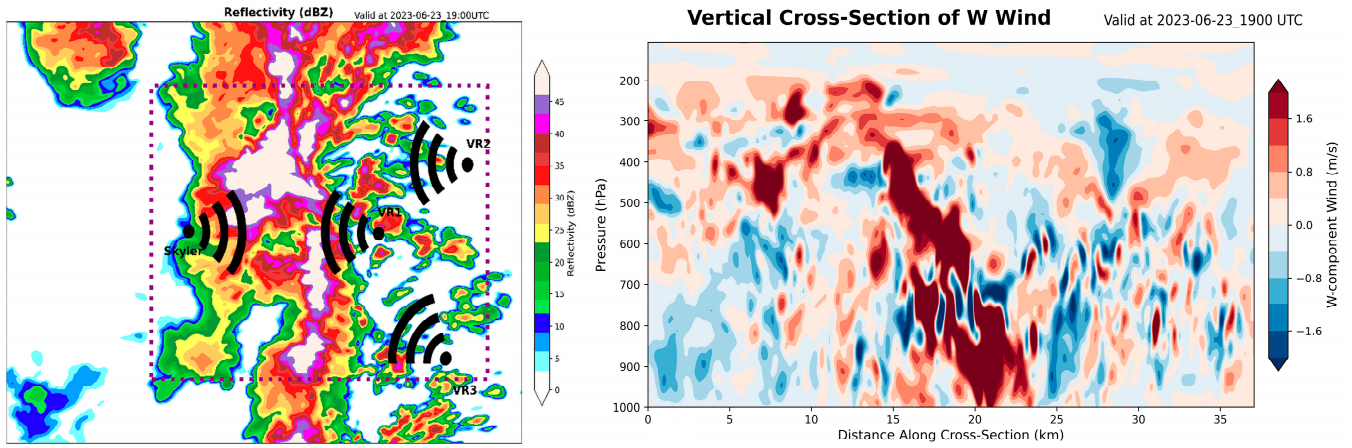
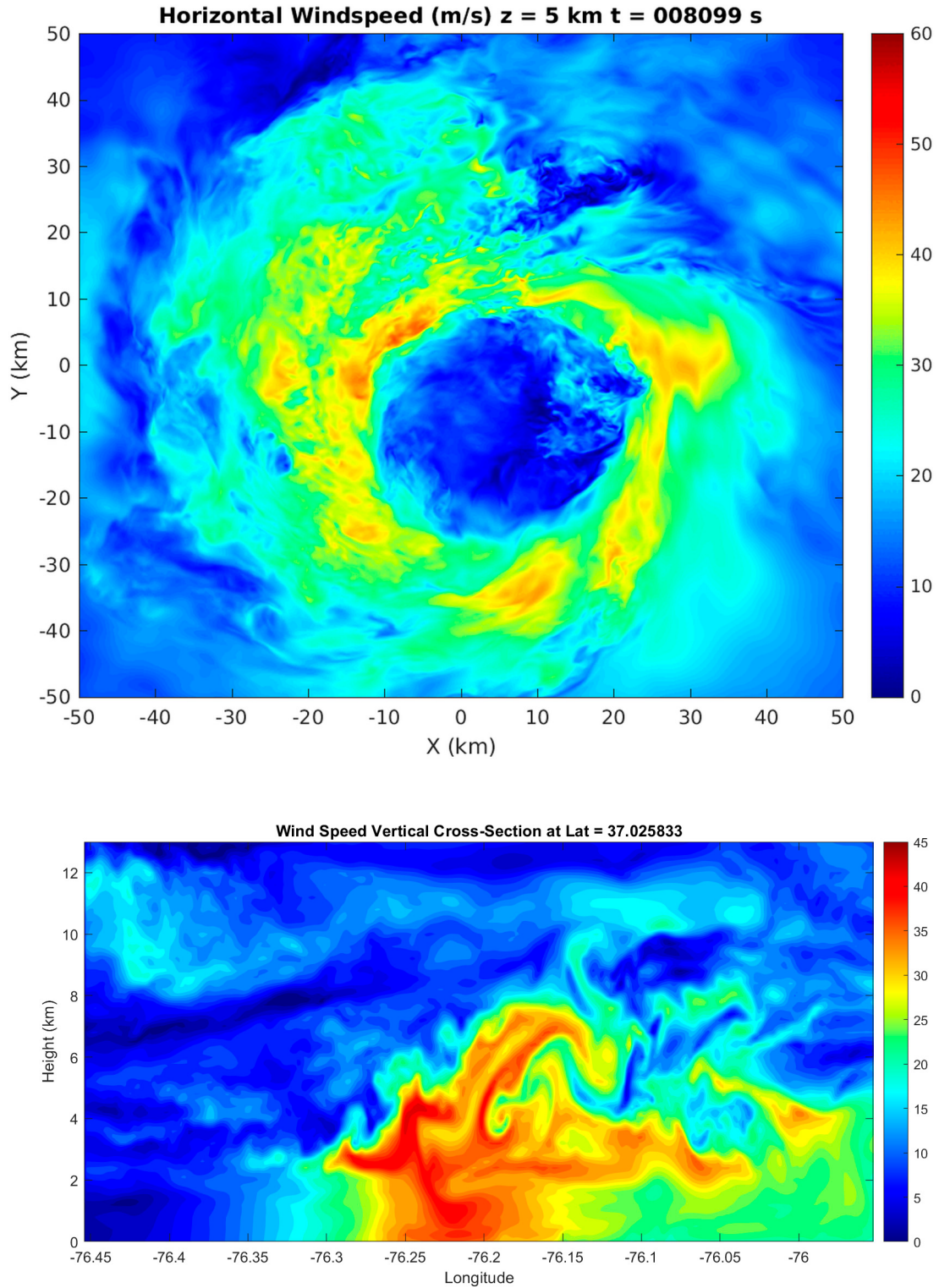


Supplementary Materials

A Ground-Based Multi-Doppler Wind Retrieval Algorithm for Turbulent Convection: An LES-Based Radar Wind Retrieval Framework

