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Infrared Sounding in NWP

NOAA IR Sounding Workshop
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Outline

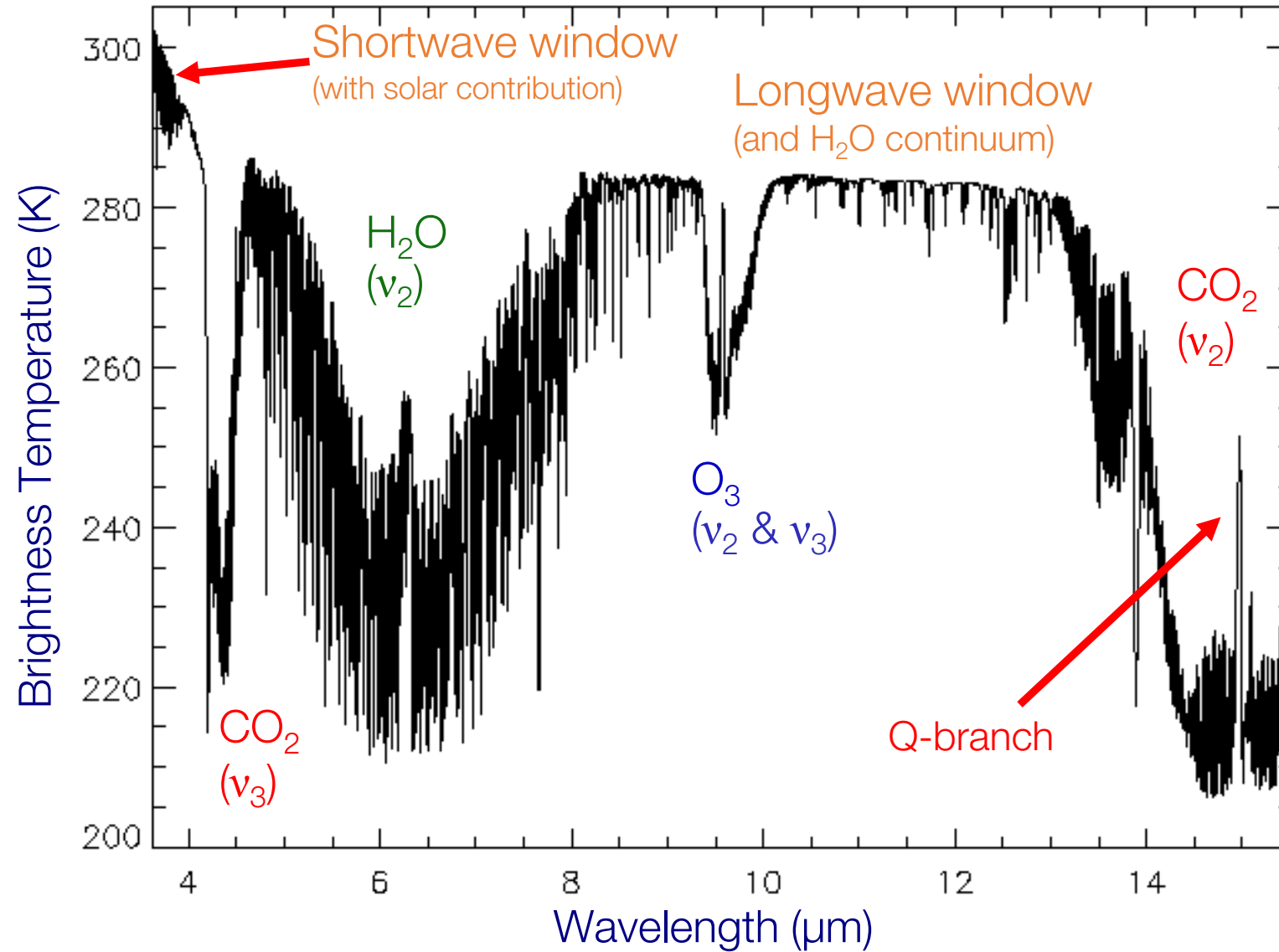
- Current use of IR sounders in NWP
 - Spectral coverage
 - Correlated errors
 - Clouds
- Some questions to be addressed
 - The tradeoff
 - The 15micron band
 - Auxiliary data
- In summary



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Overview of Infrared Spectrum and Use in NWP

