1

What to expect:

- ❑ Convince you light curves are awesome
- ❑ Convince you we need a giant library for them

Show off the ridiculous amount of data we collected

Talk about spectral type and wavelength dependence of variability

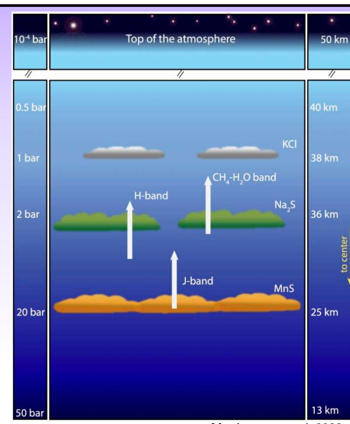
Temporal stability of light curves according to spectral type

Summarize and plug where you will be able to find our light curves

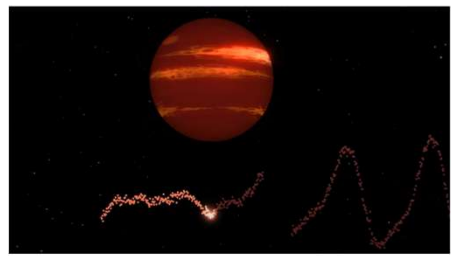
2

WHAT DO LIGHT CURVES TELL US

- ❑ By analyzing the periodicity, amplitude, and shape of light curves, we can infer:
  - Cloud layer distribution and coverage
  - Wind and atmosphere circulation
  - Possible presence of non-cloud contributors (e.g. magnetic activity or disequilibrium chemistry)
- ❑ Using light curve modelling techniques, we are able to determine if clouds can be the sole contributor of the variability we see – and in many cases its not!



Manjavacas et. al. 2022



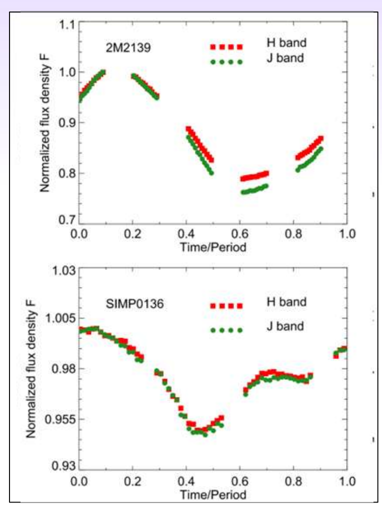
Jet Propulsion Laboratory

1/20

3

WHY DO WE NEED A LIBRARY

- ❑ Past variability studies have been limited to small samples or heterogeneous reductions.
- ❑ These light curves are often not publicly accessible for reprocessing
- ❑ In order to produce models of atmospheric circulation, it is necessary to have large sample of light curves to inform the physics.



Karalidi et. al. 2015

2/20

4

SO, WHAT DID WE DO?

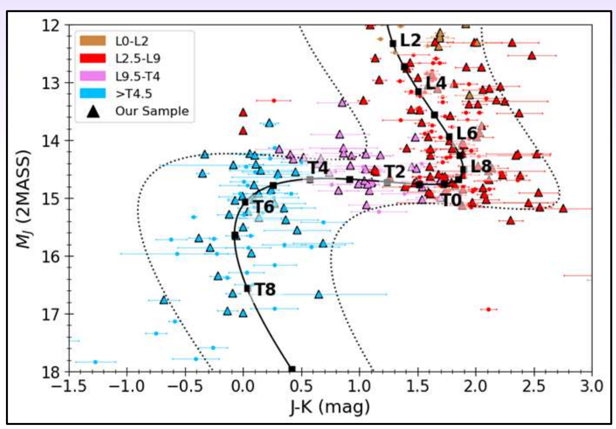
- ❑ The BDLCL is the first uniform, reprocessed sample of 305 brown dwarf light curves of L, T, and Y dwarfs.
- ❑ This enables population-level comparisons and robust correlative tests between physical parameters and variability.

NASA/JPL-Caltech/Backyard Worlds

3/20

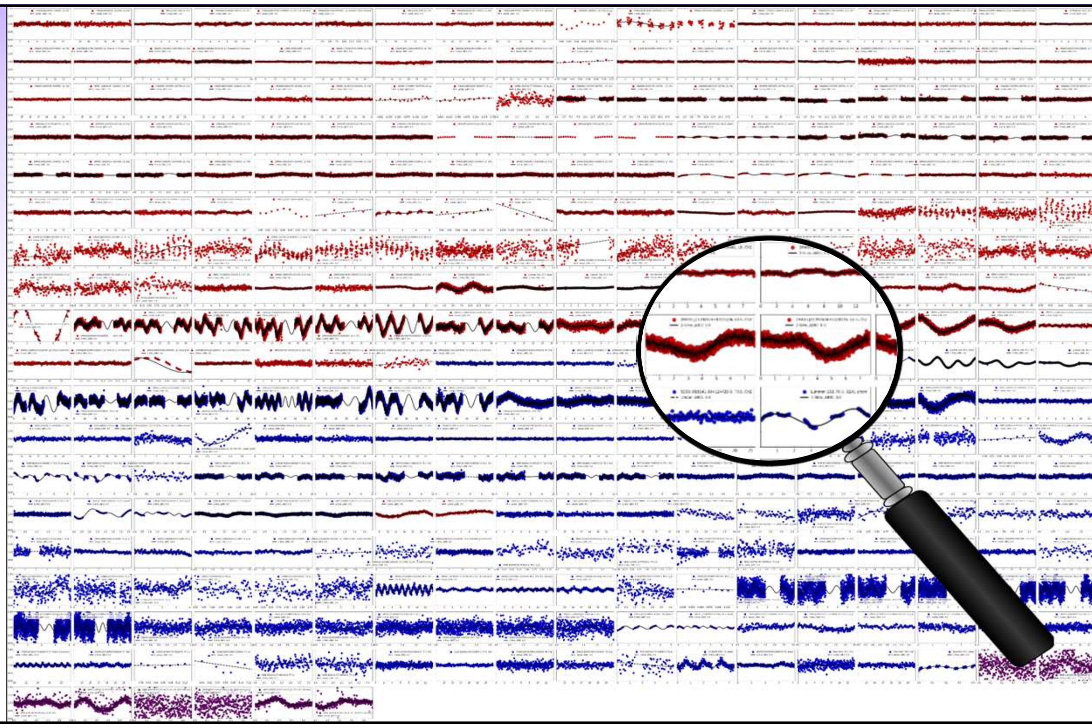
SO, WHAT DID WE DO?

- ❑ 113 total brown dwarfs in our sample
  - 63 L dwarfs
  - 47 T dwarfs
  - 3 Y dwarfs
- ❑ Compiled 305 light curves
  - 111 in Channel 1 (at 3.6 microns)
  - 101 in Channel 2 (at 4.5 microns)
  - 93 in J-band (centered at 1.25 microns)



Manjrawala et. al. (under review)

4/20



5/20

7

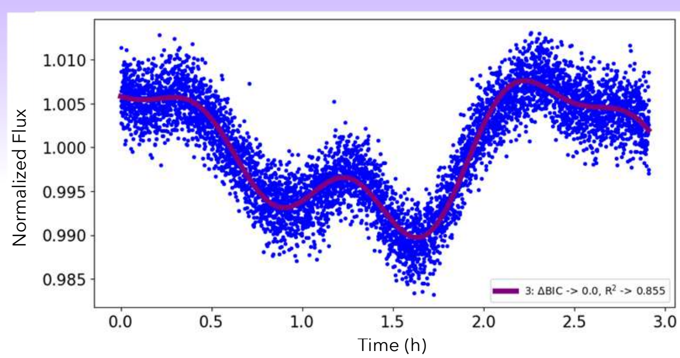
OUR METHODOLOGY

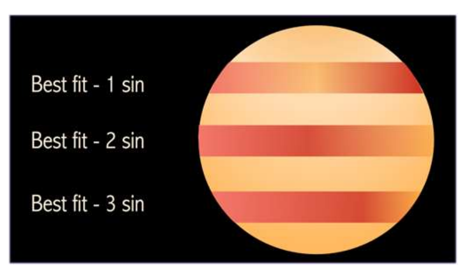
- ❑ We use four primary fits on each of the light curves
  - Linear fit
  - 1 sine term
  - Sum of 2 sines
  - Sum of 3 sines

$$f(t) = \sum_{i=1}^{3} A_i \sin(B_i t + C_i) + D_i$$

- ❑ Follow methods of Apai et. al. 2017
  - Sinusoidal terms represent planetary scale waves and spots

