



First results of the COSMO Priority Project 'Tackle deficiencies in quantitative precipitation forecasts'

S. Dierer¹, J. Achimowicz⁹, T. Andreadis⁸, M. Arpagaus¹, E. Avgoustoglou⁸, M. Baldauf², C. Cacciamani³, U. Damrath², R. Dumitrache¹⁰, V. Fragkouli⁸, A. Fucello⁴, F. Grazzini³, T. La Rocca⁴, P. Louka⁸, P. Mercogliano⁷, P. Mezzasalma³, M. Milelli⁵, E. Oberto⁵, A. Parodi⁶, I. V. Pescaru¹⁰, U. Pflüger², P. Prohl², I. Pytharoulis⁸, A. Sanna⁵, Ch. Schraff², F. Schubiger¹, A. Seifert², K. Starosta⁹, J. Steppeler², M. Tesini³, E. Zala¹

¹MeteoSwiss (CH), ²DWD (D), ³ARPA-ER (IT), ⁴UGM (IT), ⁵ARPA-P (IT), ⁶Uni Genova (IT), ⁷CIRA (IT), ⁸HNMS (GR), ⁹IMGW (PO), ¹⁰NMA (RO)



Outline

- Aim of COSMO priority project 'Tackle deficiencies in quantitative precipitation forecasts' (PP QPF)
- Overview of PP QPF
- Selection of test cases
- List of sensitivity studies
- First results of the sensitivity studies
- Conclusions and Outlook



Aim of PP QPF

Good quantitative precipitation forecast is a challenging task – not only but also in the COSMO model:

The aim of PP QPF is improved knowledge about

- most suitable namelist settings or
- parts of the model that need to be reformulated to obtain a better QPF at 7 km horizontal grid size

The project has a focus on model deficiencies – not on errors from e.g. large scale conditions



Overview of PP QPF

- Task 1: Selection of test cases representative for „typical“ QPF deficiencies of COSMO model
- Task 2: Definition of sensitivity studies
- Task 3: Run sensitivity studies and draw conclusions
- Task 4: Idealized runs for moist benchmark cases



Selection of test cases



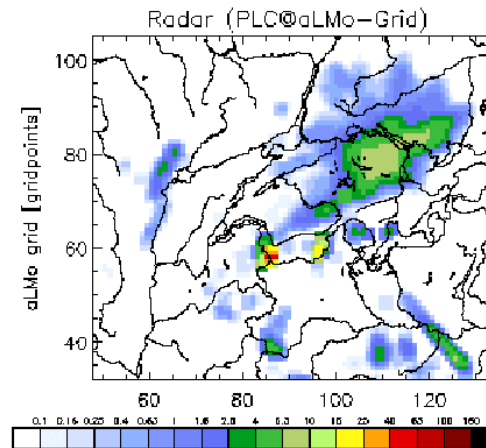
Selection of cases of poor QPF

- Selection of single cases reflecting general problems of QPF in every country
- Large scale situation should be well predicted in order to concentrate on poor performance of COSMO model
- Concentration on “newer” cases (2005 or later) in order to avoid deficiencies due to an old model version
- To ensure this, cases are rerun with reference version
- Every country defines of final list of 3 test cases

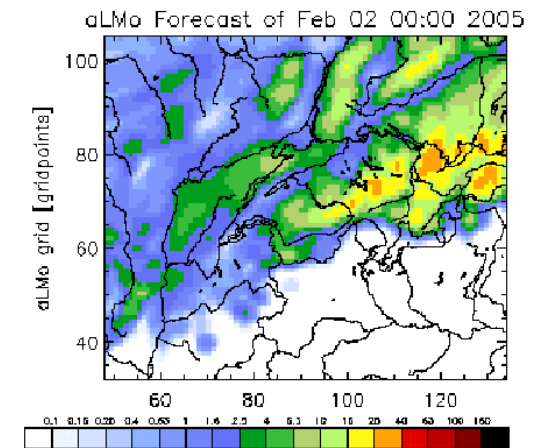


Example: 02.02.2005 - test case selected by MeteoSwiss

24h precipitation on
02.02.2005: radar and
forecast
(northerly large scale flow)

