"Photo-type"- A faster way towards a large sample of brown dwarfs

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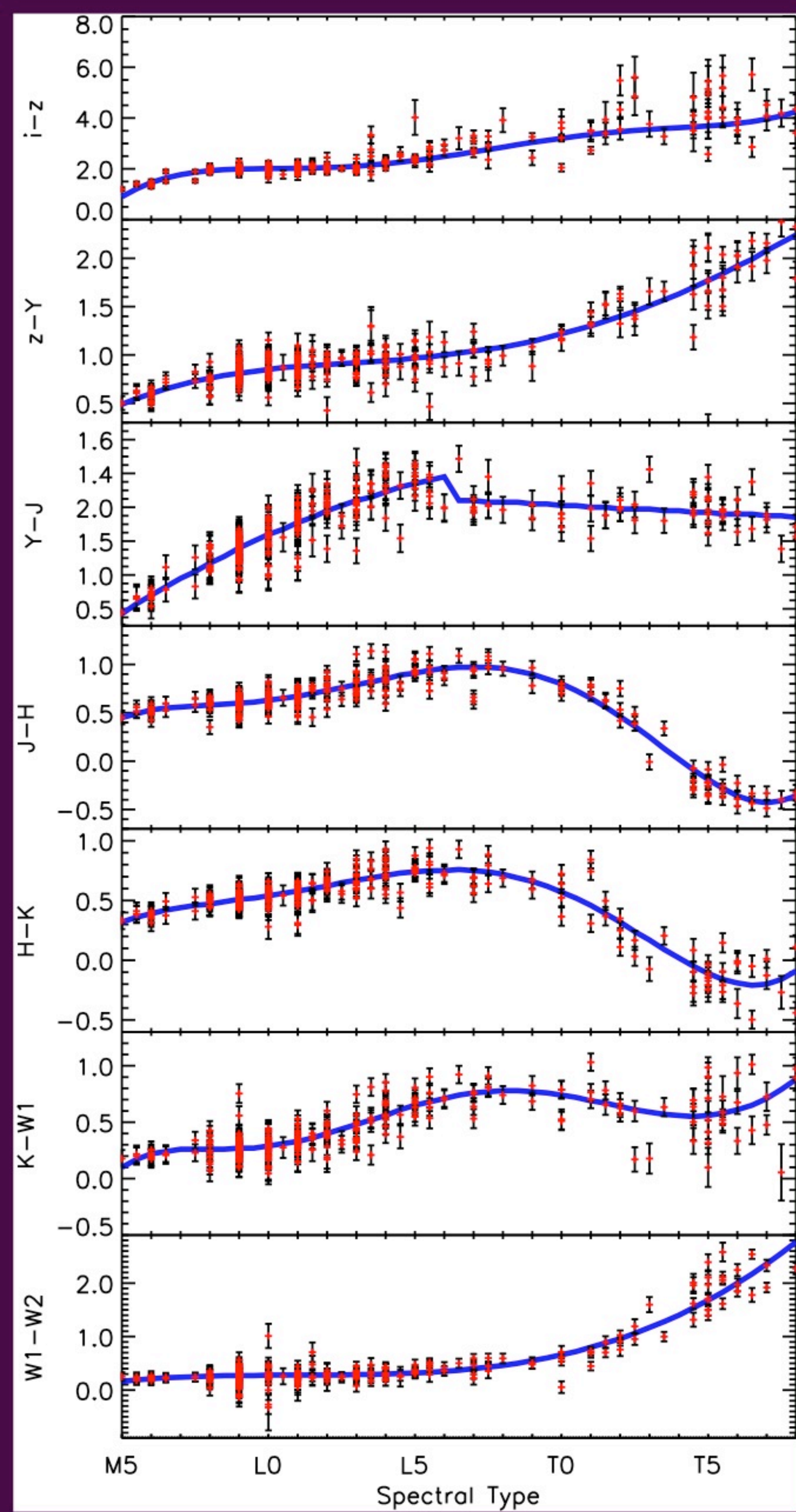
As part of a project to classify all point sources in the UKIDSS Large Area Survey into classes stars, brown dwarfs and quasars, we have developed a method to identify and accurately classify brown dwarfs using photometry alone.

