The nowcasting system INCA-BE in Belgium and its performance in different synoptic situations

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(Dated: 30 May 2012)

1. Introduction

Meteorological services worldwide experience the increased demand of forecasts with short lead-times (nowcasts) with a high temporal and spatial resolution and a high update frequency. In last years, nowcasting products especially for precipitation, have become increasingly popular amongst the broad public. Also more and more nowcasting applications find their way to mobile devices and platforms.

Until recently, the Royal Meteorological Institute of Belgium (RMI) could not fully satisfy this demand, since it had no dedicated nowcasting system producing these nowcasts. In the beginning of 2010, the RMI started the implementation of the INCA system in Belgium: INCA-BE. INCA (Integrated Nowcasting through Comprehensive Analysis, see Haiden et al. 2011 for a comprehensive description) is a nowcasting system that has been developed at the meteorological service of Austria (ZAMG). We adapted the system for a domain around Belgium and for our local observational data flow. It was integrated in our operational chain during spring 2012. This first operational version is used internally by our forecasters, and also by some external test-users like the regional hydrological services. The system is, however, under constant development, and new features and improvements will be added in the future.

More and more meteorological services in Europe have adopted INCA as their operational nowcasting system including Slovakia, Slovenia, Croatia and Poland. Also, an ambitious European program with 16 partners is currently ongoing (April 2010 – September 2013) to set up an INCA version for Central Europe: INCA-CE (Kann et al. 2012). INCA-CE will be a transnational weather information system using state-of-the-art nowcasting, which will allow an improved prediction of severe situations like heavy rainfall and associated flooding risks. In this contribution, we concentrate on the current status of INCA in Belgium.

2. Overview

INCA-BE covers a domain of 600×590 km^2 with 1 km resolution (601×591 gridpoints), and with a “Belgian Lambert 2008” projection (EPSG 3812). The domain does not cover only Belgium, but also Luxembourg, the Netherlands (almost completely), the north of France, a large part of western Germany and the southeast coast of the U.K. A significant part of the domain consists of a water surface (the North Sea and the Channel).

The INCA software suite consists of different modules which we have grouped into four categories: *basic*, *precipitation*, *convection* and *cloudiness*. Each of these categories contains different meteorological fields and has different forecast lead times and update frequencies:

1. Category *basic*
   As the name suggests, this category contains the basic meteorological fields 2m temperature and 10m wind. Apart from these two, also 2m dewpoint, 2m relative humidity, snowfall level, freezing level, wind chill and ground temperature are calculated. The forecast extends up to +12h with a time step of 1 hour, and the forecast is updated twice an hour.
2. Category *precipitation*
   The fields precipitation intensity and precipitation type are forecasted for the next four hours, with a time step of 10 minutes and an update frequency of 10 minutes as well.
3. Category *convection*
   This category contains fields to assess the stability of the atmosphere and are calculated every hour, but no forecast of these fields is provided, only analysis. These fields include: CAPE, CIN, LCL, Level of free convection, Lifted Index, Showalter Index, Deep Convection Index, Trigger temperature, Trigger temperature deficit, Equivalent pot. Temperature, Moisture convergence, Flow divergence and Precipitable water.
4. Category *cloudiness*
   This category contains the fields cloudiness and visibility. Also only analysis is provided, no forecast. The update frequency is 10 min.

3. Input data

3.1 NWP data

NWP data are a crucial input source for all modules in INCA-BE. The NWP that is used in INCA-BE is the limited area model ALARO (Deckmyn et al., 2010) which runs operationally at the RMI. ALARO is a version of ALADIN with a new physics package so that it is suitable for higher resolutions. The NWP fields are 1-hourly, at a resolution of 4 km, with 46 levels in the vertical. Four ALARO forecast runs per day are performed (00Z, 06Z, 12Z, 18Z) and are integrated to +36 h. Post-processed fields are available roughly 4 hours after analysis time. The ALARO forecast fields used in INCA-BE are geopotential, temperature, relative humidity, u-, v-, w- wind components (3-d fields), 2m temperature and relative humidity, u-, v- 10m-wind components, precipitation, total cloudiness, low cloudiness, and surface temperature (2-d fields). The three-dimensional fields are provided on 15 pressure surfaces with a vertical resolution of 25 hPa up to 900 hPa, 50 hPa up to 700 hPa, and a resolution of 100 hPa above.

