Machine Learning on Spectral Data Of Enceladus' Plume

Image Credit: NASA/JPL-Caltech

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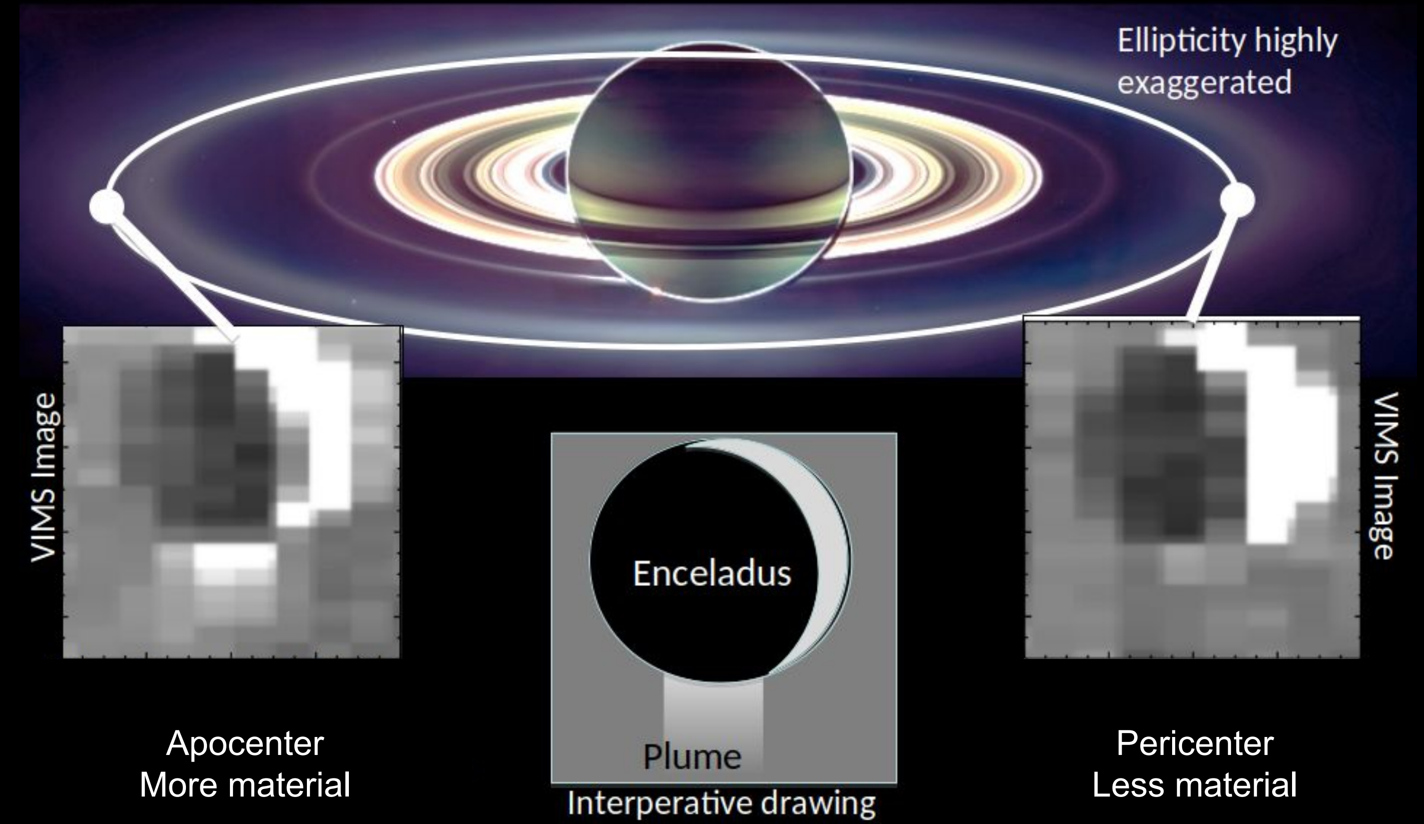
The Problem: Saturn’s moon Enceladus