Templates

We use the quasar and star templates from Hewett et al. 2006 and Maddox et al. 2012, but empirically calibrate our own M>5, L- & T-dwarf templates.

As shown on the left, this is done by fitting polynomials to the SDSS/UKIDSS/WISE colours of 301 known M-, L- & T-dwarfs. We add a systematical error of 0.05 as there is an intrinsic scatter in the dwarf colours.

The templates, for seven different colours, are provided by the polynomial fits. Then the spectral class of an object is determined by the minimum χ^2 fit summing over all colours.

Of particular interest is the curve for Y-J, which requires a discontinuity at spectral class L6, apparently related to the sudden disappearance of hydride absorption lines in the Y band.

It is worth mentioning that the i-z relation for T-dwarfs is not very well defined, but this does not influence our classification process as the errors on T-dwarfs in SDSS are very large, due to their faintness.

Accuracy of "photo-type"

We compare the spectral types of 247 known rediscovered dwarfs to our "photo-type" classifications and quantify the scatter using robust statistics. Our L- and T-dwarf classifications are accurate to 1.5 and 1.0 spectral types respectively.

The 2 outliers (diamonds) are listed in the literature as peculiar, and potential binaries currently under investigation.

So far, we obtained IRTF spectra for four of our classified objects, and all agree to 1 spectral type with our 8-band "photo-type" classification. Two of the spectra are shown below (Thank you Jackie Faherty).
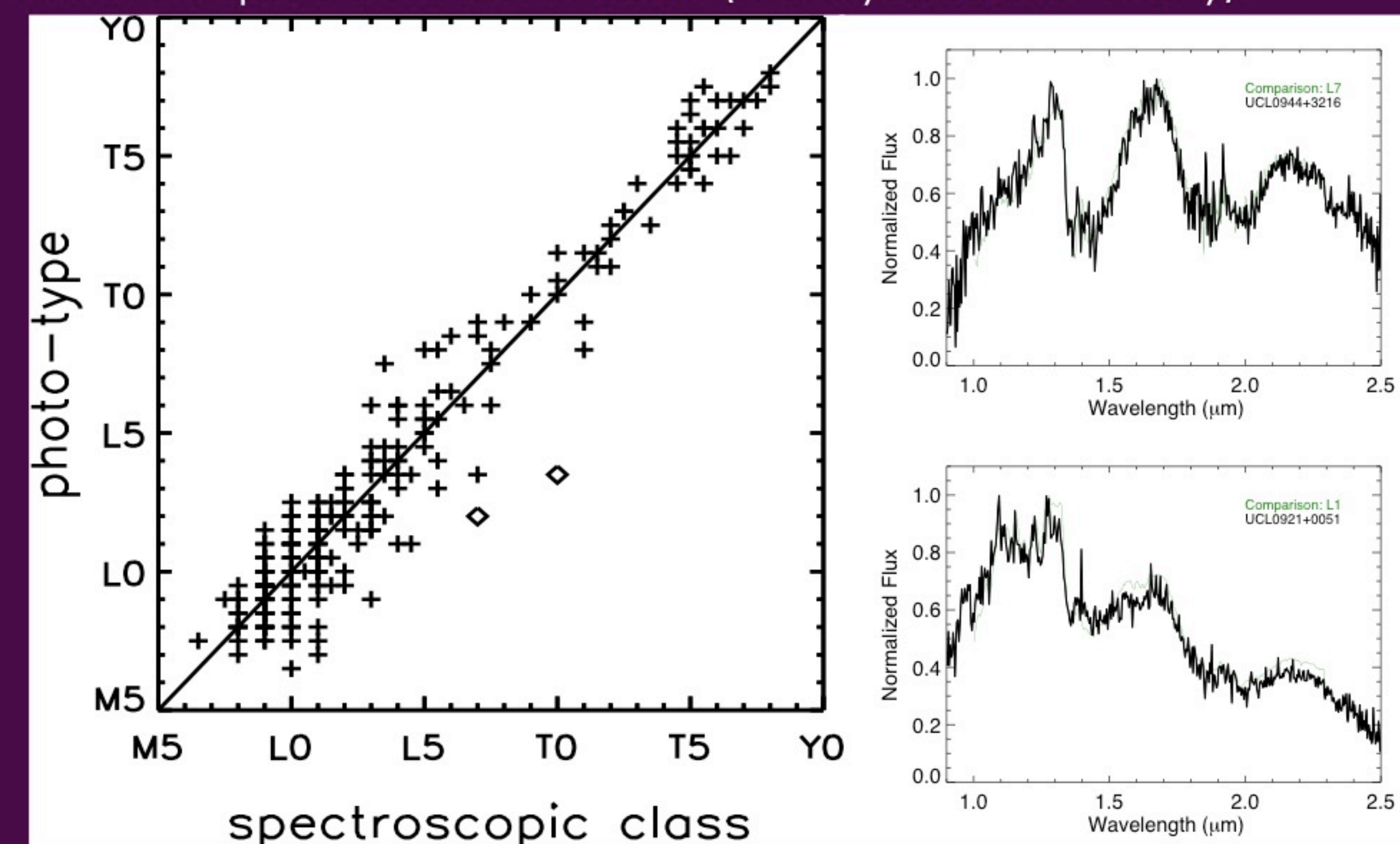
Completeness

