Characterisation of Mesospheric Temperature Inversions (MTI's) studied over SANAE (Antarctica) using sounding of the atmosphere broadband emission radiometry (SABER) temperature data.

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Outline

- Introduction
- Aim of this project
- Atmosphere layers
- Data and methods of analysis
- Results
- Current status of work

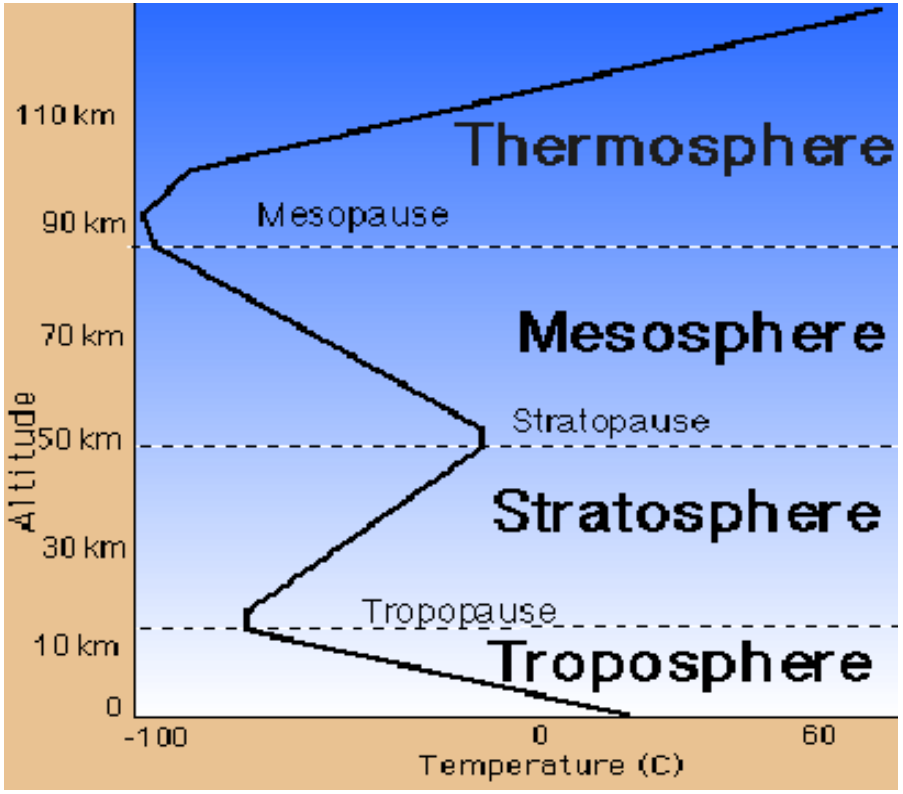
Introduction

- This study focuses on investigation of MILs at high latitude (72^{o} S to 3^{o} W).
- Mesosphere Temperature Inversion (MTIs) or sometimes called Mesosphere Inversion Layers (MIL's) is defined as the positive lapse rate of the temperature profile in comparison to the climatological profiles.
- Most studies were conducted at lower latitude, this investigation beefs up high latitude studies
- There are two types of MIL's
  - The lower MIL's
  - The upper MIL's
- Causes of MILs - Chemical heating, Gravity waves ,Tides waves & Planetary waves
- Reports suggest that upper (lower) MIL's are usually driven by tides (planetary waves)

Aim of this project

- The purpose of this study is to provide a statistical analysis of MIL's characteristics such as their amplitude, thickness and altitude of occurrence.
- Seasonal variation amplitude will be investigated
- Planetary waves as possible drivers behind MIL's will be investigated

Atmospheric layers



- There are four atmospheric layers in the atmospheric vertical temperature structure,
- The first layer starts from approximately 0-15 km which is called troposphere and the second layer starts above troposphere, which is just above 15 km and it is called stratosphere.
- The mesosphere region starts above 50 km which is where the mesospheric temperature inversion are monitored.

Instrumentation

- Data was collected and analysed using sounding of the atmosphere using broadband emission radiometry (SABER) instrument.
- SABER instrument is one of four instruments on NASA's TIMED satellite.
- SABER is a 10 channel broadband limb scanning infrared radiometry covering the spectral range from 1.27 µm to 17 µm. SABER provides vertical distributions of temperature and concentrations of energetically important species.
- The TIMED satellite has the latitudinal coverage of 52^{o} N to 93^{o} S and 52^{o} S to 83^{o} N.
- Consequently, the measurements always cover the latitudinal range 52^{o} S to 52^{o} N.
- During the Northward viewing phase, the measurement is taken in the 52^{o} S to 83^{o} N latitudinal range while in the Southward viewing phase, the measurement is taken in the 52^{o} N to 83^{o} S latitudinal range.
- The satellite takes about 60 days to change the viewing phase

Data

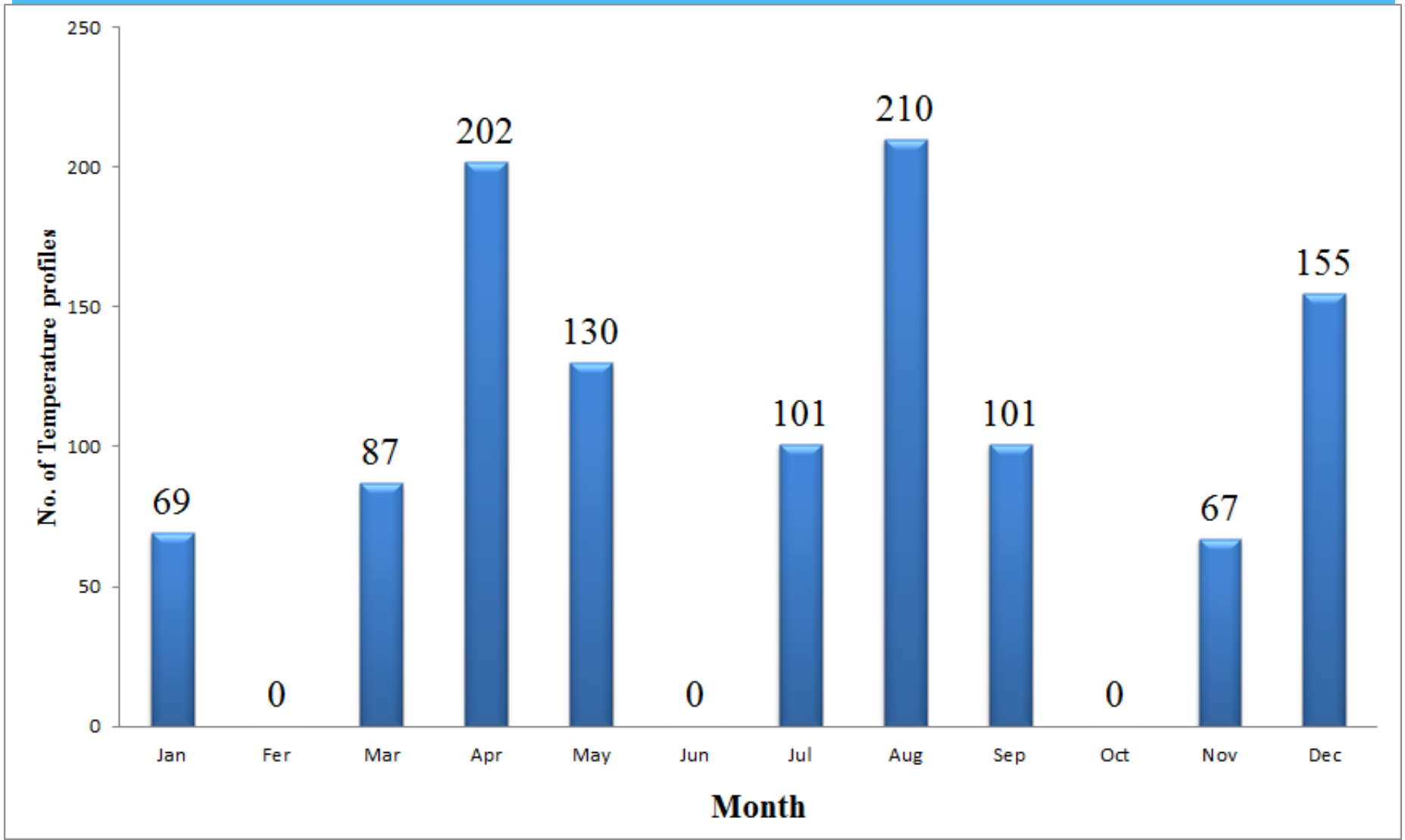
- The current study concentrated on the investigation of MIL's at high latitude over SANAE (-72^{o} to -3^{o}).
- The temperature profiles were extracted in a latitudinal range of (-69^{o}, -75^{o}) and at (347^{o} to 7^{o}) longitude.
- This location was chosen to establish the relationship between the MIL's and the planetary waves observed by HF radar located at SANAE.
- Due to the 60 day alternating of the satellite data is not always at 72^{o} S, instead the data is available during the following months: March-May, July-September and November to January.
- The daily temperature profiles used spans the temporal range 2002 to 2011 while a special extent is from 20 km to 120 km.
- The altitude resolution of the temperature profile alternates around 0.4 km, thus the temperature profiles were then re-sampled at 0.5 km.