Manjrawala et. al. (under review)





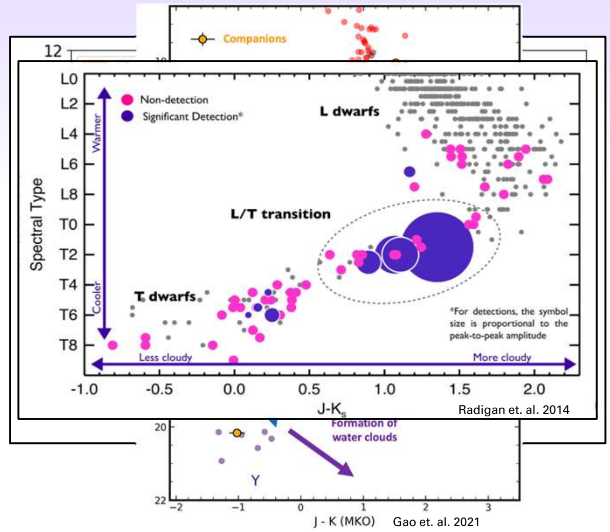
Credit: Natalia Oliveros-Gomez

6/20

8

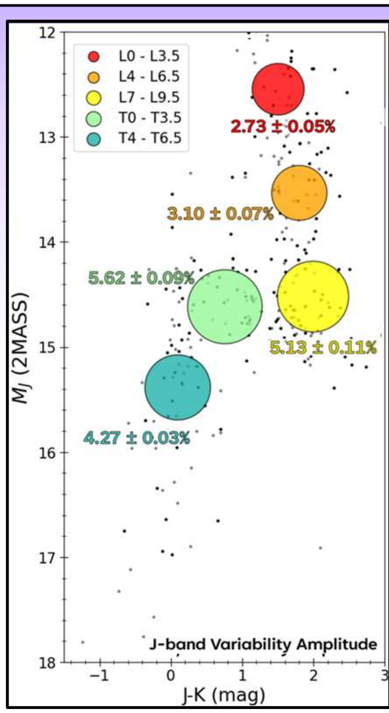
SPECTRAL TYPE DEPENDENCE OF VARIABILITY

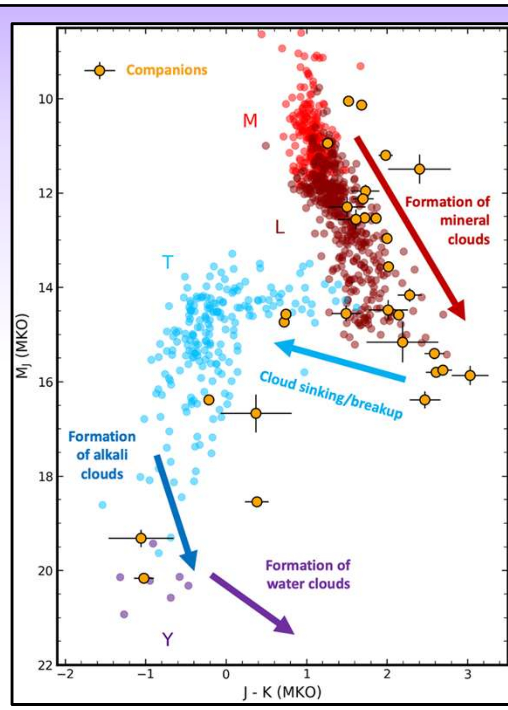
- ❑ L dwarfs modelled best by cloud atmospheres
  - Thick silicate and irons clouds suppressing irradiation of flux from interior
- ❑ L/T transition is best described by patchy, segmented cloud structures
  - Works such as Radigan 2014 have explained that the silicate cloud breakup causes the highest amplitudes of variability in the J-band.
- ❑ T dwarfs modelled best by cloudless atmospheres
  - Clouds have broken fully and descended beyond photosphere



