Towards Error Characterization in *i*Quam SSTs Using Three-way Analyses with AVHRR and AATSR CCI SSTs

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Introduction

In situ SSTs reported in the NOAA *i*Quam system (www.star.nesdis.noaa.gov/sod/sst/iquam/) are dominated by different data types during different periods of the satellite era. Their respective errors should be characterized, to facilitate seamless transition from one *in situ* standard to another for consistent calibration and validation of reprocessed historical satellite data. This study uses triple-collocations between *i*Quam *in situ* SSTs and two satellite datasets (both IR based, but different in their sensor measurement principles and retrieval methodology), CCI AVHRR17 and Envisat AATSR from 2003 – 2009. Root mean square errors are estimated for ships, drifters, Argo floats, and tropical and coastal moorings. Errors are largest for ships, and smaller and more consistent for drifters, tropical moorings, and Argo floats, with the coastal mooring found in between. Errors in the AVHRR and AATSR CCI SSTs are also estimated, as a by-product of our analyses. Errors are larger in AVHRR and smaller in the AATSR SSTs.

Data

In situ SSTs are from *i*Quam, which uniformly processes and quality controls data from various sources. *i*Quam v2 data are freely available in NetCDF format, compatible with the GHRSST Data Processing Specification (GDS2). The most recent month's data is updated twice daily in NRT and past months could be reprocessed at anytime as long as there is new data available. Five major *in situ* types are analyzed in this study, including ships, drifters, Argo floats, and tropical and coastal moorings.

Satellite SSTs have global and daily coverage and thus are well suited for triple collocation analysis with *in situ* data. SST retrievals from NOAA-17 AVHRR and ENVISAT AATSR, derived by the ESA SST Climate Change Initiative (CCI) program [Merchant et al., 2014] are chosen for this study. Seven years of AVHRR L2P v1.0 and AATSR L3U v1.1 data from Jan 2003 – Dec 2009 are used in this study, obtained from CEDA, www.ceda.ac.uk. Only nighttime data are used, to minimize the effects of the unknown diurnal cycle.

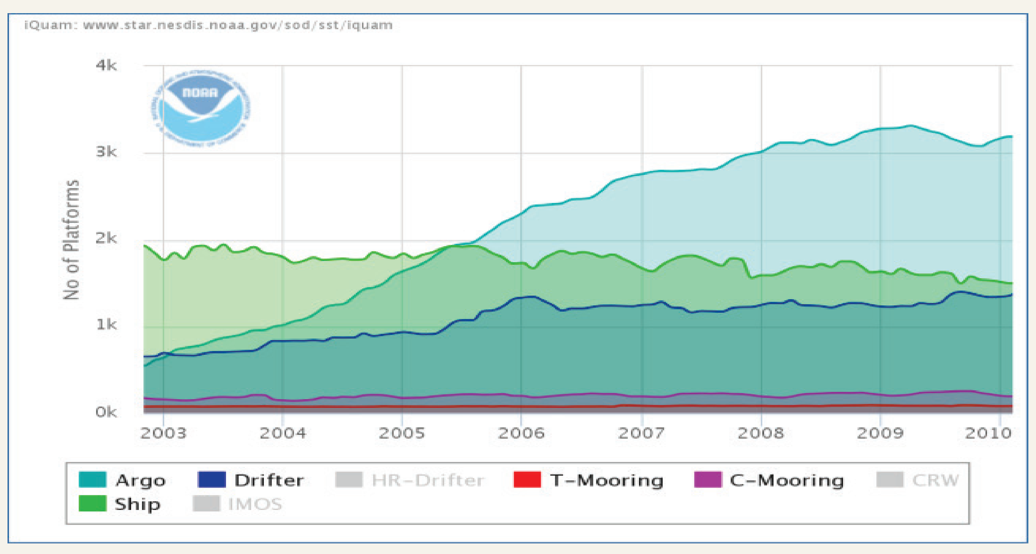

Figure 1: Time series of No. of Platforms in iQuam2.

