European High-Resolution Soil Moisture Analysis

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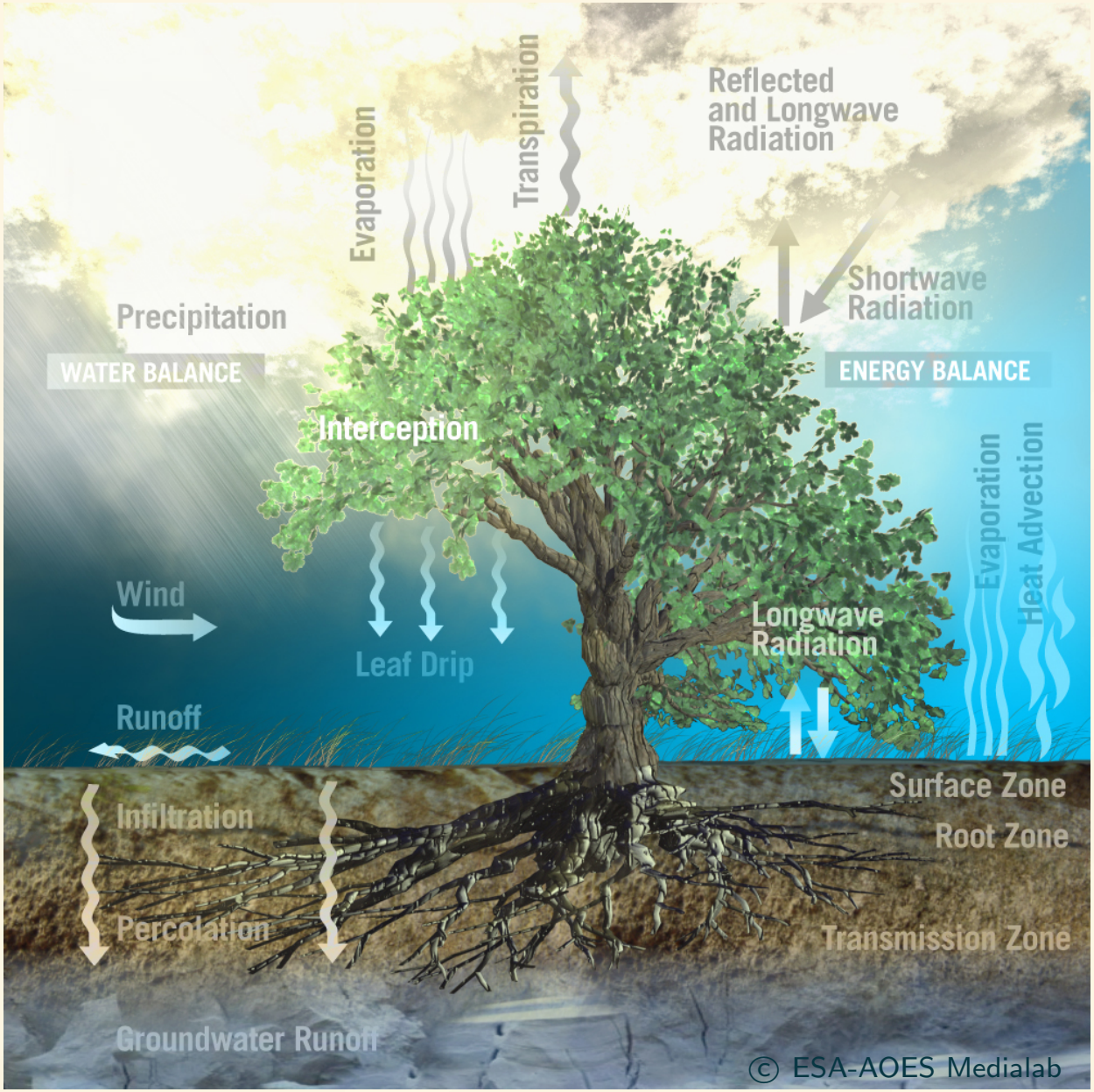
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

EUMETSAT Fellow Day
Darmstadt, Rosenmontag 2019

Overview


Transpiration
Evaporation
Reflected and Longwave Radiation
Shortwave Radiation
Precipitation
WATER BALANCE
ENERGY BALANCE
Interception
Evaporation
Heat Advection
Wind
Leaf Drip
Longwave Radiation
Runoff
Surface Zone
Root Zone
Infiltration
Percolation
Transmission Zone
Groundwater Runoff
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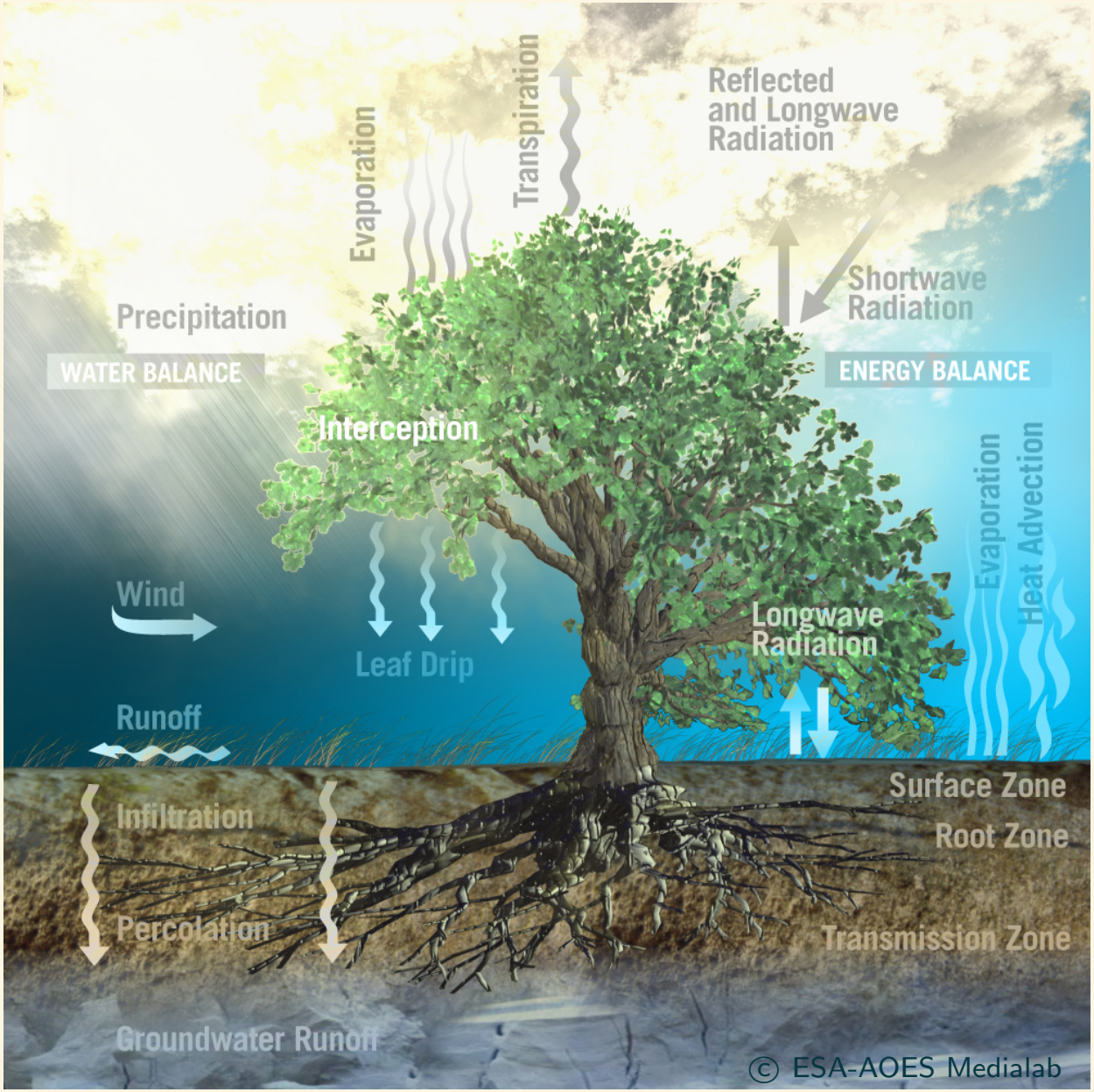

- Data assimilation
- SCATSAR-SWI
- Error estimation
- Resolution experiments
- Comparison with HSAF

The data assimilation system

- SURFEX Offline Data Assimilation (SODA)
- Simplified Extended Kalman Filter (sEKF)
- Atmospheric forecast: AROME cy40
- 2.5 km resolution

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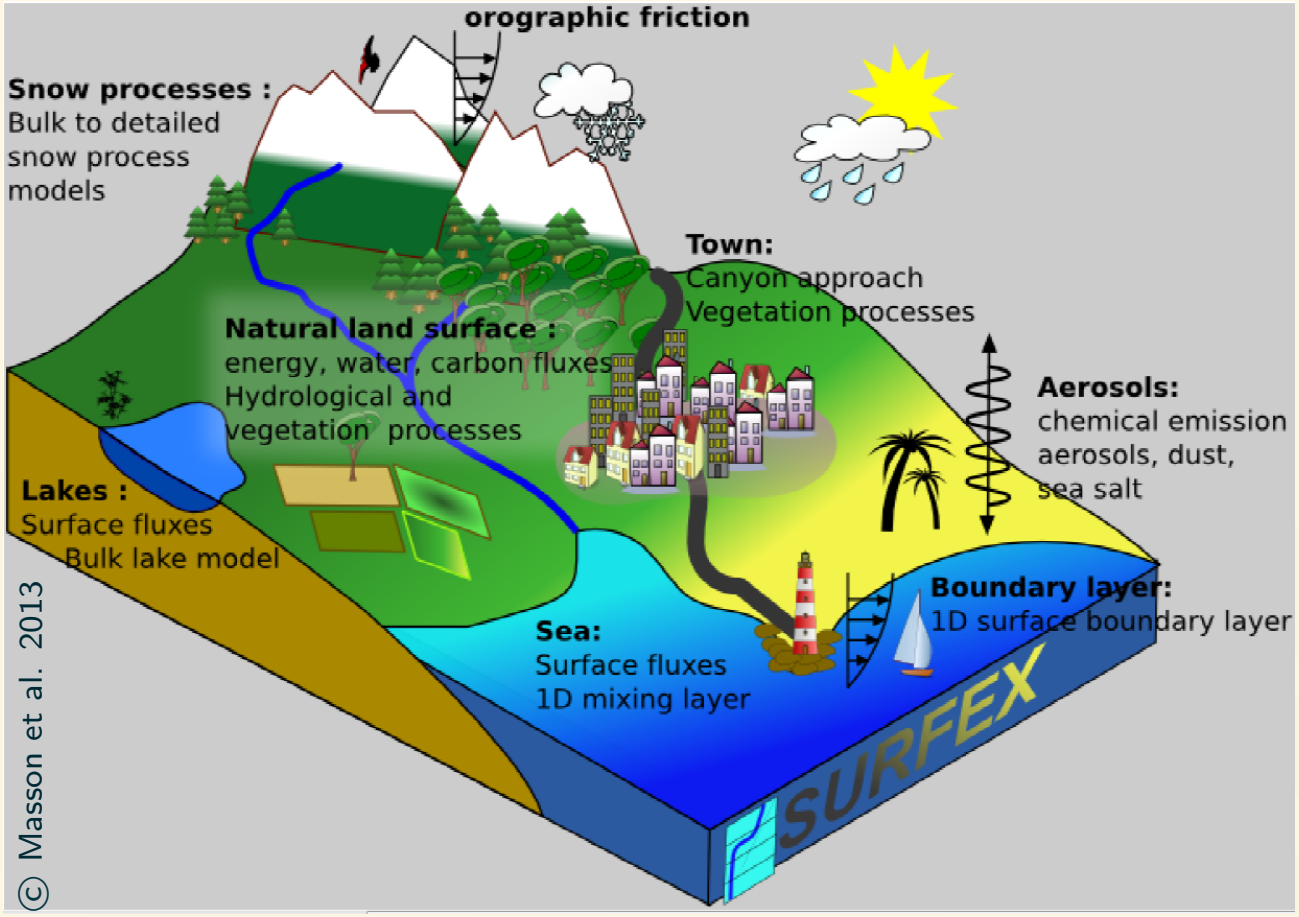

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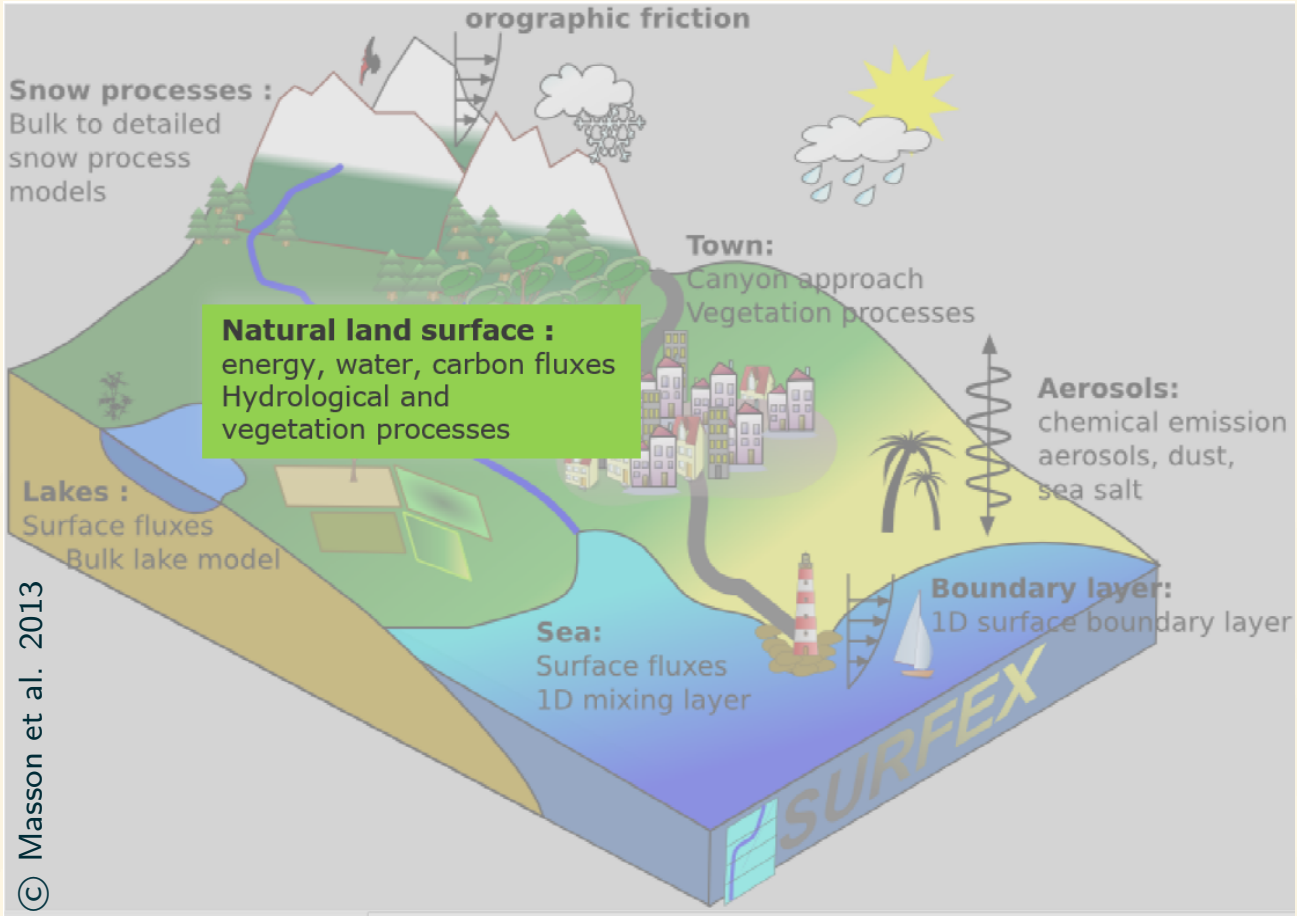

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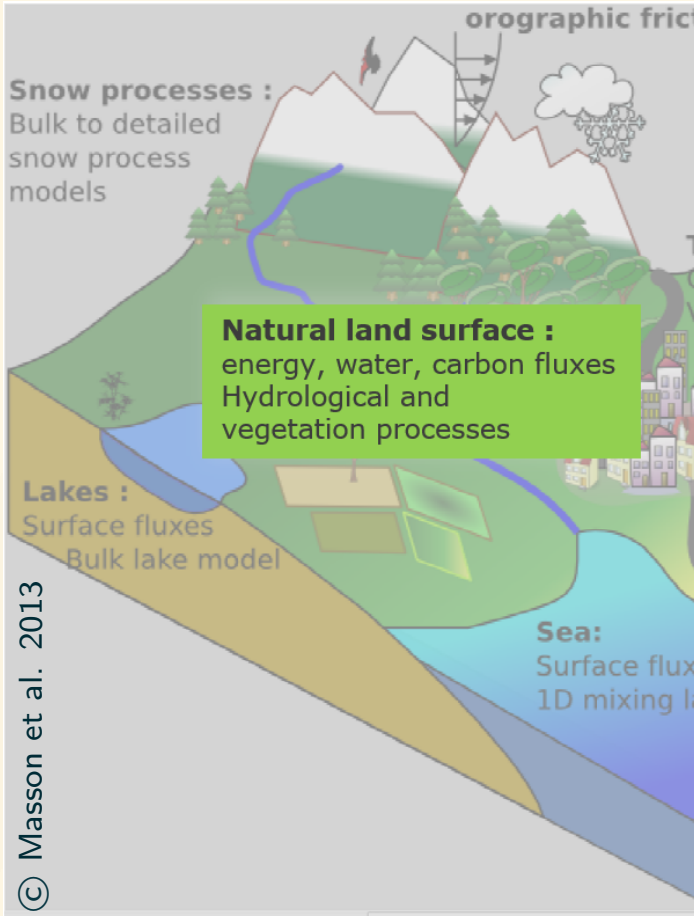
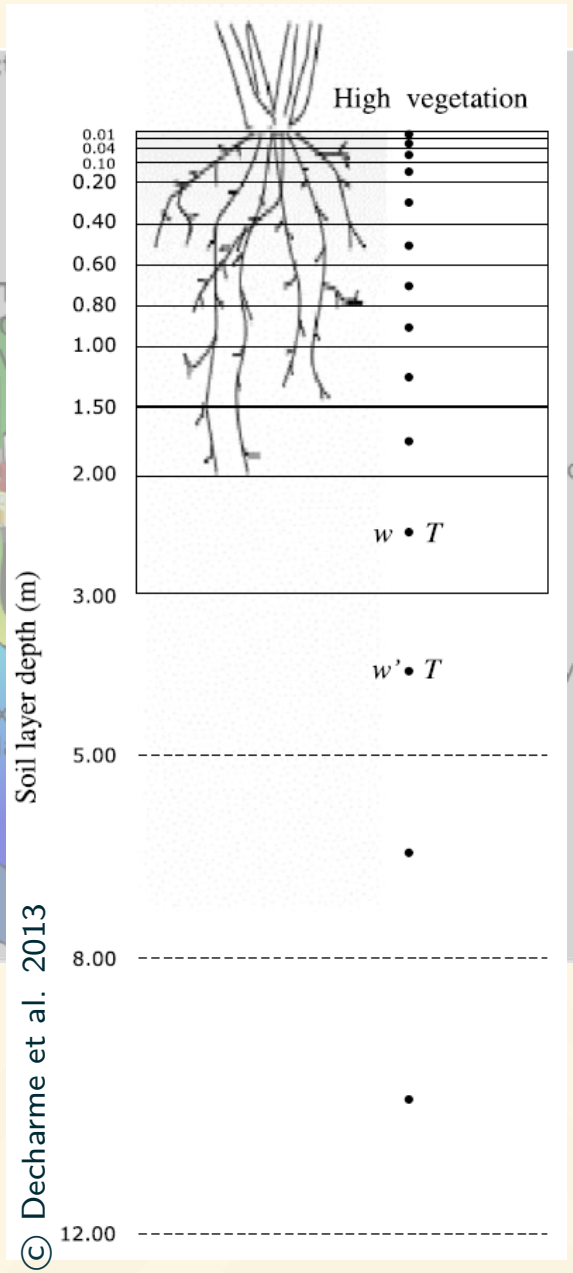
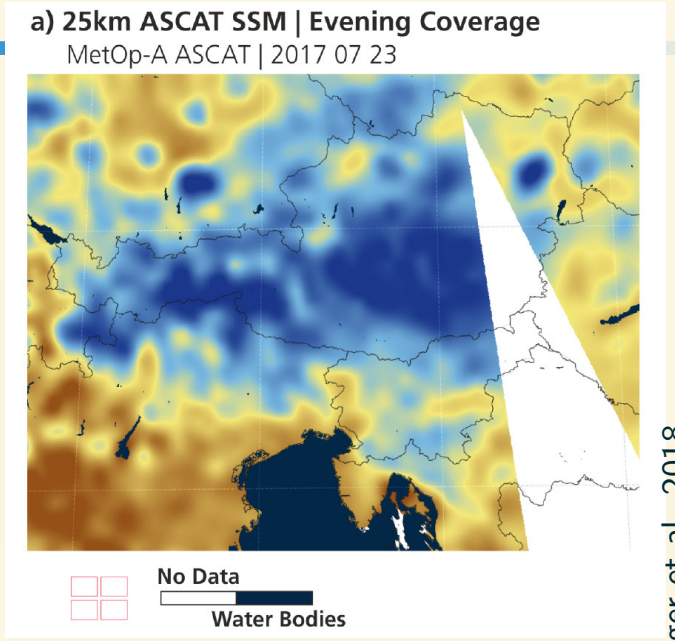
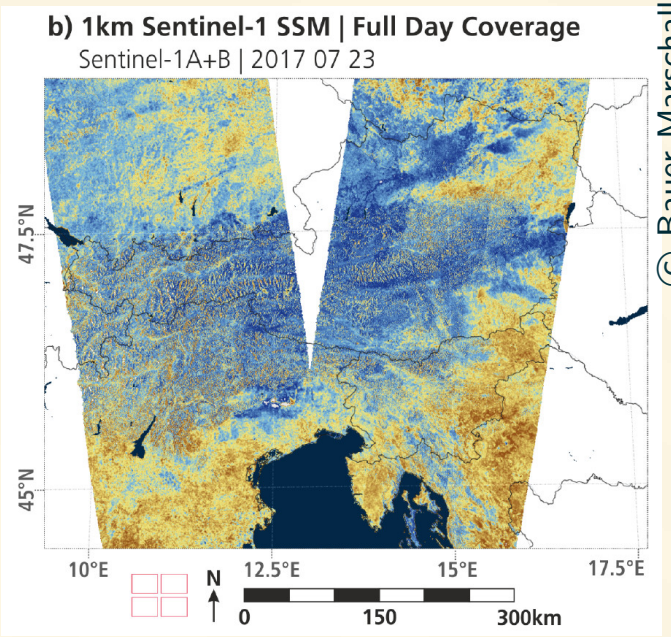
- SURFEX Offline Data Assimilation (SODA)
- Simplified Extended Kalman Filter (sEKF)
- Atmospheric forecast: AROME cy40
- 2.5 km resolution
- Interaction Soil Biosphere Atmosphere (ISBA)
- Diffusion scheme
- 14 soil layers





