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Kyoto University
Keynote

DWD Capabilities in the Field of Extreme Flash Flood generating Precipitation with a view on Forecast, Monitoring, Warning and Hydro-Climatological Assessment

Andreas Becker
Precipitation Monitoring Unit and Global Precipitation Climatology Centre, Deutscher Wetterdienst, Frankfurter Straße 135, 63067 Offenbach am Main, Germany
Email: andreas.becker@dwd.de

Also in Germany, flash floods as a result of heavy precipitation events pose an increasing risk to the community due to their destructive potential and the challenge to predict and warn their occurrence with sufficient lead time to allow for mitigating measures. Rather physical reasoning than observational evidence tells us so far that an increase in heavy precipitation indices is likely to occur in consequence of an ongoing global warming. Moreover the characteristics of precipitation might change towards more intense, small-scale and short-term events posing an additional challenge to both, observational and forecasting systems. In addressing the need for high-resolution precipitation forecasts, DWD is heading for a so-called integrated precipitation forecast system, which is, however, quite demanding on computational and logistical resources. Therefore another approach is also taken, rather to utilize observational information to understand the characteristics of flash flood generating precipitation events through risk mapping providing guidance for adaptation measures. In Germany the re-processing of radar data turns out to serve new insights for the very small- and short-scale events. In areas lacking weather radar surveillance a more comprehensive examination of gauge statistics and documentation of historic inundations might be a suitable path as well.

Given the so far rather weak evidence for trend in heavy precipitation, the World Climate Research Programme (WCRP) of the World Meteorological Organisation has launched a number of “grand challenges”, i.e. strategic goals. Among those there is the GC “Understanding and Predicting Weather and Climate Extremes” that also aims for a substantially improved observational data base with regard to precipitation, being the core task of the Global Precipitation Climatology Centre (GPCC), that collects, quality assures and processes rain gauge data world-wide to derive and publish gridded data products for the community. Since a few years GPCC products also encompass daily precipitation and droughts providing new insights also for the Egypt. Key features and applications shall be presented. However, given the strong intermittent character of precipitation in Egypt in general, a proper approach towards disaster risk reduction would always take low-regrets options that reduce exposure and vulnerability upfront into account, to supplement reliance on any best possible and cost-efficient early warning system.
DWD Capabilities in the Field of Extreme Flash Flood Generating Precipitation
with a view on Forecast, Monitoring, Warning and Hydro-Climatological Assessment

Andreas Becker and Detlev Majewski

Motivation

No Wadis in Germany, but Flash Floods!

-> Early Summer 2016

Stromberg

Braunschbach

Flash Flood in Braunschbach, 29th May 2016

Just 1h of heavy precipitation generates a devastating flash flood in Braunschbach, Germany

Improved Monitoring, Forecast and Warning

To Do’s in Germany

Historical German record events
Simmersbach 2016
Braunschbach 2016

Totals in Simmersbach and Braunschbach have been substantially below theoretically possible record totals encountered in Germany and world-wide despite their devastating impacts — there is a need for early prediction and warning even in Germany but certainly in Egypt...
The Second International Symposium on Flash Floods in Wadi Systems

2 Forecast: Weather Forecasting Process Chain

Observation Analysis / Forecasting (0-2h, 2h-7 days) Post-Processing: Meteorologist Customer

- Numerical Weather Prediction (2h-7 days)
- Data assimilation: Dynamical, Physical, Ensemble
- Object-based workbench
- Nowcasting (0-2h)
- Model-Post-Processing and applications: FV3, MM5, WRF, AROME, AEMET, DWD, AUTOFISH, NCAWS, IRENA
- NIMH, Climate, Autowarn, Nico-Stech,
- Aviation forecasts
- Guidance, warnings, 3 regional offices
- Warnings, alerts, 6 regional offices

Evaluate the uncertainty of measurement, initial state (analysis), and forecast!

