P6.7 CELL TRACKING AND WARNING INDICATORS DERIVED FROM OPERATIONAL RADAR PRODUCTS

P. Lang *
German Meteorological Service, DWD, Meteorological Observatory Hohenpeissenberg, Germany

1. INTRODUCTION

The challenge of operational cell analysis includes the instant analysis of a broad spectrum of convective cells under various conditions. Wilson et al. (1998) give an excellent status report of thunderstorm nowcasting.
In DWD, the German Meteorological Service, cells are discernible at 5 and 15 time steps by the base reflectivity product PX (2D, 200x200km^2) and the 12-layer reflectivity product PZ (3D, 400x400x12km^3). These online standard products of each of the 16 federal network radars require a complete interpretation of current convective cell activity. Consequently the CONRAD program (CONvection in RADar products) was defined and is tested as a simple selective cell tracking program with cell stage analysis and warning items. Its aim is getting an online estimate and presentation of current cell activity for nowcasting and public use.

2. CELL CORE IDENTIFICATION

The CONRAD cell analysis runs separately on the 2D PX and on the 3D PZ radar products with different detection areas, algorithms and mode times.
The definition of a 'primary' cell core is focused on the pure convective reflectivity >46 dBZ of a >15km^2 core base. Also single base pixels of >55 dBZ are indicators of slim cells and hail potential. A number and a time code identify recognised cells. In the 3D PZ cell analysis a VIL and volume estimate as well as the cell top and vertical hail structure further characterise the cell state and its warning status.

2.1 Cell recognition and cell track

In the 5min time steps the 2D core recognition is achieved by a 9km maximum track increment around the recent cell. It seldom covers another independent neighbouring cell. The 15min 3D recognition in a 24km radius is occasionally confronted with multiple precursor or follower cells. Here the vicinity to forecasted cell positions or a minimum approach decides on the cell links and tracks. Each precursor candidate also has to be checked for other reasonable links. Thus any contacts of cells to each other are generally favoured.
The recognition of a cell core continues the individual cell code number, the track and forecast vector as well as the lifetime and cell mass trend.

Corresponding author address:
Peter Lang, DWD FE3Hp Meteorological Observatory D82383 Hohenpeissenberg, Albin Schwaiger Weg 10, Germany, e-mail: peter.lang@dwd.de

2.2 Warning indicators and cell characteristics

Beside cell tracking and good validation of cell state and activity, an estimate of the warning potential is essential for operational purposes. Even 50%-75% of all tracked primary cells follow the basic DWD hail warning. So the present status1-warning of a >66% probability for hail at ground is derived from >55dBZ in the cell core volume. This is enhanced by >55dBZ in the primary ice layers above 6 km height as a warning status 2 (100% at ground, hail size >1,5cm) according to Witt et al. (1998).
In the 2D product hail at cell base is also assumed when a >55dBZ core of >12km^2 is found. The warning indicator of flash flood with a chosen threshold of 12 mm/30min is fulfilled when relevant core regions with an estimated or real reflectivity overlap started reaching this limit. A 30min forecast of a hail and flood warning is merely set when the recent two time steps repeated these warnings.
The complementing gust warning is used experimentally and does not yet include detailed Doppler products. Only an estimated leading gust front formation can be derived from a cell base velocity > 17m/s (5min detection) or a clear downdraft line structure (>20km) which can evolve into a bow echo (Lee et al., 1992). Also a downburst of a 6km high hail shaft with a > 10km cell top can be a gust indicator.
The philosophy of the presented cell analysis is to collect a fixed number of 40 parameters of cell characteristics, indicators and markers for each cell at each time step. Among those are the core centre coordinates, the cell stage, the volume and the top height. The warnings (except gust warning), the lifetime, the propagation vector, and the forecast position as well as the cell origin make the list complete.

3. VERIFICATION OF CELL CHARACTERISTICS

So far the main achievement was a reverse verification of cell impact. The hail and flood reports in the media as well as radar rain accumulations and the DWD Meteorological Application and Presentation System MAP were checked by issued warning messages of CONRAD. The public observation of distinct cell impact is immediate but spatially very highly or very lowly concentrated (no verification). For example one status-2 hail warning during a flood event could not be verified. Detailed widespread verification is in progress. Nearly all the cell stages are in the mature category of cell development but with finer distinctions. They are linked to the water equivalent core mass or to the amount of cell base pixels and >55dBZ cores.
A sudden volume increase or decrease triggers a "trend" symbol (+, -), which often marks the cell decay.