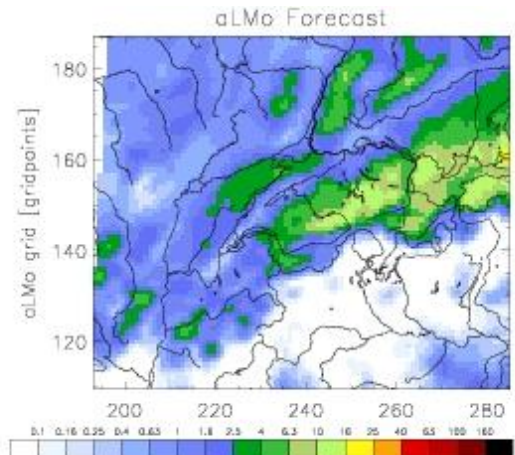
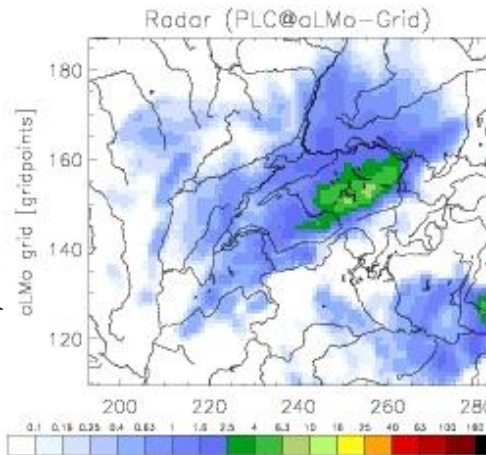


Radar



Operationell

24h precipitation of all
situations in 2005 with
northerly large scale flow:
average precipitation pattern
from radar and forecast





List of test cases from all countries

DATE	INSITUTION	Overestimation (+)/underestimation (-)	Stratiform (strat)/convective(con)	
06.12.2004	LM-DWD	+	strat	warm sector
18.03.2005	LM-DWD	+	strat	orography
03.05.2005	LM-DWD	+	Strat+conv	Warm front
21.06.2005	LM-DWD	-	conv	Cold front
02.02.2005	aLMo	+	strat	Cold front
22.03.2005	aLMo	+	strat	Warm front
12.07.2005	aLMo	+	conv	-
17.12.2005	aLMo	+	Mainly strat	orography
24.09.2004	LAMI	-	conv	Cold front
10.04.2005	LAMI	+	conv	Occluded front
17.08.2006	LAMI	+/-	conv	front
09.09.2005	LAMI	+	conv	-
27.03.2005	LAMI	-	strat/conv	front
01.12.2005	EuroLM	-	mainly strat	?
03.12.2005	EuroLM	+/-	Strat/conv	?
17.12.2005	EuroLM	-	strat/conv	?
15.09.2005	LM-HNMS	+	conv	orography
23.11.2005	LM-HNMS	+	Strat+conv	Cold front
26.11.2005	LM-HNMS	+/-	Strat+conv	Warm+cold front
03.05.2005	LM-IMGW	+	strat	Warm front
04.05.2005	LM-IMGW	+/-	conv	cold front
09.06.2005	LM-IMGW	-	conv	occluded
09.08.2005	LM-IMGW	+/-	?	cold front
23.06.2005	LM-NMA	+	strat+conv	cold front
02.07.2005	LM-NMA	+/-	strat	Cold front
12.07.2005	LM-NMA	+	conv	-



