

Supplemental information for:

Fungal diversity differences in the indoor dust microbiome from built environments on Earth and in Space

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Table S1: Adonis values for fungal beta diversity based on Bray-Curtis Dissimilarity between Earth-based residential house dust and dust collected from the International Space Station.

Variable	R ²	P-value
Original Dust Samples only		
Location (Earth vs. ISS)	0.232	0.001
Fungal Time-of-Wetness Samples (All)		
Location (Earth vs. ISS)	0.347	0.001
Time of Wetness	0.015	0.003
Day	0.011	0.007
85% RH only		
Location (Earth vs. ISS)	0.121	0.001
Time of Wetness	0.159	0.001
Day	0.007	0.793
100% RH only		
Location (Earth vs. ISS)	0.145	0.001
Time of Wetness	0.090	0.002
Day	0.025	0.086
6-hour TOW only		
Location (Earth vs. ISS)	0.398	0.001
Relative Humidity	0.013	0.438
Day	0.017	0.255
12-hour TOW only		
Location (Earth vs. ISS)	0.374	0.001
Relative Humidity	0.027	0.066
Day	0.008	0.816
18-hour TOW only		
Location (Earth vs. ISS)	0.175	0.001
Relative Humidity	0.185	0.001
Day	0.009	0.838
24-hour TOW only		
Location (Earth vs. ISS)	0.104	0.001
Relative Humidity	0.201	0.001
Day	0.008	0.786

Table S2: Fungal and bacterial alpha diversity comparisons between Earth-based and ISS dust for all conditions compared in this study.

Alpha Diversity Metrics			
Fungi			
Condition	Location	Mean OTU	Mean Shannon Index
Original Dust	Earth	465.2	5.11
	ISS	102.33	2.6
85% ERH 6-hours	Earth	516.91	5.59
	ISS	124.08	3.4
85% ERH 12-hours	Earth	416.2	5.13
	ISS	104.58	3.04
85% ERH 18-hours	Earth	517	5.28
	ISS	100.18	2.85
85% ERH 24-hours	Earth	397.6	4.97
	ISS	49	1.62
100% ERH 6-hours	Earth	374.11	5.25
	ISS	90.83	2.66
100% ERH 12-hours	Earth	403.27	5.04
	ISS	53.42	1.81
100% ERH 18-hours	Earth	405.58	4.61
	ISS	37.33	1.55
100% ERH 24-hours	Earth	240.5	3.67
	ISS	41.25	1.33
Bacteria			
Original Dust	Earth	236.5	6.72
	ISS	101.5	4.73
50, 85, 100% Day 14 24-hours	Earth	103.88	6.05
	ISS	52.56	5.04

