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Bureau of Meteorology



# Report from the Australian RDAC to GHRSSST-XIX

Helen Beggs<sup>1</sup>, Christopher Griffin<sup>1</sup>, Pallavi Govekar<sup>1</sup>, Leon Majewski<sup>1</sup>, Janice Sisson<sup>1</sup>, Nicole Morgan<sup>2</sup> and Susan Wijffels<sup>2,3</sup>

<sup>1</sup>Bureau of Meteorology, Melbourne, Australia

<sup>2</sup>CSIRO Oceans and Atmosphere, Hobart, Australia

<sup>3</sup>Woods Hole Oceanographic Institution, MA, USA

19<sup>th</sup> GHRSSST Science Team Meeting, Darmstadt, Germany, 4<sup>th</sup> – 8<sup>th</sup> June 2018

28 Feb 2018

## Real-time GDS1.6:

- Daily Global 0.25° SSTfnd L4 ("GAMSSA")
- Daily Regional 1/12° SSTfnd L4 ("RAMSSA")

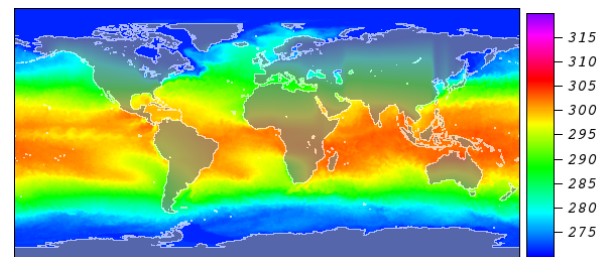
## Real-time GDS2.0:

- **RAMSSA and GAMSSA L4 from 2006/2008 to present**
- IMOS fv01 HRPT AVHRR SSTskin
  - 1 km L2P and 0.02° L3U, day/night L3C, day/night L3S
- **IMOS fv01 VIIRS SSTskin**
  - 0.02° L3U, day/night L3C, day/night VIIRS+AVHRR L3S
- Himawari-8 10-min<sup>-1</sup> 2 km L2P SSTskin

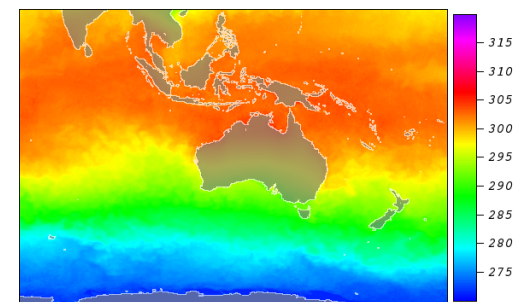
## Reprocessed GDS2.0:

- IMOS HRPT AVHRR L2P/L3U/L3C/L3S fv02 products from 1992 to 2016 (NOAA-11 to 19)
- **IMOS AVHRR + VIIRS L3C/L3S fv02 products from 2015 to 2016**
- IMOS MTSAT-1R Hourly 0.05° L3U (2006 to 2010)

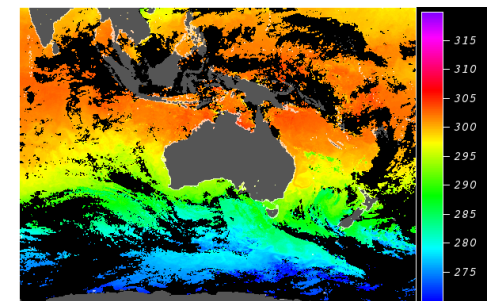
GAMSSA GDS2 L4 SSTfnd



RAMSSA GDS2 L4 SSTfnd



1-day night VIIRS+AVHRR L3S SSTskin



# Data Availability

- **Real-time GDS1.6**

- Operational L4 (RAMSSA/GAMSSA): PO.DAAC, LTSRF and BoM OPeNDAP server

- **Real-time GDS2.0**

- **Operational L4 (RAMSSA/GAMSSA): BoM OPeNDAP server – Contact [gbrsst@bom.gov.au](mailto:gbrsst@bom.gov.au)**
- IMOS fv01 HRPT AVHRR:
  - L2P: BoM OPeNDAP server - Contact [gbrsst@bom.gov.au](mailto:gbrsst@bom.gov.au)
  - L3U/L3C/L3S: <http://portal.codb.org.au> and [http://rs\\_data1.mel.esire.au/thredds/catalog/imos\\_ers/est/gbrsst/catalog.html](http://rs_data1.mel.esire.au/thredds/catalog/imos_ers/est/gbrsst/catalog.html)
- **IMOS fv01 VIIRS L3C/L3S: BoM OPeNDAP server – Contact [gbrsst@bom.gov.au](mailto:gbrsst@bom.gov.au)**
- Himawari-8 L2P: Contact [gbrsst@bom.gov.au](mailto:gbrsst@bom.gov.au)

- **Reprocessed GDS2.0**

- IMOS fv02 HRPT AVHRR:
  - L2P: NCI server - Contact [gbrsst@bom.gov.au](mailto:gbrsst@bom.gov.au)
  - L3U/L3C/L3S: <http://portal.codb.org.au> and [http://rs\\_data1.mel.esire.au/thredds/catalog/imos\\_ers/archive/est/gbrsst\\_fv02/catalog.html](http://rs_data1.mel.esire.au/thredds/catalog/imos_ers/archive/est/gbrsst_fv02/catalog.html)
- **IMOS fv02 VIIRS L3C/L3S: NCI server – Contact [gbrsst@bom.gov.au](mailto:gbrsst@bom.gov.au)**
- IMOS MTSAT-1R L3U: IMOS Thredds server at [http://rs\\_data1.mel.esire.au/thredds/catalog/imos\\_ers/est/gbrsst/L3U/mtsat1r/catalog.html](http://rs_data1.mel.esire.au/thredds/catalog/imos_ers/est/gbrsst/L3U/mtsat1r/catalog.html)



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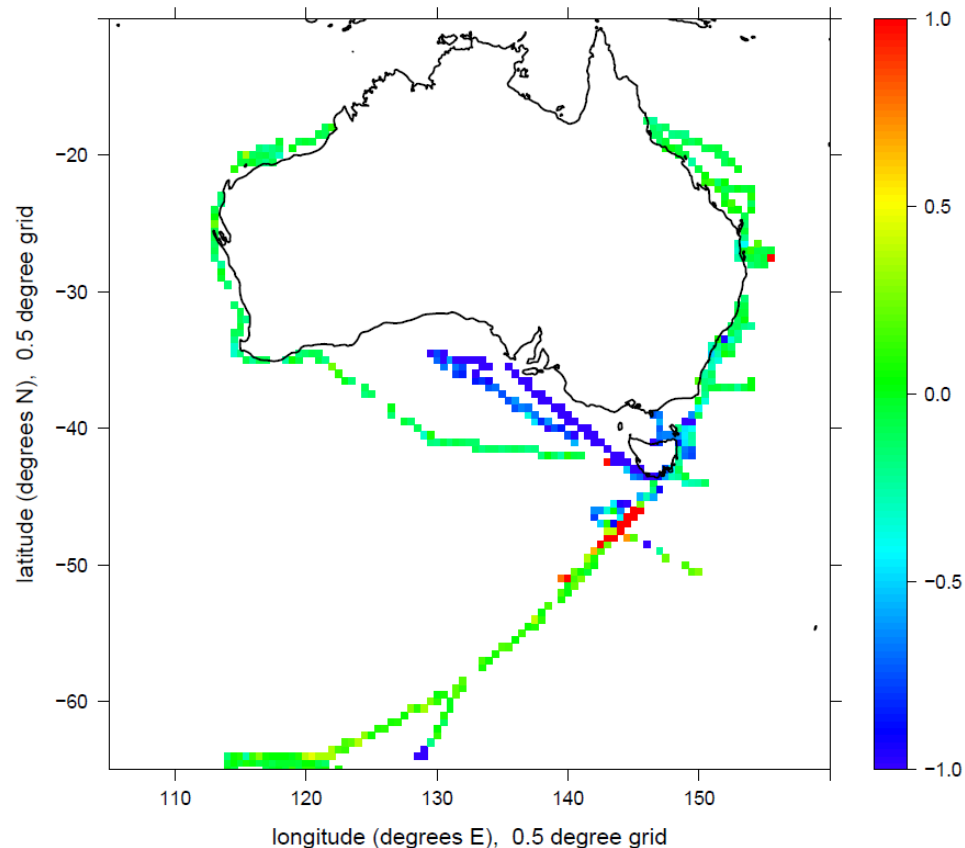
# ISAR SSTskin from RV Investigator

Contacts: Helen Beggs, Janice Sisson, Nicole Morgan  
<http://imos.org.au/sstsensors.html>



