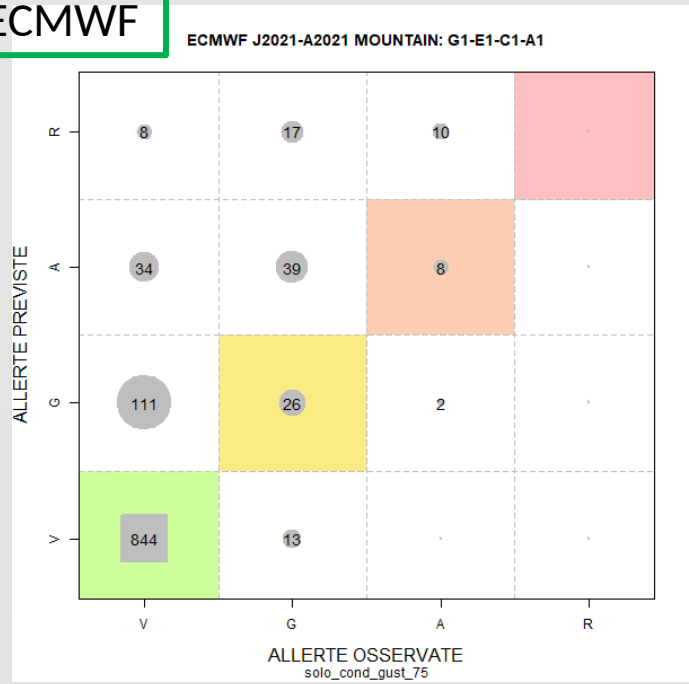

Models – mountain areas

Condition on 90th percentile of wind gust in the area

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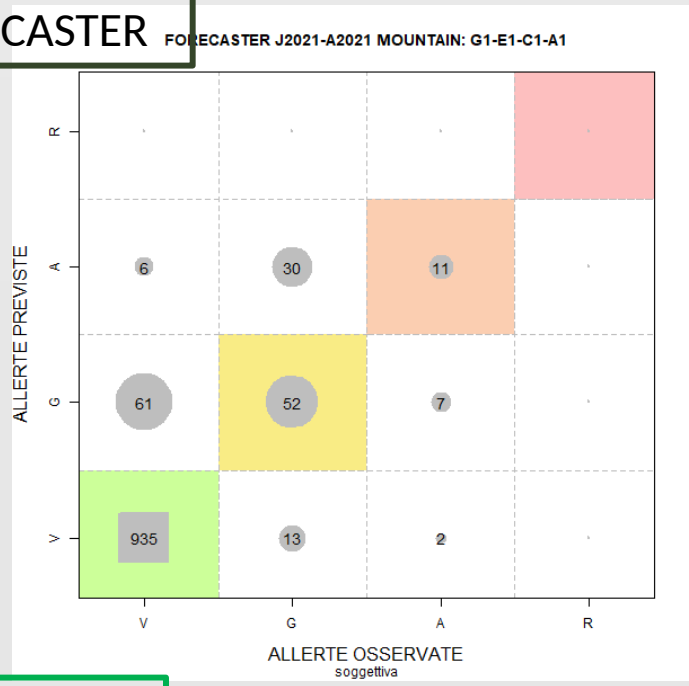
FORECASTER



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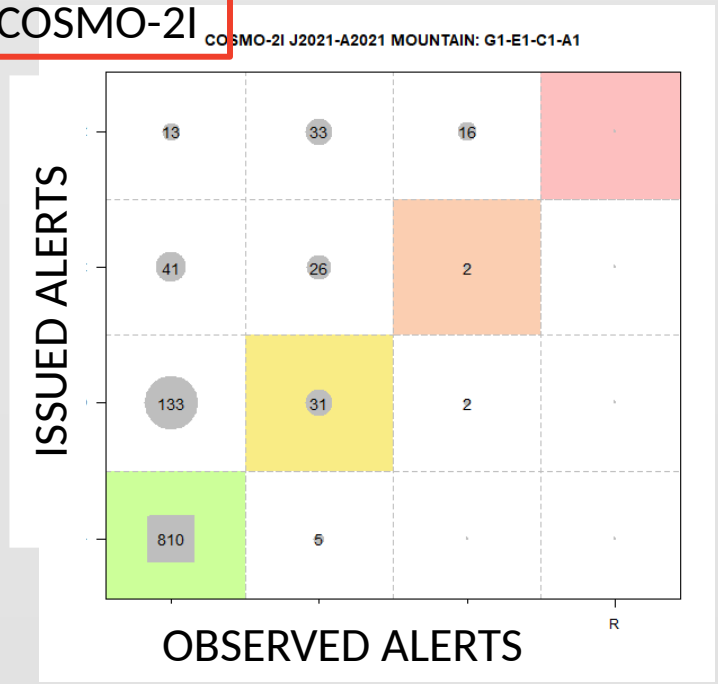

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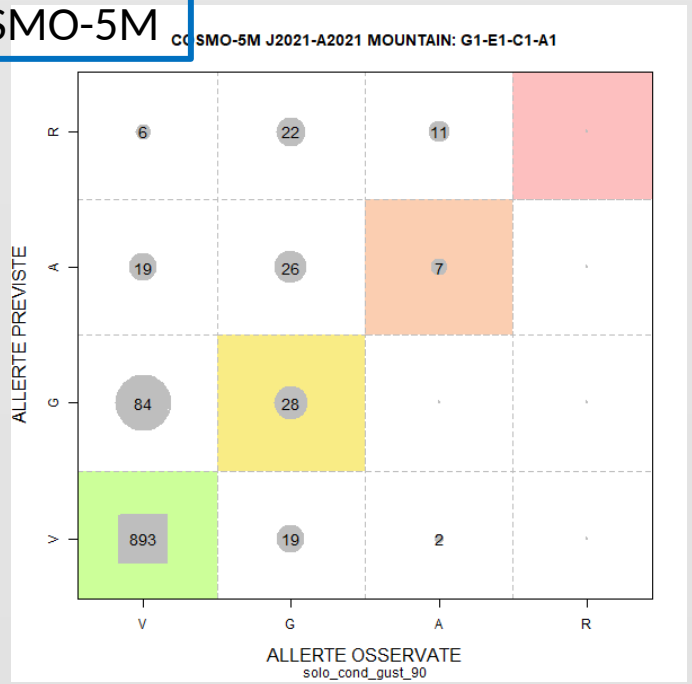

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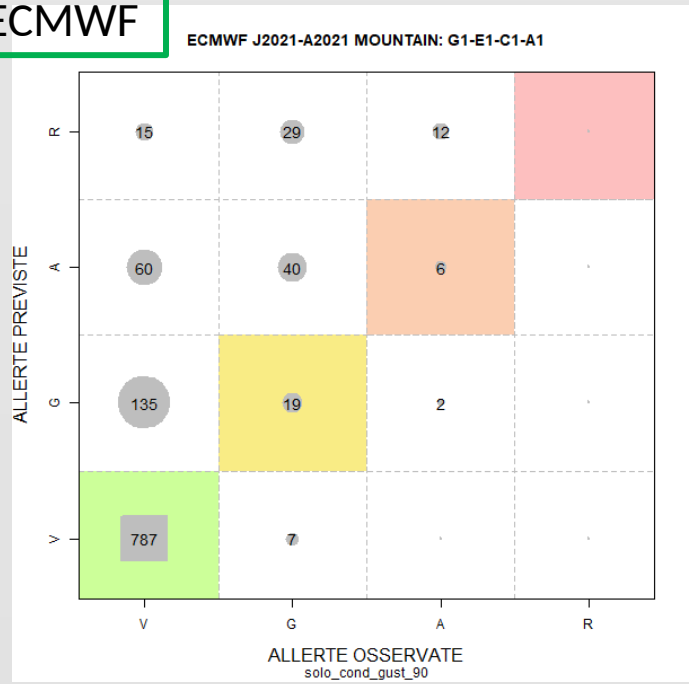

Models – hill areas

Condition on 50th percentile of wind gust in the area

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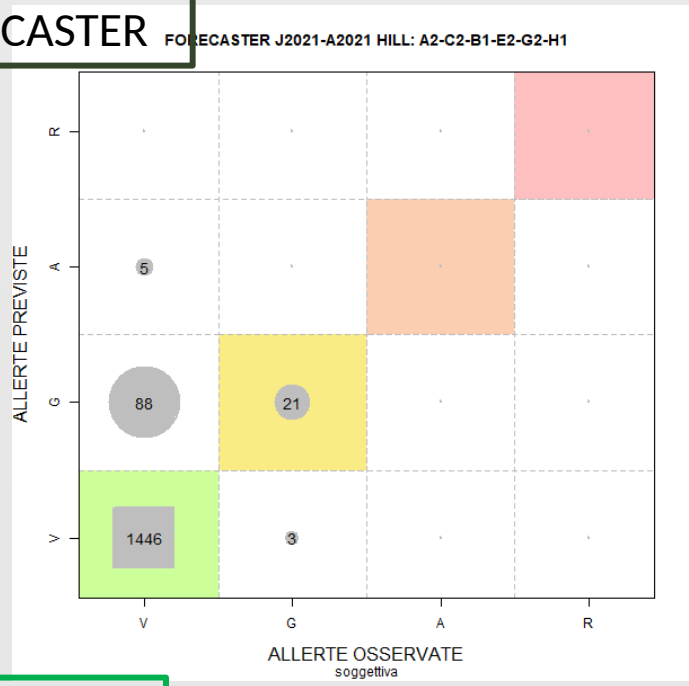
FORECASTER



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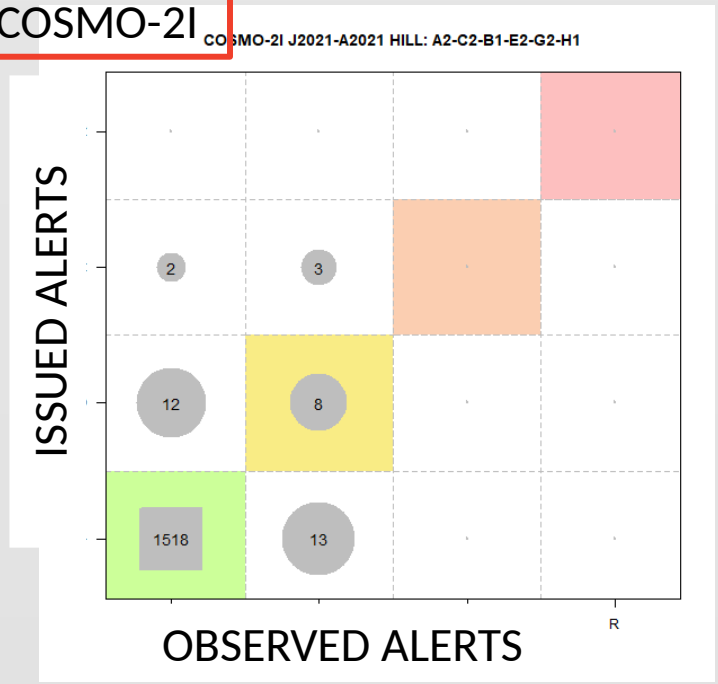

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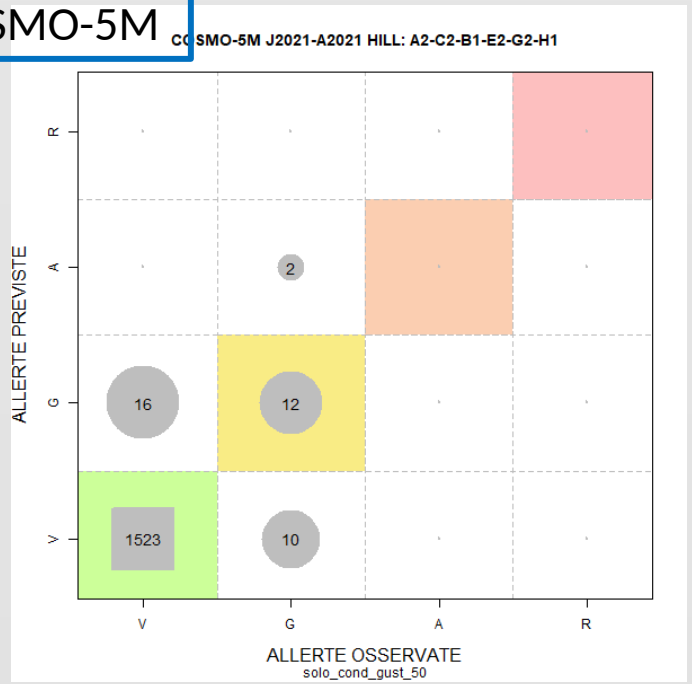

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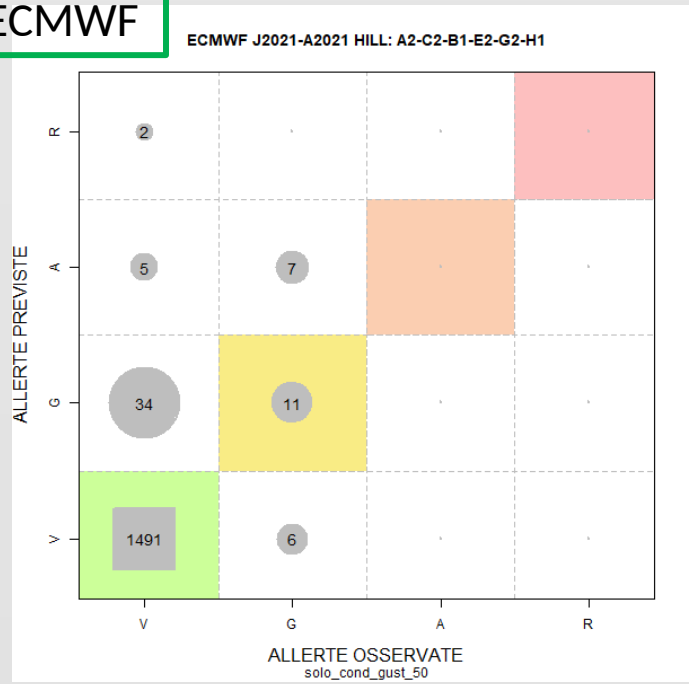

Models – hill areas

Condition on 75th percentile of wind gust in the area

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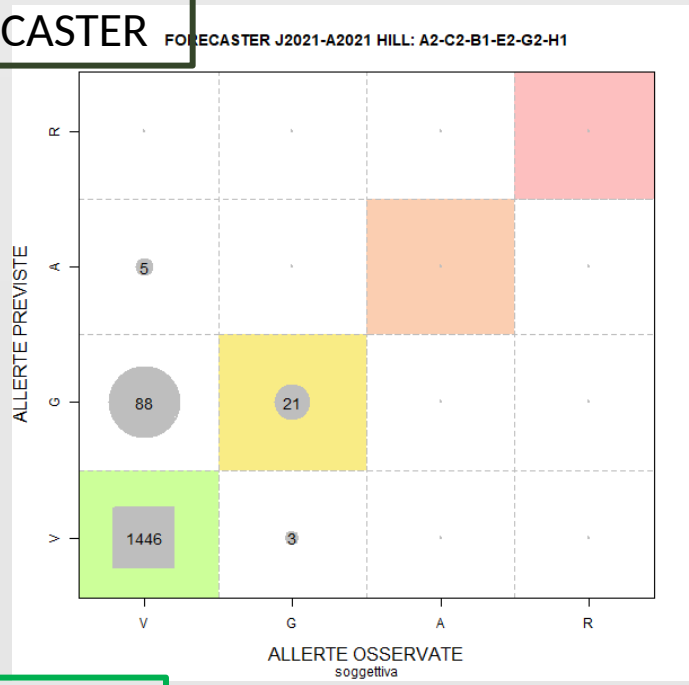
FORECASTER



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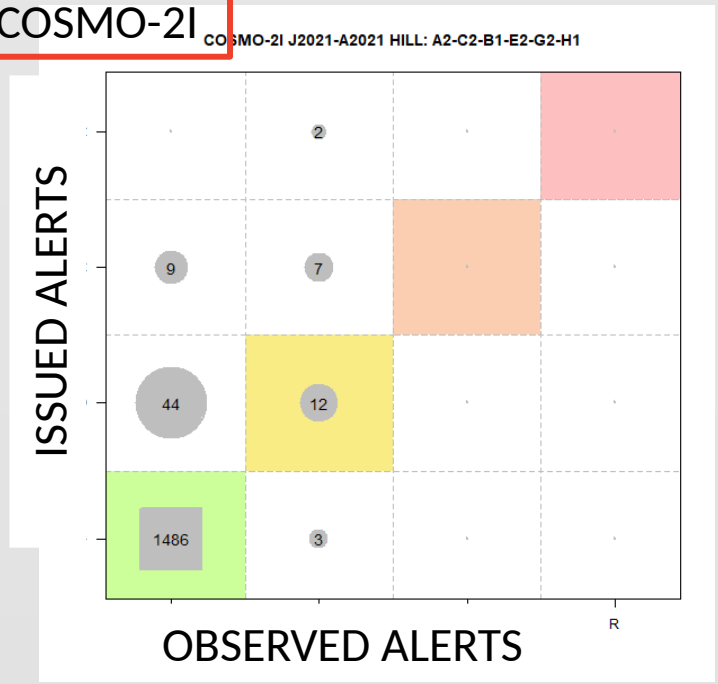

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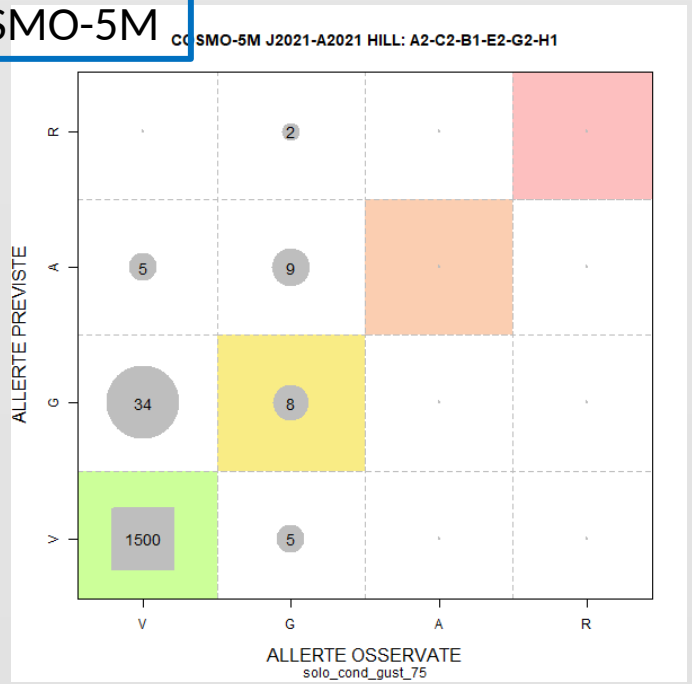

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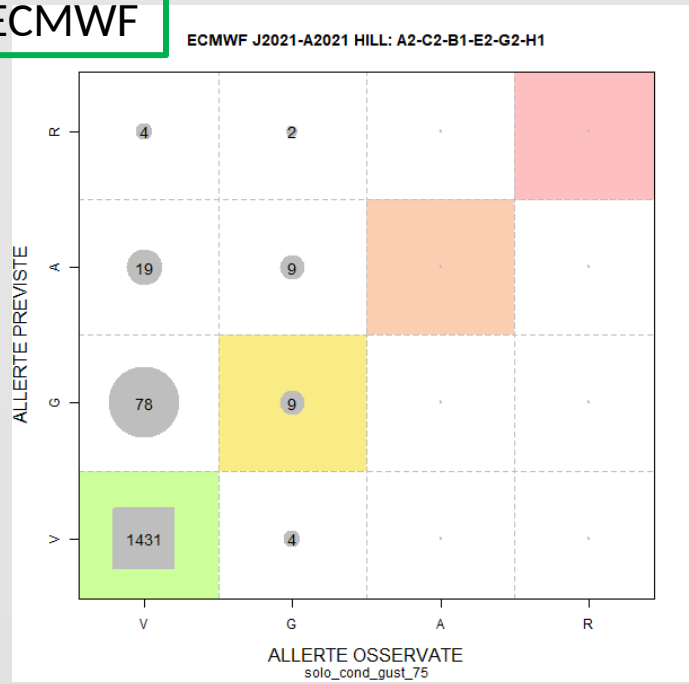

