Improved simulation of snowpack and leaf area index through the dynamic vegetation model in Noah-MP V5: insight into current and future model developments

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Accurate representation of canopy is necessary to predict snow water equivalent (SWE)
Land surface models (LSMs) are powerful tools for simulating the coupled processes governing snow accumulation, melt, and redistribution, as well as vegetation growth, productivity, and water use (Niu et al., 2011; He et al., 2023).

Canopy cover in the LSMs can be represented by two parameters:

- Leaf area index (LAI)
- Maximum green vegetation fraction (MGVF)

LAI and MGVF can be dynamically calculated using vegetation carbon content, stomatal resistance, and soil carbon content.
Noah-MP, a state-of-the-art LSM has been setup for the exploring the impact of dynamic vegetation on the snow and leaf area index simulation.

Simulation has been set-up at 1 km spatial and hourly temporal resolution over two HUC-4 catchment in California.

We have used two sets of forcing data over both catchment which include National Water Model (NWM) retrospective forcing and NLDAS-2.

NLDAS-2 forcing data has been downscaled to 1km using the WRF-Hydro Meteorological Forcing Engine (MFE).

We have setup three kind of simulation using dynamic LAI, and combination of dynamic and gridded input MGVF.
### ACRONYMS

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<td>LAI</td>
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<td>MGVF</td>
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3 vegetation options × 2 forcing × 2 catchments = 12 simulations
Fig: 2. Precipitation downscaling.
Fig: 3. Temperature downscaling.
Fig: 4. SWE variations across different simulations.
Fig: 5. SWE at station locations using nearest neighborhood method.
Fig. 6. Simulated LAI under different dynamic vegetation configurations.
CANOPY SHADING DELAYS THE PEAK SNOWMELT

Fig: 7. Snowmelt variations across different simulations.
Fig: 8. Seasonal and ephemeral snow cover simulation under NLDAS2 forcing.
Fig: 9. Seasonal and ephemeral snow cover simulation under NWM (AORC) forcing.
GRIDDED OBSERVATIONS ARE INCONSISTENT OVER HIGHER ALTITUDE

Fig: 10. SWE variations across different altitude.
Conclusion

- Dynamic vegetation improves the SWE and LAI over California.
- These improvement accounts up to 20-30% of daily snow water equivalent
- NWM Retrospective forcing underestimates the precipitation over California.

Perspective

- Running RAPID model to evaluate the impact of dynamic vegetation on streamflow generation.
- Demonstrate the role of dynamic vegetation on runoff, evapotranspiration and soil moisture flux partitioning.
- Implement the dynamic root uptake model to further improve the LAI and flux partitioning (Niu et al., 2020).
• Representing the fractional frozen soil permeability (Agnihotri et al., 2023; WRR).
• Representing the dual permeability (macro pores and micro pores) for enhanced preferential flow (Farmani et al., 2024; HESSD).
• Representing the surface ponding depth to capture the peak flows (Farmani et al., 2024; HESSD).