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Investigation of Lower Atmosphere Propagation of a High Energy Laser Operating at 1.31525 μm Using the Atmospheric Compensation Simulation Wave Optics Code

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Background: To use the AFIT-designed one-on-one engagement model, HELEEOS (High Energy Laser End-to-End Operational Simulation), there were 126 different scenarios used as the basis of the program in order to evaluate other scenarios. These tie points were processed in another program, ACS (Atmospheric Compensation Simulation), to find the peak irradiance to use in HELEEOS. With the tie points, there was no true structure of the parameters and they were numbered depending on the order they were developed.

	A	B	C	D	E	F	G	H	I	J
1	Parameter #	Power	Platform Altitude	Slant Range	Turbulence	Platform Velocity	Wind Velocity	Beam Profile	Focus Distance	Atmosphere
2	1	25000 W	2000 m	4500 m	0.5 x H/V 5/7	100 m/s perp	4 m/s	Top Hat	at target range	Standard
3	2	50000 W	3000 m	6000 m	1 x H/V 5/7	100 m/s parallel	10 m/s	Gaussian	5% beyond	TBD
4	3	100000 W	4000 m	9000 m						
5	4	150000 W								
6	Position #	1	2	3	4	5	6	7	8	9

Decoder Table

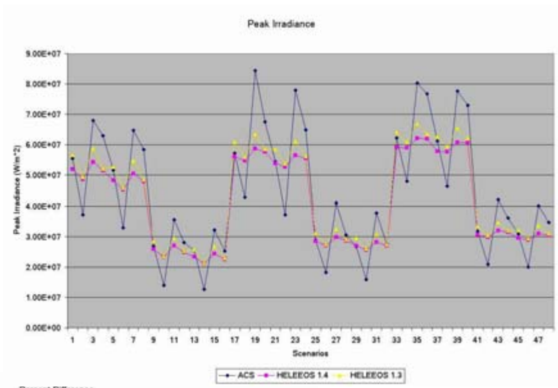
From the parameters we chose, there is a possibility of 2,304 different scenarios. Given the time we had for the runs to process, we narrowed our selection and it resulted in 384 scenarios (selected parameters are highlighted). Using the .in files from the old tie points, we changed the input commands to reflect the different components of the scenarios. With the .in files ready and put into folders, we were ready to start the runs.

Once the scenario runs were completed, the output results were put in a spreadsheet with the description of the scenario. The outputs given by ACS for each run were peak irradiance, total power in a 2.5 cm square, X beam diameter, Y beam diameter, average beam diameter, and total integrated power. The only output we were concerned about is peak irradiance. This is the connection used for HELEEOS.

Project: To get started, there needed to be a system to set up the new scenarios. We decided on nine different parameters we wanted to explore – power, platform altitude, slant range, turbulence, platform velocity, wind speed, beam profile, focus distance, and atmosphere. With these parameters, we developed a decoder chart to name the scenario files. Depending on which parameters we were using and the position of the parameter, the corresponding numbers made up the file number. This system is very versatile; more parameters or more choices for each parameter can be easily added without much confusion for the file names.

