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Comparing LCRES and NR QuikSCAT Coastal Wind Retrievals

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for sharing their 2007 QuikSCAT retrievals

Motivation: Two Approaches to Land Contamination

- QuikSCAT sigma-0 measurements near coast are contaminated by land
- Land sigma-0 is ~10 dB brighter than ocean -> biases wind speed high
- Effect depends on: distance to coast, measurement geometry, wind speed

- LCRES (Fore & Stiles 2022):
  - Subtract expected land sigma-0 from static climatological table
  - E(sigma-0 | lat, lon, polarization, azimuth) -- time-invariant

- Noise Regularization / NR (Grieco et al. 2024):
  - Estimate land contamination instantaneously from surrounding data
  - CDF matching separates sea and land sigma-0 components

Quality Control Applied to Data

- QC Masking (identical for LCRES and NR):
  - Coast distance < 5 km: excluded
  - JPL poor coastal processing flag (bit 5): excluded
  - JPL ice edge flag (bit 8): excluded
  - KNMI variational/knmi QC failures (bits 16-17): excluded
  - Rain (coastal, ≤40 km): reject only if rain_not_usable=0 AND rainy=1
  - Rain (open ocean, >40 km): reject if rain_not_usable=1 OR rainy=1
  - Direction statistics: exclude observations where mean speed (LCRES+NR)/2 < 3 m/s

- Buoy matchup QC:
  - Time difference satellite-buoy < 30 minutes
  - Buoy wind speed < 25 m/s
  - Direction statistics: exclude buoy wind speed < 3 m/s

Global LCRES/NR difference stats

LCRES − NR Statistics by Distance from Coast (2007, Global)
Speed/component units: m/s | Direction units: degrees | Dir stats exclude mean speed < 3 m/s

Dist (km)	N (millions)	Spd Bias	Spd Std	Spd MAD	U Bias	U Std	U MAD	V Bias	V Std	V MAD	Dir cStd	Dir MAD
5-10	3.4	+0.404	1.333	0.658	-0.108	2.403	0.876	+0.010	2.026	0.761	29.2	7.4
10-15	6.1	+0.051	1.113	0.543	-0.083	2.196	0.787	+0.005	1.908	0.713	28.7	7.3
15-20	7.4	-0.119	0.943	0.474	-0.072	2.035	0.721	-0.000	1.794	0.665	27.8	6.9
20-30	13.1	+0.020	0.800	0.412	-0.087	1.884	0.653	-0.002	1.661	0.607	26.5	6.4
30-40	16.0	+0.311	0.659	0.386	-0.113	1.754	0.597	+0.002	1.545	0.557	24.4	5.7
40-60	20.5	+0.313	0.577	0.387	-0.138	1.597	0.589	+0.001	1.245	0.501	21.2	5.1
60-100	38.6	+0.312	0.565	0.384	-0.148	1.454	0.565	+0.007	1.154	0.476	18.9	4.7
100-150	45.0	+0.306	0.559	0.382	-0.152	1.371	0.551	+0.016	1.096	0.463	17.1	4.5

- The directional Median Absolute Difference stats are much lower than the standard difference. For Gaussian errors one would expect std. dev. to be 1.5 x MAD but here it is closer to 4X which suggests the differences are driven by the outliers.
- There are similar issues for u and v with std. dev. at the nearest coastal bin around 3X MAD.
- Speed is less effected by outliers with std. dev. Only 2X MAD.

Buoy Colocation Methodology

- 67,771 QuikSCAT-buoy collocations, full year 2007
- 223 NDBC buoys, temporal match within 30 minutes
  - only 3 of 223 buoys in the dataset have median coast distance < 20 km, and
  - buoy 42007 (5 km offshore Biloxi, MS) provides 248 of the 261 observations for 5-20 km QS winds
  - other 13 colocations come from buoys 44034 (18.5 km, ME), 44032 (19 m, ME), 44258(5 km, Nova Scotia), and 46026 (17 km, San Francisco).
- Both LCRES and NR retrievals on same 12.5 km grid
- Distance bands: 5-20, 20-30, 30-40, 40-60, 60-100, 100-150, and > 150 km from land
- Ascending/descending orbit split as geometry proxy:
  - QuikSCAT sun-synchronous: ascending ~6 AM, descending ~6 PM local
  - Different orbit direction -> different azimuth angles at each buoy

Comparison of Buoy Metrics for NR and LCRES

Percentage Difference in Error Metrics: LCRES vs NR Against Buoys (2007)
PD = 100 \times (NR_err - LCRES_err) / mean(NR_err, LCRES_err) Negative (blue) = LCRES worse | Positive (red) = NR worse
Direction stats exclude buoy wind speed < 3 m/s

