Abundance Variation of Dense Gas Tracers in the Gould Belt

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RADEX Model Fits to NGC 1333

Using the Green Bank Ammonia (K-Band) Survey (GAS) maps, we can make controlled measurements of how the abundances of key molecular tracers vary across different star forming regions. To demonstrate the novel application of the non-LTE RADEX model to spectral stacking and fitting, I will apply it to the NH_3 (1,1) GAS emission map of NGC 1333 in Fig. 1 binned according to the Herschel H_2 column density map in Fig. 2 [1,2].

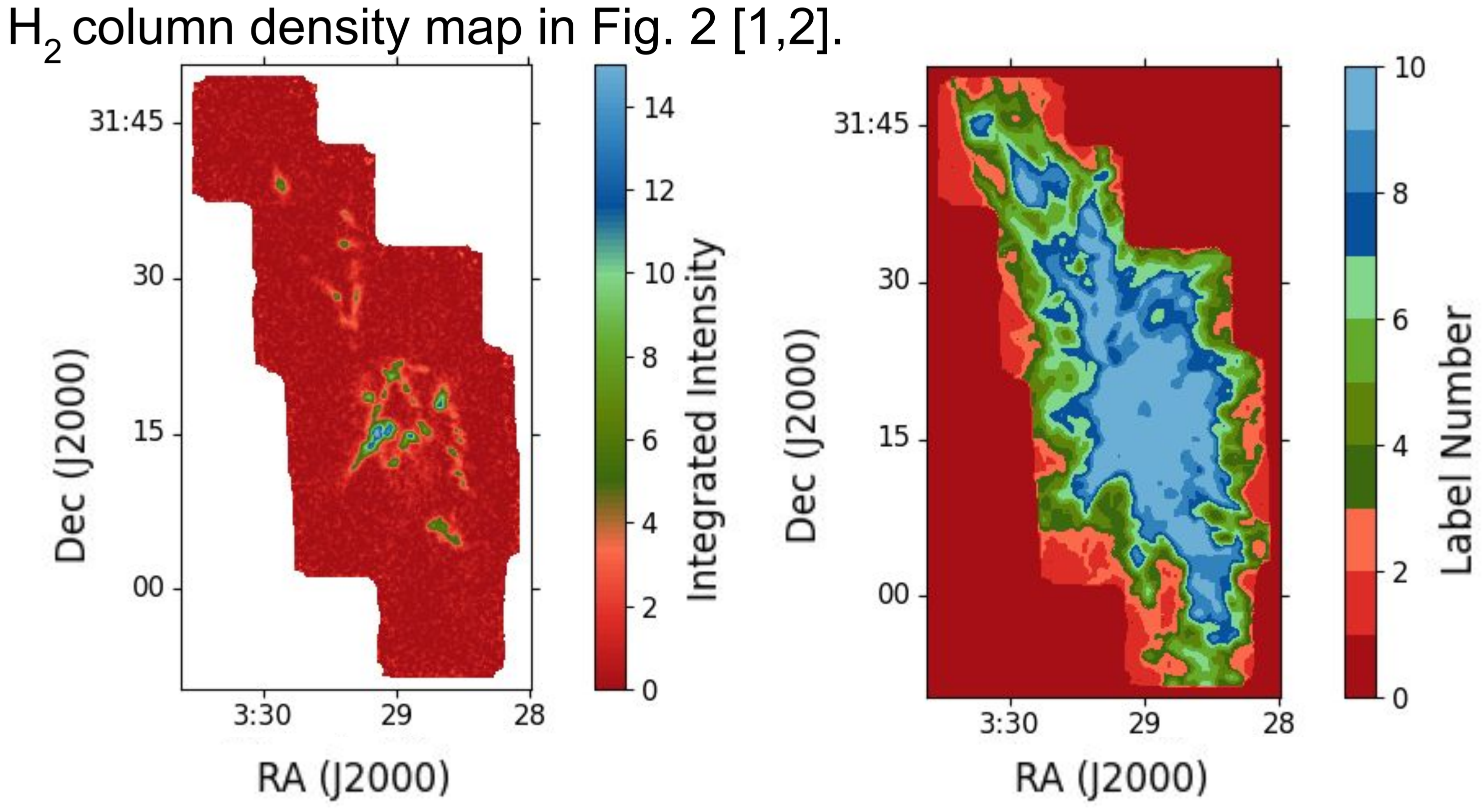

Fig. 1/Fig 2: Integrated intensity emission map and Herschel H_2 column density map of NGC 1333. The column density map is split up into 10 equally sized percentile bins [1,2].

