Keynote

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

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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.

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

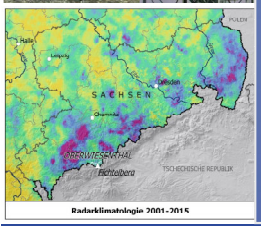
DWD Capabilities in the Field of Extreme Flash Flood Generating Precipitation

with a view on Forecast, Monitoring, Warning and Hydro-Climatological Assessment

Andreas Becker[1] and Detlev Majewski

Jan Nicolas Breidenbach, Peter Finger, Mario Hafer, Thomas Junghänel, Christine Kolbe, Anja Meyer-Christoffer, Kira Rehfeldt, Elke Rustemeier, Udo Schneider, Peter Stender, Cathleen Sterker, Ewelina Walawender, Elmar Weigl, Dr. Tanja Winterrath, Dr. Markus Ziese

[1]Head Precipitation Monitoring Unit and Global Precipitation Climatology Centre, Department for Hydrometeorology, Deutscher Wetterdienst



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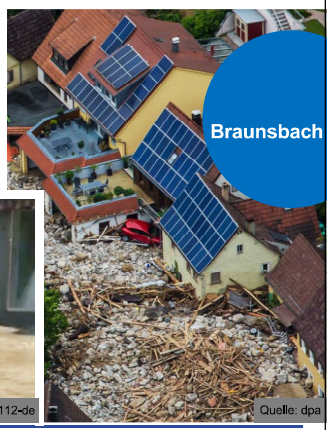
1 Motivation
2 Forecast
3 Monitoring
4 Warning
5 Hydro-Climatological Assessment

1 Motivation

No Wadis in Germany, but Flash Floods!

-> Early Summer 2016

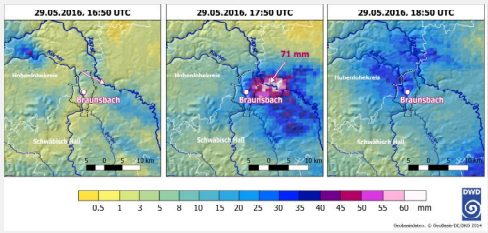


1 Motivation

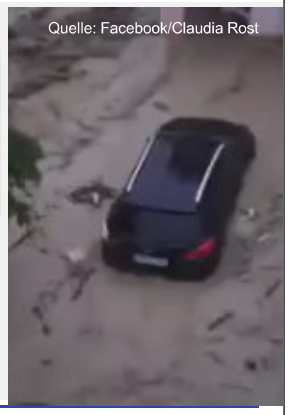
Flash Flood in Braunsbach, 29th May 2016

Summer 2016

1h-Totals of Precipitation

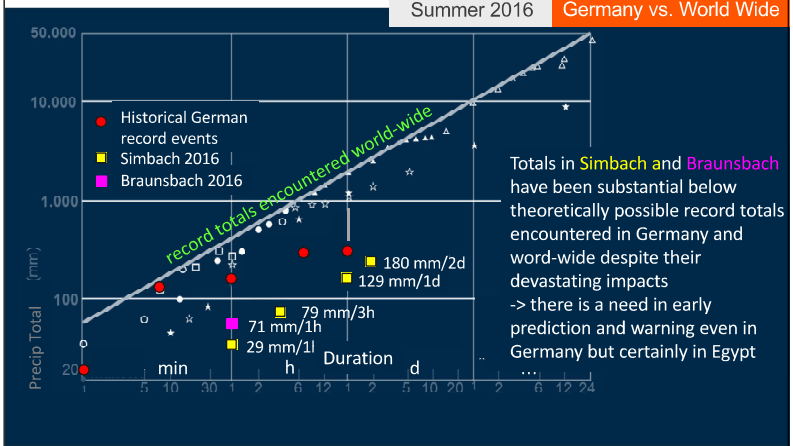


Just 1h of heavy precipitation generates a devastating flash flood in Braunsbach, Germany



1 Motivation

Summer 2016 | Germany vs. World Wide



Totals in Simbach and Braunsbach have been substantial below theoretically possible record totals encountered in Germany and word-wide despite their devastating impacts
-> there is a need in early prediction and warning even in Germany but certainly in Egypt
…

