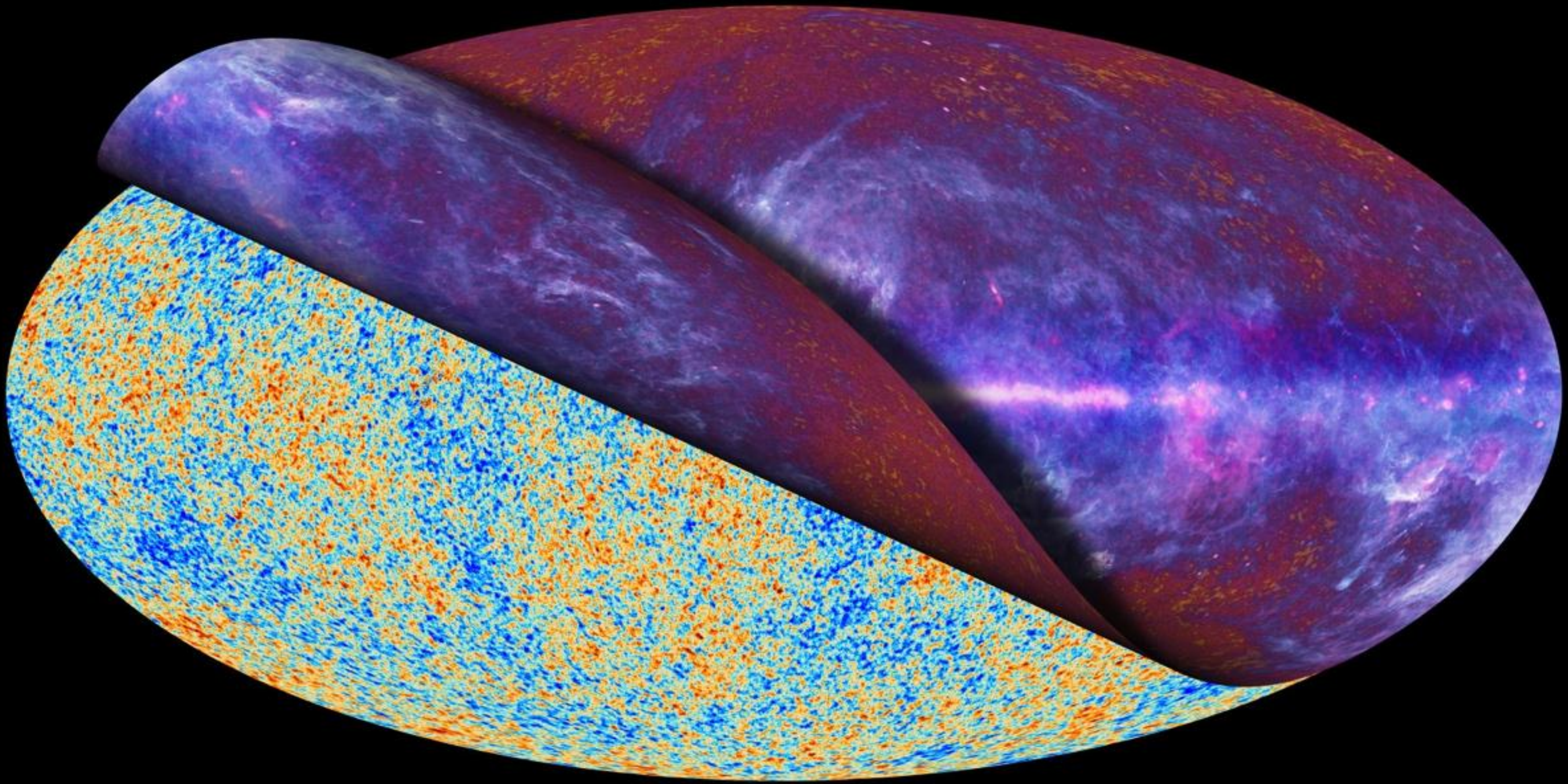
