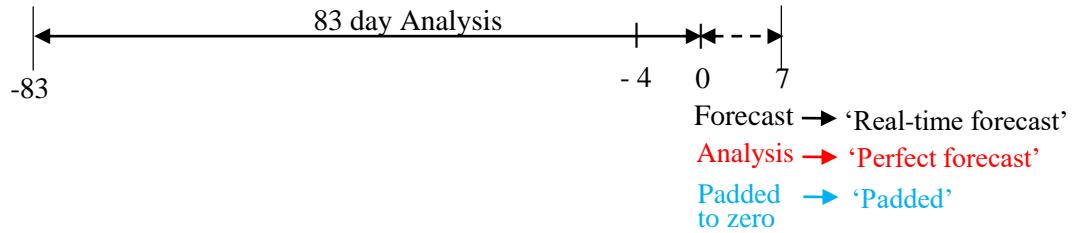


Figure 1. The theoretical horizontal structures of some of gravest equatorial wave modes in the resting atmosphere. The Kelvin wave, the $n=0$ westward-moving mixed Rossby-gravity (WMRG) the $n=1$ and 2 westward-moving Rossby (R1 and R2) waves. The meridional trapping scale y_0 has been taken to be 6° and the zonal wave number $k=6$. Vectors indicate horizontal wind. Colours shadings indicate divergence (10^{-6} s^{-1}) with convergence set to be positive. Colour contours lines are vorticity (10^{-6} s^{-1}) with blue lines for positive vorticity and red lines for negative vorticity; the contour interval is 0.6 starting from ± 0.2 for Kelvin, WMRG and R1, and the contour interval for R2 is doubled. The amplitude of the wave is determined by setting the appropriate (q_0, v_0, v_1, v_2) to 1.

(a) Real-time wave datasets



(b) Diagnostic analysis dataset

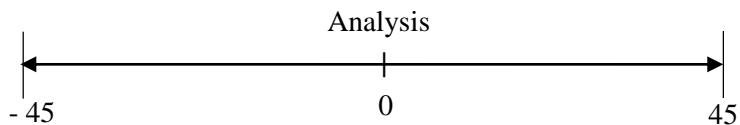


Figure 2. Schematic of procedures to create 4 wave datasets for developing and testing real-time analysis technique. Projection is performed for each 90 day time series in the analysis and forecast data in 2015-2016 by sliding the 90-day time window one day forward for each projection to form four year equatorial wave datasets. (a) Three Real-time wave datasets: First, 90 day time series consists of 83 analysis and 7 day forecast data, the projected waves at the last 12 days are used to form ‘Real-time forecast’ dataset, with the last 7 days, labelled as ‘day 0-7’ being forecast, and the previous 5 days labelled as ‘day -4 to 0’ being analysis data; Secondly, the last 7 days are replaced by analysis data to form ‘Perfect forecast’ dataset to examine the edge effect; Thirdly, the last 7 days are replaced by data padded to zero to form ‘Padded’ dataset to test the usefulness of the forecast data. (b) 90 day time series is analysis data, projected waves at the central day is used to form ‘Diagnostic-analysis’ dataset.

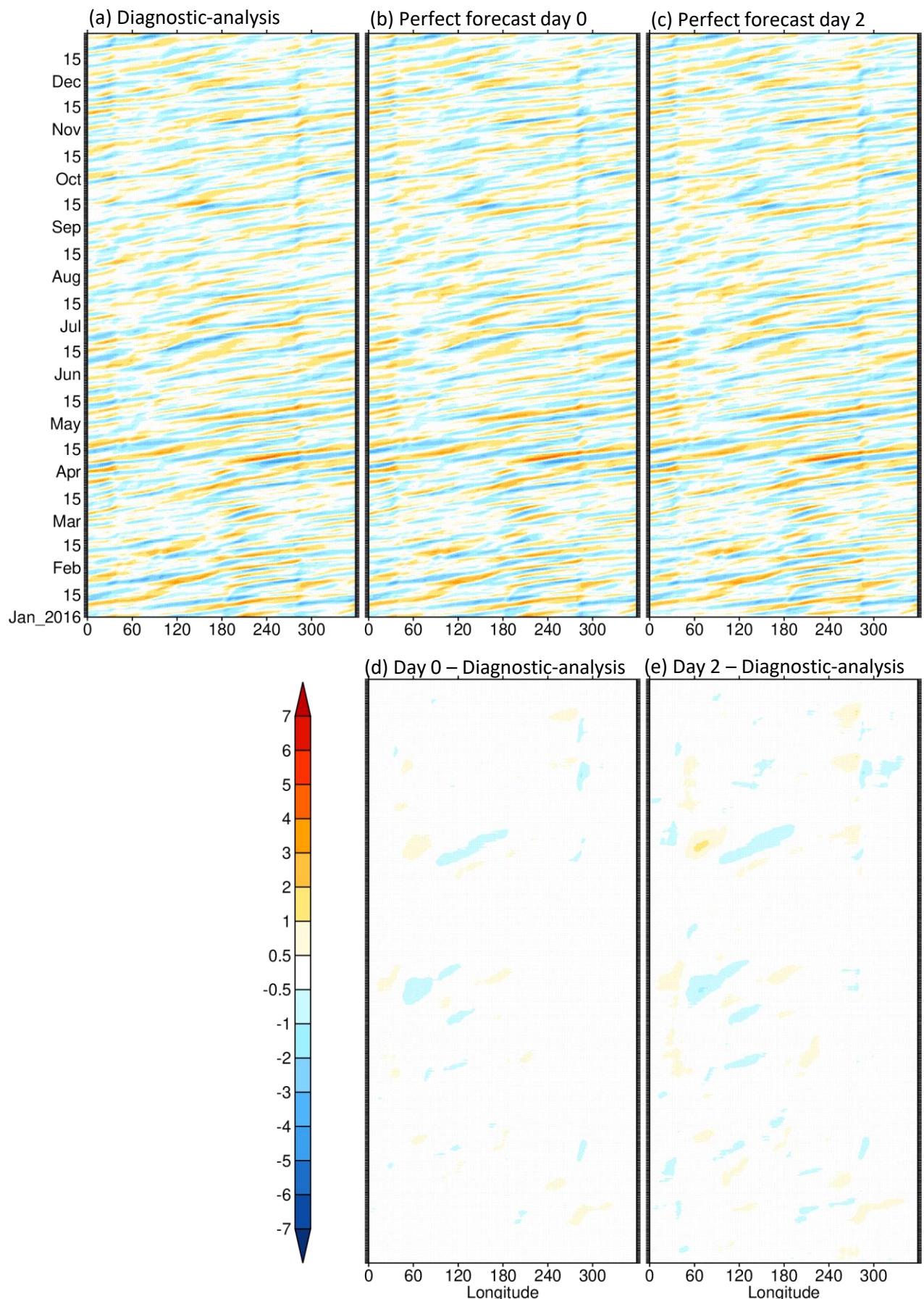


Fig.3. Longitude-time diagrams of 850-hPa Kelvin wave equatorial u in 2016 identified from Met Office analysis data for (a) Diagnostic analysis, (b) Perfect forecast dataset at day 0, (c) Perfect forecast dataset at day 2, (d) difference between Perfect forecast day 0 and Diagnostic-analysis. (e) difference between Perfect forecast day 2 and Diagnostic-analysis.

