

Comparison of Argo and Aquarius sea surface salinity probability distributions

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Abstract

Using Argo in situ and Aquarius version 3.0 sea surface salinity, we compare measured salinity across metric distributions. In addition to traditional comparisons between mean or median values, the 1%, 10%, 25%, 50%, 75%, 90% and 99% quantiles of the statistical distributions are compared. The datasets compare well at the median, which is to be expected as the Aquarius retrieval algorithm is based on calibration with Argo central characteristics. The datasets are less similar at the tails of the distributions, especially in the lower tail. In general, Argo data are much peakier, with more of the observations concentrated in the center of the distribution. This is true across seasons, ocean basins and hemispheres. Aquarius is better able to capture the low and high tail values which are most prevalent during periods when the surface salinity is rapidly changing.

Data

Dates: Aug 25, 2011 to June 1, 2014 **Area:** worldwide between 30°S to 30°N. **Range:** 20 to 40psu

Aquarius

- V3.0 Level 2 data were binned and averaged into 1/2° along-track latitude intervals
- Data with a land fraction greater than 1/2% were removed.
- Gross range check; deletion of obviously erroneous values; a check for valid orbital position.

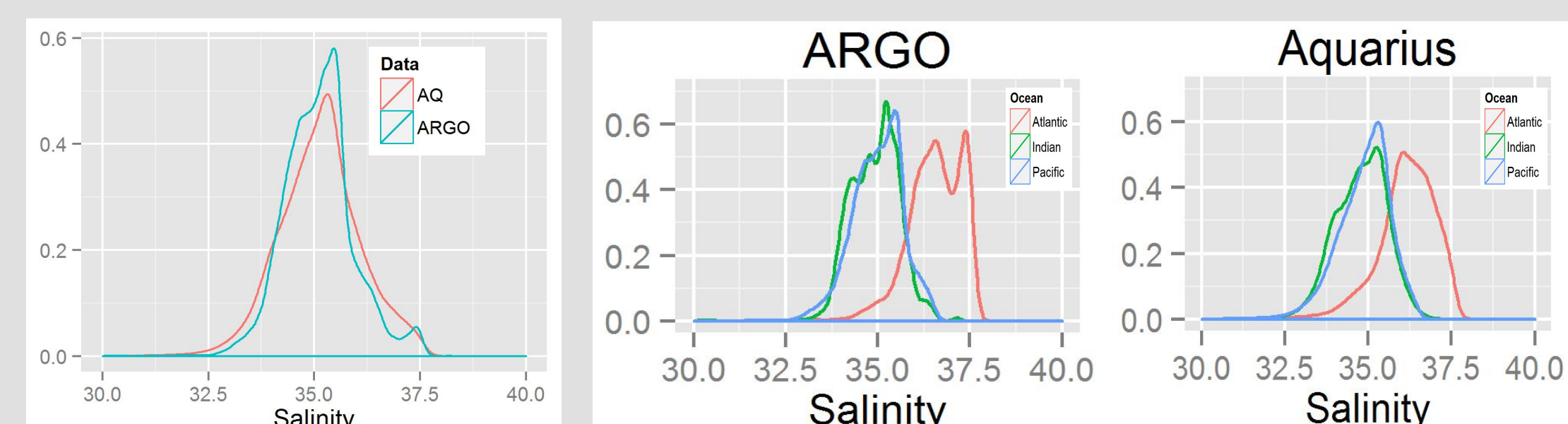
Argo Floats

- Only topmost salinity value (above 10m in depth) were incorporated
- Salinity measurements from the Argo floats deployed during the SPURS mission in September of 2012 in the North Atlantic were removed for this analysis, so as not to bias from oversampling
- Only floats within 100 km of Aquarius measurements were used to avoid shoreline bias

Note: Argo measures bulk surface salinity (top 10m), whereas Aquarius measures skin values (top 1cm), adding yet one more caveat while making direct comparisons

