Report of the ExoPlanet Task Force
Astronomy and Astrophysics Advisory Committee

Errata

The calculations described on pages 85-92 of Chapter 9 ("Depth of search comparisons") employed an incorrect mass-radius relation for iron-rock planets, due to the misapplication of the fitting formulas of Fortney et al. (2007) (specifically, $\log_e$ was used instead of $\log_{10}$). Fig. 1 shows the original and corrected mass-radius relations.

The most important effect of this error was to make the prospects for using JWST/NIRSpec to characterize the atmospheres of transiting planets appear more favorable than they are in reality. Furthermore, some of the assumptions made in the JWST/NIRSpec calculation may be regarded as overly optimistic. The selectively-absorbing portion of the planetary disk was taken to be an annulus with thickness $10H$, where $H = kT/\mu g$ is the pressure scale height. A thickness of $10H$ would require unusually high atomic or molecular absorption. Also, the calculations used $\mu = 18$ amu, the value for water vapor, but the pressure is likely to be dominated by heavier species. Both of these choices cause the signal to be larger than expected for an Earthlike planet.

In addition, due to an editing error, the last sentence of the last full paragraph on page 88 erroneously referred to "secondary eclipse events" instead of transit events. This editing error had no effect on the calculation, which was indeed performed for transits.

We have repeated the calculations using the corrected mass-radius relation and an annulus of thickness $5H$ with $H = kT/\mu g$ and $\mu = 28$ amu. Fig. 2 is the revised version of Fig. 9.3(b) from the original report, showing the depth of search for a hypothetical all-sky transit mission. Fig. 3(a) is the revised version of Fig. 9.3(c), showing the subset of the systems from the all-sky survey that are characterizable with JWST/NIRSpec. The sharp boundary at 10 $M_\oplus$ reflects the threshold in our calculation between iron-rock planets and gas giants. Transmission spectroscopy of iron-rock planets with NIRSpec using our criteria ($R = 100$ at 2μm, SNR > 10 per resolution element after observing 10 transits) will be extremely challenging or impossible.[1]

The results are very sensitive to the values of the planetary radius and its atmospheric scale height. Fig. 3(b) shows the results for ice-rock planets (or "water worlds") in which the ice-mass fraction is 90%, using the mass-radius relation from Fortney et al. (2007). Many more such planets are characterizable, including some planets in the habitable zone.

The results also depend sensitively on the criteria for characterizability. As another example, we consider NIRCam photometry using a filter centered at 2 μm with bandwidth 0.5 μm. We assume that 1 e^-/s is recorded at AB 28.0 mag (based on the aperture of 25 m^2 and an overall throughput of 50%) and that the noise is dominated by photon noise from the star. We require SNR > 5 for observation of a single transit. (In practice, the atmospheric absorption feature probably will not fill the entire band, and multiple transit observations would be needed.) As above, the selectively-absorbing annulus has a width $5H$ with $H = kT/\mu g$ and $\mu = 28$ amu. The results are shown in Figs. 3(c) and 3(d), for iron-rock and ice-rock planets, respectively. Unsurprisingly,

[1] It should be noted that even the choice of $5H$ may be considered optimistic. On Earth, almost all the water is in the troposphere, which extends to a height of about 17 km or approximately $2H$.

the prospects are better with this more forgiving definition of characterizability.

In light of these revisions, the prospects for JWST to characterize the atmospheres of transiting planets are more limited in both the range of planetary types and the range of observing modes. Nevertheless, the ExoPTF remains convinced that the M-dwarf track is a fruitful and worthwhile parallel track to the more expensive and prolonged G-dwarf track, by providing near-term opportunities for revealing studies of planetary properties through radial-velocity surveys, transit surveys, and observations with Spitzer and JWST.

