

Suggested Sensitivity Studies for the COSMO Priority Project: 'Tackle deficiencies in precipitation forecasts'

A status report of COSMO-PP QPF task 2 and 3

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Task 2: Model changes

- Task 2.1: Initial conditions
- Task 2.2: Numerics
- Task 2.3: Microphysics
- Task 2.3: Convection
- Task 2.3: Surface / PBL

Task 3: Case studies

COSMO-PP QPF Task 2: A List of Standardized Model Changes

Task 2.1: Suggested changes of the initial conditions

Task 2: Model changes

● Task 2.1: Initial conditions

● Task 2.2: Numerics

● Task 2.3: Microphysics

● Task 2.3: Convection

● Task 2.3: Surface / PBL

Task 3: Case studies

Sensitivity study	Type	Label	LM modification	Expected sensitivity	Recommended analysis
Reduction of soil moisture by 20%	S	WSO08	Minor code change: src_soil_multlay.f90	Homogenous reduction of precipitation	Soil moisture, 2m-Temperature and moisture, vertical profiles of T and qv
Increase of soil moisture by 20%	S	WSO12	Minor code change: src_soil_multlay.f90	Homogenous increase of precipitation	Soil moisture, 2m-Temperature and moisture, vertical profiles of T and qv
Reduction of atmospheric water vapor mixing ratio by 10% in cloud free regions	S	QV090	Minor code change: lmorg.F90	Homogenous reduction of precipitation	Vertical profiles of T and qv
Increase of atmospheric water vapor mixing ratio by 10%. Excess water is transferred to cloud water or cloud ice respectively, but without a change in temperature, i.e. without latent heat release.	S	QV110	Minor code change: lmorg.F90	Homogenous increase of precipitation	Vertical profiles of T and qv

Task 2.2: Suggested changes of numerical methods

Task 2: Model changes

● Task 2.1: Initial conditions

● **Task 2.2: Numerics**

● Task 2.3: Microphysics

● Task 2.3: Convection

● Task 2.3: Surface / PBL

Task 3: Case studies

Sensitivity study	Type	Label	LM modification	Expected sensitivity	Recommended analysis
Leapfrog core with tri-cubic semi-lagrange advection of water vapor and hydrometeors	O	LFsl3	Code changes: src_leapfrog.f90, numeric_utilities.f90 and organize_dynamics.f90	Less diffusive; improved flow over terrain	Vertical profiles of T and qv
Runge-Kutta core with tri-cubic semi-lagrange advection of water vapor and hydrometeors	O	RKsl3	Code changes: src_runge_kutta.f90, numeric_utilities.f90 and organize_dynamics.f90	Less diffusive; improved flow over terrain	Vertical profiles of T and qv
Runge-Kutta core with flux-form of water vapor and hydrometeors	O	RKbott	Various namelist settings	Less diffusive; improved flow over terrain, mass conservation.	Vertical profiles of T and qv , vertical cross sections of w .
Runge-Kutta core with T '- p '-dynamics and flux-form advection of water vapor and hydrometeors	O	RKtp	New LM version (all files).	Less diffusive; improved flow over terrain, mass conservation, buoyancy terms.	Vertical profiles of T and qv , vertical cross sections of w .
Orography	S	Oro	INT2LM namelist: eps_filter=0.1	Slightly increased orographic precipitation.	Vertical cross sections of w .

Task 2.3: Suggested changes of microphysical parameterizations

Task 2: Model changes

- Task 2.1: Initial conditions
- Task 2.2: Numerics
- **Task 2.3: Microphysics**
- Task 2.3: Convection
- Task 2.3: Surface / PBL

Task 3: Case studies

Sensitivity study	Type	Label	LM modification	Expected sensitivity	Recommended analysis
Modified microphysics with a new cloud autoconversion scheme	O	MICRO1	Minor change: src_gscp.f90	Reduced drizzle, higher cloud water content.	Vertical profiles or cross sections of cloud water, ice and snow content.
Modified microphysics with extreme changes in snow properties and the new cloud autoconversion	S	MICRO2	Code Change: src_gscp.f90	Reduced drizzle, higher cloud and ice water content. Increased transport of precipitation to the lee side of mountains. Reduced precipitation amount.	Vertical profiles or cross sections of cloud water, ice and snow content. Cloud cover.
Modified microphysics with moderate changes in snow properties and the new cloud autoconversion	D	MICRO3	Code Change: src_gscp.f90	Reduced drizzle, higher cloud and ice water content. Increased transport of precipitation to the lee side of mountains. Slightly reduced precipitation amount.	Vertical profiles or cross sections of cloud water, ice and snow content. Cloud cover.

