2010 International Conference on Biology, Environment and Chemistry
IPCBEE vol.1 (2011) © (2011) IACSIT Press, Singapore

A Study on Effectiveness of Ecologic Protection Techniques along Desert Route

Chen Ai-Xia
School of Environmental Science＆Engineering
Chang'an University
Xi'an, China
Email:chenaixia9912@163.com

Abstract*—The research focuses on applications of ecological protections in the desert route – the Sanggendalai ~ Gongzhugeng highway crossing Otindag Sandy land. Some protective measures are brought forward, as sand barriers of low upright grid, sand barriers of tall upright grid, and composite typed sand barriers etc. Furthermore, these sand barriers and their sand breaking effectiveness like soil improvement, vegetation recovery etc are traced by means of field survey. Namely, (1) the low upright sand barriers have raised surface roughness up to 5.64cm, and wind velocity at the near surface (0.25m) within sand barrier reduces to 2.39m/s from previous 6.5m/s, which means the surface windproof efficiency averages to 63.1%; the near surface wind velocity within the high upright sand barrier goes down to 2.7m/s from 6.5m/s, its wind proof efficiency gains 58.5%; the near surface wind velocity within the composite sand barriers downgrades to 4.6m/s from previous 9.5m/s, of its maximum windproof efficiency up to 74.8%. (2) Compared to sand drifting area, the bulk density of soil inside the low and high upright barriers drops by 14.2%, soil porosity rises by 16% and soil water content upward by 77.8% at peak. The same to the increase of soil organic matter, hydrolysable nitrogen, available P content, available K content etc, that illuminate amelioration of local soil because of various sand barriers. (3) The applications of ecologic protections improve the local route environment apparently, 65% ~ 70% of its vegetation coverage fraction in sand drifting area after the highway project in comparison with 5% previously.

Keywords*：*highway*；*ecology*；*sand barrier*；*sand break effect

I. INTRODUCTION

Thanks for the national policy of Development of the West Regions in China, some desert roads are successively under construction in Otindag Sandy land, MU Us Desert, Huobq Sandland and Tengger Desert etc. And construction experiences are continuously coming forward [1-5], such as LUO Junbao[6] and his sand fixation and control techniques on the basis of research on sand hazard control and mechanism in different deserts through China. Of the biologic sand barrier technique commonly adopted as available measures, effectiveness for wind breaking and sand fixing varies owing to different materials, norms and planting densities [7-10]. This article, in example of Sanggendalai ~ Gongzhugeng Highway traversing Otindag Sandy land, brings forward ecologically protective techniques in highway region, namely, a new sand control measure, composed of low upright grid barrier, tall upright grid barrier and composite typed sand barriers. Furthermore, on-the-spot survey and investigation proceed, focusing upon its effectiveness from various sand barriers as soil amelioration, and vegetation recovery. Such will render support and reference for later desert road protections in optimization and explorations.

Inner Mongolia Transportation Science and Technology Project (NJ-2004-17)

II. SURVEY OF RESEARCH AREA

The Sanggendalai ~ Gongzhugeng Highway, selected as study area, has its length of 64.6km traversing Otindag Sandy land. The whole project area lies in a semiarid steppe, chilly, windy, sandy and rainless, of its annual mean wind velocity 3.2~5.5m/s and maximum wind speed 28.4m/s. 70% of the region are covered with fixed and semifixed dunes, 15~20m high, and 30% active dunes, with its vegetation coverage 30~50%. It is a region of intensified wind erosion [11]. Ecological protection along the route purposes at decrease of sand hazard upon roadbed and improvement of local ecologic surroundings. 30m windward and leeward beyond both sides of roadbed along the desert road, low vertical grid barriers are mounted, composed of yellow willow, and little spike willow mostly. Their wattles are cut into 58cm long, stuck into sand, 38cm above ground, of its density 21~25 tress for each linear meter. The grid has its size of 1.2m× 1.2m. Within the sand barrier, some sand-resistant plants are spread about, like prairie milk vetch, sand sagebrush, and lobule caragana, hdysarum leave are stuck in. At the steep slopes of cut section and top of sand slope, multi tall vertical sand barriers are set up, at interval of 2~4m, and 4~5m intervals for barriers at windward slope. Little spike willow and yellow willow wattles are grown in at density of 21~25 wattles for each linear meter, of the sand barrier porosity 0.3~0.4, and of the barrier height 1.5~1.7m. In areas of active dune, 50~80m winward and 40~50m leeward on both sides of roadbed, tall vertical barriers are collaborating with low grid barriers.

