Data quality control of time variable data

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Overview

- The VOLTAIRE project
- Work package 2: Quality control of time variable data
  - » Radar data QC algorithms + QCTool
  - » Raingauge QC algorithms
- Applications and synergies
- Open Questions
- Conclusions

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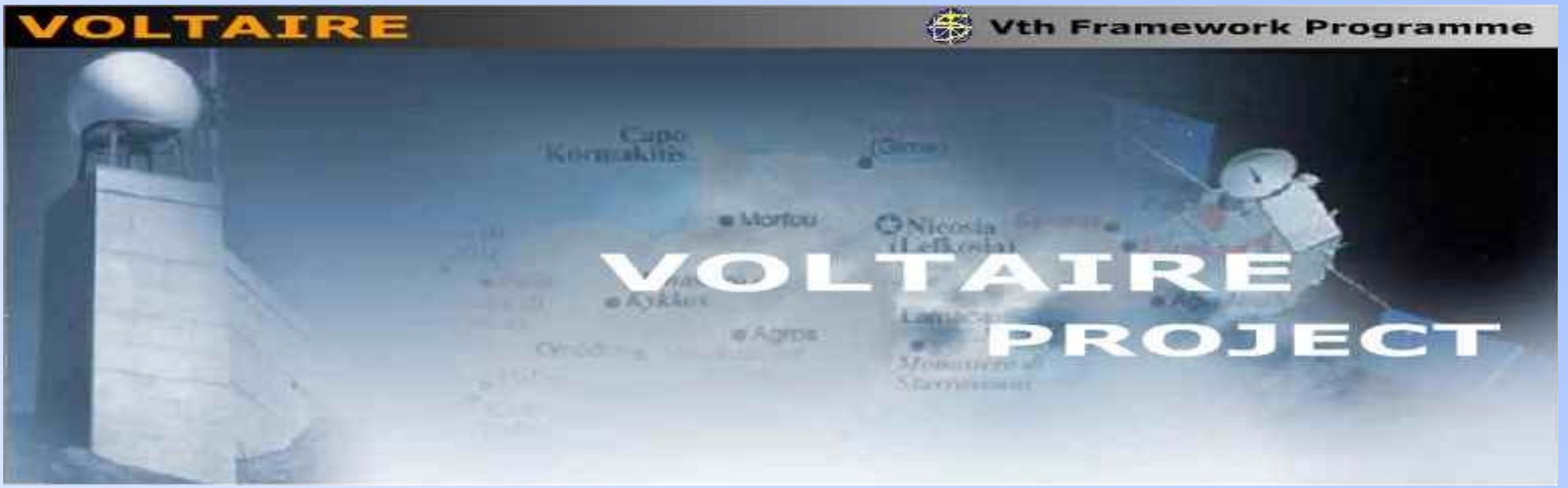
The VOLTAIRE project



Duration: November 2002 – April 2006

http://www.voltaireproject.org

The VOLTAIRE project

- Analysis of currently available TRMM data over Europe
- Comparison to standard rainfall measurements by radar and raingauges
- Comparison to standard rainfall forecasts by numerical model use
- Preparation for the European part of the GPM (Global Precipitation Measurement) mission

The VOLTAIRE project

Politecnico di Torino (Project coordinator)
Electronics Department
Italy

Agenzia per la Protezione dell'Ambiente e per i servizi Tecnici
Italy

Università di Camerino
Math. and Phys. Dept.
Italy

Universitat Politècnica de Catalunya
Grup de Recerca Aplicada en Hidrometeorologia
Spain

Einfalt&Hydrotec GbR
Germany

George Mason University
School of Computational Sciences
Center for Earth Observing and Space Research
NASA/Goddard Space Flight Center/912.1
USA

University of Ljubljana
Dept. of Physics
Slovenia

Meteorological Service of Cyprus
Cyprus

MeteoSvizzera
Locarno Monti
Switzerland

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Workplan: QC of time variable data

- Literature review
- Literature pool
- Definition of common data format: HDF5 based radar data metadata + format complying with OPERA and COST717 documents
- Definition of “Quality Control” (with COST 717)
- Algorithm pool of selected methods
- Offline tests on data from Cyprus, Switzerland and Spain
- Online tests on data from Cyprus and Spain
- Tests on other data (Germany, Thailand)

Work done: QC of time variable data

- Literature review
- Literature pool
- Definition of common data format: HDF5 based radar data metadata + format, complying with OPERA and COST717 documents
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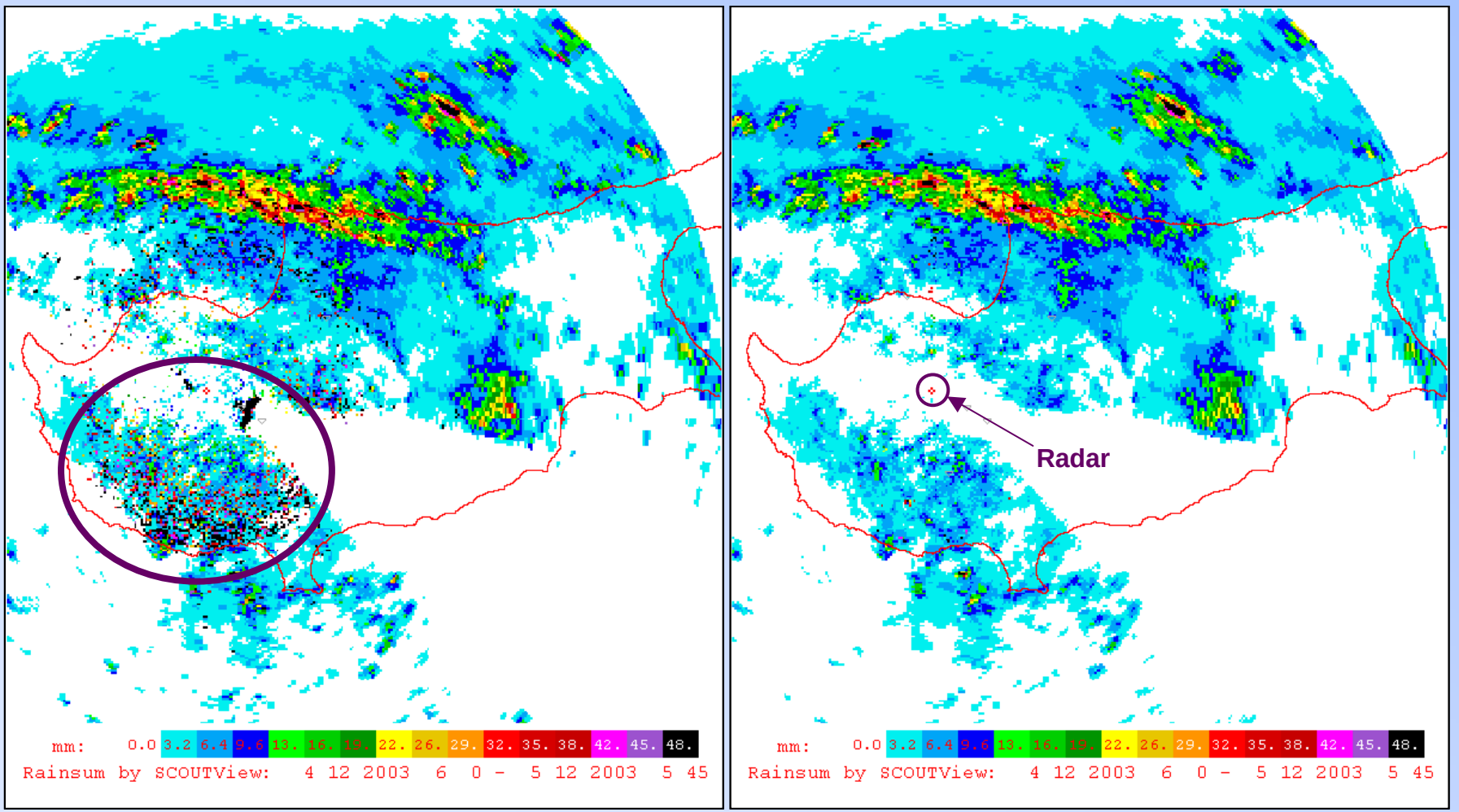
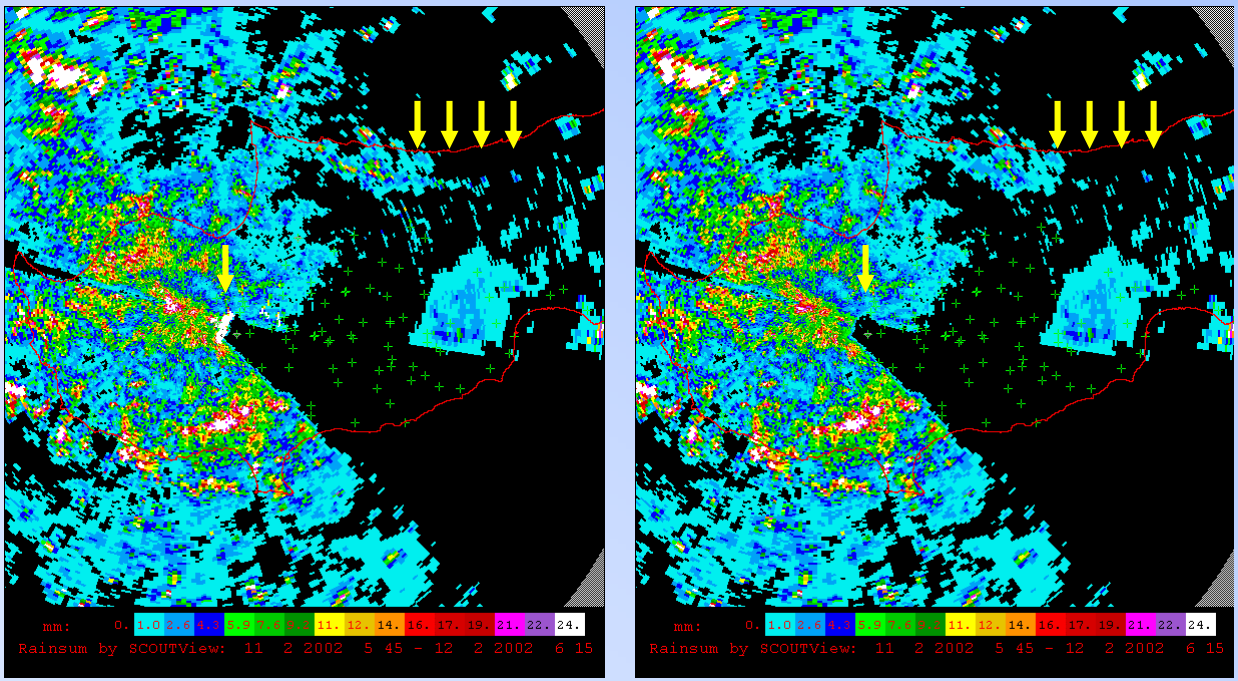
QC algorithms for radar data

