7.1
I could apply exponential smoothing to my cycling power output data to determine whether my training is effective. I track my average power outputs over various of time periods, and ideally these should be increasing if the training is effective. However, there is a lot of variation in daily output based on things like rest, nutrition, weight and where I am in my monthly and annual training cycles.

I would need at least a few years' worth of power output data. Ideally I would also have data on my sleep, weight, and calorie intake so I could compare them to the smoothed data and see how strongly any of them correlated to periods of good performance.

The Alpha would probably be closer to 0 than 1, as the data is fairly noisy and would need a decent amount of smoothing.

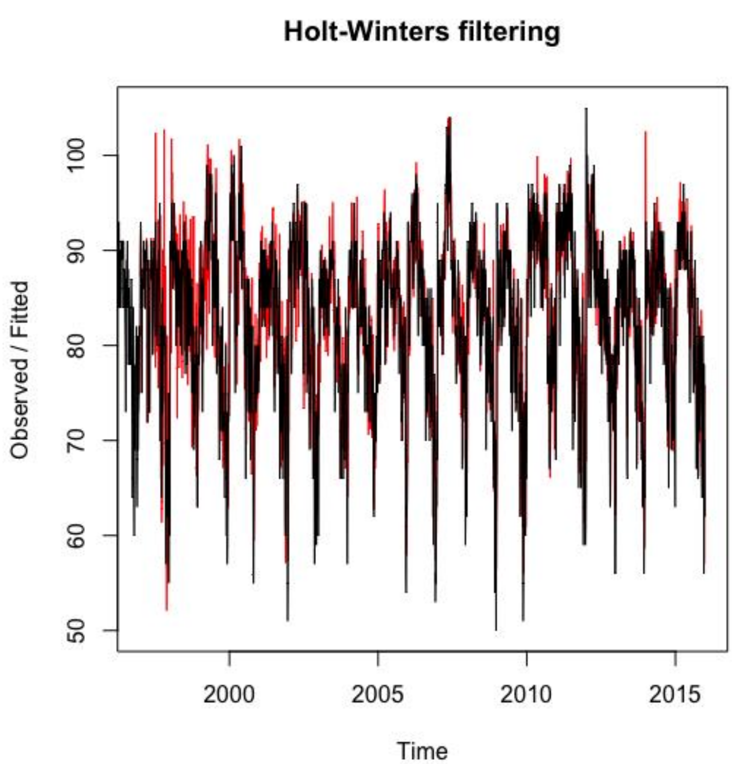
7.2

Please review the included R file (7.2.R) and Excel file (seasonality.xlsx) along with this submission.

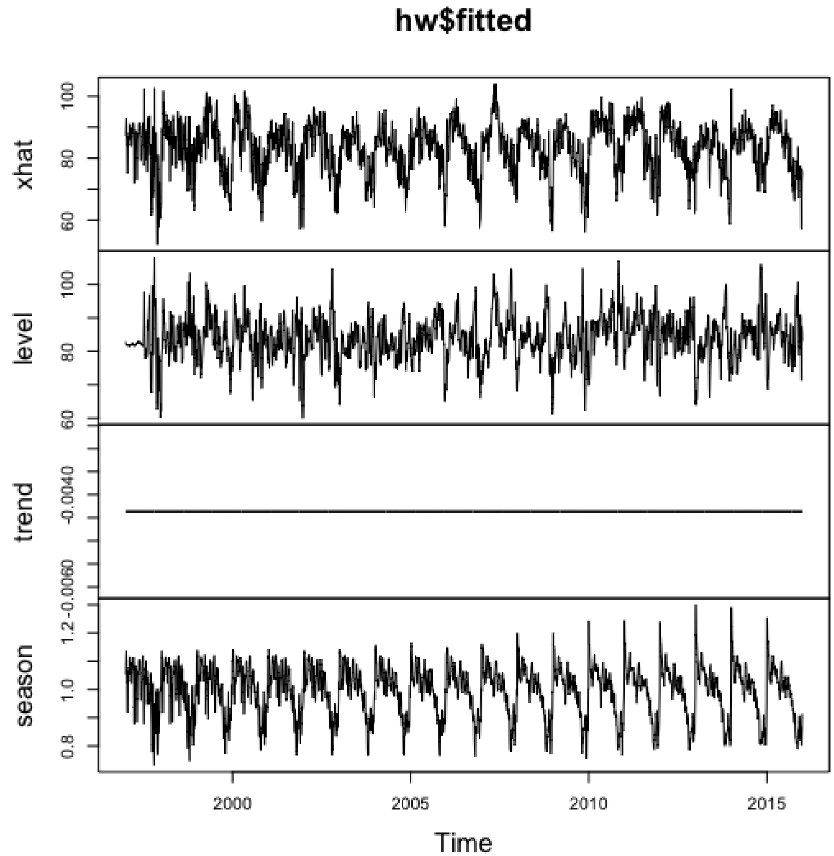
First, I converted the temperature data into a single vector, then converted that to a time series object for use in the Holt Winters model. I ran the Holt Winters model on the data, using Alpha, Beta, and Gamma factors and multiplicative seasonality. This should better capture the non-linearity of the data than an additive model.

