CMB-S4 collaboration meeting

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New PR4 polarized dust maps

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CMB-S4

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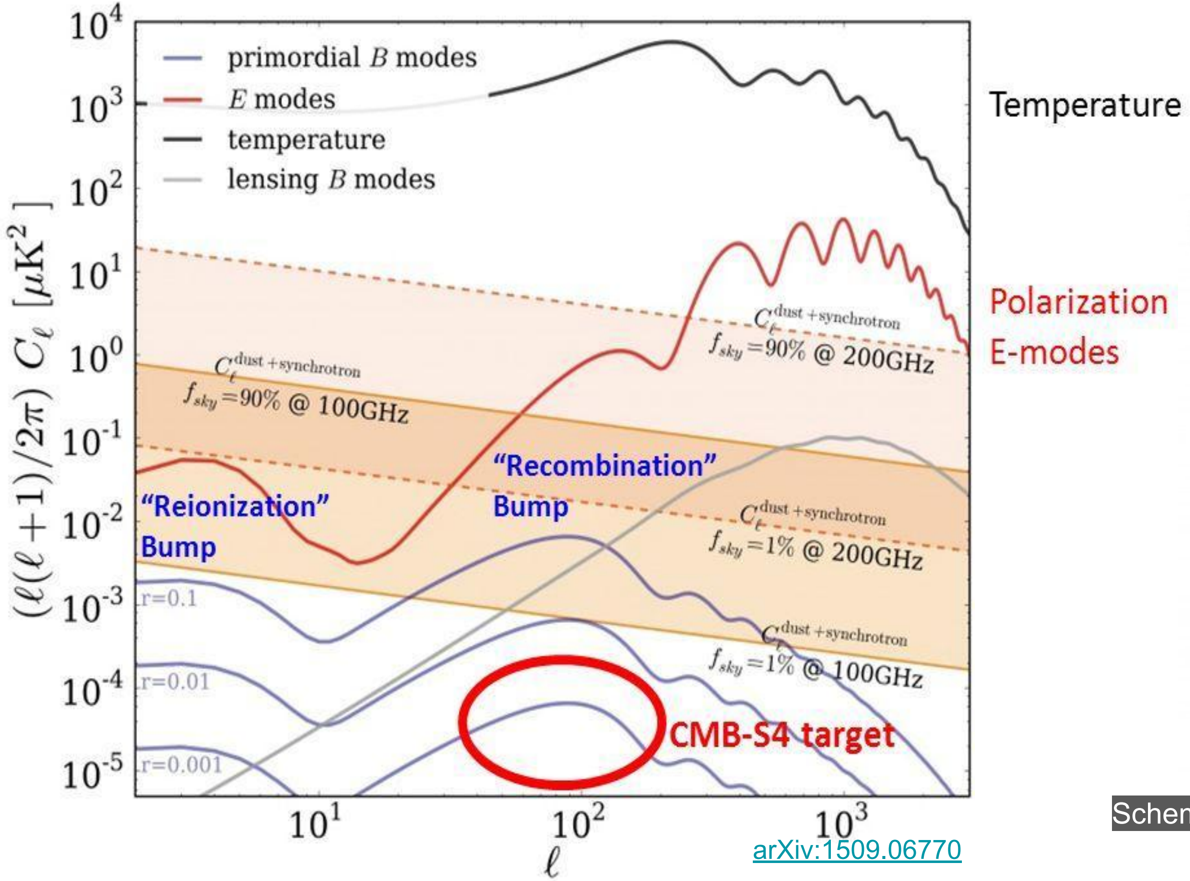
Disclaimer: All the work shown here is preliminary!

