Deliverable 6.1: Initial Astrophysical Sky Model

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Work Package WP6 - Component separation

Revision History

Version	Authors	Date	Changes
1.0	Kristian Joten Andersen Hans Kristian Eriksen Trygve Leithe Svalheim Ingunn Kathrine Wehus	May 31st, 2018	Initial Version

Contents

1 Introduction

Gibbs sampling has been performed with Commander on new detector maps from NPIPE in order to acquire the best possible HFI maps for future component separation of the LFI channels. In a feedback loop with NPIPE we've managed to improve the foreground components maps, giving better residual maps at HFI.

2 Initial Astrophysical Sky Model

The initial astrophysical sky model foreground component maps are available for all consortium members at the Oslo “Owl” cluster at:

/mn/stornext/d14/bp/initial_sky_model/

The depository includes the full resolution foreground component maps and band residual maps. The component maps and chi-squared map are shown in Figs. 1-7. All plots are from Svalheim’s Master thesis.

In order to perform the best possible Gibbs sampling of the LFI channels in the furture of Beyond Planck, one needs the best possible HFI band maps and HFI component maps to initiate on, as these channels will be freezed, i.e. non changing, in the Gibb’s sampling of the LFI channels. In collaboration with NPIPE in a feedback loop of detector sky maps from NPIPE and component separation with Commander, the foreground component maps and the HFI band maps have been improved. The addition of new improved HFI single detector maps have been essential for this improvement. The sky maps used to derive the new foreground component maps are NPIPE version 5v21.

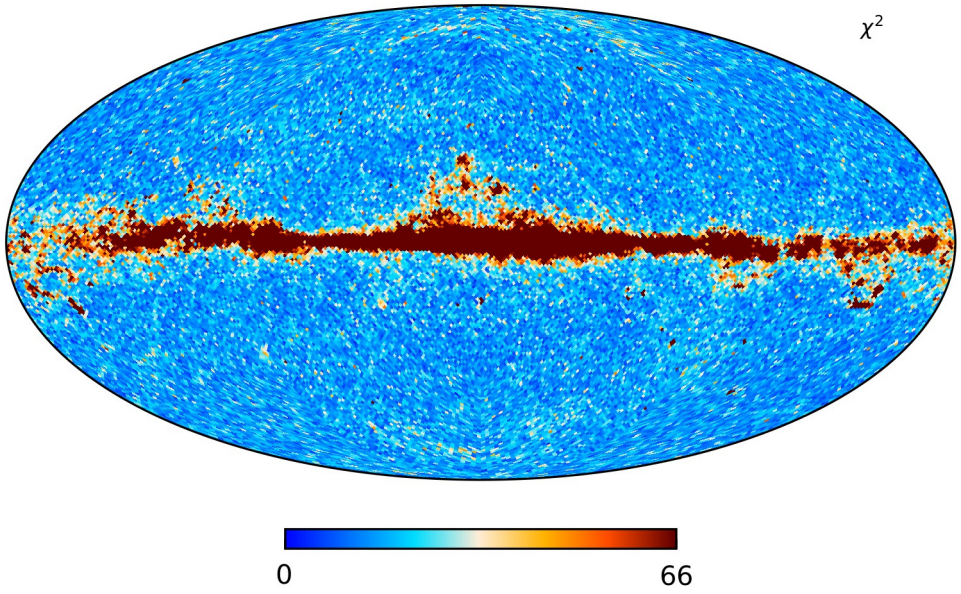

Figure 1. The figure shows the chi-squared (X^2) map of the Commander Gibbs sampling of the NPIPE version 5v21 sky maps. The map is plotted with 1 degree smoothing with an upper limit of 66.

