# Is “single component” enough for the thermal dust emission?

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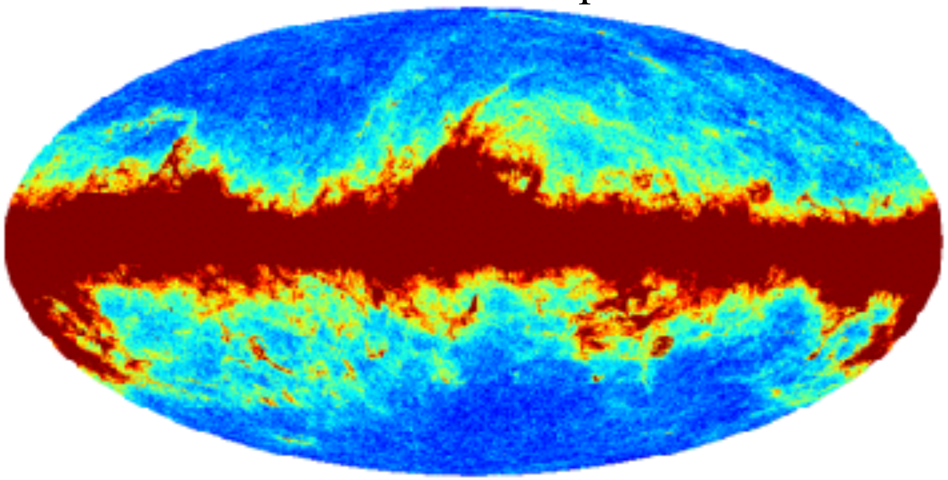
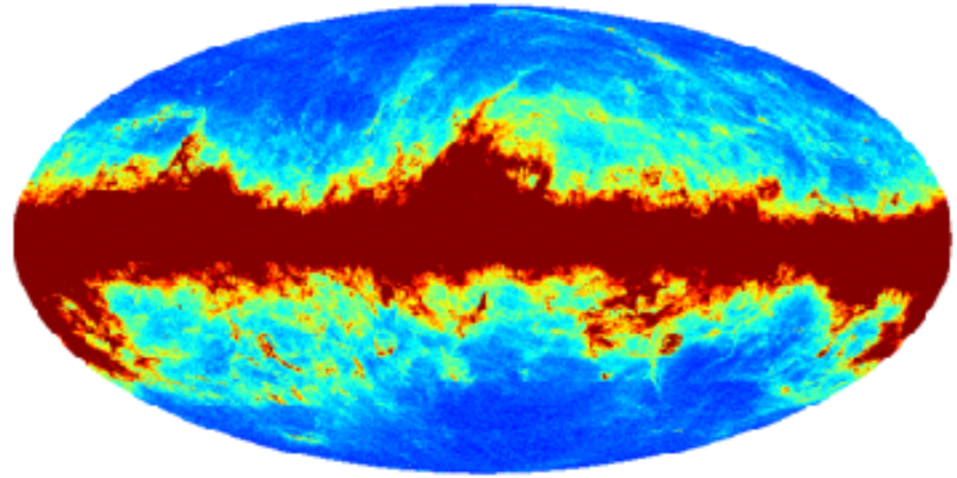
For Nordita 2017 in Stockholm