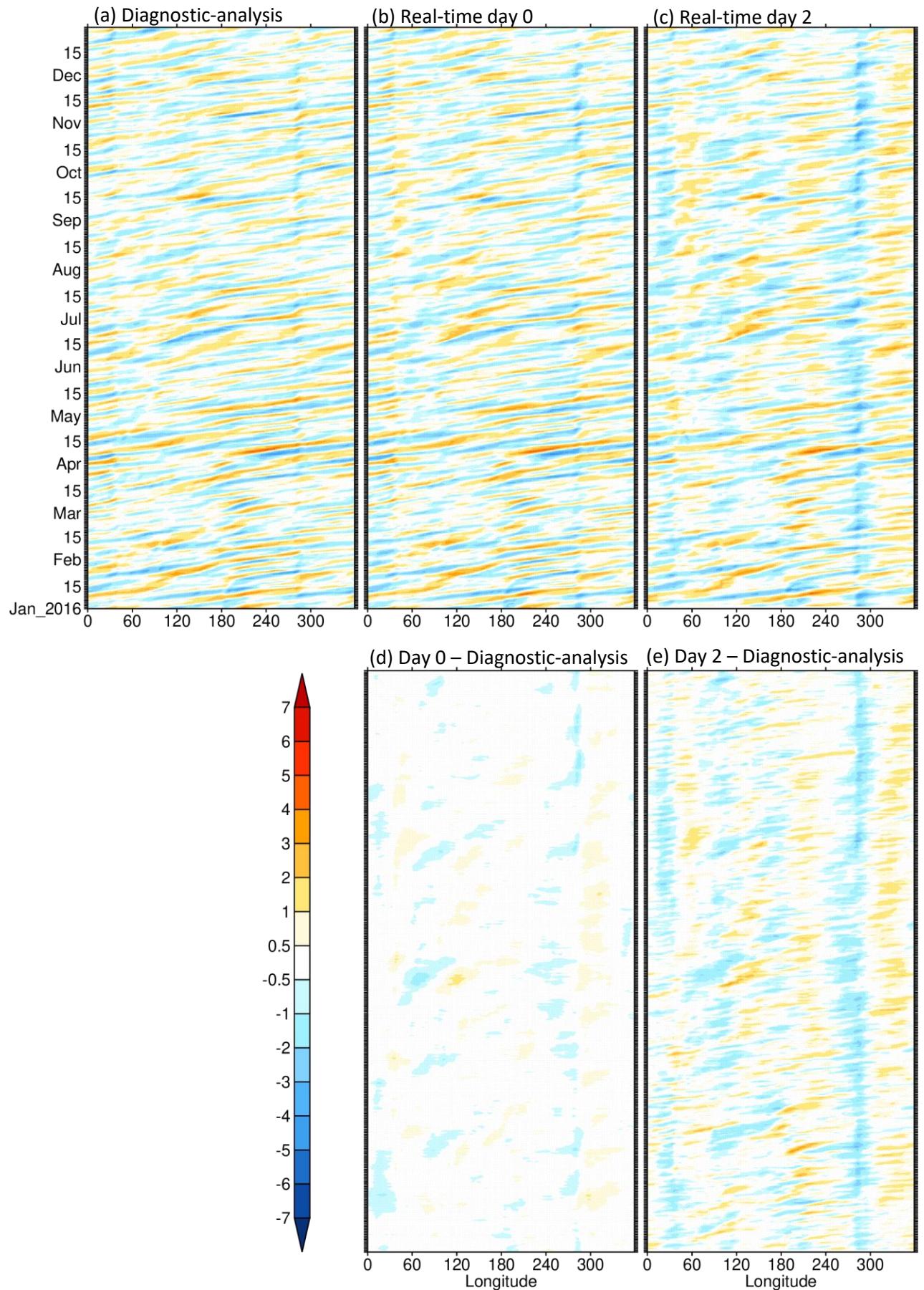


Fig.4. Longitude-time diagrams of 850 hPa Kelvin wave equatorial u for (a) Diagnostic-analysis, (b) Real-time wave-dataset day 0 (Real-time analysis), (c) Real-time wave-dataset day 2 (Real-time forecast), (d) difference between Rea-time day 0 and Diagnostic-analysis, (e) difference between Real-time day 2 and Diagnostic-analysis.