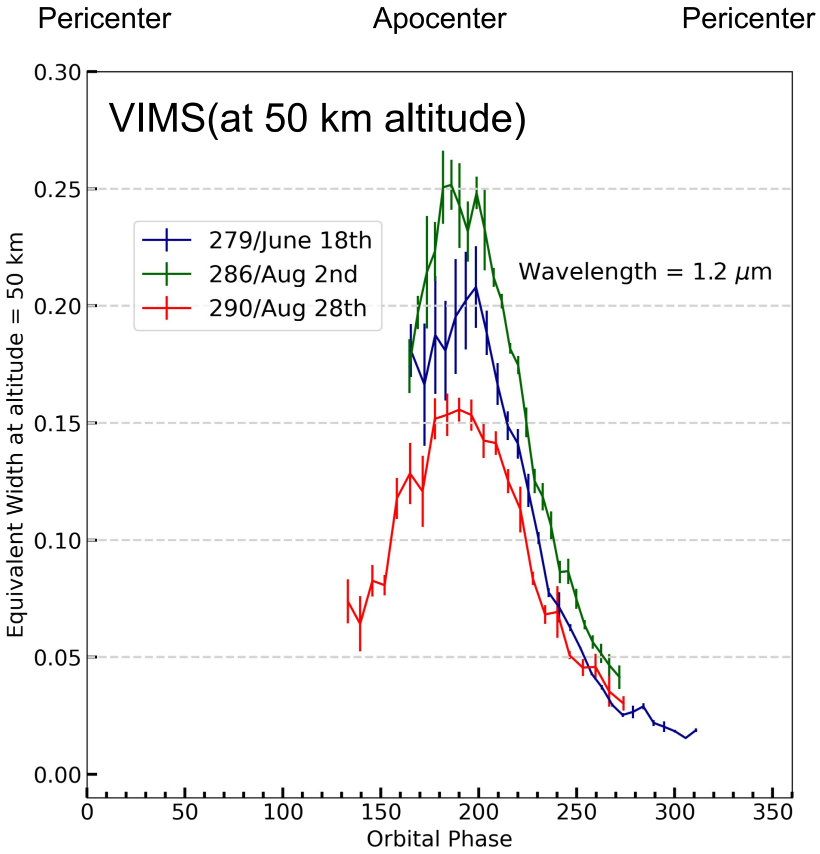
Image Credit: NASA/JPL-Caltech

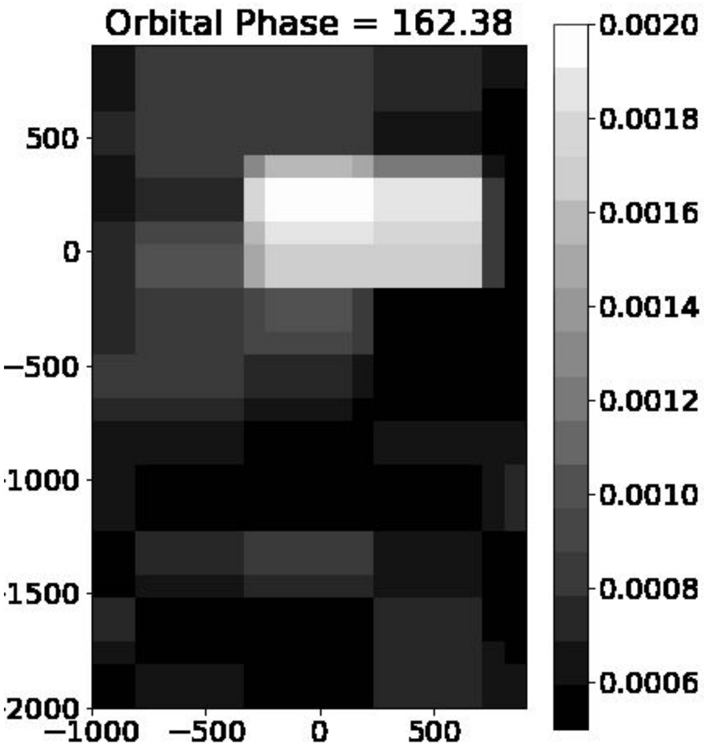
Periodic Temporal Variations in Plume brightness due to Tidal stresses



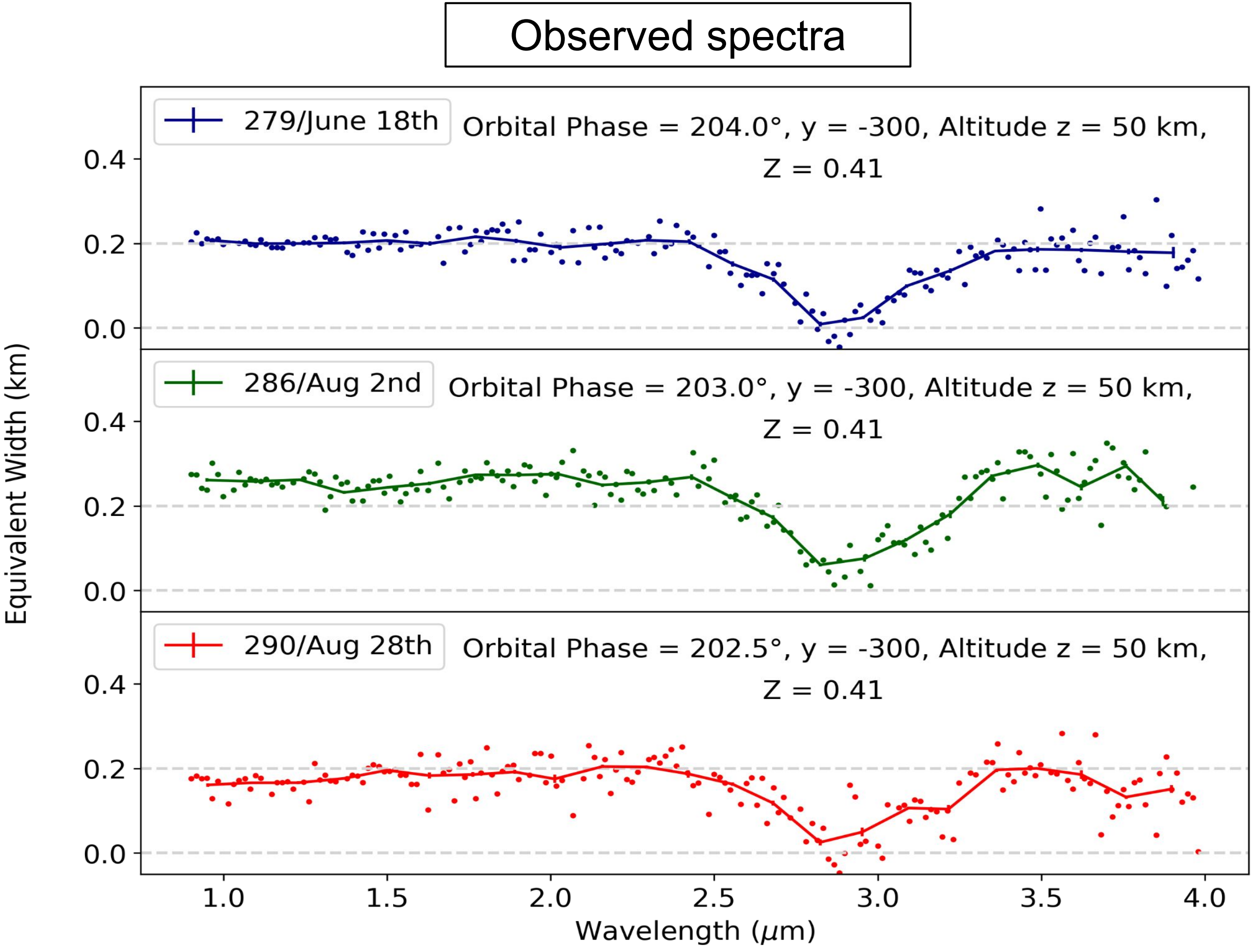
Hedman et al. An observed correlation between plume activity and tidal stresses on Enceladus (Nature 2013)