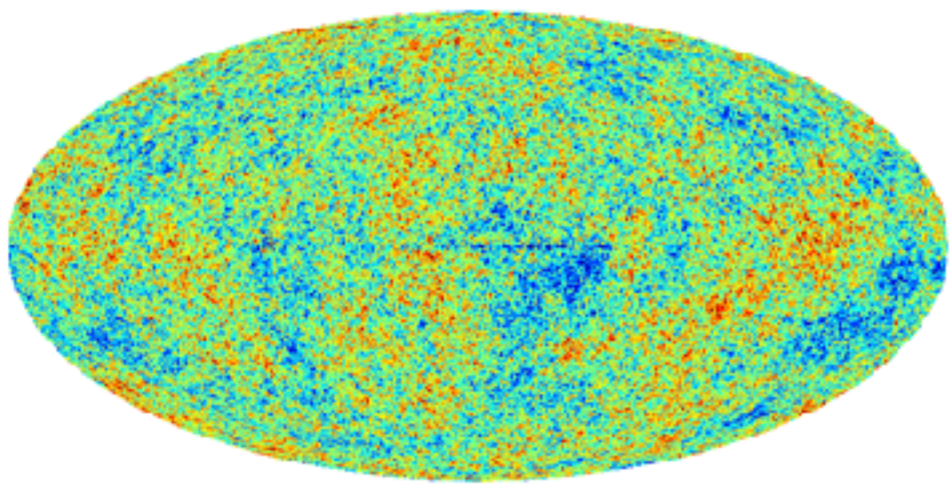
353 GHz total map



353 GHz dust estimation



CMB



A good foreground estimation is required to get a good CMB detection

# Some estimations of the thermal dust emission

- Planck 2013
  - Planck 2013 results. XI. All-sky model of thermal dust emission, 2014 A&A 571, A11
- Planck 2015
  - Planck 2015 results. X. Diffuse component separation: Foreground maps, 2016, A&A, 594, A10
- GNILC
  - Planck intermediate results. XLVIII. Disentangling Galactic dust emission and cosmic infrared background anisotropies, 2016, A&A 596, A109
- Different estimations, but same assumption: **single component** thermal dust
  - Example of multi-component assumption: "Foreground Bias From Parametric Models of Far-IR Dust Emission", 2016, A. Kogut, D.J. Fixsen.

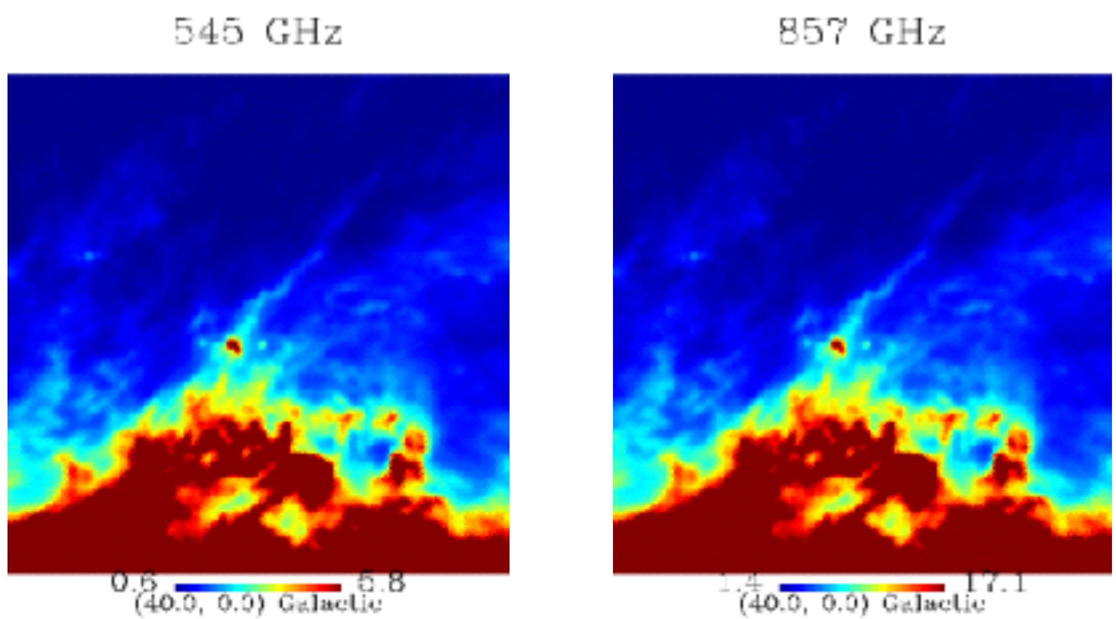
- Line of sight → We know for sure that the real thermal dust emission is **not** single component.
- Therefore, a meaningful discussion should be:
  - Is "single component" good enough as an approximation?
  - Especially for extrapolation down to ~100 GHz
- Simplification of the discussion
  - Multi dust component?
  - Multi other component?
  - Variation of the parameter as function of frequency?
  - Many other possibilities, but we discuss only

# What happens if we don't answer this question

- Real case is multi, but assume single?
  - For a few high freq. bands: still good fit
  - But extrapolation will not be reliable
- Real case is single, but assume multi?
  - Can fit even the noise, systematics…
  - Over fitting
- Therefore, we should have a clear answer to "Is single component good enough"?
  - If good enough: Fine! we can continue to use the current estimations
  - If not good enough: Multi-frequency experiments will be preferred.