Velocity Prior Map

All pixels of gas in Fig. 1 are at different line-of-sight velocities. Each pixel is assigned a velocity and then shifted to a common reference velocity of 0 km/s for stacking using the resultant velocity prior map generated by the procedure outlined in Fig. 3.

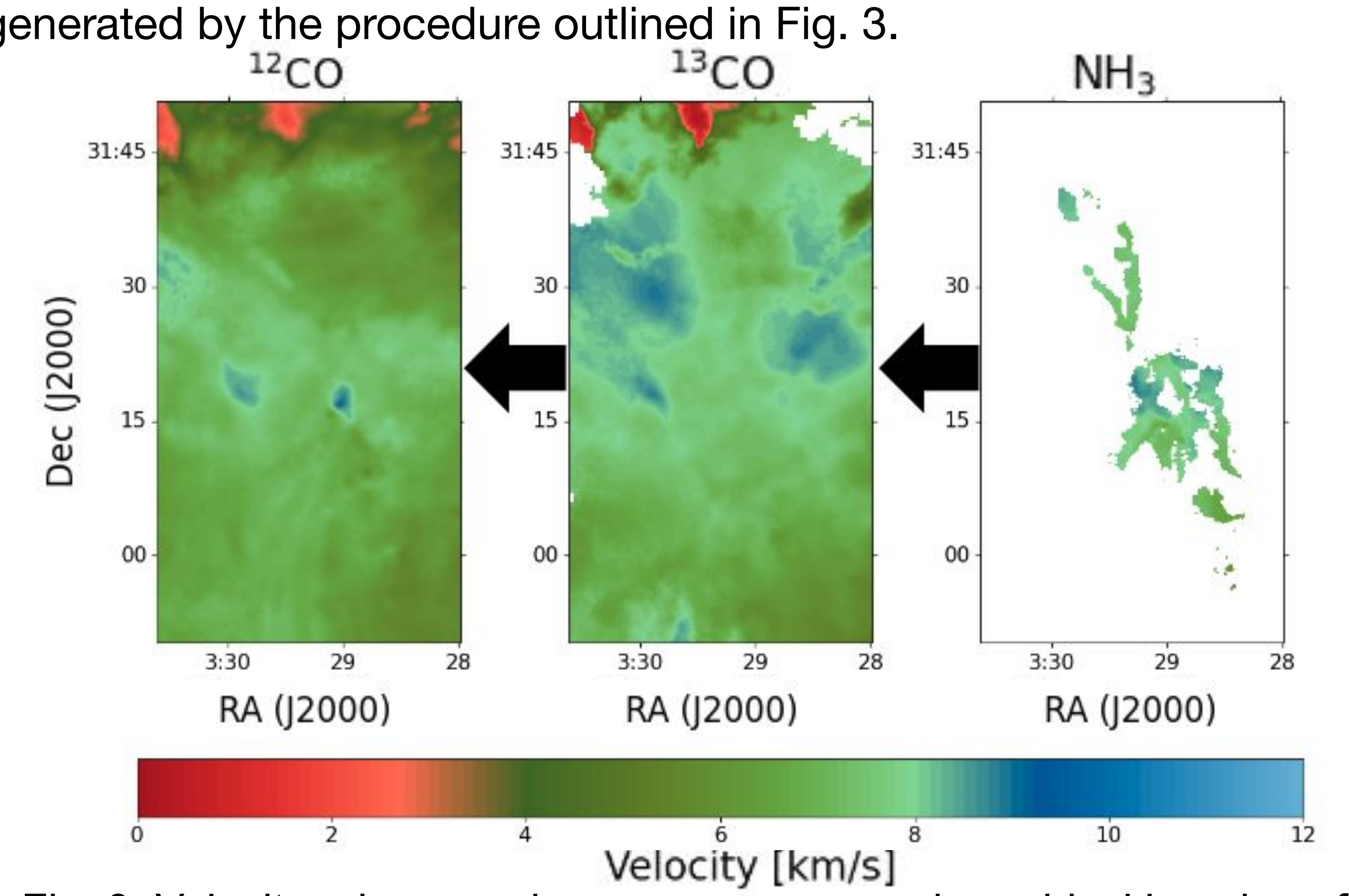

Fig. 3: Velocity prior map determined through hierarchical layering of COMPLETE ^{12}CO and ^{13}CO velocity maps and the NH_3 GAS map of NGC 1333 [2,3,4].

