UCAR/COMET: Outreach Project Final Report: August 26, 2004
(Partners Project/UCAR Award #S03-38670)

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Using GOES SSTs to Retrieve Over-Ocean Air Temperatures in Support of Local Data Assimilation and Modeling Efforts

1. PROJECT OBJECTIVES AND ACCOMPLISHMENTS

A. Miscellaneous Project Accomplishments
*The PI (Dr. Lazarus) hired a graduate student, in support of the proposed work, August 2003. The student was supported (in part) under this grant through July 2004.

*During September 2003, we began receiving a blended GOES-W/GOES-E SST data stream provided by Eileen Maturi from NOAA-NESDIS. The data are high spatial resolution (6 km) and are posted hourly at gp12.ssd.nesdis.noaa.gov. The GOES-12 satellite imager generates SSTs using two channels (3.9 and 11µm). The use of these two channels allows the satellite to generate SSTs 24 hours a day in 30 minute intervals. The 30 min. data are combined to produce hourly SST files. Removal of both cloud-contaminated radiances (via a cloud mask) and radiances that are affected by sunglint at 3.9 µm, precede application of the regression-based SST retrieval algorithm (Maturi et al. 2004). We are subsampling the hourly 6km blended GOES SST product for a region centered on Florida and surrounding waters from about 24°N to 31°N latitude and about -85°W to -77°W longitude (e.g., see Figure 4) – which corresponds to the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) domain configuration at the NWS office in Melbourne Florida. The NWS Melbourne office is running ADAS at 15 min. intervals and short-term ARPS forecasts are generated from these analyses every 6 hours (for ARPS/ADAS products see http://www.srh.noaa.gov/mlb/ldis/4km/ldis_currentwx_temp.html).

*The SST data are archived, at Florida Tech, on a Sun Solaris workstation and backed up on 5 Gb tapes.

B. Data Quality Evaluation

*We are particularly interested in both the reliability and quality of the data. As stated previously, data collection began in September of 2003. Because of processing issues, the hourly grids are only available in 'near-real' time (about a three hour lag). In an attempt to evaluate the quality of the GOES-SSTs we compared the GOES SSTs with the SSTs from 4 NDBC buoys (Figure 1) located in the NWS Melbourne ADAS domain. We use the *closest* satellite measured SST (i.e., no interpolation of the GOES SST to the buoy location). The buoy-GOES distances are given in Table 1. By using the closest SST we are able to directly compare the temperatures recorded by both instruments without having to do any additional interpolations. Obviously, in regions of significant SST gradients this might be problematic.

Table 1- *Buoy/GOES-12 nearest grid point distance.*

Buoy #	Δ Lat.	Δ Lon.	Total Distance
41009	0.025°	0.005°	~2.83km
41010	0.015°	0.005°	~1.76km
41012	0.015°	0.015°	~2.35km
42036	0.025°	0.025°	~3.92km

We show a couple of correlation plots of the GOES-12 vs. buoy SSTs for buoy #41009/October 2003 (Figure 2) and buoy #42036/December 2003 (Figure 3). For the month shown, buoy #41009 SSTs are about 0.5 degree warmer than that of the GOES SSTs and are relatively poorly correlated (due, in part, to a few rogue points), in contrast, buoy #42036 December SSTs are highly correlated.

Summary statistics for September of 2003 to May 2004 are shown (for all four buoys in the ADAS domain) in Tables 2-5.

Table 2 – *Monthly correlation statistics for buoy 41009 and GOES-12 SSTs.*

Buoy #	Month	year	# of obs.	Mean Buoy SST	Buoy SST St. Dev.	Mean GOES-SST	GOES-SST St. Dev.	Correlation
41009	October	2003	263	27.73	0.55	27.19	0.74	0.42
	November	2003	252	26.45	0.70	26.12	0.83	0.44
	December	2003	187	23.78	1.01	23.43	1.22	0.82
	January	2004	283	22.75	0.73	22.52	0.95	0.54
	February	2004	154	22.21	0.96	22.33	0.92	0.43
	March	2004	245	22.87	0.88	22.84	1.02	0.58
	April	2004	279	22.91	0.94	22.77	0.98	0.64
	May	2004	305	24.65	0.83	24.77	0.88	0.62
	June	2004	143	27.39	1.01	27.12	0.94	0.89

Table 3 – *Same as Table 2 but for buoy 41010.*

Buoy #	Month	year	# of obs.	Mean Buoy SST	Buoy SST St. Dev.	Mean GOES-SST	GOES-SST St. Dev.	Correlation
41010	October	2003	251	27.65	0.51	27.02	0.73	0.50
	November	2003	221	26.25	0.42	25.79	0.69	0.46
	December	2003	89	24.5	0.48	24.14	1.08	0.59
	January	2004	148	23.57	0.53	23.09	1.05	0.57
	February	2004	88	22.6	0.65	22.55	1.15	0.55
	March	2004	177	23.4	0.69	23.40	0.95	0.72
	April	2004	190	22.83	0.89	22.48	1.10	0.80
	May	2004	302	25.27	0.65	24.90	0.81	0.80
	June	2004	183	28.14	0.78	27.49	0.76	0.87

Table 4 – *Same as Table 2 but for buoy 41012.*

Buoy #	Month	year	# of obs.	Mean Buoy SST	Buoy SST St. Dev.	Mean GOES-SST	GOES-SST St. Dev.	Correlation
41012	October	2003	277	26.92	0.52	26.23	0.63	0.66
	November	2003	312	26.15	0.42	25.63	0.73	0.30
	December	2003	264	24.39	0.52	22.96	0.85	0.77
	January	2004	***	***	***	***	***	***
	February	2004	***	***	***	***	***	***
	March	2004	***	***	***	***	***	***
	April	2004	301	21.85	1.03	21.6	1.04	0.69
	May	2004	374	24.01	0.90	23.78	1.02	0.77
	June	2004	202	26.86	1.11	26.30	1.07	0.87

Table 5 – *Same as Table 2 but for buoy 42036*

Buoy #	Month	year	# of obs.	Mean Buoy SST	Buoy SST St. Dev.	Mean GOES-SST	GOES-SST St. Dev.	Correlation
42036	October	2003	353	26.01	0.83	25.78	0.92	0.86
	November	2003	478	24.35	0.66	24.29	0.96	0.70
	December	2003	288	20.75	1.46	20.53	1.42	0.95
	January	2004	291	19.55	0.89	19.33	0.95	0.86
	February	2004	147	18.26	0.57	18.44	0.77	0.63
	March	2004	392	19.51	0.72	19.52	0.81	0.75
	April	2004	277	20.36	0.93	20.47	1.18	0.83
	May	2004	419	24.18	1.66	24.19	1.71	0.96
	June	2004	234	28.61	1.05	28.05	1.00	0.89

SST correlation varies from buoy-to-buoy and monthly – with the best agreement associated with the Gulf of Mexico buoy (#42036). The correlations do not appear to be associated with variability as months with large standard deviations for both platforms (e.g., May 2004) yield highly correlated SSTs. The correlations are likely affected by cloud cover (i.e. the GOES cloud mask), unfortunately we have not investigated to what extent clouds impact the results presented herein. There are also well known/documented differences between bulk SST measurements (i.e. buoy) and skin SST values (i.e. observed via satellite, Wick et al., 1996). Monthly mean SSTs are quite good however, with most months indicating less than a half degree difference between the GOES and buoy SSTs.

