Molecular vs continuum emission: a morphological comparison in ALMAGAL clumps

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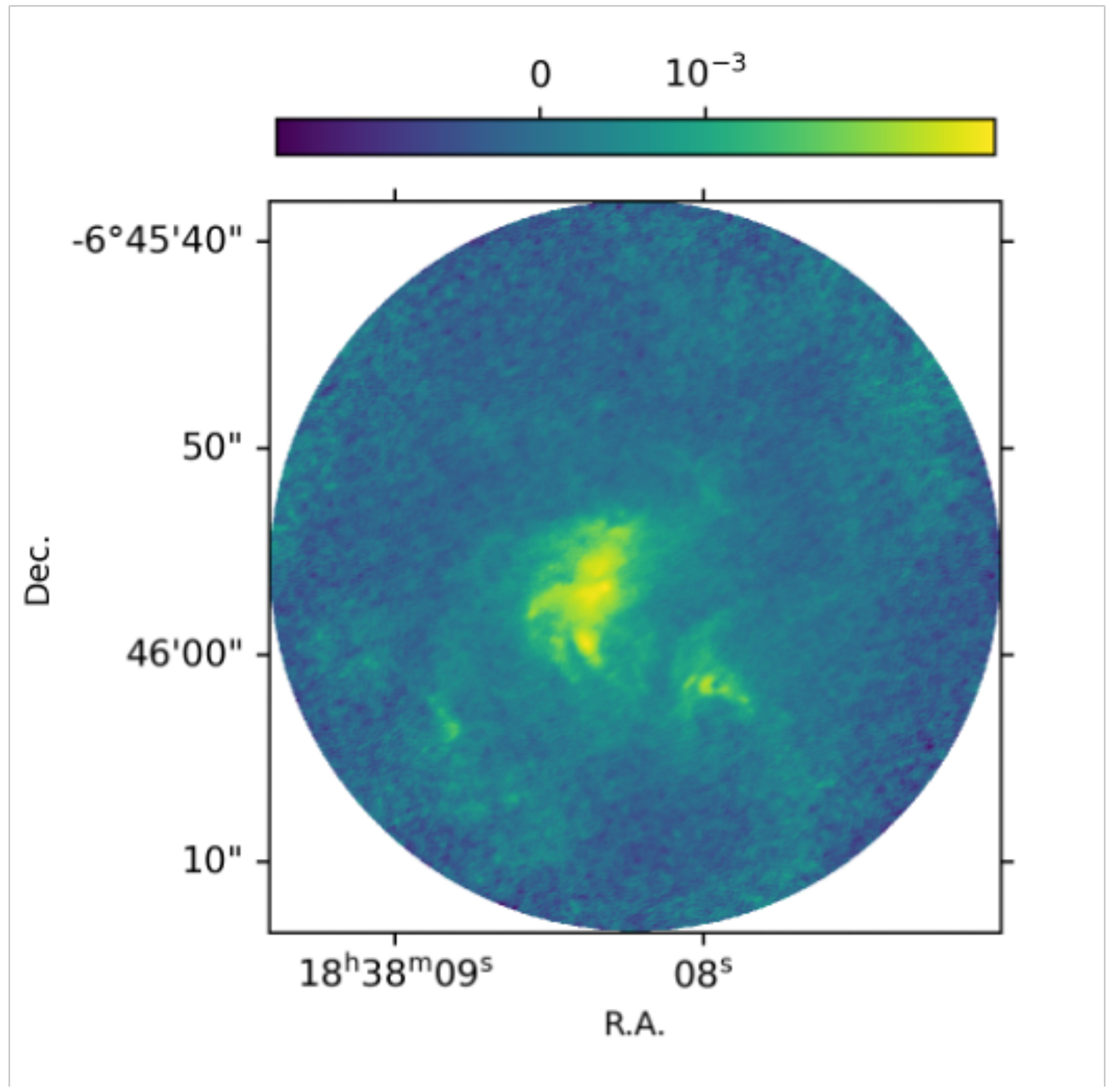
ALMAGAL

