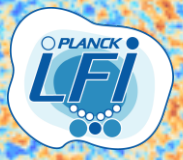
PLANCK 2014

THE MICROWAVE SKY IN TEMPERATURE AND POLARIZATION



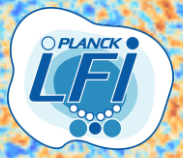
HFI PLANCK

Consistency of the Planck Data

C. R. Lawrence, JPL

On behalf of the Planck Collaboration

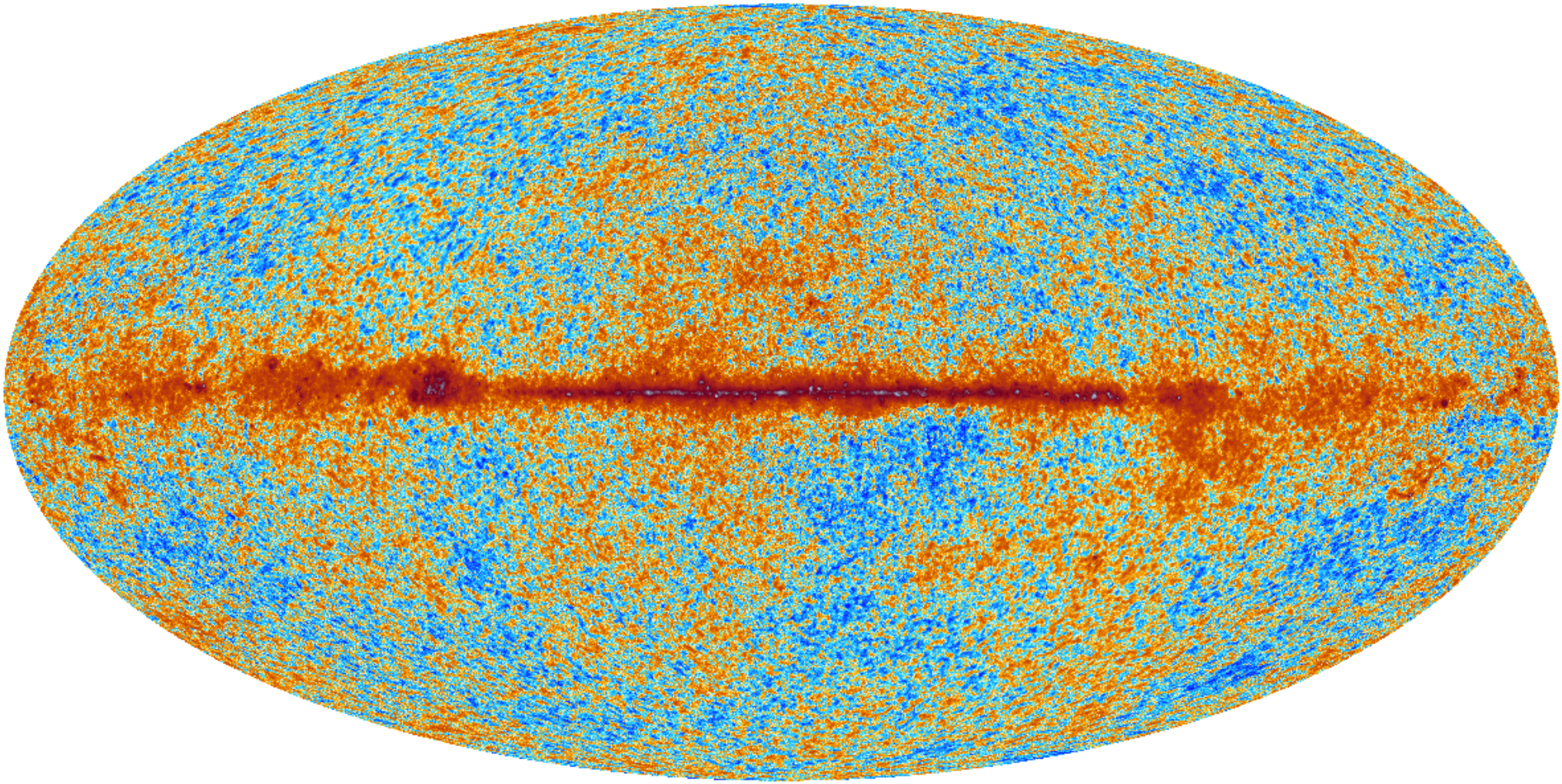
planck



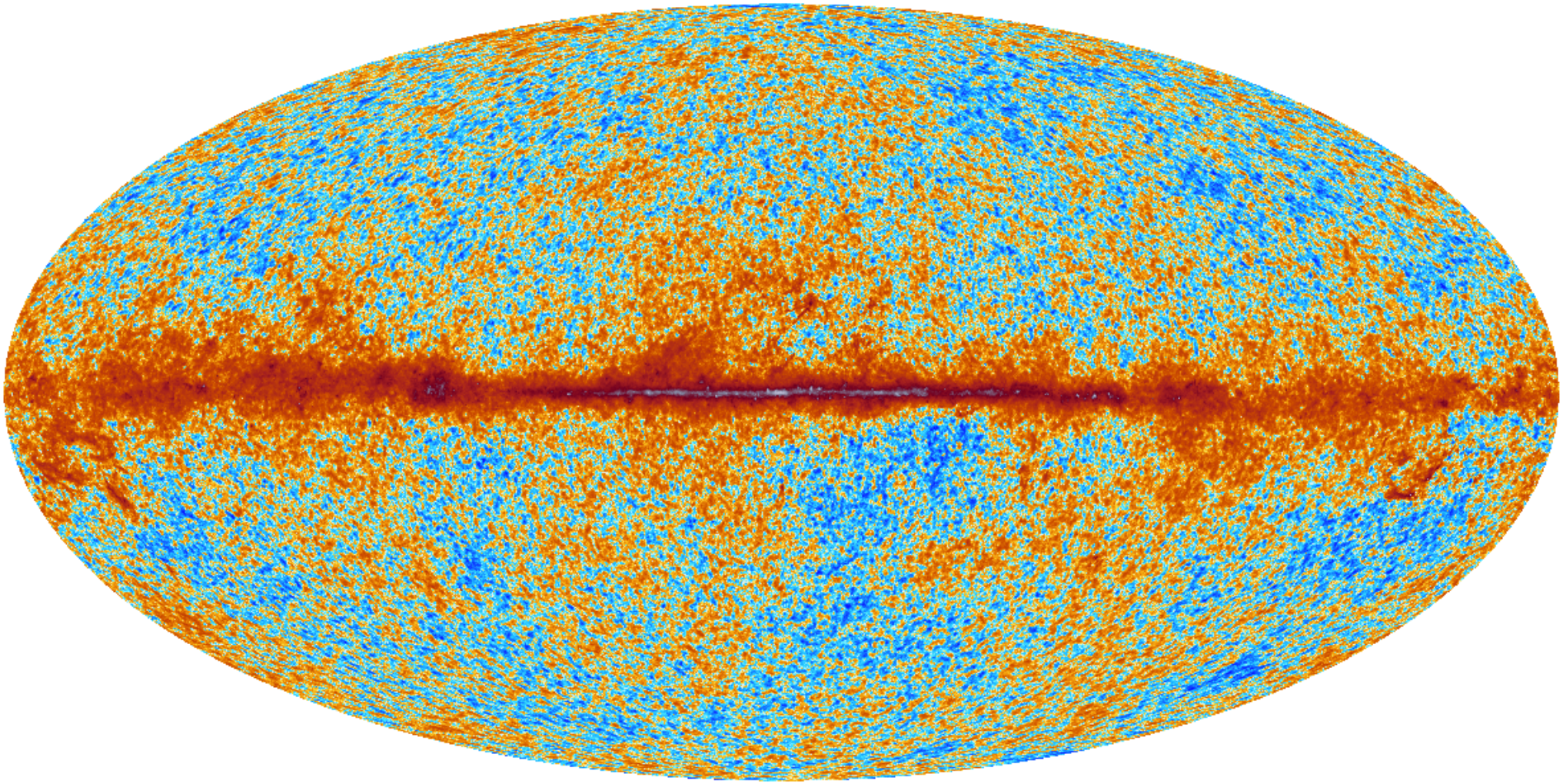
Outline

- Comparison of maps
- Calibration
- More maps
- Comparison of power spectra

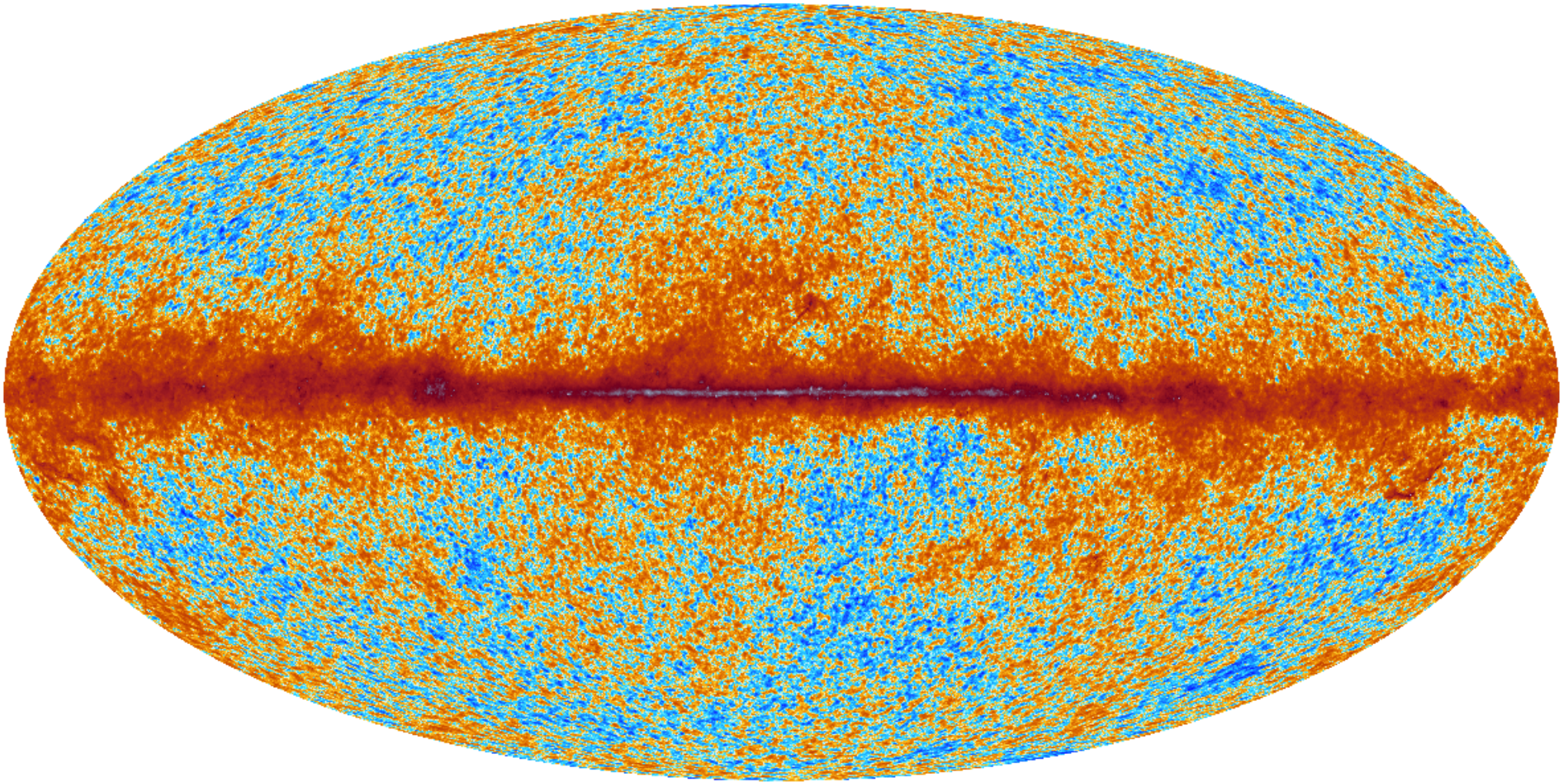
70 GHz


-10^3 -10^2 -10 -1 0 1 10 10^2 10^3 10^4 10^5 10^6
30–353 GHz: δT [μK_{CMB}]; 545 and 857 GHz: surface brightness [kJy/sr]

