Satellite monitoring of large-scale air pollution in East Asia

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Abstract: The detection of sandstorms and industrial pollutants has been the emphasis of this study. Data obtained from meteorological satellites, NOAA and GMS, have been used for detailed analysis. MODIS and Landsat images are also used for the application of future KOMPSAT-2. Verification of satellite observations has been made with air pollution data obtained by ground-level monitors. It was found that satellite measurements agree well with concentrations and variations of air pollutants measured on the ground, and that satellite technique is a very useful device for monitoring large-scale air pollution in East Asia. The quantitative analysis of satellite image data on air pollution is the goal in the future studies.

Keywords: Satellite monitoring, air pollution detection, sandstorms, the Yellow Sea, NOAA-N satellites

1. Introduction

The successful launch of Russian Sputnik in 1957 was a revolutionary tool for data imagery enhancement, enabling closer observations of clouds and weather systems to be made. A million photographs taken at the ground cannot replace one valuable image from a satellite. Satellite image data has allowed for the monitoring of large-scale air pollution including a hazy layer, forest-fire smoke plume, dust-storm, volcanic emission, industrial emission, acid fog and the list goes on [1;2;3;4;5].

East Asia has become the third industrial region of the world, and emission from human and industrial activities is ever increasing. Satellite technology is useful for monitoring the large-scale air pollution in the Yellow Sea region. It is planned that KOMSAT-2 of Korea will be launched in late 2004, and an application will be made for the monitoring of local air pollution. For the purpose of the present paper was to used to detect wide-spread air pollution around the Korean Peninsula.

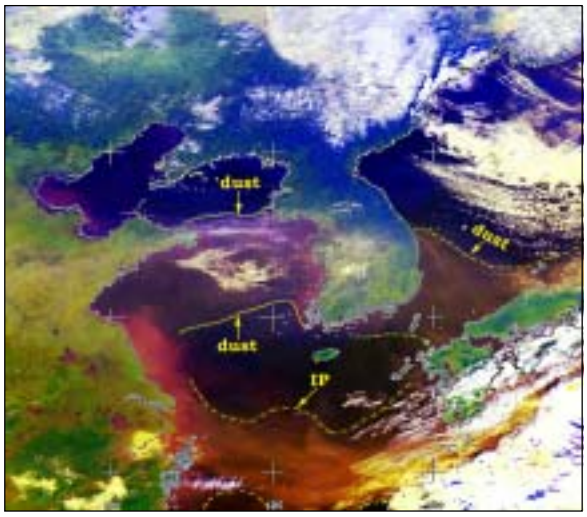

Fig. 1. Satellite (NOAA-17; 1120LST, 12 Nov. 2002) image showing an elongated duststorm from the west of Beijing via the Shantung Peninsula and the Yellow Sea to south Korea and the Korea East Sea. Also, a continental plume of anthropogenic origin (IP) is visible near Shanghai to southwest Japan.

2. Observations

Fig. 1 shows satellite (NOAA-17; 11:20 LST, 12 Nov. 2002) detection of air pollutants over the Yellow Sea – Korea - Korea East Sea and over the East China Sea. An elongated dust plume moved from the Gobi Desert in Mongolia and N China, creating heavy dust-fall on 11 November over north Korea. Meanwhile, another elongated plume from near Shanghai to the south of Kyushu, in Japan, was flowing out of S China. This plume was of industrial origin.

Fig. 2 shows a MODIS (Terra) image on the same day. This image also identified two giant plumes: one over the south of Shantung Peninsula - the Yellow Sea-south Korea; the second plume over the East China Sea. Our GMS images (not included here) also showed two elongated plumes with lesser distinction.

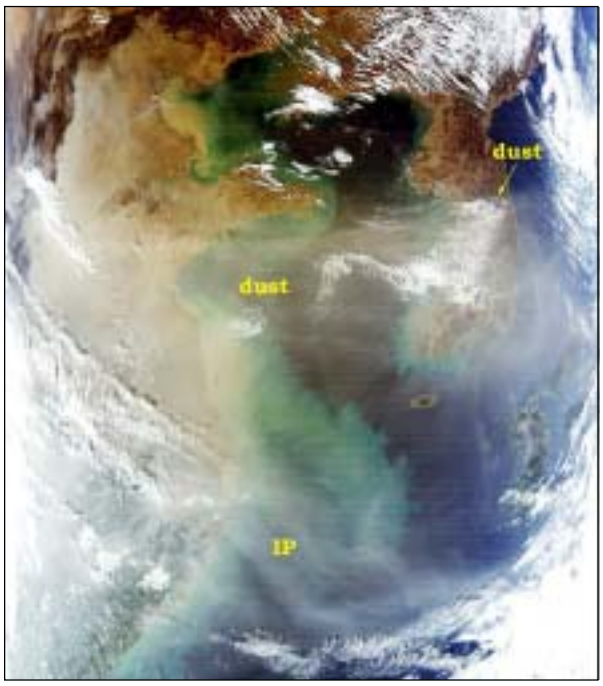

Fig. 2. Same as Fig. 1, but for a MODIS image (12 Dec. 2002).