1 Motivation

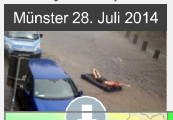
Improved Monitoring, Forecast and Warning

To Do's in Germany

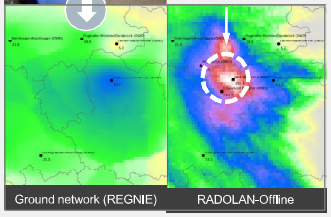
Ombrometer and Radar

Heavy Precipitation

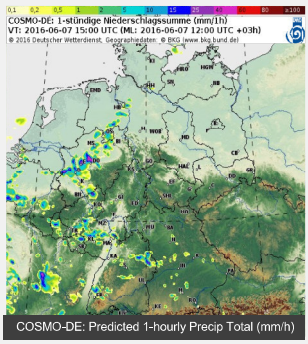
Münster 28. Juli 2014

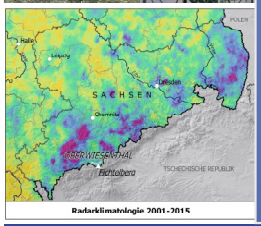


Improved Detection of local extreme events through radar based monitoring



Forecast





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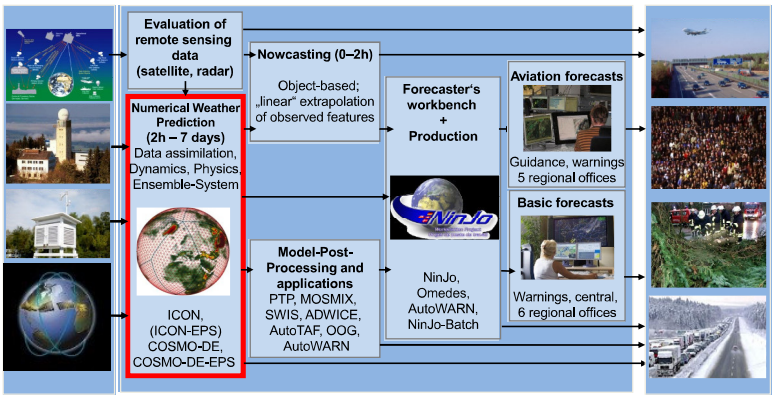
3 Monitoring
4 Warning
5 Hydro-Climatological Assessment

2 Forecast: Weather Forecasting Process Chain



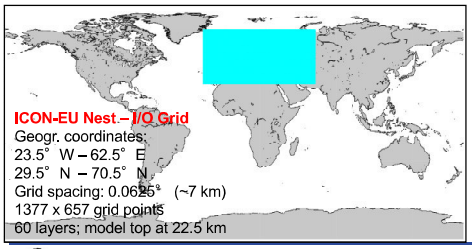
Quantify the uncertainty of measurement, initial state (analysis), and forecast!

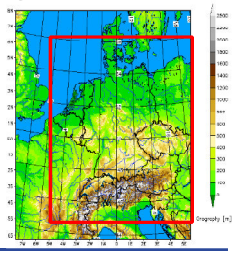
The *deterministic* NWP system at DWD in October 2016

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 21UTC
1 grid element: 173 km²

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 21UTC
1 grid element: 43 km²

COSMO-DE
Grid spacing: 2.8 km
Layers: 50
Forecast range:
27/45 h at 00, 03, 06, 09, 12, 15, 18, 21 UTC
421x461 grid points
1 grid element: 8 km²



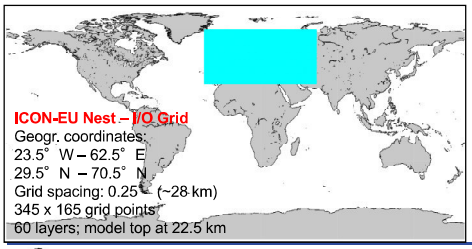


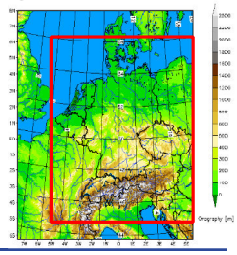
The *probabilistic* NWP system at DWD in October 2016

