# 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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# INTRODUCTION



*Snow storage and redistribution*

↓

*Snow seasonality*

*Albedo and radiation budget*

↓

*Runoff generation*

- Accurate representation of canopy is necessary to predict snow water equivalent (SWE)

# REPRESENTING THE VEGETATION IN EARTH SYSTEM MODELS

- Land surface models (LSMs) 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 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.

# DOMAIN DISCRETIZATION AND SIMULATION SETUP



- 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.

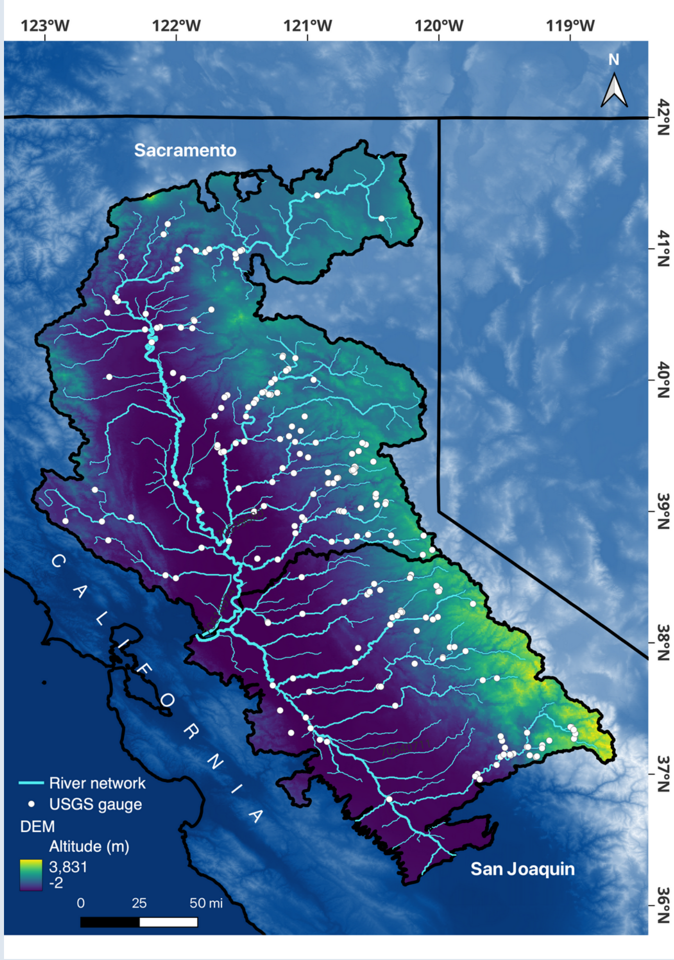


Fig: 1. Study Area

# SIMULATION PLAN

| ***ACRONYMS*** | DynVeg_Off | DynVeg_STR | DynVeg_GVF |
|---|---|---|---|
| LAI | Look up table | Dynamic | Dynamic |
| MGVF | Monthly climatology | Monthly climatology | Dynamic |

