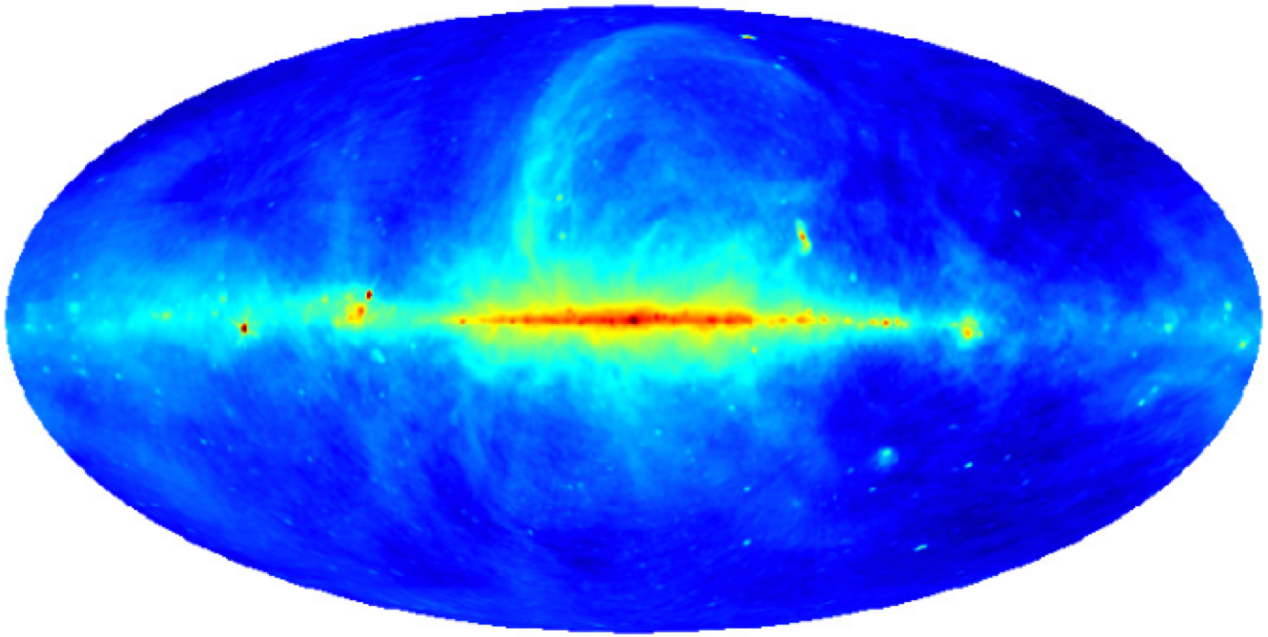
Exploiting sparsity for CMB component separation

M. Irfan, J. Bobin, M. A. Miville-Deschênes, I. Grenier

CMB foregrounds for B-mode studies

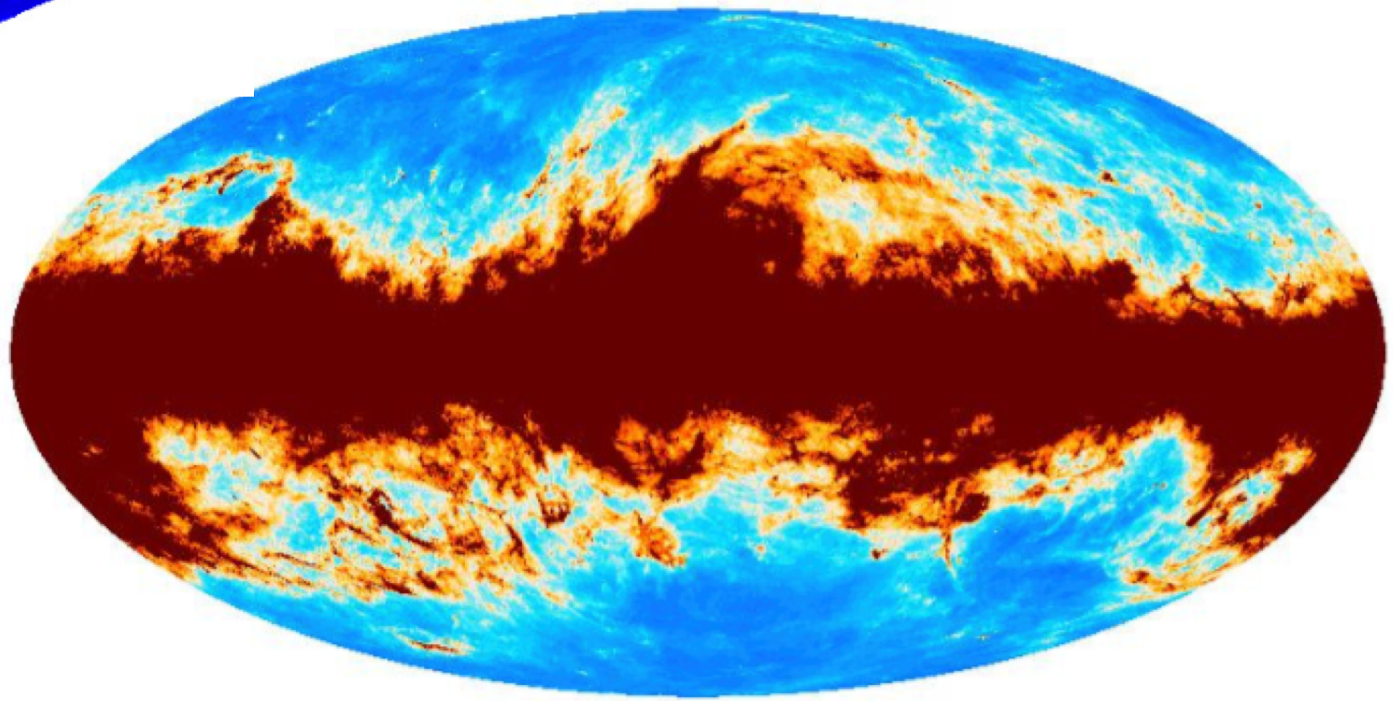
Tenerife, 18/10/18

The main culprits



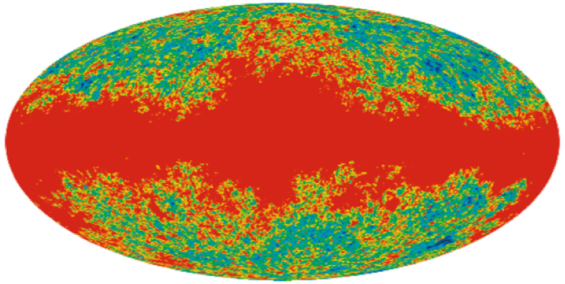
Haslam et al. 1982

Planck Collaboration 2018

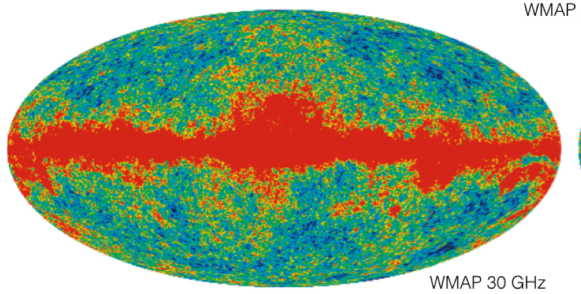


premise: Parameter Recovery Exploiting Model Informed Sparse Estimates

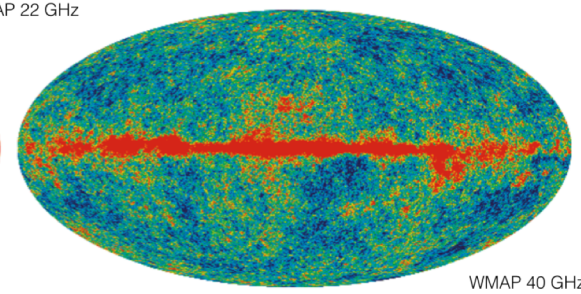
- Parametric:



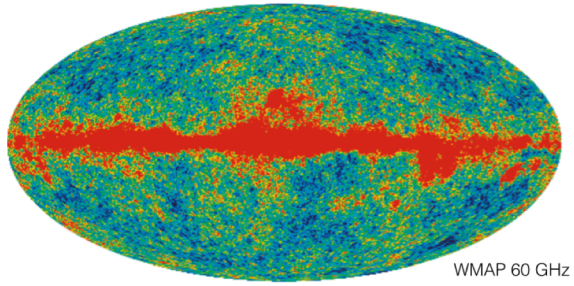
WMAP 22 GHz



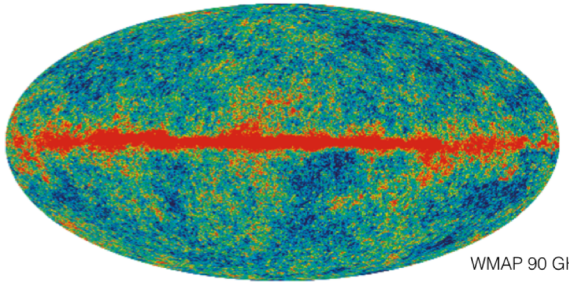
WMAP 30 GHz



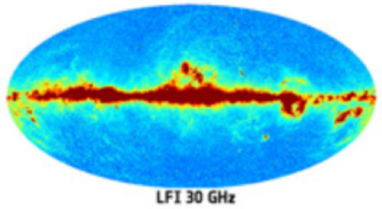
WMAP 40 GHz



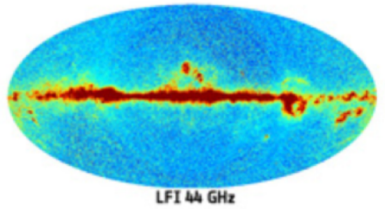
WMAP 60 GHz



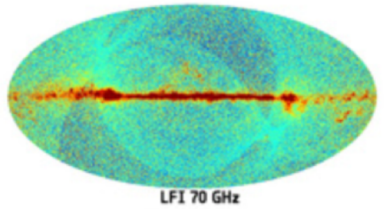
WMAP 90 GHz



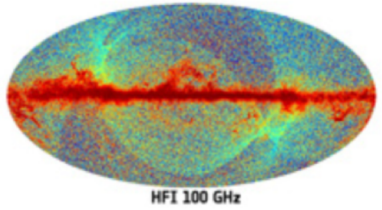
LFI 30 GHz



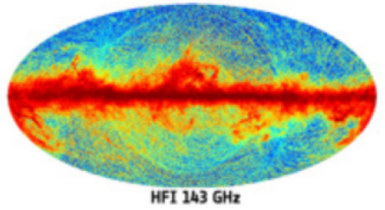
LFI 44 GHz



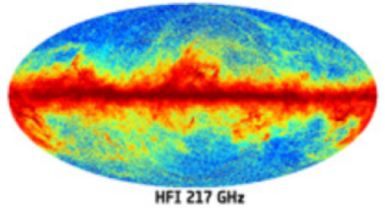
LFI 70 GHz



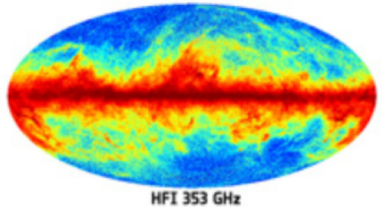
HFI 100 GHz



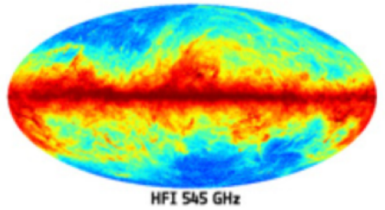
HFI 143 GHz



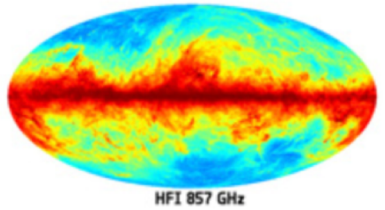
HFI 217 GHz



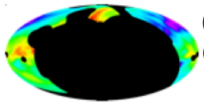
HFI 353 GHz



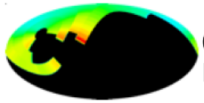
HFI 545 GHz



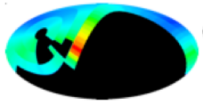
HFI 857 GHz



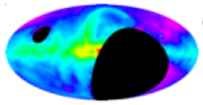
0.010 GHz Caswell 1976



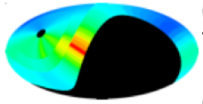
0.013 GHz Bridle 1967



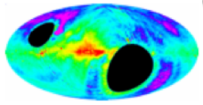
0.017 GHz Bridle 1967



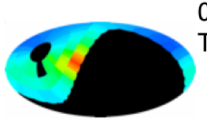
0.022 GHz Roger at al 1999



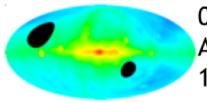
