Sea fog detection near Korea peninsula by using GMS-5 Satellite Data(A case study)

Hyo-Sang Chung, Byong-Jun Hwang, Young-Haw Kim* and Eun-Ha Son

Remote Sensing Research Laboratory
Meteorological Research Institute, Seoul 156-720, Korea
**Satellite Divison, Korea Meteorological Administration, Seoul 156-720, Korea*
Fax: +82-2-841-2787, E-mail: hbj@metri.re.kr

Abstract

The aim of our study is to develop new algorism for sea fog detection by using Geostational Meteorological Satellite-5(GMS-5) and suggest the techniques of its continuous detection.

So as to detect daytime sea fog/stratus(00UTC, May 10, 1999), visible accumulated histogram method and surface albedo method are used. The characteristic value during daytime showed A(min) > 20% and DA < 10% when visble accumulated histogram method was applied. And the sea fog region which detected is of similarity in composite image and surface albedo method.

In case of nighttime sea fog(18UTC, May 10, 1999), infrared accumulated histogram method and maximum brightness temperature method are used, respectively. Maximum brightness temperature method(T_max method) detected sea fog better than IR accumulated histogram method. In case of T_max method, when infrared value is larger than T_max, fog is detected, where T_max is an unique value, maximum infrared value in each pixel during one month. Then T_max is beneath 700hPa temperature of GDAPS(Global Data Assimilation and Prediction System). Sea fog region which detected by T_max method was similar to the result of National Oceanic and Atmosheric Administration/Advanced Very High Resolution Radiometer (NOAA/AVHRR) DCD(Dual Channel Difference). But inland visibility and relative humidity didn't always agreed well.

Key Words : sea fog, GMS-5 satellite, visible accumulated histogram, IR accumulated histogram

Introduction

Fog and low stratus, Unlikely other types of clouds, appear relatively warm on infrared images especially if the fog layer is not too thick since their temperature is close to that of the underlying sea surface. So fog detection on infrared satellite imagery is difficult(Scorer,1986). Moreover in some cases, fog top has a higher temperature than the surrounding area due to temperature inversion.

A great deal of basic research on fog detection was conducted using multispectral channels of National Oceanic and Atmospheric Administration(NOAA) Advanced Very High Resolution Radiometer(AVHRR).

The use of the bispectral technique for the specific purpose of nighttime fog detection was first accomplished in Great Britain(Eyre et al. 1984). Prior to this work, AVHRR channels 3, 4 and 5 were used to flag and remove cloudy pixels and to improve the accuracy of global sea surface temperatures(McClain et al. 1983)

Besides, diferences in the radiative properties of clouds observed in various visible and IR wavelengths were determined theoretically by Hunt(1973). These techniques exploit the distinct emissivities of straitform clouds at the two wavelengths.

The use of two window channels for fog detection is not effective during hours of sunlight. It is not necessary during daylight, however, since fog and stratus clouds have distinctive characteristics in high-resolution(1㎞) Geostationary Operational Environmental Satellite (GOES) visible imagery.

Within a country, Kim et al.(1997) tried detecting fog and low level cloud during nighttime using brightness temperature difference between channel 3(6.7㎛) and channel 4(11㎛) from NOAA/AVHRR. but NOAA satellite cannot offer us continuous observed data except for one time, 18UTC during nighttime. So it is not effective for fog detection.

This study focused on fog detection of continuity using Geostationary Meteorological Satellite-5(GMS-5), whose observed data is received by an hour and evoluting algorism.

Data process

The use of Geostational Meteorological Satellite-5(GMS-5) data by a hour made it possible that we detect fog/stratus incessantly.

In case of IR1, IR2, IR3 and visible channel, the grid was formed with five lines × five pixels image data in correspondence to an intersection of longitudial and latitudial lines at intervals of 0.25 degrees. At the same time, with numerical meteorological processed data, GDAPS(Global Data Assimilation and Prediction System), cloud masking was conducted.