Data

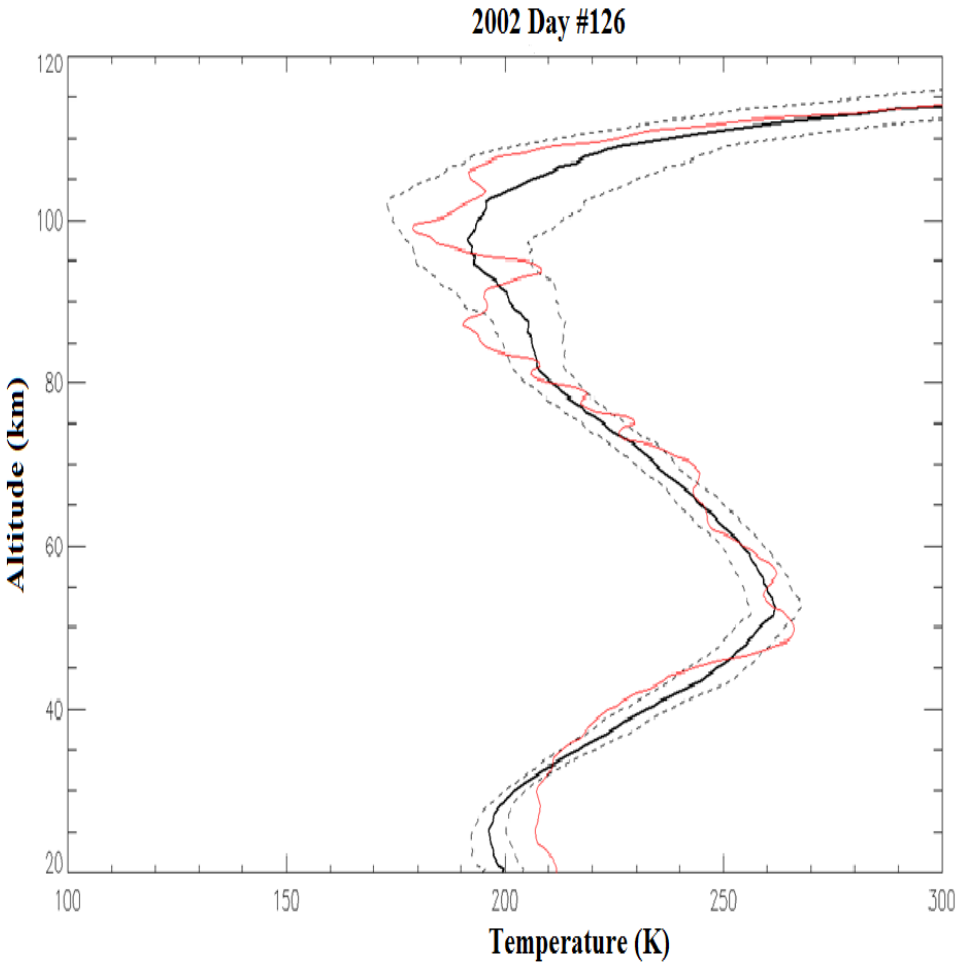
Number of Profile extracted from 2002 to 2011

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	0	0	11	29	17	0	8	29	19	0	8	29	150
2003	15	0	12	24	22	0	13	26	17	0	8	29	166
2004	14	0	12	25	20	0	13	28	12	0	10	27	161
2005	13	0	11	25	20	0	9	25	17	0	11	30	161
2006	13	0	9	23	18	0	12	27	11	0	10	30	153
2007	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	4	0	10	25	7	0	15	23	9	0	6	1	100
2010	4	0	12	26	12	0	15	24	7	0	7	4	111
2011	6	0	10	25	14	0	16	28	9	0	7	5	120
Total	69	0	87	202	130	0	101	210	101	0	67	155	1122

Data

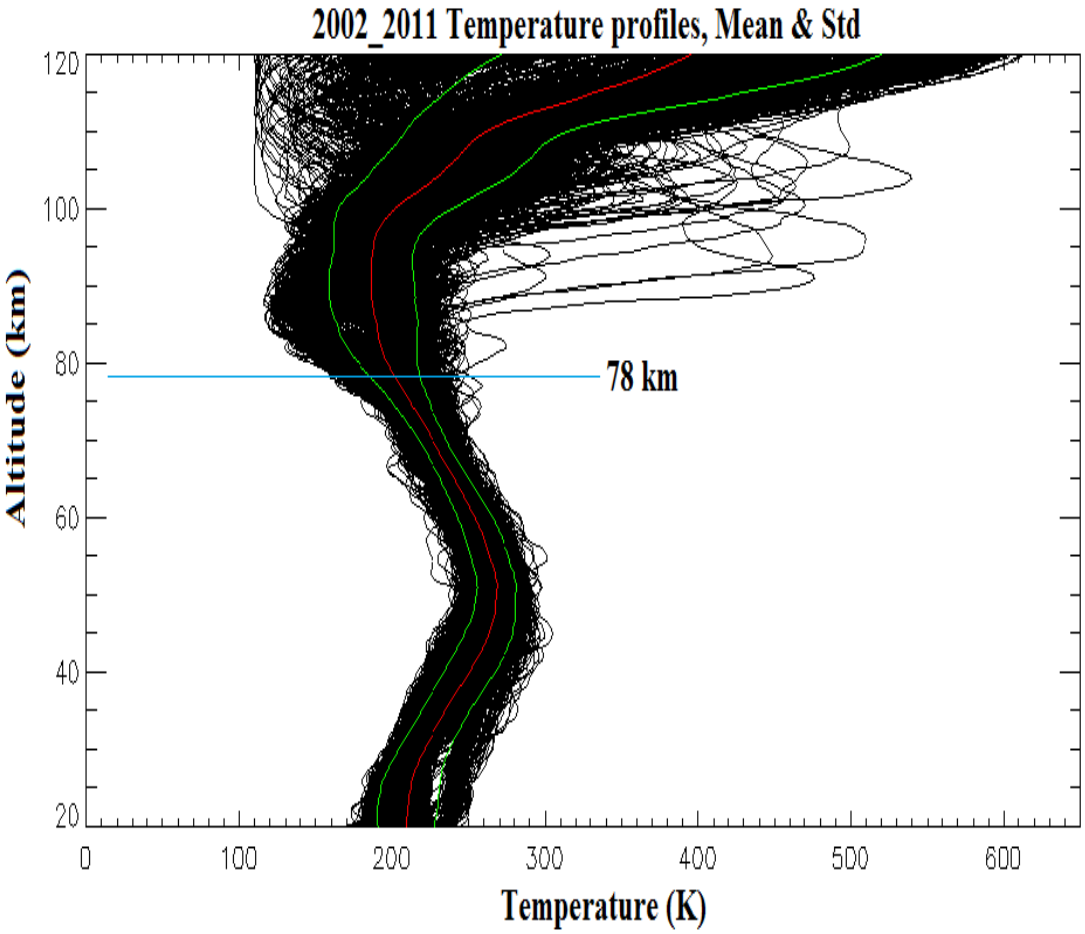

250
200
150
100
50
0
No. of Temperature profiles
69
0
87
202
130
0
101
210
101
0
67
155
Jan
Fer
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Quality test on the temperature profiles



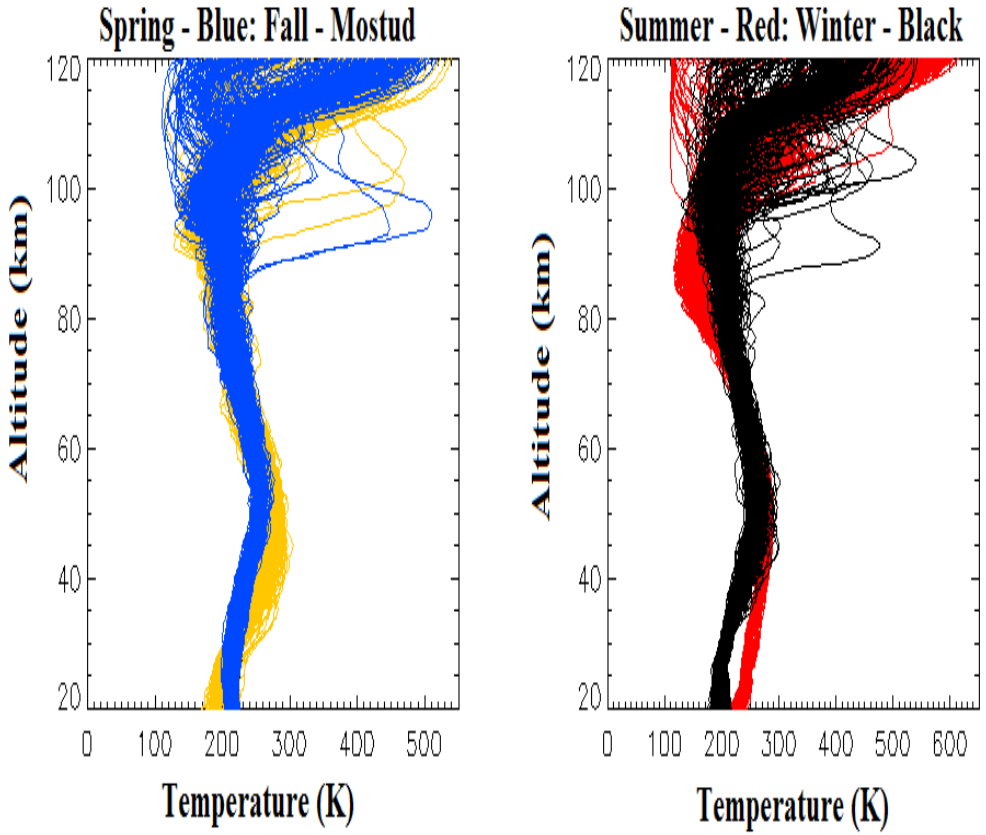
- The quality check was done to see if a temperature profile conforms to the following criteria
  - A temperature profile mimics the overall behaviour
  - 80% of the profile is within 2σ.
- Example is given for the temperature profile for 6 of May 2002
- The quality check was done on all the temperature profiles; all of them conform to the standards.

