

Galactic dust as seen by *Planck*

Planck Collaboration

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Dust as a tracer of matter

- ★ Dust is well mixed with the gas – traces the structure of the ISM (HI, H₂ and HII)

Planck

All-sky survey of sub-mm/mm dust emission *dust column density and dust properties*

- ★ Relation between dust emission, extinction and gas column density
- ★ Variations of the spectral energy distribution of dust across the sky – nature of the dust particles and their evolution



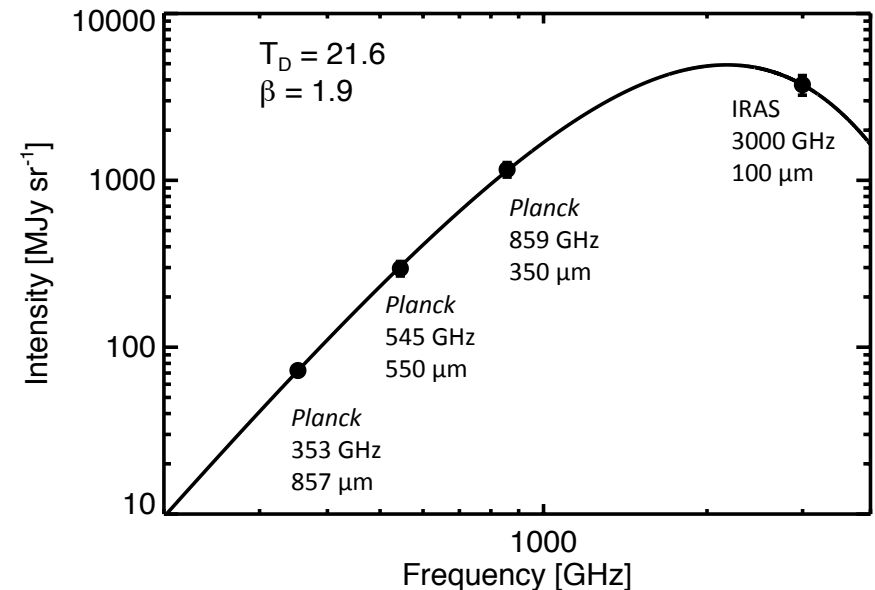
Dust emission

Model the 353 – 3000 GHz (IRAS), 100 – 850 μm ,
emission: dominated by the largest ($> 0.05 \mu\text{m}$)
grains, which are in equilibrium with the ISRF

$$I_\nu = \tau_{\nu_0} B_\nu(T_{\text{obs}}) \left(\frac{\nu}{\nu_0} \right)^{\beta_{\text{obs}}}$$