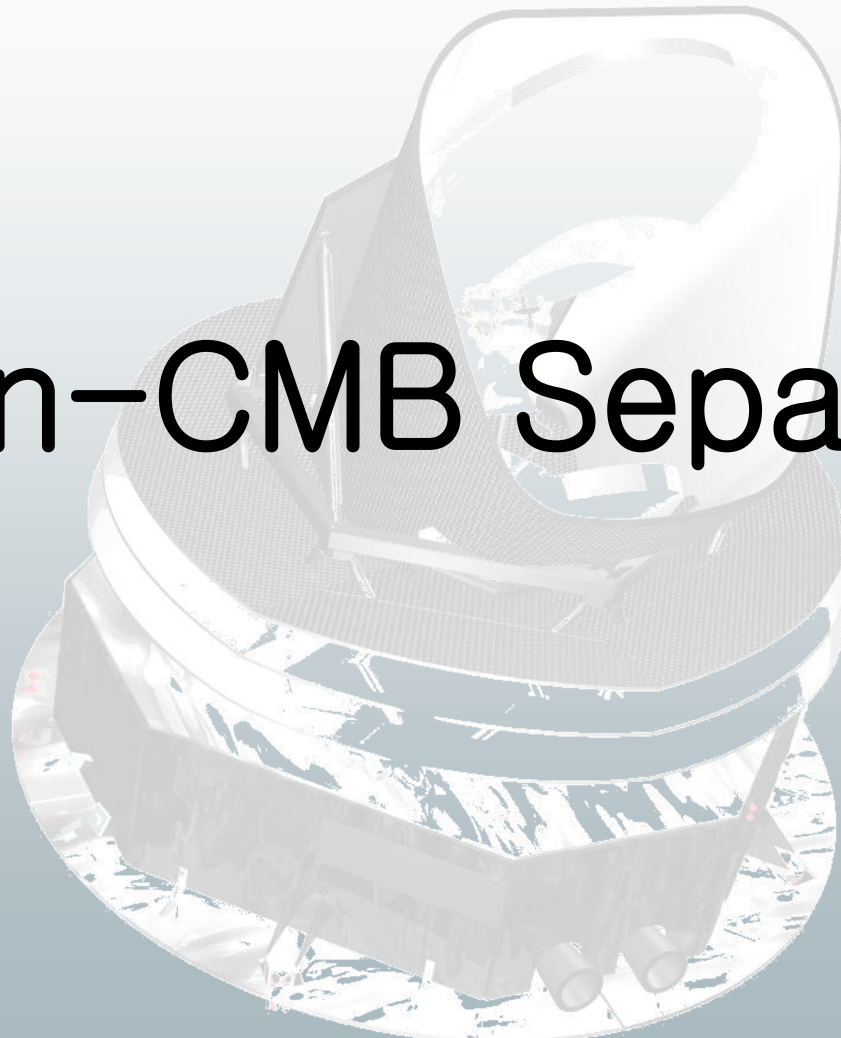


