Intro to ExoEarth Finder

Exoplanet characterization with realistically crummy observations

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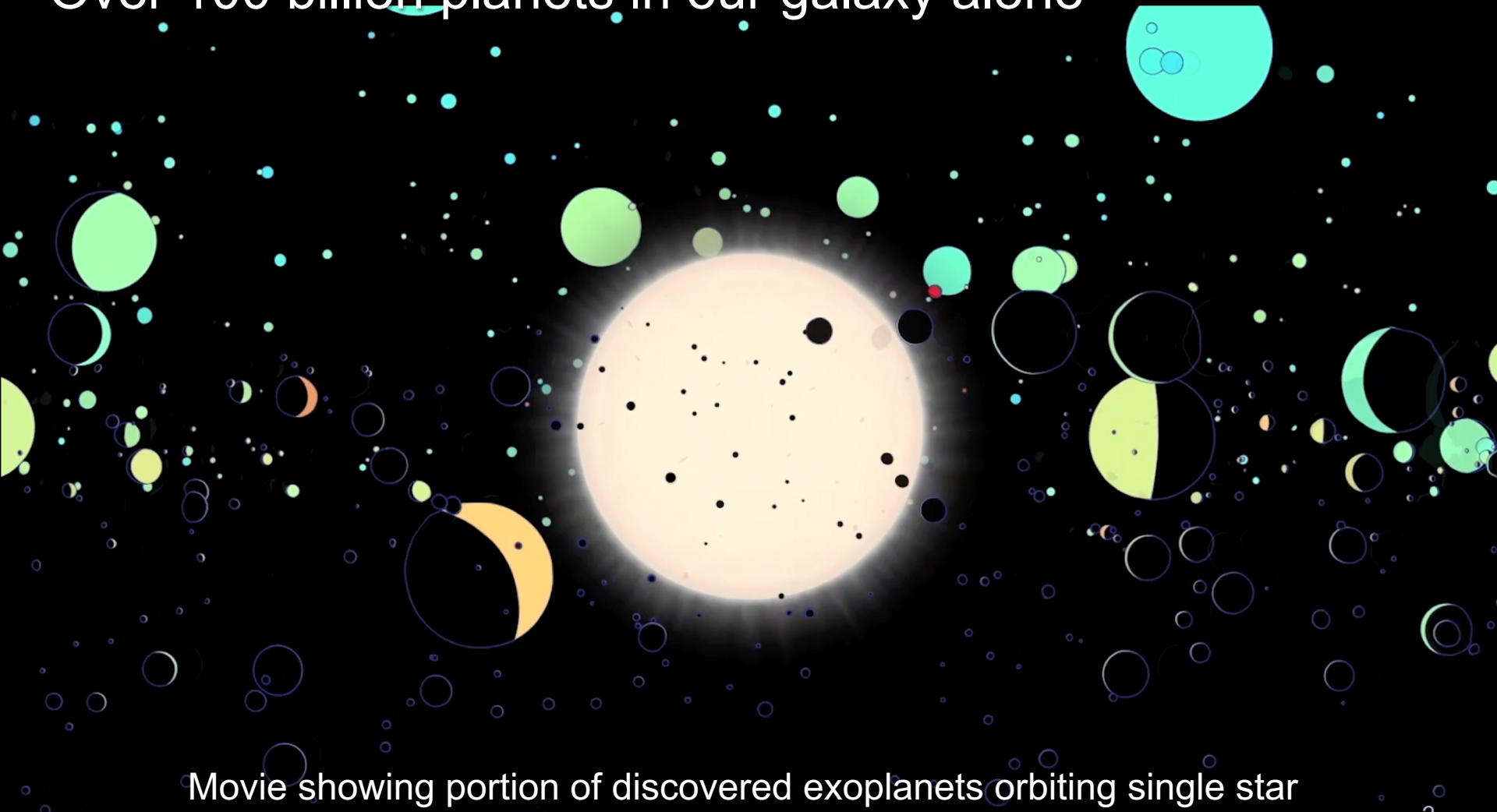
Exoplanets are everywhere