3.2 Surface station observations

Temperature, dewpoint, humidity and wind data are extracted from our surface station observations database every hour. This database contains data from several station networks. For the Belgian territory, these include not only our own AWS network consisting of 17 stations, but also the stations operated by Belgocontrol (the Belgian air safety authority) and the stations operated by the military. The total number of stations for which we have hourly data available in near-real time is 30. For the neighbouring countries, the SYNOP stations are used. The delay of the latter data is somewhat larger, but generally we find that roughly 110 foreign stations inside the INCA-BE domain are available within 25 min. Due to the time delay between the domestic and the foreign (synop) stations, we decided to perform two independent INCA-BE runs of the hourly fields each hour. The first run is scheduled at T+16min, the second at T+42min. The first run provides a quick view on the passed hour mainly intended for time-critical nowcasting purposes, while the second run is based on a larger number of stations and hence provides more accurate analyses. Ground temperature data are available for 10 stations from our AWS network.

For the precipitation module, the ingestion of station data is far from complete. The situation is different for this module because 10 minute data is required and standard synop stations do not provide such high frequency data. Our own AWS network does record 10 min data, but transfers them to our institute only once an hour. In the near future, the situation will improve by ingestion of the precipitation data from the gauge networks operated by the regional hydrological services.

3.3 Radar composite

At the RMI, we generate a near-real time composite of three C-band Doppler radars: our own radar in Wideumont (south of Belgium), the Belgocontrol radar at Brussels Airport (center of Belgium), and the Avesnois radar of Météo-France (north of France). The composite is available every five minutes, with a delay of roughly five to ten minutes. This composite will soon be enlarged by a fourth radar: our new dual-polarization radar in Jabbeke near the Belgian coast. Unfortunately, also with this new radar, the composite radar domain does not fully cover the INCA-BE domain. This would be solved by adding the precipitation data of surface stations outside the radar domain or the ingestion of data from other radars inside the INCA-BE domain. This could be done by ingesting into INCA-BE (a part of) the European radar composite which is generated by Odyssey, the Eumetnet/OPERA Data Centre, see http://www.knmi.nl/opera).

3.4 Satellite products

The INCA-BE cloudiness and visibility analyses are based on a combination of sunshine duration data from our AWS network and Cloud Types, a SAF product derived from MSG. The cloudiness module (so far the only INCA module using satellite data) is already implemented in INCA-BE, but not yet operational.

4. INCA-BE internal webportal

Quite some effort was done to present all INCA-BE output to our internal users, mainly the forecasters, in a clear but complete way. A dedicated webpage was written for this purpose. In Fig. 1 a snapshot of this webportal is given. We have grouped the output into the different categories mentioned in §1. The category can be chosen by the blue buttons in the top left corner (‘basic’, ‘precip’ or ‘convec’). The category ‘basic’ is shown in Fig. 1.

Most of the space on the page is taken by the graphical output. The circles on the image represent stations that provided data for this INCA-BE run; the two stars indicate the location of two ongoing mass events (see §5). The image is a static image, but values can be retrieved from the image interactively by moving the mouse over certain predefined places (stations, towns, outdoor events). By clicking on such a predefined place, a meteogram is generated at the bottom of the page for this particular place. On this meteogram, analysis values are plotted in white, while forecasted values are shown in purple.

