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

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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

Process	Scheme	Model
Radiation	RRTM (later with McICA & McSI)	ICON
	$\delta$ 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



- **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



/TUNING/	OPER_NOW	TEST_OLD	REF_NEW	TEST_NEW	TEST_I300m	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_I300m	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.					
lmulti_layer	.TRUE.	N.A.	N.A.	N.A.	N.A.	-
/IOCTL/	OPER_NOW	TEST_OLD	REF_NEW	TEST_NEW	TEST_I300m	Explanation
lbdclim	.TRUE.	.TRUE.	.TRUE.	.TRUE.	.TRUE.	-

- Model sensitivity study using several configurations
- Adaptions needed in
  - COSMO Namelist
  - Int2Im Namelist

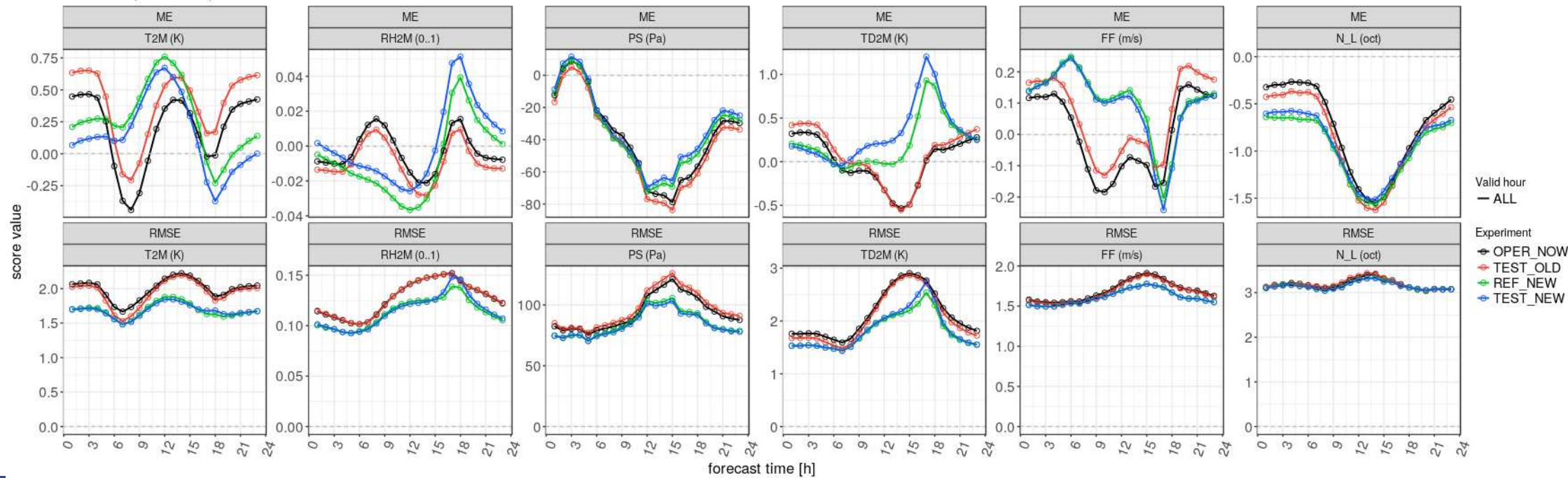
/CONTRL/	OPER_NOW, TEST_OLD	REF_NEW	TEST_NEW	Explanation
lbdclim	.TRUE.	.TRUE.	.TRUE.	Use the climate mode because we run for 3 months
lssso	.TRUE.	.TRUE.	.TRUE.	SSO_STDH and SSO_SIGMA are used by new schemes
itype_albedo	3	3	3	-
itype_aerosol	1	2	2	2 activates the Tegen climatology
itype_ndvi	0	0	1	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.

U. Schöttler

# Numerical experiments - Hindcasts

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

2016/03/01-01UTC - 2016/05/30-09UTC  
INI: 00 UTC, DOM: ALL, STAT: ALL



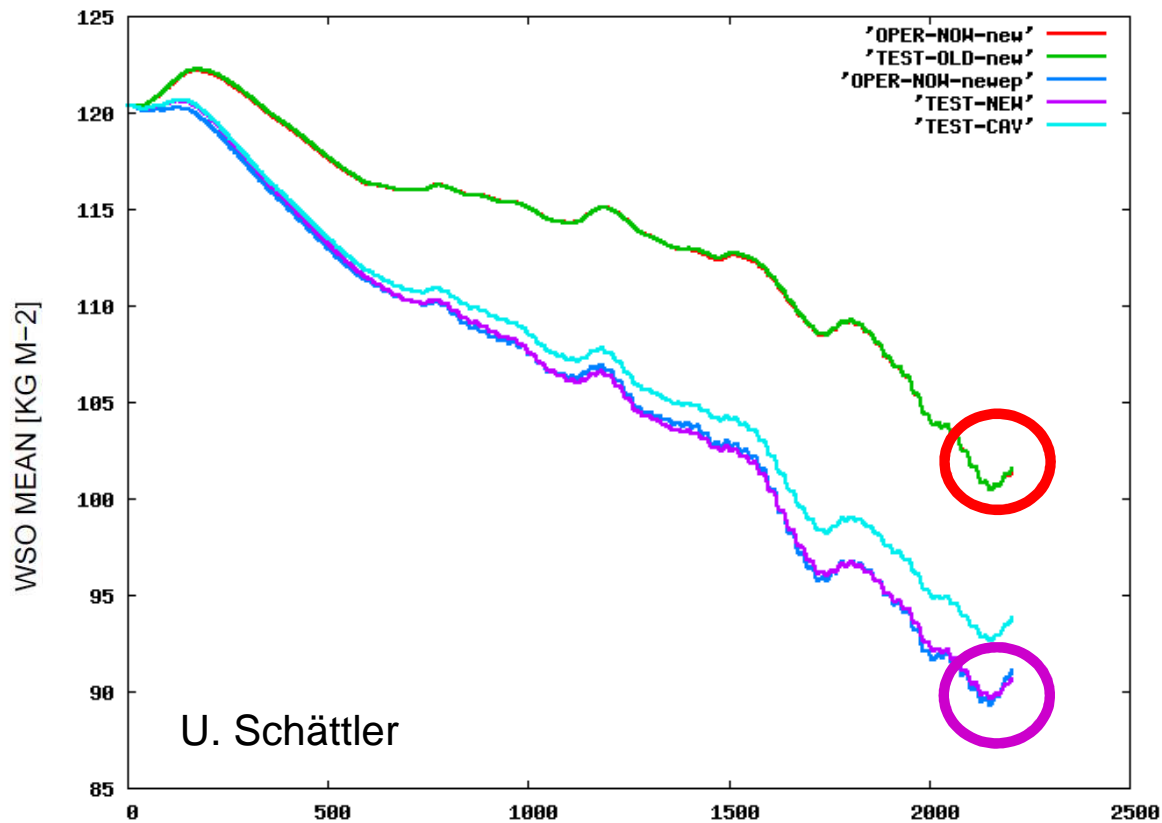
# Numerical experiments - BACY

		Binary	Namelist		
V5.4	OPER_NOW	March	April	May	BACY
V5.5R	TEST_OLD	March	April	May	NUMEX
V5.5	TEST_NEW	March	April	May	BACY