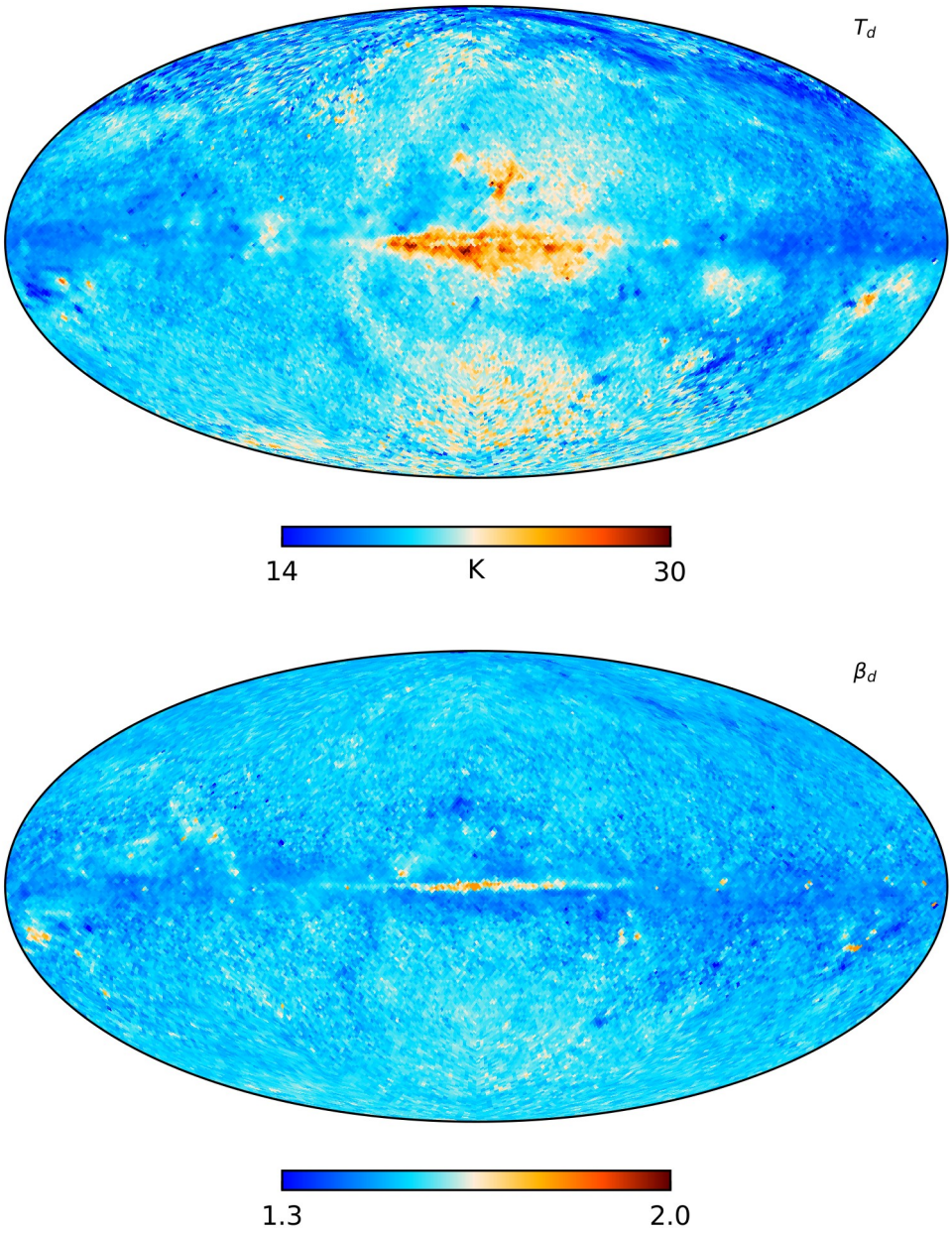

Figure 2. The figure shows (top) the dust temperature (T_d) map (in kelvins) and (bottom) the dust power law coefficient (β_d) map of the Commander Gibbs sampling of the NPIPE version 5v21 sky maps. The maps are plotted with 1 degree smoothing.

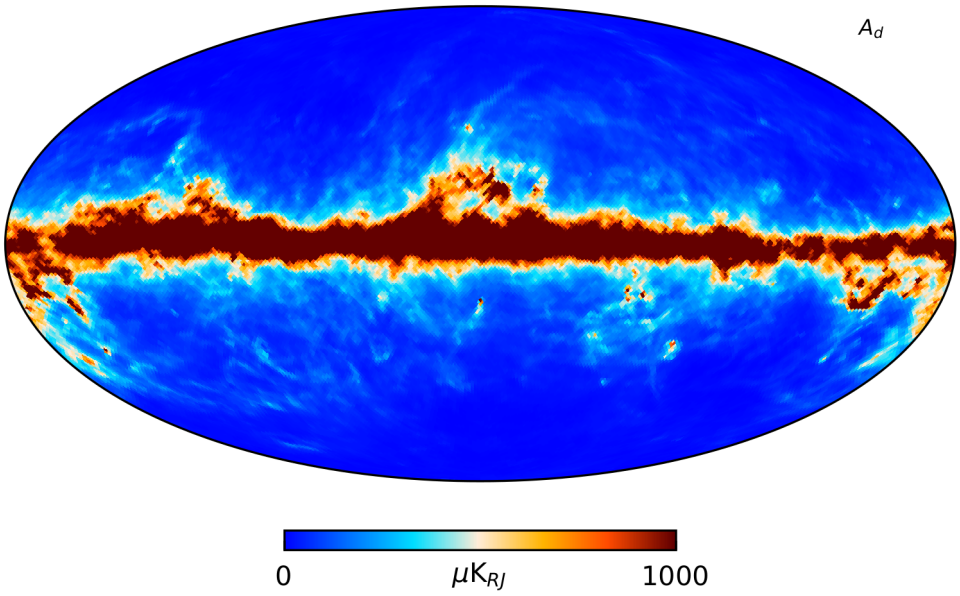

Figure 3. The figure shows dust amplitude (A_d) map (in micro kelvins) of the Commander Gibbs sampling of the NPIPE version 5v21 sky maps. The map is plotted with 1 degree smoothing.

