Models of Taurus and Orion filaments

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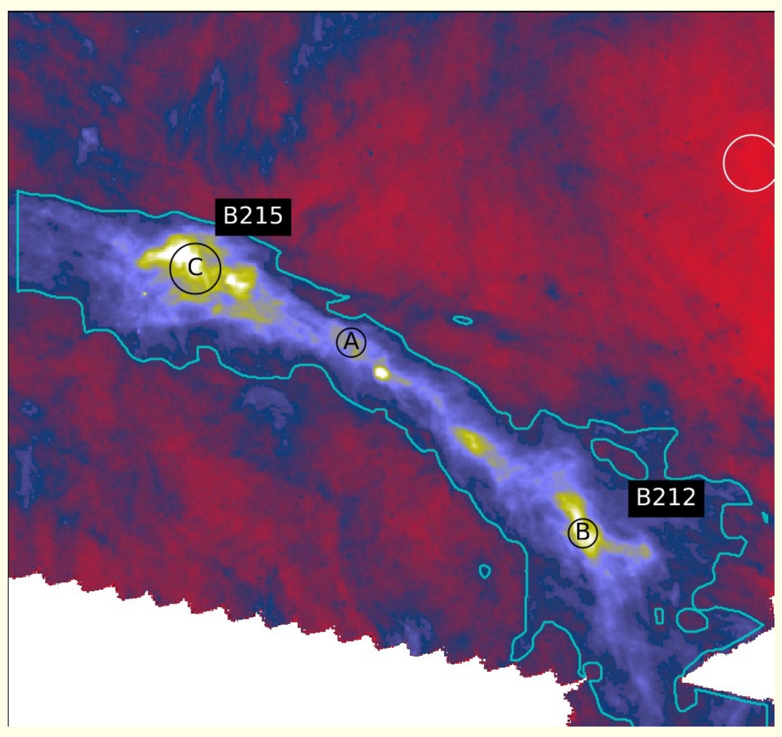
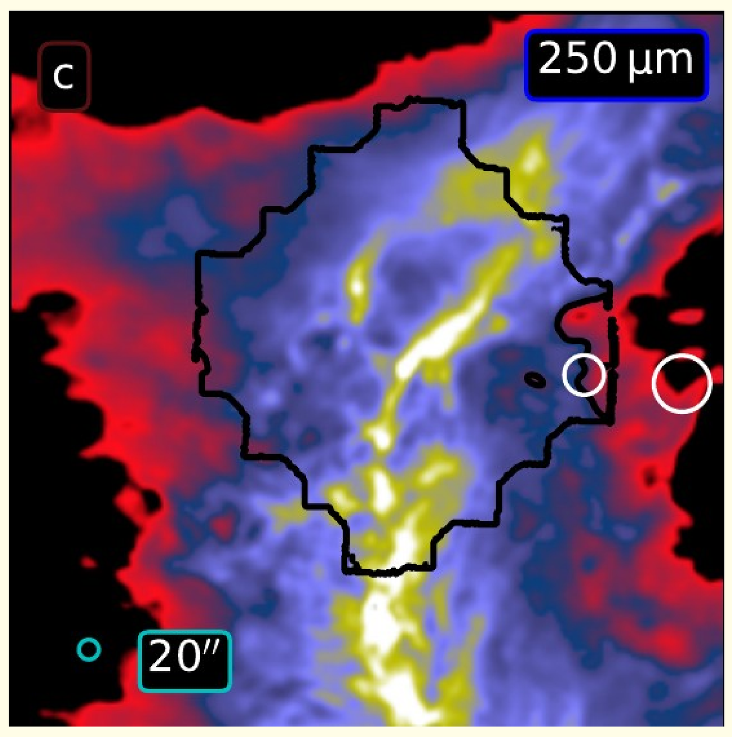
We have studied dust emission in two well-known filamentary clouds. The **LDN 1506** field in Taurus has a filament and starless cores. The Orion Molecular Cloud 3, **OMC-3**, is in comparison a more massive region of star formation, but is still one of the most quiescent parts of the Orion cloud A. The predictions of 3D radiative transfer models were compared to Herschel far-infrared (FIR) maps and the near-infrared (NIR) extinction derived from background stars.

The LDN 1506 models are sensitive to the assumed line-of-sight cloud extent and the radiation field spectrum. Data are consistent with a factor of 2-3 increase in the dust FIR opacity relative to diffuse clouds, but with only weak evidence for dust property variations within the field. The mass estimates can differ almost by an order of magnitude, depending on the assumed dust properties.

The OMC-3 models are less sensitive to the cloud shape, due to the higher column density and radiation field. The combined FIR and NIR data are best matched with grains $a \leq 0.3$ µm. The NIR extinction is mostly correlated with FIR emission, excluding larger grain sizes. However, the NIR extinction map is relatively flat over the central ridge, a possible sign of further grain growth.