Temperature profiles



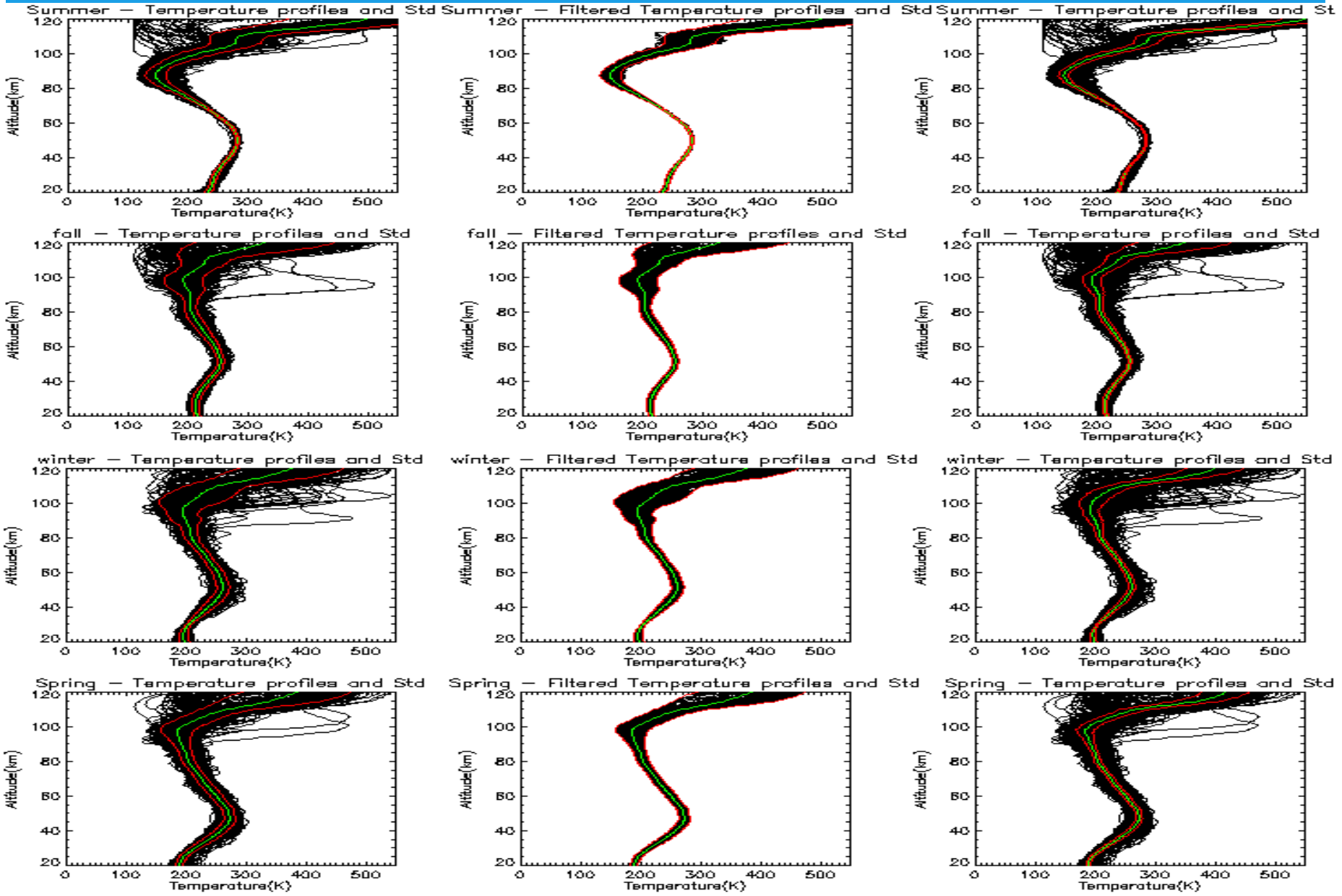
- The temperature profiles (black), the mean (red) and standard deviation (green) from 20 to 120 km altitude over the period of 2002 to 2011.
- Standard deviation increases above 78 km. There are 2 possible reasons
  - Different behavior of temperature profiles in different seasons
  - Extremely large temperature observed above 80 km

Separation of the data according to seasons

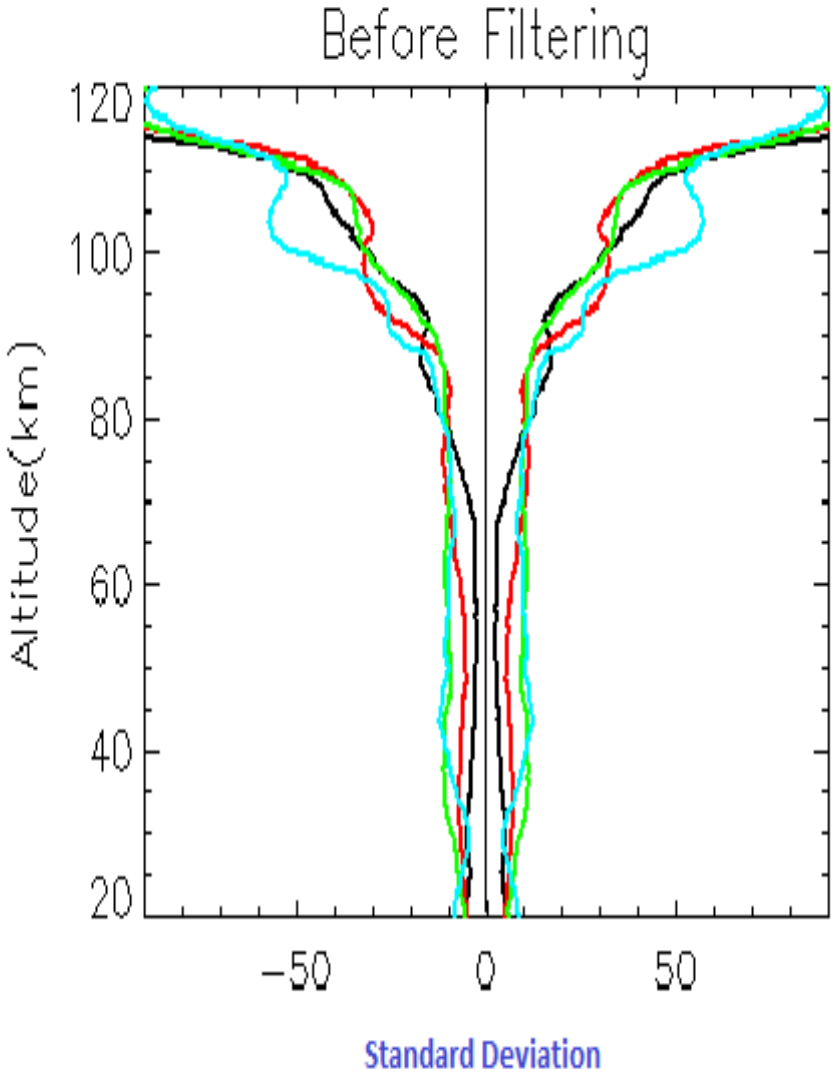


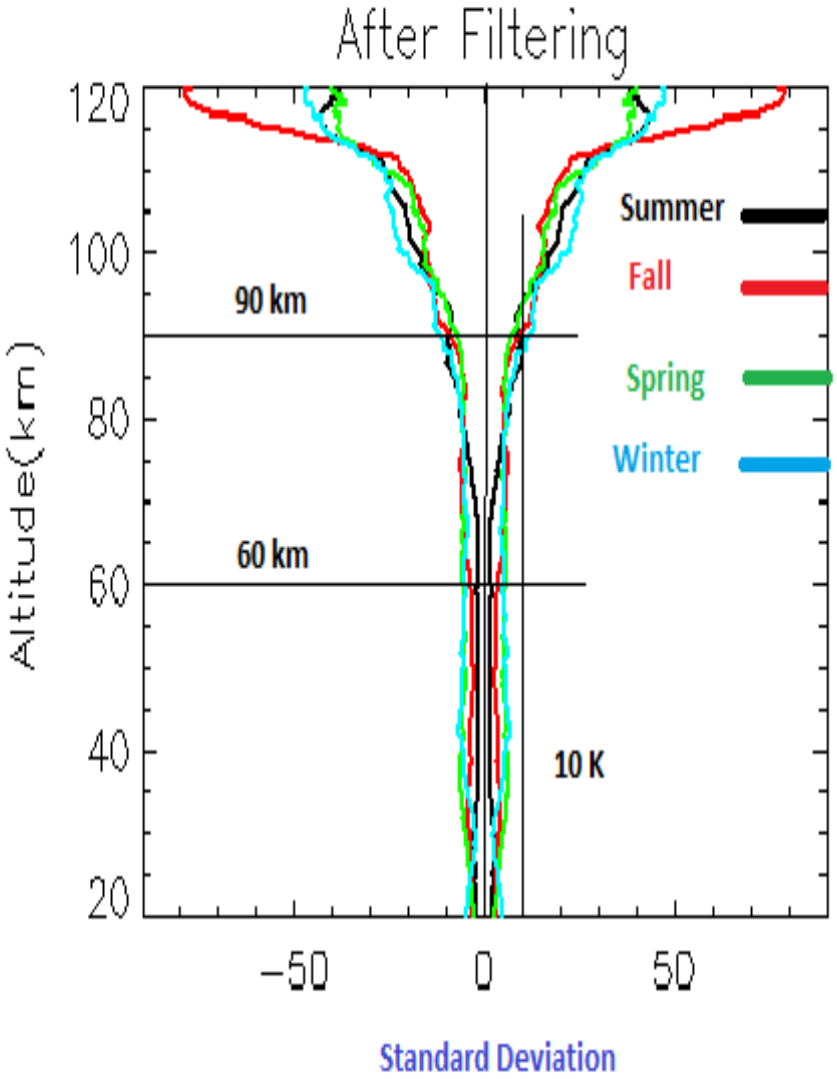
- Temperature profiles plotted as a function of altitude were separated according to the seasons.
- The spring (blue), fall(mustard) on the left panel and on the right panel, summer (red) and winter (black).
- The temperature profiles indicate the differences around 20 km to 40 km altitude and around 90 km altitude.

