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Dust clouds "Kosa" from the east Asian dust storms in 1982-1988 as observed by the GMS satellite

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Abstract

In oder to examine how often dust storms in the east Asia and the resultant dust clouds "Kosa" occur and can he observed by the geostationary meteorological satellite, the GMS visible and infrared images were surveyed for the period of 1982 to 1988. Twenty one cases were presented ; in which about a half of the duststorms were identified in the infrared images in cloud-free area. Streaky feature of the dust storms mostly at the early stage and their subsequent change to fuzzy patches possibly in the mature or decaying stage which are identical of so-called dust clouds, were useful to find the duststorm in their sources area in the satellite images. Some of the dust clouds reported in a synoptic observation in Japan, though it was minor dust storm, was not identified in the GMS images.

The phenomenologically significant dust clouds "Kosa" on their transport route were identified upto the distance of about 3000 km and more far from the sources with transversal extent of about 500 to 1500 km over Japan Islands and the vicinity. The average transport speed was 40 km/h (15m/s). Synoptic weather condition clearly governs the behavior of the dust clouds, which is discussed for each the cases.

1. Introduction

"Kosa" is the name of a phenomenon in which visibility is reduced by dust clouds coming from Asian continent and/or the dust-fall or brown-colored particulates deposited on the ground in Japan. The dust clouds "Kosa" is sometimes called as the dust storm "Kosa". In this paper, we distinguish between dust storm and dust cloud., the former is a phenomenon occurring in the source area where the dust clouds are generated and the latter dust cloud itself on its transport route. The case studies on the transport of Kosa in 1978 and 1979 was conducted by meteorogical analysis (Murayama 1980) and a transport model simulation for the some cases (Murayama and Kimura 1984) and a physical properties of Kosa as aerosols was experimentally studied (Murayama and Collaborator 1984, Murayama 1987). In this report, we intend to clarify how often the dust clouds "Kosa" in the transport stage and their sources i. e.,dust storms can be identified in the GMS images. No detailed analysis was undertaken on specific cases but a basic information was sought for further study like an estimation of dust loading in the troposphere.

2. Procedure and general description

The time serial GMS images were surveyed to find the extent of Kosa dust clouds over the sea by using the visible images, with only a synoptic report that "Kosa" was observed at some of weather station in Japan. When Kosa was identified as the area of patches brighter than the sea and darker than the water cloud in the visible images, it location was temporarily tracked back to in the previous day and then the dust clouds over the land were searched in the infrared images until arrive at the presumed source areas as shown in

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Fig1.. The dust storms thus found showed a special appearance, usualy fuzzy patches, different from the water clouds. It is colder than the land and warmer than the water clouds in the infrared images. Because the water clouds covered frequently the source areas where the dust storms appeared, the dust clouds were not always found as a clear feature.

Then we checked synoptic surface weather charts published to ascertain whether the dust storms appeared. In this instance, the charts are not necessarily satisfied our purpose, because synoptic observation times 00 and 12 UT are the early morning and the late evening respectively at the source area corresponding to the time when the dust storms are not active in the sources, i.e. Asian arid region, of 100-110E. The dust storm and/or weaker one, liftup of the dusts plotted in with WMO codes of the weather reports, were frequently found in Gobi desert and Chinese loessland,i.e., arid and semi-arid areas in the east Asia. The GMS images were surveyed in this way for the period of 1982 through 1988. Thus we found twenty one events of Kosa. Day-to day extent of the dust clouds "Kosa" were drawn in a sketched form, in the Fig 2. The dust cloud, significantly appeared in winter and spring in Japan, were transported from Chinese coast through East China sea to Japan Islands and farther to the Pacific, till the distance of 3000 Km and more, as long as observed in GMS images, far from the source area with transversal extent of about 500~1500km. Average transport speed was 40 km/h between the source and Japan Islands. It depends on geeatly on the synoptic weather situation.

