

Poster1-97 **REFRACTIVITY DISTRIBUTIONS OVER THE KANTO AND OSAKA PLAINS AND THEIR IMPACTS ON THE RAINFALL FORECASTS**

Hiromu Seko<sup>\*1,3</sup>, Eiichi Sato<sup>1</sup>, Hiroshi Yamauchi<sup>2</sup>, Yoshinori Shoji<sup>1</sup>, and Shinsuke Satoh<sup>4</sup>

<sup>1</sup>Meteorological Research Institute, Tsukuba, Japan,

<sup>2</sup>Japan Meteorological Agency, Tokyo, Japan,

<sup>3</sup>Japan Agency for Marine-Earth Science Technology, Yokosuka, Japan,

<sup>4</sup>National Institute of Information and Communications Technology, Kokubunji, Japan

**1. INTRODUCTION**

Water vapor and temperature near the surface play crucial roles in the initiation of convection cells. However, their behaviors (fluctuations) just before the initiation of convection cells still are not completely understood. In this study, the temporal and spatial fluctuations of refractivity, which is a function of water vapor and temperature, were obtained from the phase data of Doppler radars, and the features of refractivity fluctuations were investigated by the comparisons with the rainfall regions, temperature and horizontal wind fields observed by Automatic Weather Stations.

After confirming the relations with the refractivity fluctuations and the initiation of convection cells, the phase data of Doppler radars were converted to the relative humidity (RH), and the impact of RH derived from refractivity on the rainfall forecasts of local heavy rainfalls was investigated by the data assimilation experiments with the nested system of LETKF (Local Ensemble Transform Kalman Filter) (Seko et al, 2013).

**2. FEATURE OF REFRACTIVITY FLUCTUATIONS**

The radio wave transmitted from Doppler Radar is delayed by the atmosphere. The delay is measured from the radio waves reflected by the fixed structures, such as power transmission towers and buildings. Because the delay is the total value of refractivity along the path, the refractivity at each point is obtained by taking the difference of the delay along the path (Fabry et al, 1997, Seko et al 2009). To reduce the noise in the refractivity distributions, the spatial smoothing of the delay distributions was performed before taking the difference of them (not shown).

Figure 1 shows the temporal fluctuations of the phase differences, which are corresponding to those of refractivity, with 10-minute interval, obtained by the Doppler radar of Meteorological Research Institute (MRI) on 19<sup>th</sup> August 2017. The increased regions (indicated by warm colors) moved south-westward from the east (indicated by large blue arrows). These