Task 2.3: Suggested changes of convection schemes

Task 2: Model changes

- Task 2.1: Initial conditions
- Task 2.2: Numerics
- Task 2.3: Microphysics
- **Task 2.3: Convection**
- Task 2.3: Surface / PBL

Task 3: Case studies

Sensitivity study	Type	Label	LM modification	Expected sensitivity	Recommended analysis
Modification of the Tiedtke convection scheme regarding evaporation, turbulent entrainment, mixed-phase saturation adjustment and exchange of cloud water and cloud ice with grid-scale variables	D	CONmod	Code Changes: src_conv_tiedtke.f90, src_leapfrog.f90, slow_tendencies.f90 and others.	Weaker convection	Convection (htopcon) and cloud cover. Cross sections of vertical velocity.
Kain-Fritsch-Bechtold convection scheme including explicit exchange of ice and cloud water to the grid-scale variables	D	CONkfb	Code Changes: src_conv_bechtold.f90, src_leapfrog.f90, slow_tendencies.f90 and others.	Modified convection	Convection (htopcon) and cloud cover. Cross sections of vertical velocity.
Subgrid cumulus convection scheme turned off	S	CONoff	namelist setting: lconv=.false.	No subgrid convection, unrealistic upscaling of convection. Deteriorated forecast.	Cross sections of vertical velocity. Cloud cover.

Task 2.3: Suggested changes of surface / PBL scheme

Task 2: Model changes

- Task 2.1: Initial conditions
- Task 2.2: Numerics
- Task 2.3: Microphysics
- Task 2.3: Convection
- **Task 2.3: Surface / PBL**

Task 3: Case studies

Sensitivity study	Type	Label	LM modification	Expected sensitivity	Recommended analysis
Decreased scaling factor of the laminar sublayers for scalars	S	RLAM01	namelist setting: rlam_heat=0.1	Increased vertical exchange of heat and moisture.	2m-Temperature and moisture, vertical profiles of T and qv
Increased scaling factor of the laminar sublayers for scalars	S	RLAM50	namelist setting: rlam_heat=50	Decreased vertical exchange of heat and moisture.	2m-Temperature and moisture, vertical profiles of T and qv
Decreased stomatal resistance	S	STO50	namelist setting: crs_min=50	Increased vertical exchange of moisture.	2m-Temperature and moisture, vertical profiles of T and qv
Increased stomatal resistance	S	STO250	namelist setting: crs_min=200	Decreased vertical exchange of moisture.	2m-Temperature and moisture, vertical profiles of T and qv

Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
 - 18.03.2005 / Numerics
 - 18.03.2005 / Microphysics
 - 18.03.2005 / Surface
 - 18.03.2005 / Precip
 - 03.05.2005 / Initial conditions
 - 03.05.2005 / Numerics
 - 03.05.2005 / Microphysics
 - 03.05.2005 / Convection
 - 03.05.2005 / Surface
 - 03.05.2005 / Precip
-

COSMO-PP QPF Task 3: QPF case studies - A preview

Case 18.03.2005: Initial conditions

Task 2: Model changes

Task 3: Case studies

● 18.03.2005 / Initial conditions

● 18.03.2005 / Numerics

● 18.03.2005 / Microphysics

● 18.03.2005 / Surface

● 18.03.2005 / Precip

● 03.05.2005 / Initial conditions

● 03.05.2005 / Numerics

● 03.05.2005 / Microphysics

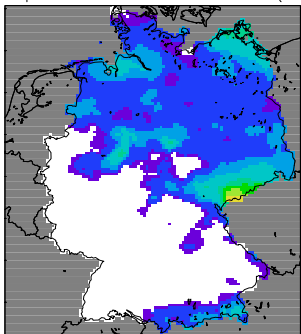
● 03.05.2005 / Convection

● 03.05.2005 / Surface

● 03.05.2005 / Precip

Observations

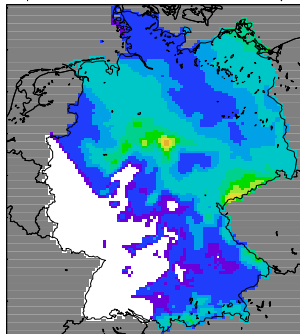
Precipitation 18.03.2005 06:00 UTC + 24h (Obs)



Mean: 1.86398 Min: 0 Max: 30.4 Var: 7.53878

CTRL

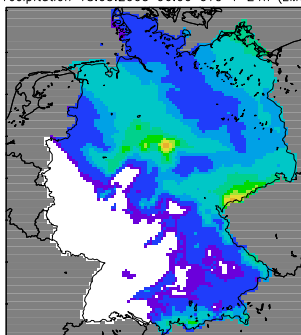
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.0163 Min: 0 Max: 34.0322 Var: 17.7073

