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Sandia National Laboratories

# Methane Gas Prediction in Arctic Sediments along Alaska's North Slope

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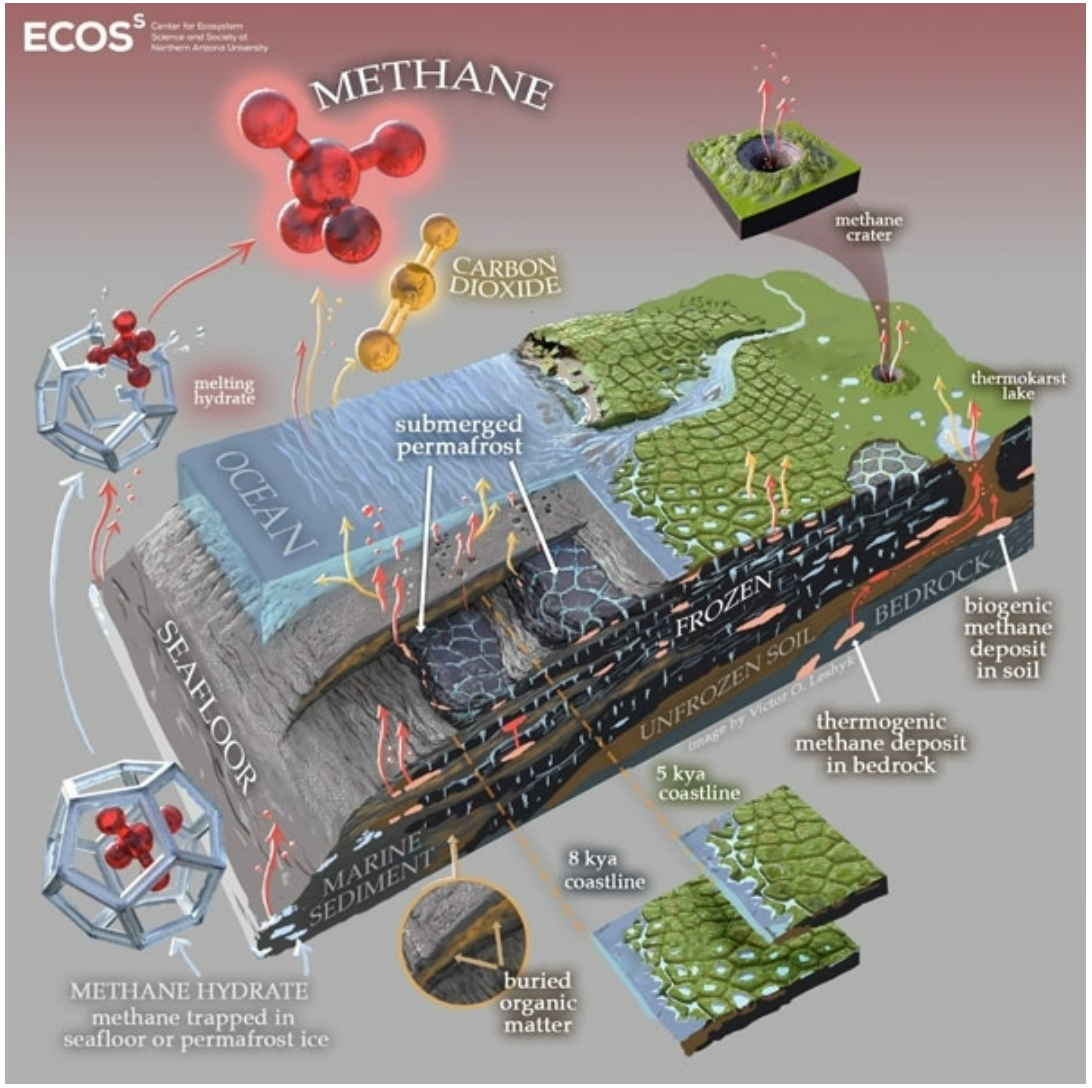
# Arctic Methane - The Sleeping Giant