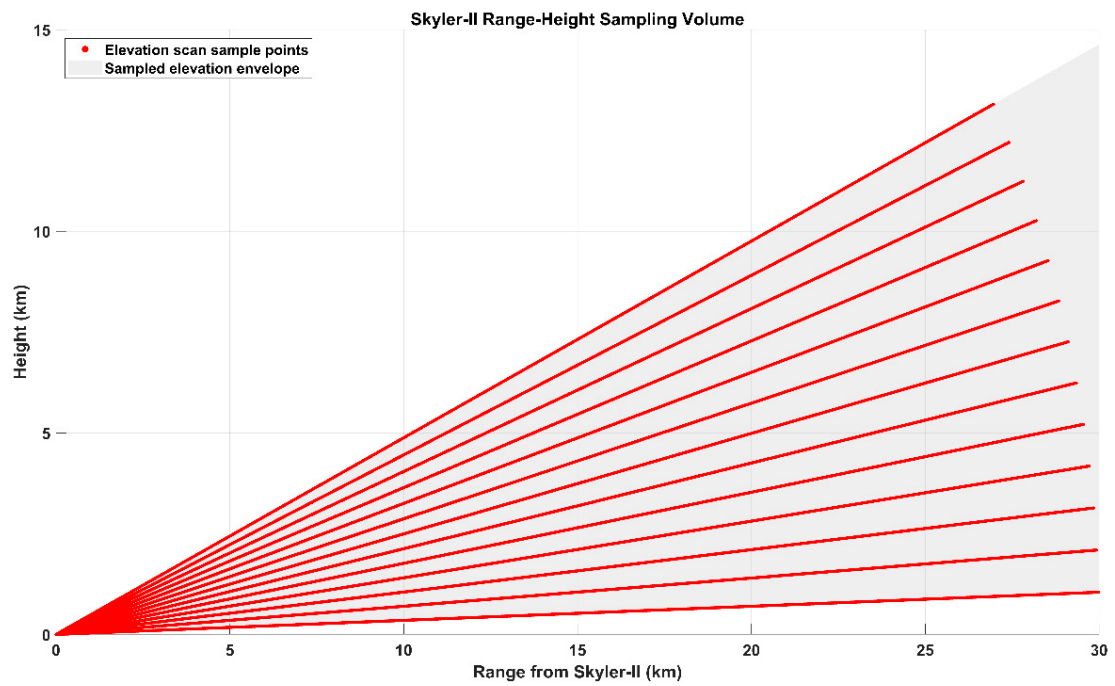


Supplementary Figure S1. (A) WRF-LES squall-line environment used for the radar retrieval experiments. Left: simulated reflectivity with the radar network geometry indicated. Right: vertical cross-section of vertical velocity through the convective system.



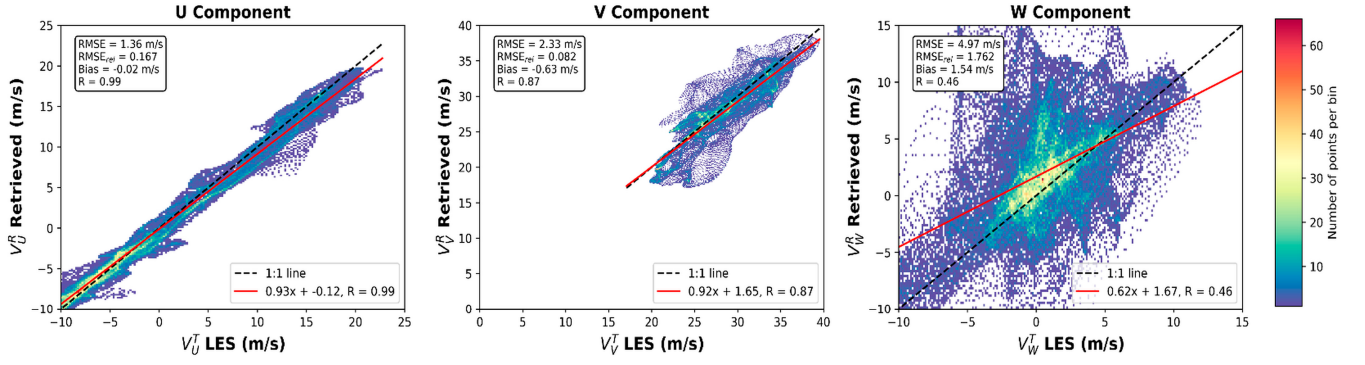
Supplementary Figure S1. (B) NUMA-LES hurricane wind structure used as the truth environment. Top: horizontal wind speed at 5 km altitude. Bottom: vertical cross-section of wind speed through the hurricane circulation.

Supplementary Figure S1. (A) WRF-LES squall-line environment used for the radar retrieval experiments and NUMA-LES hurricane wind structure used as the truth environment, (B) NUMA-LES hurricane wind structure used as the truth environment.

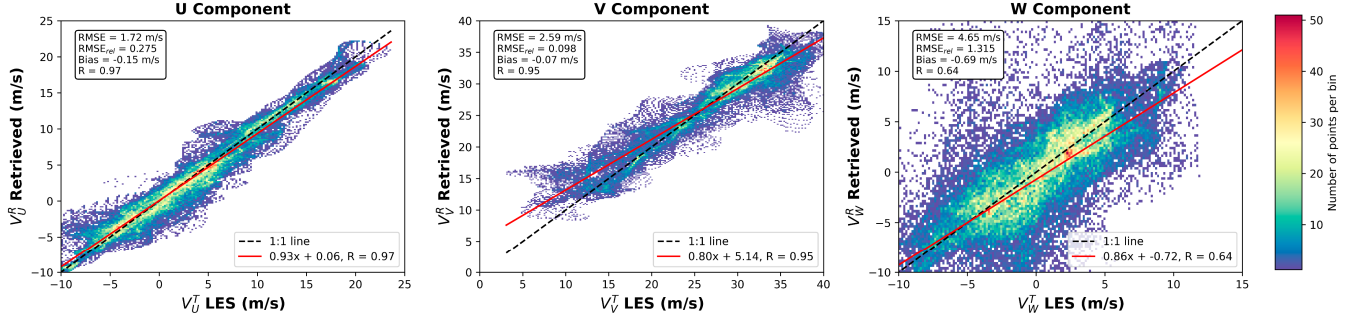


Supplementary Figure S2. Skyler-II range-height sampling geometry showing the elevation scan points and the sampled elevation envelope.