3. Synoptic weather consideration

Meteorological conditions are briefly described in the followings for each the dust storm and dust cloud event. The area which has a potential of dust storm and liftup of the dust is shown in Fig 1. In Fig 2 (A) through (U) the dust storms and the subsequent dust clouds "Kosa" are illustrated in for twenty one cases we found by procedure described

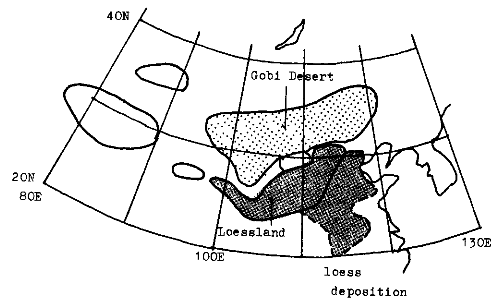
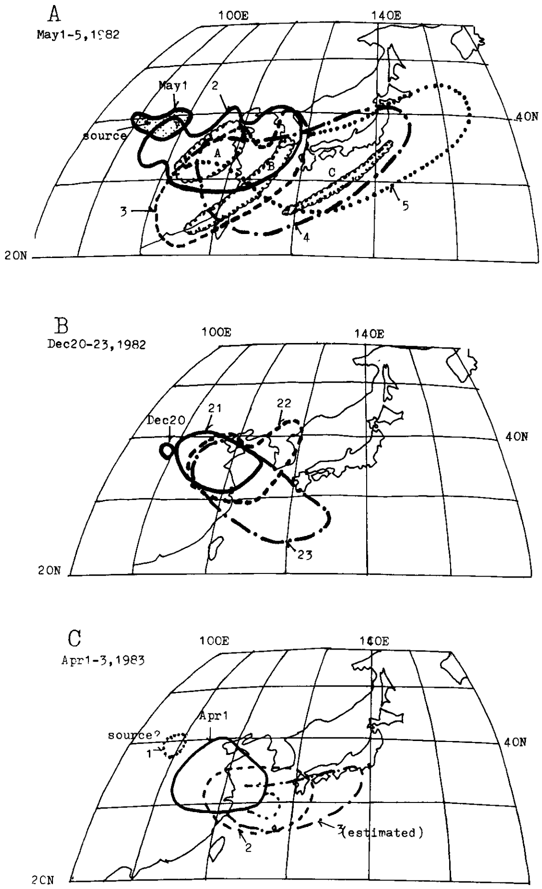
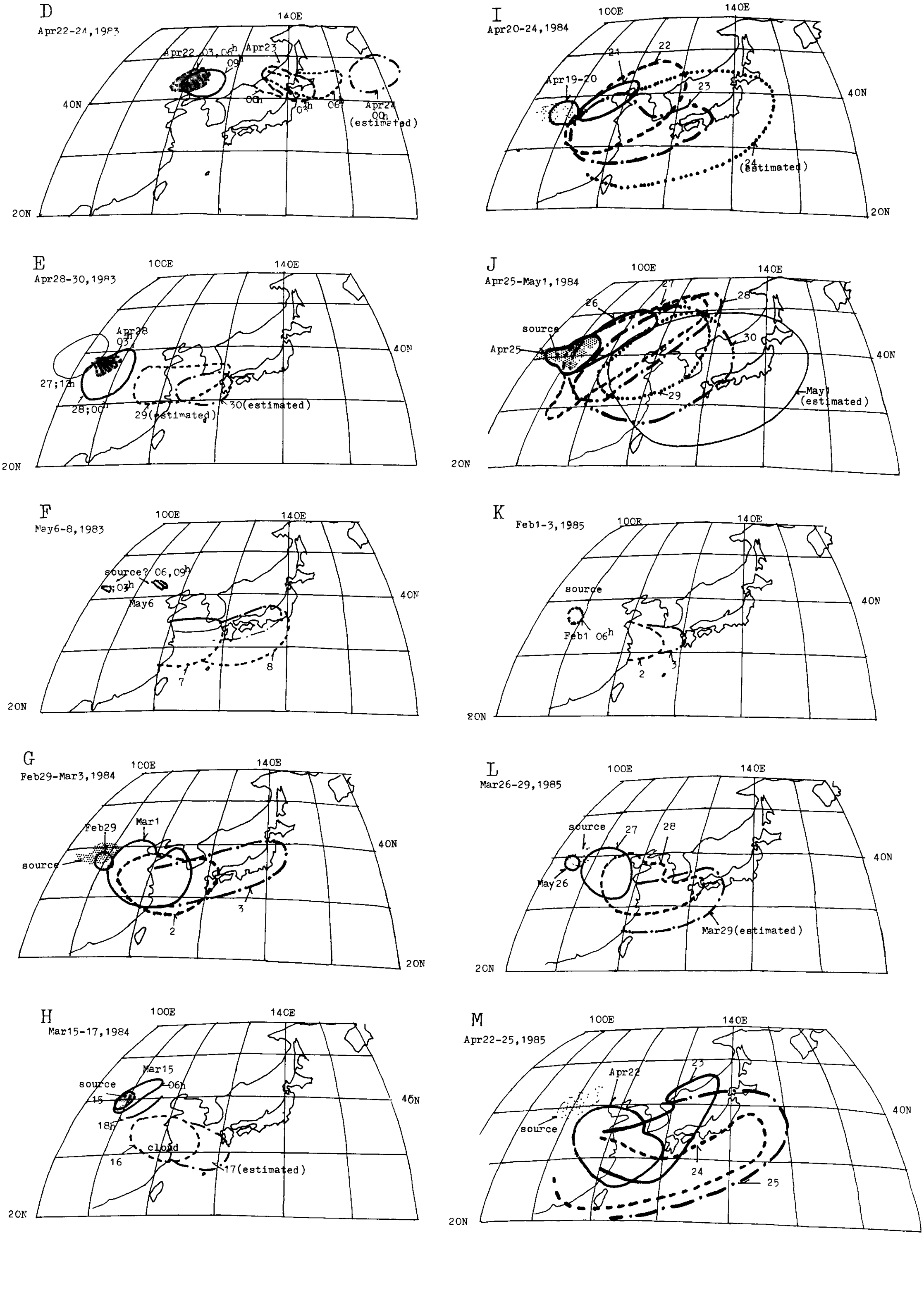