Elimination of extremely large temperature above 80 km

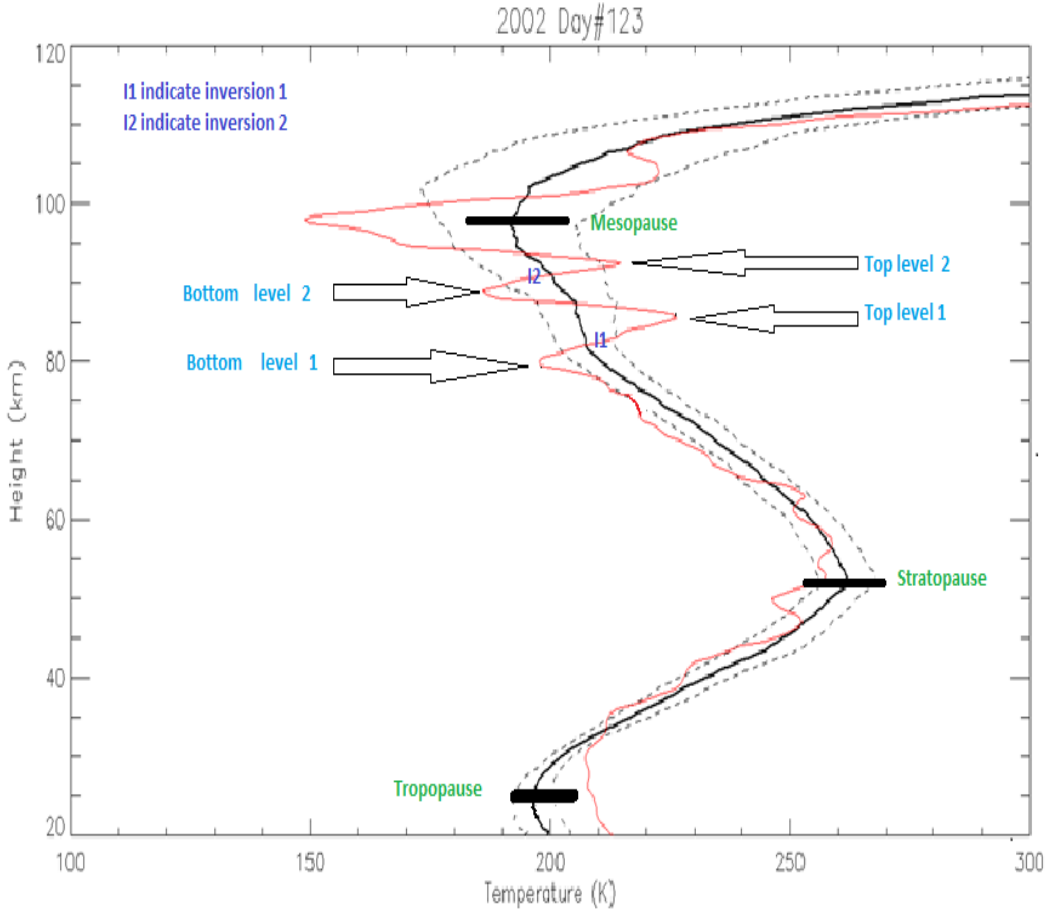


Determination of the maximum altitude





Identification of MIL's

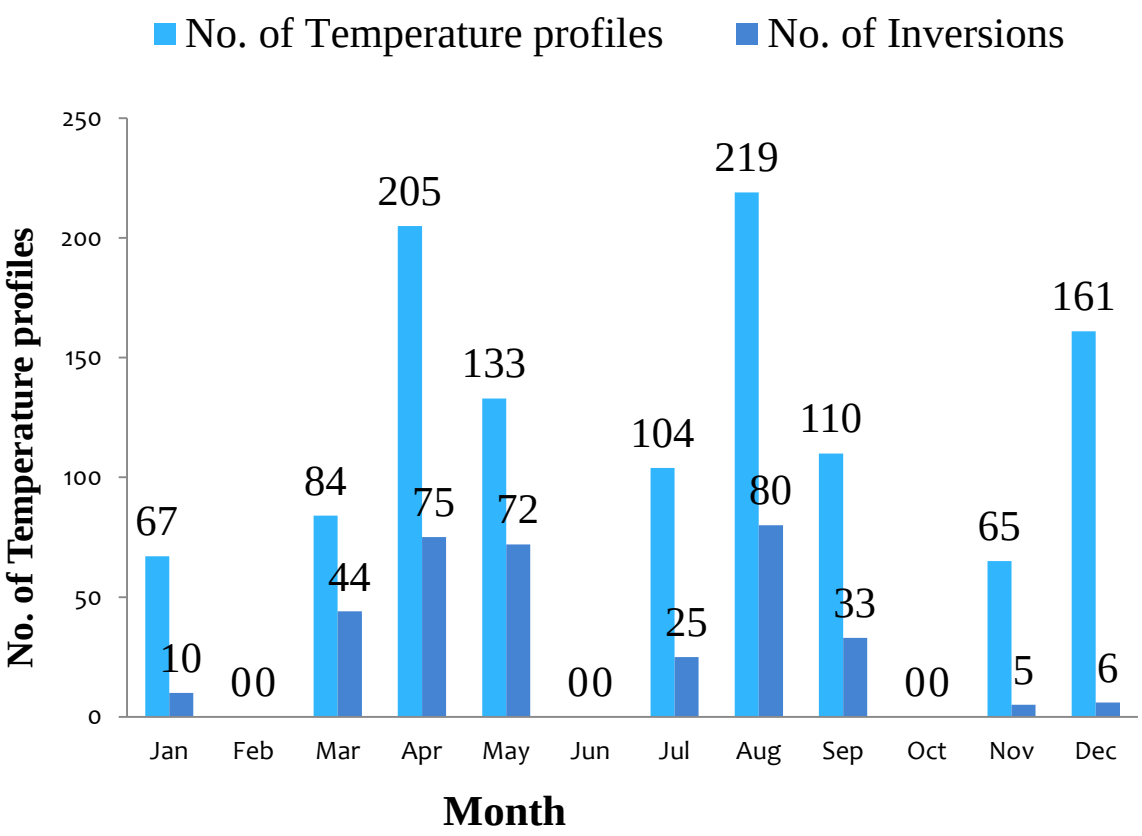


- This diagram indicates two inversions that are noted by I1 and I2.
- Example is given for the temperature profile for 3 of May 2002
- The top and bottom levels of the inversion are indicated by the arrows.
- The first inversion is observed at about 79-85 km altitude.
- The second is observed at about 86-90 km altitude.

Criterion for extraction of significant MIL's

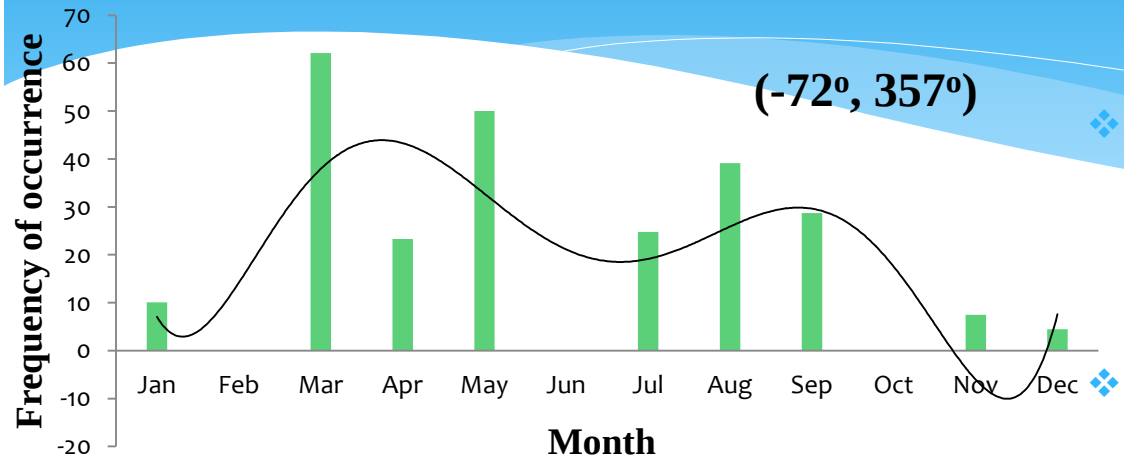
- Heights
  - The bottom of an inversion should be 5 km above the stratopause and the top should be below 90 km.
- Amplitude ≥ 10
  - The amplitude is the difference between the maximum temperature and minimum temperature of inversion layer.
- Thickness ≥ 4
  - The thickness is the difference between the altitude at the top and the altitude at the bottom of inversion layer.

Significant MIL's and the total number of temperature profiles

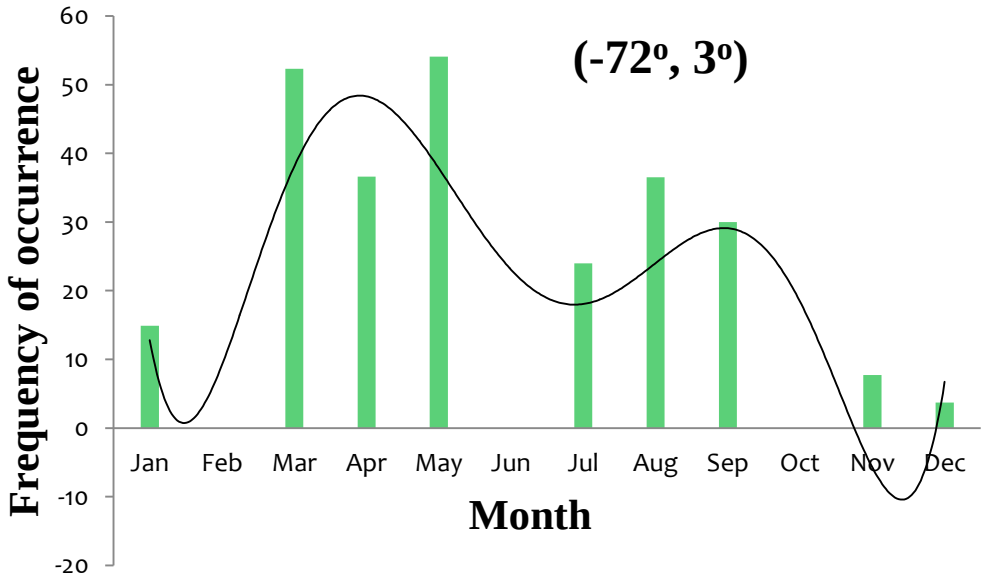


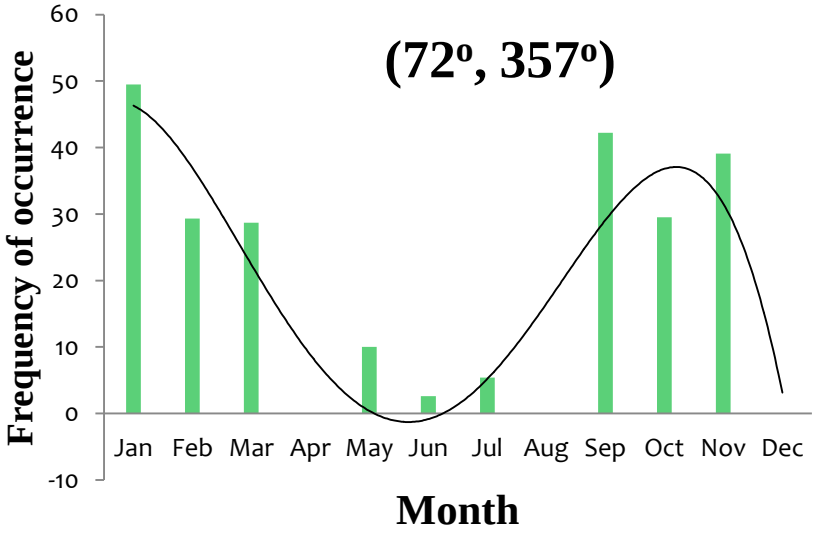
- The figure illustrates a monthly frequency of occurrence and a number of temperature profiles
- A total of 1122 temperature profiles were extracted from 2002-2011
- Out of 1122 temperature profiles, 322 inversions were identified