4016 confirmed exoplanets as of this morning

Over 100 billion planets in our galaxy alone

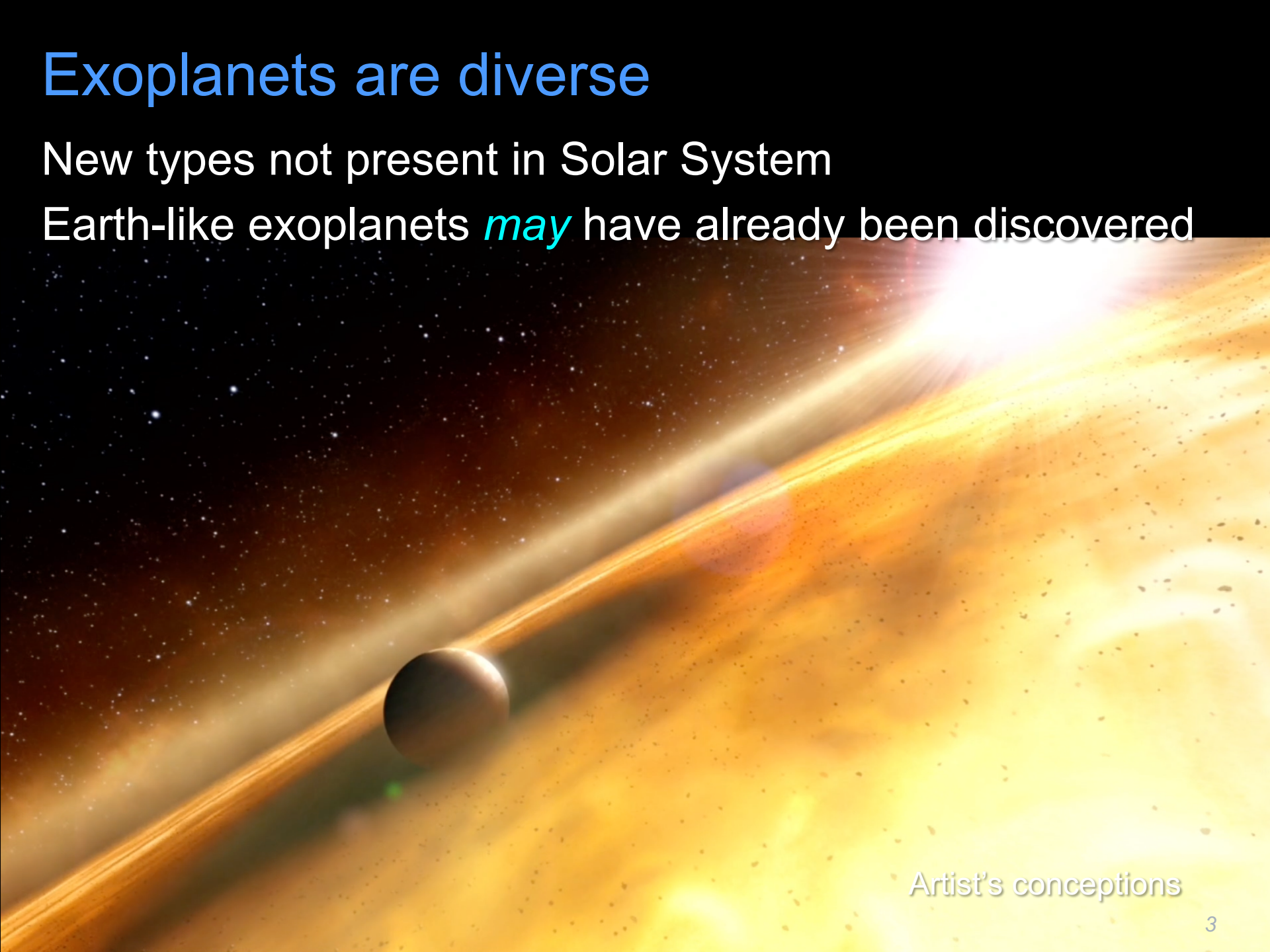


Movie showing portion of discovered exoplanets orbiting single star

Exoplanets are diverse

New types not present in Solar System

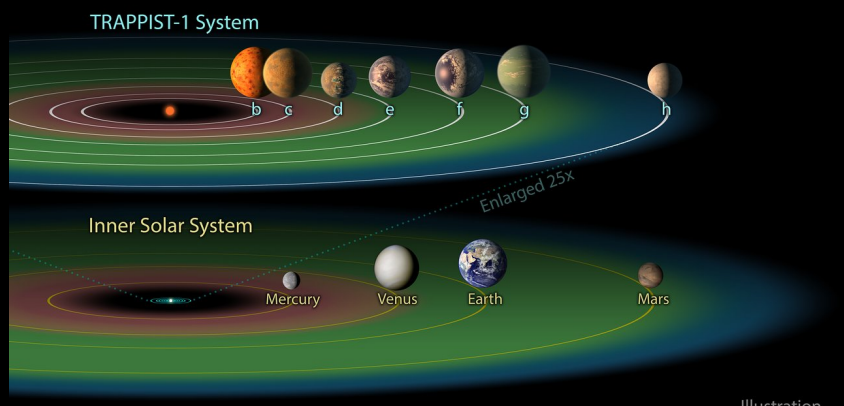
Earth-like exoplanets *may* have already been discovered