The model found the best fit with the following alpha, beta, and gamma values:
alpha: 0.615003
beta : 0
gamma: 0.5495256

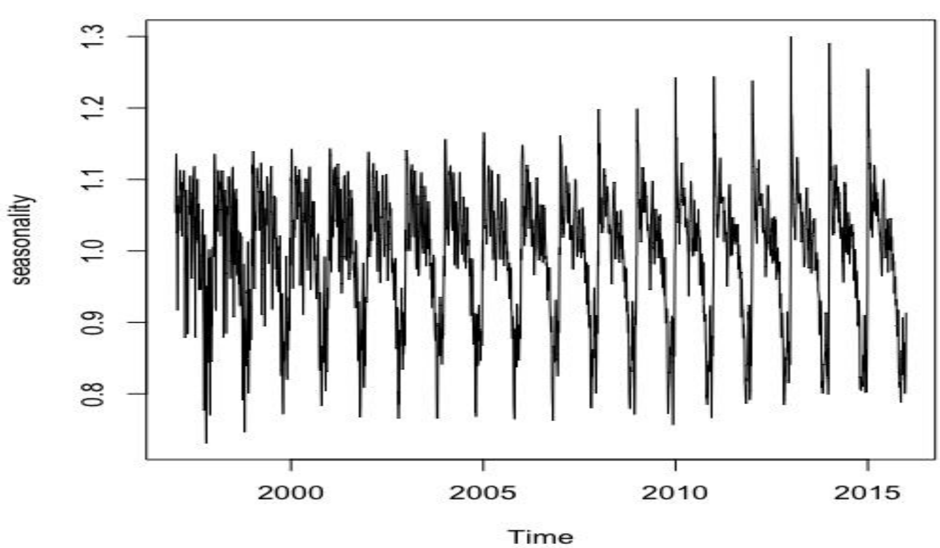
A plot of the original data and smoothed temperature data using those values is below:



I also plotted the fitted factors:



Interestingly, the best fit did not include any smoothing for trend. The seasonality factor looks to have higher peaks in later years. I stored this data in a separate vector and plotted it.