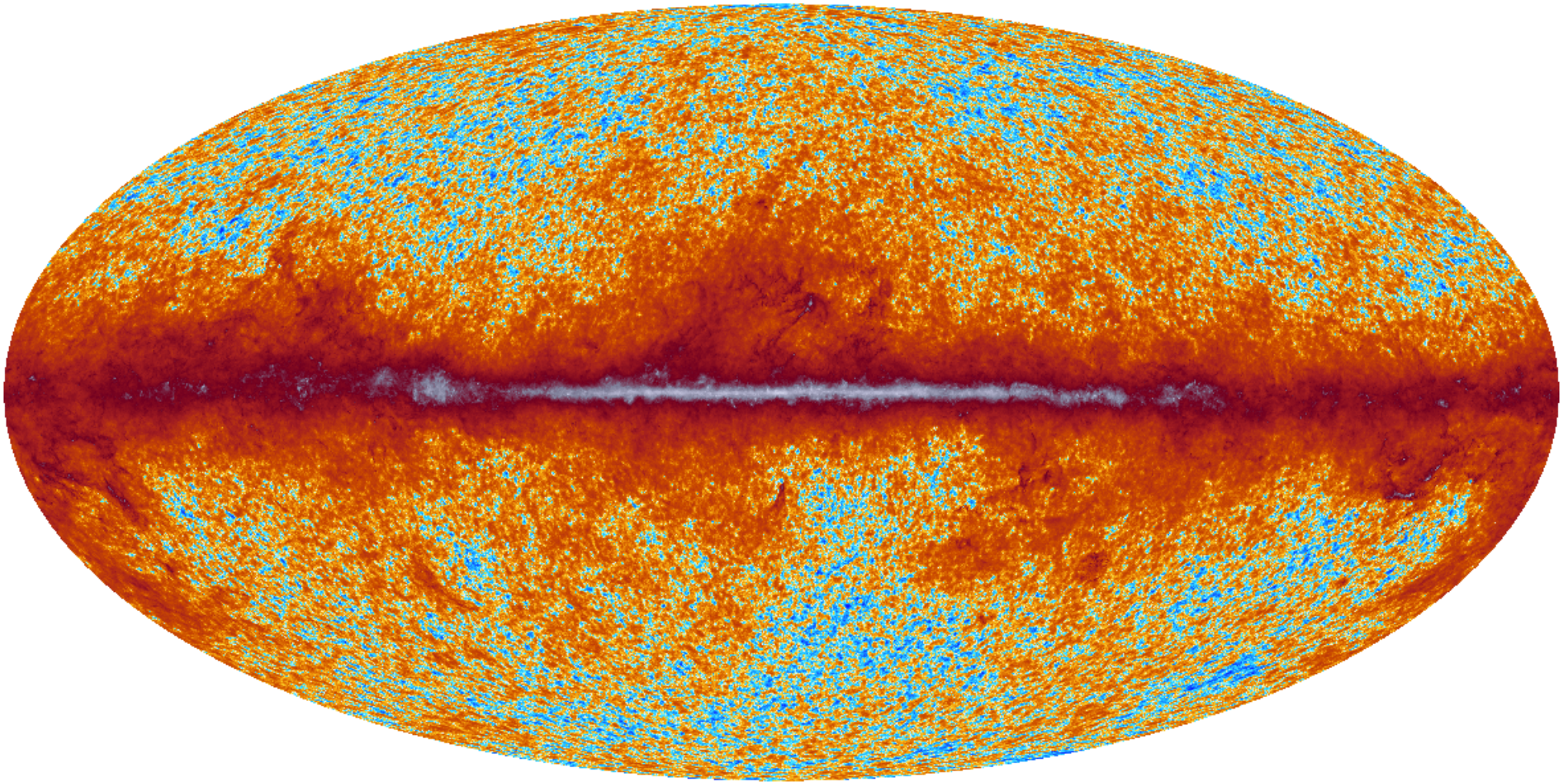
100 GHz



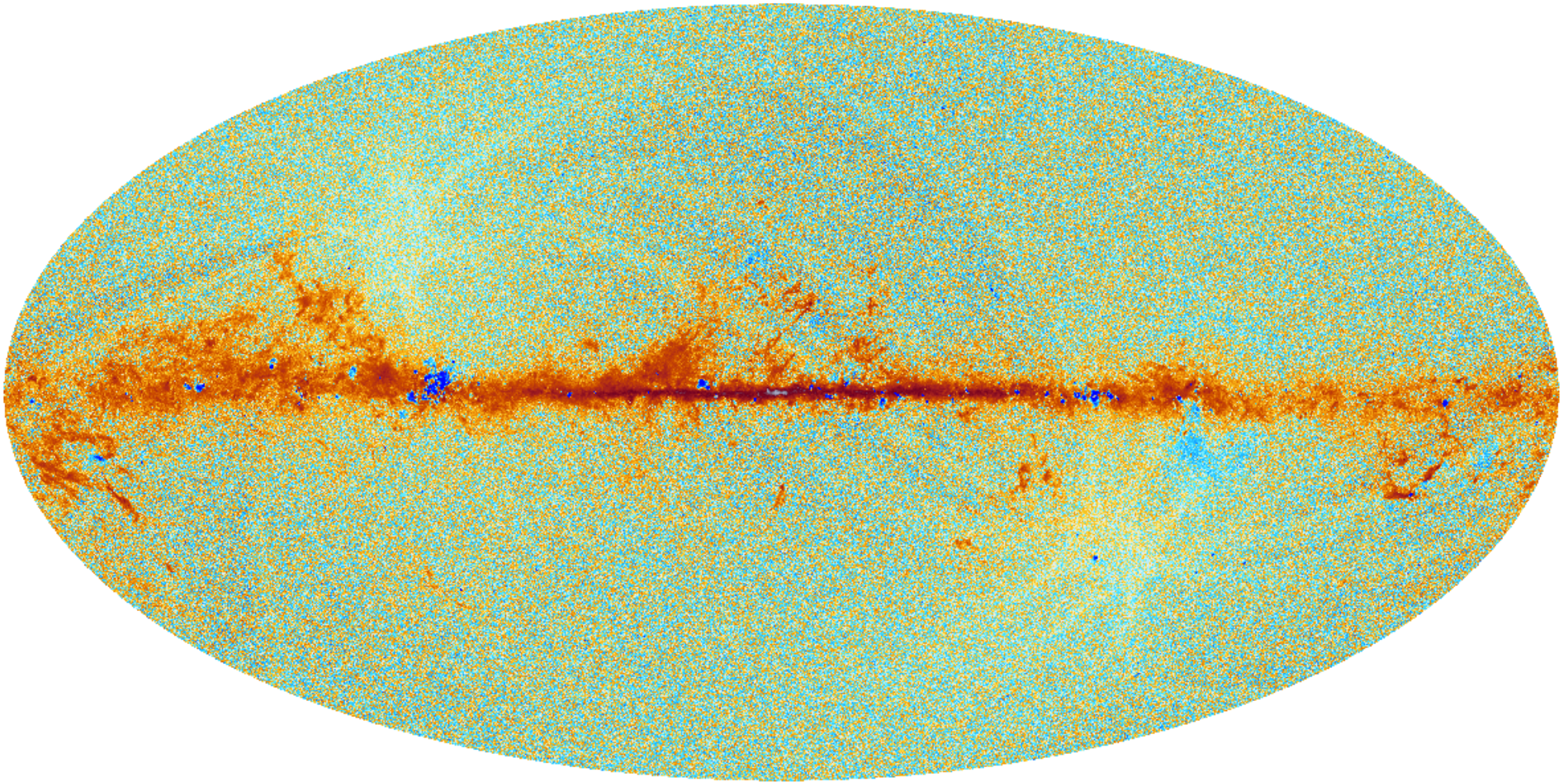
143 GHz

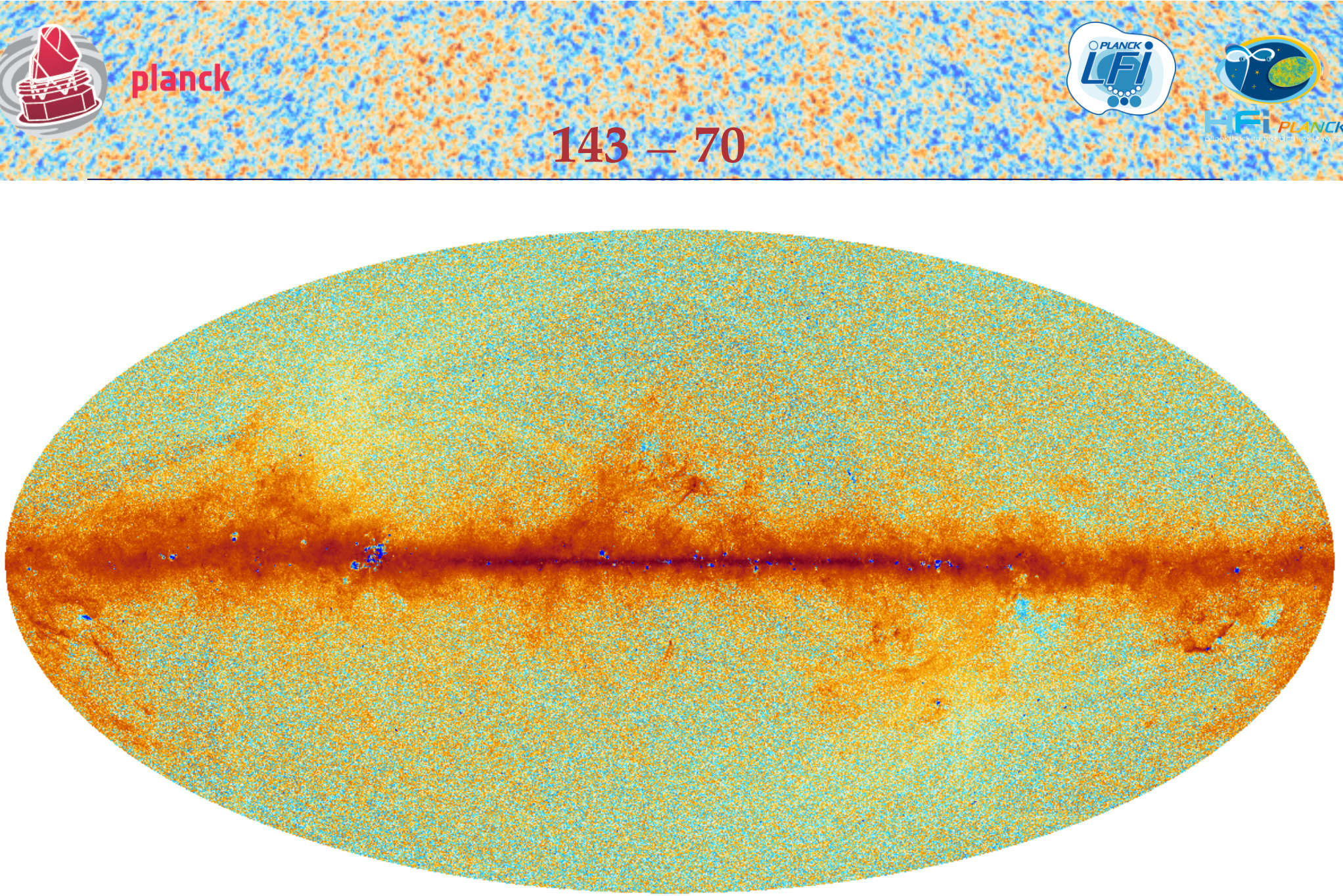


