# Decomposing Titan's far-infrared Haze B feature


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Abstract !

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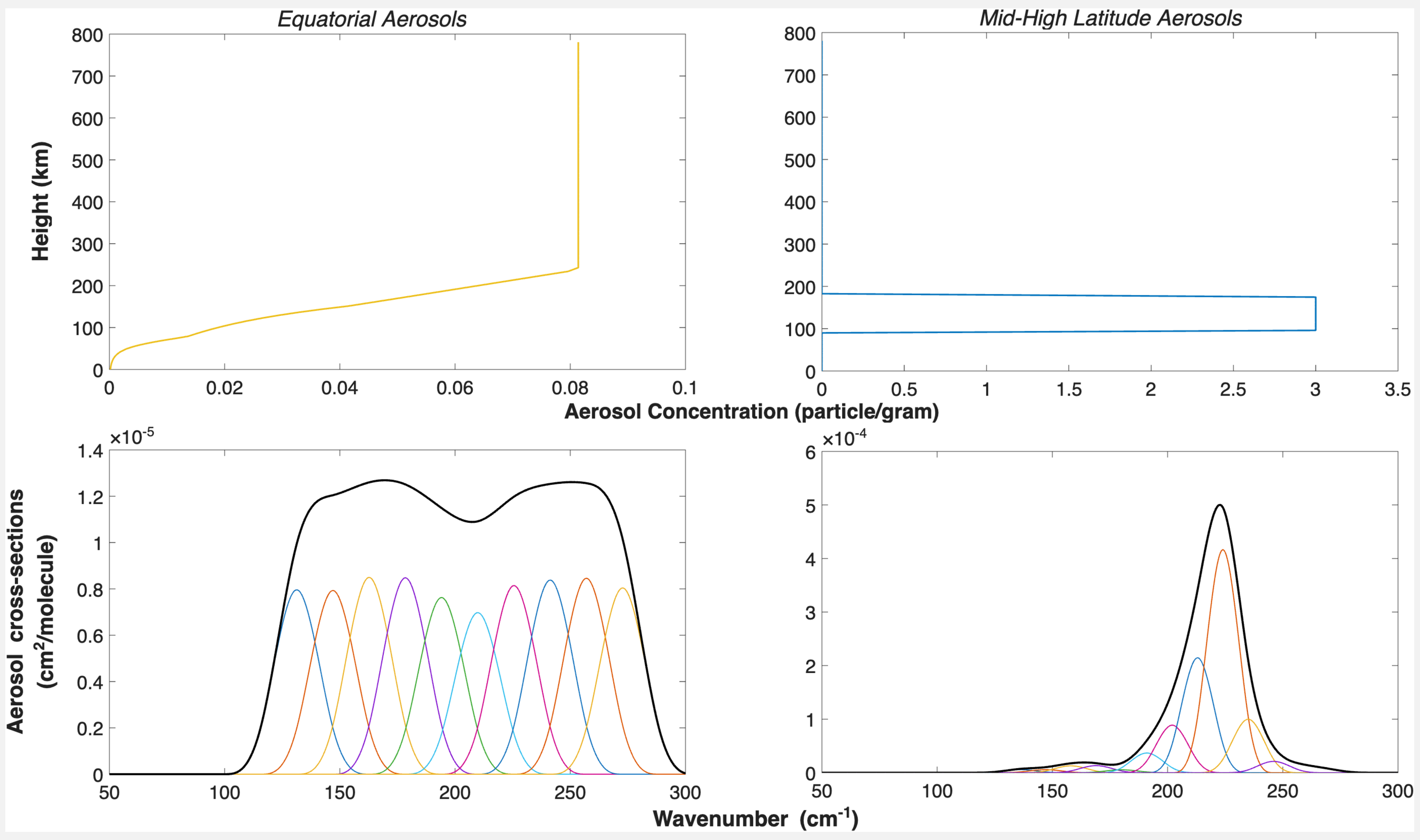
## Background

Saturn's largest moon, Titan, is a chemical powerhouse of hydrocarbons and nitriles. Its nitrogen and methane rich atmosphere photodissociate and recombine to form a vast array of complex organics such as Benzene ($C_6H_6$), Hydrogen Cyanide (HCN) and Acetylene ($C_2H_2$). At colder temperatures, these species can condense, co-condense, polymerise and aggregate to form ice clouds and hazes of substantially large particles (*Vuitton 2025*).

