SEASONAL ATMOSPHERIC TEMPERATURE PROFILES OVER THE NORTHERN HEMISPHERE

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ABSTRACT

Seasonal atmospheric temperature profiles over the Northern Hemisphere are presented. Mean tropospheric temperature profiles as a function of latitudinal belts are estimated from global meteorological data sets. Neural network algorithms were applied to archived radiosonde measurements, retrieved temperature profiles from remote sensing methods, standard atmosphere supplement profiles, and monthly solar insolation. For these investigations, we draw upon a wealth of observed global climate data sets which allows us to explore aspects of temperature profiles throughout varied regions in the Northern Hemisphere. From ground based and satellite observations, it has been observed that seasonal changes in conjunction with latitudinal variations can produce temperature profiles that can significantly differ from the standard atmosphere, especially for higher latitude geographical regions. Parameterization of mean monthly tropospheric temperature profiles in the Northern Hemisphere are examined and specific characteristics are analyzed. Radiosonde temperature profiles from various global radiosonde stations were used to test the temperature profile neural network's performance.

1. INTRODUCTION

1.1 Previous research has shown the feasibility of using neural networks to provide mean climatological temperature profiles over the Northern Hemisphere (Yee, et al, 2011). Seasonal changes in conjunction with latitudinal variations can produce temperature profiles that can significantly differ from the standard atmosphere.

This study investigates the performance of using mean climatological temperature profiles for specific locations in the Northern Hemisphere. Several radiosonde locations over the world were selected to represent different seasons and latitudes in order to compare RMS errors between the climatological temperature profiles and the measured radiosonde profiles for each location.

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1.2 Latitudinal and seasonal variations of the atmosphere has been calculated for altitudes from the surface up to 10 kilometers. For the model atmospheres that are included in this paper, the seasons will be representative of several months as defined by table1.1. The latitudinal regions include the tropics, the subtropics, the mid-latitudes, the subarctic, and the arctic. The tropics between the equator and approximately 15N. Latitude, in general, do not have seasonal changes in its climate and therefore, the mean temperature profiles in this latitude zone have little variation from each other.

Seasonal Months	
Seasons	**Months**
Winter	Dec, Jan, Feb
Spring	Mar, Apr, May
Summer	Jun, Jul, Aug
Fall	Sept, Oct, Nov

Table 1.1 Months associated with each season.

2.0 LATITUDINAL LAND AND OCEAN COVERAGE

Temperature profiles are influenced differently over land and ocean so it is prudent to be aware of the land and ocean coverage along a latitudinal zones. Oceans cover approximately 61 percent of the Northern Hemisphere in contrast to the 81 percent coverage of the Southern Hemisphere (Sellers, 1965). Table 2.1 gives the percent ocean coverage along latitude zones.

Latitudinal Land and Ocean Coverage			
Latitude Zone	Coverage (percent)		Mean Elevation (meters)
	Ocean	Land	
80-90° N	93.4	6.6	137
70-80° N	71.3	28.7	220
60-70° N	29.4	70.6	202
50-60° N	42.8	57.2	296
40-50° N	47.5	52.5	382
30-40° N	57.2	42.8	496
20-30° N	62.4	37.6	366
10-20° N	73.6	26.4	146
0-10° N	77.2	22.8	158

Table 2.1 Latitudinal land and ocean coverage for the Northern Hemisphere.

Most of the land areas in the northern hemisphere are between 40 and 70 N latitude. The lower (0-20 N) and higher latitudes (70-80 N) have over 70 percent ocean coverage. Between 20-50 N latitudes the highest peaks can be found such as the Himalayas, Alps and the U.S. Rockies.

3.0 FEATURES OF TEMPERATURE PROFILE MODEL

The basis of the temperature profile model for the different latitudinal zones is a neural network algorithm. Detailed atmospheric temperature profiles for each laitude belt has been compiled in a compendium of data for the Northern Hemisphere (Yee, et al, 2012).

Features of the Algorithm are outlined as follows:

- The model produces a mean seasonal temperature profile with latitudinal dependence for the Northern Hemisphere.
- The model is a neural network based algorithm that uses the archived radiosonde measurements (pre2000 data sets), retrieved temperature profiles from remote sensors, climatological information and the solar insolation at the top of the atmosphere.
- The model is valid from sea level up to 10 kilometers atmospheric height.

4.0 TEST CASES

4.1 Radiosonde temperature profiles for a month were obtained from several global radiosonde locations as shown in Table 4.1.