- **1 Oct 2014:** Infrared Autonomous SST Radiometer installed on RV Investigator along with SBE38 water intake temperature sensor
- **24 Mar 2016 onwards:** Real-time ISAR SSTskin and SBE38 SSTdepth available from [http://thredds.aodn.org.au/thredds/catalog/MOS/SOOP/SOOP-ASF/MLMJ\\_Investigator/meteorological\\_sst\\_observations/catalog.html](http://thredds.aodn.org.au/thredds/catalog/MOS/SOOP/SOOP-ASF/MLMJ_Investigator/meteorological_sst_observations/catalog.html)

Median (RT ISAR – in situ) (K)





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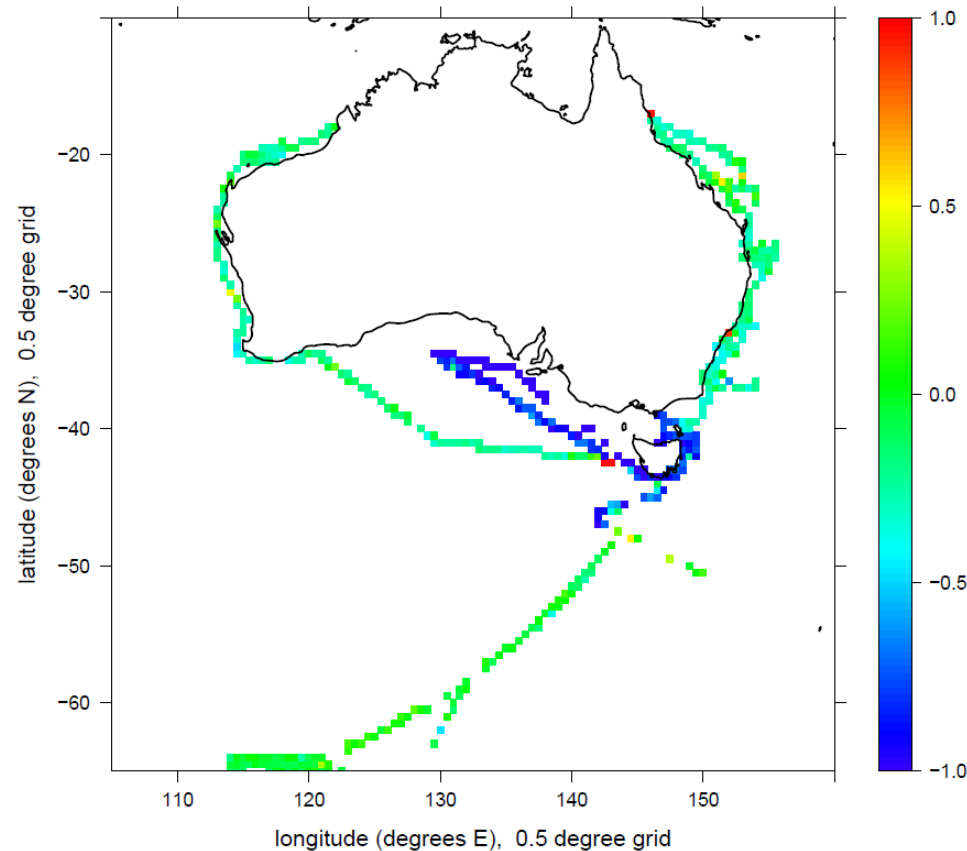
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- **Feb 2018:** ISAR data Oct 2014 to Dec 2017 reprocessed to L2R format using Werenfrid Wimmer's v3.1 code. Data available at <http://www.marlin.csiro.au/geonetwork/srv/en/a/search#!bdf91f86-2968-4711-873e-2761383bb207>

## Median (L2R ISAR – in situ) (K) QL ≥ 3





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# IMOS HRPT AVHRR + VIIRS GHRSSST products

Lead: H Beggs, L Majewski; Developers: C Griffin, P Govekar

<http://imos.org.au/sstproducts.html>

22 Feb 2016

**Format:** GHRSSST v2.0 L2P/L3U/L3C/L3S netCDF4

**Depth:** skin (day-only/night-only), foundation (day+night)

**Resolution:** L3U/L3C/L3S:  $0.02^\circ \times 0.02^\circ$  averaged over 1 day to 1 month

**Available:** over 2 domains (Australia and Southern Ocean)

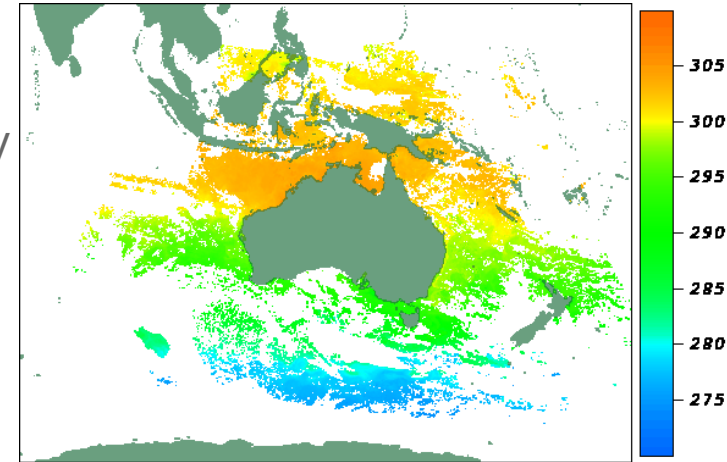
- AVHRR-only: 1992 – present
- **VIIRS + AVHRR: 2015 – present**

Maps of AVHRR and VIIRS+AVHRR daily L3S SST at <https://www.star.nesdis.noaa.gov/sod/sst/arms/>

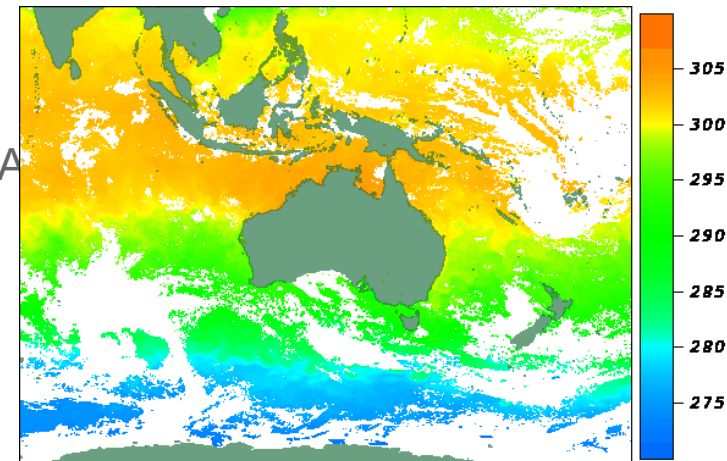
## Inputs:

- Brightness temperatures from AVHRR radiometers on NOAA 11 to NOAA-19
- ACSPO S-NPP VIIRS L3U SSTsubskin

1-day night L3S (QL=4, 5) **without** VIIRS



1-day night L3S (QL=4, 5) **with** VIIRS



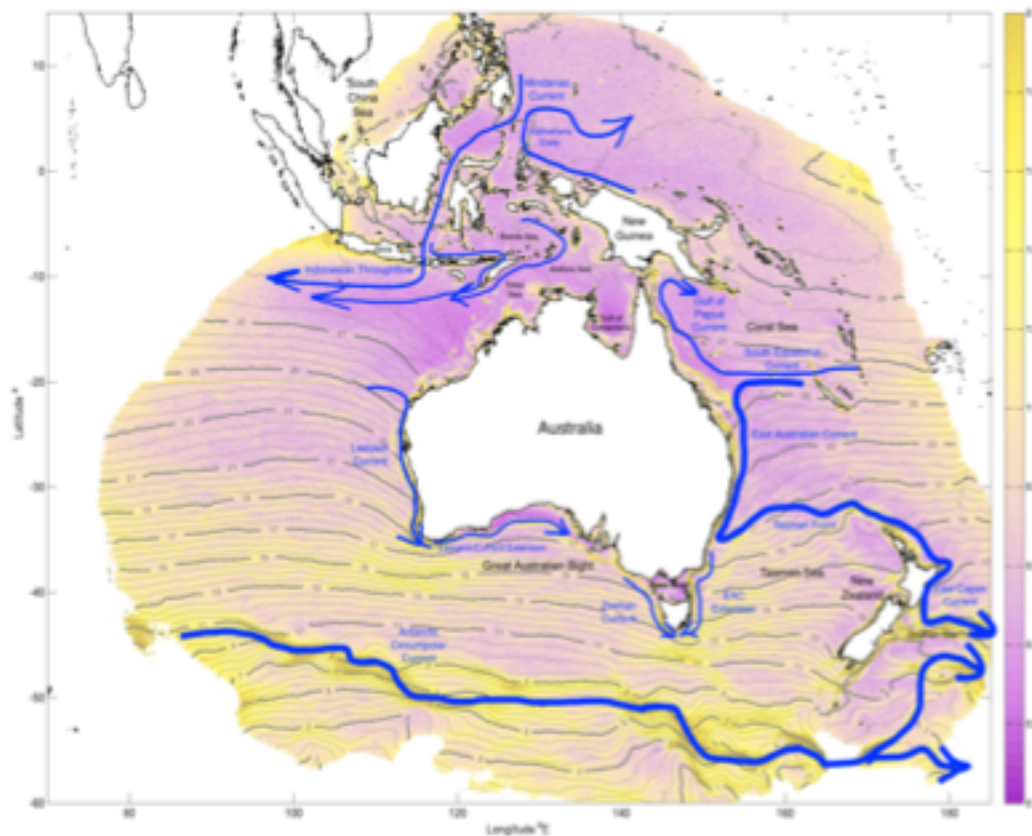
# SSTAARS Atlas

## The Killer App for HRPT AVHRR SST?

Susan Wijffels, Helen Beggs, Chris Griffin et al.

