Numerical Prediction on Snowfall Intensity in the Mountainous Coastal Region

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The formation of a severe snow storm occurred in the mountainous coastal region near Mt. Taegualyang and Kangnung city in the eastern part of Korea was investigate from 0900LST, December 7 through 9, 2002, using MM5 model. As synoptic scale easterly wind induced a great amount of moisture from the East Sea into the inland coastal region and sea-breeze further induced more moisture from the basin toward the top of the mountain side. The lifted moisture toward the mountain top was cooled down along the eastern slope of the mountain and near the mid of the mountain, the moisture was much cooled down with relative humidity of 100% under the air temperature below 0^0C, resulting in the formation of snow. Relative humidity of 100% generally occurred at the 5km away from the coast toward the inland mountain and the band of 100% RH was parallel to the coastal line. The 100% band coincided with minimum air temperature band and line

Key words: Snowfall intensity, MM5 model, Convective boundary, Internal gravity waves, Nocturnal surface inversion layer

1. Introduction

The driving mechanisms on snowfall and rainfall are basically similar, but the prediction of snowfall is quite different from one of rainfall. Is generally due to the reason how much cooling is necessary to make for the formation of snowfall[(1)]. In the recent years, frequent snowfalls have taken in the mountainous coastal area in Korea. In the coastal sites, we classified three categories such as category 1-the positions of high pressure system in the north China and low pressure system in the south sea of Korea, category 2-the passage of trough in the behind region of high pressure through the eastern coastal sea and category 3-the influence of strong easterly wind from the East Sea.

In this study, the case of category 3 was investigated in detail using MM5 numerical model.

2. Numerical methods and data

The case study of snowfall in the mountainous coastal region had been undertaken from 0000UTC December 6, 2002 through 1200UTC December 9, 2002. The numerical model used was MM5 V3.5 and NCEP data was inserted as initial input data for the model. During the period, horizontal, vertical wind and air temperature fields, 3 hours accumulated snowfall amount, mixing ratio inside snow, relative humidity and sensible and latent heat fluxes in order to understand the driving mechanism of snowfall.

During the snowfall, special attentions were given to relative humidity, mixing ratio and sensible heat flux. In the numerical process, a triple nesting were made with grid numbers of 125x105 with horizontal 27km interval and vertical grid number of 23 in the coarse domain and in the second domain, grid number of 82x82 with 9km interval and in the third domain, grid number 61x61 with 3km interval. 9km. 2.50 degree interval terrain date was used for the largest domain and then the 0.9km interval data was used for fine mesh domain. MRF method was adopted as boundary layer process in the planetary boundary layer, simple ice method for the prediction was also considered. When we have snowfall, we also simultaneously have rainfall and 3 hours accumulated snowfall was treated as the summation of ice and water.

A three-dimensional non-hydrostatic grid point

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model of MM5 in a terrain following coordinate system[19], was adopted for 4 days numerical simulation on meteorological phenomena from 0900 LST, December 6 to 0900 LST, December 9, 2002 by PC Pentium 4 with one-way triple nesting at Kangnung National University[11]. There were 22 levels in the vertical spread from 10 m to 10 km with sequentially larger intervals between levels with increasing altitude. As meteorological input data for MM5 model, ENCP data was used .

3. Results and Discussion

During the snowfall period from 1200LST December 7 to 1800LST, December 8, the type of high pressure system in the north and low pressure system in the south influenced the whole Korean peninsula and under the such pressure system, north-easterly wind and easterly wind prevail near the Kangnung city in the eastern mountainous coastal region. The easterly wind could induce a lot of amount of moisture from the East Sea toward Kangnung city and then the induced moisture further went to the top of mountain, called Taegulyung of 868m height. The uprising moisture should be cooled down and saturated, resulting in snowfall.

The snowfall band was in the coincided area of minimum sensible heat flux band and its negative value area. Similarly to the latent heat, the snowfall band was detected in the area of minimum value of latent heat flux. Simultaneously, the snowfall band directly coincides the area of relative humidity of 100%. After the saturated water vapors forms a great low cloud near the right side of the mountain top under westerly wind, it falls down below 0^{0}C air temperature, resulting in the formation of snow. As it falls down toward the ground over 0^{0}C air temperature, it becomes rain. When cloud is developed along the eastern slope of the mountain and goes down toward Kangnung city and remains over the city, snowfall occurs in the Kangnung city area. As the cloud of ice phase closes to the ground surface of the city, the phase of snow was changed into the phase of rain. However, when the distance between the cloud base and the ground is very close, snow phase still remains rain phase, the distance is far, snow phase was changed into rain phase.

