

Investigations of dust heating in M81, M83, and NGC 2403 with Herschel and Spitzer

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Abstract

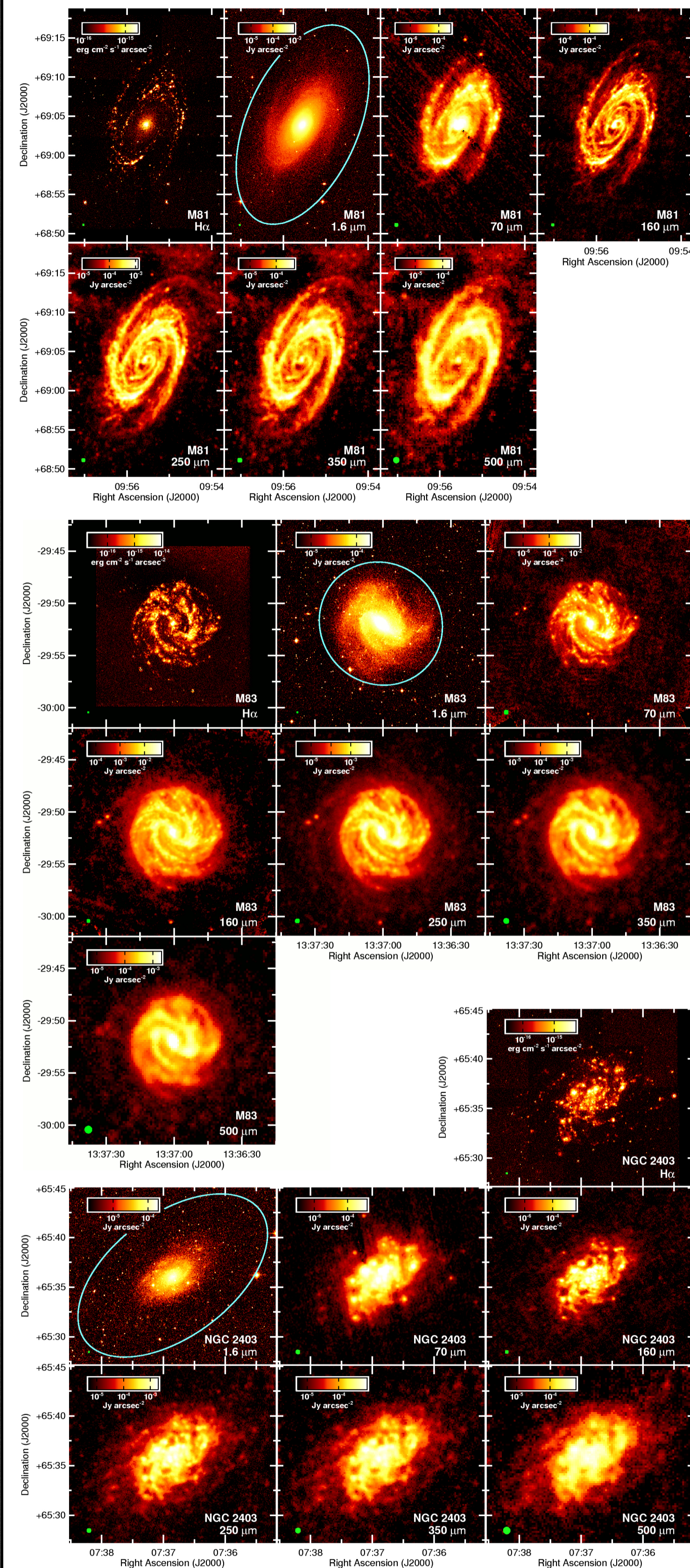
We use Herschel Space Observatory and Spitzer Space Telescope 24-500 μm data along with ground-based optical and near-infrared data to understand how dust heating in the nearby face-on spiral galaxies M81, M83, and NGC 2403 is affected by the starlight from all stars and by the radiation from star forming regions. We find that 70/160 μm surface brightness ratios tend to be more strongly influenced by star forming regions. However, the 250/350 and 350/500 μm surface brightness ratios are more strongly affected by the light from the total stellar populations, suggesting that the dust emission at $>250 \mu\text{m}$ originates predominantly from a component that is colder than the dust seen at $<160 \mu\text{m}$ and that is relatively unaffected to star formation activity.