$$I_\nu = \kappa_0 (\nu/\nu_0)^\beta r \mu m_{\text{H}} N_{\text{H}} B_\nu(T)$$

$$\tau_{353} = \frac{I_{353}}{B_{353}(T)}$$



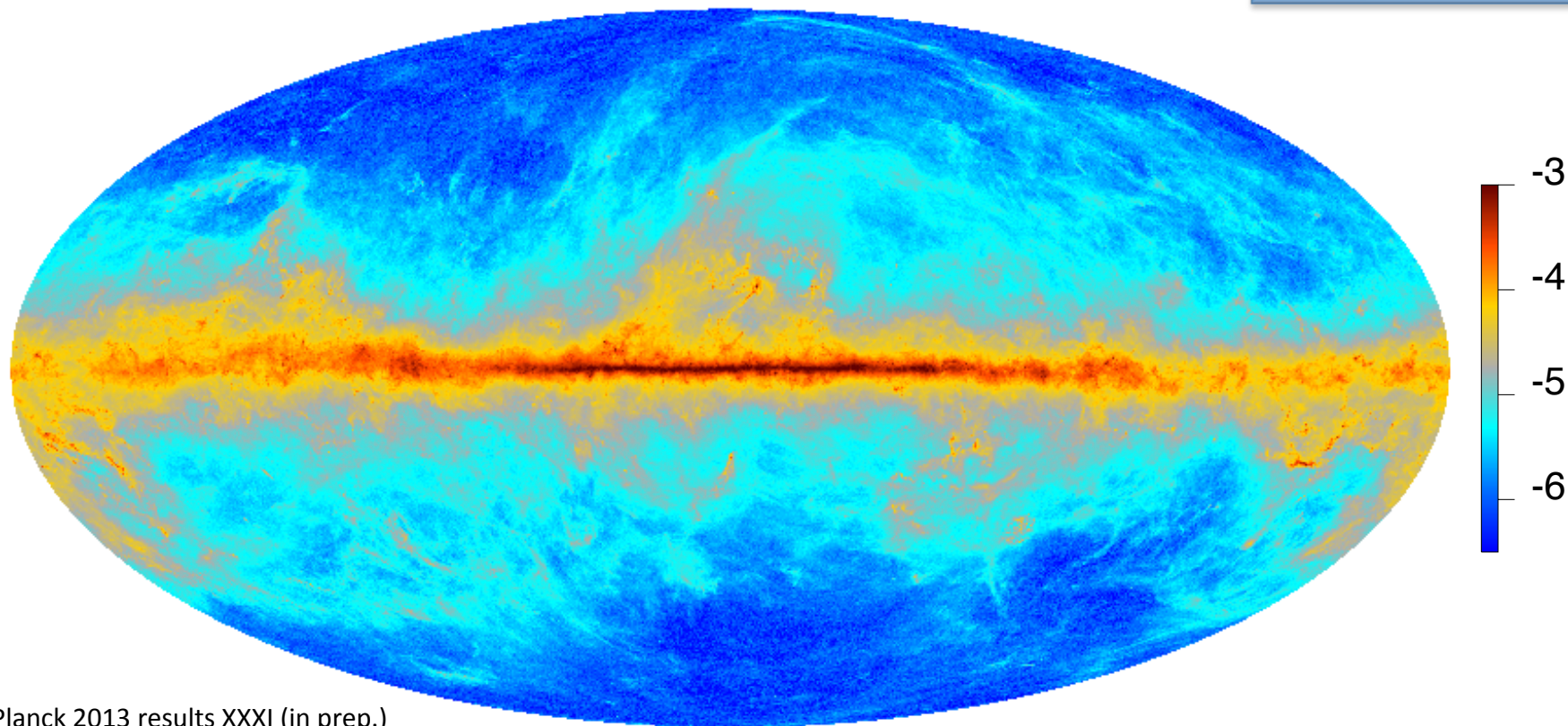


Dust optical depth

http://www.sciops.esa.int/index.php?project=planck&page=Planck_Legacy_Archive

Available in the Planck
Legacy Archive

$$\tau_{\nu} = \sigma_e(\nu) N_{\text{H}}$$



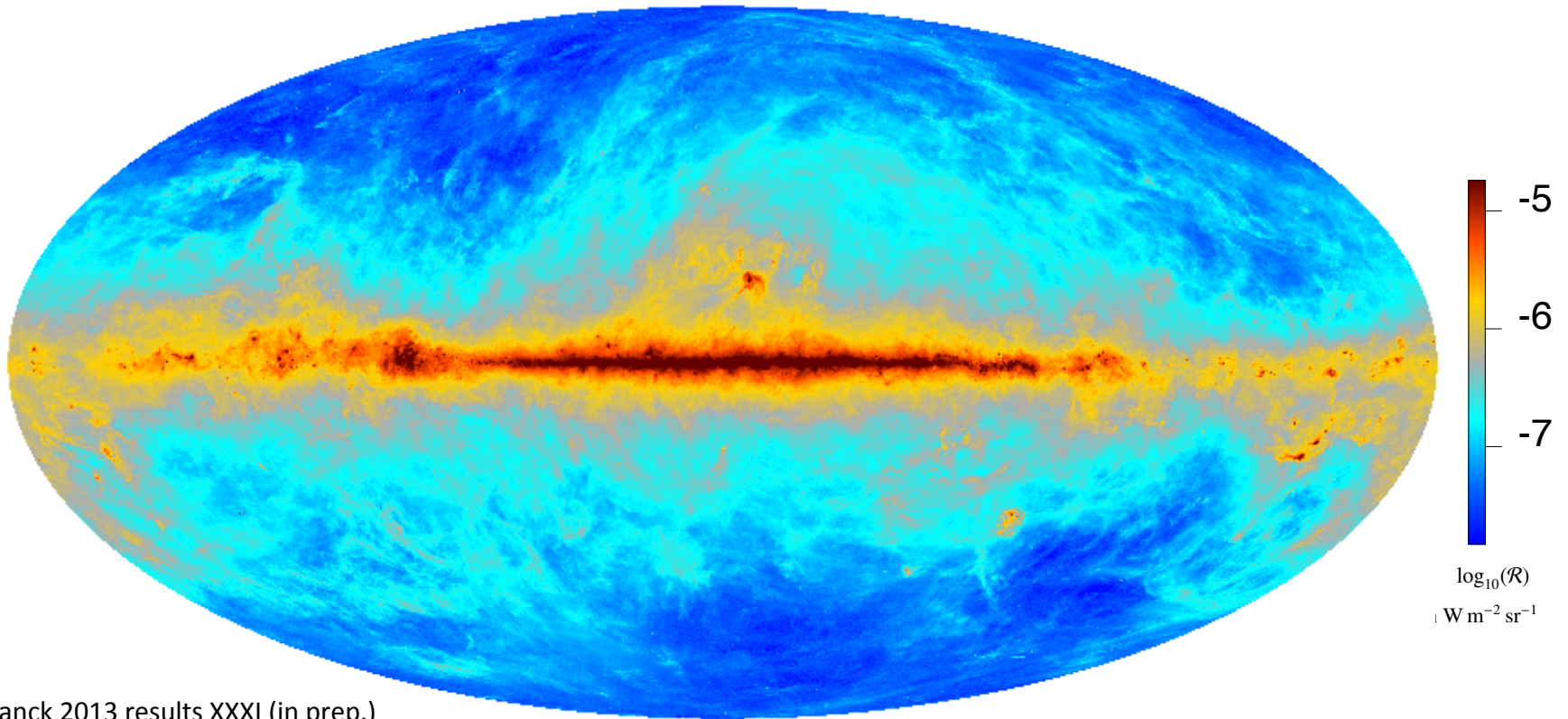
Planck 2013 results XXXI (in prep.)

