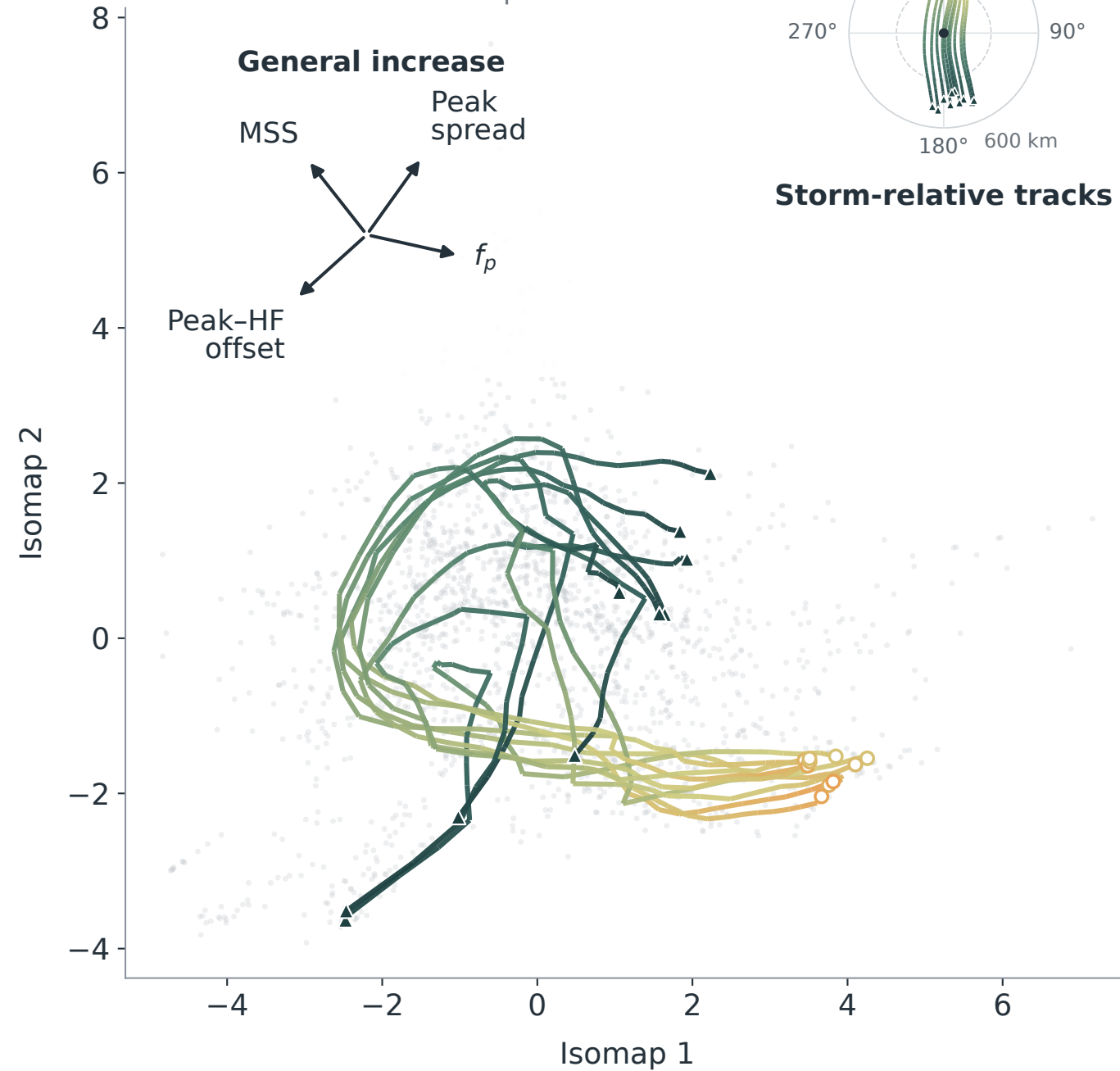


a Idalia buoy trajectories

9-hour smoothing
Three-dimensional Isomap fit



b History improves prediction

Held-out RMSE of log response

Peak directional spread

Component crosswind variance

Wind only: 0.288 **-28%**

With history: 0.208

Peak-HF directional offset

Historical crosswind

Wind only: 1.259 **-15.5%**

With history: 1.064

HF directional spread

Historical wind curl

Wind only: 0.117 **-14%**

With history: 0.100

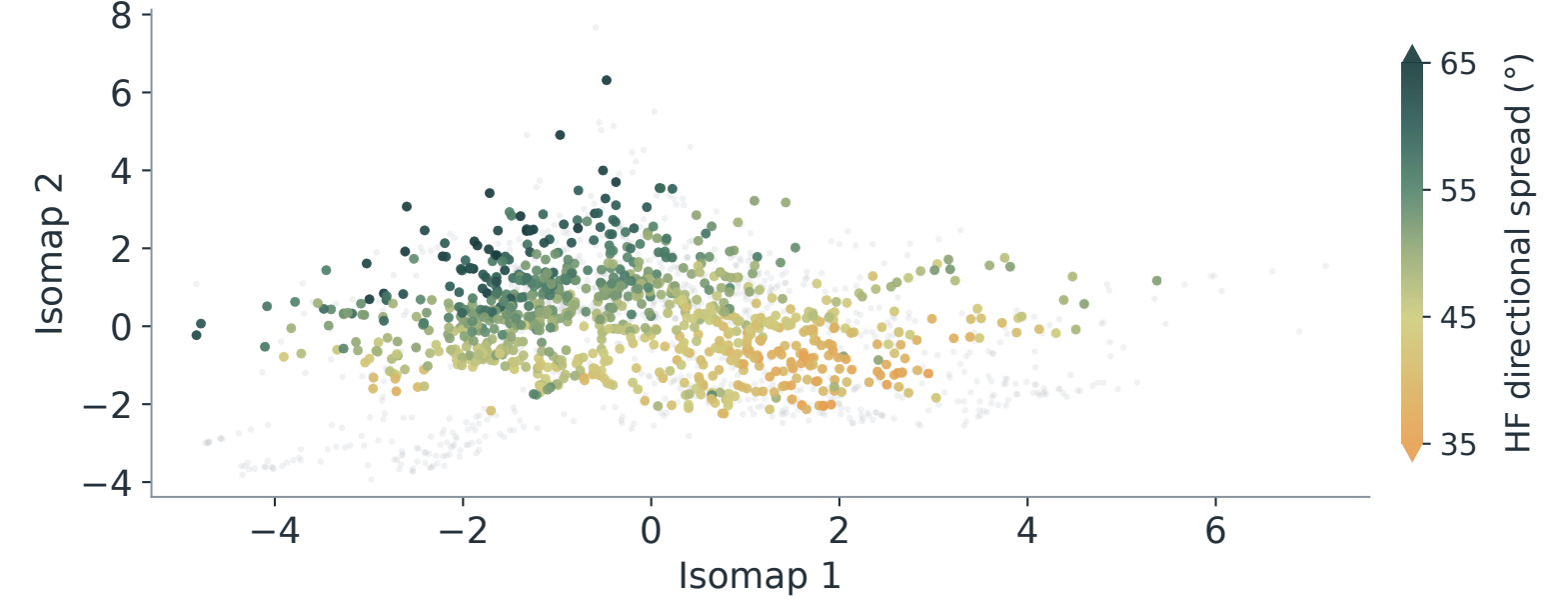