The error in the mass-radius relationship also affected the depth-of-search calculations regarding the detectability of planets with coronagraphs (pages 89-92), although the effect was comparatively minor. Fig. 4 shows the corrected versions of the depth-of-search figures for 2.5m and 4.0m space coronagraphs, and for a 30m ground-based telescope with adaptive optics.

We thank Tom Greene for bringing these issues to our attention. We also note that since the publication of our report, two other groups[2] have undertaken more detailed calculations regarding the characterization of transiting planets with JWST.

[2]Kaltenegger & Traub 2009, ApJ, in press [arxiv:0903.3371]; Deming et al. 2009, PASP, submitted [arxiv:0903.4880]

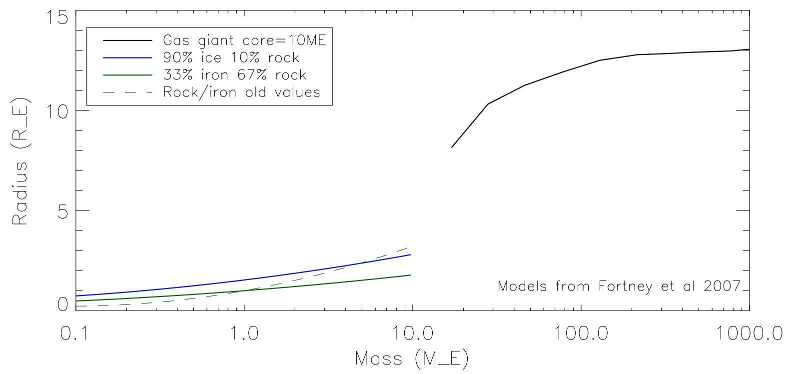


Figure 1: The original (dashed line) and corrected (solid green line) theoretical mass-radius relations for iron-rock planets. Also shown is the relation for ice-rock planets (solid blue line) and gas giants (black line).

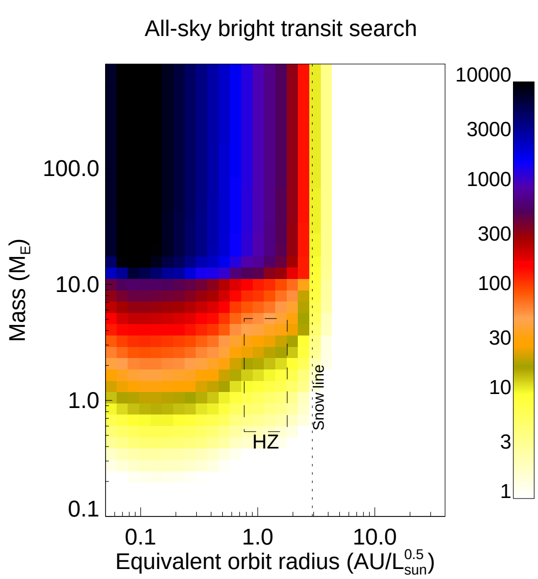
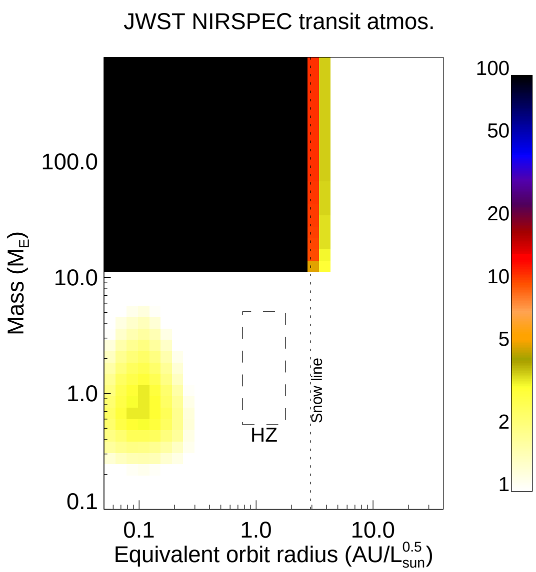
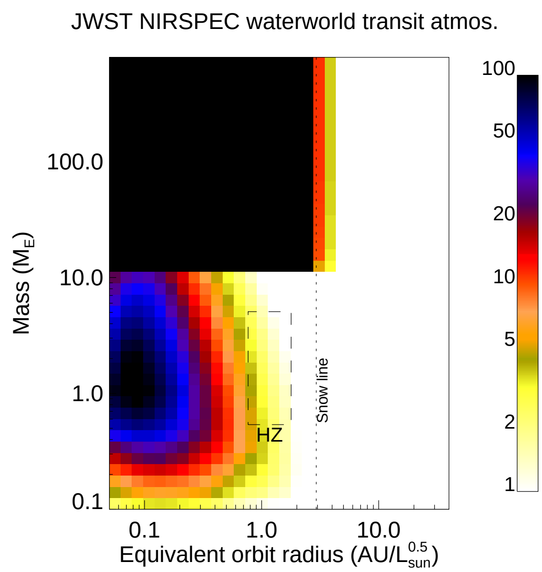


