Drought Replication Skill using Noah-MP and Observed Vegetation

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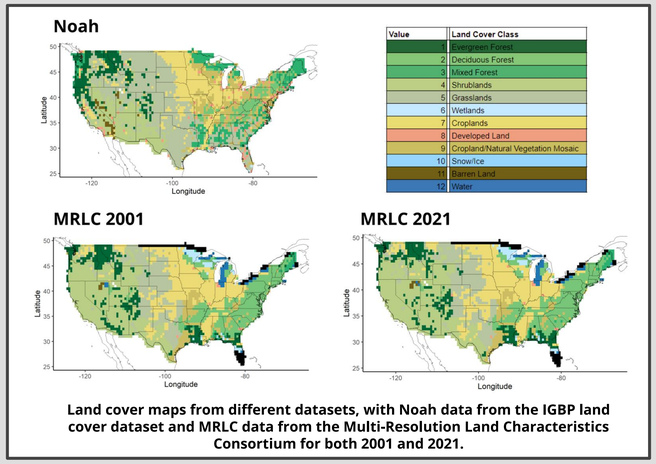
Motivation and Methods



Land cover maps from different datasets, with Noah data from the IGBP land cover dataset and MRLC data from the Multi-Resolution Land Characteristics Consortium for both 2001 and 2021.

Research Questions:

- Is vegetation cover in the continental US different in the Noah-MP land-surface model from what is observed with the Multi-Resolution Land Characteristics (MRLC) dataset?
- How does this difference in land cover affect drought replication skill of the Noah-MP model to match the USDM?

Hypothesis:

With more changes in land cover, there will be greater differences in the skill of the USDM to accurately classify droughts.

Category	Description	Example Percentile Range for Most Indicators
None	Normal or wet conditions	30.01 or Above
D0	Abnormally Dry	20.01 to 30.00
D1	Moderate Drought	10.01 to 20.00
D2	Severe Drought	5.01 to 10.00
D3	Extreme Drought	2.01 to 5.00
D4	Exceptional Drought	0.00 to 2.00

Soil Moisture Percentile values (right) have corresponding USDM categories (left), which were used to classify observed droughts in order to compare the two.

- Replicating USDM drought categorizations using Soil Moisture Percentile (SMP) values from Noah-MP land-surface model using observed meteorology from 2000 to 2019
- Using Heidke Skill Score (HSS) and Probability of Detection (POD) to assess model skill, determining how well the USDM classified droughts compared to true SMP values over the same area
  - Calculated how well the Noah-MP model replicated USDM using the following criteria: 1) drought or no drought, 2) exact category of a drought, and 3) within ±1 category of the observed drought conditions
- Comparing POD and HSS of drought detection skill over different areas of land cover

Recorded USDM		Observed USDM from SMP: Drought	Observed USDM from SMP: No Drought
	Drought	Hit	False Alarm
	No Drought	Miss	Correct Rejection

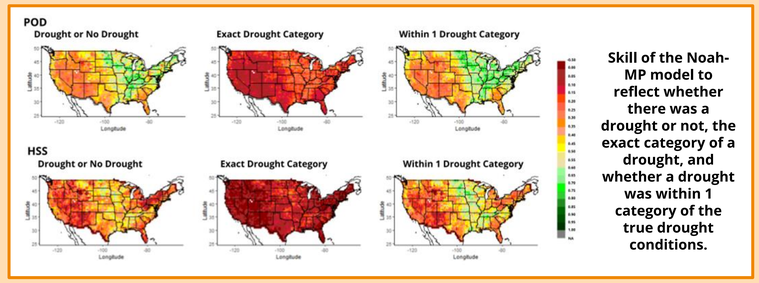
$$POD = \frac{hits}{hits + misses}$$

$$HSS = \frac{(hits + correct\ rejections) - (expected\ correct)_{random}}{N - (expected\ correct)_{random}}$$

$$(expected\ correct)_{random} = \frac{1}{N}[(hits + misses)(hits + false\ alarms) + (correct\ rejections + misses)(correct\ rejections + false\ alarms)]$$

A contingency table was used to calculate POD and HSS for each of the conditions using observed drought categories and actual USDM categories.

