Modeling the Earth Sun System

Introduction

Imagine that you are a natural philosopher (early scientist) working before we knew that the solar system is geocentric. Imagine further that what we know of as modern science has yet to be born. At this time, a great debate is raging among natural philosophers regarding the nature of the Earth/Sun system.

One group, the Traditionalists, is in favor of the *Great Turtle* hypothesis. The Great Turtle swims in the Cosmic Ocean with the Earth on its back. The Sun in this system is merely one of the Great Turtle's many helpers. The Sun swings around the Earth/Turtle system in a great circle illuminating all so that the turtle can see where it is going. Another group, the Heretics, believes that the turtle is a myth. They are in favor of the hypothesis that the Earth is spherical, spins on its axis, and goes around the Sun, which is fixed in space. Furthermore, they claim that the Earth's axis of rotation is tilted with respect to its path around the Sun.

These two groups hold regular conferences aimed at settling the debate. The conferences mostly involve a lot of shouting, name calling, and contests involving feats of strength. After each conference, the general opinion of the assembly at large shifts slightly one direction or the other based on which group has devised the most clever insults and who has sold the most t-shirts. Needless to say, the debate has yet to be firmly settled.

You belong to a third group of philosophers, the Observers, who believe that no hypothesis can be called true without what you call "proof." Your group believes that the only way to discover the inner workings of the natural world is through direct observation and experimentation. "Proof" involves comparing observational "evidence" to predictions made by one or more hypothesis.

One observed phenomenon that could help untangle the Sun/Earth debate is that the Sun sets at different positions on the horizon throughout the year. Some of your people have worked hard to develop mathematical models for both the Great Turtle hypothesis and the Tilted Earth hypothesis. The results of their computations are presented in the graphs on Pages 7 and 8**.** Each graph shows the azimuth of sunset versus the Julian day. Although the two models are quite similar, there is enough difference that careful observation should distinguish between them.

Procedure

Your task is to make careful observations of the Sun's azimuth at sunset and compare your data to the computed values. You have already made the required observations. To perform the comparison, you will calculate a number that describes the "goodness of fit" of your data to each model.

1. For each observation, look up the Julian day number in the **Julian Day** table on page 9. The Julian day number is a count of the number of days elapsed since January 1st in a given year. For example, January 2nd is Julian day 2 and December 31st is Julian day 365.

2. Record the observation date, Julian Day number, and your measured azimuth on both the **Tilted Earth Comparison** table and the **Great Turtle Comparison** table.

3. Carefully plot your data on the set of curves titled **Raw Data - Not Corrected**.

4. Now we are going to correct your raw data for any "west finding" error you may have had. For each data point on each plot, calculate the difference in azimuth between your point and the calculated curve on that Julian day. Record the error for each data point in the first column labeled Error.

Error = Measured Azimuth - Computed Azimuth

5. Calculate the average error and record it in the space below each table.

6. Now calculate the **Corrected Azimuth** and record it in the appropriate columns.

Corrected Azimuth = Measured Azimuth - Average Error

7. Carefully plot the Corrected Azimuth on the set of curves labeled **Corrected Data**.

8. Once again, calculate the error as we did in Step 4 and record it in the **Corrected Error** column

9. Finally, we will calculate the **ROOT MEAN SQUARE** (RMS) error for each curve. The curve with the lowest RMS wins. The RMS error is the square root of the sum of the squares of the errors. What a mouthful, no? To calculate the RMS, do the following:

    1. Square the value of each error. (after squaring, there should be no negative numbers).

    2. Add together all of the squared values.

    3. Take the square root of the result.

    4. Divide the result of Step 3 by the number of observations.

    Record the RMS error in the space at the bottom of each table.

Report

In the space below (or on a separate page if typing is your thing), write a short presentation that you would give at the next conference presenting your results. Briefly describe what you have done in your own words, tell the conference **which model is likely correct**, and **tell them why** you think its correct. Remember, this is before modern science, so **defend the Scientific Method**!