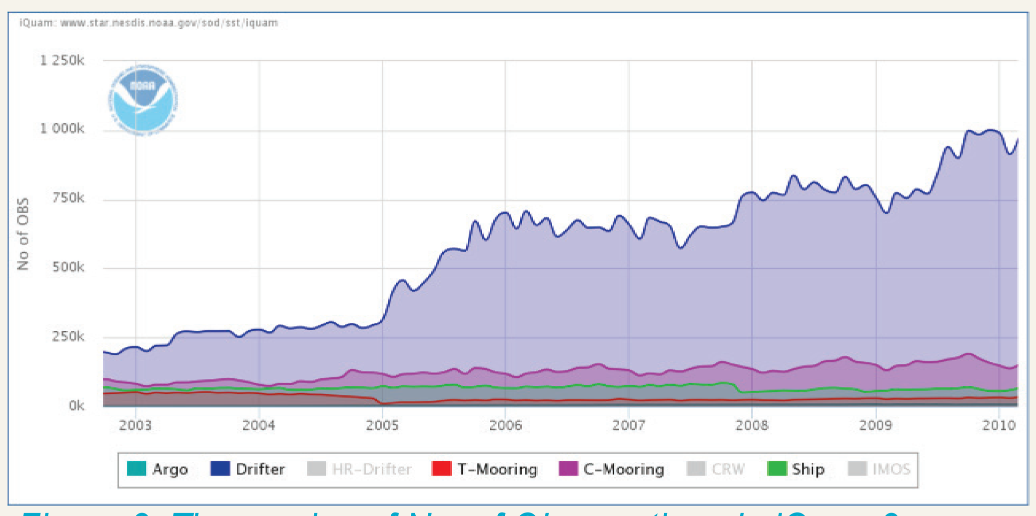

Figure 2: Time series of No. of Observations in iQuam2.

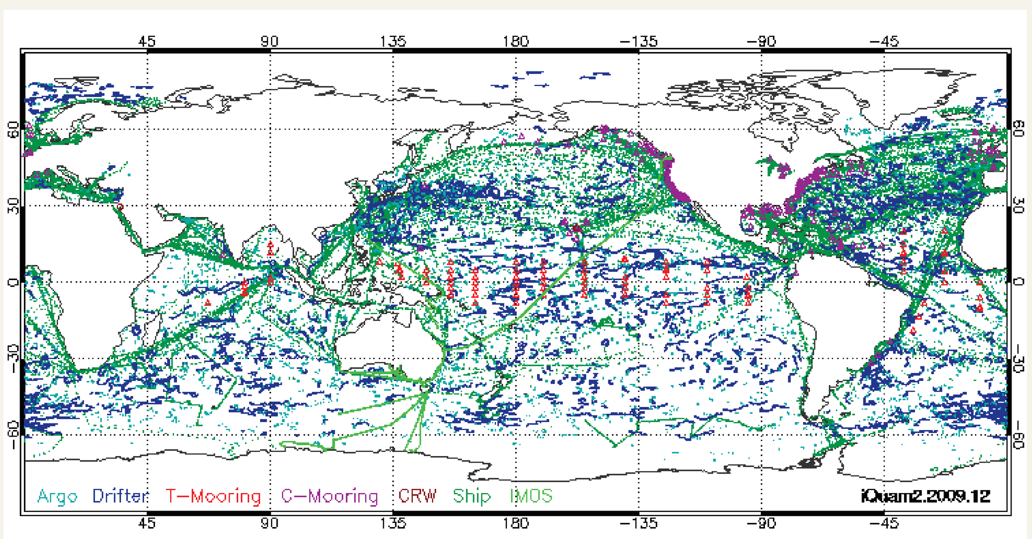

Figure 3: Global map of iQuam2 data for Dec 2009.

Methodology

The triple collocation method has been used to assess the net RMS errors in three sets of independent SST measurements by matching up triplets in space and time [e.g. *O'Carroll 2008; Xu and Ignatov, 2010; Gentemann, 2014*]. In addition to the mutual independencies, another critical assumption in the triple collocation analyses is minimization of match-up noise. A sensitivity study is conducted to evaluate the match-up criteria for triple collocation analysis. A space-time window of 15km by 4hr is chosen based on the following analyses.

