Study on impact of SRTM based High-resolution Topography in Complex Coastal Area

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1. Introduction

An industrial complex specially located in coastal area seriously affect on air quality near residential area. Gwang-yang bay, where is the southern part of the Korean Peninsula, is one of the densely accumulated industrial areas. And air pollution over the area also increase with the density of industrial complex.

Since petrochemical industry occupied major part of the Gwang-yang bay complex, so air pollutants associated with photochemical reaction are mainly emitted over the area. Photochemical ozone which is one of the major species of air pollutants, is regulated by the environmental authority and its regulation values is 100ppbv per 1hour. However ozone concentration over the area often exceed the regulation value. For this reason exact estimation of ozone concentration is necessary to prevent air pollution problems.

Coastal area with complex terrain is often influenced by local wind such as land-sea breeze and mountain-valley wind. So air pollution over the area is also complicate because of complex wind system. Therefore, precise understanding of the impact of atmospheric circulation is important to predict the air quality in coastal area with complex terrain.

Although the Automatic Weather System, AWS and Air Quality Monitoring Station, AQMS is now in operating routinely, it is difficult to analyse air pollution precisely because the horizontal resolution of observation data is unsuitable for estimation. Not only observation but numerical sinuation is one of the good equipments to analyse atmospheric impact on the estimation of air pollution in the Gwang-yang bay.

Accuracy of atmospheric data is directly influenced on the estimation of air quality. So exact atmospheric information with high temporal and spatial resolution are required to predict precise air pollutants concentrations.

Spatial resolution of USGS provided data is 30 arc second data. However the 30 arc resolution is not adequate to use for simulation over very complicate topography like the Gwang-yang bay area. Thus in order to impact of accuracy of topographic data on atmospheric circulation, numerical simulation with high and low spatial resolution are carried out. The high resolution of topography data used in this study is produced from the Shuttle Radar Topography Mission, SRTM by NASA, and its interval is 3 arc second(~90m). And low resolution is USGS 30 arc second(~900m) data.

2. Methodology

2.1 SRTM data

The Shuttle Radar Topography Mission is a project between NASA (National Aeronautics and Space Administration) and NGA (National Geospatial-Intelligence Agency). This project set the goal to map the world in three-dimensions. SRTM used dual Spaceborne Imaging Radar (SIR-C) and dual X-band Synthetic Aperture Radar (X-SAR) as a baseline interferometer. This Two radars get two images at the same time. These images combined and made an one three-dimensions image. The NASA Space Shuttle Endeavour equipped with two radar went and came back for 11-22 February, 2000. SRTM collected data over 80% of the Earth's land surface between 60N and 56S latitude.

SRTM data mainly applied to make a digital topographic map of land surface. This data has 3 arc second resolution (approximately 90 meters) for global coverage of latitude and longitude . The final form of SRTM meet the absolute horizontal and vertical accuracies of 20 meters (circular error at 90% confidence) and 16 meters (linear error at 90% confidence), respectively. The vertical accuracy is 10 meters. This is better than horizontal and vertical accuracy.

2.2 Model Domain

WRF model version we used is 3.0. The domain configuration for ARW is shown in Fig. 1. The first domain is 100 x 100 grid point with 5-km grid spacing, and second domain is 111 x 111 grid point with 1-km grid spacing with 1-way nesting, and third, fourth and fifth domain is 91 x 91 grid point with 0.2-km grid spacing also with 1-way nesting. Domain d03, d04 and d05 represent mountainous, coastal and island area respectively.

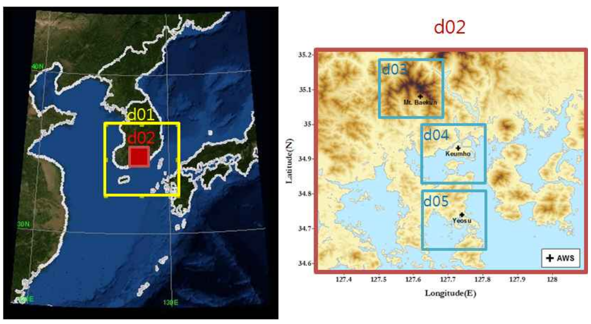

Fig.1. WRF-ARW nest configuration for high resolution model runs.

2.3 Model Configuration

The numerical integration starts at 00 UTC 3 June 2007, and runs for 72 hours. No data assimilation was used, and NCEP-FNL data provided the initial and lateral boundary conditions for the outer nest. Additionally, two simulations were run to compare differences in topography data one using USGS 30 arc second data (30s) and the other SRTM 3 arc second data (3s). The other namelist physics remained fixed between the simulations, and are listed in Table 1.

