SURFEX activities at ZAMG

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LACE DAWD – Bucharest, 19.09.2018

Overview

- Soil moisture assimilation
  - Multiple soil layers
  - Variable observation error
  - Higher spatial resolution
- Temperature assimilation
  - 2m temperature
  - Land surface temperature

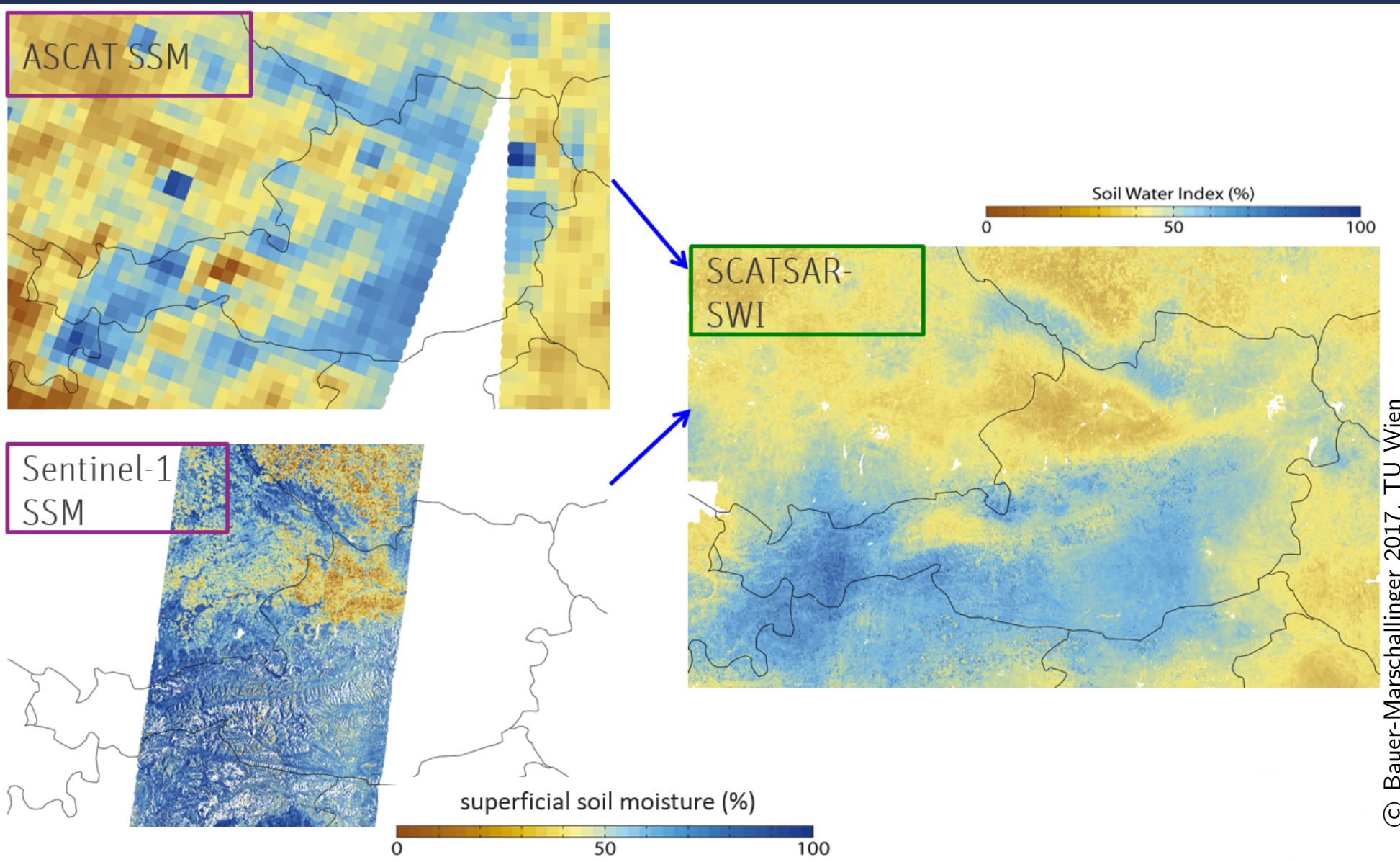
Soil moisture assimilation – multiple layers

