Evaluating and Improving Representation of Soil Knowledge in the Noah-MP

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Background

- “A 95% inclusion of available information on soil capability in model-based decision making by 2030.”

- **Noah-MP**

```plaintext
! Options for dynamic vegetation:
! 1 -> off (use table LAI; use FVEG = SHDFAC from input)
! 2 -> on (together with OPT_CRS = 1)
! 3 -> off (use table LAI; calculate FVEG)
! 4 -> off (use table LAI; use maximum vegetation fraction)

INTEGER :: DVEG ! = 4 !

! Options for canopy stomatal resistance
! 1-> Ball-Berry; 2->Jarvis

INTEGER :: OPT_CRS != 1 ! (must 1 when DVEG = 2)

! Options for soil moisture factor for stomatal resistance
! 1-> Noah (soil moisture)
! 2-> CLM (matric potential)
! 3-> SSiB (matric potential)

INTEGER :: OPT_BTR ! = 1 ! (suggested 1)

! Options for runoff and groundwater
! 1 -> TOPMODEL with groundwater (Niu et al. 2007 JGR);
! 2 -> TOPMODEL with an equilibrium water table (Niu et al. 2005 JGR);
! 3 -> original surface and subsurface runoff (free drainage)
! 4 -> BATS surface and subsurface runoff (free drainage)
! 5 -> Miguez-Macho&Fan groundwater scheme (Miguez-Macho et al. 2007 JGR, lateral flow: Fan et al. 2007 JGR)
```

★ Thousands of combinations!!
Background

• Land surface variables → important lower boundary conditions of the atmospheric system
• Surface sensible and latent heat fluxes → input for atmospheric models
Background

- Effect of soil moisture on the trajectory of air pollution

Quintanar et al., 2008, 2009
Limitations

1. The model uses a look up table for important soil properties and the values were not representative for Texas

2. Assumes 2-m deep uniform soil texture
Revised Soil Parameter Table

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<th>BB</th>
<th>DRYSMC</th>
<th>F11</th>
<th>SATSMC</th>
<th>REFSMC</th>
<th>SATPSI</th>
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</table>

118 out of 190 (62%) were significantly different for soils from Texas
Default vs. Revised

- Example: Field Capacity and Permanent Wilting Point

![Graph showing the comparison between default and revised field capacity and permanent wilting point for different soil types.](image-url)
Default vs. Revised

➢ Potential Plant Available Water

![Graph showing Default vs. Revised Potential Plant Available Water](image-url)
Simulation Comparisons

1. Default + Uniform 2-m deep soil
2. Revised + Uniform 2-m deep soil
3. Revised + Soil layering information

- Water Balance
- Energy Partitioning
- Soil water content

- Two Locations
  - East Texas (deep clay pan)
  - Central Texas (shallow soil)
Change in Water Balance

East Texas Clay Pan

Central Texas Shallow Soil

Default        Revised        Revised + Hetrog

Transpiration  Direct evaporation  Canopy interception  
Surface runoff  groundwater runoff  Δ in soil water storage

Photo by Jason Ackerson

www.cals.uidaho.edu/soilorders/i/Incept_03b.jpg
ENERGY: Latent vs. Sensible Heat

East Texas Clay Pan

Photo by Jason Ackerson
ENERGY: Latent vs. Sensible Heat

Central Texas Shallow Soil

- Revised + Heterogeneous
- Revised
- Default

Total latent heat (W m$^{-2}$) vs. Total sensible heat (W m$^{-2}$)
Soil water content for the top 1m – East Texas

**Default + Homogeneous**

<table>
<thead>
<tr>
<th>Noah-MP vs.</th>
<th>RMSE</th>
<th>NSE</th>
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</thead>
<tbody>
<tr>
<td>measurement</td>
<td>0.076</td>
<td>0.20</td>
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</table>

**Revised + Homogeneous**

<table>
<thead>
<tr>
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<th>RMSE</th>
<th>NSE</th>
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</thead>
<tbody>
<tr>
<td>measurement</td>
<td>0.098</td>
<td>-0.32</td>
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</table>

**Revised + Heterogeneous**

<table>
<thead>
<tr>
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<th>RMSE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>measurement</td>
<td>0.051</td>
<td>0.64</td>
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</table>
Conclusion

• Improving soil parameter table and considering soil heterogeneity significantly changes simulations of the water balance and energy partitioning

• Incorporating better soil information improved model prediction of soil water content

• Soil water content simulations by different models were comparable for an improved soil information case

• To achieve the goal of 95% inclusion of soil information in models, continuous communication between soil scientists and modelers is crucial
  
  • Continue field observations and improve mapping
  
  • Physics of many equations need to be updated
Research in-progress
and questions for the group

- Extend the enhancement to a more spatially-explicit description of the surface energy and water fluxes.
  → Validation dataset?

- Quality of dataset from observatory systems
  → Include soil type in the QAQC algorithms to bound observations?