Location	Latitude (degrees)	Longitude (degrees)	Elevation (meters)
Beijing	39.93 N	116.28 E	55
Prague	50.00 N	14.45 E	303
St Petersburg	59.95 N	30.70 E	78
Eureka	79.98 N	85.93 W	10

Table 4.1 Location of test cases used in this study.

4.2 St Petersburg, Russia
Petersburg is classified as Dfb by Köppen climate classification (Rubel, F., and M. Kottek, 2010). It has a humid continental climate of the cool summer subtype. Distinct moderating influence of the Baltic Sea cyclones result in warm, humid and short summers and long, cold wet winters.

4.3 Prague, Czech Republic
Prague is in the Czech Republic in Europe. It has borderline oceanic climate (Köppen Cfb). The winters are relatively cold with very little amount of sunshine. Prague is located in the shadow of the Ore Mountains and the Czech Central Highlands. Temperature inversions are relatively common between mid-October and mid-March bringing often cloudy, cold days in comparison with mountains or highlands.

4.4 Beijing, China
Beijing has a rather dry, monsoon-influenced humid continental climate (Köppen climate classification Dwa), characterised by hot, humid summers due to the East Asian monsoon, and generally cold, windy, dry winters that reflect the influence of the vast Siberian anticyclone. Spring can bear witness to sandstorms blowing in from the Mongolian steppe, accompanied by rapidly warming, but generally dry, conditions. Autumn, like spring, sees little rain, but is crisp

and short. In July the mean monthly surface temperature is 26.0 °C (79.2 °F).

4.5 Eureka, Canada
Eureka is in the Canadian territory of Nunavut with a Koppen classification ET (polar tundra). It is on Fosheim Peninsula, Ellesmere Island, Qikiqtaaluk Region and is the second-northernmost permanent research community in the world. Arctic tundra contains areas of stark landscape and is frozen for much of the year. The settlement sees the midnight sun between April 10 and August 29, with no sunlight at all between mid-October and late February.

4.6 The radiosonde data sets that were collected to perform the preliminary data analysis for the four test locations representing different seasons are as follows:

A. St Petersburg January 1-31, 2011
(00HR and 12HR RAOBS)
B. Prague April 1-30, 2011
(00HR and 12HR RAOBS)
C. Beijing July 1-31, 2011
(00HR and 12 HR RAOBS)
D. Eureka October 1-31, 2011
(00HR and 12HR RAOBS)

(http://weather.uwyo.edu/upperair/sounding.html)
(http://esrl.noaa.gov/raobs/)

4.7 The overall climatology of surface temperatures at the selected locations is given in table 4.2 to give an overview of the seasonal variation for the sites (http://www.blueplanetbiomes.org/climate.htm).
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(a) PRAGUE CZECH data derived from GHCN 2 Beta. 2383 months between 1771 and 1981.
(b) BEIJING data derived from GHCN 1. 1457 months between 1841 and 1988.
(c) EUREKA,N.W.T. data derived from GHCN 1. 521 months between 1947 and 1990.

5.0 DATA ANALYSIS

For the case study, selected radiosonde observations from the year 2011 were collected for different months of the year at various locations. The months selected reflect the peak seasons of winter, spring, summer, and fall. Table 5.1 is the mean monthly near surface temperatures taken by radiosonde launchings corresponding to data taken in Section 4.6 of this paper.

Surface Temperature	0 Hr Avg	12 Hr Avg	Grand Average	Surface Height (m)
Eureka, Canada	-19.3	-19.9	-19.6	10
Prague, Czech	7.6	14.9	11.2	303
Beijing, China	24.8	28.8	26.8	55
St Petersburg, Russia	-7.6	-6.5	-7.1	4

Table 5.1 Mean radiosonde surface temperatures corresponding to data sets in Section 4.6.

For the data analysis, the radiosonde temperature profiles as a function of height were interpolated to height increments of 500 meters from sea level up to 10 kilometers in order to perform the comparisons between the collected radiosonde measured temperatures, the model profile temperatures and the standard atmosphere (US Standard Atmosphere, 1966, 1976) temperatures at each height increment. The results are shown in graphs 5.1, 5.2, 5.3, and 5.4. The RMS errors for each case study is summarized in table 5.2.

LOCATION	Standard Atmsphere RMS Errors (Celsius)	Mkey Model RMS Errors (Celsius)
St Peterburg	14.3	3.0
Prague	1.8	2.9
Beijing	14.1	1.4
Eureka	21.9	10.2

Table 5.2 Summary of Standard Atmosphere RMS errors and Model RMS errors for test cases: St Peterburg, Prague, Beijing, and Eureka.

