Plotting

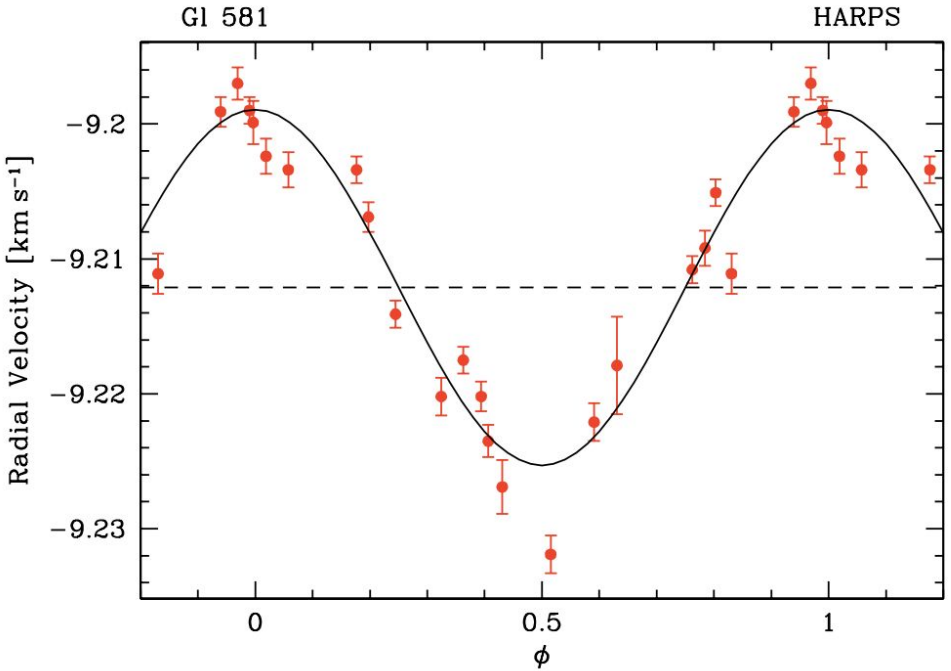
ASTR 2910 ⋆ Week 6

Why make plots?

A picture is worth a thousand words (or numbers)...

Table 2. Radial-velocity measurements and error bars for Gl 581. All values are relative to the solar system barycenter.

JD-2 400 000	*RV* [km s^{-1}]	Uncertainty [km s^{-1}]
53152.71289	−9.2235	0.0012
53158.66336	−9.2319	0.0014
53511.77355	−9.2202	0.0014
53520.74475	−9.1999	0.0016
53574.52223	−9.2024	0.0013
53575.48075	−9.2069	0.0011
53576.53646	−9.2202	0.0011
53577.59250	−9.2221	0.0014
53578.51061	−9.2108	0.0010
53578.62960	−9.2092	0.0013
53579.46256	−9.1991	0.0011
53579.62115	−9.1970	0.0012
53585.46167	−9.2034	0.0013
53586.46516	−9.2141	0.0010
53587.46481	−9.2269	0.0020
53588.53827	−9.2179	0.0036
53589.46202	−9.2051	0.0010
53590.46379	−9.1990	0.0010
53591.46638	−9.2034	0.0010
53592.46481	−9.2175	0.0010



Source: [Bonfils+2005]

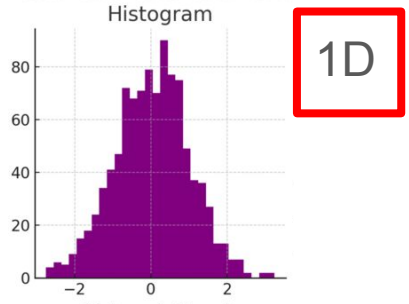
Why make plots?