- 2 km seasonal climatology (1992 – 2016)
- **Inputs:** IMOS daily night-time AVHRR L3S SST
- Robust fit using 4 seasonal harmonics and trend fitted to cloud-free, debiased pixels
- For each  $0.02^\circ$  pixel: daily climatological SST, mean, decadal trend, monthly seasonal harmonics and percentiles
- **Access:** <http://portal.aodn.org.au> (search for "SSTAARS")
- Paper: Wijffels et al, *J. Mar. Systems*, under review
- Poster: Mon 17:00 – 18:00

### Annual mean SST and gradient from SSTAARS



# IMOS Himawari-8 AHI GHRSSST Products

Lead: Helen Beggs, Developer: Chris Griffin

1 Jan 2018 00 – 01 UTC

**Format:** GHRSSST v2.0 L3C netCDF4

**Depth:** skin, foundation

**Resolution:** Hourly,  $0.02^\circ$  SST<sub>skin</sub> and Daily,  $0.02^\circ$  "pre-dawn" SST<sub>wnd</sub>

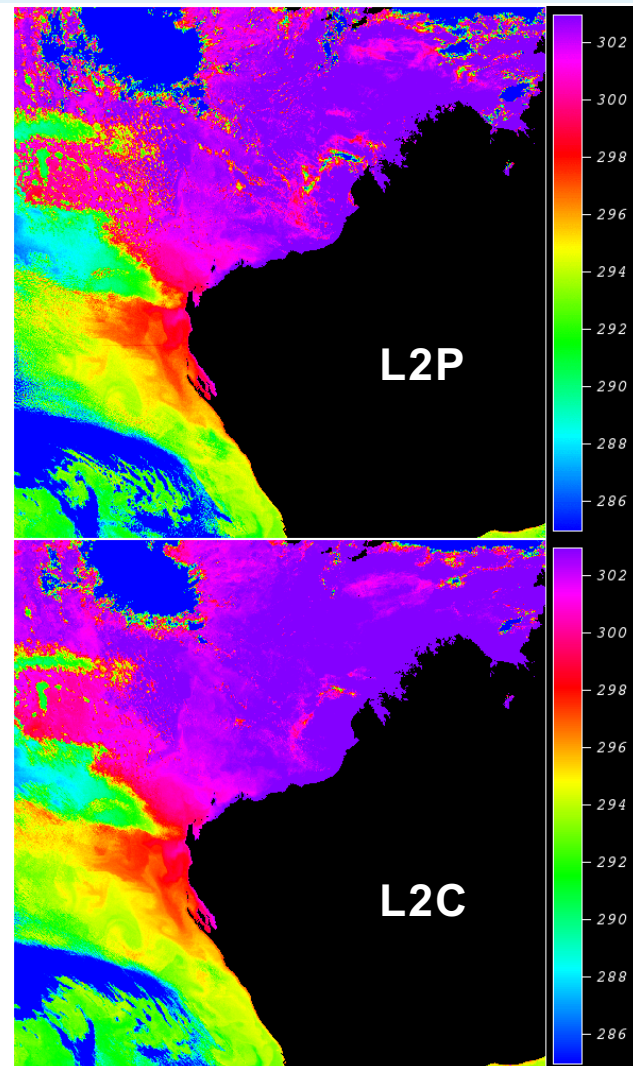
**Domain:** IMOS Australian grid ( $70^\circ\text{E}$  to  $170^\circ\text{W}$ ,  $70^\circ\text{S}$  to  $20^\circ\text{N}$ )

**Available:** Experimental hourly L3C products to be released July 2018

**Method:** Composite H-8 2 km 10-min L2P SST to hourly L2C by selecting the "best" retrieval for each grid cell within the 1-hour period, based on pixel quality level, spatial and temporal consistency.

Composite L2C data on GEO projection to IMOS  $0.02^\circ$  L3C grid using weighted averaging of overlapping pixels.

Composition method involves no smoothing or interpolation.





# IMOS Himawari-8 AHI GHRSSST Products

Lead: Helen Beggs, Developer: Chris Griffin

1 Jan 2018 00 – 01 UTC

**Format:** GHRSSST v2.0 L3C netCDF4

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**Resolution:** Hourly,  $0.02^\circ$  SST<sub>skin</sub> and Daily,  $0.02^\circ$  "pre-dawn" SST<sub>fd</sub>

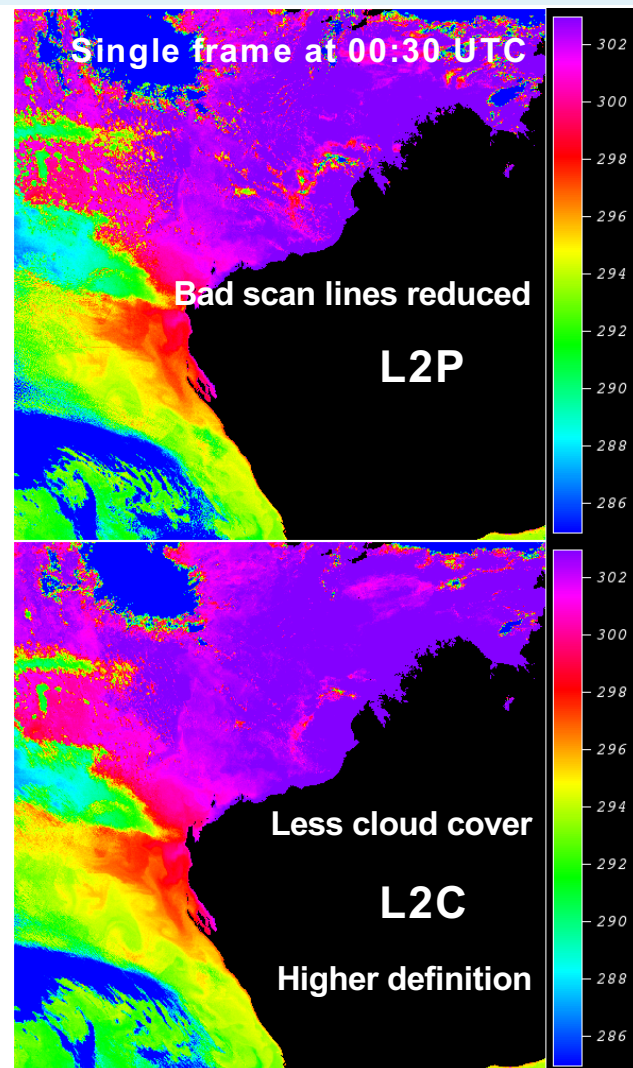
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Composition method involves no smoothing or interpolation.



# Future SST Work in 2018-2019

- Use RV Investigator ISAR data to validate Sentinel-3, Himawari-8 and VIIRS SST
- Release IMOS VIIRS L3U/L3C, Multi-sensor L3S and RAMSSA/GAMSSA L4 in GDS2 format on AODN (<http://portal.aodn.org.au>)
- July 2018: Release experimental Himawari-8 L2C and IMOS L3C files
- Tune optimal interpolation of ACSPO VIIRS L3U SSTs into RAMSSA and GAMSSA daily SST analyses before operational release
- Continue to develop new L4 product based on Ensemble OI (Tue presentation)
- Add NOAA-20 VIIRS L3U data to all BoM L3, L4 and ocean models
- Include METOP-A/B FRAC L2P SSTs in the IMOS L3 Product Suite
- Provide external on-line access for new L2P/L3U/L3C/L3S SST validation data and plots (currently internal access only)
- Investigate using VIIRS and Himawari-8 data to study coastal upwelling

# Issues to be raised at G-XIX

- Has any recent validation been performed on the NCEP Global Weekly OISST v2 analysis (Reynolds et al., 2002, J. Clim.)? (Most widely used SST product for climate studies)
- How best to produce a climatology from L3 or L4 SSTs, and how best to compare different climatology data sets? (Thur Discussion Session)
- Under the new GHRSSST R/GTS how to distribute:
  - IMOS HRPT AVHRR L2P data (1992 to present)? (Not publicly shared)
  - new GDS2 RAMSSA/GAMSSA L4 data? (Shortly to be available from the Australian Ocean Data Network (AODN) at <http://portal.aodn.org.au>)
  - IMOS AVHRR L3U/L3C/L3S, VIIRS L3C and AVHRR+VIIRS L3S products? (Available from <http://portal.aodn.org.au> )



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# Questions?