Spectral Stacking and Fitting

The spectra in the velocity shifted emission map are added together to draw faint spectral line signals out from the noise. The spectral lines are added together according to the bins of the Herschel H_2 column density map in Fig. 2 to give the stacked spectra in Fig. 4. Each bin determines a unique set of pixels that are stacked, allowing for the properties of the densest parts of the cloud to be compared to the less dense parts [5].

Using PySpecKit and the RADEX model, which outputs line intensities given the kinetic temperature of the cloud, the spectral linewidth, the column density of the fitted species, and the volume density of the collider species as shown in Table 1, the spectral line fits are obtained and shown in Fig. 4. A comparison of fit parameter values to H_2 column density bins is given in Fig. 5 [6,7].

Parameter	Name	Typical Value
$T_K(0)$	Kinetic Temperature [K]	12-14 K
$\log_{10}N(0)$	Column Density of NH_3 [cm^{-2}]	(12,16) cm^{-2}
$\log_{10}n(0)$	Volume Density of H_2 [cm^{-3}]	(2,6) cm^{-3}
$\sigma(0)$	Line Width [km/s]	0.2-1.5 km/s
$v(0)$	Velocity Offset [km/s]	Fixed to 0 km/s

Table 1: The parameters for spectral fitting with the non-LTE RADEX model [7].