In scientific research, plots serve two key purposes:

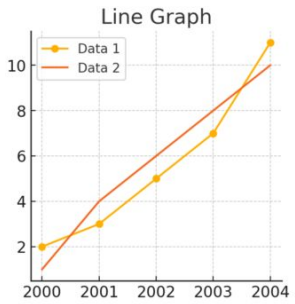
1. Data exploration
    a. Easier to identify trends and patterns
    b. Easier to spot outliers or anomalies
2. Communication
    a. Summarizing results clearly and concisely
    b. Making research outcomes more shareable ($$$ plots!)

Types of plots

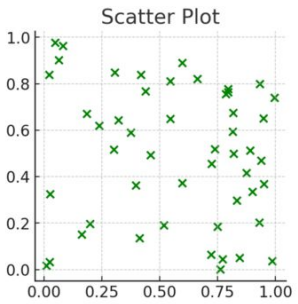
Four of the most common plot types in astronomy:



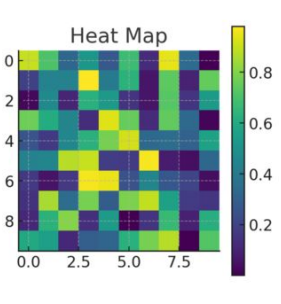
1D



2D



2+D



3D

How to choose which type of plot to use? Consider:

- Type of data: categorical or numerical?
  - In astronomy research, the answer is almost always “numerical”
- Dimensionality of data: 1D, 2D, 3+D?
  - For 2D plots: should the points to be connected (e.g. timeseries, spectra) or not?

What makes a good scientific plot?

Great plots are **simple**, **self-contained**, and **not misleading.**

How to achieve this:

1. Axes are clearly labeled, with appropriate tick marks and scaling
2. Legend explain different colors/markers (don’t rely on the caption!)
3. Error bars and uncertainties are included where applicable
4. Non-informative content is minimized (no distracting colors!)
5. Plot conveys just a few key pieces of information

