EKF surface assimilation activities at ZAMG

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Overview

- SWI assimilation
- T assimilation
- SURFEX 8.1

SWI assimilation

SWI (soil wetness index)

$SWI(t)=(w2(t)-w_{wilt}) / (w_{fc} - w_{wilt})$

SWI = 0

SWI > 1

https://pbs.twimg.com/media/BrDr2N-CcAA9KFW.jpg

http://www.lz.de/_em_daten/_cache/image/1xMCj9FBSGvTKutG2LF1AP56tc2COKSkNs2pIJQjTOlczLIkug1hUs7g/120603-1708-schlamm.jpg

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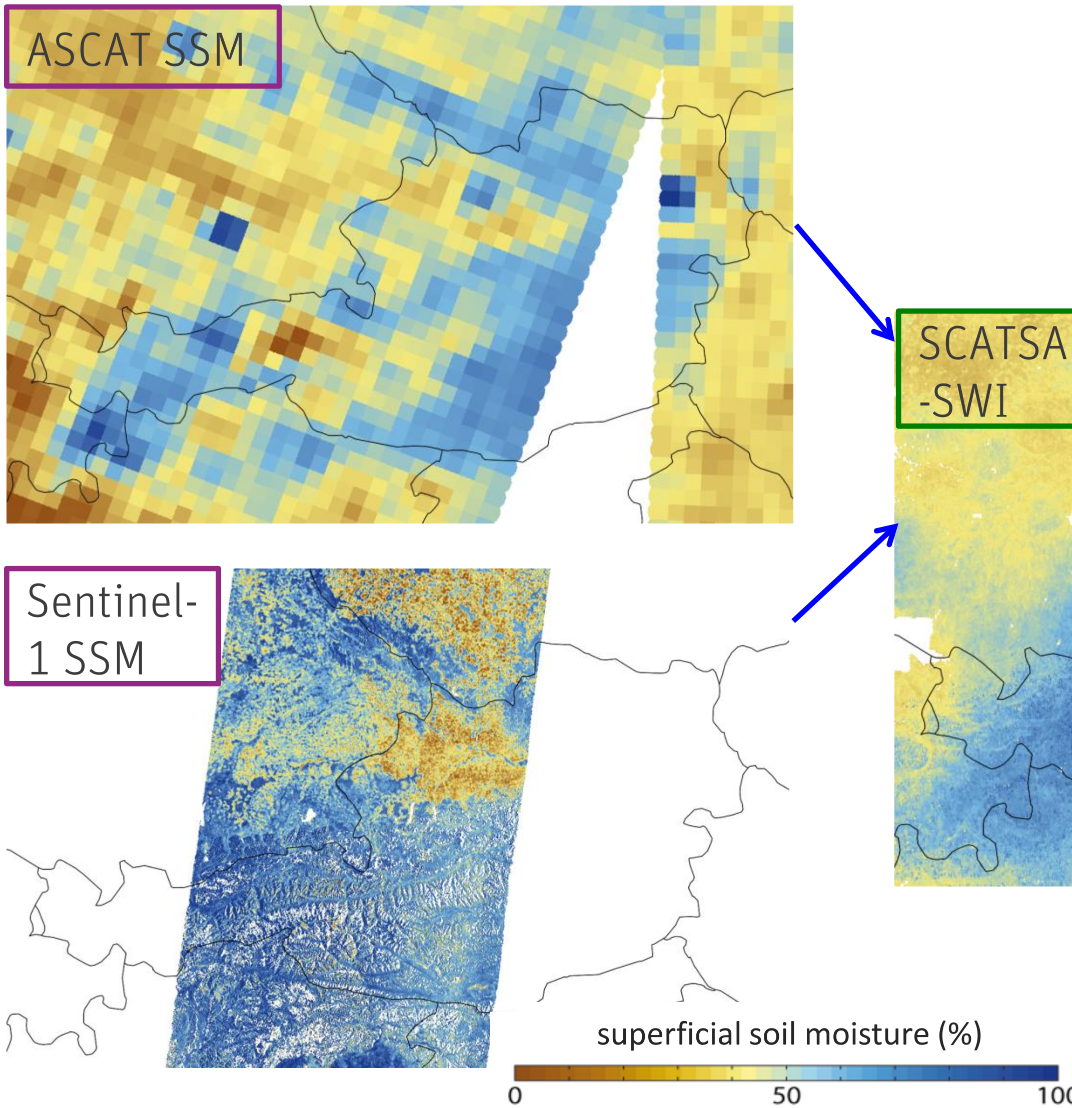
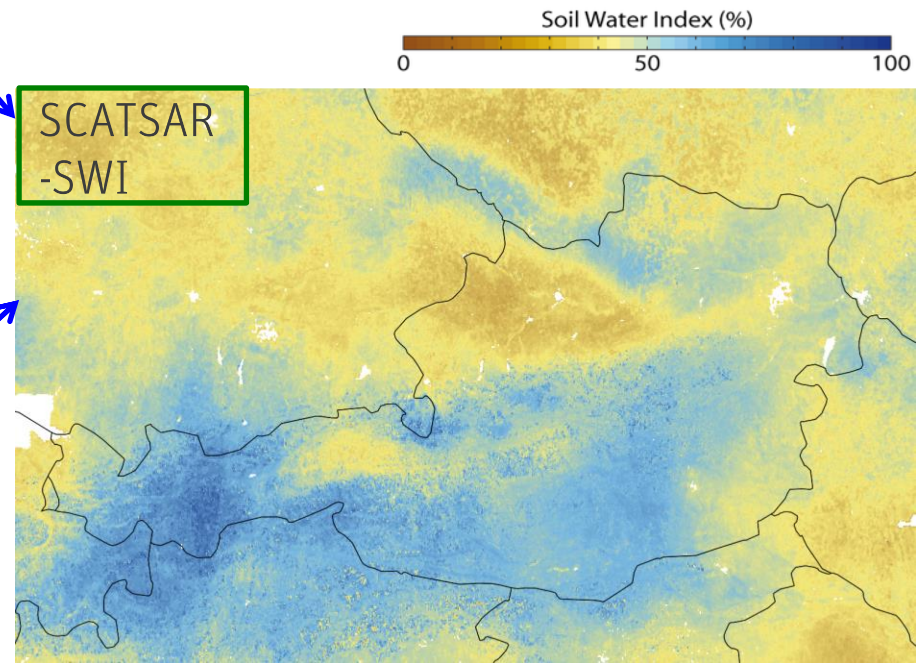
SWI assimilation – the SCATSAR-SWI data set





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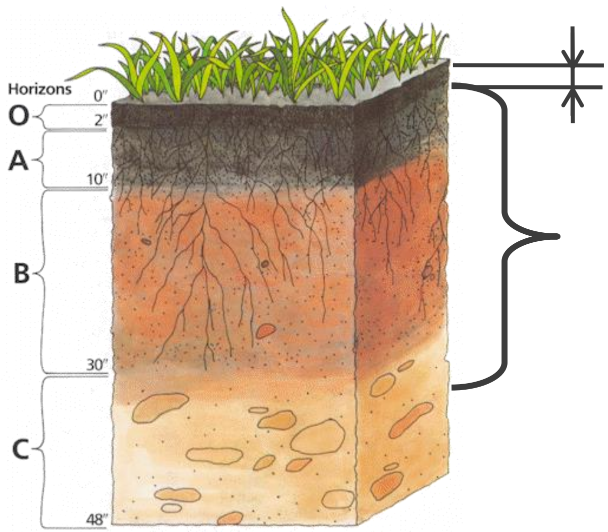
SWI assimilation – the SCATSAR-SWI data set

The method below describes the exchange between surface (Θ_s) and the reservoir below (Θ).

- T ... characteristic time
- m_s ... SSM (at the surface)

$$\frac{d\Theta}{dt} = \frac{1}{T}\left(\Theta - \Theta_s\right) \quad \Longrightarrow \quad \Theta(t) = \frac{1}{T}\int_{-\infty}^{t} \Theta_s(t') e^{-\frac{t-t'}{T}} dt' \quad \Longrightarrow \quad SWI(t) = \frac{\sum_i m_s(t_i) e^{-\frac{t-t_i}{T}}}{\sum_i e^{-\frac{t-t_i}{T}}}$$



SSM – measured (~5cm) surface Θ_s

SWI - estimated reservoir Θ (root zone)

Wagner, W., G. Lemoine, H. Rott (1999)
A Method for Estimating Soil Moisture from ERS Scatterometer and Soil Data, Remote Sensing of Environment, 70, 191-207.