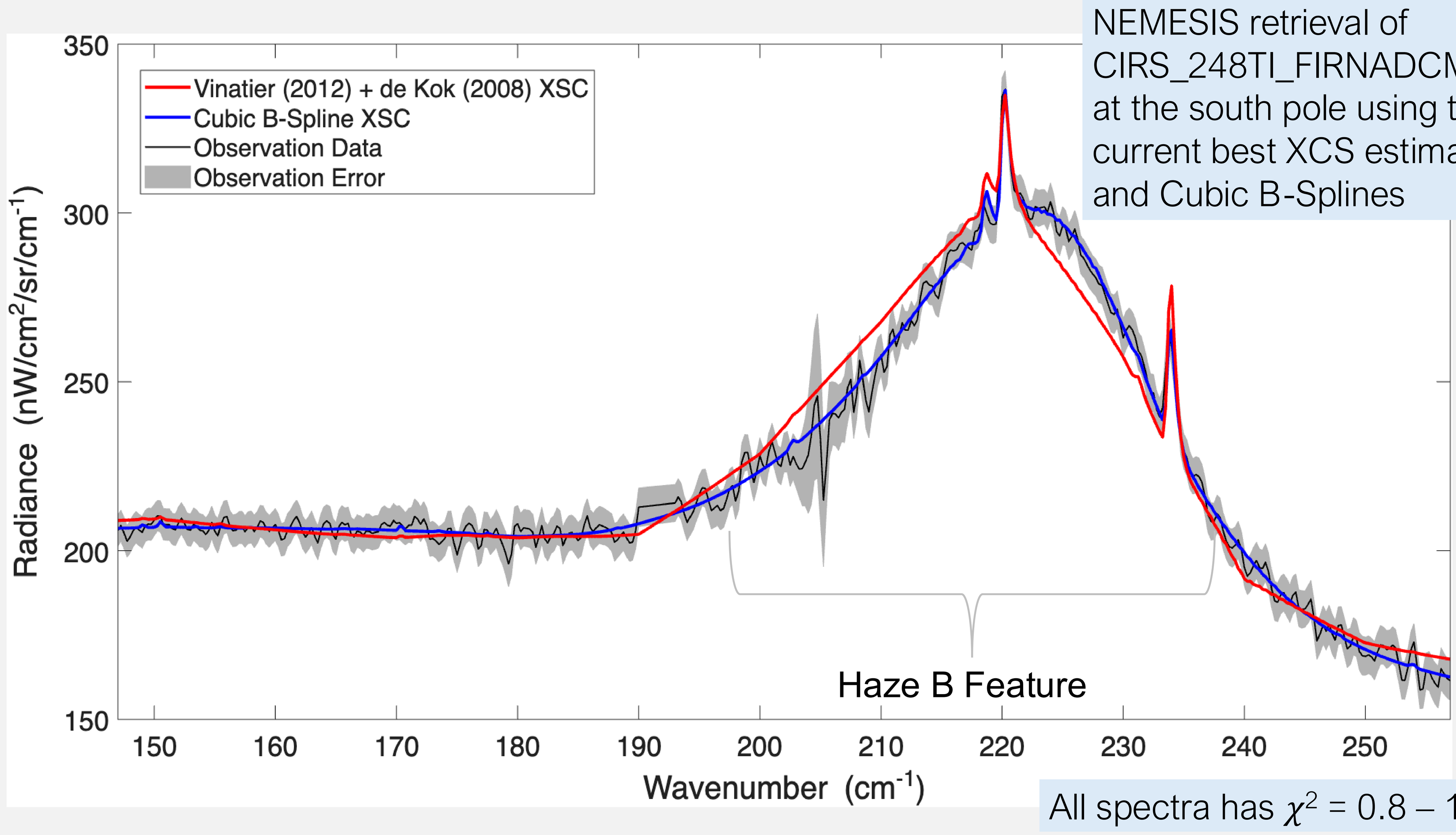
During its 13-year mission (2004-2017) in the Saturnian system, the Cassini spacecraft captured millions of spectra of Titan, probing its climate. In the far-infrared range (0 – 600 $cm^{-1}$) of the Composite Infrared Spectrometer instrument (CIRS), lies a distinct broad spectral feature known as Haze B (or the Haystack), a polar stratospheric ice cloud of unknown composition (*de Kok 2007, Jennings 2012, Anderson 2018*). Spanning ~ 200 – 250 $cm^{-1}$, little is known about this feature, making modelling and fitting this region difficult.