Frequency of types with poor QPF's

	underestimation	Mixed (under-/overestimation)	overestimation
Preliminary list	11 (20%)	13 (24%)	30 (56%)
Final list	6 (30%)	5 (25%)	9 (45%)

by Ulrich Damrath, DWD



Weather situations associated with poor QPF

	Preliminary list	Final list
Warmfront	8 (15%)	3 (15%)
Mixed (WF/CF)	3 (6%)	1 (5%)
Coldfront	22 (41%)	9 (45%)
Occlusion	11 (20%)	3 (15%)
Trough	5 (9%)	2 (10%)
No front	5 (9%)	2 (10%)

by Ulrich Damrath, DWD



List of sensitivity runs



Different fields of sensitivity studies

- 1. Changes of initial conditions
- 2. Changes of numerical methods
- 3.1 Changes of microphysics
- 3.2 Changes of convection schemes
- 3.3 Changes of PBL schemes



List of sensitivity studies

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 q_v
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 q_v
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 q_v
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 re- lease.	S	QV110	Minor code change: lmorg.F90	Homogenous increase of precipitation	Vertical profiles of T and q_v

by Axel Seifert, DWD



List of sensitivity studies

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 q_v
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 q_v
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 q_v , 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 q_v , vertical cross sections of w .
Orography	S	Oro	INT2LM namelist: eps_filter=0.1	Slightly increased orographic precipitation.	Vertical cross sections of w .

by Axel Seifert, DWD



List of sensitivity studies

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 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.

by Axel Seifert, DWD



List of sensitivity studies

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: loconv=false.	No subgrid convection, unrealistic upscaling of convection. Deteriorated forecast.	Cross sections of vertical velocity. Cloud cover.

by Axel Seifert, DWD



List of sensitivity studies

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 q_v
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 q_v
Decreased stomatal resistance	S	STO50	namelist setting: crs_min=50	Increased vertical exchange of moisture.	2m-Temperature and moisture, vertical profiles of T and q_v
Increased stomatal resistance	S	STO250	namelist setting: crs_min=200	Decreased vertical exchange of moisture.	2m-Temperature and moisture, vertical profiles of T and q_v

by Axel Seifert, DWD



Runs of sensitivity runs



Runs of sensitivity studies (finished end 02/2007)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
06.12.2004																							
18.03.2005																							
03.05.2005																							
21.06.2005																							
02.02.2005																							
22.03.2005																							
12.07.2005																							
17.12.2005																							
24.09.2004																							
10.04.2005																							
17.08.2006																							
09.09.2005																							
27.03.2005																							
01.12.2005																							
03.12.2005																							
17.12.2005																							
15.09.2005																							
23.11.2005																							
26.11.2005																							
03.05.2005																							
04.05.2005																							
10.06.2005																							
09.08.2005																							
23.06.2005																							
02.07.2005																							
12.07.2005																							



First results from sensitivity studies for German, Swiss and Romanian cases

- All together 10 cases:
 - 5 cases of overestimated winter precipitation
 - 4 cases of overestimated summer precipitation
 - 1 case of underestimated summer precipitation
- Comparison of 24h area average precipitation of sensitivity study, control run and observations