3 vegetation options × 2 forcing × 2 catchments = 12 simulations

# PRECIPITATION DOWNSCALING USING PRISM DATA

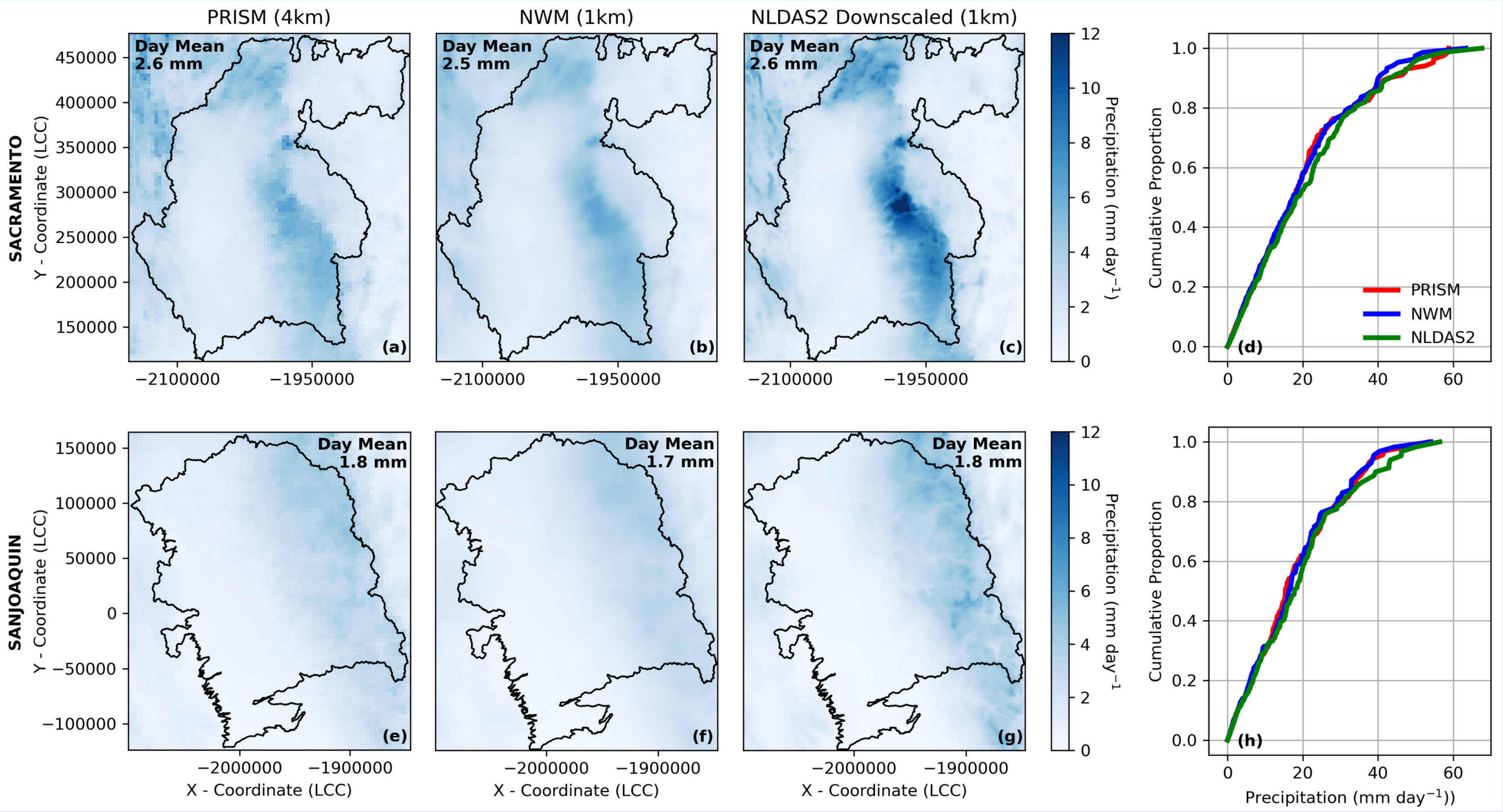


Fig: 2. Precipitation downscaling.