[H_3R] Wind Retrieval Performance Metrics (Bias, RMSE, RMSE_rel, R) at 2 km

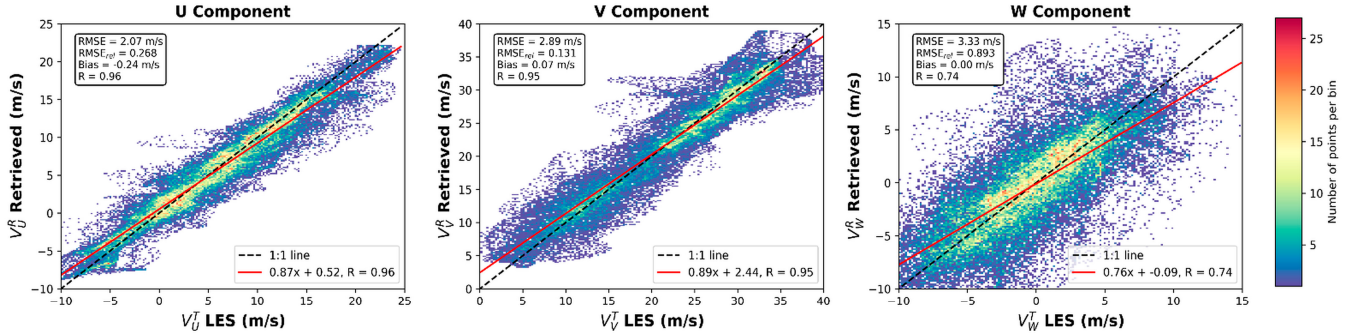


[H_3R] Wind Retrieval Performance Metrics (Bias, RMSE, RMSE_rel, R) at 3 km

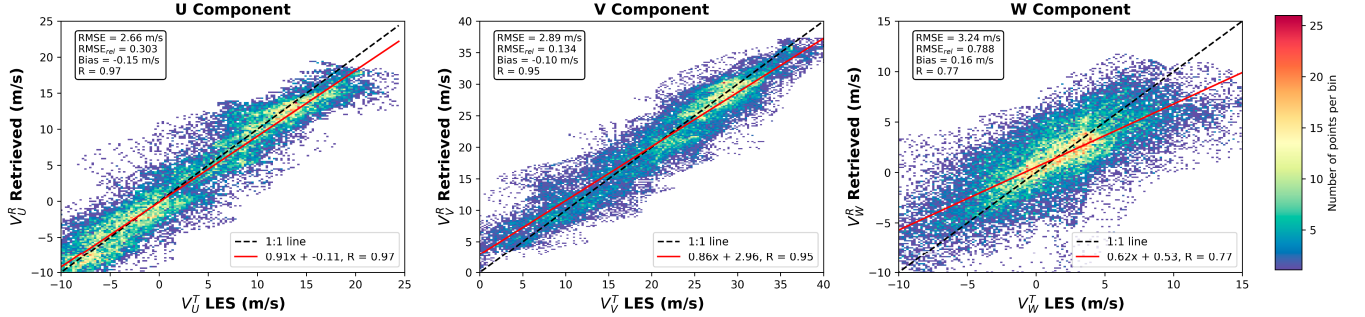


(A) Scatter-density comparisons of retrieved and LES-truth wind components for the H_3R experiment at 2 km (top) and 3 km (bottom).