700hPa temperature of GDAPS was utilized as criterion value of low-level cloud mode.

When infrared bright temperature was higher than 700hPa temperature of GDARPS, low-level cloud mode was determined.

Daytime Fog Dtection Method

1. Visible accumulated histogram

This method is to use frequency of reflectance of VIS accumulated by selected pixels. Figure 1. shows the concept of this method, which utilize values of A(max) , A(min) and DA. Where, A(max) is the value of reflectance of VIS corresponding to 84% of the accumulated frequency, A(min) is the value of reflectance of VIS corresponding to 16% of the accumulated frequency, and DA is reflectance difference between A(max) and A(min). These values were applied to fog detection because they in fog or stratus is lower distinctively than in low-level cloud. In this study, when DA was less than 10% and A(min) was greater than 20%, fog or stratus were choosed(Fig. 2).

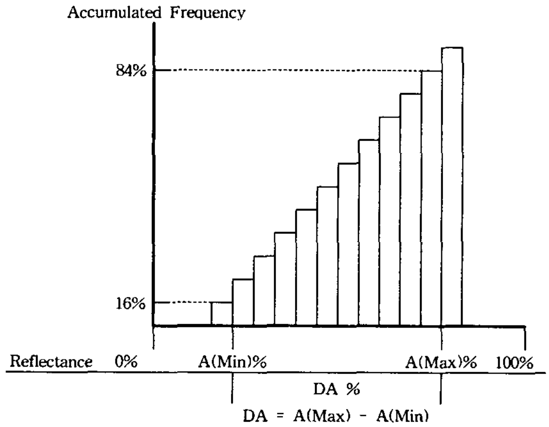

Fig. 1. Concept of cloud classification by visible dat histogram shows frequency of reflectance of VIS accumulated by the selected pixels. A(Min) is The value of reflectance of VIS corresponding to 16% of the accumulated frequency. A(Max) is the value of reflectance of VIS corresponding to 84% of the accumulated frequency. DA is reflectance difference between A(Max) and A(Min), (Tokuno, 1996).

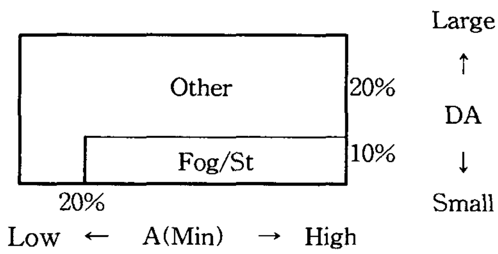

Fig. 2. Cloud classification in low cloud mode. A grid is classified into three classes(Cu, Fog and Other) by the two-dimensinal histogram formed

by A(Min) and DA, (Tokuno, 1996).

2. Surface albedo

This method is to complement visible accumulated histogram for daytime fog detection. Earth albedo is unique value for each pixel, minimum albedo corresponding to 16% of the accumulated frequecy for one month. In this study, characteristic value of fog detection was determined in surface albedo plus 0.1, fog was proved when albedo data observed in GMS-5 is less than that.

Nighttime Fog Detection Method

1. IR accumulated histogram

In infrared satellite imagery, it is difficult to detect fog and low clouds. Especially for nighttime fog, only infrared channel data values are used. It is difficult to distinguish the temperature of top of fog and sea surface because they have a similar value using infrared channel data. Just its light difference appears under clear sky. In this study, IR accumulated temperature histogram method, Tokuno method (1996) was applied, which utilized characteristic values of DT, DDT12 and DT12(min). DT is difference of infrared value between corresponding to 84% and 16% of the accumulated frequency in infrared channel 1. DDT12 is difference of infrared value corresponding to 84% and 16% of the accumulated frequency between infrared channel 1 and infrared channel2. And DT12(min) is minimum value corresponding to 16% of the accumulated frequency in infrared channel 2. Fog was proved when it is satisfied that DDT12 is less than 0.5K, DT12(Min) is less than DT is less than 0.5K. (Fig. 3)