Thank You!

**Contact: [helen.beggs@bom.gov.au](mailto:helen.beggs@bom.gov.au)**

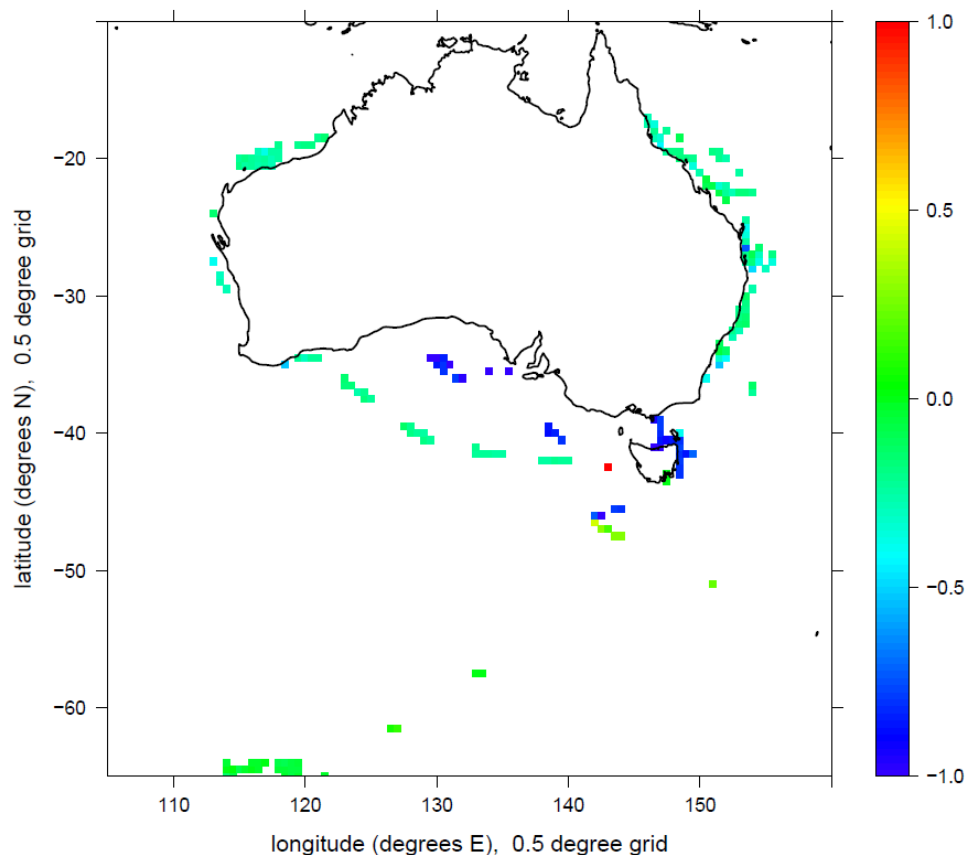
Additional slides for discussion

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## Median (L2R ISAR – in situ) (K) QL = 5

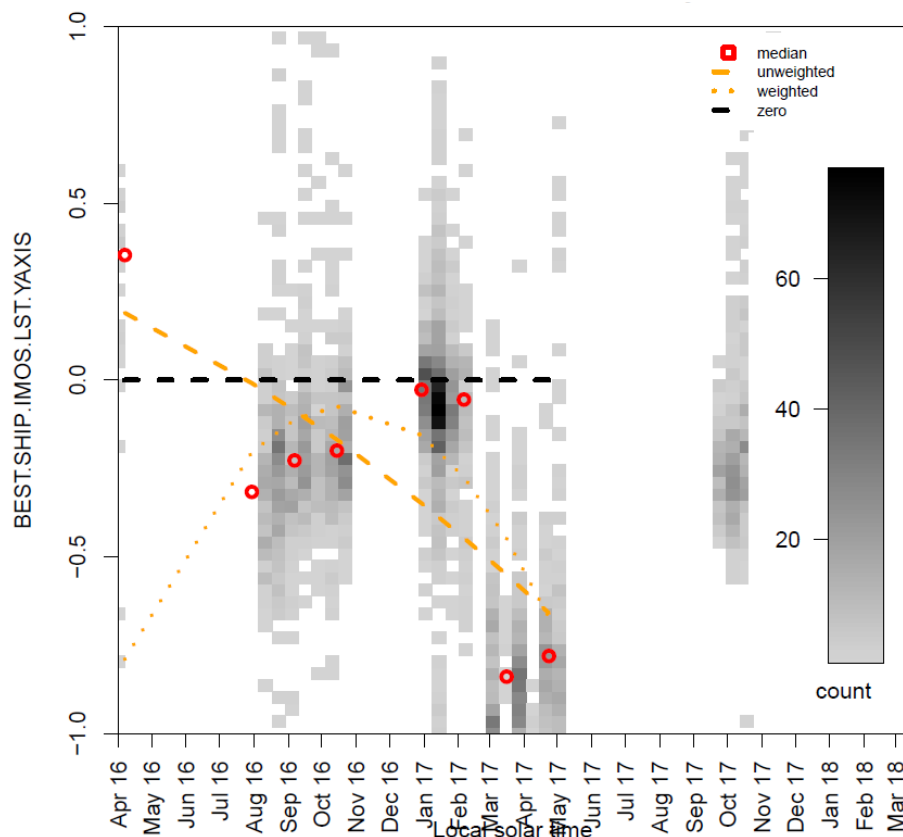


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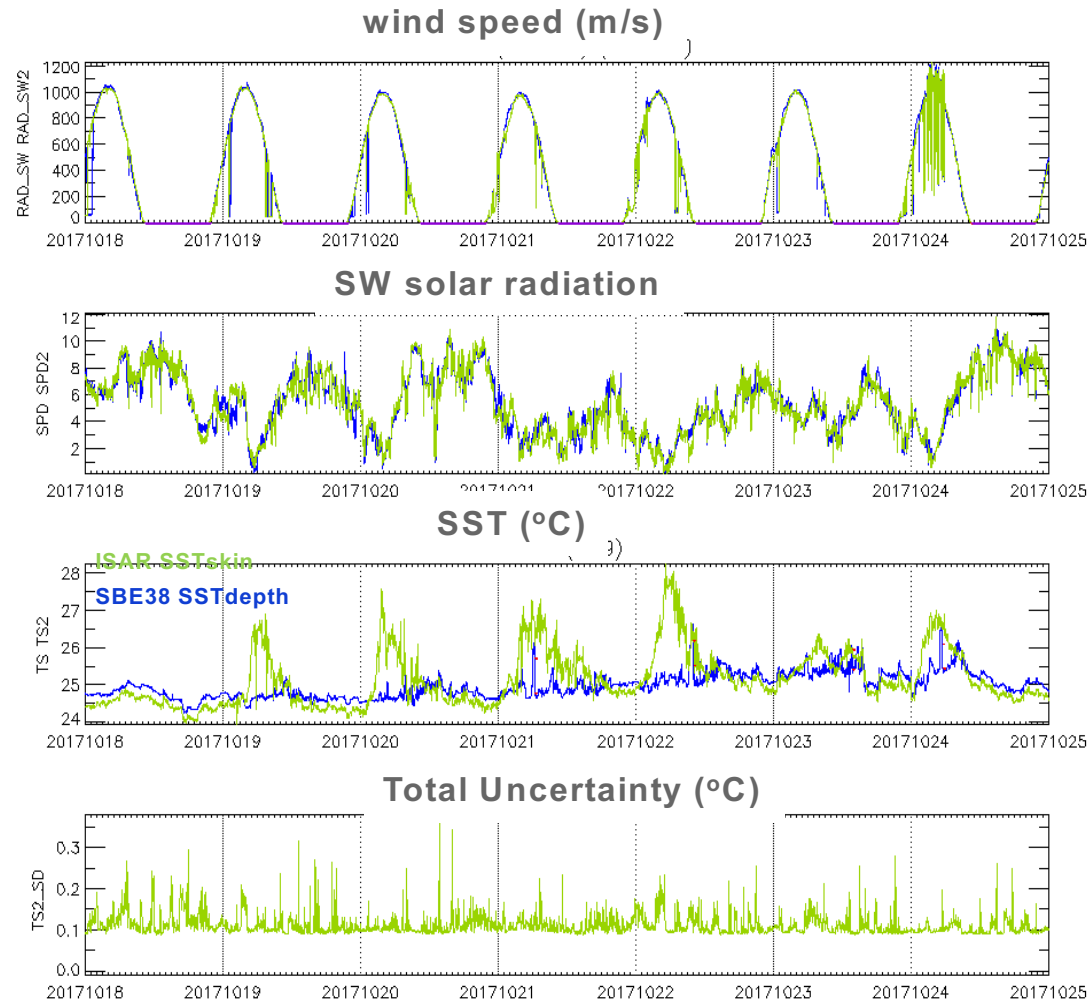
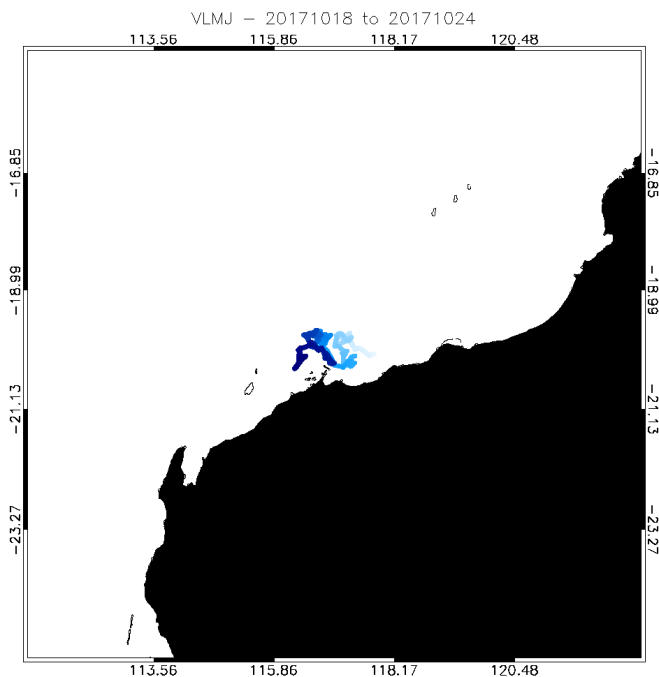
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## Median (L2R ISAR – in situ) (K) QL ≥ 3



