Young Brown Dwarfs at Low Spectral Resolution

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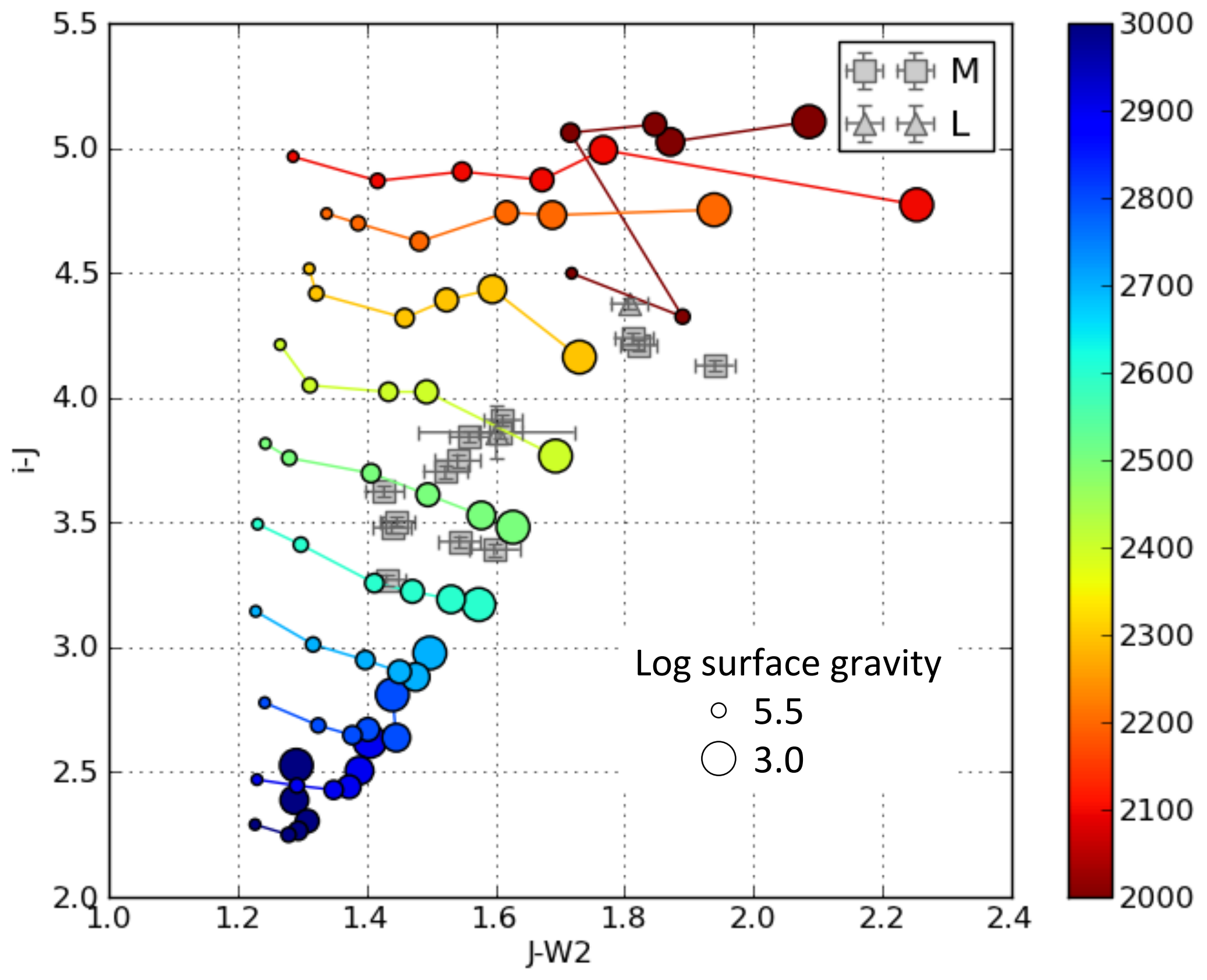
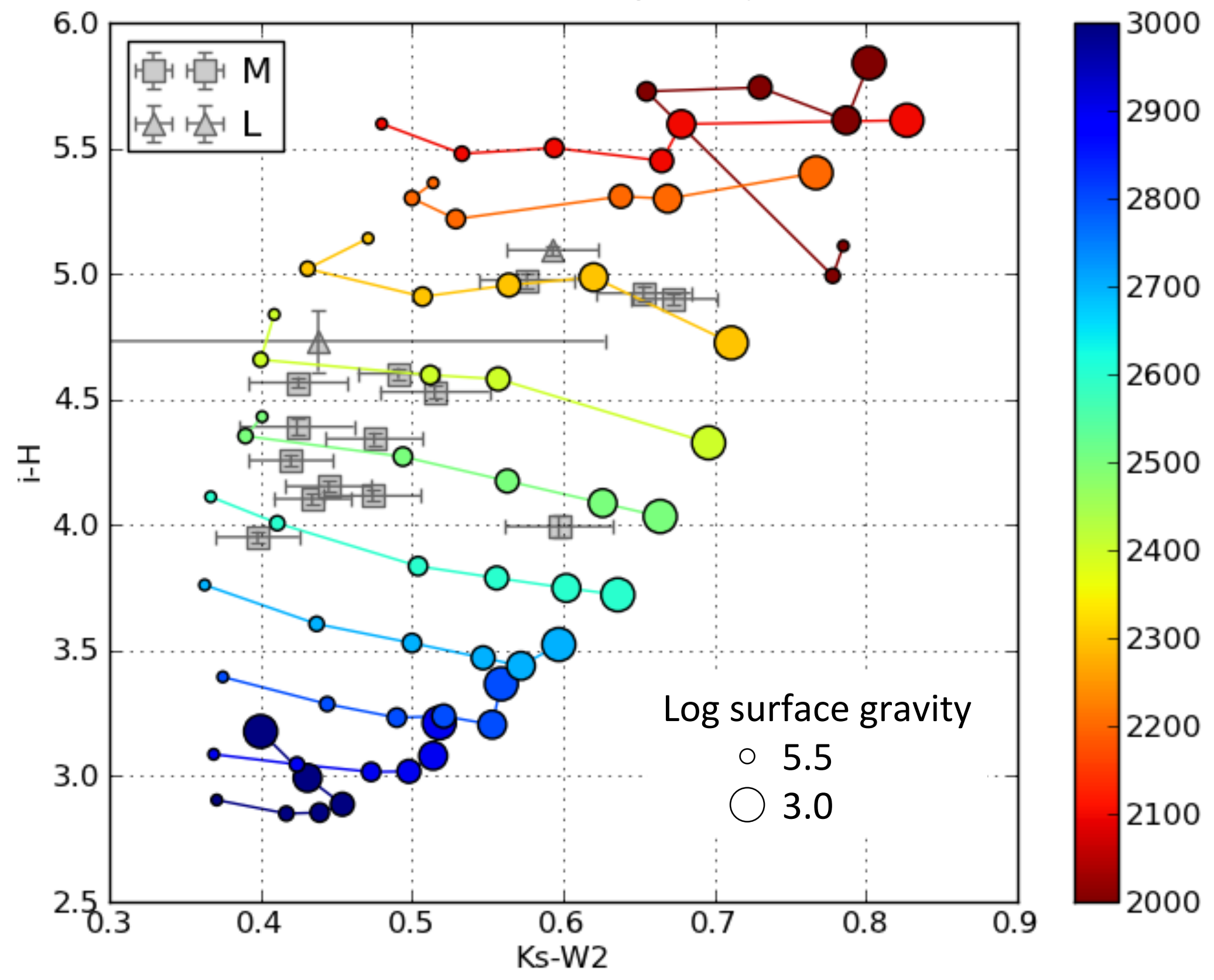
We are testing the utility of colors, very low resolution (R~30) near-infrared spectra, and optical through mid-infrared spectral energy distributions in distinguishing young, low-gravity objects from field brown dwarfs and in disentangling estimates of temperature and gravity. An increasing number of young (~10–100s Myr) brown dwarfs are being discovered and characterized, and their observational properties are enticingly similar to directly-imaged planetary mass companions. However, the ambiguity of the effects of physical parameters such as effective temperature, surface gravity, metallicity, and dust and clouds on observational properties is particularly troublesome at low effective temperatures (<2500 K). Developing efficient and reliable methods to characterize these objects is of key importance to understanding the formation and evolution of substellar objects and the atmospheric properties of massive gas giant planets. We present preliminary results using PHOENIX model atmospheres and the extensive database of optical and near-infrared spectra and parallaxes gathered by the BDNYC, our Brown Dwarf research collaboration based in New York City.

