Priority Programme DFG
“Quantitative Precipitation Forecast”:

Scientific Preparation and Coordination of the SSP 1167 Intensive Observations Period (IOP)

Characteristics of the Experimental Region*

Southern German Low Mountain Region

* proposed by
Institute for Meteorology and Climate Research,
(University Karlsruhe/Research Center Karlsruhe)
Institute of Physics and Meteorology
(University of Hohenheim)

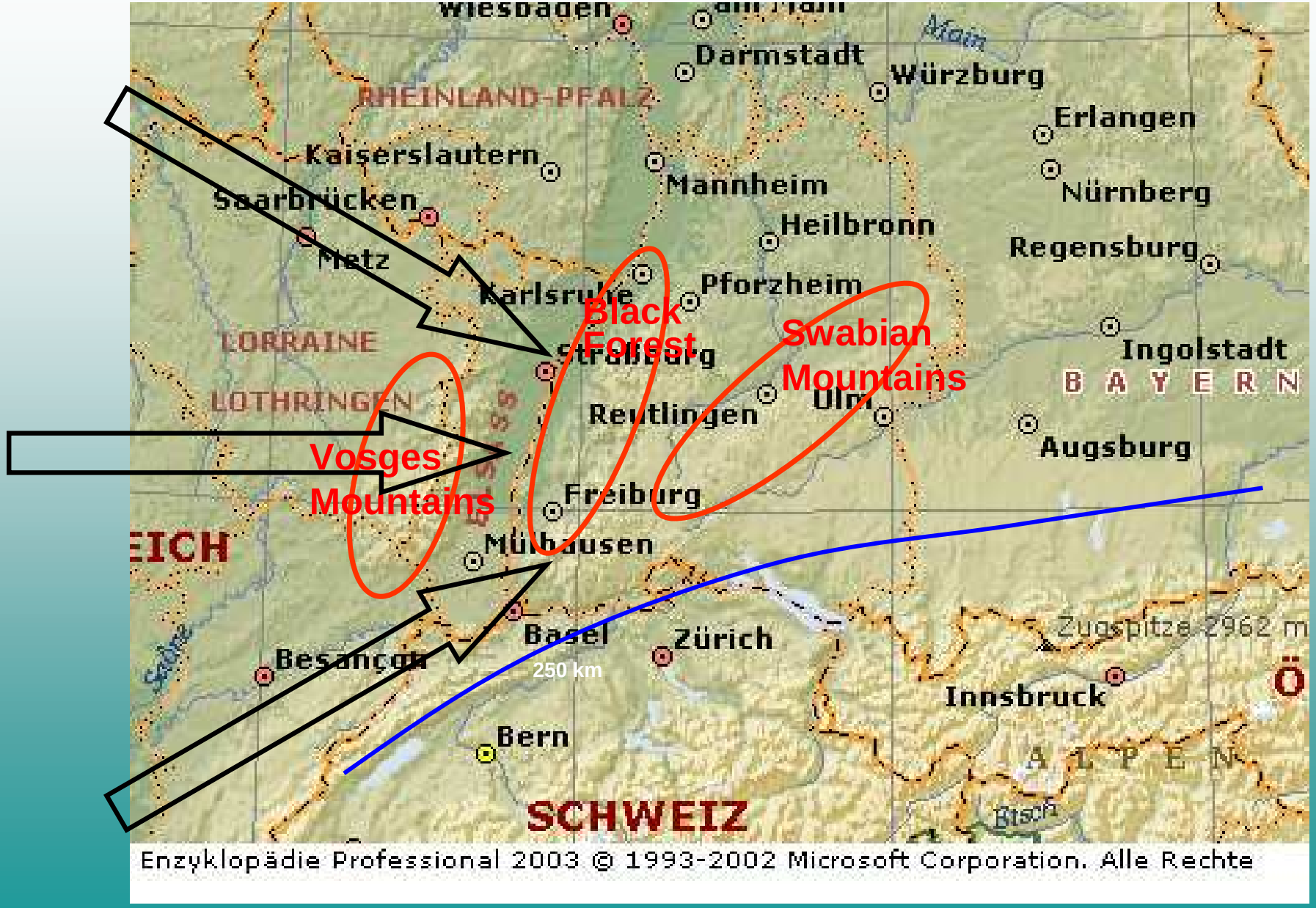
Scientific Preparation and Coordination of the SSP 1167 Intensive Observations Period (IOP)

Characteristics of the Southern German Low Mountain Region

- Orography and land use
- Weather characteristics
- Forecast validation for Limited Area Model LM (DWD)

Orography Europe

Orography


Wiesbaden
Darmstadt
Main
Würzburg
RHEINLAND-PFALZ
Erlangen
Kaiserslautern
Mannheim
Nürnberg
Saarbrücken
Heilbronn
Metz
Regensburg
Karlsruhe
Pforzheim
Black Forest
Swabian Mountains
LORRAINE
LOTHRINGEN
Straßburg
Ingolstadt
BAYERN
Reutlingen
Ulm
Augsburg
Vosges Mountains
Freiburg
Mülhausen
Basel
Zürich
Zugspitze 2962 m
Besançon
250 km
Innsbruck
Bern
SCHWEIZ
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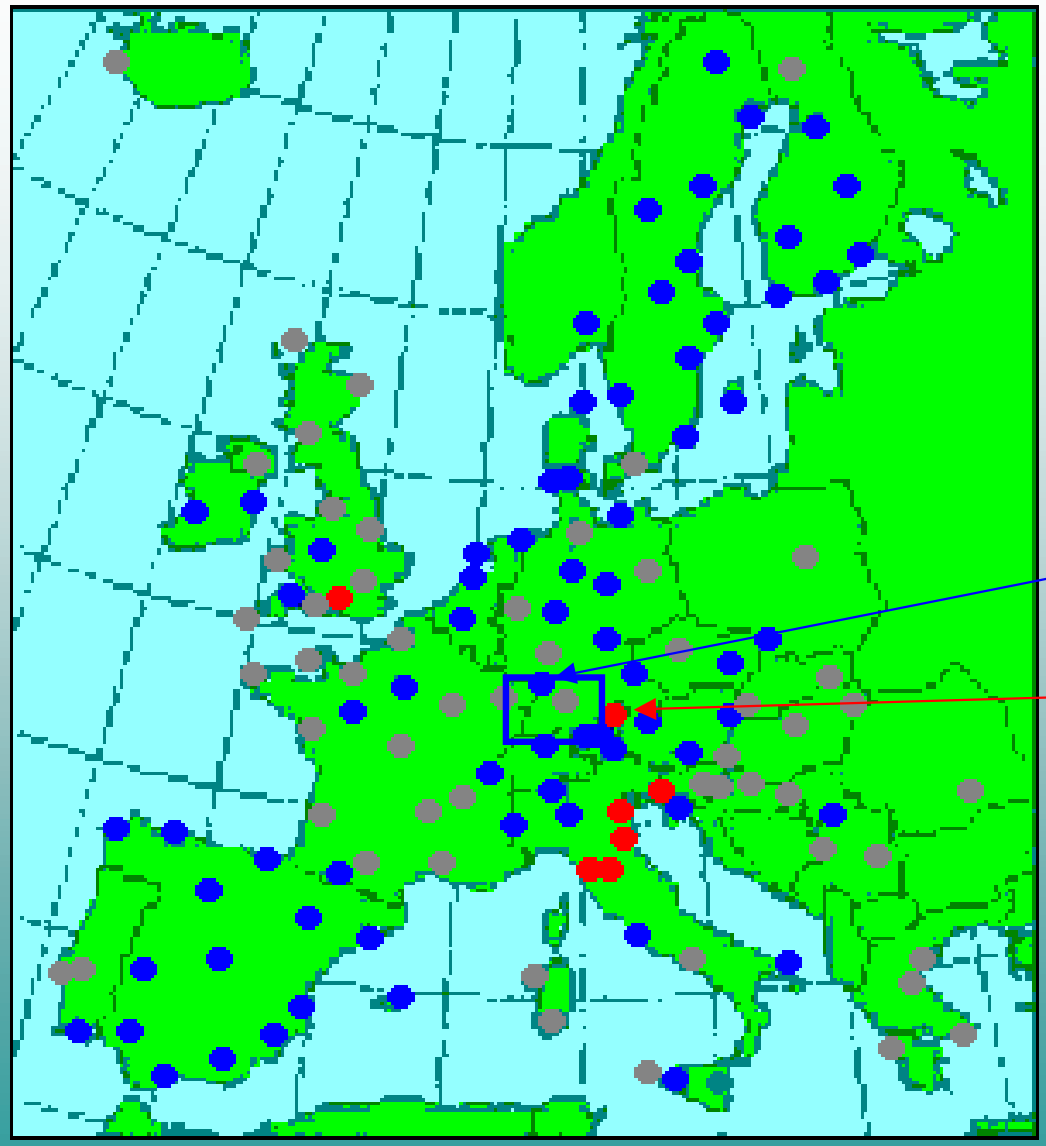
Orography world

Station networks

Precipitation Radar Network



conventional weather radar
doppler radar
polarimetric doppler radar

Research Radar Systems

FZK Doppler Radar continuously operated since 1996

DLR Polarisation Doppler Radar

U Bonn Doppler Radar

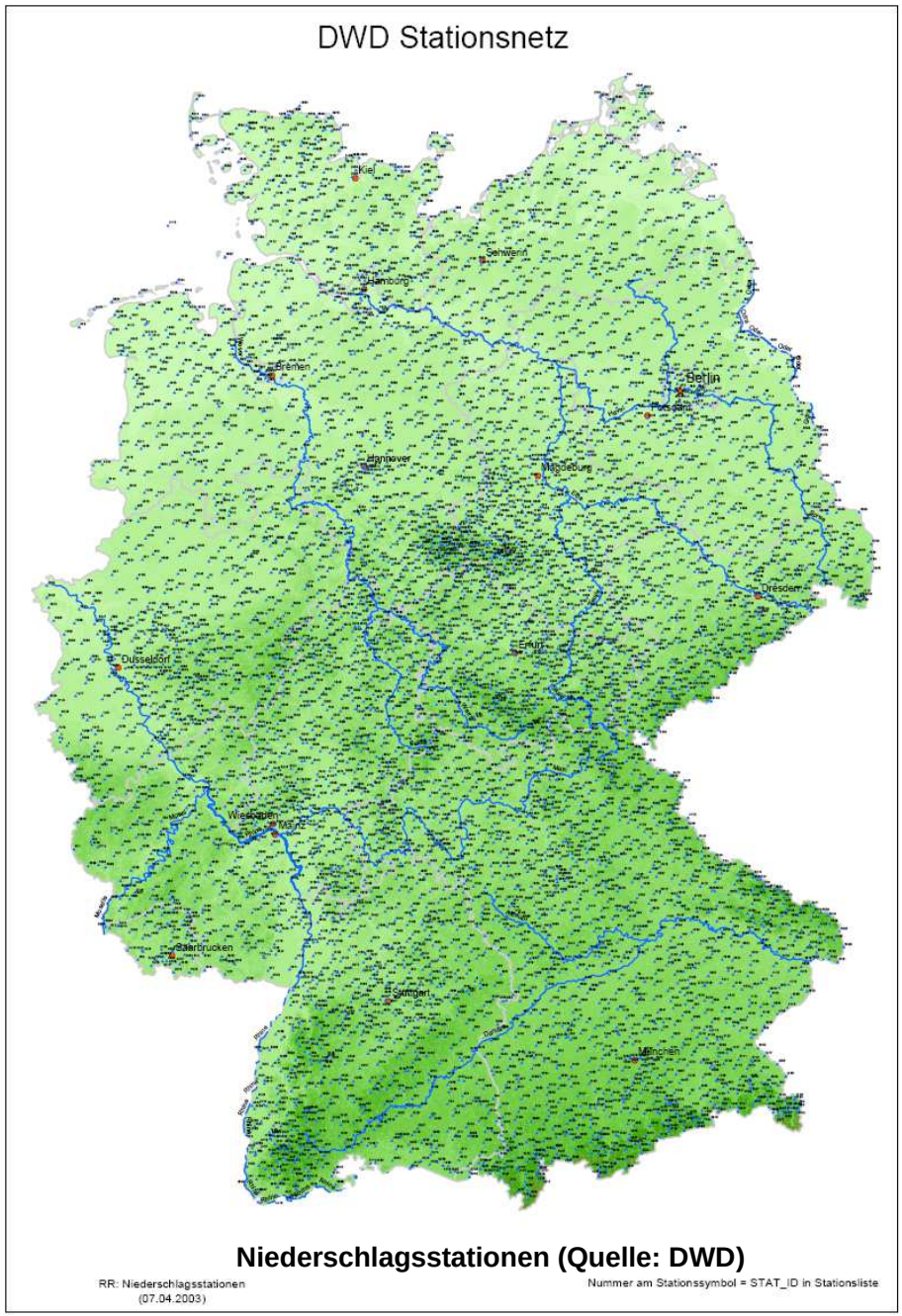
Aerological stations

Aerological stations (Quelle: DWD)