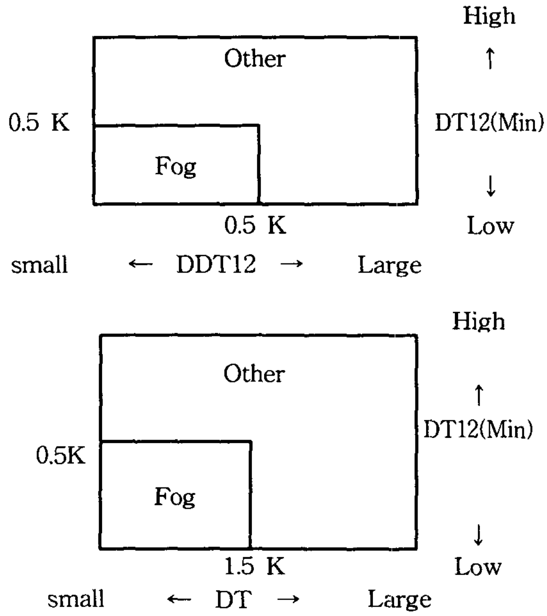

Fig. 3. Fog detection in low cloud mode for nighttime.

2. Maximum brightness temperature

Maximum brightness temperature method(T_max method) is determined as unique infrared value under clear sky, which is maximum value of infrared channel 1 in one pixel for one month. It was used as characteristic value(T_max) of fog. In this study, fog was proved when infrared value is less than T_max minus 6, and T_max minus 4, in case of land and sea, respectively. Such a constant 6, 4 is considered by difference of specific heat flux.

A case study

An are of 61×81 pixels over the Korean peninsular and Japan has been selected. Case days was selected due to composite image of GMS-5 and DCD image of NOAA ; 00UTC, 5. 10. 1999 for daytime fog and 18UTC, 5. 10. 1999 for nighttime fog.

Above described methods of fog detection were applied on case days. Fig 4. shows vertical profile of water vapor variation from 00UTC, 5. 9. 1999 to 00UTC, 5. 11. 1999. It is radiosonde observation data in Osan observation. Water vapor variation, that is, difference between air temperature and dew point temperature, increased, as time went gradually. And the case day had cold advection type with aspect of synoptic meterological field(Fig. 5).

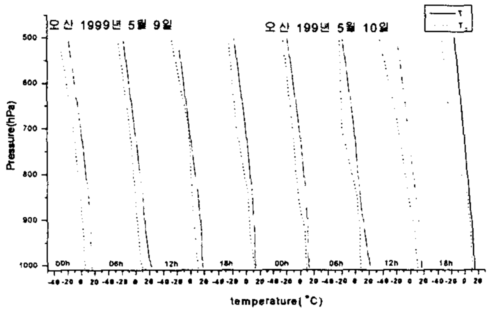

Fig. 4. Vertical profile of T(air temperature) and Td(dew point temperature) at Osan observation station.

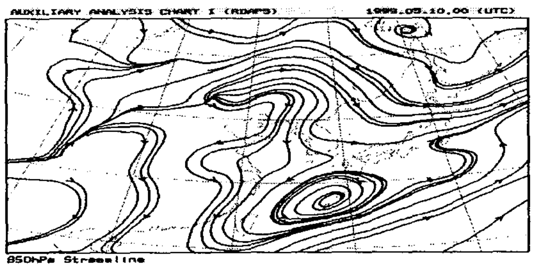

Fig. 5. streamline in 850hPa for 00UTC May.10 1999.

Results

Fog detection during the daylight hours was relatively straightforward using albedo, conventional visible channel data through two method; visible accumulated histogram method and surface albedo method. Surface albedo method detected much more fog area in western costal area as well as away from land than visible accumulated histogram method. And fog area detected by surface albedo method was much more similar with composite image(Fig. 6(a)). But at present, oceanographical observed data from the oceans such as ships or ocean buoys is not sufficient to make a real certification.