Planck unveils the Cosmic Microwave Background



Non-CMB Separation

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On behalf of the Planck collaboration

The scientific results that we present today are a product of the Planck Collaboration, including individuals from more than 100 scientific institutes in Europe, the USA and Canada

Planck is a project of the European Space Agency, with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.

Non-CMB Separation

- Methodology
- Foreground model
- Inputs
- Results
- Validation
- Conclusions

Methodology

- Planck adopts a pixel based parametric approach for separating diffuse foregrounds
- Parameters in the pixel domain: spatially varying spectral indices and amplitudes of foreground components
- Fitting procedure: Markov Chains Monte Carlo over the multi-frequency datasets
- Main references: Brandt et al. 1994 (main idea), Eriksen et al. 2006 (efficient fitting through Gibbs sampling), Eriksen et al. 2008 (Jeffrey's prior is introduced), Stompor et al. 2009 (high resolution fitting on the basis of chains conducted at low resolution)
- Implementation in the Commander-Ruler code which was used for all results presented in the Planck XII paper

Foreground model

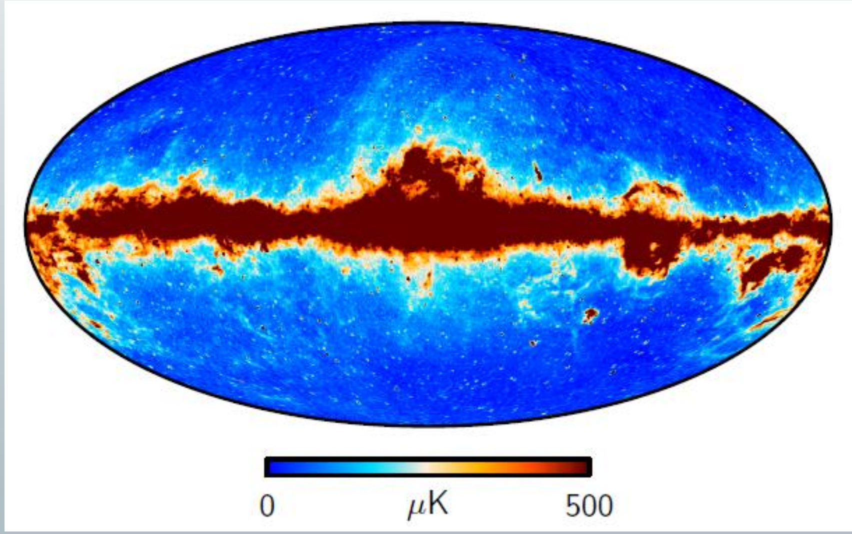
- Low frequency amplitude at 30 GHz and spectral index, effectively describing a mixture of various astrophysical effects, as Brehmsstrahlung (free-free), Anomalous Dust Emission (AME), Synchrotron
- CO amplitude at 100 GHz
- Thermal Dust amplitude at 353 GHz and grey body temperature and emissivity
- Monopoles and dipoles over the frequency channels which are considered for separation, to be estimated separately, at low resolution (Wehus et al. 2013)

Inputs

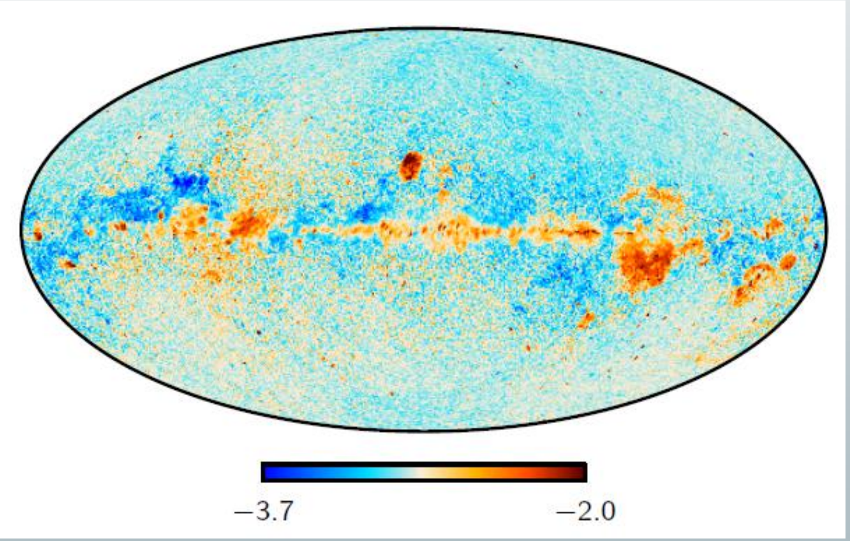
- Planck sky maps, 30-353 GHz, total and half-ring datasets
- Instrumental noise
- Beam transfer functions
- Spectral indices estimation at low resolution takes as inputs the maps are smoothed to 40 arcminutes common resolution, re-pixelized at Nside=256
- Mixing matrices are applied to the Ruler resolution dataset corresponding to 7.1 arcminuted

Results

Using Planck data alone, only a single low frequency component can be estimated, here evaluated at 30 GHz