The Data: Cassini cameras recorded aperiodic variations in the plume output





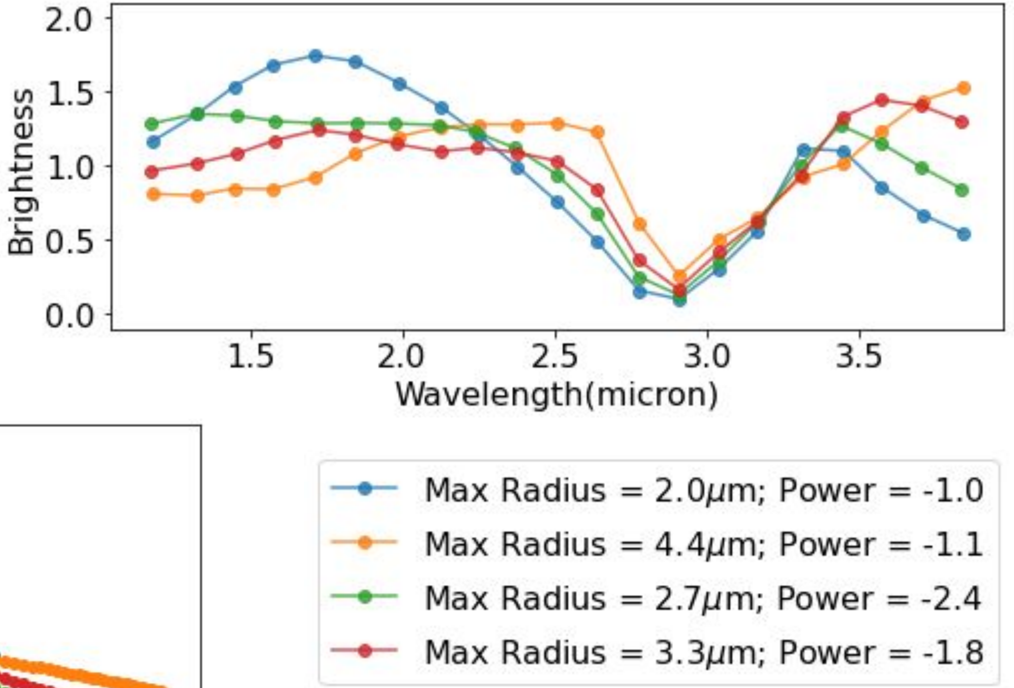
Variations across wavelength can be related to change in particle properties



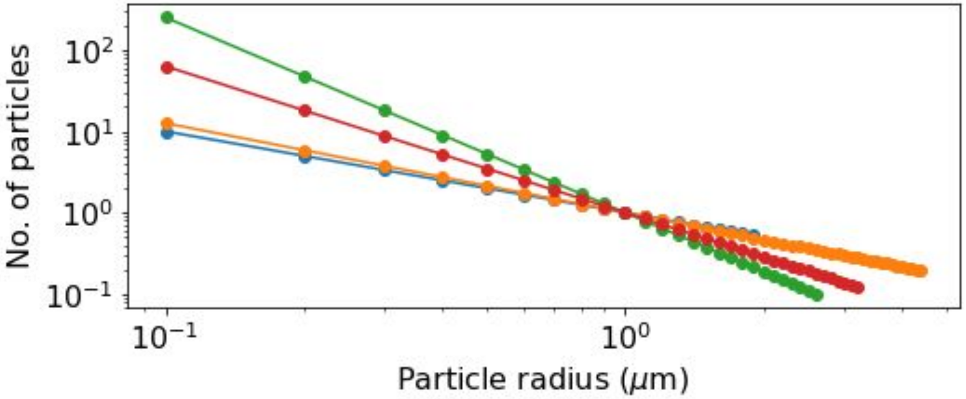
Mie Scattering theory can help derive information about particle size

Mie scattering theory describes how light scatters off a particle cloud when the particle size is approximately the same as the wavelength of scattered light.