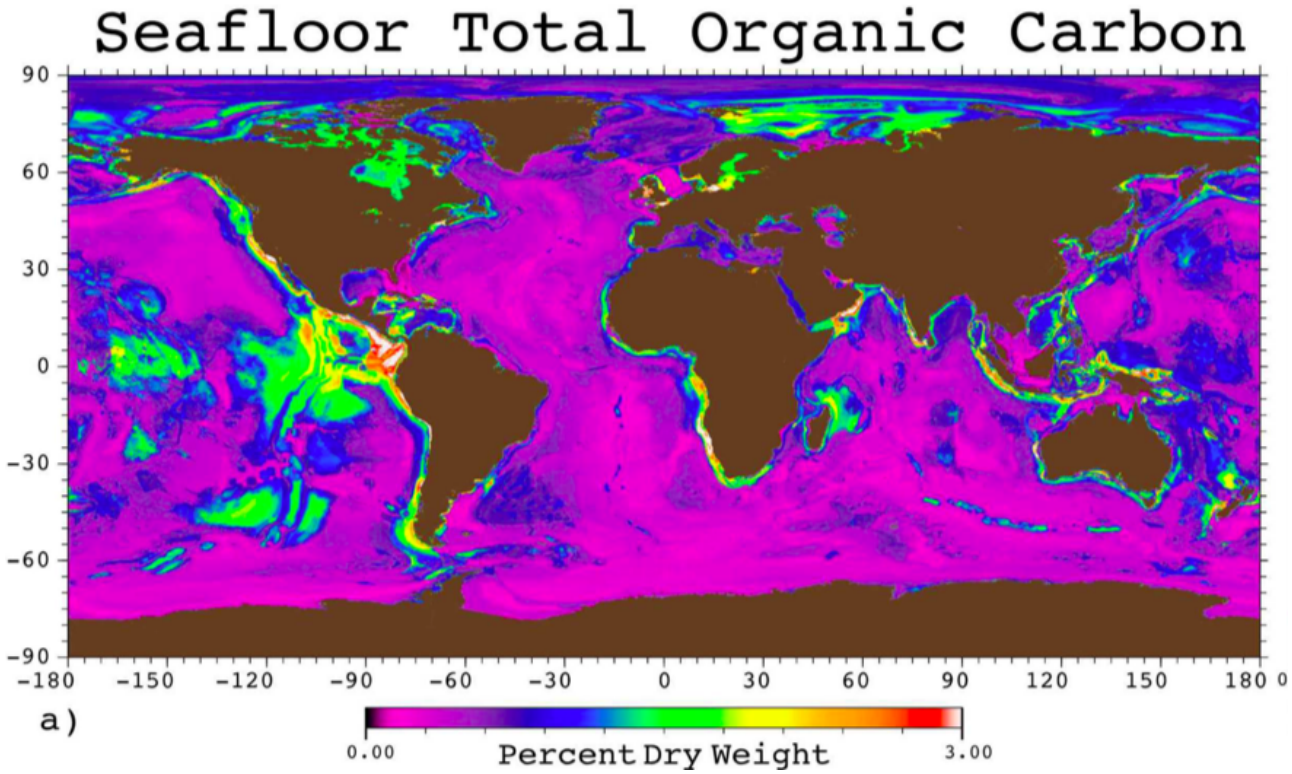
- Methane deposits in the Arctic are called “sleeping giants” as they contain huge amounts of frozen methane
- As Arctic Sea temperatures rise, methane deposits destabilize and release gas into the sediments & atmosphere
- Methane ($CH_4$) warms the atmosphere at a rate 80 times faster than $CO_2$
- Probabilistic predictions of subsurface methane gas concentrations over time are imperative to understand long-term implications
  - Predictions for the Arctic regions can be improved by taking glacial and interglacial periods into consideration




**ARCTIC THAW** — This artistic diagram of the subsea and coastal permafrost ecosystems emphasizes greenhouse gas production and release. (Artwork by Victor Oleg Leshyk, Northern Arizona University.)

# Methodology - GPSM

- To estimate methane gas concentrations in Arctic sediments over time, critical seabed parameters such as porosity, sedimentation, and TOC must be known.
  - Probabilistic estimations of these parameters can be made using geospatial machine learning techniques
- The Global Predictive Seabed Model (GPSM) provides estimations and uncertainties for sedimentation rate, TOC, heat flux, sediment porosity, seafloor depth, and seafloor temperature
  - Resolution is up to 5 arc-minute spacing across the globe
  - Developed at NRL by Warren Wood and Ben Phrampus