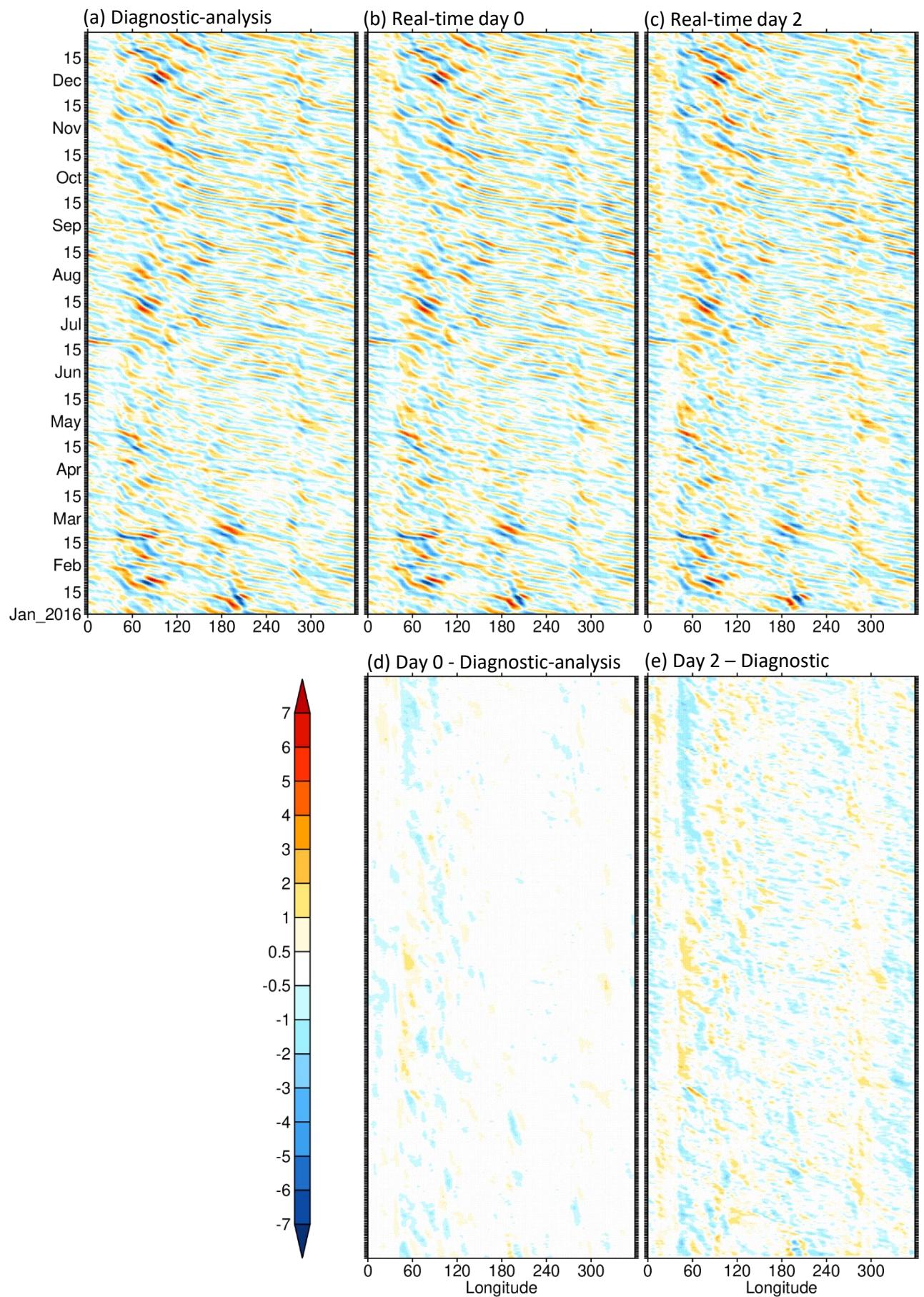


Fig.5 As for Fig.4 but for 850-hPa WMRG equatorial v in Real-time wave-dataset.

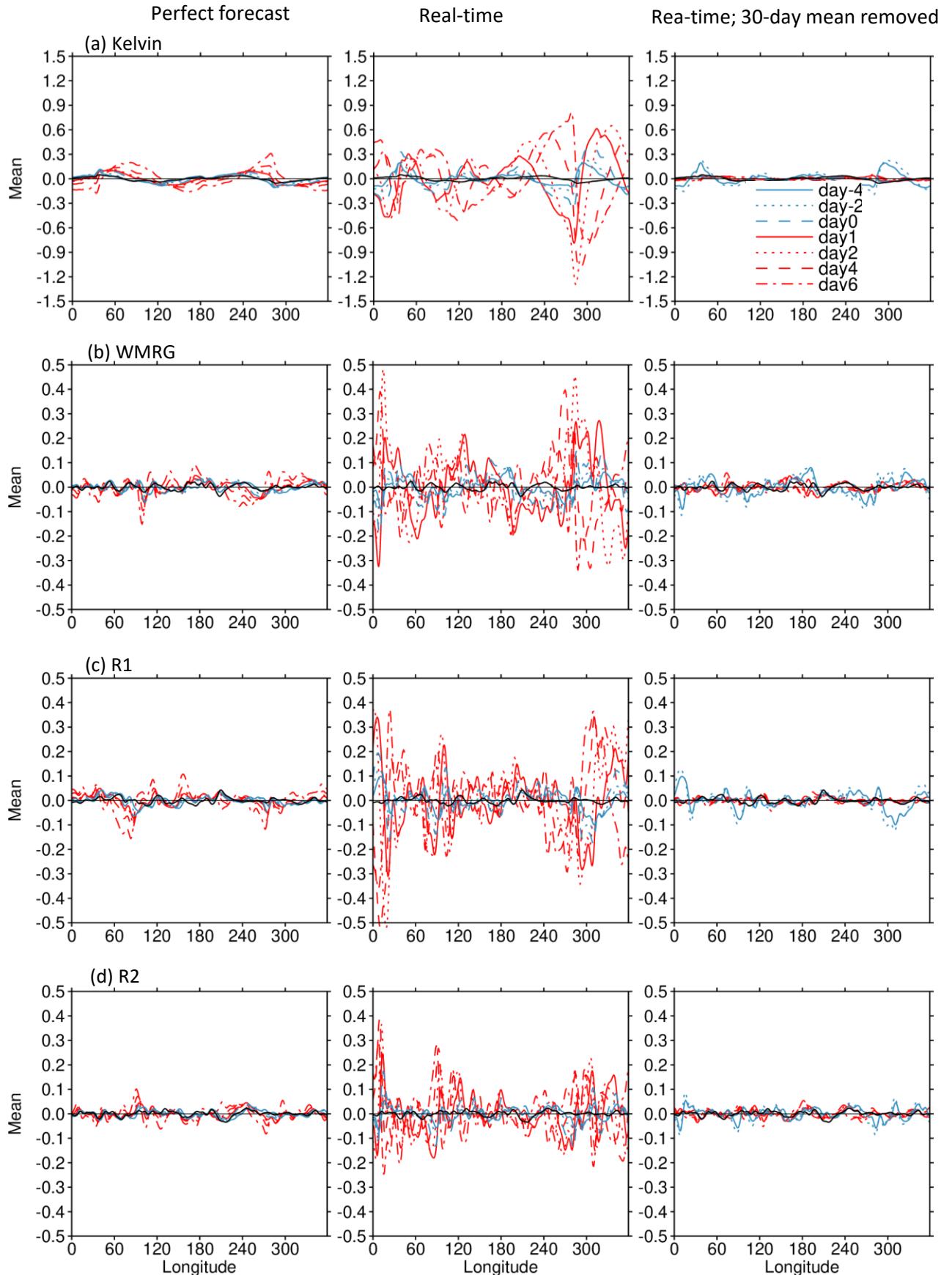


Fig.6 12-month mean winds for (a) Kelvin wave, (b) WMRG, (c) R1 and (d) R2, in (left) Perfect forecast dataset, (middle) Real-time wave-dataset and (right) Real-time wave-dataset with previous 30-day mean removed for day 0-7.

