

Supplementary materials

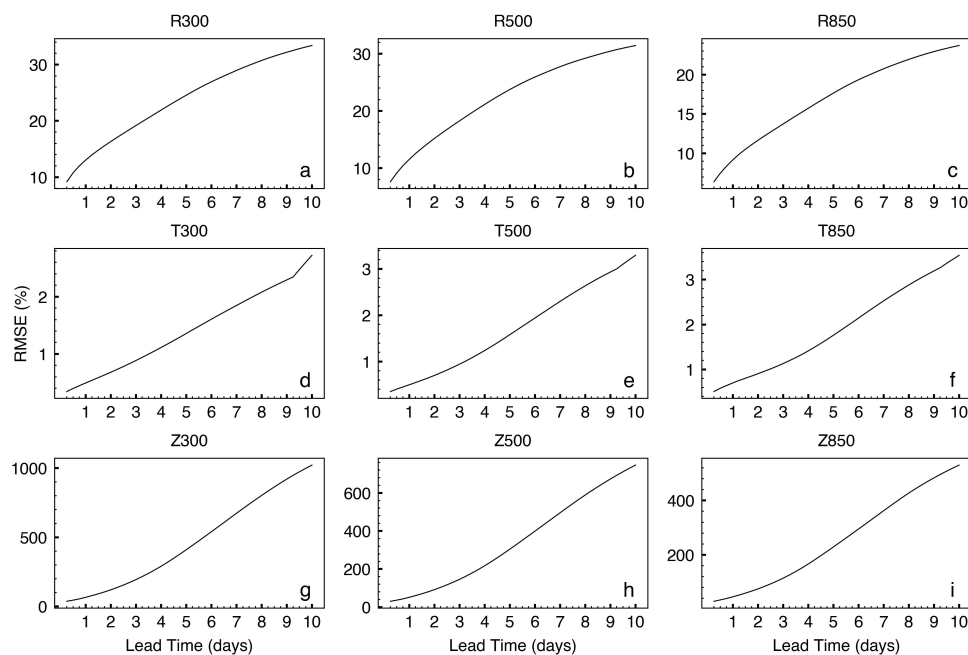


Fig. S1 The time-averaged globally-averaged latitude-weighted RMSE of EXP_CTRL for R300 (a), R500 (b), R850 (c), T300 (d), T500 (e), T850 (f), Z300 (g), Z500 (h), and Z850 (i) in 10-day forecasts.