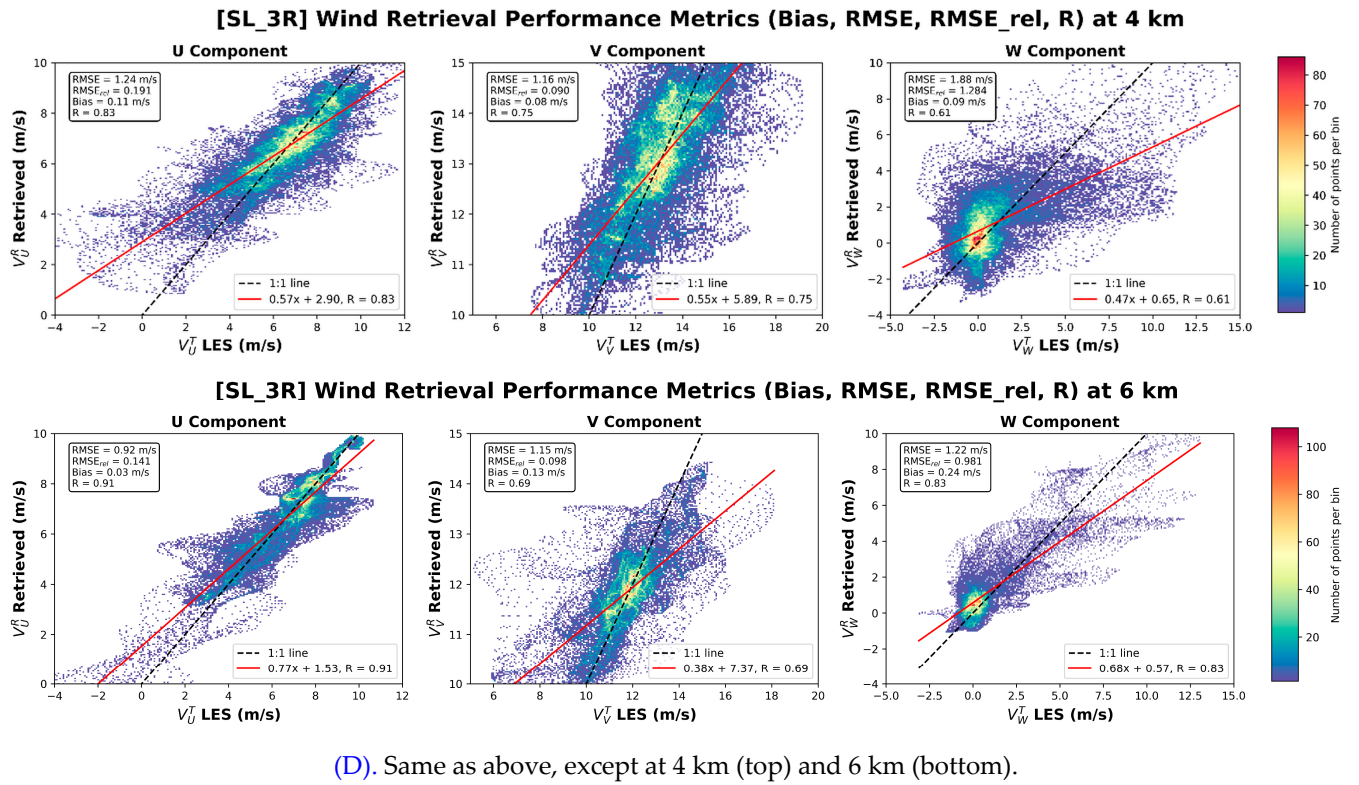
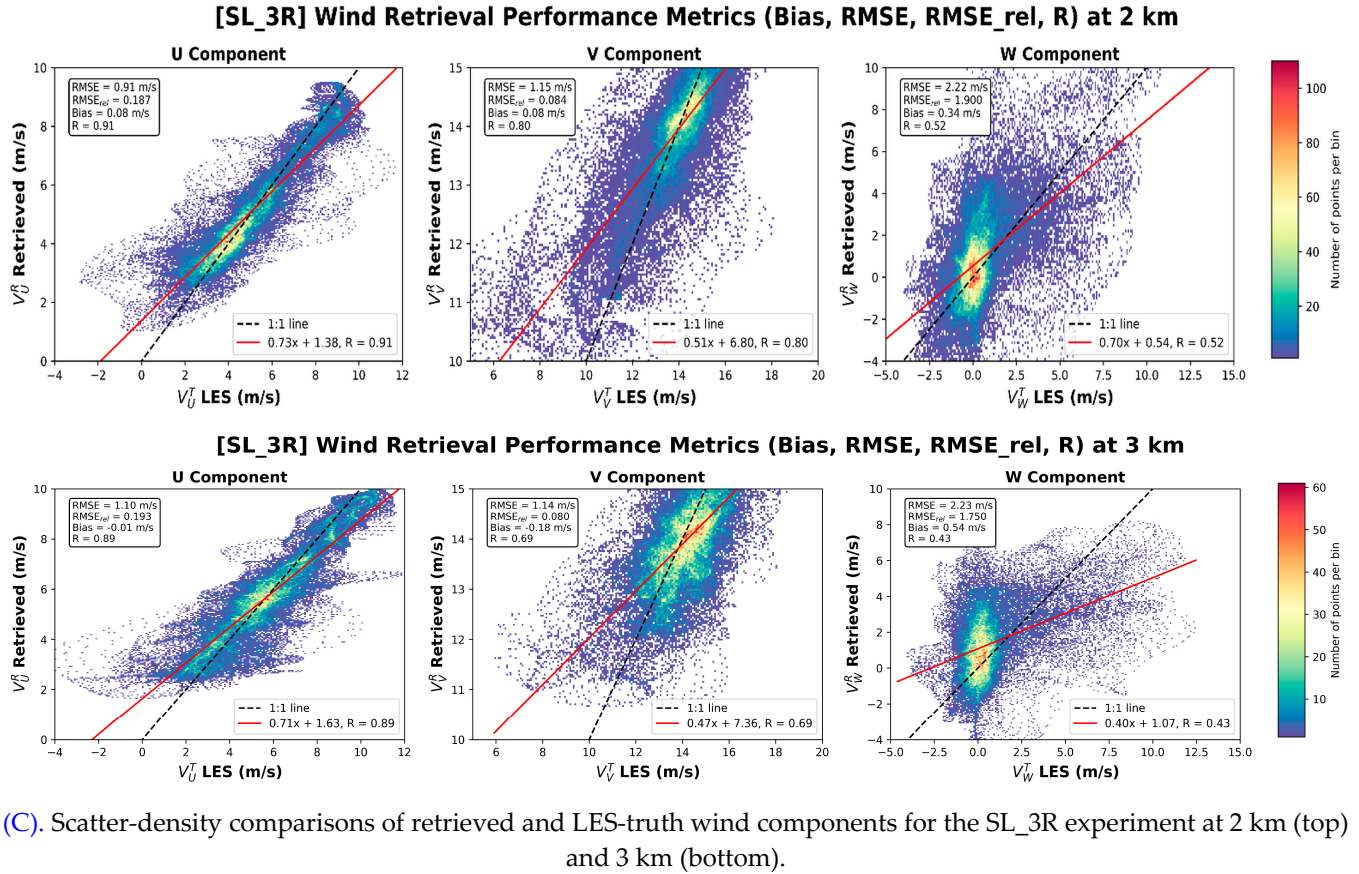
[H_3R] Wind Retrieval Performance Metrics (Bias, RMSE, RMSE_rel, R) at 4 km