Fig. 1 The area vulnerable to the dust storm and/or liftup of the dust. Light stippled areas is Gobi desert while heavy stippled loessland.

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140E
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28;00h
29(estimated)
30(estimated)
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Apr25-May1,1984
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source
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Mar26-29,1985
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27
28
May26
Mar29(estimated)
H
Mar15-17,1984
100E
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40N
20N
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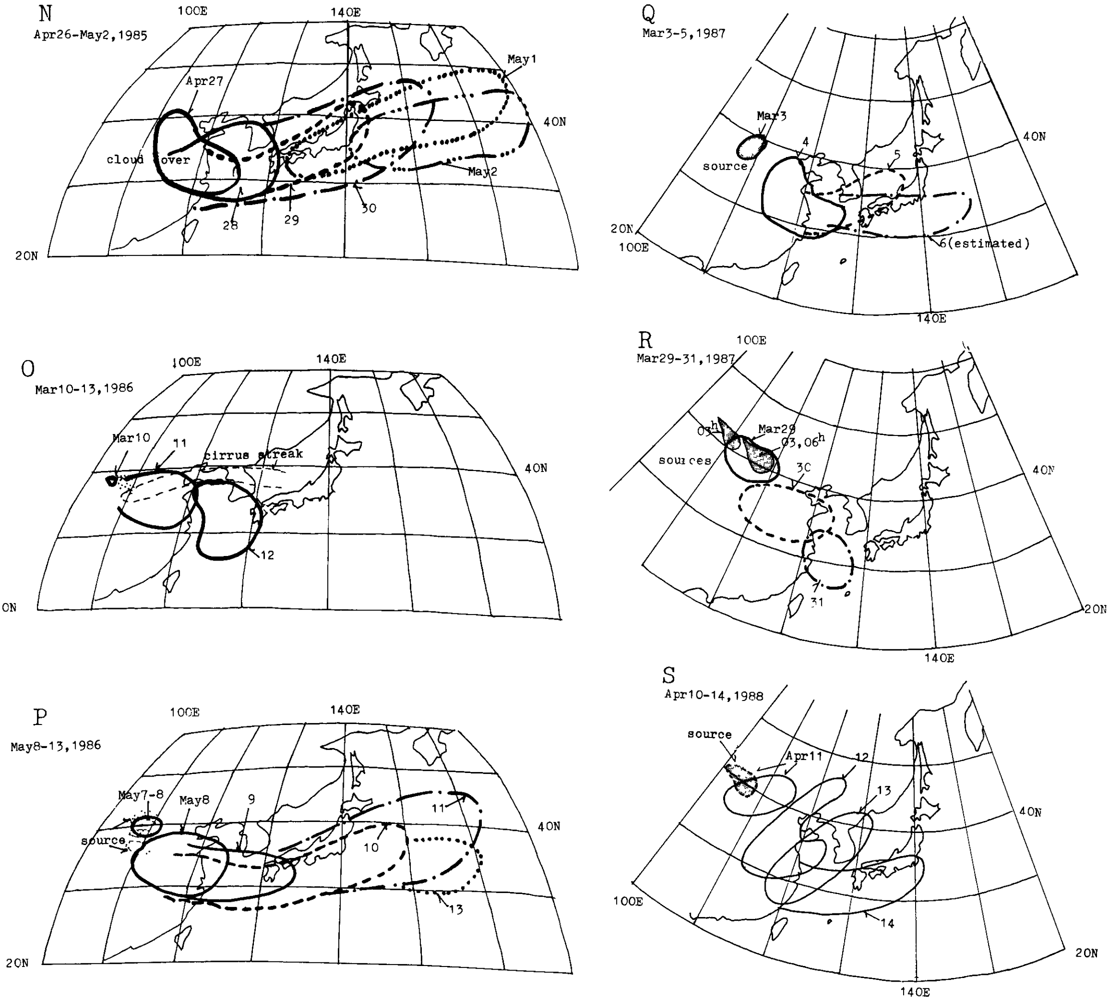

Fig. 1 The area vulnerable to the dust storm and/or liftup of the dust. Light stippled areas is Gobi desert while heavy stippled loessland.