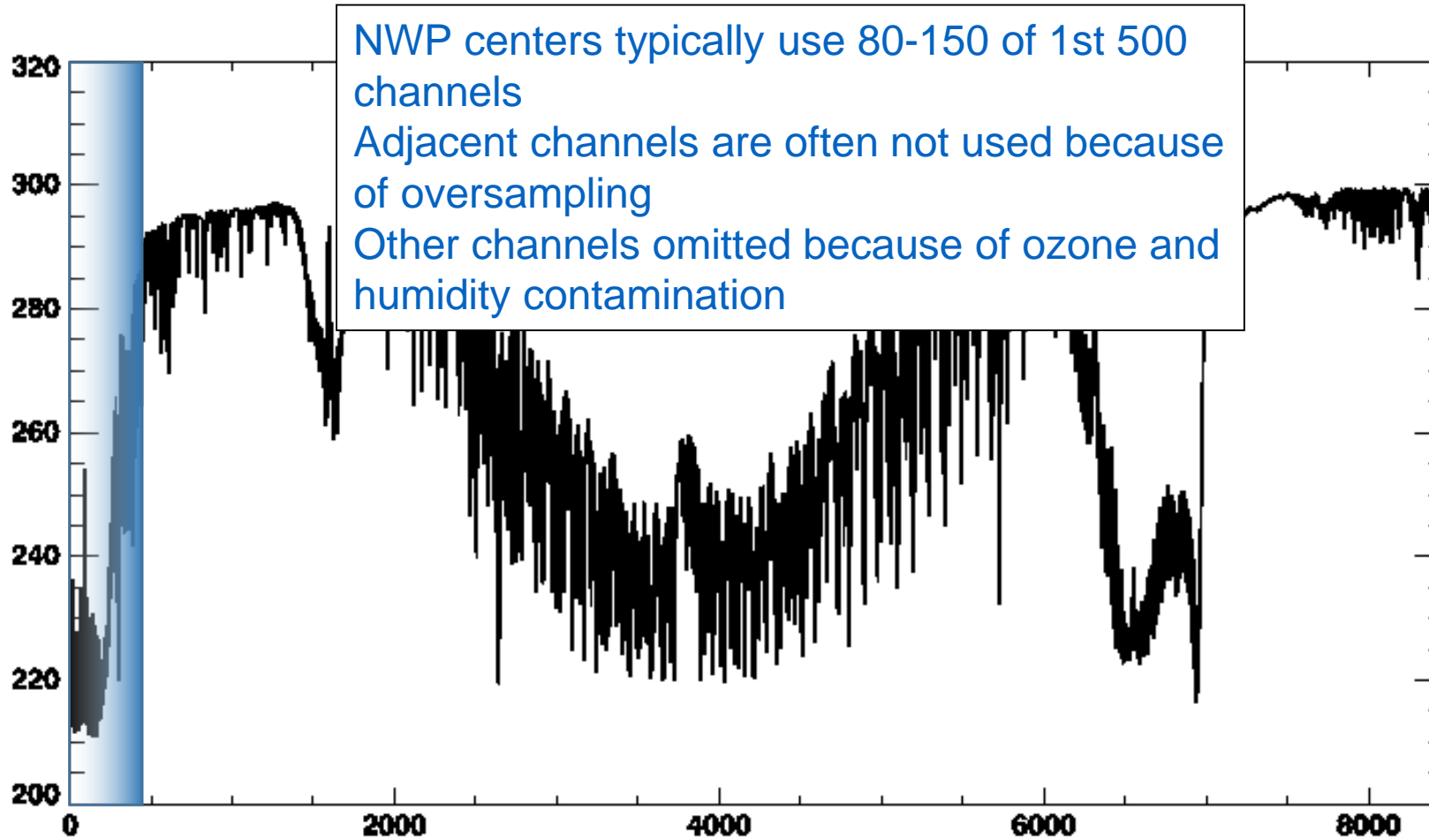
An Infrared Spectrum



Regions of the Infrared Spectrum

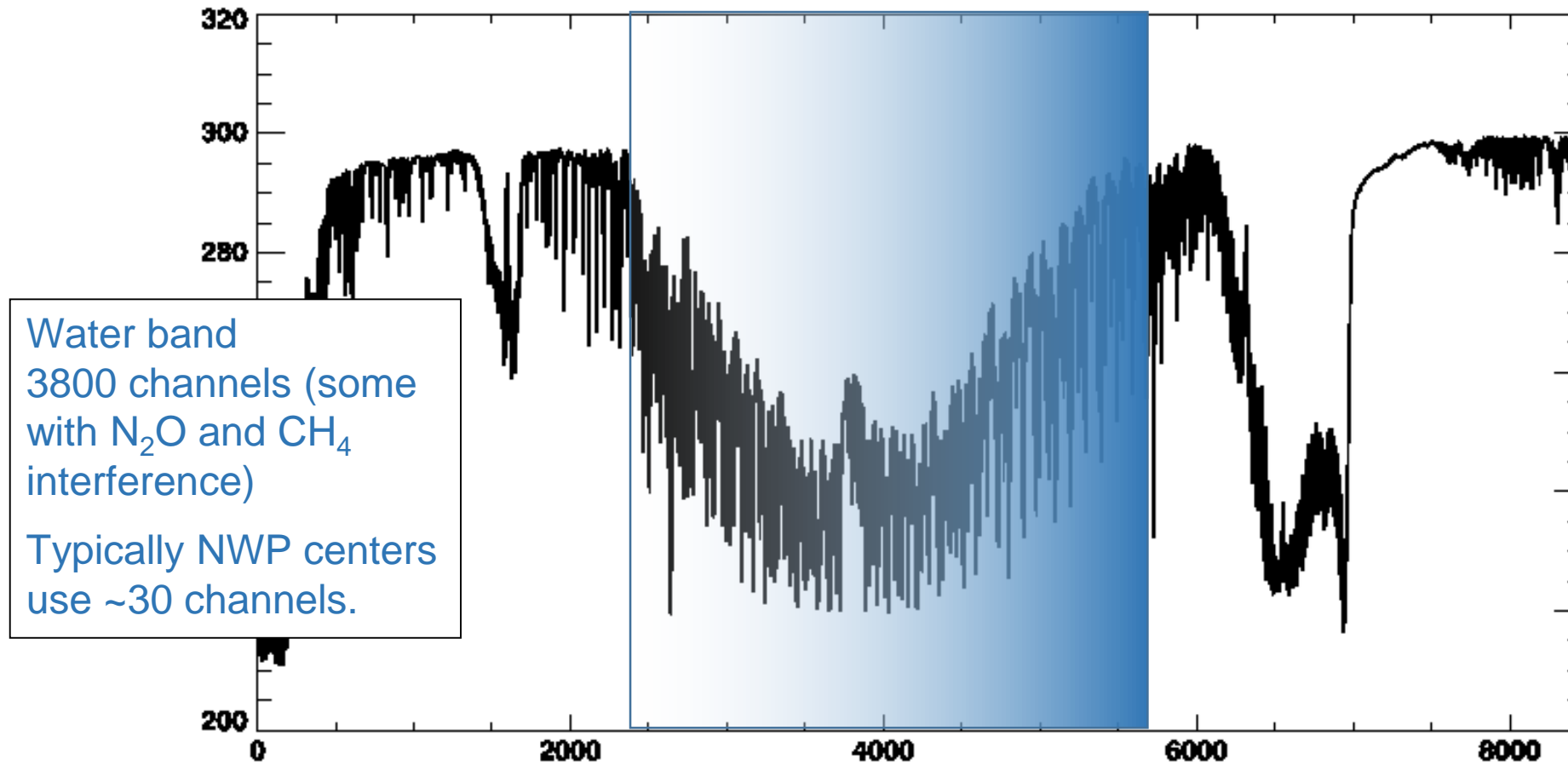
Flipped the spectrum into wavenumber space!

