

Fig. 1: Zoom-in from the full simulation domain on the MC and finally on the central part of the cloud (from left to right), demonstrating the power of the used zoom-in technique.

## Overview

We present zoom-in simulations of the self-consistent formation of molecular clouds (MCs) in galactic environments [1]. We model their formation from kpc-scales down to 0.1 pc, incorporating the **chemical evolution of H<sub>2</sub> and CO**.

Our simulations build up on the galactic-scale SILCC simulations including supernova feedback and chemistry using the FLASH code [2,3]. We apply a zoom-in technique, which allows us to follow the formation of MCs, while simultaneously keeping the large-scale environment. With this technique we model the evolution of MCs over a few Myr, reaching an unprecedented resolution of 0.1 pc, which allows us to resolve the filamentary structure of MCs.

## Modelling molecular clouds: What is needed?

The top right figure shows that atomic hydrogen envelopes the molecular component. CO is mainly present in the densest parts of the cloud. We investigate in detail the **resolution dependence** of the **chemical and dynamical evolution** to obtain converged results.

With a resolution of 1 pc or above, the amount of H<sub>2</sub>, CO, as well as the velocity dispersion are underestimated by up to a factor of 2 (bottom right). Also, the filamentary structure is resolved only poorly.

Towards later stages, predominantly molecular H<sub>2</sub> gas (red line, right figure) can also be found in low density gas ( $n = 30 \text{ cm}^{-3}$ , blue line). Estimating relative timescales shows that H<sub>2</sub> is transported there by **turbulent mixing** from denser parts. This process would thus significantly complicate the chemical postprocessing of simulations without a chemical network.

To summarize, our results show that **on-the-fly chemical modelling** combined with a **resolution of  $\sim 0.1 \text{ pc}$**  is required to accurately model the dynamical and chemical evolution of MCs.