Tilted Earth Comparison

Observation Date	**Julian Day**	**Measured Azimuth**	**Error**	**Corrected Azimuth**	**Corrected Error**

Average error in azimuth before correction: ______________________

RMS error in azimuth after correction: ________________________

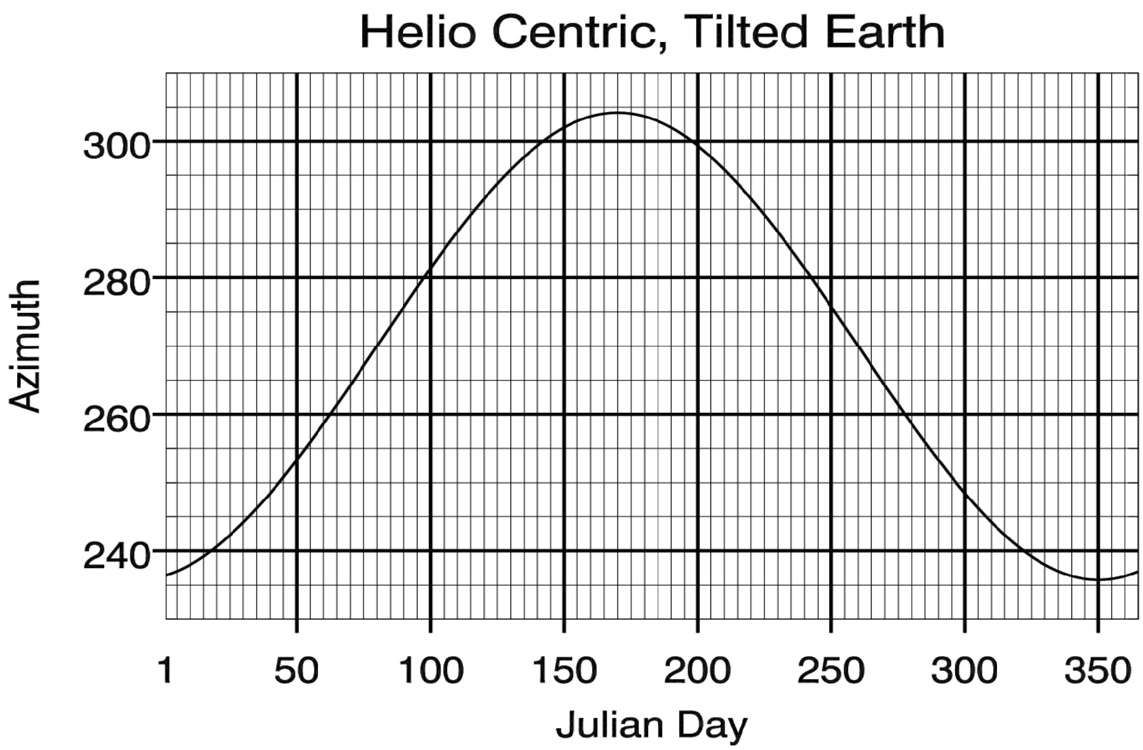
Great Turtle Comparison

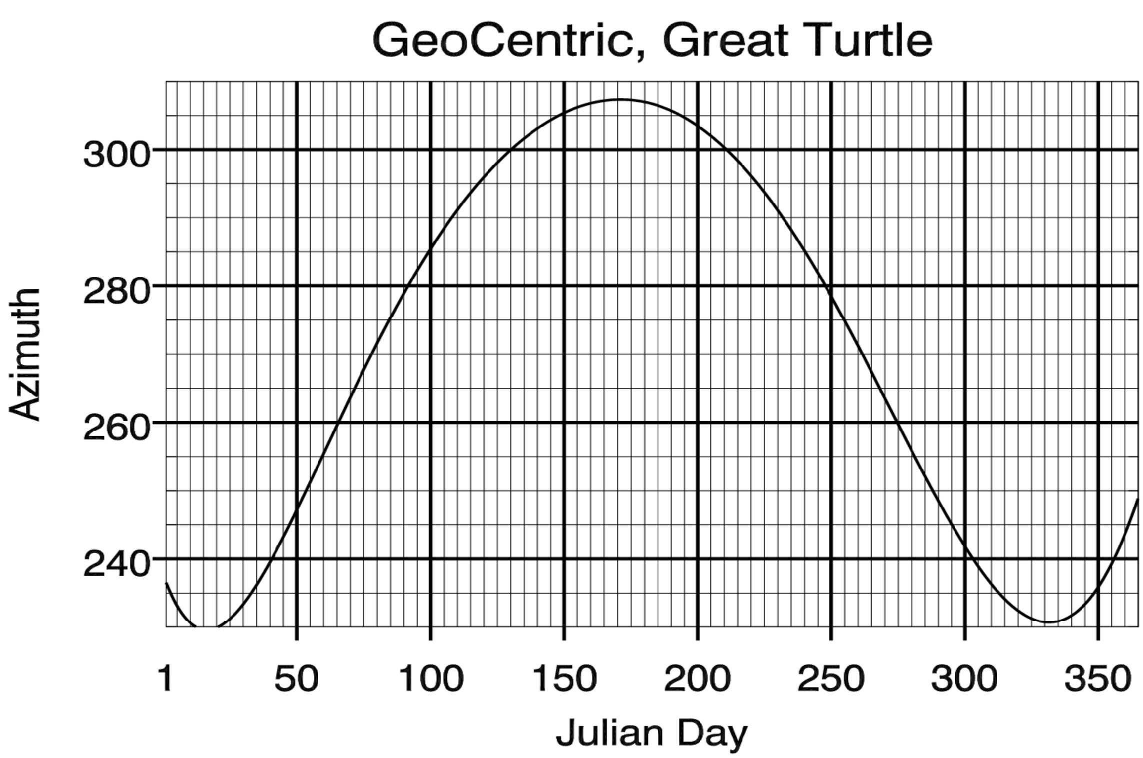
Observation Date	Julian Day	Measured Azimuth	Error	Corrected Azimuth	Corrected Error

Average error in azimuth before correction: ______________________

RMS error in azimuth after correction: ________________________

Corrected Data





Julian Day Numbers (Leap Year)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1	32	61	92	122	153	183	214	245	275	306	336
2	2	33	62	93	123	154	184	215	246	276	307	337
3	3	34	63	94	124	155	185	216	247	277	308	338
4	4	35	64	95	125	156	186	217	248	278	309	339
5	5	36	65	96	126	157	187	218	249	279	310	340
6	6	37	66	97	127	158	188	219	250	280	311	341
7	7	38	67	98	128	159	189	220	251	281	312	342
8	8	39	68	99	129	160	190	221	252	282	313	343
