Real-time hourly Precipitation Analysis and Forecasts combining Radar and Rain Gauge Measurements for operational use at the German National Meteorological Service (DWD)

by

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- **RADOLAN**: Real-time precipitation analyses based on precipitation radar products online adjusted with rain gauges
  --> *status and outlook*

- **RADVOR-OP**: Real-Time precipitation forecasts based on radar measurements
  --> *short summary*
**RADOLAN: Radar-Online-Adjustment**

**Task:**
Real-time provision of temporally and spatially high resoluted precipitation products covering the hydrological catchment area of Germany as basis for flood risk management applications of the German water management authorities.

**Project:**
Developed and operationally implemented from 1997 until 2004 with financial support by the water authorities of the German „Länder“.
RADOLAN: Radar-Online-Adjustment

RADOLAN-Input 1: Radar Network of DWD

16 operational C-Band Doppler Radars with 125 km range for Quantitative Radar Precipitation Measurements covering the whole area of Germany since spring 2000:

Precipitation scans (256 classes) at each site every 5 min with spatial resolution of 1 km x 1° Azimuth

-> Replacement of all DWD radars (OP and RTD) by new ones until year 2011

-> Addition of radar precipitation data from neighbour countries
RADOLAN: Radar-Online-Adjustment

RADOLAN-Input 2:
Rain Gauge Networks of DWD and German „Länder“

~ 200 Weather Stations with Full-Time Observers (Wst I) resp. Automatic Weather Stations (Wst II)

~ 300 Weather Stations (Wst III) and ~ 500 Hydrometeorological Stations (Nst(A)) with Volunteer Observers

~ 300 Hydrometeorological Stations by German „Länder“

-> Addition of more German „Länder“ network stations

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RADOLAN: Radar-Online-Adjustment
Routine Online-Adjustment Scheme at DWD

**Input 1:** Radar-Data (16 locations; every 5 min) per AFD

**Preprocessing I of Radar Data**
- (every 5 min)
  - Correction of Orographic Attenuation
  - Use of a variable Z-R-Relationship
  - Compositing for the area of Germany

**Monitoring of Precipitation**
- (every 60 min)
  - Triggering of hourly data retrieval of additional rain gauge stations (Nst A) + „Länder"

**„first time“**
- (hh:35)

**Input 2:** Rain Gauge Data (Selection every 60 min) per RADOLAN

**Preprocessing II of Radar Data**
- (two times every 60 min)
  - Summation up to hourly composites
  - Statistical clutter suppression and filling of „clutter gaps“ (only 2nd time)

**„second time“**
- (hh:45)

**Preprocessing III of Radar Data with Surface Data**
- (every 60 min)
  - Smoothing of unrealistic gradients
  - Pre-Adjustment (BORAMA)

**Online-Adjusted Quantitative Radar Precipitation Products**
- (Resolution: 1 hourly, 1 x 1 km; available within 30 min)

**Adjustment of Radar Data with Rain Gauge data**
- (every 60 min)
  - Calculation of Gauge/Radar P Totals
  - Interpolation on 1 x 1 km grids
  - Adjustment
RADOLAN: Radar-Online-Adjustment

Adjustment procedure:
1. **Difference** between rain gauge and radar precipitation value calculated at the station location for 80 % of the gauge stations -> spatial interpolation of the differences on 1 x 1 km grid

2. **Quotient** of rain gauge and radar value calculated at the station location for the same 80 % of the gauge stations -> spatial interpolation of the quotients on 1 x 1 km grid

3. Gauge location specific selection of best adjustment method based on comparison of spatially interpolated results of 1) and 2) with the gauge data of the 20 % gauge stations not used before

4. Calculation of adjustment matrix for all pixels by using inverse distance weighting for gauge specific adjustment values selected under 3)

5. Best adjustment of pre-processed radar precipitation by using the matrix calculated under 4)
RADOLAN Examples

Operational:
Gauge-adjusted hourly precipitation composites for Germany

Future (to be operational until end 2006):
6h, 12h, 24h radar precipitation composite for Germany

Future (in 2007):
Time series of hourly precip for specific German river catchment areas
RADOLAN example:
Event on 27 July 2005
(Hourly precipitation on 19:50 and 20:50 UTC in a radius of 50 km around Frankfurt/Main)

Upper row:
Hourly gauge-only based precipitation distribution with maxima of 13.4 mm on 19:50 UTC (left) vs. 19.1 mm on 20:50 UTC (right)

Lower row:
Hourly gauge-adjusted Radar precipitation distribution with a around 10 - 15 km small W-E oriented "precipitation trace" with maxima of more than 50 mm/h (on 19:50 UTC; left) vs. more than 30 mm/h (on 20:50 UTC; right)
Further developments of RADOLAN

1) Central European quantitative precipitation composit:

Enlargement of the RADOLAN-area (Germany) by neighbouring radars to enable complete coverage of the hydrological catchment area of Germany.

Example on 25.11.2005, 01.50 UTC:

Left: without Nancy (France)
Right: with Nancy (France)

-> precipitation in the SW region (catchment area of Moselle river) can only be detected with the radar of Nancy

2) Adjustment method (e.g. input by German research project OPAQUE):

Improvement of the Radar-gauge adjustment methods (Factor, Quotient) by integration of a third pixel-specific adjustment method (Merging), which also allows to fill spatial gaps with gauge data in case of non-availability of Radar
Further developments of RADOLAN

3) Quality-Composite (input by several national German research projects): Improvement of the data quality of the RADOLAN-Composites by using the locally generated quality products (for better correction of ground clutter, bright band, attenuation, radial circles and spokes)

Example on 02.01.2006 19:35 UTC:

Left: without local correction of radial circles around Radar of Hanover,

Right: with local correction of radial circles (Testbetrieb)

-> the 5 concentric circles around a radar location are detected and corrected by the automatic quality control
Further developments of RADOLAN

4) Composite production:
Improvement of radar composite production

Example on 19.07.2005, 05:50 UTC (24h sum)
Project RADVOR-OP: Radar supported near real-time precipitation forecasts for operational use

**Task:**
Development of more precise operational precipitation forecasts

1) High resolved numerical weather prediction model (**LM-Nowcasting**)
2) Development and tracking of convective/advective precipitation fields based on online-adjusted quantitative radar precipitation (**RADAR-Nowcasting**)

**Goal:**
Operational provision of temporal and spatial high resolved precipitation forecasts in Germany as input for various flood risk management applications by the Water Management authorities of the German „Länder“
RADVOR-OP: Radar based quantitative precipitation nowcasting
-> Forecast for the next two hours, 2006 still pre-operational

Resolution:
- 1 km spatial
- 60 min temporal
- update every 15 minutes

Features:
- Tracking of convective cells (1h)
- Tracking of stratiform fields (1; 2h)
- Characterization (every 15 min) of vertical precipitation structures as convective or stratiform
- Estimation of the temporal evolution of the cells/field (plan)
- Separation of liquid and solid precipitation (plan)
Promising LMK forecast results from the test period

LME 7 km  RADOLAN  LMK 2.8 km

Hourly rainfall: 24.08.2006, 14:00-15:00 UTC / model start of 24.08, 00 UTC
Thank you for your attention!!!

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http://www.dwd.de/RADOLAN
http://www.dwd.de/RADVOR-OP

More info on DWD Radar activities at ERAD:
-> Posters P2.8, P5.5, P5.7 until today 11:30
-> Posters P6.4, P6.5, P8.8, P10.3, P10.4
-> Presentation by T. Mammen today 17:00