Nested leave-one-storm-out validation;
1,068 observations across four storms.

Gray bar: wind-only RMSE
Colored segment: error reduction
Each row has its own RMSE scale

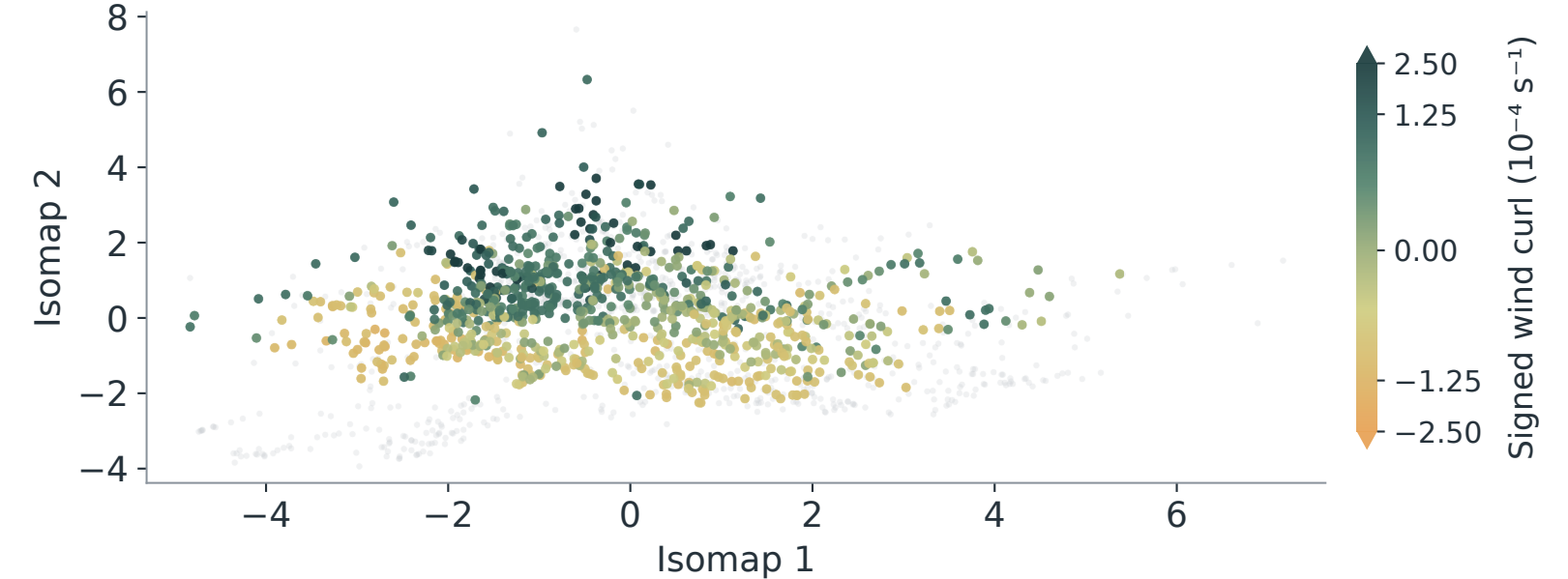
c Spectral state and forcing history

Neither variable was used to construct the embedding.

HF directional spread



Historical signed wind curl



902 matched observations

HF-tail component history · Gaussian center 360 min, $\sigma = 45$ min

Positive curl: counterclockwise · Color midpoint: median curl