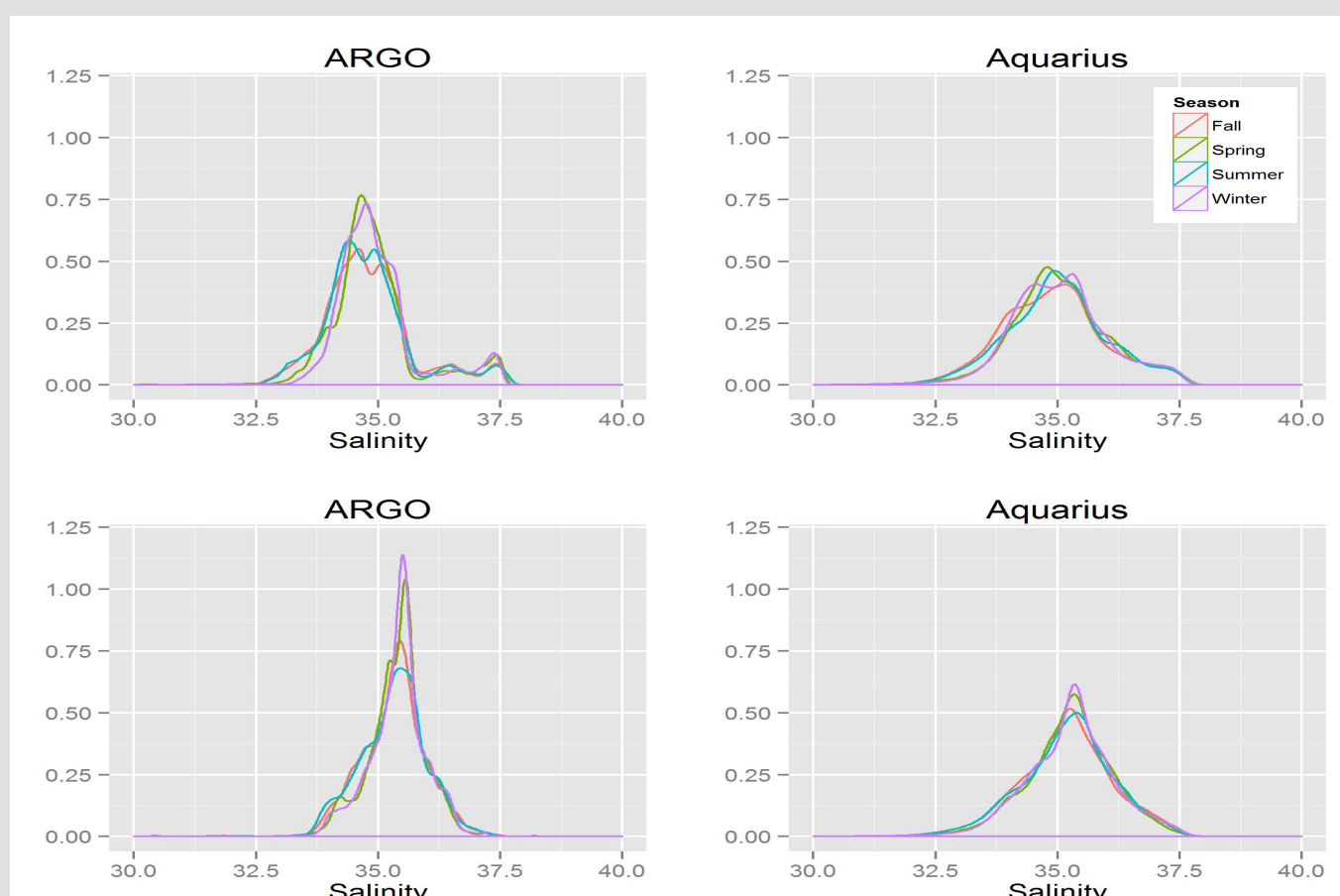
Exploratory Data Analysis by Season

Aquarius exhibits a much smoother distribution of salinities, likely an artifact of the retrieval algorithm used to extract salinity values from brightness temperature measurements



(Fig. 1, 2) Density plot comparisons of Aquarius and Argo worldwide (left) and by ocean basin (right)

Note the difference in densities in the Atlantic ocean, with Argo consistently capturing more values of salinity near 37.5psu. This indicates that Aquarius, which captures salinity as a swath average, is able to pick up large magnitude but localized and unlikely events.