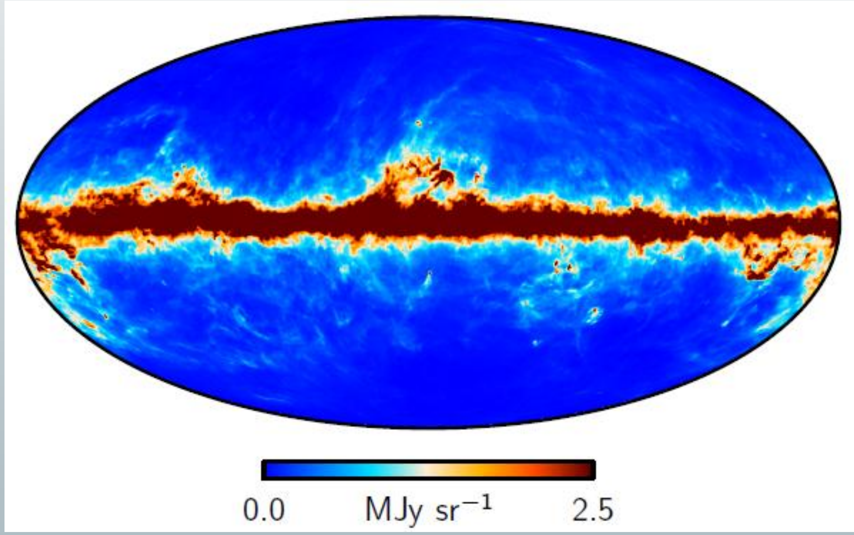
An effective spectral index describes the superposition of AME, free-free and synchrotron

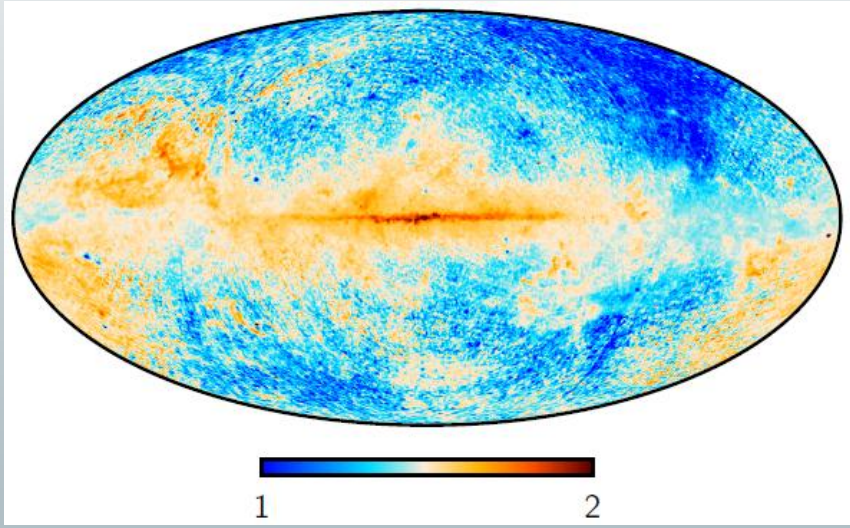


Results

The thermal dust amplitude is estimated at 353 GHz, with a thermodynamic temperature which is assumed to be 18 K +/- 0.05 K

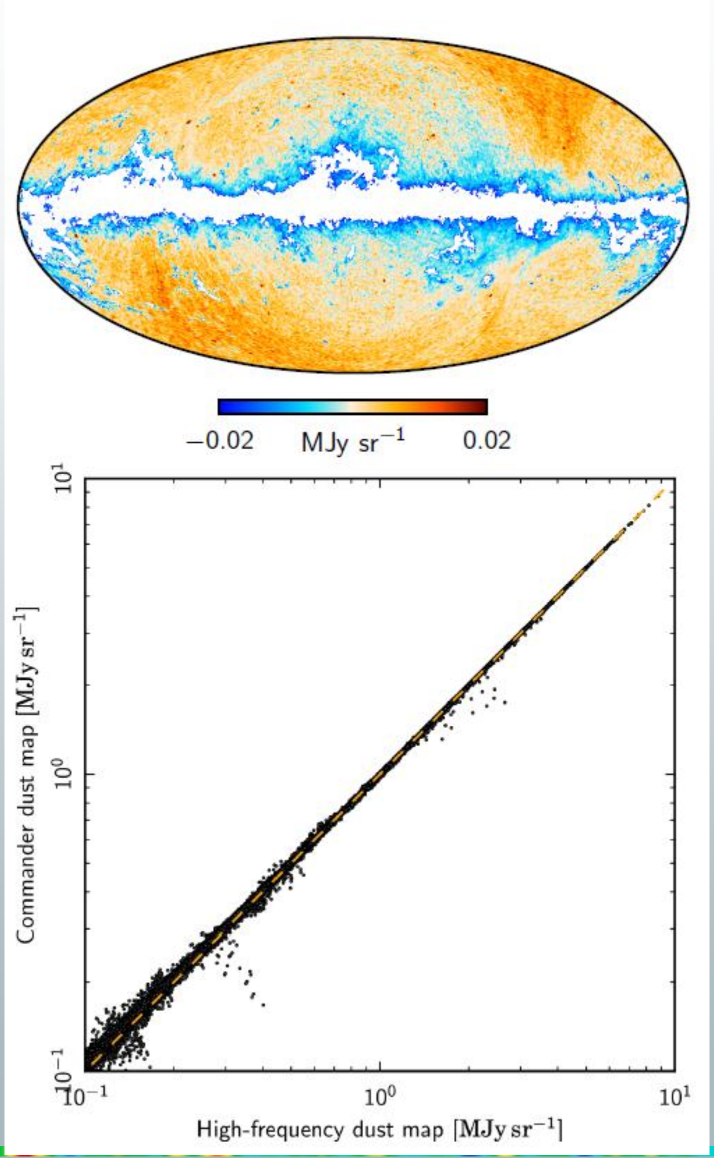
The emissivity reveals large scale features which can be associated to different phases of the interstellar medium





