With continual improvement in retrieval, cloud masking, and validation techniques, high-quality and high-frequency observations from operational geostationary satellites can track the diurnal cycle of SSTs and more.

**HISTORY OF GOES SST PRODUCT GENERATION.** Geostationary Operational Environmental Satellite (GOES) data offer the unique capability of tracking the movement and development of oceanic features, such as large eddies or irregularities along the Gulf Stream (Humolt 1977). The National Aeronautics and Space Administration (NASA) launched the first GOES (GOES-1) in October 1975, and since then there have been 12 more satellites in the series. Because of such factors as low digitization levels, poor spatial resolution, and inclusion of only a single infrared (IR) channel, the early GOES did not have the measurement precision necessary to produce useful sea surface temperature (SST) estimates (Maul et al. 1978; Maul 1981). The first GOES mission to demonstrate the ability to retrieve SSTs was GOES-5, with the visible–infrared spin–scan radiometer (VISSR) Atmospheric Sounder (VAS), where the newly available 3.9-μm channel, together with the 11- and 12-μm channels, was used to obtain SSTs with an accuracy of 0.9–1.0 K (see Bates and Smith 1985). However, the data were inadequate to generate high-quality SST products because of the poor spatial resolution of this imager (8–16 km), the poor signal-to-noise performance of the VISSR instrument, and
the limited access to certain geographic regions. The operational SST retrievals continued to be solely generated from the polar-orbiting satellites with their higher-resolution (1-4 km) 10-bit multichannel IR sensor capable of providing thermal IR data of sufficient quality (Walton 1988).

In May 1994, NASA launched GOES-8, which included a five-band multispectral radiometer with channel characteristics as shown in Table 1. New sensor technology, along with three-axis platform stabilization, increased dwell time per pixel, increasing both spatial resolution and signal-to-noise ratio. Thus, for the first time, a geostationary sensor provided thermal IR radiance data of sufficient precision to permit SST retrieval similar to that of polar-orbiting sensors, as well as an improved spatial resolution (~4 km in the IR at subsatellite point; Menzel and Purdom 1994). GOES-8 was followed 1 yr later by the launch of GOES-9 and 3 yr later by GOES-10 (April 1997) as a backup for GOES-8 and -9. The imager was chosen as the primary instrument from which to obtain SSTs. While it is possible to produce skin temperatures from the GOES sounder instrument (e.g., Hayden et al. 1996), they have a lower spatial resolution (~10 versus 4 km) and less coverage [primarily the continental United States (CONUS)] than the SSTs produced by the imager.

In 1997 the National Environmental Satellite, Data, and Information Service (NESDIS), together with the University of Wisconsin—Madison (information online at www.wisc.edu/), devised a plan to generate operational SSTs from GOES-8 and -9. The University of Wisconsin—Madison developed experimental SST retrieval algorithms based on satellite in situ regression, while NESDIS developed a research-to-operations program that transformed GOES SST products into operational products. NOAA CoastWatch (CW) and the National Weather Service (NWS) obtained information from various user groups to determine what type of GOES SST products they needed, including their area of coverage, frequency, and resolution.

In 1998 NESDIS established a GOES SST algorithm working group to validate new products and to provide recommendations for further modifications (see Maturi et al. 2001). In December 2000 the GOES SST product became operational, which included continuous quality monitoring. When the data between January and March 2001 indicated that the GOES SST products and matchup database needed further improvements, researchers at the University of Edinburgh began to evaluate the operational GOES SST algorithm to identify possible improvements, including such elements as the retrieval algorithm, the cloud-detection, and the matchup database methodology.

