

*VOSA: A short introduction.*  
*SEDs in the Virtual Observatory*

Miriam Cortés Contreras

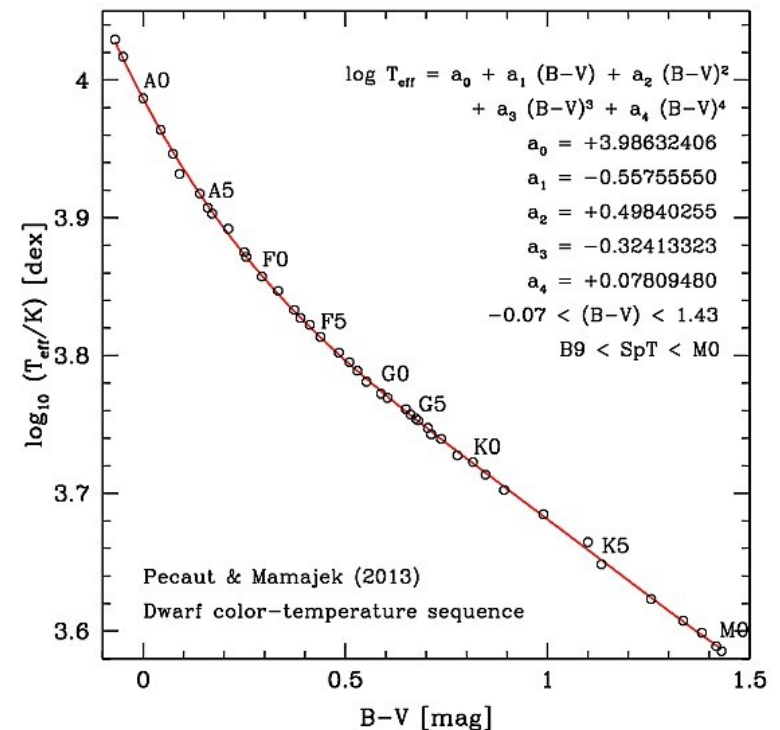
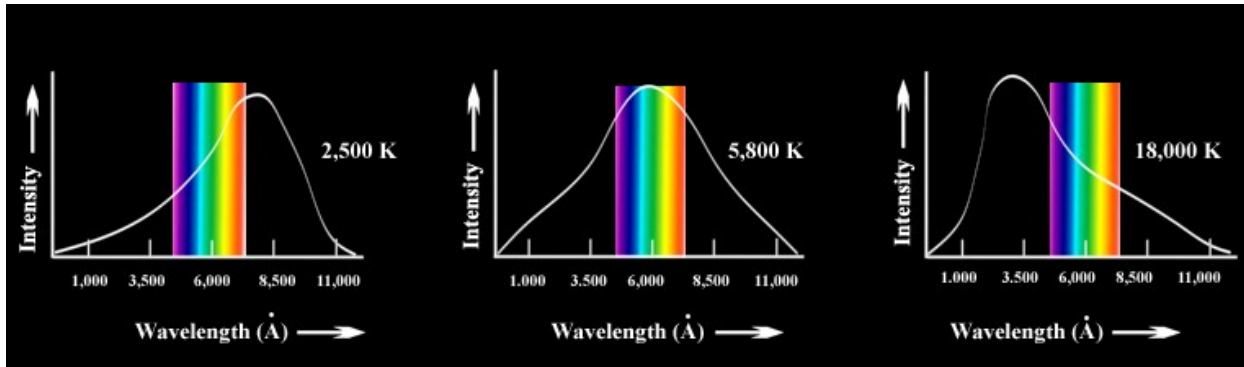
Enrique Solano, Carlos Rodrigo



