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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COSMO-PP QPF Task 2:

A List of Standardized Model Changes

Task 2.1: Suggested changes of the initial conditions

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 transfered 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

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

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 extrem 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

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

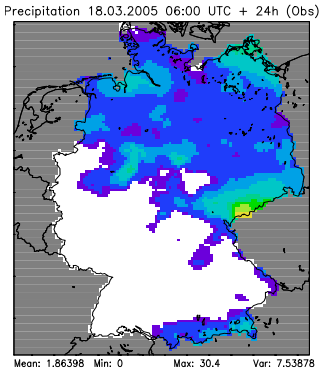
Sensitivity study	Type	Label	LM modification	Expected sensitivity	Recommended analysis
Decreased scaling factor of the laminar sublayers for scalars	S	RLAM01	namelist setting: rlam_heat=0.1	Increased vertical exchange of heat and moisture.	2m-Temperature and moisture, vertical profiles of T and qv
Increased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

COSMO-PP QPF Task 3:

QPF case studies - A preview

Case 18.03.2005: Initial conditions

Observations



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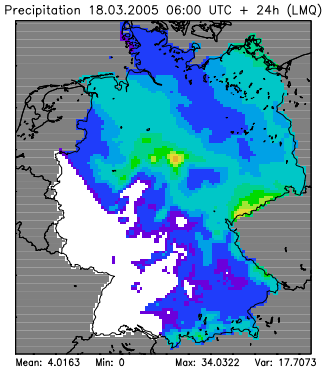

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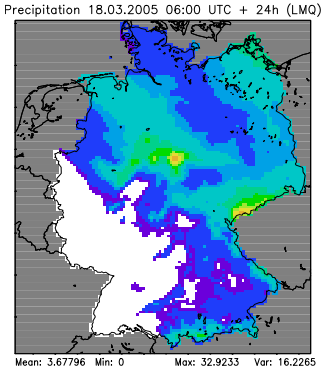

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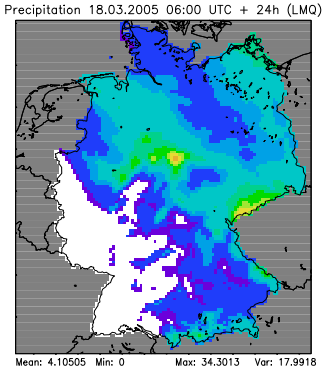

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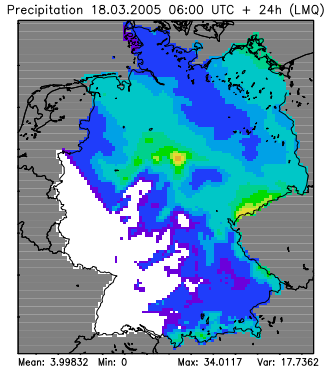

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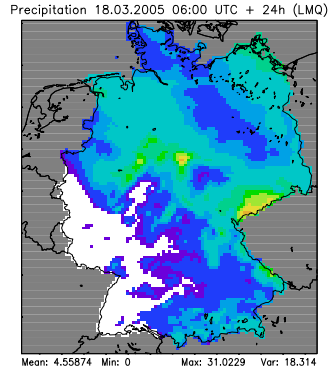
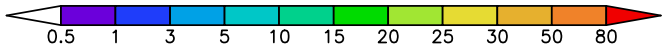
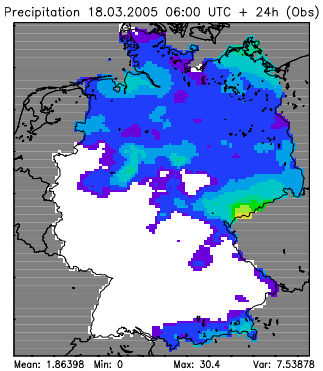


accumulated precipitation in mm



Case 18.03.2005: Numerical methods

Observations



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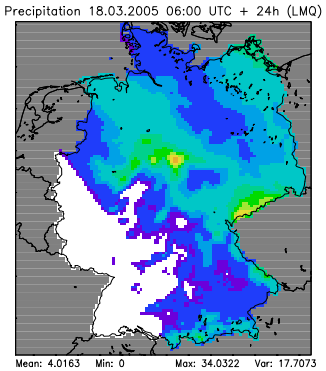

