Collaborative ionospheric observations using VIPIRs in Japan and Korea

Takuya Tsugawa[1], Michi Nishioka[1], Hideo Maeno[1], Takumi Kondo[1], Mamoru Ishii[1], Jong-Yeon Yun[2], Young-Sil Kwak[3,4]
1. National Institute of Information and Communications Technology, Japan
2. Korean Space Weather Center, National Radio Research Agency, Korea, 3. Korea Astronomy and Space Science Institute, Korea
4. Korea University of Science and Technology, Korea

Abstract

National Institute of Information and Communications Technology (NICT) installed Vertical Incidence Pulsed Ionospheric Radar (VIPIR) at four stations, Wakkanai (Sarobetsu), Kokubunji, Yamagawa, Okinawa (Ogimi), in 2016 for routine ionospheric observations in Japan. VIPIR can separate the O- and X-modes of ionospheric echoes which have improved the availability of automatic scaling of the ionogram. A new ionograms scaling method has been developed using these VIPIR ionograms and AI method. Using this method, the scaling accuracy and successful scaling rate for ionospheric parameters such as foF2. Every 15 minutes, each VIPIR diagnose the ionosphere in the vertical incident manner and the other three VIPIRs perform oblique incidence observation. Such oblique-incident observation can provide information on the ionosphere at the midpoint between the stations. Korean Space Weather Center (KSWC) also installed VIPIR at two stations, Juju and Icheon, in 2016. NICT and KSWC have started trail international oblique-incident sounding observations with VIPIRs since September 2016. Increasing the number of stations can increase the observation points even on the sea where is a blank area of vertical observation. These observation data are important as input for ionospheric data assimilation and/or tomography. On the other hand, it remains as an issue how to arrange the observation interval and observation mode of VIPIRs.

1. Introduction

- VIPIR2, which has developed in NOAA, was installed to Wakkanai, Kokubunji, Yamagawa, and Okinawa in 2016 for routine ionosonde observation.
- Specifications of VIPIR2 are shown in Table 1. Major advantages of VIPIR2 are
  - Digital signal processing for precise mixing and filtering
  - O-X mode separation (Figure 1) by 8ch Rx antenna array
  - 16 bit sampling for greater dynamic range
  - Lower power consumption

Table 1. Specification of VIPIR2

Method	Single pulse
Observation mode	Vertical/oblique
Ave./Peak Tx power	32W / 4kW
Frequency rage	1-30 MHz
Observing height	60-1500km
Intensity resolution	16 bit
Observing interval	Routine: 15 min Special: TBD
Sweeping time	~15 sec
Pulse repeating rate	50-100 Hz
Tx	1 ch
Rx	8 ch

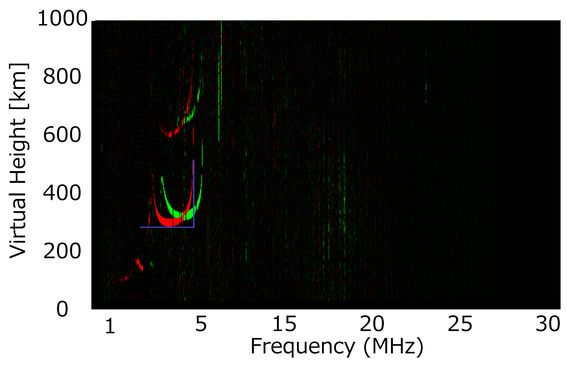

Figure 1. O-X mode separated ionogram by VIPIR2

2. Realtime autoscaling system

- Major ionospheric parameters such as foF2 and foEs are scaled on a real-time basis and provide through our web site (Figure 2).
- The current ionogram autoscaling method does not use O-X mode information (Figure 3).

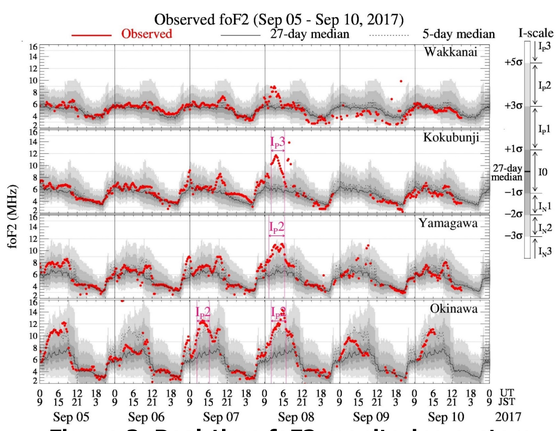

Figure 2. Real-time foF2 monitoring system (http://swc.nict.go.jp/trend/ionosphere.html)

