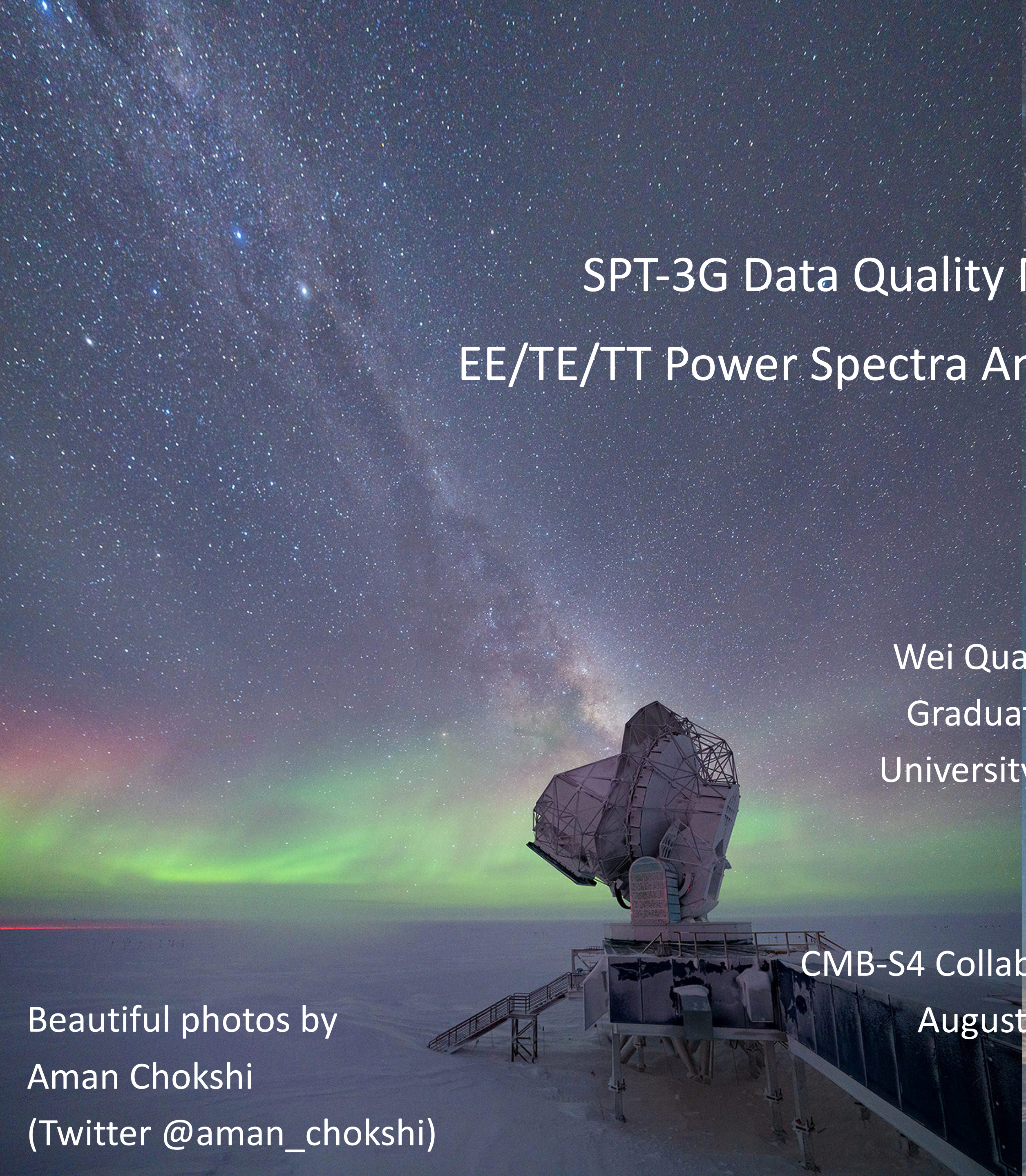

SPT-3G Data Quality Monitoring System and EE/TE/TT Power Spectra Analysis using 2019+2020 Data

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University of Chicago

CMB-S4 Collaboration Meeting
August 18, 2022

Beautiful photos by
Aman Chokshi
(Twitter @aman_chokshi)

A quick introduction of myself

Hello!

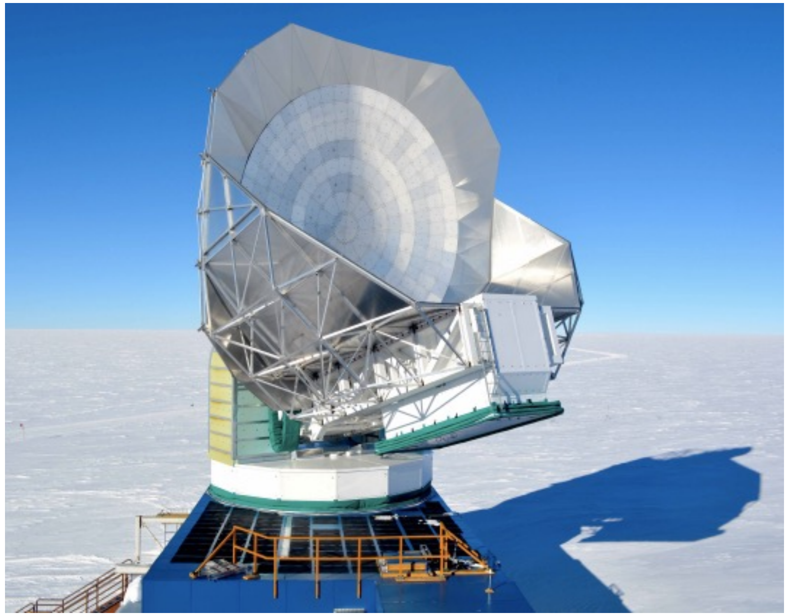
I am a graduate student at the Univ. of Chicago.

- I have been working on SPT-3G for several years.
- My advisors are Tom Crawford and John Carlstrom.
- I am hoping to graduate at around this time next year and currently thinking about future research directions.