Outline

1. Why do we need to revise the foreground maps?
2. Strategy to improve foreground maps: extended-GNILC
3. Results and perspectives

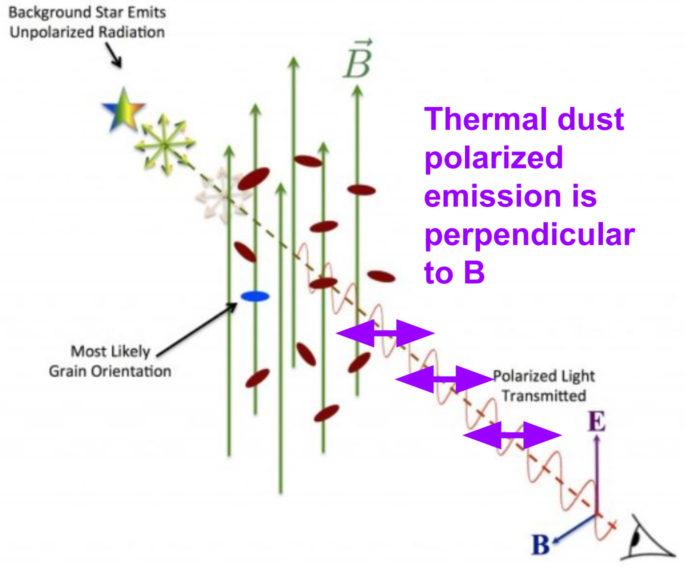
Importance of foreground modeling



arXiv:1509.06770

Power spectra of theoretical CMB signal and foregrounds

Focus of this talk:
Polarized dust emission



Schematic view of the origin of the polarized dust emission

Pasiphae

State of the art of foreground maps

- Official polarized dust Planck PR3 products (A&A 641 (2020)):
  - Commander (+PR4)
  - SMICA
  - GNILC (A&A 596, A109 (2016)): single and variable resolution maps

In this talk, focus on comparison with GNILC PR3 product

What can be improved?

- GNILC PR3 maps resolution for polarized dust is low (60–80 arcmin) in cleanest sky regions

⇒ We want high resolution and high SNR maps to better characterize the foreground emissions!

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Improving dust models: Method

<u>Goal:</u> Obtain a better polarized dust emission map: in resolution and SNR

<u>xGNILC method:</u>

- GNILC goal: reconstruct the diffuse emission of a complex component originating from correlated emission sources
- Basic idea: compute a signal-to-noise ratio to conduct a PCA locally in space and angular scale using a needlet (spherical wavelet) decomposition
- **xGNILC** (shown at yesterday's JSAC talk!): Extended GNILC implementation in Python, by Shamik Ghosh (arXiv:2312.07816)
- Specificity of xGNILC: Prior assumption of a parametric model for regions with low SNR

<u>Observations for this analysis:</u>

- Planck 30 GHz (for sync) + HFI 100−353 GHz

Improving dust models: Pipeline

<u>Goal:</u> Obtain a better polarized dust emission map: in resolution and SNR

1) Signal maps:
    a) Subtract from PR4 frequency maps Wiener filtered CMB map
    b) Mask the galactic plane + inpaint bright polarized sources
2) Nuisance maps:
    a) Residual CMB
    b) Instrumental noise
3) Put all these maps in KRJ
4) Perform xGNILC with 3 needlet bands
5) Recombine needlets into polarized galactic signal E, B maps at 10 arcmin

GNILC PR3 vs xGNILC PR4

Differences between GNILC PR3 and xGNILC PR4

	GNILC PR3	xGNILC PR4
Input maps	PR3	PR4 (less noisy)
Processing pipeline: needlet regions with low SNR	GNILC: Throw away	xGNILC: Use of a prior: MBB with T = 19.6K and β = 1.5 (A&A 641 A11 (2020))