A plot in the wild

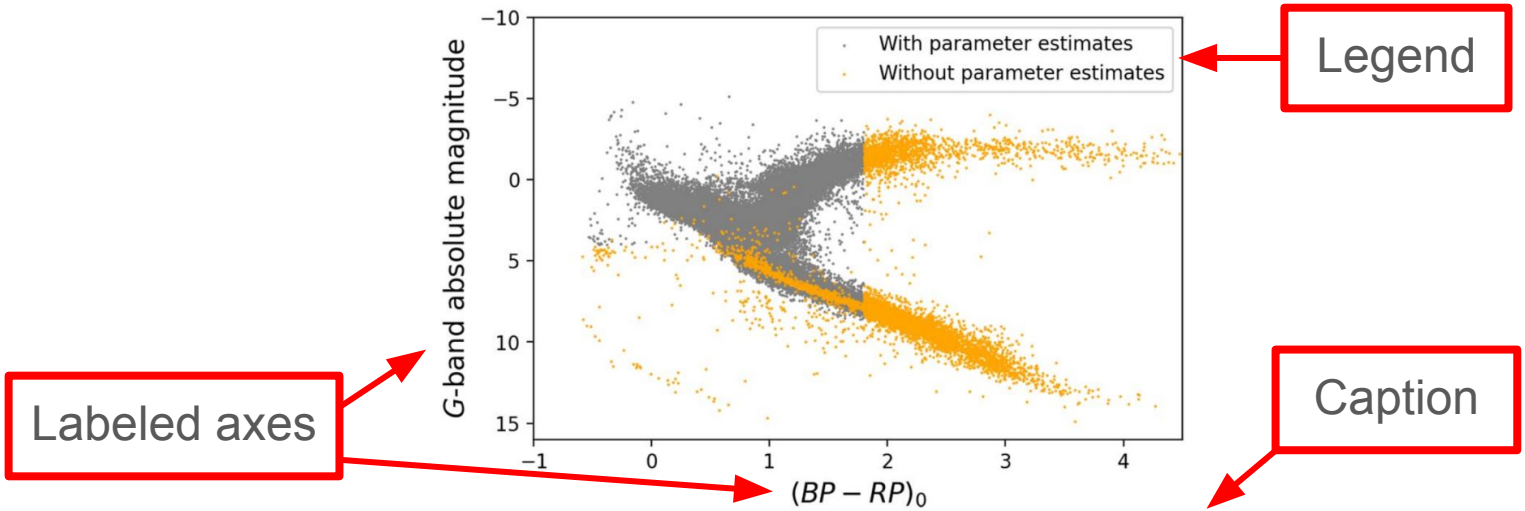


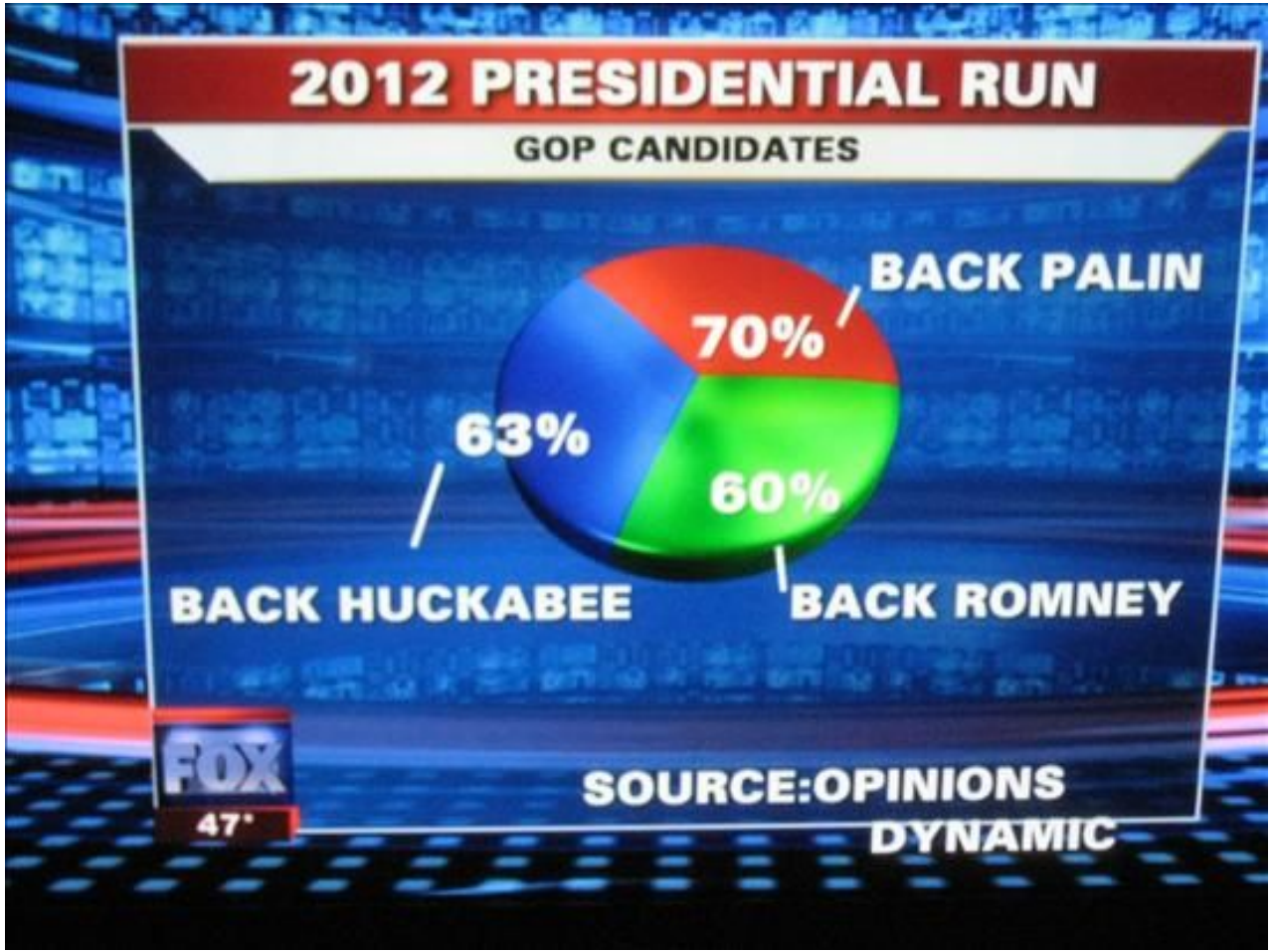
Figure 18. Distribution of KIC stars (orange circles) without reliable parameter estimates on the color–*G*-band absolute magnitude diagram. The background gray circles represent stars with well-determined atmospheric and physical parameters.