Observations: SCATSAR-SWI





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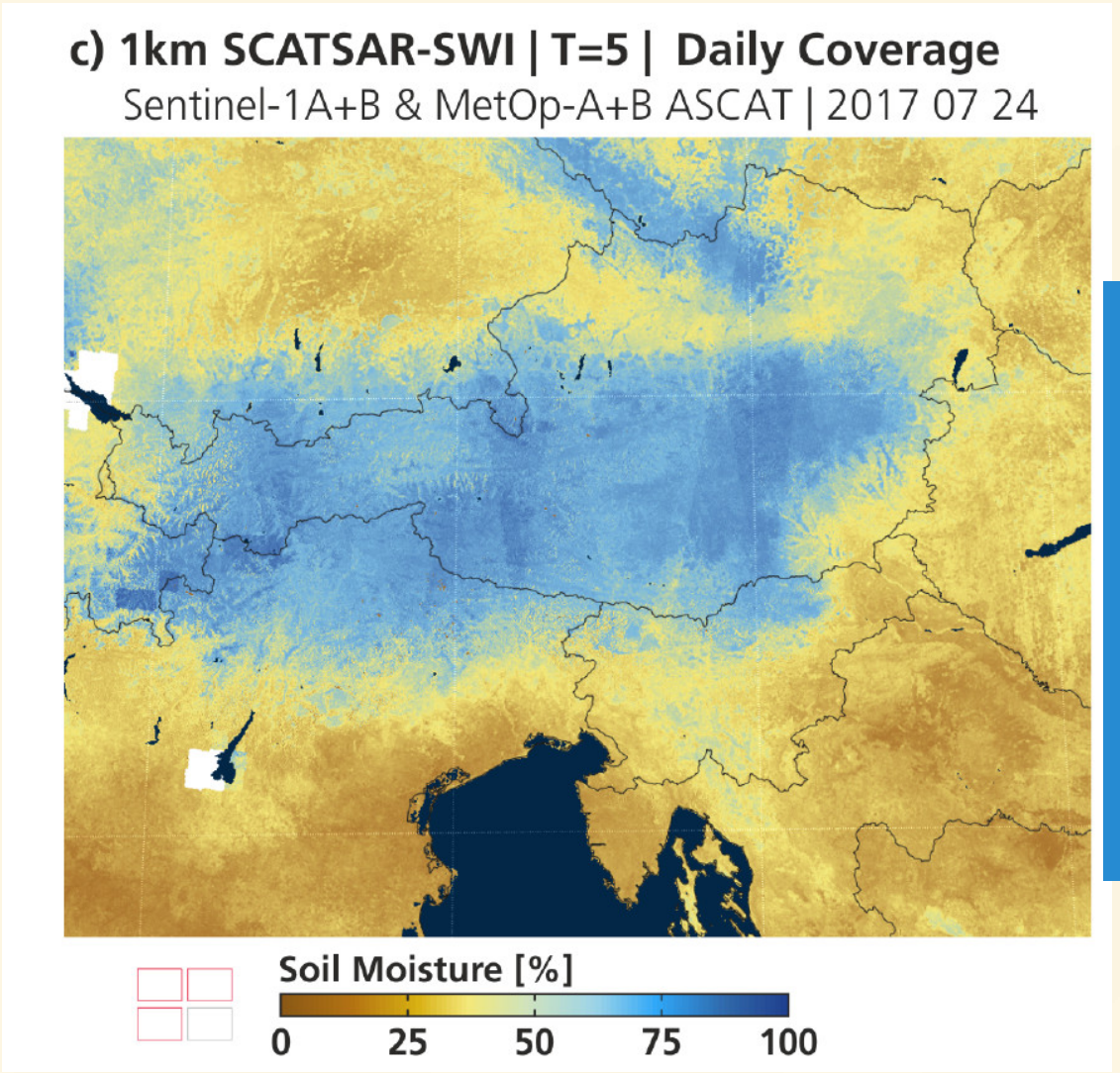

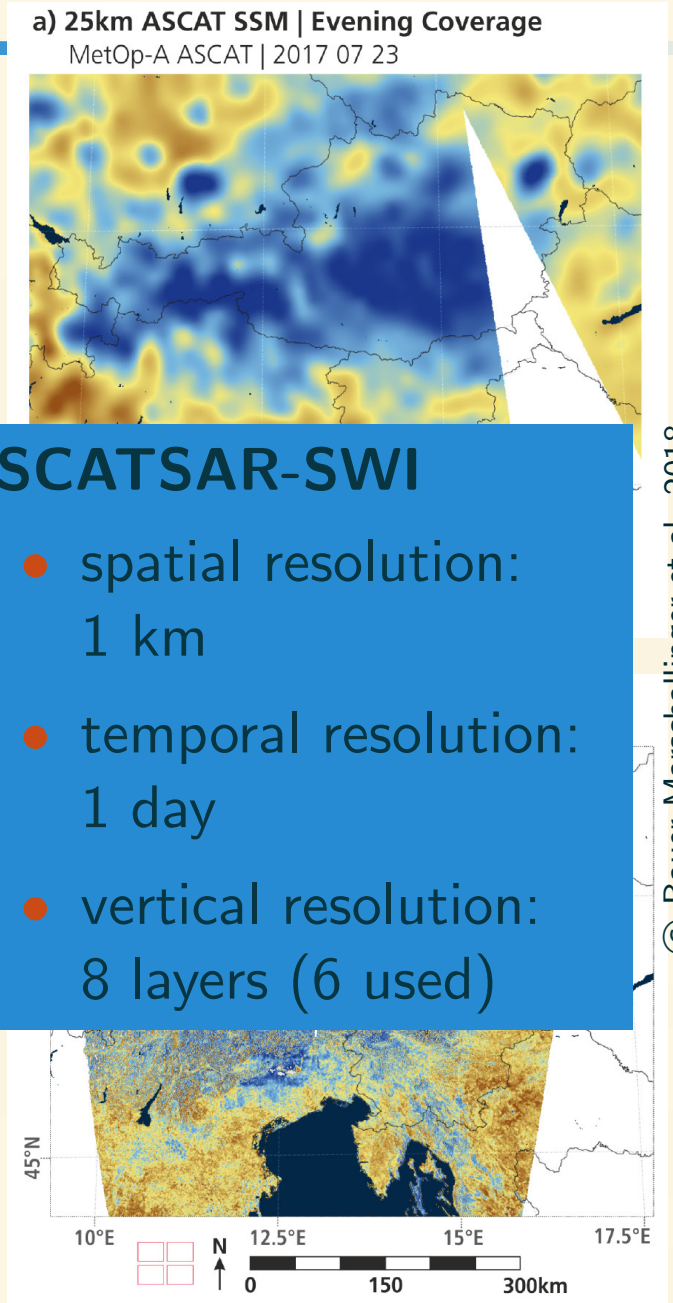

SCATSAR-SWI

- spatial resolution: 1 km
- temporal resolution: 1 day
- vertical resolution: 8 layers (6 used)

Observation error

- Standard setup:

  constant observation error over whole domain: STD $= 0.2$

- Approach:

  estimate error variances for each grid point with

  Triple Collocation Analysis (Stoffelen 1998)

$$\Theta_{\text{meas}} = \alpha + \beta\Theta_{\text{true}} + \epsilon$$
$$\Rightarrow \sigma_\epsilon^2$$

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$$\Theta_{\text{meas}} = \alpha + \beta\Theta_{\text{true}} + \epsilon$$
$$\Rightarrow \sigma_\epsilon^2$$

$\Rightarrow$ Kalman gain

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

Triple Collocation Analysis

Assumptions*:

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

*cf. Gruber et al. 2016

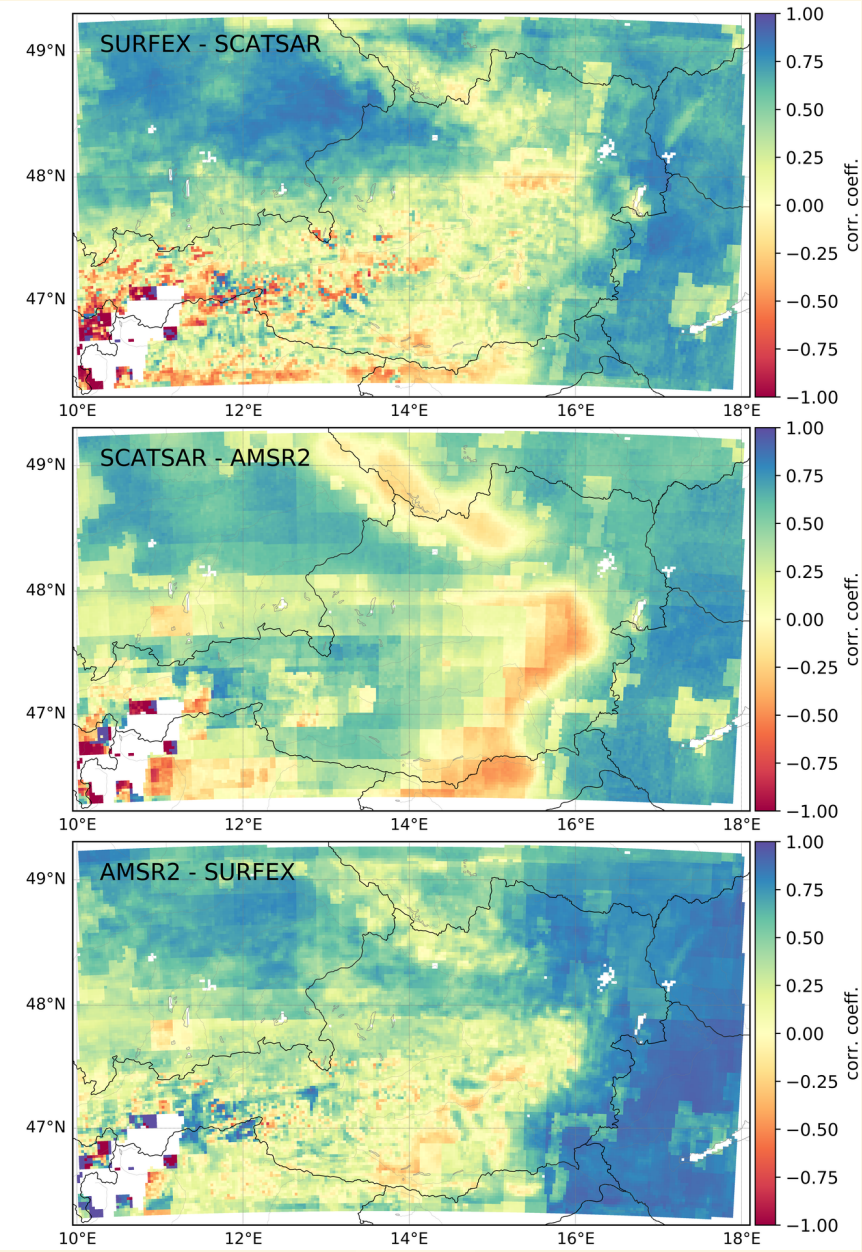
Triple Collocation Analysis

Assumptions*:

- Signal stationarity $\Leftarrow$ same seasonal patterns
- Error stationarity $\Leftarrow$ long data samples
- Independency between Θ and ϵ $\Leftarrow$ effects negligible
- Zero error cross-correlation $\Leftarrow$ different type of data sets:
  - SCATSAR (active satellite data)
  - AMSR2 (passive satellite data)
  - SURFEX model as reference

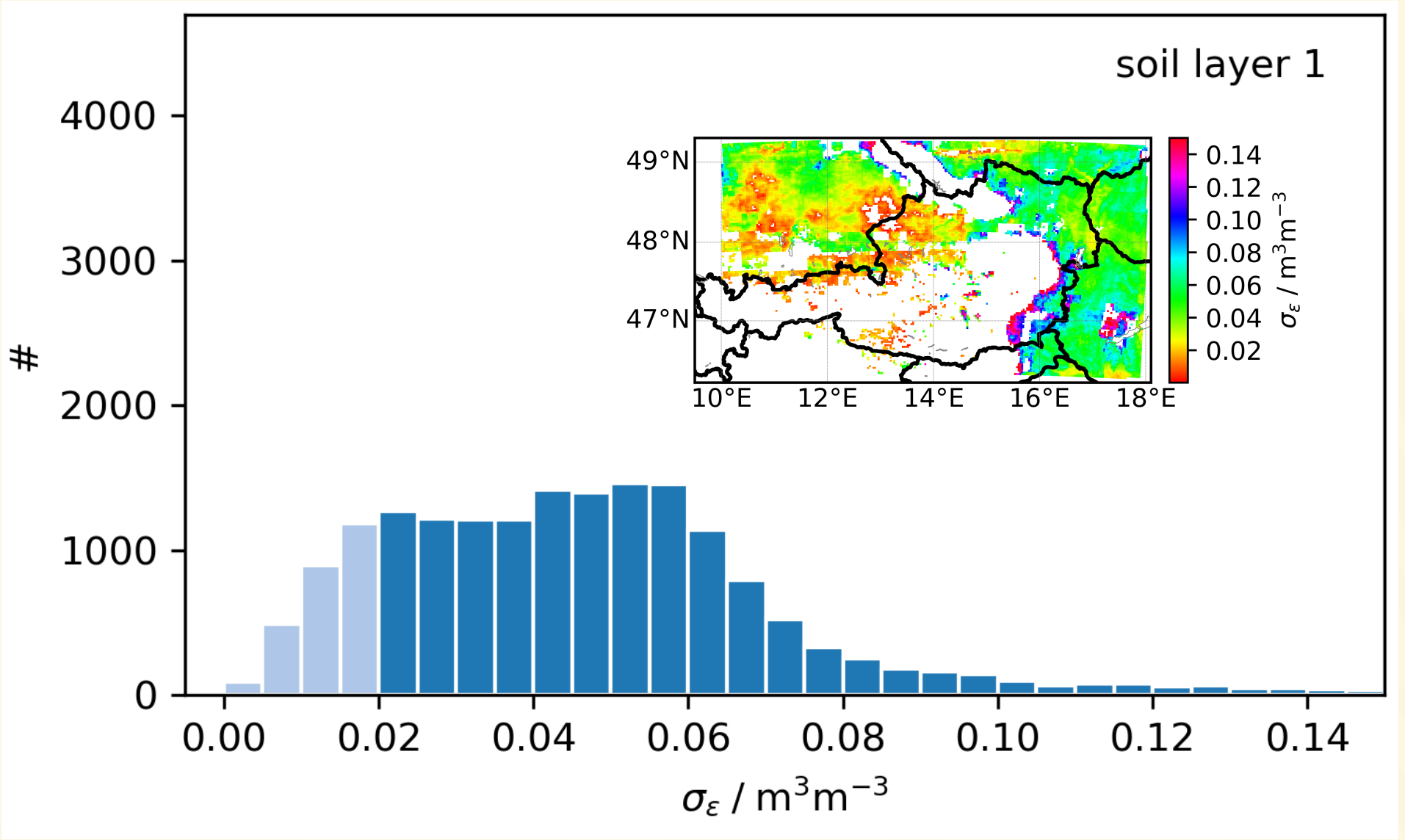
*cf. Gruber et al. 2016

Correlation between datasets



- best correlation in flatlands
- correlation between SCATSAR and AMSR2 worse with increasing depth
- edgy structures due to masked regions (frozen conditions)

