High-resolution Volatiles and Minerals Mapper (HVM^3) Measurement Sensitivity

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Agenda

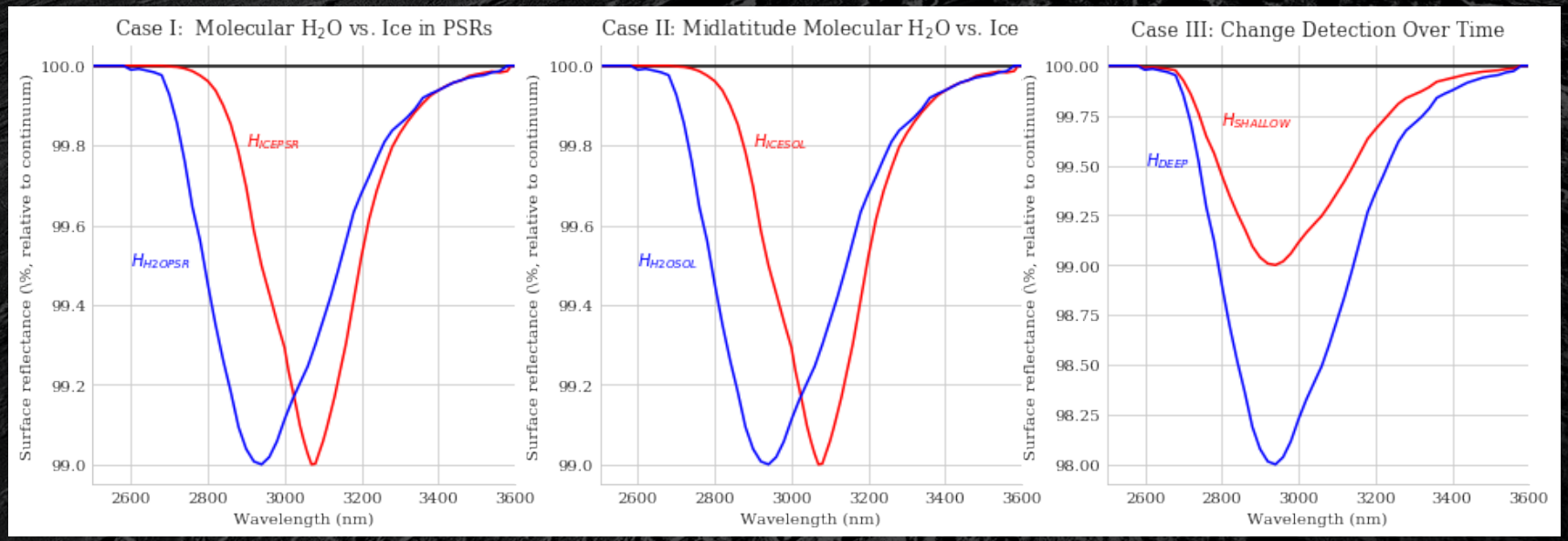
- Describe the HVM3 science observations
- Define reference "stressing case" observations for critical mission objectives.
- Review basic factors influencing instrument sensitivity and resulting performance impacts