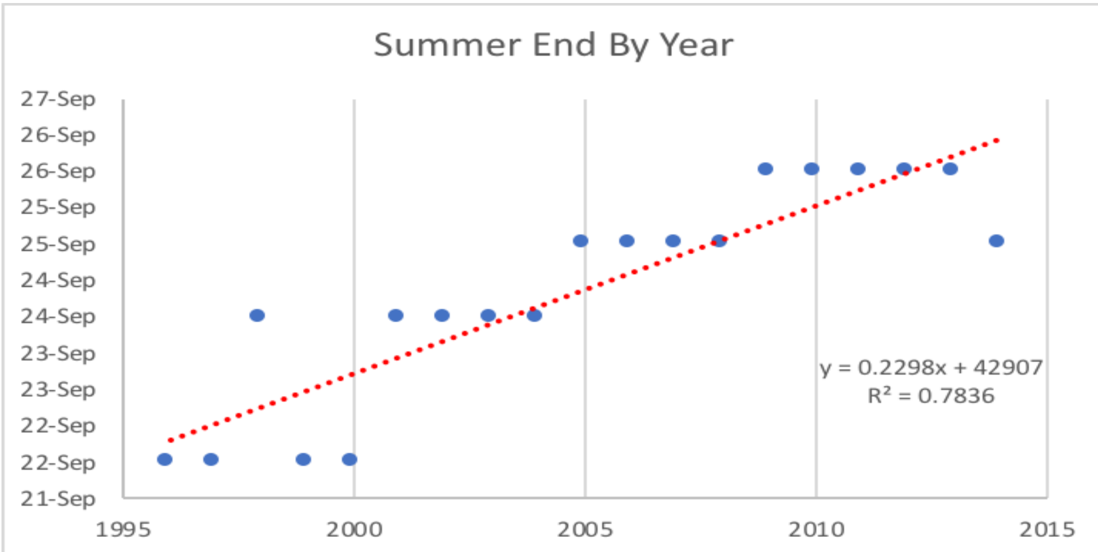


Although this doesn't indicate that summers are ending later in those years, it does indicate that temperature highs and lows throughout the time period we are analyzing appear to have more variability.

I then converted the seasonality vector into separate columns for each year, and exported the data so I could apply my excel CUSUM model. With the seasonality data loaded in excel, I applied a similar CUSUM analysis as in last week's analysis. I used a Mu value equal to the mean temperature for the month of July. I used a C value of (.5 * standard deviation) and a T of (5 * standard deviation). With these values the CUSUM model detected a change between September 22nd and September 26th each year. This is a much tighter range than when using the raw temperature data, where I found an end to summer within a wide range from early September to early October. This makes sense given that the Holt Winters model is smoothing the raw temperature data.

