Core mass estimates in simulated observations

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We examine the mass estimation of molecular cloud cores. We use magnetohydrodynamic (MHD) simulations and radiative transfer calculations to produce synthetic sub-millimetre and infrared surface brightness maps. Based on these maps we estimate dust temperature and cloud column densities. The 'observed' core masses are compared with the true masses. We estimate the reliability and the biases in the core mass spectra obtained from observations using noise levels typical of current Herschel observations. Using high resolution AMR (Adaptive mesh refinement) simulations, we study how protostellar sources embedded in the cloud cores affect the estimated mass spectra. The protostars cause internal heating that could affect the determination of mass spectra. We conclude that in the densest cores the core masses are strongly underestimated. However, when the cores are heated by internal radiation sources, the dust becomes easier to observe and hence the observed mass spectra begins to resemble the true mass spectra.

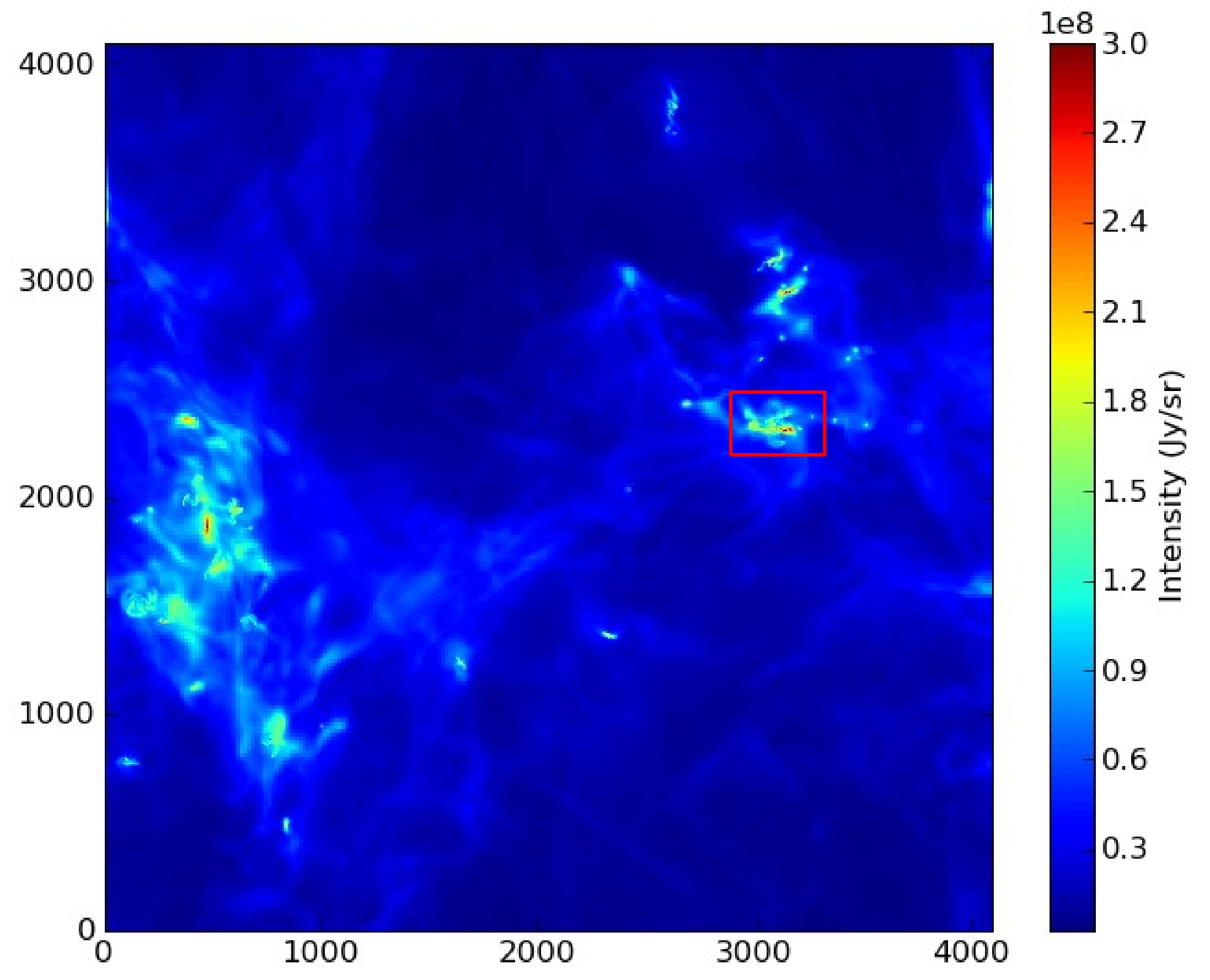

Figure 1. High opacity model: simulated intensity map before adding noise.