Synop-Stations

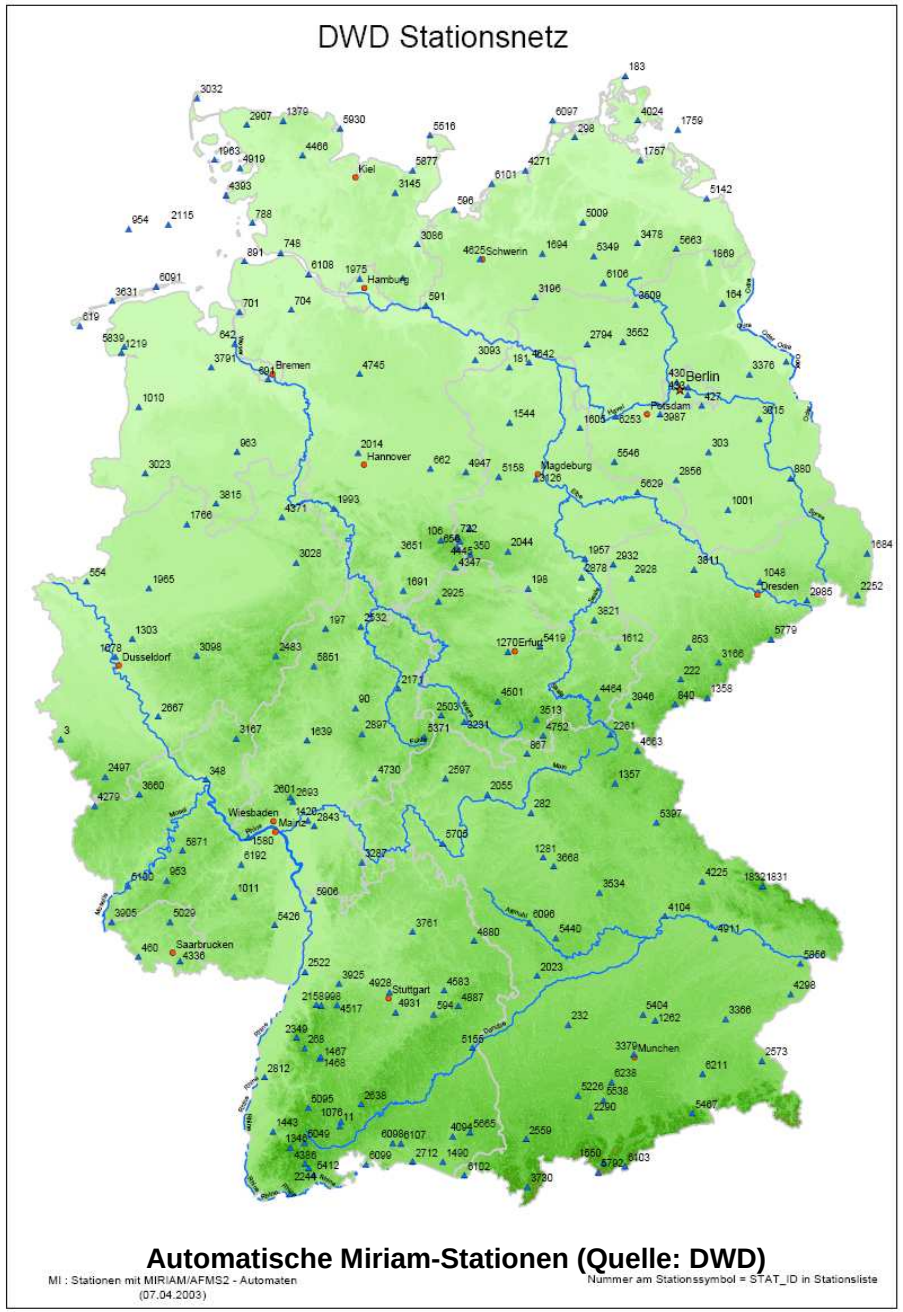
Synoptic station network (Quelle: DWD)

Rain gauges



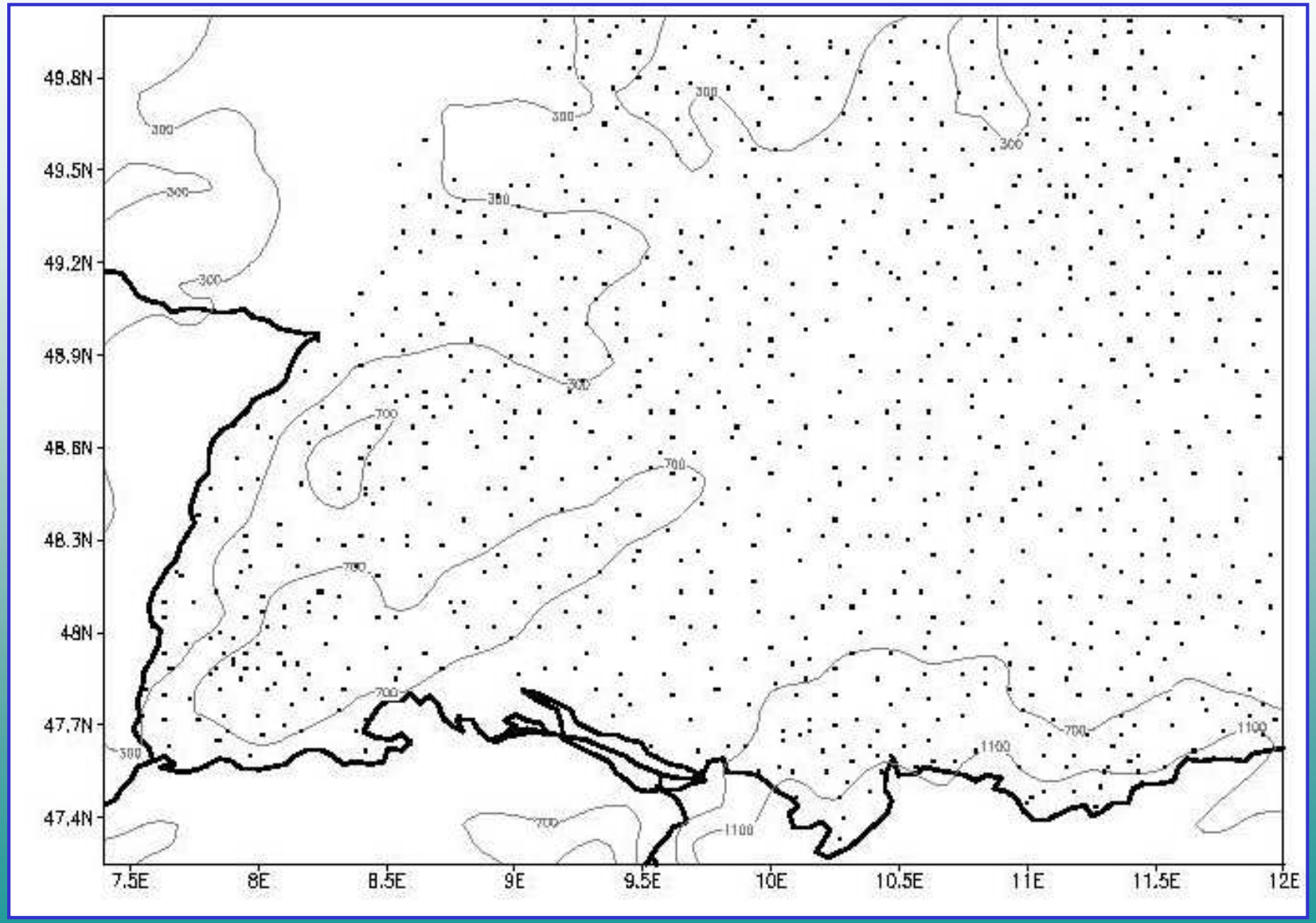
Niederschlagsstationen (Quelle: DWD)

automatic Miriam

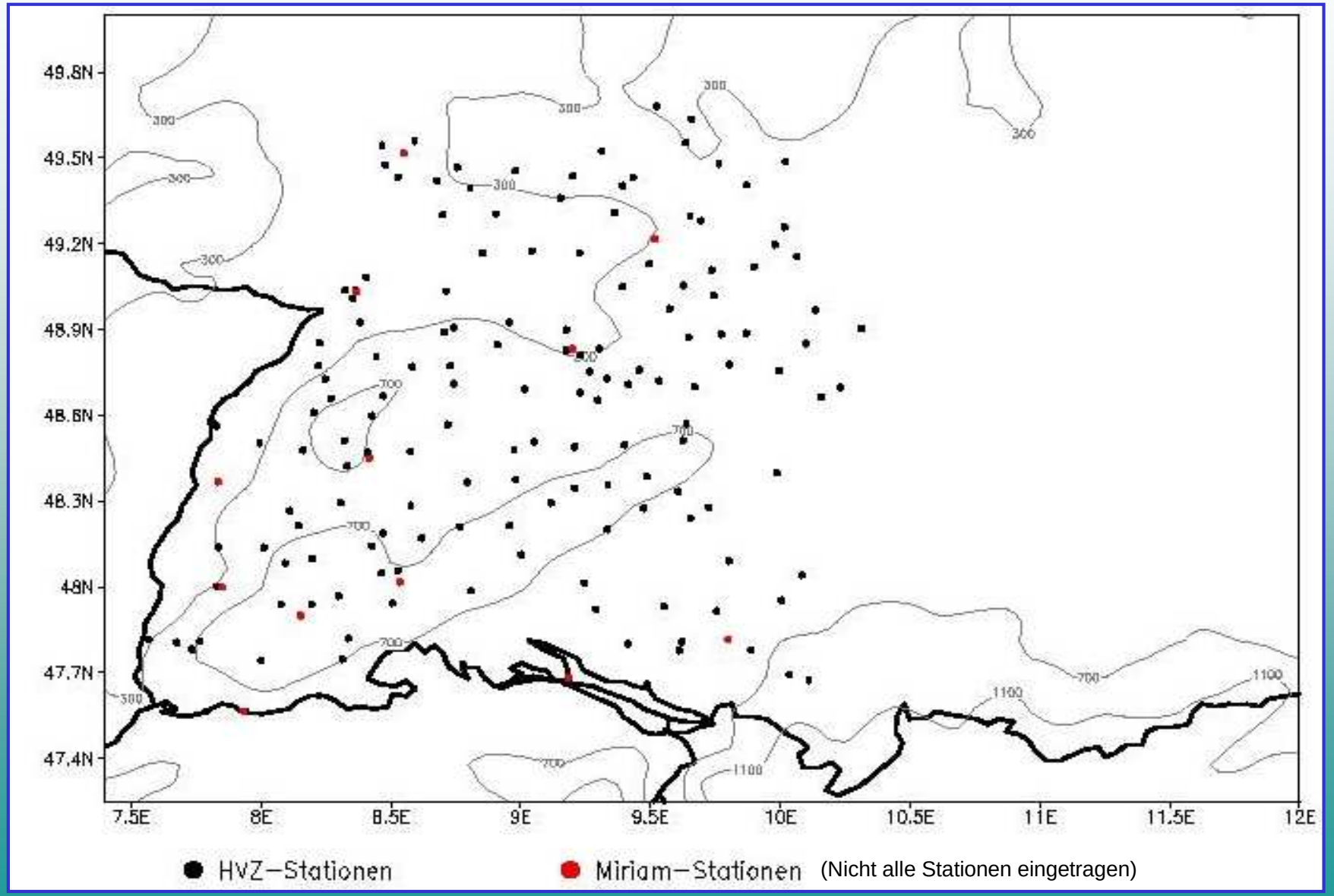


Automatische Miriam-Stationen (Quelle: DWD)

904 DWD-precip stations in Figure
24-hour sums

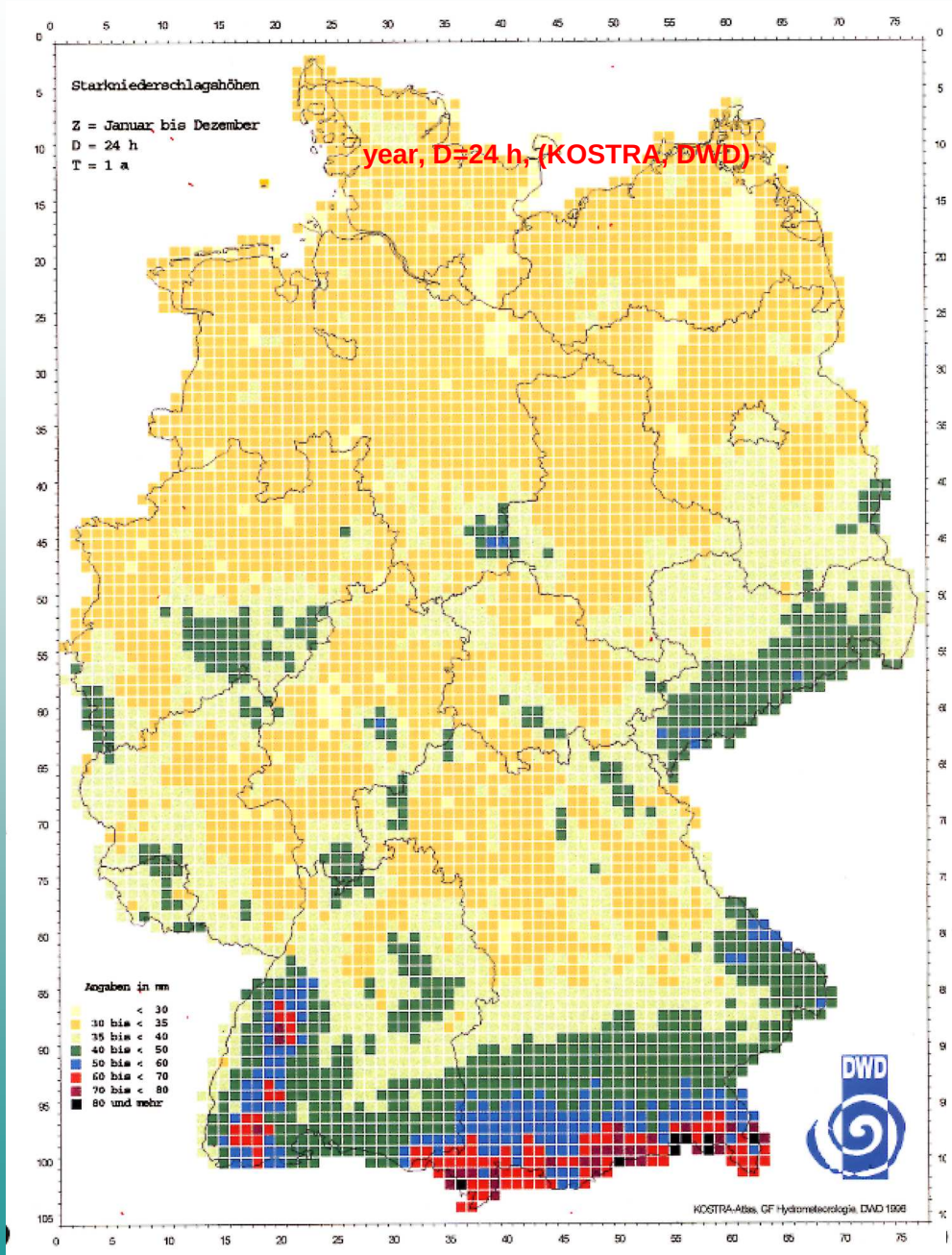


158 stations of Hochwasservorhersagezentrale BaWü: 10-minute resolution
34 DWD-MIRIAM stations: 10 minute resolution