Converted to E(B-V) by comparison with quasar reddening (SDSS).



Dust radiance

$$\mathcal{R} = \int_{\nu} I_{\nu} d\nu \propto U \overline{\sigma_a} N_{\text{H}}$$



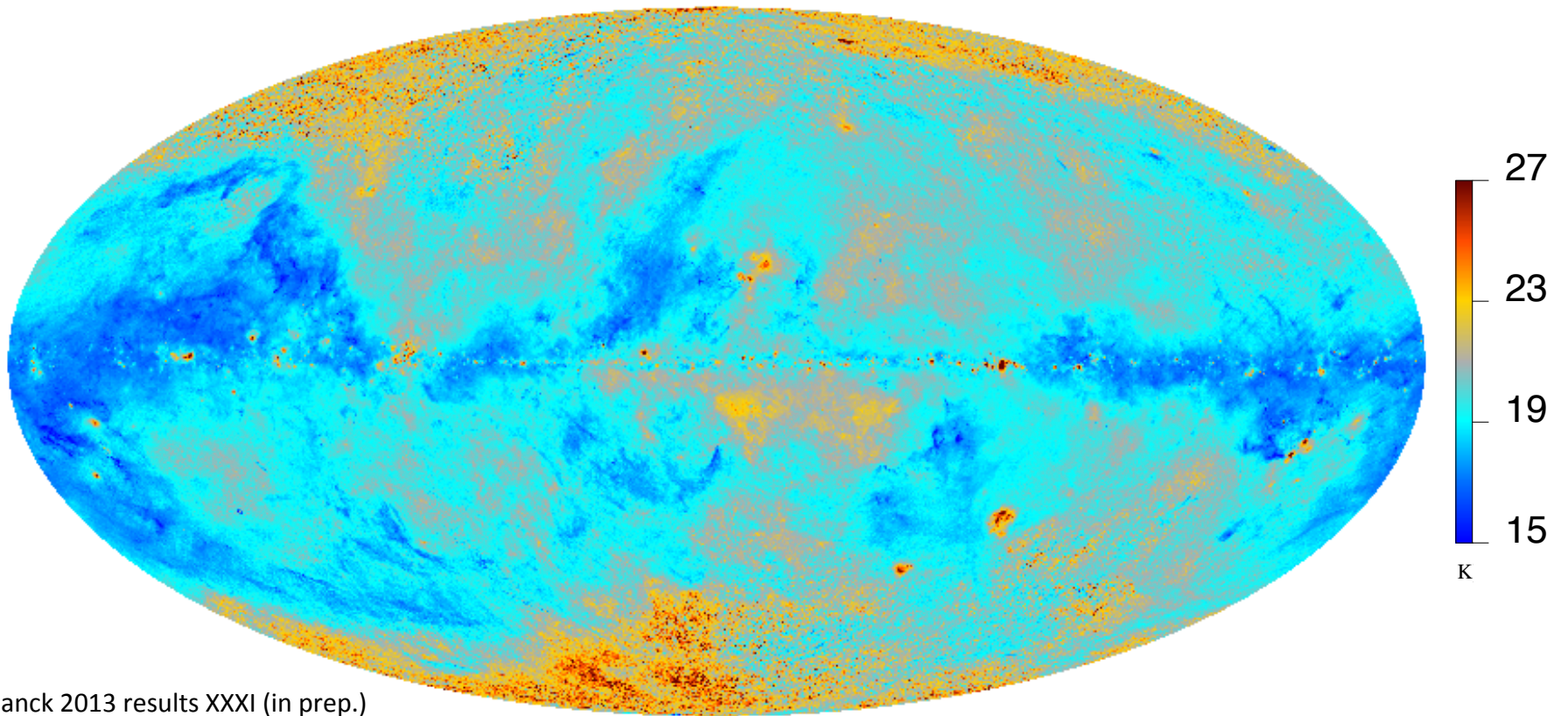
Planck 2013 results XXXI (in prep.)

Converted to E(B-V) by comparison with quasar reddening (SDSS).