(Fig. 3) Density plots of Aquarius and Argo by season in the N Hemisphere (top) and S Hemisphere (bottom)

- Seasons are defined as [N – (S)]:
 - **Winter:** J, F, M – (J, A, S)
 - **Spring:** A, M, J – (O, N, D)
 - **Summer:** J, A, S – (J, F, M)
 - **Fall:** O, N, D – (A, M, J)

- Argo captures more of the mean behavior (peakier), especially in the spring and winter for both hemispheres. This possibly indicates that low salinity events are stronger but in very small pockets/areas.
- Argo also captures more of a bimodal trend in the N hemisphere.

| | 0.01 | 0.05 | 0.10 | 0.25 | 0.50 | 0.75 | 0.90 | 0.95 | 0.99 |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Argo | 33.07 | 33.82 | 34.11 | 34.55 | 35.10 | 35.56 | 36.14 | 36.55 | 37.42 |
| Aquarius | 32.74 | 33.48 | 33.81 | 34.32 | 34.97 | 35.48 | 36.03 | 36.45 | 37.43 |

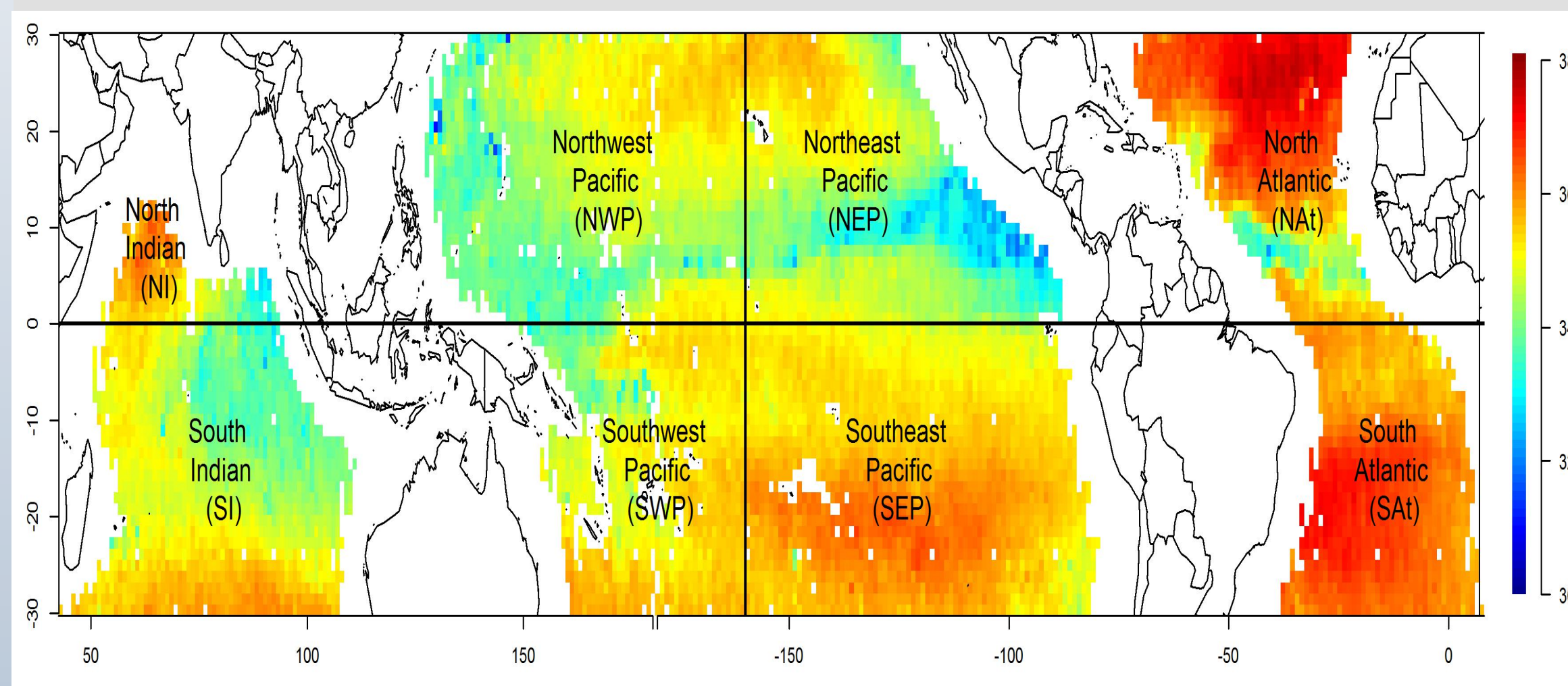
(Table 1) Quantile comparisons of Argo and Aquarius worldwide