Lee et al., 2019

# Methodology - Dakota

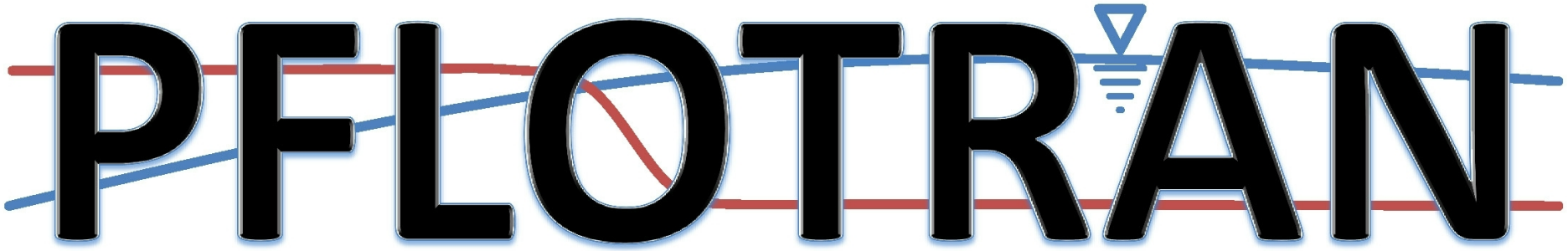
- Dakota optimizes simulation codes and provides uncertainty quantification of parameter studies
- For this study, Dakota samples on GPSM parameter means and standard deviations to determine a coupled distribution of all parameters for each sample location
- Initially only five parameters were chosen for sampling
  - Developed generalized script to flexibly select parameters to sample