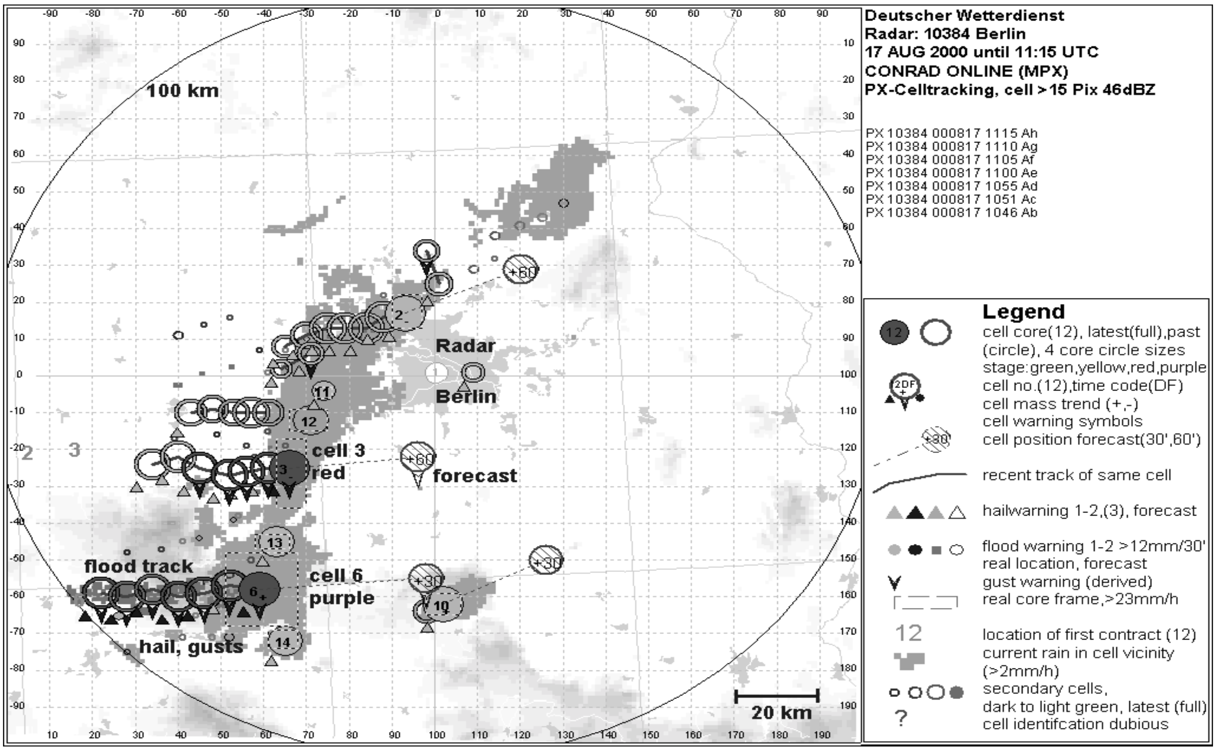

Fig. 1: CONRAD online product (PX). Cell tracking and warning symbols (legend) of primary cells on 17 Aug. 2000, 11:15 UTC, Berlin area, with a 30min-cell history and a 30-60min forecast. Reported hail and gust at Wittenberg, south of Cell 6. Notice isolated secondary cells and the combining N-S precipitation band >2mm/h.

The 2D cell stage is orientated by the 3D cell mass. The radar-radar verification of cell stage and warnings shows some influence by differences in technical radar performance, sight and resolution, especially on hail warnings. In real radar images and MAP data (METEOSAT, cloud cover, no local lightning detection), also ANAPROP pseudo-cells can be verified.

4. RESTRICTIONS ON OPERATIONAL CELL IDENTIFICATION AND ANALYSIS

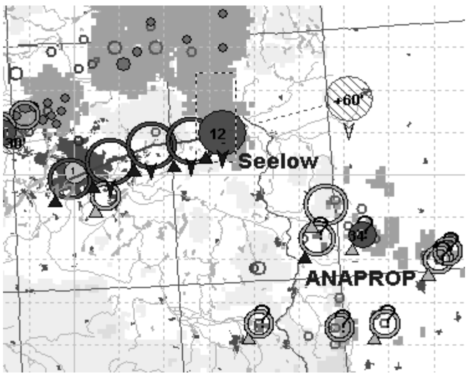

Fig. 2: CONRAD online PZ of 17 Aug. 00, Berlin area 02:43-03:43 UTC. Close-up of Cell 12 (stage red) at Seelow with hail and gust symbols and reports concurrent with marked ANAPROP pseudo-cells (?) in SE.

In most night-time ANAPROP conditions pseudo-cell cores can be identified at insufficient clutter filtering. From stationary pseudo-cells flood warnings are often issued. A simple algorithm implied 'flat cells' and a vertical reflectivity gradient (>14 dB/km) which is not typical for hydrometeor distribution in cell top regions. It provides 3 ANAPROP states, one of which is clearly ANAPROP (marker in the 40 parameters cell list).
These still tested ANAPROP states are not applicable to the 5min cell base detection of the 2D product. Also spurious echoes on the Baltic Sea are subjects to the ANAPROP check. Moving ships with a single >55dBZ base pixel and echo tops up to 7km are mostly eliminated due to their size and the ANAPROP check.
Other pseudo-cells based on 2D bright-band reflectivity (15km^2 of >46dBZ) are rarely found.