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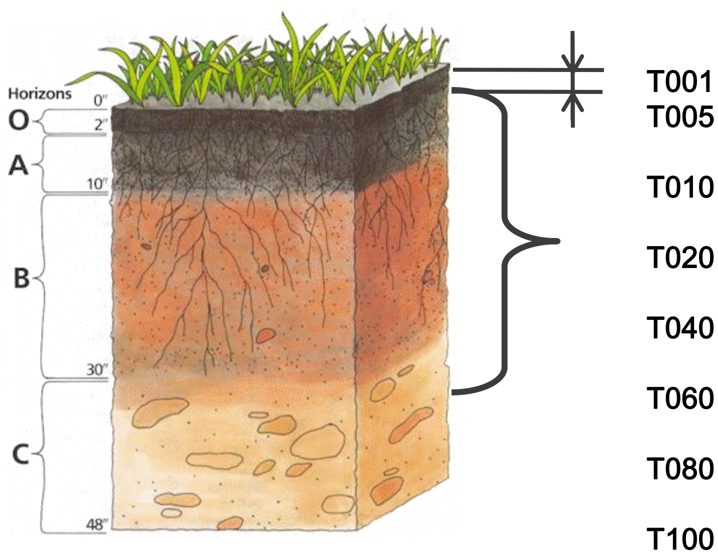

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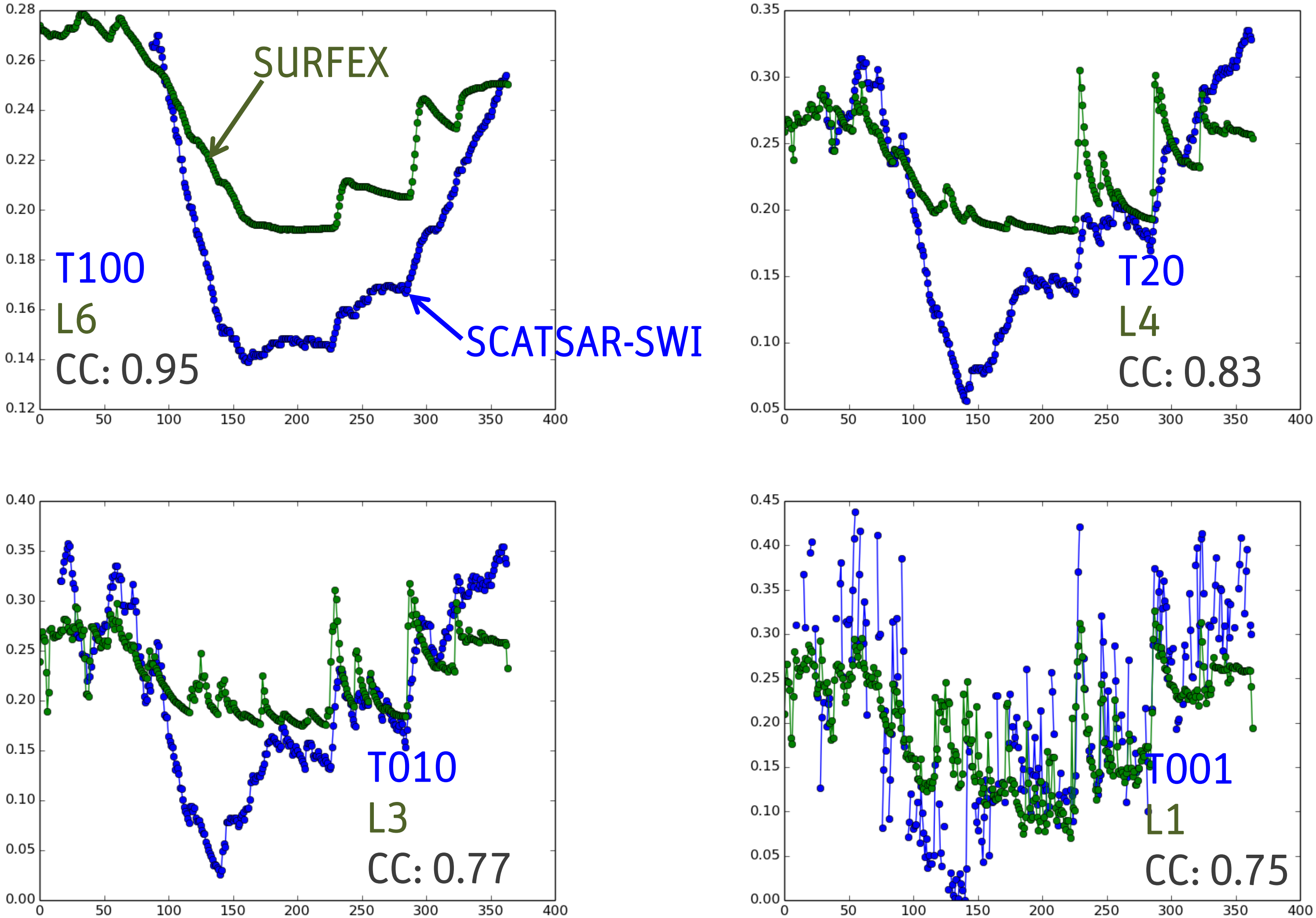
SWI assimilation - Correlation Coefficient

SM time series for a grid point in the Marchfeld in 2015



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SWI assimilation - Modifications in SURFEX / AROME

CY40T1 (SURFEX 7.3) for AROME
- add modifications from HIRLAM to use ISBA diffusion scheme

SURFEX 8.0 for soil data assimilation
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SFXTOOLS CY40T1
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GL
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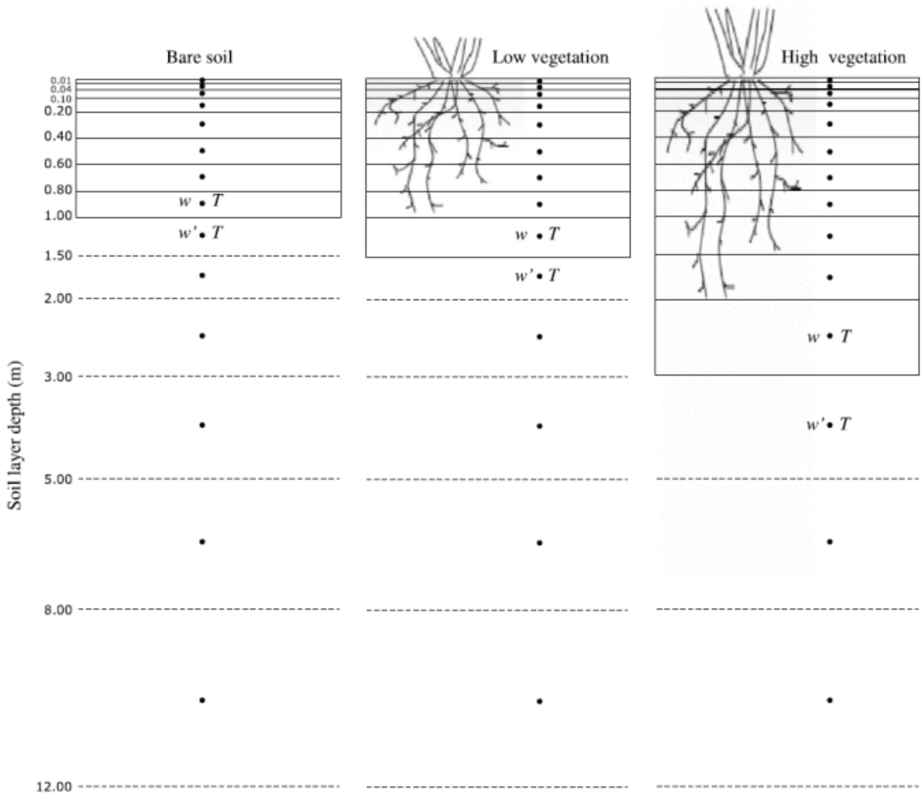
Modifications in SURFEX / AROME

ISBA Diffusion scheme (CY40/43)



Decharme et al., 2013, JGR

+) more realistic than F-R
+) more options for data assimilation
+) soil layers fit well to SCATSAR-SWI data
+) will be the new standard for AROME (F-R won‘t be maintained in CY44 and higher)
-) not well tested, bugs

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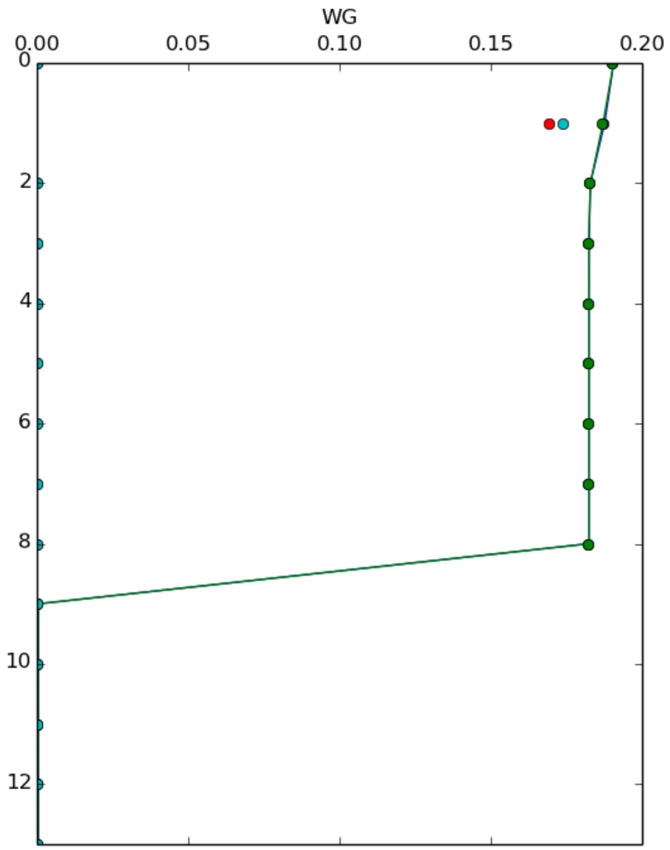
SODA functionality tests