Mie Spectra/Theoretical Spectra



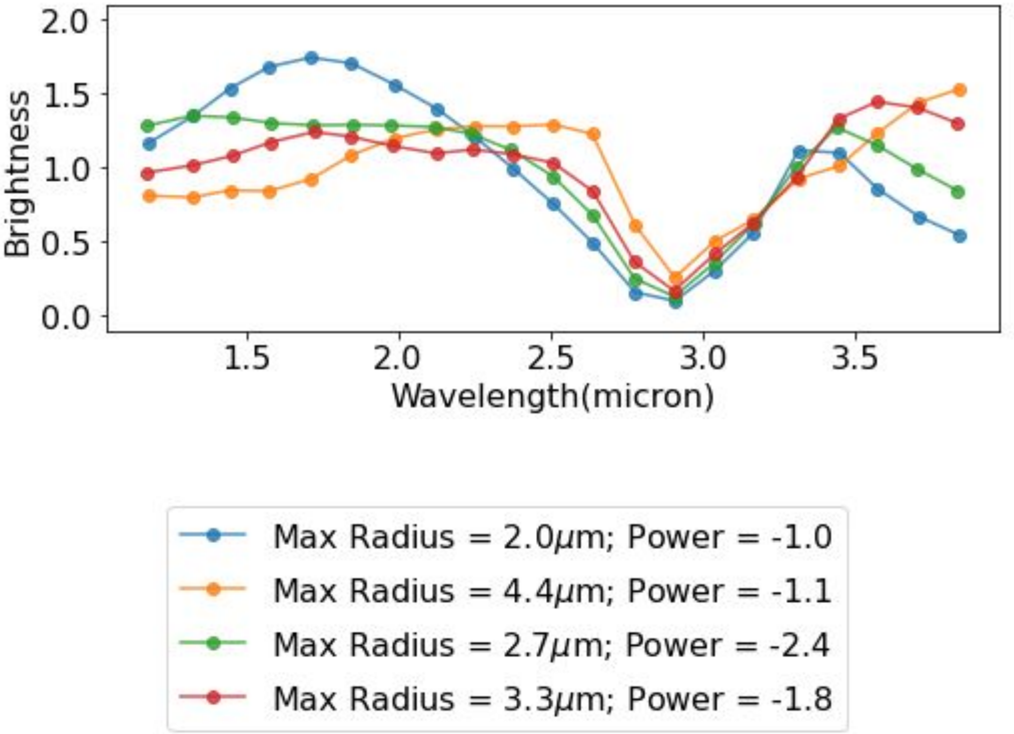
Size distribution



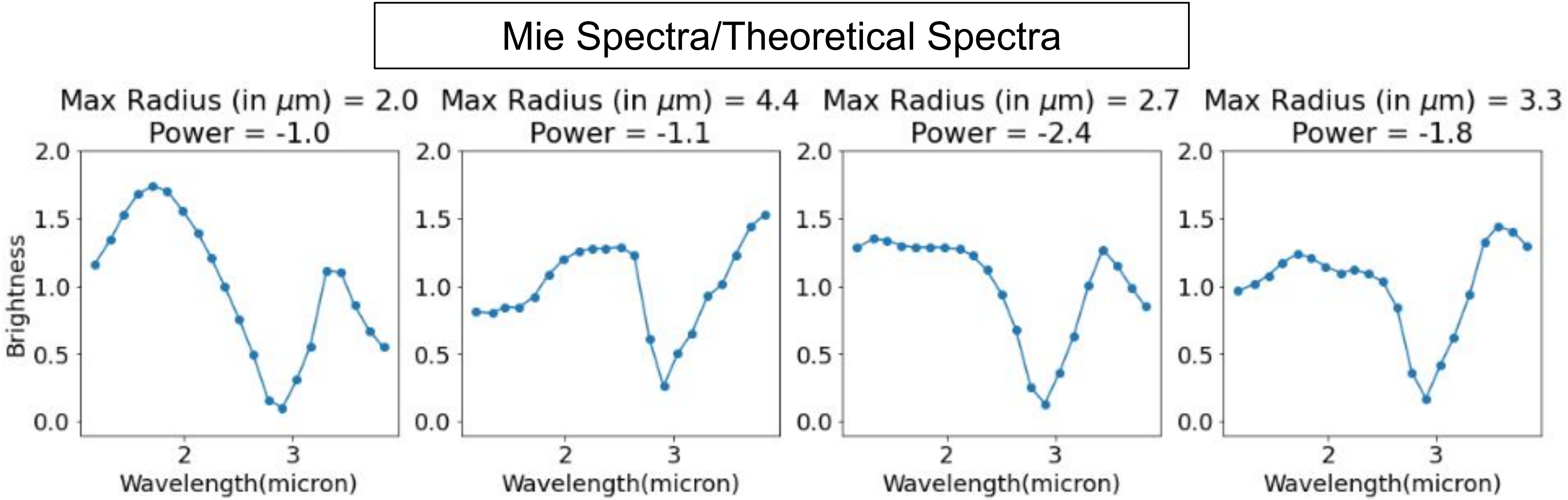
Why Machine Learning?