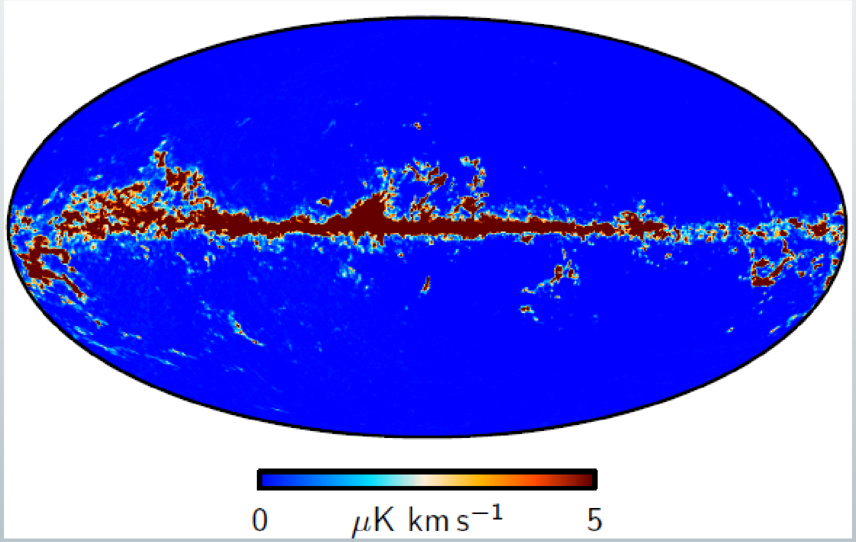
Results

- The thermal optical depth is estimated from high frequency channels (353-857 GHz, see Miville-Deschenes talk)
- Difference is evaluated on a large sky fraction, revealing systematics differences mostly at intermediate Galactic latitudes
- Scatter plots reveal a good correspondance between the two estimations of the dust at 353 GHz