# Numerical experiments - BACY

DOMAIN AVERAGED SOIL MOISTURE 27-81 cm

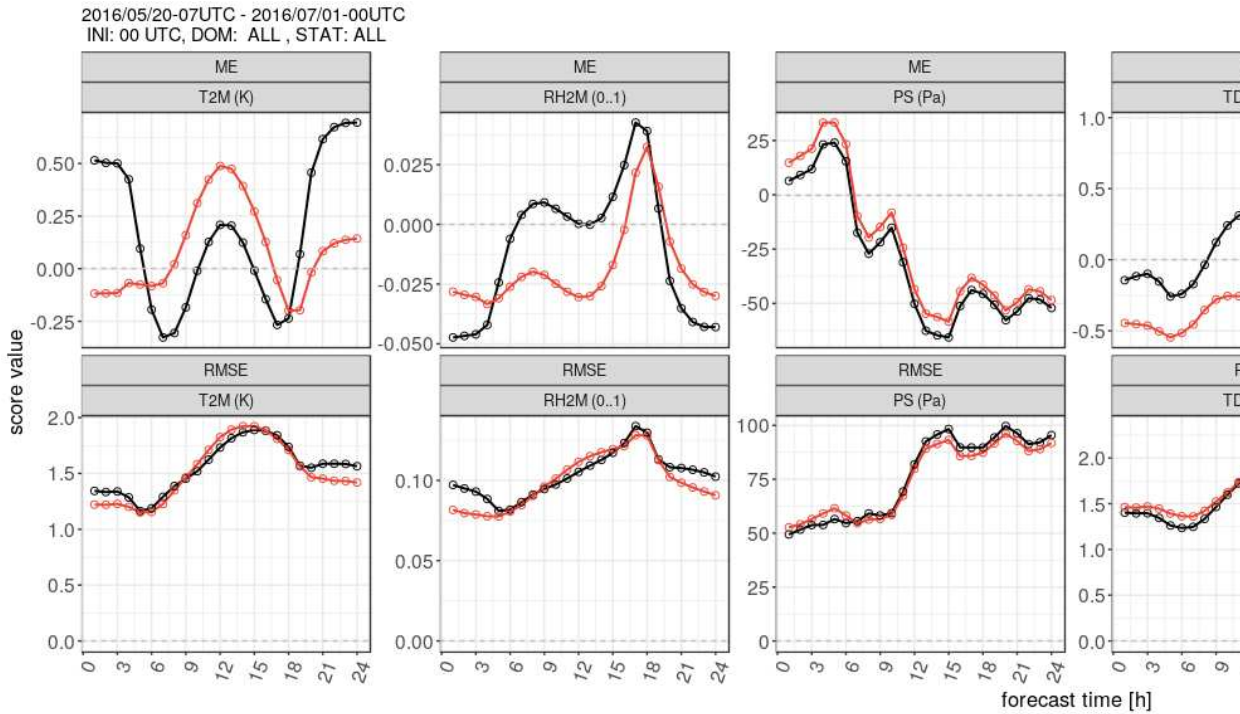


1. OPER-NOW: wet soil
  - COSMO 5.4 with operational configuration
2. TEST-NEW: dry soil
  - COSMO pre5.5 with ICON setup