Model-based color diagnostics

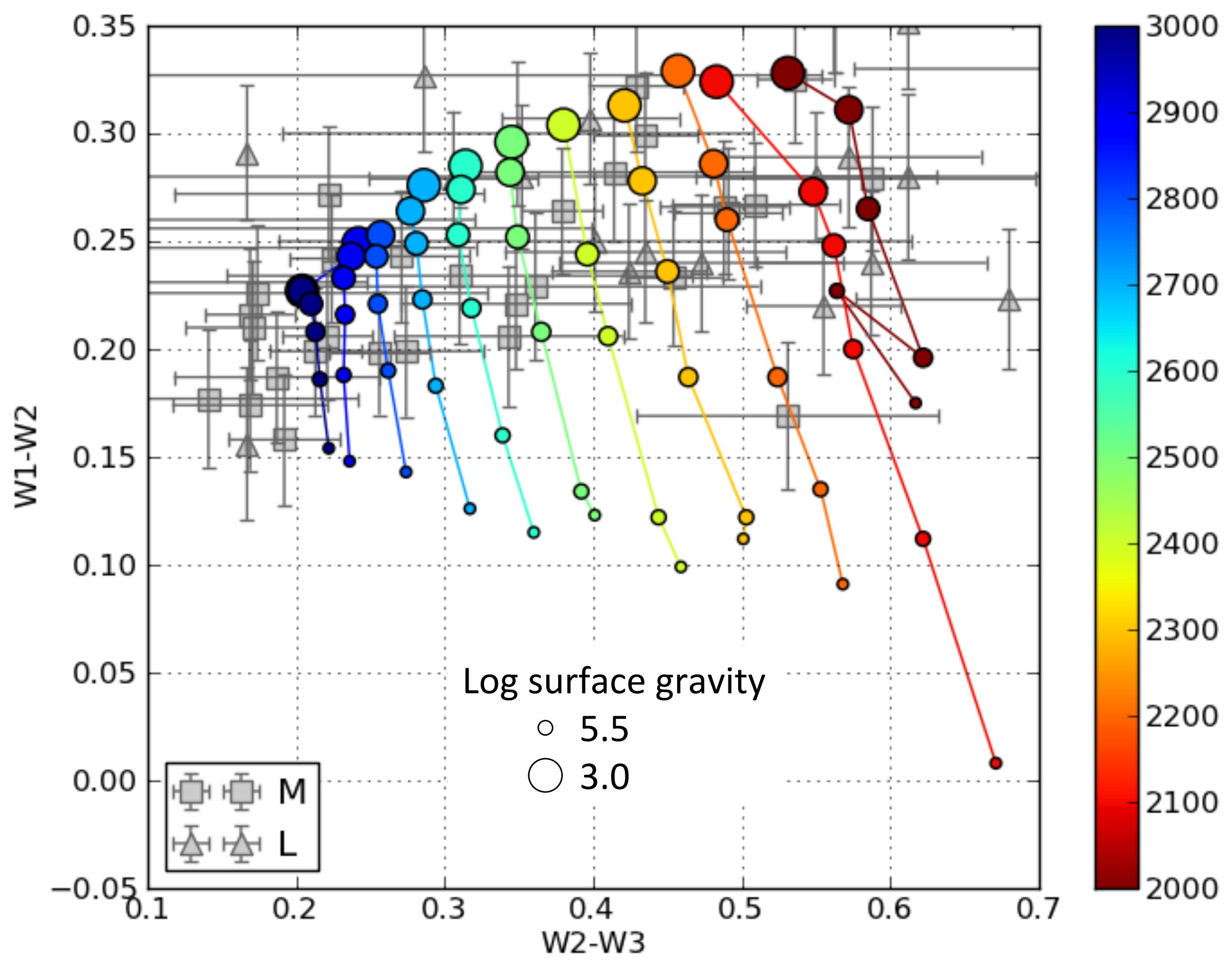
We calculate a complete suite of colors from SDSS, 2MASS, and WISE bands using synthetic spectra from BT-Settl CIFIST2011 atmosphere models for a range of effective temperatures and surface gravities at solar metallicity. Color-color plots below show how colors change from high surface gravity (small circles) to low surface gravity (large circles) connected by iso-temperature lines corresponding to the color bar.



Above & below: Temperature and gravity are degenerate for SDSS–2MASS versus 2MASS–WISE colors at temperatures corresponding to mid- to late-M dwarfs, while 2MASS–WISE colors are gravity-sensitive for L dwarfs.

