Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Evaluation of the COSMO model with redesigned physics data structure and ICON physics components

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Motivation

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- Strategic goal: COSMO model with redesigned data structure and improved physics components from ICON

- Main aims:
  - Improvement of COSMO model forecast skills in boundary-forcing from ICON,
  - Reduction of code maintainance for unified physics components

- Development steps:
  - Technical implementation: new interfaces, merge and adaption
  - Numerical experiments: Hindcasts, BACY, NUMEX
  - Verification: web-based app using feedback files from model runs

Physics in COSMO 5.5

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Process	Scheme	Model
Radiation	RRTM (later with McICA & McSI)	ICON
	δ two-stream	COSMO
Sub-grid scale orographic drag	blocking, GWD	ICON/COSMO
Microphysics	prognostic: water vapor, cloud water, cloud ice, rain and snow	ICON/COSMO
Convection	mass-flux shallow and deep Tiedtke-Bechtold	ICON
	Tiedke, (Tiedtke-Bechtold)	COSMO
Turbulent transfer	prognostic TKE	ICON/COSMO
Land	tiled TERRA + soil moisture analysis	ICON
	TERRA	COSMO

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Numerical experiments

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- **Hindcasts**: forecast only runs using analysis files from hard disk
  - Advantage: very fast, several months in a couple of hours, including verification, good for sensitivity studies
  - Disadvantage: no data assimilation, i.e. no feedback from modified physics on the analysis

- **BACY**: data assimilation and forecast runs on hard disk
  - Advantage: much faster than experiments with database access
  - Disadvantage: very hard disk space consuming, only selected periods can be investigated

- **NUMEX**: data assimilation and forecast runs with database access
  - Advantage: quasi operational setup, no limitation of the period
  - Disadvantage: depending on the database could be very slow

ndcasts

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/TUNING/	OPER_NOW	TEST_OLD	REF_NEW	TEST_NEW	TEST_l300m	Explanation
tkhmin	0.4	0.4	0.75	0.75	0.75	-
tkmmin	0.4	0.4	0.75	0.75	0.75	-
rat_sea	20.0	20.0	7.5	7.5	7.5	-
pat_len	500.0	500.0	750.0	750.0	750.0	-
tur_len	150.0	150.0	500.0	500.0	300.0	-
a_hshr	0.2	0.2	2.0	2.0	2.0	-
c_soil	1.0	1.0	1.75	1.75	1.75	-
wichfakt	0.0	N.A.	N.A.	N.A.	N.A.	-
/PHYCTL/	OPER_NOW	TEST_OLD	REF_NEW	TEST_NEW	TEST_l300m	Explanation
itype_vdif	-2	-1	1	1	1	-
ltkeshs	.FALSE.	.FALSE.	.TRUE.	.TRUE.	.TRUE.	-
itype_sher	1	1	0	0	0	-
imode_tran	1					
imode_turb	1					
icldm_tran	0					
lconf_avg	.TRU					
itype_albedo	3					
itype_aerosol	1					
itype_root	1					
itype_heatcond	1					
itype_evsl	2					
cwimax_ml	-					
idiag_snowfrac	-					
lemiss	.FAL					
lstomata	.FALSE.	.FALSE.	.FALSE.	.TRUE.	.TRUE.	-
lmulti_layer	.TRUE.	N.A.	N.A.	N.A.	N.A.	-
/IOCTL/	OPER_NOW	TEST_OLD	REF_NEW	TEST_NEW	TEST_l300m	Explanation
lbdclim	.TRUE.	.TRUE.	.TRUE.	.TRUE.	.TRUE.	-

/CONTRL/	OPER_NOW, TEST_OLD	REF_NEW	TEST_NEW	Explanation
lbdclim	.TRUE.	.TRUE.	.TRUE.	Use the climate mode because we run for 3 months
lsso	.TRUE.	.TRUE.	.TRUE.	SSO_STDH and SSO_SIGMA are used by new schemes
itype_albedo	3	3	3	-
itype_aerosol	1	2	2	2 activates the Tegen climatology
itype_ndvi	0	0	1	1 activates a yearly cycle for PLCOV and LAI based on an averaged ndvi ratio.
itype_rootdp	0	0	4	4 takes the input from the external data set without modifications. This is done in the COSMO-Model now.
lemiss	.FALSE.	.FALSE.	.TRUE.	take a map from the external parameters for the thermal radiative surface emissivity.
lstomata	.FALSE.	.FALSE.	.TRUE.	take a map from the external parameters for the minimum stomata resistance of plants.

- Model sensitivity study using several configurations
- Adaptions needed in
  - COSMO Namelist
  - Int2lm Namelist

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Numerical experiments - Hindcasts

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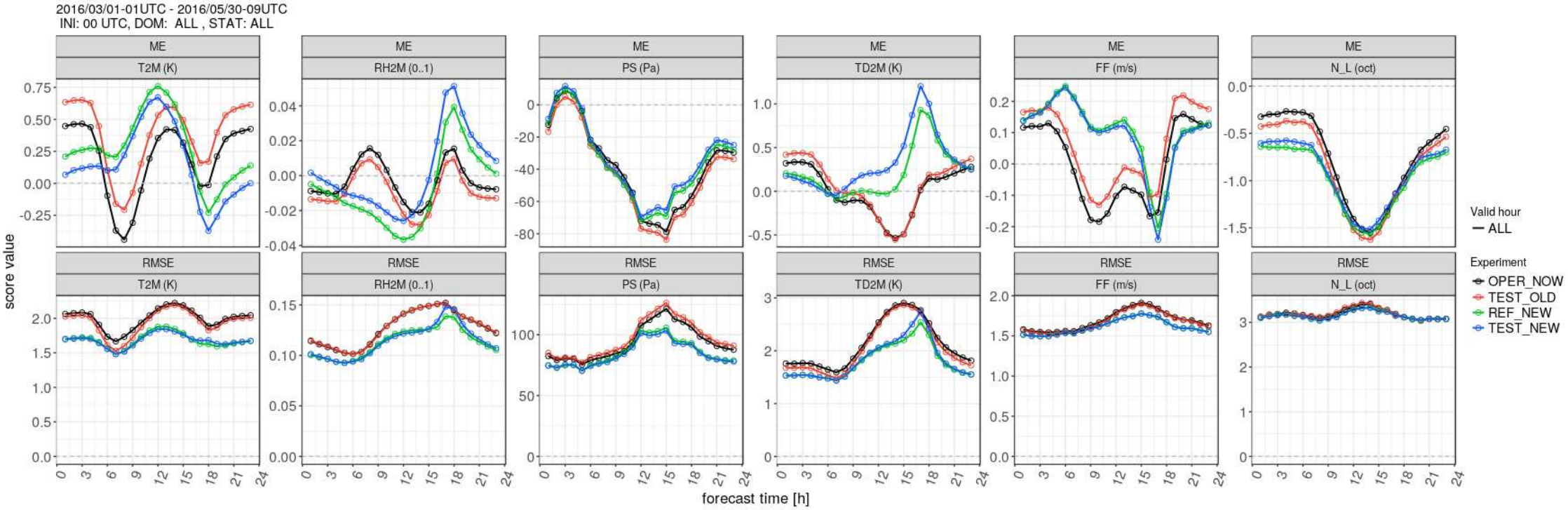
- Hindcast period March, April, May 2016
- Sensitivity study for several configurations
- Mean error and RMSE for selected parameters



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Numerical experiments - BACY