5. GRAPHIC PRESENTATION OF CELL TRACKS AND WARNINGS

CONRAD is separately applied to the 5min cell base (PX) and the 15min (PZ) cell column product with the result of different resolution and new cell identifiers.
Each online product shows the present cells as circles, filled with the colour code of the cell stage (Fig. 1), completed by the cell number, the moving core frame and the track and core position in +30min (or +60min, at cell lifetime ≥ 60min). The online image also shows all former cell circles and tracks of the last 30min

(PX) and 60min (PZ), respectively. All present and recent warning symbols assigned to its general cell position are visible on a detailed geographical underlay. In addition all cell tracks with a longer period can be shown correspondingly in an offline product with cell symbols and time coding.

6. ADDITIONAL CELL CHARACTERISTICS

The online 3D analysis of the cells concentrates on single cells with the suppression of surrounding stratiform precipitation. For the visual detection of squall line structures the aligning >28dBZ reflectivity enclose the cell symbols. Also the real local flood pixel (>12mm/30min) are marked in addition to the general flood warning symbol. Finally a new type of cell stage is incorporated, identified as 'developing secondary cell'. These cells have a 3km towering reflectivity of >28dBZ reaching up to 6km which are typical for long periods of medium convection consistent with the cellular lightning activity from MAP. These slim towers are not tracked but indicate the developing and decaying stage of the cell lifecycle and frequently the mean direction of propagation (Fig. 2).

7. RESULTS FROM WARNING EVENTS

Operational cell analysis has to satisfy exact meteorological measurements as well as public warning demands derived from weather effects. Thus, large hail damage has to be 'verified' by appropriate warnings from significant reflectivity signatures only. Do hail cores up to 12km with extreme VIL values correspond with large-hail observations and vice versa? Some observations of an updraft cut-off process during a stable hail growth circulation above 6km appear to precede a severe hail damage.
The analysis of local or more widespread flooding is the basis for a subsequent forecasting success. Cell merger or a slower propagation due to cell rotation or wing development is often responsible for local flooding, more than a temporary intensity increase.
A considerable length of a low-level line structure often represents a gust front formation like this of the verified gust warning near Seelow, Fig. 2.

8. PRELIMINARY CELL STATISTICS

The best statistical tracking success is obtained from the 5min tracking of the cell base during stable wind conditions at selected days. Cells older than 40 minutes, for example, showed stabilised tracks with deviations of 0-30° at a mean velocity of e.g. 60 km/h. Generally a mean 30° or 10km error is common in 30min position forecast. Also 66% of all track vectors remained below 20° fluctuation. A 15% core area fluctuation is frequently observed at sequences of 5min time steps.
The cell speed of 17 Aug. 00 in the Berlin area reached > Bft 8 and an appropriate gust potential. Extreme cell cores of >150 km^2 developed at least one base pixel with a hail indicating reflectivity >55dBZ. The wide spectrum of 2D hail indicators finally results in a high range between possible and definite hail identification and a low warning threshold.
Fig. 3 shows the frequent formation of a line structure (with bow and gust potential) in larger cells on the assumption of elliptical cores. Then, most lines have a larger secondary tower in developing stage than normal cell structures.

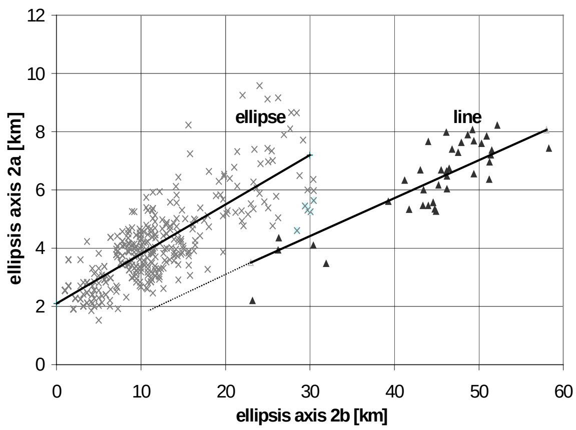

Fig.3: Derived cell core ellipses and axes, 17 Aug. 00. Line structures can be separated by an axis relation >5:1, starting at ~10km line length.

9. CONCLUSIONS:

CONRAD is a good operational nowcasting tool for a selective radar image interpretation of convective cell activity and warning status. Its symbol marking is even practical for public use. The local flood warning is very reliable and hail occurrence >1.5cm at ground is derived from 55dBZ above 6km. A forecast uncertainty of 10km or <30° for 30min appears to be acceptable. Prior to primary cell development long periods of medium convection are characterised by secondary cells and their tracks. In further studies 2001 the 2D and 3D analysis will be coupled.

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