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Remote estimation of geologic composition using interferometric synthetic-aperture radar in California's Central Valley

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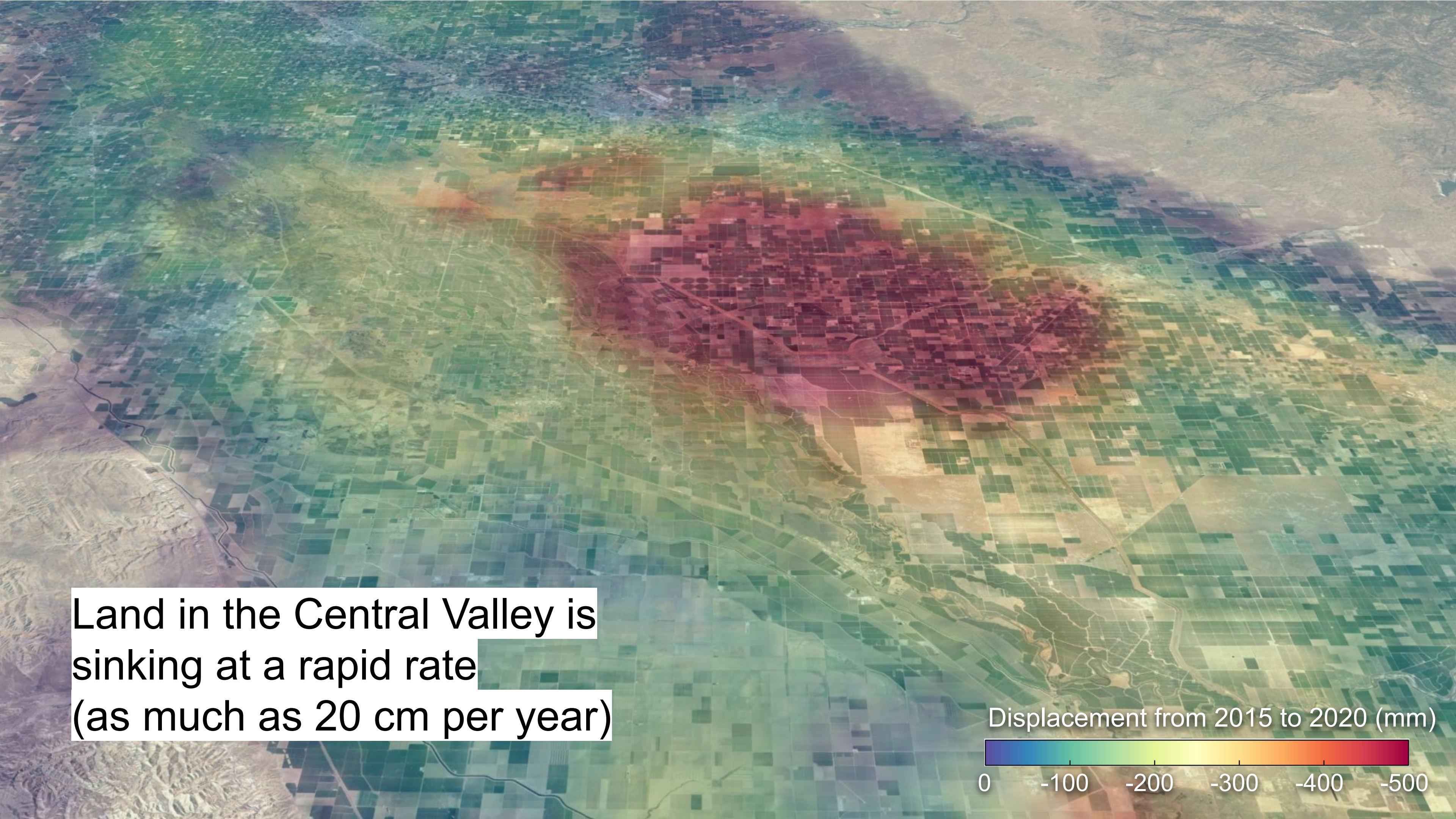
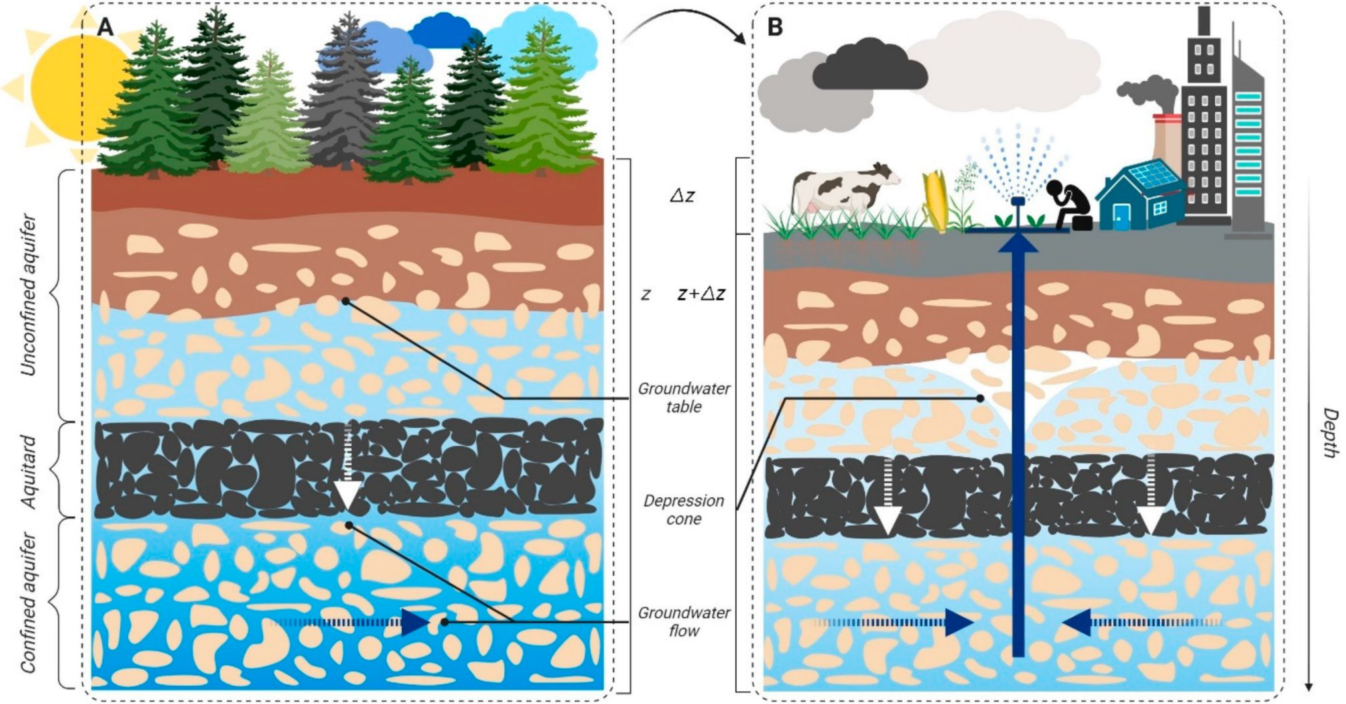
NeurIPS Tackling Climate Change with Machine Learning


