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Meteorological programme at Maitri, Antarctica during 28th expedition

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ABSTRACT

India Meteorological Department has established a meteorological observatory at Maitri in the year 1990. The study of Antarctic meteorology is one of the most important objectives of the Indian Scientific Expedition to Antarctica (ISEA). India Meteorological Department has been actively participating from the beginning in all expeditions to Antarctica. The aim of IMD in participating in the expedition is to:

- Prepare the climatology of Indian station, Maitri.
- Find out tele-connection if any between the behavior of Indian Monsoon and Antarctic weather systems.
- Study of Ozone hole phenomena over Antarctica.
- Providing weather information and forecast for station and convoy operations.

The Study of influence of Antarctic weather on Global Warming is also important, in the present scenario.

INTRODUCTION

IMD's Antarctic expedition program begins from the time ship starts sailing to Antarctica from Cape Town. During onward and return journeys, synoptic observations are taken every 3 hours and are transmitted to HQ every 6th hour by e-mail. This helps in day to day analysis as the observational network over sea is very poor.

As part of ongoing weather monitoring & analysis, synoptic observations are regularly taken from Maitri and transmitted in real time basis to Global Telecommunication System so that it can be used by all forecasting offices as meteorological disturbances does not obey any political boundaries. Besides this, in order to find out the current status of stratospheric Ozone depletion over Antarctica in spring season and stratospheric warming, ozone ascents are taken every week. This data also helps the international ozone monitoring community to determine the degree & extent of ozone hole i.e. intensity as well as area wise. Continuous measurements of diffused and direct solar radiation and fortnightly release of radiometer sonde helps the study of radiation balance over Indian station. Surface ozone and atmospheric turbidity are other important measurements.

Scientific objectives:

The objectives during 28th ISEA are to study Antarctic meteorology and ozone profile i.e. its vertical distribution and seasonal variation. To achieve this, following procedure is adopted.

1. Continuous recording of synoptic observations with weather parameters such as atmospheric pressure, wind speed & direction, temperature, cloud base, horizontal visibility and significant weather phenomena.

2. Recording of direct and diffused solar radiation by thermo-electric pyranometer for radiation balance studies.

3. Continuous recording of surface ozone.

4. Atmospheric turbidity measurements over Maitri station.

5. Monitoring of weather systems with the help of weather charts received from South African Weather Services and NOAA cloud imageries to give local weather forecasts for day to day logistic operations and also for helicopter operations.

General weather:

Several factors contribute in making Antarctica one of the coldest and least hospitable places on the earth. It is a continent surrounded by an ocean so interior areas do not benefit from the warming influence of ocean water. The interior of Antarctica receives the most indirect sun rays for a shorter period of the year and no sunlight at all for the remaining part, which makes it cooler. Most land area (around 98%) are covered by snow and ice hence most of sunlight is reflected back rather than being absorbed. Minimum recorded temperature in Antarctica is around (-89)ºC at Vostok on July 21st 1983. The average elevation of interior parts of Antarctica (specially Eastern) is around 2 km (peak 4.7 km, Wilkes Land). Due to this frigid temperature, little or no moisture is held in the troposphere over interior Antarctica.

So, practically there is no cloud formation and generally clear skies are observed at the South Pole. The extreme dryness of the air causes any heat that is radiated back into the atmosphere to be lost instead of being absorbed by the water vapor in the atmosphere. The average snow precipitation over interior side is around 50 mm per year. The annual average temperature is - 50º C. So extremely low temperature, several months of complete darkness, fierce winds and blowing snow are characteristic of interior Antarctica.

However, along the coast, weather disturbances are more frequent and cloudy skies are more common due to the maritime influences and polar circulation patterns. As the temperature starts to fall after summer, the continent cools rapidly .This results in large pressure differences at the edge of the landmass, and leads to an increase in storm activity. The cyclones carry the warmer moist air from the northern latitudes into the continent but may not penetrate very far inland. The polar cyclonic storm strengthens faster and moves at double the speed of tropical storms (above 50 kmph). In Southern Hemisphere, cyclonic storm usually starts in middle latitudes and generally travels from west to east under the influence of polar westerlies and moves to the south under the effect of Coriolis effect bringing moisture and heat to the frigid Antarctic continent. The moisture freezes and is deposited as snow as it moves inland. Most precipitation in coastal areas falls as snow and is highly variable depending on the location.