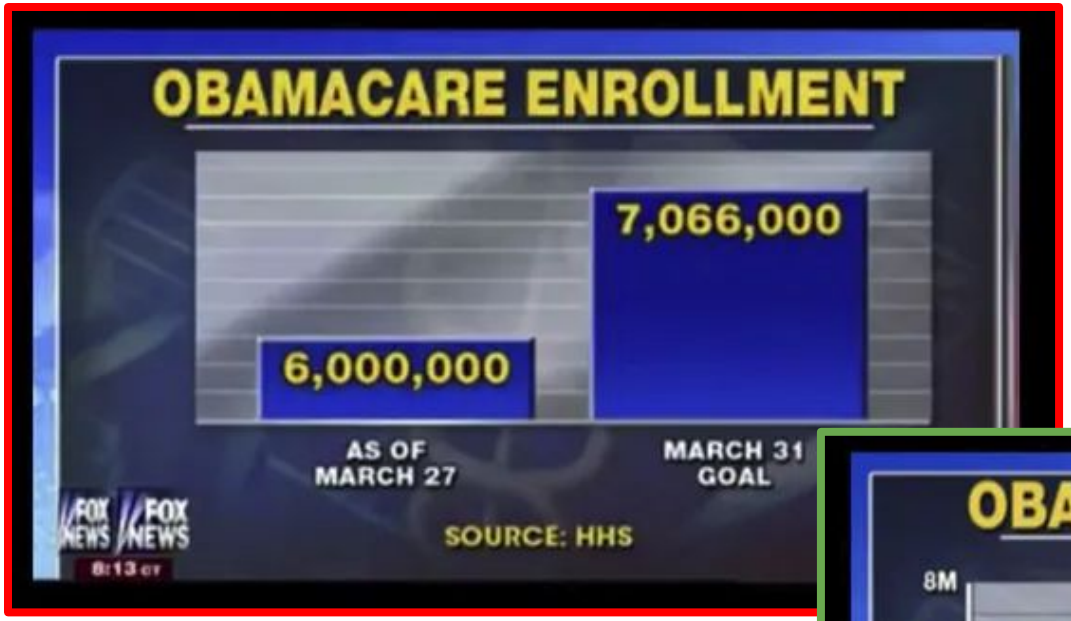
Plots in research papers usually don't have titles. Instead, they're accompanied by captions that explain what the plot shows and the result it supports.

Source: Zhang+2025

What makes a bad scientific plot?

1. Using the wrong type of plot
2. Too much information
3. Lack of context (missing axis labels, legends, or units)
4. Misleading visuals (common in the news…)


2012 PRESIDENTIAL RUN
GOP CANDIDATES
BACK PALIN
70%
63%
60%
BACK HUCKABEE
BACK ROMNEY
FOX
47'
SOURCE:OPINIONS
DYNAMIC


OBAMACARE ENROLLMENT
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newsroom


Books circulated this month
3600
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3000
y-axis
Library A
Library B
Library C


