The implementation of the nowcasting system INCA for Belgium: current status

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Abstract

In the beginning of 2010, the Royal Meteorological Institute of Belgium (RMI) started the implementation of the INCA system 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 icing potential, wind chill, wind gusts and visibility. Several of these fields are analysed in a three-dimensional grid. For the calculation of these fields, INCA ingests a wide range of observational and model data: radar composites, data from automatic weather stations, satellite data and NWP output. The nowcasts of the fields gradually converge towards the NWP forecast for longer lead times. INCA has been developed at the national meteorological service of Austria (ZAMG), and is currently used in some European countries as the operational nowcasting system. We report on the current status of the implementation of INCA at the RMI, and discuss some first results. Especially the performance of INCA in a domain with a coastal region and with a relatively flat topography compared to Austria, will be an important point of interest in the evaluation of the system.

1. Introduction

The improvement of the forecasts for short lead-times (nowcasts), including the dissemination of accurate warnings in case of severe events, is a key project for the RMI for the coming years. More and more end-users are interested in accurate and precise (locally and timely) short-term predictions, but currently the RMI cannot fully satisfy this demand since there is no dedicated system producing these nowcasts. The development of an own nowcasting system from scratch at the RMI would require a lot of time, resources and manpower. Joining the development of an existing “consortium” of meteorological services with a common nowcasting system is a much more fruitful approach. INCA (Integrated Nowcasting through Comprehensive Analysis, Haiden et al. 2010) is a nowcasting system for the analysis and nowcasts of several meteorological fields: temperature (3d), humidity (3d), wind (3d), precipitation (2d), precipitation type (2d), cloudiness (2d) and global radiation (2d). In addition, also some derived fields are computed. Most of these fields are convective parameters such as lifted condensation level (LCL), convective available potential energy (CAPE), or equivalent potential temperature. Attempts were already made to improve the precipitation forecast using these fields (Steinheimer and Haiden, 2007), but the results so far were neutral. Other derived fields are snowfall line and surface temperature needed for precipitation type (snow, rain, snow/rain mix, freezing rain), as well as icing potential. INCA ingests a wide range of observational and model data: radar composites, data from automatic weather stations, soundings, satellite data and NWP output. The nowcasts of the fields gradually converge towards the NWP forecast for longer lead times.

INCA has been developed at the meteorological service of Austria (ZAMG), and it is actively maintained, updated and extended by the same institute. More and more meteorological services in Europe have adopted INCA as their operational nowcasting system. At this moment, INCA is implemented in the meteorological services of Slovakia, Slovenia, Croatia and Poland, and also MeteoSwiss (Switzerland), CHMI (Czech Republic) and TSMS (Turkey) have decided to acquire and install the system. Hence, the community of INCA users and developers is steadily growing, and initiatives for a closer collaboration between the meteorological services running INCA have already been taken. Recently, an ambitious European program has been approved to set up an INCA version for several countries in Central Europe: INCA-CE. INCA-CE is a collaboration of 16 partners from 8 Central European countries, including 7 national and regional weather services, one research institute, and 8 regional authorities in the field of hydrology, civil protection, and road management. The goal is to set up a web-based, 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. The kick-off meeting of this program took place in Vienna in the beginning of May 2010, and the project will last for 3.5 years.

An additional advantage of INCA in our case is the strong coupling of this nowcasting system with the NWP model ALADIN. The performance of INCA is, however, optimised especially for mountainous regions. Its performance in a region with a relatively flat topography and a strong sea-land contrast has still to be verified. The latter point is of particular interest for the Austrian developers.

In a first phase, an experimental version of INCA-BE will be installed at our institute, gradually implementing more and more INCA modules. The main challenge in this phase is the organisation of a streamlined data flow from the different data sources into the system, as fast as possible after new data have become available. In a second phase, INCA-BE will be fine-tuned, verified and evaluated. A fully operational and validated version of INCA for Belgium is planned to be available in the course of 2011.