A zone of low pressure, called Antarctic circumpolar trough lies between 60º and 65ºS and contains variable winds flowing from west to east. In this region fierce storms sweep warm moist air from the middle latitudes towards the pole, causing clouds and precipitation (mostly as snowfall).Between the Antarctic circumpolar trough and the continent, a narrow ring of easterly winds exists, called the coastal polar easterlies. Cold winds flowing off the continent are diverted to the west as a result of the Coriolis effect. This region is calmer and clearer than that of the Antarctic circumpolar trough. So, coastal areas are characterized by milder temperatures and very high precipitation rates, mainly as snowfall. Annual precipitation varies from 500 mm to 1000mm. Summer temperatures can go to a high of 10ºC.

Salient Meteorological Features During The XXVIII ISEA (Year 2009)		
1	Lowest Temperature recorded	-36.2° C om 23.08.2009
2	Highest Temperature recorded	+06.4°C on 06.02.2009
3	Maximum gust	110 knots (213 kmph) on 05.07.2009
4	Number of Blizzards	37
5	Lengthiest Blizzard	135 hours 12.06.2009 / 0500 hrs to 17.06.2009/ 2000 hrs
6	Highest pressure (MSLP)	1016.8 hPa on 30.04.2009
7	Lowest pressure (MSLP)	0951.4 hPa on 16.06.2009
8	Maximum pressure diurnal variation	47.7 hPa on 18.05.2009
9	Total number of aurora observed	1

Salient features of Synoptic parameters during 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg MSL	984.2	983	982.2	989.7	994.2	988.5	987.1	989.8	987.1	985.4	991.2	987.4
Highest MSL	994.8	999.5	995.5	1016.8	1012.9	1014.1	1006	1007.5	1006.8	1001.4	1010.7	995.6
Lowest MSL	964.9	957.8	955	965.8	951.5	951.4	956.6	951.7	956.8	965.5	973.8	978
Avg Temp	-0.8	-4	-7.7	-15.6	-14.1	-12.6	-16.5	-21	-16.9	-13	-5.1	-1.1
Max Temp	5.2	6.4	0.4	-6.2	-3.2	-6.1	-6.3	-5.6	-7.5	-3.8	3.2	4.4
Min Temp	-5.9	-10.8	-16.8	-27.3	-26.8	-27.8	-32.8	-36.2	-32.9	-24.6	-13.6	-18
Avg Max	2.1	-0.6	-4.7	-12.1	-11.4	-10.4	-13.7	-17.3	-14.5	-10.8	-1.8	1.9
Avg Min	-3.2	-5.5	-11.4	-19.2	-16.5	-15.5	-18.7	-25.3	-20.6	-15.9	-8.6	-5.3
Avg wind kts	16	18	15	20	25	27	22	16	18	16	13	9
Max gust	75	93	85	100	99	92	110	80	76	74	74	62
No of days >23 kts	26	24	28	22	27	30	27	28	27	23	27	15
No.of Blizards	2	0	5	4	6	5	2	4	4	4	1	0

History of Blizzards during 2009							
			Extreme Values (with Date/Time)				
S.No	Date/Time		MSL Pressure (hPa)		Temperature ^{O}C		Wind (Knots)
	Commencement	Cessation	Max.	Min.	Max.	Min.	Max.
	Continued	01.01.09	999.4	982.5	3.9	-3.6	68
1	from 31.12.08/1630	840	30/1500	01/0900	31/1200	02/0000	01/0600
	25.01.09		976.3	971.9	+01.`0	-1.7	75
2	2230	26.01.09 0140	26/0600	26/1500	26/1200	26/0300	26/1200
	3/3/2009	3/3/2009	973.3	971.9	-2.4	-4.8	31
3	955	1215	03/1200	03/1000	03/1200	03/1000	03/1000
	7/3/2009	8/3/2009	985	978.3	-8.4	-10.2	48
4	1700	100	07/1800	08/0000	08/0000	07/1800	Jul-00
	9/3/2009	10/3/2009	975.7	973.6	-5.2	-8	54
5	2300	2110	10/1200	10/0000	10/0300	Oct-00	10/0800
	16-03-09	16-3-09	976.8	965.9	-4.6	-10.4	85
6	330	2110	16/0600	16/1500	16/2100	16/0600	16/1400
	23-03-09	24-03-09	993.4	991.7	-6.2	-8.8	50
7	425	625	23/1800	23/0600	24/0600	23/0600	24/0500
	3/4/2009	5/4/2009	991.6	983.9	-9.3	-14.5	75
8	2130	1430	05/1200	04/1800	04/0000	05/1200	04/1200
	10/4/2009	11/14/2009	978	975.3	-18.3	-20.5	72
9	1830	1030	Oct-00	11/0000	11/0900	Oct-00	Oct-00
	12/4/2009	13-04-09	985.1	976.6	-8	-11	70
10	1830	445	Dec-00	13/0300	13/0300	Dec-00	13/0200
	20-04-09	21-04-09	990.1	965.8	-8.3	13.8	100
11	730	1900	20/0900	21/0900	21/1800	20/0900	21/0200
	6/5/2009	8/5/2009	996.2	983..9	-6.4	-14	92
12	1900	2300	Jun-00	08/0600	08/2100	06/2100	07/2000