*We are tracking the availability of the GOES SST data over the ADAS domain. We calculate the percentage of good data (defined as a ratio of the total number of ‘good’ hourly observations divided by total number of hours for the month) for each GOES-12 grid point in the ADAS domain. By ‘good’ we mean data that are not flagged due to cloud cover, sun glint, etc. Figures 4a and 4b illustrate data availability (i.e. consistency) for the months of October and December 2003. The lowest data availability occurs in the coastal zone of the ADAS domain (<%10) and is quite pronounced along the NE Gulf of Mexico in December. Note also that, for the month of December, the data availability is generally less across the entire domain -- especially in the far eastern portion of the domain where the amount of available data decreases from around 50% in September to less than 20% in October.

C. Temporal Variability

*The temporal variability (standard deviation) across the ADAS domain is illustrated (for the same months shown in Figure 4) in Figures 5a and 5b. As one might expect, GOES-SST variability is seasonally dependent with lower variability during the summer and higher variability during the winter (with maximum variability on the order of 1° and 2° respectively). Note that a 'cool tongue' is evident on both figures as a region of locally enhanced variability along and east of the Florida coastline from Palm Beach northward. In part, the increased winter variability may be an artifact of the decreased availability (due to cloud cover) as there is a noticeable decrease in data (on the order of 10%-20%) over a significant portion of the domain from October to December 2003. Areas of enhanced SST variability occur offshore of Jacksonville and Tampa (December) while October SST variability is fairly uniform across the domain. The Gulf Stream edge appears as a narrow 'strip' of increased variability approximately 50 km offshore the central Florida east coast.

*We have performed a cursory examination of the seasonal scatter in the SST and air temperatures. In particular, we have looked at the SST/air temperature differences (using buoy #41010 for 1998-2002) as a function of the meridional wind component for summer months (JJA, Figure 6a) and winter months (DJF, Figure 6b). Again, as one might expect, the scatter is greatest in winter for northerly winds. Interestingly, the southerly flow in winter closely resembles the summer pattern with little change in SST/air temperature spread as a function of the meridional wind component.

D. RUC Evaluation (Future Work)

During the course of the year, via conversations with Steven Weygandt (Stan Benjamin's FSL group), it was pointed out that the RUC 2 m air temperature and dew point have not been evaluated over the ocean. We had begun to examine these fields for the RUC analyses only. As it turns out, observation errors are assumed to be quite small, hence the analyses are drawn quite closely to the buoy and ship temperatures (Note however that this does not answer the question regarding the quality of the RUC 2 m temperatures away from the buoy/ship locations). Due to time constraints, the NWS office in Melbourne uses short-term RUC forecasts (~1-3 h) and not the RUC analysis to initialize their ADAS grids (i.e. first-guess field). The PI believes that a thorough RUC evaluation (over the open ocean) would be worthwhile effort – especially since the quality of the RUC <u>short-term</u> 2 m temperature and dew point forecasts is unknown.

E. Air Temperature Estimation

The primary objective of the project was to develop an application whereby satellite SSTs could be used to estimate the 2m over-ocean air temperatures for the summer months. Here, we apply a simple model which, through linear regression, relates the SSTs to the air temperatures (for summer only). Clearly, as demonstrated previously, application of a simple regression technique is not feasible other than for summer months as there are important factors (in addition to water temperature) that affect the over-ocean air temperature (e.g., heat and moisture fluxes). These factors obviously are far more significant during the cool season as suggested by Figures 7a and 7b. Herein, we demonstrate the utility of a simple linear regression (to predict the 2 m air temperature) for the months of May and June 2004 using GOES-12 SSTs and NOAA buoys 41009, 41010, and 42036 (see Fig. 1). Regression coefficients are estimated using 15 years (1989-2003) of SST data from buoys 41009 and 41010 and 10 years (1994-2003) for buoy 42036. We do not present results for buoy 41012 as it is only two years old and thus lacks sufficient historical data necessary to estimate robust regression coefficients. Using the SSTs and 2 m air temperatures from each of the three buoys we calculate monthly regression coefficients. The method of least squares is utilized to determine the free parameters (coefficients) a and b via minimization of the following quadratic relationship

$$J = \sum \left[y^o - y^m \right]^2$$

where y^o are the observed (buoy) air temperatures, $y^m = ax + b$ are the modeled air temperatures, and x are the input (buoy) SSTs. May/June coefficients are used to estimate the air temperatures at each of the buoys. Table 6 shows the regression coefficients for both months at the three buoy locations.

Table 6 – *Regression coefficients for each buoy locations calculated using May and June buoy SSTs and T_{air} (see text for details).*

Monthly Regression Coefficients			
		Coefficients	
Buoy #	Month	a	b
41009	May	0.9305	1.2757
	June	0.8047	4.7382
41010	May	1.0042	-1.0577
	June	0.8308	3.8925
42036	May	0.962	0.6716
	June	0.8039	4.9321

Air temperature is estimated using GOES-12 SST data and the appropriate coefficients. Calculations are performed for all hours at each buoy location for the months of May and June (provided that the GOES SST data exist). Regression estimates for both months are compared to the observed (buoy) air temperatures. The simple regression method performs quite well for May 2004 for all buoy locations (Figures 8-10). It is worth pointing out that the largest differences between the observed and regressed air temperatures occur in association with the passage of a cold front at the beginning of the month. As one might expect, this results in an over-estimate of the air temperature (Figure 11). Note also that lower variance exhibited by the forecasted air temperatures (i.e., less than observed) are a direct result of their dependence on SSTs. With the exception of early May 2004, monthly mean air temperature estimates are within 1^o C of the observed air temperatures for all buoy locations. With the exception of buoy 42036 (May), standard deviations are reasonable as well where for all buoys $\sigma < 1^o$ C (Table 7).

Table 7 – *Monthly statistics for buoy (observed) and forecasted (regression) air temperatures, and hourly temperature differences.*

		Buoy T(air) °C		Regression T(air) °C		Difference °C	
Month	Buoy #	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
May	41009	24.5315	1.0258	24.3243	0.8197	0.7922	0.7593
	41010	24.1879	1.2539	23.9369	0.8183	0.8873	0.7146
	42036	23.7471	1.8572	23.9538	1.6613	0.6086	0.5695
June	41009	26.985	1.1192	26.5922	0.7495	0.3625	0.2628
	41010	27.2429	0.8313	26.995	0.6703	0.5403	0.38
	42036	28.0225	0.839	27.4906	0.8007	0.4381	0.3596

For all buoys (both months) observed air temperatures are higher than their regression counterparts (except 42036 for May) – indicating that, at least for these months, the regression is biased high. in the data that can possibly be corrected to further improve the accuracy of this method. The bias may, in part, be a result of the differences between bulk and skin temperature measurements, however this is not clear since buoys 42036 and 41009 have May SSTs that are comparable or lower than those from the GOES-12.