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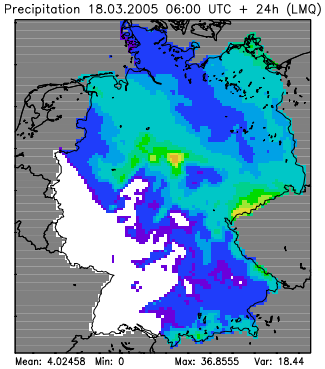

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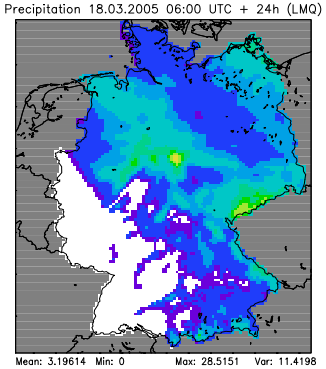
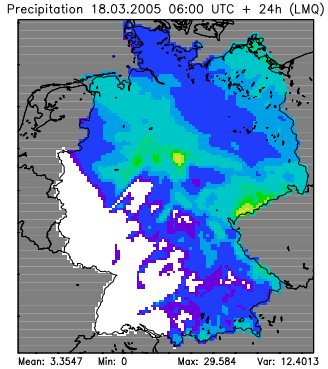


RKbott



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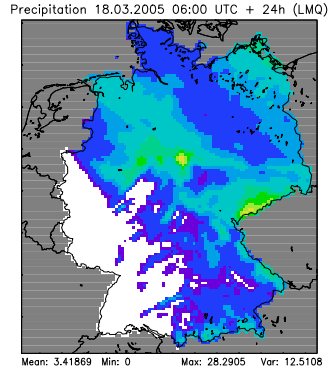
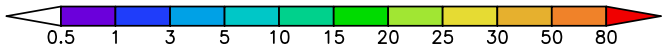
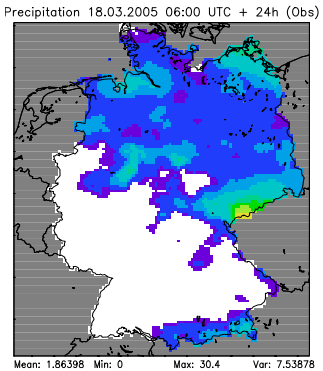


accumulated precipitation in mm



Case 18.03.2005: Cloud microphysics

Observations



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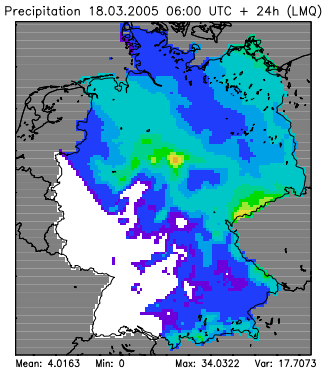

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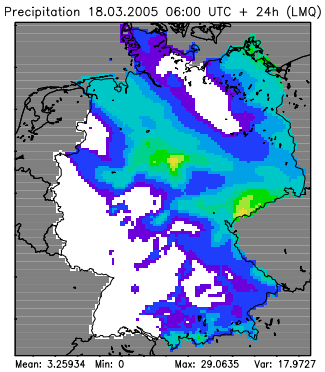

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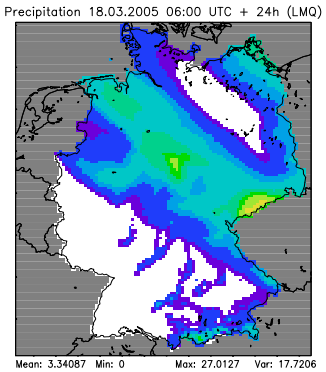