Models – hill areas

Condition on 90th percentile of wind gust in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
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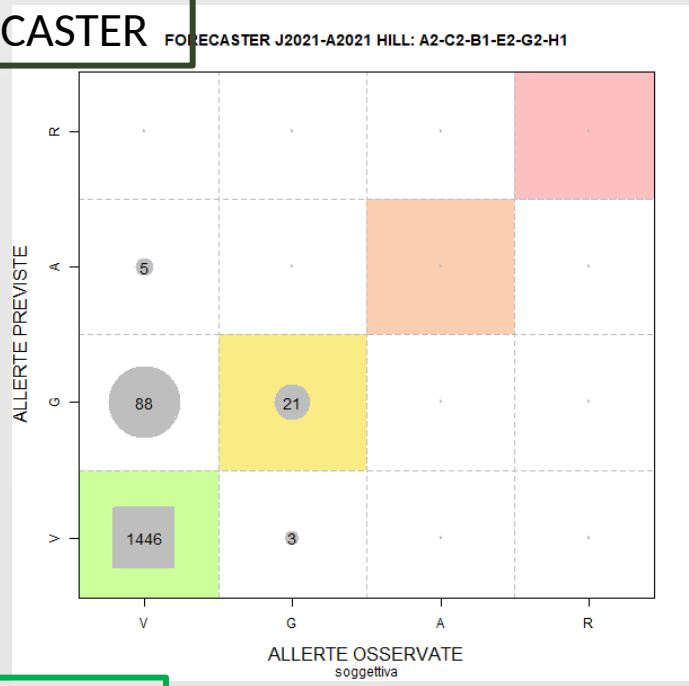
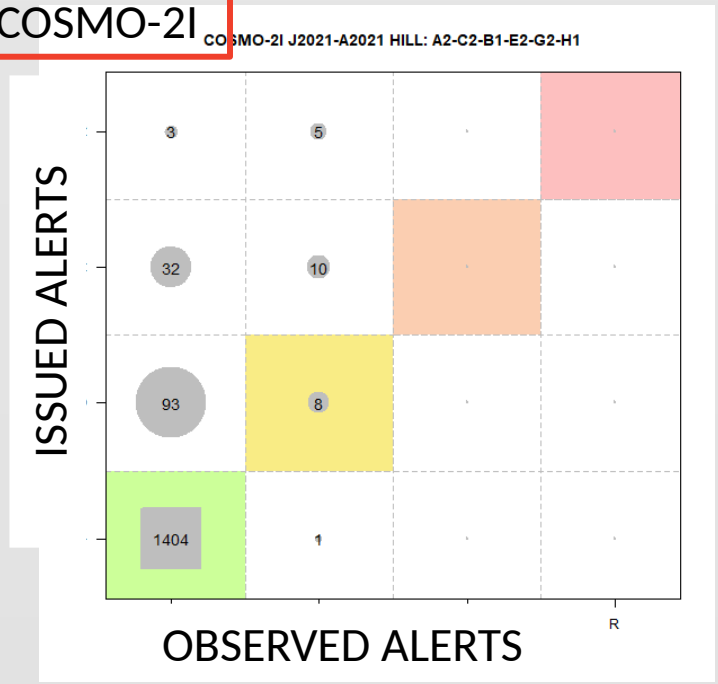
FORECASTER



COSMO-2I



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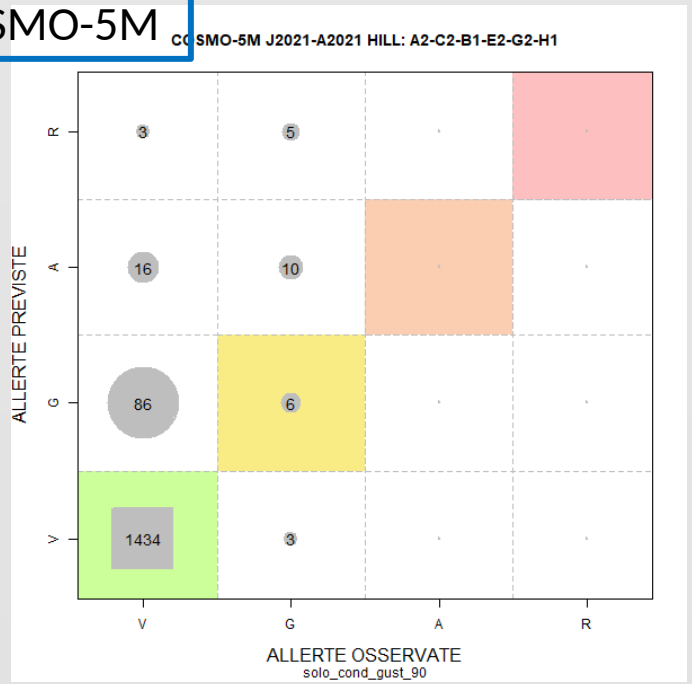

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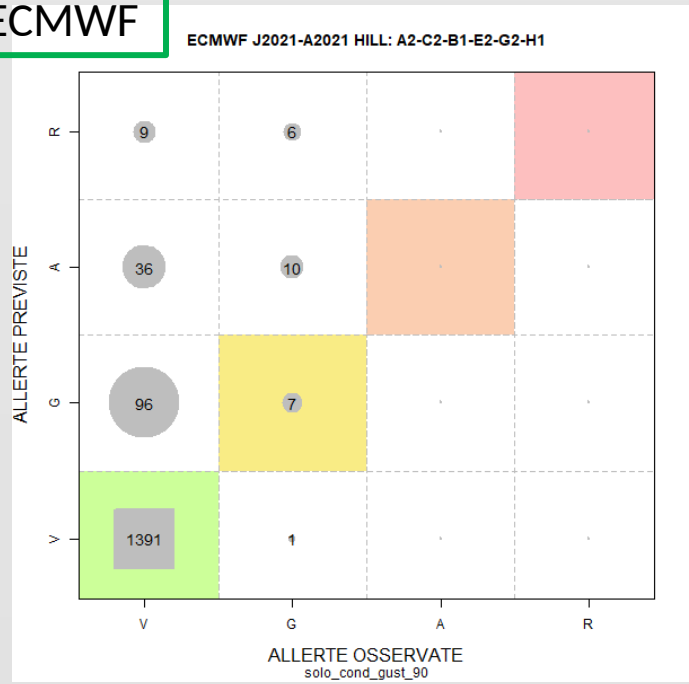

Models – plain areas

Condition on 50th percentile of wind gust in the area

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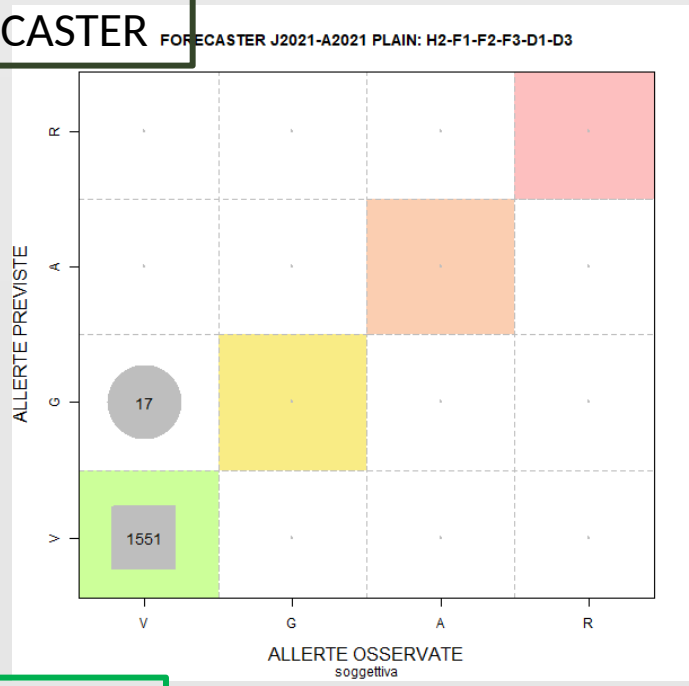
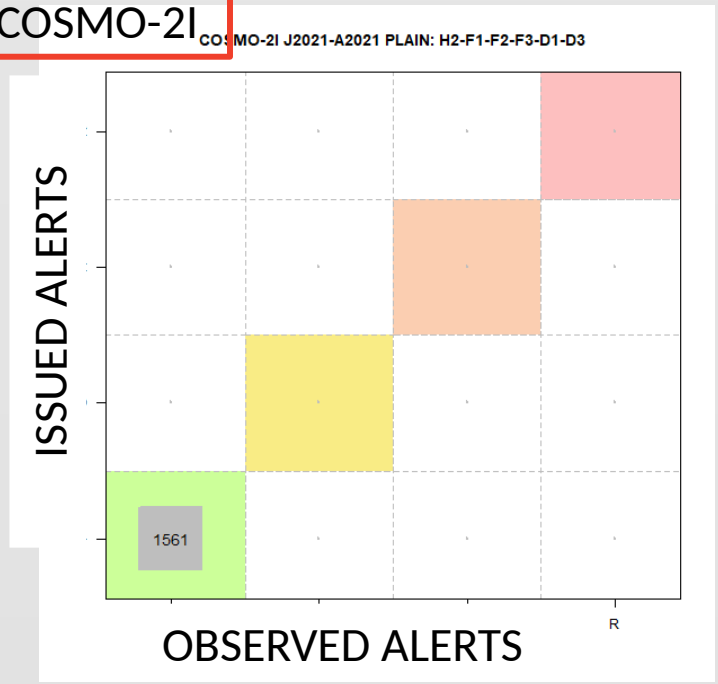
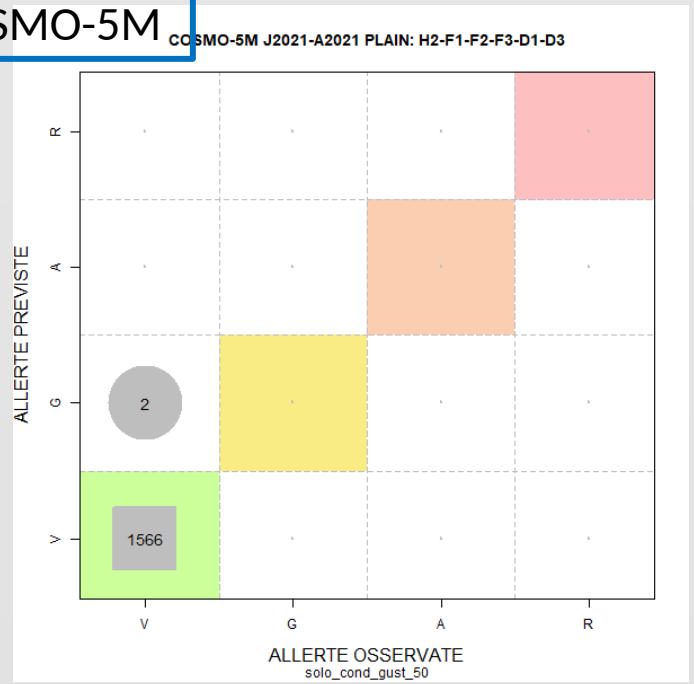
FORECASTER



COSMO-2I



COSMO-5M



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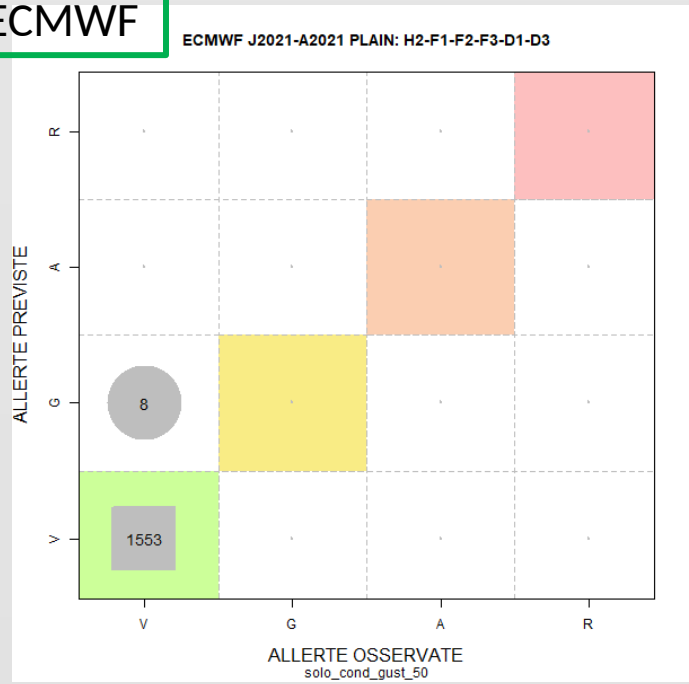

Models – plain areas

Condition on 75th percentile of wind gust in the area

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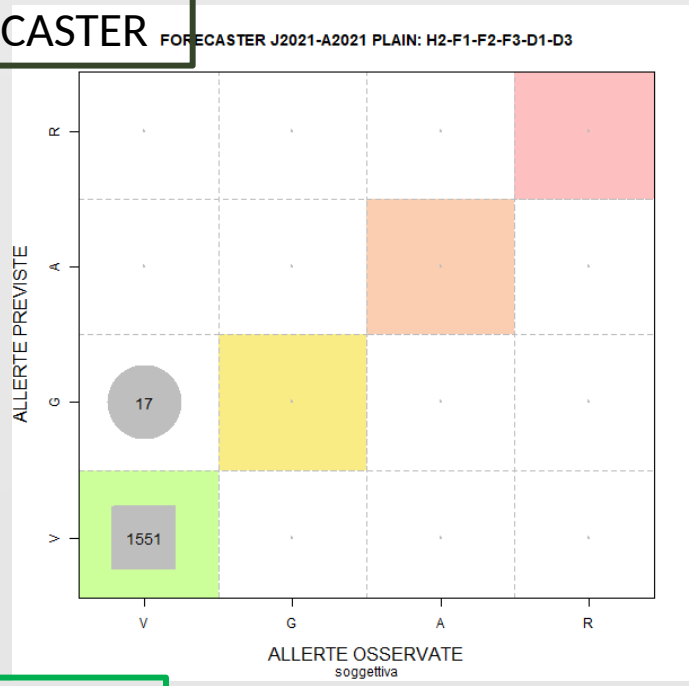
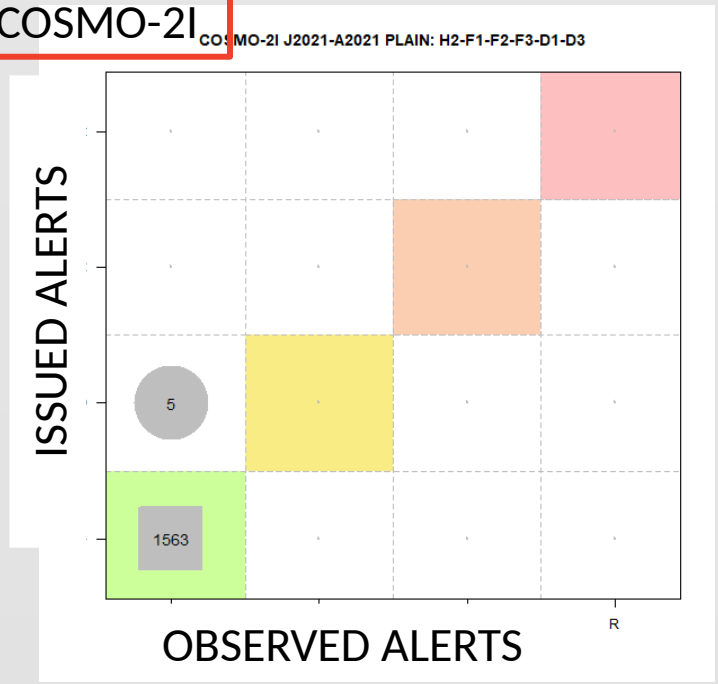
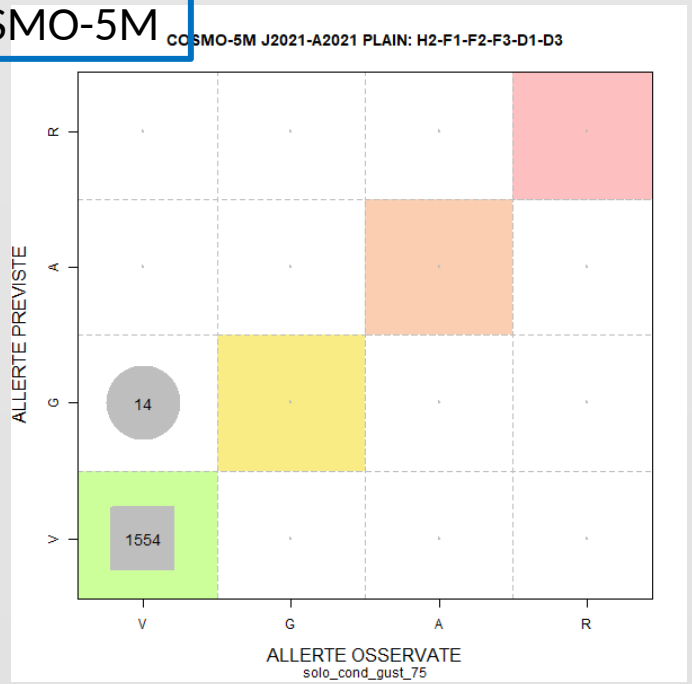
FORECASTER



COSMO-2I



COSMO-5M



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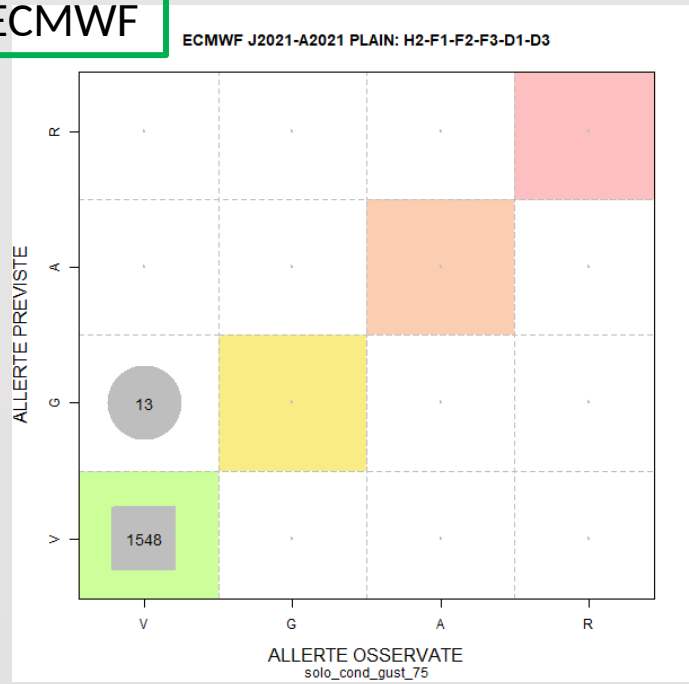