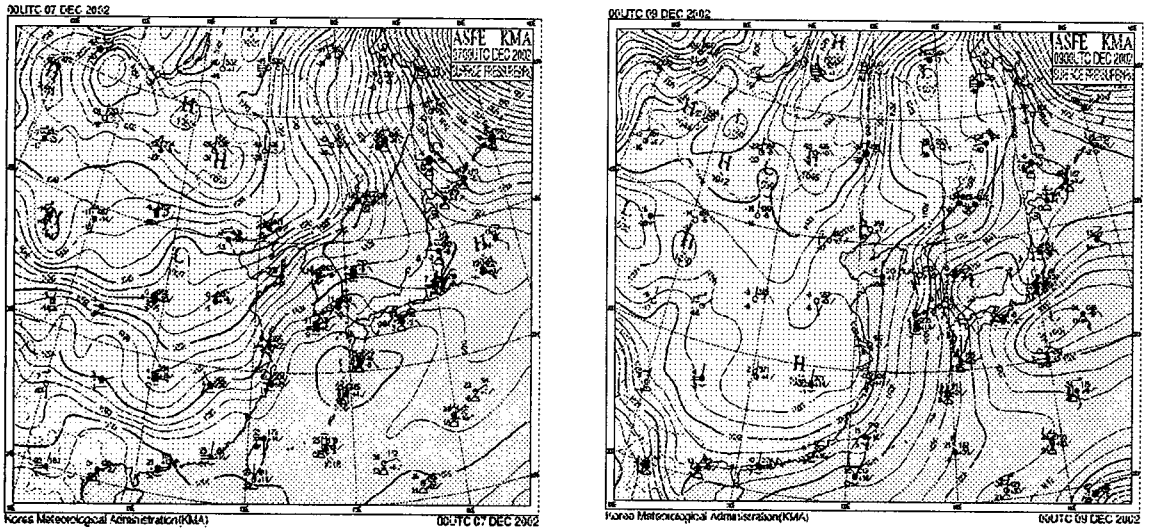

Fig. 1. Surface weather map at 0900LST December 7, 2002 and 0900LST, December 9, 2002.

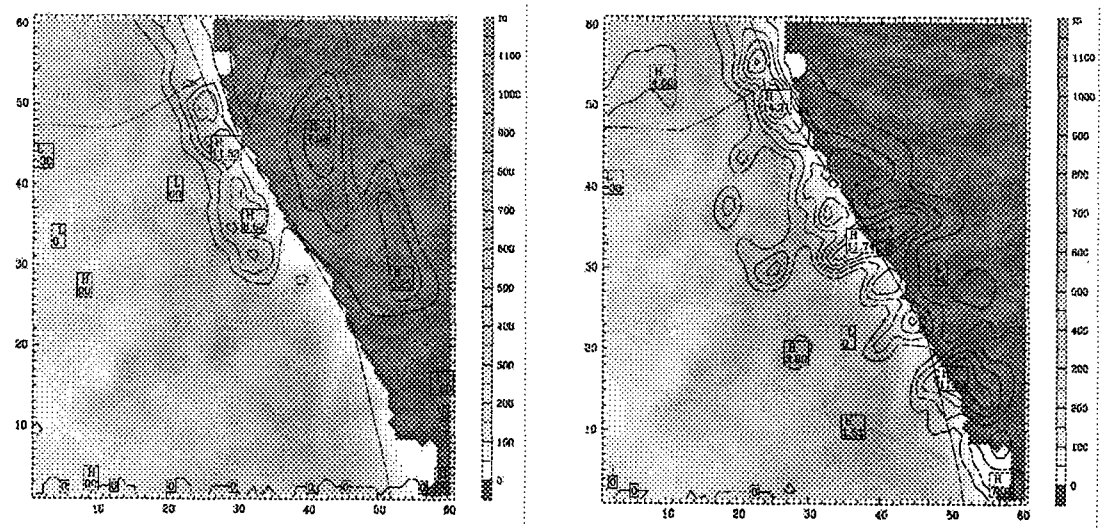

Fig. 2. Total rainfall amount (mm) in past 3 hours near Kangnung coastal region at 1200LST, December 7 and 1800LST, December 8, 2002.

