

From Inherited Waves to Local Forcing: Frequency-Dependent Wave Adjustment during Typhoon Saudel

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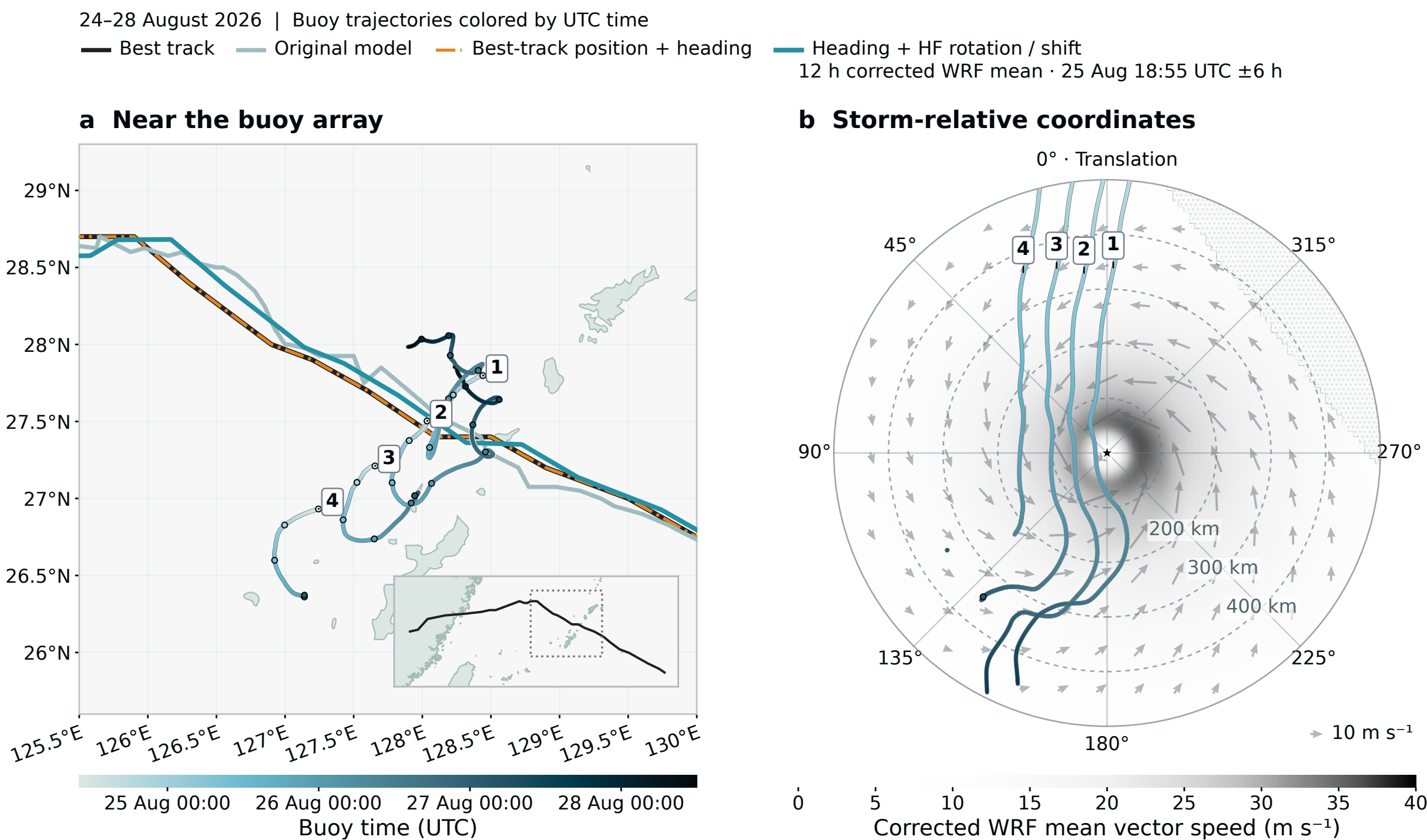
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How do we reconstruct directional wave evolution under a moving tropical cyclone?

