Physical properties of of metal-poor M dwarfs

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Outline of the talk

Part 1: **Subdwarfs: what do we know ?**

Part 2: **Sample & Observations**

Part 3: **Spectroscopic sequences**

Part 4: **Physical parameters**

Conclusions and future work

Goal of the project

Our goal is to derive
the physical parameters
of M subdwarfs
and compare to solar-metallicity M dwarfs

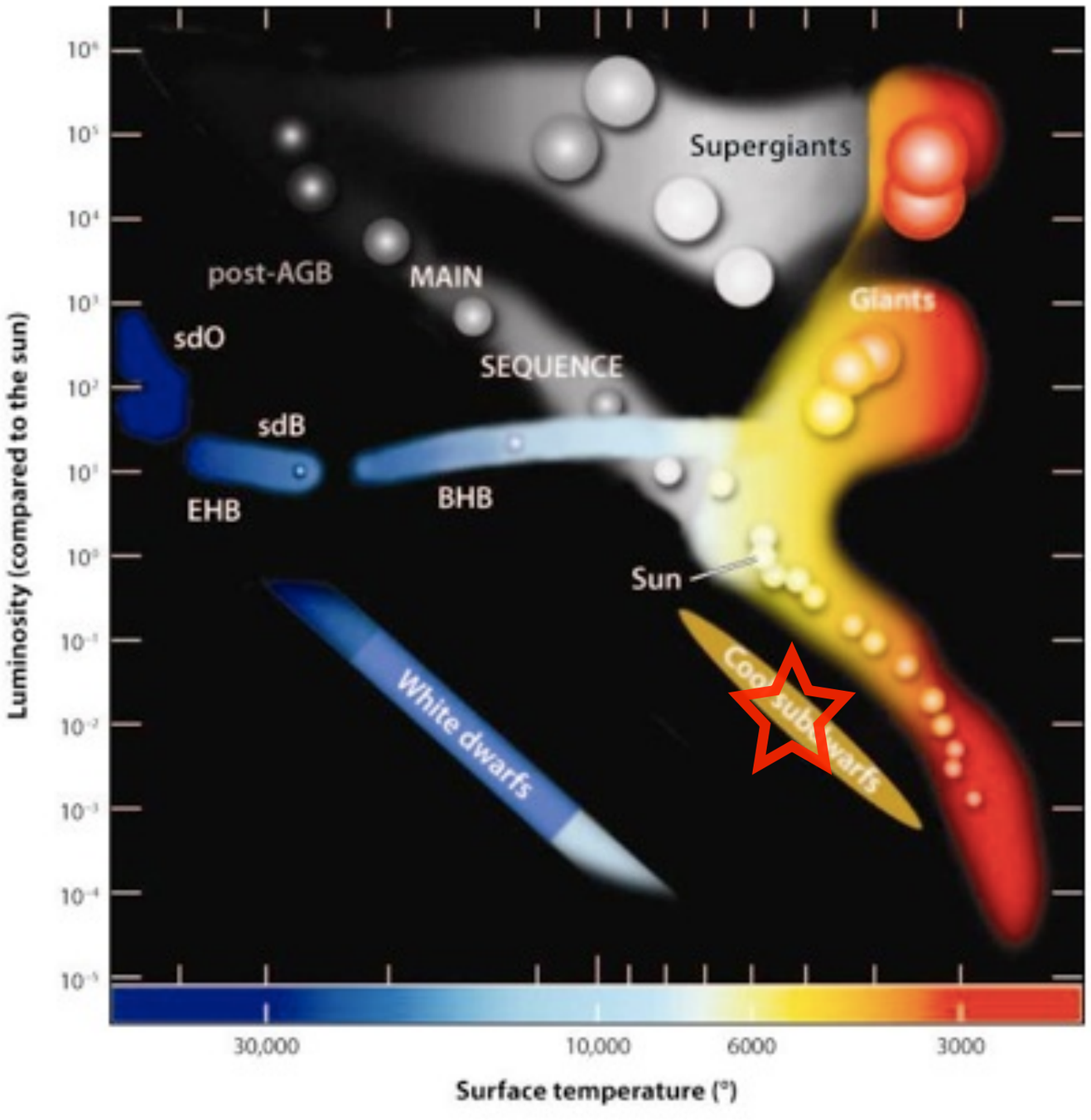
(1) Cooler subdwarfs have more flux in the NIR