2. Roadmap for INCA-BE

The official cooperation agreement between both institutes was signed in September 2009. The project started on Feb 1, 2010. A strict schedule for such an implementation is difficult to fix, but we decided to keep to the following roadmap. As explained in Sect. 1, the implementation of INCA-BE consists of an installation phase, and a fine-tuning and evaluation phase. The first phase is ongoing, and we divided this phase into six subparts.

In the first part of the first phase, the INCA-BE domain has to be defined, and it had to be checked if the standard INCA projection should be replaced by a projection that is more appropriate for Belgium. If so, the projection had to be changed inside the INCA code itself. The second part consists of adapting the NWP output available at our institute so that it is suitable as input for INCA. Not all fields required by INCA were present in our standard NWP output, so some fields had to be added in the post-processing of the model. In the third part, the INCA modules that are responsible for the fields temperature, humidity, dew point and wind, are implemented. The fourth part includes the implementation of the precipitation analysis and forecast module. In this part, the biggest challenge is to ingest the radar data into INCA-BE. Finally, the fifth and sixth parts contain the implementation of the INCA convective analysis fields, and of the INCA cloudiness module respectively.

The second phase consists of further fine-tuning of the system, and, most importantly, its verification and evaluation. At the time of writing (June 2010), the third part of the first phase is finished, and the first results of this are shown in this contribution. We expect to implement the precipitation module in the autumn of 2010.

3. INCA-BE domain and projection

In the original INCA at ZAMG, INCA-AU hereafter, the domain consists of an area of 600×350km at a resolution of 1 km (601×351 gridpoints). In the horizontal, a Lambert conical projection (Bessel ellipsoid) is used, with reference latitudes 46° and 49° N, and a central reference point at 47°30’ N, 13°20’ E. It was tested if this default INCA projection was suitable for a domain centered around Belgium. It turned out that, although there were no technical objections or difficulties, we considered this projection not suitable for INCA-BE: the grid would be too tilted with respect to a lat-lon grid, and the visual appearance of the national borders in this projection would be rather uncommon **(Fig. 1, left)**.

Therefore, the decision was made to replace the default INCA projection by a projection that is more suitable for Belgium. We opted for the “Belgian Lambert 2008” projection **(Fig. 1, right)**. This projection is promoted as the official Belgian projection by the National Geographic Institute (NGI) of Belgium. It is also a Lambert conical projection, but the GRS80 ellipsoid is used, instead of the older Bessel one. The reference latitudes are 49° 50' N and 51° 10' N, and the central reference point is at 50°47’52”134 N, 4°21’33”177 E. The advantage of changing to this projection is not only the fact that it is more suitable for our region, but it is also well documented by the NGI. This might be a convenient feature of future INCA-BE products when they will be delivered to our clients.