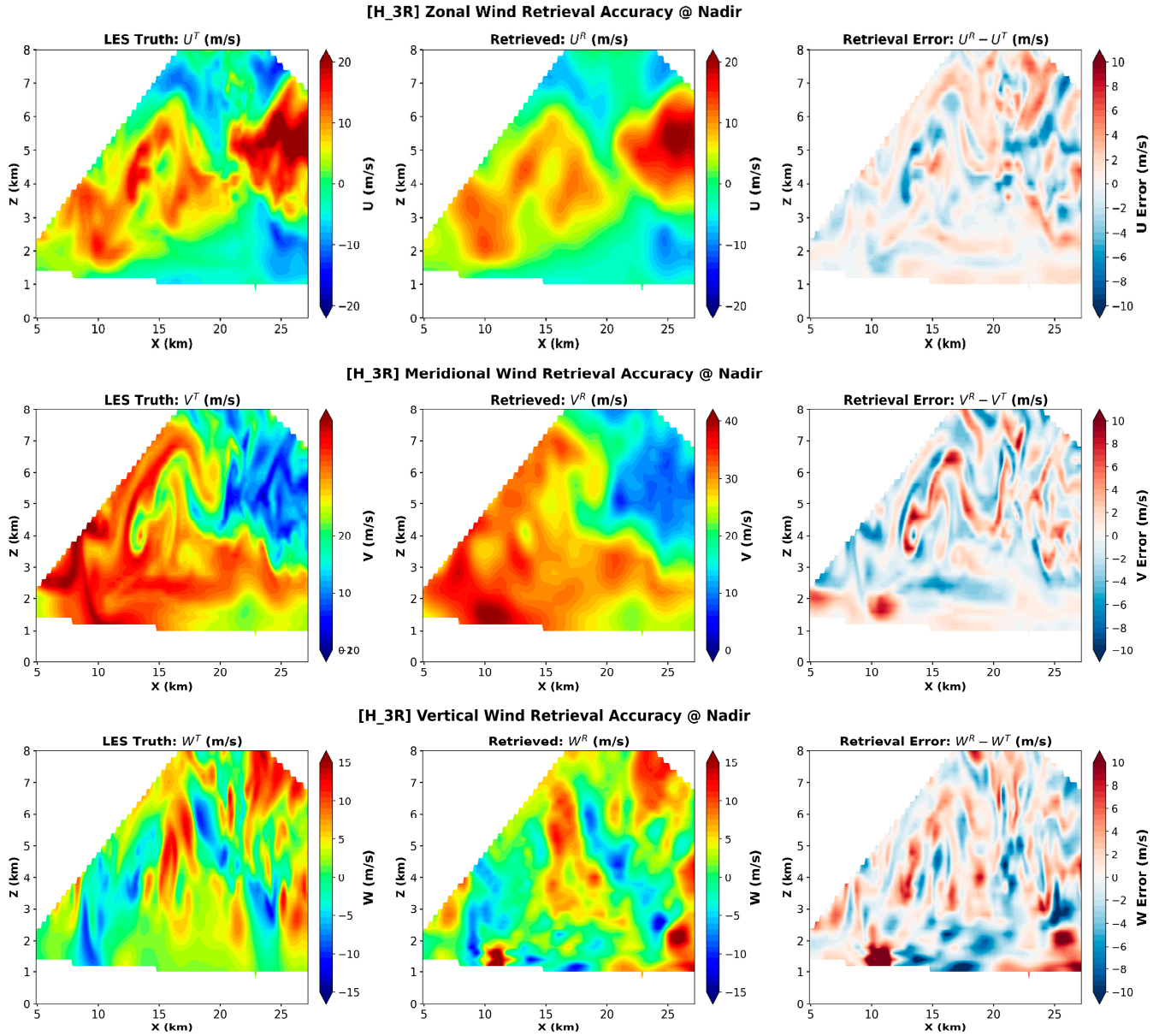
[H_3R] Wind Retrieval Performance Metrics (Bias, RMSE, RMSE_rel, R) at 6 km



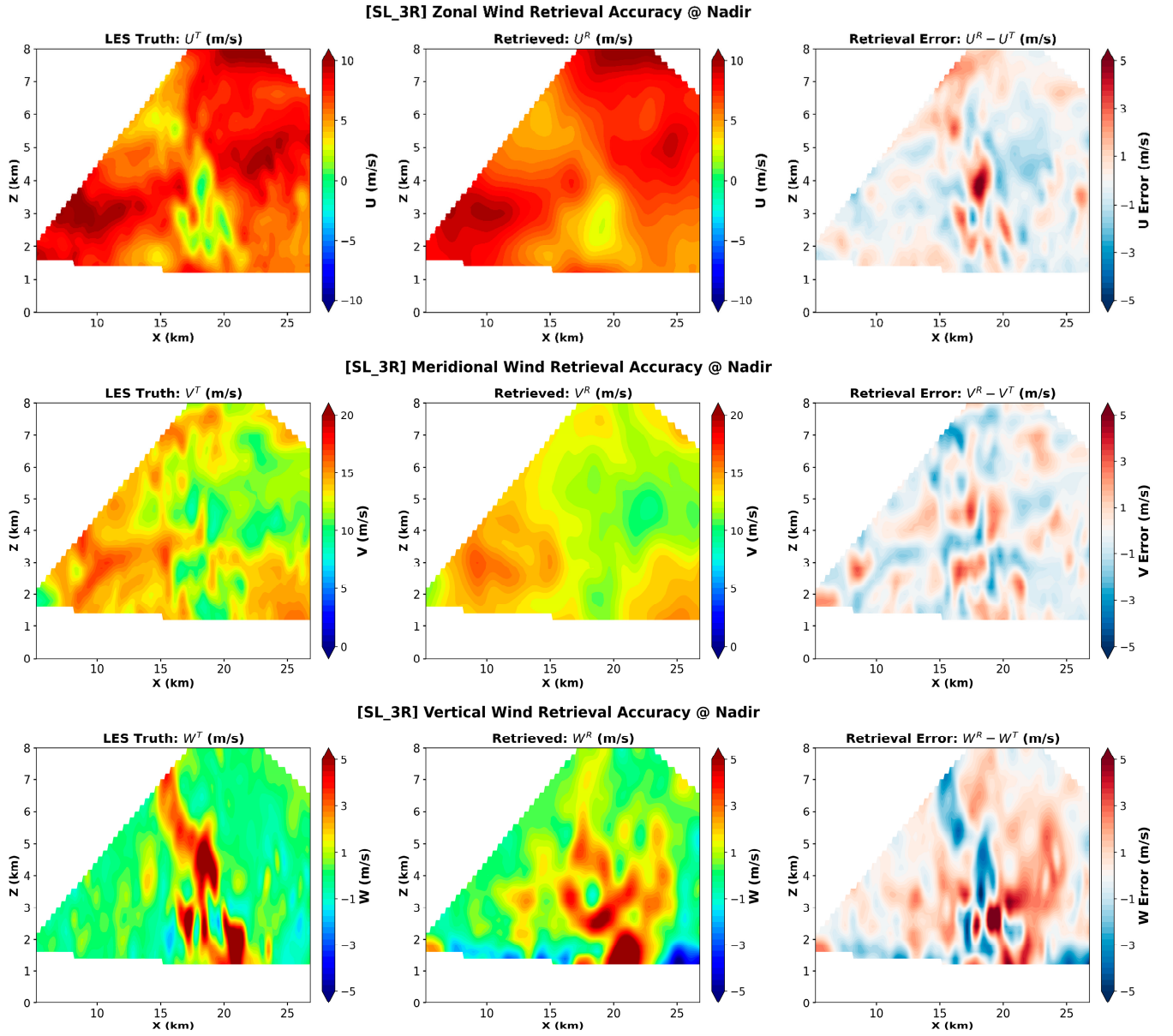
(B) Same as above, except at 4 km (top) and 6 km (bottom).