1-Sep	0.05727367	0.0393789	0.03189186	0.01055667	0.02029855	0.01112909	0	0	0	0	0	0	0	0.01927728	0.02378953	0.02296833	0.00543157	0.00162374	0.0071394
2-Sep	0.19813924	0.15150468	0.13336037	0.08433785	0.07979018	0.0722274	0.04087842	0.03228185	0.02962567	0.01149361	0	0	0	0.00059325	0.00540232	0.00220063	0	0	0
3-Sep	0.17010276	0.14501577	0.16860633	0.13982735	0.13115138	0.13149917	0.0813439	0.06716266	0.06035073	0.03751929	0.02088976	0.00425662	0.00559743	0	0	0	0	0	0
4-Sep	0.1782847	0.18382482	0.18202173	0.14440142	0.13239655	0.12446871	0.06705868	0.06255682	0.05994575	0.04700214	0.0244973	0	0	0	0.00150529	0.03658547	0.05082613	0.03774248	0.04935296
5-Sep	0.14984024	0.17602887	0.17189996	0.12895048	0.1357276	0.1019363	0.04970715	0.05738511	0.05128917	0.05457421	0.04279073	0.01618783	0.00330109	0	0.00029656	0.05559352	0.05838314	0.0494554	0.05383711
6-Sep	0.09636616	0.13346226	0.14093697	0.10035003	0.16411637	0.12035393	0.06615465	0.10152974	0.09148411	0.09071973	0.07208996	0.05201672	0.03259921	0.01643321	0.00141368	0.07269424	0.07151369	0.06540667	0.06145037
7-Sep	0.04100664	0.07192491	0.08549306	0.06339234	0.15250789	0.11592686	0.07315851	0.11581046	0.09790274	0.09756046	0.09564187	0.07685788	0.05247145	0.035859	0.01210299	0.10557832	0.08332357	0.07857672	0.07435681
8-Sep	0	0.00865431	0.02751261	0.01321559	0.08644188	0.06739836	0.04150325	0.07830691	0.10600489	0.10037832	0.09794137	0.07925082	0.05530483	0.0346035	0.00716398	0.10060068	0.08791308	0.07803344	0.09166774
9-Sep	0	0	0	0.01287363	0.05663161	0.03665998	0.00354295	0.03668011	0.05216779	0.0552595	0.06303001	0.04987527	0.03797674	0.02772416	0.00239573	0.07352263	0.08252117	0.07516571	0.09631198
10-Sep	0.0031375	0.00133255	0.00135741	0	0.02526303	0	0	0	0.00710252	0.01701037	0.02193491	0.0122409	0.0094062	0.01660306	0	0.04505643	0.06022313	0.05994089	0.08150182
11-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01344508	0	0.02327829	0.04203984	0.0436088	0.05563954
12-Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00074061	0.0264418	0.02572154	0.02963817
13-Sep	0.07425162	0.04646535	0.01425217	0.00454798	0	0	0.02511093	0.00465525	0.00425983	0	0.02155521	0.01565851	0.00706976	0	0.00682927	0	0.02038212	0.02413654	0.03616979
14-Sep	0.13610396	0.10042648	0.05936156	0.03733559	0.02382416	0.0103279	0.03729128	0.01688072	0.01472837	0.00377982	0.00627814	0.01664567	0.00290408	0	0	0	0	0.01750396	0.05527267
15-Sep	0.114025	0.09113323	0.06032134	0.03803366	0.04364387	0.04939653	0.03992738	0.0215538	0.03743313	0.01438683	0.00310522	0.01453987	0.02302012	0.02063884	0.01154543	0.01739291	0	0.01295081	0.05491319
16-Sep	0.14038895	0.11224201	0.07654861	0.07107955	0.09076887	0.09815219	0.08012193	0.05724984	0.06788616	0.04564019	0.02243869	0.04570559	0.05306692	0.04103438	0.03320711	0.07734612	0.04668837	0.03699747	0.05955007
17-Sep	0.16607183	0.13134316	0.0966088	0.09688768	0.12940187	0.12874066	0.1160735	0.09235816	0.0877922	0.07298148	0.04108582	0.0635948	0.10523474	0.10888433	0.07888779	0.11384404	0.09044354	0.09755057	0.10556577
18-Sep	0.23967485	0.19718206	0.16508172	0.15507094	0.18567242	0.17830964	0.17603933	0.14699514	0.13526733	0.11280378	0.07501423	0.09138141	0.10856371	0.10954748	0.08993799	0.13422375	0.12769419	0.14549325	0.15299402