(2) Future deep surveys will be sensitive to cooler subdwarfs

Part 1

Subdwarfs

Goal of the project



Heber U. 2009.
Annu. Rev. Astron. Astrophys. 47:211–51

First generation of stars in our Galaxy

Important tracers of Galaxy enrichment

Population II stars

Dearth of metals in their atmospheres

Large proper motions

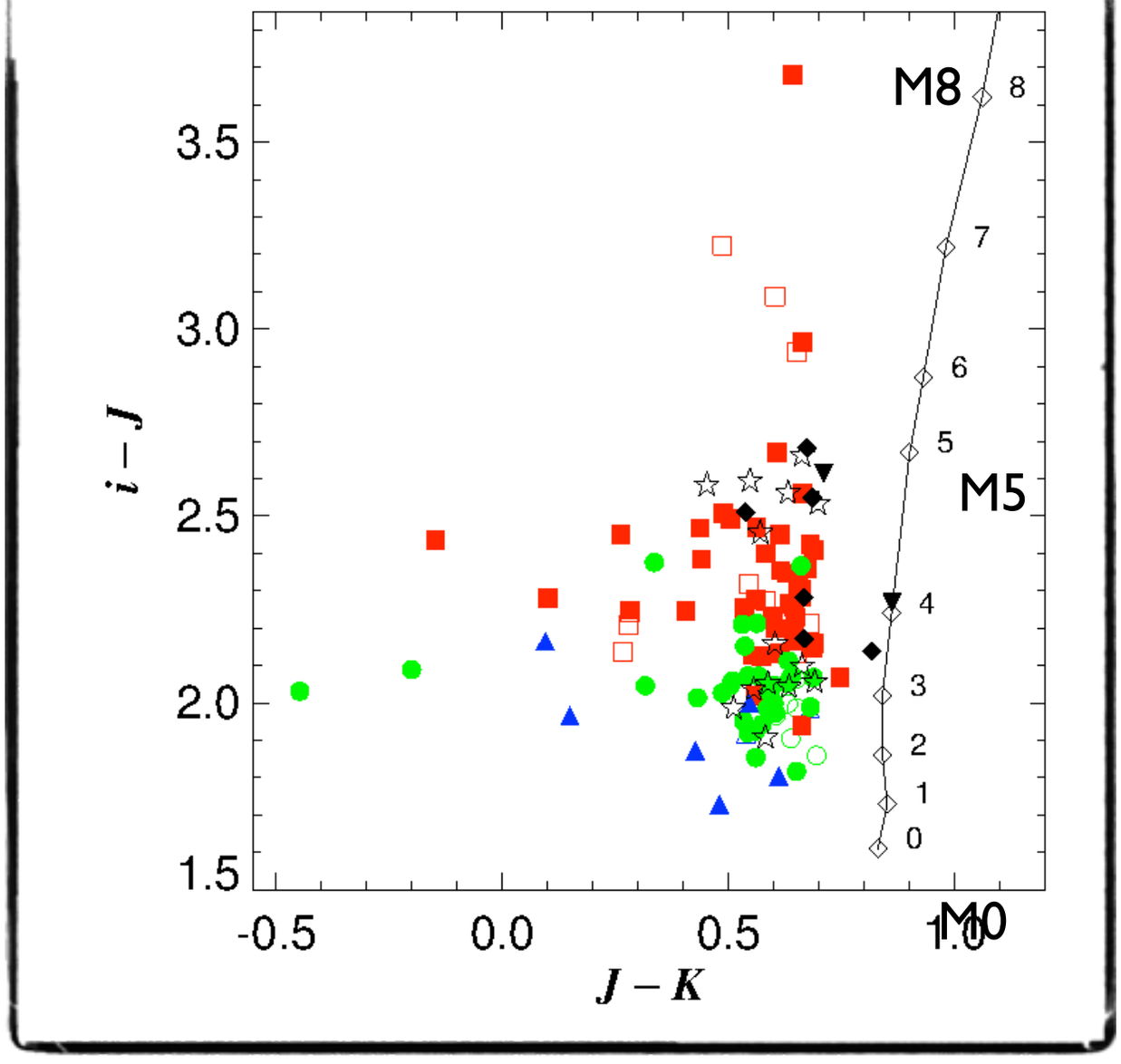
Large heliocentric velocities

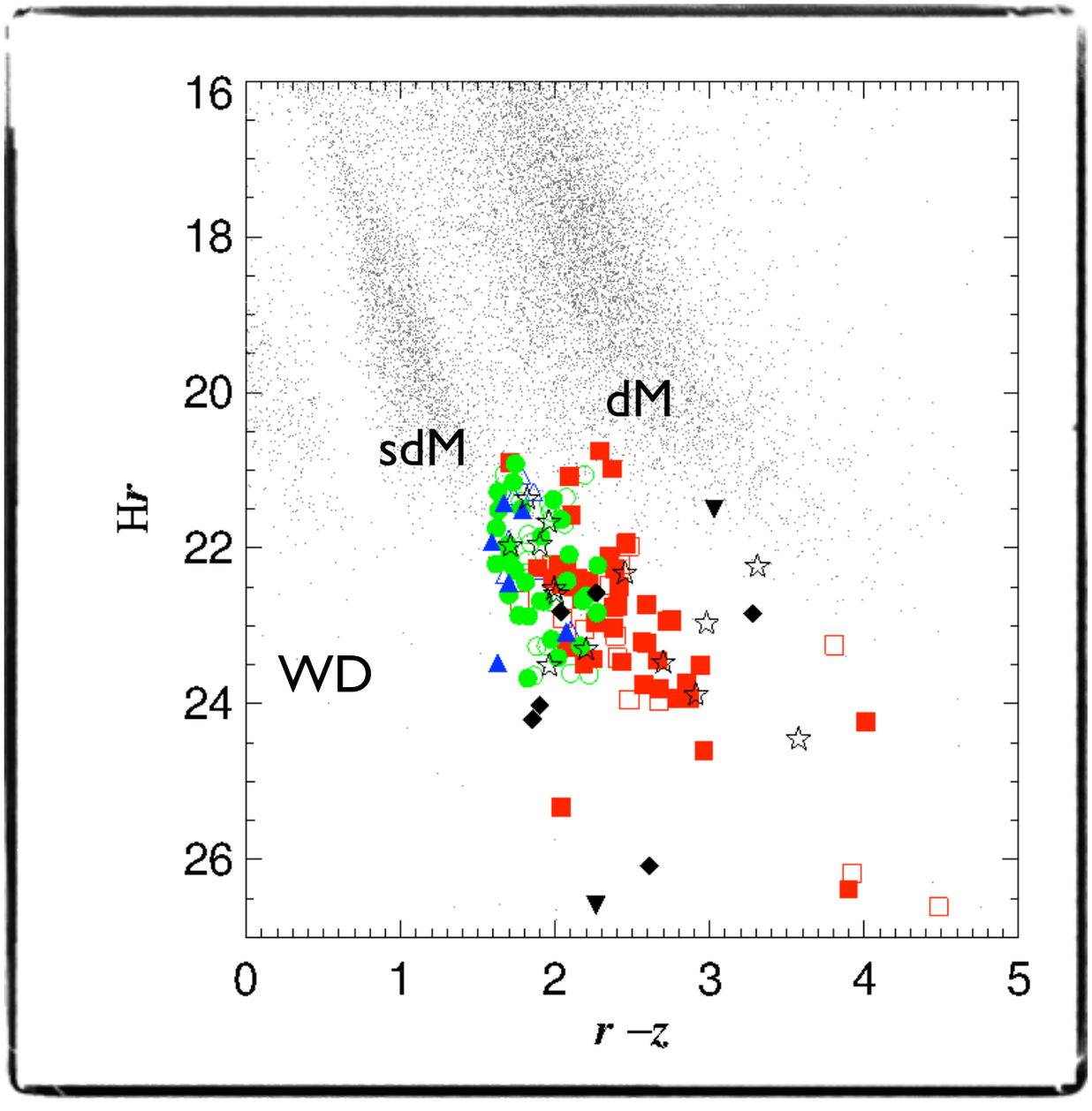
Thick disk and halo kinematics

Photometric properties

Bluer optical and NIR colours than solar-type M dwarfs

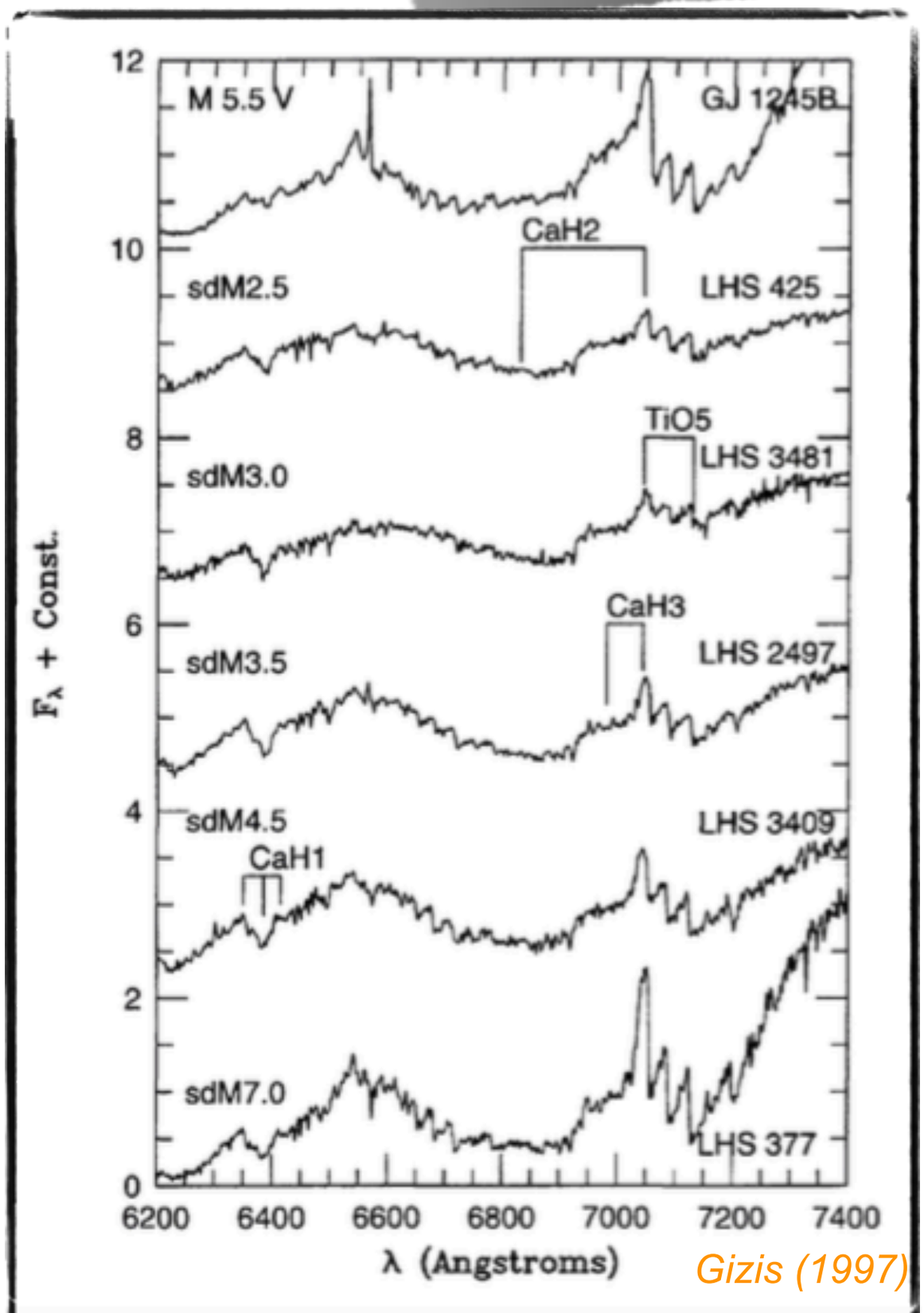
Lodieu et al. (2017)





http://svo2.cab.inta-csic.es/vocats/ltsa/

Spectroscopic properties



Gizis (1997)

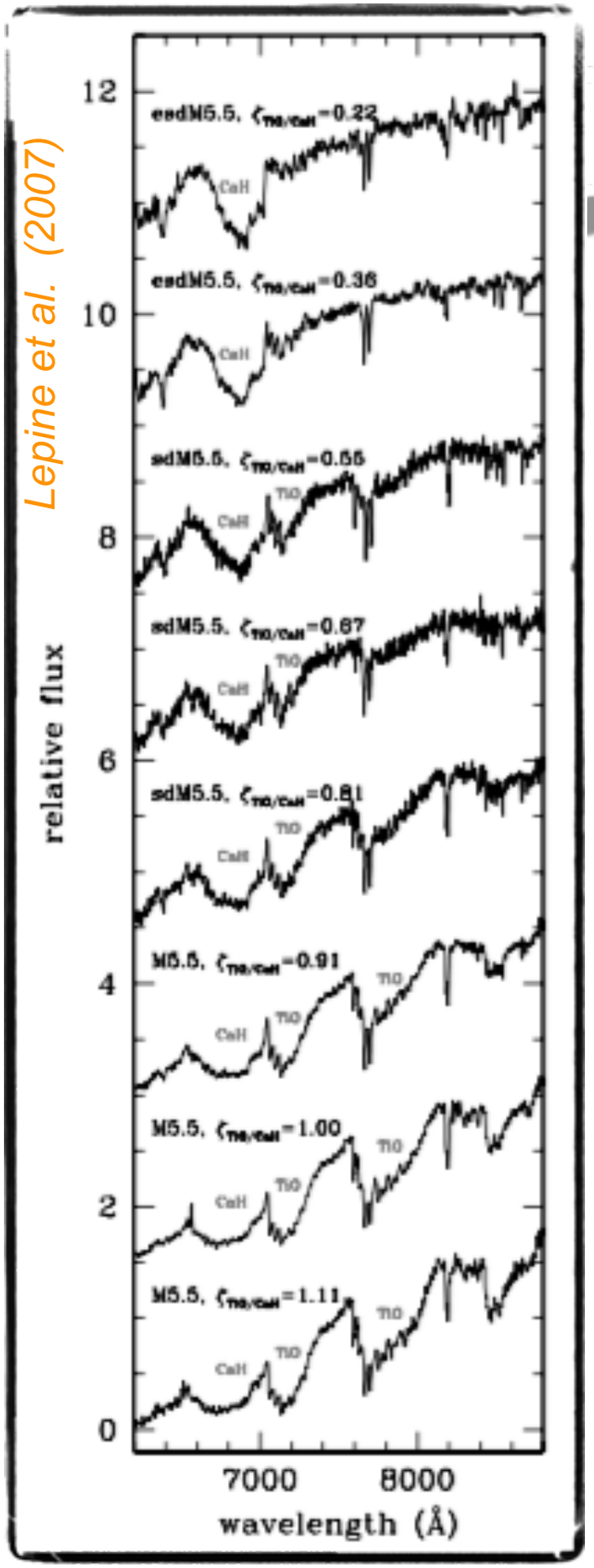
Strong CaH absorption bands

Weakening of the TiO bands

Indices for metal-poor features:

Band	S1	W	S2
TiO 5	7042-7046	7126-7135	
CaH 1	6345-6355	6380-6390	6410-6420
CaH 2	7042-7046	6814-6846	
CaH 3	7042-7046	6960-6990	

Gizis (1997)



Spectral classification (I)

1) Revision of the original scheme of Gizis (1997)

2) Addition of new metallicity class: usdM (sdM & esdM)

3) Introducing new parameter: $T_{TiO/CaH}$ where lower numbers indicates lower metallicity