The GOES SST algorithm required further development and revision with the launch (in July 2001) of GOES-12, which replaced GOES-8 in April 2003 as the operational GOES-East (E) satellite. Because the imager on GOES-12 no longer carried the 12-μm channel, thus eliminating the conventional split-window capability for daytime retrievals (see Table 1;

<table>
<thead>
<tr>
<th>Channel No.</th>
<th>GOES-8-11</th>
<th>GOES-12-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channe l No.</td>
<td>Wavelength (μm)</td>
<td>~Subpoint field of view (km)</td>
</tr>
<tr>
<td>1 (visible)</td>
<td>0.52–0.72</td>
<td>1</td>
</tr>
<tr>
<td>2 (infrared)</td>
<td>3.78–4.03</td>
<td>4</td>
</tr>
<tr>
<td>3 (infrared)</td>
<td>6.47–7.02</td>
<td>8</td>
</tr>
<tr>
<td>4 (infrared)</td>
<td>10.2–11.2</td>
<td>4</td>
</tr>
<tr>
<td>5 (infrared)</td>
<td>11.5–12.5</td>
<td>4</td>
</tr>
<tr>
<td>6 (infrared)</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>
FIG. I. NOAA/NESDIS GOES SST operational product coverage. This is a 24-h merged geostationary SST product derived from GOES-W (11), GOES-E (12), MSG-9, and MTSAT-IR data. There is a modest gap in coverage between MSG-9 and MTSAT-IR in the Indian Ocean. The data used were for the period of 26-27 Aug 2007.

Hillger et al. 2003), a new daytime SST algorithm was developed utilizing the 3.9- and 11-\(\mu\)m channels (Merchant et al. 2008). Additional improvements to the algorithm included a Bayesian cloud-detection methodology discussed below. In June 2003, after 2 months of validation, the \textit{GOES-12} SST product became operational.

NOAA's generation of geostationary SST products is now moving toward near-global coverage (Fig. 1). In October 2003, after the failure of Japan's first Multifunctional Transport Satellite (MTSAT), the long-serving \textit{GOES-9} was moved over the western Pacific in order to produce GOES SST products for that region. Then, in November 2005, the Japanese \textit{MTSAT-IR} replaced \textit{GOES-9}, thus requiring further modification to the \textit{GOES} SST algorithm. Unfortunately, because of early problems with calibration accuracy (Pushell et al. 2006), NOAA only recently began to generate SST products from MTSAT. Finally, in June 2006, \textit{GOES-11} replaced \textit{GOES-10} as the operational \textit{GOES-West} (W) platform, which, together with data from the \textit{Meteosat Second Generation (MSG)-9} Spinning Enhanced Visible and Infrared Imager (SEVIRI), gives NOAA coverage of the eastern Atlantic, Mediterranean, Red Sea, and western Indian Ocean.

**OPERATIONAL GOES SST ALGORITHMS.**

\textit{GOES} imagers observe large sectors of both the Northern and Southern Hemispheres every half-hour, using five different spectral channels (at 0.6, 3.9, 6.7, 10.7, 12, or 13.3 \(\mu\)m). NESDIS uses channels at 3.9, 10.7, and 12 \(\mu\)m (the latter when available) to generate SSTs and determine cloudy pixels at night, substituting the visible channel for the 3.9-\(\mu\)m channel in daytime cloud detection. These data produce SST retrievals at \(-4\)-km resolution every half-hour (at the subsatellite point), which are remapped into composites in an hourly equal-angle gridded product.

\textit{Initial operational algorithm.} The original operational \textit{GOES} SST algorithms used for \textit{GOES-8} and -\textit{10} were based on a statistical–empirical algorithm similar to that used for AVHRR data (Wu et al. 1999). The initial operational algorithm of Wu et al. screened the data for cloud contamination using a series of threshold tests, combined with a retrieval algorithm derived by regressing satellite measurements versus in situ buoy measurements over a test period of 1996/97.

Daytime is defined for each pixel where the solar elevation is above 10°. Night is defined for each pixel as the sun zenith angle below \(-5°\), and the twilight condition (during which no retrievals are performed)
is deemed to be between these limits. For cloud detection, the visible data are averaged to ~4-km visible resolution and the gradual degradation of the visible channel response is taken into account through the calibration updates in the Man–computer Interactive Data Access System (McIDAS) software upgrades.