Single resolution at 80 arcmin

Variable resolution in function of SNR in regions of sky

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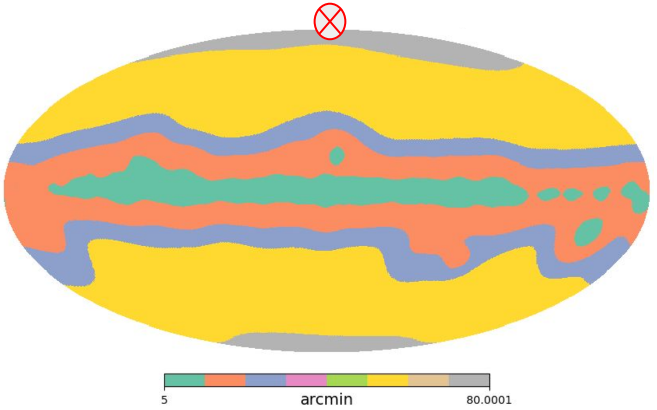
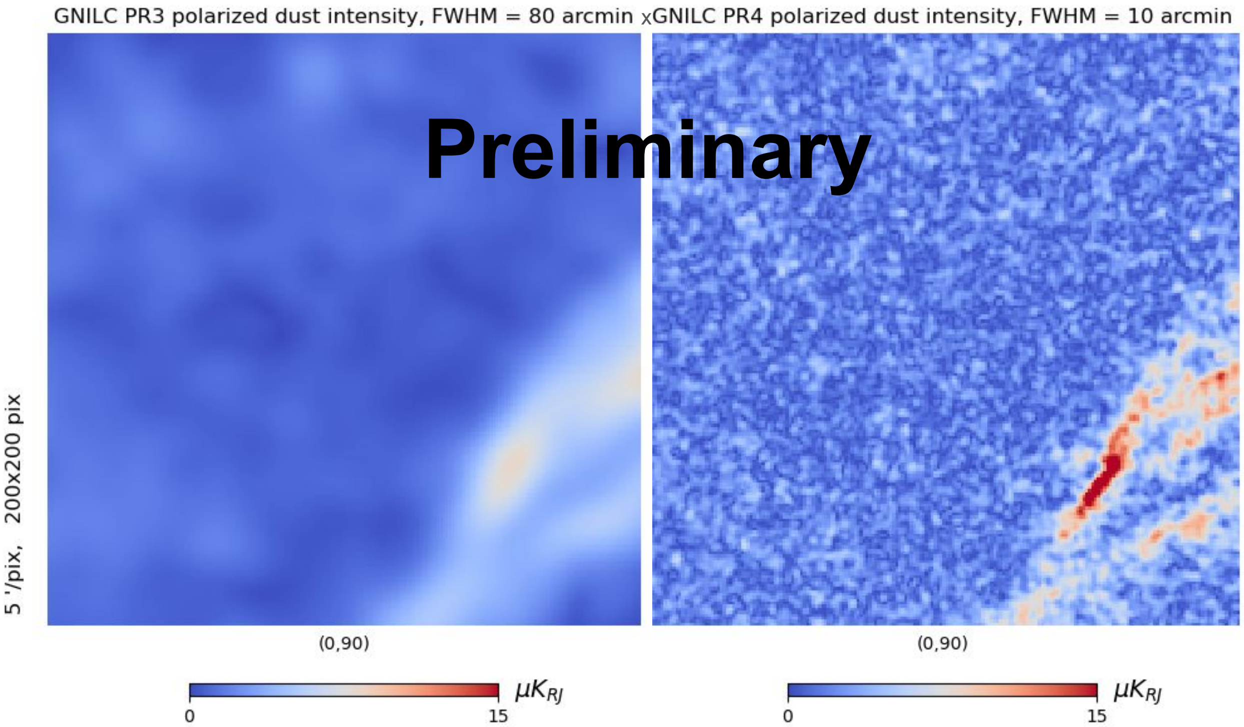
Map-based comparison: 80 arcmin VS 10 arcmin

