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IMOS Ship SST for Satellite SST Validation

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Acknowledgments: Werenfrid Wimmer³, John Horvath¹, Martin Buggeln⁴, Joel Cabrie¹, Alan Thomas⁵, Graeme Ball⁵

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18th GHRSSST Science Team Meeting, Qingdao, 5th - 9th June, 2017



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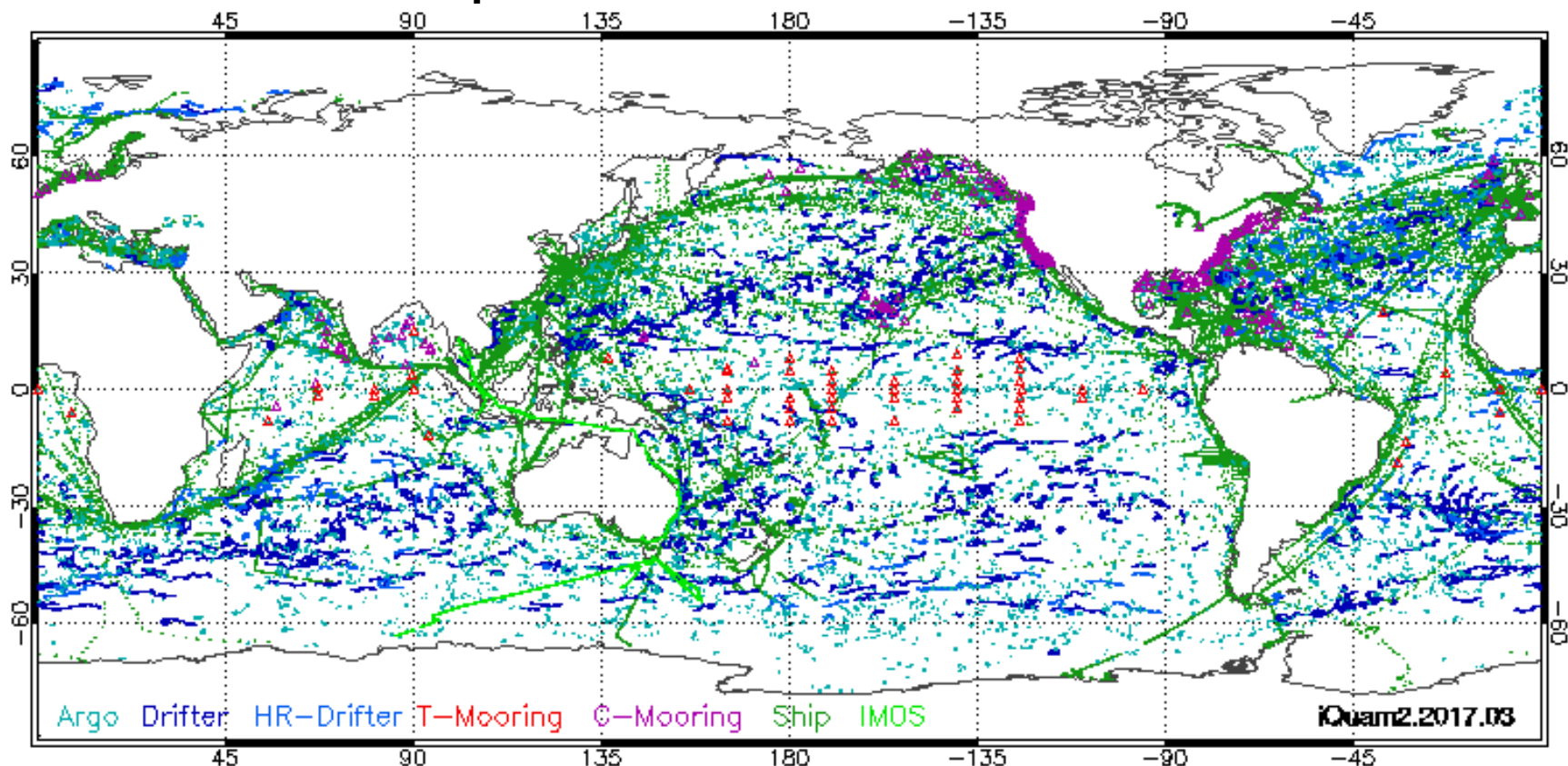
Overview

- Why use ship SST for satellite validation?
- Ship SSTdepth from the Australian Integrated Marine Observing System (IMOS)
- Satellite SST validation using IMOS Ship SSTdepth
- IMOS Ship SSTskin from RV Investigator
- Future plans

Constellation of Fiducial Reference SST sensors for satellite SST cal/val

- **Drifters:** High number of obs but inhomogeneous coverage
- **Tropical Moorings:** Long time series with higher accuracy than drifters
- **Ships:** Similar accuracy to standard drifters if equipped with radiometer or calibrated SSTdepth sensor and better coastal coverage
- **Argo:** Higher accuracy than drifters and better spatial coverage than drifters or ships, although far lower number of obs

In Situ SSTdepth observations from iQUAM2 for Mar 2017





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IMOS Ship SSTdepth

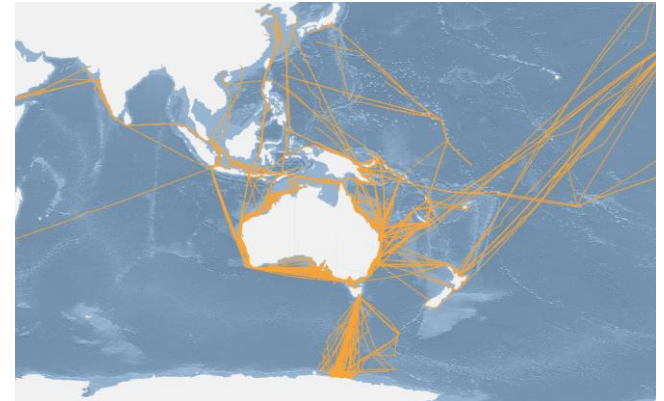
<http://imos.org.au/sstsensors.html>

- Since 2008, 21 ships have reported QC'd, RT SSTdepth to GTS, IMOS Ocean Portal and iQUAM v2
 - 9 used through-hull (SBE 38) sensors
 - 12 used hull-temperature (SBE 48) sensors
- 4 of these ships also reported QC'd meteorological and flux data to IMOS Ocean Portal and SAMOS

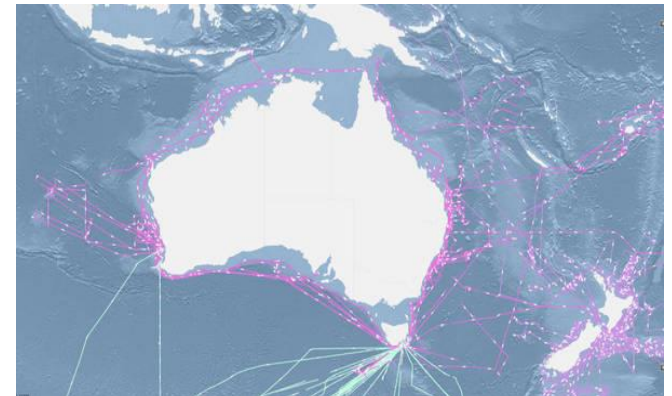
Hull-Temperature Sensor on SoT-II



SOOP SST



RV SST + met + fluxes





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IMOS Ship SST Automated QC

- BoM employs an automated QC method based on SAMOS (<http://samos.coaps.fsu.edu>) QC for all IMOS ship meteorological and SST measurements
- Tests in order of application:
 1. Verify existence of time, lat, lon for every record
 2. Flag data not within physically possible bounds
 3. Flag non-sequential and/or duplicate times
 4. Flag positions where vessel over land
 5. Flag unrealistic vessel speeds
 6. SST only: Climatology test (SST more than 3K above/below Bureau's most recent SST analysis in vessel location – either RAMSSA or GAMSSA)
 7. SST only: Flag data where AVOF ship speed is below 2.5 m/s.
- Once any datum's flag is changed, it will not be altered further by any subsequent test.