Fig. 6(d) and (e). show that western coastal area, Pohang and Mokp'o, had low visibility ($\leq 1km$) and high relative humidity($\geq 80\%$) during daytime. these region agreed well with image of fog detection(fig. 6(b) and (c)).

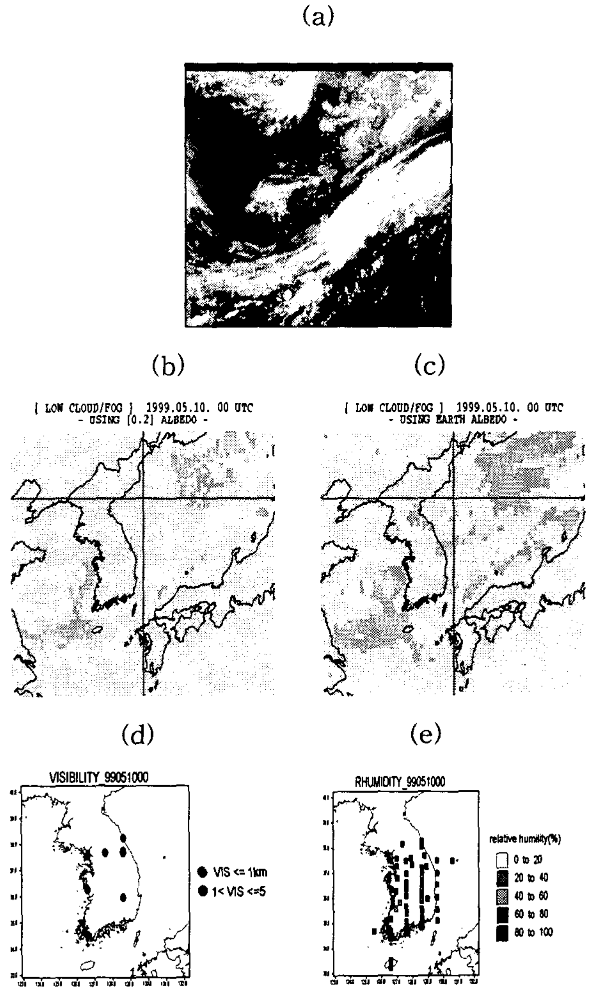

Fig. 6. (a)Composite image, (b)visible accumulat-ed histogram image, (c)surface albedo image, (d)visibility and (e)relative humility at 00UTC, 10 May, 1999.

Fog detection during nighttime using infrared accumulated histogram method(Tokuno method, 1996) and maximum bright temperature was a little bit unstable. Comparing with NOAA DCD image, which proved stable by many experiment, that detected boundaries of fog area located in western-southern costal area of korean peninsular(Fig. 7(b) and inland fog, while this don't take fog area at all(Fig. 7(a)).

As a result, infrared accumulated method(Tokuno method) using GMS-5 data was not appropriate to area surrounded with korean peninsular. And maximum brightness temperature method will be needed some complement in detecting fog/Stratus because low level cloud was detected as fog.