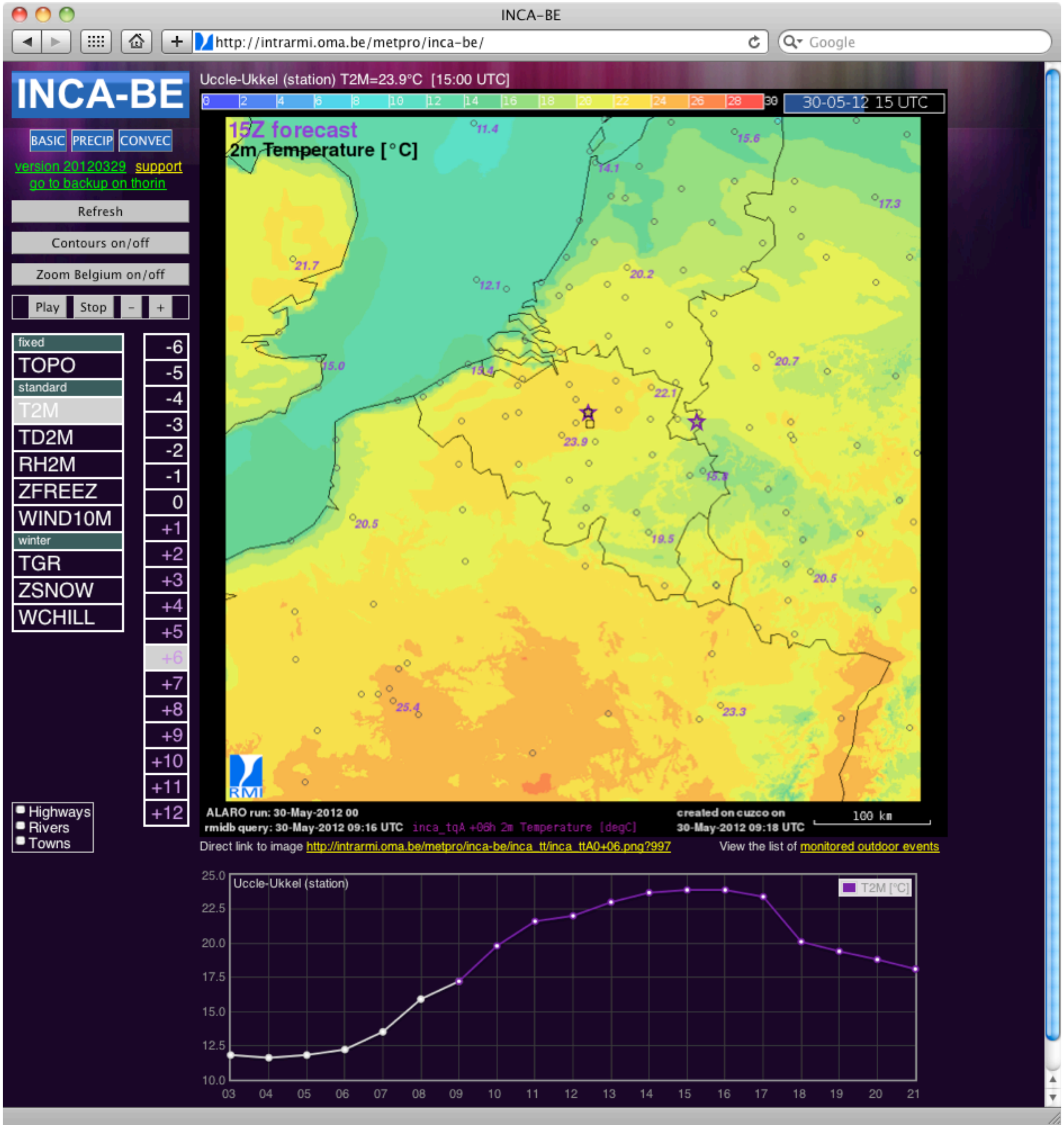

Figure 1: Snapshot of the INCA-BE webportal for the internal users (mainly forecasters) of the RMI

The left part of the webpage contains a field browser and a time browser (from -6h to +12h) to change the image depicted on the page. Above these two browsers, following buttons (in grey) are available: "Refresh" to check for the latest INCA-BE output, "Contours on/off" to enable or disable contours on the image, "Zoom Belgium on/off" to enable or disable a zoom of the image on Belgium, and "Play/Stop/-/+" to activate animation (in time) and control the speed of this animation. With the radio buttons in the bottom left corner of the page, the user can activate three different overlays for a better geographical referencing: an overlay with "Highways", one with "Rivers" and a last one with "Towns".

5. Outdoor Event Forecast

After the severe weather during the Pukkelpop festival on August 18, 2011, which made five casualties, it was decided by the RMI to offer a custom product for organisers of outdoor events: the "Outdoor Event Forecast". This product contains detailed forecasts (both for short and longer lead times) for the specific location of an event. Moreover, a privileged contact by phone with a forecaster on the day of the event is assured, who will provide detailed nowcasts for the coming hours.

