Use of ACSPO VIIRS L3U SST in the Australian Bureau of Meteorology

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Introduction

Satellite imagery for sea surface temperatures (SST) has been acquired around Australia on a daily basis since the early 1990's. Building on the archives and processing expertise of CSIRO and the Bureau of Meteorology (BoM), the Integrated Marine Observing System (IMOS) has made these data available as a consistently processed, calibrated and formatted archive of SST maps for the Australasian region. As part of IMOS, BoM has produced GHRSST L2P and 0.02º gridded L3U, L3C and L3S products from HRPT AVHRR SST data from NOAA satellites over two domains (Australia and Southern Ocean) from 1992 to present. BoM need the Suomi National Polar-orbiting Partnership (S-NPP) VIIRS SSTs as a follow-on to NOAA-19 AVHRR. NOAA/STAR produces an Advanced Clear-Sky Processor for Oceans (ACSPO) VIIRS 0.02º L3U SST product with grid aligned with IMOS 0.02º L3U product. This ACSPO VIIRS L3U product has been assessed at BoM for ingestion into various operational products and systems.

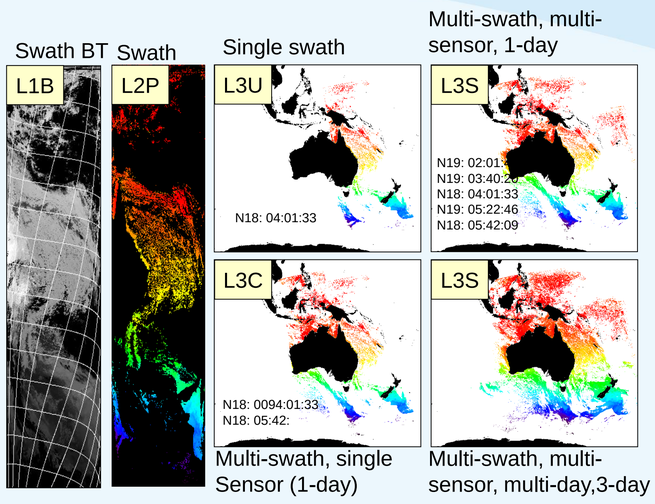

Fig. 1 Different types of IMOS AVHRR SST products (following GHRSST conventions).

Constructing IMOS VIIRS L3U product

produces GHRSST L2P, L3U, L3C and L3S products
IMOS Project and

At the BoM, the ACSPO VIIRS L3U files are customized to match with standard IMOS file format.

- Only the ACSPO VIIRS L3U files that have data on IMOS grid are processed further.
- ACSPO VIIRS L3U files are modified by adding ancillary fields to match up with standard IMOS L3U files (e.g. sea ice, winds, dt_analysis)
- l2p_flags are redefined using modified ancillary fields.
- The quality level is redefined as the minimum of the original VIIRS_NPP ACSPO_v2.40 quality_level and quality_level calculated using Sensor Specific Error Statistics (SSES). The latter is calculated using SSES bias and SSES standard deviation estimates.

For a single swath, VIIRS L3U SSTs have slightly greater spatial coverage to IMOS fv01 NOAA-15/18/19 L3U SSTs but with no worse quality (e.g. Fig 2).

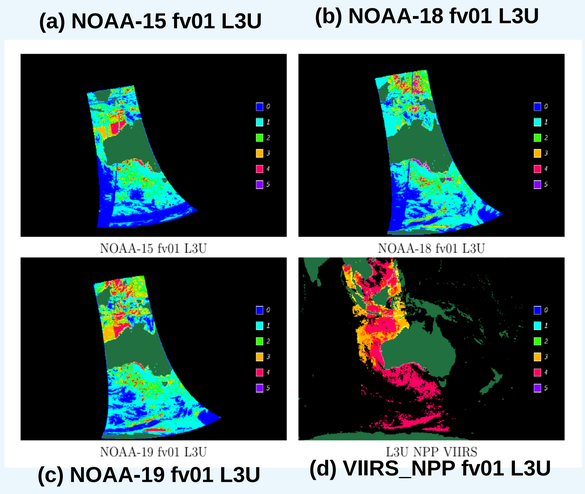

Fig 2. Quality levels for a single swath from (a) NOAA-15, (b) NOAA-18, (c) NOAA_19 and (d) VIIRS_NPP.

Multisensor L3S products

The data from NOAA-15, NOAA-18, NOAA-19 and VIIRS_NPP data is composited to construct new "Multisensor" L3S product.