Frequency of occurrence at (-72º, 357º)

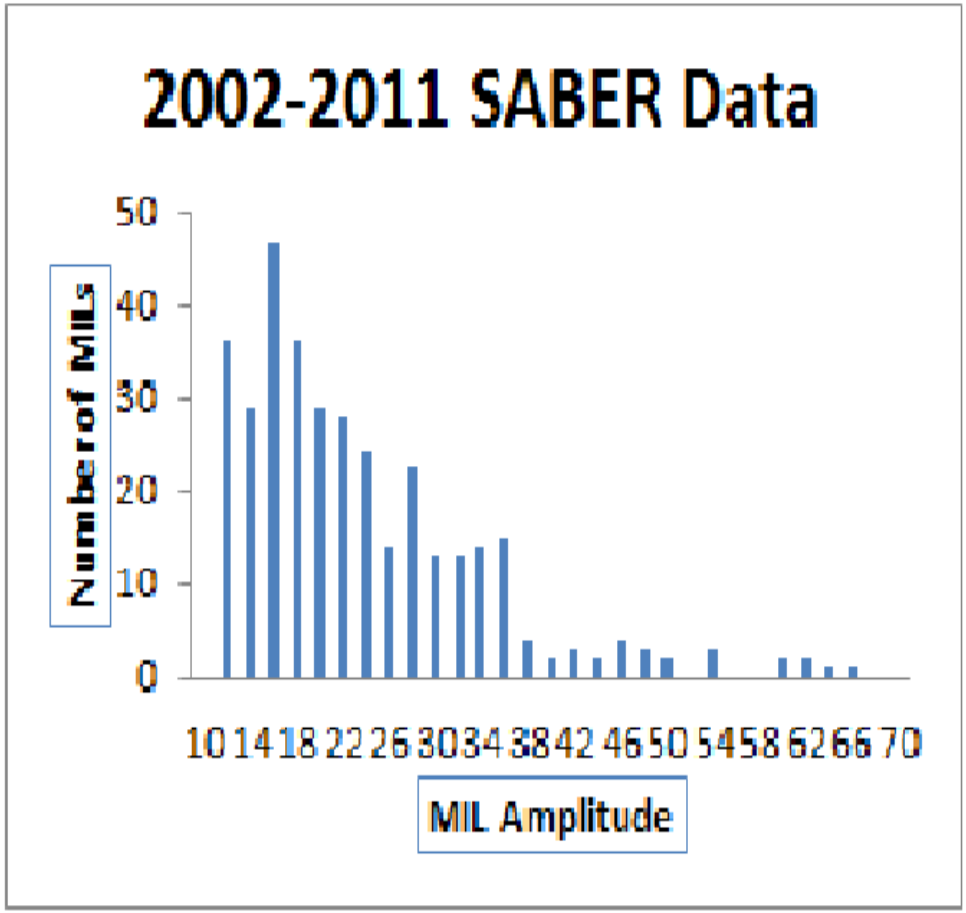


- This plot indicates a signature of semi-annual cycle with a maximum frequency of occurrence in March, followed by a secondary peak in May.
- Seasonally it shows the maximum during the fall and spring and the minimum in summer and winter.



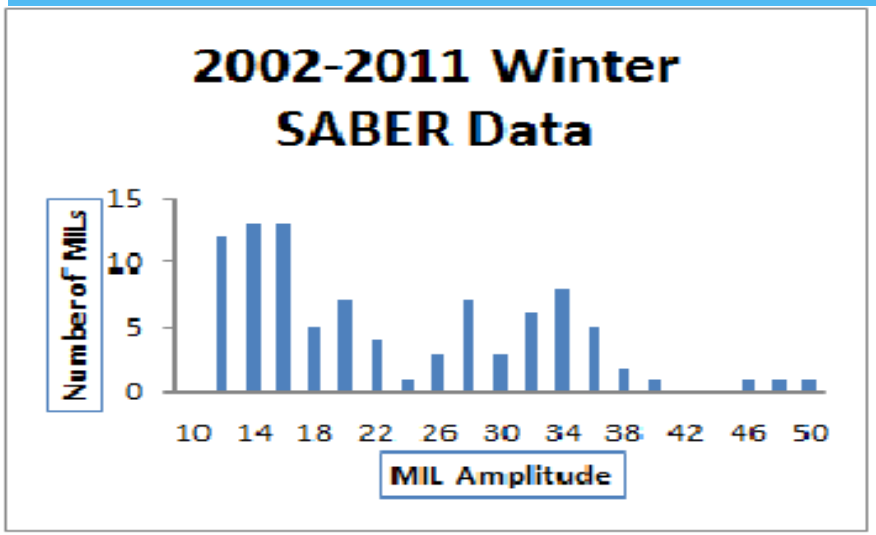


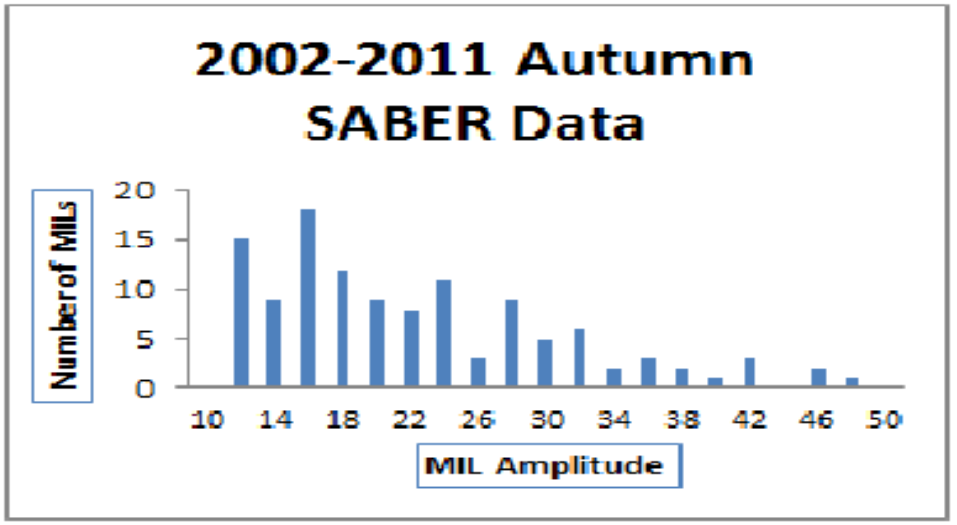
Results

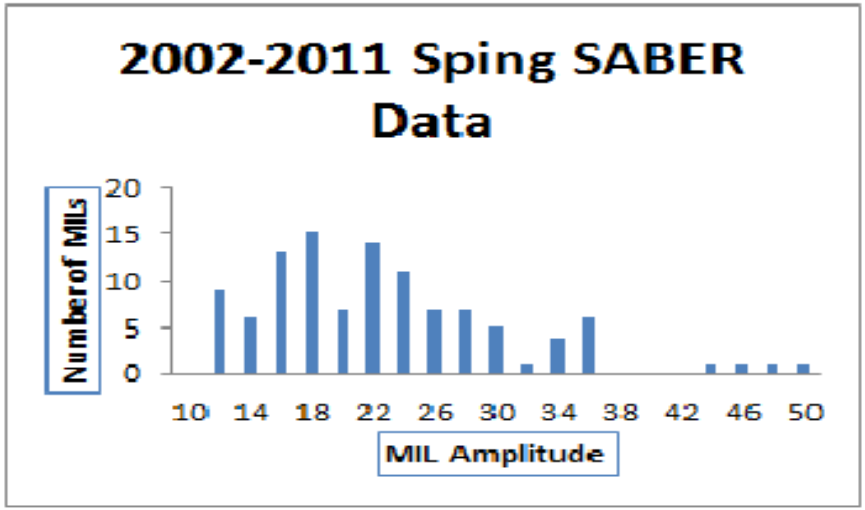


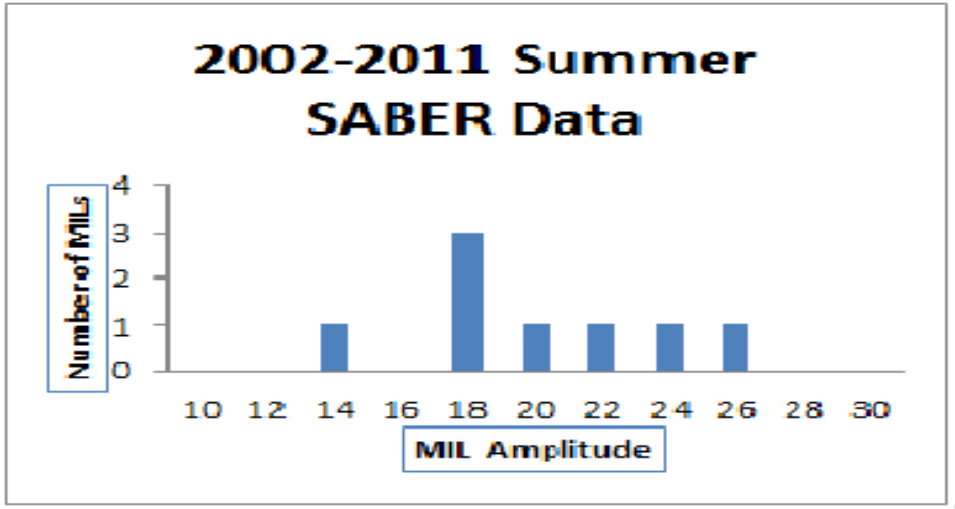
- The distribution of MIL's amplitude over SANAE
- The MIL amplitude varied from 10 K to 70 K.
- It shows the higher frequency of occurrence in the smaller amplitudes.
- The frequency of occurrence displays a right hand skewed, maximum in the 10-34 K intervals, and decreasing to large amplitude.