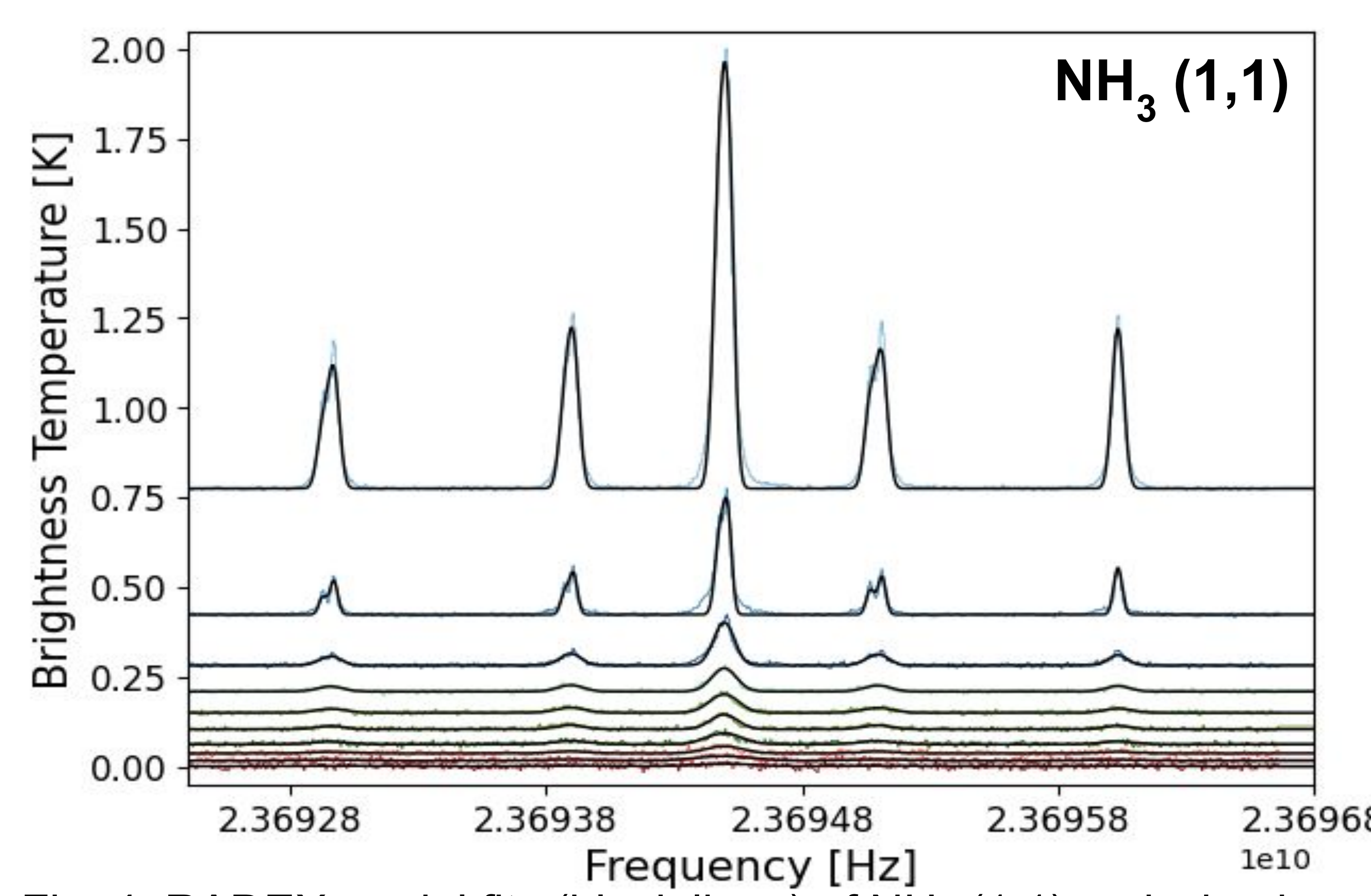

Fig. 4: RADEX model fits (black lines) of NH_3 (1,1) emission in NGC 1333 to the spectra stacked according to column density bins (coloured lines) with the parameters given in Table 1. The spectra are coloured according to the column density bins in Fig. 2, going from low to high column density from bottom to top.

Fit Parameters

Fitting with fixed volume density results in small parameter errors.