OBS = SWI_T005 | CTRL = WG2



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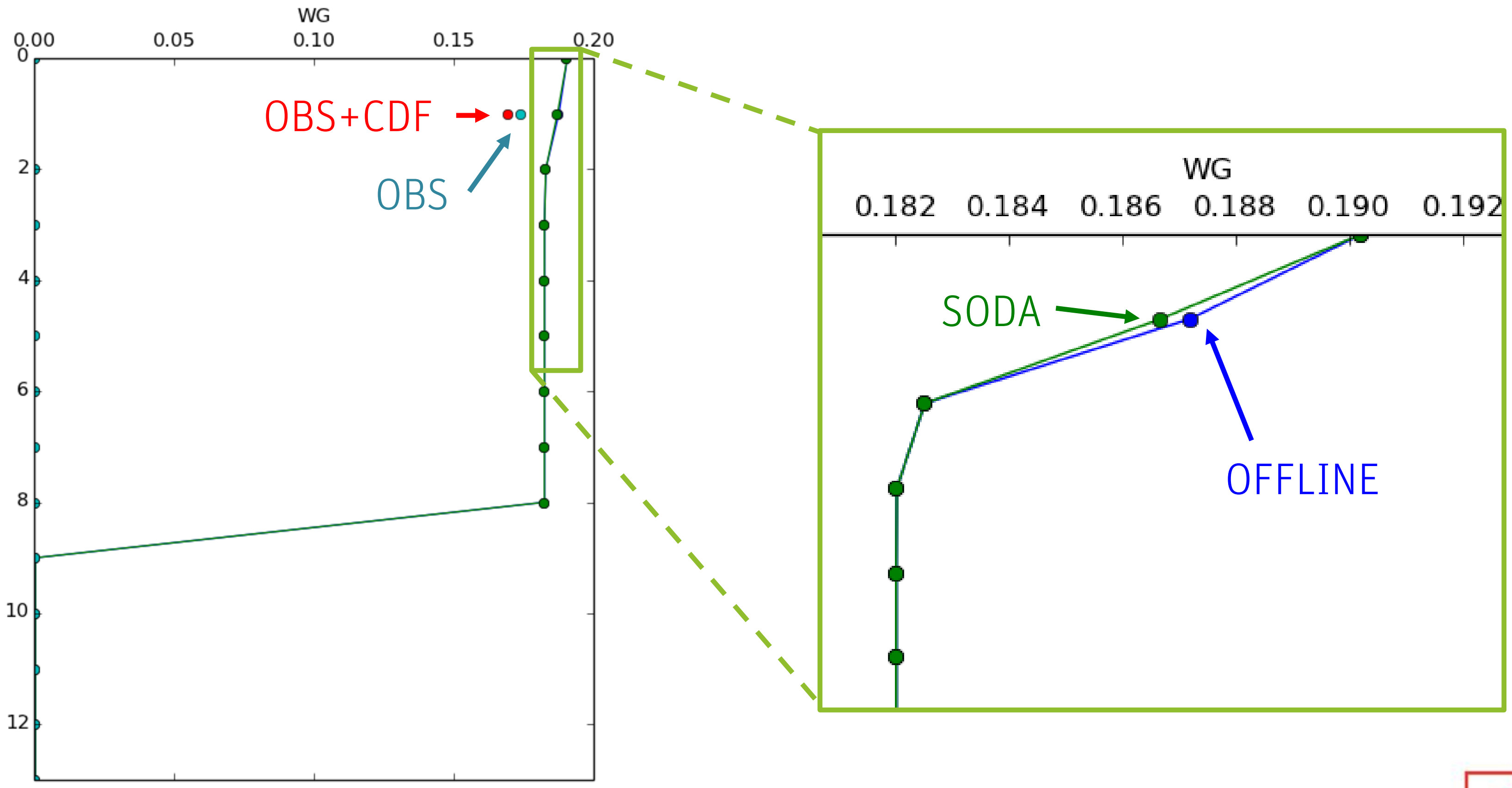
SODA functionality tests

OBS = SWI_T005 | CTRL = WG2



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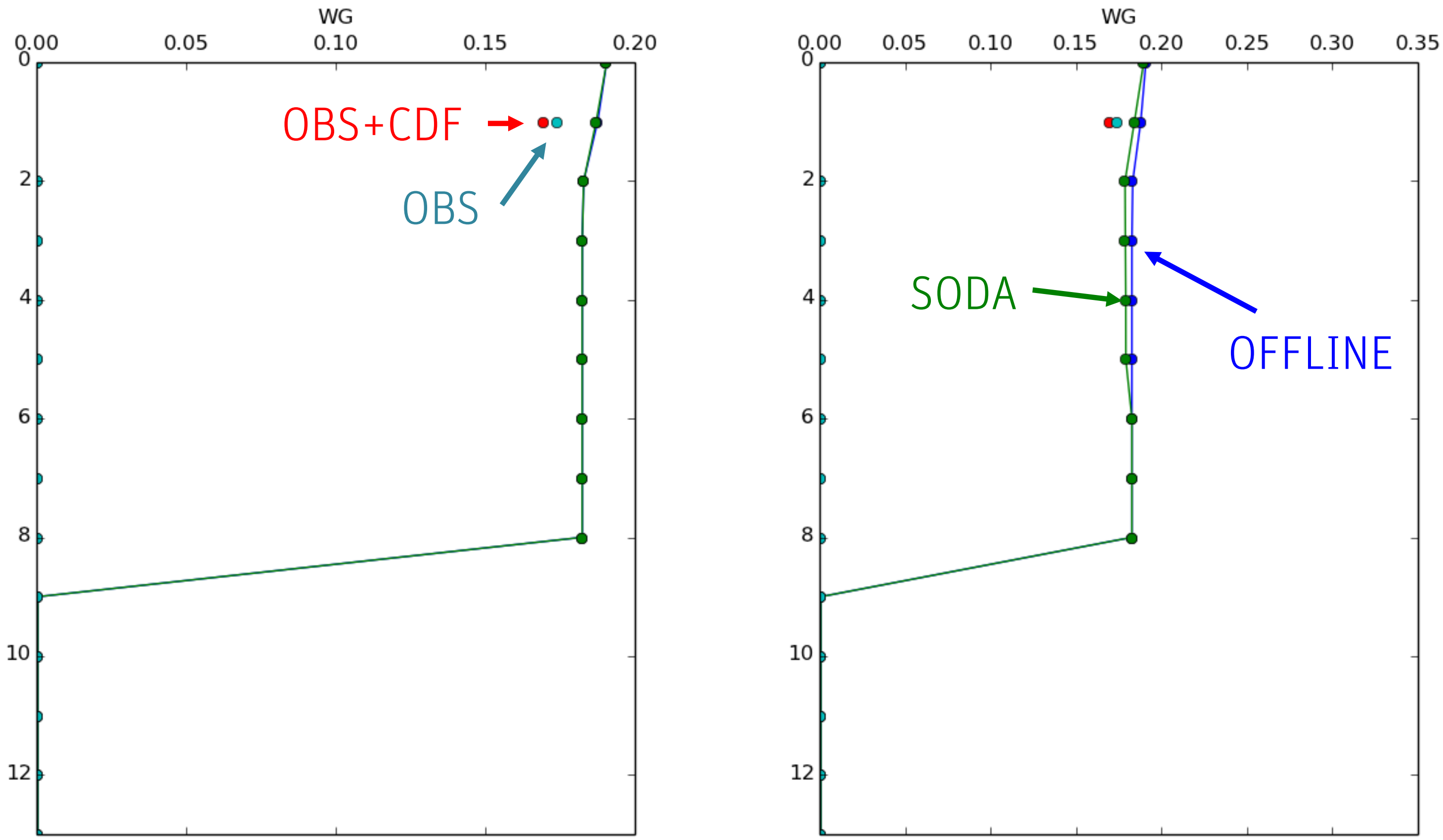
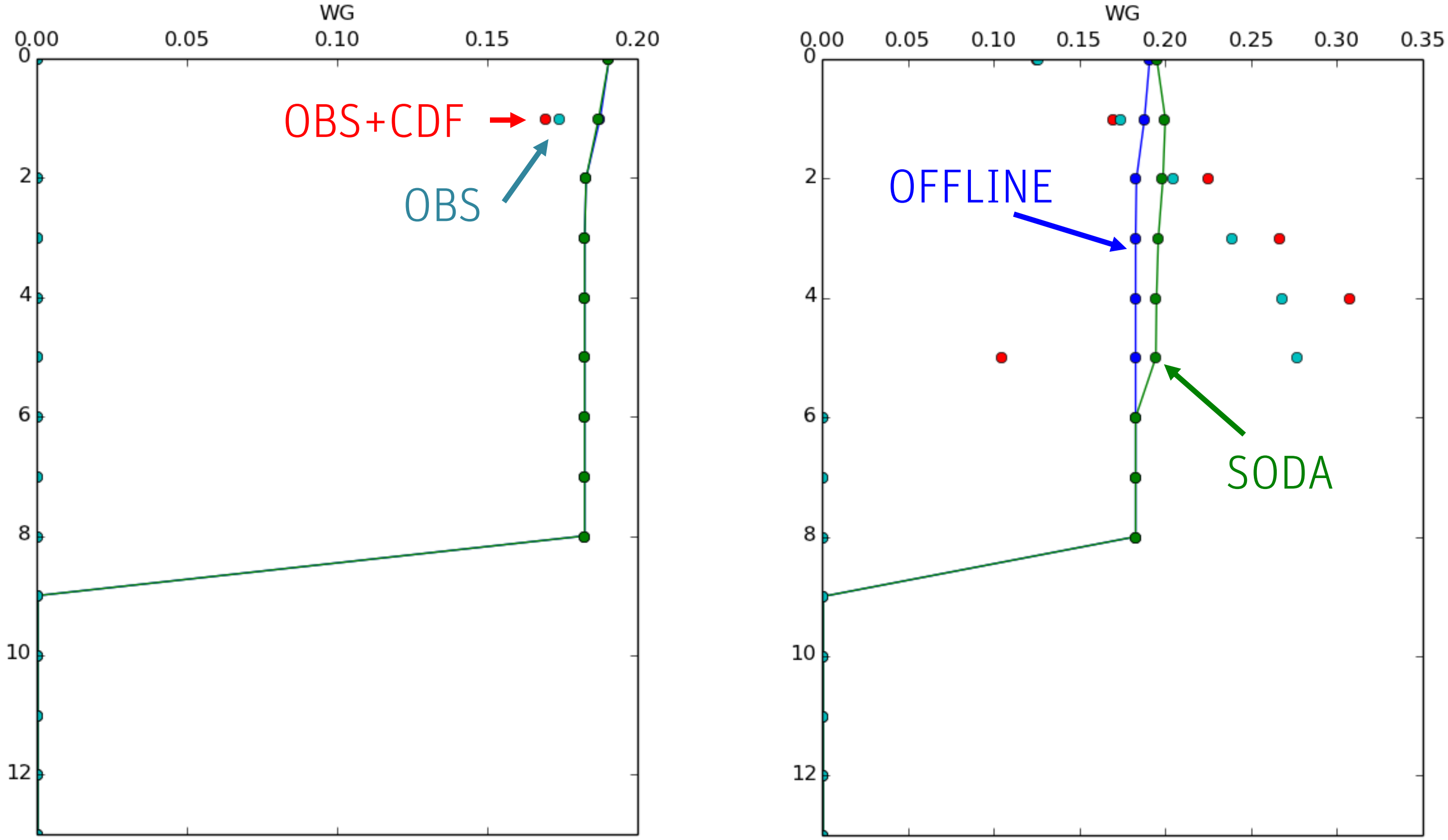
SODA functionality tests