7/20

9

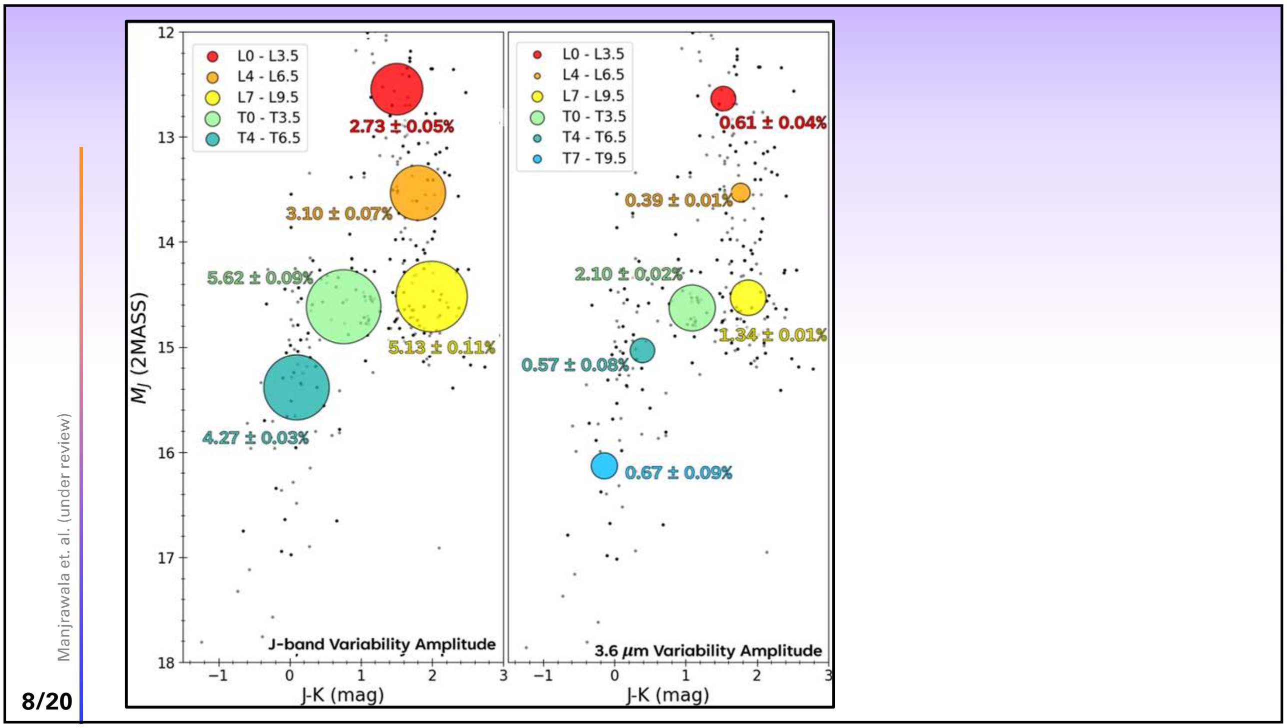




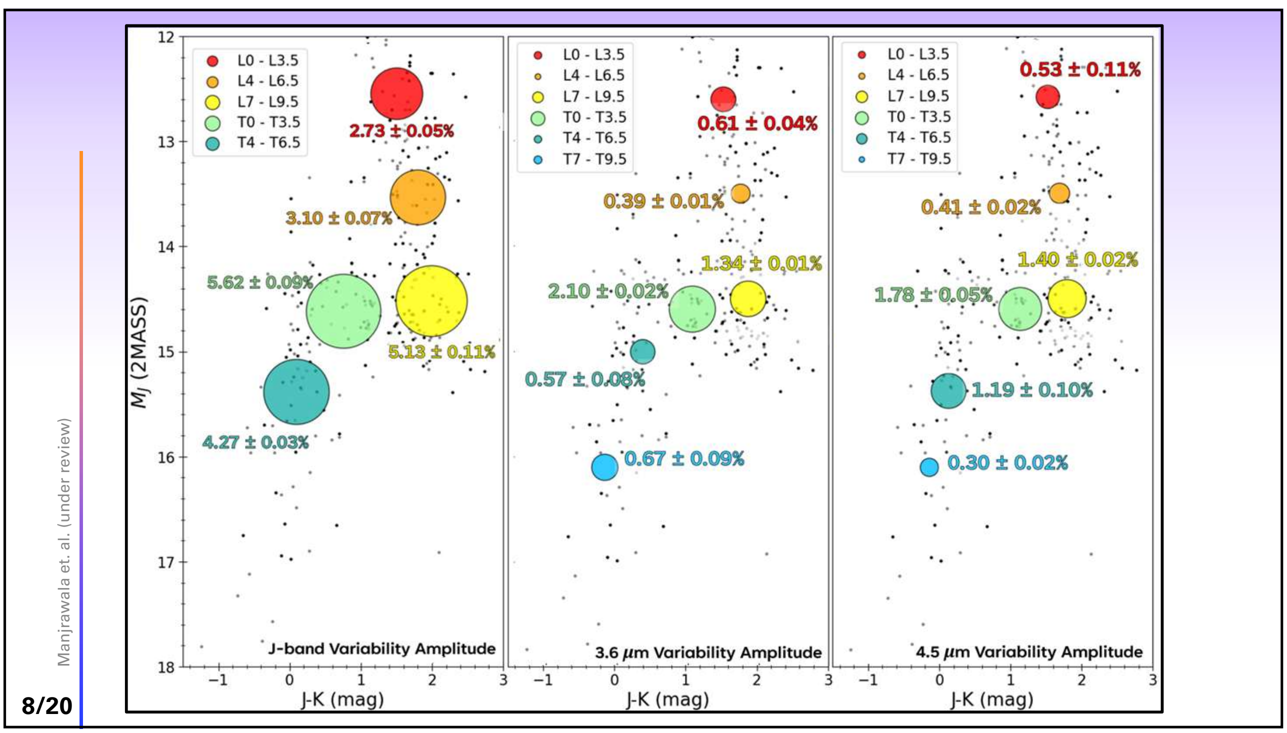
Manjrawala et. al. (under review)

8/20

10


L0 - L3.5
L4 - L6.5
L7 - L9.5
T0 - T3.5
T4 - T6.5
2.73 ± 0.05%
3.10 ± 0.07%
5.62 ± 0.09%
5.13 ± 0.11%
4.27 ± 0.03%
J-band Variability Amplitude
T7 - T9.5
0.61 ± 0.04%
0.39 ± 0.01%
2.10 ± 0.02%
1.34 ± 0.01%
0.57 ± 0.08%
0.67 ± 0.09%
3.6 μm Variability Amplitude
M_J (2MASS)
J-K (mag)
Manjrawala et. al. (under review)
8/20

11


L0 - L3.5
L4 - L6.5
L7 - L9.5
T0 - T3.5
T4 - T6.5
2.73 ± 0.05%
3.10 ± 0.07%
5.62 ± 0.09%
5.13 ± 0.11%
4.27 ± 0.03%
J-band Variability Amplitude
T7 - T9.5
0.61 ± 0.04%
0.39 ± 0.01%
1.34 ± 0.01%
2.10 ± 0.02%
0.57 ± 0.08%
0.67 ± 0.09%
3.6 μm Variability Amplitude
0.53 ± 0.11%
0.41 ± 0.02%
1.40 ± 0.02%
1.78 ± 0.05%
1.19 ± 0.10%
0.30 ± 0.02%
4.5 μm Variability Amplitude
M_J (2MASS)
J-K (mag)
Manjrawala et. al. (under review)
8/20

12

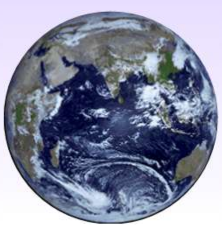
Spectral and Wavelength Influence on Variability

- Amplitudes of variability are significantly larger at all spectral ranges in J-band compared to mid-infrared wavelengths
- The L/T transition displays a peak in amplitude at each wavelength illustrating the turbulent nature of this spectral range
- The mechanism inducing variability in the L/T transition, whether clouds or not, extends across pressure regions of the atmosphere

12/20

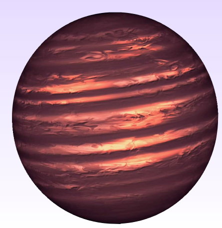
13

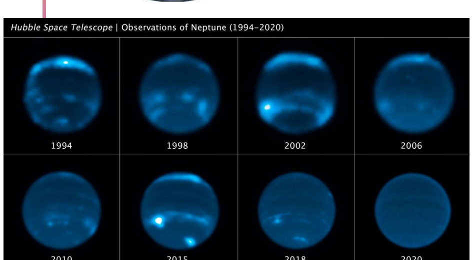
TEMPORAL STABILITY OF LIGHT CURVES



We observe cloud evolution over time in other targets →

But does cloud evolution happen in brown dwarfs? And if so, is there any correlation in this evolution?





Our goal was to understand any wavelength-dependence or spectral type-dependence of this cloud evolutions

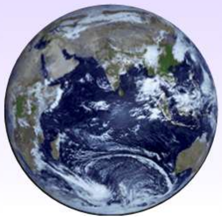
And ideally the mechanisms causing them!

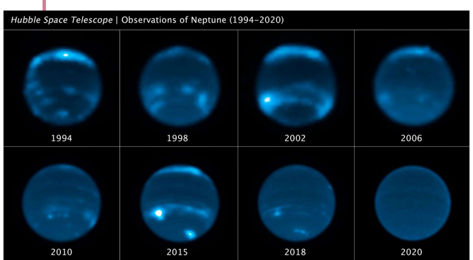
Manjrawala et. al. (under review)

13/20

14

SAMPLE FOR TEMPORAL STABILITY





Meet our cast of time-evolving brown dwarfs

- 3.6 microns: (6 objects)
  - L5.0 (8 epochs), L5.0 (8), L8.5 (8), T0.5 (8), T2.5 (8), and T6.5 (8).
- 4.5 microns: (7 objects)
  - L5.0 (8), L5.0 (8), L8.5 (8), T0.5 (8), T2.5 (8), T6.5 (2), and T6.5 (8).
- J-band: (10 objects)
  - L5.0 (2), L5.0 (2), L7.0 (4), T1.0 (2), T2.5 (5), T3.0 (3), T3.0 (2), T4.0 (4), T6.0 (6), and T6.5 (4).

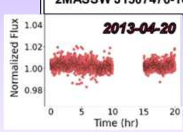
Manjrawala et. al. (under review)

14/20

15

3.6 microns

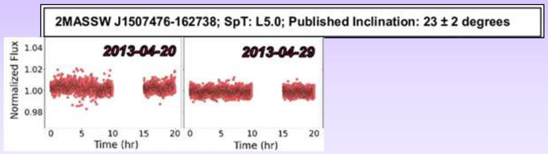
2MASSW J1507476-162738; SpT: L5.0; Published Inclination: 23 ± 2 degrees