Problem	2D-data	3D-data
Attenuation	"cumulative gate-by-gate algorithm" "mountain return method"	-
Ground Clutter & Speckle	"clutter map" "texture-based algorithm" "segment size"	"vertical and horizontal substitution"
Classification convective / stratiform	"3 criteria"	"2 methods"
Vertical profile (VPR)	"climatological or idealised profile" "maximum method"	"MAVPR" "Mesobeta profiles"
Radial anomalies	"radial filter" "beamblock"	"EMITTER"
Anomalous propagation (ANAPROP)	"motion filter"	"tilt-test"

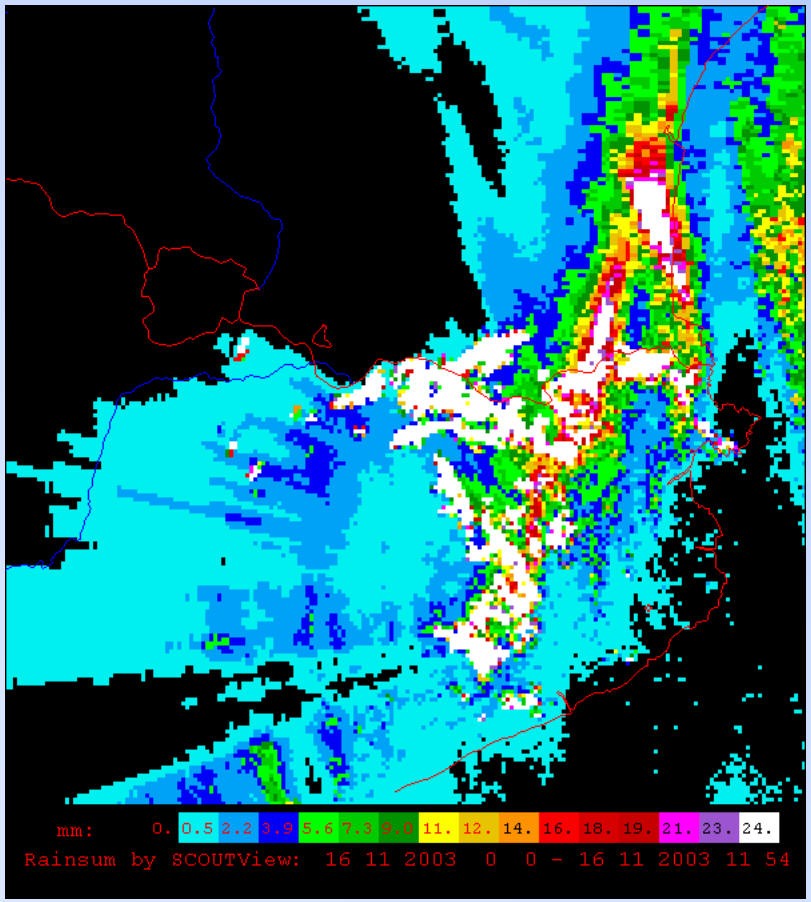
Correction of speckle (Cyprus Kykkos radar data)

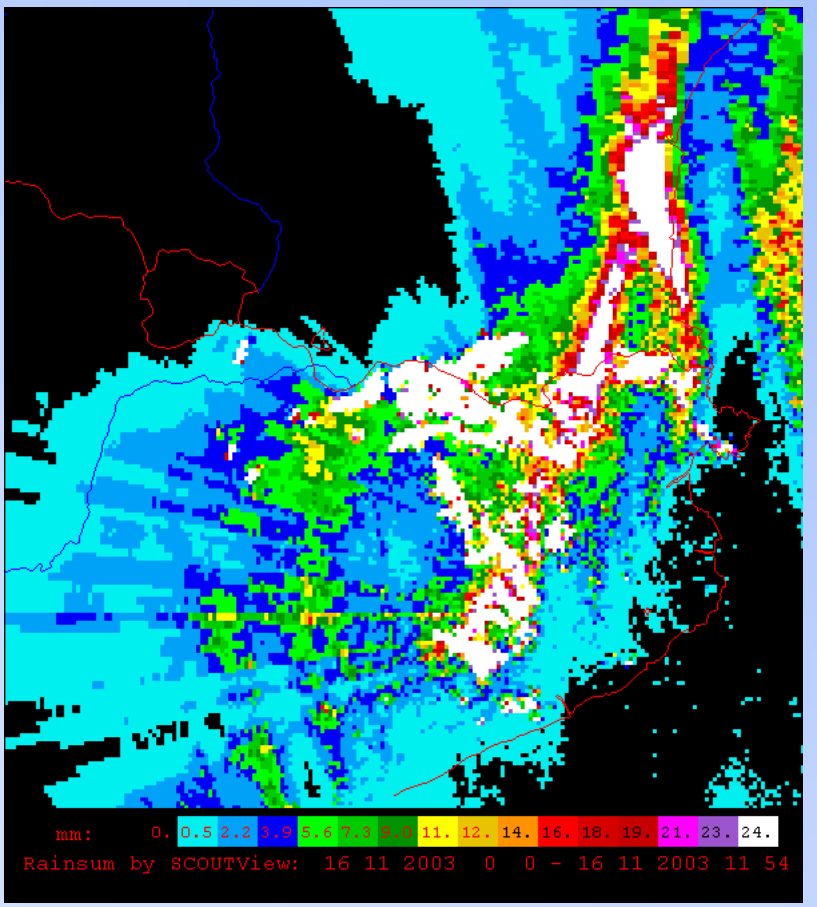


Cluttermap application (Cyprus Kykkos radar data)

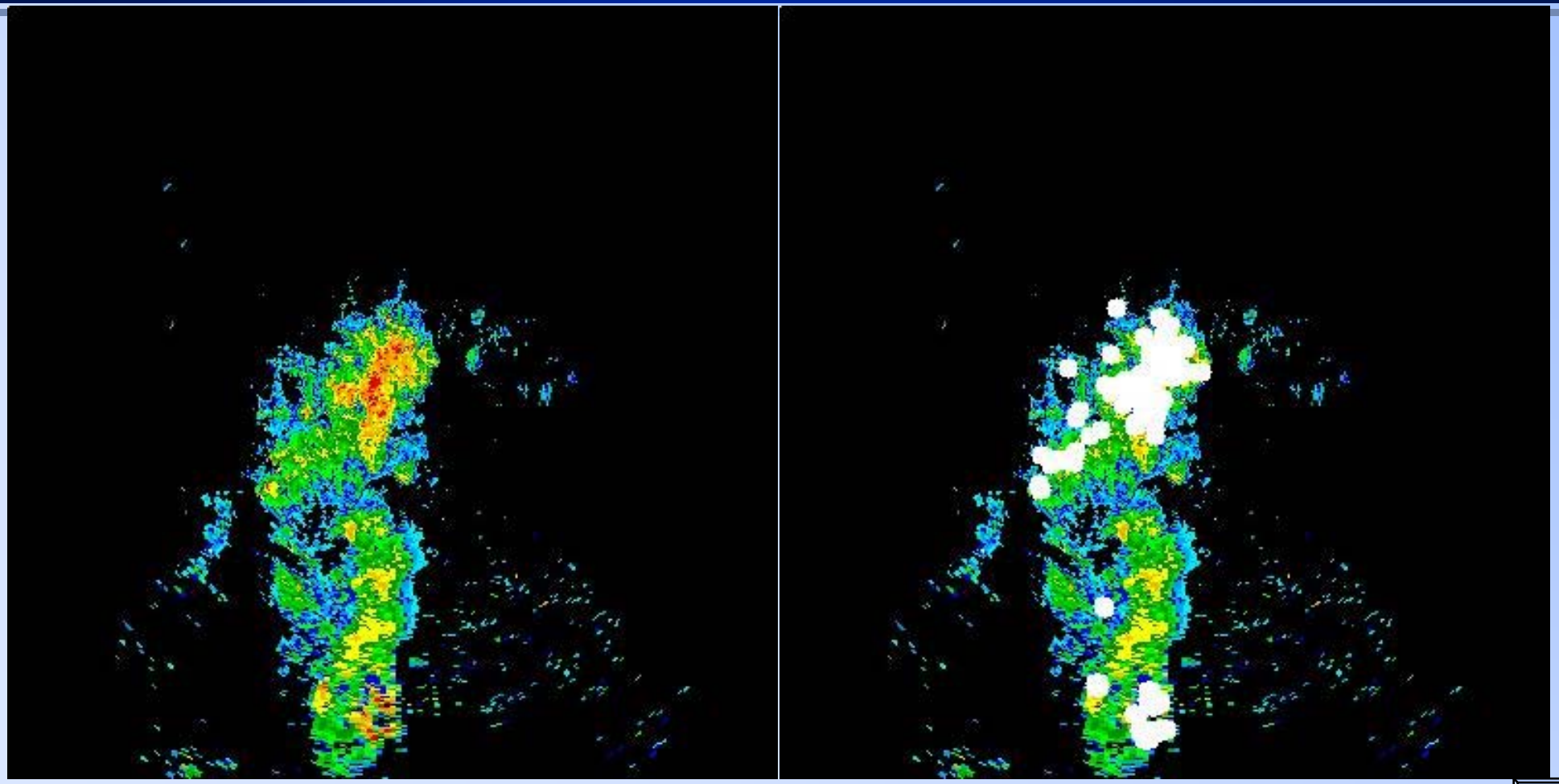


Attenuation correction - attempt (Catalunya Puig d'Arques radar data)