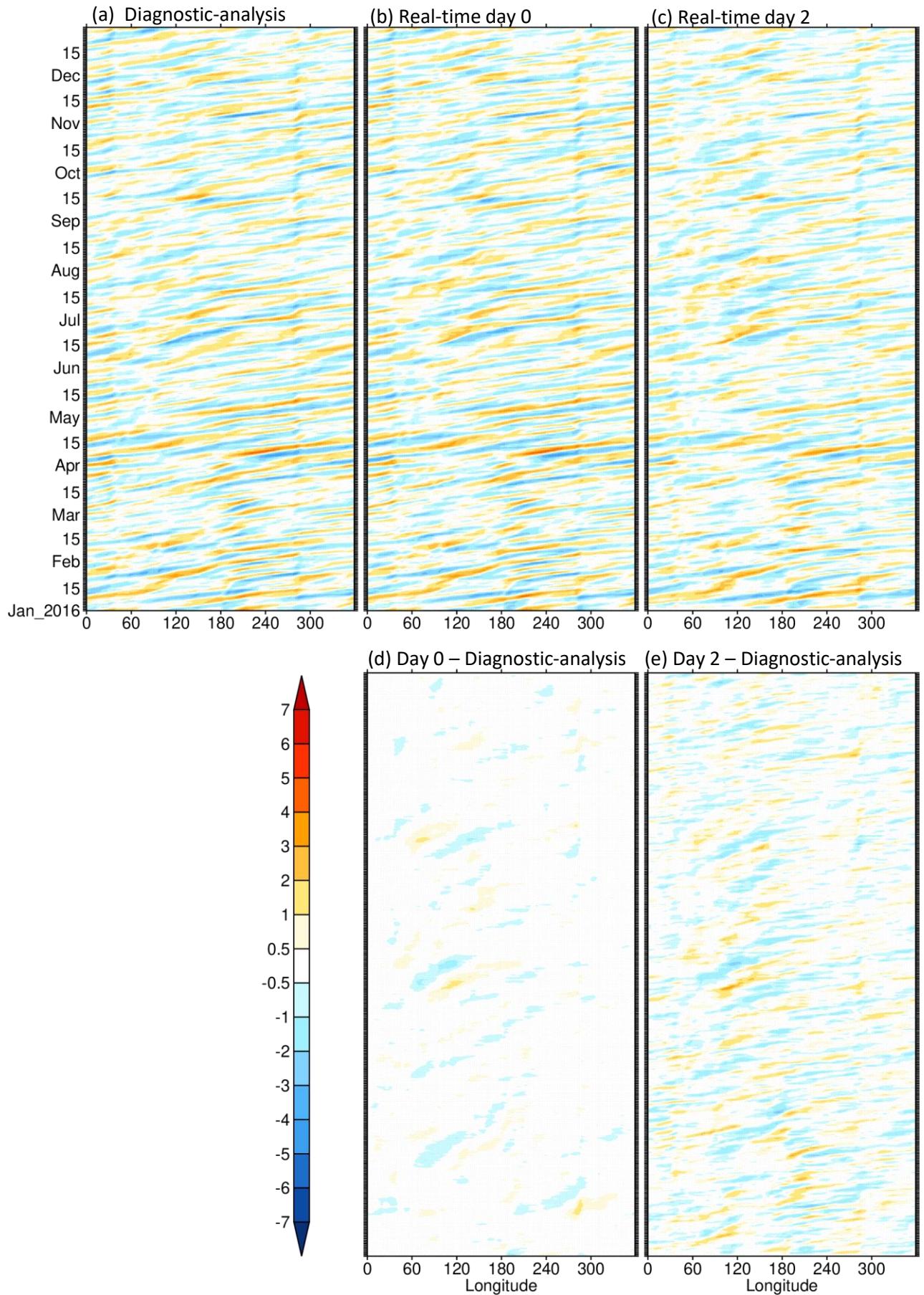


Fig.7 As for Fig.4 but for 850-hPa Kelvin wave equatorial u with the previous 30-day mean of the u being removed for day 0-7 in Real-time wave-dataset to reduce the systematic error in the forecast.