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13	11/5/2009	13-05-09	986.3	971.1	-11.2	-13.2	74
	830	700	11/09 00	Dec-00	12/1200	11/1800	Dec-00
14	18-05-09	19-05-09	958.7	951.5	-7..5	-8.4	54
	2330	07 30	19/0600	19/0000	19/0000	19/0300	18/2345
15	20-05-09	20-05-09	995.6	985.5	-14.5	-15.4	76
	100	08 30	20/0900	20/0300	20/0300	20/0600	20/0200
16	23-05-09	23-05-09	1001.3	999.2	-10.1	-11.3	54
	06 00	23 00	23/2100	23/0900	23/2100	23/0600	23/1700
17	24-05-09	27-05-09	1011.4	989.3	-6.8	-14.8	108
	10 00	19 00	26/0600	27/0600	27/0000	25/1800	26/2000
18	1/6/2009	1/6/2009	1012.4	1009.2	-12.3	-13.9	46
	0	1300	01/0000	01/0900	01/0900	01/0000	01/0430
19	7/6/2009	8/6/2009	987.6	982.4	-12.2	-12.7	65
	2200	400	Jul-00	08/0330	08/0300	Jul-00	Jul-00
20	12/6/2009	17-06-09	991	951.4	-6.8	-15.4	92
	500	2000	14/1200	16/0000	17/0000	14/0600	15/2230
21	18-06-09	19-06-09	973.8	966	-7.8	-11.6	44
	1700	200	19/0600	18/1700	19/0300	18/1500	18/2000
22	28-06-09	29-06-09	1009.6	998.5	-7.6	-10.6	76
	1400	700	28/1500	29/0900	29/0900	28/1800	29/0200
23	4/7/2009	4/7/2009	981.4	973.7	-7.5	-9	62
	400	1700	04/1700	04/0600	04/1200	04/0400	04/0530
24	5/7/2009	6/7/2009	984	974.4	-7.1	-11.4	110
	400	2300	05/0900	06/0300	05/1500	05/1800	05/1600
25	5/8/2009	5/8/2009	982.2	981	-10.6	-12.3	36
	1450	1830	05/1500	05/1800	05/1800	05/1500	05/1530
26	6/8/2009	6/8/2009	979.5	969.8	-11	-11.9	50
	545	1100	06/0900	06/0600	06/0600	06/0900	06/0550
27	17-08-09	18-08-09	977.6	964.8	-7.6	-11.6	80
	1750	1430	18/0000	18/1200	18/1200	17/1800	18/0915
28	19-08-09	20-08-09	988.7	962.8	-14.8	-23.4	78
	200	30	20/0000	19/0300	19/0300	20/0020	19/1600