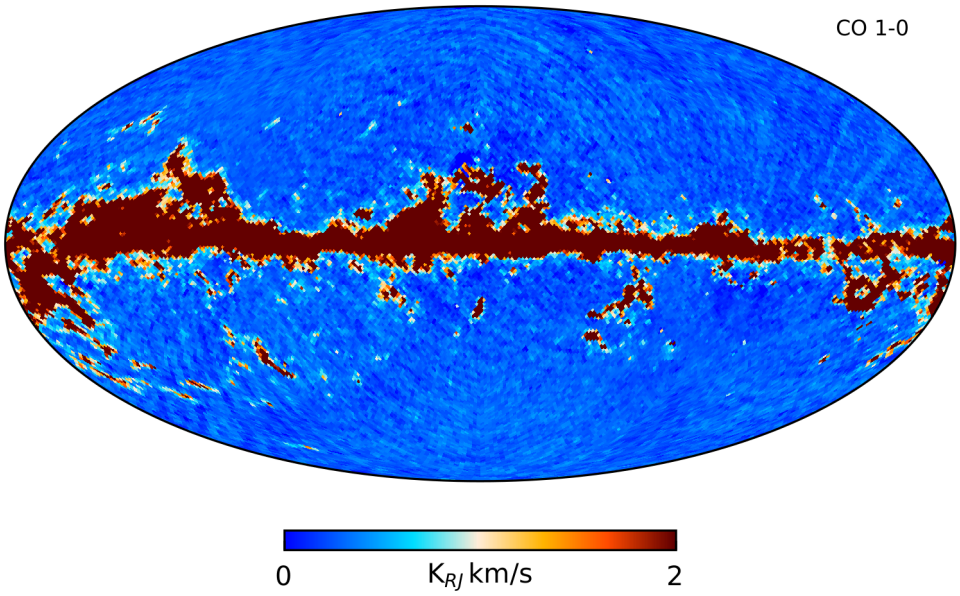

Figure 4. The figure shows CO component map at 100 Ghz (in kelvin kilometers per second), i.e. the CO 1→0 line, of the Commander Gibbs

sampling of the NPIPE version 5v21 sky maps. The map is plotted with 1 degree smoothing and an upper limit of 2 K_{RJ} km/s.