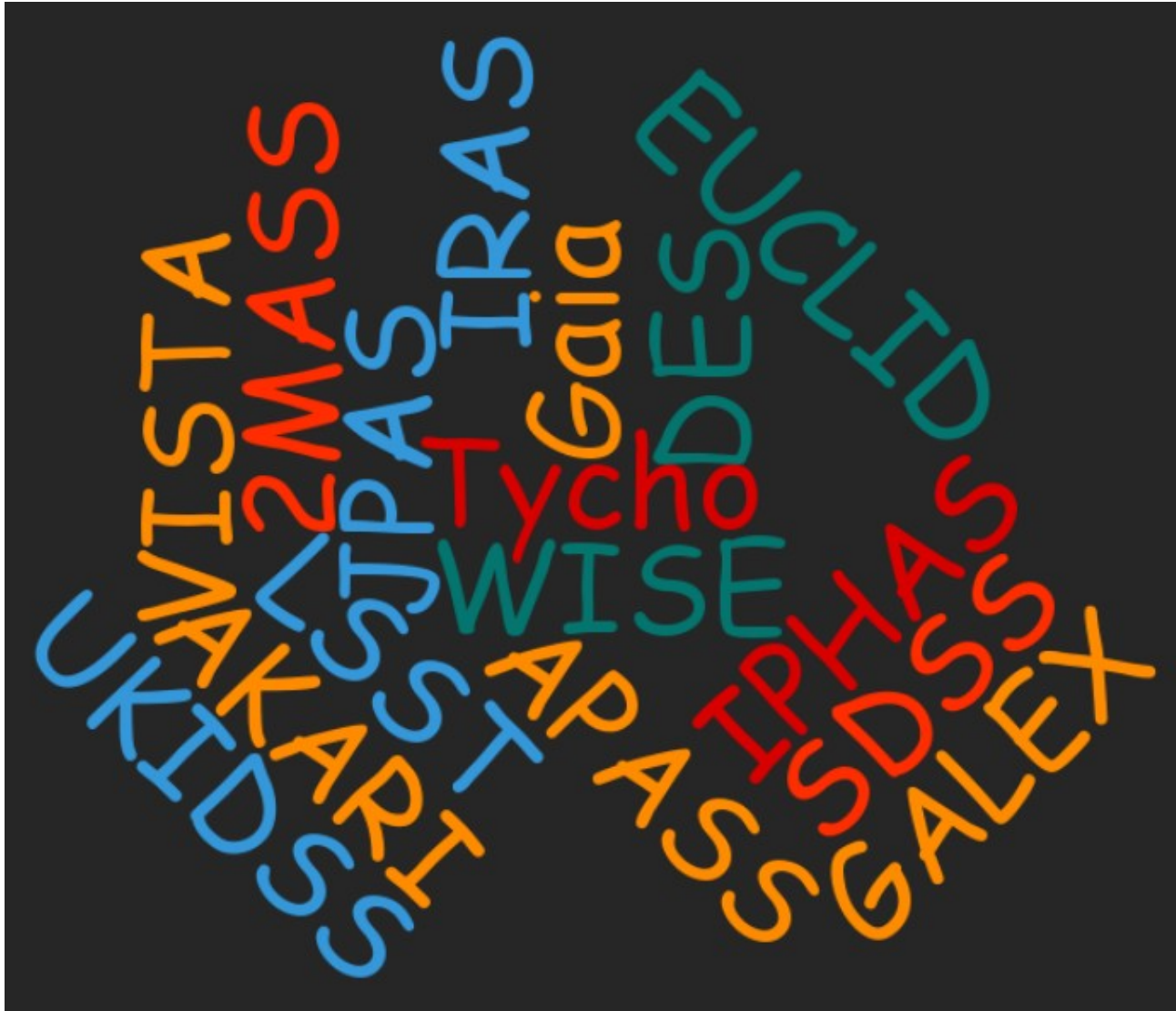
Astronomy ESFRI & Research Infrastructure Cluster  
ASTERICS - 653477