Before coming to Chicago,

- I got my bachelor's degree from the Univ. of Washington.
- I grew up in China and then Japan. (Always moving east!)

A quick introduction of the South Pole Telescope



South Pole Telescope

- 10 m primary mirror
- 1.6’/1.2’/1.0’ resolution at 95/150/220 GHz

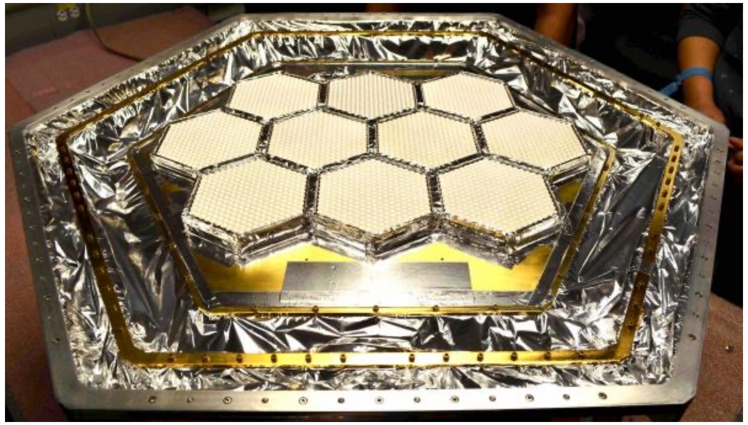
SPT-SZ focal plane

- 2007 - 2011
- 960 bolometers
- 95/150/220 GHz

SPTpol focal plane

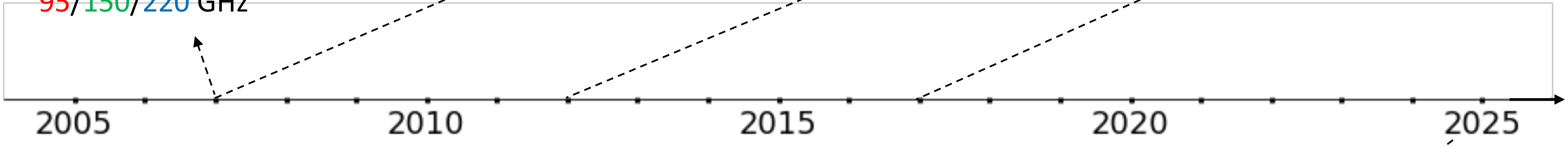
- 2012 - 2016
- 1,600 bolometers
- 95/150 GHz
- Pol. sensitive