The completeness of our sample will help us determine physical and spatial parameters of brown dwarfs. It is calculated using Monte Carlo simulations of 1000 L0-T8 (Δ 0.5) template SEDs between 15.0 and 19.0mag (Δ 0.05mag) with Gaussian errors and determining how many are above the detection limit in YJHK and i or z. The plot illustrates that brighter than J=17.5 we are highly complete for all spectral types except for the latest T dwarfs near the magnitude limit. The black crosses illustrate the brown dwarfs in our sample.
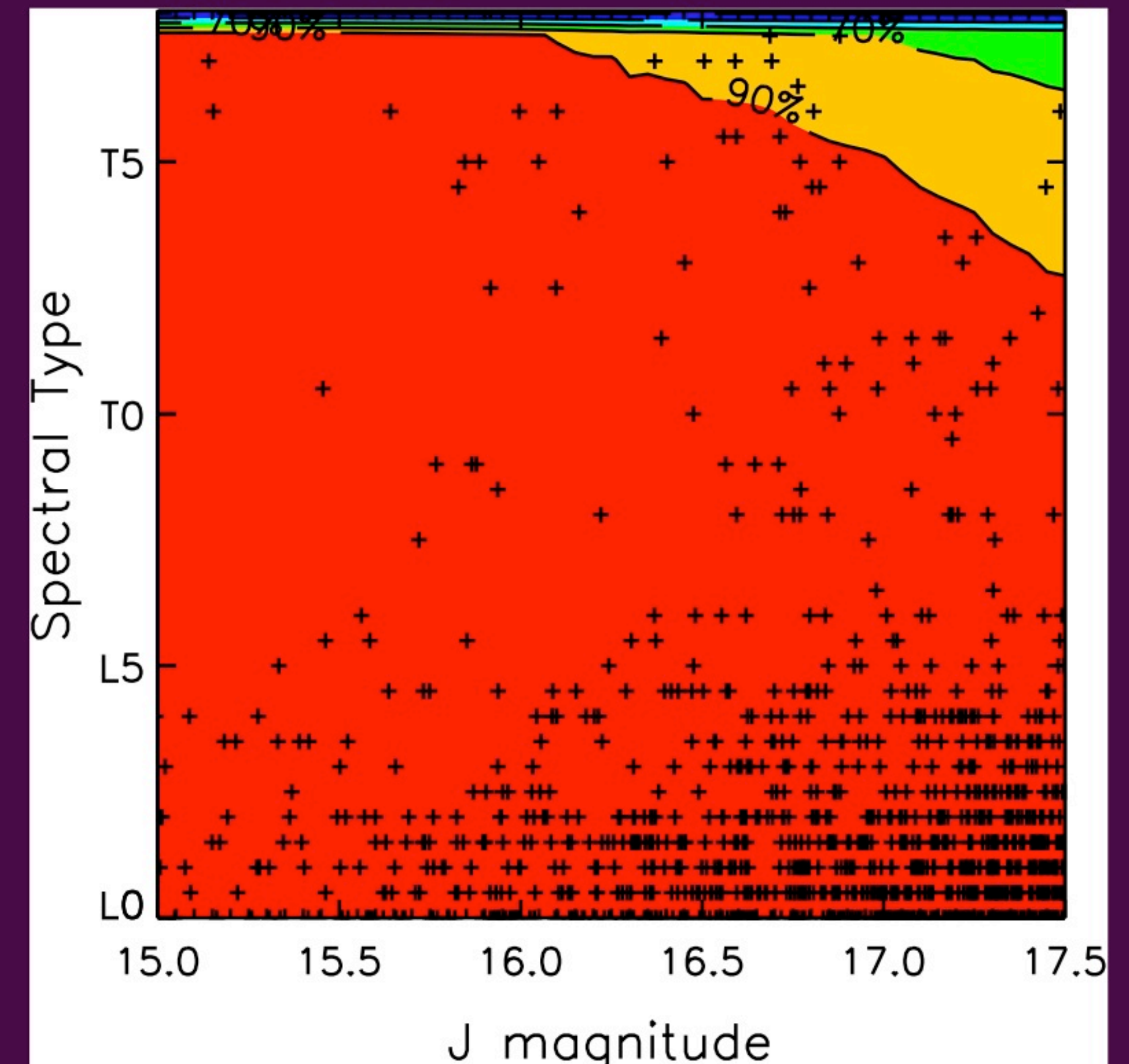