19-Sep	0.30049389	0.25093746	0.22751467	0.22238708	0.22264811	0.21423211	0.22159184	0.18606789	0.17751289	0.14858524	0.12471109	0.12790001	0.13669364	0.14788996	0.12658121	0.16904232	0.16076444	0.1682105	0.18343026
20-Sep	0.36046585	0.29971761	0.27565466	0.3069283	0.28576956	0.26668346	0.25957245	0.21589857	0.22455561	0.19215088	0.18852837	0.18629998	0.19245913	0.18355747	0.15333814	0.18404742	0.18466065	0.18513184	0.20714538
21-Sep	0.43239695	0.37801563	0.34757863	0.35823873	0.36116164	0.33084783	0.32059483	0.28106376	0.28342829	0.24721663	0.24350359	0.24878137	0.26362169	0.24903958	0.21144576	0.22184869	0.20601247	0.23946167	0.24675257
22-Sep	0.46682121	0.47477682	0.42453743	0.44493552	0.46025307	0.41863818	0.41948196	0.39107668	0.36982534	0.33542309	0.3075722	0.29428412	0.29297067	0.27231081	0.24773922	0.27007098	0.2411808	0.26053473	0.28178971
23-Sep	0.46436144	0.47785192	0.45041605	0.47732845	0.48786048	0.45493653	0.45843488	0.43175303	0.40605266	0.38091138	0.34303901	0.33605979	0.33435944	0.31133979	0.29072065	0.30864962	0.291689	0.30257989	0.33787859
24-Sep	0.46139891	0.47179039	0.46339813	0.48725402	0.49295097	0.52208198	0.5437371	0.5105877	0.48013303	0.44832817	0.40686935	0.38241484	0.38993044	0.35821692	0.34437214	0.36085372	0.35337141	0.38818631	0.41717583
25-Sep	0.42244259	0.48925539	0.48061828	0.49445321	0.50402658	0.56708664	0.61265515	0.57551769	0.54865233	0.52244944	0.5010794	0.4683738	0.46136024	0.41845457	0.39324371	0.39578385	0.38531365	0.44874043	0.48324548
26-Sep	0.42048508	0.48893176	0.47878613	0.49013418	0.54512351	0.5970549	0.63793778	0.60866307	0.59536812	0.59676029	0.57538314	0.55075879	0.54385092	0.499008	0.505916	0.49497798	0.46135943	0.4966381	0.54424971
27-Sep	0.48017433	0.55477623	0.5237346	0.53480356	0.58812523	0.62707481	0.6661403	0.63928116	0.65154888	0.63932259	0.62213694	0.60423168	0.61148306	0.58136697	0.58799416	0.58302111	0.53848933	0.56055361	0.59922283
28-Sep	0.58953132	0.64472172	0.61745055	0.61353384	0.64844953	0.67110661	0.69592543	0.69430933	0.69504395	0.68267881	0.66177781	0.64800424	0.64020417	0.61676954	0.64699622	0.66199957	0.61976487	0.64103184	0.68332739
29-Sep	0.73520606	0.75382033	0.73644227	0.72899995	0.75481649	0.7802471	0.80191714	0.81356964	0.79725643	0.77288019	0.76980873	0.75285966	0.7273832	0.72260769	0.73971896	0.74331777	0.70614815	0.72860318	0.77897936
30-Sep	0.97773755	0.94880365	0.91774744	0.91070614	0.9153393	0.9307231	0.92856012	0.92725702	0.90083627	0.87856341	0.86582402	0.85509588	0.82348039	0.81871197	0.8404207	0.85246967	0.84144263	0.85189793	0.86687716
1-Oct	1.19480943	1.17672458	1.11186112	1.09746023	1.08858495	1.08788371	1.0688129	1.05726039	1.01906921	0.99221226	0.95510338	0.94574874	0.94420588	0.92928393	0.9422987	0.99352274	0.97825663	0.97225655	0.97035479
2-Oct	1.33842197	1.34656363	1.29868692	1.27825361	1.26097113	1.2429903	1.21359827	1.20779166	1.16097298	1.12311314	1.07802027	1.05757486	1.06328548	1.04734917	1.05791744	1.11309209	1.1085904	1.09769625	1.09058824
3-Oct	1.33545944	1.38407689	1.37743424	1.35611967	1.35094287	1.34164267	1.32041748	1.33104003	1.29139098	1.25620782	1.20532108	1.19164117	1.1810118	1.1624387	1.19930554	1.23270179	1.22715587	1.21685936	1.22557749
4-Oct	1.50323311	1.5258113	1.50160885	1.50270973	1.49020057	1.47626431	1.45512811	1.43785188	1.40214474	1.36763753	1.31448295	1.29998552	1.28144194	1.27074157	1.32249945	1.33934477	1.31651162	1.30565196	1.36436224