0.5 m



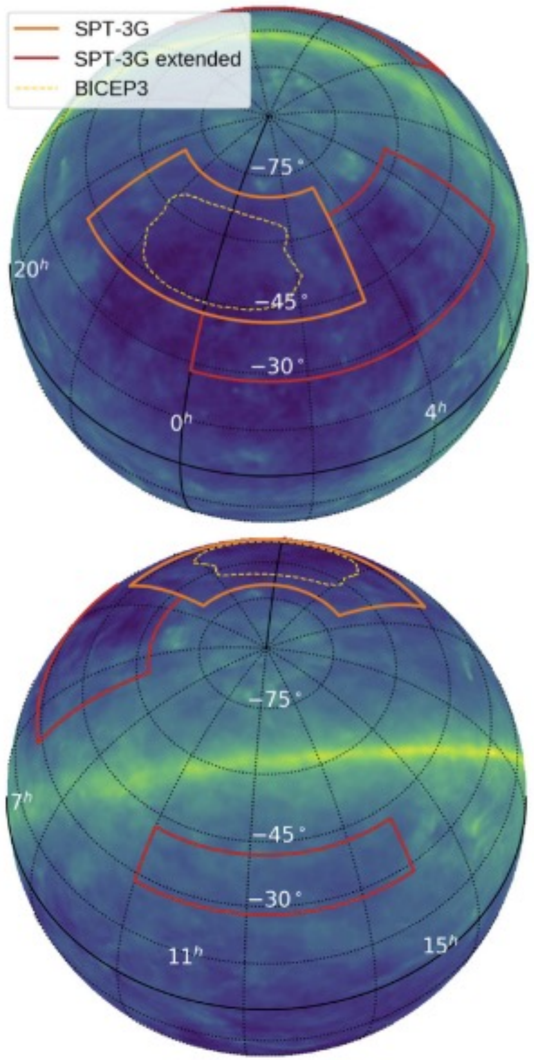
SPT-3G focal plane

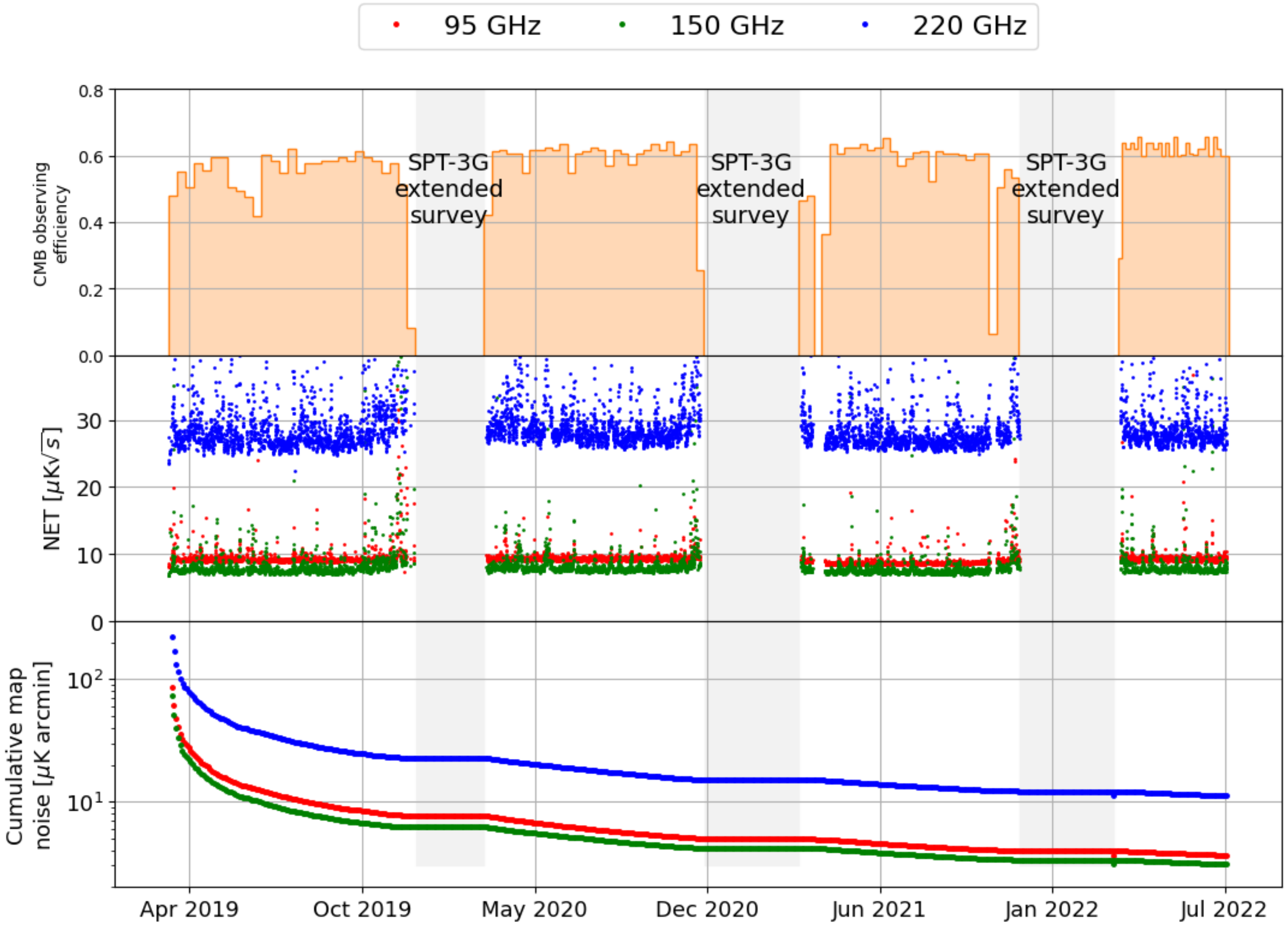
- 2017 - present
- 16,000 bolometers
- 95/150/220 GHz
- Pol. sensitive



SPT-3G+ planned to be deployed

Stable operations of SPT-3G at full capacity



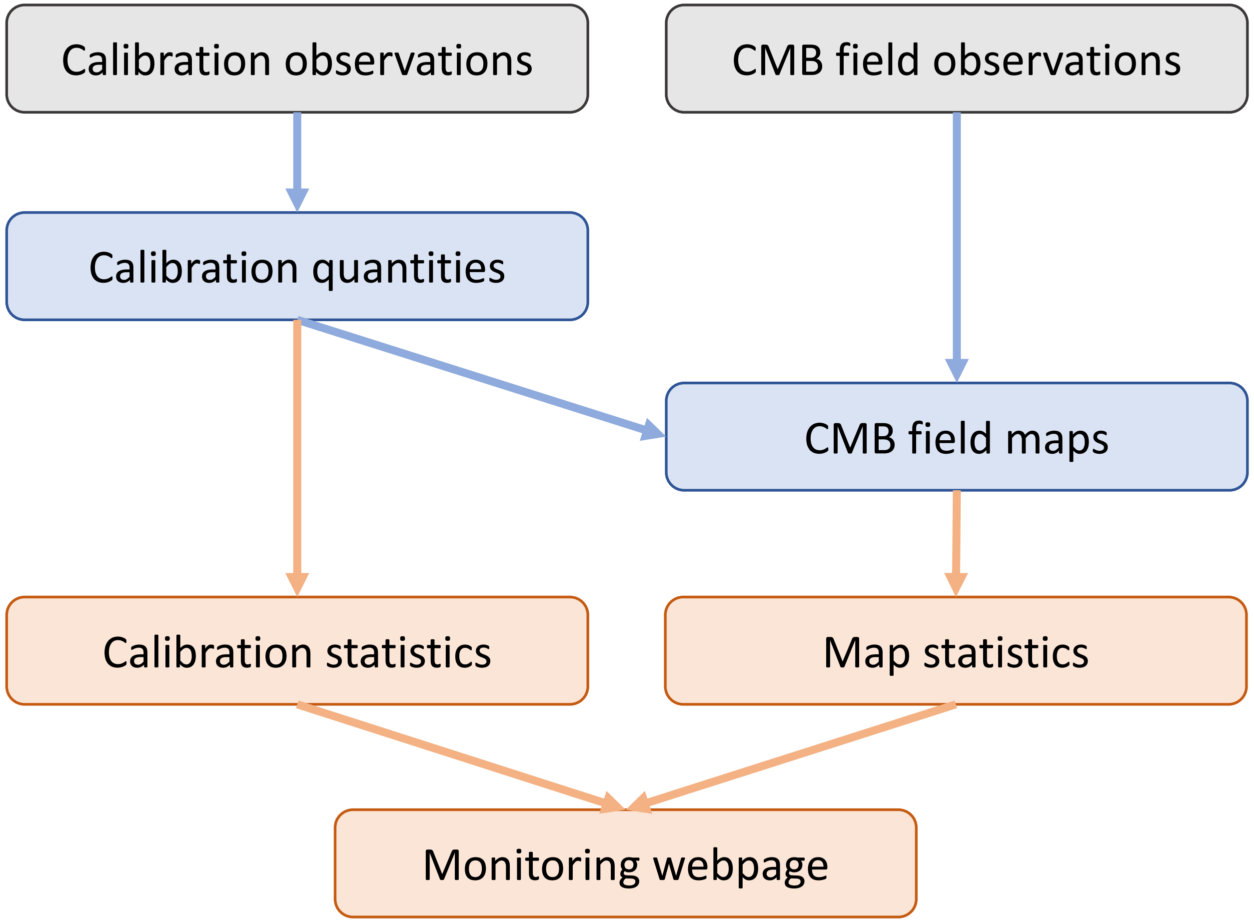


Figures adapted from [J. A. Sobrin et al, 2022 ApJS 258 42](#).