These measurements produced the following regression equations:

\[
\begin{align*}
\text{GOES-8 (day)} & = -12.10 + 1.0472T_1 + 0.2634(T_4 - T_2) + 0.4284(T_4 - T_2)^2 + 1.09845, \\
\text{GOES-8 (night)} & = 0.34 + 1.0095T_2 + 0.1123(T_2 - T_4) + 0.85535, \\
\text{GOES-10 (day)} & = -20.13 + 1.0707T_1 + 1.7041(T_1 - T_4) + 0.1401(T_1 - T_4)^2 + 1.9099, \\
\text{GOES-10 (night)} & = -27.74 + 1.1010T_2 + 0.3933(T_2 - T_4) + 3.34125, \\
\end{align*}
\]

where \(T_1\), \(T_4\), and \(T_2\) are brightness temperatures (K) for the 3.9-, 11-, and 12-\(\mu\)m channels, respectively, and \(S\) is the fractional excess air mass \(s\) (satellite zenith angle) \(- 1\).

Unfortunately, residual cloud contamination in the regression matchup database compromised the usefulness of the SST algorithms. When applied to aggressively cloud-screened nighttime data from GOES-8, SSTs from the Wu et al. (1999) algorithm had a relatively high scatter (0.7 K rms) as well as a warm bias of ~0.3 K. In contrast, experimental SST retrieval algorithms derived from MODTRAN 4 simulations achieved negligible bias and a scatter of only 0.4 K rms. The results from the Wu et al. algorithm indicated the presence of cloud contamination in the training dataset (i.e., a warm bias and excessive noise resulted when the source of contamination was no longer in the input data). May and Osterman (1998) used the same approach as Wu et al., which presented similar problems. As a result, NESDIS adopted a radiative transfer approach (e.g., Brisson et al. 2002) that resulted in an improved product.

**Radiative transfer model–based algorithms.** As mentioned above, the first major upgrade utilized a radiative transfer model (RTM) to generate the input data for algorithm training. Some of the advantages of RTM-based training over the regression approach are 1) the specification of coefficients in advance, 2) no susceptibility of the coefficients to errors resulting from cloud-detection problems, and 3) no bias of the retrieval coefficients toward regions with in situ data. However, RTM coefficients do require empirical offset adjustments because of the compounding effect of small mismatches between model atmospheric profiles and observed radiances (a more complete discussion of the strengths and limitations of this method is found in Merchant and Le Borgne (2004)).

Better prediction of channel brightness temperatures for an ensemble of atmosphere profiles and SST values came with a new retrieval method based on regression of SST versus RTM. In addition, a new parameterization eliminated the quadratic term used in the initial daytime algorithms and included more airmass-dependent terms. The full form of the equation is shown in the current operational algorithm below. Additional improvements included a better sun-glint mask and an “envelope” check to flag unreasonable brightness temperatures, as well as adjustments to the threshold cloud mask and better matchup techniques.

**The GOES-12+ algorithm.** The GOES SST algorithms prior to GOES-12 depended on data from the 12-\(\mu\)m channel. The latest GOES instruments have a new channel at 13.3 \(\mu\)m in place of the 12-\(\mu\)m channel. These data require a new retrieval scheme that ensures daytime SST retrievals still be available in the operational product. Thus, the GOES-12 RTM algorithm uses the 3.9- and 11-\(\mu\)m channels (a “dual window” methodology) to derive the correction for atmospheric water vapor, though such daytime application of dual-window retrieval is not without substantial challenges.