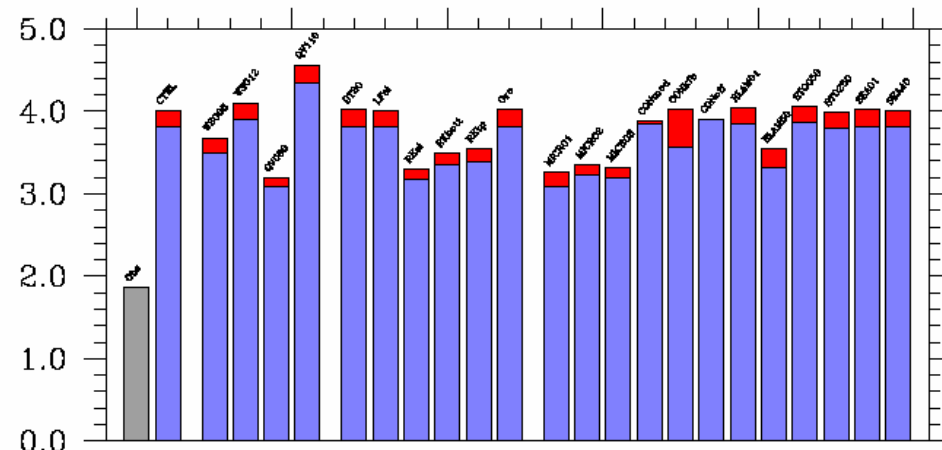
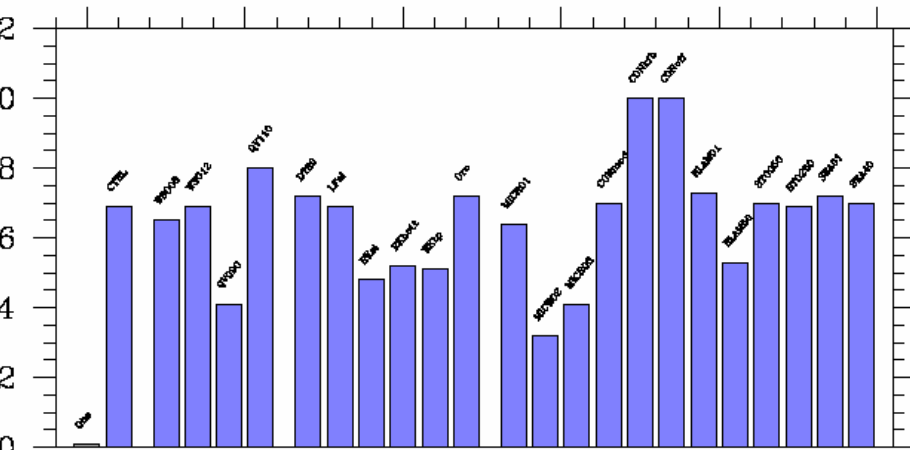
Winter cases with overestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