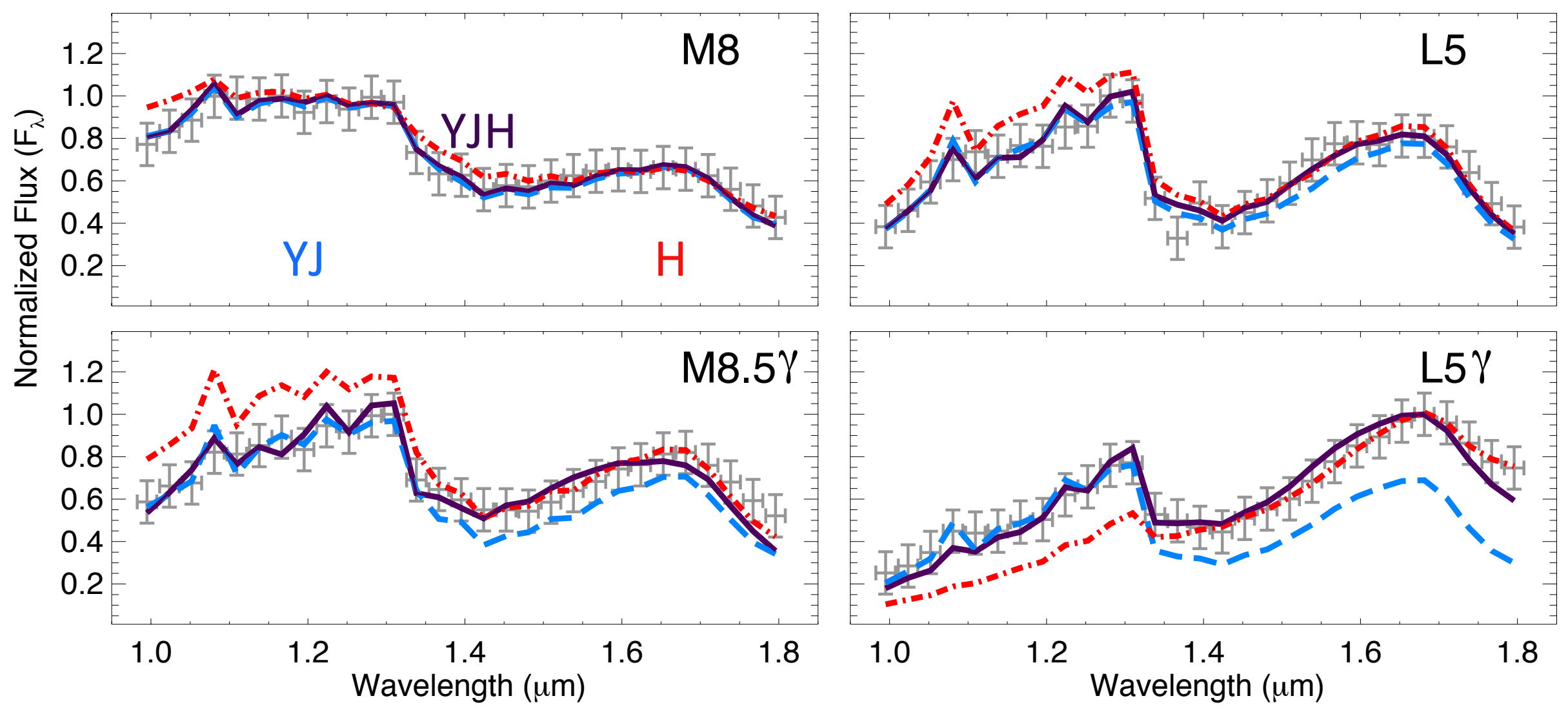


Below: W2–W3 is temperature sensitive and W1–W2 is increasingly gravity sensitive at cooler temperatures.



Filippazzo et al. 2013, in prep.