Introduction

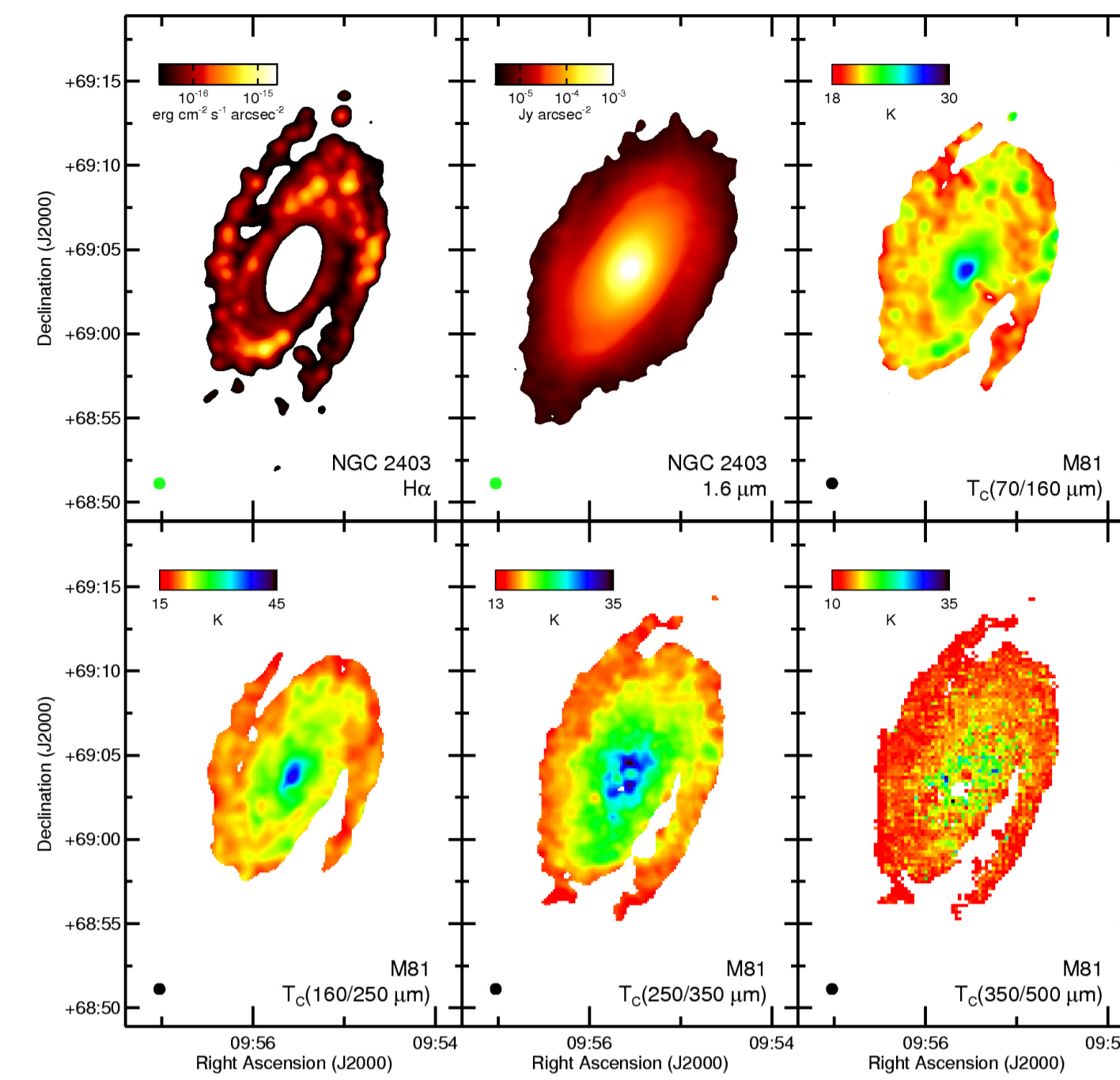
The goals of the analysis here are to understand dust heating sources in nearby spiral galaxies. We want to determine whether the dust seen at 70-500 μm is heated by star formation or the total stellar population. This follows up recent contradictory results from Herschel early science on the relation of dust to star formation. Boquien et al. (2010, A&A, 518, L70) and Verley et al. (2010, A&A, 518, L68) demonstrated that the 100-250 μm flux densities of star forming regions in M33 can be correlated with other tracers of star formation. However, Bendo et al. (2010, A&A, 518, L65) inferred that the dust emitting at $>160 \mu\text{m}$ in M81 was heated by the total stellar population, including evolved stars in the disc and bulge.