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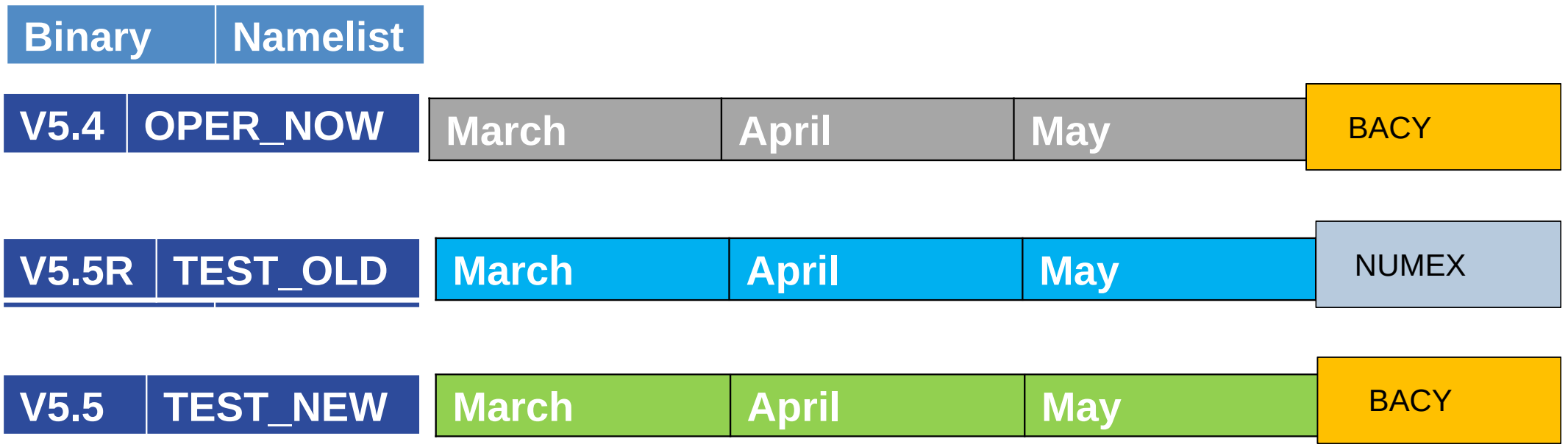

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Numerical experiments - BACY

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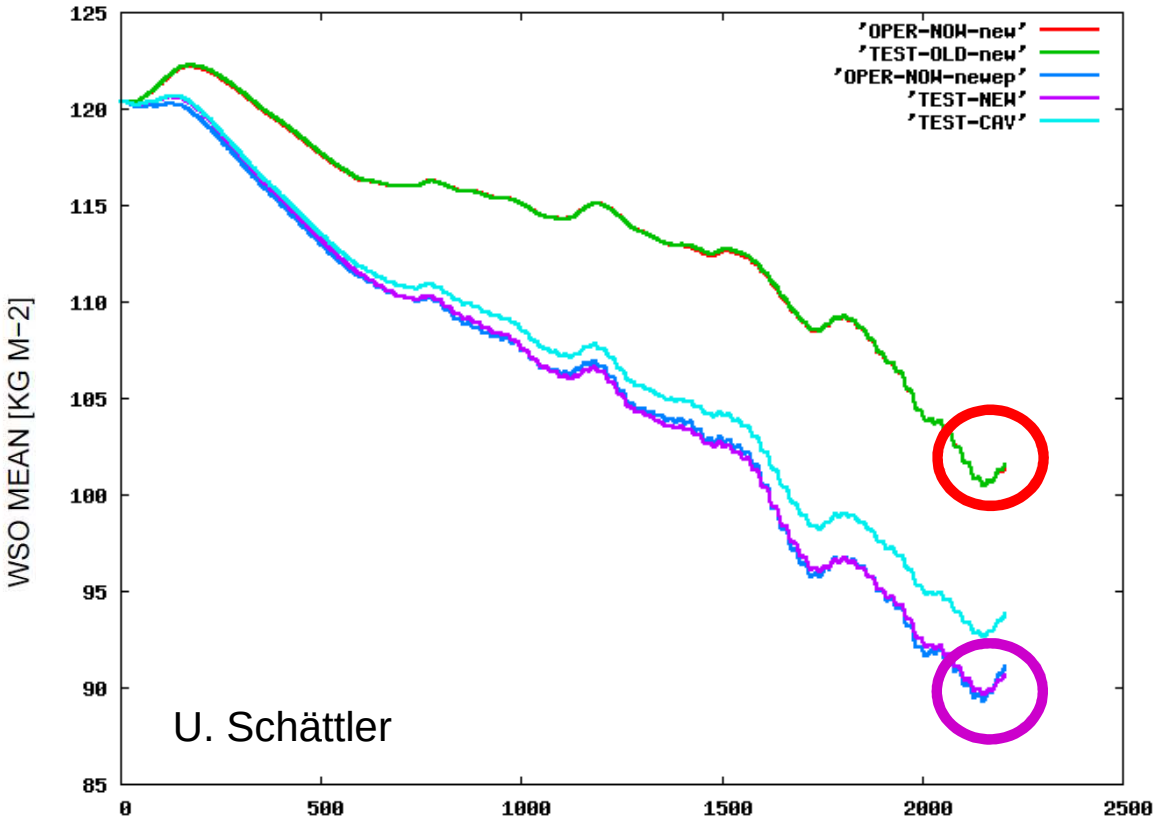
DOMAIN AVERAGED SOIL MOISTURE 27-81 cm