15/20

16

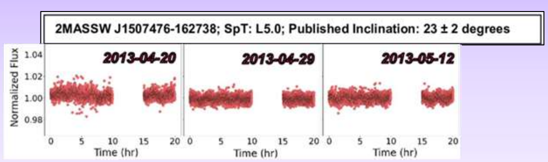
3.6 microns



15/20

17

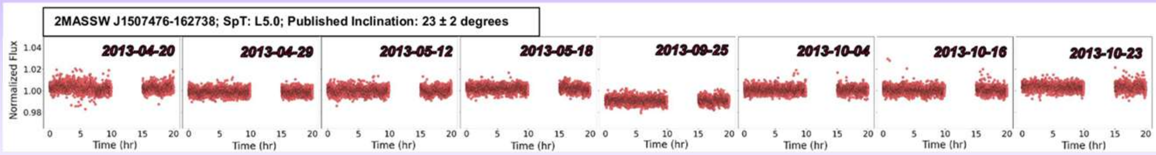
3.6 microns



15/20

18

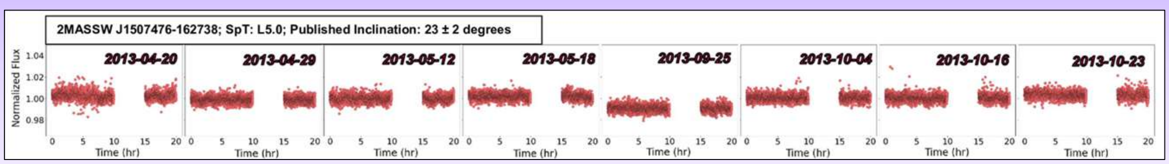
3.6 microns

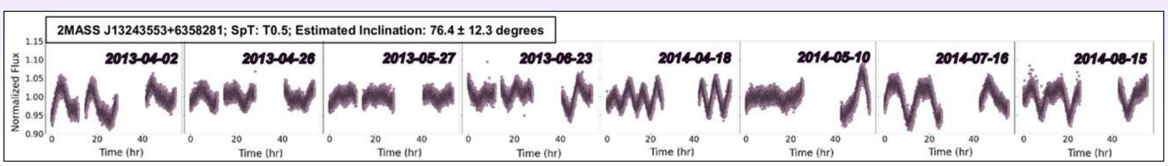


15/20

19

3.6 microns

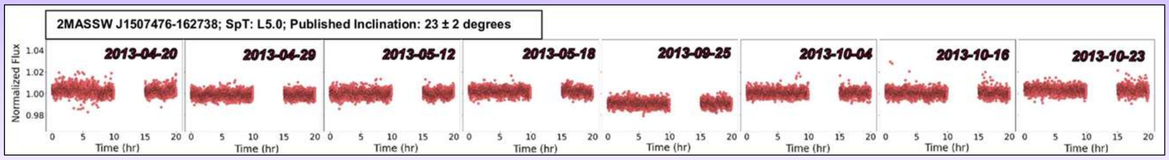


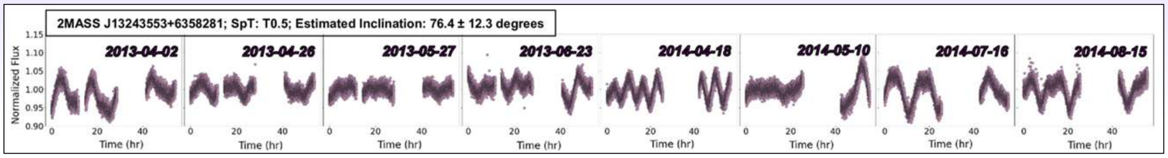


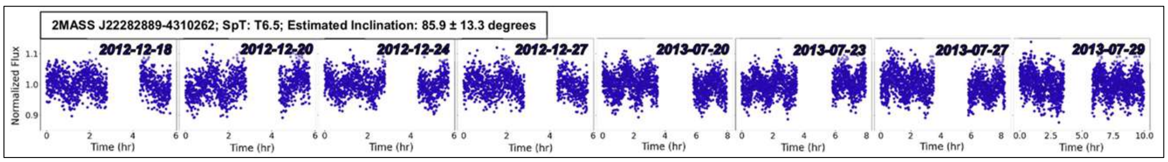
15/20

20

3.6 microns



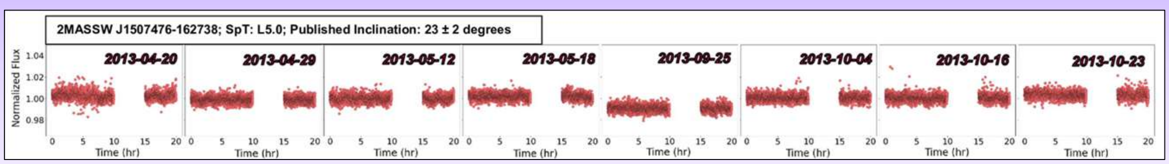


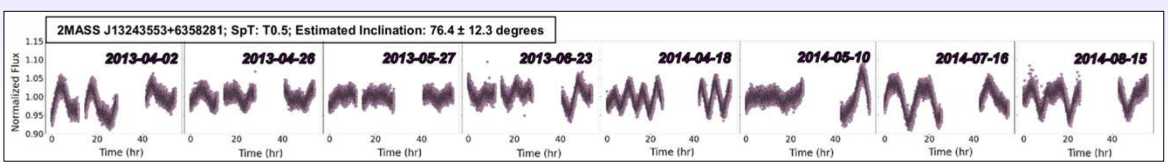


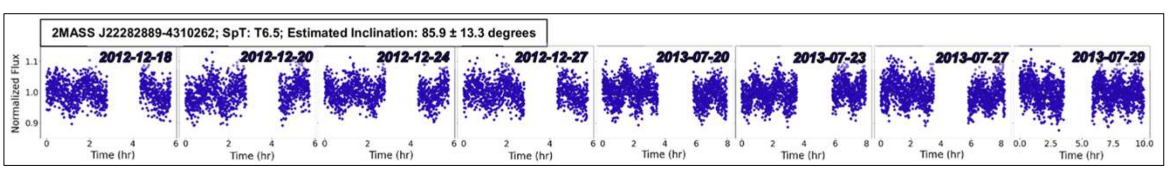
15/20

21

3.6 microns

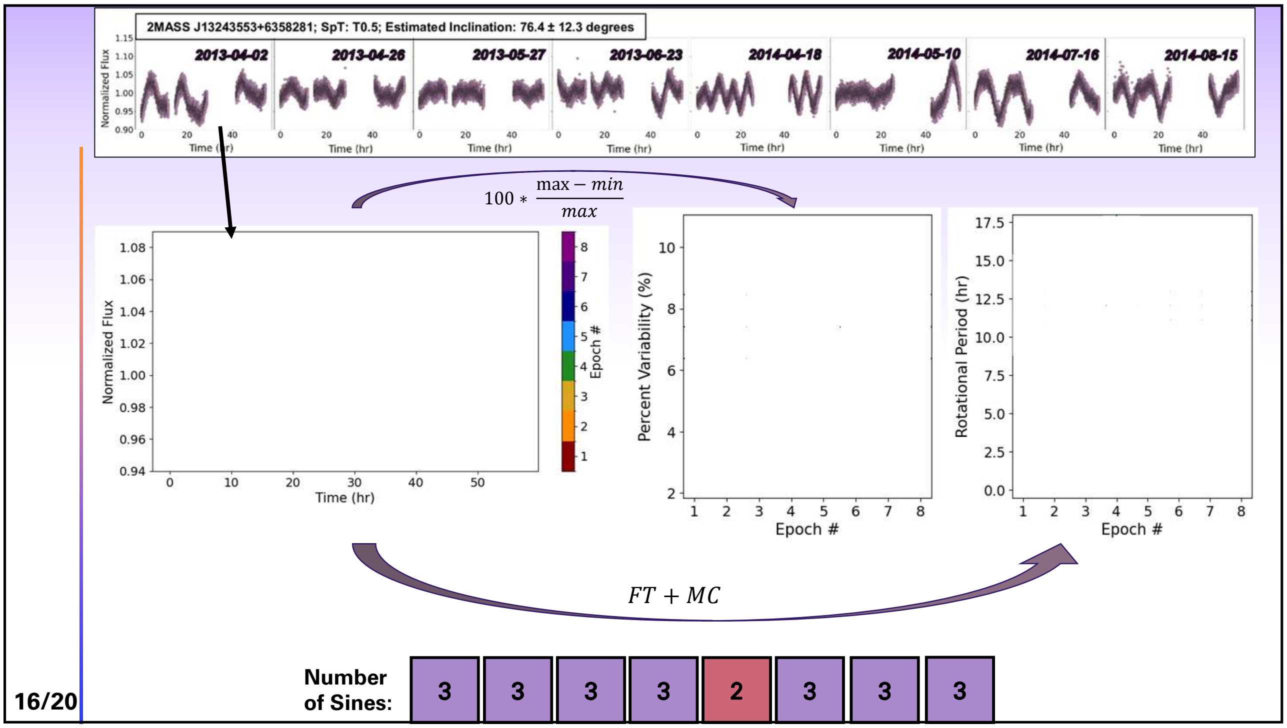




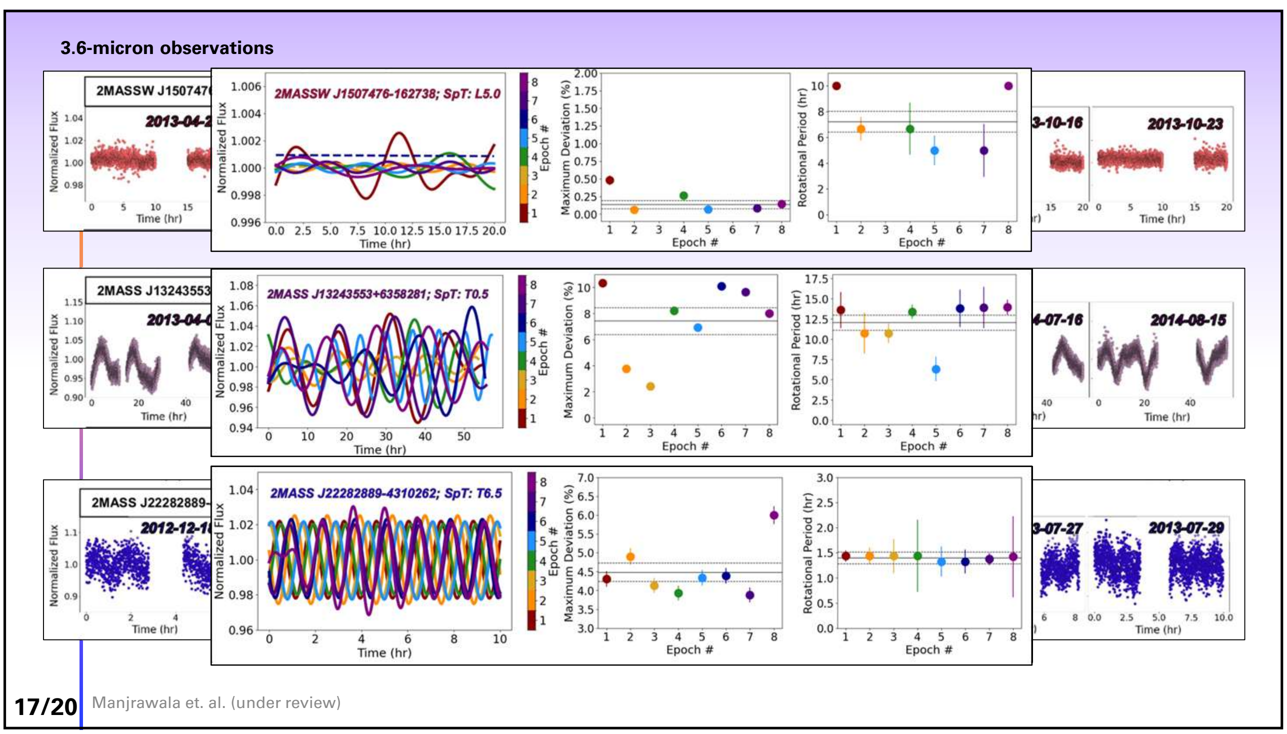


16/20

22

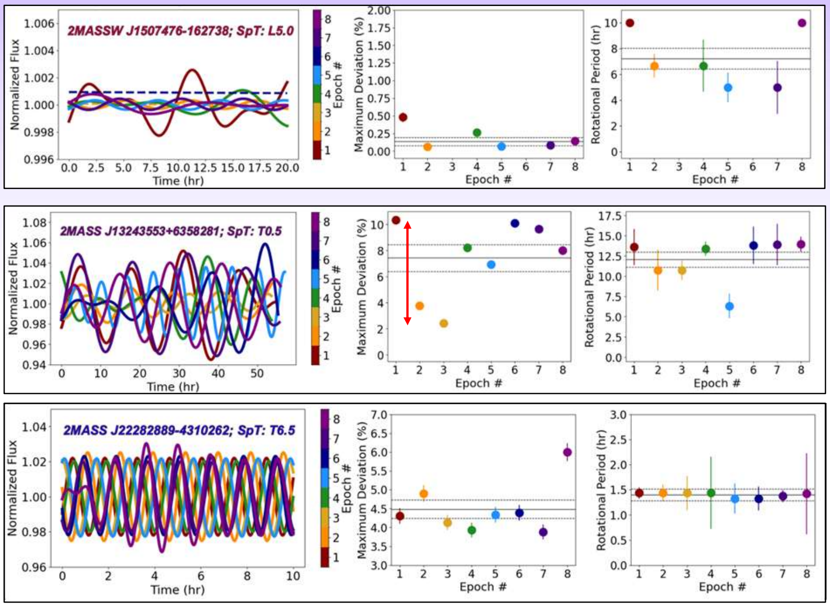

2MASS J13243553+6358281; SpT: T0.5; Estimated Inclination: 76.4 ± 12.3 degrees
2013-04-02
2013-04-26
2013-05-27
2013-06-23
2014-04-18
2014-05-10
2014-07-16
2014-08-15
Normalized Flux
Time (hr)
$100 * \frac{\max - min}{max}$
Percent Variability (%)
Rotational Period (hr)
Epoch #
$FT + MC$
Number of Sines:
3
3
3
3
2
3
3
3
16/20

23


3.6-micron observations
2MASSW J1507476-162738; SpT: L5.0
2MASS J13243553+6358281; SpT: T0.5
2MASS J22282889-4310262; SpT: T6.5
Normalized Flux
Time (hr)
Maximum Deviation (%)
Rotational Period (hr)
Epoch #
17/20
Manjrawala et. al. (under review)

24

3.6-micron observations



Maximum Deviation is relatively stable for early L dwarfs!