Artist's conceptions

Wealth of potential habitable environments

Opportunity to study habitability and life as functions of …



Planet orbit & rotation

Planet size

Type of host star

Planet age

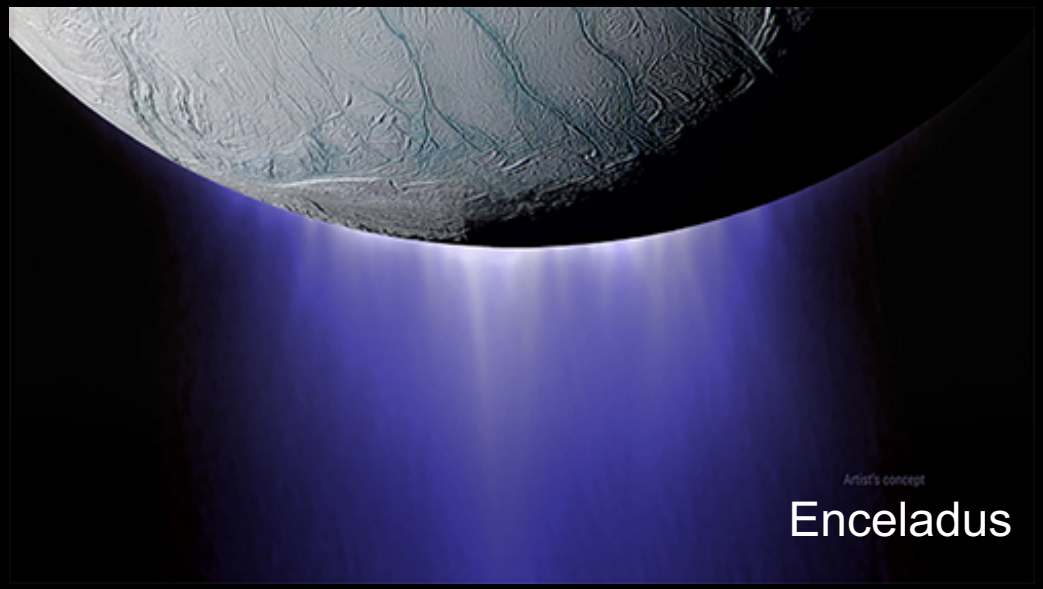
An astronomer’s image of a planet

An astronomer’s image of a planet

What kind of inhabited environment can you detect on an exoplanet?

Global biosphere

Robust atmosphere
strongly affected by life.



~~Subsurface ocean~~

No atmosphere to speak of.
No obvious surface signs of life.

What does “habitable” mean to astronomers?

Habitable : An environment capable of sustaining multiple generations of organisms

So … where do I point my telescope?