Fig. 2 Day-to day extent of "Kosa" dust clouds illustrated with contour lines from their sources where the dust storm occurred. The sources shown by hatched areas were identified in the infrared images. The contour lines of the dust clouds with "estimated" was subjectively drawn by using slight change of brightness of the images.
A) May1-5, 1982 event, in Which A, B, and C in the figure indicates brighter area of the dust clouds for each May 2,3, and 4. B) Dec 20-23 event, C) April 1-3, 1983 event, D) Apr 22-24, 1983 event , E) Apr 28-30 event, F) May 6-8, 1983 event, G) Feb 29-Mar3, 1984 event, H) March 15-17, 1984 event, I) Apr 20-24, 1984 event, J) Apr 25-May1, 1984 event, K) Feb 1-3, 1985 event, L) Mar 26-29, 1985 event, M) Apr 22-25, 1985 event, N) Apr 26-May2, 1985 event, O) Mar 10-13, 1986 event, P) May 8-13, 1986 event, Q) Mar 3-5, 1987 event, R) Mar 29-31, 1987 event, S) Apr 10-14, 198 event, T) Apr 16-20, 1988 event. and U) Apr 16-19, 1987 event.

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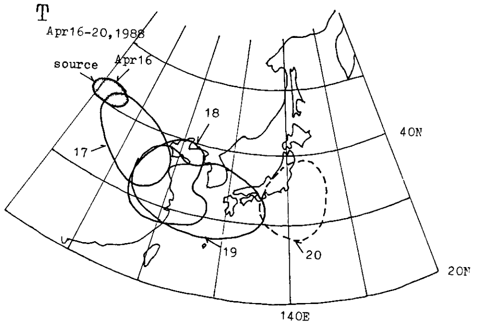

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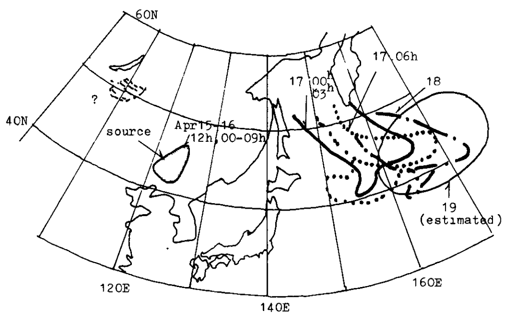

the above.