SPT-3G data quality monitoring system

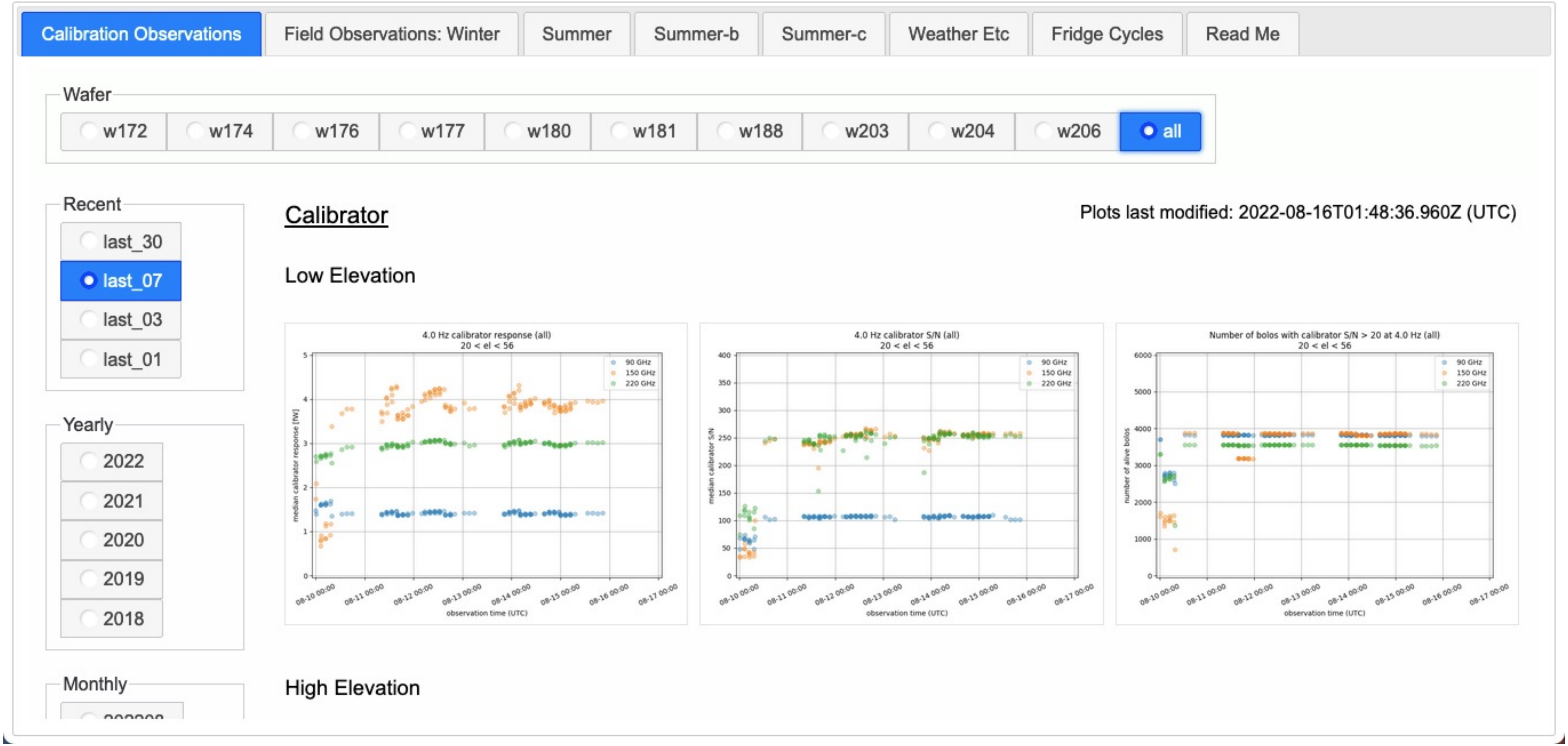
At the south pole, a few pipelines automatically process our data to help with stable operations.

1. Raw data from calibration observations are analyzed to result in calibration quantities.
2. Calibration quantities and raw data from field observations are combined to result in maps.
3. Calibration quantities and maps are analyzed to result in summary statistics and data quality metrics.
4. Summary statistics and data quality metrics are displayed on a webpage.