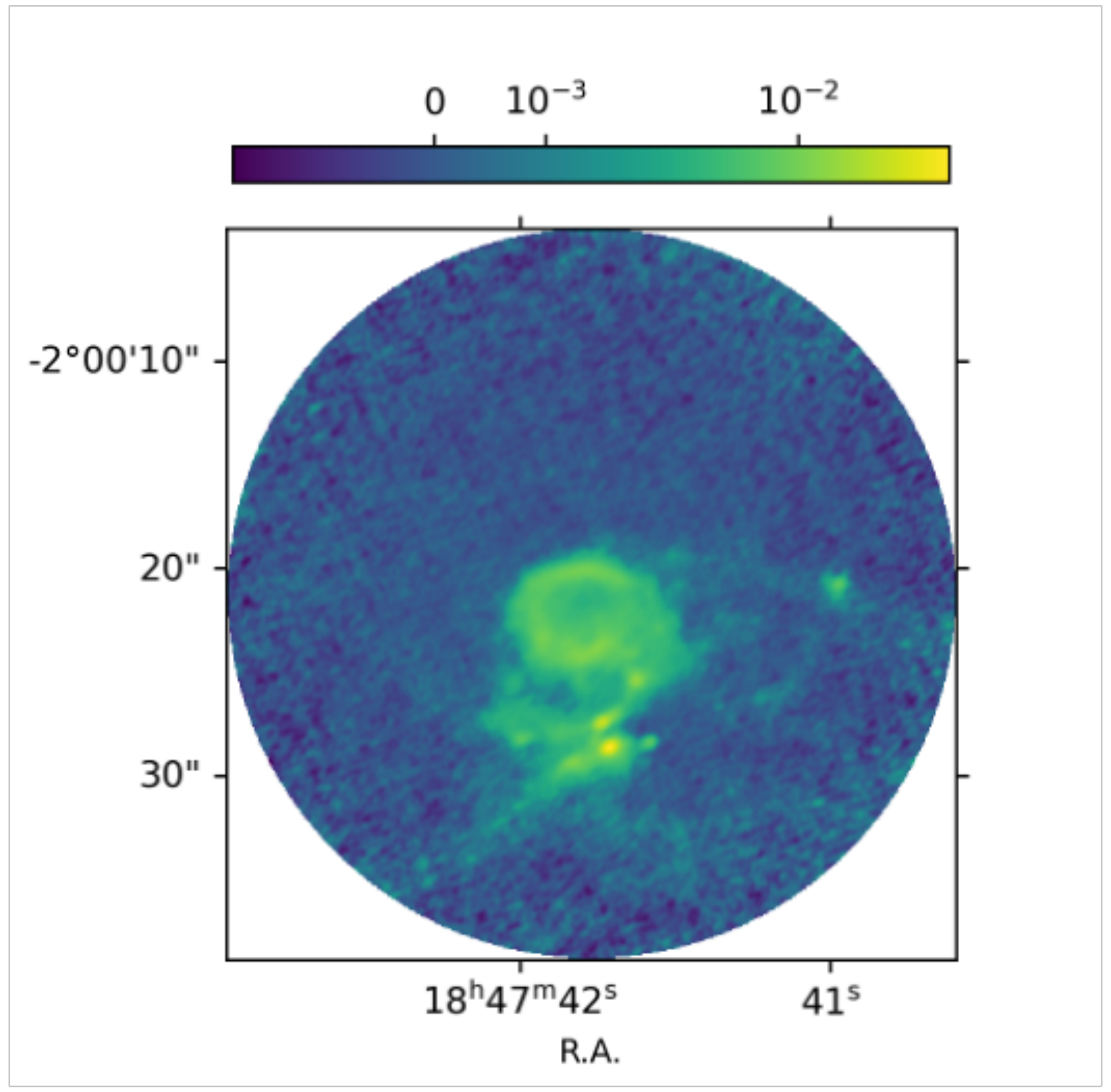
IAPS ISTITUTO DI ASTROFISICA E PLANETOLOGIA SPAZIALI

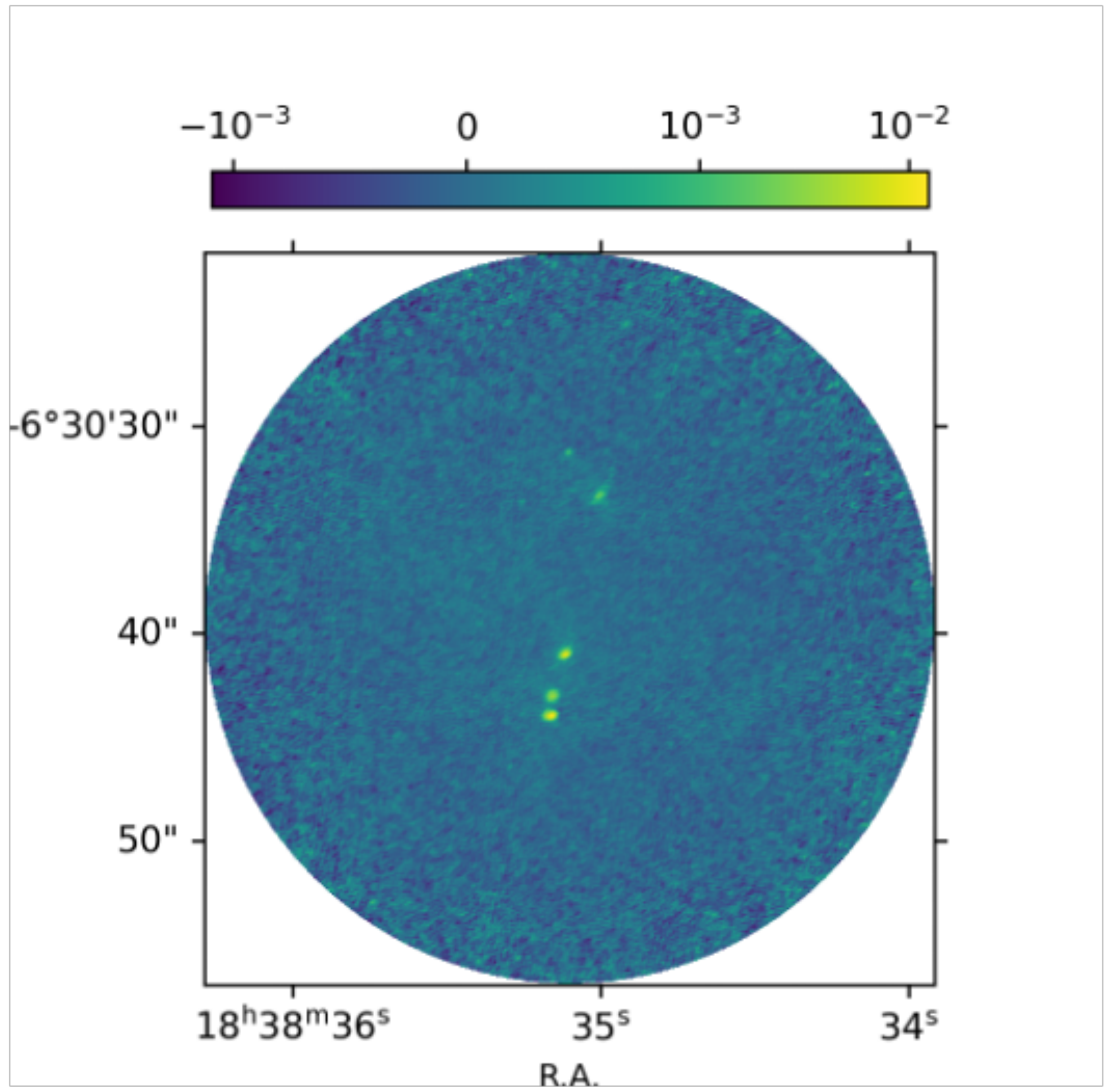
erc European Research Council

the ALMAGAL survey

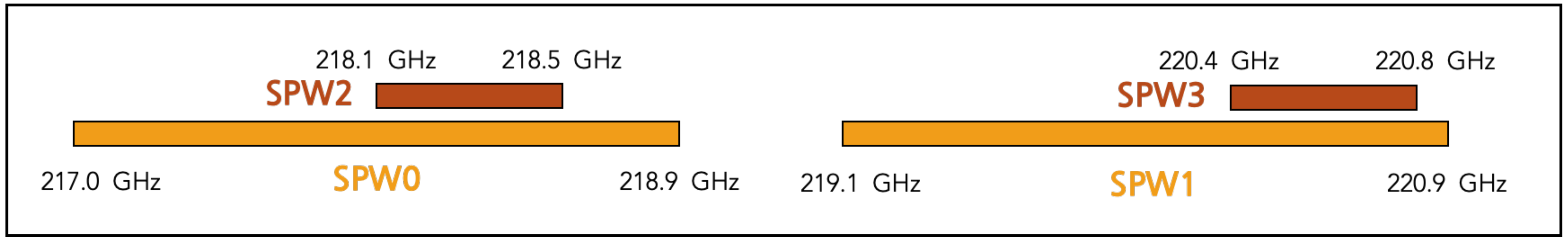
- 1017 high-mass star-forming regions
- All evolutionary stages
- Different galactic environment
- M>500Msun and d<7.5 kpc
- homogeneus linear resolution of ~1000AU







