

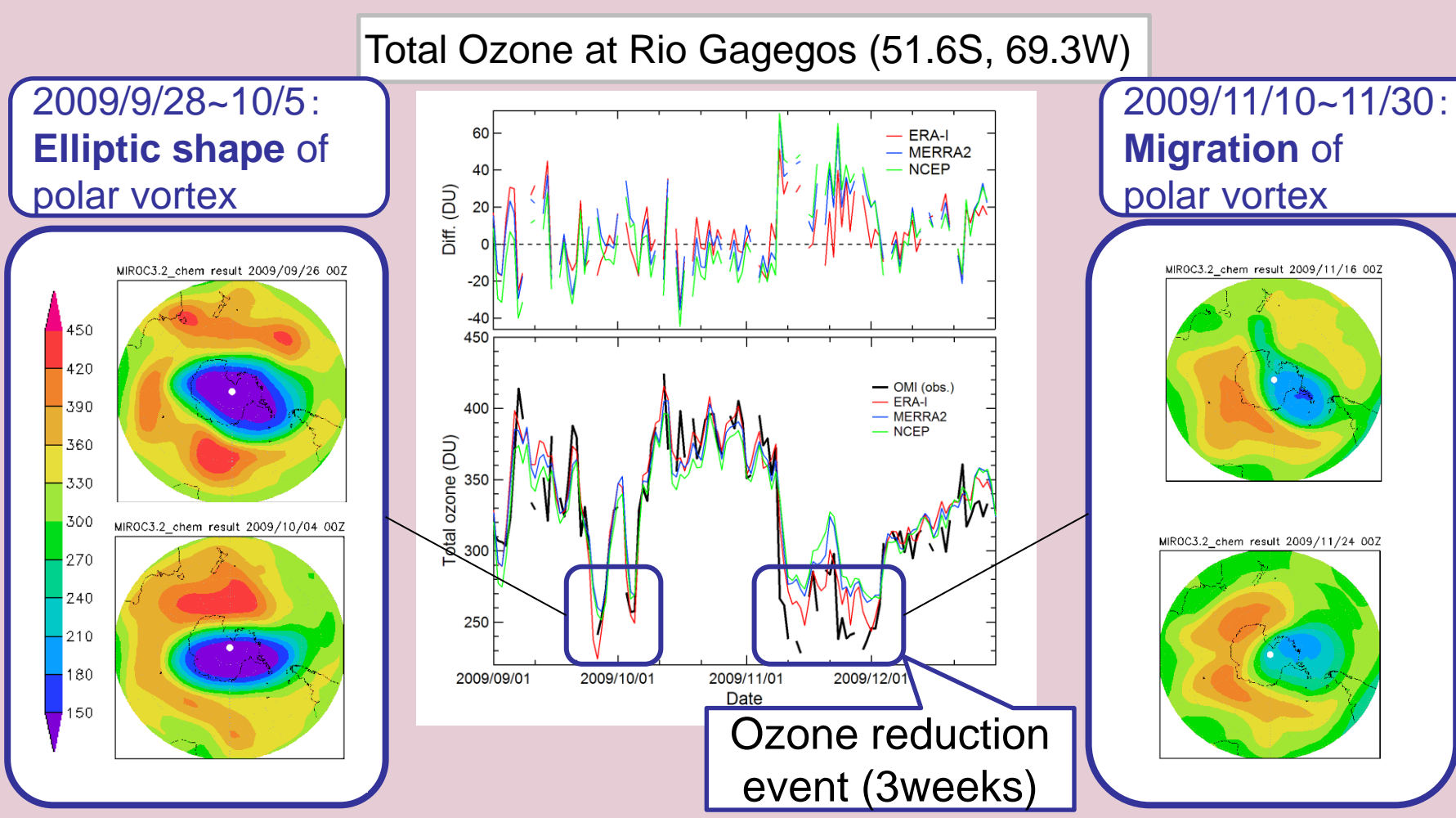


# A CCM Forecast Experiments of the Ozone Reduction Event Over the Southern Tip of South America in November 2009 Using Ozone Assimilated Initial Data