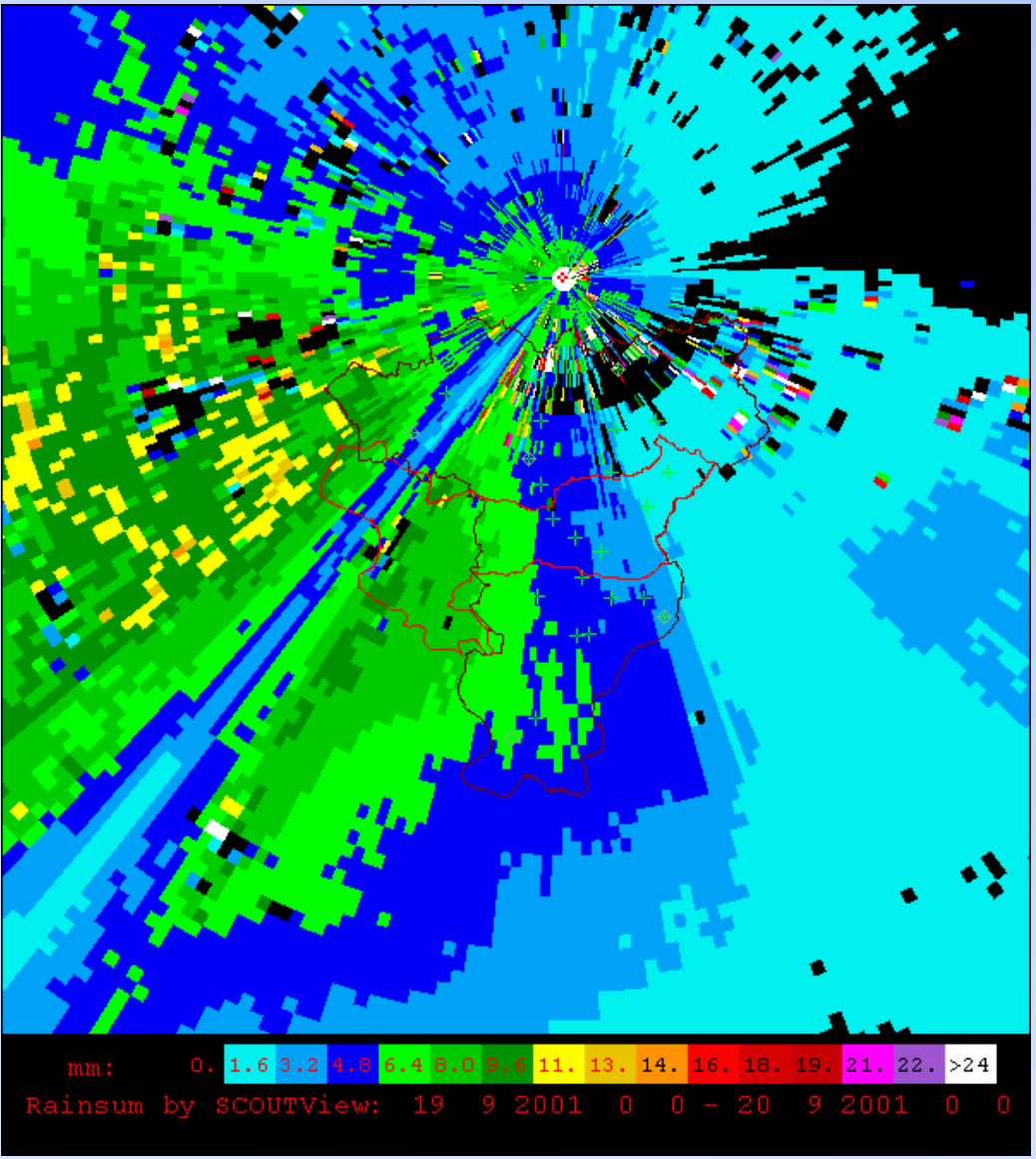




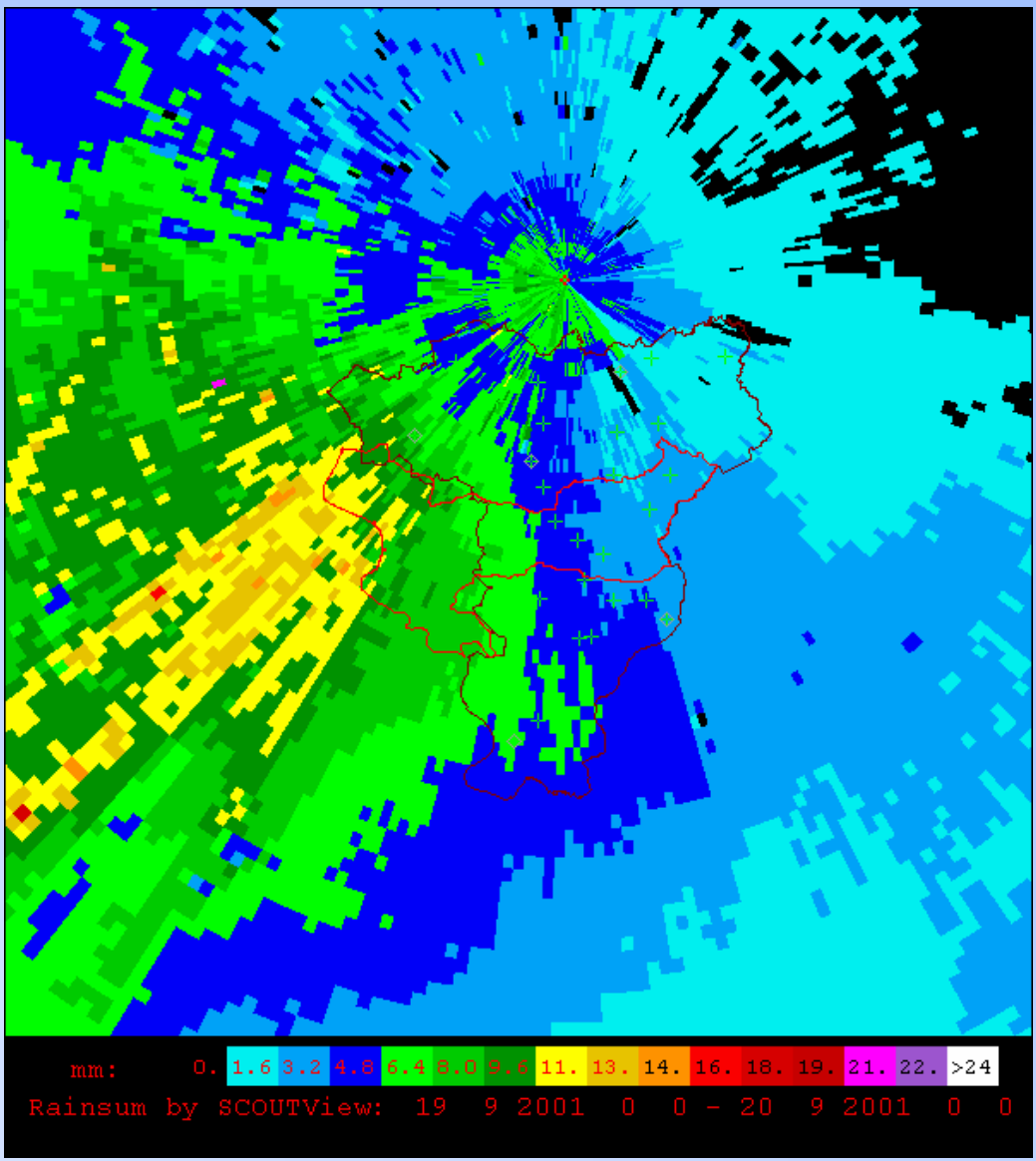
Convective / stratiform distinction (MeteoSwiss Monte Lema radar)



Beamblock + cluttermap (German Essen radar)