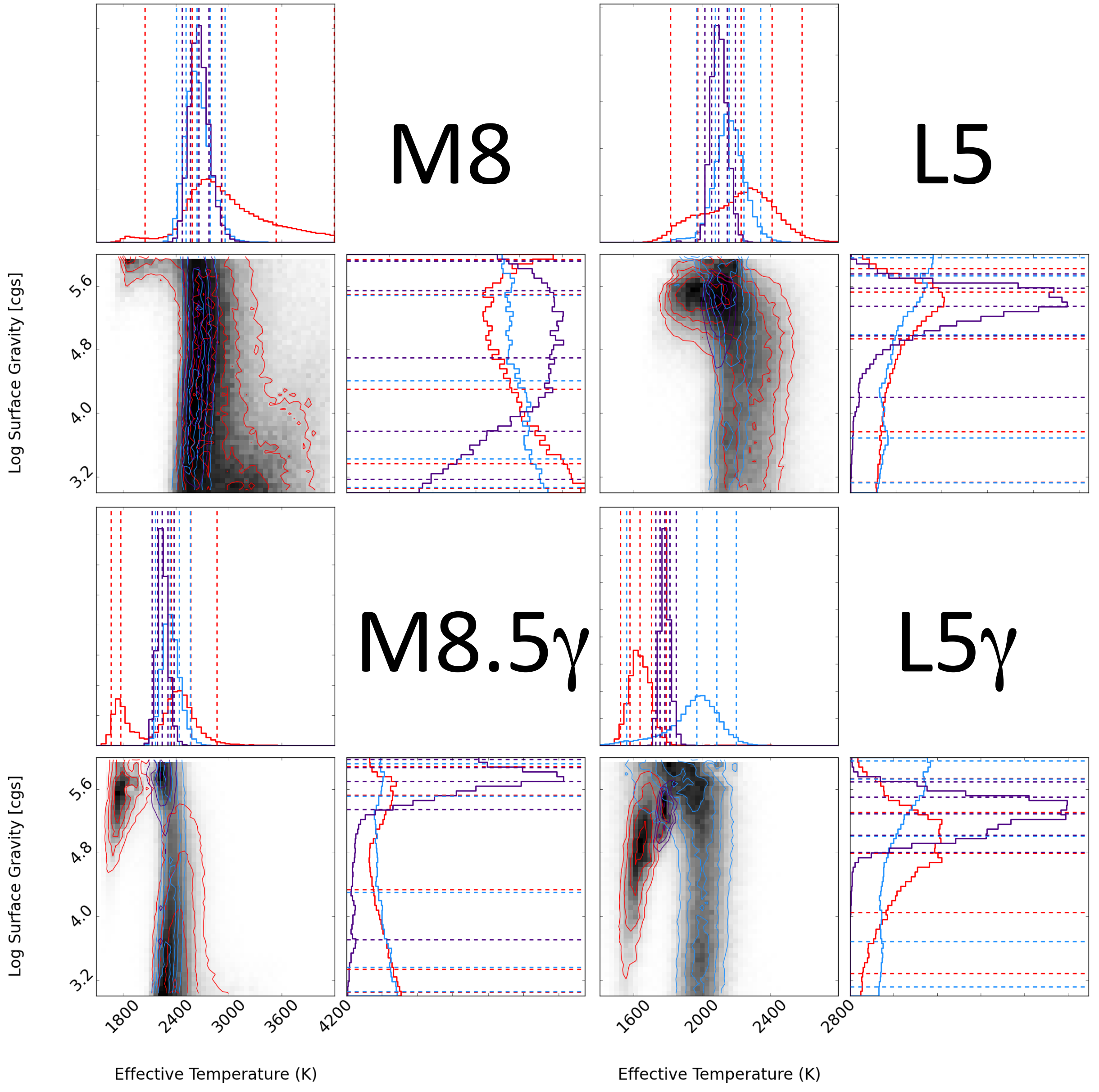
Low resolution NIR spectra



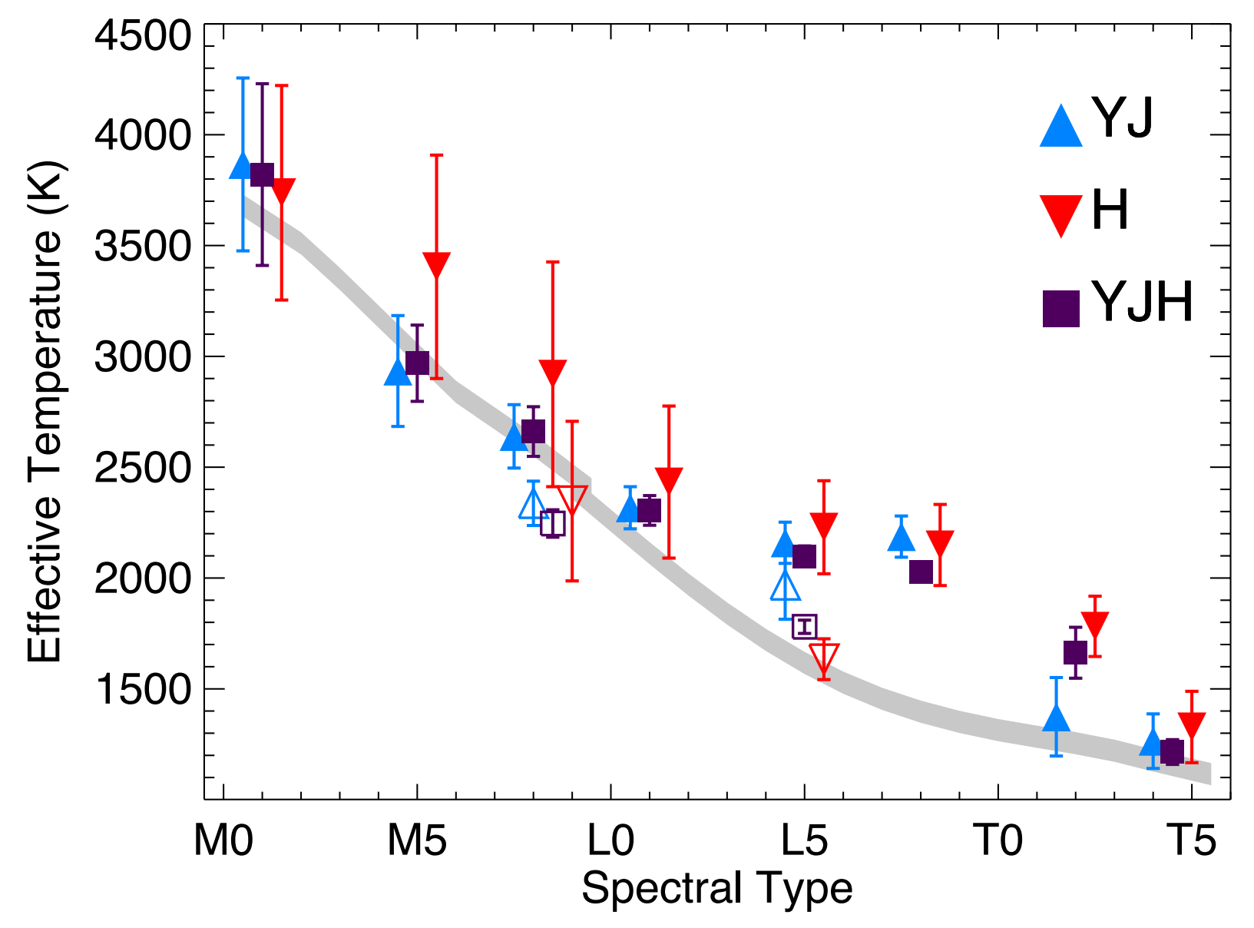
We simulate low-resolution YJH spectra of late-type young and field objects as observed by Project 1640 high contrast integral field spectrograph at Palomar Observatory (gray bars) and fit synthetic spectra from PHOENIX model atmospheres (*dusty* for M/L dwarfs and *cond* for T dwarfs) to complete YJH (purple) and separate YJ (blue) & H (red) spectra.

Rice et al. 2013, in prep.

Templates are SpeX/IRTF spectra from Cushing et al. 2005, Rayner et al. 2009, Rice et al. 2010, & Faherty et al. 2013.