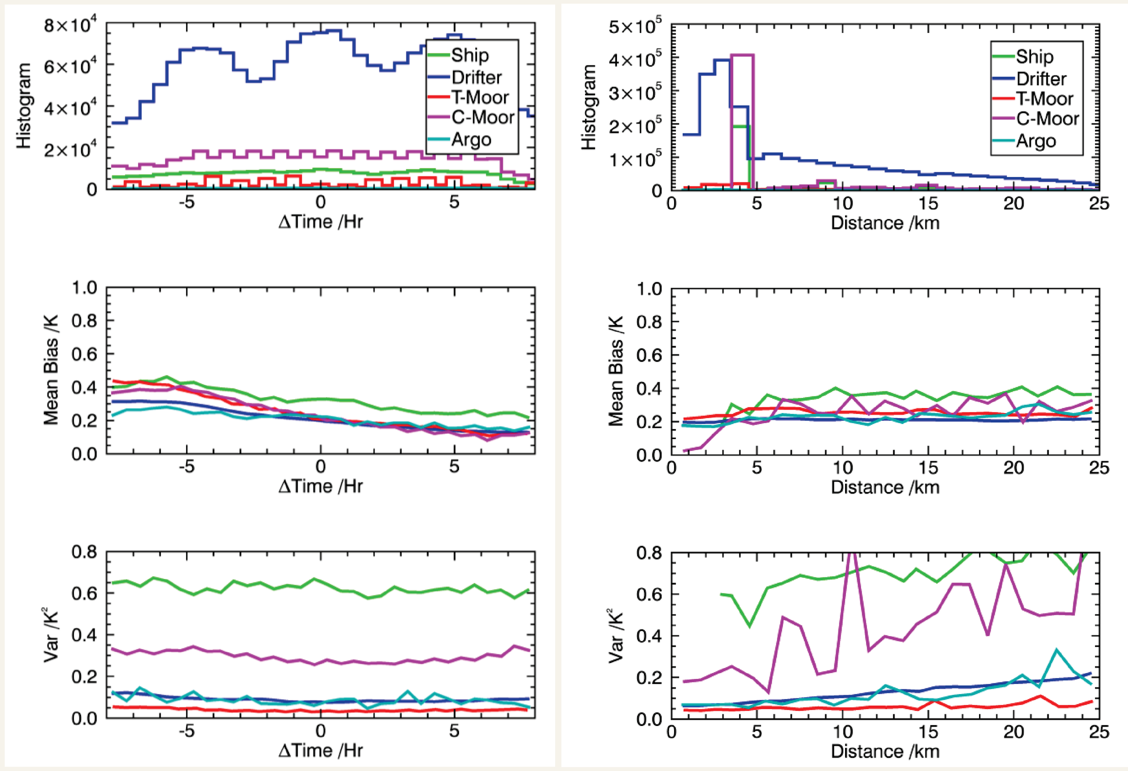

Figure 4: iQuam-AATSR match-up noise sensitivity over time (left) and space (right) separation. (Top, middle and bottom panels show histogram, mean bias and variance, of match-up ΔSST, respectively)

Global Statistics

Triplets are formed, by selecting all three measurements within the defined space-time window. Three-way analysis is then conducted globally, and stratified in space/time. Global error statistics are shown in Table 1. Both satellite skin SSTs show are biased -0.2-0.3K cold with respect to *in situ* SSTs, as expected. Ships have the largest net root-mean squared error ~0.74K, while drifters and Argo floats have smaller errors of ~0.22K. Coastal moorings have ~0.4K error, and tropical moorings show the lowest error of 0.18K. These error statistics are fairly stable over time (see time-series in Fig.5).

Table 1: Three-way error statistics of iQuam-AVHRR-AATSR.