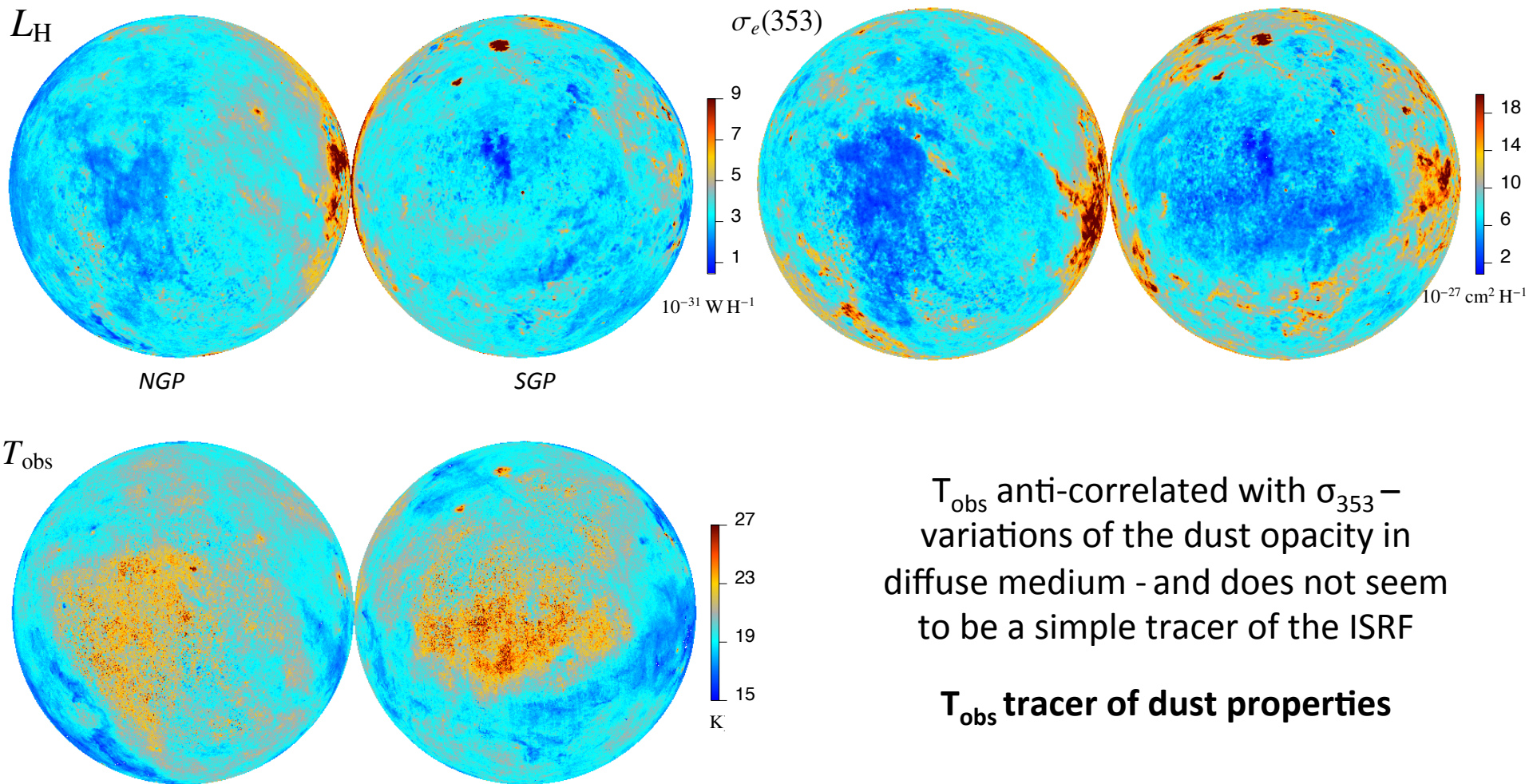
Observed dust temperature

Available in the Planck
Legacy Archive





Radiance vs optical depth



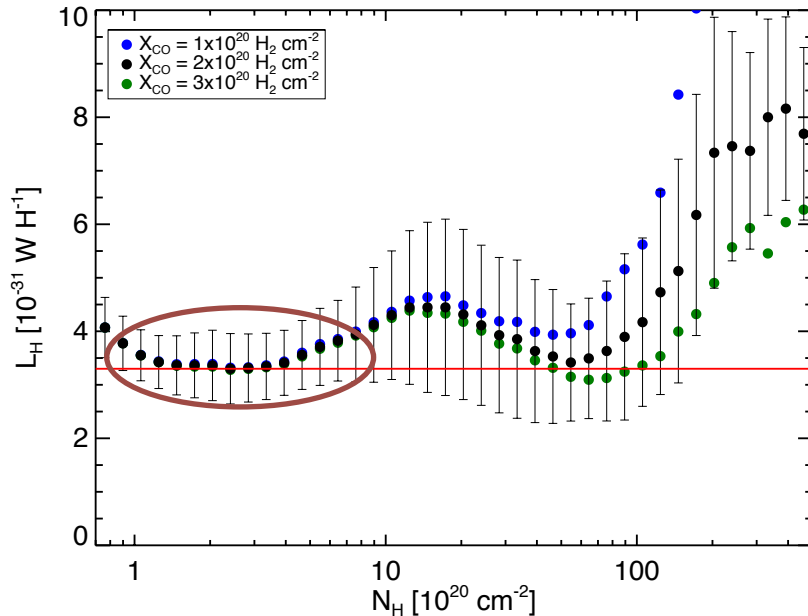
T_{obs} anti-correlated with σ_{353} –
variations of the dust opacity in
diffuse medium - and does not seem
to be a simple tracer of the ISRF

