Environmental forcing of Antarctic food web dynamics - a multi-tiered approach employing multispectral imagery, field spectroscopy, and stable isotope analysis
Reflectance values for 2150 different wavelengths were binned to 6 or 7 bands, depending on the sensor. These binned values simulate how these sensors detect the spectral reflectance of these guano samples. A partial least squares regression (PLSR) modeling approach was used to associate stable isotope values (and therefore diet) to the convolved spectra. This approach decomposes covariates (in this case, reflectance values for each spectral band of the aforementioned sensors) into 'principal components', which are fit to predict the response variable (i.e., δ^{15}N or δ^{13}C values obtained from SIA).

The appropriate number of principal components was selected by minimizing the root mean square error. Results from these analyses reveal that spectra obtained from these satellite sensors can indeed predict δ^{15}N (our proxy for penguin diet) with high confidence. Spectra convolved to the relevant Landsat 8 OLI bands explain 82% of the variance in δ^{15}N values (Fig. 1). These results are based on a subset of the samples collected thus far (less than one third) - this relationship is expected to improve once all available samples are processed.

Investigating dietary change from Landsat imagery
To examine potential changes in the spectral properties of penguin colonies over time, we obtained spectral reflectance values derived from the Landsat 4 TM, Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI sensors. Spectral information was acquired from an automated algorithm designed to detect Adélie penguin (Pygoscelis adeliae) colonies from Landsat imagery (Schwaller et al. 2013).

Using these reflectance values and the quantitative relationship derived from the PLSR analyses outlined above, we predicted δ^{15}N values (our diet proxy) at these Adélie penguin colonies, dating back to 1984. To investigate potential changes in penguin diet over time, we modeled these predicted δ^{15}N values using a hierarchical Bayesian approach, which allowed us to treat missing data in time series as latent states to be sampled and allowed us to better assess parameter uncertainty (Gelman and Hill 2006).
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$$y_{ij} \sim N(\mu_{ij}, \sigma^2)$$

$$\mu_{ij} = \alpha_j + \beta_j \times YEAR$$

$$\alpha_j \sim N(\mu_{\alpha}, \sigma^2_{\alpha})$$

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\[
y_{ij} \sim N(\mu_{ij}, \sigma^2)
\]

\[
\mu_{ij} = \alpha_j + \beta_j \times \text{YEAR}
\]

\[
\alpha_j \sim N(\mu_\alpha, \sigma_\alpha^2)
\]

\[
\beta_j \sim N(\mu_\beta, \sigma_\beta^2)
\]