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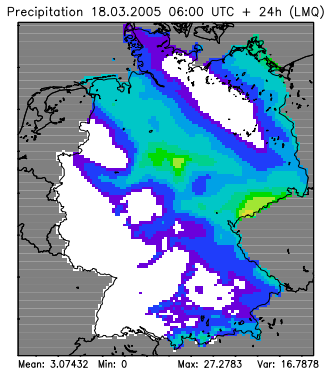
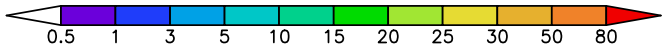
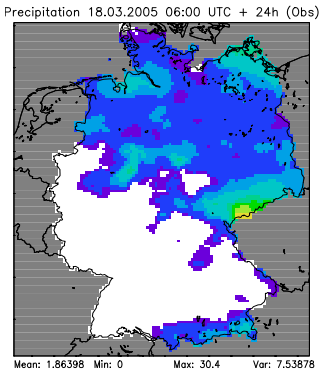


accumulated precipitation in mm



Case 18.03.2005: Surface / PBL

Observations



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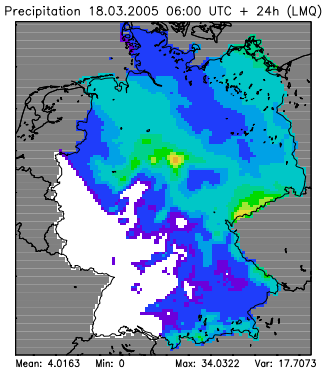
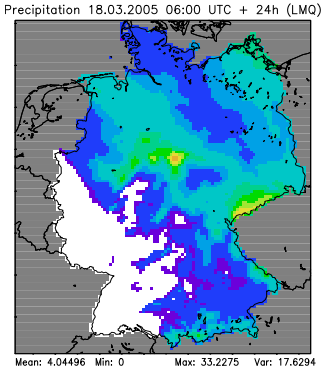
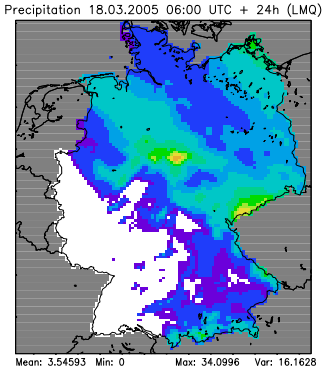


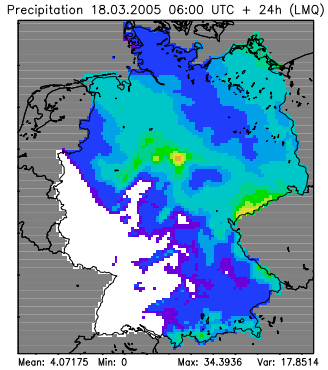
RLAM01



RLAM50



STO050



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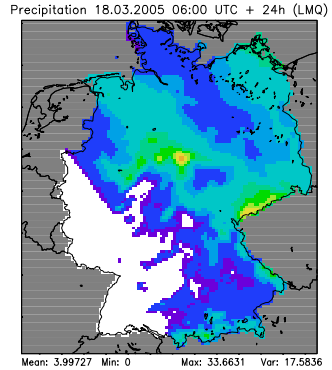
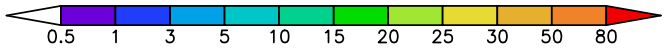
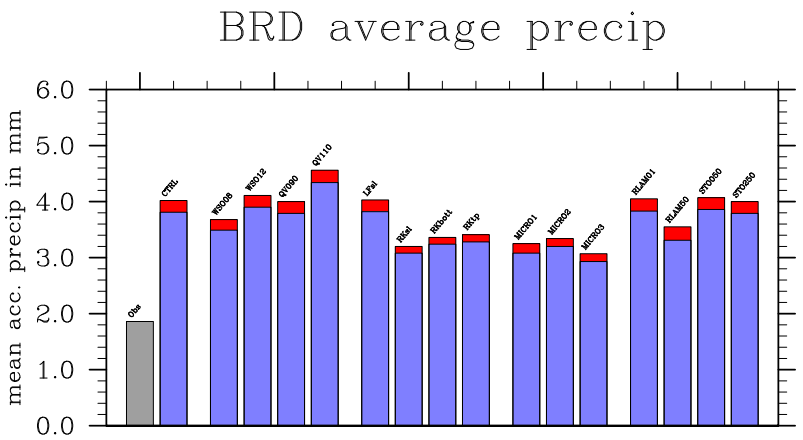
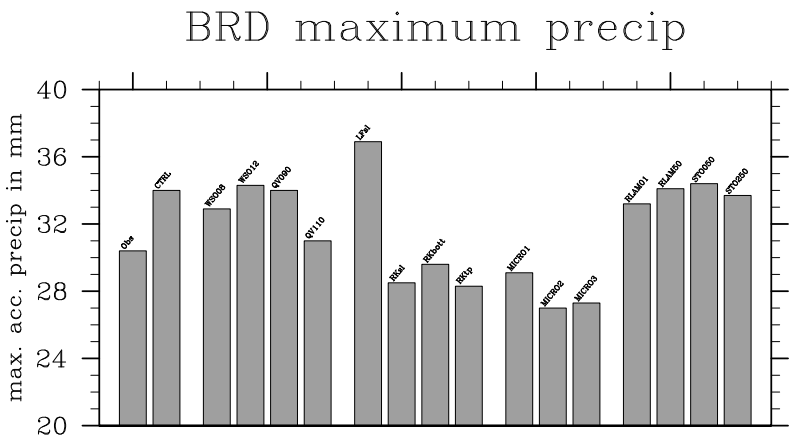