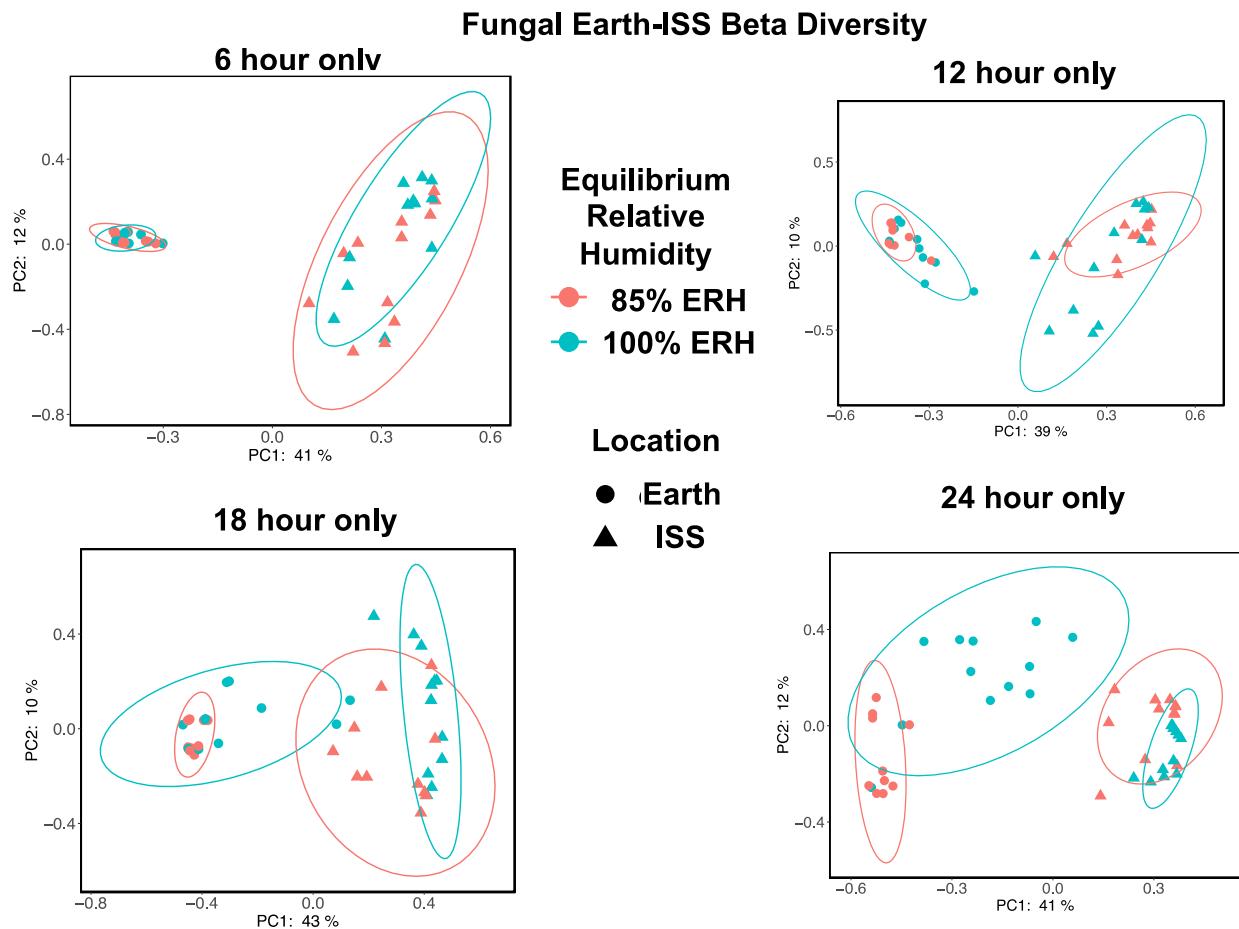


Figure S1: Fungal beta Bray Curtis dissimilarity principal coordinate analyses plots for time of wetness (TOW) samples separated out by each TOW value. For each plot, location of dust samples was indicated by shape (Earth – circle, ISS – triangle) while relative humidity conditions were indicated by color (85% - red, 100% blue). Ellipses represent 95% confidence interval for each set of data.

Table S3: Differential abundance comparison of fungal species between Earth-based house dust and ISS dust in original dust samples. A total of 791 fungal species were identified where 24 were significantly more abundant in ISS samples and 199 were more abundant in Earth-based house dust.

Differential Abundance Analysis Original Dust Samples (Earth-based vs ISS Dust)

Fungal Species	Unadjusted P-value	Adjusted FDR P-value
More abundant on International Space Station		
<i>Aspergillus sydowii</i>	<.0001	<.0001
<i>Aspergillus unguis</i>	<.0001	<.0001
<i>Malassezia restricta</i>	<.0001	<.0001

<i>Malassezia globosa</i>	<.0001	<.0001
<i>Candida albicans</i>	<.0001	<.0001
<i>Rhodotorula mucilaginosa</i>	<.0001	0.0011
<i>Penicillium paczoskii</i>	<.0001	0.0002
<i>Cyberlindnera jadinii</i>	<.0001	0.0006
<i>Aspergillus ruber</i>	<.0001	0.0011
<i>Aspergillus flavus</i>	<.0001	0.0023
<i>Malassezia sympodialis</i>	<.0001	0.0024
<i>Aspergillus nidulans</i>	<.0001	0.0027
<i>Rhodosporidiobolus fluvialis</i>	0.0002	0.0053
<i>Aspergillus tamarii</i>	0.0003	0.0061
<i>Penicillium gladioli</i>	0.0004	0.0076
<i>Aspergillus falconensis</i>	0.0008	0.0131
<i>Penicillium concentricum</i>	0.0019	0.0239
<i>Fusarium acutatum</i>	0.0027	0.026
<i>Penicillium chrysogenum</i>	0.0036	0.03
<i>Candida tropicalis</i>	0.0036	0.03
<i>Malassezia arunalokei</i>	0.0035	0.03
<i>Malassezia dermatis</i>	0.0041	0.0324
<i>Papiliotrema laurentii</i>	0.0054	0.0366
<i>Aspergillus fischeri</i>	0.0055	0.0366