4) Based on >400 M subdwarfs with some binaries

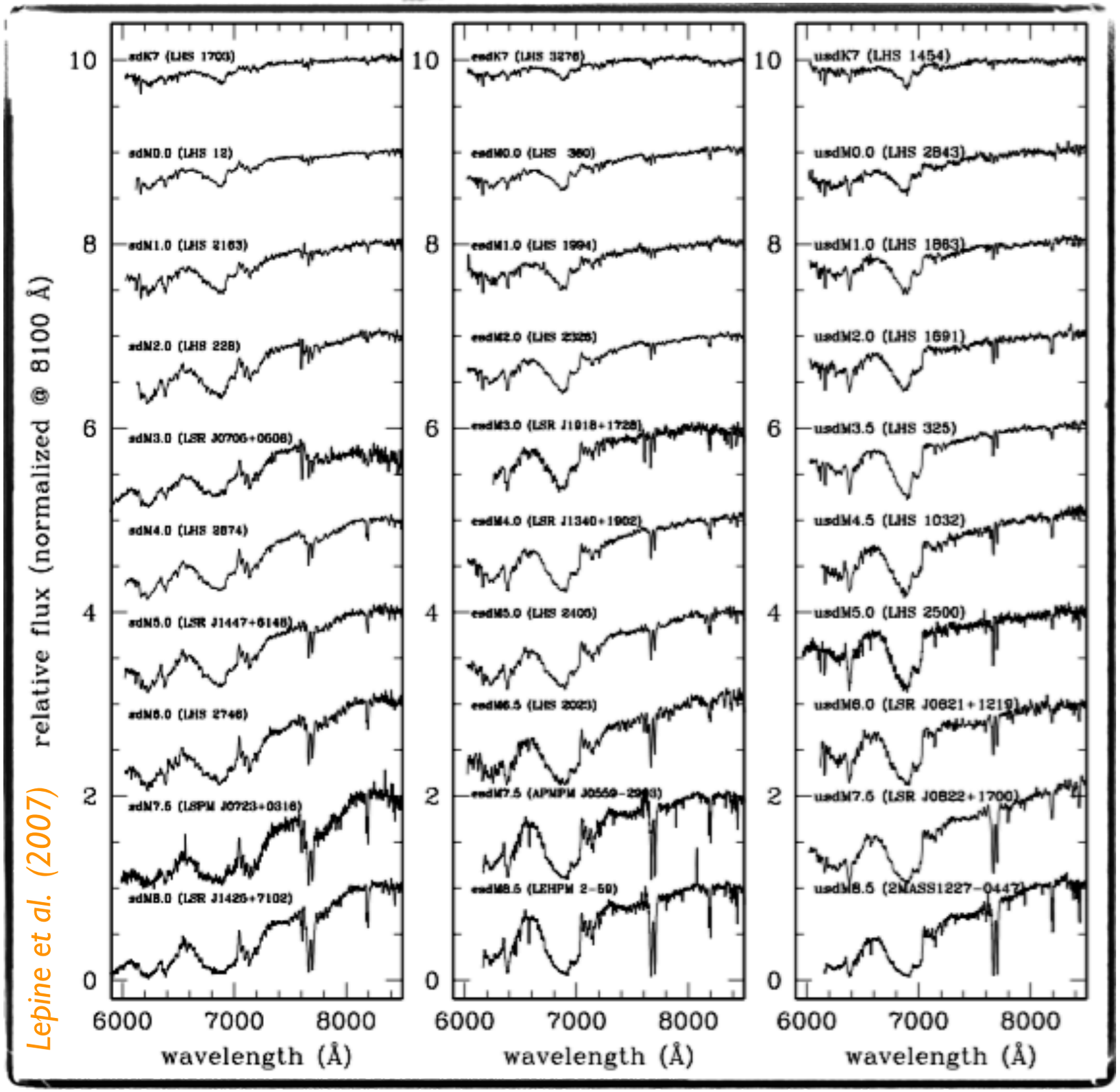
5) Valid for M dwarfs although possible saturation after M8-M9

Gizis (1997)

Lepine et al. (2007)

Jao et al. (2008)

Spectral classification (II)



Spectral sequence for the 3 metal-poor classes of M dwarfs from Lepine et al. (2007)

Left: sdM

Middle: esdM

Right: usdM

Part 2

Sample & Observations

Sample

1) Spectra downloaded from the SDSS archive

2) Optical spectra covering 3200-9200 Angstroms

3) Low-resolution optical spectra: R~1800

4) Spectral classification based on the scheme designed by Lepine et al. (2007)

5) Range in spectral types: M0 to M8-M9 depending on the metal class

==> 18 sdM, 17 esdM, and 16 usdM

Observations

Medium-resolution UVB + VIS + NIR spectra collected with VLT X-shooter for 16 sdM, 16 esdM, 12 usdM and 16 M solar-type dwarfs downloaded from the ESO Science Archive

{ sdM0.0 - sdM9.5
esdM0.0 - edM8.5
usdM0.0 - udM8.5

vs

dM0.0 - dM9.0

Arm	λ-range	N. of orders	scale[1]	Slit	Resolution
	(nm)		("/pix)		
UVB	300-560	12	0.16-0.20	1.3”	R=4000
VIS	550-1020	15	0.16-0.18	1.2”	R=6700
NIR [3]	1020-2480	16	0.21-0.28	1.2”	R=3900