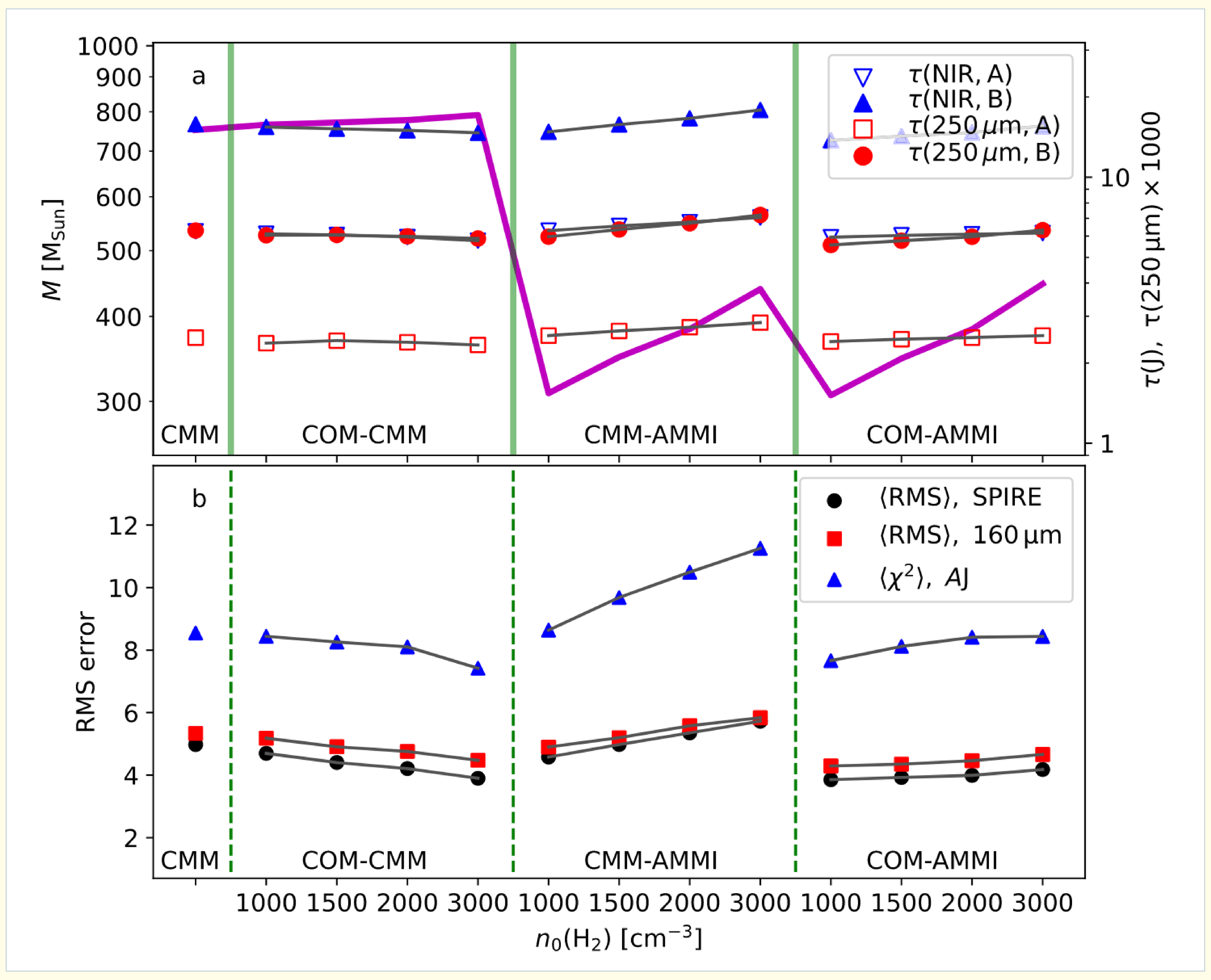




LDN 1506

The figure below shows results for some 3D models that were fitted to the FIR Herschel observations (Juvela 2024). These use the Compiegne et al. (2011) dust model (COM) and the THEMIS models for core-mantle-mantle (CMM) and aggregate grains with ice mantles (AMMI; Jones et al. 2017). We also examined models where the dust properties change as a function of density. For example CMM-AMMI means a change from CMM to AMMI at higher densities.