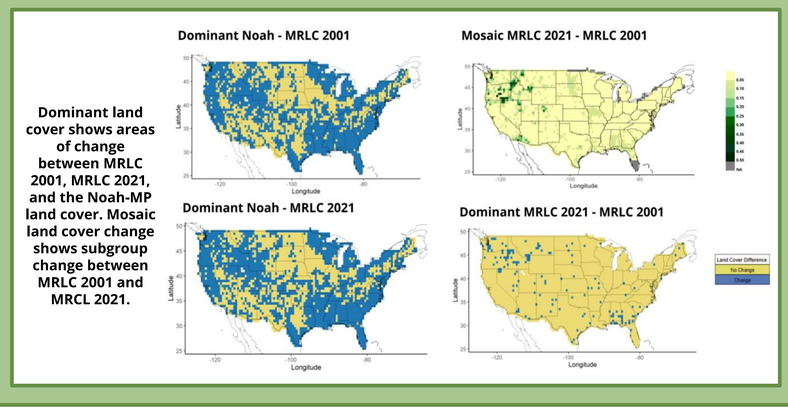
Model Performance



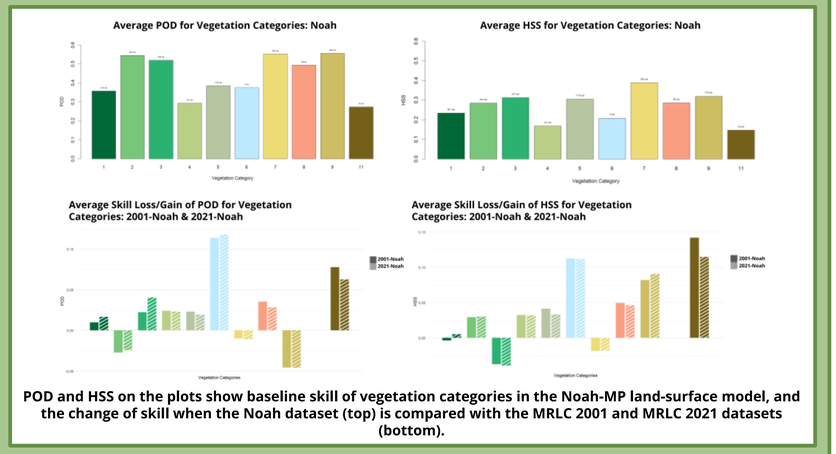
Skill of the Noah-MP model to reflect whether there was a drought or not, the exact category of a drought, and whether a drought was within 1 category of the true drought conditions.

- Model shows skill at replicating drought, particularly over the Central US and Mississippi River Basin
- More strict criteria leads to reduced skill, but model shows best skill when allowing for one classification category of error

Land Cover



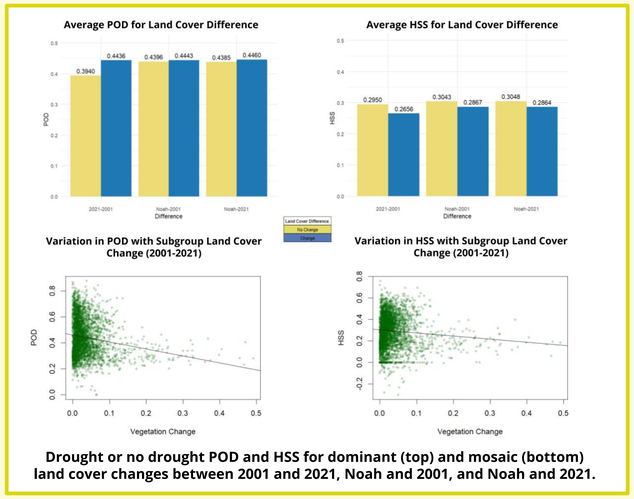
Dominant land cover shows areas of change between MRLC 2001, MRLC 2021, and the Noah-MP land cover. Mosaic land cover change shows subgroup change between MRLC 2001 and MRCL 2021.



POD and HSS on the plots show baseline skill of vegetation categories in the Noah-MP land-surface model, and the change of skill when the Noah dataset (top) is compared with the MRLC 2001 and MRLC 2021 datasets (bottom).

- Statistically significant differences in both POD and HSS when comparing among different vegetation categories in the Noah-MP land-surface model and the MRLC data
- Statistically significant differences in POD and HSS when comparing the Noah-MP model to the MRLC dataset

Discussion



Drought or no drought POD and HSS for dominant (top) and mosaic (bottom) land cover changes between 2001 and 2021, Noah and 2001, and Noah and 2021.

- Dominant Land Cover Difference:
  - No significant difference in POD between areas of land cover change when comparing to areas of no change between the Noah-MP land-surface model and MRLC datasets
  - Statistically significant difference in POD over areas of land cover change when comparing 2001 and 2021 of the MRLC dataset; areas of change having a significantly lower POD
  - Statistically significant difference in HSS over areas of land cover change when comparing 2001 and 2021 of the MRLC dataset; areas of change having a significantly lower HSS
- Subgroup Land Cover Difference:
  - Weak negative linear relationship between sub-grid heterogeneity changes and POD as well as HSS for drought or no drought skill
    - More subgroup land cover change is weakly correlated with a lower skill score

Conclusions

- When validated with SMP values, the Noah-MP drought categorizations were most accurate in reflecting a drought within one category of the observed drought conditions, with a drop in accuracy in reflecting exact drought category, and a subsequent increase in accuracy for reflecting whether or not there was a drought
- For all three vegetation cover datasets, different land cover classes showed significantly different drought detection skill, with the highest skill being in areas of cropland
- Land cover change affected USDM drought detection skill measured by both POD and HSS for changes between MRLC 2001 and MRLC 2021, showing decreased skill of drought detection in areas of change
  - There was a only statistically significant difference in skill over areas of land cover change between Noah and MRLC 2001/2021 when measured with HSS
  - Increased change was correlated with worse drought detection skill
- Overall, MRLC land cover classification showed improved drought detection skill when compared to the Noah-MP model

References & Acknowledgements

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