- Large parameter space to explore
- Pattern recognition
- Determine the best fit model
- Can be robust to fluctuations/noise

Mie Spectra/Theoretical Spectra



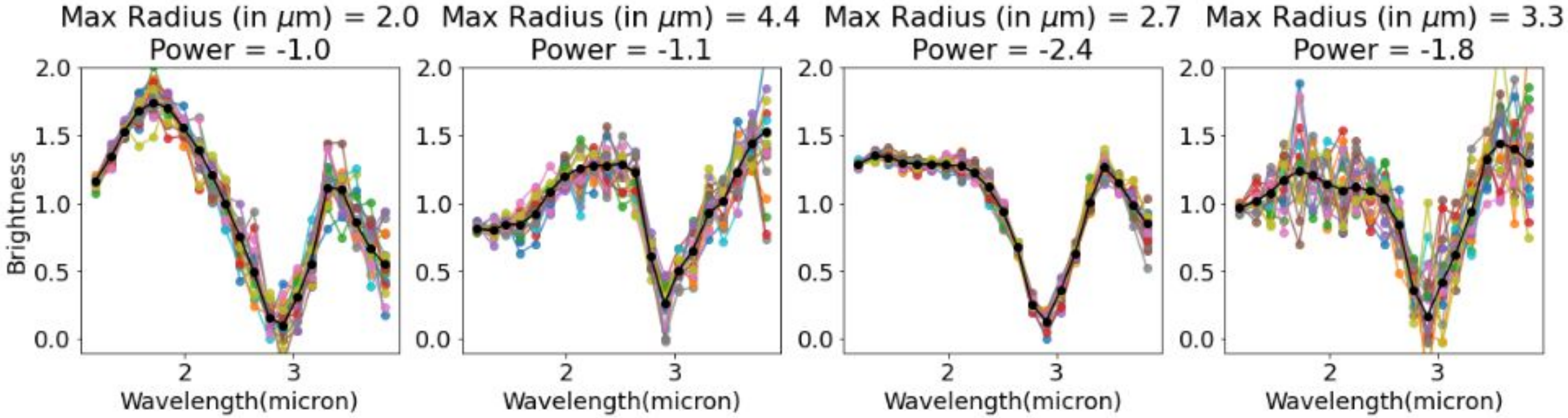
No noise present in the theoretically generated data



Data Augmentation: How to make the predictions Robust against noise?

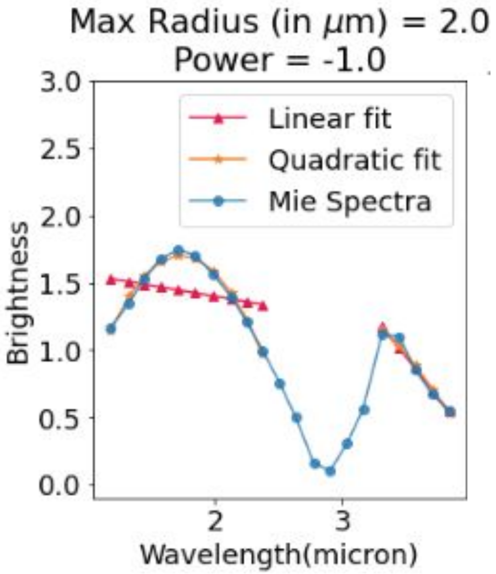
Mie spectra with added noise = Mie spectra + [(Standard normal distribution) * (Error on Plume spectra)]

Mie Spectra/Theoretical Spectra with added noise



Feature Engineering: What set of features to use?