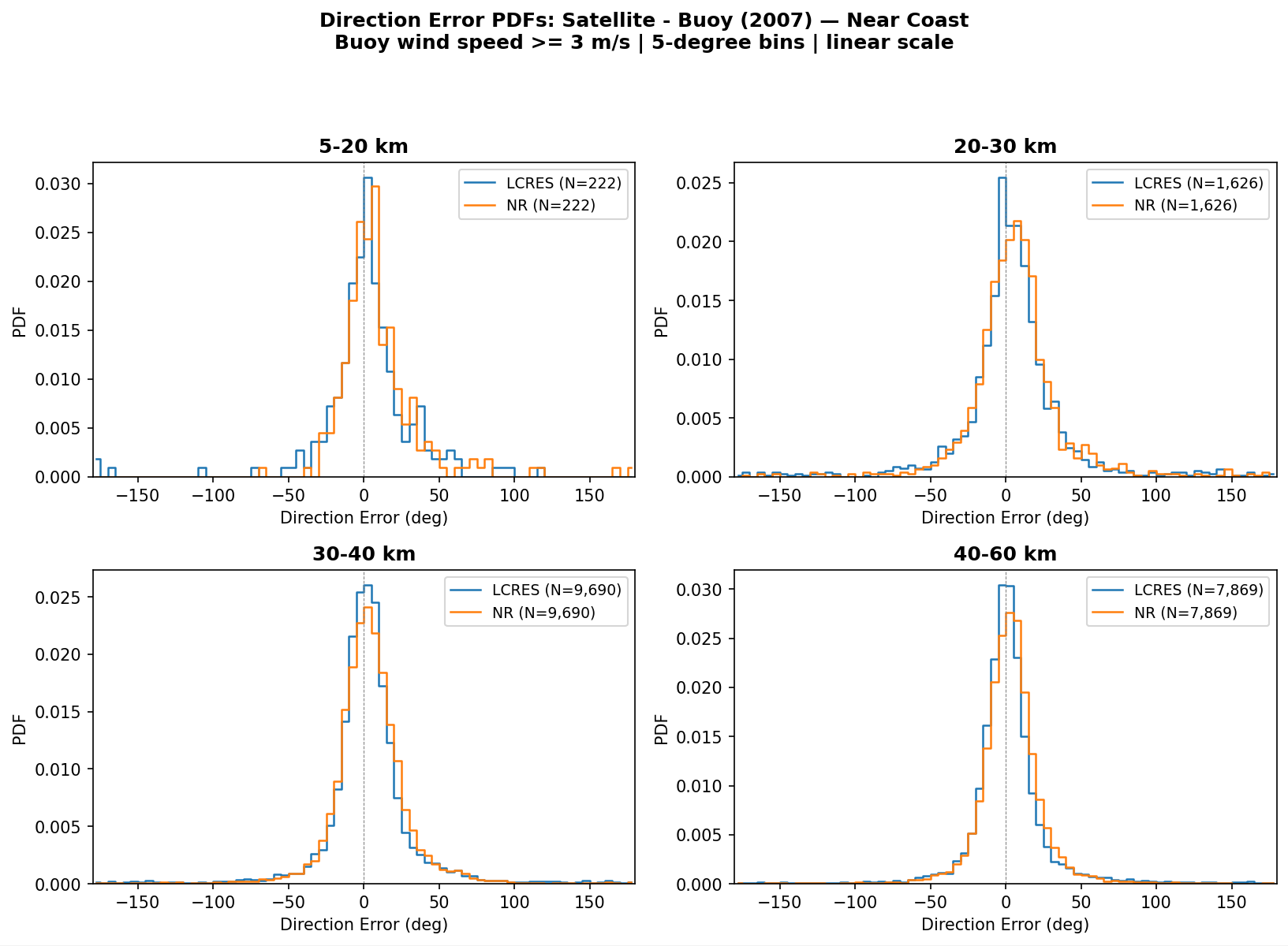
Dist (km)	N	PD Spd |Bias|	PD Spd Std	PD Spd MAD	PD U Std	PD U MAD	PD V Std	PD V MAD	PD Dir cStd	PD Dir MAD
5-20	261	-45.6	-15.5	-11.8	-6.4	-18.8	-13.8	-10.0	-12.7	-4.9
20-30	2,012	-27.4	-7.6	-7.2	-13.2	-1.0	-7.0	-2.6	-9.9	+5.8
30-40	11,064	-93.8	-9.6	-7.3	-14.7	+1.4	-5.5	+0.7	-11.1	+12.5
40-60	8,856	-99.4	-7.5	-3.1	-23.8	+2.6	-5.6	+5.5	-14.5	+9.5
60-100	5,457	+145.6	-6.4	+4.7	-11.2	+11.0	+4.3	+14.9	-1.4	+22.1
100-150	2,180	-89.0	-4.7	+6.7	-7.5	+19.9	+6.4	+19.0	+3.1	+28.0
>150	29,928	+97.0	-3.5	+9.9	-7.0	+13.9	+8.7	+22.7	+6.5	+27.4

- White boxes - for most metrics and distances from land to two techniques are similar will percent differences in metrics < 10%.

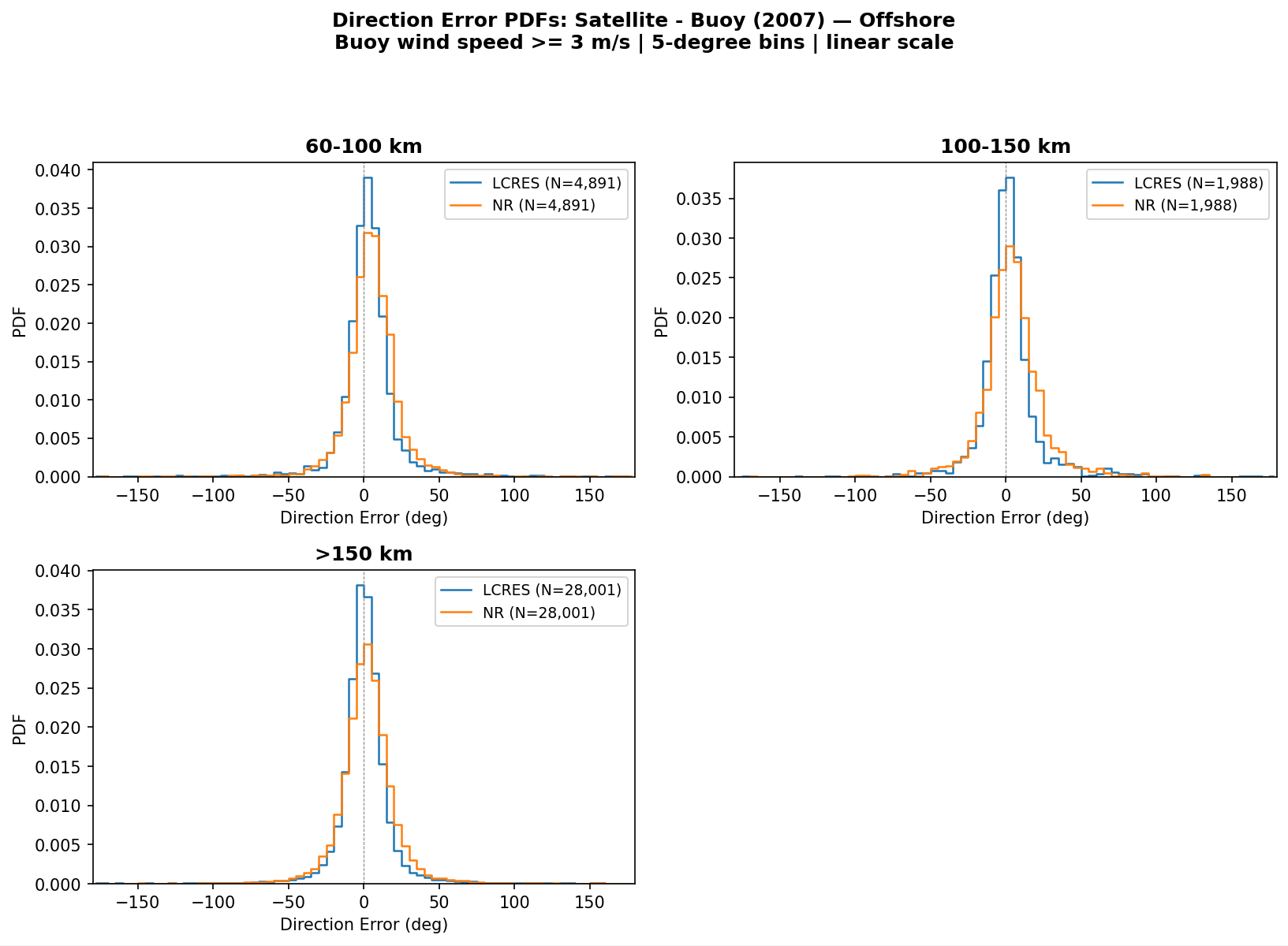
- Blue boxes (NR best): Speed biases w.r.t buoys while small over all are generally much better for NR for all distances from coast except 60-100 km and > 150 km. There is also a significant improvement for NR for zonal wind standard deviation and directional standard deviation near coast w.r.t buoys.