Triple Collocation Analysis - SCATSAR error STD



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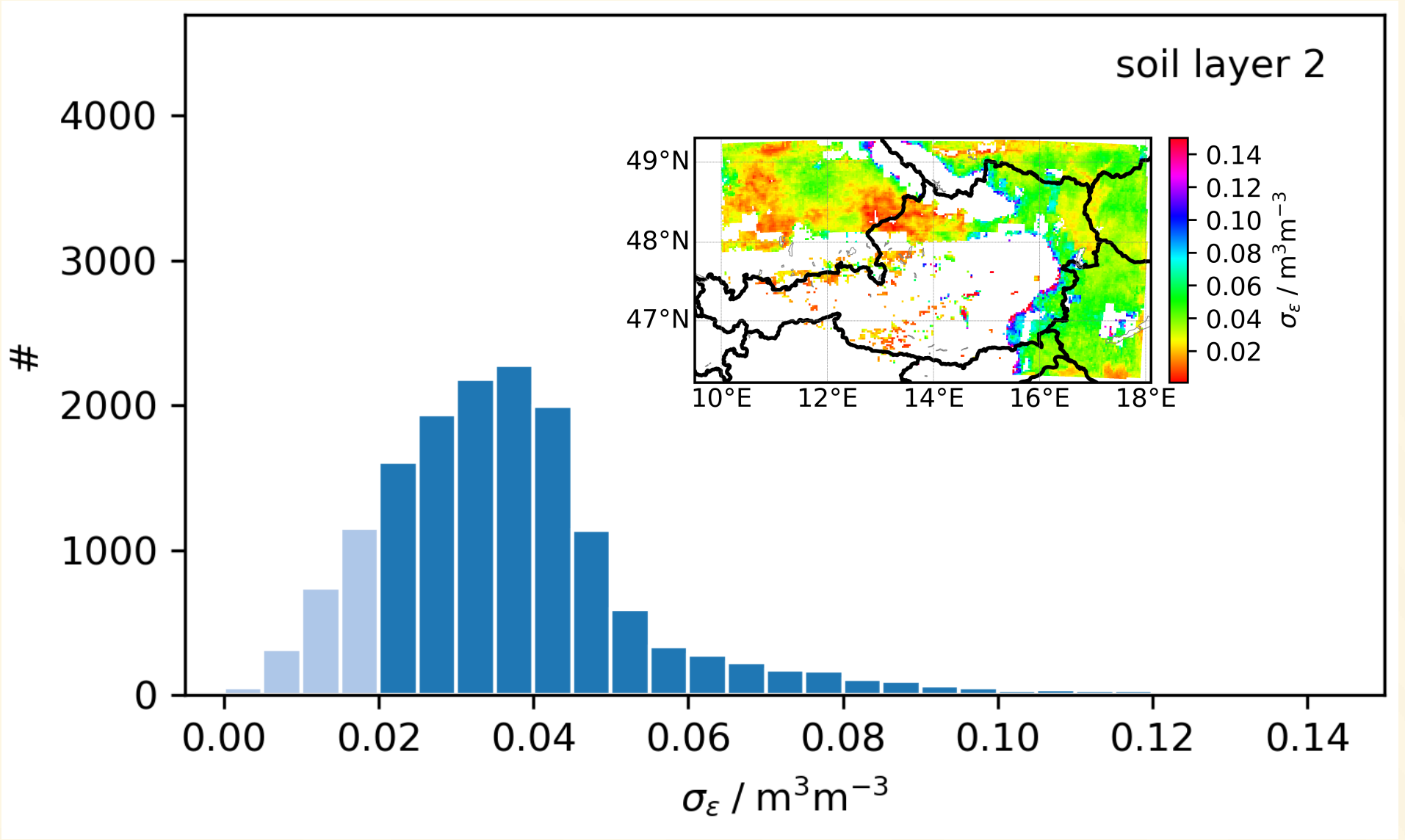

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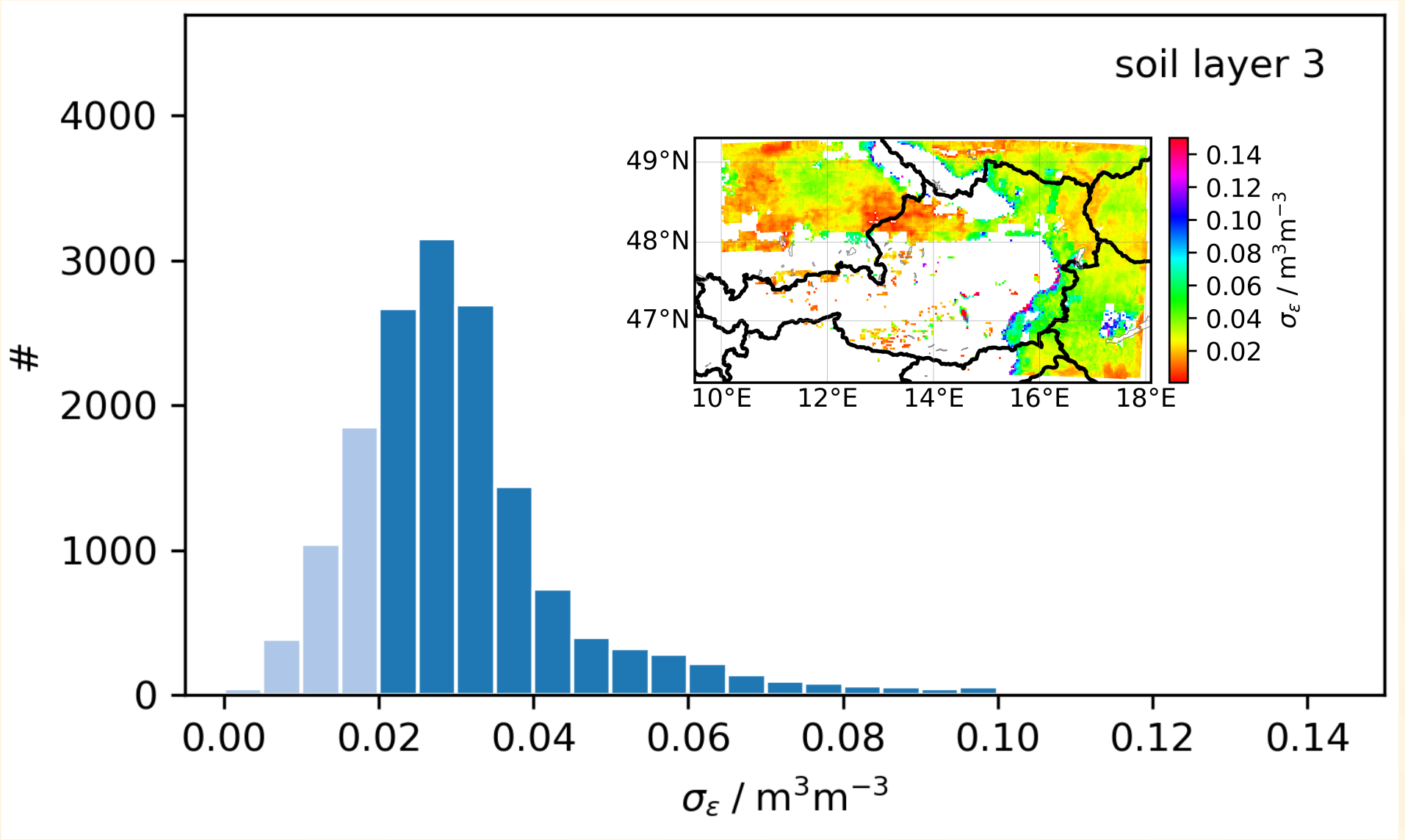

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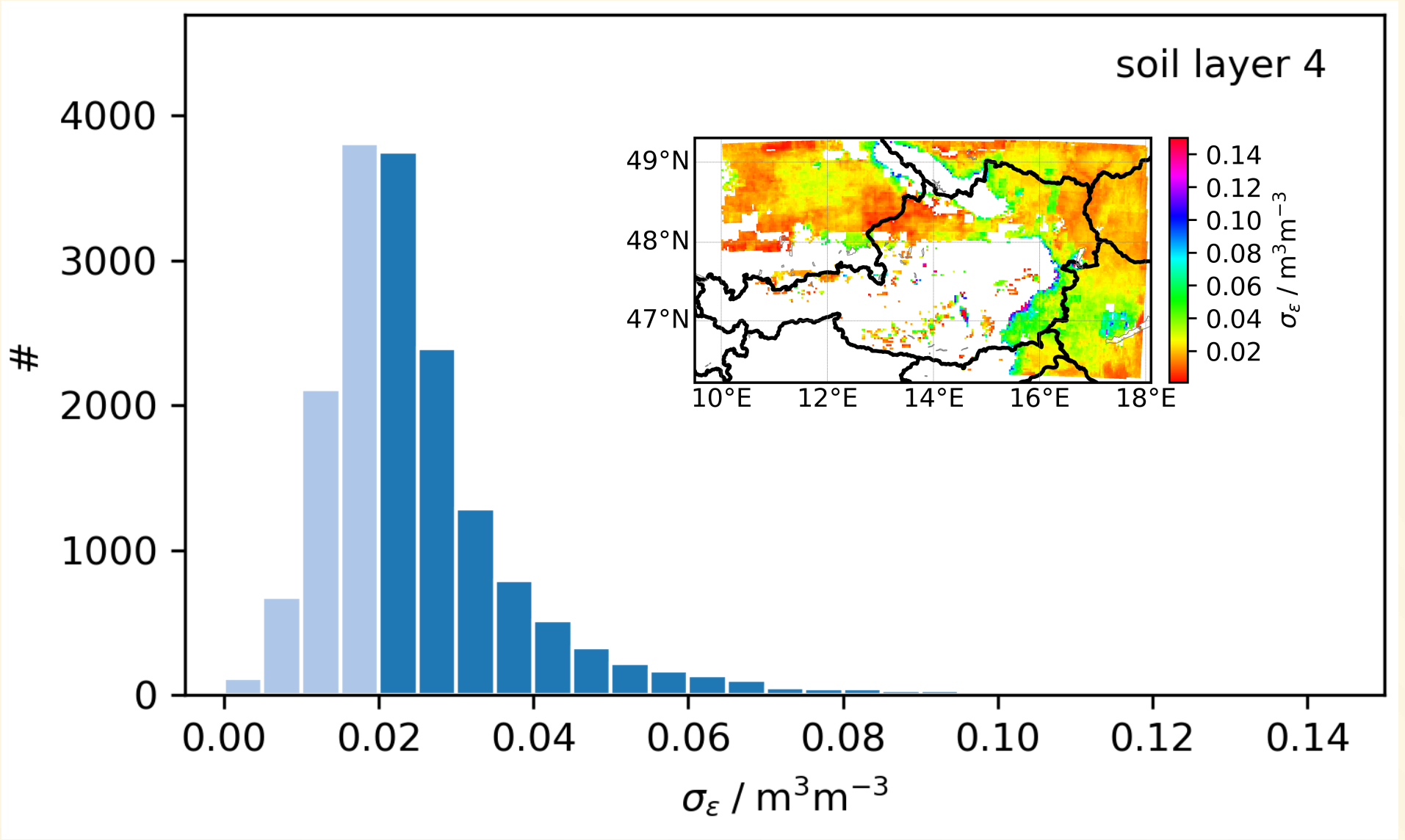

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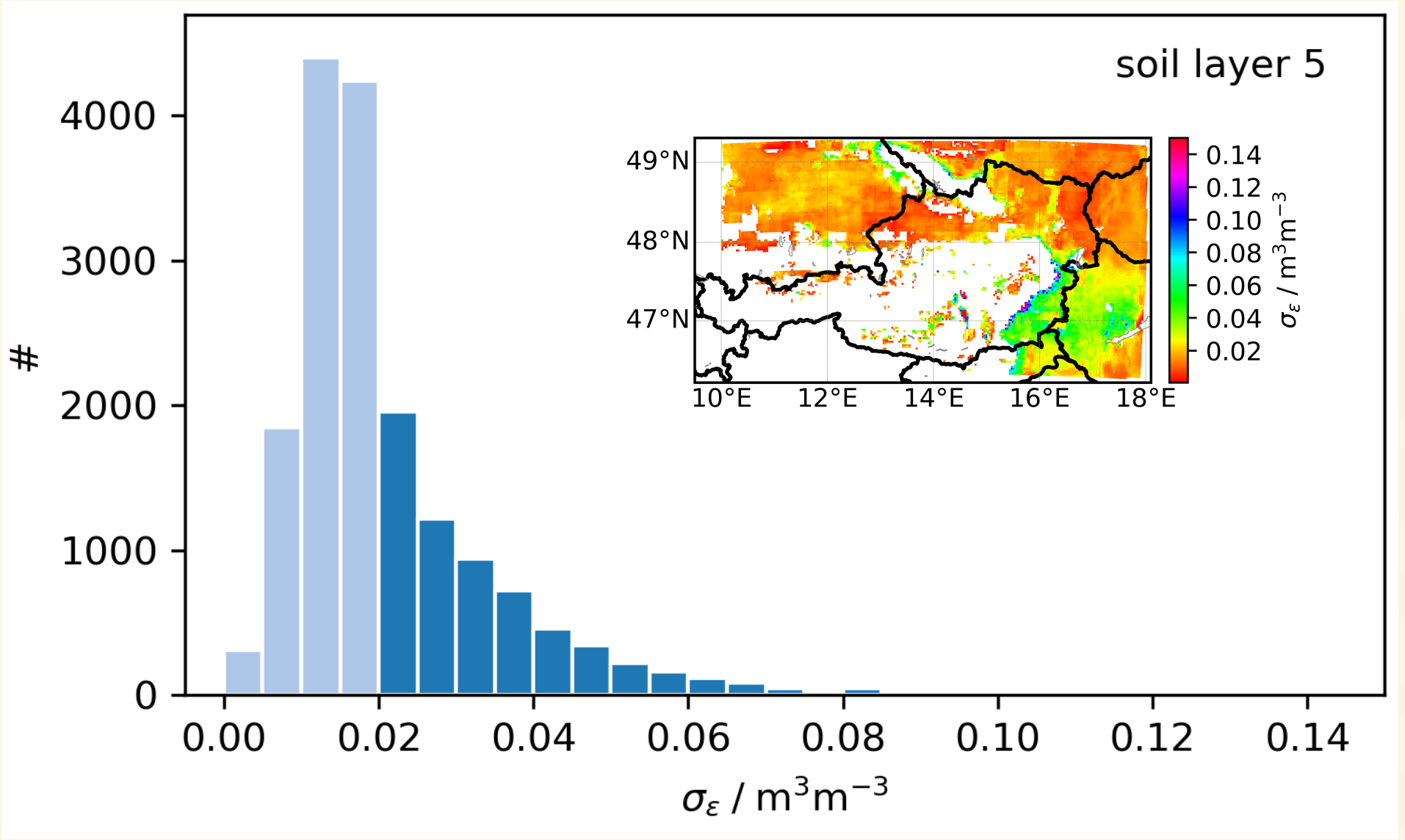

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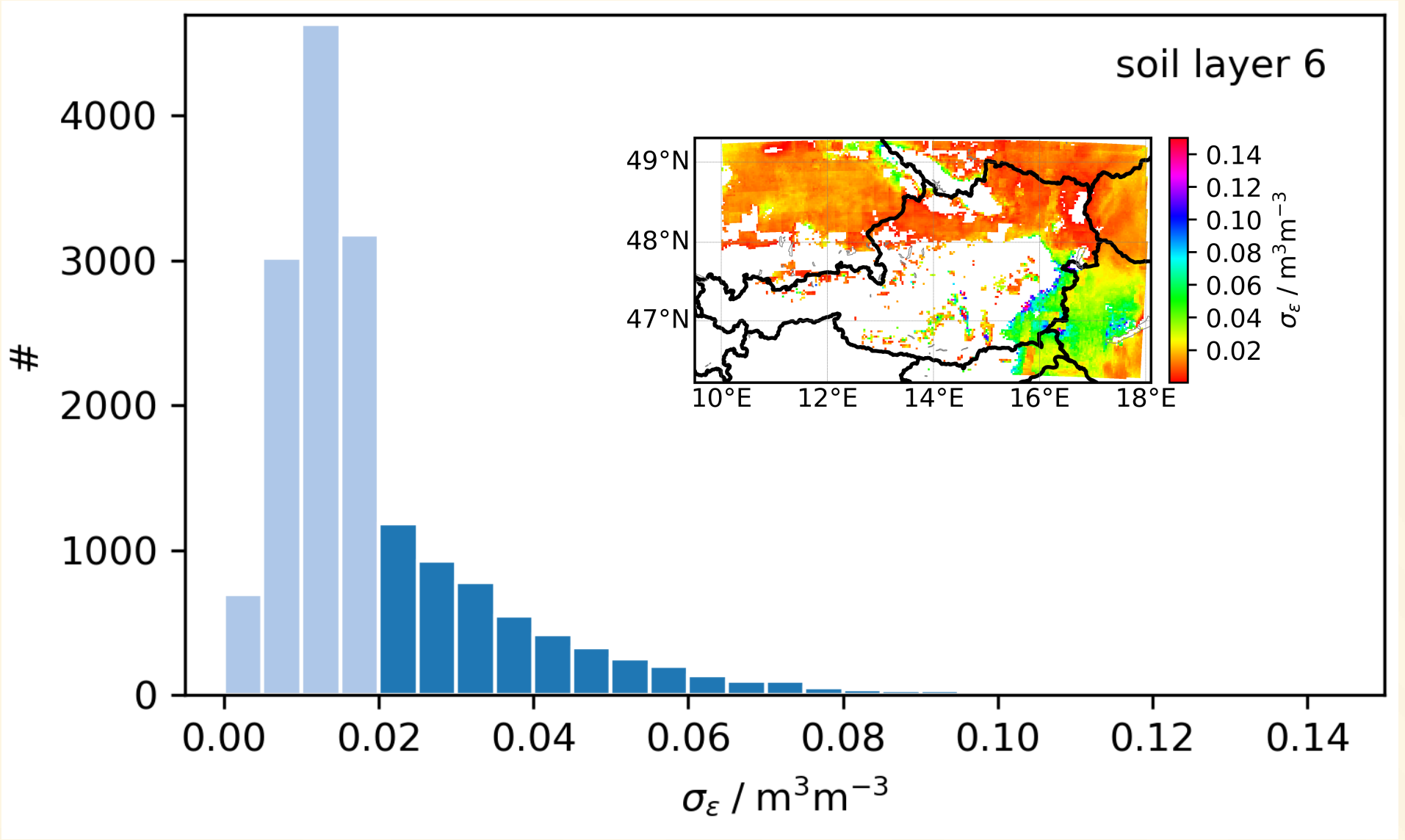
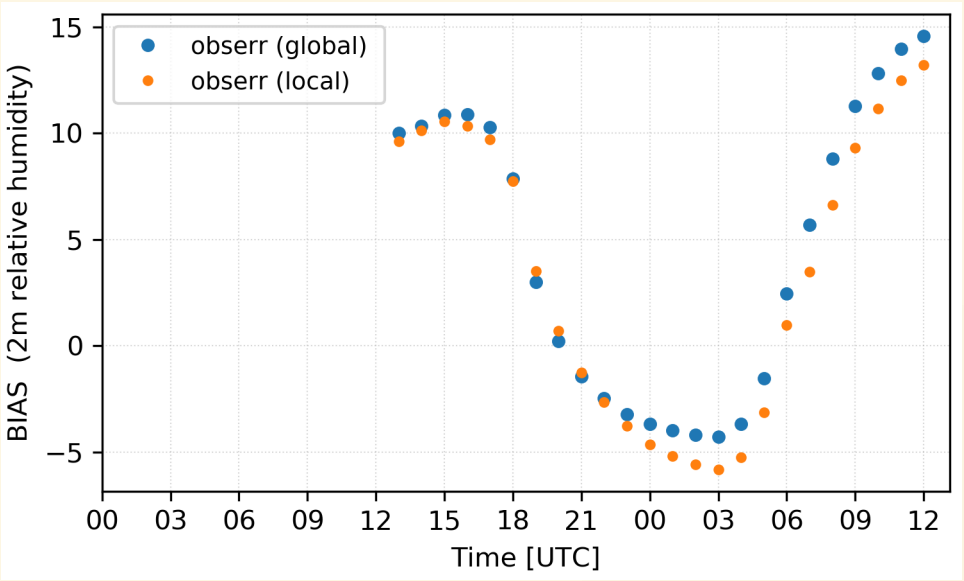


Verification of T_{2m} & HU_{2m} (Austrian SYNOP stations, June 2016)