III. RESEARCH METHOD

A. Wind velocity measuring

In July 5 ~ 7, 2008, wind speed monitoring points were spotted respectively inside the low upright barriers at K39+500, tall upright barriers at K42+800 and composite barrier at K41+550 along the Sanggendalai ~ Gongzhugeng Highway. 4 wind speed measuring marks are set up in low barriers, 4 wind speed measuring marks in tall barriers, and 6 marks in composite barriers. At height of 0.25m of each mark, there stores cup-counter anemometers No. 1, 3, 5, 7, 9, 11, and at heights of 2m, No. 2, 4, 6, 8, 10, and 12. Wind speed measuring adopts PC-2F multichannel anemometer, automatically recording once every 30s. Inside the low and tall barriers, monitoring lasts 70min continuously, and 80min inside the composite barriers. In this research, the average wind velocity accepts values of 5min lasting for statistics.

B. *Soil Environment Measuring*

In July 15, 2008, 3 sample plots in low upright barriers, tall upright barriers, and active dene are selected as CG in the study area. 2 points come out of each sample plot, and 18 soil samples are fetched 0-5 ㎝, 5-15 ㎝, 15cm-30cm under surface. Each soil sample is measured with soil physical properties as bulk density, porosity, water content, and chemical properties as organics, hydrolysable nitrogen, Olsen-P, Olsen-K.

C. *Survey of Route Vegetations*

In July 5-7, 2008, sample spots are chosen at low barriers, tall barriers and active dene areas along the desert route for vegetation sampling, mainly vegetation coverage, height and species.

IV. RESULT AND ANALYSIS

A. *Effectiveness of Windbreak from Various Barriers*

1）*low vertical barrier*

No. 1 mark for wind measuring is spotted 10m beyond barrier, NO. 3 mark 10m inside the barrier, No. 3 mark 20m inside the barrier and No.4 mark at outer margin of the barrier. The wind velocity measurements at 0.25m inside the barrier are presented in table 1, so are the wind velocity curves in Fig. 1.

Table1 and Fig.1 indicate that wind speed goes down obviously at 0.25m high inside the low barrier along the desert route, as the wind speed averages to 2.39m/s, compared to the previous 6.47m/s in naked surface. The surface windproof efficiency goes in average up to 63.1%. All shows the good result after low barrier installation.

2）*tall vertical barrier*

No. 1 mark is spotted 5m beyond the first row of barrier, No.2 mark behind the barrier (1H), No.3 mark 3H behind the barrier, No. 4 mark 5H behind the barrier. The wind speed measurements at 0.25m are presented in table 2, and then so are the wind speed curves in Fig.2.

Table2 and Fig.2 indicate that wind speed goes down obviously (0.25m high) inside the low barrier along the desert route, from 6.5m/s to 2.7m/s. The surface windproof efficiency amounts to 58.5%. The remarkable decline of wind speed sources from the rows of tall upright barriers.

3）*composite barrier*

No.1 and 2 marks for wind speed measuring of the composite barriers are spotted 26m and 5m windward at open sites, No.3 and 4 marks at 1m and 29m behind the barrier, No.5 and 6 at center of low grid and roadbed slope. The measurements are shown in table 3, and wind speed curve then in Fig.3.

On both sides of the road, high upright and low upright barriers are combined together, namely, 50m~80m tall barriers at windward collaborating with 30m low upright barriers, and at leeward 40~50m tall upright barriers working with 30m low upright barriers. That renders excellent results. The on-the-spot test of such combinations illustrates that, 0.25m above the surface, its wind speed goes down to 4.6m/s from the previous 9.5m/s, of its maximum windproof efficiency up to 74.8%.

4）*comparison of windproof efficiency from various barriers*

Wind speed measurement at various barriers educes various windproof efficiencies. Details in table 4.

The tall vertical barriers perform in its blockade of active dene and decrease of wind velocity, and the low upright barriers in blockade of active dene and protection of seedling grownup. The composite barriers combined the above two virtues to its optimum.