We have also produced a single set of regression coefficients for May and June. These coefficients were produced using a combined 10 years of data from 41009, 41010 and 42036 (1994-2003). Table 8 shows that the air temperature estimates are only slightly worse when estimated at the three buoy locations using a single set of regression coefficients (compare mean differences columns). In general, monthly mean differences in the hourly temperatures for the two methods are less than 0.1 ^{o}C.

Table 8 – *Same as in Table 7 using a single set of regression coefficients obtained from a combination of 3 buoys (see text).*

		Regression T(air) ^{o}C		Difference ^{o}C	
Month	Buoy #	Mean	St. Dev.	Mean	St. Dev.
May	41009	24.1622	0.7790	0.8195	0.7264
	41010	24.2725	0.7194	0.9169	0.8063
	42036	23.6602	1.5254	0.6785	0.5531
June	41009	26.5612	0.8060	0.4045	0.2700
	41010	26.8994	0.6917	0.6385	0.4098
	42036	27.3427	0.8623	0.5831	0.4353

Although not available at the time of this report, regression estimates for the months of July and August are likely to produce excellent agreement as the correlation between the SSTs and the air temperatures increases.

2. SUMMARY OF UNIVERSITY/ NWS EXCHANGES

*In collaboration with Pablo Santos (NWS Miami), we have been producing (beginning in December 2003) near-real time SST composites and data latency maps over the ADAS domain. Both products have been made available to the NWS in NetCDF format and are now being viewed on the AWIPS platform (with assistance from Jason Burks, NWS Huntsville) by all regional forecast offices. The SST composites are also being used (by Dr. Santos) to initialize the workstation Eta in south Florida. The composites are created by overwriting (hourly) the 6 km gridded GOES data provided by NOAA NESDIS. The NetCDF files are posted to the SRH server hourly in the AWIPS -- making them available to all Florida NWS forecast offices in real-time! An example of an imported AWIPS image is shown in Figure 12.

*The data latency map provides a 'time stamp' for the SST composites – giving the forecaster valuable information regarding how current the analysis is across the domain. In Figure 13, data less than 6 h old is given in purple with older data represented by shades of blue, green and red respectively. SSTs that have not been updated in more 80 hours are given as black and are generally found near the coast where the SST retrievals are problematic. For interpretation purposes, a visible GOES-12 satellite image corresponding to the time of the SST composite is shown. Although only the most recent visible image is shown, previous visible imagery indicates that cloud coverage is responsible for the corresponding the increased data latency over the northeastern Gulf of Mexico and coastal waters off northern and central Florida.

*The high resolution SST data set is also being used for modeling purposes at the NWS in Miami as part of a recently completed, and separate, COMET Partners Project involving the Co-PI (Pablo Santos). Specifically, they are examining the impact, on precipitation skill, for two different Workstation Eta configurations: 1.) initialization with the high resolution SST composites (from FIT) and 2.) initialization with NCEP's real time global SST (RTG-SST) analysis (Etherton et al., 2004). The title of this project is "Improving WsEta performance through incorporation of high-resolution diagnostic datasets at NWS-MIA".

3. PRESENTATIONS AND PUBLICATIONS

Related talks include:

Invited talk at University of Miami 31 October 2003
1. *Using satellite data to produce near real-time high resolution analyses and forecasts*
Dr. Steven Lazarus (presenter), Brad Zavodsky, and Corey Calvert. Florida Institute of Technology *and* David Sharp, Peter Blottman and Scott Spratt (National Weather Service Melbourne, FL), Pablo Santos (NWS Miami).

68th Annual Meeting Meeting of the Florida Academy of Sciences, University of Central Florida 12 March 2004.

2. *The Development of an Algorithm to Map GOES-12 SSTs to Near-Surface Over-Ocean Air Temperatures*
Corey Calvert (presenter), Dr. Steven Lazarus. Florida Institute of Technology, and Pablo Santos (National Weather Service, Miami, FL).

Abstract in Florida Scientist (ISSN: 0098-4590), Vol. 67, pg 20.

3. Calvert, C., S. Lazarus, P. Santos, and D. Sharp: Assimilation of Multi-Satellite High Resolution Sea Surface Temperatures for a Real-Time Local Analysis and Forecasting System. Submitted for the Ninth Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS).

4. Etherton, B., P. Santos, S. Lazarus, and C. Calvert: The effect of using AWIPS LAPS and High Resolution SSTs to locally initialize the Workstation Eta. Submitted abstract to the Ninth Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS).

4. SUMMARY OF BENEFITS AND PROBLEMS ENCOUNTERED

4.1a Academic Partner Issues

A. Data Availability

Heretofore we have discussed issues related to data quality, timeliness, and availability -- all critical issues in the context of operational meteorology. We are also monitoring the hourly flow of the GOES-12 SST data. As an illustration in Figure 15, we show five distinct 24-hour periods illustrating the percentage of 'good' data (i.e. number of good data divided by total number of grid points in the ADAS domain) collected each hour. The gap in the data stream during the hours of 5-6 UTC is a result of data processing at NESDIS (Maturi, personal communication). The data fall off around the hour of 17 UTC is a result of sun glint which saturates the GOES-12 sensor. During the remainder of the day the amount of 'good' data depends, for the most part, on the cloud cover. Although not likely a critical issue, the data drop off at these hours will impact the composites and, in cases where the data are used to initialize a forecast (e.g., at 6 UTC), will lead to a 'slightly' older first-guess field.

B. Information Spreading and Validation

We have demonstrated that a simple regression model performs quite well for the warm season months of May and June. Although it is not clear how one might 'piece together' the regression coefficients (estimated from the individual buoys) so as to produce a continuous 2 m air temperature estimate across the entire domain, we show positive results whereby we combine the data from all the buoys to produce a single set of coefficients for the domain. The error in forecasted air temperature estimated from a single set of regression coefficients is comparable to the forecast from coefficients obtained for each individual buoy (both on the order of 0.5 ^{o}C) – suggesting that a single set of coefficients can be applied (for the summer months) to yield a 2 m air temperature forecast across the entire domain.

C. Alternative Methods (Future Work)

Alternatives to a simple regression model were discussed in our 6 month report. The proposed modifications (see below) might allow one to extend the regression model to the cool season. The proposed methodologies involve using meso-Eta surface fluxes and/or horizontal temperature advection to:

- *i.)* Reduce the scatter present in the SST/air temperature *regression* during the winter months.
- *ii.)* Iteratively adjust the first-guess air temperature using a diagnostic technique assuming steady, inviscid, horizontally homogeneous turbulence and mean flow (see Bourras et al. JAM 2002).

It was also previously noted that for method 2.) above we'd also need the radiative flux divergence from the Eta model. We have begun to archive the relevant model variables at the buoy locations.

A follow-up proposal in order to pursue these issues (as well as the RUC evaluation) would be worthwhile (but not currently pursued) as their answers will ultimately determine what, if any, algorithm is necessary or appropriate.

4.1b Academic Partner Benefits

A. Collaboration

The collaboration with the Miami National Weather Service office has engendered a state-wide interest and cooperation with respect to coastal forecasting issues. In particular, FIT, NWS Melbourne and NWS Miami have met several times during the past year, both in Miami and in Melbourne. The PI anticipates that this project will serve as a significant mechanism for future collaborative efforts between these two offices and FIT and has the potential to have an impact on all offices in the state because of our efforts to make the SST data available in both AWIPS friendly NetCDF format and standard text output for modeling efforts.