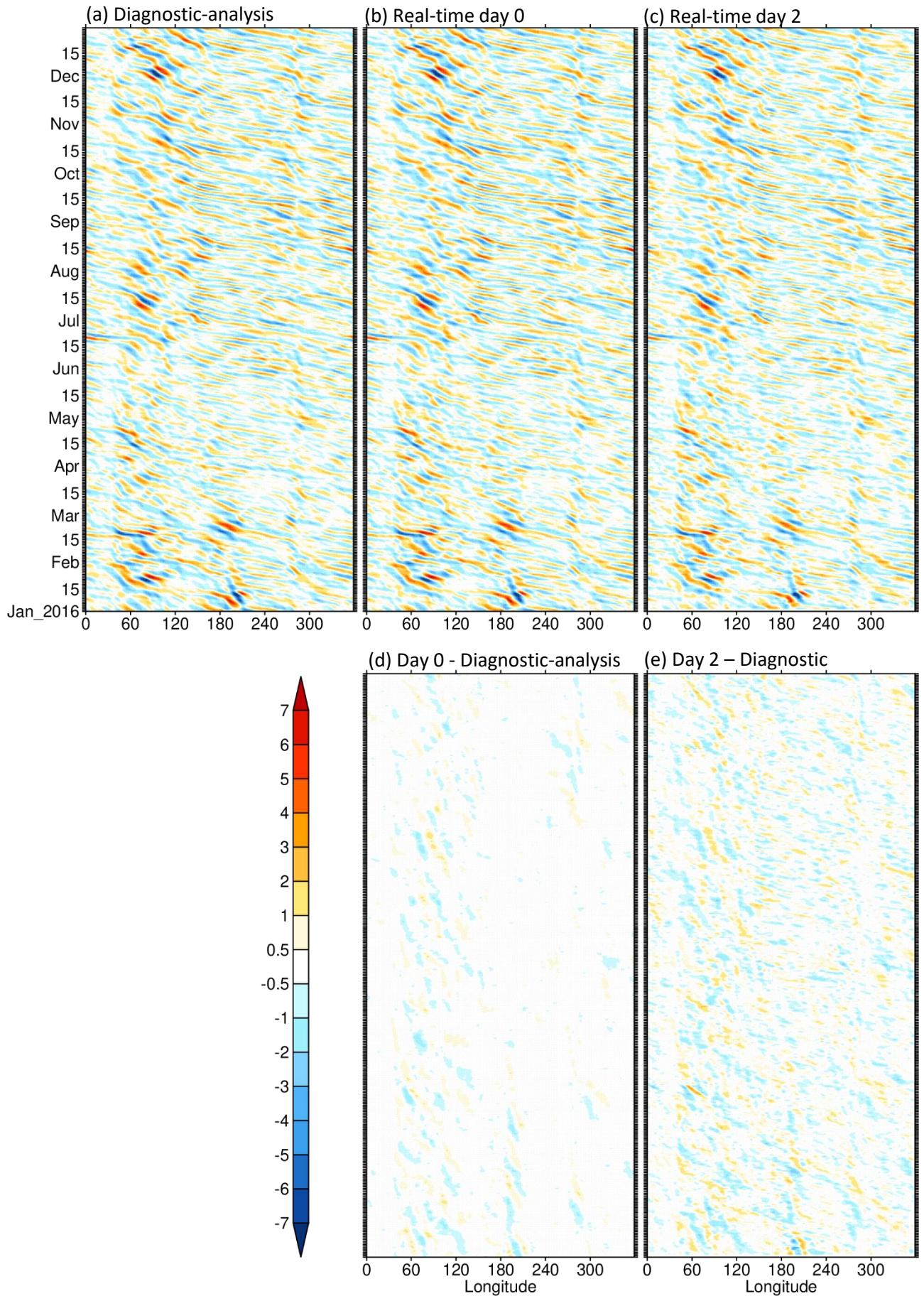


Fig.8 As for Fig.4 but for 850-hPa WMRG equatorial v with previous 30-day mean removed for day 0-7 in Real-time wave-dataset.

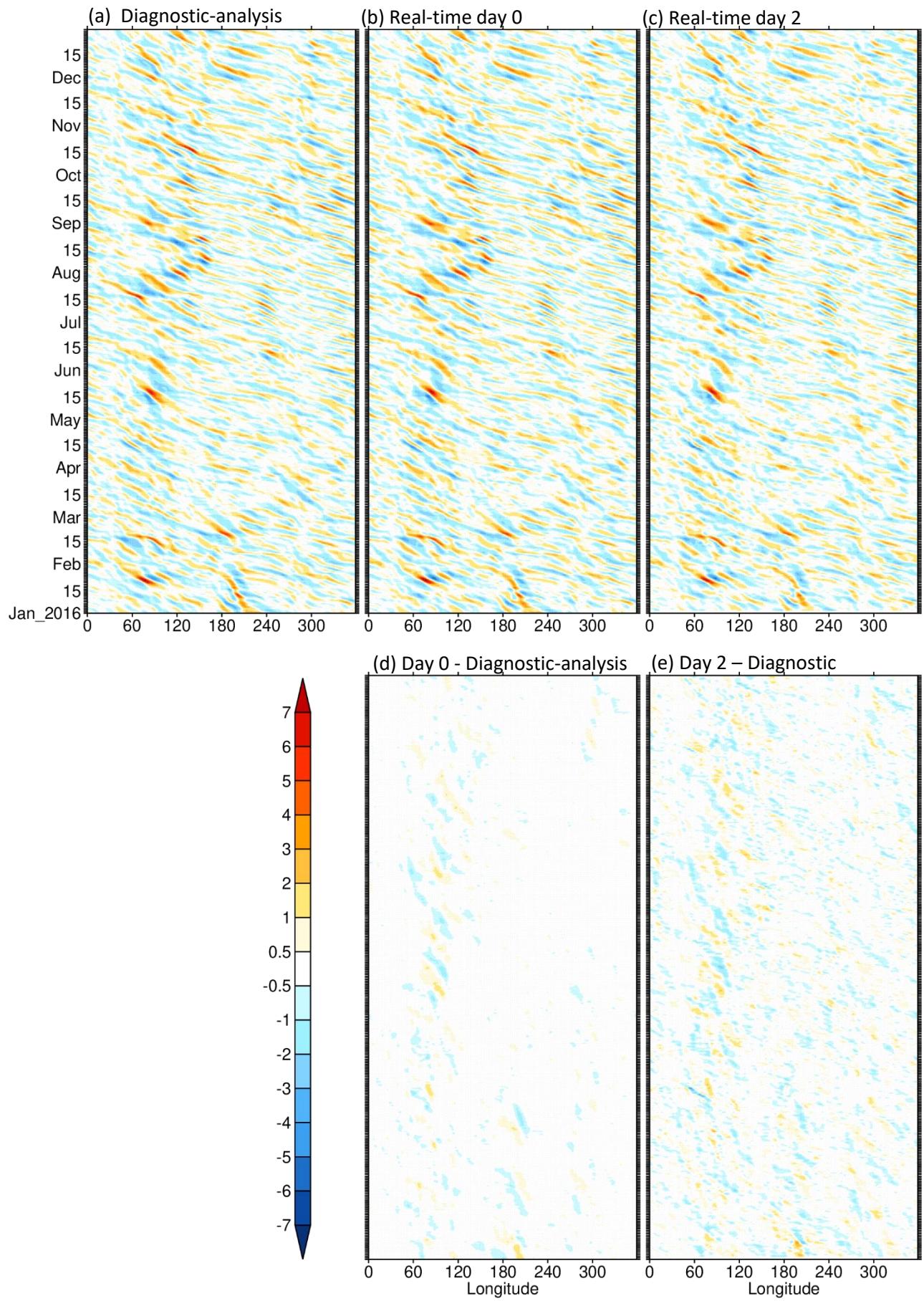


Fig.9 As for Fig.4 but for 850-hPa R1 wave off equatorial v at 80°N with previous 30-day mean removed for day 0-7 in Real-time wave-dataset.