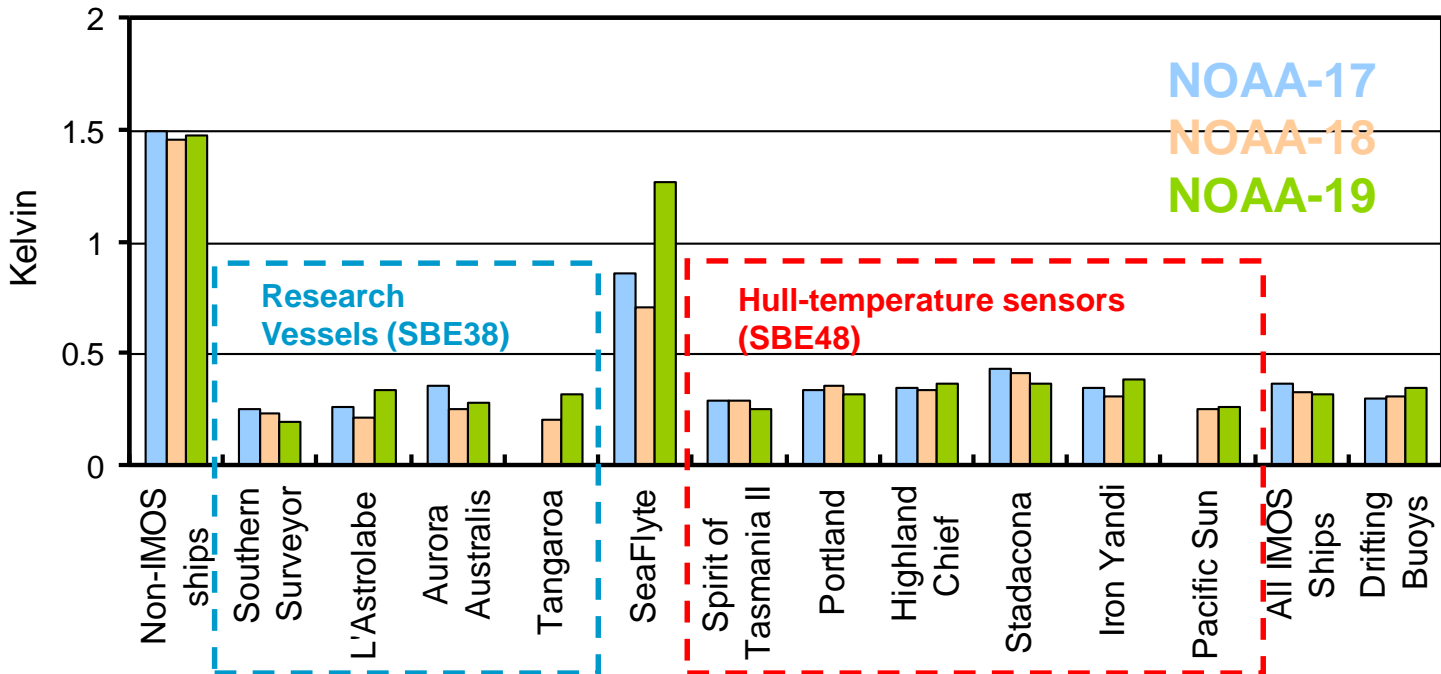
IMOS Ship SSTdepth

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

IMOS ship SSTdepth have comparable errors to drifting buoys when compared with HRPT AVHRR and AATSR L2P SST. See Beggs et al., 2012, *J. Operational Oceanography*, **5**, 59-73.

Night-time StDev(HRPT AVHRR SSTdepth – In Situ SSTdepth) for 1 Dec 2008 to 1 Jun 2011 over 60° E – 190° E, 70° S – 20° N. QL ≥ 4. Matchups: ±2 h, same AVHRR pixel:

Stand. Dev. (AVHRR SST - In Situ SST)





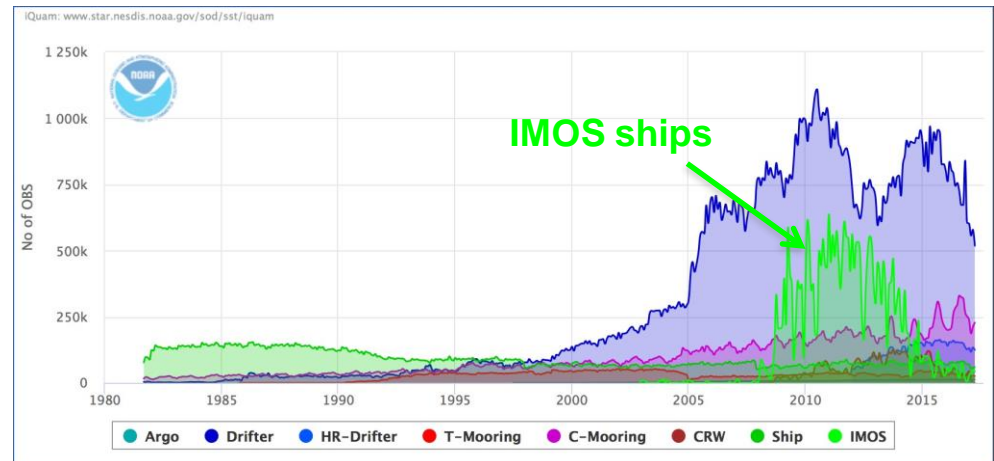
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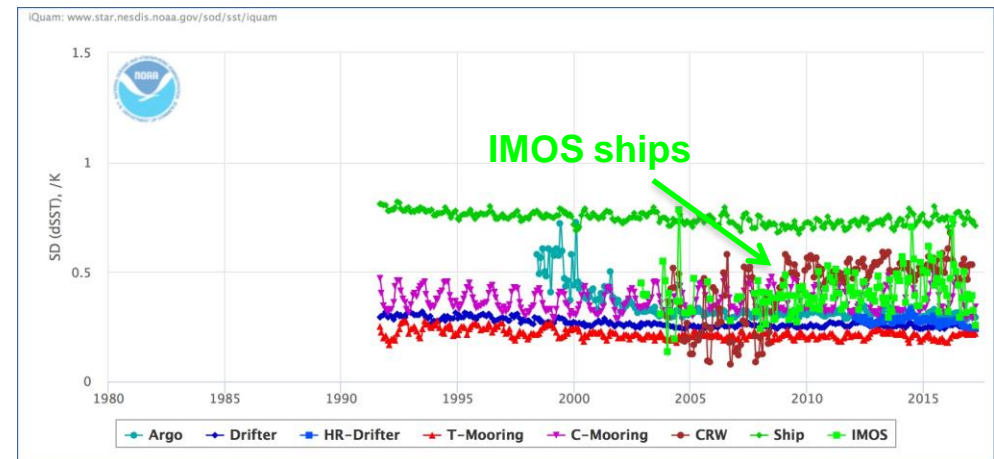
IMOS Ship SSTdepth in iQUAM v2

- IMOS ship SSTdepth are ingested in NRT into NESDIS In Situ SST Quality Monitor system, iQUAM v2 <https://www.star.nesdis.noaa.gov/sod/sst/iquam/v2>
- Comparisons against CMC L4 SSTs show IMOS Ship SSTdepth has comparable standard deviations to SSTs from Coral Reef Watch and coastal moorings
- CRW, Argo and most of IMOS data are not ingested into CMC
- Drifting and Tropical Mooring SSTs are ingested into CMC

NESDIS iQUAM v2 Number in situ SST obs



NESDIS iQUAM v2 SD(in situ SST – CMC)





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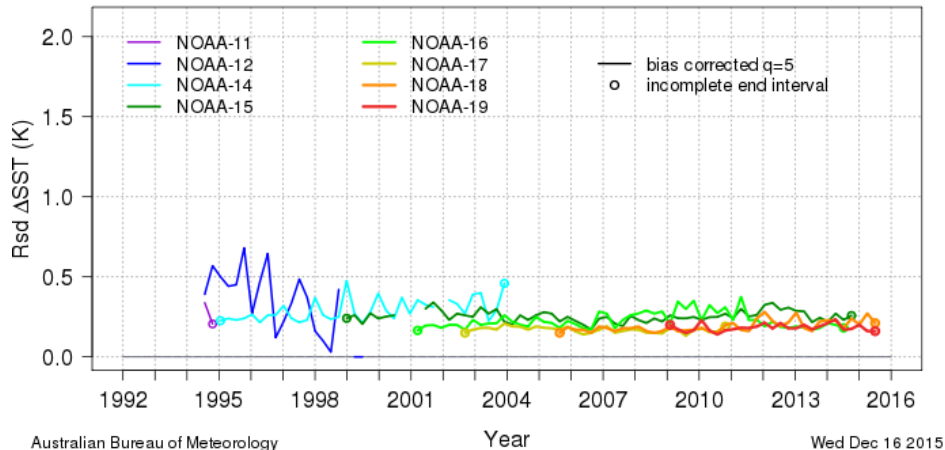
IMOS Ship SSTdepth used for online validation of IMOS 1 km AVHRR SST