Grounding assumptions and objectives

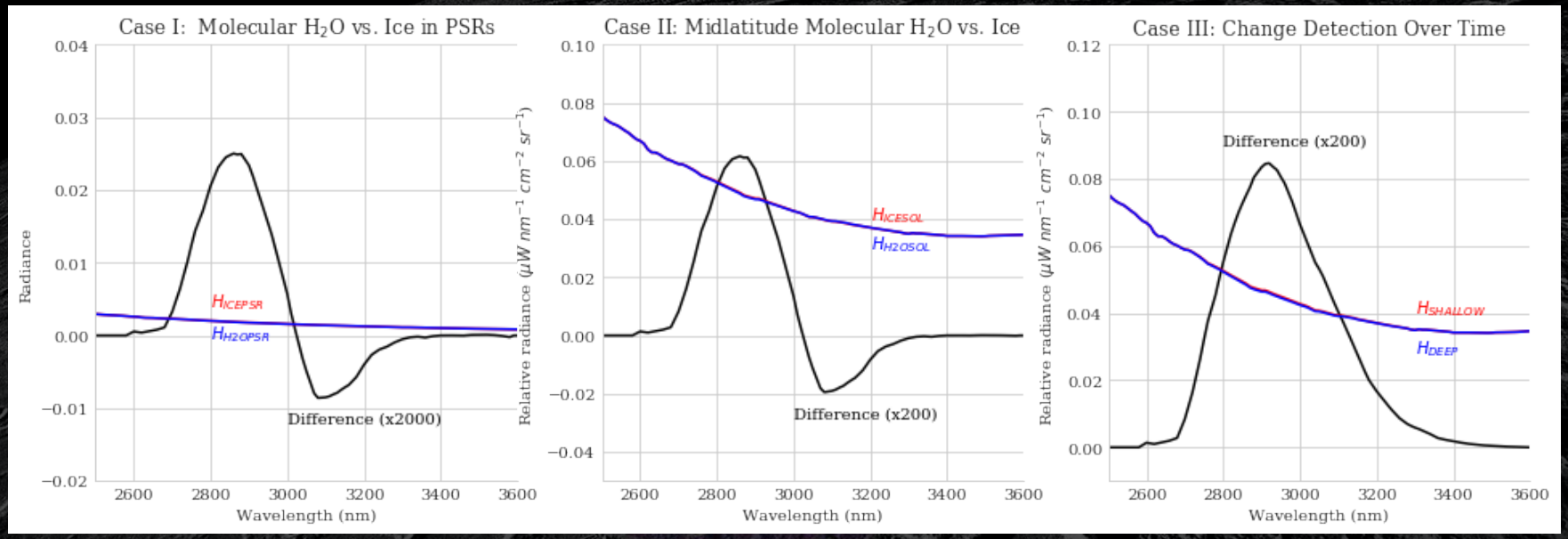
- Assume a background substrate based on a reference measurement of lunar regolith - the Apollo BKR1LR117 sample.
- Assume thermal emissivity effects can be removed
- Capture performance for core science objectives using a “hypothesis test” discriminating a null and test hypothesis spectrum via likelihood ratio.
- Three stressing hypothesis tests encompass the range of different HVM^3 performance needs
- The three cases all involve the signature of lunar water volatiles expressed in the 2500-3600 nm range
- Since this is the most difficult region due to low signal, it envelopes broader performance questions.
- Include errors due to observation noise
- Exclude physical uncertainties in scene content (e.g. intimate mixing, thermal state, roughness).