Summary

We developed a new method "photo-type" to accurately classify brown dwarfs using multi-wavelength photometry from SDSS (iz), UKIDSS (YJHK) and WISE(W1W2) alone. It is based on Bayesian template fitting, where flat priors are assumed and therefore the maximum likelihood is equivalent to the minimum χ^2.

The accuracy of "photo-type" is 1.5 spectral types for L- and 1 spectral type for T-dwarfs. Applying a magnitude cut at J=17.5mag leads to our sample being highly complete except for the faintest latest T dwarfs.

This allows us to produce a statistically significant sample of L- and T-dwarfs that can be used for determining characteristics of these objects without having to wait for spectroscopic follow up. By investigating the outliers, we can find binary candidates and peculiar sources for further investigation. We also present an updated accurately classified sample of over 1000 brown dwarfs from SDSS+UKIDSS+WISE.
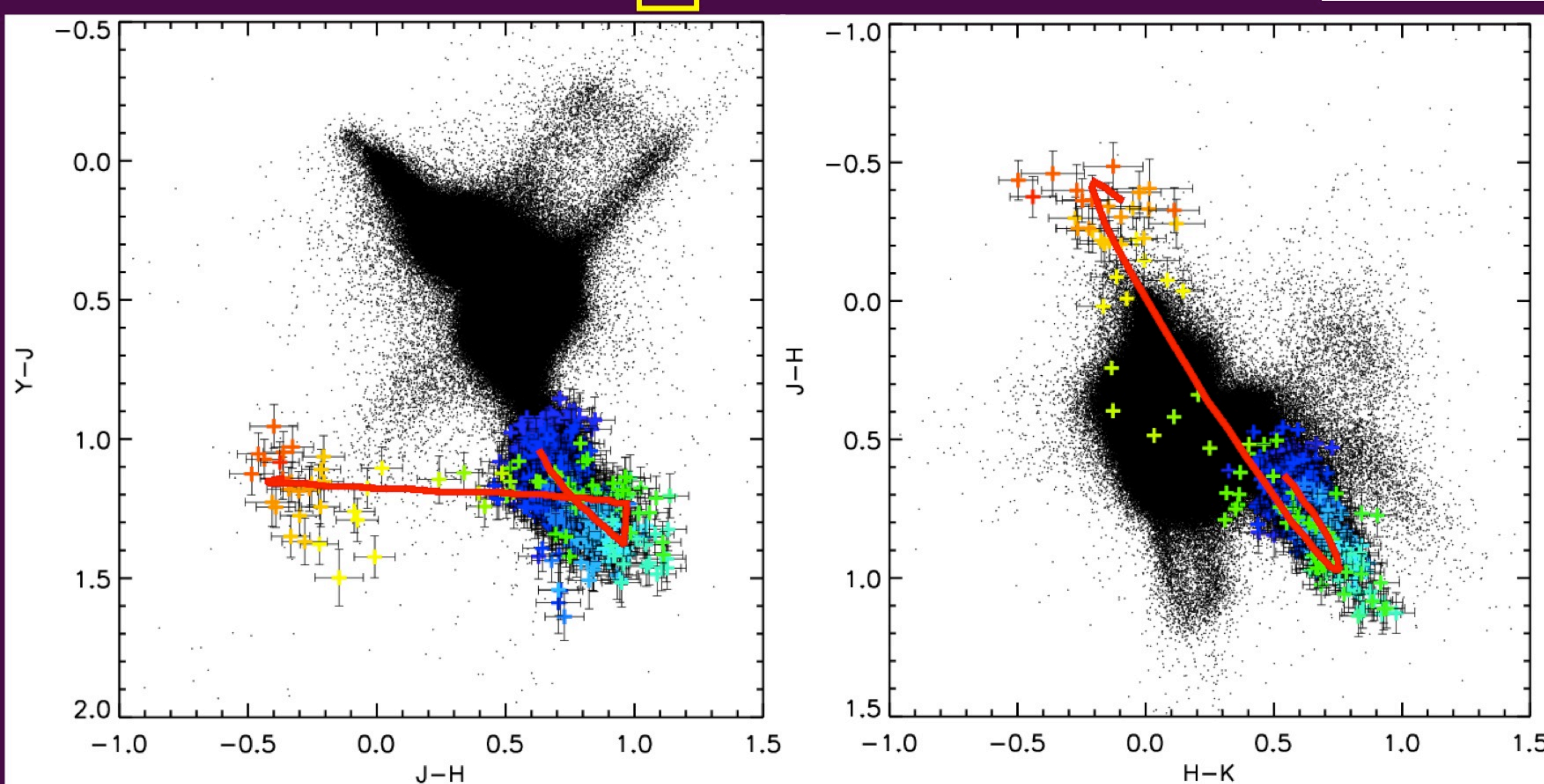
The Final Sample

We have applied this search method to the UKIDSS LAS over 3400deg[2]. The YJH and JHK colour diagrams illustrate the largest homogeneous photometrically selected sample of L0-T8 dwarfs to date. The red line represents the Y-J vs. J-H and J-H vs. H-K colours of templates from L0 to T8. The 1138 classified L- & T-dwarfs (247 were previously known) are plotted colour coded including their errorbars where dark blue crosses show L0 , light blue represents L5, green T0, dark yellow T5 and red the one T8 dwarf in our sample.

This is the largest homogeneous sample of L- and T-dwarfs and will be valuable for statistical studies.

Peculiar (high χ^2) objects are being further investigated to determine if they are unresolved binaries or indeed peculiar sources.