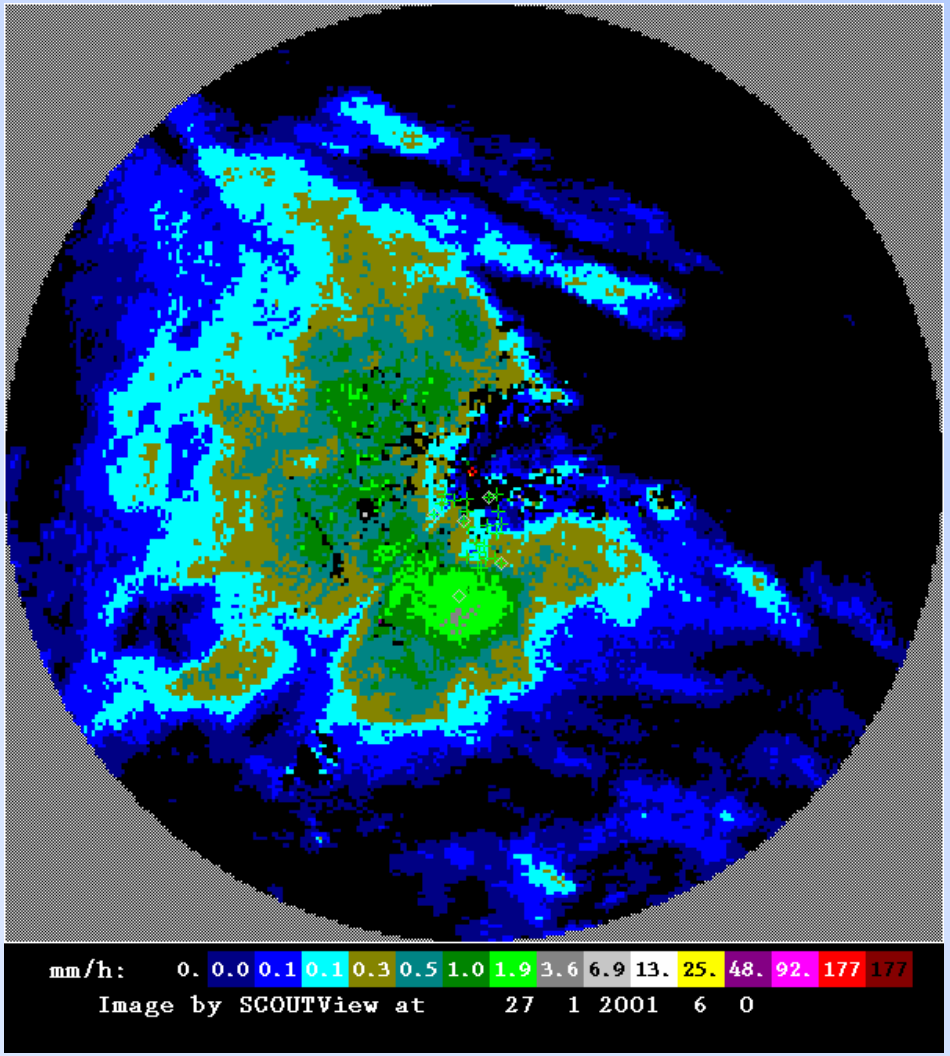


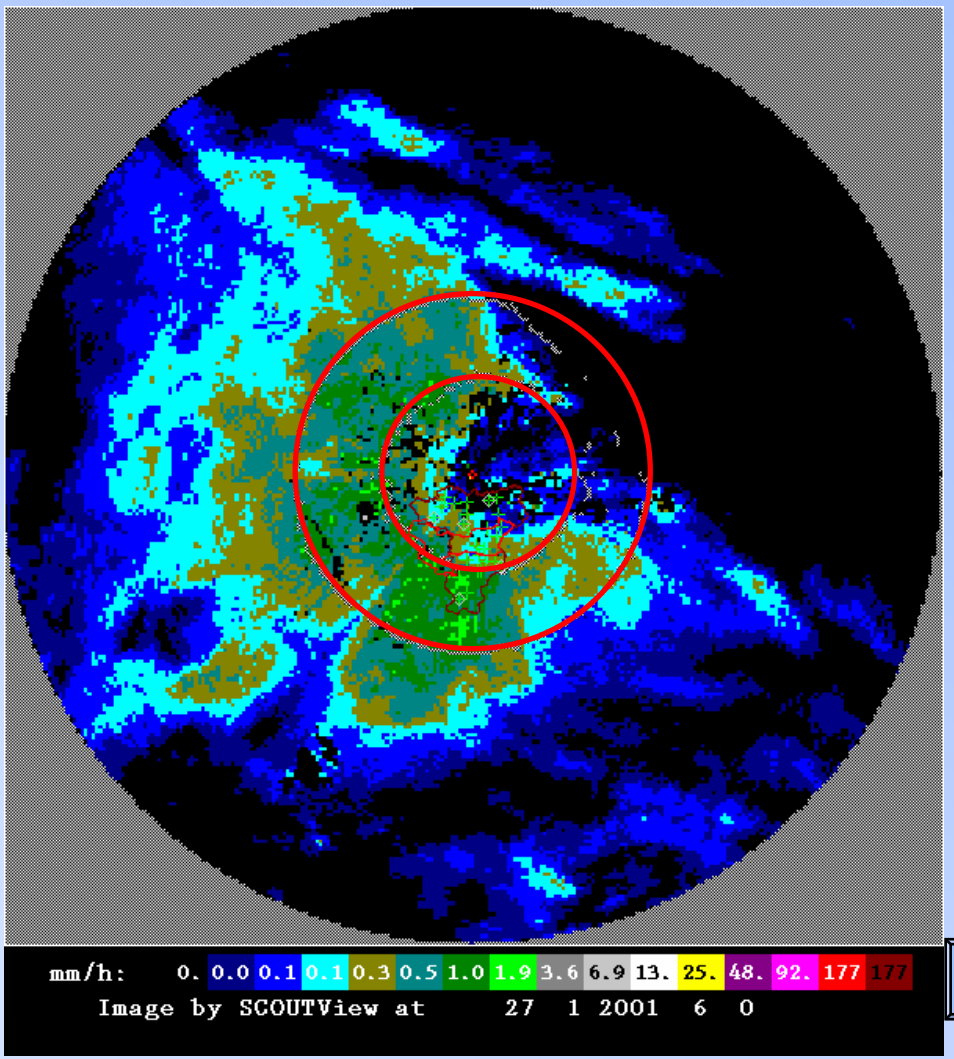
original



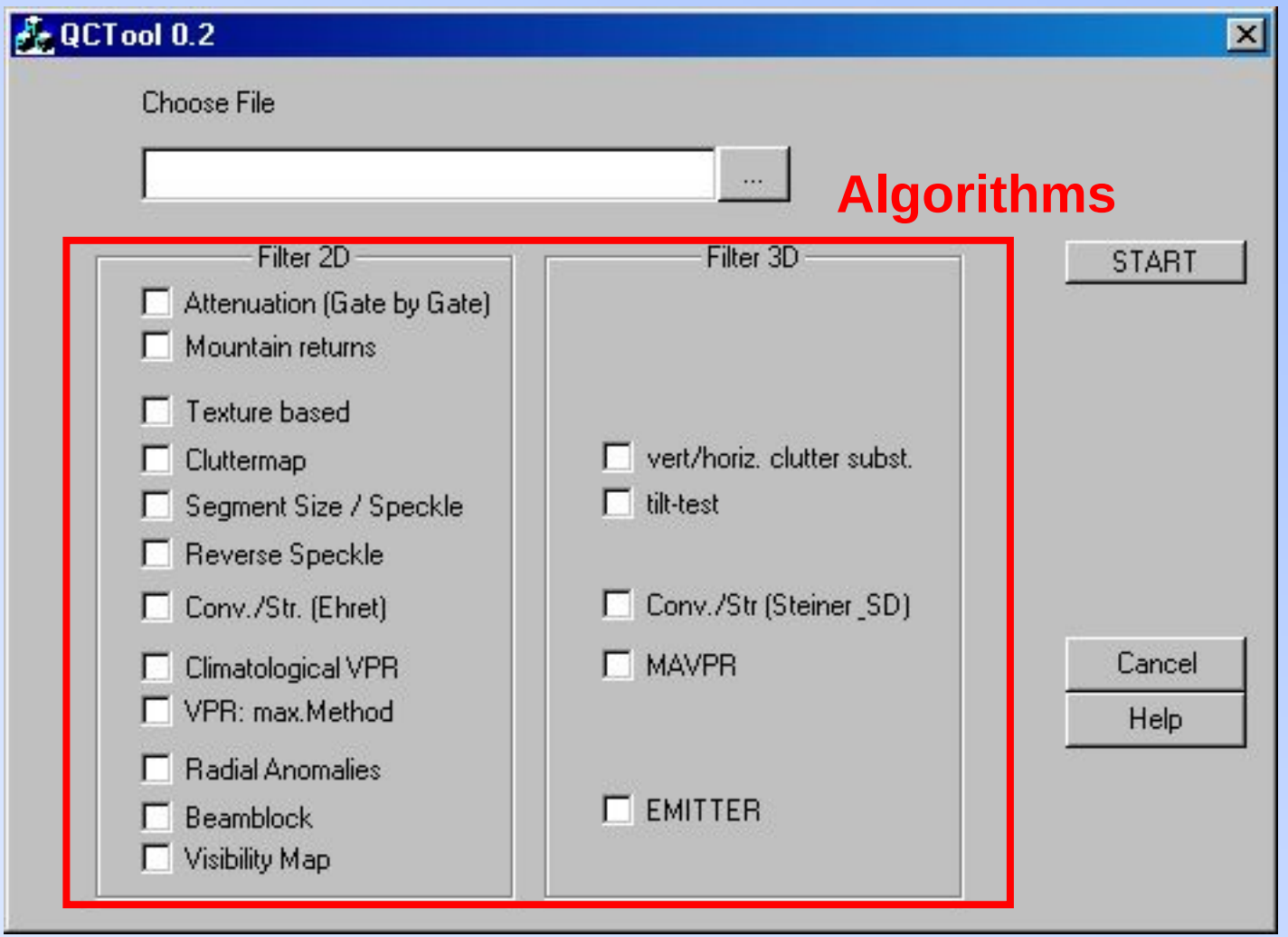
corrected

Bright band correction (German DWD Essen radar)





QCTool


QCTool 0.2
Choose File
...
Algorithms
Filter 2D
Attenuation (Gate by Gate)
Mountain returns
Texture based
Cluttermap
Segment Size / Speckle
Reverse Speckle
Conv./Str. (Ehret)
Climatological VPR
VPR: max.Method
Radial Anomalies
Beamblock
Visibility Map
Filter 3D
vert/horiz. clutter subst.
tilt-test
Conv./Str (Steiner_SD)
MAVPR
EMITTER
START
Cancel
Help

QC algorithms for raingauge data

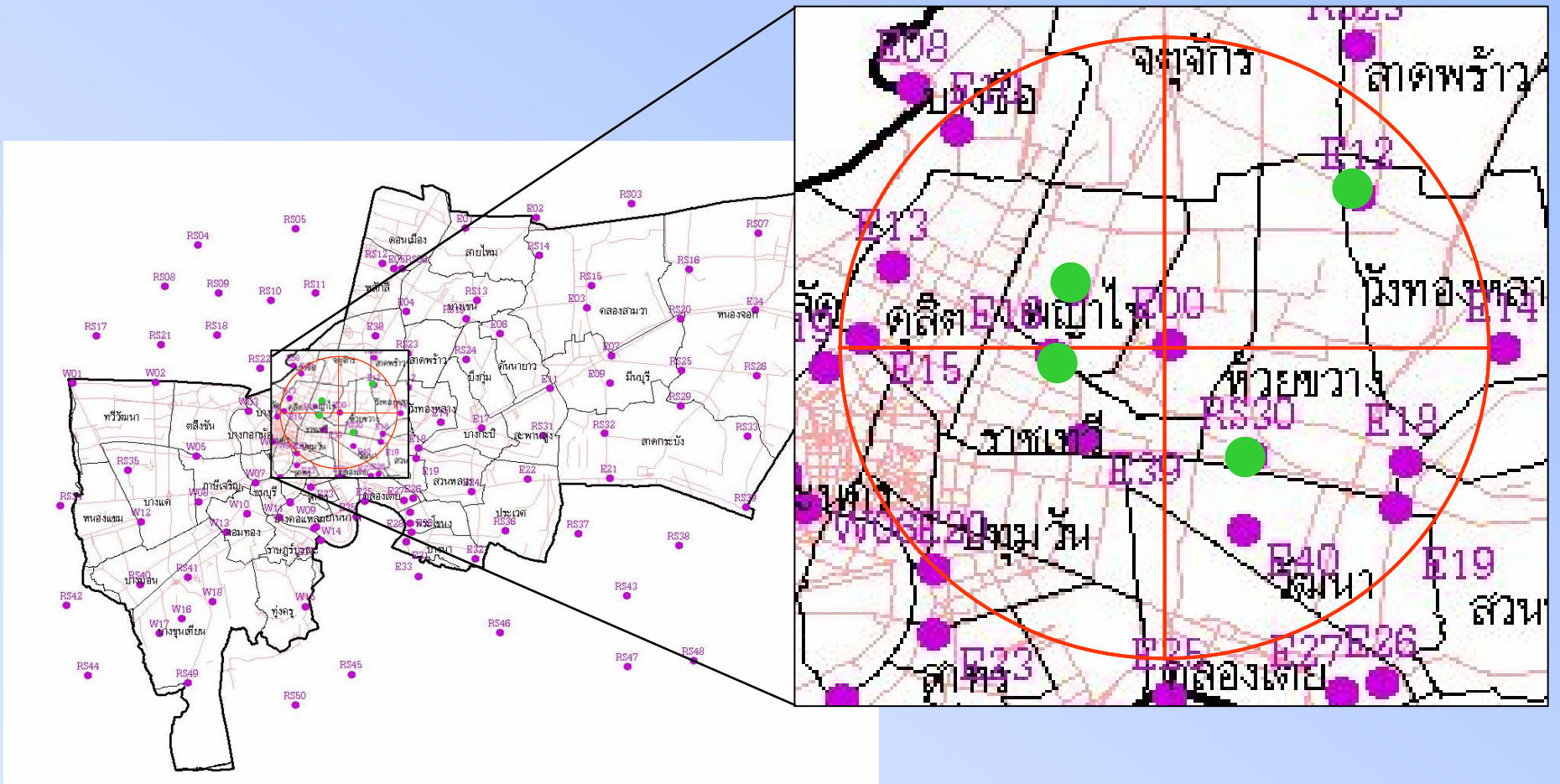
- Extreme values
  - 1 minute
  - 5 minutes
  - 60 minutes
  - 1440 minutes
- Suspect zero values
- Radar / raingauge comparison

