Himawari-8 and Multi-sensor sea surface temperature products and their applications

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Introduction

Sea surface temperature (SST) products within a few kilometres of coasts that can resolve fine-scale features, such as ocean upwelling, are increasingly in demand. The Australian Bureau of Meteorology (Bureau) currently produces operational, real-time SST from the Himawari-8 geostationary satellite every 10 minutes at ~2 km spatial resolution. These native resolution SST data have been composited to experimental hourly, 4-hourly and daily SST products and projected onto the rectangular Integrated Marine Observing System (IMOS) grid at 0.02 x 0.02 degrees. In response to user requirements for gap-free, highest spatial resolution and highest accuracy SST data, the Bureau is experimenting with compositing geostationary Himawari-8 data with data from the Visible Infrared Imaging Radiometer Suite (VIIRS) and Advanced Very High-Resolution Radiometer (AVHRR) satellite sensors installed on polar-orbiting satellites to construct new "Multi-sensor L3S" products. The compositing reduces data gaps due to clouds and provides easy-to-use, more gap-free SST data.

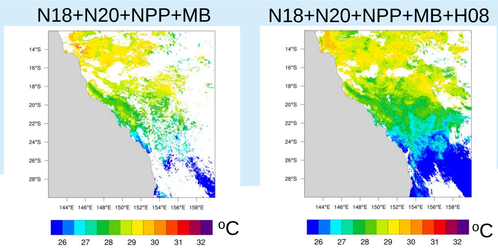

Fig. 1. Addition of Himawari-8 data to AVHRR+VIIRS L3S SST significantly improves data coverage over Great Barrier Reef region for 15th March 2020.

IMOS Himawari-8 SST Products

Himawari-8 L2P:

- The Radiative Transfer Model (RTTOV12.3) and Bayesian cloud clearing method based on the ESA CCI SST code developed at the University of Reading is used to retrieve Himawari-8 L2P SST[1]
- Sensor Specific Error Statistics (SSES) model developed at the Bureau is then applied to those L2P files[2]
- The quality level is reassessed using SSES[2]
- Native grid, full disk

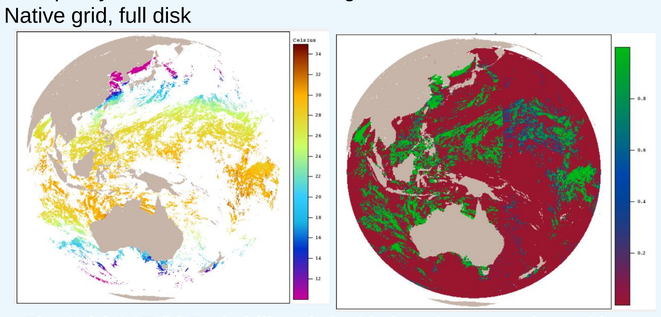

Fig. 2. (a) SST (b) Probability of pixel being clear as estimated by Bayesian cloud detection from Himawari-8 L2P file for 15th March 2020.

Himawari-8 L3C:

- Data sourced from Himawari L2P SSTskin
- Hourly, 4-hourly and daily night-time L3C products
- IMOS 0.02º x 0.02º grid