ICON-EPS; M40
Grid spacing: 40 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 21UTC
1 grid element: 1638 km²

ICON-EU-EPS Nest
Grid spacing: 20 km
Layers: 60
Forecast range:
120 h at 00, 06, 12 and 18 UTC
30 h at 03, 09, 15 and 21UTC
1 grid element: 407 km²

COSMO-DE-EPS; M20
Grid spacing: 2.8 km
Layers: 50
Forecast range:
27/45 h at 00, 03, 06, 09, 12, 15, 18, 21 UTC
421x461 grid points
1 grid element: 8 km²





2 Forecast: Integriertes Vorhersagesystem (IVS)

Integrating Nowcasting

and

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

2 Forecast: Integriertes Vorhersagesystem (IVS)

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) .

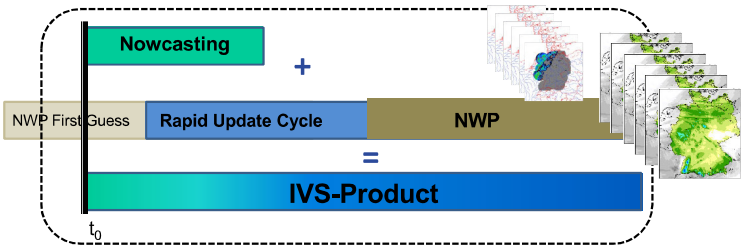
Nowcasting
Feature based, e.g. detection of convective cells in radar images; estimation of propagation speed and direction; „linear" extrapolation of detected objects/features. Update-rate of new forecasts ~ 5 to 15 min.

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).

2 Forecast: Integriertes Vorhersagesystem (IVS)

Seamless Detection and Ensemble Assimilation / Forecasting

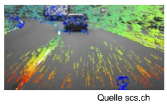


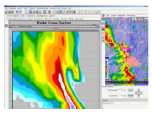
Combination of (advanced) Nowcasting and (improved) NWP

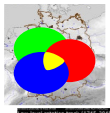
Integrated Forecasting System (IVS)

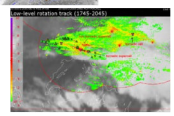
2 Forecast: Integriertes Vorhersagesystem (IVS) - Advanced Nowcasting

- Estimate the **uncertainty of Nowcasting products**
  - EPS for the calculation (on pixel level) 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 (KonRad-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 HIW**
  - Gust detection, rotation-track, VIL-track, VII-track
  - Reduce negative impact of wind turbines (renewable energy)
  - Use dual-polarization data, e.g. for rain/snow, hail size


Quelle scs.ch



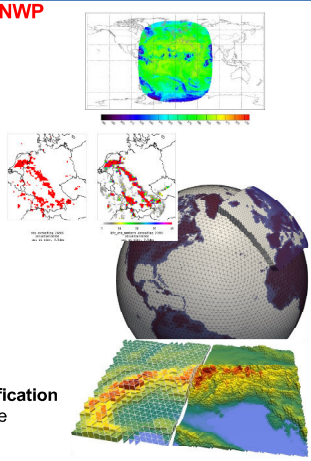


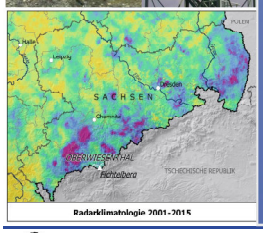


2 Forecast: Integriertes Vorhersagesystem (IVS) –

Further Development of convective scale NWP

- Assimilation of new **observations**
  - Radar volume data, consistence 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-EDA)
  - RUC forecasts
  - Ensemble (features, perturbations, calibration)
- Development of new **EPS-based products and verification**
  - Detection of HIW, precipitation, gusts, turbulence
  - Consistency between global and regional EPS