06.12.2004

18.03.2005

BRD average precip

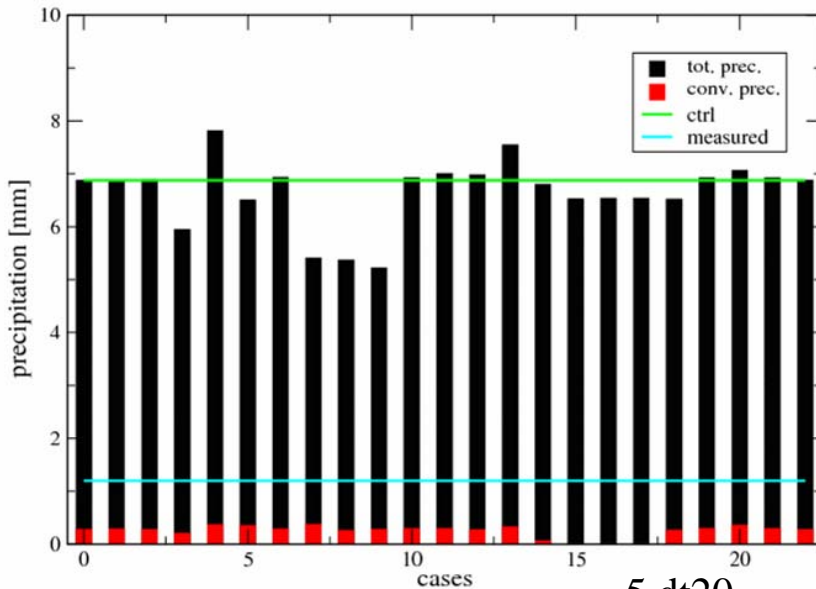
BRD average precip



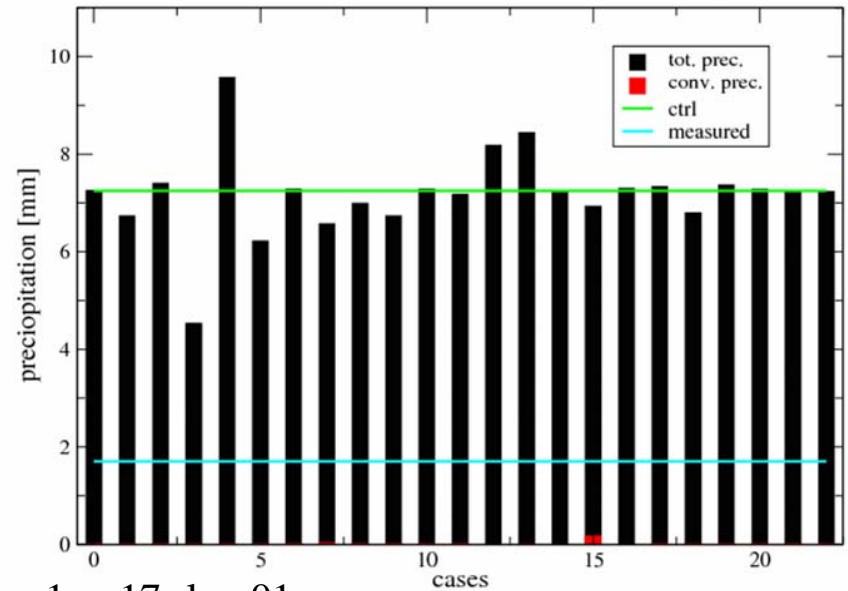


Winter cases with overestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

02.02.2005



22.03.2005

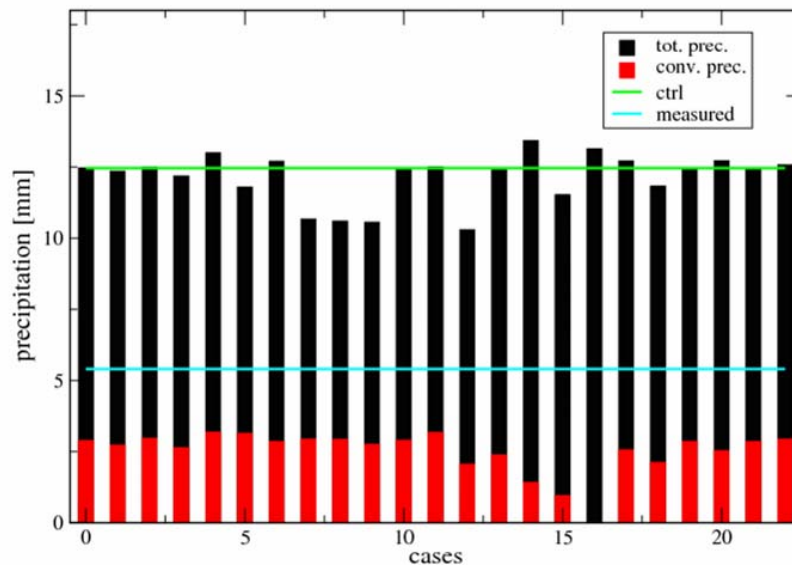


- | | | |
|----------|-----------|-----------|
| 5 dt20 | 11 micro1 | 17 rlam01 |
| 0 ctrl | 6 lfls3 | 12 micro2 |
| 1 wso80 | 7 Rksl3 | 13 micro3 |
| 2 Wso120 | 8 rkbott | 14 conmod |
| 3 Qv090 | 9 rktp | 15 conkfb |
| 4 Qv110 | 10 oro | 16 conoff |
| | | 18 rlam50 |
| | | 19 sto050 |
| | | 20 sto250 |
| | | 21 sea01 |
| | | 22 sea40 |



Winter cases with overestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

17.12.2005



0 ctrl	5 dt20	11 micro1	17 rlam01
1 wso80	6 lfls13	12 micro2	18 rlam50
2 Wso120	7 Rksl3	13 micro3	19 sto050
3 Qv090	8 rkbott	14 conmod	20 sto250
4 Qv110	9 rktp	15 conkfb	21 sea01
	10 oro	16 conoff	22 sea40