Part 3

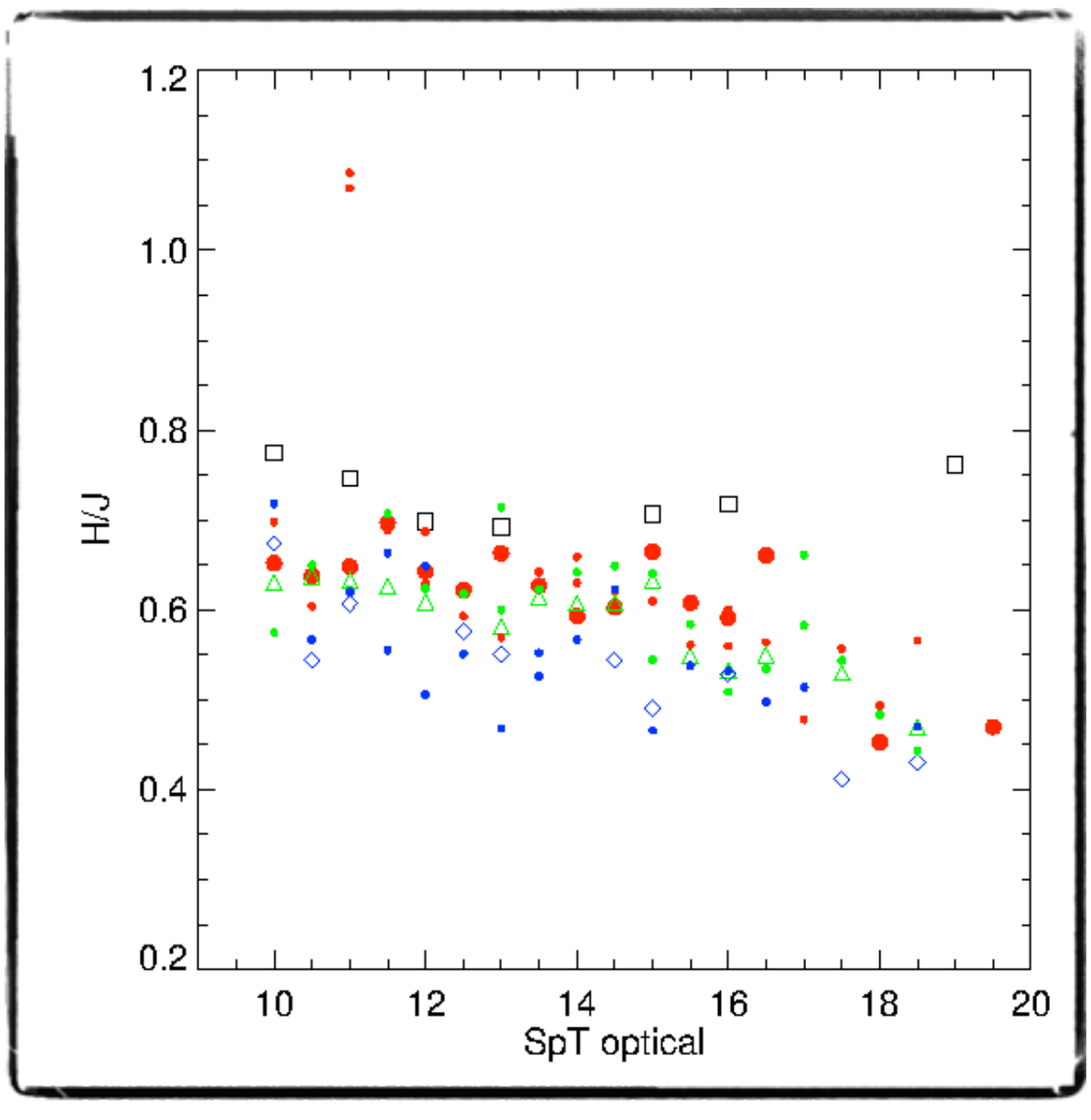
Spectroscopic sequences

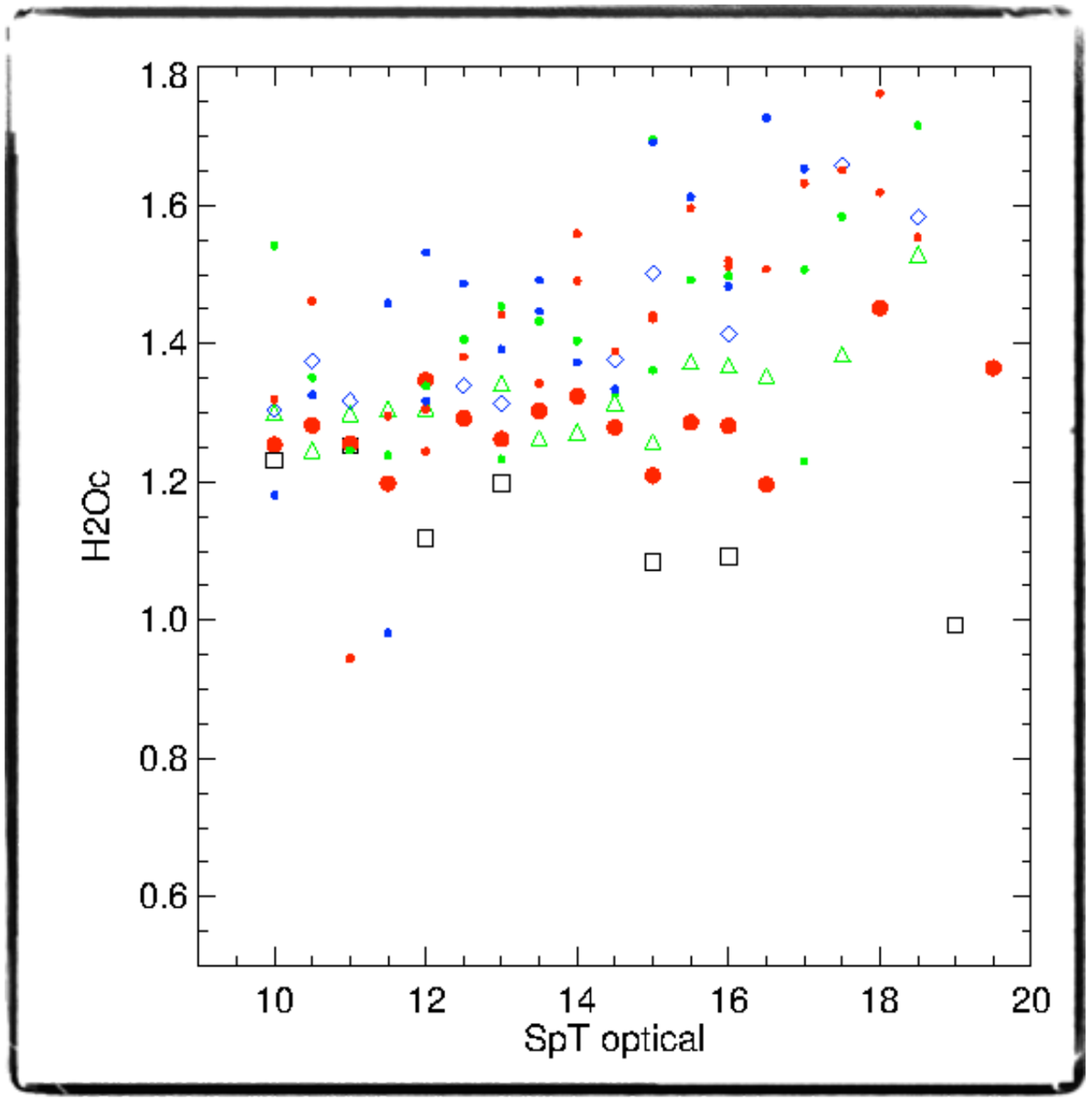
Colour Scheme

dM sdM esdM usdM

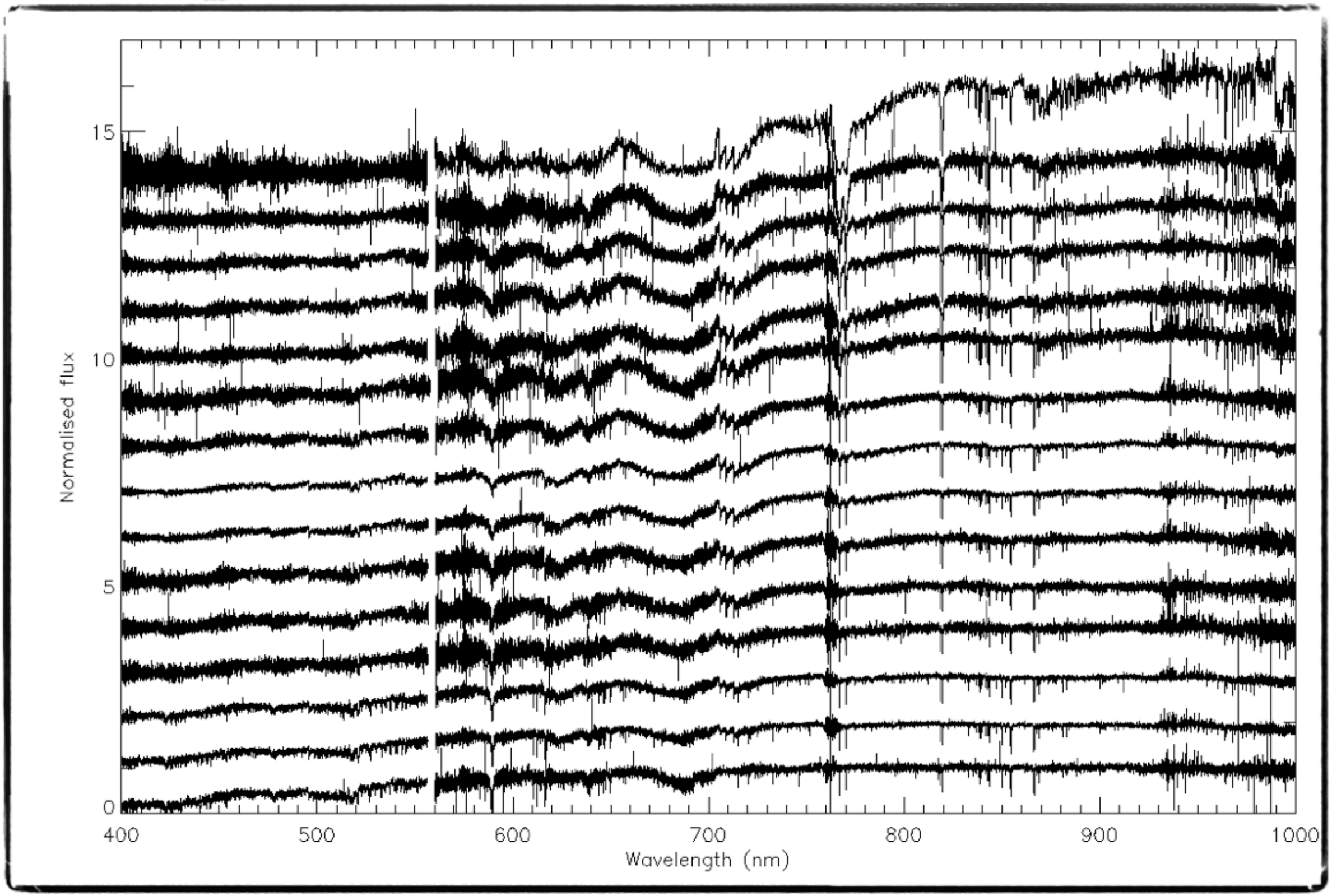
Spectral indices

Measure of all spectral indices available in the literature to design a NIR classification