SURFEX:
- 8.1, sEKF assimilation
- + WG 3-6 as OBS, WG 3-6 as CTRL

MODEL:
- AROME CY40T1 + SURFEX 7.3
- 2.5 km grid, 90 layers

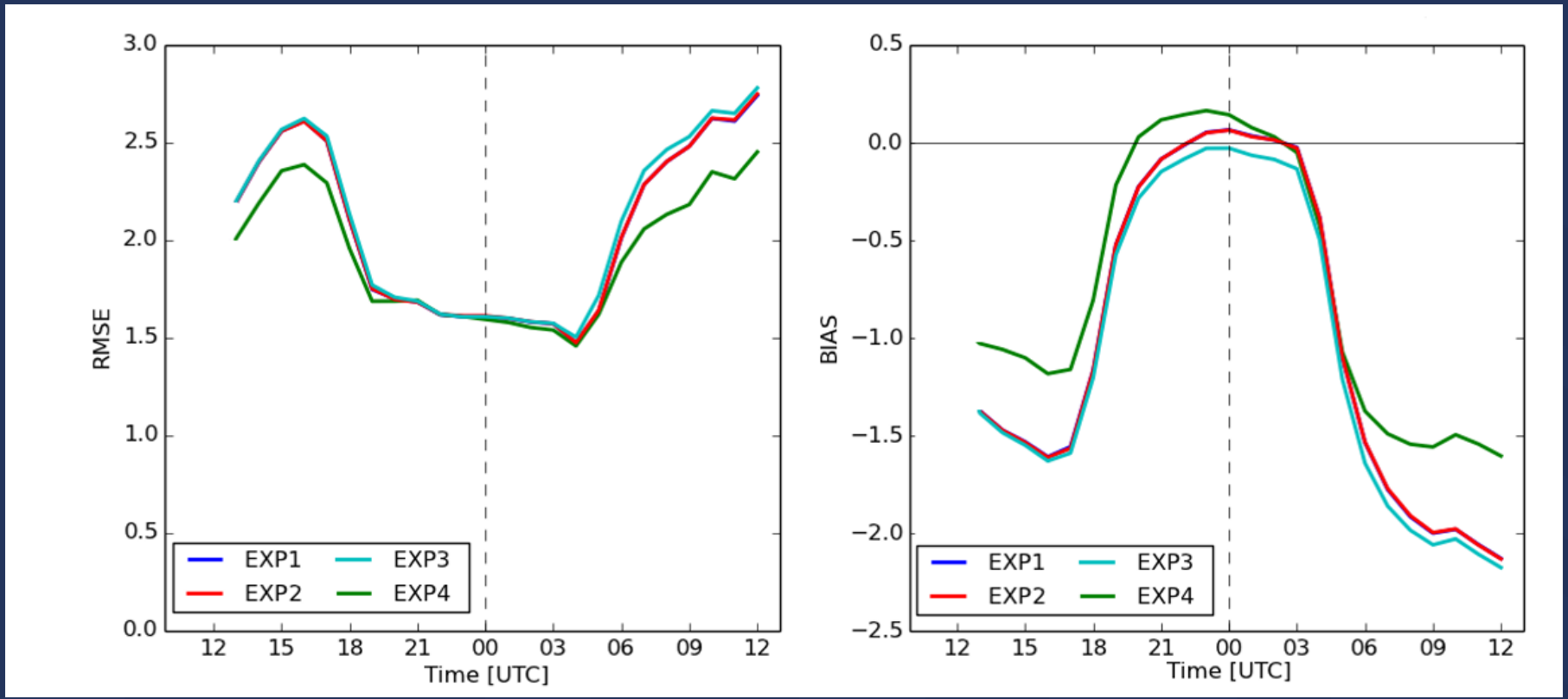
DATA:
- SCATSAR-SWI: combined Sentinel-1 SAR & MetOP ASCAT
- spatial resolution: 1 km
- temporal resolution: 1 day (12UTC)
- Copernicus product starting in autumn 2018

SCATSAR-SWI



Verification

T2M against flatland SYNOP stations in Austria (May-June 2016)