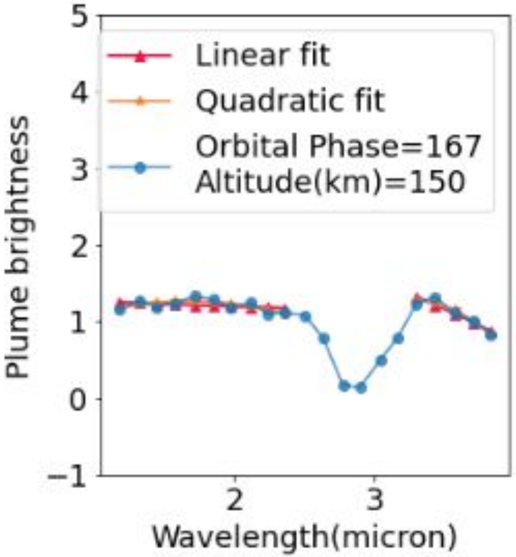
Mie spectra/Theoretical Spectra



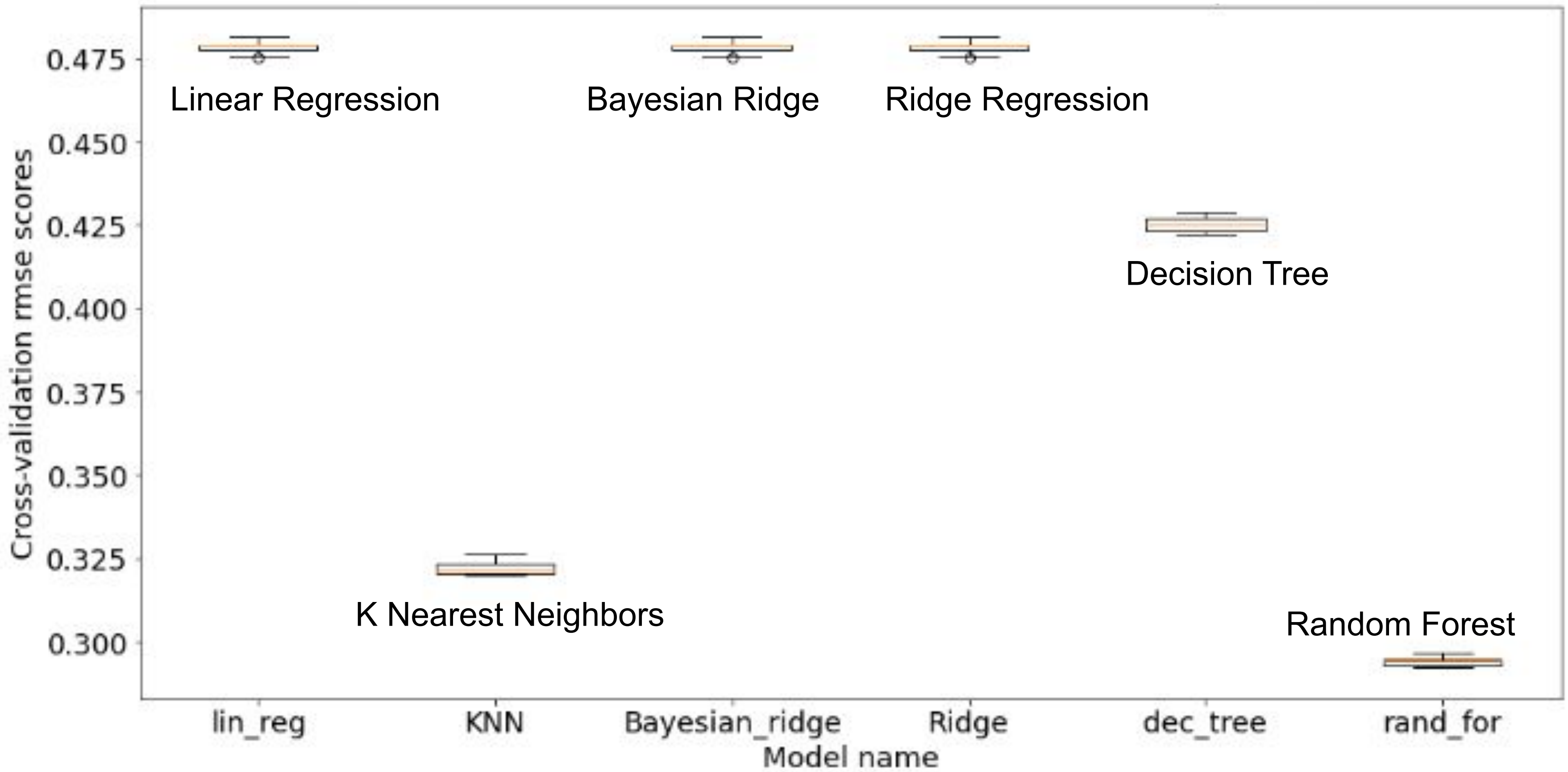
Option 1:
Linear and quadratic fit parameters of the spectra

Option 2:
Brightness at different wavelengths as features

Observed spectra

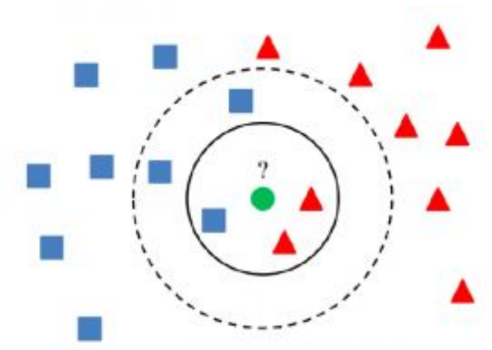


Cross validation scores for a few of the compared models

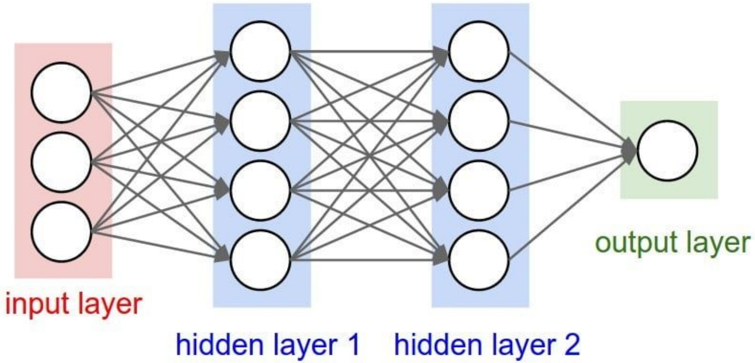


Which model to choose?