Introduction The conditions in cold molecular cloud cores determine many fundamental aspects of star formation: stellar mass distribution, formation efficiencies, evolution timescales etc. In order to understand the early phases of star formation, we must study the cold cloud cores. The initial mass function (IMF) appears to be directly linked to the core mass function (CMF) of pre-stellar cores (Motte et al. 1998, 2001; Johnstone et al. 2000; Enoch et al. 2008). However, large temperature gradients and changes in dust emissivity could distort core mass estimates and even affect the shape of the derived core mass spectra. Also internal heating caused by protostars could affect the estimated mass spectra. We investigate these errors by combining magnetohydrodynamic (MHD) simulations and radiative transfer modeling of dust emission.

Some effects were already examined in Malinen et al. (2009) where also the consequences of spatially varying dust properties were tested. The study was based on cloud models obtained from MHD calculations on uniform grids. In this poster we present the results from a study where we use cloud models derived from MHD runs performed on hierarchical grids. With automatic mesh refinement (AMR) one can follow the evolution of individual cores much further (see Collins 2010) and, because of the stronger density and temperature variations, also the errors in the derived core masses may be larger. Our main interest is not in the shape of the CMF but in the changes caused by observational biases. The results obtained in this study are more thoroughly presented in Malinen et al. (2010).

Calculations We present here a study made with two MHD model clouds, another with cores of moderate opacity (maximum column density 10^{25} $1/cm^2$) and another with cores of high opacity (maximum column density 10^{26} $1/cm^2$). The size of both clouds is 10 pc. The dust properties were kept constant throughout the volume although the mass is strongly concentrated in the densest regions. We calculated surface brightness maps of dust emission with our 3D radiative transfer programs (Juvela & Padoan 2003; Lunttila et al. 2010) and added to the maps noise typical of current Herschel observations.

Dust colour temperatures were estimated from surface brightness maps at two wavelengths and the core masses were estimated using correct dust absorption cross section (κ) and spectral index (β) for the dust model. We used the automatic clump finding method Clumpfind (Williams et al. 1994) to locate clumps in column density maps and derived the core mass spectra, i.e. number of cores vs. core mass.

We investigated the effect of internal heating by adding protostellar sources in the range of ~0.3-120 solar luminosities to the most prominent cores and derived the mass spectra again. We also compared the core masses in the surroundings of the source positions before and after adding the sources in order to have an objective definition for the core.

Results One of the simulated intensity maps is shown in Figure 1. Closeups of the intensity map and colour temperature map before and after adding the sources are shown in Figure 2. The mass spectra and core masses within a fixed radius in moderate opacity model are shown in Figure 3. The core mass spectra with and without sources in high opacity model are shown in Figure 4. Without the sources the core masses are strongly underestimated. With the sources the observed mass spectra comes closer to the true mass spectra. The same effect can also be seen in Figure 5.