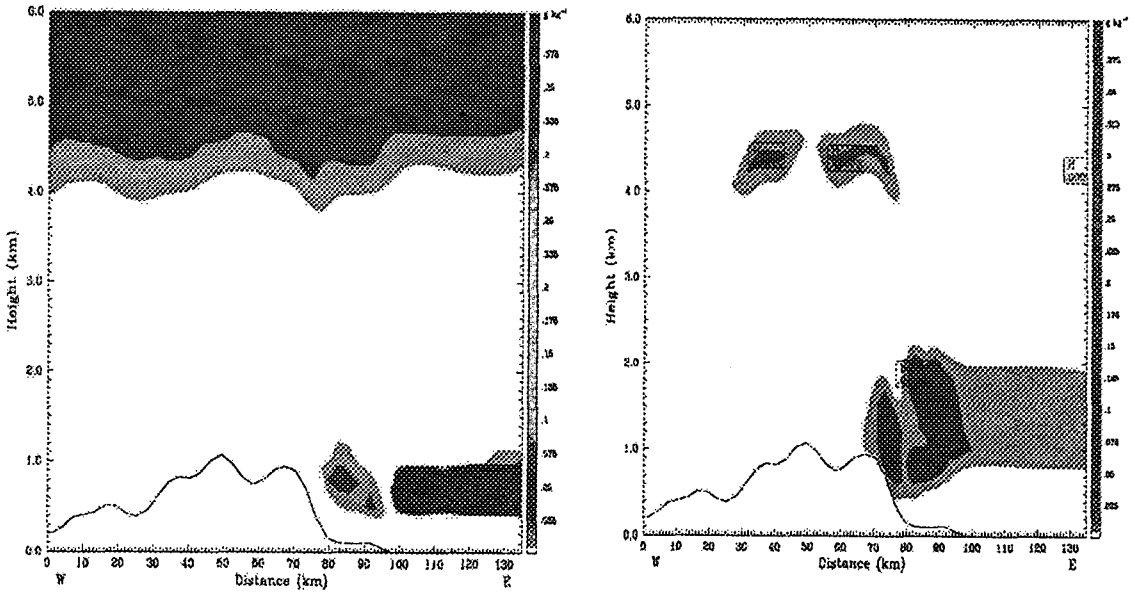

Fig. 3. Total cloud mixing ratio (g/kg) near Kangnung coastal region at 0600LST, December 7 and 1800LST, December 7, 2002.

