Experiences with Radiance in Daylighting Design, Part VIII

18th International Radiance Conference
August 21-22, New York City

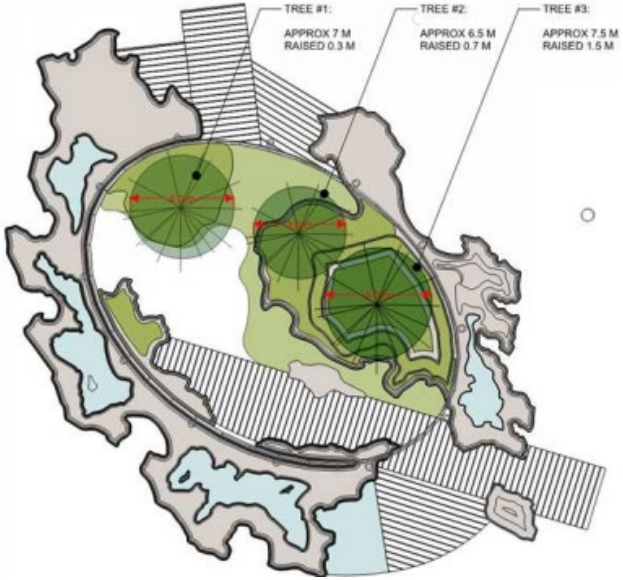
Zack Rogers, P.E., IESNA, LEED AP BD+C
Daylighting Innovations, LLC

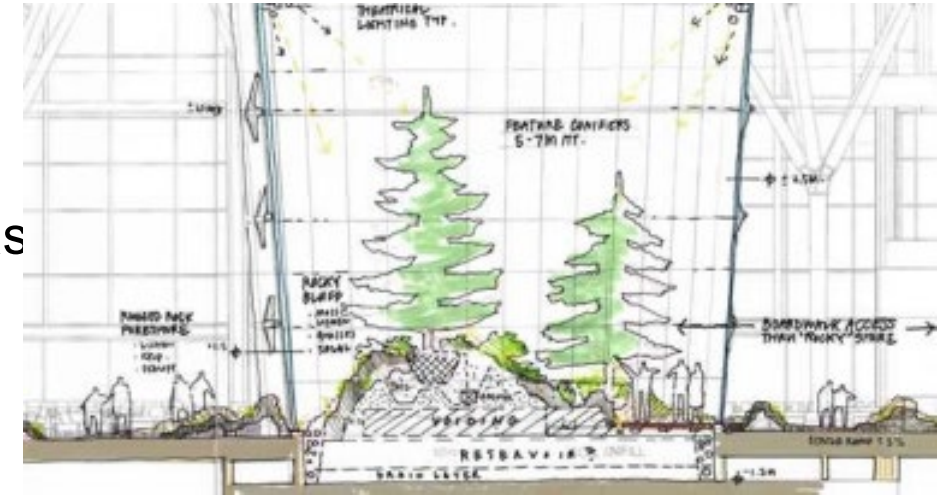
Presentation Outline

- Vancouver Airport
  - Plant and solar focal point studies
  - Art projection studies
- Annual sky and sun modeling
  - Annual sunband method
  - Periodic sky generator
- IESNA Daylight Modeling and Simulation task group
  - Documenting Modeling and simulation standards
  - Developing gold standard annual test cases
- School studies
  - MLK Jr Cafeteria retrofit
  - Jones K-12 / Robeson – new school designs
  - Hillwood HS – gym and passive wings
  - Vanderbilt – Melanopic lux calcs

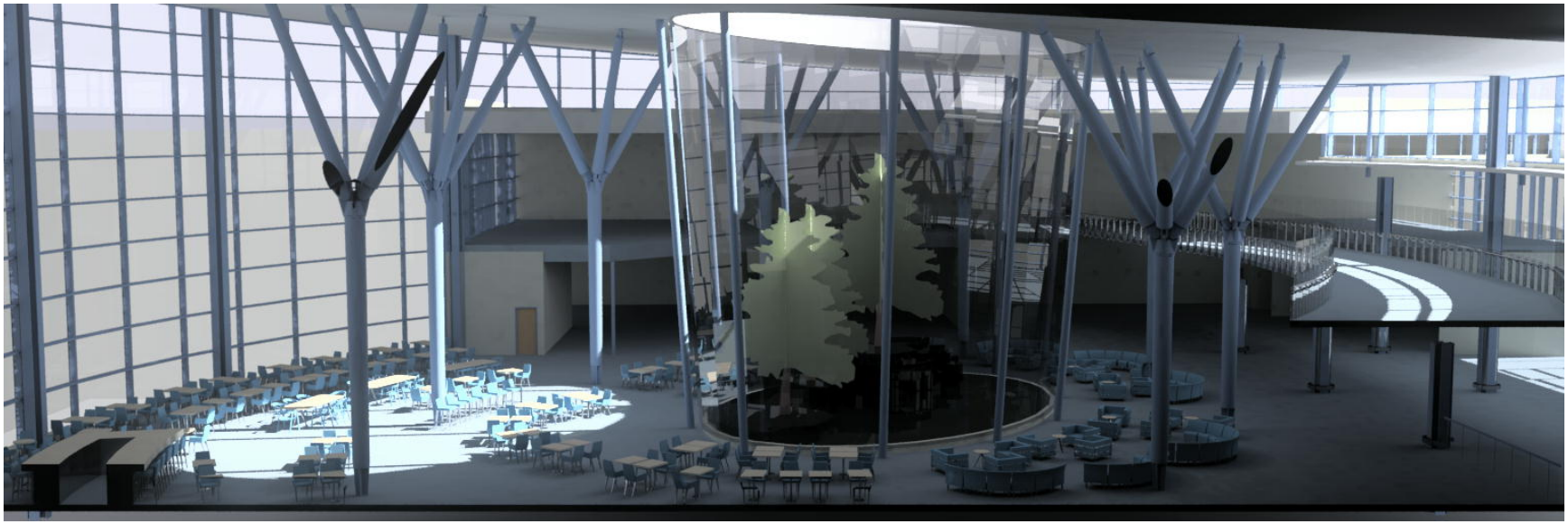
Vancouver Airport Plant and Visibility Analyses

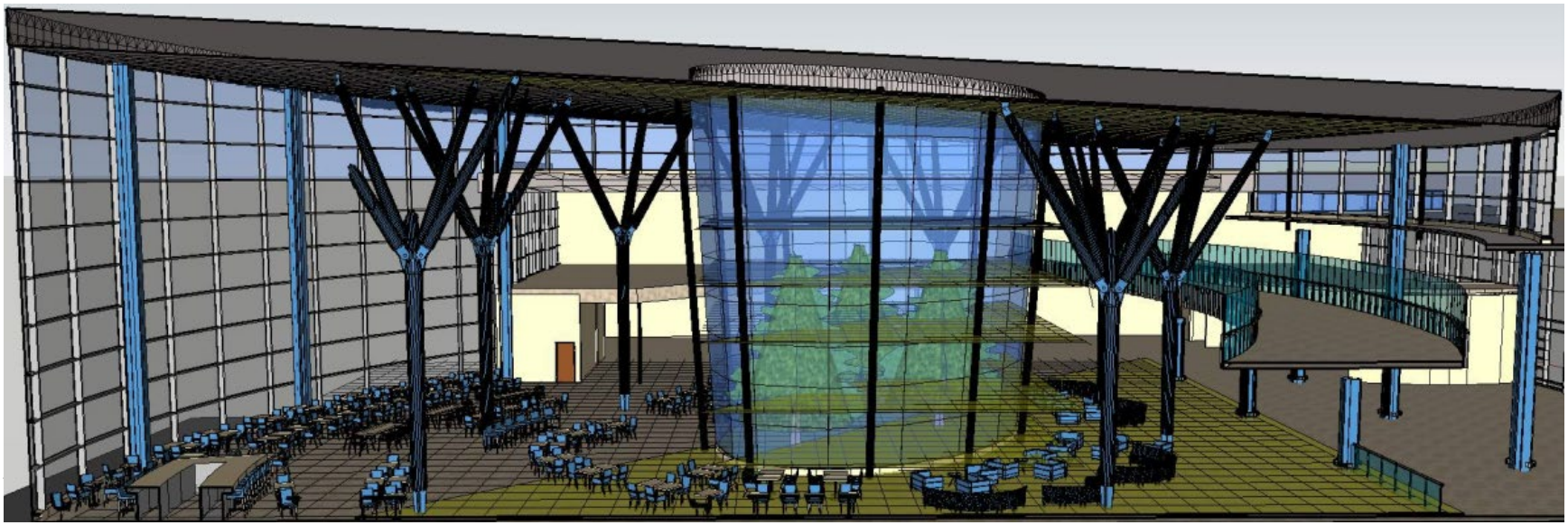
- New public gathering hub in new airport expansion wing
- Local natural landscape exhibit in exterior glazed atrium
- Concern over adequate light for plants and focal points creating too much light
- Concern over visibility of exhibit and interior stage areas
- Concern over light projection based art installations



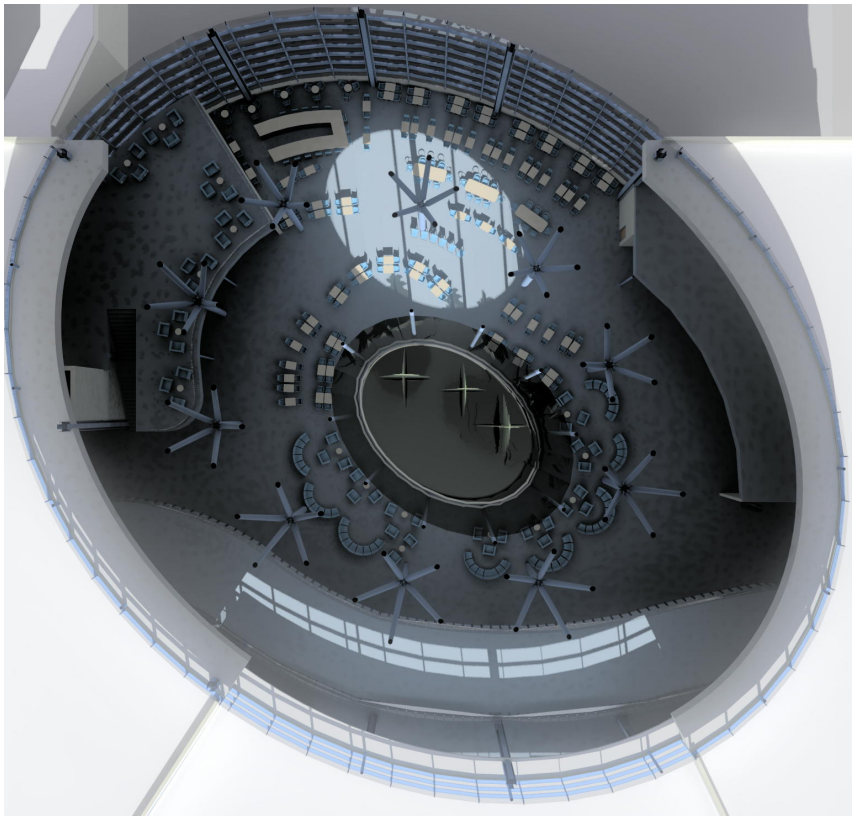


Model section





Model renderings



Daylight for plant sufficiency – 0.5m high

Notes

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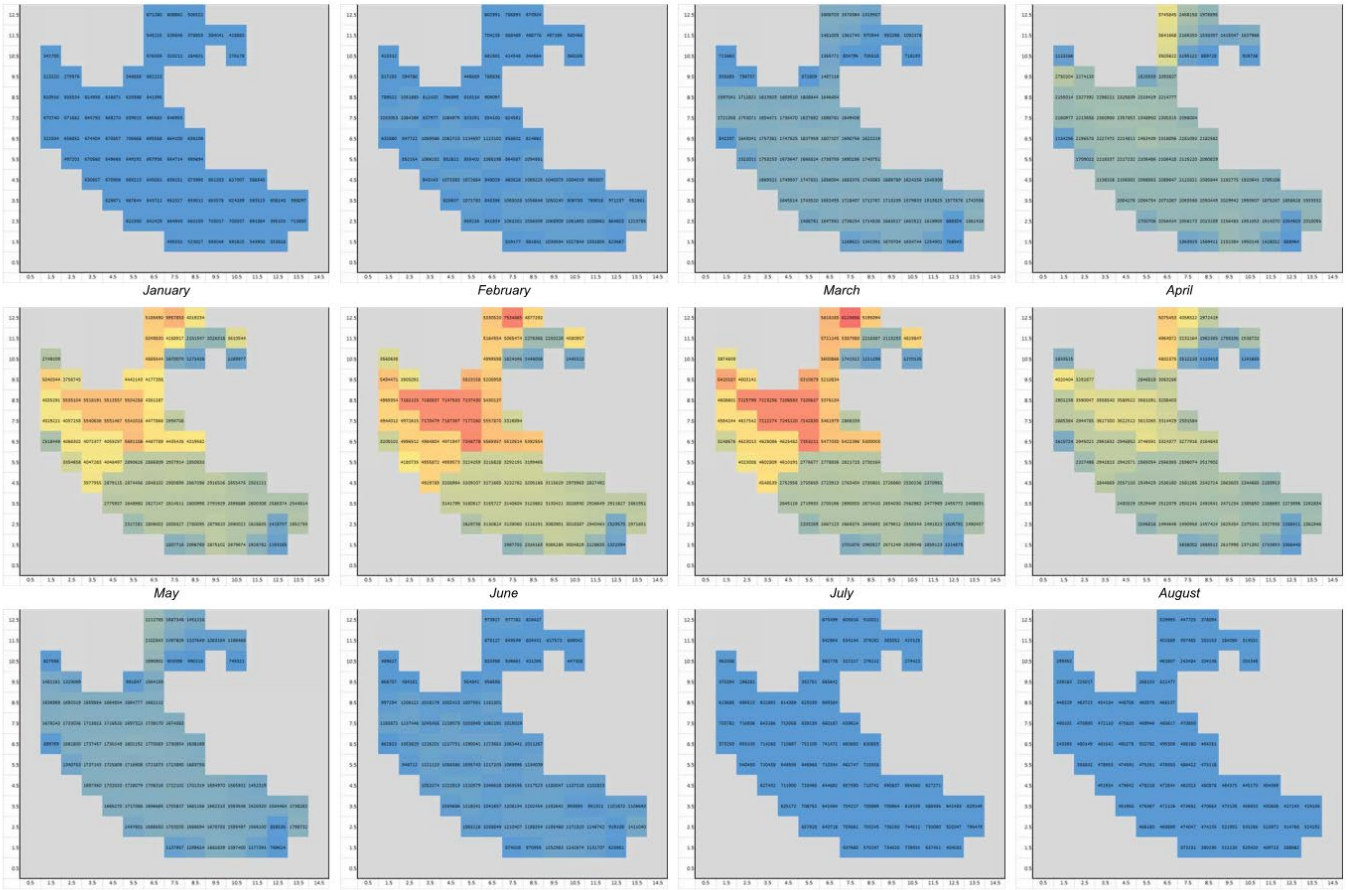

Daily Lux-Hours / Month	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mth Lux-Hours
1	18504	7911	19194	20969	16428	23593	23196	10273	20758	12872	16539	20666	6910	22111	20112	26762	11006	15019	4589	26821	22813	7354	22038	21274	16034	15557	29081	25267	31681	21399	33311	590044
2	28368	10115	5545	27023	29933	31732	30247	34707	28501	36328	14637	14556	36882	36454	44544	46049	16721	41897	38520	27710	45210	50481	37731	39015	39271	40998	14584	18255				866014
3	45028	51977	42505	35163	50390	51021	18537	31216	42401	63242	61611	34772	38183	40847	32425	40720	70586	26375	53986	67032	35636	71392	75804	34209	35091	34412	78876	75983	27309	60682	76734	1504145
4	43087	45003	57627	55044	55100	71443	78653	28866	68872	92098	40110	62753	55986	23157	65767	94034	40089	86198	73809	89920	95283	68921	52181	85997	68920	68824	89775	87419	74159	114633		2033729
5	123589	89848	87556	94874	20633	95583	98386	98432	119723	111887	108209	62883	95915	136703	68230	125221	113191	117716	134823	131969	154629	131840	145019	93308	100034	144318	133605	154937	65178	104872	155993	3419105
6	125563	123077	150366	142298	132278	153196	145551	145238	147237	163036	141869	163879	114333	72343	60932	155228	160023	120488	159959	110307	138348	147062	161027	128611	119010	108348	117633	146396	151905	134554		4040095
7	144258	143067	142870	155831	154227	143391	71566	166354	136589	142094	148812	143659	134513	136923	132267	130054	144725	92572	65283	63548	106650	116417	116746	117749	117007	128012	100152	116536	120589	116572	104978	3854009
8	108193	120704	98660	121311	99355	97418	123364	83988	84586	104167	78468	79767	87669	59760	53567	89029	86757	77276	92915	92088	104886	87483	84333	65813	54317	55669	82202	67556	92040	91050	87284	2711676
9	72112	78366	48775	83713	45188	83040	43090	42362	40939	43490	41997	39659	37867	72853	65259	40095	53598	38710	48325	72739	33184	55103	38642	53090	47399	65731	30788	34947	59049	41923		1552032
10	58005	32934	41986	41750	55675	44237	36719	39174	44203	14795	43587	53121	10487	33150	34811	47955	12074	26204	44837	14640	13844	37337	36946	14256	35342	11141	12050	34312	42613	35559	13338	1017080
11	32020	29749	33488	26528	14895	17903	8758	26146	32730	7833	5512	23148	32227	32082	7265	20404	26080	23431	28525	21653	20485	25824	5764	22010	27512	11387	9801	19789	8882	11338		613167
12	9775	13068	23016	20881	21394	20737	18216	16712	16828	19864	5630	11864	15813	12890	7164	6341	13112	4440	5817	5013	20944	3357	13432	21644	16619	19948	16545	6420	16264	9785	18537	432070

Daylight for plant sufficiency – 5m high

Notes

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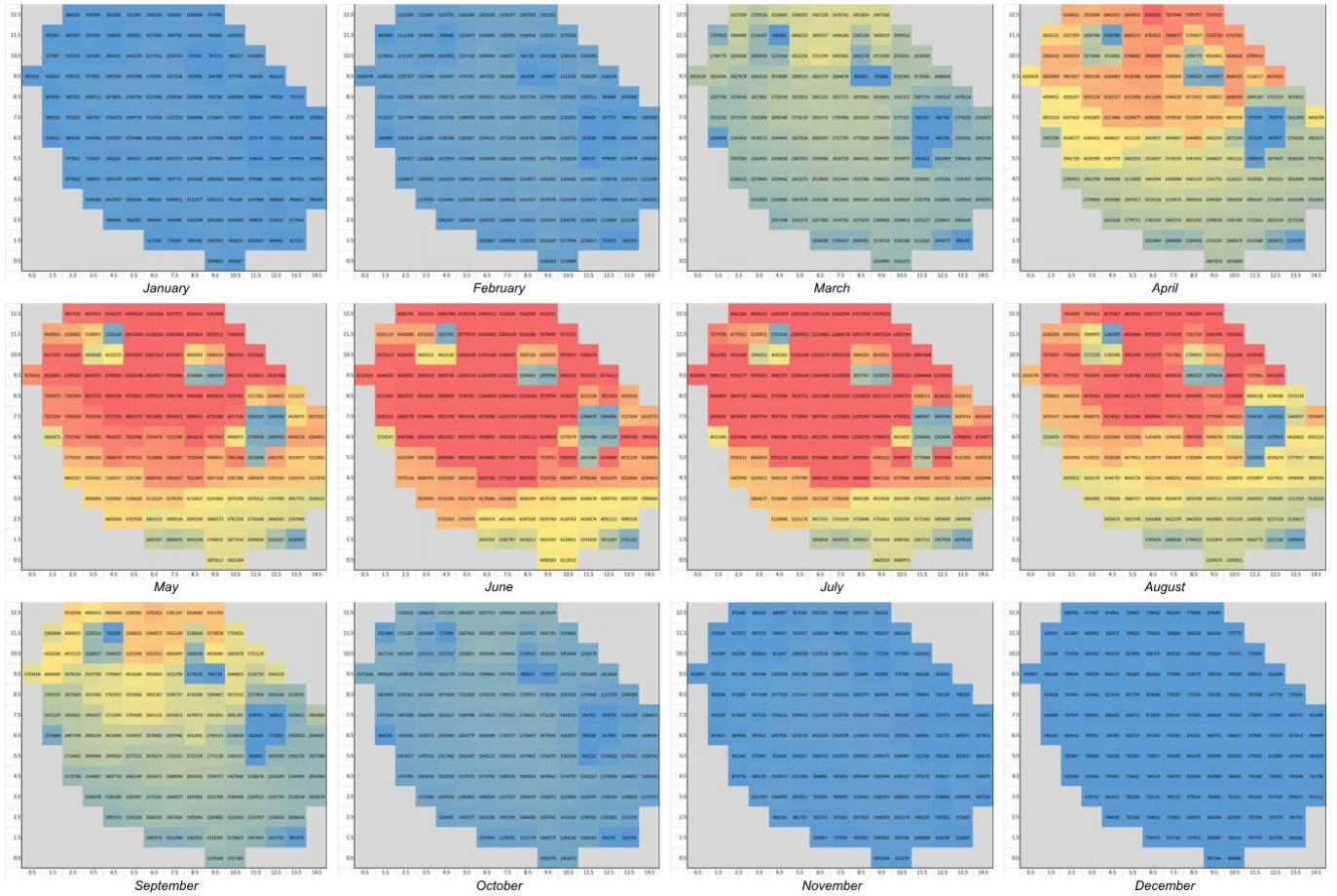
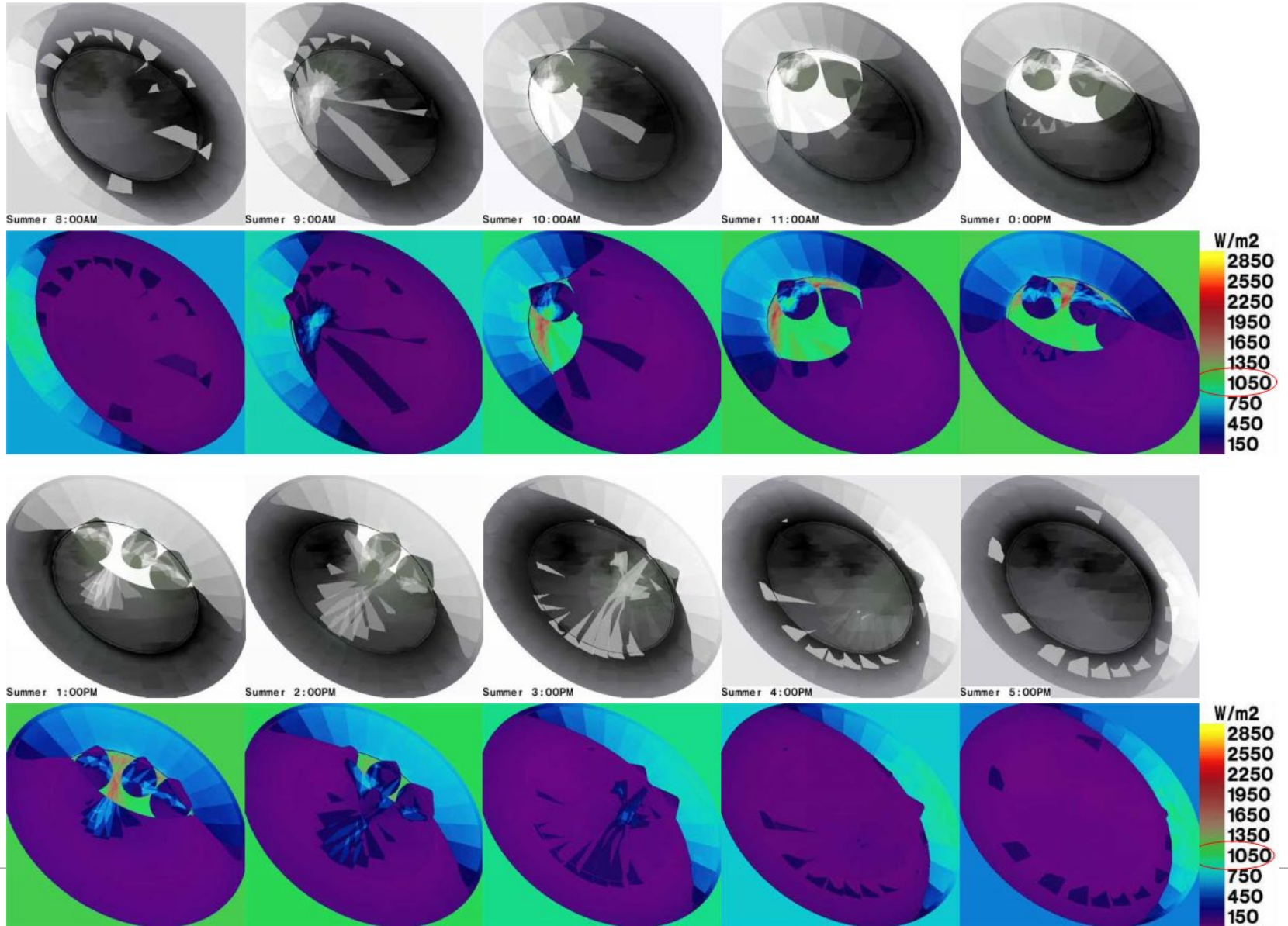
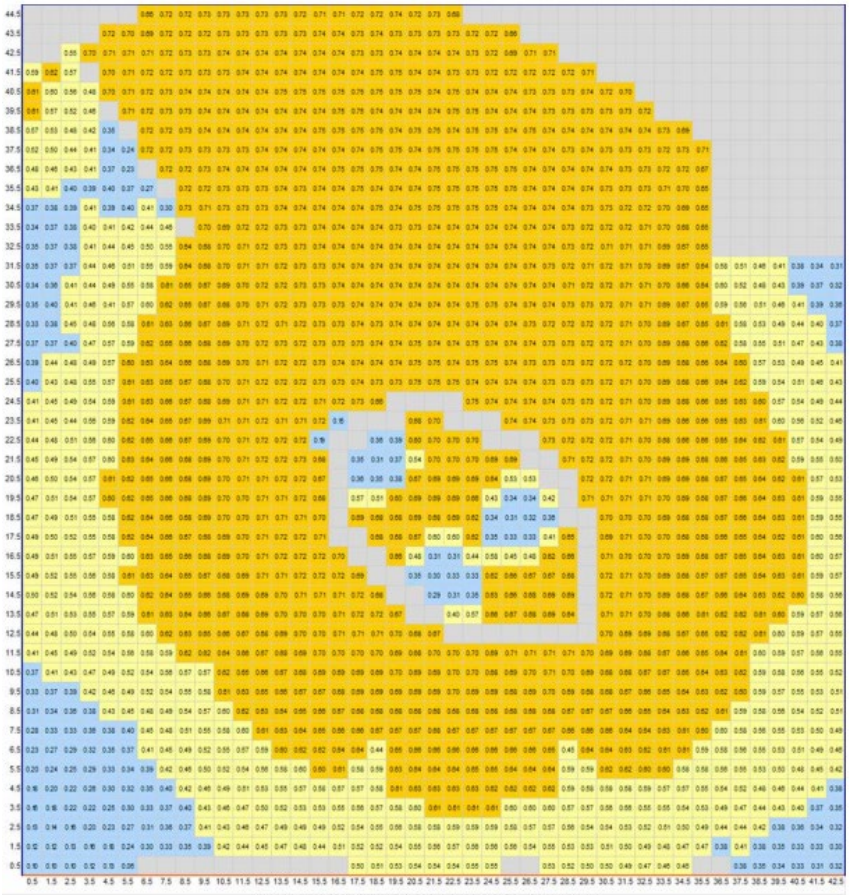