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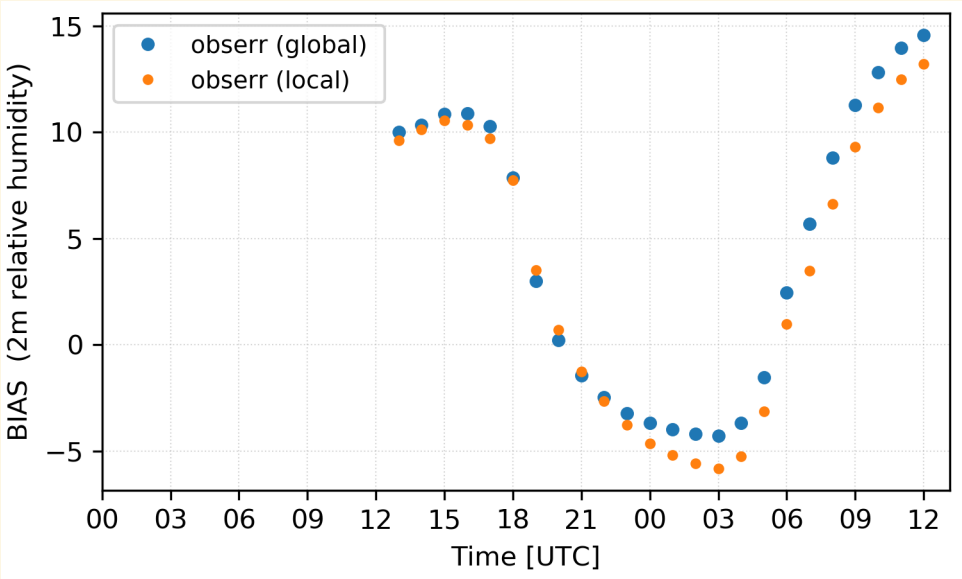

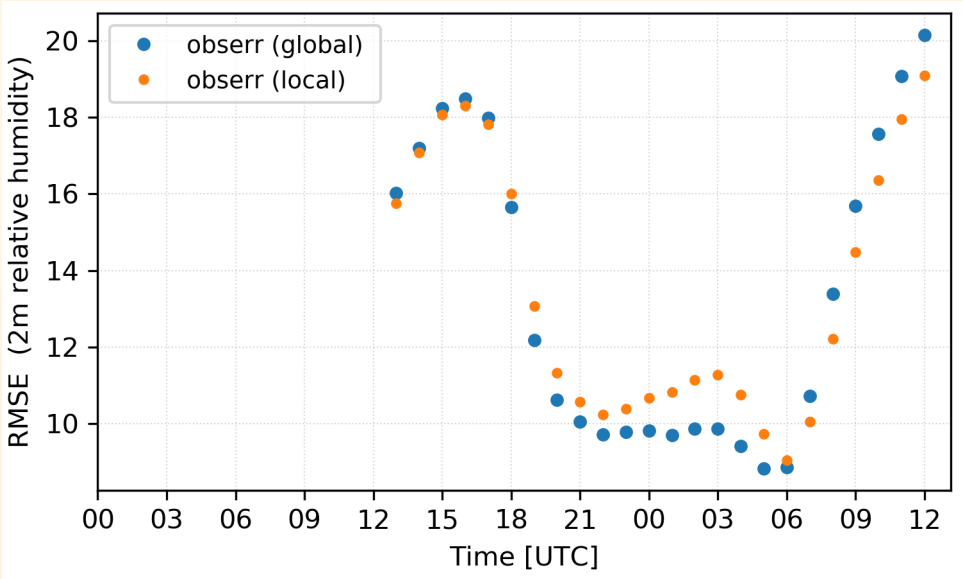

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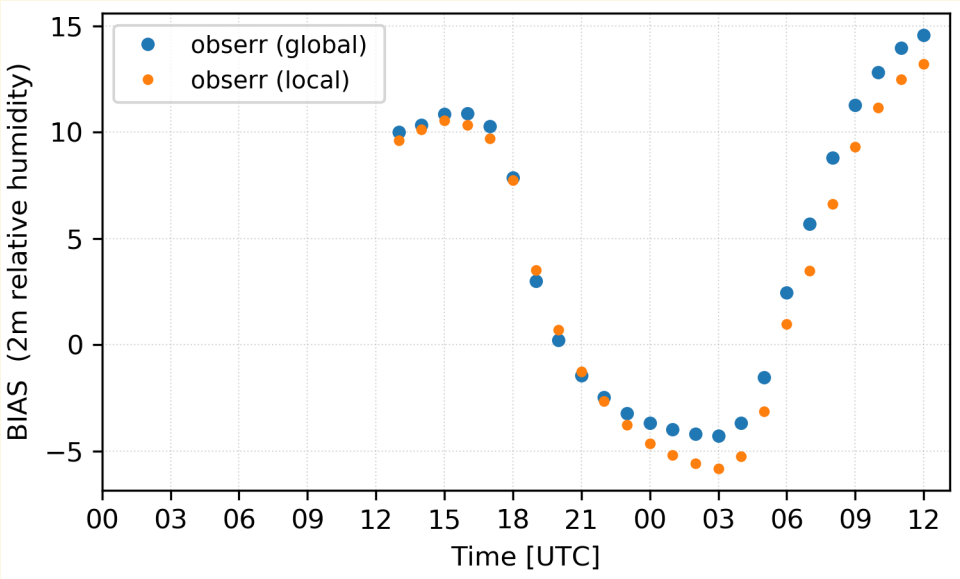

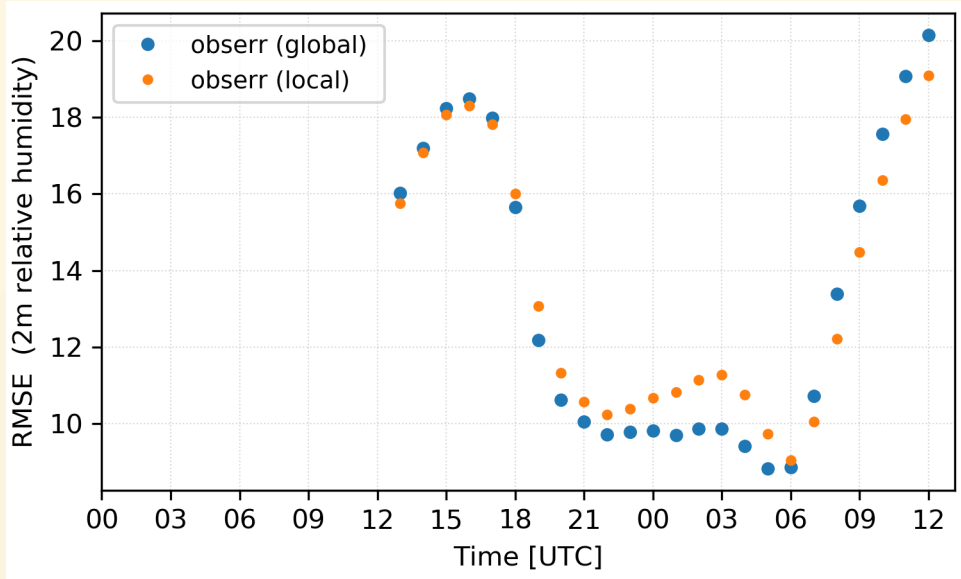

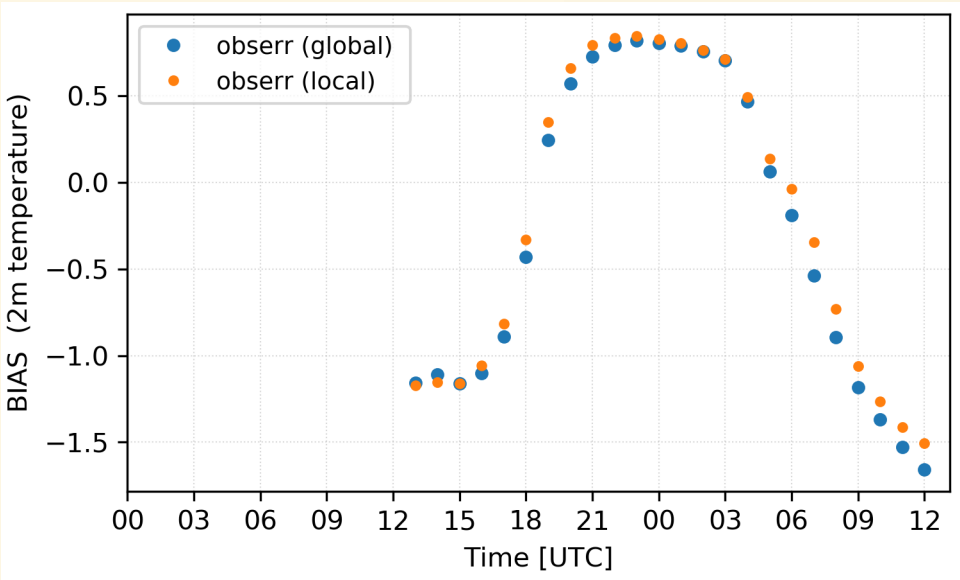

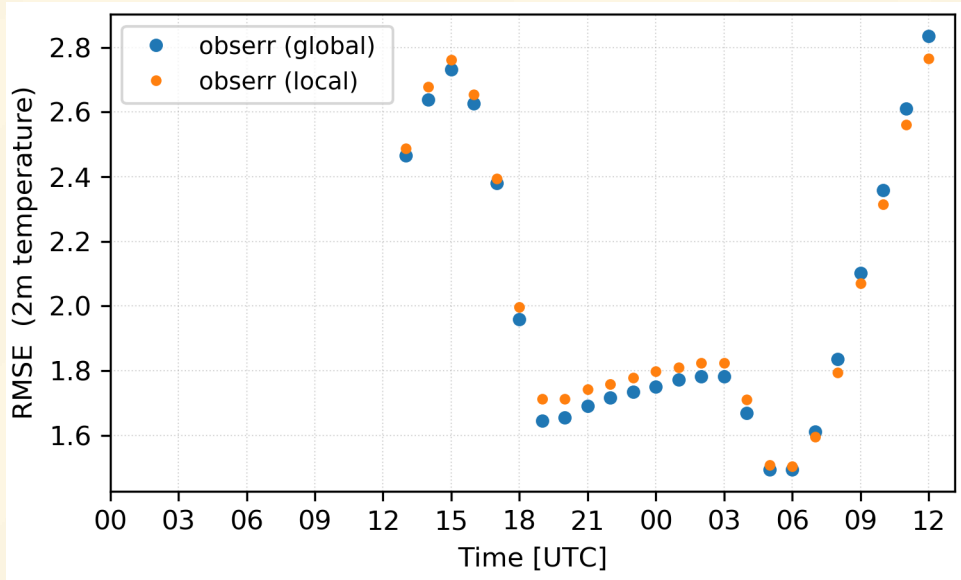

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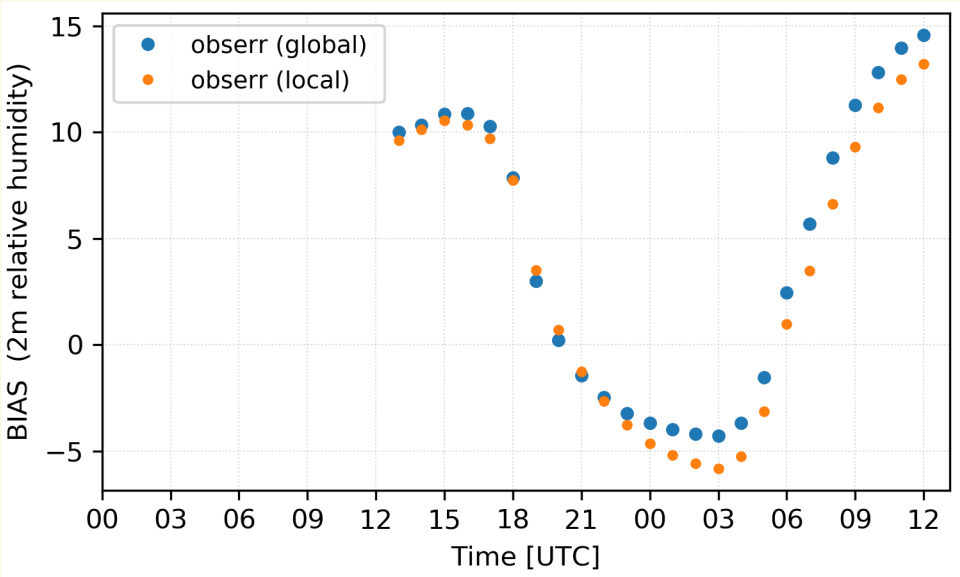
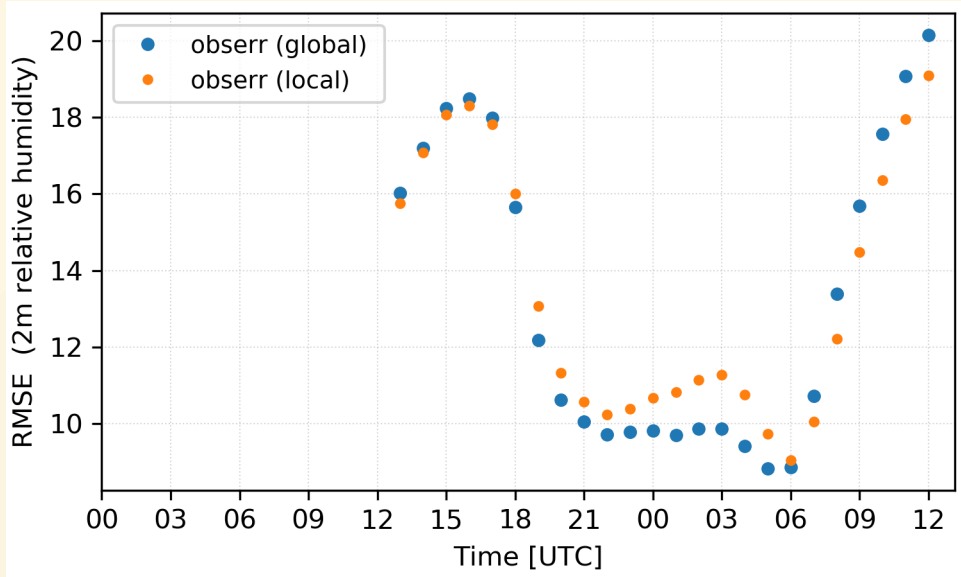
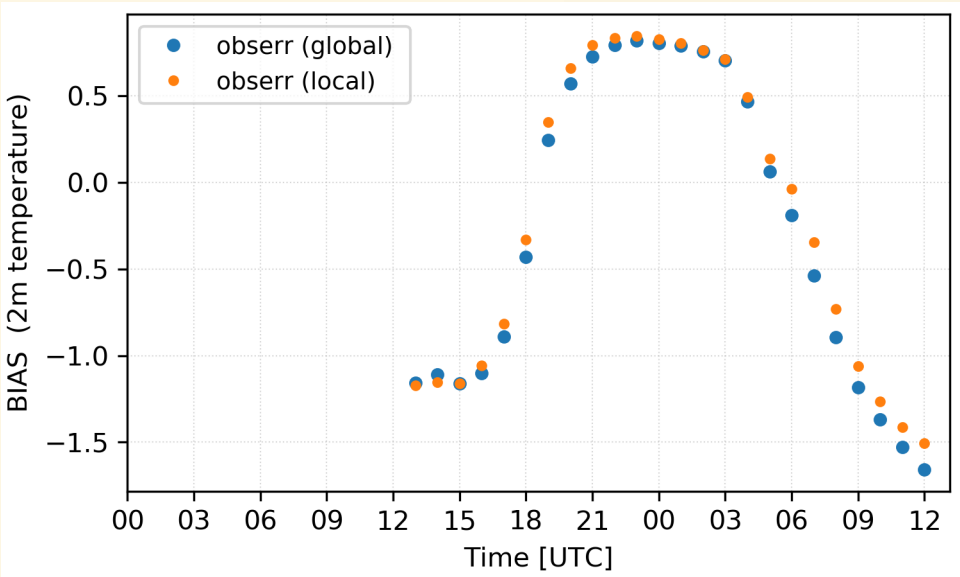
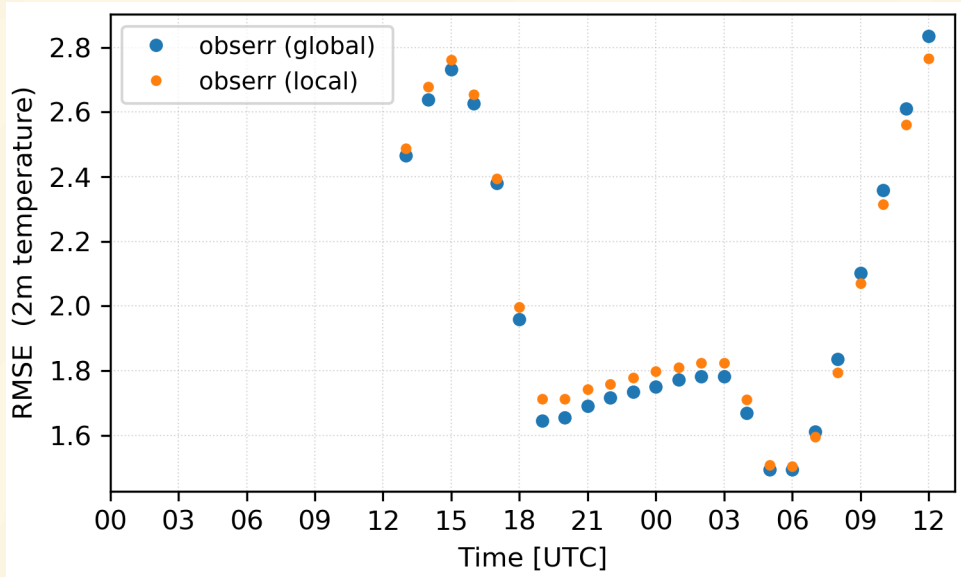




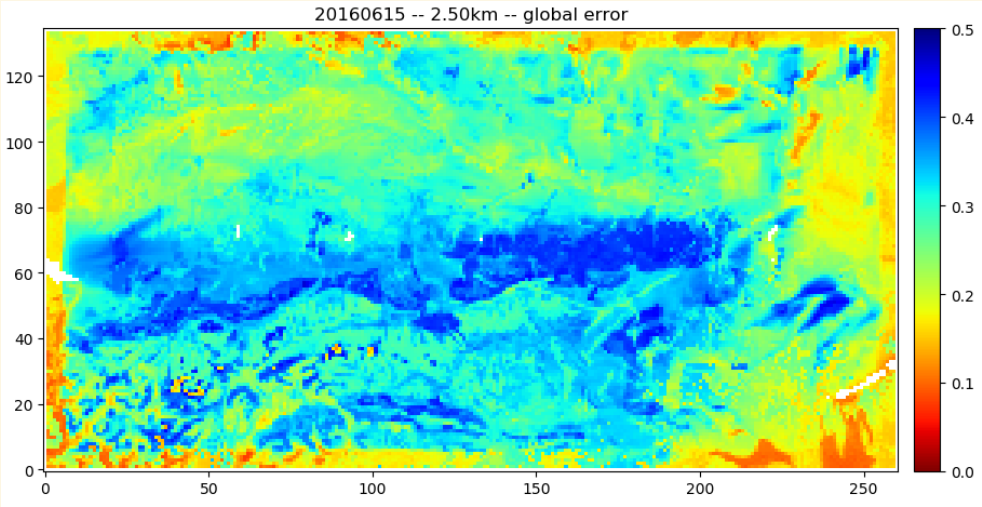




Unclear trend, problems with indefinite matrix in EKF

1.25 km resolution

Austrian domain, uppermost soil layer WG1 / (m^3 m^{-3})