0.026 GHz Turtle at all 1962



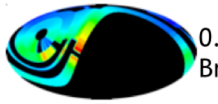
0.035 GHz Dwarakanath et al 1990



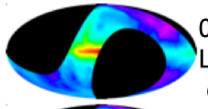
0.038 GHz Turtle et al 1962



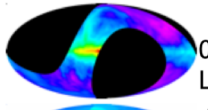
0.045 GHz Alvarez et al 1997



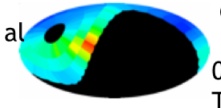
0.081 GHz Bridle 1967



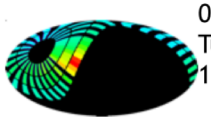
0.085 GHz Landecker et al 1970



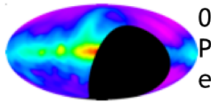
0.150 GHz Landecker et al 1970



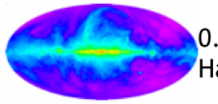
0.176 GHz Turtle et al 1962



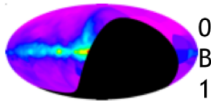
0.400 GHz Turtle at al 1962



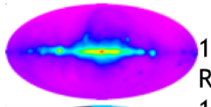
0.404 GHz PaulinyToth et al 1962



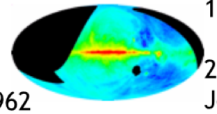
0.408 GHz Haslam 1982



0.820 GHz Berkhuijsen 1972



1.420 GHz Reich&Reich 1986

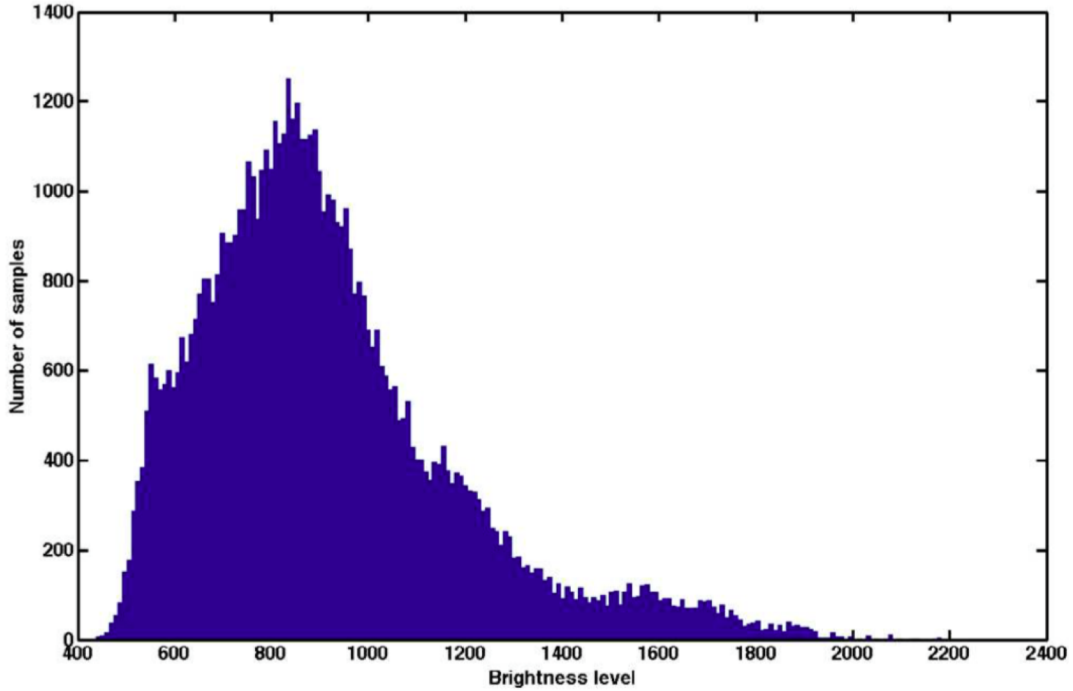


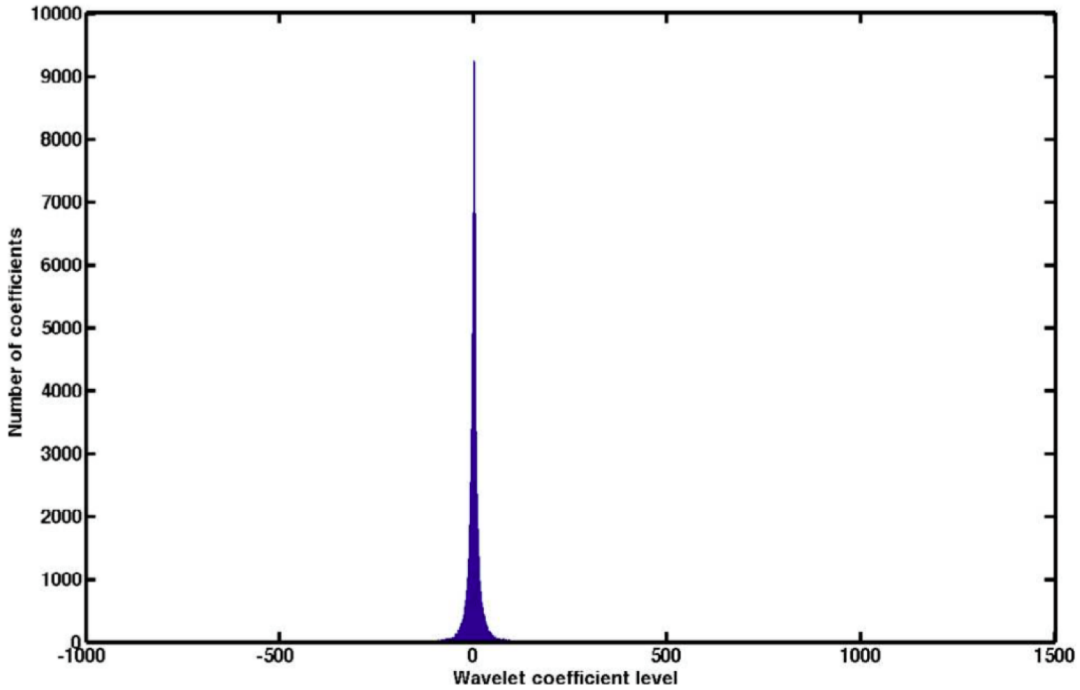
2.326 GHz Jonas et al 1998

Low freq data documented in De Oliveira-Costa 2008

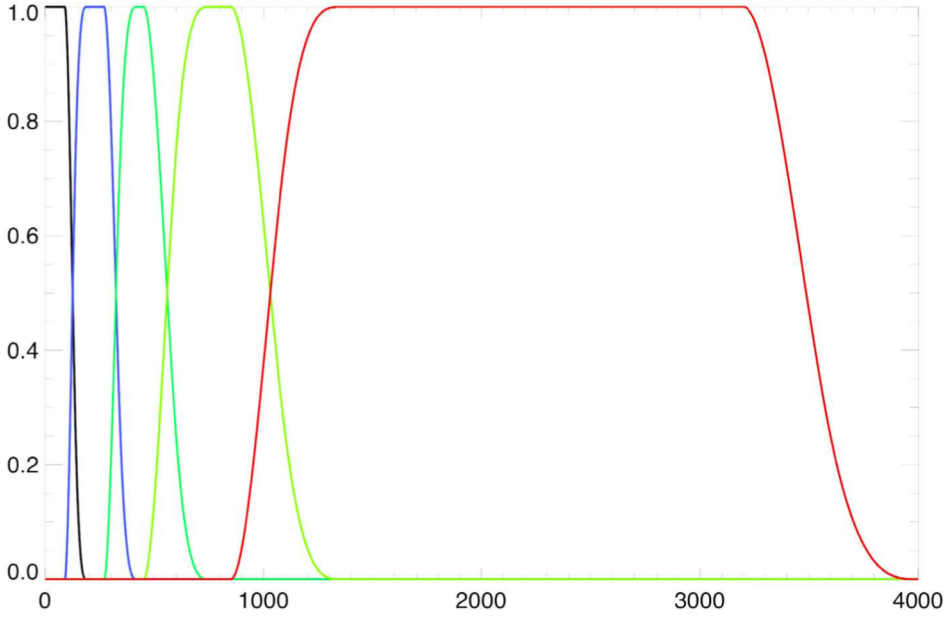
premise: Parameter Recovery Exploiting Model Informed Sparse Estimates