Daily Lux-Hours / Month	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Mth Lux-Hours
1	32168	11858	35430	33229	24635	38541	35027	15367	37527	19255	24741	31066	10338	37451	35063	42547	16466	22469	6870	40414	34204	11004	33013	31832	24005	23276	44785	37914	47606	32032	49806	919941
2	42249	15137	8299	37746	44071	46803	40839	50861	42137	49431	21923	21819	45349	54097	62350	62039	25072	46862	40543	41452	48989	60616	56473	58175	44452	61301	21818	27309				1178214
3	67421	65819	54454	52714	74922	69156	27753	46718	62634	94812	90663	52014	57238	61112	48569	72071	108970	39584	81287	105317	73869	107383	123877	76768	81389	81233	122042	116362	40852	94827	136094	2387923
4	109120	108701	126653	123500	130276	120601	128329	43197	135985	170584	60665	149802	140668	34657	118479	177677	60505	130929	111026	169764	165403	191306	78043	147653	194442	195713	190244	213767	201176	207103		4135967
5	200544	209523	210096	153792	30883	221015	220236	228609	230175	236481	236158	94355	152542	251347	102575	234206	206687	186515	273607	266919	267804	266400	275129	140772	178853	290247	276330	290380	109778	176304	293427	6511688
6	193225	190314	310389	234090	246181	317981	303632	306015	305084	268863	286992	298041	176342	108773	91533	299510	324212	186690	301614	172118	220456	301978	319532	205229	181035	163839	179377	300300	275421	209245		7278013
7	304199	303066	302569	280456	310176	253941	107254	282715	281629	296052	294600	268004	278609	273226	276695	272266	278456	139611	99056	96091	215995	261332	262673	252908	245615	213523	177601	224311	245368	182013	241002	7521011
8	219950	241180	205462	258037	226118	226945	242573	213415	206044	210577	202637	200828	194984	89525	80206	167943	135514	121262	168943	165957	195248	180289	162539	159807	157752	152965	158612	131199	171725	157928	157084	5563246
9	108787	145258	73009	133084	125404	143410	117352	111213	106763	108672	106431	100885	95822	118064	119902	88349	103696	82718	72409	120617	71820	94304	76052	80220	80834	103624	46081	52276	93750	62780		2943586
10	92569	49274	65100	68164	84503	61642	50567	52656	66137	22132	54913	78882	15711	48735	52273	65612	18101	39200	60344	21915	20759	54838	51922	21376	41919	16672	18033	43254	58121	48303	19962	1463590
11	43169	40194	46177	39527	22286	26788	13105	39031	47980	11719	8245	35140	48296	48326	10868	30617	39470	35485	44171	32738	34887	38805	8641	35457	43672	17094	14750	34136	13312	16972		921060
12	14688	19645	35971	35145	35623	31332	32467	31836	32328	34687	8441	17769	23688	19305	10726	9494	21942	6666	8759	7519	33983	5032	20131	38852	25023	36907	24798	9633	24467	14688	31429	702976

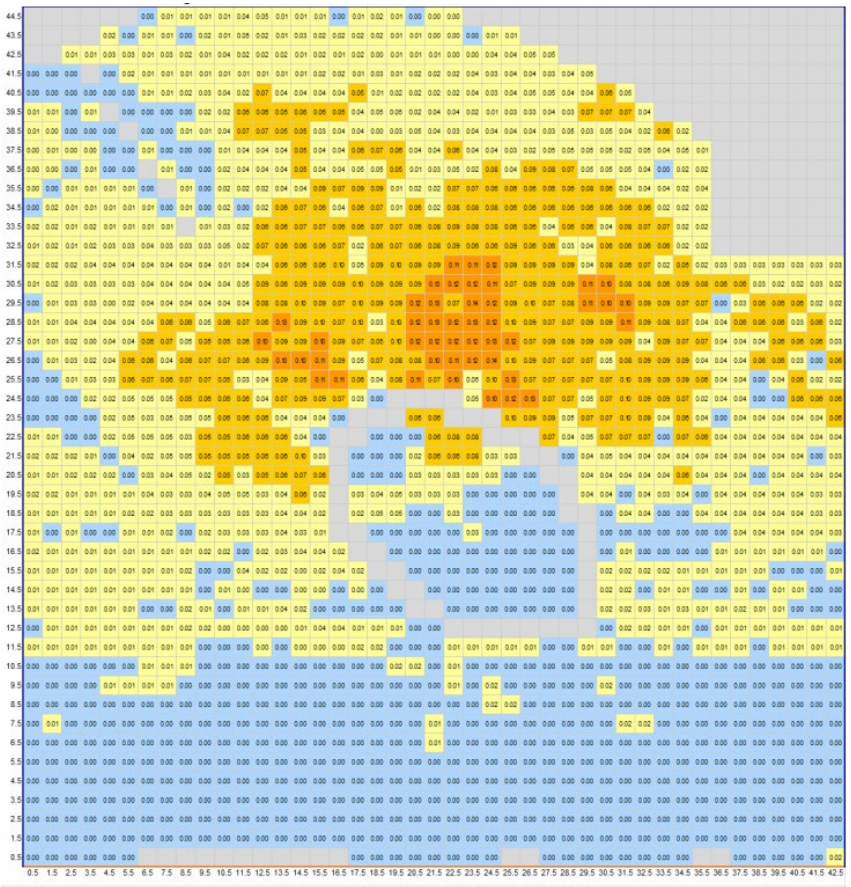
Solar reflection focal point



Daylight sufficiency and daylight excess

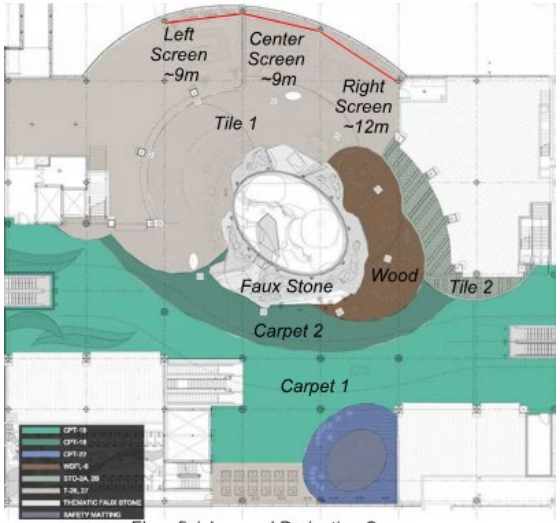


Annual Daylight Saturation (base 1000lux)

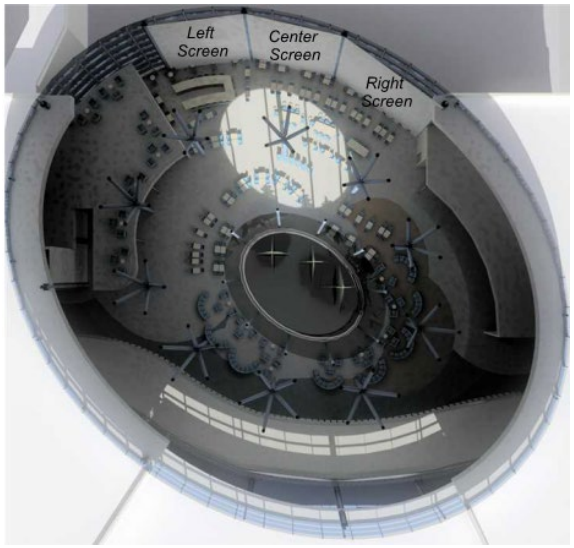


Annual Daylight Excess (DE) base 10,000lux

Interior screen projection



Floor finishes and Projection Screens



Screen illuminance

Left Screen

	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
9.5	541	519	507	515	513	503	508	501	504
8.5	575	558	520	517	504	514	516	516	519
7.5	560	553	517	580	526	521	523	531	534
6.5	511	512	538	576	567	538	576	531	535
5.5	457	494	508	501	545	550	578	543	553
4.5	477	541	486	526	553	547	568	550	581
3.5	464	554	573	596	544	557	658	689	681
2.5	534	678	519	621	532	683	704	661	849
1.5	575	569	693	661	745	926	586	652	984
0.5	555	615	595	528	549	825	846	668	866

Center Screen

	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
9.5	512	518	520	521	526	524	523	523	526
8.5	524	528	528	527	532	534	539	543	539
7.5	540	543	544	541	581	552	543	567	550
6.5	539	544	556	555	587	555	569	605	608
5.5	558	560	558	566	569	557	605	720	618
4.5	641	558	575	571	597	563	830	615	628
3.5	776	606	659	828	574	661	614	626	802
2.5	756	768	694	613	709	829	627	633	649
1.5	812	628	712	576	687	826	744	635	793
0.5	614	566	792	598	872	878	617	787	789

Right Screen

	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
9.5	553	523	534	544	541	546	556	559	560	579	602	638
8.5	538	541	547	551	590	560	571	571	589	664	617	647
7.5	552	564	563	570	572	661	588	668	589	599	684	163
6.5	572	572	717	589	590	598	599	596	598	758	617	601
5.5	663	678	581	594	590	605	783	802	809	726	766	642
4.5	677	730	726	708	864	649	630	632	803	774	653	653
3.5	779	678	827	721	729	696	640	754	747	1014	679	1010
2.5	701	1217	814	1195	767	890	657	937	776	779	918	923
1.5	624	989	932	742	749	686	681	909	791	802	1064	956
0.5	738	940	820	649	1263	900	799	830	901	1168	1093	1064

Annual Average

Left Screen

	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
9.5	2129	2041	2219	2706	2985	2371	2514	2392	2441
8.5	6463	6463	2468	2560	2362	2593	2542	2496	3098
7.5	6437	6389	2312	8062	2369	2497	2539	2608	2700
6.5	2291	2285	3616	8073	7761	3468	8315	2544	2607
5.5	2207	3645	3621	2436	3501	3504	8315	2690	4260
4.5	3864	38672	2206	3548	4663	3489	4448	4470	4217
3.5	4895	38838	38521	38027	4698	3503	47428	47405	47403
2.5	39167	45079	4721	44564	2787	46754	47074	47766	52029
1.5	40733	38842	44437	46427	47079	52291	8766	35055	52081
0.5	38844	40195	38527	3214	3482	47080	47405	47768	52059

Center Screen

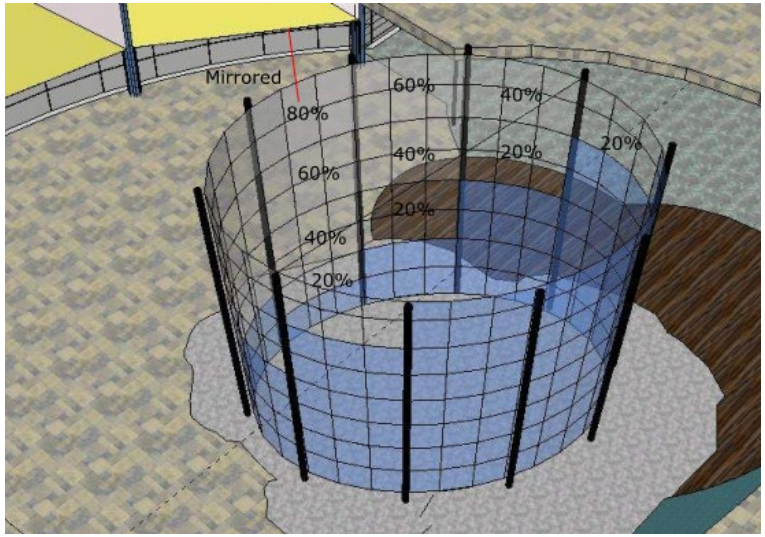
	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
9.5	2483	2393	2371	2697	2312	2563	2499	2595	2677
8.5	2437	2666	2653	2416	2440	2600	2737	3051	2692
7.5	2666	2598	2575	2620	6179	2585	2820	3026	2670
6.5	2505	2623	2776	2520	6210	2565	2774	7166	7174
5.5	2673	2745	2623	2649	2893	2559	7099	50802	7253
4.5	16774	2709	3550	3370	6132	2920	49636	7143	7170
3.5	44229	18146	42401	52502	2825	40598	7060	7097	52039
2.5	41345	45701	18509	18549	41728	50496	18686	18686	18841
1.5	45521	9277	14259	3151	36275	45542	45510	9530	45193
0.5	7419	3016	45534	7986	45843	45527	8489	45181	45199

Right Screen

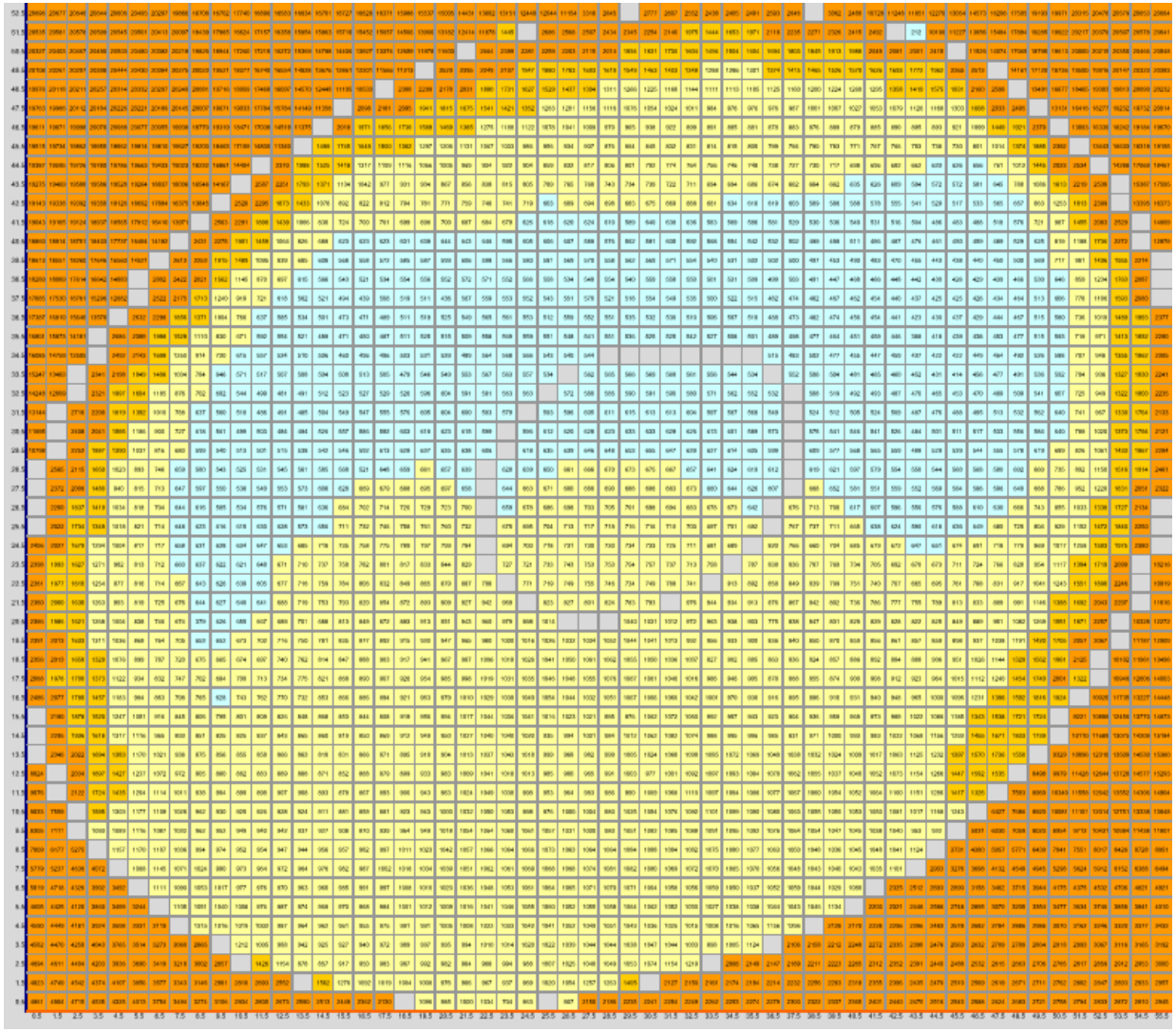
	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
9.5	4511	2633	2782	2730	3036	2763	3006	3334	2909	3243	3361	3547
8.5	3476	2700	2706	2756	5469	2853	2820	2935	3651	21920	4114	3081
7.5	2912	2740	2907	2872	2911	36288	3142	36434	3221	3236	36297	1120
6.5	3969	3114	47605	3995	2906	3052	3014	3019	3268	48269	3211	3433
5.5	15555	15713	2927	3001	3025	2993	52112	54710	54649	46370	48114	3383
4.5	15614	15617	15617	16487	48246	6455	3285	3226	47252	46311	3747	3550
3.5	38758	38023	38613	16483	16482	30522	3578	17329	17252	60553	4045	64394
2.5	15556	54672	16777	59709	16392	48255	3976	47259	17334	17175	60975	61002
1.5	3434	60642	58443	15570	15524	11467	5320	57075	17336	17191	60975	61002
0.5	36743	57499	15853	3596	60131	60441	16516	16727	56306	60580	67830	68681

Annual Max

Cascading frit for stage visibility/backdrop and reflection



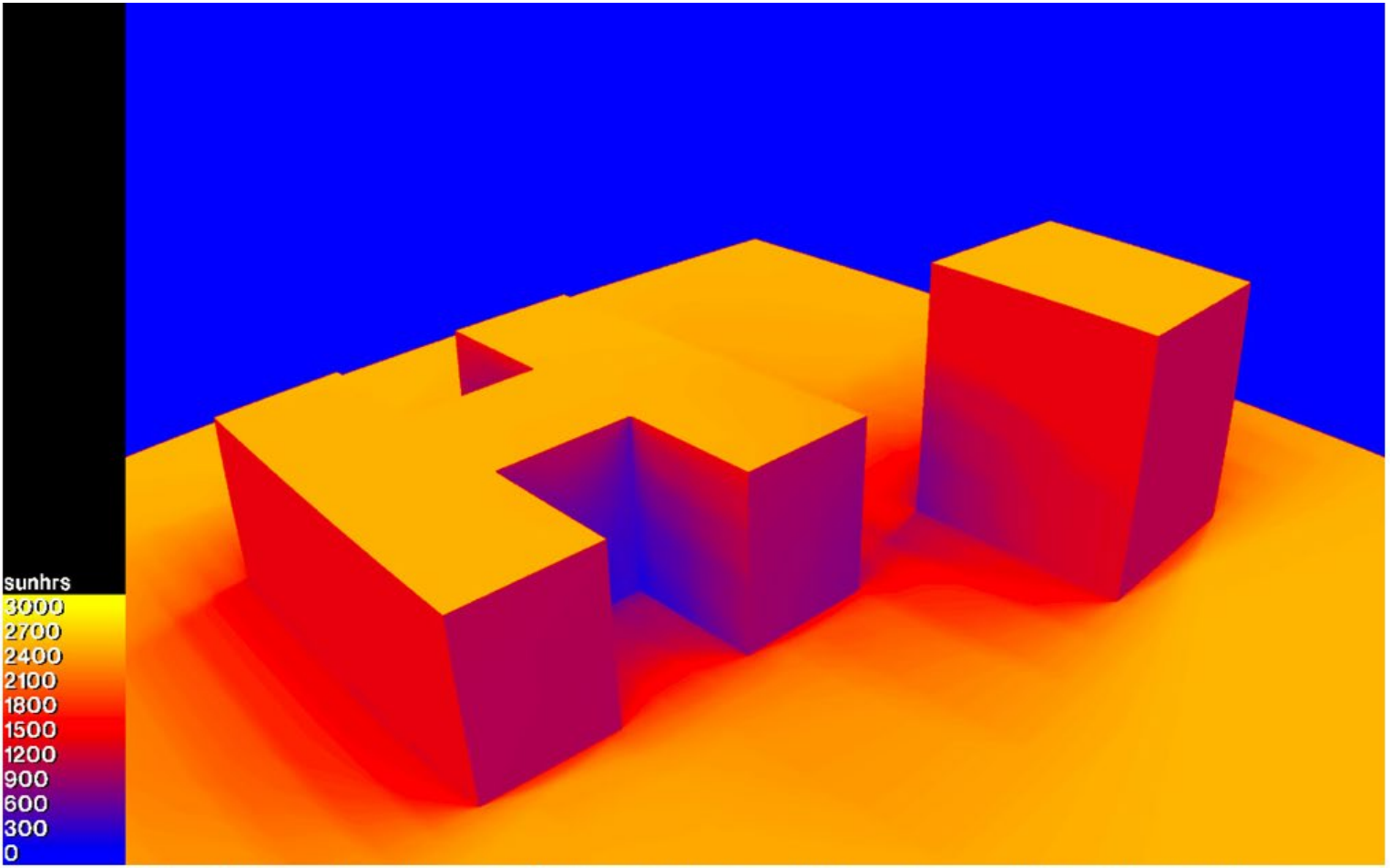
Ceiling Illuminance for sky projections

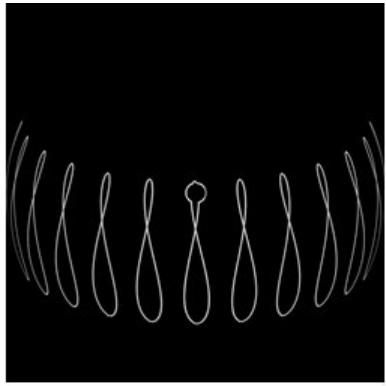


Annual Sky and Sun modeling

- Need for quicker and more accurate annual or periodic sky modeling
- Development of a sunband method over an ‘analemma’ sky
- Development of a new periodic cumulative sky for linux and windows
- Concept of ‘effective’ sunlight hours
- Dynamic 3d viewer implementation and new color maps
- Work in progress and in collaboration with Perkins and Will

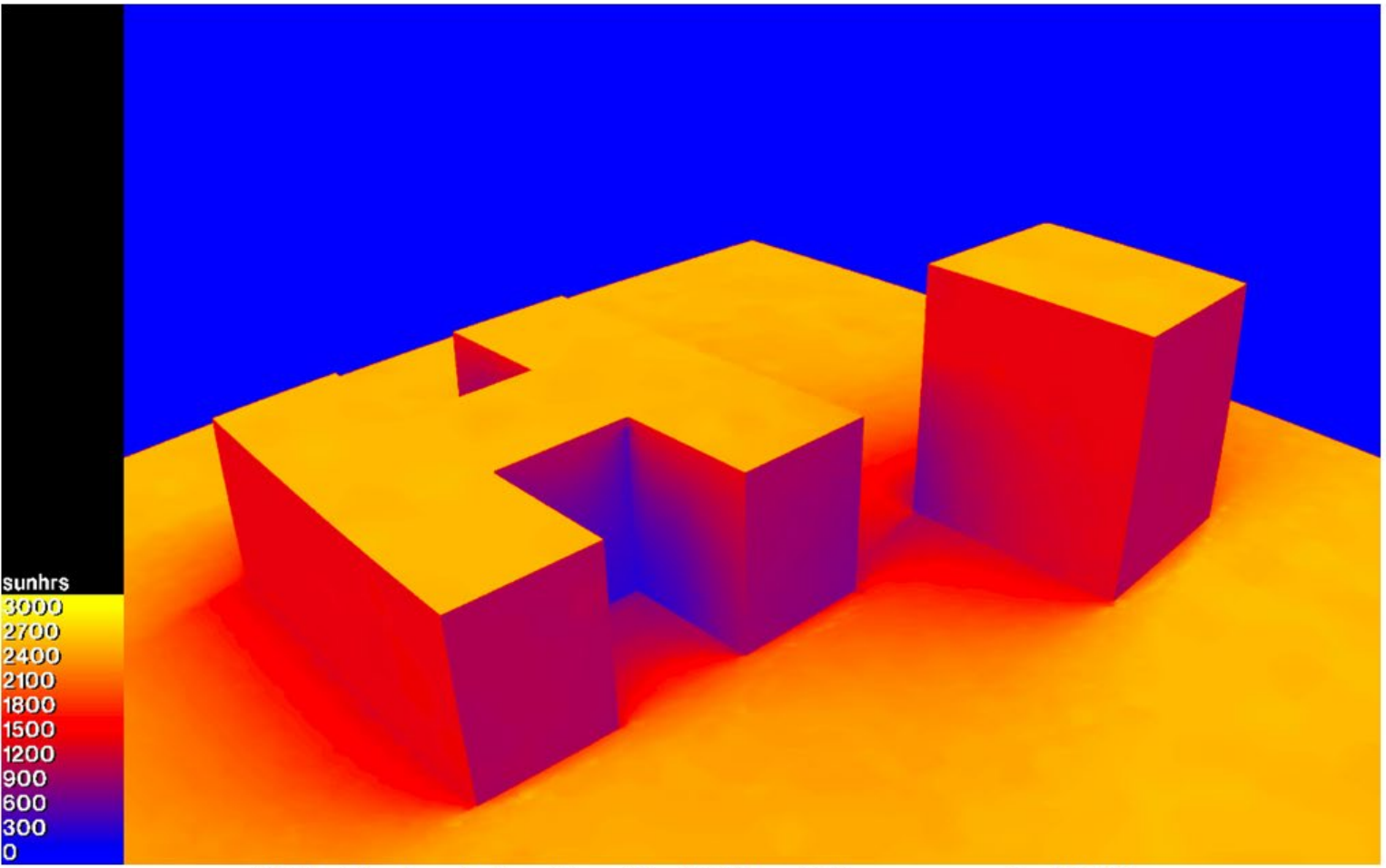
20deg Latitude – All suns

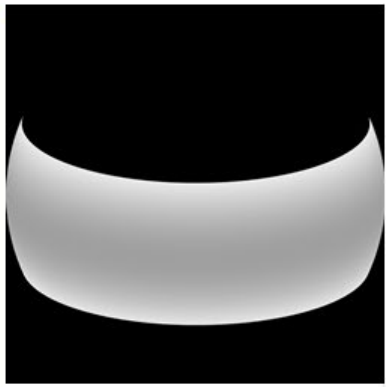




20° Lat All Suns *- Run Time: 1,040s+60s (17+1min) - Settings: hhh -ab 0 -ds 0 -dt 0 -dc 1 -dr 0*