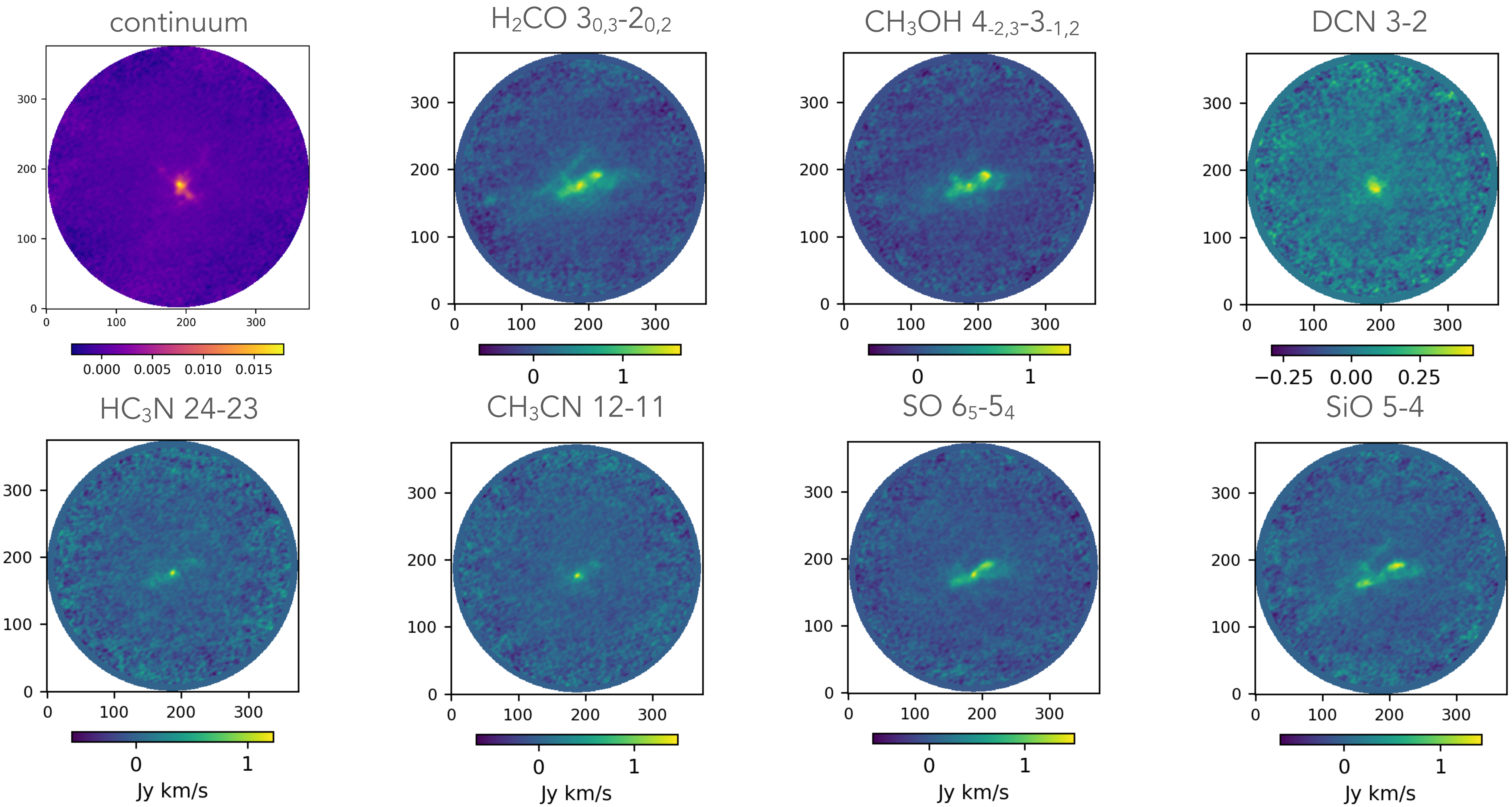
the molecular emission



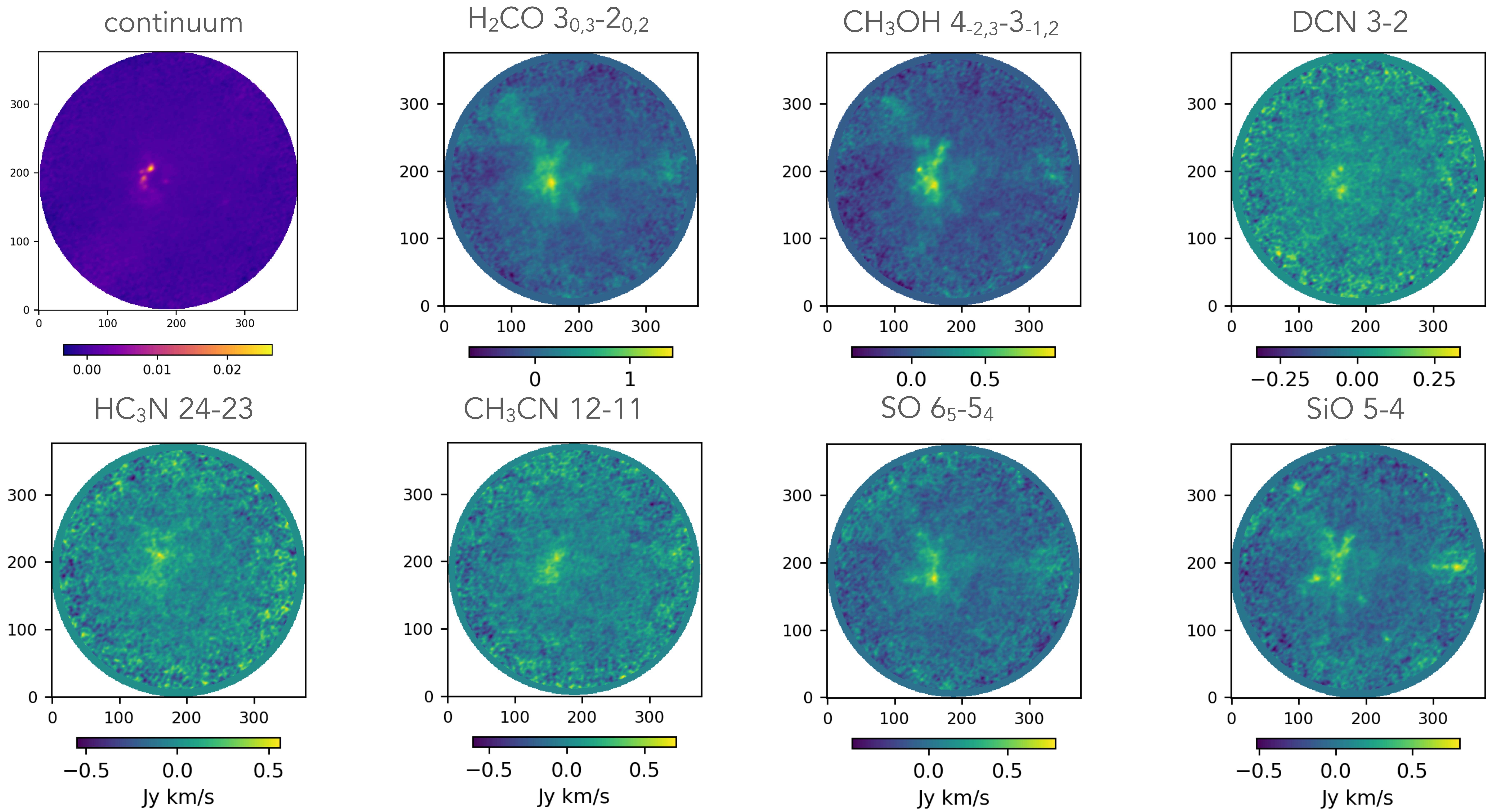
transition	ν [GHz]	$\log_{10} A_E$	E_U/κ_B [K]	$n_c(20\,K)$ [cm^{-3}]	$n_c(100\,K)$ [cm^{-3}]
SiO $5-4$	217.104980	-3.284	31.26	9.8×10^5	7.2×10^5
DCN^a $3-2$	217.238538	-3.340	20.85	5.5×10^6	2.1×10^6
H_2CO $3_{0,3}-2_{0,2}$	218.222192	-3.550	20.96	7.8×10^5	4.7×10^5
HCCCN $24-23$	218.324723	-3.083	130.98	1.3×10^6	7.7×10^5
CH_3OH $4_{-2,3}-3_{-1,2}$	218.440063	-4.329	45.46	1.3×10^5	8.8×10^4
H_2CO $3_{2,1}-2_{2,0}$	218.760066	-3.802	68.11	3.1×10^5	2.4×10^5
SO 6_5-5_4	219.949442	-3.874	34.98	$4.6\times10^{5\,b}$	3.4×10^5
CH_3CN 12_1-11_1	220.743011	-3.199	76.01	2.0×10^6	8.7×10^5
CH_3CN 12_0-11_0	220.747261	-3.196	68.87	2.0×10^6	8.7×10^5

We selected 7 commonly detected molecular species to investigate how their morphology compares to the dust continuum emission

the molecular emission



the molecular emission



We aim to analyze:

- an extremely large sample of sources
- 7 molecular species

↓

We need to use a tool to condense all the informations

the astroHOG

HOG

HOG : Histrogram of Oriented Gradients

Soler, J.D., and the THOR collaboration.
A&A, 622 (2019) A166

the astroHOG

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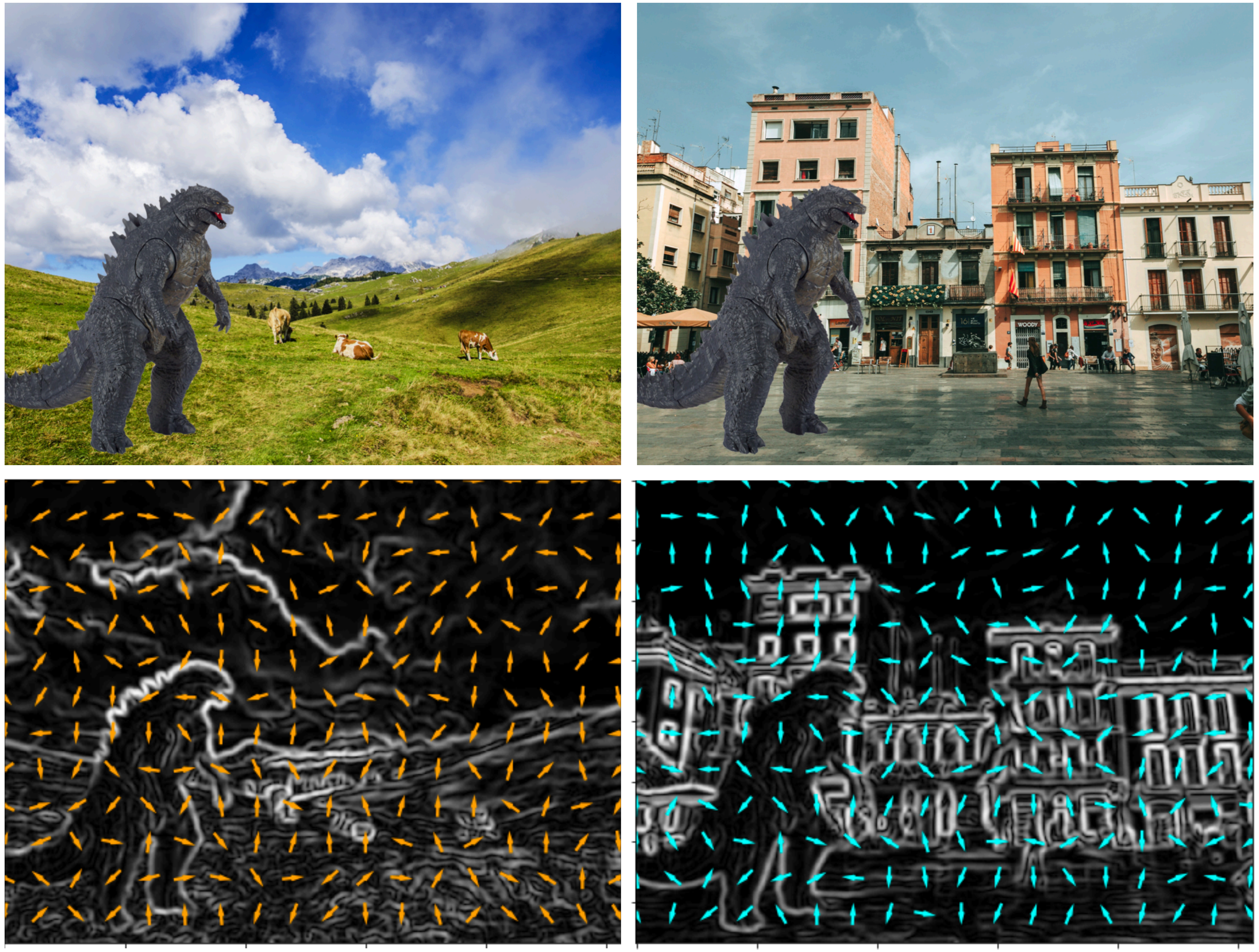