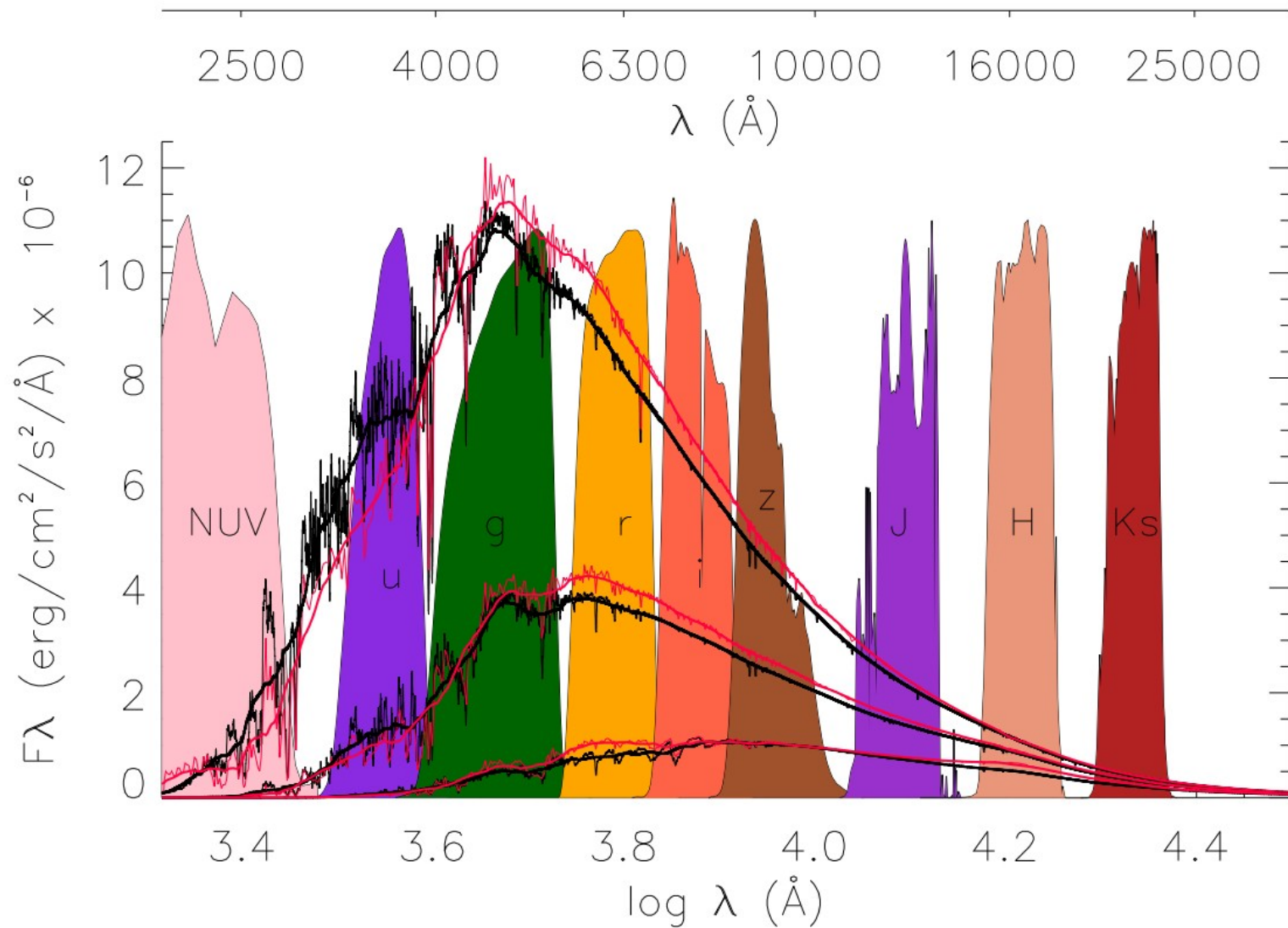
# Why SEDs (Spectral Energy Distributions)?



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# Building SEDs: Difficulties

- Discovery of information: Observational photometry and theoretical models.

## Infrared

### 2MASS All-Sky Point Source Catalog

2MASS has uniformly scanned the entire sky in three near-infrared bands to detect and characterize point sources brighter than about 1 mJy in each band, with signal-to-noise ratio (S/N) greater than 1

More Info.