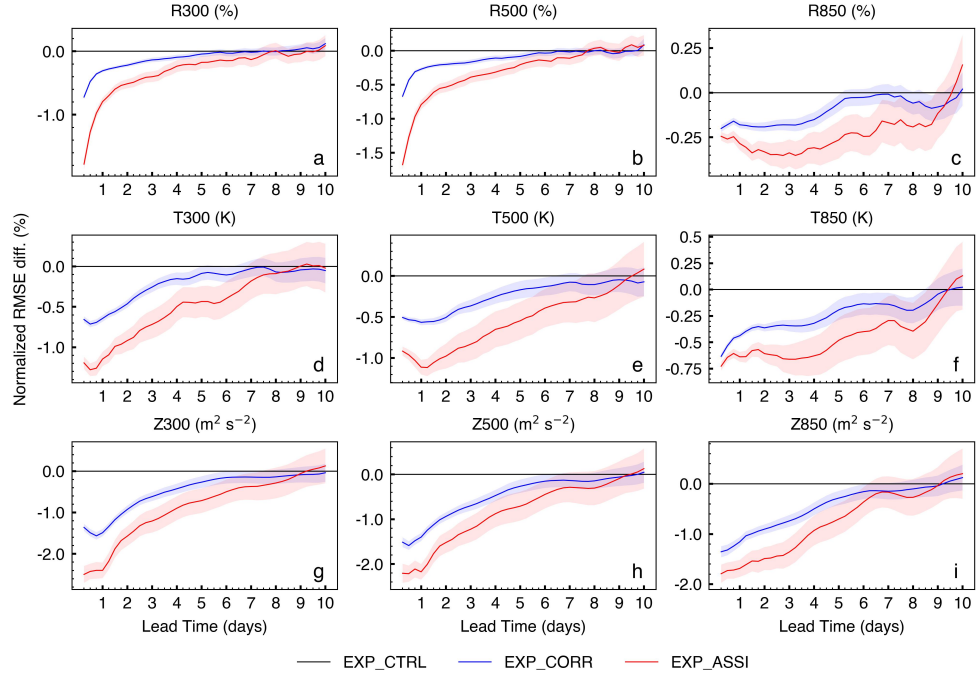


Fig. S2 Comparison of 10-day forecasts after a single assimilation for Northern Hemisphere (20°N-90°N). a to i The time-averaged normalized RMSE difference of EXP_CTRL, EXP_CORR and EXP_ASSI for R300 (a), R500 (b), R850 (c), T300 (d), T500 (e), T850 (f), Z300 (g), Z500 (h), and Z850 (i). The shaded areas represent 95% confidence intervals of the t-test.

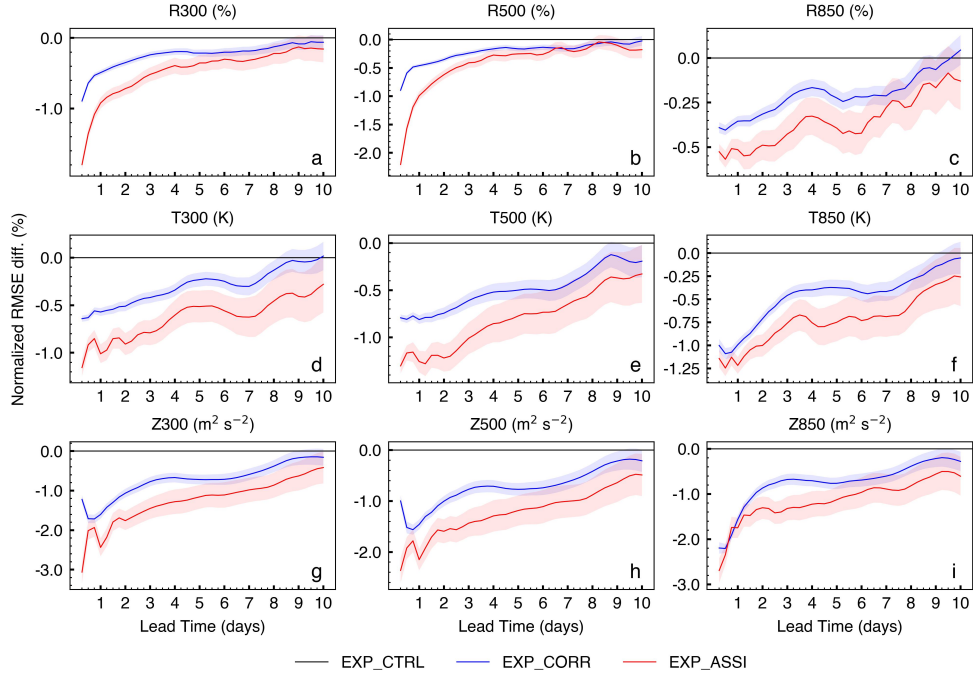


Fig. S3 Comparison of 10-day forecasts after a single assimilation for Southern Hemisphere (90°S - 20°S). a to i The time-averaged normalized RMSE difference of EXP_CTRL, EXP_CORR and EXP_ASSI for R300 (a), R500 (b), R850 (c), T300 (d), T500 (e), T850 (f), Z300 (g), Z500 (h), and Z850 (i). The shaded areas represent 95% confidence intervals of the t-test.