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the astroHOG

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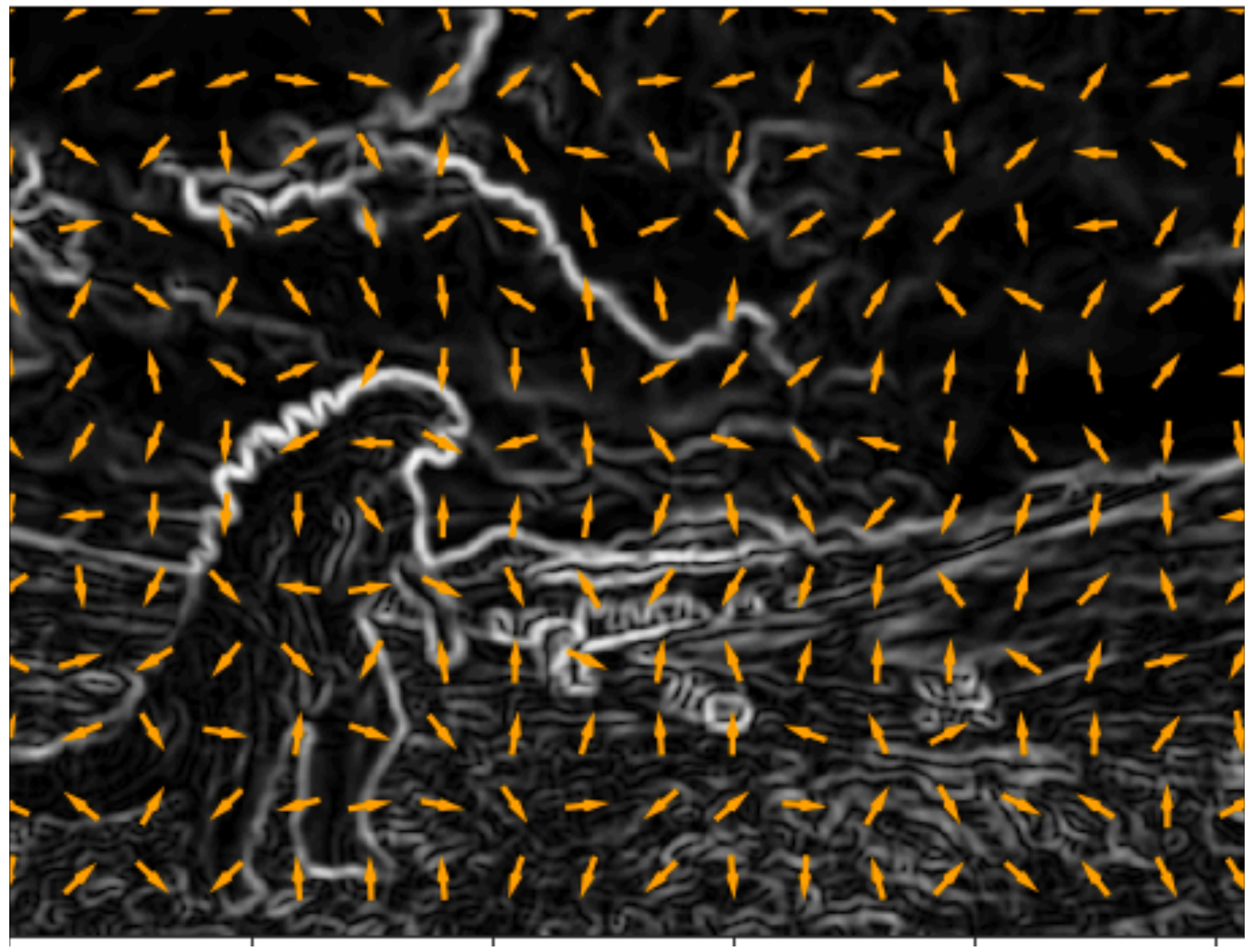
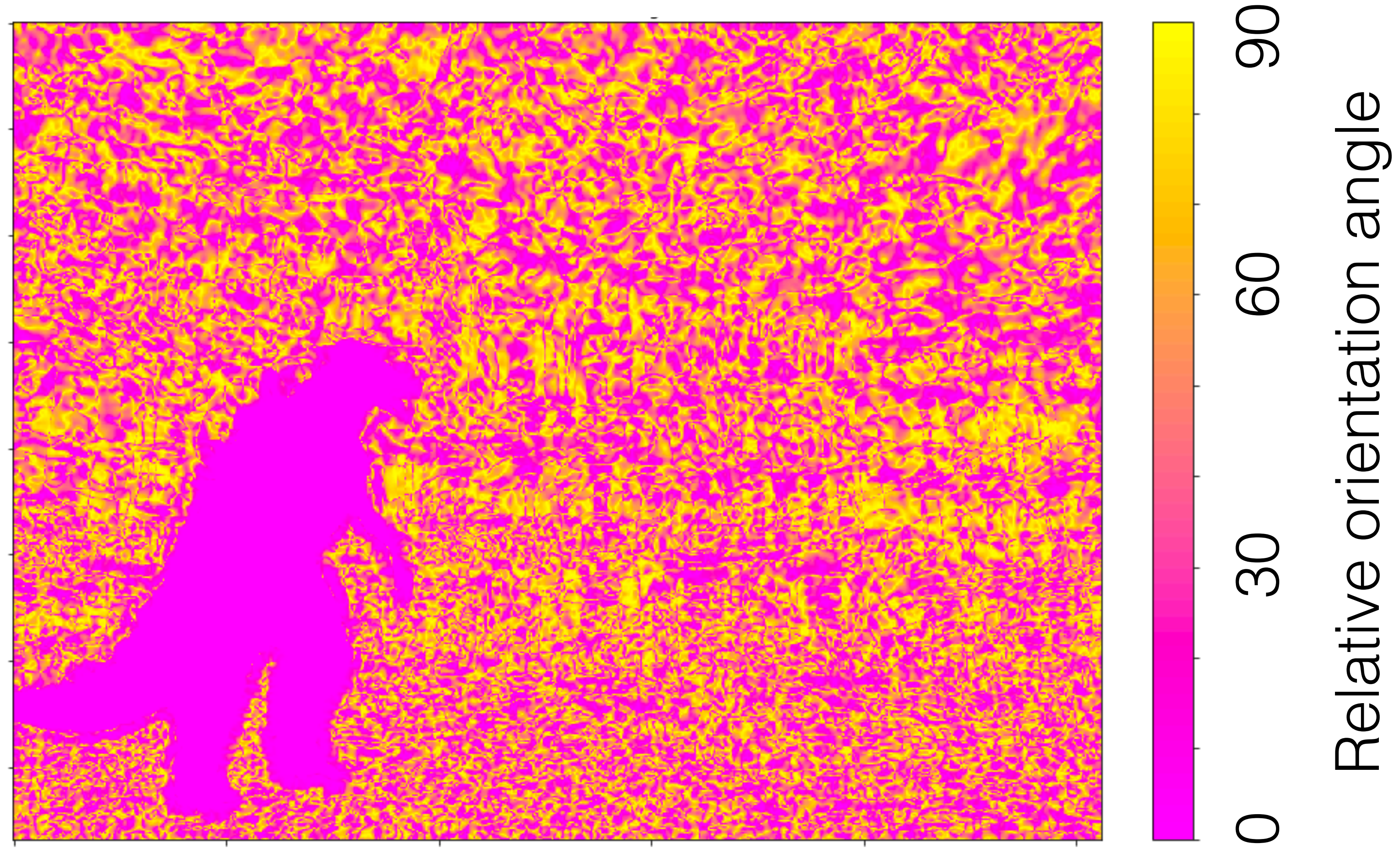
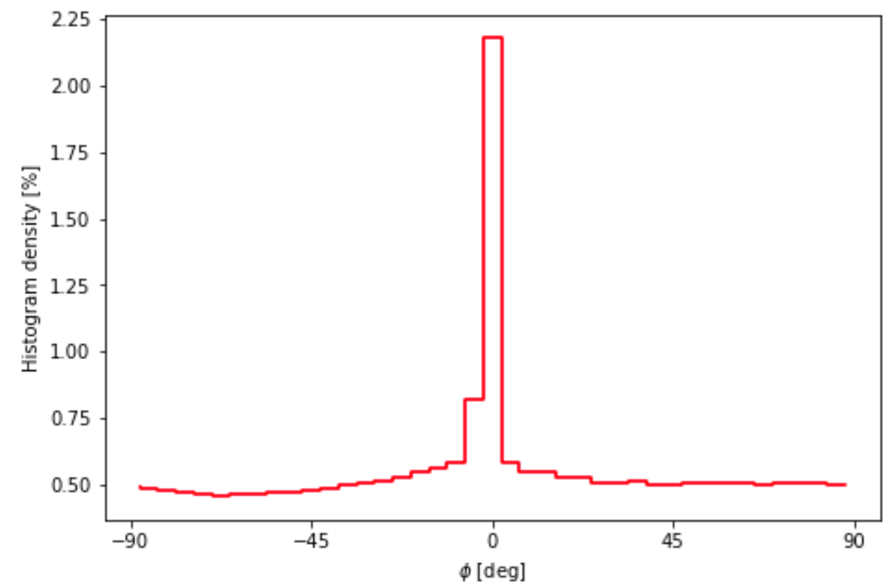




$$V = \frac{\sum_k^N w_k \cos 2\phi_k}{\sqrt{\sum_k^N (w_k)^2/2}}$$

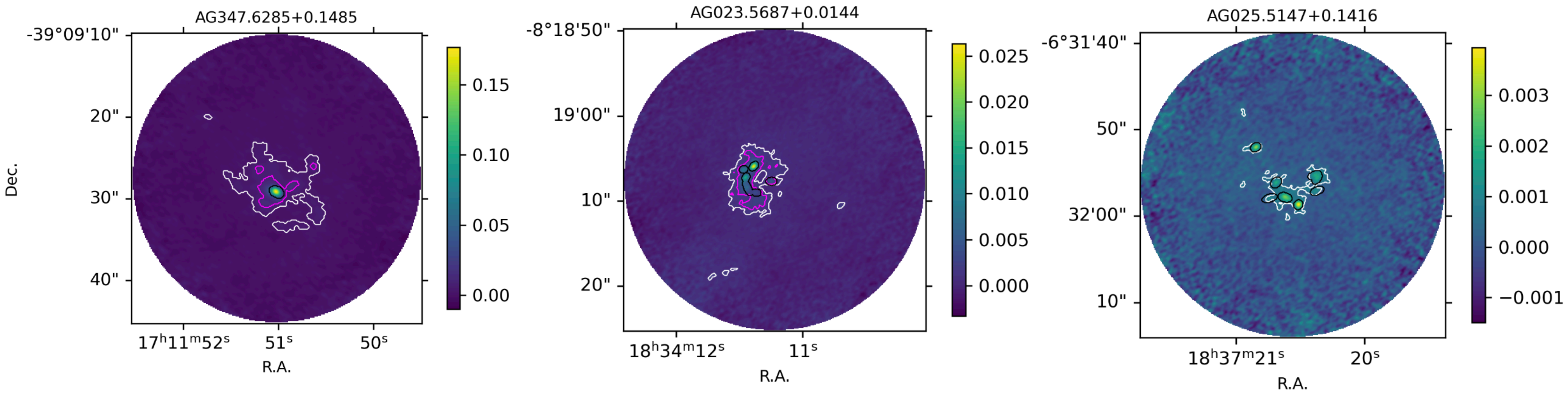


significant **positive** values mean a certain degree of **parallel gradients** in the two images

significant **negative** values mean a certain degree of **perpendicular gradients** in the two images

methodology

We defined **3 continuum mask** in which evaluate the morphological correlation with the line emission