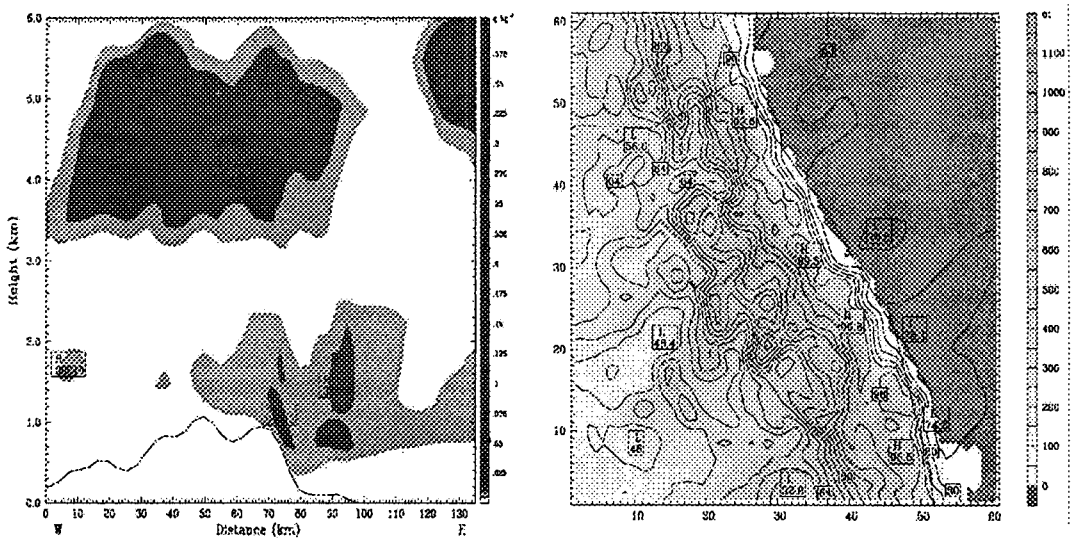

Fig. 4. Total cloud mixing ratio (g/kg) and relative humidity (%) near Kangnung coastal region at 1200LST, December 8 and 1800LST, December 8, 2002.

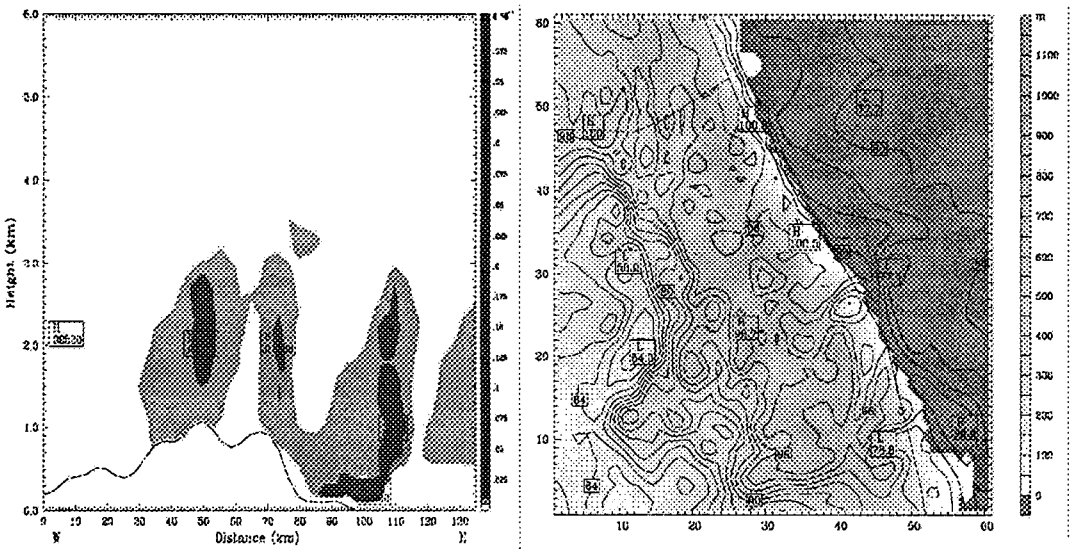

Fig. 5. Total cloud mixing ratio (g/kg) and relative humidity (%) near Kangnung coastal region at 1800LST December 8, 2002.