EXP1=Reference	EXP2	EXP3	EXP4
OBS	WG1	WG1	WG1-6
CTRL	WG1	WG1-6	WG1-6

Verification

- 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

Observation error

SURFEX:
- 8.1, sEKF assimilation
- + XERROBS for each grid point can be read from file

MODEL:
- AROME CY40T1 + SURFEX 7.3
- 2.5 km grid (259x133), 90 layers, time step 50 s

DATA:
- SCATSAR-SWI
- spatial resolution: 1 km
- temporal resolution: 1 day

Random errors

- Standard setup: constant observation error over whole domain

$\Rightarrow$ Kalman gain

$$\boldsymbol{K}' = \boldsymbol{P}_k \boldsymbol{H}_k^T (\boldsymbol{H}_k \boldsymbol{P}_k \boldsymbol{H}_k^T + \boldsymbol{R}_k)^{-1}$$

Random errors

- Standard setup: constant observation error over whole domain

  $\Rightarrow$ Kalman gain

$$\boldsymbol{K}' = \boldsymbol{P}_k \boldsymbol{H}_k^T (\boldsymbol{H}_k \boldsymbol{P}_k \boldsymbol{H}_k^T + \boldsymbol{R}_k)^{-1}$$

- Approach: estimate random error for each grid point with Triple Collocation Analysis (Stoffelen 1998)

$$\left(\Theta_i = \alpha_i + \beta_i \Theta + \epsilon_i\right)_{i=1,2,3}$$

$$\Rightarrow \sigma^2_{\epsilon_i}$$

$$\Rightarrow \boldsymbol{R}$$

Triple Collocation Analysis

Assumptions (cf. Gruber et al. 2016):

- Signal stationarity
- Error stationarity
- Independency between Θ and ϵ
- Zero error cross-correlation

Triple Collocation Analysis

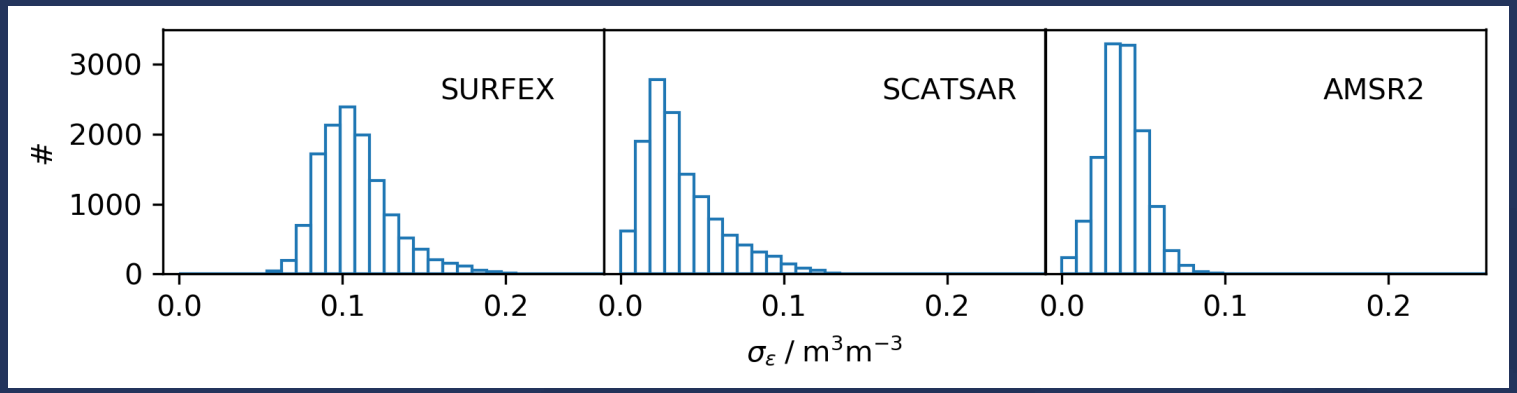
Assumptions (cf. Gruber et al. 2016):