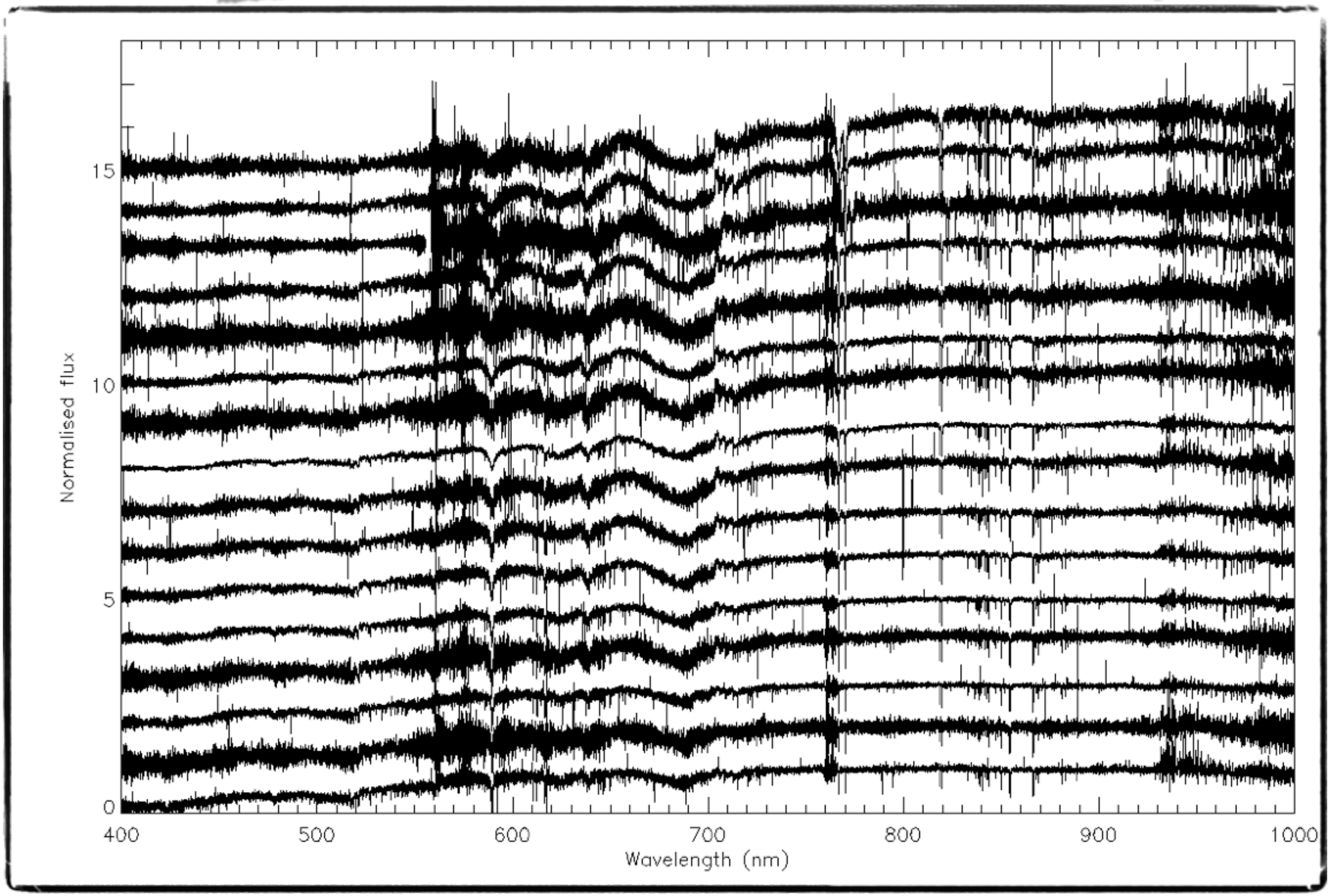




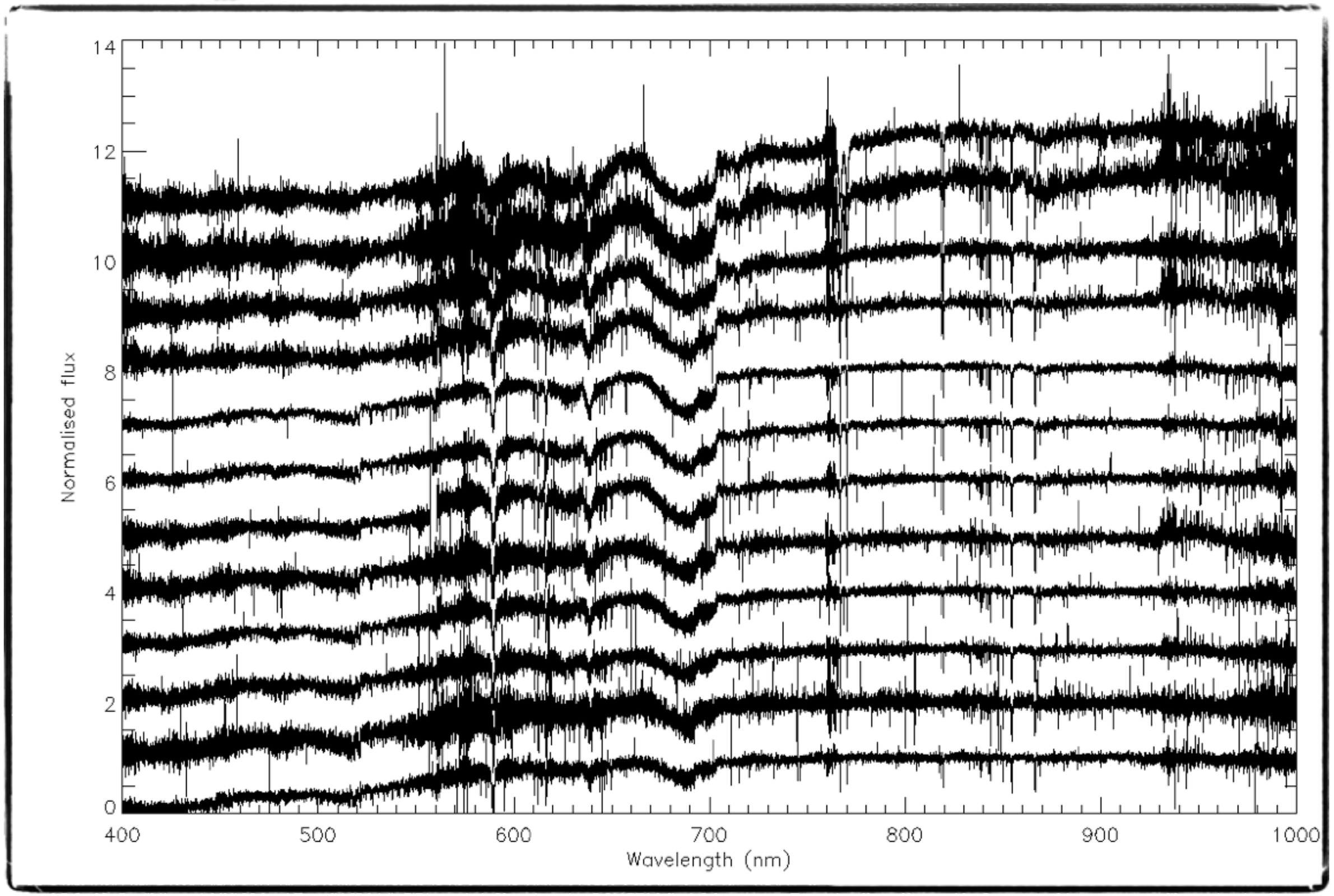
UVB + VIS sequence of sdM



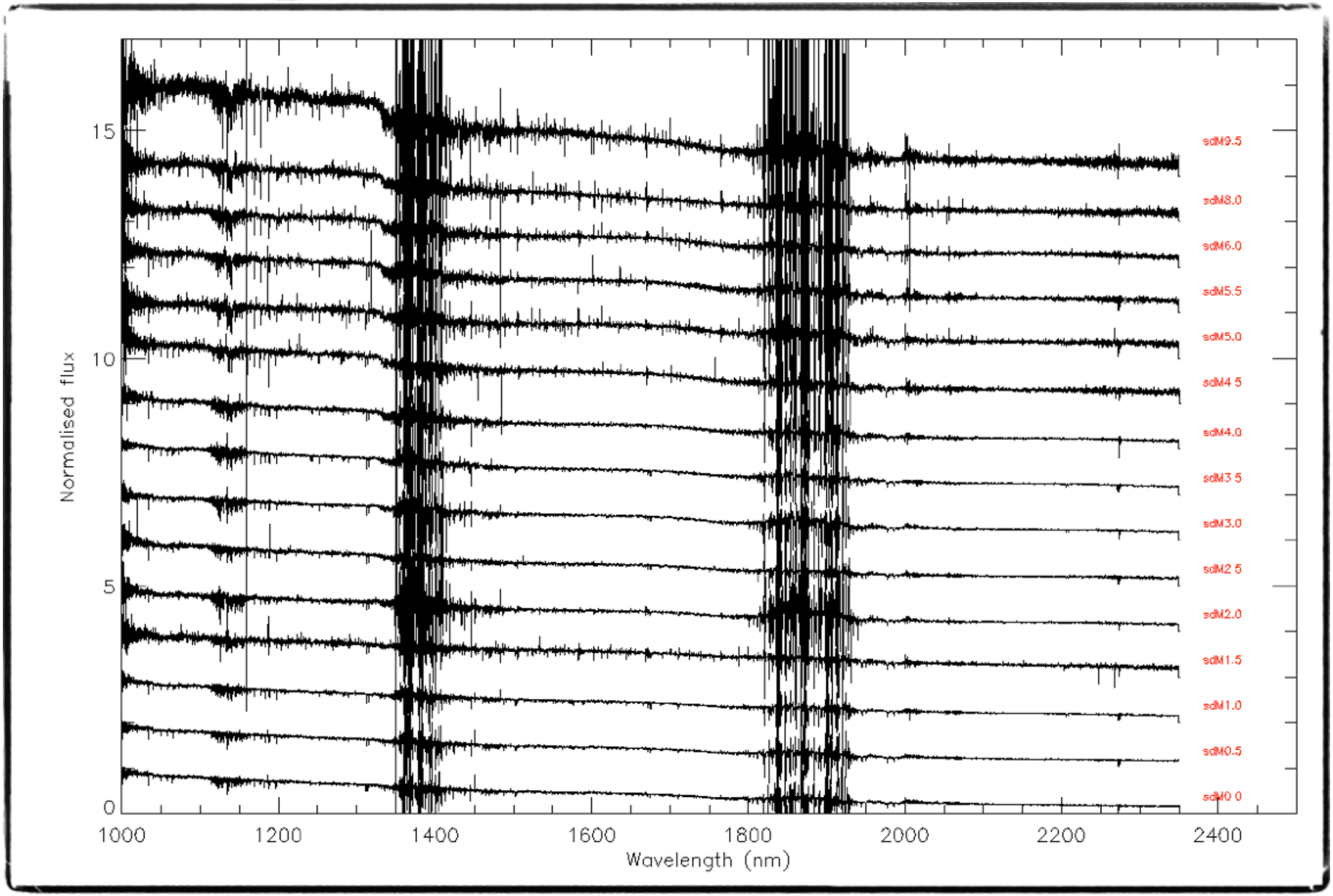
UVB + VIS sequence of esdM



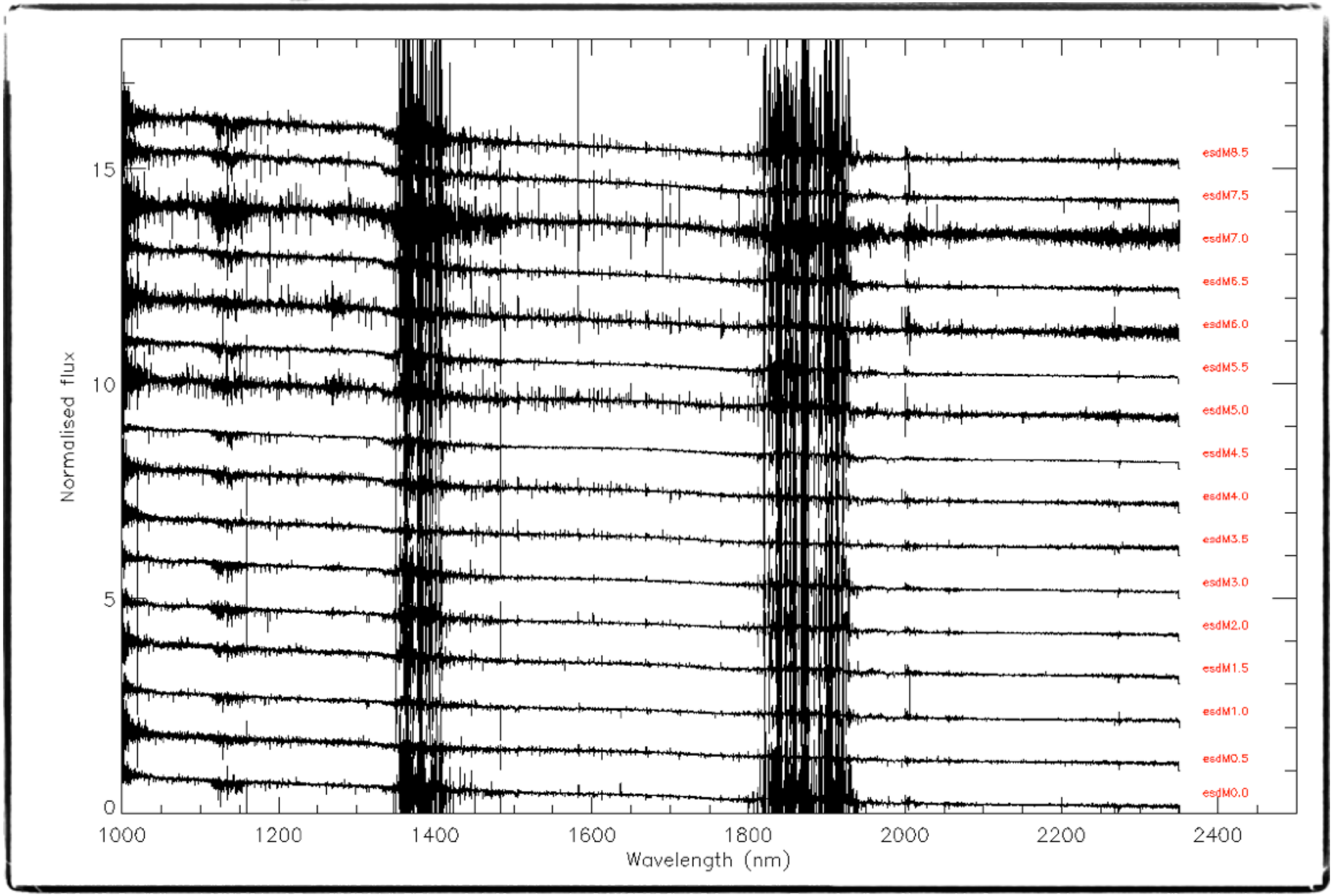
UVB + VIS sequence of usdM



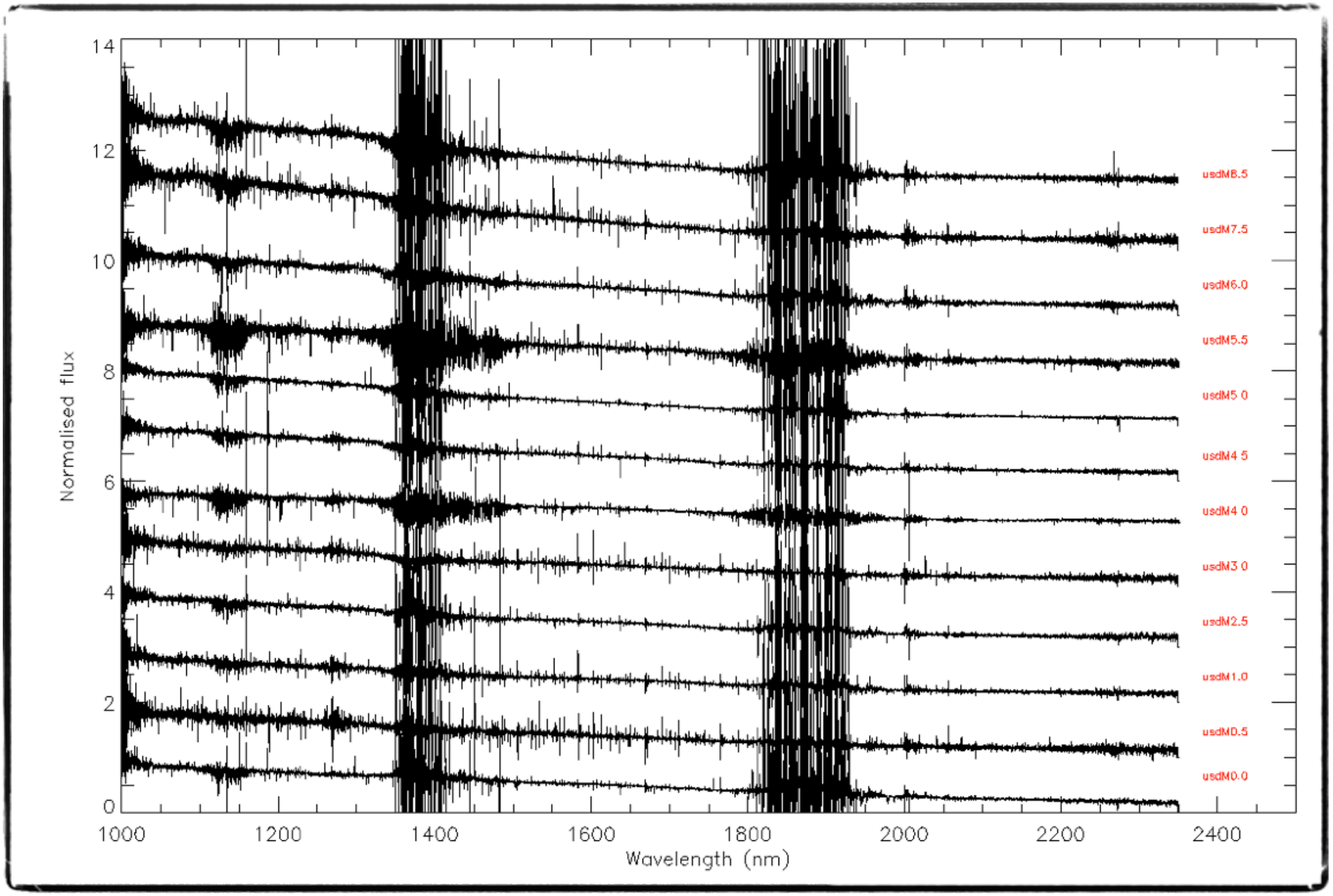
NIR sequence of sdM



NIR sequence of esdM