A) *May 1-5, 1982 event* : the source:Gobi desert and loessland. ESE-ward passage of the cold front of extratropical cyclone located 100E, 45N on May 1; 20-30 knots NW wind in the cold air sector associated with the dust storms. Travelling anticyclone helped the long range transport of the dust clouds. (detailed analysis is given in the other report) (see Fig 3)

B) *Dec 20-23, 1982 case* ; the source: loessland? With E-ward movement of extratropical cyclone located 107 E, 47N on Dec20. 20-40 knots of NW wind prevailed in the source area. Outbreak of the continental high to east China sea brought the dust.

C) *Apr 1-3, 1983 case*; the source is not sure but possibly in Gobi desert and loessland, No particular meteorological condition found except 15 knot NW wind west of the source area. Weak travelling high to the southwestern Japan.

D) *Apr 22-24, 1983 case* ; the source: the eastern edge of Gobi desert. E-ward movement of the cold front of extratropical cyclone located 130E, 51N on Apr22 in the east of the source region, where 20-25 knots NW wind prevailed. Sparse data available in the source area. The dust storms in the early or developing stage were observed with streaky patterns of the dust clouds in daytime (03 and 06UT) and in the mature or decaying stage with fuzzy and smoothy pattern in the late evening (09UT) as shown in Fig 4, The dust cloud passed over the northern Japan (the northern Japan usually experiences Kosa in winter).

E) *Apr 28-30, 1983 case* ; the source: Gobi desert and loessland.

With E-ward movement of the cold front of extratropical cyclone located 118E, 40N on Apr28, 15-30 knots of NW wind in the cold air sector, the source area prevailed. Streaky pattern of the dust clouds along the wind direction is seen at 06UT of Aug 28 and fuzzy smoothy patches at 09UT in the infrared picture as shown in Fig 4. Dusty area also was in the west of the above source on Apr 27. Eastward outbreak of Chinese continental high but seperated into two and the trailing high loading the dust remained in the continent that resulted in insignificant Kosa event in Japan.

F) *May 6-8, 1983 case*, No particular weather condition except the eastward movement of the extratropical cyclone located 118E, 44N on May 6. No source clearly identified.

G) *Feb23-Mar3, 1983 case*, The source; Gobi desert and loessland.

Strong anticyclone was stationary in the area centered near 105E, 40N during Mar 1-4 with the lows to the east and the consequent high pressure gradient produced NW wind of 15 knots or so continuously. Eastward outbreak of Chinese continental high brought the dust clouds to Japan.

H) *Mar 15-17, 1984 case*; the source: Gobi desert (duststorm) and loessland (liftup of the dust). NW wind associated with E-ward movement of the extratropical cyclone located 115E, 45N on