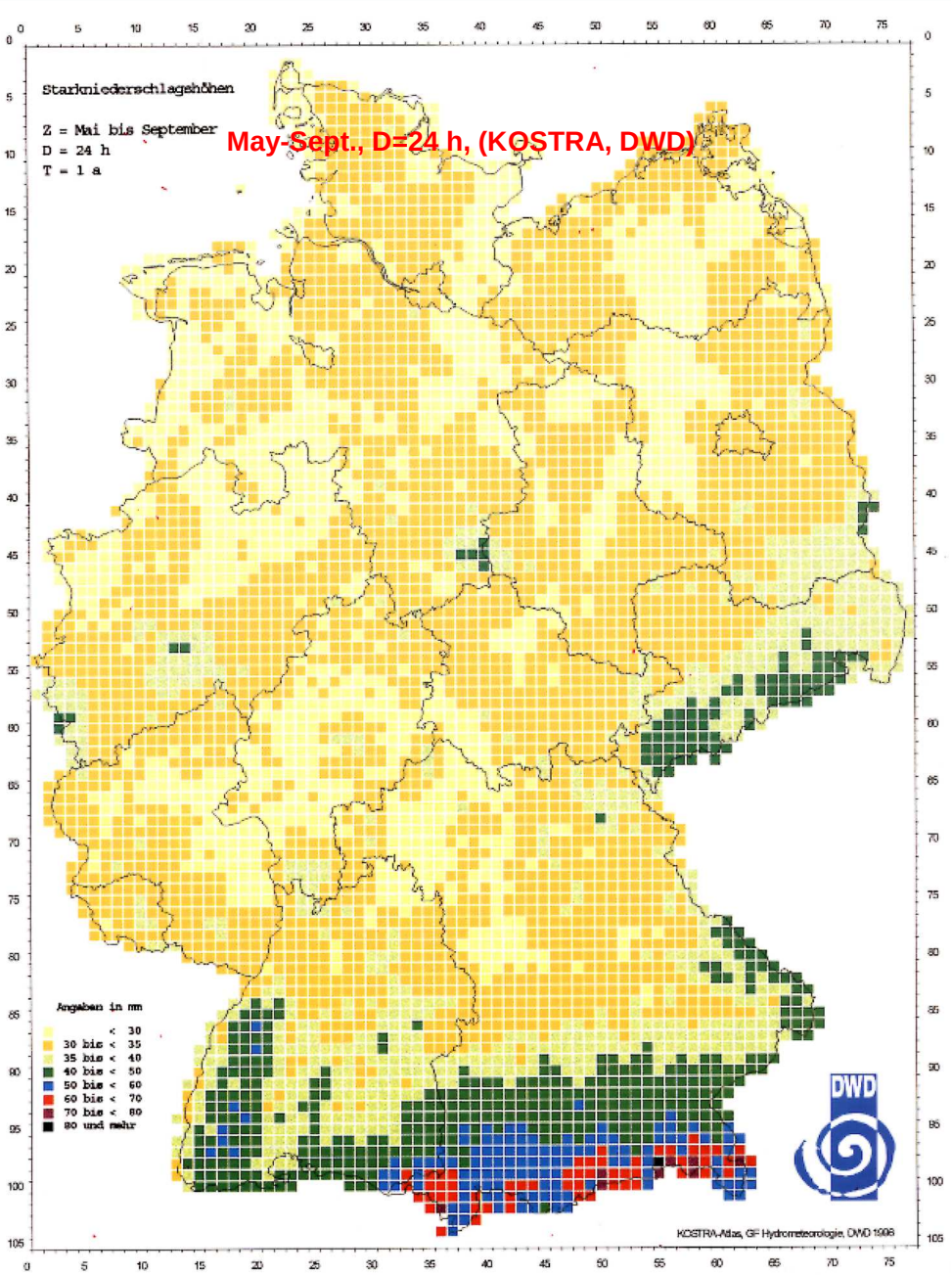


Weather, precipitation

Heavy precipitation in Germany

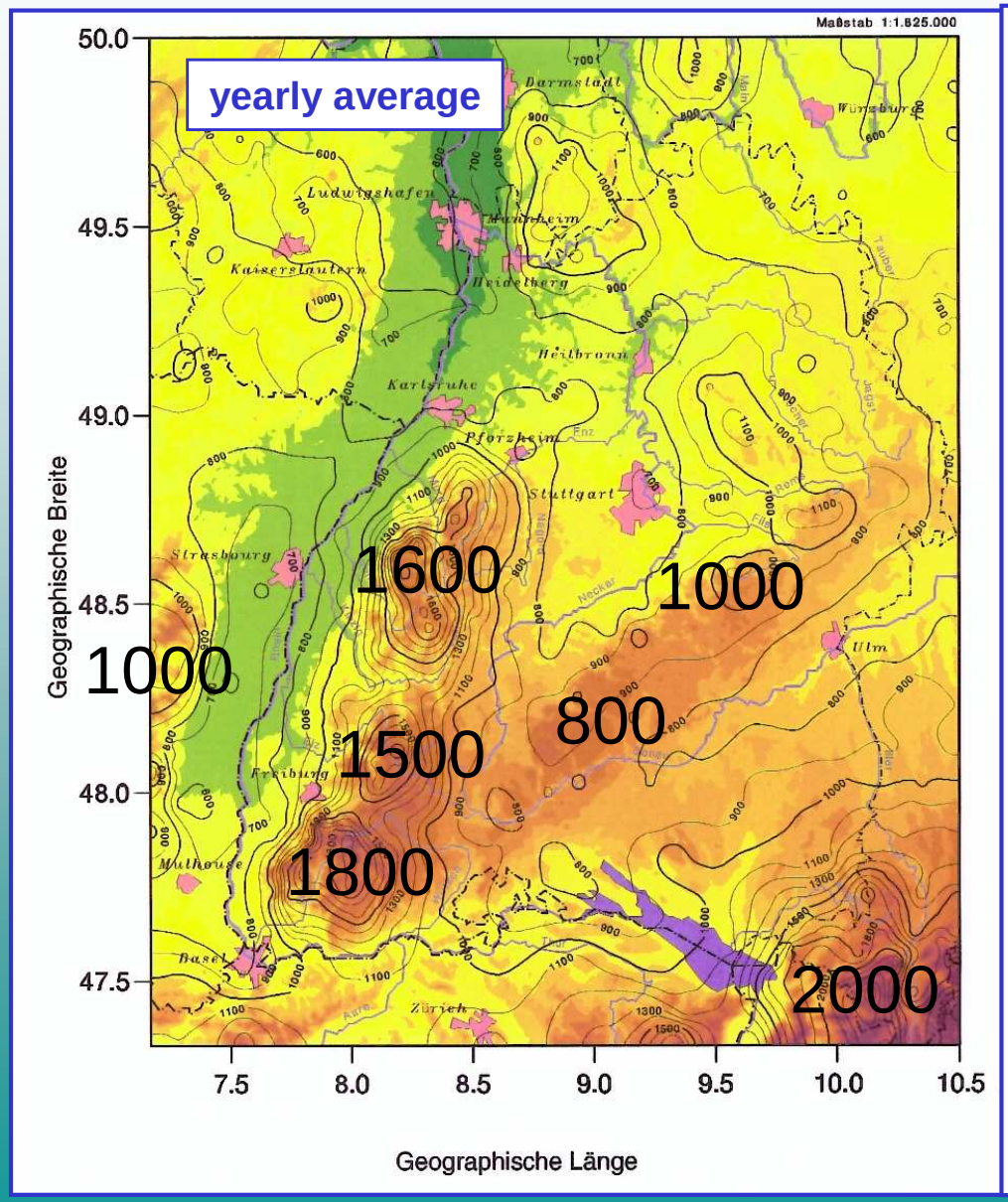


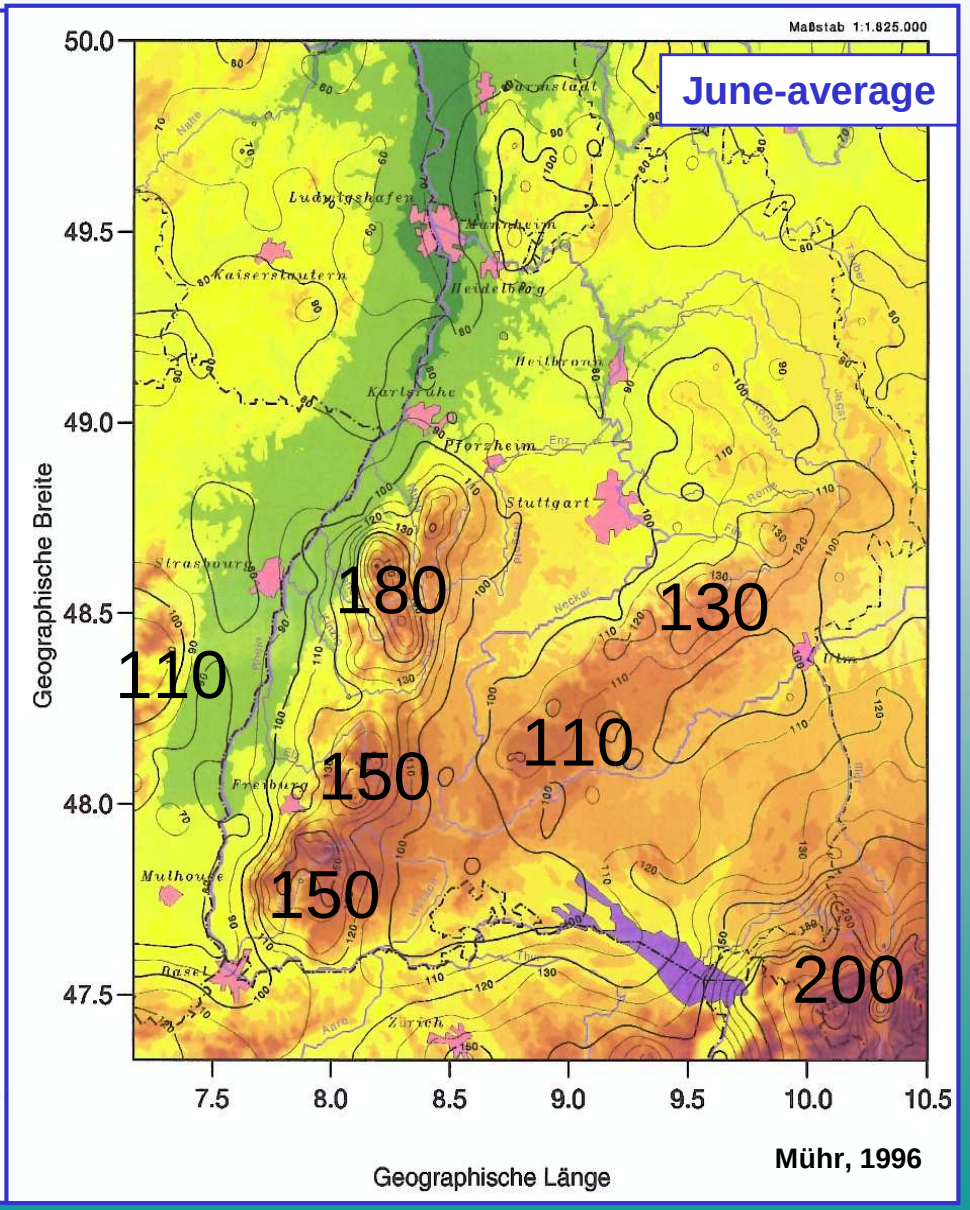
year, D=24 h, (KOSTRA, DWD)



May-Sept., D=24 h, (KOSTRA, DWD)

