Supplement of Weather Clim. Dynam., 7, 1837–1852, 2026
https://doi.org/10.5194/wcd-7-1837-2026-supplement

Supplement of

Spread/error relationship and spatial error representation in precipitation nowcasting: comparison of STEPS and generative AI

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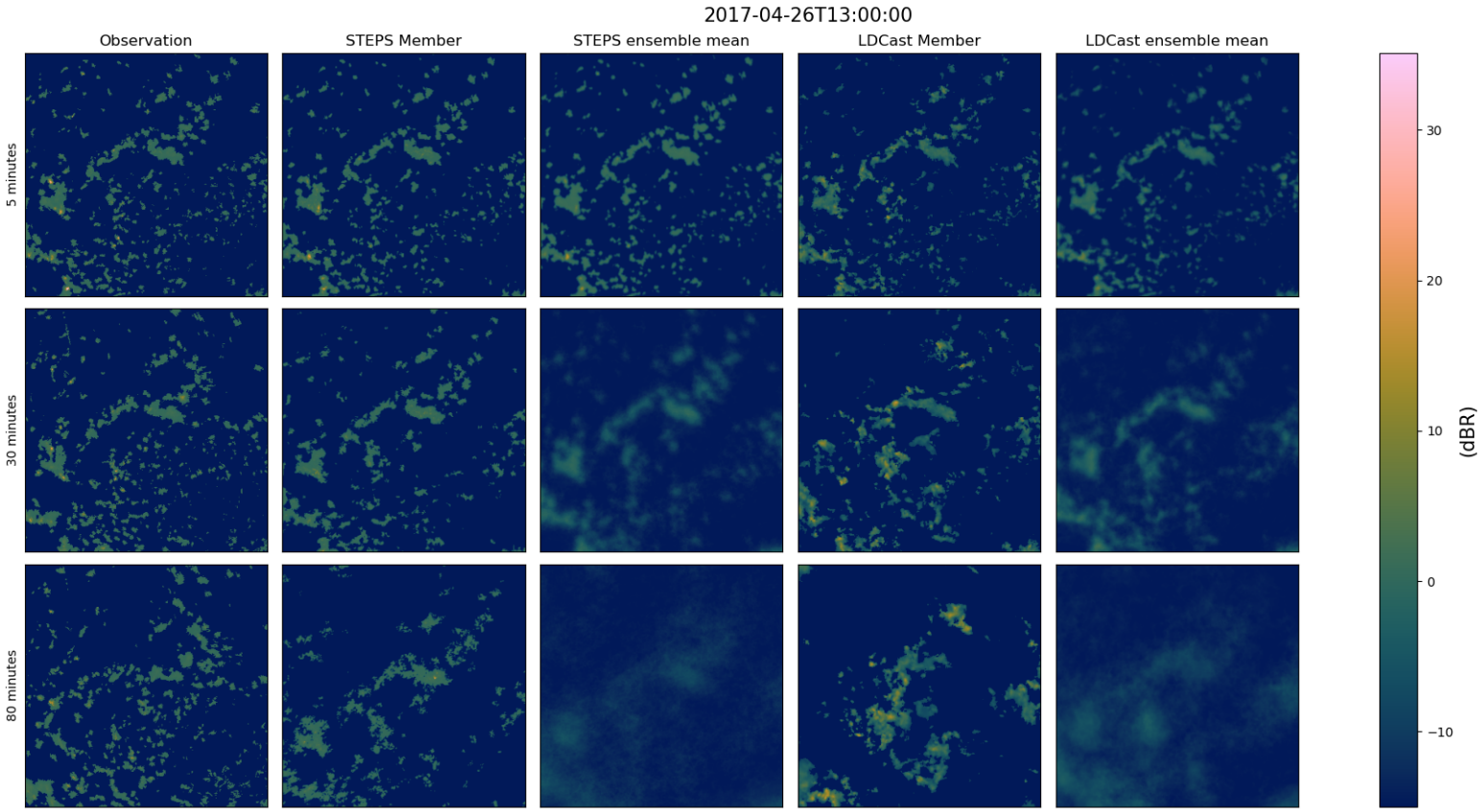

Figure S1: Examples of nowcasts in the convective case: observations in the first column, an example of a STEPS ensemble member in the second column, the STEPS ensemble mean in the third column, an example of a LDCast ensemble member in the fourth column and the LDCast ensemble mean in the fifth column.

S1 Examples of nowcasts

This Section presents Figures of STEPS and LDCast nowcasts, as well as ensemble standard deviation as a function of space for one convective event (Fig. S1 and Fig. S2) and one stratiform event (Fig. S3 and Fig. S4).

In Figs. S2 and S4, the pixels in the ensemble mean error field with positive values are those for which the ensemble mean underestimated the rain, while the pixels with negative values are those for which the ensemble mean overestimated the rain. Because of the smoothing of the mean, pixels with underestimated values form sharp structures, while those with overestimated values form smoothed structures.

Here, in contrast with the rest of the work, pixels of STEPS nowcasts for which no value was available were not attributed the observed values. Missing values in STEPS nowcasts were ignored to compute the mean and the standard deviation. The white pixels at the bottom of the second column of Fig. S3 are pixels for which the displayed member was missing values.

S2 Examples of eigenvectors of ensemble covariance matrices

Examples of eigenvectors of ensemble covariance matrices are presented in this Section, for one convective and one stratiform event, for STEPS and LDCast ensembles and their MAAFT surrogates (Figures S5 to S12). The pixel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ is also displayed to allow a comparison of spatial patterns.

The spatial patterns in the error and in the eigenvectors are the main interest on these Figures, so the subplots do not share the same color scale.