| Ocean | Product | 0.01 | 0.05 | 0.10 | 0.25 | 0.50 | 0.75 | 0.90 | 0.95 | 0.99 |
|----------|----------|-------|-----------|------------------|----------|---------------------|-------|-------|-------|-------|
| Atlantic | Aquarius | 34.27 | 34.97 | 35.38 | 35.95 | 36.52 | 37.13 | 37.45 | 37.57 | 37.74 |
| | Argo | 28.47 | 35.02 | 35.57 | 36.06 | 36.57 | 37.17 | 37.44 | 37.51 | 37.62 |
| Indian | Aquarius | 32.94 | 33.52 | 33.76 | 34.18 | 34.74 | 35.23 | 35.62 | 35.87 | 36.20 |
| | Argo | 33.27 | 33.90 | 34.08 | 34.42 | 34.96 | 35.38 | 35.68 | 35.91 | 36.44 |
| Pacific | Aquarius | 32.65 | 33.41 | 33.78 | 34.29 | 34.92 | 35.39 | 35.74 | 35.98 | 36.35 |
| | Argo | 33.07 | 33.75 | 34.08 | 34.52 | 35.03 | 35.48 | 35.79 | 36.09 | 36.45 |
| Ocean | Product | N | \bar{x} | 95% CI for μ | σ | 95% CI for σ | | | | |
| Atlantic | Aquarius | 3651 | 36.45 | (36.40, 36.50) | 0.81 | (0.78, 0.85) | | | | |
| | Argo | 3651 | 36.43 | (36.36, 36.51) | 1.19 | (1.14, 1.25) | | | | |
| Indian | Aquarius | 7789 | 34.71 | (34.66, 34.75) | 0.73 | (0.70, 0.77) | | | | |
| | Argo | 7789 | 34.89 | (34.83, 34.94) | 0.84 | (0.81, 0.89) | | | | |
| Pacific | Aquarius | 30068 | 34.82 | (34.77, 34.87) | 0.80 | (0.77, 0.84) | | | | |
| | Argo | 30068 | 34.97 | (34.92, 35.02) | 0.76 | (0.73, 0.80) | | | | |

(Tables 2, 3) Quantile comparisons of Argo and Aquarius across ocean basin. Standard deviation calculated using bootstrap method to compare variability within data products.