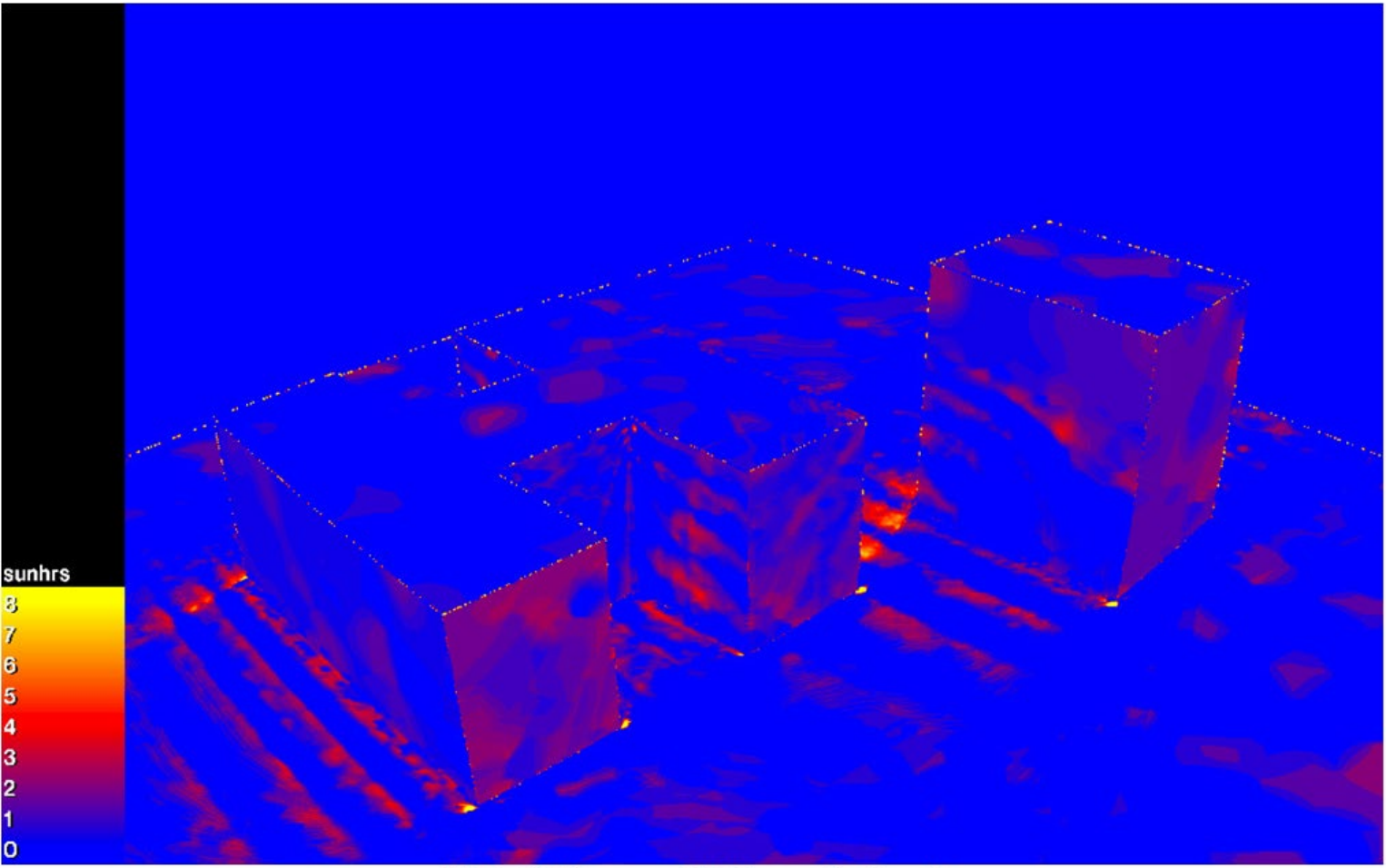
20deg Latitude – Sunband





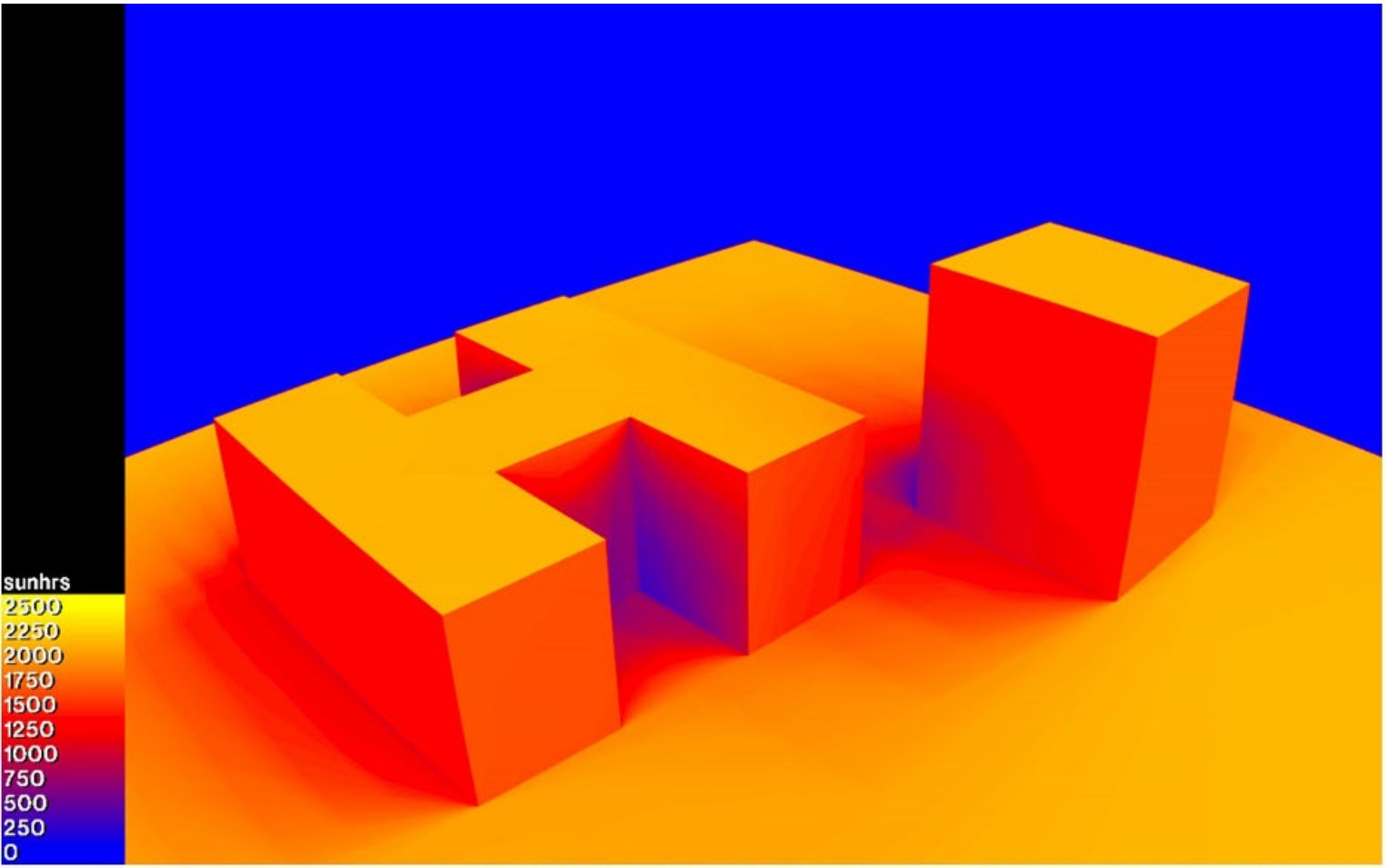
20° Lat Sunband *- Run Time: 21s (9+12) - Settings: mmm -af -ad 2048*

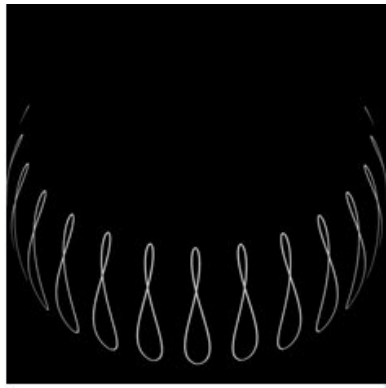
20deg Latitude – Difference



20° Lat Difference (All Suns - Sunband)

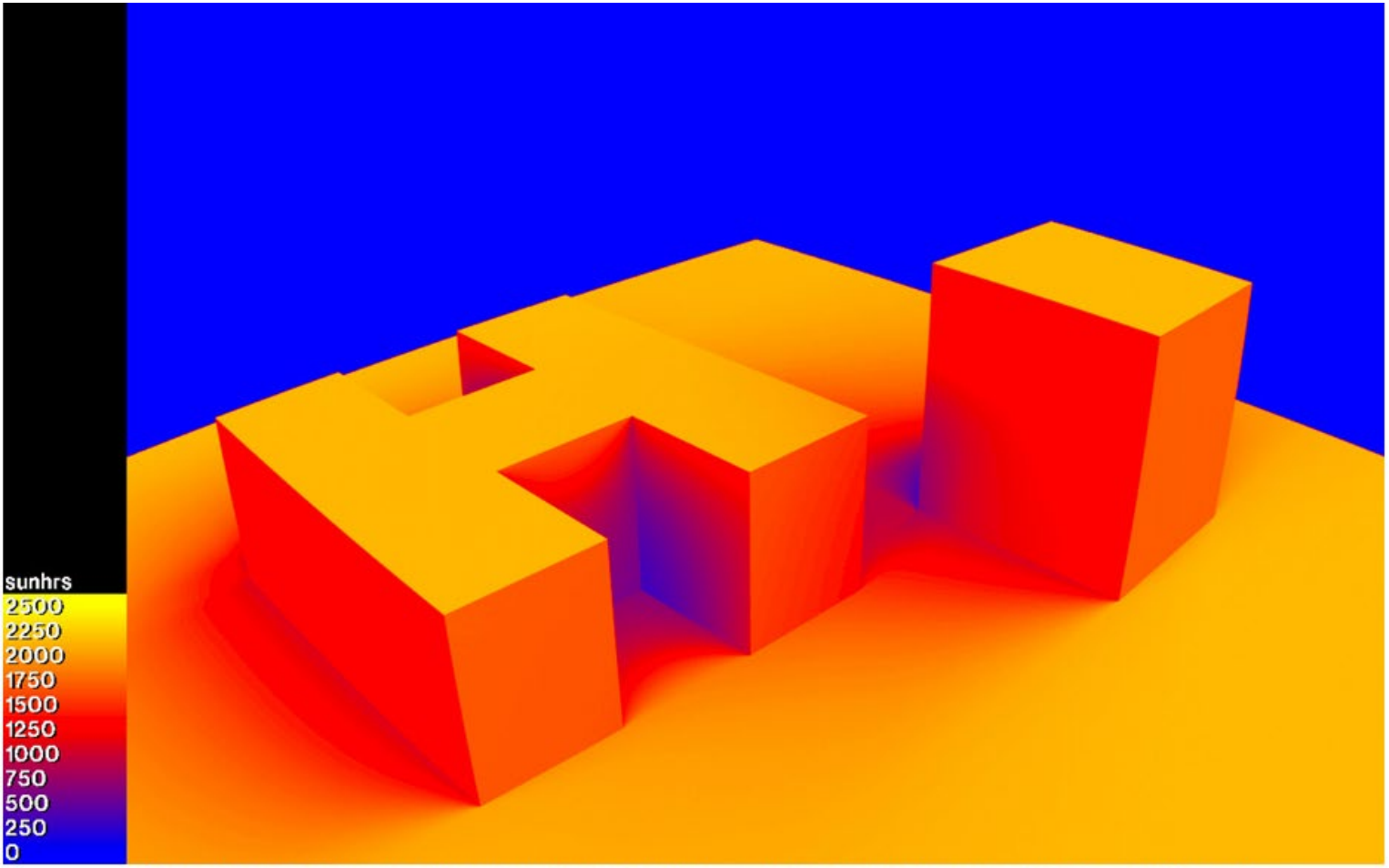
40deg Latitude – All suns

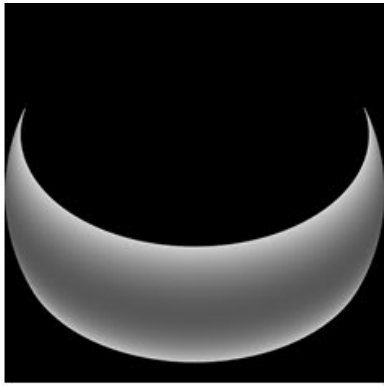




40° Lat All Suns *- Run Time: 1,040s+60s (17+1min) - Settings: hhh -ab 0 -ds 0 -dt 0 -dc 1 -dr 0*

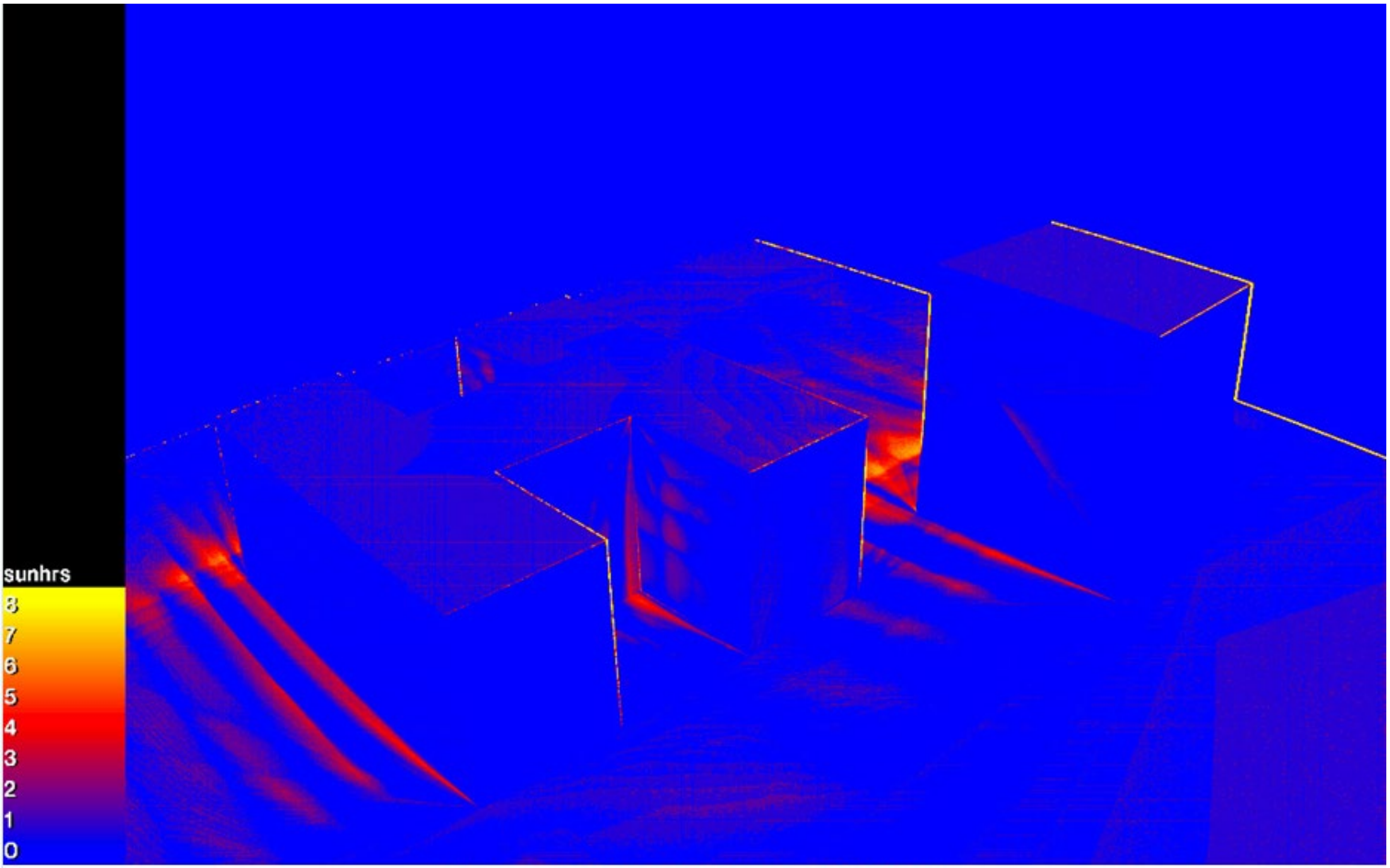
40deg Latitude – Sunband





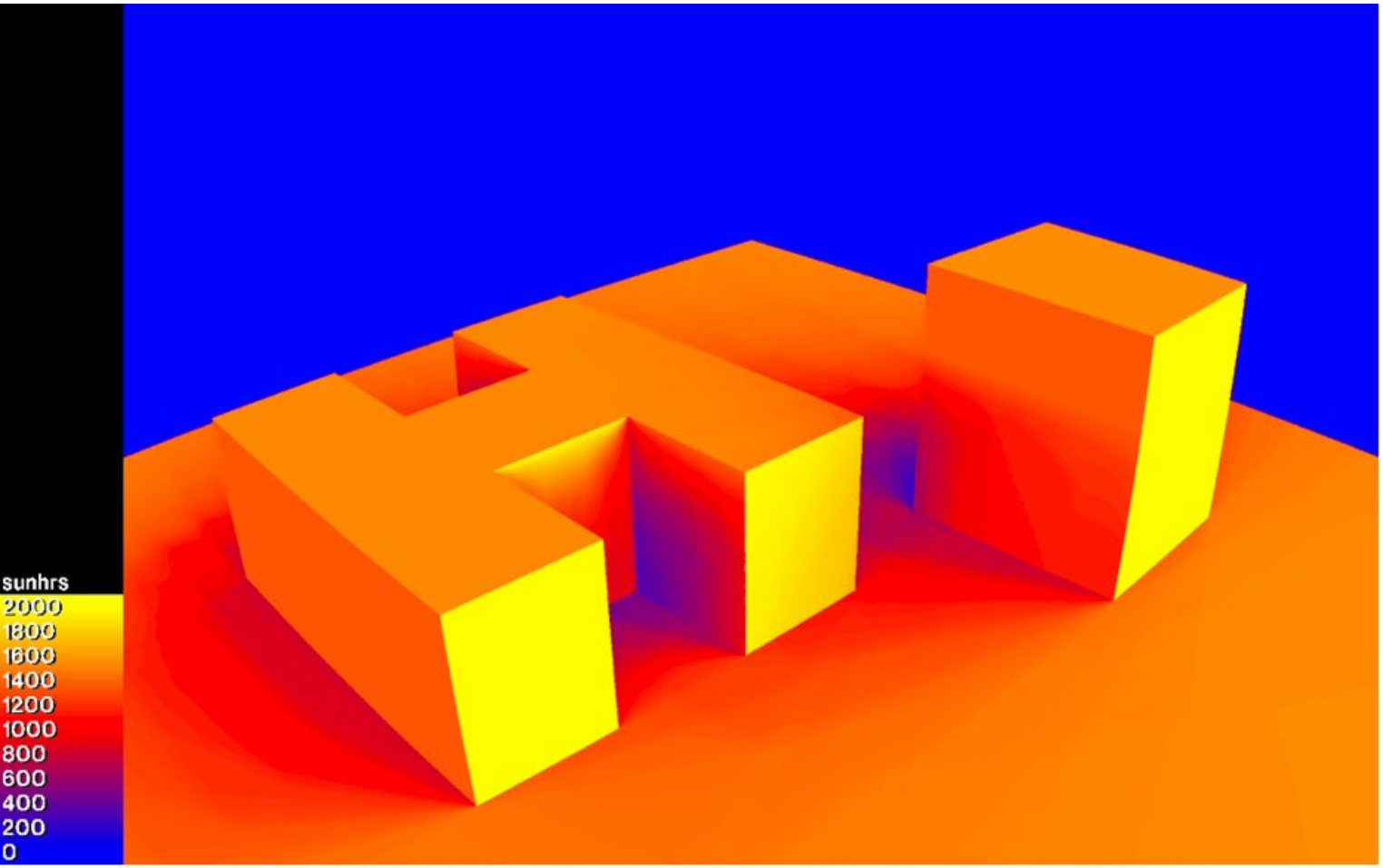
40° Lat Sunband *- Run Time: 71,212s (4.75hrs) - Settings: hhh -ab 1 -ad 8192 -ar 200 -aa 0*

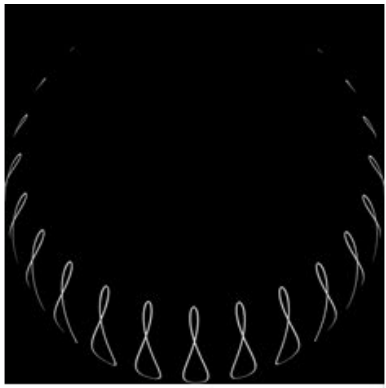
40deg Latitude – Difference



40° Lat Difference (All Suns - Sunband)

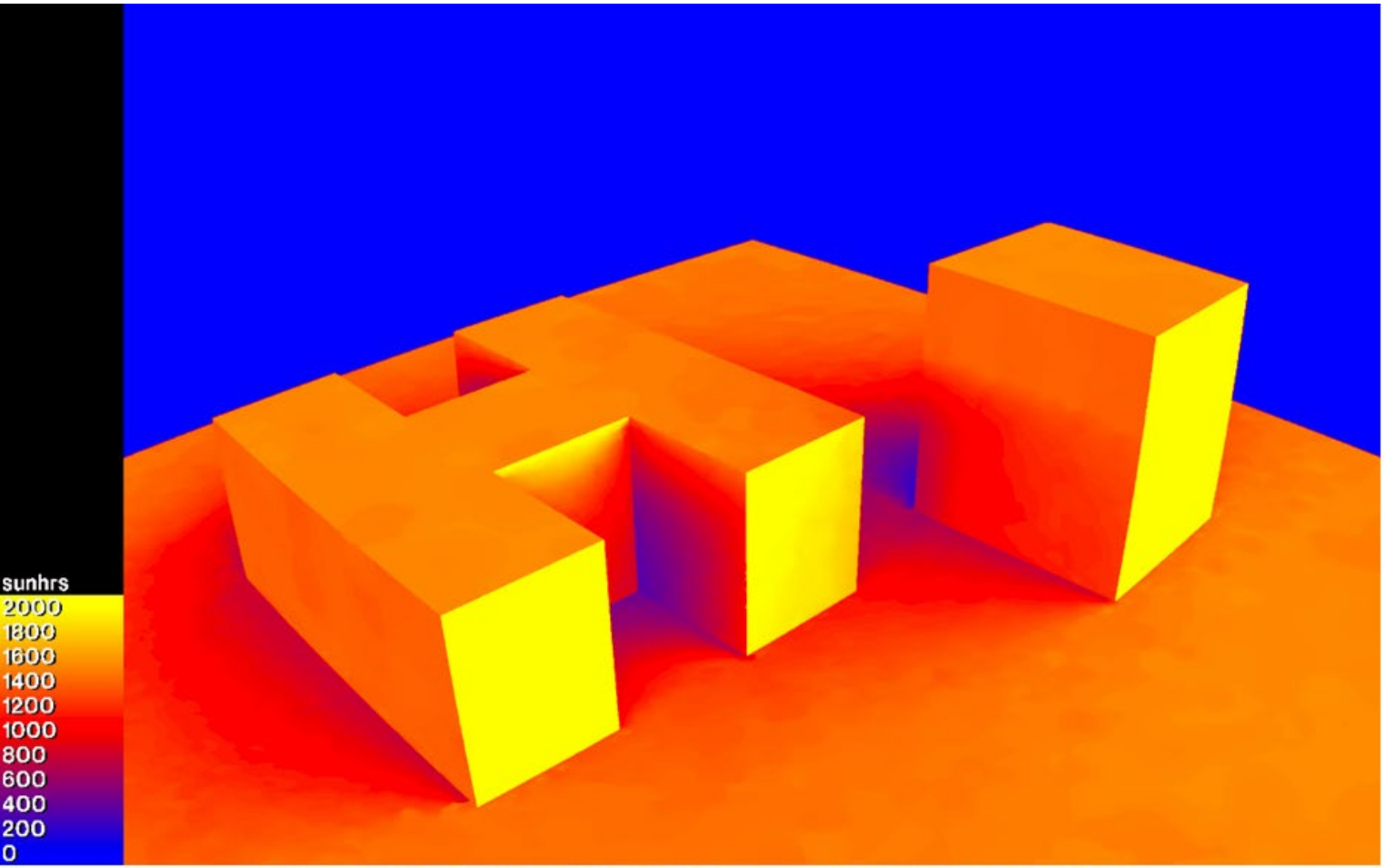
60deg Latitude – All suns





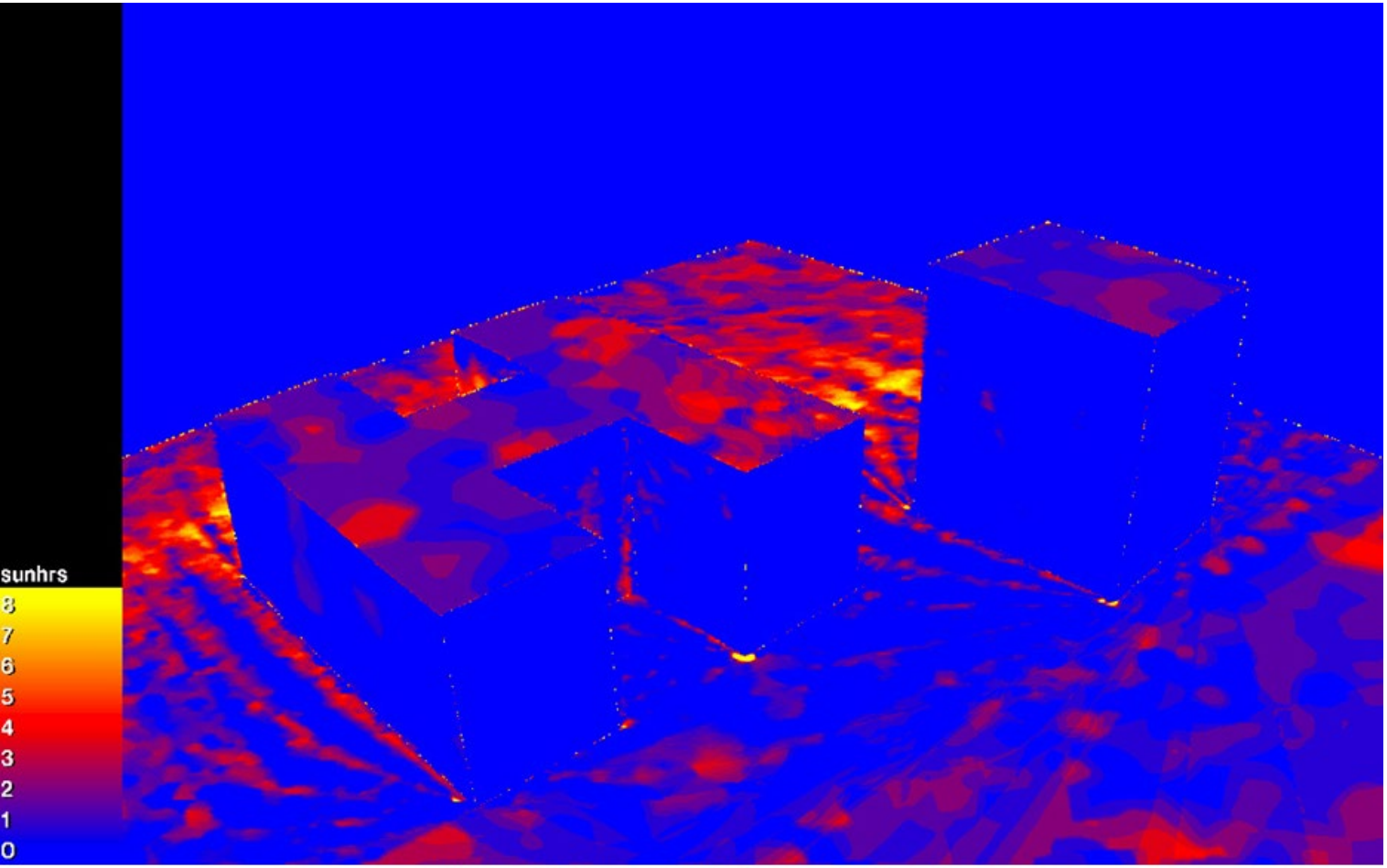
60° Lat All Suns *- Run Time: 186s+??s - Settings: mll -ab 0 -ds 0 -dt 0 -dc 1 -dr 0*