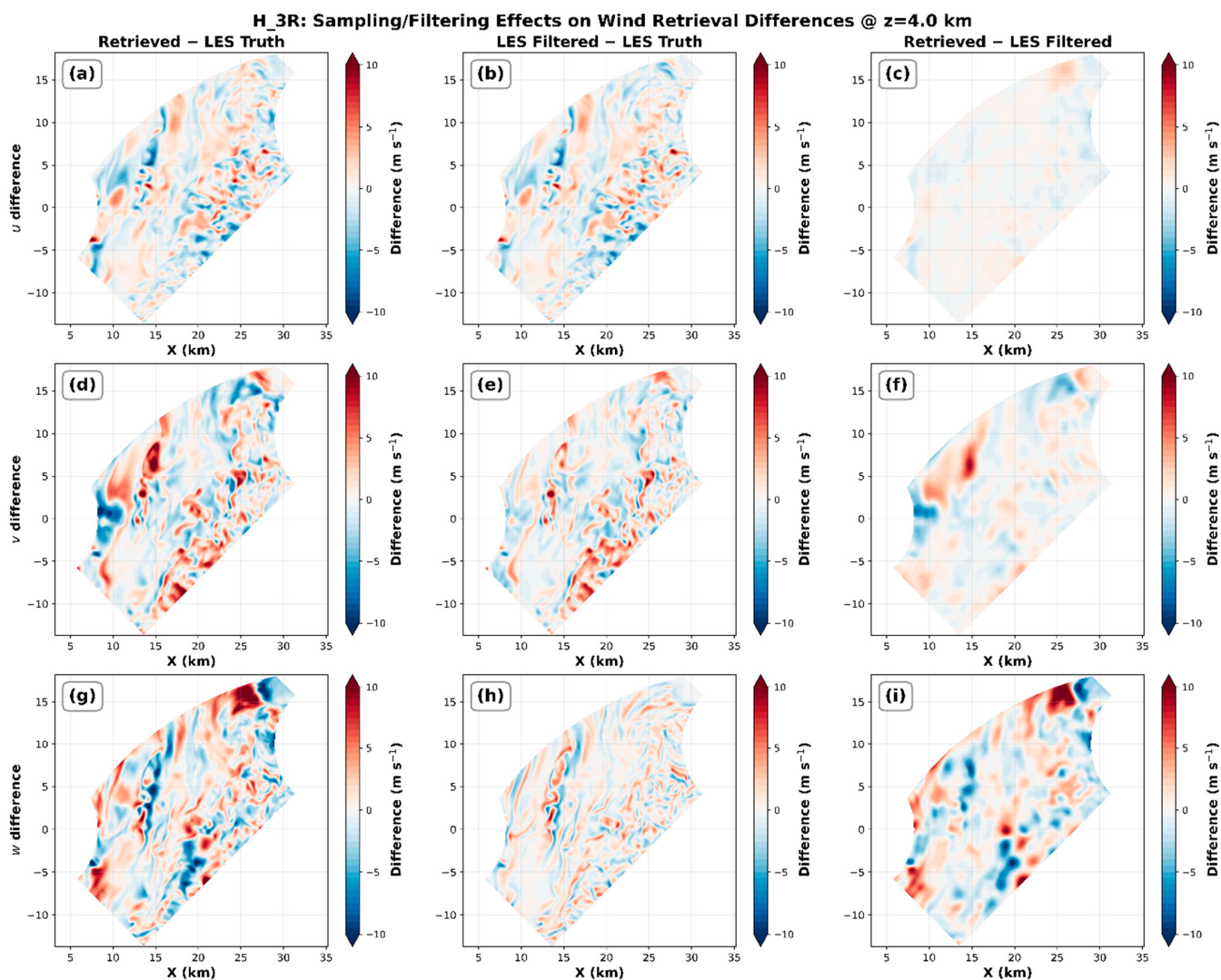
Supplementary Figure S3. Scatter-density comparisons of retrieved and LES-truth wind components for the H_3R and SL_3R experiments at 2, 3, 4 and 6 km.