217 GHz

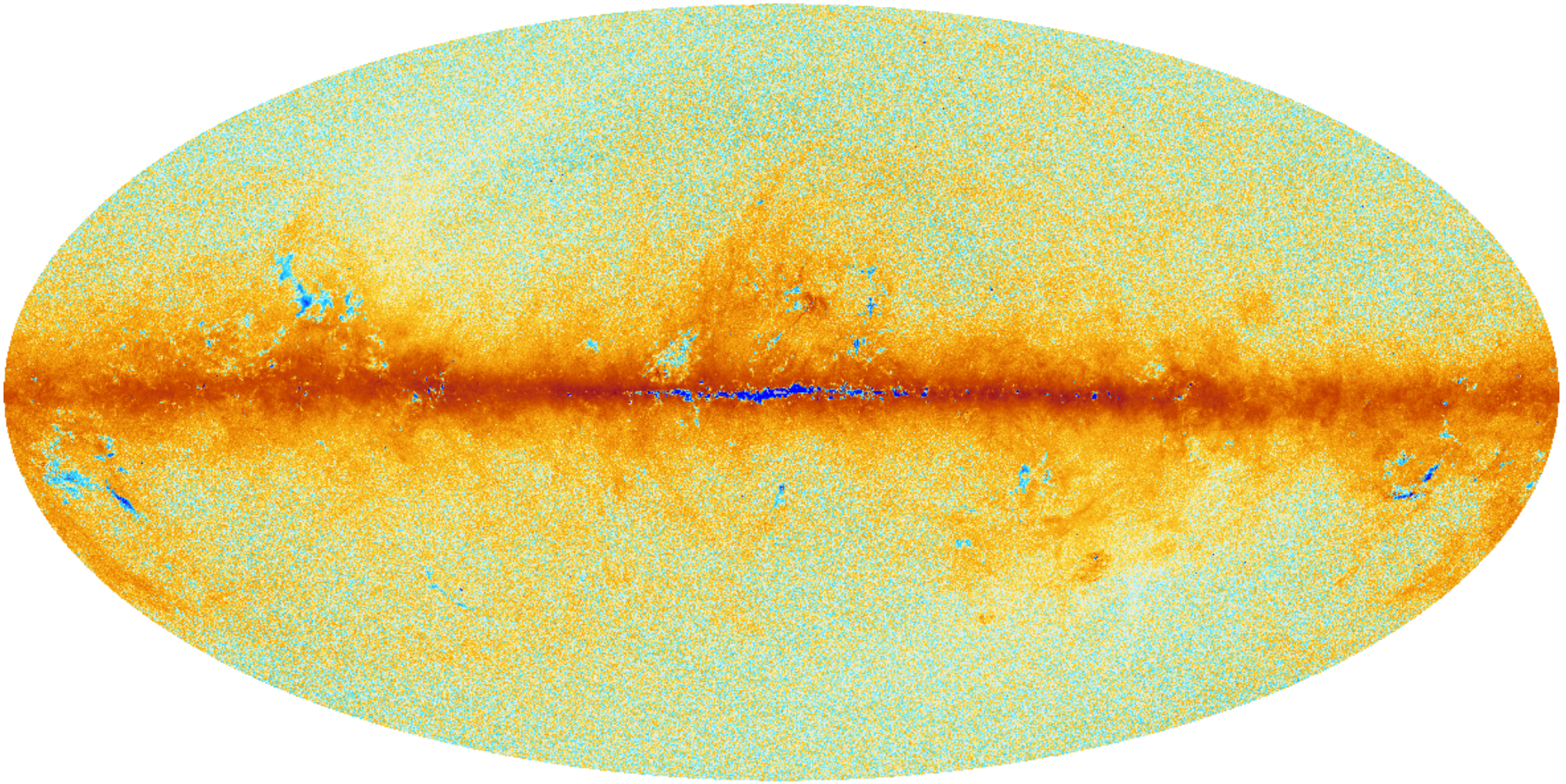


100 − 70




143 – 70

143 – 100



Photometric Calibration

Important changes in 2014:

- Primary calibration signal for both LFI and HFI changed from the "Solar dipole" to the "orbital dipole"
- Both LFI and HFI made improvements in calibration, taking advantage of improved beam models and better control of systematic effects

Dipoles

Solar dipole ≡ dipole induced by the motion of the Solar system barycenter wrt the CMB
Orbital dipole ≡ modulation of the Solar dipole induced by the orbital motion of Planck around the SS barycenter

- Solar dipole depends on $T_{\rm CMB}$

  motion of SS barycenter wrt CMB
  - In 2013, Planck calibrated on the WMAP7 Solar dipole
- Orbital dipole is differential, and the velocity of Planck around the SS barycenter is known with exquisite accuracy.
  - Amplitude $240\,\mu$K
  - In 2014, LFI and HFI have systematics under control at a level that can measure such a small signal with precision.

Removes the error in the WMAP Solar dipole as a common source of error for LFI and HFI. Gives a shift of +0.28 % in gain calibration for both LFI and HFI.

Preliminary

Improvements in Calibration — LFI

- Use full 4π beam to convolve with dipole (solar + orbital + relativistic quadrupole), rather than "pencil beam" as in 2013
  - Improves both null tests and the quality of the polarization maps
  - Gives average shifts of +0.15%, +0.035%, and +0.17% in gain calibration at 70, 44, and 30 GHz, respectively.
- Reduce the effects of $1/f$ noise with an improved destriping code.

  Remove Galactic sidelobe contamination

  Improve calibration smoothing algorithm — better SNR with less susceptibility to transients
  - Give better null test results, and a shift of +0.4% in gain calibration

Preliminary

Improvements in Calibration — HFI

- Improved determination and handling of near and far sidelobes
- Improved ADC non-linearity correction
- Improved handling of very long time constants
  - Give an average shift of +0.5% in gain calibration

Preliminary

Comparisons of Calibration

- Look at consistency of LFI and HFI Solar dipole estimates
- Compare measurements of first acoustic peak after component separation

Compare Dipoles

Experiment	Amplitude [μK]	Latitude	Longitude
LFI.....	3365.5 ± 3	$48^\circ.26$	$264^\circ.01$
HFI DPC	3364.1 ± 2	$48^\circ.23 \pm 0^\circ.1$	$263^\circ.96 \pm 0^\circ.03$
Planck 2014 nominal	3364.5 ± 2[a]	$48^\circ.24 \pm 0^\circ.1$	$264^\circ.00 \pm 0^\circ.03$
WMAP.....	3355[b] ± 8	$48^\circ.26 \pm 0^\circ.03$	$263^\circ.99 \pm 0^\circ.14$

[a] 0.06 %

[b] 0.28 % lower than Planck 2014 measurement

The change to orbital dipole calibration gives a common +0.28% shift in gain calibration for both LFI and HFI.

Preliminary

Compare Amplitudes During Component Separation

- Both SMICA and Commander calculate amplitude scaling factors applied to the input frequency maps that minimize residuals in the CMB component fitted to the data.
- These amplitude scaling factors provide an assessment of the relative calibration accuracy across frequencies

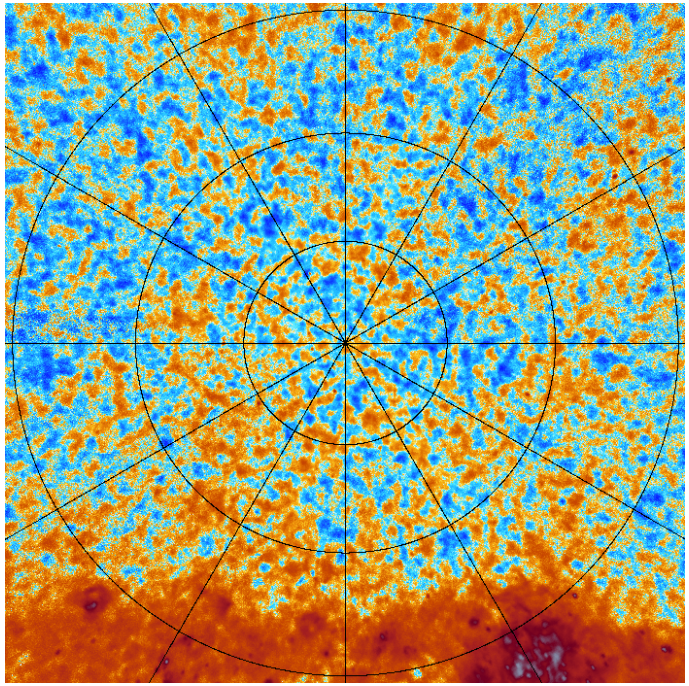
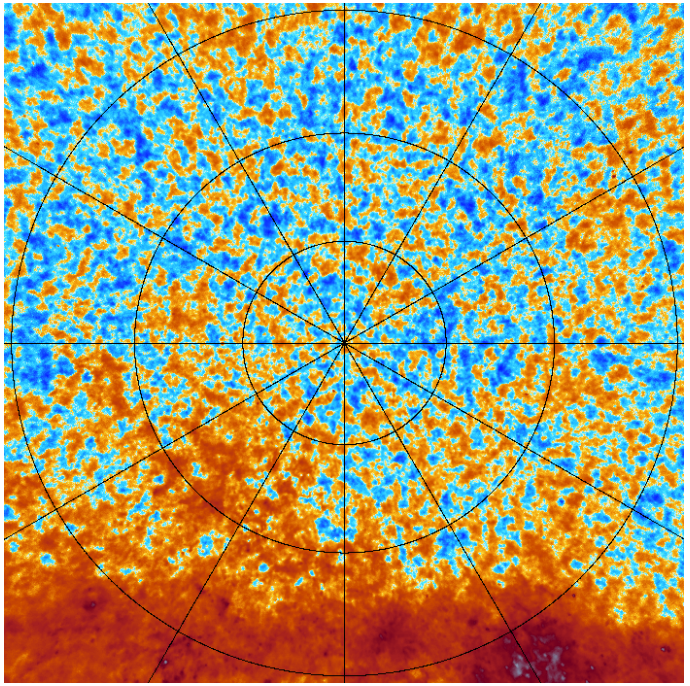
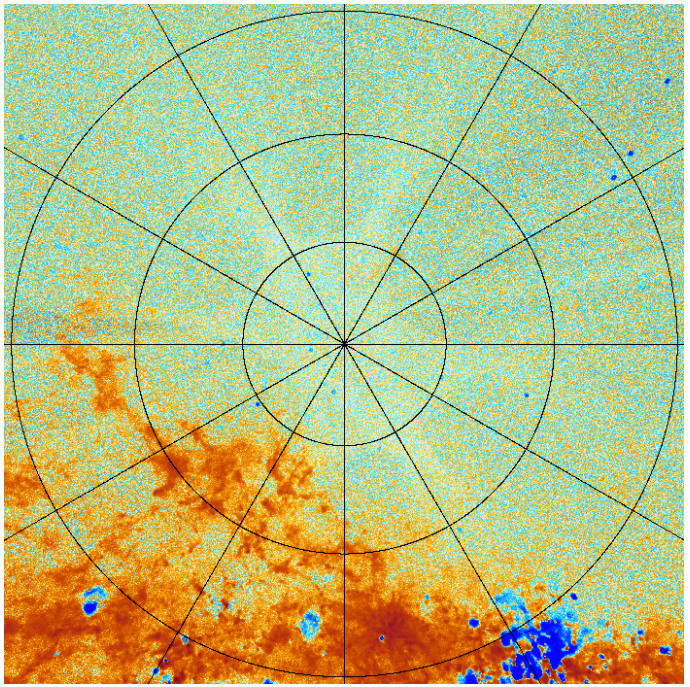
Compare Amplitudes During Component Separation

	Intercalibration Factors [%]	
	SMICA	Commander
Frequency [GHz]	$100 \leq \ell \leq 700$	$25 \leq \ell \leq 100$
30	...	-0.3 ± 0.1
44	...	0.3 ± 0.1
70	-0.13 ± 0.04	0.0 ± 0.1
100	0.08 ± 0.02	0.1 ± 0.02
143	Reference frequency	Reference frequency
217	0.29 ± 0.03	Det. 1 reference frequency
353	0.80 ± 0.16	0.6 ± 0.1

- The SMICA and Commander calculations of relative calibration factors cover different ℓ ranges and handle residual monopoles and dipoles somewhat differently. We don't expect exact equality.
- From 30–217 GHz, agreement is a few tenths of a percent.