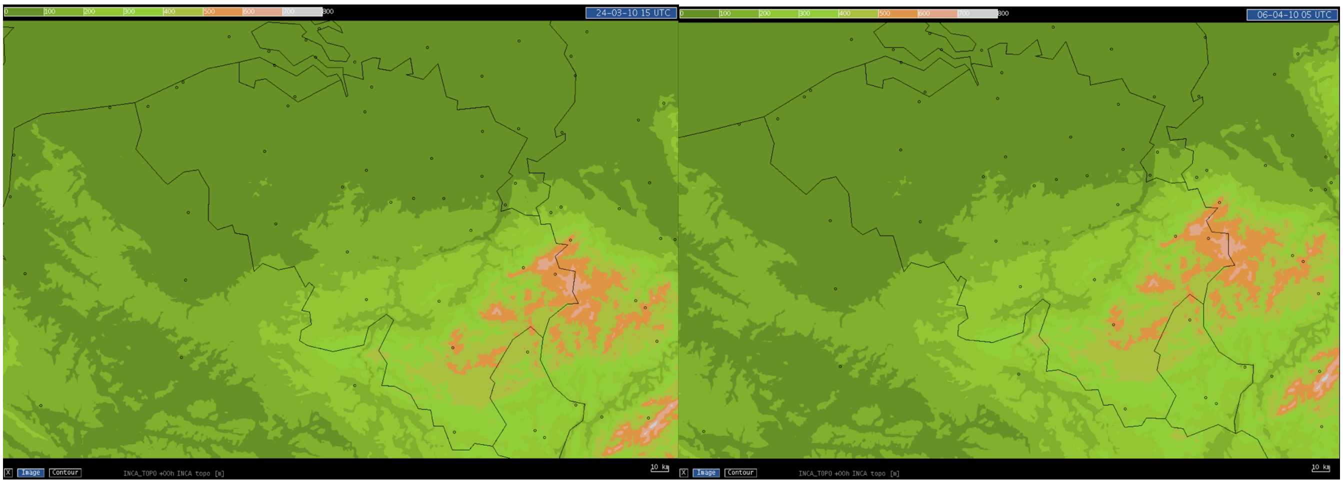

Figure 1: (Part of) the INCA-BE domain in two different projections. Left panel: the default INCA-AU projection which is a Lambert projection with a Bessel ellipsoid and centered on Austria; Right panel: the projection that we have chosen as the standard INCA-BE projection: a Lambert projection with a GRS80 ellipsoid and centered on Belgium.

In the definition of the INCA-BE grid, we chose to define a rather large domain. The total domain covers 600×590 km (601×591 gridpoints), and is centered on the geographic center of Belgium. 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 south-east coast of the U.K. Also note that a significant part of the domain consists of a water surface (the North Sea and the Channel). The INCA-BE topography map generated by the INCA setup script is shown in **Fig. 2**. The 1-km topography used in INCA is obtained through bilinear interpolation from the global 30'' elevation dataset provided by the US Geological Survey (GTOPO30, 1996).

4. Data sources

4.1 NWP output: ALARO-0 4km

For the three-dimensional INCA analyses of temperature, humidity, and wind, NWP forecast fields provide the first guess on which corrections based on observations are superimposed. For this purpose the output of the limited area model ALARO-0 is used which runs operationally at the RMI. ALARO-0 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-0 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. ALARO-0 forecast fields used in INCA 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. The domain of the ALARO-0 model is shown in **Fig. 3**. As required by INCA, this domain completely covers the INCA-BE domain. For more information on the model, and the activities of our institute in the field of NWP in general, see Deckmyn et al. (2010).

4.2 Surface station observations

At the time of writing, only hourly temperature, 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 the 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 domain are available within 25 min. A possibility is to perform several INCA runs per hour (depending on how much CPU time is available) with each run using an increasing number of stations, but this implies that the quality of the nowcast will depend on the starting time of the run, which might be confusing for (untrained) clients.

4.3 Soundings

Our institute performs three soundings per week, scheduled on 12h UTC on Monday, Wednesday and Friday. The main purpose of these soundings is the measurement of the ozone profile. The data of a sounding are available approx. 1.5 hours after its launch. The data are already formatted in such a way that they can be ingested in the INCA-BE system, but it still has to be verified whether or not sounding data increase the analysis quality and forecast skill of INCA-BE. There are other sounding stations with more frequent launches situated inside the INCA-BE domain. For the moment, none of them are ingested into the INCA system, but we will certainly investigate the feasibility to ingest these data with a time delay as short as possible.

4.4 Radar

As already mentioned in Sect. 2, the precipitation module is not yet implemented for INCA-BE. Therefore, the radar data ingestion is not yet realised. At the RMI, we have 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, and the delay is roughly five to ten minutes. The coverage of the radars compared to the INCA-BE domain is shown in **Fig. 2**. As can be seen on this figure, the composite radar domain does not fully cover the INCA-BE domain. This will partly be solved by adding the precipitation data of surface stations outside the radar domain. However, on a longer term, the ingestion of data from other radars will be considered. Other important C-band radars for the INCA-BE domain are the Dutch radars (KNMI) in De Bilt and Den Helder, the German radars (DWD) in Essen and Neuheilenbach, the French radars (Météo-France) of Abbeville, Arcis and Nancy, and the English radar (MetOffice) of Turnham. Rather than setting up bilateral agreements to exchange the data of these radars, a better strategy would be to ingest into INCA (a part of) the European radar composite which will be generated by the future OPERA data center (e.g. Holleman et al. 2009; Huuskonen et al., this volume).