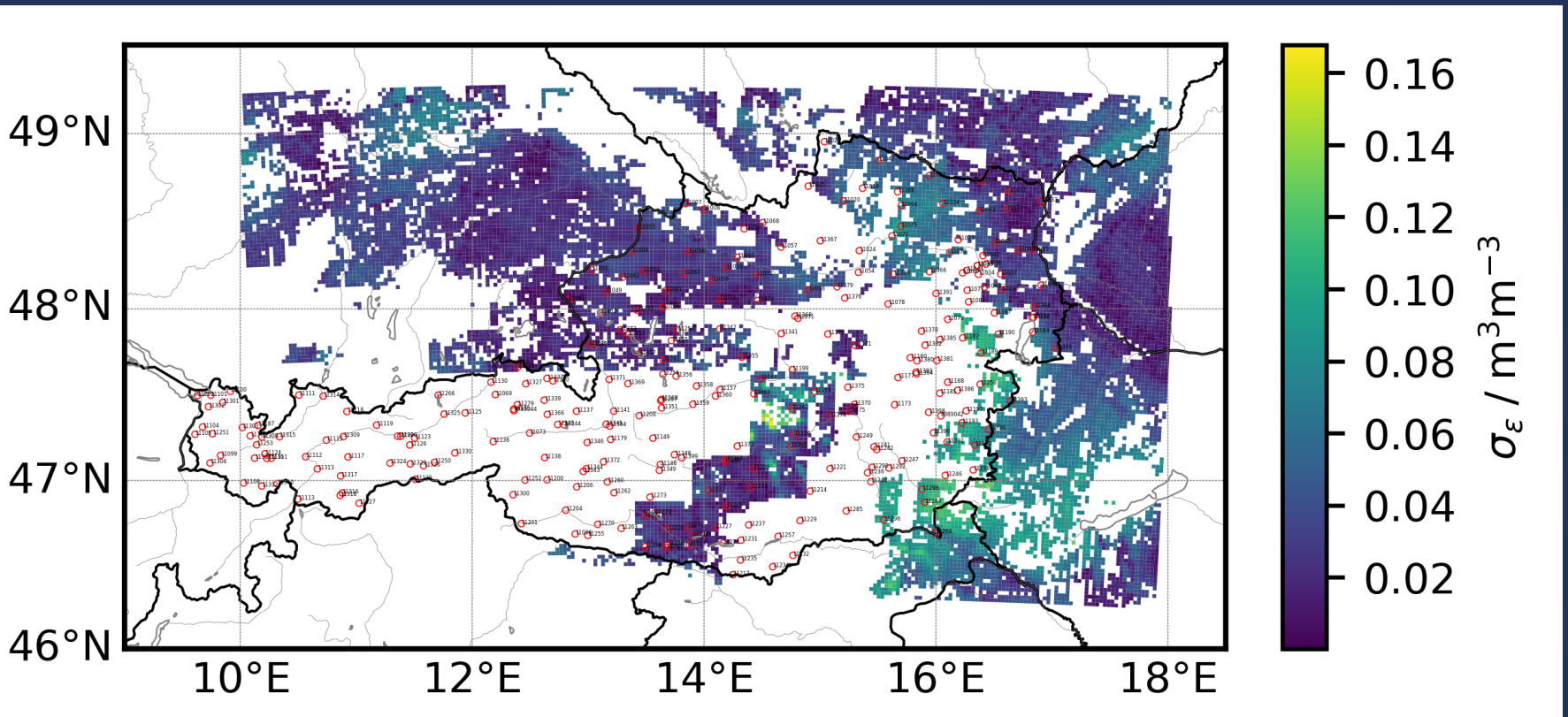
- Signal stationarity $\rightarrow$ data sets measure same seasonal patterns
- Error stationarity $\rightarrow$ long data samples
- Independency between Θ and ϵ $\rightarrow$ effects negligible
- Zero error cross-correlation

  $\rightarrow$ different type of observations:

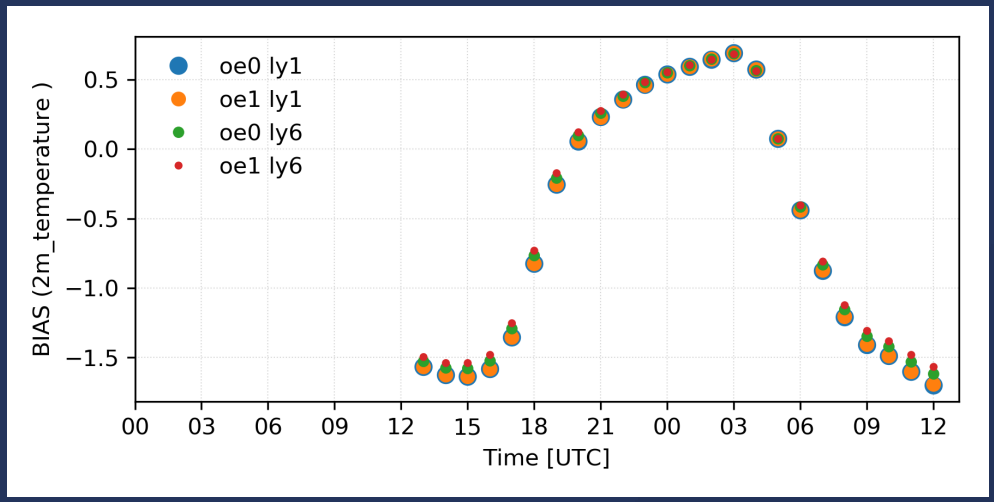
  - SCATSAR (active satellite data)
  - AMSR2 (passive satellite data)
  - SURFEX model as reference

