THE USE OF QUICKSCAT WIND TO ESTIMATE THE VERTICAL VELOCITY IN TYPHOON AND SNOWSTORM

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ABSTRACT:

This study examines moisture supplement from the warm ocean in snowfalls of two cases and heavy rainfall of Typhoon case. The QuickSCAT wind is used to evaluate the convergence of moisture fluxes in the storms from the sea in estimation of the amount of heavy snowstorm and rainfall. The results show that enough water vapor transport from ocean to atmosphere induced the severe storms, because strong QuickSCAT-derived vertical velocity nearly concurred with heavy snowfall and rainfall. In the present study, we attempted to show that QuickSCAT wind can be used to forecast the severe weather events, such as heavy snowfall and rainfalls.

KEY WORDS: Manuscripts QuickSCAT wind, vertical velocity

1. INTRODUCTION

Torrential rainfall and snowfall have frequently occurred with severe storms in recent years over the coastal zone in the Korean Peninsula. In general, moisture transport from the ocean leads to severe weather events with topography over that region. However, little information over the ocean can be obtained in regions not covered by either sufficient ship observations or buoy data. Additionally, despite the important information obtained from radar data on rainfall and snowfall, it is difficult to detect the strong echo of heavy snowstorm and rainfall. Therefore, the QuickSCAT wind is used to evaluate the convergence of moisture fluxes in the storms from the sea in order to estimate the amount of heavy snowstorm and rainfall. The vertical velocity produced by the QuickSCAT wind is calculated by the kinematic method, which is based on integrating of the continuity equation in the lower atmosphere (Holton, 2004). In this study, cases of two snowstorms on 2 Mar and 5 Mar 2005, and Rusa of the 15th Typhoon in 2002 are examined. Data sets and methods used in this study are described in section 2 and section 3. Results are shown in section 4. Summary and discussions are given in section 5.

2. DATA

2.1 QuickSCAT wind

The microwave scatterometer seawinds was launched on the QuikBird satellite in June 1999. It is referred to this instrument as QuikSCAT. The primary mission of these seawinds scatterometers is to measure winds near the ocean surface. Sea winds scatterometers are essentially radars that transmit microwave pulses down to the Earth's surface and then measure the power that is scattered back to the instrument. This "backscattered" power is related to surface roughness. For water surfaces, the surface roughness is highly correlated with the near-surface wind speed and direction. Hence, wind speed and direction at a height of 10 meters over the ocean surface are retrieved from measurements of the scatterometer's backscattered power. Wind speed is measured from 3 to 20 meters/second with an accuracy of 2 meters/second, wind direction has an accuracy of 20 degrees and resolution is 25 kilometers.

2.2 Ground-based observation data

For comparison purpose, the 76 synoptic stations over the Korean Peninsula is used as the amount of synoptic rainfall and snowfall.

2.3 Model data

The RDAPS based on the PSU/NCAR MM5 has run as the operational model twice a day, 00UTC and 12UTC since June 1999 and has analyzed by 3-D optimal interpolation method since November 2002. The RDAPS is triply nested-grid model with horizontal grid resolution of 30km, 10km and 5km, and has vertically 33 layers. The RDAPS of 30km is analyzed by 3-D optimal interpolation method, and uses FDDA during 12 hours for reducing initial problem of model. The vertical velocity is calculated by the momentum equation for the non-hydrostatic model.

3. SATELLITE-DERIVED ESTIMATION OF VERTICAL MOTION

The first step in using the QuickSCAT wind to derive vertical velocity involves the upward transformation of the 1000hPa wind (100m height at standard atmosphere) from the QuickSCAT 10m wind, flux-profile relationships based on Monin–Obukhov surface layer theory can be used. This process follows the approach described in de Rooy and Kok (2004) with a few modifications. We assume neutral condition and m of roughness length that is intermediate value between the 10-4 m of open sea and 10-3 m of coastal zone (Stull, 1988). For the transformation from 10 to 100 m, this can be written as follows:

$$u_{100m} = u_{10m} \frac{\ln(100m/z_0)}{\ln(10m/z_0)} \quad (1)$$

u_{10m} is the wind speed at 10 m; z_0 is the roughness length.

The second step is integrating the continuity equation in the low atmosphere to obtain an estimate of vertical velocity (omega) using the divergence of trans-formed 1000hPa wind. That is known as the kinematic method, because it makes use of the motion field only, but not the dynamical equstion.