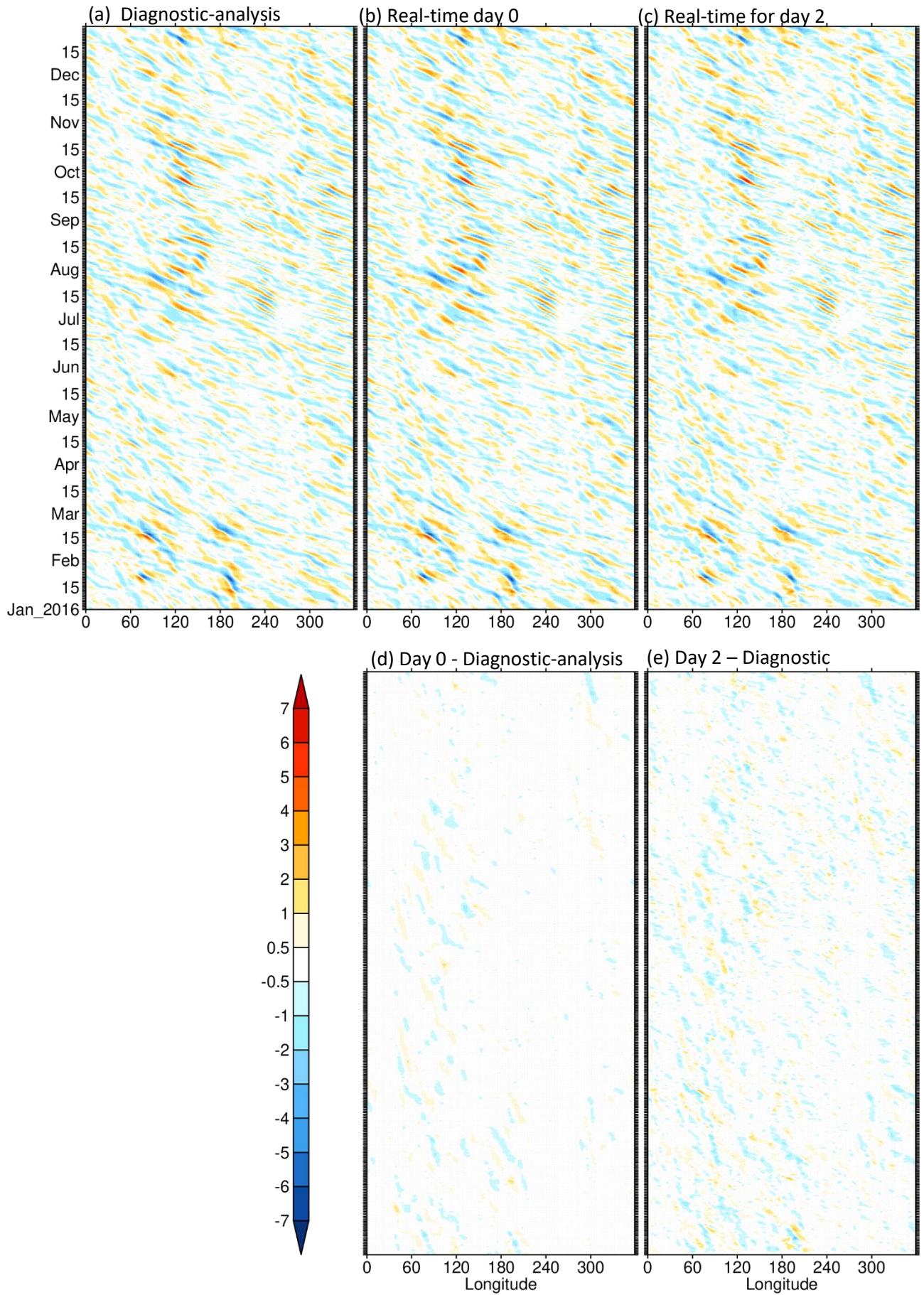


Fig.10 As for Fig.4 but for 850-hPa R2 wave off equatorial v at 13°N with previous 30-day mean removed for day 0-7 in Real-time wave-dataset.

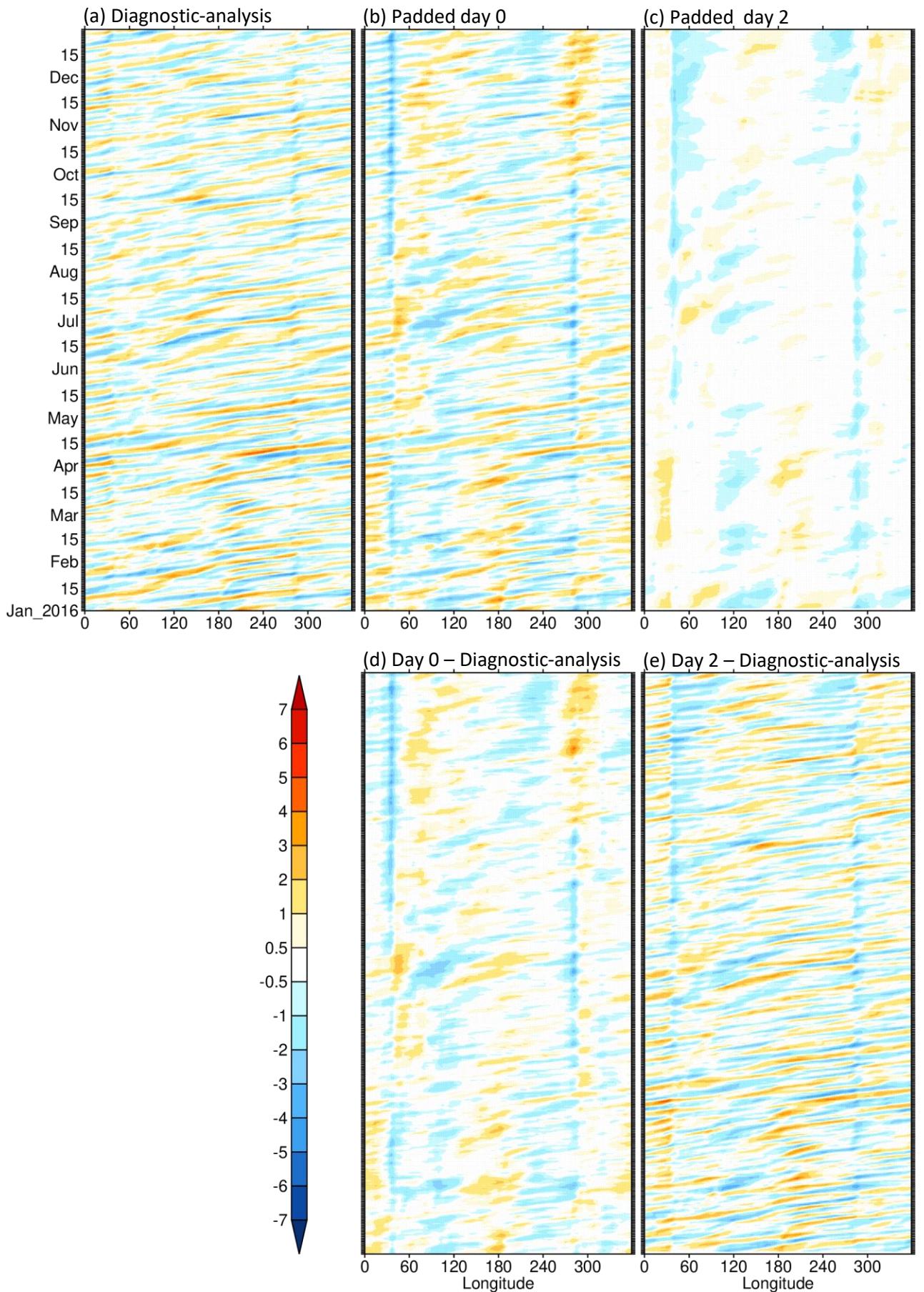


Fig.11 As for Fig.4 but for Kelvin wave equatorial u identified form Padded dataset.