To support the forecaster with the composition of these nowcasts, we have integrated the biggest outdoor mass events in Belgium (mainly music festivals) into the INCA-BE system. On the actual dates of the events, their location will be marked by a clear star on the INCA-BE maps (see Fig. 1), and meteograms will be generated by clicking on the mark (similarly as shown in Fig. 1). The database contains more than 40 outdoor events for the summer season of 2012.

6. Performance in different synoptic situations

6.1 Snow case on March 05, 2012

On March 05 of this year, there was a peculiar case with snow starting in the western provinces of Belgium, and later in the center and the south of the country. The precipitation was caused by a low coming from the North Sea entering our country from the north of France. The snowfall level field was reaching the ground at analysis time (Fig 2, upper left), while temperatures at 2 meter were still slightly positive (Fig. 2, upper right). The bottom panels of Fig. 2 show the precipitation intensity (left) and precipitation type (right) at analysis time. The light blue colour on the latter figure represents snow, while the green and khaki colors stand for mix rain+snow and rain respectively. Although we did not perform a quantitative verification of the analysis and forecast fields, a qualitative evaluation of these results seemed to confirm the good performance of INCA-BE in this situation. The qualitative evaluation of the snowfall was done by collecting media articles and by visual inspection of the images delivered by our weather webcam network.