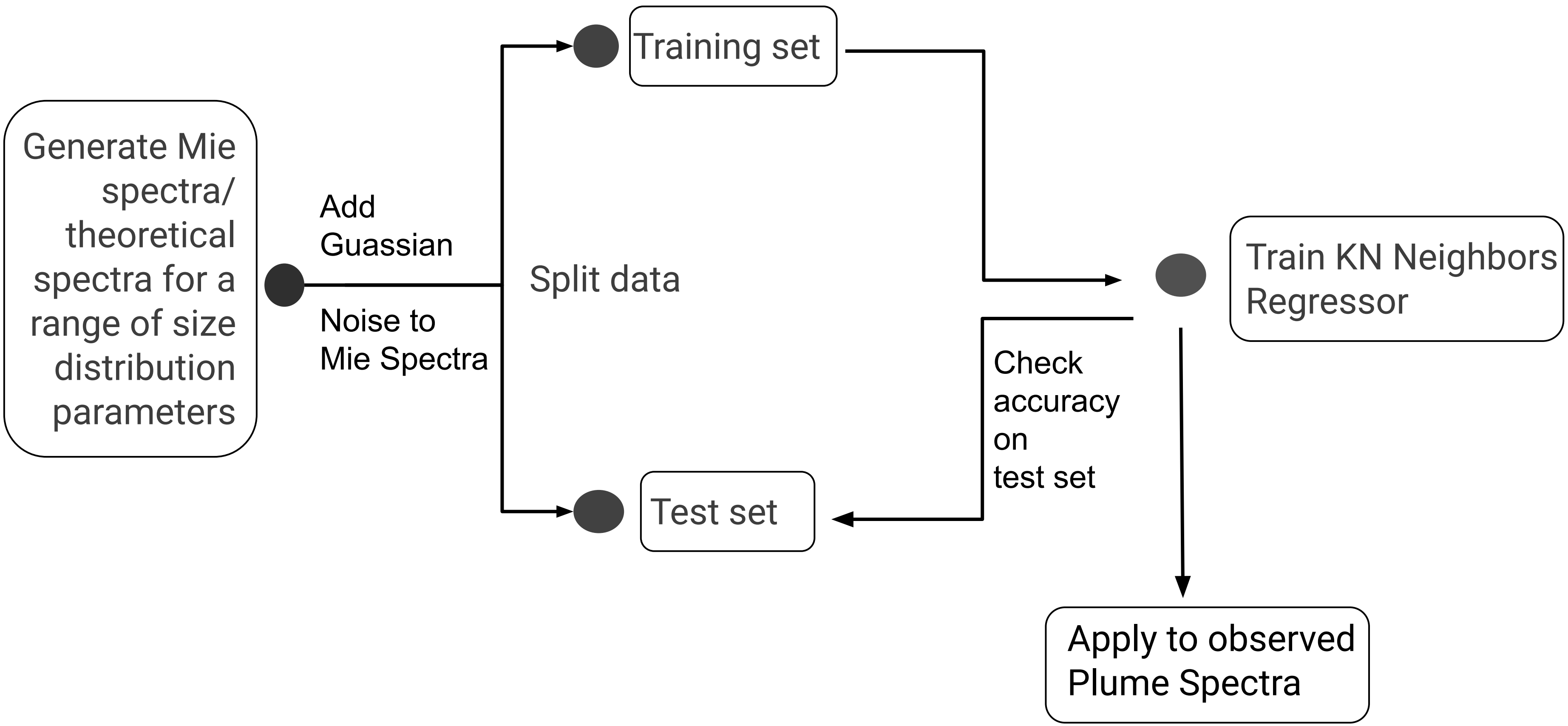
K Nearest Neighbors



Deep Neural Network

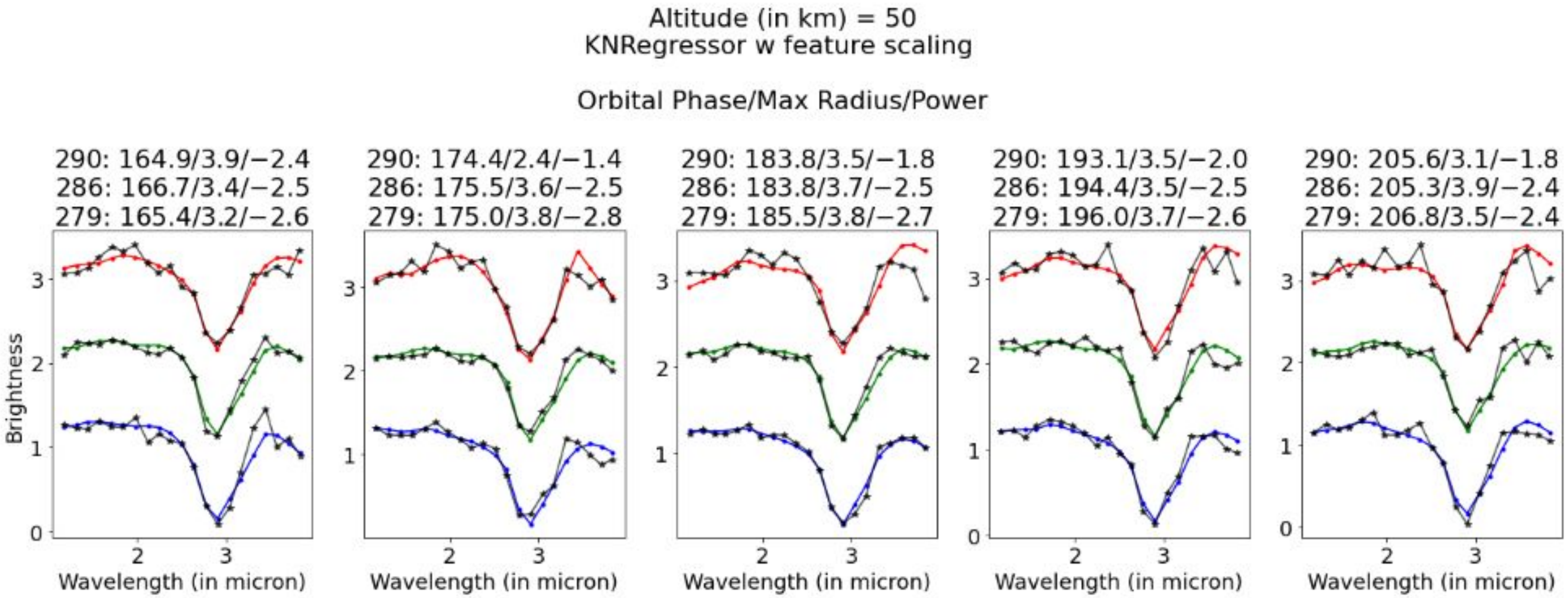


Machine Learning Algorithm

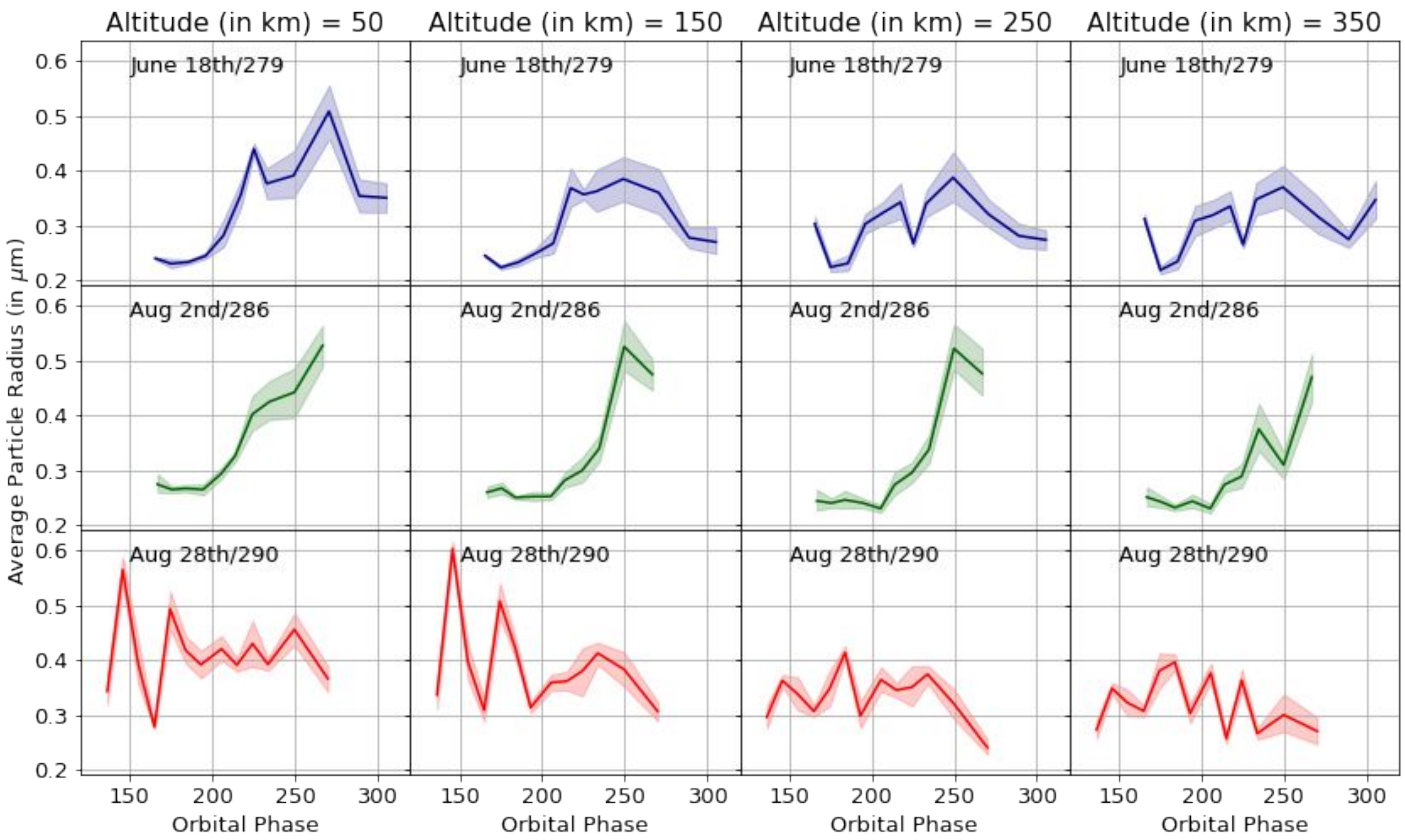


Comparing results obtained using the ML Model

Mie Spectra/Theoretical Spectra plotted over Observed Spectra



Results: Enceladus Plume particles' average size estimated using Machine Learning



Let’s connect!

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