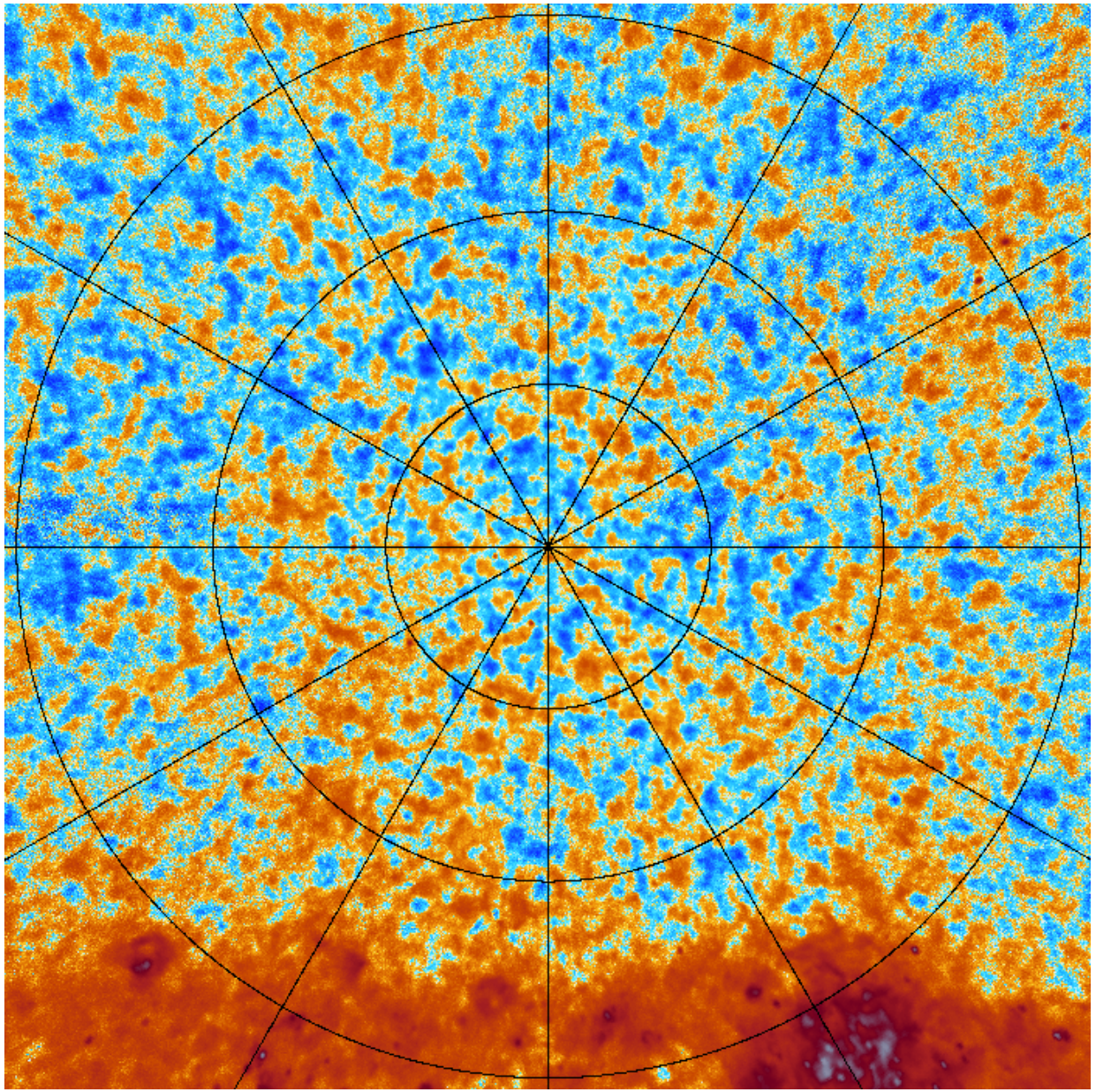
Preliminary

North Ecliptic Pole: 70, 100, Diff

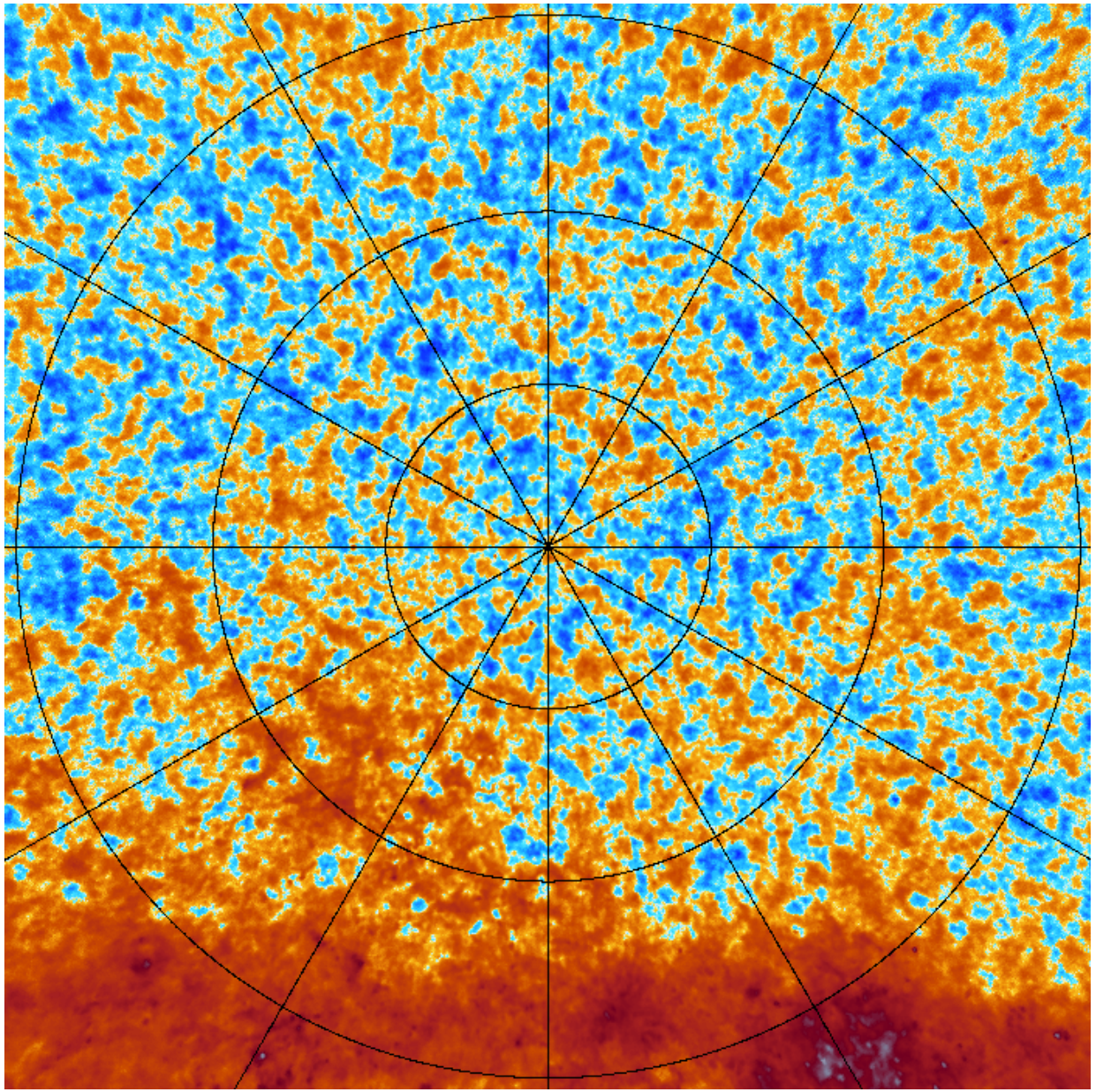




60° patches

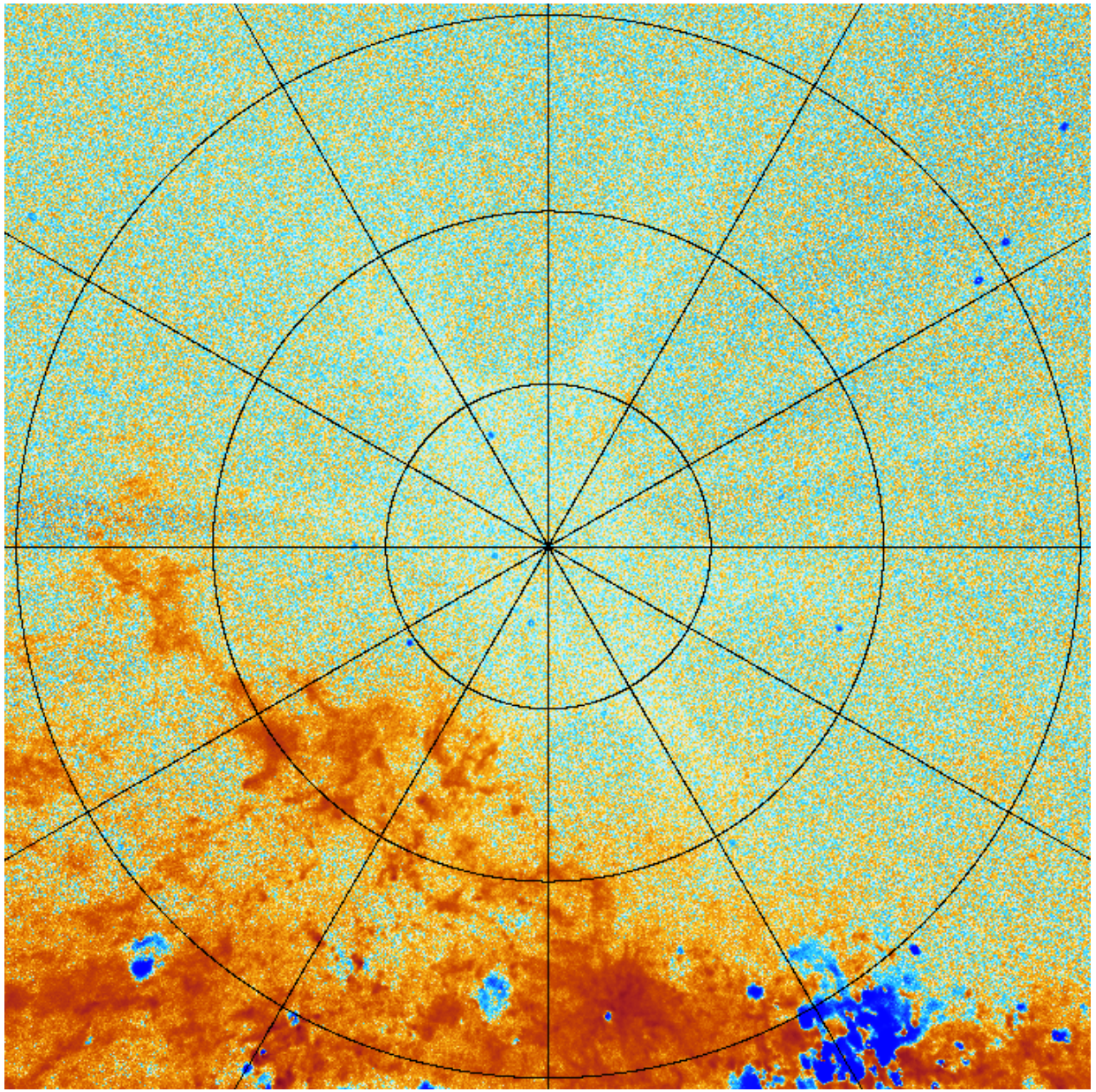