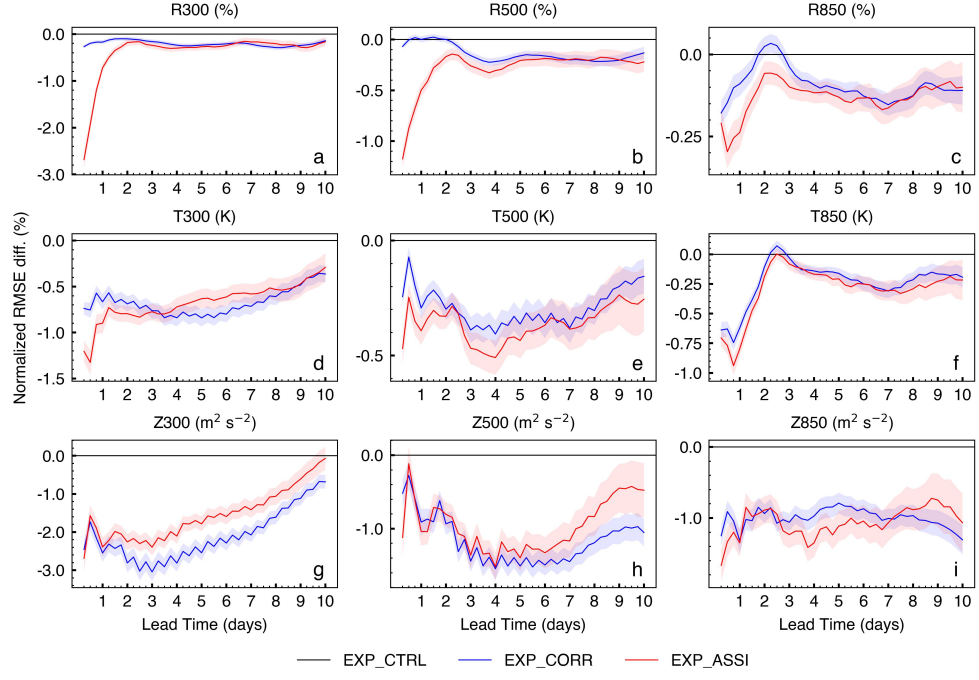


Fig. S4 Comparison of 10-day forecasts after a single assimilation for Tropics (20°S-20°N). a to i The time-averaged normalized RMSE difference of EXP_CTRL, EXP_CORR and EXP_ASSI for R300 (a), R500 (b), R850 (c), T300 (d), T500 (e), T850 (f), Z300 (g), Z500 (h), and Z850 (i). The shaded areas represent 95% confidence intervals of the t-test.