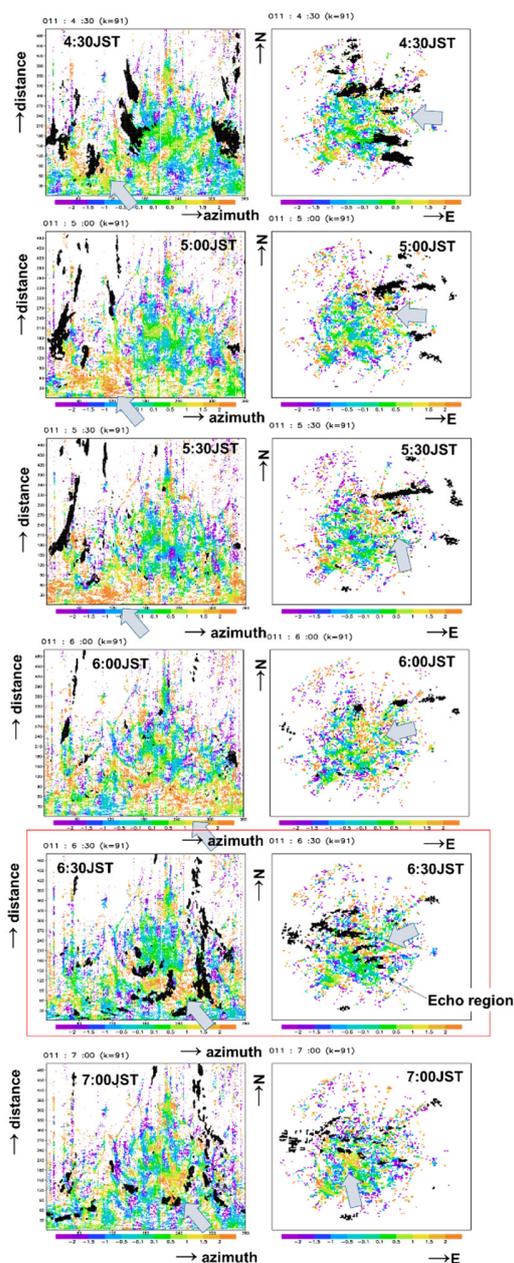


Fig. 1 Temporal fluctuations of phase differences with 10-minute intervals obtained by MRI radar.

\* Corresponding author address: Hiromu Seko  
 Meteorological Observation Research Department,  
 Meteorological Research Institute, 1-1, Nagamine  
 Tsukuba Ibaraki 305-0052, Japan; e-mail: hseko@mri-  
 jma.go.jp

regions coincided with the cold and northeasterly flow behind the sea-breeze front (Fig. 2). The scattered rainfall regions (indicated by black color) appeared all at once at 0630JST (UTC+9 hour) when these increased regions passed. It suggests that weak convection cells were generated by the intrusion of cold and humid airflow from the east. This result also means that the initiation of convection cells can be grasped by the monitoring the refractivity fluctuations.

### 3. DATA ASSIMILATION EXPERIMENT

A local heavy rainfall which developed in the Osaka Plain from 15JST to 17JST on August 5<sup>th</sup>, 2017 (indicated by a red circle in Fig. 3) was used as the case event of the data assimilation experiment in this study. Figure 4 is the phase differences with 5-minute intervals obtained by the Doppler radar of the Kansai-International airport. The temporal fluctuations show that the increased and decreased regions moved smoothly. The smooth movements mean that the refractivity fluctuations were caused by the atmosphere. This feature is common to that observed in Kanto Plain (Fig. 1). From the temporal fluctuations of phase differences, the observed RH was estimated by using the first-guess temperature and pressure

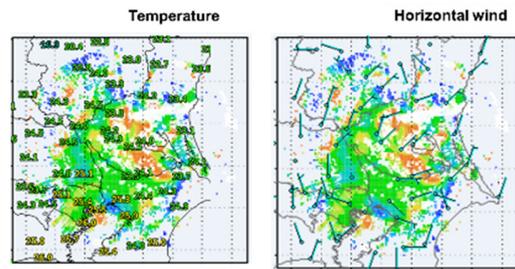


Fig. 2 (Left) Temperature and (Right) horizontal wind distributions obtained by AMeDAS. Colored regions indicate the temporal fluctuations of phase differences.

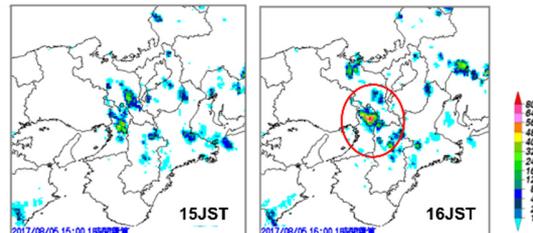


Fig. 3 Rainfall distributions at 15JST and 16JST on 5<sup>th</sup> August 2017 obtained by JMA's radars.

