



Tropical Biases in Models and Reanalysis Products

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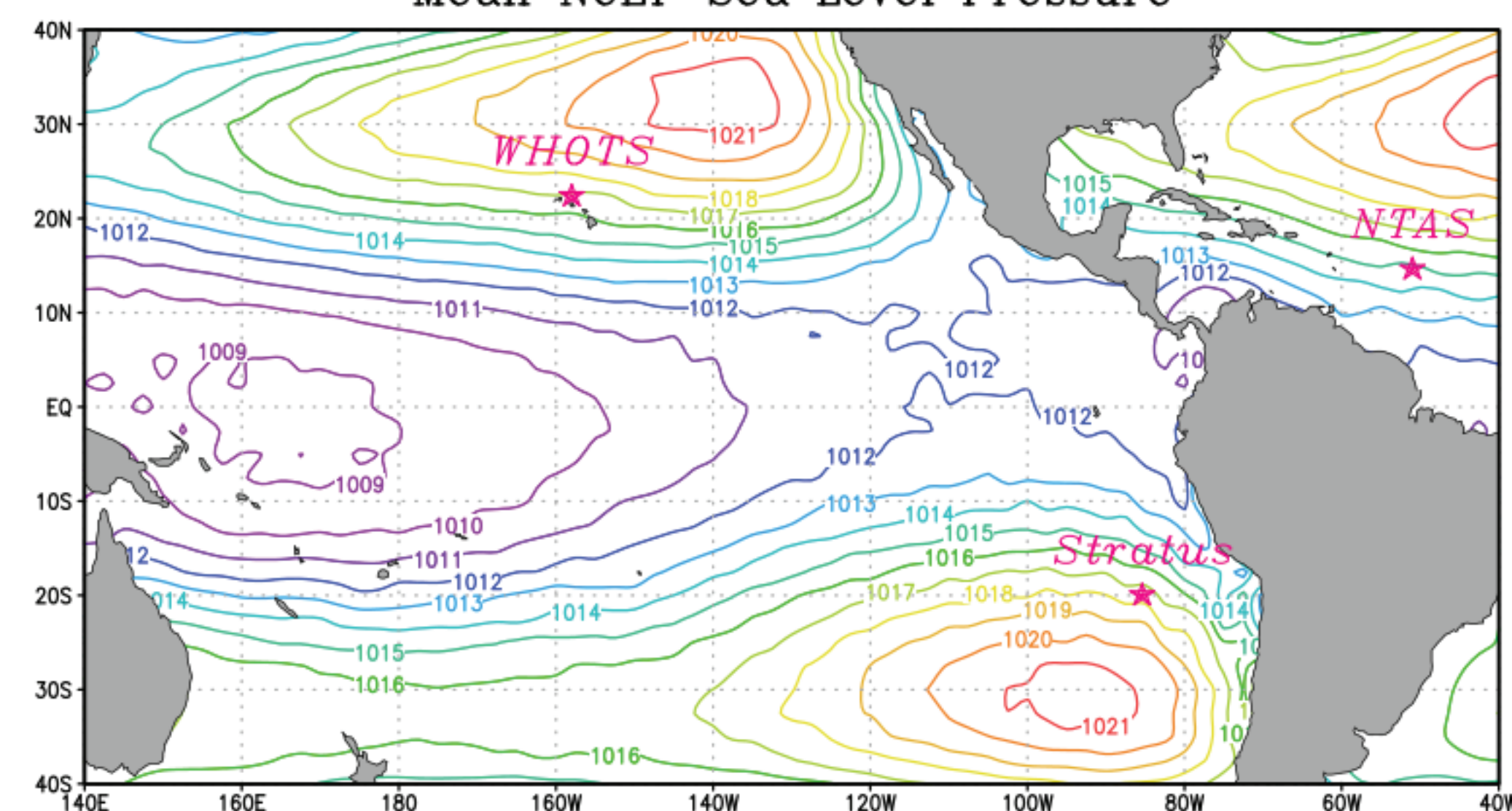
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BACKGROUND

The surface fluxes at three Ocean Reference Sites (ORS) were used to separately investigate potential biases and trends in models and reanalysis products. The three ORS include the Woods Hole Oceanographic Institute/Hawaii Ocean Time-series (WHOTS) mooring in the Northern Subtropical Pacific, the Stratus mooring in the eastern Pacific and the Northwest Tropical Atlantic Station (NTAS) in the Atlantic. These sites represent three different components of the tradewind system and provide a basis for evaluating various data and model products in these different regimes.