**Top:** Vertical profiles used to derive the equatorial background haze from Vinatier 2010 (left) and Haze B from de Kok 2007 (right).
**Bottom:** Scaled cubic B-splines and their summed extinction cross-section

## Approach

- Using NEMESIS-scaled Cubic-B splines, determine the aerosol extinction cross-sections (XCS) of 156 Cassini CIRS FIRNADCMP FP1 observations
- Calculate the average equatorial cross-sections to characterise the main photochemical haze, otherwise known as Haze 0
- Fit Haze 0, and find the aerosol cross-sections across all observations
- Using peak cross-section as a proxy, investigate the spectral, latitudinal and temporal variation of Haze B




NEMESIS retrieval of CIRS_248TI_FIRNADCMP001 at the south pole using the current best XCS estimate and Cubic B-Splines

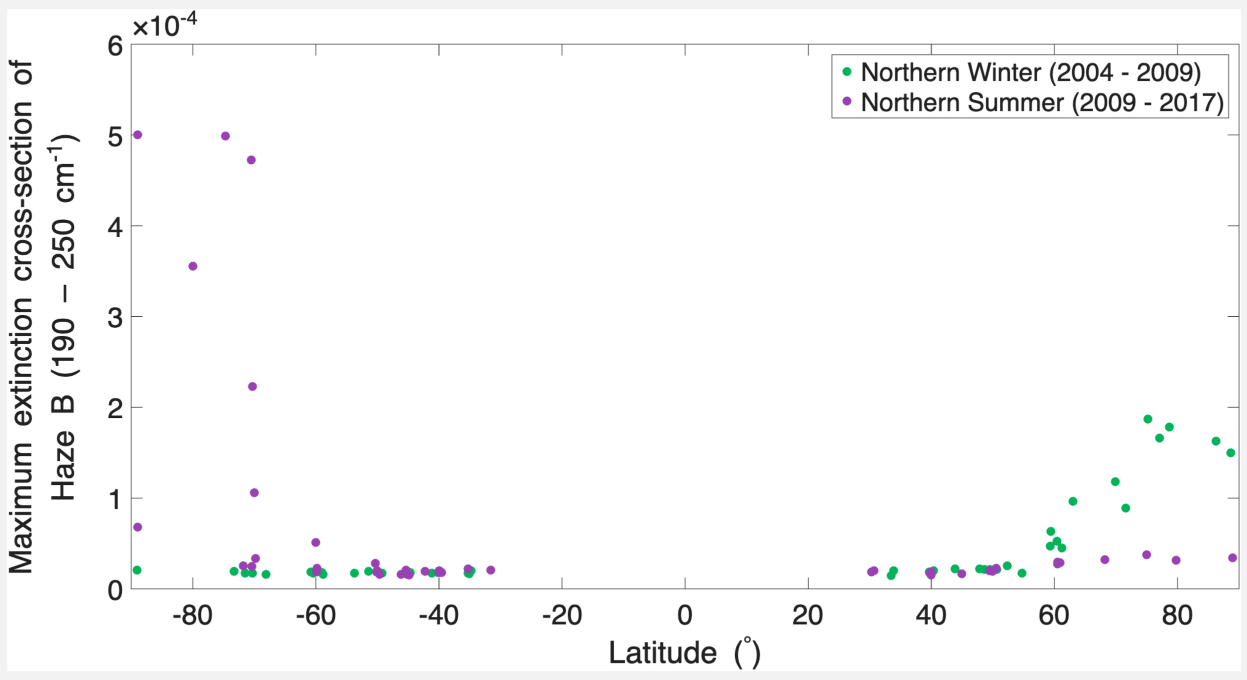
All spectra has $\chi^2$ = 0.8 – 1.9

## Representing a curve with Cubic B-Splines

Curves and lines can be represented as a sum of simpler basis functions such as Gaussians, polynomials or triangles. These basis functions can be used to smooth and fit noisy data.

Cubic B Splines are smooth, flexible, continuous and finite piecewise cubic functions defined by a series of knot points. The resulting splines overlap and can represent complex curves without imposing strict forms.

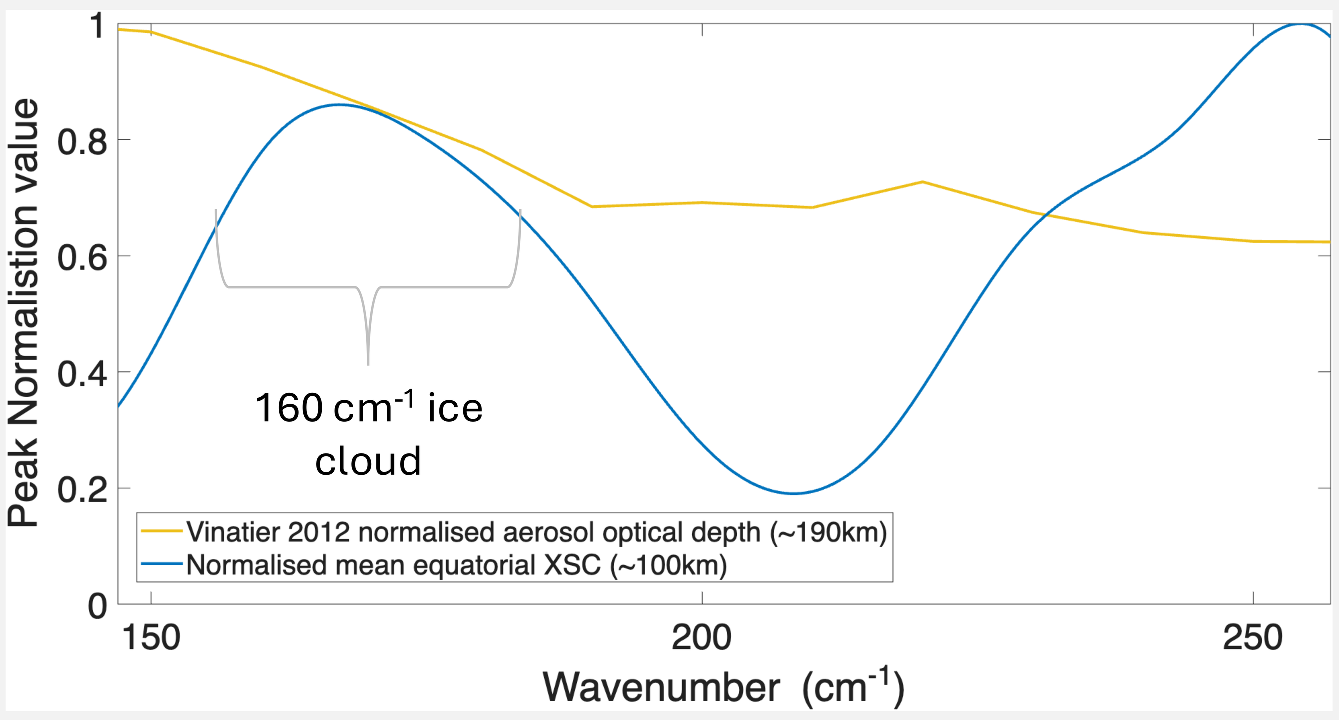
They have been used extensively in Titan Science, including *Teanby 2017* and *Wright 2025*.