DAKOTA

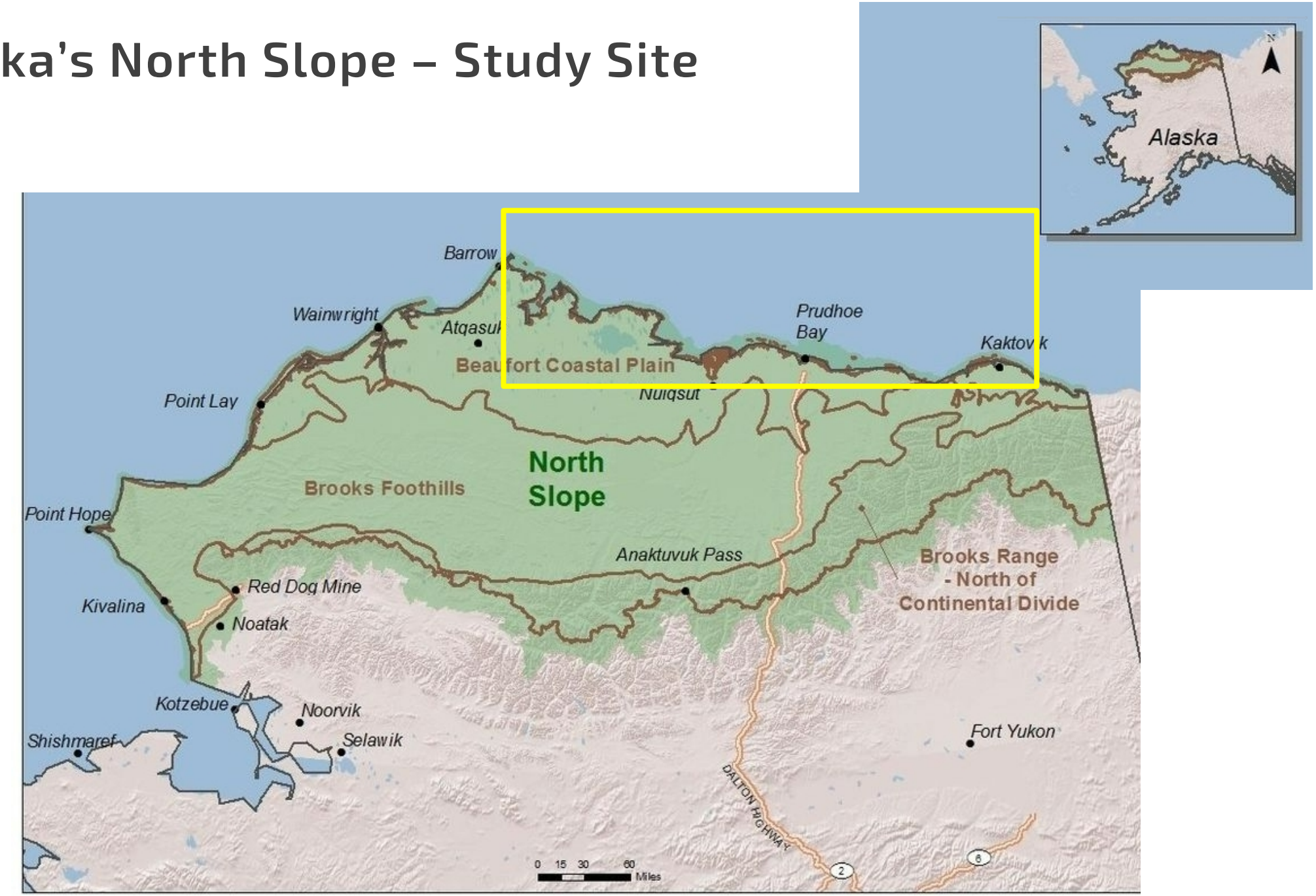
Explore and predict with confidence

# Methodology - PFLOTRAN

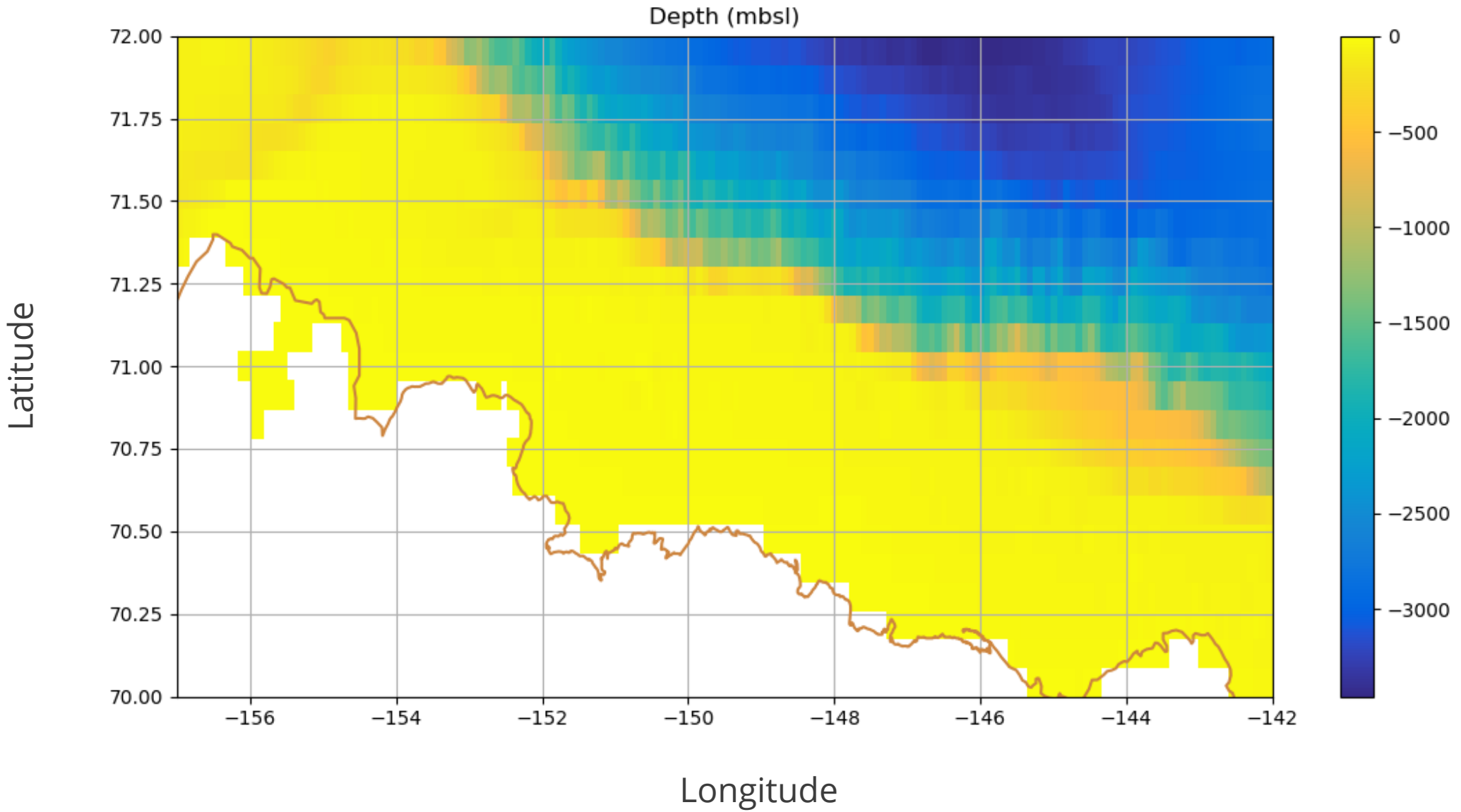
- PFLOTRAN is a massively parallel, multiphase flow reactive multicomponent transport simulator
- Initial conditions and boundary conditions for the simulations depend on seabed parameters with associated uncertainties as well as the GPSM values
- Multiple realizations of the variable combinations (sampled by Dakota) are used to perform simulations for the study area to create maps predicting the location and amount of free gas in the sediment