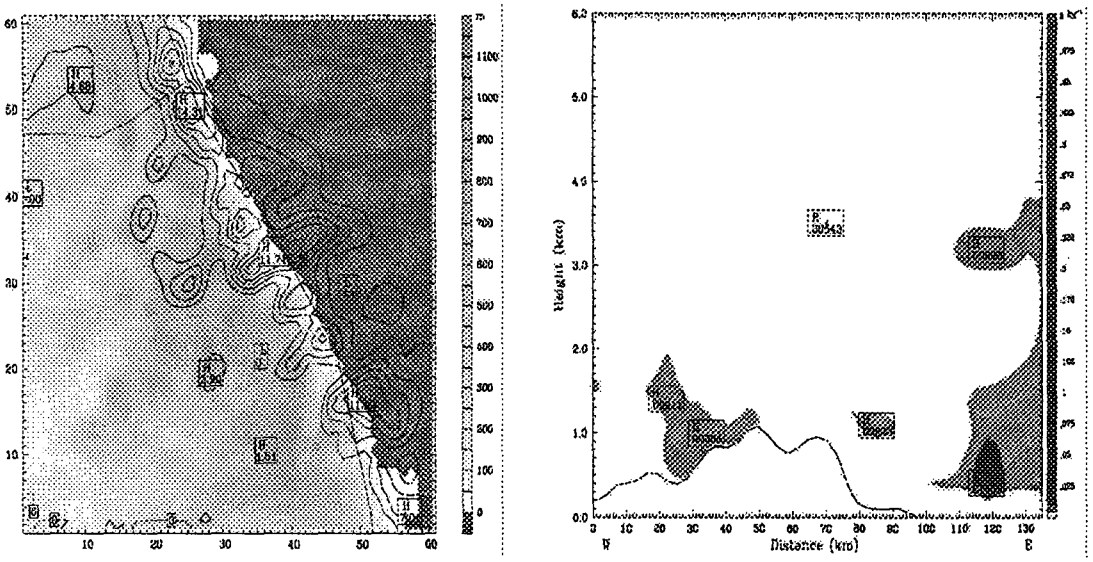

Fig. 6. Total rainfall amount (mm) and total cloud mixing ratio (g/kg) near Kangnung coastal region at 1800LST December 8, 2002 and 0000LST December 9, 2002.

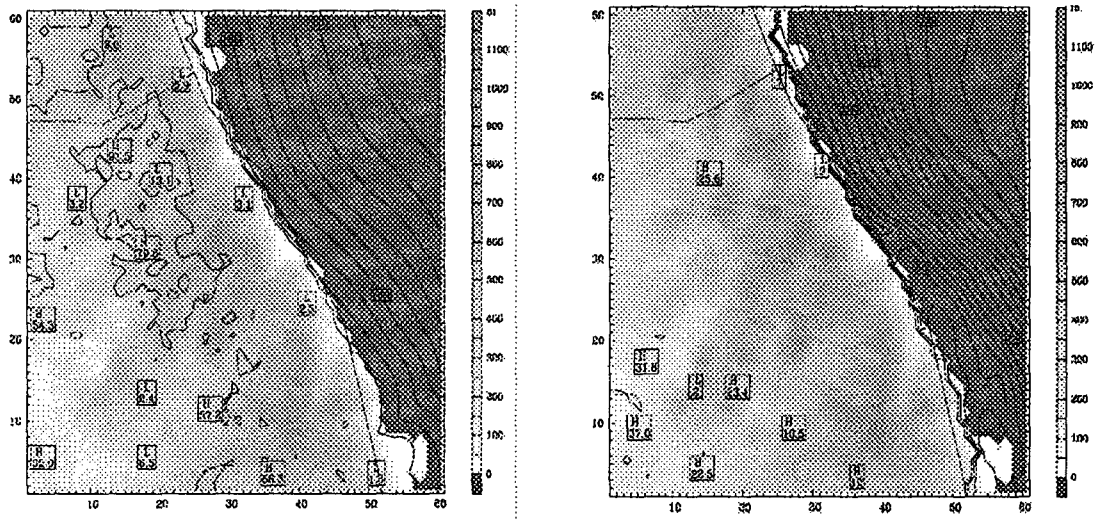

Fig. 7. Latent heat flux (W/m2) near Kangnung coastal region at 1200LST, December 7 and 1800LST, December 8, 2002.

From 2100LST December, the wind direction was changed from easterly to north-westerly. Under the north-westerly wind, it was very difficult to expect the intrusion of moisture from the East Sea. Even if north-westerly wind coming from northern China made air parcels be

cooled down, air parcels with a small amount moisture could not be saturated, resulting in no existence of snowfall in the coastal region (Fig. 1, 2 and 3).

4. Conclusions

During the snowfall period, north-easterly wind and easterly wind prevail in the eastern mountainous coastal region and this wind could induce moisture from the East Sea-coastal area toward the top of mountain in the west. The uplifted moisture should be cooled down and saturated, under westerly cool air masses, resulting in the formation of ice and rain particles inside low cloud.

Snowfall band coincided minimum sensible heat flux band or negative value area. It is similar to latent heat flux band, where snowfall occurred. Snowfall band directly coincided the area of relative humidity of 100%. Below 0^{0}C air temperature, water droplet of cloud can form ice phase like snow, as low cloud moved down toward the ground surface of coastal area in the east. As low cloud closed the ground surface, snow phase was changed into rain phase under higher air temperature over than 0^{0}C. However, if the distance is too close between cloud base and the ground surface, snow phase still remains rain phase, showing snowfall in the coastal basin..

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