More abundant in Earth-based House Dust *Only 24 out of 119 species

shown

<i>Neoascochyta desmazieri</i>	<.0001	<.0001
<i>Epicoccum brasiliense</i>	<.0001	0.0001
<i>Coniosporium apollinis</i>	<.0001	0.0002
<i>Rhodotorula babjevae</i>	<.0001	0.0008
<i>Pseudopithomyces chartarum</i>	<.0001	0.0011
<i>Pyrenopeziza pratorum</i>	<.0001	0.0011
<i>Vishniacozyma tephrensis</i>	<.0001	0.0017
<i>Xenodidymella humicola</i>	<.0001	0.0019
<i>Bipolaris sorokiniana</i>	<.0001	0.0022
<i>Pseudopithomyces rosae</i>	<.0001	0.0025
<i>Umbilicaria calvescens</i>	<.0001	0.0027
<i>Phaeosphaeria ampeli</i>	<.0001	0.0031
<i>Naganishia globosa</i>	0.0001	0.0043
<i>Curvibasidium pallidicoralli</i>	0.0001	0.0043
<i>Candida parapsilosis</i>	0.0002	0.0053
<i>Cystofilobasidium macerans</i>	0.0002	0.0053
<i>Cladosporium</i>		
<i>sphaerospermum</i>	0.0002	0.0053
<i>Articulospora proliferata</i>	0.0002	0.0053
<i>Preussia flanaganii</i>	0.0002	0.0053
<i>Monographella nivalis</i>	0.0002	0.0054
<i>Caloplaca ferrarii</i>	0.0002	0.0057
<i>Paracremonium inflatum</i>	0.0003	0.007

<i>Didymella nigricans</i>	0.0004	0.0076
<i>Knufia marmoricola</i>	0.0004	0.008

Table S4: Kruskal-Wallis test statistics for fungal alpha diversity metrics comparing Earth-based residential house dust to dust collected from the ISS.

Fungal Alpha Diversity Kruskal-Wallis Statistics Earth-based vs. ISS Dust

Condition	Richness			Shannon Diversity		
	H	P-value	Q-value	H	P-value	Q-value
Original Dust Samples						
Earth vs. ISS	18.44	< 0.0001	< 0.0001	17.20	< 0.0001	< 0.0001
Fungal Time of Wetness (All Samples)						
Earth vs. ISS	150.56	< 0.0001	< 0.0001	125.56	< 0.0001	< 0.0001
Fungal Time-of-Wetness 85% ERH Only						
Earth vs. ISS	65.27	< 0.0001	< 0.0001	58.04	< 0.0001	< 0.0001
Fungal Time-of-Wetness 100% ERH Only						
Earth vs. ISS	65.46	< 0.0001	< 0.0001	56.19	< 0.0001	< 0.0001
Fungal Time-of-Wetness 6 hour Only						
85% ERH, Earth vs. ISS	16.51	< 0.0001	< 0.0001	15.03	0.0001	0.0001
100% ERH, Earth vs. ISS	14.73	0.0001	0.0001	14.19	0.0002	0.0002
Fungal Time-of-Wetness 12 hour Only						
85% ERH, Earth vs. ISS	15.66	< 0.0001	< 0.0001	15.65	< 0.0001	< 0.0001
100% ERH, Earth vs. ISS	16.52	< 0.0001	< 0.0001	14.56	0.0001	0.0001
Fungal Time-of-Wetness 18 hour Only						
85% ERH, Earth vs. ISS	15.78	< 0.0001	< 0.0001	12.34	0.0004	0.0004
100% ERH, Earth vs. ISS	17.30	< 0.0001	< 0.0001	17.28	< 0.0001	< 0.0001
Fungal Time-of-Wetness 24 hour Only						
85% ERH, Earth vs. ISS	15.66	< 0.0001	< 0.0001	15.65	< 0.0001	< 0.0001
100% ERH, Earth vs. ISS	17.30	< 0.0001	< 0.0001	17.28	< 0.0001	< 0.0001