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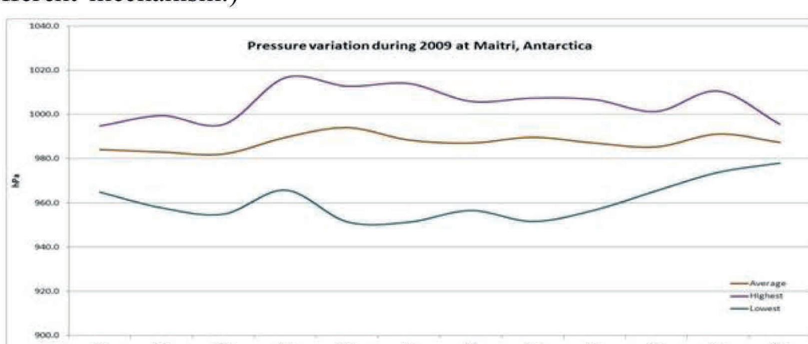
	2/9/2009	2/9/2009	998.5	997.8	-18.4	-18.5	41
29	1700	2200	02/1800	Feb-00	02/1800	Feb-00	Feb-30
	14-09-09	14-09-09	989.2	986.4	-12.6	-19.8	44
30	200	1930	14/1800	14/0300	14/1800	14/0300	14/1100
	21-09-09	21-09-09	996.4	990.1	-13.6	-14	64
31	100	2300	21/2100	21/0300	21/1200	21/1800	21/0500
	24-09-09	25-09-09	992.2	985.6	-11.4	-13.1	74
32	1320	30	24/1500	25/0000	25/0000	24/1800	24/2030
	6/10/2009	7/10/2009	985.8	982.7	-14.1	-20.4	60
33	1300	800	06/1800	Jun-00	06/1800	Jun-00	Jun-30
	14-10-09	19-10-09	992.6	972.3	-6.6	-11.6	74
34	30	1000	18/0300	17/1700	17/2300	14/0100	17/1700
	20-10-09	20-10-09	980	978.5	-9.5	-9.6	40
35	320	1000	20/0600	20/0900	20/0600	20/0900	20/0400
	23-10-09	24-10-09	992	983.9	-13.2	-14.7	56
36	400	400	24/0000	24/0300	23/1200	23/2100	24/0500
	3/11/2009	7/11/2009	985.5	973.8	-3.1	-7	74
37	100	1300	14/1200	03/1200	04/1200	03/0300	03/1400

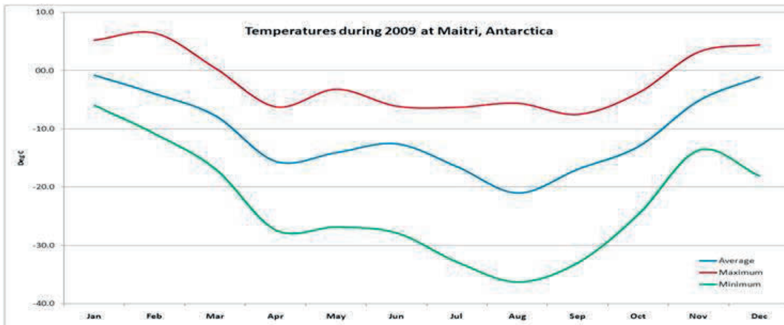
Atmospheric Pressure:

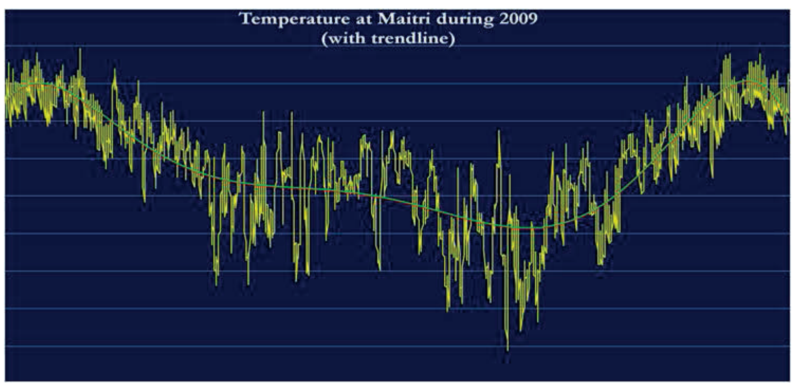
In general a significant fall of pressure indicates an approaching bad weather. In Antarctica, there are occasions when a significant drop of pressure did not cause any bad weather and on the contrary a little rise in pressure was associated with bad weather. This is an important point for weather forecasters in Antarctica especially from India (where they study cyclones with Coriolis forces, but in Antarctica fontal systems follow a different mechanism.)



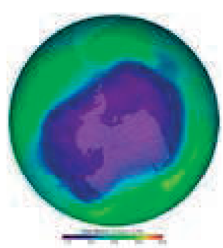
Temperature

The following graph depicts the temperature variations i.e. maximum, minimum and average during the year 2009.