North Ecliptic Pole: 70



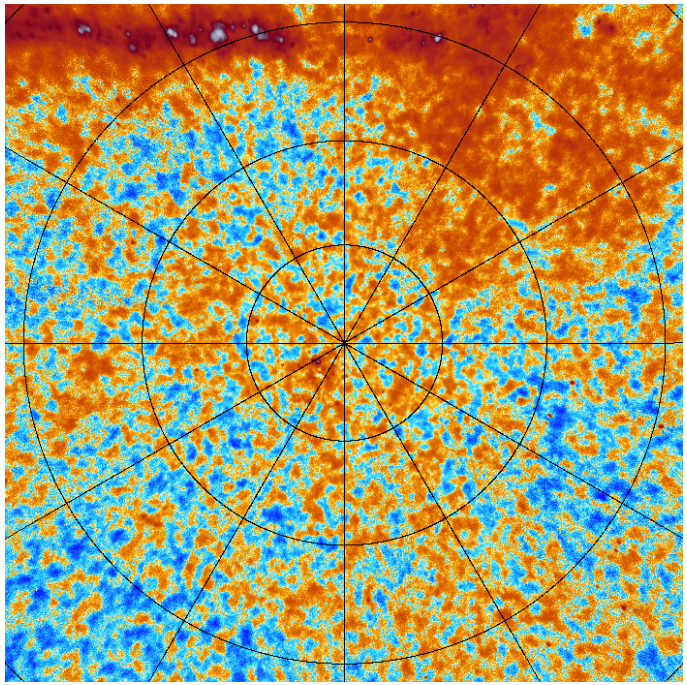
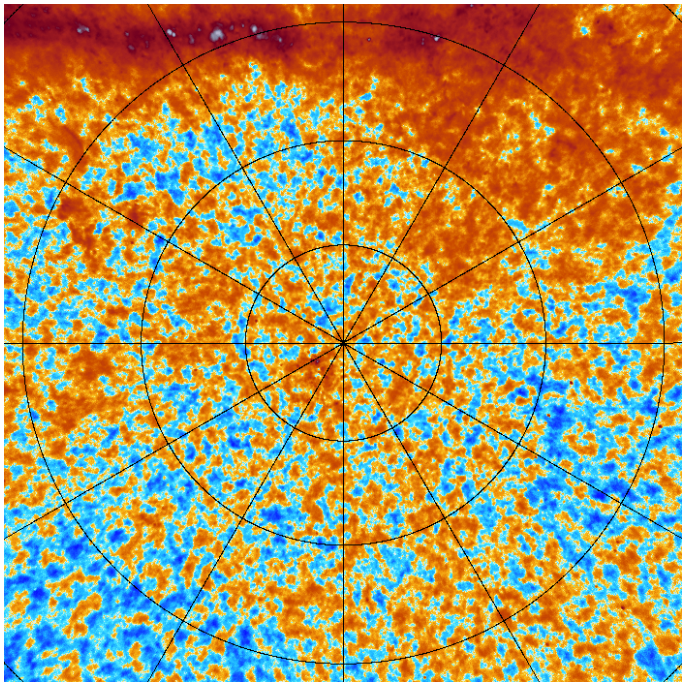
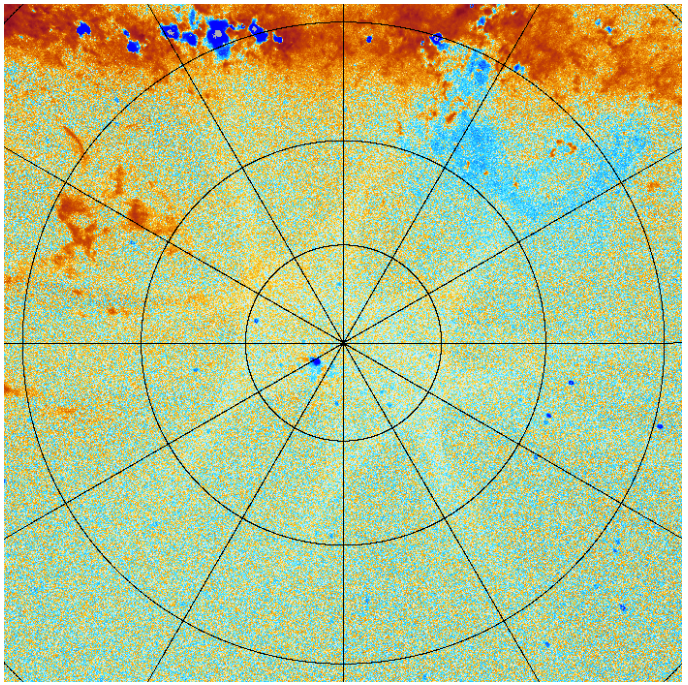
North Ecliptic Pole: 100