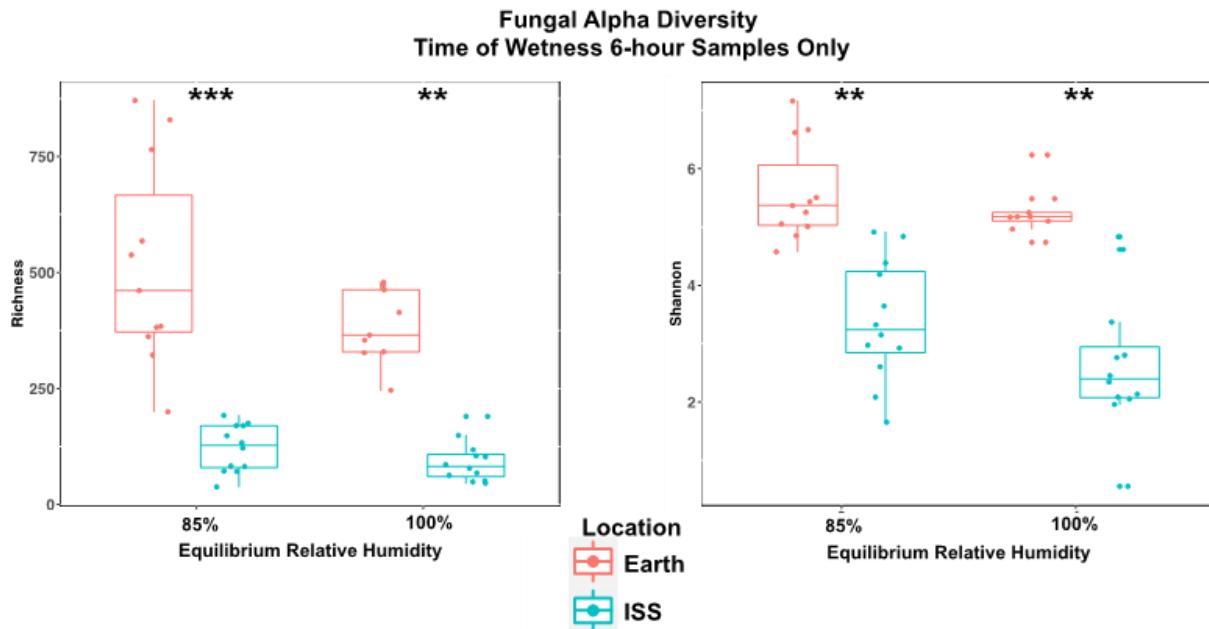


Figure S2: Fungal Richness and Shannon diversity plots for 6-hour time of wetness samples comparing relative humidity (RH) conditions (85% and 100% RH) for Earth-based house dust and dust collected from the ISS. Location is indicated by color (Earth – Red, ISS- Blue). ** Indicates Kruskal-Wallis t-test significance of $P < 0.001$, while *** indicates $P < 0.0001$.

