DESI SIMULATED IMAGE QUALITY

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desi-data telecon 3.14…

DELIVERED IMAGE QUALITY

- Delivered image quality depends on:
  - zenith seeing at reference wavelength $S(t, \lambda_0)$
  - observing wavelength λ
  - observing airmass X
  - instrumental PSF $I(\lambda, \ldots)$

$$DIQ(t, \lambda, X, \ldots) = S(t, \lambda_0)\ (\lambda / \lambda_0)^{\alpha}\ X^{\beta} \oplus I(\lambda, \ldots)$$

IMPLEMENTATION IN DESI SIMULATIONS

- Instrumental PSF modeled as offset Gaussian:
  - Gaussian RMS derived from Zemax ray tracing
  - offset combines ray tracing with model of spatially correlated achromatic stochastic variations.
  - DESI-doc-2720

$$DIQ(t, \lambda, X, \ldots) = S(t, \lambda_0)\,(\lambda / \lambda_0)^{\alpha}\, X^{\beta} \oplus \boldsymbol{I(\lambda, \ldots)}$$

IMPLEMENTATION IN DESI SIMULATIONS

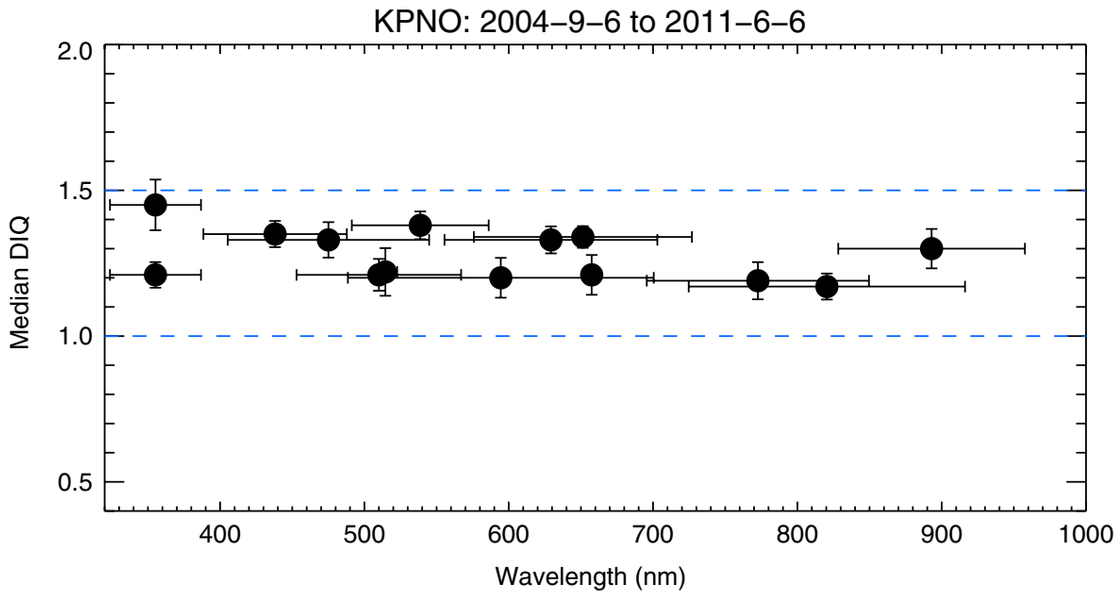
- Nominal seeing $S(t, \lambda_0)$ generated by surveysim and passed to specsim via quickgen:
  - Wavelength scaling $\alpha = -1/5$
  - Airmass scaling $\beta = 0$
- Kolmogorov theory describes turbulence with a single scale (Fried parameter $r_0 \sim 10$cm) and predicts $\alpha = -1/5, \beta = +3/5$.
- Von Karmen turbulence adds outer scale parameter ($L_0 \sim 30$m) and predicts $\alpha \sim -0.29, \beta \sim +0.64$.

