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Weather Forecasting in Frigid Desert of Antarctica

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Abstract

Scientific activities in Antarctica need a strong logistic backup, helicopter support being one of them. Flying in Antarctica is heavily dependent on weather conditions which are decidedly of unique nature. In the present report weather in Schirmacher Oasis and nearby coastal area in East Antarctica is discussed in the backdrop of flying requirements and an attempt has. been made to devise some thumb rules for prediction of weather in the studied area.

Introduction

Antarctica, as is well known, is endowed with the harshest climate on the surface of earth. All along the coast of this icy continent frequent changes in weather take place very rapidly. Antarctica is the fifth largest contient, Lager than the USA and Europe but the weather stations on this continent are highly sparse. North America which is smaller than Antarctica has hundreds of synoptic, hourly, upper air and radar stations across the continent while this icy continent, constrained by its climate and difficult accessibility, has'only about 35 twelve hourly reporting stations. These stations are located mainly around the coast and their observations are rarely available on real time basis for forecasting. In the absence of a regular flow of meteorological inputs from highly sparse data network, forecasting in Antarctica becomes a challenging and formidable task, Air operations play a vital role in successful completion of scientific expeditions in Antarctica. It is the only mode of transportation between the ship in polynya waters and Indian station Maitri, and other sites including the mountains further south where scientific studies are conducted by the Indian scientists. Accurate weather forecasting for such operations is of prime importance, especially since the terrain is totally white and featureless with meagre navigational and radio aid.

This report presents an account of the weather conditions encountered in the austral summer of 1991-92 during XI Indian expedition to Antarctica. Important landmark of this expedition was providing air support to scientists

on Payer mountains which is tormented by strong katabatic winds, and recce of the terirain south of Conrad mountains upto latitude 7236'30"S.

Meteorological Programme of IAF.

The main tasks assigned for this expedition were as follows:

a) to observe and record meteorological parameters during voyage and at Antarctica,

b) to provide aviation weather forecast for safe and efficient flying activities,

c) to advise expedition leader regarding expected weather conditions for successful planning'of various operations, and

d) to formulate local forecasting hints or thumb rules for future expeditions.

Since some common observations were also being made by meteorologists from India Meteorological Department (IMD) and Indian Navy, the workload of recording tie observatictes was shared by all these members.

In order to complete the tasks assigned, following actions were taken during voyage and at Antartica :

a) *During voyage* - i) recording of synoptic observations, ii) studying available facsimile charts.

b) *At Antarctica* - i) recording half hourly Met report (METAR) using available instruments and studying the variation of meteorological parameters, ii) studying the synoptic weather systems as seen on the facsimile charts received from Pretoria and/ or Molodezhnaya, investigating their development and movement, and correlating them with weather conditions at polynya and Maitri, iii) studying aviation weather hazards in Antarctica and their effects on helicopter operations, and iv) developing thumb rules or local hints on forecasting.

Met facilities available on-board ship

The following met instruments/equipments were available on board the ship MV Thuleland for recording the meteorological parameters:-

i) Two precision Aneroid Barometers

ii) One weekly Barograph

iii) Two Aneroid Barometers

iv) One Assman Psychrometer

v) Two Whirling Psychrometers

vi) DR Wind instrument for wind direction and speed

vii) Hand held cup anemometer

Forecasting aids on-board ship

By using above instruments, *local* met parameters viz.pressure, temperature, wind speed and direction, and cloud cover were recorded regularly between 0600 and 1800 UTC during the entire period of stay in Antarctica. In addition to these, some other aids were made use of for forecasting. These are-

a) Satellite Imageries: Weather satellite receiver WSR 524C of Feed Back company of U.K. was provided for receiving satellite imageries from polar orbiting NOAA satellites. The system also has a Philips monitor (14 inches) and 'Mitsubishi' video printer model P50B for display and printout of satellite imageries, respectively. With the use of an omnidirectional antenna, regular satellite imageries were received during voyage and stay in Antarctica.

b) Facsimile weather charts: RAYFAX - 1200 radio facsimile receiver was available on board ship. Weather charts from Pretoria were received during voyage and at Antarctica while charts from Molodezhnaya, the Russian station responsible for issuing weather charts for eastern Antarctica, were received only during stay in Antarctica.

c) Upper winds and air-borne weather reports; There was no arrangement for measuring upper winds at ship or Maitri on routine basis. The RNS-252 Navigation Computer of MI-8 helicopter and Doppler system on board naval helicopters -'Chetak' were used for obtaining upper wind profile below one kilometre during flying operations. During bad weather period there was, therefore, no way to record upper winds for the study of weather systems. Regular in-flight weather reports were obtained from MI- 8 and 'Chetak' helicopters which proved to be great help in the study of local weather.