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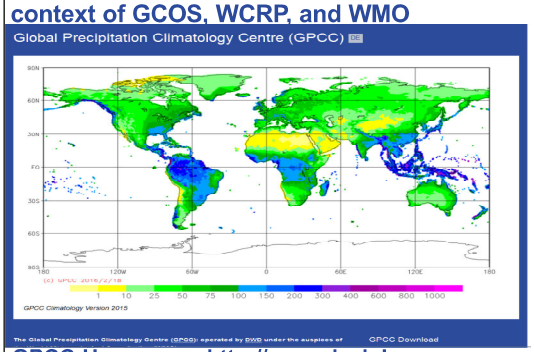
1. Motivation
2. Forecast
3. **Monitoring**
4. Warning
5. Hydro-Climatological Assessment

3 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

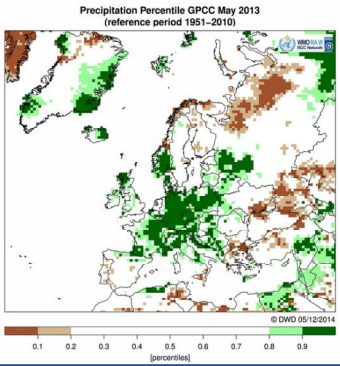
-> free access to the gridded GPCC analysis products

3 Monitoring Global: GPCC product portfolio extended recently

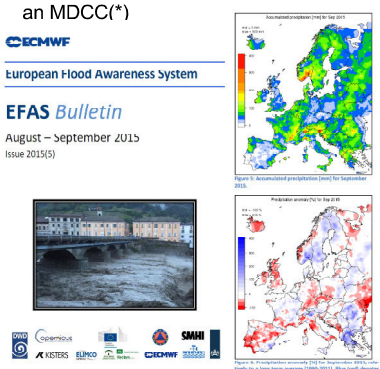
GPCC Product	Spatial Resolution	Time Coverage	DOI	Possible Application
First Guess Monthly	1.0°	2004 - present	Yes	drought monitoring
First Guess Daily	1.0°	2009 - present	Yes	analysis of extremes
Monthly Monitoring Version 5	1.0°, 2.5°	1982 - present	Yes	calibration of satellite data
Full Data Monthly Version 7	0.5°, 1.0°, 2.5°	1901 - 2013	Yes	hydrological studies
Full Data Daily Version 1	1.0°	1988 - 2013	Yes	analysis of extremes
HOAPS/GPCC global daily precipitation Version 1	0.5°, 1.0°, 2.5°	1988 - 2008	Yes	analysis of extremes
HOMPRA Europe Version 1 (coming soon)	1.0°	1951 - 2005	Not yet	trend analysis
VASClimo Dataset	0.5°, 1.0°, 2.5°	1951 - 2000	No	trend analysis
Precipitation Climatology Version 2015	0.25°, 0.5°, 1.0°, 2.5°	1951/2000	Yes	for application as a reference, and for utilization of the anomaly interpolation method
Interpolation Test Dataset	1.0°	1988	Yes	comparison of interpolation schemes
Drought Index Version 1	1.0°	2013 - present	Yes	drought monitoring
Drought Index Version 1.1	1.0°	1952 - 2013	Yes	drought monitoring

3 Monitoring Global: Regular Monitoring for WMO & EFAS

Percentile Plots to supplement precipitation anomaly analyses of GPCC for reporting in Bulletins of RCC RA VI and WMO report for special periods (decadal, pentad etc..)

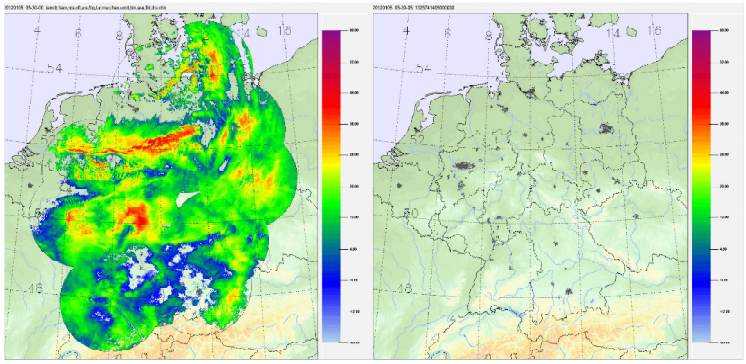


Copernicus EMS: GPCC is member of 2nd generation EFAS (European Flood Awareness System) in the function of an MDCC(*)