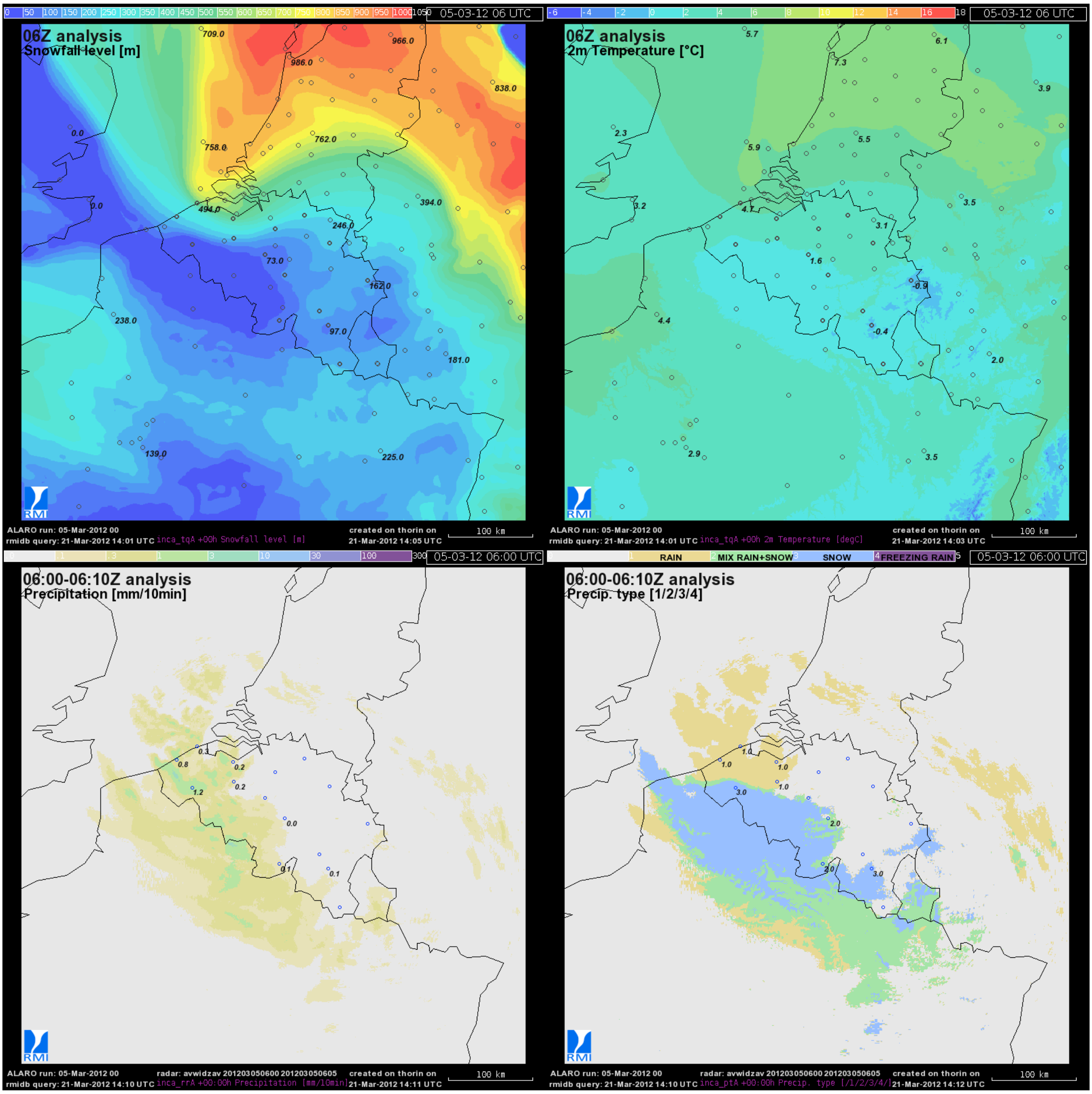

Figure 2: Snow case of March 05, 2012. The precipitation was caused by a low coming from the North Sea entering our country from the north of France. Upper left panel: snowfall level indicating the height of the snowfall layer; upper right panel: 2m temperature; lower panels: precipitation intensity (left) and precipitation type (right). Note the occurrence of snow while temperatures are slightly positive. All images are analysis fields at 06Z.