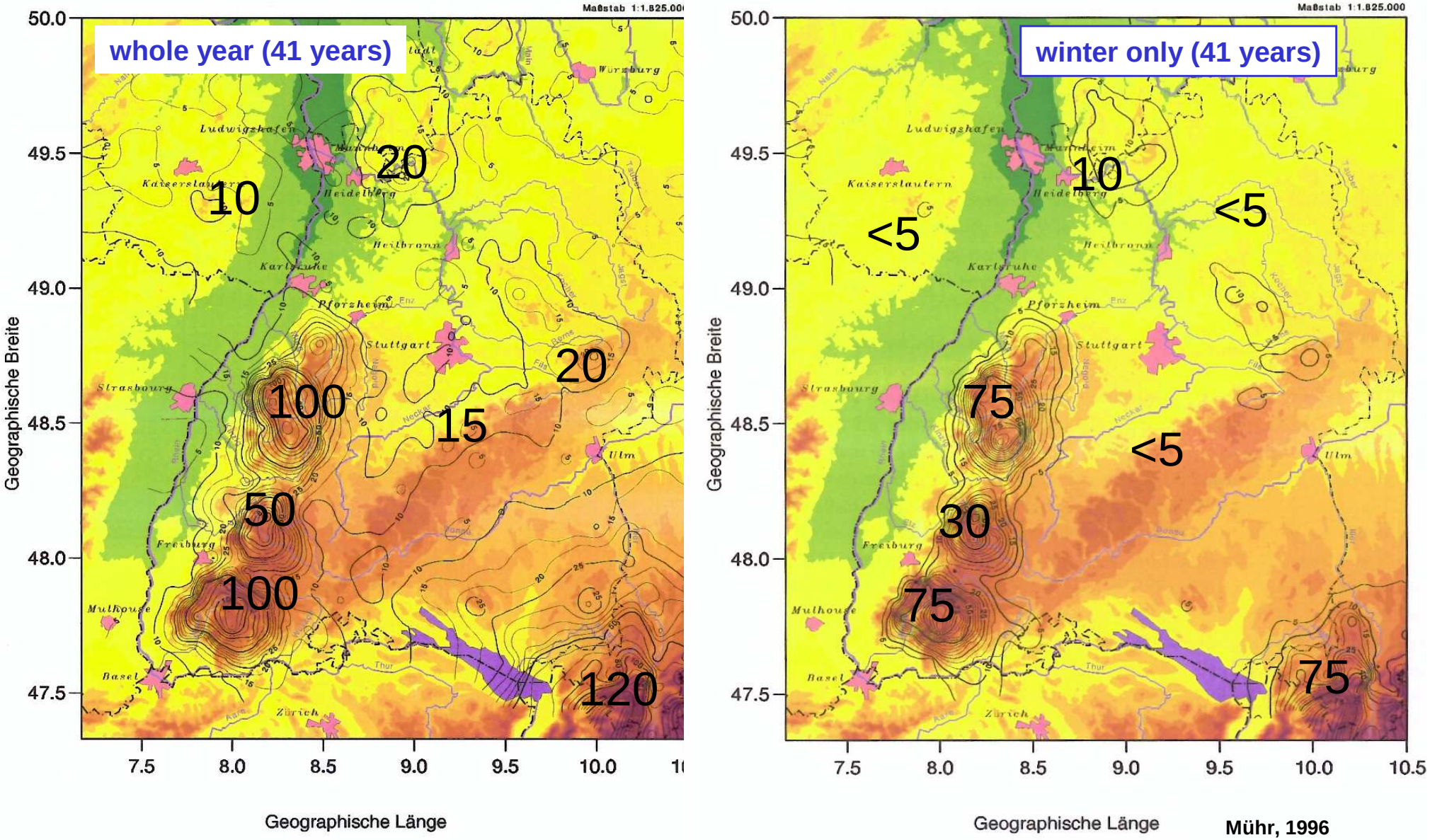
Average precipitation in Southern Germany





Mühr, 1996

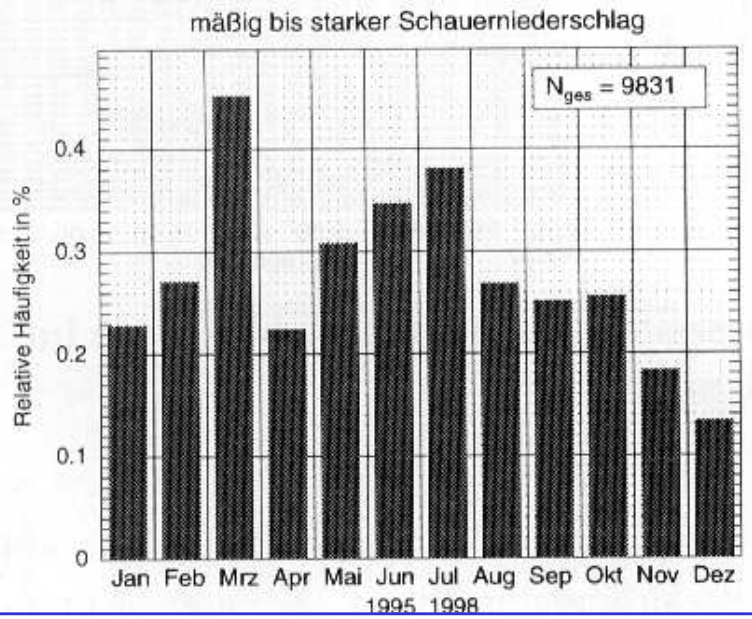
days with heavy rain > 50 mm/d

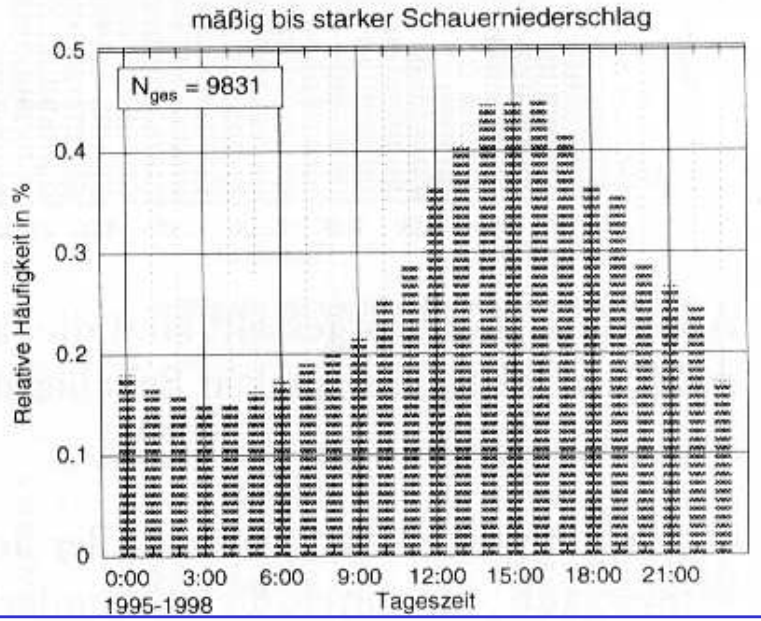


Mühr, 1996

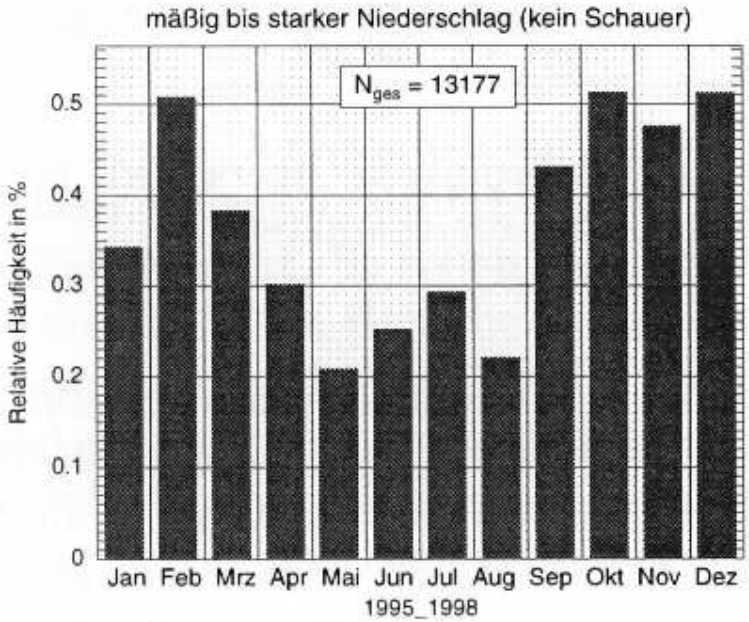
Mean seasonal and diurnal cycles of precipitation