Mean NCEP Sea Level Pressure



I. WHOTS [\[http://www.soest.hawaii.edu/whots/\]](http://www.soest.hawaii.edu/whots/)

With support from NOAA and the National Science Foundation (NSF), the WHOI HOT Site (WHOTS) surface mooring has been maintained at Station ALOHA since August 2004. The objective of this project is to provide long-term, high-quality air-sea fluxes as a coordinated part of the HOT program and contribute to the goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The approach is to maintain a surface mooring outfitted for meteorological and oceanographic measurements at a site near Station ALOHA by successive mooring turnarounds.

II. Stratus [\[http://www.whoi.edu/science/PO/stratus/surface_mooring.html\]](http://www.whoi.edu/science/PO/stratus/surface_mooring.html)

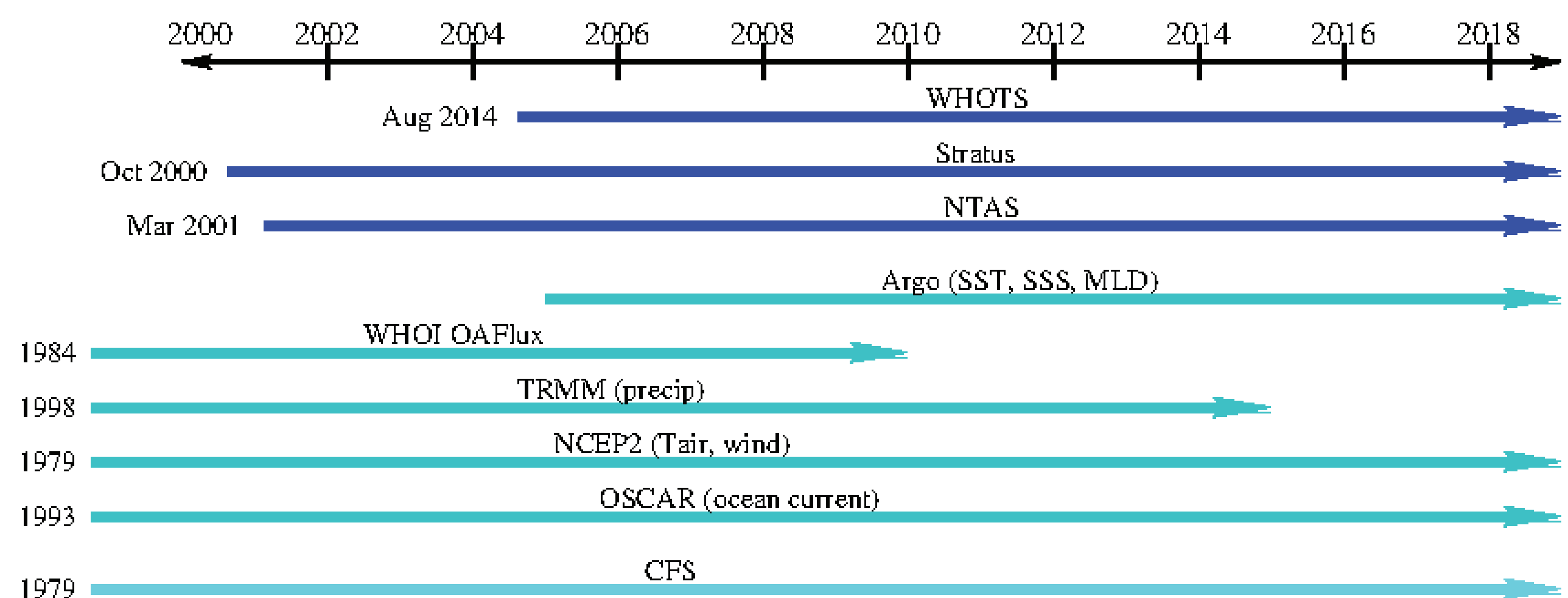
As part of the Eastern Pacific Investigation of Climate (EPIC) program, the UOP group has undertaken a study of Long-Term Evolution and Coupling of the Boundary layers in the Stratus Deck regions of the eastern tropical Pacific. The goal of the Stratus project is to observe and understand air-sea interactions and the surface forcing in the region of the cold tongue/inter-tropical convergence zone (ITCZ). A fully-instrumented surface mooring has been maintained at 20°S, 85°W to collect accurate time series of surface meteorology and upper ocean temperatures, velocities and salinities.