Longwave CO₂ Band



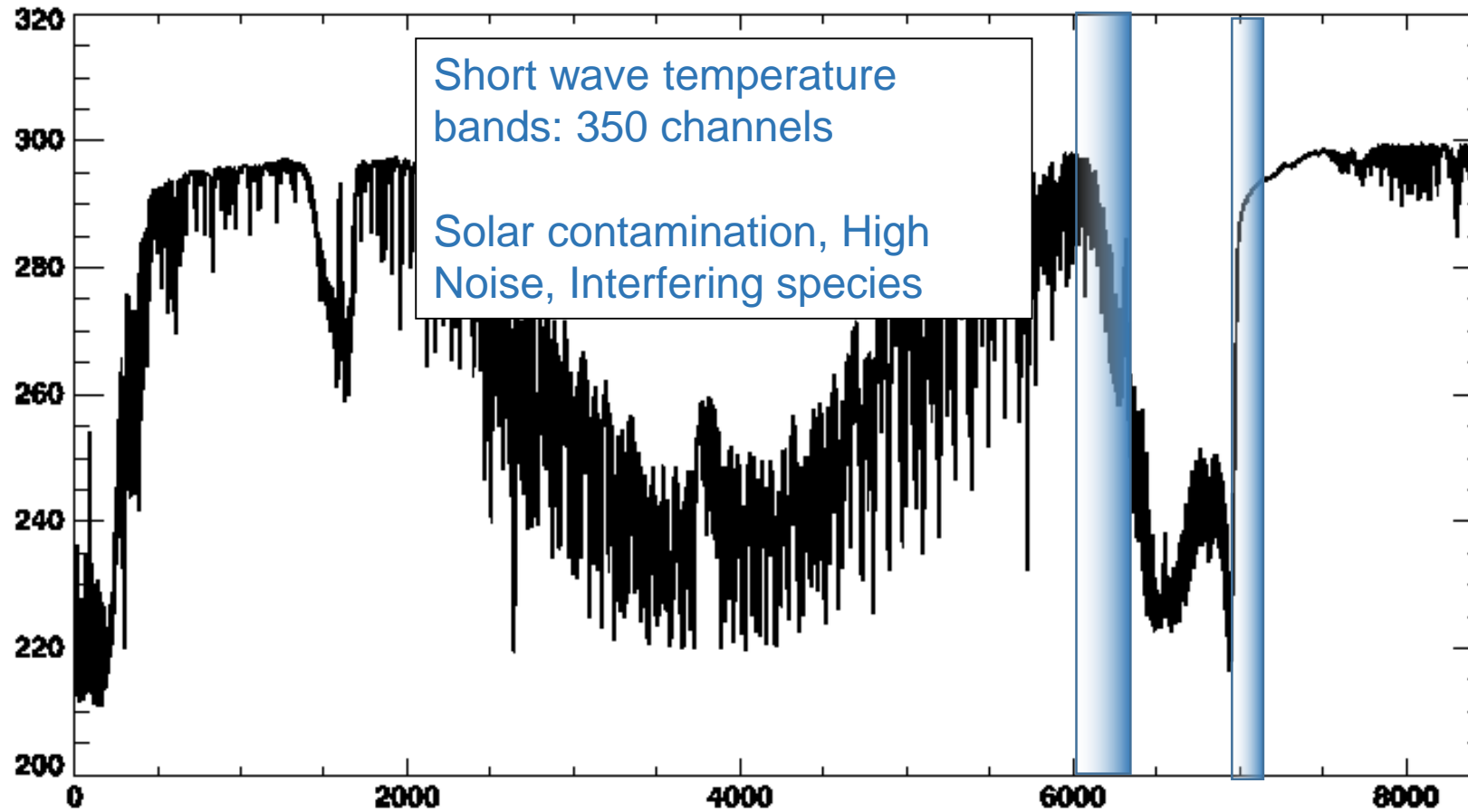
Regions of the Infrared Spectrum

The 6.3 μm Water Band



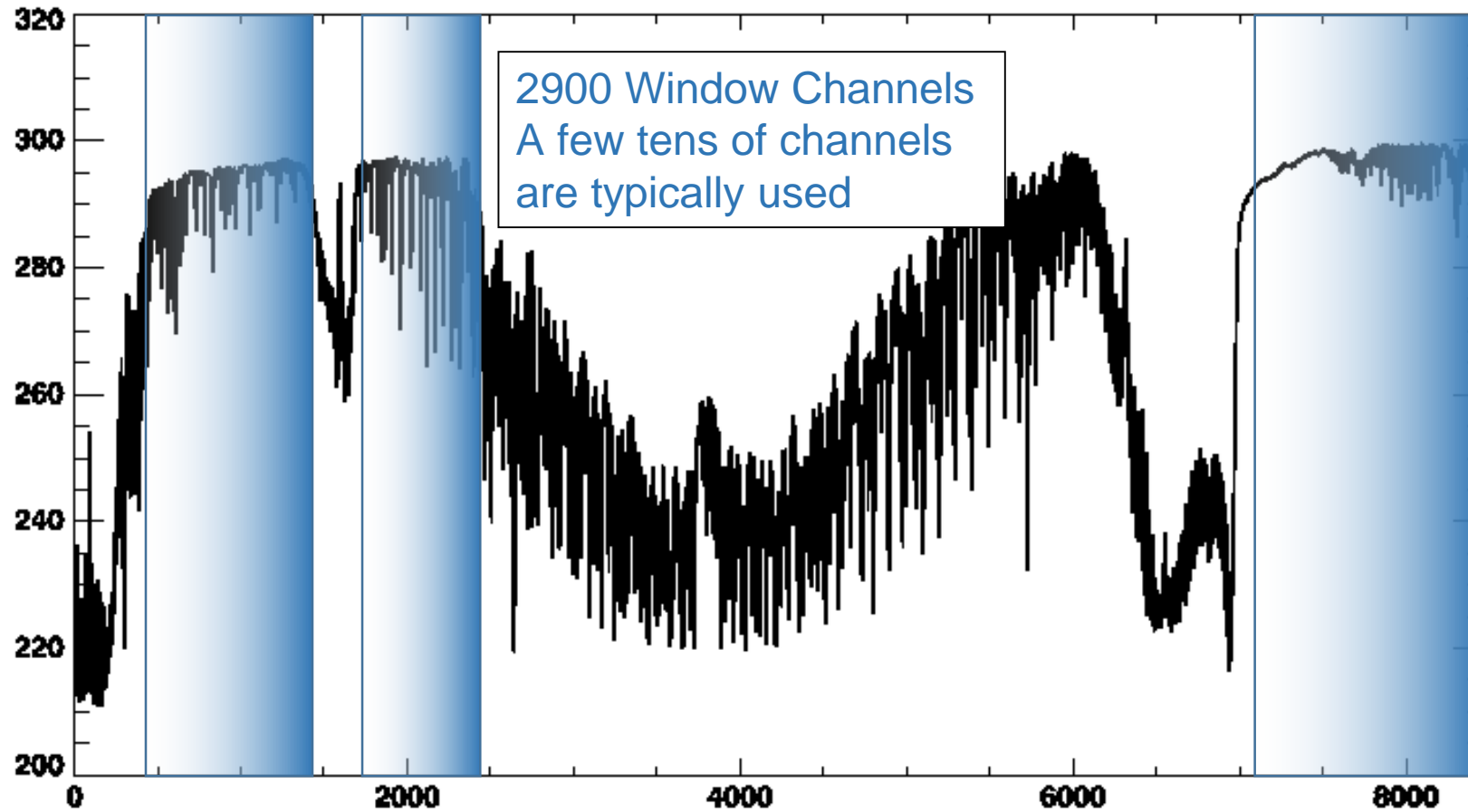