WSO08

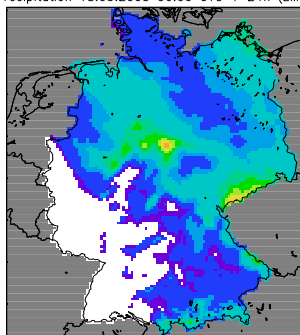
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.67796 Min: 0 Max: 32.9233 Var: 16.2265

WSO12

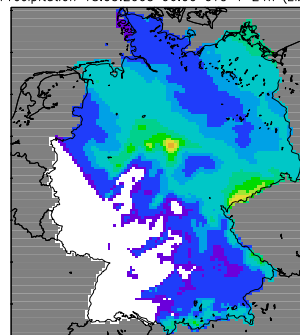
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.10505 Min: 0 Max: 34.3013 Var: 17.9918

QV090

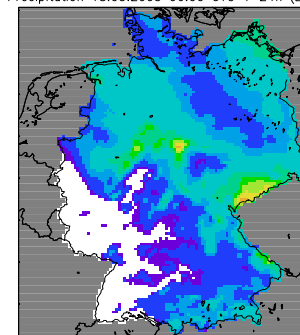
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.99832 Min: 0 Max: 34.0117 Var: 17.7362

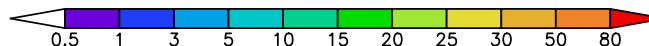
QV110

Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.55874 Min: 0 Max: 31.0229 Var: 18.314

accumulated precipitation in mm



Case 18.03.2005: Numerical methods

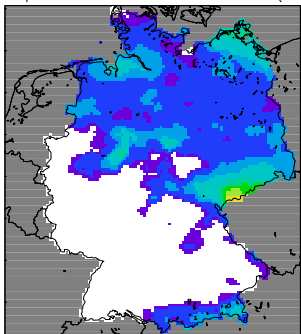
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

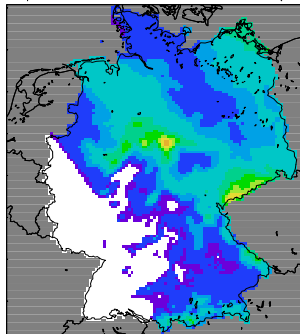
Precipitation 18.03.2005 06:00 UTC + 24h (Obs)



Mean: 1.86398 Min: 0 Max: 30.4 Var: 7.53878

CTRL

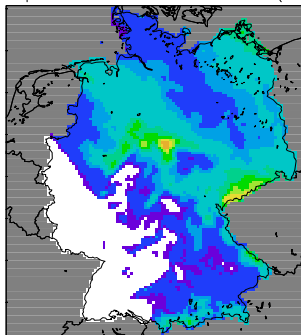
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.0163 Min: 0 Max: 34.0322 Var: 17.7073

LFs1

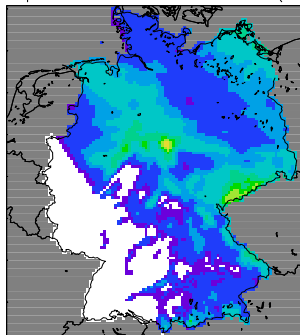
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.02458 Min: 0 Max: 36.8555 Var: 18.44

RKs1

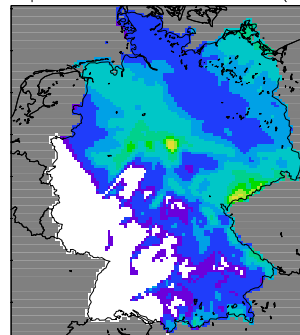
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.19614 Min: 0 Max: 28.5151 Var: 11.4198

RKbott

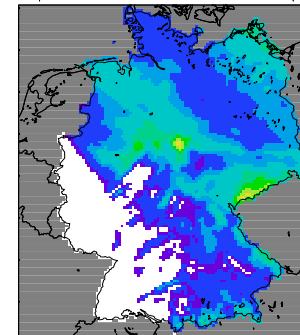
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.3547 Min: 0 Max: 29.584 Var: 12.4013

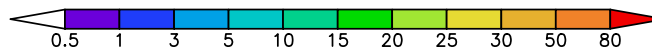
RKtp

Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.41869 Min: 0 Max: 28.2905 Var: 12.5108

accumulated precipitation in mm



Case 18.03.2005: Cloud microphysics

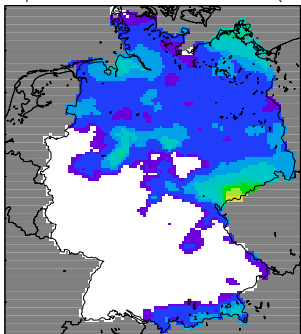
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

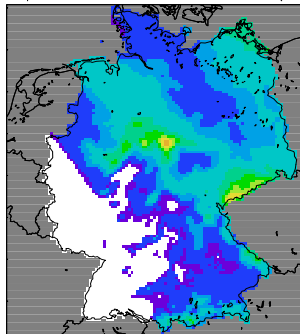
Precipitation 18.03.2005 06:00 UTC + 24h (Obs)