B. Real-time SST analysis

In addition to the proposed work to improve upon the first-guess 2 m air temperature over the ocean, the PI expects to eventually assimilate the SST composites into both the real-time ADAS/ ARPS cycle at the NWS Melbourne office (the subject of a recently submitted COMET Co-Op proposal).

C. Student Interaction and Education

The benefits to the graduate student working on this project are many as the student has gleaned valuable information regarding real-time/operational data processing and analysis, learned how to script, has had many positive interactions with NWS office personnel, applied Gempak to extract data from gridded files, and has begun to code with the IDL graphics package. Most importantly, this work (and the COMET financial support provided) is serving as the primary research component for the graduate student's Masters degree.

4.2a Forecast Partner Issues

An issue that has persisted throughout the year is the lack of source documentation for the GOES data stream. Because of differences in the spectral channels between GOES-12 and GOES-8, it was determined early on in the course of this project that the application of the GOES-8 algorithm (to the GOES-12 data stream) would not be a simple or necessarily straightforward process. Fortunately, a relatively recent SST retrieval algorithm has been developed for the GOES-12. The data have been provided (by NCEP) in near real-time. Despite requests however, we have yet to receive coherent documentation regarding the data processing and regression algorithm (to our knowledge, this documentation does not currently exist). Of course, in order to thoroughly evaluate the data stream and ensure that the data are used properly in operations (e.g., for assimilation, display, etc.), a working understanding of the algorithm methodology, quality control, etc. would have considerable utility.

4.2b Forecast Partner Benefits

The Weather Forecast Office (WFO) in Miami has benefited from this project via the acquisition of both diagnostic as well as enhanced prognostic tools that were not available to the office before. FIT is providing WFO Miami real time GOES SSTs (GSST) that are being ingested in AWIPS. This represents a significant forecast aid when editing forecast grids over water such as air temperatures, moisture, and wave heights. Wave heights across the Gulf Stream are much higher when there is a northerly component of the wind across the southeast Florida Atlantic coastal waters. Identification of the Gulf Stream location, via the SSTs, is very important for practical forecast reasons. The availability of GSST in AWIPS and IFPS represents, in and of itself, an important diagnostic tool. In addition, the GSST composites produced by FIT are currently being used to initialize the Workstation Eta at WFO Miami in real-time. As a result, the availability of GSST for the office's modeling efforts represents a significant enhancement of their high resolution prognostic tools. These are direct/tangible benefits that have been achieved over a relatively short time period (i.e. < 6 months!). Additionally, the GSST data set is being shared with other FL offices.

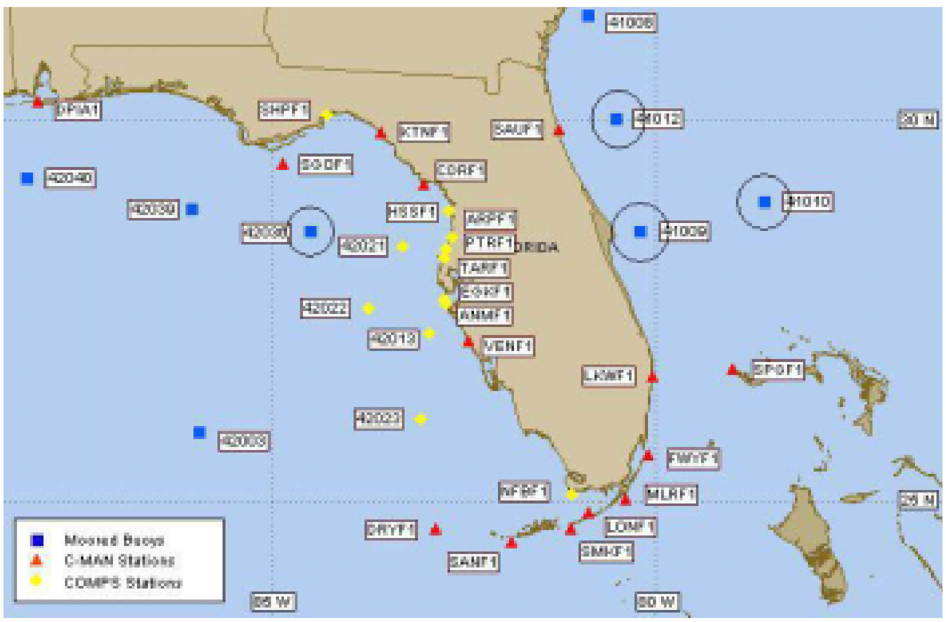


Figure 1: NOAA buoy locations offshore Florida. Circles indicate buoys for which statistics are calculated herein.

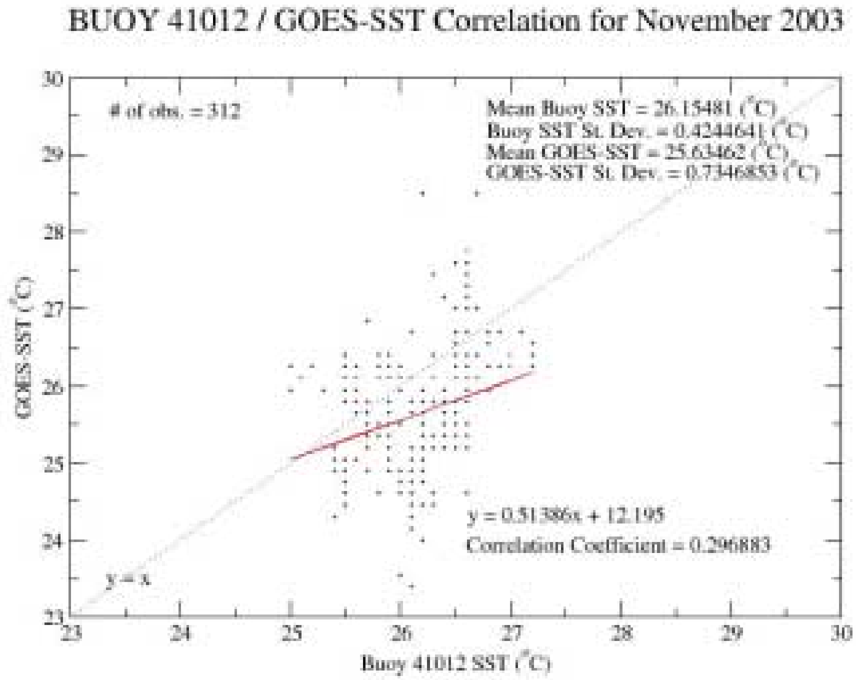


Figure 2: Buoy (41012) versus GOES-12 SSTs for November 2003.