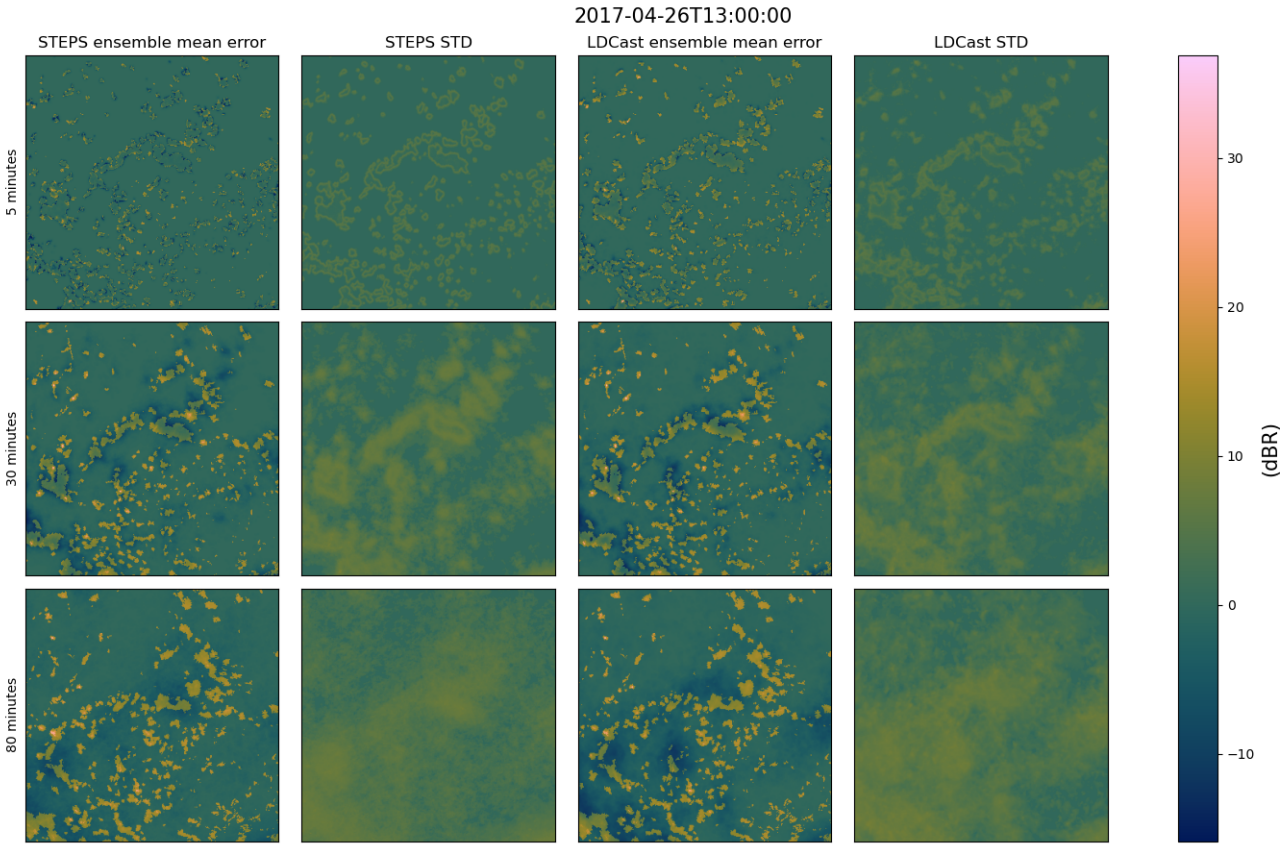

Figure S2: For the convective case: standard deviation in the STEPS ensemble (second column) and the LDCast ensemble (fourth column) as a function of space, compared with the pixel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for STEPS (first column) and for LDCast (third column).

S3 $\cos\gamma(\boldsymbol{e}, \boldsymbol{p})$ for SPEC ensembles

Figure S13 shows the time evolution of $\cos\gamma(\boldsymbol{e}, \boldsymbol{p})$ for SPEC ensembles.

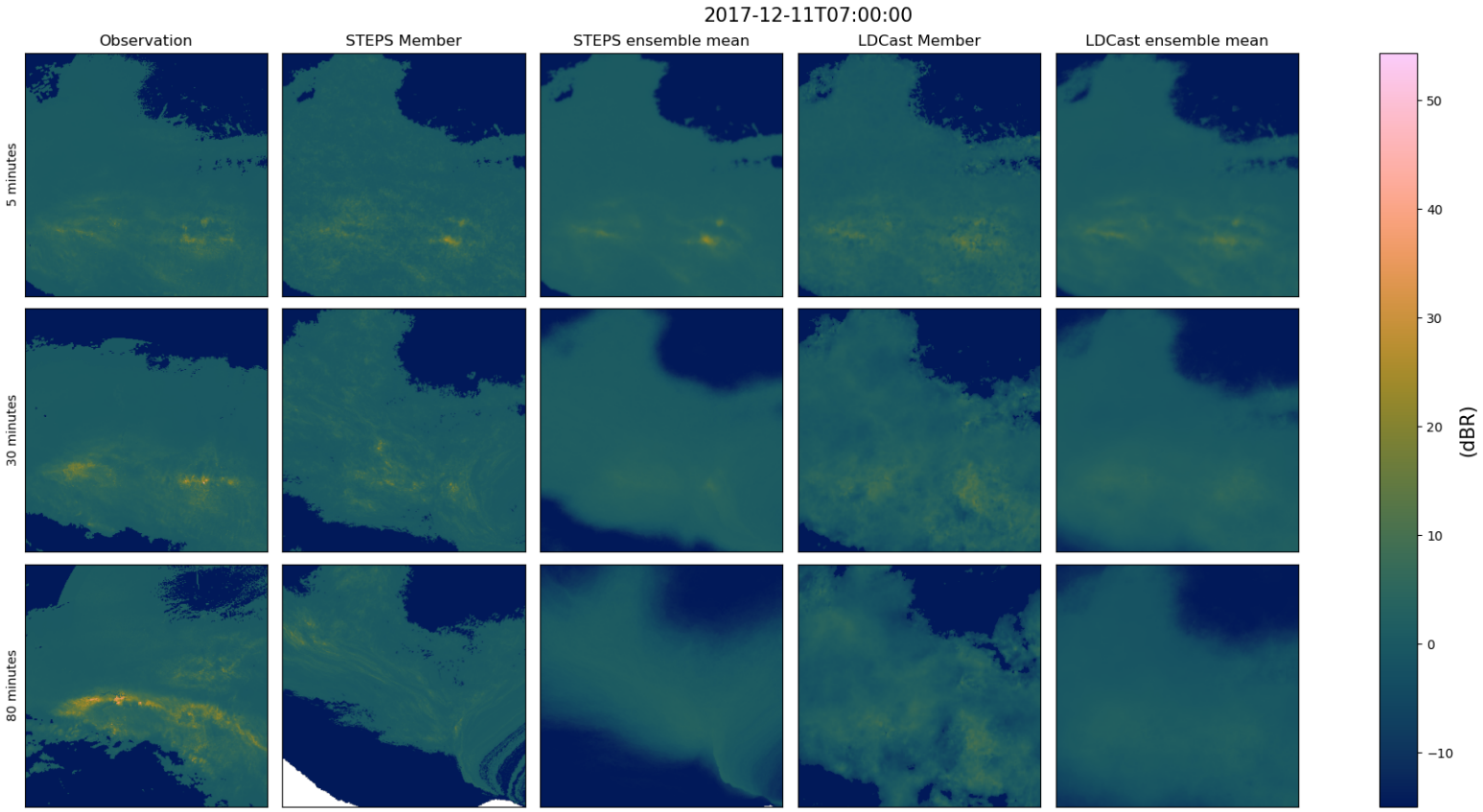

Figure S3: Examples of nowcasts in the stratiform case: observations in the first column, an example of a STEPS ensemble member in the second column, the STEPS ensemble mean in the third column, an example of a LDCast ensemble member in the fourth column and the LDCast ensemble mean in the fifth column. The represented STEPS member lacks values for some pixels.