Mean: 1.86398 Min: 0 Max: 30.4 Var: 7.53878

CTRL

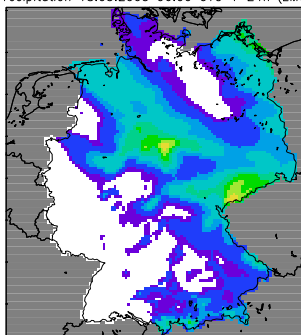
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.0163 Min: 0 Max: 34.0322 Var: 17.7073

MICRO1

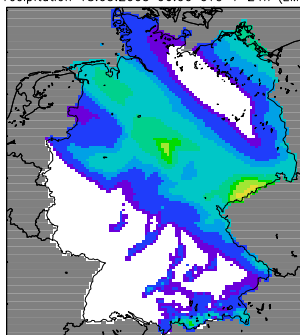
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.25934 Min: 0 Max: 29.0635 Var: 17.9727

MICRO2

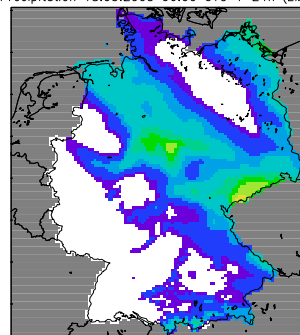
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.34087 Min: 0 Max: 27.0127 Var: 17.7206

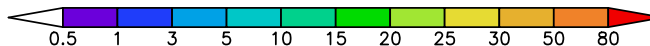
MICRO3

Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.07432 Min: 0 Max: 27.2783 Var: 16.7878

accumulated precipitation in mm



Case 18.03.2005: Surface / PBL

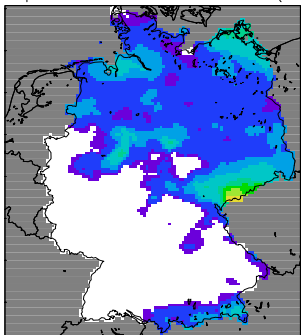
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

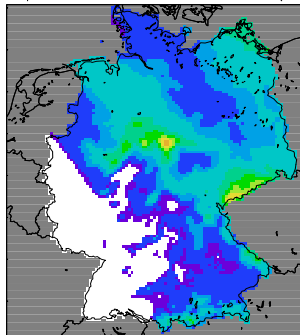
Precipitation 18.03.2005 06:00 UTC + 24h (Obs)



Mean: 1.86398 Min: 0 Max: 30.4 Var: 7.53878

CTRL

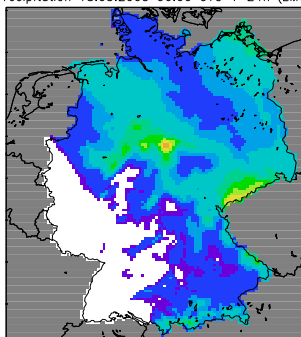
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.0163 Min: 0 Max: 34.0322 Var: 17.7073

RLAM01

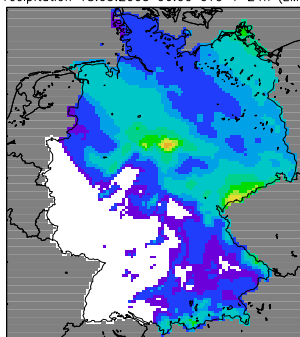
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.04496 Min: 0 Max: 33.2275 Var: 17.6294

RLAM50

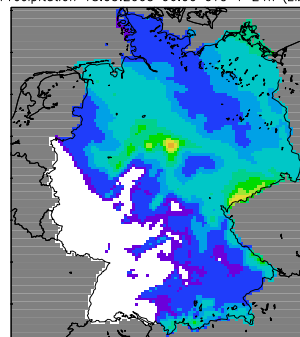
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.54593 Min: 0 Max: 34.0996 Var: 16.1628

STO050

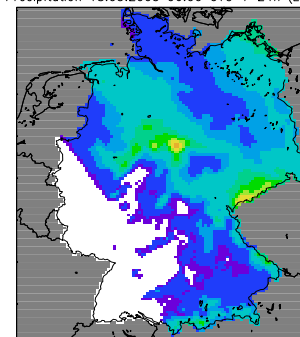
Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 4.07175 Min: 0 Max: 34.3936 Var: 17.8514

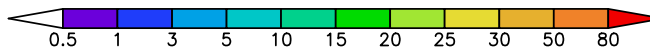
STO250

Precipitation 18.03.2005 06:00 UTC + 24h (LMQ)