ARW Option (Ver. 3.0)
Morrison 2-moment scheme
RRTM long wave radiation scheme
Duhida short wave radiation scheme
YSU PBL
No cumulus
Noah land-surface model

3. Results

Fig.2 show the topography in numerical model with different spatial resolution. Upper and lower panels indicates HGT values of USGS and SRTM data, respectively. And we can easily find the difference of two HGT values in all domains.

In case of d03, shape of valleys and hills in SRTM data looks more detailed and complex in comparison with USGS data-based HGT. The up and down of topography produced from SRTM data become sharp in all domains because the resolution of SRTM data is higher.

Especially, The HGT contour in d04 for two topography data shows clear differences in mountain and landfill near coast. And SRTM topography in d05 is also more reliable than USGS data.

Fig.3 shows the wind vectors and temperature for two cases in domain 3 at 1500 LST. There is some difference of wind vector over mountainous area. In particular wind direction between two cases is great discrepance. This is result from the difference of topography data resolution. So atmospheric circulations can be modified strongly by the topography data resolution.

And Due to the high resolution of topography in SRTM case, the curvature of isothermal lines over mountainous area is complicated and sharply changed.

On the other hand, we can find little difference of HGT values in coastal area in Fig 4. However, accuracy of coastal line in SRTM case is more clear and reliable. This reliable coastal line make the great performance of numerical simulation. The difference of temperature simulated in two cases in domain 4 is little in comparison with domain 3. Little difference of temperature is caused by the lower resolution of land-use data. For this reason, high accuracy of land -use data with high resolution is also one of the important factors to estimate precise wind and temperature And it is considerable that the difference in temperature around mountain area is revealed along with wind direction because this will influence on advection not only temperature but pollutant.

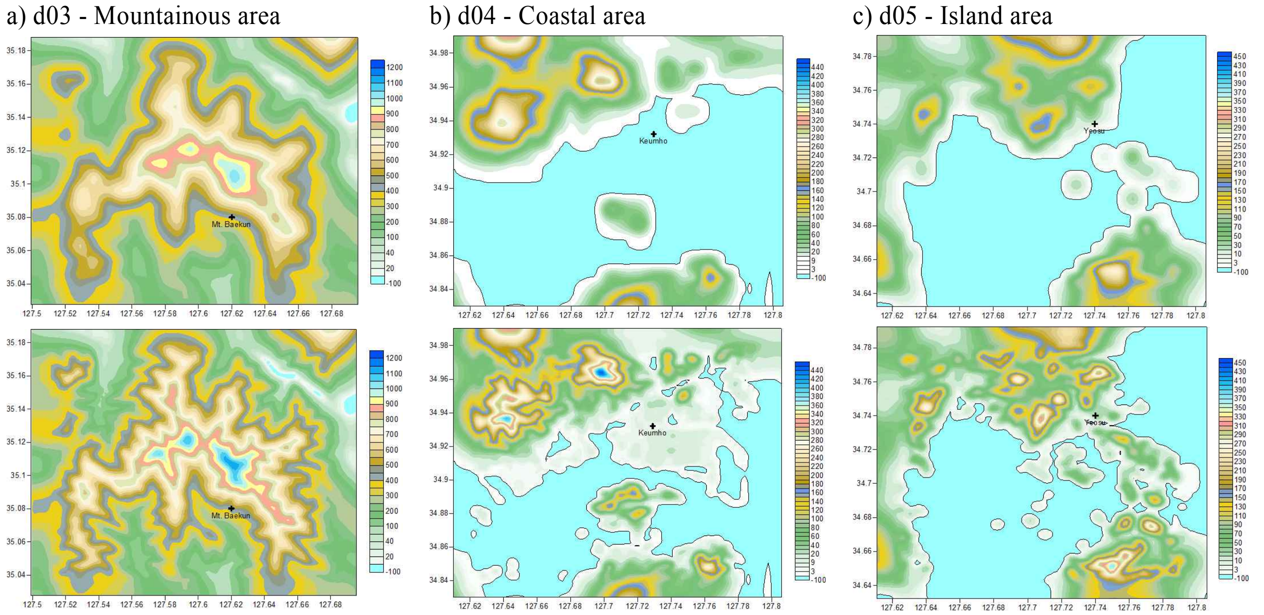

Fig. 2. Topography differences in model input data(HGT) for a) d03, b) d04 and c) d05 by using USGS 30s (upper raw) and SRTM 3s (bottom raw). Plus sign on the each map indicates Automatic Weather System site.