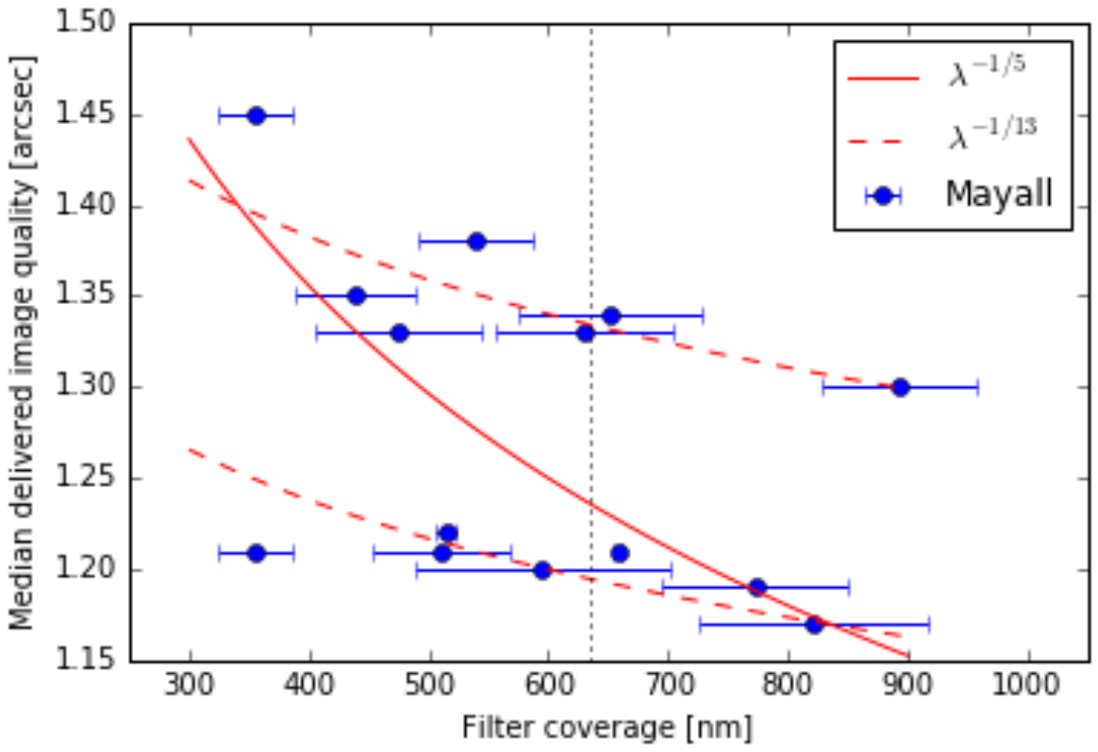
$$DIQ(t, \lambda, X, \ldots) = S(t, \lambda_0)\ (\lambda / \lambda_0)^{\alpha}\ X^{\beta} \oplus I(\lambda, \ldots)$$

OBSERVED WAVELENGTH SCALING AT KPNO

- Fig. 9 from Dey & Valdes 2014:

"Mayall MOSAIC data show no significant trends" (in wavelength)