III. NTAS [\[http://uop.whoi.edu/currentprojects/NTAS/ntas.html\]](http://uop.whoi.edu/currentprojects/NTAS/ntas.html)

The Northwest Tropical Atlantic Station (NTAS) project for air-sea flux measurement was conceived in order to investigate surface forcing and oceanographic response in a region of the tropical Atlantic with strong SST anomalies and the likelihood of significant local air-sea interaction. The primary science objectives of the NTAS project are to determine the in-situ fluxes of heat, moisture and momentum, and then to use these in-situ fluxes to make a regional assessment of flux components from numerical weather prediction models and satellites. Data from the surface mooring at 15°N, 51°W has been collecting data since early 2001.

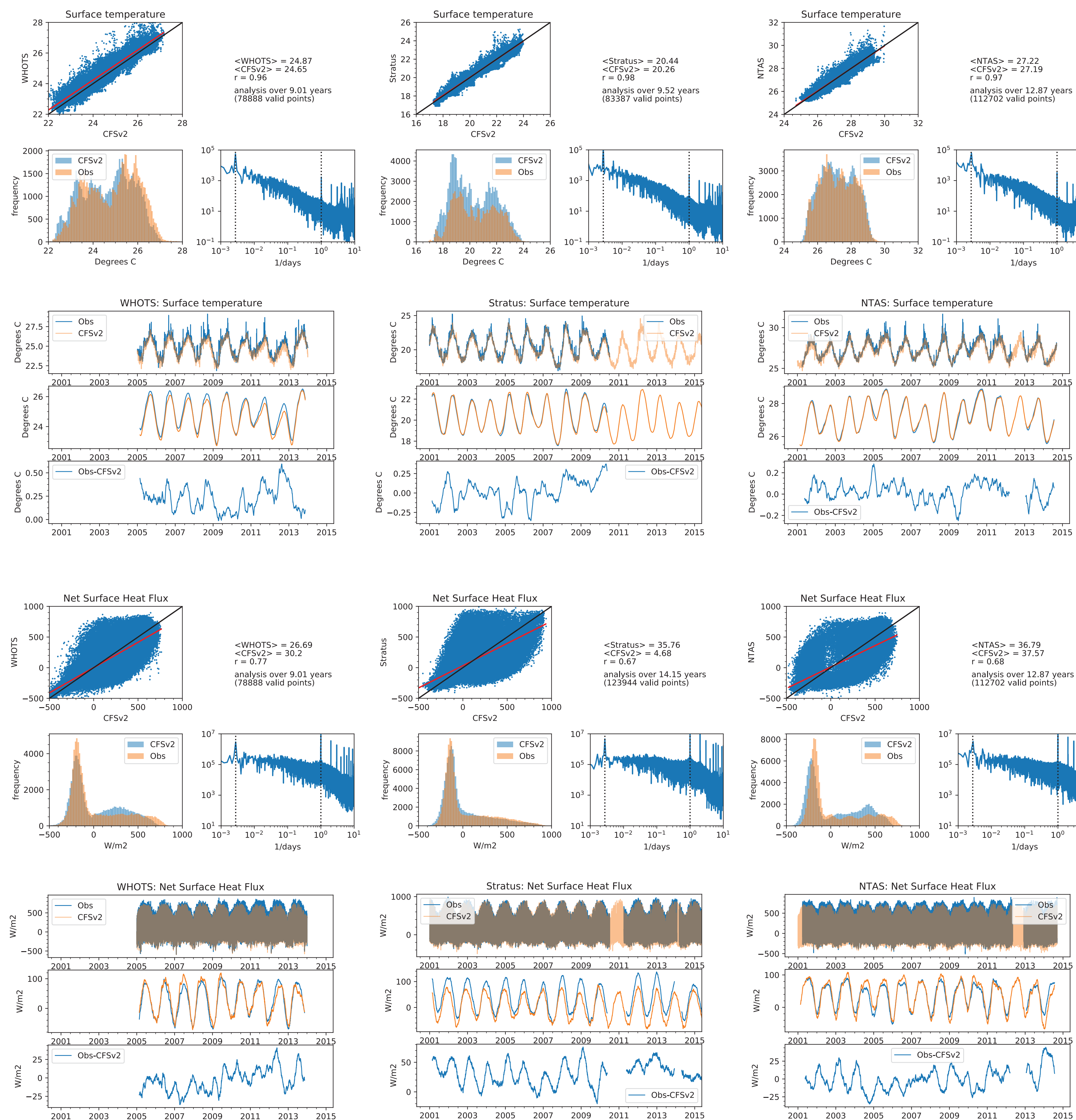
IV. Data Products [\[http://apdrc.soest.hawaii.edu\]](http://apdrc.soest.hawaii.edu)

The data from the three ORS have been aggregated into single time-series for each site. The surface variables were then compared to data products constructed from a variety of in situ and satellite records. These include sea surface temperature (SST), sea surface salinity (SSS), and mixed layer depth from Argo profiling floats; surface heat fluxes from the Woods Hole Oceanographic Institution OaFlux product; satellite-derived rainfall from the Tropical Rainfall Measuring Mission (TRMM); and surface current estimates from Ocean Surface Current Analysis Real-time (OSCAR). In addition to these data, output from the NCEP Climate Forecast System (CFS) and CMIP-5 models were used in the comparison. All output are available from the Asia-Pacific Data Research Center (APDRC). The table below shows the temporal ranges for each product. All comparison were done with monthly mean output except the CFSv2 comparison that were done with hourly data.