L/T transition shows substantial instability of maximum deviation!

T dwarfs appear relatively stable with higher amplitudes than the L dwarfs

17/20 Manjrawala et. al. (under review)

25

Spectral Dependence of Temporal Stability

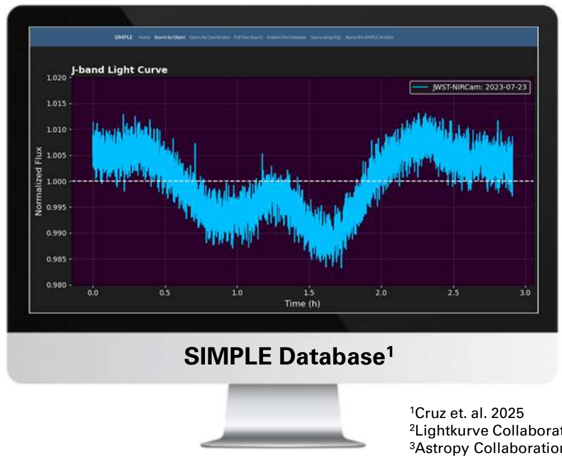
- ❑ L dwarfs display suppressed amplitudes of variability across several epochs, frequently varying from low amplitude to entirely non-variable over time.
- ❑ The L/T transition displays the largest and most extreme variation between epochs, showing ~8% change between the minimal amplitude and maximal amplitude.
- ❑ T dwarfs are relatively stable across multiple epochs with amplitudes of variability greater than L dwarfs, but less than the L/T transition.

18/20

26

WHAT COMES NEXT

- All the light curves that we have compiled will find a new, publicly accessible home on the SIMPLE Database
- Will be searchable by object and downloadable into a single, easy to read format compatible with Lightkurve[2] and astropy[3] packaging.



[1]Cruz et. al. 2025
[2]Lightkurve Collaboration et al. 2018
[3]Astropy Collaboration et al. 2022

Manjrawala et. al. (under review)

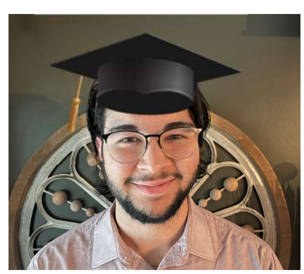
19/20

27

THANK YOU FOR LISTENING

If you are interested in learning more about our analysis or want to discuss my results, I'd love to talk!

I am looking for graduate/PhD programs for the upcoming Fall 2026 recruitment cycle!