http://imos.org.au/sstdata_validation.html

Delayed mode fv02 L2P

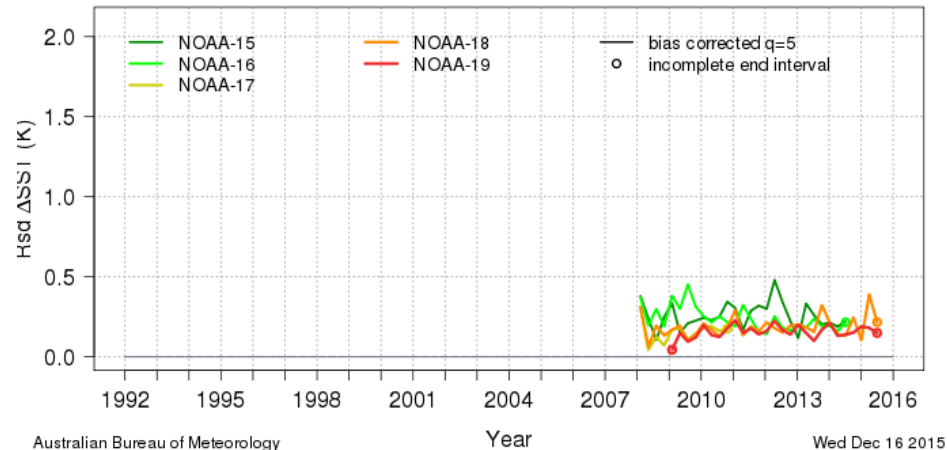
Drifting Buoys

Rsd of fv02 L2P NOAA SSTskin - drifting buoys SSTskin for night over 90 days



IMOS Ships

Rsd of fv02 L2P NOAA SSTskin - imos ships SSTskin for night over 90 days





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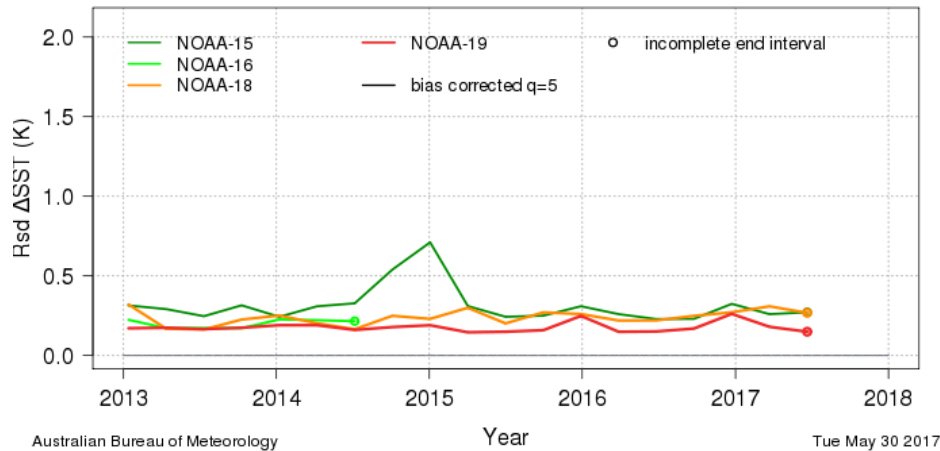
IMOS Ship SSTdepth used for online validation of IMOS 1 km AVHRR SST

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Real-time fv01 L2P

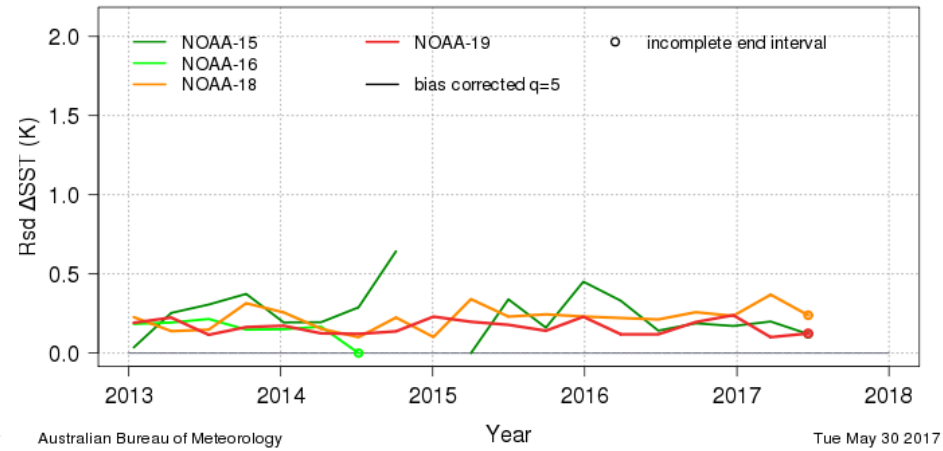
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IMOS Ships

Rsd of fv01 L2P NOAA SSTskin - imos ships SSTskin for night over 90 days





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IMOS Ship SSTskin ISAR SST from RV Investigator

- **1 Oct 2014:** Infrared **A**utonomous **S**ST **R**adiometer installed on RV Investigator by CSIRO along with SBE38 water intake temperature sensor
- **24 Mar 2016 onwards:** RT ISAR SSTskin and SBE38 SSTdepth supplied to IMOS Ocean Portal: <https://portal.aodn.org.au/>
- **Jun/Jul 2016:** FRM4STS lab+lake inter-comparison of CSIRO ISAR SST radiometer with reference blackbody and 34 other ship-borne SST radiometers
 - CSIRO ISAR instrument compared favourably with other similar radiometers within $0^{\circ} \text{ C} < \text{SST} < 45^{\circ} \text{ C}$ range, being 0.04° C to 0.15° C colder than the NPL reference blackbody.
 - CSIRO ISAR measured surface water temperatures on average 0.189 K colder than mean water temperatures of the 10 radiometers



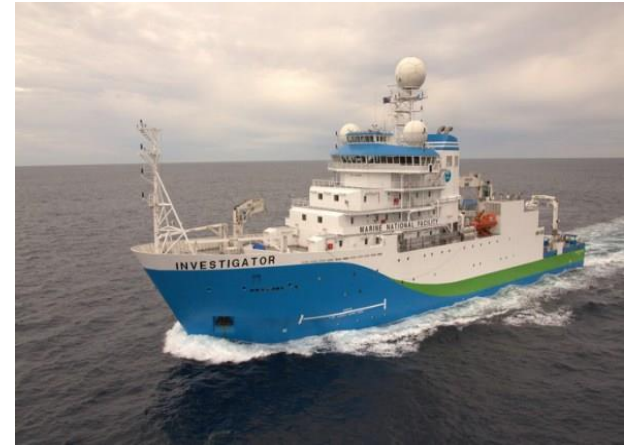


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IMOS Ship SSTskin ISAR SST from RV Investigator

- **Dec 2016 onwards:** Reprocessed all ISAR data from 26 Oct 2014 to ASCII format using Werenfrid Wimmer's v2.7.0 Uncertainty Code:
<http://www.marlin.csiro.au>
- **14 Mar 2017:** Sentinel-3 SLSTR SST Matchup Dataset v4.1 ingested RV Investigator ISAR SSTskin data for period 12 Jul to 15 Nov 2016:
<http://www.ifremer.fr/cerweb/sentinel-3/mdb-slstr>
- **30 May 2017:** Reprocessed ISAR SSTskin merged with IMOS meteorological and SSTdepth data for IN2017_V01 (14 Jan – 3 Mar 2017)