The deterministic NWP system at DWD in October 2016

Global model ICON
- Grid spacing: 13 km
- Layers: 90
- Forecast range: 180 h at 00 and 12 UTC
- 120 h at 06 and 18 UTC
- 30 h at 03, 09, 15 and 21 UTC

ICON-EU Nest
- Grid spacing: 6.5 km
- Layers: 60
- Forecast range: 120 h at 00, 06, 12 and 18 UTC
- 30 h at 03, 09, 15 and 21 UTC

COSMO-DE
- Grid spacing: 2.8 km
- Layers: 50
- Forecast range: 27/5 h at 00, 03, 06, 09, 12, 15, 18, 21 UTC

1 grid element: 43 km²

The probabilistic NWP system at DWD in October 2016

ICON-EPS; M20
- Grid spacing: 2.8 km
- Layers: 50
- Forecast range: 27/5 h at 00, 03, 06, 09, 12, 15, 18, 21 UTC

COSMO-DE-EPS; M20
- Grid spacing: 2.8 km
- Layers: 50
- Forecast range: 27/5 h at 00, 03, 06, 09, 12, 15, 18, 21 UTC

Forecast: Integratetes Vorhersagesystem (IVS)

Integrating Nowcasting and convection resolving hourly rapid update cycle (RUC)
Numerical Weather Prediction (NWP)

Integrated Forecasting System (IVS) for Nowcasting and very short range forecasts

DWD is employing very different approaches for nowcasting (0 – 2h) and very short range forecasts (2 – 6/12 h).

Nowcasting
- Feature based, e.g. detection of convective cells in radar images; estimation of propagation speed and direction; „linear“ extrapolation of detected objects/features.
- Update-rate of new forecasts ~ 5 to 15 min.

Very short range forecasts
- NWP model based, analysis of the initial state taking as much as possible high resolution observational data into account; solution of the hydrodynamical equations on a high resolution 3D-grid for the atmosphere and the surface/soil.
- Update-rate of new forecast ~ 3 h.

Integrated Forecasting System (IVS)
- Combination of both approaches to an ensemble-based seamless forecast product for forecast ranges from 0 to 6 (12) h with a rapid update rate (~1 h).

25-27 October 2016
The Second International Symposium on Flash Floods in Wadi Systems

**Forecast: Integrientes Vorhersagesystem (IVS)**

**Seamless Detection and Ensemble Assimilation / Forecasting**

- **Nowcasting**
  - Rapid Update Cycle
  - NWP
  - NWP First Guess
- **IVS-Product**
- **Integrated Forecasting System (IVS)**

- **Forecast: Integrientes Vorhersagesystem (IVS) - Advanced Nowcasting**
  - Estimate the uncertainty of Nowcasting products
  - EPS for the calculation of optical flow
  - EPS for the detection and forecasting of objects
  - Earlier detection of initiation of severe thunderstorms
  - 3D-detection and tracking of convective cells (KoinRad-3D)
  - Combination of radar, lightning, satellite, Synop, NWP data
  - Convergence zones based on doppler wind data
  - Convective Initiation based on satellite data
  - Forecasting of the trend of development
  - NWP RUC for near storm environment
  - Trend of development according to “ingredients method”
  - Life cycle of convective cells

- **Development of new Level-2 products for the detection of HHW**
  - Gust detection, rotation-track, VIL-track, VIL-track
  - Reduction negative impact of wind turbines (renewable energy)
  - Use dual-polarization data, e.g. for rain/snow, hail size

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**Further Development of convective scale NWP**

- Assimilation of new observations
  - Radar volume data, consistency with LHN
  - SEVIRI Infrared and SEVIRI Near-VIS
  - Screen-level observations
  - Lightning (LPI - lightning potential index)
- Further development of model physics / dynamics
  - Physical parameterizations
  - Two-moment cloud microphysics
  - Interaction of physics and dynamics
  - Model grid spacing <1km (or less)
- Development of Rapid Update Cycle NWP
  - Data assimilation (RUC-EQA)
  - RUC forecasts
  - Ensemble (features, perturbations, calibration)
- Development of new EPS-based products and verification
  - Detection of HHW, precipitation, gusts, turbulence
  - Consistency between global and regional EPS

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**Monitoring Global: Rain gauge based precipitation analysis**

**The Global Precipitation Climatology Centre (GPCC)**

- A German contribution to Climate Monitoring and Research in context of GCOS, WCRP, and WMO
- Monthly precipitation analyses for the earth’s landsurface based on the largest monthly in situ precipitation data-base of the world;
- The GPCC database holds precipitation observation data from more than 100,000 stations in more than 190 countries and regions

**GPCC-Homepage:** http://gpcc.dwd.de

-> free access to the gridded GPCC analysis products

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**Monitoring Global: GPCC product portfolio extended recently**