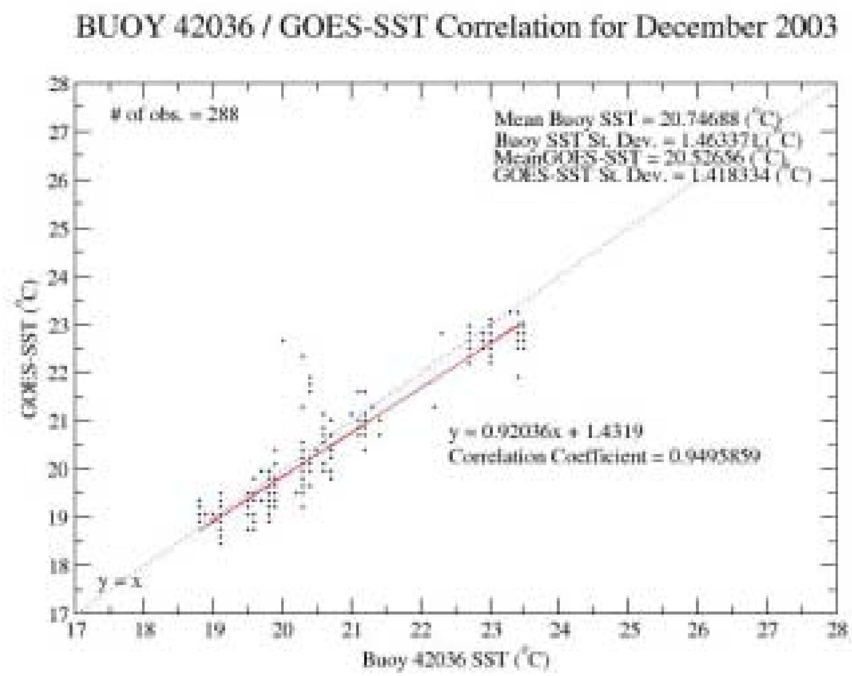


Figure 3: Buoy (42036) versus GOES-12 SSTs for December 2003.

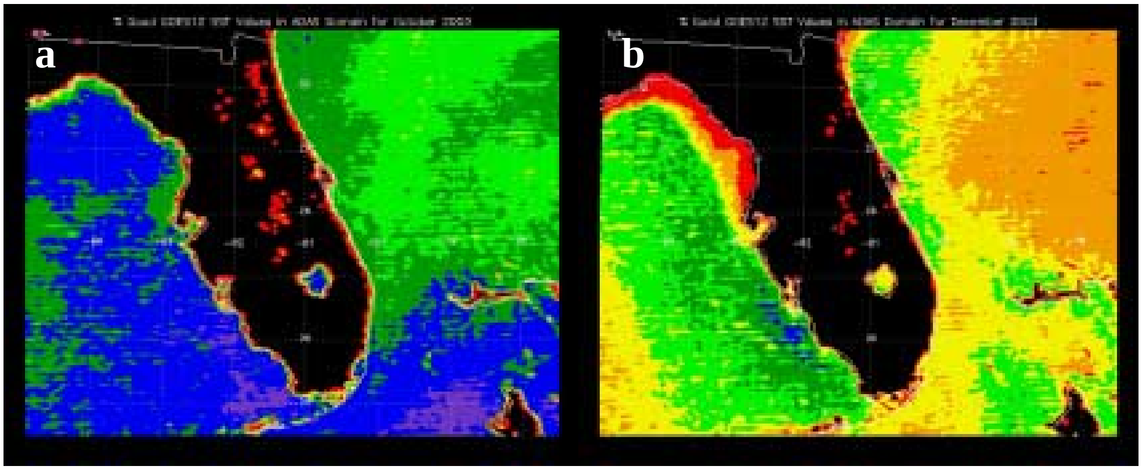


Figure 4: GOES-12 SST % good data for a.) October 2003 and b.) December 2003. See below for color table.

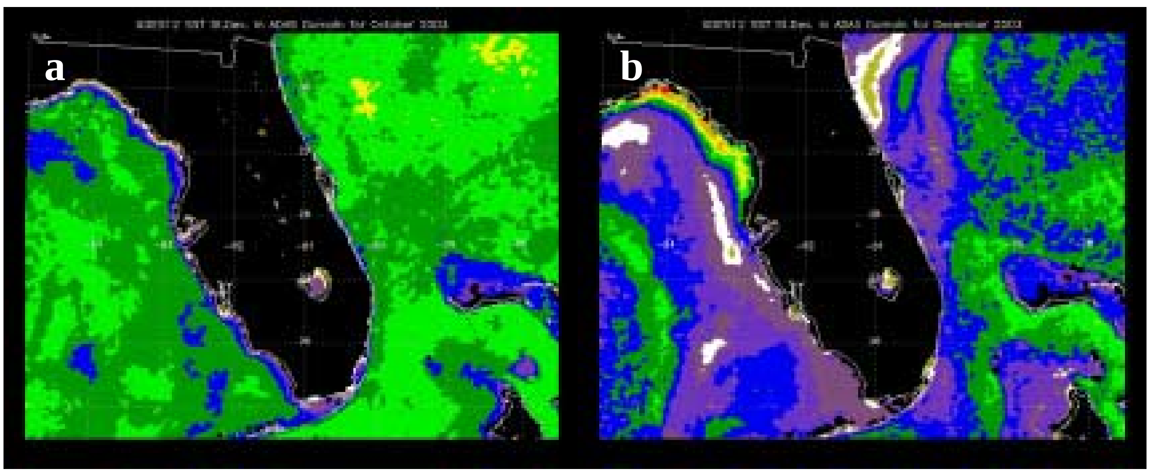


Figure 5: GOES-12 SST standard deviation (σ) in degrees Celsius for a.) October 2003 and b.) December 2003. See below for color table.

Standard Deviation (^{o}C)

0		1.0-1.2	
0.0-0.2		1.2-1.4	
0.2-0.4		1.4-1.6	
0.4-0.6		1.6-1.8	
0.6-0.8		1.8-2.0	
0.8-1.0		>2.0	

