

Exoplanet Mission Science Yield Modeling

Rhonda Morgan and Dmitry Savransky



Cornell University



June 12, 2016

What we'd like

are specific, verifiable predictions as to what will be discovered by a given exoplanet imaging system

What we can reasonably expect

are expectation values of a small number of science yield metrics with (hopefully) defensible errorbars

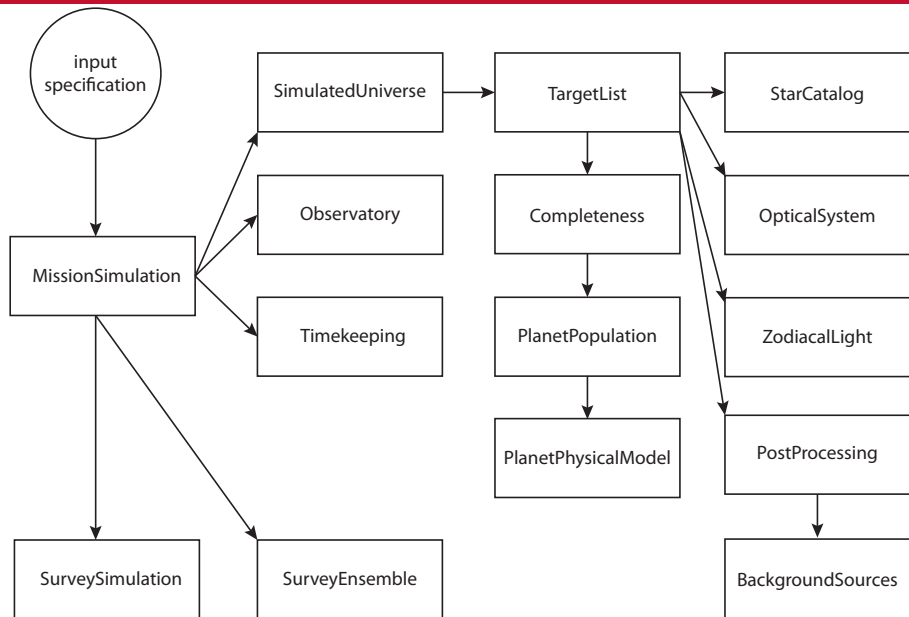
- We must be able to describe the **range** of potential science yields. This means either:
 - Placing absolute bounds on the values of metrics (incredibly hard)
 - Describing the distributions of the metrics (still pretty hard)
- In trying to describe the distributions of science yield metrics, you can either try to directly calculate the moments of the distributions, or take a Monte Carlo approach



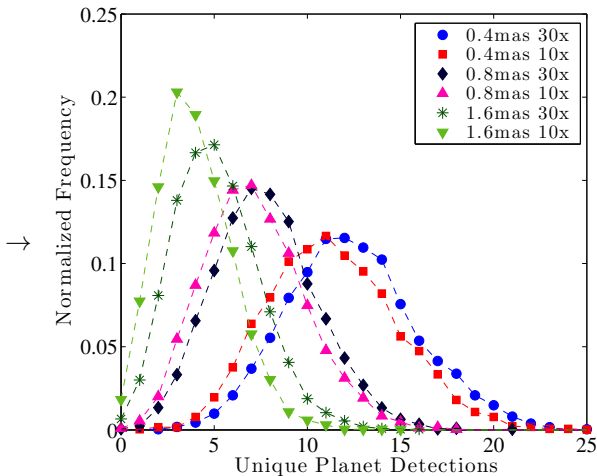
- There are a lot of semi-autonomous pieces that go into a science yield prediction
- It is difficult to predict *a priori* which assumption will be the one that limits the yield
- Different people care most about different things
- It is very difficult to build dynamic constraints into analytical modeling tools

A proposed solution

Create a software architecture where every model component can be independently upgraded/changed