Analysis by Season and Region

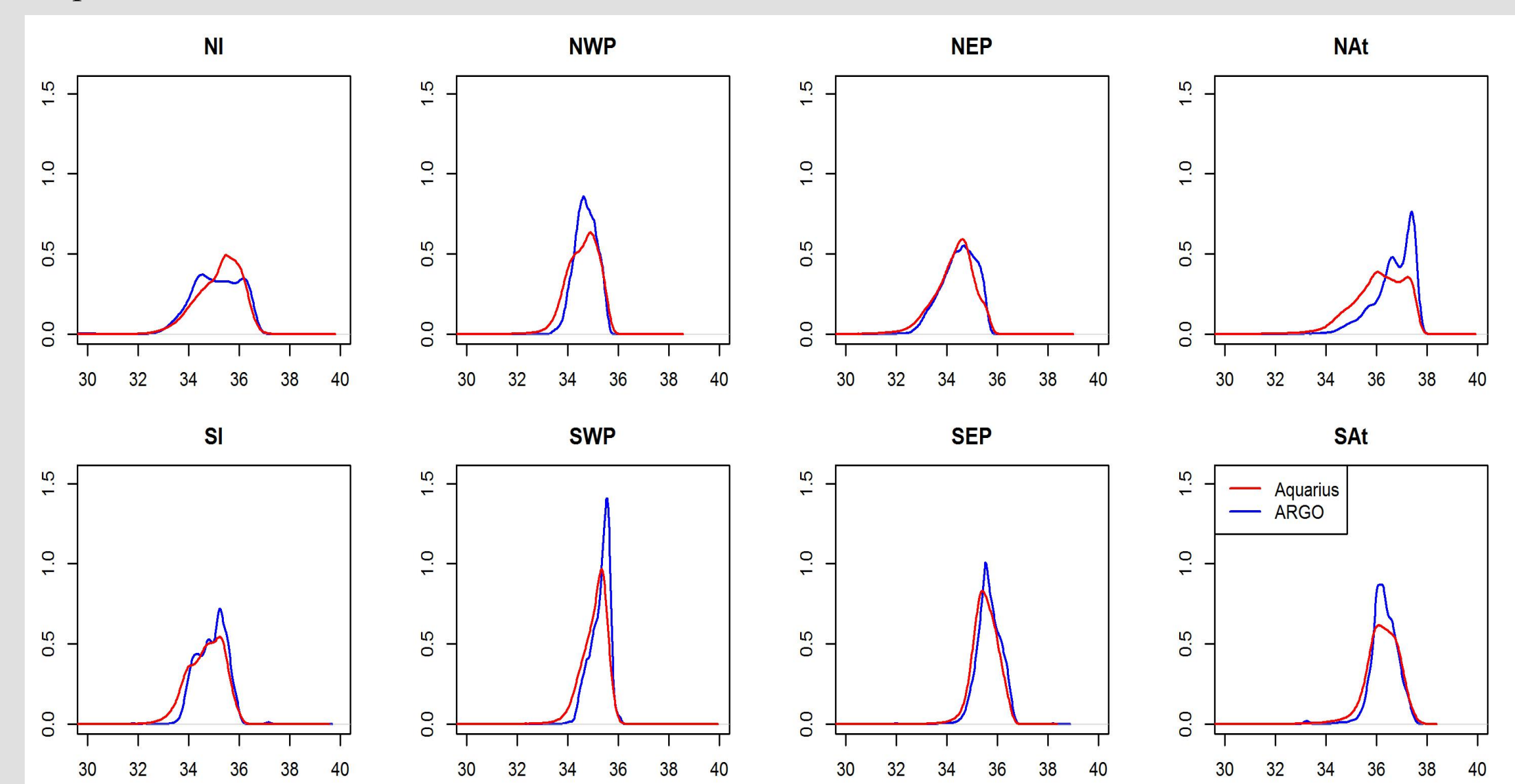
The data were split into eight regions (by ocean and hemisphere, with the Pacific split even farther due to its larger area) to allow for more localized analysis and comparisons.