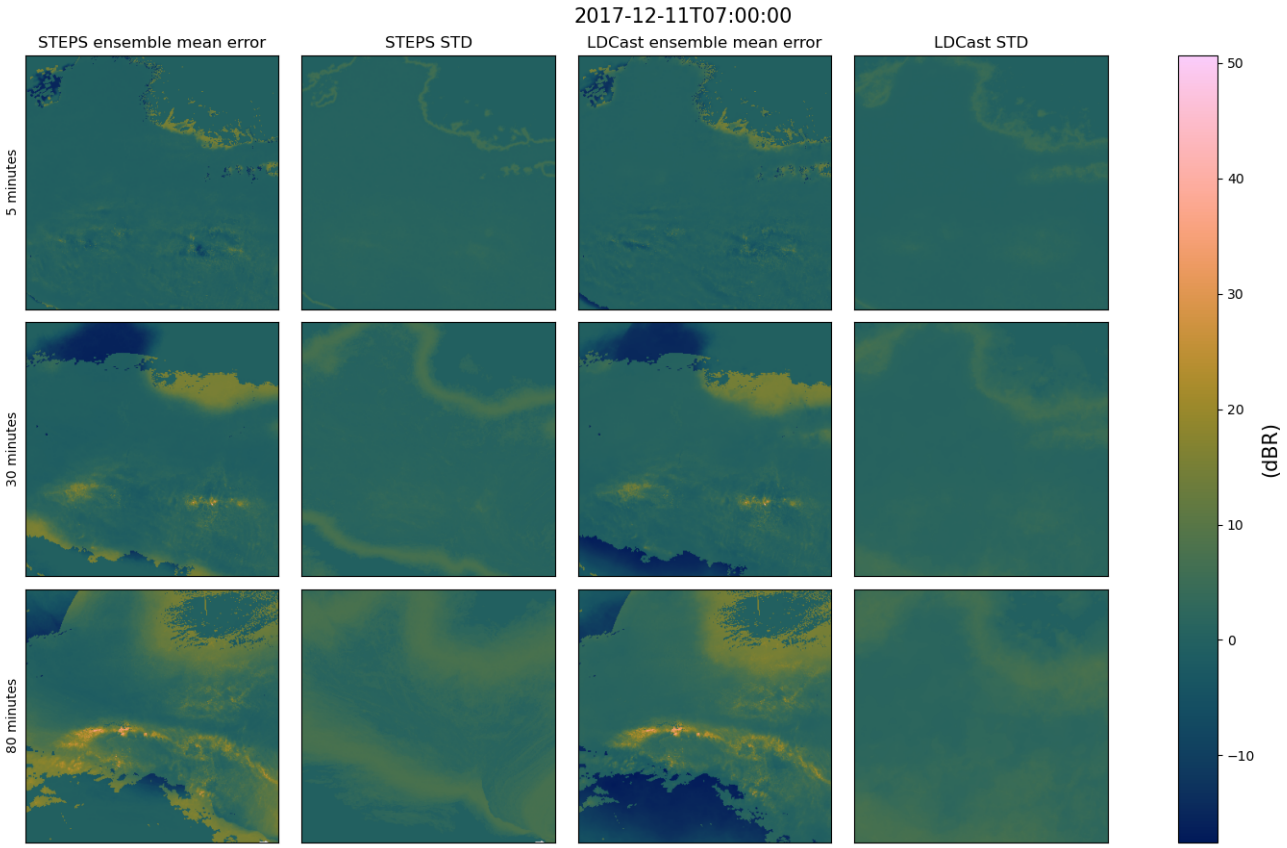

Figure S4: For the stratiform case: standard deviation in the STEPS ensemble (second column) and the LDCast ensemble (fourth column) as a function of space, compared with the pixel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for STEPS (first column) and for LDCast (third column).

