



Potential uses of Sofar wave data for Navy wave model validation and assimilation

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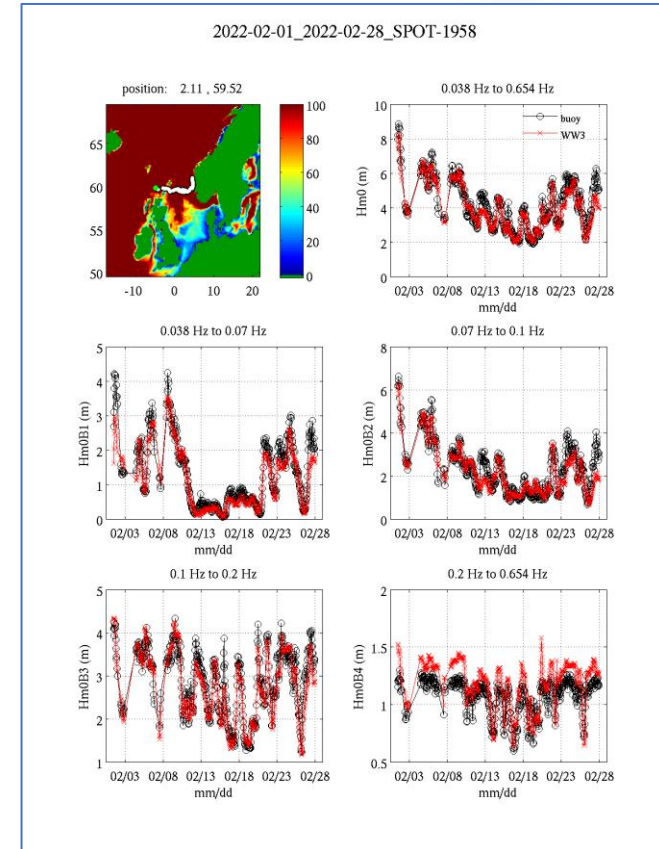
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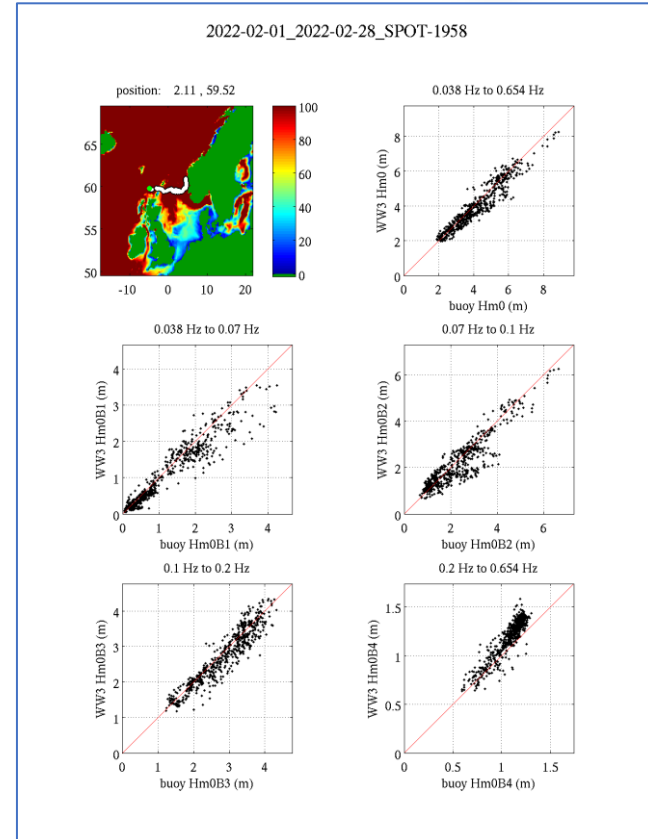
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- Feb 2022 example.
- For a single spotter buoy ('SPOT-1958'), we have spectral data (black) that can be used to validate a global wave model hindcast (red).
- Top left: buoy position during Feb 2022 (green dot=starting position).
- Top right: Comparison of significant waveheight (SWH)
- 4 lower panels: Comparison of "partial waveheight", i.e. contribution from 4 frequency bands. (together, they sum to SWH, in "sqrt of sum of squares" fashion)