Fig. 3 illustrates air pollution data measured at Chongwon in central Korea. With the sandstorm approach, the values of dust particles (PM10 and PM2.5) increased rapidly from 19:20 LST, 11 November, and visibility was significantly reduced. At 22:00 LST, PM10 concentrations were increased to a maximum, 1200 ug/m3. Maximum concentrations of SO_2, CO, O_3 also occurred at around 20:00 LST with the sandstorm arrival on 11 November. According to satellite images taken on 10 November, the industrial plume from China was over the Korean Peninsula. Fig. 3 shows supporting evidence on an air pollution episode over Chongwon on 10 October, and high values of SO_2, CO and O_3 were recorded during the same day.

Fig. 4 shows another case of air pollution over the Yellow Sea and highlights how it was spreading over the Korean Peninsula and adjacent seas. Fig. 4a is a NOAA-17 image at 11:28 LST, 14 September 2003, while Fig. 4b is obtained by NOAA-16 at 13:43 LST, 16 September 2003. A magenta colour in the image indicated air pollution plumes and mass [4]. Both images clearly show extensive air-pollution masses over the Yellow Sea, East China Sea and Korea.

On 12 September 2003, a typhoon swept and passed through SE Korea, and it was observed that concentrations of each air pollutant were at their minimum and at their background level. However, the

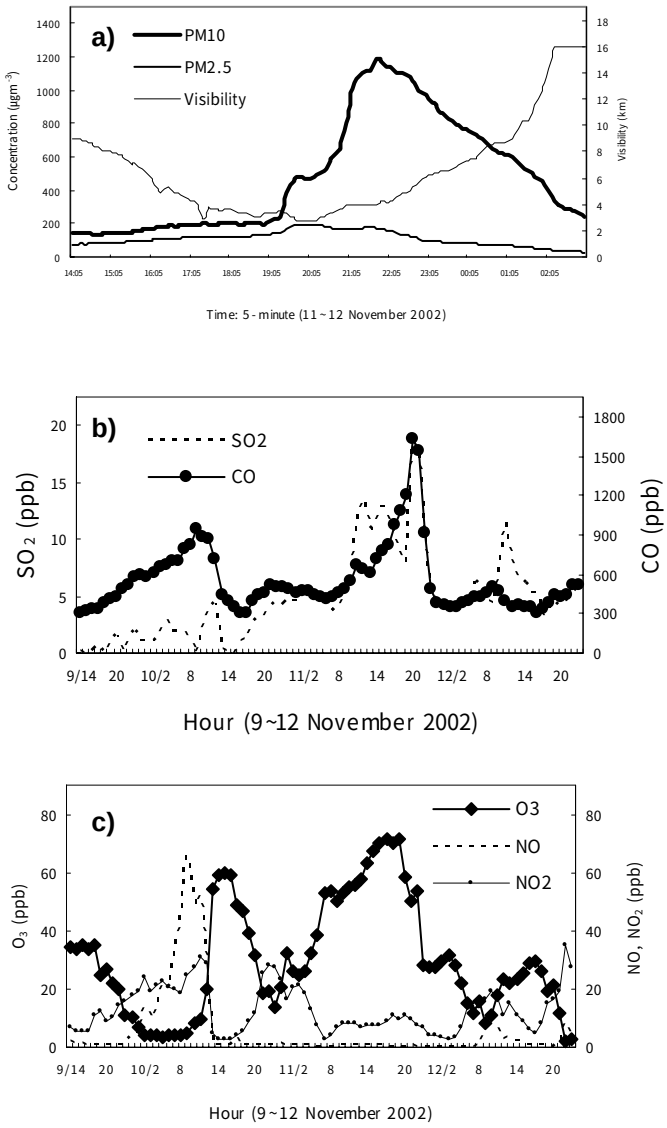

Fig. 3 a) Variations of 5-minute mean values of PM10 and PM2.5 (μgm^{-3}) with visibility (km) observed in Chongwon-Chongju, Korea during the event of a sandstorm and associated dustfall on 11 and 12 November 2002.

b) Variations of hourly mean values of SO_2 and CO (ppb) observed in Chongwon-Chongju, Korea from 9 to 12 November 2002.

c) Variations of hourly mean values of photochemical oxidants (O_3, NO and NO_2 in ppb) observed in Chongwon-Chongju, Korea from 9 to 12 November 2002.

levels of air pollutant increased from the afternoon of 14 September, with the arrival of massive plumes from the Yellow Sea. Maximum concentrations of each pollutant occurred on 14, 15 and 16 September as shown in Fig. 5. In particular, concentrations of CO, PM10 and PM2.5 were ever increasing (Table 1).

