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The road toward a full, high resolution Molecular Cloud catalog of the Galaxy

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Abstract. The statistical description of Giant Molecular Cloud (GMC) properties relies heavily on the performance of automatic identification algorithms, which are often seriously affected by the survey design. The algorithm we designed, SCIMES (Spectral Clustering for Molecular Emission Segmentation), is able to overcome some of these limitations by considering the cloud segmentation problem in the broad framework of the graph theory. The application of the code on the CO(3-2) High Resolution Survey (COHRS) data allowed for a robust decomposition of more than 12,000 objects in the Galactic Plane. Together with the wealth of Galactic Plane surveys of the recent years, this approach will help to open the door to a future, systematic cataloging of all discrete molecular features of our own Galaxy.

Keywords. methods: analytical, techniques: image processing, ISM: clouds.

Introduction. Since the first large surveys of early 1980s, the intrinsic clumpiness of the molecular interstellar medium (ISM, Leroy *et al.*2013) drove the cataloging of those clumps, the larger of which (typically 40 pc and 10^5 $M_\odot$) have been called GMCs (Solomon *et al.*1979). The statistical description of GMC properties has provided important insights into the physics of the star formation. GMCs appear roughly gravitationally bound and present a hierarchical structure (e.g., Solomon *et al.*1987). These observations suggest that clouds are sustained against gravitational collapse by turbulence, which might also explain the low star formation efficiencies observed in the Galaxy (e.g., Mckee & Ostriker 2007).Those conclusions have been mostly obtained by applying automatic algorithms to decouple the discrete ISM features from the more diffuse intra-cloud medium. Unfortunately those algorithms struggle to recognize GMCs as single entities once they span several resolution elements (as for the most recent high resolution Galactic Plane surveys). The algorithm we designed (SCIMES, Colombo et al., MNRAS in press) by applying the spectral clustering paradigm to dendrograms of molecular gas emission (see Rosolowsky *et al.*2008) appears to be able to overcome such difficulties. The spectral clustering technique selects the relevant objects within the dendrogram, based on the clustering properties of ISM chosen and the scale of the observation. SCIMES might also be used to find other molecular gas structure (as clumps, filaments, and "Giant Molecular Associations"), given enough dynamical range to define their hierarchy and the correct set of clustering criteria. In this aspect, every ISM structure might be seen as a sub-class of a more extended class of objects: the "Molecular Gas Clusters".

The COHRS cloud catalog. We applied SCIMES on the COHRS data (Dempsey *et al.*2013). COHRS mapped the ^{12}CO(3-2) emission from the inner Galactic Plane ($b \leqslant |0.5°|$, $10.25° \leqslant l \leqslant 55.25°$, $-30 \leqslant v_{\rm LSR} \leqslant 155$ km/s) with a spatial and spectral resolution of 16.6" and 1 km/s, respectively. We cataloged 12,641 objects in total. The dendrogram together with the cluster-

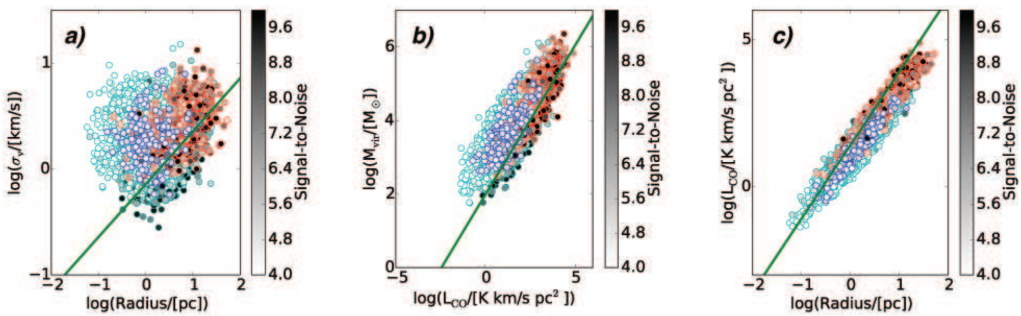

Figure 1. COHRS cloud scaling relations. Red circles indicate clouds with a well defined distance, blue circles mark objects where the distance point falls within one of the parental structures, while cyan circles represent isolated objects whose distance is given by the closest distance point in the PPV space. Green lines indicate the fits by Solomon *et al.*1987.

ing approach allows to automatically identify a variety of gas morphologies including coherent filamentary structures and holes within the molecular ISM. We generate physical properties of the clouds using the high quality distances obtained by the Bolocam Galactic Plane Survey (Ellsworth-Bowers *et al.*2015) and we plot those properties against each other to probe the validity of the "Larson's laws" within this sample. We do not observe a clear size-line width relation (Fig 1a), but the scatter is introduced mostly by uncertain distance clouds. Nevertheless, clouds appear to have, on average, similar surface brightness as predicted (Fig 1b). Given the low scatter in the CO luminosity-virial mass relation (Fig 1c), $X_{\rm CO}$ does not vary much from the adopted Galactic value: $X_{\rm CO(3-2)} = 5 \times 10^{20}\,{\rm cm^{-2}\,K^{-1}\,km^{-1}}$ (in a picture consistent with self- gravitating clouds). In the future we will study how the properties, the morphology, and the turbulence of these clouds influence their star formation capability. This analysis (Colombo *et al.*in preparation) will give the guidelines to create the full, high resolution molecular cloud catalog of entire Galactic Plane.

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