	No. Matchup	Bias (IQ-AV)	Bias (IQ-AT)	SD (IQ)	SD (AV)	SD (AT)
Ship	120,020	0.36K	0.30K	0.74K	0.37K	0.22K
Drifter	839,641	0.30K	0.20K	0.22K	0.36K	0.15K
T-moor	39,899	0.34K	0.22K	0.18K	0.41K	0.04K
C-moor	255,773	0.22K	0.21K	0.40K	0.37K	0.29K
Argo	5,385	0.31K	0.21K	0.22K	0.39K	0.15K

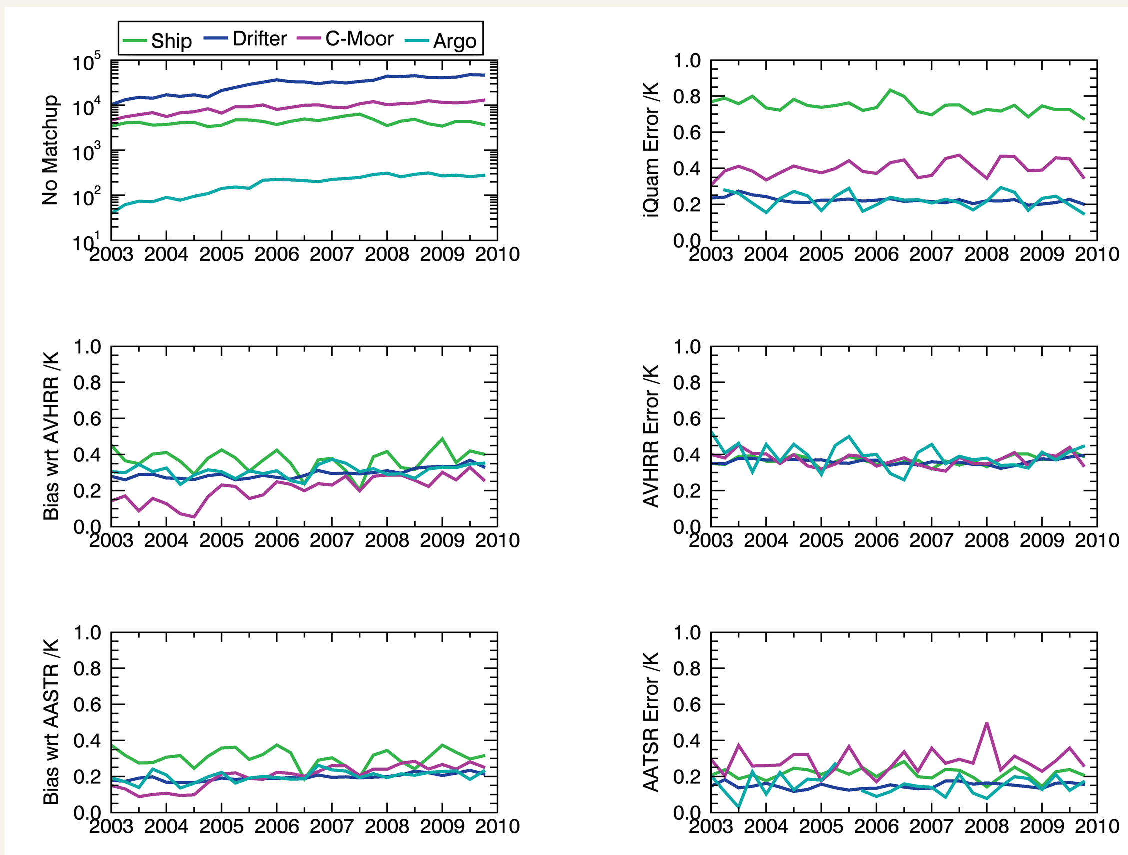

Figure 5: Quarterly time-series of three-way analyses.

References

O'Carroll et al. (2008), JTECH
Xu and Ignatov (2010), JGR
Merchant, et al. (2014), Geoscience Data Journal
Xu and Ignatov (2014), JTECH
Gentemann (2014), JGR

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Geographic Patterns

The geographic patterns show that errors are larger for both *in situ* and satellite in dynamic regions such as coastal areas, Gulfstream and Kuroshio.