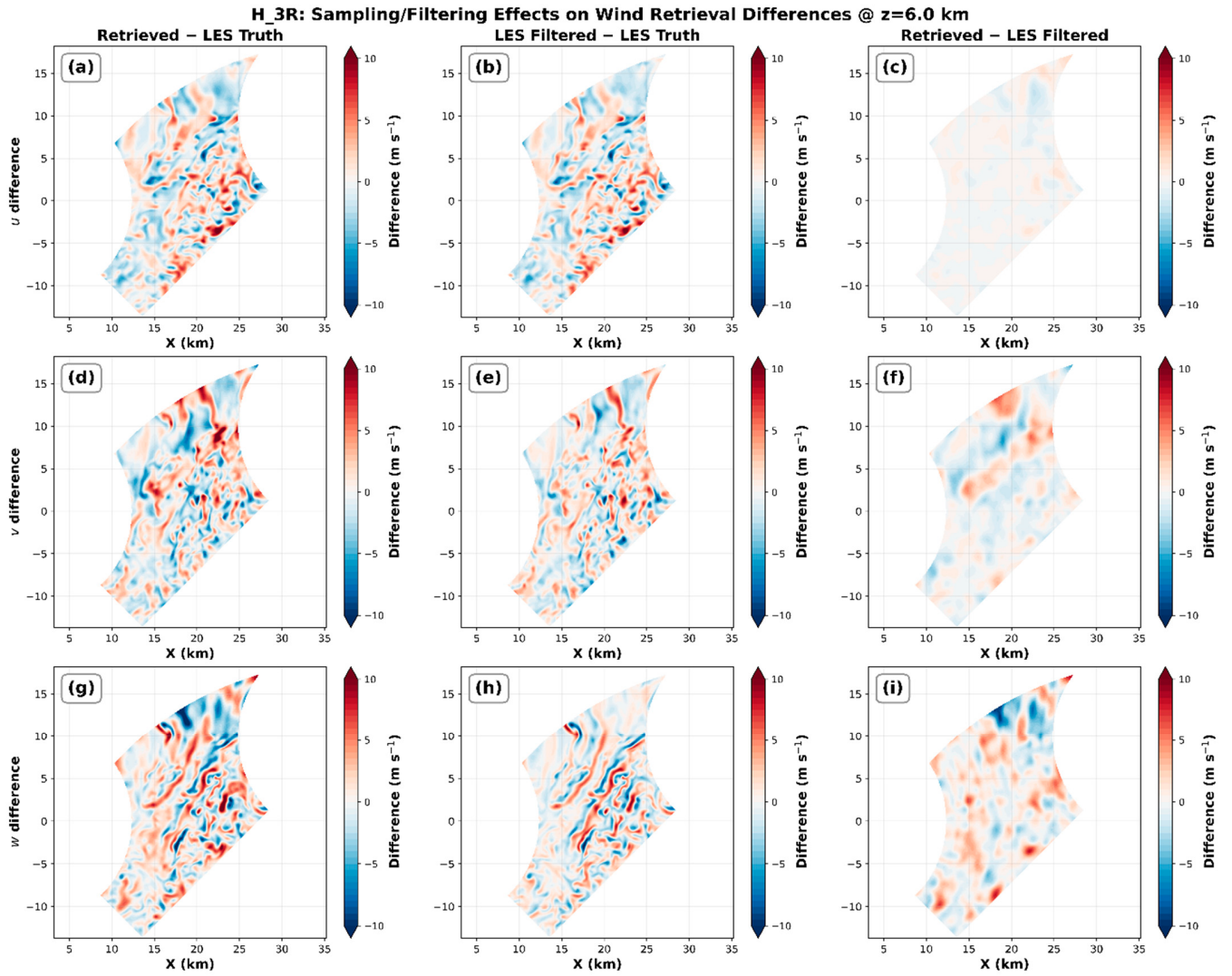
Supplementary Figure S4. Vertical cross-sections of the 3D wind fields along the central line ($Y = 0$) of the common Cartesian retrieval grid for the hurricane three-radar configuration (H_3R). Shown are the zonal wind (u), meridional wind (v), and vertical velocity (w) for the LES truth (left columns), retrieved winds (middle columns), and retrieval error (right columns; retrieved—truth).



Supplementary Figure S5. Vertical cross-section of 3D wind fields along the central line ($Y = 0$) of the common Cartesian retrieval grid for the Squall line three-radar configuration (SL_3R). Shown are the zonal wind (u), meridional wind (v), and vertical velocity (w) for the LES truth (left columns), retrieved winds (middle columns), and retrieval error (right columns; retrieved–truth).

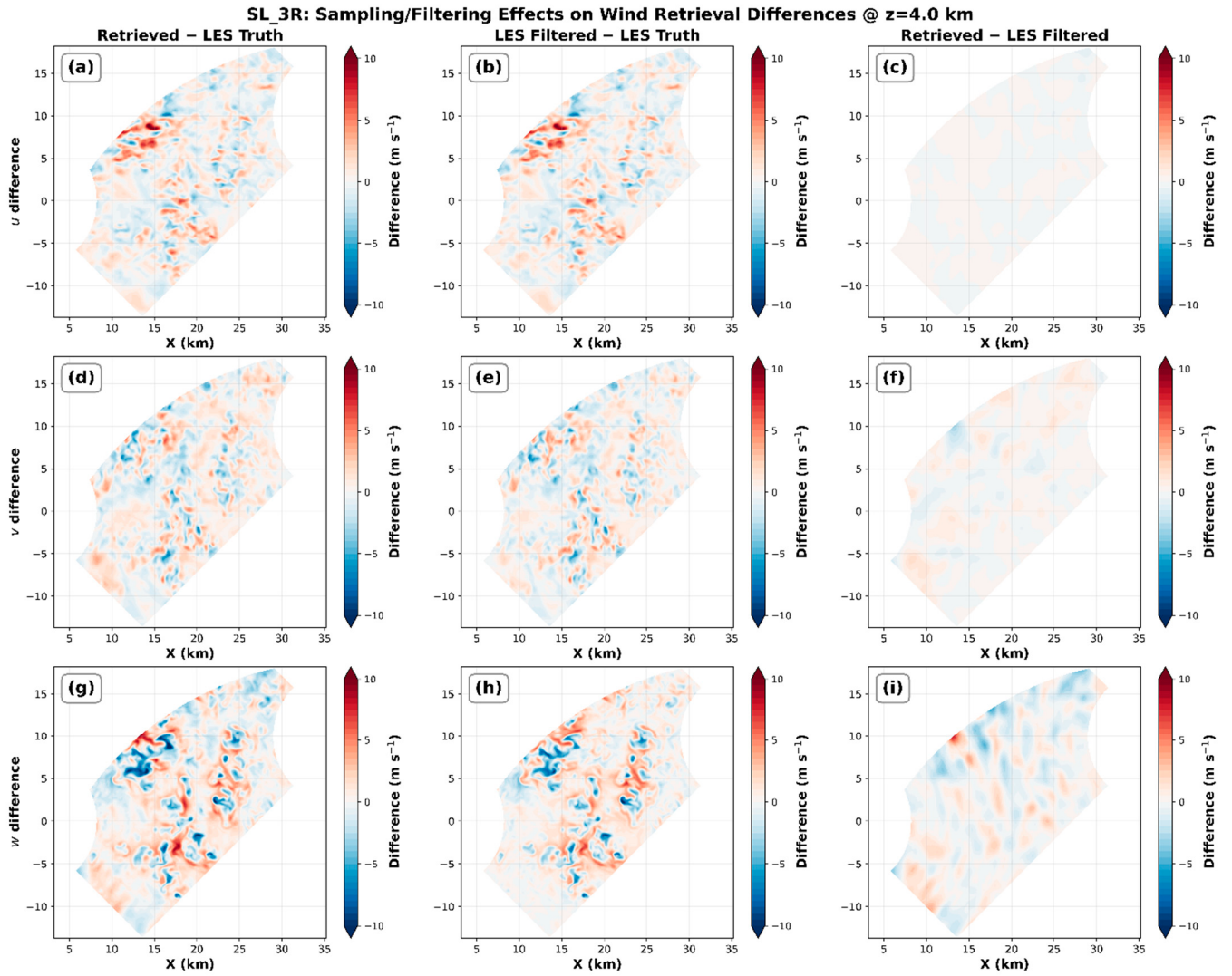


Supplementary Figure S6. (A) Sampling/filtering diagnostic for the H_3R experiment at 4 km. Columns show the total retrieval difference (retrieved-LES truth), the sampling/filtering contribution (LES filtered-LES truth), and the residual retrieval difference (retrieved-LES filtered) for u , v , and w .