Land in the Central Valley is
sinking at a rapid rate
(as much as 20 cm per year)
Displacement from 2015 to 2020 (mm)
0
-100
-200
-300
-400
-500

Land subsidence has a significant impact on groundwater sustainability



Guzy & Malinowska 2020

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Groundwater depth measurements are spatially and temporally sparse and irregular

https://www.usgs.gov/media/images/measuring-groundwater-level

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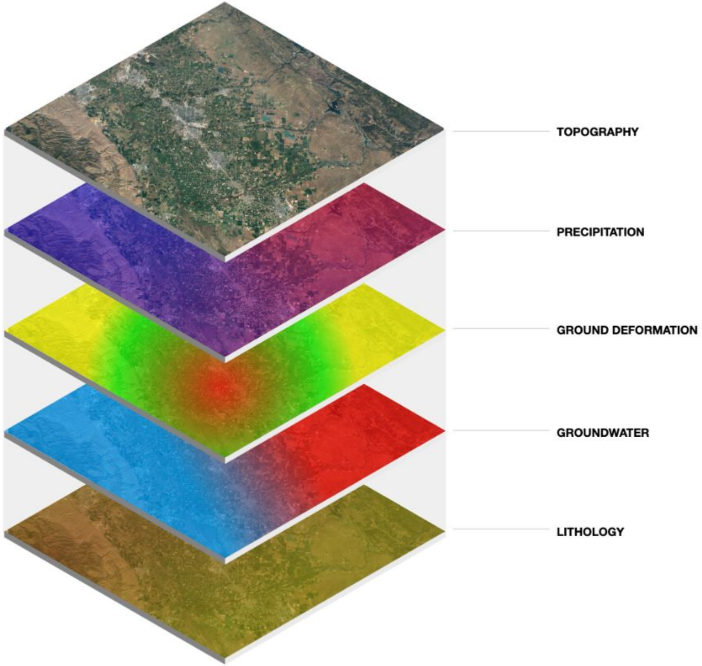
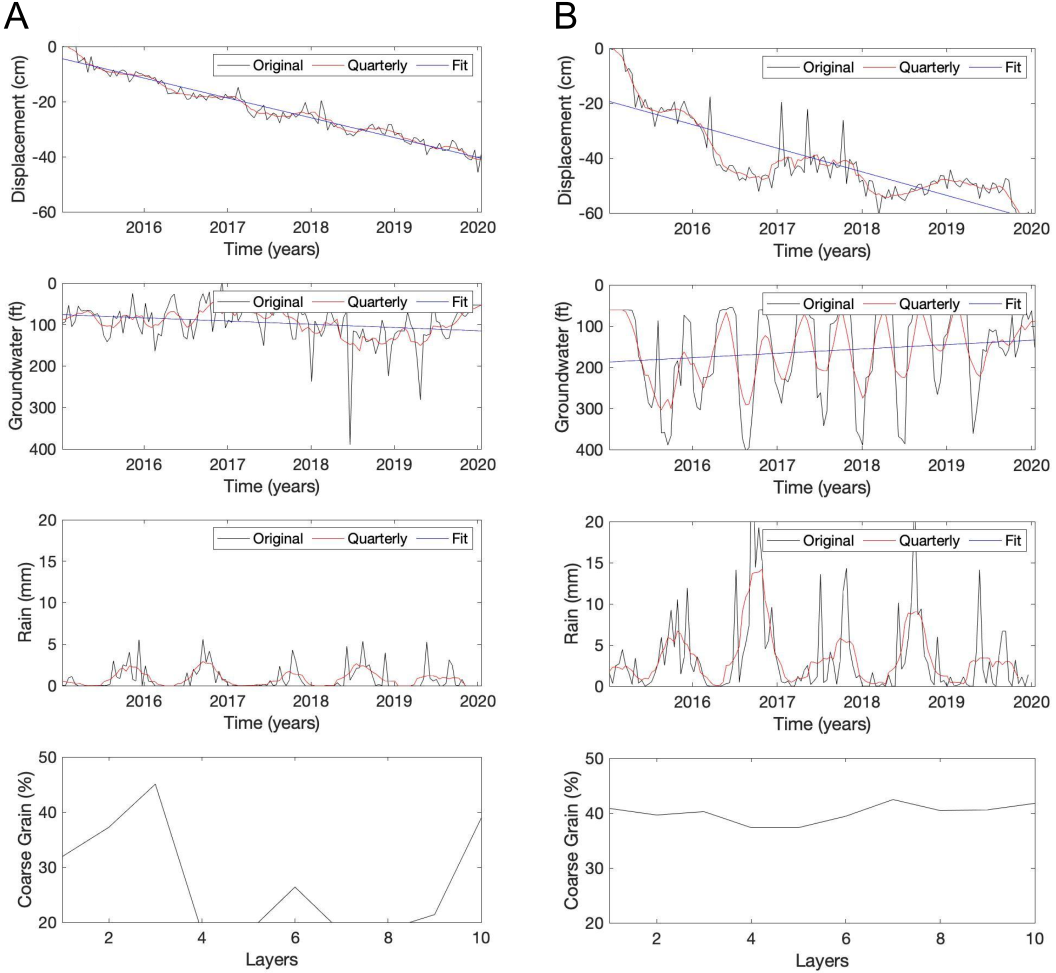
Regions with different temporal dynamics of land displacement





