Evolution of the Star-Forming Main Sequence Relations up to $z\sim12$ in the JWST Fields

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INTRODUCTION

Star formation is one of the key processes to understand the evolution of galaxies across cosmic time. Various studies have found a positive correlation between star formation rate (SFR) and stellar mass of the galaxies. Such a correlation is known as the **Star-Forming Main Sequence (SFMS).** This research aims to extend the study of the SFMS evolution to $z\sim12$ using combined photometric data and galaxies images from the James Webb Space Telescope (JWST) and Hubble Space Telescope (HST).

DATA

We used observational data from the **JWST** and **HST** archive on the Dawn JWST Archive (DJA) website in four fields: CEERS, COSMOS-Web, FRESCO GOOD-S, and PRIMER-UDS. The data have been pre-processed using ***grizli*** (Brammer, 2022).

UVJ DIAGRAM

We separated star-forming and quiescent galaxies using UVJ color diagram. The galaxies lie on the top left of UVJ diagram are **quiescent galaxies** and the rest are **star-forming galaxies**. To determine the boundaries, we used criteria from Williams et al. (2009) for $z < 2$ and Valentino et al. (2023) for $z \geq 2$. Then, we obtained a sample of 48404 star-forming galaxies.

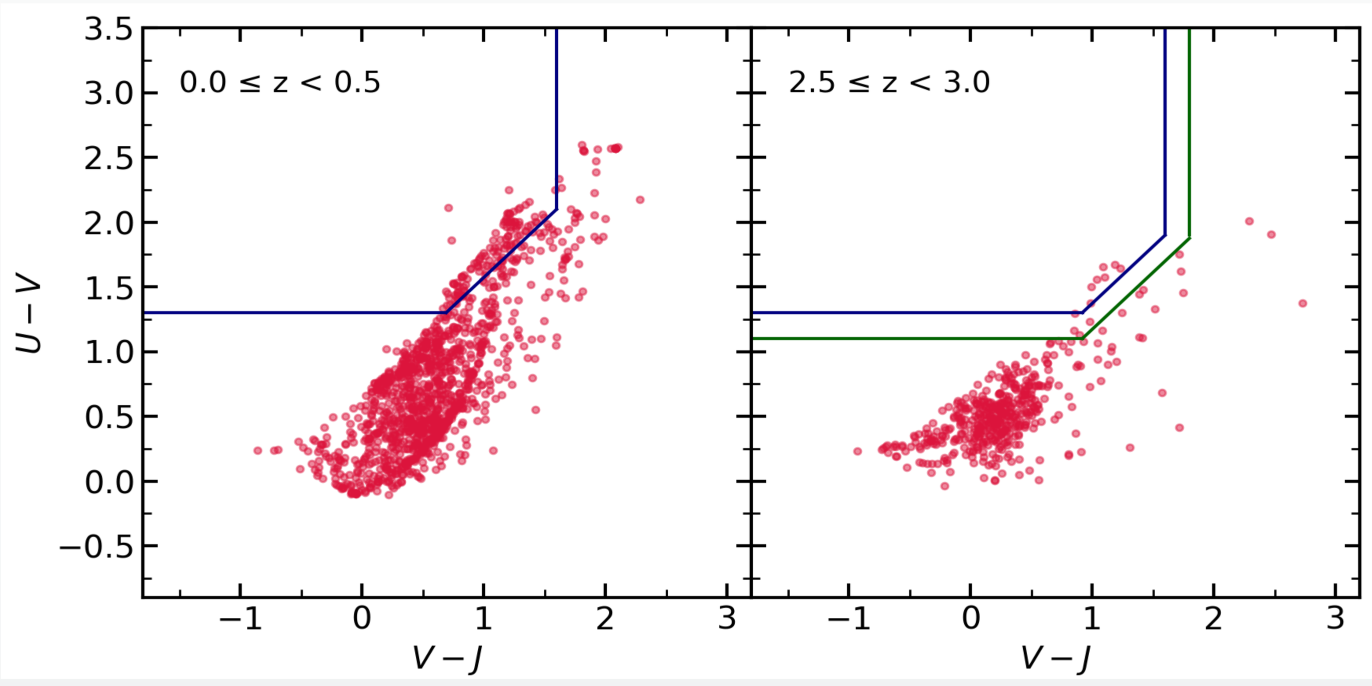

Figure 1. Examples of data selection process based on UVJ diagram. Blue lines are boundary from Williams et al. (2009) and green line is from Valentino et al. (2023).