→ GNILC PR3 variable resolution and **xGNILC PR4**

80 arcmin



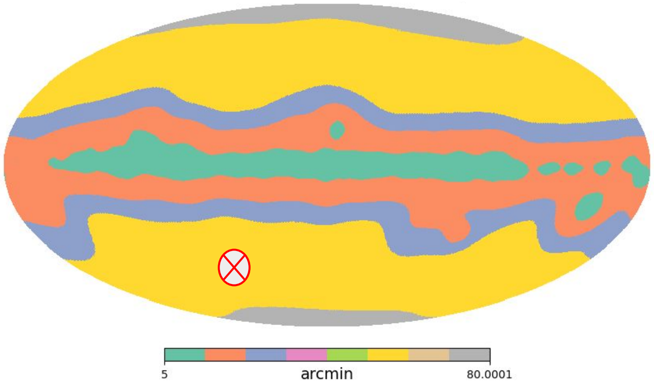


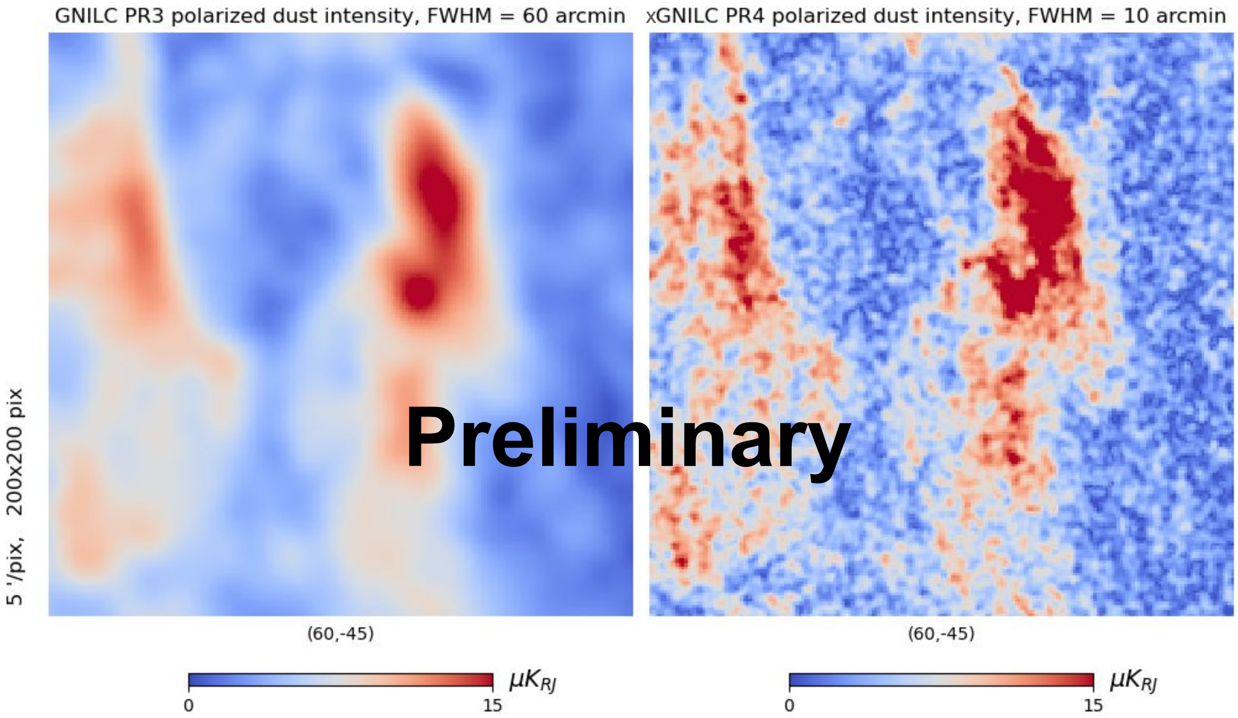
Polarized intensity 16°x16° patch, centered at the North Galactic Pole:
Left: PR3 at 80 arcmin, Right: **PR4 at 10 arcmin**