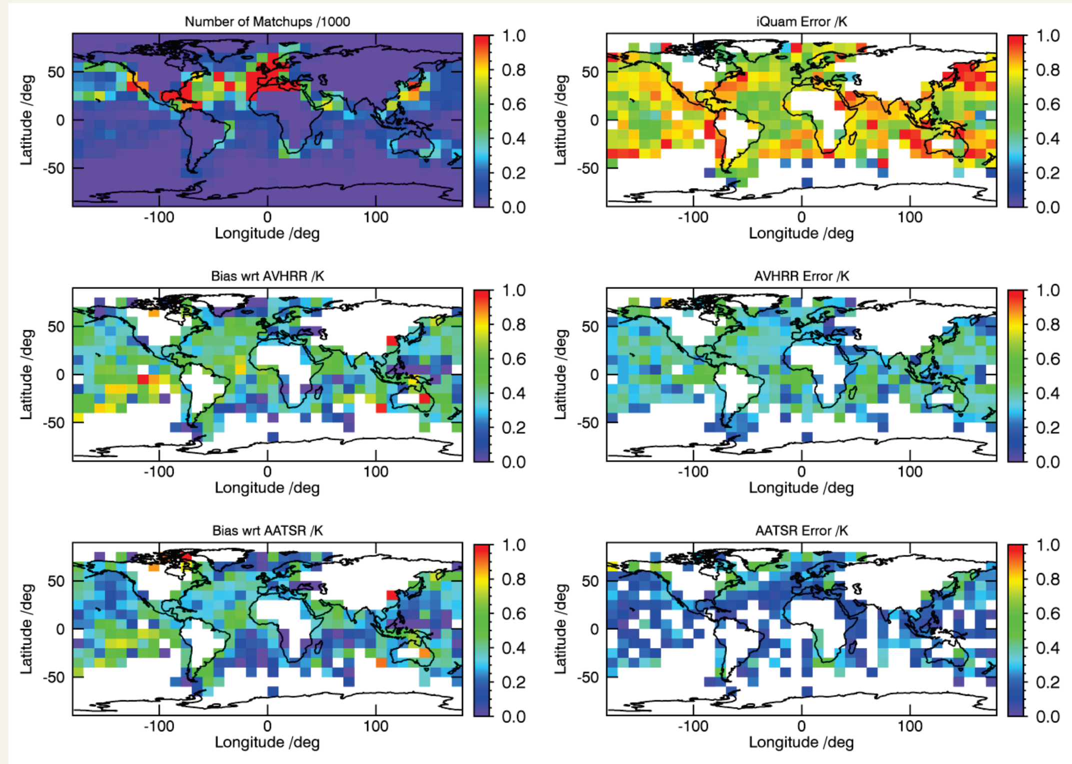

Figure 6: Geographic pattern of three-way error statistics of Ships-AVHRR-AATSR.