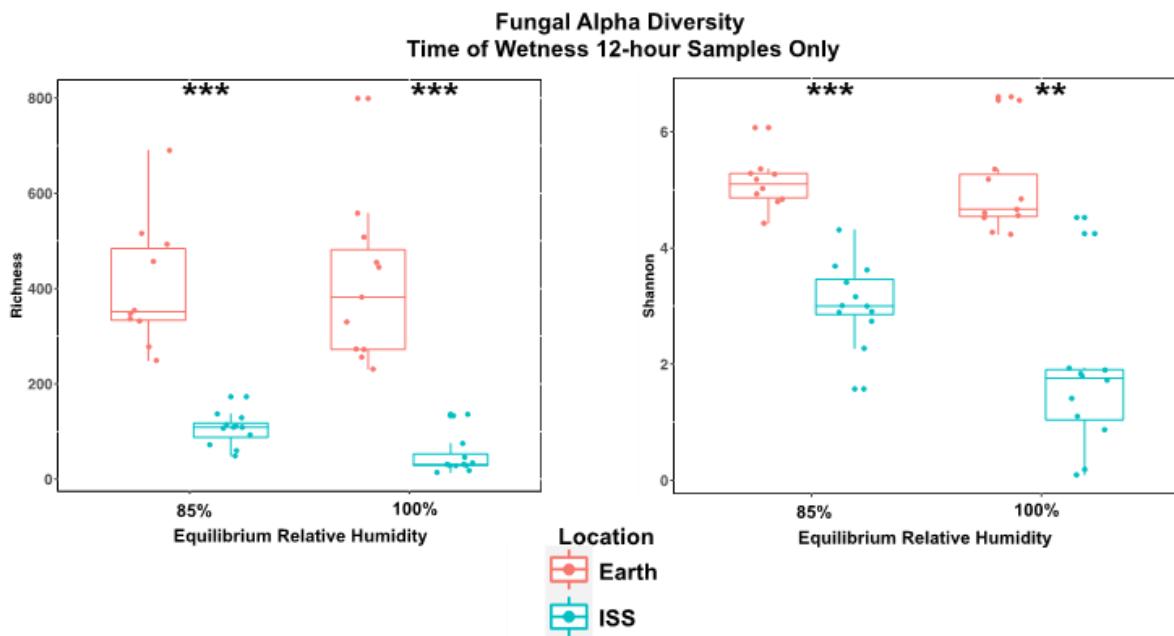


Figure S3: Fungal Richness and Shannon diversity plots for 12-hour time of wetness samples comparing relative humidity (RH) conditions (85% and 100% RH) for Earth-based house dust and dust collected from the ISS. Location is indicated by color (Earth – Red, ISS- Blue). ** Indicates Kruskal-Wallis t-test significance of $P < 0.001$, while *** indicates $P < 0.0001$.

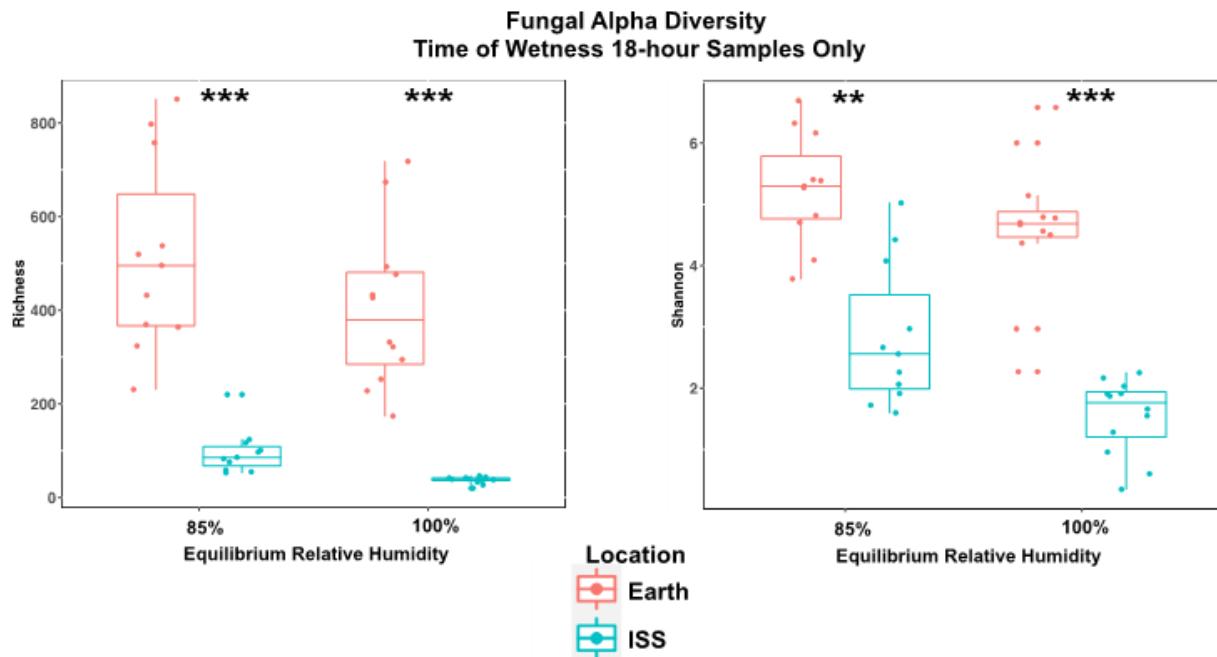


Figure S4: Fungal Richness and Shannon diversity plots for 18-hour time of wetness samples comparing relative humidity (RH) conditions (85% and 100% RH) for Earth-based house dust and dust collected from the ISS. Location is indicated by color (Earth – Red, ISS- Blue). ** Indicates Kruskal-Wallis t-test significance of $P < 0.001$, while *** indicates $P < 0.0001$.