The difficulties in deriving accurate SSTs without the 12-\(\mu\)m channel are threefold, as follows: 1) accounting for solar contribution to the 3.9-\(\mu\)m channel, 2) detecting and masking areas of sun glint (where the solar contribution is too high to be corrected), and 3) adapting cloud detection to compensate for the lack of the 12-\(\mu\)m channel. Advanced GOES-12 algorithms (see Merchant et al. 2008) estimate and adjust for contamination to the 3.9-\(\mu\)m channel prior to generation of the SST algorithm. This adjustment corrects both for ocean surface reflection outside the glint region and for atmospheric scattering of solar irradiance. Nighttime retrieval uses the same coefficients, but without the need to apply a prior adjustment to the 3.9-\(\mu\)m brightness temperature. The daytime standard deviation between GOES-12 SST and drifting buoys is 0.84 K. The daytime SSTs remain significantly less accurate than with split-window observations. In addition, the retrieval algorithm needs further research.
Current operational algorithms. The current GOES SST algorithm is of the following form:

\[
SST = a_0 + a'_0 S + \sum (a_i + a'_i S) T_i,
\]

where \(T_i\) is channel brightness temperature (K), \(I\) is the GOES imager channel number (i.e., 2, 4, 5), \(S\) is the fractional excess air mass, and the \(a_i\) are linear retrieval coefficients.

The GOES-11, GOES-12, MTSAT, and MSG algorithms all use this form for the RTM retrieval algorithm. GOES-12 requires prior application of sun glint and atmospheric scattering algorithms during the daytime, as discussed in the GOES-12 algorithm section above. Table 2 lists the operational coefficients from GOES-8 through -13 and MTSAT and MSG.

Estimating the probability of clear sky. Detection and rejection of cloud interference is an important and often problematic step for SST products. We have adopted a probabilistic approach that replaces the traditional threshold-based cloud screening in operational SST products. This new methodology uses Bayes’s theorem to estimate the probability of a particular pixel being clear of cloud contamination (Saunders and Kriebel 1988). The estimate involves a comparison of satellite-observed brightness temperatures compared with those predicted for the given location and view angle using surface and upper-air data from the National Centers for Environmental Prediction’s (NCEP) Global Forecast System (GFS; using the 6- and 12-h forecast) and the Community Radiative Transfer Model (CRTM). The CRTM is the new operational fast radiative transfer scheme (Han 2006). [This method is described in detail in Merchant et al. (2005).] Figure 2 shows the Bayesian “mask,” derived from placing the threshold for probability of clear sky at 0.98. The conventional threshold-based mask has arbitrarily screened some

| Table 2. Operational coefficients for GOES-8 through -13, MTSAT, and MSG. |
|-----------------|----------------|-----------------|----------------|----------------|
|                | Constant        | 3.9 µm          | 11 µm           | 12 µm           |
|                | \(x1\)          | \(x\{sec0 -1\}\) | \(x1\)          | \(x\{sec0 -1\}\) | \(x1\)          | \(x\{sec0 -1\}\) |
| GOES-8 Day     | -10.53          | -17.62          | 0.0             | 0.0             | 2.927           | 0.695            | -1.891           | -0.631           |
| GOES-9 Day     | -12.98          | -8.50           | 0.0             | 0.0             | 3.55541         | 0.31219          | -2.51366         | -0.27704         |
| GOES-10 Day    | -5.99           | -12.40          | 0.0             | 0.0             | 2.676           | 0.588            | -1.652           | -0.542           |
| GOES-11 Day    | -18.01          | -6.52           | 0.0             | 0.0             | 3.3188          | 0.1466           | -2.2588          | -0.1174          |
| GOES-12 Day    | -2.10           | 1.147           | 1.177           | 0.073           | -0.162          | -0.069           | 0.0              | 0.0              |
| GOES-13 Day    | -6.32           | 2.35            | 1.2027          | 0.0628          | -0.1724         | -0.0616          | 0.0              | 0.0              |
| MTSAT Day      | -11.53          | -13.93          | 0.0             | 0.0             | 3.9477          | 0.2425           | -2.9122          | -0.1879          |
| MTSAT Night    | -5.37           | -3.20           | 1.0039          | 0.0962          | 0.7913          | -0.0694          | -0.7727          | -0.0088          |
| MSG Day        | -20.53          | -4.51           | 0.0             | 0.0             | 3.4938          | 0.2676           | -2.4241          | -0.2462          |
| MSG Night      | 0.52            | -10.23          | 0.9073          | -0.0296         | 0.9297          | 0.3418           | -0.8289          | -0.2694          |
areas of the image as cloudy that the Bayesian mask shows as more than 99.9% likely to be clear. The latter also shows greater SST structure based on SST images, especially in colder waters. In addition, the Bayesian cloud mask is more flexible than the threshold-based method because it allows the user to select the range of confidence of clear pixels in their SST application.