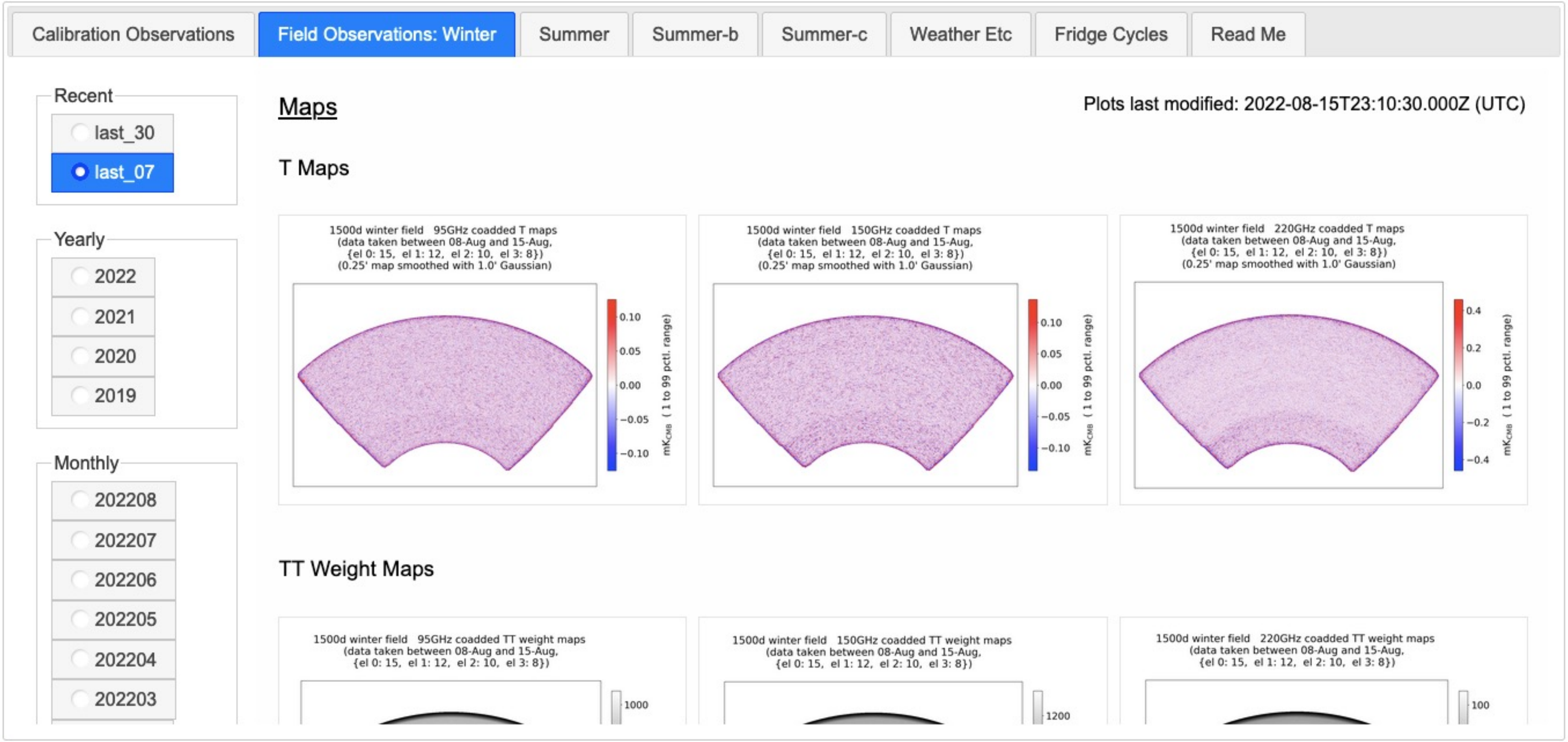


I have been actively involved in the development and maintenance of our data quality monitoring system together with Adam Anderson, Sasha Rahlin, and others.

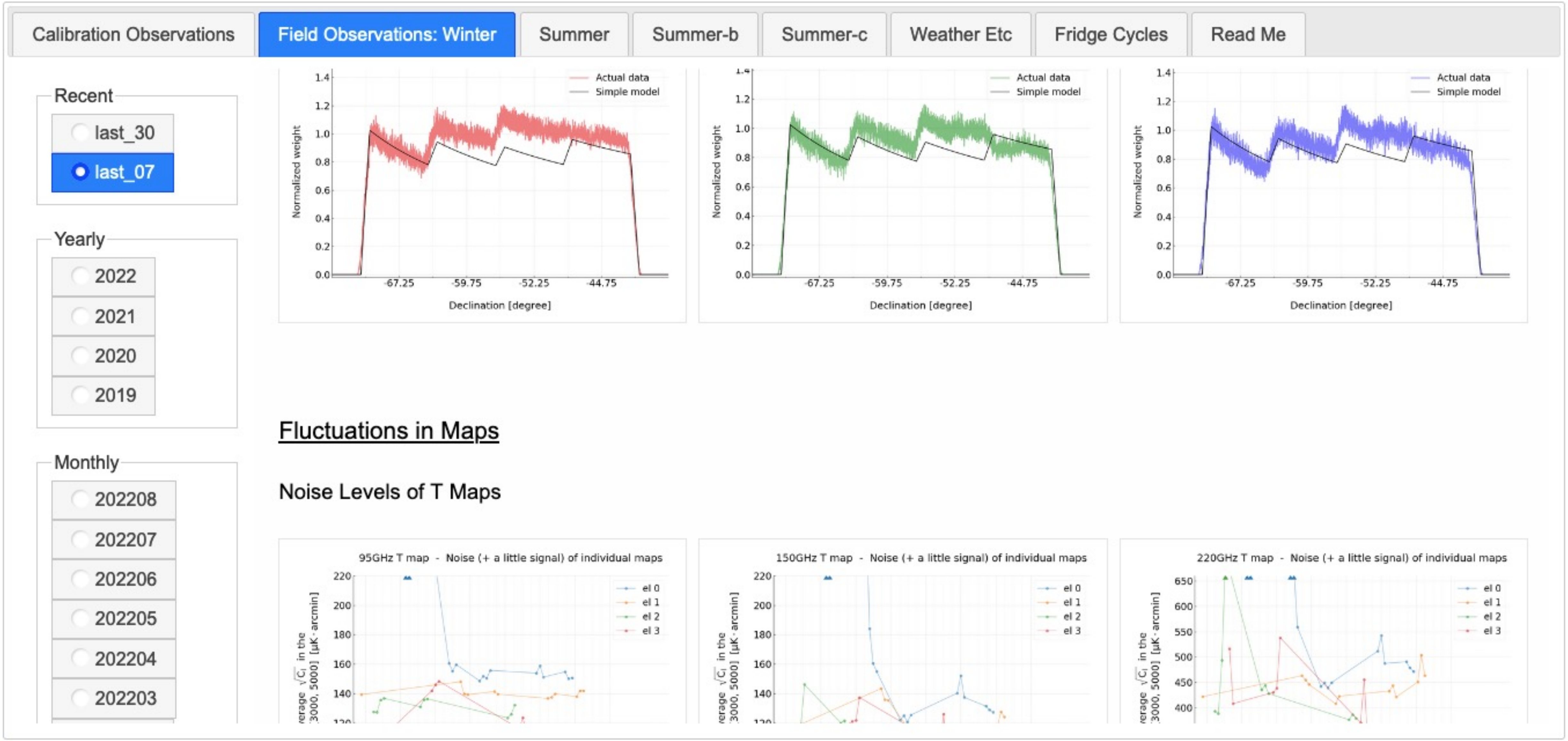
Data quality monitoring webpage screenshots