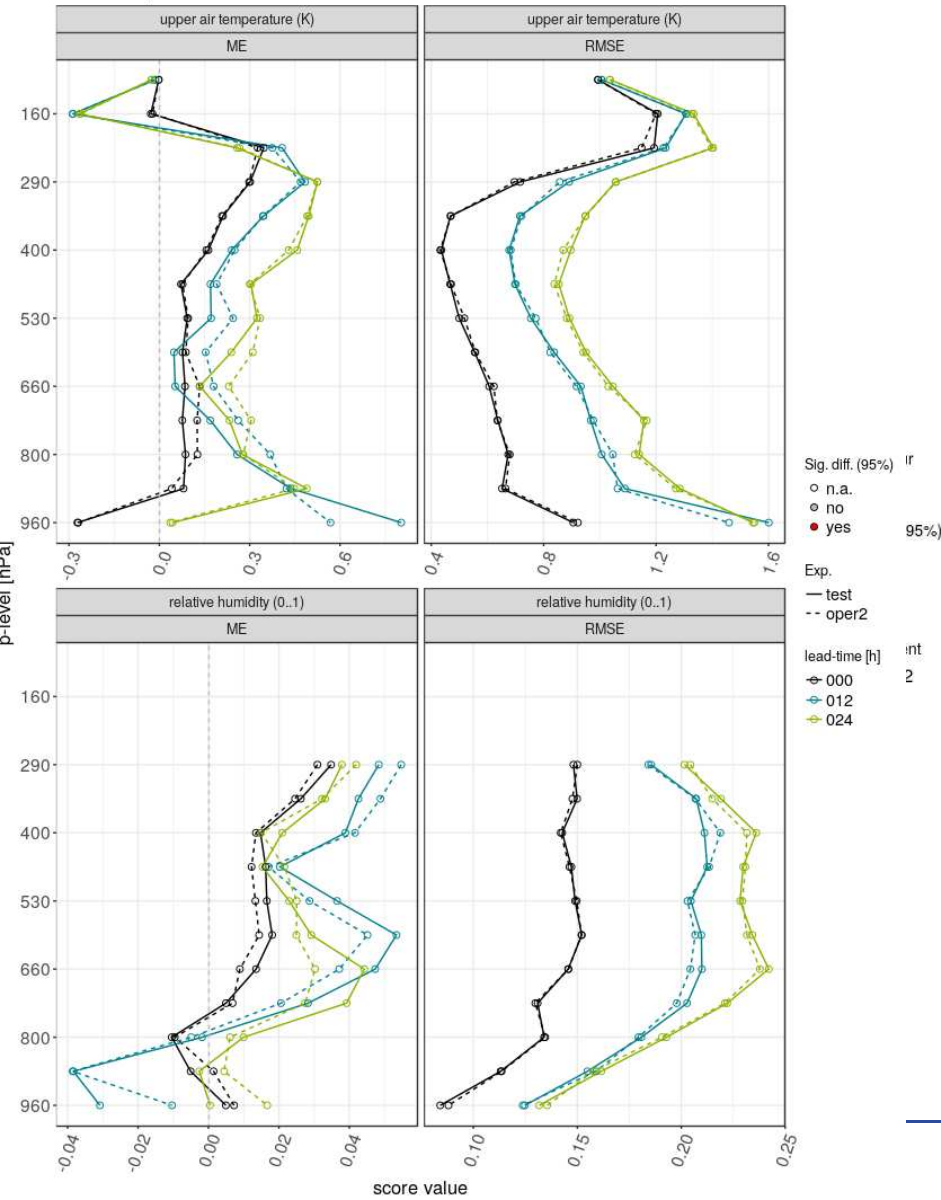




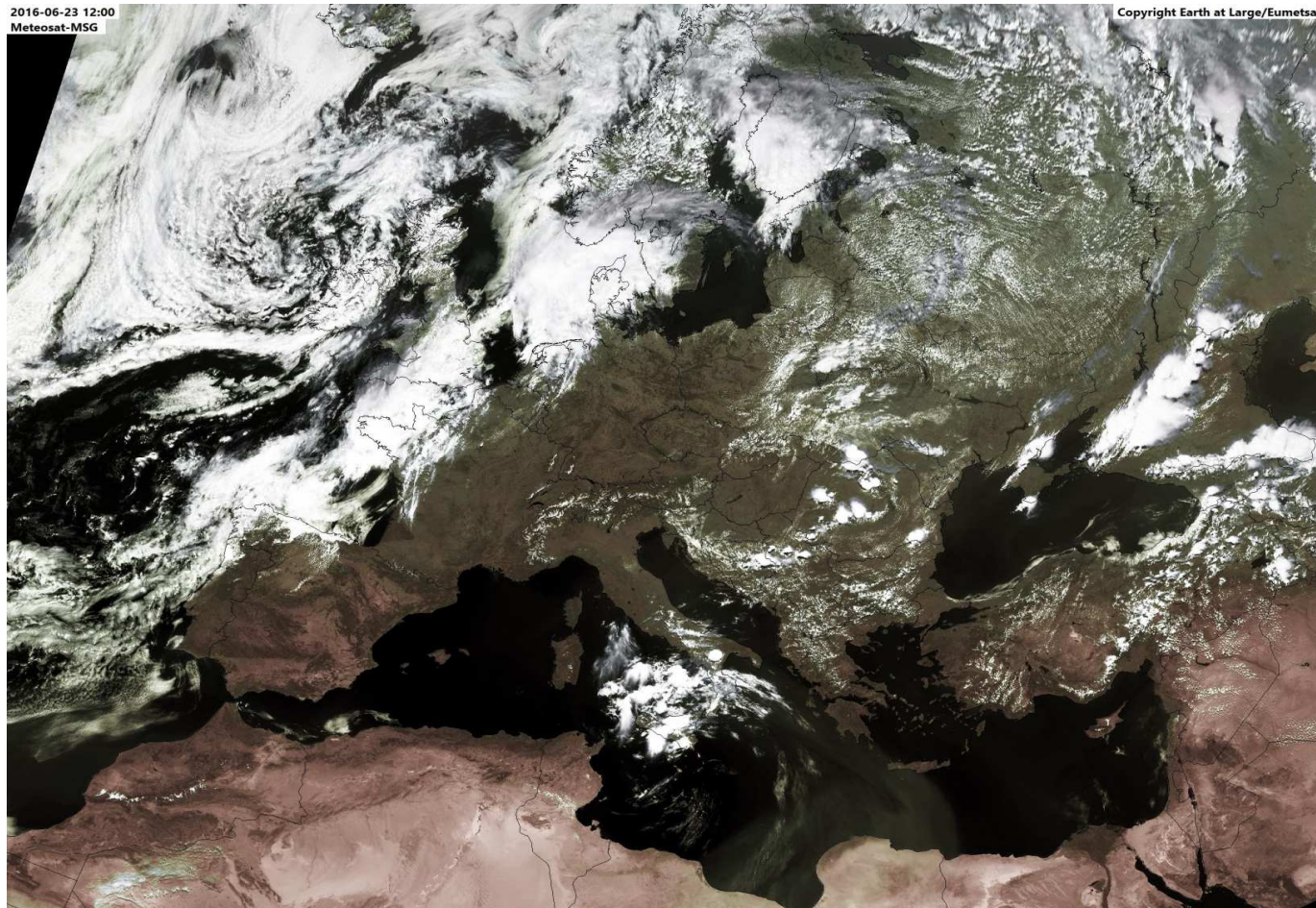
# Numerical experiments - BACY



2016/05/20 - 2016/07/01  
INI: 00 UTC, DOM: ALL



# Case study 23.06.2016



- Summer case with less clouds in central Europe - avoid cloud impact
- Considering
  - Global radiation
  - Soil moisture
  - Sensible heat flux
  - Latent heat flux
  - Bowen ratio

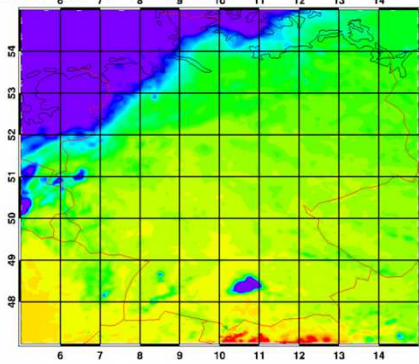




# Case study 23.06.2016

## OPER-NOW

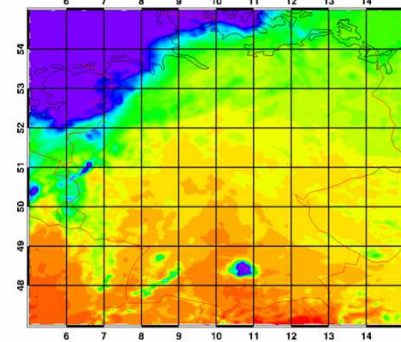
ASOB S/(1-ALB RAD) 2016062312 + 001 h  
mean: 765.17 std: 196.73 min: 46.31 max: 1141.00



## TEST-NEW

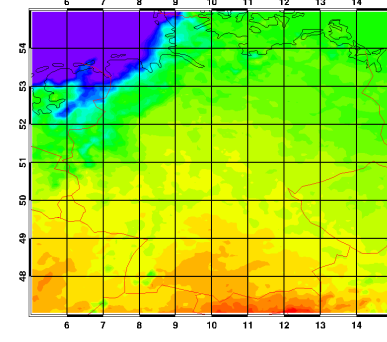
### Global Radiation

ASOB S/(1-ALB RAD) 2016062312 + 001 h  
mean: 816.23 std: 190.69 min: 56.72 max: 1198.79