**GOES SST products.** This section describes how the SST products are generated from the GOES-11, GOES-12, MTSAT-1R, and MSG imagers. Single-band imagery from the NESDIS GOES Remap Server is merged into a multiband McIDAS “AREA” file. The data include both visible and IR channel data at the finest IR resolution. In addition, forecast data from the NOAA GFS, consisting of model temperature and humidity profiles, plus surface and integrated model parameters, are obtained. The gridded data are interpolated to the nominal time (nearest hour) of the SST retrieval.

**Processing.** SST retrieval is performed by one main program according to the following steps: 1) gross cloud checks on satellite imagery are performed, 2) SST retrievals with coefficients based on a particular satellite are computed, 3) Bayesian cloud probability estimates are computed, 4) SST and cloud probability are obtained from McIDAS, and 5) SST products are generated.

**Output products.** Hourly gridded SST products are generated by taking the clearest pixels, weighted by the Bayesian probability, of the three half-hourly files for each sector and resampling the result to an equal angle grid of a 1/20° resolution. This procedure is not expected to result in any significant temperature bias. For MTSAT there is only one image per hour, eliminating any need for merging. Other
gridded products include 3- and 24-hourly hemispheric averages, 3-hourly regional sector images for NOAA’s CW regions (online at www.coastwatch.noaa.gov), and a daily (0.1° × 0.1°) global multisensor satellite SST analysis. The Global Ocean Data Assimilation Experiment (GODAE) High-Resolution SST Pilot Project level 2 preprocessed product (GHRSSST-L2P) is generated for each hemispheric sector of GOES-11, GOES-12, MTSAT, and MSG each half-hour. Buoy matchups are generated hourly, and include buoy SST, retrieved SST, satellite brightness temperatures (BT), model BT, and other information.

**Product distribution.** All GOES SST products are sent to the NESDIS product server (140.90.195.61) as soon as they are created. Registered users can access them through anonymous FTP. The CW sector products are collected and formatted to CW Hierarchical Data Format (HDF) and are distributed on the CW server (online at www.coastwatch.noaa.gov). The GOES GHRSSST-L2P data are collected and distributed by the Jet Propulsion Lab (JPL) Physical Oceanography Distributed Active Archive Center (PODAAC; available online at http://ghrsst.jpl.nasa.gov).

**APPLICATIONS.** GOES SST products represent a uniquely powerful dataset for studying both diurnal warming of the ocean surface and the evolution of mesoscale features, such as fronts and eddies (Walker et al. 2003). Since their operational implementation in December 2000, these products have become one of the most requested by the NOAA CoastWatch community.

The National Marine Fisheries Services (NMFS), the NOAA Coral Reef Watch Program, the National Weather Service forecasting community, and the climate community represent the four primary users of the GOES SST products.

The NMFS uses GOES SST in support of coastal applications, particularly studies related to commercial fisheries management and protection of endangered species [e.g., turtle exclusion for fishing and mammal protection; see Seiki et al. (2001)]. At the Pacific Islands Fisheries Science Center, Howell et al. (2008) initiated the TurtleWatch product (Fig. 3) to help reduce inadvertent interactions between Hawaii-based pelagic longline fishing vessels and loggerhead turtles by providing a near-real-time product recommending the area to avoid the deployment of shallow nets. The TurtleWatch provides a timely, easily understood, and science-based tool to both the industry and managers to aid in decisions regarding the Hawaii Longline Fishery. TurtleWatch was released in December 2006 and was correct in identifying the area where more than 65% of the loggerhead turtle catch occurred during the first quarter of 2007.

