Recent Improvements to the NOAA AVHRR SST Product at the Australian Bureau of Meteorology

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The Bureau of Meteorology is Australia's National Weather Forecasting agency and, as such, has primary responsibility for monitoring the atmosphere and the oceans in the Australian region. The Space Based Observations Section, within the Observations and Engineering Branch of the Bureau, provides users within the Bureau with satellite data. This data includes both imagery and derived products from geostationary and polar-orbiting spacecraft. One of these products is the operational NOAA-AVHRR SST system.

The operational satellite SST system is McIDAS based, comprising FORTRAN legacy code, and based on McClain et al. (1985). The system was rewritten in 1998 for the AVHRR/3 on NOAA-KLM and, at this time, was extended to full resolution rather than computing SSTs over a 4x3 pixel box. The algorithm used is the Multi-Channel SST (MCSST) (McClain et al., 1985) with global coefficients provided by NOAA/NESDIS. Image navigation is carried out using the TBUS broadcasts that, whilst providing sufficiently accurate information for satellite tracking, can contain significant errors in position. The output of the system is provided as single-byte data with a precision of 0.2 degrees Celcius.

The SST data is distributed to internal clients (within the Bureau) for use in SST analyses and is also used in the generation of an Australian Region SST mosaic. This mosaic is a rectilinear (Latitude/Longitude Grid) projection, 8700 lines x 11000 elements in size, at 1.5km resolution at the Equator. Rather than an analysis, the mosaic is a running, 14-day, weighted average. Each pixel of the mosaic is a weighted mean of the latest observation with the previous observation, the weight of which is inversely proportional to the square of its age in days. The mosaic is archived daily.

Automated matchups with collocated ships and buoys are computed daily and the results made available on an internal Bureau web site. Underperforming in-situ observation platforms are flagged and removed from the calculations.

Two main areas for improvement have been highlighted with the operational satellite SST system. Firstly, for any high resolution analysis or mosaic, the image navigation must be as accurate as possible. Secondly, the algorithms currently in use may not be the best available.

As mentioned, image navigation is critical if a high-resolution product is to be generated. Any navigation enhancements must be fully automatic for operational use in real-time processing (i.e. no human interaction). The navigation must be accurate (1 pixel or better), consistent and reliable. In this regard, TBUS ephemeris data is not sufficient and the satellite pitch, roll and yaw must also be taken into account.

Improved navigation of the imagery is carried out using the Common AVHRR Processing System (CAPS) (see http://www.dar.csiro.au/rs/Capshome.html), which is an extension of Tcl/Tk for processing AVHRR, and ATSR-2 GBT satellite data. CAPS can also display and reproject MODIS, MISR and ASTER data. CAPS uses the 'Clift' navigation model for AVHRR: delivering approximately 1-pixel accuracy using orbital elements, satellite attitude and clock correction files downloaded from CSIRO Marine Research, Hobart. The orbital elements are computed by coastline and feature pattern matching, using a least-squares fit to a set of image chips after each pass (Hobart data only at present). The computed ephemeris works well in other parts of the world and also has good accuracy over the short term meaning it can be used on passes where there is little or no land present.

To improve the SST algorithm itself, a parallel system using the Non-Linear SST (NLSST) algorithm (Walton et al., 1998) was set up. The method was compared with the MCSST using a match data set with collocated ship/buoy observations. For both algorithms the NOAA/NESDIS global SST coefficients were used. The comparison incorporated the upgraded navigation. Collocations were based on a time window of +/- 3 hours either side of the satellite observation and used a 4x4 pixel box (in satellite projection), centred on the reported observation location. The period studied was 31st May to 18th July, generating over 6000 matches for all spacecraft, and over 2800 matches for NOAA-17.

Examination of the experimental results, shown in Figure 1, shows an improvement to RMS Error and bias as expected, however the RMS values were slightly higher than reported in other studies. The low bias indicated that the cloud clearing was working adequately. The likely cause of the higher than expected errors was the unknown navigational errors in buoy/ship data.