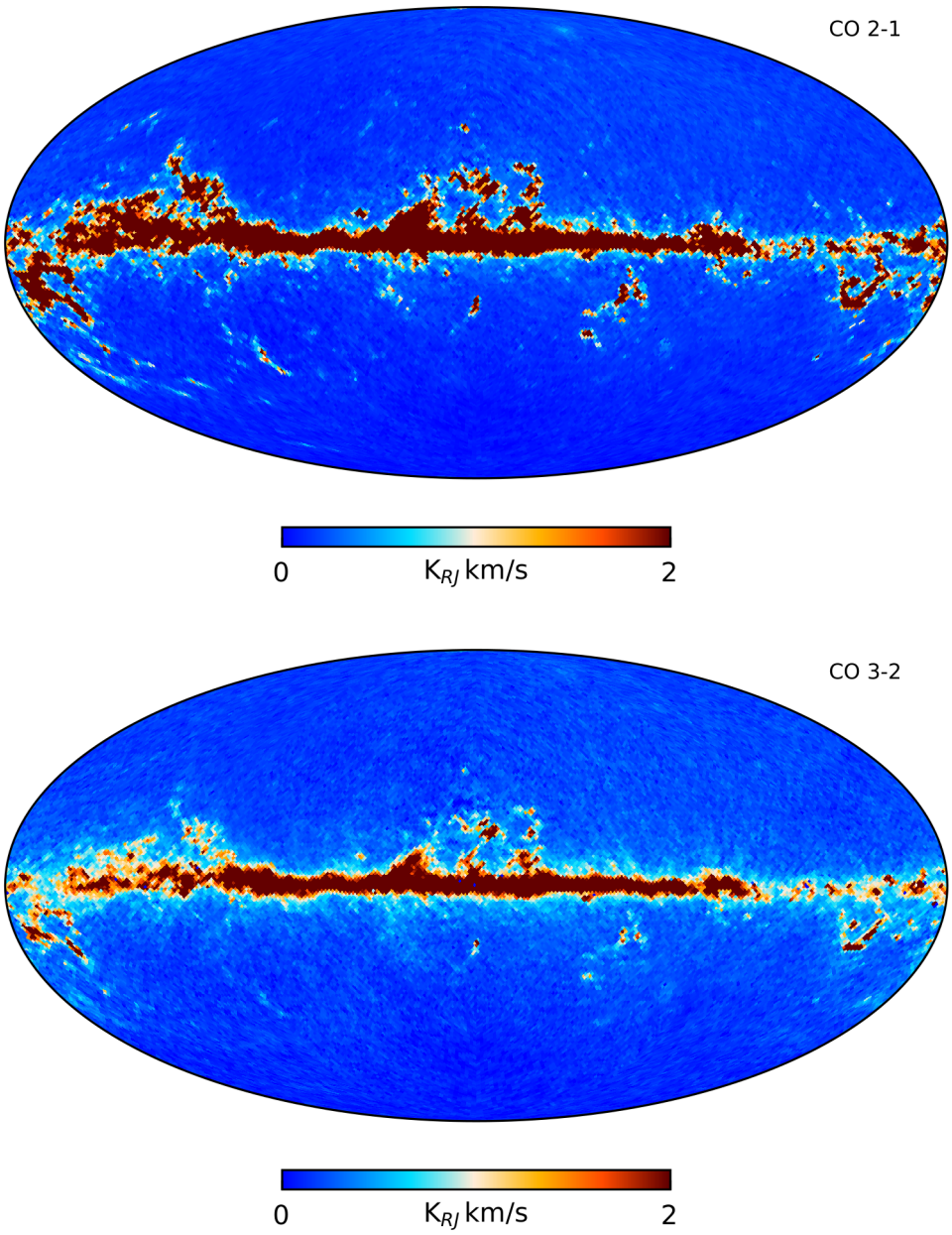

Figure 5. The figure shows CO component maps at 217 Ghz (top) and 353 GHz (bottom) (both in kelvin kilometers per second), i.e. the CO 2→1 and 3→2 lines, of the Commander Gibbs sampling of the NPIPE version 5v21 sky maps. The maps are both plotted with 1 degree smoothing and an upper limit of 2 K_{RJ} km/s.