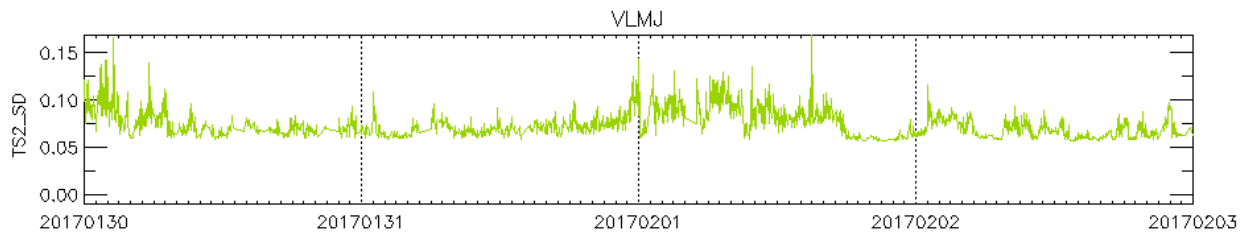
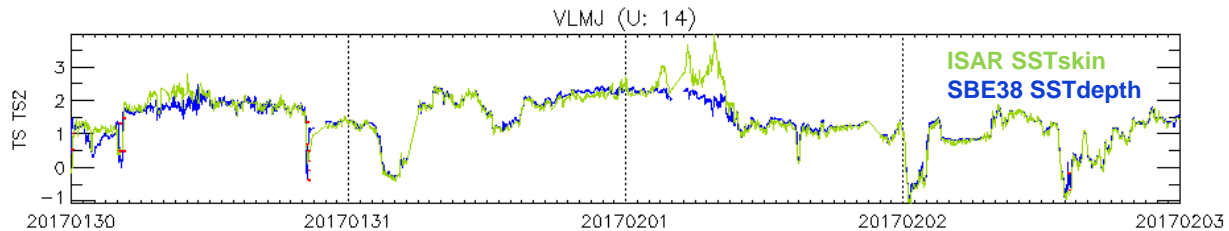
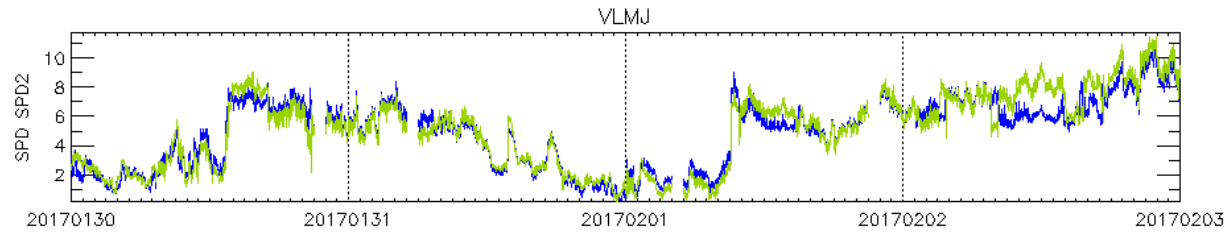
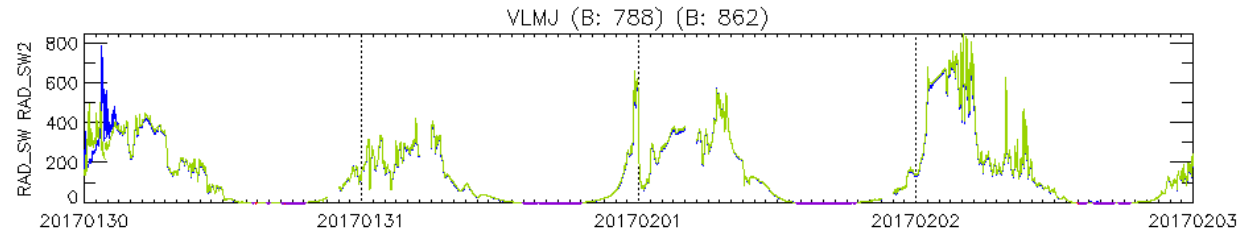
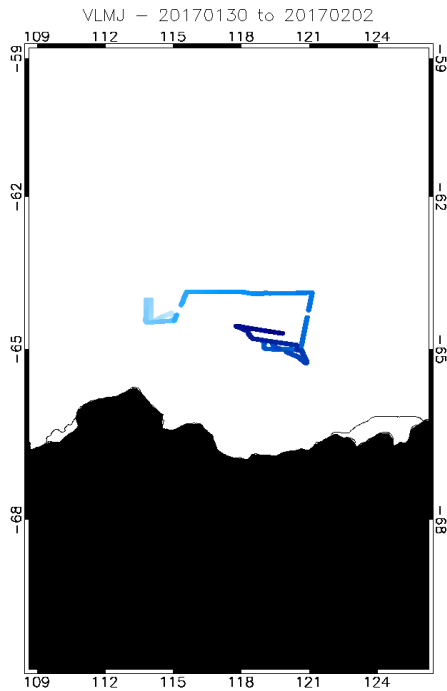




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RV Investigator SSTskin and SSTdepth IN2017_V01 (Antarctic Cruise 14 Jan – 3 Mar 2017)

Shown here are Short-Wave Solar Radiation, Wind Speed, SBE 38 SSTdepth, reprocessed ISAR SSTskin and ISAR total uncertainty (2σ) for 30th Jan to 3rd Feb 2017.





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RV Investigator Cruise Tracks

- CSIRO's RV Investigator Cruise Plans (inc voyage tracks) are at:
<http://mnf.csiro.au/Voyages/Investigator-schedules/Plans-and-summaries.aspx>
- CSIRO's RV Investigator past voyage tracks are at:
<http://www.cmar.csiro.au/data/underway/>
 - On this page select "Survey" from top left then the current or past voyage ID from the drop-down box. This will then display a plot of the actual cruise track.
- Good quality ISAR data available:
 - IN2016_V04: 30 Aug 2016 – 23 Sep 2016: Sydney to Brisbane along east coast of Australia.
 - IN2016_V05: 26 Sep 2016 – 26 Oct 2016: Brisbane to Great Barrier Reef to Brisbane.
 - IN2016_V06: 28 Oct 2016 – 14 Nov 2016: Brisbane to Brisbane (off Queensland coast).
 - IN2017_V01: 13 Jan 2017 – 6 Mar 2017: Hobart to Antarctica to Hobart.
 - IN2017_V02: 15 Mar 2017 – 30 Mar 2017: Hobart to Southern Ocean to Hobart.



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Summary and Future Plans

- IMOS provides high quality, QC'd, ship SSTdepth and SSTskin data that are useful for satellite SST validation, particularly in regions lacking in other in situ SST (coastal Australia, Indonesian waters, Southern Ocean)
- Jul 2017: Reprocessed RV Investigator ISAR and meteorological data available from 28 Oct 2014 to 30 Mar 2017 from:
http://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-ASF/VLMJ_Investigator/catalog.html
- Jul 2017 onwards: Joel Cabrie (Marine Operations Manager, BoM) will take over leading the IMOS Ship SST Sensors Sub-facility from Helen Beggs
- Late 2017 onwards: BoM to use RV Investigator ISAR SSTskin to validate Himawari-8 SSTskin, concentrating on diurnal warming and cold upwelling events. All RV Investigator ISAR data (Oct 2014 to Mar 2017) will be reprocessed to GHRSSST L2r netCDF format for upload to Shipborne Radiometry Network DB.
- Further information: <http://imos.org.au/sstsensors.html>
- Data Access: <https://portal.aodn.org.au/> Email: helen.beggs@bom.gov.au



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Extra slides for discussion

Hull-Mounted temperature sensors on Australian Volunteer Observing Fleet vessels

SeaBird's SBE 48 is a high-accuracy temperature recorder, designed for shipboard determination of sea surface temperature

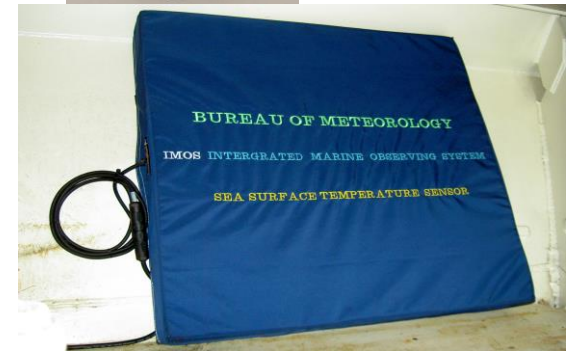
Mounted with magnets just below the water line, the SBE 48's temperature sensor is in contact with the **inside** of the ship's hull. Important to insulate hull and sensor from interior air temperature using a 1 m x 1 m foam insulation pad.

Currently installed as part of IMOS on:
PV Spirit of Tasmania II
MV Stadacona

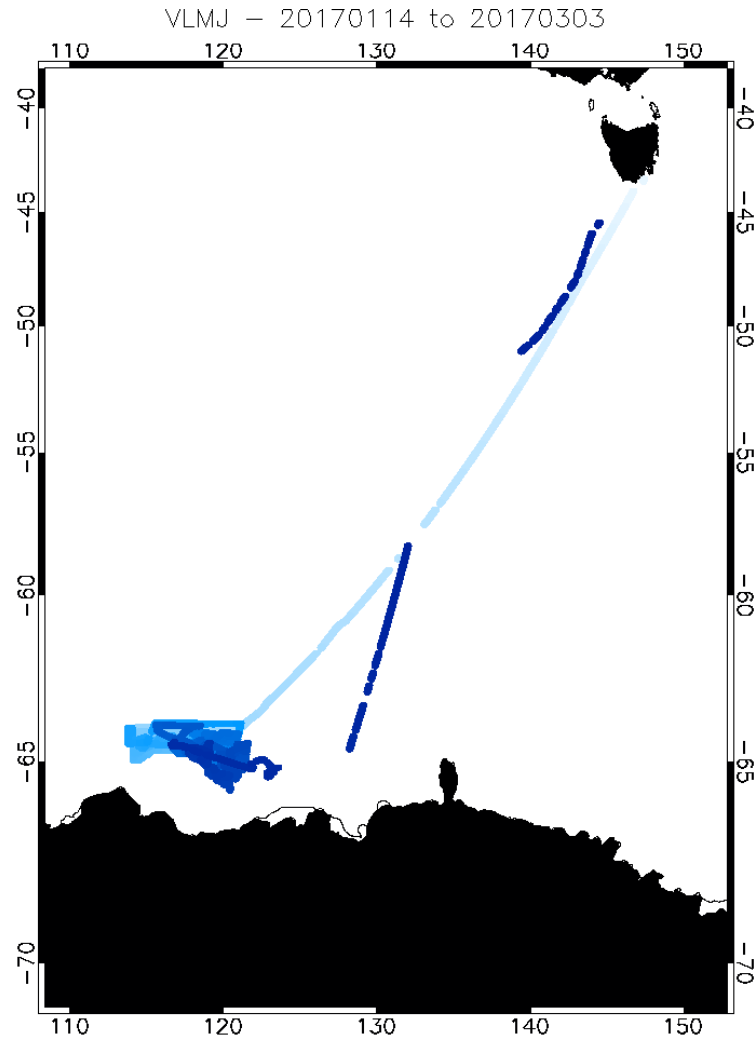
Data relayed through ship to the automatic weather station on the bridge using wireless modems