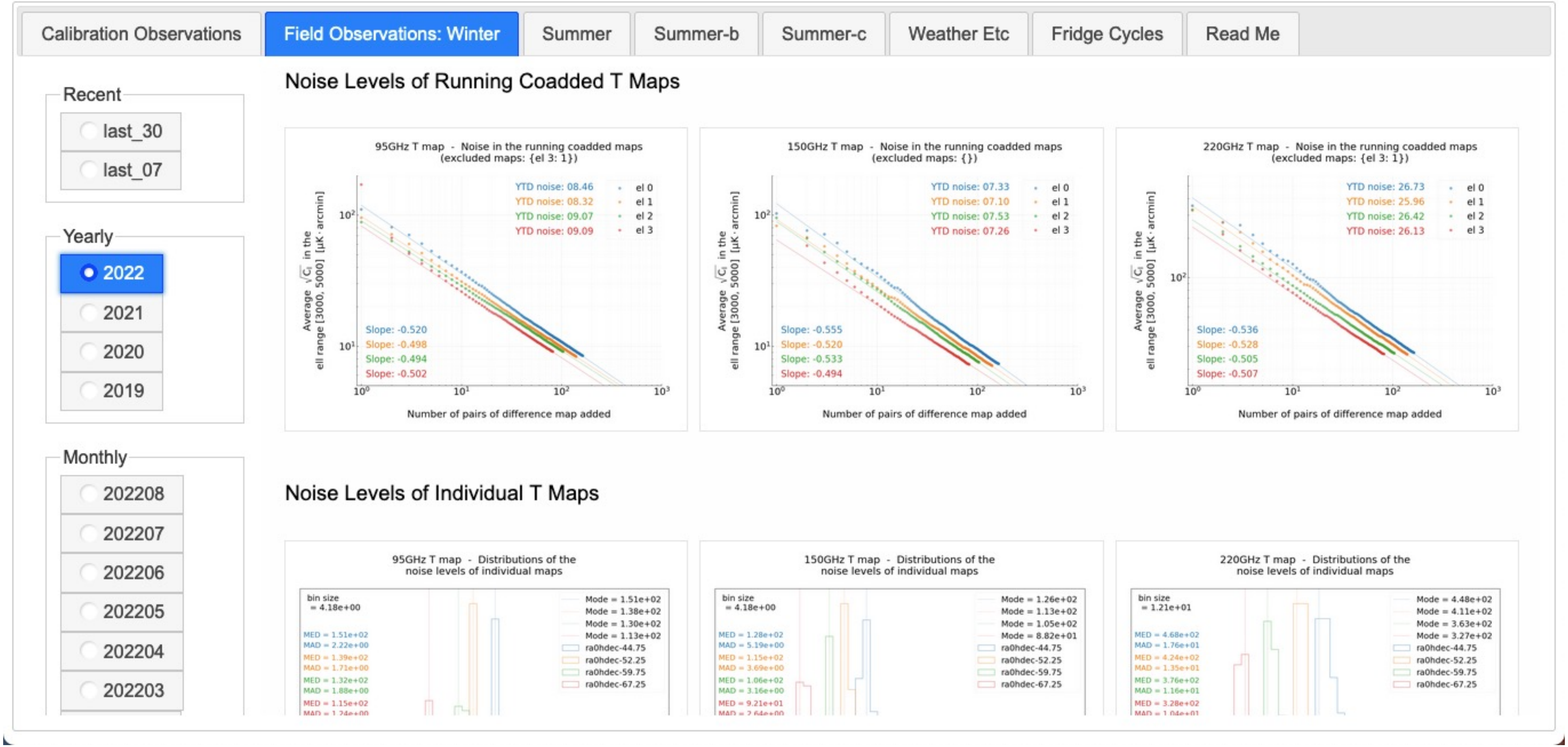
Data quality monitoring webpage screenshots



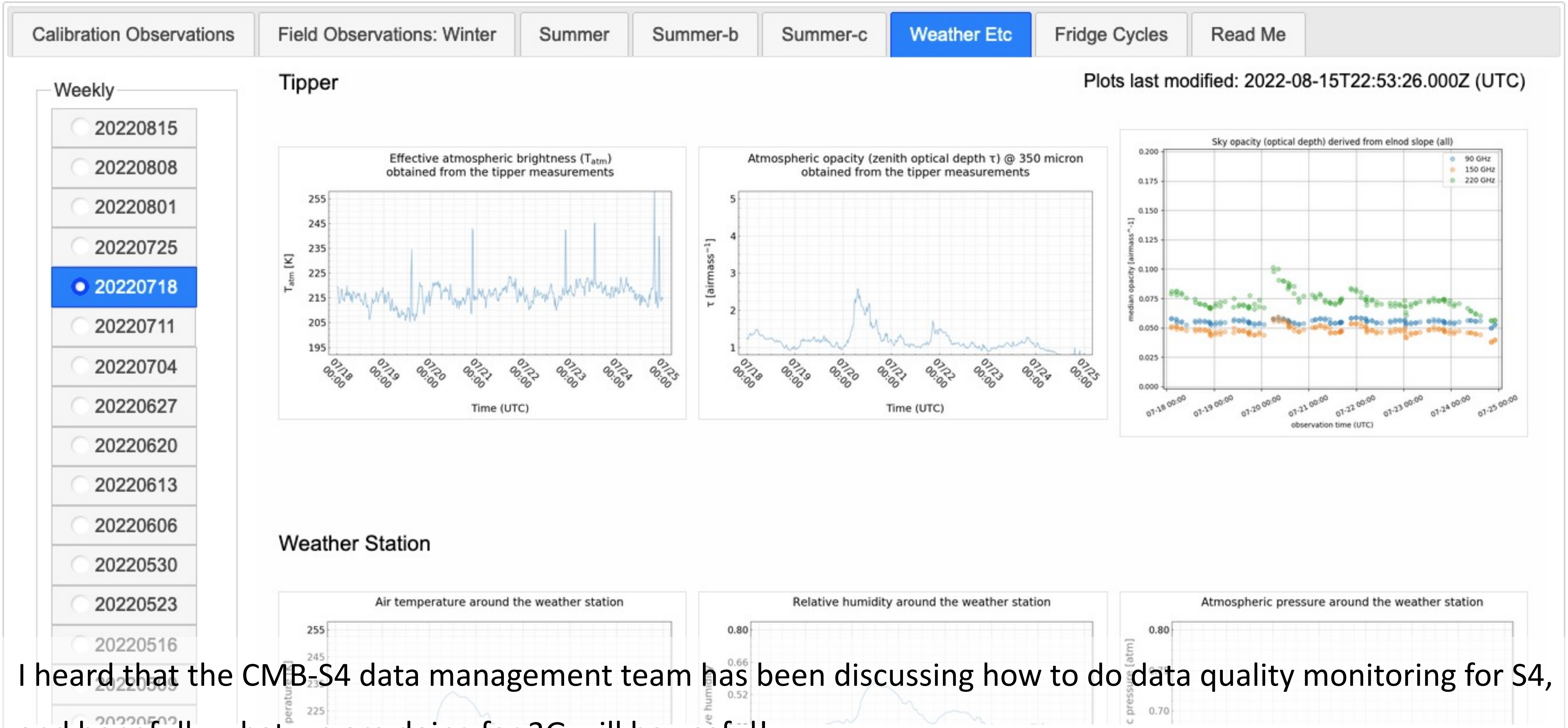
Data quality monitoring webpage screenshots