TABLE1 WINDBREAK MEASUREMENT OF LOW UPRIGHT BARRIER UNIT：M/S

Time	No.1 cup WV	No.2 cup WV	No.3 cup WV	No.4 cup WV	No.5 cup WV	No.6 cup WV	No.7 cup WV	No.8 cup WV
14:00	5.9	7.0	2.8	9.0	2.8	8.6	2.3	7.9
14:05	6.0	8.3	2.7	9.3	2.6	10.0	2.7	9.2
14:10	6.2	8.5	2.9	9.4	2.8	9.6	2.3	9.0
14:15	6.1	7.5	2.2	8.7	2.2	8.1	2.9	8.7
14:20	6.0	7.6	2.5	8.7	2.4	7.8	2.2	8.0
14:25	6.5	8.8	3.0	10.1	2.5	10.2	2.8	9.0
14:30	6.4	7.4	2.3	8.4	2.1	9.2	2.5	8.2
14:35	6.9	9.2	3.0	10.1	2.7	9.9	3.0	8.9
14:40	7.2	9.6	3.4	10.4	2.4	9.1	1.9	9.4
14:45	6.0	7.6	2.6	8.4	2.0	7.5	2.0	7.4
14:50	6.4	7.4	2.3	8.4	2.1	9.2	2.5	8.2
14:55	7.2	9.1	3.0	9.7	2.7	10.2	2.4	9.2
15:00	6.5	8.2	2.4	9.3	2.5	9.6	2.7	8.9
15:05	6.4	7.4	2.3	8.4	2.1	9.2	2.5	8.2

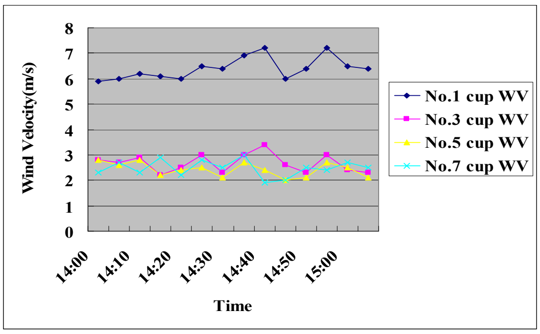

Figure 1 WV Curves at 0.25m along low upright barrier（Note:No.1,3,5,7 cups）

TABLE 2 WINDBREAK MEASUREMENT OF TALL UPRIGHT BARRIER UNIT：M/S

Time	No.1 cup WV	No.2 cup WV	No.3 cup WV	No.4 cup WV	No.5 cup WV	No.6 cup WV	No.7 cup WV	No.8 cup WV
17:10	7.5	9.8	3.1	8.2	3.7	7.4	3.2	6.8
17:15	7.7	10.2	3.3	9.1	3.5	8.2	3.5	8.3
17:20	8.2	10.9	3.2	9.0	3.5	7.7	3.3	7.9
17:25	6.7	8.7	2.1	7.4	2.9	6.4	2.8	8.0
17:30	6.5	8.2	2.3	7.2	3.0	6.2	3.3	7.3
17:35	6.4	8.0	2.9	7.9	3.2	7.0	3.1	7.4
17:40	6.3	8.4	2.6	7.8	3.6	7.4	3.4	7.7
17:45	6.1	8.0	2.7	7.0	2.6	6.1	2.1	5.8
17:50	5.5	7.3	2.1	6.8	2.7	6.3	2.5	6.1
17:55	5.6	7.3	2.0	5.7	2.3	4.6	2.2	5.6
18:00	6.3	8.2	2.0	7.0	2.8	6.0	2.4	6.4
18:05	4.7	6.2	1.8	5.5	2.1	4.5	1.7	5.0
18:10	4.6	6.0	1.5	5.6	2.3	5.0	1.8	5.0
18:15	4.8	6.7	2.4	5.3	2.1	3.8	1.2	4.6