The data was screened for missing or questionable data values. The results are shown in figures 5.1, 5.2, 5.3, and 5.4. The test case with the closest agreement between the standard atmosphere temperatures and the radiosonde mean temperatures is the Prague location (average 1.8^{o}C RMS error). This case matches closely with the idealized mid-latitude spring or fall standard atmosphere temperature profile. The test case with closest agreement between the Mkey Model temperatures and the radiosonde mean temperature is the Beijing location (average 1.4^{o}C RMS error). For most of the test cases, the Mkey model matched the radiosonde measurements better than the standard atmosphere. Both models did not match the Eureka test case well.

6.0 CONCLUSION

Latitudinal variations of the mean temperature profiles are shown to be significantly different than the standard atmosphere. Test cases were selected to represent a diversity of climate regions and seasons. For these test cases, the RMS errors between the model and the mean temperature profiles ranged from 1.4^{o}C to 10.2^{o}C. The RMS errors between the standard atmosphere and the mean temperature profiles ranged from 1.8^{o}C to 21.9^{o}C. Both the standard atmosphere and the Mkey temperature profile model did not match the Eureka test case well. Eureka is located in the arctic region at a latitude of 79.98^{o}N and will require further investigation.

7.0 RECOMMENDATIONS

• Collect and assemble climatological temperature profiles for other latitudinal belts for the different seasons to compile more complete data sets.
• Perform test and evaluation at other geographical locations
• Perform sample tests to determine value to the aeronautic and aerospace community
• Investigate arctic weather patterns and effects on the mean temperature profiles.
• Investigate broader applications of the model

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Mean Surface Temperatures				
Month	Eureka, Canada	Prague, Czech	Beijing, China	St Petersburg, Russia
Jan	-36.6	-1.3	-4.6	−5.5
Feb	-38.1	0.2	-1.8	−5.8
Mar	-37.1	3.6	4.7	−1.3
Apr	-27.7	8.8	13.6	5.1
May	-10.5	14.3	20.0	11.3
Jun	2.1	17.6	24.4	15.7
Jul	5.5	19.3	26.0	18.8
Aug	3.2	18.7	24.7	16.9
Sep	-7.8	14.9	19.8	11.6
Oct	-22.0	9.4	12.6	6.2
Nov	-31.4	3.8	3.9	0.1
Dec	-34.8	0.3	-2.6	−3.7
Year	-19.5	9.2	11.8	5.8

Table 4.2 Climatological mean monthly surface temperatures
for test locations (GHCN 1).