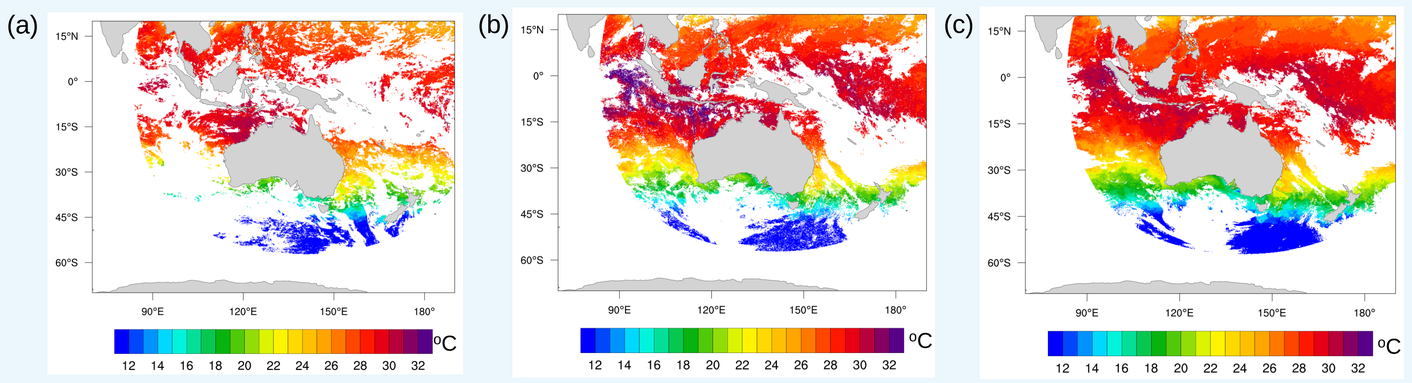

Fig. 3. SST with quality level >=3 from Himawari-8 L3C file for (a) 1-hour (b) 4-hours and (c) night 15th March 2020.

IMOS new Multi-sensor products

Data sources

- IMOS H08-AHI L2P files for Himawari-8
- The ACSPO VIIRS L3U files for Suomi NPP and NOAA-20
- OSISAF FRAC AVHRR L2P files for MetOpB
- IMOS AVHRR-18 L2P files for NOAA-18

In order to merge data from different satellite sensors, the quality level (QL) of each dataset to be merged is redefined as the minimum of the original QL provided by the data provider and QL calculated using Sensor Specific Error Statistics (SSES). The latter is calculated using SSES bias (μ_{sses}) and SSES standard deviation (σ_{sses}) estimates.

$$q_{sses} = \frac{1}{\sqrt{2}}\sqrt{\max\left(\left(\frac{\sigma_{sses}}{\sigma_0}\right)^2 + \left(\frac{\mu_{sses} - \mu_0}{\sigma_{sses}}\right)^2 - 1, 0\right)}$$

$$q_s = \lfloor 5\exp^{\eta q_{sses}} \rceil$$

Different data sources can then be combined using q_s, *provided that* η/σ_0 = constant, where η is a scaling parameter and the half square brackets in the q_s equation represent the "nearest integer" function.

- Data from NOAA-18, Suomi NPP, NOAA-20, MetOp-B and Himawari-8 L3C files are composited using an equal weighted averaging method to construct the new experimental Multi-sensor L3S product[2].

Different versions of Multi-sensor L3S SST products:
fv01-Operational data (NOAA-18+N20+NPP+MetOpB)
fv02-Reprocessed data in delayed mode(NOAA 15-20+NPP+MetOpA+MetOpB)
fv03-Experimental data (Himawari-8+NOAA18+N20+NPP_MetOpB)

Adding Himawari-8 SST data to existing data streams for operational Multi-sensor L3S (NOAA-18 and Suomi NPP, NOAA-20 and MetOpB, Fig 3a and Fig 4a), shows significant improvement in spatial coverage (Fig 4b and Fig 5b), specifically for quality level=4.