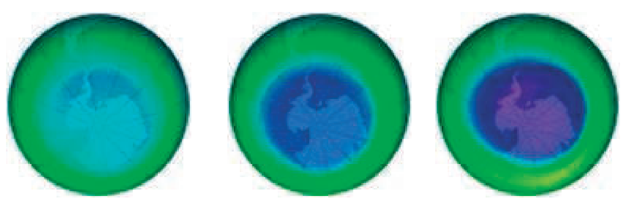


Ozone Hole over Antarctica

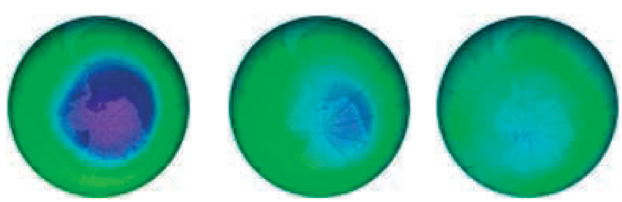


As temperature in the lower stratosphere falls below –80°C, Polar Stratospheric Clouds (PSC's) start to form. In the area over Antarctica, there are stratospheric cloud ice particles that are not present at warmer latitudes. Reactions occur on the surface of the ice particles that accelerate the ozone destruction caused by stratospheric chlorine. Polar regions get a much larger variation in sunlight than anywhere else, and during the 3 months of winter spend most of time in the dark without solar radiation. Temperatures hover around or below –80°C for much of the winter and the extremely low Antarctic temperatures cause cloud formation in the relatively "dry" stratosphere. These Polar Stratospheric Clouds (PSC's) are composed of ice crystals that provide the surface for a multitude of reactions, many of which speed the degradation of ozone molecules. This phenomenon has caused documented decreases in ozone concentrations over Antarctica. In fact, ozone levels drop so low in spring in the Southern Hemisphere that scientists have observed what they call a "hole" in the ozone layer. The ozone destruction process requires conditions cold enough for stratospheric clouds to form. Once these stratospheric clouds form the process can take place, even in warmer conditions.

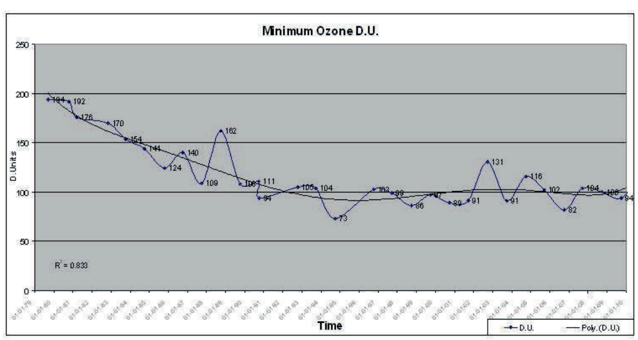
The ozone hole builds up over the winter months, peaking at around September and breaking up again by December

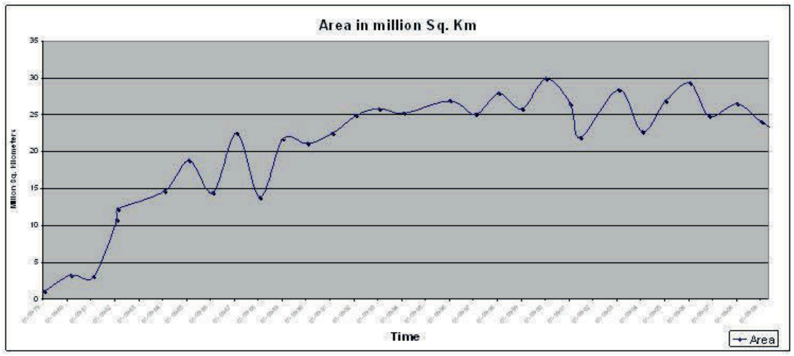


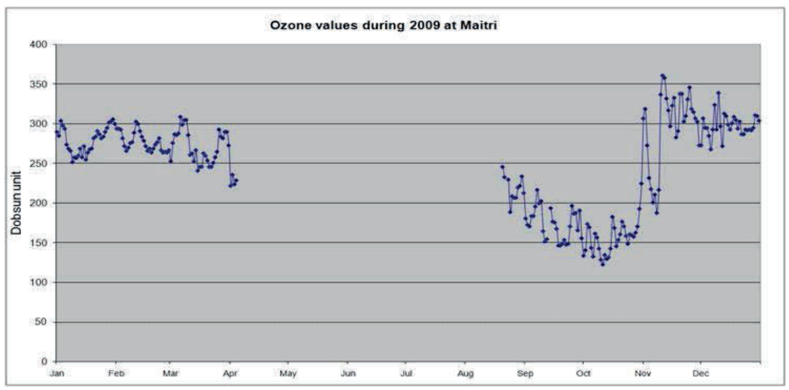
July August September



October November December







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References

The British Antarctic Ozone survey bulletin, The Ozone Hole Inc.