1. OPER-NOW: wet soil
   - COSMO 5.4 with operational configuration

2. TEST-NEW: dry soil
   - COSMO pre5.5 with ICON setup

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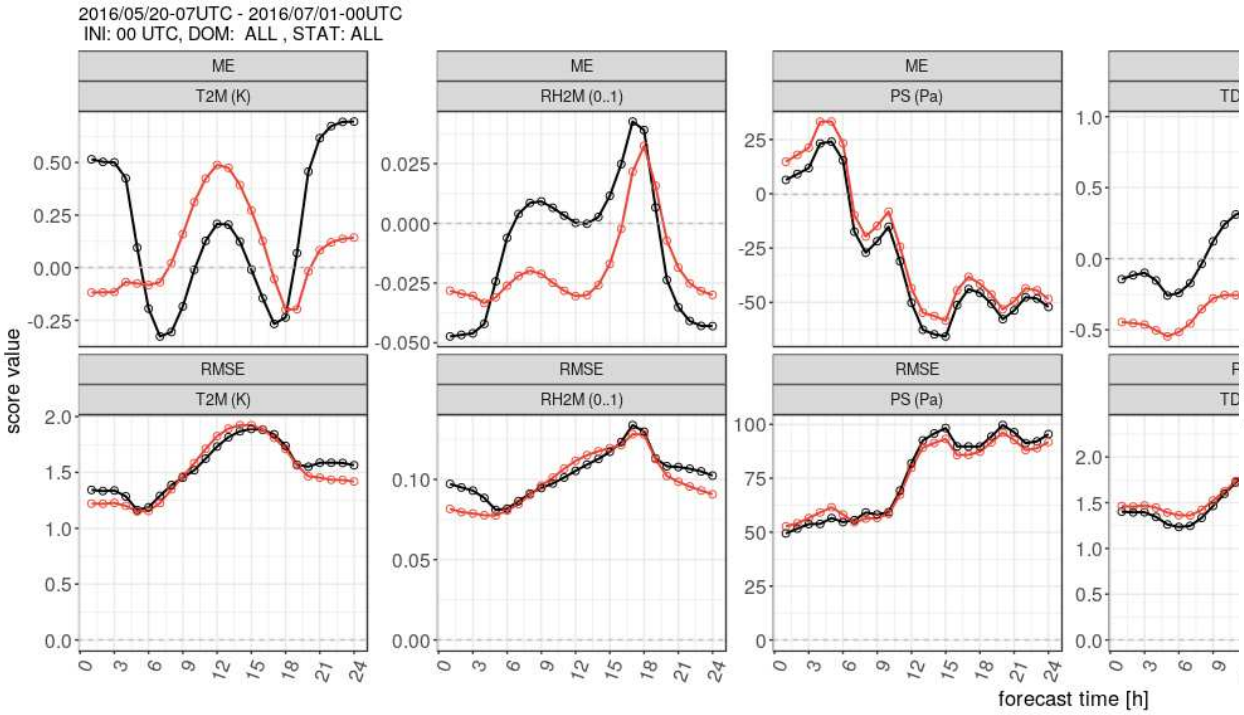
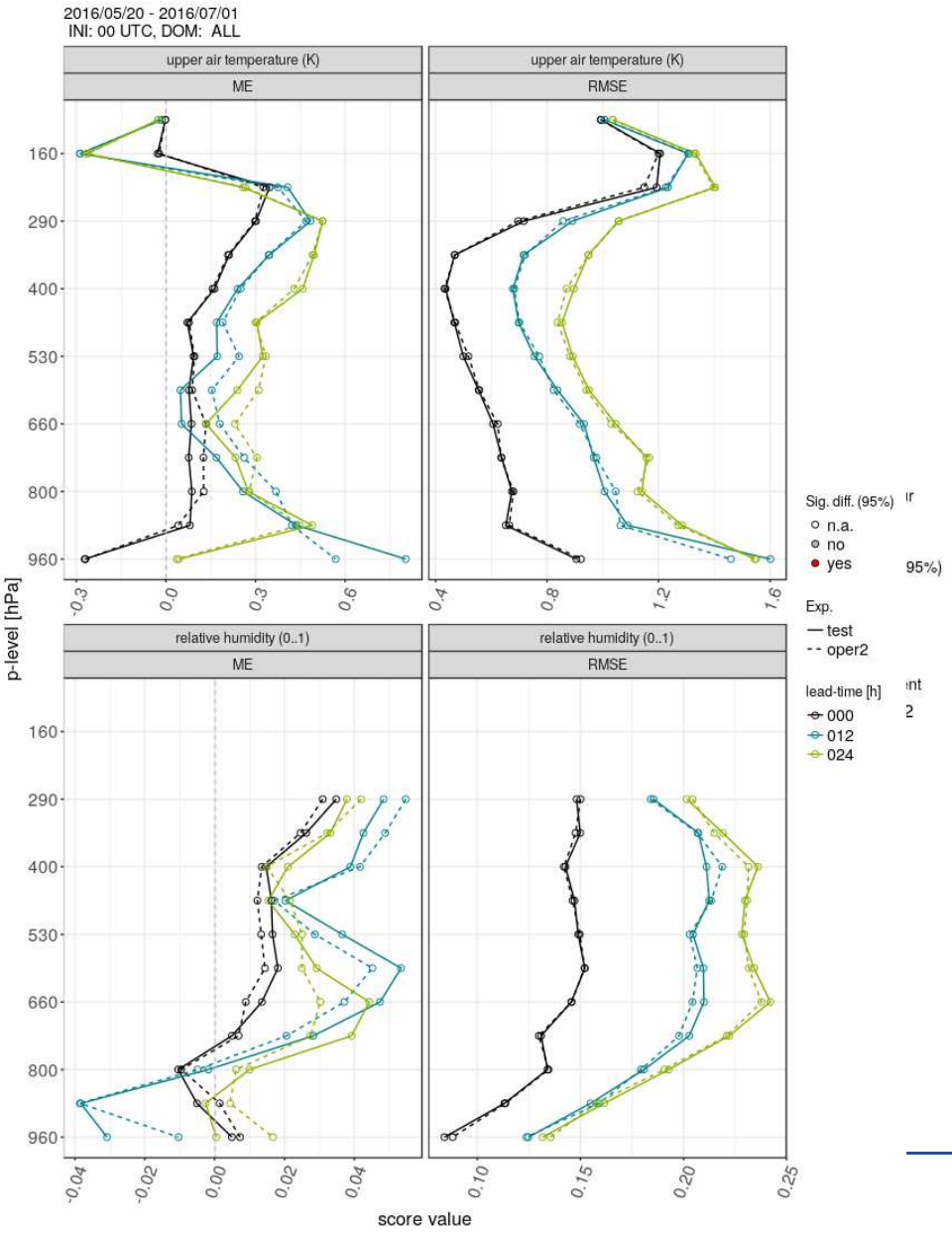
Numerical experiments - BACY





Case study 23.06.2016

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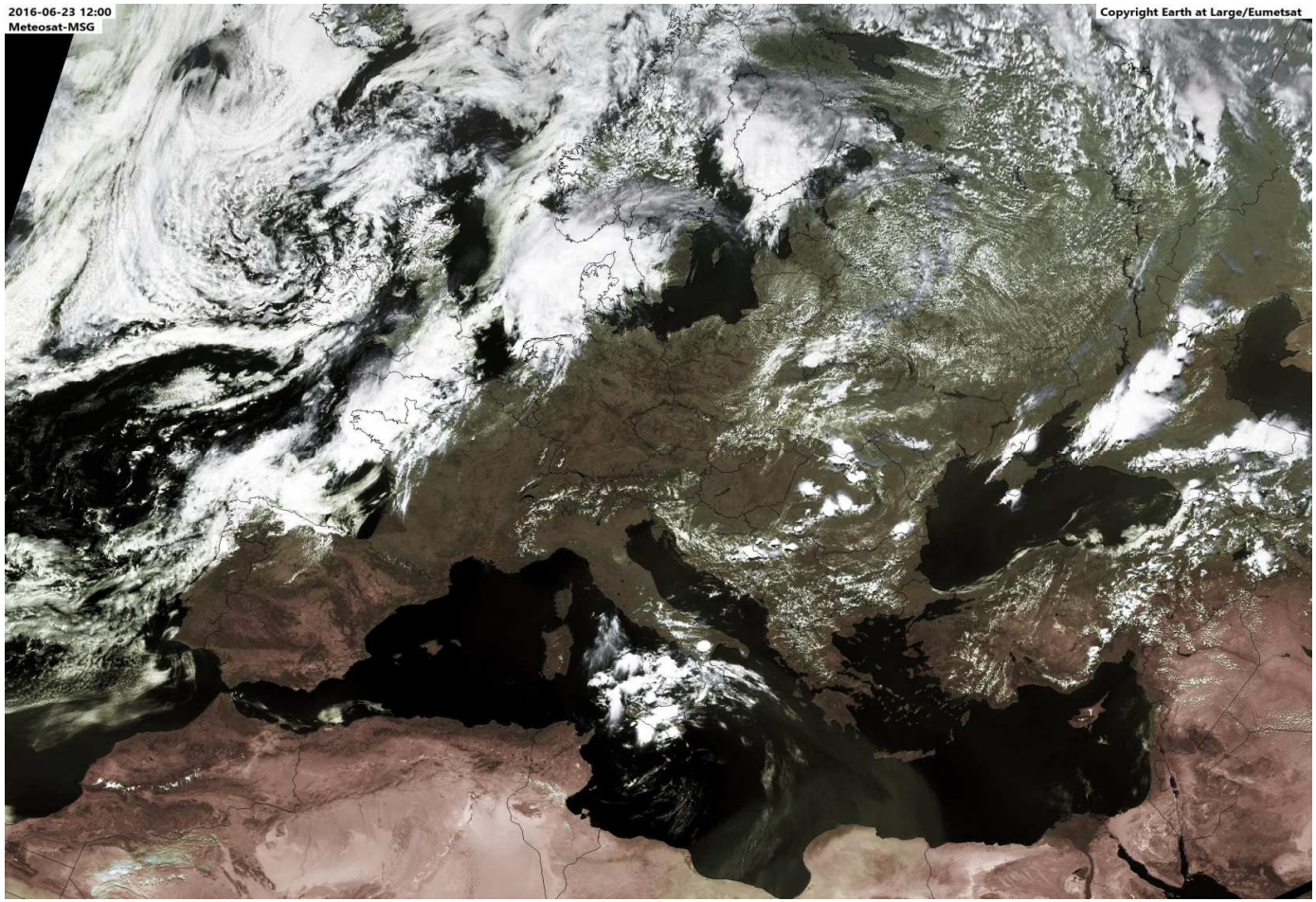