Github

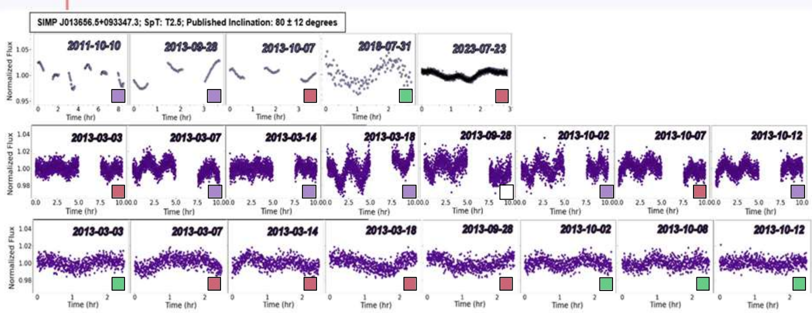
Website

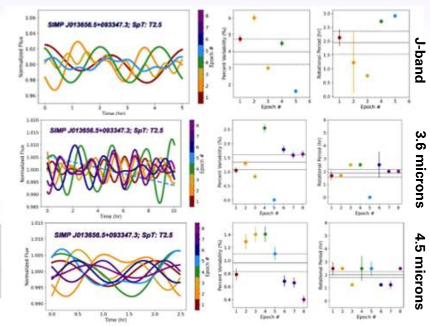
20/20

28

SIMP J013656.5+093347 (T2.5)

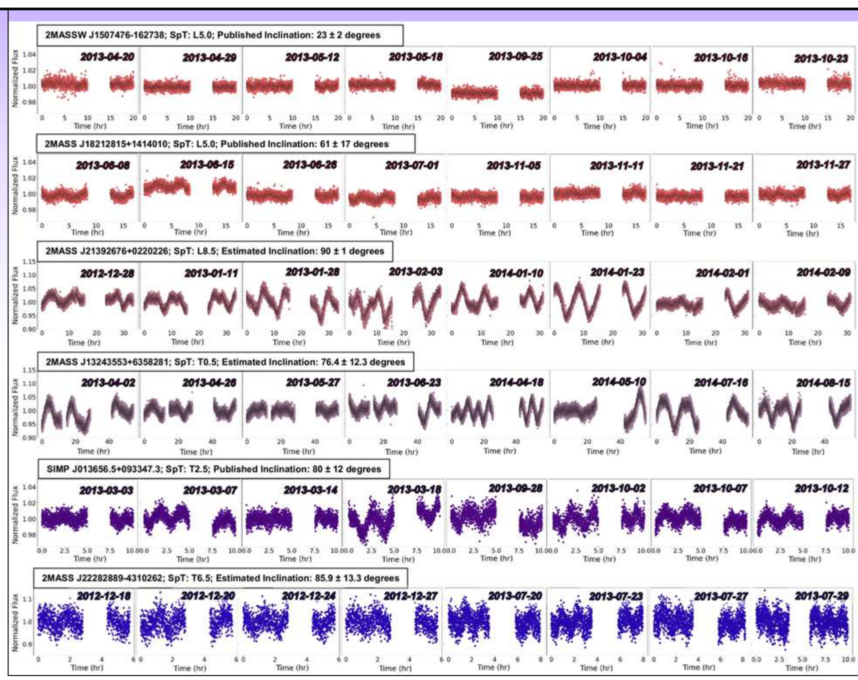
- With all the light curves we have, we are able to perform a pressure-dependence of stability using a few notable targets with multiple epochs at each wavelength
- SIMP0136 is an L/T transition dwarf where we can observe the J-band showing the highest level of instability for rotational period and maximum deviation.





Manjrawala et. al. (under review)

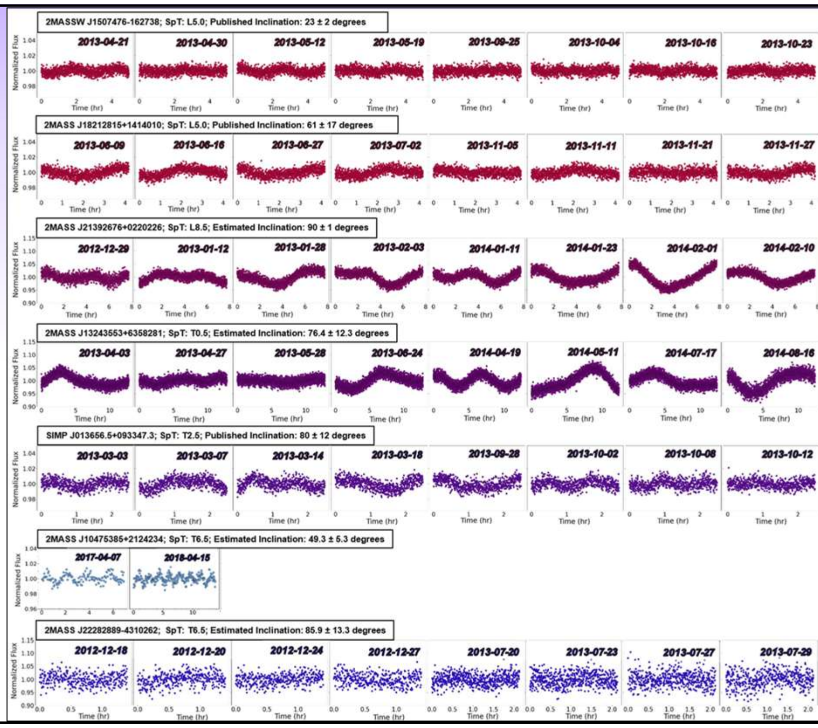
29



Manjrawala et. al. (under review)

30

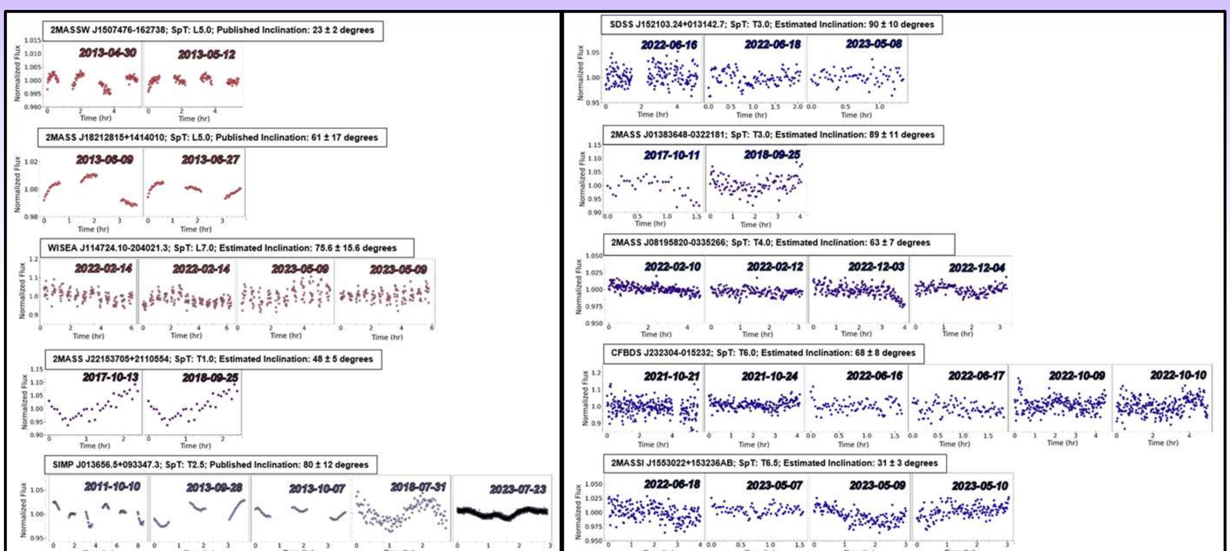
4.5 microns



Manjrawala et. al. (under review)