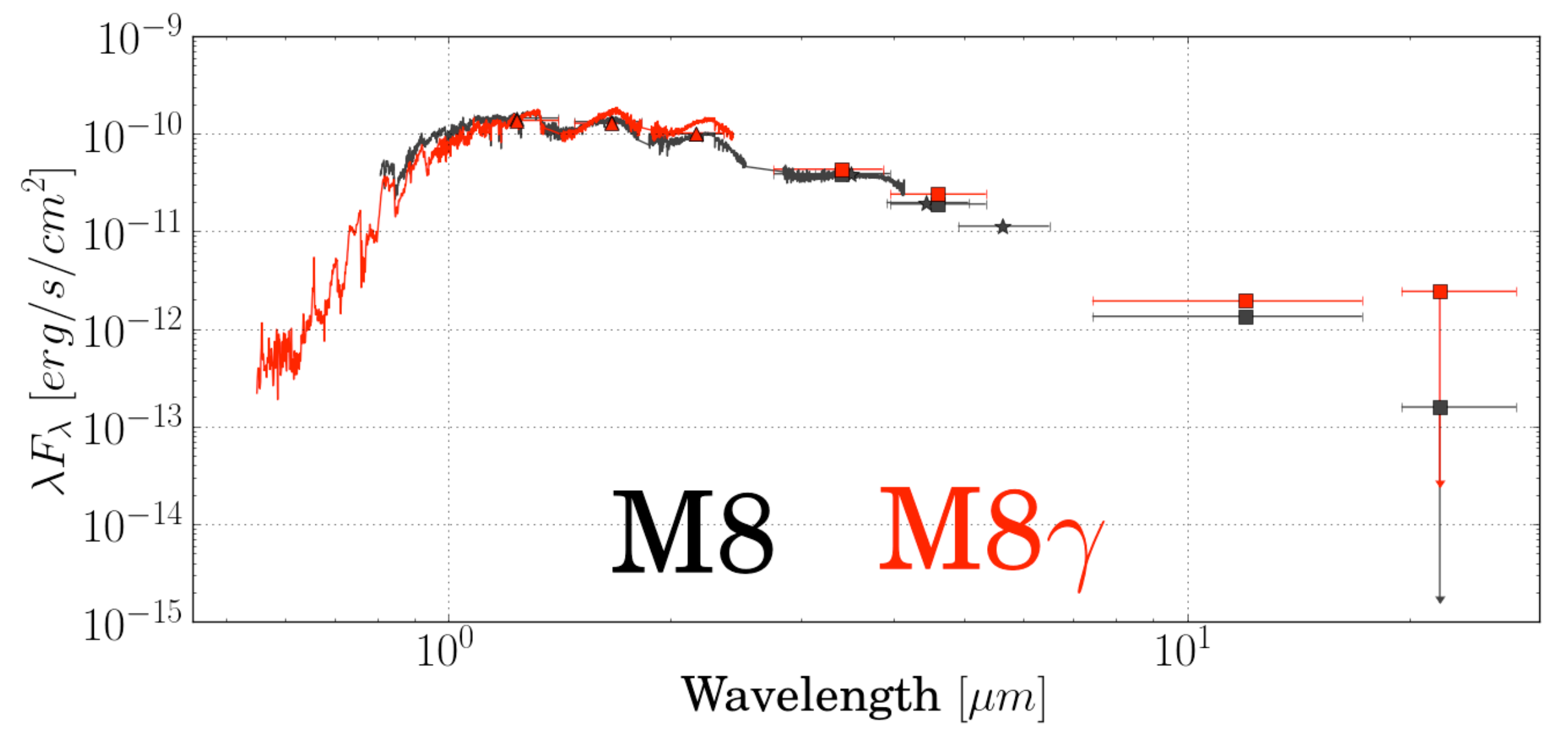
MCMC likelihood distributions for each simulated spectrum provide a complete characterization of the model parameter space. Fits to young objects produce lower temperature and similar surface gravities compared to field objects of the same spectral type, likely indicating deficiencies in the simplistic dust treatment at low temperatures and gravities.



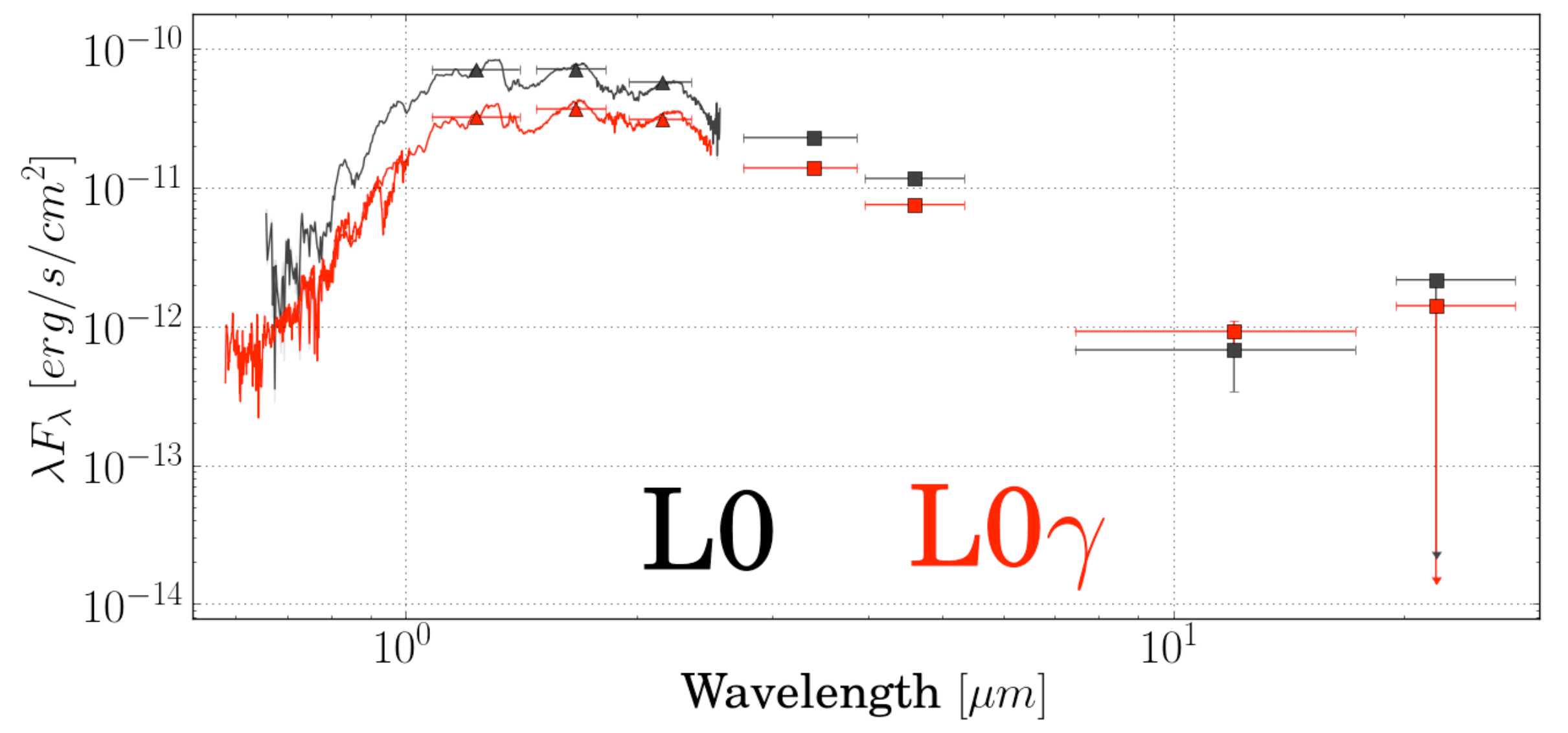
Young objects (open symbols) are fit by lower-temperature models than field objects of the same spectral type. Most fits are consistent with empirically-calibrated temperature predictions (Luhman 1999 & Stephens et al. 2009).