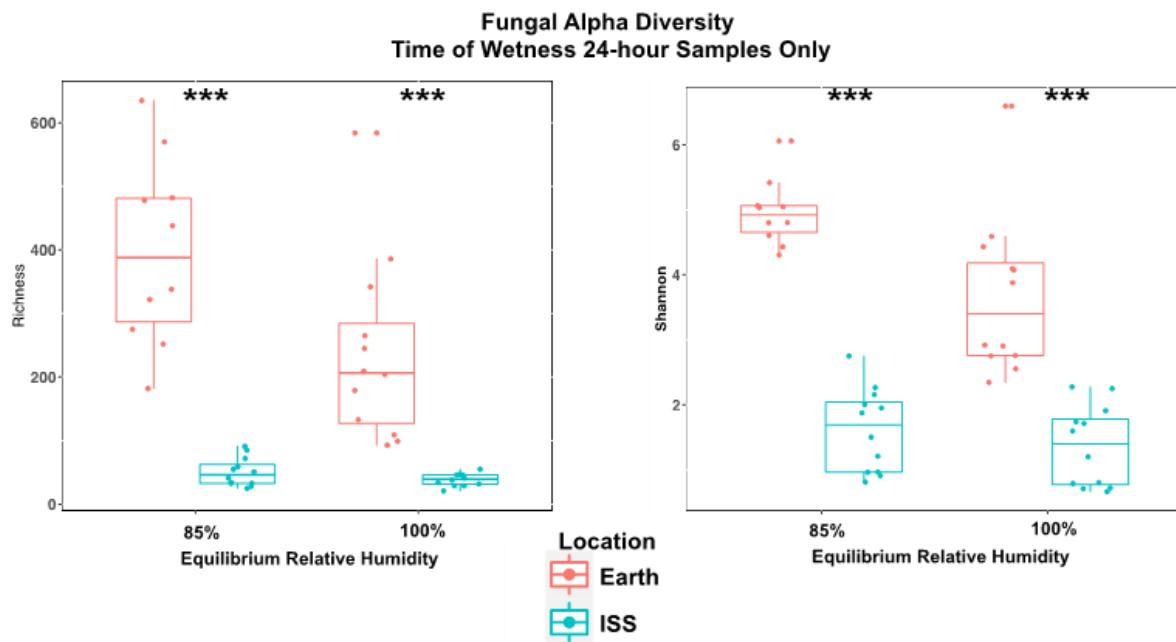


Figure S5: Fungal Richness and Shannon diversity plots for 24-hour time of wetness samples comparing relative humidity (RH) conditions (85% and 100% RH) for Earth-based house dust and dust collected from the ISS. Location is indicated by color (Earth – Red, ISS- Blue). *** Indicates Kruskal-Wallis t-test significance of $P < 0.0001$.

Table S5: Differential abundance comparison of fungal species between Earth-based house dust and ISS dust in all TOW conditions (6, 12, 18, and 24 hours) at 100% RH. A total of 521 fungal species were identified where 26 were significantly more abundant in ISS samples and 456 were more abundant in Earth-based house dust.

Differential Abundance Analysis TOW 100% RH Samples (Earth-based vs ISS Dust)

Fungal Species	Unadjusted P-value	Adjusted FDR P-value
More abundant on International Space Station		
<i>Aspergillus sydowii</i>	<.0001	<.0001
<i>Aspergillus unguis</i>	<.0001	<.0001
<i>Aspergillus falconensis</i>	<.0001	<.0001
<i>Penicillium paczoskii</i>	<.0001	<.0001
<i>Candida albicans</i>	<.0001	<.0001
<i>Malassezia restricta</i>	<.0001	<.0001
<i>Malassezia globosa</i>	<.0001	<.0001
<i>Colletotrichum theobromicola</i>	<.0001	<.0001
<i>Aspergillus ruber</i>	0.0001	0.0002
<i>Aspergillus conicus</i>	0.0001	0.0002
<i>Malassezia sympodialis</i>	0.0002	0.0002
<i>Aspergillus tamarii</i>	0.0001	0.0002
<i>Lasiodiplodia margaritacea</i>	0.0001	0.0002
<i>Penicillium gladioli</i>	0.0003	0.0005
<i>Penicillium sclerotigenum</i>	0.0003	0.0005
<i>Rhodotorula mucilaginosa</i>	0.0006	0.0008
<i>Aspergillus nidulans</i>	0.0005	0.0008
<i>Malassezia dermatitis</i>	0.0008	0.0011