% Good Data

0		50-60	
0-10		60-70	
10-20		70-80	
20-30		80-90	
30-40		90-100	
40-50		100	

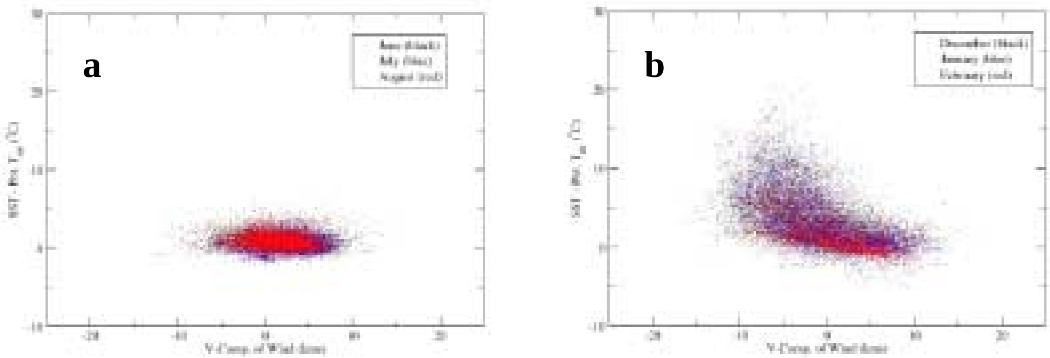
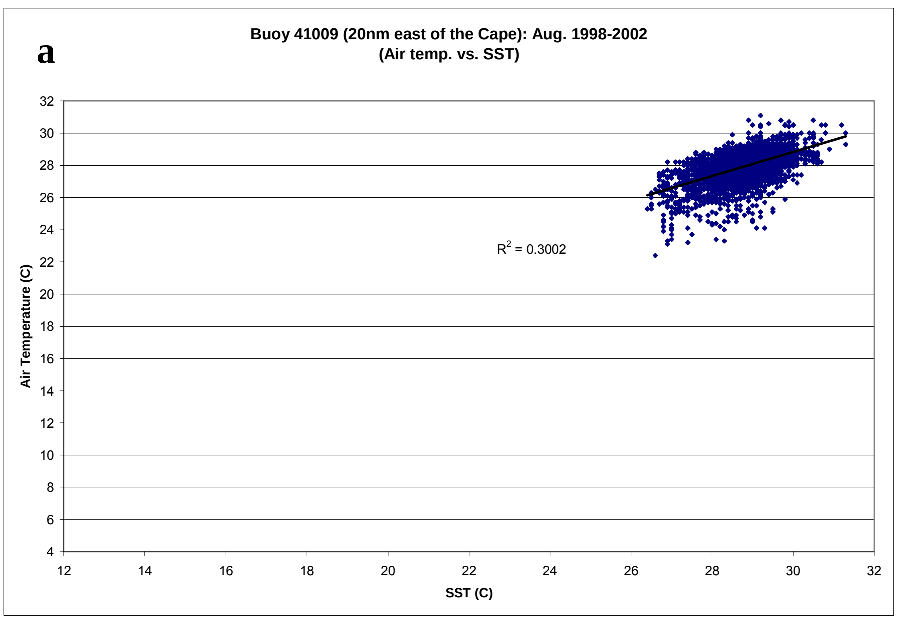


Figure 6: SST/air temperature differences versus the meridional wind component for buoys 41009 and 41010 during a.) June, July, August and b.) December, January, February.



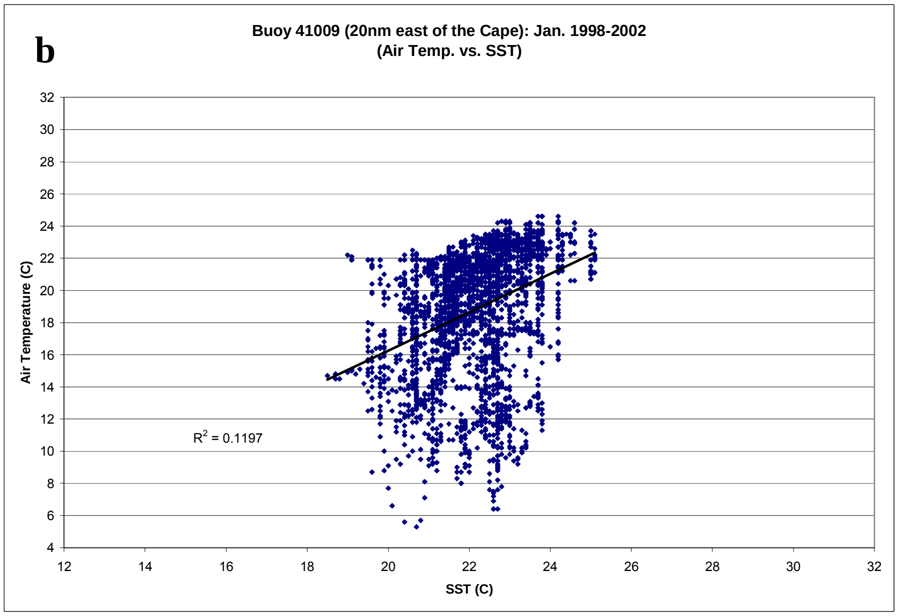


Figure 7: Five-year (1998-2002) buoy SST/ T_{air} scatter diagram for a.) August, and b.) January.

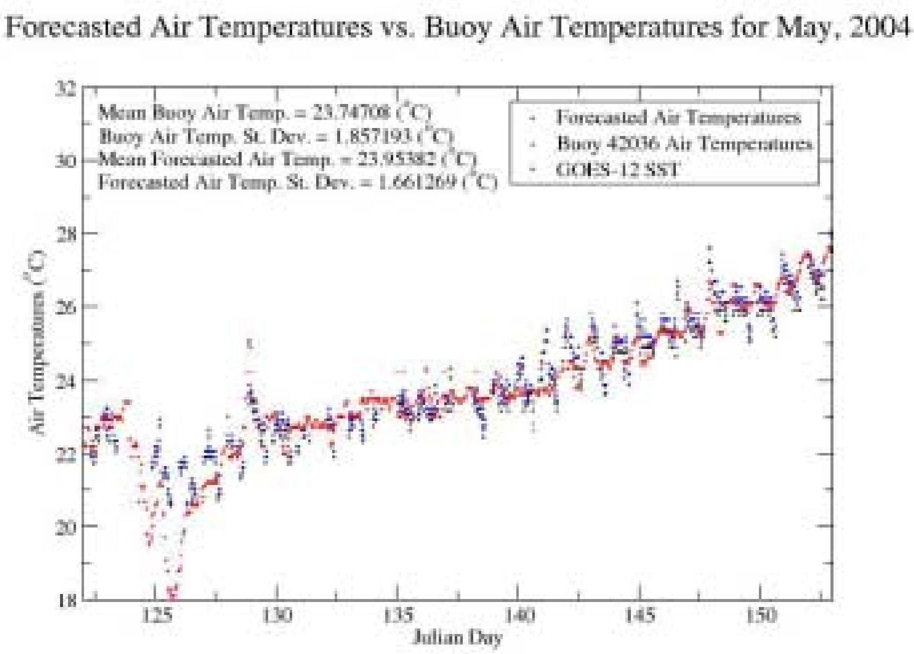


Figure 8: Estimated air temperatures at buoy 42036 for May, 2004.

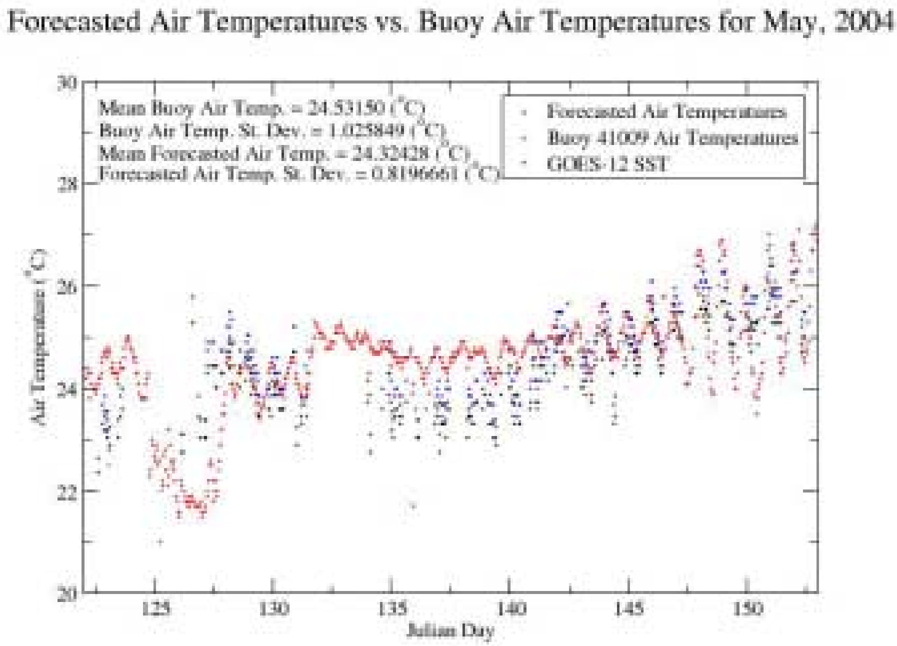


Figure 9: Same as in Figure 8 but for buoy 41009.