Models – plain areas

Condition on 90th percentile of wind gust in the area

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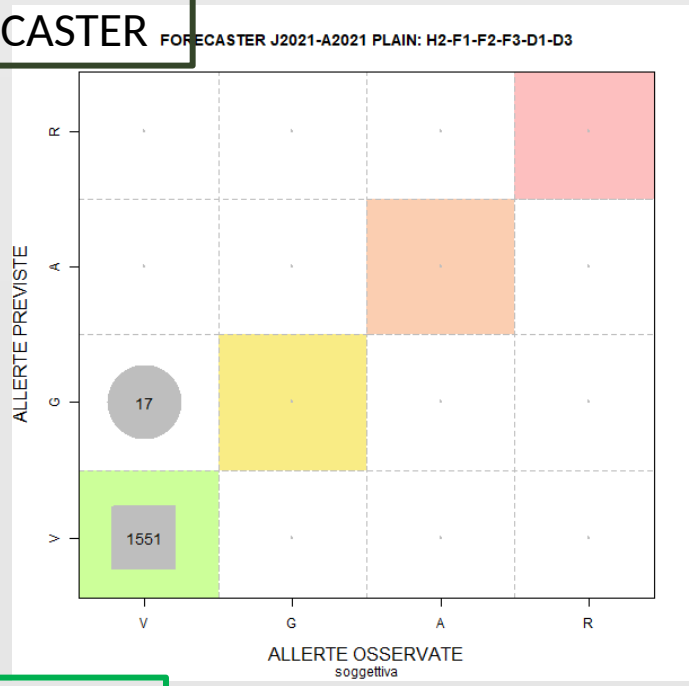
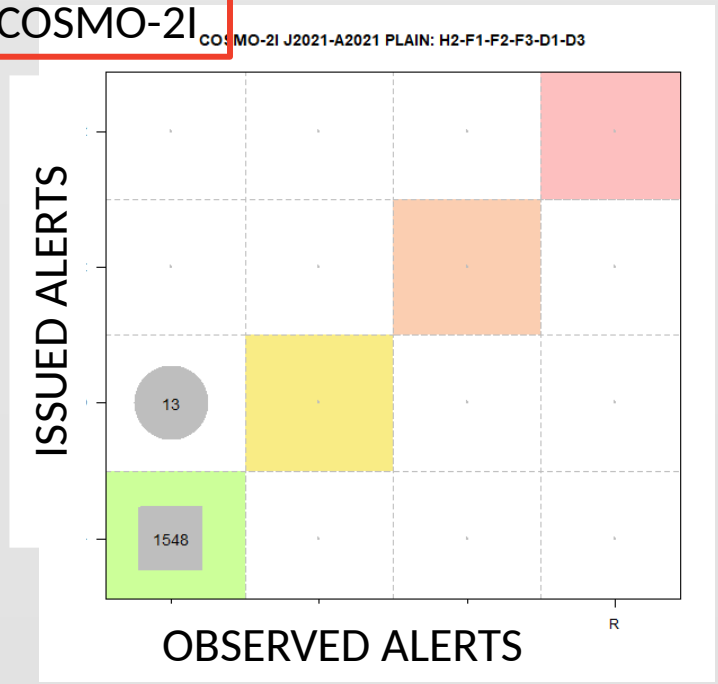
- RED(R): Wg90>24.4 m/s (B10) for at least 3 hours throughout the day

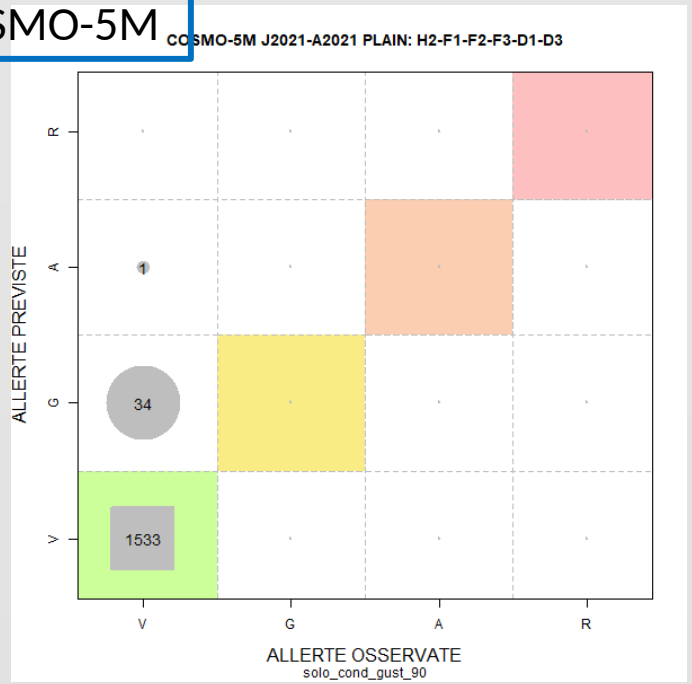
FORECASTER



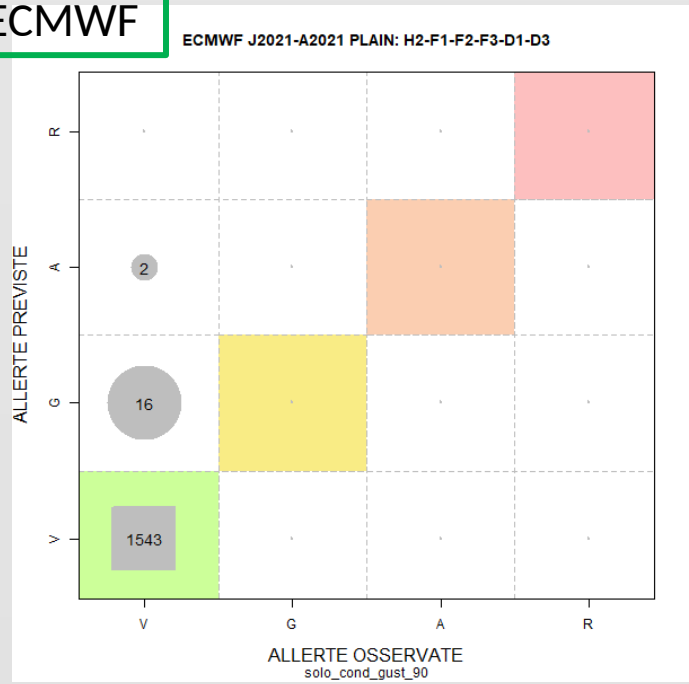
COSMO-2I



COSMO-5M



ECMWF



Ongoing outcomes

- WS overestimation in costal stations resulting from standard verification is misleading strong wind are underestimated (but they are few cases in a season)
- Forecasters don't rely on 10m ws to issue alerts
- Considering the 50% of coverage of points with gust over the thresholds reduce the number of false alarm but hits are also reduced with an increase of misses for all the 3 models
- In the case in which the thresholds are exceeded by the 25% of points, differences between models can be noted:
  - COSMO models seem a little better for Orange cases, also FA for Yellow cases are reduced but still more misses than those of forecasters
  - ECMWF has lower misses but higher FA
  - Hits for all models are lower than those of forecasters

- Considering selected gust on the coverage of 25% and 10 % of the area tend to reduce the number of misses but the number of false alarm increases and hits are lower than those of forecasters
- In general, it seems that forecasters are able to report the orange and red cases of models to yellow cases, while they seem unwilling to lower the cases from yellow to green

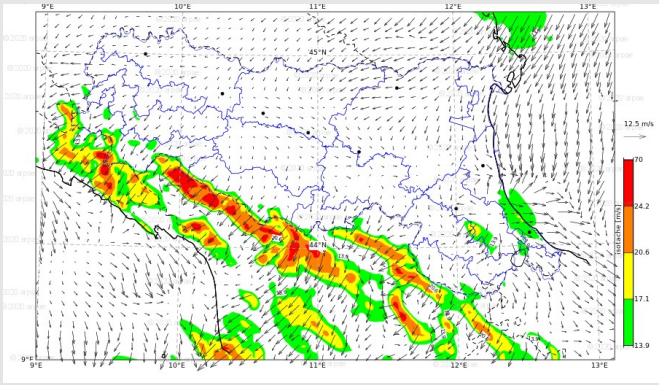
How can we explain the large number of False Alarm?

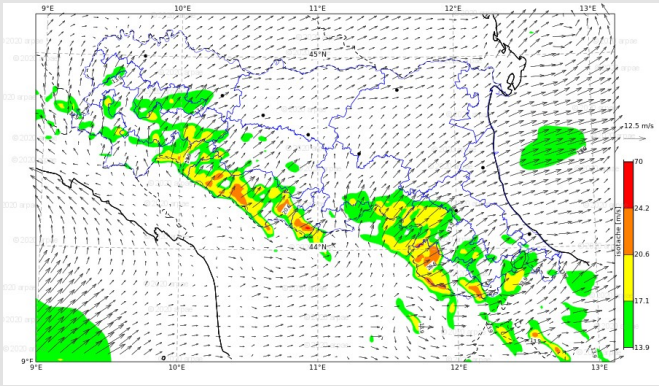
Are models output the reason of this overestimation?

Which is the best wind variable to use? 10m wind speed or wind gust?

Different scenarios have been considered applying the conditions to determine the "color of the alert" to:

- Maximum of 10m wind in the area (at least on point in the area greater than threshold)
- 50th of wind gust distribution over the area (50 % points of the area greater than threshold)
- 75th of wind gust distribution over the area (25 % points of the area greater than threshold)
- 90th of wind gust distribution over the area (10 % points of the area greater than threshold)
- Combination of scenario define by conditions on wind gust and 10m wind speed exceeding a lover threshold (Beaufort 6)





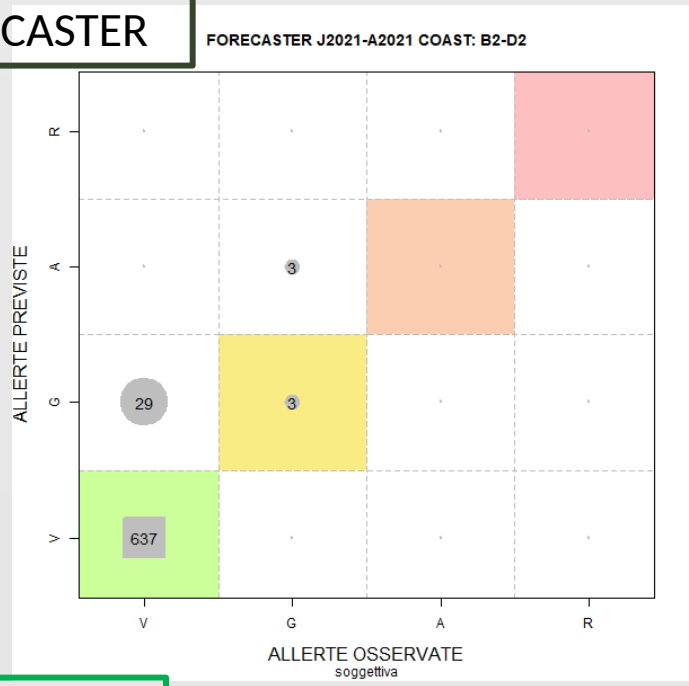
Models – costal areas

Only GUST conditions

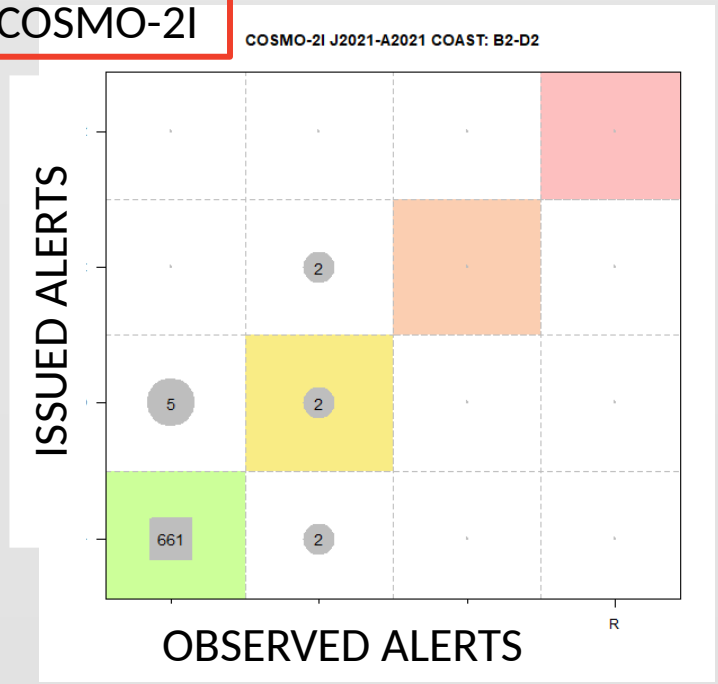
Condition on 75th percentile of wind gust in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg75> 24.4 m/s (10) for at least 3 hours throughout the day

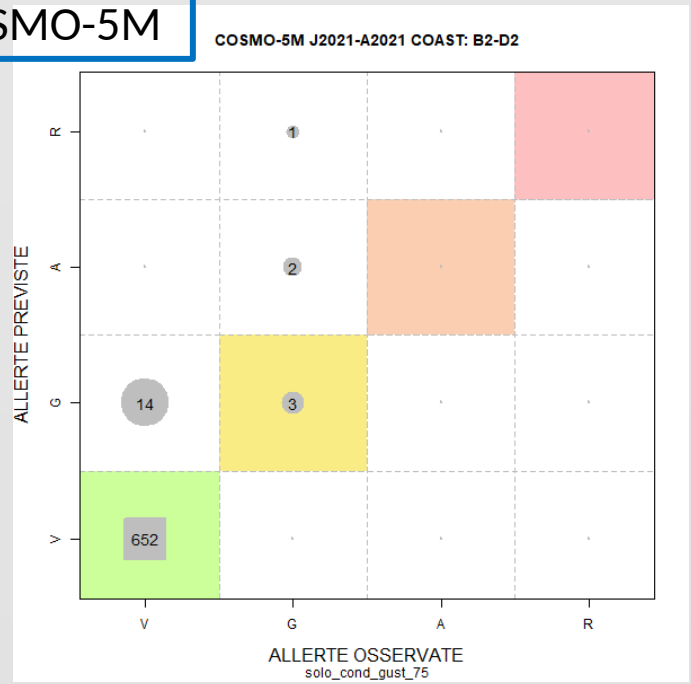
FORECASTER



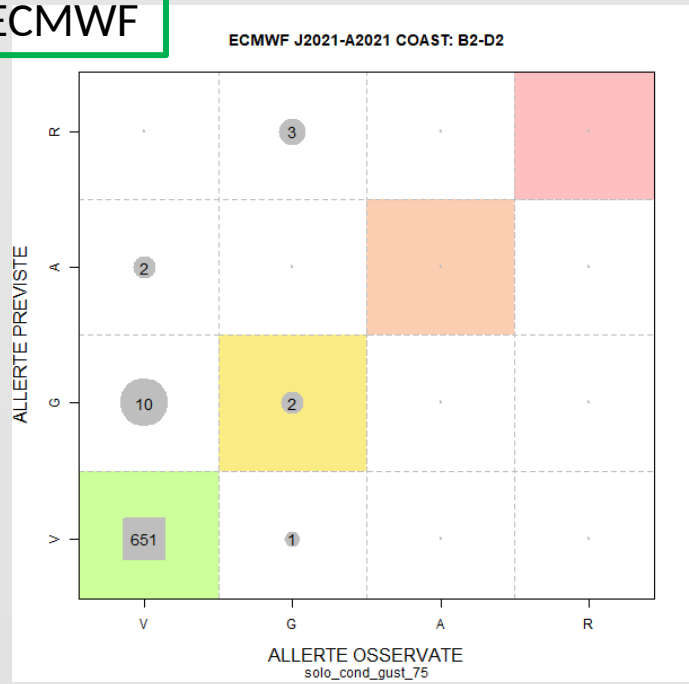
COSMO-2I



COSMO-5M



ECMWF

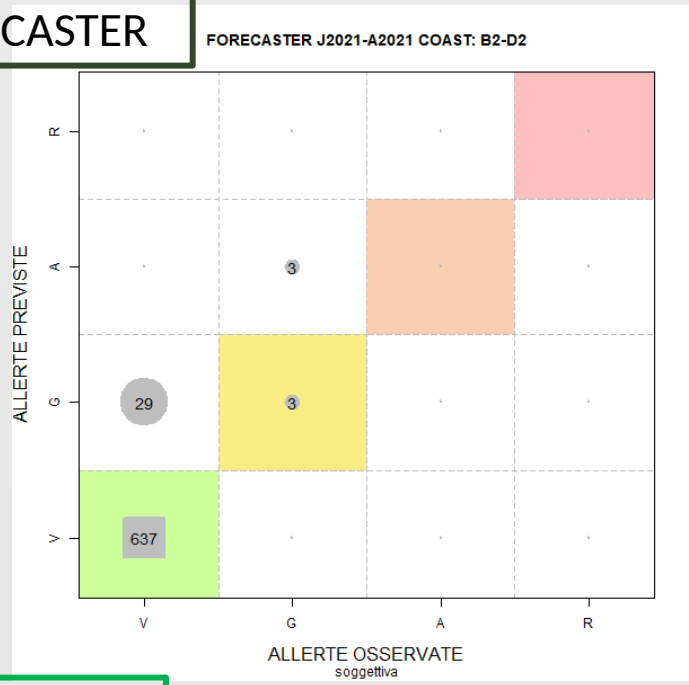


Models – costal areas

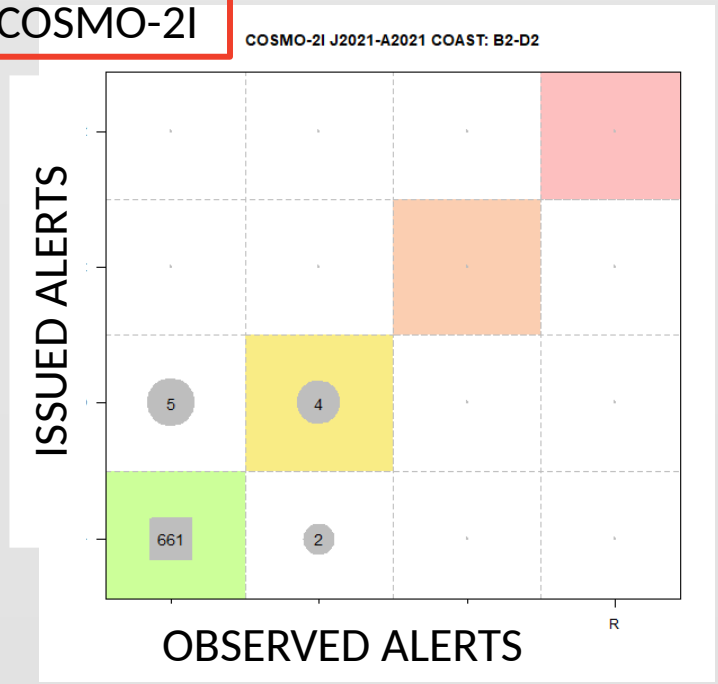
Condition on 75th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day + WS>17.2 m/s (B8)
- RED(R): Wg75>24.4 m/s (B10) for at least 3 hours throughout the day+ + WS>20.8 m/s (B9)