# TEMPERATURE DOWNSCALING USING NCAR LAPSE RATE

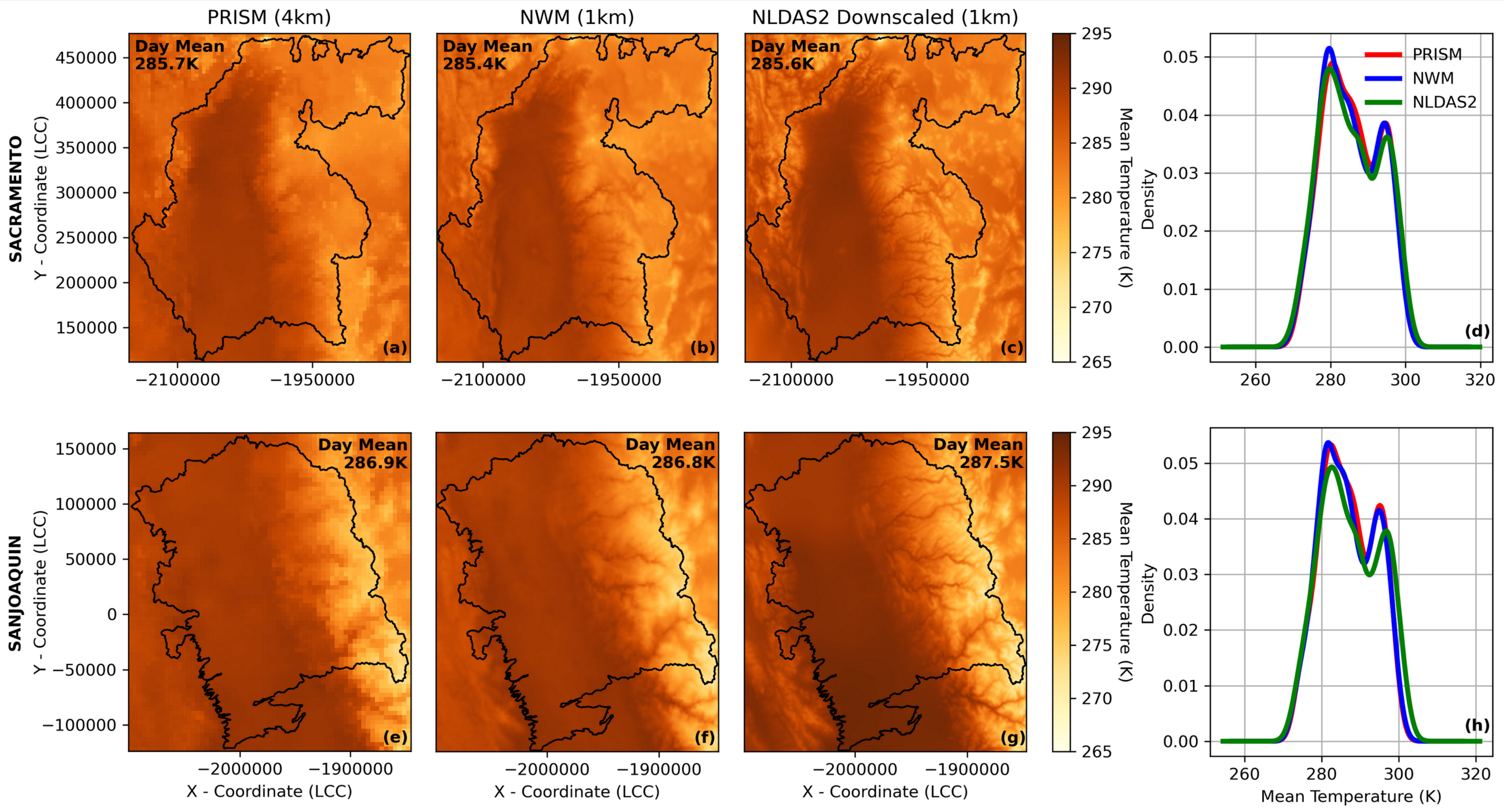


**Fig: 3. Temperature downscaling.**

# SWE SENSITIVITY TOWARDS DYNAMIC VEGETATION AND PRECIPITATION



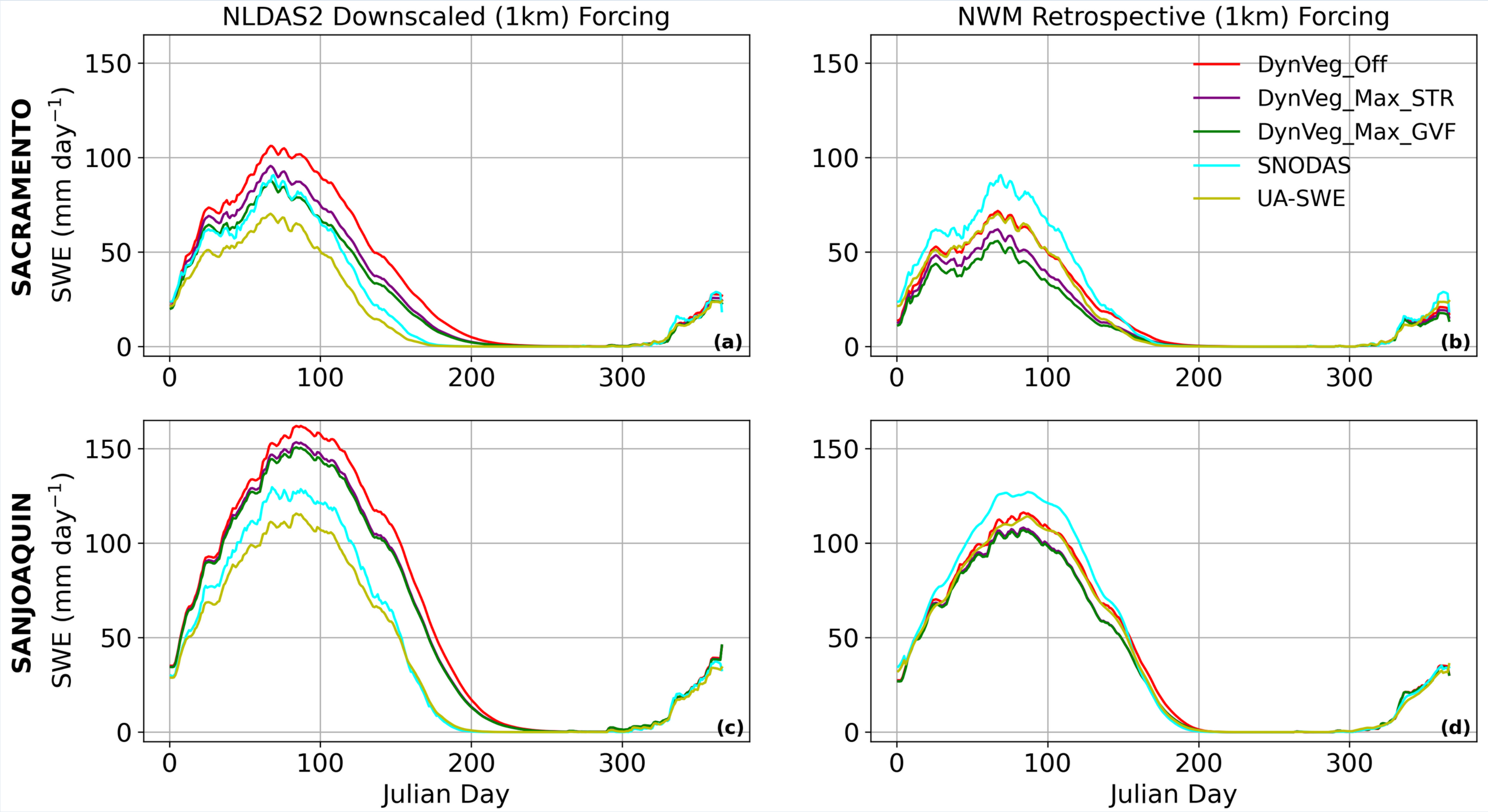