OBS = SWI_T005 | CTRL= WG2 | CTRL = WG1, WG2, WG3, WG4, WG5, WG6



SODA functionality tests

OBS = SWI_T001,T005,T010,T020,T040,T060 | CTRL = WG1 - 6



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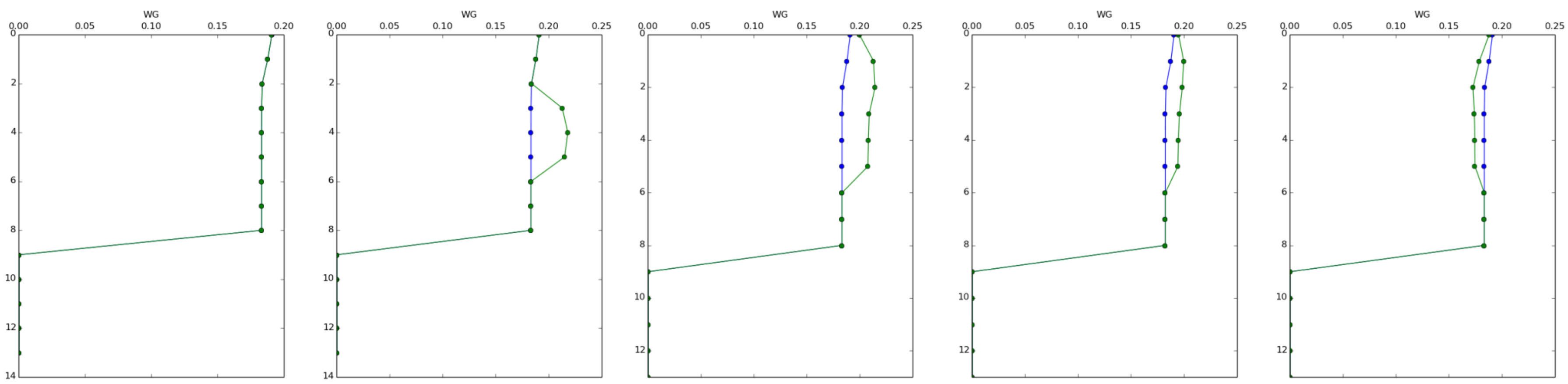
SODA functionality tests

Different solutions, and all of them are correct.
more control variables = more computational effort
What is the best solution? It depends!



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SWI assimilation - Results

2015 (Jan-Dec) is used as training data set for bias correction
2016 (Jan-June) is used for assimilation experiments:

OBS	CTRL	EXPERIMENT
none	none	RR
SWI 1-6	WG 1-6	EXP 3
SWI 1	WG 1	EXP 4
SWI 2-4	WG 2-4	EXP 5
SWI 6	WG 6	EXP 6

validation against Austrian TAWES stations – because we have no in-situ soil moisture measurements

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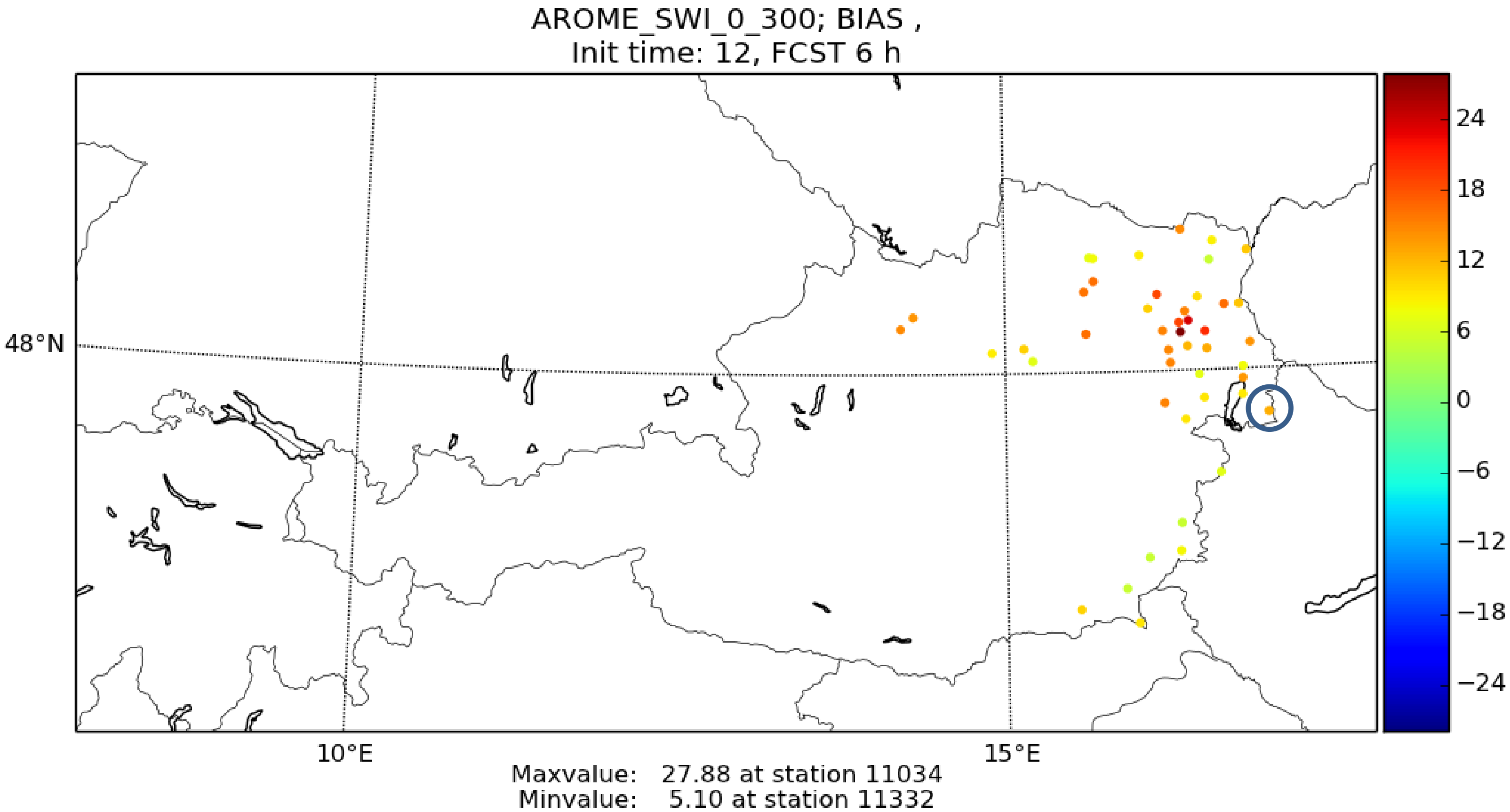
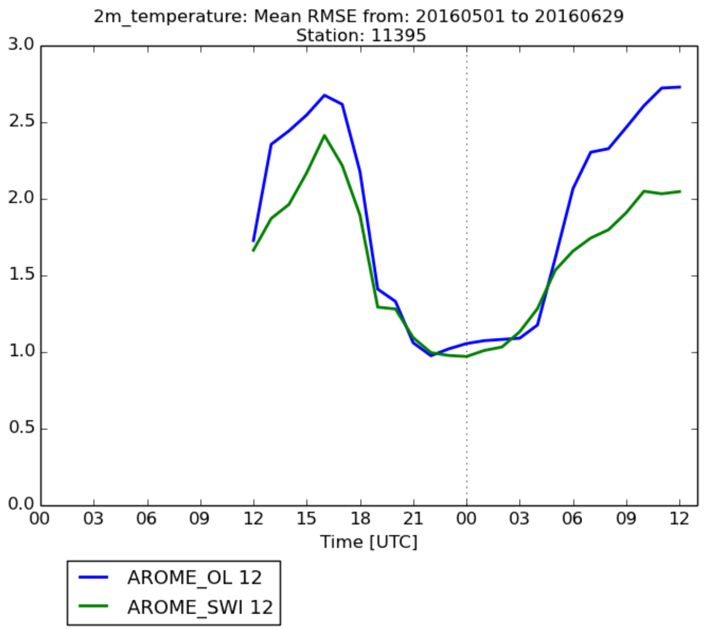
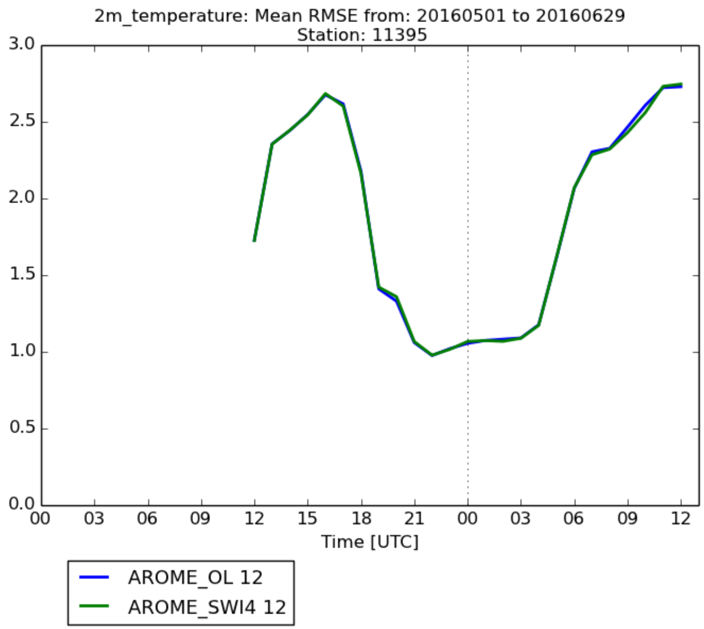
SWI assimilation - Results