Regions of the Infrared Spectrum

Shortwave CO₂ Band



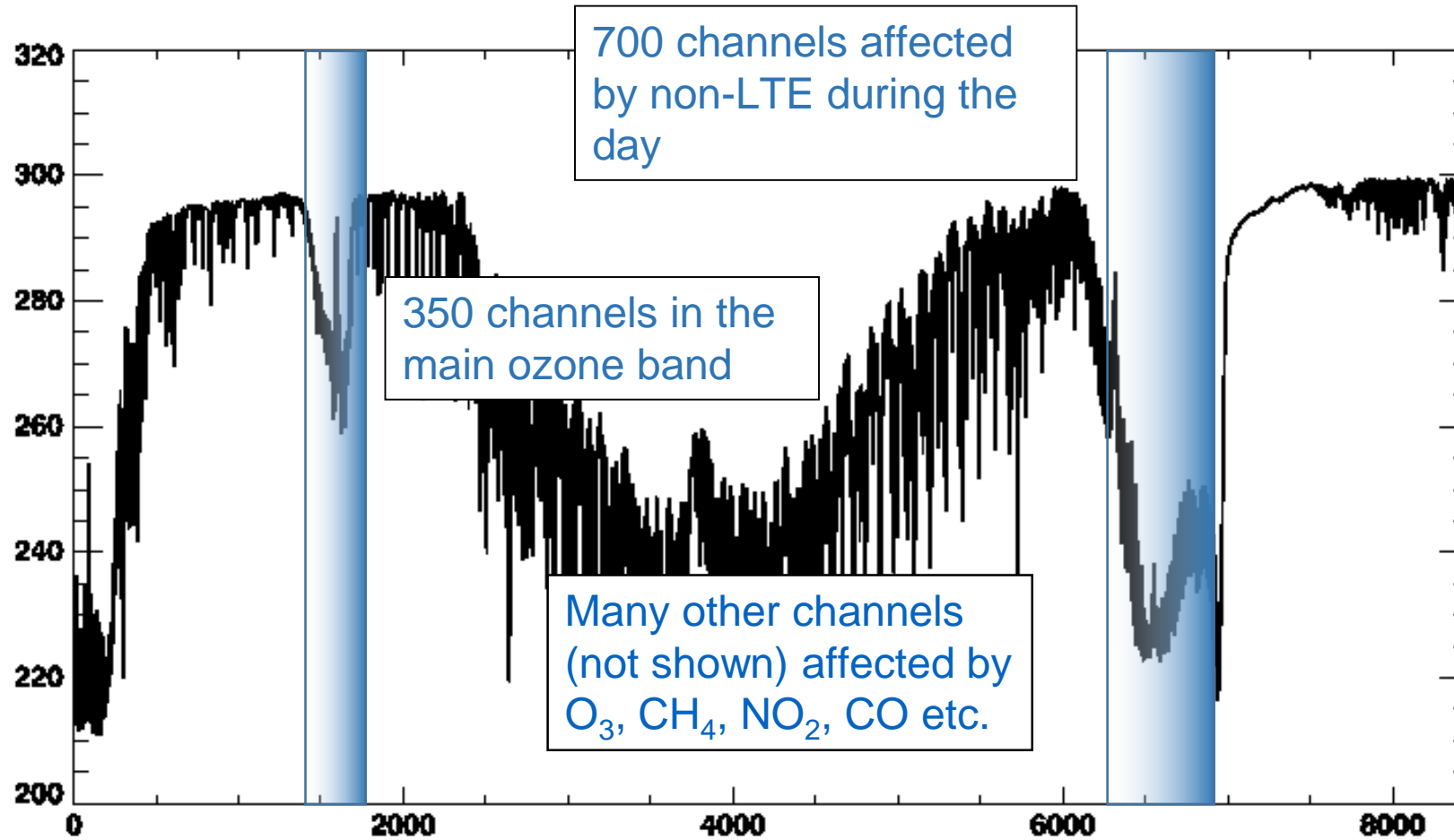
Regions of the Infrared Spectrum