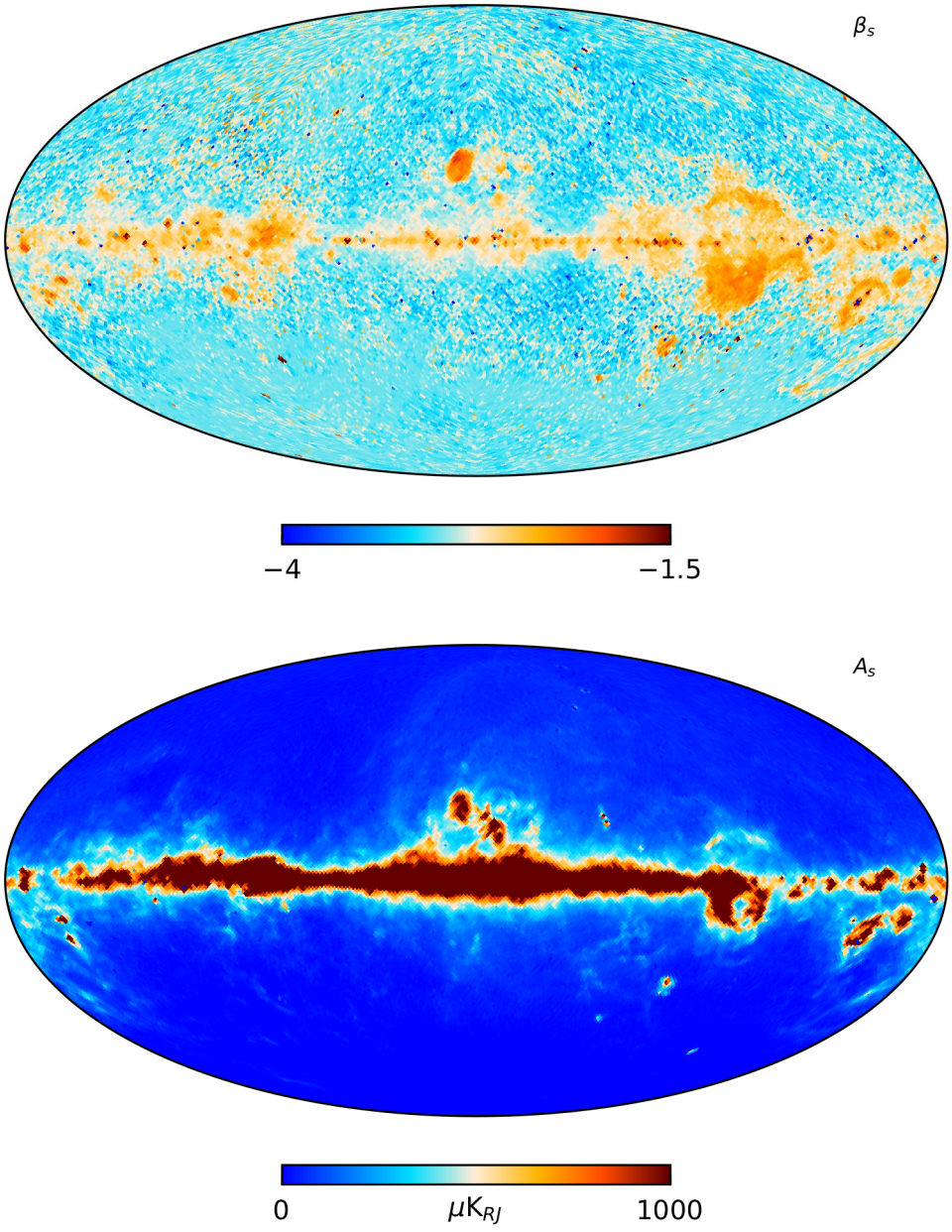

Figure 6. The figure shows (top) the synchrotron power law coefficient (β_s) map and (bottom) the synchrotron amplitude (A_s) map (in micro kelvins) of the Commander Gibbs sampling of the NPIPE version 5v21 sky maps. The maps are plotted with 1 degree smoothing.

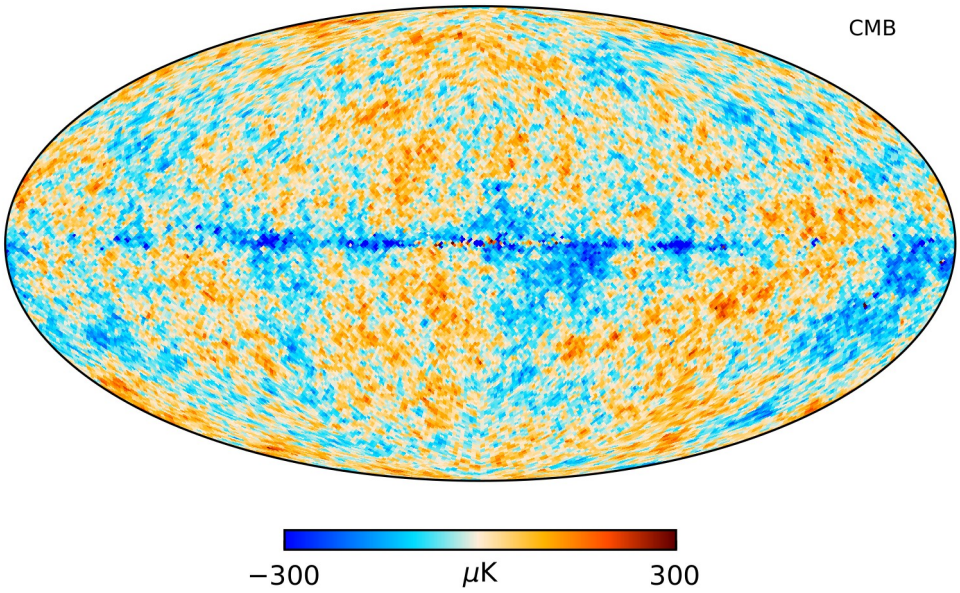

Figure 7. The figure shows the map of the CMB fluctuations (in micro kelvins) of the Commander Gibbs sampling of the NPIPE version 5v21 sky maps. The map is plotted with 1 degree smoothing.

2.1 Tasks Performed

The following tasks have been performed on the sky maps from NPIPE:

- Commander 1: Low resolution Gibb's sampling for band gain and bandpass correction, CO line ratio estimation and creation of new low resolution component maps.
- Commander 2: Full resolution Gibb's sampling with input component maps and instrumentation parameters from Commander 1. Output of new high resolution component maps.
- Feedback of the new component maps to NPIPE for further improvement of the detector sky maps.

2.2 Planck 2015 comparison

As mentioned above one wants the best possible HFI sky maps to initiate the Gibb's sampling of the LFI channels. Until now the Planck 2015 results (see Planck Collaboration 2015) are the best model for the foregorund components and would have been the initialization maps of the HFI channels if we did not have better maps. By comparing the new maps to the Planck 2015 results one can see a clear improvement in the residual maps for many detectors. Figures 8-10 show the residual maps of three detectors of the Planck 2015 results and the new sky model. All new sky model plots are from Svalheim's Master thesis.