SED FITTING

We performed spectral energy distribution (SED) fitting procedure to determine the stellar mass and star formation rate of the galaxies. In this work, we used ***dense basis*** package (Iyer et al. 2019) as a SED fitting tool. For the cosmological model, we used ΛCDM with $H_0 = 70\ \mathrm{km\ s^{-1}\ Mpc^{-1}}$, $\Omega_m = 0.3$, and $\Omega_\Lambda = 0.7$.

RESULT: RELATION

We show the relation between stellar mass and star formation rate from our sample galaxies in Figure 2. To determine the SFMS relation, we fitted the data with the linear relation (based on Santini et al. 2017):

$$\log \mathrm{SFR} = \alpha \log(\mathrm{M}/\mathrm{M}_{9.7}) + \beta$$

We found the **slope** and **normalization** of the SFMS:

$$\alpha = 0.015z^2 - 0.117z + 0.770$$
$$\beta = -0.494 + [0.973 \times \ln(0.765 + z)]$$

where $\mathrm{M}_{9.7} = 10^{9.7}\mathrm{M}_\odot$, α is the slope of the star-forming-main sequence, β is the normalization of the star-forming main sequence at $\log \mathrm{M}/\mathrm{M}_\odot = 9.7$, and z is redshift.

RESULT: INTERPRETATION

The SFMS relation indicates that the star formation rate has a strong correlation with the stellar mass of the galaxy.

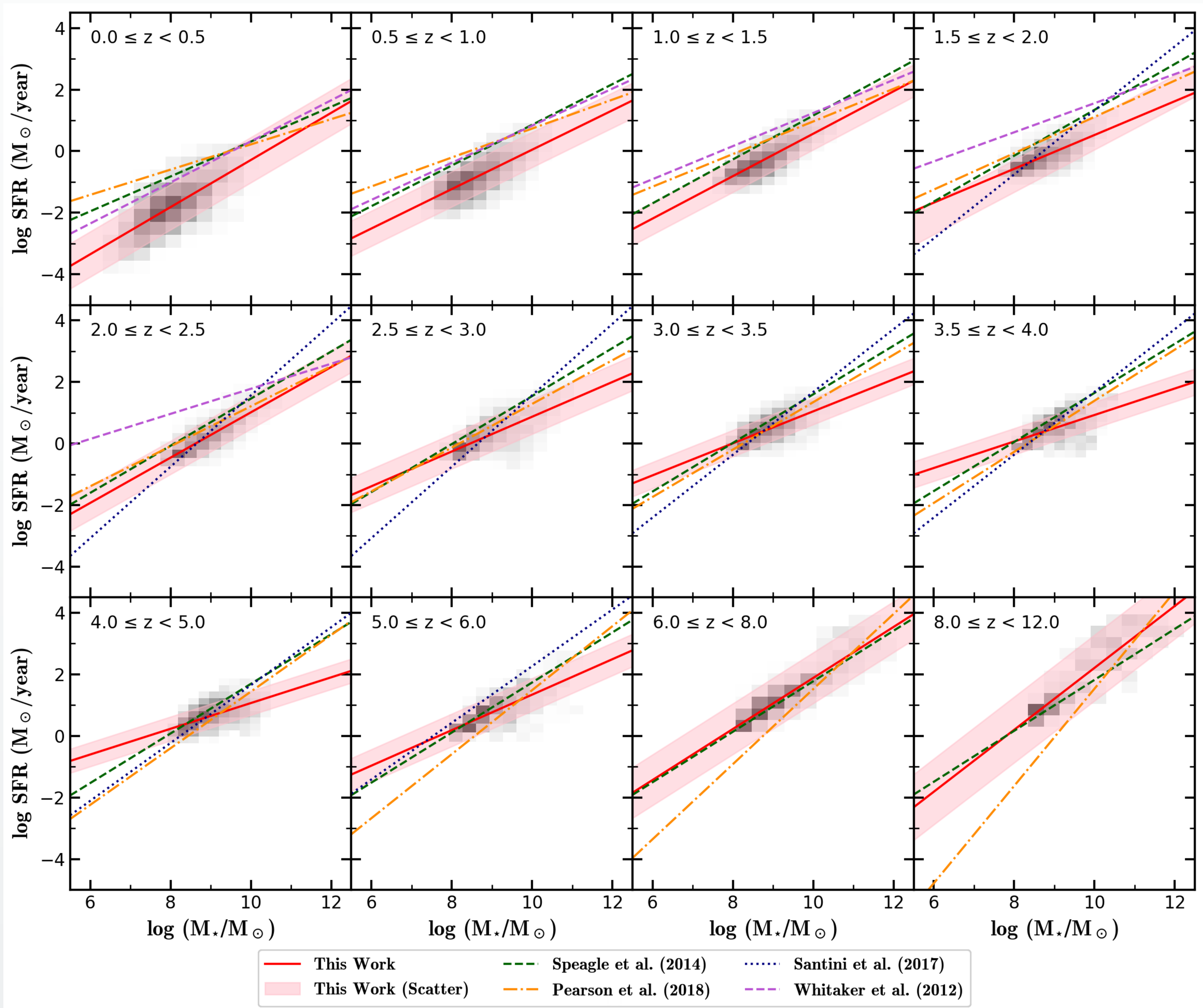

Figure 2. Star formation rate as a function of stellar mass from our sample of star-forming galaxies. Galaxies are shown in grey density plot (the darker color represents a denser area)

The **normalization** of the SFMS increases with redshift → Galaxies at high redshift have high abundance of gas for star-forming process.

The **slope** of the SFMS has a "valley" at $z\sim4$.

- At $z > 4$, SFR is dominated by galactic bulge → strongly depends on the bulge mass
- At $z\sim4$, star formation shifted from galactic bulge to galactic disk
- At $z < 4$, SFR is dominated by galactic disk → strongly depends on the disk mass

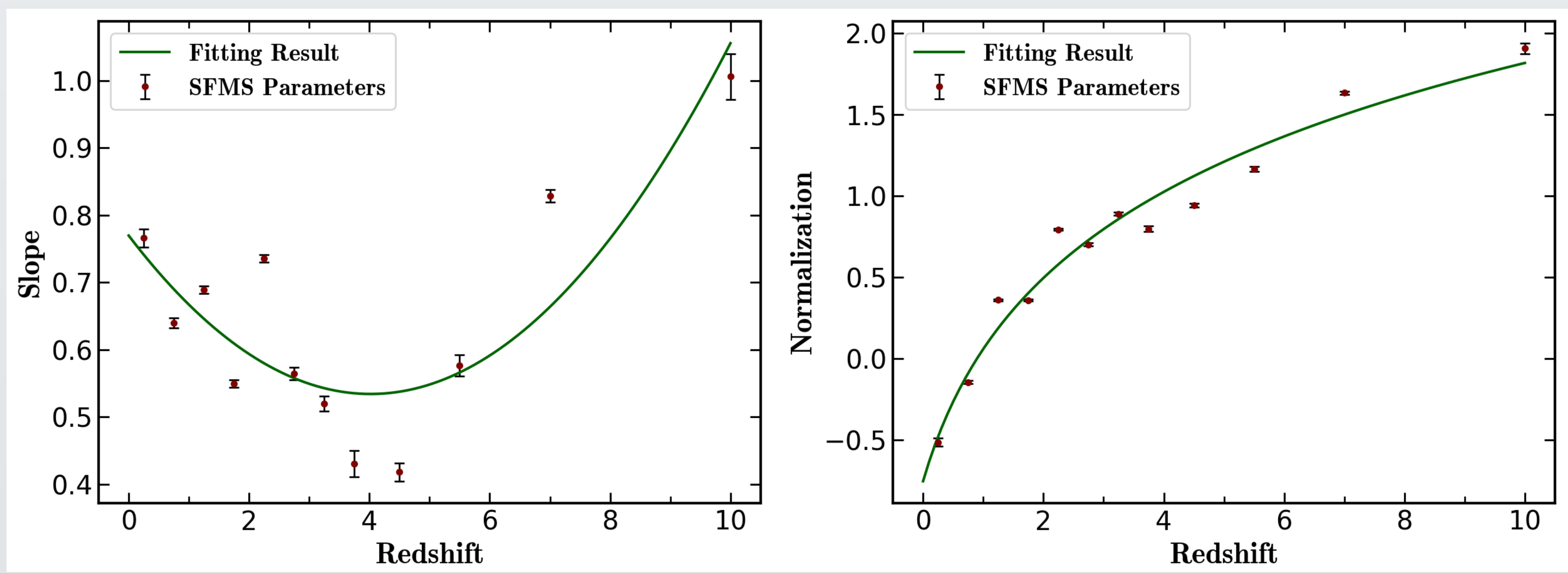

Figure 3. The evolution of slope (top) and normalization (bottom) of the SFMS.

FUTURE WORK & ACKNOWLEDGEMENT

To better depict the star formation mechanism in the main sequence, we will continue to perform **spatially resolved SED fitting** in our future work.

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Evolution of Dust and Gas throughout Cosmic Time

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