# RV Investigator SSTskin and SSTdepth IN2017\_V05 (North-West Shelf)

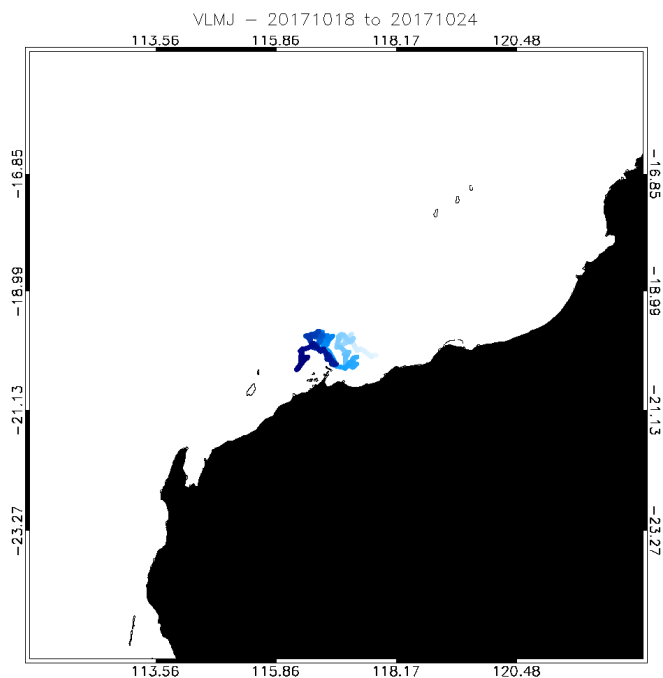
Strong diurnal warming was measured by the ISAR from 18<sup>th</sup> to 24<sup>th</sup> Oct 2017 during calm winds and clear skies



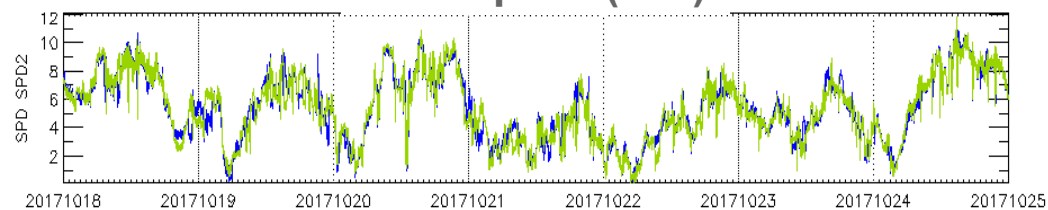


# RV Investigator SSTskin and SSTdepth IN2017\_V05 (North-West Shelf)

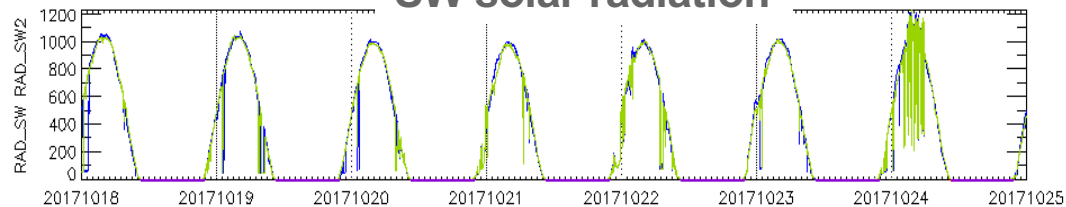
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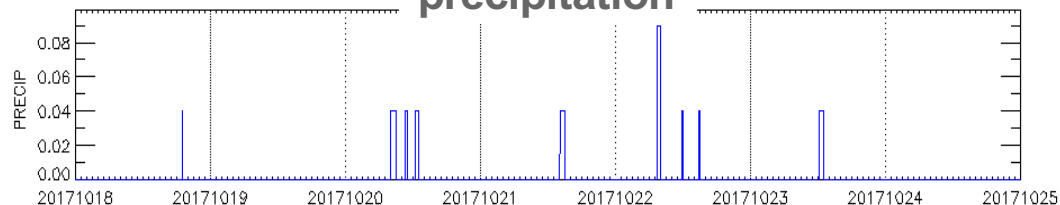
wind speed (m/s)