Need a prediction about what physical conditions sustain life

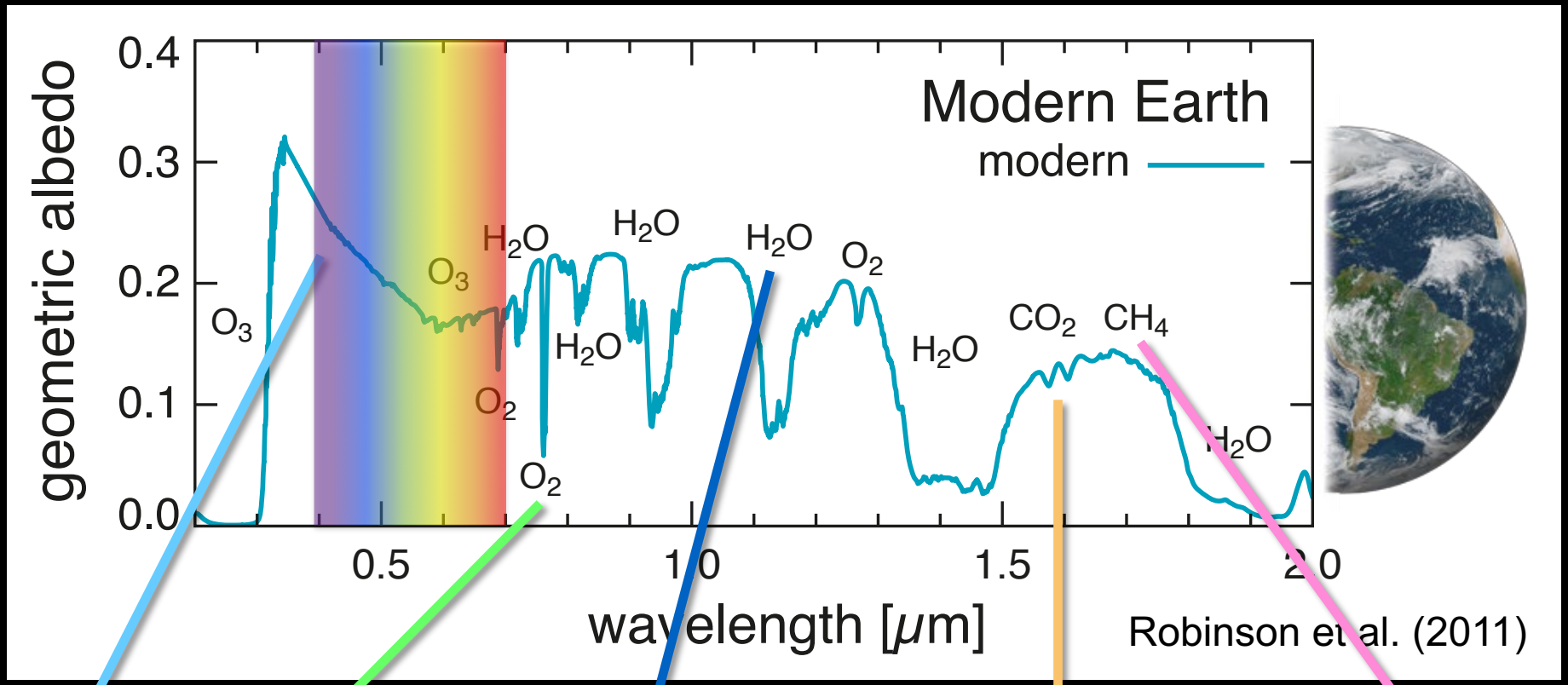
What does “habitable” mean to astronomers?

1. Search for life outside the Solar System = Search for global biospheres
2. Earth is fundamental model for global biosphere
3. All Earth life needs water. So …

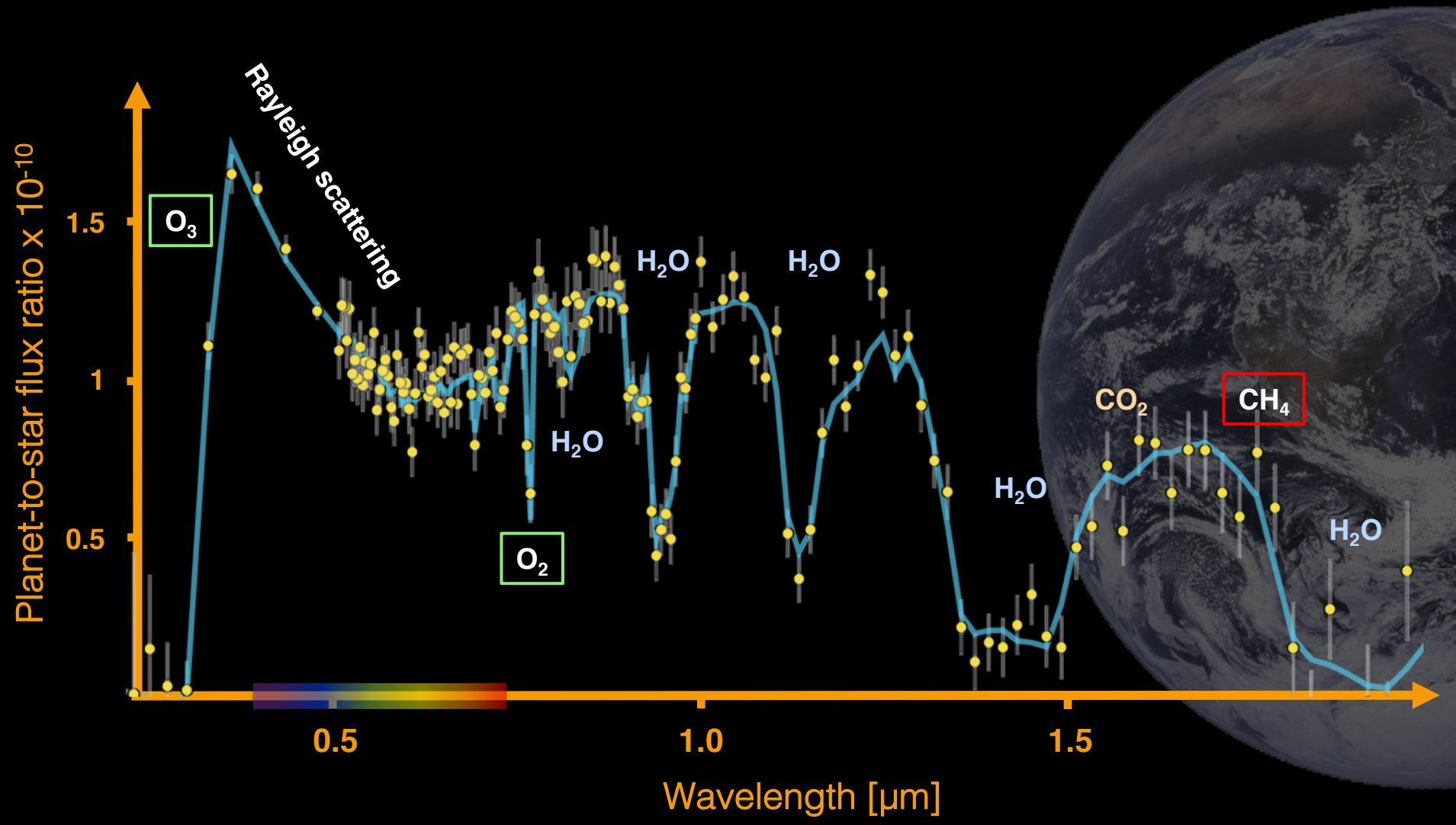
Habitable : Liquid water on planet surface