Results

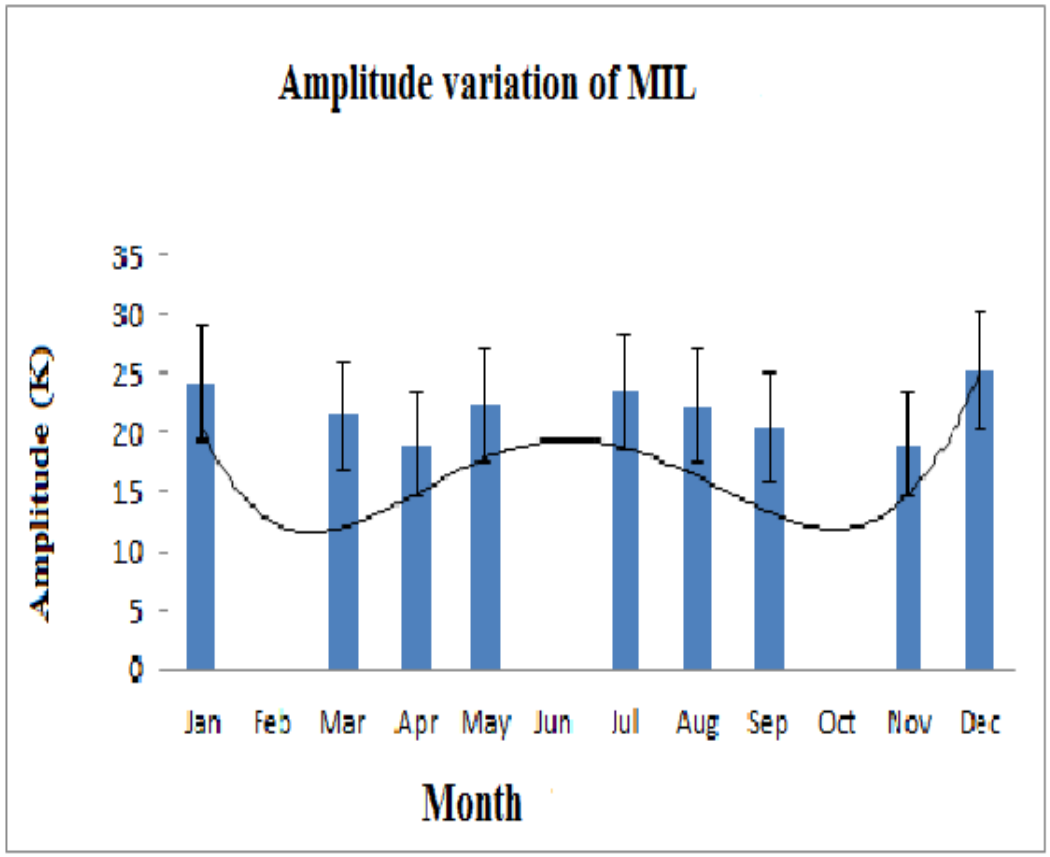

2002-2011 Winter SABER Data
Number of MILs
0
5
10
15
10 14 18 22 26 30 34 38 42 46 50
MIL Amplitude


2002-2011 Autumn SABER Data
Number of MILs
0
5
10
15
20
10 14 18 22 26 30 34 38 42 46 50
MIL Amplitude


2002-2011 Sping SABER Data
Number of MILs
0
5
10
15
20
10 14 18 22 26 30 34 38 42 46 50
MIL Amplitude

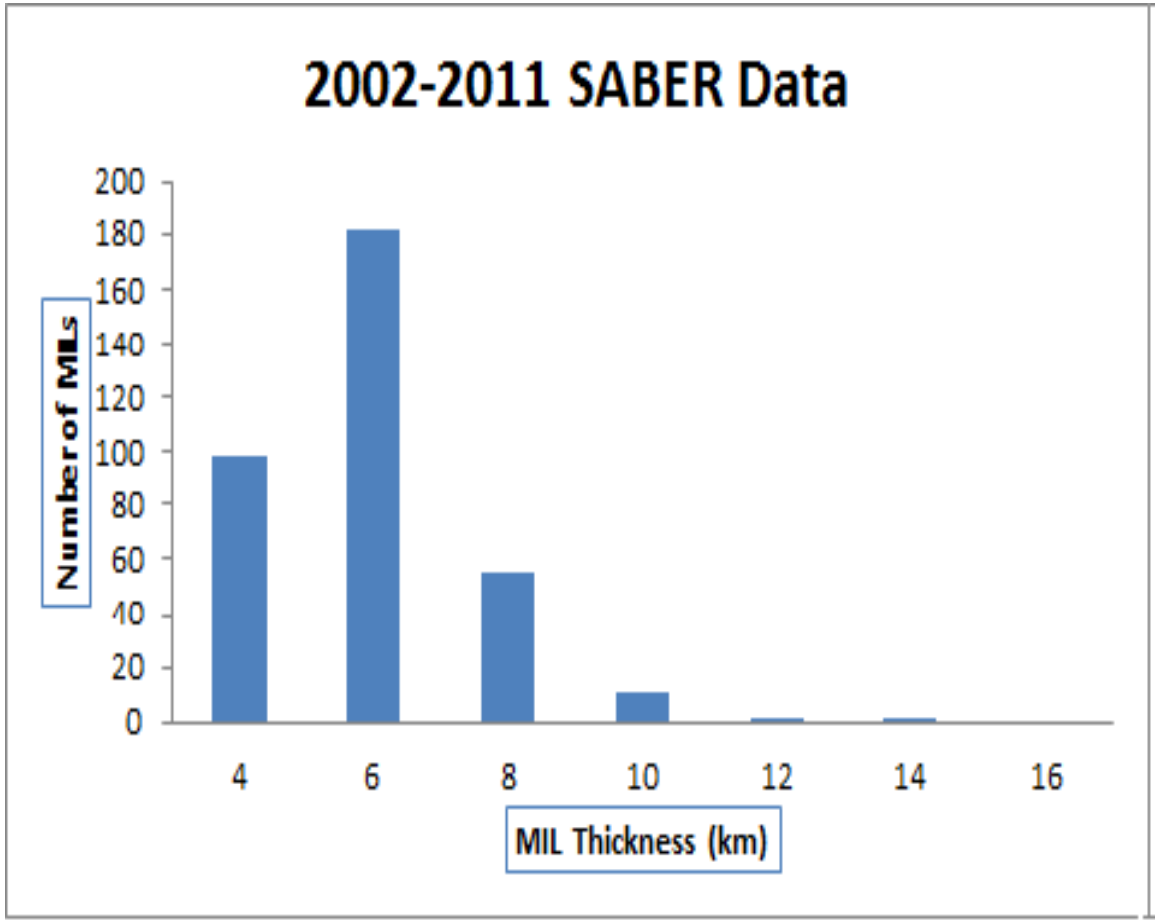

2002-2011 Summer SABER Data
Number of MILs
0
1
2
3
4
10 12 14 16 18 20 22 24 26 28 30
MIL Amplitude

Results



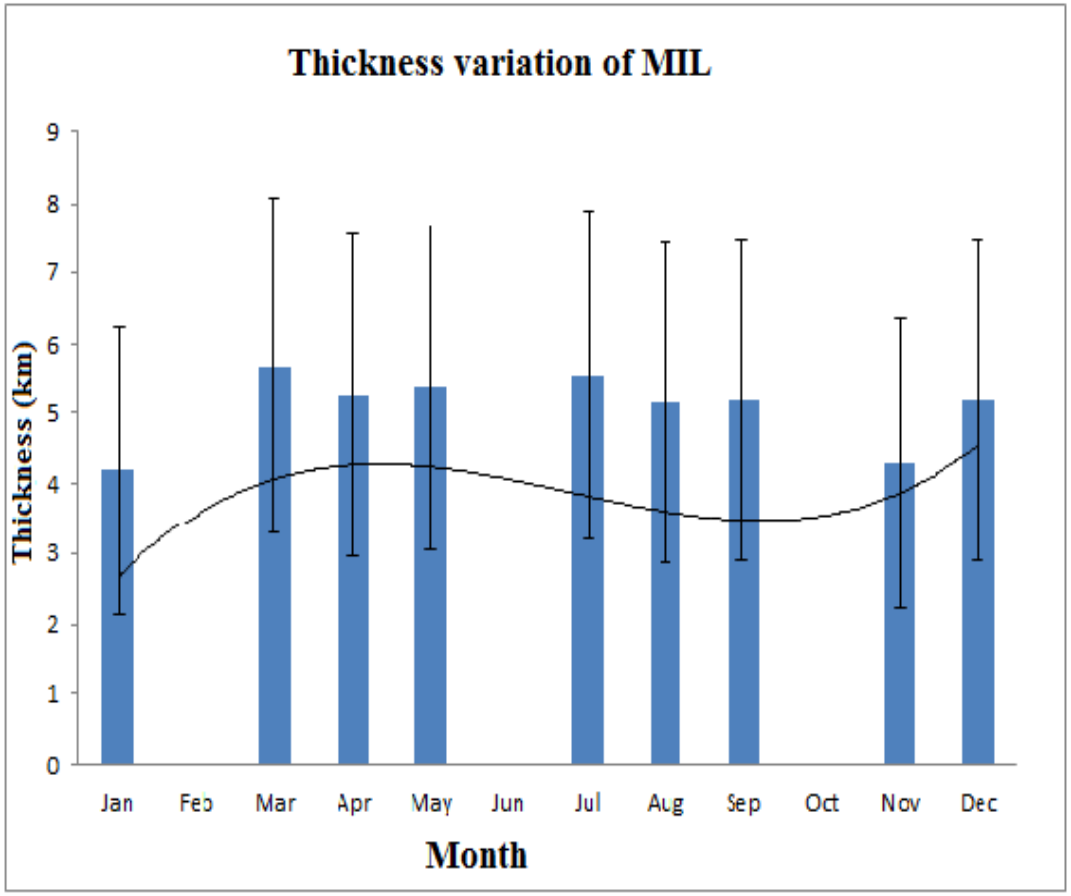
- The monthly mean MIL's amplitude, it is clear from this diagram that the monthly mean amplitude varies from 20 K to 25 K.
- It also shows a semi-annual cycle with peaks in the months of January and December.