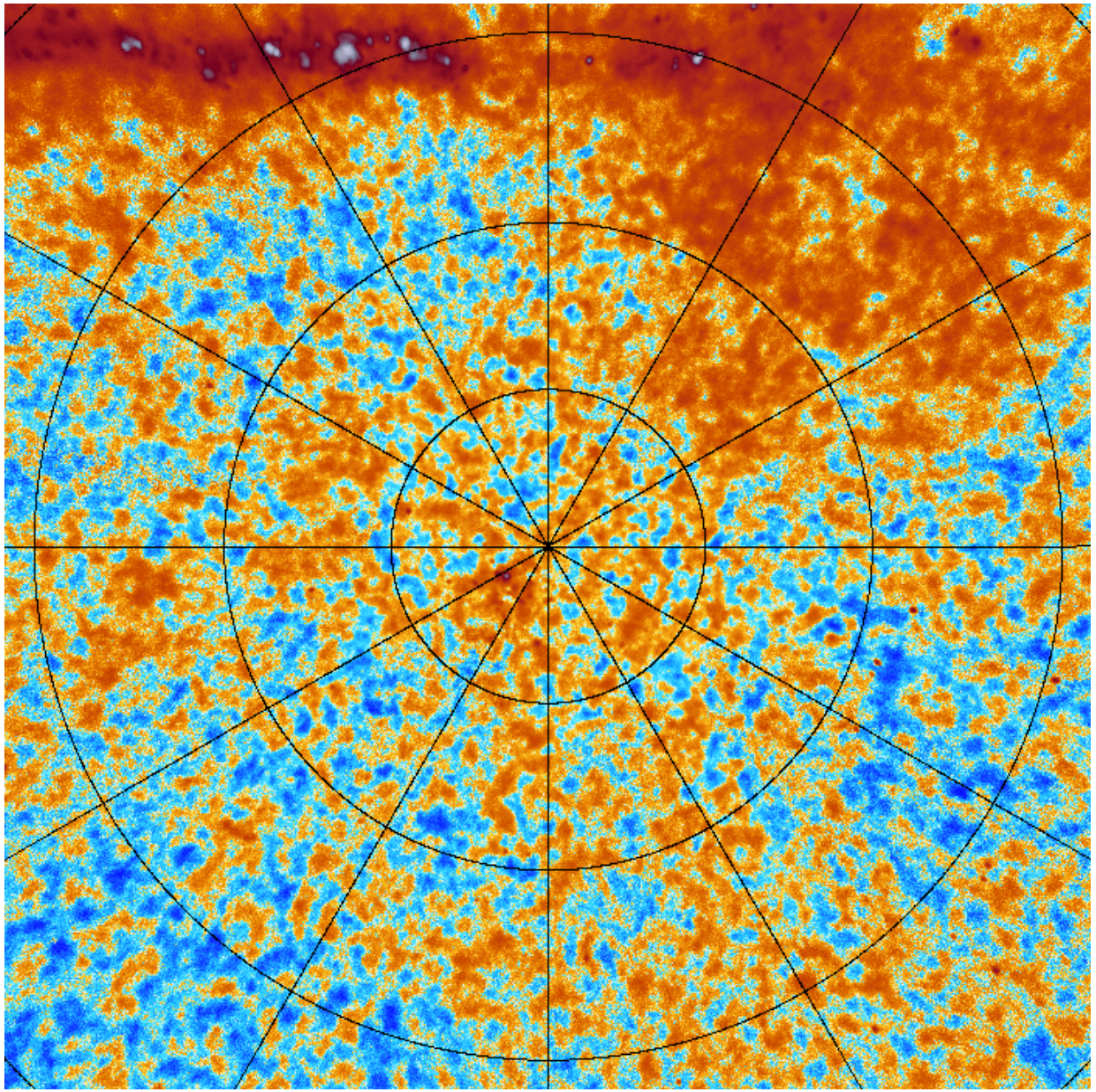
North Ecliptic Pole: Diff



South Ecliptic Pole: 70, 100, Diff

South Ecliptic Pole: 70



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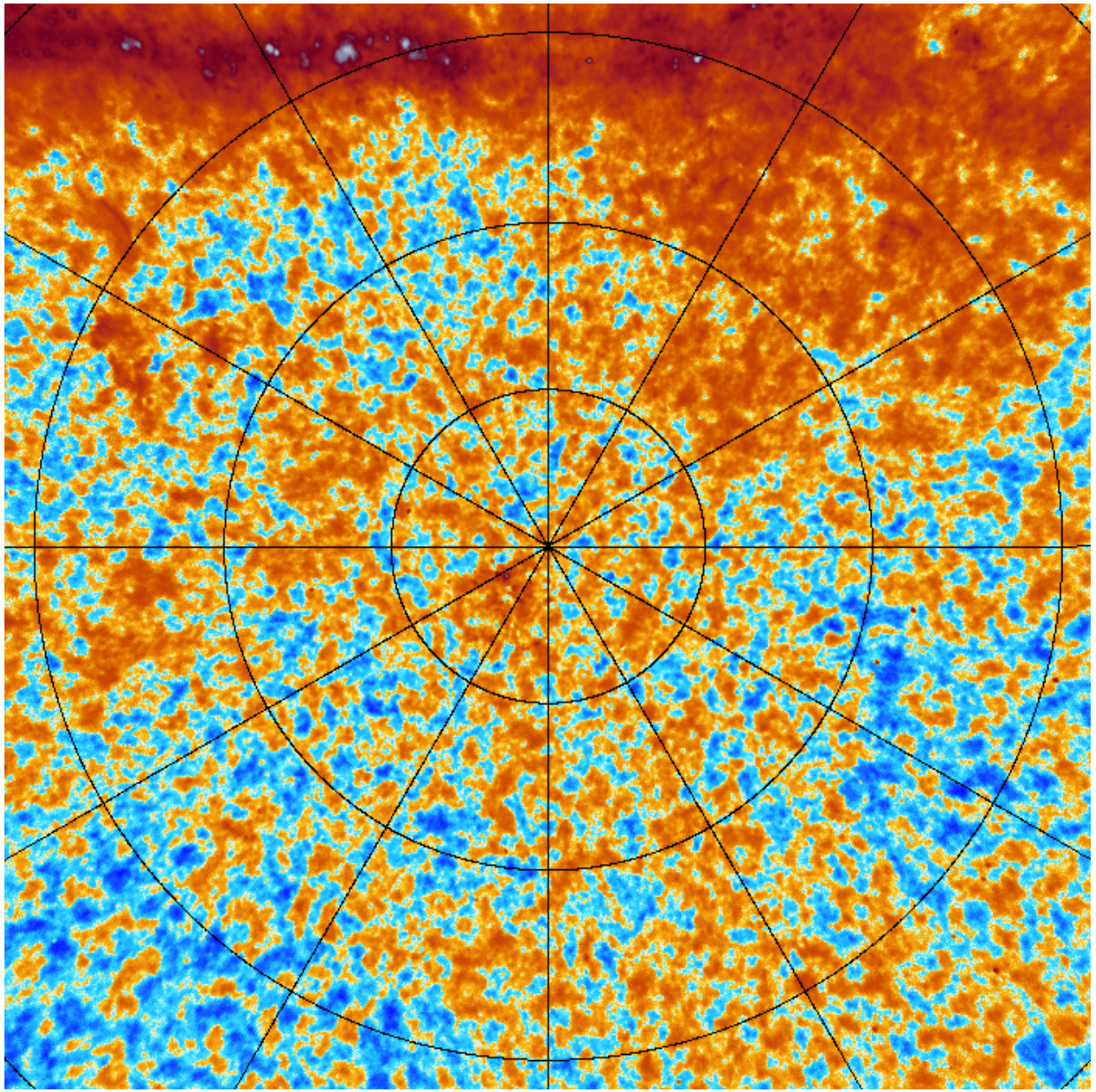
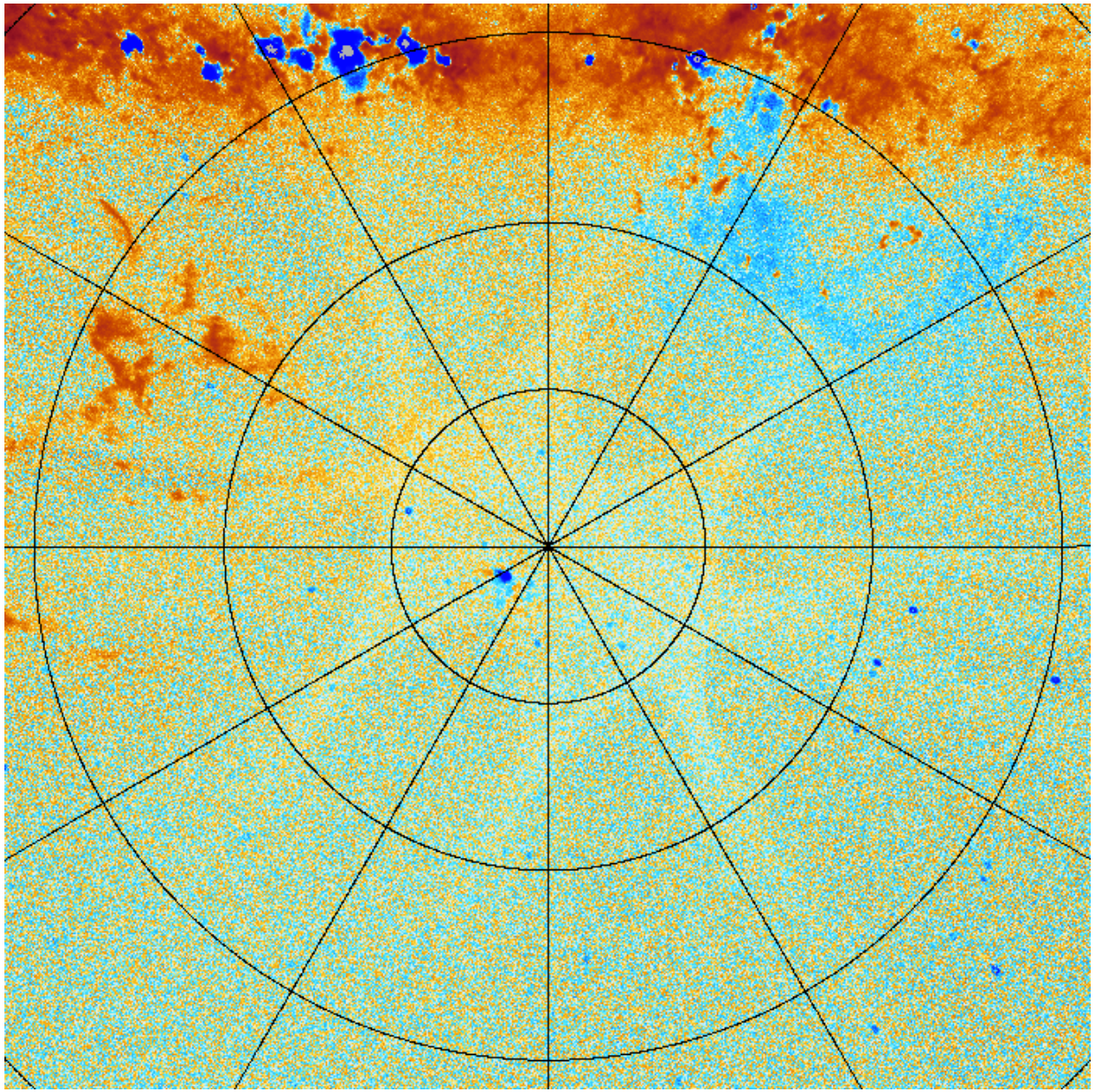
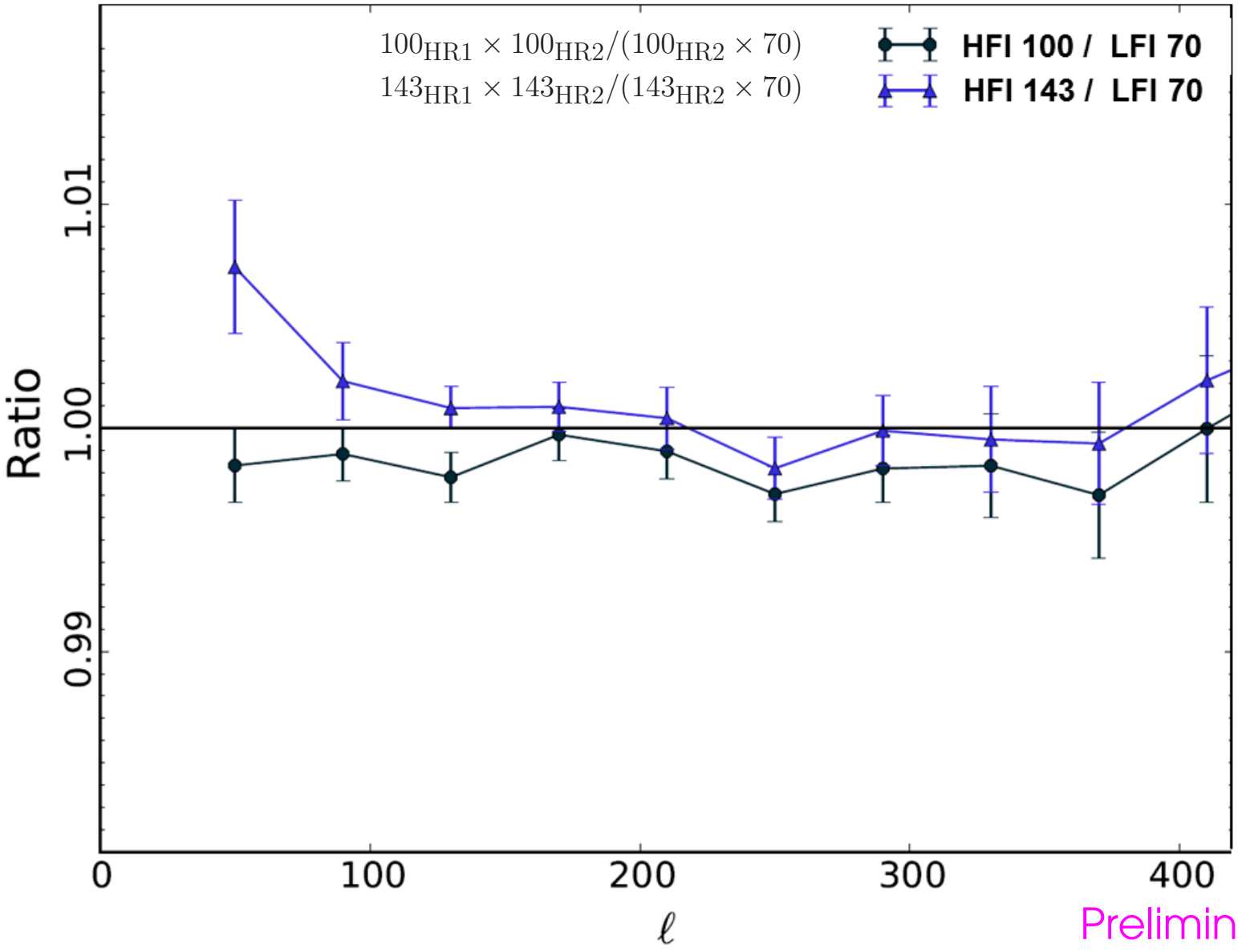