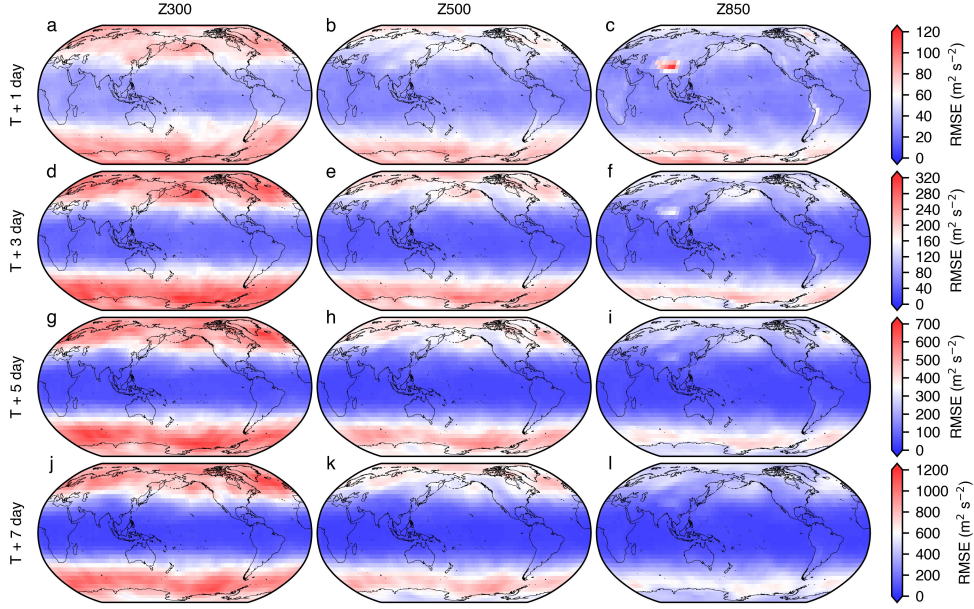


Fig. S5 Visualization of spatial distribution of the time-averaged RMSE for geopotential forecasts. (a, b, and c) The spatial distribution of the time-averaged RMSE for Z300 (a), Z500 (b), and Z850 (c) at forecast lead times of 1 day. (d, e, and f) The spatial distribution of the time-averaged RMSE for Z300 (d), Z500 (e), and Z850 (f) at forecast lead times of 3 day. (g, h, and i) The spatial distribution of the time-averaged RMSE for Z300 (g), Z500 (h), and Z850 (i) at forecast lead times of 5 day. (j, k, and l) The spatial distribution of the time-averaged RMSE for Z300 (j), Z500 (k), and Z850 (l) at forecast lead times of 7 day. The global domain is divided into 36×72 smaller regions, each with a $5^\circ \times 5^\circ$ range, within which the regionally-averaged latitude-weighted RMSE is computed.

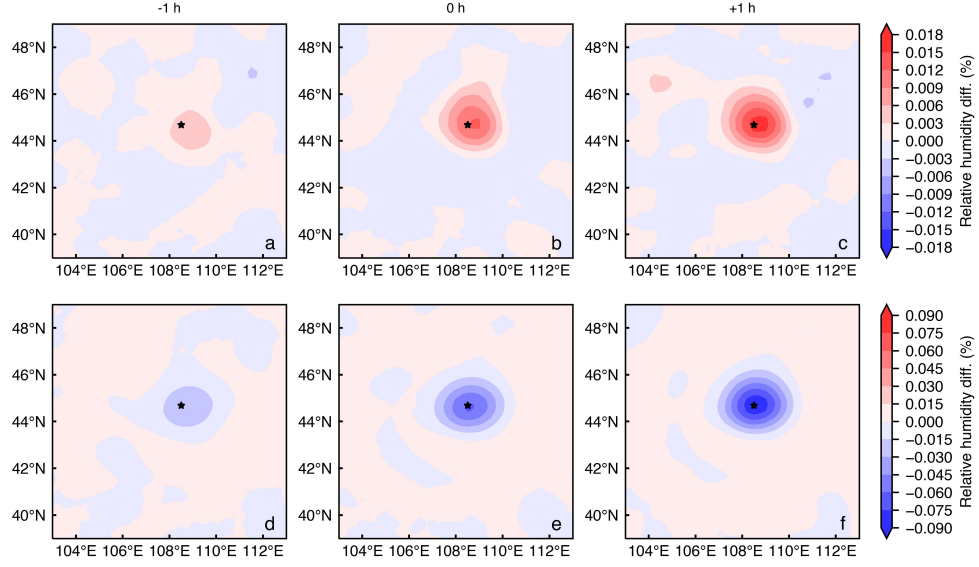


Fig. S6 The analysis increment of relative humidity resulting from introducing a perturbation to channel 9 for the clear observation (pentagram). a, b, c Horizontal distribution of R300 increments resulting from introducing a perturbation of -1 K at the beginning (a), middle (b), and end (c) of the assimilation time window. d, e, f Horizontal distribution of R300 increments resulting from introducing a perturbation of 5 K at the beginning (d), middle (e), and end (f) of the assimilation time window.