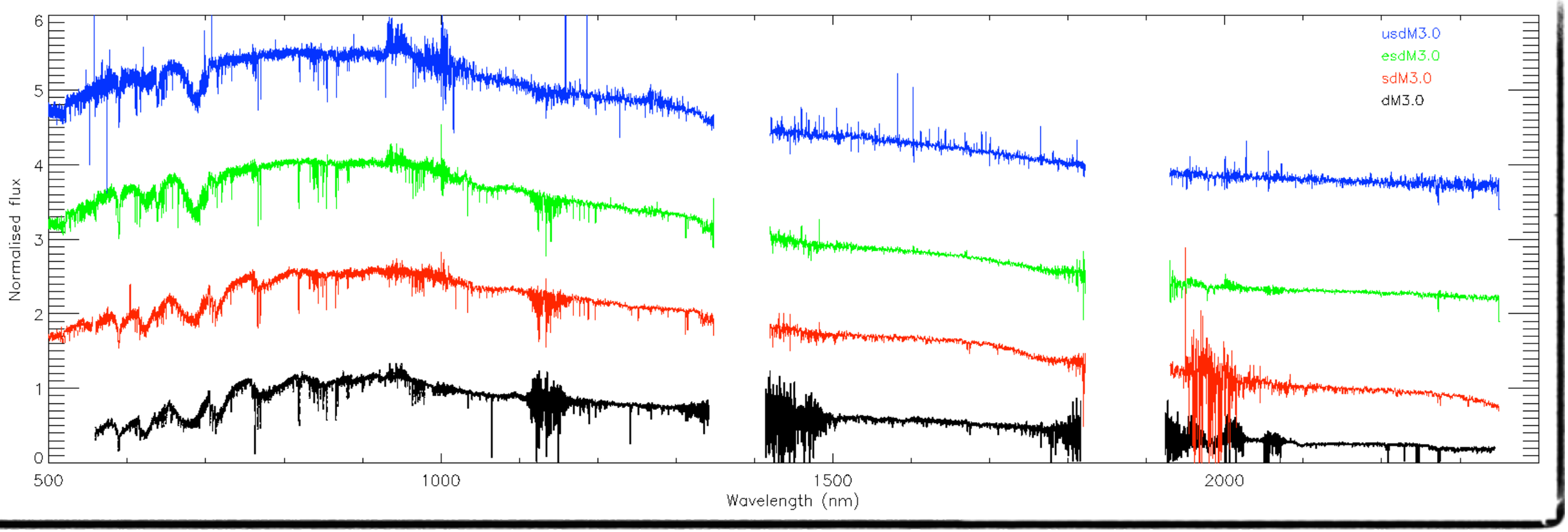


NIR sequence of usdM



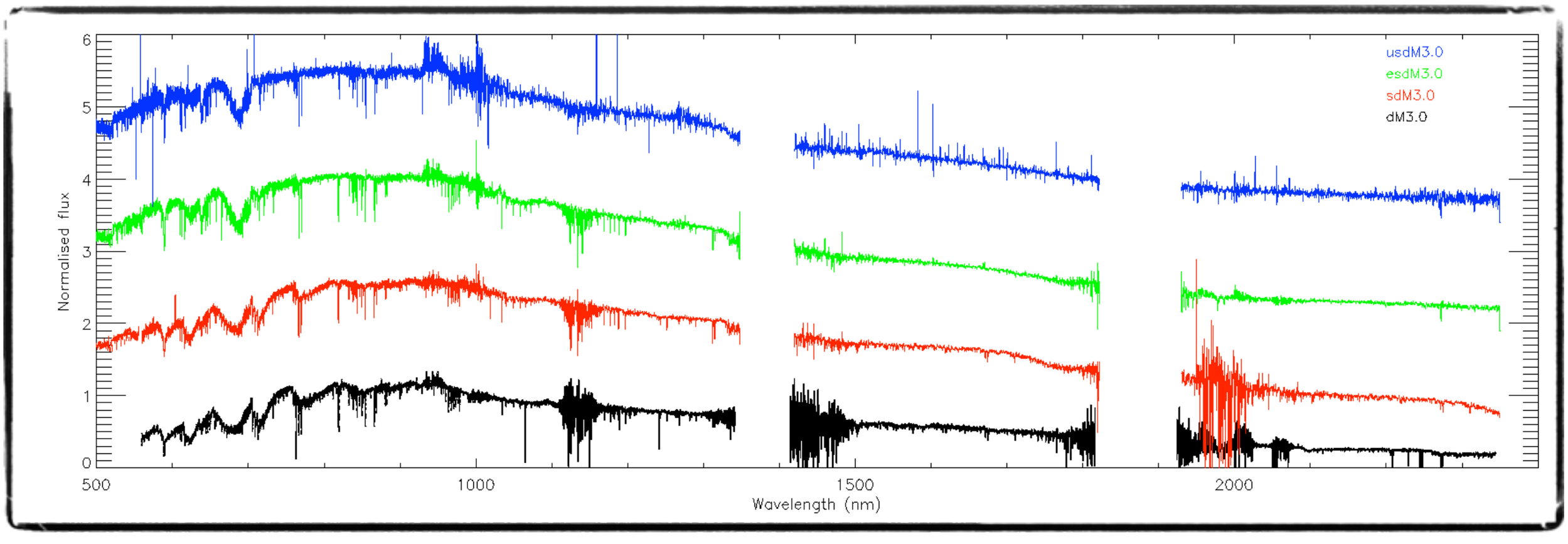
Dependence on metallicity: M3

Comparison of the full VIS+NIR spectral energy distribution of a M3 at different metallicities



Dependence on metallicity: M6

Comparison of the full VIS+NIR spectral energy distribution of a M6 at different metallicities