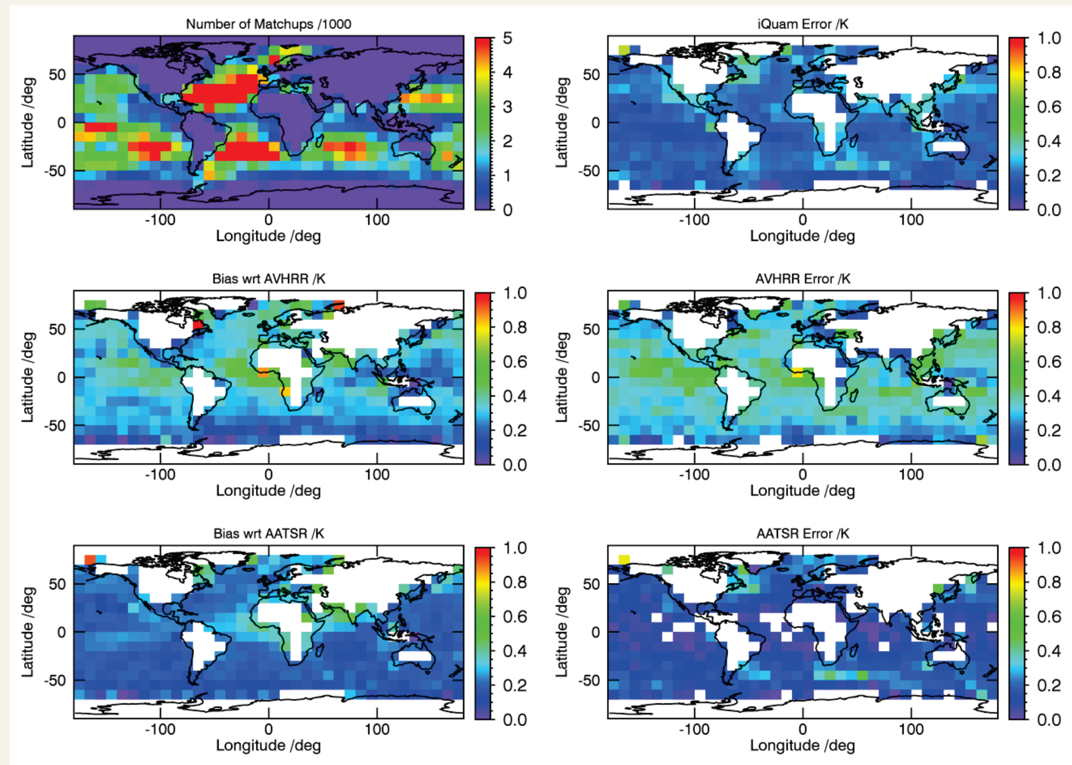

Figure 7: Geographic patterns of three-way error statistics of Drifters-AVHRR-AATSR.

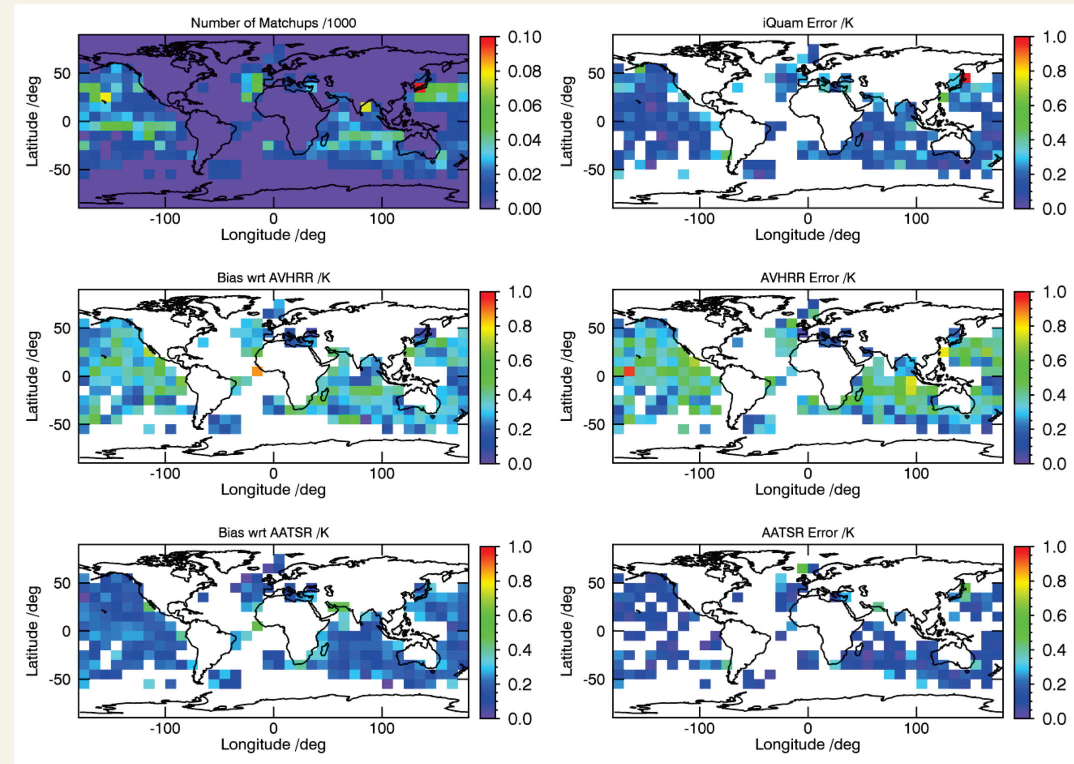

Figure 8: Geographic patterns of three-way error statistics of Argo-AVHRR-AATSR.