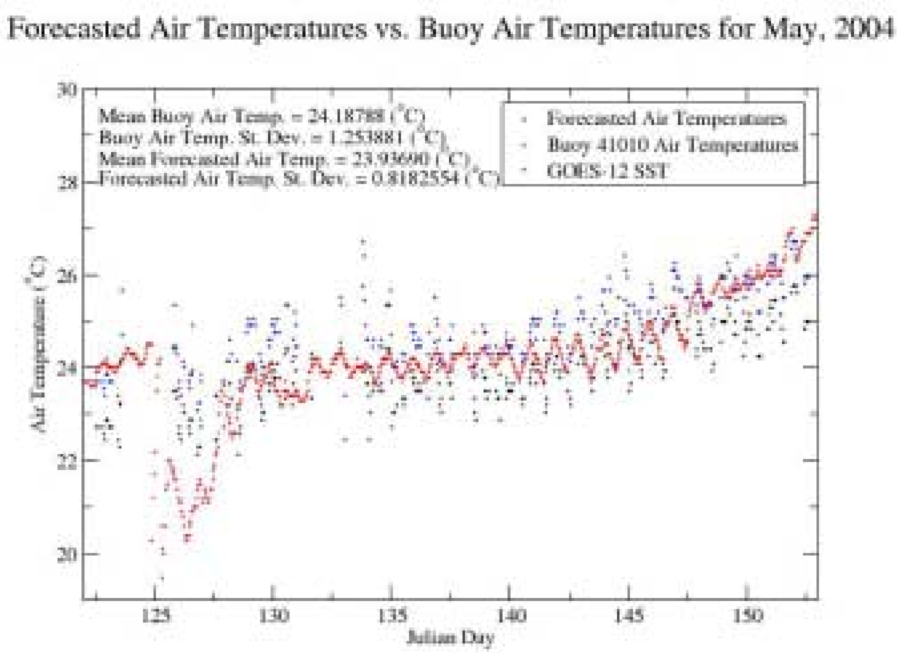


Figure 10: Same as in Figure 8 but for buoy 41010.

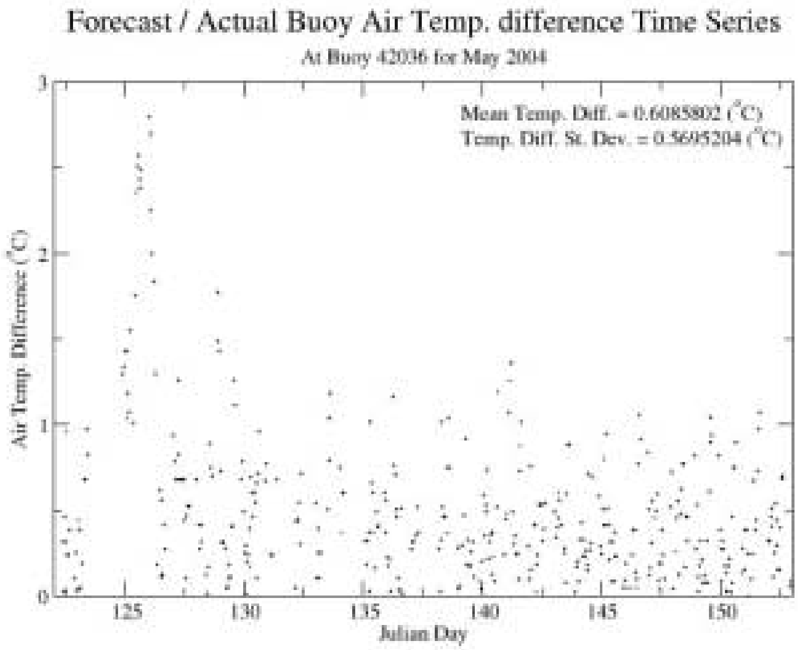


Figure 11: Time series of difference between the forecast (regression estimate) and actual air temperatures (^{o}C) at buoy 42036 for May, 2004.

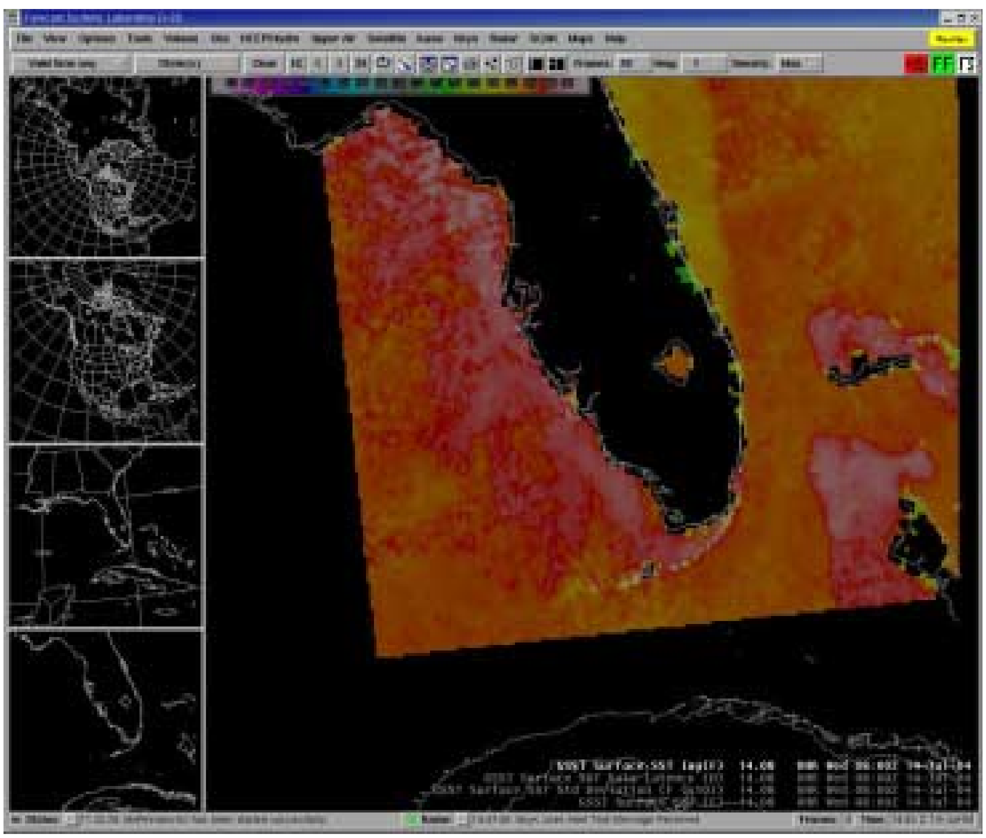


Figure 12: SST composite for 08 UTC 14 July 2004 as seen from the AWIPS platform.