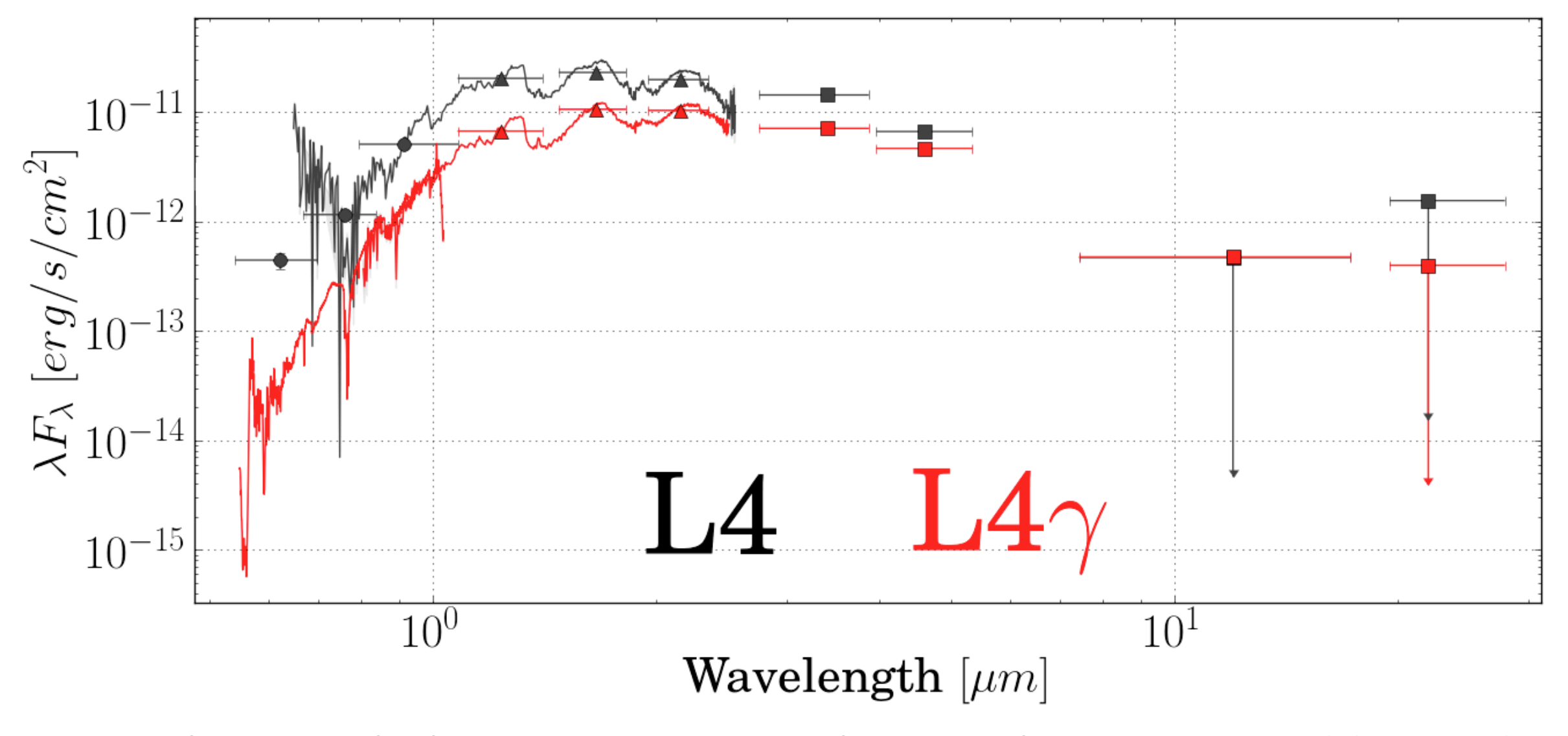
Spectral Energy Distributions

We construct optical through mid-infrared spectral energy distributions for young late-type objects (red) and field objects of the same spectral type (black). Symbols with error bars are absolute magnitudes calculated from SDSS (circles), 2MASS (triangles), and WISE (squares) photometry and Brown Dwarf Kinematics Project parallax measurements (Faherty et al. 2012). J-band magnitudes calculated from SpeX/IRTF spectra were used to align the spectra to the absolute photometry.

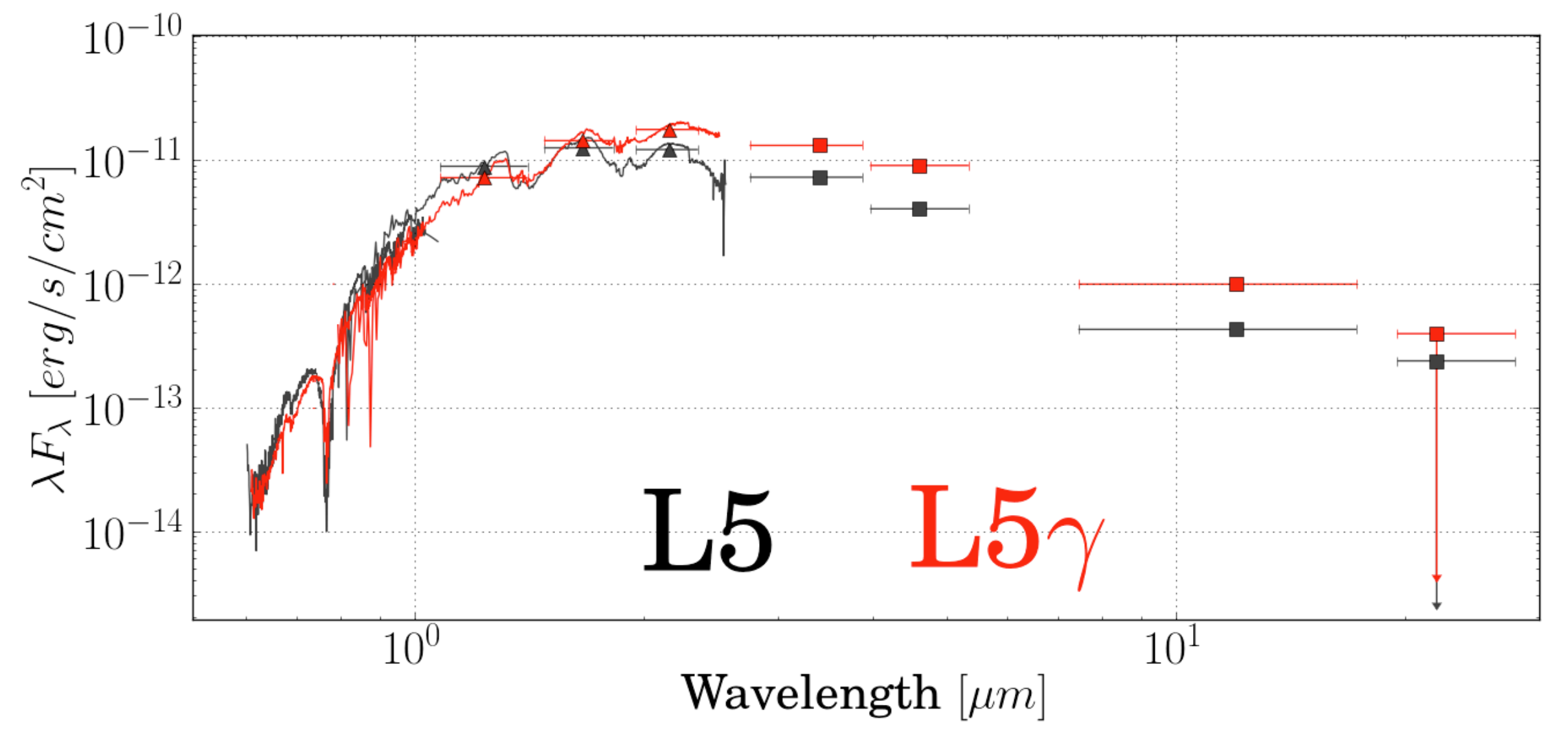


Above & below: Optically classified late-M low-gravity (γ, ~10 Myrs, see Cruz et al. 2009) object is red but similar in luminosity, while the slightly cooler L0γ is underluminous at optical through mid-infrared wavelengths.





Above & below: Later spectral type objects are redder and less underluminous at longer wavelengths, and the reddest free-floating brown dwarf (L5γ) below, is overluminous at mid-infrared wavelengths. We expect the interplay between low gravity and enhanced dust content, particularly small grains, to play a role in explaining this phenomenon.



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