Filters: ☒ 2MASS/2MASS.J ☒ 2MASS/2MASS.H

☒ 2MASS/2MASS.Ks

Search radius: 5 arcsec

Show magnitude limits

### IRAS Catalog of Point Sources, Version 2.0

This is a catalog of some 250,000 well-confirmed infrared point sources observed by the Infrared Astronomical Satellite, i.e., sources with angular extents less than approximately 0.5, 0.5, 1.0, and 2.0 arcmin in the in-scan direction at 12, 25, 60, and 100  $\mu$ m.

More Info.

Filters: ☒ IRAS/IRAS.12mu ☒ IRAS/IRAS.25mu

☒ IRAS/IRAS.60mu ☒ IRAS/IRAS.100mu

Search radius: 20 arcsec

Show flux limits

### MSX6C Infrared Point Source Catalog

Version 2.3 of the Midcourse Space Experiment (MSX) Point Source Catalog (PSC), which supersedes the version (1.2) that was released in 1999 (Cat. V/107), contains over 100,000 more sources than the previous version.

More Info.

Filters: ☒ MSX/MSX.A ☒ MSX/MSX.C

☒ MSX/MSX.D ☒ MSX/MSX.E

Search radius: 5 arcsec

Show flux limits

### AKARI/FIS All-Sky Survey Point Source Catalogues (ISAS/JAXA, 2010)

The AKARI/FIS All-Sky Survey Bright Source Catalog Version 1.0 provides positions and fluxes for 427071 point sources in the 4 far-infrared wavelengths centered at 65, 90, 140 and 160  $\mu$ m

More Info.

Filters: ☒ AKARI/FIS.N60 ☒ AKARI/FIS.WIDE-S

☒ AKARI/FIS.WIDE-L ☒ AKARI/FIS.N160

Search radius: 5 arcsec

Show flux limits

### GLIMPSE Source Catalog (I + II + 3D)

### DENIS Catalogue

This catalogue is the latest incremental release of the DENIS project. It consists of a set of 355,220,325 point sources detected by the DENIS survey in 3662 strips (covering each 30 degrees in declination and 12 arcmin in right ascension)

More Info.

Filters: ☒ DENIS/DENIS.I ☒ DENIS/DENIS.J

☒ DENIS/DENIS.Ks

Search radius: 5 arcsec

Show magnitude limits

### IRAS Faint Source Catalog

The Faint Source Survey (FSS) is the definitive Infrared Astronomical Satellite data set for faint point sources.

More Info.

Filters: ☒ IRAS/IRAS.12mu ☒ IRAS/IRAS.25mu

☒ IRAS/IRAS.60mu ☒ IRAS/IRAS.100mu

Search radius: 20 arcsec

Show flux limits

### AKARI/IRC mid-IR all-sky Survey (ISAS/JAXA, 2010)

The AKARI/IRC Point Source Catalogue Version 1.0 provides positions and fluxes for 870,973 sources observed with the InfraRed Camera (IRC)

More Info.

Filters: ☒ AKARI/IRC.S9W ☒ AKARI/IRC.L18W

Search radius: 5 arcsec

Show flux limits

### C2D Spitzer and Ancillary Data

C2D Fall '07 Full CLOUDS Catalog (CHA-II, LUP, OPH, PER, SER)

Filters: ☒ Spitzer/IRAC.11 ☒ Spitzer/IRAC.12

☒ Spitzer/IRAC.13 ☒ Spitzer/IRAC.14

☒ Spitzer/MIPS.24mu ☒ Spitzer/MIPS.70mu

Search radius: 5 arcsec

Show flux limits

### Taurus Catalog

### AMES-Dusty 2000

The AMES-Dusty Model grid of theoretical spectra. Brown dwarfs/extrasolar planets atmosphere models without irradiation but including dust opacity (fully efficient dust settling). Wavelengths have been converted to air wavelengths.

### Kurucz ODFNEW /NOVER models

ATLAS9 Kurucz ODFNEW /NOVER models. Newly computed ODFs with better opacities and better abundances have been used.

### BT-Settl-CIFIST

The BT-Settl Model grid of theoretical spectra. With a cloud model, valid across the entire parameter range and using the Caffau et al. (2011) solar abundances. Wavelengths have been converted to air wavelengths.