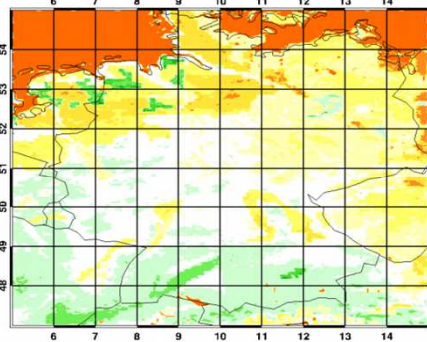
## ICON-EU

ASOB S/(1-ALB RAD) 2016062312 + 001 h  
mean: 815.68 std: 180.38 min: 43.07 max: 1153.40

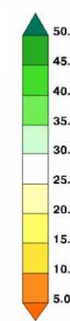
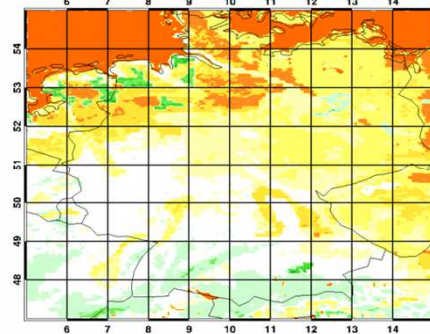


### Soil Moisture LEV5

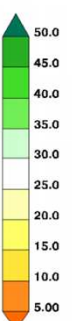
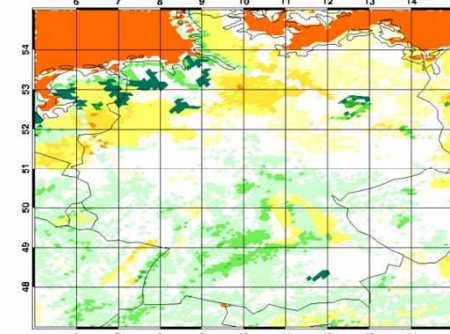
{ DWD 20160623 0 0-0 1 depthBelowLandLayer 27 W\_SO kg m-2 } \* 0.19  
mean: 22.38 std: 10.34 min: 0.00 max: 58.97



{ DWD 20160623 0 0-0 1 depthBelowLandLayer 27 W\_SO kg m-2 } \* 0.19  
mean: 20.11 std: 9.89 min: 0.00 max: 59.57



{ DWD 20160623 0 0-0 1 depthBelowLandLayer 27 W\_SO kg m-2 } \* 0.19  
mean: 25.31 std: 10.49 min: 0.00 max: 70.06



# Case study 23.06.2016

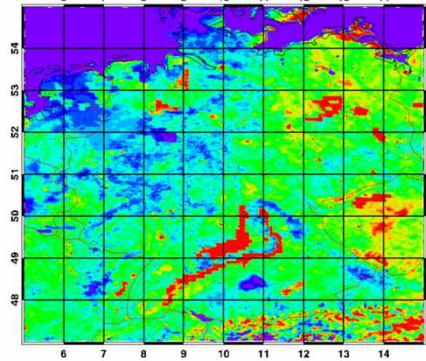
## OPER-NOW

## TEST-NEW

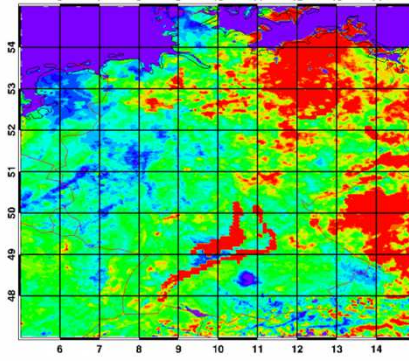
### Sensible Heat Flux

## ICON-EU

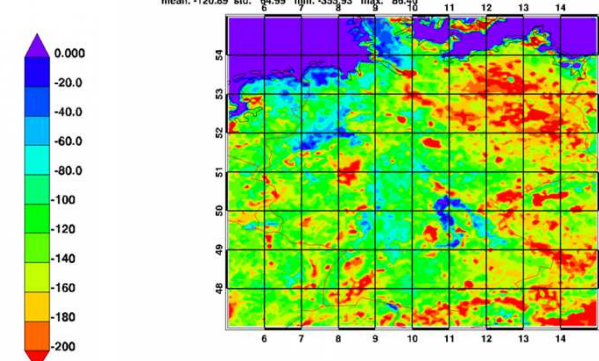
DWD 20160623 1200 0-1 h surface 0 ASHFL\_S W m-2  
mean: -84.53 std: 62.11 min: -410.06 max: 605.00



DWD 20160623 1200 0-1 h surface 0 ASHFL\_S W m-2  
mean: -109.86 std: 82.56 min: -469.26 max: 302.52

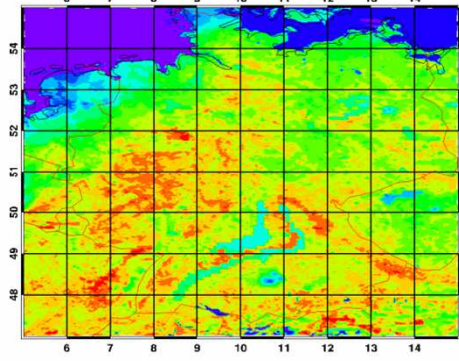


DWD 20160623 1200 0-1 h surface 0 ASHFL\_S W m-2  
mean: -120.89 std: 84.99 min: -355.93 max: 88.40

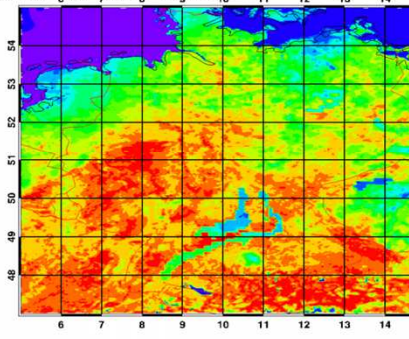


### Latent Heat Flux

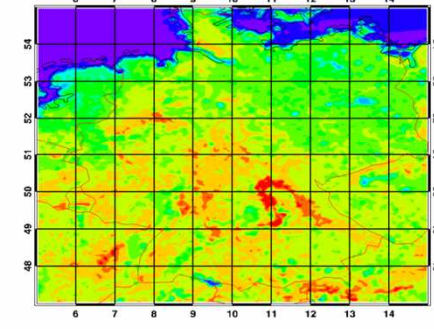
DWD 20160623 1200 0-1 h surface 0 ALHFL\_S W m-2  
mean: -317.12 std: 139.19 min: -601.78 max: 144.56



DWD 20160623 1200 0-1 h surface 0 ALHFL\_S W m-2  
mean: -344.89 std: 154.94 min: -618.05 max: 91.56



DWD 20160623 1200 0-1 h surface 0 ALHFL\_S W m-2  
mean: -317.15 std: 132.35 min: -613.42 max: 23.34