Channels Primarily Sensitive to the Surface



Regions of the Infrared Spectrum

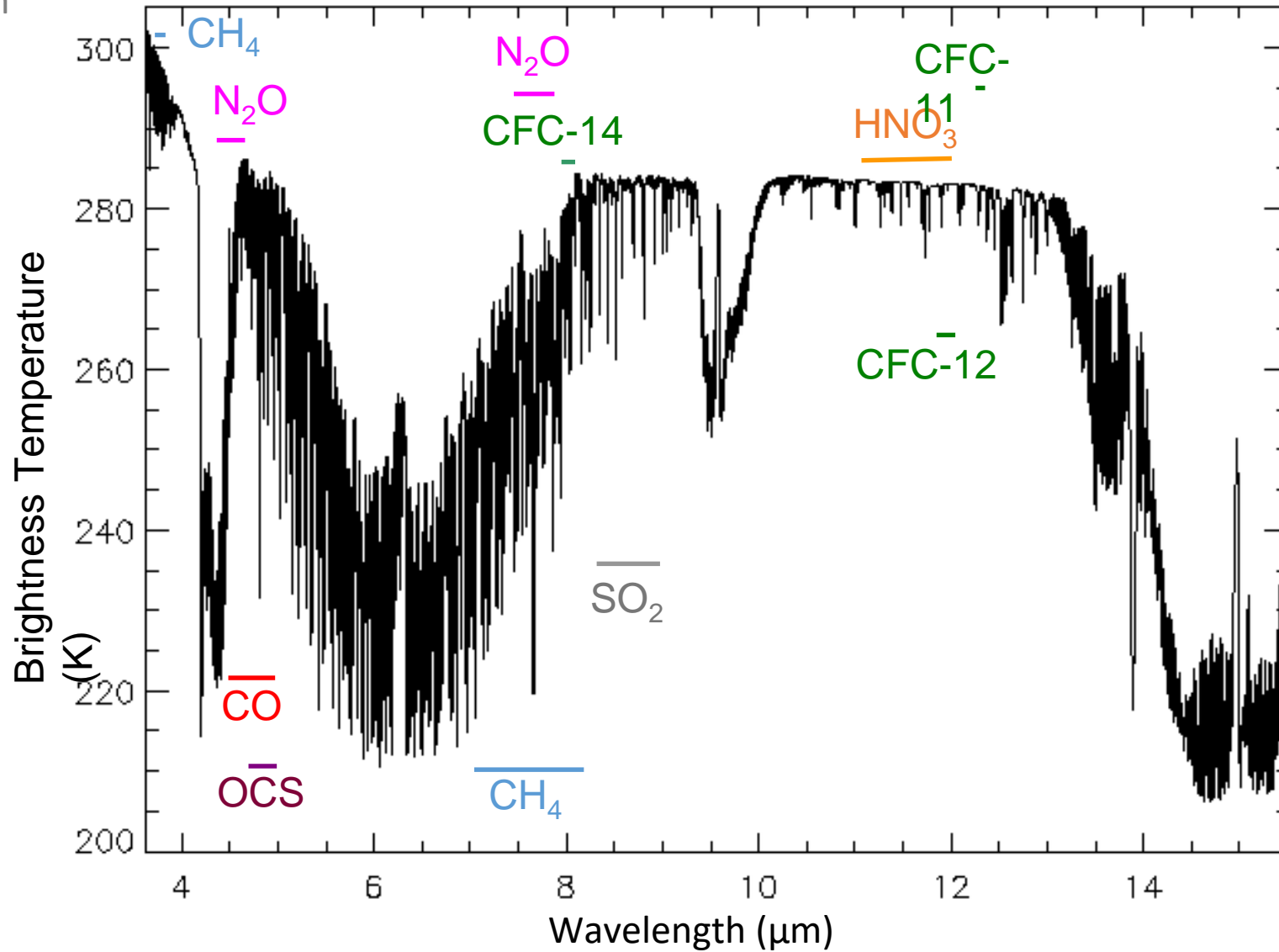
Trace Gases and RT Challenges