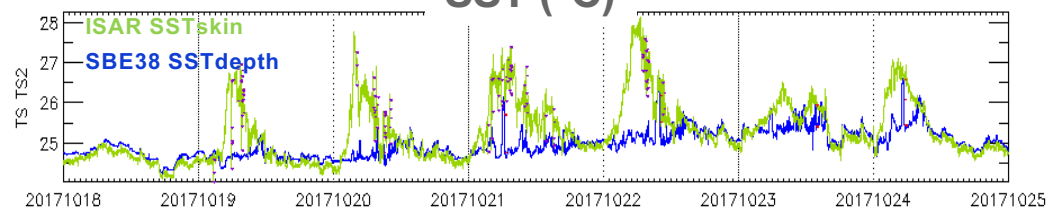
SW solar radiation



precipitation



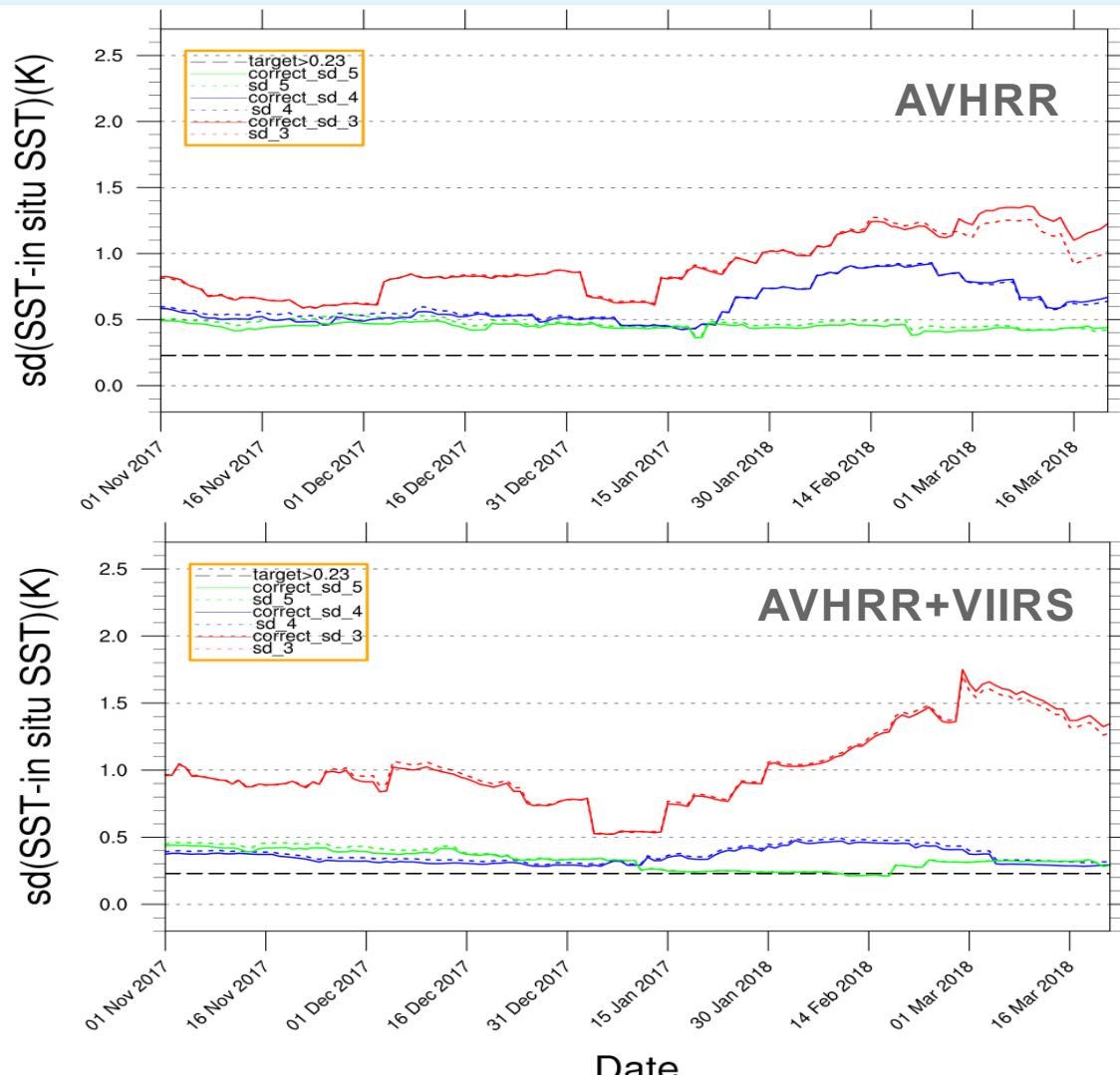
SST (°C)



# fv01 L3S SST on-line verification

## Night StDev(L3S SSTskin – Buoy SSTskin)

- L3S-01day, night only, monthly statistics, 1 Nov 2017-23 Mar 2018
- Adding VIIRS to the IMOS night-time L3S products reduced standard deviation of QL=5 SSTs by ~ 0.1 to 0.2 K, and QL=4 SSTs by 0.2 to 0.4 K





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# Geostationary Himawari-8 AHI SST

Lead/Developer: Chris Griffin

## HW8 L2P SSTskin

**Format:** GHRSSST v2.0 L2P netCDF4

**Depth:** skin

**Resolution:** 10 min<sup>-1</sup>, 2 km<sup>2</sup> at nadir, full disk

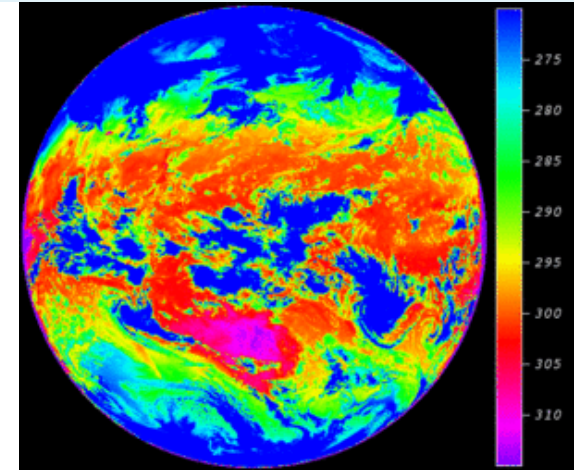
**Available:** 8 Mar 2016 to real-time

**Method:**

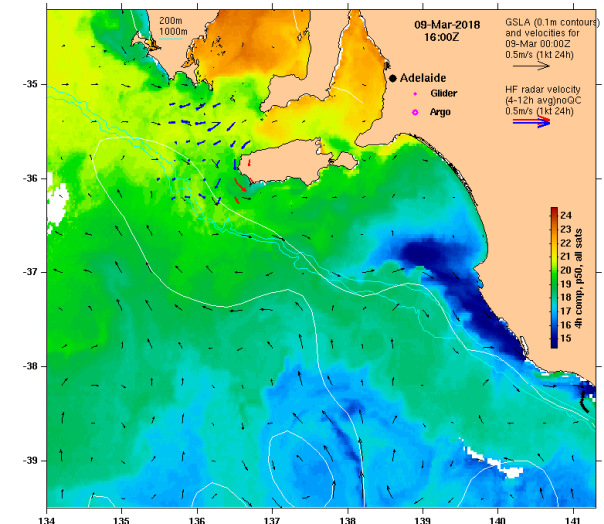
- BoM HW8 L2P SSTskin product trained to ACSP0 VIIRS L2P SSTsubskin followed by subtracting 0.17 K

**Uses:**

- Ingesting into trial SST analyses and ocean forecasts
- Ingesting into CSIRO's IMOS OceanCurrent 4-hourly, 2 km L3S SST maps for Fisheries applications (includes IMOS AVHRR L2P, BoM HW8 L2P, SeaDAS VIIRS/MODIS L2)



## CSIRO 4-hrly L3S SSTsubskin



# IMOS Himawari-8 AHI GHRSSST Products

Lead: Helen Beggs, Developer: Chris Griffin

Himawari-8 Hourly L3C (QL  $\geq$  4)

**Format:** GHRSSST v2.0 L3C netCDF4

**Depth:** skin, foundation

**Resolution:** Hourly,  $0.02^\circ$  SST<sub>skin</sub> and Daily,  $0.02^\circ$  pre-dawn SST<sub>fd</sub>

**Domain:** IMOS Australian grid ( $70^\circ\text{E}$  to  $170^\circ\text{W}$ ,  $70^\circ\text{S}$  to  $20^\circ\text{N}$ )

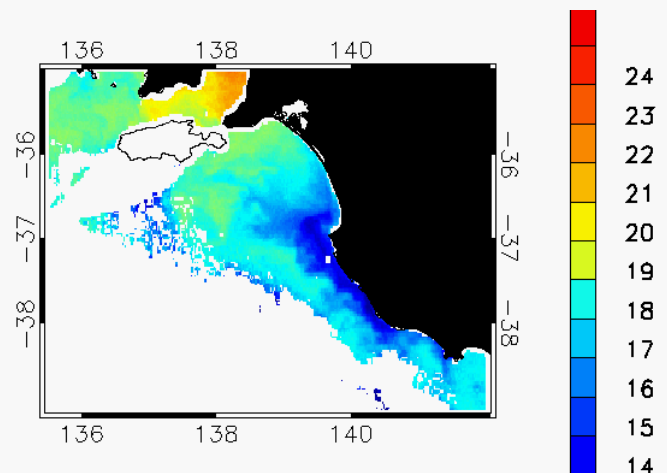
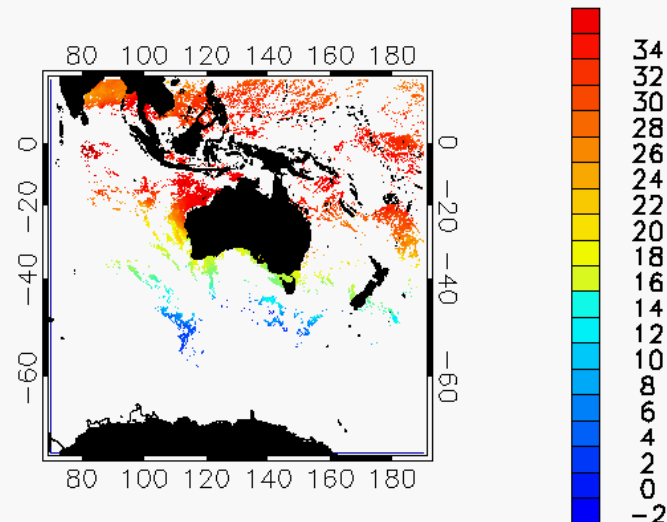
**Available:** Experimental hourly L3C products to be released July 2018

**Method:** Composite H-8 L2P SST over IMOS  $0.02^\circ$  L3C grid by selecting the best retrieval for each grid cell within the 1-hour period

## Uses:

- Incorporating into IMOS Multi-Sensor L3S products
- Validating high-res ocean models
- Coastal upwelling and diurnal variation research