Winter cases with overestimated precipitation **- change of 24h area average precipitation** **sum in the sensitivity studies**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
06.12.2004			Dark Blue	Red			Dark Blue	Dark Blue	Dark Blue		Light Blue	Dark Blue	Dark Blue		Red	Red		Light Blue					
18.03.2005	Light Blue		Dark Blue	Orange			Dark Blue	Dark Blue	Dark Blue		Dark Blue	Dark Blue	Dark Blue					Light Blue					
02.02.2005			Dark Blue	Red	Light Blue		Dark Blue	Dark Blue	Dark Blue						Light Blue	Light Blue	Light Blue	Light Blue					
22.03.2005	Light Blue		Dark Blue	Red	Dark Blue		Light Blue		Light Blue			Red	Red		Light Blue			Light Blue					
17.12.2005							Dark Blue	Dark Blue	Dark Blue			Dark Blue		Orange	Light Blue	Orange		Light Blue					

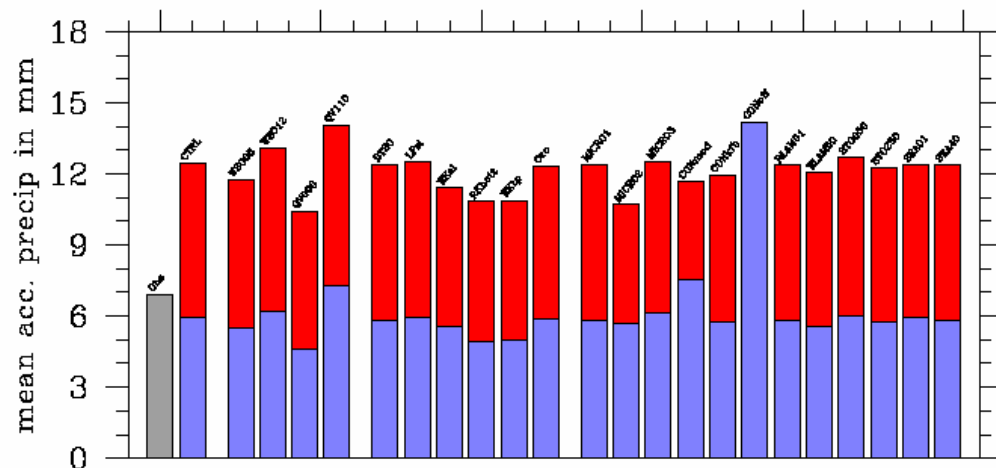
- | | | | |
|----------|----------|-----------|-----------|
| | 5 dt20 | 11 micro1 | 17 rlam01 |
| O ctrl | 6 flsl3 | 12 micro2 | 18 rlam50 |
| 1 wso80 | 7 Rksl3 | 13 micro3 | 19 sto050 |
| 2 Wso120 | 8 rkbott | 14 conmod | 20 sto250 |
| 3 Qv090 | 9 rktp | 15 conkfb | 21 sea01 |
| 4 Qv110 | 10 oro | 16 conoff | 22 sea40 |



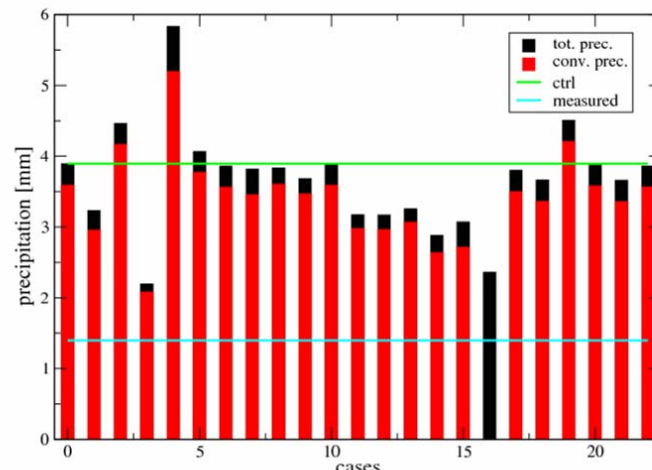
Summer cases with overestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