QC algorithms for raingauge data extreme values

- Table of findings (here: daily sum > 44 mm)

station	d/c	date - time	value	no	comment
638	c	19 9 1999 23 50	137.4	16	High Value (daily)
118	c	20 9 1999 23 40	117.6	16	High Value (daily)
123	c	20 9 1999 23 40	167.2	16	High Value (daily)
124	c	20 9 1999 23 40	63.2	16	High Value (daily)
129	c	20 9 1999 23 40	167.6	16	High Value (daily)
132	c	20 9 1999 23 40	99.4	16	High Value (daily)
185	c	20 9 1999 23 40	175.0	16	High Value (daily)
191	c	20 9 1999 23 40	257.0	16	High Value (daily)
240	c	20 9 1999 23 40	98.2	16	High Value (daily)
326	c	20 9 1999 23 40	148.8	16	High Value (daily)
638	c	20 9 1999 23 40	240.2	16	High Value (daily)

QC algorithms for raingauge data suspect zero values



QC algorithms for raingauge data suspect zero values

- Table of findings and detailed info on processing

station	d/c	date - time	value	no	comment
RE15#	c	21 9 1999 0 0	19.6	32	daily sum too low

```
-------------------------------------
 Control stations for station  RE00#   : (      8.00 mm)
 NorthWest: RE13#    with a distance of        5522 m:      2.50 mm
 SouthWest: RE16#    with a distance of        2258 m:     10.50 mm
 SouthEast: RE40#    with a distance of        3931 m:     19.50 mm
 NorthEast: RE12#    with a distance of        4686 m:      1.00 mm
 mean and standard deviation of control stations          8.38      7.37
 confidence interval (lower / upper bounds):     -6.36     23.11
```

QC algorithms for raingauge data radar - raingauge comparison

- AQC algorithm developed by NASA (Amitai, 2000)
  - » Pointwise comparison radar – raingauge
    - – Portion of rainfall amount where only radar data are > 0 mm
    - – Portion of rainfall amount where only raingauge data are > 0 mm
    - – Time with rainfall at radar AND raingauge
    - – Logarithmic correlation radar / raingauge
    - – Correction factor (bias)
  - » Daily control step
  - » (Interpolated) minute time step
- Method to determine when adjustment with raingauges is feasible

Algorithm availability

- QCTool demo version
  - » Free – on VOLTAIRE website and from authors
- QCTool professional version
  - » License – from authors
- C++ software library
  - » License – from authors
- HDF5 interface
  - » Free – on VOLTAIRE website and from authors
- Included in SCOUT software

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Applications and synergies

- Online application of (part) of the algorithms in
  - Bangkok, Thailand (since 2004)
  - Kamp-Lintfort, Germany (since 2005)
  - Ankara, Turkey (presumably in 2006)
- Detailed discussions in COST 717 (Use of radar observations in hydrological and NWP models)
- Dissemination of results towards the hydrology community (IWA – International Water Association)
  - Short course “Radar for hydrologists” in Copenhagen, August 2005
  - 6th and 7th workshop on Precipitation in Urban Areas, December 2003 and December 2006

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Open questions: Evaluation methods

- Comparison with raingauges
- Comparison of accumulated radar images
- Statistical methods (e.g. spatial variance)

Open Questions: Discussion

- Which evaluation method tells you that a correction improved the data?
- What are the look and the statistical parameters of an „ideal“ radar image?
- Other evaluation methods?

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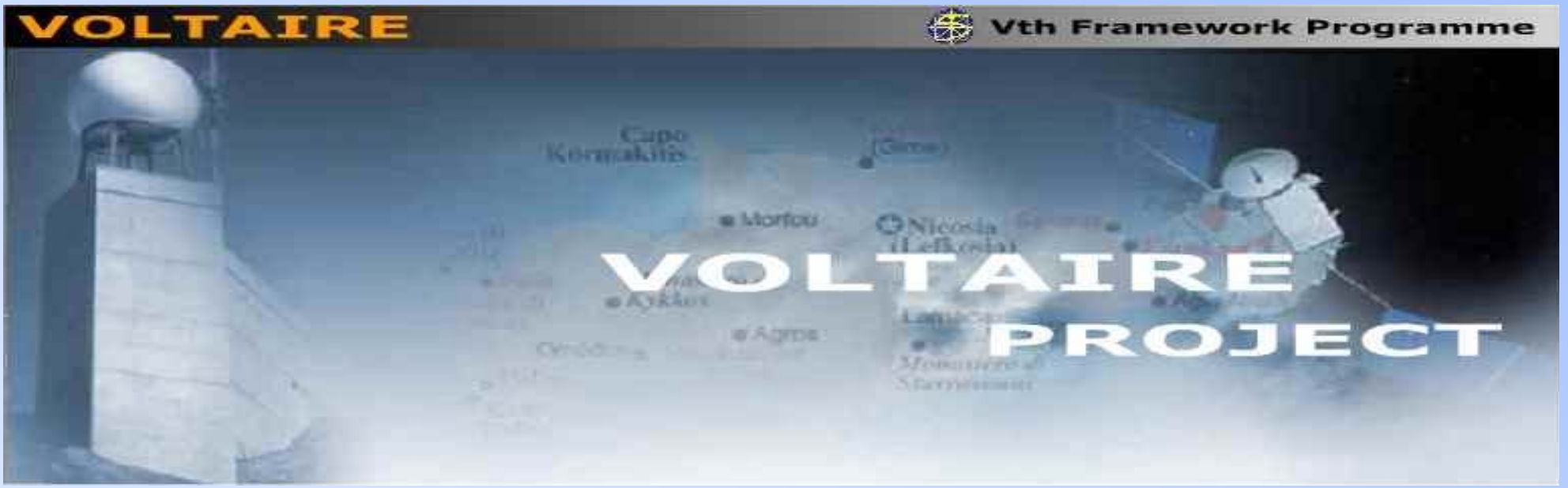
Conclusions

- The VOLTAIRE project has provided results on rainfall in the Mediterranean Area
- One objective was the application of TRMM results for the preparation of the European part of the GPM mission
- A concept for a common radar data exchange format has been defined and implemented
- A library with algorithms for radar and raingauge data quality control with fast calculation has been developed and is available now

Thank you very much for your attention !



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SPARE SLIDES

Comparison with raingauges

- Visual comparison of radar and raingauge time series
  - » Form and proportion of the time series
  - » Subjective method
- Only possible for parts of the radar image
- Time-consuming method
- Different measurement device
- Raingauge data must be checked

Comparison of accumulated radar images

- Visual comparison of the correction methods
- Spatial view of the whole radar range
- Subjective method
- Necessary for a plausibility check
- Accumulation time: e.g. 1 day

Determination of spatial variances

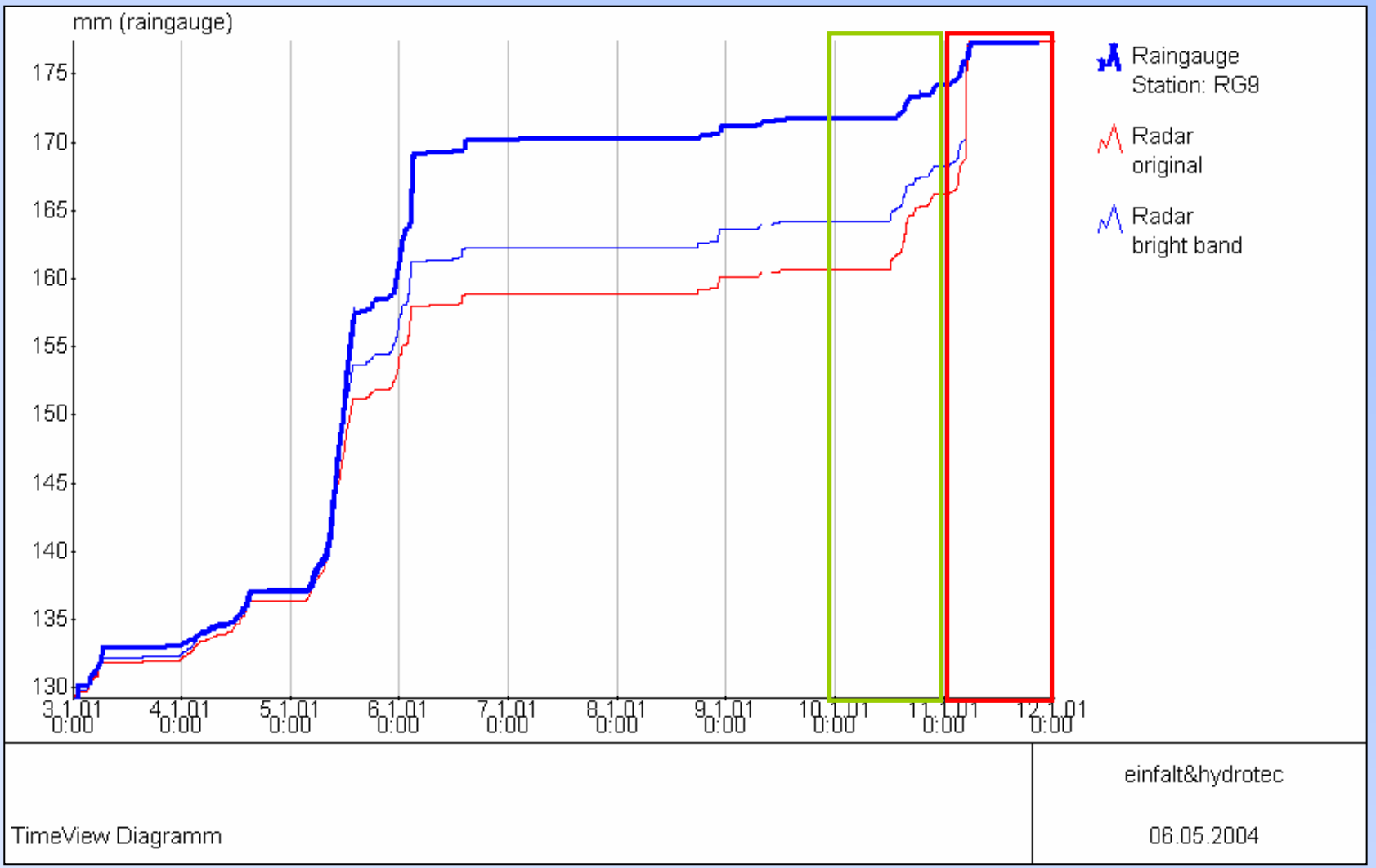
- Calculation of the sample variance / standard deviation for 9-pixel fields

$$s_N \quad \sqrt{\frac{1}{N} \sum_{i\ 1}^{N} x_i \quad \bar{x}^{\ 2}}$$

- Determination of the mean variance of one radar image
- Determination of the mean variance of the images of one day