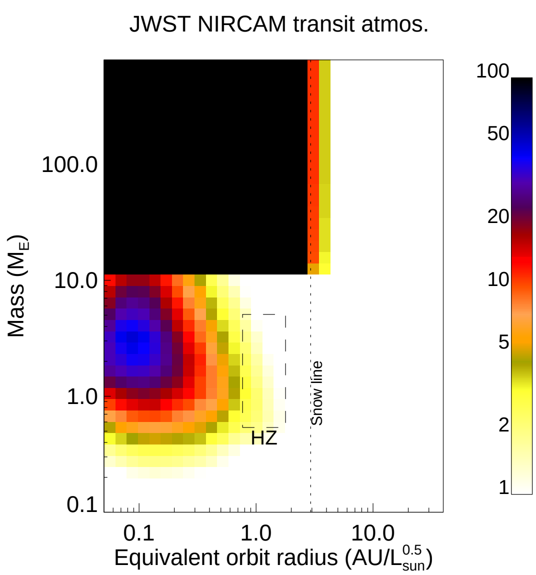
Figure 2: Revised Fig. 9.3(b) of the ExoPTF Final Report, showing the depth-of-search of a hypothetical all-sky transit survey.



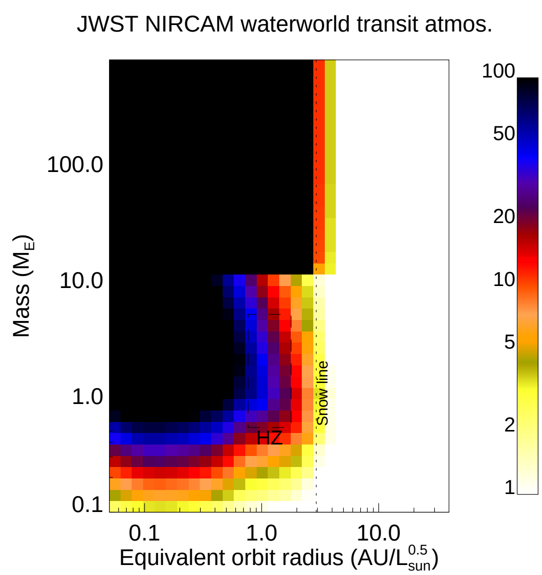
(a)



(b)