60deg Latitude – Sunband



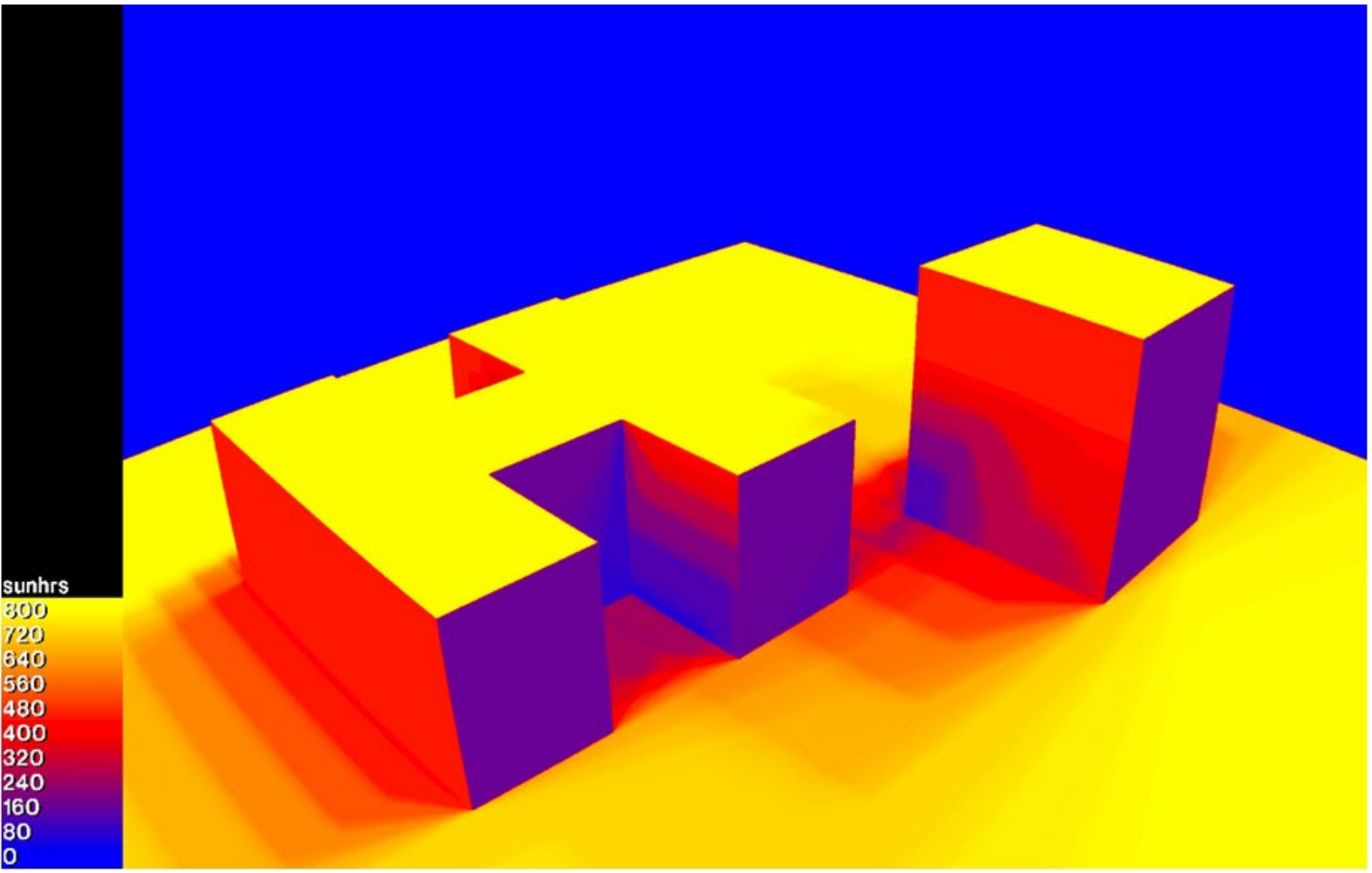
60° Lat Sunband *- Run Time: 23s (9+14) - Settings: mmm -af -ad 2048*

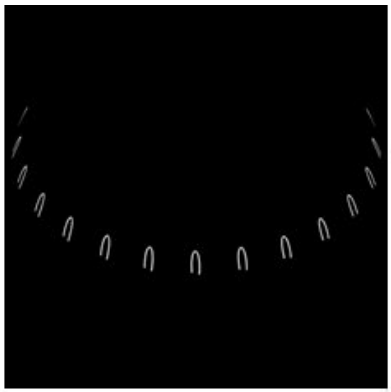
60deg Latitude – Difference



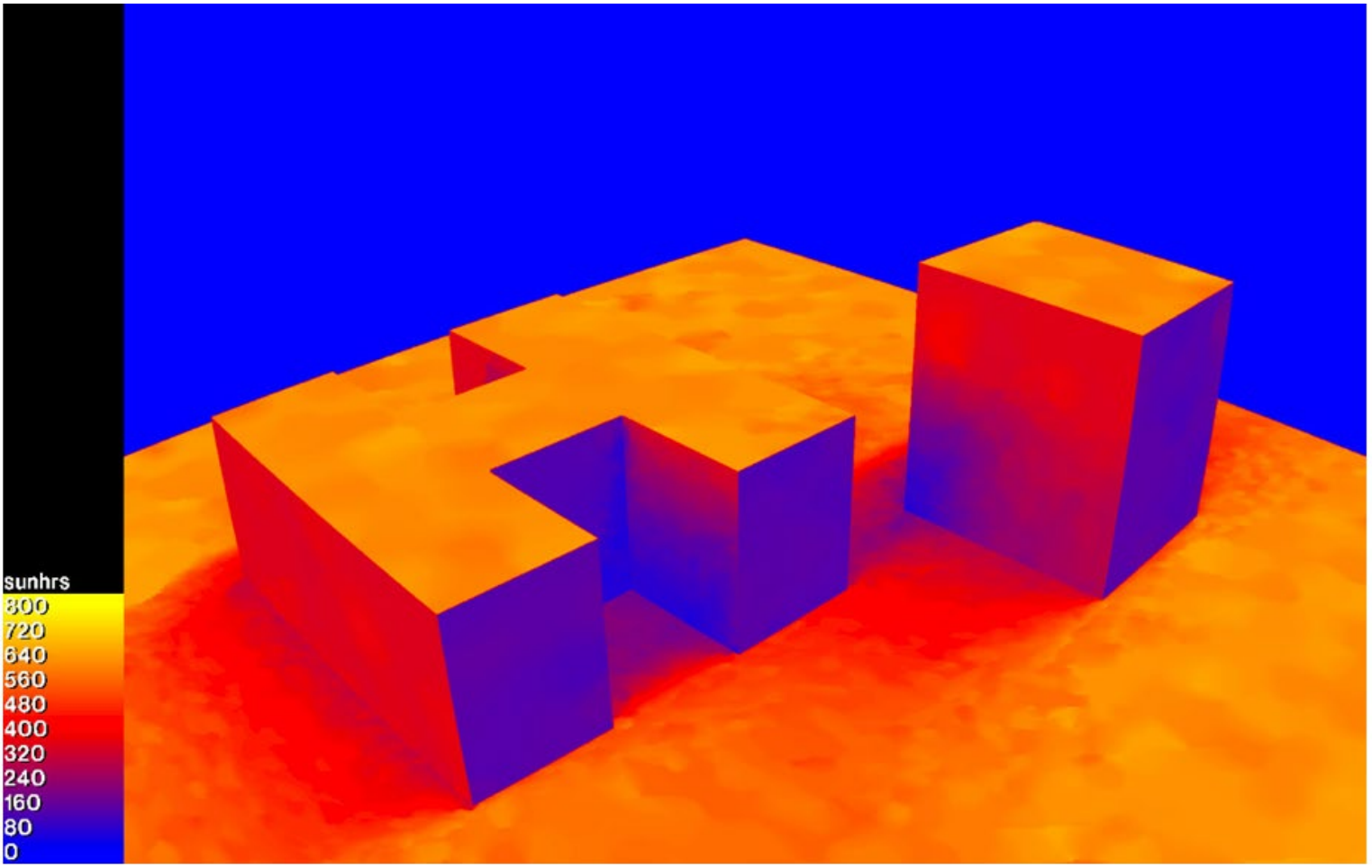
60° Lat Difference (All Suns - Sunband)