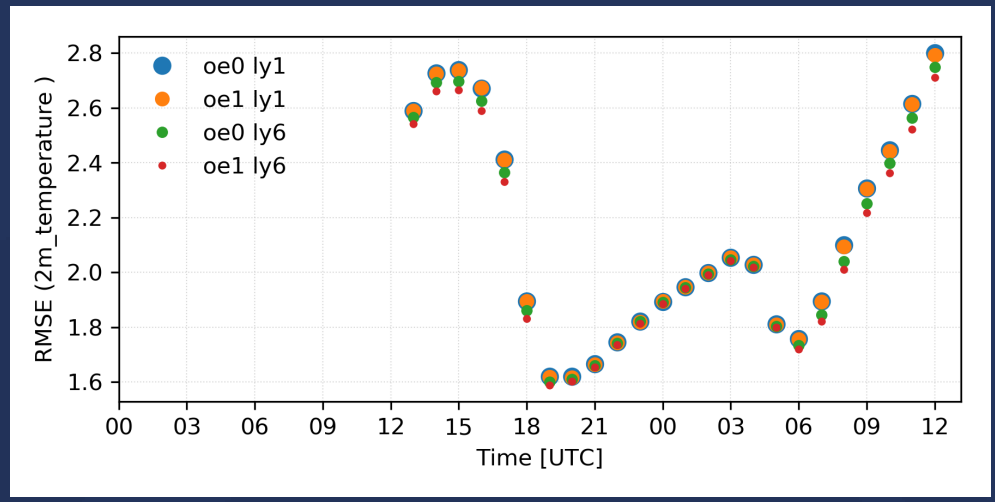
Triple Collocation Analysis

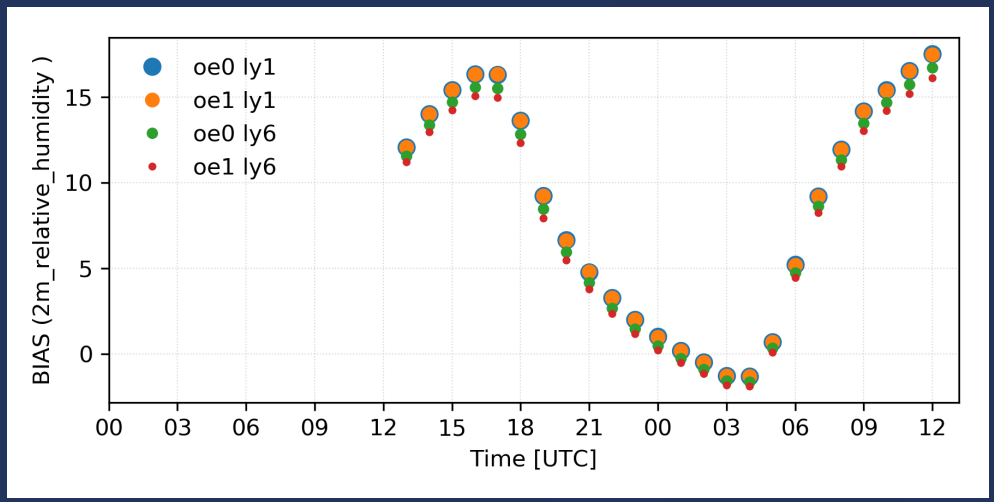


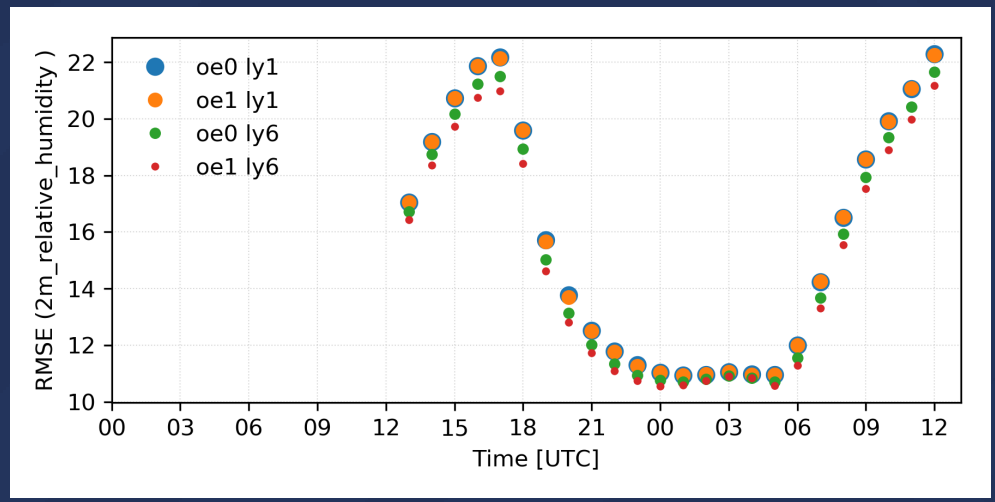


Verification (Austrian SYNOP stations, May 2016)









Slight improvement from constant (oe0) to variable (oe1) observation error and from WG 1 (ly1) to WG 1-6 (ly6) assimilation

High resolution

SURFEX:
- 8.1, sEKF assimilation

MODEL:
- AROME CY40T1 + SURFEX 7.3
- 1.25 km grid (529x259), 90 layers, time step 30 s

DATA:
- SCATSAR-SWI
- spatial resolution: 1 km
- temporal resolution: 1 day

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problematic wind speeds $\Rightarrow$ adapt model dynamics