Results



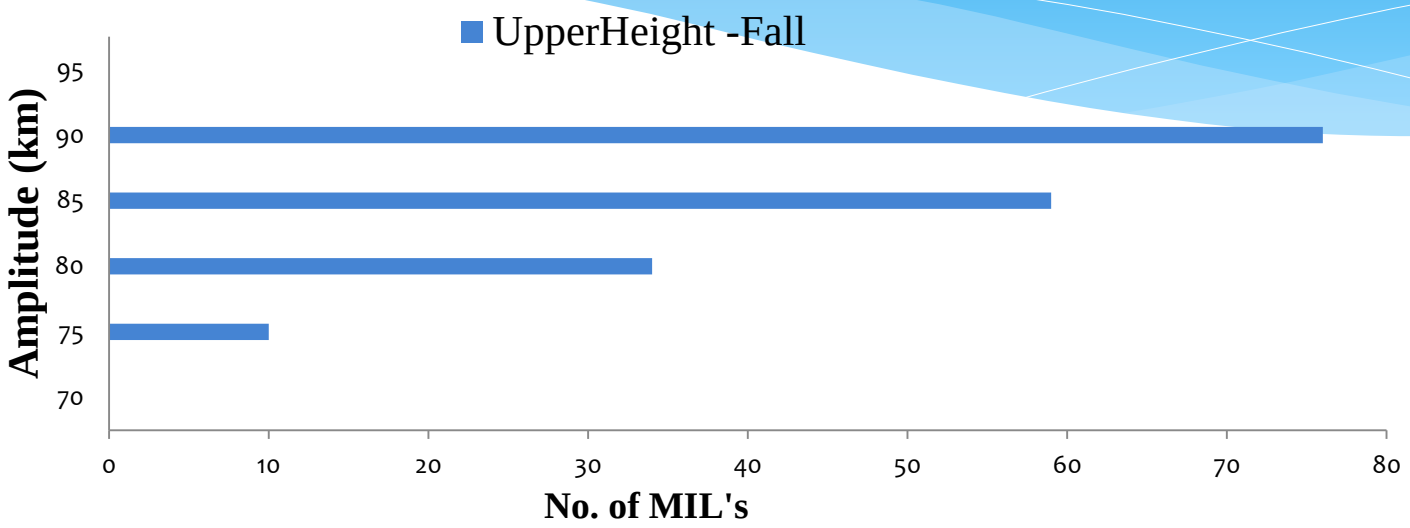
- The distribution of MIL's thickness over SANAE
- It is clear from this diagram that the thickness varies from 4 to 14 km but indicating most MILs around 6 km

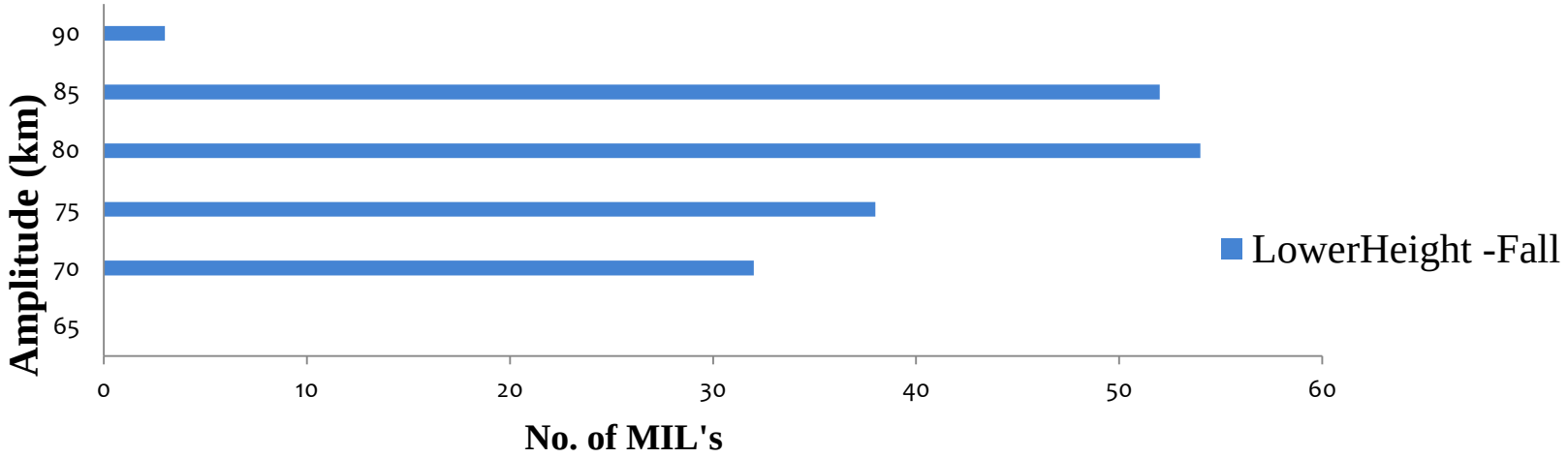
Results



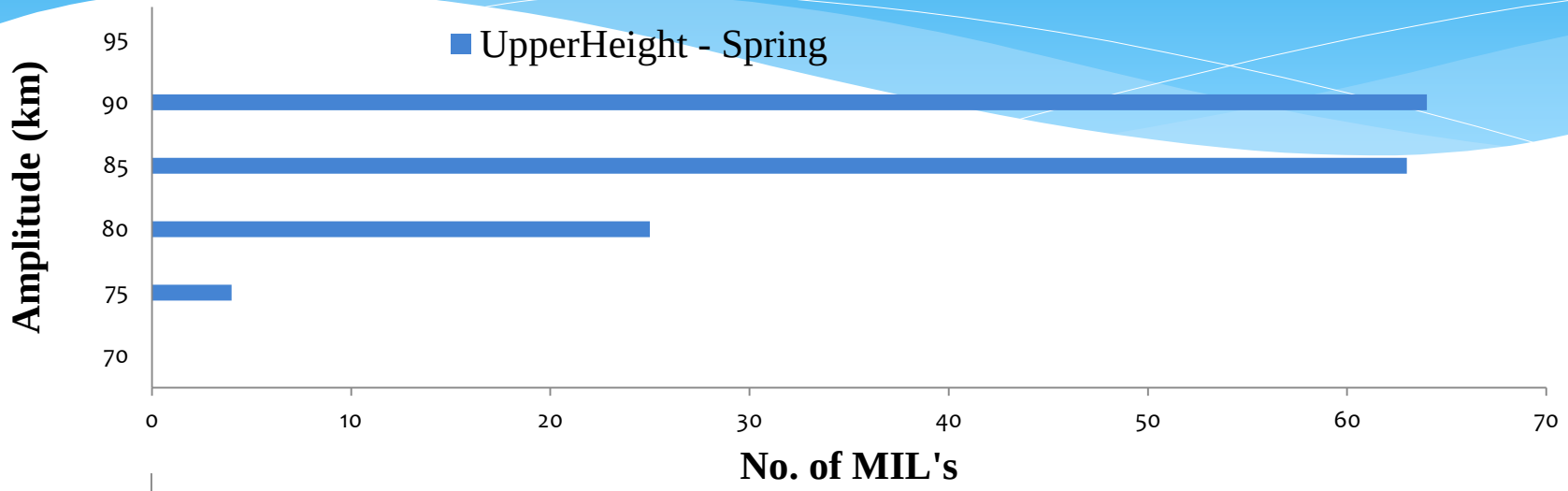
- The monthly mean MIL's thickness.
- It shows a semi-annual cycle with peaks in the months of March and July.

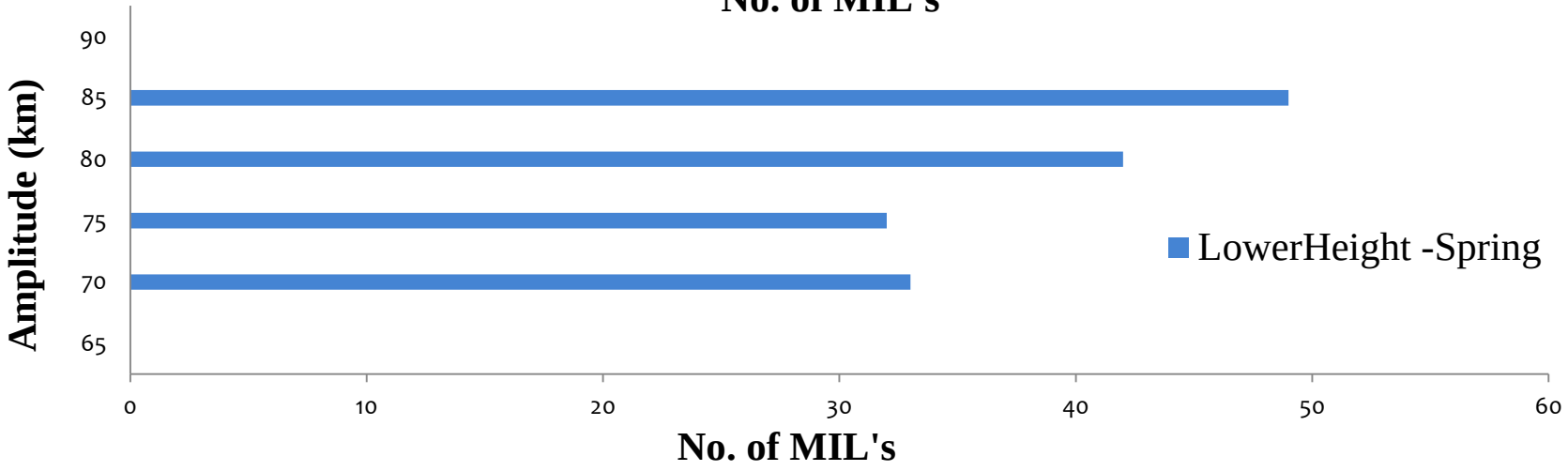
Results


UpperHeight -Fall
Amplitude (km)
95
90
85
80
75
70
0
10
20
30
40
50
60
70
80
No. of MIL's