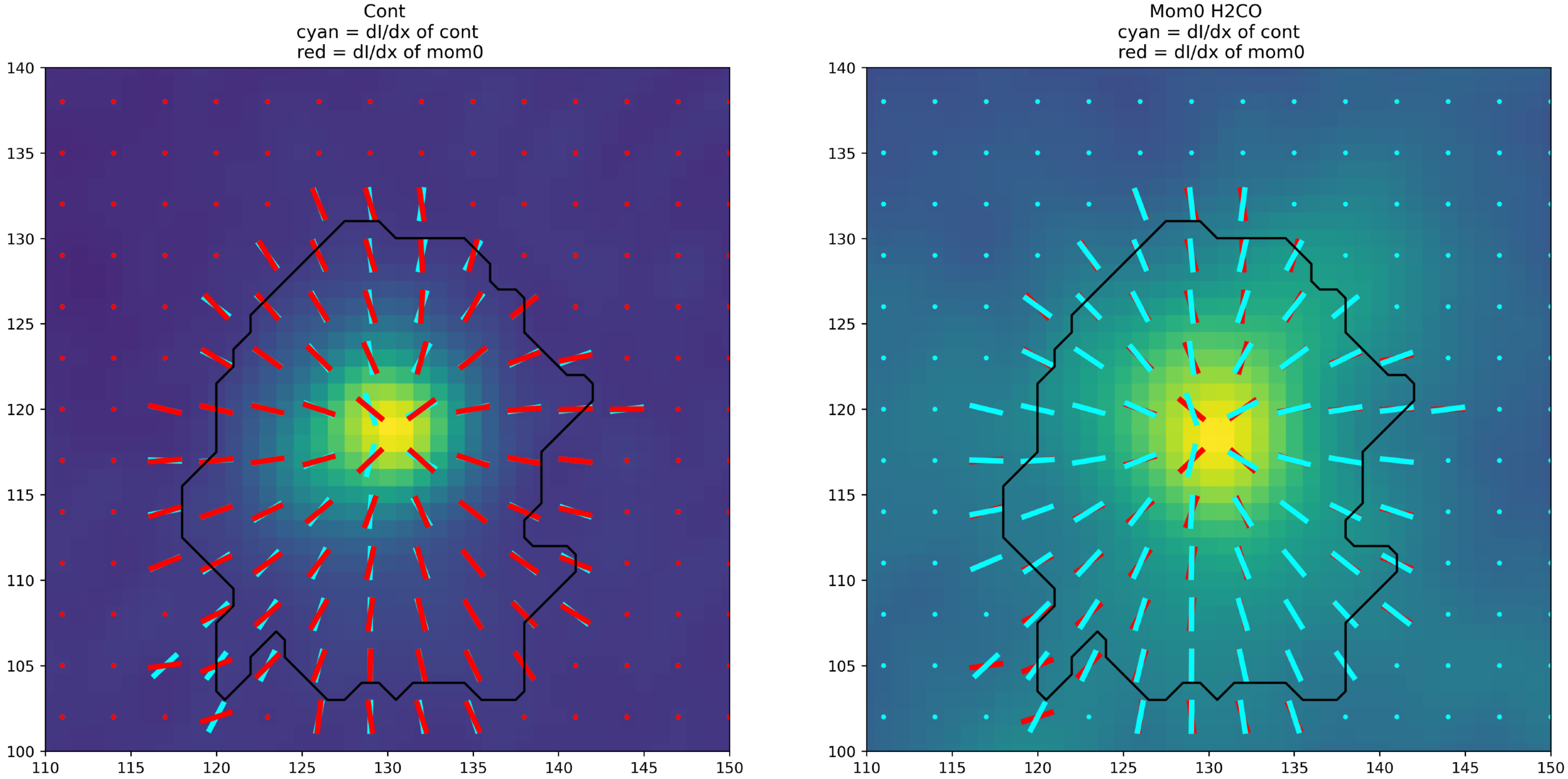


- Statistics of area of emission of molecular tracer vs continuum
- astroHOG run over the **intersection of the masks** of continuum and line
- We **normalized V**, which is dependent to N number of pixel compared

$$V = \frac{\sum_k^N w_k \cos 2\phi_k}{\sqrt{\sum_k^N (w_k)^2/2}} \xrightarrow{\phi_{ij}=0} V_{\max} = (2\,N)^{1/2} \longrightarrow \boxed{V_{\mathrm{N}} = V/V_{\max}}$$