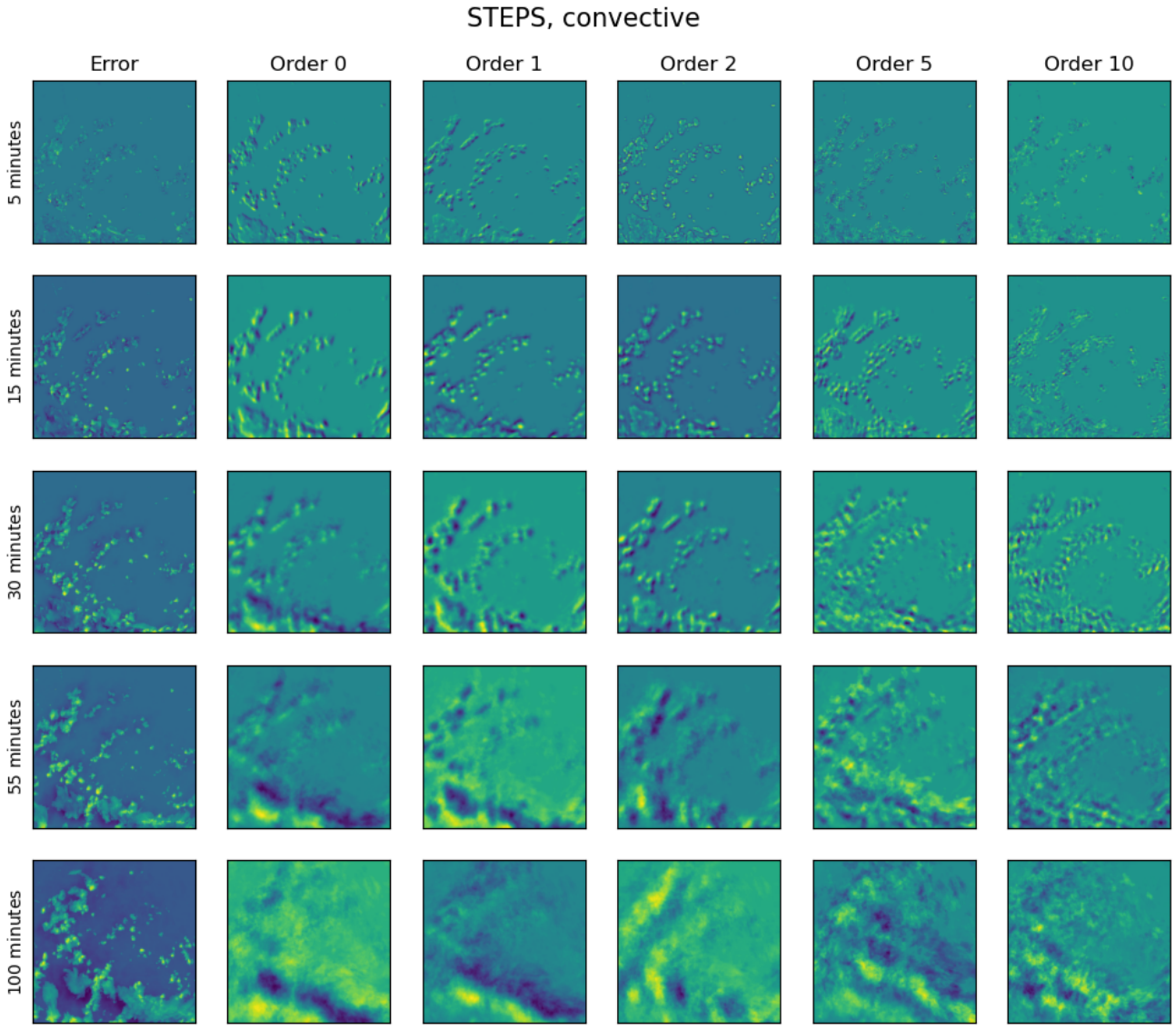

Figure S5: Eigenvectors of a STEPS ensemble covariance matrix for a convective case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

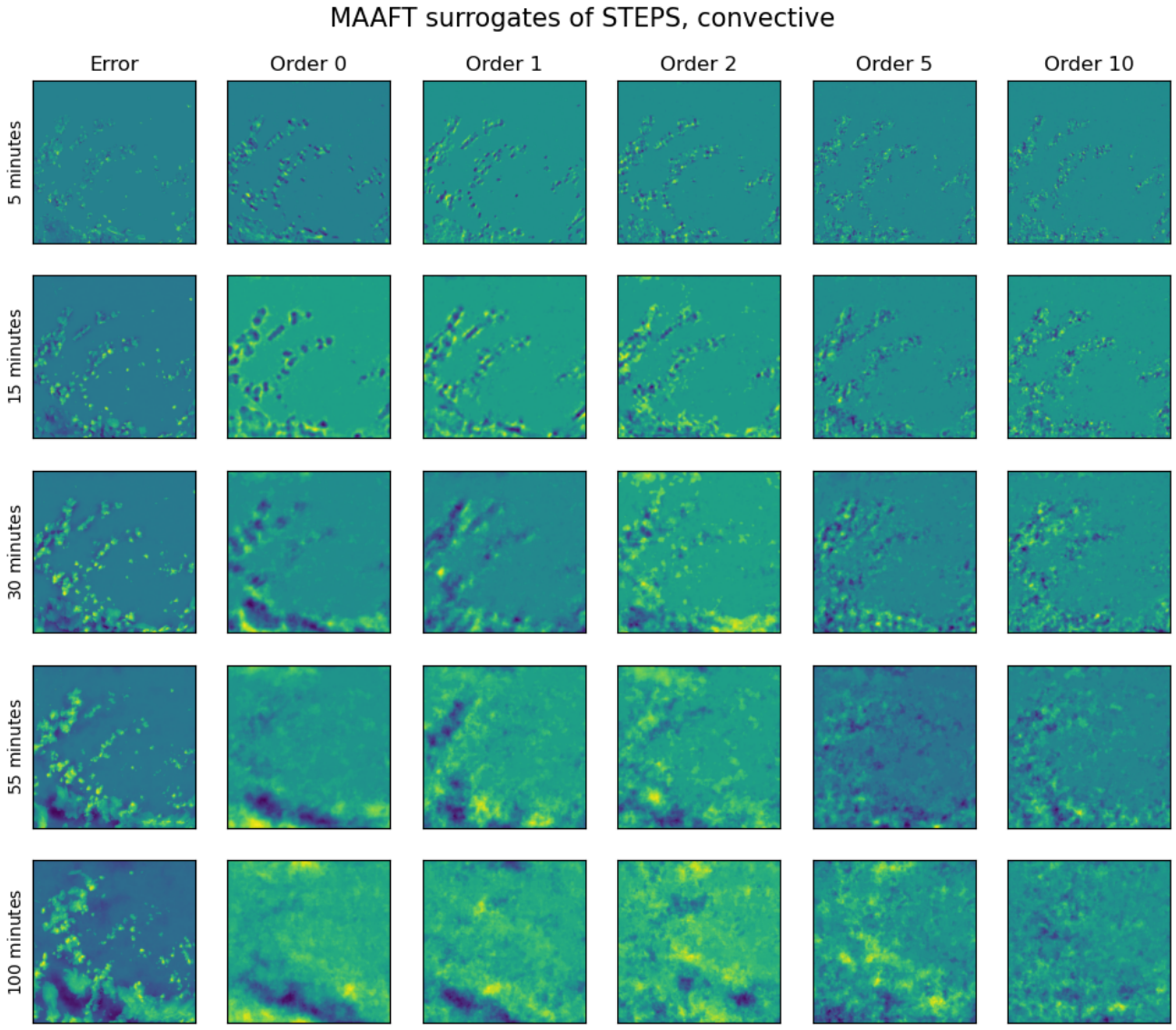

Figure S6: Eigenvectors of a MAAFT STEPS ensemble covariance matrix for a convective case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