COMPARISON TO CFSV2

Version two of the Climate Forecast System (CFSv2) is one of the operational forecast models run by NCEP. Forecasts are produced four times daily and hourly output is available. There are two sets of files, the "reanalysis" for Jan 1979 through March 2011 and the "analysis" for April 2011 to present. The analysis output is on a ~1/5th-degree grid, while the reanalysis is on a ~1/3rd-degree grid. There is also a "combined" file that interpolates all to 1/2-degree. Output was extracted for a variety of variables at the three ORS location and compared to the direct observations.



Hourly output from the CFSv2 sampled at the three ORS sites was directly compared to the observations. The panels at the left show the comparison of SST along with correlations. The lower panels show the individual time-series at each site: raw data (upper), filtered (center) and the low-frequency difference.

Variable	CFS	WHOTS	R	CFS	Stratus	R	CFS	NTAS	R
Shortwave	236.2	223.9	0.76	163.9	191.6	0.64	263.4	231.4	0.68
Longwave	62.8	57.5	0.44	41.2	42.3	0.32	63.0	52.8	0.50
Latent	137.1	133.1	0.84	106.1	106.0	0.72	157.6	137.8	0.80
Sensible	6.11	6.61	0.63	11.9	7.5	0.48	5.27	4.07	0.39
Net Heat	30.20	26.70	0.77	4.68	35.76	0.67	37.57	36.79	0.68
Precip	0.08	0.07	0.15	0.04	0.00	0.04	0.12	0.06	0.09
Pressure	1017.6	1017.4	0.98			1014.6	1014.5	0.91	
Tair	24.01	24.09	0.93	19.20	19.52	0.92	26.62	26.63	0.91
SST	24.65	24.87	0.96	20.26	20.44	0.98	27.20	27.22	0.97
Wspd	7.31	6.75	0.85	7.37	6.88	0.79	7.27	6.71	0.85
Uair	-6.08	-5.54	0.93	-5.58	-5.33	0.79	-6.68	-6.04	0.89
Vair	-0.30	-0.43	0.84	4.29	3.61	0.65	-1.36	-1.52	0.78
Taux	-0.077	-0.077	0.88	-0.073	-0.063	0.80	-0.08	-0.08	0.84
Tauy	-0.005	-0.008	0.80	0.053	0.043	0.73	-0.02	-0.02	0.76