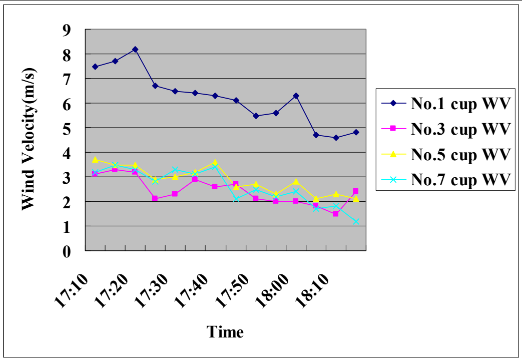

Figure 2 WV Curves at 0.25m along tall upright barrier（Note:No.1,3,5,7 cups）

TABLE 3 WINDBREAK MEASUREMENT OF COMPOSITE BARRIER UNIT：M/S

Time	No.1 WV	No.2 WV	No.3 WV	No.4 WV	No.5 WV	No.6 WV	No.7 WV	No.8 WV	No.9 WV	No.10 WV	No.11 WV	No.12 WV
10:10	6.2	8.1	5.5	7.9	5.1	6.9	2.0	5.7	1.9	6.4	4.9	6.8
10:15	5.9	7.8	6.1	8.2	4.6	6.6	2.5	7.2	1.9	6.8	6.1	8.1
10:20	6.8	8.6	6.2	8.1	4.9	6.8	2.5	7.2	1.5	7.1	5.3	7.5
10:25	5.7	7.3	5.5	7.5	4.7	6.7	2.2	6.7	1.8	8.1	5.6	8.1
10:30	6.5	8.2	5.5	7.5	4.4	6.5	2.4	6.9	1.5	7.0	5.5	7.6
10:35	6.4	8.2	6.5	8.4	5.2	7.0	2.5	7.1	1.9	7.4	5.9	7.6
10:40	6.7	7.9	5.9	8.1	5.0	7.1	2.1	6.7	1.4	6.3	6.0	8.2
10:45	7.5	9.3	7.0	9.7	5.2	7.6	2.9	7.9	1.9	6.6	6.2	8.6
10:50	7.3	9.1	5.9	8.2	4.6	6.9	2.3	6.8	1.8	7.2	6.3	8.0
10:55	6.5	8.4	5.6	7.9	4.3	6.5	2.4	7.1	1.9	7.2	5.7	7.9
11:00	7.8	9.6	6.9	9.0	6.0	8.8	2.7	8.3	2.0	7.7	6.0	8.5
11:05	6.8	8.4	5.8	8.2	4.9	7.0	2.3	8.1	1.5	6.2	5.4	7.7
11:10	6.7	8.1	6.3	8.2	4.9	7.1	2.1	6.9	1.8	7.6	6.0	7.9
11:15	7.1	8.9	6.2	8.2	5.0	7.5	2.6	7.6	1.8	7.2	6.2	9.0
11:20	6.3	7.8	5.9	8.3	5.0	7.6	2.6	7.1	1.8	7.3	5.5	8.1
11:25	7.0	8.6	6.5	8.8	5.0	7.6	3.0	8.1	2.2	8.6	5.9	8.6

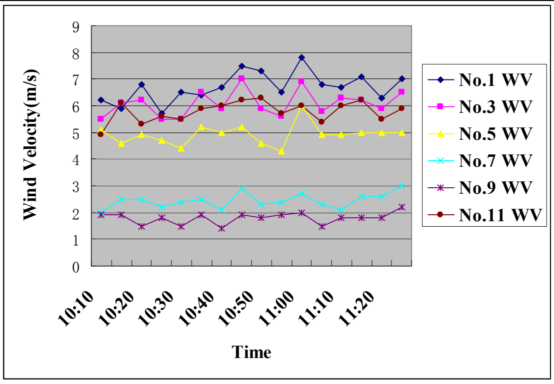

Figure 3 WV Curves at 0.25m along composite barrier（Note:No.1,3,5,7,9,11 cups）

TABLE 4 WINDPROOF EFFICIENCY COMPARISON AMONG VARIOUS BARRIERS

Barrier type / efficiency	Tall upright barrier	Low upright barrier	Composite barrier
Mean value（%）	57.7	60.4	70.5
maximum（%）	58.5	63.1	74.8

B. *Effect of Soil Improvement*

1) *improvement of soil physical properties*

Soil samples picked up in low barrier, tall barrier and active dene (CG) are measured with its physical properties as bulk density, porosity, water content etc. Results are shown in table 5.

Analysis of soil samples out of low and tall vertical barriers presents that, at spots of artificial plantation of prairie milk vetch, Korshinsk peashrub and hdysarum leave, the bulk density of soil drops by 14.2%, in comparison with that of the control group, soil porosity increases by 16% and water content increases the most by 77.8%. That illustrates the establishment of this route ecologic system is capable of amelioration of soil structure, especially from artificial plantation of pulses.