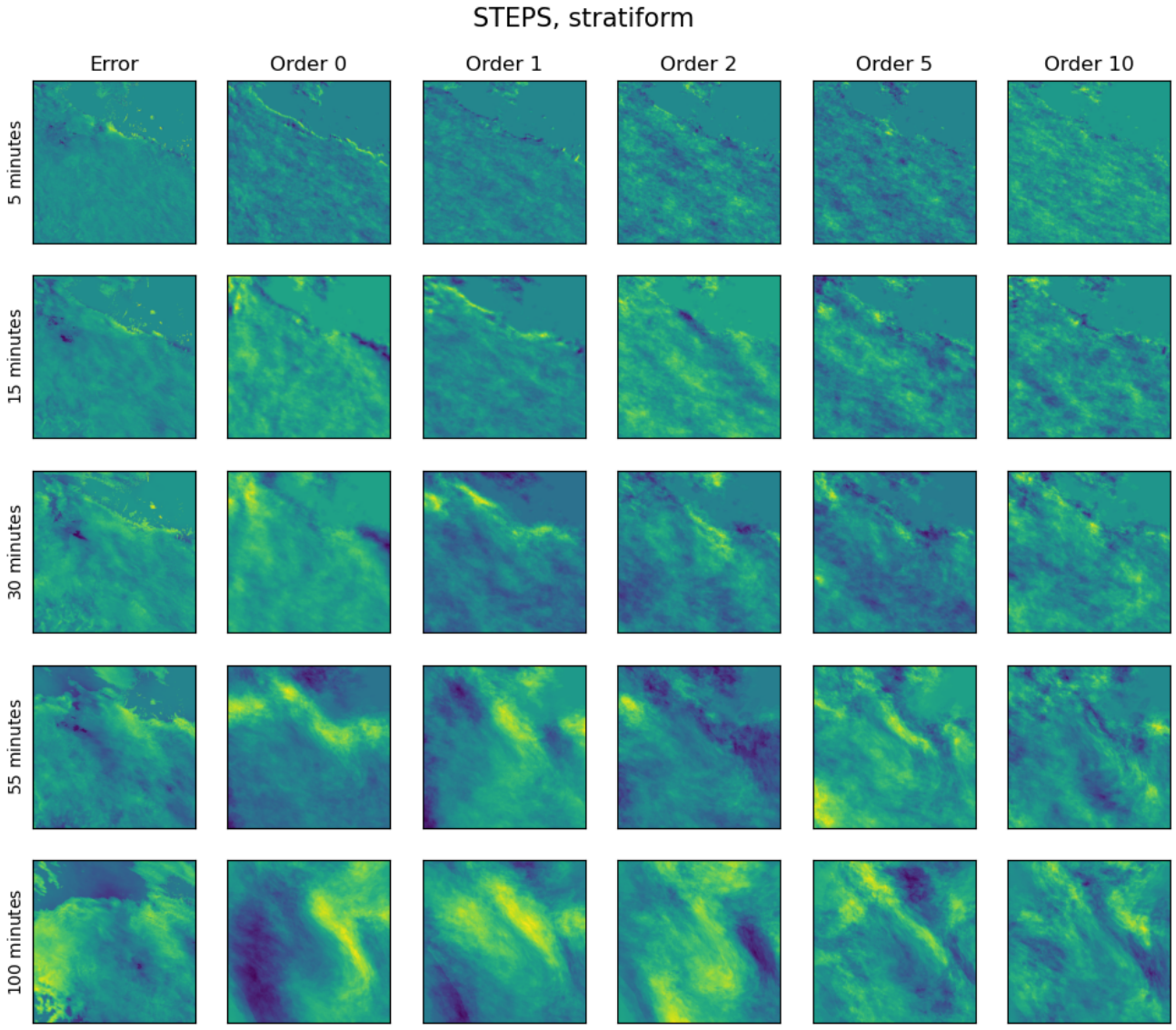

Figure S7: Eigenvectors of a STEPS ensemble covariance matrix for a stratiform case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

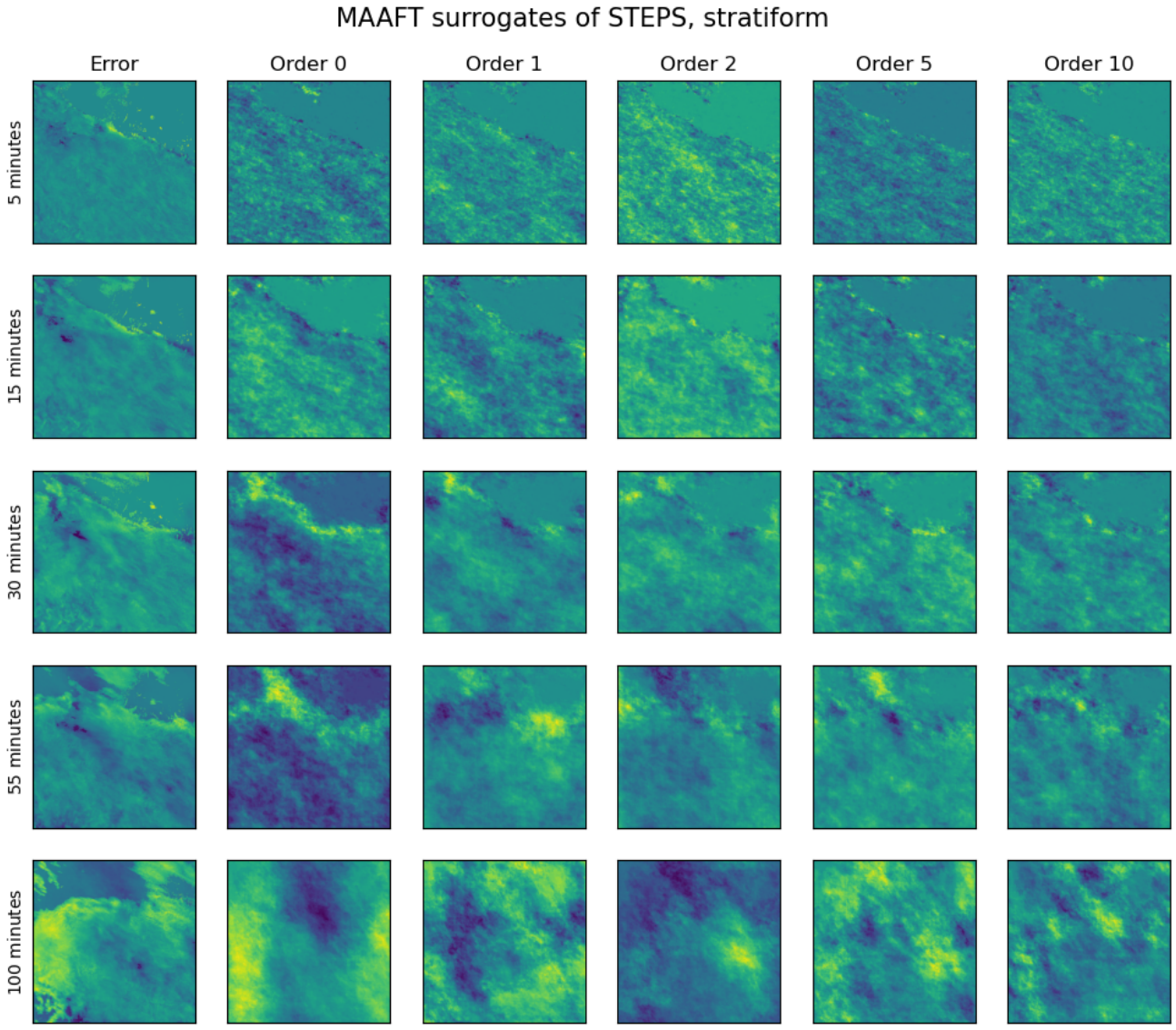

Figure S8: Eigenvectors of a MAAFT STEPS ensemble covariance matrix for a stratiform case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