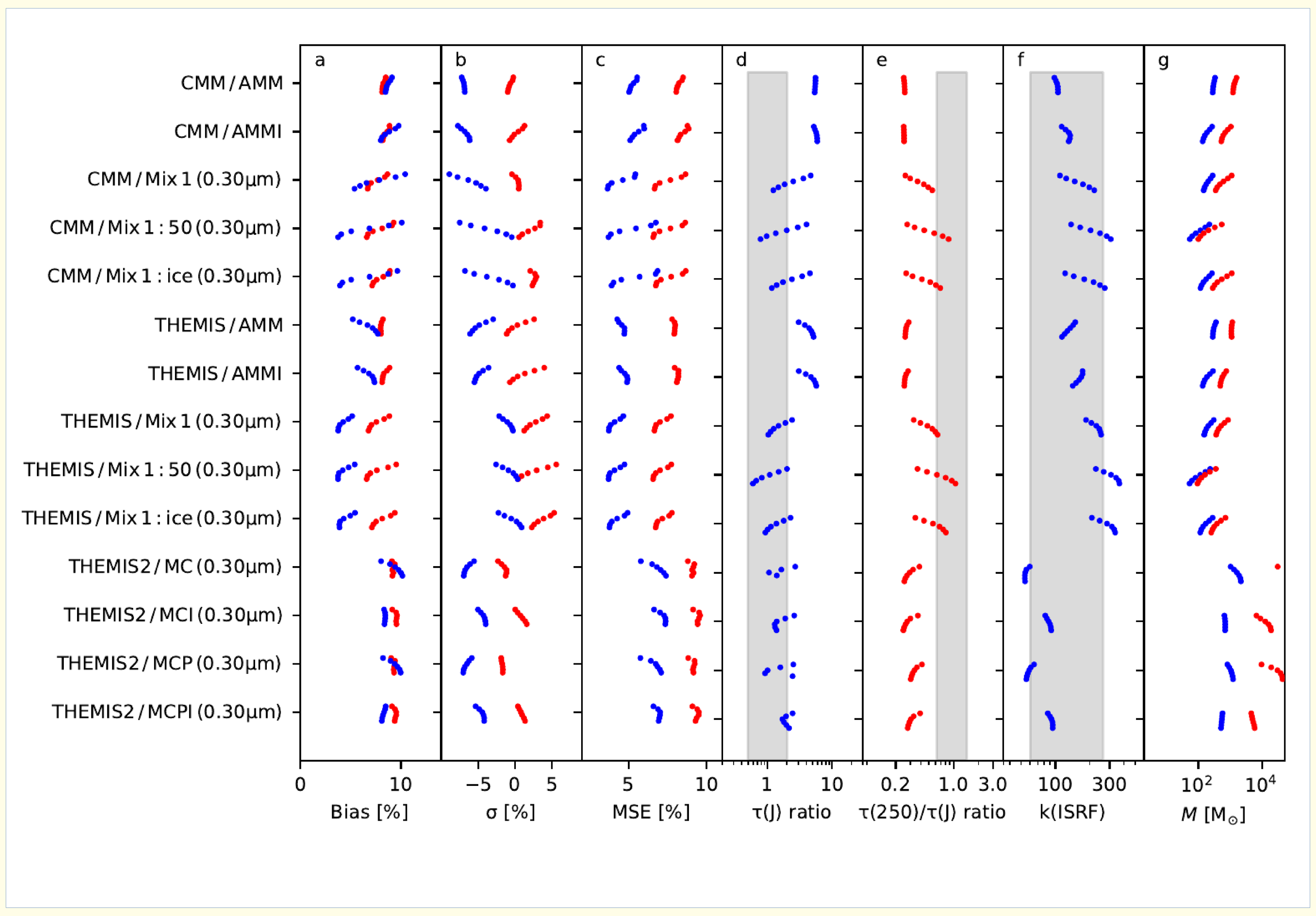
The upper frame shows the resulting model masses (magenta line, left axis) and the mean NIR and FIR optical depths (legend, right axis). The lower frames show the fit errors in the Herschel SPIRE bands (250-500 µm) and extrapolated to 160 µm and A(J) extinction. For the models with two dust models, the change in the dust properties takes place at density n_0 of molecular Hydrogen. Figure shows only a subset of the tested dust models and their combinations. Overall most models fit well to the FIR data, but with mass estimates that cover almost one order of magnitude.



OMC-3

OMC-3 was examined using a wider range of dust models (Juvela & Ysard 2025). The best fit to FIR data was obtained with mean grain sizes of up to a ~ 0.1-0.3 µm. However, larger sizes result in a flattening of the extinction curve and a poor match to the observed NIR extinction that still traces the filament well. The correlation is low only in the central ridge. This could mean even larger grains, but the low stellar density does not allow firm conclusions.

The figure below shows the fit quality for some models with spatially varying dust properties. The τ(J) ratio tests the consistency of the model NIR opacity and the extinction estimated with the background stars. The preferred radiation field strength k(ISRF) (shaded area) is estimated based on the bolometric dust emission. For the ratio τ(250µm)/τ(J) the shading corresponds to the range previously observed for a sample of dense clumps (Juvela et al. 2015). For consistency with that study, τ(J) in this ratio is estimated using the standard extinction curve.



References

Compiegne M. et al. 2011, A&A 525, A103; Jones A. et al. 2017, A&A 602, A46;

Juvela M. et al. 2015, A&A 548, A93; Juvela M. 2024, A&A 681, A75; Juvela M. & Ysard N. 2025 (submitted)