<table>
<thead>
<tr>
<th>Product</th>
<th>Spatial Resolution</th>
<th>Time Coverage</th>
<th>DOI</th>
<th>Possible Application</th>
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<tbody>
<tr>
<td>First Guess Monthly</td>
<td>1.0°</td>
<td>2004-present</td>
<td>Yes</td>
<td>drought monitoring</td>
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<tr>
<td>First Guess Daily</td>
<td>1.0°</td>
<td>2009</td>
<td>Yes</td>
<td>analysis of extremes</td>
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<tr>
<td>Monthly Monitoring Version 5</td>
<td>0.5°, 1.0°, 2.5°</td>
<td>1983-present</td>
<td>Yes</td>
<td>calibration of satellite data</td>
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<tr>
<td>NWP Monthly Version 7</td>
<td>0.5°, 1.0°, 2.5°</td>
<td>1901-2013</td>
<td>Yes</td>
<td>hydrological studies</td>
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<tr>
<td>NWP Daily Version 1</td>
<td>1.0°</td>
<td>1988-2013</td>
<td>Yes</td>
<td>analysis of extremes</td>
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<tr>
<td>ENSP/CPC daily precipitation</td>
<td>0.5°, 1.0°, 2.5°</td>
<td>1988-2008</td>
<td>Yes</td>
<td>analysis of extremes</td>
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<tr>
<td>NDSMPC (European) Version 1</td>
<td>1.0°</td>
<td>1951-2005</td>
<td>Not yet</td>
<td>trend analysis</td>
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<tr>
<td>WASClimo Dataset</td>
<td>0.5°, 1.0°, 2.5°</td>
<td>1951-2000</td>
<td>No</td>
<td>trend analysis</td>
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<tr>
<td>Precipitation Climatology</td>
<td>0.25°, 0.5°, 1.0°</td>
<td>1951/2000</td>
<td>Yes</td>
<td>for application as a reference, and for utilization of the anomaly interpolation method</td>
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<td>Drought Index Version 1</td>
<td>1.0°</td>
<td>1988</td>
<td>Yes</td>
<td>comparison of Interpolation schemes</td>
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<td>Drought Index Version 1.1</td>
<td>1.0°</td>
<td>2013</td>
<td>Yes</td>
<td>drought monitoring</td>
</tr>
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25-27 October 2016
Monitoring Global: Regular Monitoring for WMO & EFAS

Monitoring National: Radar based precipitation analysis

Monitoring: Quantitative precipitation analysis

Monitoring: The untapped source of radar data

Monitoring: Quantitative precipitation analysis

Monitoring: Quantitative precipitation analysis

RheinlandPalatinate WASSERWESENTLICHKEIT Länderebene UND LEITUNGSMANNSCHAFT

Customer (Federal State) Feedback

River gauge data at 20.09.2014, Pegel Altenbamberg / Alsenz

ca. 40 m³/s → yellow warning level

Photos: Rheinpfalz – Online 22.09.2014

Andreas Bacher and Stefan Wirth, DWD Cape in Flash Flood generating Precipitation, 21.10.2016, TU Berlin Campus II, Glienicke, Egypt.
5. Hydro-Climatological Assessment – Map Erosion Risks

Rain erosivity \( R \) factor of the Universal Soil Loss Equation (USLE)

- Current status: based on gauge data
- Annual precipitation sums
- Perspective: based on radar QPE
- Event erosivity
- Quasi-adjusted RADOLAN 5-minute data

First approach:
- RADOLAN hourly sums (RW)
- without outlier handling
- Assumption: \( L_{30, \text{max}} = 1.3 \times L_{60, \text{max}} \) too low

Source: data

5. Hydro-Climatological Assessment – Map Precipitation Risks

5. Hydro-Climatological Assessment

District-specific detection of extreme precipitation in Cologne

Design depth for a return period of one year

Exceedance of precipitation depth with return period of one year

Summary

- DWD runs and further develops its own NWP modelling system capable to warn and predict flash flood generating precipitation. The effort, however, is substantial and too costly for many other countries.
- Radar based precipitation monitoring enhanced by nowcasting methods is a less demanding layer of capability to warn against flash flood generating precipitation. It is the standard approach at DWD for flash flood warning.
- Running a network of radar systems is still resource demanding though cheap solutions of X-band networks based on ship radars exist (PATTERN Project University of Hamburg).
- Instead of a real-time capability in run-off prediction the calculation of heavy precipitation and flash flood risk maps is recommended as a cost efficient solution to identify and protect hot spot areas.
- Finally a good mapping and indication of Wadi systems offer finally the option to take low-regret measures for protection against flash floods