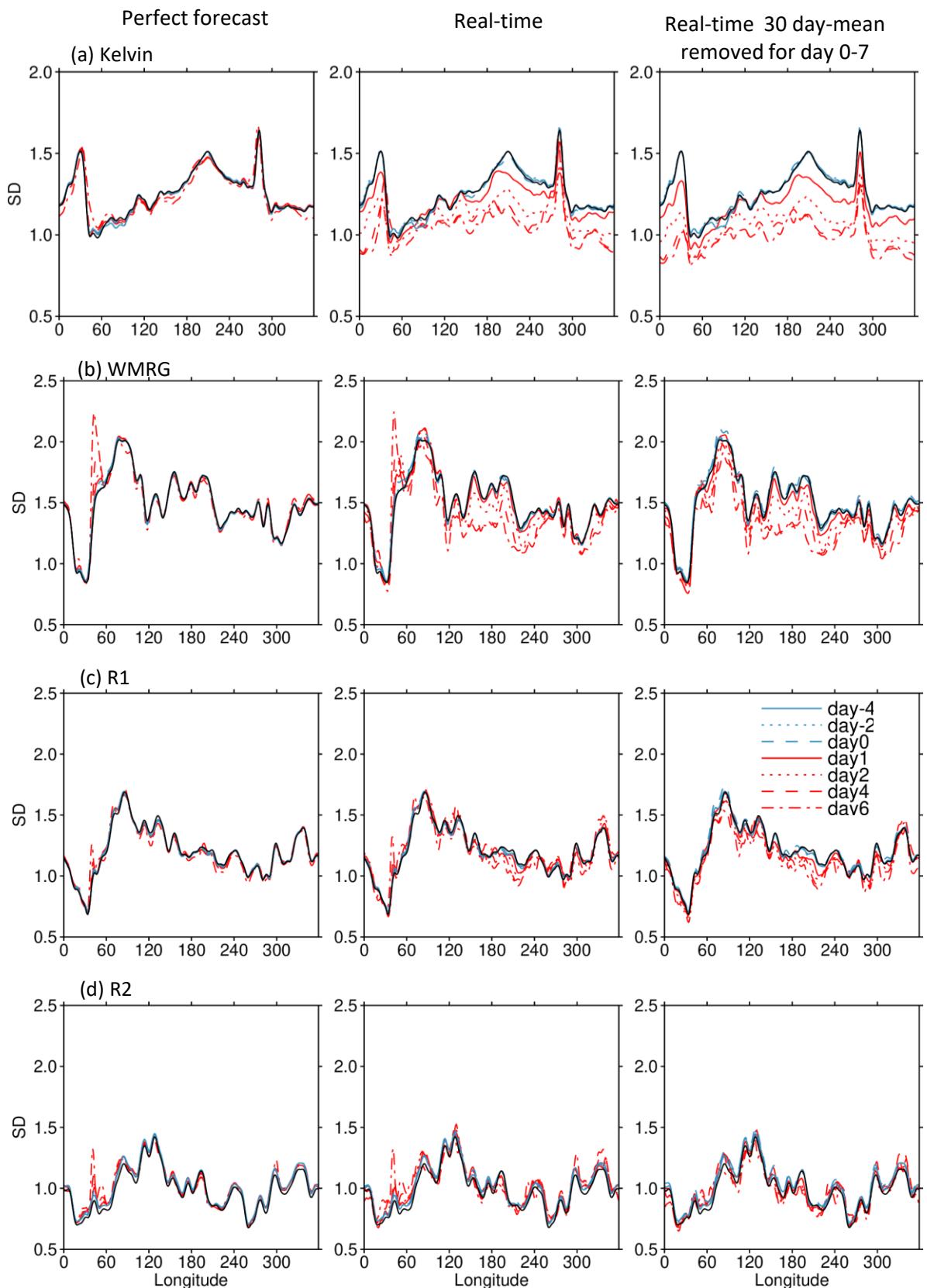


Fig.12 Standard deviations of winds versus longitude for (a) Kelvin wave, (b) WMRG, (c) R1 and (d) R2, in (left) Perfect forecast dataset, (middle) Real-time wave-dataset and (right) Real-time wave-dataset with previous 30-day mean removed for day 0-7.