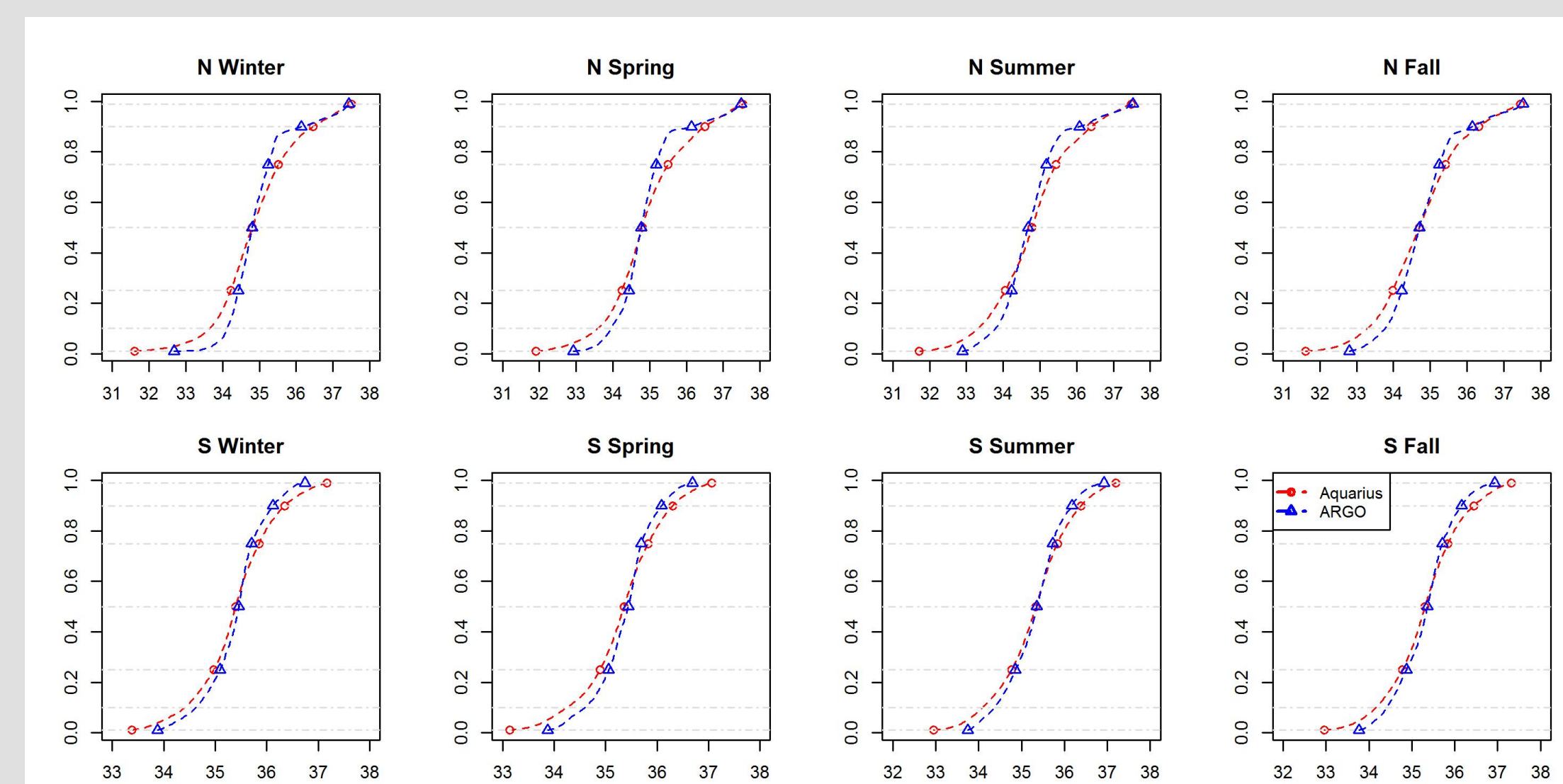
(Fig. 4) One week of Aquarius salinity measurements in mid-October 2012, showing the eight regions

When comparing Aquarius and Argo for the eight regions defined above:

- Argo tends to have more salinity values centered at the mean.
- Aquarius captures more salinity values in the lower tail.
- The South Pacific tends to have the least amount of variation in salinity values or narrowest distribution as shown both through Aquarius and Argo data.
- The North Atlantic and North Indian display both more variation and differences between data products.