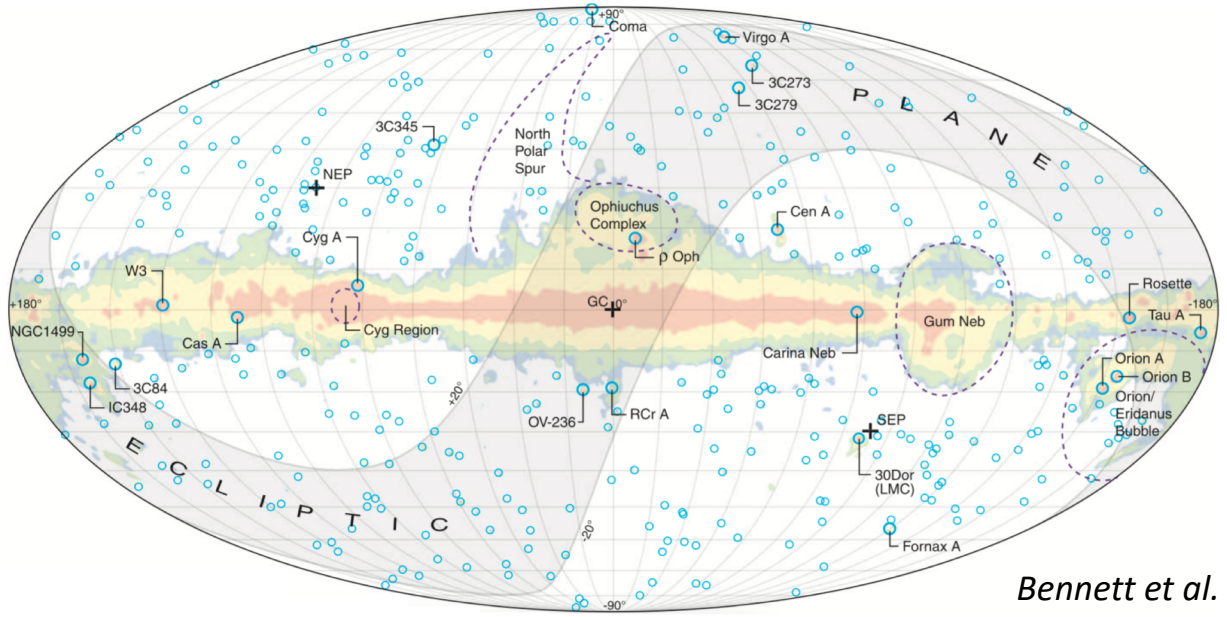
- Sparse:





Bobin et al. 2013

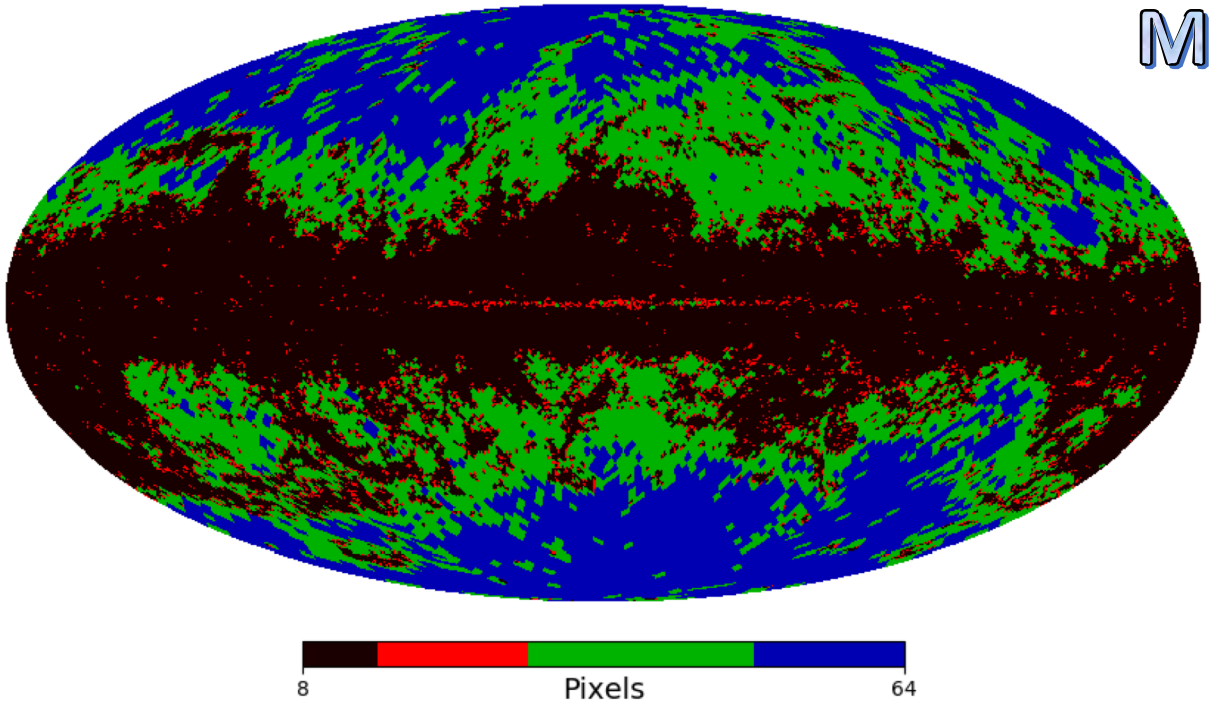




Bennett et al. 2003

premise: Parameter Recovery Exploiting Model Informed Sparse Estimates

- Two-step → super-pixel estimates then refinement:

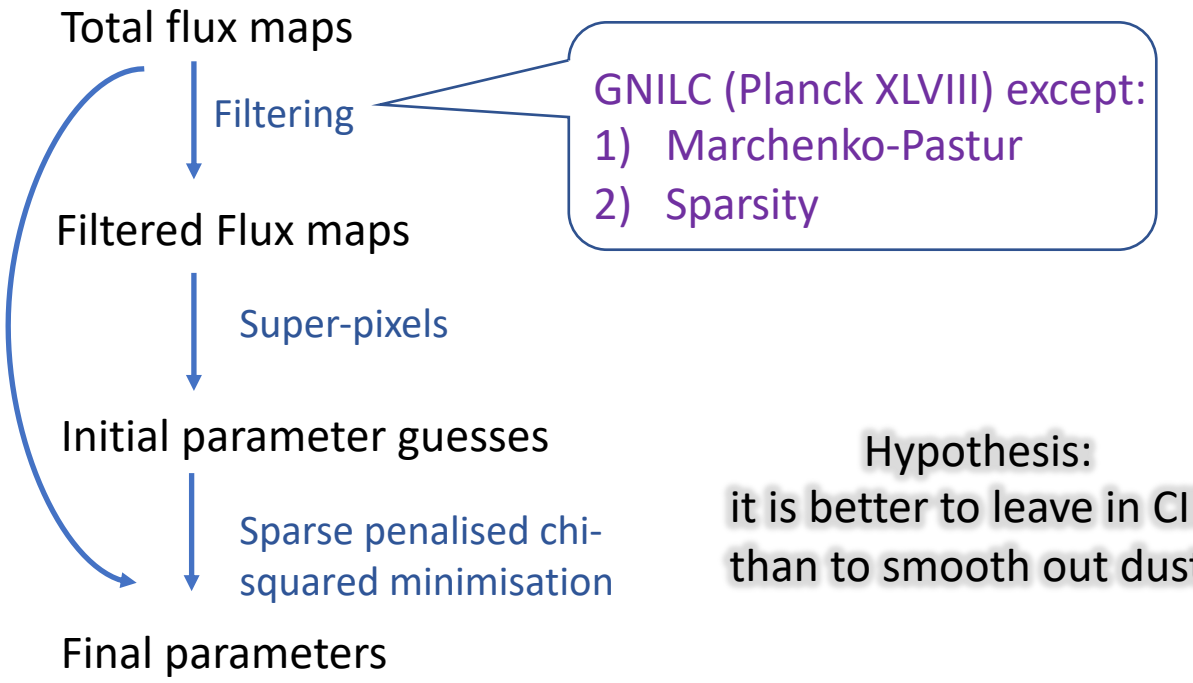


MBB, Power Law, Parabola etc.

$$\min\left(\sum_{\nu}\frac{(X_\nu - M_\nu)^2}{\sigma_\nu^2} + \lambda\,\|\alpha\|_1\right)$$

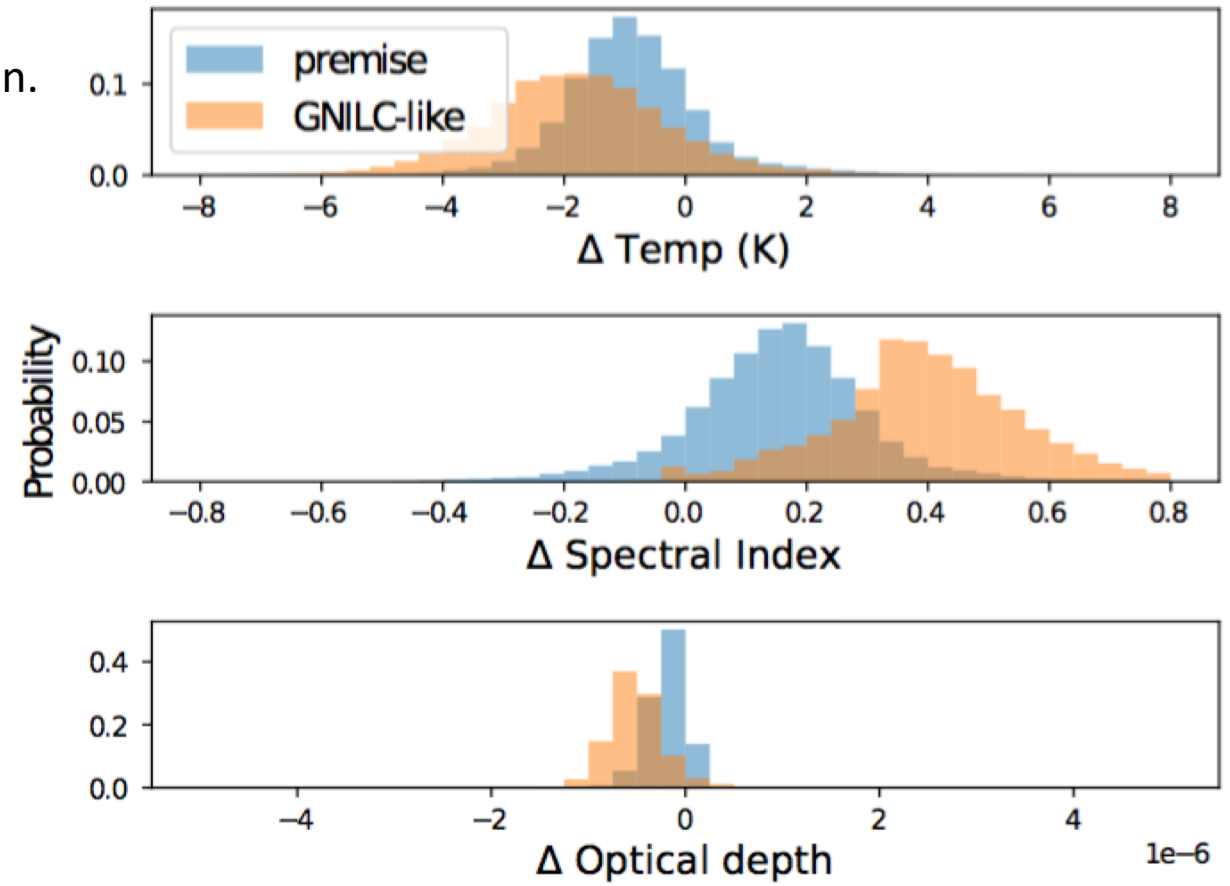
premise High: sims

- Low freq → component separation (AME, free-free, synchrotron).
- High freq → Obtaining thermal dust amidst CIB contamination.
- So far ONLY in INTENSITY.



Hypothesis:
it is better to leave in CIB than to smooth out dust.

Irfan and Bobin 2017 (https://arxiv.org/pdf/1711.10848.pdf)