# The idea

- Use a local region from two adjacent bands to derive the ratio of dust amplitude between them
  - R: ratio by data. R0: ratio by existing dust model.
- Use only the regions with very high cross-correlation coefficients between two adjacent bands to cast limits on the error R-R0



$$
\begin{aligned}
x' &= x + \Delta x \\
y' &= y + \Delta y
\end{aligned}
$$

Data Dust Non-dust

Let $R$ be the ratio given by linear regression, and $R_0$ be the expected ratio, then we have:

$$
\begin{aligned}
R_0 &= \frac{S_{xy}}{S_x} \\
R &= \frac{S_{x'y'}}{S_{x'}} \\
C(x,y) &= \frac{S_{xy}}{\sigma_x \sigma_y}
\end{aligned} \tag{4}
$$

Assume:

$$
\begin{aligned}
C(x,y) &\approx 1 \\
C(x',y') &\approx 1
\end{aligned}
$$

$$
\begin{aligned}
C(x,\Delta x) = k_x &\ll 1 \\
C(y,\Delta y) = k_y &\ll 1 \\
C(y,\Delta x) \approx k_x &\ll 1 \\
C(x,\Delta y) \approx k_y &\ll 1 \\
C(\Delta x,\Delta y) = k_\Delta &\ll 1 \\
\beta_x = \sigma_{\Delta x}/\sigma_x &\ll 1 \\
\beta_y = \sigma_{\Delta y}/\sigma_y &\ll 1
\end{aligned}
$$

We get:

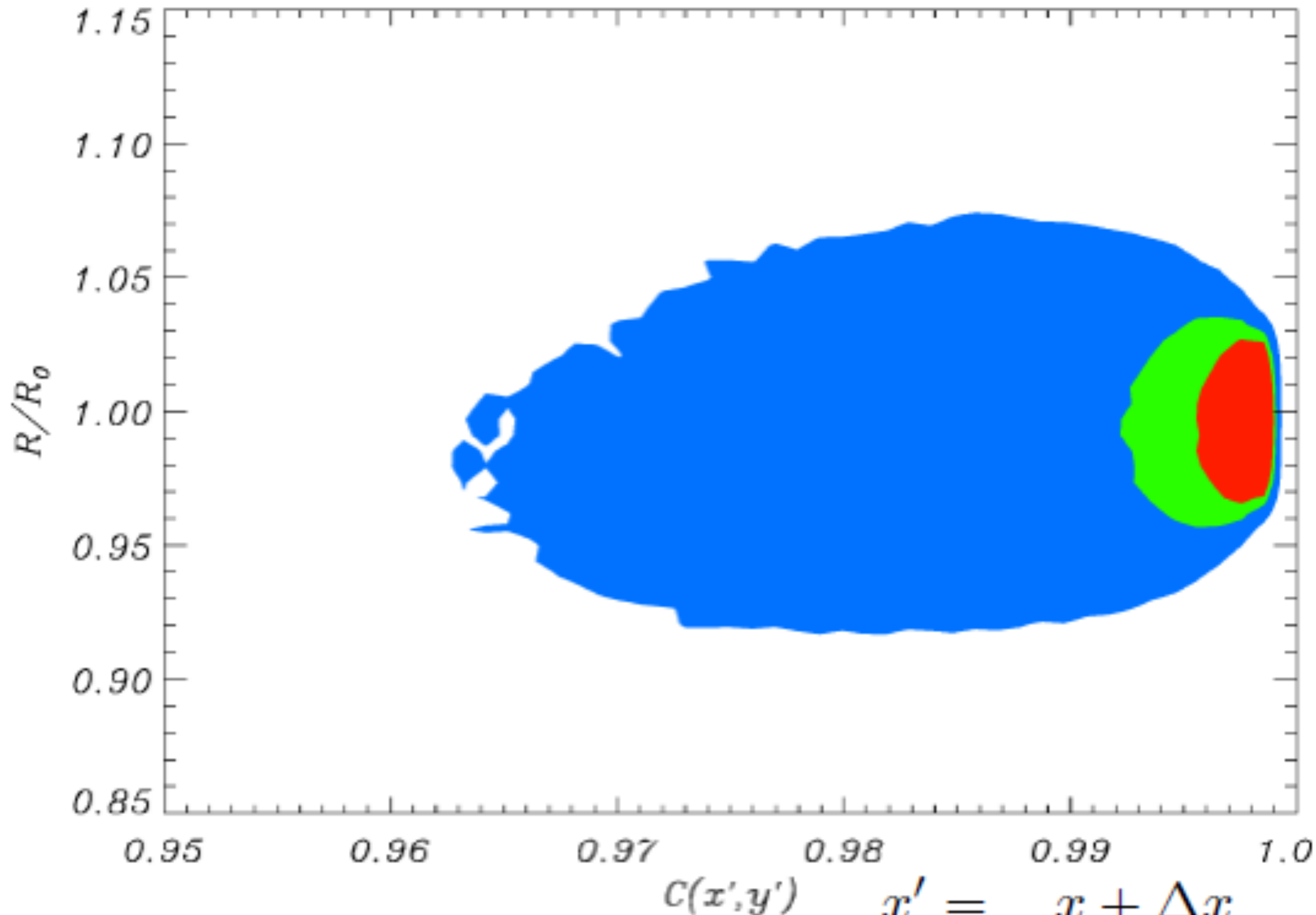
$$
\begin{aligned}
S_{x'} &= S_x(1 + 2k_x\beta_x + \beta_x^2) \\
S_{y'} &= S_y(1 + 2k_y\beta_y + \beta_y^2) \\
S_{x'y'} &= S_{xy}(1 + k_x\beta_x + k_y\beta_y + \beta_x\beta_y)
\end{aligned}
$$