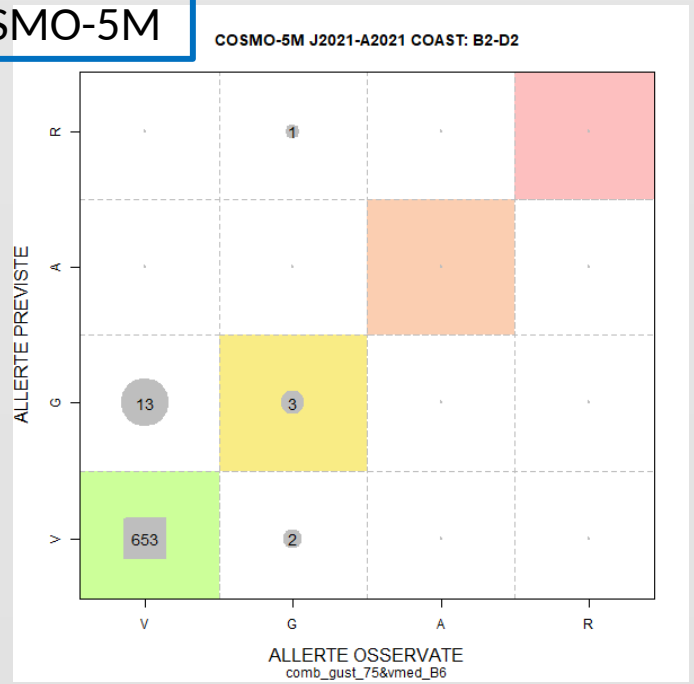
FORECASTER



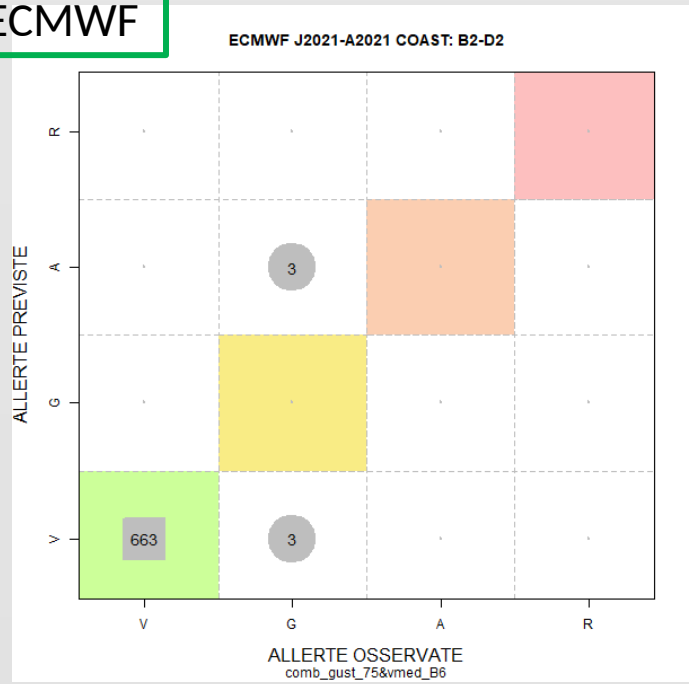
COSMO-2I



COSMO-5M



ECMWF



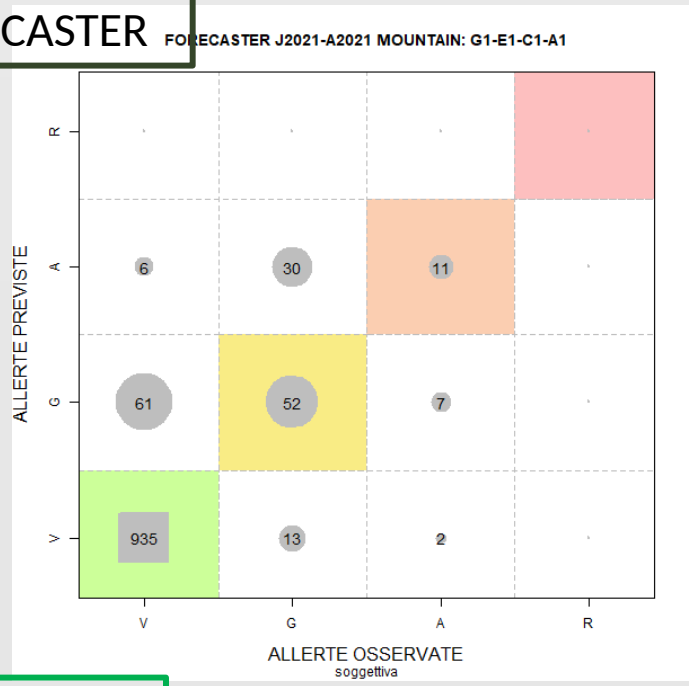
Models – mountain areas

Only GUST conditions

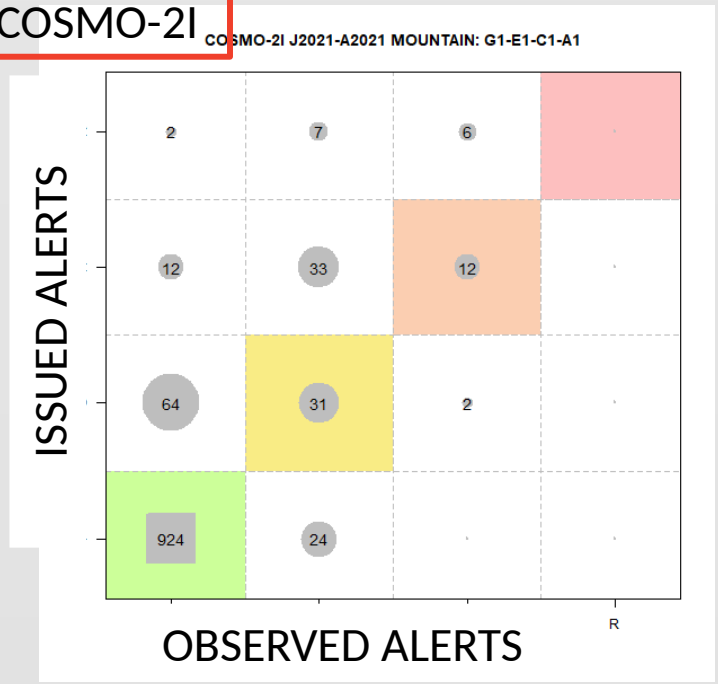
Condition on 75th percentile of wind gust in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg75> 24.4 m/s (10) for at least 3 hours throughout the day

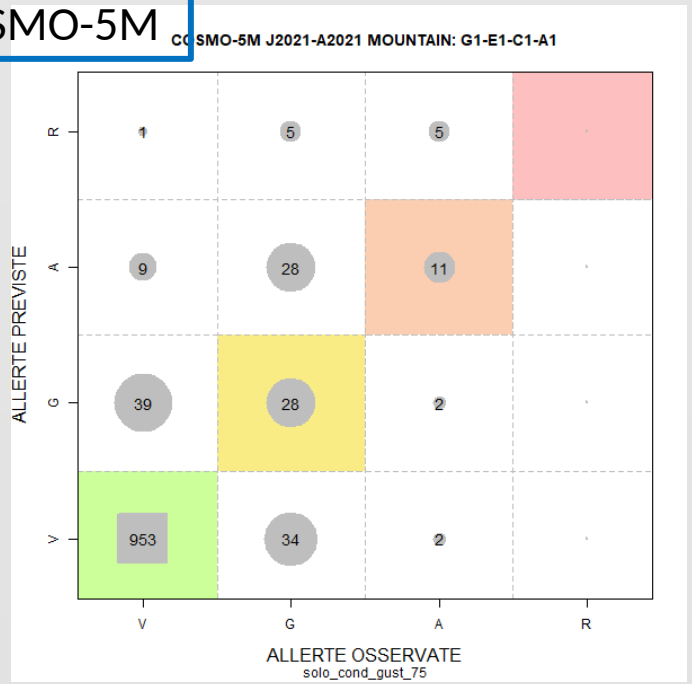
FORECASTER



COSMO-2I



COSMO-5M



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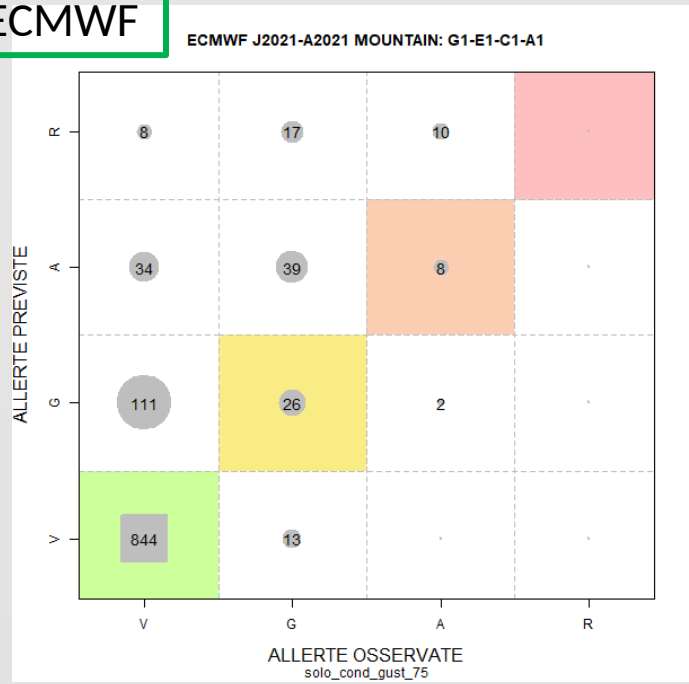
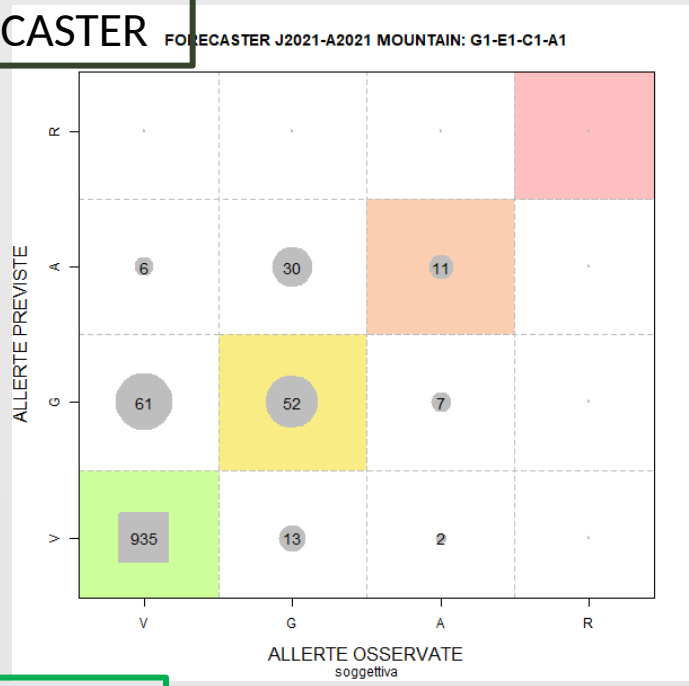


Models – mountain areas

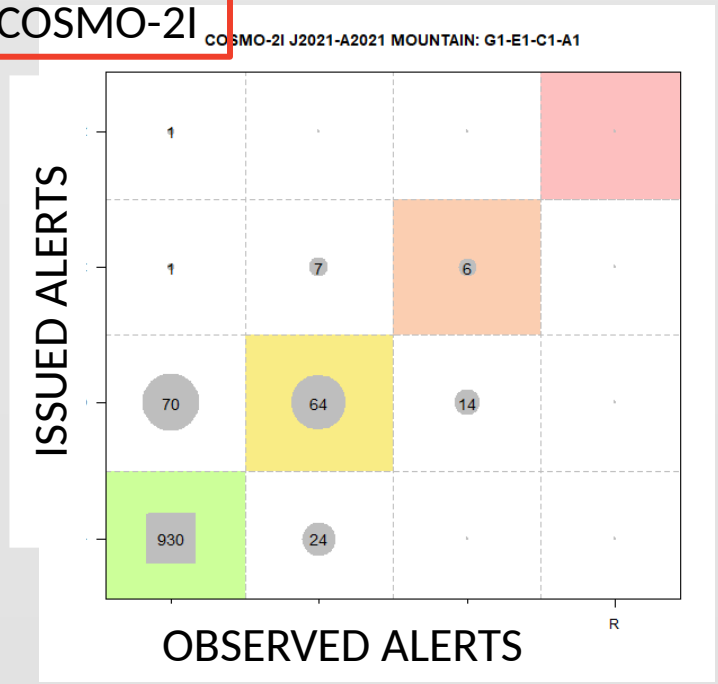
Condition on 75th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day + WS>17.2 m/s (B8)
- RED(R): Wg75>24.4 m/s (B10) for at least 3 hours throughout the day+ + WS>20.8 m/s (B9)

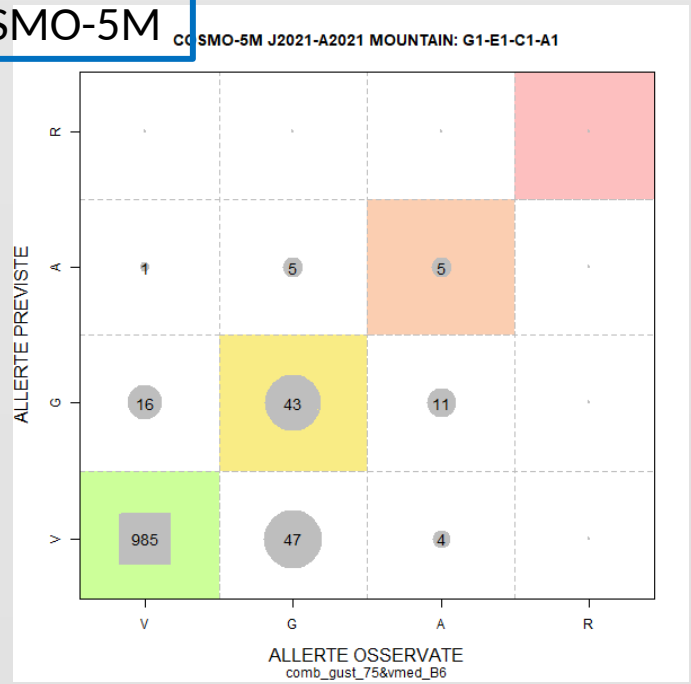
FORECASTER



COSMO-2I



COSMO-5M



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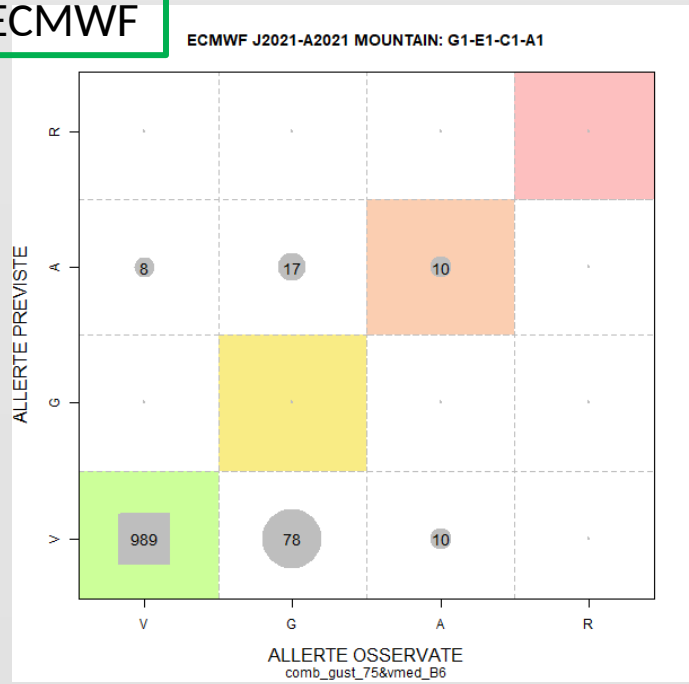


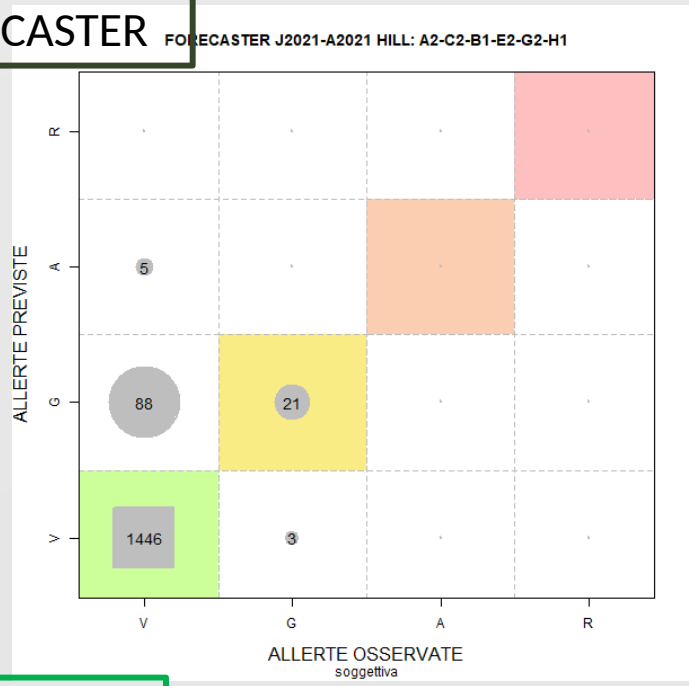
Models – hill areas

Only GUST conditions

Condition on 75th percentile of wind gust in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg75> 24.4 m/s (10) for at least 3 hours throughout the day

FORECASTER



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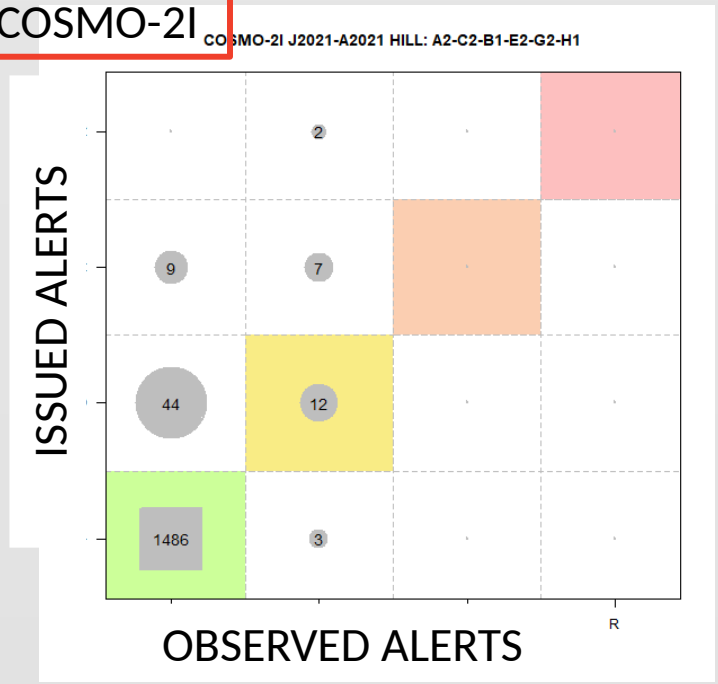
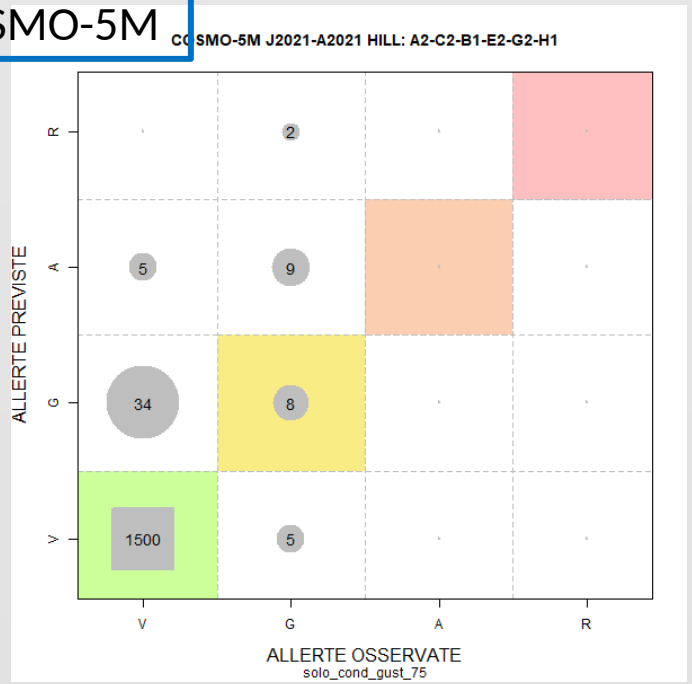


COSMO-5M



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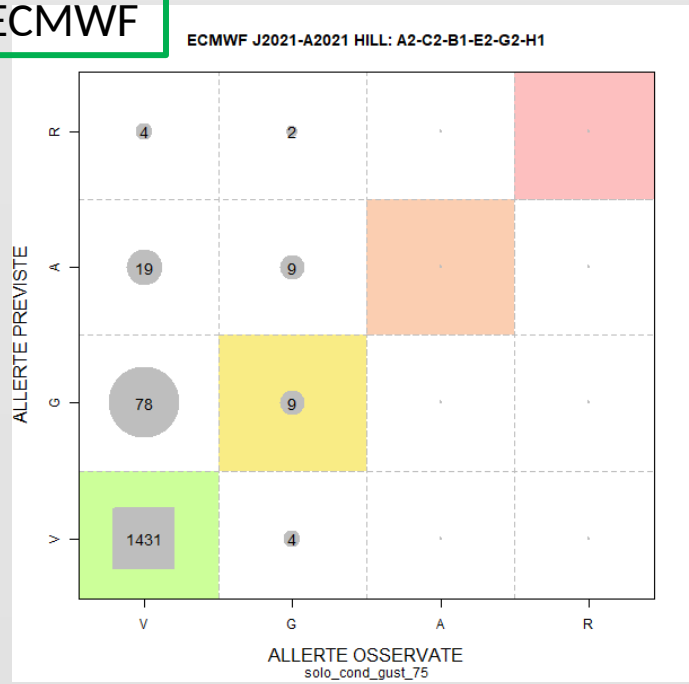