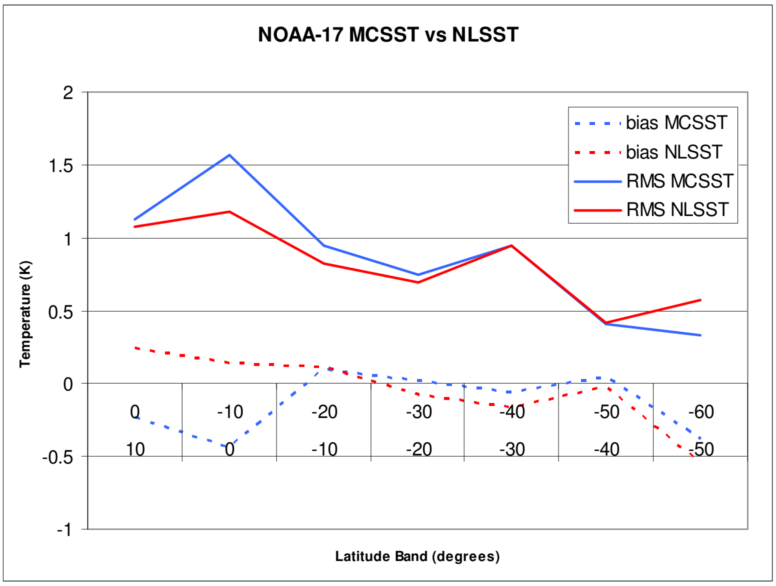

Figure 1 - Latitudinal Differences between MCSST and NLSST Algorithms for NOAA-17

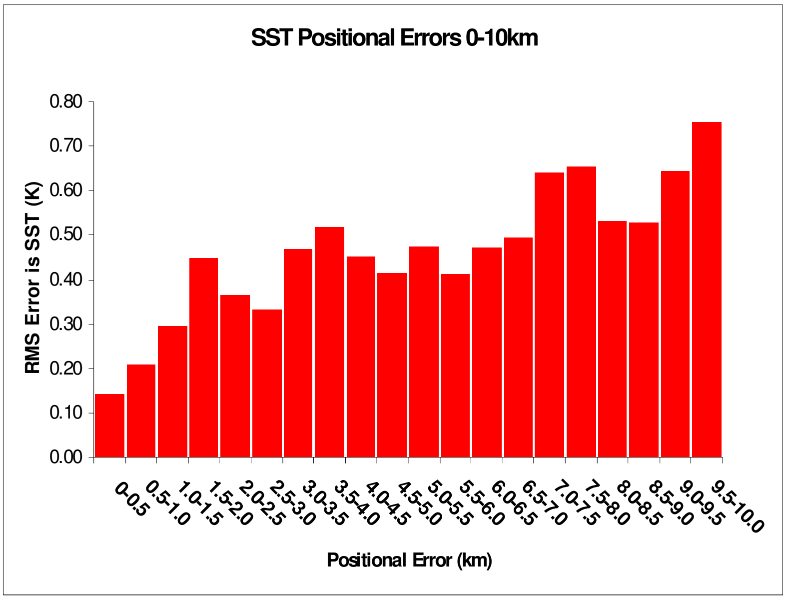

Figure 2 - Effect of Positioning Errors on SST RMS Error

The effect of positioning errors on RMS errors in SSTs was then investigated. On the GTS, ship and buoy observations are only reported to 0.1° Lat/Lon (~ 11km). The experimental method was to sample an SST value from the operational mosaic, take a random bearing and distance offset (up to 10km), and re-sample the SST. The results are based on approximately 6000 samples with roughly equal numbers of comparisons in each distance 'bin'. These results are shown in Figure 2 and demonstrate the importance of accurately positioning the in-situ observations if the RMS error is to be accurately determined.

Future developments in the Bureau's SST system can be broken into two stages. The initial stage is the operational implementation of CAPS navigation and the NLSST algorithm. This is ready for implementation now. The second step is the migration of the system from FORTRAN/McIDAS to Tcl/Tk/CAPS, and the addition of a quality/confidence flag. This will provide flexibility in output formats (netCDF, HDF, McIDAS) and will allow us to more easily generate GHRSST-L2P data (which would be difficult to achieve under the current system). Furthermore, the changes will allow greater flexibility in input data with a view to the addition of other spacecraft.

Further future developments in SST processing will result from the expansion of the Bureau X-Band network, allowing SSTs to be generated from MODIS, AIRS and NPOES. Geostationary SSTs from MTSAT-1R and Fengyun-2C will provide hourly data and increased area of coverage. It is also proposed to develop local SST coefficients for AVHRR and other spacecraft.

Towards GHRSST-L2P, the Bureau of Meteorology plans to provide local AVHRR SSTs at full resolution. It is hoped that the GHRSST-L2P format will serve both internal and external customers (e.g. GHRSST-PP, BLUElink). Although a large amount of metadata is required which significantly exceeds what is required for internal Bureau use, within resource and budgetary limitations it is planned to generate this format.

References

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