Map-based comparison: 60 arcmin VS 10 arcmin

⟶ GNILC PR3 variable resolution and **xGNILC PR4**

60 arcmin

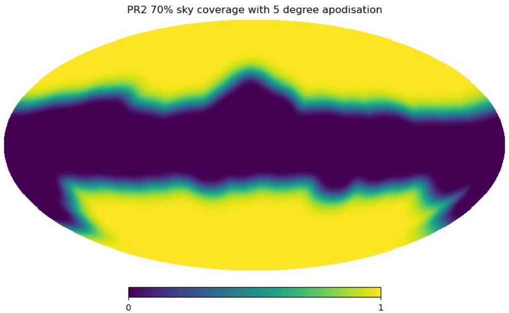


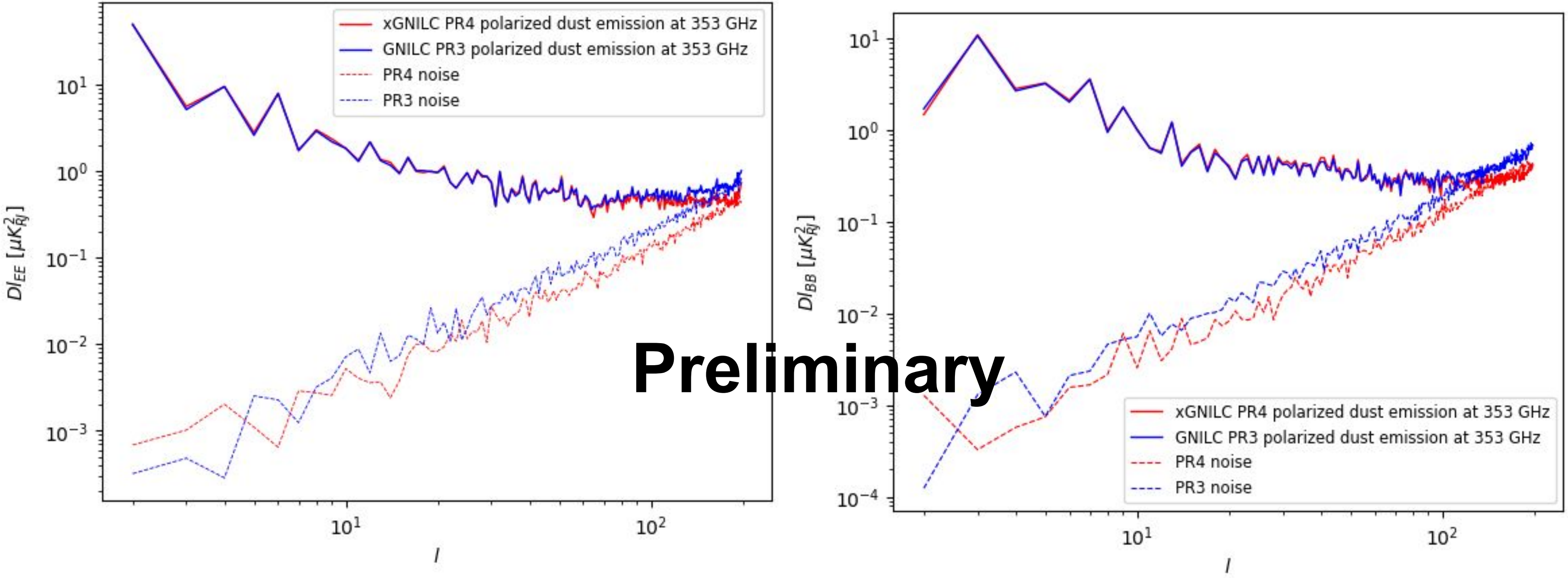


Polarized intensity 16°x16° patch, centered at the [60, -45]:
Left: PR3 at 60 arcmin, Right: **PR4 at 10 arcmin**