Models – hill areas

Condition on 75th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
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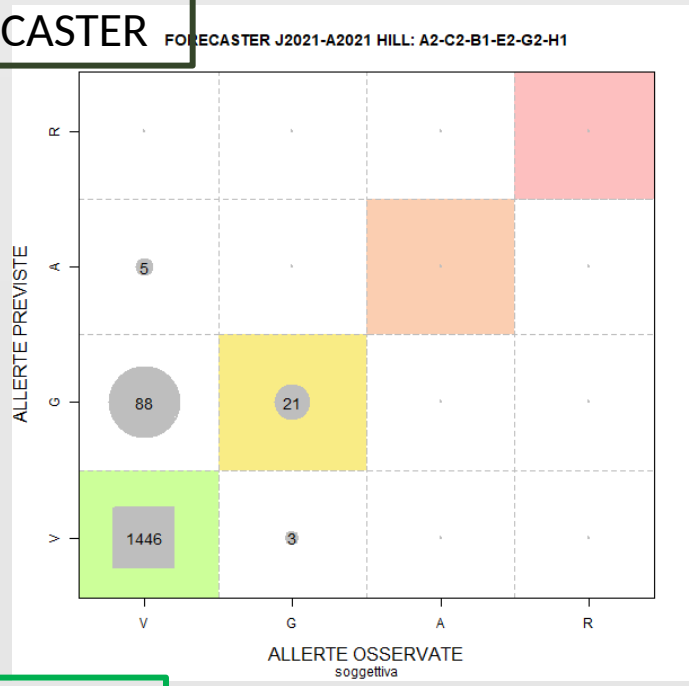
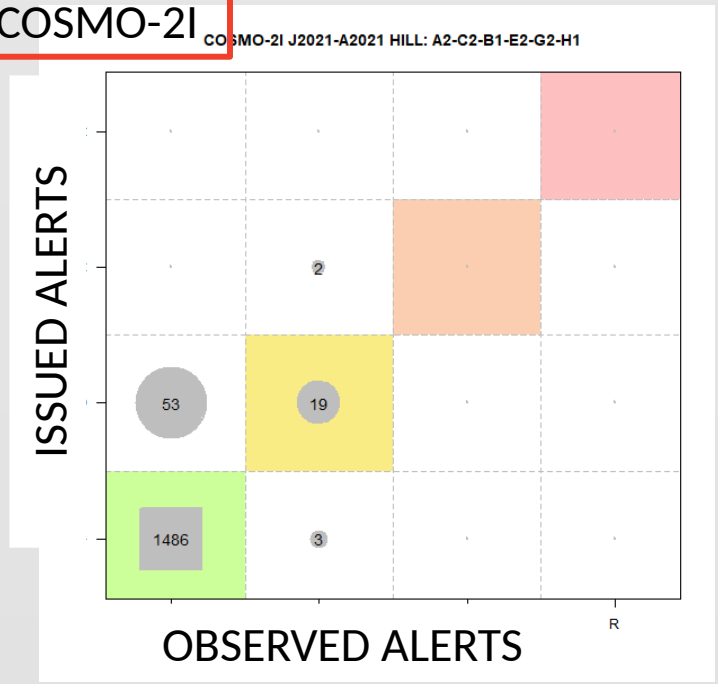
- RED(R): Wg75>24.4 m/s (B10) for at least 3 hours throughout the day+ + WS>20.8 m/s (B9)

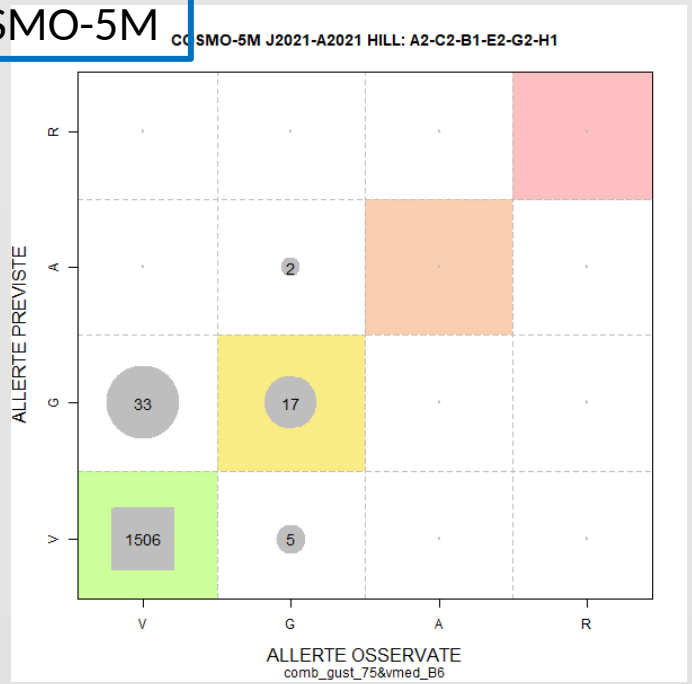
FORECASTER



COSMO-2I



COSMO-5M



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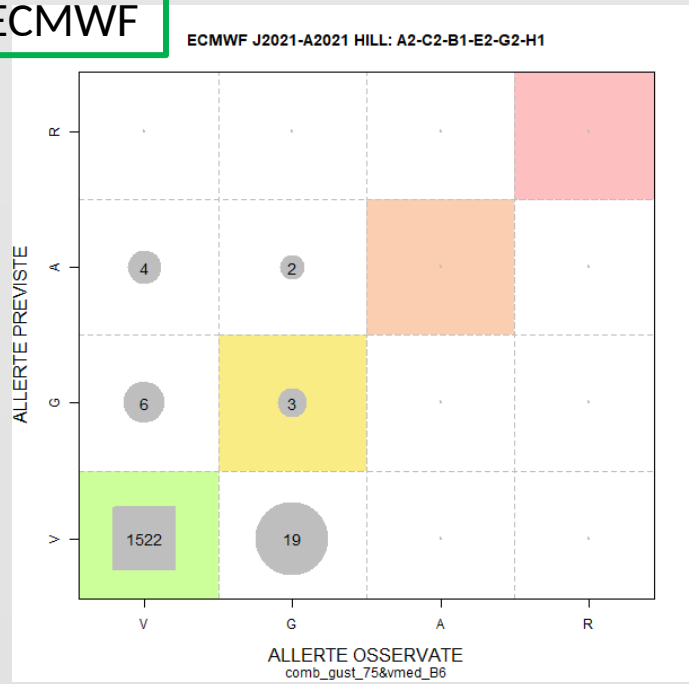

Models – plain areas

Only GUST conditions

Condition on 75th percentile of wind gust in the area

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- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day
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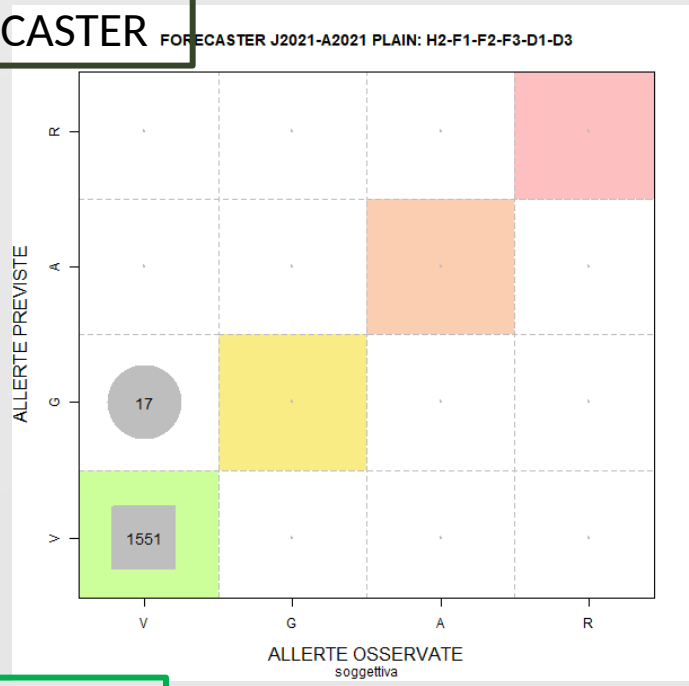
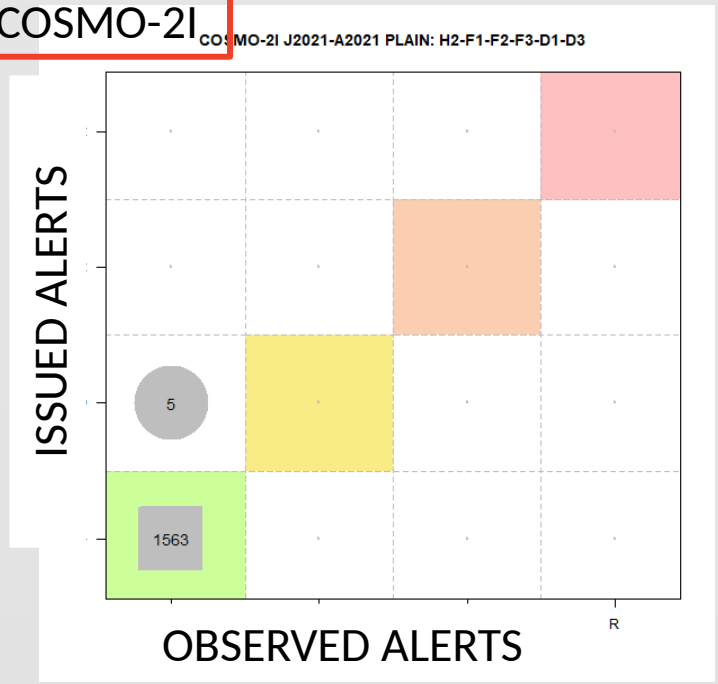
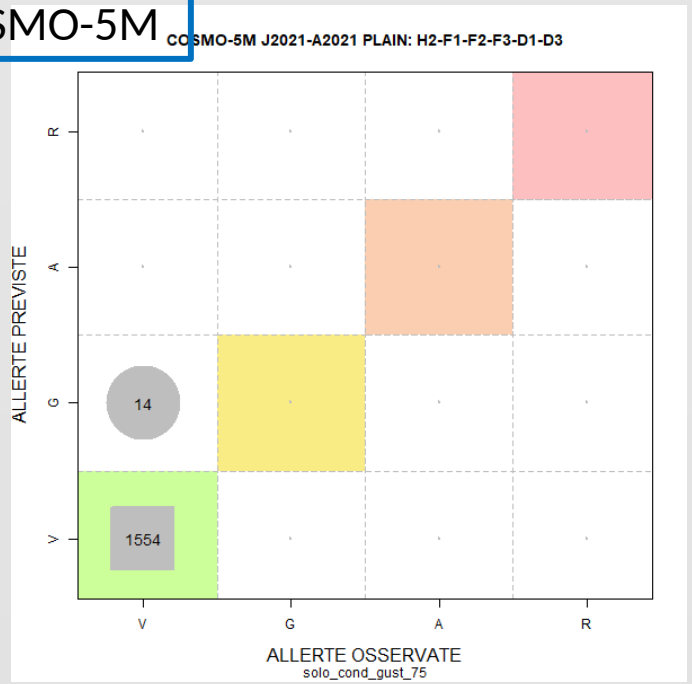
FORECASTER



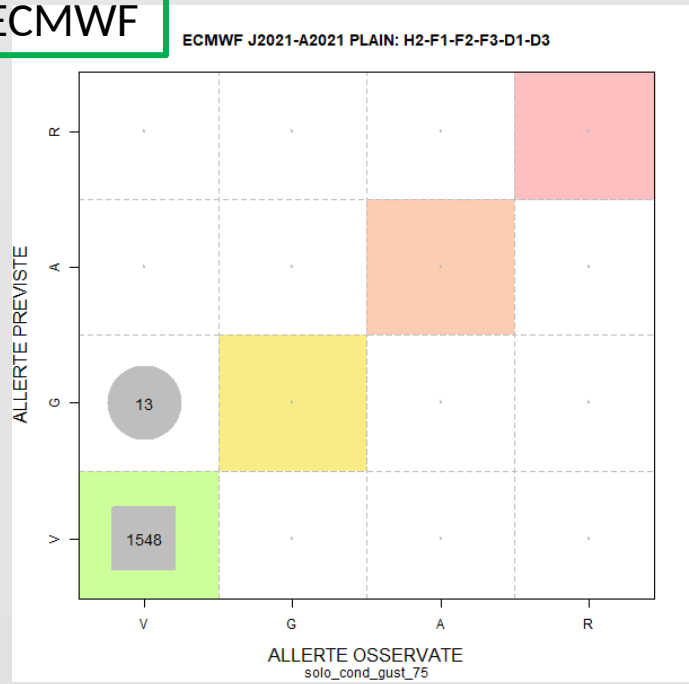
COSMO-2I



COSMO-5M



ECMWF

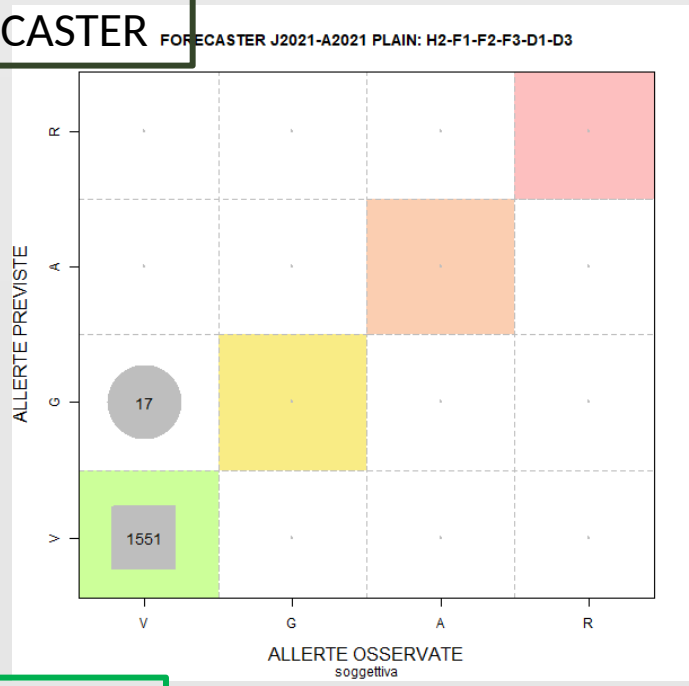


Models – plain areas

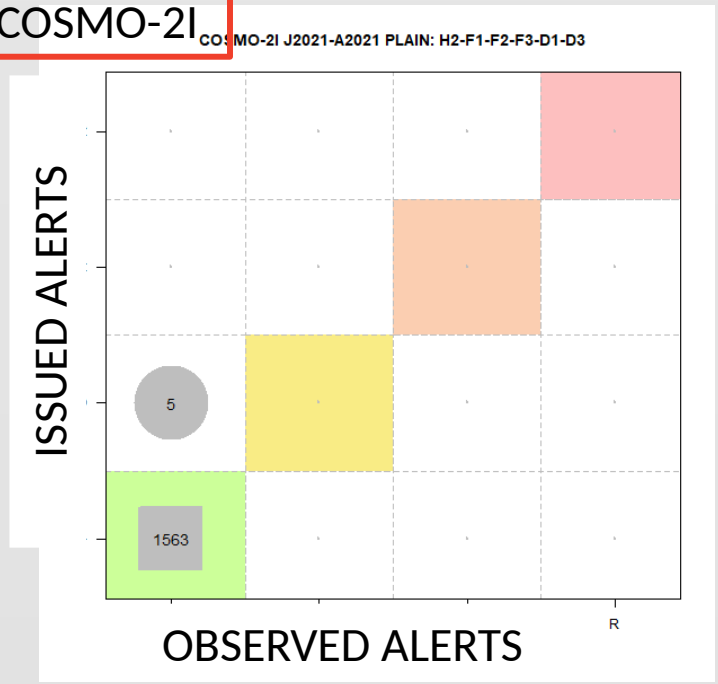
Condition on 75th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg75> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
- ORANGE(A): Wg75> 20.8 m/s (B9) for at least 3 hours throughout the day + WS>17.2 m/s (B8)
- RED(R): Wg75>24.4 m/s (B10) for at least 3 hours throughout the day+ + WS>20.8 m/s (B9)

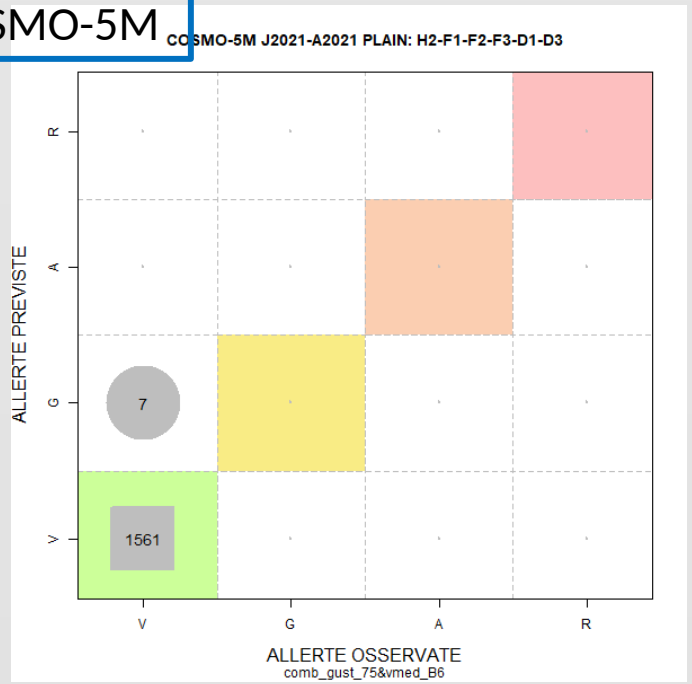
FORECASTER



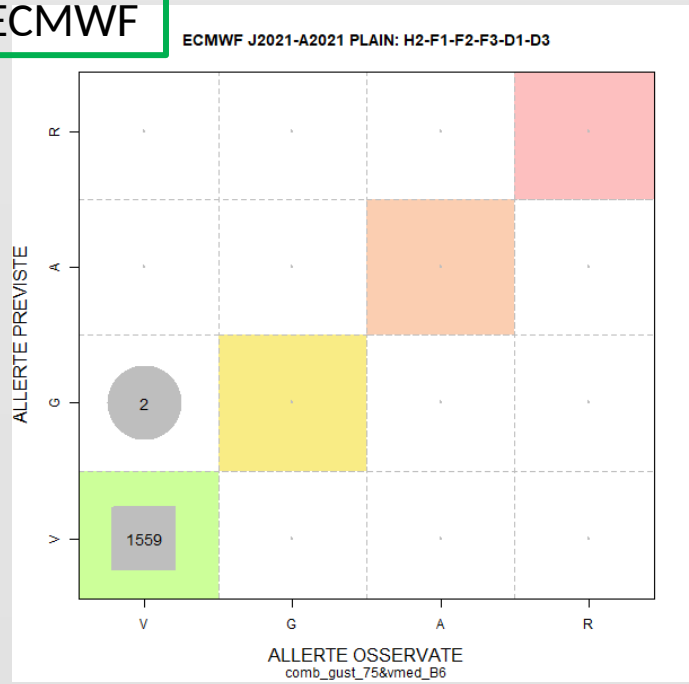
COSMO-2I



COSMO-5M



ECMWF



Ongoing outcomes

- In the case in which the thresholds are exceeded by the 25% of points but with a 10m wind speed greater than B6 (B8-B9):
  - COSMO reduces the number of FA, increases hits for Yellow case but introduce some miss for Orange case
  - ECMWF reduce the the number of FA but increases misses also for yellow case