<i>Penicillium atramentosum</i>	0.0009	0.0012
<i>Rhodosporidiobolus fluvialis</i>	0.0011	0.0015
<i>Saccharomyces cerevisiae</i>	0.0029	0.0035
<i>Aspergillus fischeri</i>	0.0044	0.0051
<i>Malassezia arunalokei</i>	0.0046	0.0053
<i>Aspergillus flavus</i>	0.0051	0.0058
<i>Trichothecium roseum</i>	0.0071	0.008
<i>Naganishia liquefaciens</i>	0.0374	0.0406

More abundant in Earth-based House Dust *Only 26 out of 456 species shown

<i>Alternaria tenuissima</i>	<.0001	<.0001
<i>Fusarium culmorum</i>	<.0001	<.0001
<i>Cladosporium delicatulum</i>	<.0001	<.0001
<i>Mycosphaerella tassiana</i>	<.0001	<.0001
<i>Fusarium proliferatum</i>	<.0001	<.0001
<i>Nigrospora oryzae</i>	<.0001	<.0001
<i>Wallemia tropicalis</i>	<.0001	<.0001
<i>Echinoderma jacobi</i>	<.0001	<.0001
<i>Plectosphaerella oligotrophica</i>	<.0001	<.0001
<i>Aureobasidium namibiae</i>	<.0001	<.0001
<i>Cladosporium halotolerans</i>	<.0001	<.0001
<i>Vishniacozyma victoriae</i>	<.0001	<.0001
<i>Xenodidymella humicola</i>	<.0001	<.0001

<i>Cladosporium sphaerospermum</i>	<.0001	<.0001
<i>Pseudopithomyces chartarum</i>	<.0001	<.0001
<i>Neoascochyta desmazieri</i>	<.0001	<.0001
<i>Naganishia albida</i>	<.0001	<.0001
<i>Filobasidium magnum</i>	<.0001	<.0001
<i>Cystofilobasidium macerans</i>	<.0001	<.0001
<i>Coniosporium apollinis</i>	<.0001	<.0001
<i>Rhodotorula babjevae</i>	<.0001	<.0001
<i>Bipolaris sorokiniana</i>	<.0001	<.0001
<i>Phaeosphaeria ampeli</i>	<.0001	<.0001
<i>Epicoccum brasiliense</i>	<.0001	<.0001
<i>Trichosporon caseorum</i>	<.0001	<.0001
<i>Pseudopithomyces rosae</i>	<.0001	<.0001

Bacteria – Original Dust Comparisons

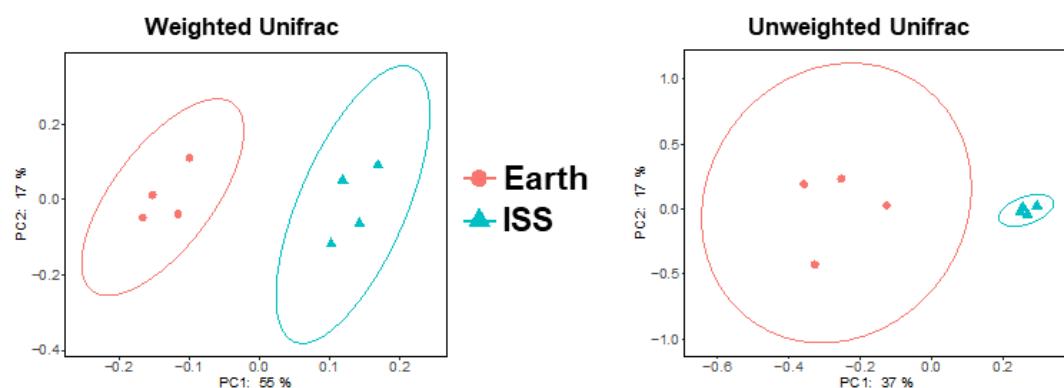


Figure S6: Bacterial beta diversity with Bray Curtis dissimilarity principal coordinate analyses plots for original dust samples. Location of dust samples are indicated by shape (Earth – circle, ISS – triangle). Ellipses represent 95% confidence interval for each set of data.