2) *improvement of soil chemical properties*

Soil samples picked up in low barrier, tall barrier and active dene (CG) are measured with its chemical properties, including soil organics, hydrolysable nitrogen, Olsen-P, Olsen-K etc. Results are shown in table 6.

Measurement of soil nutrients in areas of low and high upright barriers, as well as active dene (CG), displays that, spots with barriers contain much higher organics, hydrolysable nitrogen, Olsen-P and Olsen-K than in active dene. The 0~5cm layer of surface at tall barriers covers organics and hydrolysable nitrogen contents higher than in active dene, and contents of Olsen-P and Olsen-K lower than in low grid barriers. The 5~15cm layer of soil all nutrients at low grid barriers go to the peak.

Table 6 presents that, owing to the function of vegetation barrier and biology inside sand barriers, especially biologic root secretion and putrefaction of deadwood and shatters, soil environment in barrier area has been improved entirely.

C. Variance of Route Vegetations

Sample spots are selected out of areas of low, tall barriers and active dene, for investigation of vegetation coverage, height and species. It is shown in table 7.

Table 7 makes clear that the new ecologic protections along the route improved the local biology, rising up the route vegetation coverage up to 65%~70% from the previous 5%. Meanwhile, wild plants species increase, of the perennial wild foliage coverage up to 2~4 in each square meter. Composed mostly of wild plants as micromicron, sand sagebrush, *Agriophyllum squarrosum*, *Polygonum divaricatum* etc. the wild vegetation coverage amounts to 15%, compared to the previous 5% prior to the road construction.

TABLE 5 MEASUREMENT OF SOIL PHYSICAL PROPERTIES IN RESEARCH AREA

Sample plot	depth/cm	Unit W/(g/cm^3)	porosity/%	Water content/%	Remark
In low upright barrier	0-5	1.50	39.10	5.63	To grow up triennial prairie milk vetch, Korshinsk peashrub, and hdysarum leave
	5-15	1.61	35.28	4.76	
	15-30	1.72	36.10	4.58	
In tall upright barrier	0-5	1.52	39.38	5.87	To grow up triennial yellow willow, prairie milk vetch, Korshinsk peashrub, hdysarum leave and sand sagebrush
	5-15	1.60	35.00	5.39	
	15-30	1.62	35.36	4.93	
Active dene（CG）	0-5	1.75	33.86	3.31	
	5-15	1.78	32.21	3.52	
	15-30	1.68	36.10	3.52	

TABLE 6 VARIANCE OF SOIL CHEMICAL PROPERTIES IN RESEARCH AREA

Sample plot	depth/cm	organics/%	Hydrolysable N(mg/kg)	Olsen - P/(mg/kg)	Olsen － K/(mg/kg)
In low upright barrier	0-5	0.20	19.5	2.34	36.0
	5-15	0.28	19.5	2.50	42.5
	15-30	0.28	18.0	2.28	32.5
In tall upright barrier	0-5	0.31	20.5	2.06	35.5
	5-15	0.27	15.5	1.95	33.5
	15-30	0.25	15.0	1.80	31.8
Active dene（CG）	0-5	0.05	5.0	1.85	20.5
	5-15	0.13	11.0	1.68	28.0
	15-30	0.12	8.7	1.65	22.5

TABLE7 VEGETATION INVESTIGATION ALONG SANG~GONG HIGHWAY

Spot	Vegetation coverage（%）	Vegetation height（m）	Artificial plants	Wild plants
Low barrier	65～70	1.0～1.2	Hdysaram leave, prairie milk vetch, Korshinsk peashrub, sand sagebrush, wheat	*Agriophyllum squarrosum, Polygonum divaricatum*
High barrier	68～70	1.2～1.4	Yellow mellow, prairie milk vetch, *Caragana microphylla,* garcinia bark	*Agropyron desertorum.* Brown sand sagebrush, *Agriophyllum squarrosum, Polygonum divaricatum*
Active dene	〈5	0.4～0.6		*Agriophyllum squarrosum,* sand sagebrush, camel thorn

V. CONCLUSIONS

Vegetation investigation and measurement of soil environment, as well as wind speed monitoring, at areas of low, tall vertical barriers and composite barriers indicate evident ecologic benefit inside different barriers along the desert route. Here are the practical conclusions:

(1) The low upright barrier has raised the surface roughness up to 5.64cm, and wind velocity at the near surface (0.25m) within sand barrier drops to 2.39m/s from previous 6.5m/s, which means the surface windproof efficiency averages to 63.1%; the near surface wind velocity within the high upright sand barrier goes down to 2.7m/s from 6.5m/s, of its wind proof efficiency averages to 58.5%; the near surface wind velocity within the composite sand barrier downgrades to 4.6m/s from previous 9.5m/s, of its maximum up to 74.8%.