### BT-COND

The BT-COND Model grid of theoretical spectra. Brown dwarfs/extrasolar planets atmosphere models without irradiation but including dust opacity (no dust settling) but updated abundances. Wavelengths have been converted to air wavelengths.

### BT-NextGen (AGSS2009)

The NextGen Model grid of theoretical spectra; Gas phase only, valid for  $T_{\text{eff}} > 2700$  K. Updated opacities. Wavelengths have been converted to air wavelengths.

### Black Body

Black Body flux.  $T_{\text{eff}}$  from 10 to 200000 K.

### NextGen

The NextGen Model grid of theoretical spectra.

### Morley 2012

Morley et al. 2012 T/Y dwarf models

### Saumon 2012

Saumon et al. 2012 T dwarf models

### TMAP

TMAP. Hydrogen+Helium I/LTE Models

### GRAMS - C-rich grid

### AMES-Cond 2000

The AMES-Cond Model grid of theoretical spectra. Brown dwarfs/extrasolar planets atmosphere models without irradiation and no dust opacity (no dust settling). Wavelengths have been converted to air wavelengths.

### Husfeld et al models for non-LTE Helium-rich stars

Husfeld et al models for non-LTE Helium-rich stars

### BT-Settl

The BT-Settl Model grid of theoretical spectra; With a cloud model, valid across the entire parameter range. Wavelengths have been converted to air wavelengths.

### BT-DUSTY

The BT-DUSTY Model grid of theoretical spectra. Brown dwarfs/extrasolar planets atmosphere models without irradiation but including dust opacity (fully efficient dust settling) and updated abundances. Wavelengths have been converted to air wavelengths.

### BT-NextGen (GNS93)

The NextGen Model grid of theoretical spectra; Gas phase only, valid for  $T_{\text{eff}} > 2700$  K. Updated opacities. Wavelengths have been converted to air wavelengths.

### Koester

The Koester Model grid of theoretical spectra. Only for solar metallicity.

### DRIFT-PHOENIX

Drift-Phoenix is a computer code that simulates the structure of an atmosphere including the formation of clouds. The code is part of the Phoenix-code family. Drift describes the formation of mineral clouds and allows to predict cloud details, like the size of the cloud particles and their composition

### Morley 2014

Morley et al. 2014 Y dwarf and exoplanet models

### TMAP (Grid 1)

TMAP. Hydrogen+Helium I/LTE Models

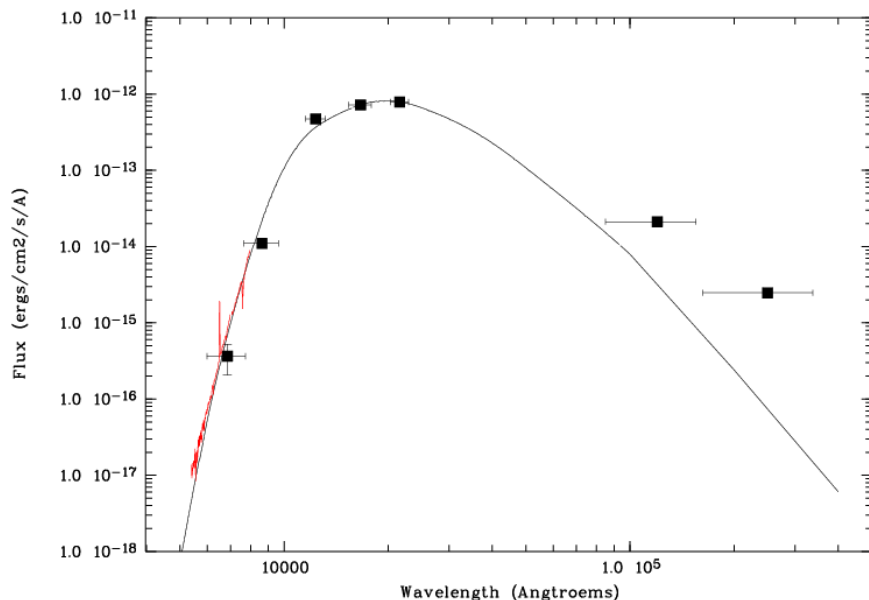
### TMAP - Tubingen

Tubingen I/LTE Model Atmosphere Package

### GRAMS - O-rich original grid

# Building SEDs: Difficulties

- Data Manipulation: From magnitudes to fluxes**



[I/337/gaia](#)