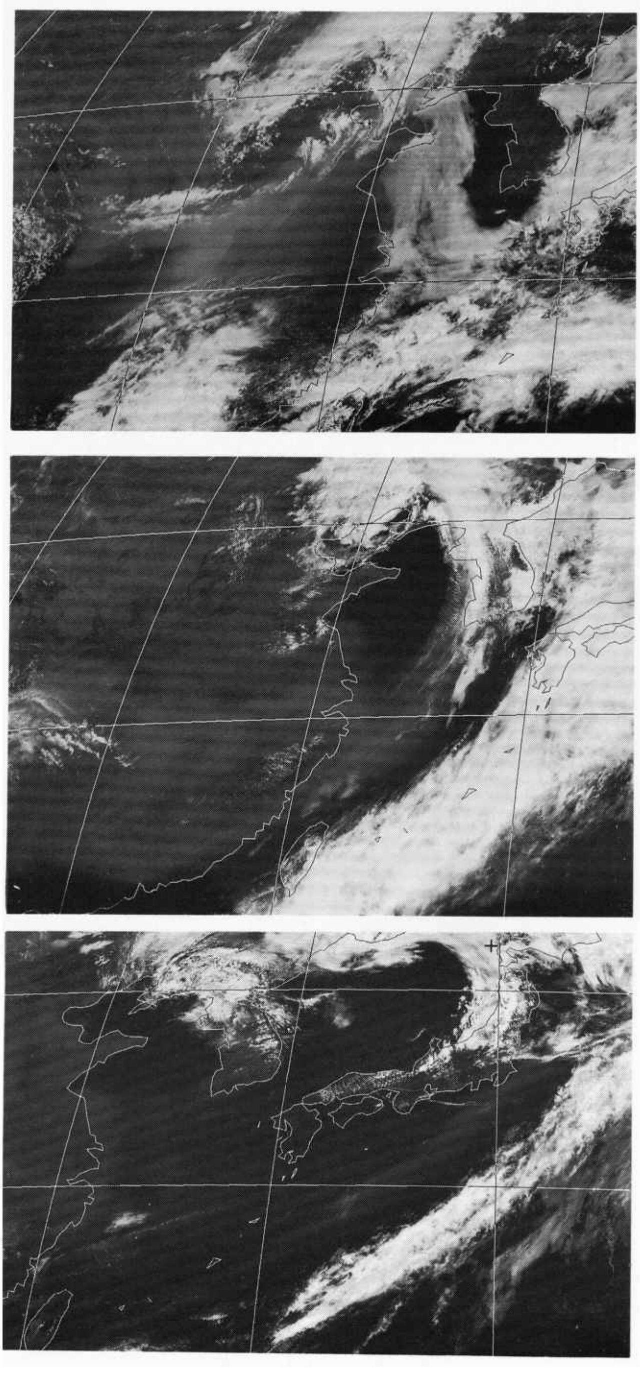

Fig. 3 GMS visible images on May 2,3, and 4, 1982 ; 03UT showing "Kosa" dust clouds. The dust cloud on the low water cloud (stratus) over the east China sea reduced reflectance of the stratus as in the May2 image.

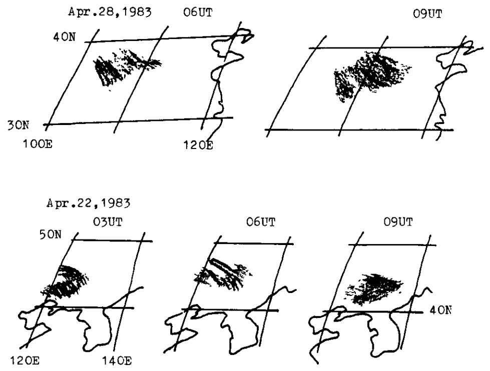

Fig. 4 The dust storms identified in the infrared images.
the upper: Apr28, 1983:06UT and 09UT
the lower; Apr22, 1983: 03UT, 06UT and 09UT.

Mar15. Seperated high from the continental high moved to the east China sea accompanying the dust clouds.

I) *Apr 20-24, 1984 case*; the source:Gobi desert.

NE-ward passage of cold front of extratropical cyclone located 114E, 47N on Apr 19. 20-30 knots NW wind in cold air sector, in the dust storm area and SW wind in the warm sector (liftup of the dusts). There was a liftup of the dust in loessland on 20th. Travelling anticyclone brought the dust clouds to Japan. (Kosa aerosol sampling at Nagasaki in other report).

J) *Apr 25-May1, 1984 case*; the source: Gobi desert and loessland. NE-ward passage of cold front of the extratropical cyclone located 113E, 47N on Apr25. 20-30 knots NW wind in the source area. With low pressure gradient, the eastward transport of the dust clouds was very slow.

K) *Feb 1-3, 1985 case*; the source; not surely identified but loessland?

No particular weather condition except the high near the source and the low in the east of the source.

L) *Mar 26-29, 1985 case*; the source: Gobi desert and loessland. 5-20 knots NW wind associated with E-ward movement of the extratropical cyclone located 116E, 46N on Mar26. Liftup of the dust also in loess-deposited plain. Eastward outbreak of the continental high slowly brought the dust clouds in to the western Japan.

