Assimilation of the SCATSAR-SWI with SURFEX: Resolution studies over Austria*

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Satellite inspired hydrology in an uncertain future Reading, 27.11.2019





| Motivation | Surface model | Observations | DA system | Verification | Summary | 2/10 |
|------------|---------------|--------------|-----------|--------------|---------|------|
| Motivat | tion | | | | | |

Soil moisture assimilation can improve NWP...

... under the right circumstances



| Motivation | Surface model | Observations | DA system | Verification | Summary | 2/10 |
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| Motiva | tion | | | | | |

Soil moisture assimilation can improve NWP...



... under the right circumstances

- optimise use of observations & observation error
- valuate benefit of higher resolution

| Motivation | Surface model | Observations | DA system | Verification | Summary | 3/10 | | | |
|-------------------------------|----------------|--------------|-----------|--------------|---------|------|--|--|--|
| Data assimilation with SURFEX | | | | | | | | | |
| SURFEX | K Offline Data | Assimilation | n (SODA) | | | | | | |



| Motivation | Surface model | Observations | DA system | Verification | Summary | 3/10 |
|--|--|----------------------|---|--------------|---------|------|
| Data a | ssimilation w | vith SURFE | Х | | | |
| SURFEX | K Offline Data | Assimilation | ı (SODA) | | | |
| ⊳ simp | lified Extended I | Kalman Filter | | | | |
| | orographic f | viction | | | | |
| Snow processes Bulk to detailed snow process models | orgraphic h | Town: | | | | |
| Lakes : | atural land surface : nergy, water, carbon fluxes ydrological and egetation processes | Vegetation processes | Aerosols: chemical emission aerosols, dust, sea salt | | | |
| Surface fluxes | del Sea: | Bound | lary layer: face boundary layer | | | |
| ion et al. | Surface f 1D mixin | luxes glayer | | | | |
| © Mass | | SUI | | | | |





| Motivation | Surface model | Observations | DA system | Verification | Summary | 4/10 |
|------------|---------------|--------------|-----------|--------------|---------|------|
| | | | | | | |

Observations: SCATSAR-SWI



c) 1km SCATSAR-SWI | T=5 | Daily Coverage Sentinel-1A+B & MetOp-A+B ASCAT | 2017 07 24





Copernicus Global Land Service

the

provided freely via

interna

Observations: SCATSAR-SWI



| Motivation | Surface model | Observations | DA system | Verification | Summary | 5/10 |
|------------|---------------|--------------|------------|--------------|---------|------|
| Observa | tion error: | Triple Collo | cation Ana | alysis | | |

• Estimation of error variances of soil moisture signal Θ_{true}

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

• Kalman gain:

```
\mathbf{K} = \mathbf{B}\mathbf{H}^{\mathcal{T}}(\mathbf{H}\mathbf{B}\mathbf{H}^{\mathcal{T}} + \mathbf{R})^{-1}
```

| Motivation | Surface model | Observations | DA system | Verification | Summary 5/10 |
|--|--|---------------------|-----------------------------------|--------------|---|
| Observ | ation error: T | riple Col | location Ar | nalysis | |
| Estima of soil | ition of error var moisture signal | $\Theta_{ m true}$ | 1.0 - SURFEX 0.8 - 0.6 - | | urban I [192] forests II [26350] herbaccous, shrub II [2040] crops II (35432) bare land II [3] |
| $\Theta_{ m me}$ | $ \alpha_{\text{ras}} = \alpha + \beta \Theta_{\text{true}} $ $ \Rightarrow \sigma_{\epsilon}^{2} $ | $+\epsilon$ | 0.4 - 0.2 - 1.0 - SCATSAR | | sswamp, inland waters II [163] ssburban II [1684] vineyards II [46] all covers |
| • Kalma | n gain: | | Ho 0.8 - Part 0.6 - U 0.4 - | | urban I (185) forests II (25746) herbaceous, shrub II (1981) crops II (34438) bare land II (3) swamp, inland waters II (161) suburban II (1588) |
| K = | $\mathbf{B}\mathbf{H}^{T}(\mathbf{H}\mathbf{B}\mathbf{H}^{T}+$ | $(\mathbf{R})^{-1}$ | Ö 0.2 | | all covers |

1.0 - SMAP

0.000

0.025 0.050

0.075 0.100

 σ_{ϵ} / m³m⁻³

0.8

0.6

0.4

0.2

urban I [182]

forests II [24523] herbaceous, shrub II [1887]

crops II (32892) bare land II (3) swamp, inland waters II (1491

suburban II [1582] vineyards II [46] all covers

0.125 0.150 0.175

| Motivation | Surface model | Observations | DA system | Verification | Summary | 5/10 |
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 Estimation of error variances of soil moisture signal Θ_{true}

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

Kalman gain:

 $\mathbf{K} = \mathbf{B}\mathbf{H}^{\mathcal{T}}(\mathbf{H}\mathbf{B}\mathbf{H}^{\mathcal{T}} + \mathbf{R})^{-1}$

• Apparent cover dependency mostly insignificant



| Motivation | Surface model | Observations | DA system | Verification | Summary | 6/10 |
|------------|---------------|--------------|-----------|--------------|---------|------|
| Tho da | ta assimilati | on system | | | | |

system



- June 2018 (1 month spin-up)
- Austrian domain





- June 2018 (1 month spin-up)
- Austrian domain
- 2.5 km vs. 1.25 km
- Global vs. local observation error





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| Motivation | Surface model | Observations | DA system | Verification | Summary | 8/10 |
|------------|---------------|----------------------|-----------|--------------|---------|------|
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Verification against T_{2m} & HU_{2m} of Austrian TAWES stations

Global vs. local obs. error

- no dependency on altitude
- no dependency on land cover



| Motivation | Surface model | Observations | DA system | Verification | Summary | 8/10 |
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Verification against T_{2m} & HU_{2m} of Austrian TAWES stations

Global vs. local obs. error

- no dependency on altitude
- no dependency on land cover

2.5 km vs. 1.25 km

- improvement for day time
- degradation for night time
- adapted model dynamics problematic when soil cool





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|------------|---------------|--------------|-----------|--------------|---------|-------|
| Summa | ry & Outloo | ok | | | | |

- Observation error obtained with Triple Collocation Analysis
 - ▷ Water balance: visible impact, unclear pattern
 - \triangleright NWP: almost no impact on $T_{\rm 2m}$ & $HU_{\rm 2m}$
- Increasing grid sampling to 1.25 km
 - Water balance: small improvement
 - ▷ NWP: day time performance improved
 - night time might profit of better model dynamics

| Motivation | Surface model | Observations | DA system | Verification | Summary | 10/10 |
|-------------------|---------------|--------------|-----------|--------------|---------|-------|
| Summary & Outlook | | | | | | |

- Observation error obtained with Triple Collocation Analysis
 - ▷ Water balance: visible impact, unclear pattern
 - \triangleright NWP: almost no impact on $T_{\rm 2m}$ & $HU_{\rm 2m}$
- Increasing grid sampling to 1.25 km
 - Water balance: small improvement
 - NWP: day time performance improved
 - night time might profit of better model dynamics
- ▷ Surface DA on 500 m
- Run computations on European domain