[Post annotation](#)

[Gaia DR1 \(Gaia Collaboration, 2016\)](#)

[GaiaSource data \(Download Gaia Sc](#)



start AladinLite

<a href="#">Full</a>	<a href="#">RA_ICRS</a> deg	<a href="#">DE_ICRS</a> deg	<a href="#">&lt;Gmag&gt;</a> mag
<a href="#">1</a>	063.4107528711	-89.9888879972	17.965
<a href="#">2</a>	037.5117084305	-89.9858176527	16.664
<a href="#">3</a>	084.7593492719	-89.9781776713	18.553
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<a href="#">5</a>	070.9024070024	-89.9715663343	19.829
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<a href="#">7</a>	073.1733654732	-89.9817426647	20.019
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<a href="#">9</a>	029.9573489468	-89.9759664621	18.649
<a href="#">10</a>	020.0044580076	-89.9836077196	19.202

GAIA DATA RELEASE DOCUMENTATION

[Gaia Data Release 1 Documentation release D.0](#)

[\[-\] Gaia Data Release 1 Documentation release D.0](#)  
[I Introduction to Gaia DR1](#)  
[II Gaia Data Processing](#)

[5.2 Properties of the input data](#)

**5.3 Calibration models**

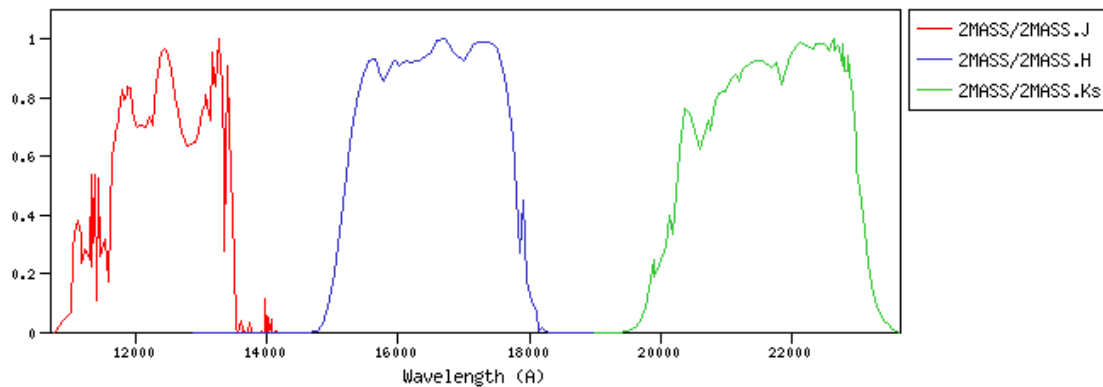
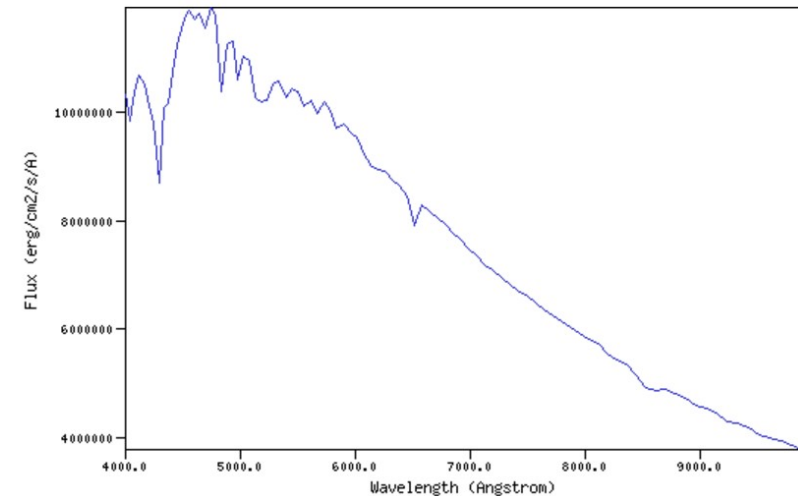
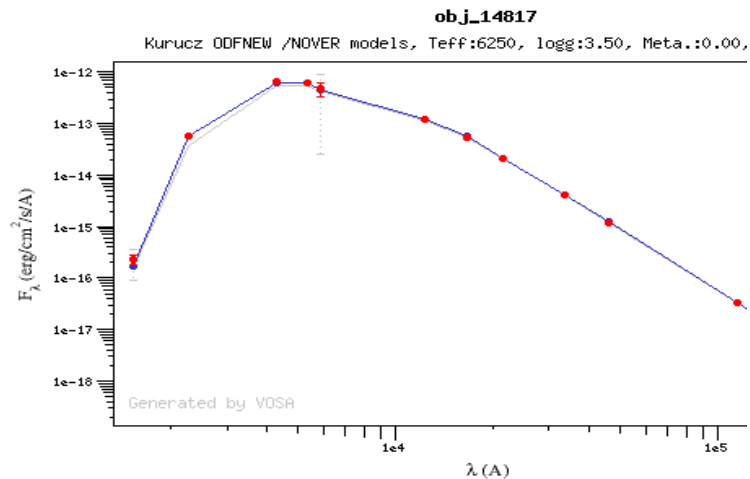
[5.4 Processing steps](#)