We get:

$$1 \approx \frac{1 + k_x\beta_x + k_y\beta_y + \beta_x\beta_y k_\Delta}{\sqrt{(1 + 2k_x\beta_x + \beta_x^2)(1 + 2k_y\beta_y + \beta_y^2)}}$$

$$R = \frac{S_{x'y'}}{S_{x'}} \approx \frac{\sigma'_y}{\sigma'_x} = \frac{(1 + 2k_y\beta_y + \beta_y^2)}{(1 + 2k_x\beta_x + \beta_x^2)} R_0$$

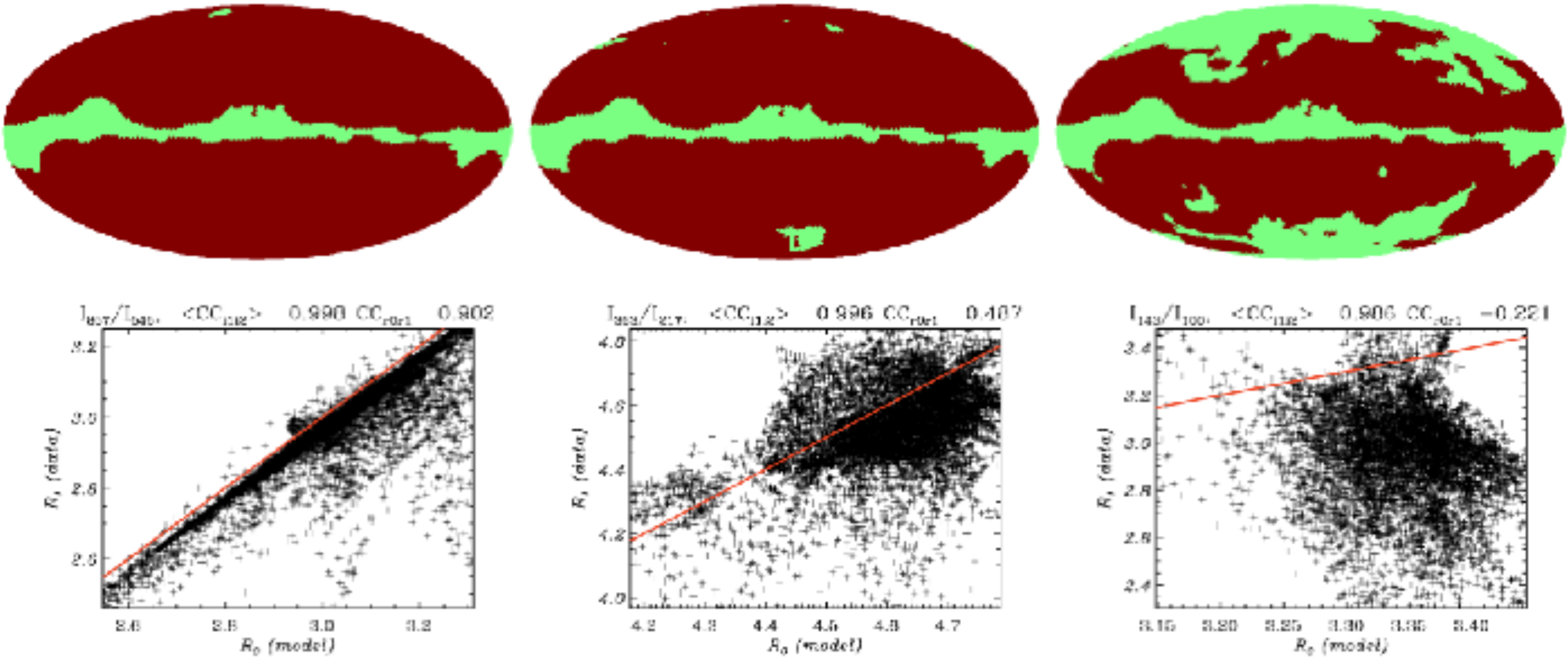
By Taylor expansion, we see that 1-R/R0 and 1-C(x',y') are same level small numbers → This is the limitation we need!