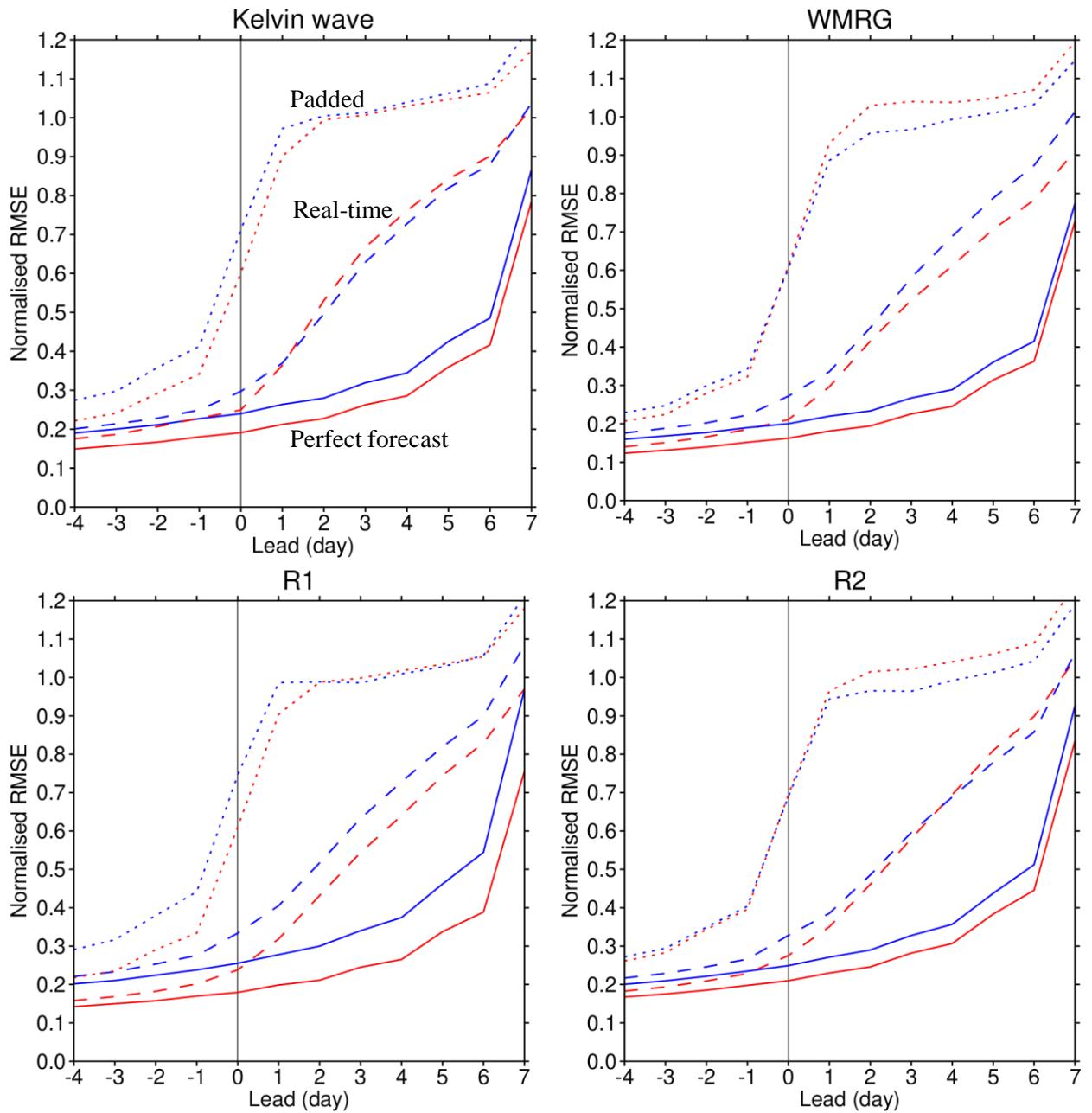


Fig. 13 Standardised root mean square errors (RMSE, divided by the standard deviations of Diagnostic-analysis) for waves at 850 hPa (red) and 200 hPa (blue) in 2016 for Perfect forecast dataset (solid), Real-time wave-dataset (dashed) and Padded dataset (dotted).

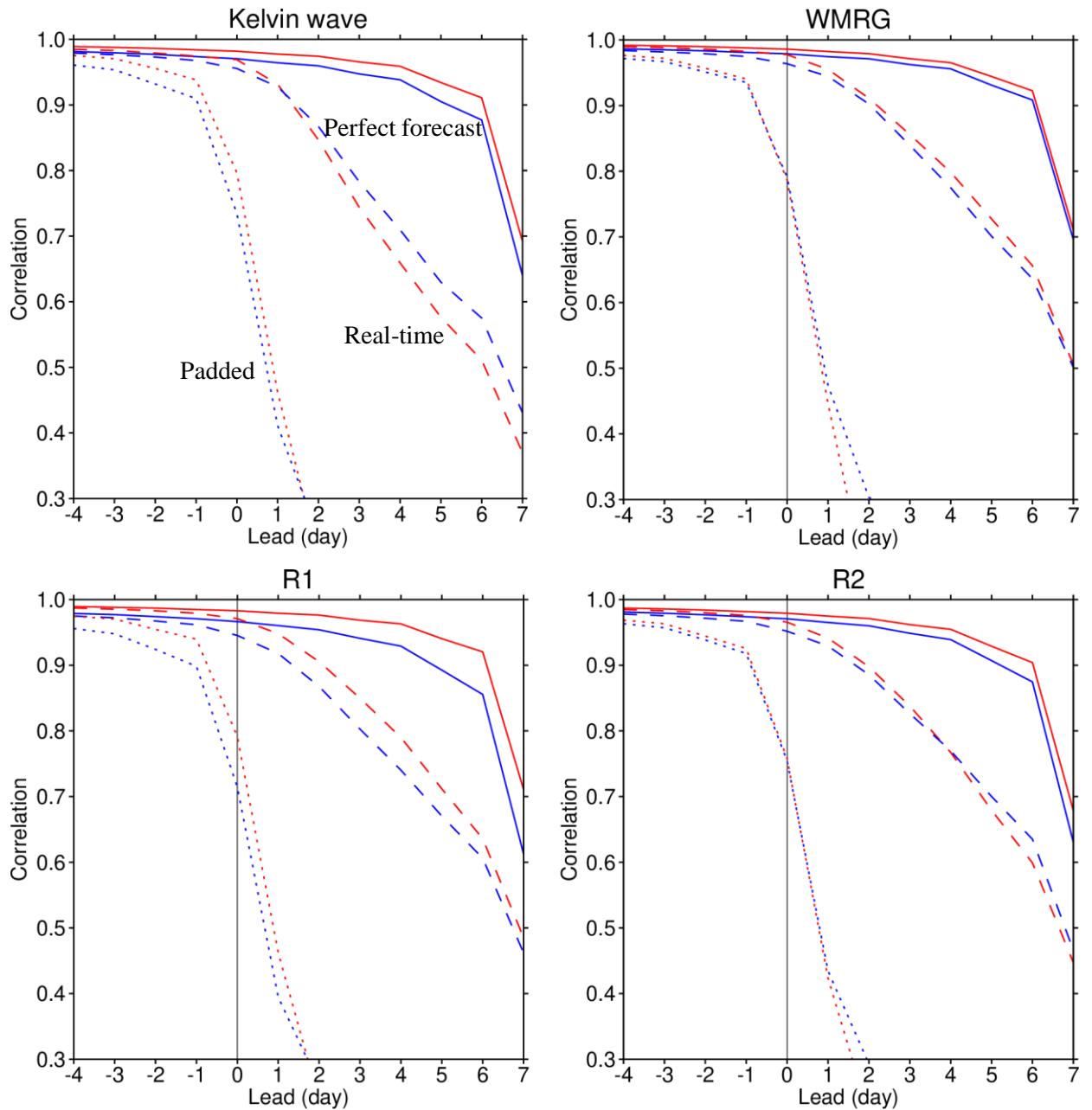


Fig.14 Correlations of waves in 2016 identified in Perfect forecast dataset (solid), Real-time wave-dataset (dashed) and Padded dataset (dotted) with those in Diagnostic-analysis at 850 hPa (red) and 200 hPa (blue).