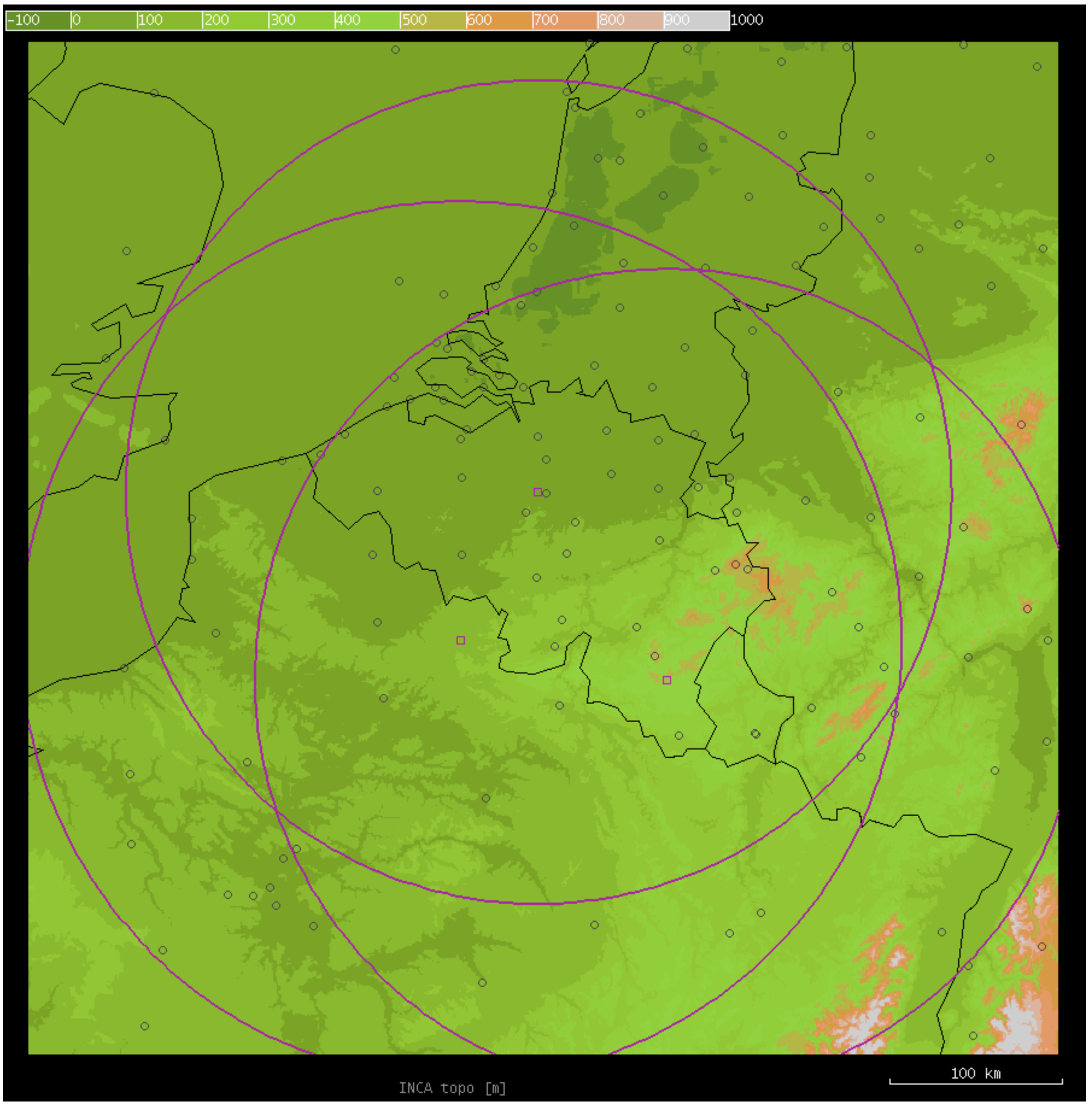

Figure 2: The INCA-BE topography generated by the INCA setup script. Superimposed are the positions of the radars and their ranges (purple squares and circles) for which we have data in near-real time, and the surface stations (small circles).