T_{obs} tracer of dust properties

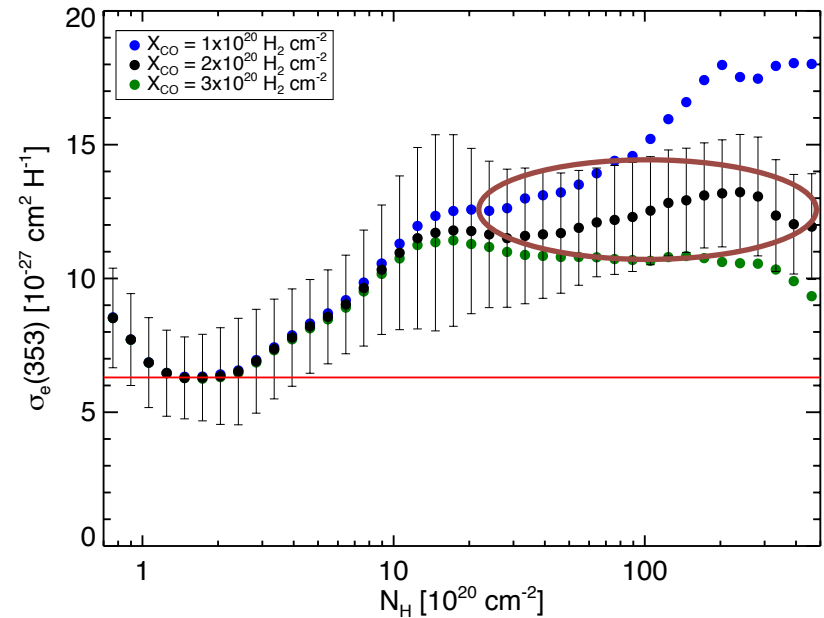


Radiance vs optical depth

(HI + CO + DG) / (HI + CO)



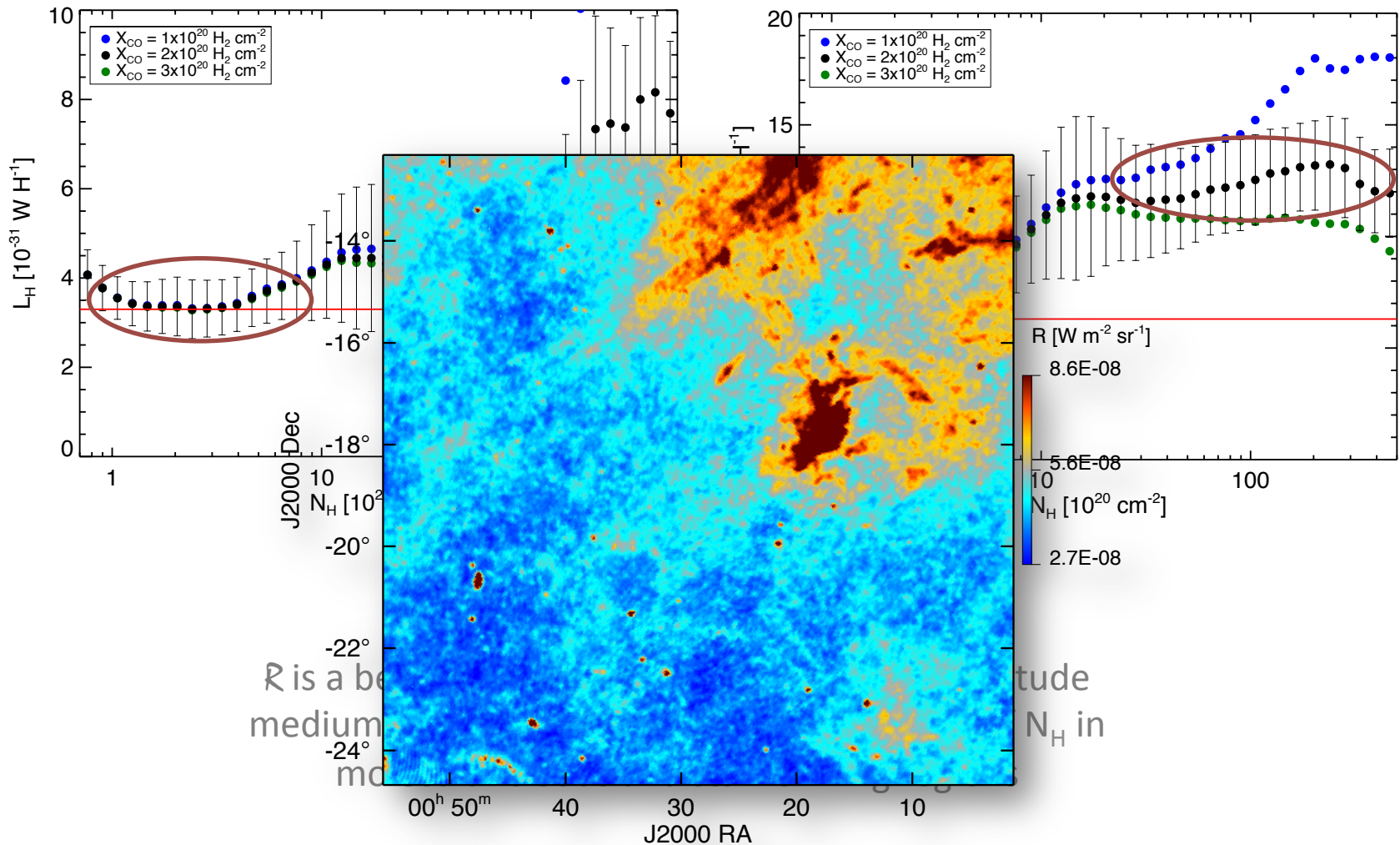
HI + CO



$\mathcal{R}$ is a better tracer of N_H in the diffuse high latitude medium, whereas τ_{353} holds as a good tracer of N_H in molecular clouds and star forming regions