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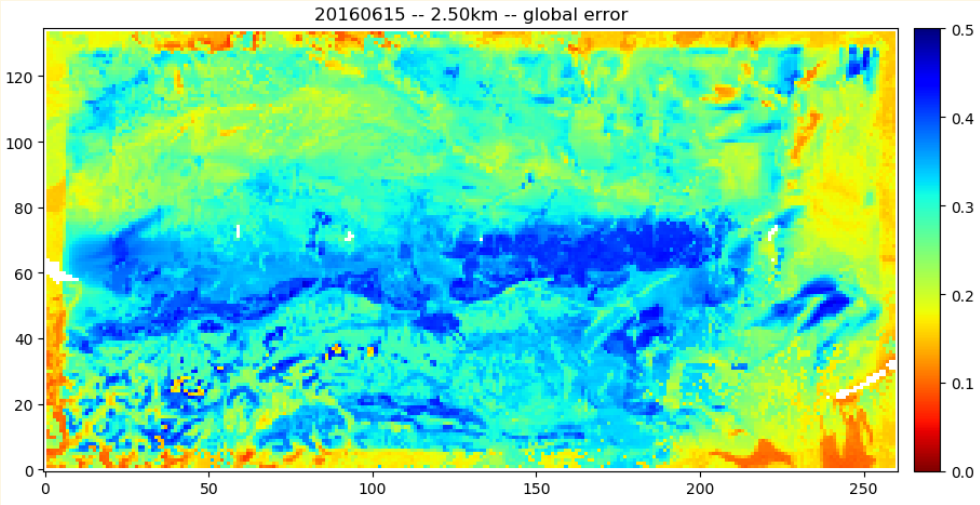
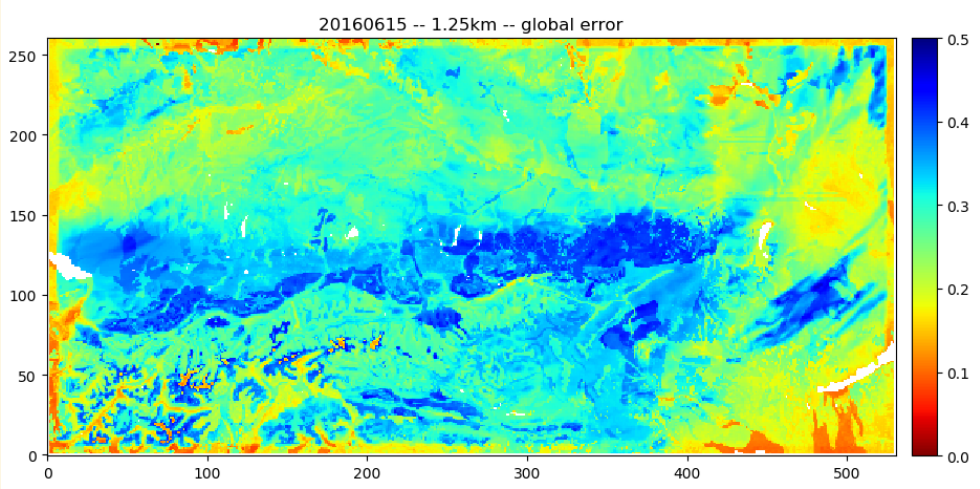


Adapt model dynamics for 1.25km



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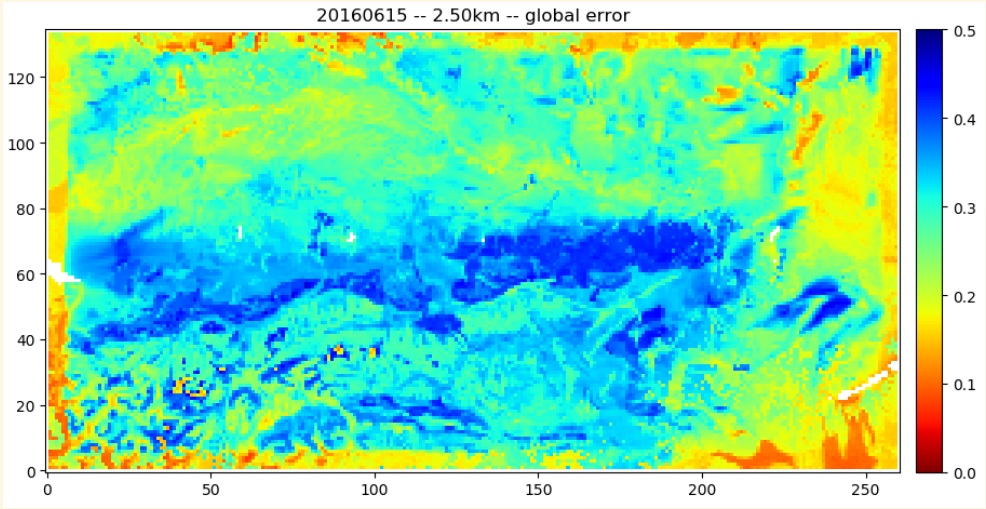

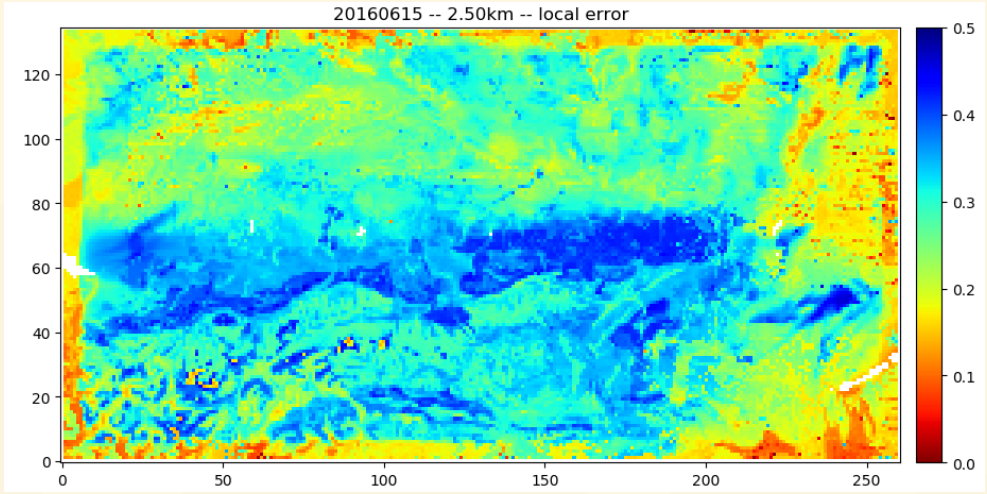

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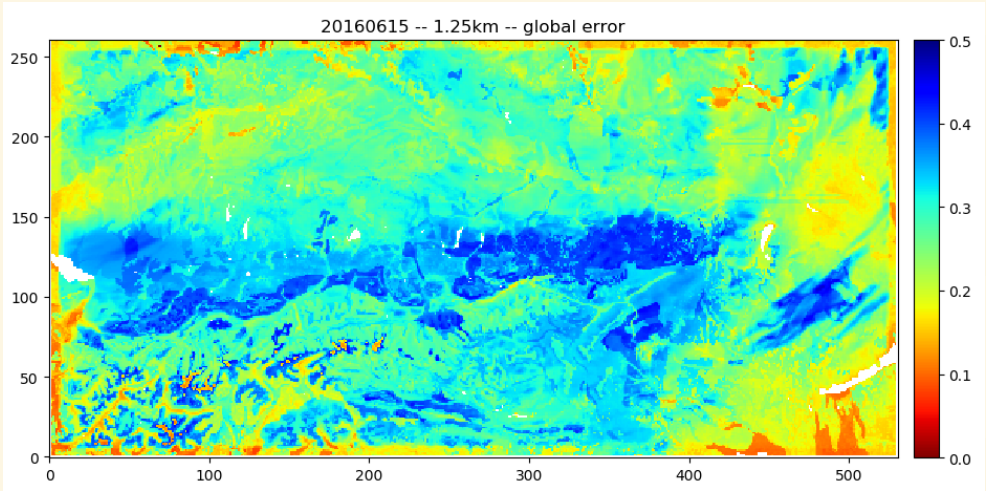

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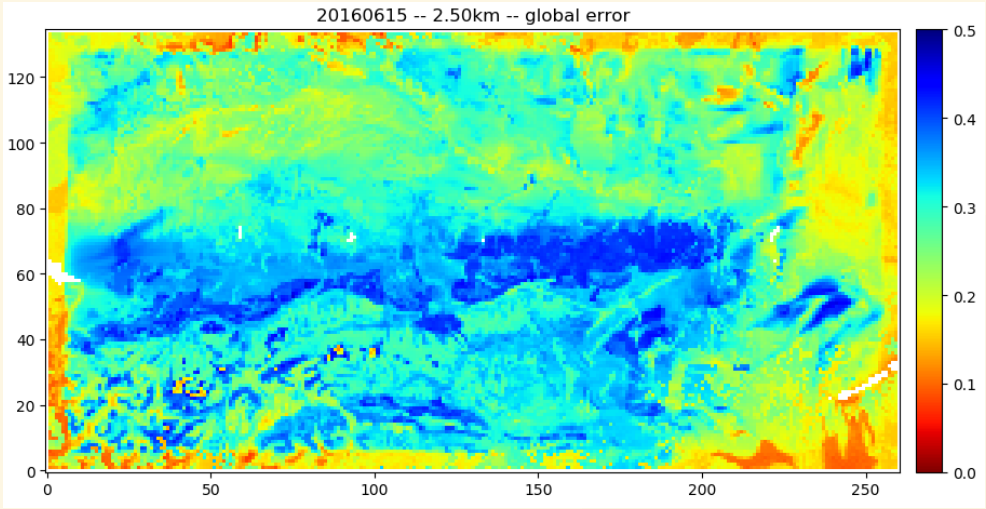

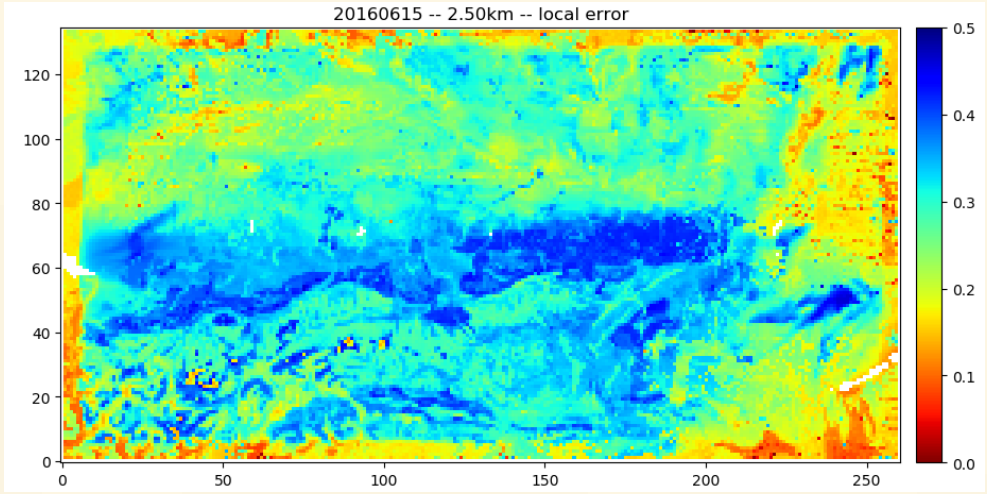

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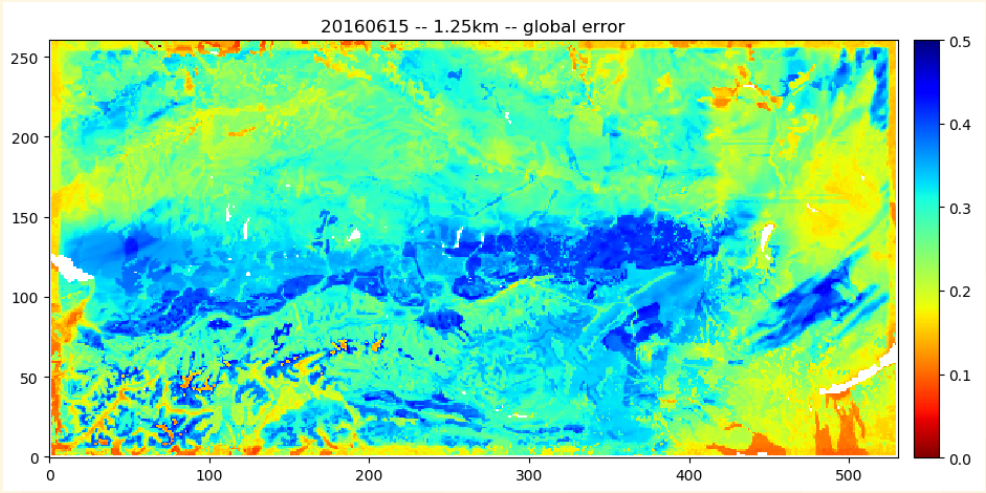

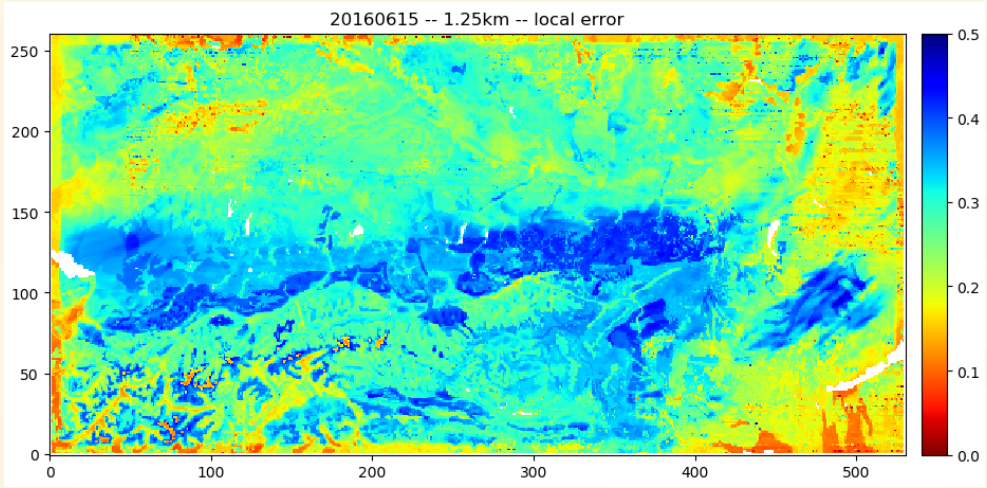

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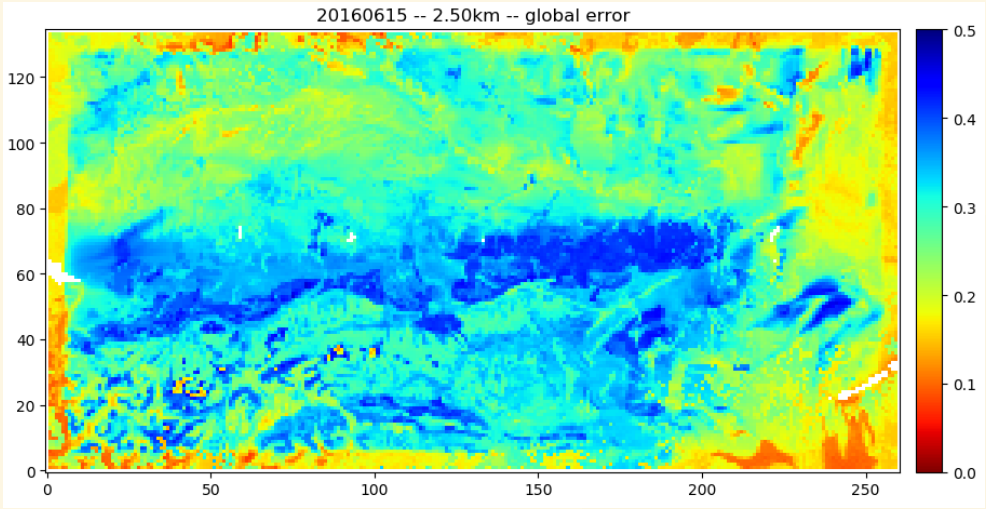

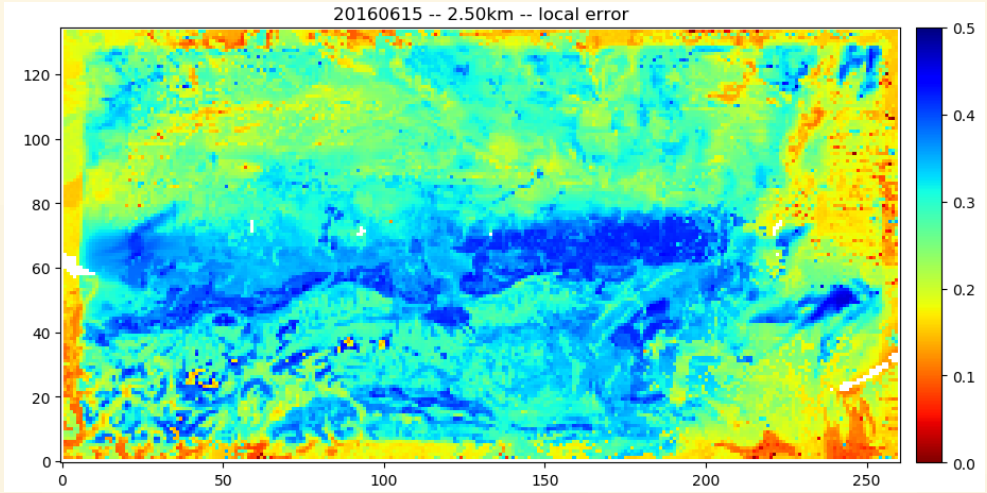

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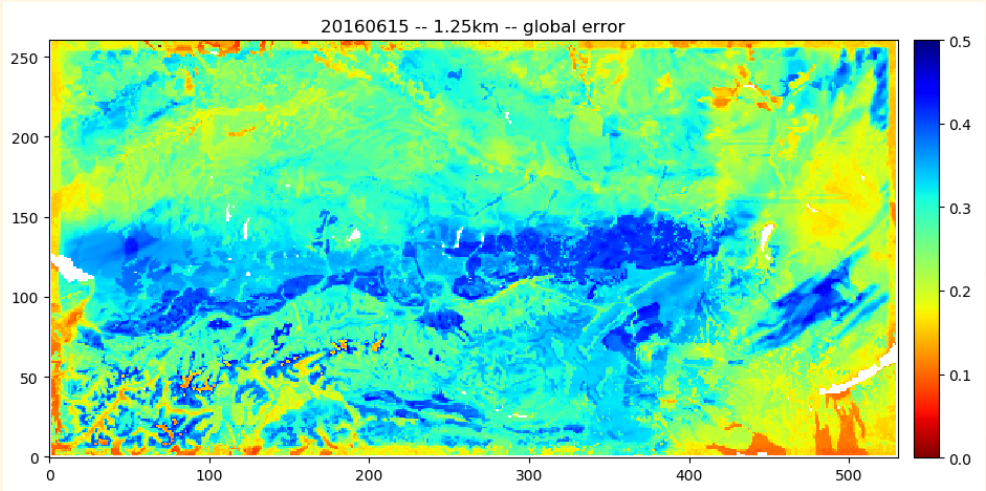