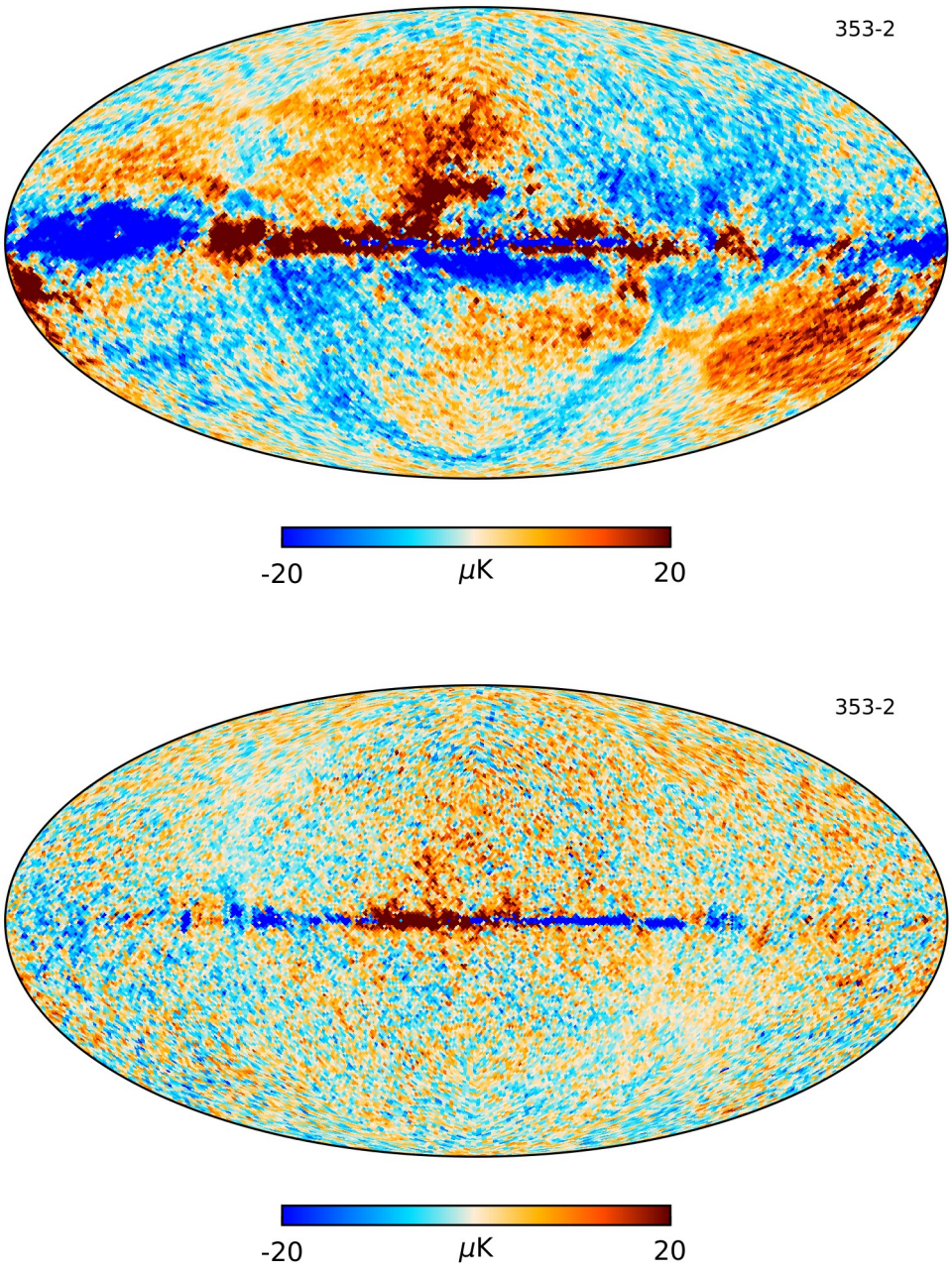

Figure 8. The figure shows the residual maps of detector nr. 2 at 353 Ghz for the Planck 2015 results (top) and the new sky model in collaboration with NPIPE (bottom). The maps are plotted with 1 degree smoothing with upper and lower limits of ±20 micro kelvins.