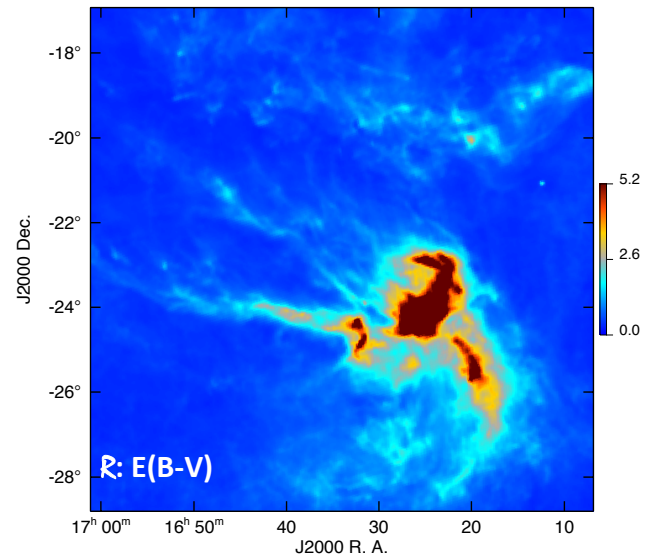
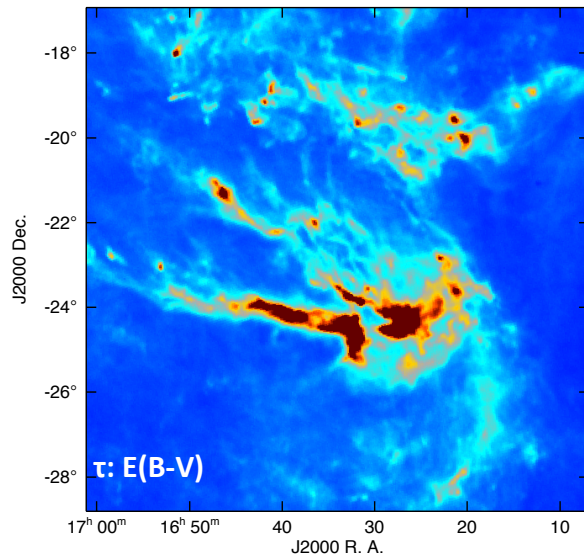
Radiance vs optical depth



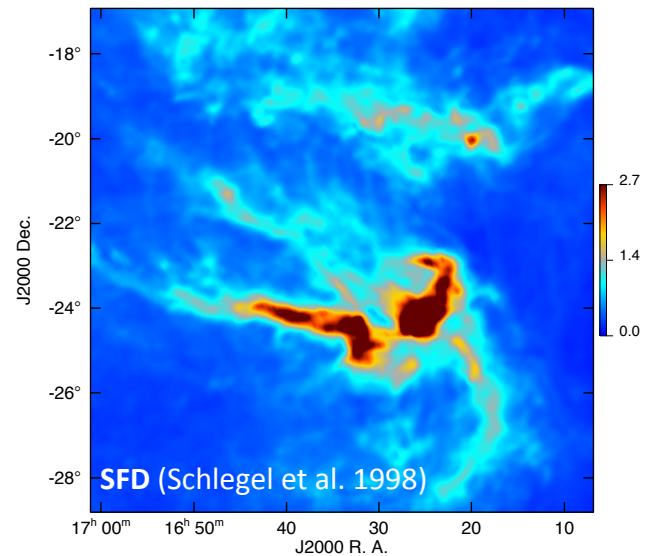
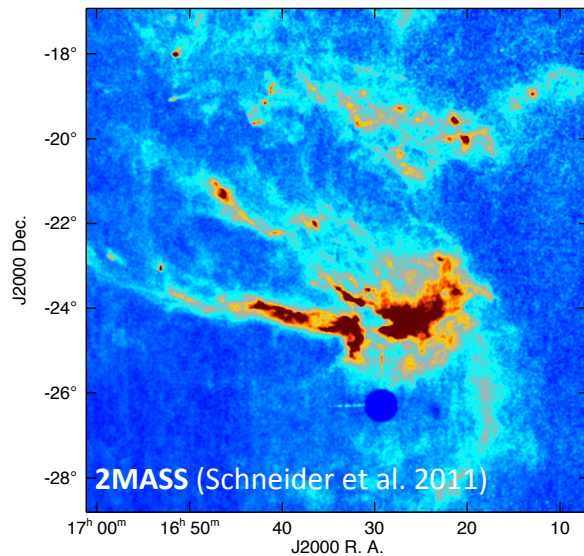