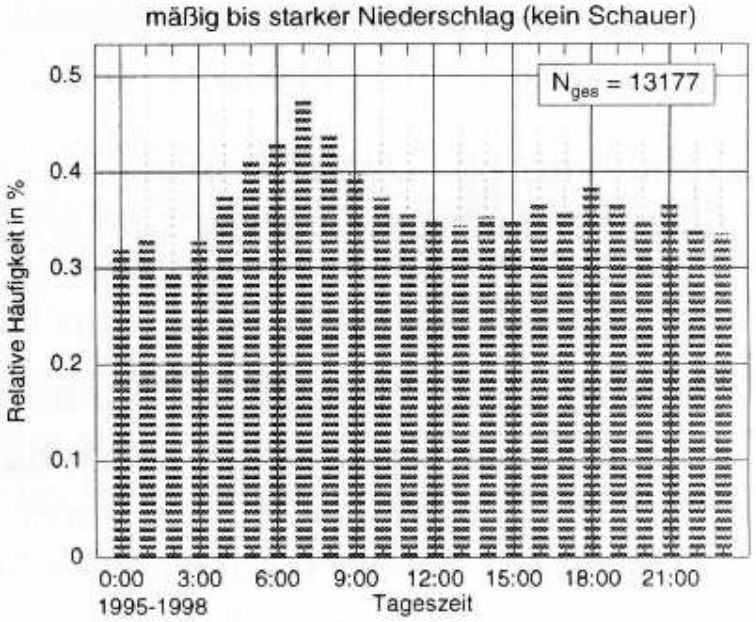
moderate and heavy rain, shower





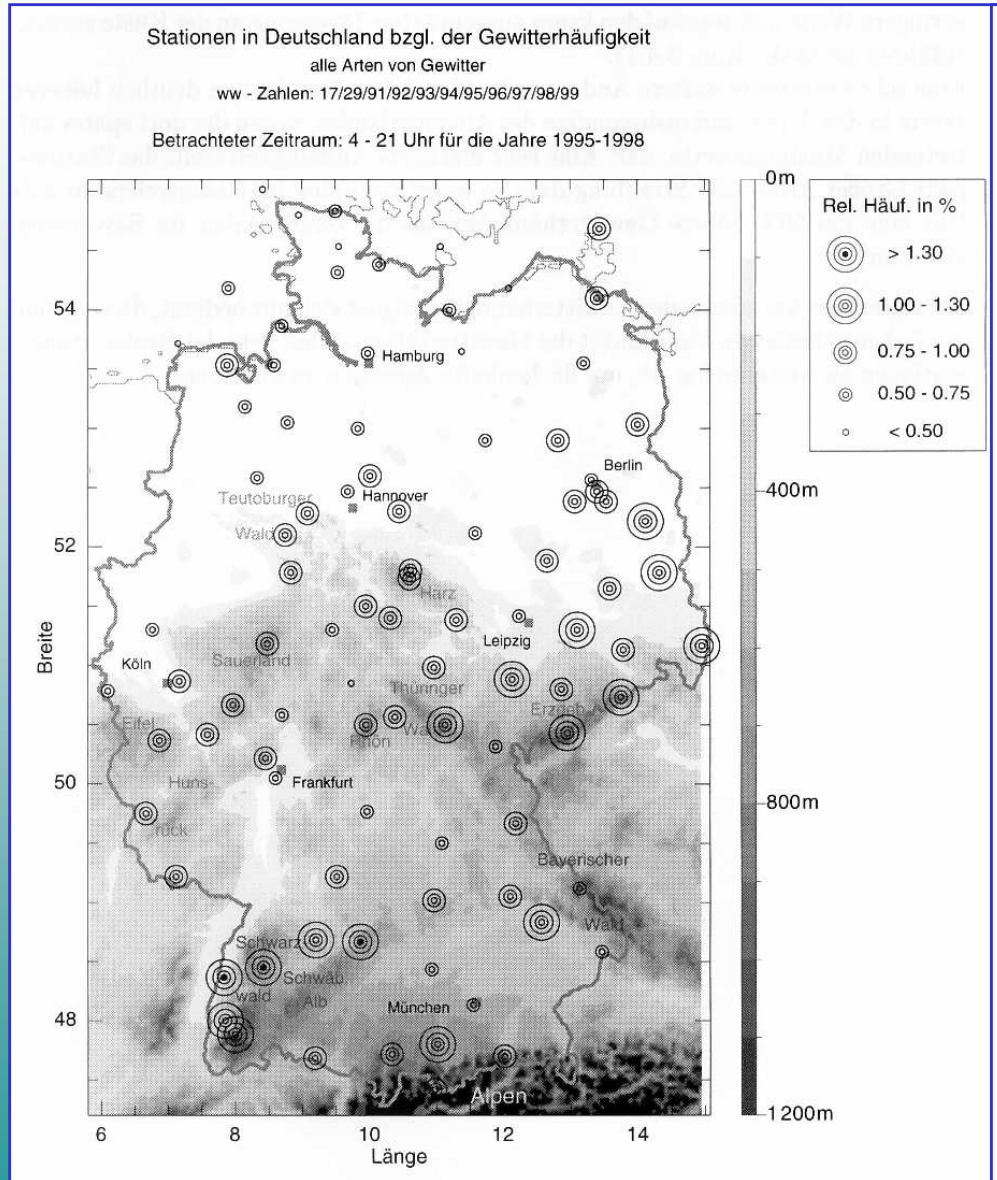
moderate and heavy rain, no shower

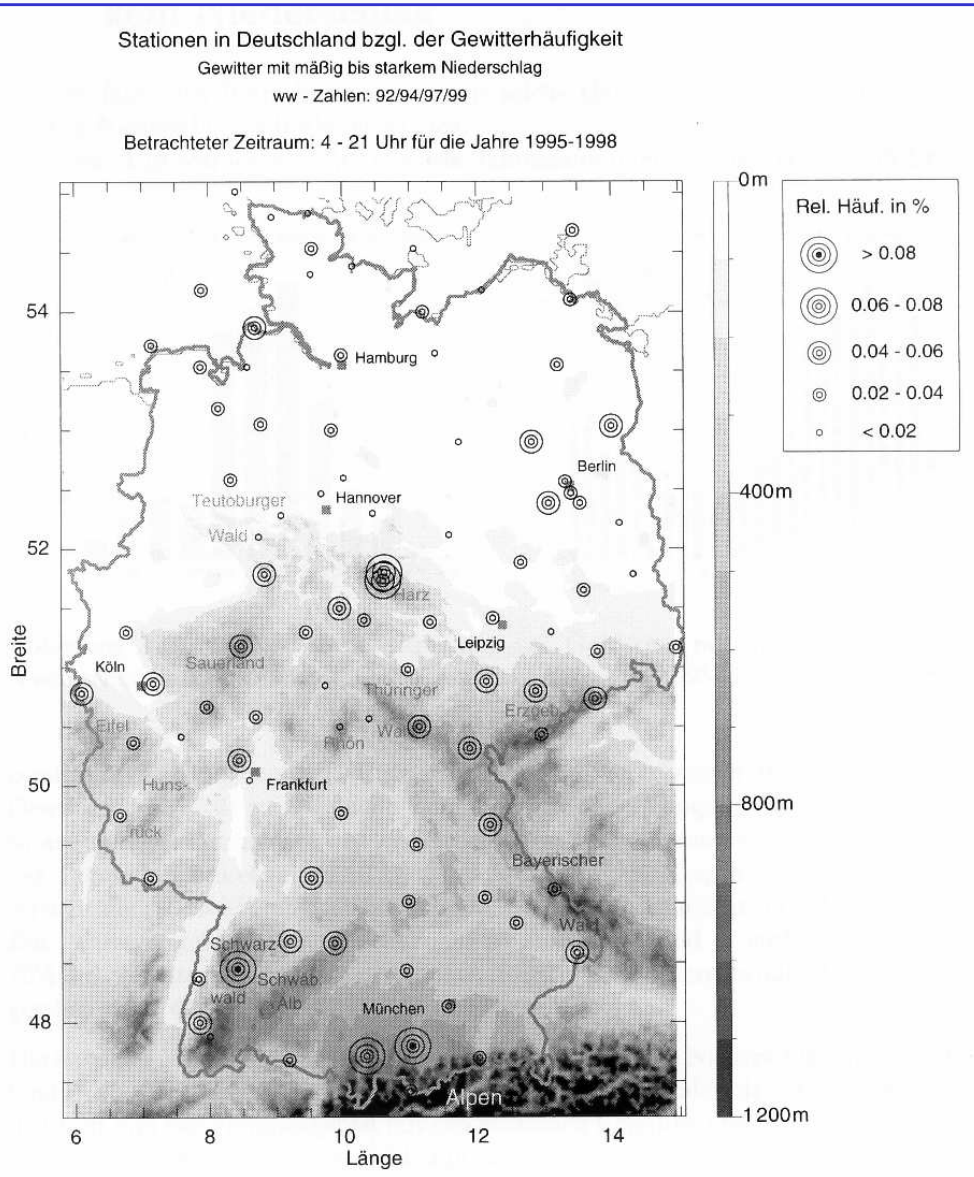




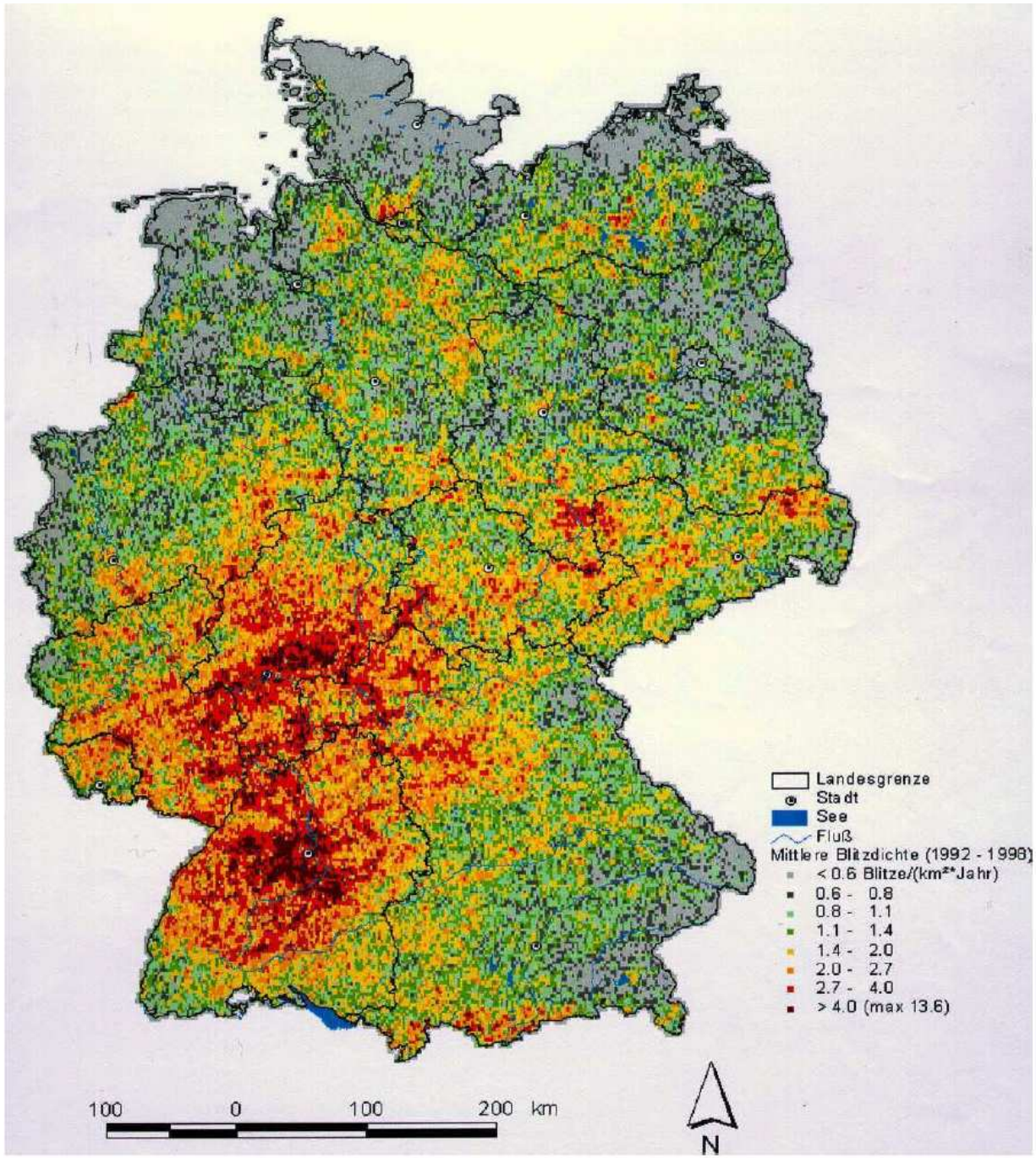
Hofherr, 1999

Thunderstorm frequencies



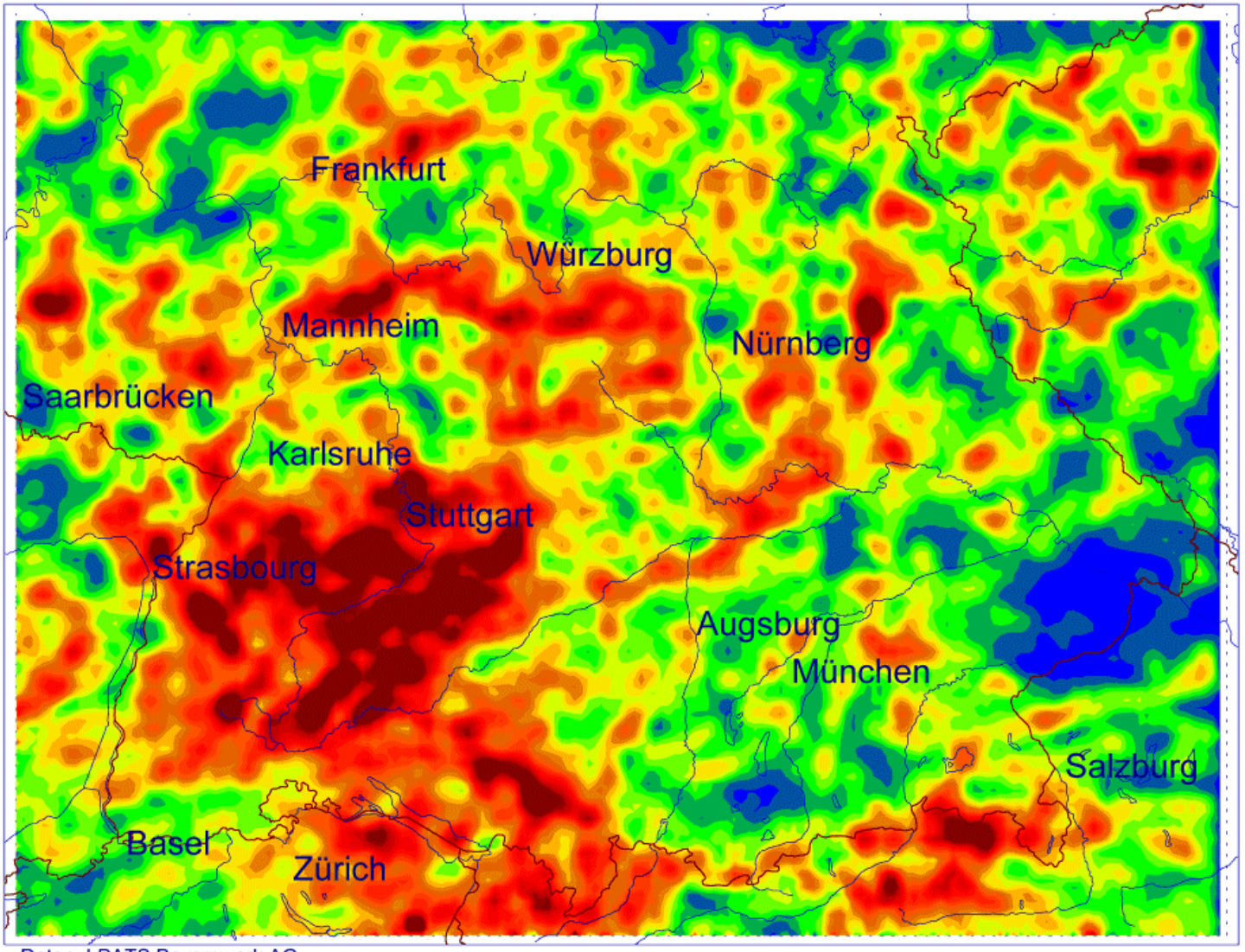


Quelle, DWD Synop-Daten, Hofherr,1999



Average lightning frequency: number/km^2/year

1992-1998, GDV der Deutschen Versicherer



lightning density 1994

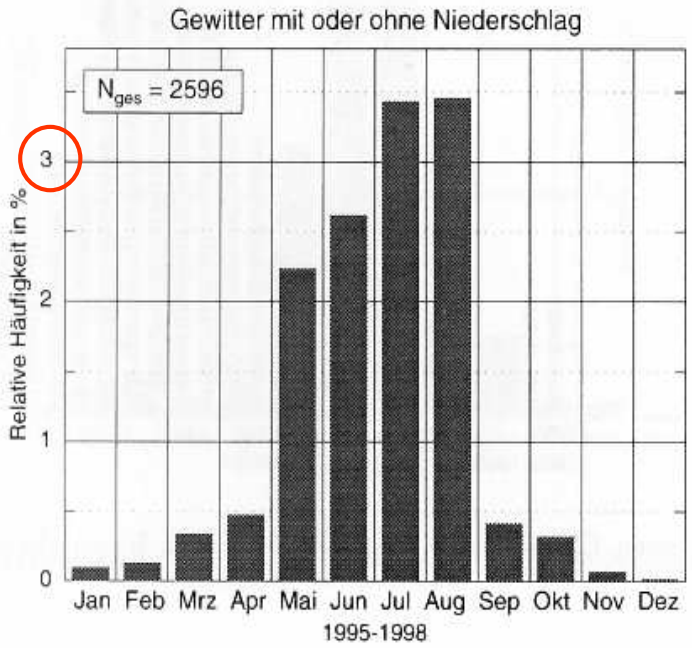
- maximum northern BF, Swabian mountains
- numbers/km^2 vary from 0 to 10 in the 1990s
- similarity of spatial distribution in different years