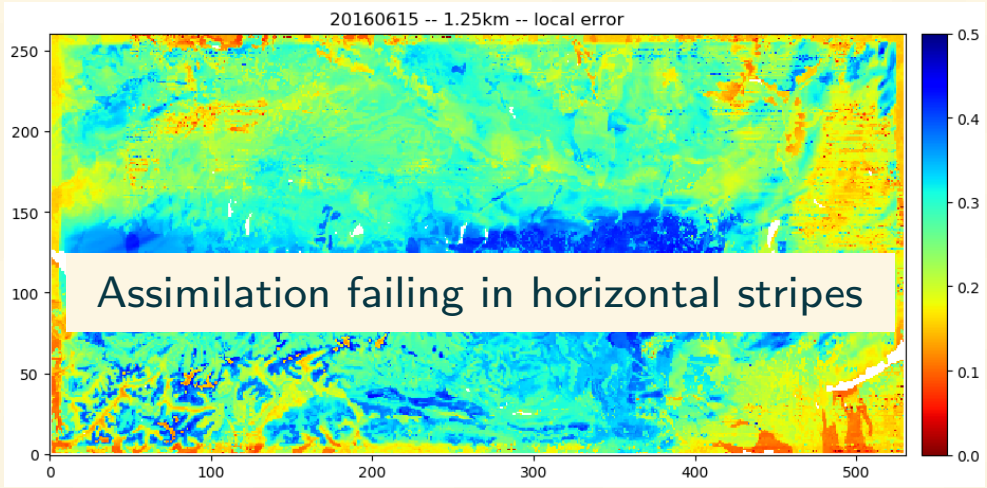

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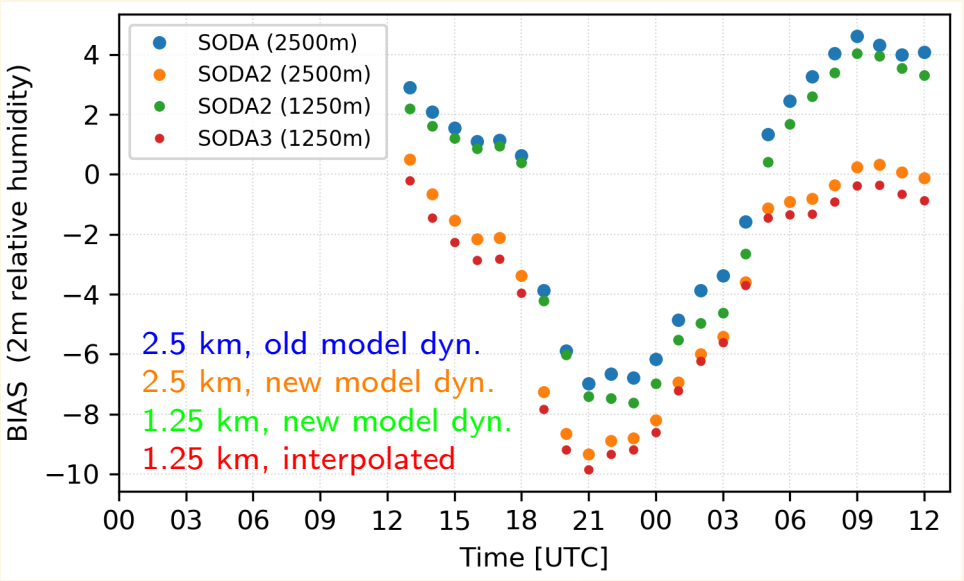

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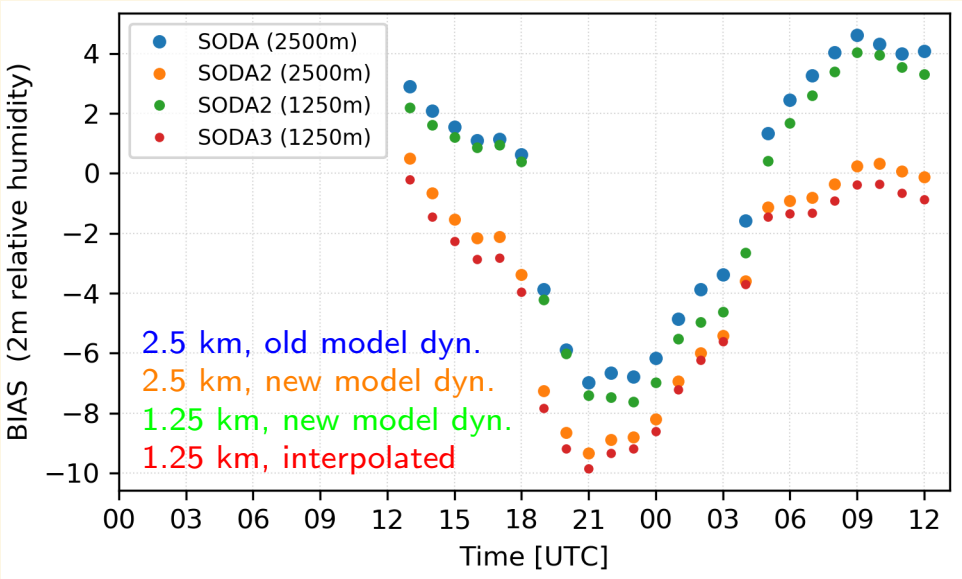

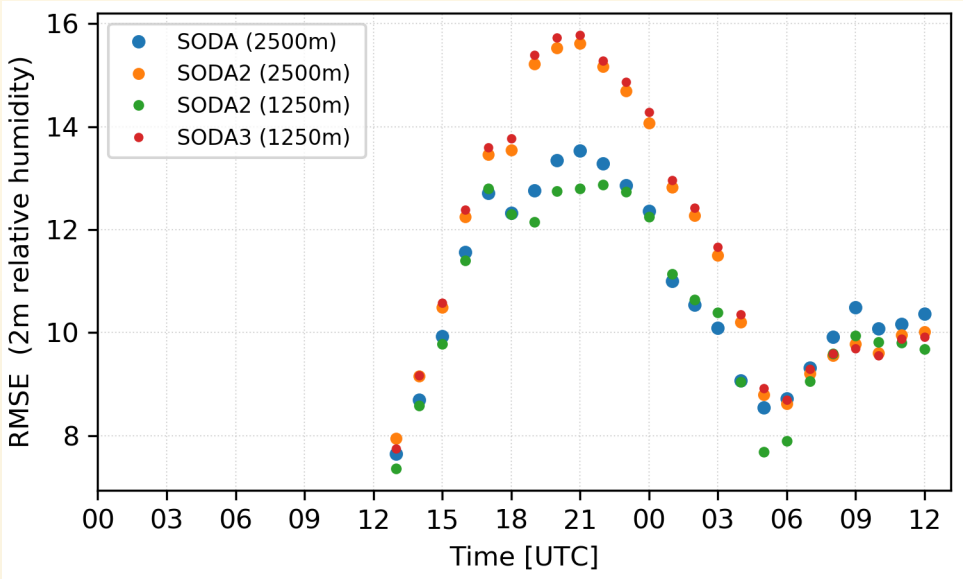

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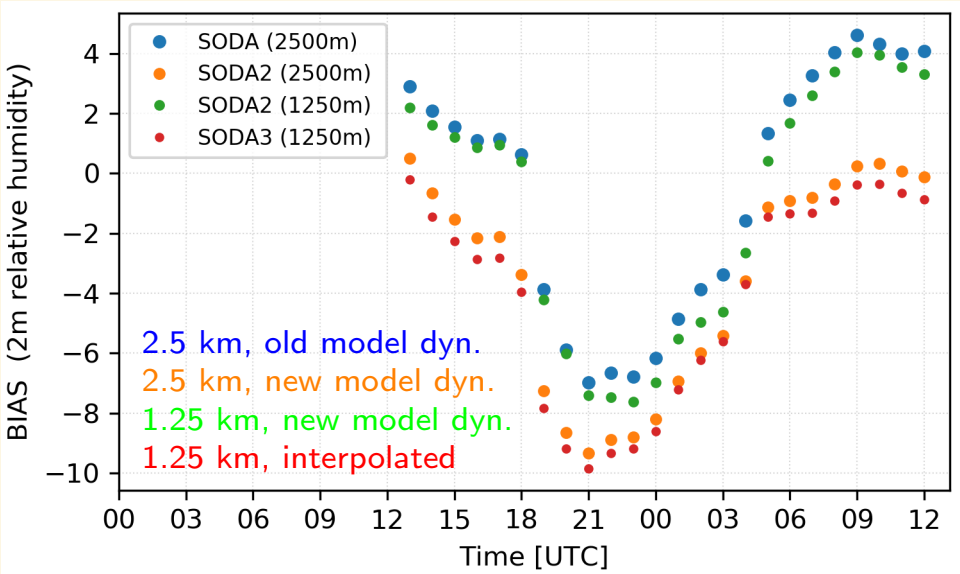

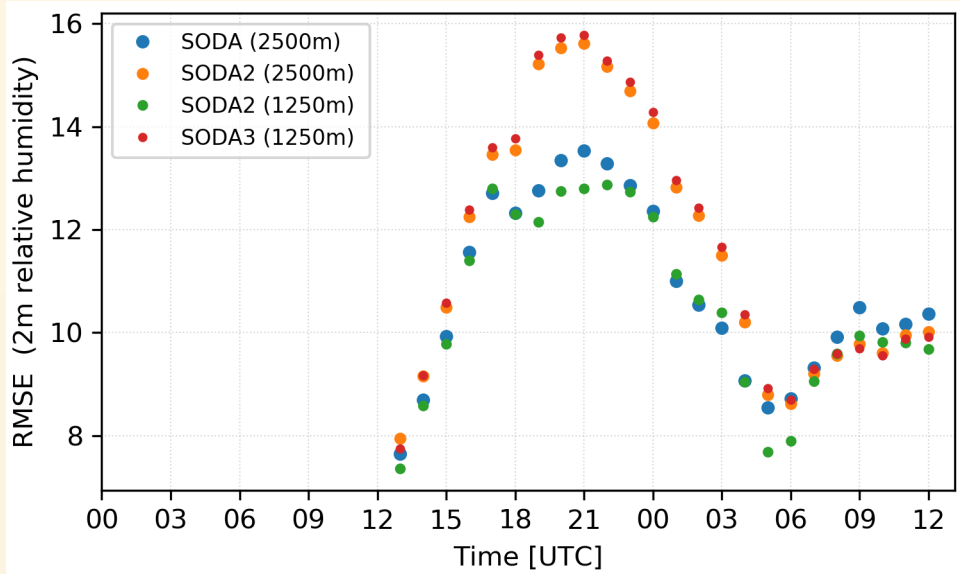

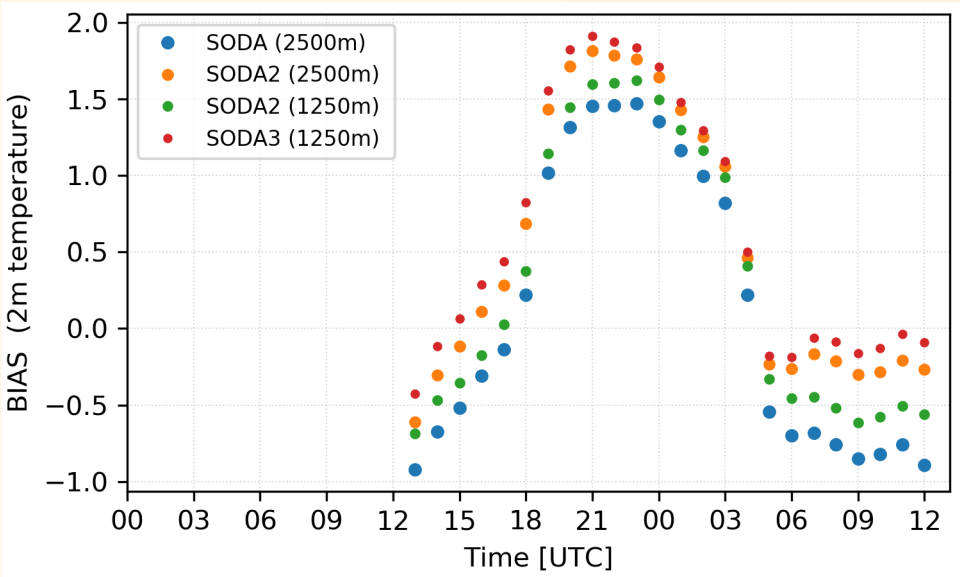

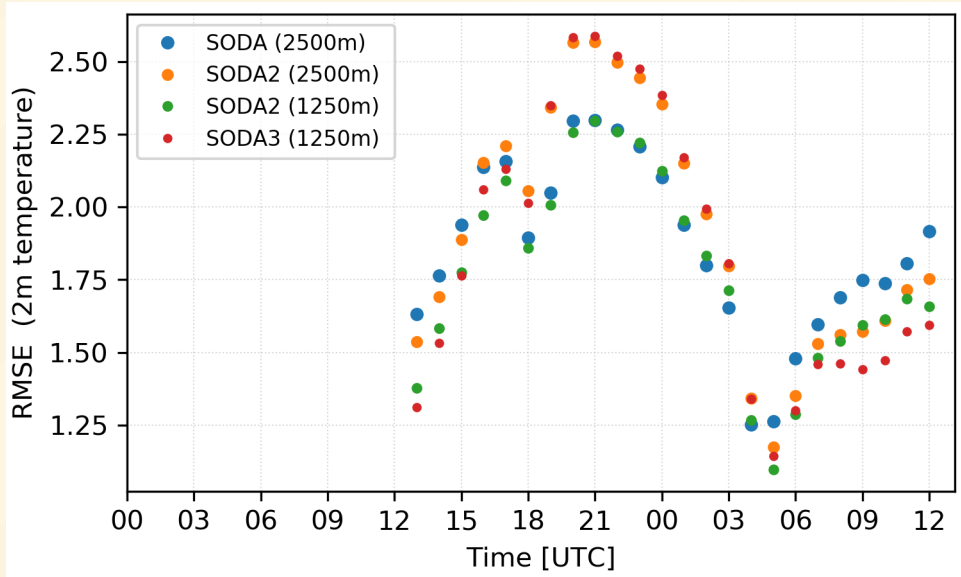

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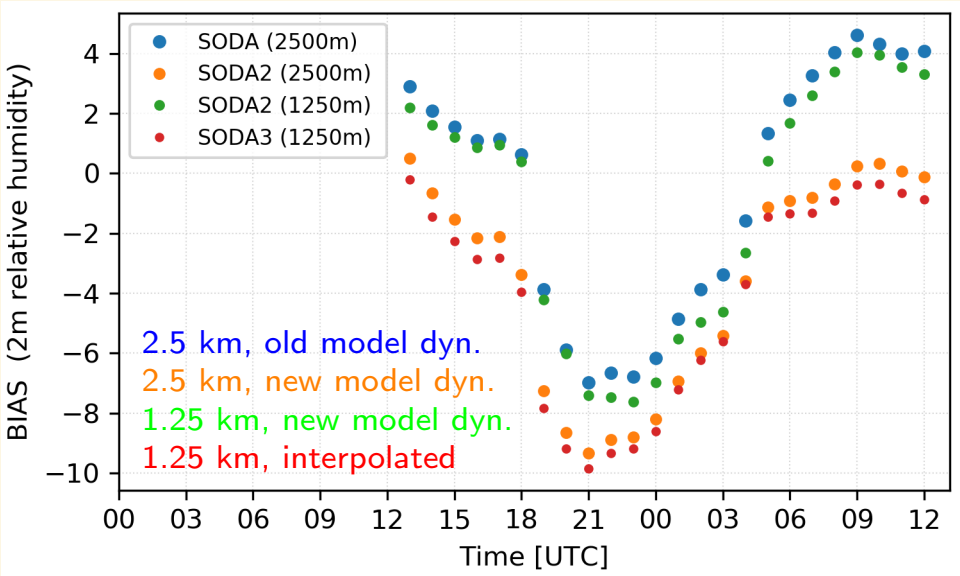

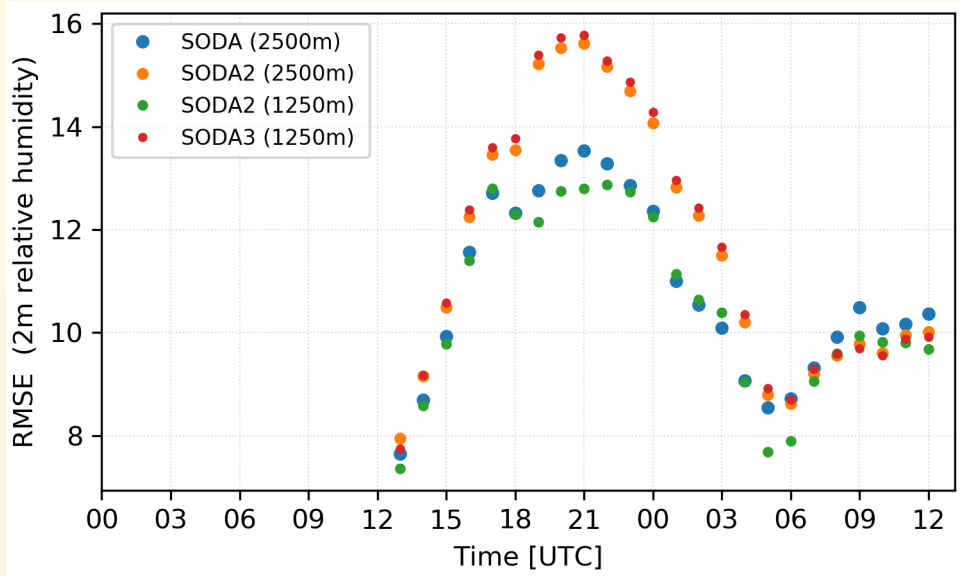

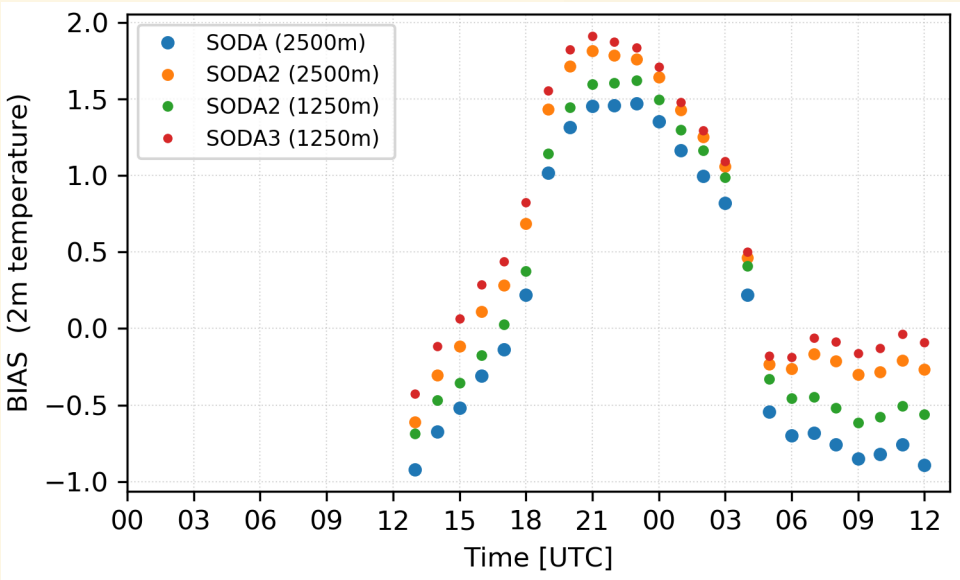

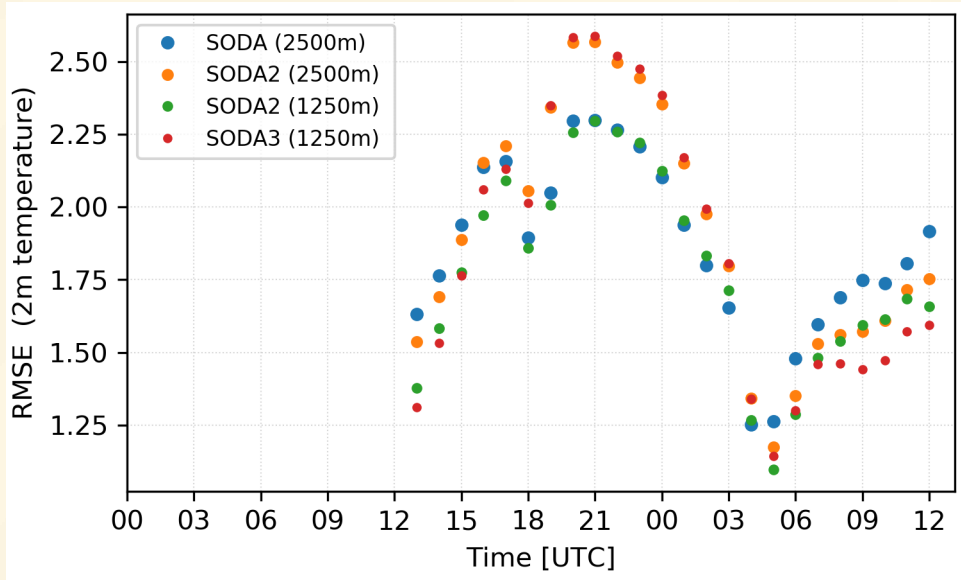

Positive trend for 1.25 km assimilation, but new model dynamics worse

Comparison with the HSAF SM-DAS2 product

- SODA-SM
  - SCATSAR-SWI (6 layers)
  - SURFEX (ISBA-DIF), sEKF
- HSAF SM-DAS2
  - ECMWF assimilation system (EKF, HTESSEL)
  - MetOp/ASCAT soil moisture