Conclusions

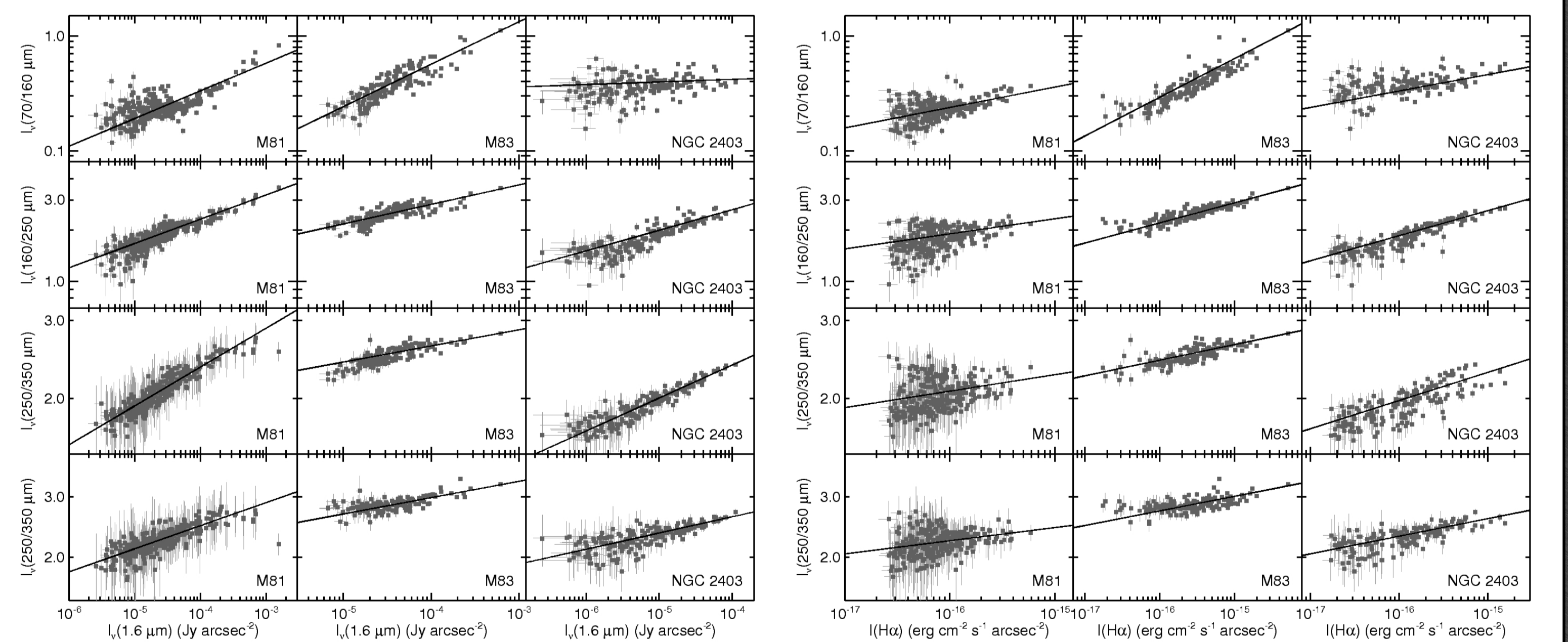
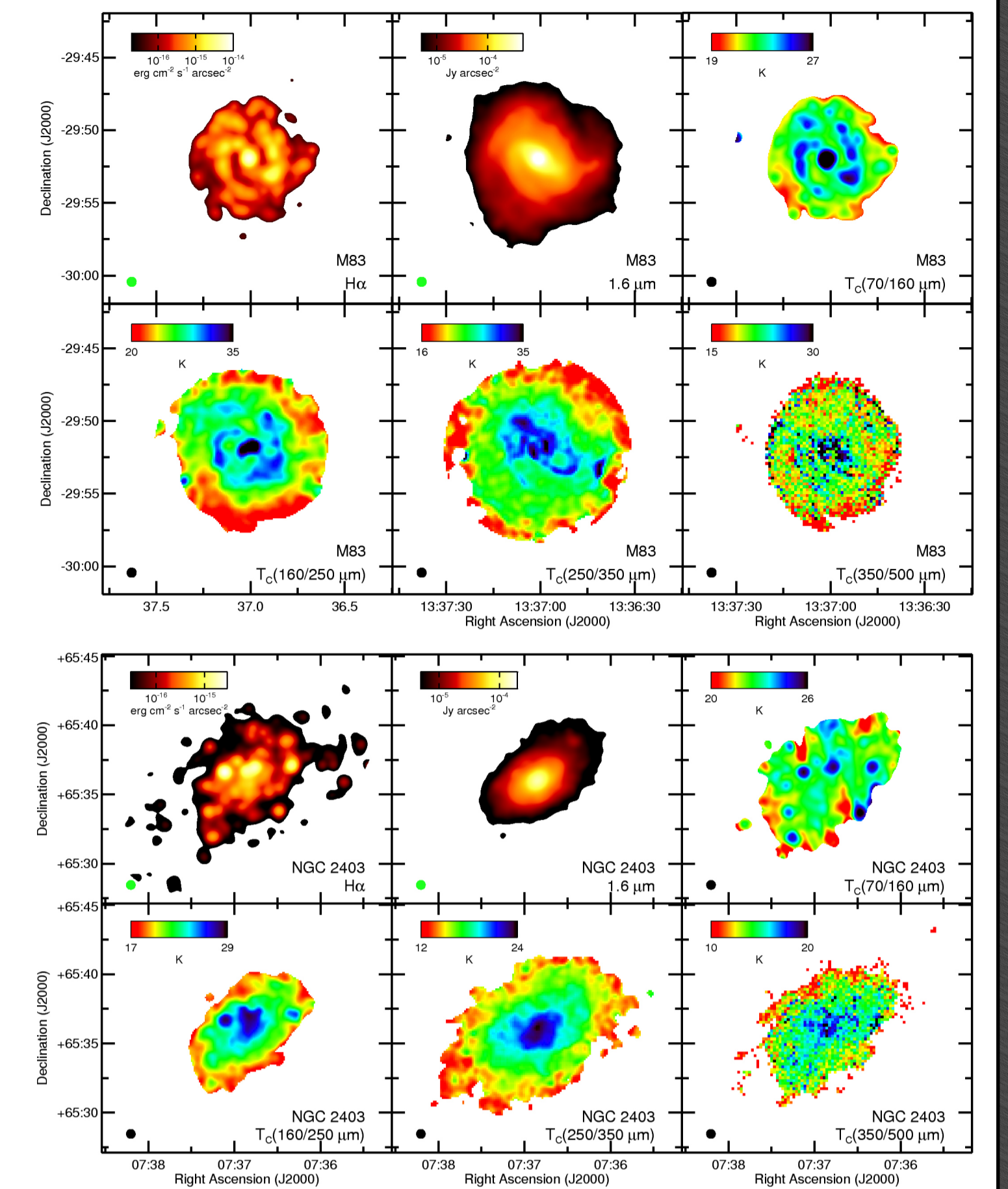
- Emission at $<160 \mu\text{m}$ in these galaxies generally originates from dust heated by star forming regions, although it is possible for evolved stars (such as the bulge stars in the central 3 kpc of M81) to heat the dust that emits at 70 μm .
- Emission observed at $>250 \mu\text{m}$ in these galaxies originates from dust primarily heated by the total stellar population, including evolved stars in the galaxies' bulges and discs.
- The correlation between far-infrared emission measured in individual wave bands and other star formation tracers may be the result of the Schmidt law (relating star formation to the gas available to fuel it) and not a result of the dust being heated by star forming regions.
- Dust emission models and extragalactic SED templates need to be redesigned to take into account dust components that are largely unaffected by star forming regions.