**Fig: 4. SWE variations across different simulations.**

# SWE COMPARISON AT CDWR STATIONS SITES IN CALIFORNIA

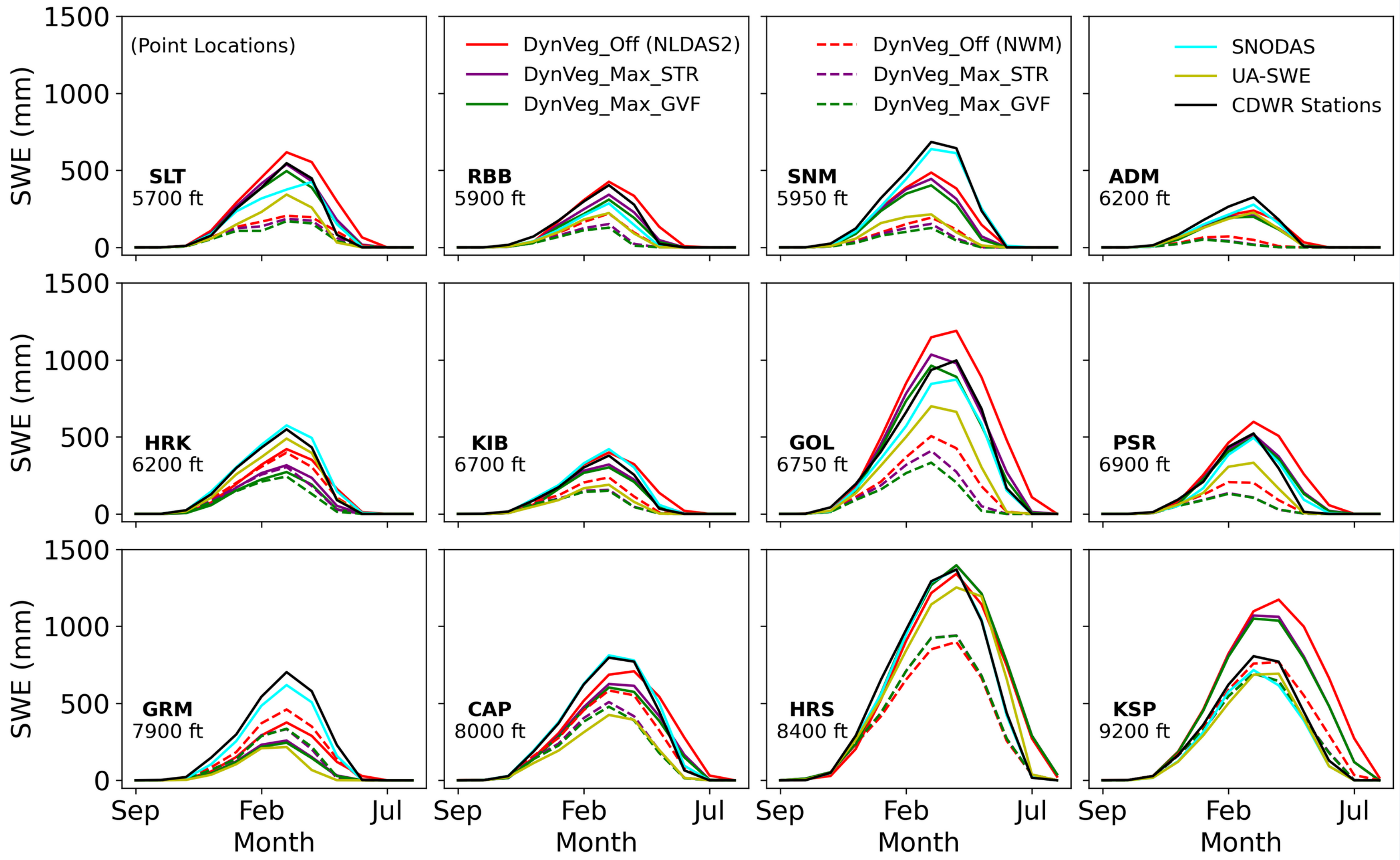


Fig: 5. SWE at station locations using nearest neighborhood method.