- Red boxes (LCRES best): LCRES speed bias w.r.t buoys is better for 60-100 km and >150 km from coasts. Directional, zonal, and meridional MAD are substantially better than NR more than 60-km from the coast

Direction Difference from Buoys
Histograms from 4 regions closest to land



Direction Difference from Buoys
Histograms from 3 regions furthest from land



Summary

- LCRES appears to have worse speed biases near the coast than NR possibly because the land sigma-0 model used does not account for temporal variation.
- LCRES appear to have more directional outliers near the coast than NR which lead to a significant increase in standard deviation w.r.t buoys
- NR appears to have worse speed biases and median absolute direction error > 150 km from land.
  - For 60-150 km speed bias performance is mixed with NR doing much better in the 100-150 km range but worse for 60-100 km.
- Globally median absolute differences between NR and LCRES are small for u, v, speed, and direction, but outliers in direction difference seem to dominate standard difference estimates in direction, and u and v.

Backup Slides

Direction Difference from Buoys
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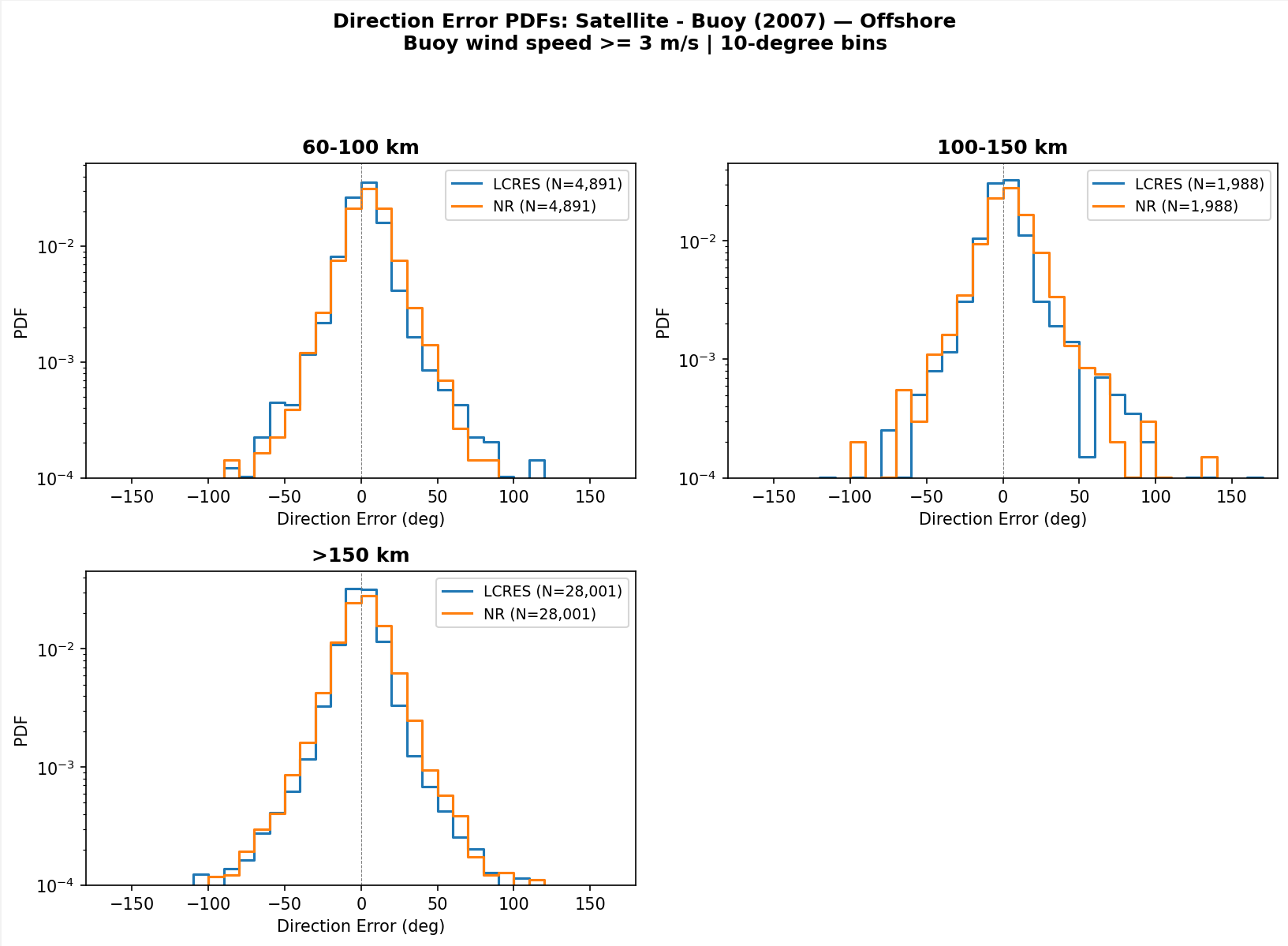