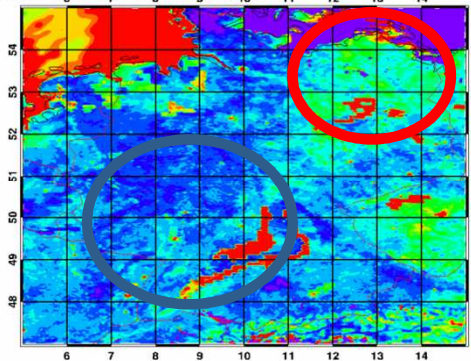




# Case study 23.06.2016

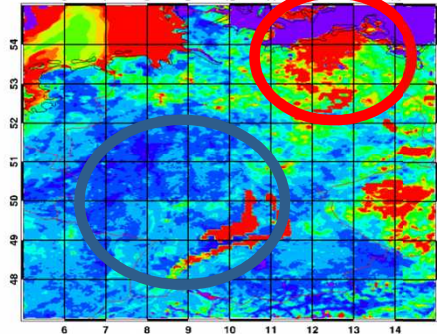
## OPER-NOW

ASHL S/ALHFL S 2016062312 + 001h  
mean: 0.63 std: 108.82 min: -505.30 max: 30809.28

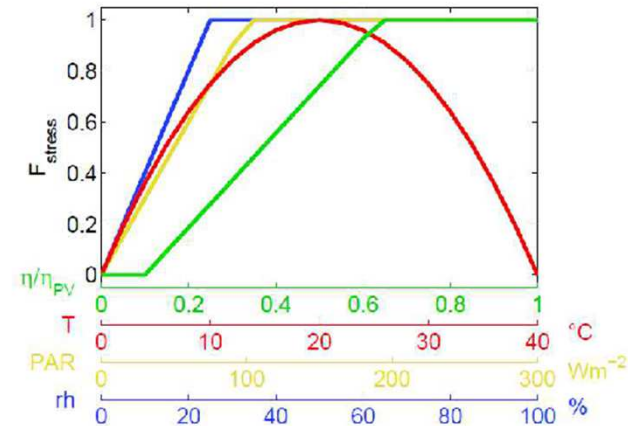


## TEST-NEW Bowen Ratio

ASHL S/ALHFL S 2016062312 + 001h  
mean: -0.39 std: 203.34 min: \*\*\*\*\* max: 5253.69



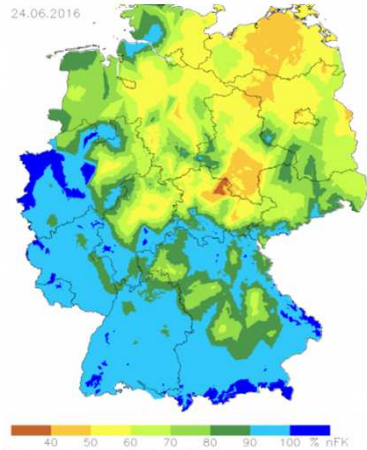
## TERRA – Evapotranspiration



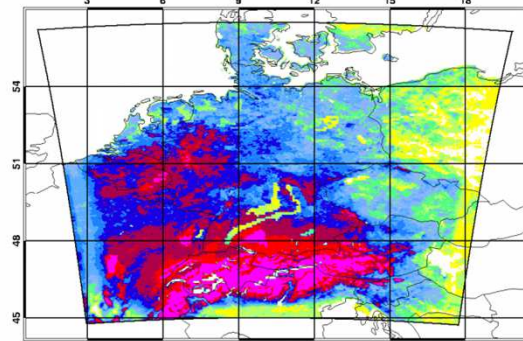
## Plant available water

(Ament, 2006)

$$r_{stom}^{-1} - r_{stom}^{max-1} - \left( r_{stom}^{min-1} - r_{stom}^{max-1} \right) F_{rad} F_{\eta} F_{tcv} F_{hsm}$$



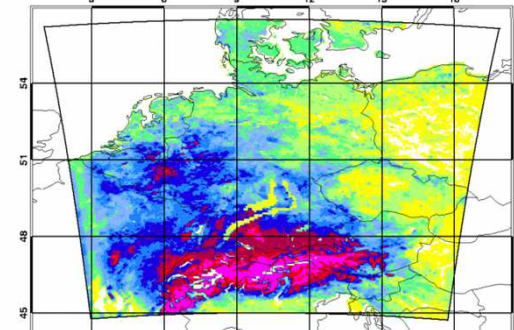
W\_SO 27-81cm [%nFK] 2016062312 CDE CTRL V5.4  
mean: 46.59 std: 34.89 min: 0.00 max: 163.77



## OPER-NOW



mean: 36.36 std: 31.15 min: -0.00 max: 188.44



## TEST-NEW

2018



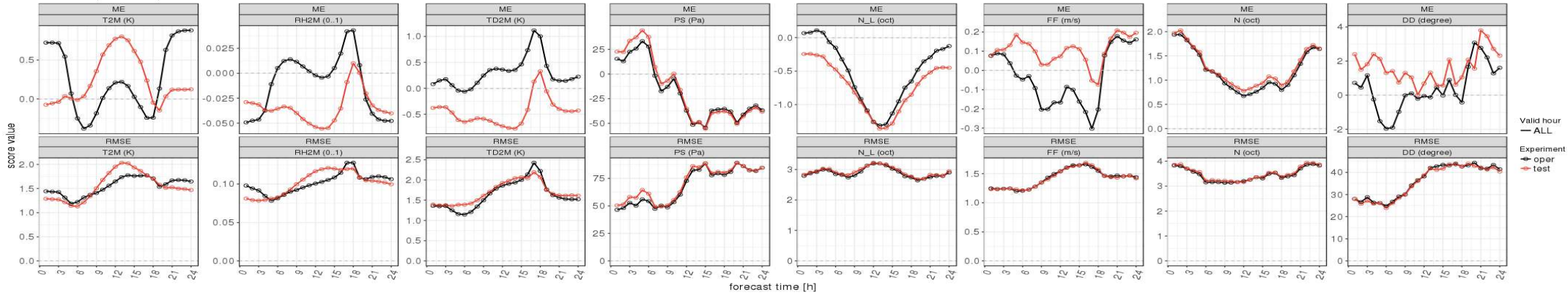
KU3

Deutscher Wetterdienst (Erstmit. 23.6.2017, 11:18:00)  
Geobispdaten © Bundesamt für Kartographie und Landvermessung (www.bkg.bund.de)

