Operational forecast of thunderstorms over Piemonte region: verification and past cases re-forecasts

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Thunderstorm Forecasting Operational Chain

**COSMO-I7**

PROC1: employs KI, CAPE, SWEAT, SLI, Δθe500, QPF

**ECMWF-IFS**

PROC2: employs KI and QPF, better results in summer

**Others GCM & LAM**

Human (Forecaster) considerations

**ARPA FORECASTERS FINAL WARNINGS**

**USERS: CIVIL PROTECTION, ecc..**
Thunderstorm Forecasting over Piemonte Region

- 11 Alert Areas
- 36 h Warnings

- Observed Thunderstorm “yes” if QPF exceeds over an area 25mm/1h or 40 mm/3h with at least 1 lightning over the same area
How much our methods are reliable in forecasting Thunderstorms? (COSMO-I7 model and Post-Processing Procedures in particular)

How good and how much improvable are our operational forecasts?
COSMO-I7 derived Post-Proc. Procedures vs. Human Forecasts

- Human Alerts: POD~0.4, BIAS~0.8
- Automatic Alerts: POD~0.7, BIAS~3
- Forecasters follow COSMO-I7 and the Post Proc. Procedures, heavily decreasing BIAS (and POD, as direct consequence)
- No significant improvement in the last 4 years
- Human Warnings better over the North
Investigating the problem:
Re-Forecasting 10 Significant Cases

1. 13/7/2008 – Heavy Hail and 1 casualty – some MA
2. 13/9/2008 – Hail and small tornado TO-Plains
3. 6/6/2009 – Hail and small tornado E-Plains
4. 5/7/2009 – Heavy Thunderstorms not Forecasted
5. 7/7/2009 – Some Light Thunderstorms, many FA
7. 19/6/2010 – Heavy Thund. And heavy hail over Turin
8. 24/7/2010 – Light Showers, many False Alarms
9. 11/8/2010 – Many Missed Alarms
10. 20/8/2010 – False Alarms on the plains, spatial error
The Game: Internal Web Page for Forecasters

0: light/no thunderstorms
1: moderate thunderstorms
2: severe thunderstorms (Warning)
QPF – Mean Error Analysis

QPF - Mean Error for Alert Area - False Alarm Cases

Alps  Appennines  Plains

OPER.  ECMWF-IFS  ECMWF&COSMO-I7
QPF Analysis –Results

- Generally, QPF underestimation prevailed in re-forecasts (as in operational context)
- Light improvement of the ECMWF+COSMO re-forecast, and minimal signals of worsening
- Operational forecasts tend to underestimate the precipitation (cautiously), and forecasters that used ECMWF & COSMO-I7 fields in the game forecasted more rain than usual, showing over most areas slightly better results
- ECMWF-IFS re-forecasts tended to underestimate the most, and showed improvements only for the “selected” False Alarms cases.
Alerts – Analysis

POD

ECMWF-IFS: Av. POD= 0.42
Av. BIAS= 0.65

ECM + COSMO-I7: Av. POD= 0.54
Av. BIAS= 0.92

ECM + C-I7 + Post-Pr.: Av. POD= 0.71
Av. BIAS= 1.24

BIAS

Re-Forecasting with:
Alerts – Case by Case Analysis

Case 1 – Severe Thunderstorm – Some Missed Alarms

Case 2 – Severe Thunderstorm

POST-PROCESSING
Alerts – Case by Case Analysis

Case 9 – Missed Alarms

Case 10 – Spatial Error

POST-PROCESSING
**Alerts – Results**

- Post processings seemed to help forecasters in improving performances in re-forecasting: the POD went from around 0.5 to around 0.7, with a correlated moderate BIAS increase;
- ECMWF-IFS alone alerts simulation have been unexpectedly good, obviously with low POD (0.4);
- Around 47% of total re-forecasts improved operational ones, while 45% were worser (the rest were equivalent);
- Only 39% Post Processing re-forecasts were worser
- This means that operational forecasts are still improvable with a deeper analysis
Causes of Error in Operational Forecasts:

1. **(Too strong) Correlation with End-Users:** interfacing Civil Protection Managers may cause Forecasters to be cautious in issuing alerts and sometimes to change their warning intentions.

2. **Persistence:** “Yesterday” Forecast Errors can bias and cause opposite Errors in “Today” Forecasts – not in the simulation.

3. **More time dedicated to Thunderstorm Forecasting in the re-forecast with respect to the operational context.**

4. **Warning Areas too small:** verification results would be better if we consider to alert or not the whole region; is models spatial accuracy in positioning thunderstorms greater than Warning areas dimension?
Conclusions and future steps

- Operational QPF and Warnings are improvable.
- Post-Processing Warnings are useful, but knowing that they have a higher BIAS than other instruments is important.
- Future improvement of Post-Processing trying to include other atmospheric variables.
- Need to perform a (difficult) cost-loss analysis to determine if a forecast with higher POD and higher BIAS (and consequently more Falses) is better than a less alarmistic one, with low POD.
- Post-Processing Procedures have been extended in 2011 to all over Italy in a new internal website that connects Civil Protection Regional Centres - Verification.
Thank you for your attention
COSMO-I7 derived Post-Proc. Procedures vs. Human Forecasts

- Human Warnings better over the North
- Automatic POD better over the Alps
- Automatic Procedures Overestimation from 1.5 (plains) to 8 (Western Alps)
- Forecasters followed COSMO-I7 and the Post Proc. Procedures, but heavily decreasing BIAS (and POD, as direct consequence)
QPF – Mean Error Analysis

QPF - Mean Error for Alert Area - False Alarms

- OPER.
- ECMWF-IFS
- ECMWF&COSMO-I7

Alps
Appennines
Plains
QPF – RMSE Analysis

QPF - Root Mean Squared Error for Alert Area - False Alarms

- OPER.
- ECMWF-IFS
- ECMWF&COSMO-17

Alps
Appennines
Plains
Alerts – Case by Case Analysis

Case 3 – Severe Thunderstorms

Case 4 – Missed Alarms

ECMWF-IFS

POST-PROCESSING
Alerts – Case by Case Analysis

Case 5 – False Alarms

Case 6 – Missed Alarms
Alerts – Case by Case Analysis

Case 7 – Severe Thunderstorm – Missed Alarm

Case 8 – False Alarms