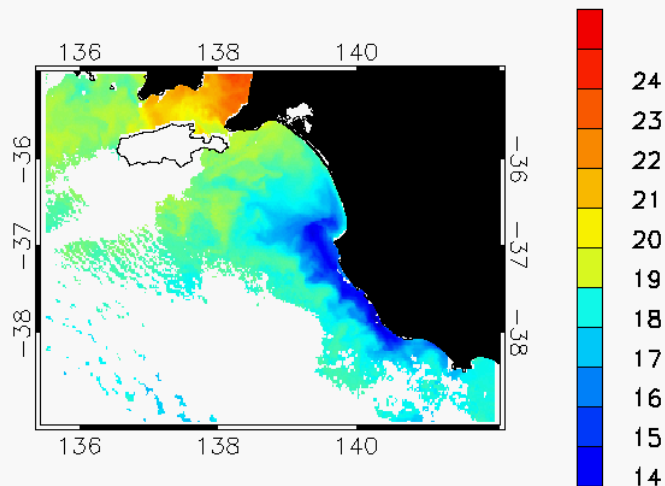
6 Mar 2018 15:30 UTC



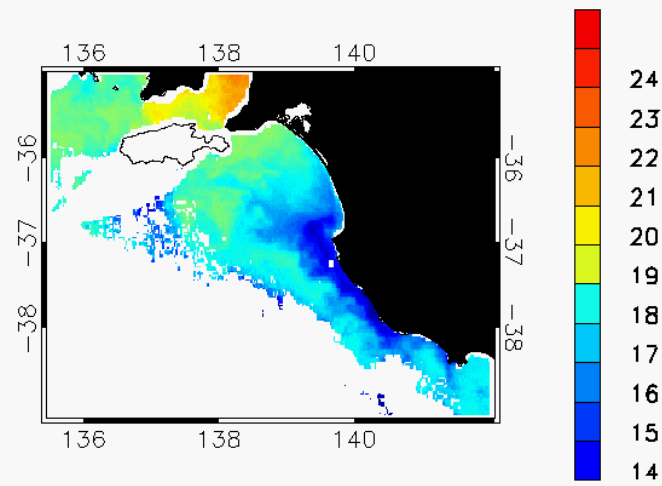
# Can VIIRS and HW8 be used to study coastal upwelling?

## Case Study: Bonney Coast 6 March 2018 (HW8 not bias-corrected)

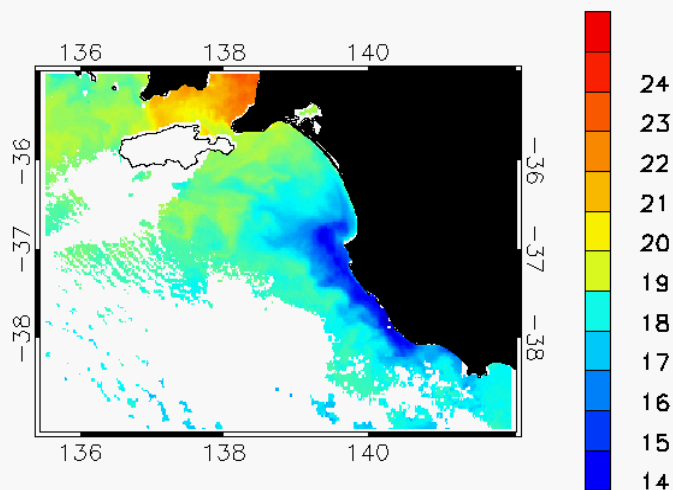
IMOS VIIRS Night L3C 15:20 UTC (QL  $\geq 4$ )



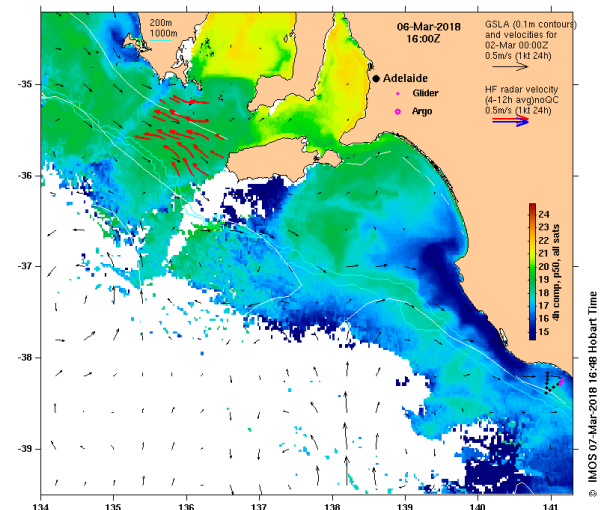
Himawari-8 Hourly L3C 15:30 UTC (QL  $\geq 4$ )



IMOS Multisensor Night L3S 15:20 UTC (QL  $\geq 4$ )



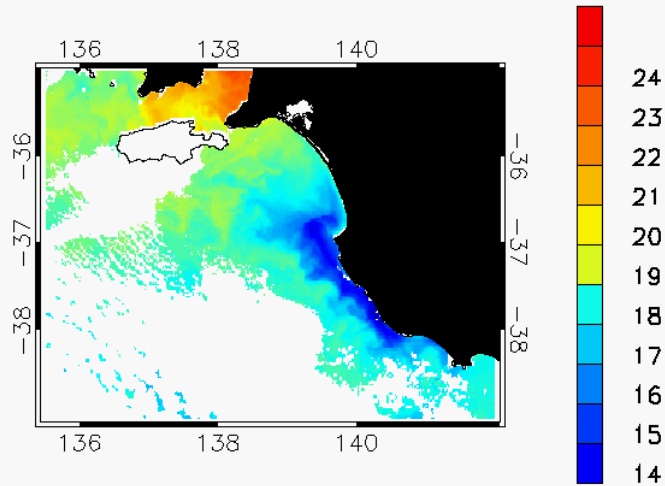
CSIRO 4-hrly L3S 16 UTC (HW8 QL  $\geq 4$ )



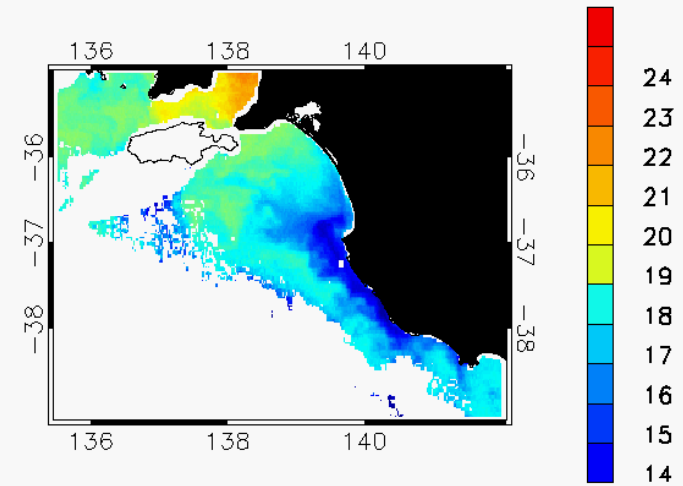
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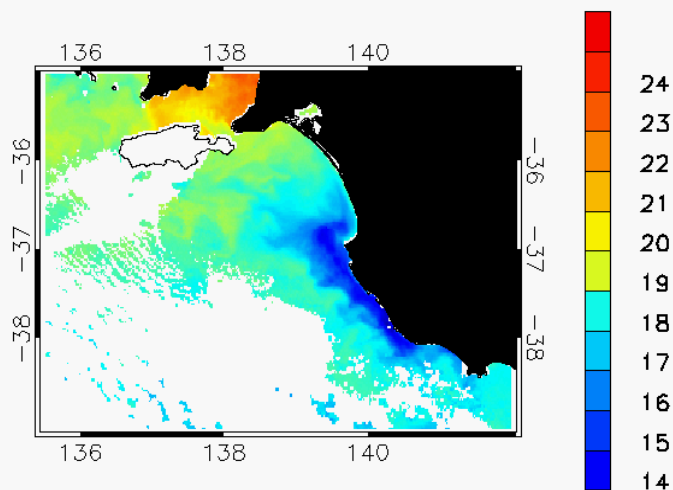
IMOS VIIRS Night L3C 15:20 UTC (QL $\geq$ 4)



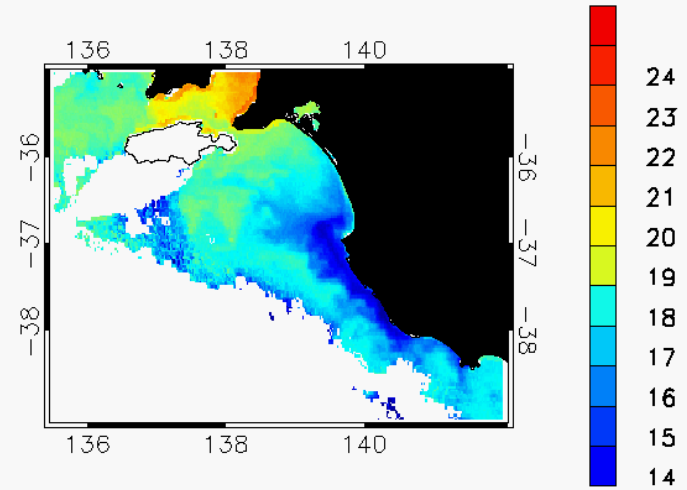
Himawari-8 Hourly L3C 15:30 UTC (QL $\geq$ 4)