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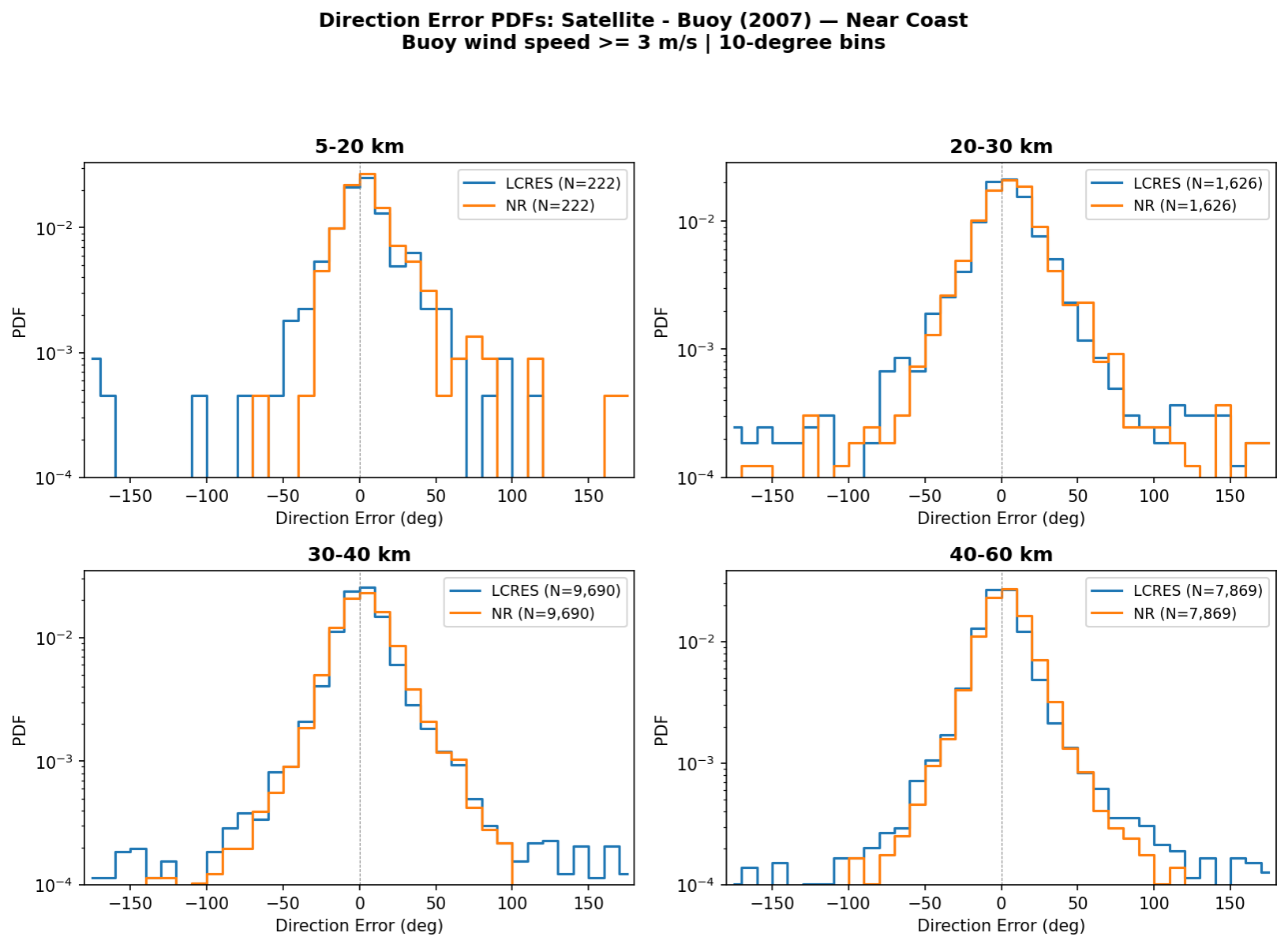