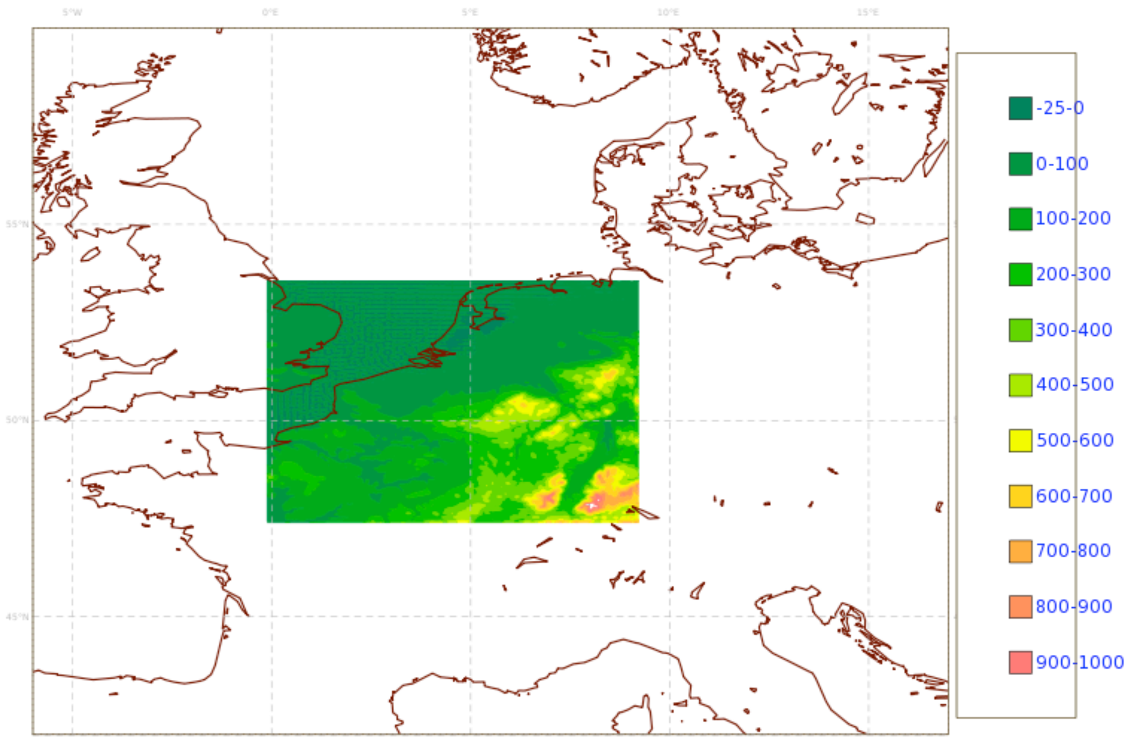

Figure 3: The domain of the NWP model (ALARO-0 4km) used in INCA-BE; the topography field (in m) is shown here.