The high spatial resolution (0.75-1.5 km) and accuracy of VIIRS SST data, in conjunction with existing 1-4 km High Resolution Picture Transmission (HRPT) AVHRR SST data, shows significant improvement in spatial coverage (Fig. 3).

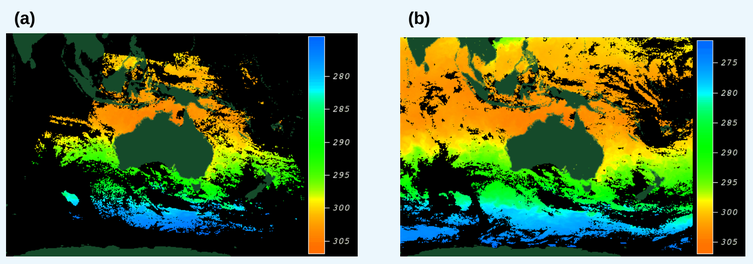

Fig 3. Sea surface temperatures with quality level 4 and 5 For L3S-1day night file from (a) NOAA-18/19 and (b) Multi-sensors (NOAA-15/18/19 and VIIRS_NPP) for 22nd February 2016.

Applications

ACSPO VIIRS L3U SST is a high priority data stream to add to satellite data ingested into the following BOM operational products:

- Global 10 km OceanMAPS and regional 4 km eReefs (GBR) ocean general circulation models
- Daily regional 1/12º and global 1/4º foundation SST L4 analyses (RAMSSA and GAMSSA)
  - Formed by optimally interpolating day and night in situ and satellite SST data (IMOS HRPT AVHRR L2P, NAVO GAC AVHRR L2P, JAXA AMSR-2 L2P), followed by filtering out when NWP wind speeds are below 6 m/s (day) and 2 m/s (night)
  - Used as boundary condition for the BoM operational regional and global NWP models
  - VIIRS L3U SSTs will be composited over the GAMSSA and RAMSSA grid (Fig. 4)

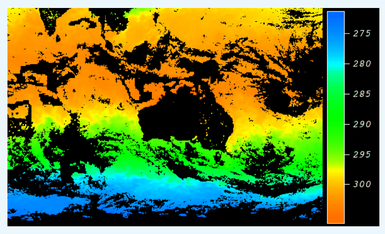

Fig.4 VIIRS_NPP day+night daily SSTfnd file on RAMSSA grid for 22nd February 2016.

In addition, the ACSPO VIIRS L3U product will be use to form IMOS 0.02º VIIRS L3C and 0.02º VIIRS+AVHRR L3S SST products. The IMOS 1-day night-only AVHRR-only L3S product is currently used as input into the BoM operational ReefTemp NextGen coral bleaching nowcasting system over the Great Barrier Reef.

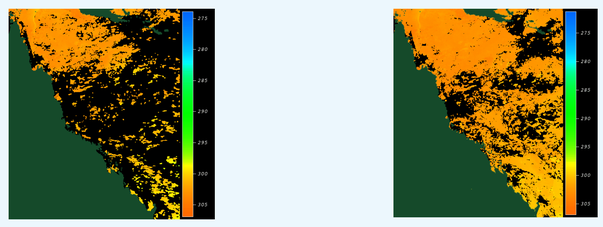

Fig. 5. IMOS night-only 1-day L3S SSTs with quality level 4 and 5 for 22nd February 2016, formed from (left) NOAA-18/19 and (right) NOAA-15/18/19 and VIIRS, over the Great Barrier Reef near Cairns, Australia.

Due to the enhanced spacial coverage (Fig. 3 and 6), the IMOS multisensor L3S SST products are expected to provide better input for applications such as BoM's ReefTemp NextGen Coral Bleaching Nowcasting system (Fig. 6) and IMOS OceanCurrent (Fig. 7).

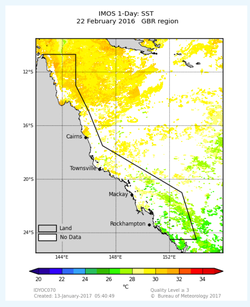

Fig. 6. BoM ReefTemp NextGen map of the 2 km SST anomaly for 22nd February 2016, off the Queensland coast, Australia, generated using IMOS night-only 1-day L3S SSTs.

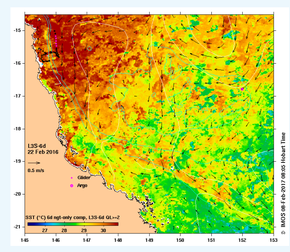

Fig. 7. IMOS *OceanCurrent* map of the 2 km SST anomaly and surface ocean current vectors for 22nd February 2016, off the Queensland coast, Australia, generated using IMOS night-only 6-day L3S SSTs.