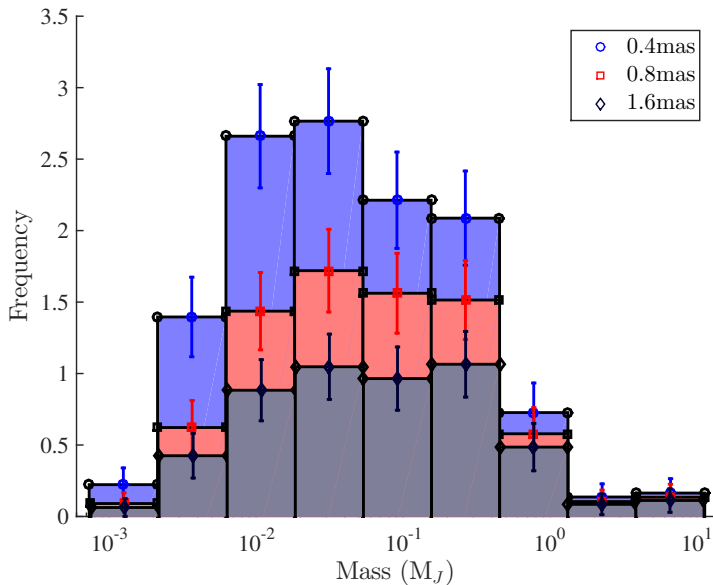
What it Does



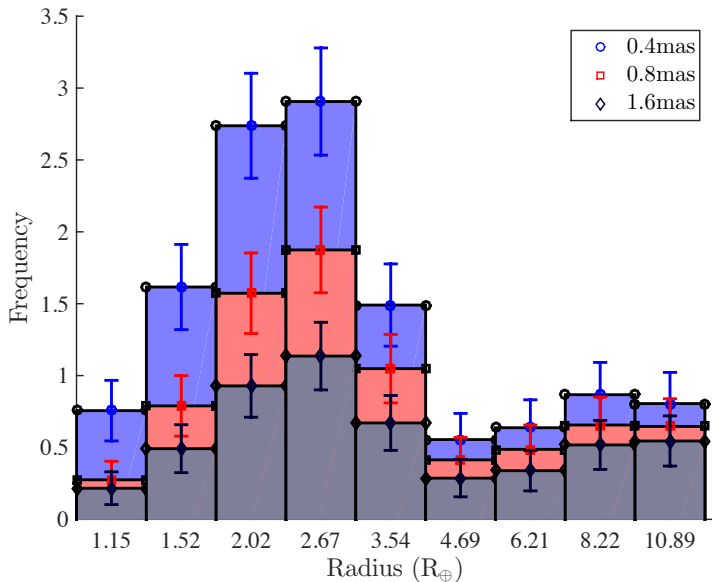
What it Does Not Do:

Prevent garbage in/garbage out

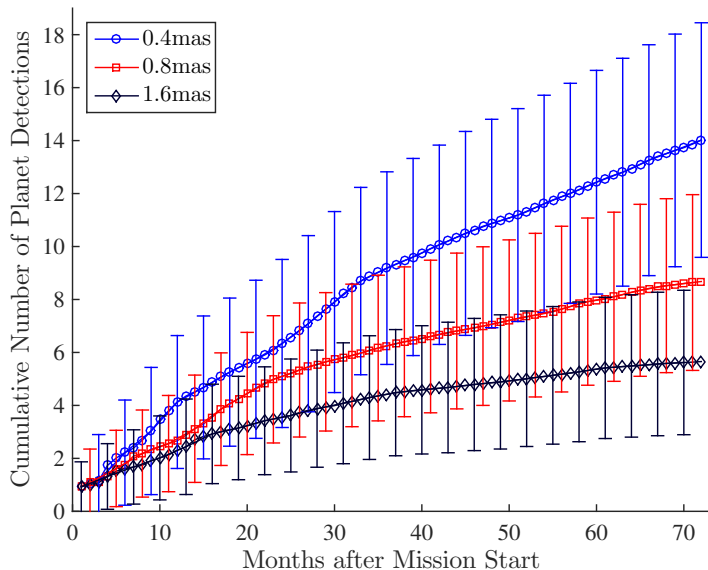
Additional Metrics are Trivial to Add



Additional Metrics are Trivial to Add



Additional Metrics are Trivial to Add



Motivating Example: Population vs. Planet Model



- Population describes distributions of parameters and occurrence rates
- Model describes derived quantities and mappings between parameters (albedo/phase, mass/radius, etc.)

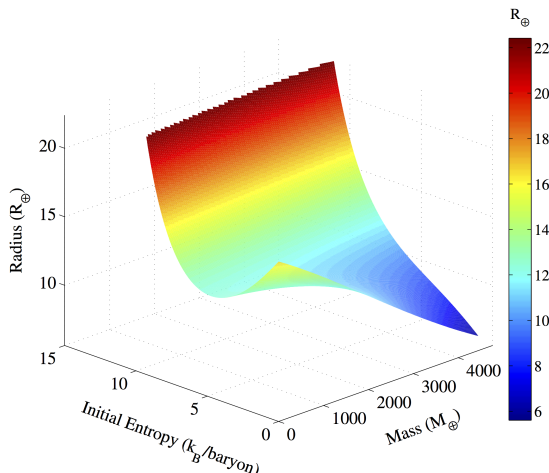


Figure: Mass-radius relationship from Spiegel and Burrows (2012).

Motivating Example: Population vs. Planet Model



- Population describes distributions of parameters and occurrence rates
- Model describes derived quantities and mappings between parameters (albedo/phase, mass/radius, etc.)

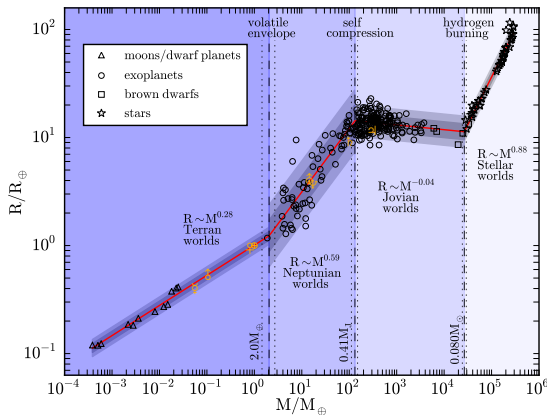


Figure: Mass-radius relationship from Chen and Kipping (2016).



- Mission Simulation Ensembles are a hugely powerful tool for answering practically any question about mission yields *if you can trust the code*
- Build confidence in simulations by releasing all code, having independent verification, and iterating on all simulation components with subject matter experts
- EXOSIMS is under active development and is continuously being updated
 - Please see <https://github.com/dsavransky/EXOSIMS> - in particular the ICD and as-built documentation
 - Comments and pull requests very welcome