Bias for RH2M if all data (SWI 1 to 6) are assimilated. All stations below 300m sea level are displayed

SWI assimilation - Results





RMSE for T2M
for the SYNOP station Andau (Burgenland)
RR = blue (both figures), EXP3 = green (left) and EXP4 = green (right)

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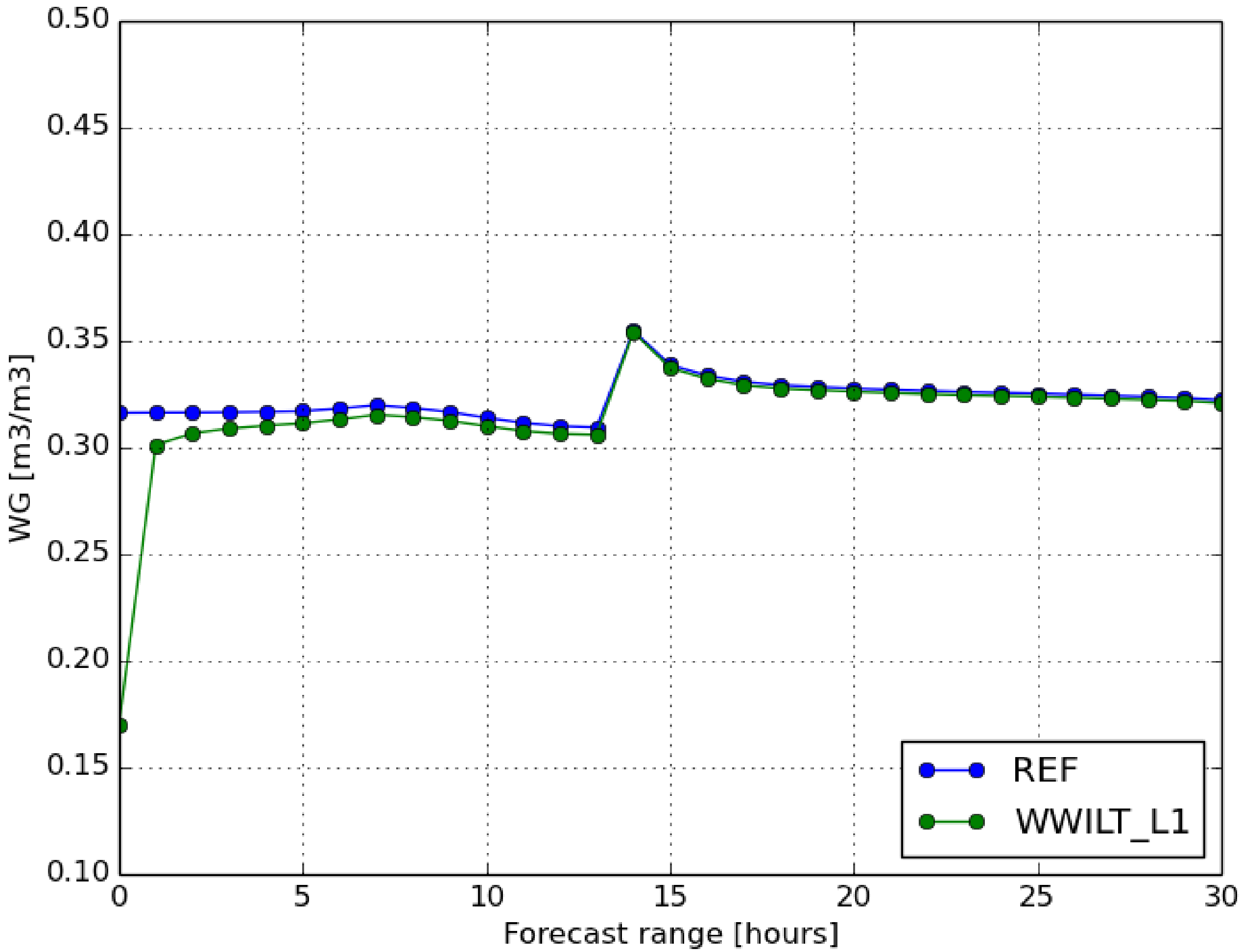
SWI assimilation - Results



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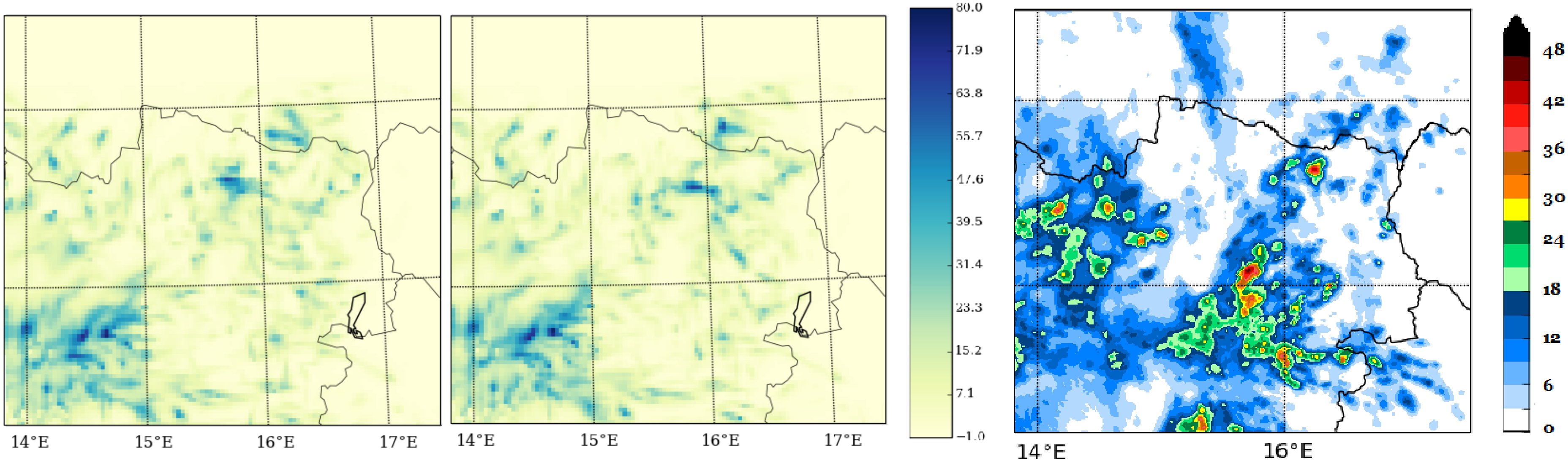
SWI assimilation - Results



24-hourly accumulated precipitation (May 19th 2016, 12UTC - May 20th 2016, 12UTC) for RR (left) and EXP4 (mid). The structures are clearly different, especially in the north-eastern part of the domain, but none of the model runs is representing the combined radar and station measurements patterns, analysed by INCA (right).