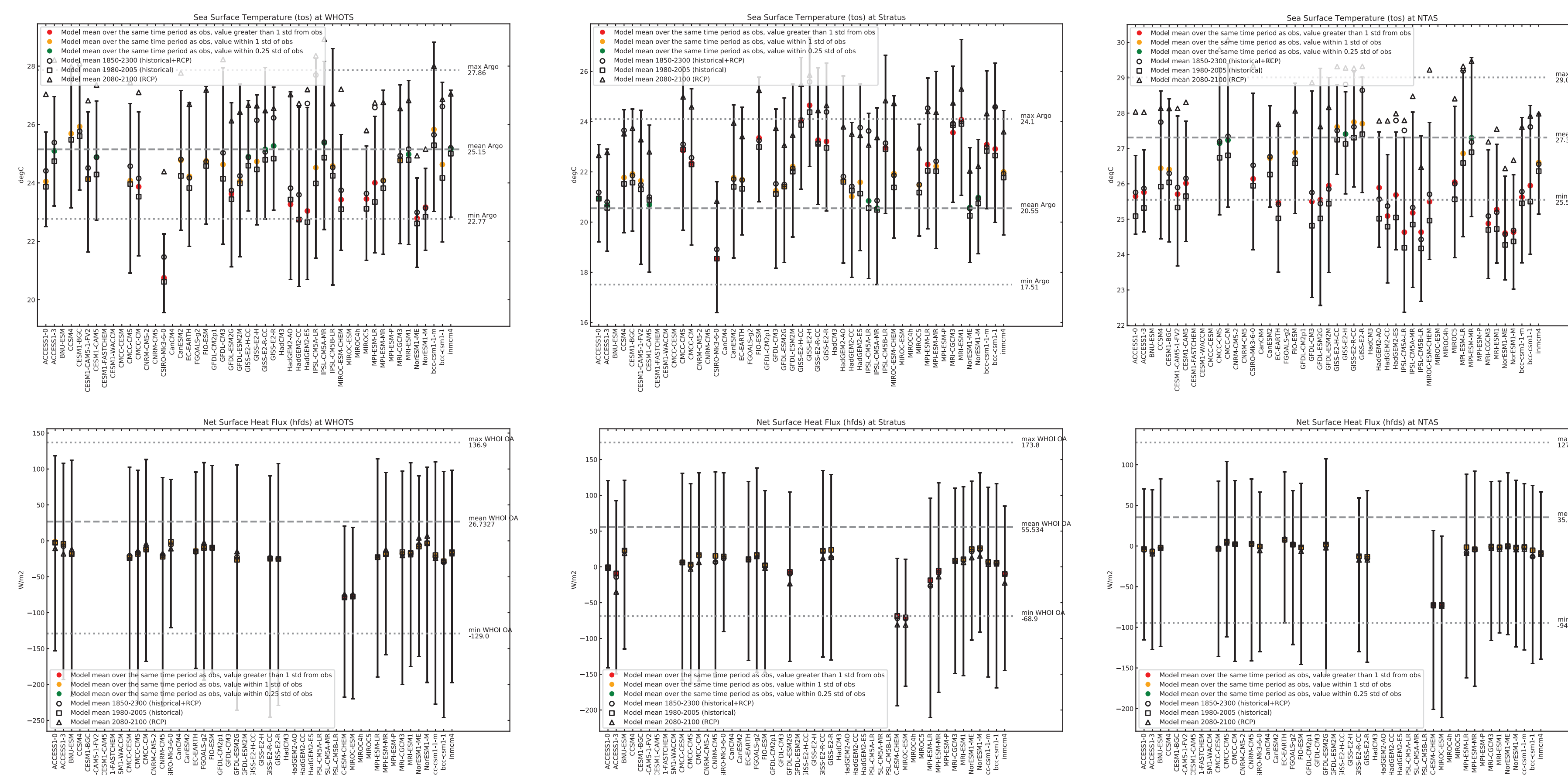
The table above shows the comparison of surface variables measures at the three ORS and sampled from CFSv2. Examples for SST and net surface heat flux are shown in the figures on the left.

	WHOTS	Stratus	NTAS
Shortwave	↑	↓	↑
Longwave	↓	↓	↓
Latent	↓	↓	↓
Sensible	↓	↓	↓
NET	↓	↓	↓

The CFSv2 reasonably simulates the net surface heat flux at WHOTS and NTAS, but there is a larger bias at Stratus, with observations showing a long-term mean of 35.8 W/m² (heating of the ocean surface) while CFSv2 only has 4.7 W/m² for the same period. A closer look at the individual components shows at WHOTS that CFSv2 over-estimates the short-wave (236 W/m² compared to observed 224 W/m²), but this is compensated by an overestimated cooling from both the long-wave and latent heat. NTAS shows a similar bias in the CFSv2 results. The net surface heat flux bias at Stratus is mostly from short-wave, likely a result of the poor representation of clouds.

COMPARISON WITH COUPLED CLIMATE MODELS (CMIP-5)

Similar to the above comparison between ORS data and CFSv2, data were extracted from both observational data products and CMIP-5 models at the three ORS locations. Monthly mean output was used in all cases, and the model time-series were constructed from the historical run up to 2005 and the RCP-8.5 experiment thereafter.



The figures on the left show comparisons between CMIP-5 model output (models given along the horizontal axes) and observations. The upper panels are comparisons to Argo-derived SST; lower panels are comparisons to WHOI OaFlux. The model and observations were sampled at the three ORS locations (WHOTS on the left, Stratus in the center and NTAS on the right).

A dashed line indicates the mean from the observations; dotted lines show the minimum and maximum values observed.

Colored dots indicated the model-derived mean taken over the same time-period as the observations; values within 0.25 std are colored green, within 1-std are colored orange and model-derived mean values larger than 1-std of the observations are colored red.

In addition, the long-term model mean is shown with an open circle, mean from the historical run (1850-2005) with a square, and the mean from the last twenty years of the century (from RCP-8.5) are shown with triangles.

Note that most models show strong cool biases at both WHOTS and NTAS but warm bias at Stratus, while in all cases the models underestimate net surface heat fluxes. The observed net surface heat flux should be warming from about 27 W/m² (WHOTS) to 55 W/m² (Stratus) while the models show around zero.

ACKNOWLEDGMENTS

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