Books circulated in a month
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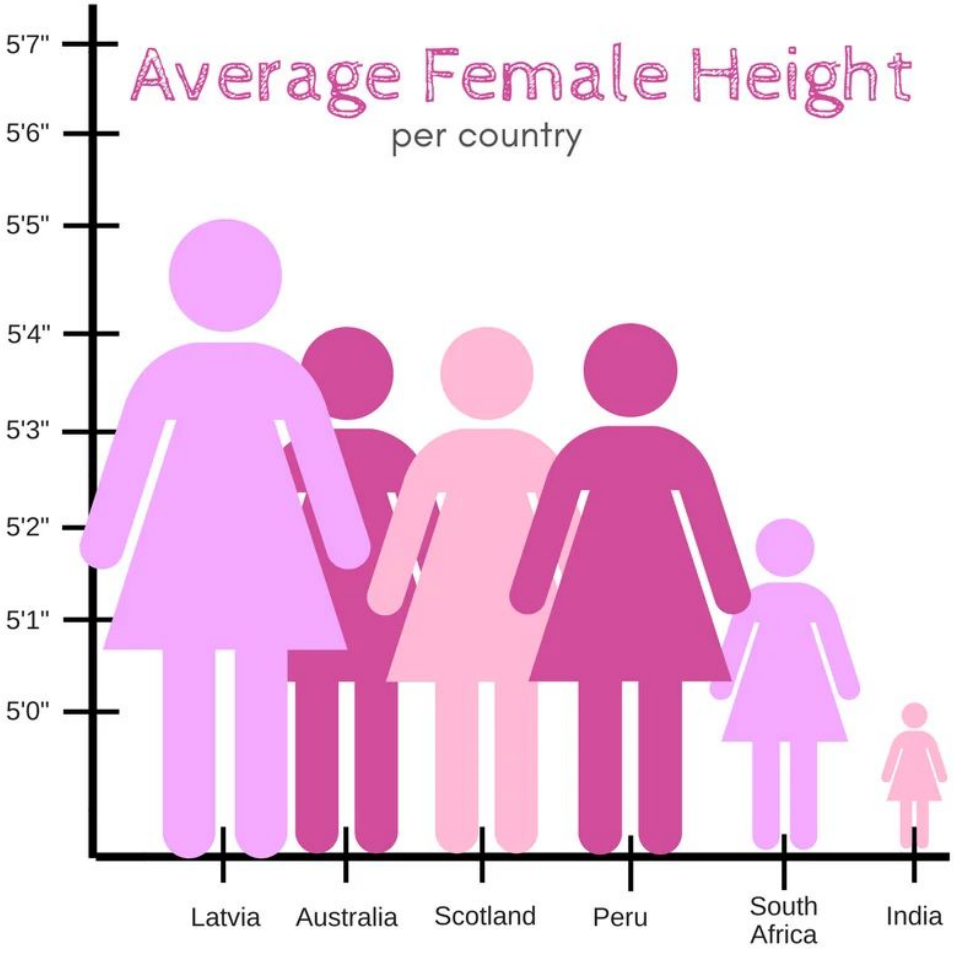