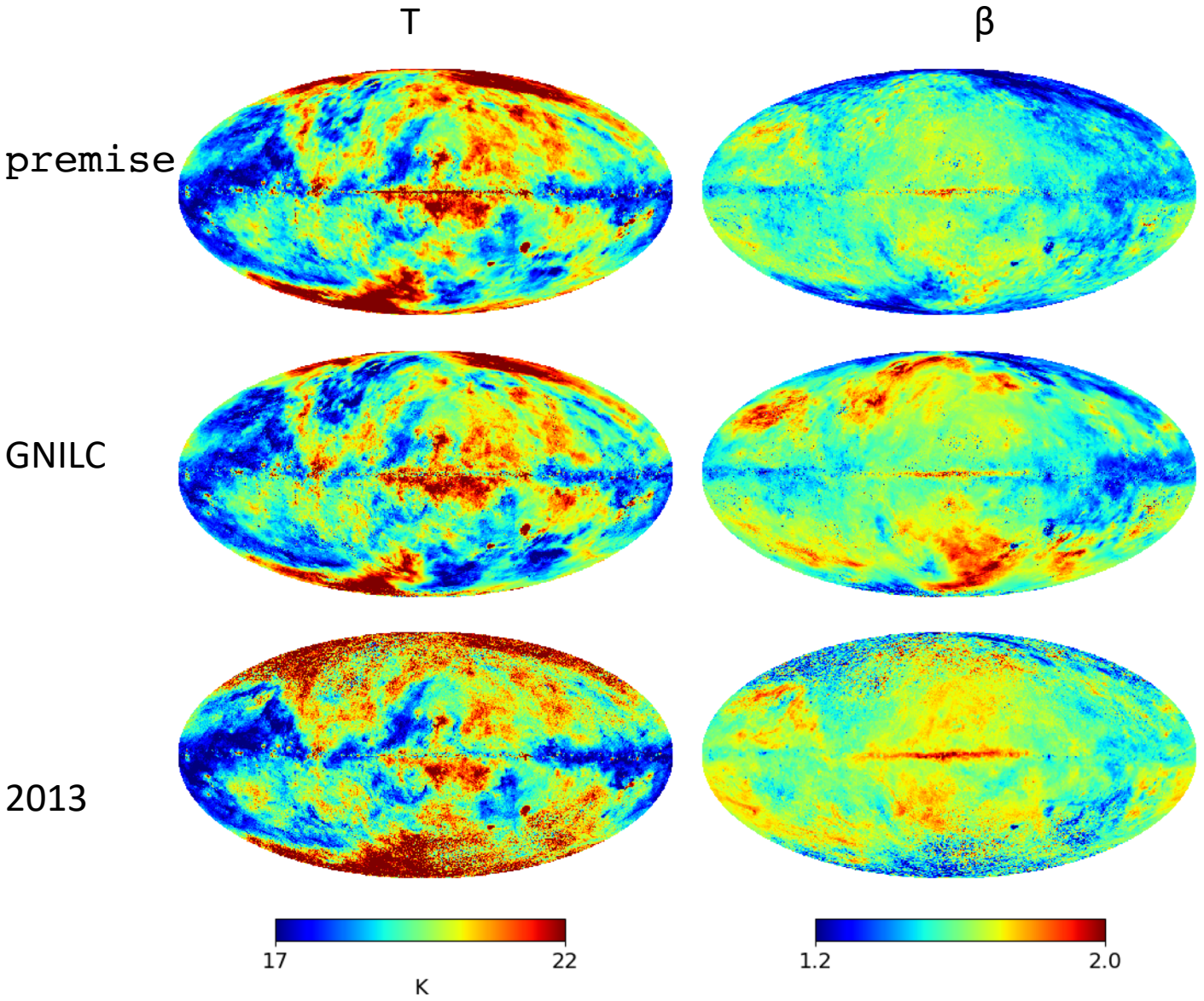


premise High: real data

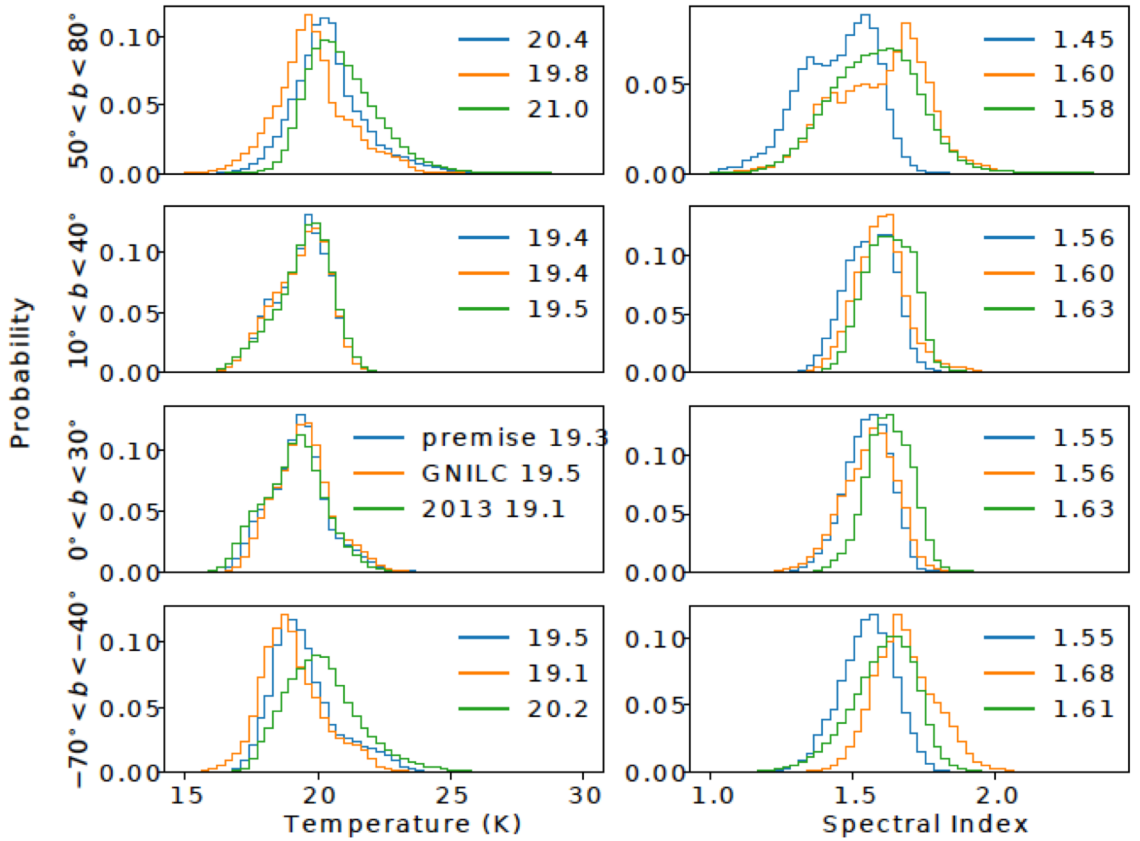
- PR2 353, 545, 857 GHz data plus IRIS 3000 GHz data → determine MBB parameters.
- 3 sets of MBB parameter maps: GNILC (Planck Legacy Archive) , Planck 2013 (MAMD) and our own.