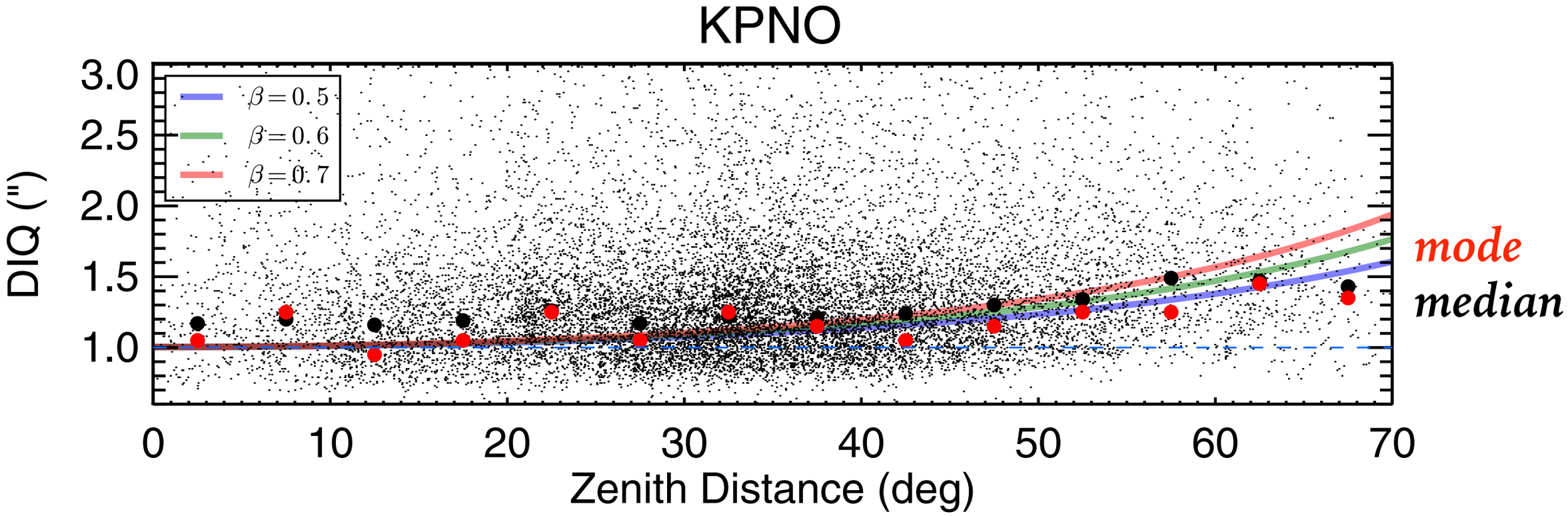




Re-plot of same data suggests there are two groups of filters, each with very mild wavelength scaling $\alpha \sim -1/13$.