LCRES/NR buoy difference stats

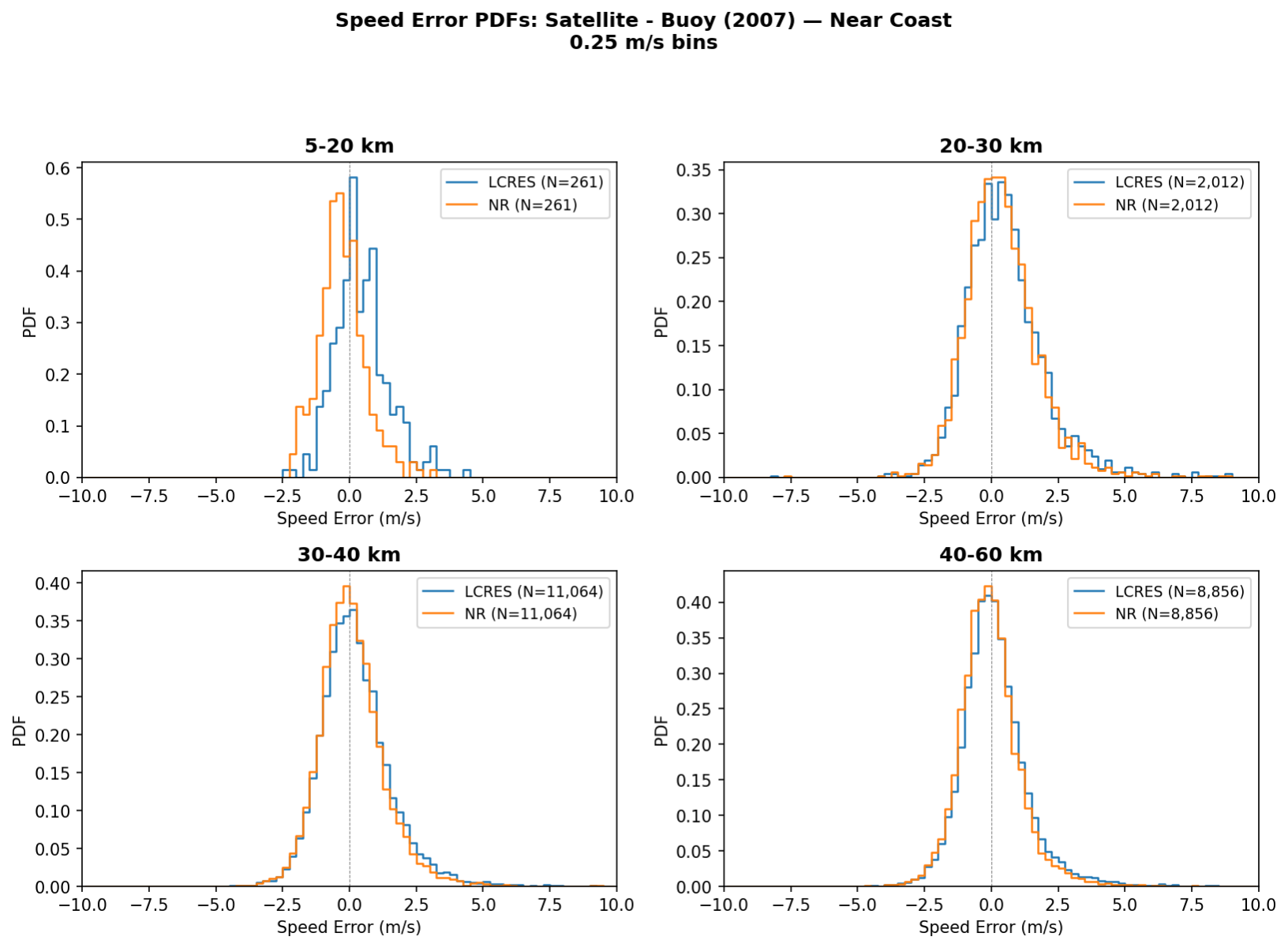
LCRES Error vs Buoys by Distance from Coast (2007)
Speed/component units: m/s | Direction units: degrees | Dir stats exclude buoy speed < 3 m/s

Dist (km)	N	Spd Bias	Spd Std	Spd MAD	U Std	U MAD	V Std	V MAD	Dir cStd	Dir MAD
5-20	261	+0.435	1.020	0.664	2.096	1.084	1.956	0.966	28.4	11.1
20-30	2,012	+0.503	1.477	0.839	2.530	1.219	2.378	1.189	31.3	12.5
30-40	11,064	+0.228	1.342	0.762	2.450	1.143	2.178	1.042	27.4	10.3
40-60	8,856	+0.118	1.319	0.673	2.448	0.969	2.101	0.924	25.4	9.1
60-100	5,457	+0.029	1.098	0.603	1.798	0.818	1.637	0.757	18.4	7.4
100-150	2,180	+0.198	1.148	0.624	1.902	0.750	1.839	0.787	19.8	7.3
>150	29,928	+0.075	1.154	0.595	1.861	0.758	1.667	0.766	19.4	7.0

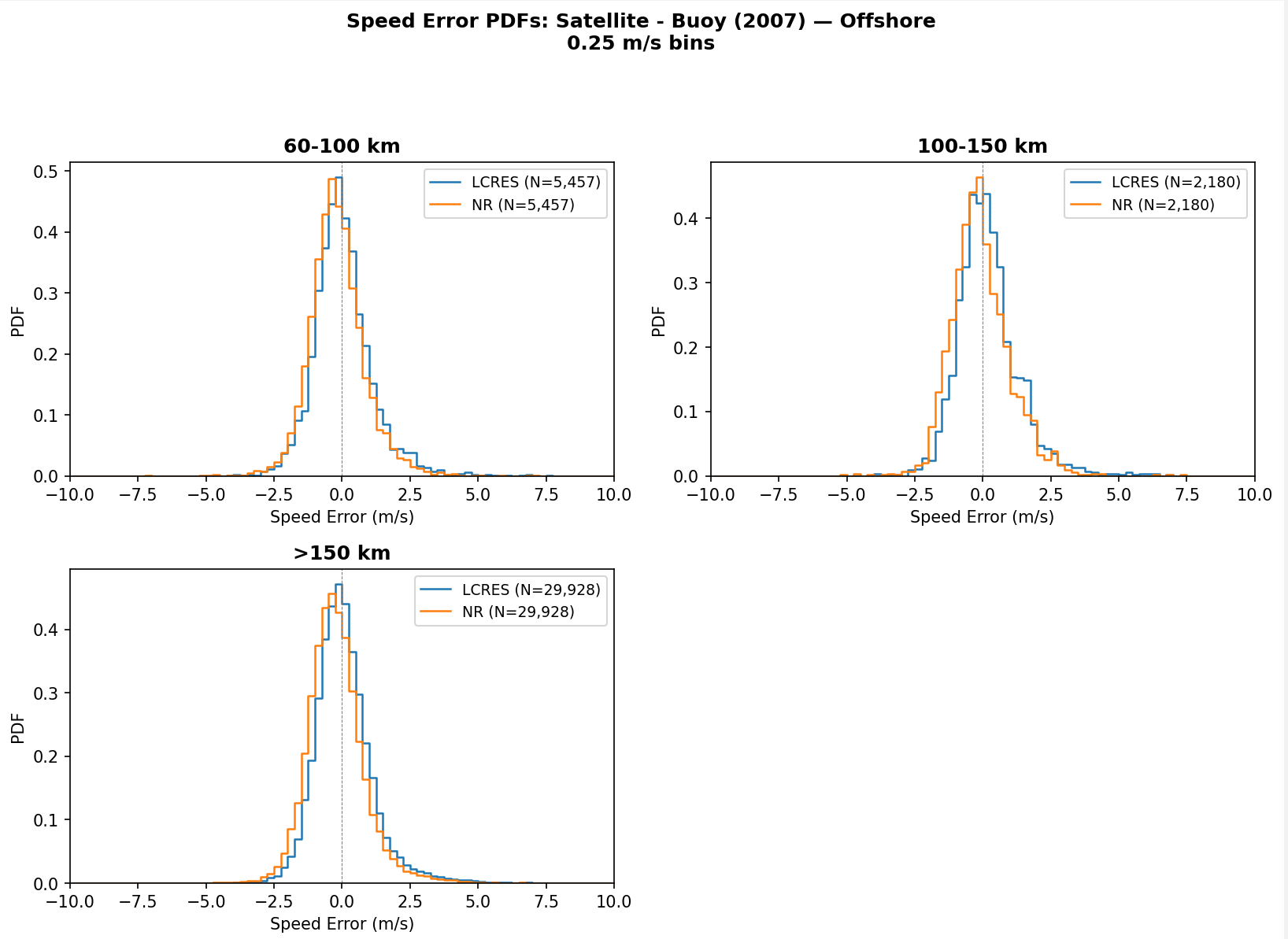
NR Error vs Buoys by Distance from Coast (2007)
Speed/component units: m/s | Direction units: degrees | Dir stats exclude buoy speed < 3 m/s