M) *Apr 22-25, 1985 case*; the sources: Gobi desert.

E-ward movement of the extratropical cyclone located 104E, 47N on Apr23. NW wind liftted up the dust. The high over the Japan Island stayed and eastward transport of the dust clouds was affected by the high.

N) *Apr 26-May2, 1985 case;* the source is not identified except that the liftup of the dust in loessland for long term from 27th to 29th.

E-ward cold front movement associated with the extratropical cyclone located 110E, 47N on Apr 27. Travelling anticyclone brought the long range transport of the dust clouds.

O) *Mar 10-13, 1986 case*; the source is probably in loessland. No liftup of the dust in the synoptic chart reported. E-ward movement of the extratropical cyclone located 110E, 45N on Mar10.

P) *May 8-15, 1986 case*. the source is in loessland and probably in Gobi desert. 10-15 knots NW wind in the source area associated with ENE-ward movement of the extratropical cyclone located 117E, 39N on May8. Travelling anti-cyclone brought the long range transport of the dust clouds.

Q) *Mar 3-5, 1987 case*; The source is probably in loessland found in the images but no report in the chart. ENE-ward movement of the extra-tropical cyclone located 117E, 38N on Mar 3. "High in the west and Low in the east" pressure pattern carried the dust cloud to the east.

R) *Mar 29-30, 1987 case*; the source: Gobi desert. 15 knots NW wind associated with ESE-ward movement of the extratropical cyclone located 110E, 40N on Mar 29. Outbreak of the Chinese continental high over the east China sea brought the dust clouds.

S) *Apr 10-14, 1988 case*; the source: Gobi desert and loessland. 15-25 knots NW wind associated with frontal passage of the the extratropical cyclone located 118E, 41N on Apr 11. Travelling high brought the dust southeastward. (Detailed analysis is given in other report)

T) *Apr 16-18, 1988 case*; the source: Gobi desert and loessland. 15-20 knots NW wind associated with slow movement of the extratropical cyclone located 118E, 49N on Apr 16. No other significant weather situation to carry the dust clouds. (Detailed analysis is given in other report)

U) *Apr 16-19, 1987 case*.

This is a particular case in which no synoptic weather report of the dusts against that the dust clouds were found in the GMS images. The source was assumed to 124E, 44N (stippled area) by using 850 hPa wind during Apr 16-17 and the liftup of the dust from Apr 15;12UT to Apr16: 09 UT there (? means the area where once suspected as the dust source).

4. Conclusion

In almost all the cases, northwesterly high wind prevailed in the source area.

Significant dust storms associated with cold front passage, i.e., nine cases of twenty. Seven cases of which were significant, two others were slow movement of the front and the source far from the front. In some cases, the dust storm was observed in their early or developing stage and in the mature or decaying stage. In one case, the high wind does not associated with the cyclone or cold front but with very large pressure gradient continued for days in the source area. Transport of the dust clouds was controlled by the synoptic weather condition. Travelling anticyclone contributes to a long-range transport of the dust clouds.

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GMSで観測された1982－88年の東アジアの砂塵嵐による黄砂

村山信彦*

東アジアの乾燥地帯で発生する砂塵嵐とその結果生じたダスト雲である黄砂が、GMSでどの程度で観測され、どのように輸送されるかを知る目的をもって、1982～88年の7年間のGMS可視赤外画像写真を調べた。21例が検出できたが、そのうち半分の例では発生源の砂塵嵐が赤外画像を用いて同定できた。砂塵嵐の初期/成長期と推定される筋状のダスト雲、最盛期/減衰期の推定されるぼやけて滑らかなパターンのダスト雲がみられ、砂塵嵐発生域の同定に役立った。

黄砂の輸送過程における水平の広がりを衛星画像だけで推算したところ、顕著な場合発生域から風下距離3000km以上まで、南北の広がり500～1500kmをもって存在するのが確認できた。平均の輸送速度は40km/時であった。ダスト雲の移動には、総観気象場が大きく関与している。