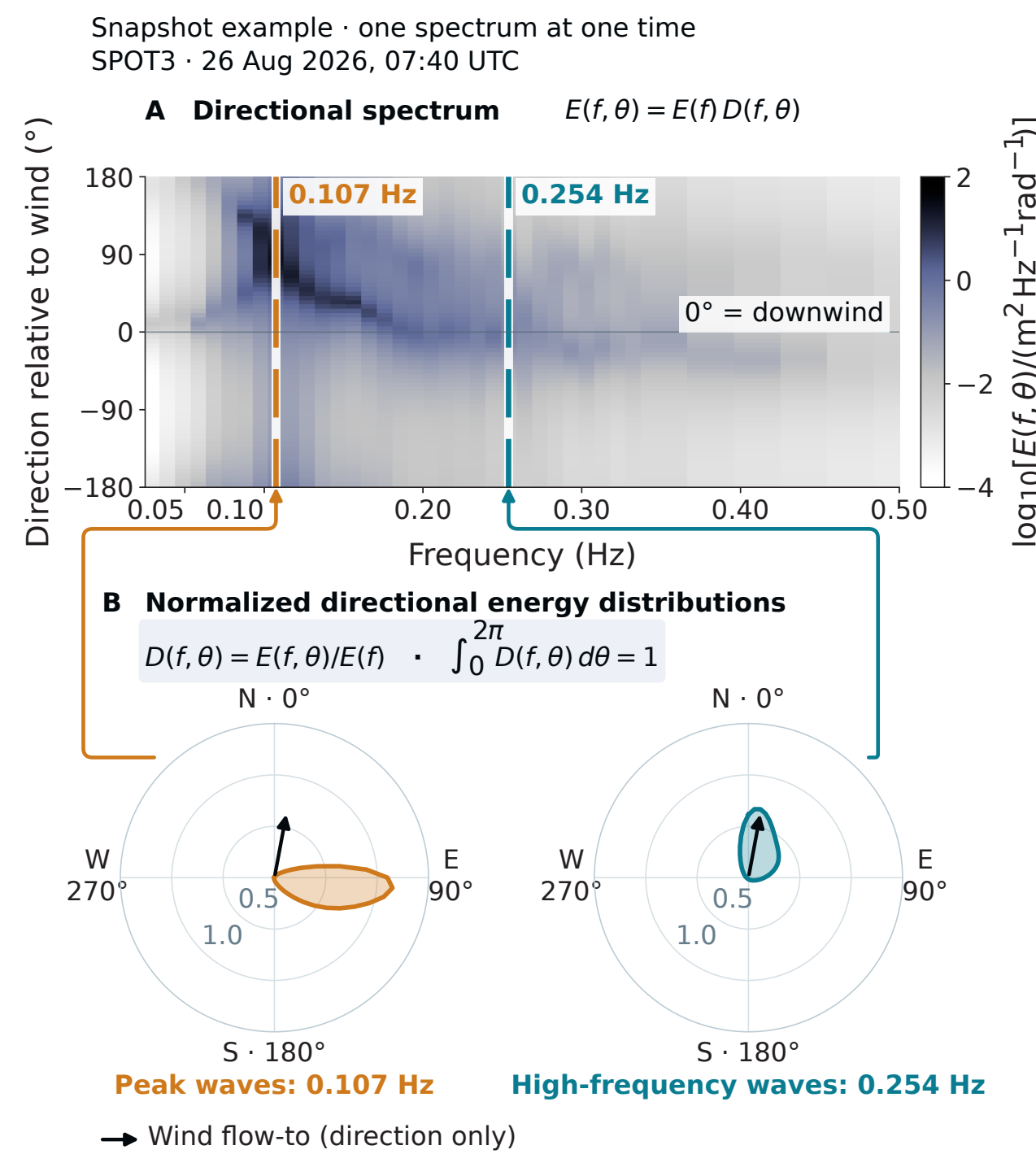
Four drifting Spotter buoys sampled the evolving wave field during Typhoon Saudel (24-28 August 2026).