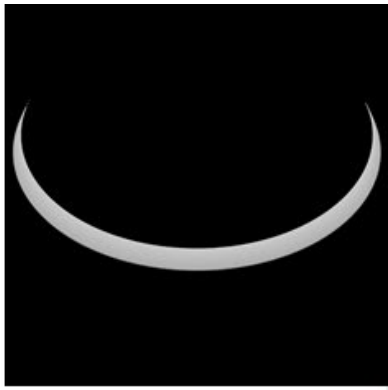
40deg Latitude – All summer suns



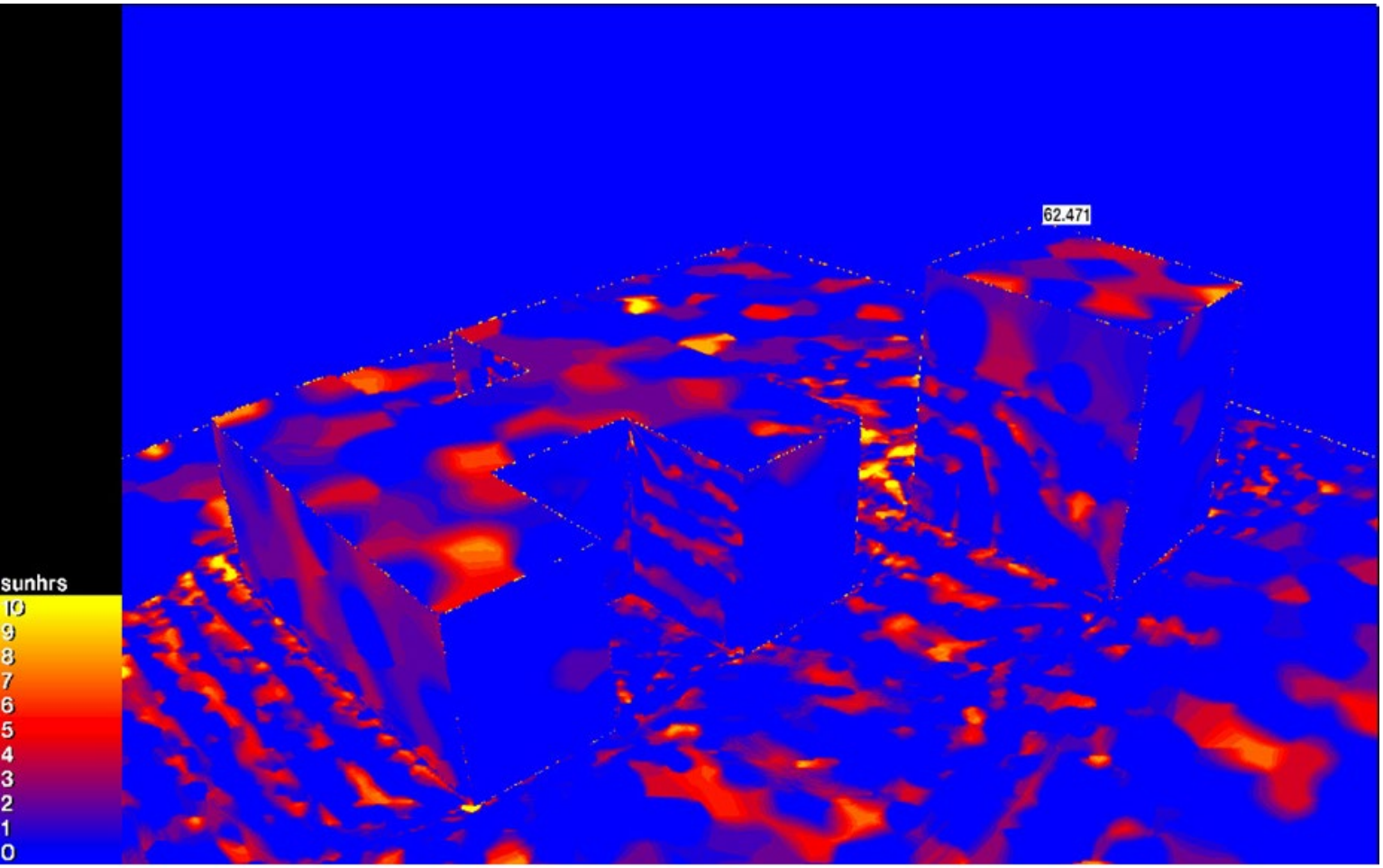


40deg Latitude – Summer Sunband

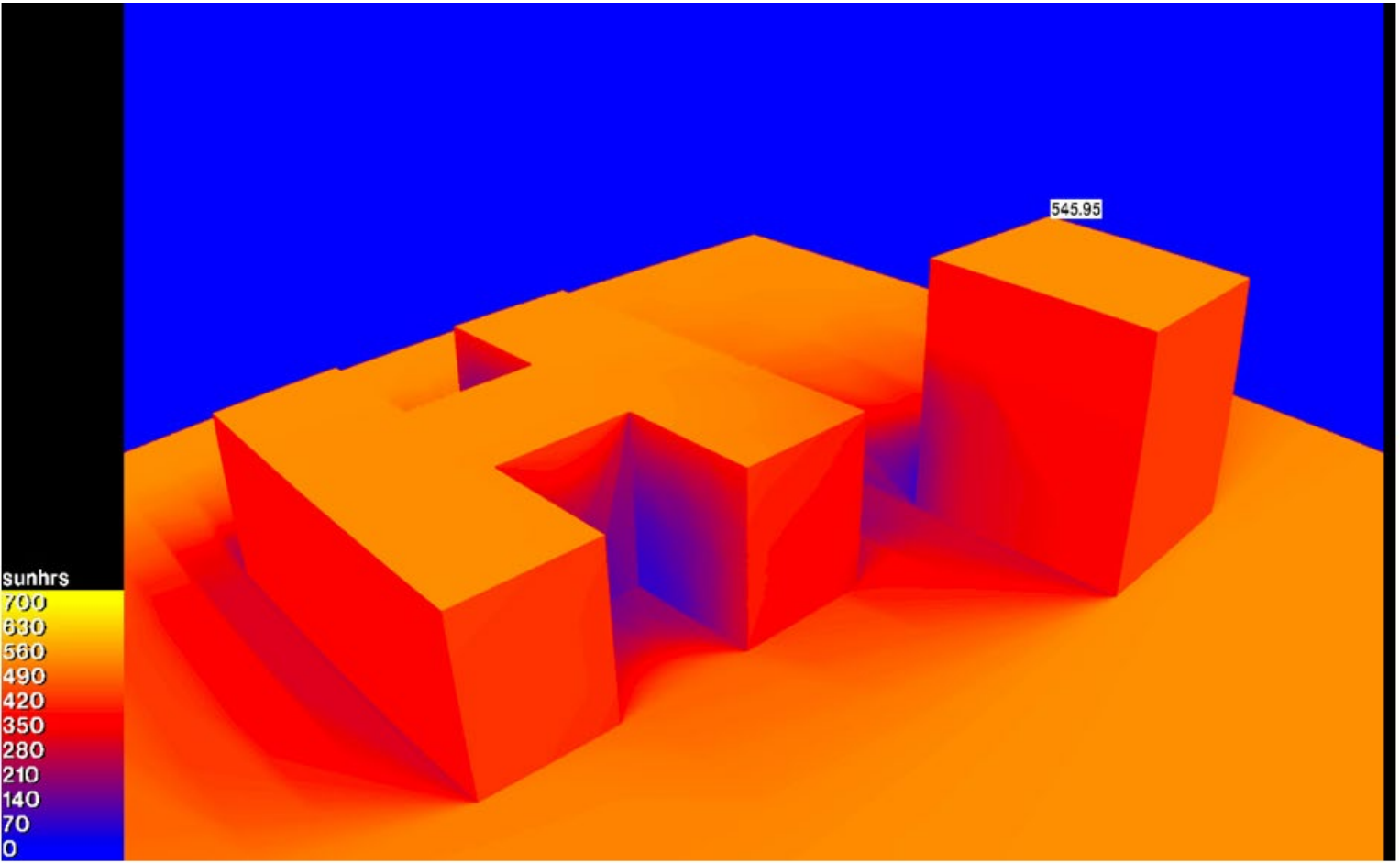


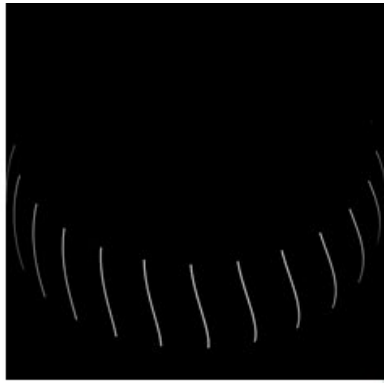


40deg Latitude – Summer Difference

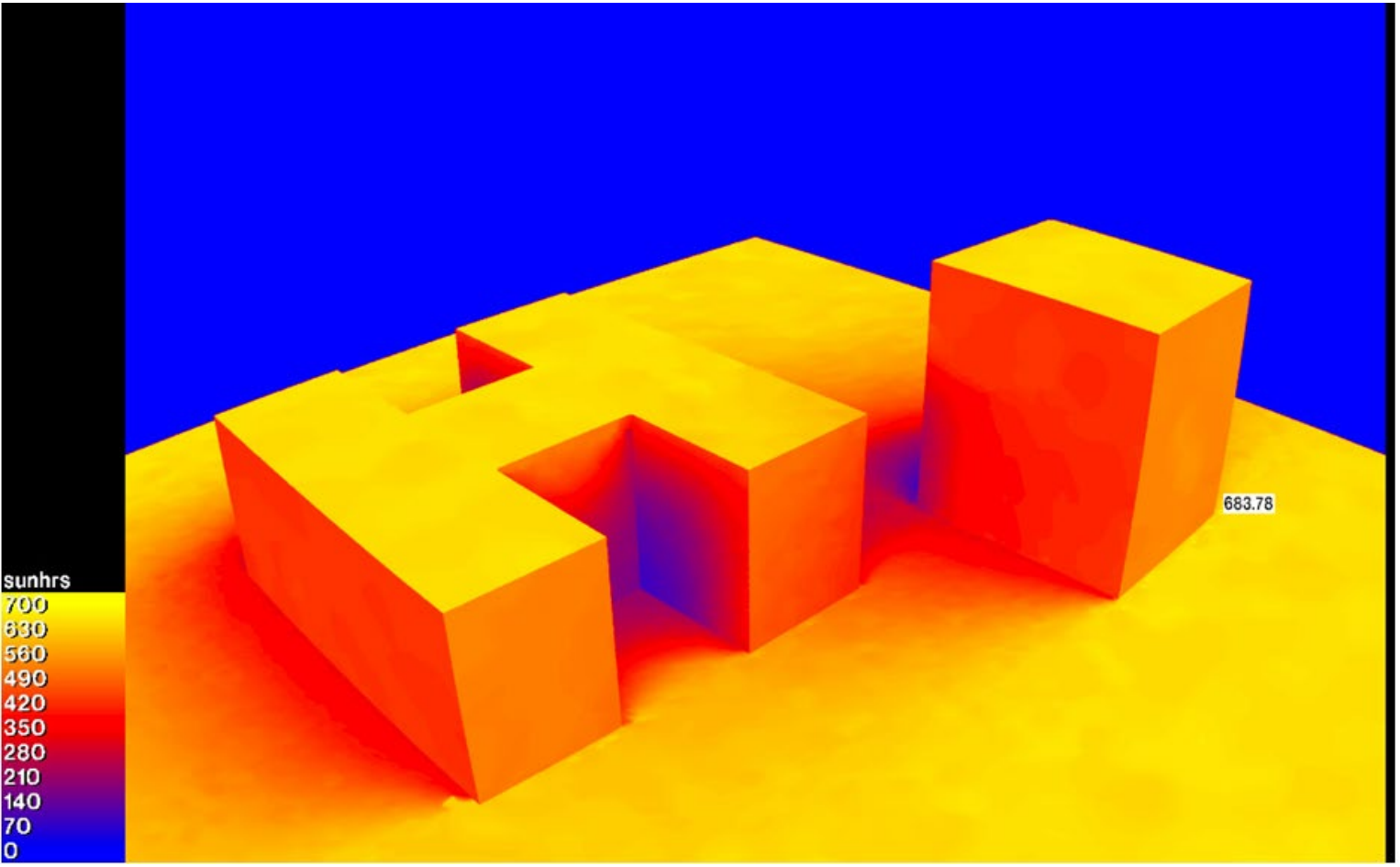


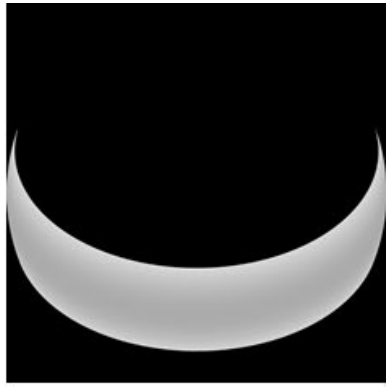
40deg Latitude – All fall suns



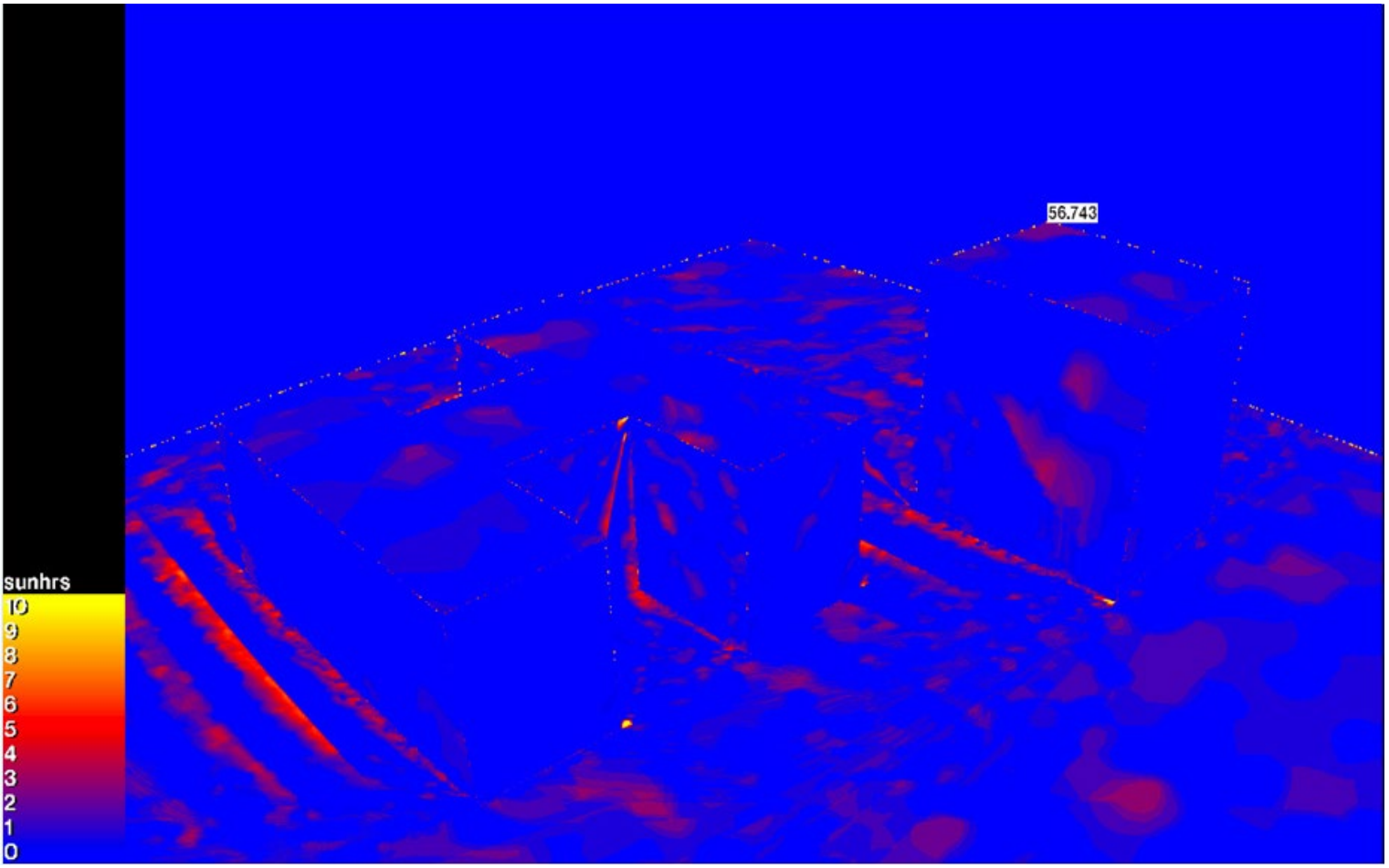


40deg Latitude – Fall Sunband

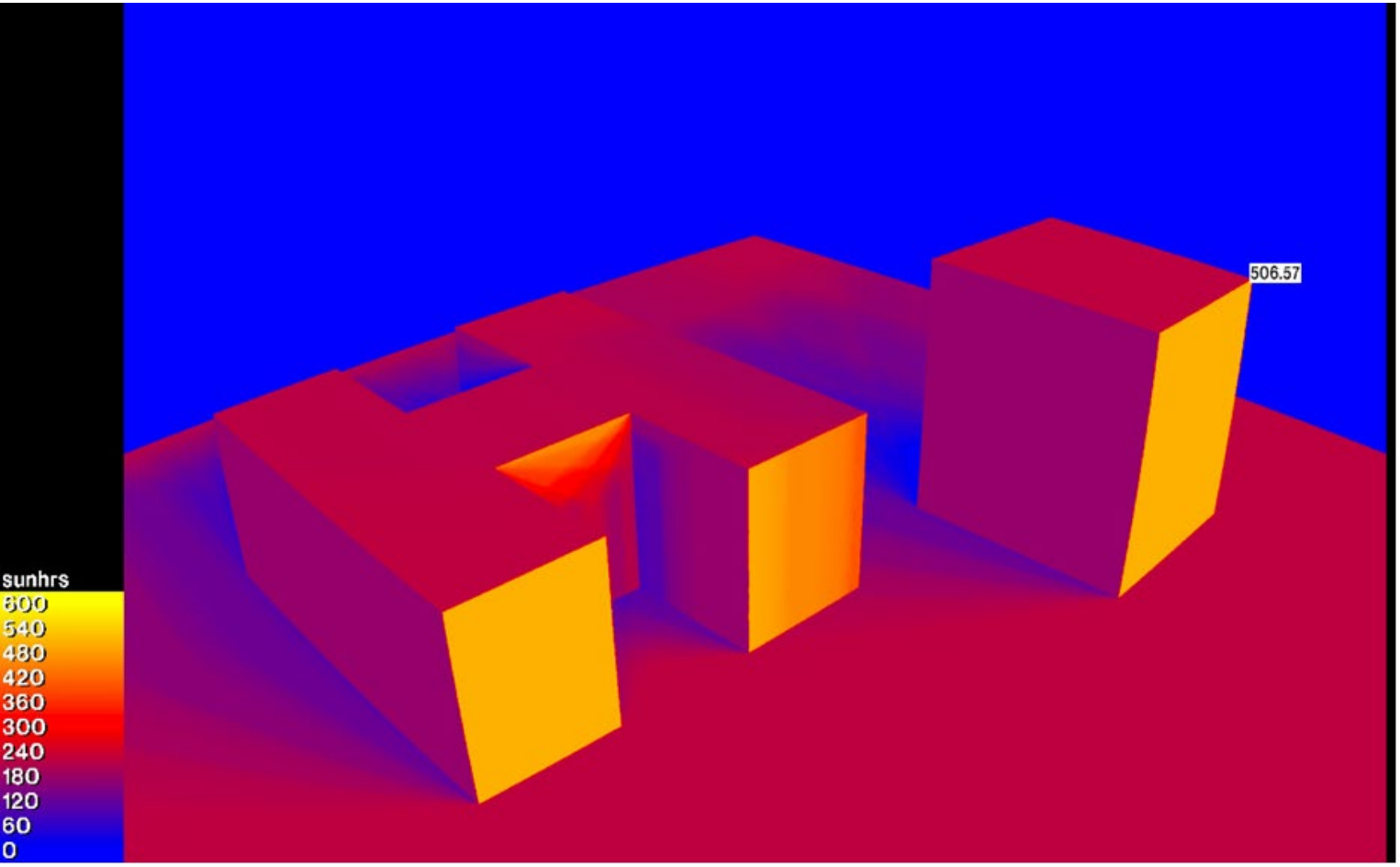


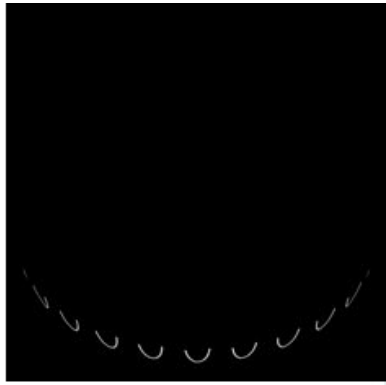


40deg Latitude – Fall Difference

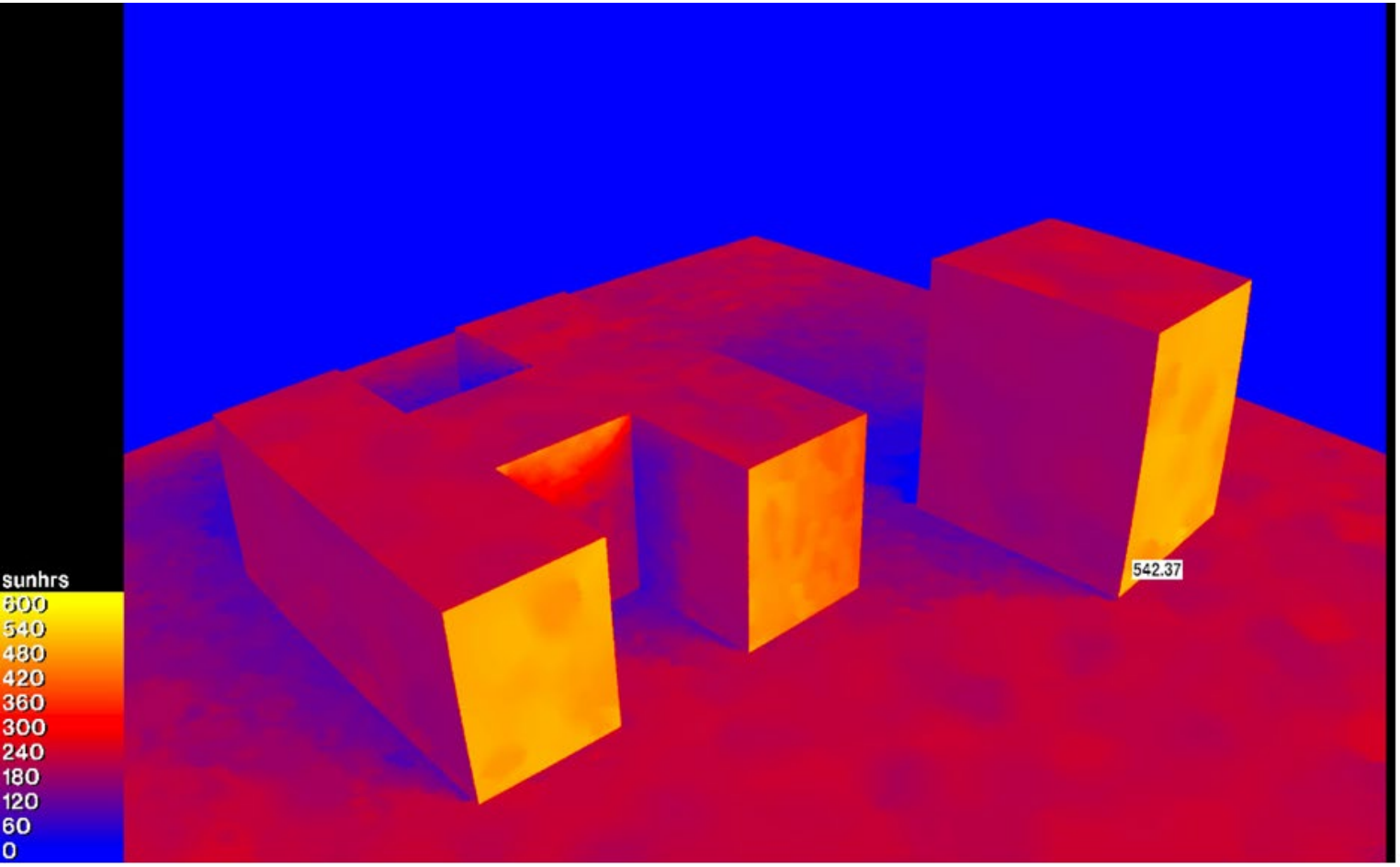


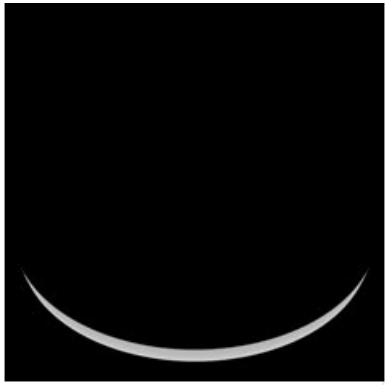
40deg Latitude – All winter suns



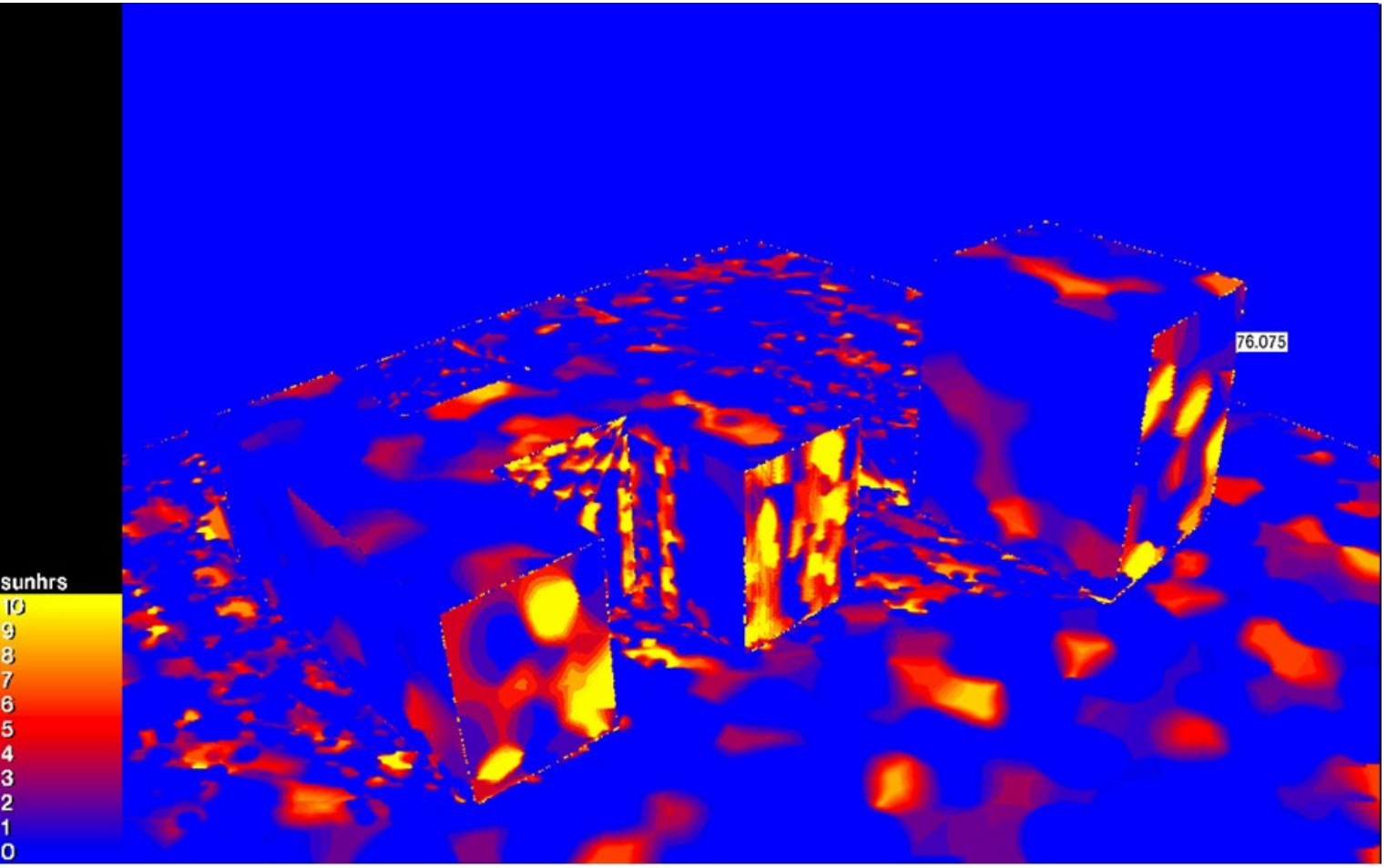


40deg Latitude – Winter Sunband

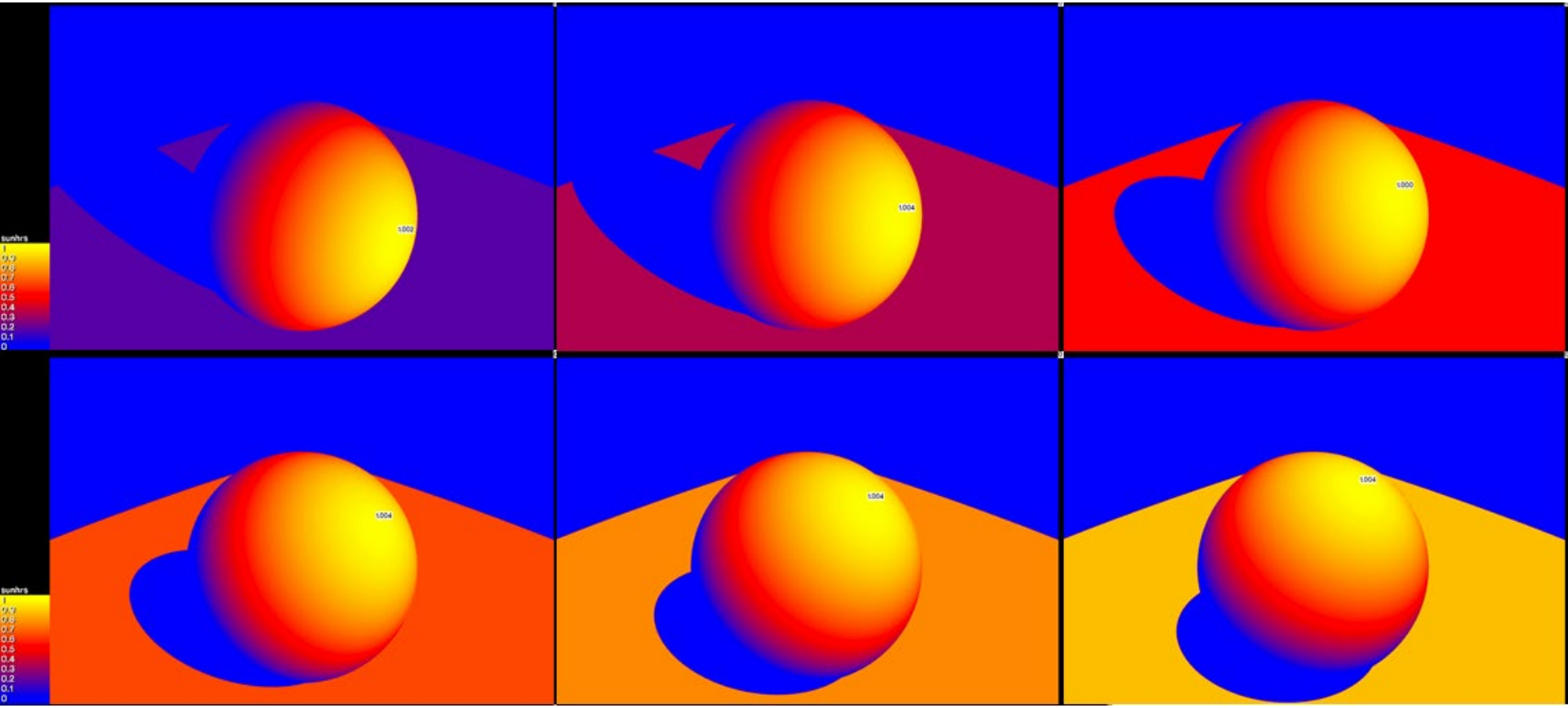




40deg Latitude – Winter Difference

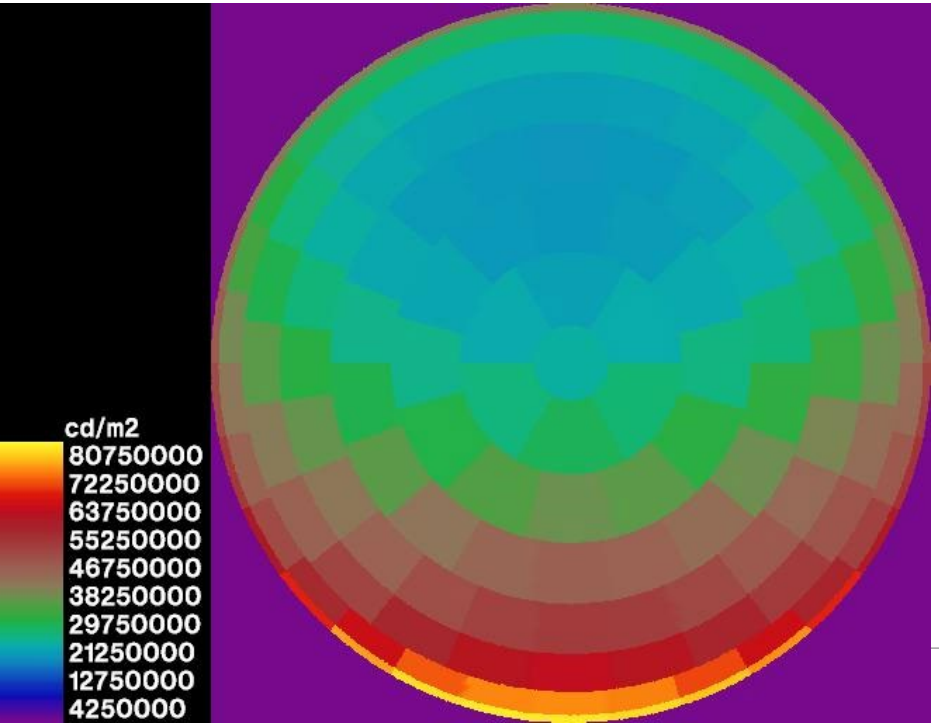


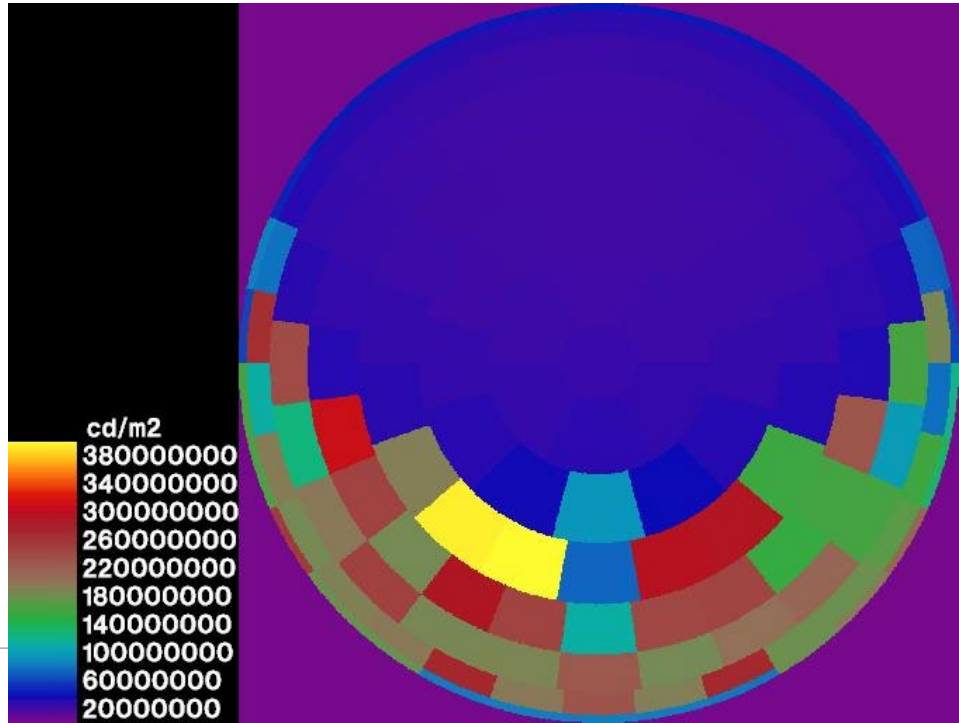
Effective Sun Hours



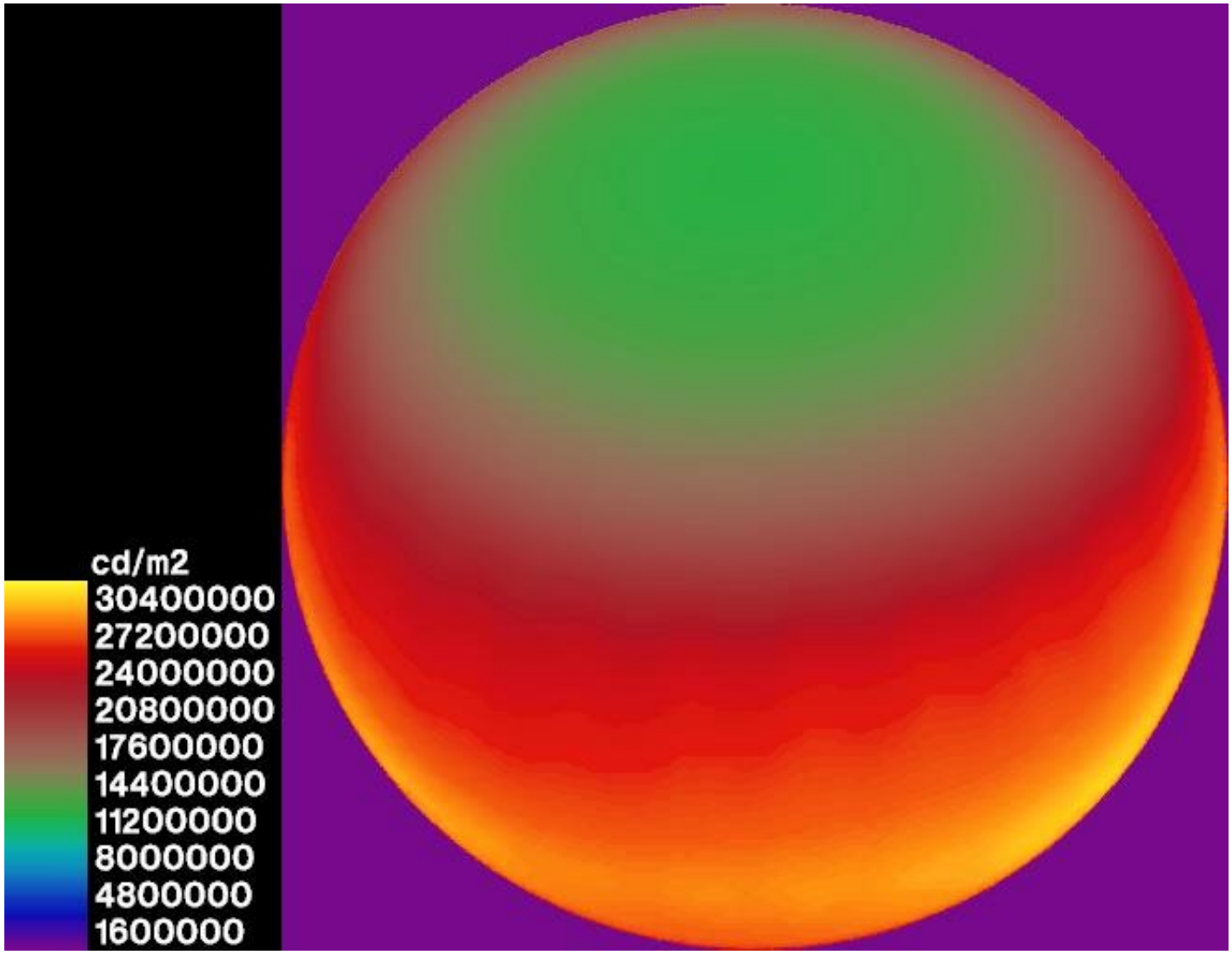
Historical options for annual sky

- GenCumulativeSky.exe
  - Two options – sky only or with solar radiation assigned to patches
  - Very quick <5sec
- Radmap.py
  - Integrated into script to produce radiation maps for a scene
  - Takes a while to simulate 1-5min

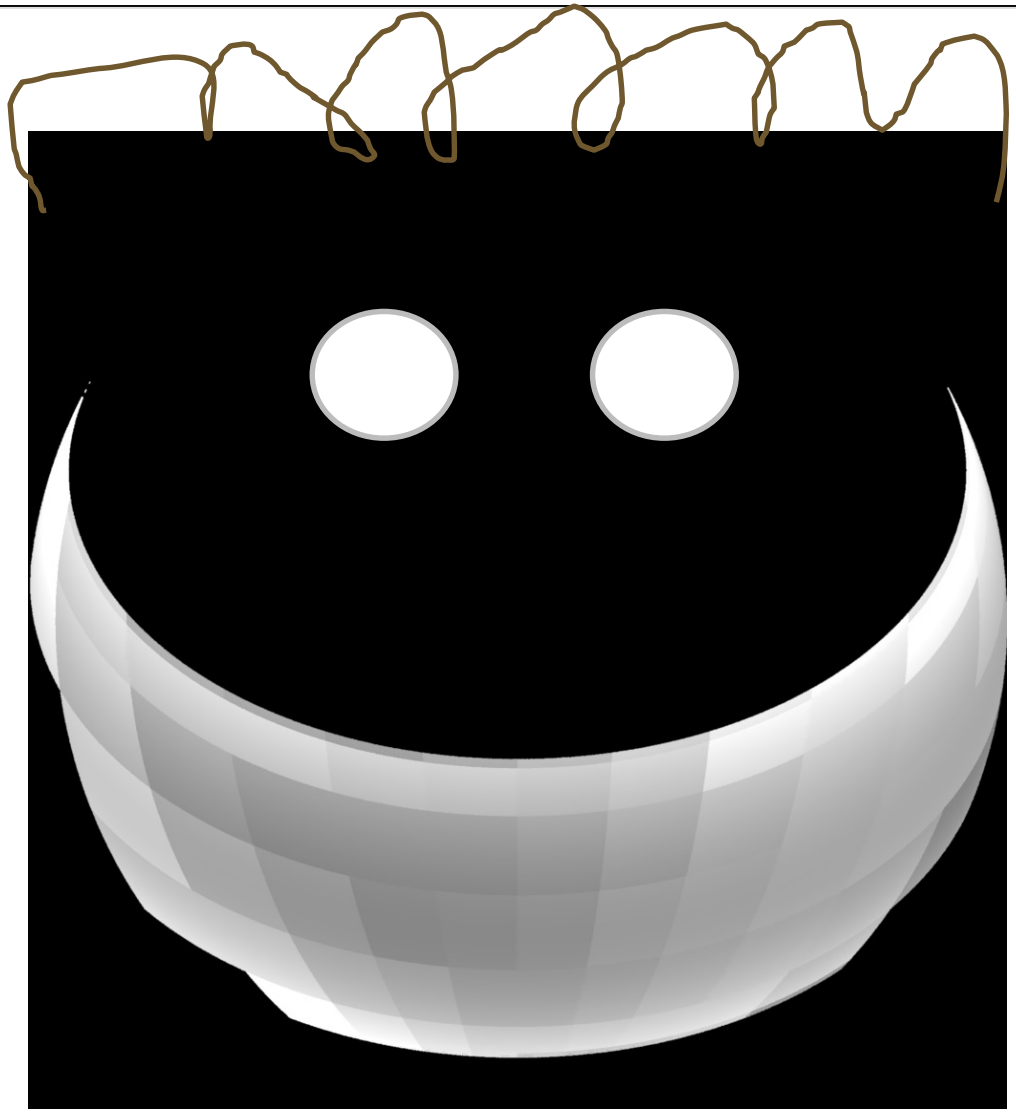




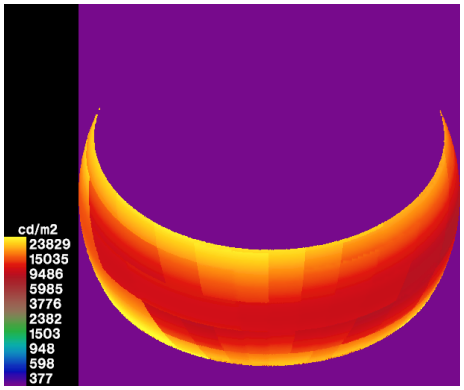
New Cumulative sky generator – WEA_gensky.py