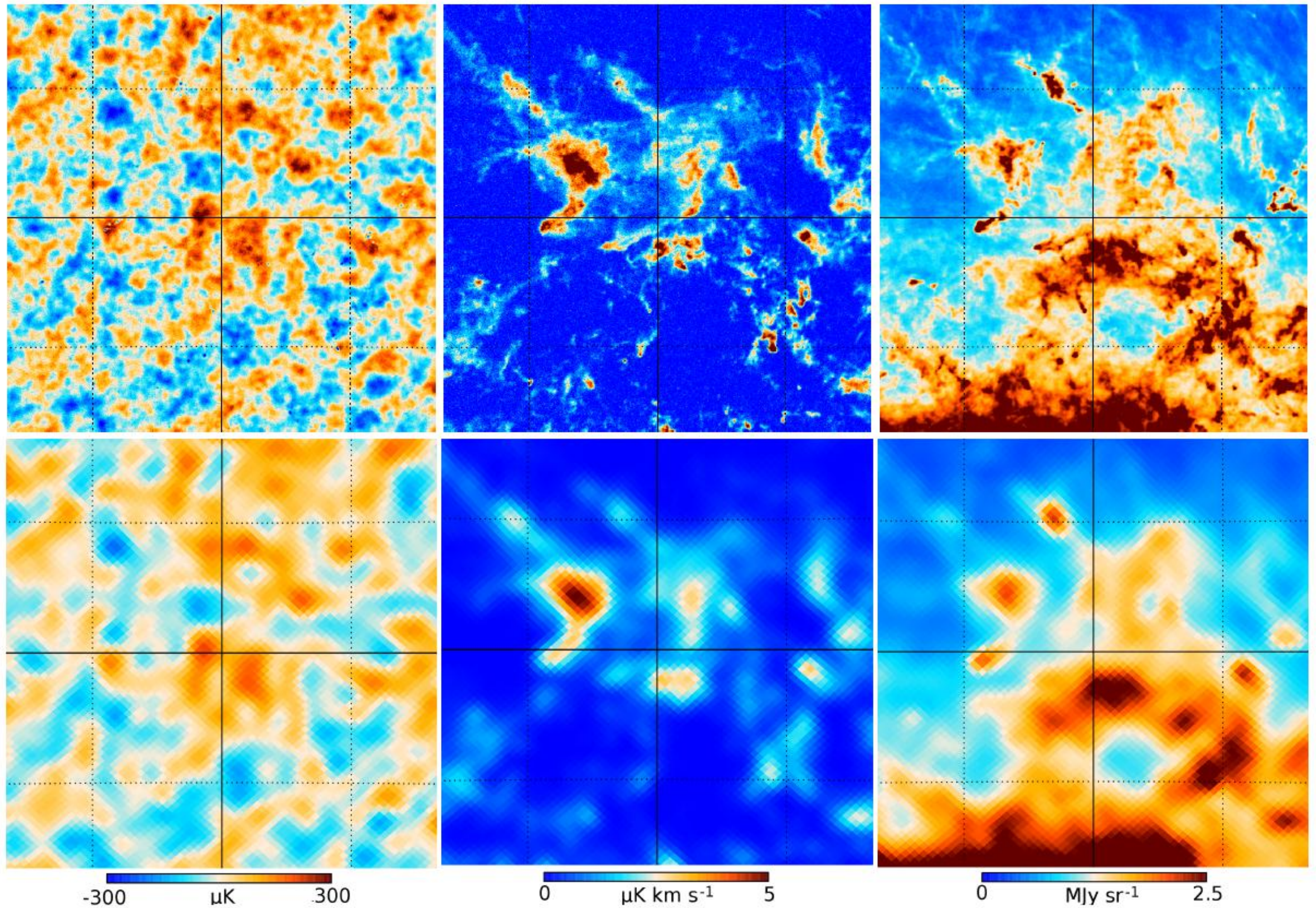


Results

- CO emission is modelled as a constant line ratio over the full sky
- Advantage: high signal to noise ratio
- Disadvantage: systematics uncertainty on CO amplitude per pixel
- Mostly relevant as a driver for follow up CO observations



Results

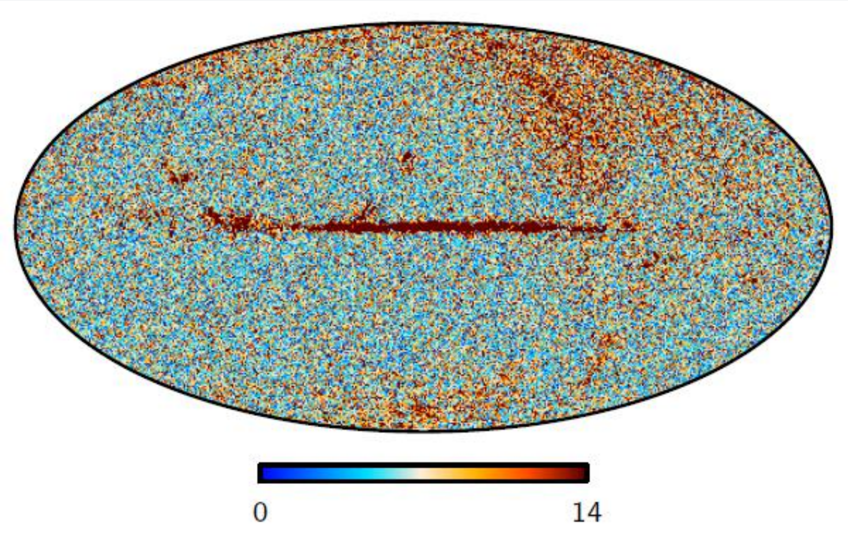


(a) CMB amplitude (b) CO amplitude at 100 GHz (c) Thermal dust amplitude at 353 GHz