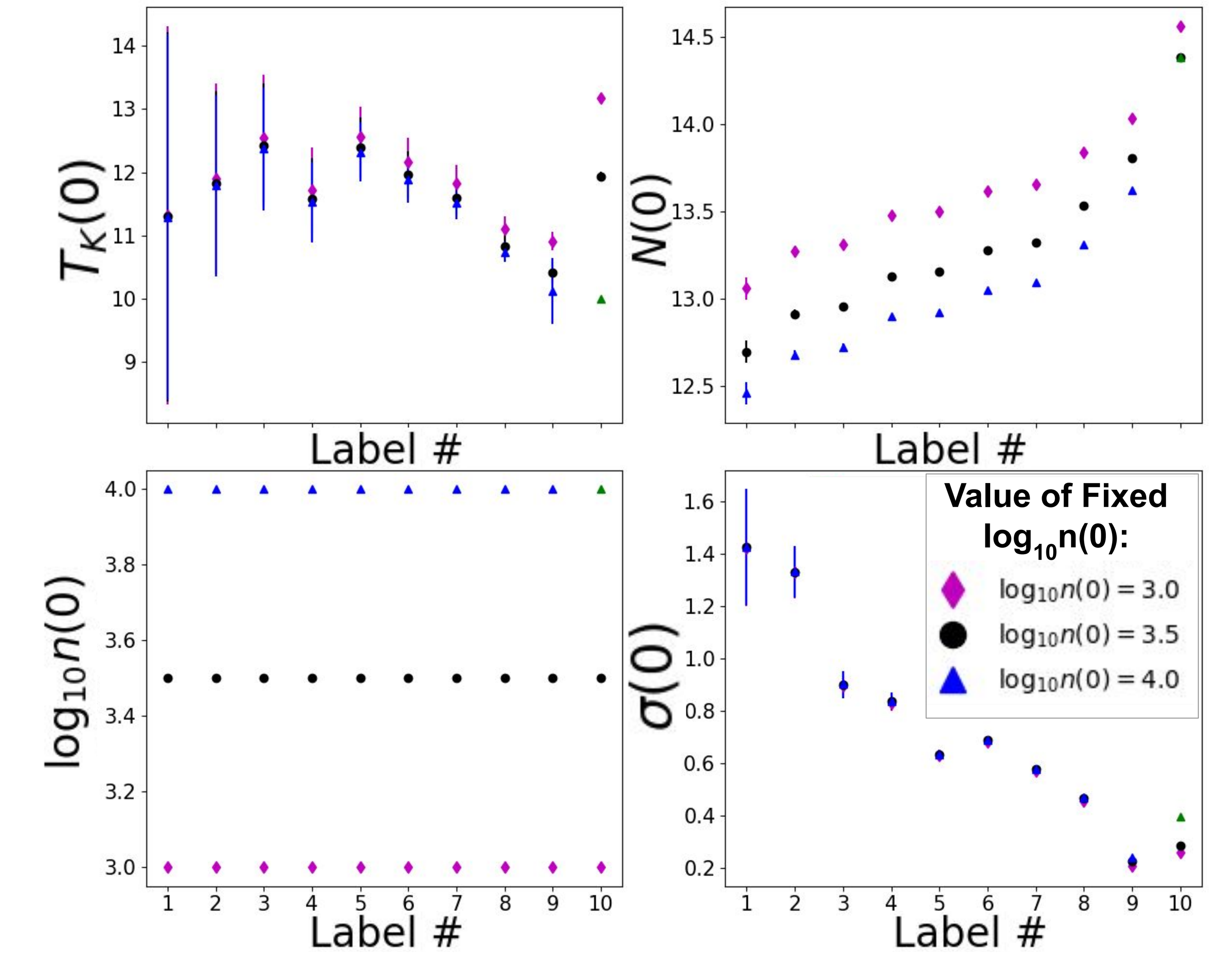

Fig 5: Fit parameters for Fig. 4 plotted against the H_2 column density bins, going from low to high column density with label number.

Next Steps

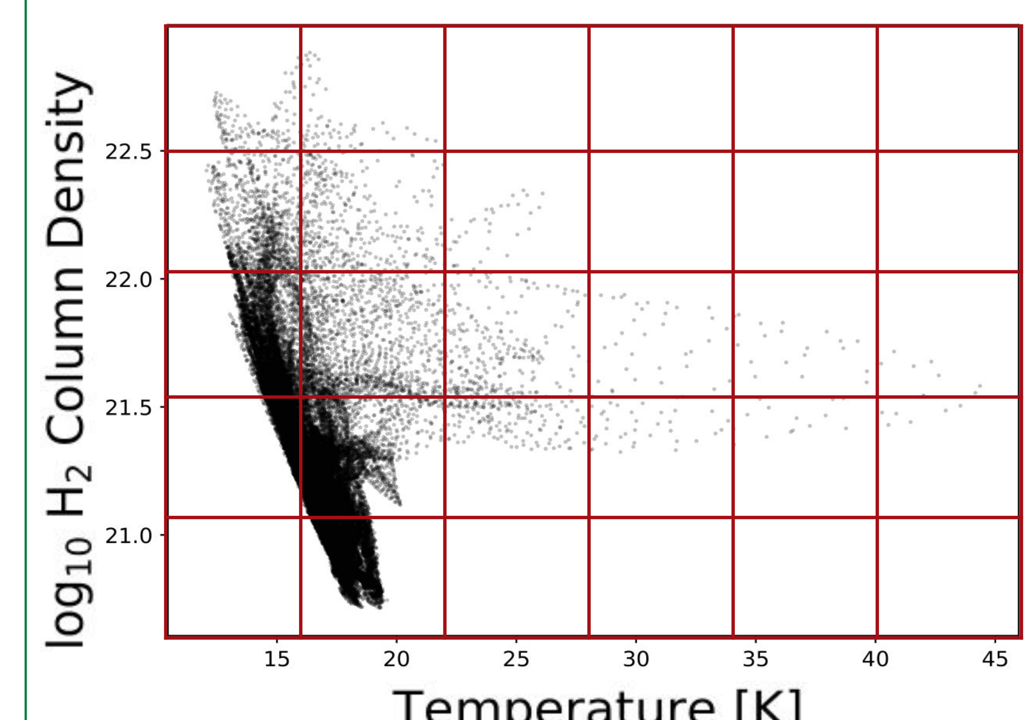

Fig. 6: H_2 column density plotted against dust temperature pixel-by-pixel.

- Create stacking bins by gridding the H_2 column density and dust temperature space [2,8].
- Expand stacking and fitting procedure to rare-carbon chains, using a gaussian model.

Acknowledgments

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