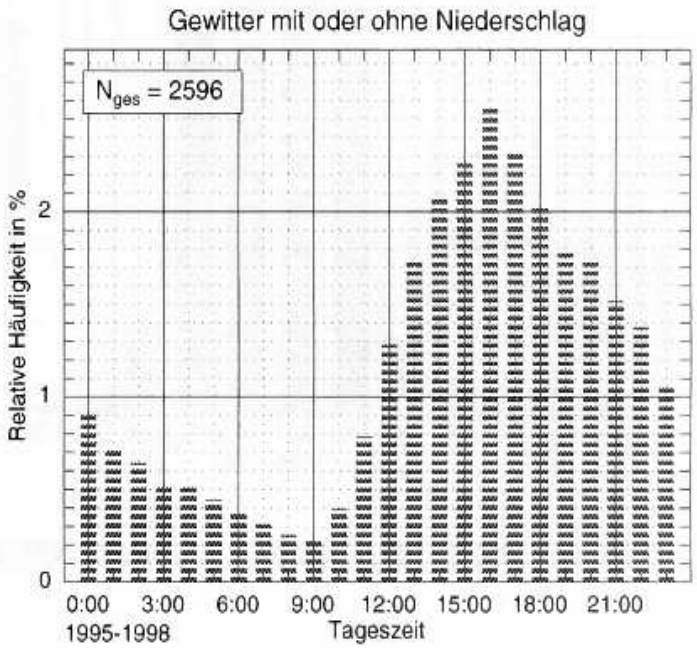
Finke und Hauf, 1999

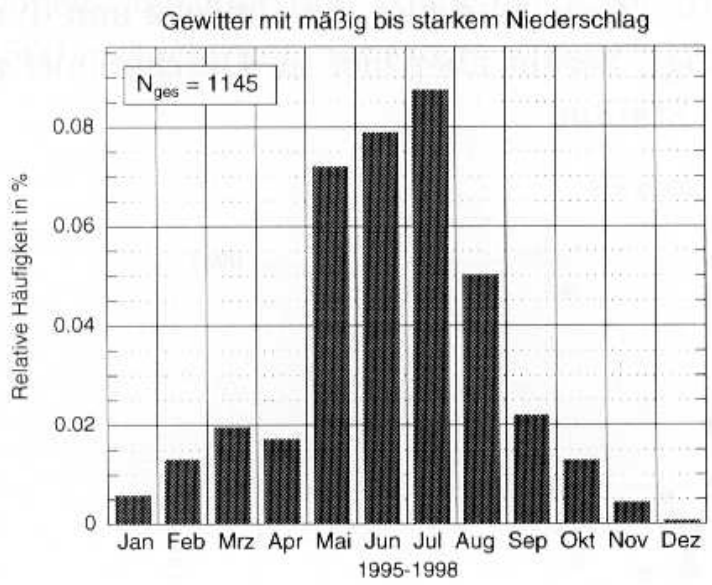
Mean seasonal and diurnal cycles of thunderstorms

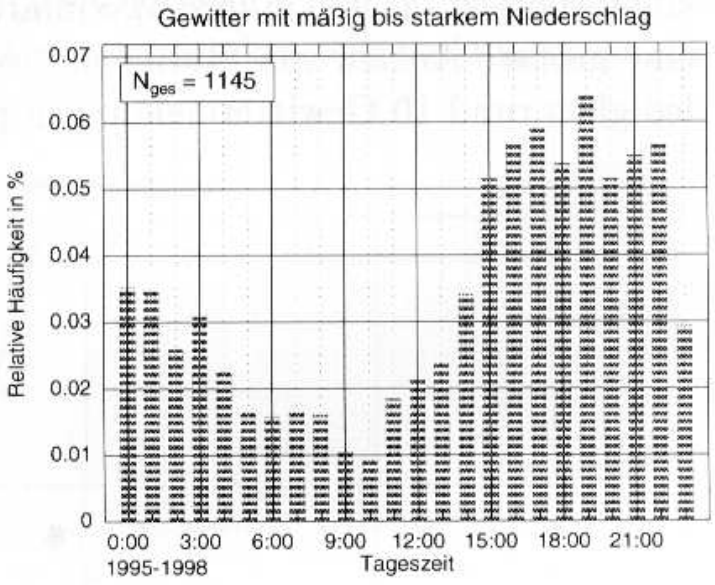
Black Forest, Swabian Mountains

Germany







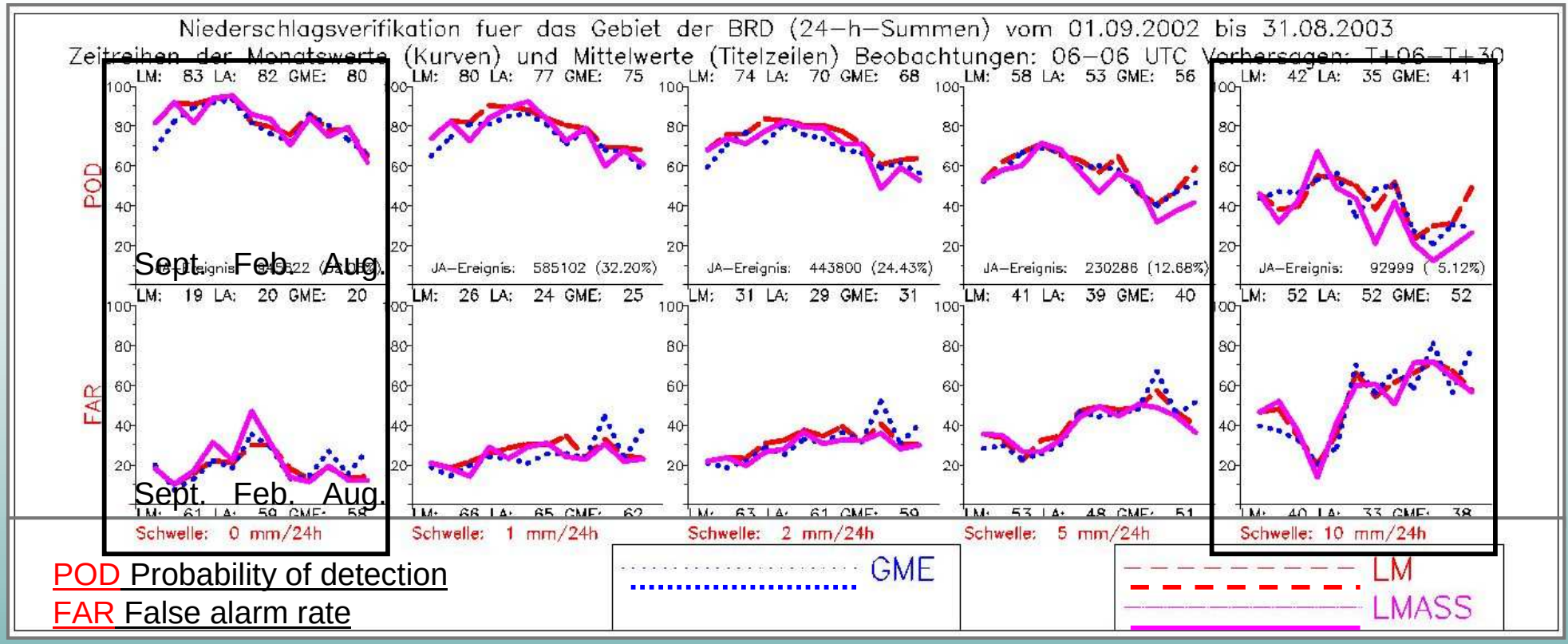


Hofherr, 1999

How well is precipitation forecasted by Limited Area Model LM ?

- **DWD verification results exist only for Germany**
- **IMK studied 11 cases of precip forecasts Southern Germany**

GME und LM verification for Germany (Damrath und Heise, DWD, 2003)



POD Probability of detection
FAR False alarm rate

Rain at all:

- **all models POD > 70 %, poorer in summer**
- **all models FAR < 40 %, poorer in spring**

> 10mm/day:

- **all models POD < 50 % in summer**
- **POD(LMASS) < POD (LM, GME)**
- **all models FAR > 60 % in summer**

QPF problems with LM (Heise, DWD):

General problem areas:

- parametrization of precip formation
- data assimilation
- verification

Convection related:

- **large errors at high precipitation**
- **wrong positioning**
- **wrong diurnal cycle of convection (too much rain too early)**
- **precipitation is too widespread - without structure**
- **mesoscale humidity variations remain unrepresented**
- **dynamical influences on precip formation seems to be wrong**

How well is precipitation forecasted by Limited Area Model LM ?