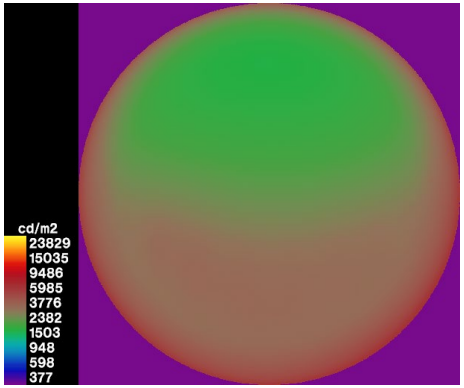
Sunband Weighted by Cloud Cover

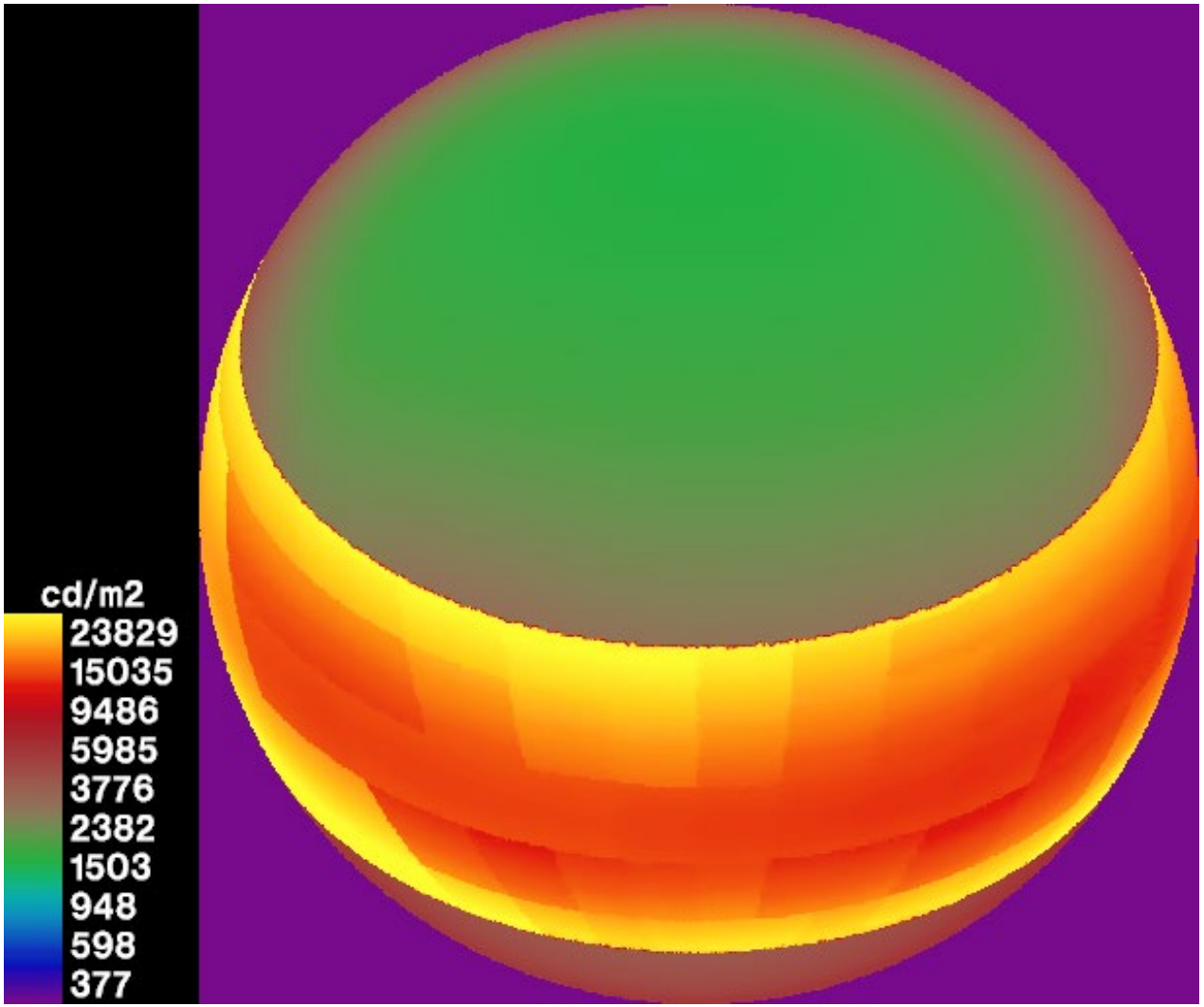


Final Annual Sky and Sunband combined

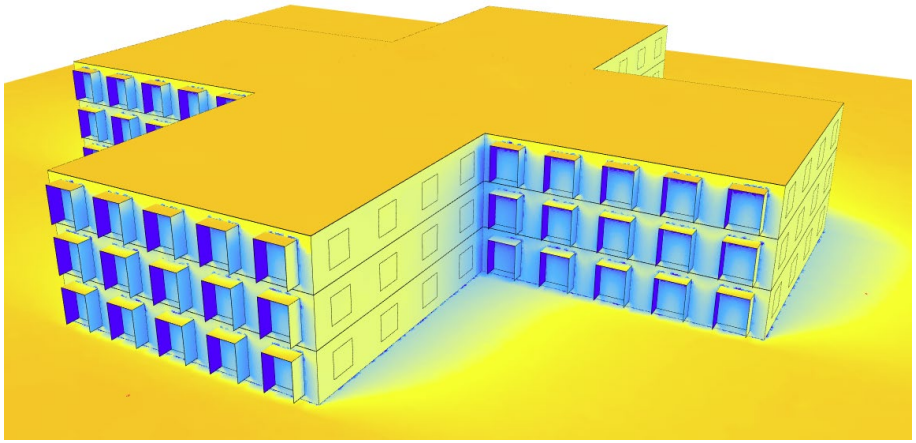


+

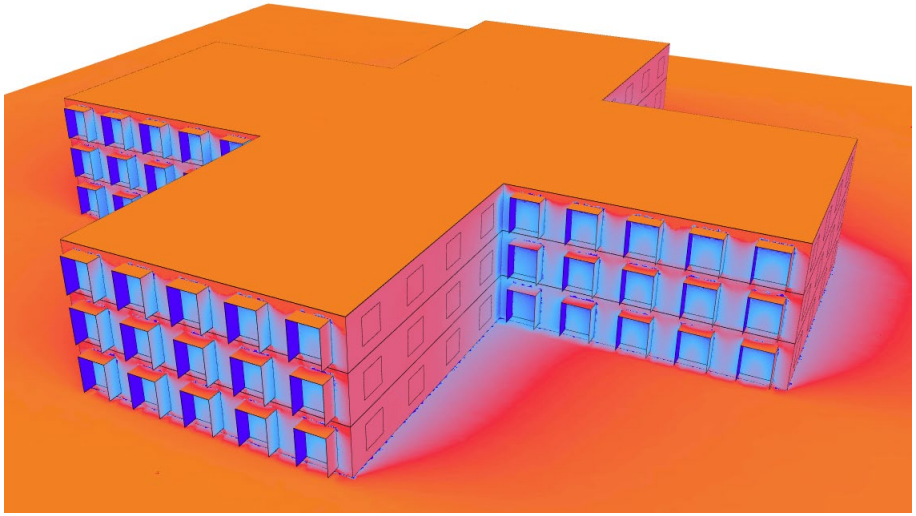




Dynamic 3d implementation with new color maps



Solar radiation with ‘cool 2 hot’ color map



Effective sunhours with ‘sunhr’ color map

IESNA Daylight Modeling and Simulation Standards

- Daylight Modeling and Simulation Task Group
  - Task group for the larger IESNA Daylighting Metrics committee
  - Focused on modeling and simulation methods and standards

- Goal to release a Technical Memorandum (TM-XX) in Spring 2020
  - Overall outline and gold standards
  - With areas of assumption needing further research highlighted

- Continued development through 2020-2021 with interim Committee Reports (CR) as necessary

- Ultimately developed into an IESNA Lighting Practice (LP-XX) document

IESNA Daylight Modeling and Simulation standards

1. Purpose/Background
2. Daylight Modeling Methods and Standards
   - i. Sun and Sky Models
   - ii. Surface and Material Modeling
   - iii. Site and Surroundings
   - iv. Fenestration and Window Treatments
   - v. Interior geometry
3. Simulation for Daylight Sufficiency – Methods and Standards
   - i. Shading control simulation standards
   - ii. Periodic simulation methods
   - iii. Simulation settings
   - iv. Daylight responsive electric lighting control
   - v. Simulation output standards
   - vi. Daylight sufficiency metrics
   - vii. Whole building energy predictions
   - viii. Simulation for plants / animals / artwork preservation

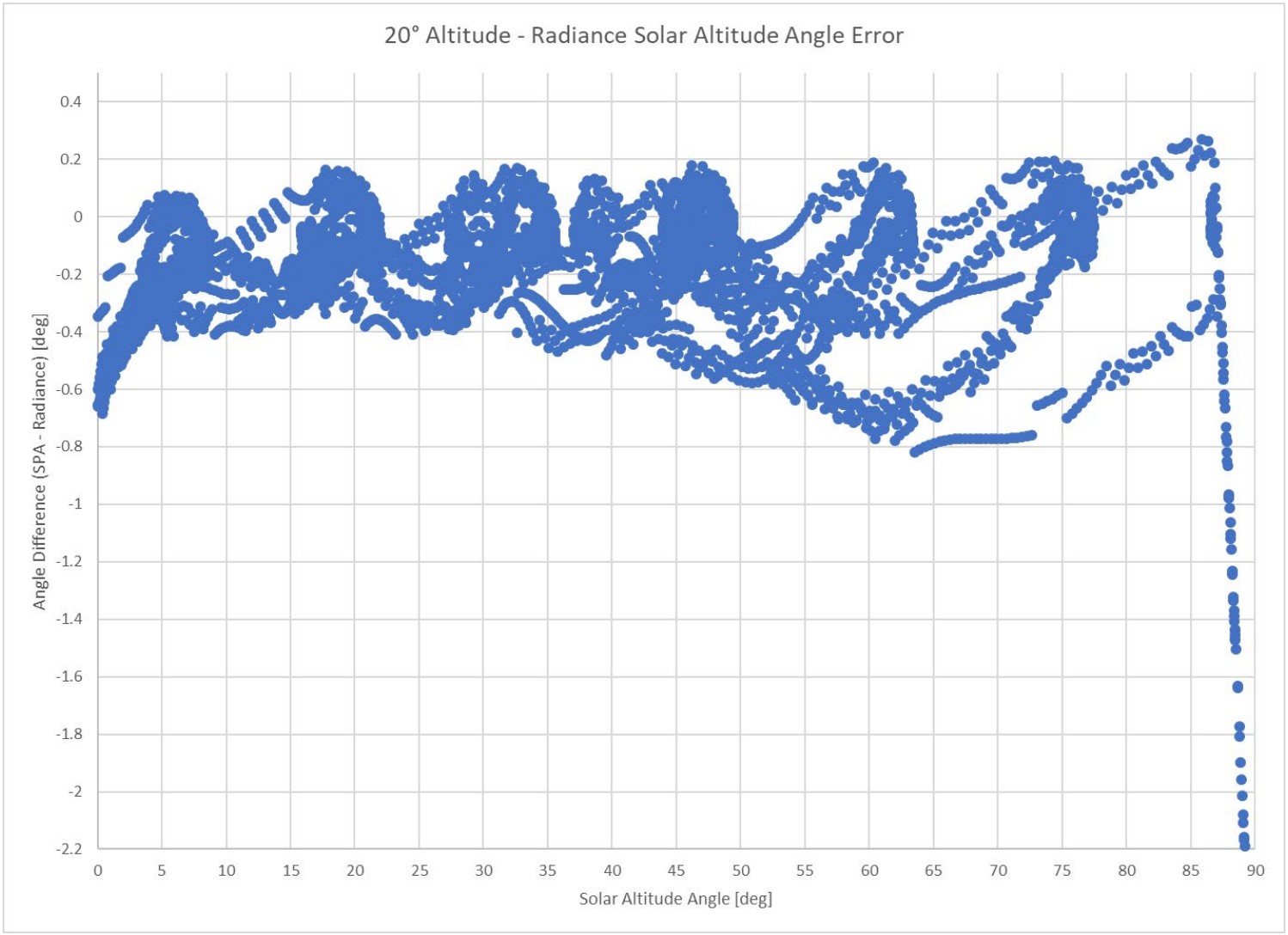
IESNA Daylight Modeling and Simulation standards

4. Simulation for Daylight Quality – Methods and Standards
   i. Representative time and daylight condition standards
   ii. Spatial and orientation standards
   iii. Simulation setting adjustments
   iv. Glare analysis methods and standards
   v. Circadian Rhythm Simulation
5. Test Cases
   i. Test Case Geometry
   ii. Sufficiency test cases
   iii. Whole building energy test cases
   iv. Qualitative test cases

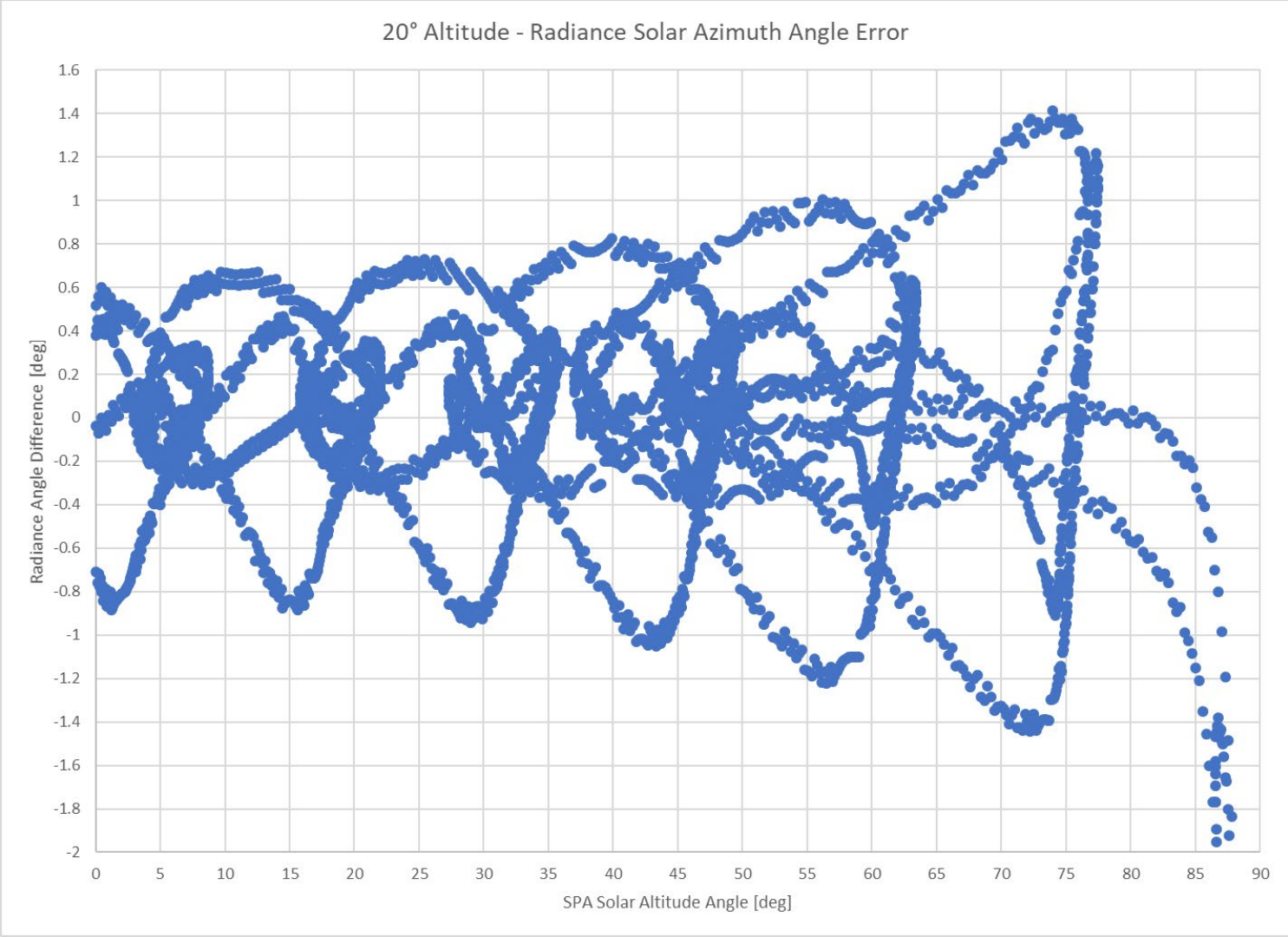
NREL Solar Position Algorithm vs Radiance Solar

- Comparison of NREL's Solar Position Algorithm vs. the Spencer-Moon equations in Radiance
- Good news – altitude angles and azimuth angles are largely within +/- 1° - likely very little impact on daytime calculations
- Less good news – possible bigger impact on the number of annual daylit hours
  - 20° lat – 4,436 (SPA) vs 4,414 (Rad) daylit hrs – 22 hrs lost!
  - 40° lat – 4,428 (SPA) vs 4,388 (Rad) daylit hrs – 40 hrs lost!
  - 60° lat – 4,478 (SPA) vs 4,394 (Rad) daylit hrs – 84 hrs lost!
- Daytime hours are not always ½ of 8760 or 4380 due to refraction from the atmosphere – places on article circle have most (4,647hrs)
- What to do? Update radiance code with year input that turns on SPA

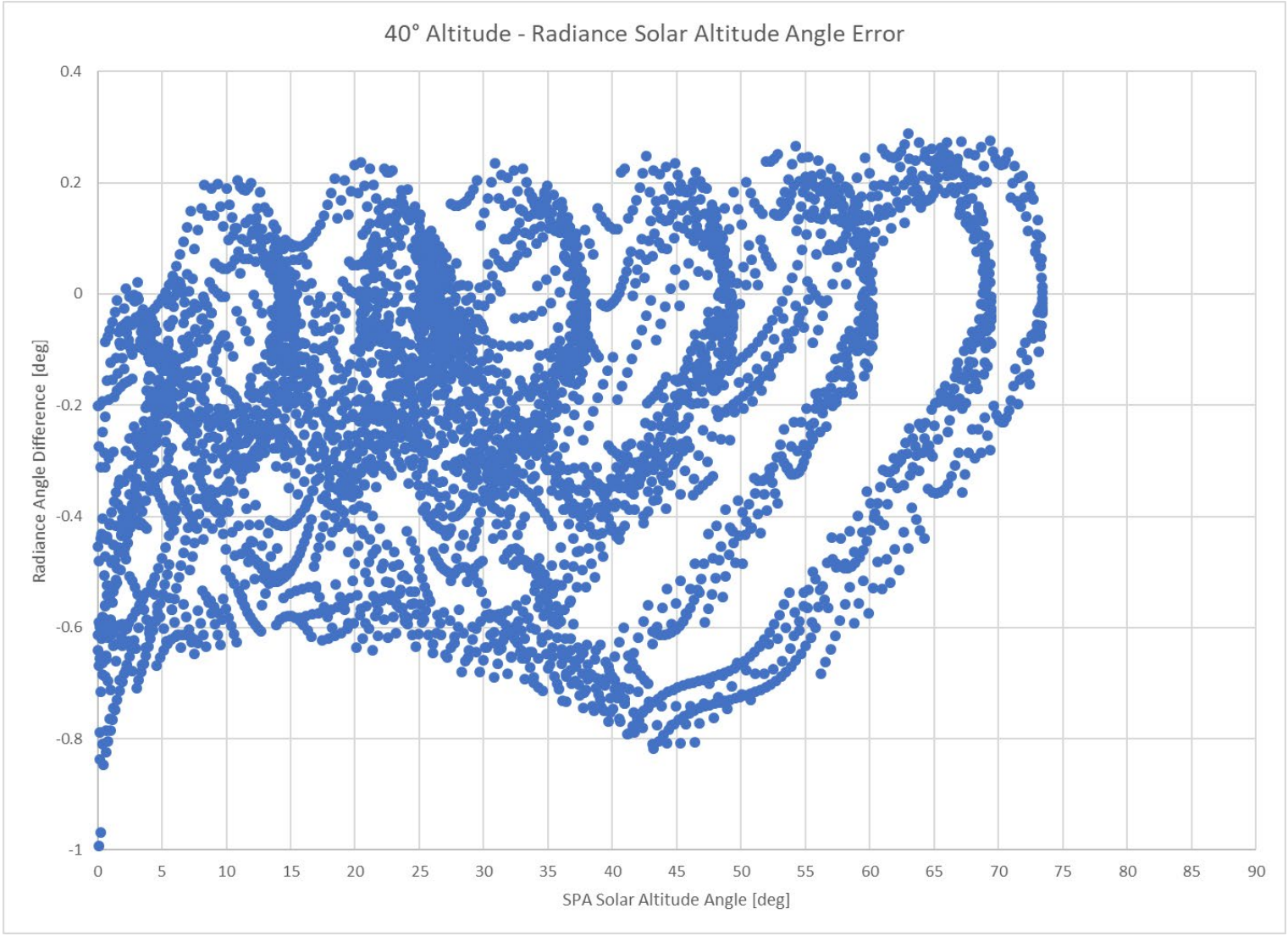
20° Latitude Altitude Angle Error – 22 lost hours



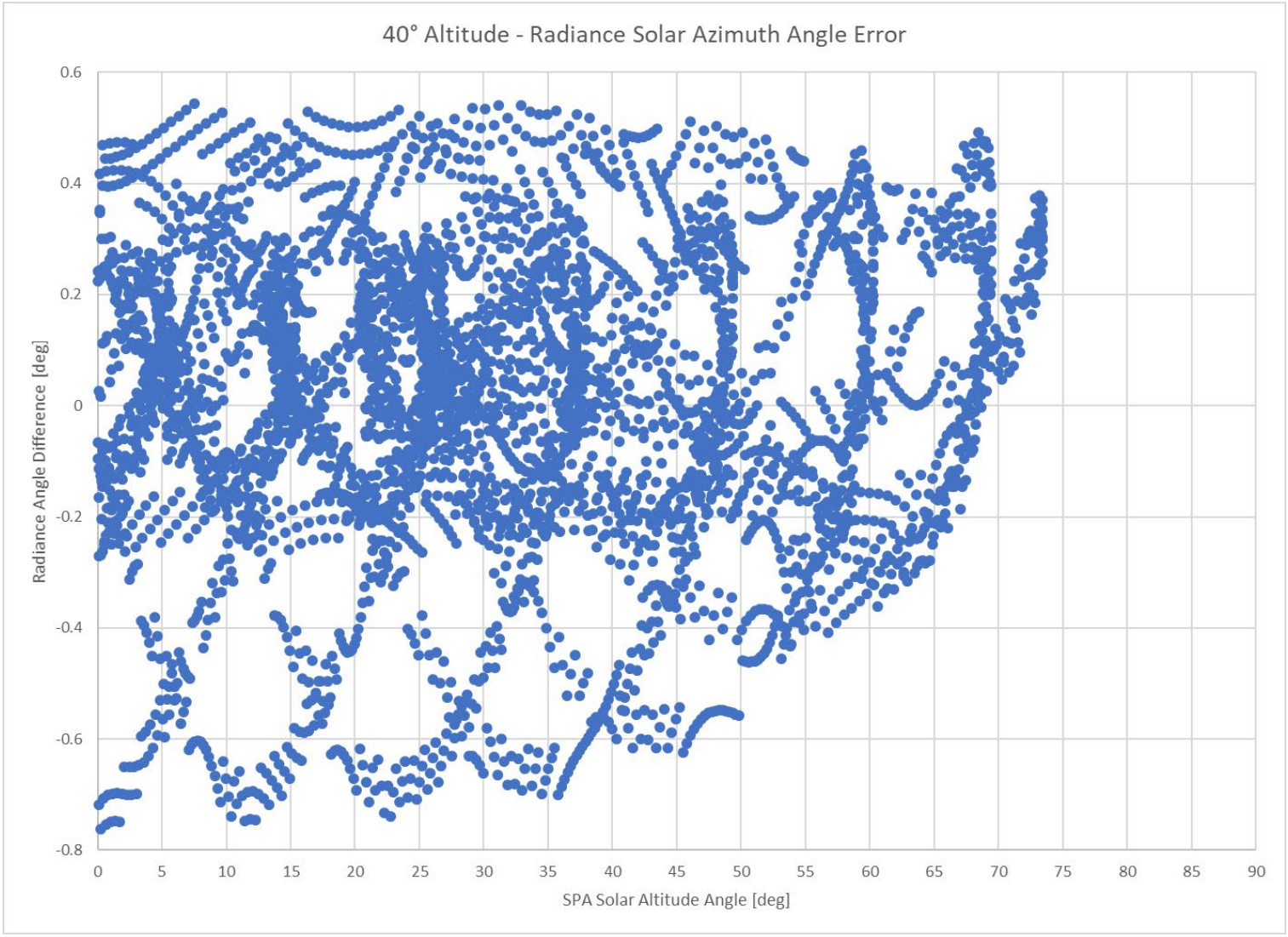
20° Latitude Azimuth Angle Error – 22 lost hours