accumulated precipitation in mm



Case 18.03.2005: Mean and Max. Precip.



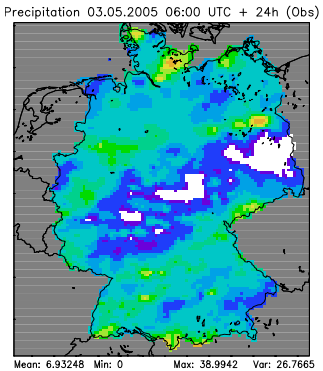


(blue: grid-scale rain, red: convective precipitation)

- 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

Observations



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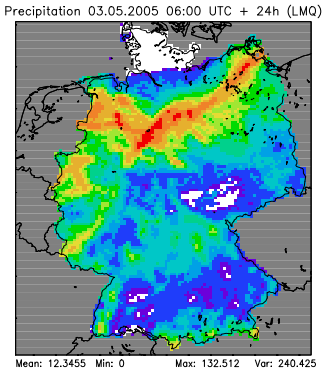

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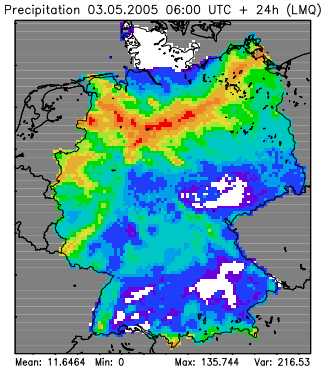
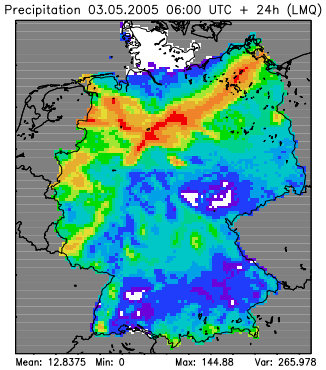
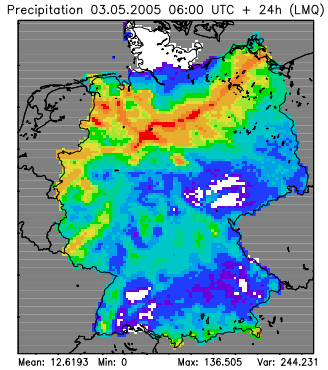