# DIFFERENCE IN SWE IS THE RESULT OF CANOPY INTERCEPTION/SHADING

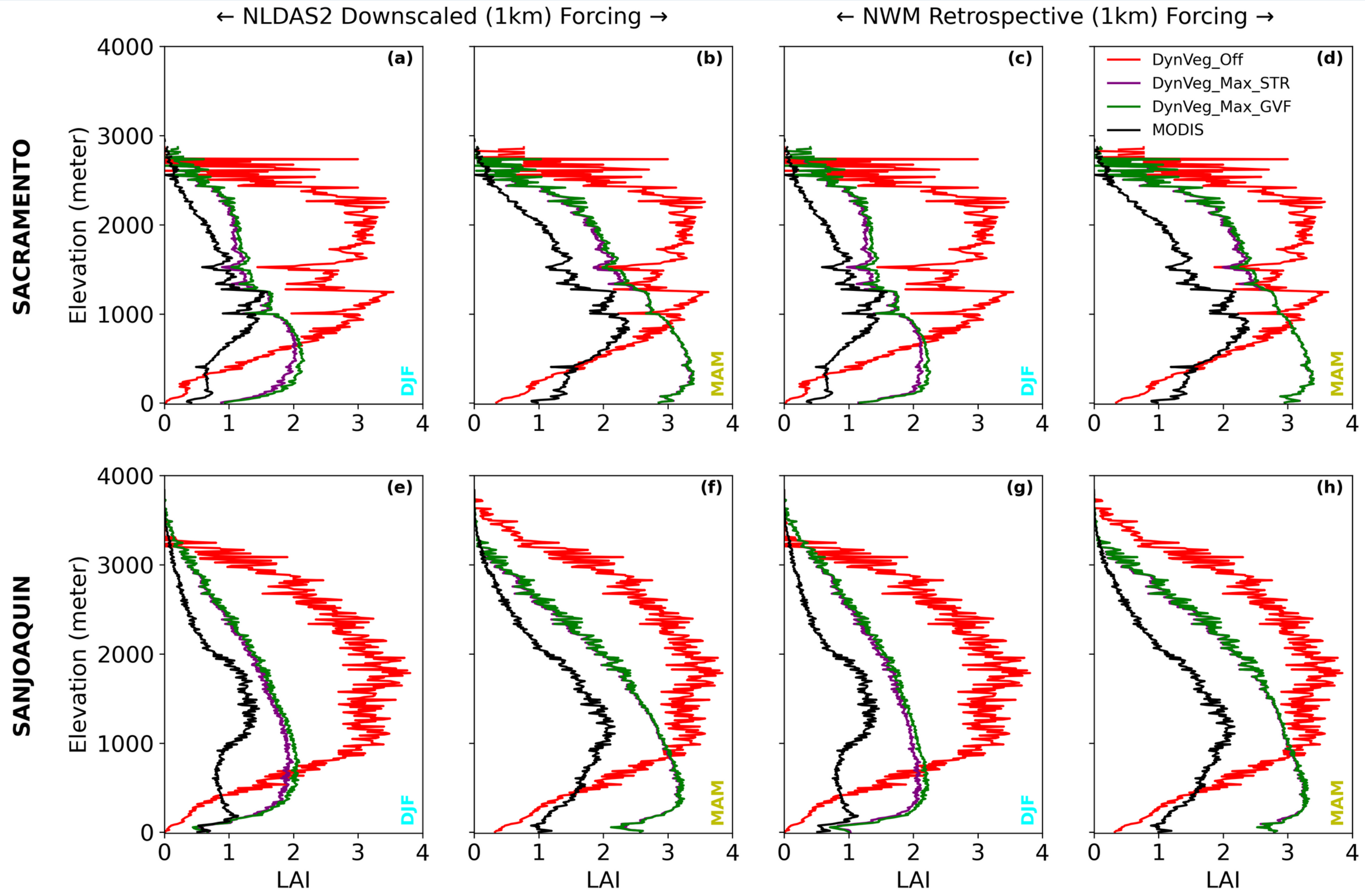


**Fig: 6. Simulated LAI under different dynamic vegetation configurations.