Three cases

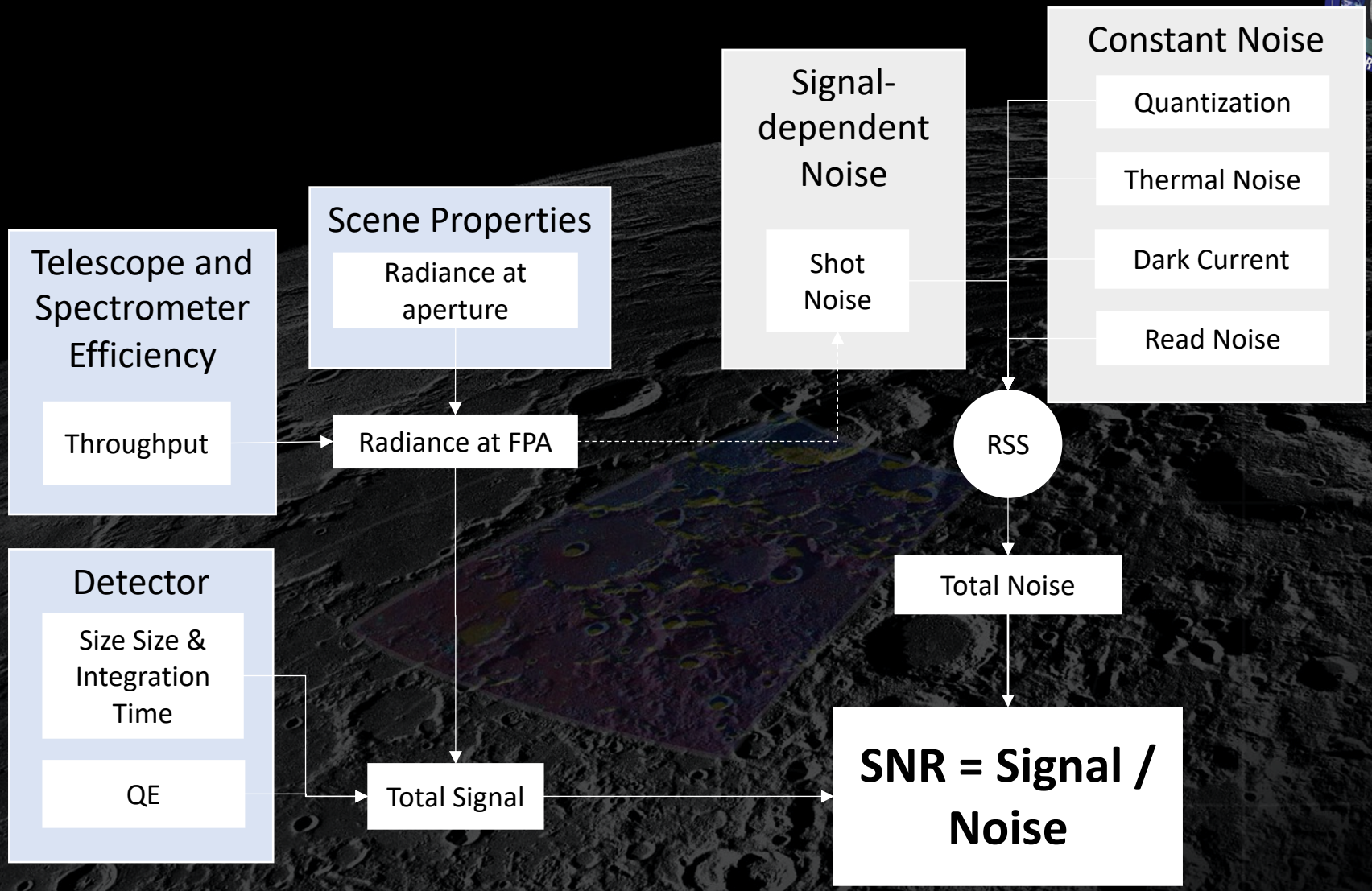
Case	Null	Test	Substrate	Illumination	T	Coincidence	Integration	Binning
PSR	Molecular H2O 1%	Water Ice 1%	Regolith	Scattered	80K	Yes	0.21 s	x5 or x80
Midlatitude	Molecular H2O 1%	Water Ice 1%	Regolith	θ_S=85	300K	Yes	0.043 s	x1
Change Detection	Molecular H2O 1%	Molecular H2O 2%	Regolith	θ_S=85	300K	No	0.043 s	x1