# BACY - Verification

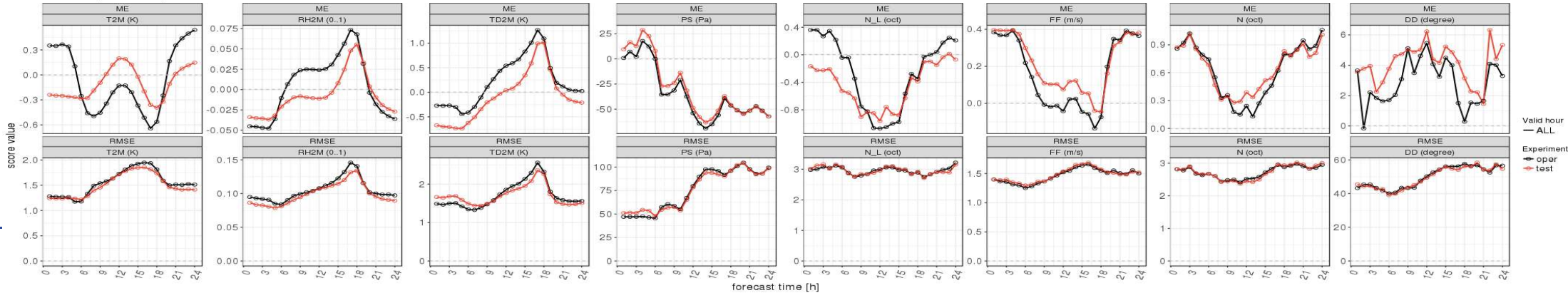
## North East

2016/05/20-08UTC - 2016/07/01-00UTC  
INI: 00 UTC, DOM: ALL, STAT: ALL



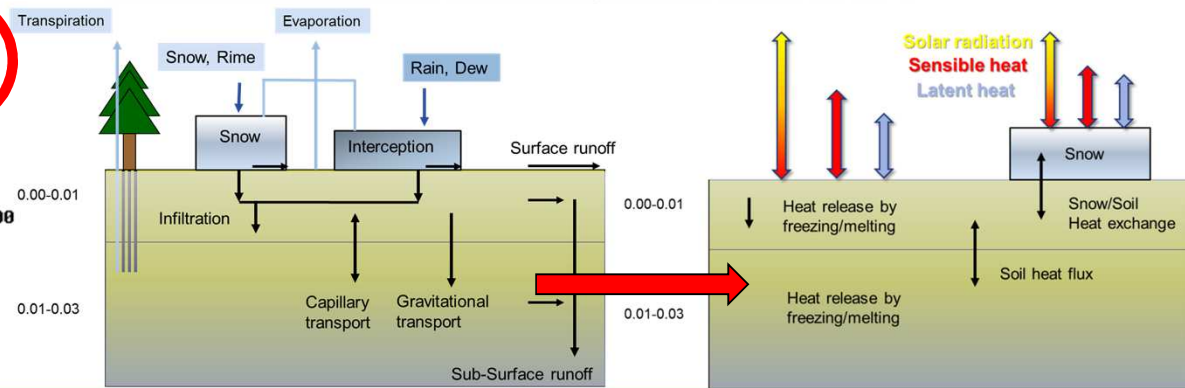
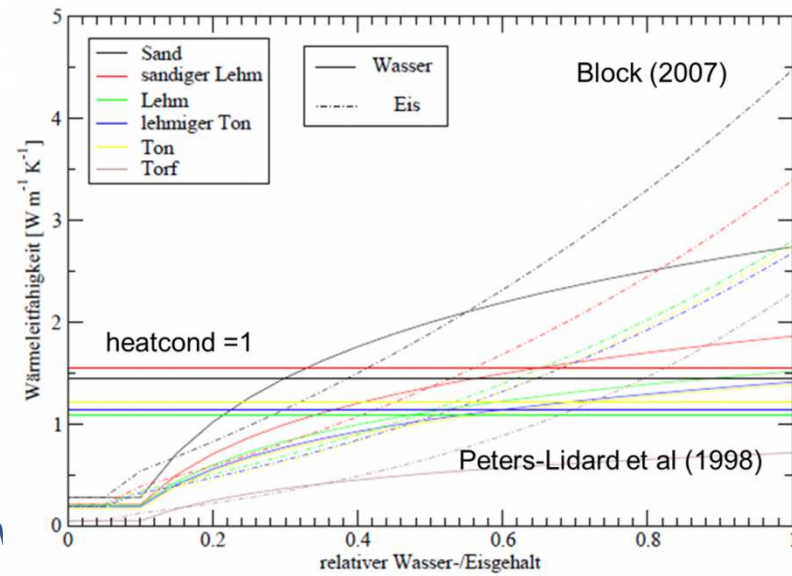
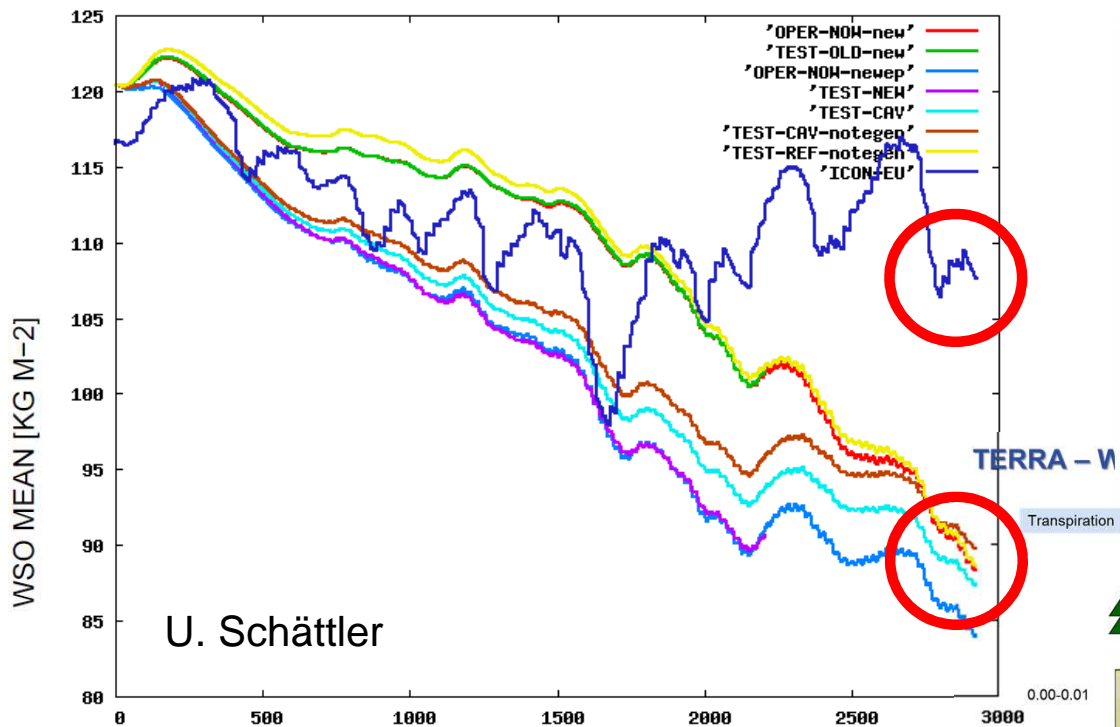
## South West