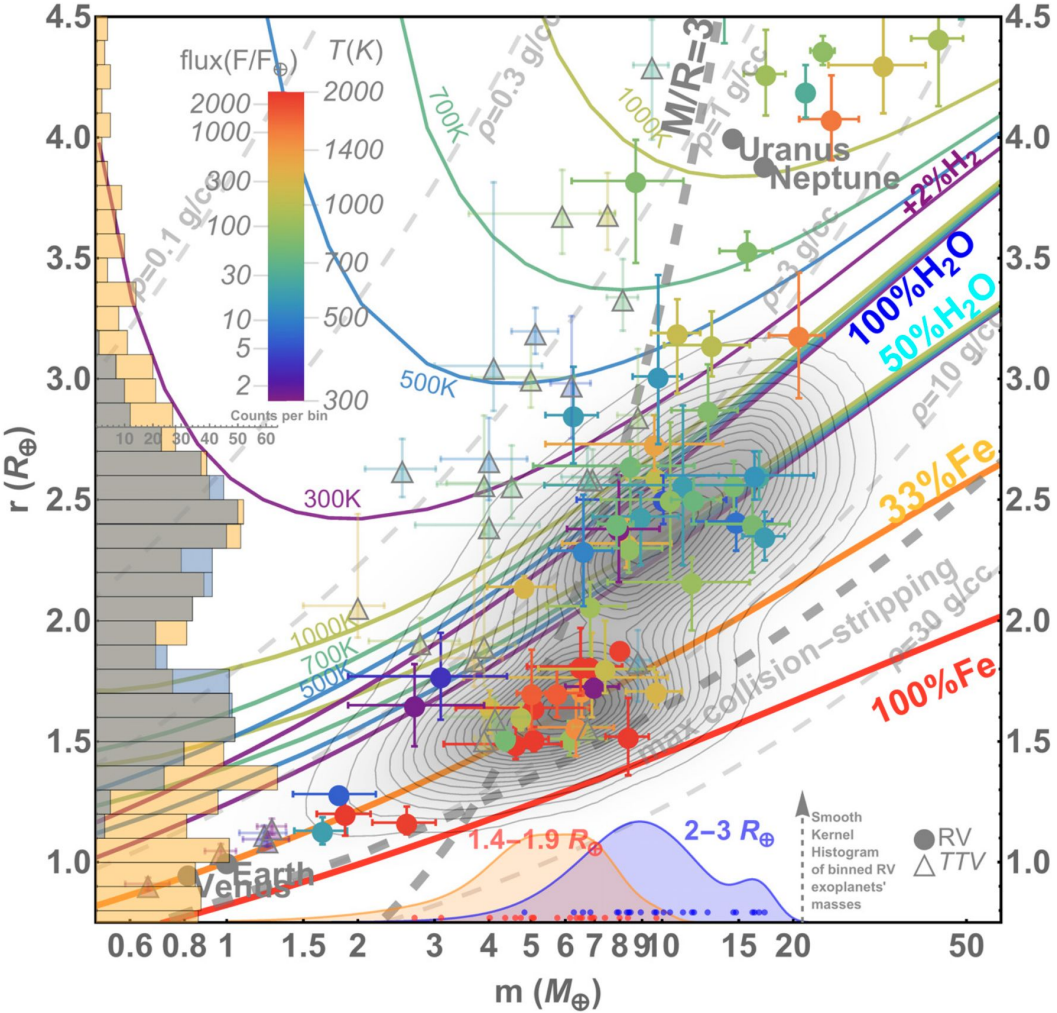
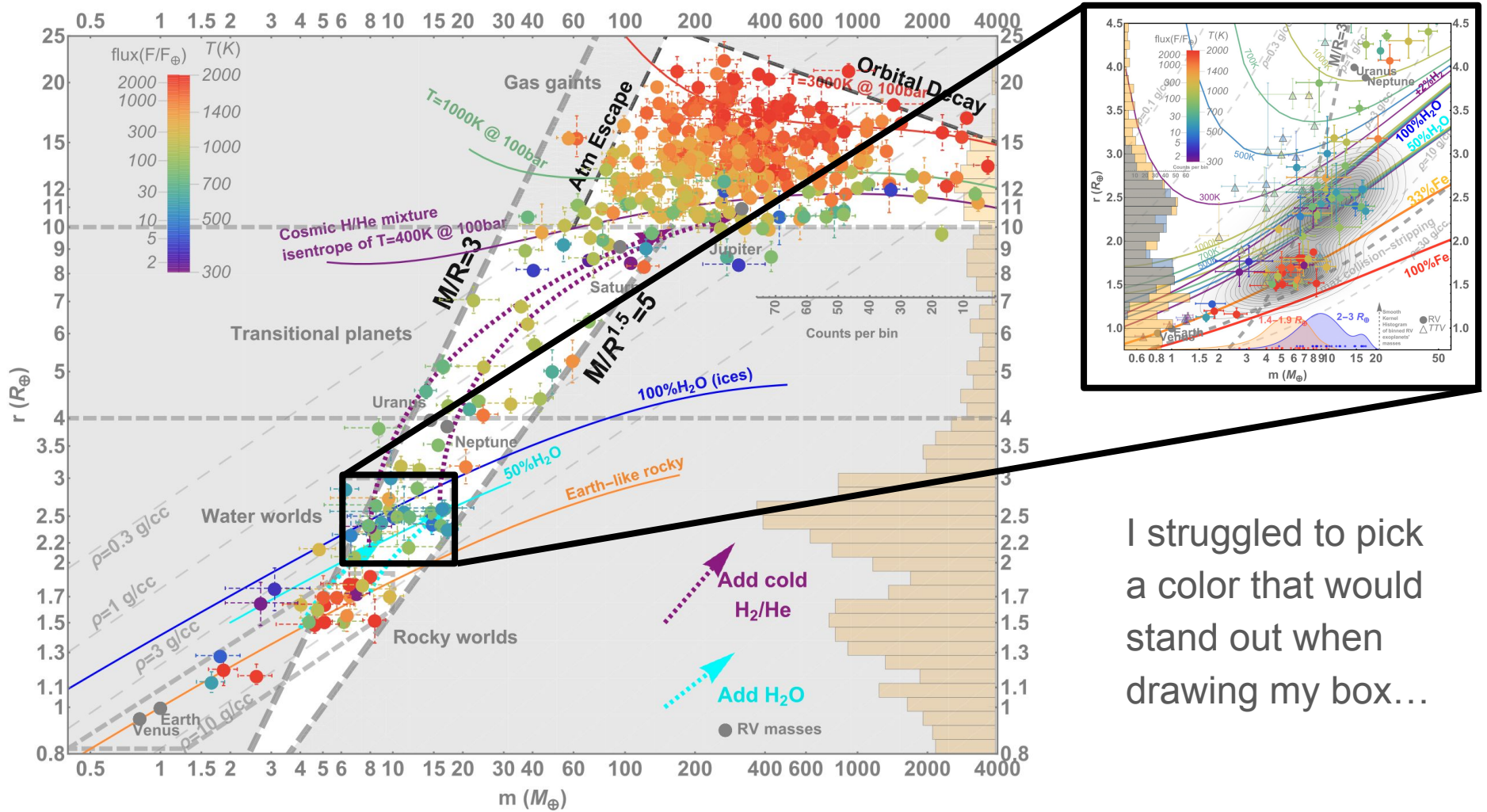