$$m_x = -2.5 \log_{10} \left( \frac{F_x}{F_{x,0}} \right)$$



# Building SEDs: Difficulties

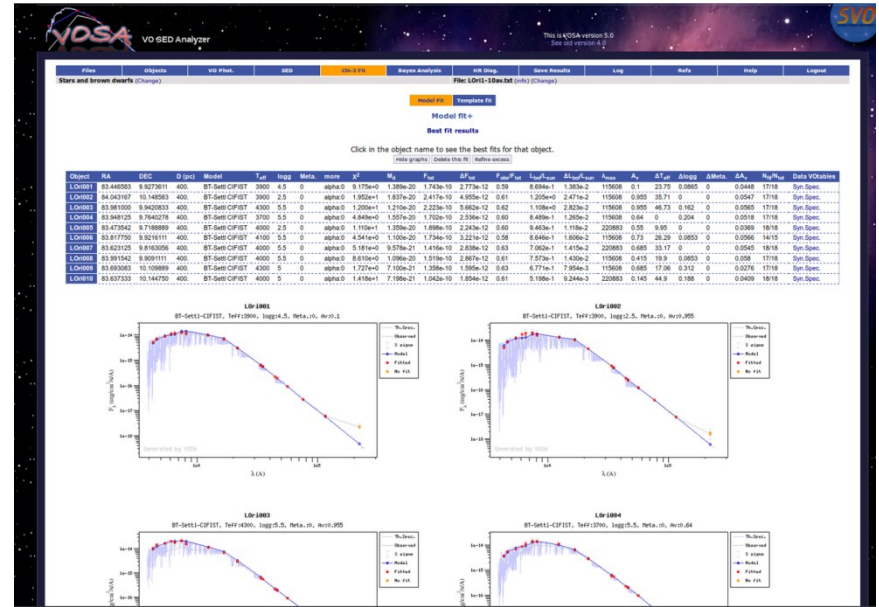
- **Data Manipulation: From theoretical spectra to synthetic photometry**



# VOSA to the rescue



<http://svo2.cab.inta-csic.es/theory/vosa/>



- Available since 2008.
- > 1500 users.
- > 4.700.000 objects.
- > 100 refereed papers.