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SWI assimilation - Results

- Significant*) improvement for T2M and RH2M in flatlands

  short-range (up to +24h) forecasts
  if all data are assimilated, non-significant otherwise

- No clear trend for mid-range mountains
- No impact (nothing to assimilate) for mountain stations
- No impact for precipitation forecasts.

*) Mann-Whitney-Wilcoxon

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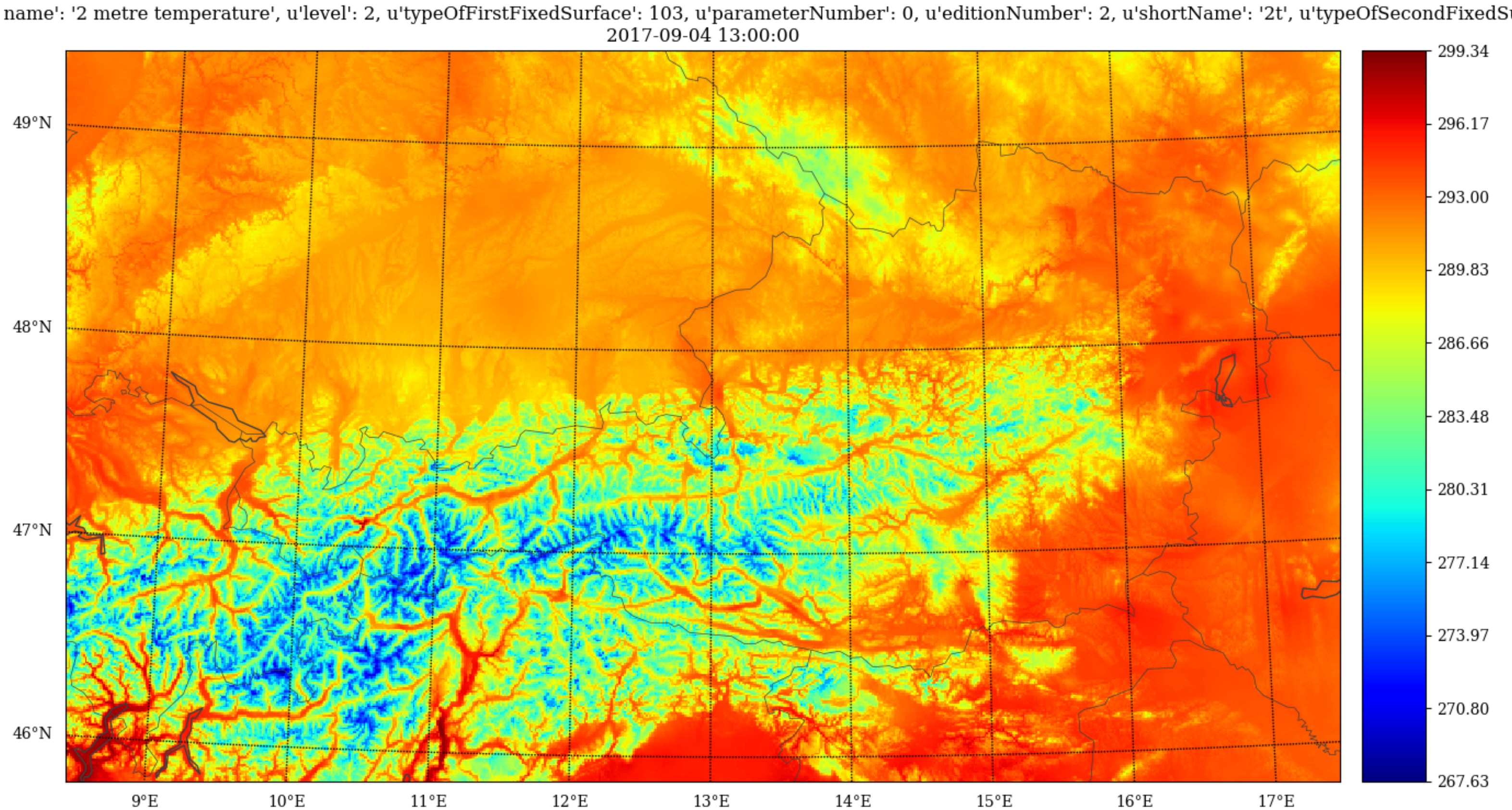
T assimilation

Task: assimilate LST (land surface temperature) from satellites (Sentinel-3, MSG, MODIS)

1. try something that should work - assimilate T2M
2. adapt SURFEX 8.0/8.1 so it can work with LST
3. improve 2.

T assimilation – step 1: input data

T2M – INCA analyses
 gridded values on 1km grid of Austria



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T assimilation – step 1: model configuration

CY40T1 (SURFEX 7.3) for AROME
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SFXTOOLS CY40T1
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GL
- add SURFEX output fields for GRIB conversion

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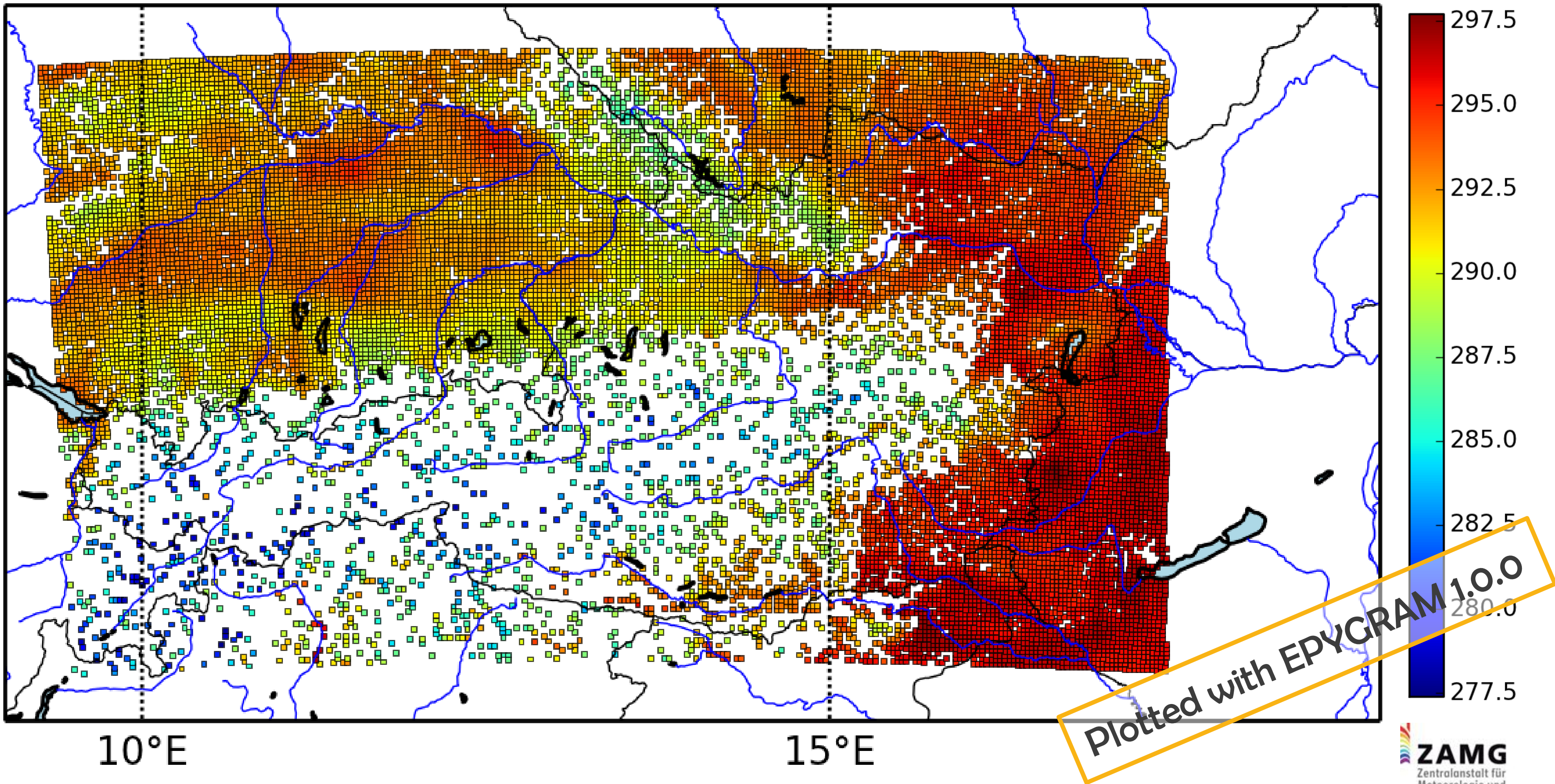
T assimilation – step 1: results