Individual ID Statistics

Distribution of errors in individual IDs for different in situ types as well as satellites can be fit by log-normal PDFs, which can be used to model the *a priori* distribution of performance metrics of in situ sensors.

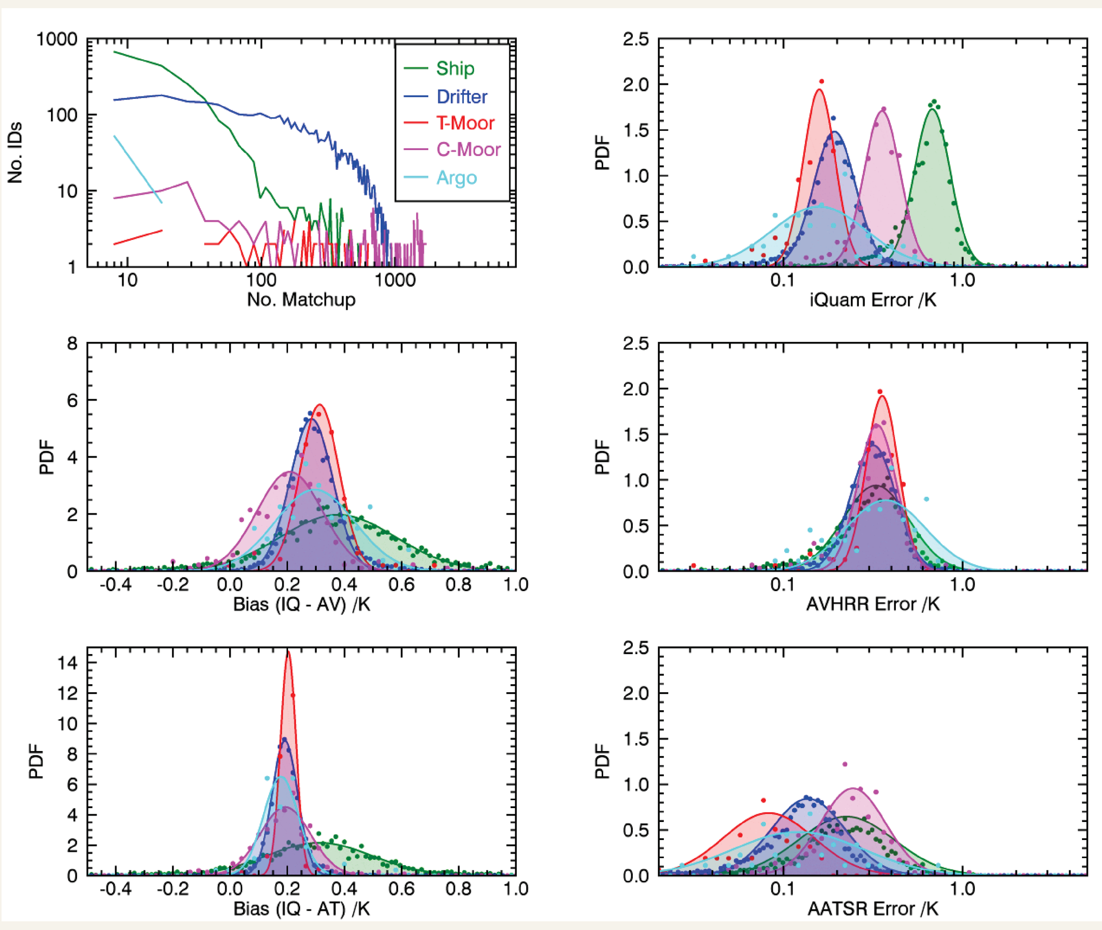

Figure 9: Distribution of tree-way error statistics of individual IDs and the log-normal PDF fitting.