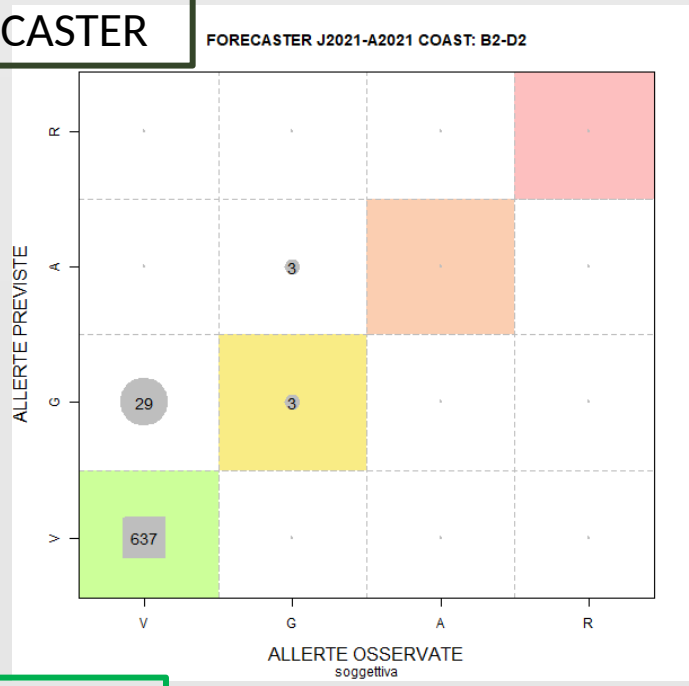
Models – costal areas

Only GUST conditions

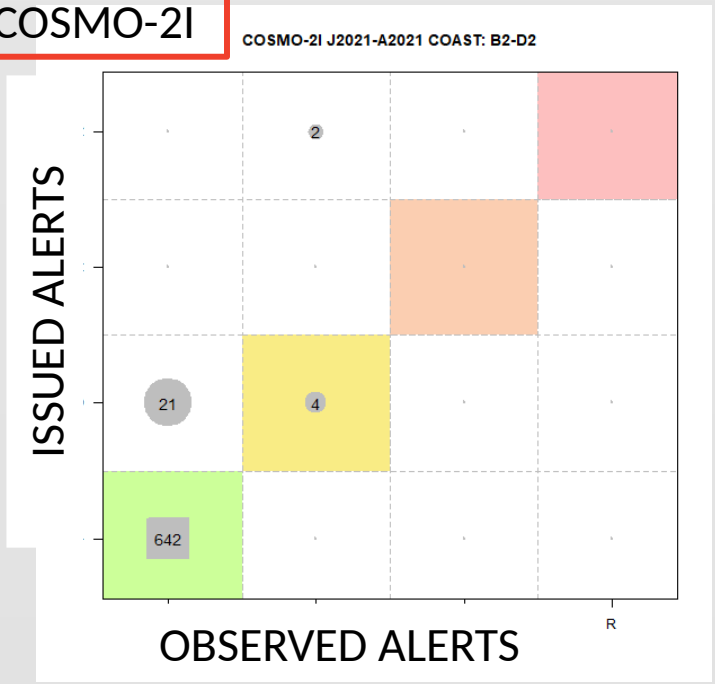
Condition on 90th percentile of wind gust in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg90> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg90>24.4 m/s (B10) for at least 3 hours throughout the day

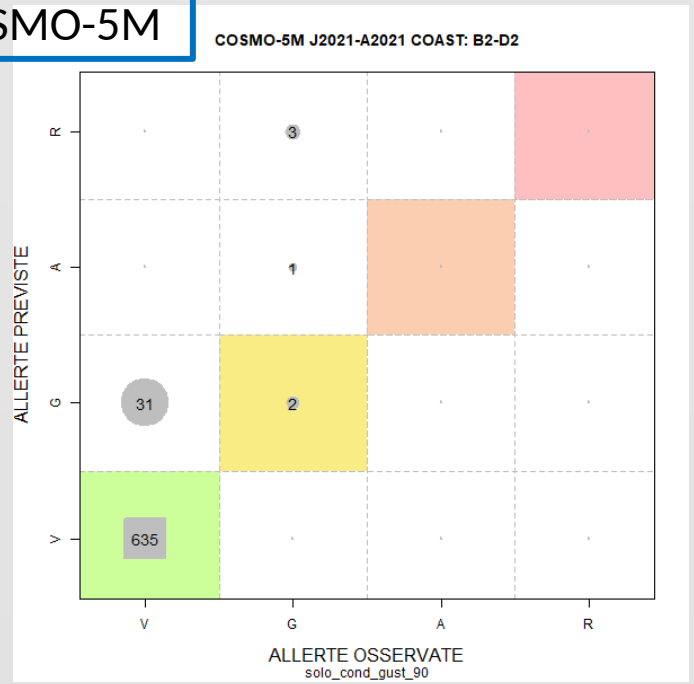
FORECASTER



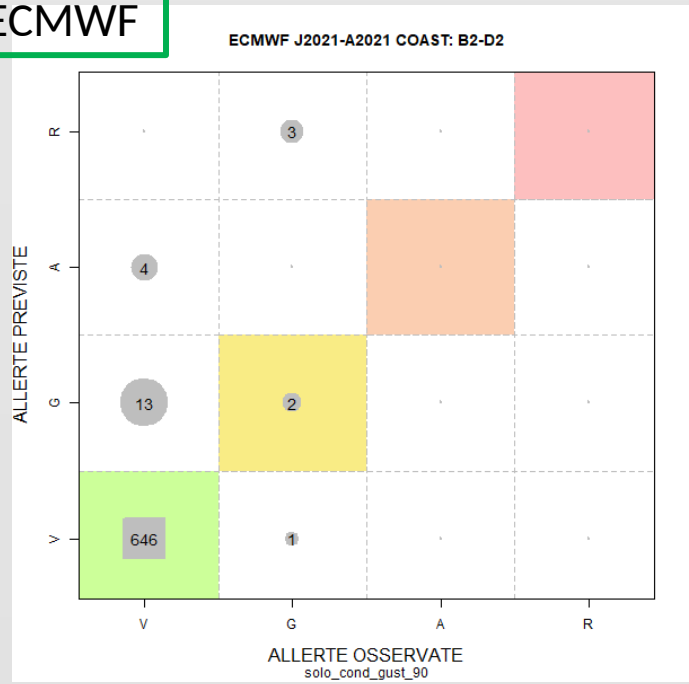
COSMO-2I



COSMO-5M



ECMWF

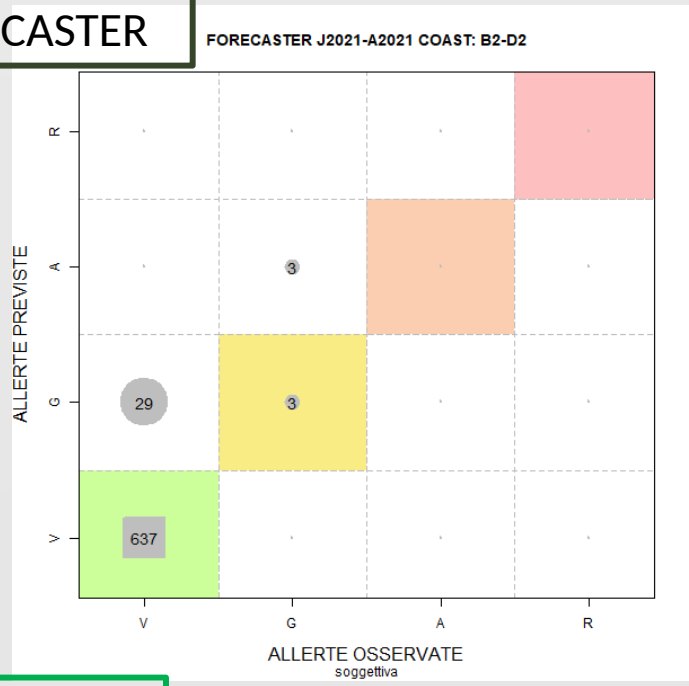


Models – costal areas

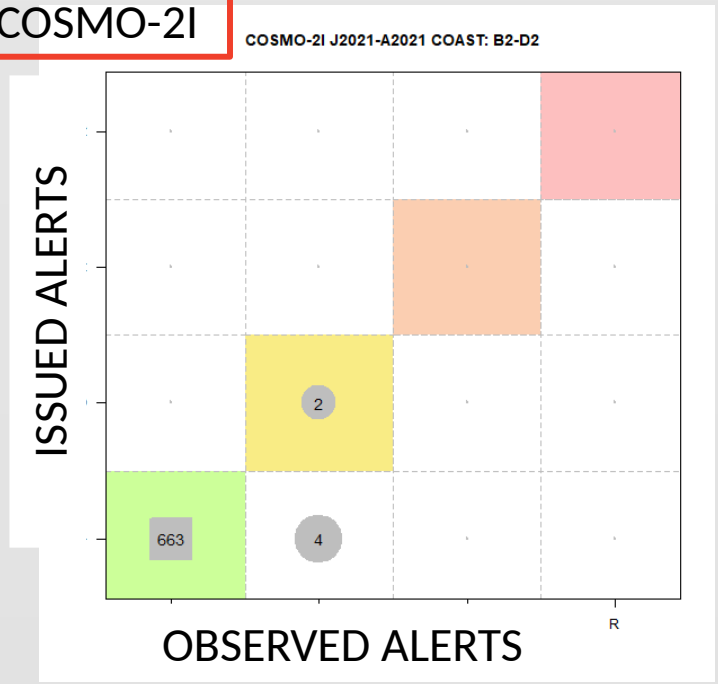
Condition on 90th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
- ORANGE(A): Wg90> 20.8 m/s (B9) for at least 3 hours throughout the day + WS>17.2 m/s (B8)
- RED(R): Wg90>24.4 m/s (B10) for at least 3 hours throughout the day+ + WS>20.8 m/s (B9)

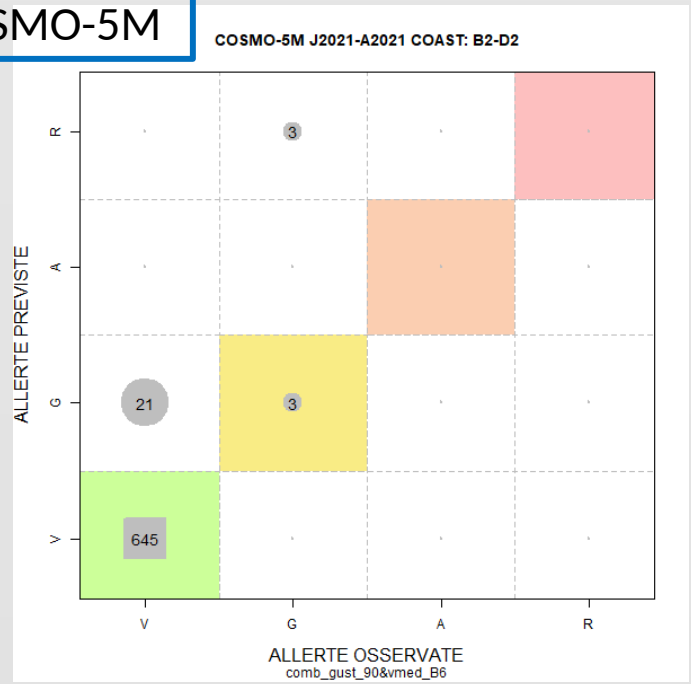
FORECASTER



COSMO-2I



COSMO-5M



ECMWF

Models – mountain areas

Only GUST conditions

Condition on 90th percentile of wind gust in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
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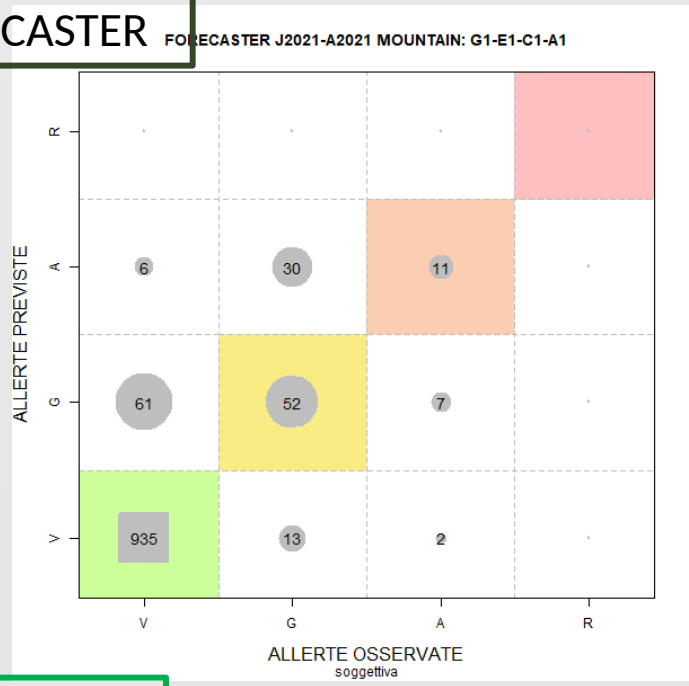
FORECASTER



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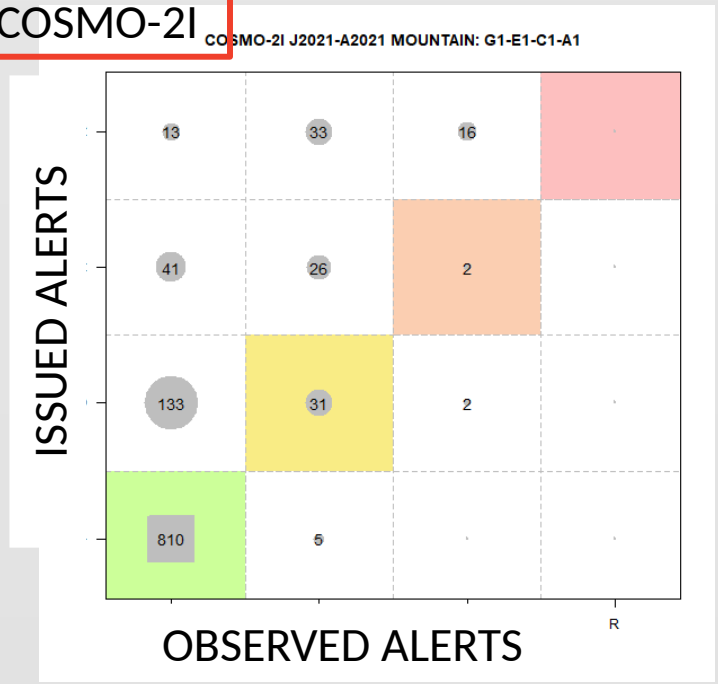

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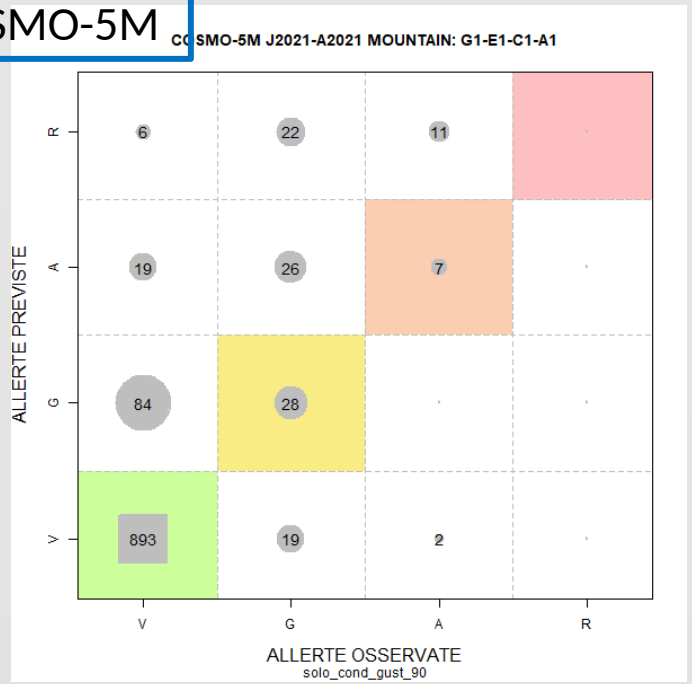
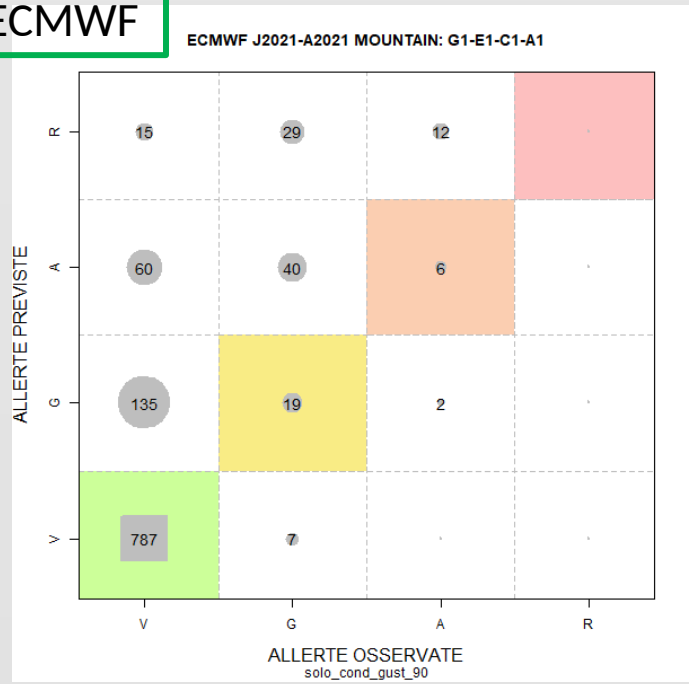


ECMWF



Models – mountain areas

Condition on 90th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
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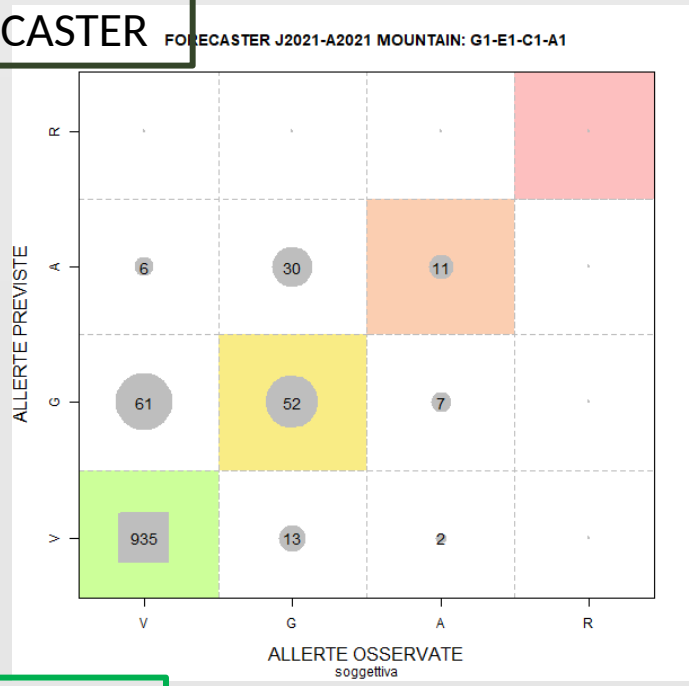
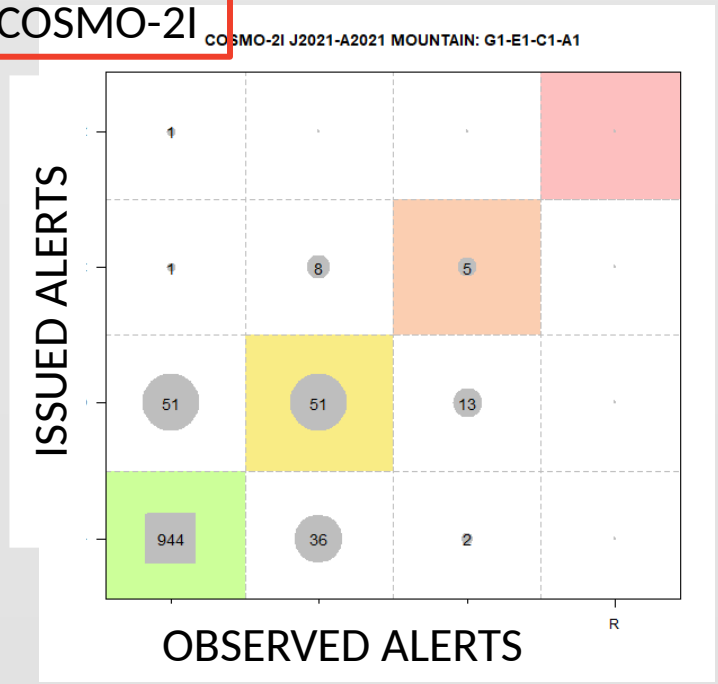
FORECASTER