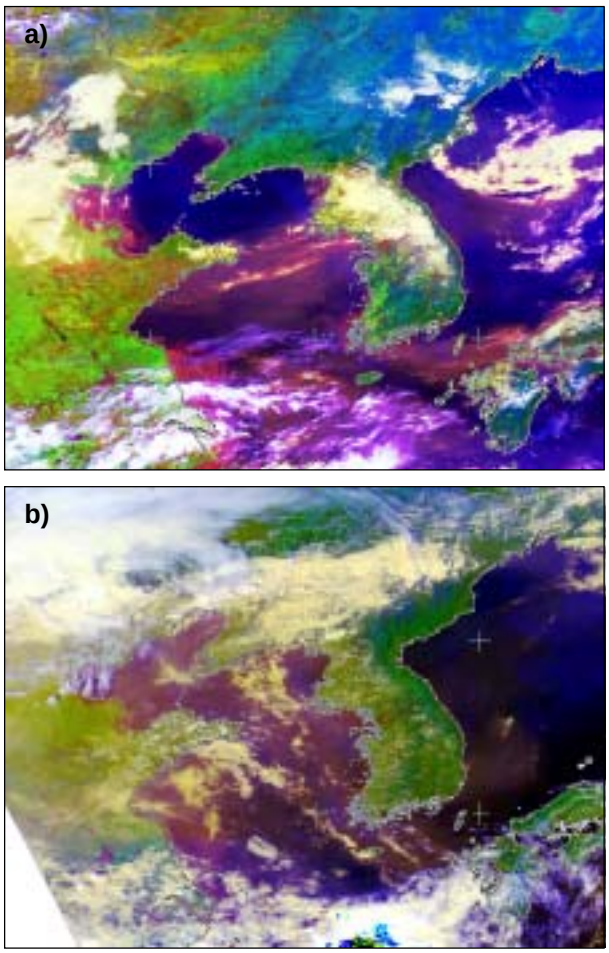

Fig. 4. Satellite images showing extensive air pollution over the Yellow Sea, East China Sea and Korea: a) NOAA-17, 14LST, 14 Sept. 2003; b) NOAA-16, 13LST, 16 Sept. 2003.

Table 1. Daily concentrations of air pollution measured in Chongwon-Chongju, central Korea.

Date	PM10 (μgm^{-3})		PM2.5 (μgm^{-3})		CO (ppb)		SO_2 (ppb)		O_3 (ppb)		NO (ppb)		NO_2 (ppb)	
	Mean	Max.	Mean	Max.	Mean	Max.	Mean	Max.	Mean	Max.	Mean	Max.	Mean	Max.
13 Sep.	21	43	12	29	223	335	0	1	30	37	0	1	3	6
14 Sep.	51	79	40	62	331	391	2	5	37	62	0	1	5	17
15 Sep.	80	110	64	94	538	950	1	3	23	73	3	14	16	28
16 Sep.	85	122	68	104	626	812	2	10	25	66	2	10	15	26
17 Sep.	72	116	55	98	555	756	1	5	17	57	7	47	20	38
18 Sep.	39	78	29	58	453	612	1	2	13	27	3	12	14	28

3. Landsat image and application

Landsat data contained 8 channels and horizontal resolution were 30 ~ 60 m. Fig. 6 depicts Landsat image over the Pohaang area in SE Korea. In the