- Summer case with less clouds in central Europe
  - avoid cloud impact

- Considering
  - Global radiation
  - Soil moisture
  - Sensible heat flux
  - Latent heat flux
  - Bowen ratio

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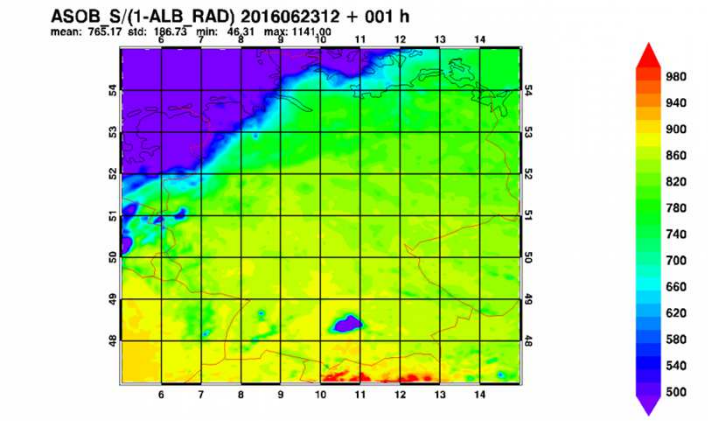
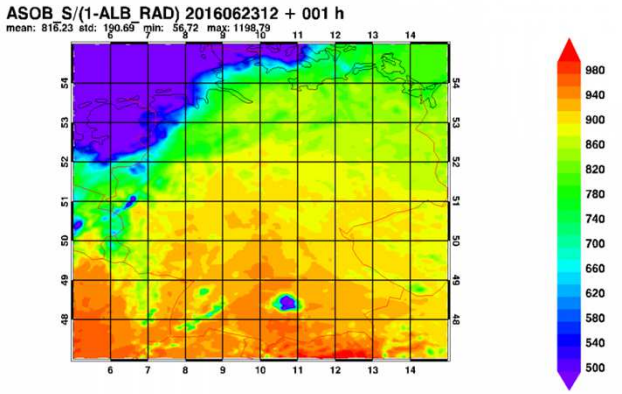
OPER-NOW

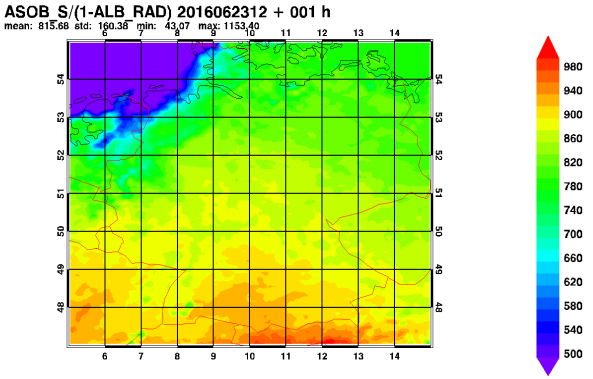
TEST-NEW

ICON-EU

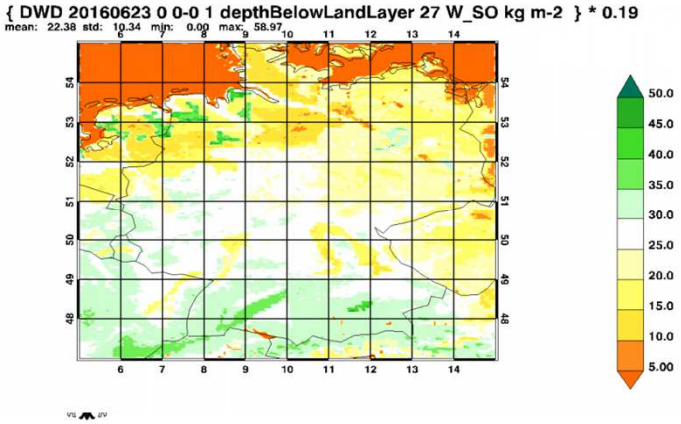
Global Radiation

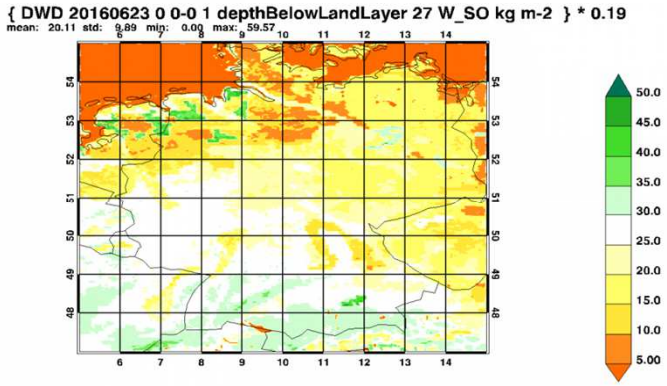


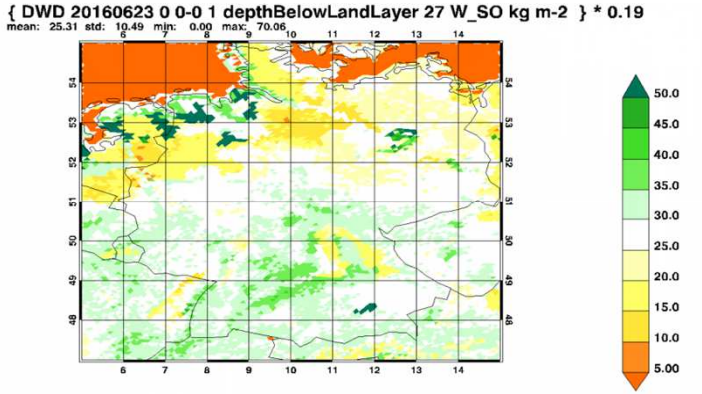




Soil Moisture LEV5







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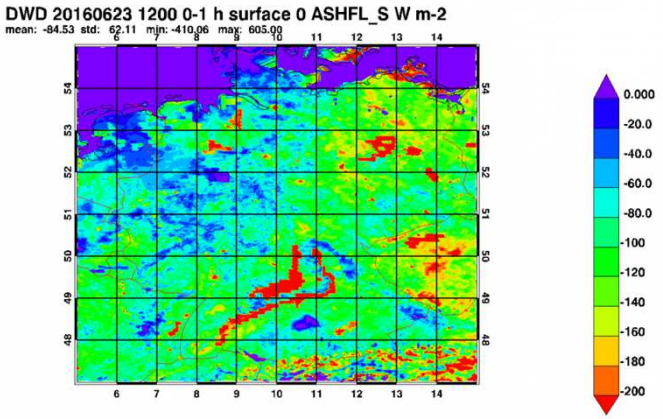
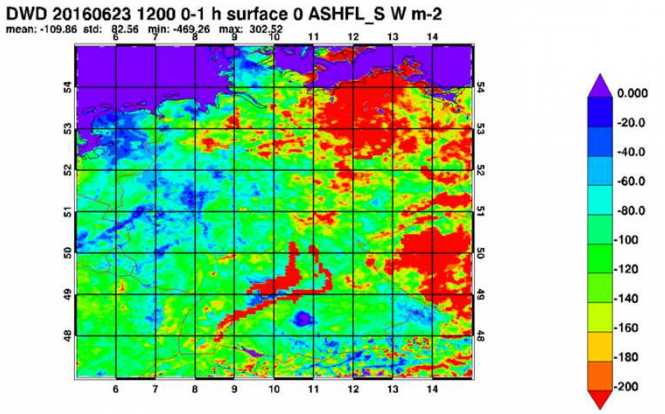
OPER-NOW