$$x' = x + \Delta x$$
$$y' = y + \Delta y$$

Data Dust Non-dust

Test by simulations
(allow 30% chance correlation
between dust/non-dust components)




Using r=10-deg disc as patches, CC is
at least 0.95

Note that the CMB map (SMICA) is excluded in advance

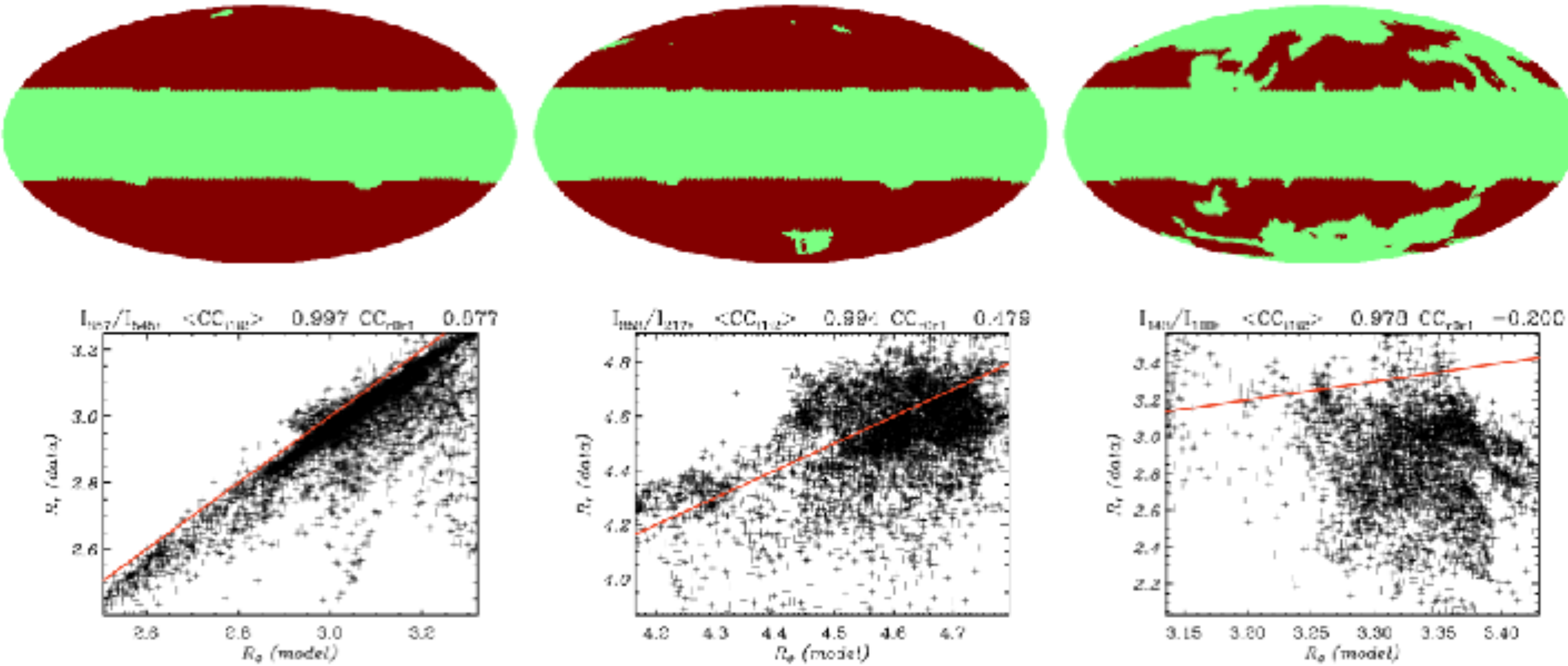


FIG. 4: Similar to Fig. 3 but use only the $|b| > 30^\circ$ region. There is no essential difference to Fig 3.