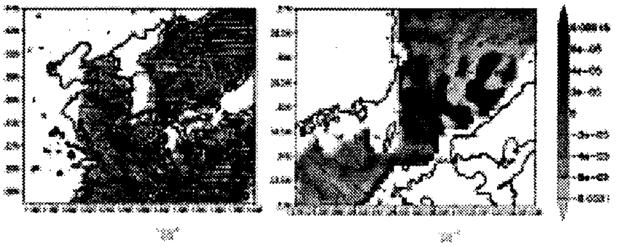
$$\omega(p) = \omega(p_s) - \int_{p_s}^{p} \left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) dp \quad (2)$$

4. RESULT

4.1 Case 1: 5 March 2005, snowstorm

Figure 1 shows the QuickSCAT wind, convergence and estimated omega. A north-easterlies accompanied with anticyclonic vorticity over the northern part of East Sea are distributed over the East Coast (Figure 1a). Additionally, the strong horizontal convergence zone due to speed convergence and weak directional convergence is extended to east from Busan (Figure 1b). The convergence is formed from the effect of confluence between north-easteries and westerlies. As shown in figure 1(a) and (c), in definition, vertical velocity coincides with convergence zone over the East Coast, the south of East sea and a portion of the south of West sea. Heavy snowfall is observed over those regions in in-situ observation data (Figure 4d).

(a) (b)



(c) (d)

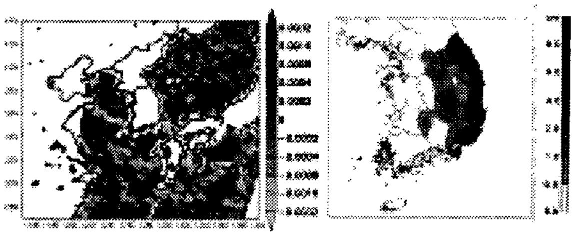


Figure 1 QuickSCAT wind and calculated convergence (a) around the Korean Peninsula, (b) over the southeast part of the Korean Peninsula. (c) the QuickSCAT-derived vertical velocity at evening pass 5 March 2005. (d) 3hourly accumulated snowfall during the period from 09UTC to 12UTC March 2005.

For comparison purposes, Figure 2(a) shows RDAPS omega, and Figure 2(b) shows omega estimated with RDAPS u, v wind components. RDAPS omega is extended to east from Busan as well as QuickSCAT-estimated omega and distributed over the middle part of East Sea. However, the difference between the RDAPS omega and the QuickSCAT-estimated omega is that RDAPS result shows only a weak vertical velocity over a portion of the middle of the Yellow Sea because there is no directional convergence such as QuickSCAT wind. Since the directional convergence is in general tightly linked to wind direction, the different pattern of RDAPS wind direction in comparison with QuickSCAT reveals the reason of different convergence pattern (Figure 2c).

(a) (b) (c)

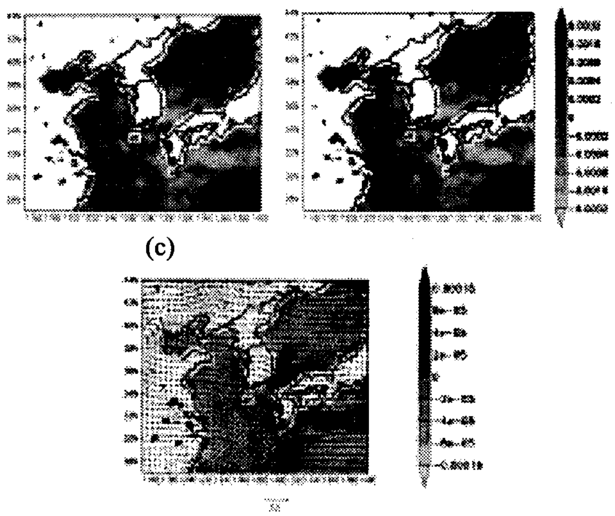


Figure 2 (a) RDAPS omega, (b) omega estimated with RDAPS u, v wind components and (c) RDAPS wind and calculated convergence at 12UTC 5 March 2005.

4.2 Case 2: 2 March 2005, snowstorm

The snowstorms in this case recorded a maximum snowfall in the Central Region during the period from 18UTC 2 March to 21 UTC 2 March (Figure 3a). Figure

3(b) shows the QuickSCAT wind and convergence at morning pass (about 22UTC) 2 March. A north-westerly is dominant over the Yellow Sea, and small convergence zones are shown near the Tae-an Peninsula, extending into the Yellow Sea. However, the convergence zone is not sufficient to make vertical velocity for formation of heavy snowfall because that is too small. Figure 3(c) shows QuickSCAT wind and convergence over the Yellow Sea at evening pass (about 09UTC) 1 March that is 9 hours before the recorded time of maximum snowfall. The convergence zones co-exist over the center of the Yellow Sea and the region extended from north to south along the middle of the West Coast. Therefore, moisture could be provided enough to make snowstorm before the heavy snowfall.