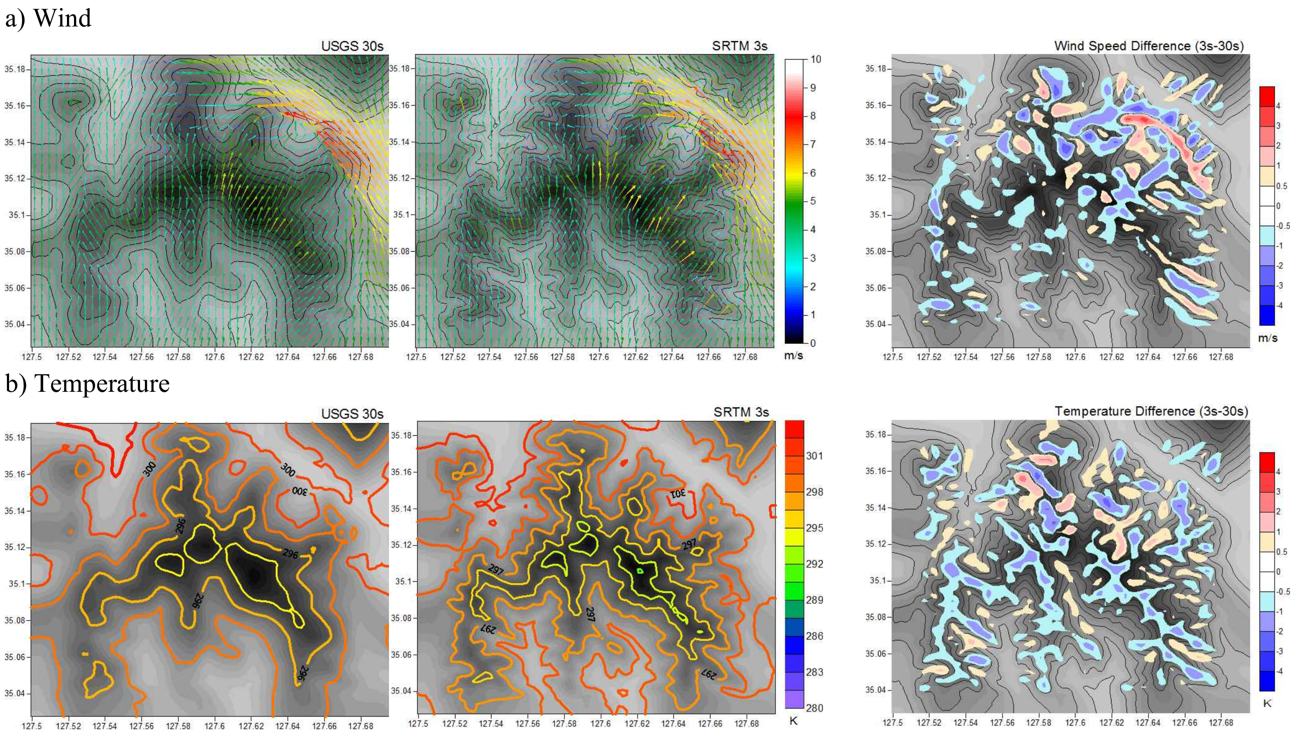

Fig. 9. Simulation results of a)wind and b)temperature using USGS 30s (left), SRTM 3s (middle) and difference of them (right) for d03 at 15LST 4 June