NOAA’s Coral Reef Watch Program requires SST climatologies for hindcasting and nowcasting coral bleaching warnings and assessments. Geostationary satellites, in clear-sky areas, provide a measure of the diurnal variation, which may be of significance compared to SST products that are only derived from polar orbiters, which only observe at the same time or two each day. This information is necessary to accurately monitor thermal stress (the main cause of bleaching). Current techniques use a single nighttime image to represent the SST for each day. Given that the coral is sensitive to absolute maximums, as well as

![TurtleWatch product generated for the Pacific Island region using GOES SST data for 17-18 Jan 2008. This product identifies the fishing exclusion zones for shallow nets to avoid turtle entrapment.](image-url)
thermal exposure (over time), a bleaching prediction technique based on full diurnal observations of SST (Leichter et al. 2006) is superior to the currently used polar orbiter techniques, which are being updated just once per day.

The National Weather Service’s Ocean Modeling Branch, Ocean Prediction Center, the Climate Modeling Branch, and the Tropical Prediction Center assimilate the GOES SST products into their forecast models.

The climate community requires accurate GOES SST data that account for the diurnal SST effects on, for example, the descending branch of the Walker circulation. It also requires interannual-to-decadal studies related to the El Niño/La Niña region, both of which are covered by the GOES SST products. The frequent temporal sampling of the GOES data also permits better resolution of westward propagation of tropical instability waves, particularly when substantial but evolving cloud cover prevails, for example, during seasonal transitions of the intertropical convergence zone (ITCZ), the region where the northeasterly and southeasterly trade winds converge, forming a continuous band of clouds or thunderstorms near the equator (Legeckis et al. 2002).

GOES SST can also provide a historical record of higher temporal sampling of SST during the tropical cyclone seasons in the eastern North Pacific and North Atlantic basins. Examples of a few of the GOES SST products and their applications are described below.

**SST frontal index product.** One operational use of GOES SST retrievals is to resolve SST fronts (Breaker et al. 2005), in particular in the four following regions: upwelling regions near the western coast of the United States, the Loop Current in the Gulf of Mexico, the Gulf Stream in the northwest Atlantic, and the Gulf of Maine (where tidal mixing occurs). As GOES SST frontal products became operational in December 2006, NESDIS created an operational oceanic frontal index. This product describes the probability density of sea surface front formation on the coasts of California, Oregon, Washington, and Massachusetts. Fronts are often accompanied by surface convergence and influence surface flow (Bowman 1978), and they play an important role in upper-ocean processes. Fronts can impact ocean fisheries, for example, by influencing the spatial distribution of biological productivity and by controlling the accumulation of marine debris, which serves as a beacon to higher trophic levels. Oceanic fronts are an important part of the California Current System (CCS) and are vital to the understanding and management of fisheries within the CCS. A recent paper (Castelao et al. 2006) evaluated and used the Oceanic Front Probability Index to study the topographical and seasonal influences on the northern CCS off the coast of Oregon. Specific applications include use in the selection of marine protected areas within the National Marine Sanctuaries, as well as inclusion as a core dataset for the West Coast Regional Associations of the Integrated Ocean Observing System.

Figure 4 shows an example of the SST frontal index product off the U.S. East Coast.

**Oceanic processes.** Legeckis et al. (2002) showed the versatility of the GOES SST retrievals in the following three areas: tracking westward-propagating tropical instability waves in the Pacific, the time history of the Loop Current in the Gulf of Mexico (also see Legeckis and Zhu 1997), and the formation and precession of cyclonic eddies west of the Hawaiian Islands.