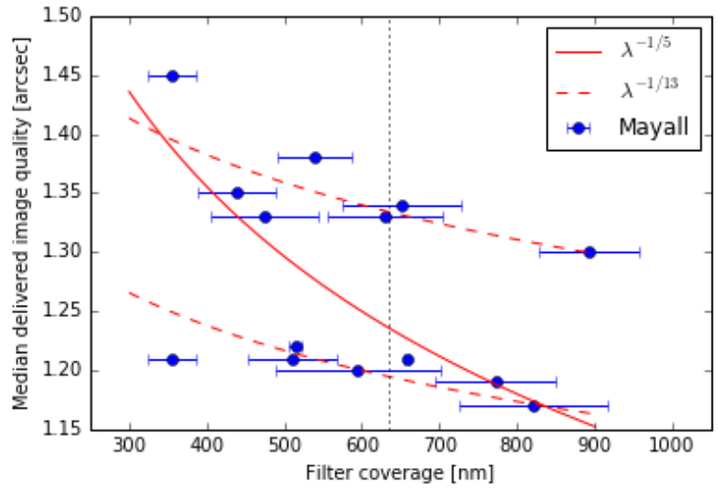
OBSERVED AIRMASS SCALING AT KPNO

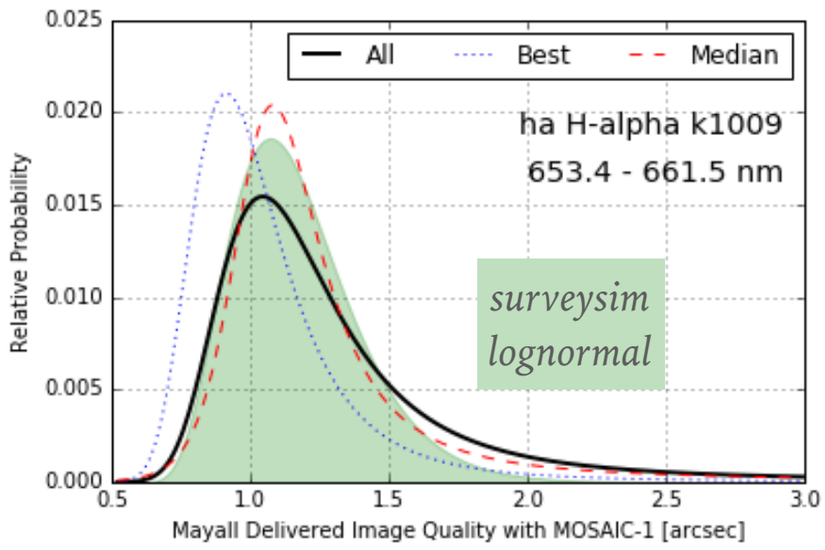
- Fig. 10 from Dey & Valdes 2014: “no significant variation of the DIQ on the zenith distance for angles $< 50°$.”
- Superimpose curves of different β.
- Conclusion: nominal $\beta = 0.6$ probably ok.

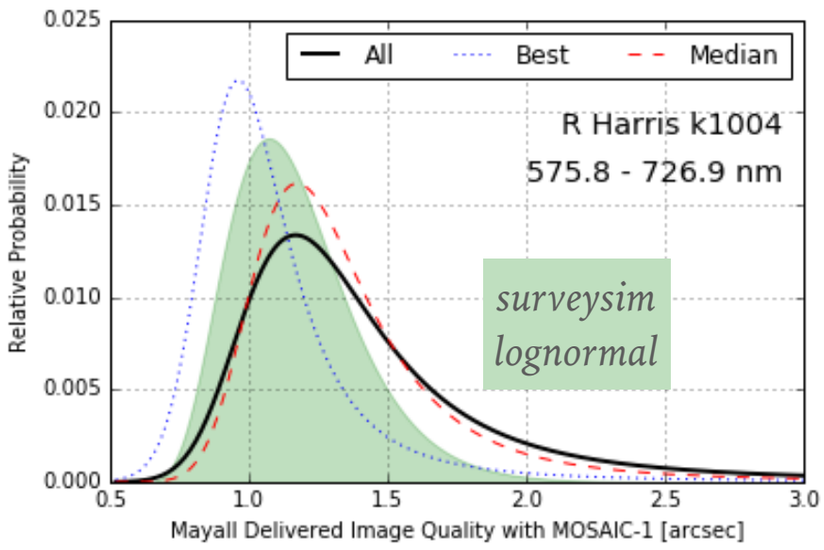


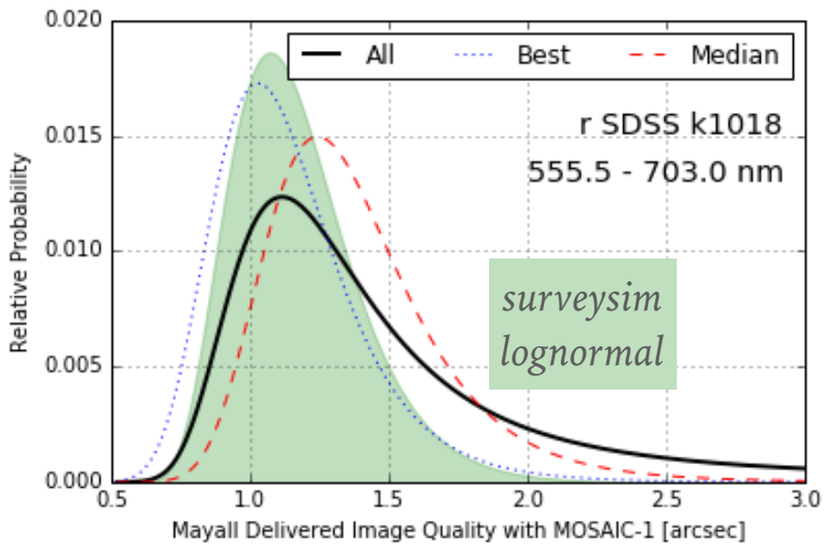
DISTRIBUTION OF ZENITH SEEING

- Modeled as lognormal in surveysim.
- 5-parameter model in Dey & Valdes 2014:
  - which filter is most representative of what DESI should expect at 635nm?
  - surveysim tails are probably underestimated.