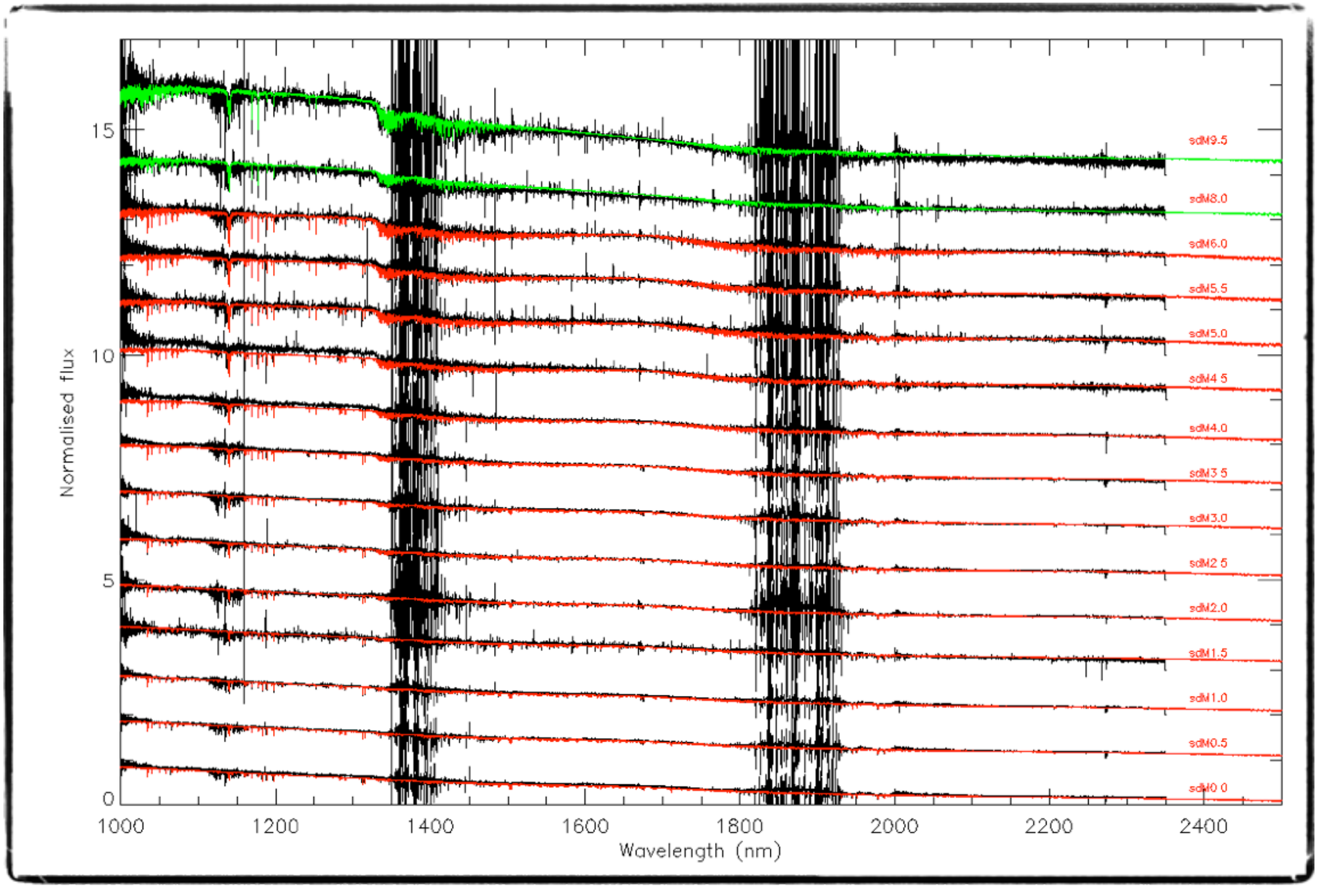


Part 4

Physical parameters

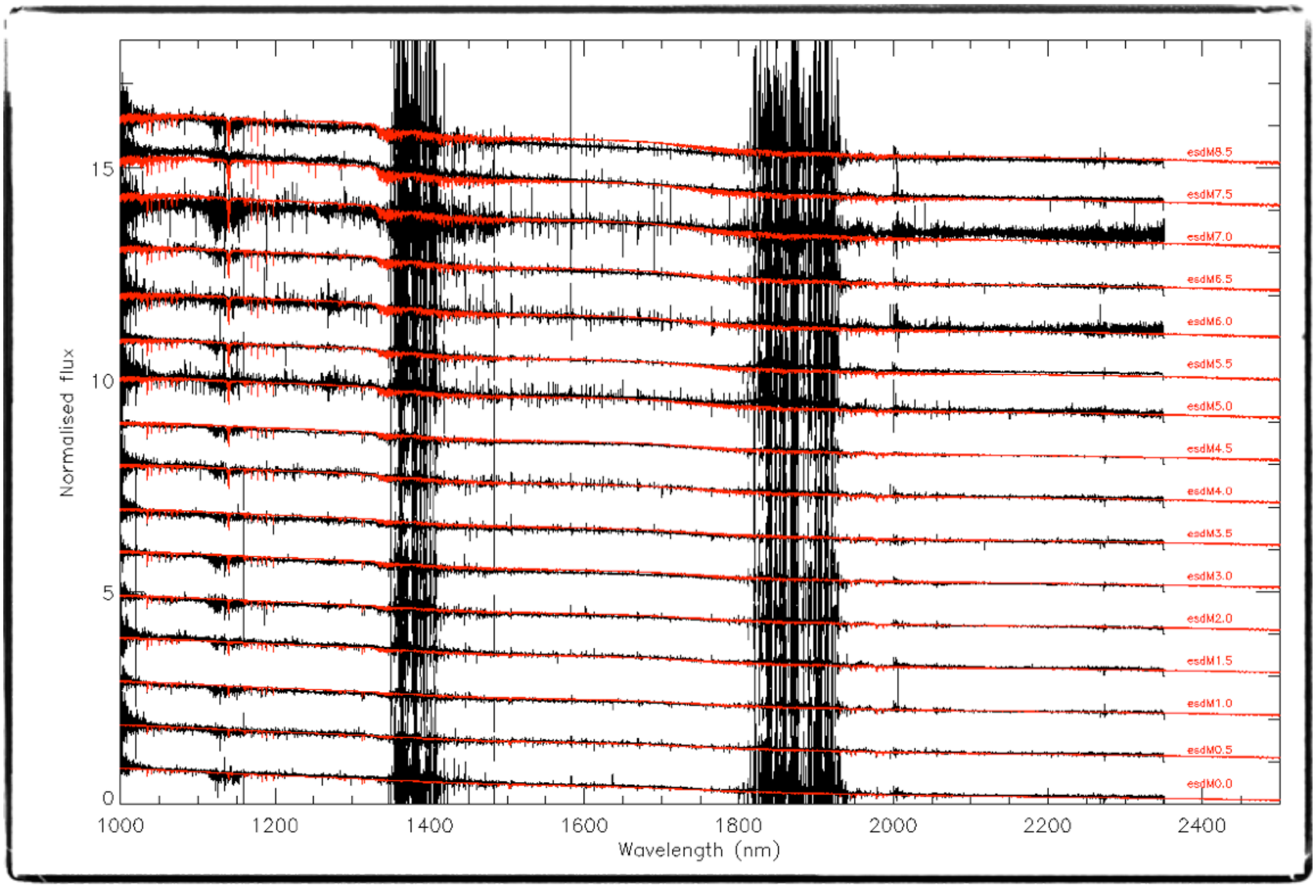
sdM: observations vs models

Teff = 3800-2700K; *log*(g) = 5.5+/-0.5 dex; [M/H] = -1.0+/-0.5 dex



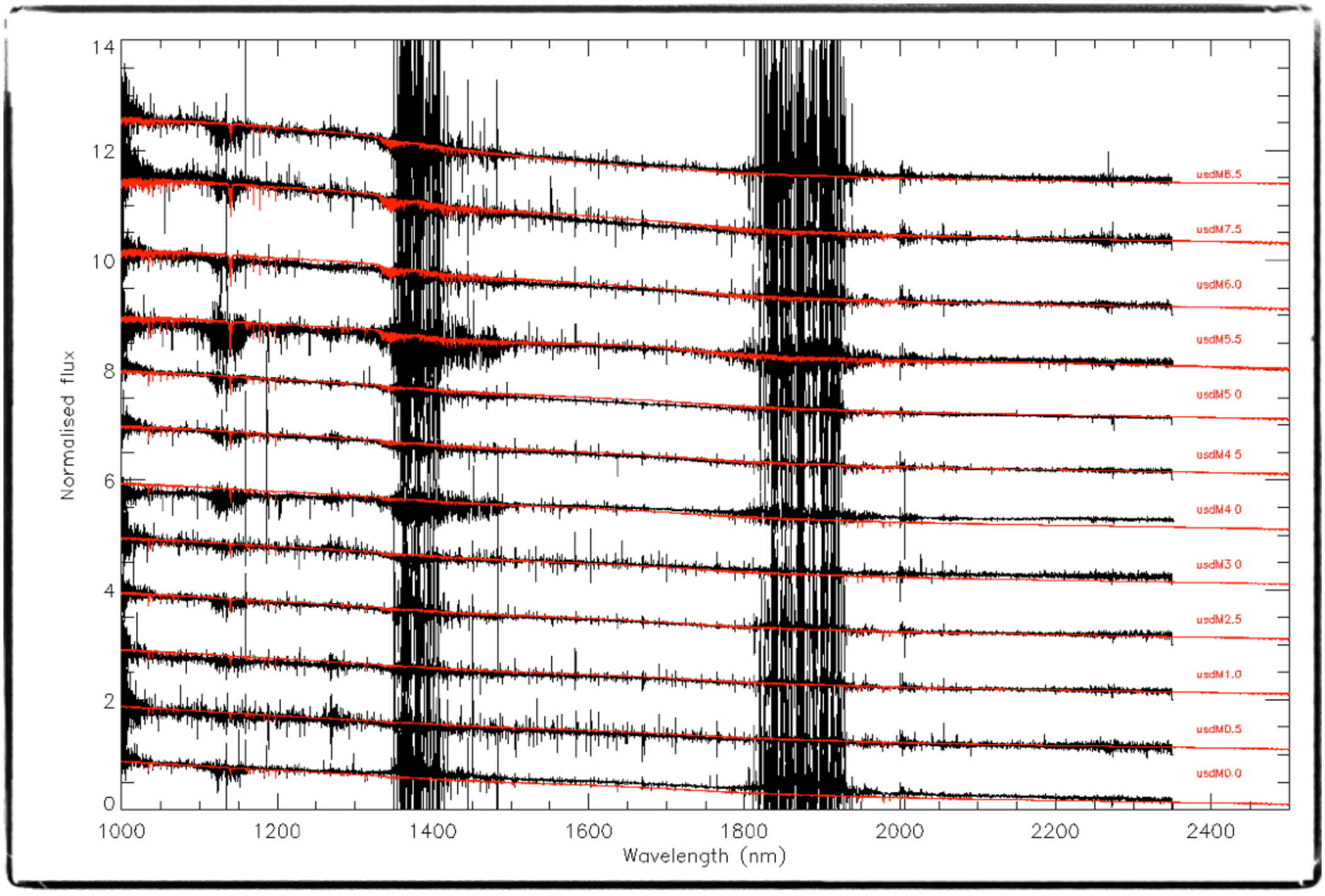
esdM: observations vs models

Teff = 3800-3000K; *log*(g) = 5.5+/-0.5 dex; [M/H] = -1.5+/-0.5 dex

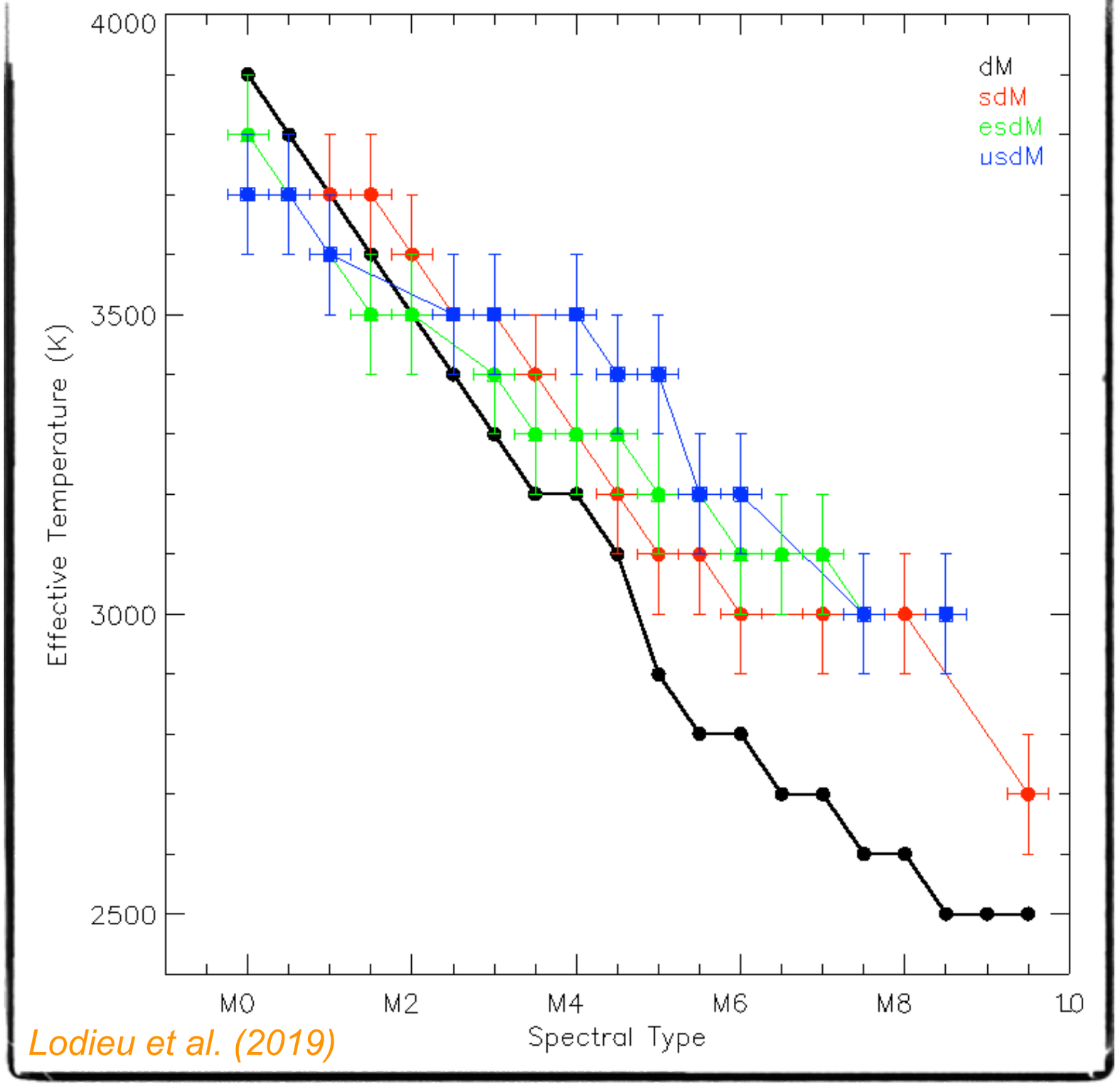


usdM: observations vs models

Teff = 3700-3000K; *log*(g) = 5.5+/-0.5 dex; [M/H] = -2.0+/-0.5 dex



Comparison with field M dwarfs



Lodieu et al. (2019)

We find similiar Teff for subdwarfs and solar-type M0-M2 dwarfs

Teff increases with lower metallicity for SpT = M4 and later

The sdM8 and sdM9.5 have lower metallicity than other subdwarfs ==> possible issue with current optical classification below 3000K

