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Bayesian CMB foreground separation with a correlated log-normal model

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Separation problem for diffuse foregrounds

- Several physical components: $s^{(\alpha)}$
- Observations at different frequencies: $d^{(\nu)}$
- Components have different frequency spectra: $R^{(\nu,\alpha)}$
- Observational noise: $n^{(\nu)}$

$$d = R\,s + n$$

Bayesian reconstruction of all signal components:

$$P(s|d) = \frac{P(d|s)\,\boxed{P(s)}}{P(d)}$$

State-of-the art: Use Gaussian prior for CMB, flat prior else.

Prior model

1) Log-normal prior for foreground components:

$$P(\log(s)) \text{ Gaussian}$$

- s always positive
- Fluctuations varying over orders of magnitude (Galactic plane and halo)

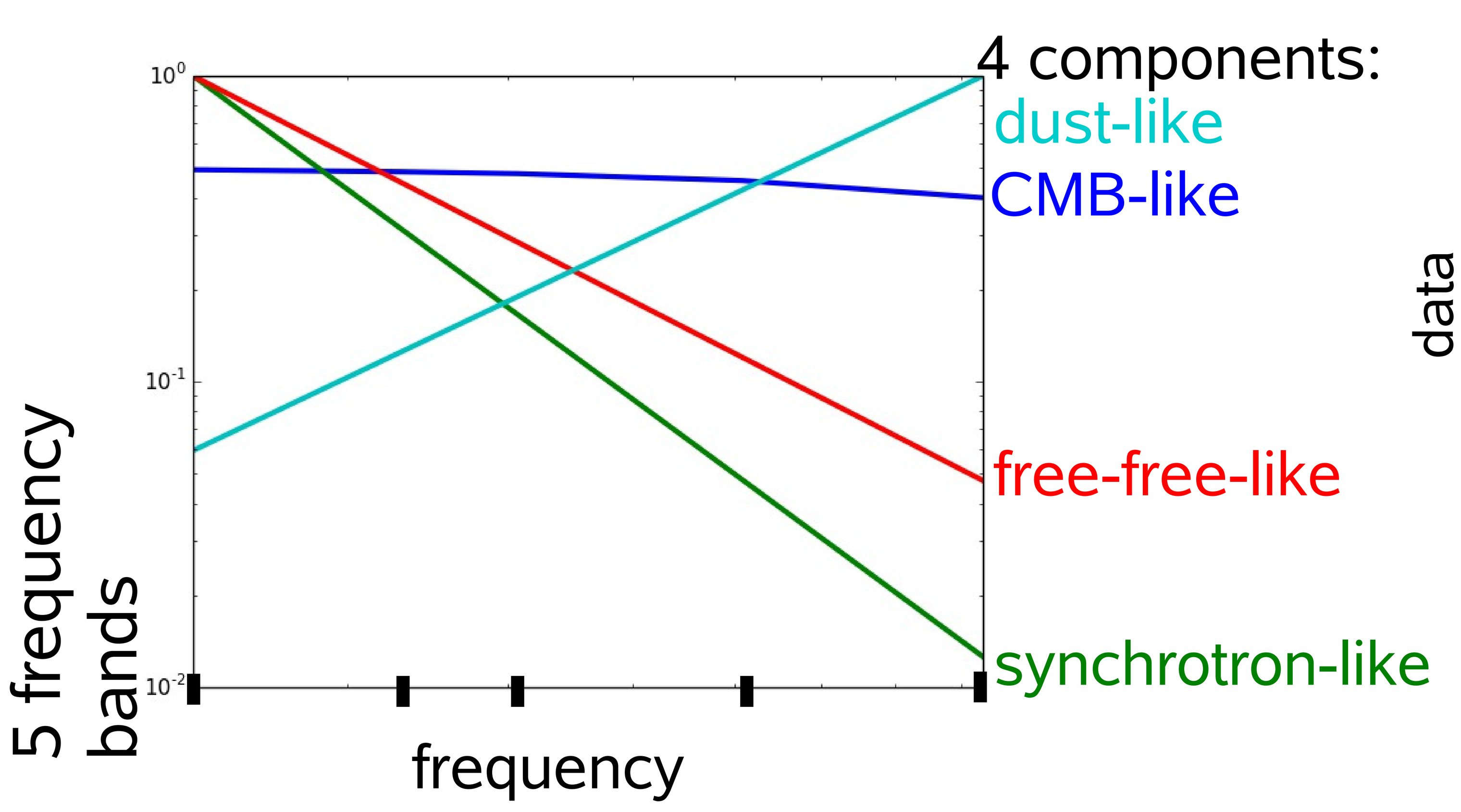
2) Allow for correlations, both within one component and across components