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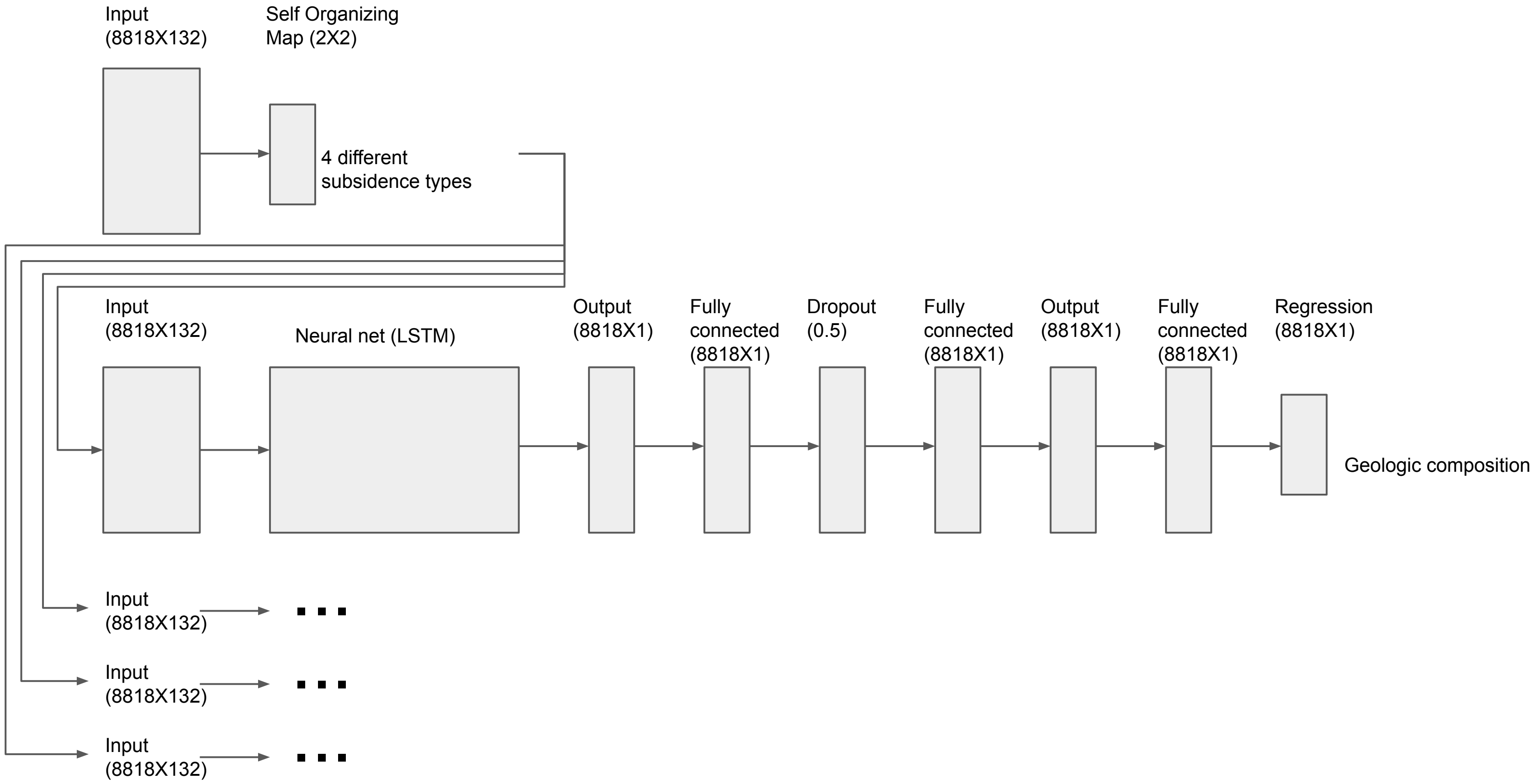
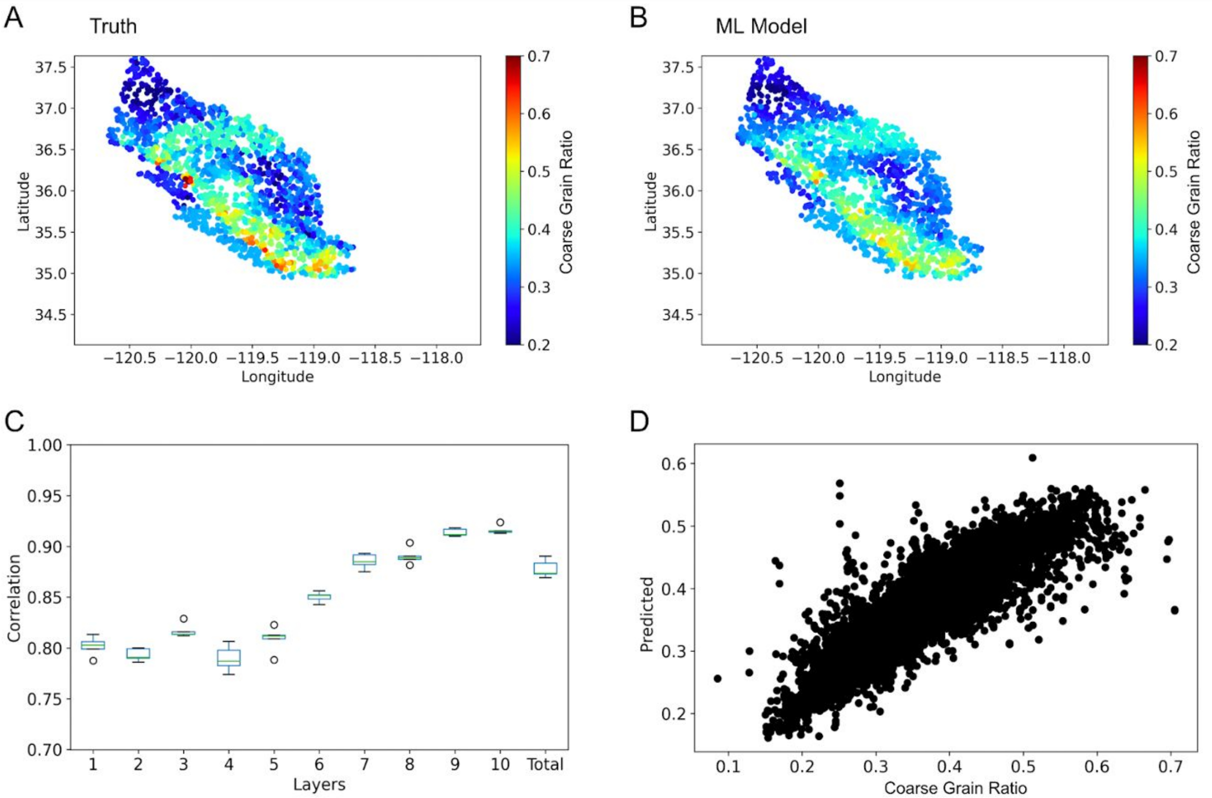
Model architecture: unsupervised + supervised LSTM (* 8818 locations, 132 time points)



Remote estimation of geologic composition: Temporal changes of land subsidence have predictive power for geologic composition



Geologic composition prediction using InSAR land deformation data.
(A) Ground truth coarse grain ratio of the entire layer and (B) estimated coarse grain ratio.
(C) Correlation between model output and ground truth at different layers of geologic composition.
(D) Scatter plot between the ground truth and estimated geologic composition of the entire layer (R=0.88).

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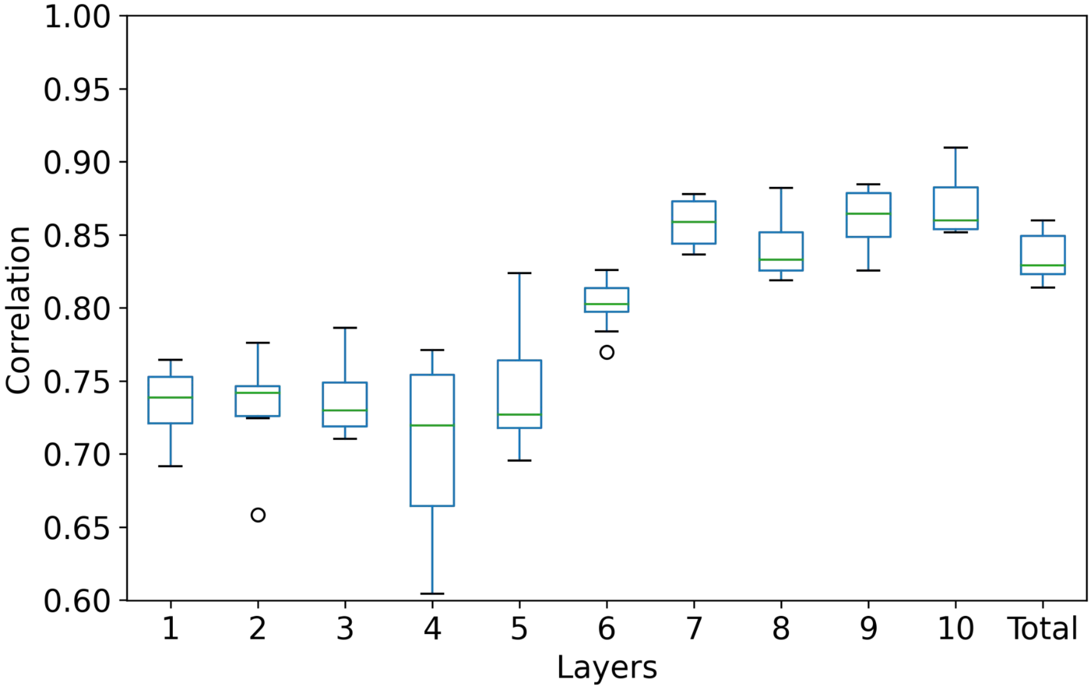
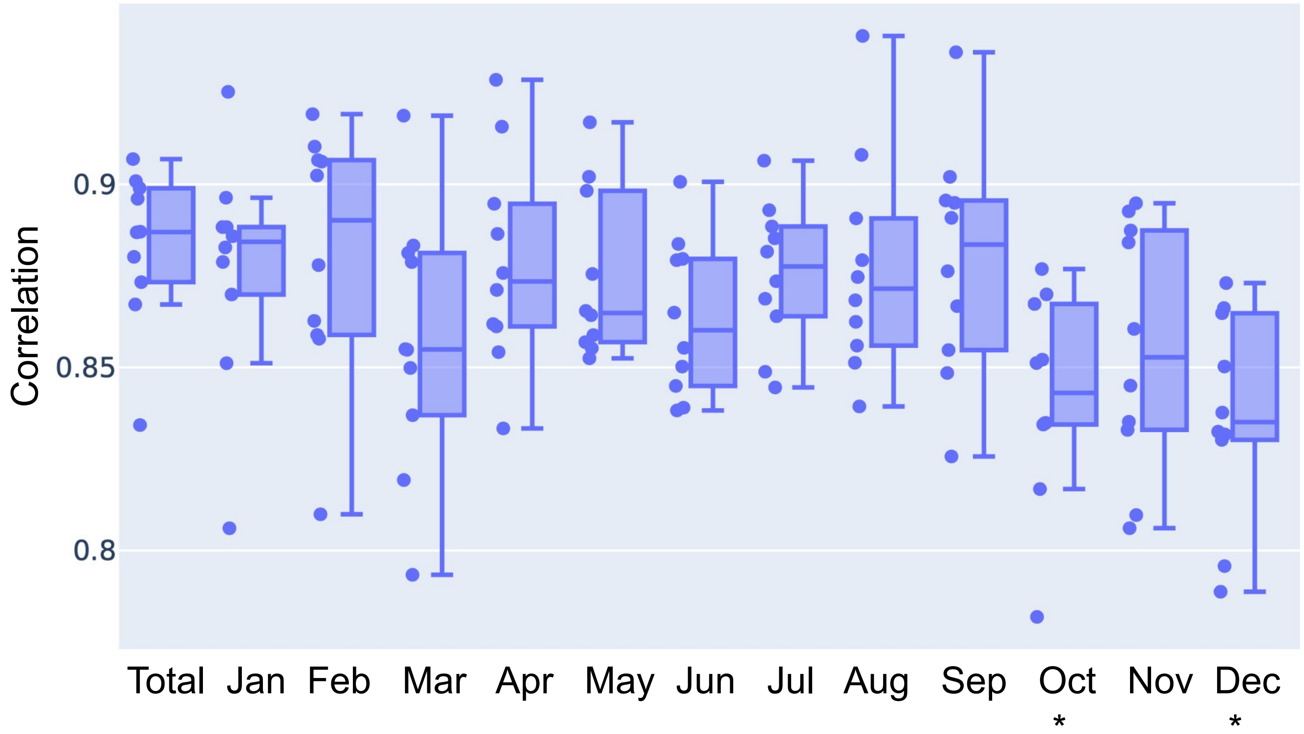
Geologic composition prediction with distant data sampling (minimum distance between samples was 10km) using InSAR land deformation data



- Distant data sampling was performed to reduce the impact of spatial correlation of adjacent data points.
- Total prediction performance dropped from 0.88 to 0.83, but remained largely unchanged.

Explainable Model: Which time of year contributed the most to the estimation? Leave-One-Month-Out Performance Test



- A significant decline in correlation in October and December (P<0.001)
- Most of the precipitation occurs in late autumn and winter
- Precipitation has influenced time-series changes in InSAR land deformation

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Conclusions & Next steps

- We showed that geological composition can be estimated remotely using InSAR land deformation data
- In-situ measurements of geological composition are critical to understanding hydrology and monitoring groundwater availability
- However, in-situ measurements are expensive and time consuming
- If geologic composition can be measured remotely using this model, high spatial resolution geologic composition can be quickly quantified only with InSAR satellites without in-situ measurements
- The next step is to apply this model to other regions, including US High Plains and North China Plains, to evaluate its generalizability