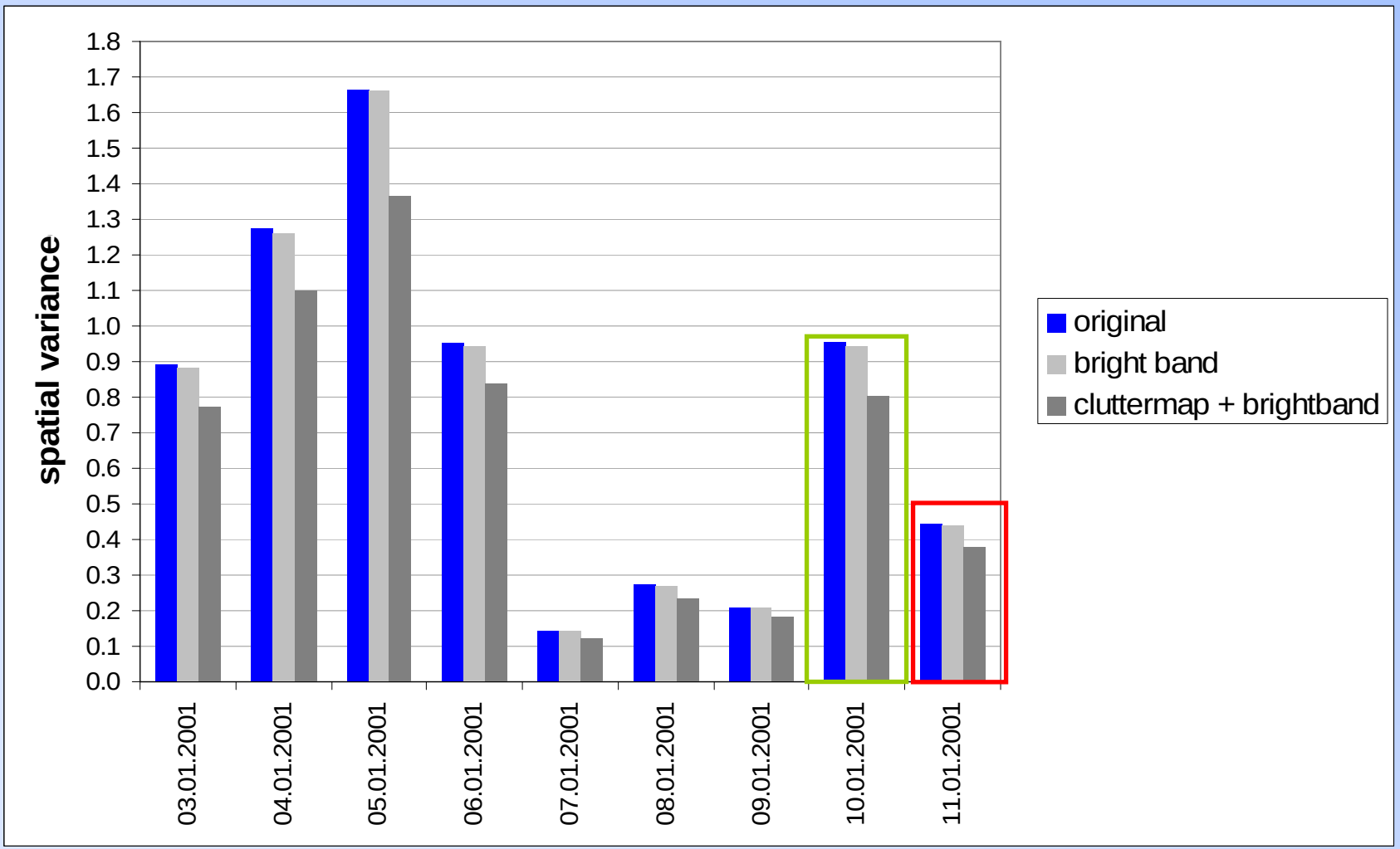
Comparison with raingauges

Example: bright band correction

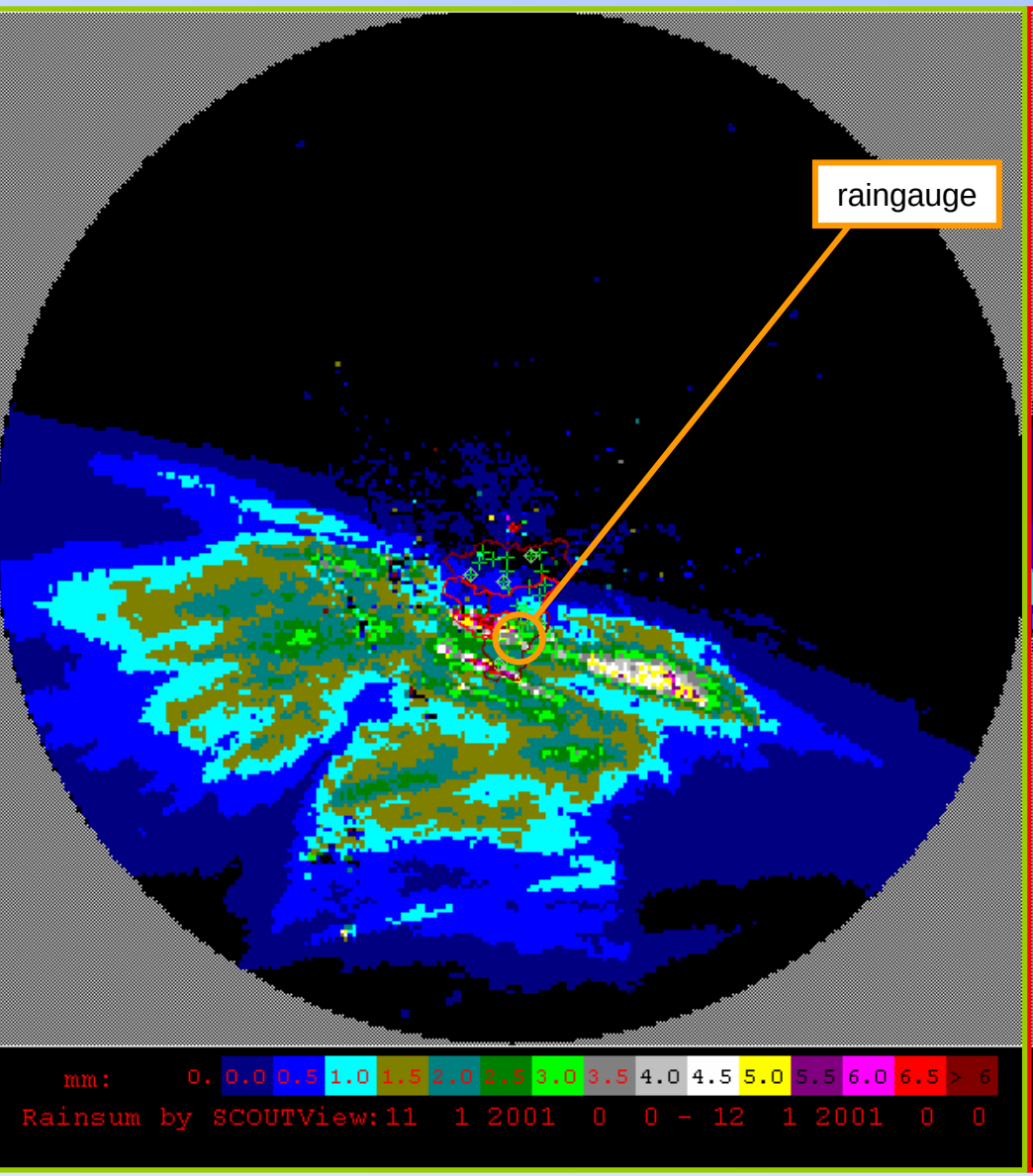


Comparison of the spatial variances

Example: bright band correction



Comparison of accumulated radar images



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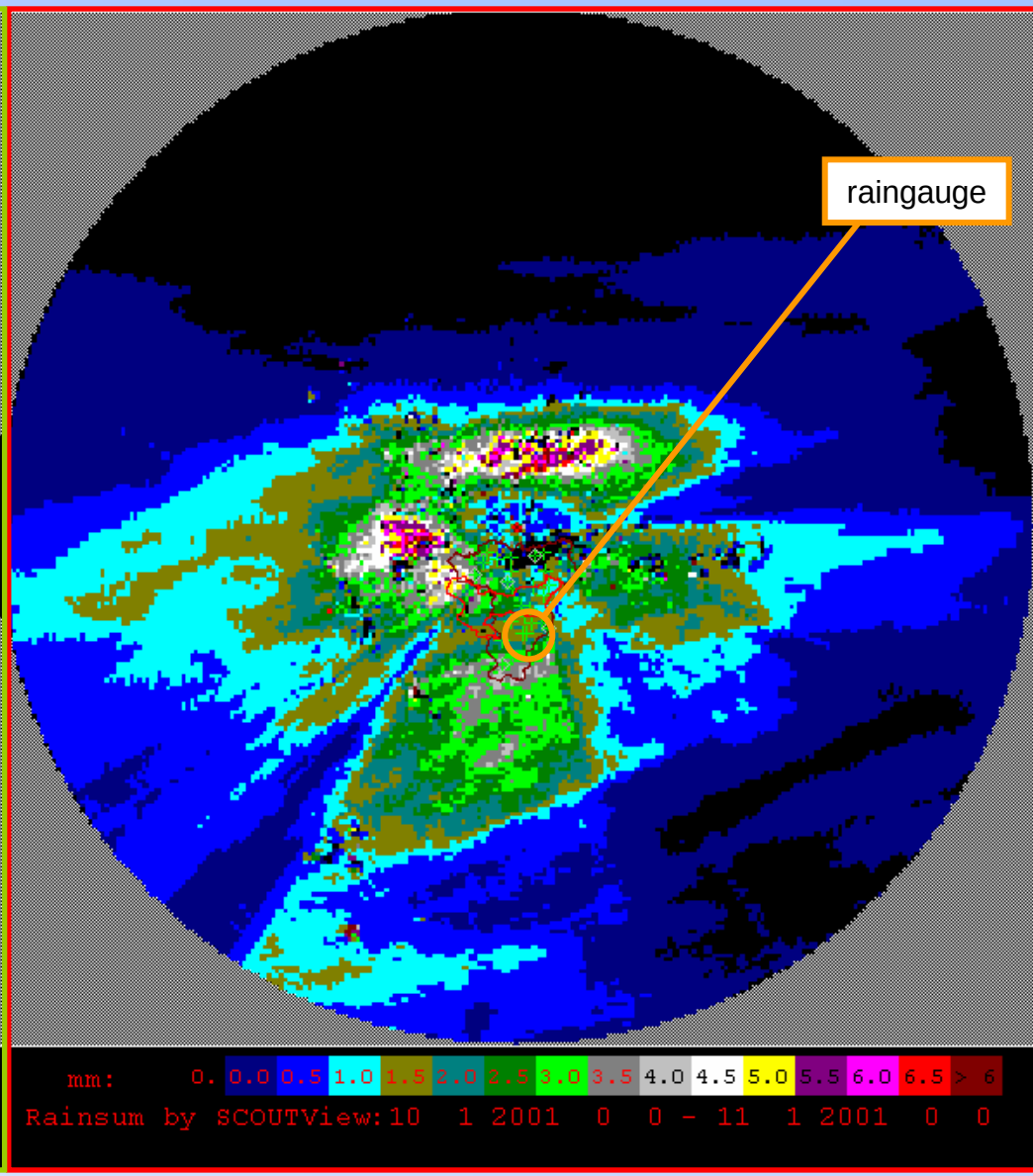
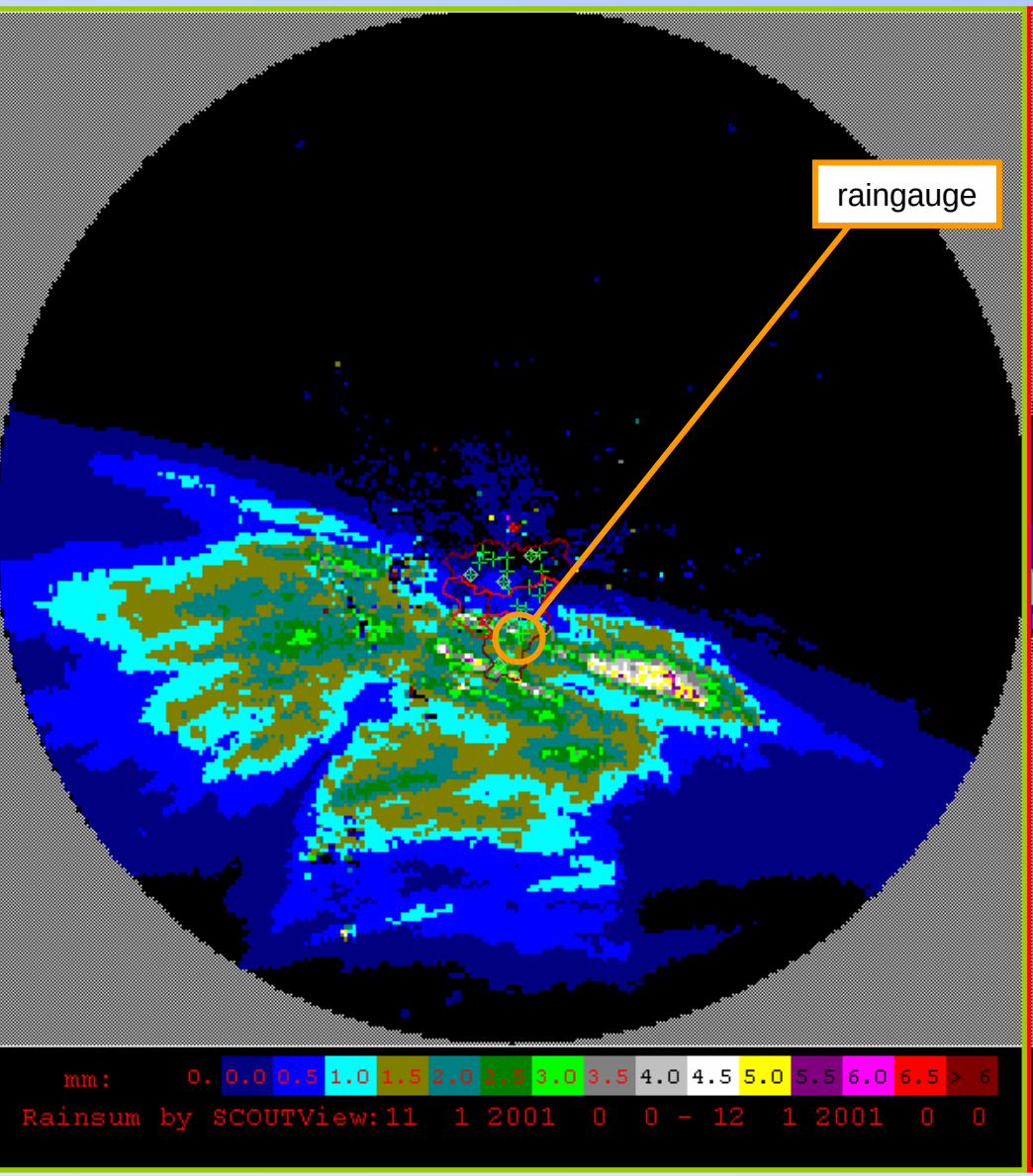
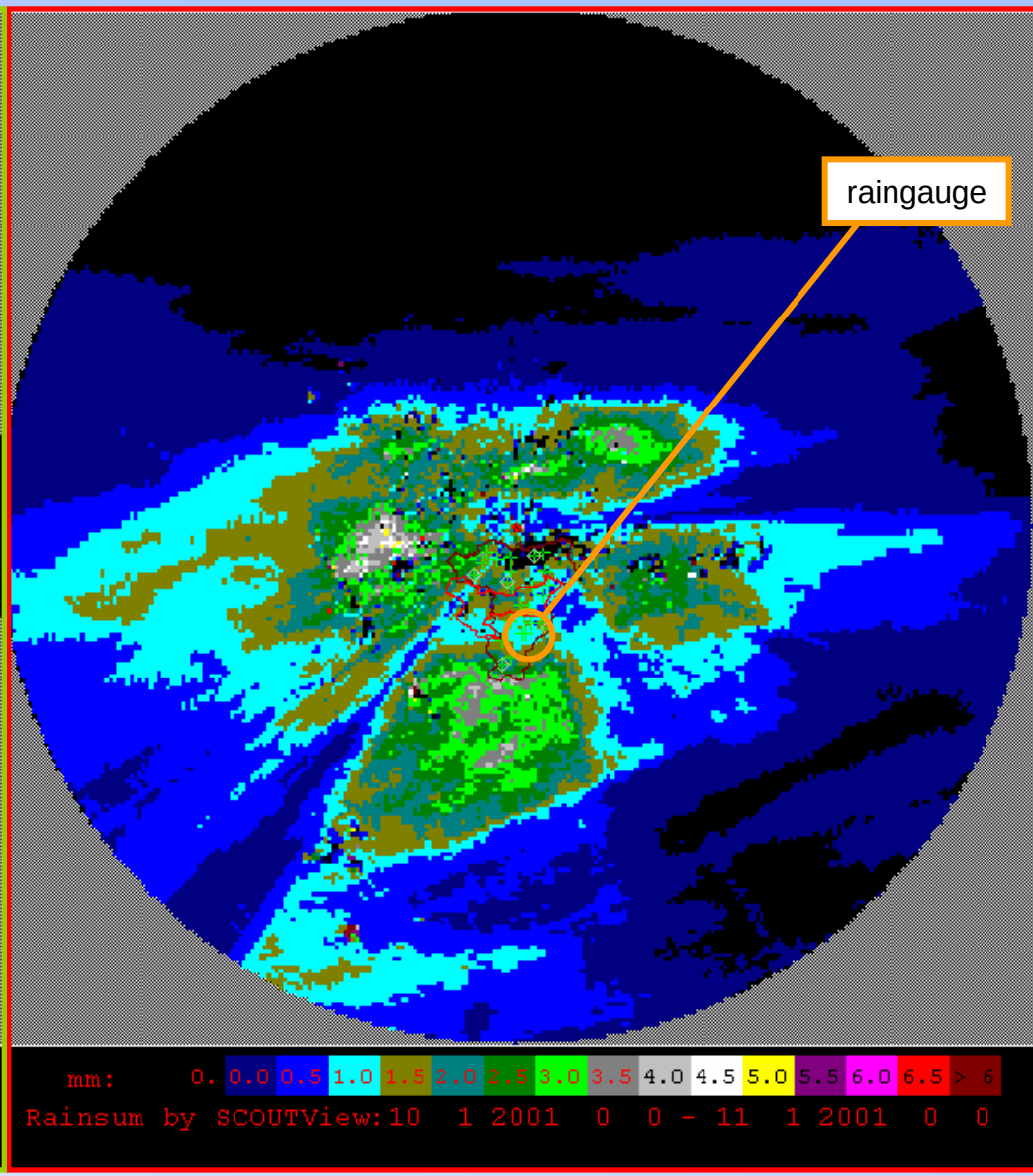


original

Comparison of accumulated radar images



bright band



bright band

Performed work

- Literature review of Quality Control (QC) procedures for rainfall measurements
- Creation of a literature pool
- Development of an HDF5-based radar data format complying with international standards (→ WP)
- Development / implementation of 17 radar QC algorithms in a portable C++ library
- Development / implementation of 3 raingauge related QC algorithms in a portable C++ library