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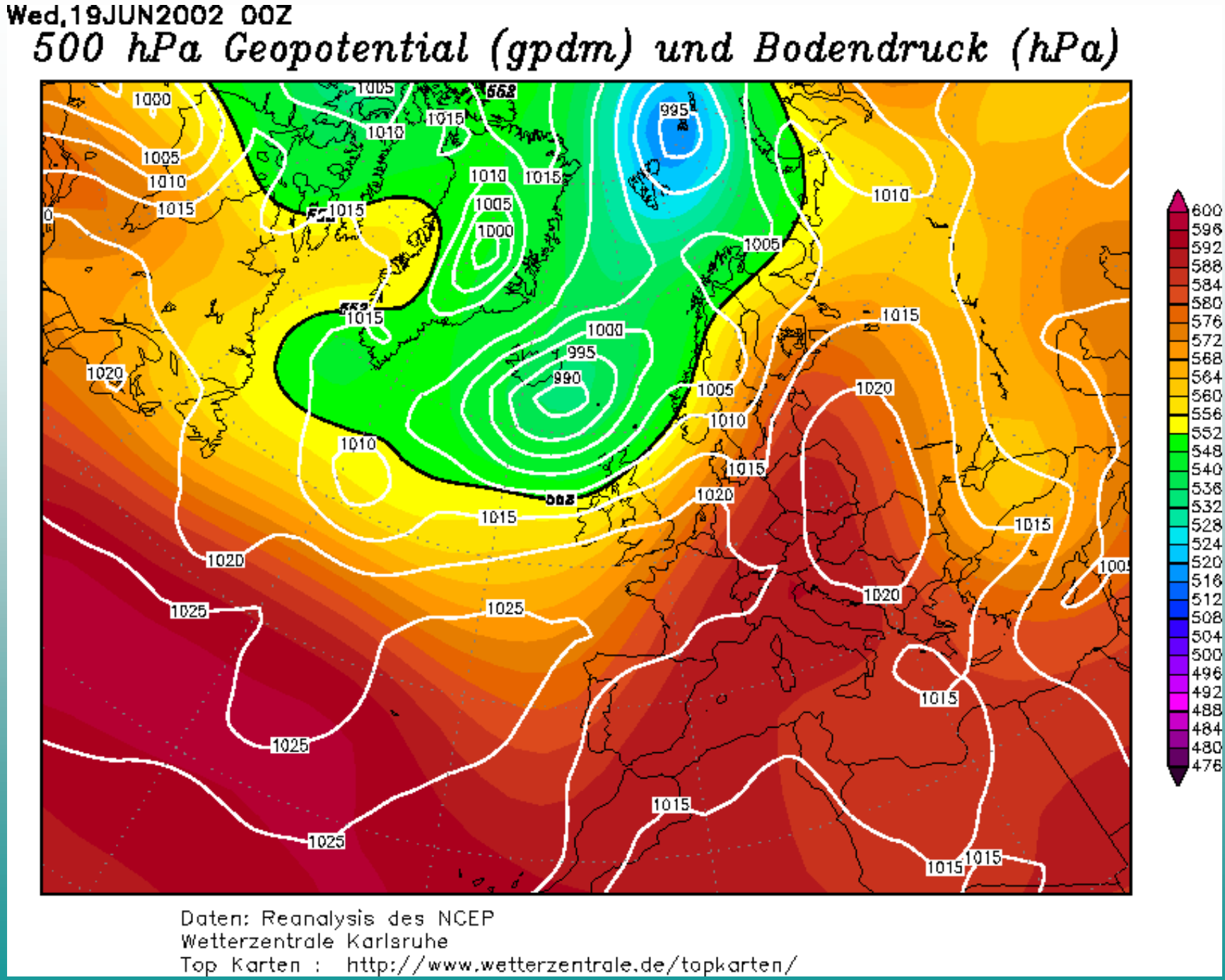
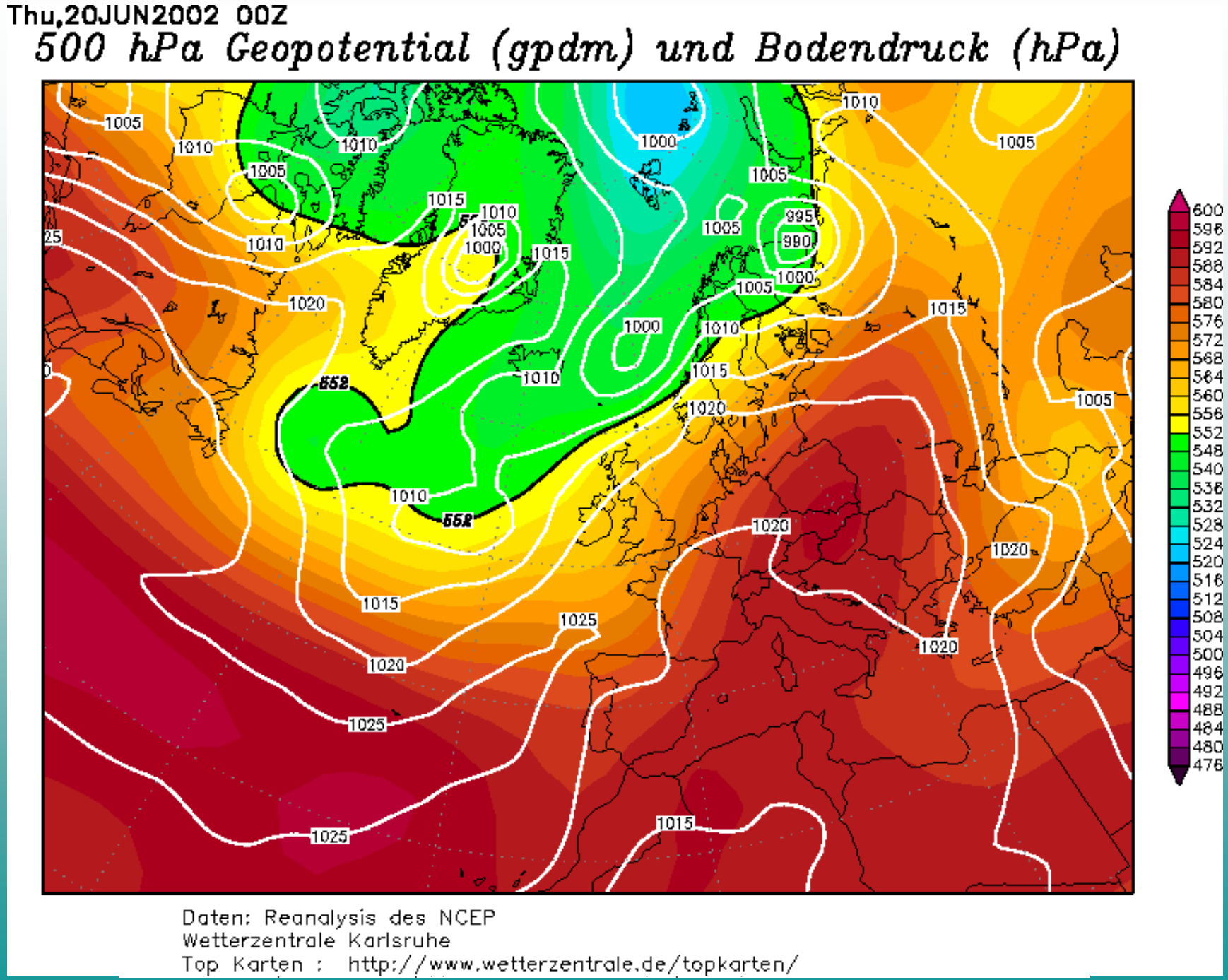
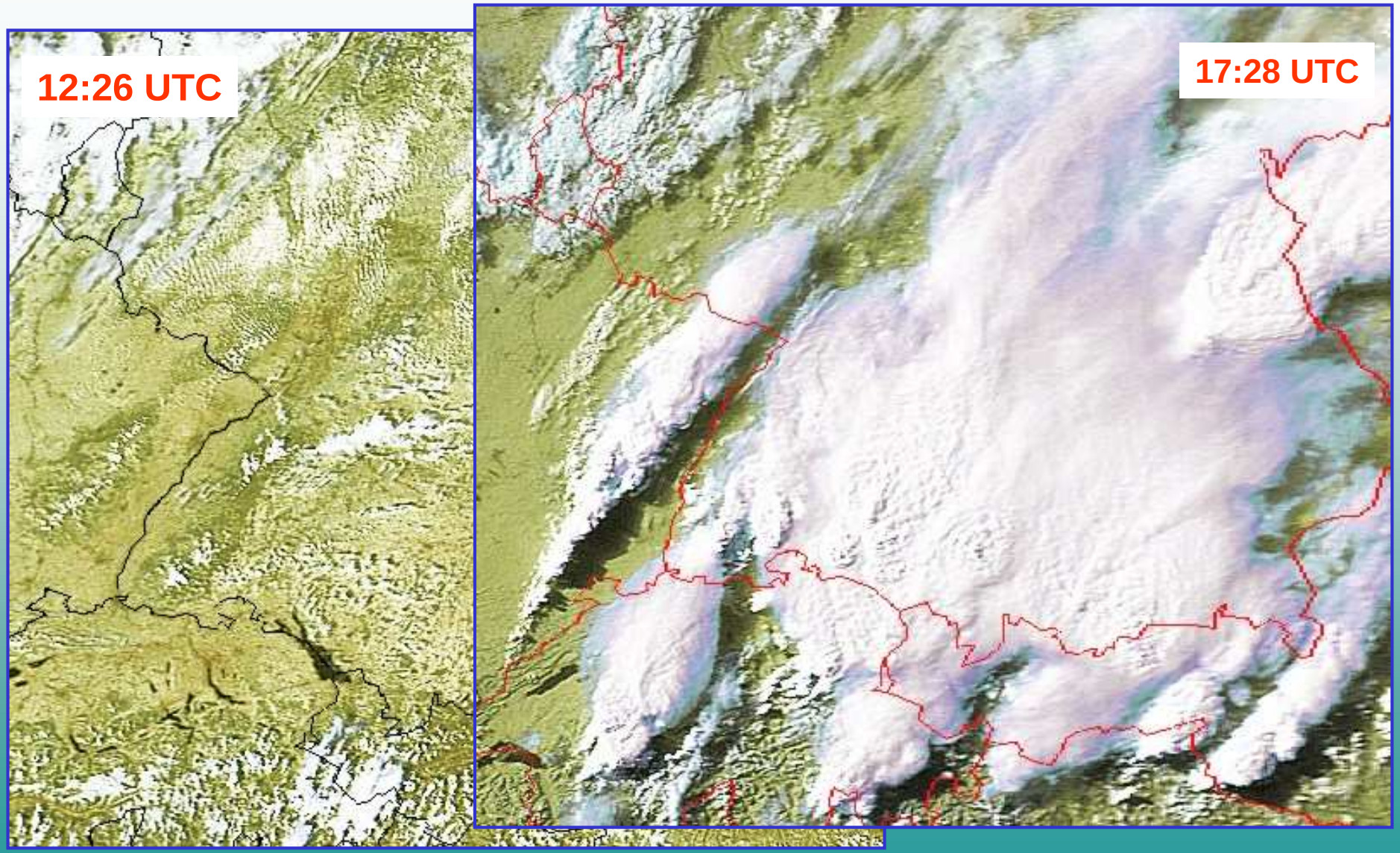
Case: Summer precipitation from non-frontal convection



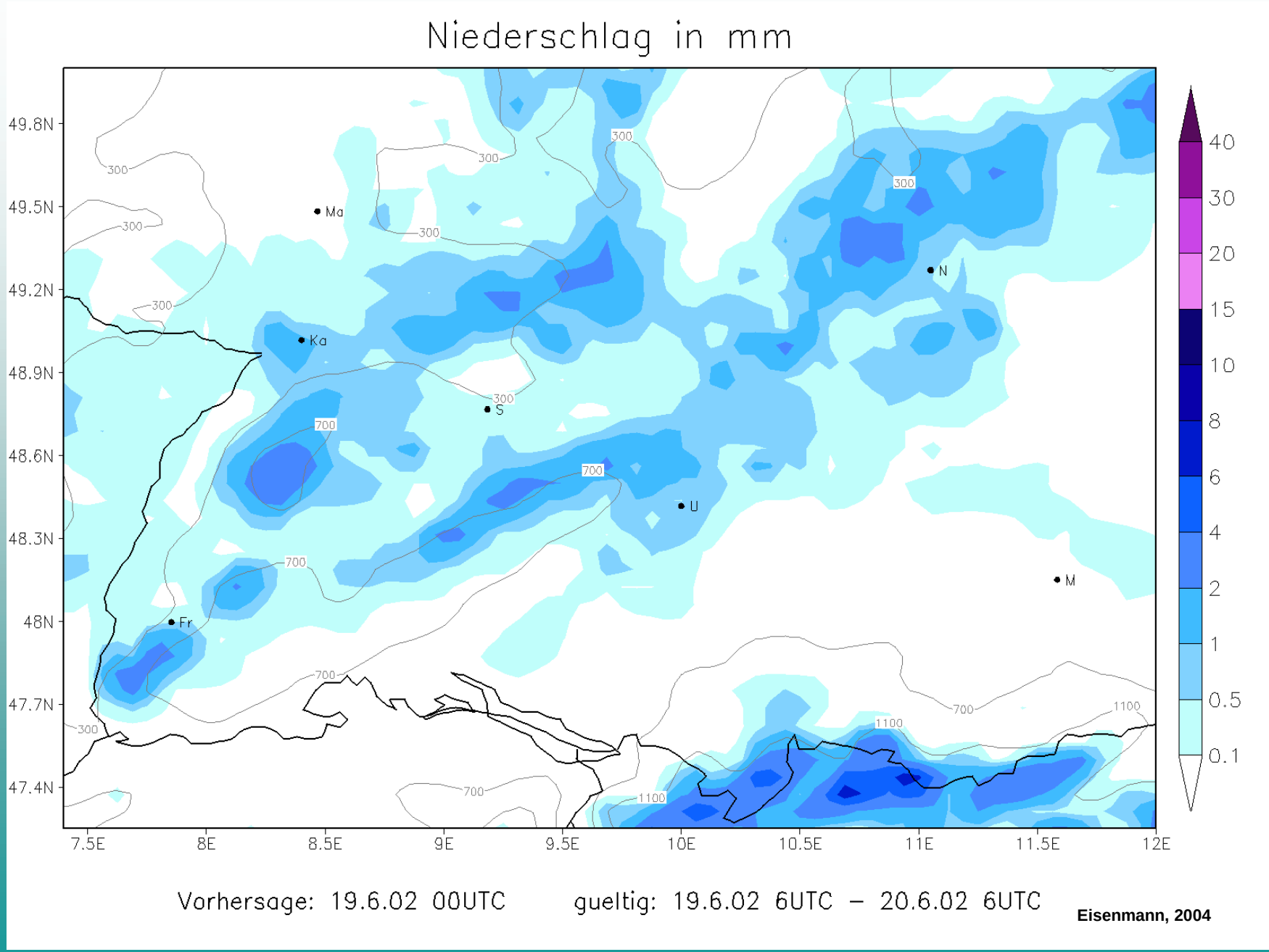
Case: Summer precipitation from non-frontal convection