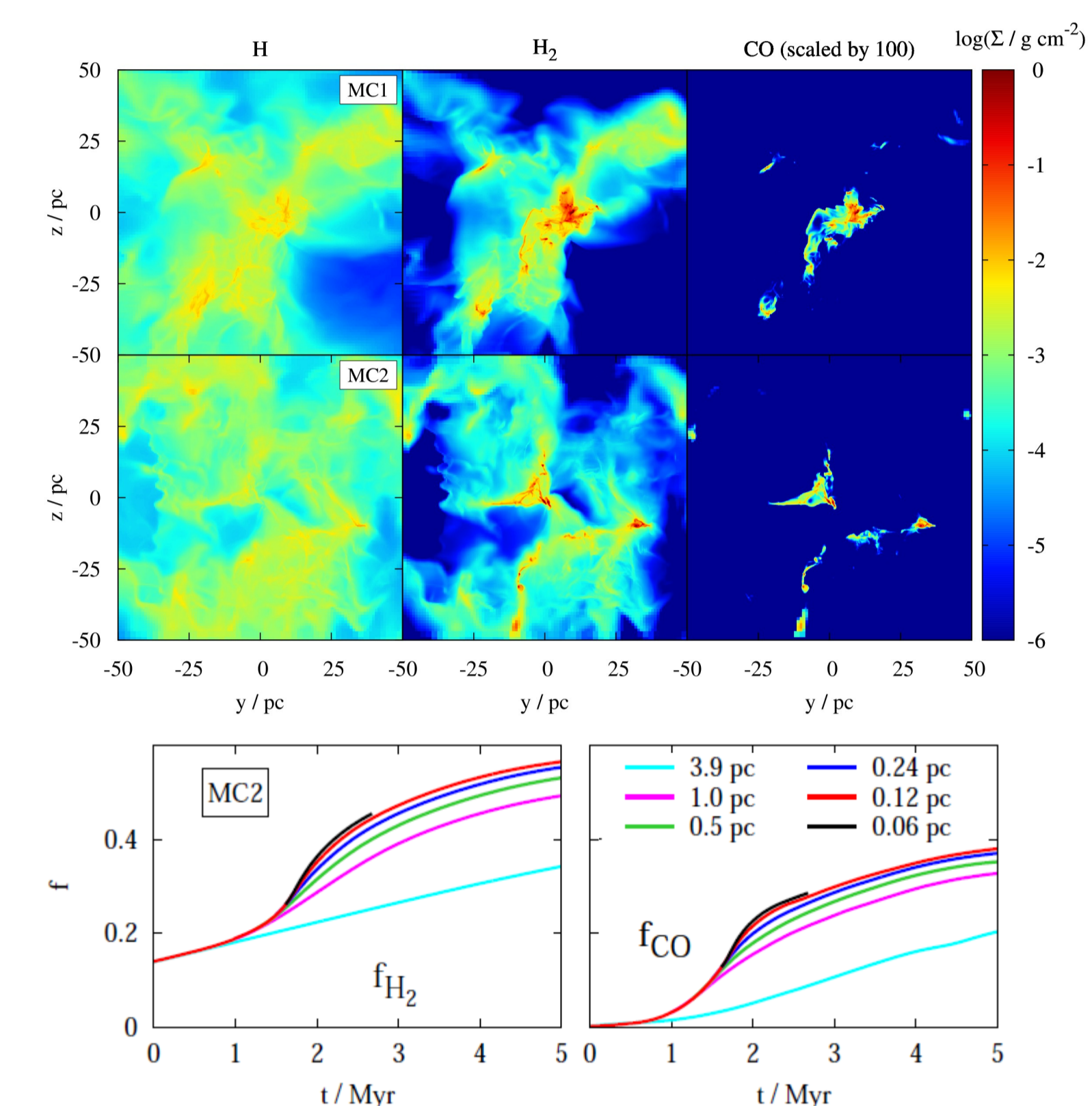
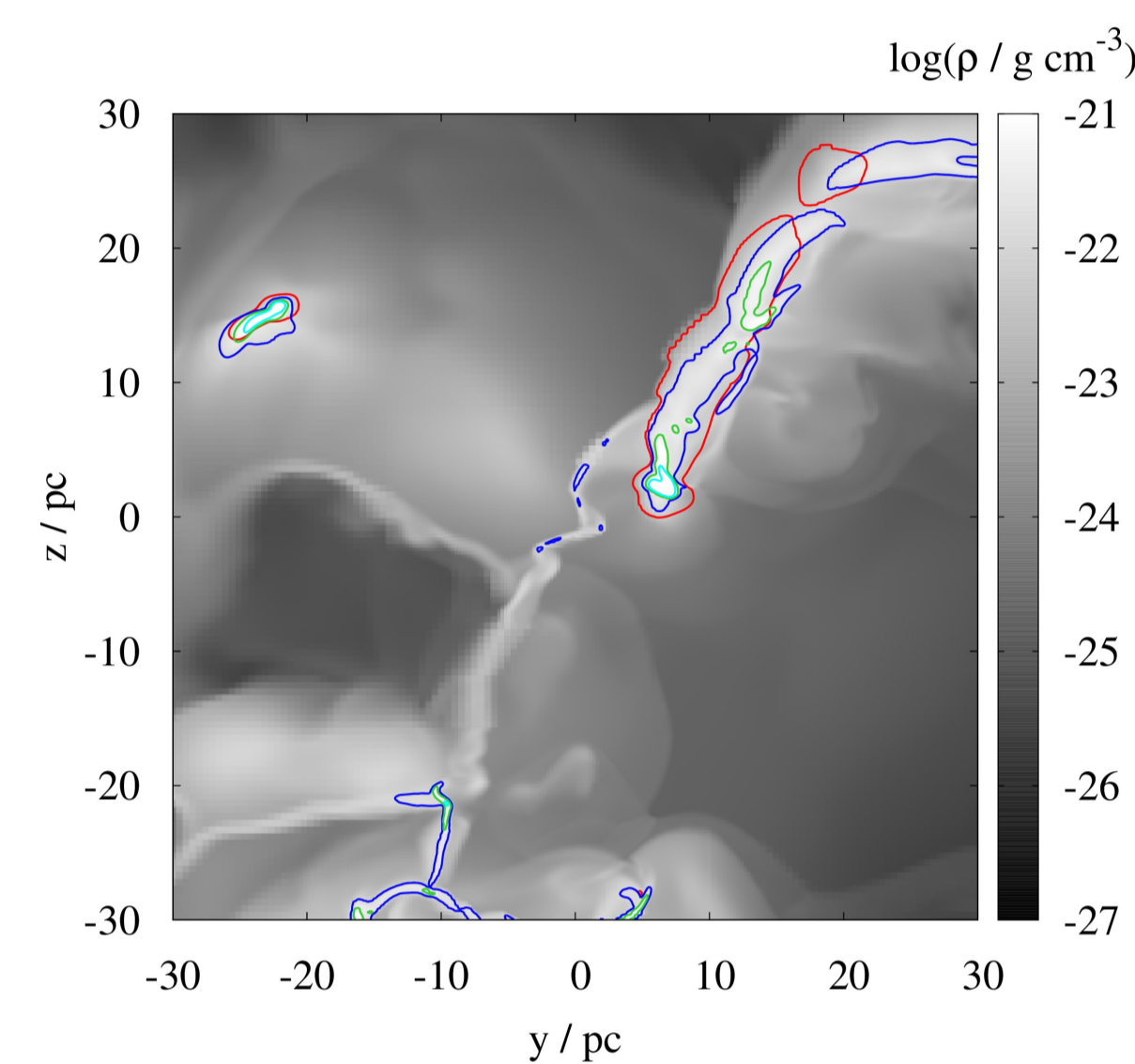