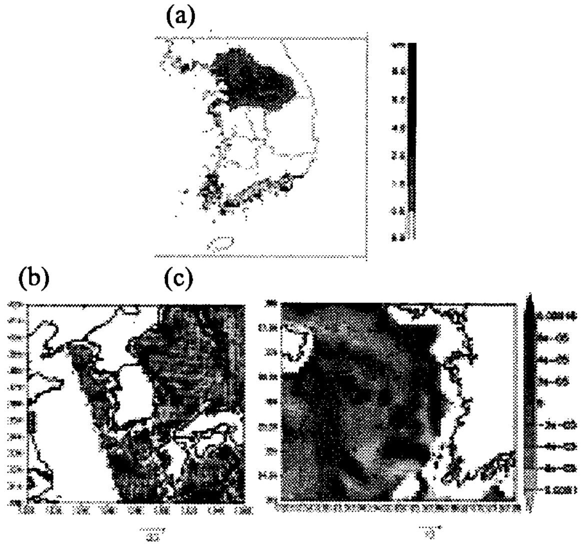


Figure 3 (a) Distribution of 3hourly accumulated snowfall from 18UTC 2 March to 21 UTC 2 March. (b) QuickSCAT wind and calculated convergence at morning pass 2 March around the Korean Peninsula. (c) at evening pass 1 March over the Yellow Sea.

4.3 Case 3 : 31 August 2005, Typhoon Rusa

The center of Typhoon located at the ocean 150km away from Jeju Island, descending air current and the spiral structure characteristics of the typhoon are shown in Figure 4a. The typhoon has a direct influence on the Korean Peninsula, and large convergence zone and vertical velocity are found along the East Coast and South Coast (Figure 4b) where heavy rainfall are observed (Figure 4c). Figure 4(d) shows omega estimated with RDAPS u, v components. That is quite similar to QuickSCAT in the spiral structure character-istics of the typhoon while that is not founded the structure of typhoon eye and eye wall. According to the comparison between QuickSCAT estimated omega in Figure 4(b) and RDAPS estimated omega in Figure 4(c), we can show that those have a little different pattern to each other because of the time lag of 2 hours between QuickSCAT observation time and RDAPS analysis time.

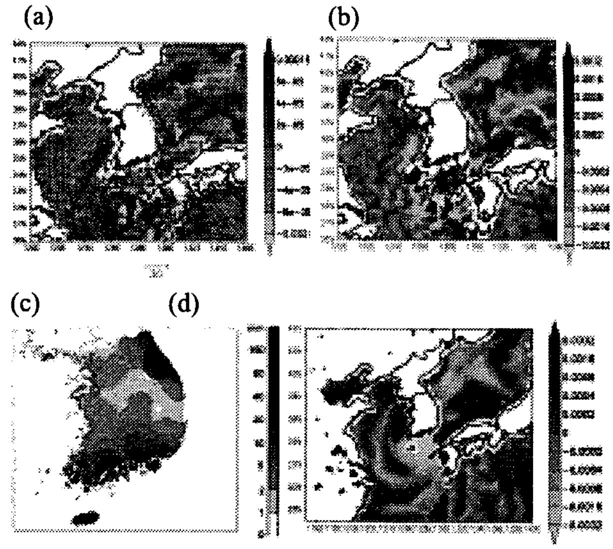


Figure 4 QuickSCAT wind and calculated convergence (a) around the Korean Peninsula (b) the QuickSCAT-derived vertical velocity at evening pass 5 March 2005, (c) 3hourly accumulated rainfall and (d) omega estimated with RDAPS u, v wind components at 00UTC 31 August 2002.

5. SUMMARY AND DISCUSSION

In this study, we assess the use of QuickSCAT-derived vertical velocity in snowstorms and typhoon. A useful concept in using the QuickSCAT wind is the kinematic method of integrating continuity equation. Based on our results, there is little difference between omega calculated by the non-hydrostatic momentum equation and omega estimated using the kinematic method.

In the present study, we attempted to show that QuickSCAT wind can be used for forecasting of the severe weather events, such as typhoon, heavy snowfall and rainfall by typhoon and severe storms. The QuickSCAT-estimated vertical velocity field shows that strong upward motions coincide with heavy snowfall and rainfall, or the upward motions have a lag of hours before the onset of heavy snowfall and rainfall. That supplies enough moisture from the ocean to make the severe storms.

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