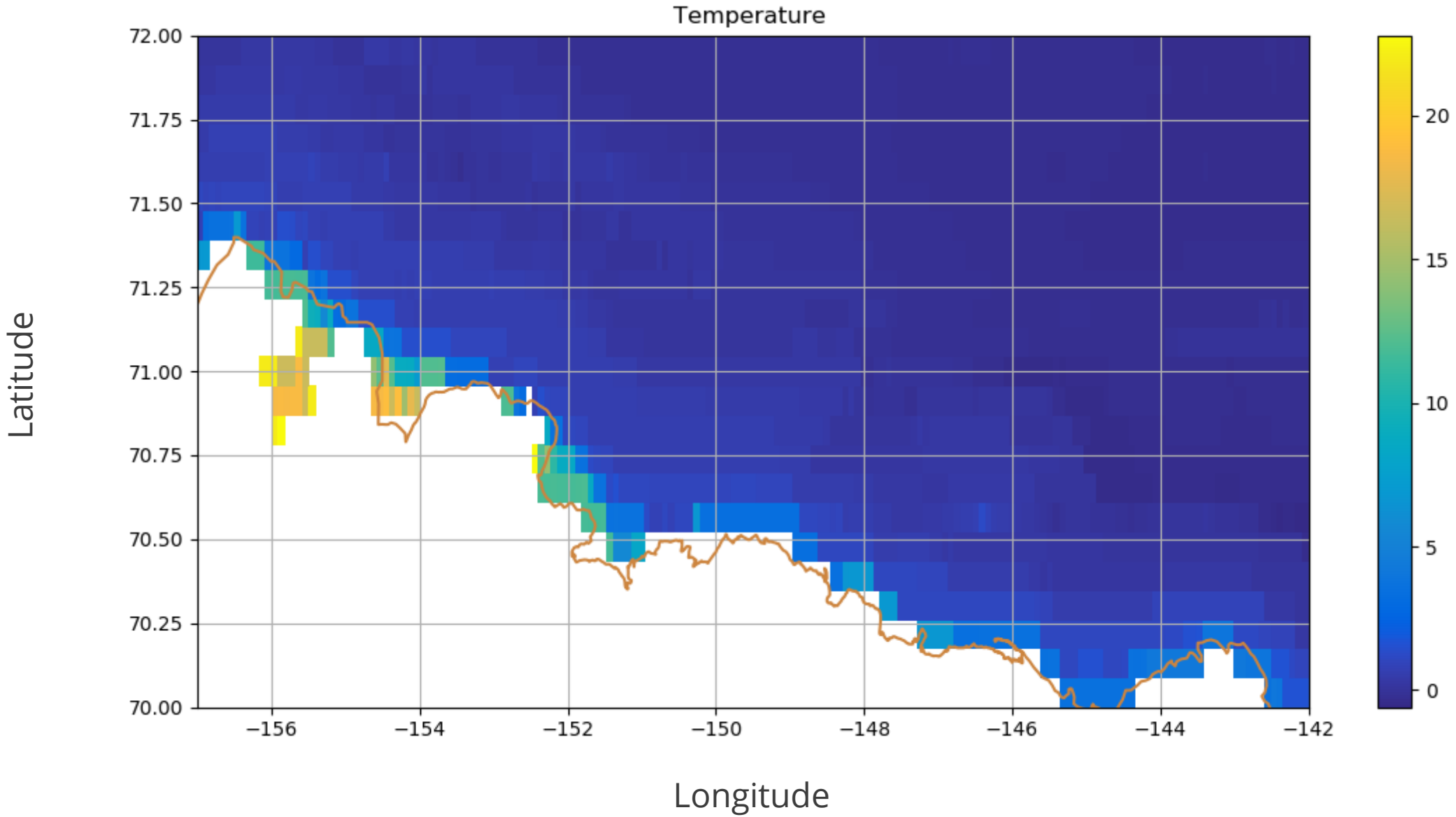
# Alaska's North Slope – Study Site



# Alaska's North Slope – Depth Profile



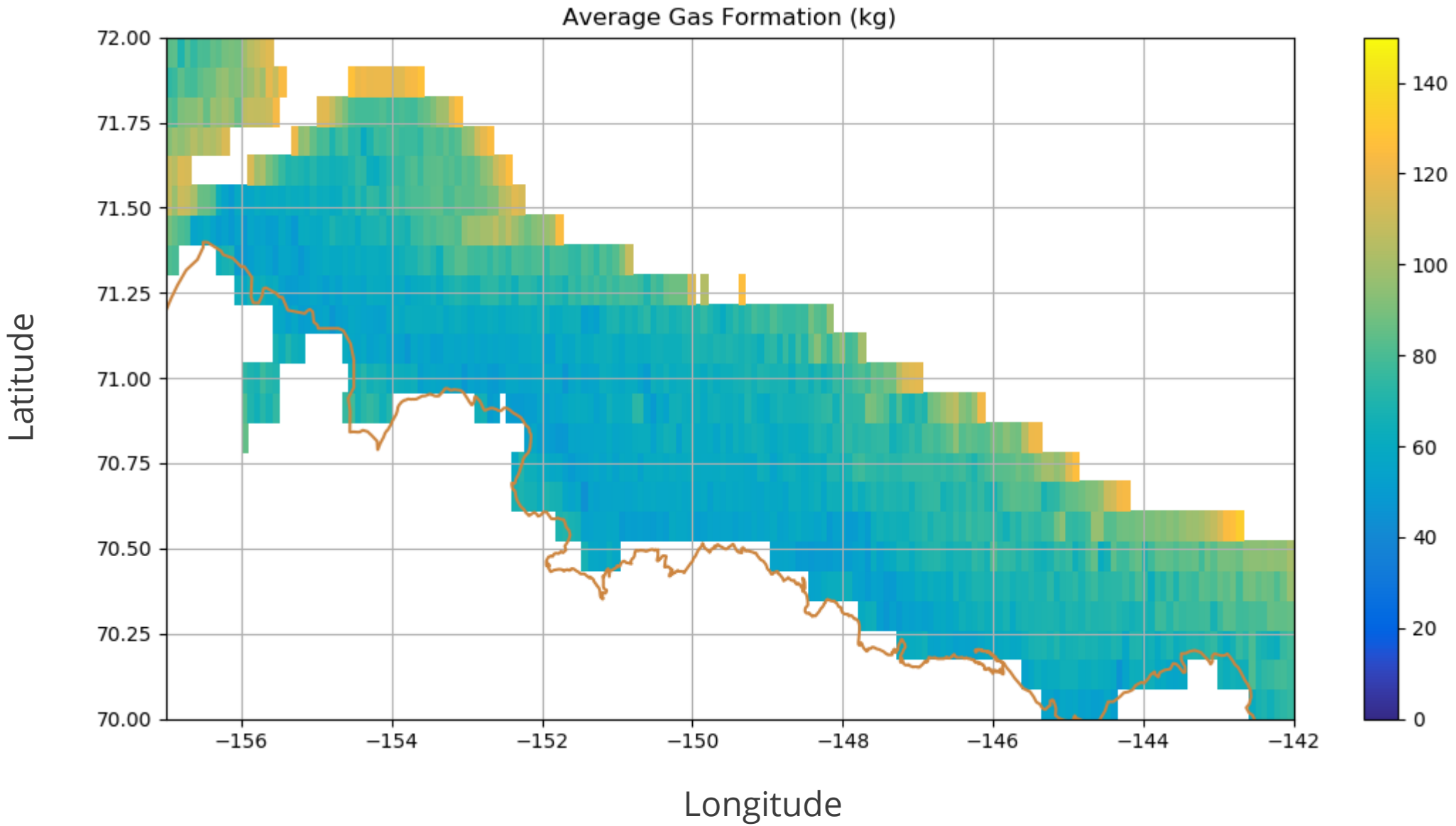
# Alaska's North Slope – Seafloor Temperature (°C)



# Simulation Details

- 1565 sample locations were run as 120 kyr simulations on CEE
- Minimum temperature was capped at 0.1°C in PFLOTRAN as ice was forming at top of column
- Depth at each location was held constant
- Sampled parameters were TOC, sedimentation rate, seafloor temperature, and heat flux

# Results – Average Gas Formation



# Conclusions and future work

- Gas formed at all locations along the North Slope, primarily near the top of the sediment columns
- Gas formation increases with increasing distance from shore
- Future work for the rest of the summer will be to run simulations for multiple glacial periods as well as incorporate site specific porosity variations.
  - May significantly impact locations of gas formation


# Thank You! Questions?

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