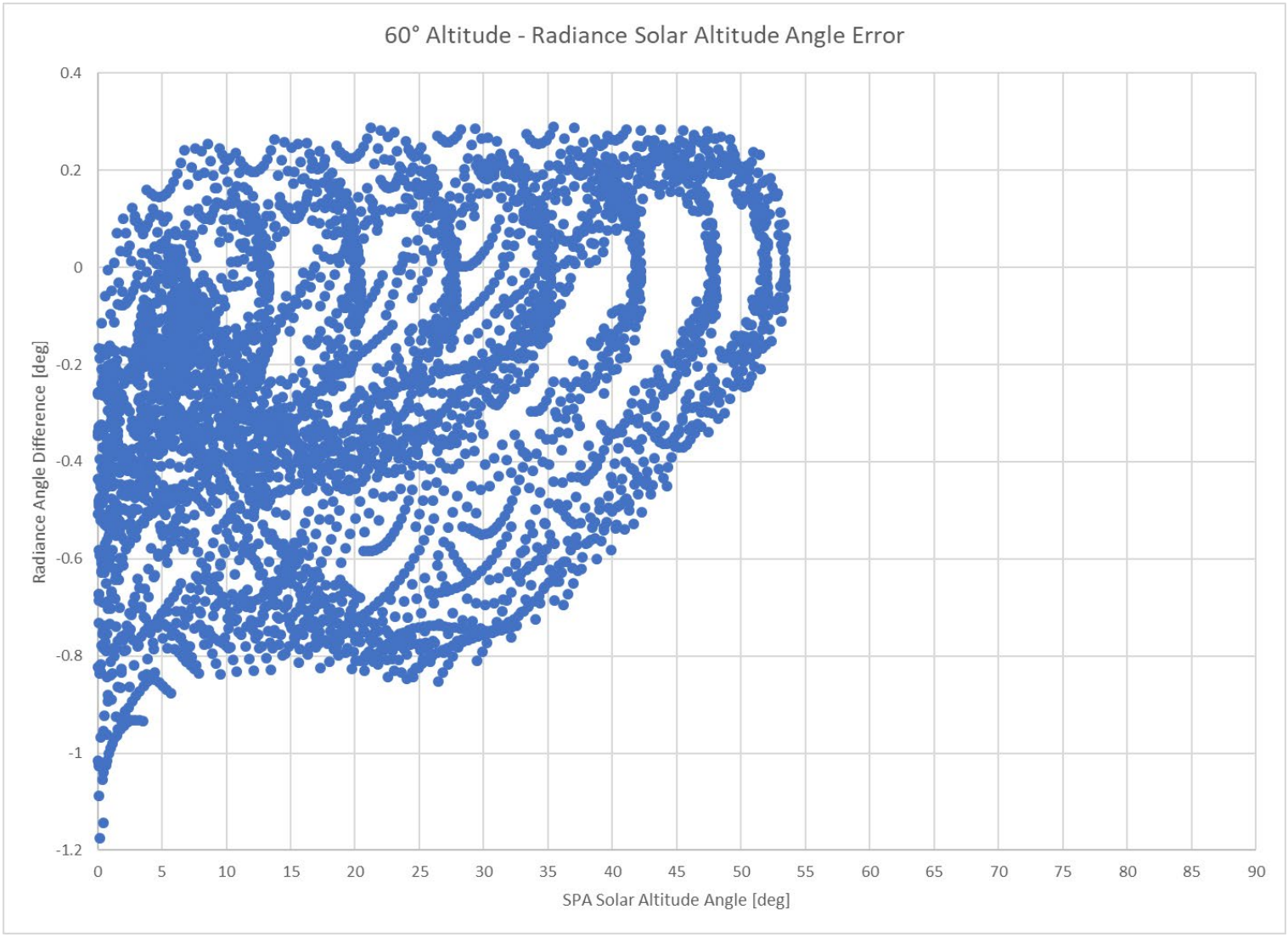
40° Latitude Altitude Angle Error



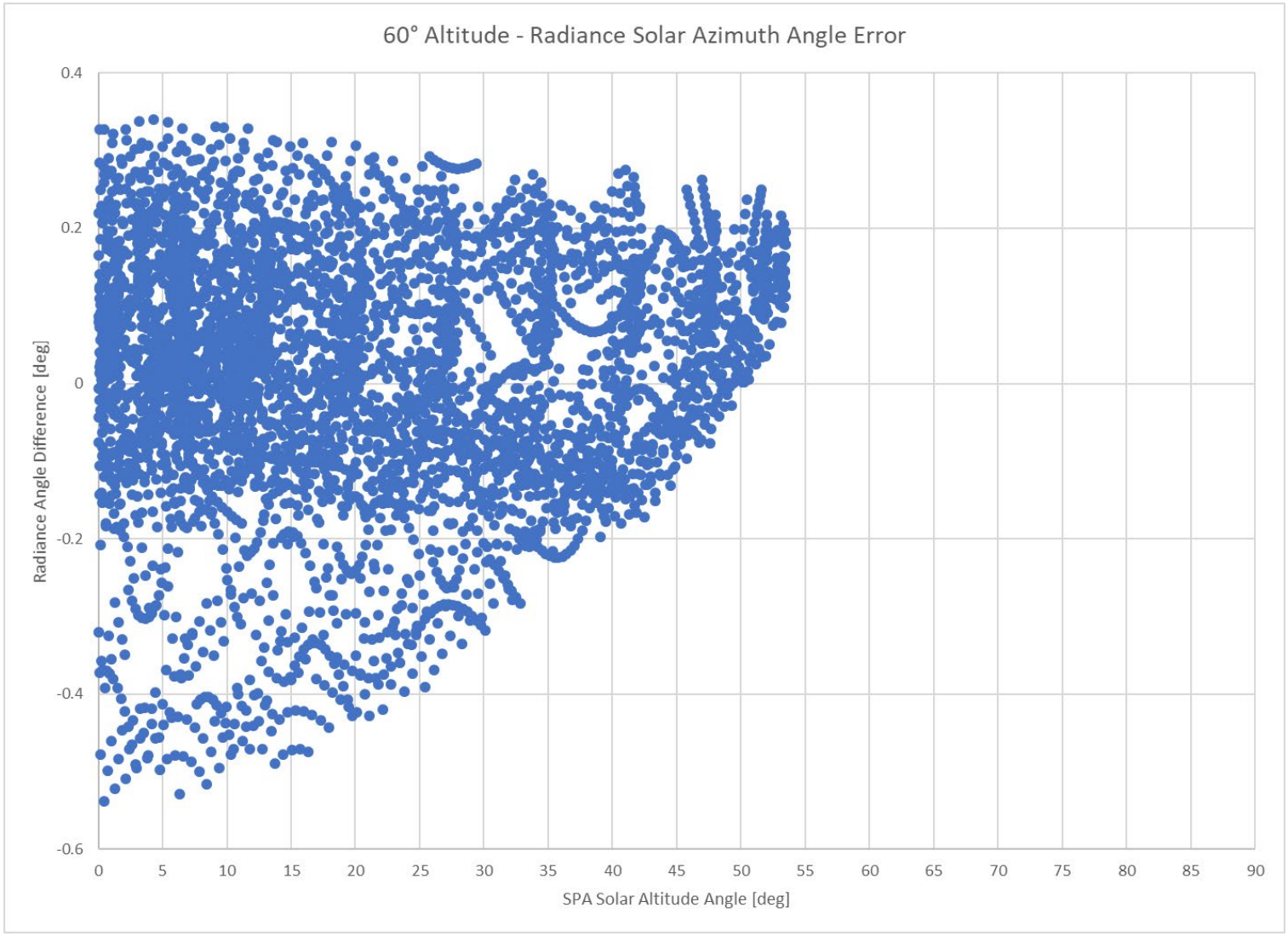
40° Latitude Azimuth Angle Error



60° Latitude Altitude Angle Error



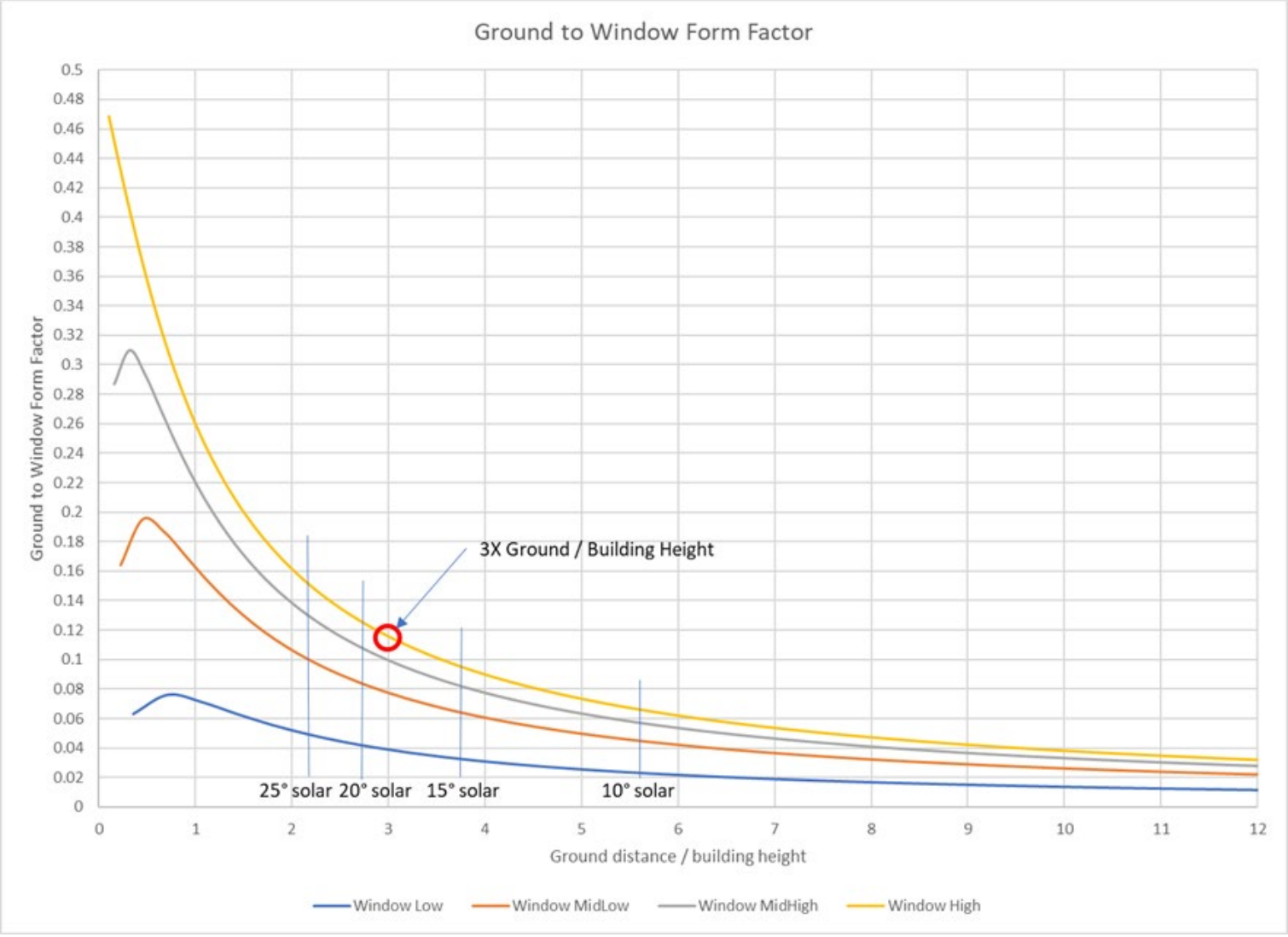
60° Latitude Azimuth Angle Error



Perez Sky Efficiency and Dew Point Temperature

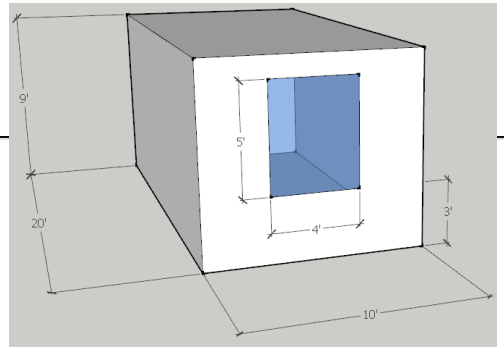
- Weather files often provide both Radiometric and Photometric data
  - Photometric data often derived from Radiometric using Perez efficacy functions which include dew point temperature adjustments
  - Gendaylit currently applies Perez efficacy functions to radiometric data but defaults to a constant dew point modifier that 'works well for Freiburg'
- Quick impact study on Boulder weather
  - Radiometric data and solar spectrum: Annual - 499kWh/m2, Day – 180Wh/m2
  - Photometric data and solar spectrum: Annual - 455kWh/m2, Day – 146Wh/m2
  - Using visual spectrum
    - Radiometric annual – 355kWh/m2 or 14289 avg lux
    - Photometric annual – 345kWh/m2 or 13915 avg lux
- Good news! – not a huge annual error (~3% visual - ~10%solar)
- Worse new! – single day check saw a solar error of 23%
- Where to go?
  - Useradiometric data and -O 1 for solar
  - Use photometric data and -O 0 for visual
  - Hardcode –O options to data type options in gendaylit?
  - Add –td option to gendaylit and see if these conversion errors go down

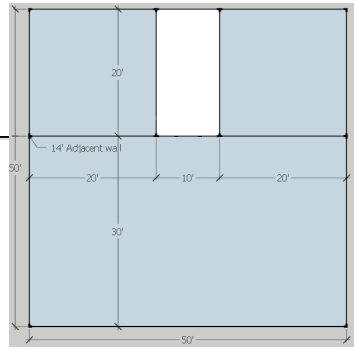
Extents of ground

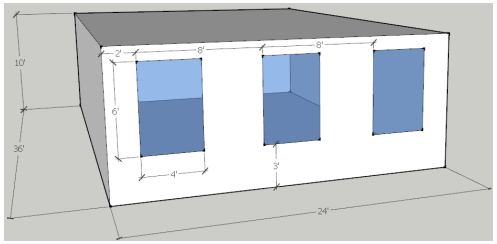


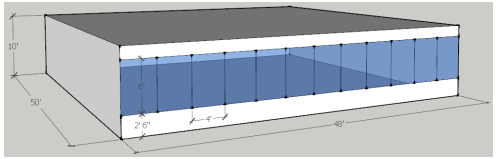
Test Cases - Basic

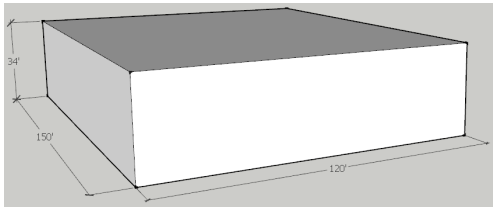
- Small room
  - Represents single office, conf room, dorm room, break room residential spaces…
- Medium room
  - Represents classroom, shared office, mid-size conf rooms, retail space..
- Large room
  - Open offices, restaurants, retail/strip mall storefronts…
- High-bay space
  - Represents gymnasium, commons/atrium, media centers, large conf rooms…
- Warehouse space
  - Represents warehouses, big-box retail, conf floors…
- Atrium space – not shown

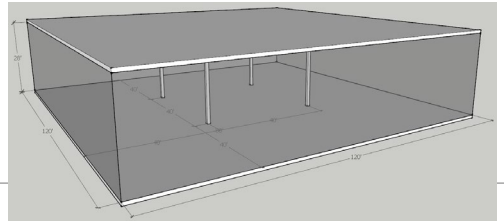




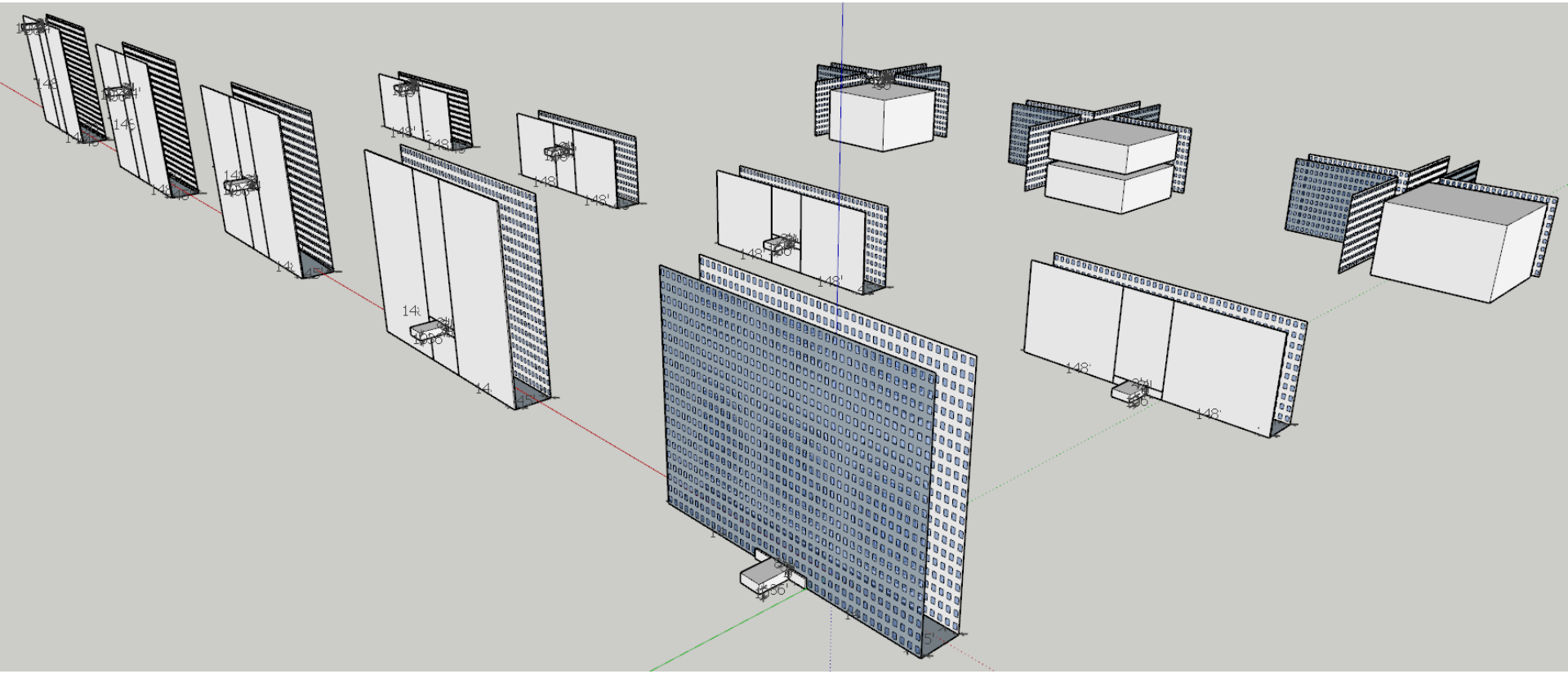




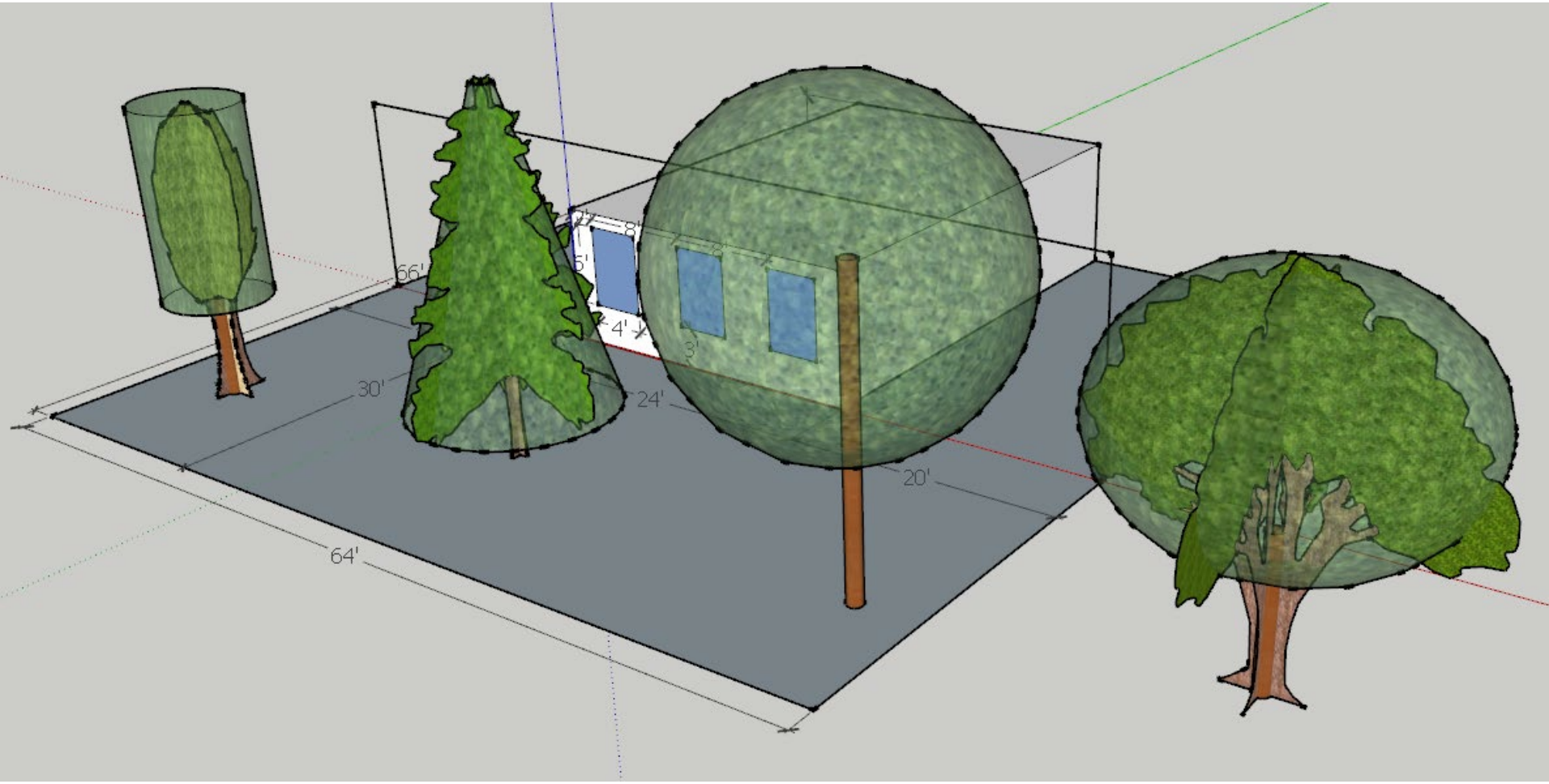




Test Cases – urban surroundings



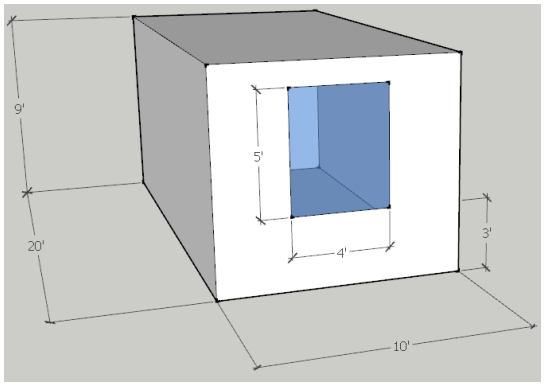
Test Cases – trees / vegetation

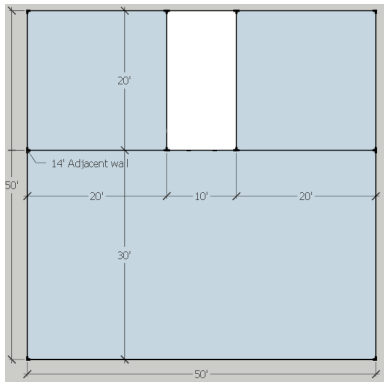


Gold Standards Simulations

- AnnualBruteForce.py --rad Radfile --wea EPWfile [--wdm W|G|L|E] --opt Optfile [--mat MatFile] --pts PtsFile [--rot RotDeg] [--genc] [--skyc “r g b”] [--grndc “r g b”] [--snow]

- Script reads in a weather file, radiance file, and a pts file and simply runs every daylit hour
- Parallel processing built-in
- Small room timing:
  - ~2days on 8 core-machine
  - ~4hrs on 96 core-machine
- Simulation will be run with and without window treatments
- Annual summary data, annual illum file will be provided as gold standard
- An annual comparison tool will be developed with gold standards loaded





	2	3	4	5	6	7	8
13	20	21	21	21	21	20	20
12	21	22	22	22	22	22	21
11	23	24	24	24	24	24	24
10	26	27	27	27	28	27	27
9	30	31	101	100	100	31	31
8	35	35	105	105	105	36	36
7	81	40	110	110	111	41	97
6	86	88	117	118	119	104	102
5	91	96	127	130	128	112	109
4	98	106	183	143	199	122	115
3	174	309	320	282	334	208	194
2	176	322	416	410	434	222	228

	2	3	4	5	6	7	8
13	6	6	6	6	6	6	6
12	6	6	6	6	6	6	6
11	6	6	6	6	6	6	6
10	6	6	6	6	6	6	6
9	6	6	8	8	8	6	6
8	6	7	9	9	9	6	6
7	8	7	9	9	9	7	9
6	9	9	10	11	10	10	9
5	10	10	12	12	12	11	10
4	11	12	15	14	16	13	12
3	14	20	22	22	23	17	15
2	15	22	29	30	29	20	17

	2	3	4	5	6	7	8
13	7	7	7	7	7	7	7
12	7	8	8	8	8	8	7
11	8	8	9	9	9	8	8
10	9	10	10	10	12	10	9
9	10	11	13	13	13	11	10
8	12	13	16	16	16	13	12
7	16	15	18	19	18	16	16
6	18	21	23	23	23	21	19
5	22	26	28	30	29	26	23
4	27	33	40	39	40	33	27
3	33	48	56	58	56	45	34
2	36	60	78	84	79	56	37

School Studies

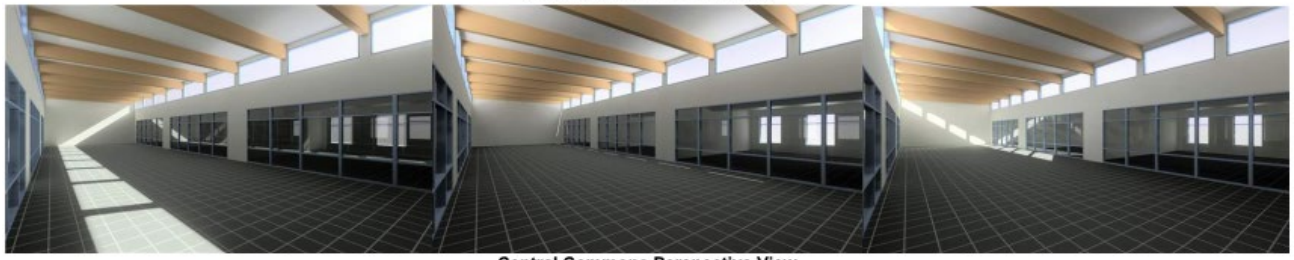
- MLK Jr - 360 cafeteria remodel
- Jones K-12 - new school classroom wing
- Vanderbilt Univ School of Nursing – Wellness melanopic lux calcs
- Hillwood HS – gym studies and passive classroom wings
- Robeson HS – classroom wing and gym revit vs radiance comparisons

MLK Jr HS – Cafeteria remodel

MLK Jr HS – Cafeteria remodel

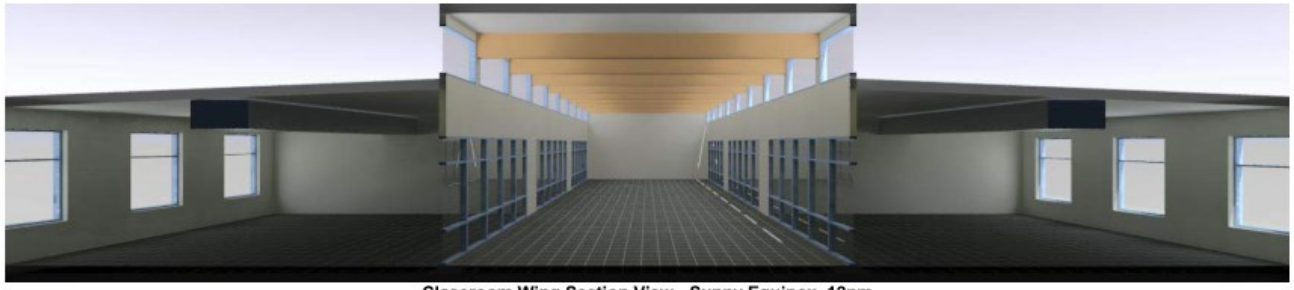
Jones County K-12 School

West Classroom Section View



Central Commons Perspective View

East Classroom Perspective View



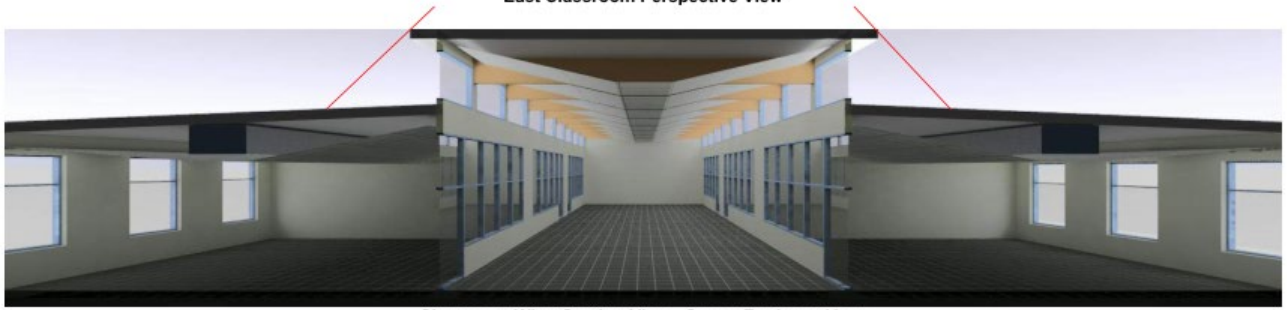
Classroom Wing Section View - Sunny Equinox, 12pm

Jones County K-12 School

West Classroom Section View

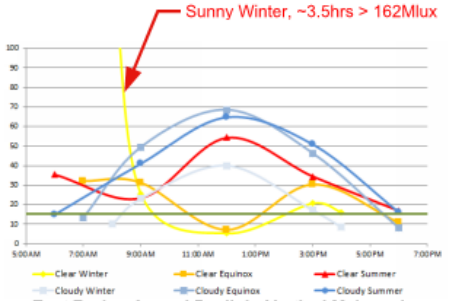
Central Commons Perspective View

East Classroom Perspective View

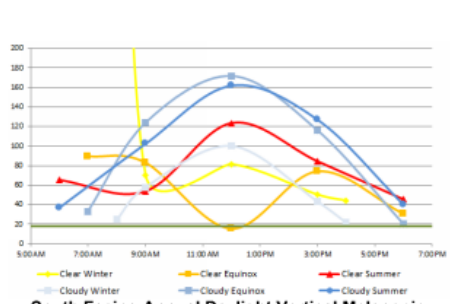


Classroom Wing Section View - Sunny Equinox, 12pm

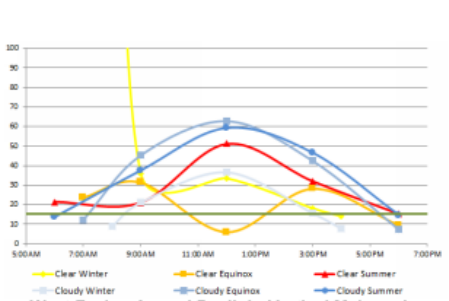
Vanderbilt School of Nursing - Wellness Calcs



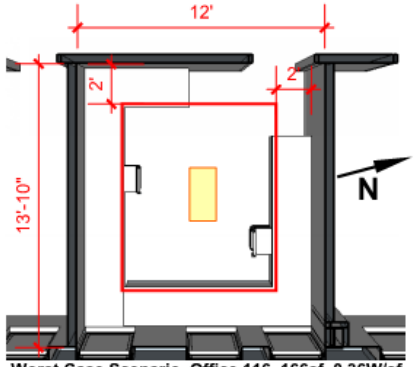
East Facing Annual Daylight Vertical Melanopic Illuminance, [Mfc]



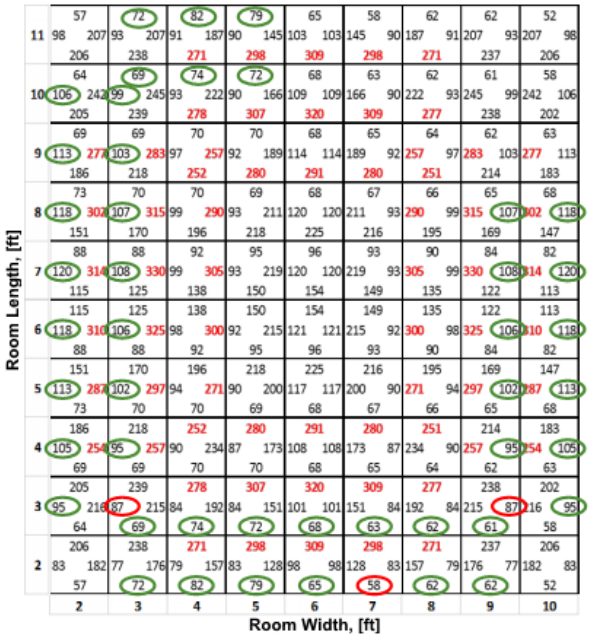
South Facing Annual Daylight Vertical Melanopic Illuminance, [Mfc]