Data quality monitoring webpage screenshots



Data quality monitoring webpage screenshots



I heard that the CMB-S4 data management team has been discussing how to do data quality monitoring for S4, and hopefully what we are doing for 3G will be useful!

2019+2020 EE/TE/TT analysis

Several exciting analysis projects are underway using the 2019+2020 data.

- Low-ℓ BB, high-ℓ TT, mid-ℓ EE/TE/TT power spectra
- Lensing reconstruction/delensing
- Point source finding, cluster finding

etc.

I am leading the EE/TE/TT project using 2019+2020 winter data together with Etienne Camphuis, a graduate student at the Institut d'Astrophysique de Paris (IAP).

2019+2020 EE/TE/TT analysis

Like our 2018 EE/TE analysis (*Dutcher, Balkenhol et al, Phys. Rev. D 104, 022003*), we are using

- the MASTER formalism (*Hivon et al, 2002 ApJ 567 2*):

  filter timestreams to make them roughly white noise to reduce the full maximum likelihood solution to a simpler bin-and-average method, then estimate the filtering bias using simulations

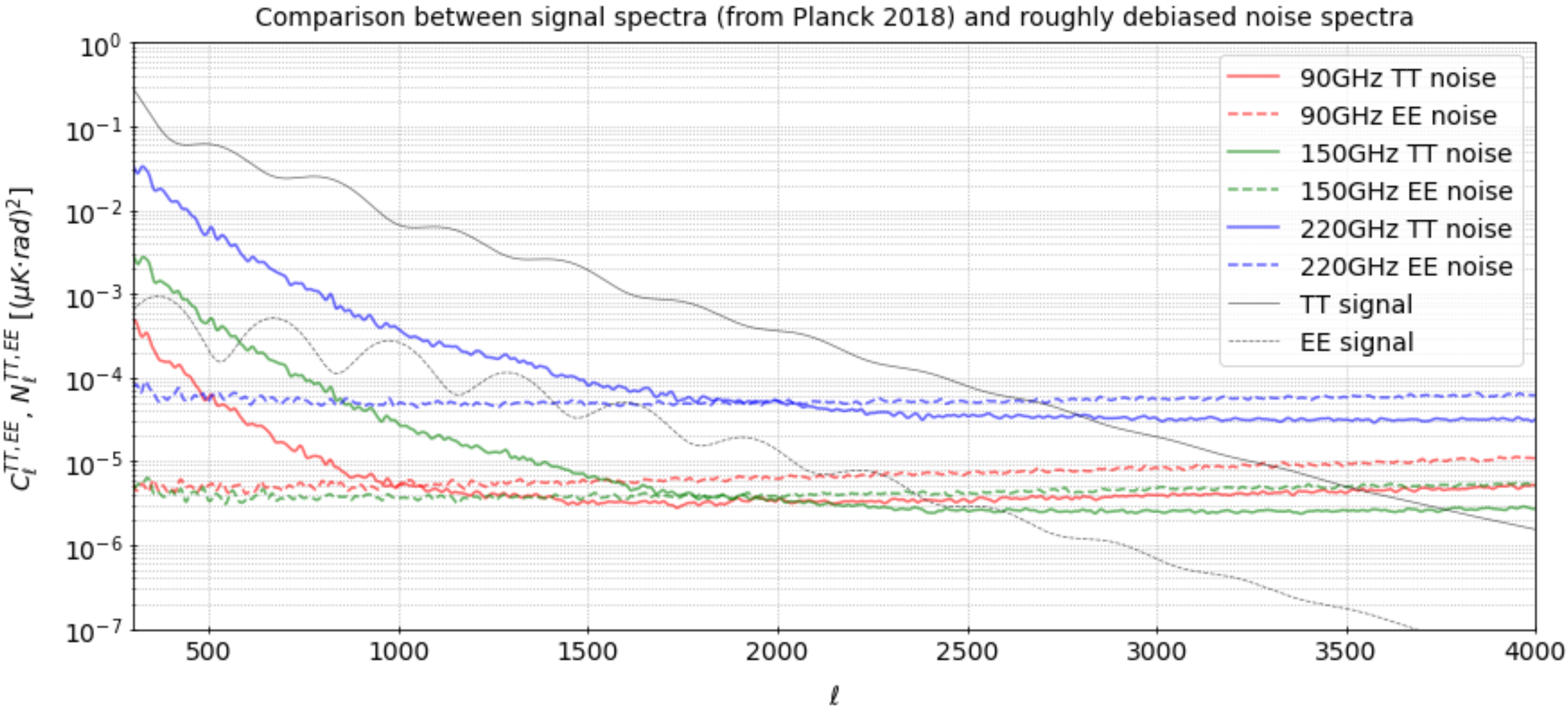
- a cross-spectrum approach (*Polenta el al, JCAP11(2005)001*):

  average cross-spectra among a number of partial-depth coadds to reduce the noise bias that might result from an approach of calculating auto-spectra of full coadds