Dist (km)	N	Spd Bias	Spd Std	Spd MAD	U Std	U MAD	V Std	V MAD	Dir cStd	Dir MAD
5-20	261	-0.273	0.874	0.590	1.965	0.897	1.704	0.874	25.0	10.6
20-30	2,012	+0.382	1.368	0.780	2.217	1.207	2.217	1.159	28.4	13.2
30-40	11,064	+0.082	1.220	0.708	2.114	1.158	2.061	1.050	24.5	11.7
40-60	8,856	-0.040	1.224	0.652	1.926	0.995	1.987	0.976	22.0	10.0
60-100	5,457	-0.185	1.030	0.632	1.607	0.913	1.709	0.879	18.1	9.3
100-150	2,180	-0.076	1.095	0.668	1.764	0.916	1.961	0.953	20.4	9.7
>150	29,928	-0.215	1.115	0.657	1.735	0.871	1.820	0.961	20.7	9.3

Speed Error Histograms – near coast



Speed Error Histograms – far from coast



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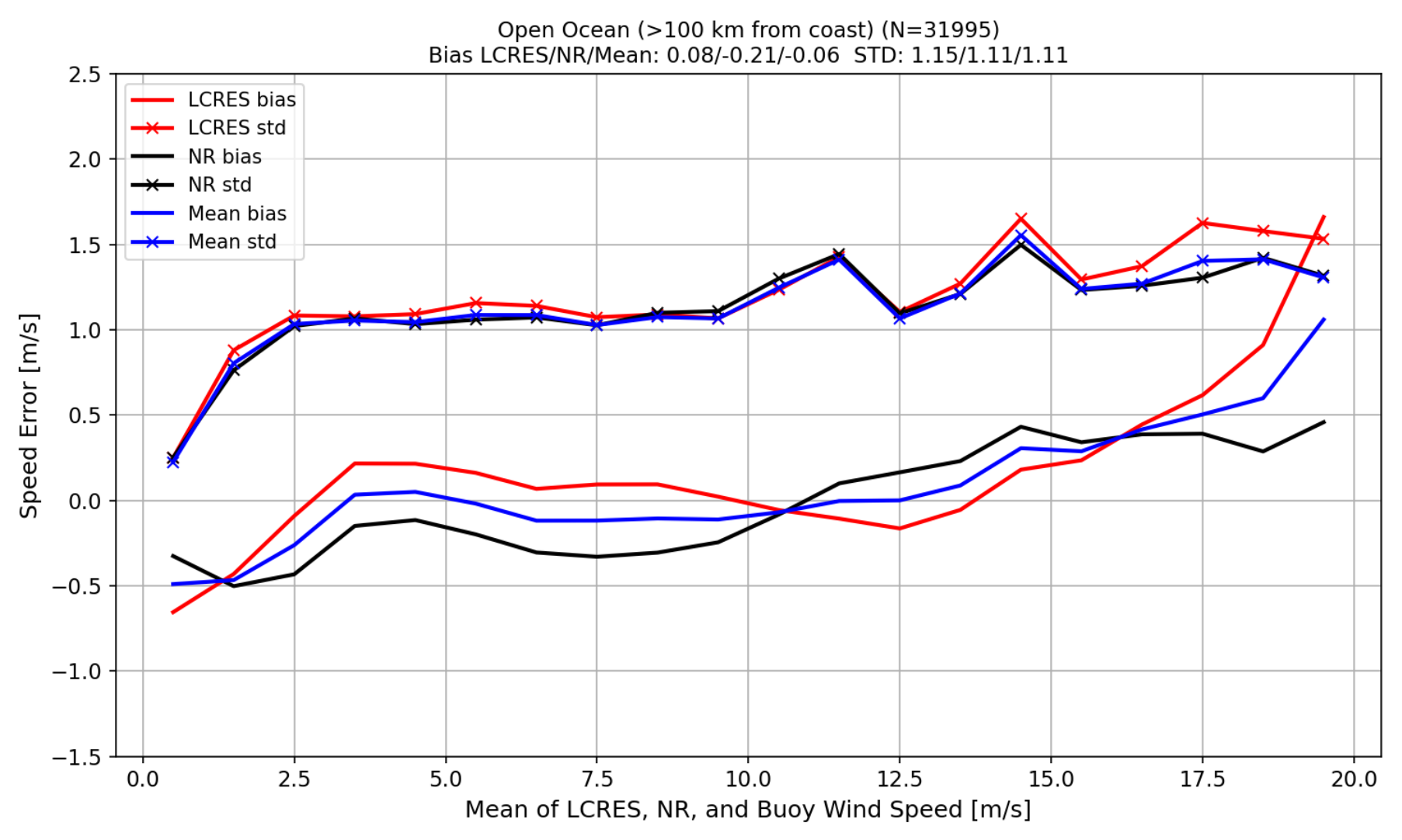
- Distance bands: 5-10, 10-20, 20-40, 40-100, >100 km from coast