## Latitude

- high in the poles, beginning at +/- 60
- follows Titan's seasonal trends
- Higher in the south than the north

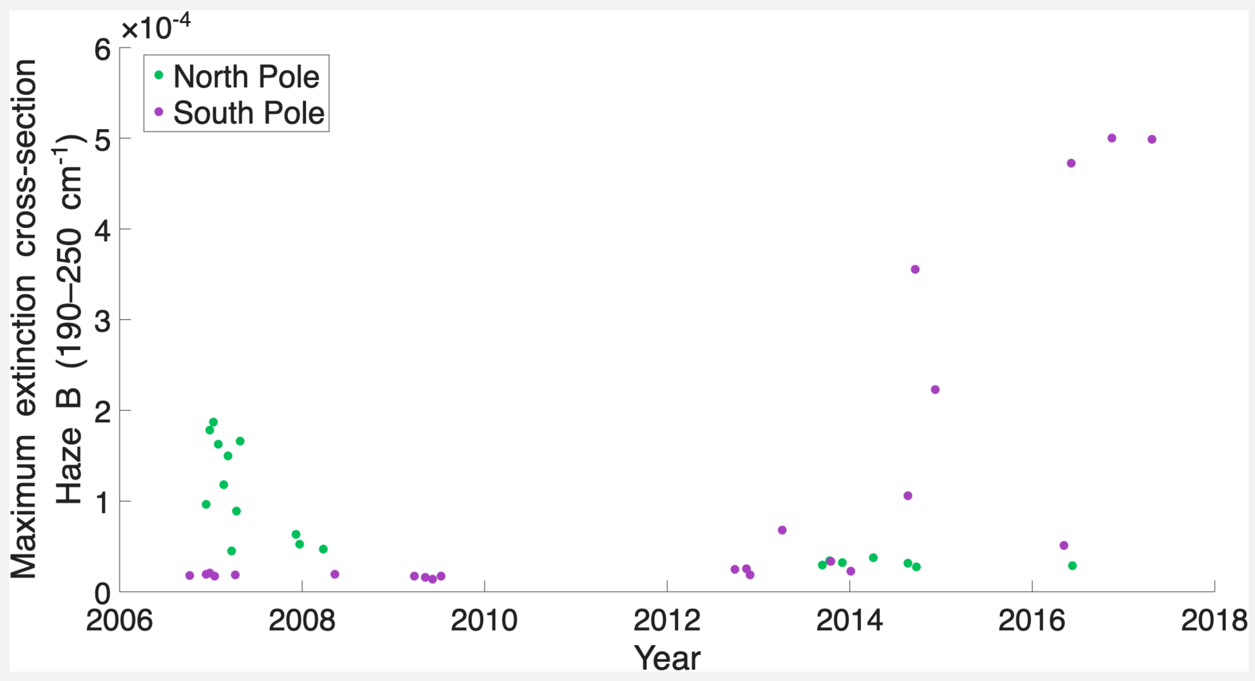
## Results

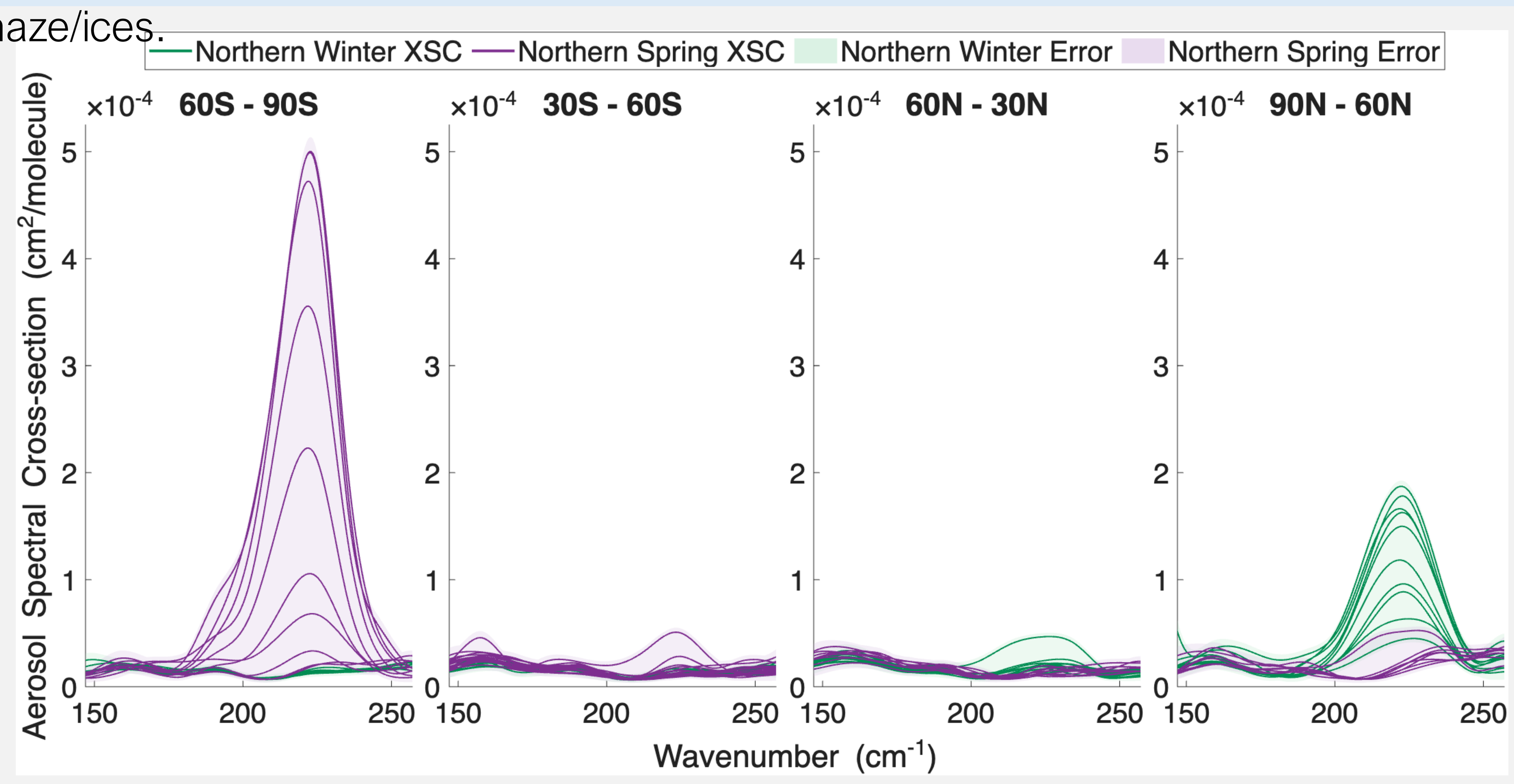



Shape comparison between mean equatorial XCS (Haze 0), and the commonly used model (*Vinatier 2012*) derived from *Anderson 2011* extinction coefficients. Our model captures more fluctuations because lower altitudes are more sensitive to haze/ices.

## Time

- Haze B in the north dissipates after 2008
- Haze B in the south starts forming ~ 2013/2014




**Main Finding:** Haze B peaks at the north pole during winter (223.5 $cm^{-1}$), and at the south pole during spring (222.5 $cm^{-1}$) suggesting evolving properties.

## Key Takeaways

- Improved Fitting: Cubic-B splines can be used to empirically fit the aerosol extinction cross-section of CIRS spectra, improving the fit on the spectra
- Better sensitivity: The derived Haze 0 XCS fluctuates more than the standard model, possibly capturing hazes and ices (*160 cm⁻¹ cloud*) at lower altitudes
- Haze B follows the seasonality of Titan, being more pronounced in the south pole possibly due to colder temperatures, with evidence of aerosol evolution