5-Oct	1.71951564	1.71698932	1.67653906	1.67060419	1.64874908	1.63132917	1.59526898	1.5641826	1.52821954	1.49987863	1.4371537	1.41716219	1.39377045	1.41816015	1.45937376	1.4604561	1.42819318	1.41472357	1.47198792
6-Oct	1.9597531	1.94127721	1.9076445	1.89240682	1.87580809	1.86354284	1.80893788	1.76495783	1.72501053	1.70505272	1.64549497	1.60458137	1.56746652	1.56850978	1.59747532	1.59687524	1.55564449	1.53788538	1.57409875
7-Oct	2.24840322	2.21454018	2.15552952	2.12886651	2.12804414	2.11716931	2.06300641	2.0104725	1.9599546	1.93522973	1.88068777	1.82472792	1.77591707	1.74388296	1.74509406	1.7464568	1.73628882	1.72862022	1.73561808
8-Oct	2.31716008	2.32964038	2.33057686	2.31535036	2.3654482	2.33380465	2.30858589	2.25455552	2.20473999	2.17390239	2.11948637	2.05712013	2.02315188	1.9697117	1.94911093	1.94188522	1.94744793	1.9419075	1.9258637
9-Oct	2.48308686	2.49732409	2.50296554	2.49527284	2.56799776	2.56734643	2.56225886	2.50595226	2.45937858	2.43094932	2.35803473	2.29729713	2.26071433	2.19134767	2.15745487	2.1598448	2.14902421	2.13701903	2.11602968
10-Oct	2.62315388	2.63904151	2.64957916	2.65046971	2.71009027	2.71728684	2.728905	2.69124026	2.66074673	2.62847184	2.55892903	2.50704793	2.47146823	2.42567815	2.3822759	2.39454661	2.36738265	2.34089461	2.31618949
11-Oct	2.79911204	2.80819642	2.80309734	2.80330482	2.83976727	2.84760096	2.84980314	2.8496609	2.81666408	2.78121516	2.72283972	2.71801608	2.68035313	2.63749003	2.59518826	2.62172096	2.5854431	2.55566247	2.52726502
12-Oct	2.97490345	2.98807735	2.97491155	2.97855574	2.99711002	2.99236313	2.97455042	2.95712003	2.94471388	2.93367364	2.90198746	2.89991885	2.87000132	2.86007195	2.82818115	2.83687981	2.79085584	2.75818143	2.7329789
13-Oct	3.10196392	3.12508667	3.11799593	3.14613066	3.15467616	3.14510893	3.12938108	3.09946695	3.11236721	3.09520242	3.09727946	3.08811986	3.05985315	3.04535058	3.02586733	3.03279883	2.99619438	2.96031108	2.93641989
14-Oct	3.15605942	3.23393717	3.24301857	3.25503619	3.27237137	3.27708841	3.29537978	3.25845867	3.28059735	3.25865189	3.25442383	3.24108297	3.21407669	3.22422787	3.22756171	3.22613612	3.18914725	3.16574416	3.16348783
15-Oct	3.18581351	3.30861635	3.32123894	3.34240606	3.36265072	3.37907136	3.45354085	3.43817994	3.46232642	3.43351101	3.42196089	3.40485165	3.3738066	3.40710422	3.40683477	3.40015792	3.3671532	3.37454837	3.39467551
16-Oct	3.22768942	3.3871009	3.40281369	3.41625363	3.43287023	3.49753535	3.56316087	3.55919976	3.57133554	3.56338622	3.59162655	3.57729234	3.53854956	3.5799026	3.58504222	3.56795981	3.54504138	3.54967483	3.58382141
17-Oct	3.24522512	3.39378709	3.42949131	3.44371457	3.46895006	3.56855037	3.64717571	3.66482039	3.66507599	3.67142434	3.68513474	3.67389247	3.68596073	3.76808665	3.76309874	3.73999537	3.71767451	3.72727171	3.74281302
18-Oct	3.45825502	3.57262311	3.57998776	3.59191946	3.59645296	3.67826853	3.7421938	3.76024195	3.76337435	3.75937416	3.75593082	3.76358128	3.80407752	3.89509523	3.90426061	3.89814964	3.8814801	3.8923909	3.91274156
19-Oct	3.70778799	3.79104151	3.77218838	3.78745258	3.79082469	3.83575376	3.87703294	3.87435564	3.88830829	3.87042419	3.85836781	3.86913034	3.92332226	3.99799209	4.00829938	4.05268844	4.04148215	4.0809371	4.10529157