Aviation hazards

The main weather hazards for aviation in Antarctica are as follows :

a) Blizzards
b) Low clouds
c) Strong winds/katabatic winds
d) Whiteouts
e) Fog
f) Precipitation
g) Turbulence.

a) *Blizzards:* Blizzard is a special weather phenomenon in Antarctica wherein the surface snow starts blowing in association with strong winds reducing the visibility significantly.Wind speed anywhere between 5 - 10 m/sec can cause

drifting snow in case of easily available loose snow particles. In drifting snow, the horizontal visibllty at the height of observer's head is not impaired. The blowing snow is caused due to strong wind resulting in a sharp fall in the visibility. Both phenomena have been included to-describe blizzard. Along the coast line, blizzards occur under the influence of eastward moving low pressure areas south of 60°S. The duration and severity of blizzards depend upon the rate of movement of these low pressure systems. A blizzard can be as short lived as 6 to 8 hours and at times may continue with unabated fury for 8 to 10 days. However, they normally last for 2 to 3 days.

b) *Low clouds:* Low clouds are more frequent over polynya and shelf even though Maitri weather is usually clear of low clouds. Low clouds normally approach from east/ESE direction. Therefore, any appearance or drifting of the clouds from this direction would subsequently lead to overcast conditions within a short interval of time.

c) *Strang winds:* Strong surface winds adversely affect the helicopter operations. Strong winds of more than 30 kts from east/ESE direction can be expected in association with eastward moving low pressure area (LOPARs). Normally the winds are stronger over polynya than Maitri under the influence of a pressure system. Surface winds continue to be stronger even after the passage of a system due to *katabatic winds,* which is a characteristic feature of Artarctic coastal areas.

d) *Whiteouts:* A typical phenomenon observed in Antarctica is one in which, the ground appears as a white surface merged into white or grey overcast sky removing any distinction between the two. Such a phenomenon where horizon is lost, is called a whiteout. During whiteout conditions there is no perception of depth and height as a result of which disorientation sets in. However, any dark object may be easily discernible or recognised. This condition may occur due to overcast state of the sky with low and medium clouds (stratiform), fog, blowing drifting snow and snowfall.

e) *Fog:* Fog frequency is more over polynya than in the interior areas of the continent December and January are favourable months for the formation of fog. Advection fog is more common than the radiation fog. The latter occurs over shelf area towards evening hours.

f) *Precipitation:* Liquid precipitation generally does not occur over Antarctica. The precipitation is in the form of snowfall, which may comprise snow flakes, grains or ice prisms. Due to frequent blowing snow and/or drifting snow over shelf and continent, it is extremely difficult to separate them from precipitation.

Weather conditions at Antarctica

During stay in Antarctic waters (polynya) from 23 December 1991 to 25 February 1992, there have been exceptionally long spells of bad weather, one each in December' 91, January "92 and February'92. There was one long spell of good weather in Januaiy'92 for 13 days from 02 January to 14 January during which uninterrupted flying was carried out and two-short spells of good weather in February'92 (01 to 08 Feb and 21 to 25 Feb). A total of 11 blizzards were experienced. A brief description of each bad weather spell is given below:

(a) ***/ spell (24 Dec 91 to 01 Jan 92):*** **Seven low pressure areas (LOPARs) with frontal characteristics moved during this spell, overcast conditions prevailed on most of these days and the winds were blowing from E/ESEly direction at 25 to 30 kts frequently gusting to 40 kts. Three blizzards were experienced during this phase. At the time of blizzards wind speed exceeded 40 kts. Total duration of blizzards was 52.30 hrs and the maximum wind recorded was 100/62 kts on 29 Dec' 91.**

(b) ***II spell (14 Jan to 29 Jan 92):*** **During this phase, eleven LOPARs moved north of polynya resulting in overcast conditions. Steep pressure gradient prevailed on most of the occasions, giving rise to strong E/ESEly/30-35 kts wind gusting upto 45 kts. A moderate wind speed of 15 kts was prevailing briefly from. 21 to 24 Jan 92. Three blizzards (total duration 134.45 hrs) were experienced and the maximum wind recorded was 120/60 kts on 18 Jan 92. During this spell, air sorties were carried out on one full day (17 Jan) and partly on two days (16 and 20 Jan). During the period of light winds (15 kts), intermittent snow fall was recorded.**

(c) ***III spell (09 Feb to 20 Feb 92):*** **Nine intense systems affected the weather of the ship and that at Maitri. Five blizzards occurred during this phase. Winds were ESEIy/35 kts gusting upto 50 kts. Maximum wind recorded was 110/65 kts on 14 Feb 92. Flying was possible on one full day (18 Feb) and restricted flying on three days.**

Climatological statistics

The climatological statistics worked out from meteorological observations of this expedition are given in appendices to this report under following heads:

1. **Appendix 'A'- Occurrence of good, partially good and bad weather elements and days.**
2. **Appendix 'B'- Mean and extreme temperatures.**
3. **Appendix 'C'- Details of blizzards.**

Local forecasting hints from analysis of the systems

The following inferences and forecasting hints can be drawn from the available synoptic data and observations:

a) Pressure systems north of 6C°S latitude normally do not affect weather over polynya.

b) Pressure systems between 60 and 63°S With the trough extending southwards,moderately affect the weather resulting in blizzards with less than 50 kts wind.

c) LOPARs south of 63°S may cause intense bad weather conditions.

d) Deterioration of weather may start after a LOPAR crosses 0° moving towards east and lies south of 60°S. It continues to be bad till the system crosses 30°E longitude and remains sooth of 60°S latitude. Intense weather may be experienced when the system lies between 10 and 25 °E and south of 63°S.

e) LOPARs developing in situ over continent around 70°S: 10°E affect the weather at Maitri first and later that of polynya.

f) LOPARs between 20°W and 20°E and south Of 55°S show frequent breaking up and merging.

g) LOPARs with centres between 63°-67°S and 25°-30°E with a trough extending towards south-west may give rise to overcast weather with strong E/ESEly winds.

h) The frequency and severity of LOPARs increases from January to February and second fortnight of February is more prone to bad weather spells.

j) The LOPARs moving from west to east have no fixed speed of movement. In some cases the speed is as fast as 30° longitudes per day or as slow as 1 ° longitude per day or even stationary. The average speed of movement can be taken as 10 to 15° longitudes per day. The slow movement is invariably associated with the presence of a well marked ridge ahead of the system.

k) High pressure ridges equally play an important role in determining the weather conditions over polynya.

Improvement in weather: **Approach of a ridge from west or south (from continent) may give rise to significant improvement in weather conditions over polynya. The approach of a ridge is indicated by the following parameters - i) decrease in wind speed, ii) change in wind direction from SSEly to SSWly or Wly/light variable, iii) decrease in cloudiness of low and medium clouds.**

Deterioration in weather **Whenever a ridge is seen ahead of a LOPAR approximately along 30-40°E and extending southwards upto 60-65 °E, the**

systems have a tendency to slow down or stagnate and move towards SSE. Ridge extending from continent to 65°S causes the same effect on the movement of the systems.

l) Cloud movements : Low and medium clouds generally move from east/ESE direction. On some occasions they may drift from southerly direction. High clouds generally approach from west/NW direction. Normally the cloudiness on the northern horizon is more than other sectors and it does not affect the shelf area near polynya; the base of clouds (all types) is usually lower than the observed base of clouds over tropics. Convective clouds are not seen due to low level inversion and stability.

m) Steep pressure gradient (20 mb) between 60°S and polynya and 5°E to 20°E results in strong winds from ESE or easterly direction. Erratic pressure tendency and kinks on barographic charts give rise to gustiness of winds.

n) Bad weather spell can occur during both phases viz,positive and negative pressure changes.

p) A steep fall in pressure need not necessarily be associated with approach of an intense bad weather but at the same time, a slight drop may result into severe weather conditions.

q) Initial fall in pressure even upto 10 to 15 mb is normally not associated with increase in wind speed. With further fall in pressure, wind speed is strengthened and reaches a maximum value just before or even after the formation of pressure trough.

r) Increase in wind speed and gustiness gives advance notice of approach of a bad weather spell, normally the time gap between increase in wind speed and bad weather being 12 to 18 hours. Fair weather with strong E-ESE/25-30 kts wind, gusting upto 40 kts, may get changed to overcast condition with blowing snow after an interval of about 12 hours.

s) Decrease in wind speed to less than 15 kts during bad weather spell may cause temporary cessation of blowing snow/drifting snow and cloudiness may continue.

t) Six hourly and 12 hourly pressure changes do not give positive indications about deterioration/improvement in weather conditions.

u) Upper winds: The low level winds below one kilometre are generally E-ESE/15-20 kts (as obtained from helicopters). Low level winds show backing and increase to 30-50 kts at least 12 hours in advance of a bad weather spell. Veering of wind/decrease in speed may indicate clearance in weather. Generally turbulence is experienced in case of wind shear as is seen over Petermann and Payer mountains.

v) Visibility: In the absence of moisture and dust particles, the visibilty is excellent over Antarctica. Due to this reason the distances are quite deceptive. The main causes behind deterioration of visibility and whiteout are fog and blowing/drifting snow. If fog is seen on the northern horizon and prevailing winds are light/NNE, it may get advected over polynya. Cloudy to overcast condition with stratiform clouds may also cause whiteout condition even though visibility may be more than 5 km.