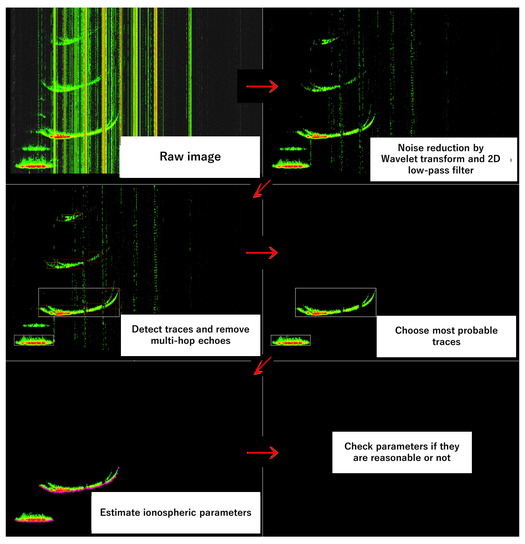

Figure 3. Current ionogram autoscaling method

3. New autoscaling method

- We are developing a new autoscaling method in order to improve the scaling accuracy using O-X mode separated ionograms and artificial intelligence (AI) technique. The procedure has five steps as follows:

Step1. Calculate intensity (TOTAL, X, O) for each frequency and altitude. Then remove background noise.

Step2. Create an intensity transformation palette separately for E and F regions using AI (Faster-RCNN) and manually scaled data.
＊Auto-detection of F-region echo by AI method is shown by blue lines in Figure 1.

Step3. Create an ionogram image with intensity normalized to 0-255 separately for E and F regions

Step4. Binarize the ionogram and reduce the periodic noise and multi-hop echo

Step5. Apply the current autoscaling method for the extracted echo trace

- Using one-year Kokubunji foF2 data in 2018, we compared the scaling accuracy and successful rate between current and new methods (Table 2).

Table 2. Comparison between the current and new autoscaling methods

foF2	Current	New
Scaling Rate	**80.0 %**	**99.8 %**
Mean Error*	**0.26 MHz**	**0.12 MHz**
Error < 0.2MHz	16942	21864
0.2 < Error ≤ 1.0MHz	3769	4401
1.0 MHz < Error	709	479

* “Error” is defined as “difference between auto- and manually scaled parameters”.

4. Oblique Sounding

- Oblique observation makes it possible to expand observational area (Figure 4a).
- In 2016, Korean Space Weather Center (KSWC) also installed VIPIR at two stations, Juju and Icheon (Figure 4b), as NICT (Figure 4c).