3 Monitoring National: Radar based precipitation analysis

From Precip-Scan to a the composite product of the network of 17 DWD radars



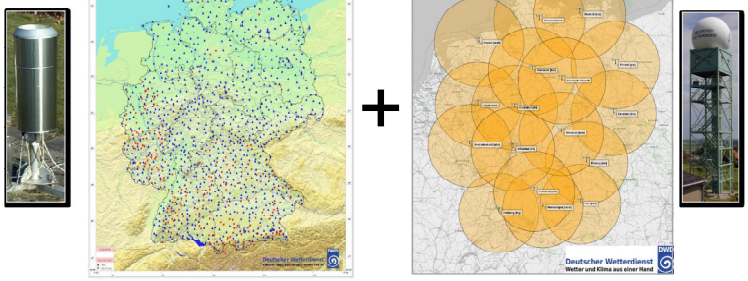
Provided every 5 Minutes

3 Monitoring: Quantitative precipitation analysis

RADOLAN – Radar Online Adjustment

Automatic precipitation stations of DWD and selected federal states (Nov 2015: 1226)

17 C-band Doppler radar sites



Quantification of the radar-based precipitation data with rain gauge data

3 Monitoring: The untapped source of radar data

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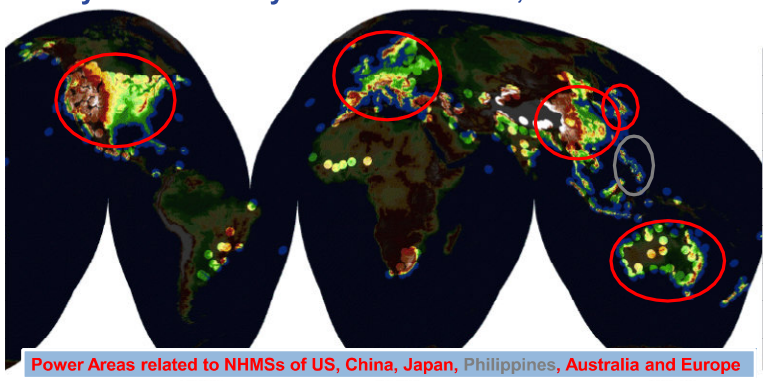
World wide weather radar coverage
> 800 systems listed by Heistermann et al., 2013



Power Areas related to NHMSs of US, China, Japan, Philippines, Australia and Europe

http://www.hydrol-earth-syst-sci.net/17/863/2013/hess-17-863-2013.pdf Heistermann et al. (2013), HESS

3 Monitoring: Quantitative precipitation analysis

RheinlandPfalz
LANDESAMT FÜR UMWELT, WASSERWIRTSCHAFT UND GEWERBEAUFSICHT

Customer (Federal State) Feedback

Heavy Precipitation in „Donnersbergkreis“ at 20.09.2014

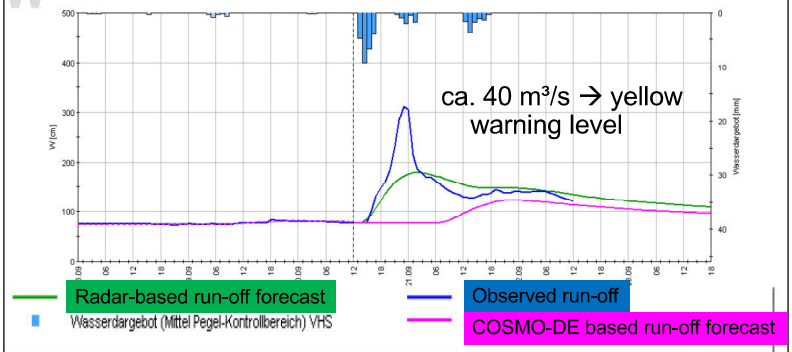
Photos:
Die Rheinpfalz – Online 22.09.2014

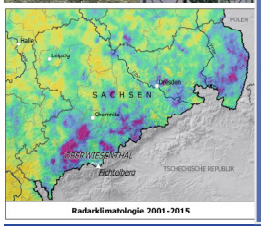
3 Monitoring: Quantitative precipitation analysis