03.05.2005

BRD average precip



12.07.2005

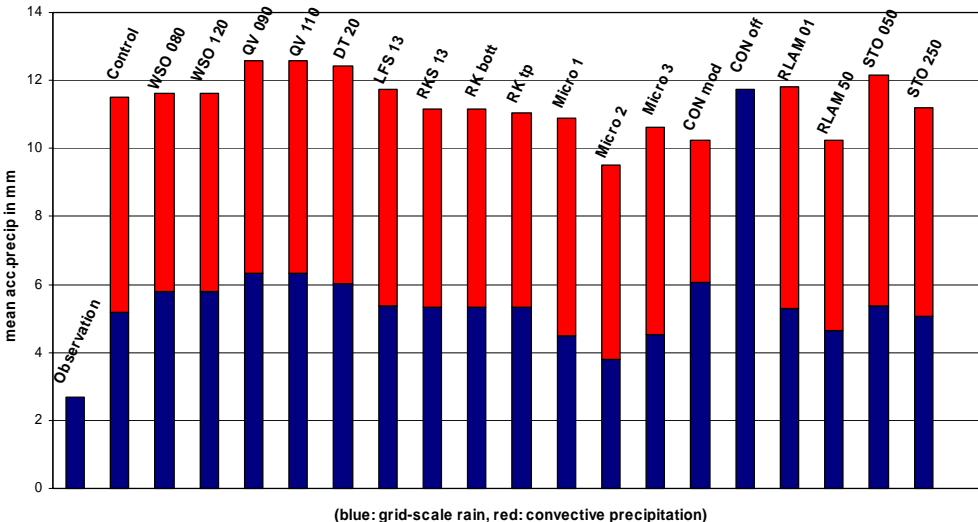


	5 dt20	11 micro1	17 rlam01
0 ctrl	6 lfls3	12 micro2	18 rlam50
1 wso80	7 Rkls3	13 micro3	19 sto050
2 Wso120	8 rkbott	14 conmod	20 sto250
3 Qv090	9 rktp	15 conkfb	21 sea01
4 Qv110	10 oro	16 conoff	22 sea40

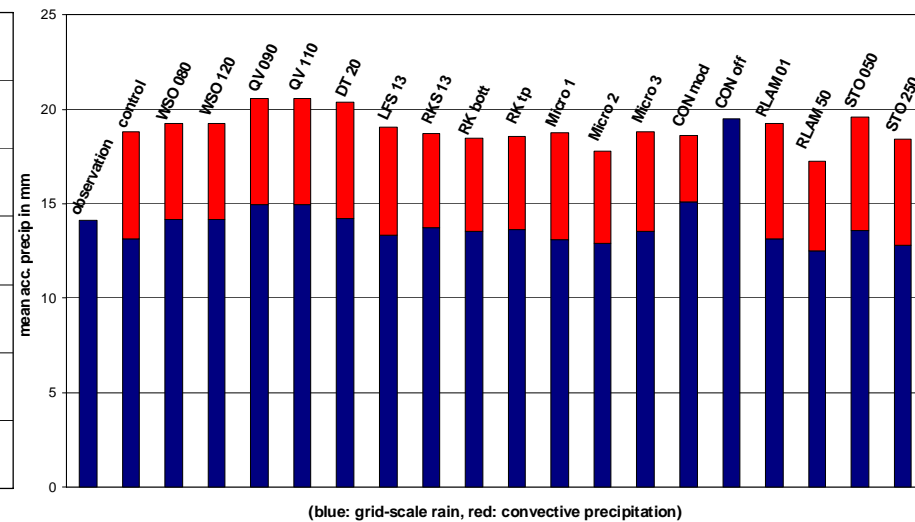


Summer cases with overestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

AVERAGE PRECIPITATION
23.06.2005



AVERAGE PRECIPITATION
02.07.2005





Summer cases with overestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
03.05.2005	Blue		Dark Blue	Orange			Blue	Blue	Blue			Blue		Blue	Blue	Red							
23.06.2005			?	Orange	Orange							Blue	Blue	Blue				Blue	Orange	Blue			
02.07.2005			?	Orange	Orange							Blue						Blue					
12.07.2005	Blue	Orange	Blue	Orange							Blue	Blue	Blue	Blue	Blue	Dark Blue				Orange			