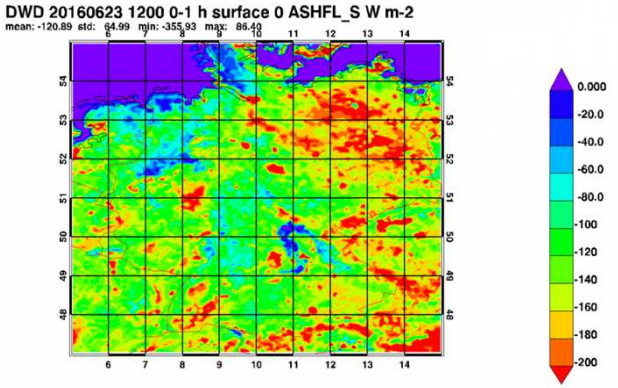
TEST-NEW

ICON-EU

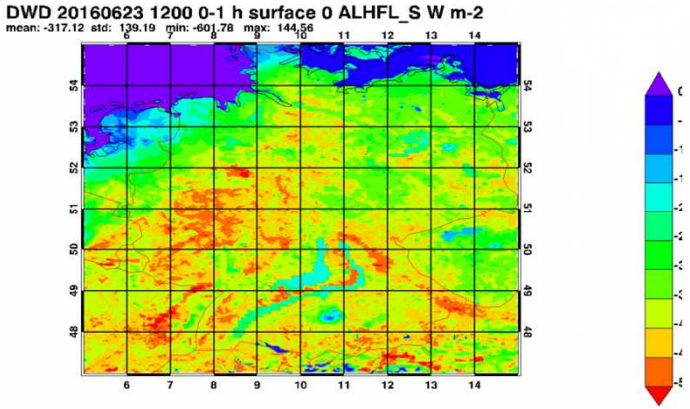
Sensible Heat Flux

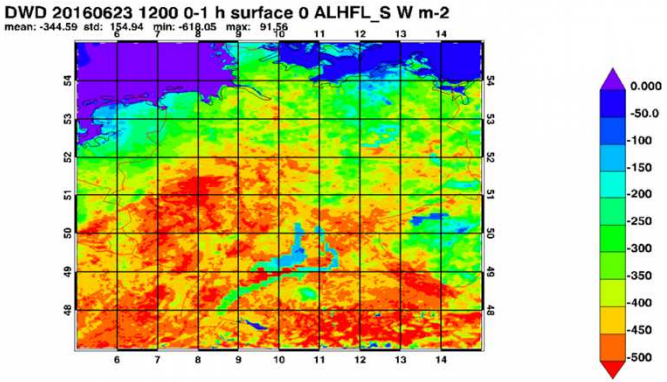


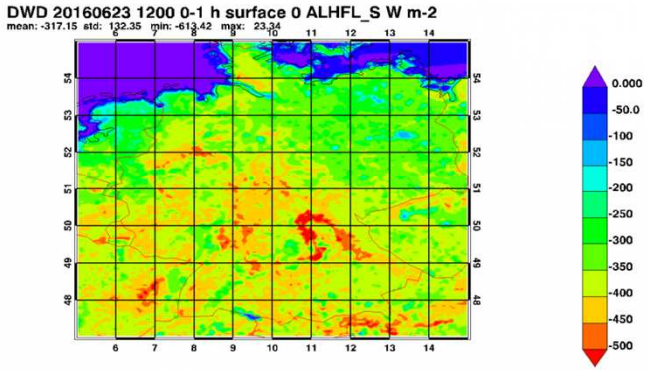




Latent Heat Flux







Case study 23.06.2016

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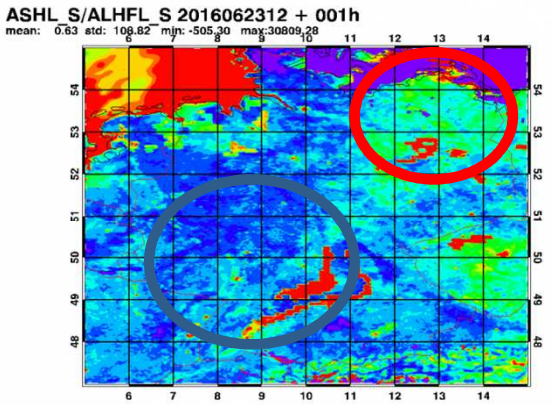
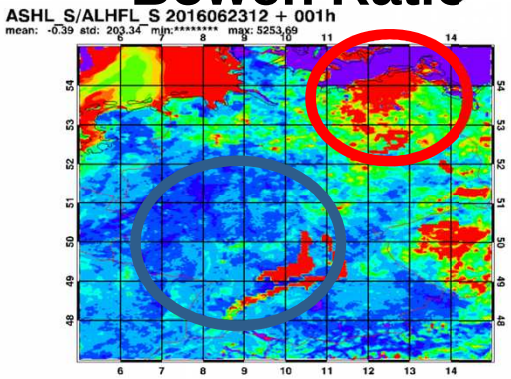
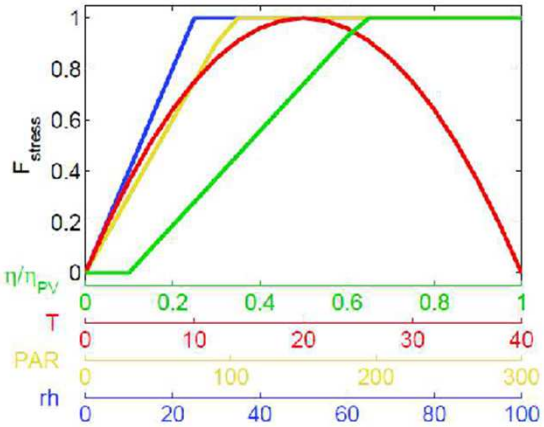
OPER-NOW



TEST-NEW Bowen Ratio



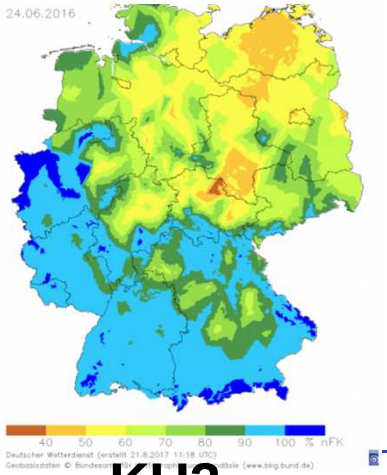
TERRA – Evapotranspiration



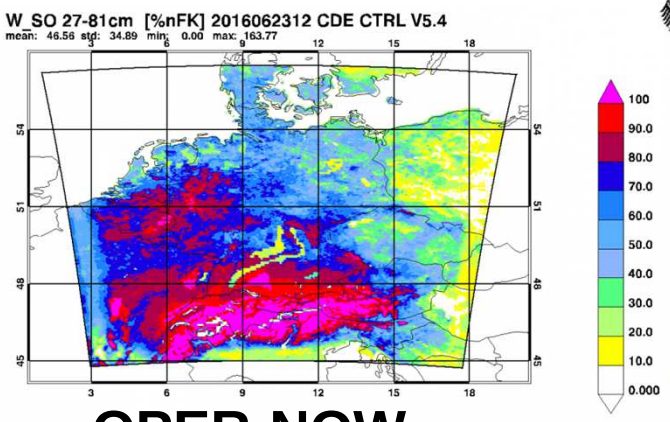
(Ament, 2006)

$$r_{stom}^{-1} = r_{stom}^{max\,-1} - \left(r_{stom}^{min\,-1} - r_{stom}^{max\,-1}\right) F_{rad} F_{\eta} F_{tem} F_{hum}$$