NOAA-VIS Satellitenbilder vom 19.06.2002

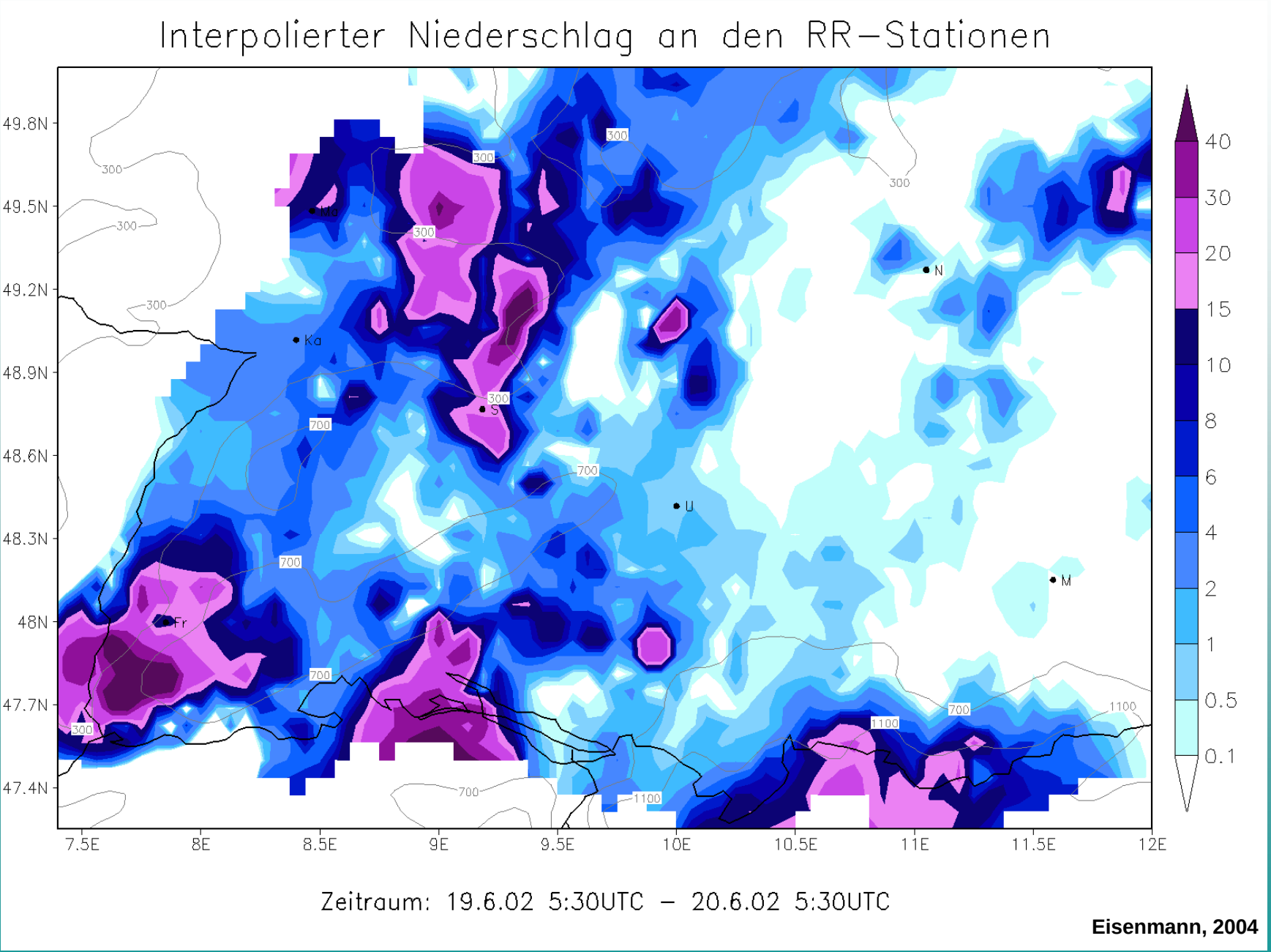


LM-simulation (7 km) with Tiedke convection parametrization



Interpolated measurements

June 19, 2002



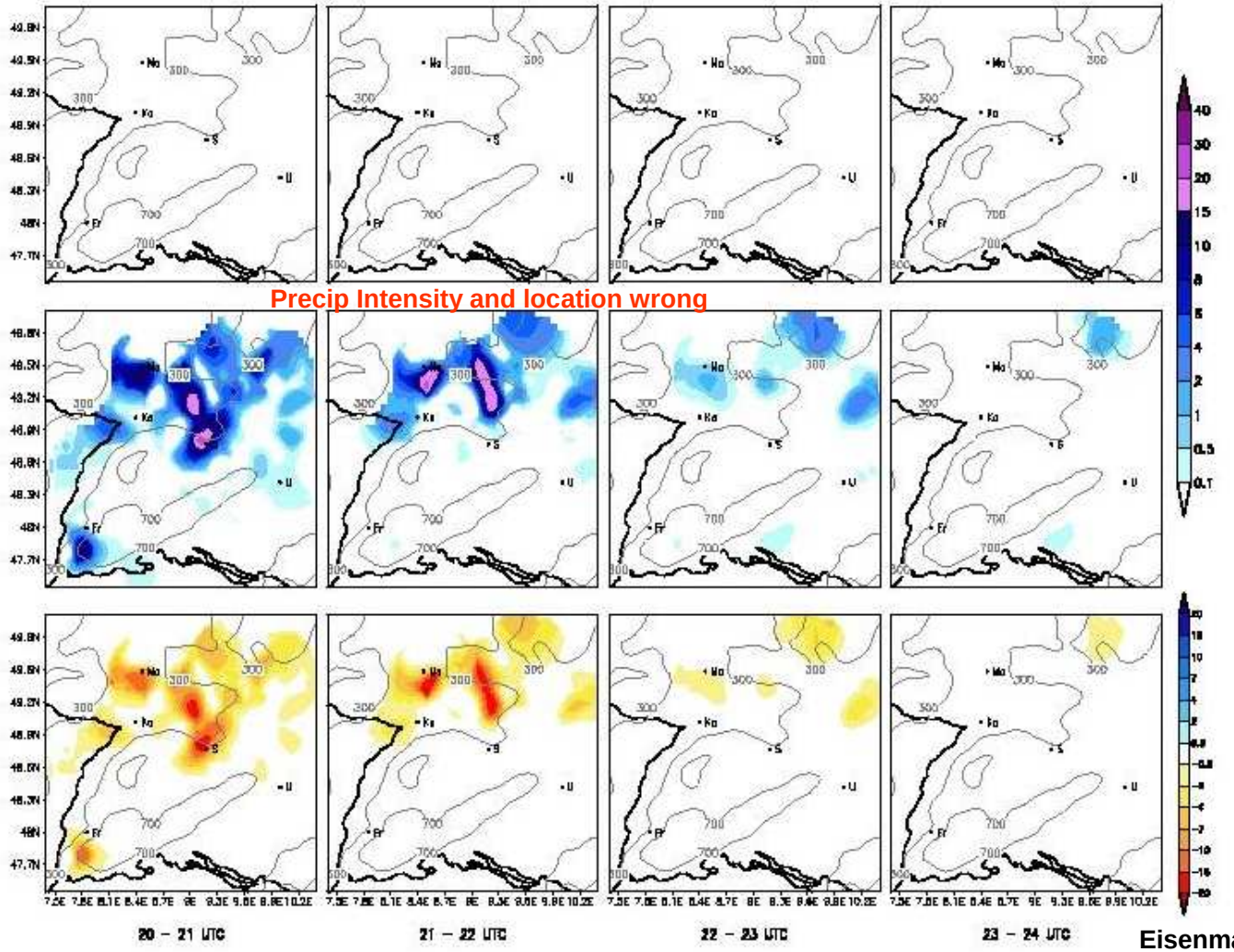
Eisenmann, 2004

LM-simulation (7 km) with Tiedke convection parametrization, temporal evolution

LM 7 km

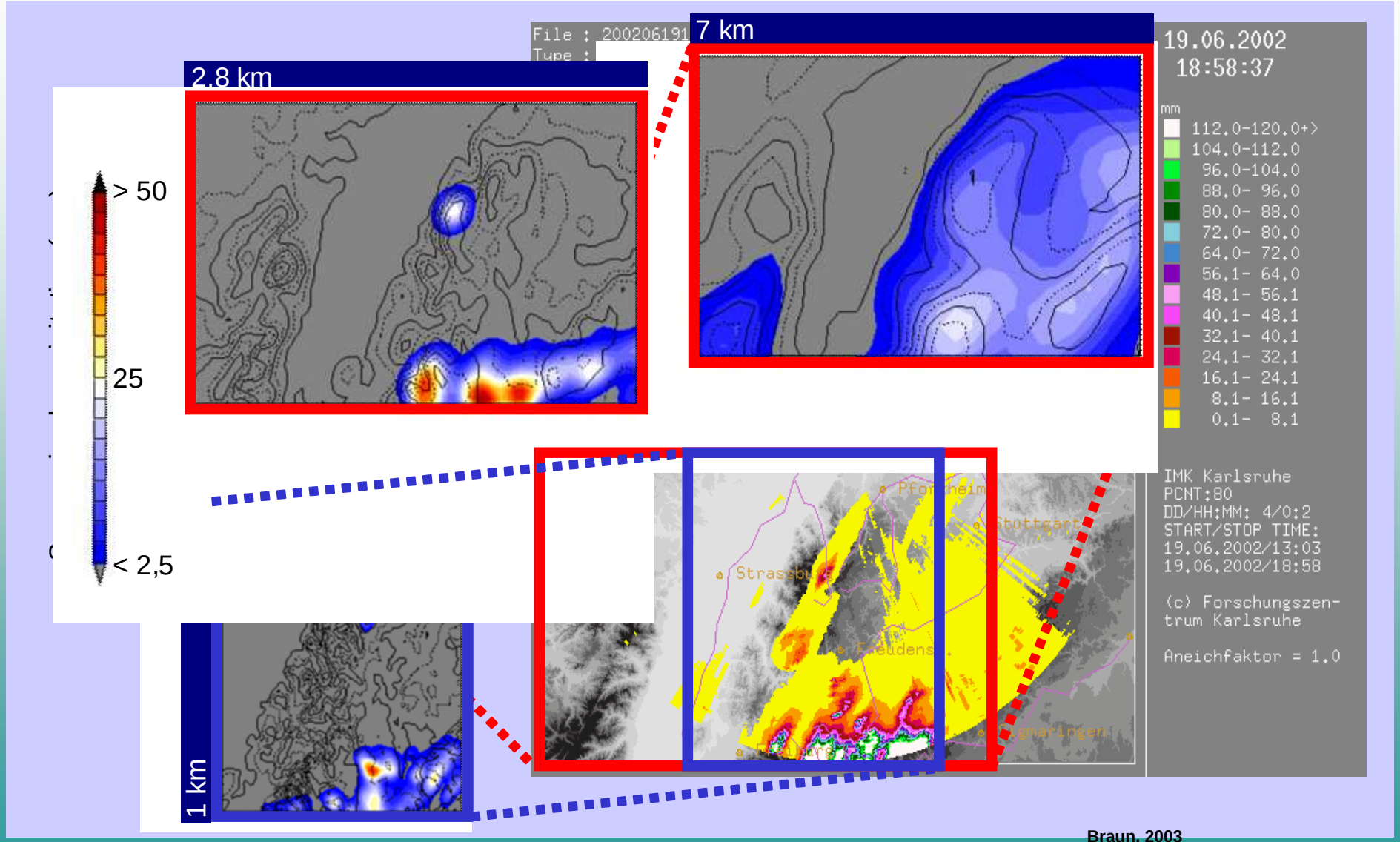
data

difference



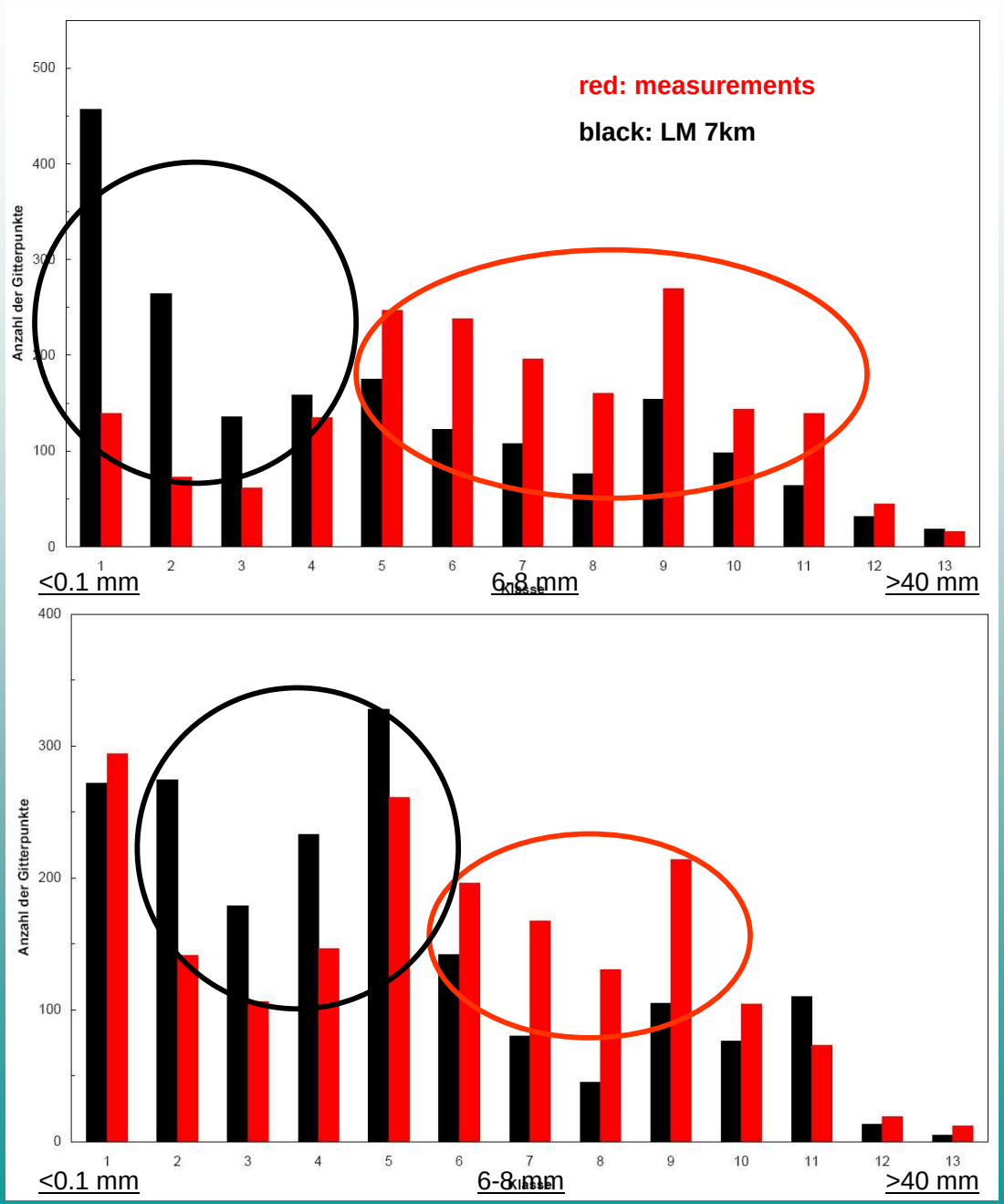
Eisenmann, 2004

LM precip forecasts, June 19, 2002
resolution effects



Braun, 2003

Comparison of 12 cases of convective precipitation



6 frontal cases

6 non-frontal cases (positive vorticity advection)

Eisenmann, 2004

QPF problems with LM (Heise, DWD):

General problem areas:

- parametrization of precip formation
- data assimilation
- verification

Convection related:

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COPS – The QPF experiment over low mountain regions

Convection triggering by secondary circulations and inhomogeneity of temperature and humidity fields

Scale: 1 km to 20 km in low mountain region

- Process: Convective processes are modified by secondary circulations in low-mountain regions
- QNV link: Convective precipitation

Triggering of embedded convection by cross-circulations at fronts and convergence lines

- Scale: 20 km to 100 km
- Process: Differential surface heating and moisture fluxes near fronts cause secondary circulations and convection by mean uplift
- ONV-link: squall-line formation

Activation of potential instability by synoptic scale processes

- Scale: > 100 k-
- Process: Destabilization of air masses and deep convection by large-scale uplift and orographically induced low-level convergence
- QNV-link: Pre-frontal precipitation

COPS – The QPF experiment over low mountain regions

Underlying hypothesis

QPF improvement cannot be achieved/validated without a dedicated field experiment

Why ?

Precipitation is initiated by physical processes, being sub-gridscale to forecast models, ...

or

QPF for convective precipitation failure arises from the unknown superposition of

- **„flow over complex terrain“ induced low-level convergence,**
- **convection from surface heating/moistening,**
- **positive vorticity advection on the synoptic scale,**
- **differential heating and secondary circulations near fronts**