MODEX Approach to Diagnose and Improve Snow Processes and Phenology in E3SM Land Model (ELM) in Northern High-Latitude Regions

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Project: NGEE Arctic
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In high-latitude Arctic, modeling land surface processes, e.g. snow, relevant phenology, and consequent soil and plant responses are of great challenge in Earth System, mostly due to highly heterogeneous surface across scales and lacking reliable data in those remote and harsh regions. In this study, we present an offline land surface simulation using Energy Exascale Earth System Model's (E3SM) Land Model (ELM) over northern high-latitude regions (>=60ºN) at half- degree spatial resolution. This offline ELM is driven by GSWP3 (Global Soil Wetness Project Phase 3) v2 forcing data from 1901-2015. Model results are evaluated using ILAMB tool package and NCAR Land Diagnosis Tools (as shown on https://elm-ngee-webserver.ornl.gov). Improvement aiming to high resolution pan-Arctic modeling via model development and experiment data integration (MODEX) are explored in NGEE Arctic Project. By using ILAMB tools and available datasets, we find that ELM simulation of vegetation LAI and total soil organic matter (SOM) remarkably well, but still mismatch both spatially and temporarily.
Severe under-estimation of LAI (and thus SOM) and phenological shifts apparently exists in Northeastern Siberian Russia and Northeastern Canada. Regional analysis by NCAR Land Diagnosis Tools reveals that such bias can be tracked back to both snow-fall data in model forcing, e.g. heavy or extended winter snowing, and model snow processes and consequent phenology. Station-level snowfall and snow depth observations at VanKarem, Northeastern Siberian Russia, for an example, demonstrated that snowfall in GSWPv2 forcing data could be too high, which caused ELM snow melt lasting until mid-July and thus short growing seasons especially for heavy-snowing winters. At another exampled station at Alert, Canada, historical air temperature and snowfall are comparable to GSWPv2 forcing, but ELM simulated much deep snow and very short snow-free period compared to the observed. Initial tests show that snowfall adjustments and ELM snow or phenology modification can improve model performance in relevant regions. It implies that both data integration and model development and assessments are critical to further improve ELM performance in pan-Arctic.