- Ascending/descending orbit split as geometry proxy:
  - QuikSCAT sun-synchronous: ascending ~6 AM, descending ~6 PM local
  - Different orbit direction -> different azimuth angles at each buoy

- Focus buoys (largest RMS LCRES-NR difference):
  - 42007: Biloxi, MS (5 km from coast)
  - 42035: Galveston, TX (40 km from coast)
  - 44034: Eastern Casco Bay, ME (24 km from coast)

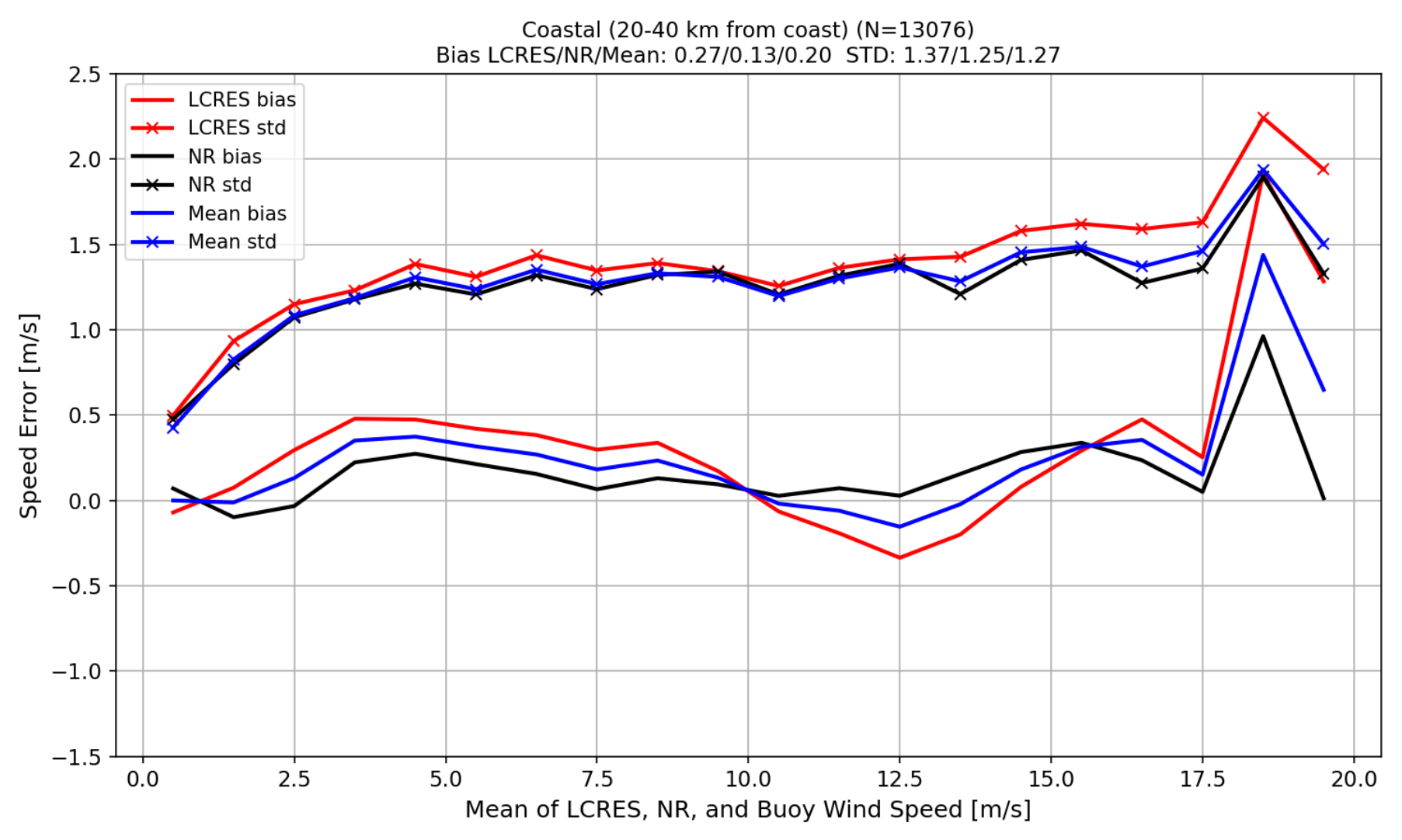
Open Ocean Baseline (>100 km from coast)