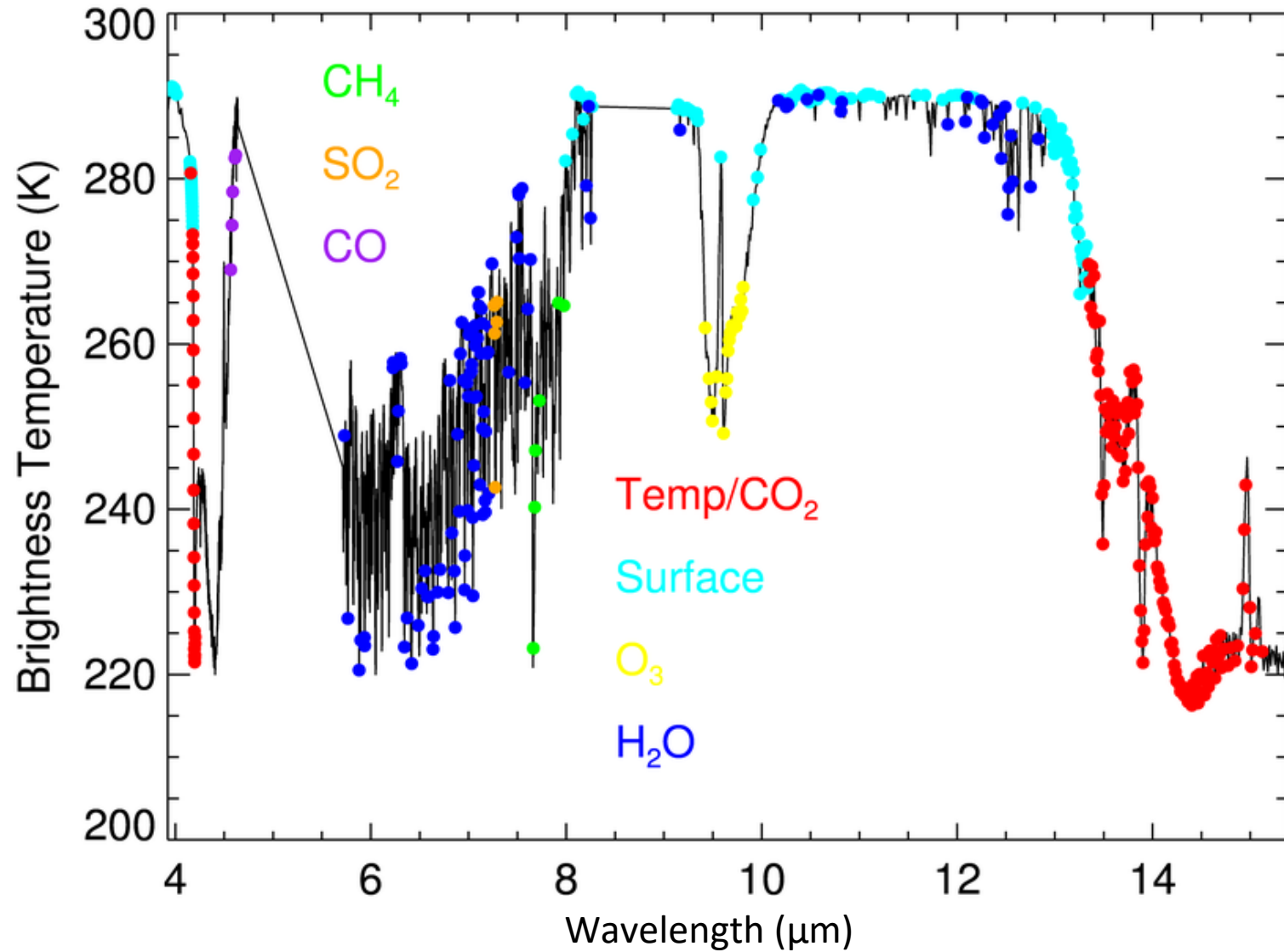
Regions of the Infrared Spectrum

Trace Gases

Flipped the spectrum back into wavelength space.