Extended view of nearby molecular clouds

Rho Ophiucus
molecular cloud



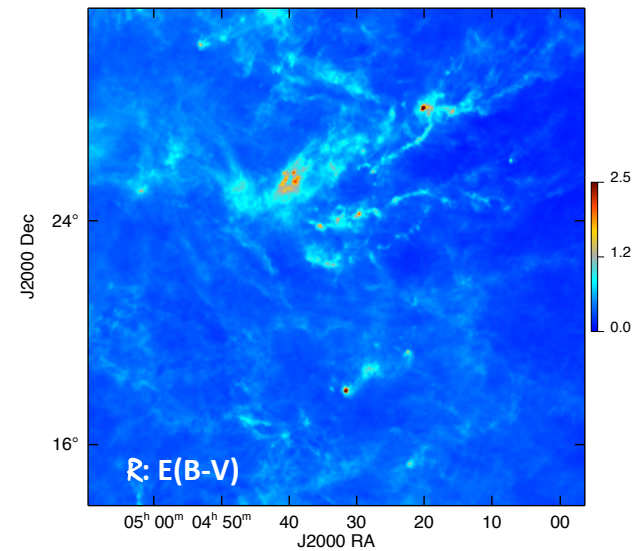
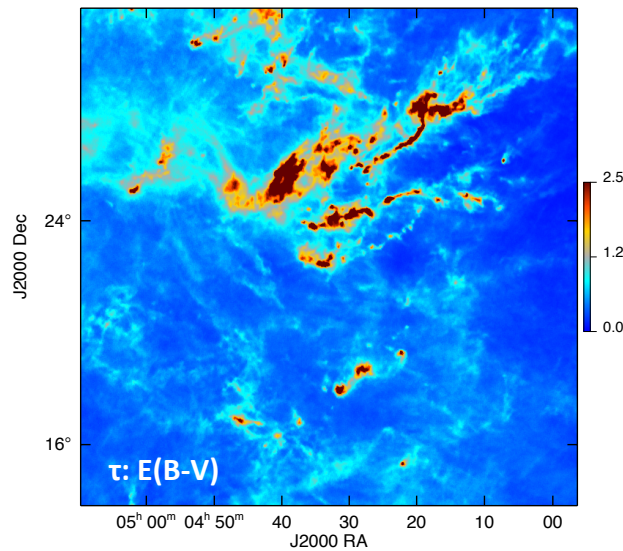
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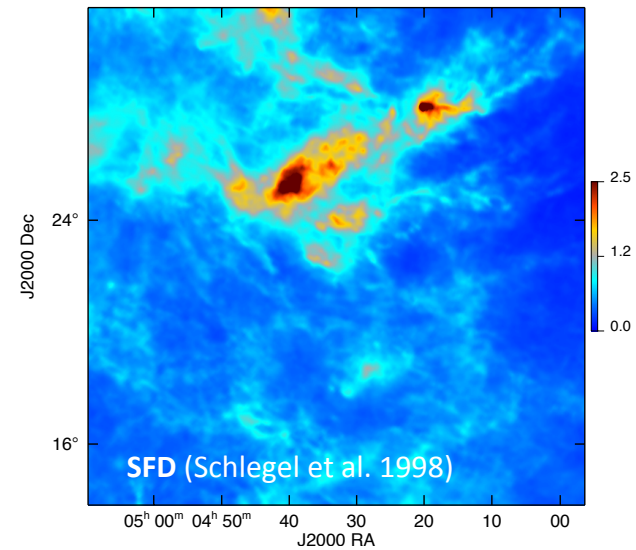
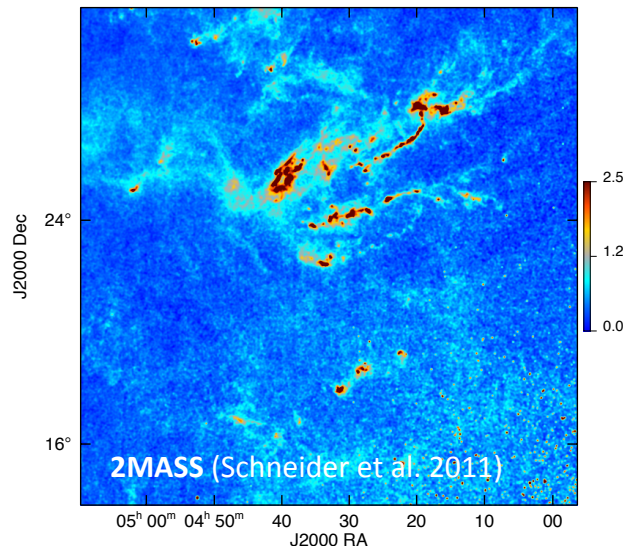