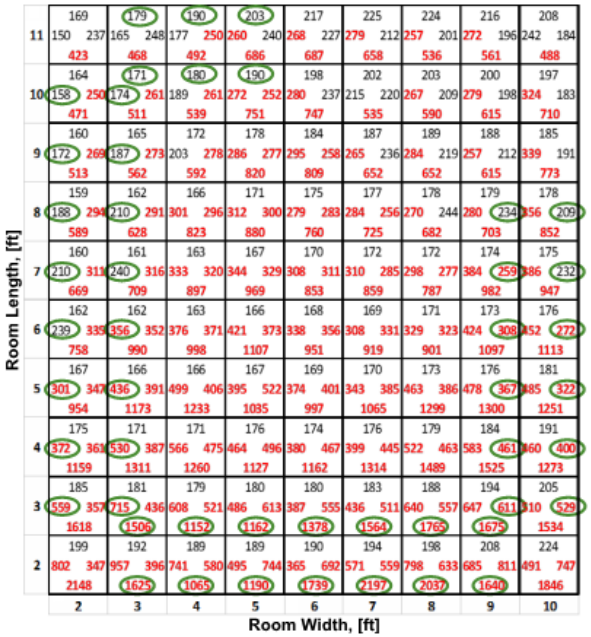
West Facing Annual Daylight Vertical Melanopic Illuminance, [Mfc]



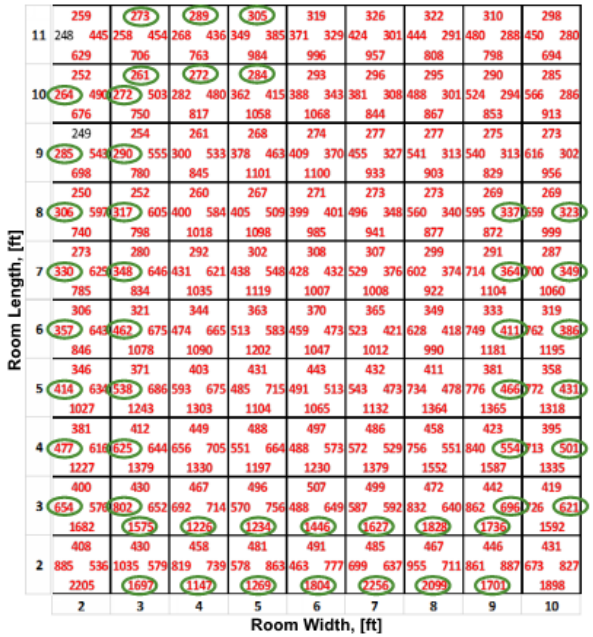
Worst Case Scenario, Office 116, 166sf, 0.36W/sf



Electric Lighting Vertical Melanopic Illuminance [Mlux]



Annual Average Daylight Vertical Melanopic Illuminance [Mlux]

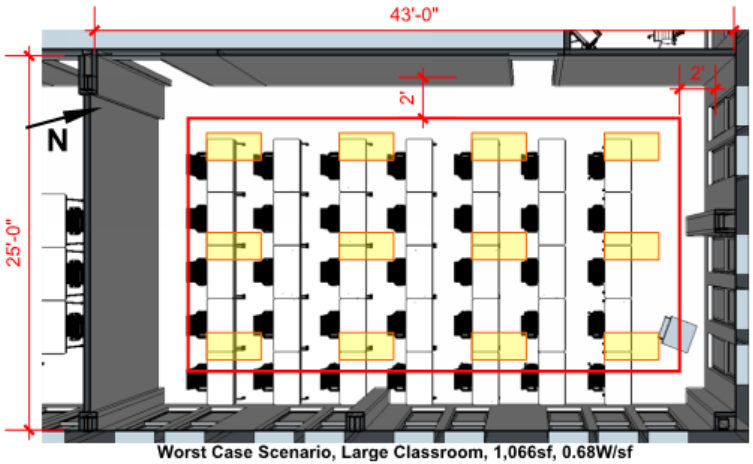


Annual Average Combined Vertical Melanopic Illuminance [Mlux]

Vanderbilt School of Nursing - Wellness Calcs

Room Length, [ft] \ Room Width, [ft]	2	3	4	5	6	7	8	9	10
7	193 195 428	237 187 404	255 323 332	251 386 412	265 320 445	278 350 332	264 448 371	264 379 438	277 340 338
	340	476	507	453	504	553	484	481	553
6	222 219 507	274 189 469	287 368 358	270 451 471	293 348 523	318 392 363	284 525 415	286 422 515	318 366 374
	283	328	345	350	368	381	366	368	376
5	311 228 489	425 196 445	451 338 368	402 430 469	448 353 489	492 374 361	430 497 417	430 428 484	492 368 356
	330	425	456	425	463	497	453	451	494
4	288 234 523	340 200 479	363 371 376	361 461 492	381 363 533	394 394 376	379 535 433	376 443 523	392 381 376
	307	412	438	389	435	476	415	415	476
3	332 232 520	440 197 476	463 366 374	417 458 489	463 361 530	510 394 371	445 533 430	445 440 520	507 379 376
	261	306	325	323	343	356	340	340	353
2	345 222 481	448 188 435	479 327 358	448 420 458	487 345 479	520 361 350	476 487 407	476 417 476	517 358 348
	274	381	407	356	399	445	381	384	445
1	297 207 487	343 175 458	368 350 340	368 435 451	386 332 510	397 366 345	386 507 392	386 404 497	394 345 366
	170	207	230	207	224	247	227	218	254
	350 180 384	487 153 368	520 275 314	466 371 363	520 282 402	569 298 320	499 428 324	499 340 394	566 293 330
	110	121	187	168	141	183	186	140	178

Electric Lighting Vertical Melanopic Illuminance [Mlux]



Worst Case Scenario, Large Classroom, 1,066sf, 0.68W/sf

128 115 213	139 115 225	152 125 244	162 135 260	172 148 283	184 157 314	196 172 337	205 180 367	223 193 423	247 204 486
266	270	325	331	335	386	400	410	441	487
115 120 220	120 116 225	129 128 248	137 138 274	146 146 277	157 160 322	169 168 348	180 176 401	200 193 455	222 202 551
305	329	378	394	410	432	451	462	510	545
113 133 244	113 129 266	119 146 277	125 158 296	134 168 332	147 186 365	158 186 403	174 201 442	195 210 530	229 225 598
367	397	450	477	484	511	528	542	577	606
119 154 278	114 159 293	118 181 314	126 196 341	135 205 364	146 223 406	159 231 433	176 234 495	204 249 577	240 256 657
434	491	549	560	597	606	633	632	647	671
131 184 335	123 199 333	126 236 357	130 248 394	138 255 399	154 272 440	168 282 472	183 283 526	211 297 607	245 305 716
551	637	687	706	732	730	736	743	762	774
151 234 410	141 275 384	142 361 425	148 336 463	158 331 454	169 362 500	184 354 556	205 358 589	230 382 657	274 376 800
738	871	904	915	962	936	938	953	907	894
184 302 554	169 424 474	170 539 532	177 452 632	183 446 565	193 560 574	212 488 711	228 456 653	266 552 639	300 516 908
1127	1374	1170	2450	1442	1283	1268	1415	1240	1083
241 337 967	214 897 908	207 1488 461	214 342 1084	222 915 1001	237 1013 487	248 389 1128	270 900 1051	299 992 473	344 446 962
2116	2636	1365	1762	2585	1892	1562	2615	2017	714

Annual Average Daylight Vertical Melanopic Illuminance [Mlux]

323 310 407	334 310 420	347 319 439	356 330 454	367 343 478	379 352 509	391 367 531	400 375 561	418 388 617	441 399 680
461	465	520	526	530	580	594	604	636	681
309 315 415	315 311 420	323 322 443	332 332 468	341 340 471	351 355 516	363 363 542	374 371 595	394 387 650	417 396 745
499	523	572	588	604	626	646	657	704	740
308 328 438	307 324 460	313 340 472	320 353 490	329 363 527	341 381 560	353 380 598	368 395 636	389 404 724	424 419 793
562	591	644	672	679	706	723	736	772	800
313 349 473	309 353 487	312 375 508	320 390 535	330 400 559	340 417 600	353 425 627	371 428 690	399 443 772	434 450 852
628	686	744	754	791	800	827	826	841	866
326 379 530	317 393 528	321 430 551	324 442 588	332 450 594	348 467 634	363 477 667	378 478 720	405 492 802	440 500 911
746	831	882	900	927	924	930	937	956	969
345 428 605	336 469 578	336 555 619	343 531 658	353 525 648	364 556 695	378 549 751	399 552 783	425 577 851	468 571 995
933	1066	1099	1110	1157	1131	1133	1148	1102	1089
379 497 748	364 619 669	364 734 727	371 647 826	377 641 759	387 754 768	407 682 906	422 651 847	460 746 834	494 711 1102
1321	1569	1365	2644	1636	1477	1463	1610	1434	1278
435 531 1162	409 1092 1102	402 1683 655	409 537 1278	417 1110 1196	431 1208 681	443 584 1323	465 1095 1245	494 1187 667	538 640 1156
2310	2831	1559	1957	2780	2087	1757	2810	2211	909

Annual Average Combined Vertical Melanopic Illuminance [Mlux]

504 640 1410	561 677 1350	559 1034 1458	697 1103 1375	838 1168 793	936				
1187	2822	3085	2924	1180					

Hillwood HS – Gym Studies

Southwest Perspective, Sunny Equinox at noon

Northwest Perspective, Sunny Equinox at noon

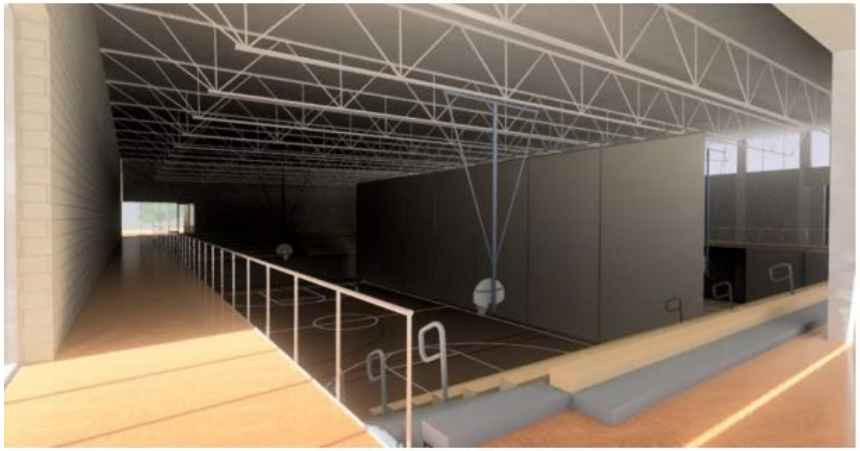
Southeast Perspective, Sunny Equinox at noon

Northeast Perspective, Sunny Equinox at noon

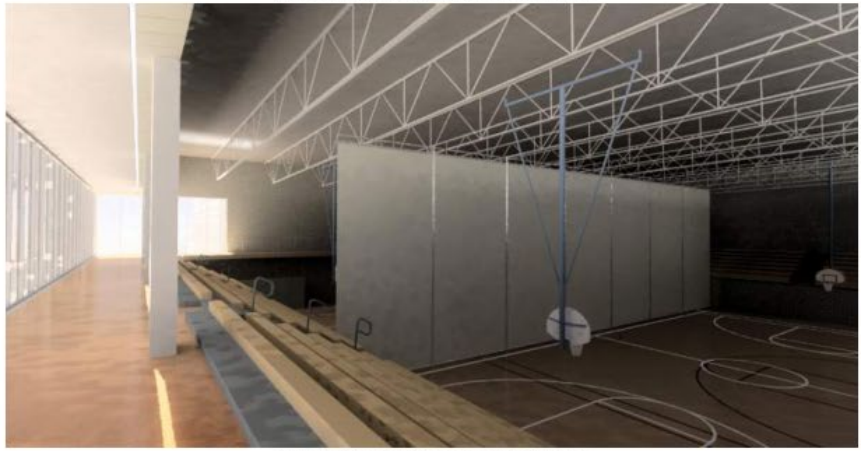
Hillwood HS – Gym Studies

Southwest Perspective, Sunny Equinox at noon

Northwest Perspective, Sunny Equinox at noon



Southeast Perspective, Sunny Equinox at noon



Northeast Perspective, Sunny Equinox at noon

Hillwood HS – Gym Studies

Southwest Perspective, Sunny Equinox at noon

Northwest Perspective, Sunny Equinox at noon

Southeast Perspective, Sunny Equinox at noon

Northeast Perspective, Sunny Equinox at noon

Hillwood HS – Gym Studies

Southwest Perspective, Sunny Equinox at noon

Northwest Perspective, Sunny Equinox at noon

Southeast Perspective, Sunny Equinox at noon

Northeast Perspective, Sunny Equinox at noon

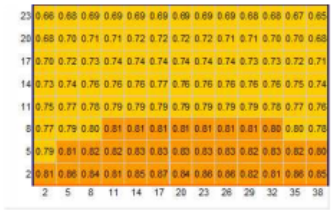
Hillwood HS – passive thermal strategies

South Class - Sunny Equinox, 12pm

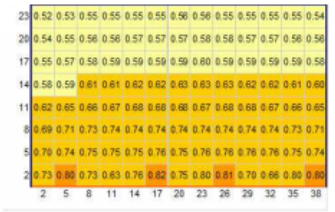
South Façade - 42%WWRint, 16%WFR, 25%WWRext

North Façade - 42%+WWRint, 16%+ WFR, ??%WWRext

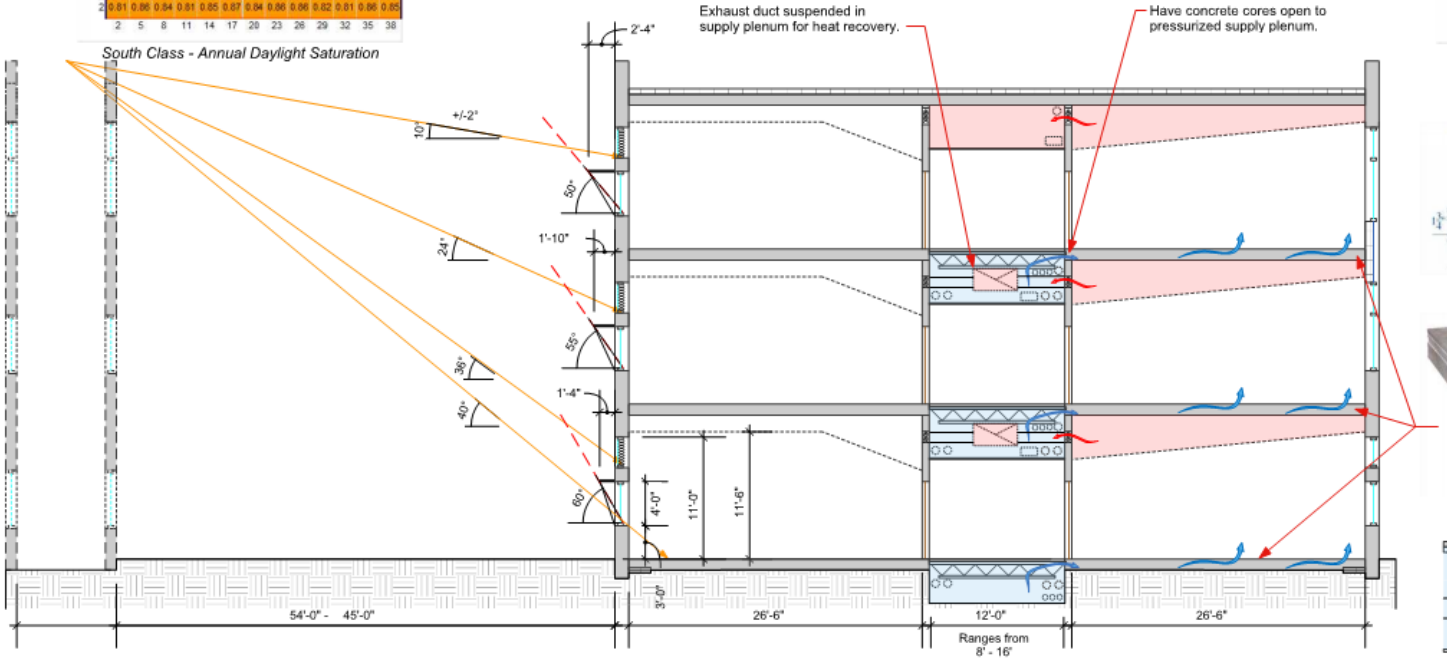
North Class - Sunny Equinox, 12pm



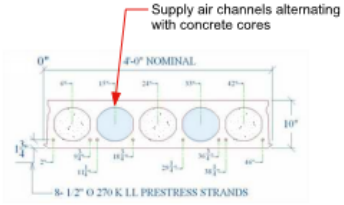
South Class - Annual Daylight Saturation



North Class - Annual Daylight Saturation

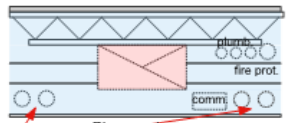


Alternative 2 Classroom Wing Section



Hollow core plank section

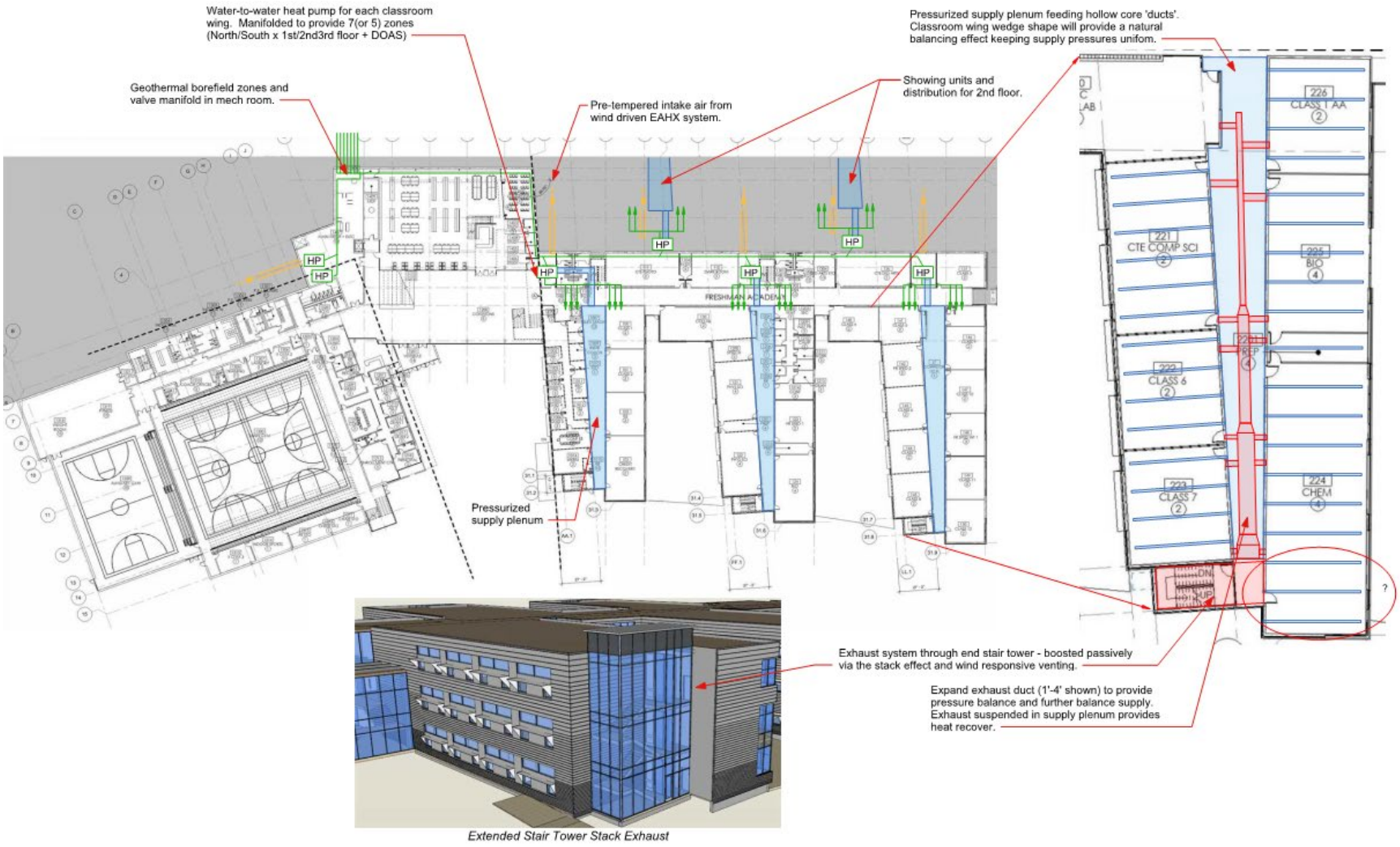
Hollow core floor option



Plenum closeup

Radiant floor loops

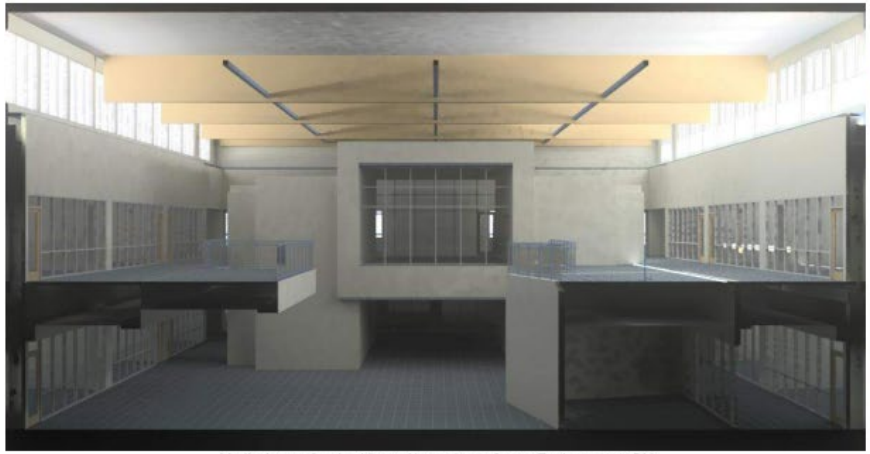
Hillwood HS – passive thermal strategies



Robeson County MS Prototype

Media Center Section View - Base Case, Sunny Equinox, 12:00PM

Media Center View from West - Base Case, Sunny Equinox, 12:00PM



Media Center Section View - Alternative 2, Sunny Equinox, 12:00PM

Media Center View from West - Alternative 2, Sunny Equinox, 12:00PM

Robeson County MS Prototype

Base Case - View from Northwest Corner, Sunny Equinox, 12pm

Alternative 1 - View from Northwest Corner, Sunny Equinox, 12pm

Base Case - View from Southeast Corner, Sunny Equinox, 12pm

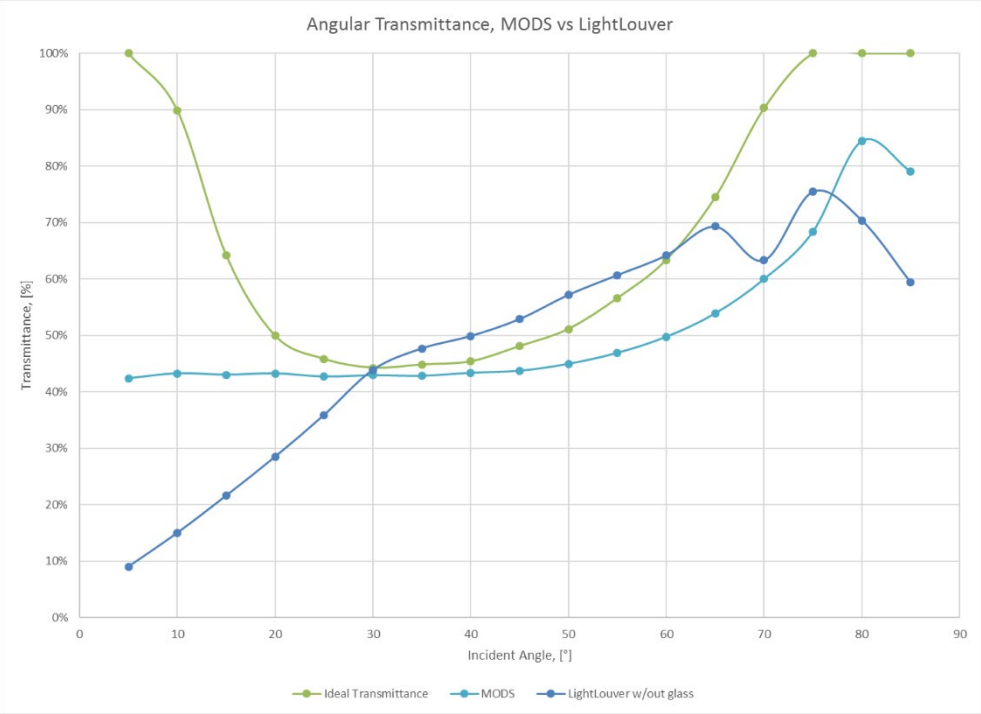
Alternative 1 - View from Southeast Corner, Sunny Equinox, 12pm

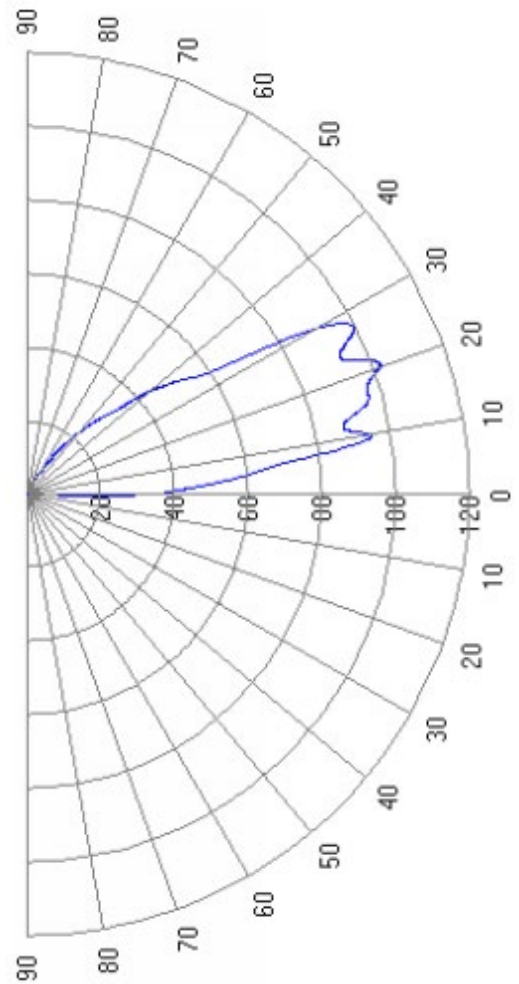
Base Case - Sectional Rendering, Sunny Equinox, 12pm

Alternative 1 - Sectional Rendering, Sunny Equinox, 12pm

LightLouver MODS

- Next generation LightLouver is in the works!
  - Patents approved
  - Prototype underway
  - BSDF files available soon – contact me if interested!





Questions?

Experiences with Radiance in Daylighting Design, Part VIII

18th International Radiance Conference
August 21-22, New York City

Zack Rogers, P.E., IESNA, LEED AP BD+C
Daylighting Innovations, LLC