2016/05/20-08UTC - 2016/07/01-00UTC  
INI: 00 UTC, DOM: ALL, STAT: ALL



# Numerical experiments

DOMAIN AVERAGED SOIL MOISTURE 27-81 cm



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J. Helmerl et al., ICCARUS 2018

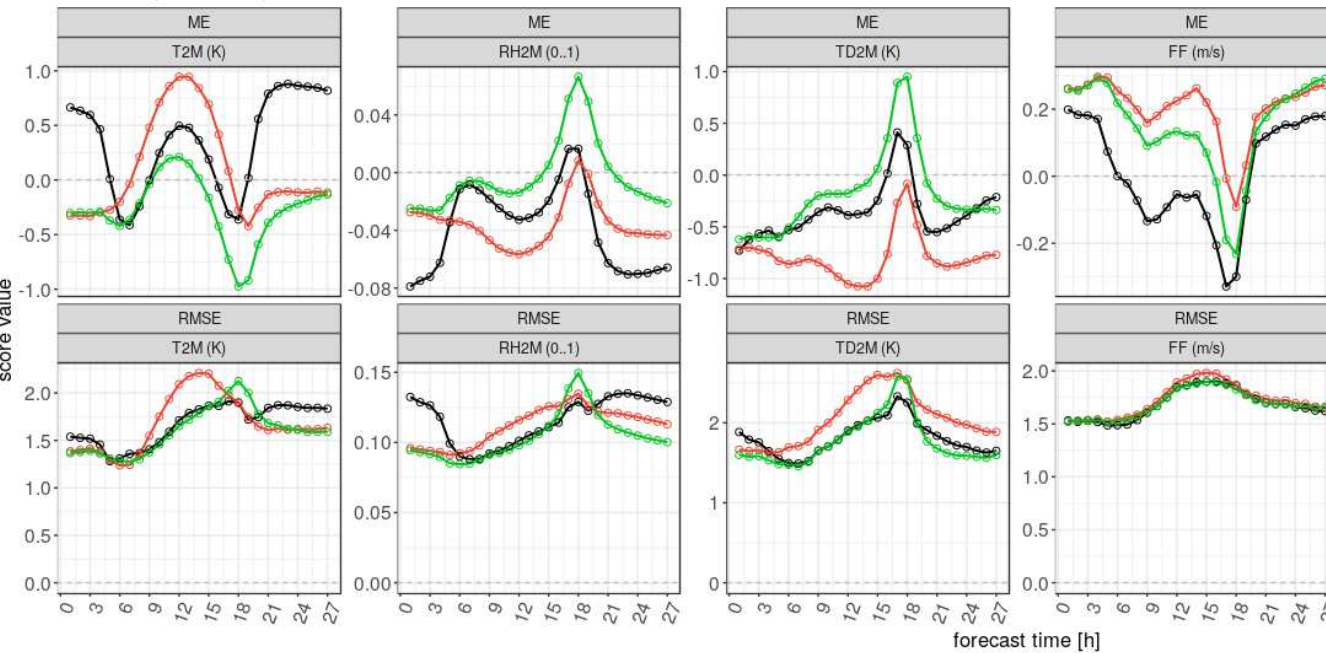




# Numerical experiments – Pseudo S

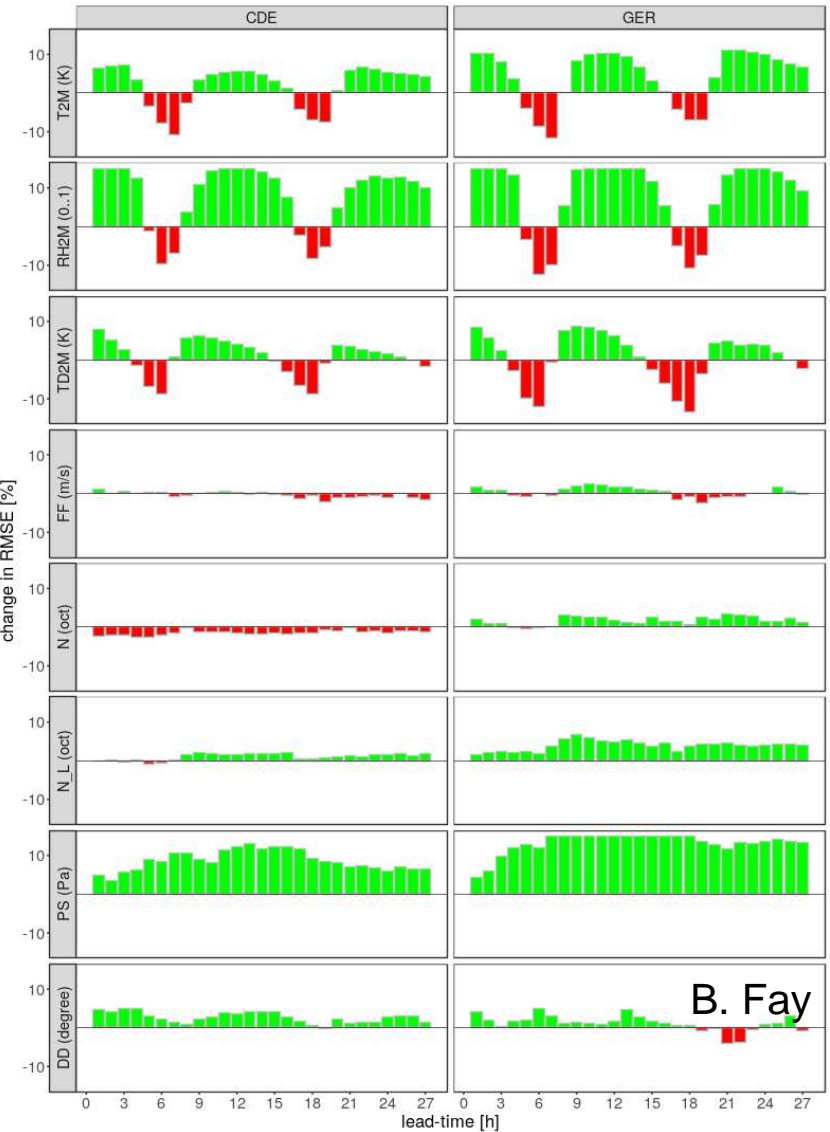
- SMA emulation: Replacing COSMO-D2 soil moisture field with interpolated field from ICON-EU
- Verification of the forecasts for June 2017 against reference

2017/06/01-00UTC - 2017/06/30-21UTC  
INI: 00 UTC, DOM: CDE, STAT: ALL



Forecasts initialized from 2017/06/01 to 2017/06/30  
Change in RMSE [%]