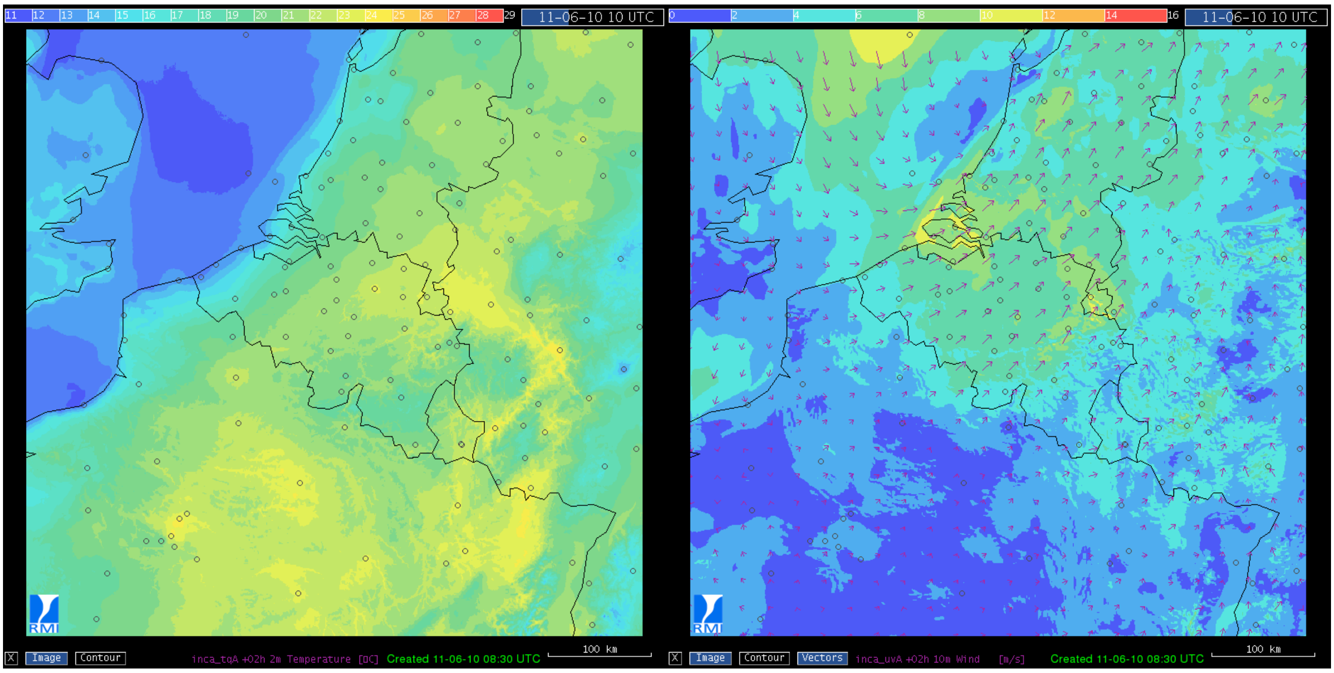

Figure 4: Examples of a 2m temperature (left) and 10m wind (right) forecast (+2h) generated by INCA-BE. This forecast is valid for 11-June-2010 at 10:00 UTC and was generated at 08:30 UTC, using station data recorded at 08:00 UTC, and using the NWP run of 00:00 UTC.

4.5 Satellite products

During daylight, the INCA Cloudiness Analysis is based on a combination of sunshine duration and Cloud Types, a SAF product derived from MSG. Also the cloudiness module (so far the only INCA module using satellite data) is, however, not yet implemented for INCA-BE.

5. INCA-BE first results

In **Fig. 4**, we give some images of the INCA-BE output produced so far. These images will be produced once INCA-BE runs operationally. In this figure, we show 2m temperature and 10m wind forecasts (+2h). The circles on the maps indicate the position of stations which delivered data for this INCA run. **Fig. 5** shows a zoom on Belgium of the temperature forecast in Fig. 4 (note that the two temperature images do not have the same colour scale). The high detail, the effect of the high resolution topography and the strong land-sea contrast are clear from these figures.

6. Conclusions

This contribution is only intended as a progress report, and it is clear that still a lot of work has to be carried out. From Sect. 5 we retain that the first results of INCA-BE are encouraging. Although a thorough verification is not yet carried out, a first qualitative evaluation of the available INCA-BE products (temperature, humidity and wind analyses and forecasts) is very positive. We are currently in the process of implementing the precipitation module in INCA-BE. Future work includes the implementation of the convective analysis fields, and of the cloudiness module. After this first phase, the actual implementation of the software, the important phase of fine-tuning and verification will be carried out. In the near future, more and more fields will become available. Especially there is a big demand for detailed precipitation forecasts which will be delivered by INCA-BE soon.