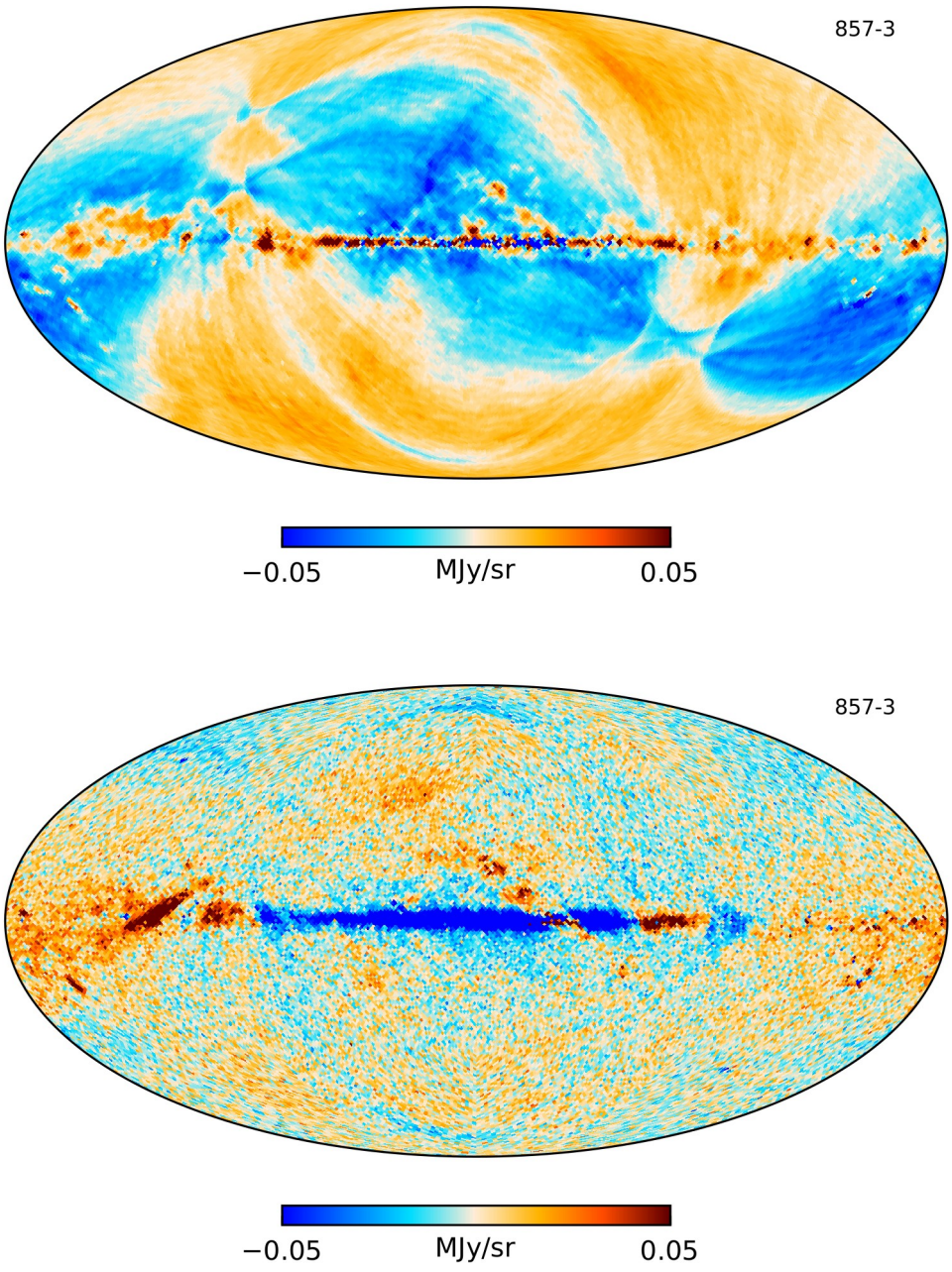

Figure 9. The figure shows the residual maps of detector nr. 3 at 857 Ghz for the Planck 2015 results (top) and the new sky model in collaboration with NPIPE (bottom). The maps are plotted with 1 degree smoothing with upper and lower limits of ±0.05 megajanskys per steradian.