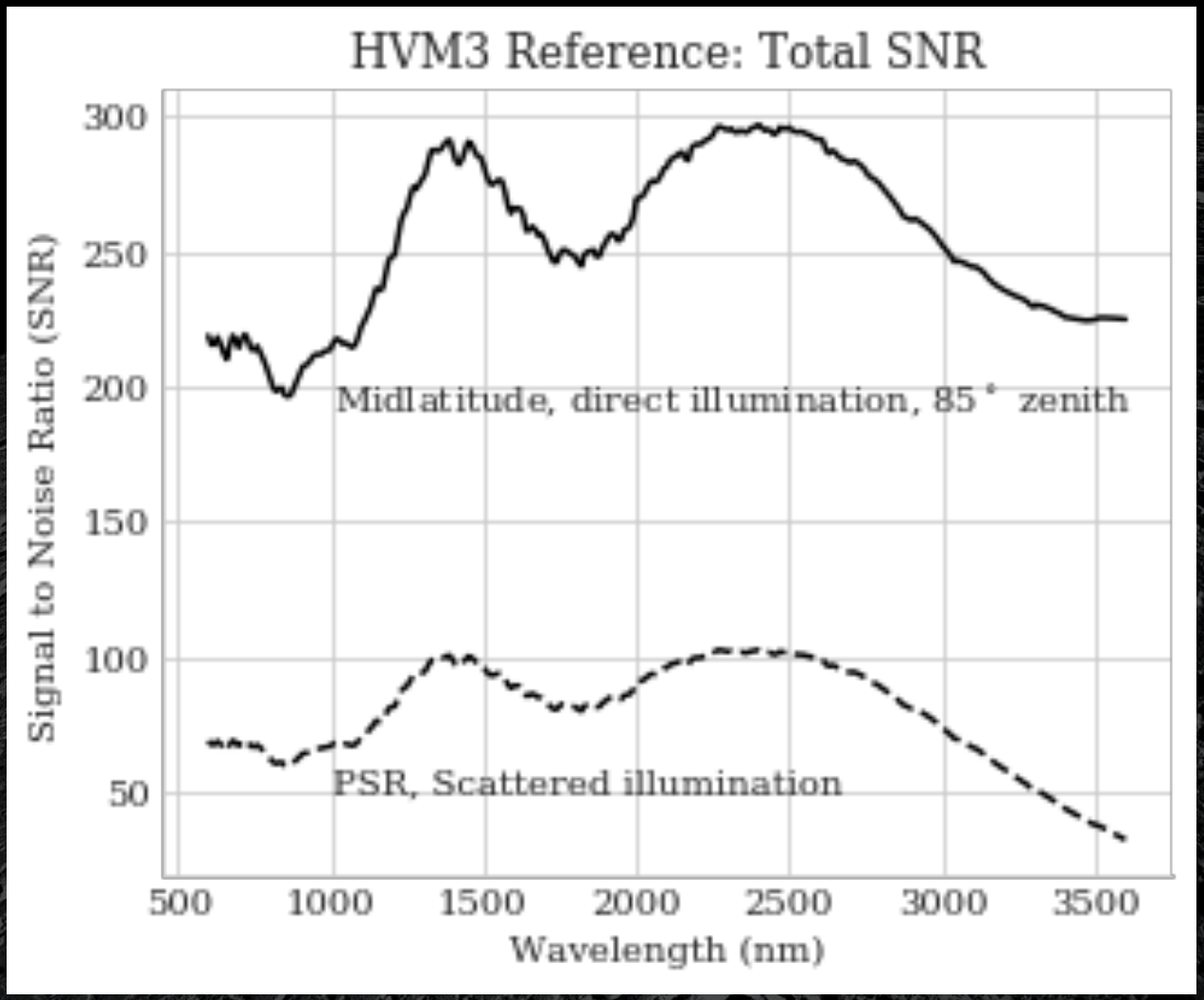
Translating to Radiance units



Community-standard instrument noise calculation



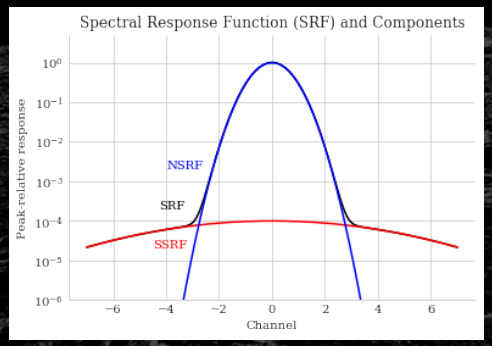
HVM^3 SNR examples

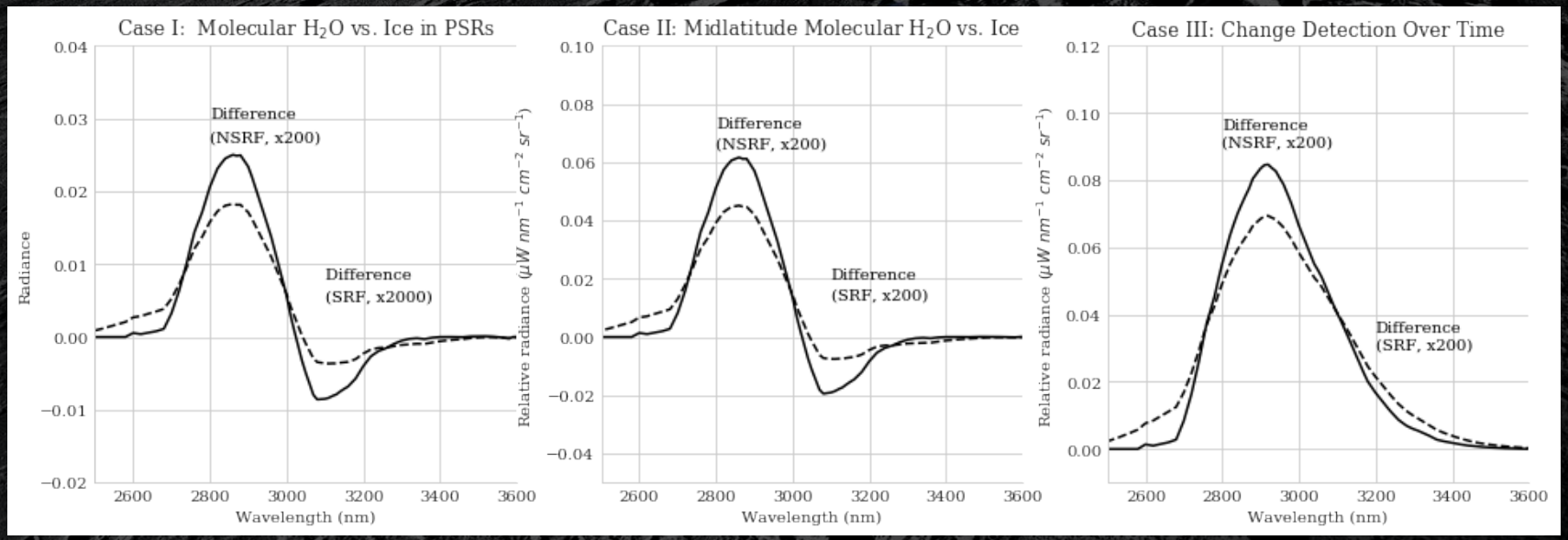


Spectral response function broadening

We augment our model as in (Thompson et al., *Remote Sensing of Environment* 2018) to include the departure of spectral and spatial response beyond the Gaussian specification.

It is often correctable during analysis, but we will conservatively assume no correction is applied.