9	9	40	69	100	130	161	191	222	253	283	314	344
10	10	41	70	101	131	162	192	223	254	284	315	345
11	11	42	71	102	132	163	193	224	255	285	316	346
12	12	43	72	103	133	164	194	225	256	286	317	347
13	13	44	73	104	134	165	195	226	257	287	318	348
14	14	45	74	105	135	166	196	227	258	288	319	349
15	15	46	75	106	136	167	197	228	259	289	320	350
16	16	47	76	107	137	168	198	229	260	290	321	351
17	17	48	77	108	138	169	199	230	261	291	322	352
18	18	49	78	109	139	170	200	231	262	292	323	353
19	19	50	79	110	140	171	201	232	263	293	324	354
20	20	51	80	111	141	172	202	233	264	294	325	355
21	21	52	81	112	142	173	203	234	265	295	326	356
22	22	53	82	113	143	174	204	235	266	296	327	357
23	23	54	83	114	144	175	205	236	267	297	328	358
24	24	55	84	115	145	176	206	237	268	298	329	359
25	25	56	85	116	146	177	207	238	269	299	330	360
26	26	57	86	117	147	178	208	239	270	300	331	361
27	27	58	87	118	148	179	209	240	271	301	332	362
28	28	59	88	119	149	180	210	241	272	302	333	363
29	29	60	89	120	150	181	211	242	273	303	334	364
30	30		90	121	151	182	212	243	274	304	335	365
31	31		91		152		213	244		305		366