From dust emission to extinction

Taurus
molecular cloud

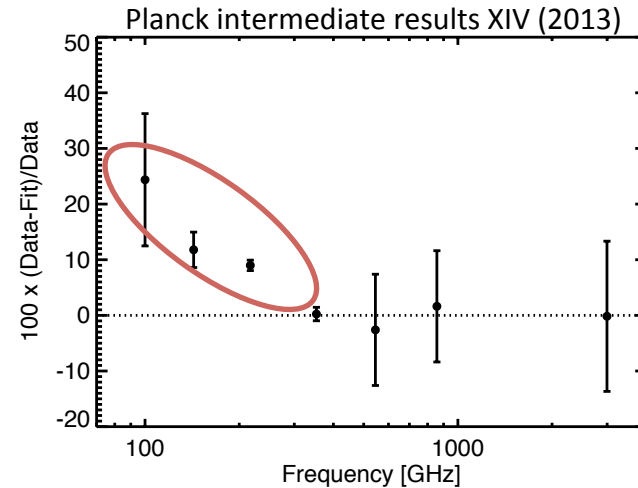
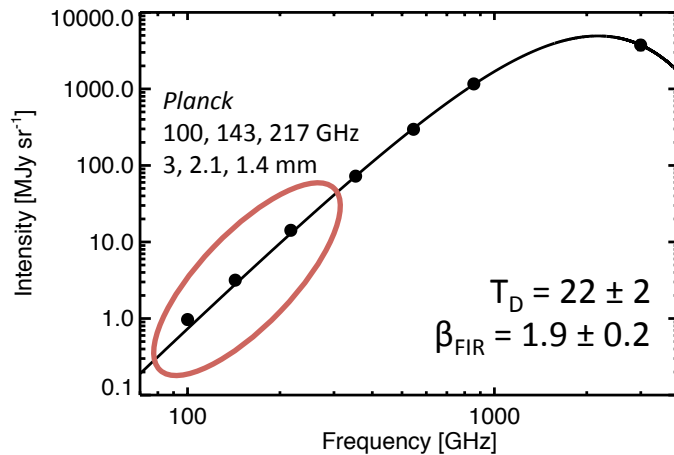


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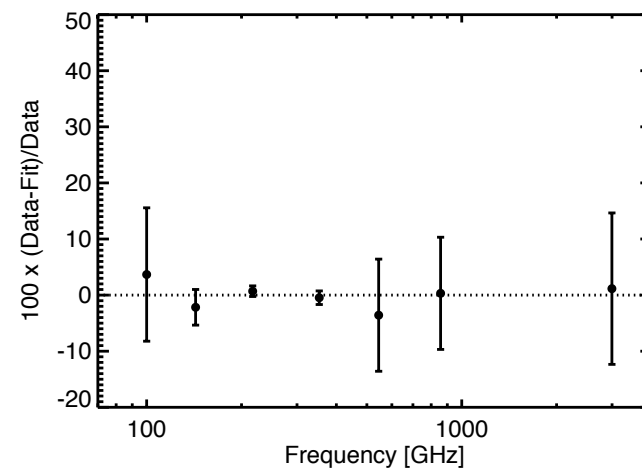
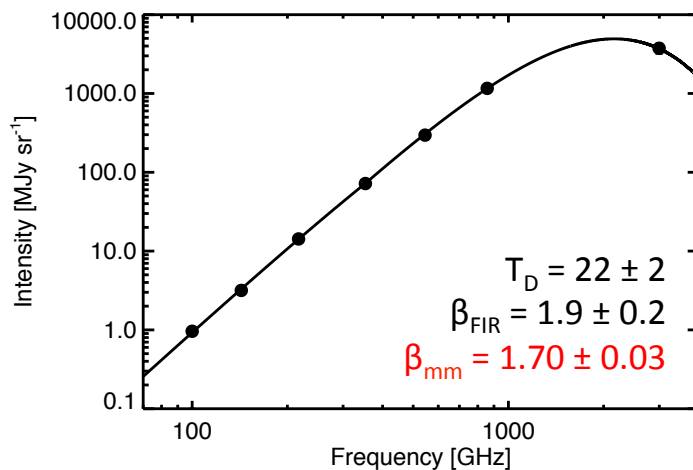




Dust SED down to mm wavelengths



Flattening of the dust SED at mm wavelengths in all environments
(cirrus, molecular clouds, Galactic plane)





A new physical dust model

Compiègne et al. (2011) and Draine & Li (2007) models

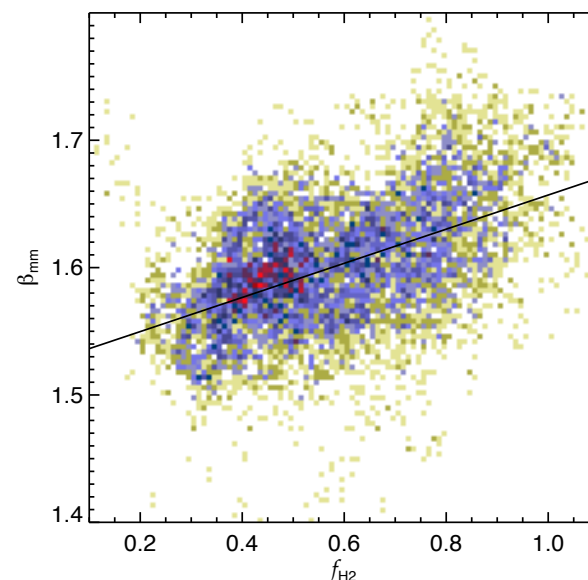


Models suggested to explain the flattening of the dust emission (e.g. Meny et al. 2007, Draine & Hensley 2013, Jones et al. 2013) → *polarization data*

Increase of the opacity by a factor of two in dense medium – explained by existing models (Stepnik et al. 2003, Köler et al. 2012) – however these *cannot* explain the variations observed in the diffuse medium

Neither they predict a **variation of the mm spectral index from atomic to molecular media** - evolution of carbon dust within the ISM (Jones 2012, Jones et al. 2013)

Planck intermediate results XIV (2013)



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.