**

# CANOPY SHADING DELAYS THE PEAK SNOWMELT

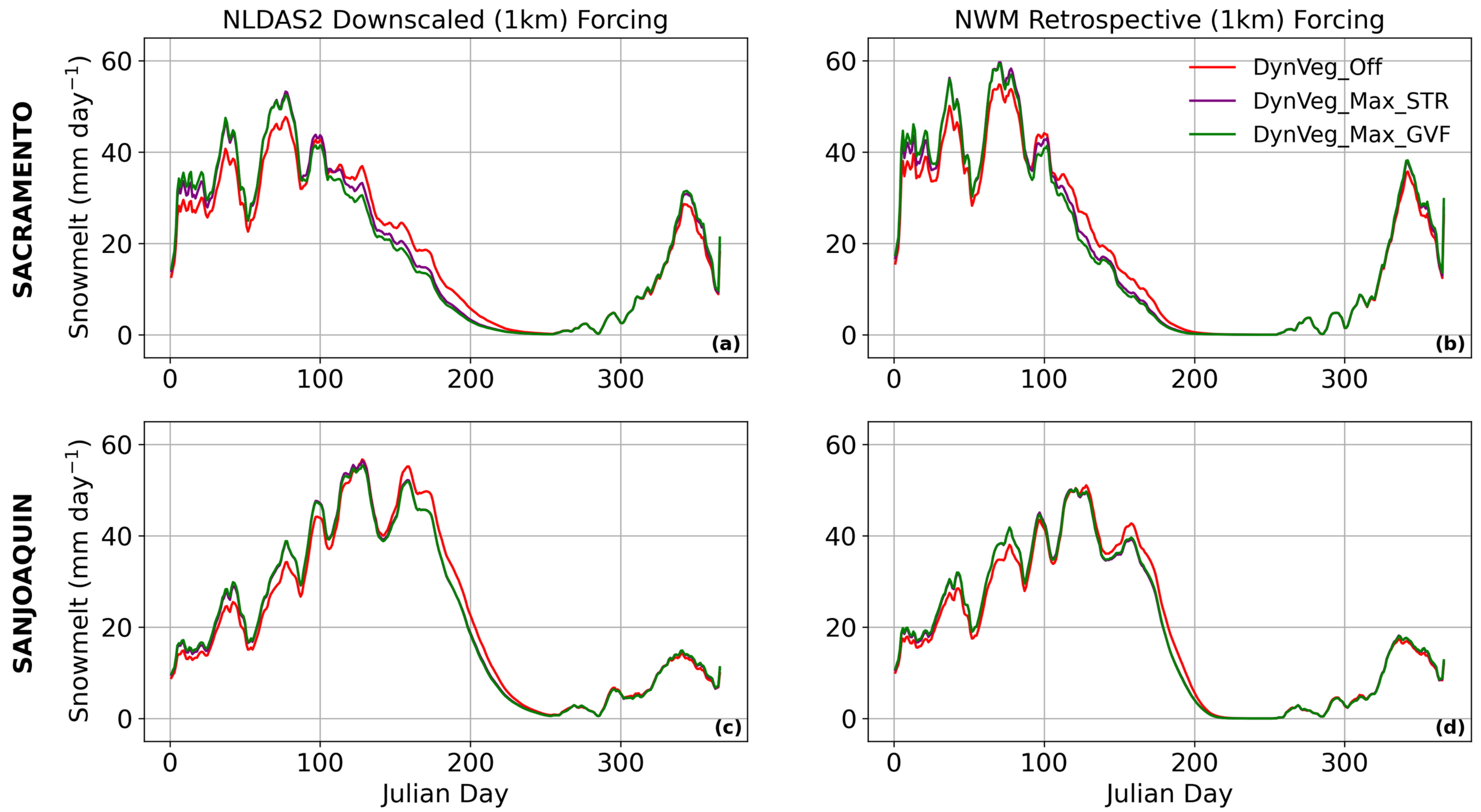


**Fig: 7. Snowmelt variations across different simulations.**

# IMPACT OF DYNAMIC VEGETATION ON SEASONAL/EPHEMERAL SNOW COVER

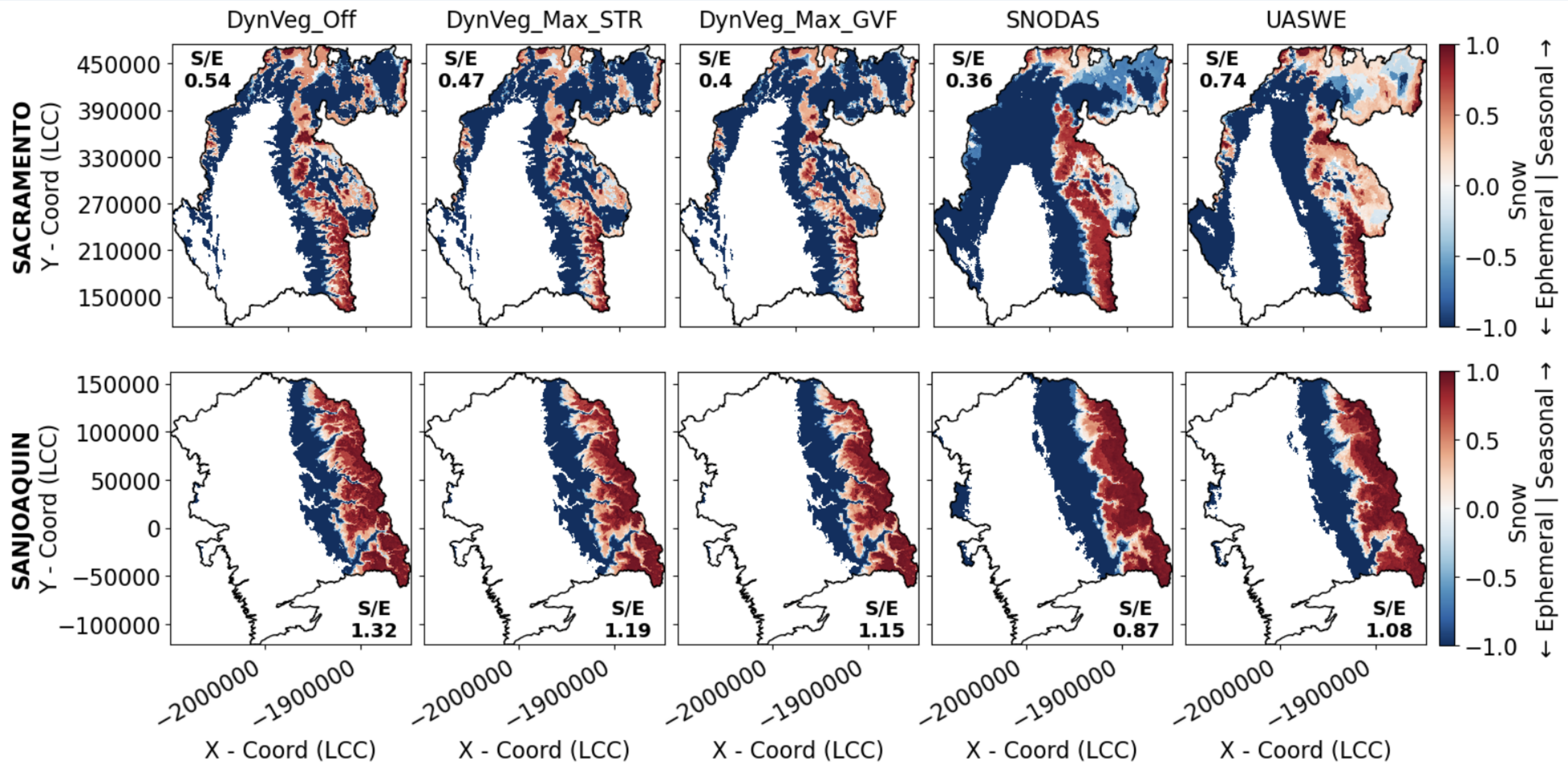