Case study for 20170906 12UTC - Observations



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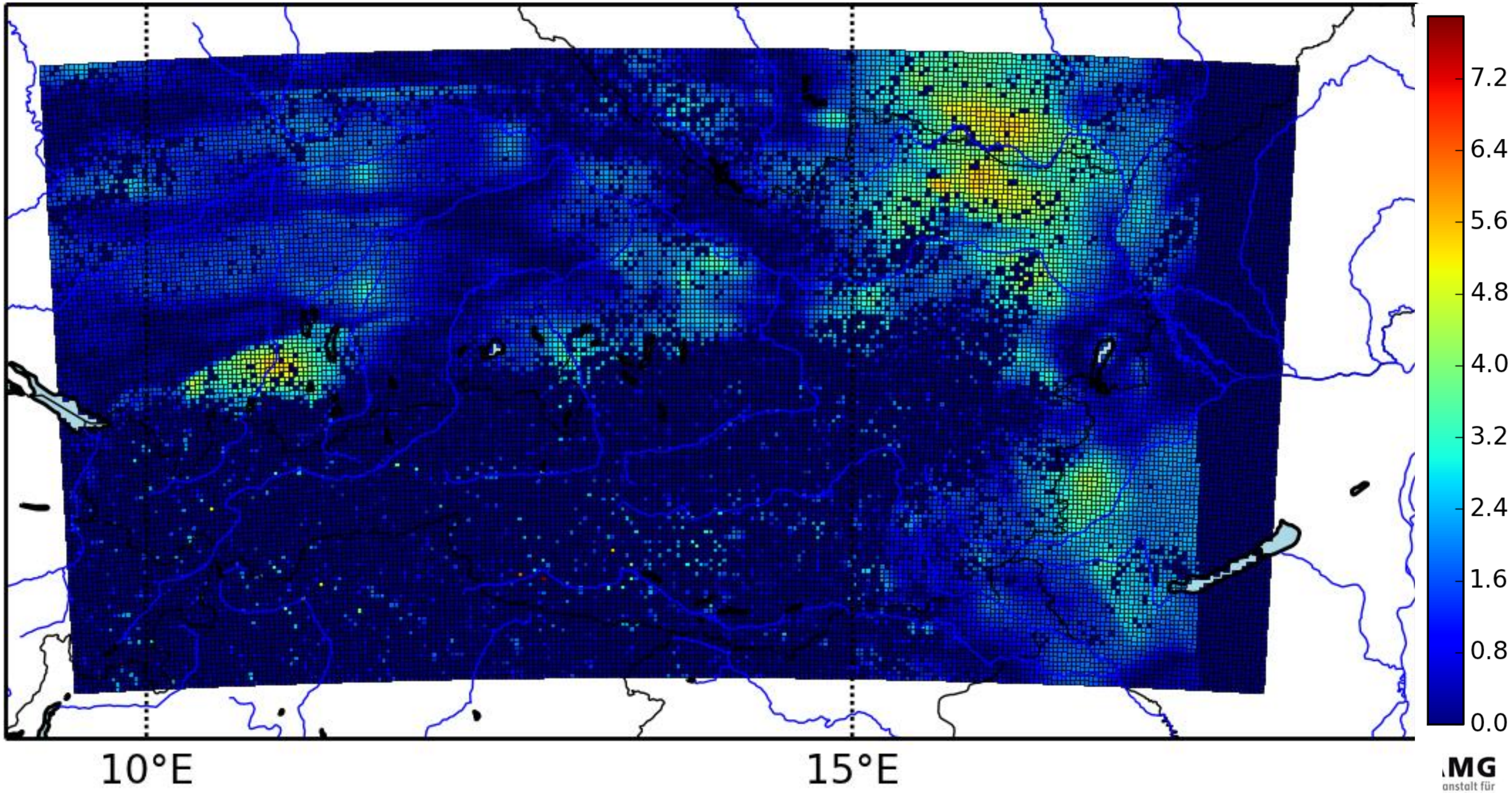
T assimilation – step 1: results

Case study for 20170906 12UTC - Innovations



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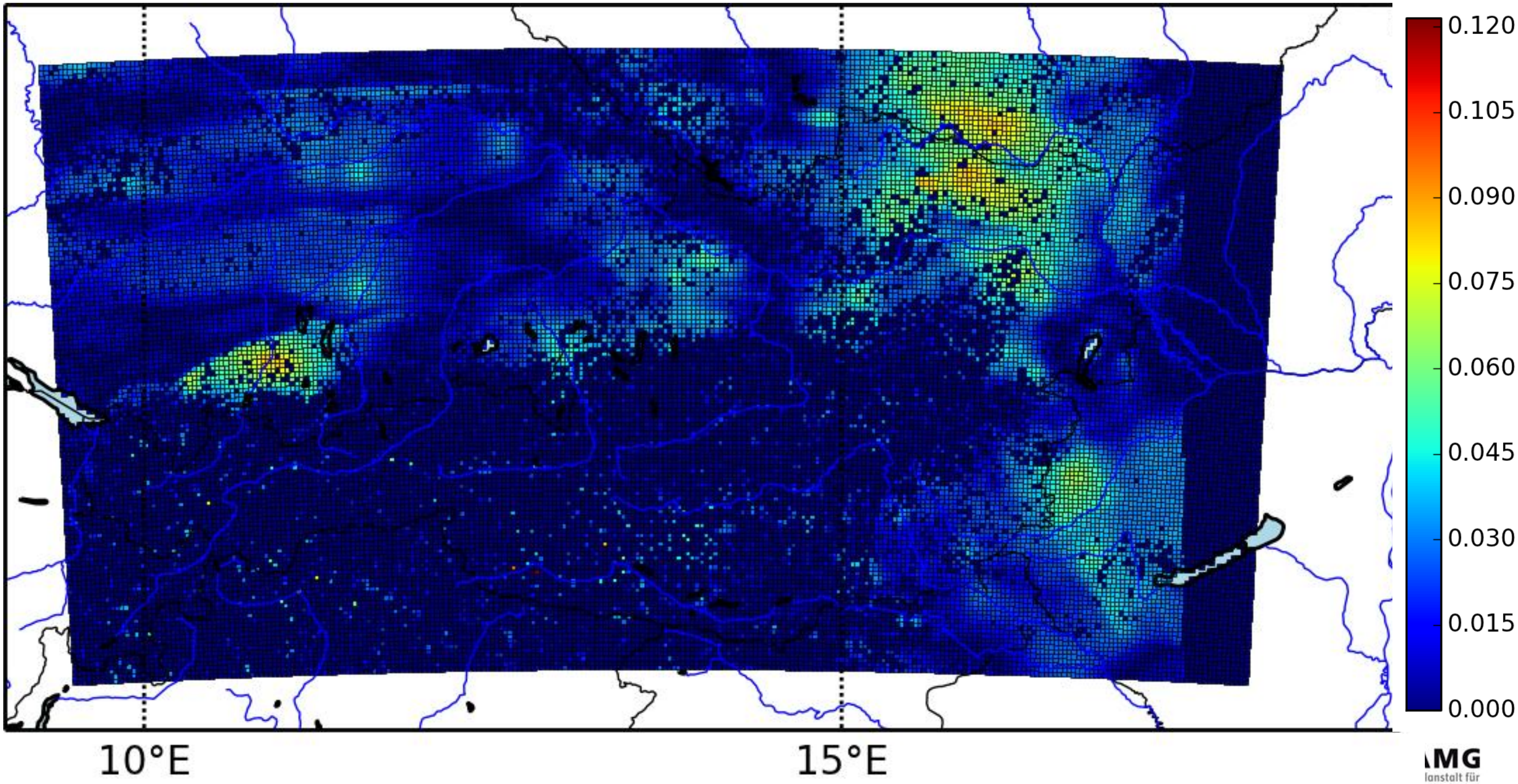
T assimilation – step 1: results

