Using Wind Spectra to Assess Scatterometer Resolution

E. Rodríguez
Jet Propulsion Laboratory
California Institute of Technology

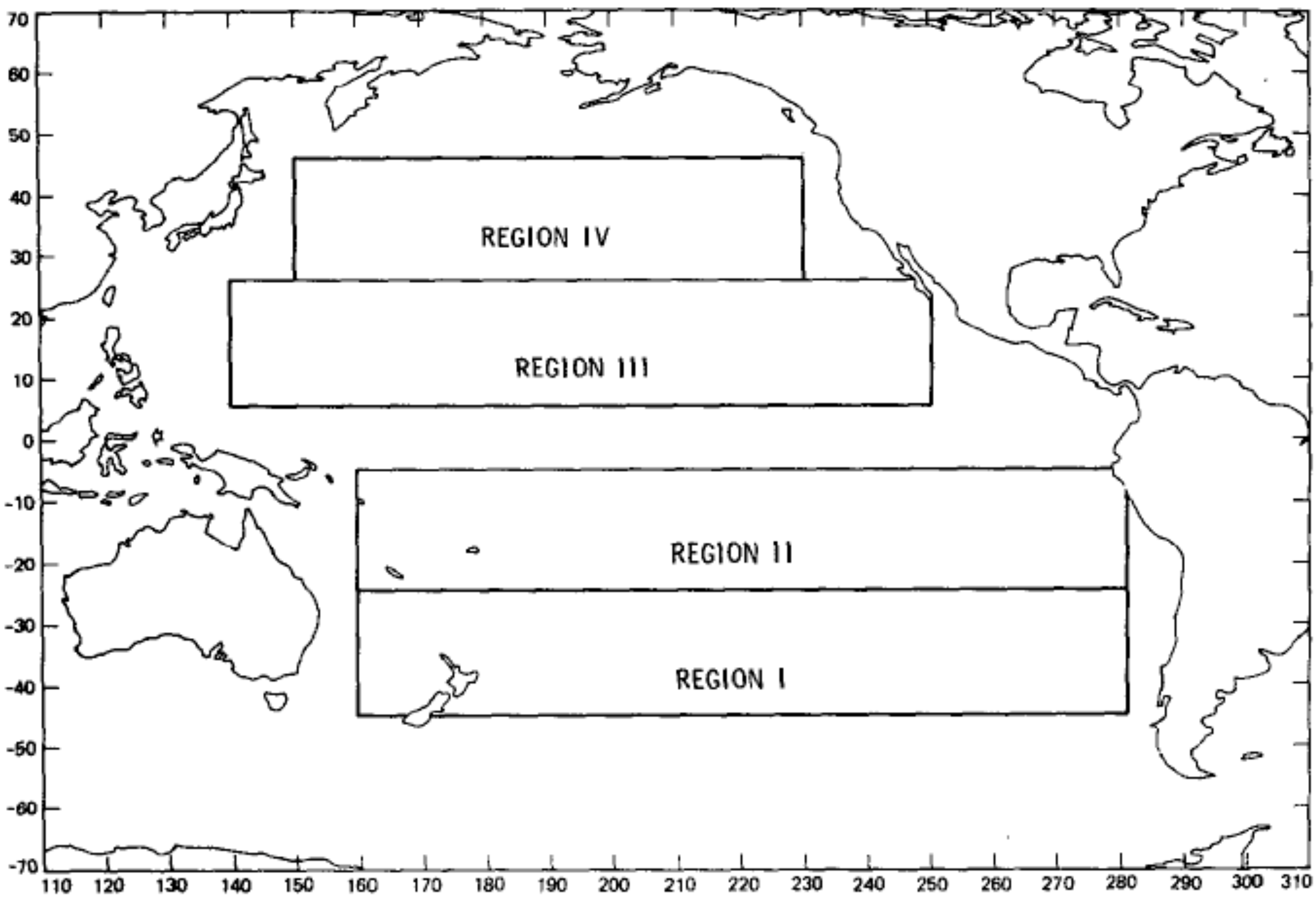
Not a new idea…

- Freilich and Chelton (1986) took a first look at the spectral behavior of Winds
- Subsequently, many investigators have looked at the spectra (Patoux & Brown, Milliff & Morzel, Chelton & Freilich)
- What is slightly new is the use of the spectra to determine resolution for Qscat/Ascat
  - Although Dudley Chelton is always advocating this definition of resolution
  - Resolution is signal dependent
- Have had some discussions recently with Ad Stoffelen and Marcos Portabella about the approach
  - Correlation based estimation vs direct spectral estimation

Spectral Estimation Method

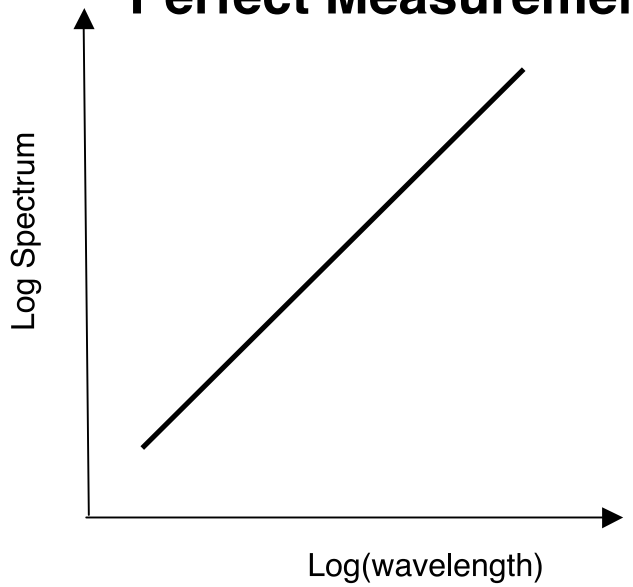
- Spectral method:
  - Extract data record for selected area
  - Remove mean and linear trend
  - Weight
  - IFFTI^2
  - Ensemble average
- Correlation method
  - Extract data record for selected area
  - Compute correlation function for ensemble
  - Weight
  - FFT
- The two methods should be identical for infinite record (or periodic) signals
  - They need not agree when signal lengths are truncated before the correlation has vanished

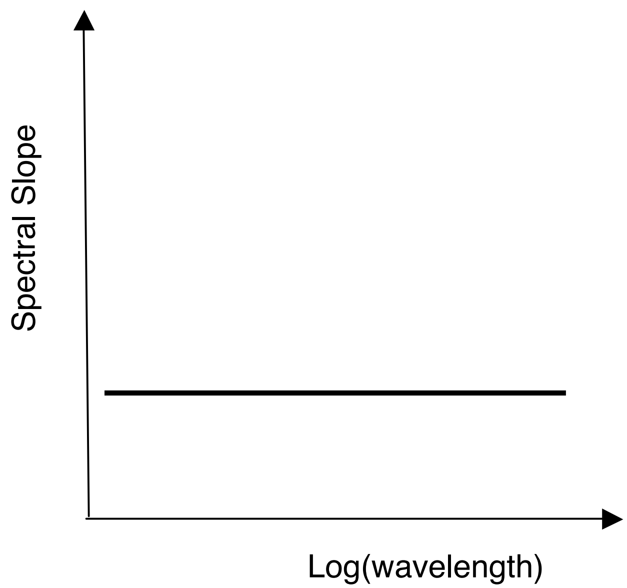
Regions for Spectrum Studies



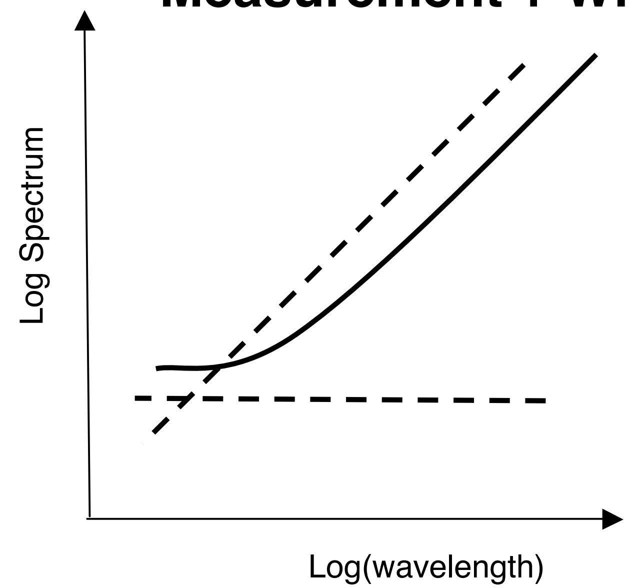
What to Expect for Spectra

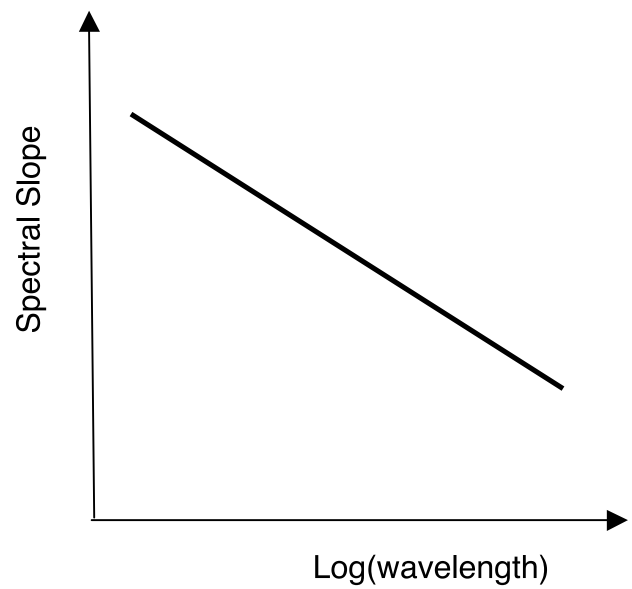
Perfect Measurement





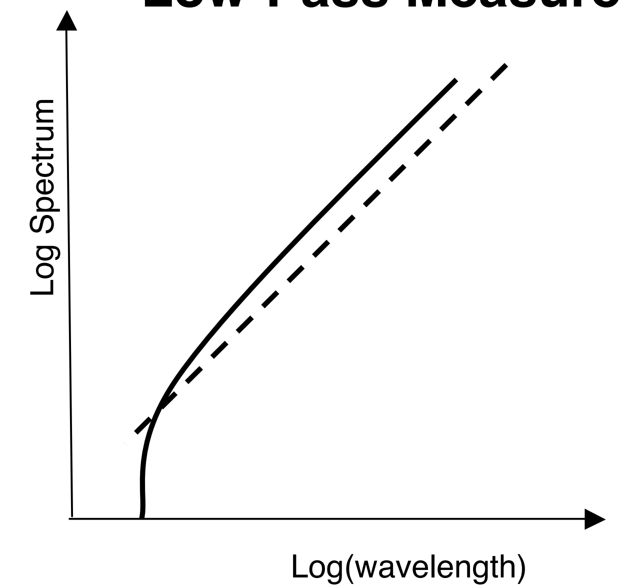
Measurement + White Noise



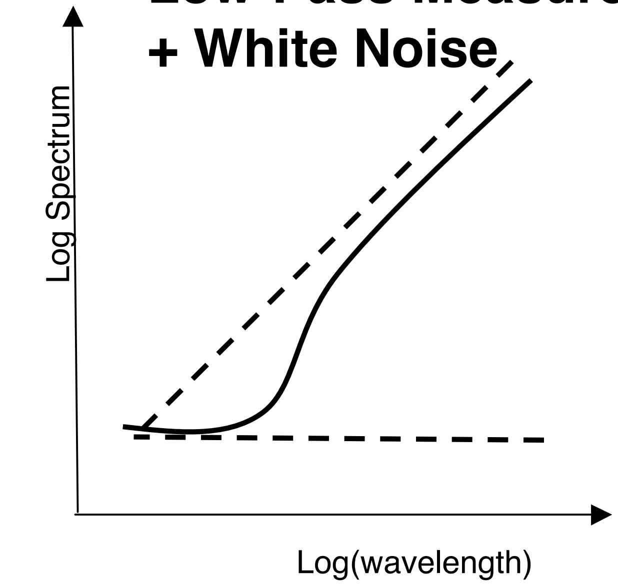


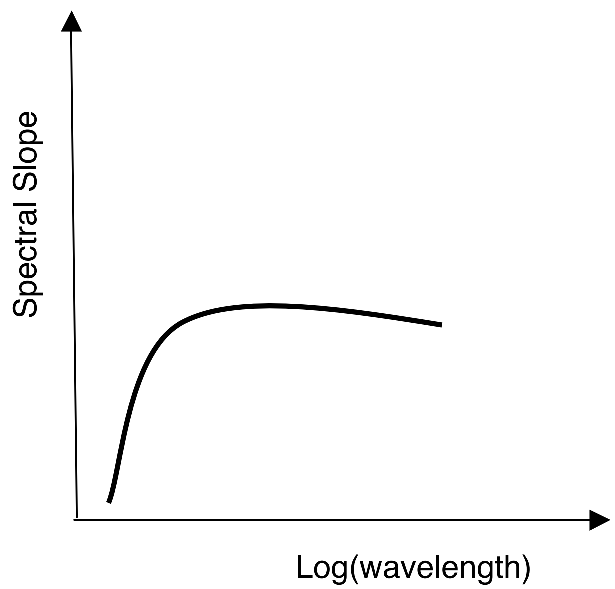
What to Expect for Spectra

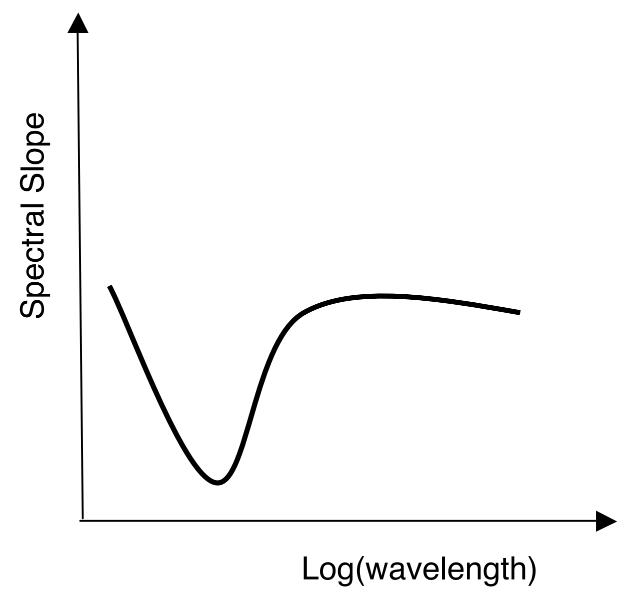
Low-Pass Measurement



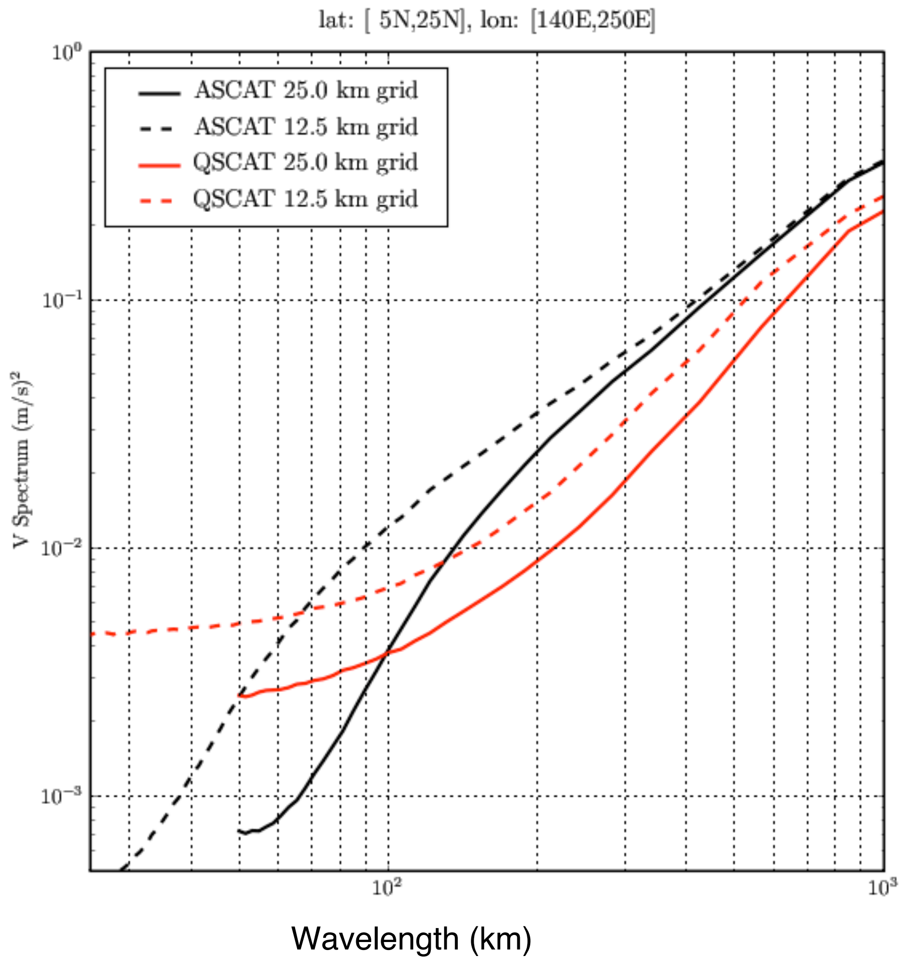
Low-Pass Measurement + White Noise

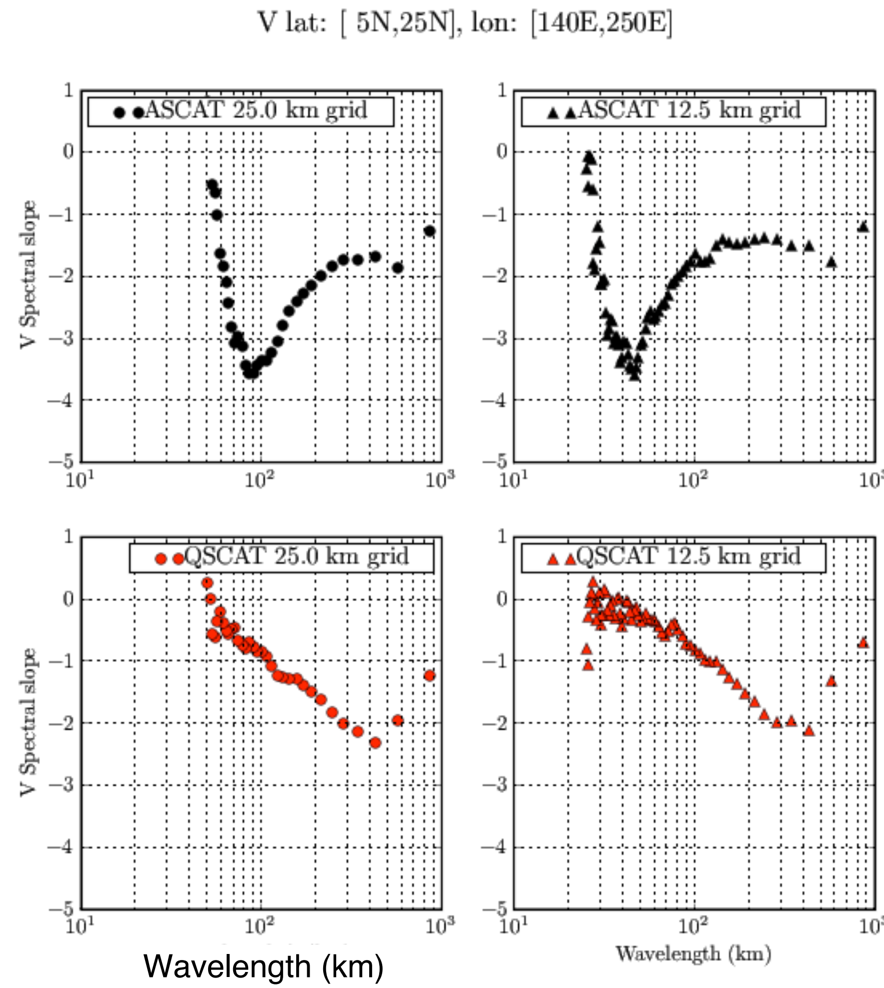




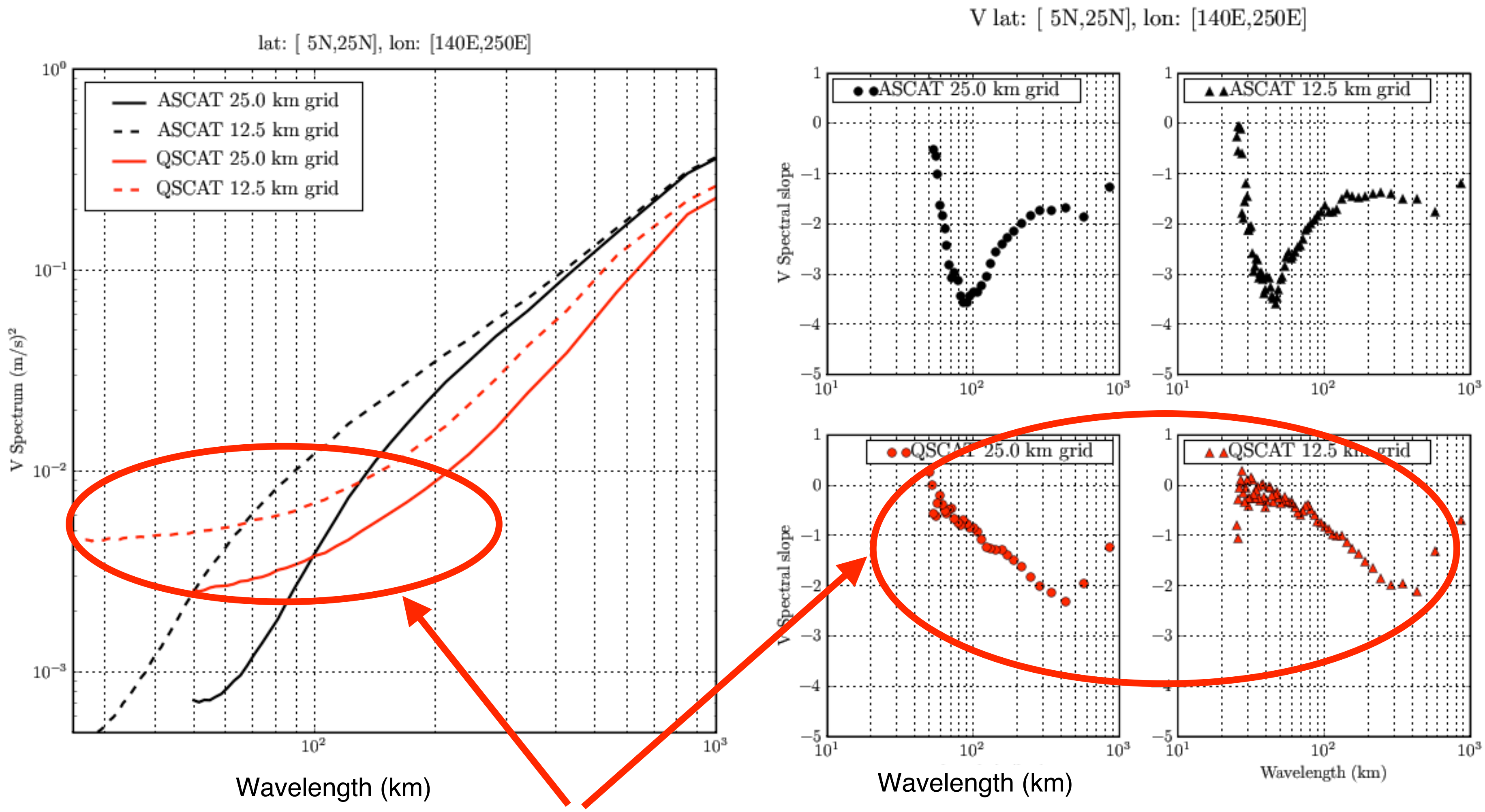


Tropical Spectra Example
Region III



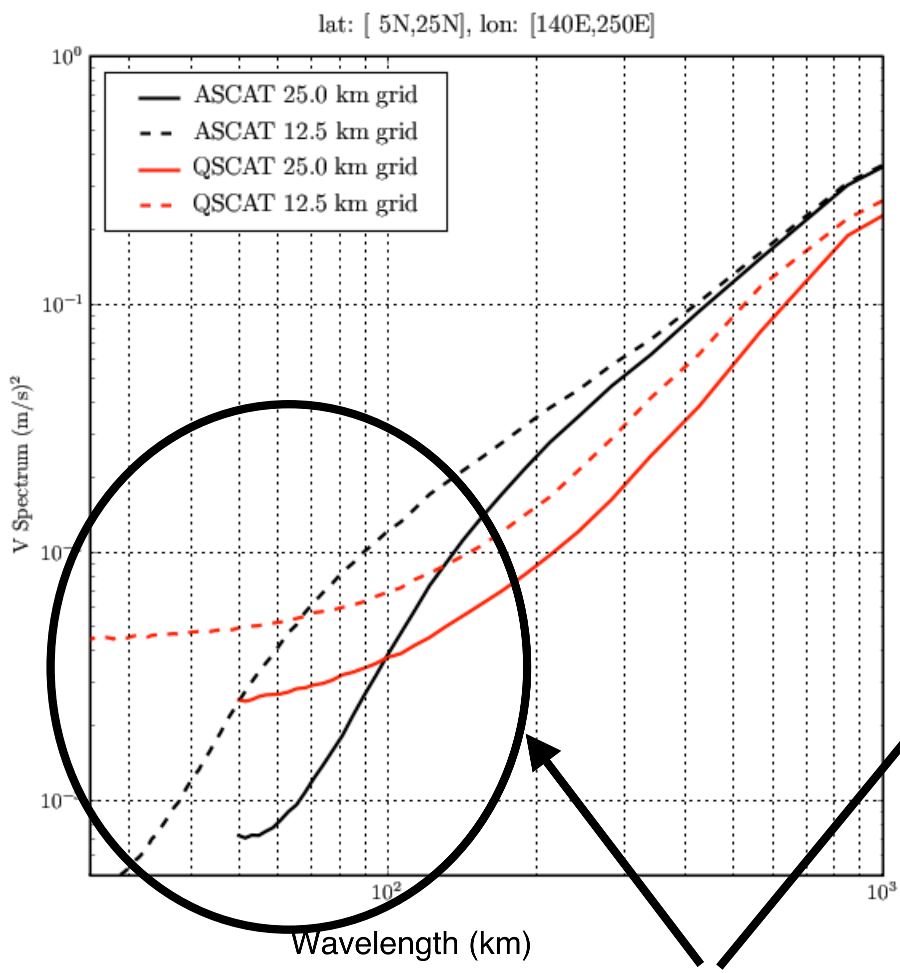


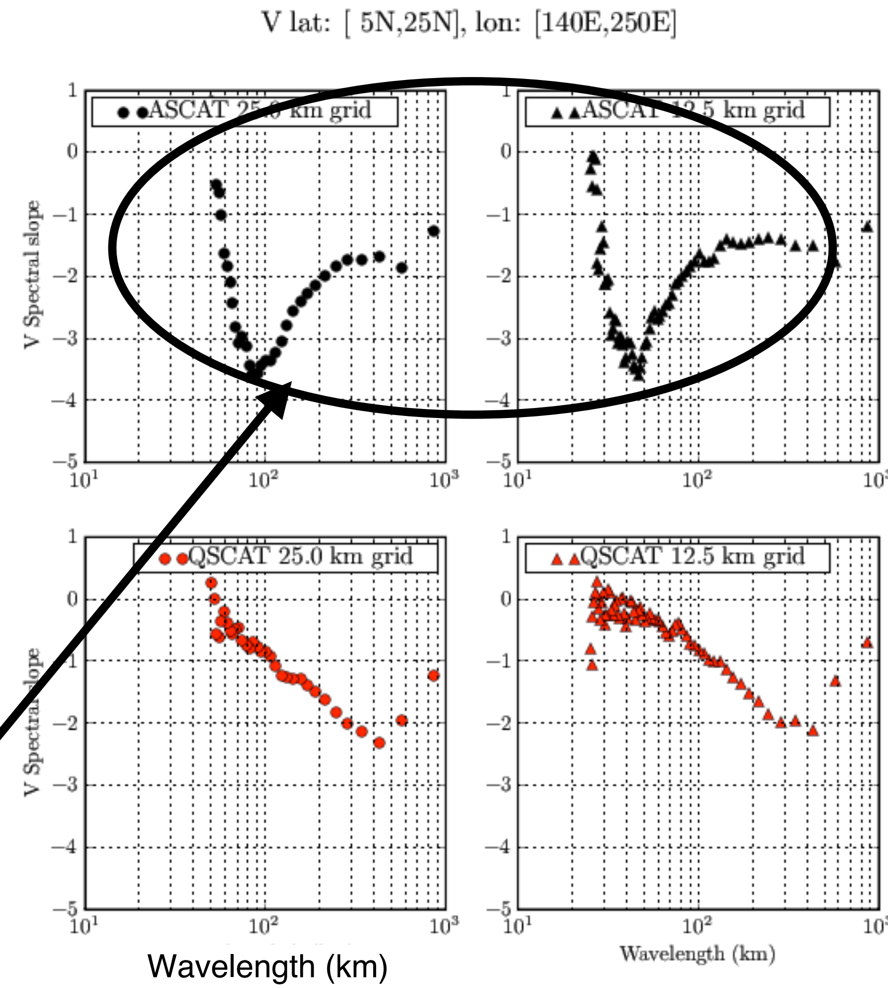
Tropical Spectra Example
Region III



White noise dominated spectrum

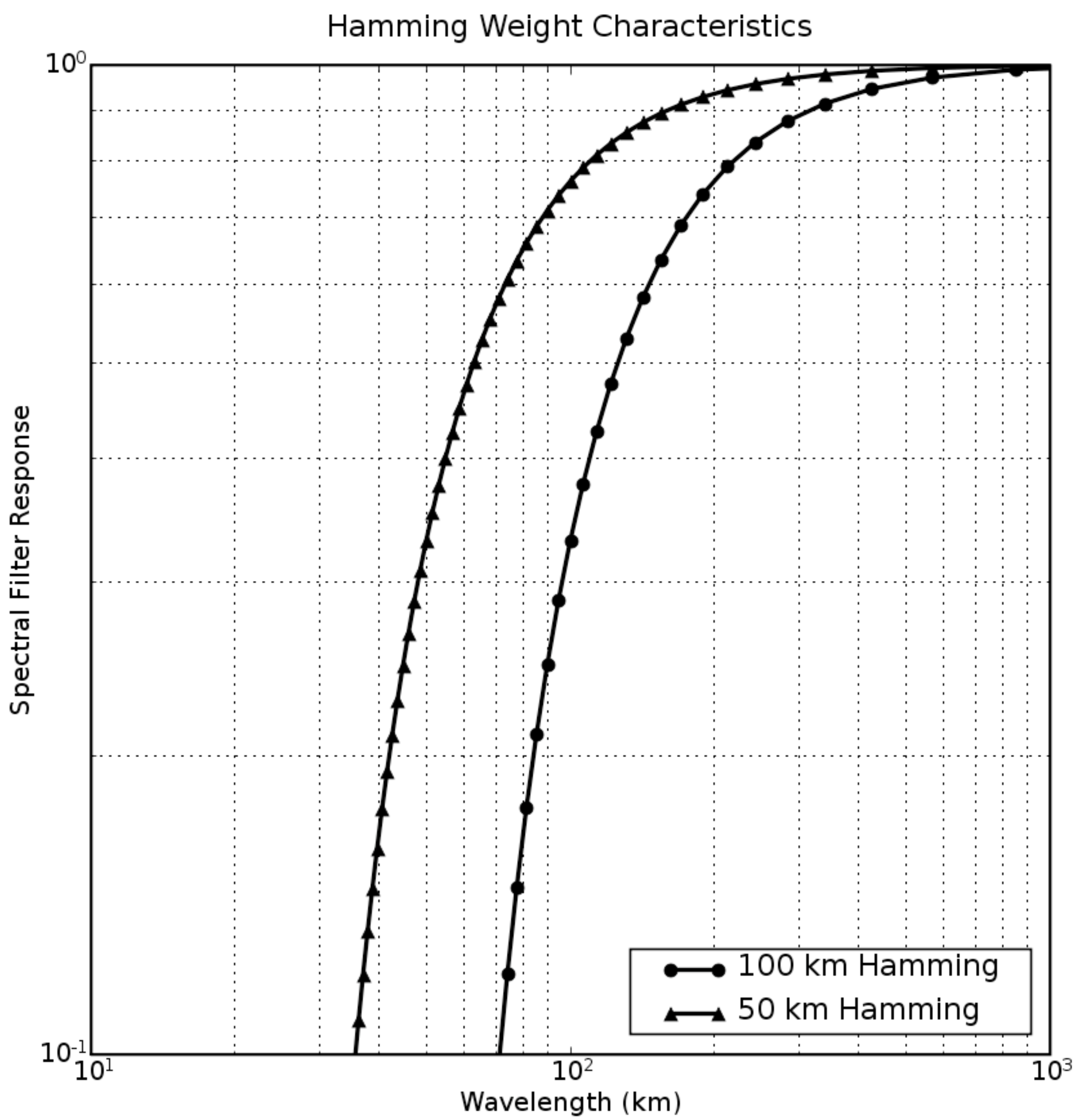
Tropical Spectra Example
Region III



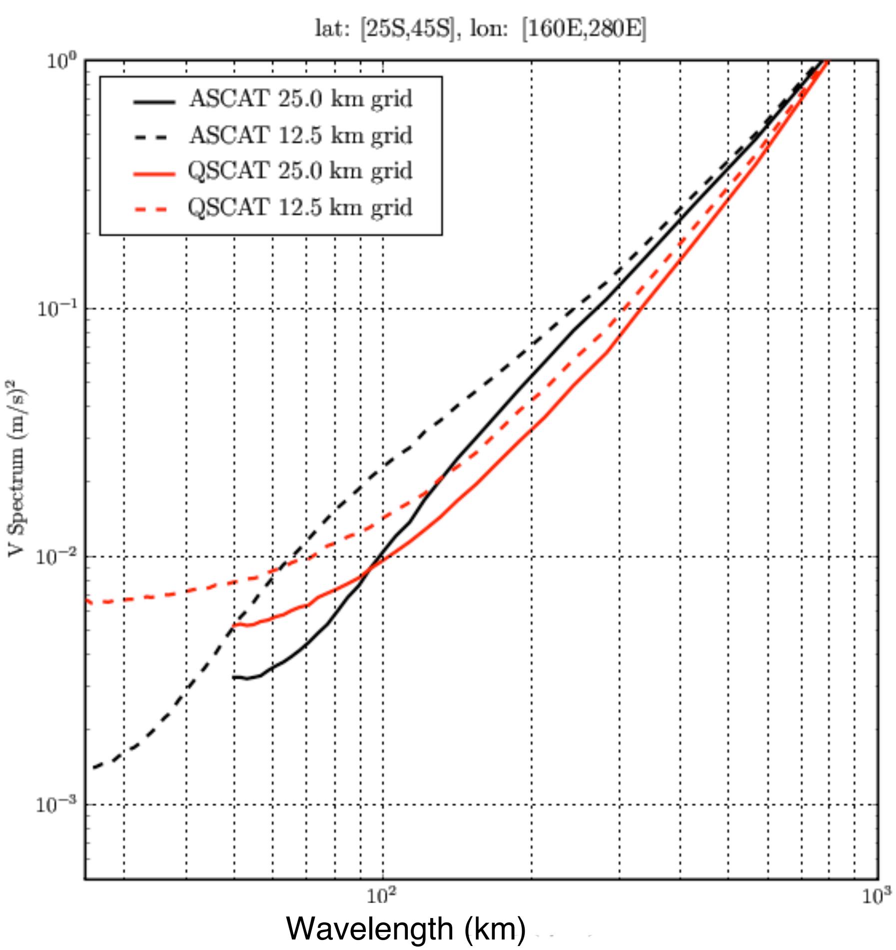


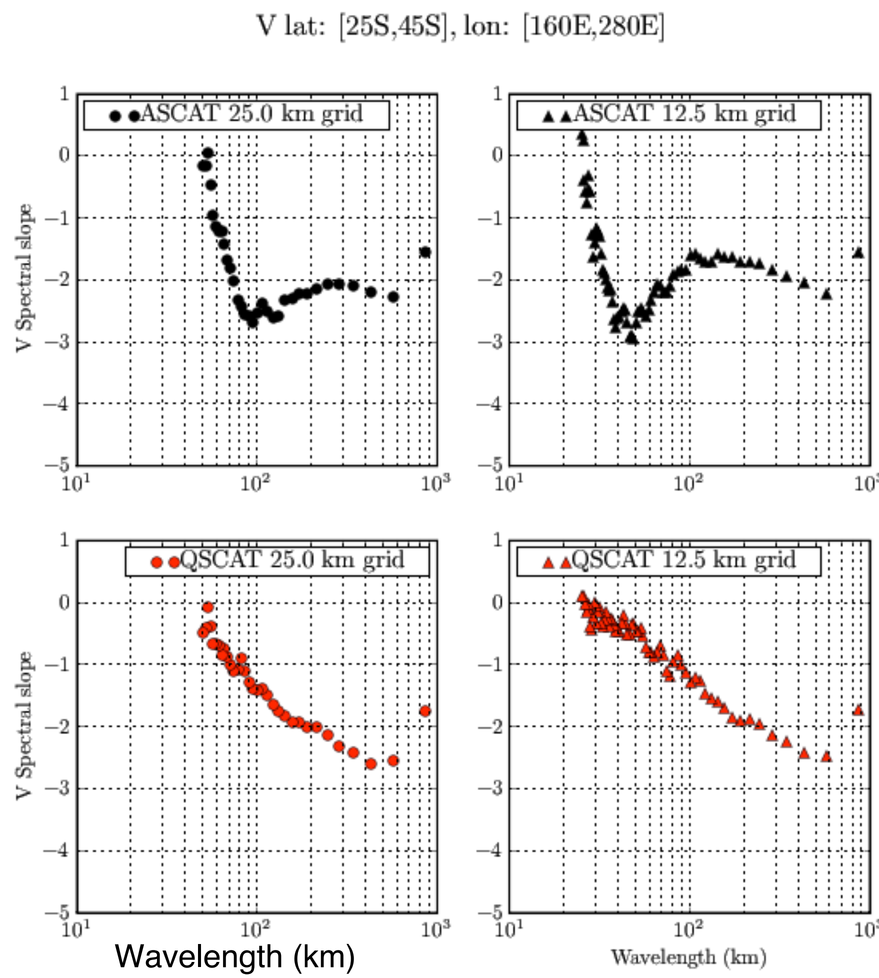
Low-pass filter dominated spectrum (+ small noise)

Hamming Weight Spectrum

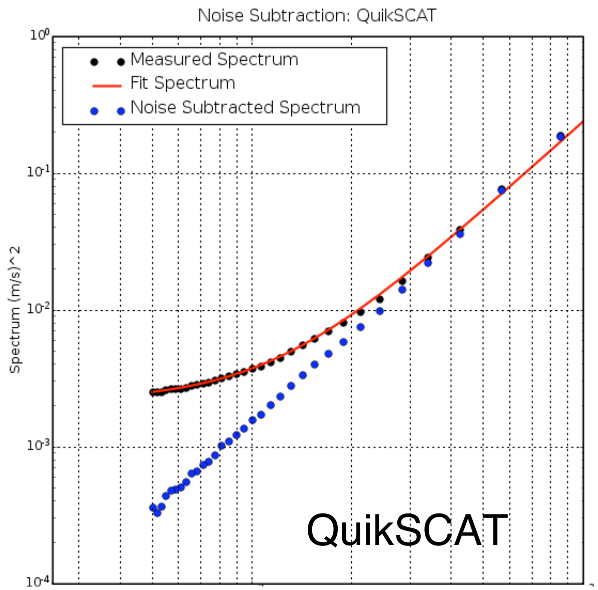


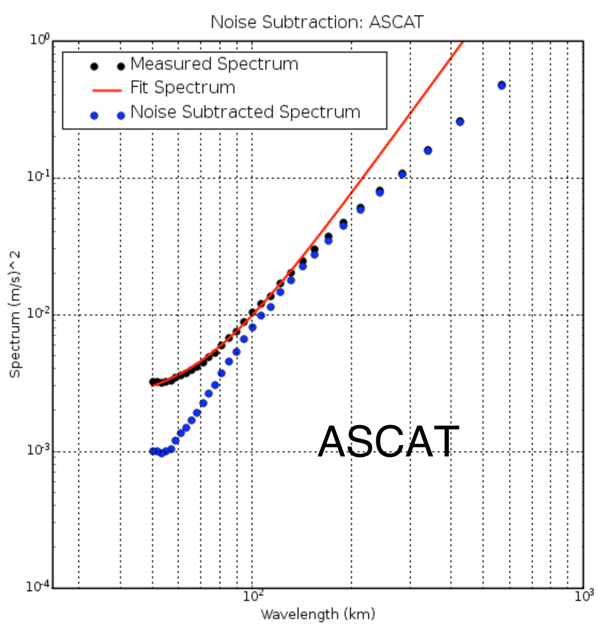
Mid-Latitude Spectra
Region 1





Removing White Noise Contribution



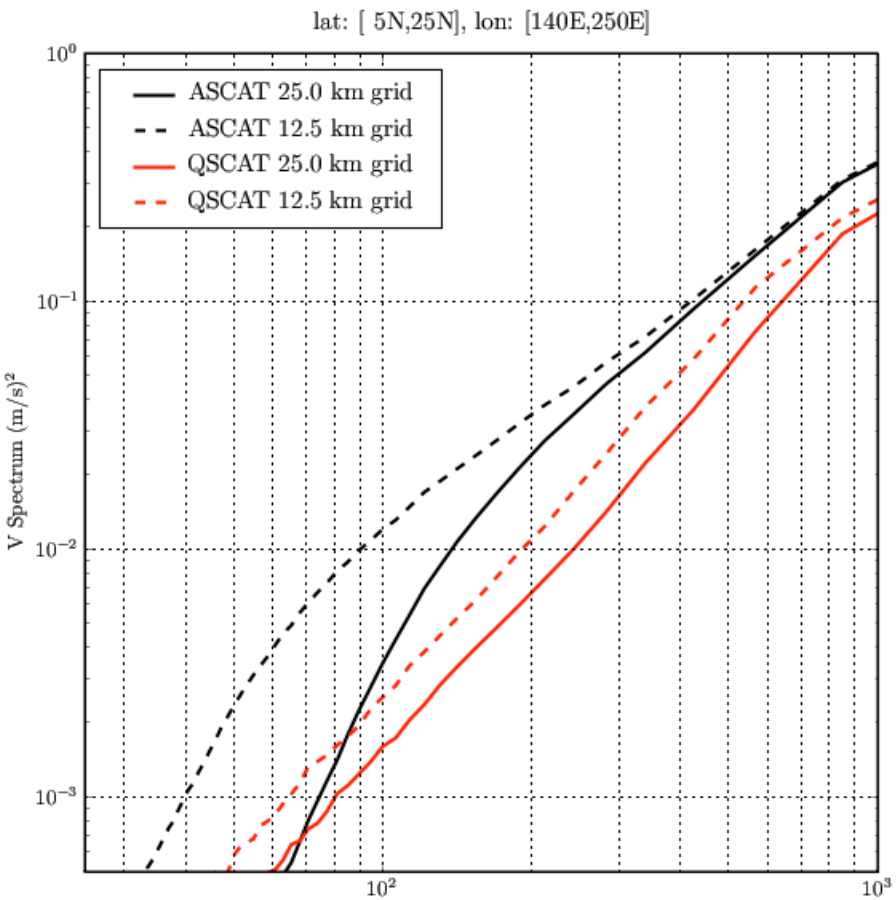


- Assume spectrum can be modeled as

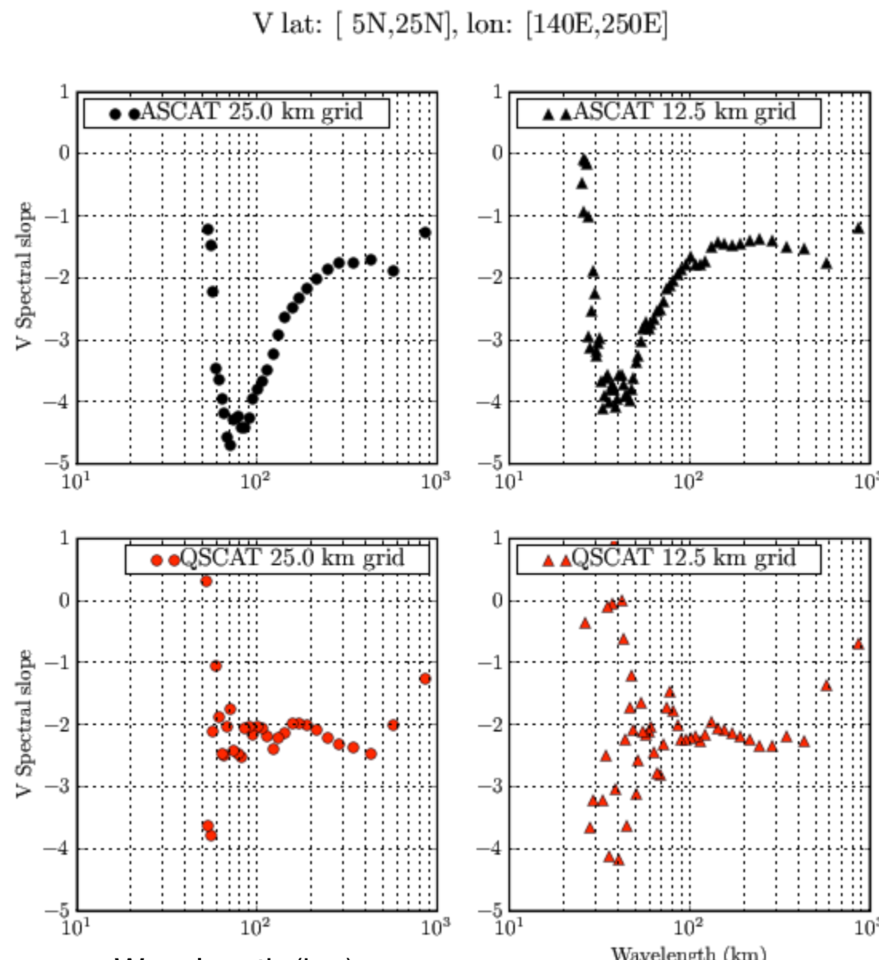
$$S(k) = ak^{-b} + n$$

- Perform nonlinear fit for spectral parameters, fitting in the high frequency region
- Subtract estimated n from measured spectrum to get an estimate of the signal spectrum
- Due to ASCAT low-pass roll-off, the process is suboptimal for ASCAT: noise is underestimated
- The QuikSCAT fits are excellent

Corrected Tropical Spectra
Region III

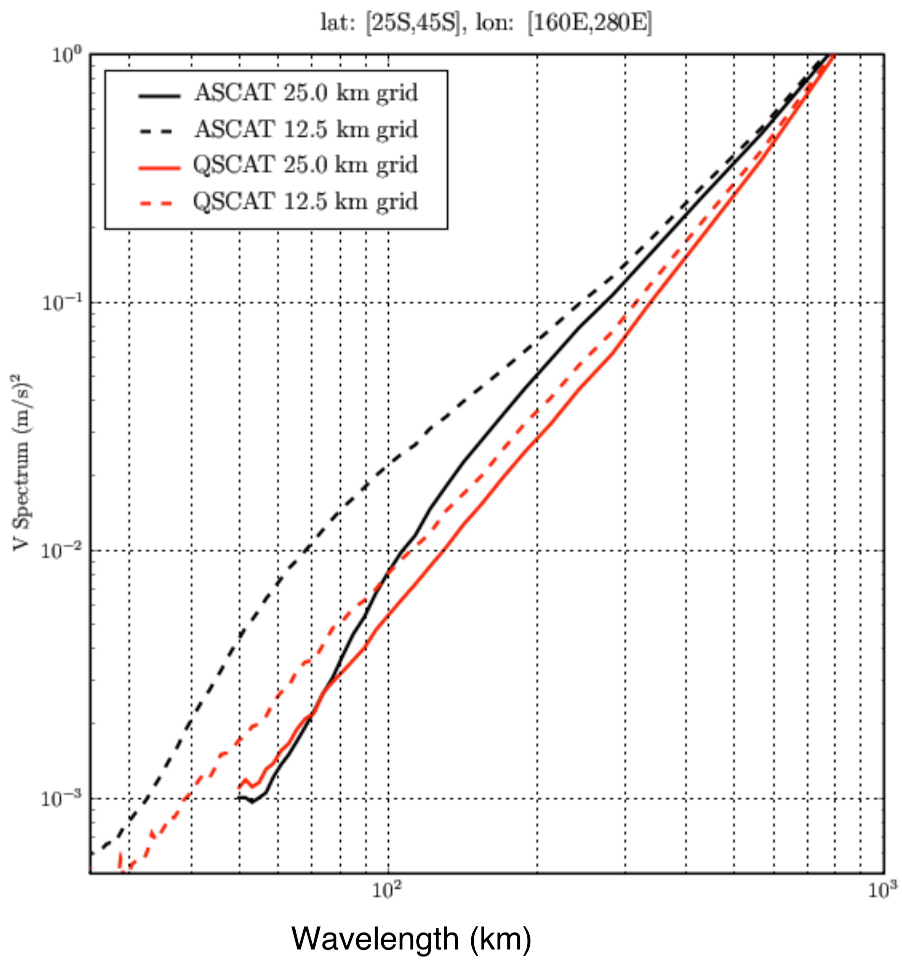


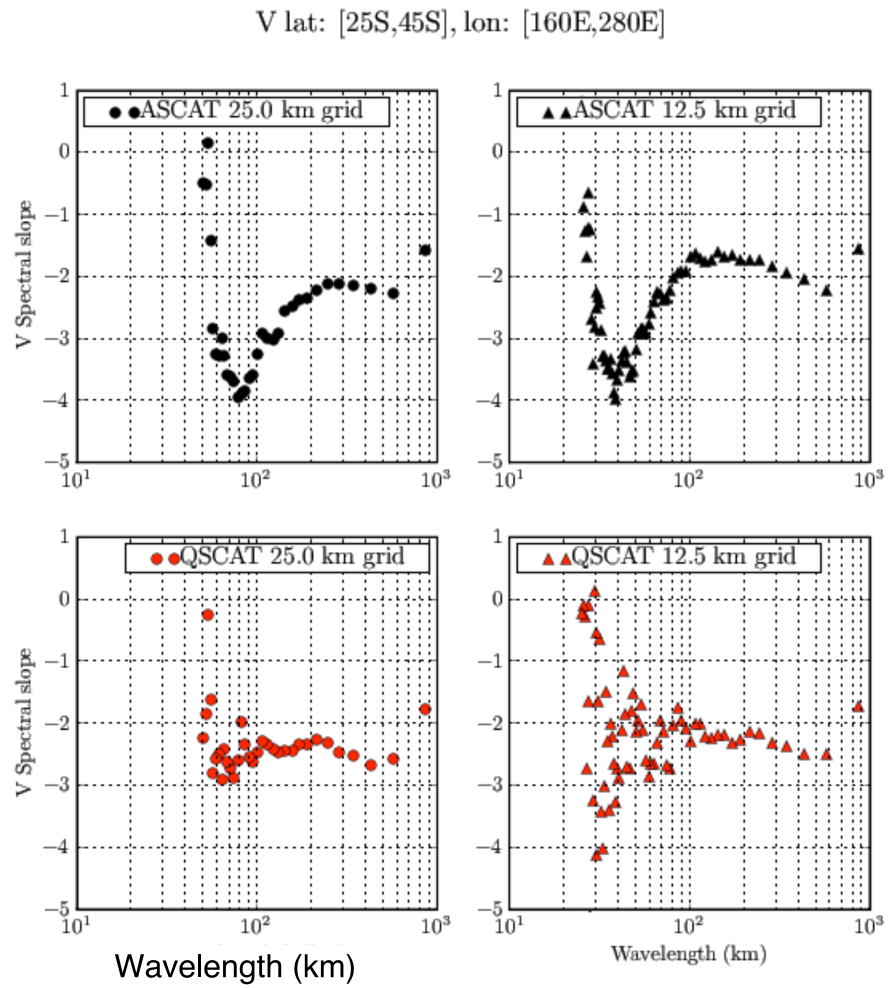
Wavelength (km)



Wavelength (km)

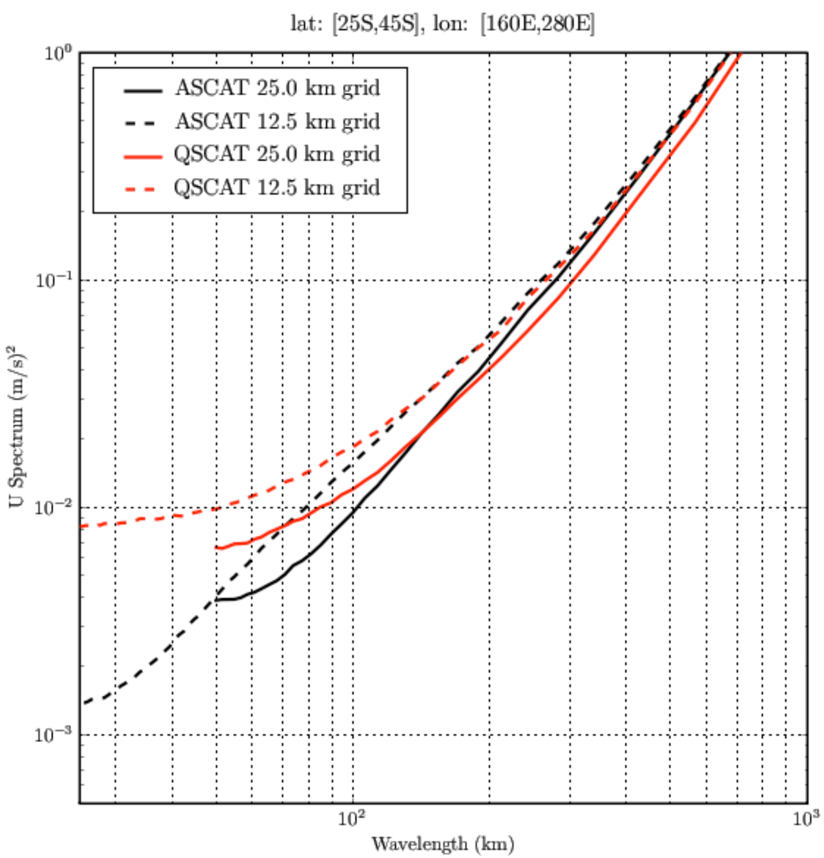
Corrected Mid-Latitude Spectra
Region I

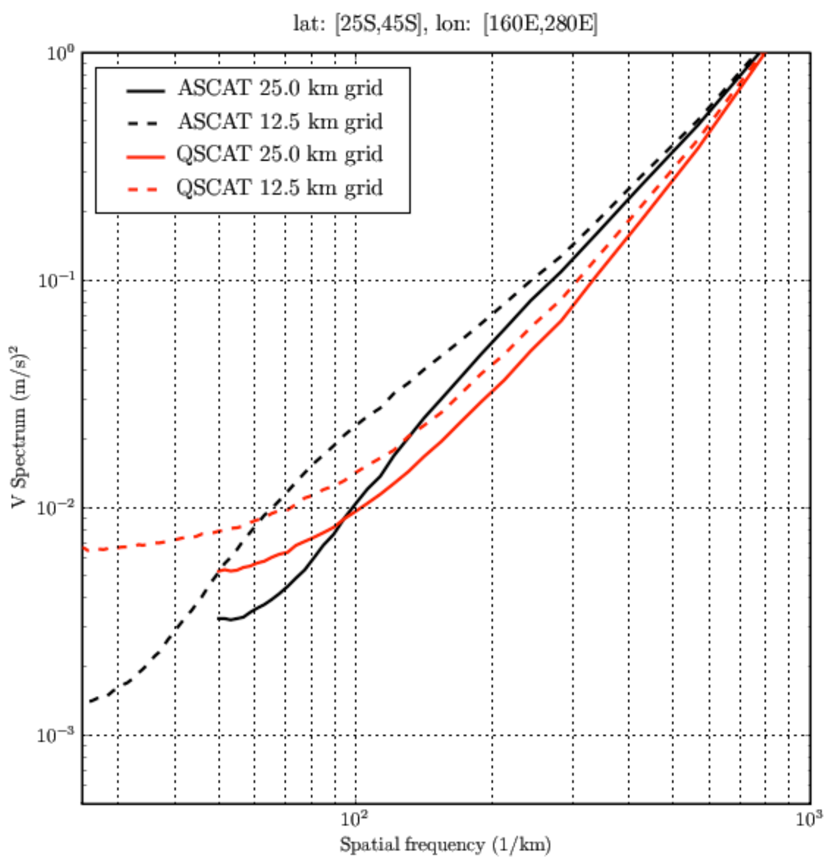




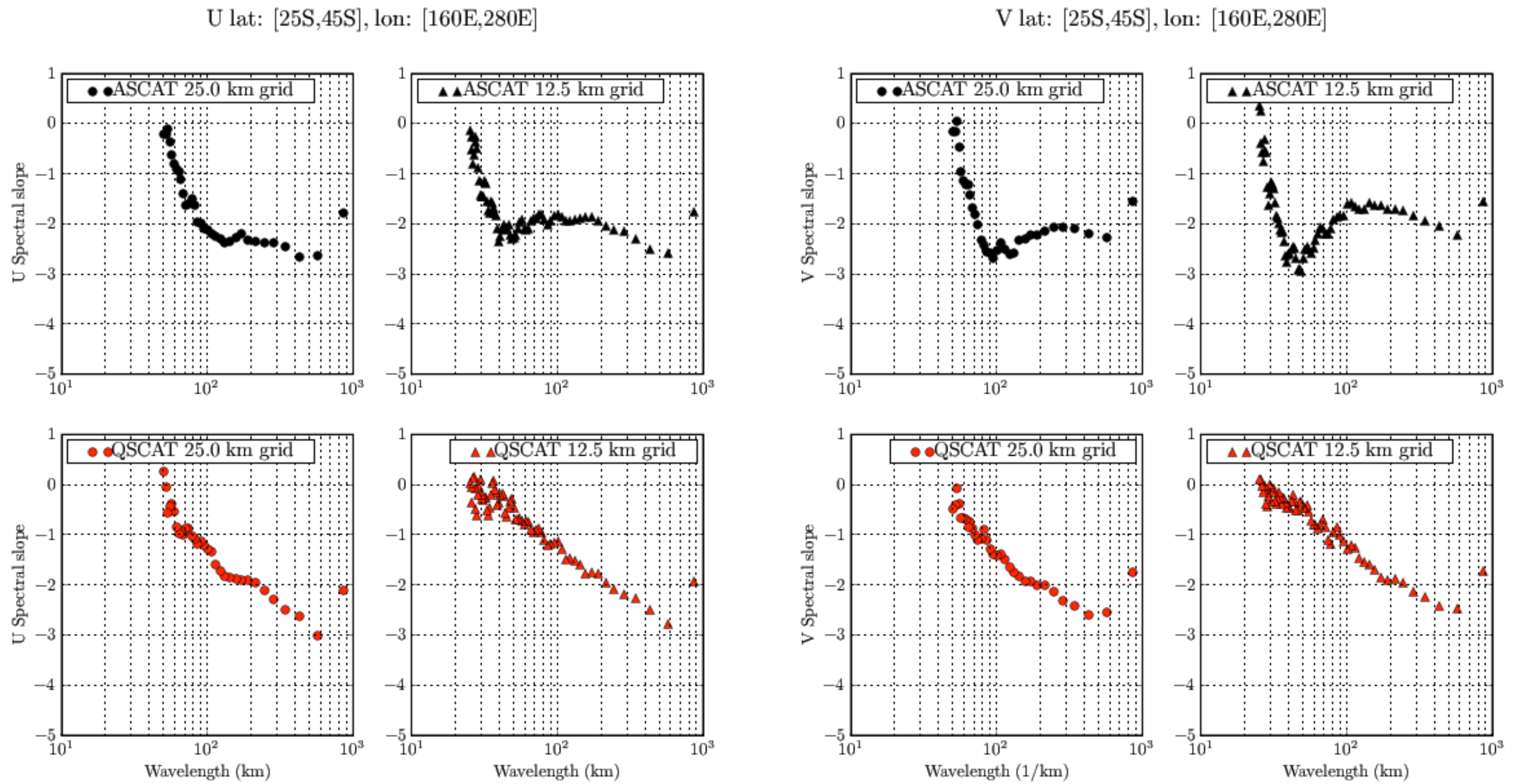
Backups

Region I Spectra

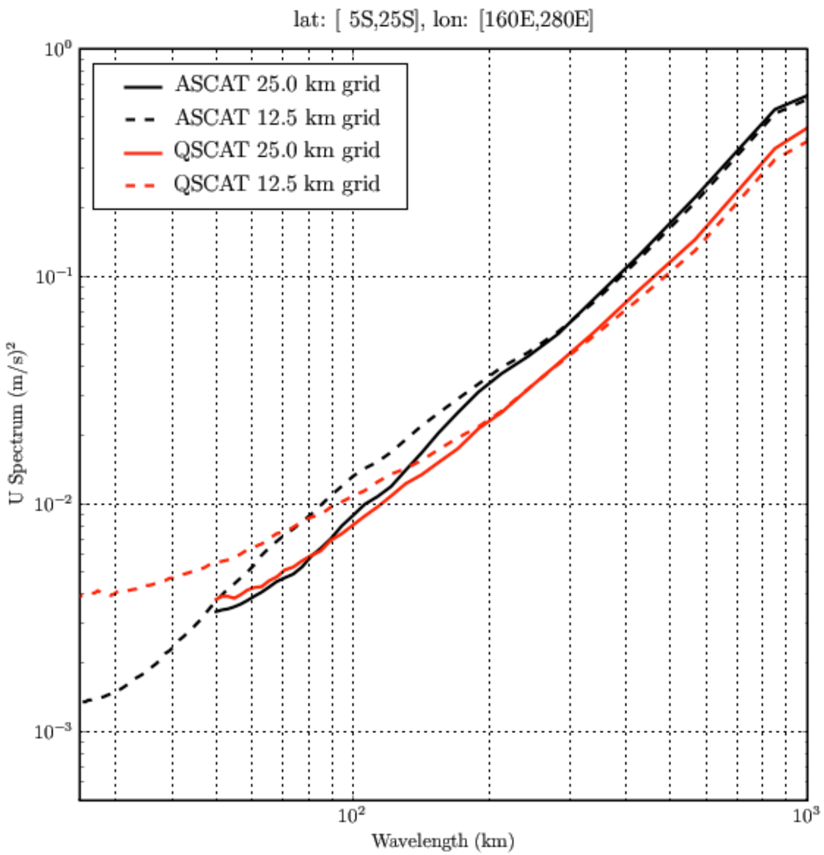


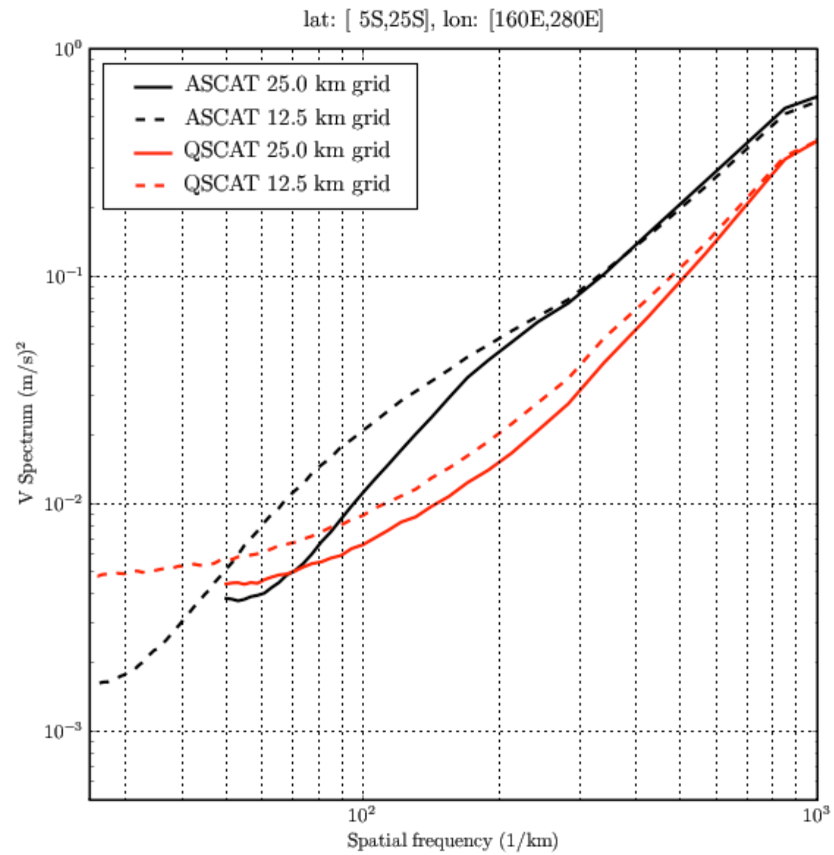


Region I Spectral Slopes

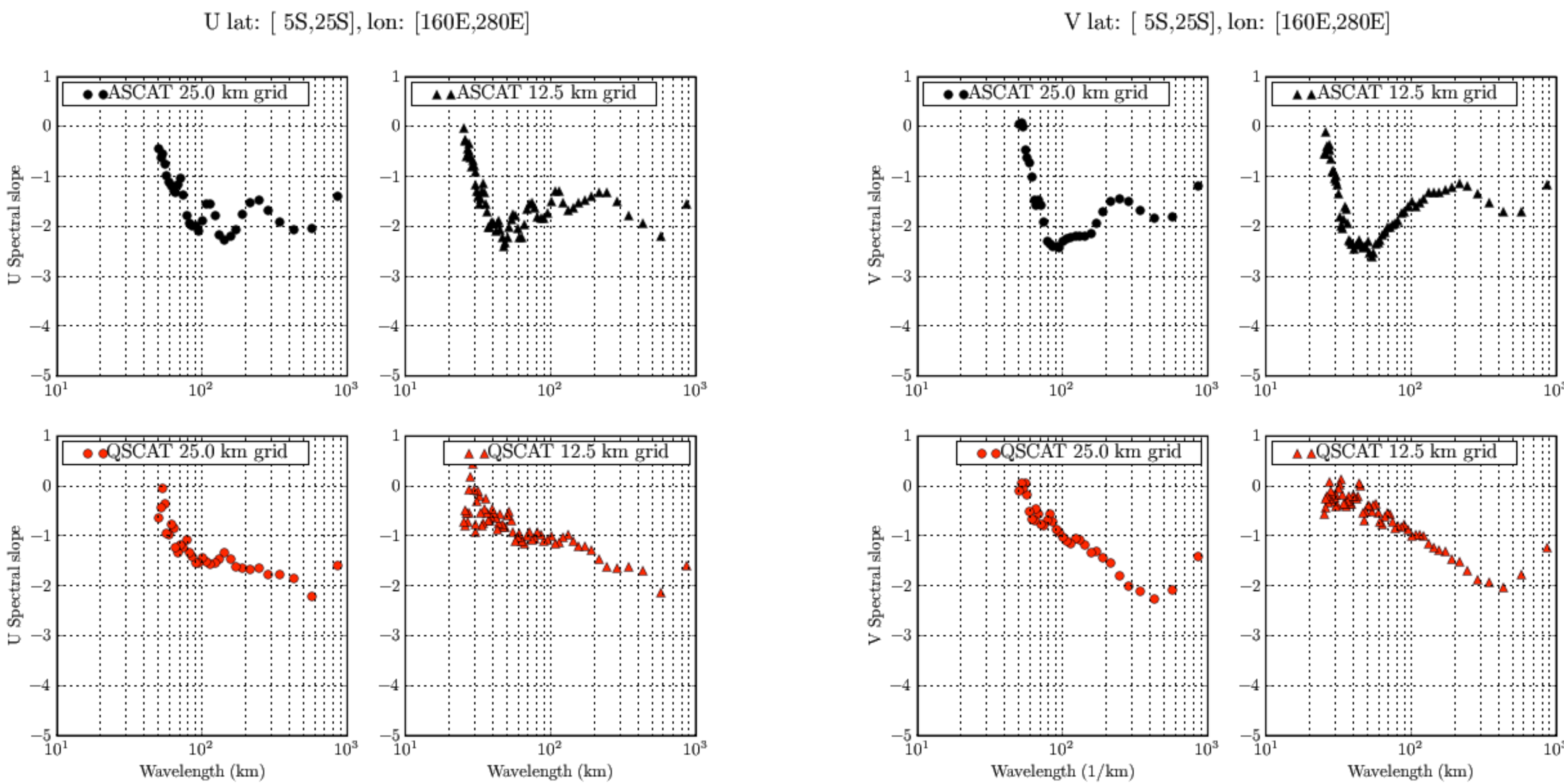


Region II Spectra

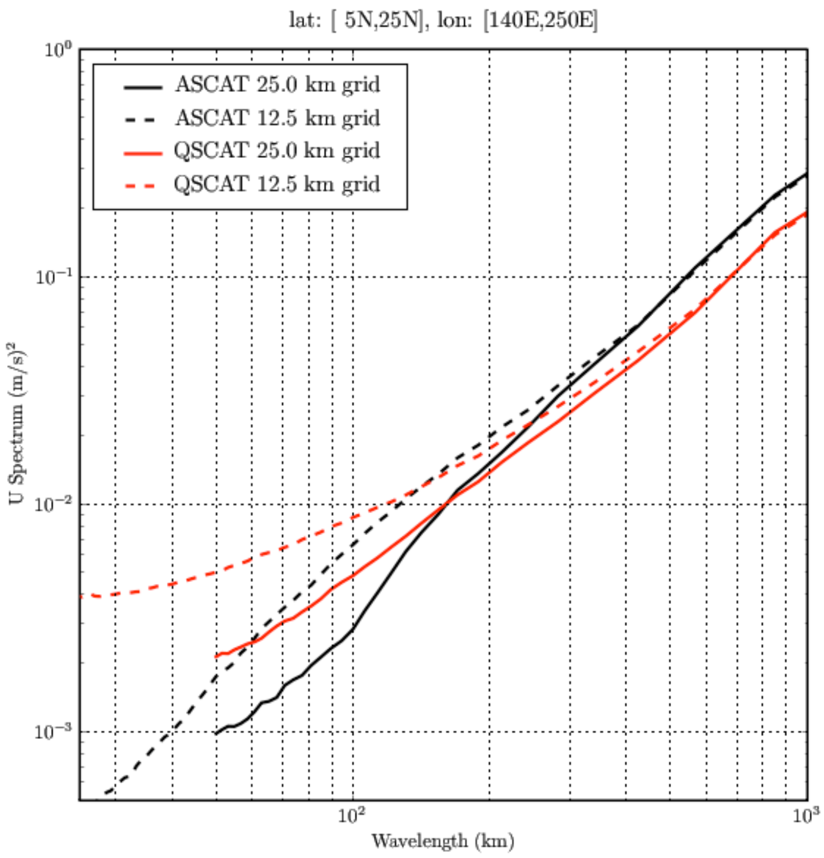


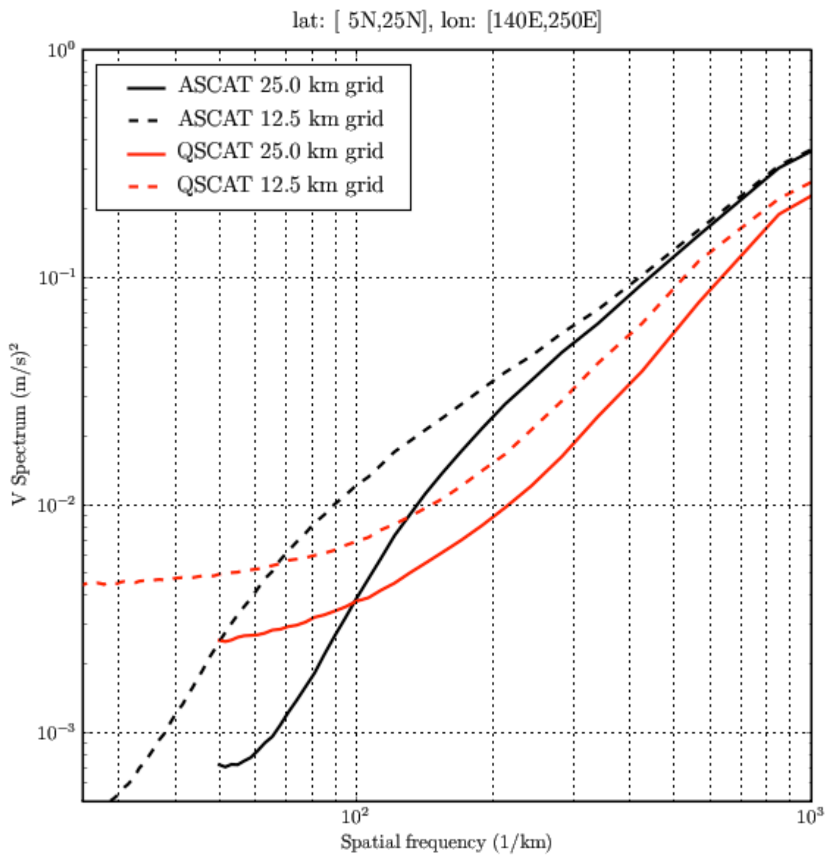


Region II Spectral Slopes

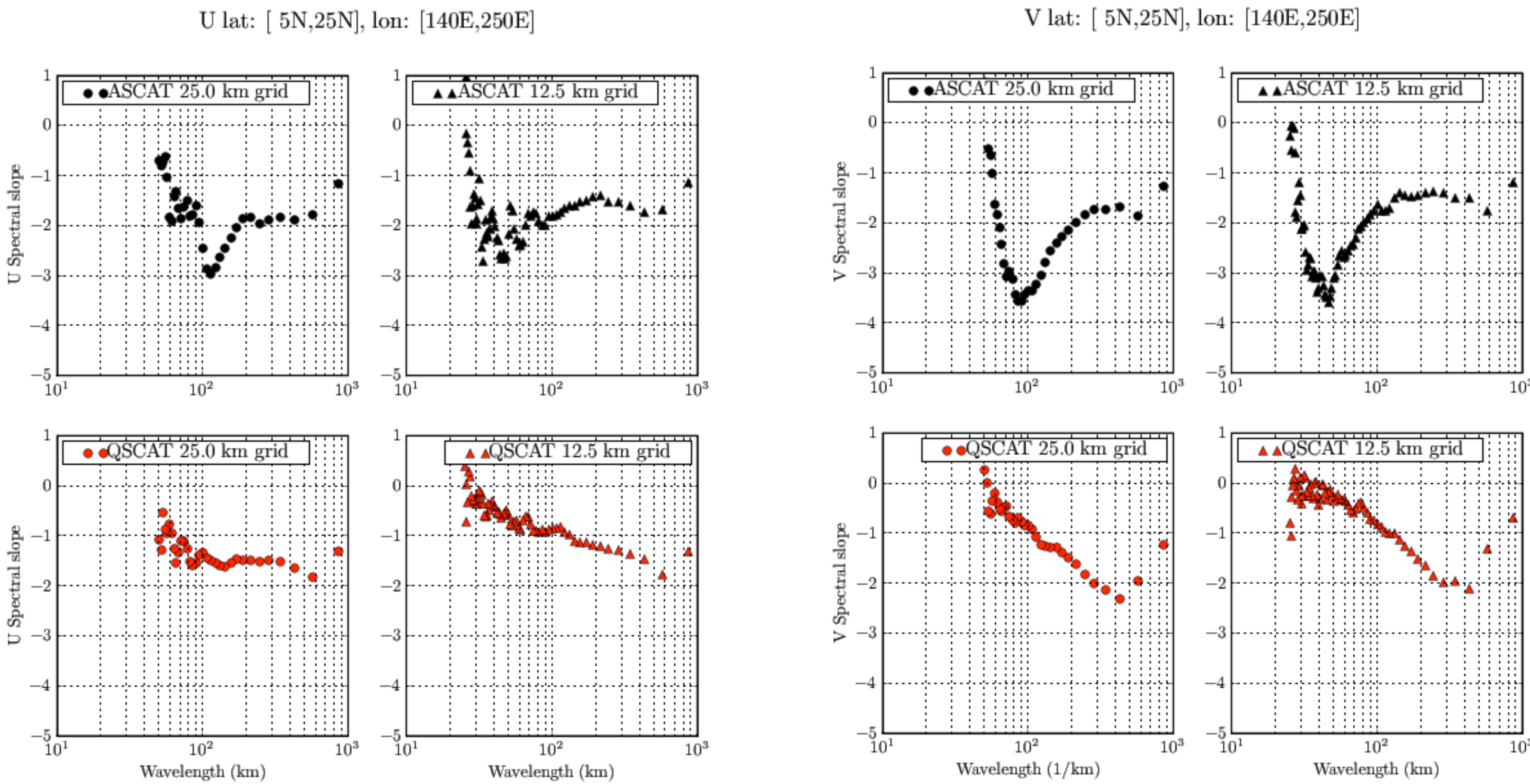


Region III Spectra

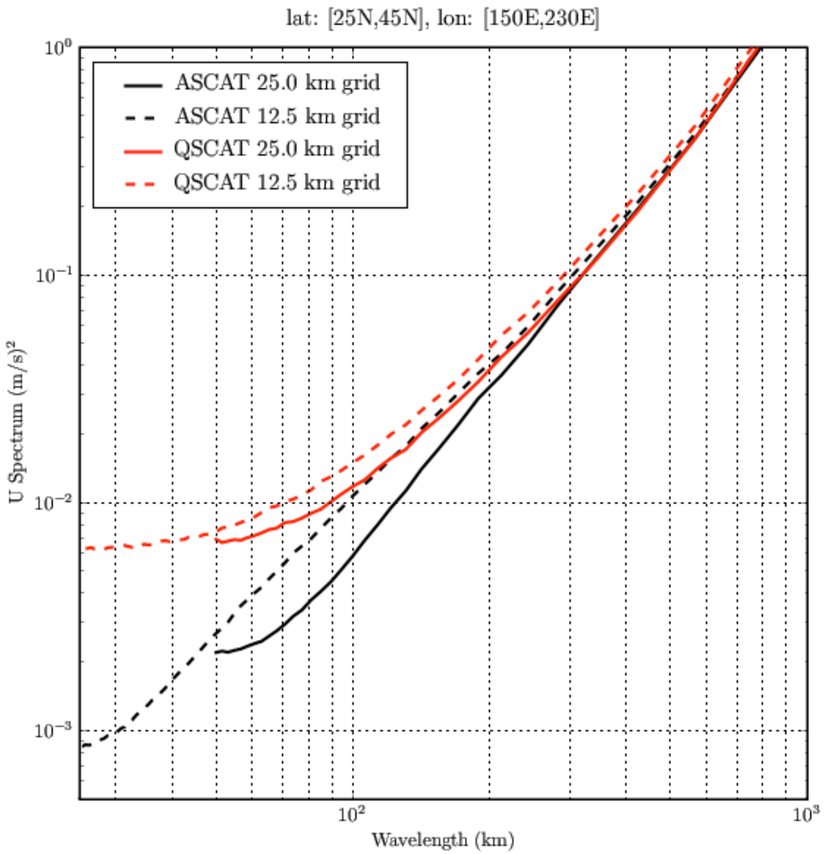


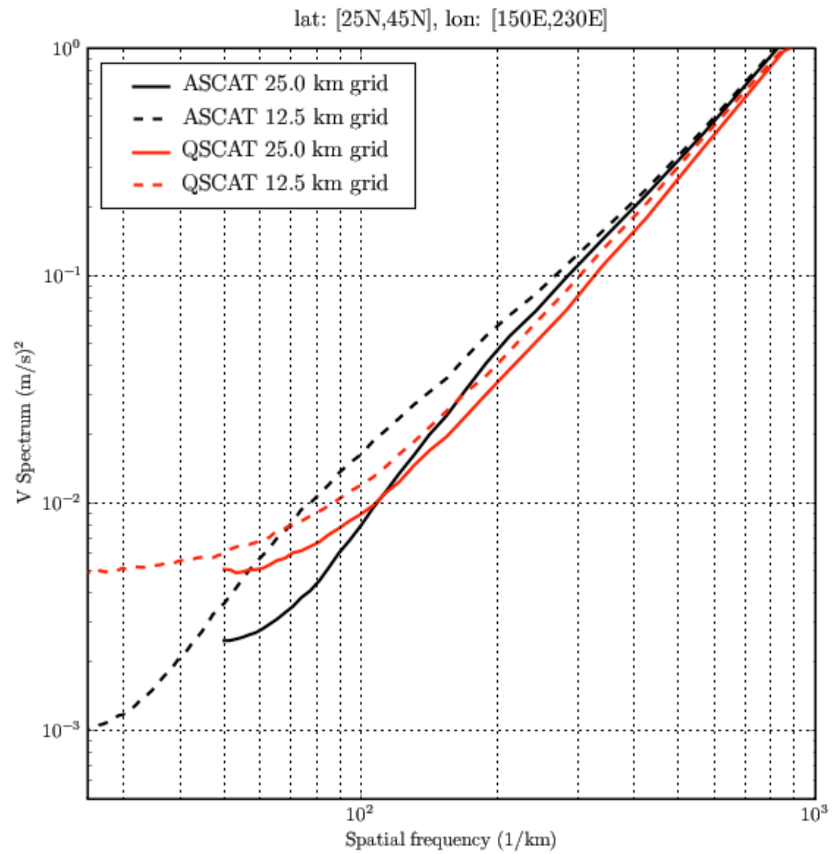


Region III Spectral Slopes

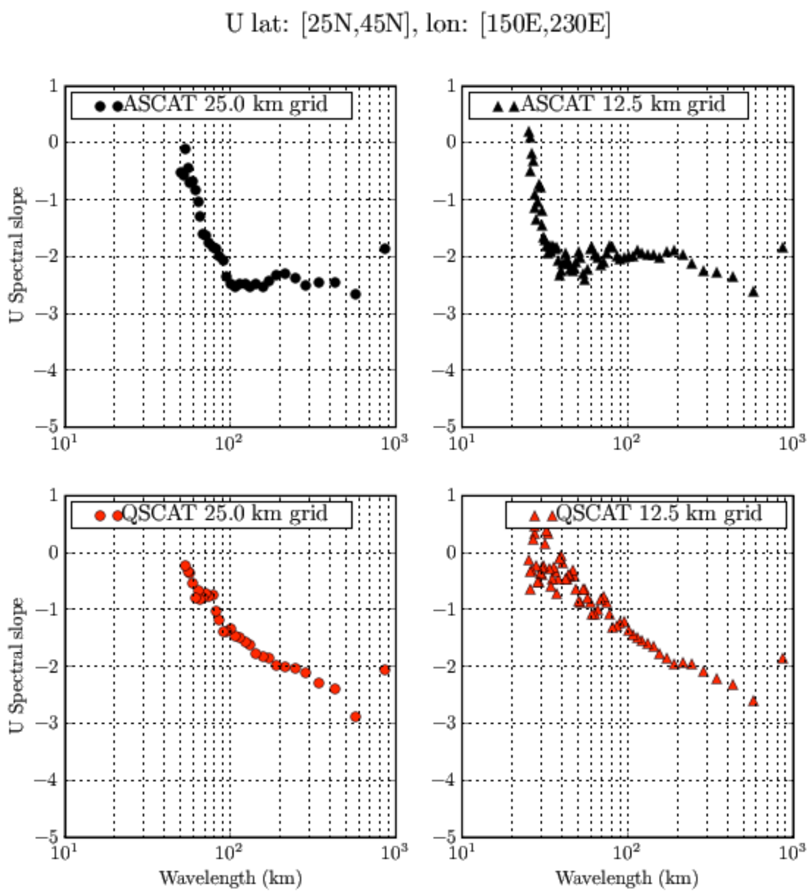


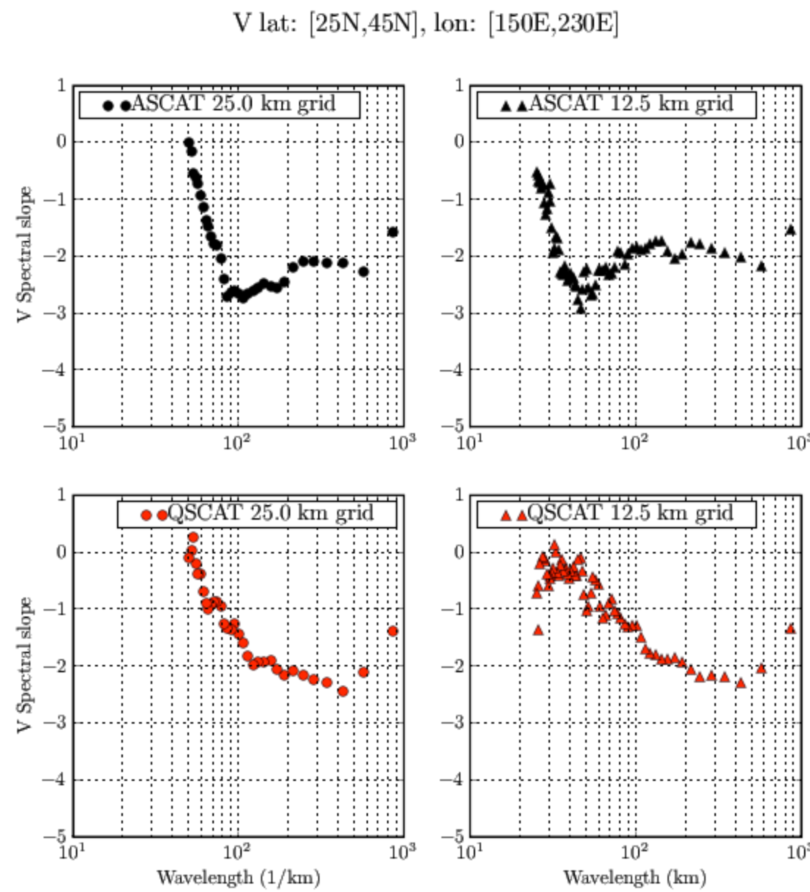
Region IV Spectra





Region IV Spectral Slopes





Estimated Spectral Slopes

	Qscat U slope	std	Qscat V slope	std	Ascat U slope	std	Ascat V slope	std
25 km								
Region 1	-1.90	0.10	-1.89	0.10	-2.32	0.06	-2.28	0.06
Region 2	-1.60	0.11	-1.43	0.11	-1.82	0.09	-1.92	0.09
Region 3	-1.50	0.12	-1.45	0.12	-2.28	0.16	-2.43	0.16
Region 4	-1.82	0.08	-1.98	0.08	-2.44	0.08	-2.41	0.08
12.5km								
Region 1	-1.76	0.11	-1.73	0.11	-1.99	0.05	-1.70	0.05
Region 2	-1.29	0.10	-1.37	0.10	-1.50	0.05	-1.38	0.05
Region 3	-1.10	0.12	-1.36	0.12	-1.58	0.05	-1.51	0.05
Region 4	-1.78	0.08	-1.87	0.08	-2.02	0.05	-1.85	0.05

- Spectral noise and signal estimates are consistent with co-located cross-correlation data: ASCAT has lower white noise at high frequencies due to low-pass

- ASCAT spectral slopes exhibit distortions of to scales ~200km

- ASCAT underestimates slopes relative to QuikSCAT

- 12.5 km slopes are consistently higher than 25 km slopes: is the noise not white?