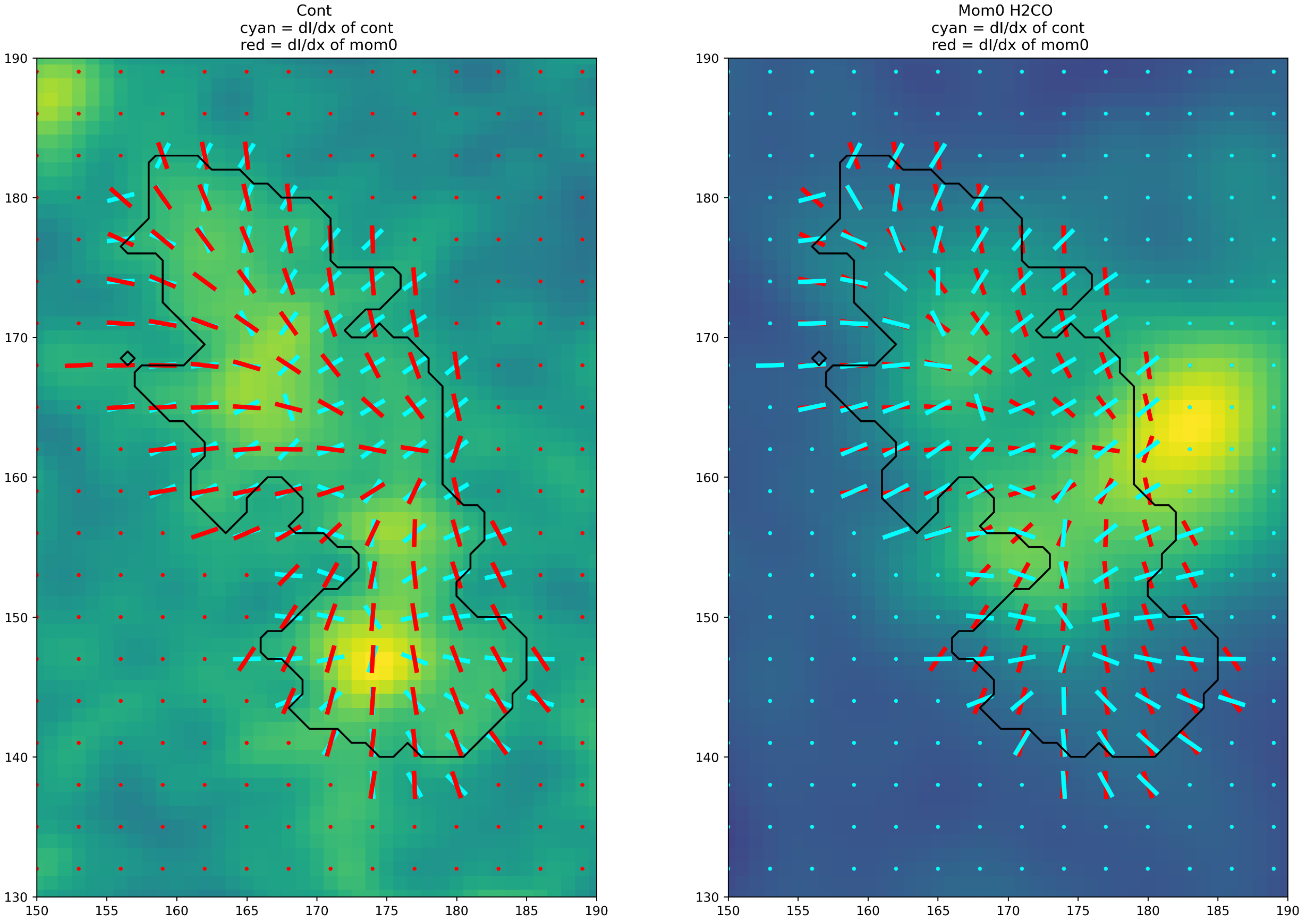
example 1

V_N=78.5%

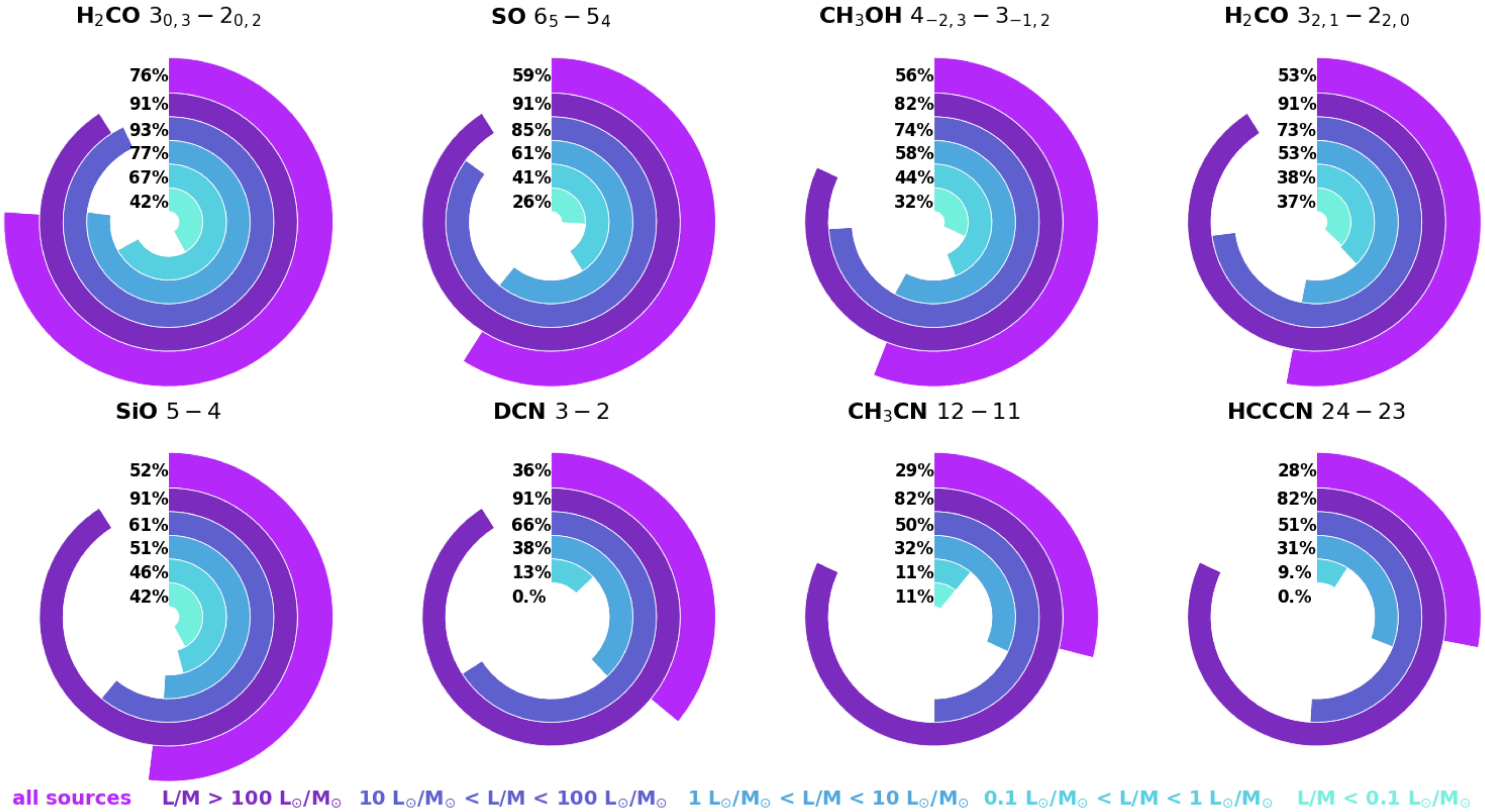


example 2

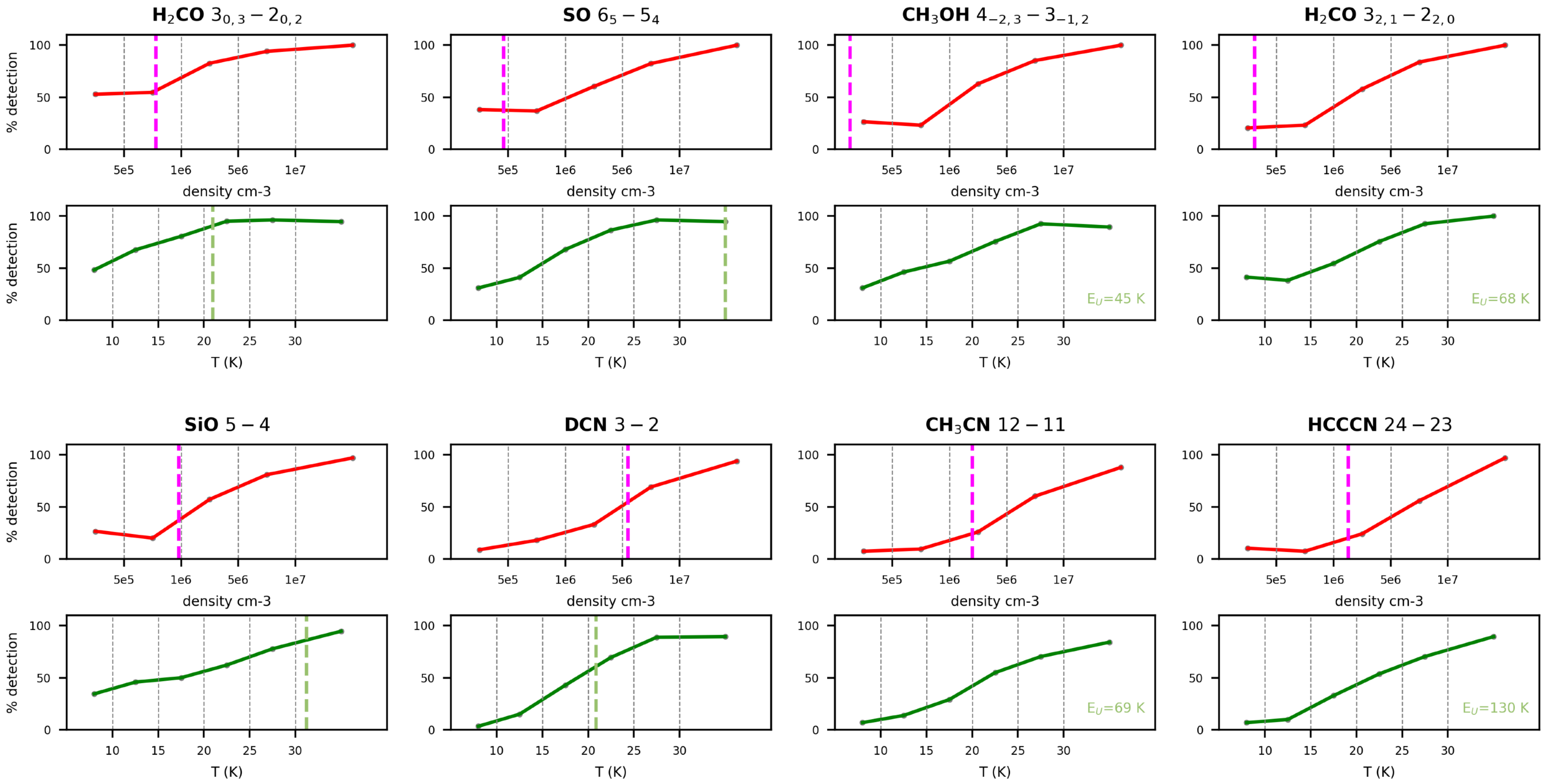
Source V_N=3.5%



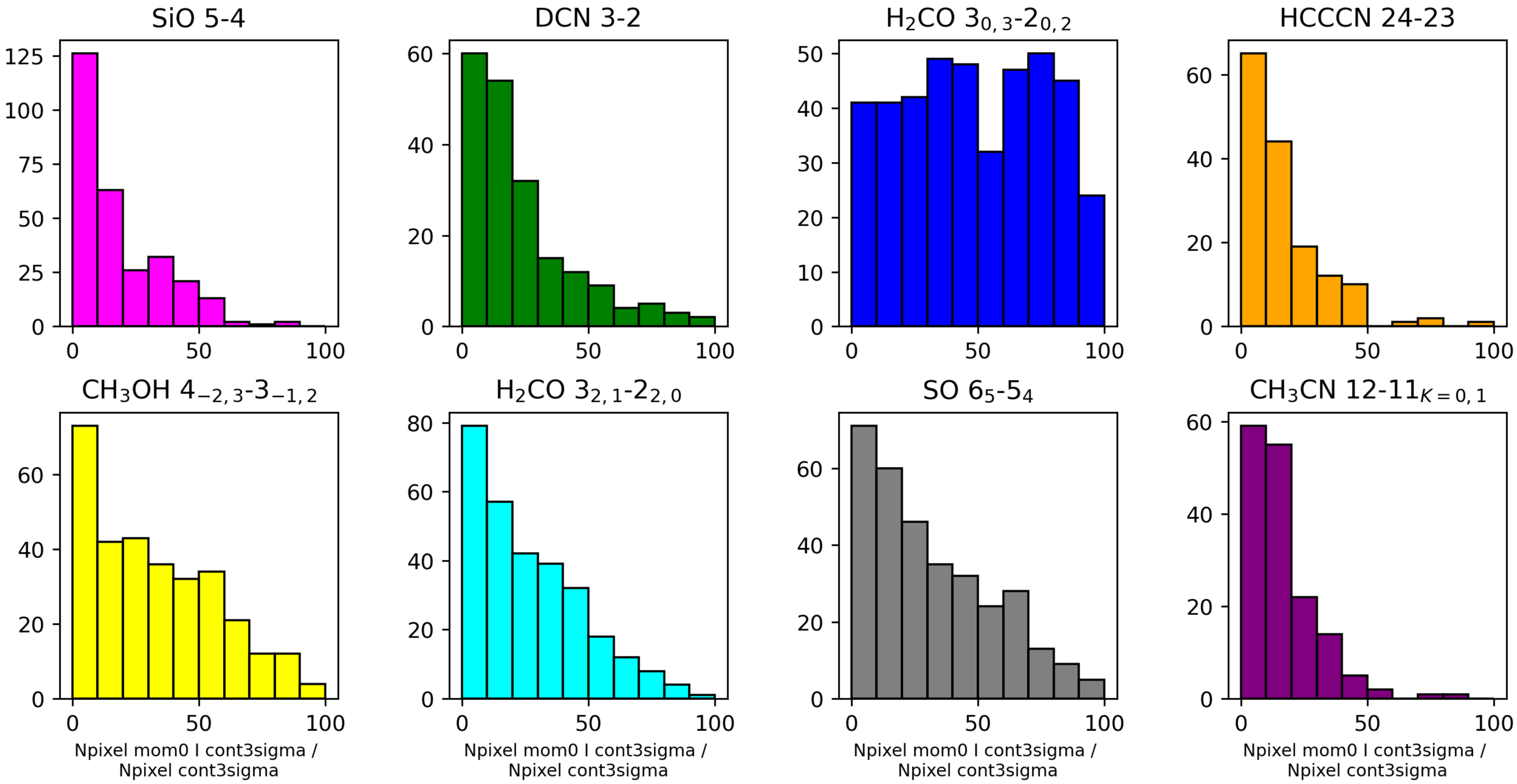
statistics of detection



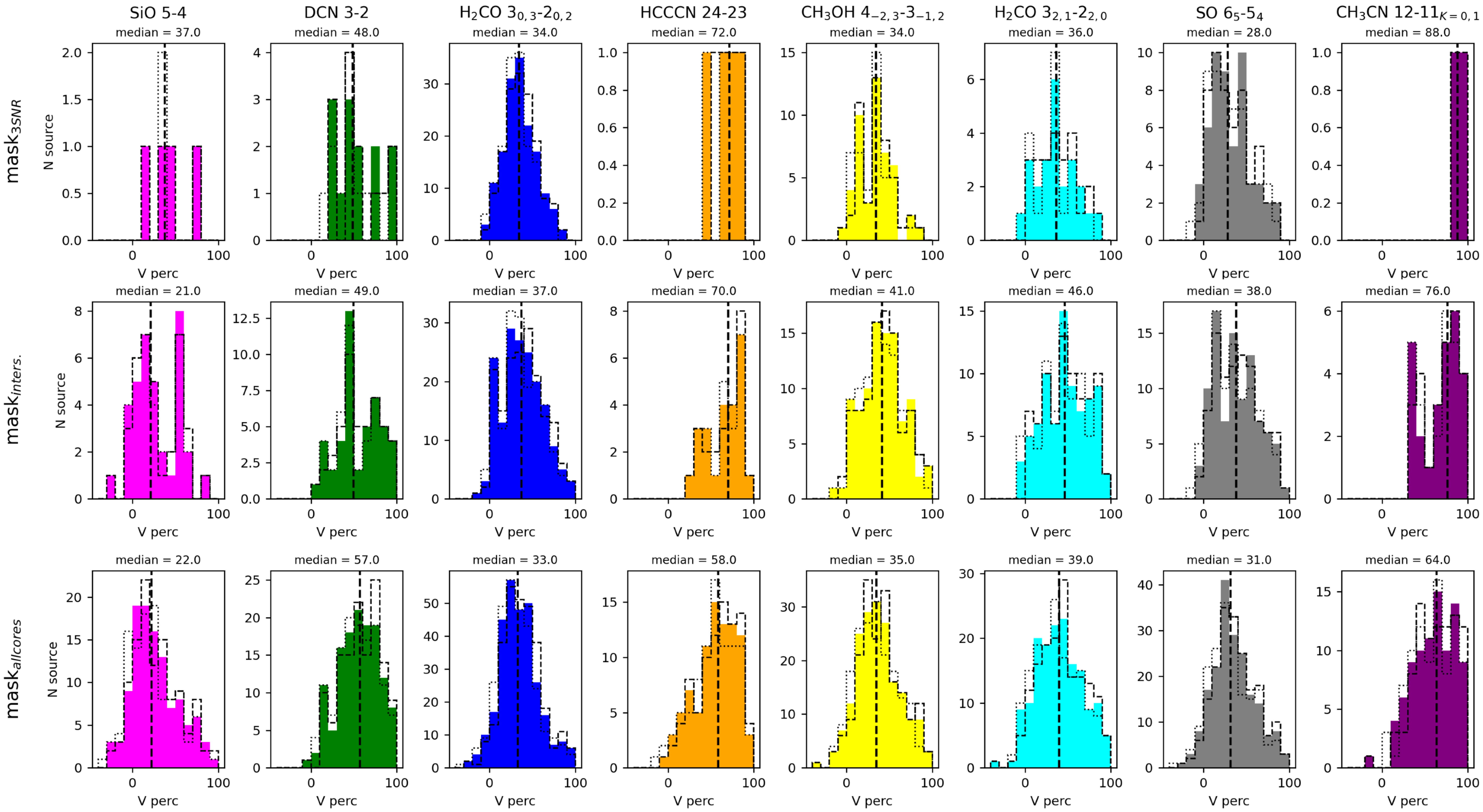
statistics of detection



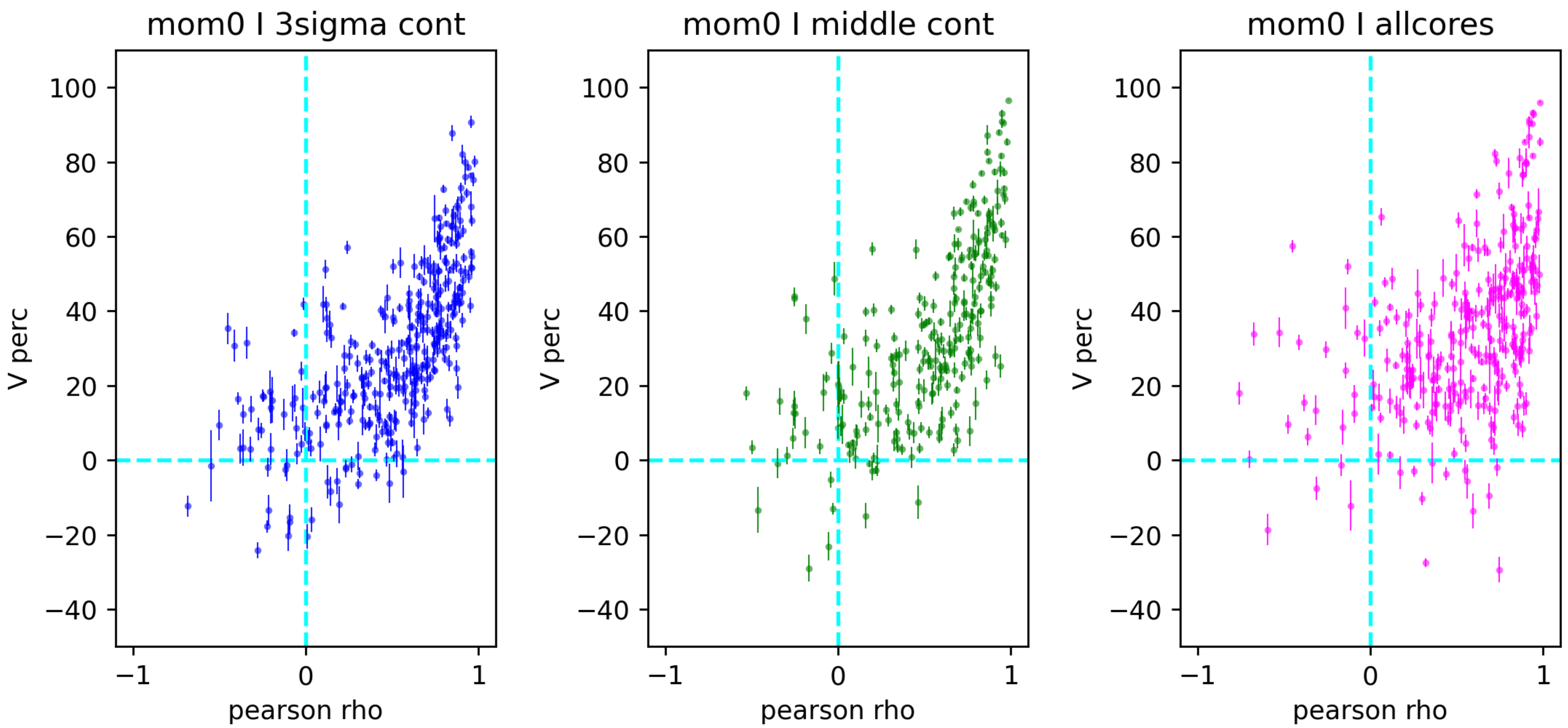
area of emission vs continuum



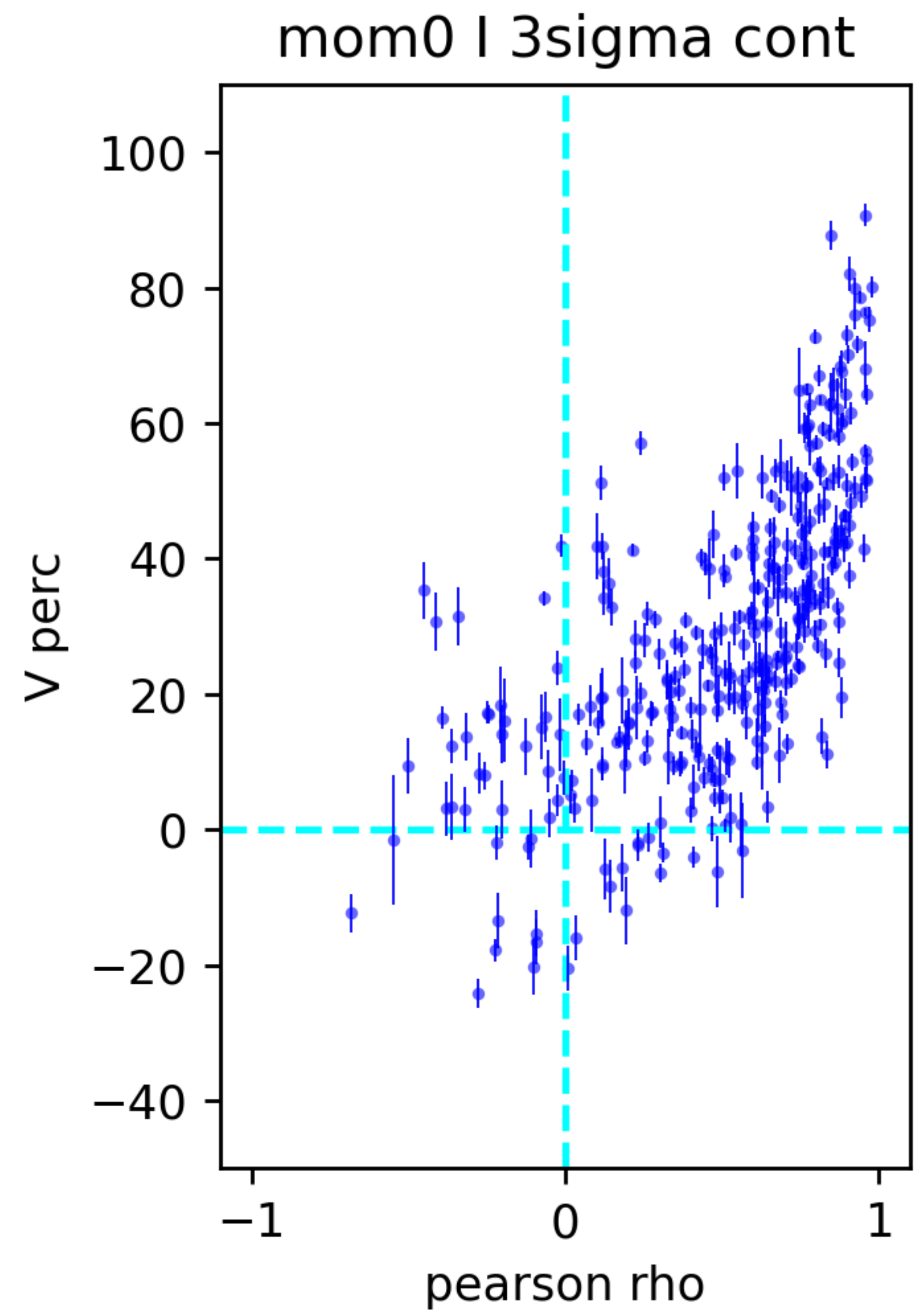
results of the morphological analysis with astroHOG



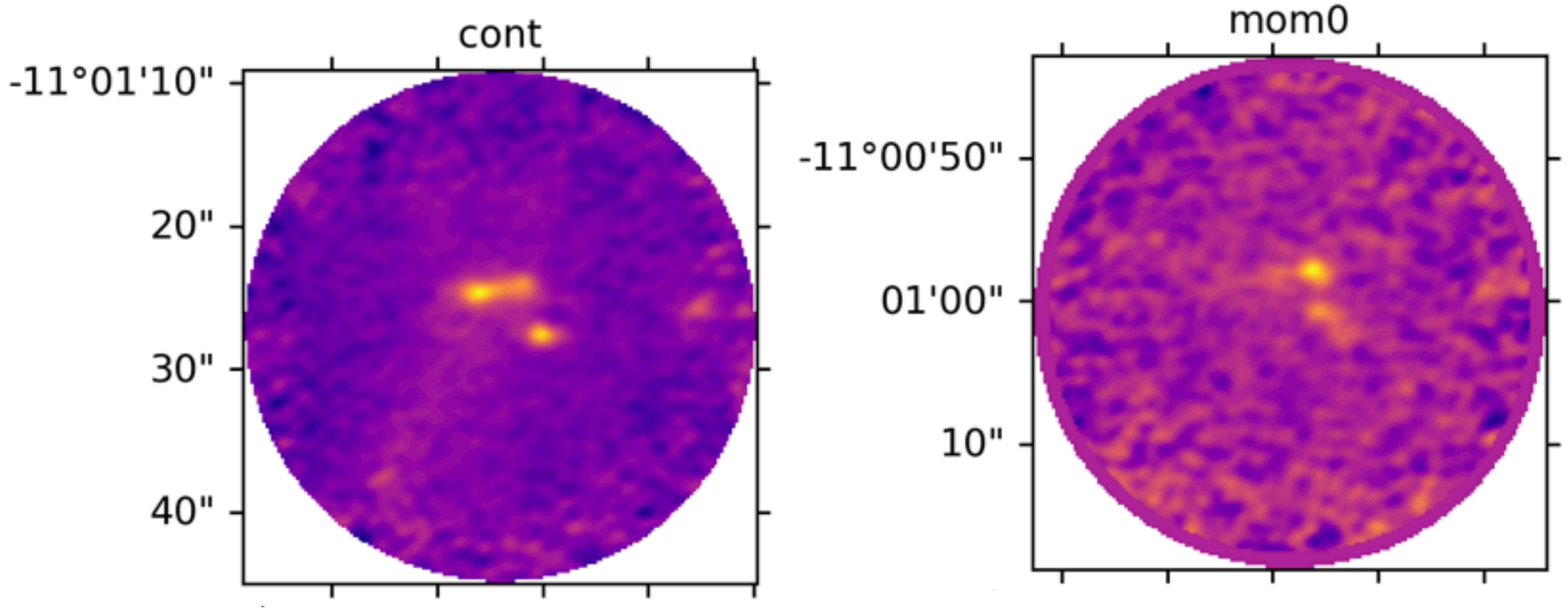
astroHOG vs Pearson's coefficient



astroHOG vs Pearson's coefficient



V_N = 36% Pearson's coefficient = 0.01



astroHOG morphological analysis is **more accurate than intensity-based correlator**. Two clear cases:

1. In sources with very bright Hot Cores where the continuum is correlated with the lines, surrounded by extended emission in lines and continuum not correlated, the **high dynamical range biases the results on intensity-based correlator**. It will results on good values, even if only a small part of the emission, i.e. the bright core, is actually morphologically correlated

2. In sources in which there are **multiple dense cores**, if the line emission follows the morphological emission of all the cores, but **the brightest one in the continuum is not also the brightest in the line emission** the intensity-based correlators will give low values of correlation, while astroHOG will give correctly an high correlation value of V_N.

main results

1. H_2CO, CH_3OH and SO have significant sources with diffuse emission cospatial to continuum
2. SiO diffuse emission when present is not cospatial with the continuum emission from statistics of intersection mask
3. On cores SiO show the lowest median value of correlation, followed by H_2CO, CH_3OH, and SO
4. DCN, HCCCN and CH_3CN shows good morphological correlations on cores around 60%
5. Pearson's and V have some positive correlation, but in general intensity correlation do not automatically mean good morphological correlation

Thank you for your attention!

astroHOG is available on GITHub

https://github.com/solerjuan/astroHOG/