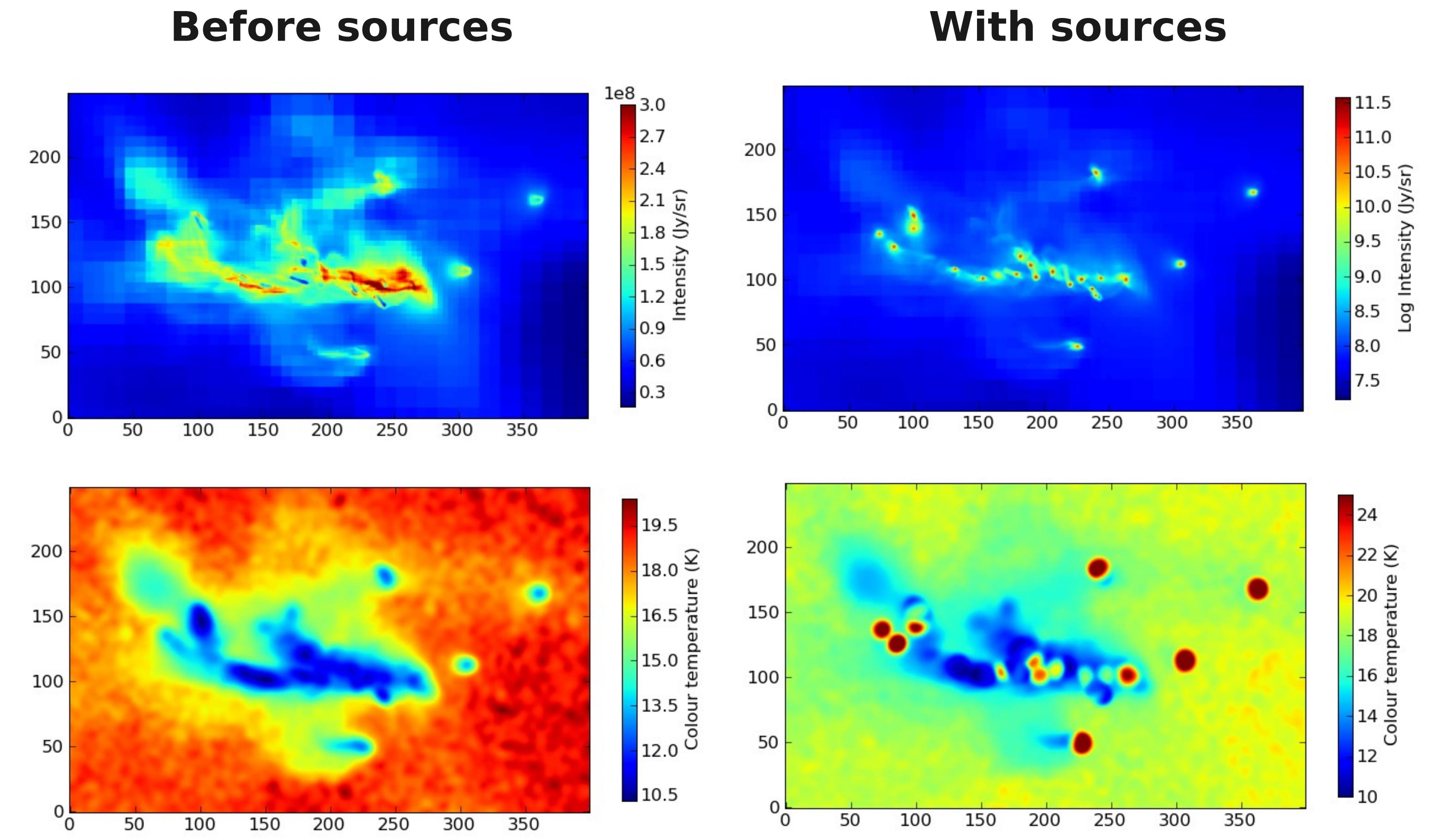

Figure 2. High opacity model: closeup of the area marked with a rectangle in Figure 1 of intensity and colour temperature maps before (left frame) and after (right frame) adding the sources.