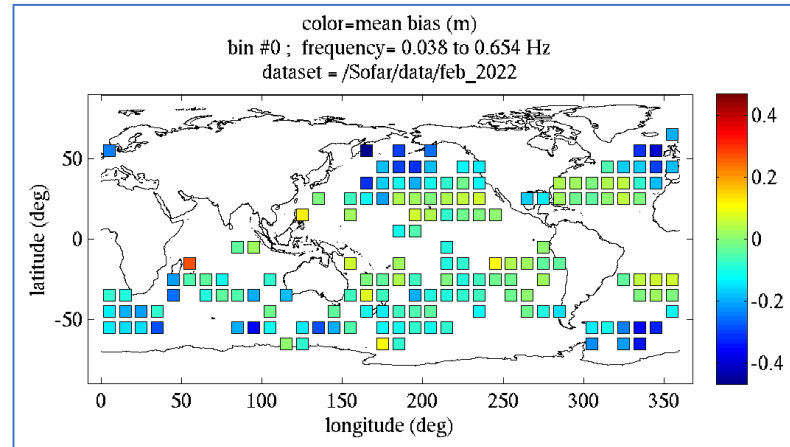
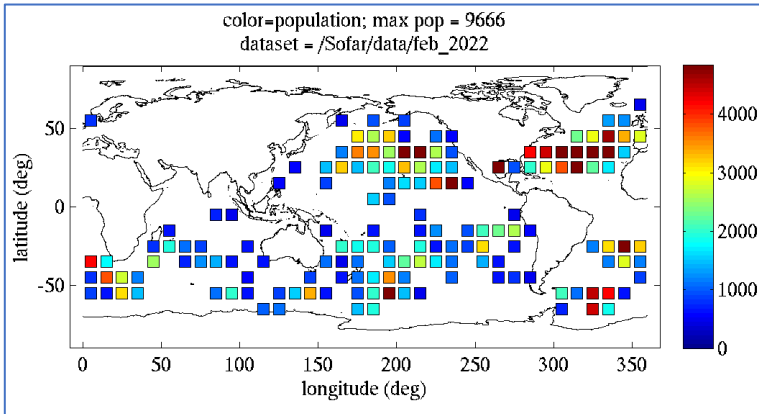
- Extra complexity: Co-location of spectral information from non-moored buoy.
- Directional information is also available from buoy and model, but is not considered here.



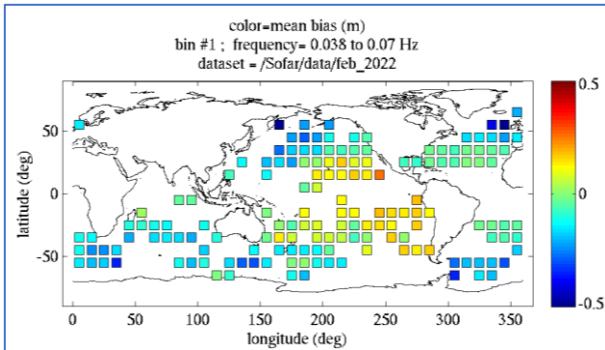
- This is like the prior slide, except the comparison is as a scatter plot, instead of time series.
- With this type of co-location done, we can easily build statistics for all 5 of these parameters.
- However, there were 581 comparisons like this for Feb. 2022.
- 581 sets of 5 scatter plots each....this is a lot to sort through.



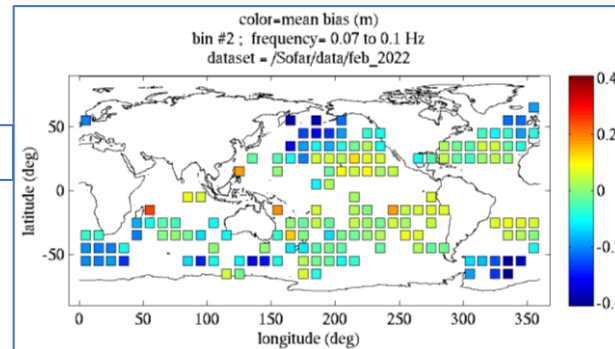
- We want to distill the data somewhat, while still retaining information about a) geographic variation and b) frequency variation.
- Here, we look at mean bias within $10^\circ \times 10^\circ$ geographic bins.
- Like before, we will look at 4 frequency bins, but to start with, we plot:
 - Left panel : number of co-locations
 - Right panel : bias for SWH.



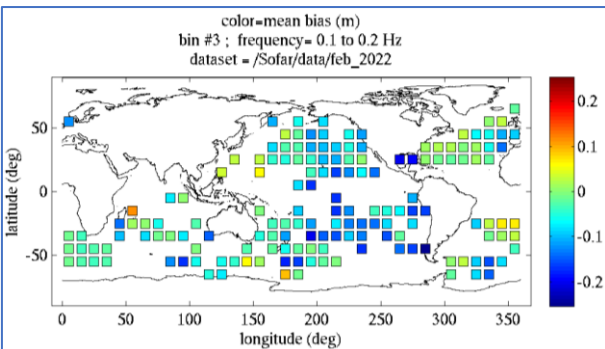
- Now we look at the 4 frequency bands.