Mean: 3.99727 Min: 0 Max: 33.6631 Var: 17.5836

accumulated precipitation in mm



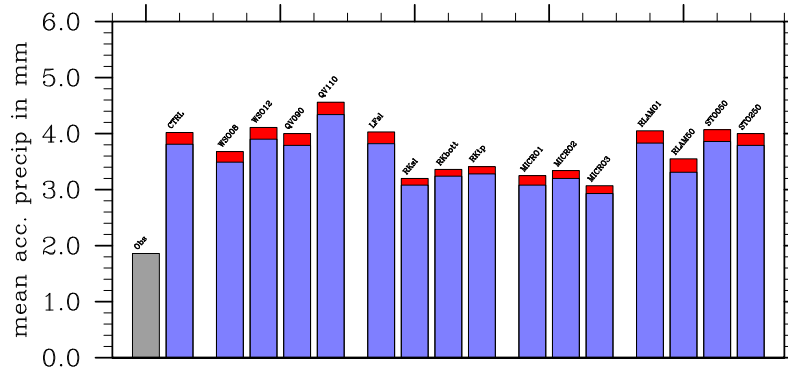
Case 18.03.2005: Mean and Max. Precip.

Task 2: Model changes

Task 3: Case studies

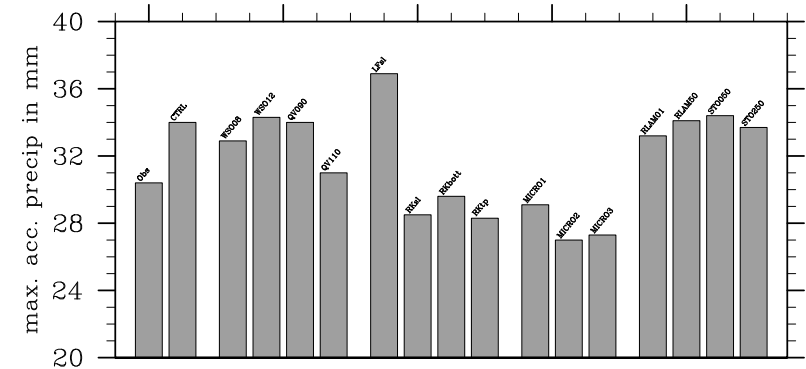
- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

BRD average precip



(blue: grid-scale rain, red: convective precipitation)

BRD maximum precip



- Total precipitation amount shows a weak sensitivity to numerics and microphysics, but is probably strongly constrained by the large-scale model.
- Maximum precipitation is sensitive to numerics and microphysics.

Case 03.05.2005: Initial conditions

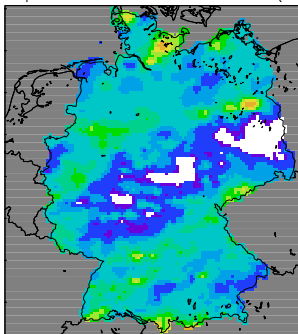
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

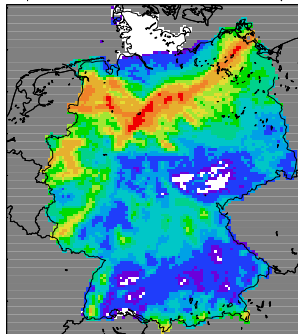
Precipitation 03.05.2005 06:00 UTC + 24h (Obs)



Mean: 6.93248 Min: 0 Max: 38.9942 Var: 26.7665

CTRL

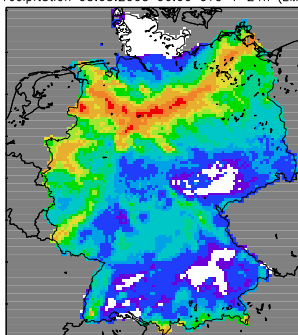
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3455 Min: 0 Max: 132.512 Var: 240.425

WSO08

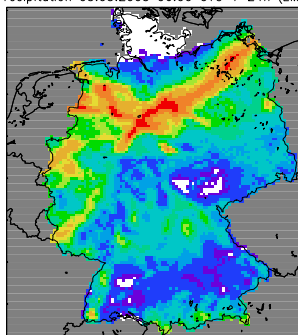
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 11.6464 Min: 0 Max: 135.744 Var: 216.53

WSO12

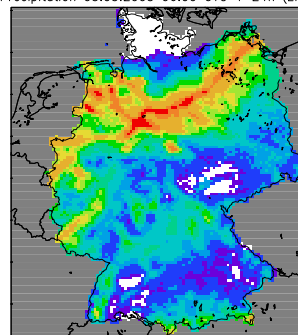
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.8375 Min: 0 Max: 144.88 Var: 265.978

QV090

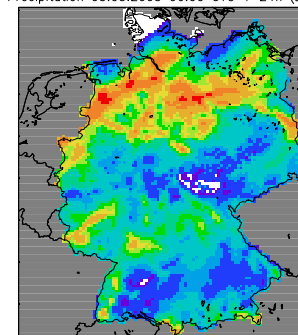
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.6193 Min: 0 Max: 136.505 Var: 244.231