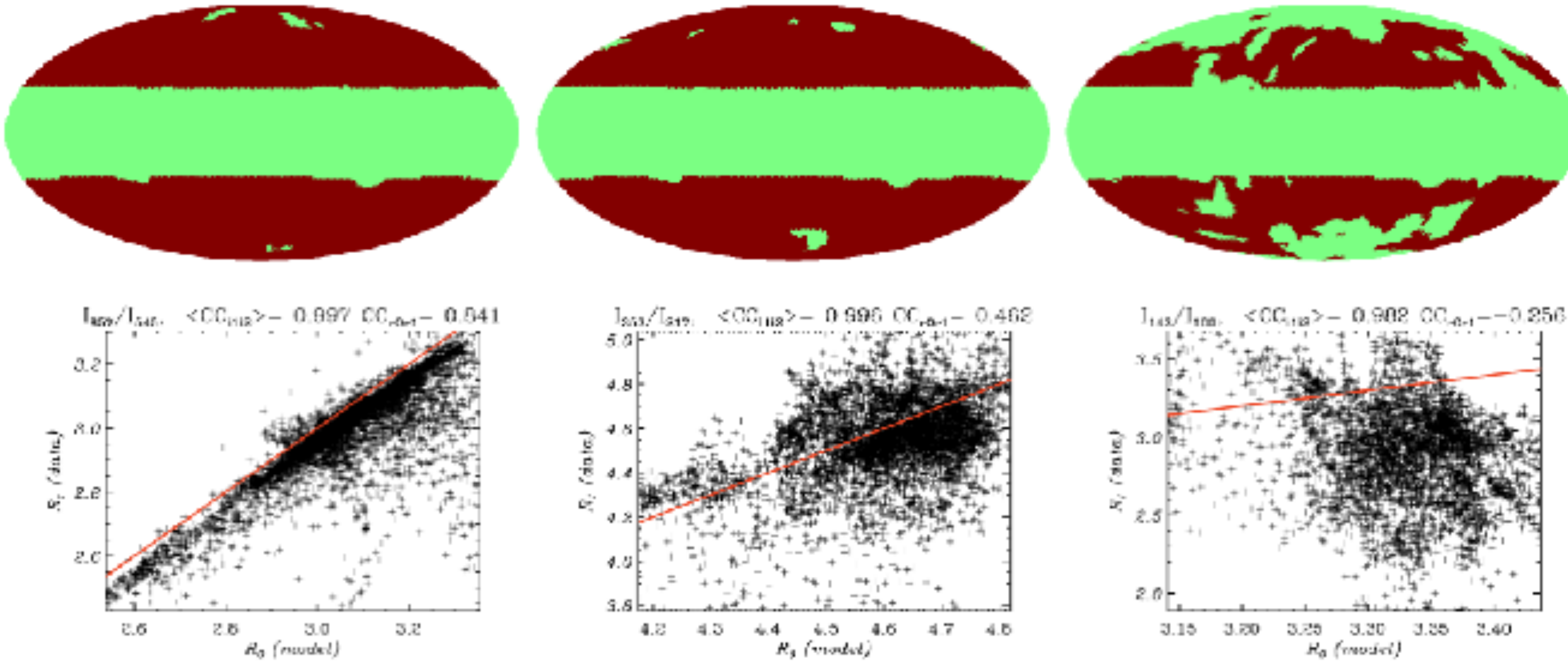


FIG. 5: Similar to Fig. 3, but with 5° smoothing to the input maps and use only the $|b| > 30°$ region. There is no essential difference to Fig 3.