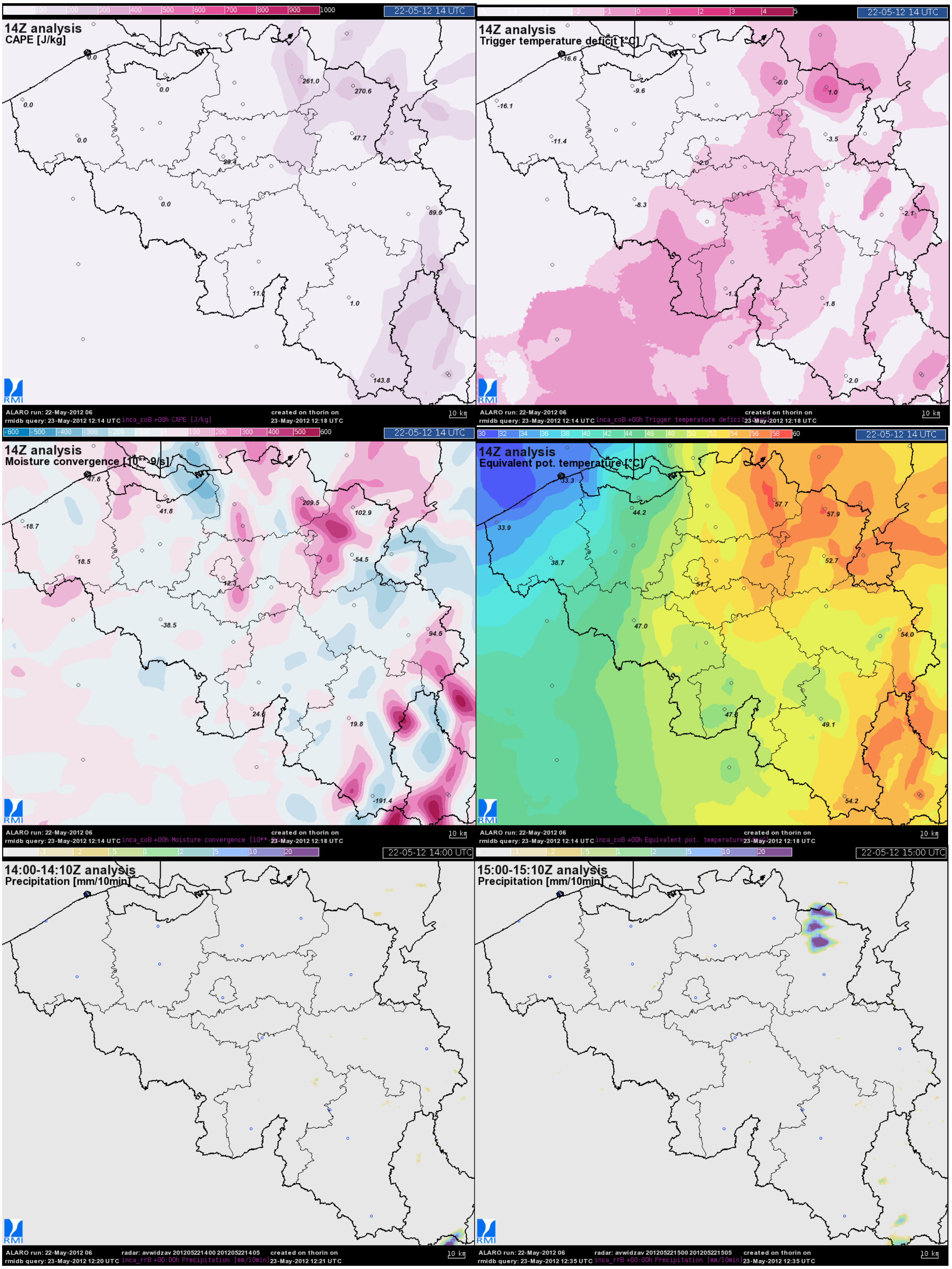

Figure 3: Illustration of the potential of the predictive skill for convection initiation in INCA-BE. The four top panels show convective analysis fields at 14Z. They all show consistently high values in the northeast of the country. At this time, no precipitation is detected (bottom left panel), but one hour later, three convective cells have emerged in the precipitation analysis (bottom right panel).

6.2 Pre-convective environment on May 22, 2012

The precipitation forecast is a pure conservative one for the first two hours, and after that it blends with the NWP for the next hours. The system performs very well in the case of large-scale stratiform precipitation, or in cases where cells are relatively isolated and long-lived. In convective situations with a high degree of complexity, including merging, splitting, initiation and decay of cells, a conservative forecast has only a limited predictive skill.

However, by making use of the convective analysis it is sometimes possible to have an indication on the location or region where severe convection might develop or intensify, in the case of an unstable atmosphere. Especially this holds for trained and skilled forecasters. As an example of such a situation, we present here the convective analysis of May 22, 2012, at 14Z. The fields CAPE, Trigger Temperature Deficit, Moisture Convergence and Equivalent Potential Temperature are shown in Fig. 3. All these fields have consistently high values in the north-east part of Belgium. At 14Z, no precipitation has been recorded yet (Fig 3, lower left panel), but one hour later (Fig. 3, lower right panel) some clear intense cells are observed in this very region.

This example shows that INCA-BE has the potential for a prediction of initiation of convective activity, or at least it is possible to refine the precipitation forecast by introducing intensification or decaying of cells by using the information from the convective analysis. Steinheimer & Haiden (2007) did some experiments in this field, but the results were rather neutral. However, their methodology could be improved at certain points (e.g. by introducing more predictive fields for convection initiation like water vapour content).

7. Conclusion

In 2010, the Royal Meteorological Institute of Belgium started the implementation of the INCA system (Integrated Nowcasting through Comprehensive Analysis) in Belgium: INCA-BE. INCA is a nowcasting system for the analysis and nowcasts of several meteorological fields, like temperature, humidity, wind, cloudiness, precipitation and precipitation type, and some derived fields like wind chill, snowfall height and visibility. It operates at a horizontal resolution of 1km, and on an hourly basis (10 min for the precipitation fields). It has been developed at the Austrian national weather service (ZAMG), and it is currently used in several European countries as the operational nowcasting system.

INCA-BE has now reached the operational stage: the system is implemented on an operational machine and a dedicated webportal to present its output is created. A first qualitative look at some specific situations reveals that the performance of the system is quite encouraging. This statement is further confirmed by the experience of the forecasters. A thorough verification has not been carried out yet, but is planned in the future.

We have also highlighted a possible research topic in the discussion of a pre-convective situation in §6: the development of a non-conservative precipitation forecast that predicts the intensification or decay of convective cells. A first study was realised some years ago by Steinheimer & Haiden (2007), but this study could be revived and extended.

Acknowledgment

We thank the Austrian INCA team for sharing their code and for their support, Mateusz Giszterowicz and Janko Merše for the useful hints, and Alex Deckmyn for adapting the ALARO output. We also want to thank the INCA-CE consortium for the fruitful and pleasant meetings in some magnificent places across Central Europe.

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