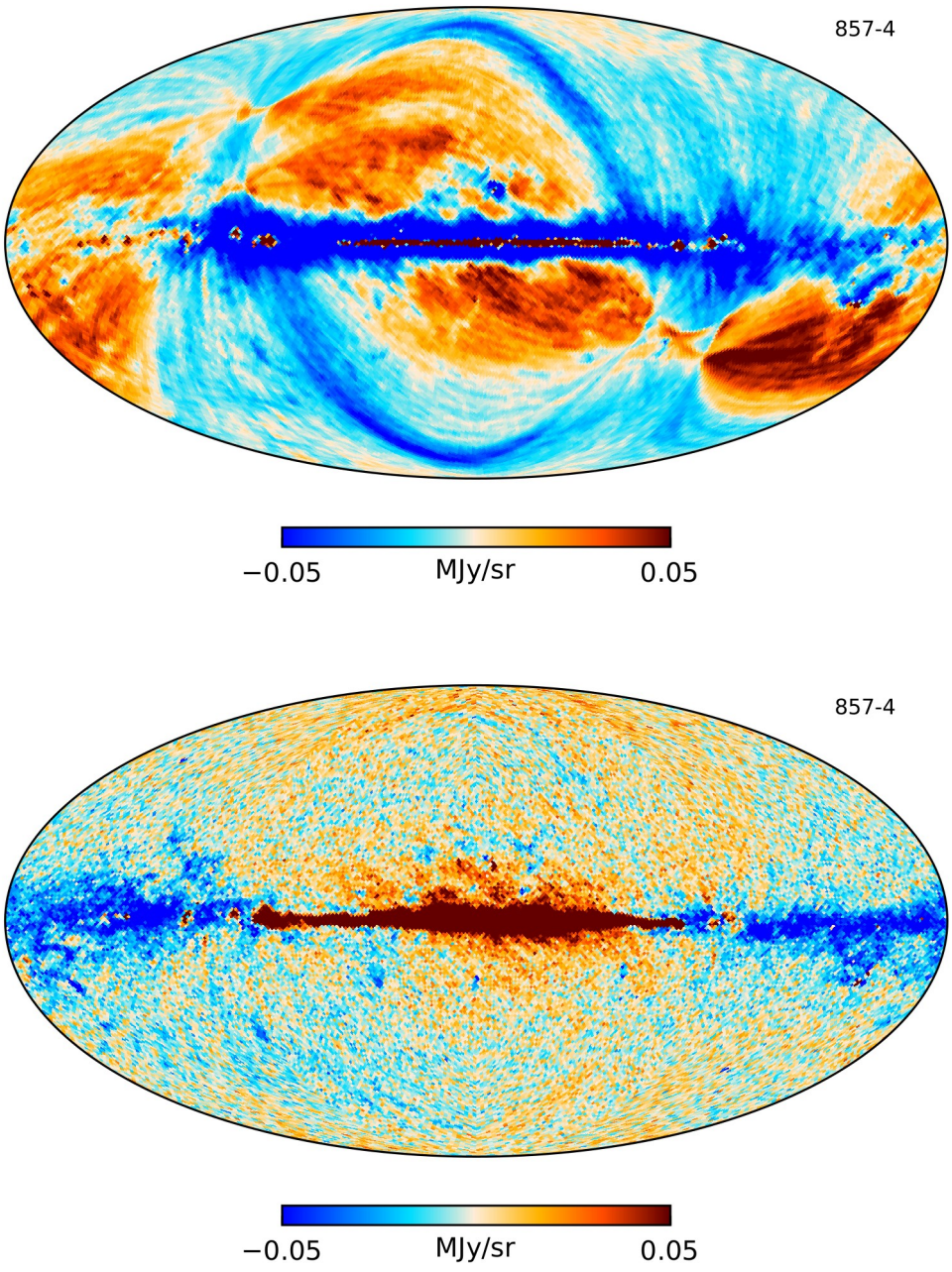

Figure 10. The figure shows the residual maps of detector nr. 4 at 857 GHz for the Planck 2015 results (top) and the new sky model in collaboration with NPIPE (bottom). The maps are plotted with 1 degree smoothing with upper and lower limits of ±0.05 megajanskys per steradian.

2.3 Future improvements

With the inclusion of single detector channels at the HFI frequencies, Commander 2 has shown problems correcting for radio sources as the memory usage has grown beyond the Owl cluster's capacity. This is likely a bug in the code that are currently being examined. Until this bug is fixed, all full resolution Gibbs sampling with Commander 2 is not correcting for radios ources, which are showing as bright sources in the CMB maps.

In adition to radio sources, work is being done in reducing the noise in the CO maps by estimating and fitting new monopoles and dipoles for each band.

Furthermore, the component separation group aims to include sky maps from WMAP and Haslam in the Commander Gibbs sampling. The WMAP detectors are in the frequency range of 23-94 GHz while the Haslam map is at 408 MHz. The latter is of great use as it (most likely) makes the calibration of the synchrotron power law more accurate The WMAP maps will also assist in implementing and calibrating a spinning dust component as well.

3 References

Planck 2015 results. X. Diffuse component separation: Foreground maps, Planck Collaboration, 2016, A&A, 594, A10

Improving the Planck sky maps with Bayesian component separation, Svalheim, T. L., 2018, Master thesis, in preparation