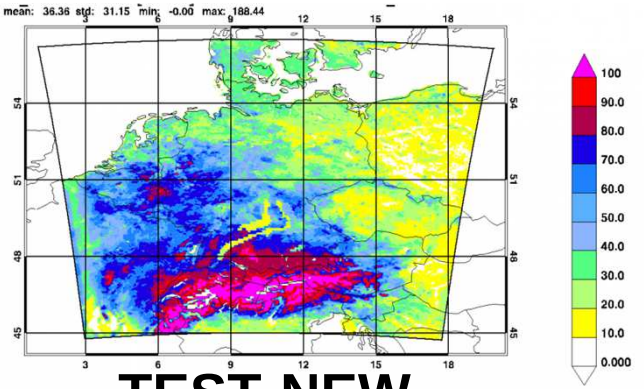
Plant available water



KU3



OPER-NOW



TEST-NEW

BACY - Verification

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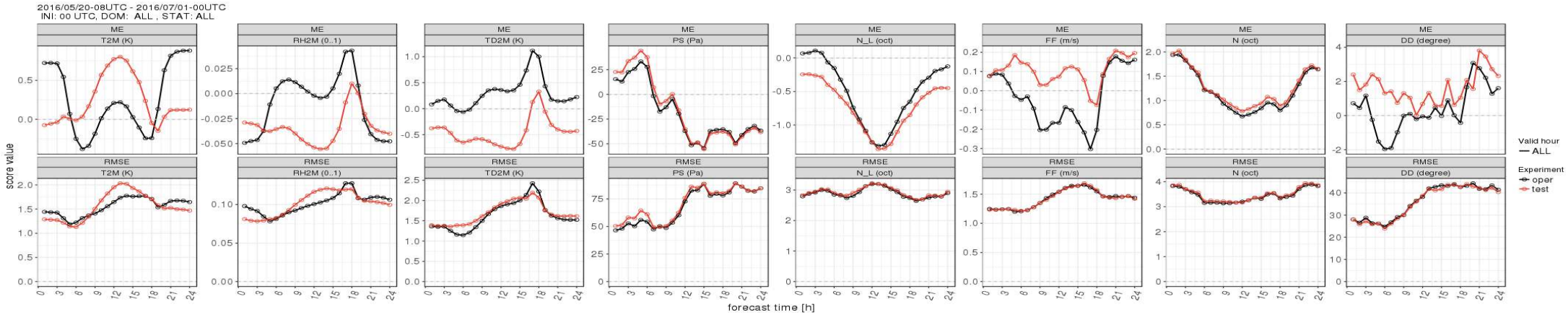
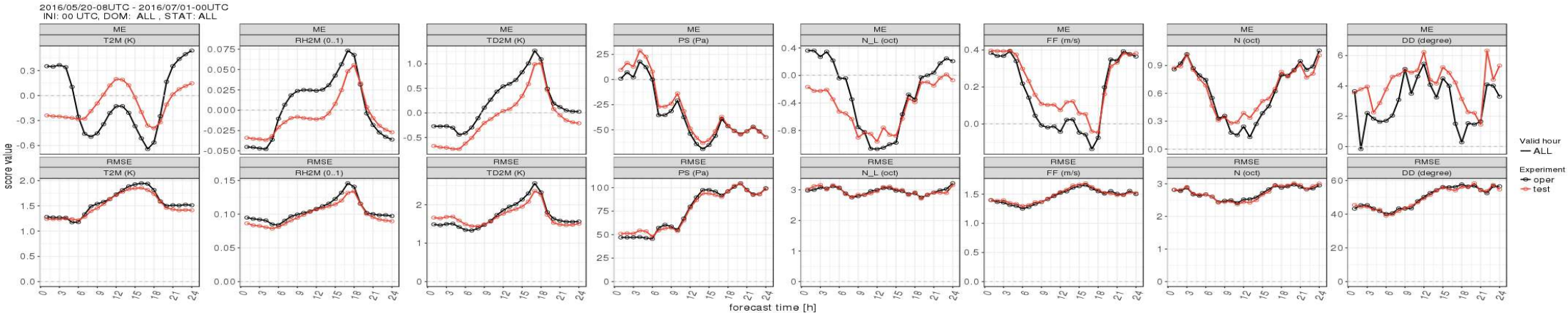
North East



South West



Numerical experiments

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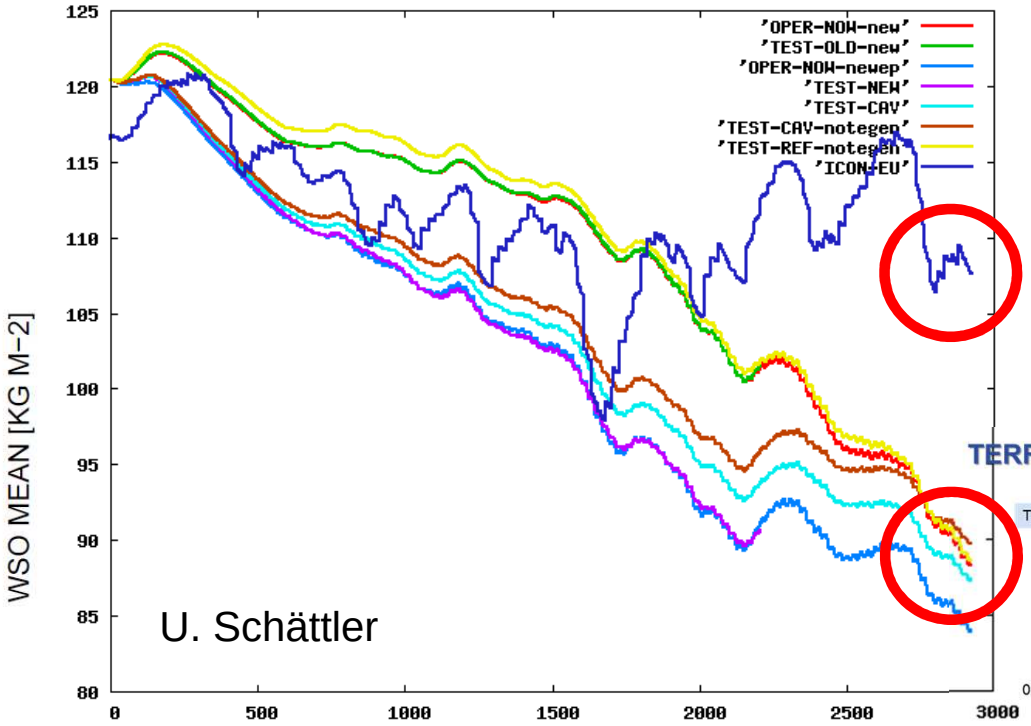
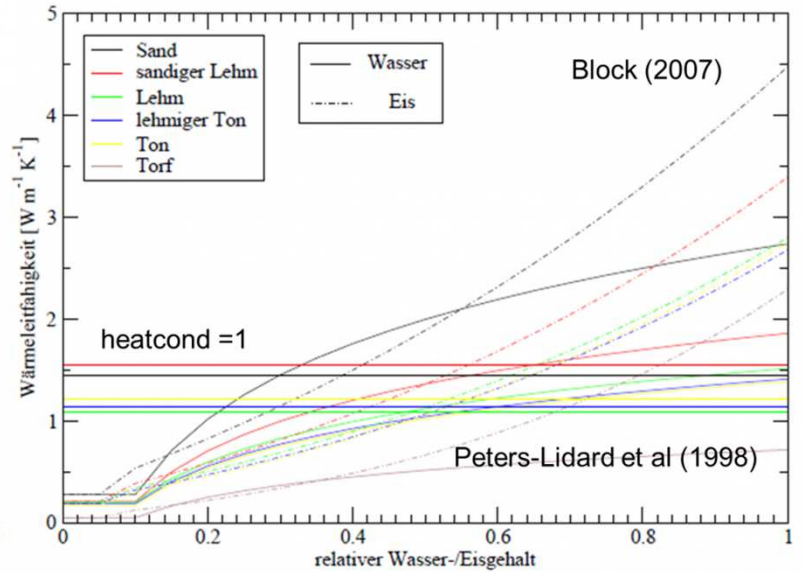
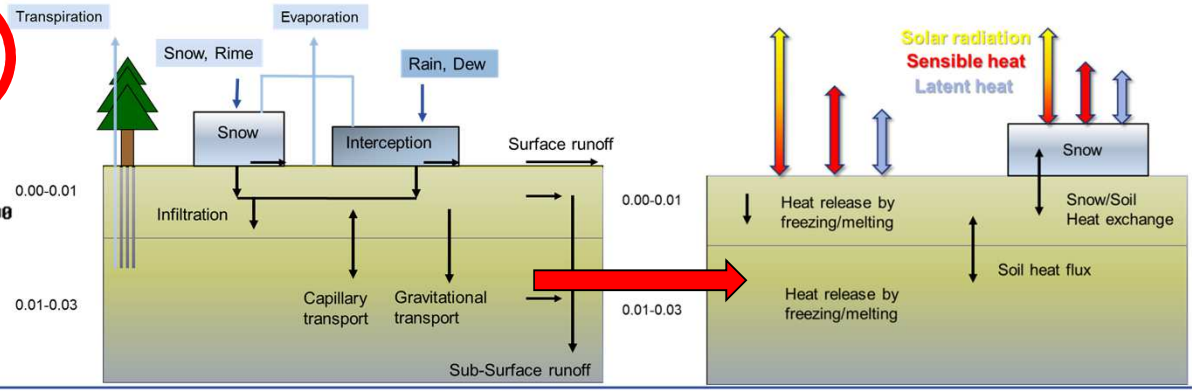
DOMAIN AVERAGED SOIL MOISTURE 27-81 cm