20-Oct	3.89613484	3.97781933	3.97140535	4.00316451	4.0018911	4.02106957	4.04365183	4.02006091	4.02359244	3.99834653	3.9978195	4.00453108	4.05482592	4.10095746	4.1239702	4.21136035	4.20646117	4.23713054	4.27010582
21-Oct	3.94994418	4.06202757	4.089982	4.13450134	4.14501167	4.15907982	4.18970257	4.14894337	4.1467983	4.12827171	4.1318027	4.13079293	4.16523207	4.19676933	4.21881629	4.31558389	4.31197392	4.34661962	4.38299643
22-Oct	3.97852379	4.13469946	4.20950106	4.23399473	4.245997	4.264698	4.32608272	4.29470302	4.28690012	4.30093426	4.2946152	4.29927035	4.32956037	4.3377145	4.35480839	4.4325065	4.41937335	4.46340609	4.51792327
23-Oct	4.1528952	4.29301981	4.36772631	4.42254889	4.42634233	4.42861252	4.50434295	4.4677989	4.4597109	4.47159821	4.513047	4.48904924	4.52960919	4.52677265	4.53676696	4.5933443	4.57006815	4.62542319	4.6722917
24-Oct	4.27739083	4.42498998	4.48048133	4.55139552	4.56495344	4.57442567	4.63368382	4.61841025	4.60731159	4.66600618	4.7117519	4.73731514	4.79233243	4.77977282	4.76444843	4.79749369	4.75956843	4.80303356	4.83895747
25-Oct	4.40108749	4.51640098	4.56508107	4.63244253	4.65260891	4.69214744	4.77518051	4.7656212	4.74195266	4.8299105	4.88728248	4.93287407	4.9681384	4.98190383	4.97869891	4.99888638	4.95382687	5.02079386	5.03797552
26-Oct	4.50024313	4.61911787	4.65289965	4.70355841	4.73637023	4.81551639	4.88309484	4.89704226	4.86948755	4.94771499	4.99704978	5.04466378	5.08190249	5.12079519	5.1157144	5.14525655	5.10935421	5.17879322	5.18568836
27-Oct	4.59930747	4.76331659	4.78324425	4.80400332	4.82789596	4.96732997	5.02075764	5.04889771	5.01108494	5.07680859	5.10914031	5.15988022	5.23042218	5.28655972	5.29550483	5.31518277	5.30211863	5.3437799	5.34532707
28-Oct	4.62533281	4.83341793	4.86401641	4.88912213	4.90782456	5.05980143	5.1041545	5.17376929	5.14490477	5.21047273	5.2441456	5.28315792	5.39747577	5.42651452	5.45175554	5.48465506	5.52209968	5.56078025	5.56450982
29-Oct	4.63949241	4.83583805	4.88867304	4.93081931	4.97039996	5.10376671	5.15501625	5.20693553	5.21096256	5.2849598	5.30551007	5.38113982	5.4867977	5.5111595	5.57261043	5.66311706	5.71922732	5.73443951	5.7582426
30-Oct	4.65395081	4.83927334	4.88986201	4.93505167	4.98561871	5.09385167	5.18156329	5.21205987	5.22717318	5.29945197	5.32485096	5.40842602	5.50573632	5.57144235	5.64424485	5.76405742	5.84564509	5.85945827	5.91618098
31-Oct	4.68135316	4.8798873	4.929632	4.96796089	5.0140052	5.11309891	5.23588071	5.25812278	5.25870406	5.32412196	5.36426655	5.43472107	5.52271598	5.59600661	5.66953951	5.79824174	5.87418816	5.92074714	6.0218713

When I ran the model with raw temperature data last week there was an extremely slight trend to later summer end dates, but with a lot of variability and certainly not enough to definitely claim that summer is ending late. With the smoothed data there is a clearer trend towards later summer end dates in the seasonality data, with a shift from September 22nd to September 26th occurring over the time period.



Although I do think this gives a clearer indication of a trend to later summer end dates than last weeks' results did, I still don't think it is enough to conclusively state that summer end dates are getting later. We just don't have enough data in 20 years to make a conclusion about something that would be happening gradually over such a long time period.