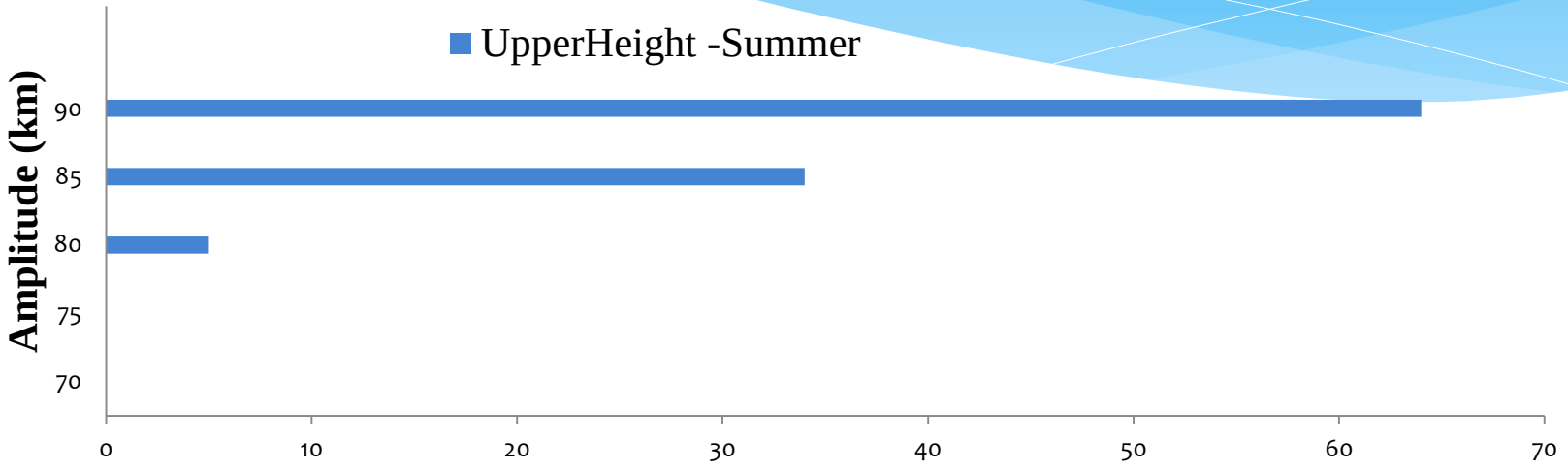

Amplitude (km)
90
85
80
75
70
65
0
10
20
30
40
50
60
No. of MIL's
LowerHeight -Fall

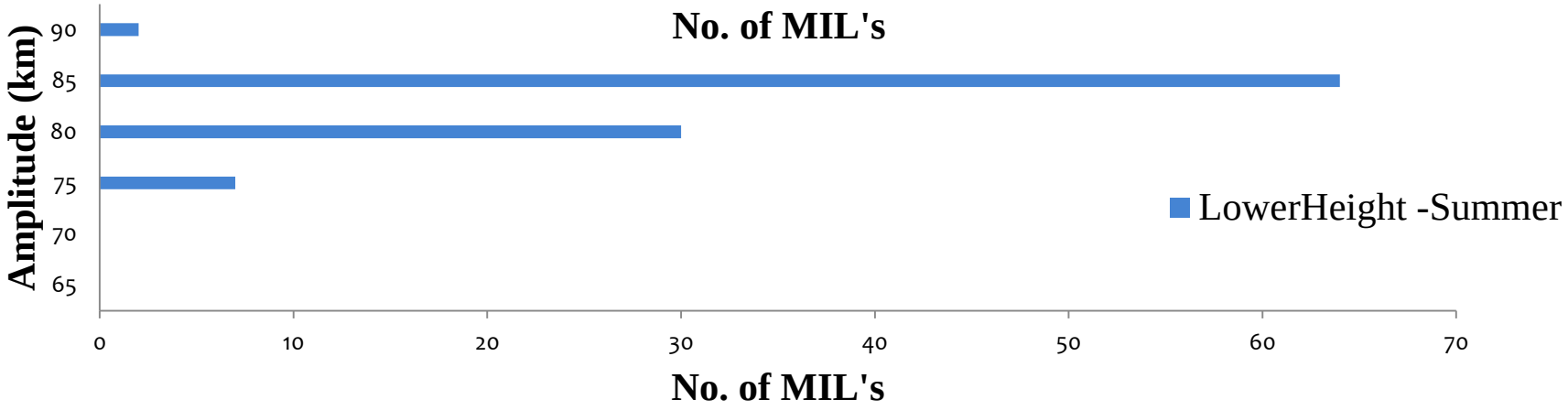
Results


UpperHeight - Spring
Amplitude (km)
95
90
85
80
75
70
0
10
20
30
40
50
60
70
No. of MIL's

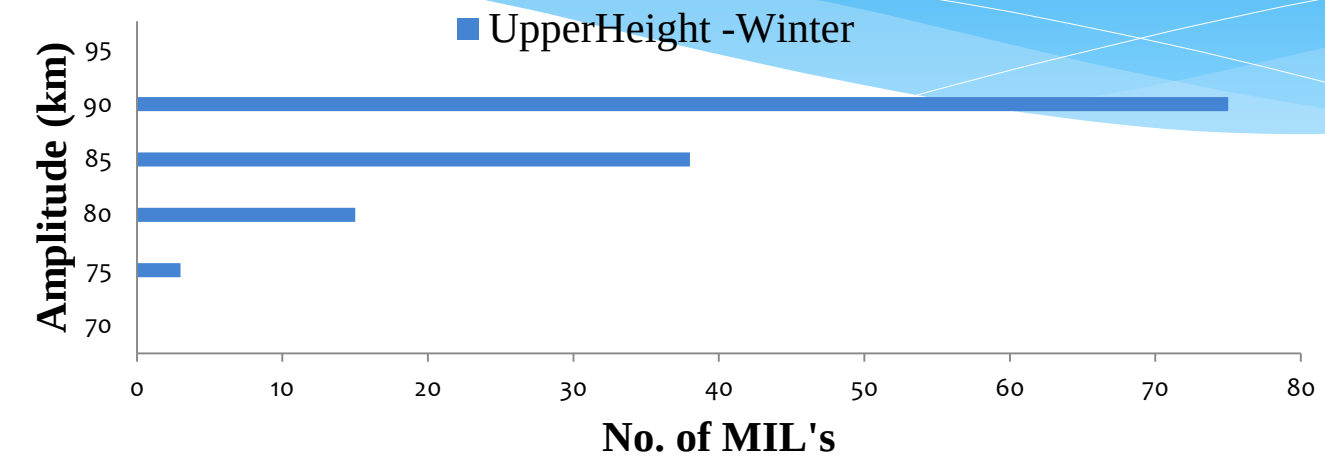

Amplitude (km)
90
85
80
75
70
65
0
10
20
30
40
50
60
LowerHeight -Spring
No. of MIL's

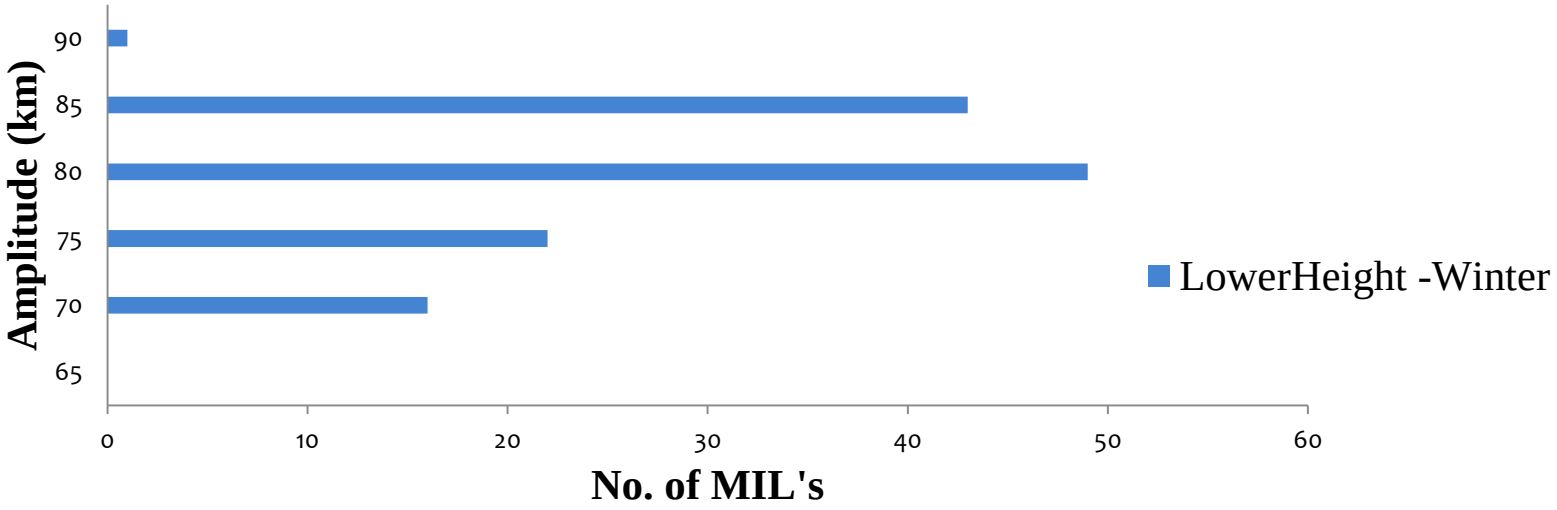
Results


UpperHeight -Summer
Amplitude (km)
90
85
80
75
70
0
10
20
30
40
50
60
70
No. of MIL's


Amplitude (km)
90
85
80
75
70
65
0
10
20
30
40
50
60
70
No. of MIL's
LowerHeight -Summer

Results


UpperHeight -Winter
Amplitude (km)
95
90
85
80
75
70
0
10
20
30
40
50
60
70
80
No. of MIL's


Amplitude (km)
90
85
80
75
70
65
0
10
20
30
40
50
60
No. of MIL's
LowerHeight -Winter

Current status of work

- A complete statistical analysis and characterisation of Mesosphere Temperature Inversions is successfully achieved in this project.
- Possible Sources (Planetary waves)

Thanks!!!!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SOUTH AFRICAN NATIONAL
SPACE AGENCY