Performed work

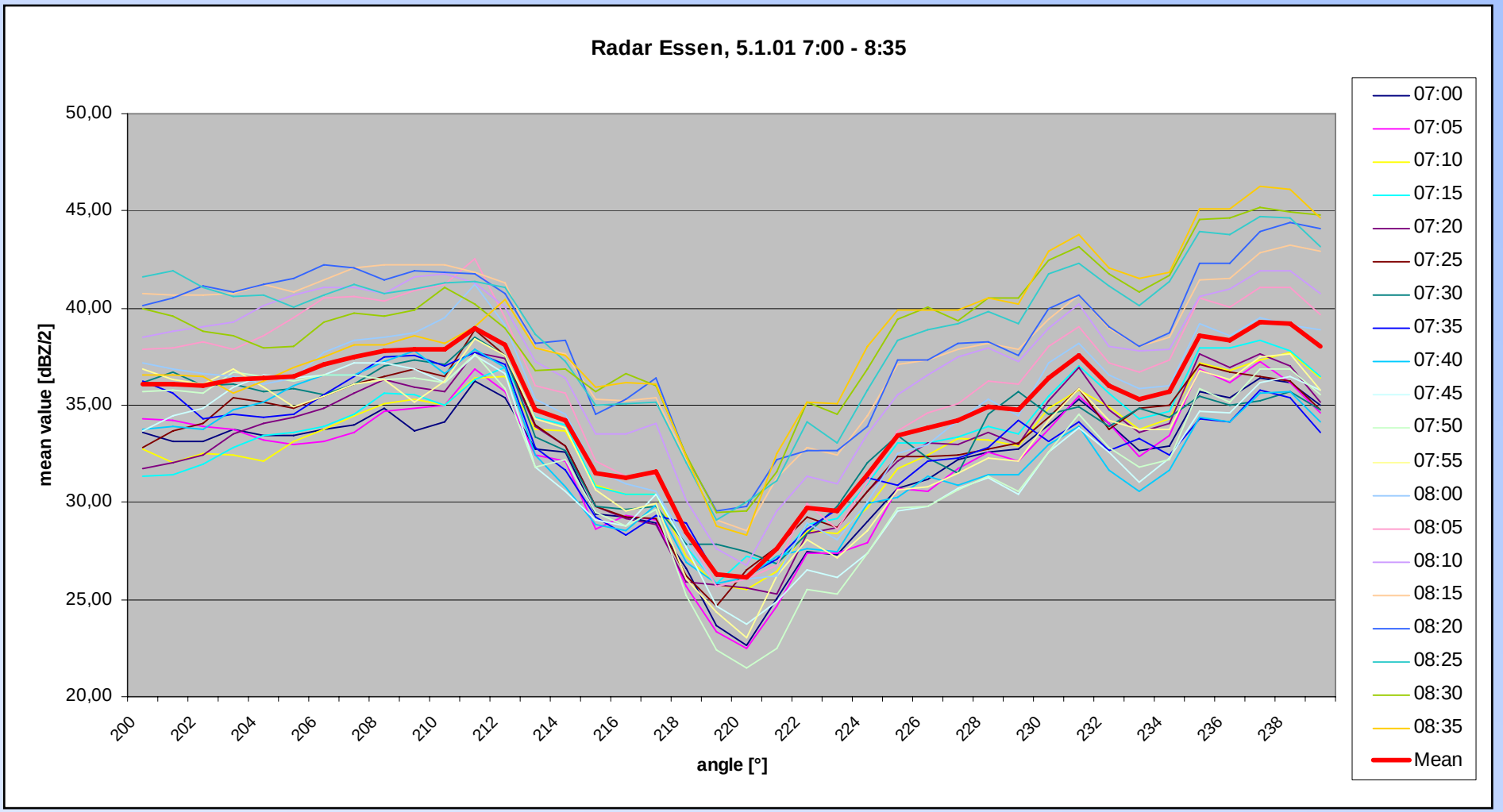
- Demonstration software QCTool
- Successful offline and online tests on radar data from Switzerland, Spain (Catalunya, only offline) and Cyprus (→ WP)
- Successful offline tests of raingauge-related algorithms on data from Switzerland / Italy (→ WP)
- Online application of (part) of the algorithms in Bangkok, Thailand (since 2004) and Kamp-Lintfort, Germany (since 2005)
- Dissemination via ERAD conferences

2. Example “beamblock”

Filter description:

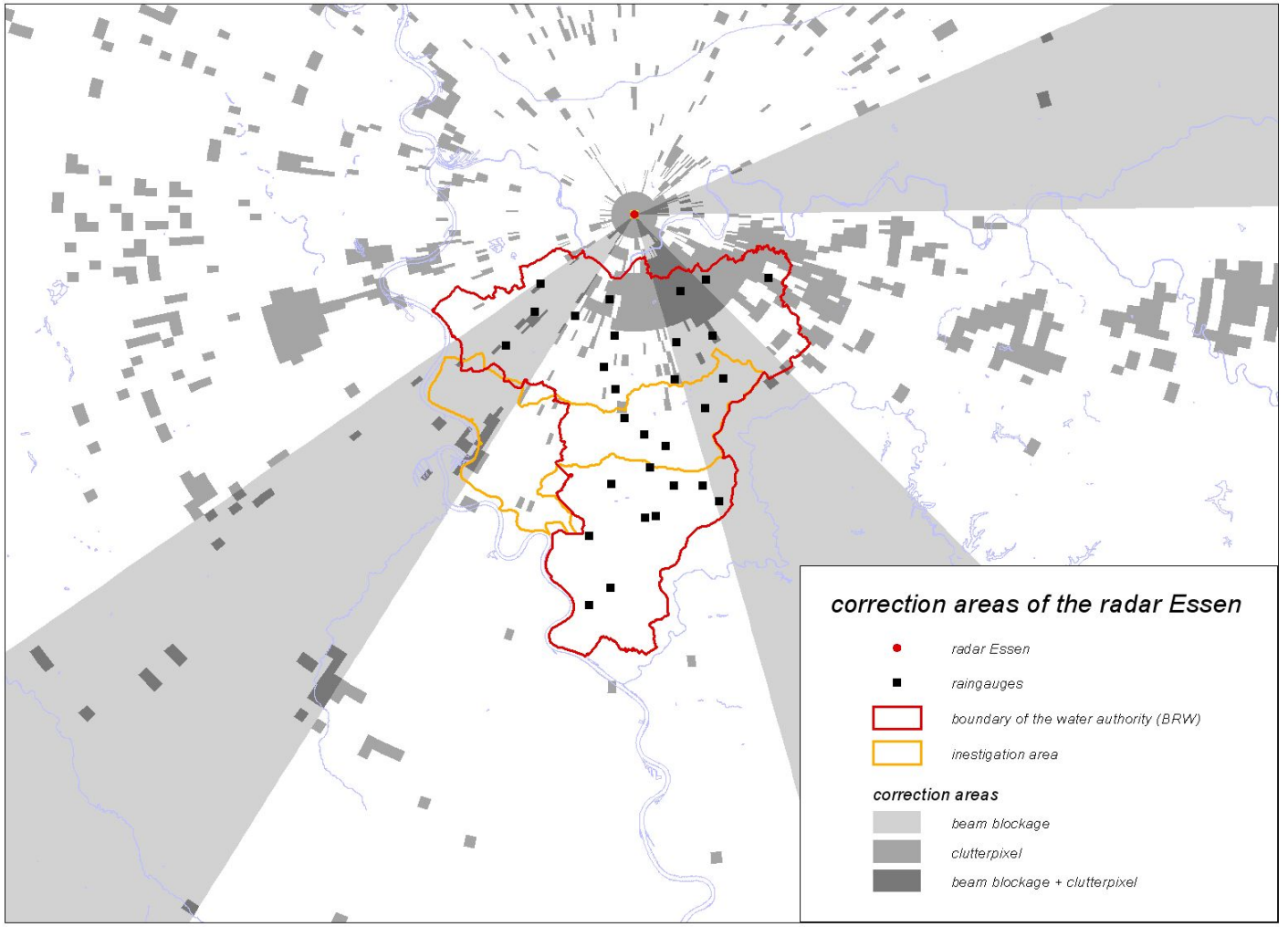
- correction of constant wide (2°-30°) radial anomalies (attenuated, not blocked)
- comparison of ray sums over all distances for each angle
- calculation of constant correction factor or constant dBZ-value for addition

2. Example “beamblock”



2. Example "beamblock"

correction areas



Filter limits radial anomalies

“Radial filter”:

- wide radial anomalies (>5°)
- too short radial anomalies
- detection is more difficult for cartesian than for polar data

“beamblock”:

- wide radial anomalies (>30°; correction value imprecise)
- constant correction value for the whole ray
- temporal variances of correction value

Example bright band

Problem description:

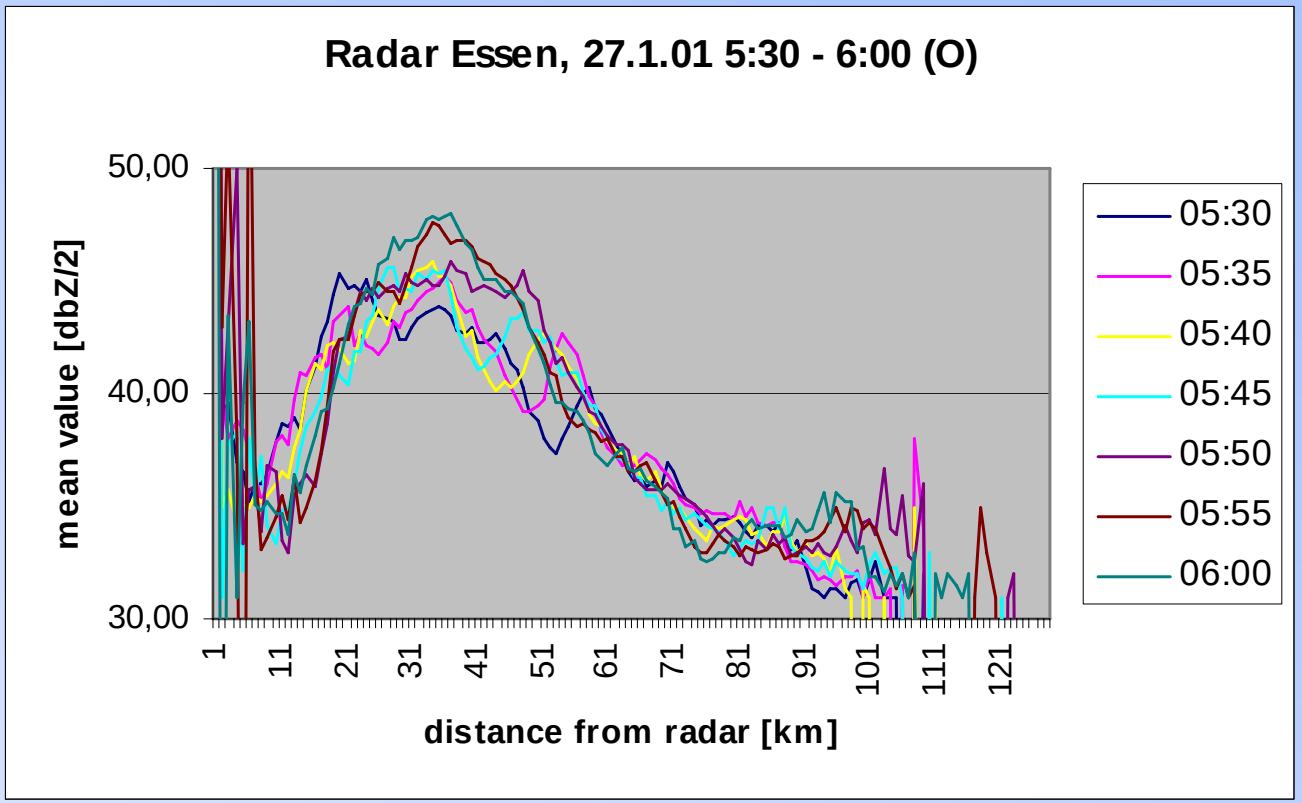
- high radar reflectivity of the melting layer
- often observed in stratiform precipitation in winter

2D algorithm:

- based on a idealised simplified vertical profile
- use of ground temperatures

Example bright band

1. Step:
   - determination of the freezing level
   - calculation of the BB thickness
2. Step:
   - circular computation of mean reflectivities
   - determination of pronounces maximum » peak of BB



Example bright band

3. Step:

- combination of the two zero degree levels (of step 1+2)
- BB correction with linear interpolated factors