COSMO-2I



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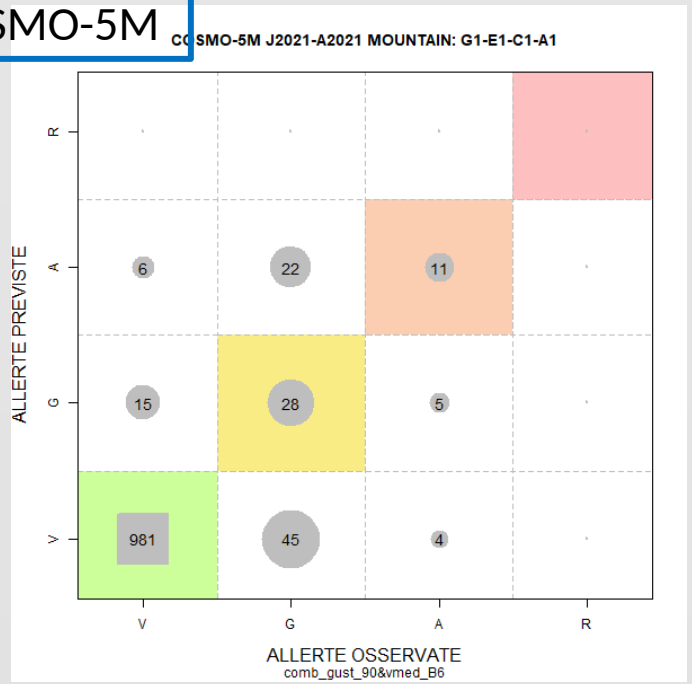

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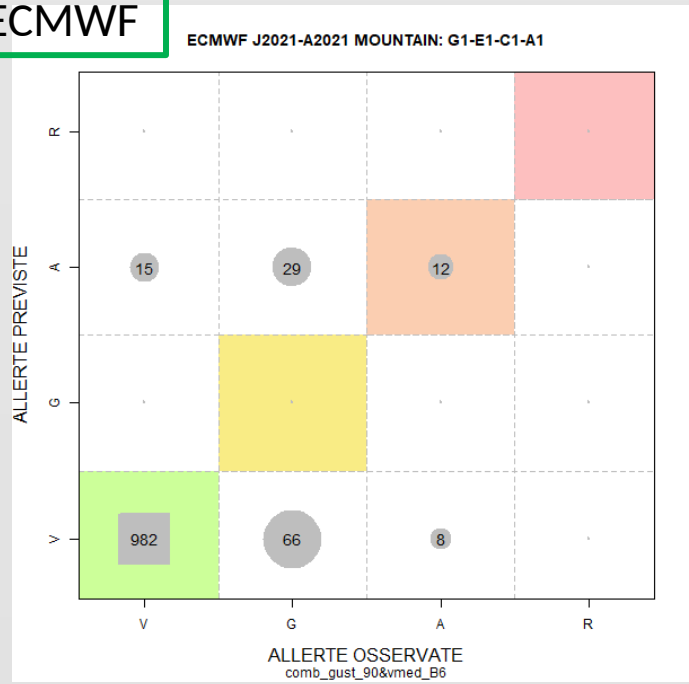

Models – hill areas

Only GUST conditions

Condition on 90th percentile of wind gust in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
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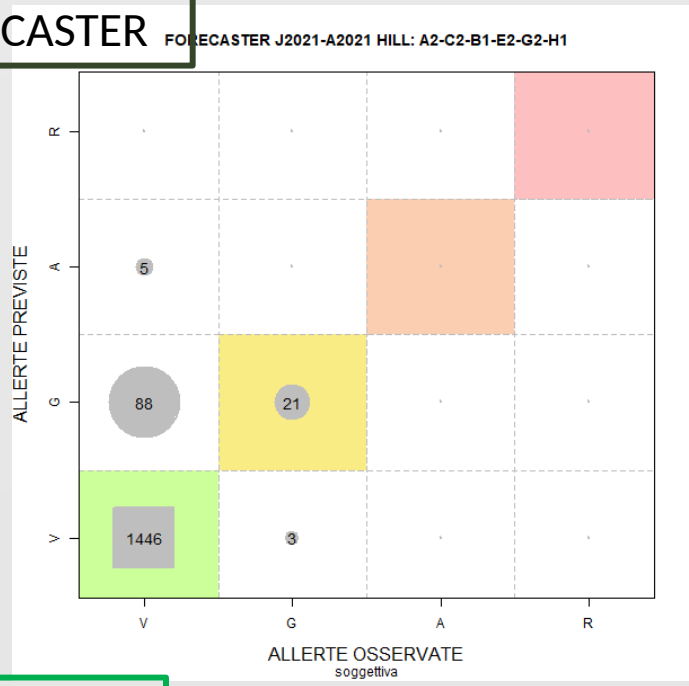
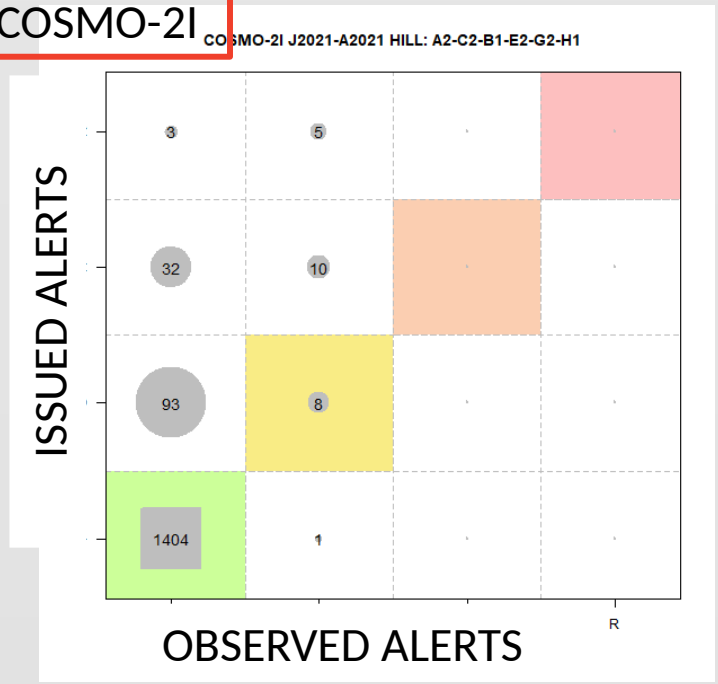
- RED(R): Wg90>24.4 m/s (B10) for at least 3 hours throughout the day

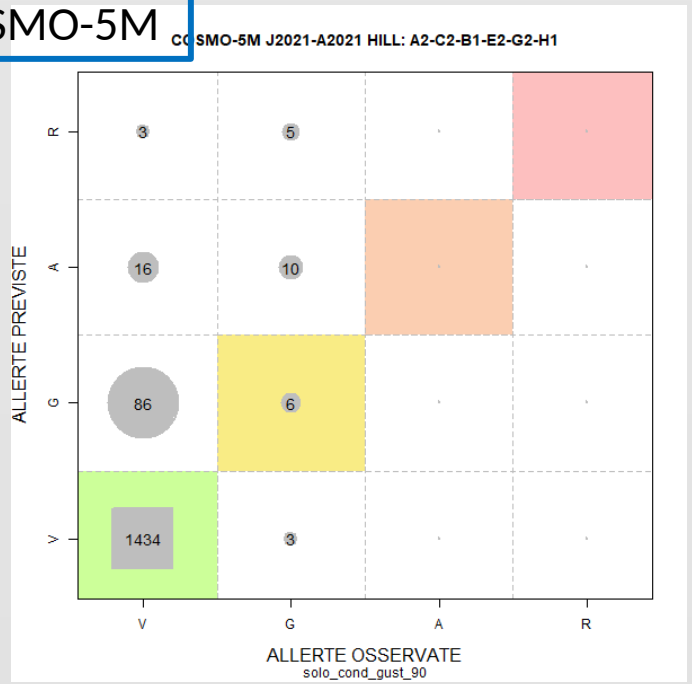
FORECASTER



COSMO-2I



COSMO-5M



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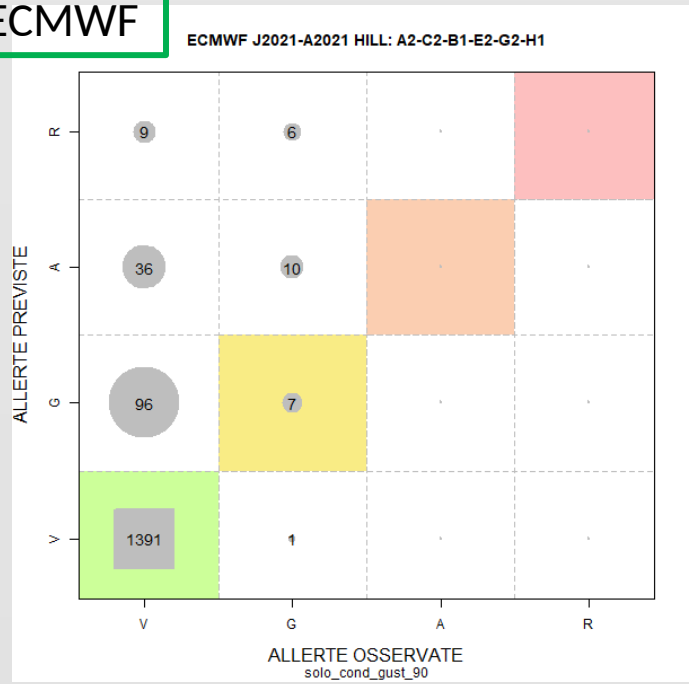

Models – hill areas

Condition on 90th percentile of wind gust in the area + daily max 10m wind speed in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day + WS > 10.8 m/s (B6)
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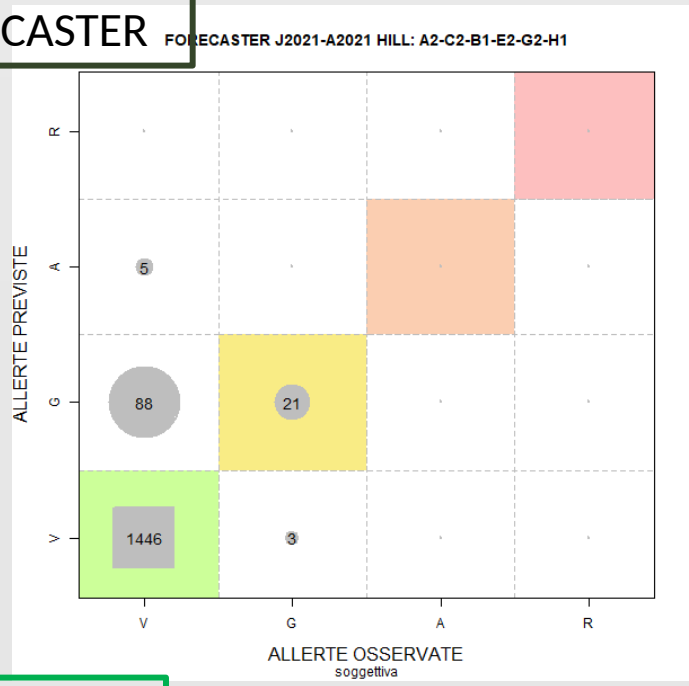
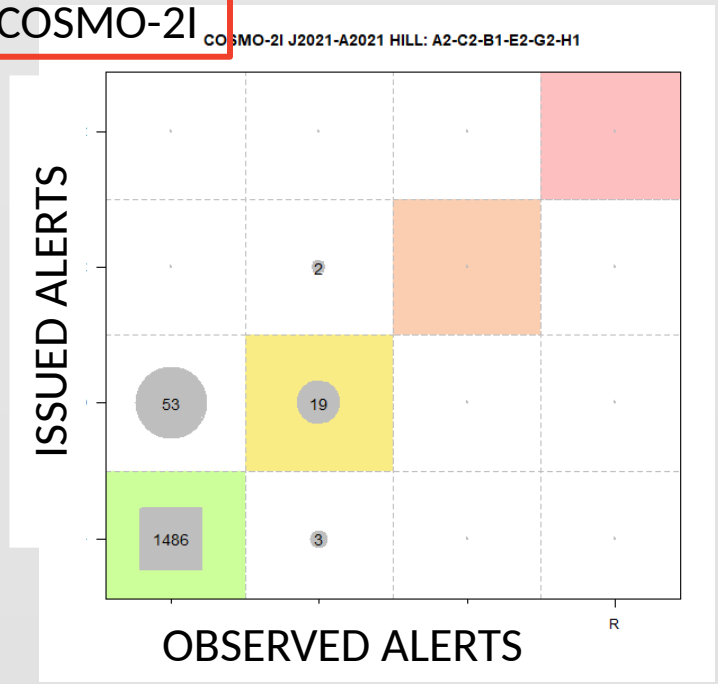
FORECASTER



COSMO-2I



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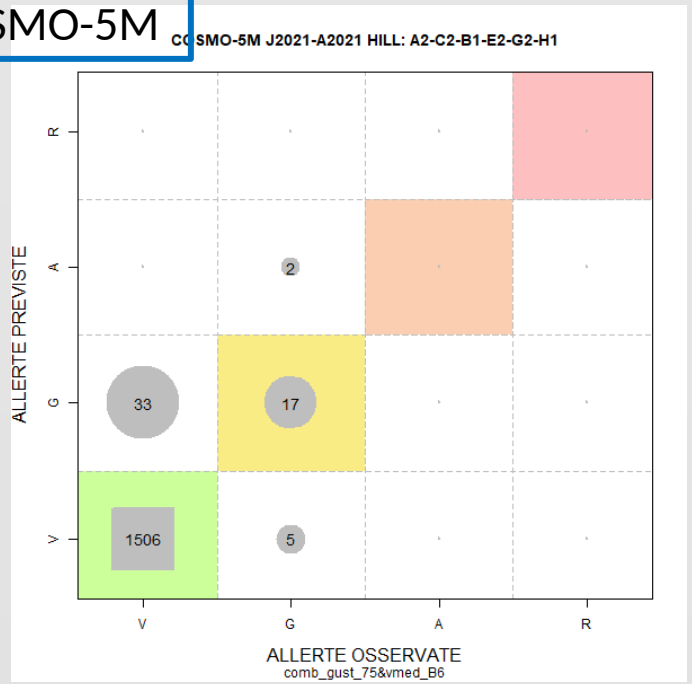

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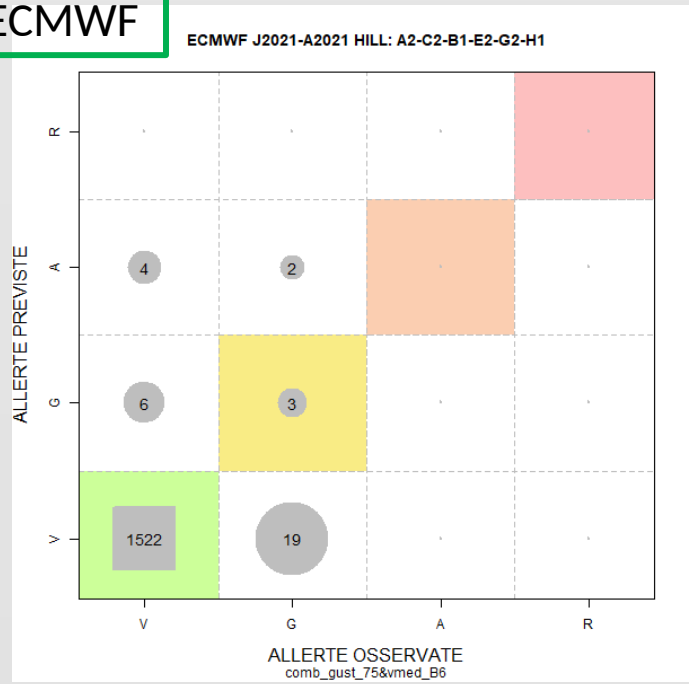


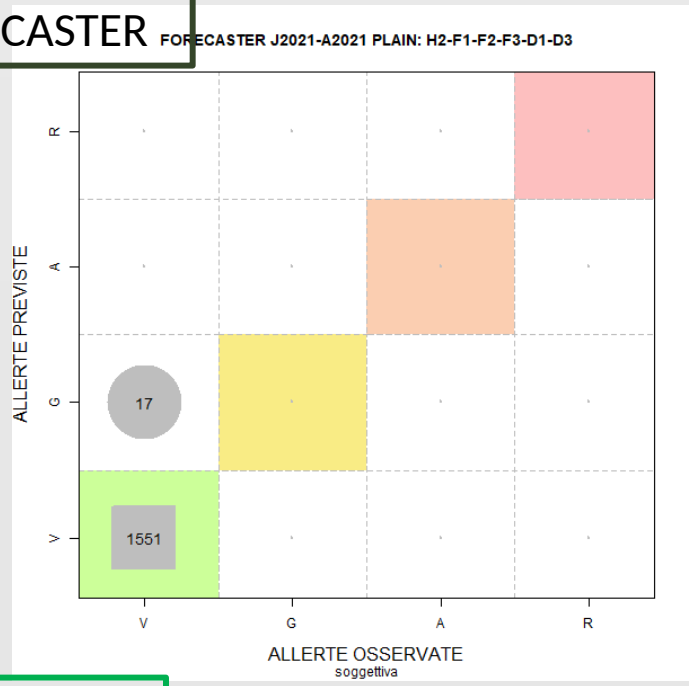
Models – plain areas

Only GUST conditions

Condition on 90th percentile of wind gust in the area

- YELLOW (G): Wg90> 17.2 m/s (B8) for at least 3 consecutive hours throughout the day
- ORANGE(A): Wg90> 20.8 m/s (B9) for at least 3 hours throughout the day
- RED(R): Wg90>24.4 m/s (B10) for at least 3 hours throughout the day

FORECASTER



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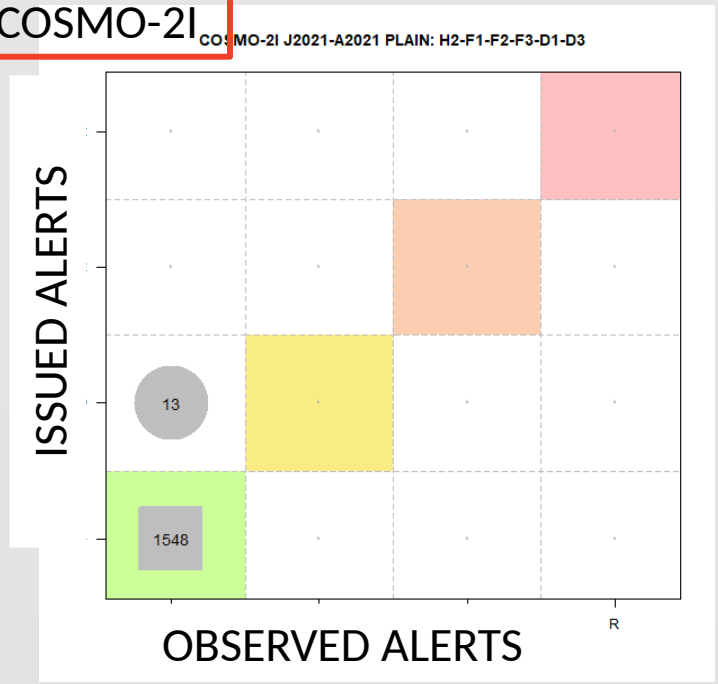
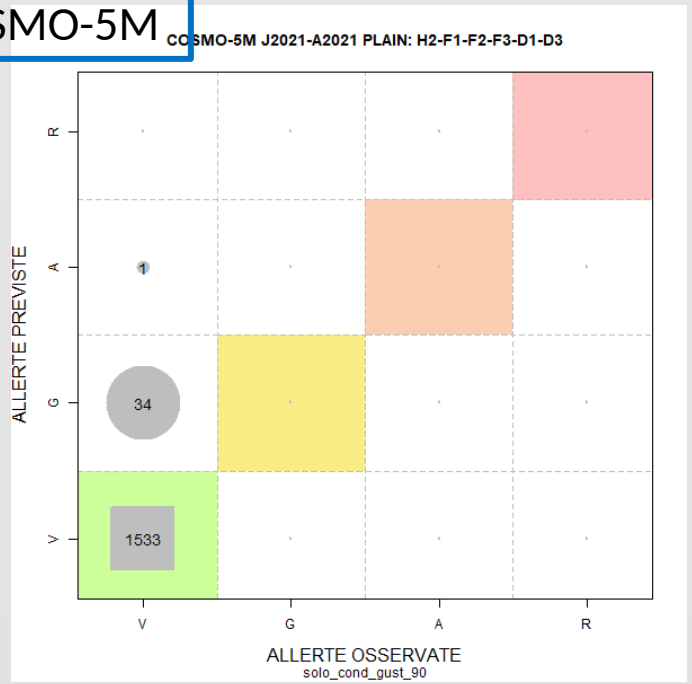
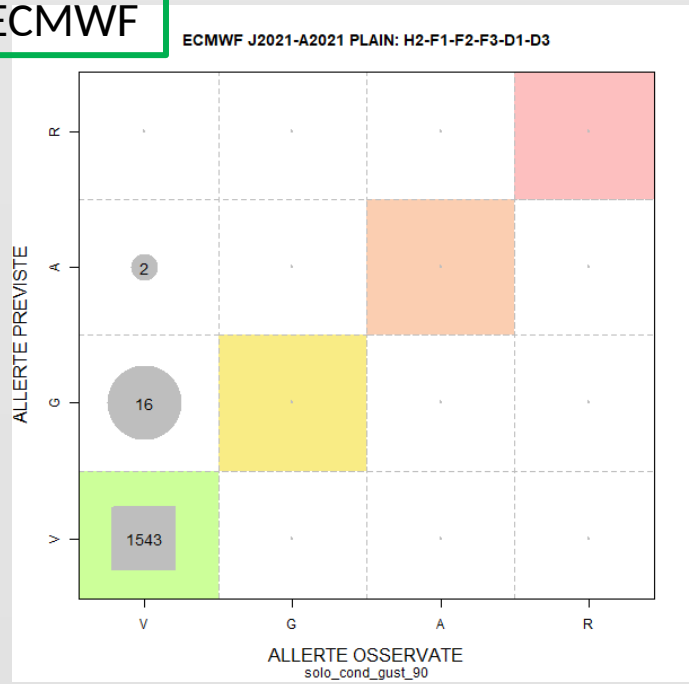