Fig. 2: Top: Column density of chemical species for two MCs. Bottom: Resolution dependence of the H<sub>2</sub> and CO fraction. Left: H<sub>2</sub> (red line) is present in low density gas.

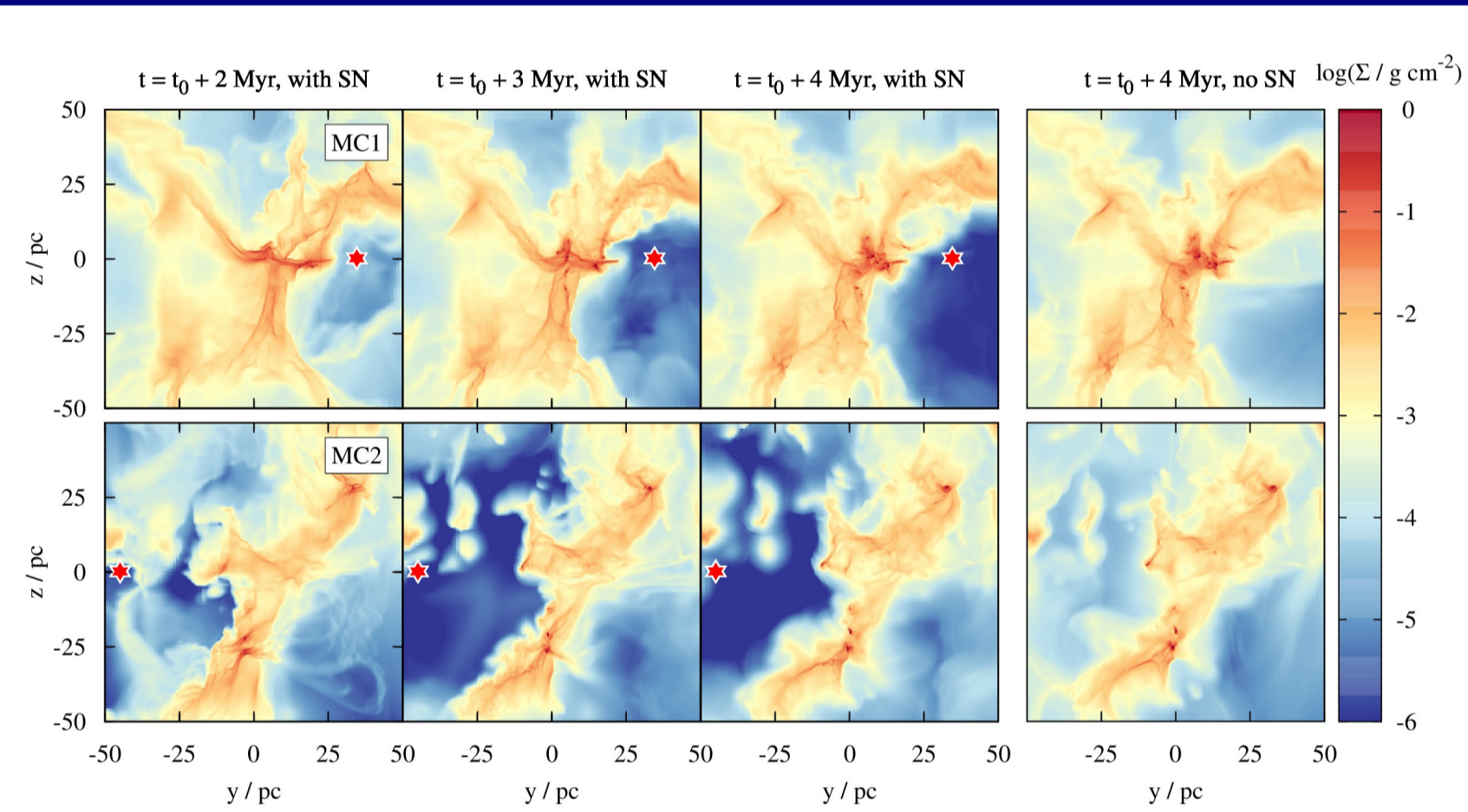
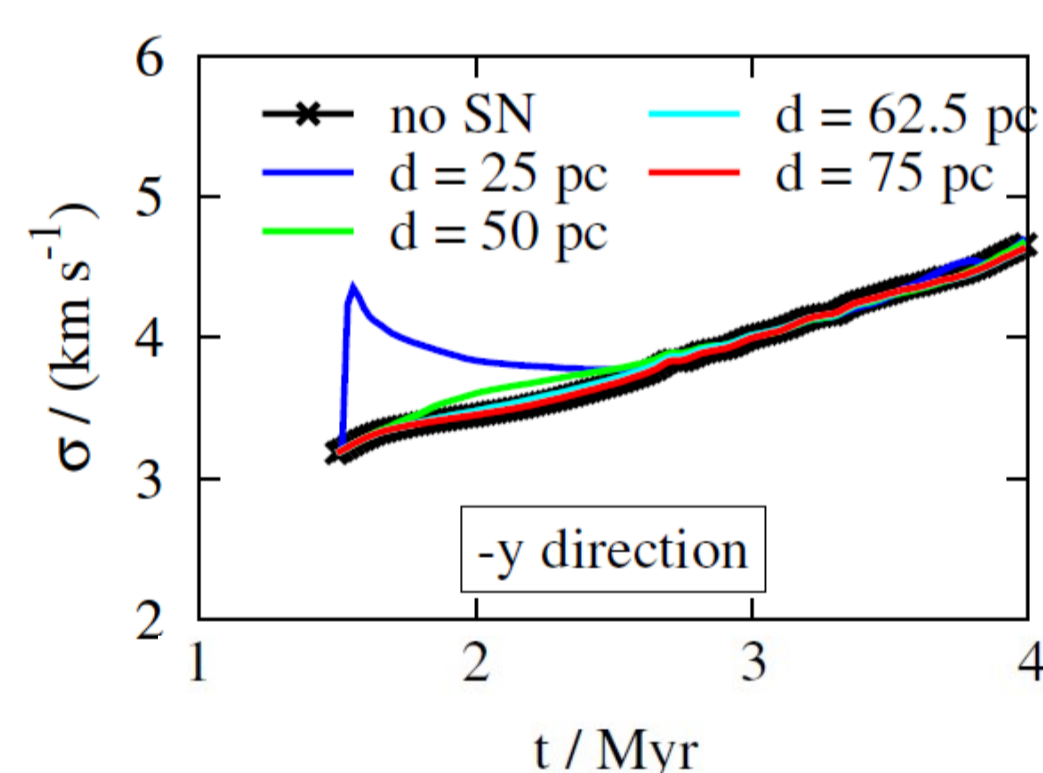