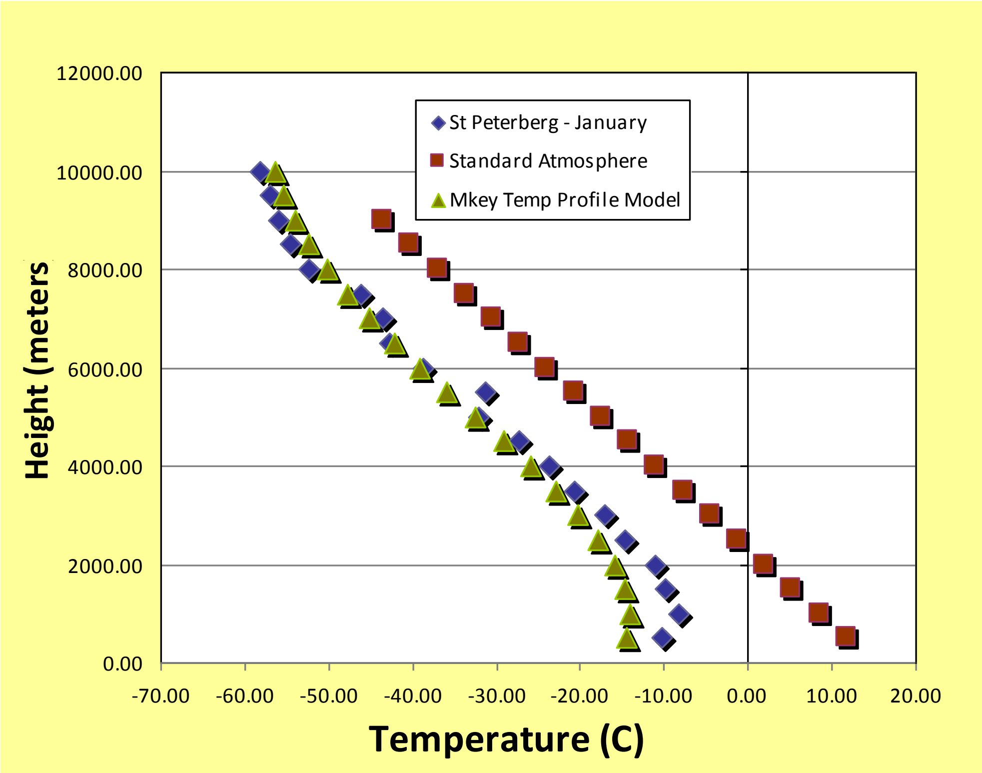

Figure 5.1 Comparison of St Peterburg radiosonde test case (January 2011) with standard atmosphere and Mkey temperature profile model.

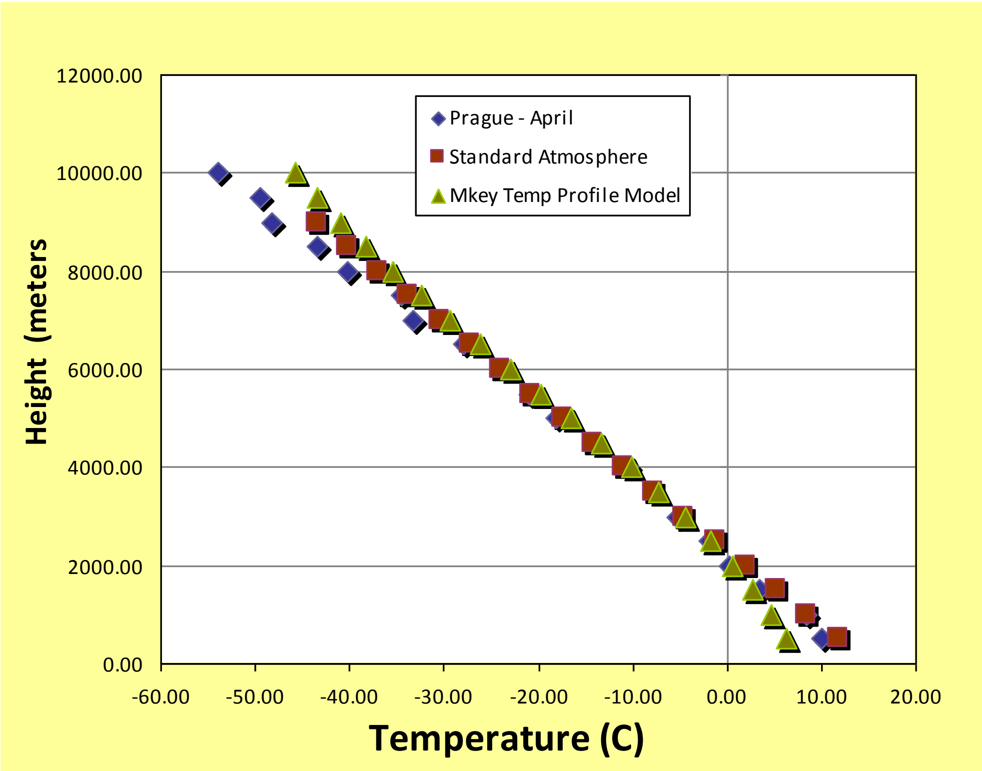

Figure 5.2 Comparison of Prague radiosonde test case (April 2011) with standard atmosphere and Mkey temperature profile model.