LCRES and NR agree well far from shore

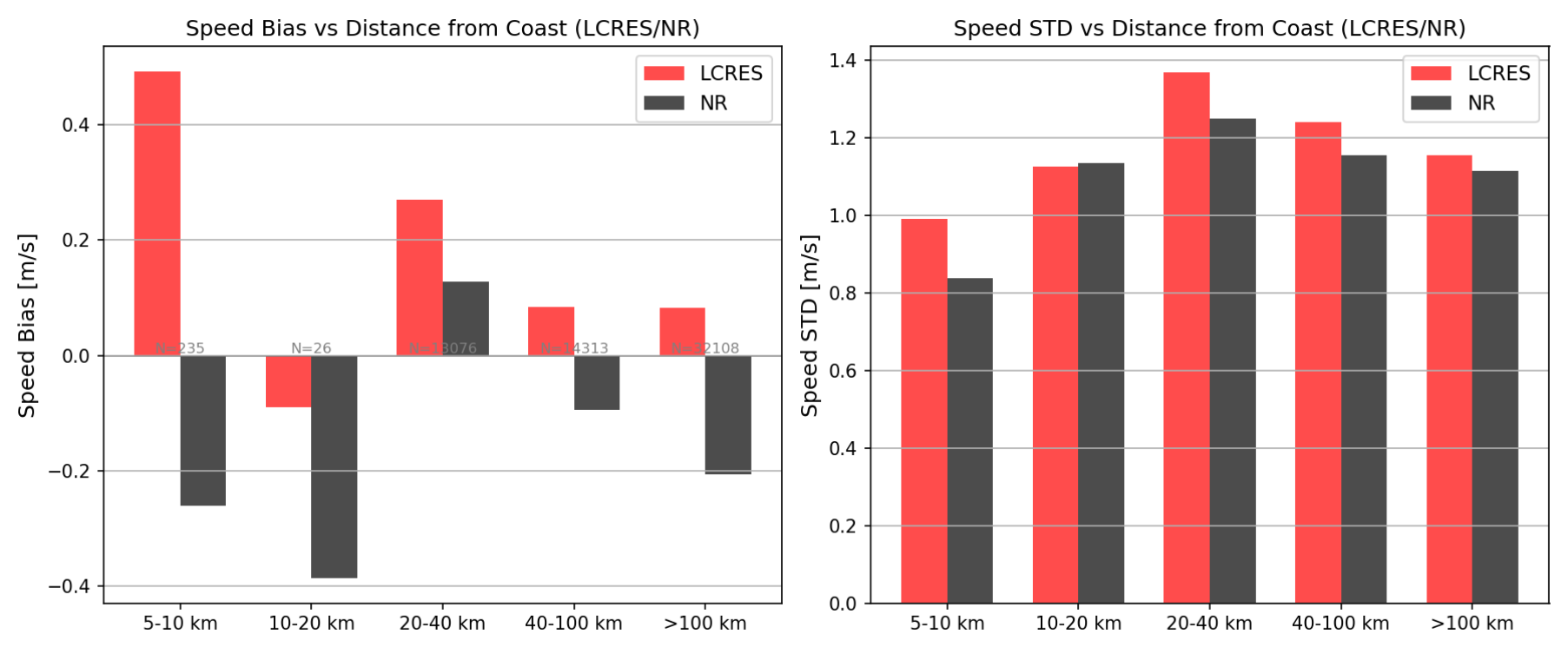


Coastal Performance (20-40 km from coast)

LCRES-NR divergence increases near shore

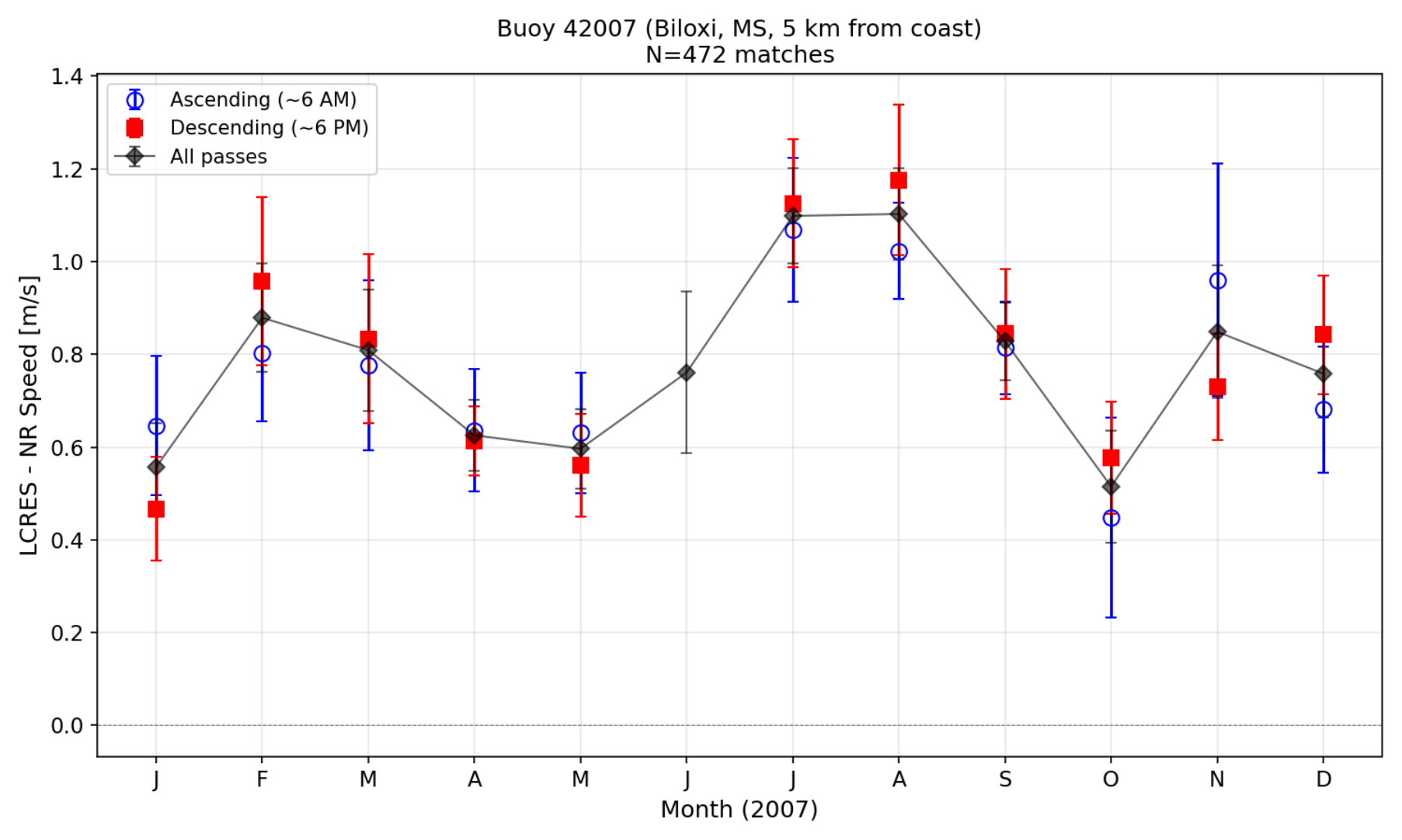


Speed Bias by Distance from Coast



Monthly LCRES-NR Bias: Buoy 42007

Biloxi, MS (30.1N, 88.8W, 5 km from coast)



Monthly LCRES-NR Bias: Buoy 42035

Galveston, TX (29.2N, 94.4W, 40 km from coast)