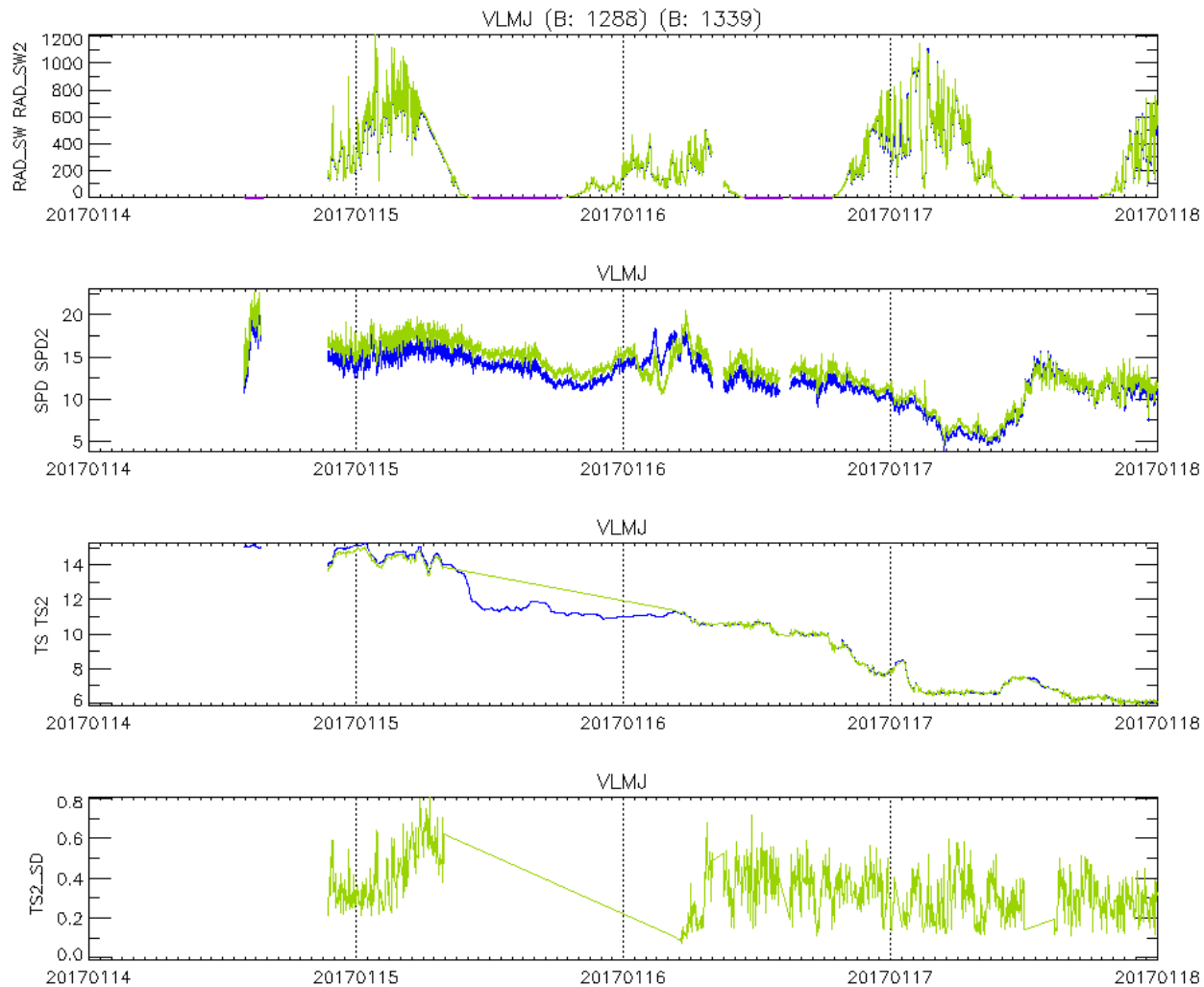
Weight: 2.3 kg
Dimensions:
78 mm x 76 mm
x 273 mm



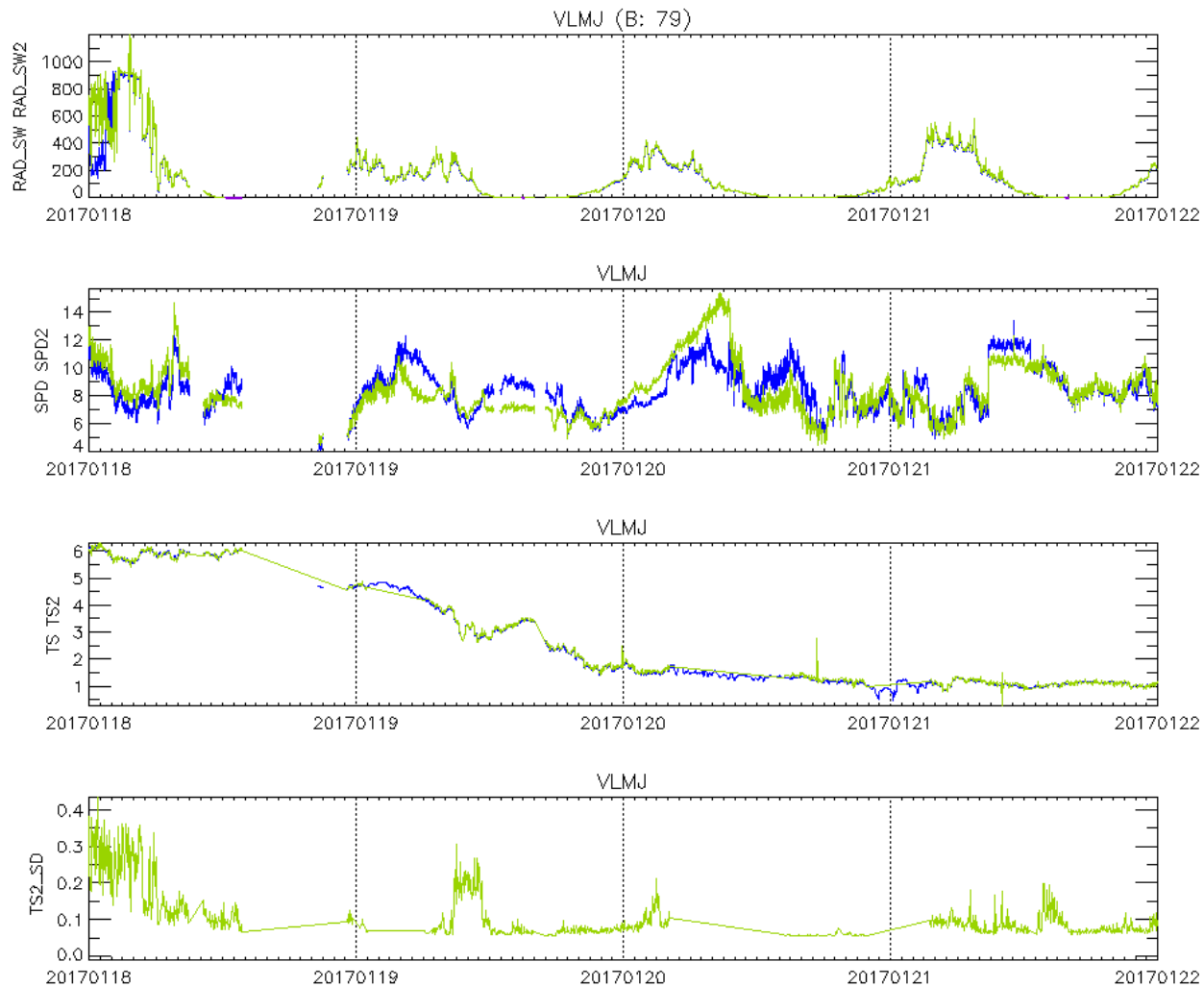
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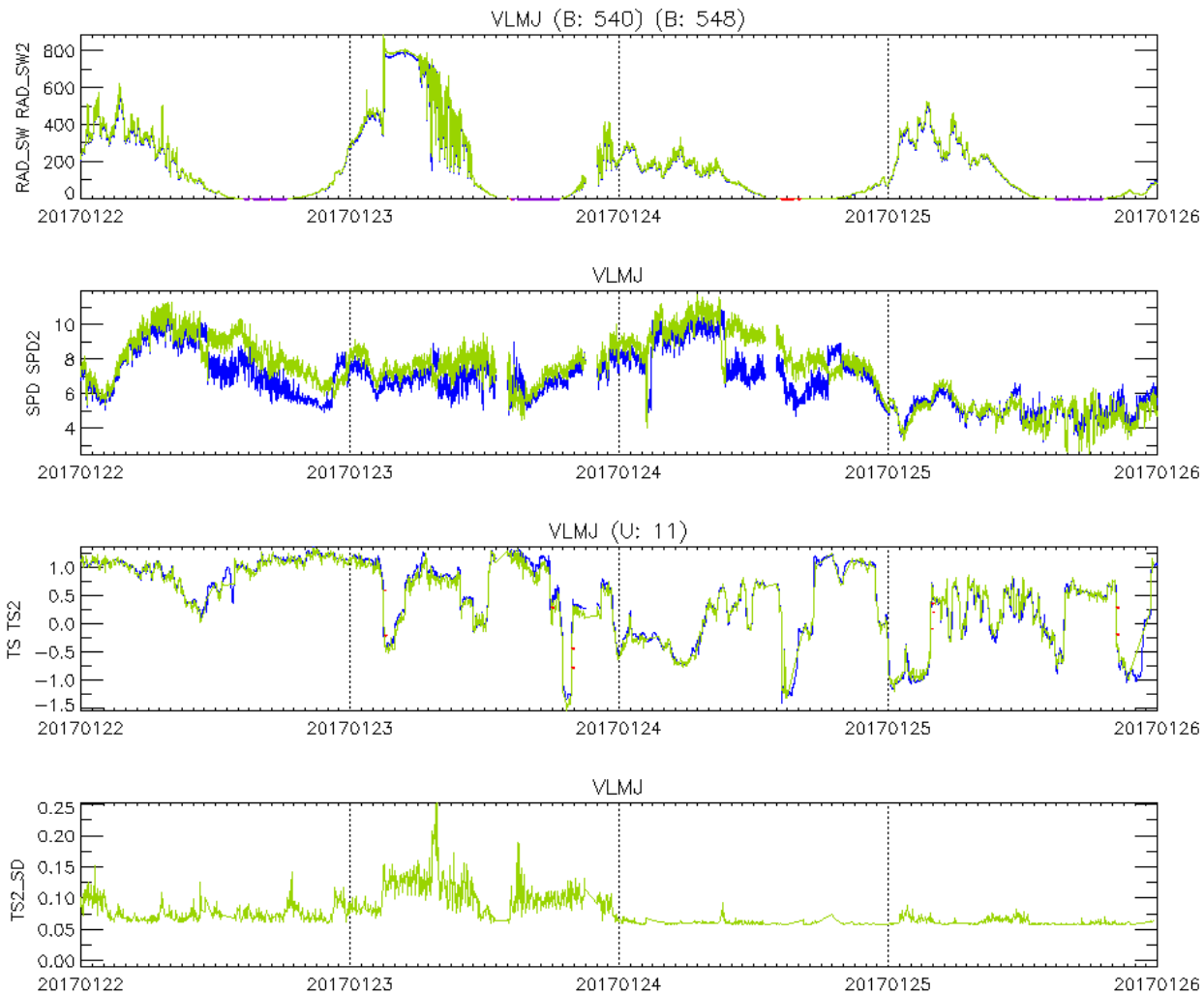