CrIS FSR 431 Channel Selection



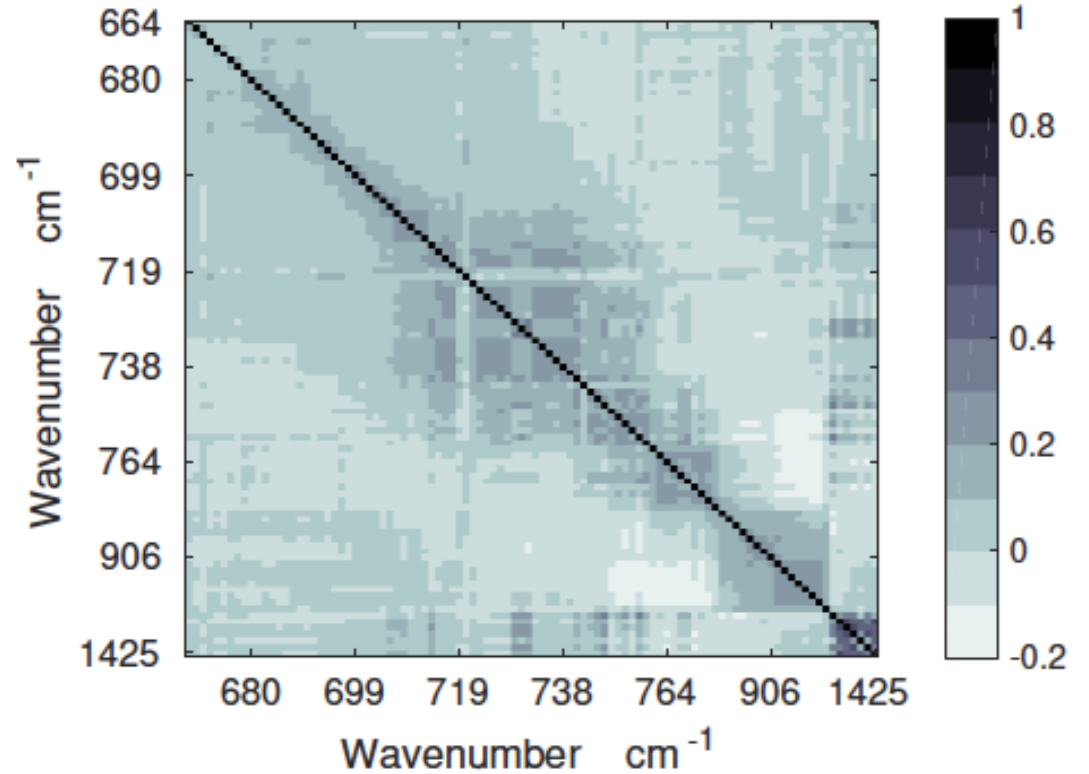
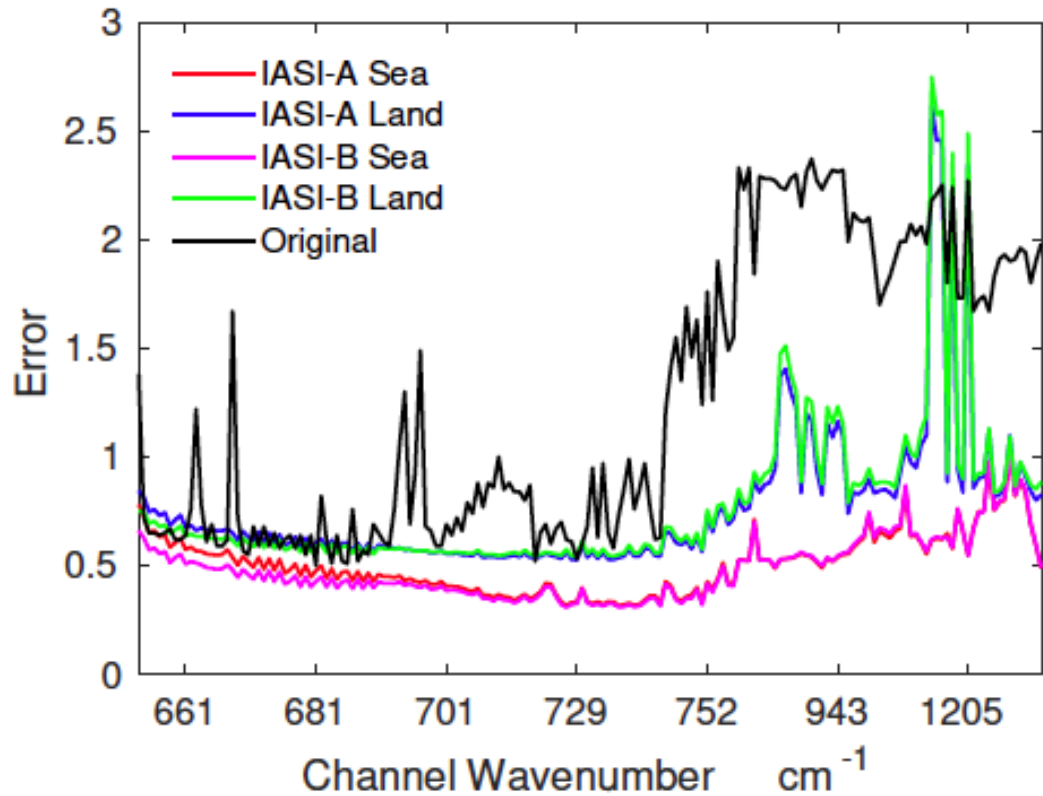


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Observation Errors

Introduction of Correlated Errors



Correlation matrix after reconditioning and variance inflation



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Clouds

Clouds

- Clouds provide the biggest signal in the infrared spectrum
 - ... but we are still struggling to use this information
- There are three main strategies for dealing with clouds:
 - Avoid them
 - Simply clear-sky assimilation
 - Correct for them
 - E.g., cloud cleared radiances (requires low instrument noise)
 - Model them
 - Grey cloud or full hydrometeor fields
 - Choice of whether to update the model hydrometeor fields
 - Small FOVs which are more likely to be homogeneous are preferable.