31

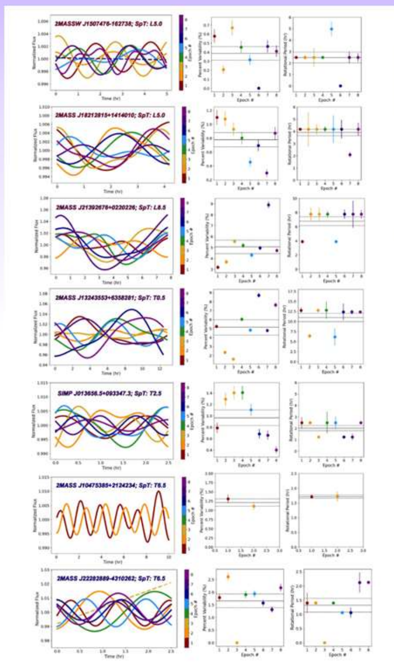
J-band



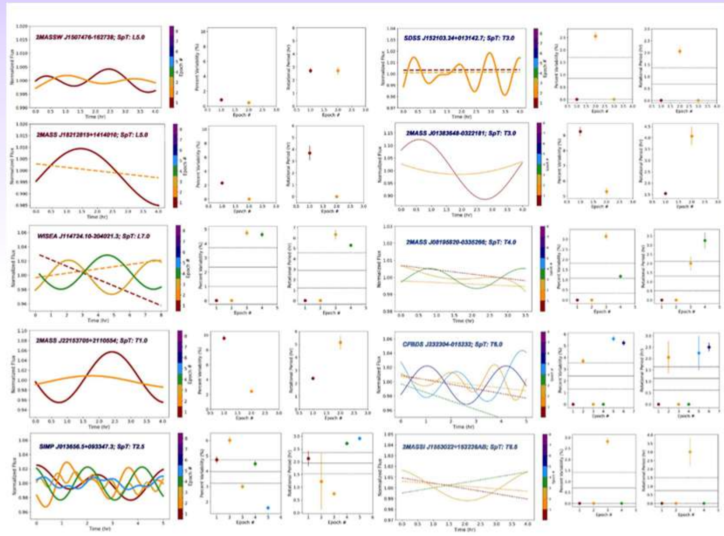
Manjrawala et. al. (under review)

32

4.5 micron observations



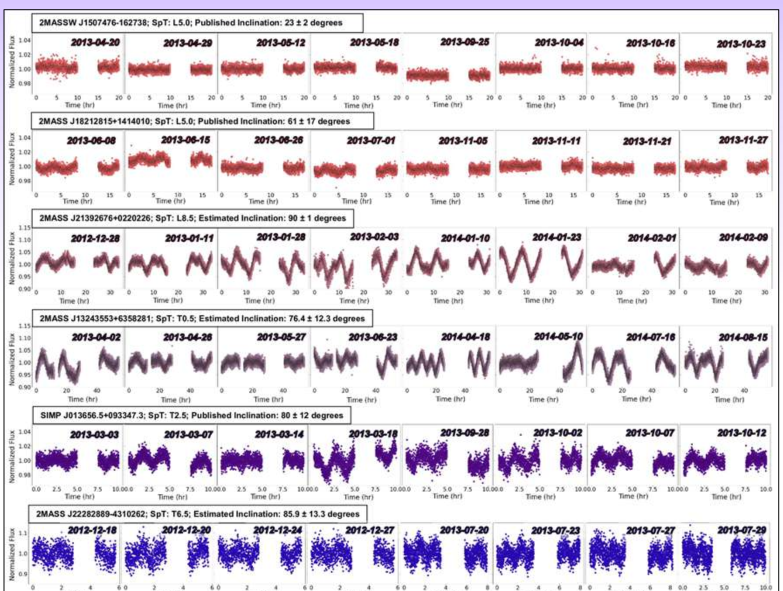
J-band observations

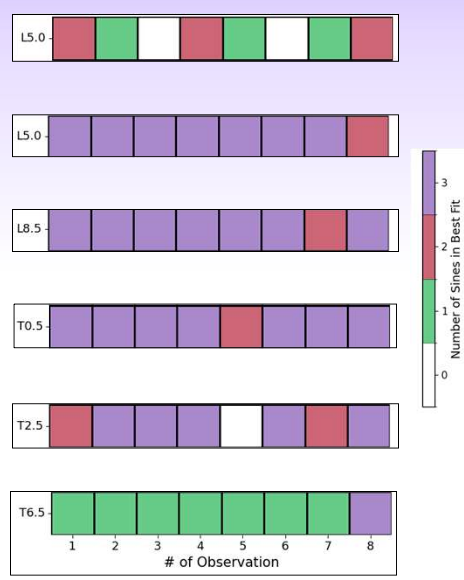


Manjrawala et. al. (under review)

33

3.6-micron observations





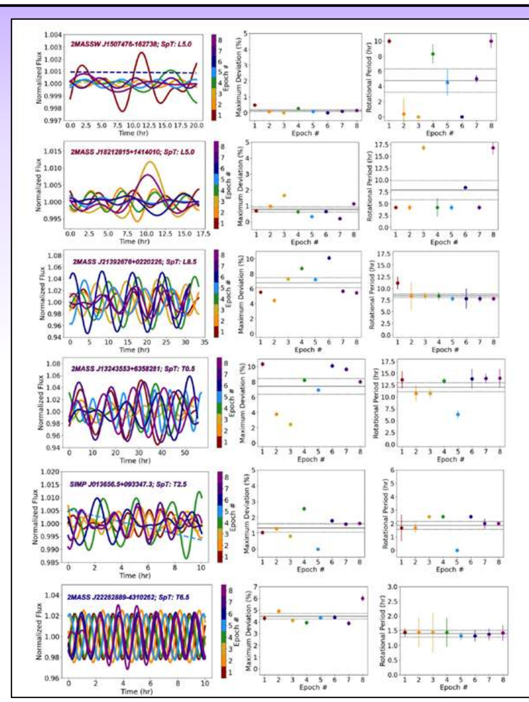
Manjrawala et. al. (under review)

34

3.6 microns

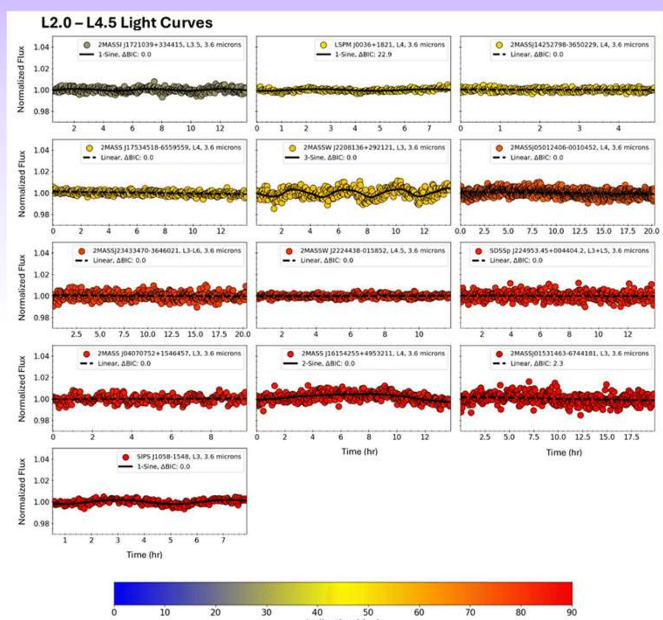
RESULTS (2 OF 2)

- We find that the stability of rotational period is generally stable with only a few notable exceptions.
- L dwarfs show instability with significantly low amplitudes, which could be attributed to systematic errors or noise
- L/T transition dwarfs appear to show the highest level of instability in their amplitudes of variability
  - This suggests that the clouds features in the L/T transition are not only patchy, but rapidly evolving over time
- We see T dwarfs present instability more significant than the L dwarf, but much less significant than the L/T transition dwarfs.