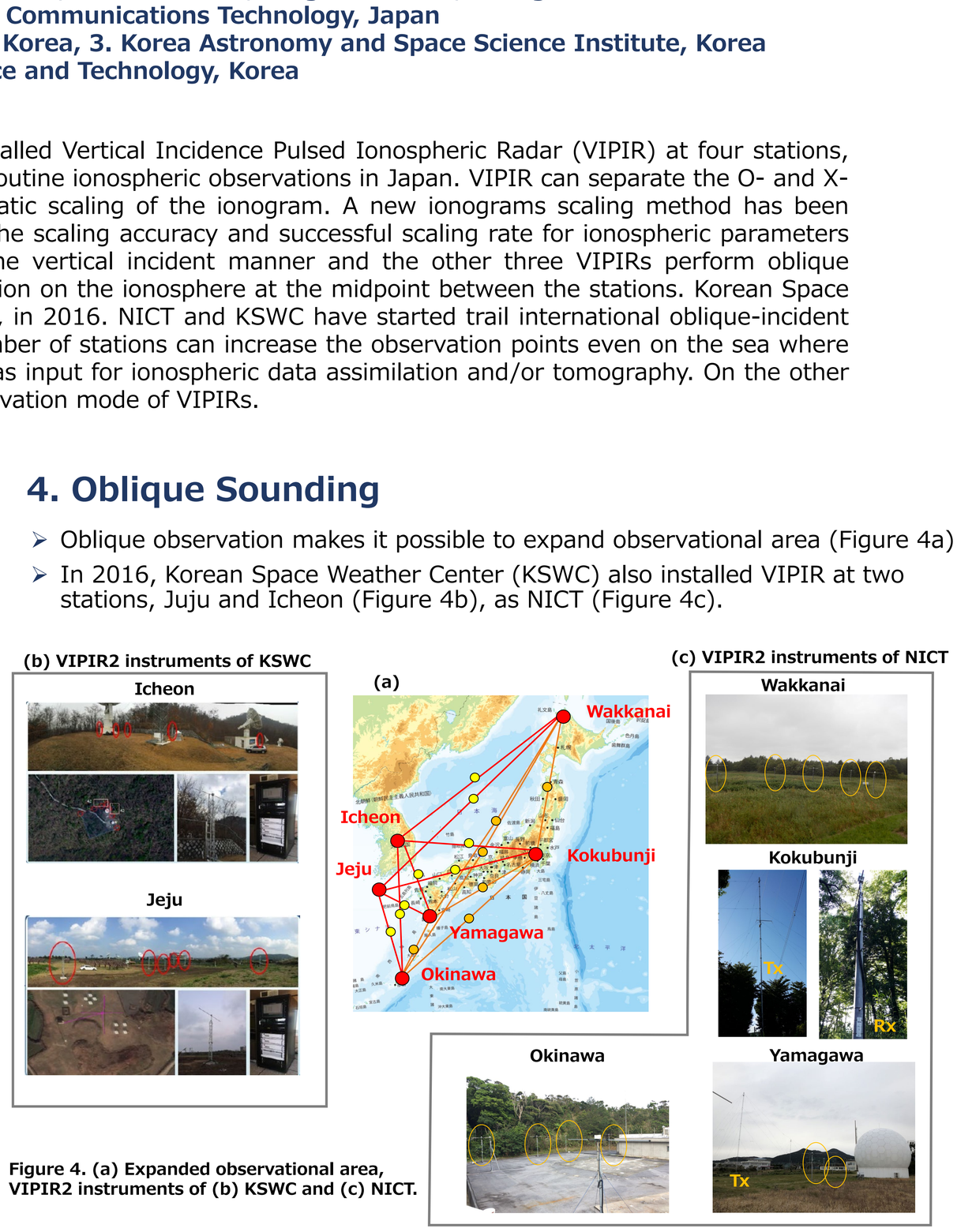

Figure 4. (a) Expanded observational area, VIPIR2 instruments of (b) KSWC and (c) NICT.

- KSWC has started oblique sounding trial observations (Figure 5). NICT is ready to start international oblique sounding observations after sharing KSWC transmitting information.
- We want to conduct logarithm sweep modes for scientific purposes. Also, since number of VIPIRs in neighboring countries will increase in near future, we need to arrange observation schedule and mode (Figures 6).
- As a future work, technique for extracting ionospheric parameters from oblique sounding should be developed.

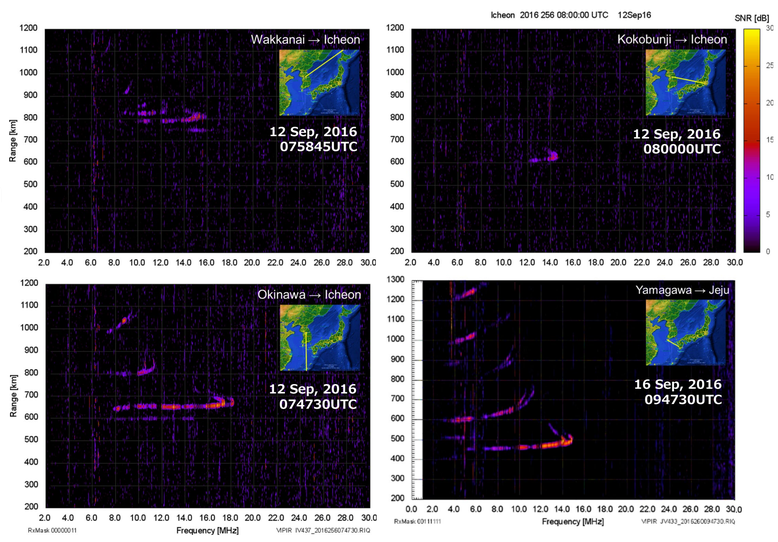

Figure 5. Ionograms of oblique observations

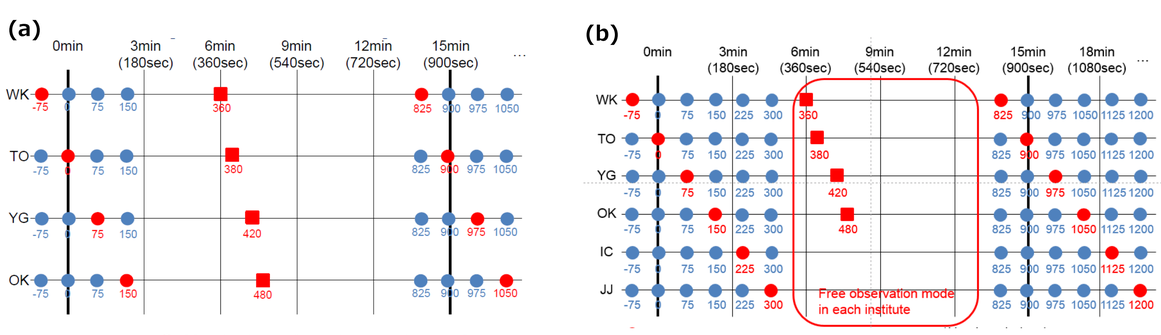

Figure 6. KSWC&NICT operation schedule; (a) current, (b) a future option (Numbers below icons represent seconds from every 0 min.)

Summary

- VIPIR2 was installed to Wakkanai, Kokubunji, Yamagawa, and Okinawa in 2016 for routine ionosonde observations.
- A new ionograms scaling method has been developed using VIPIR ionograms and AI method. The scaling accuracy and successful scaling rate for foF2 are greatly improved. We will develop the method for other parameters and for operation.
- NICT and Korean Space Weather Center (KSWC) have started international oblique sounding trial observations with VIPIR system since Sep 2016. Observation schedule and mode need to be arranged.