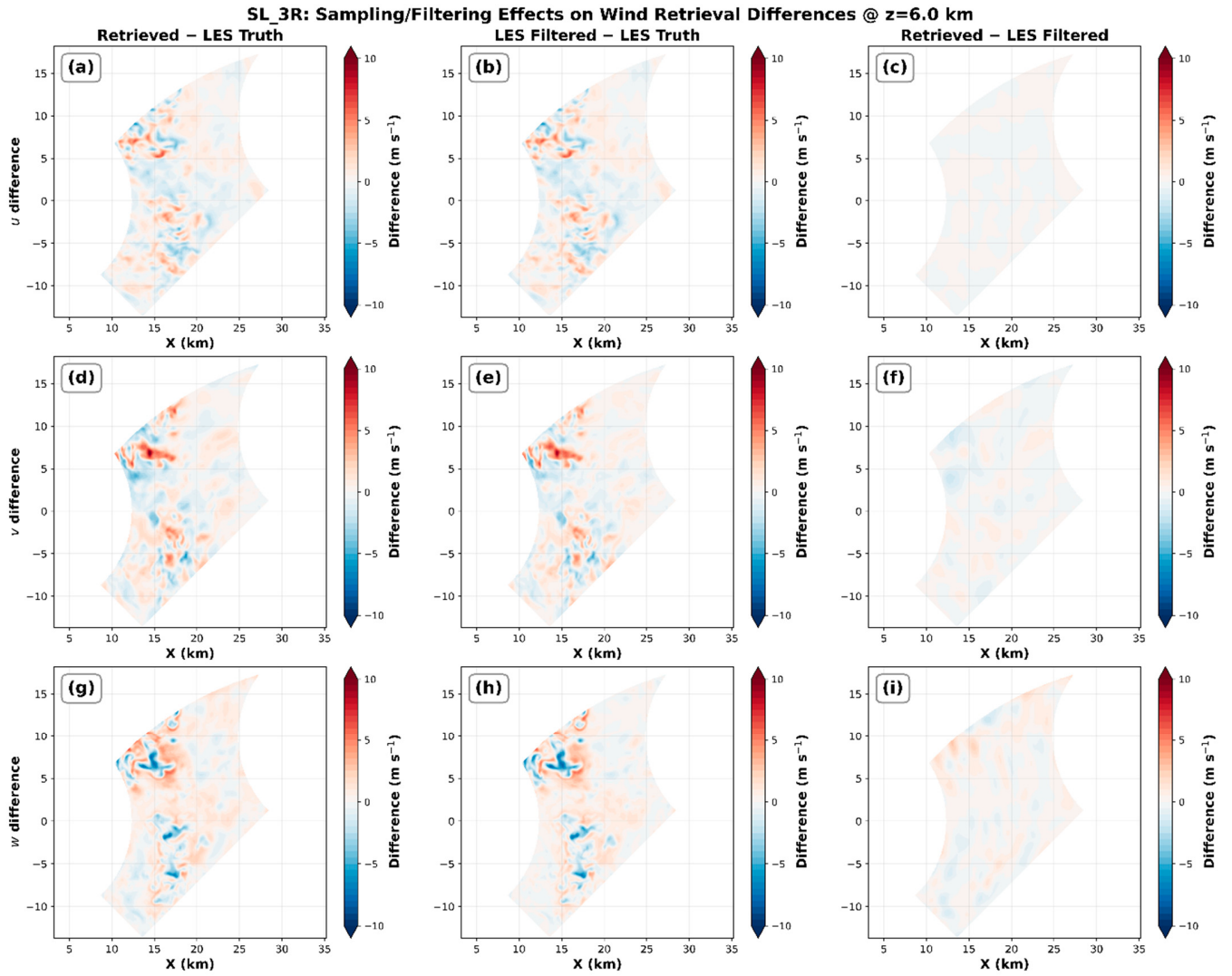


Supplementary Figure S6. (B). Same as above, except for the H_3R experiment at 6 km.

Supplementary Figure S6. Sampling/filtering diagnostic for the H_3R experiment at 4 km and 6 km. Columns show the total retrieval difference (retrieved-LES truth), the sampling/filtering contribution (LES filtered-LES truth), and the residual retrieval difference (retrieved-LES filtered) for u , v , and w .



Supplementary Figure S7. (A). Sampling/filtering diagnostic for the SL_3R experiment at 4 km. Columns show the total retrieval difference (retrieved-LES truth), the sampling/filtering contribution (LES filtered-LES truth), and the residual retrieval difference (retrieved-LES filtered) for u , v , and w .



Supplementary Figure S7. (B). Sampling/filtering diagnostic for the SL_3R experiment at 6 km. Columns show the total retrieval difference (retrieved-LES truth), the sampling/filtering contribution (LES filtered-LES truth), and the residual retrieval difference (retrieved-LES filtered) for u , v , and w .

Supplementary Figure S7. Sampling/filtering diagnostic for the SL_3R experiment at 4 km and 6 km. Columns show the total retrieval difference (retrieved-LES truth), the sampling/filtering contribution (LES filtered-LES truth), and the residual retrieval difference (retrieved-LES filtered) for u , v , and w .

Supplementary Table S1. Skyler-II radar scan parameters used in the LES-based radar wind retrieval framework.

Parameter	Value used in the framework
Radar	Skyler-II X-band dual-polarization phased-array radar
Scan type	Sector volume scan
Volume update time	30 s
Azimuthal sector	~90°
Azimuthal sampling	~0.64°
Elevation angles	13 tilts from 2° to 26°
Elevation spacing	2°
Range-gate spacing	~24 m
Maximum radial range	30 km
Pulse resolution	Varies from 84.4 to 119.8
PRF	3906.35 Hz
Retrieval variable used	Synthetic Doppler radial velocity
SNR	Not included in the current OSSE
Dual-polarization variables	Not used in current retrieval experiments