Methodology	Parameter	Resolution (arcmin)	Nside
GNILC	T	Various	2048
	β	Various	2048
	τ	Various	2048
2013	T	5	2048
	β	30	2048
	τ	5	2048
premise	T	5	2048
	β	5	2048
	τ	5	2048

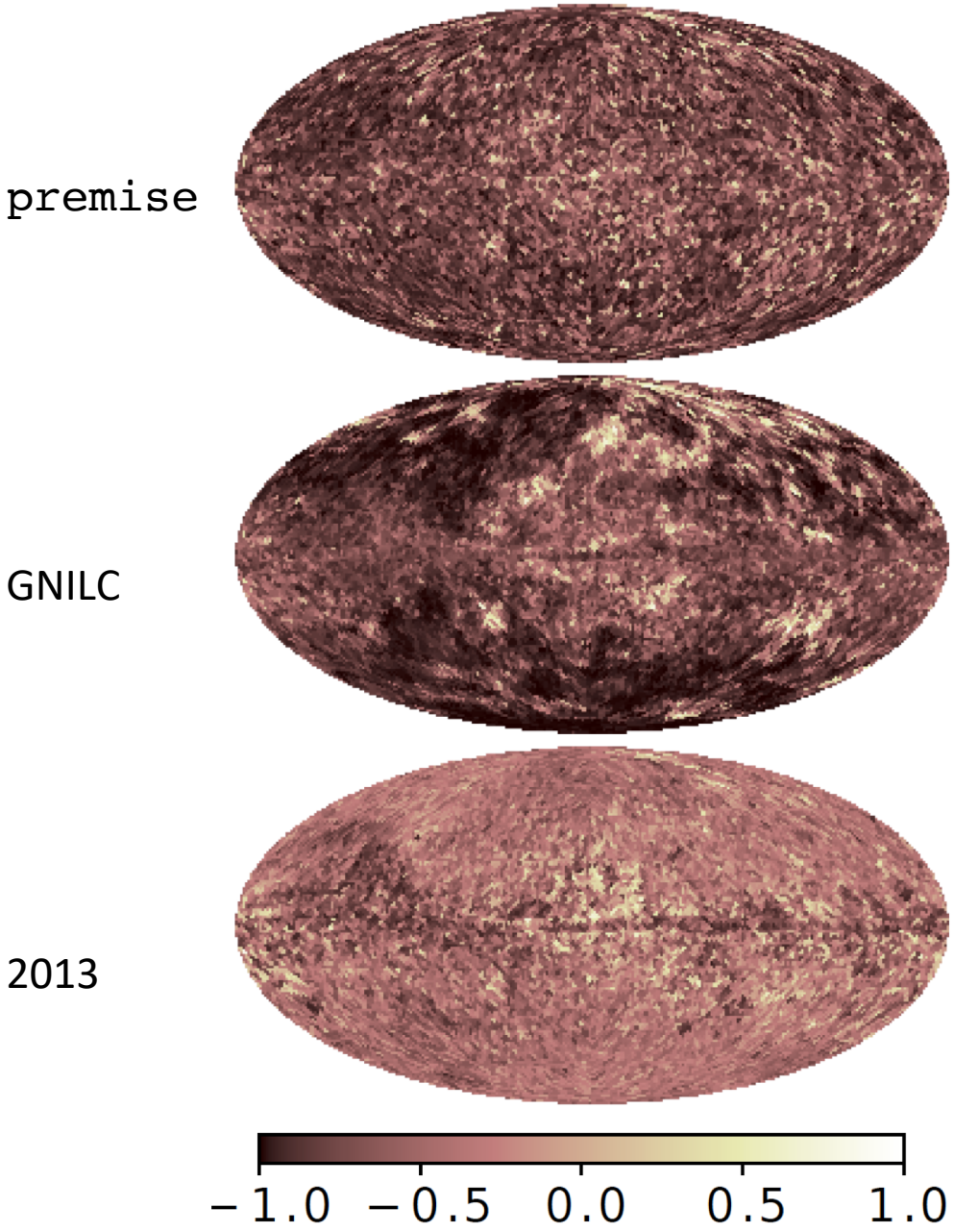
MBB temperature and spectral index

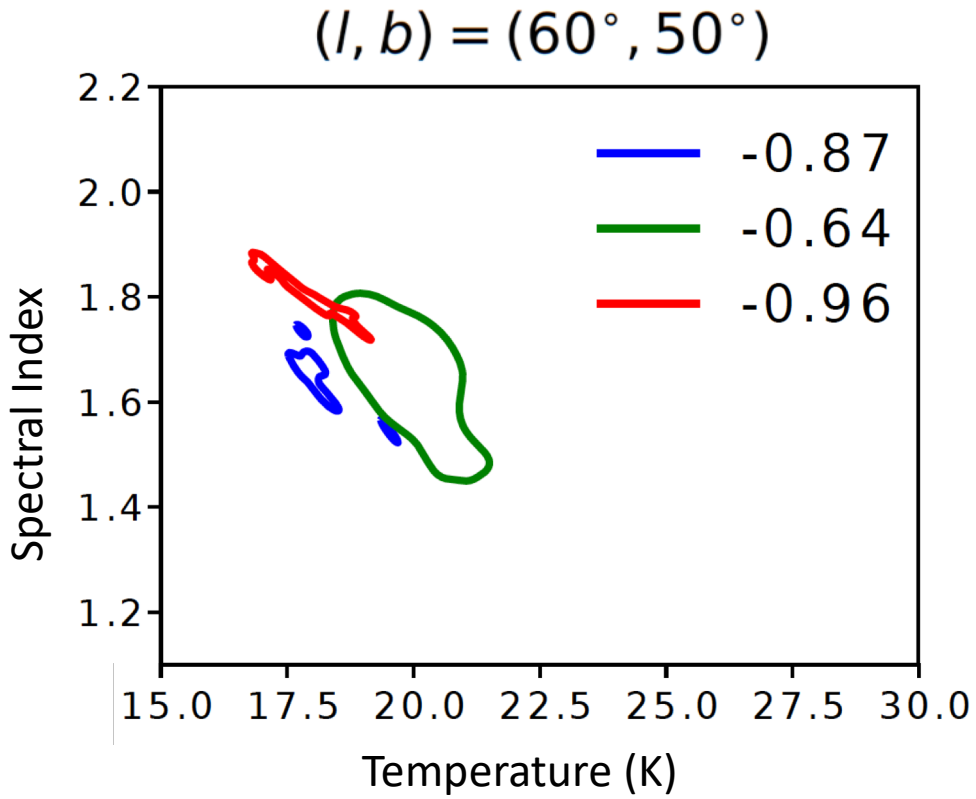


Methodology	Ave T (K)	Ave β
GNILC	19.4	1.60
2013	19.7	1.61
premise	19.5	1.54

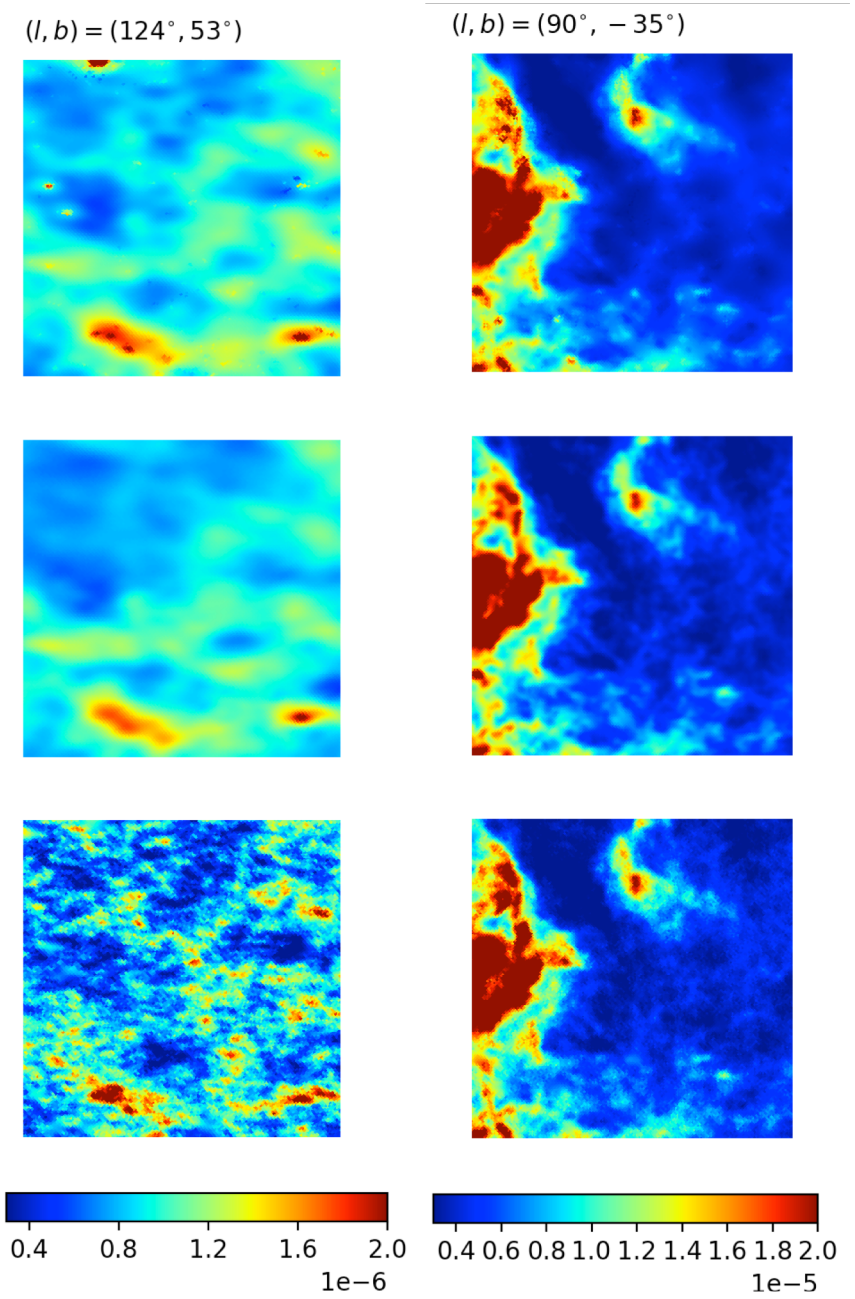


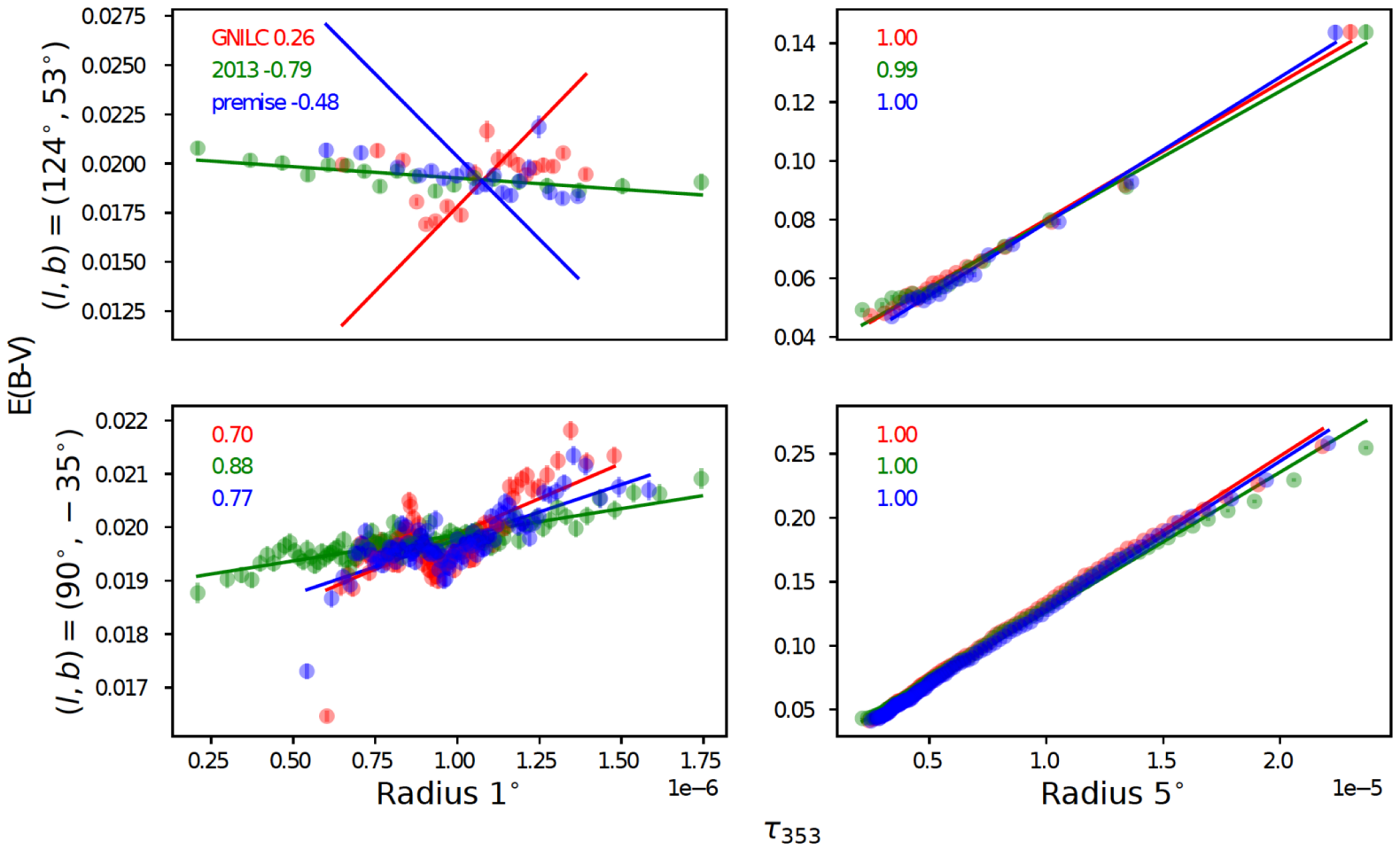
MBB Anti-Correlations





MBB optical depth at 353 GHz





Green et al. 2018 (map of interstellar reddening)

Conclusion

- New parametric method: 1) both pixel and wavelet domain
  2) exploiting sparse nature of foregrounds
  3) two step → initial guesses followed by refinement

- Currently tested on high frequency → extracting thermal dust from CIB contaminated maps

- MBB maps to be made public on CosmoStat website:

http://www.cosmostat.org/people/melis-irfan/