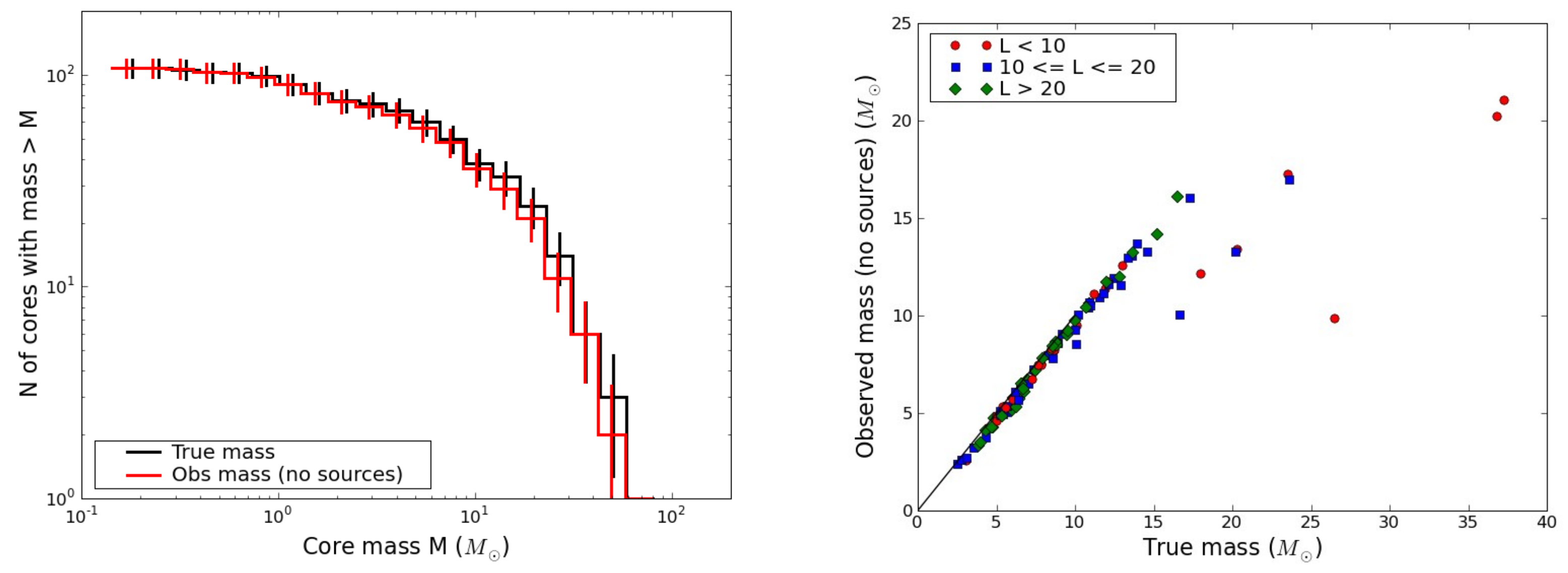

Figure 3. Moderate opacity model (without added sources): (Left) Cumulative core mass spectra. (Right) Core masses (within 20 pixel radius) divided to three categories according to the luminosity (L) of the source. True mass vs. observed mass before adding the source (L means the luminosity of the source to be added in the clump and is related to the mass of the clump).