South Ecliptic Pole: Diff



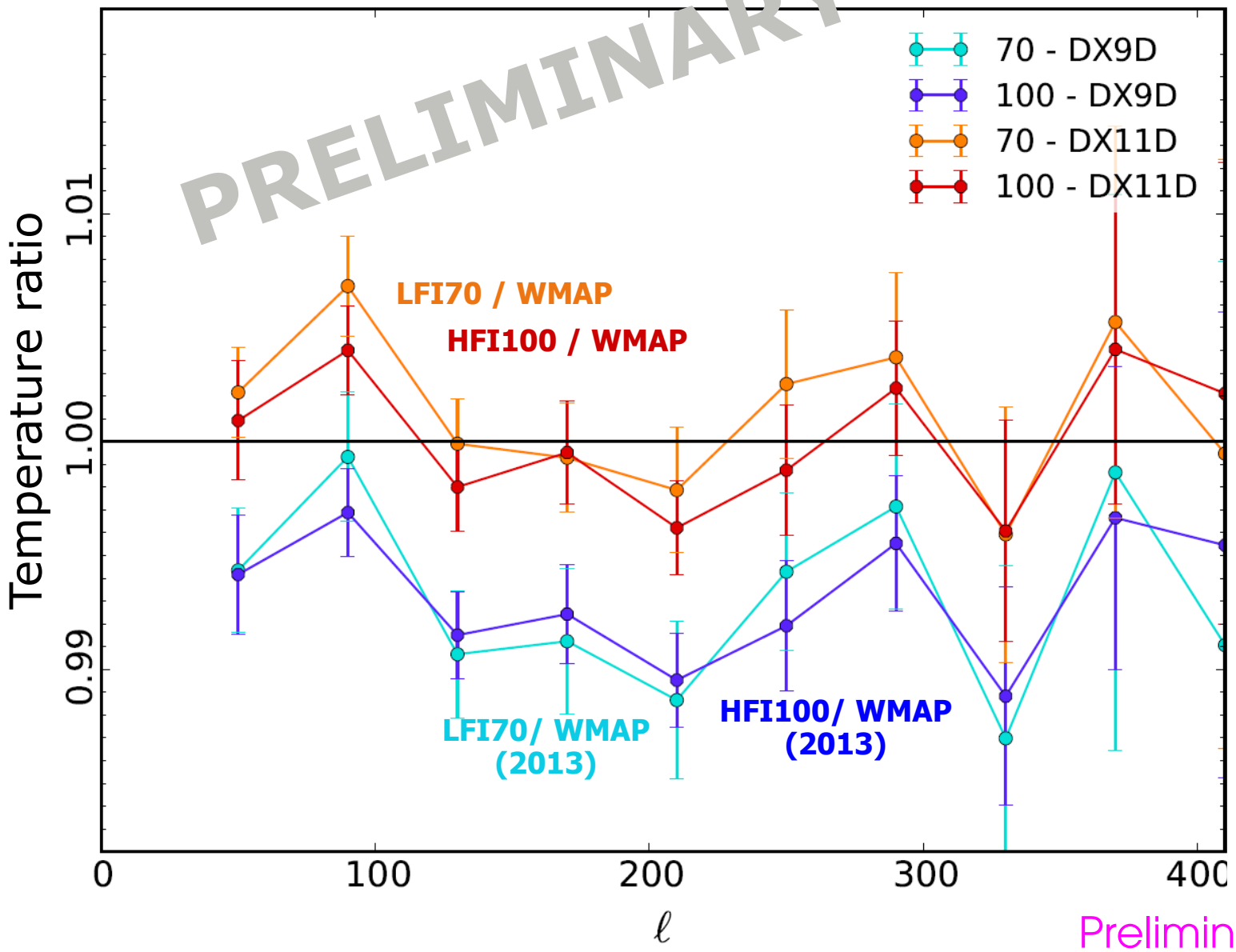
LFI-HFI Temperature Ratio



Preliminary

LFI-HFI-WMAP Temperature Ratio

WMAP is V band



Summary

- Overall photometric calibration has changed by +0.83% for LFI
  +0.78% for HFI
  - Orbital dipole calibration and the elimination of the Solar dipole error accounts for 0.28%.
  - Better understanding of beams and various systematics, mostly different for LFI and HFI, accounts for the rest.
- Agreement between LFI, HFI, and WMAP over the first peak is now at a level of a few tenths of a percent.
- Maps and map differences between frequencies provide spectacular confirmation that Planck sees the same CMB at all frequencies.