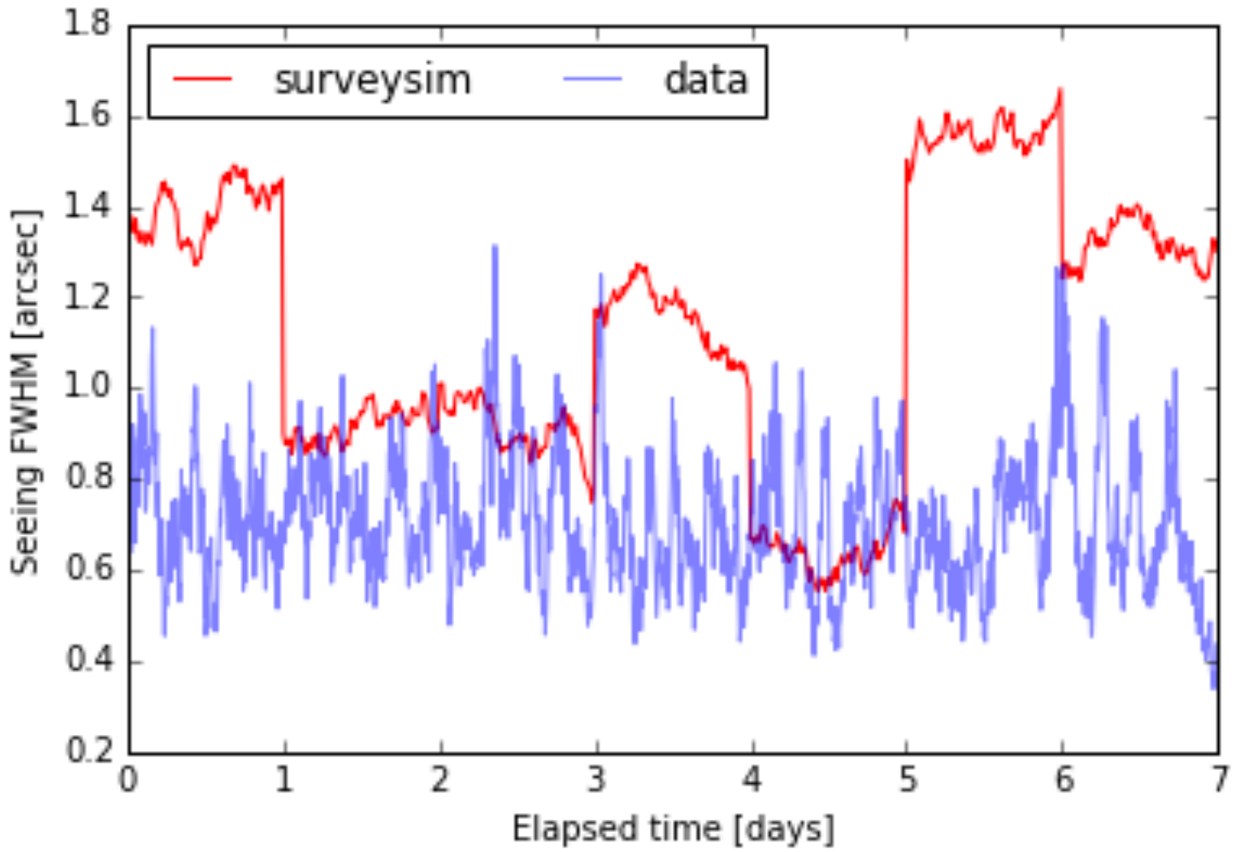


TIME EVOLUTION OF ZENITH SEEING

- Relevant for short-term forecasts, e.g. online ETC.
- Modeled as random walk during each night in surveysim:
  - not stationary! (mean, variance grow with time)
- Alternative stationary models:
  - Gaussian random field: $PSD(f, \lambda_0) \rightarrow S(t, \lambda_0)$
  - Linear autoregressive models AR(n):
    - $S(t_i) = a_1 S(t_{i-1}) + a_2 S(t_{i-2}) + \ldots + \varepsilon_i$
- Useful data sets:
  - DIMM seeing at Cerro Pachon (LSST) every 5 mins for 2 years.
  - Anything comparable from KPNO?

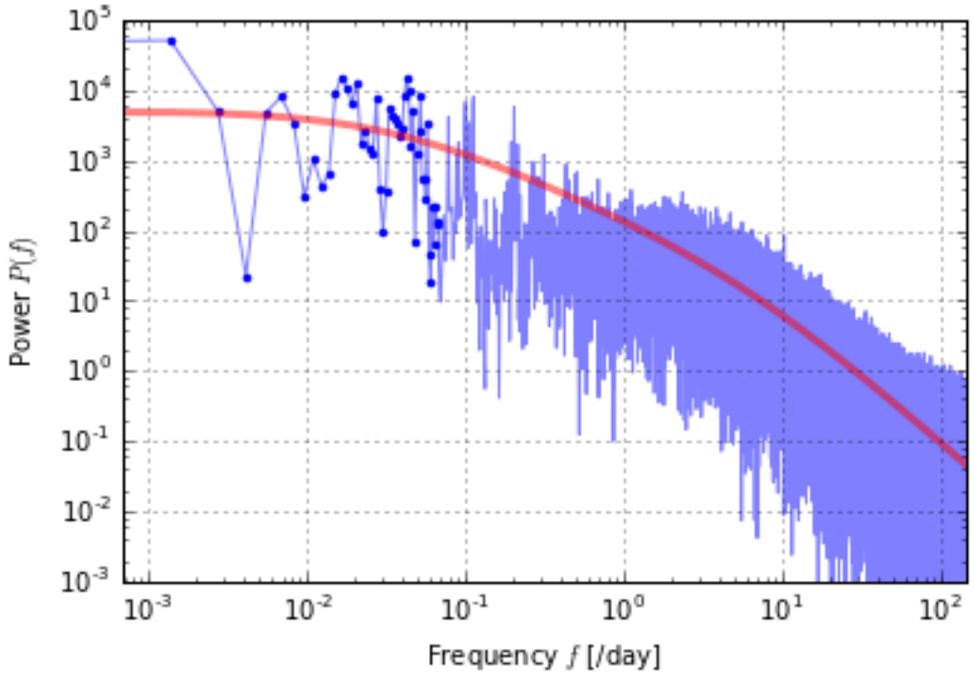
TIME EVOLUTION OF ZENITH SEEING

- Current simulation has artificial jumps at start of each night.
- Compared with Cerro Pachon DIMM data, fluctuations within a night are too small.

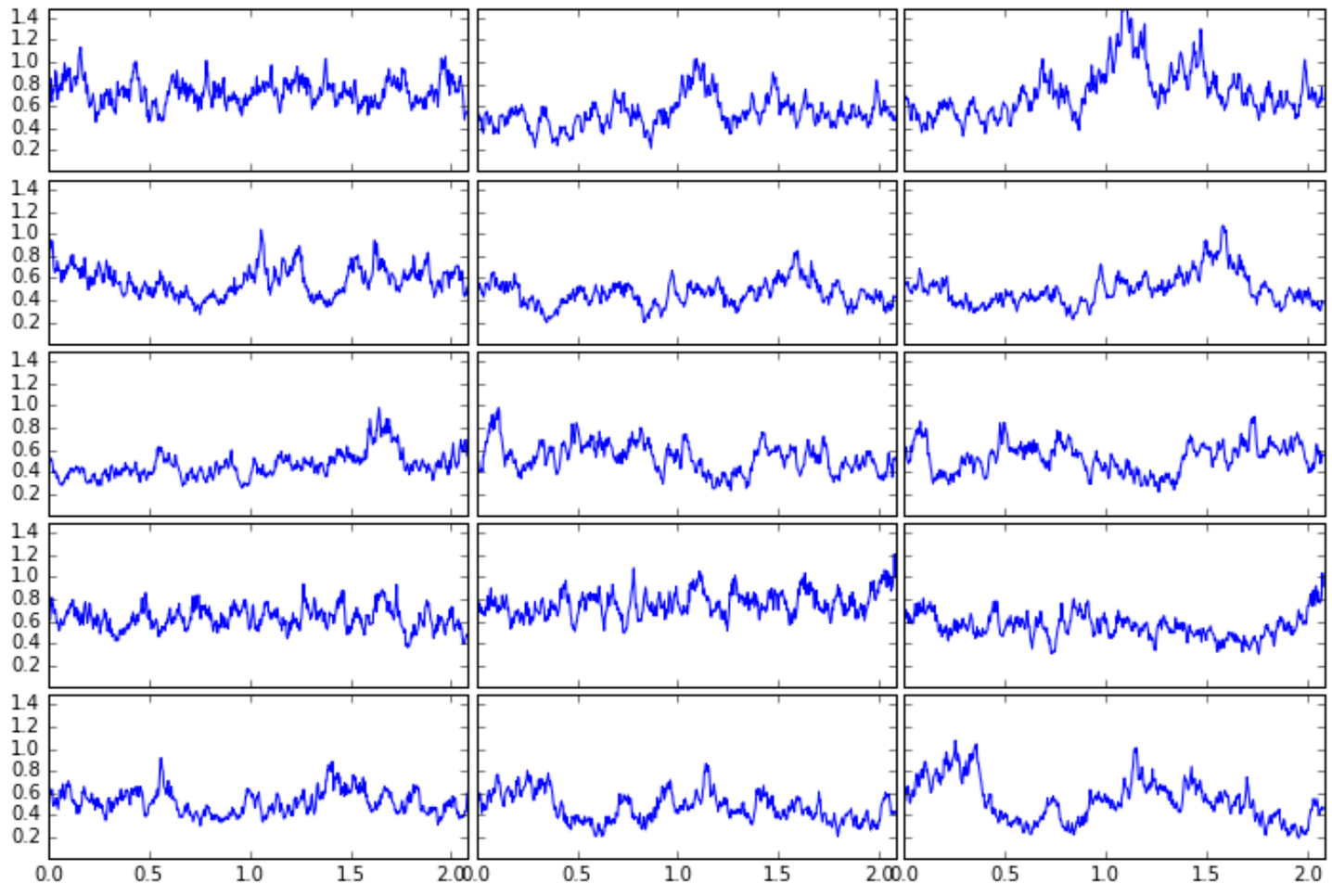


TIME EVOLUTION OF ZENITH SEEING

- Can rescale Cerro Pachon power spectrum to simulate KPNO seeing time series as a Gaussian process.



Which time series are data / simulated?



NEXT STEPS

- Add seeing dependence on airmass in specsim.
- Surveysim upgrades:
  - Seeing distribution from Dey & Valdes 2014.
  - More realistic time evolution model.
    - Implement in surveysim or desimodel?
- Study exposure time dependence on seeing:
  - Nice standalone project for new student / postdoc.
  - Use similar strategy to moon exposure-time study.
  - Compare with surveysim model:

```
a, b, c = 4.6, -1.55, 1.15
f_seeing = (a+b*seeing+c*seeing*seeing) / (a-0.25*b*b/c)
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