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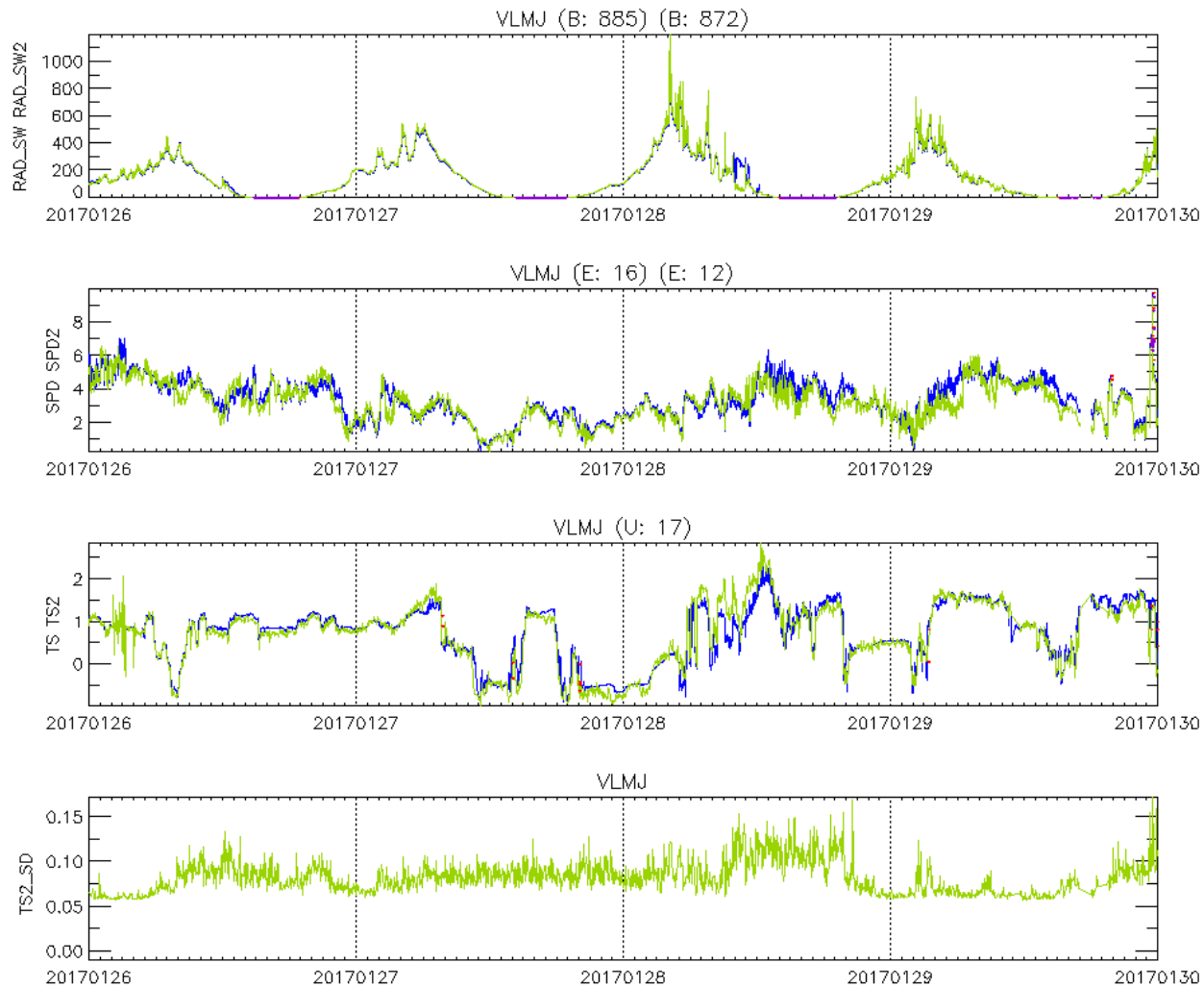