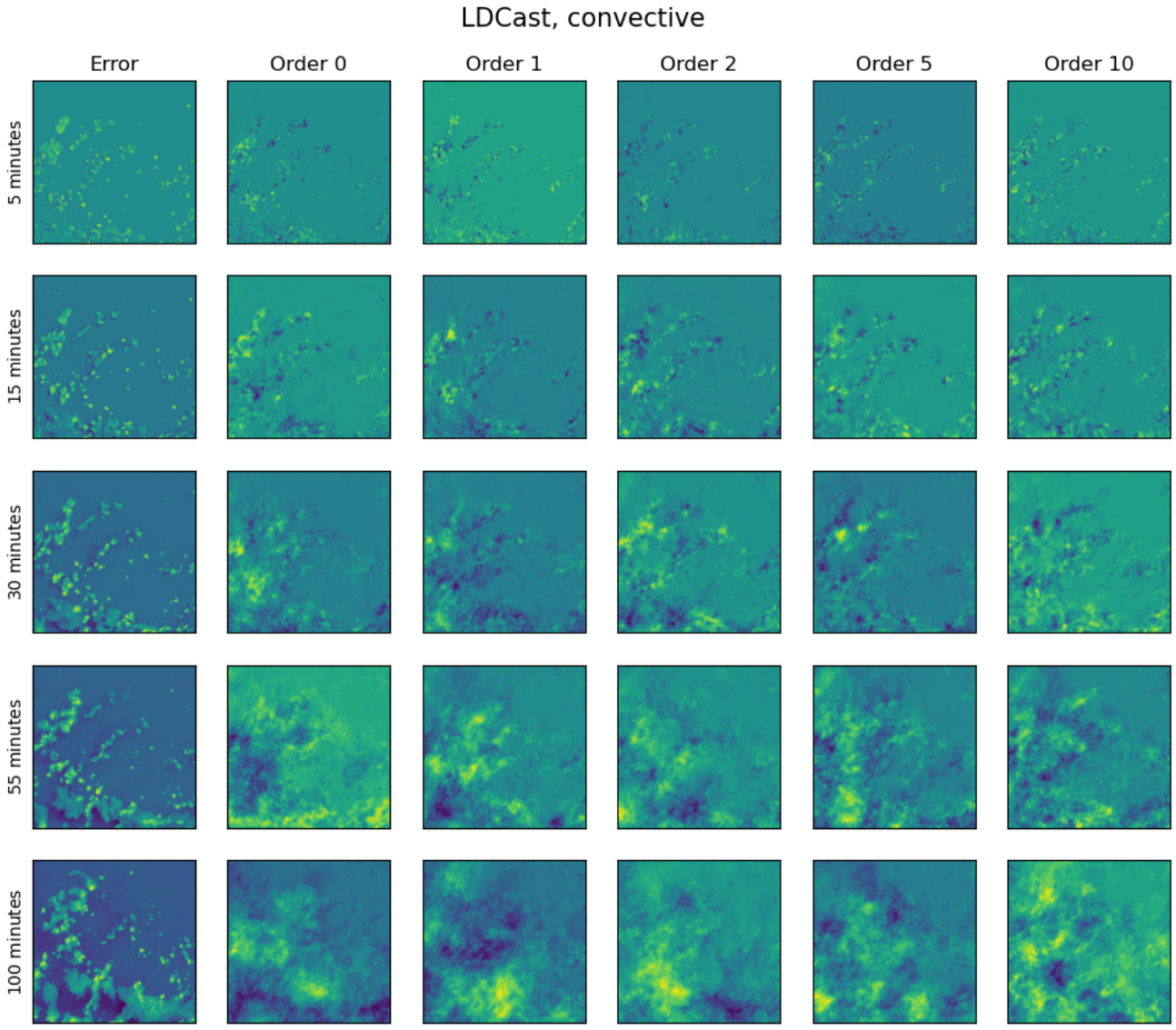

Figure S9: Eigenvectors of a LDCast ensemble covariance matrix for a convective case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

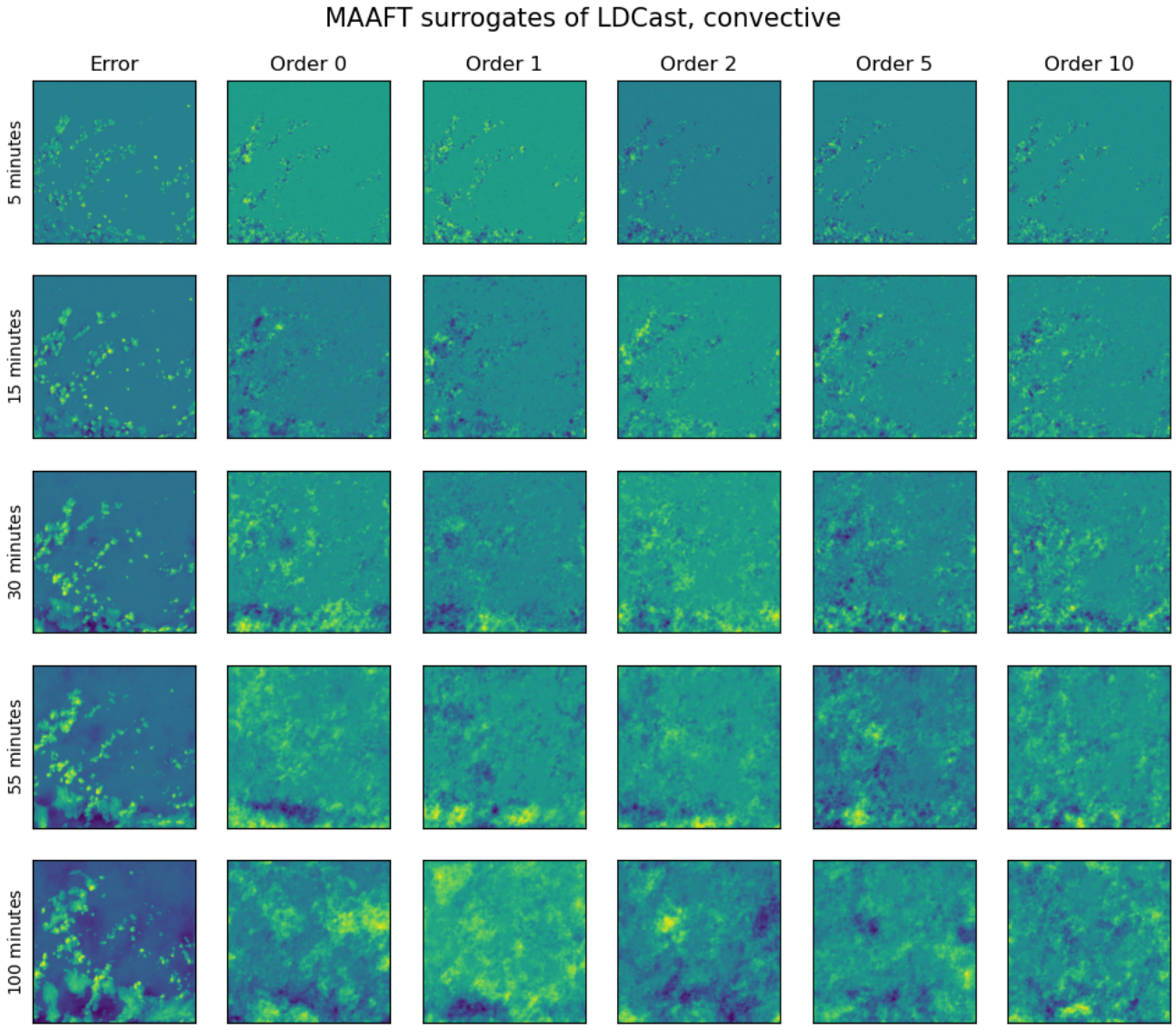

Figure S10: Eigenvectors of a MAAFT LDCast ensemble covariance matrix for a convective case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

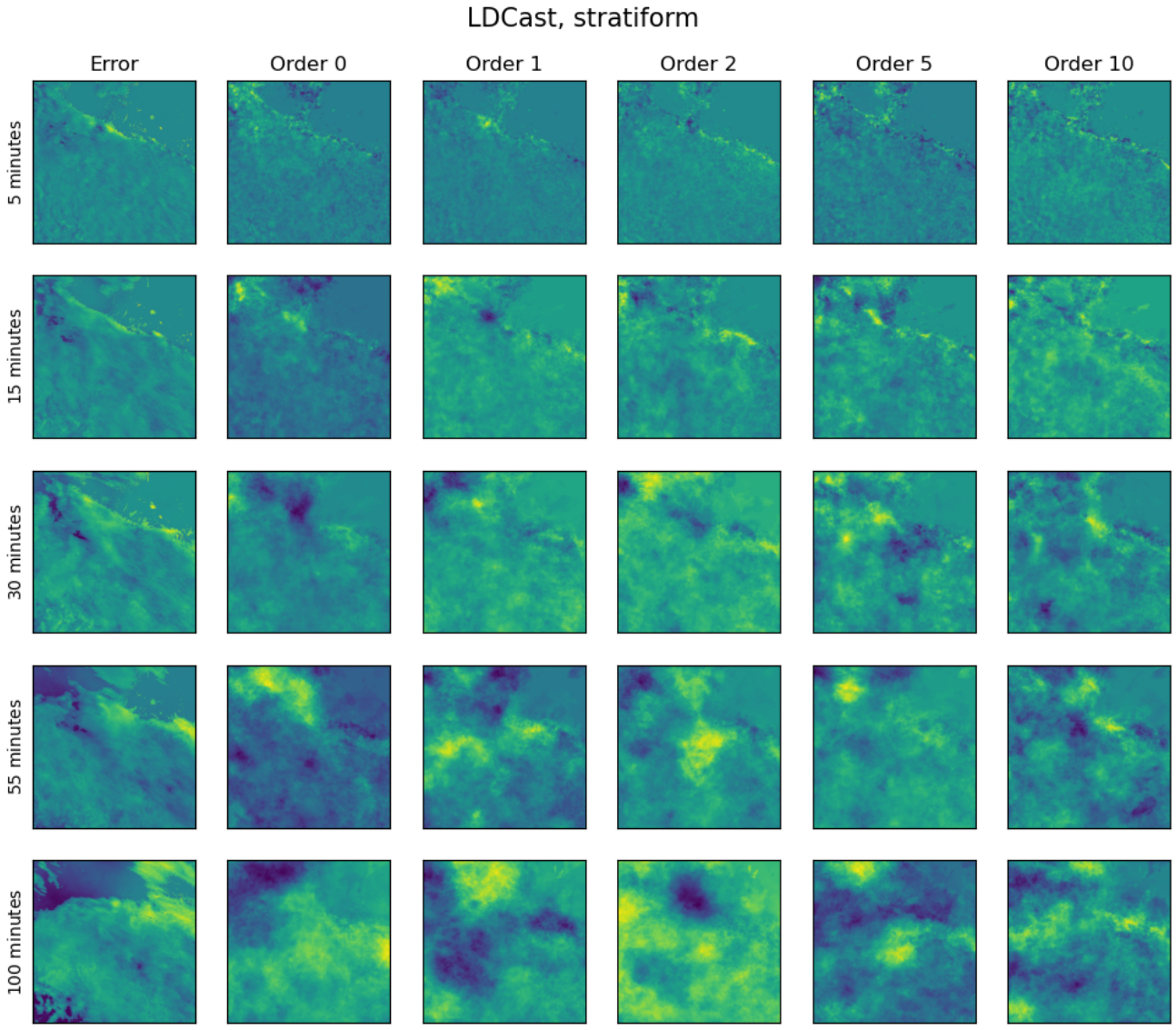

Figure S11: Eigenvectors of a LDCast ensemble covariance matrix for a stratiform case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