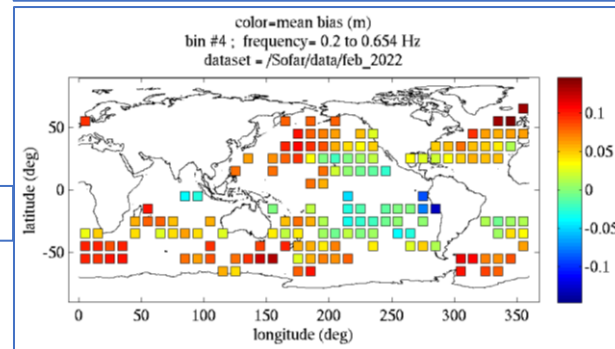
Lowest frequencies



Low-to-mid frequencies



Mid-to-high frequencies



Highest frequencies

Example validation



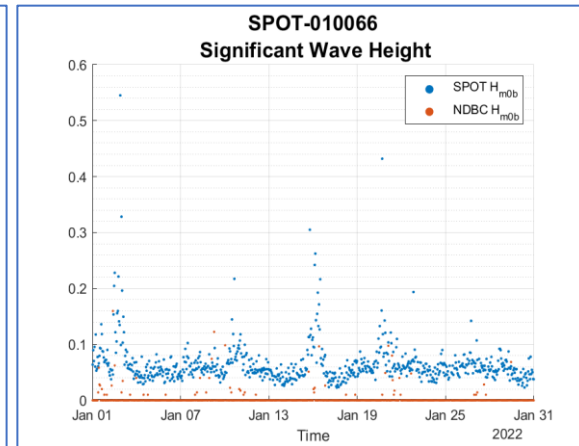
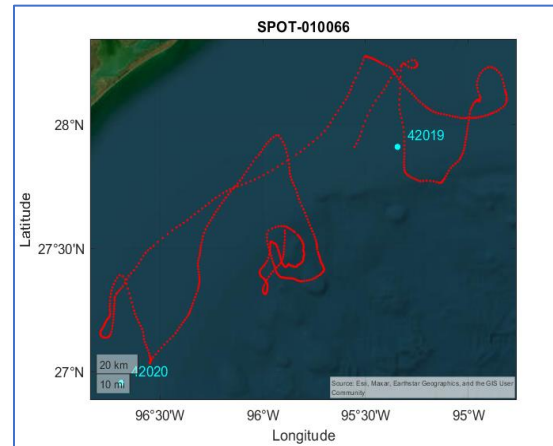
- We looked at 5 parameters here. Any spectrum-derived wave parameter can be validated in similar fashion.
 - Examples: Frequency spreading (important for rogue waves), directional spread, mean square slope, Stokes drift (at any vertical level, but evaluation at $z=0$ is most common), dominant period, significant steepness, ...
- We looked at bias here. We can also look at other error metrics
 - Examples: RMSE, scatter index, correlation
- This is a continuous hindcast/analysis, so $\tau=0$ by definition. One could also evaluate the dependence of skill on forecast range (τ).
- We looked at the global model here. In principle, one could also evaluate a regional model, though observational data volume will (obviously) be much reduced.

Bottom line: Potential huge contribution to wave model validation efforts.

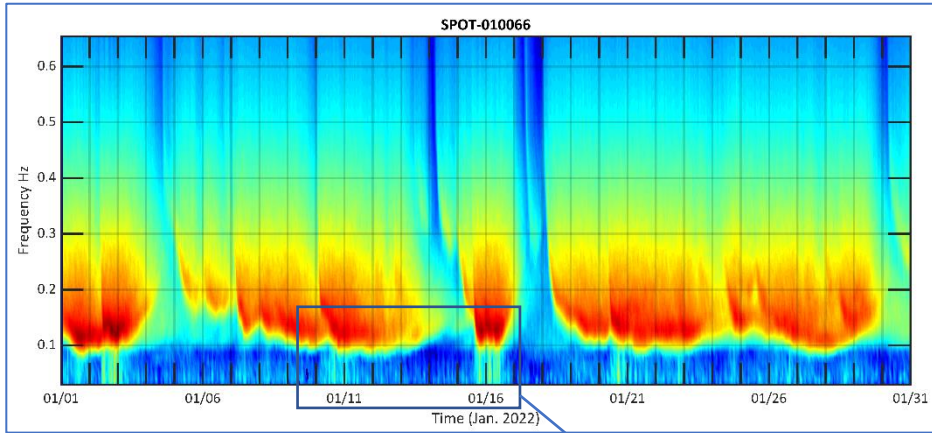
- In some cases, there is more low frequency energy reported by the Sofar buoy than predicted by the model, where intuition suggests that the model may be “more correct” (e.g. we do not expect significant low frequency energy in western Gulf of Mexico in January)
- Sofar suspects instrument noise may play a role. (“not implausible”)
- Evaluation by Aubrey Geary (NRL NREIP) confirms intuition (comparison vs. moored buoys).

- Problem is small in absolute sense, but not small in relative sense.
- Problem is evident in only a small minority of our comparisons (recall that we looked at 581 buoys).
- Problem is only evident in some types of comparison.
- Pieter Smit has plans to look at filter.

Comparison vs. moored buoys provided by Aubrey Geary (NRL NREIP, summer intern)



Quality control discussion



Log of spectral density, $\ln(E(f))$, shown.
Plot created by David Wang, NRL 7330