**GOES SST L2P.** In February 2007 GOES SST preprocessed level 2 products (L2P) became available. These
FIG. 5. GOES SST L2P product of the GOES-E in the Northern Hemisphere at 1515 UTC 28 Mar 2006. (a) SST, (b) aerosol optical depth field, (c) proximity confidence (Bayesian cloud proximity), (d) surface solar irradiance, (e) wind speed, (f) SST standard deviation, and (g) SST bias. Similar SST products are available from MTSAT and MSG.
products are standardized GOES SST retrievals combined with ancillary information, such as environmental conditions and retrieval errors. GOES-E generates, nearly every half-hour, a Northern Hemispheric sector (20°–60°S, 30°–105°W) and a Southern Hemispheric sector (45°–20°S, 30°–105°W). Similarly, GOES-W generates, nearly every half-hour, a Northern Hemispheric sector (0°–60°N, 105°W–180°) and a Southern Hemispheric sector (45°S–0°, 105°W–180°). The GOES SST L2P products are derived from the half-hourly GOES-East and West, both with northern and southern sectors. L2Ps are useful for numerous applications, including 1) providing well-characterized SST data for the GHRSSST Pilot Project (GHRSSST-PP), 2) providing GOES SST data with retrieval bias information for ocean modeling, 3) allowing removal of retrieval bias in all geostationary SST products, and 4) producing diurnal cycle information.

Figure 5 shows example GOES SST L2P product fields.

VALIDATION AND QUALITY CONTROL OF THE PRODUCTS. Validation methodology. NOAA/NESDIS generates a matchup database for validation of the GOES SST retrieval algorithms. This database serves to maintain and improve the GOES SST products by matching up observations from the global drifting buoys in native satellite projection and resolution every half-hour. The buoys used in the matchup program are extracted from the National Centers for Environmental Prediction (NCEP). These buoys are quality controlled using the NCEP Optimal Interpolation SST (OISST) analysis (Reynolds and Smith 1994) prior to their being matched with the GOES SST retrievals. NOAA stores the matchup files electronically in the Comprehensive Large Array-Data Stewardship System (CLASS), which one may access through the Web. The Web site provides user access capabilities that aid in finding and obtaining data. Figure 6 shows a time series of the bias and standard deviation for daytime and nighttime GOES-8 through -12 SSTs. Major changes to the algorithm are indicated on the graphs. The time series also indicates the level of adjustments, including bias corrections, which can be applied to the GOES SST products. We also note that changes to cloud screening methods can cause changes in the standard deviation and bias of SST against in situ data, as seen with the introduction of Bayesian cloud screening. Because the Bayesian mask is determined by a single threshold applied to the estimated probability of clear sky, there is the opportunity to trade off coverage and validation performance against the severity of the cloud mask by adjusting that threshold possibility. Further, it is likely that the bias seen after the introduction of the Bayesian cloud mask is actually reflecting the true effect of errors in the GOES calibration, which will have been masked to some extent when using the previous, less accurate cloud masks.

An automated validation system computes the statistics on a monthly basis using a matchup file to calculate the following factors: the number of matches, maximum bias, means bias, and standard deviation. Experimental GOES SST retrievals undergo a validation process for several months to determine whether the bias and the standard deviation are
within an acceptable quality range. Once accepted, the retrieval algorithms become operational for product generation.

Quality control of the products. Validation of the SST products ensures quality control. The bias and standard deviation generated from the validation statistics determine whether the products are within an operationally acceptable range of quality. NESDIS determines causes for loss of quality and makes appropriate changes to bring the product back to operational standards. A GOES SST reprocessing system is part of the validation system to test and regenerate all SST products when either a retrieval error is discovered or a new component of the algorithm requires testing. This reprocessing allows distributors and developers to compare and contrast the SST products derived from different retrieval schemes, and thus determine the best retrieval scheme.

Conclusions. NESDIS is committed to providing the user community with the highest-quality GOES SST products possible. Ongoing efforts include updating the retrieval methodology, maintaining a robust satellite SST-to-buoy matchup dataset, and implementing more accurate cloud mask schemes, as well as generating coefficients that are more consistent with future radiance bias corrections. These improvements will ensure state-of-the-art products as we move toward the future and continue to generate operational SST products from all geostationary satellites.

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The contents of this paper are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA, the U.S. government, or CICS.

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