Case study for 20170906 12UTC - Increments



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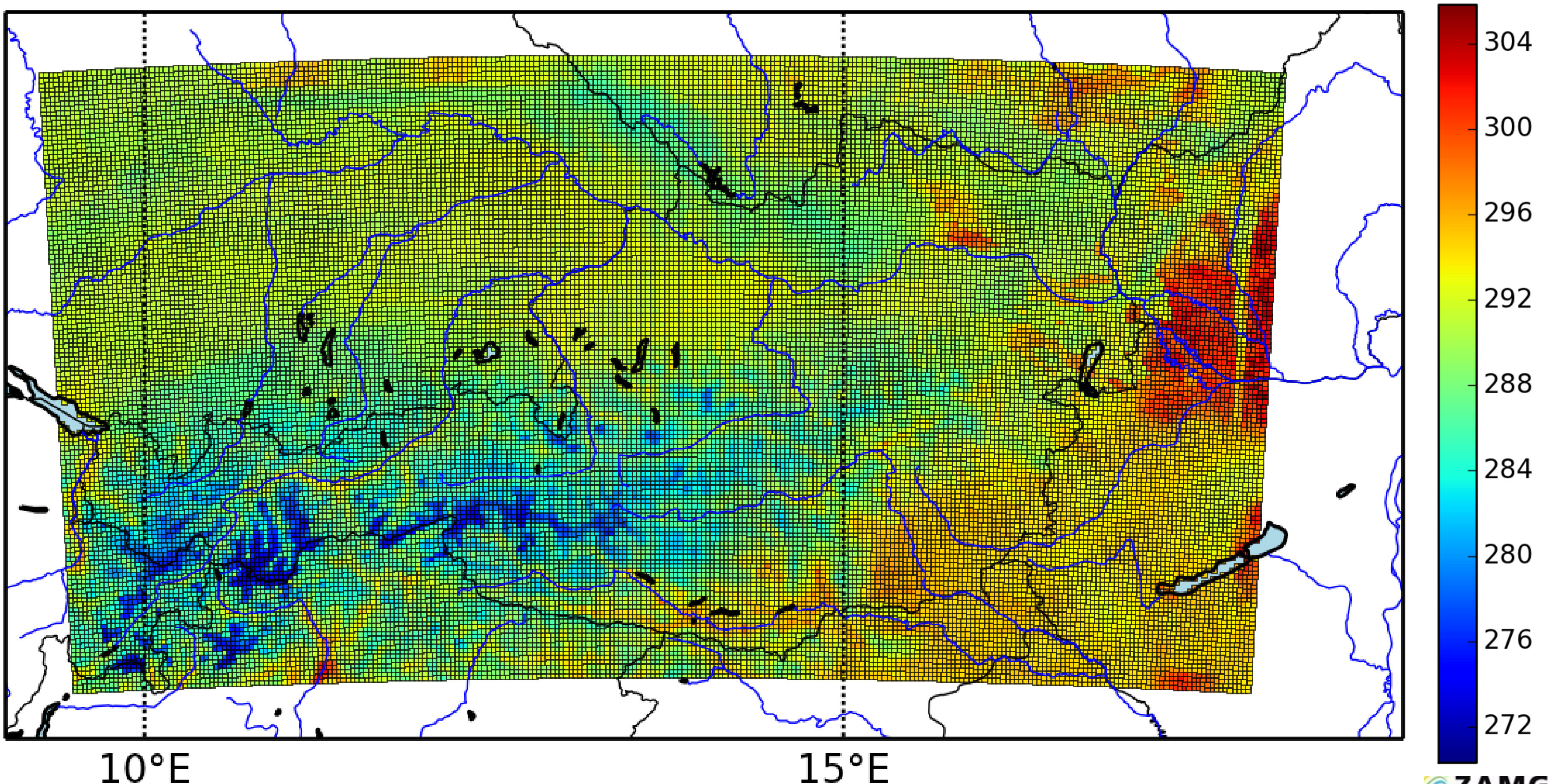
T assimilation – step 1: results

Case study for 20170906 12UTC - Analysis



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T assimilation – step 2: model configuration

CY40T1 (SURFEX 7.3) for AROME
- add modifications from HIRLAM to use ISBA diffusion scheme

SURFEX 8.0 for soil data assimilation
- add soil moisture assimilation for layers 3-6 in OFFLINE & SODA (Observations and control variables)
- add TS assimilation for layer 1 in OFFLINE & SODA

SFXTOOLS CY40T1
- modify I/O to convert LFI-files from 7.3 to 8.0 and back again

GL
- add SURFEX output fields for GRIB conversion

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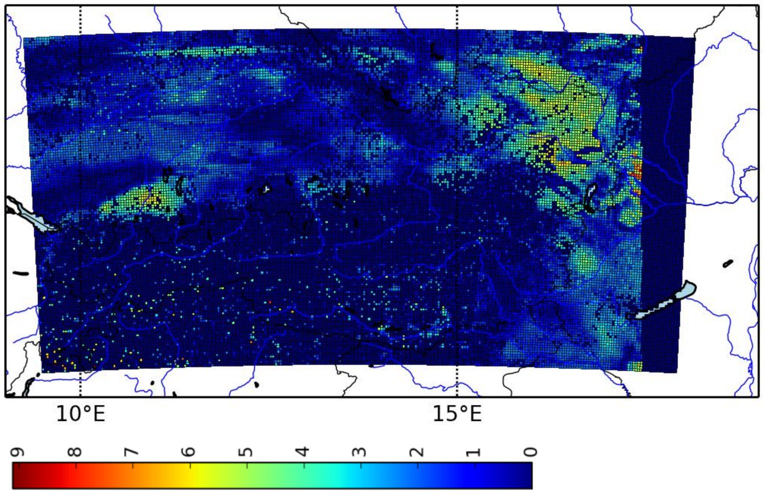
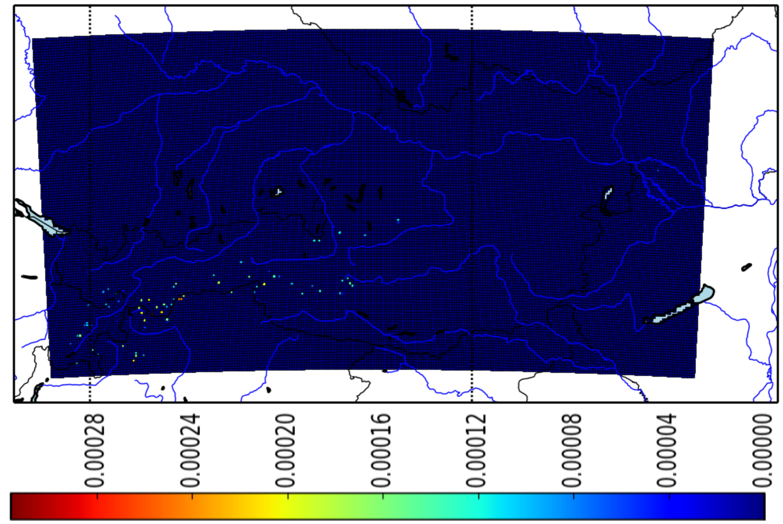
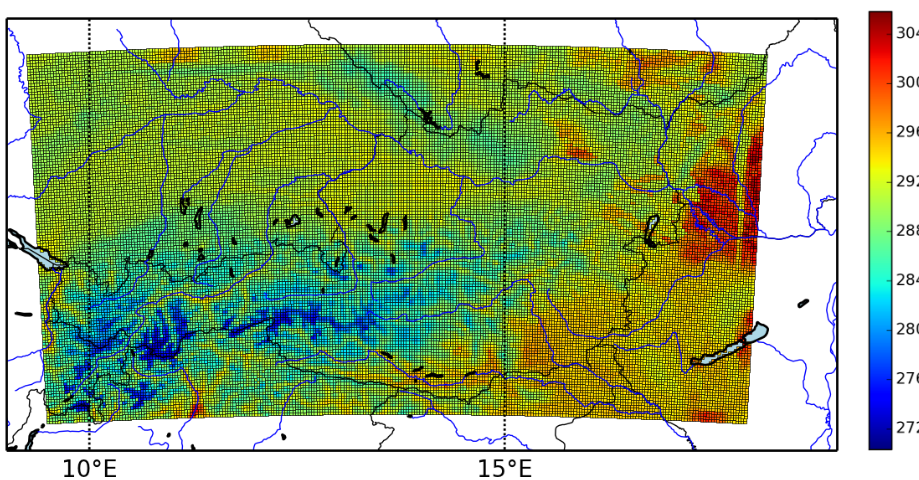
T assimilation – step 2: results

Case study for 20170906 12UTC – Innovations, Increments and Analysis







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T assimilation – step 2: results

To be continued ...

Problems in 8.0

- Restart file contains many 1e+20 fields (e.g. T2M, T2M_ISBA)
  -> use ISBA_CAN_T06 as input variable for SODA
- SODA does not write out restart file
  -> Code has been modified
- Typing error in soda.F90 (GPGD_ISBA)
  -> commented out
- ZK1 can become negative
  -> switch off assimilation for such grid points
- XI can get close to but not exactly 0 in assim_nature_isba_ekf.F90
  -> set such values XUNDEF
- XQCOBS_M cannot be defined by the user

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SURFEX 8.1

Software has been installed on HPC, based on the GIT repository of MF

OFFLINE (thanks to Stéphanie Faroux!) and SODA are running

Output file changed again (new parameter names) – postprocessing (GL, EPyGrAM) has to be adapted once more (7.3 – 8.0 – 8.1)

By default, the output written fields are all 1D-fields (there is no longer the dimension PATCH in output files), e.g. TG1P1 – cannot be used in EPyGrAM

Outlook

- Investigate SWI assimilation results and publish them
- Install 8.1 on new HPC (Nov 2017) & add ZAMG changes from 8.0
- Improve SWI assimilation -> Jasmin
- Understand T2M assimilation
- Test & improve TS assimilation
- Build up an operational system at ZAMG to assimilate SWI & T2M/TS and compare it with operational AROME (CY40T1/SURFEX7.3 with CANARI T2M, HU2M)
- Make XQCOBS_M an input variable

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Thank you for your attention!

Stefan Schneider – stefan.schneider@zamg.ac.at

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