Haruna Nakamura<sup>1,2</sup>, Toshihiko Hirooka<sup>1</sup>, Hideharu Akiyoshi<sup>3</sup>

<sup>1</sup>Department of Earth Planetary Sciences, Kyushu University, Fukuoka, Japan <sup>2</sup>Fujitsu Japan Corporation, Tokyo, Japan <sup>3</sup>National Institute for Environmental Studies, Ibaraki, Japan

The 2 ozone reduction events of ensemble forecast experiments were compared in order to quantify the model performance:



### Elliptic shape event (end of Sep. 2009):

✓ Pattern correlation coefficient (PCC) decreases with time, and the predictable period can be estimated 7-10 days

### Migration event (mid of Nov. 2009):

- ✓ Good predictability with small variation before the reduction event
- ✓ PCC decreases with the enhancement of planetary wave activity of wave 1 and 2
- ✓ With the decrease of planetary wave activity (15 Nov~), the PCC recovers
- ✓ The overall predictability seems to be better than that of the elliptic shape event

## 1. Introduction

A reduction of the total ozone over the southern tip of South America lasting 3 weeks occurred in November 2009 (Akiyoshi et al., 2018).

In this event, the polar vortex was distorted to an elliptic shape due to enhanced planetary wave activity, bringing to migration of ozone depletion region associated with the Antarctic ozone hole towards the South American continent at the time of the vortex breakup.

### =>Migration event

- ✓ How about is the predictability of the distorted ozone distribution in the beginning of the polar vortex breakup?
- ✓ It is important to understand the relation between planetary wave activity and the ozone reduction event

Generally, the reduction of total ozone over the southern tip of South America is effected by the passage of an elliptic shape of the polar vortex.

### =>Elliptic shape event

Compare ensemble forecast experiments of the 2 events

## 2. Data and Model Settings

We attempt **ensemble forecast experiments** for the ozone reduction events, using the NIES chemical-climate model (NIES CCM) with 32 ensemble members.

- ✓ Initial data are produced by the ozone assimilated NIES CCM.
- ✓ The forecast experiments are performed from the various initial dates in October-November 2009.

### ◆ Ozone Assimilated NIES CCM (Nakamura et al. 2013)

Model: MIROC3.2-Chemical Climate Model  
 Resolution: T42 (2.8°×2.8°), 34 levels (~0.1hPa)  
 Assimilation: **LETKF, 32 ensemble members, every 6 hours**  
 Assimilated data:  
**U, V, T**: Modern-Era Retrospective analysis for Research and Applications, version 2 (**MERRA-2**)  
**Total Ozone**: Aura Ozone Monitoring Instrument (**OMI**)  
**Ozone Profile**: Microwave Limb Sounder (**MLS**)

### ◆ Ozone Assimilated Initial Data

Each initial value is produced by the NIES CCM Assimilation with U, V, T, OMI O<sub>3</sub> and MLS O<sub>3</sub> every 6 hours. (1 September 2009 ~ 10 November 2009)

## 3-1. Pattern Correlation Coefficient (PCC) Analysis

To measure forecast skill, we calculate PCC (Rao et al. 2019) between forecasts and reanalysis (20–90°S)