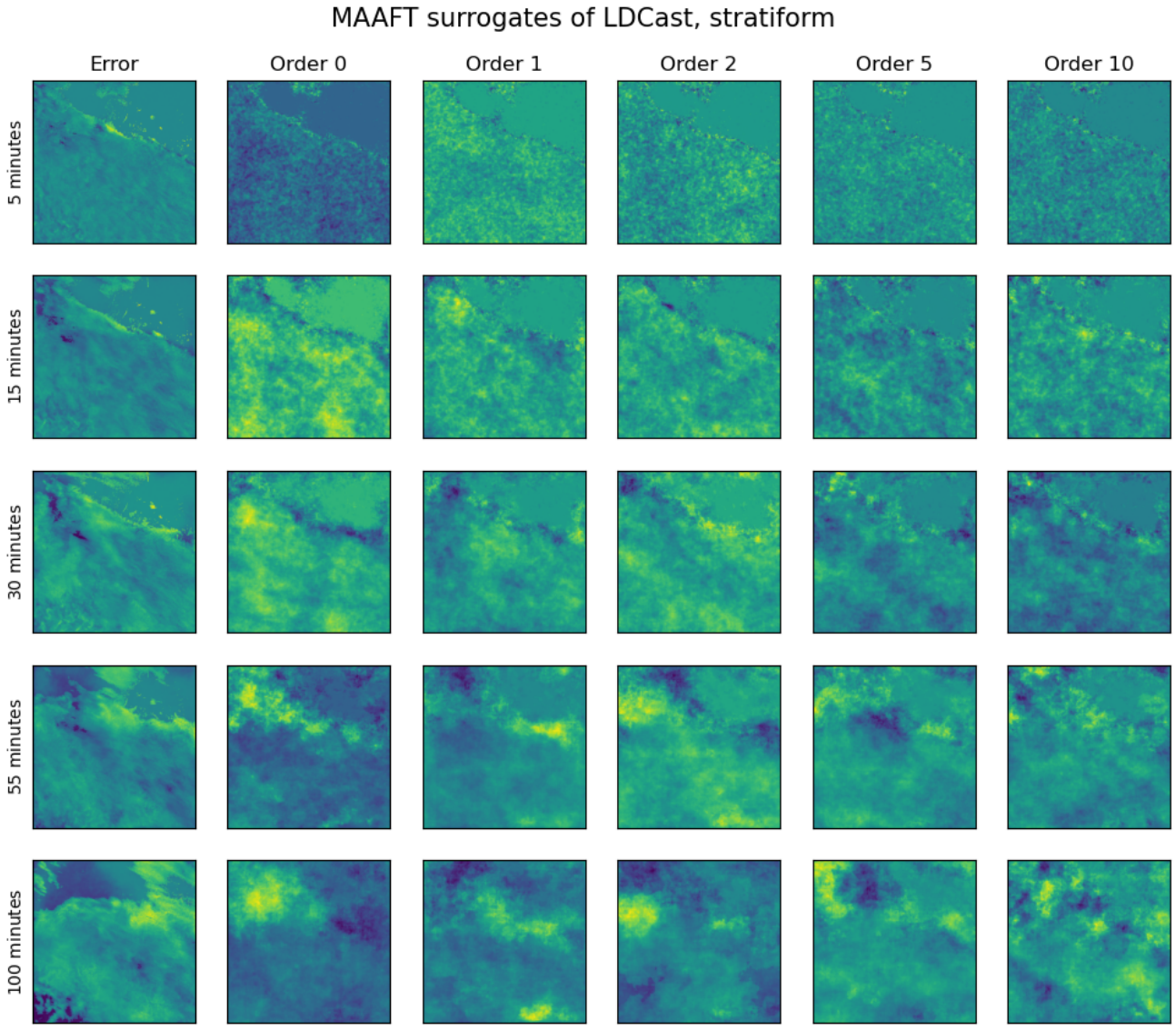

Figure S12: Eigenvectors of a MAAFT LDCast ensemble covariance matrix for a stratiform case. The first column displays the piwel-wise error $\boldsymbol{e} = \boldsymbol{y} - \bar{\boldsymbol{x}}$ for different lead times. The other columns show the eigenvectors of different orders.

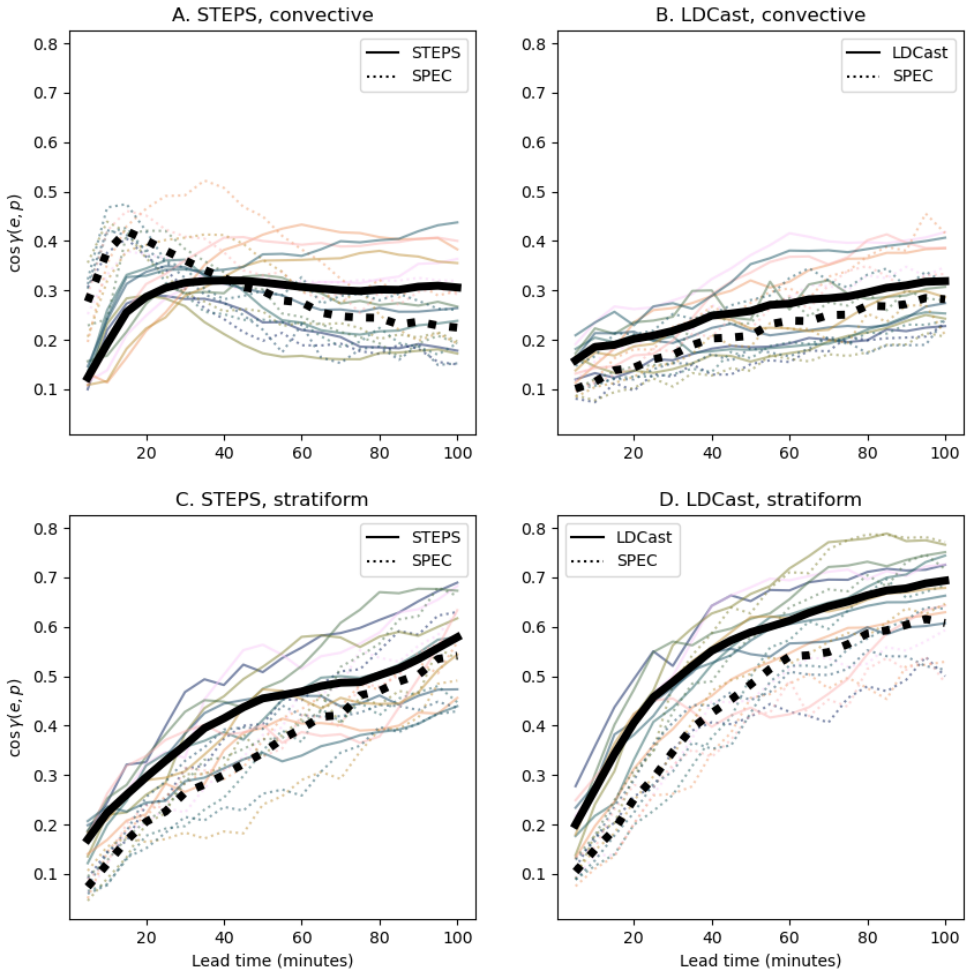

Figure S13: Same as Fig. 6 but with SPEC ensembles instead of MAAFT ensembles. Comparison of $\cos\gamma(\boldsymbol{e},\boldsymbol{p})$ of the error and its the projection on STEPS/LDCast ensembles (solid lines) with the $\cos\gamma(\boldsymbol{e},\boldsymbol{p})$ for the corresponding SPEC ensembles (dotted lines), for all lead times. Thin lines depict $\cos\gamma(\boldsymbol{e},\boldsymbol{p})$ for each event and thick lines represent the event average. The SPEC ensembles whose scores are presented in panels A. and C. are built from the corresponding STEPS ensembles, while those whose scores in presented in panels B. and D. are built from the corresponding LDCast ensembles.