Fig. 2: Top: Column density of two MCs affected by a nearby SN. The right panel show the same cloud without a SN for comparison. Right: Gain in turbulence due to a SN going off at various distances.



## Molecular clouds turbulence: Time-dependent driving?

Our MCs are initial formed by supernova (SN) shock waves driving turbulence in the diffuse ISM. However, once formed, close-by SNe have little effect on the clouds, in particular the dense regions (top left figure) [4]. The gain in **turbulence** is only moderate (a few  $\text{km s}^{-1}$ ) and **decays** within a few **100 kyr**. In addition, for SNe further away than **50 pc**, their overall effect is negligible. Furthermore, the later the SN explodes, the lower is its impact.

We thus suggest a **time-dependent driving**: At early stages, SN drives turbulence in clouds. However, as the clouds evolves, turbulence is driven mainly by **gravity** and gas accretion.

In regions with higher star formation/column density, more SNe occur. From our results we can show that above a **column density threshold** of

$$\Sigma_{\text{gas}} = 40 M_{\text{sun}} \text{ pc}^{-2}$$

SNe might be able to continuously drive turbulence in MCs. Possible regions for this are the Central Molecular Zone.

## Polarisation in molecular clouds

Using POLARIS [5] we present polarisation maps of MCs [6], using for the first time a **self-consistent theory** for **radiative torque alignment (RAT)** combined with dust polarisation radiative transfer. In particular we focus on the cause of the frequently observed **depolarisation** and the effect of **observational noise**. We show that:

- Dust grains are well aligned with the magnetic field even at high densities ( $n > 10^3 \text{ cm}^{-3}$ ) and visual extinctions ( $A_V > 1$ ), i.e. RAT remains efficient in the center of MCs.
- Depolarisation on clouds scales is caused by strong variations of the magnetic field direction along the line-of-sight.
- The effect of noise can be reduced by convolving the image. The underlying field structure can be probed with an accuracy of  $< 10^\circ$ .
- The magnetic field structure can be reliably observed in regions with intensities  $> 3$  times the noise level and column densities  $> 1 M_{\text{sun}} \text{ pc}^{-2}$ .