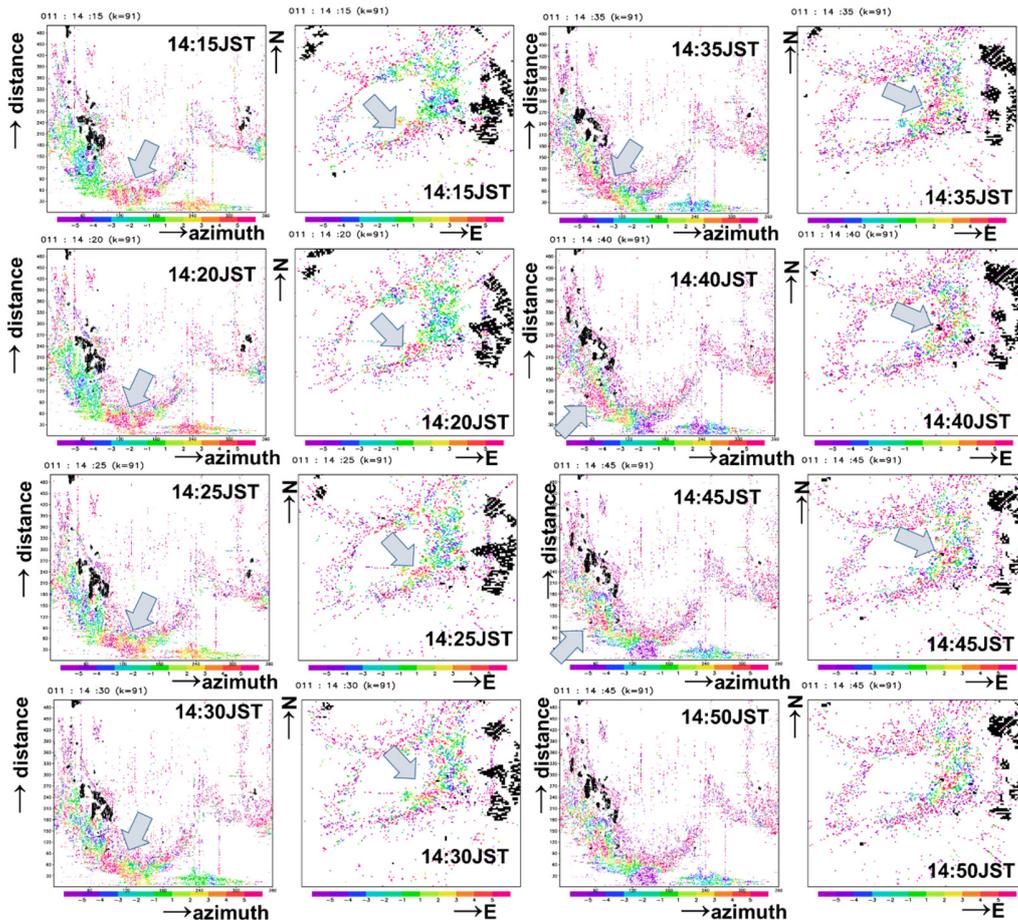


Fig. 4 Temporal fluctuations of phase differences with 5-minute intervals obtained by the Kansai-International Airport radar.

(output of numerical model). The difference of observed RH and first-guess RH (D-value) indicated that the number of data becomes smaller as the D-value becomes larger (upper panel of Fig. 5). The most of hourly increments of observed RH were in the range of -5% ~ 3% (lower panel of Fig. 5).

The reproduction of the local heavy rainfall is expected to be improved by the assimilation of the observed RH, because the refractivity affects initiation of convection cells as shown in the section 2. The observed RH, which was produced from fluctuations of phase differences, were assimilated with a nested system of LETKF, which consists of the outer and inner models. The grid intervals of the outer and inner models of the nested system are 15 km and 1.875 km. The data assimilation window and assimilation slot of the outer and inner models are 6hour/1hour and 1hour/10minutes, respectively. As the assimilation data for the outer model, the conventional assimilation data of the JMA (Japan Meteorological Agency) was used. As for inner models, the observed RH derived from phase difference, the radial wind of the Phased Array Weather Radar (PAWR) of Osaka University, the GNSS-PWV (Precipitable Water Vapor) data obtained by the GEONET (GNSS Earth Observation Network System) of the Geographical Institute, were added to the convective data of JMA, and then assimilated.