Conclusion and Suggestions

Air operations will continue to play a very important role in scientific expeditions to Antarctica. An attempt to highlight the importance of weather forecasting in Antarctica has been made, especially in view of the time bound scientific and logistic activities. Non-availability of meteorological parameters becomes a nightmare for the forecaster. The aim of this study was to make thumb rules and empirical rules using the meteorological parameters with the help of equipments which are locally available on board ship. These rules have been deduced, based on the data collected during one single expedition and need to be put on vigorous tests in subsequent expeditions to prove their validity in weather forecasting.

In view of the erratic reception of meteorological charts, the satellite imageries will play a very important role in weather forecasting, as this will be the only uninterrupted aid available to a forecaster in Antarctica. While computer generated weather forecast models are used almost as a rule over most parts of the world today, the satellite imageries will dominate and rule in Antarctica. It is, therefore, suggested that a better satellite receiver with a large memory and storage facilities than the present system be provided. It is also suggested that regular upper air ascents be taken either from ship or from Maitri to have a better understanding of weather systems.

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APPENDIX - A

(a) *Occurrence of weather elements for more than 6 hours (in days)*

Month	Total Cloud Amount. Low& medium 6/8	Low Clouds 5/8 below 450 m	Weather for, blowing snow, drifting snow, snow fall	Visibility		Whiteout
				< 5 km > 3 km	3 km	
Dec'91 (9 days)	7 (78%)	6 (67%)	6 (67%)	1(11%)	5(56%)	6 (67%)
Jan' 92 (31 days)	22(71%)	13(42%)	10(32%)	2(6%)	9(29%)	12(39%)
Feb'92 (25 days)	15(60%)	12(48%)	10(40%)	4(16%)	3(12%)	9(36%)

(b) Occurrence of weather elements for more than 3 hours but less than 6 hours (in days)

Dec'91 (9 days)	1 (11%)	1 (11%)	NIL	NIL	1(11%)	NIL
Jan'92 (31 days)	NIL	6(19%)	NIL	NIL	NIL	1(3%)
Feb'92 (25 days)	NIL	NIL	1(4%)	2(8%)	5(20%)	4(16%)

(c) Good, partially good and bad weather days vis-a-vis air sorties

Month	Good	Part, good	Bad	Total flying days			
				Full	Half	Few sorties	No flying
Dec'91	3 (33%)	NIL	6(67%)	2	NIL	3	4
Jan'92	12(38%)	6(20%)	13(45%)	17	1	1	12
Feb'92	12(48%)	1(4%)	12(48%)	11	3	3	8

The following criteria have been used for calculating good, partially good and bad weather days:

i) **Duration of the day has been taken as 0600 to 1800 hrs. Maximum flying activity was undertaken during this period.**

ii) **If any one element viz. blizzard (blowing snow/drifting snow), wind speed 33kts, visibility 5km and/or whiteout condition and low clouds 5/8 below 450 m occurred for more than 6 hrs, the day is classified as bad,if it is ≥ 3 hrs but ≤6 hrs, it is termed as partially good. If the duration of bad weather is less than 3 hours it is classified as good weather day.**

iii) **For calculating flying days the following criteria have been used : Full day - Flying ≥ 8 hours**
Half day - Flying ≥ 4 hours but < 8 hours.

APPENDIX- B

Mean and Extreme Temperatures

Month	Mean dry bulb temp.			Extreme	
	06 UTC	I2UTC	18 UTC	Highest	Lowest
Dec'91	+0.4	+ 1.4	+ 1.1	+4.7	- 1.0
				30/1400	29/1100
Jan' 92	- 1.3	+ 0.7	-0.5	+5.4	-5.0
				02/1500	15/0400
Feb'92	-4.8	-2.6	-3.0	+4.2	-10.2
				10 /1500	23/0600

APPENDIX-C

Details of Blizzards

SI.No.	Commencement		Cessation		Duration in hours	Max wind (kts)	Lowest visibility
	Date	Time UTC	Date	Time			
1	24 Dec	0600	25 Dec	0700	25.0	000/40	0500 m
2	25 Dec	0700	26 Dec	1100	23.0	120/58	0300 m
3	29 Dec	1030	29 Dec	1500	4.50	100/62	2500 m
4	14 Jan	2115	15 Jan	1800	20.25	130/45	1000m
5	18 Jan	1500	19 Jan	1800	27.0	120/60	1000m
6	25 Jan	0600	28 Jan	2130	87.5	120/44	0300 m
7	09 Feb	0700	09 Feb	1700	10.0	120/50	2000 m
8	10 Feb	1800	11 Feb	1830	24.5	120/50	1000 m
9	13 Feb	1900	14 Feb	1700	22.0	110/65	0100 m
10	16 Feb	0530	16 Feb	1000	4.50	110/46	0500 m
11	18 Feb	1400	20 Feb	0900	43.0	110/56	0500 m