  $\Rightarrow$ daily product, 25 km resolution, 4 soil layers

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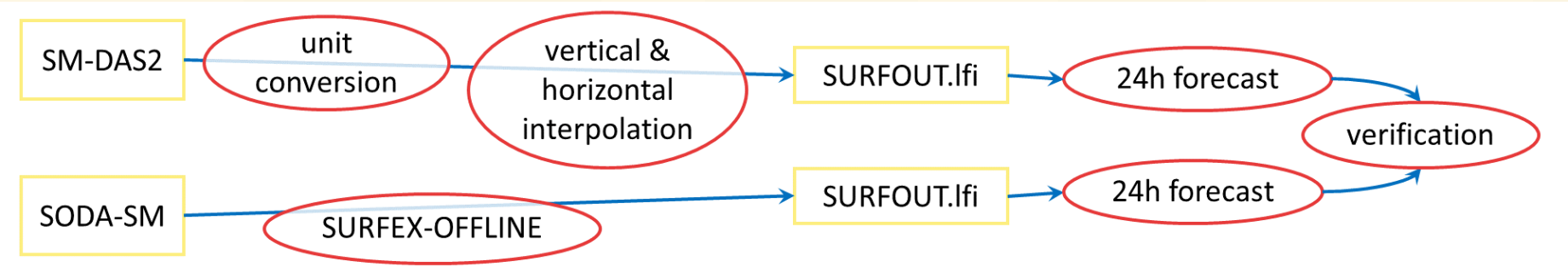
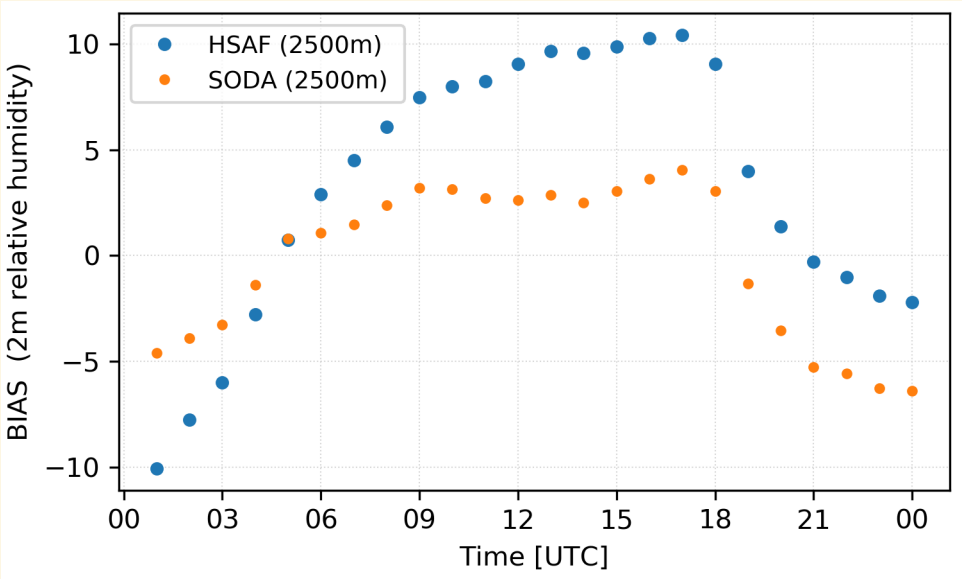
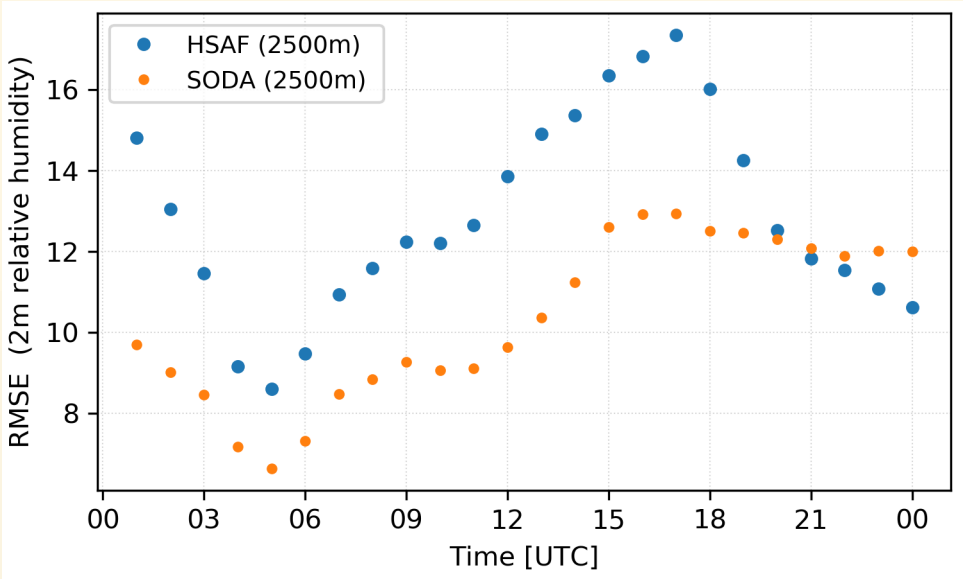


Verification of T_{2m} & HU_{2m} (Austrian SYNOP stations, June 2016)





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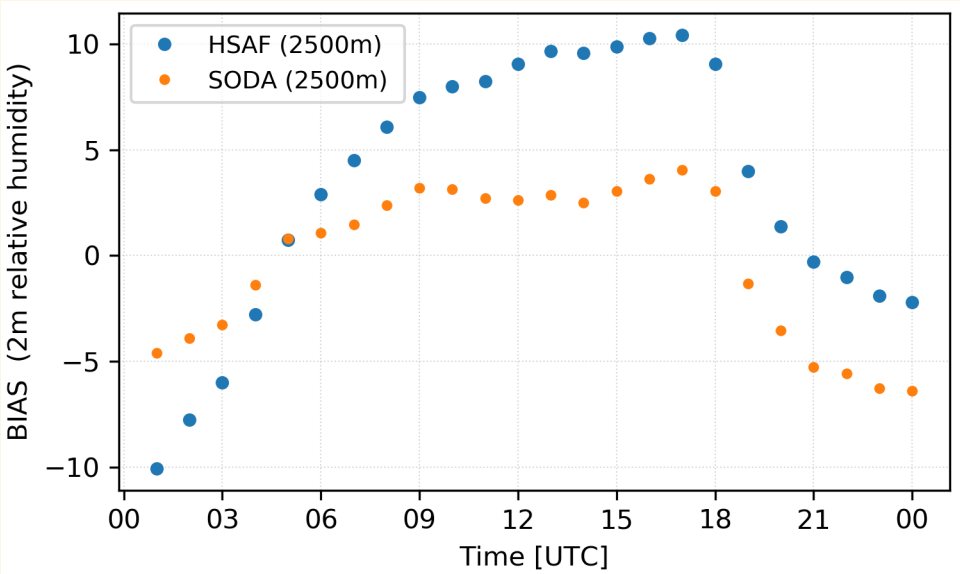

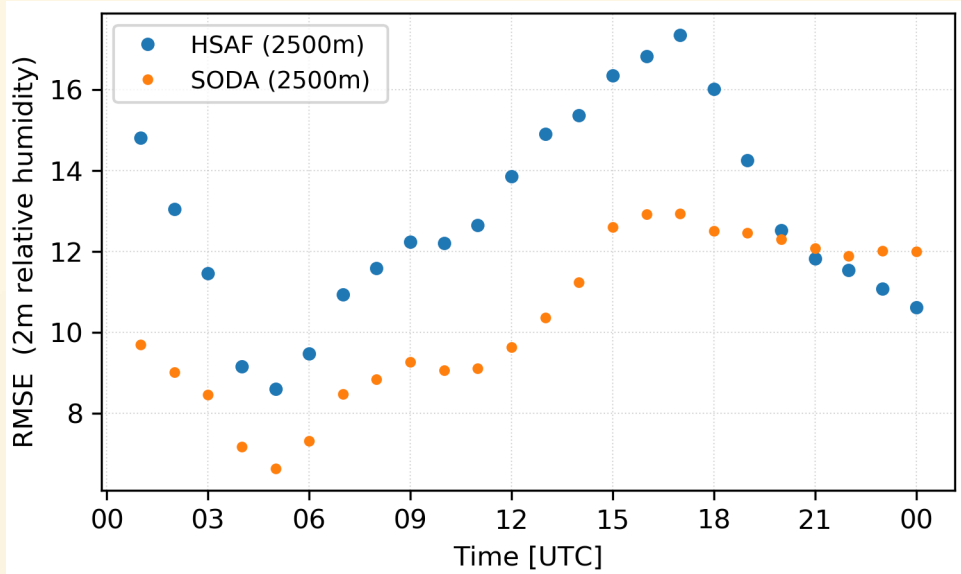

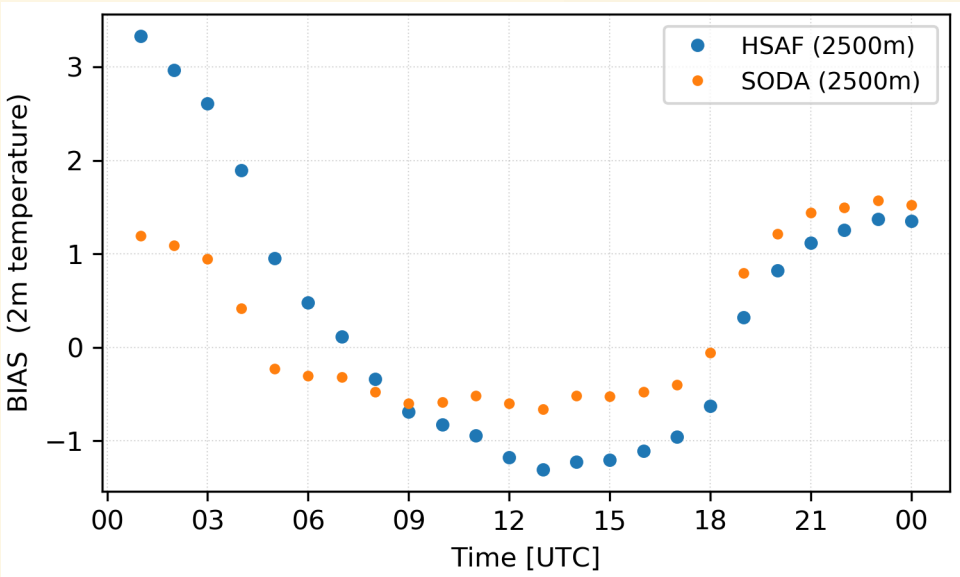

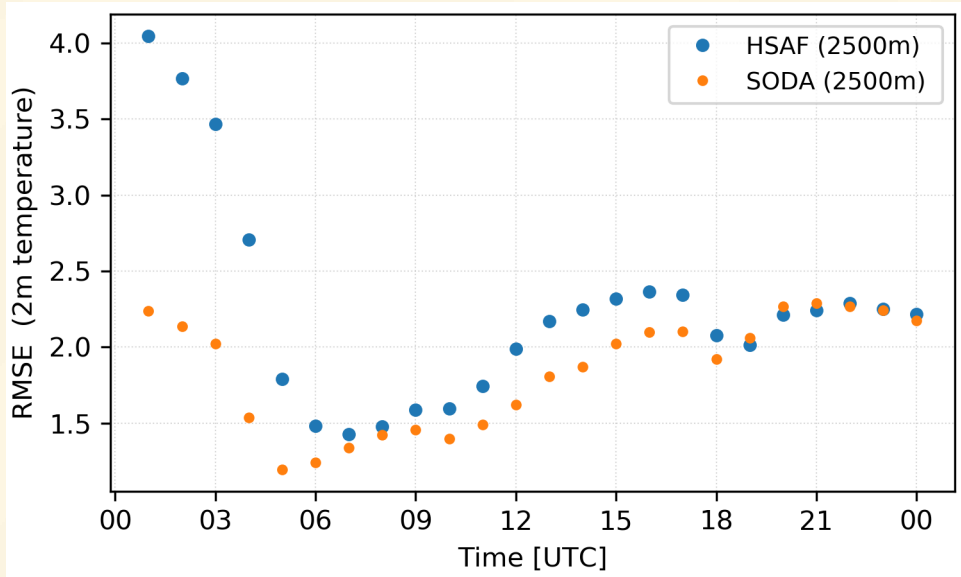

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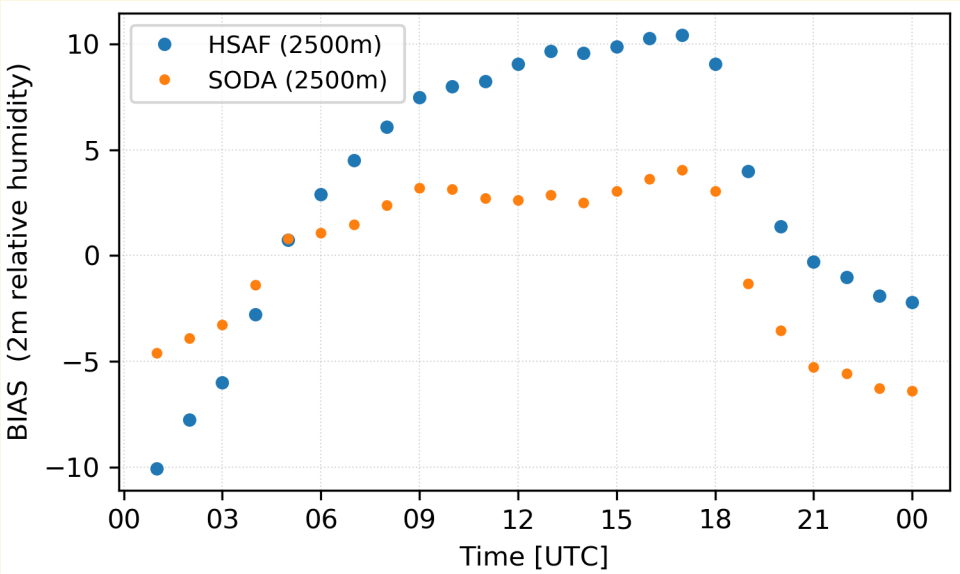
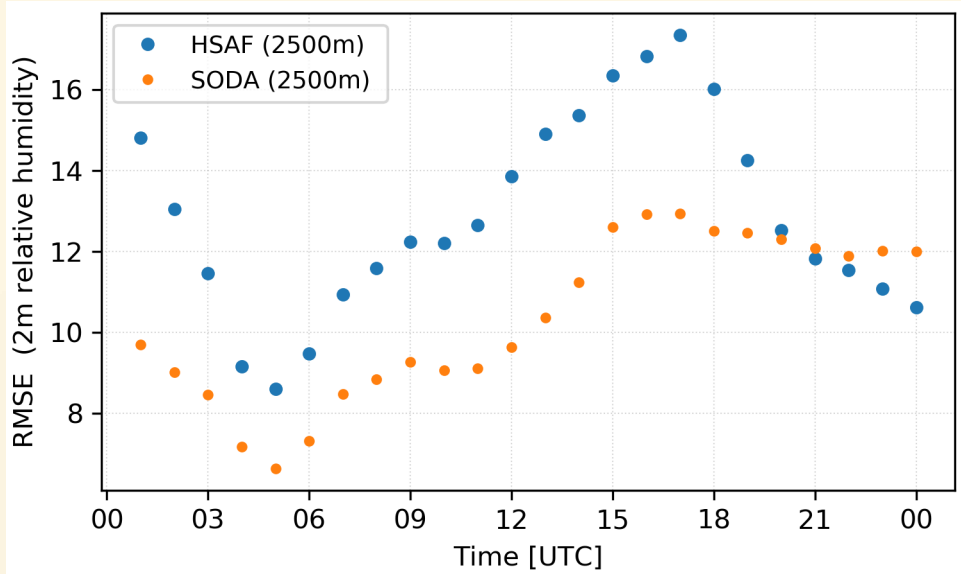
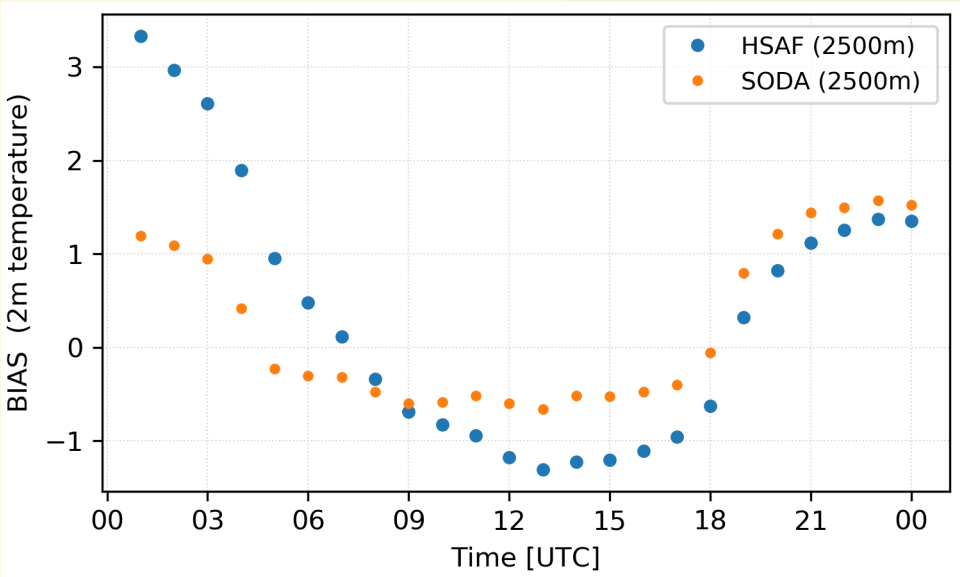
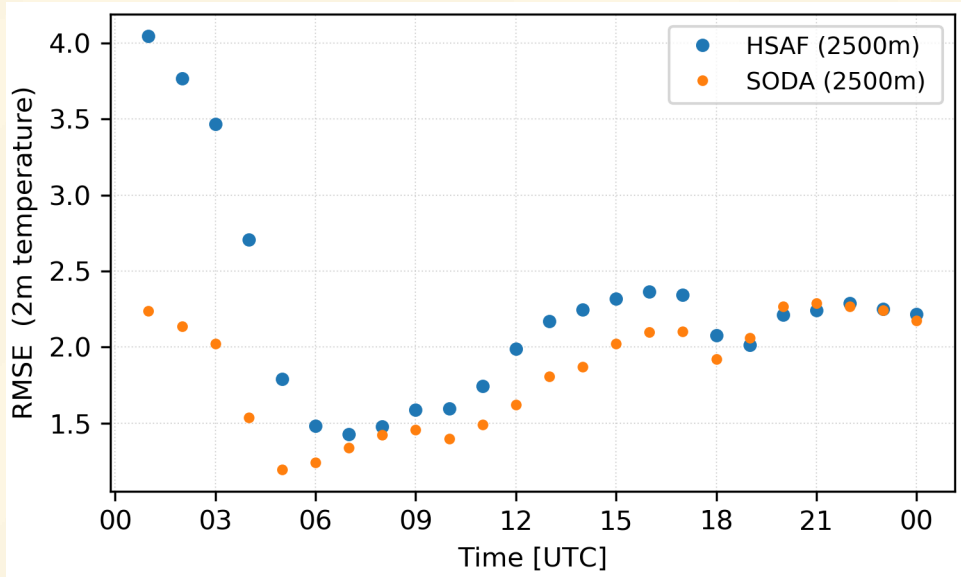