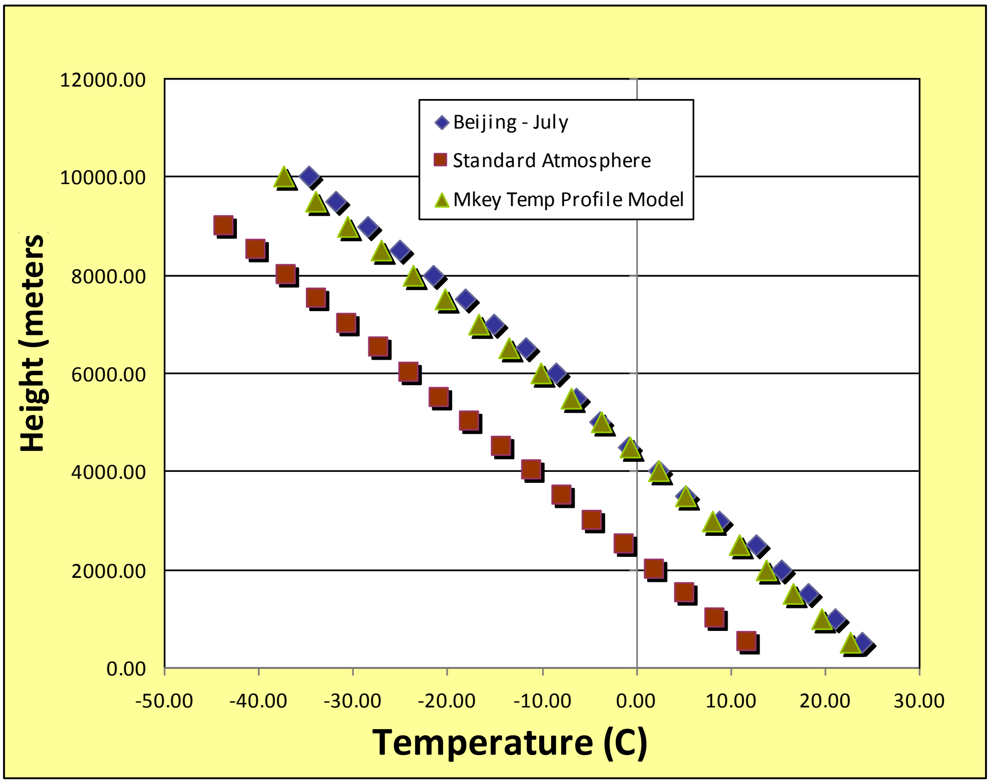

Figure 5.3 Comparison of Beijing radiosonde test case (July 2011) with standard atmosphere and Mkey temperature profile model.

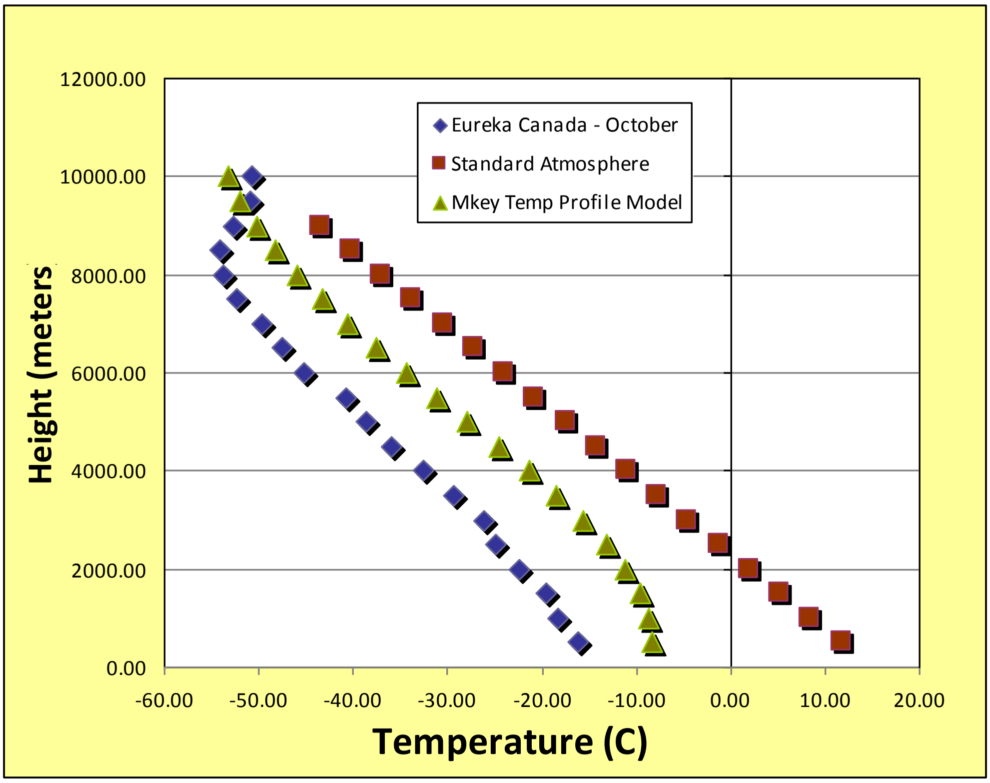

Figure 5.4 Comparison of Eureka radiosonde test case (October 2011) with standard atmosphere and Mkey temperature profile model.