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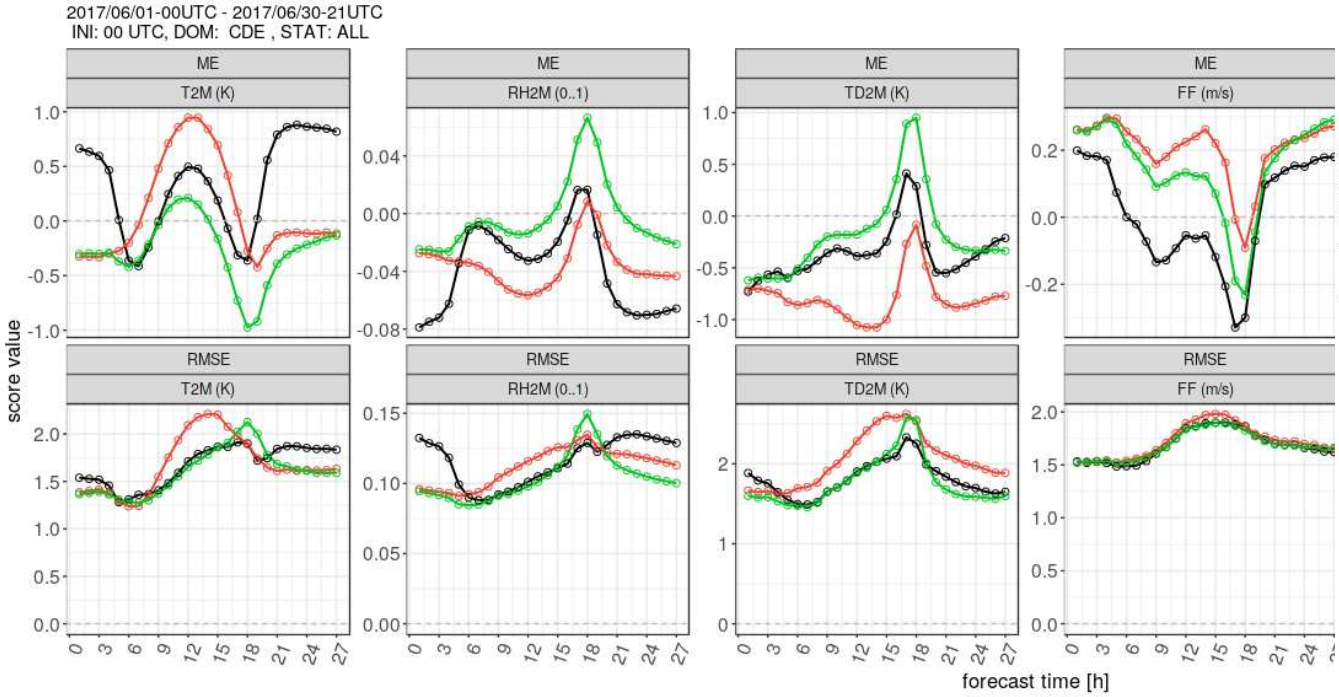
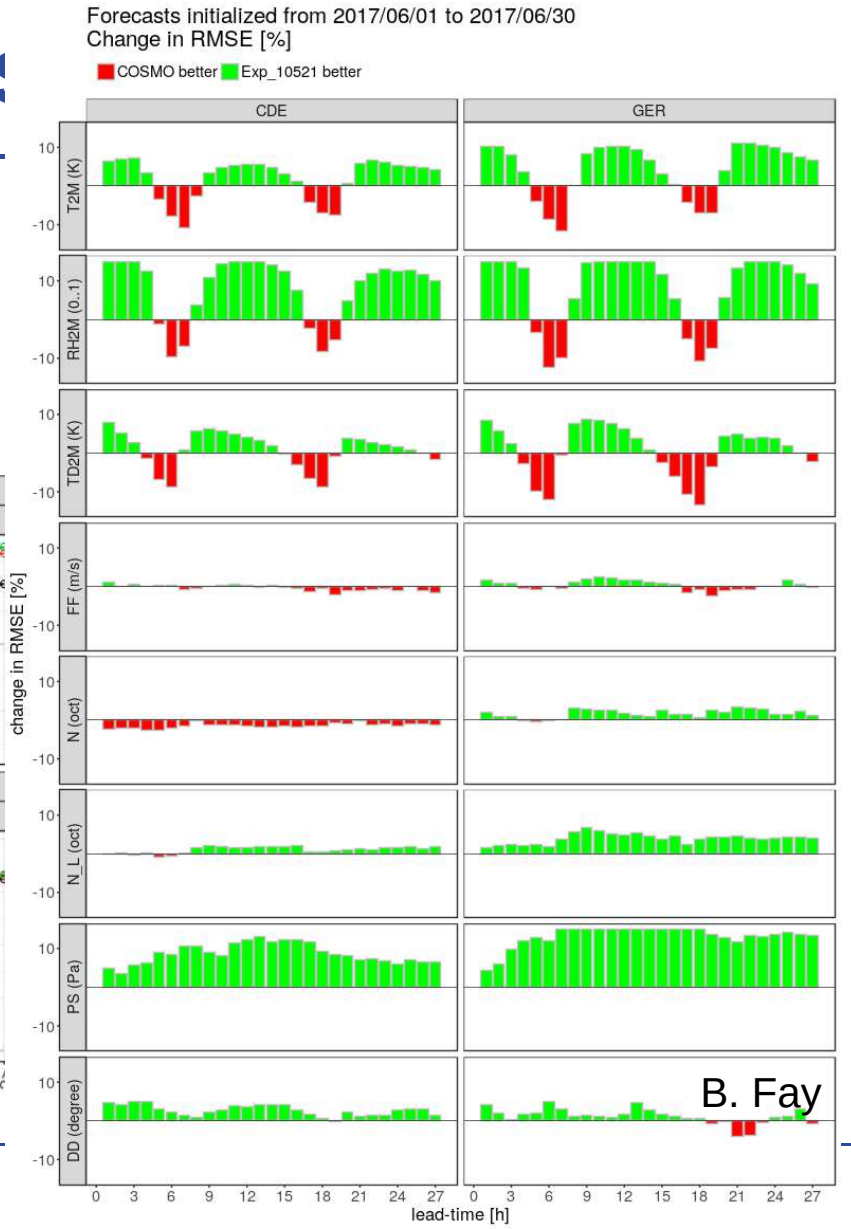
Numerical experiments – Pseudo S