(2) Compared to sand drifting area, the bulk density of soil inside the low and high upright barriers drops by 14.2%, the soil porosity rises by 16% and the soil water content upward at peak value of 77.8%. The same to the increase of soil organic matter, hydrolysable nitrogen, available P content, available K content etc, that illuminate amelioration of local soil from active dene.

(3) Applications of ecologic protections has gained the local route environment apparently, and enhanced local vegetation coverage, as 65% ~ 70% of its vegetation coverage fraction in sand drifting area after the highway project in comparison with 5% previously. Meanwhile, wild plant species are increasing obviously, as perennial plants averaging 2~4 each square meter now. Composed mostly of micromicron, sand sagebrush, *Agriophyllum squarrosum*, *Polygonum divaricatum* etc, coverage of wild plantation has upgraded to 15% out of the previous 5%.

ACKNOWLEDGEMENTS

The author expresses here her great thanks to the sponsor from the Transportation Science and Technology Project (NJ-2004-17）, to the assistance from Zhang Guang, director of Inner Mongolian Transportation Passage Office, and senior engineer Jia Tingyao, and to the support in situ data collection fromYu Jun, Cai Xinyu and Guo Yanjun.

REFERENCES

[1] BIAN Shibin, "Sand fixation and environmental protection design along YU~JING Expressway,"Highway,Vol.11,PP.67-70, Nov.2000.

[2] WANG Jian, SANG Shangqing, and HE Qing,"Microclimate Analysis of various underlying surfaces at both sides of middle section of Taklimakan Desert Road,"Journal of Desert Research, Vol.23, PP.577-580,Sep.2003.

[3] HAN Zhiwen, WANG Tao, SUN Qingwei,DONG Zhibao,and WANG Xunming,"Sand and wind hazard and its control along Taklimakan Desert Road,"Geography Journa,Vol. 58 ,PP.201-208,Mar.2003.

[4] HUANG Fuxiang,NIu Shanhai,WANG Mingxing,WANG Yuesi,and DING Guodong,"Quality relationship between vegetation coverage and weathering sediment discharge in Mu Us Desert, "Geography Journal,Vol. 56,PP.700-710, Nov.2001.

[5] LIN Yuquan,Control research on sand drifting in Shapotou of Tengger Desert,Yinchuan: Ningxia People's Publishing House,1998.

[6] LUO Junbao,Technical study on sand hazard control in desert road, Beijing：Doctoral dissertation in Beijing Forestry University, 2005.

[7] GAO Yong,QIU Guoyu,DING Guodong,QINGSHUI Yingxing,YU Yi,and HU Chunyuan etc.,"Effectiveness study from Salix Cheilophila Barrier in windproof and sand fixation,"Journal of Desert Research,Vol. 24,PP.365-370,May 2004.

[8] DONG Zhi,LI Hongli,HU Chuanyuan,and ZUO Hejun ,"Cost and benefit comparison from different sand fixations in desert route," Water and Soil Conservation Study,Vol.13PP.128-130,Apr. 2006.

[9] WANG Zhenting,ZHENG Xiaojing,"Simple model for analysis of grass grid size," Journal of Desert Research,Vol.22,PP.229-232,Aug. 2002.

[10] ZHAO Mingyan,DING Guodong,LUO Junbao,CAO Bo,ZHANG Jiayin,and CUI Liqiang,"Study of integrated control benefit from sandbag barrier along Otintdag Sandland Desert Expressway," Resources and Environment in Arid Region, Vol.23,PP.105-109,July 2009.

[11] PEI Hao, ZHANG Shiyuan，and AO Yanqing,"Analysis on climate features and its variance in Otindag Sandland,"Weather Technology, Vol.33,PP.63-67,Feb. 2005.