IMOS Multisensor Night L3S 15:20 UTC (QL $\geq$ 4)



Himawari-8 Hourly L3C 15:30 UTC (QL $\geq$ 3)



# Daily Regional and Global Multi-Sensor SST analyses (RAMSSA and GAMSSA)

Developer: Helen Beggs; Contact: Lixin Qi, Pallavi Govekar

<http://www.bom.gov.au/marine/sst.shtml>

**Format:** GHRSSST v1.6 L4 netCDF3 and **GHRSSST v2.0 L4 netCDF4**

**Depth:** Foundation SST estimate

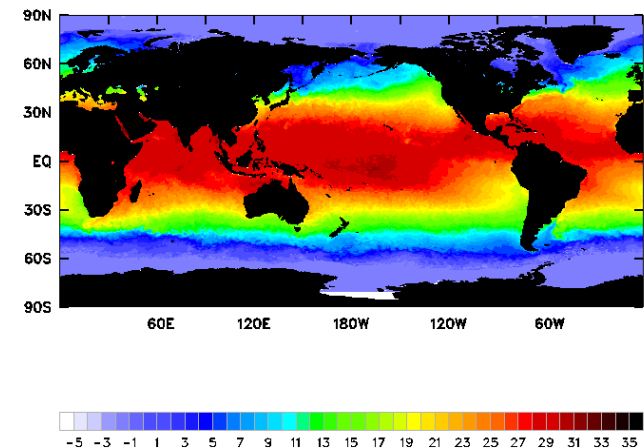
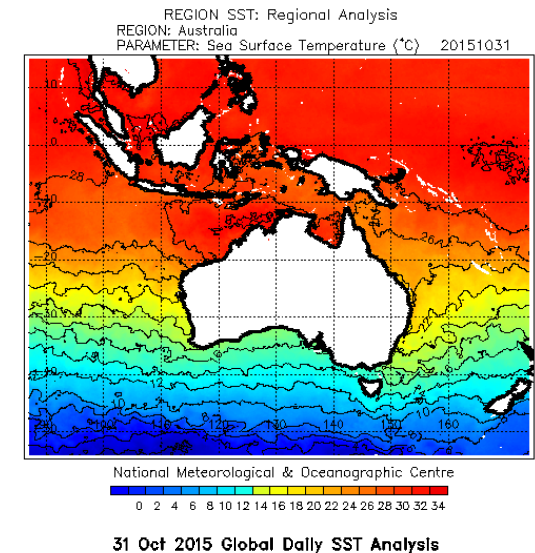
**Resolution:** Daily, 0.083° regional, 0.25° global

**Available:** 2006 to real-time (GDS1.6: AO.DAAC; **GDS2.0: BoM OPeNDAP server**)

**Method:** Optimal interpolation. Background: Combination of previous day's RAMSSA/GAMSSA SST and Reynolds and Smith (1994) climatology (1961-1990).

## Inputs:

- 1-4 km IMOS HRPT AVHRR (NOAA-18/19) **L2P** SSTskin
- 9 km NAVOCEANO GAC AVHRR (NOAA-18/19, METOP-A/B) **L2P** SST1m
- **ACSP0 VIIRS L3U SSTs (in RAMSSA test system)**
- ~50 km JAXA AMSR-2 (GCOM-W) **L2P** SSTsubskin
- Buoy and ship in situ SSTdepth (GTS)
- NCEP 9 km Sea Ice Analyses





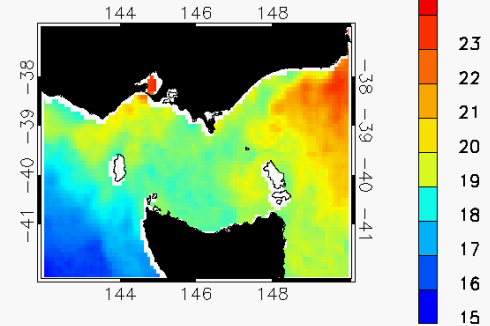
Australian Government

Bureau of Meteorology

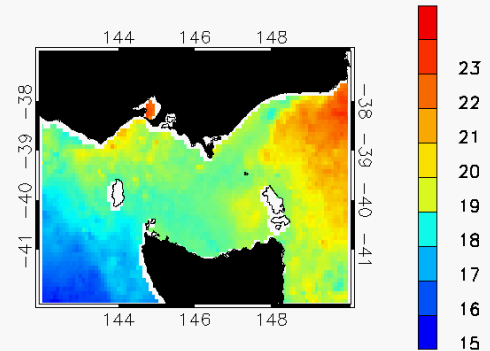
# Impact of VIIRS on RAMSSA SST analyses

- ACSP0 VIIRS L3U SST data is being tested for ingestion into the Bureau's operational daily SST analyses (1/12° RAMSSA and 1/4° GAMSSA)
- Night-only ACSP0 VIIRS L3U data converted to IMOS VIIRS L3U format (QL changed) then collated to daily 1/12° and 1/4° L3C SSTfnd data
- Optimally interpolated along with HRPT AVHRR, GAC AVHRR, AMSR-2 and in situ SSTfnd data into test RAMSSA SST analyses since 19<sup>th</sup> Feb 2018
- Mean bias and StDev of RAMSSA (t-1) – Buoy SSTfnd(t) slightly less in test RAMSSA for 19<sup>th</sup> Feb to 19<sup>th</sup> Mar 2018 compared to operational system
  - $0.09 \pm 0.41$  K cf  $0.10 \pm 0.42$  K
- Further tuning needed to optimise correlation length scales (currently 12 km for obs and 20 km for BGF) to reduce "speckliness" of test RAMSSA

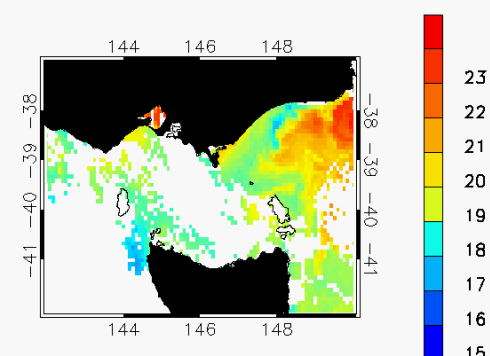
Operational RAMSSA SST



Test RAMSSA SST with VIIRS



VIIRS SST on RAMSSA grid



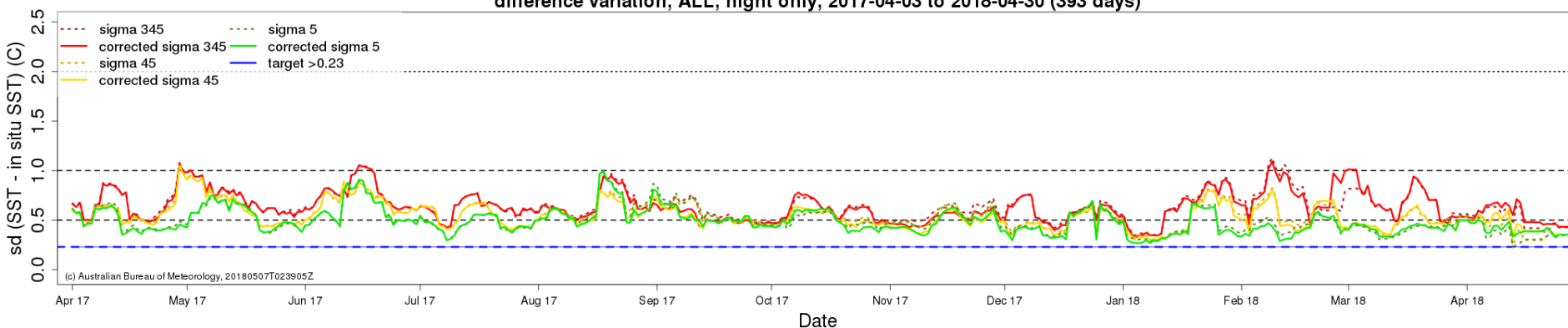


# fv01 L3S SST on-line verification

## Night StDev(L3S SSTskin – Buoy SSTskin)

### AVHRR-only

Best quality L3S 1 day fv01 drifting buoys plus tropical moorings SSTskin, weekly statistics difference variation, ALL, night only, 2017-04-03 to 2018-04-30 (393 days)



### VIIRS + AVHRR

Best quality L3S 1 day multisensor fv01 drifting buoys plus tropical moorings SSTskin, weekly statistics difference variation, ALL, night only, 2017-10-07 to 2018-04-10 (186 days)