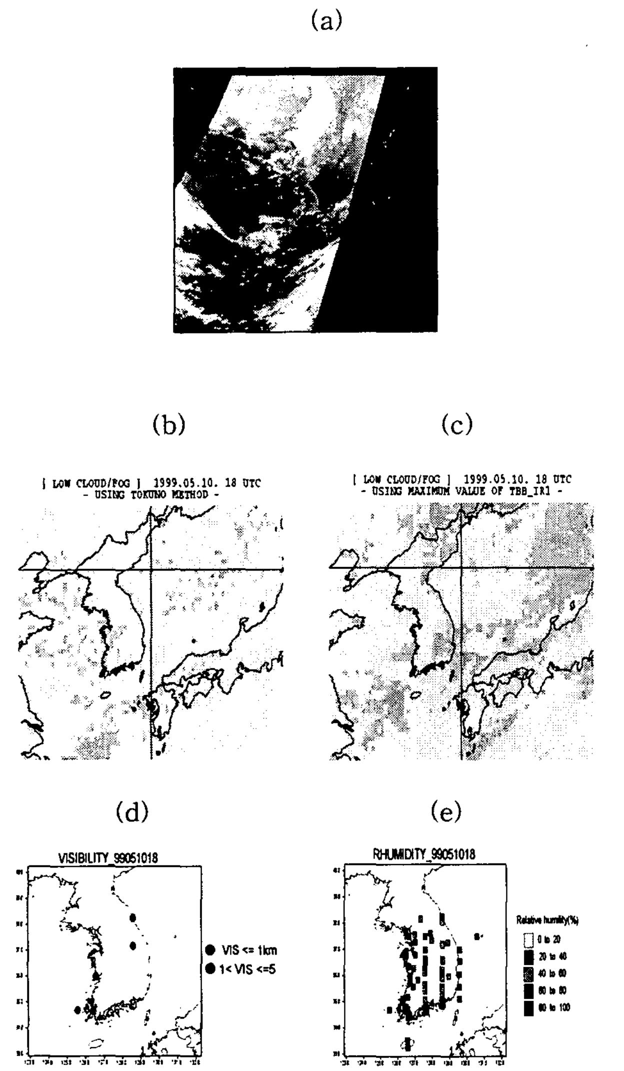

Fig. 7. (a)Composite image, (b)visible accumulat -ed histogram difference image, (c)surface albedo image, (d)visibility and (e)relative humility at 18UTC, 10 May, 1999.

Kunsan, Huksando, west-southern region of korea, had low visibility, most of inland area also had high relative humidity. Truth that western part of korean peninsula was occupied much more than eastern part by fog area, agreed well with image of fog detection using maximum brightness temperature method.

Discussion

Sea fog detection using GMS-5 data is conducted in many methods, as above described.

During daylight hours, sea fog is detected quite precisely using visible accumulated method and surface abeldo. During nighttime, while infrared accumulated histogram method, Tokuno method don't deduce characteristic value for fog detection, maximum brightness temperature method catch specific threshold for fog detection although it include some low-level cloud.

In future, we will study many case days and apply above mentioned methods, especially maximum brightness temperature for nighttime fog which needs low-level cloud removal and explanation and experiment about specific threshold. We will continue to study the sea fog detection using a new satellite, MTSAT.

Acknowledgement

This is supported by '99 basic project of Meteorological Research Institute, "sea fog detection using GMS-5 data"

Reference

김영화, 김진철, 김금란, 이희훈, 이미자, 1997 : NOAA/AVHRR 적외차 자료를 이용한 야간 안개 및 하층운 탐지, J. Atmosheric. Research. 14(1), 15-19

Ellord, G. P., 1995: Advances in the detection and analysis of fog at night using GOES multispectral infrared imagery. Wea.Forecasting, 10, 606-619.

Eyre. JR; Brownscombe, JL and Allam, RJ(1984): Detection of fog at night using Advanced Very High Resolution Radiometer (AVHRR) imagery. Meteorological Magazine 113, 266-271.

Hunt, G. E., 1973 : Radiative properties of terrestrial clouds at visible and infrared thermal window wavelengths. *Quart. J. Royal Meteor. Soc.*, 99, 346-369.

McClain, E.P. et al.1983: Multi-channel improvements to satellite temperatures. Adv. Space Res. 2, 43-47.

Scorer, R. S. (1986): Cloud investigation by satellite. Ellis Horwood Limited, Chichester

Tokunȯ, M and R. Kumabe, 1996 : Satellite Nephanalysis Information Chart(SNIC), *氣象 衛星センタ - 技術報告特別号*, 119-138