(which implies a rocky planet with an atmosphere)

Modern Earth as an exoplanet



Simulated modern Earth spectrum



Credit: G. Arney (NASA GSFC)

ExoEarth Finder activity

But there are lots of other kinds of exoplanets out there

How will you figure out what you're looking at from limited data?

This activity is about judgement, not complex analysis

Each group will get four "realistic" reflection spectra of different exoplanets – some habitable, some not

Jupyter notebook (1 / 2)

jupyter exoplanet_tool Last Checkpoint: 17 minutes ago (autosaved) Logout

File Edit View Insert Cell Kernel Widgets Help Trusted Python 2

Run Markdown

Load the packages

In [6]:
```
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
```

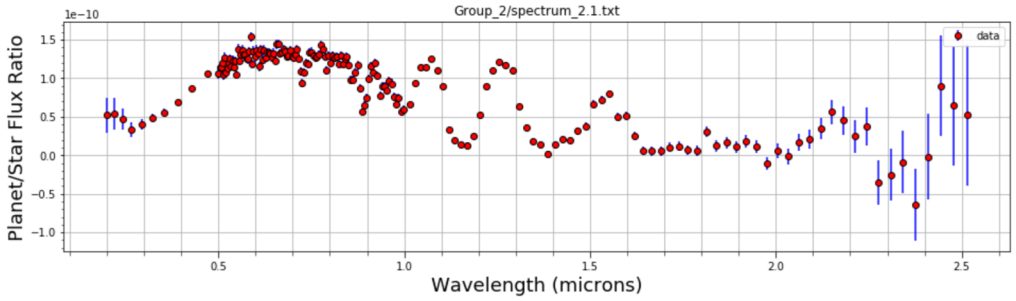
Load the data

In [34]:
```
datafile = 'Group_1/spectrum_1.1.txt'     # Change the group number and filename to loop through spectra 1 through 4
data_array = np.loadtxt(datafile)
wave = data_array[:,0]
flux = data_array[:,1]
error = data_array[:,2]
```

Plot the data

In [35]:
```
fs = 18 # set fontsize for plotting
plt.figure(figsize=(16,4))
plt.errorbar(wave, flux, yerr=error, fmt='ko', label='data', mfc='red', ecolor='blue')
plt.title(datafile)
plt.grid(axis='x',which='both')
plt.grid(axis='y',which='major')
plt.minorticks_on()
plt.tick_params('x', length=6, which='major')
plt.tick_params('x', length=4, which='minor')
plt.xlabel('Wavelength (microns)', fontsize=fs)
plt.ylabel('Planet/Star Flux Ratio', fontsize=fs)
plt.legend()
#plt.xlim([0.6,1.1])  # Zoom in by setting the x-axis and/or y-axis limits
#plt.ylim([0.0,2.0e-10])
```