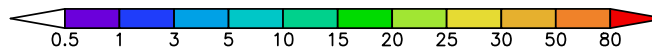
QV110

Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 14.031 Min: 0 Max: 121.263 Var: 226.754

accumulated precipitation in mm



Case 03.05.2005: Numerical methods

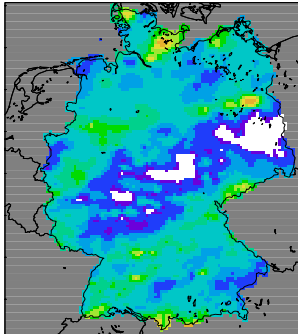
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

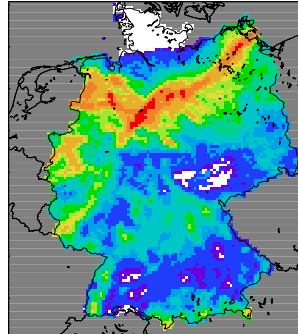
Precipitation 03.05.2005 06:00 UTC + 24h (Obs)



Mean: 6.93248 Min: 0 Max: 38.9942 Var: 26.7665

CTRL

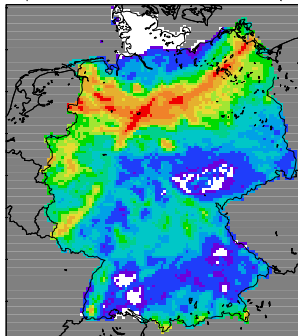
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3455 Min: 0 Max: 132.512 Var: 240.425

LFsl

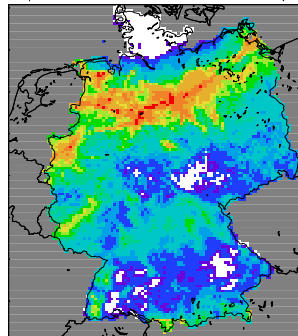
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.4947 Min: 0 Max: 123.565 Var: 258.759

RKsl

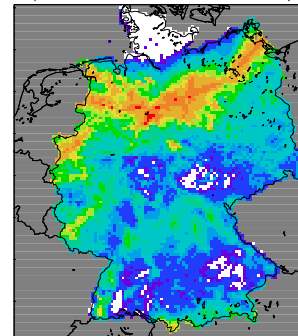
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 11.4591 Min: 0 Max: 150.017 Var: 212.368

RKbott

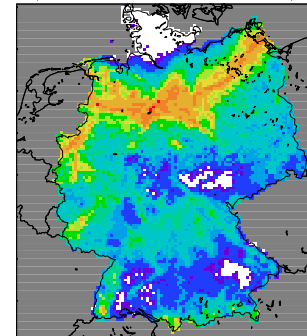
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 10.9153 Min: 0 Max: 115.646 Var: 171.705

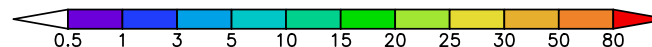
RKtp

Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 11.0649 Min: 0 Max: 97.5938 Var: 151.188

accumulated precipitation in mm



Case 03.05.2005: Cloud microphysics

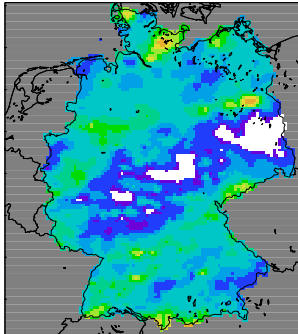
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

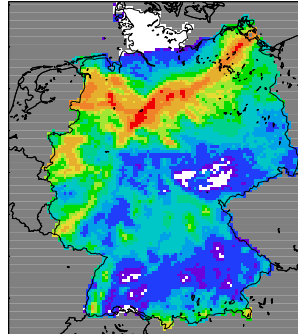
Precipitation 03.05.2005 06:00 UTC + 24h (Obs)



Mean: 6.93248 Min: 0 Max: 38.9942 Var: 26.7665

CTRL

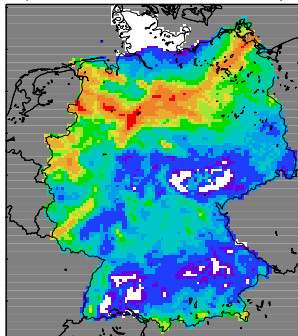
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3455 Min: 0 Max: 132.512 Var: 240.425

MICRO1

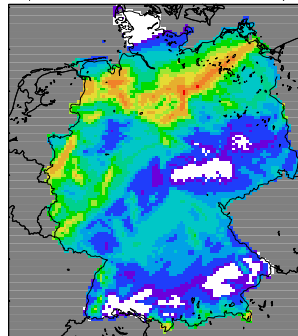
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3029 Min: 0 Max: 123.511 Var: 244.819