Directional spectra are reconstructed from measured Fourier moments using the maximum entropy method (MEM), then corrected for Doppler shifts associated with buoy motion. The resulting spectra resolve frequency-dependent wave energy and directional spreading.

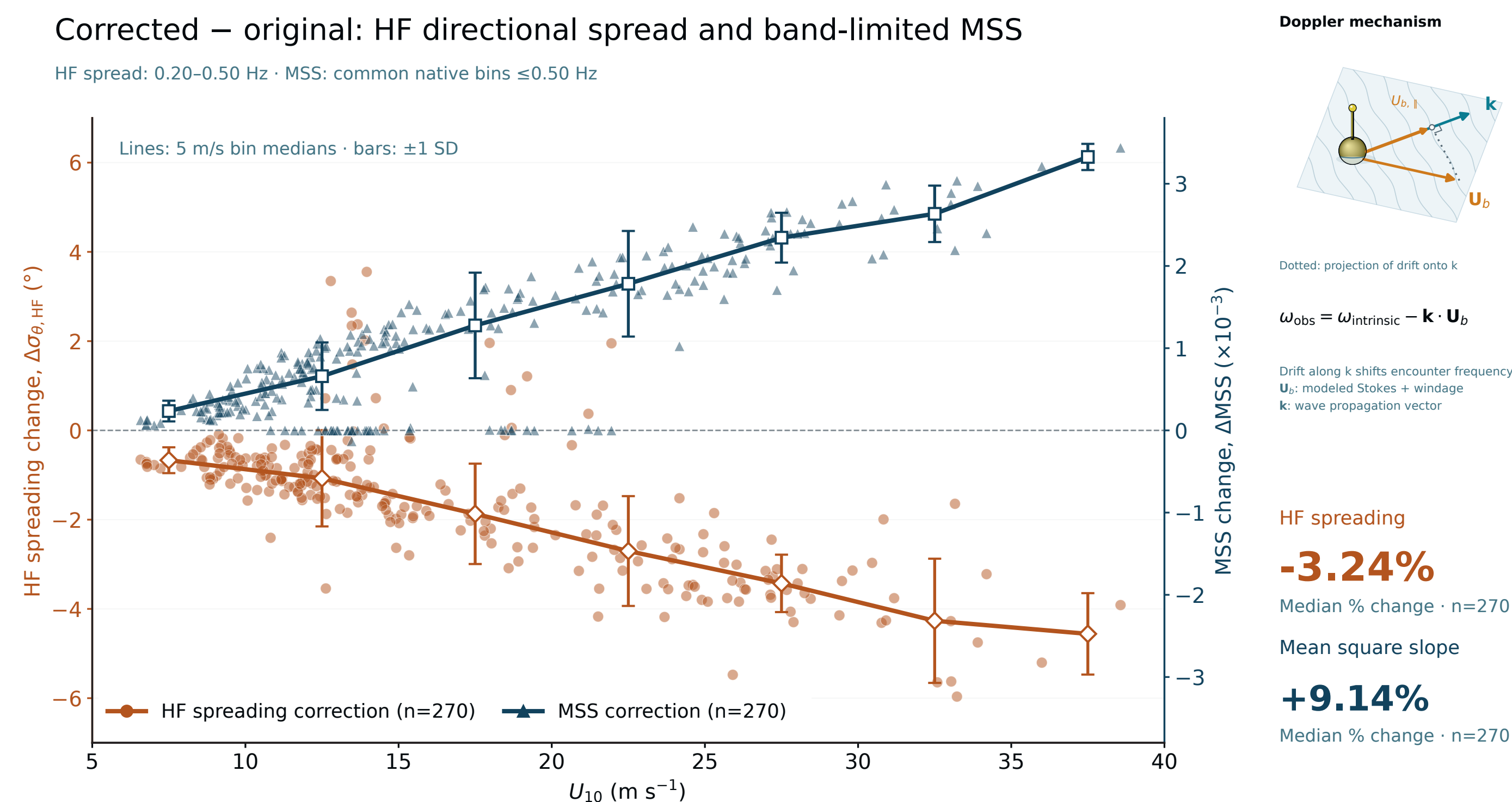
1. Sampling the evolving wave field



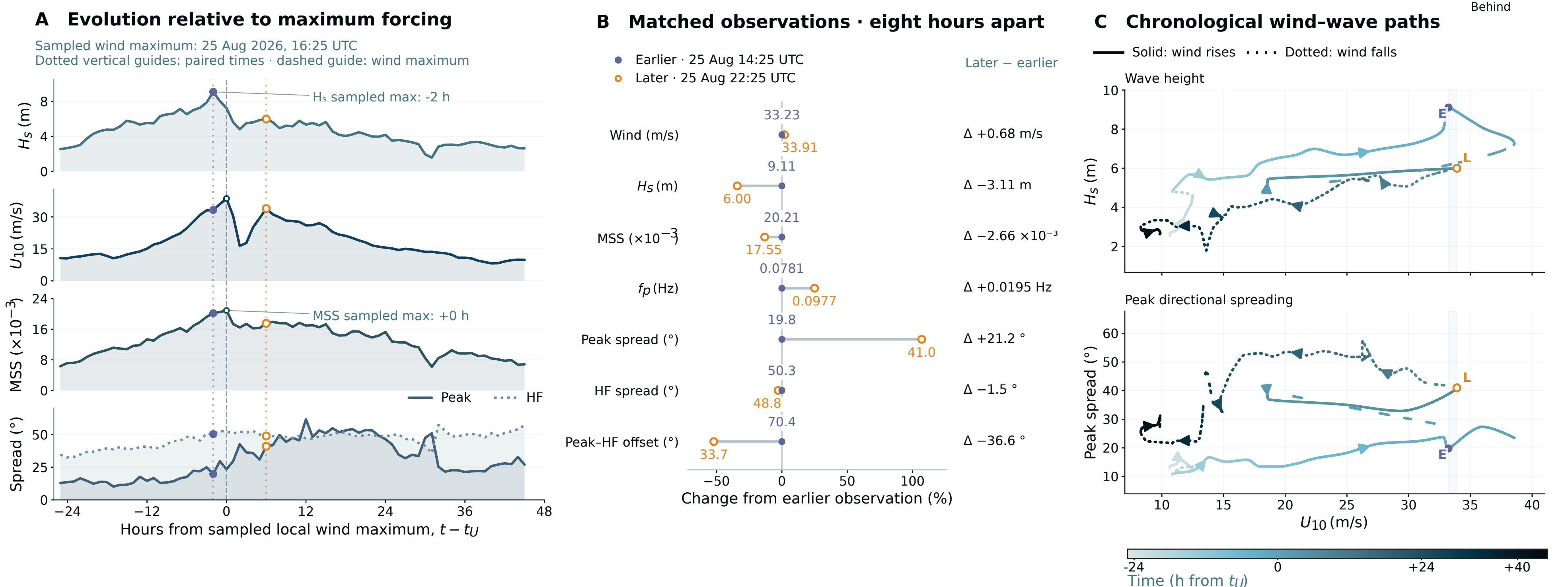
2. MEM spectral reconstruction



3. Correcting for buoy motion



4. Temporal evolution and wind-wave disequilibrium



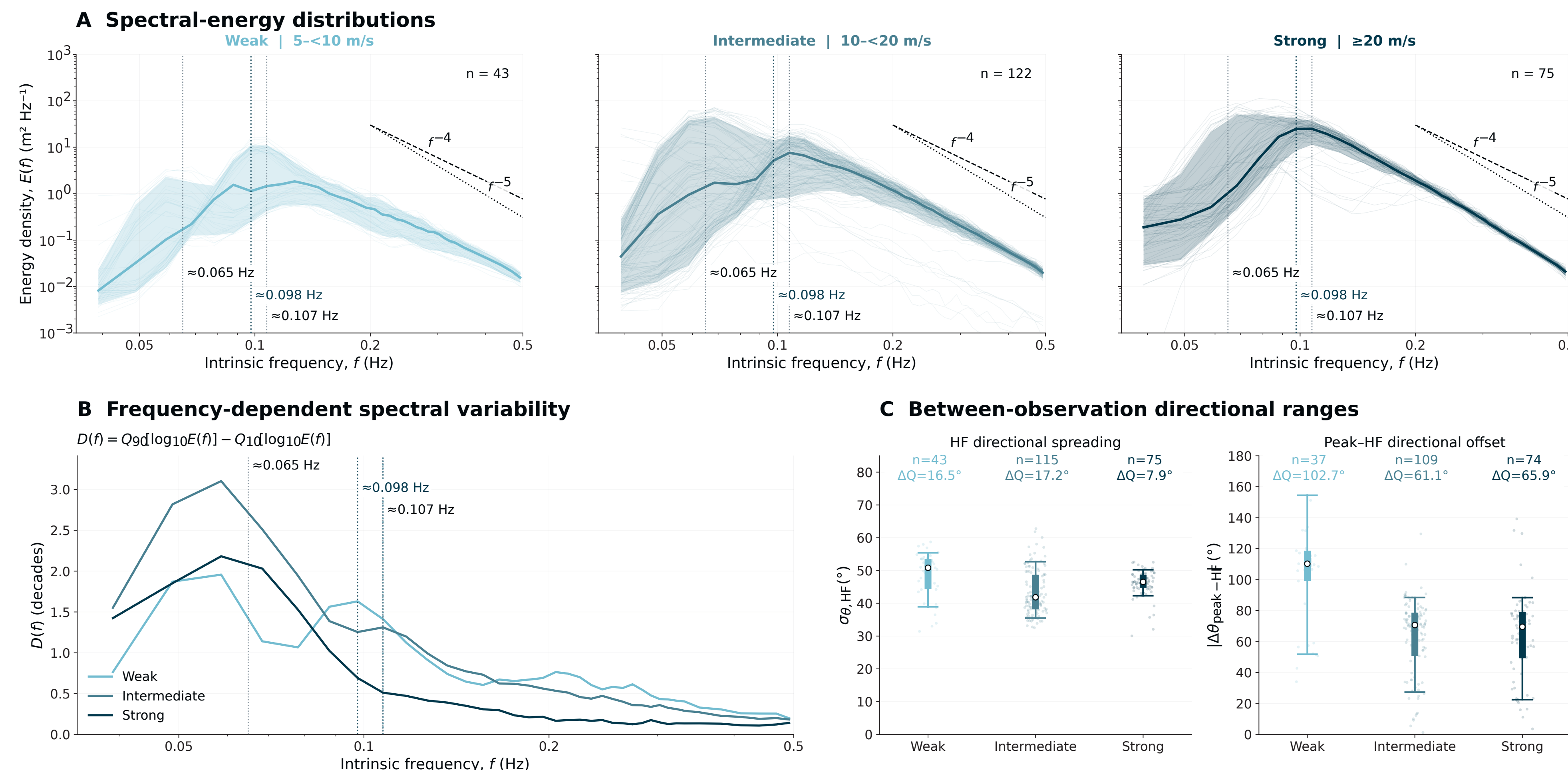
Observation 1 | Instantaneous wind does not uniquely determine wave state.

Observations eight hours apart exhibit nearly identical wind speeds (~33 m s⁻¹) but substantially different wave energy and directional structure.

Observation 2 | Energetic and directional properties follow distinct evolutionary paths.

Wave height, mean square slope, and directional spreading evolve differently through storm passage, with rising and falling winds tracing distinct wind-wave relationships.

5. Frequency-dependent spectral structure



Observation 3 | Spectral variability reorganizes across wind regimes.

Weak and intermediate winds exhibit distinct peak-frequency populations and enhanced variability near their spectral peaks. Under stronger winds, high-frequency energy spectra become more consistent, while directional variability persists.

Conclusion | Wave-field adjustment is frequency dependent, with energetic and directional properties exhibiting distinct evolution.

Stronger winds are associated with increasingly consistent high-frequency energy spectra, even as directional variability persists. Together with the distinct chronological wind-wave trajectories, these observations suggest that inherited and locally forced components coexist within an evolving sea state. The controlling mechanisms and intrinsic adjustment timescales remain unresolved.