$$\langle s_x^{(\alpha)} s_y^{(\beta)} \rangle_{(s)} \neq 0$$

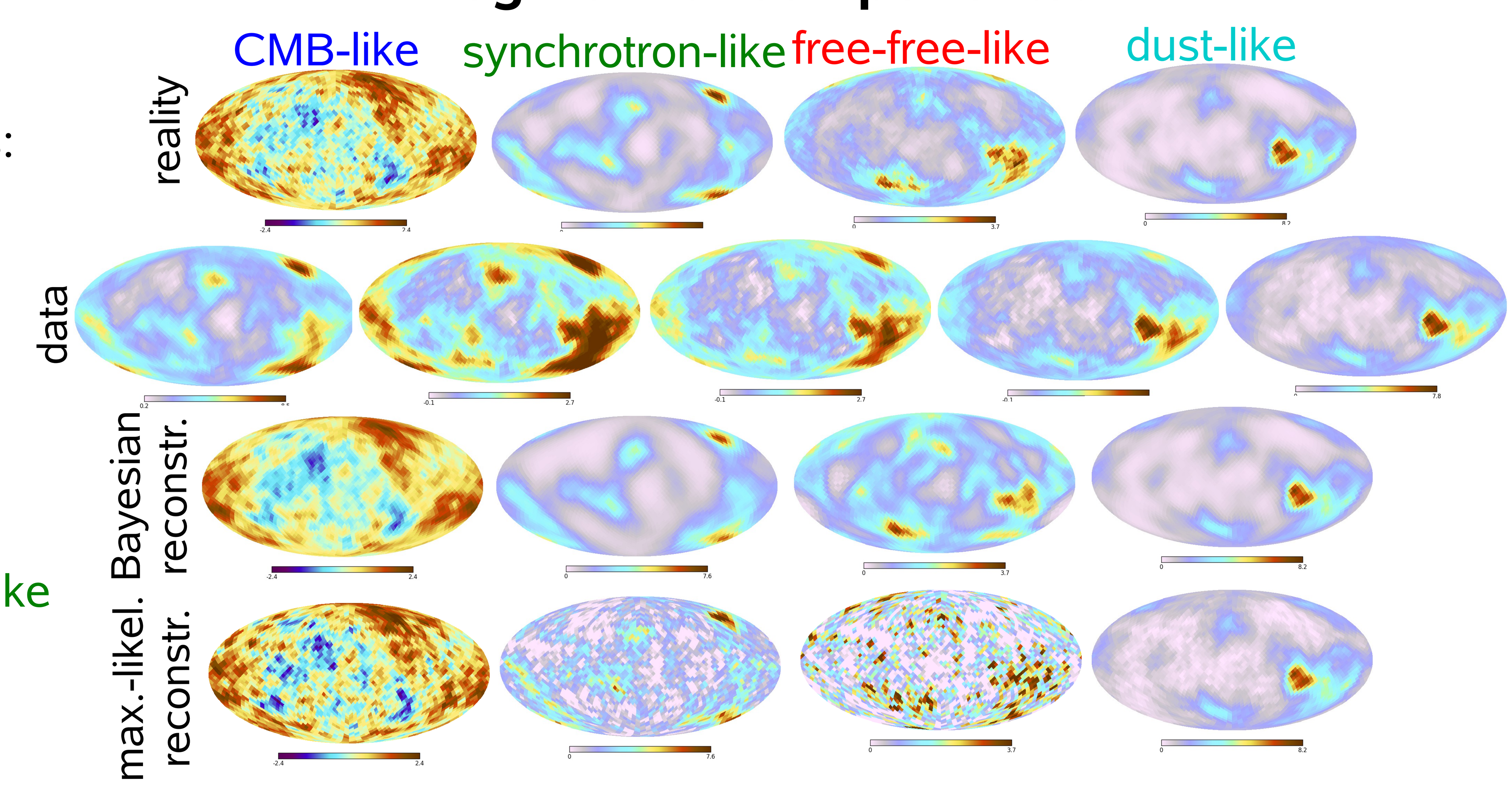
3) Gaussian CMB prior

Test cases

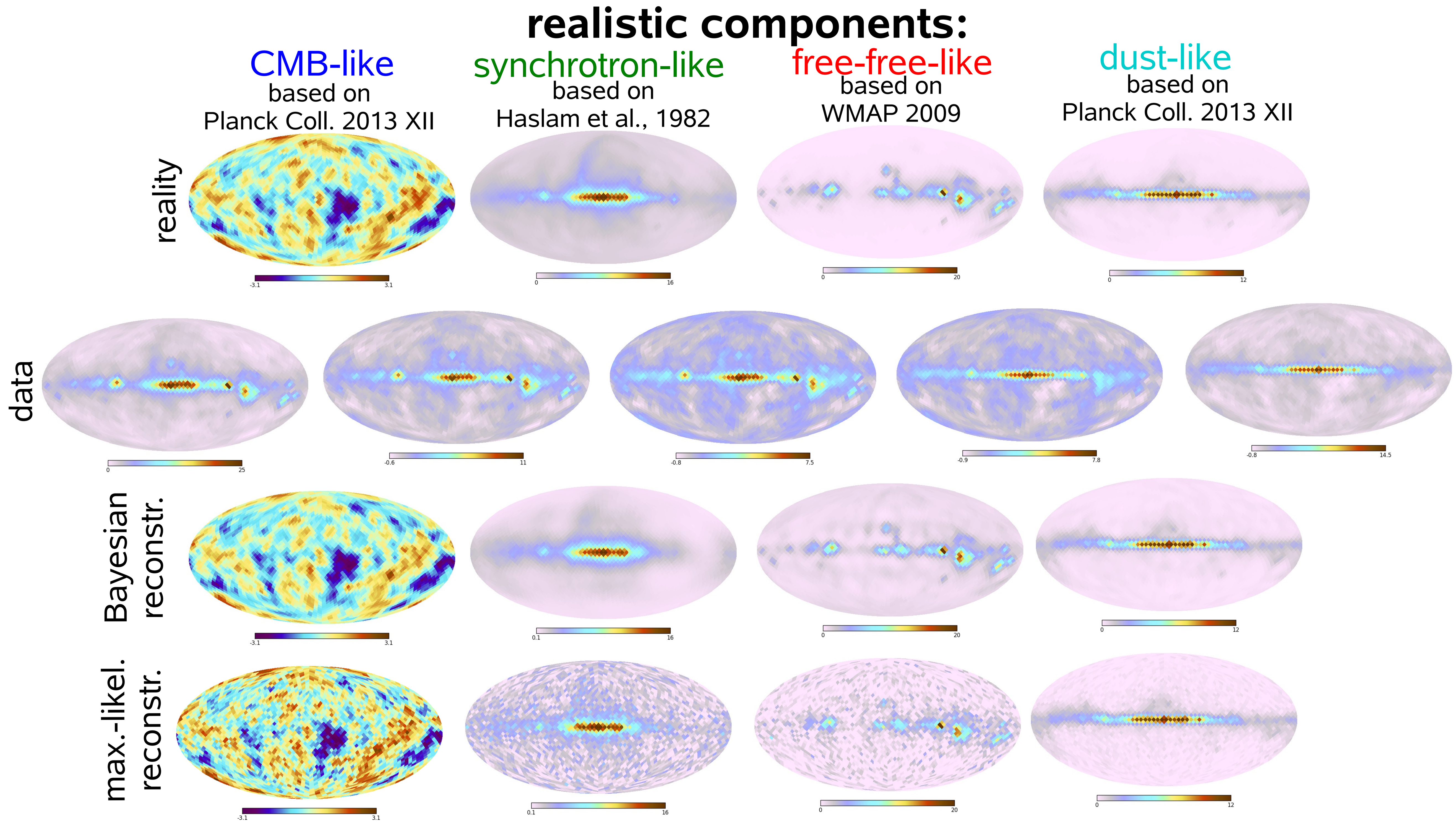
frequency spectra:



log-normal components:



realistic components:



Bottom line:
The isotropic correlated log-normal model leads to more accurate fore-ground reconstructions than a model with flat priors, even if the model assumptions are only approximately fulfilled.