Power spectra comparison

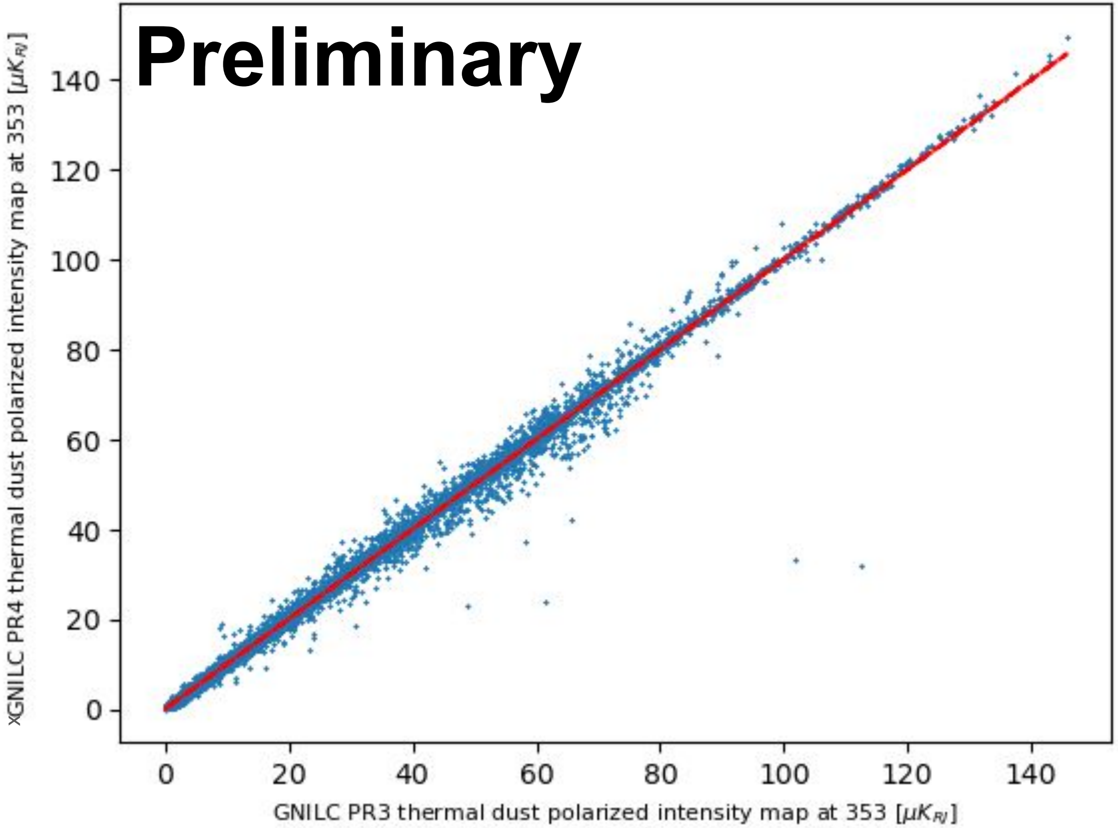
→ GNILC PR3 single resolution and xGNILC PR4: 80 arcmin

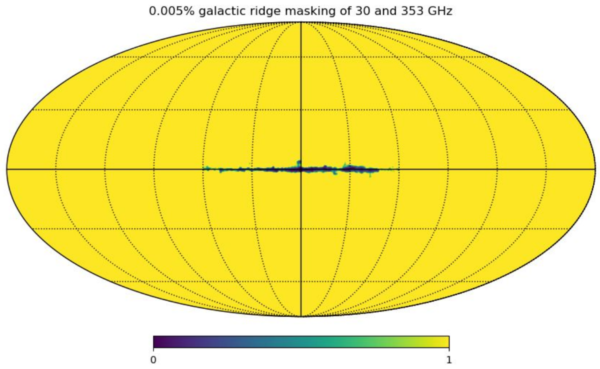




EE and BB autospectra GNILC PR3 vs xGNILC PR4 polarized dust map at 353 GHz

Consistency between GNILC PR3/PR4





⇒ Good agreement between GNILC PR3 and xGNILC PR4

P-P scatter plot between the thermal dust polarization amplitude GNILC PR3 vs xGNILC PR4 at 353 GHz

Conclusion and perspectives

- Higher angular resolution xGNILC PR4 polarized dust maps
- At the same resolution, lower noise at high ell due to PR4
- Next steps:
  - Obtain less noisy products at high resolution
  - Estimate the spectral index and temperature in patches to account for spatial variation for the prior used in low SNR regions

- CMB-S4: Future high resolution polarized dust emission templates for the Panex group