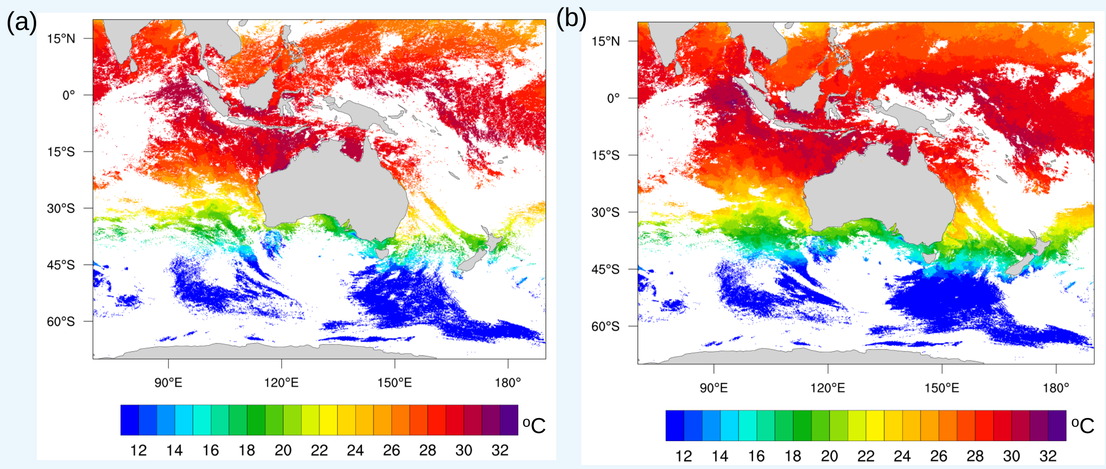

Fig. 4. SST with quality level >=3 from L3S 1-day night file from (a) operational fv01 Multi-sensor (b) Experimental fv03 Multi-sensor for 15th March 2020.

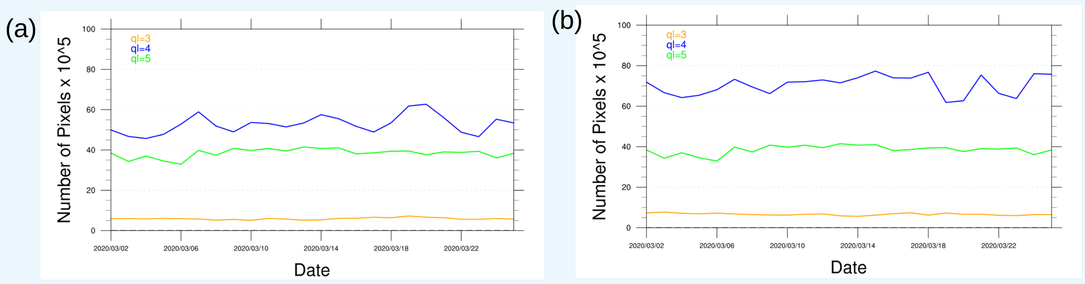

Fig. 5. Number of pixels in L3S 1-day night file from (a) operational fv01 Multi-sensor (b) Experimental fv03 Multi-sensor for March 2020 for QL = 3 (brown line), QL = 4 (blue line) and QL = 5 (green line).

Validation

As an initial validation of the Experimental fv03 Multi-sensor L3S products, we compared quality level (QL) ≥ 3 SST(0.2 m) values from IMOS L3S files with drifting and tropical moored buoy SSTs (0.2m) for the period from 1st Mar 2020 – 31st May 2020 over the Australian domain (70ºE – 190ºE, 70ºS – 20ºN). It was found that:

- Experimental fv03 Multi-sensor night L3S had more QL ≥ 3 matchups than operational fv01 Multi-sensor night L3S (Fig 4).
- Experimental Multi-sensor L3S shows similar bias and standard deviation values as operational fv01 Multi-sensor L3S SSTs for the night scenario (Fig 5).

Fig. 6. Validation statistics of the 1-day night operational Multi-sensor L3S (a) mean bias (c) standard deviation and experimental Multi-sensor L3S (b) mean bias (d) standard deviation SSTs over a 7-day moving window for March 2020. Note: Mean bias = SST - in situ SST + 0.17 (in Kelvin), Match-ups thresholds: < 10 km distance and < 6 hours time.

Applications

Given the improved data coverage with addition of Himawari-8 data, experimental fv03 Multi-sensor L3S can be used for

- Reeftemp NextGen to get information on coral bleaching risk for the Great Barrier Reef region
- IMOS OceanCurrent to monitor marine heat waves
- Identifying and studying coastal upwelling events in the Australian region
- Studying diurnal warming
- Coastal model verification

Future Plans

Over the coming 12 months, we look forward to:

- Validating fv03 Multi-sensor L3S files more extensively
- Reprocessing Multi-sensor L3S files with Himawari-8 data back to 1st January 2015
- Produce 4-hourly Multi-sensor L3S product
- Work towards making the new processing system operational.

Acknowledgements

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Further Information

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References

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2. Griffin, C., H. Beggs and L. Majewski (2017). GHRSST compliant AVHRR SST products over the Australian region – Version 1, *Technical Report, Bureau of Meteorology, Melbourne, Australia, 151pp.* http://imos.org.au/fileadmin/user_upload/shared/SRS/SST/GHRSST-DOC-basic-v1.0r1.pdf

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