Evaluating the spatial performance of hydrological models using remote sensing data

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New opportunities in satellite and airborne remote sensing
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Outline of the presentation

- Introduction
- Methods
- Results
- Conclusions

http://visibleearth.nasa.gov/view.php?id=71880
Evaluating the spatial performance of hydrological models using remote sensing data

Why is it important?

Hydrological model outputs are used by decision makers.

There is a need to evaluate the spatial patterns to make them reliable.
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**Our experience**

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Our experience
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Our main hypothesis
Evapotranspiration patterns obtained using both methods should be similar.
If not, can we make them more similar?
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- ET from DK-model
- ET from Satellite
- ET pattern evaluation
- Modify DK model inputs
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  Is the National water resources model of Denmark and is distributed, coupled Ground Water-Surface Water model. Includes unsaturated zone, ET, river routing modules and runs on MIKE-SHE at 500m.

- **How is the model calibrated?**

  Calibrated and validated against 191 discharge and around 17500 ground water head observations.

(Taken from Stisen et al. 2012)
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Different applications:
- Assessment of climatic change
- Water resources management within the EU Water framework directive
- Large scale nitrogen modeling

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What model was used?
The Two Source Energy Balance from Norman et al. 1995 was used to calculate the ET. (https://github.com/hectornieto/pyTSEB)
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ET pattern evaluation

Sensitivity analysis

A sensitivity analysis was conducted with PEST to evaluate the most sensitive parameters in the model.

Modify DK model inputs
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Data from HOBE from 3 eddy covariance sites was used to ensure quality of the data.
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- Scatterplots (r)

Results - Visual Interpretation

Results - Scatter plots (Pearson)
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- Modified DK model inputs
- Map generation
- Visual interpretation
- Scatterplots (r)
- Empirical Orthogonal Functions (EOF)
Methods

Root depth, LAI and Kc changes in time and space based on the land cover type in the Dk-Model
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Root depth and Kc changes in time and space based on the land cover type in the Dk-Model

New root depth maps based on NDVI and soil maps were created.

\[
RD_i[m] = RD_{\text{max}} \frac{\text{NDVI}_i}{\text{NDVI}_{\text{max}}} \quad \text{for forested areas,}
\]

and

\[
RD_{\text{agri}}[m] = \left( (\alpha \cdot CF_i) + \beta \right) \cdot \frac{\text{NDVI}_i - \text{NDVI}_{\text{min}}}{\text{NDVI}_{\text{max}} - \text{NDVI}_{\text{min}}}
\]

Kc is derived from remotely sensed LAI using:

\[
Kc[-] = Kc_{c,\text{min}} + (Kc_{c,\text{max}} - Kc_{c,\text{min}}) \cdot (1 - e^{(-0.7 \cdot \text{LAI})}) = 0.95 + 0.2 \cdot (1 - e^{(-0.7 \cdot \text{LAI})})
\]

Where the Kc_{\text{min}} and Kc_{\text{max}} are set to 0.95 and 1.15 respectively.
Results - TSEB ET
Results- DK model ET
Results- Modified DK model ET

Maps showing evapotranspiration for different months from April to September.
Results - Modified DK model ET

Evapotranspiration modified DK-Model

- 1.3
- 1.2 - 1.3
- 1.1 - 1.2
- 1 - 1.1
- 0.9 - 1
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- <0.5
Results
Results
Results-EOF

EOF1 - 45.2% explained variance
EOF2 - 15.7% explained variance
EOF3 - 9.86% explained variance

EOF Loadings

Modified DK-Model
Original DK-Model
Results - Ground water heads and discharge

Mean error pr. well [m] vs % Stations

- Original DK Model (Calibration)
- Modified DK Model (Validation)

Mean = -0.437  Median = -0.999  RMSE = 5.47
Mean = -0.361  Median = -0.925  RMSE = 5.50
Can a hydrological model be calibrated spatially?

Figure 3. Average hydrograph of all years in the calibration period (2001-2008) to illustrate the ensemble of nine model calibrations with different seed numbers.

Conclusions and future perspectives

• The potential of remote sensing to evaluate the spatial patterns of hydrological models has been shown.

• Remote sensing derived variables added spatial information to the model and made the spatial patterns of both models more similar.

• The Dk-model was not recalibrated. We expect the validation with the discharge stations and ground water heads to improve when done.
Thank you for your attention!

Questions?

Results