Fusing High Resolution, Physically-Based Models and Remote Sensing to Understand and Predict Water Fluxes and Stocks

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Outline

1. Improving hyper-resolution modeling for watershed predictions.
2. Hydrologic effects of forest disturbance
3. Real-time river flood forecasting
4. Soil moisture and ET processes
5. Bathymetry and surface water storage using smart sampling systems
• Need for process-based modeling constantly remarked in journal opinion papers.
• Distributed and continuous.
• Topography, land cover and soils types.
• Coupled vadose and saturated zones.
• Runoff mechanisms and channel routing.
• Water and energy balance.
• Snow processes

TRIBS: Tin-based Real-time Integrated Basin Simulator
Table II. Hydrologic components of the tRIBS distributed hydrologic model

<table>
<thead>
<tr>
<th>Model process</th>
<th>Description</th>
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<tr>
<td>Rainfall interception</td>
<td>Canopy water balance model</td>
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<td>Surface energy balance</td>
<td>Combination equation (λ,E), gradient method (H) and force-restore equation (G)</td>
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<td>Surface radiation model</td>
<td>Short-wave and long-wave components accounting for terrain variability</td>
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<td>Evapotranspiration</td>
<td>Bare soil evaporation, transpiration and evaporation from wet canopy</td>
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<td>Infiltration</td>
<td>Kinematic approximation with capillarity effects; unsaturated, saturated and perched conditions; top and wetting infiltration fronts</td>
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<td>Lateral vadose flow</td>
<td>Topography-driven lateral unsaturated and saturated vadose flow</td>
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<td>Runoff production</td>
<td>Infiltration-excess, saturation-excess, perched return flow and groundwater exfiltration</td>
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<td>Groundwater flow</td>
<td>Two-dimensional flow in multiple directions, dynamic water table</td>
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<td>Overland flow</td>
<td>Nonlinear hydrologic routing</td>
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<tr>
<td>Channel flow</td>
<td>Kinematic wave hydraulic routing</td>
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</tbody>
</table>
What are the spatially distributed hydrologic effects of forest thinning?

- **Projected Change**
  - Average Runoff Rate, \( R_{\text{proj}} \) (mm/h)
  - Vadose Zone Soil Moisture, \( \theta_{\text{proj}} \) (-)
  - Evapotranspiration, \( ET_{\text{proj}} \) (mm/y)
  - Longest Number of Days of Continuous Snow Cover, \( NDS_{\text{proj}} \) (days)
  - Maximum Season SW, \( SW_{\text{proj}} \), \( SW_{\text{max,proj}} \) (mm)

- **Reference case**
  - Average Runoff Rate, \( R_{\text{ref}} \) (mm/h)
  - Vadose Zone Soil Moisture, \( \theta_{\text{ref}} \) (-)
  - Evapotranspiration, \( ET_{\text{ref}} \) (mm/y)
  - Longest Number of Days of Continuous Snow Cover, \( NDS_{\text{ref}} \) (days)
  - Maximum Season SW, \( SW_{\text{ref}} \), \( SW_{\text{max,ref}} \) (mm)

- Changes:
  - Local runoff increases
  - Soil moisture and ET mixed patterns
  - Days with snow cover reduced between 1 and 60 days
  - Max. snow water reduced in 350 mm
Participatory modeling for water security
Radar nowcasts + tRIBS

TITAN

Nowcasting model
Thunderstorm Identification, Tracking, Analysis and Nowcasting

tRIBS: Tin-based Real Time Integrated Basin Simulator
What basin sizes are more predictable?

Flooding less predictable at Intermediate size basins (1-10% of total Area) as a result of an increased fraction of runoff producing zones.

Standard Error

$$S = \frac{Q_R}{A_c M A}$$

(a) $\mu(SE/SE_{\text{max}})$ Storm 2004
Virtual Mesonet Eddy-Covariance
Preliminary simulations at one eddy station

Latent heat flux

Soil surface temperature
Fusing L-band radiometers and observations to improve continuous and accurate modeling

**Figure 4.** Tempest UAS illustrating location of LDCR an MiCo antenna elements.

**Figure 5:** Google earth images overlay of LDCR retrieved VSM maps and in-situ measured VSM, data from (a) September 8\(^{th}\), (b) September 9\(^{th}\).

**Figure 7:** Land cover classification of IRF mapping area.
Lake and river bathymetry from UAS

Figure 3. Pix4D software outputs: Orthomosaic and corresponding Digital Elevation Model (DEM)
Figure 6. Bathymetry of Finn Creek 21 Reservoir using the single-beam echosounder. (a) Cumulative sampling points taken with the single-beam echosounder during August of 2017. (b) Bathymetric mapping built with the single-beam echosounder is shown.

Figure 8. Bathymetry of Finn Creek 21 Reservoir using UAS-SfM technique taken during August of 2017.