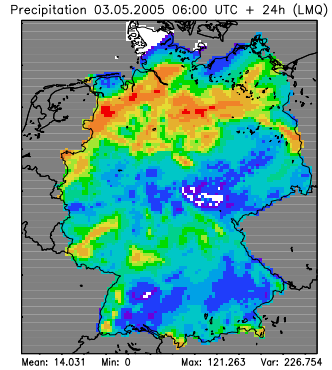
WS012



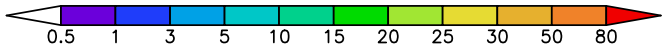
QV090



QV110

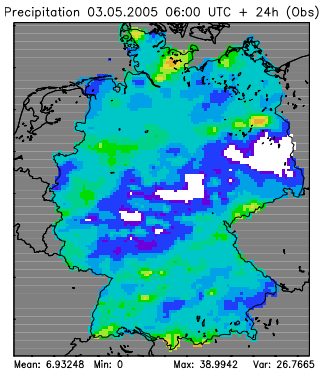


accumulated precipitation in mm



Case 03.05.2005: Numerical methods

Observations



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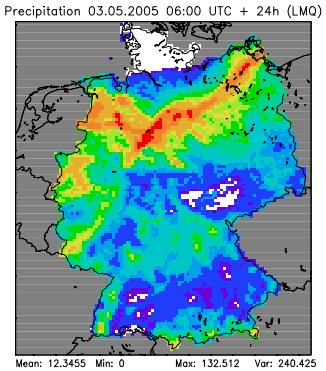
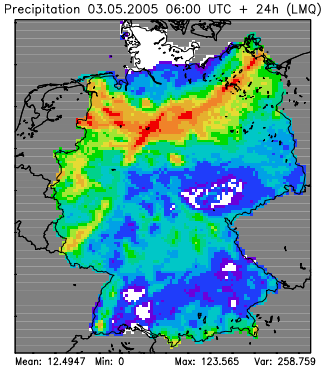
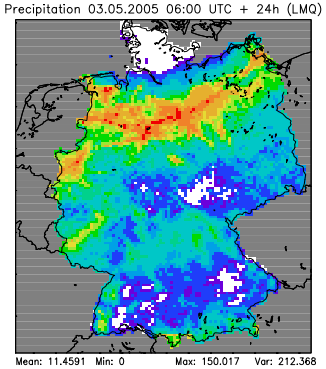


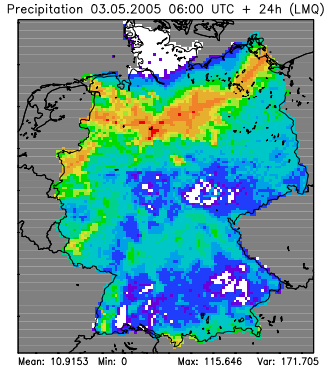
LFsl



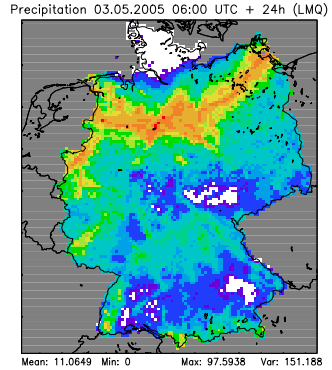
RKsl



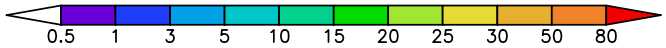
RKbott



RKtp

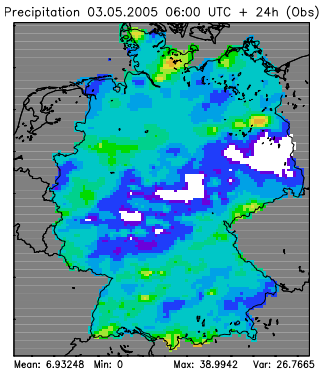


accumulated precipitation in mm



Case 03.05.2005: Cloud microphysics

Observations



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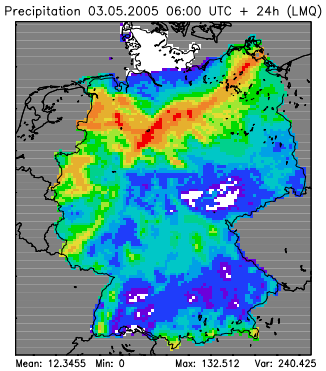
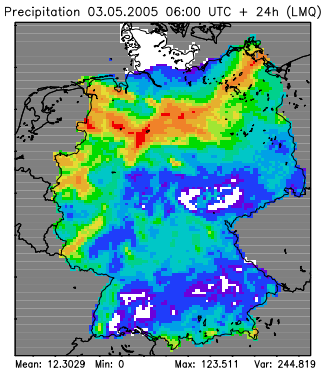