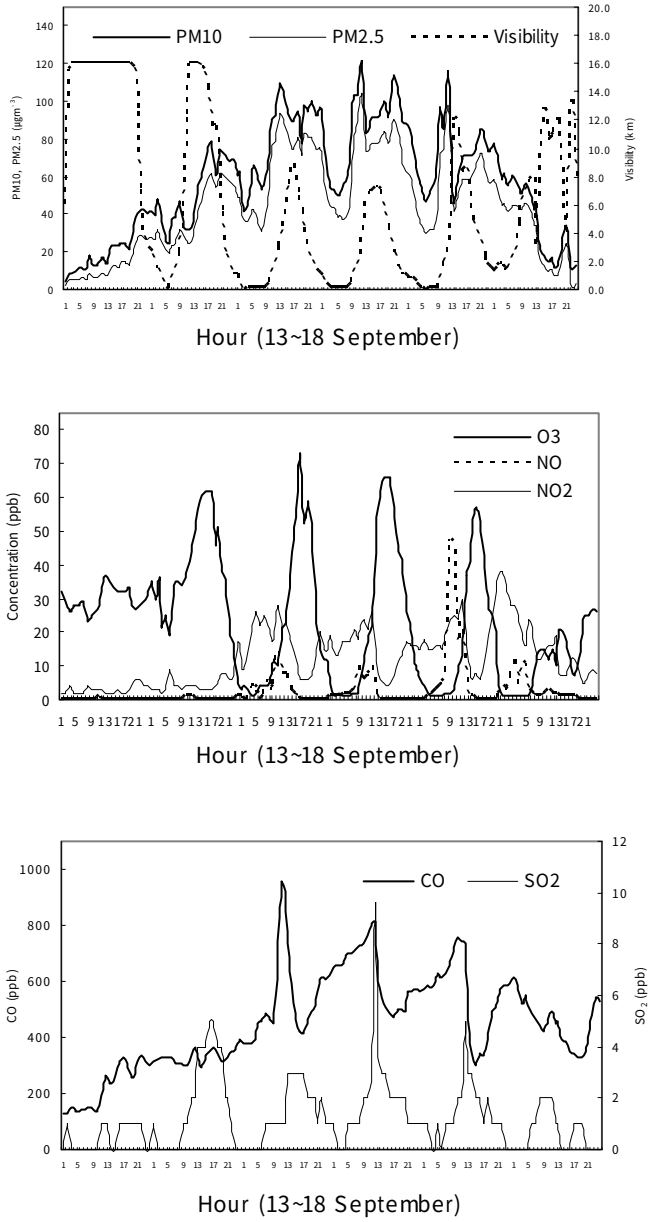

Fig. 5. Air pollution measurements at Chongwon, central Korea during 13-16 September 2003.

image, detailed vortices and flow patterns are visible. Smoke plumes were associated with the meso-scale flows. Smoke plumes over 30 m can be detected clearly with Landsat data.

In the later part of 2004, it is planned that KOMPSAT-2 (K-2) will be launched. The resolution of K-2 is 1 m. It is anticipated that smoke plumes from a tall stack chimney will be detected and that local air pollution will be monitored by K-2 commencing from 2005. This data will be in addition to our monitoring of large-scale air pollution by NOAA-N and MTSAT (GMS).

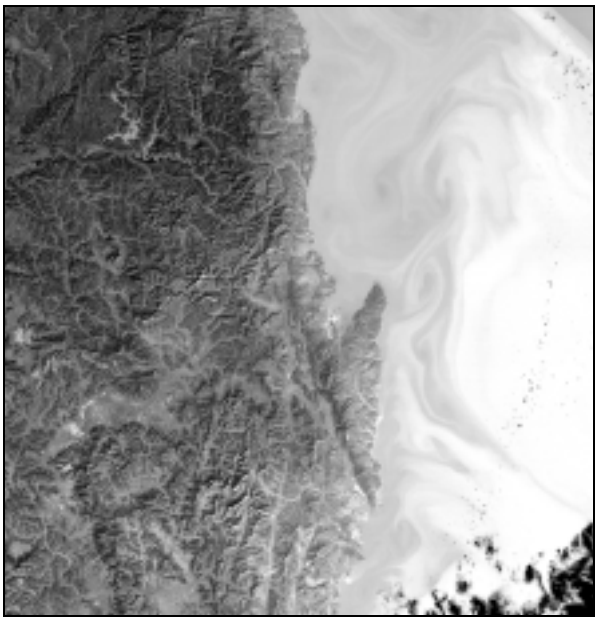

Fig. 6. Landsat image (channel 6-1) showing the Pohaang area in SE Korea (9 Nov. 2000).

4. Summary and conclusions

Monitoring of air pollution by satellites in the Yellow Sea region is carried out and discussed. We have received data directly from NOAA-N and GMS satellites for daily analysis. In addition, data obtained from MODIS and Landsat are also utilized. Landsat data is useful in studying local air pollution. It is anticipated that KOMPSAT-2 will be valuable in monitoring local emission, including a tall-stack plume.

On the other hand, the NOAA and GMS (MTSAT) already serve as useful tools in monitoring the large-scale air pollution. Our ground measurements of air pollution are also useful for indirect quantification of atmospheric loadings.

Acknowledgement

We thank to the Korea Ministry of Science and Technology for science subvention. Dr Chi KH was also helpful.

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