A visual comparison of solutions at reduced and full resolution

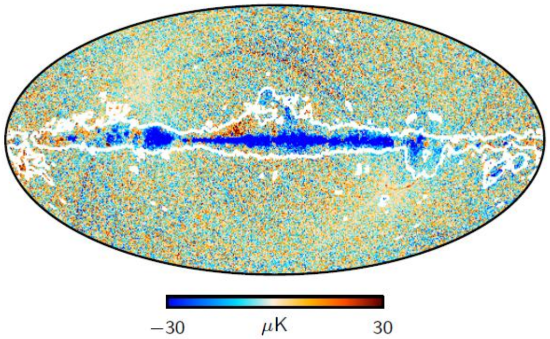
Results

- χ^2 map is used to evaluate uncertainties in the separation process
- Errors are composed by noise uncertainties and separation errors
- Large scale features are classified either as modeling errors (Galactic plane) or as noise correlation features in low foreground regions

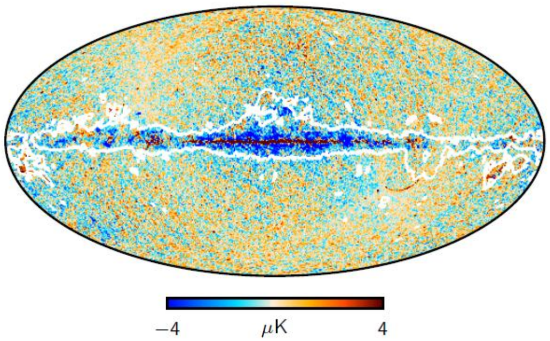


Validation

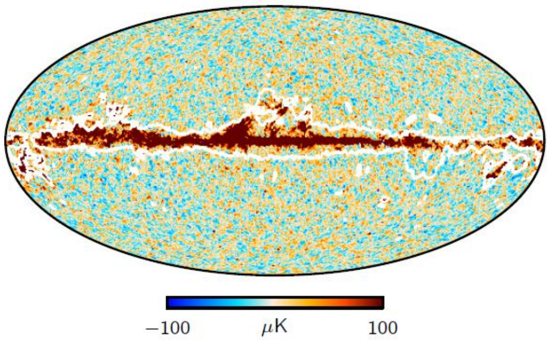
- Direct input/output differences between fitted amplitudes on FFP6 simulations
- Modeling errors are dominant over the Galactic plane
- The white line represents the Commander-Ruler χ^2 derived mask excluding 13% of the sky