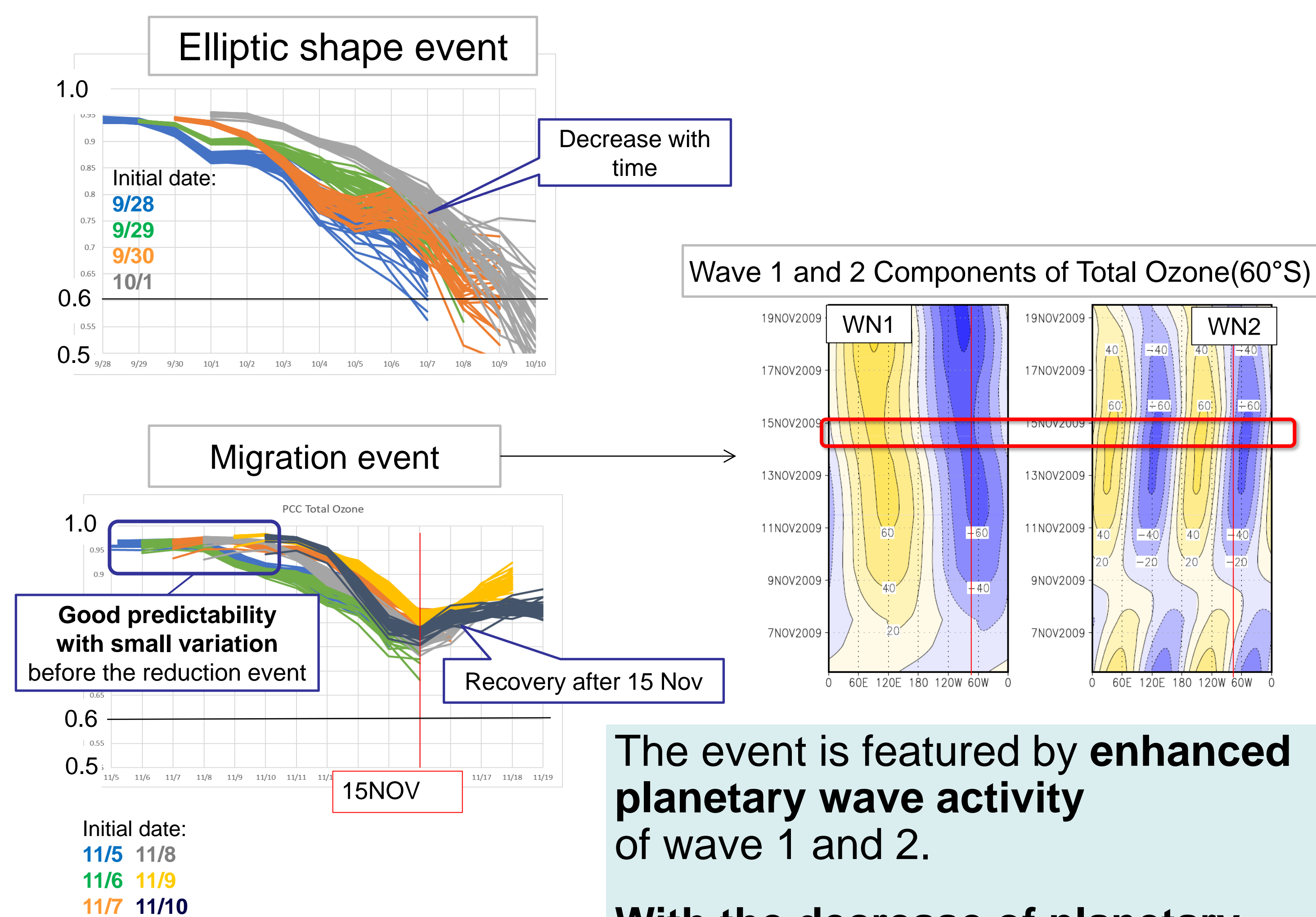
$$PCC(t) = \frac{\sum_{i=1}^n w(i) [Z_{FC}(i, t) - \overline{Z_{FC}(t)}] [Z_{RA}(i, t) - \overline{Z_{RA}(t)}]}{\sqrt{\sum_{i=1}^n w(i) [Z_{FC}(i, t) - \overline{Z_{FC}(t)}]^2} \sqrt{\sum_{i=1}^n w(i) [Z_{RA}(i, t) - \overline{Z_{RA}(t)}]^2}}$$

Z: Total Ozone or Geopotential Height (in this study)  
 FC: Forecast  
 RA: Reanalysis\*  
 w(i)=cosine of latitude

$$\overline{Z(t)} = \frac{\sum_{i=1}^n w(i) Z(i, t)}{\sum_{i=1}^n w(i)}$$

\*In this study, we use MIROC3.2 CTM result(nudge ERA-Interim) as "Reanalysis"