2m temperature

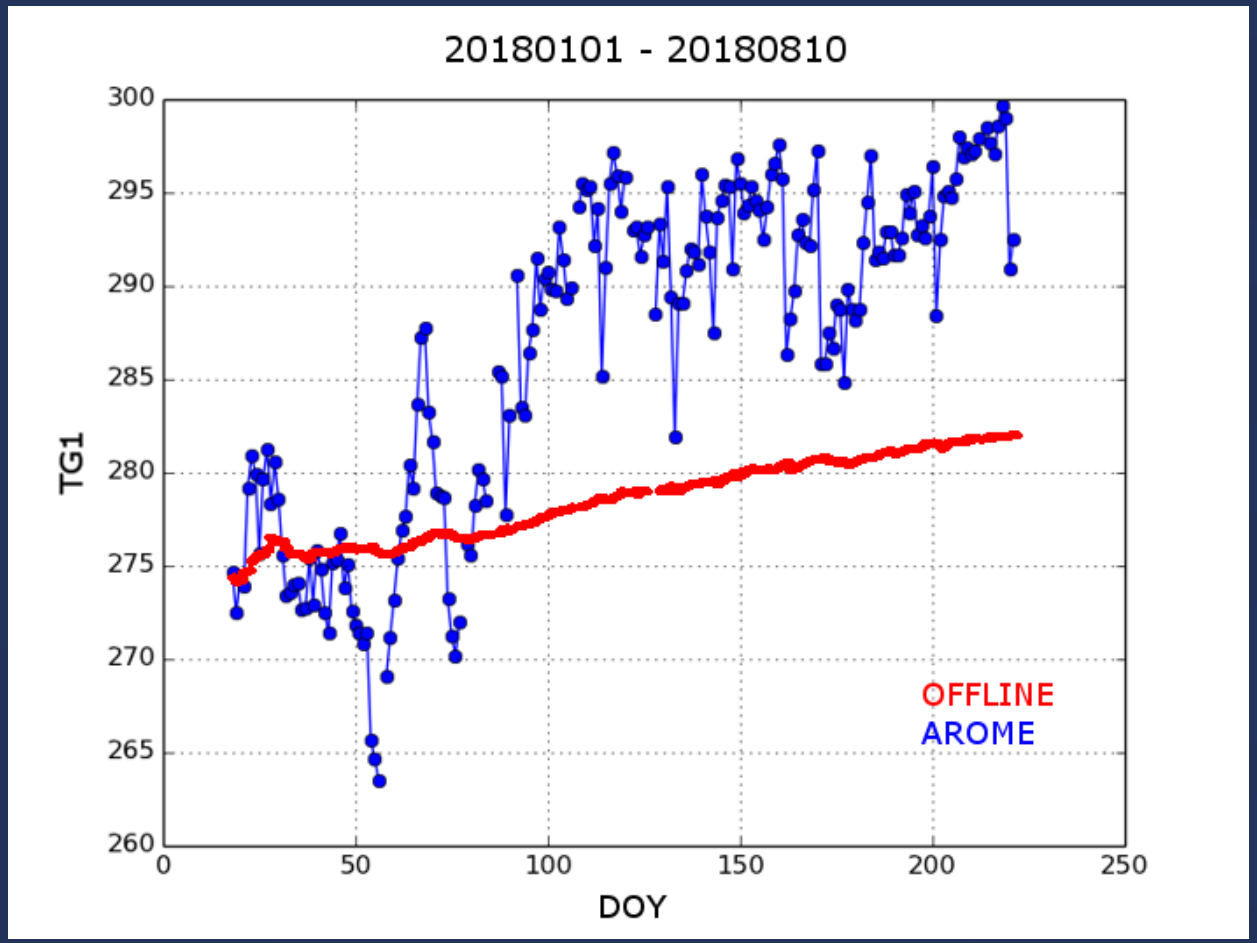
SURFEX:
- 8.1, sEKF assimilation
- + TS as OBS, TG 2-8 as CTRL
- + WGI 1-8 as CTRL
- + WG 7-8 as OBS, WG 7-8 as CTRL

MODEL:
- AROME CY40T1 + SURFEX 7.3
- 2.5 km grid, 90 layers

DATA:
- INCA analyses
- spatial resolution: 1 km
- temporal resolution: 1 hour
- different model topography than in AROME/SURFEX

Long-term test

Grid point in Marchfeld (between Wien and Bratislava):



Long-term test runs into problems: soil too cold

Land surface temperature

SURFEX:
- 8.1, sEKF assimilation

MODEL:
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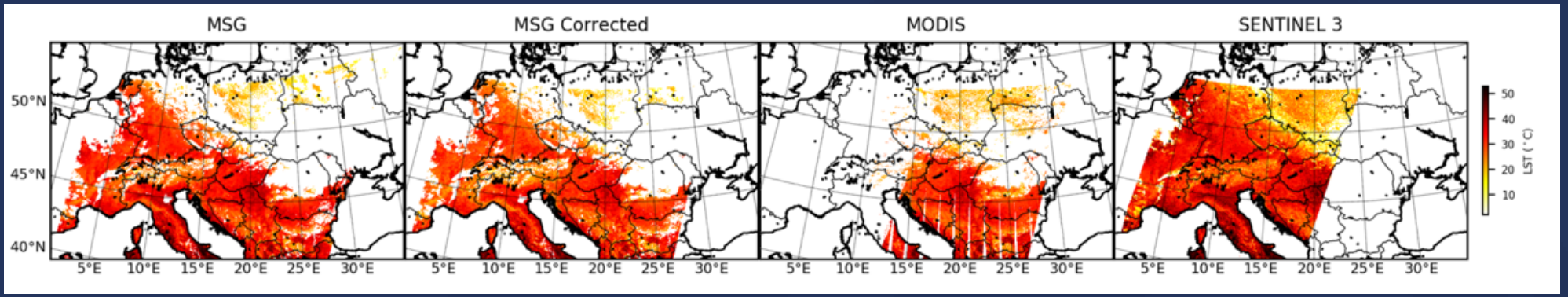
- 2.5 km grid, 90 layers