Average Female Height
per country
5'7"
5'6"
5'5"
5'4"
5'3"
5'2"
5'1"
5'0"
Latvia
Australia
Scotland
Peru
South Africa
India


r ($R_\oplus$)
m ($M_\oplus$)
flux(F/F$_\oplus$)
T(K)
Counts per bin
M/R=3
Uranus
Neptune
+2%H$_2$
100%H$_2$O
50%H$_2$O
33%Fe
100%Fe
300K
500K
700K
1000K
ρ=0.1 g/cc
ρ=0.3 g/cc
ρ=1 g/cc
ρ=3 g/cc
ρ=10 g/cc
ρ=30 g/cc
max collision−stripping
Earth
Venus
1.4–1.9 $R_\oplus$
2–3 $R_\oplus$
Smooth Kernel Histogram of binned RV exoplanets' masses
RV
TTV



I struggled to pick a color that would stand out when drawing my box…

Plotting with Python

Introduction to `matplotlib`

`matplotlib` is the most commonly used package for creating plots with Python.

It's well-documented and infinitely customizable, but not always intuitive to use… so you should make heavy use of Stack Overflow, ChatGPT, and similar tools when making plots.

Download the Jupyter Notebook `intro_to_plotting.ipynb` from Courseworks and let's get plotting!