MICRO1



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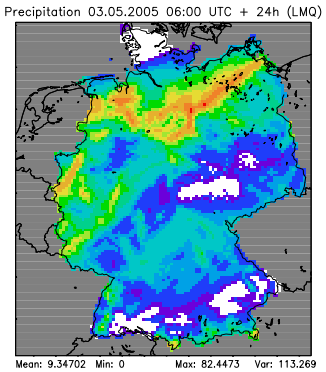
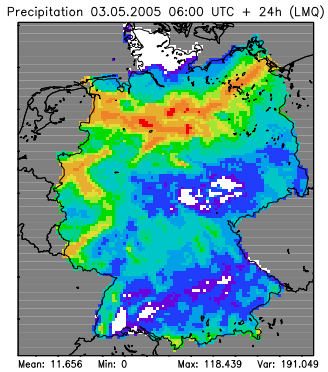
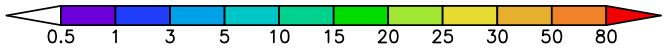


MICRO3

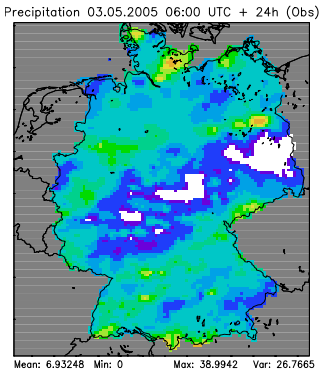


accumulated precipitation in mm

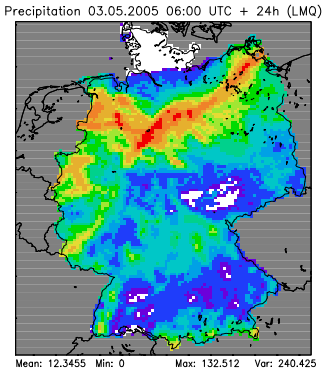


Case 03.05.2005: Convection scheme

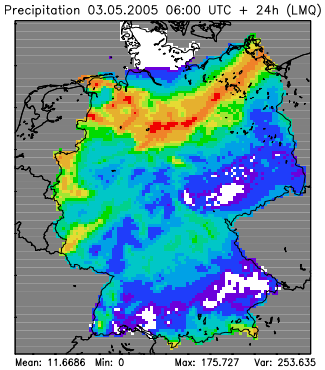
Observations



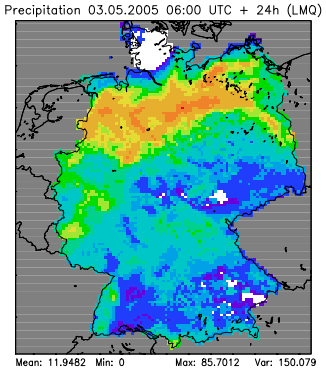
CTRL



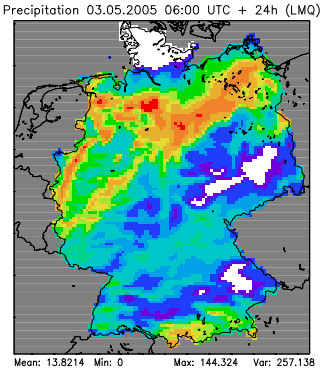
CONmod



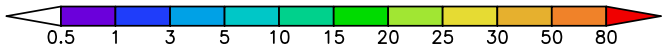
CONkfb



CONoff

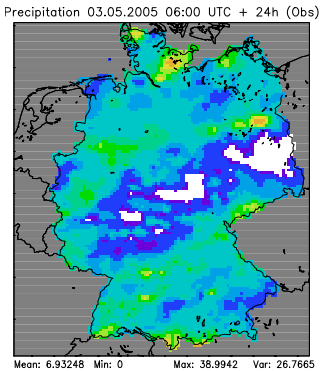


accumulated precipitation in mm