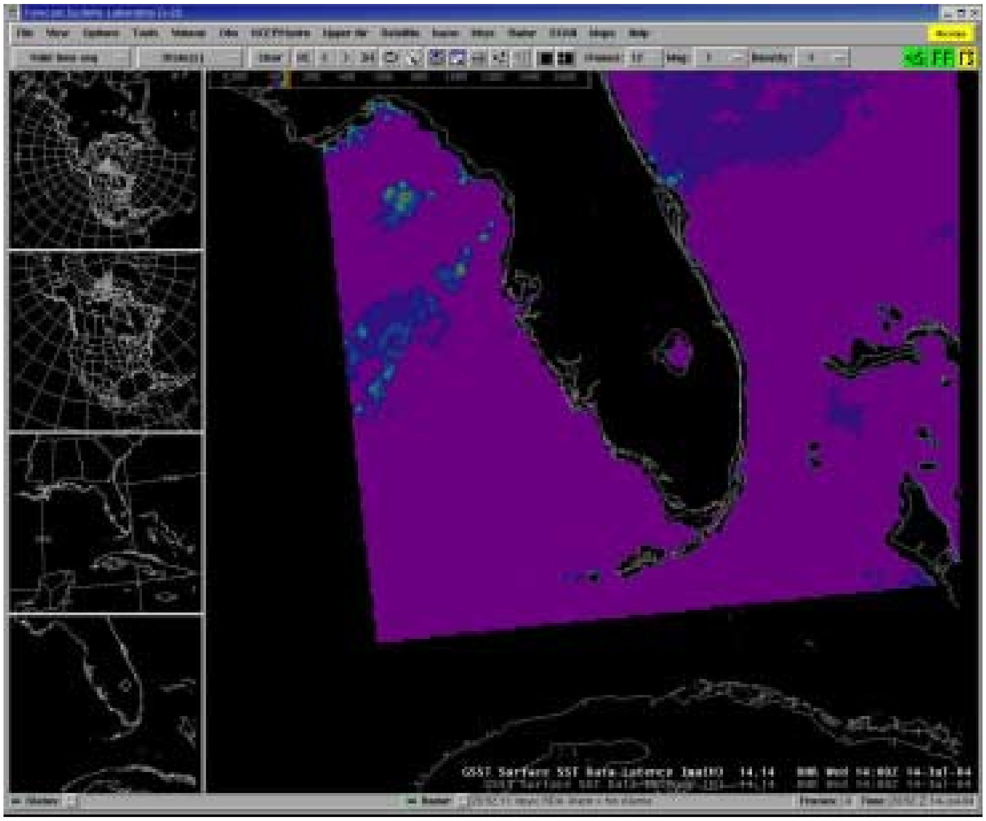


Figure 13: Same as in Figure 12 but for the data latency at 14 UTC.

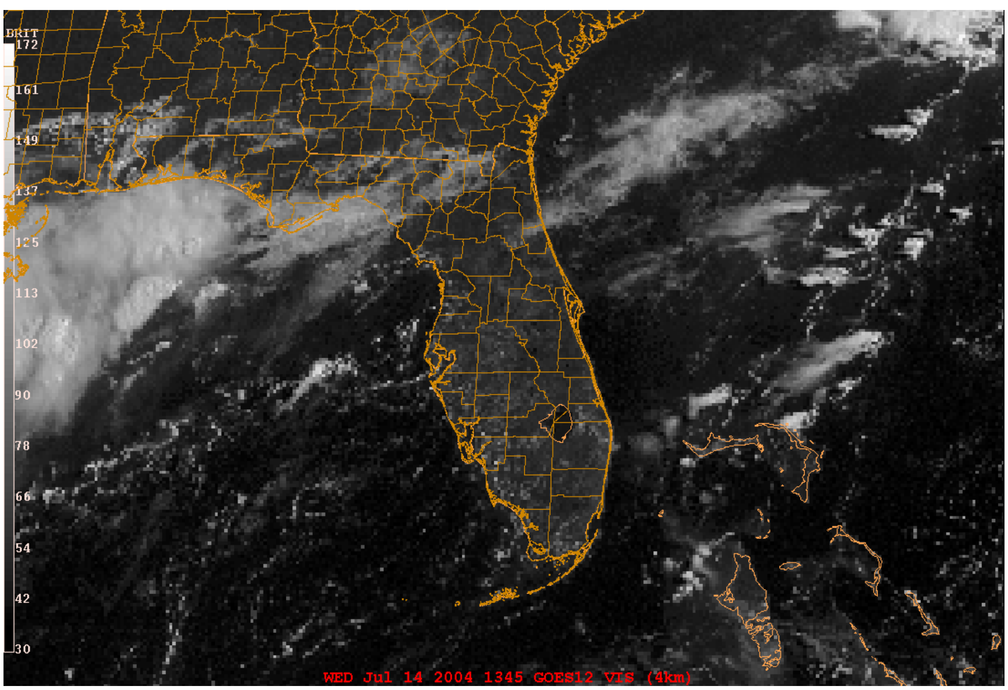


Figure 14: GOES-12 visible satellite image 1345 UTC 14 July 2004.

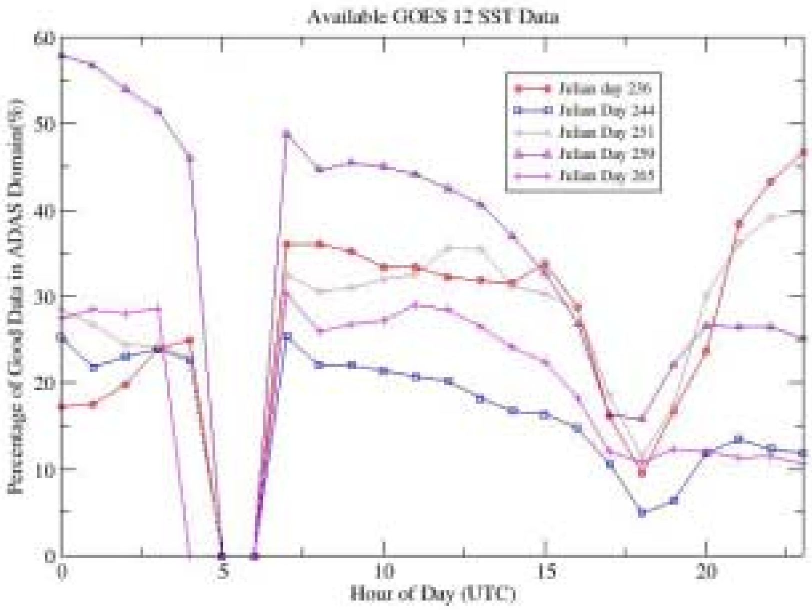


Figure 15: 24 h time series of the percentage of good data (see text) taken from 5 days in September of 2003.

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