RV Investigator SSTskin and SSTdepth

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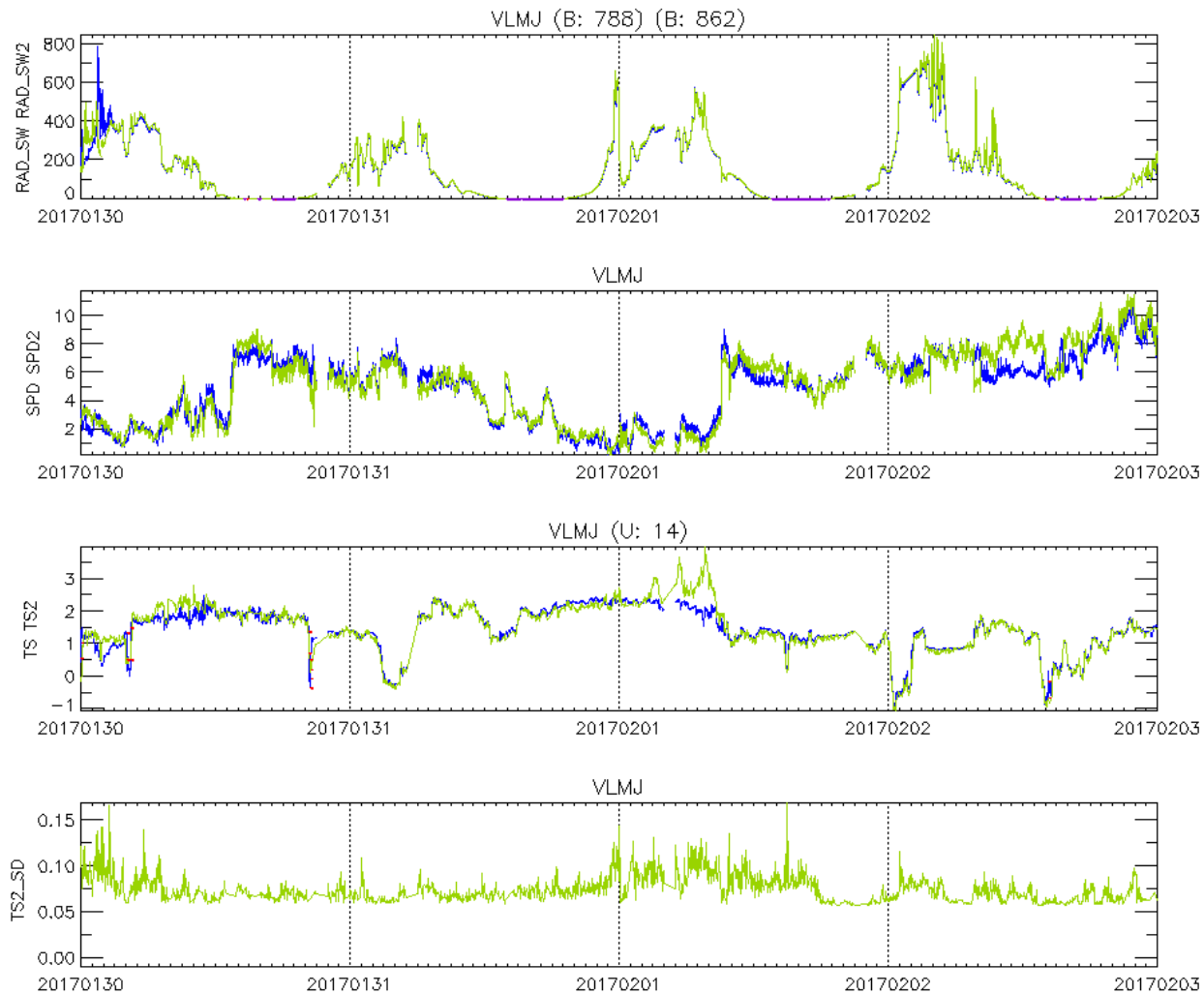


RV Investigator SSTskin and SSTdepth IN2017_V01 (Antarctic Cruise 14 Jan – 3 Mar 2017)



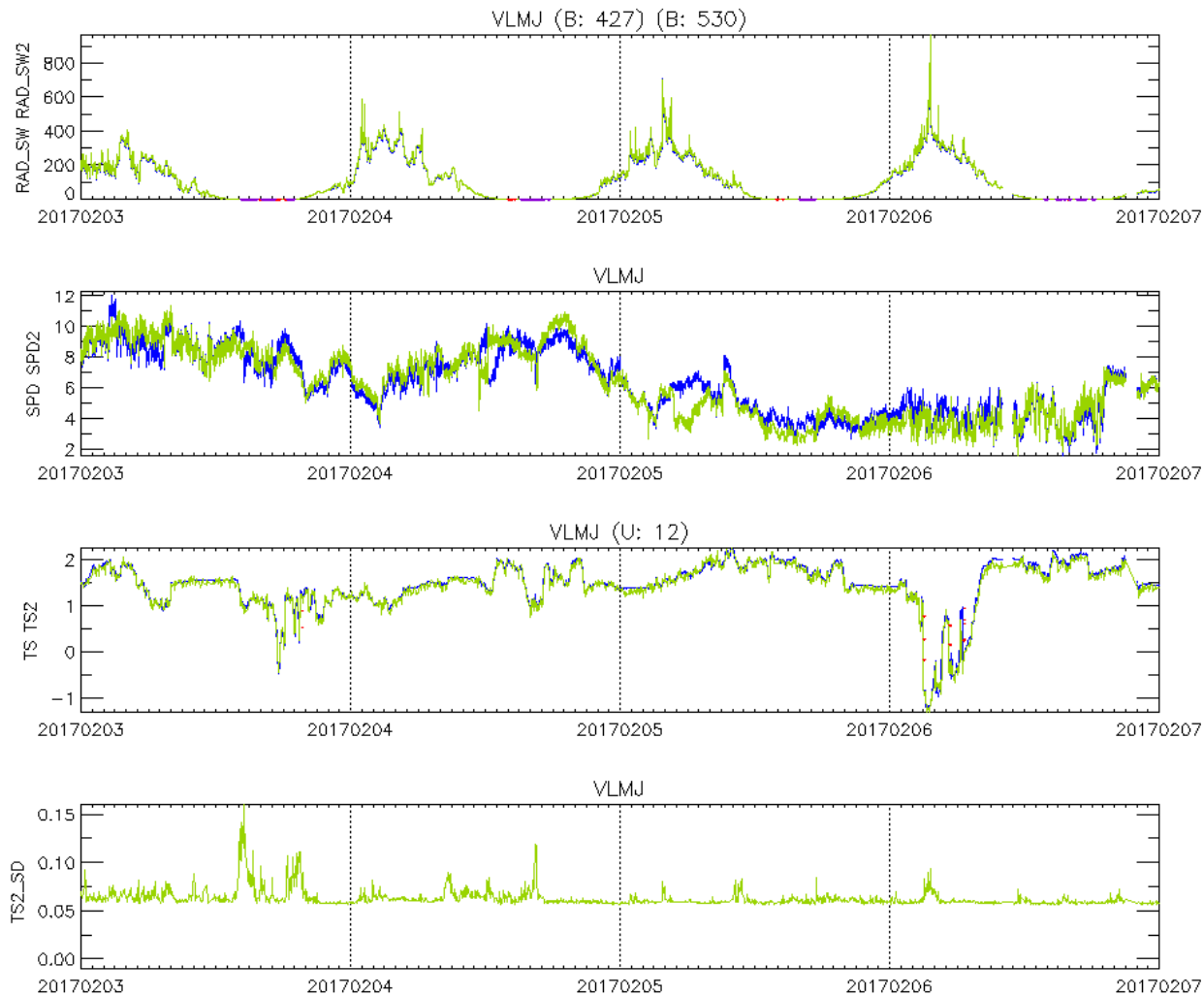
RV Investigator SSTskin and SSTdepth

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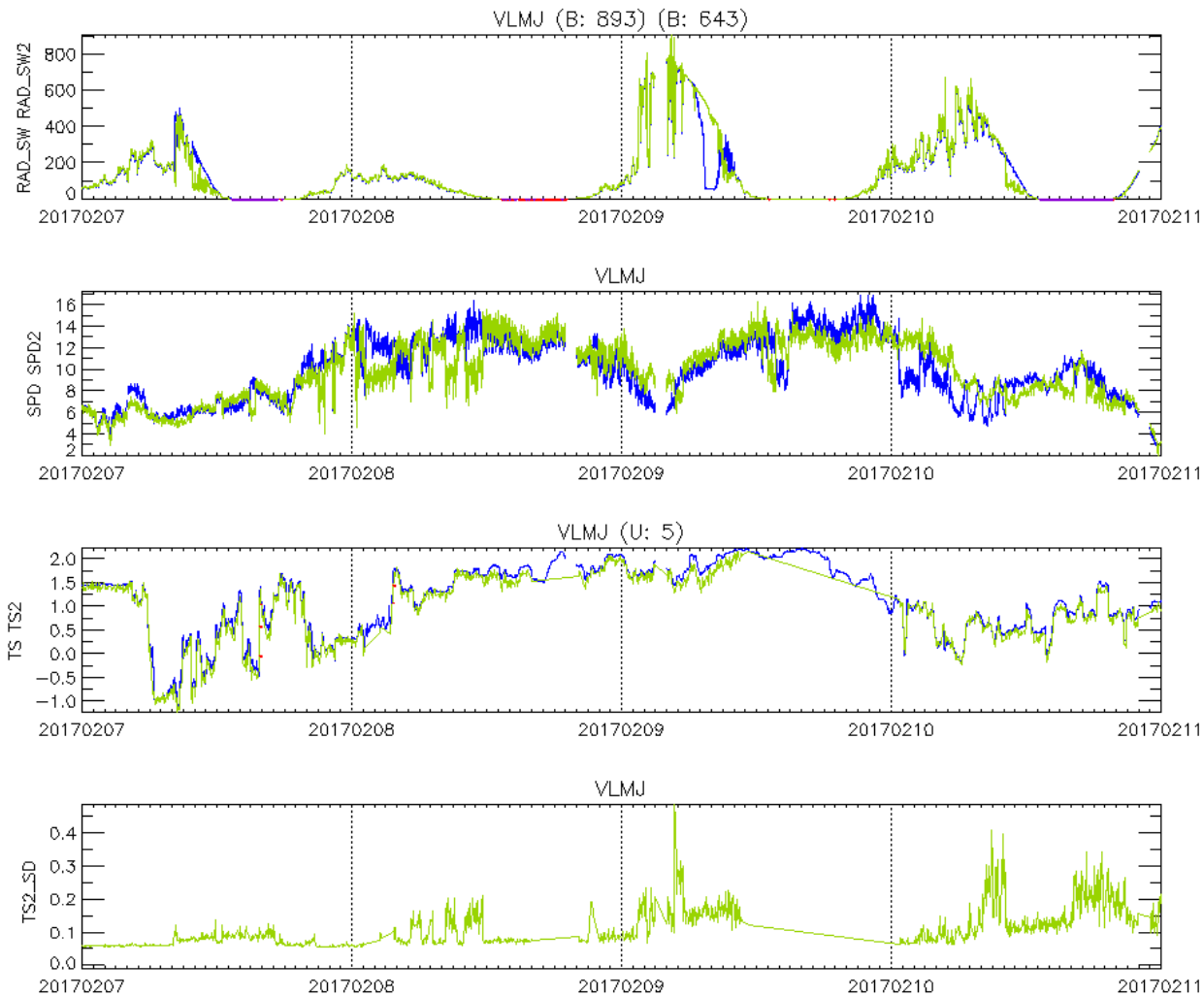