COSMO-5M



ECMWF



Models – plain areas

Condition on 90th percentile of wind gust in the area + daily max 10m wind speed in the area

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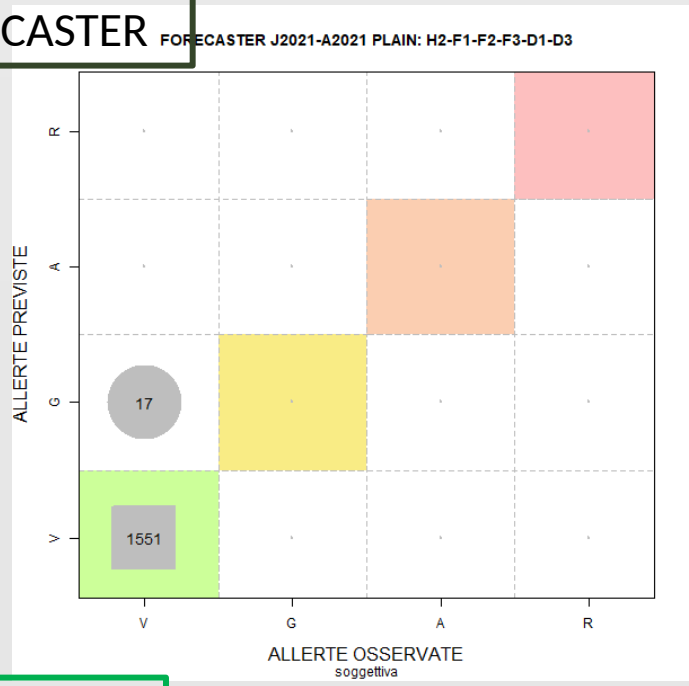
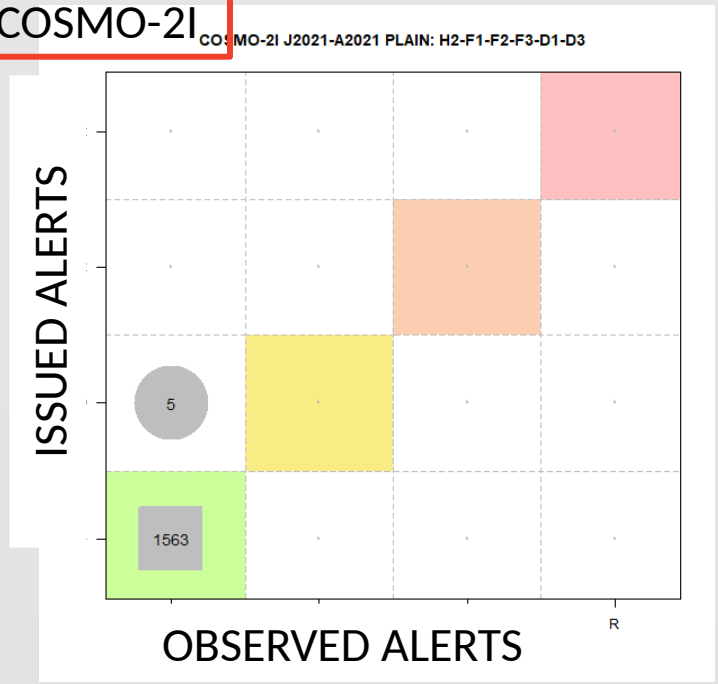
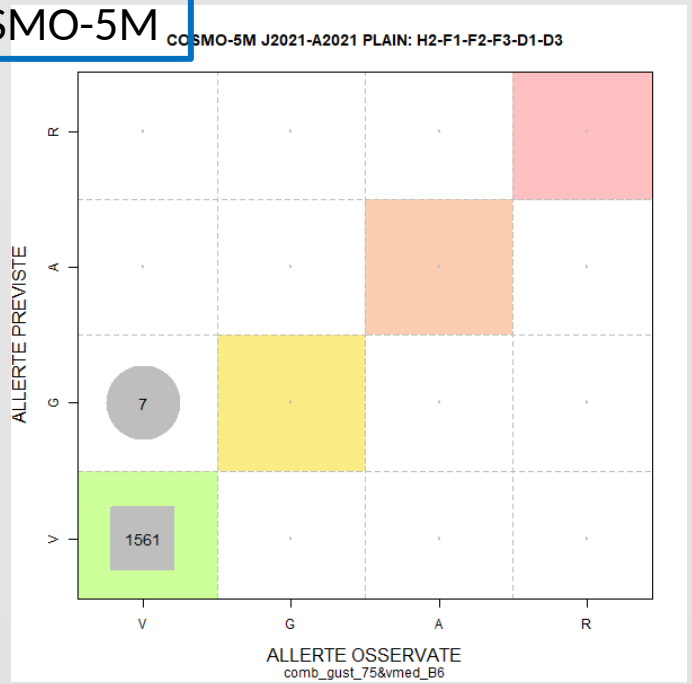
FORECASTER



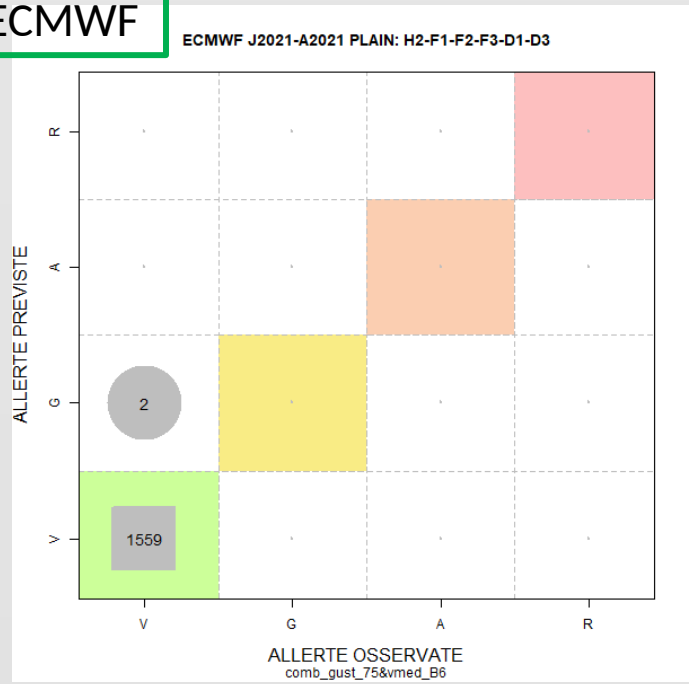
COSMO-2I



COSMO-5M



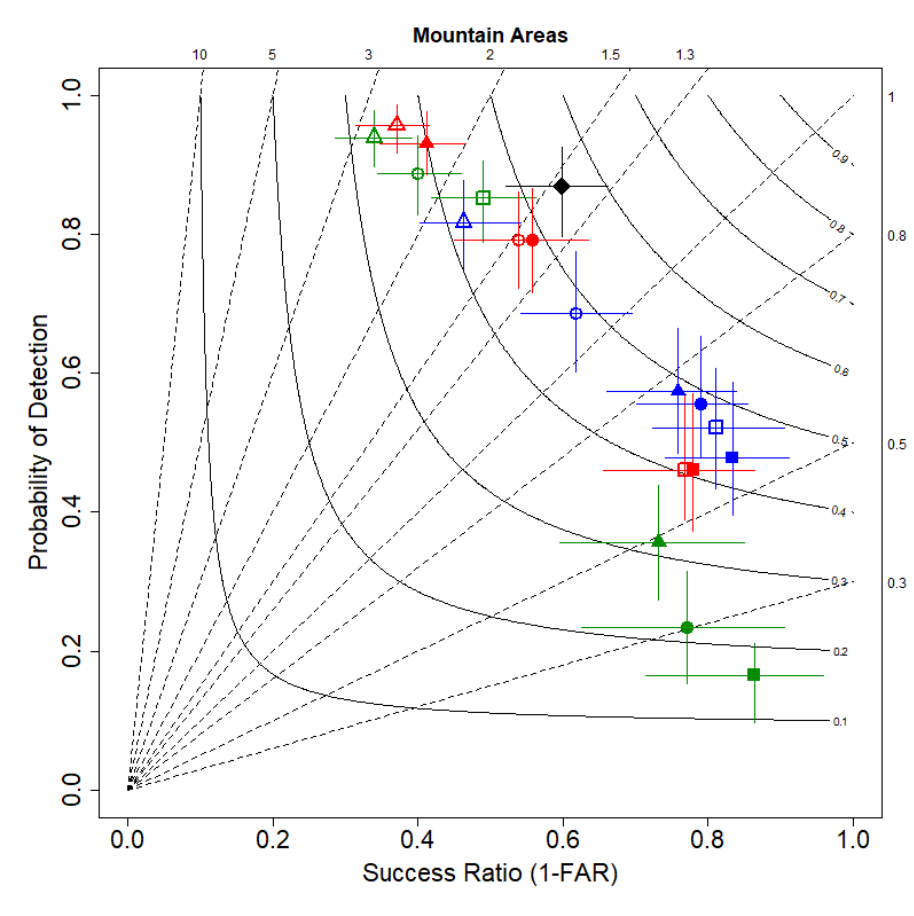
ECMWF



Ongoing outcomes

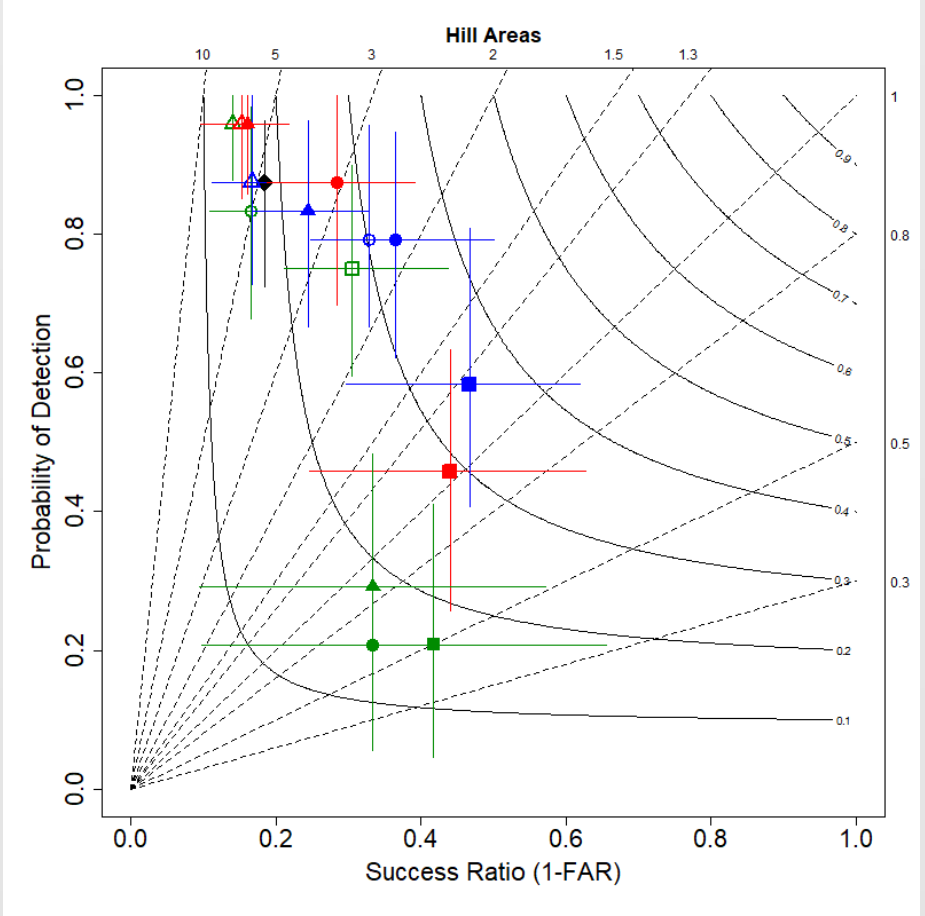
- In the case in which the thresholds are exceeded by the 25% of points but with a 10m wind speed greater than B6 (B8-B9):
  - COSMO reduces the number of FA, increases hits for Yellow case but introduce some miss for Orange case
  - ECMWF reduce the the number of FA but increases misses also for yellow case

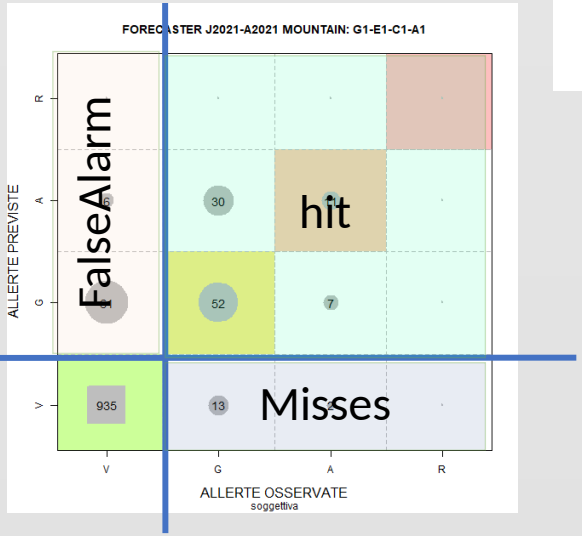
- Also in the case of selected wind gust coverage of 10% of the area the added condition on 10m wind speed reduced the number of FA but especially in mountain areas introduce a large number of misses.
- In plain areas this condition seems to work well reducing FA – no warning condition were observed



50perc_GUST
75perc_GUST
90perc_GUST
comb_50percGust&maxVmedB6
comb_75percGust&maxVmedB6
comb_90percGust&maxVmedB6

ECMWF
COSMO-2I
COSMO-5M
FORECASTER





Considering the event:
Alert=Yellow or Orange or Red
Non-Alert =Green

Ongoing outcomes

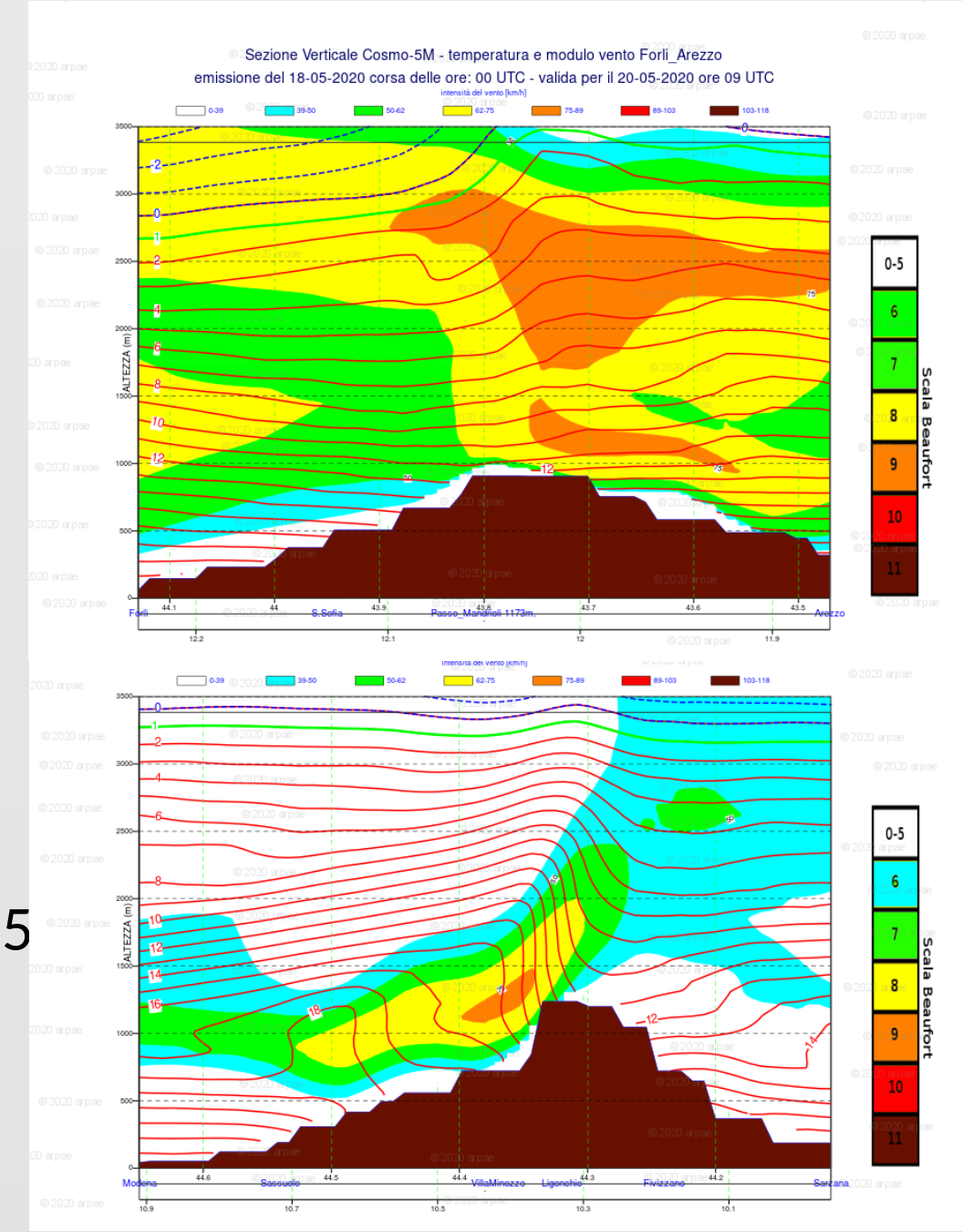
Considering all alert colors together:

- Forecasters seem to perform better than models in mountain areas while in hill area they do a lot of false alarm (also models!)
- In mountain areas, the difference using only condition on wind gust and the combination with 10m wind speed greater than Beaufort 6 (8/9) are larger for COSMO-5M and ECMWF, while in COSMO-2I are very small
- In hill areas COSMO-5M with the 50% and 25% of areal coverage for selected wind gusts + 10m wind speed condition is the best model, lower POD than forecast but less false alarms.

CONCLUSION

(of this talk not of the work!)

- It is not easier to reproduce the criteria followed by forecasters to issue alert based on models output
- On the other hand, these preliminary results don't allow to define clear rules that help forecaster for the issuing of alerts
- Probably some other combination of conditions can be tested, also considering wind speed at different levels (850 hPa in mountain areas or 925 hPa on the coast or plain areas) and/or the direction of wind speed



THANK YOU