The result of data assimilation was shown in Fig. 6. When the RH data, GNSS-PWV data and radial wind of PAWR were assimilated, the intense rainfall at the northern part of the Osaka Plain became similar to the observed one. From 14JST to 15JST, the decrease of temporal fluctuation of phase differences in Osaka Plain became smaller (Fig. 4) and water vapor there was accumulated by the convergence of horizontal flows at 15JST (Fig. 7). These conditions are favorable to the initiation of the intense convection cells that caused the local heavy rainfall. It is deduced that the favorable conditions, which were reproduced in the initial condition by the data assimilation, made the local heavy rainfall more similar to the observed one.

## References

Fabry F., C. Frush, I. Zawadzki, and A. Kilambi, 1997: On the extraction of near-surface index of refraction using radar phase measurements from ground targets. *J Atmos Oceanic Technol*, 14, 978–987.

Seko H., T. Tsuyuki, K. Saito, and T. Miyoshi, 2013: Development of a two-way nested LETKF system for cloud-resolving model. In: Park SK, Xu L (eds) *Data assimilation for atmospheric, oceanic and hydrologic applications*, vol 2. Springer, pp 489–507.

Seko H., H. Yamauchi, O. Suzuki, and K. Saito, 2009: Estimation of Temporal Variation of Refractive Index Using C-band Doppler Radar Equipped with Magnetron Transmitter. *SOLA*, 5, 145-148.

## Acknowledgments:

This work was partly supported by JST AIP Grant Number JPMJCR19U2, Japan, “Advancement of Meteorological and Global Environmental Predictions Utilizing Observational ‘Big Data’ of the MEXT, Social and Scientific Priority Issues (Theme 4) to be Tackled by Using Post ‘K’ Computer” (hp180194, hp190156), and MEXT KAKENHI Grant 17H00852, 17H02964.

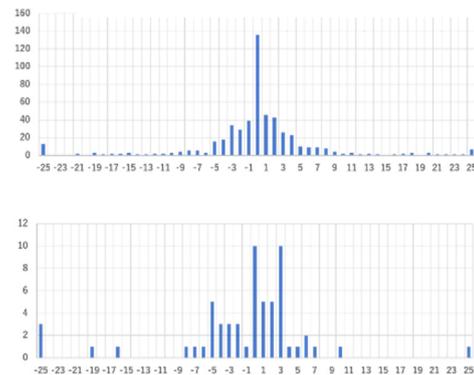


Fig. 5 (Upper) D-value distribution of RH (%) from 14JST to 19JST. (Lower) Hourly increments of RH (%) from 14JST to 19JST

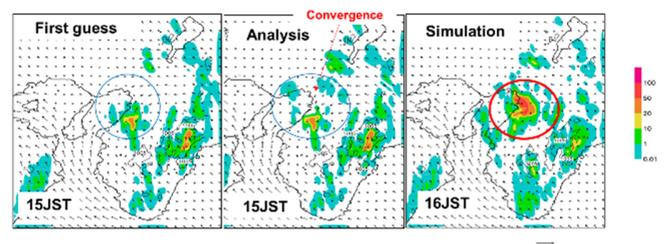


Fig. 6 Rainfall distributions of first-guess, analysis at 15JST of #003, and forecast from analyzed fields at 16JST of #003.

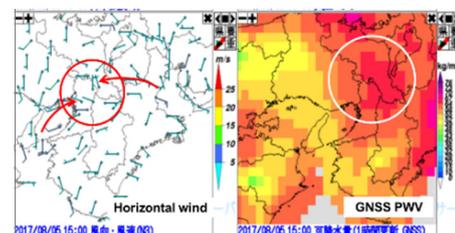


Fig. 7 Horizontal wind and GNSS-PWV distributions at 15JST 5<sup>th</sup> August 2017.