**Fig: 8. Seasonal and ephemeral snow cover simulation under NLDAS2 forcing.**

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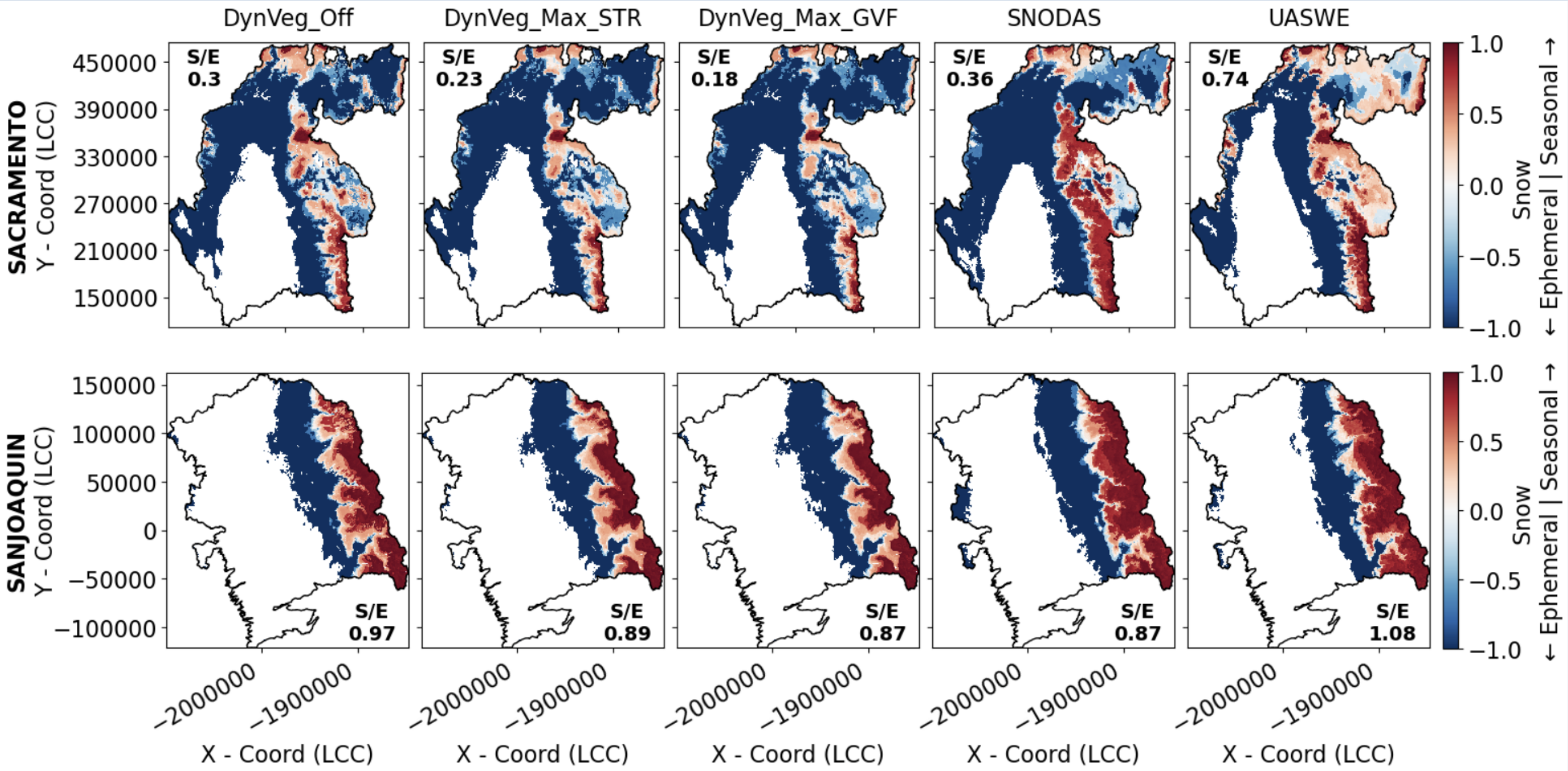