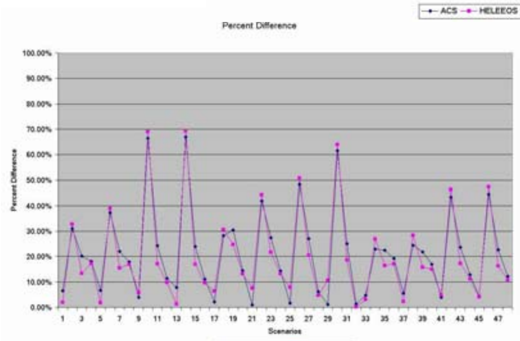
	A	B	C	D	E	F	G	H	I	J	O	P	Q	R	S	T
1	Trial Number	Power	Platform Alt	Slant Range	Turbulence	Velocity	Wind	Beam Profile	Focus Distance	Atmosphere	Peak Irradiance	Power in square	X Diameter	Y Diameter	Avg Diameter	Integrated Power
2	211111111	50000	2000	4500	0.5	100 perp	4	Top Hat	at target range	Standard	5.55515E+07	16580.3	0.0375246	0.0143726	0.0259486	38373.0
3	211121111	50000	2000	4500	0.5	100 parallel	4	Top Hat	at target range	Standard	3.70929E+07	10178.8	0.0393798	0.0129130	0.0261464	38325.1
4	211112111	50000	2000	4500	0.5	100 perp	10	Top Hat	at target range	Standard	6.79654E+07	19076.1	0.0395518	0.0147718	0.0271618	38380.1
5	211122111	50000	2000	4500	0.5	100 parallel	10	Top Hat	at target range	Standard	6.29427E+07	17101.4	0.0299042	0.0129987	0.0214514	38382.4
6	211111121	50000	2000	4500	0.5	100 perp	4	Top Hat	5% beyond	Standard	7.55280E+07	19013.4	0.0263213	0.0130114	0.0196663	38367.3
7	211121121	50000	2000	4500	0.5	100 parallel	4	Top Hat	5% beyond	Standard	5.14592E+07	13313.2	0.0224108	0.0147303	0.0185705	38336.4
8	211112121	50000	2000	4500	0.5	100 perp	10	Top Hat	5% beyond	Standard	8.73320E+07	22052.4	0.0242723	0.0130029	0.0186376	38373.5
9	211122121	50000	2000	4500	0.5	100 parallel	10	Top Hat	5% beyond	Standard	7.10212E+07	18707.2	0.0242847	0.0148130	0.0195488	38378.7
73																
74	221111111	50000	3000	4500	0.5	100 perp	4	Top Hat	at target range	Standard	5.72365E+07	17614.4	0.0340850	0.0144323	0.0242586	40892.0
75	221121111	50000	3000	4500	0.5	100 parallel	4	Top Hat	at target range	Standard	4.27418E+07	11412.3	0.0374631	0.0129192	0.0252012	40903.9
76	221112111	50000	3000	4500	0.5	100 perp	10	Top Hat	at target range	Standard	8.44941E+07	23853.6	0.0282198	0.0129528	0.0205863	40892.3
77	221122111	50000	3000	4500	0.5	100 parallel	10	Top Hat	at target range	Standard	6.75296E+07	19565.2	0.0300019	0.0147090	0.0223555	40906.5
78	221111121	50000	3000	4500	0.5	100 perp	4	Top Hat	5% beyond	Standard	8.02871E+07	20107.2	0.0262611	0.0129383	0.0195997	40892.6
79	221121121	50000	3000	4500	0.5	100 parallel	4	Top Hat	5% beyond	Standard	8.21395E+07	15965.2	0.0222366	0.0147678	0.0185022	40903.9
80	221112121	50000	3000	4500	0.5	100 perp	10	Top Hat	5% beyond	Standard	8.34171E+07	23821.5	0.0262993	0.0148261	0.0205627	40892.9
81	221122121	50000	3000	4500	0.5	100 parallel	10	Top Hat	5% beyond	Standard	7.80493E+07	20834.5	0.0242624	0.0165285	0.0203955	40909.5
190																
191	232111211	50000	4000	6000	0.5	100 perp	4	Gaussian	at target range	Standard	2.80956E+07	11546.8	0.0530776	0.0219937	0.0375357	40187.4
192	232121211	50000	4000	6000	0.5	100 parallel	4	Gaussian	at target range	Standard	1.69810E+07	7278.92	0.0588539	0.0240420	0.0414479	40099.3
193	232112211	50000	4000	6000	0.5	100 perp	10	Gaussian	at target range	Standard	4.02323E+07	15445.9	0.0434609	0.0201608	0.0318108	40203.0
194	232122211	50000	4000	6000	0.5	100 parallel	10	Gaussian	at target range	Standard	3.02562E+07	11778.8	0.0471917	0.0201643	0.0336780	40166.8
195	232111221	50000	4000	6000	0.5	100 perp	4	Gaussian	5% beyond	Standard	4.04881E+07	13235.7	0.0417097	0.0165340	0.0291219	40183.7
196	232121221	50000	4000	6000	0.5	100 parallel	4	Gaussian	5% beyond	Standard	2.86876E+07	9917.09	0.0257930	0.0202311	0.0230120	40122.8
197	232112221	50000	4000	6000	0.5	100 perp	10	Gaussian	5% beyond	Standard	4.84097E+07	16953	0.0377793	0.0184552	0.0281172	40195.9
198	232122221	50000	4000	6000	0.5	100 parallel	10	Gaussian	5% beyond	Standard	3.91449E+07	13821.2	0.0377033	0.0203092	0.0290062	40168.2

Spreadsheet with scenario descriptions and results



After all of the runs were completed for the 50 kW power cases, we started comparing the ACS peak irradiance values to the current HELEEOS values. With HELEEOS 1.4 Beta in the works, we looked at both versions - 1.3 and 1.4 Beta. The plot to the left is the peak irradiance for the 50 kW, Top Hat beam profile, and in-focus cases. HELEEOS is not capable of demonstrating a Gaussian beam profile, and due to thermal blooming laws, it is unable to process out-of-focus cases. The graph beneath it is the percent difference of those cases. Generally, the error is under 30%. There is more of an uncertainty when there is a 100 m/s parallel platform velocity with a 4 m/s wind speed, and that is under investigation.

Equation for percent difference: $\frac{|HELEEOS - ACS|}{ACS}$



Future Research: To continue with this project, it is advised to return to the original parameters, add other variant parameter (more powers, platform altitudes, slant ranges, and atmospheres) and process more runs. As the power is increased, the peak irradiance comparison to HELEEOS has more error. Thus, power levels under 100 kW should be investigated for more direct comparison to HELEEOS.