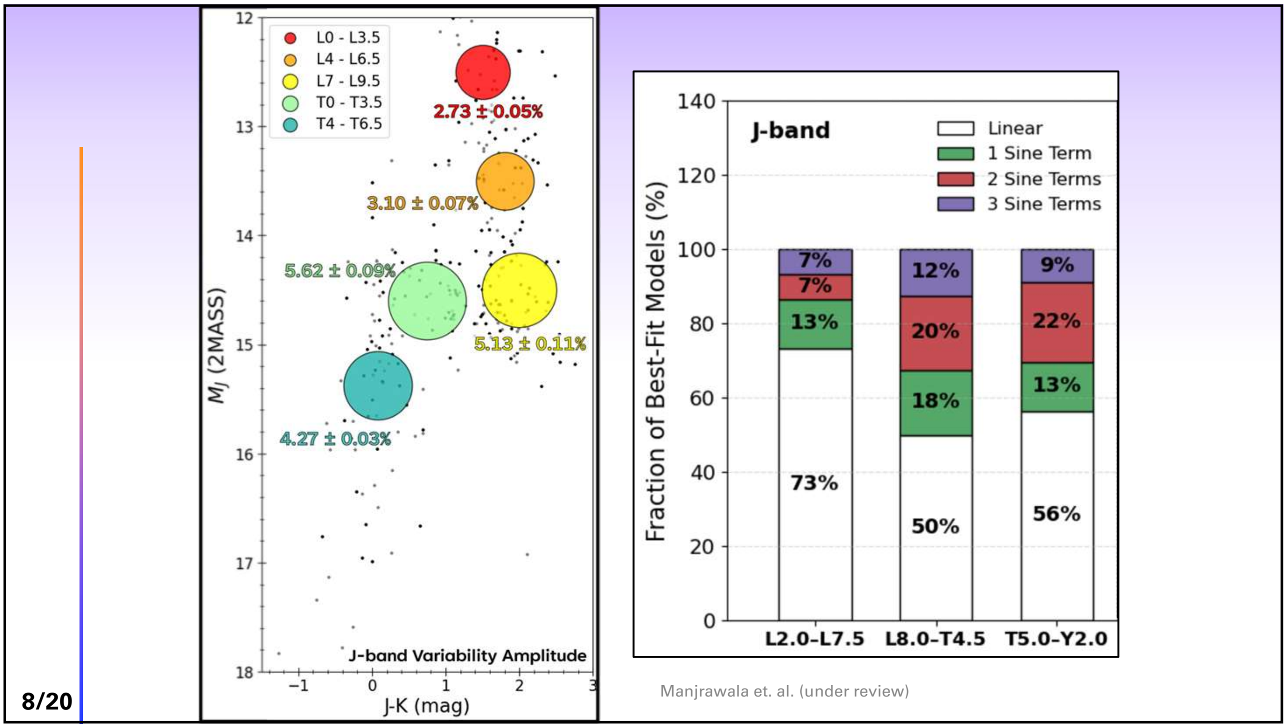
Manjrawala et. al. (under review)

35



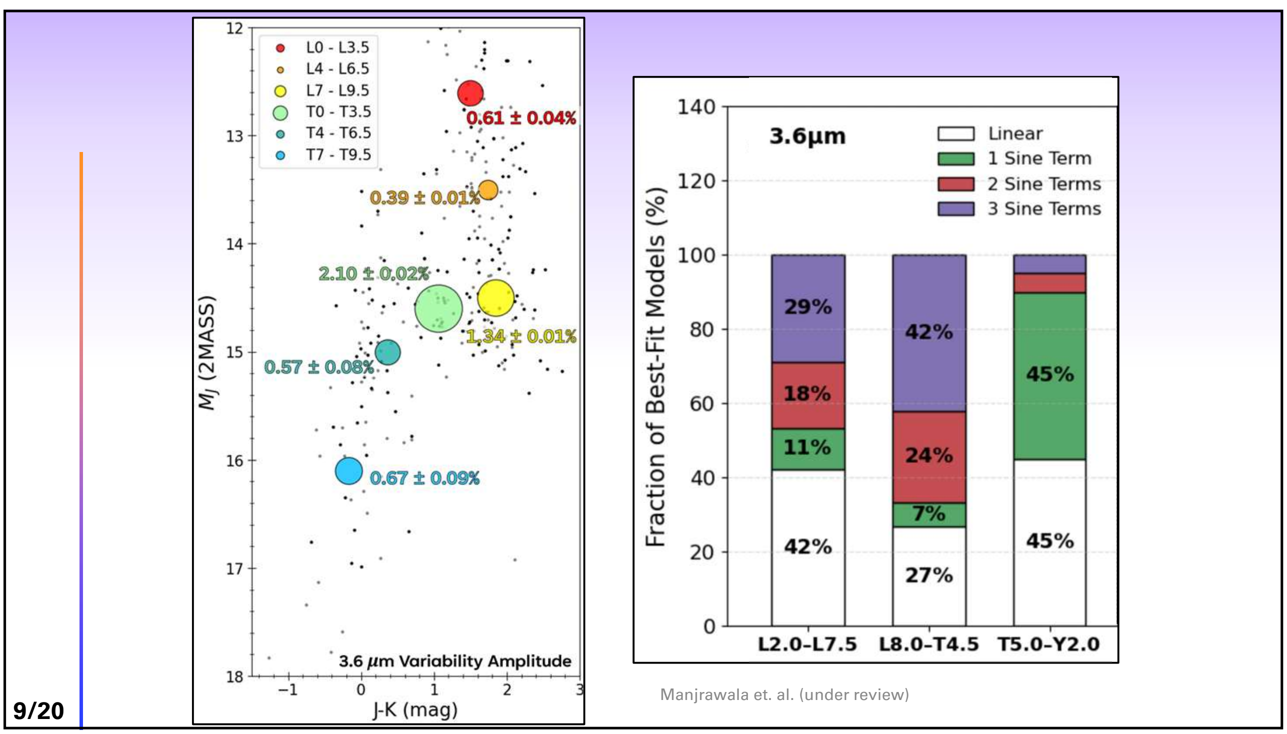
Manjrawala et. al. (under review)

36



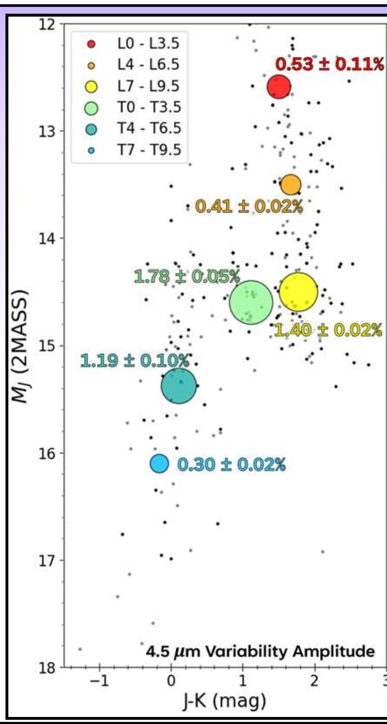
L0 - L3.5
L4 - L6.5
L7 - L9.5
T0 - T3.5
T4 - T6.5
2.73 ± 0.05%
3.10 ± 0.07%
5.62 ± 0.09%
5.13 ± 0.11%
4.27 ± 0.03%
M_J (2MASS)
J-K (mag)
J-band Variability Amplitude
J-band
Linear
1 Sine Term
2 Sine Terms
3 Sine Terms
Fraction of Best-Fit Models (%)
L2.0–L7.5
L8.0–T4.5
T5.0–Y2.0
7%
7%
13%
73%
12%
20%
18%
50%
9%
22%
13%
56%
Manjrawala et. al. (under review)
8/20

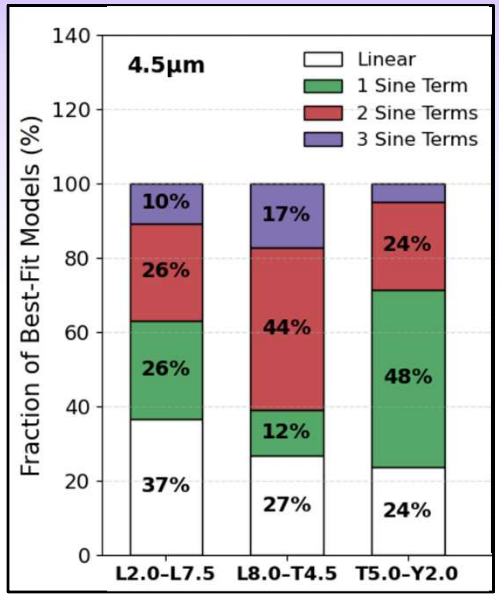
37



L0 - L3.5
L4 - L6.5
L7 - L9.5
T0 - T3.5
T4 - T6.5
T7 - T9.5
0.61 ± 0.04%
0.39 ± 0.01%
2.10 ± 0.02%
1.34 ± 0.01%
0.57 ± 0.08%
0.67 ± 0.09%
M_J (2MASS)
J-K (mag)
3.6 μm Variability Amplitude
3.6μm
Linear
1 Sine Term
2 Sine Terms
3 Sine Terms
Fraction of Best-Fit Models (%)
L2.0–L7.5
L8.0–T4.5
T5.0–Y2.0
29%
18%
11%
42%
42%
24%
7%
27%
45%
45%
Manjrawala et. al. (under review)
9/20

38





Manjrawala et. al. (under review)

10/20

39