MICRO2

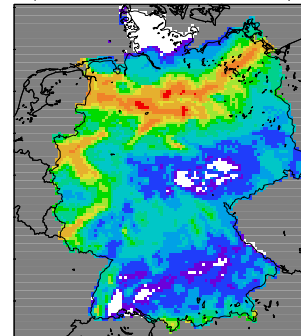
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 9.34702 Min: 0 Max: 82.4473 Var: 113.269

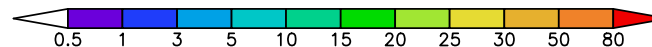
MICRO3

Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 11.656 Min: 0 Max: 118.439 Var: 191.049

accumulated precipitation in mm



Case 03.05.2005: Convection scheme

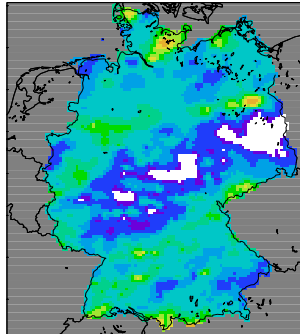
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

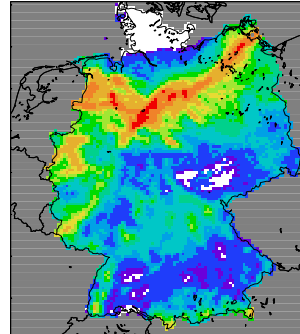
Precipitation 03.05.2005 06:00 UTC + 24h (Obs)



Mean: 6.93248 Min: 0 Max: 38.9942 Var: 26.7665

CTRL

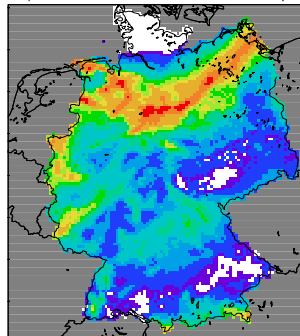
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3455 Min: 0 Max: 132.512 Var: 240.425

CONmod

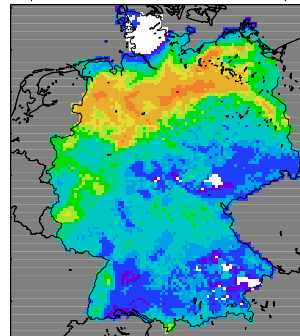
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 11.6686 Min: 0 Max: 175.727 Var: 253.635

CONkfb

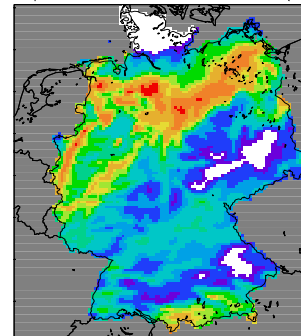
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 11.9482 Min: 0 Max: 85.7012 Var: 150.079

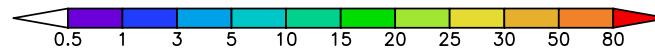
CONoff

Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 13.8214 Min: 0 Max: 144.324 Var: 257.138

accumulated precipitation in mm



Case 03.05.2005: Surface / PBL

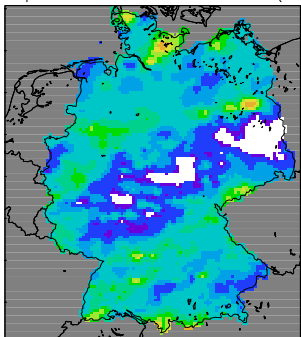
Task 2: Model changes

Task 3: Case studies

- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

Observations

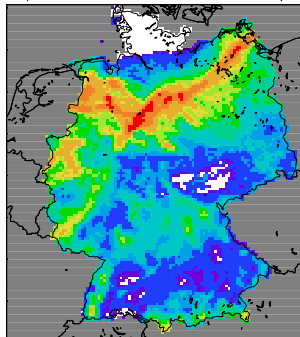
Precipitation 03.05.2005 06:00 UTC + 24h (Obs)



Mean: 6.93248 Min: 0 Max: 38.9942 Var: 26.7665

CTRL

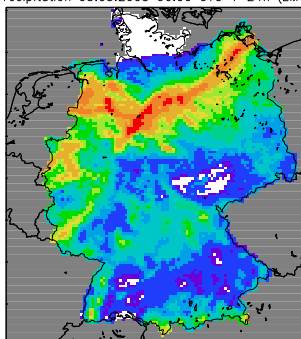
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3455 Min: 0 Max: 132.512 Var: 240.425