Unlike the 2018 analysis, we are using

- HEALPix maps instead of flat-sky maps (and the PolSpice program for spectrum estimation) to avoid certain nonideal projection effects
- analytical calculations to build bandpower covariance to reduce the simulations we need to run and the reliance on conditioning techniques (*Camphuis et al, arXiv 2204.13721*)

2019+2020 EE/TT preliminary noise spectra



2019+2020 EE/TT preliminary white noise levels

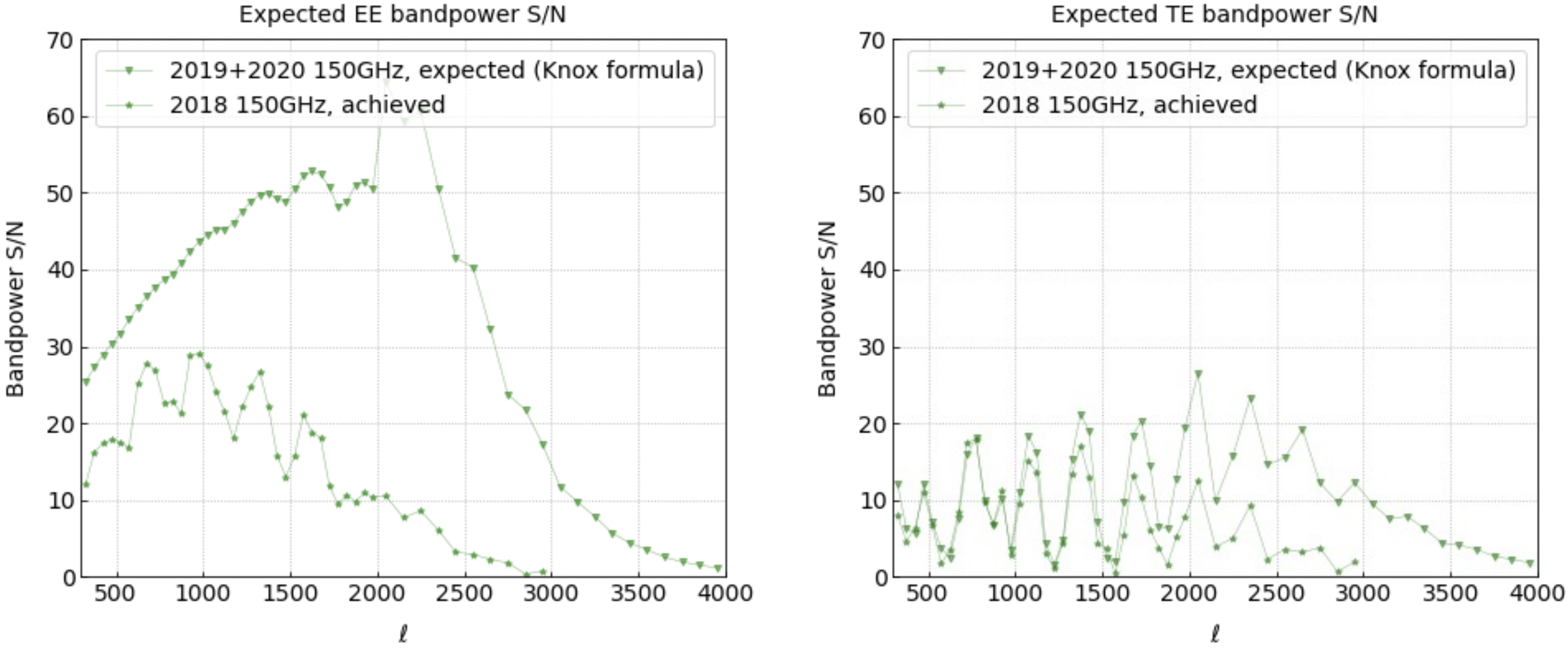
2019+2020 white noise levels are about 3.5 times lower than 2018 ones.

	2018 EE white noise levels (*Dutcher, Balkenhol et al.*)	2019+2020 EE (TT) white noise levels	2018 EE / 2019+2020 EE
90GHz	29.6	8.1 (5.4)	3.7
150GHz	21.2	6.6 (4.6)	3.2
220GHz	75	23 (16)	3.3

(Noise levels in the units of μK·arcmin)

2019+2020 EE/TE expected bandpower error bars

A comparison of bandpower error bars also looks exciting!



2019+2020 EE/TE expected parameter constraints

2019+2020 EE/TE data are expected to result in more than 50 % smaller error bars on LCDM parameters than 2018 EE/TE.

Forecasting work by Silvia Galli

	$\Omega_b h^2$	$\Omega_c h^2$	H_0	n_s	$\ln A_s$
$\sigma_{2018} / \sigma_{2019+2020}$	1.9	1.6	1.6	1.5	1.3

(Negligible difference for τ)

We would also like to include TT in the analysis, which is expected to result in up to 15 % or so improvements, assuming relevant null tests' results turn out reasonable.

A few ongoing tasks include running null tests and building covariance matrices, and we would like to be able to get the results out in a year timescale.

Summary

I have worked on SPT-3G's data quality monitoring system, which has been useful for us to monitor our data and detect issues early on, and this framework will hopefully be a useful reference for CMB-S4.

I am currently working on 2019+2020 EE/TE/TT analysis, which will result in exciting improved constraints of cosmological parameters compared to the 2018 analysis.

Thank you for your attention!

Beautiful photo by Geoffrey Chen