## THE ASTRONOMICAL JOURNAL

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### Accurate Empirical Radii and Masses of Planets and Their Host Stars with *Gaia* Parallaxes

Keivan G. Stassun<sup>1,2</sup> , Karen A. Collins<sup>1,2</sup> , and B. Scott Gaudi<sup>3,4</sup>

Published 2017 March 2 • © 2017. The American Astronomical Society. All rights reserved.

[The Astronomical Journal](#), [Volume 153](#), [Number 3](#)

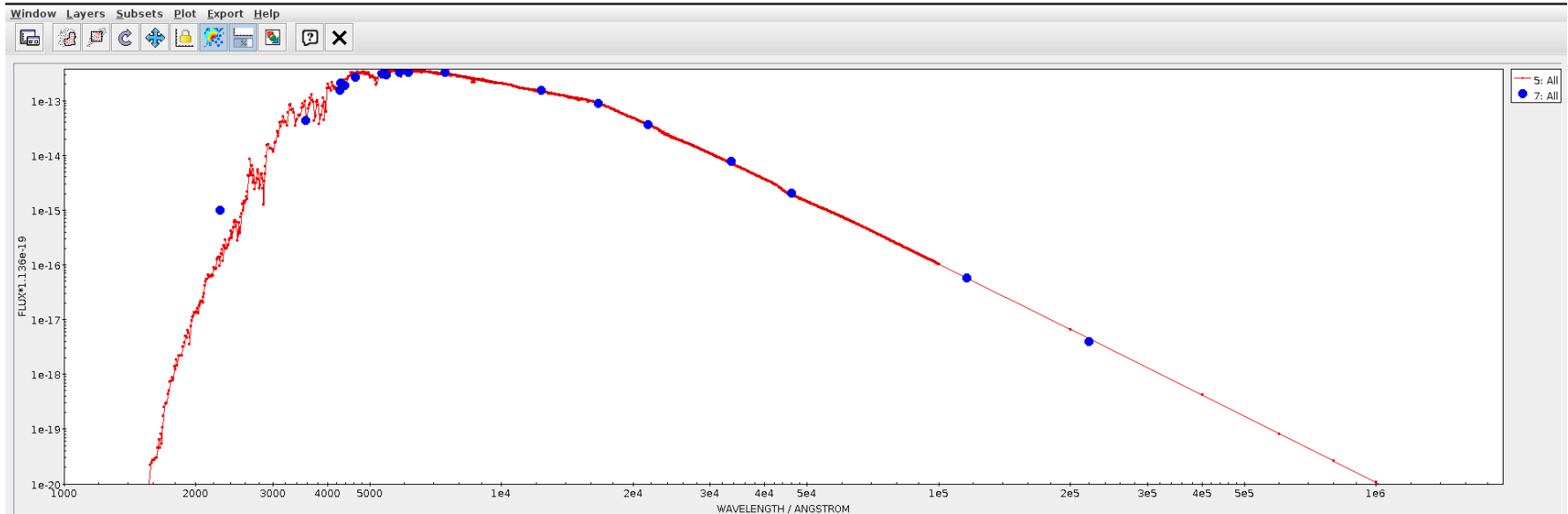
# Science case

- Masses and radii of planets are necessary to:
  - Shed light on inflated hot-Jupiters.
    - $0.2\text{-}2.1M_{\text{Jup}}$ . Radii larger than predicted by models.
    - Internal heating.
  - Planet radius as a function of irradiation, age, magnetic fields, winds,...

$$\Delta F = \left( \frac{R_{\text{planet}}}{R_{\text{star}}} \right)^2$$

$$M_p = \frac{K_{\text{RV}} \sqrt{1 - e^2}}{\sin i} \left( \frac{P}{2\pi G} \right)^{1/3} M_{\star}^{2/3}$$

# Science case



- Empirical determination (model independent) of the radii and masses of stars hosting planets.
- SED fitting  $\rightarrow F_{\text{bol}}$  and  $T_{\text{eff}}$
- $L = 4\pi D^2 F_{\text{bol}}$  (D from Gaia-DR2 parallaxes)
- $R = \sqrt{L / (4\pi\sigma T_{\text{eff}}^4)}$
- $g = G M / R^2$