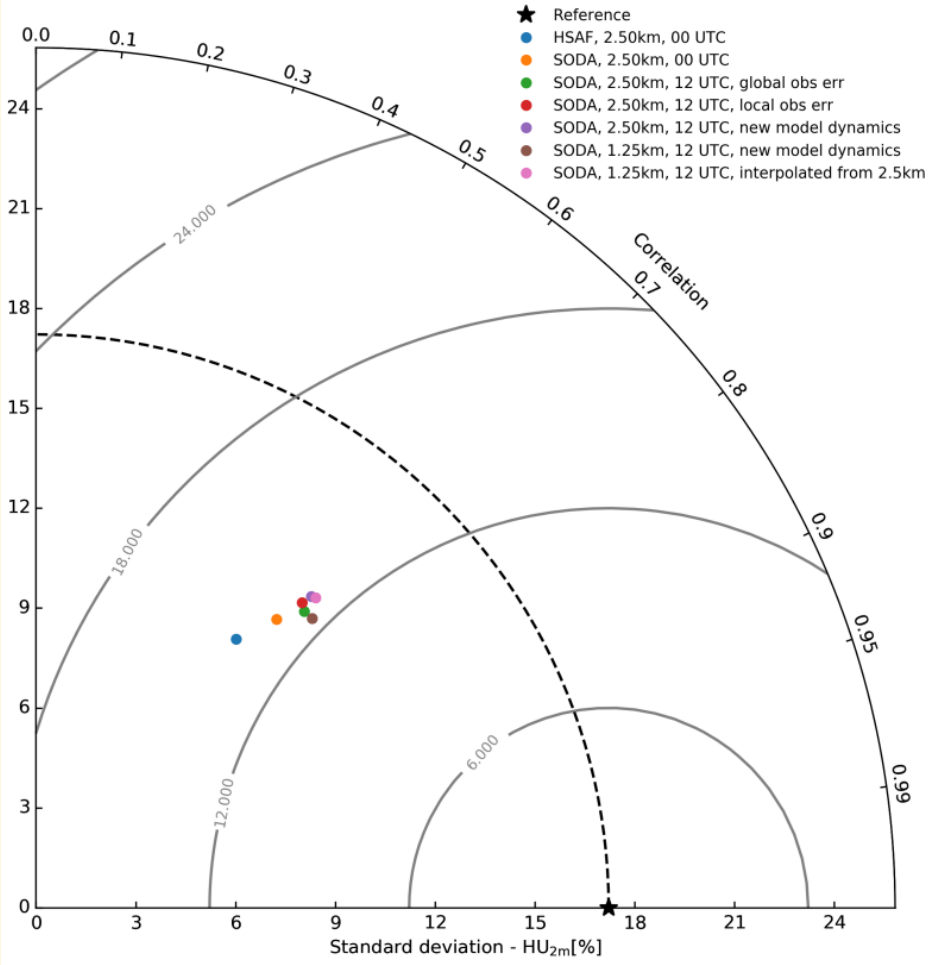


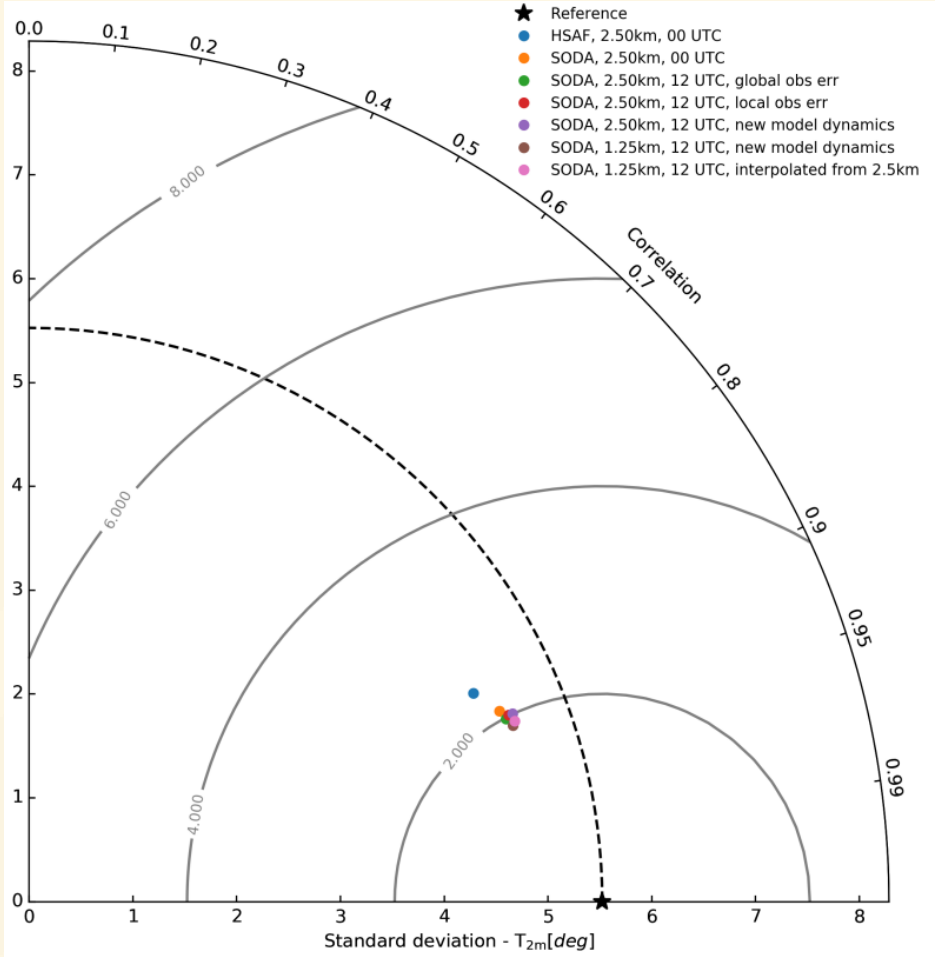




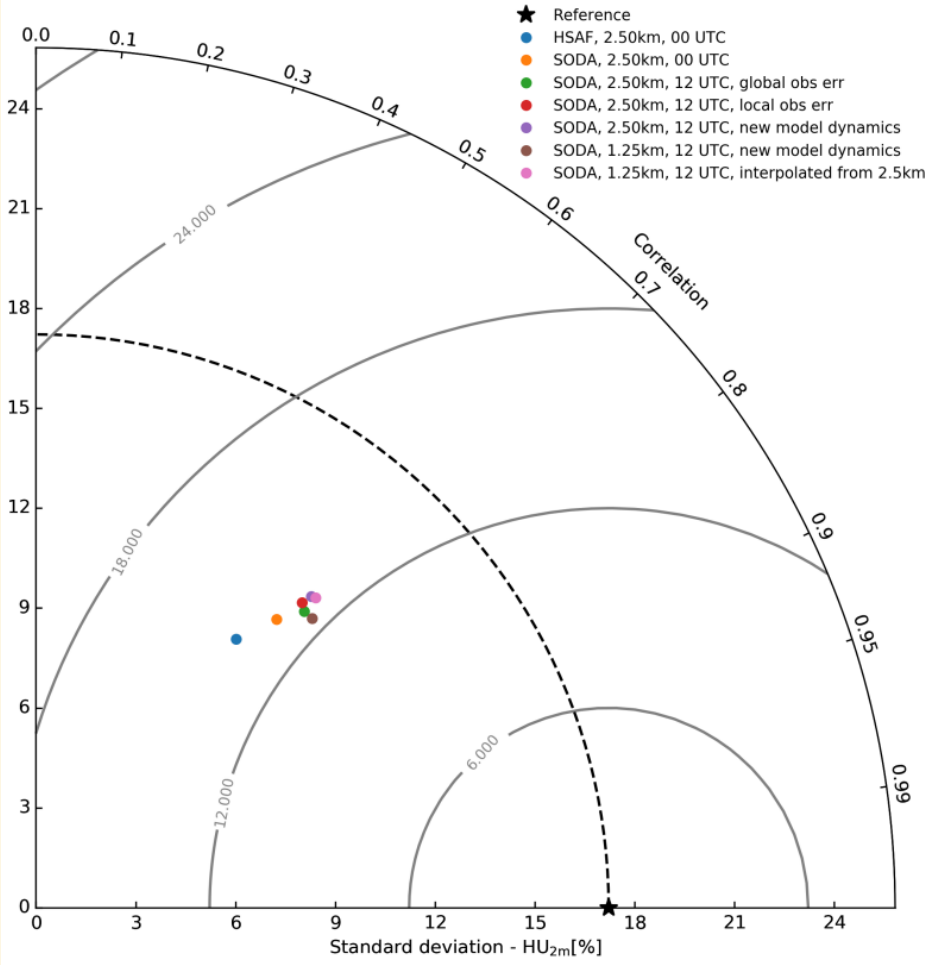
Clear improvement, especially for flatland stations

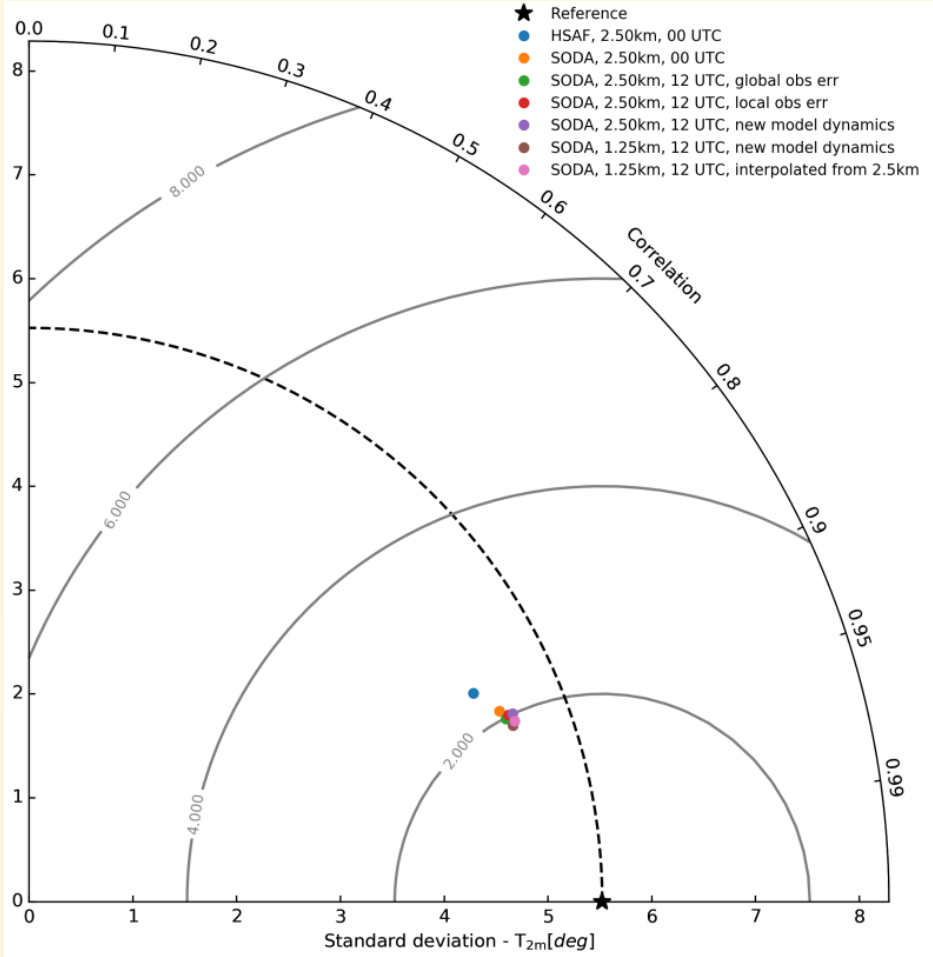
Summary


Reference
HSAF, 2.50km, 00 UTC
SODA, 2.50km, 00 UTC
SODA, 2.50km, 12 UTC, global obs err
SODA, 2.50km, 12 UTC, local obs err
SODA, 2.50km, 12 UTC, new model dynamics
SODA, 1.25km, 12 UTC, new model dynamics
SODA, 1.25km, 12 UTC, interpolated from 2.5km
Correlation
Standard deviation - HU2m[%]


Reference
HSAF, 2.50km, 00 UTC
SODA, 2.50km, 00 UTC
SODA, 2.50km, 12 UTC, global obs err
SODA, 2.50km, 12 UTC, local obs err
SODA, 2.50km, 12 UTC, new model dynamics
SODA, 1.25km, 12 UTC, new model dynamics
SODA, 1.25km, 12 UTC, interpolated from 2.5km
Correlation
Standard deviation - T2m[deg]

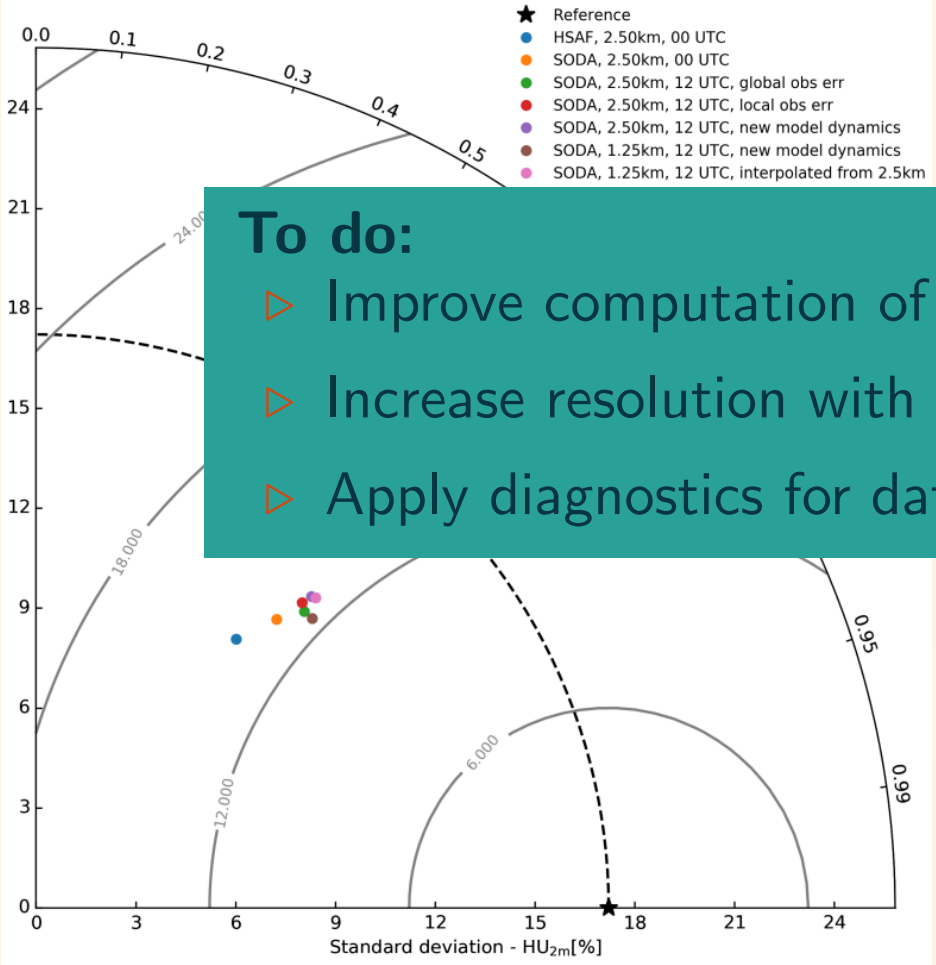
Summary

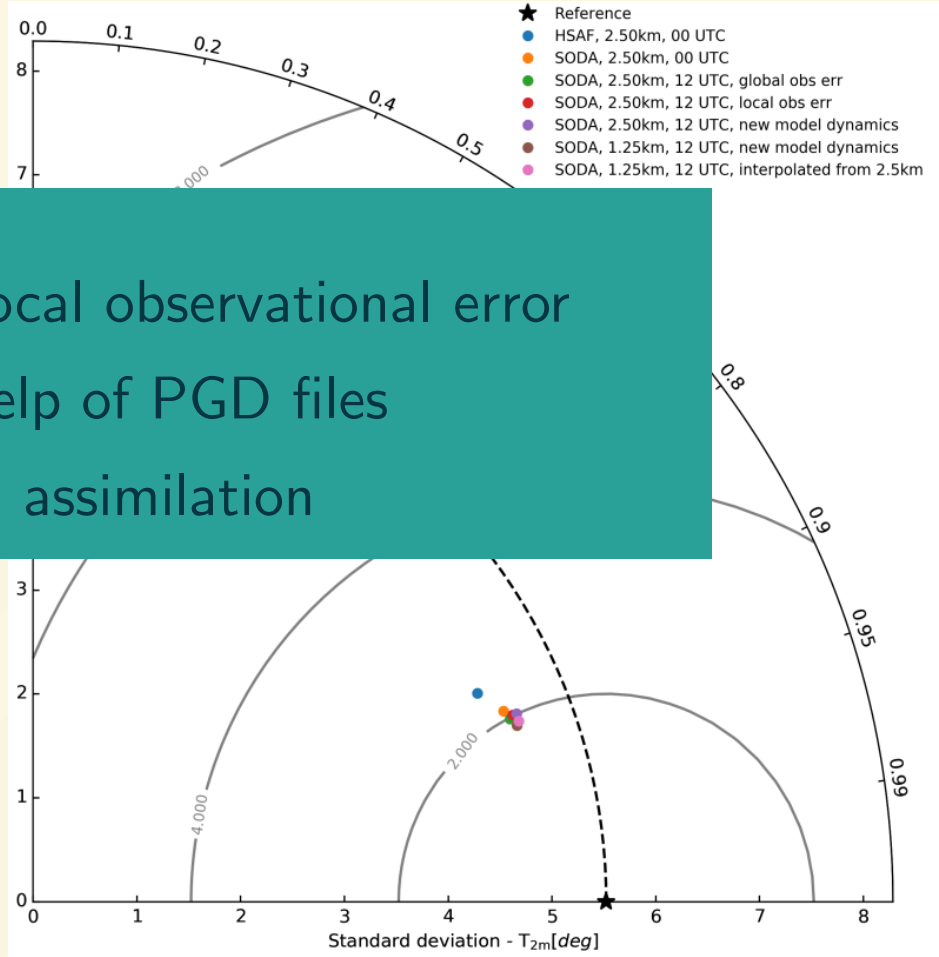




- Clear improvement in comparison with HSAF product
- Local observation error & 1.25 km need more attention

Summary





To do:

- Improve computation of local observational error
- Increase resolution with help of PGD files
- Apply diagnostics for data assimilation

- Clear improvement in comparison with HSAF product
- Local observation error & 1.25 km need more attention