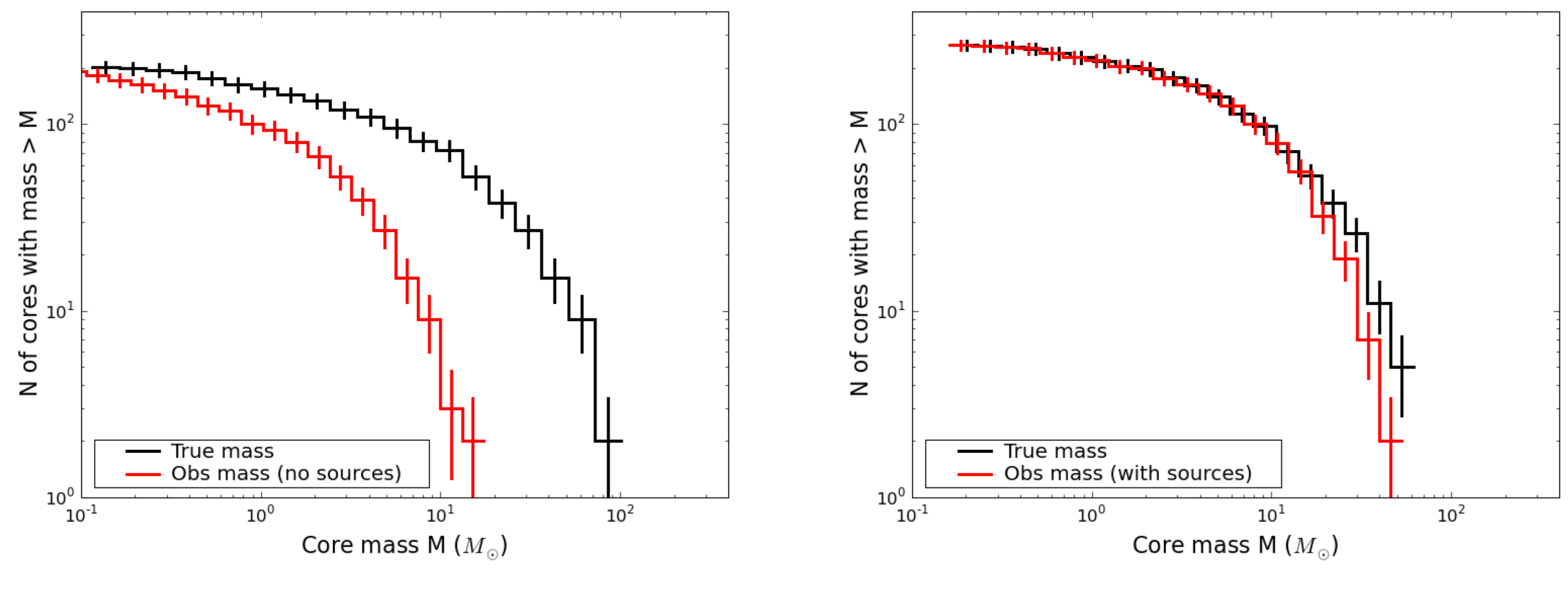

Figure 4. High opacity model: cumulative core mass spectra before adding the sources (left frame) and after it (right frame). True mass spectrum is derived from true column density map using observed clumps.

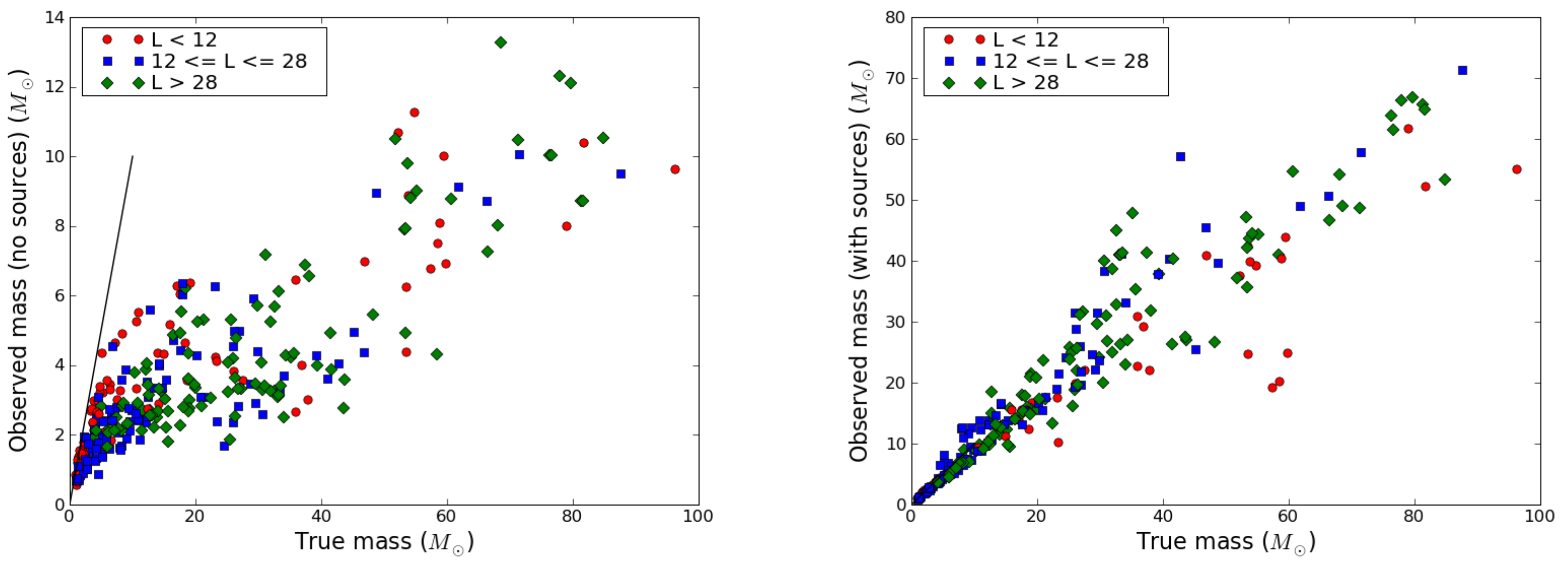

Figure 5. High opacity model: core masses (within 20 pixel radius) divided to three categories according to the luminosity (L) of the source. (Left) True mass vs. observed mass before adding the source. (Right) True mass vs. observed mass after adding the source.

References Collins, D. et al. 2010, ApJS 186, 308; Enoch et al. 2008, ApJ 684, 1240; Johnstone et al. 2000, ApJ 545, 327; Juvela & Padoan 2003, A&A 397, 201; Lunttila et al. 2010, in preparation; Malinen et al. 2009, AKARI Conference Proceedings; Malinen et al. 2010, in preparation; Motte et al. 1998, A&A 336, 150; Motte et al. 2001, A&A 372, 41; Williams et al. 1994, ApJ 428, 693