- SMA emulation: Replacing COSMO-D2 soil moisture field with interpolated field from ICON-EU
- Verification of the forecasts for June 2017 against reference





Summary and Conclusions

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- Strategic goal: COSMO with redesigned data structure and improved physics components from ICON
- Radiation scheme and TERRA configuration differs between COSMO and ICON
- Several numerical experiments (Hindcasts, BACY, NUMEX) using different configurations have been performed
- Soil moisture has larger impact with ICON physics as pseudo-SMA experiment and ICON-EU without SMA show
- Decision for using COSMO with redesigned data structure and ICON physics in a conservative configuration, other options remain possible

Final configuration

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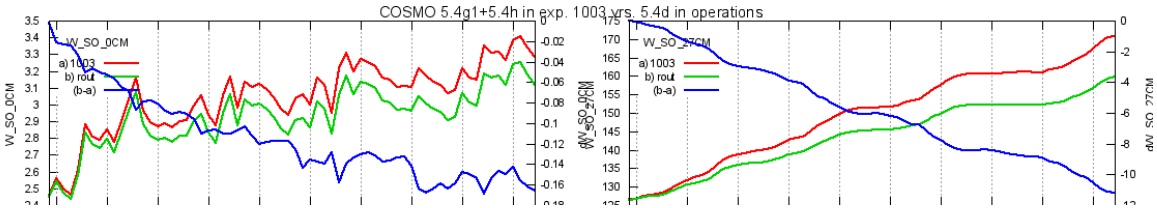
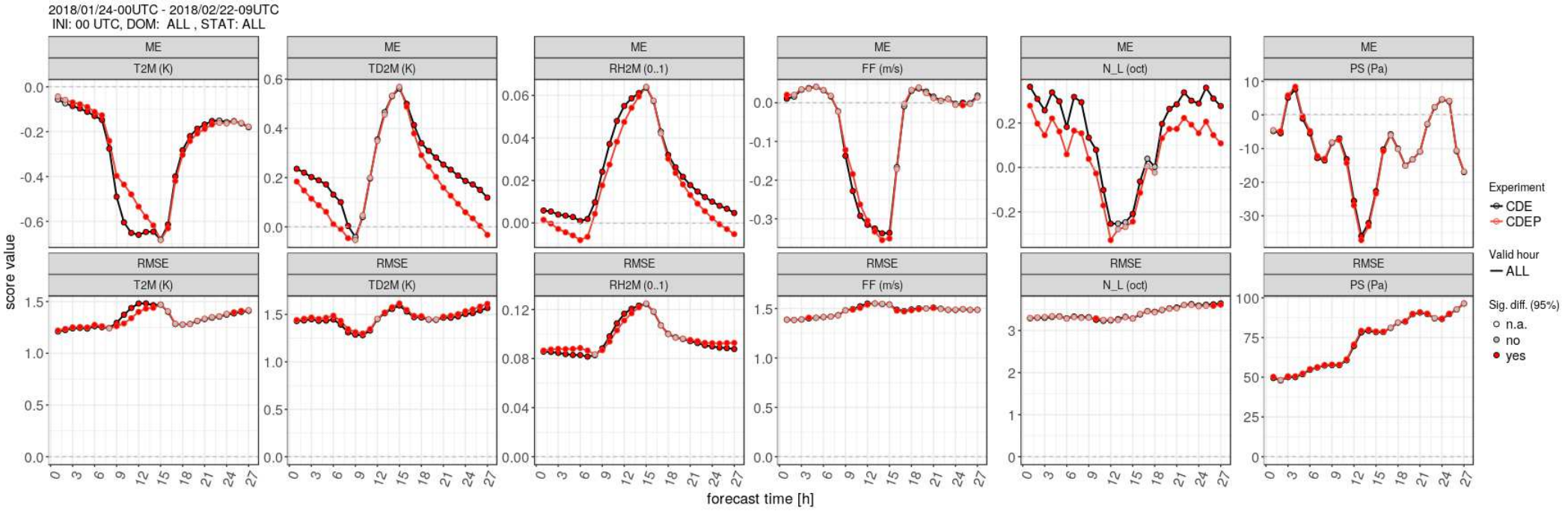
V5.5R	TEST_OLD	March	April	May	NUMEX

- Bugfix and improved runoff treatment in TERRA – higher soil moisture
- NUMEX 1003 in autumn 2017, CDE-P since 24.01.2018 for monitoring





External parameters

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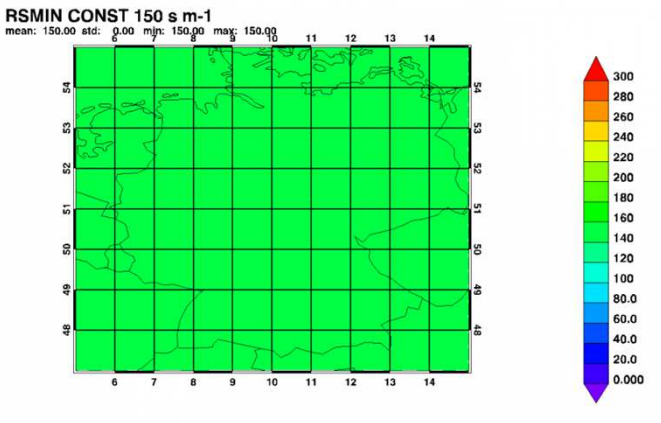
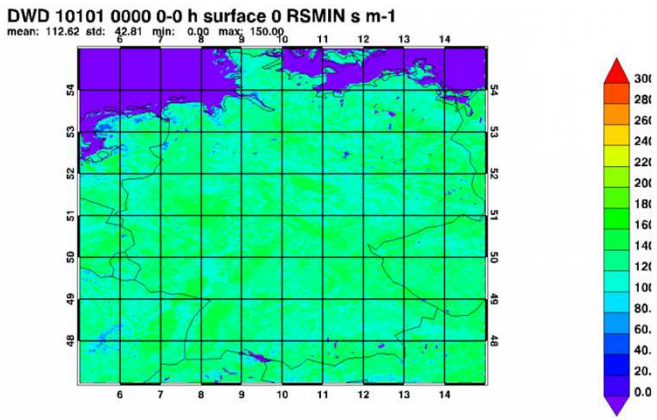
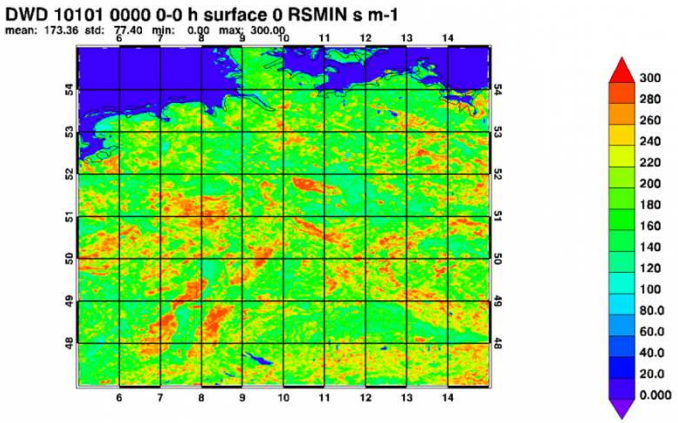
Min. Stomata resistance



OPER-NOW



TEST-NEW



ICON-EU

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