### ◆ Total Ozone PCC during the Ozone Reduction Event



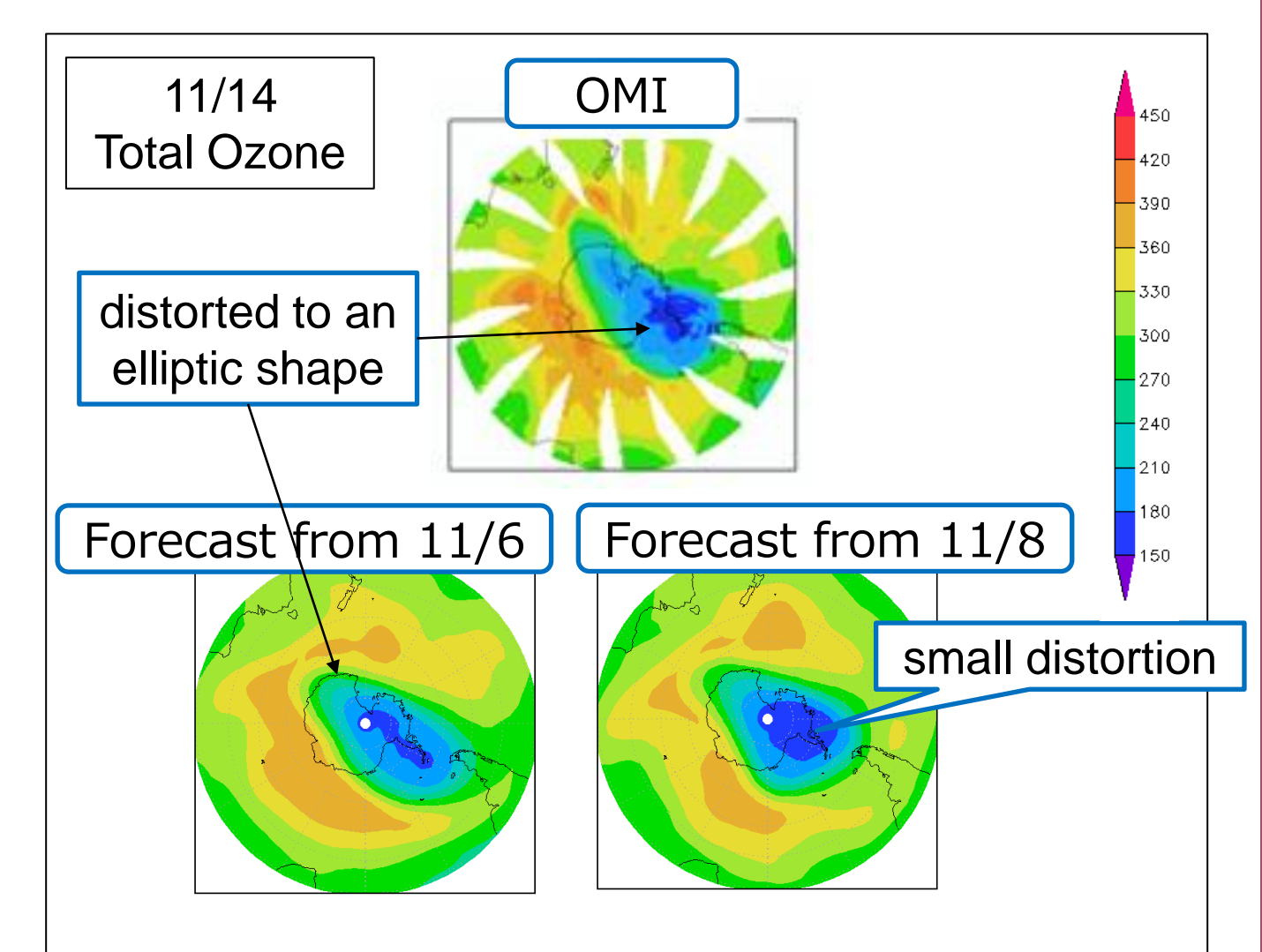
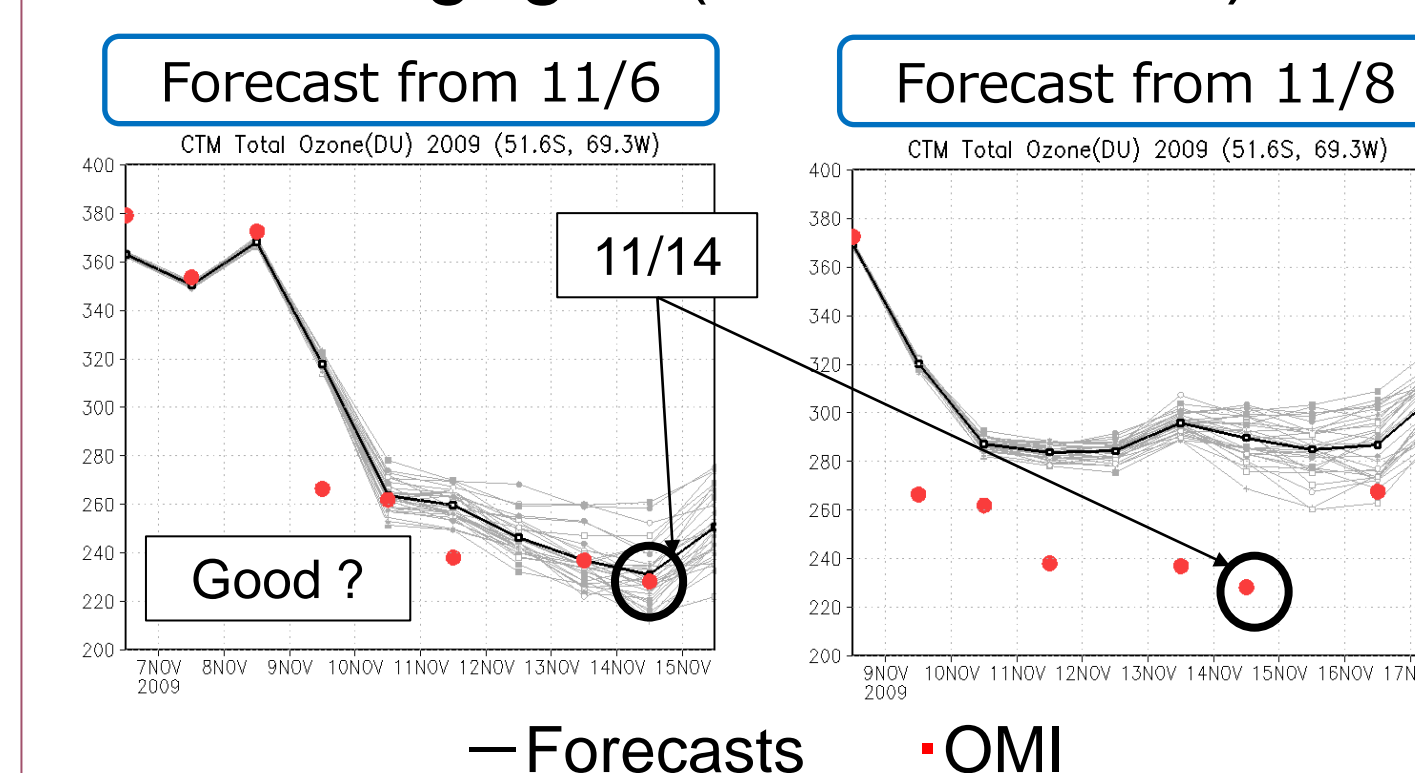
The event is featured by **enhanced planetary wave activity** of wave 1 and 2.

**With the decrease of planetary wave activity (15 Nov~), the pattern correlation recovers.**

## 3-2. 10-Day Ensemble Forecasts Using the NIES CCM Over the Southern Tip of South America

### Migration event

#### ◆ Timeseries of total ozone over Rio Gagegos (51.6S, 69.3W)



The predictability of total ozone seems to depend on the reproducibility of the **distortion of the polar vortex**.

The difference of distortion is correspond to the strength of **planetary wave activity** of wave 1 and 2

#### ◆ Wave 1 and 2 Components of Total Ozone(60°S)