**Fig: 9. Seasonal and ephemeral snow cover simulation under NWM (AORC) forcing.**

# GRIDDED OBSERVATIONS ARE INCONSISTENT OVER HIGHER ALTITUDE

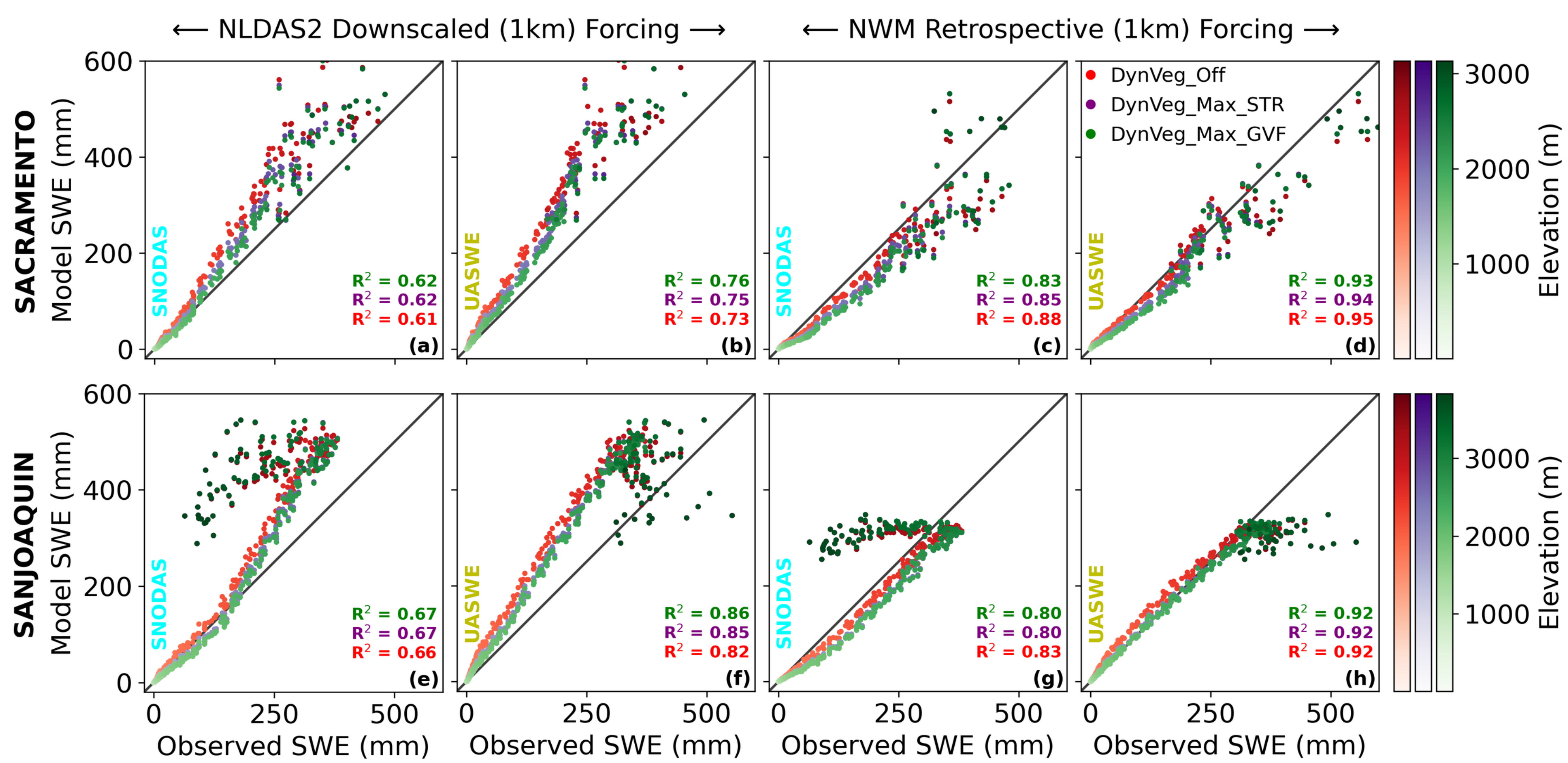


**Fig: 10. SWE variations across different altitude.**

# CONCLUSION AND PERSPECTIVE

**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).

# ONGOING MODEL DEVELOPMENT TO BE INCLUDED IN NOAH-MP V5

- 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).