These images show the Herschel and Spitzer 70-500 μm images used in this analysis as well as H α images (from Boselli & Gavazzi, 2002, A&A, 386, 124 and Meurer et al., 2006, ApJS, 165, 307) used to trace star formation and the 1.6 μm images (from Jarrett et al., 2003, AJ, 125, 525) used to trace the total stellar population. The cyan ellipses show the optical discs of the galaxies, and the green circles show the FWHM of the PSFs. Although dust tends to be found near star forming regions, this may not necessarily indicate that the star forming regions heat all of the observed dust.



These figures show the H α and 1.6 μm emission as well as 70/160, 160/250, 250/350, and 350/500 μm colour temperatures for each of the galaxies. The PSFs have all been matched to the PSF of the 500 μm data, which has a FWHM of 36'' (shown by the circles at the bottom of each map). The 70/160 μm colour temperatures correspond well to features such as spiral arms in the H α images, while the 250/350 and 350/500 μm structures correspond to the stellar structures seen in the 1.6 μm images.



The above figures show variations in infrared surface brightness ratios as functions of the 1.6 μm surface brightness and H α intensities for 36'' square subregions within the data shown in the above images (where all of the PSFs match the PSF of the 500 μm data, which has a FWHM of 36''). The 70/160 μm surface brightness ratios show a stronger correlation with H α intensity, while the 250/350 and 350/500 μm surface brightness ratios show a stronger correlation with 1.6 μm surface brightness. The 160/250 μm ratios for subregions in M83 and NGC 2403 tend to show almost equally good correlations with either H α or 1.6 μm emission, although the 160/250 μm ratios for subregions in M81 are much more closely correlated with the 1.6 μm surface brightness. This shows that emission at $<160 \mu\text{m}$ mostly originates from dust heated by star forming regions, while emission at $>250 \mu\text{m}$ originates from dust heated by the total stellar populations within galaxies, including evolved stars in the galaxies' bulges and discs.