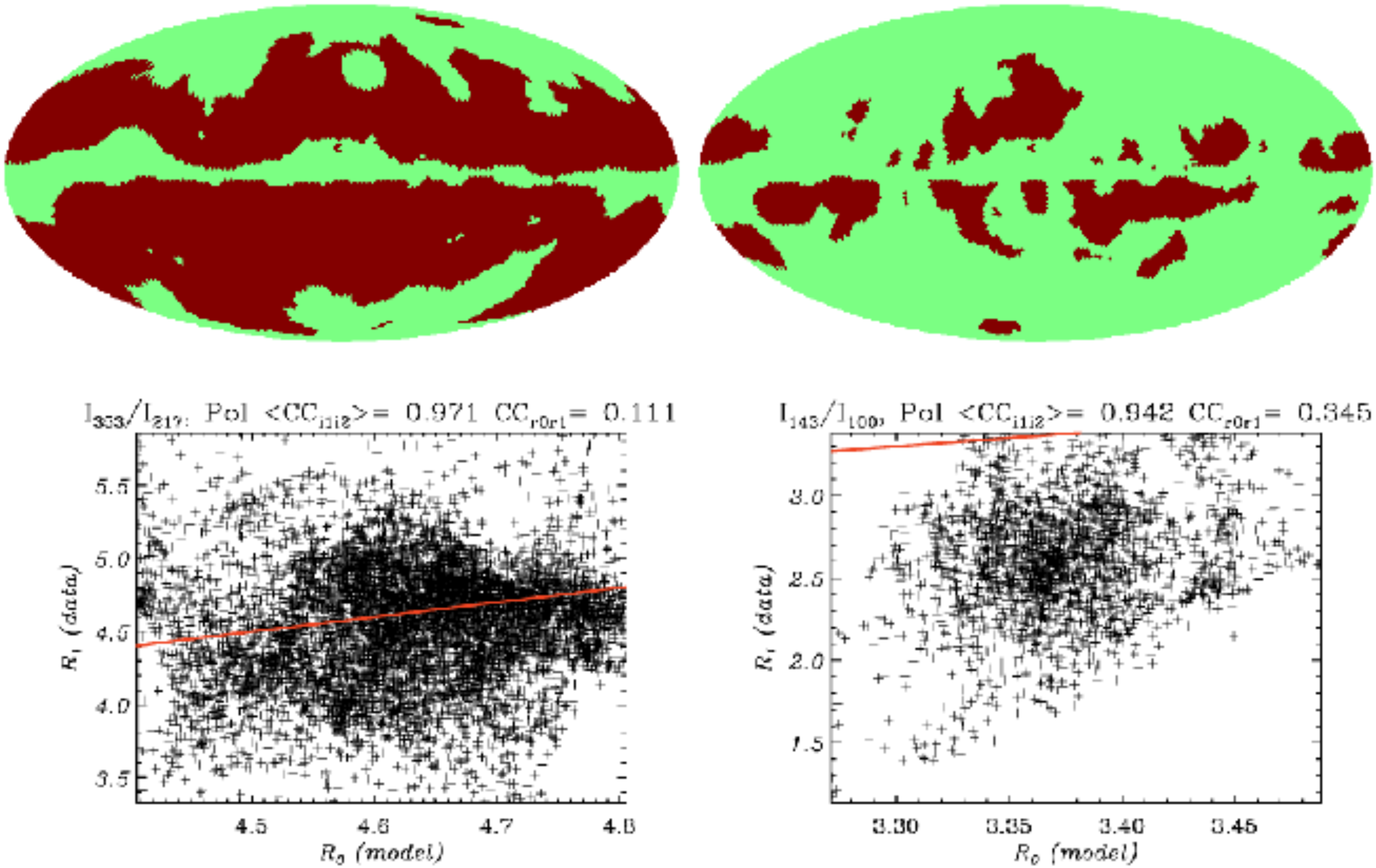



FIG. 6: Similar to Fig. 3, but with 5° smoothing to the input maps and use the polarization data. Note that there is no polarization data for 545 and 857 GHz.

# Is the deviation due to…

- Color correction
- CIB
- Free-free
- Zodiac light
- Systematic + Residual CMB
- Due to the limitation given by “High band-band correlation”:
  - Either unaffected by these issues
  - Or these issues must provide strong correlation to thermal dust

# Current conclusion

- "single component" is likely not a good assumption for the thermal dust emission
- Especially for the middle frequencies (~100 GHz)
- Measurement of more frequency bands will be great for a reliable estimation of the termal dust emission.

# Thanks!