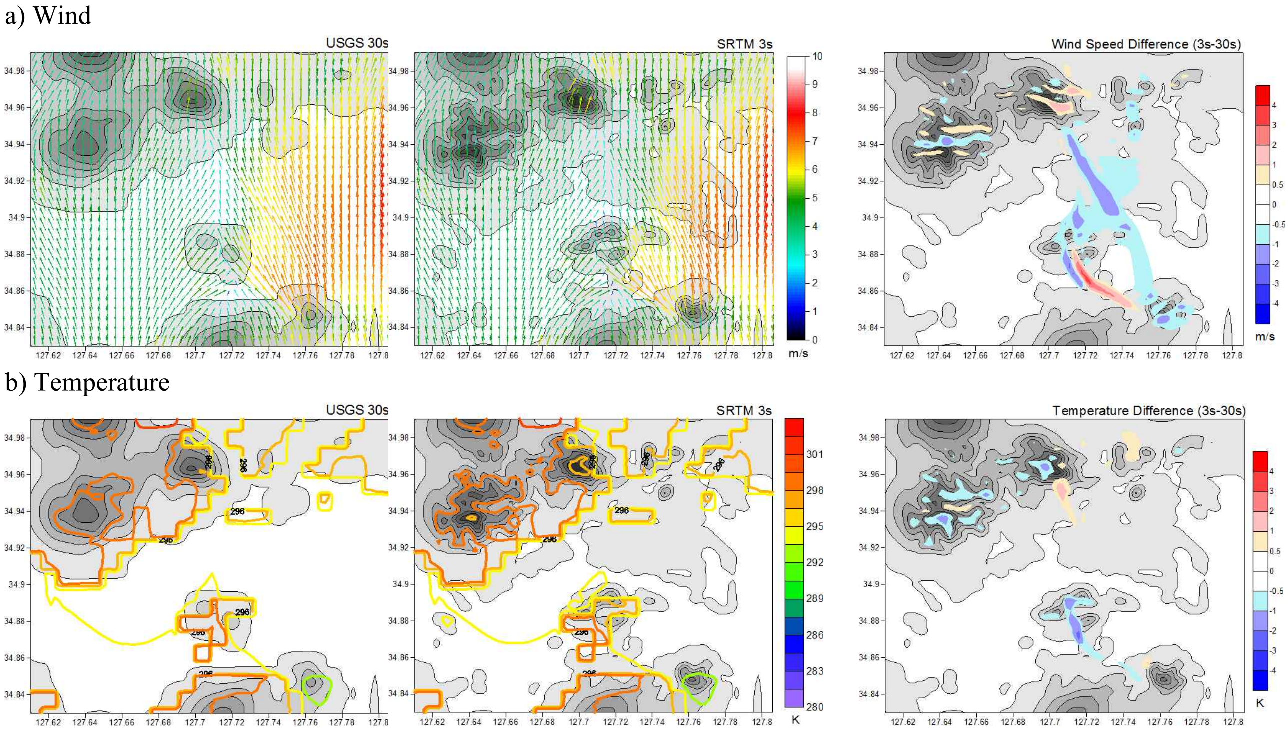

Fig. 4. As Fig. 3, but for d04

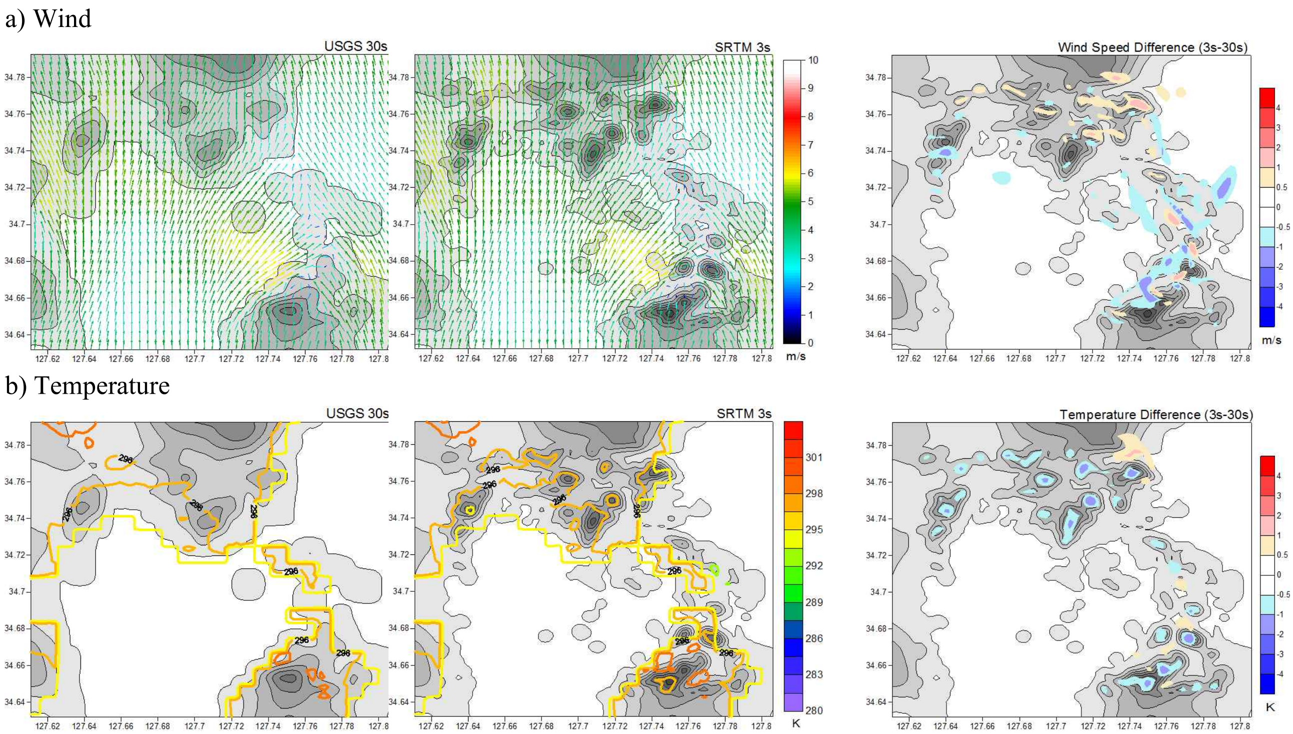

Fig. 13.As Fig. 3, but for d05