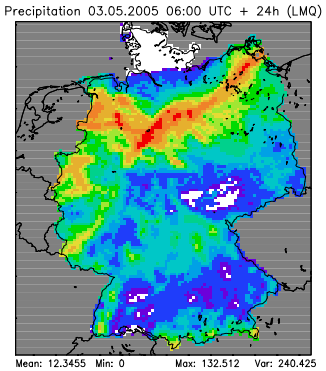


Case 03.05.2005: Surface / PBL

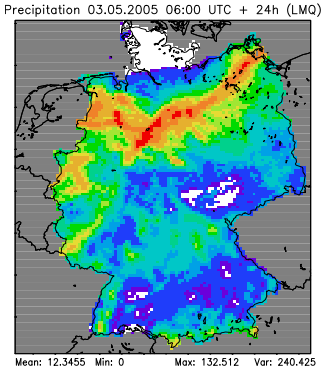
Observations



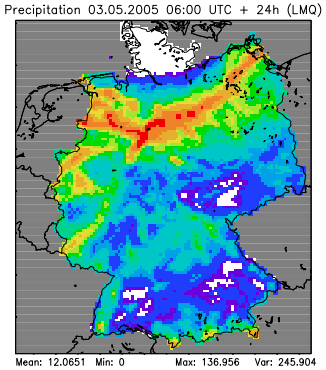
CTRL



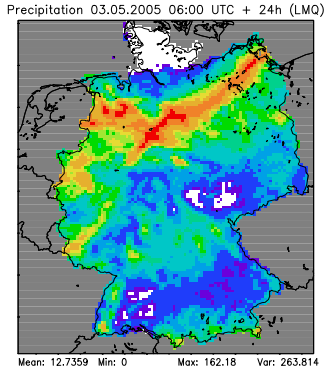
RLAM01



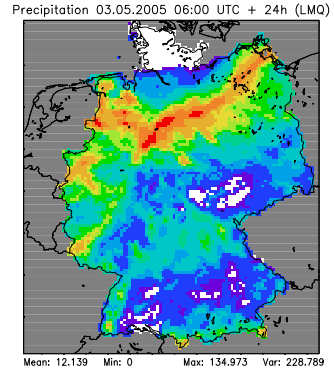
RLAM50



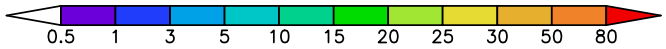
STO050



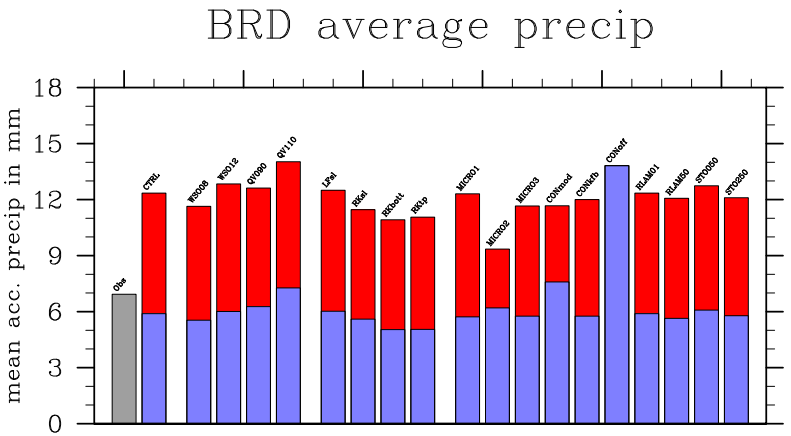
STO250

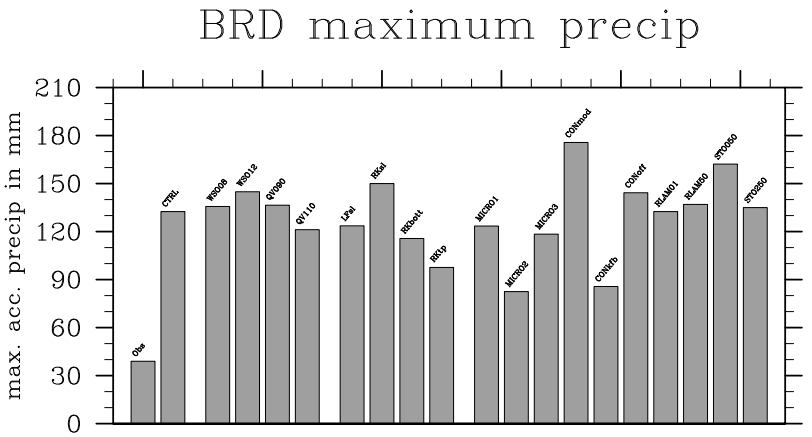


accumulated precipitation in mm



Case 03.05.2005: Mean and Max. Precip.





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

- 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.