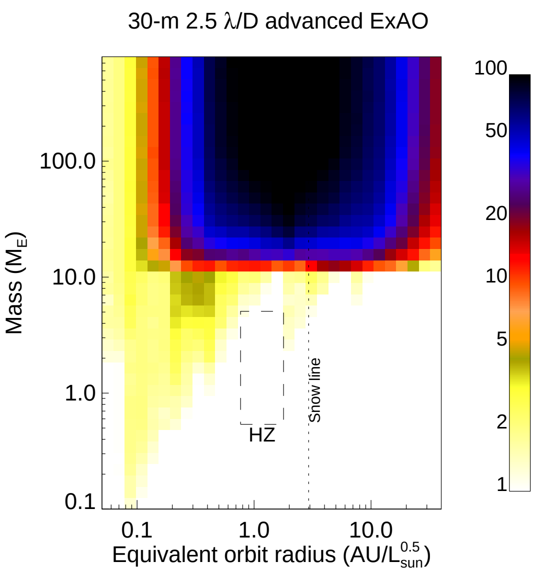


(c)

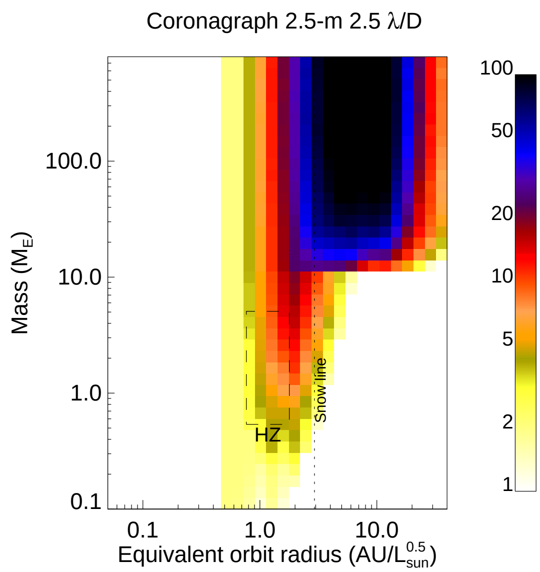


(d)

Figure 3: (a) Revised Fig. 9.3(c) of the ExoPTF Final Report. Plotted is the number of targets from a hypothetical all-sky transit survey that are characterizable by transmission spectroscopy with JWST/NIRspec, according to the criterion given on the previous page. (b) Same, but with the mass-radius relation for low-mass planets changed from iron-rock (33% iron) to ice-rock (90% ice). (c) and (d): Same as (a) and (b), but for JWST/NIRcam filter photometry using criteria described on the previous page.



(a)



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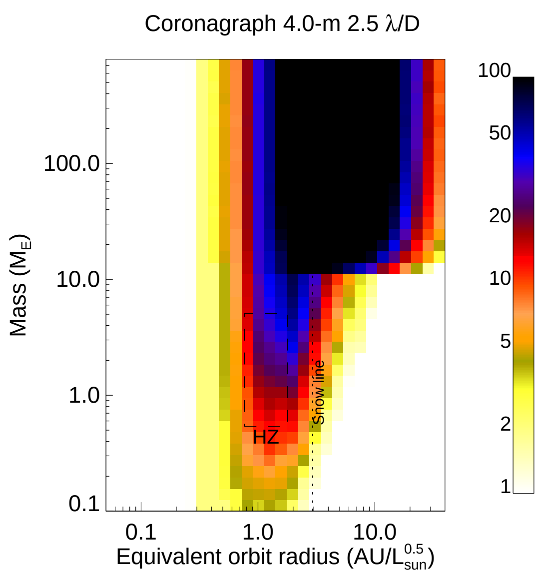

(c)

Figure 4: (a) Revised Fig. 9.4(b) of the ExoPTF Final Report, showing the sensitivity of a 30-m ground based telescope equipped with advanced adaptive optics and a $2.5\lambda/D$ coronagraph. (b) Revised Fig. 9.4(c) of the ExoPTF Final Report, showing the depth-of-search of a space coronagraph mission with a 2.5-m primary mirror and an inner working angle of $2.5\lambda/D$. (c) Revised Fig. 9.4(d) of the ExoPTF Final Report, showing the depth-of-search of a space coronagraph mission with a 4.0-m primary mirror and an inner working angle of $2.5\lambda/D$.