RheinlandPfalz
LANDESAMT FÜR UMWELT, WASSERWIRTSCHAFT UND GEWERBEAUFSICHT

Customer (Federal State) Feedback

River gauge data at 20.09.2014, Pegel Altenbamberg / Alsenz





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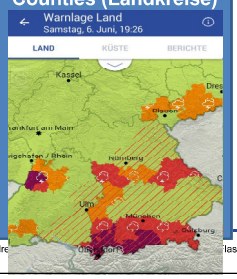
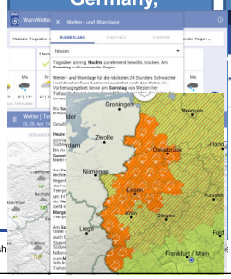
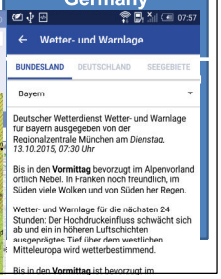
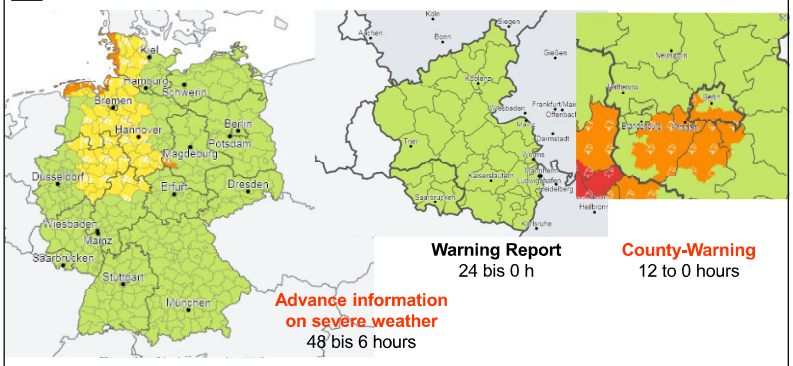
4 Warning: Three tier warning system of DWD

	Tier 1	Tier 2	Tier 3
Lead Time	0-2h 2-12h	12 - 48 h	48 - 120 h
Typ of warning	High Impact Warning	Advance warning	Early Warning
Product	county specific topic warnings	Warning reports Advance warnings	1-week forecast of weather hazards
Region	Counties (Landkreise)	Germany,	Germany
Base			

4 Warning: Three tier warning system of DWD



Warning Report
24 bis 0 h

County-Warning
12 to 0 hours

Advance information on severe weather
48 bis 6 hours

Lead time to event

Early Warnung
1-Week Forecast weather hazards
7 to 2 day

Event to be warned

4 Warning: DWD „WarnWetter"-App

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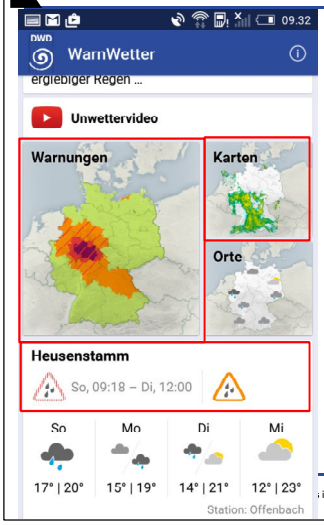
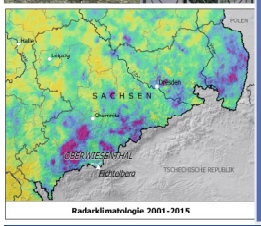
Wetter und Klima aus einer Hand



- Focus on warnings and related relevant meteorological parameters
  - Currently specific for "Landkreise" (counties)
  - Warning displayed on maps and for locations
  - Push service for weather warnings
  - Local monitoring function (Thunderstorms-, Heavy Precipitation)
- Available for Android and iOS
  - + Blackberry for civil protection features without push service and google/apple-maps
  - Windows Phone-Version Q4 2016
    - allows also for a Desktop-Version

➔ Context-Information is provided
- Radar- and Satellite data,
- Local and Area specific forecasts,
- Observations