(a) Low-frequency component residual at 30 GHz



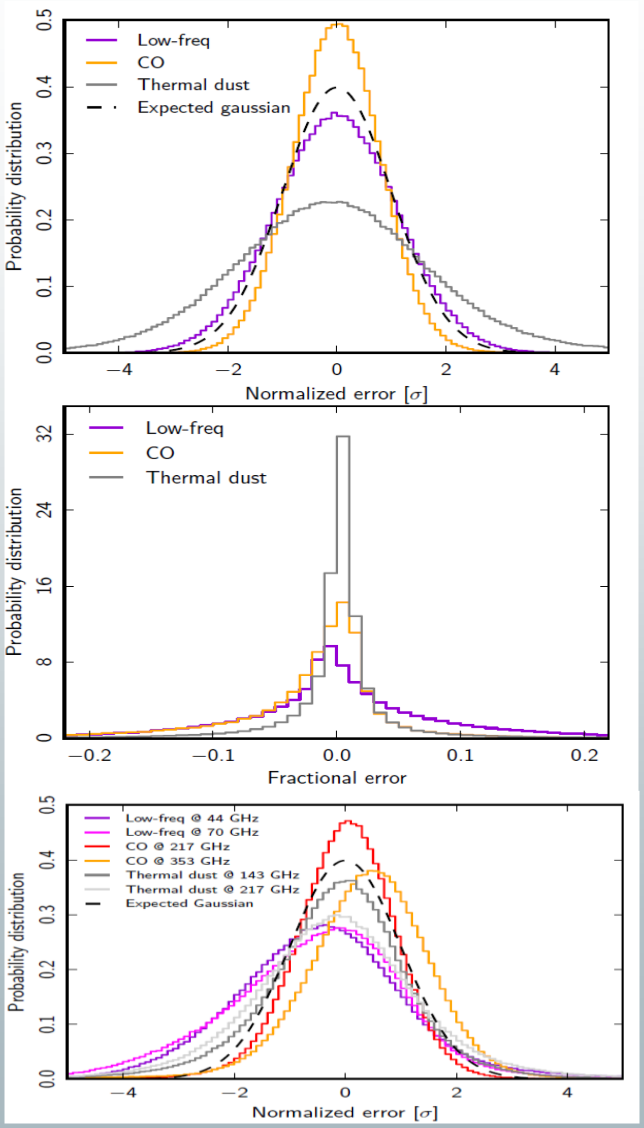
(b) CO residual at 100 GHz



(c) Thermal dust residual at 353 GHz

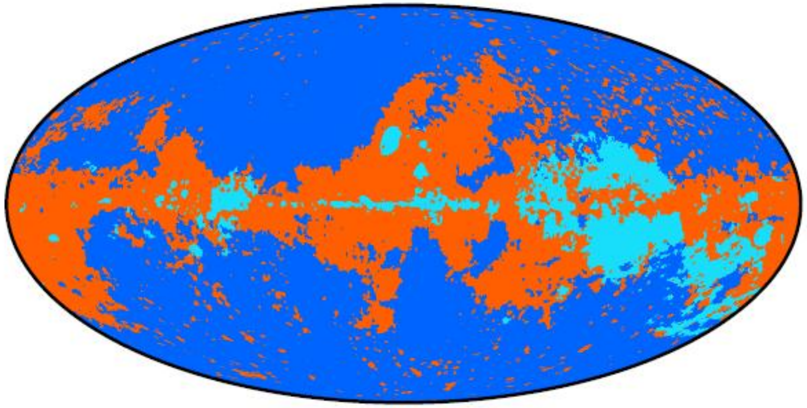
Validation

- Error characterization on FFP6 simulations, on amplitudes and spectral indeces
- Normalized error is plotted for the output and per frequency
- Fractional error is plotted for pixels where the foreground detection is above 5σ

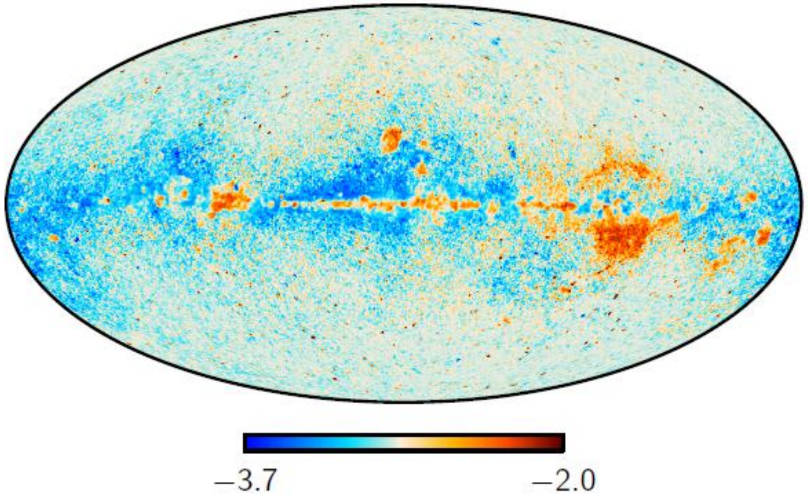


Validation

- Sky regions dominated by single components of the low frequency foregrounds on FFP6, for AME (orange), free-free (light blue), dark blue (synchotron)
- Spectral index recovery reveals correspondence with physical components



(a) Dominant low-frequency component map



(b) Low-frequency component power-law index

Conclusions

- Planck is able to separate diffuse Galactic foregrounds on 87% of the sky, quantifying uncertainties from the separation procedure as well as instrumental noise
- Planck resolves a single low frequency component amplitude and effective spectral index, CO line ratio, and a thermal dust amplitude and emissivity
- An extensive study involving other datasets is necessary for fully exploit the Planck capability of studying the astrophysical properties of foregrounds, in particular at low frequencies