Out[35]: <matplotlib.legend.Legend at 0x11392b610>



Jupyter notebook (2 / 2)

```
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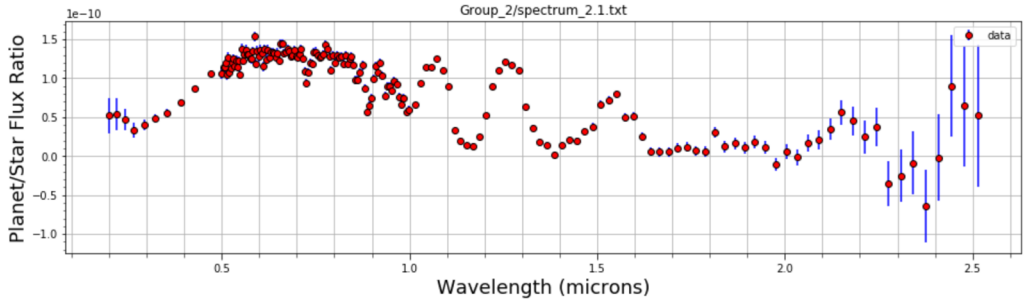

Other information about the star and planet

In [38]:
```
f = open(datafile)
meta = f.readlines()[3:5]
print(meta[0])
print(meta[1])
```

```
#  Star = Sun, Distance = 5.0 parsec

#  Planet semi-major axis = 1.0 AU, Phase angle = 90.0
```

Identify gaseous molecular absorption features

Try the Virtual Planet Lab Molecular Spectra Search Engine. Also, it can help to compare one planet to another to see what features they have in common.

http://vplapps.astro.washington.edu/vplrangemicro

What am I looking at?

Is the planet large or small?

What molecules are present in the atmosphere?

What kind of planet is this? Compare to the others.

Is this a habitable planet candidate?

Are there any potential biosignatures?

Flag for follow-up observations? Explain why.

Questions

What am I looking at?

Is the planet large or small?

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Need more challenge?

I've provided good quality data

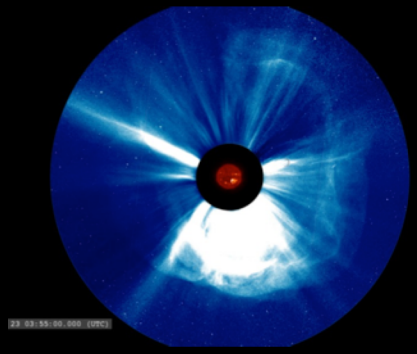
All spectra have R=150, SNR=20

If analyzing these is too easy, let me know

I can provide data with lower spectral resolution and SNR

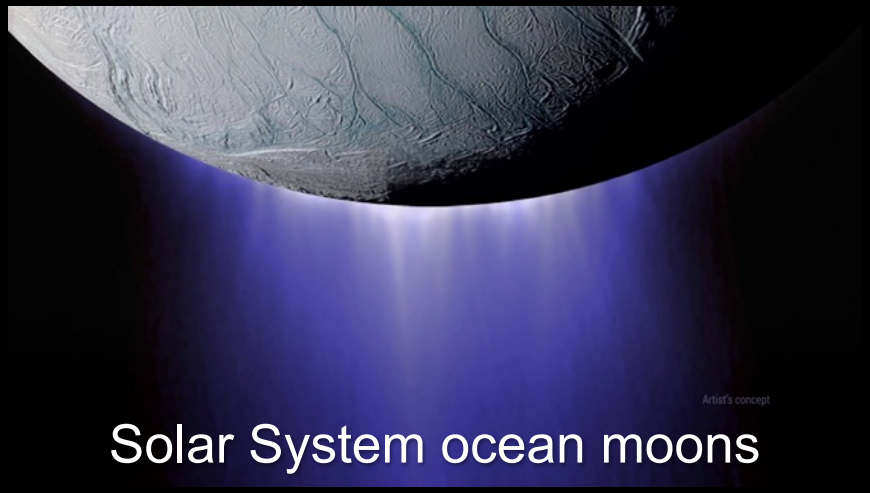
Will allow you to start exploring instrumental and data quality requirements for characterization

The search for life needs lots of voices



Space weather

Earth as template



Solar System ocean moons