■ COSMO better ■ Exp\_10521 better



B. Fay





# Summary and Conclusions

- 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

V5.5R

TEST\_OLD

March

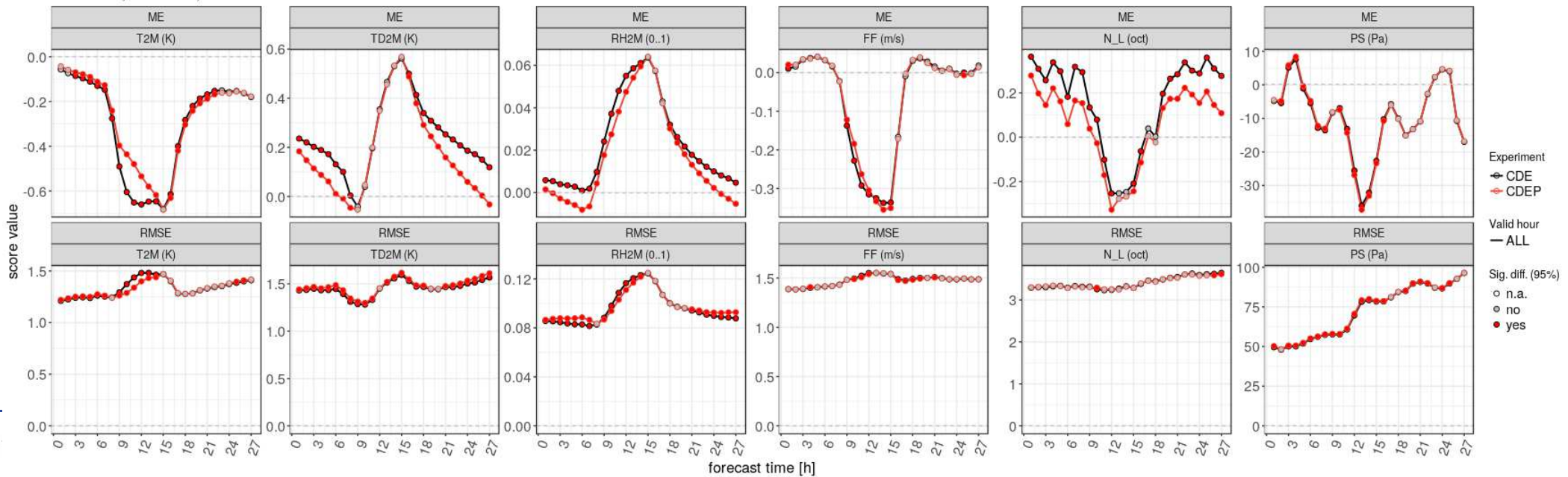
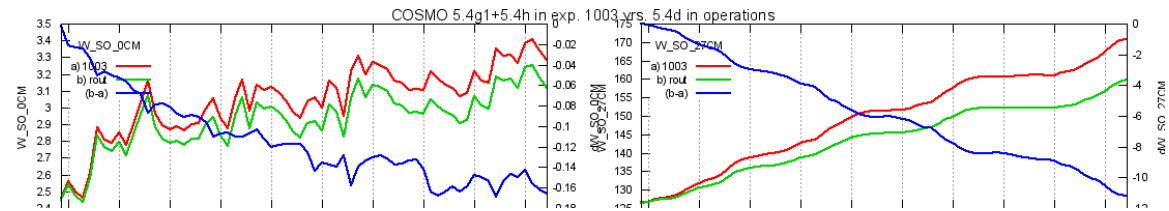
April

May

NUMEX

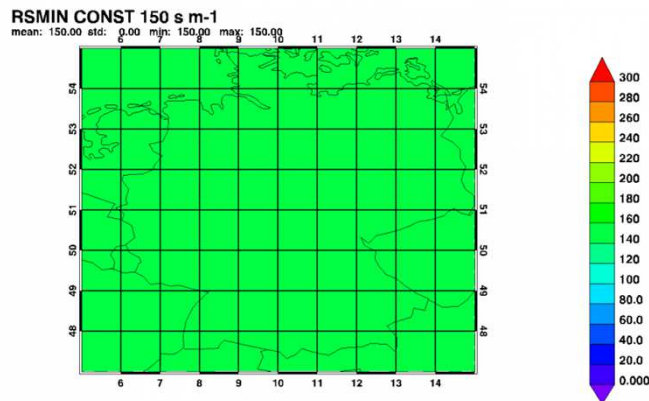
- Bugfix and improved runoff treatment in TERRA – higher soil moisture
- NUMEX 1003 in autumn 2017, CDE-P since 24.01.2018 for monitoring

2018/01/24-00UTC - 2018/02/22-09UTC  
INI: 00 UTC, DOM: ALL, STAT: ALL

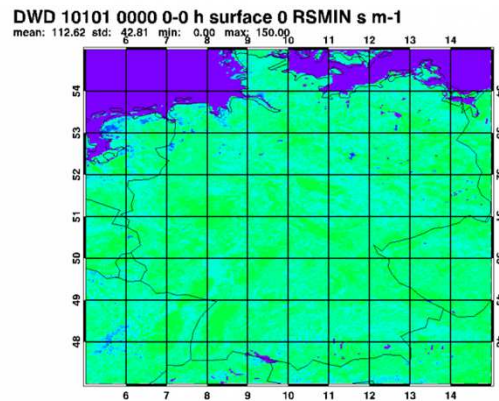


# External parameters

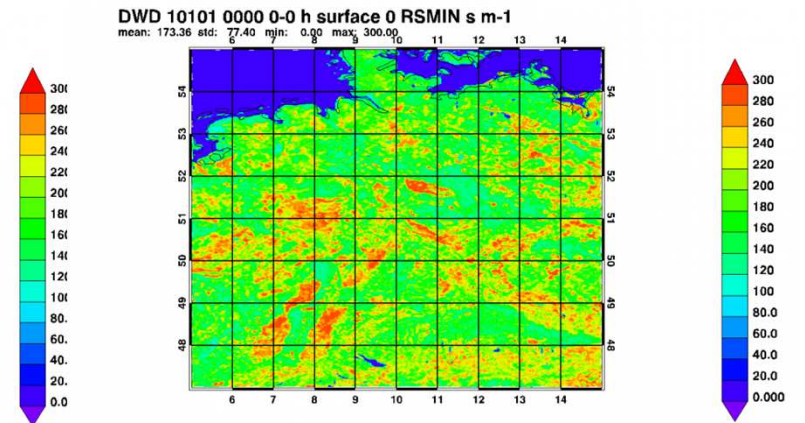
## Min. Stomata resistance



**OPER-NOW**



**TEST-NEW**



**ICON-EU**