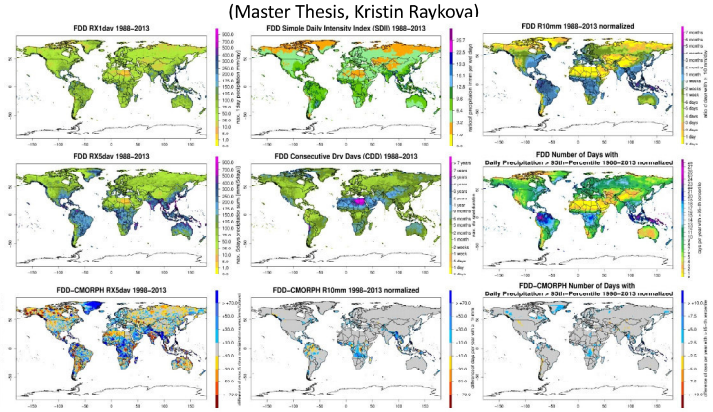


DWD Capabilities in the Field of Extreme Flash Flood Generating Precipitation with a view on Forecast, Monitoring, Warning and Hydro-Climatological Assessment

1 Motivation
2 Forecast
3 Monitoring
4 Warning
5 Hydro-Climatological Assessment

5 Hydro-Climatological Assessment – Climate Extremes

Utilization of GPCC Full Data Daily for extreme precipitation assessment
Statistical Evaluation or ETCCDI for 1988-2013
(Master Thesis, Kristin Raykova)



5 Hydro-Climatological Assessment – Map Erosion Risks

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

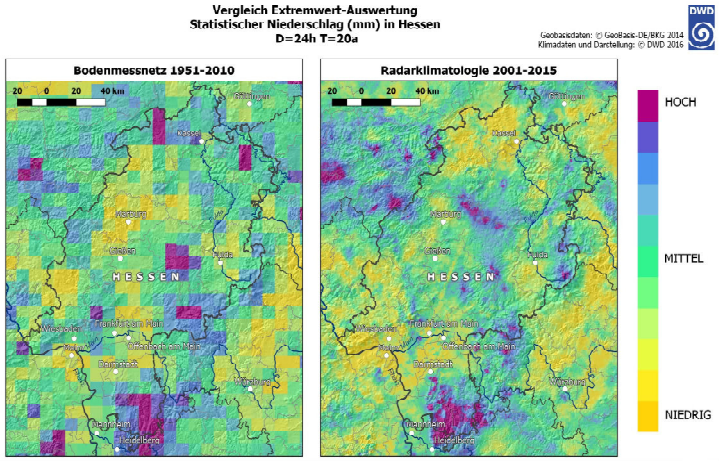
- Current status: based on gauge data
  - Annual precipitation sums
- Perspective: based on radar QPE
  - Event erosivity
  - Quasi-adjusted RADOLAN 5-minute data
- First approach:
  - RADOLAN hourly sums (RW)
  - ***without outlier handling***
  - Assumption: *I_30_max* = **1,3** x *I_60_max* → ***too low***

Agriculture

Erosion monitoring, „R-Factor“

Source: BGR

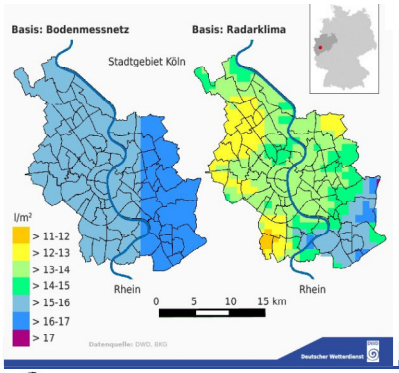
5 Hydro-Climatological Assessment – Map Precipitation Risks



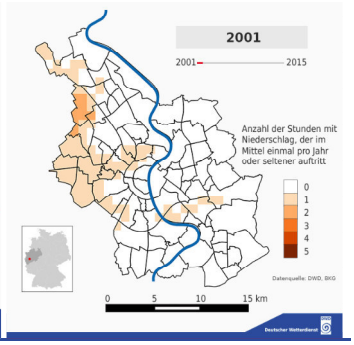
5 Hydro-Climatological Assessment

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



E Summary

- DWD runs and further develops it's 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