Part 4

Conclusions

Conclusions

(1) NIR spectroscopy for bright M subdwarfs in each metal class

(2) Comparison with BT-Settl models to infer physical parameters

(3) Effective temperatures of M subdwarfs warmer beyond M4

(4) Gravity of *log*(g) = 5.5+/-0.5 dex for metal-poor M dwarfs

(5) [M/H] = -1.0, -1.5, and -2.0 dex for sdM, esdM, and usdM, resp.

http://svo2.cab.inta-csic.es/vocats/ltsa/

Future work

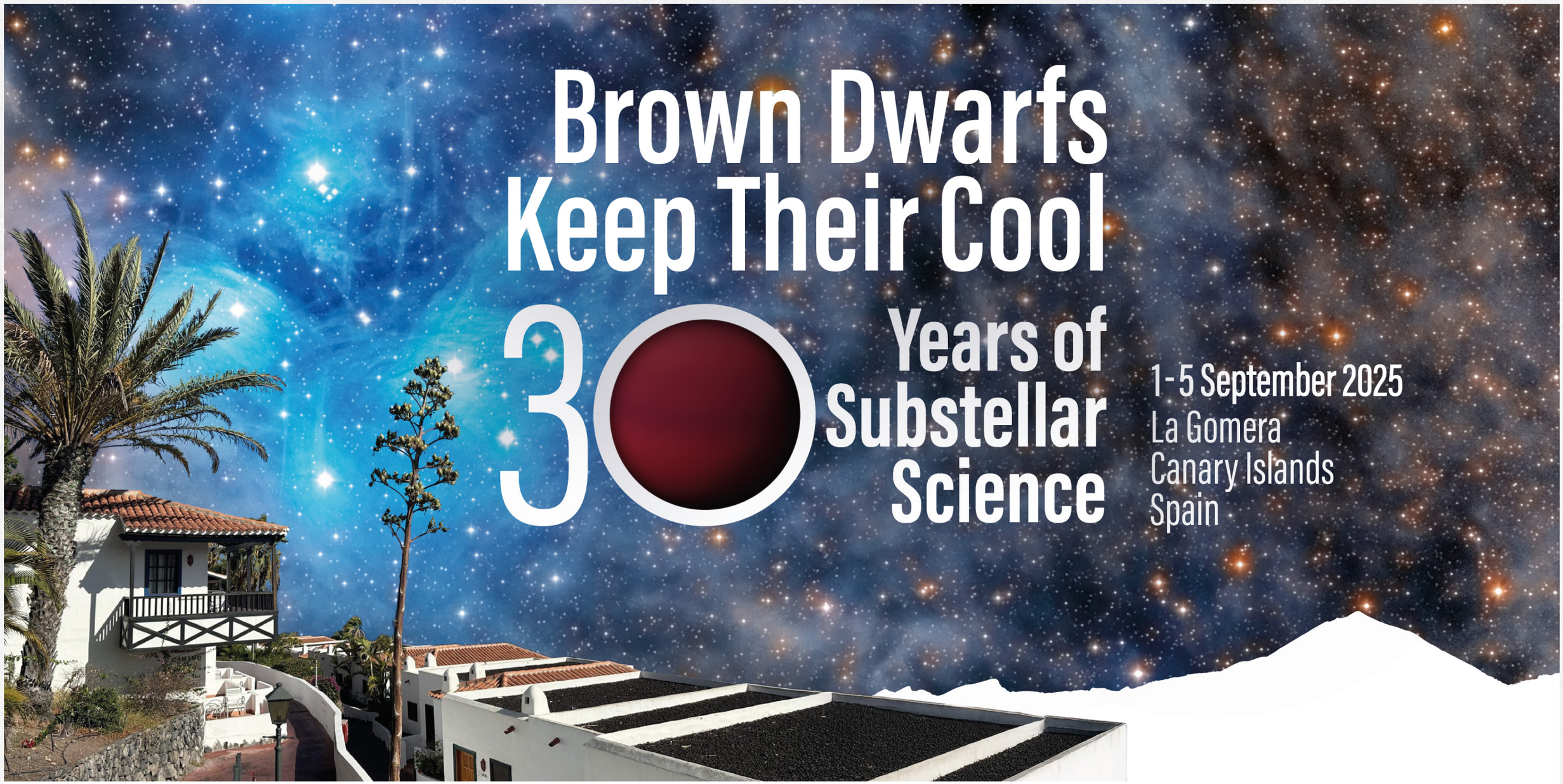
(1) Compare strengths of specific lines: observations vs models

(2) Dynamical masses and radii to test evolutionary models

(3) Search for cooler subdwarfs with LSST, Euclid, and Roman

http://svo2.cab.inta-csic.es/vocats/ltsa/

Thank you



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