RLAM01

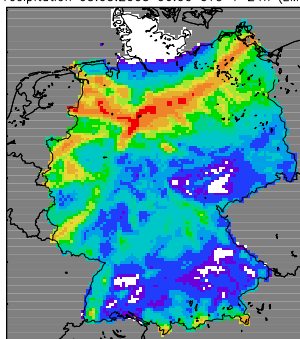
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.3455 Min: 0 Max: 132.512 Var: 240.425

RLAM50

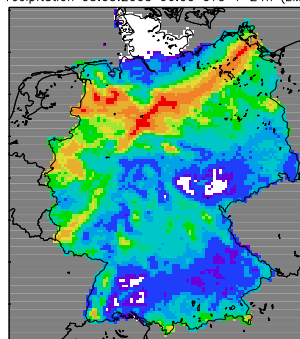
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.0651 Min: 0 Max: 136.956 Var: 245.904

STO050

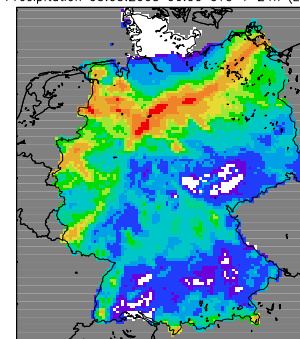
Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.7359 Min: 0 Max: 162.18 Var: 263.814

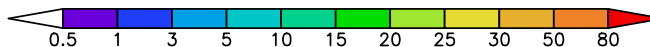
STO250

Precipitation 03.05.2005 06:00 UTC + 24h (LMQ)



Mean: 12.139 Min: 0 Max: 134.973 Var: 228.789

accumulated precipitation in mm



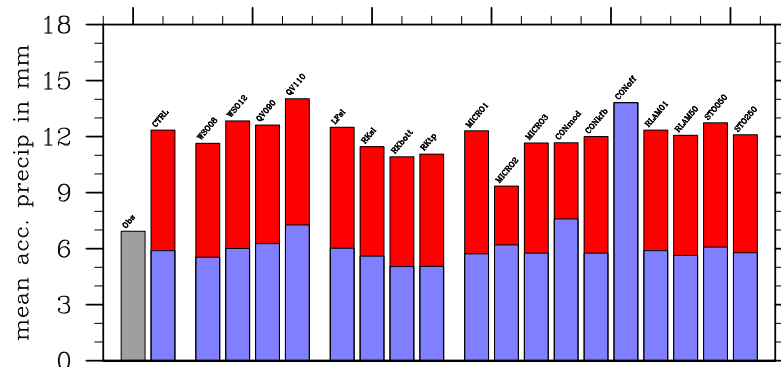
Case 03.05.2005: Mean and Max. Precip.

Task 2: Model changes

Task 3: Case studies

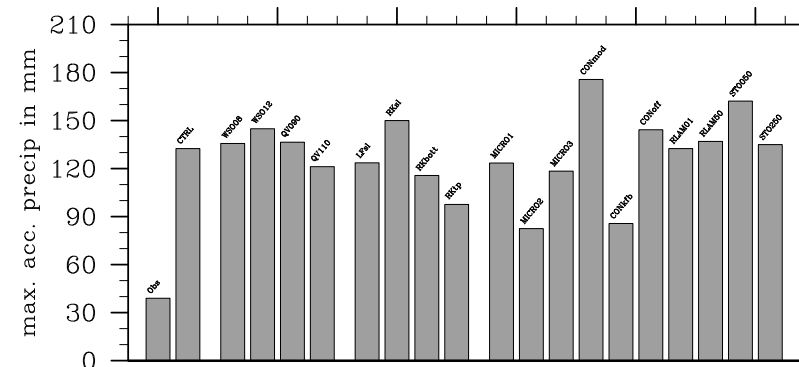
- 18.03.2005 / Initial conditions
- 18.03.2005 / Numerics
- 18.03.2005 / Microphysics
- 18.03.2005 / Surface
- 18.03.2005 / Precip
- 03.05.2005 / Initial conditions
- 03.05.2005 / Numerics
- 03.05.2005 / Microphysics
- 03.05.2005 / Convection
- 03.05.2005 / Surface
- 03.05.2005 / Precip

BRD average precip



(blue: grid-scale rain, red: convective precipitation)

BRD maximum precip



- Total precipitation amount is quite robust and in this case we found no significant improvement from any tested model variant.
- Maximum precipitation is sensitive to numerics, microphysics and the convection scheme.
- Possible problem: Upscaling of convective updrafts to 7 km grid

Summary and conclusions:

- Task 2 of the QPF Priority Project provides a set of sensitivity studies with modifications of initial conditions, numerics and physical parameterizations.
- Most sensitivity studies require some changes in the LM code.
- Preliminary results of some case studies show that it might be possible to remove some biases, e.g. improve orographic precipitation structures, but a dramatic improvement can not be expected.

Task 2: Model changes

Task 3: Case studies

● Summary and conclusions: