Subsurface Structure and Water Stores Beneath Giant Sequoias

Photo Cred: Sean Markle

Authors

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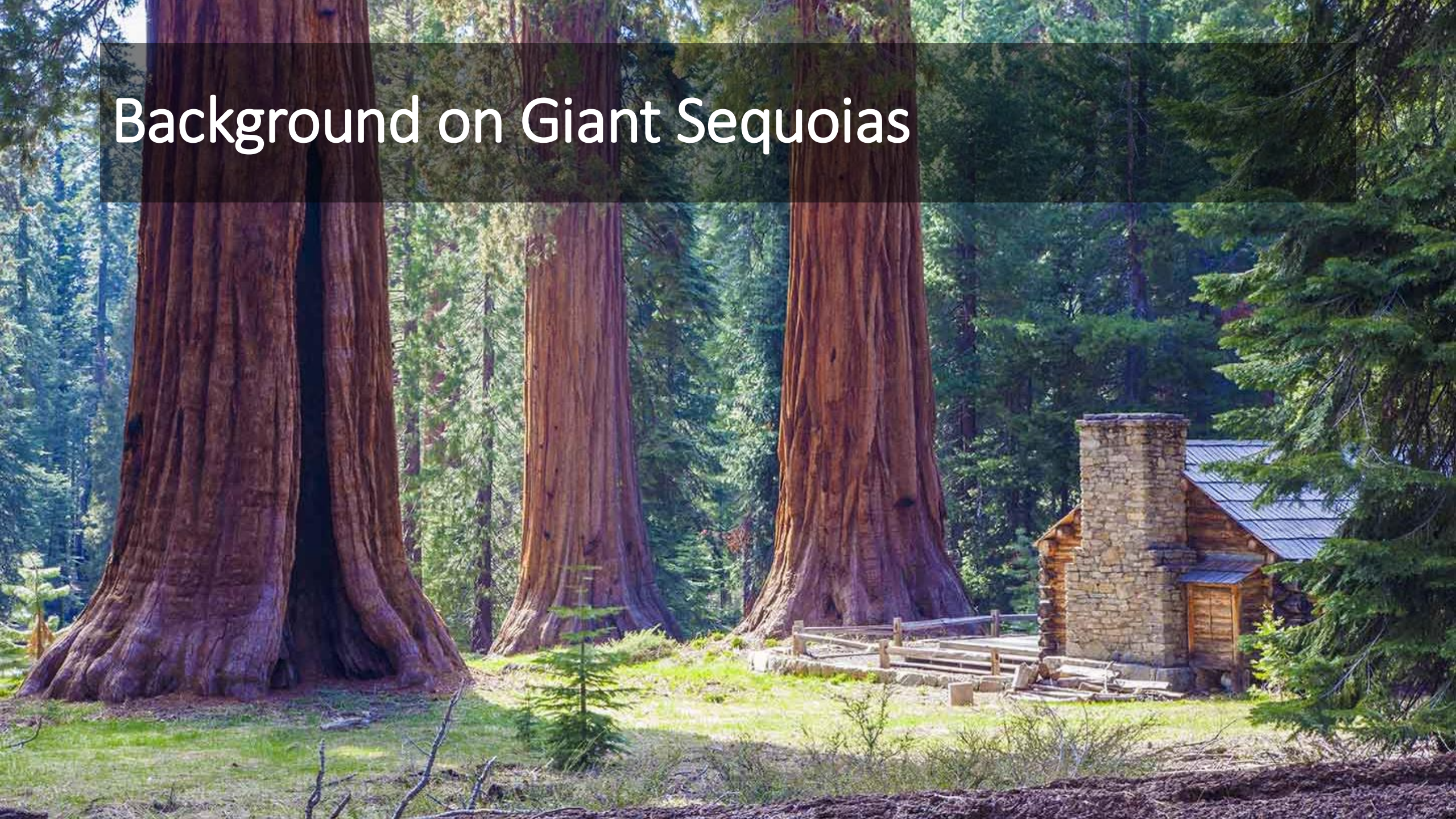
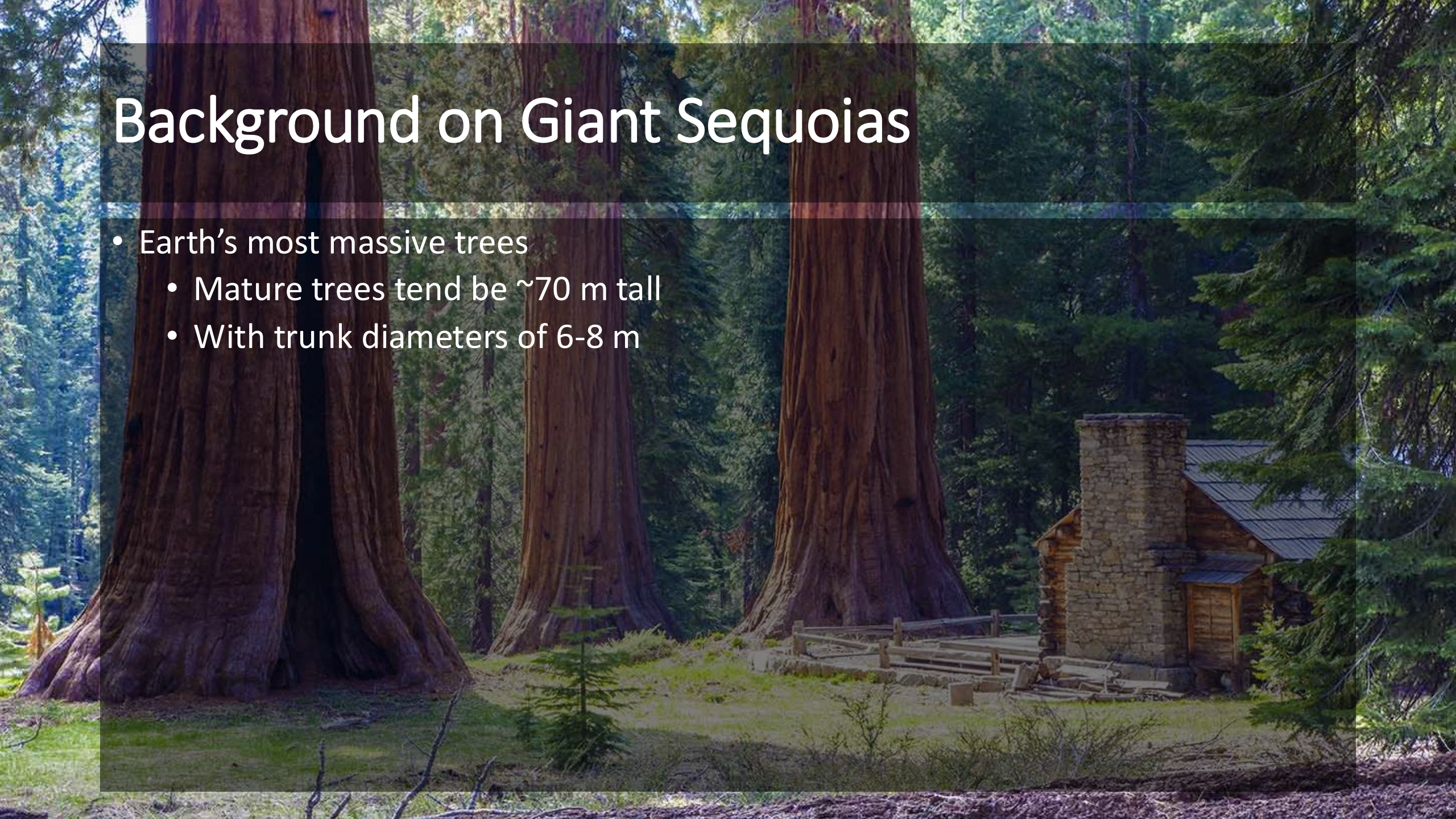
Background on Giant Sequoias



Background on Giant Sequoias

- Earth's most massive trees
  - Mature trees tend be ~70 m tall
  - With trunk diameters of 6-8 m



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  - Temperate winters with large volumes of snow supply most of the water sequoias use
- High water usage during the growing season
  - Mature trees can uptake ~2 m^3 of water per day
  - Snow melt from winter stored in the subsurface is vital during peak photosynthesis

Guiding Questions:

How much subsurface water do giant sequoias have access to, and where do they source it from?

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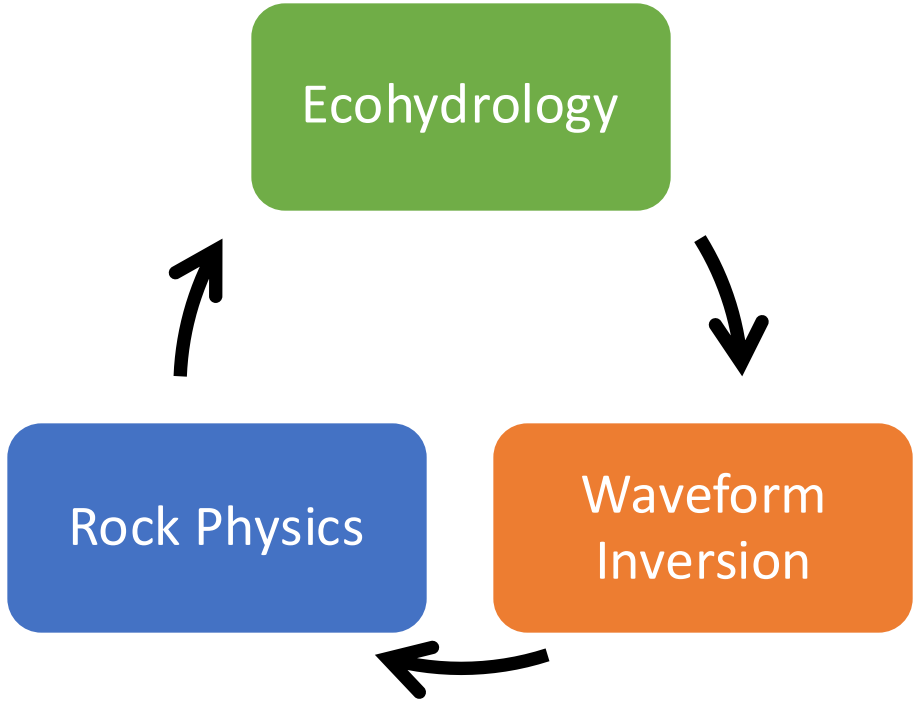
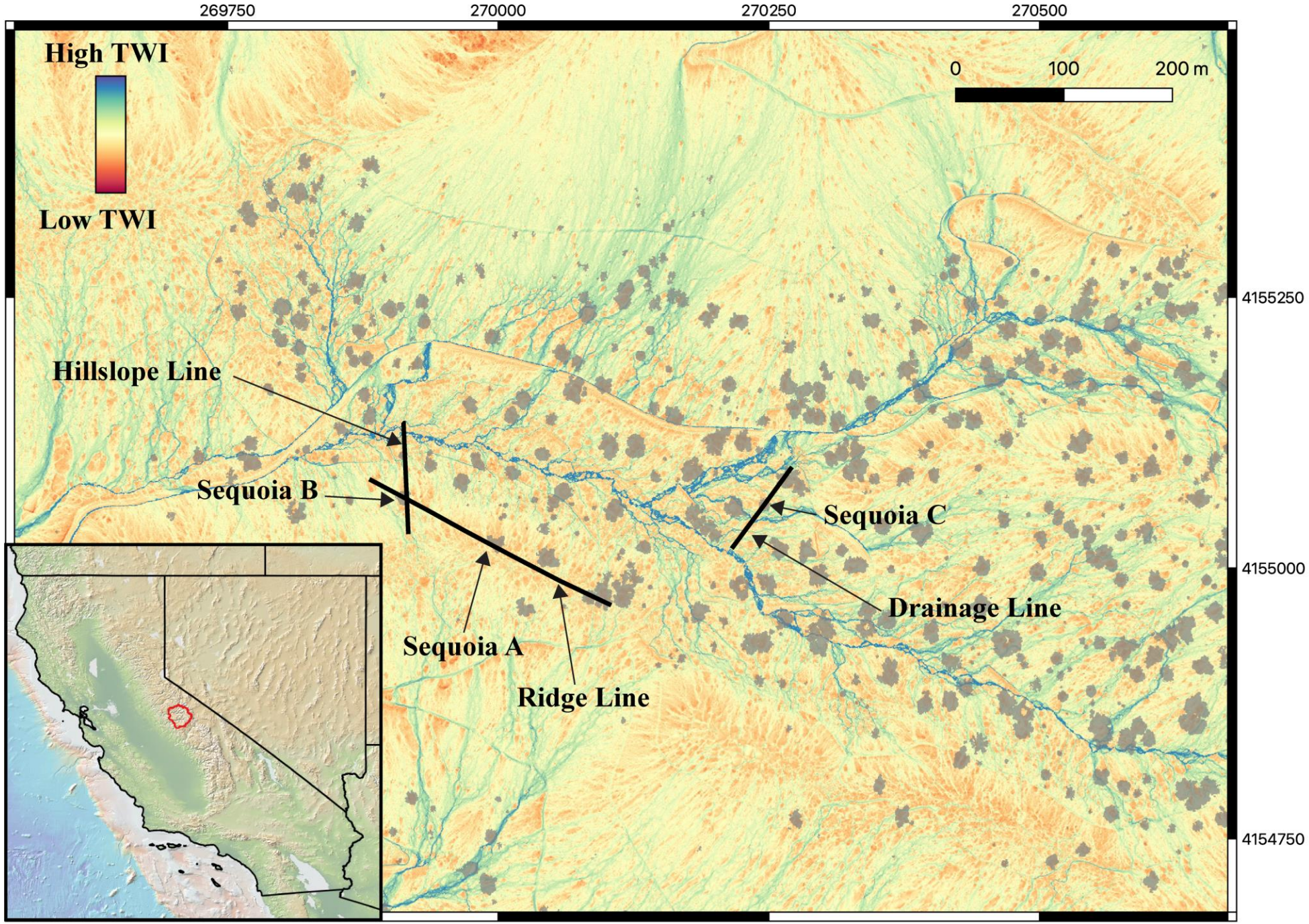


Study Site

- Within Yosemite National Park
- Upper portion of the Mariposa Grove of Giant Sequoias
- Field operations in late July – early August of 2023 and 2024


269750
270000
270250
270500
High TWI
Low TWI
0
100
200 m
4155250
4155000
4154750
Hillslope Line
Sequoia B
Sequoia C
Drainage Line
Sequoia A
Ridge Line

Data Collection

- Dense Arrays of STRYDE Nodes

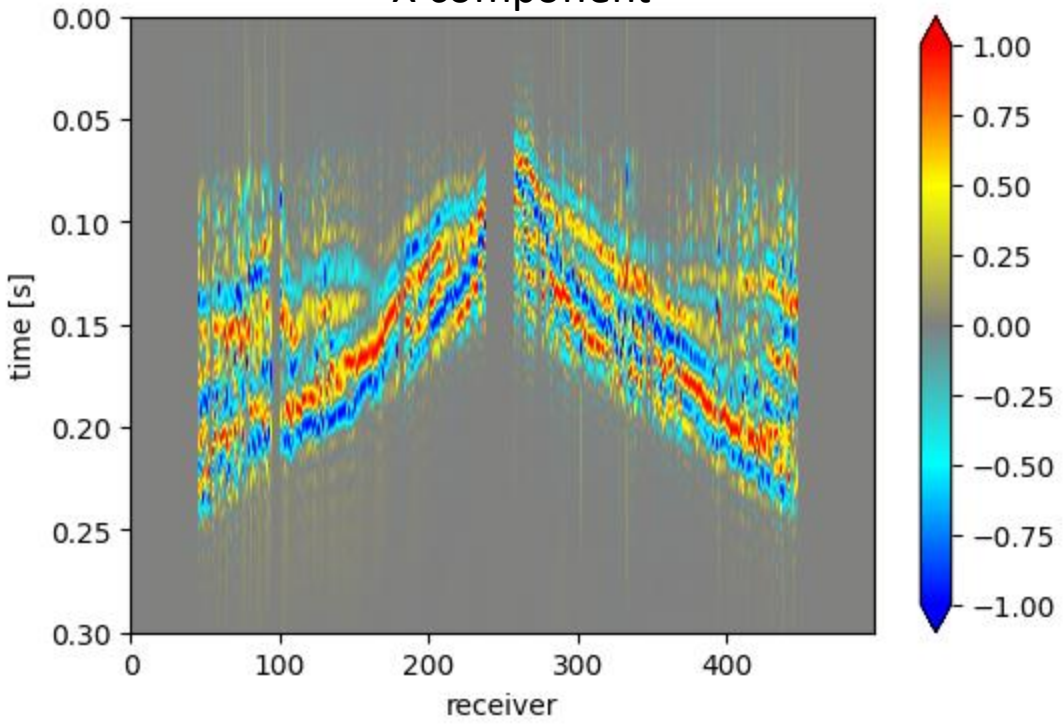
Profile	Date Collected	Z-Comp	X-Comp	Node Spacing	Source Spacing
Ridge Line	1 Aug 2023	Yes	Yes	0.5 m	5 m
Hillslope Line	22 Jul 2024	Yes	No	0.2 m	1 m
Drainage Line	25 Jul 2023	Yes	No	0.25 m	2 m

Data Collection

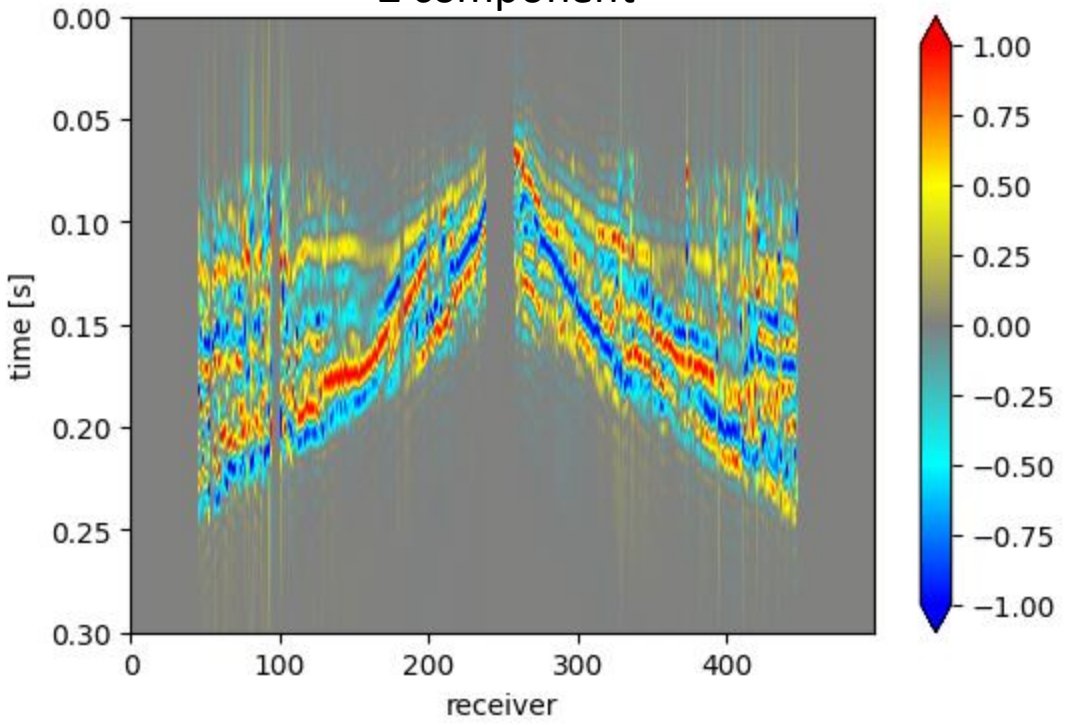
- Dense Arrays of STRYDE Nodes
- Multi Component Acquisition

Data Example from the Ridge Line

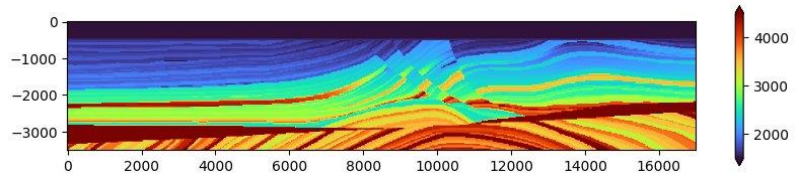
X component



Z component

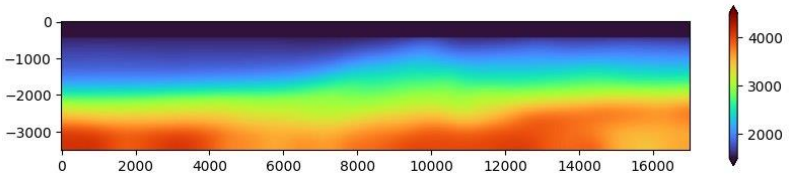


Full Waveform Inversion

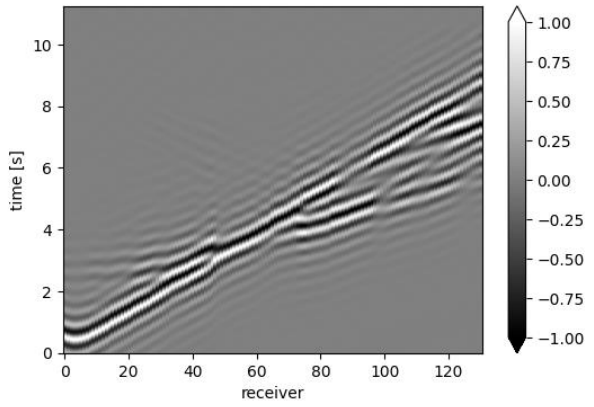


Update Earth Model

Predict Seismograms

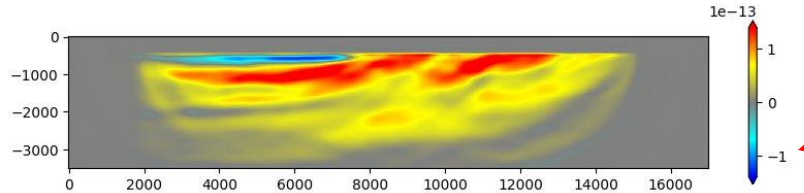


Observed Data



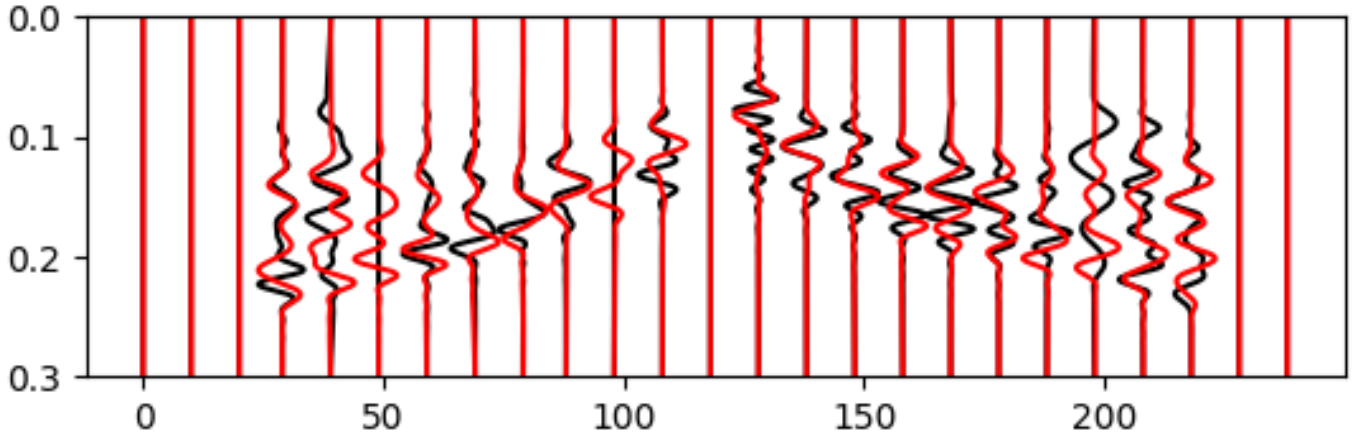
Quantify Data Misfit

Compute Gradient

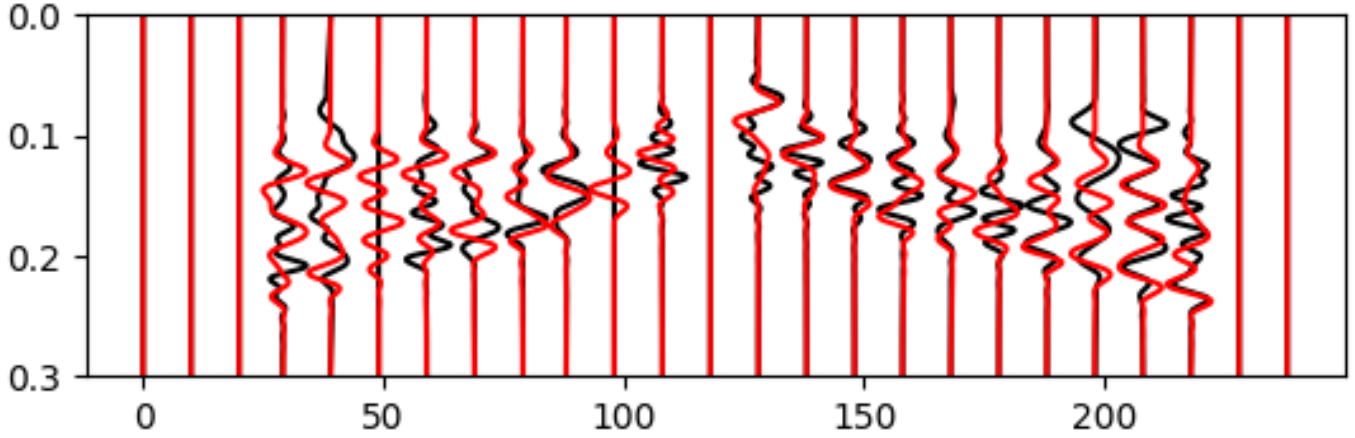


Full Waveform Inversion Results

X component



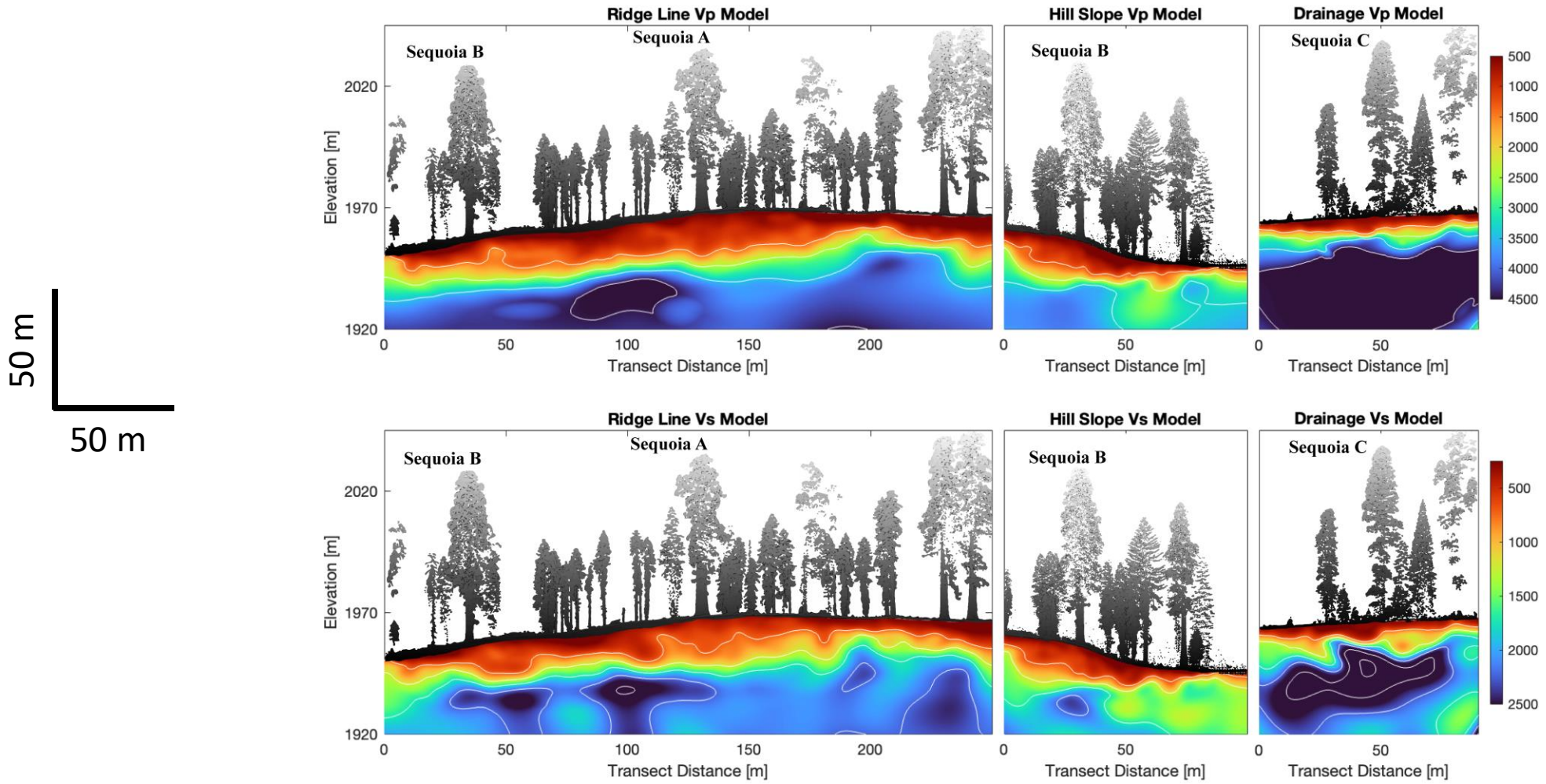
Z component



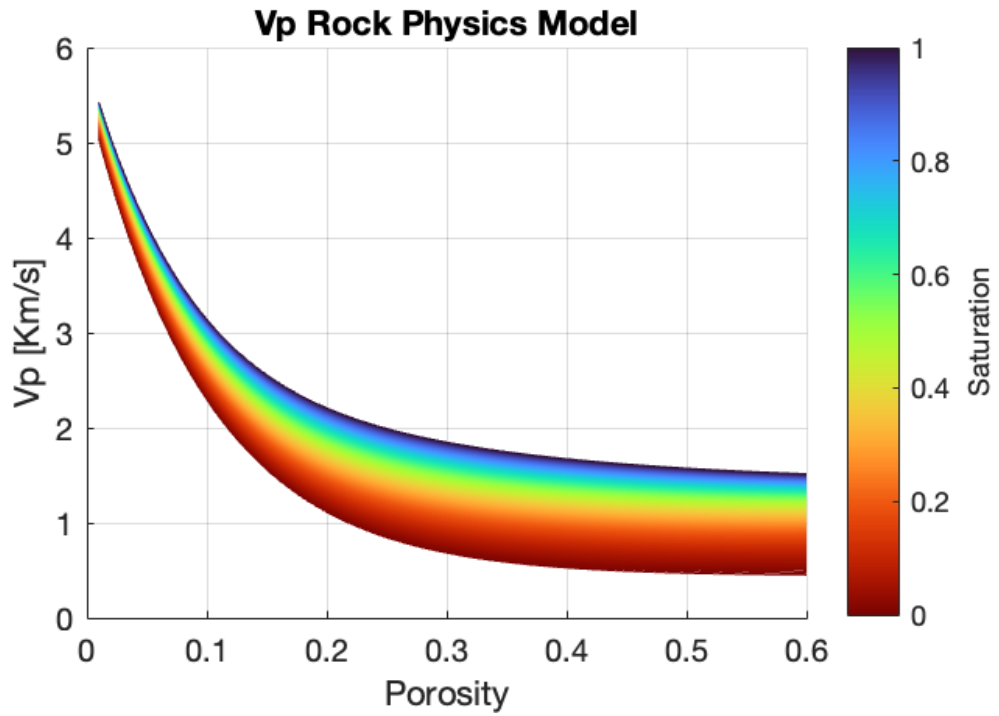
Synthetic Data

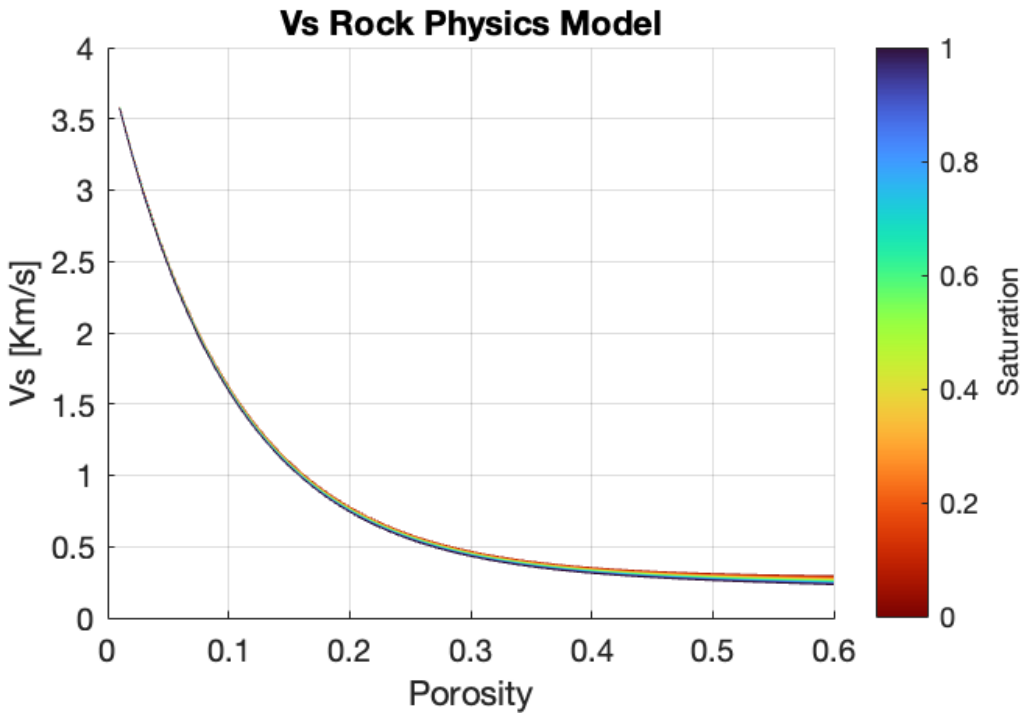
Observed Data

Full Waveform Inversion Results



Rock Physics Modelling





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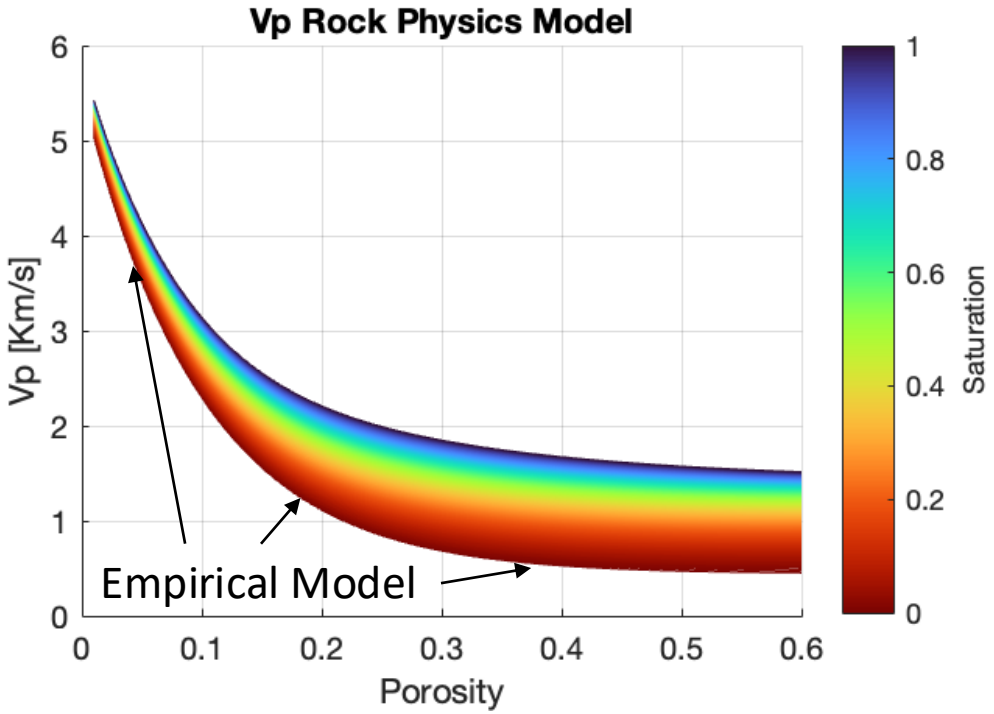

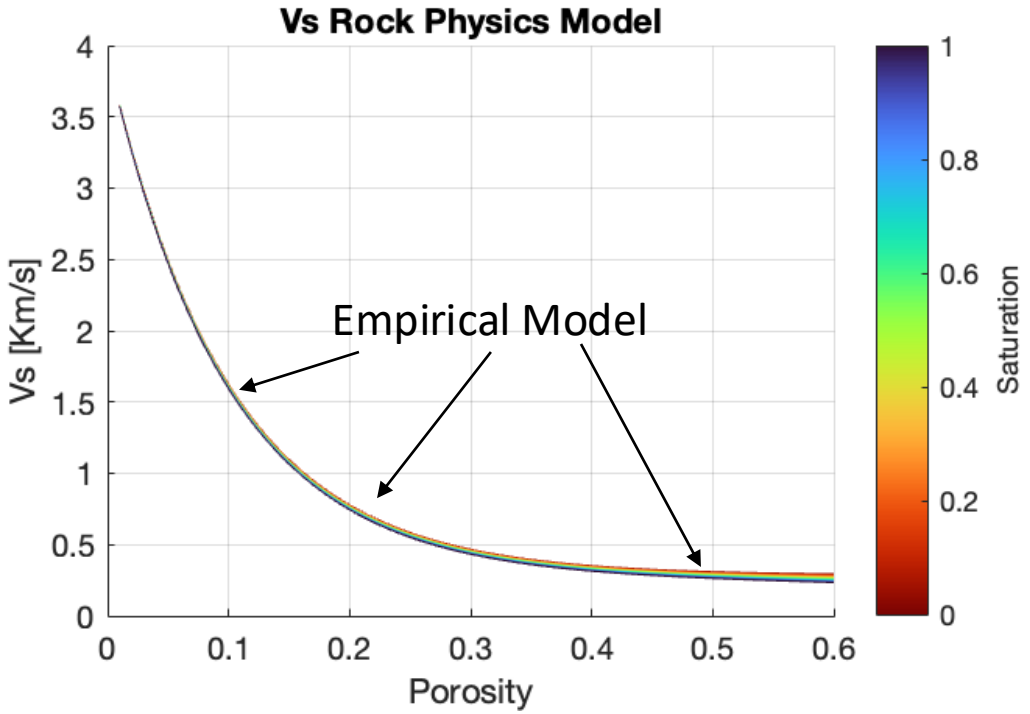

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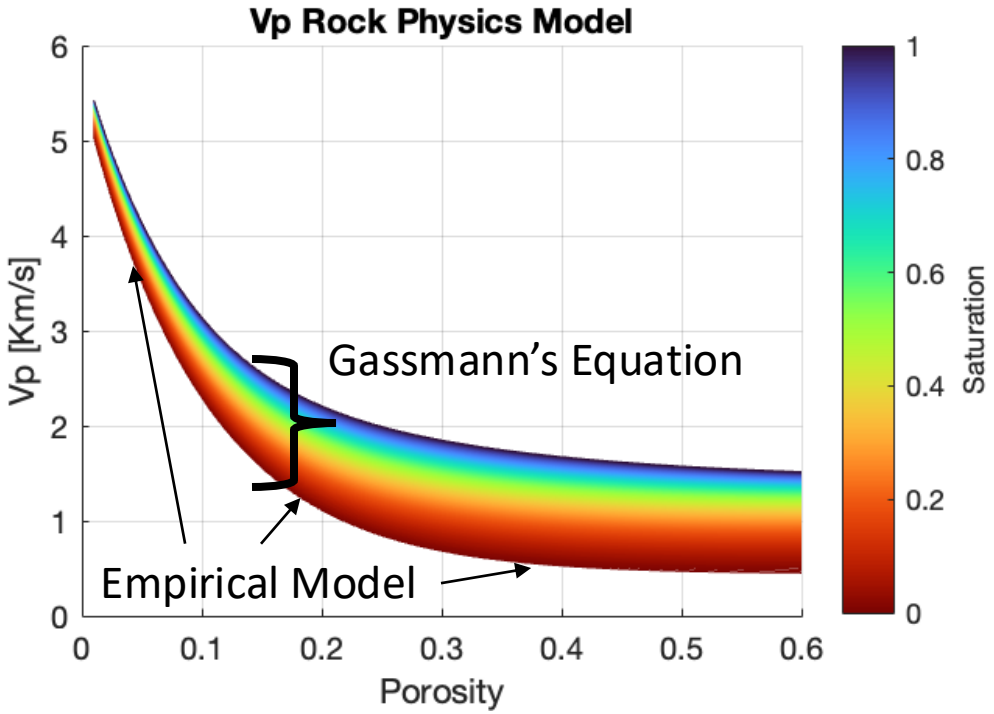
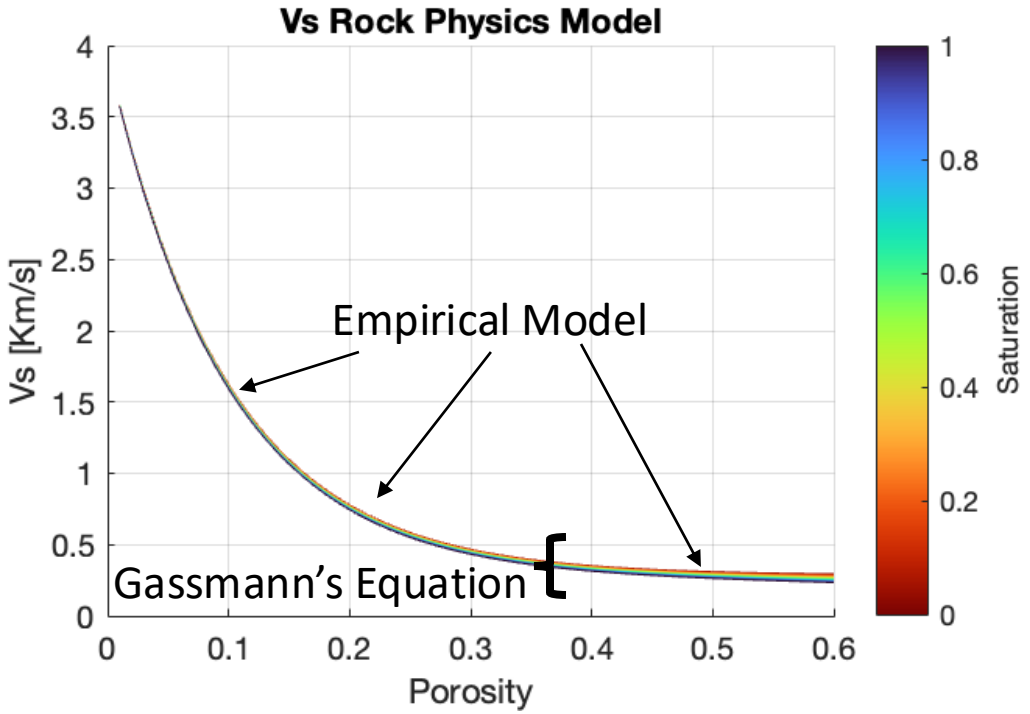
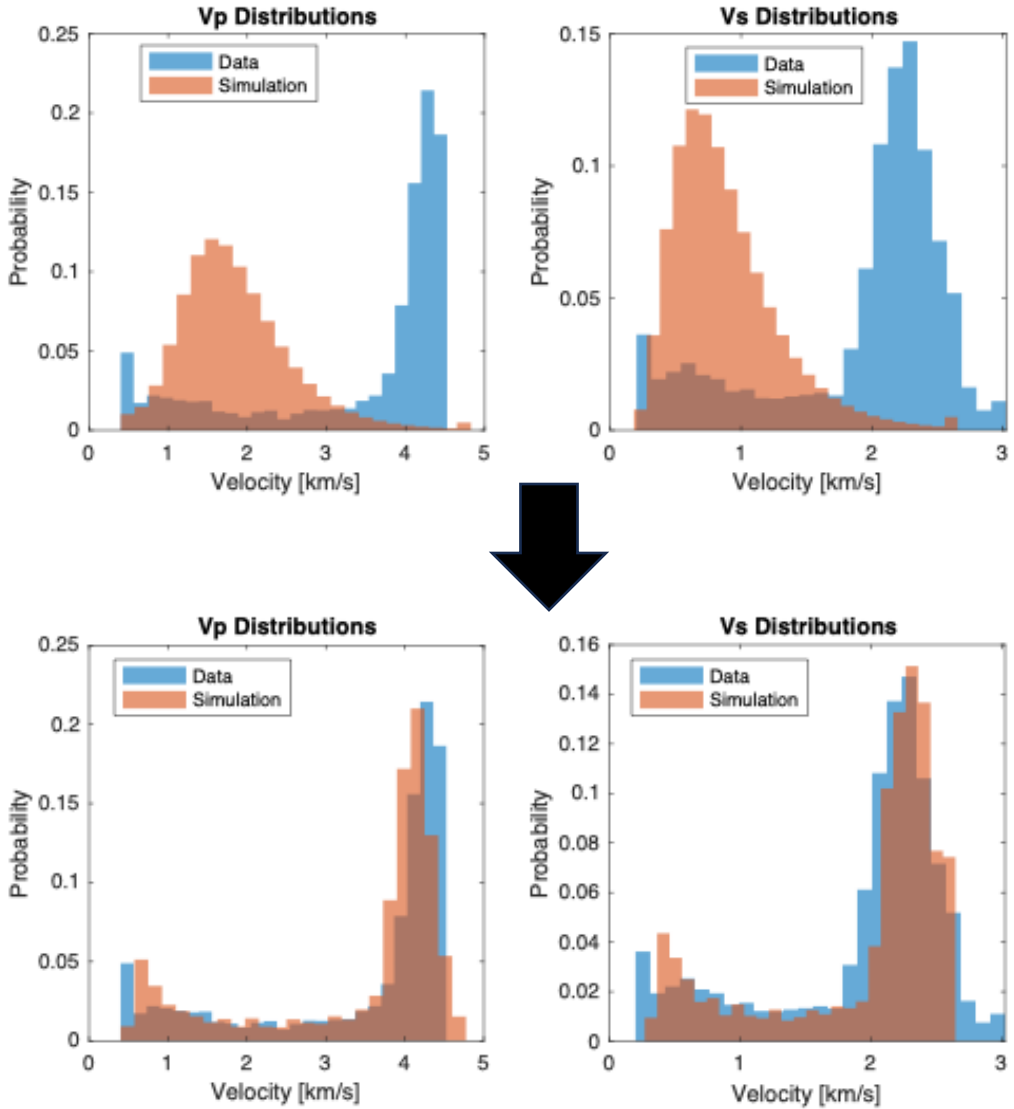


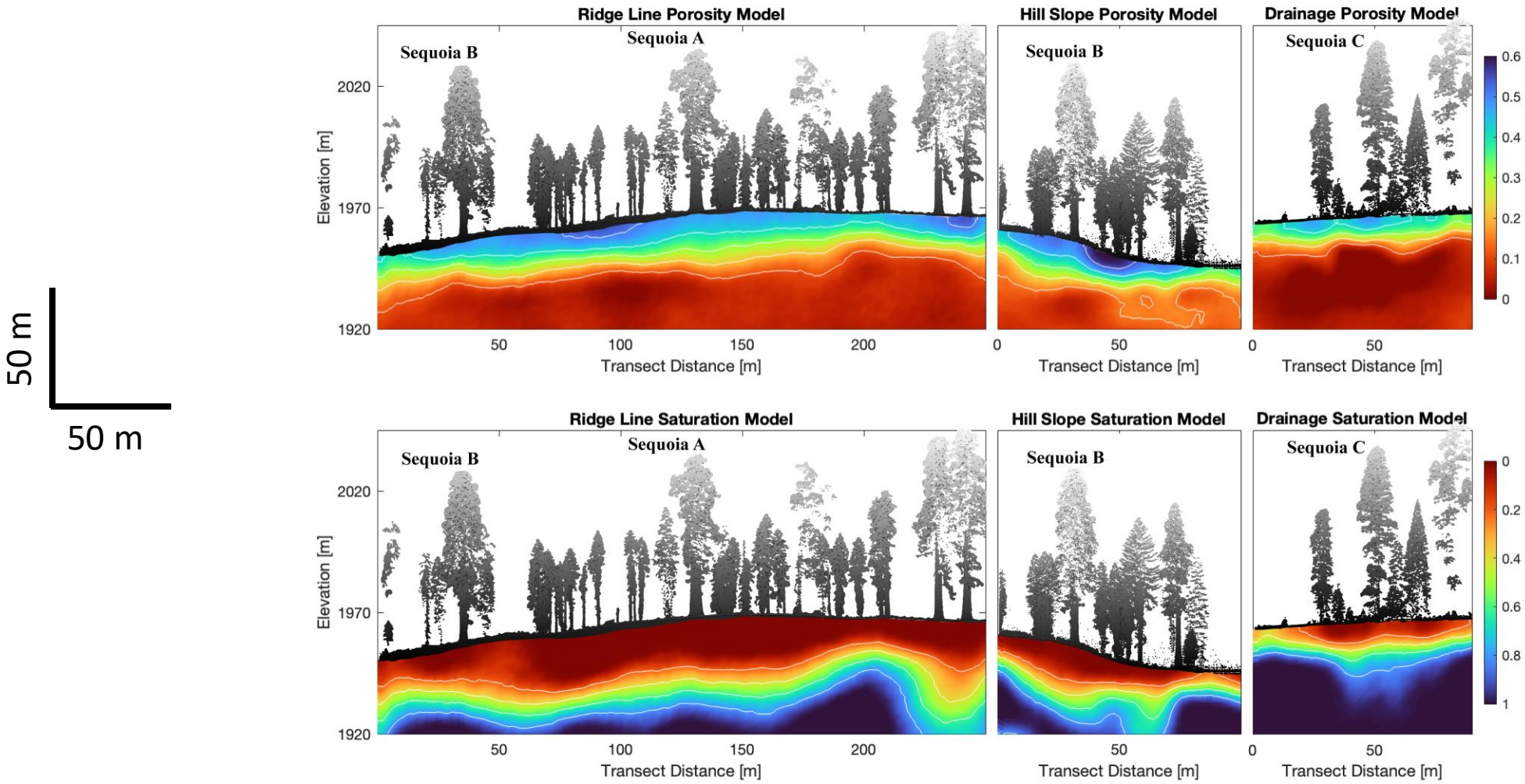


Rock Physics Inversion

1. Generating an ensemble of porosity and saturation models
2. Computing Vp and Vs using the rock physics model
3. Updating the porosity and saturation ensemble using the ensemble smoother multi-data assimilation algorithm
4. Return to step 2 until convergence



Rock Physics Inversion results



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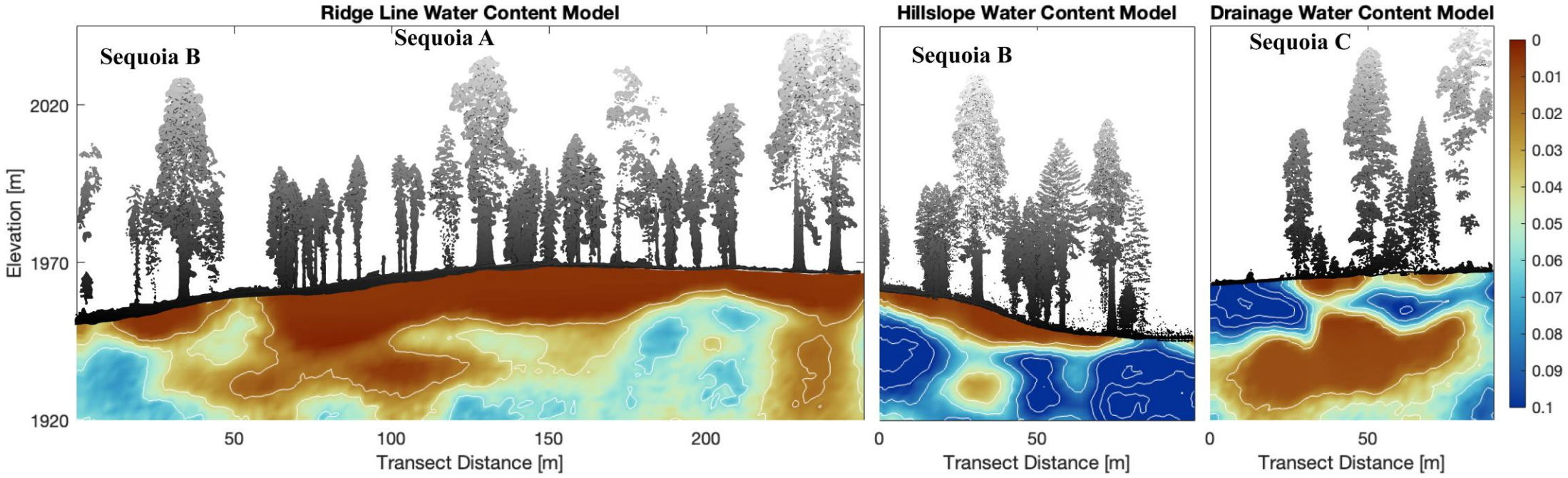

Accessible water as a function of rooting

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  - Other non-academic sources quote figures as large as 60 m
- While dense rooting in the upper 2 m of soil is often remarked upon, vertical rooting extent is poorly constrained
  - Some scientists have reported sequoia roots as deep as 14 m

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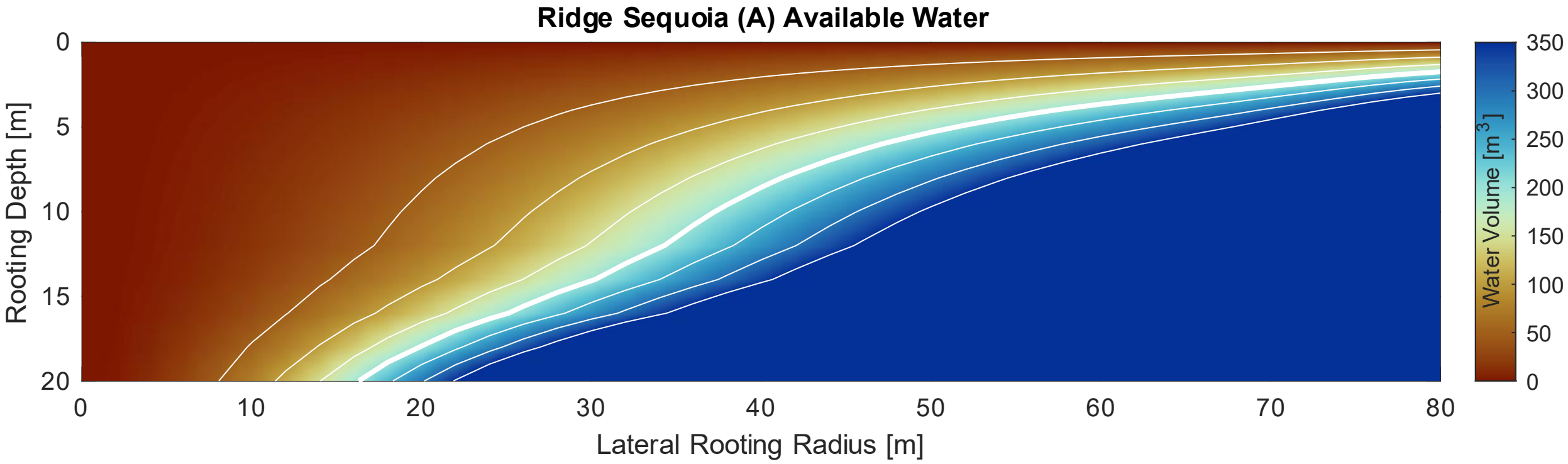

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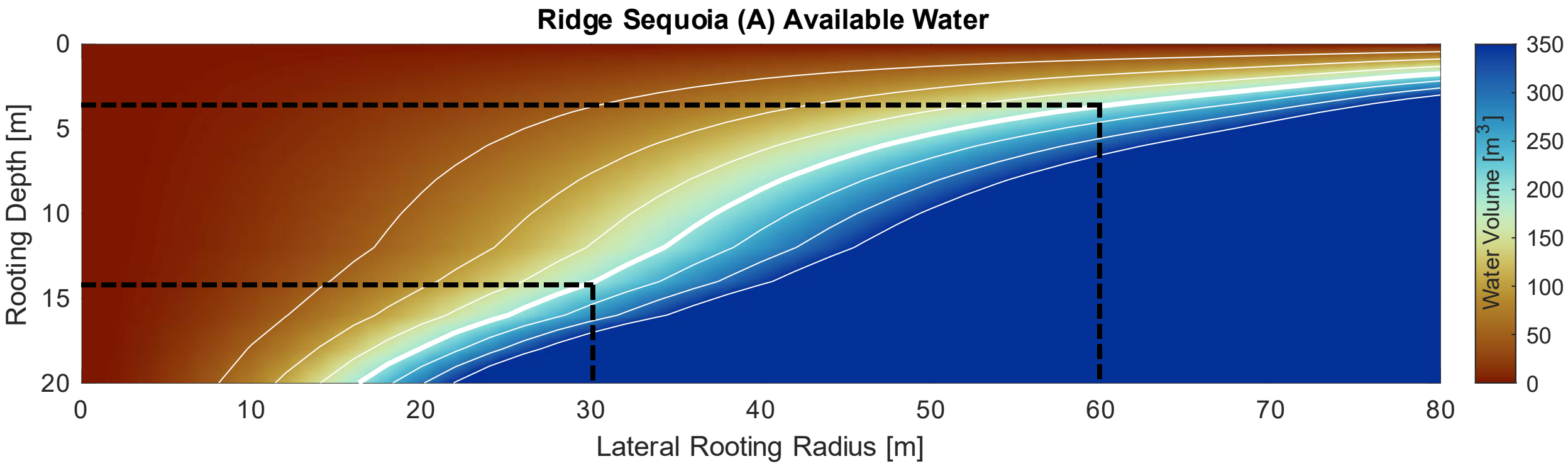

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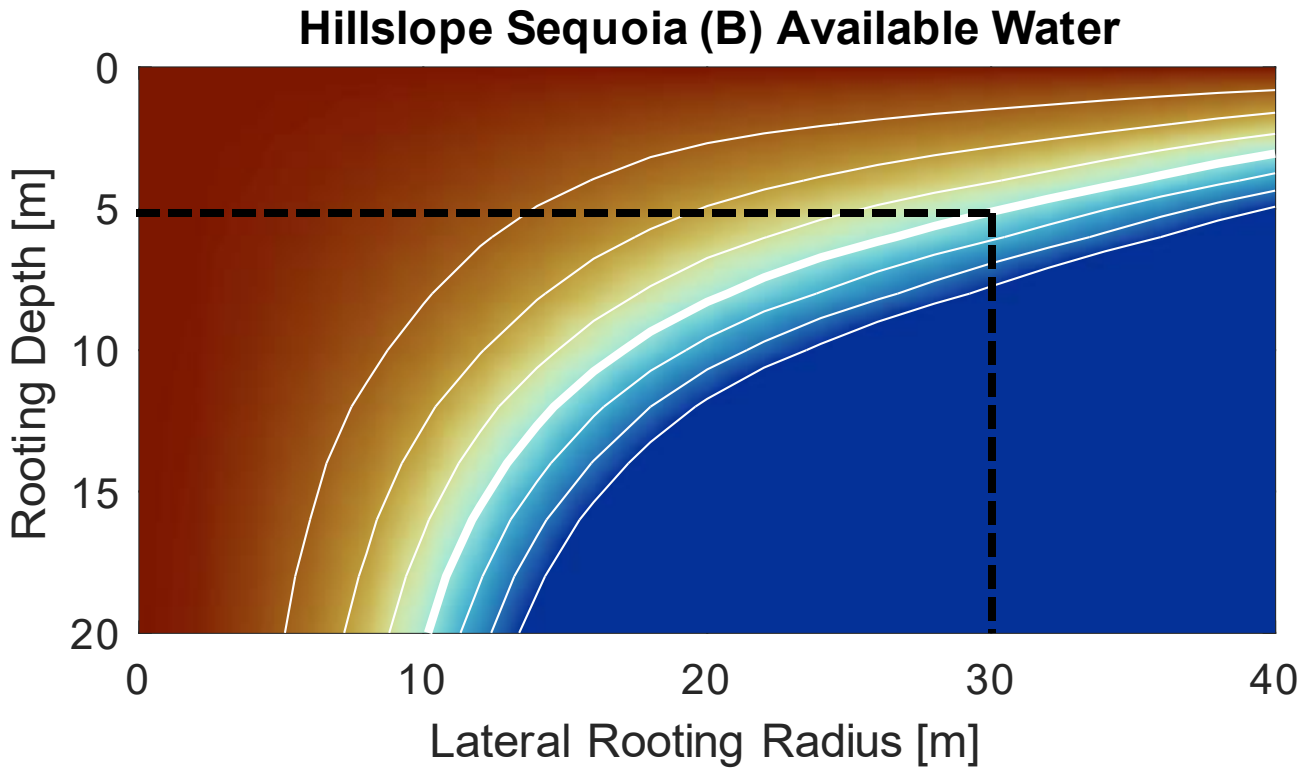

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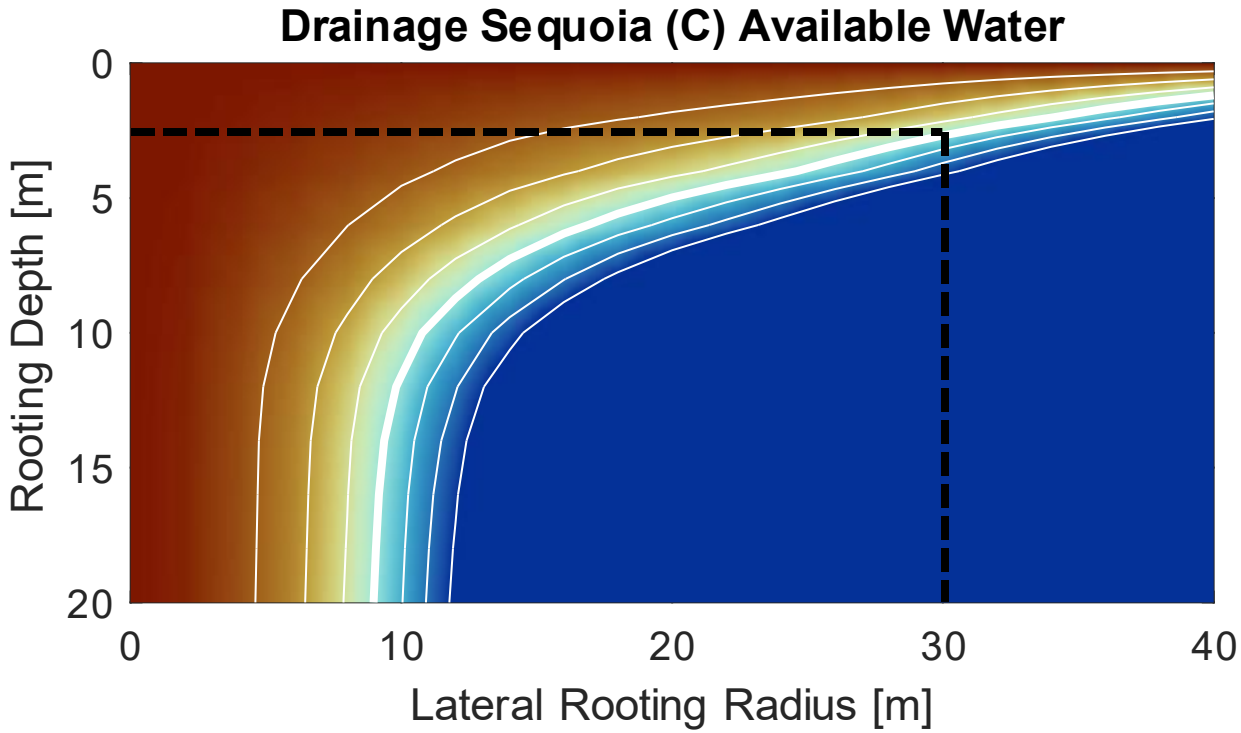

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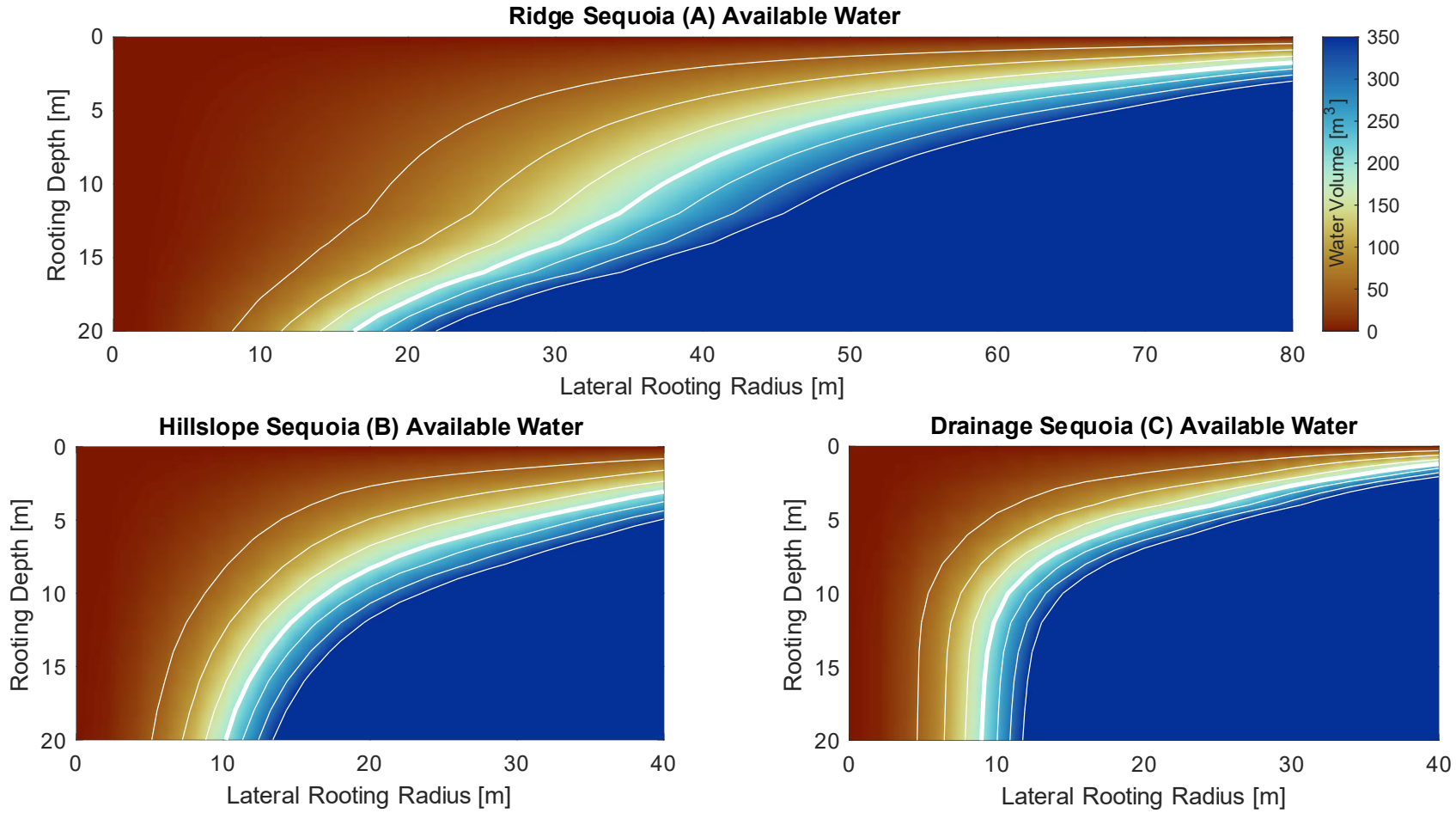

Conclusions

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- This finding is corroborated by
  - Isotopic signatures from sequoia sap flow (Ambrose et al., In Prep)
  - Ecohydrological models (McCormick et al., 2021)
  - Widespread deep rooting of trees in Mediterranean climates (Canadell et al., 1996)

Acknowledgements

- NSF Critical Zone Collaborative Network – Bedrock Cluster
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- Sean Markle

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Thank you for your attention!
Questions?
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