Equatorial Crossing Times for NOAA Polar Satellites

The satellites NOAA-15, NOAA-18, NOAA-19 and Suomi-NPP have different equatorial crossing times, with those from the NOAA satellites drifting over time (Fig. 8).
Currently, the daytime equatorial crossing time for

- NOAA-15 is ~ 18:00 LST (around sunset)
- NOAA-18 is ~ 19:00 LST (around sunset)
- NOAA-19 is ~ 15:00 LST (close to peak diurnal cycle)
- VIIRS_NPP is ~13:30 LST (early afternoon)

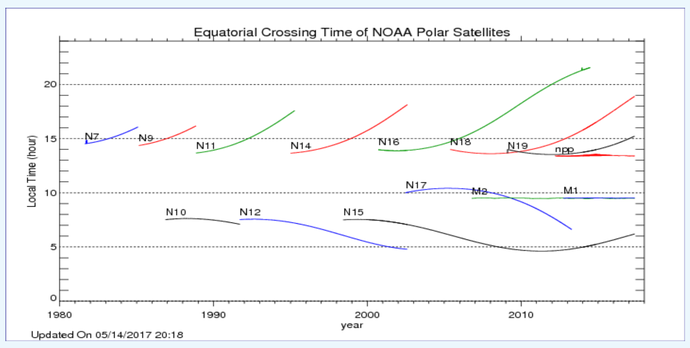

Fig. 8. Equatorial Crossing Time for NOAA Polar onboarding Satellites. Image source: https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_avhrr_ect.php

Future Plans

Over the coming 12 months, we look forward to:

- Validating VIIRS L3C/L3S files
- Reprocessing fv02 IMOS-GHRSST VIIRS L3C and multi-sensor L3S files for the period of 1st January 2015 to 31st December 2016
- From July 2017, start testing ingesting VIIRS L3C SSTfnd into RAMSSA/GAMSSA

Validation

As an initial validation of the new IMOS VIIRS products, we compared quality level (QL) ≥ 4 SST(0.2 m) values from IMOS L3C/L3S files with 24-hour drifting and tropical moored buoy foundation SSTs for the period from 1-31 Mar 2017 over the Australian domain (70ºE – 190ºE, 70ºS – 20ºN). Some observations:

- Multi-sensor L3S had ~ 3 times more QL ≥ 4 matchups than NOAA-18/19 L3S
- NOAA-18/19 L3S and Multi-sensor L3S showed similar biases and night-time standard deviations, but daytime NOAA-18/19 L3S shows greater standard deviation
- Daytime VIIRS L3C bias is larger than those for NOAA-18 and NOAA-19 platforms. It may be due to the use of different regression algorithms for day and night SST retrievals and diurnal warming. As the daytime local equator crossing time for VIIRS is 1.30 pm (Fig. 8), it is expected to catch close to maximum diurnal warming in the Australian region in the month of March (~3pm).

Matchup statistics for March 2017

L3C/L3S Product	Day Matchups	Day Bias (K)	Day SD (K)	Night Matchups	Night Bias (K)	Night SD (K)
N-18 L3C	515	-0.15	0.88	2042	-0.04	0.57
N-19 L3C	2356	0.18	0.72	1884	0.04	0.48
VIIRS L3C	8274	0.26	0.50	8041	0.07	0.48
N-18/19 L3S	2385	0.10	0.78	3368	0.00	0.54
Multi L3S	7984	0.19	0.58	9957	0.04	0.53

Table 1. Validation statistics of the operational IMOS NOAA-18/19 L3C/L3S files and new experimental IMOS VIIRS L3C and multi-sensor L3S files, showing number of matchups, mean and standard deviation of the difference between the L3C/L3S SST(0.2 m) and in situ SSTfnd observations from drifting and moored tropical buoys. Measurements are considered co-located if the satellite observation is within 2 km and the same UTC day of the in situ observation. Only SST data flagged as being of quality level = 4 or 5 are included here. Known biases with respect to the drifting buoy SST data have also been removed. IMOS L3C/L3S SSTskin values were converted to drifting buoy depths (~0.2 m) by adding 0.17K.

Further Information

Email: helen.beggs@bom.gov.au
Web site: http://imos.org.au/sstproducts.html

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IMOS Integrated Marine Observing System

*IMOS is a national collaborative research infrastructure, supported by Australian Government.
It is led by University of Tasmania in partnership with the Australian marine and climate science community.*

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