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Some questions to be addressed

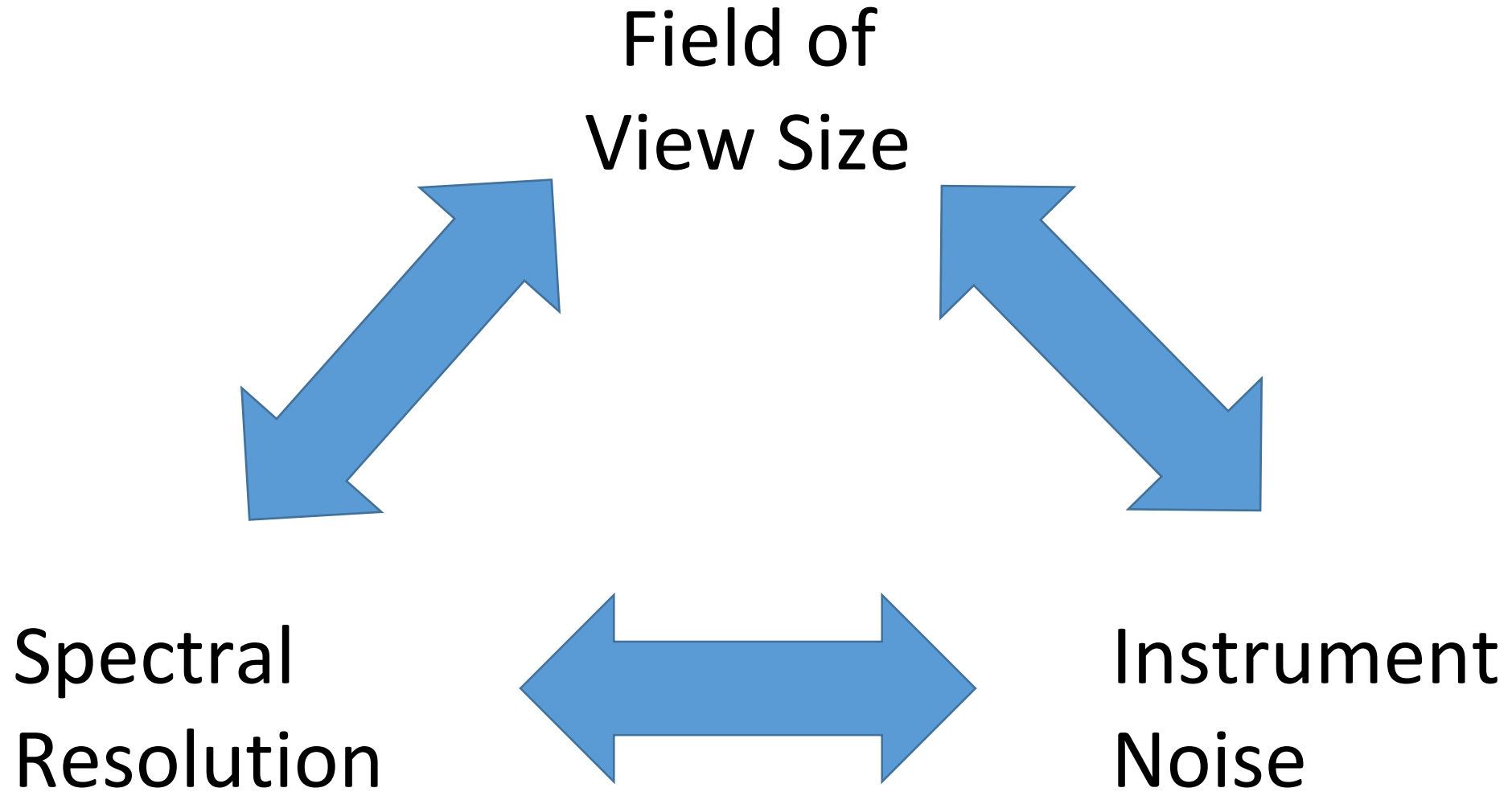


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The Tradeoff

The Tradeoff



The Tradeoff

- Instrument noise
 - Low instrument noise is crucial to high vertical resolution
 - Some channels have other, more significant sources of error (e.g representivity error in the water vapour band)
 - Some cloud clearing techniques require low noise.
- Spectral resolution
 - Limited evidence for increased impact on NWP with increased spectral resolution
 - But the $15\mu\text{m}$ line structure should be resolved and not suppressed by apodisation
 - Higher spectral resolution is needed for trace gas detection.

The Tradeoff

- Field of view size
 - Homogeneous fields of view simplify the use of infrared radiances in cloudy conditions and over land.
 - The use of cloudy IR radiances and radiances over land in a coupled-model context will become more and more important over the next decade.
 - Contiguous fields of view may not be necessary.
 - Data volumes will become a major consideration (especially hyperspectral geostationary sounders).



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Do we need the 15micron band?

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- Yes!
 - ... for now
- Currently most of the data impact is from the 15 μ m band channels.
- Some encouraging work is being done on using the 4.3 μ m band for temperature analysis
 - Questions remain on radiative transfer (solar radiation in the daytime, non-LTE)
 - Errors are non-linear in brightness temperature space
 - Most (?) NWP centers make limited or no use of these wavelengths



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Auxiliary Data

Auxiliary data

- Bore-sighted high spatial resolution imagers are a crucial part of any future system
 - As we move towards increased use of cloudy and land observations, information on the field of view homogeneity is crucial.
- There is less evidence of the utility of bore-sighted microwave observations to NWP, although some QC methods using microwave and infrared simultaneously have been developed.



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In summary

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- We are currently using a very small fraction of hyperspectral sounder data
 - Much of that reflects redundant information in the observations
 - Work continues to extract more information:
 - Correlated errors, cloudy radiances, improved use over land, shortwave channels.
- The trade-off between NEdT, FOV size and spectral resolution should continue to be explored.
- The 15 μ m band is still desired.
- Bore-sighted imagers are desirable to be able to properly use cloudy radiances.



Thank You!