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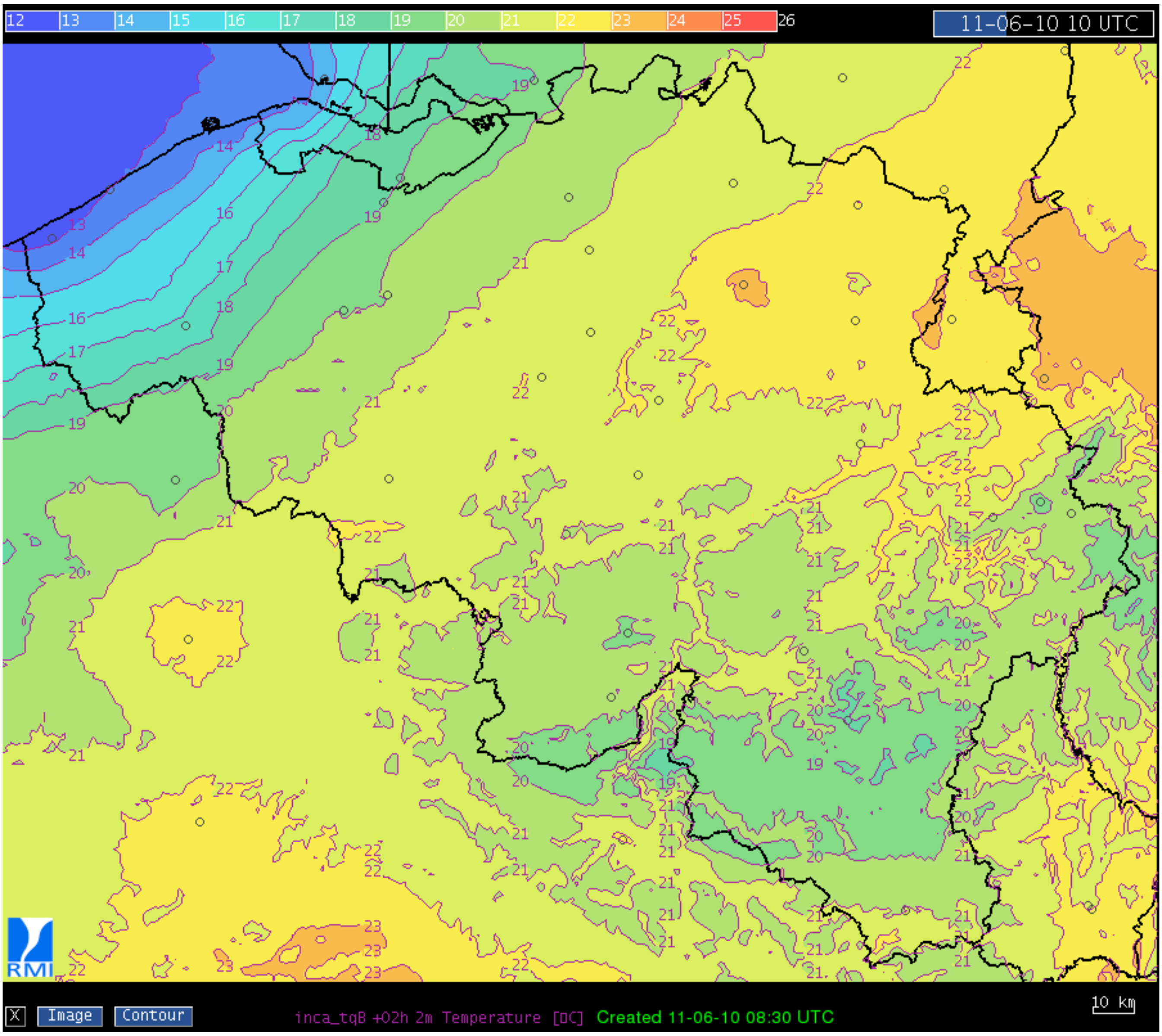

Figure 5: Zoom on Belgium for the 2m temperature forecast shown in Fig. 4. The colour scale of this figure slightly differs from the one in Fig. 4. Note the strong land-sea contrast, and the effect of the high-resolution topography, especially in the south of Belgium.

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