DATA:
- combined Sentinel-3 and MSG data
- spatial resolution: 1 km / 4 km
- temporal resolution: $\approx$ 6 days / 15 min

CDFmatching

Apply the 1 km pattern of Sentinel 3 / MODIS to MSG LST



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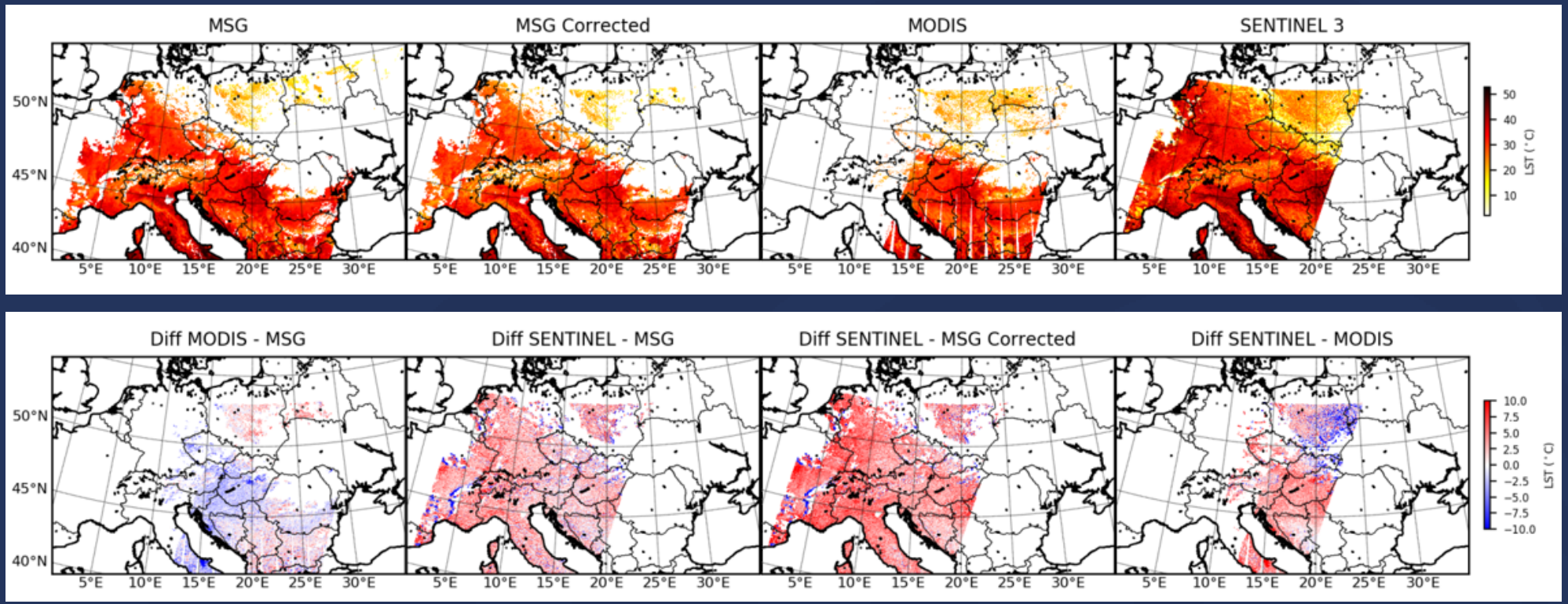

Differences larger than expected ⇒ quality flags?

Summary & Outlook

- Soil moisture assimilation:
  - ▷ improvement in flatlands
    ⇒ publish results
- Variable observation error:
  - ▷ slight improvement
    ⇒ improve calculations
- 1.25 km resolution:
  - ▷ running...
- 2m temperature:
  - ▷ soil too cold on the long term
    ⇒ understand problems
- Land surface temperature:
  - ▷ data quality?
    ⇒ test & improve

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    ⇒ test & improve
- Build up operational system at ZAMG & compare with operational AROME (CY40T1/SURFEX7.3 with CANARI T2M, HU2M)
- 100 m SM analyses for Austria (new externally funded project)
- Upgrade to CY43