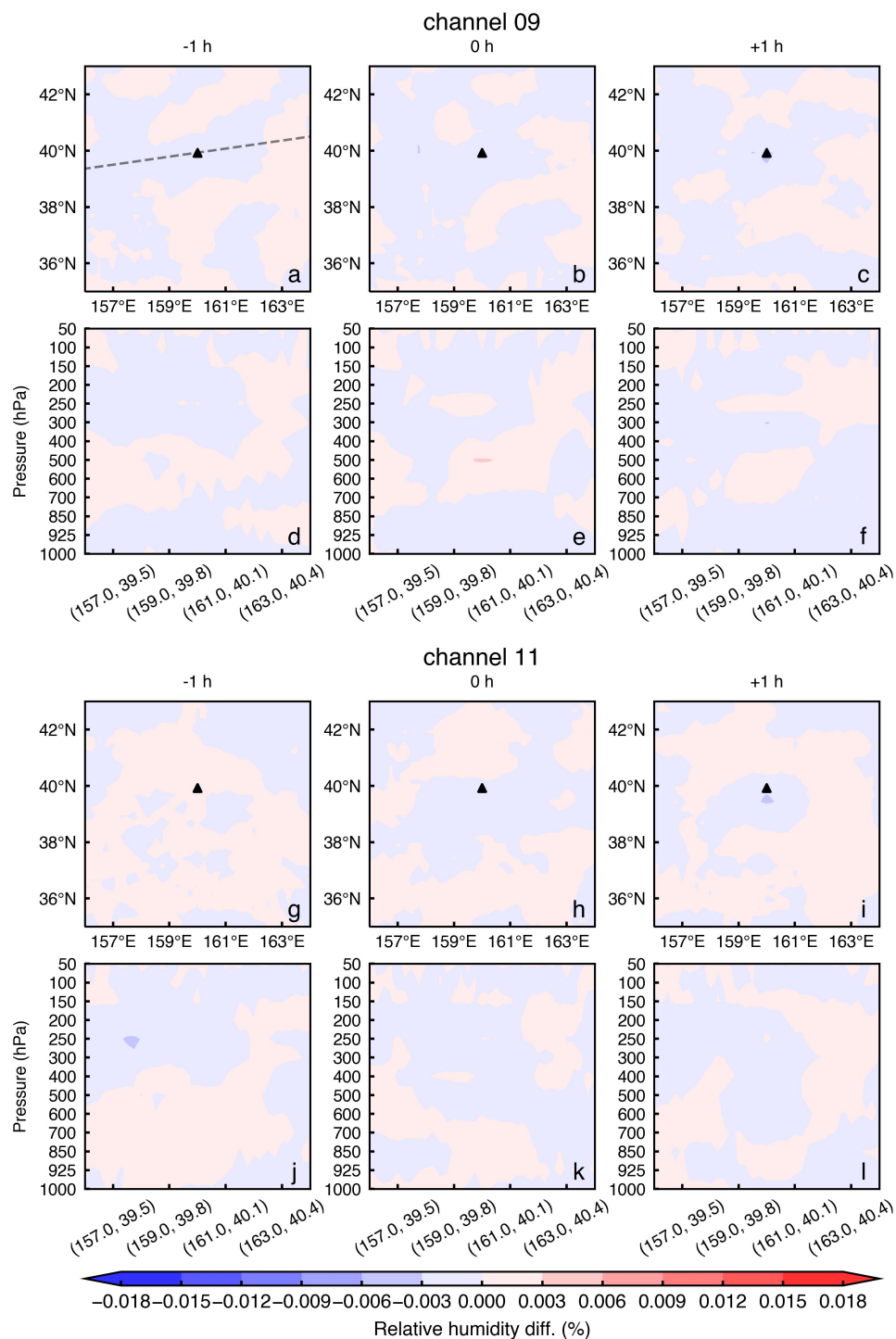


Fig. S7 The analysis increment of relative humidity resulting from introducing a perturbation of 1 K to the cloudy observation (triangle). a, b, c Horizontal distribution of R300 increments resulting from introducing a perturbation to channel 9 at the beginning (a), middle (b), and end (c) of the assimilation time window. d, e, and f Vertical distribution of relative humidity increments resulting from introducing a perturbation to channel 9 at the beginning (d), middle (e), and end (f) of the assimilation time window, obtained from a cross-section delineated by the dashed lines in (a). g, h, i Horizontal distribution of R300 increments resulting from introducing a perturbation to channel 11 at the beginning (g), middle (h), and end (i) of the assimilation time window. j, k, and l Vertical distribution of relative humidity increments resulting from introducing a perturbation to channel 11 at the beginning (j), middle (k), and end (l) of the assimilation time window, obtained from a cross-section delineated by the dashed lines in (a).

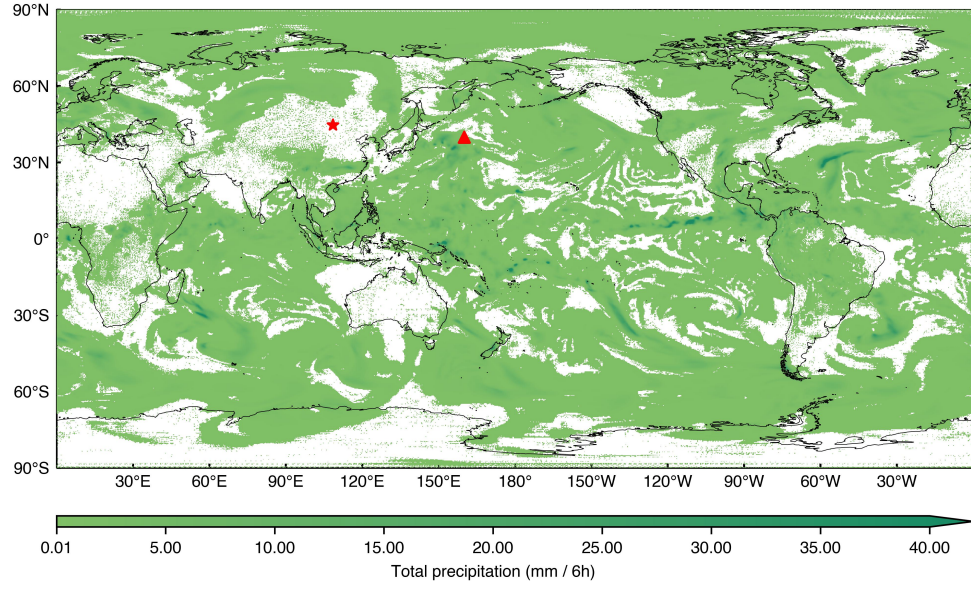


Fig. S8 Visualization of spatial distributions of total precipitation and the selected observation locations at 00:00 on October 26, 2023. The pentagram symbol represents observation under clear-sky condition, while the triangle symbol represents observation under cloudy condition.

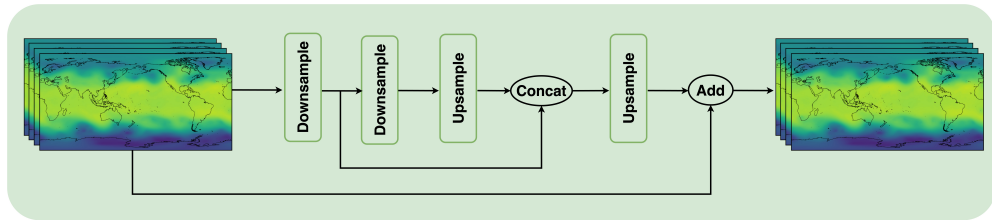


Fig. S9 Model architecture of the EXP.CORR experiment.