(Fig. 5) Density comparison of Aquarius and Argo across eight regions worldwide

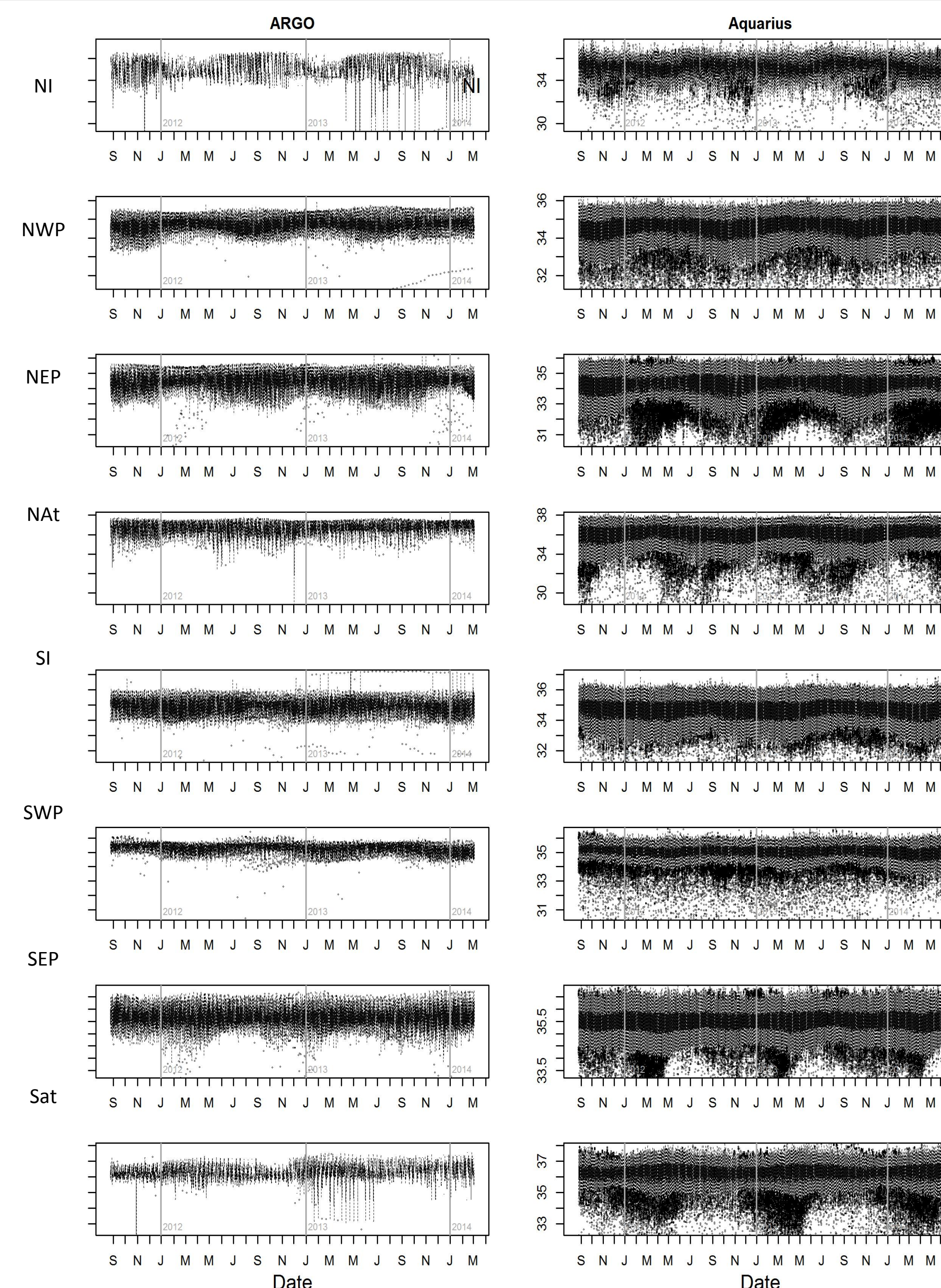


(Fig. 6) Empirical CDFs of Aquarius (red) and Argo (blue) salinity measurements across season and hemisphere

Another depiction of seasonal differences shows:

- Aquarius and Argo agree extremely well in median values, but the tail values diverge.
- This does not appear to be a function of season and is consistent across all ocean basins.

Results



(Fig. 7) Time series of salinity for ARGO (left) and Aquarius (right) boxplots. Notice that Aquarius captures much greater variability and displays a greater amount of cyclical extremes

Summary

- The probability distribution of Aquarius has shorter central peaks and longer, thicker tails, especially in the lower values of salinity—this could be either due to the lower accuracy of Aquarius, or the better ability of Aquarius to capture tail events
- While Argo can tell us about the mean SSS, Aquarius gives us more information about the variability. As this variability is the result of events that may modify SSS such as rainfall, evaporation, horizontal mixing and upwelling, Aquarius can indicate where and when these processes are occurring.
- Understanding the difference between the two products is a matter of not only doing direct point-by-point comparison, but deconvolving that comparison from the very different sampling schemes, the extremely complex Aquarius retrieval algorithm, and the space and time scales inherent in the SSS field itself.

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