Bacterial Alpha Diversity Original Dust Samples Earth-based vs. ISS Dust

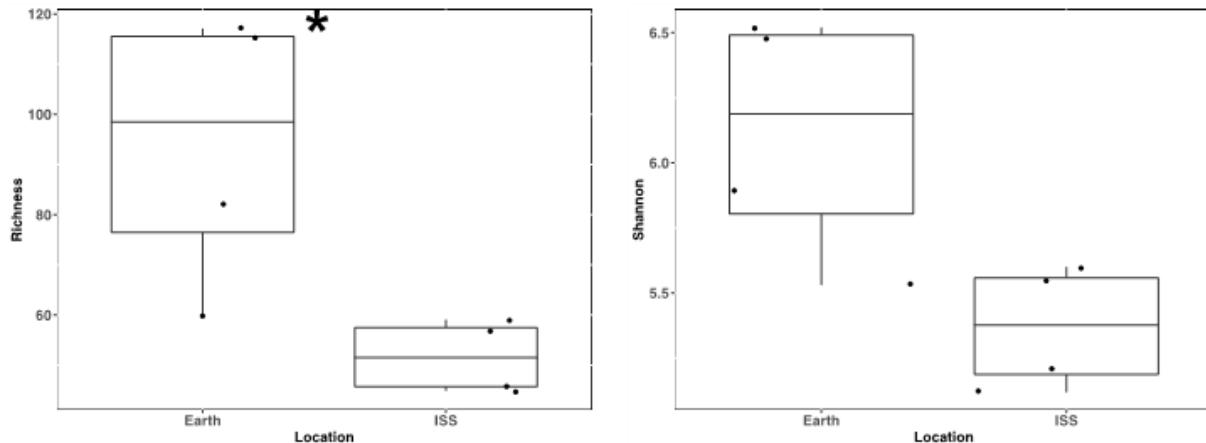


Figure S7: Bacterial Richness and Shannon diversity plots for original dust samples comparing Earth-based house dust to dust collected from the ISS. * Indicates Kruskal-Wallis t-test significance of $P < 0.05$.

Table S6: Kruskal-Wallis test statistics for bacterial alpha diversity metrics comparing Earth-based residential house dust to dust collected from the ISS.

Condition	Richness			Shannon Diversity		
	H	P-value	Q-value	H	P-value	Q-value
Bacterial Original Dust Samples						
Earth vs. ISS	5.33	0.0209	0.0209	3.00	0.0832	0.0832
Bacterial Time-of-Wetness Samples						
Earth vs. ISS	11.38	0.0001	0.0001	9.79	0.0018	0.0018

Table S7: Adonis values for bacterial beta diversity based on Bray-Curtis Dissimilarity between Earth-based residential house dust and dust collected from the International Space Station

	Unweighted Unifrac		Weighted Unifrac	
Variable	R ²	P-value	R ²	P-value
Bacterial Time-of-Wetness (Original Dust, 50%, 85%, and 100% ERH 24-hours only)				
Location	0.221	0.001	0.159	0.004
ERH	0.079	0.002	0.343	0.001
Day	0.032	0.113	0.125	0.002
Original Dust Only				
Location	0.359	1	0.538	1

Table S8: Differential abundance comparison of bacterial species between Earth-based house dust and ISS dust in original dust samples. A total of 81 bacterial species were identified where 3 were significantly more abundant in ISS samples and 11 were more abundant in Earth-based house dust.

Differential Abundance Analysis Original Dust Samples (Earth-based vs ISS Dust)

Bacterial Species	Unadjusted P-value	Adjusted FDR P-value
More abundant on International Space Station		
<i>Acinetobacter rhizosphaerae</i>	<.0001	0.0003
<i>Prevotella melaninogenica</i>	<.0001	0.0006
<i>Rothia dentocariosa</i>	0.0002	0.0021
More abundant in Earth-based House Dust		
<i>Acinetobacter lwoffii</i>	<.0001	0.0003
<i>Flavobacterium succinicans</i>	<.0001	0.0003
<i>Methylobacterium adhaesivum</i>	<.0001	0.0006
<i>Paracoccus marcusii</i>	<.0001	0.0006
<i>Prevotella copri</i>	<.0001	0.0006
<i>Bacillus flexus</i>	0.0318	0.1355
<i>Eubacterium biforme</i>	0.0305	0.1355
<i>Pseudomonas viridiflava</i>	0.0285	0.1355
<i>Candidatus Nitrososphaera SCAl</i>	0.0316	0.1355
<i>Chloroidium saccharophilum</i>	0.0316	0.1355
<i>Candidatus Nitrososphaera</i>	0.0336	0.1361