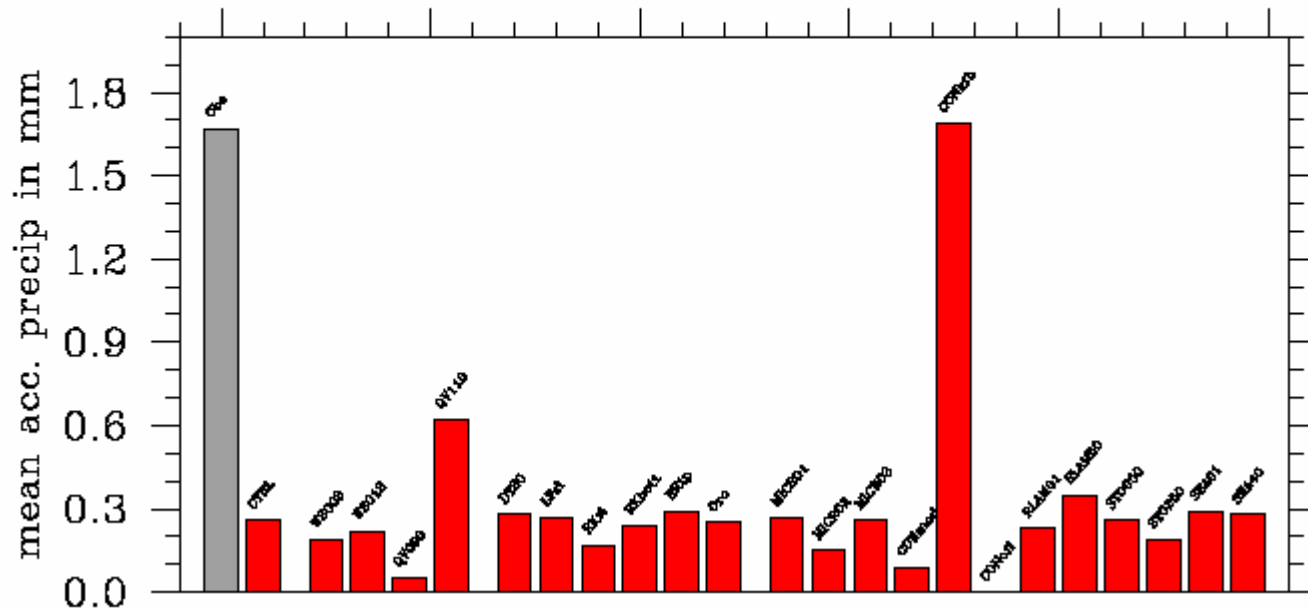
- | | | | |
|----------|----------|-----------|-----------|
| | 5 dt20 | 11 micro1 | 17 rlam01 |
| O ctrl | 6 lfls3 | 12 micro2 | 18 rlam50 |
| 1 wso80 | 7 Rksl3 | 13 micro3 | 19 sto050 |
| 2 Wso120 | 8 rkbott | 14 conmod | 20 sto250 |
| 3 Qv090 | 9 rktp | 15 conkfb | 21 sea01 |
| 4 Qv110 | 10 oro | 16 conoff | 22 sea40 |



Summer cases with underestimated precipitation - change of 24h area average precipitation sum in the sensitivity studies

21.06.2005

BRD average precip





Conclusions and Outlook

- None of the studies completely solves a QPF problem, but some give a significant improvement for single cases like
 - changes of snow microphysics for winter precipitation overestimation
 - Kain-Fritsch/Bechtold for summer precipitation underestimation
- Initial humidity is of great importance
- Runge-Kutta reduces mean precipitation in most of the cases
- Decreased vertical exchange of heat and moisture (RLAM) tends to decrease mean precipitation
- Next steps:
 - Complete statistics for all runs
 - Detailed look at runs with changes in order to understand changes, e.g. why does Runge-Kutta tend to decrease average precipitation? Why decreased vertical exchange?
 - Possibly further studies, e.g. using COSMO model version 3.22