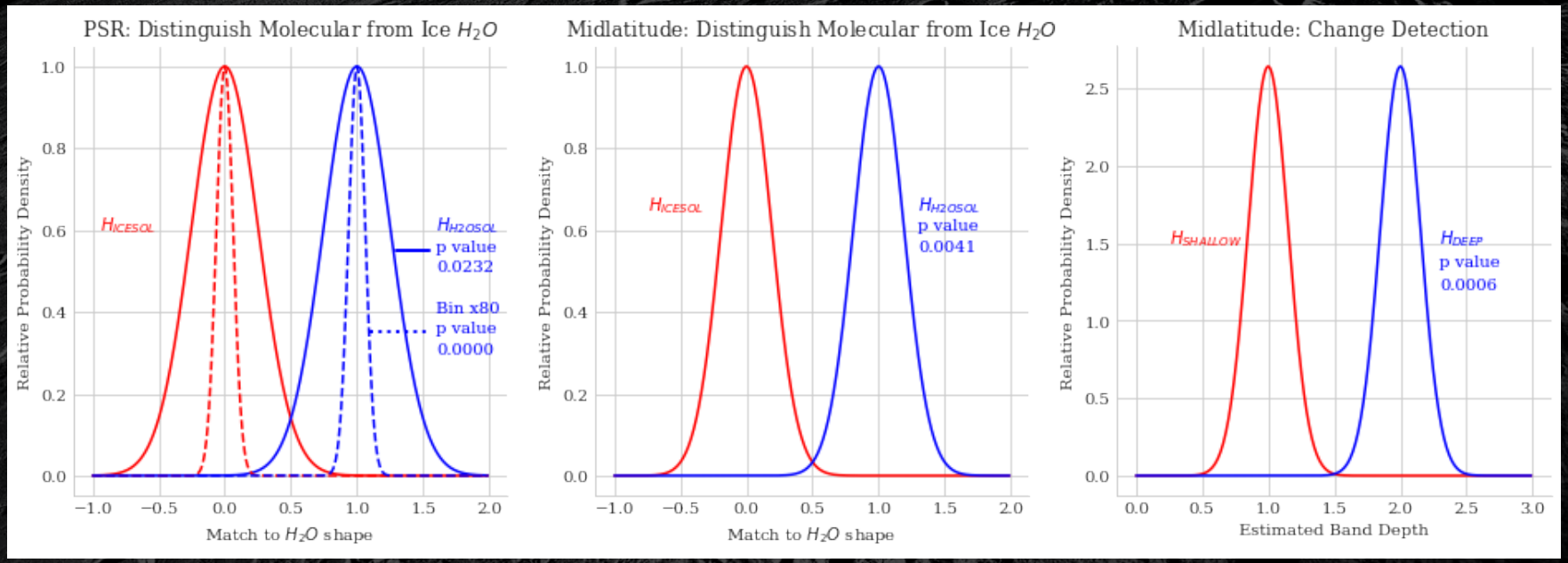
P-values and sampling distributions

The target is a (crude but orthodox) community standard p-value of 0.05

The PSR case permits 500 m and 1500 m spatial sampling options.

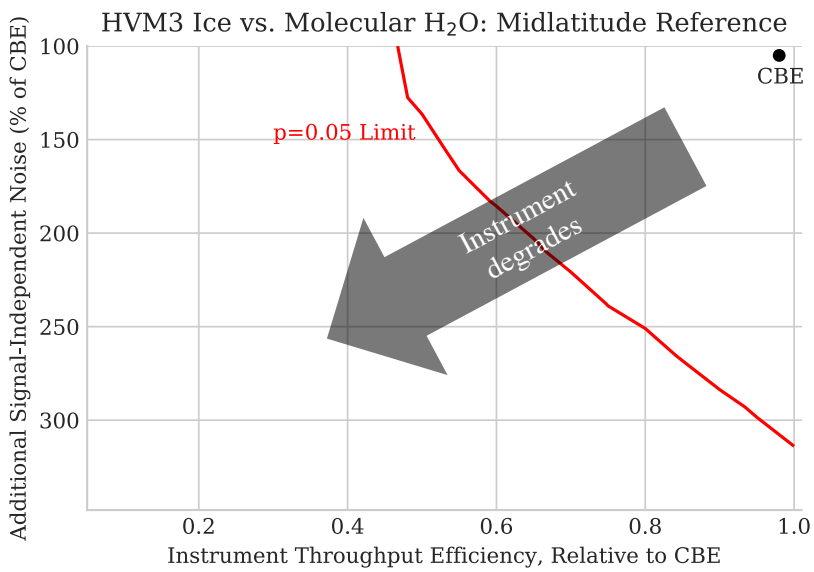
The single-spectrum midlatitude case is the “driving observation.”

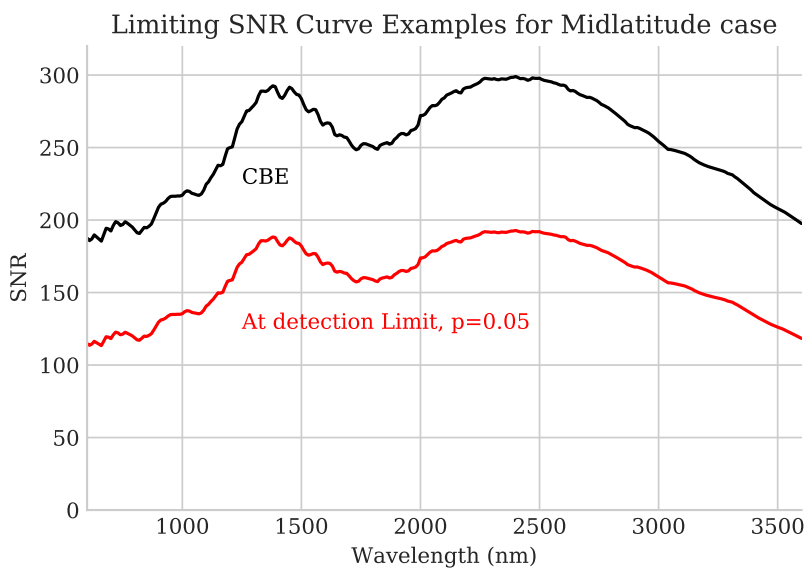
Spectral likelihood ratio test (see Thelier et al., SPIE 2008)



What is the "margin" for instrument degradation?

- The detection limit for midlatitude "Ice vs. Molecular H_2O" is currently the most challenging standard
- There is a family of SNR curves that would just barely meet the requirement
- We can portray these as a contour in the space of instrument degradations (lower left) or find example performance limits used to set hat formal component-level requirements (lower right)





Backup