Our results demonstrate the benefit (and necessity) of combining MHD simulations, alignment theories and dust polarisation radiative transfer, to make accurate predictions for the increasing number of polarisation observations.

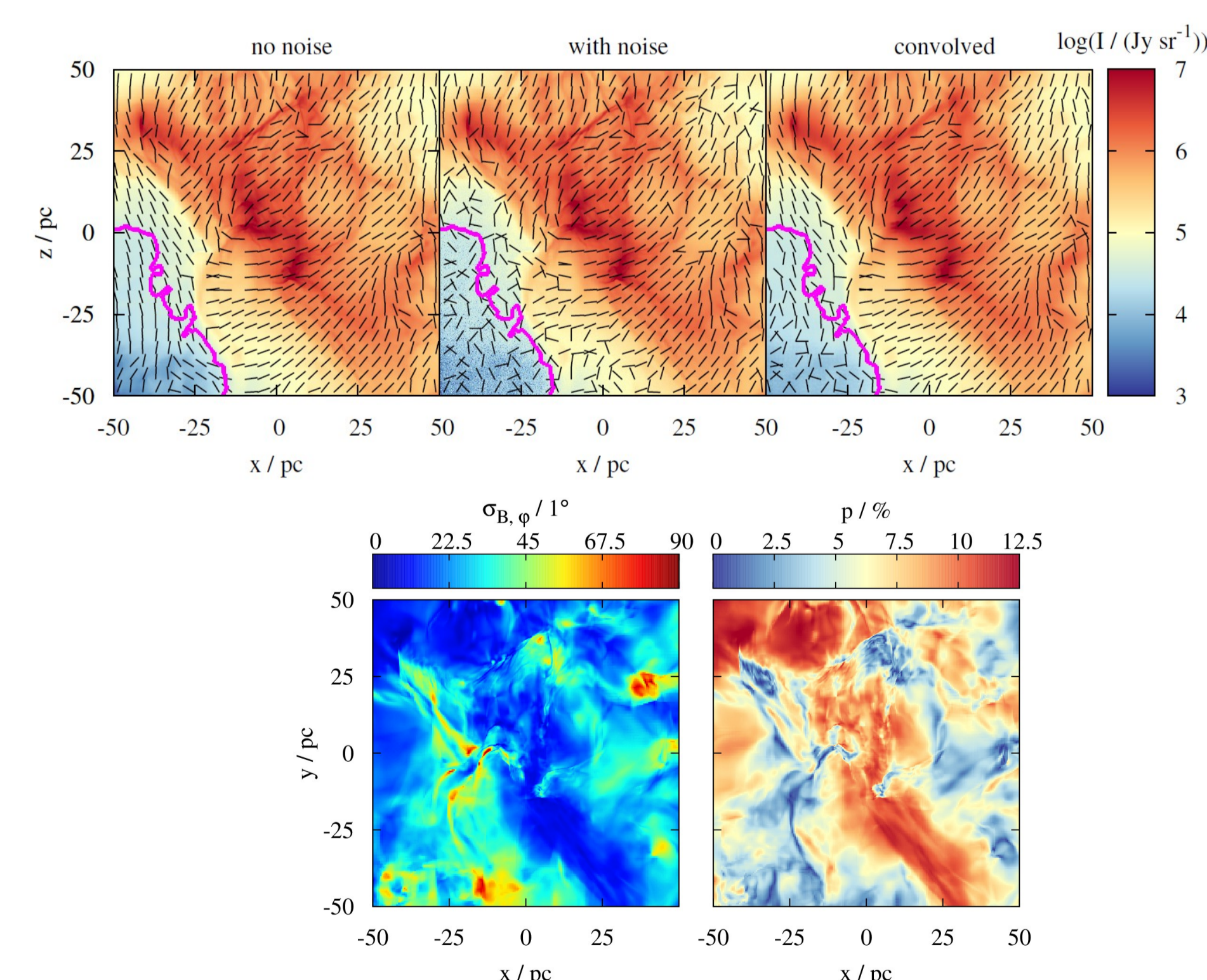


Fig. 2: Top: Column density and polarisation structure of a MC. The magenta line show the  $3\sigma$  noise level above which the polarisation structure can be probed reliably. Bottom: The degree of variation of the magnetic field along a LOS (left) is strongly correlated with the resulting polarisation degree (right).