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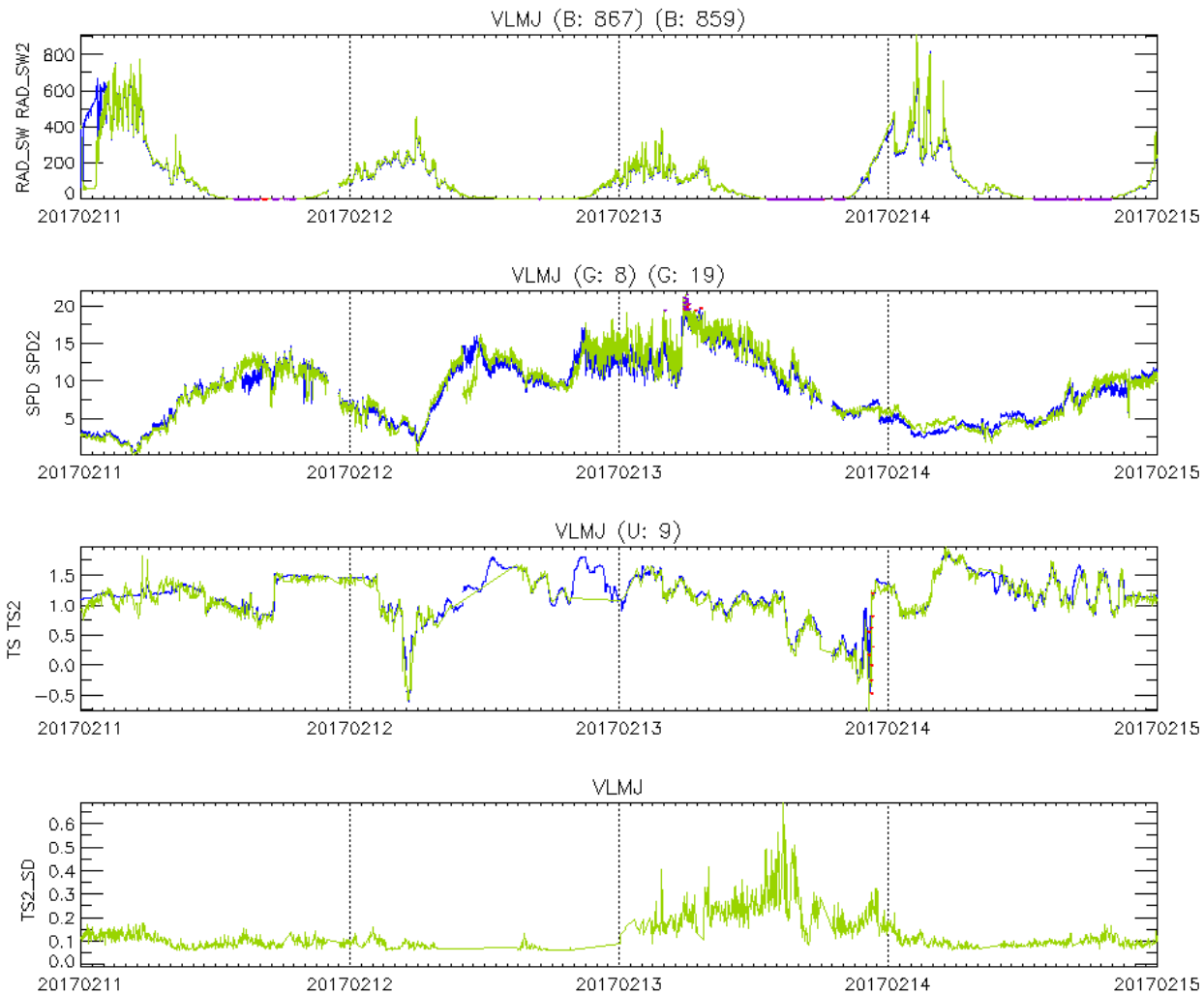


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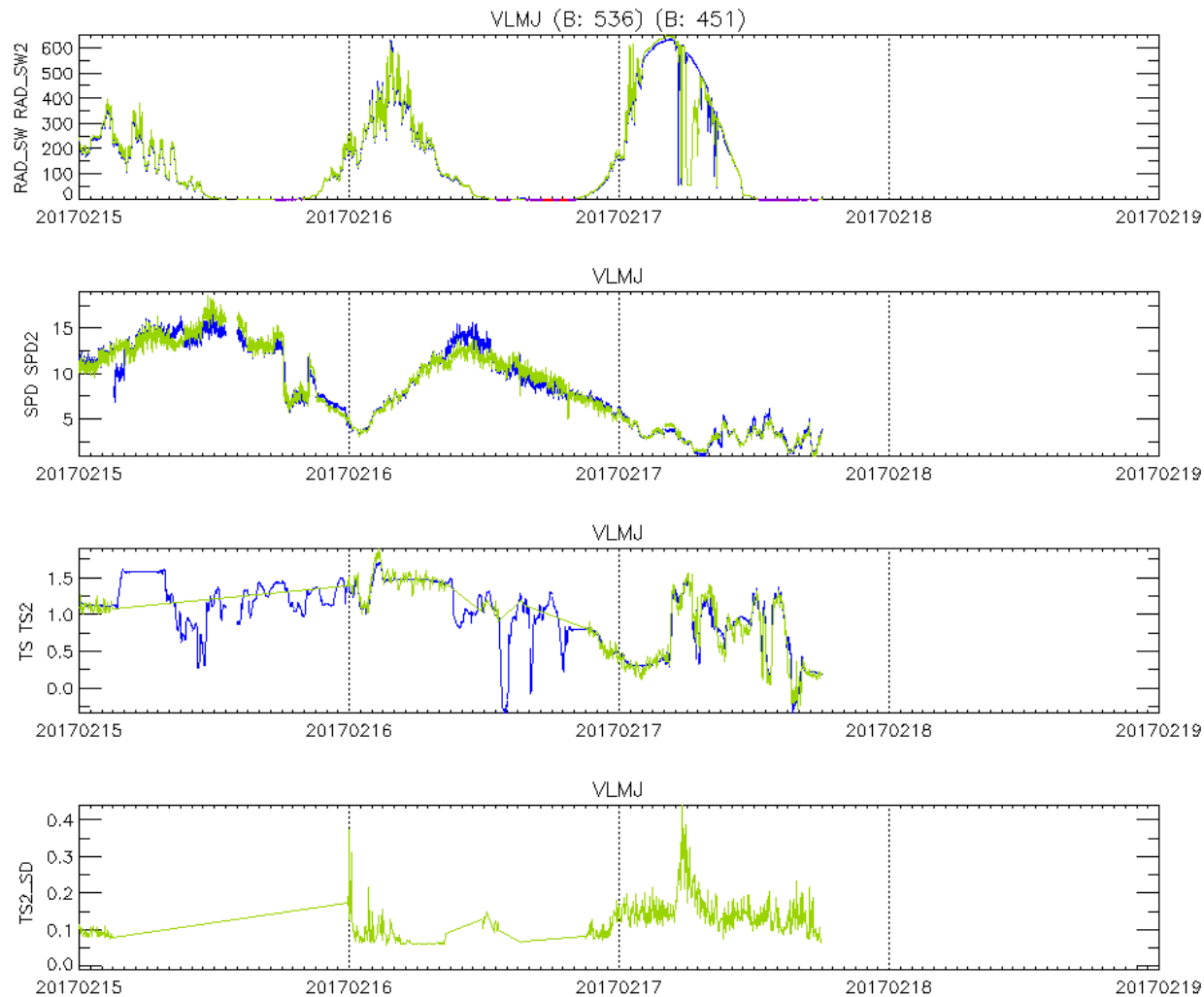


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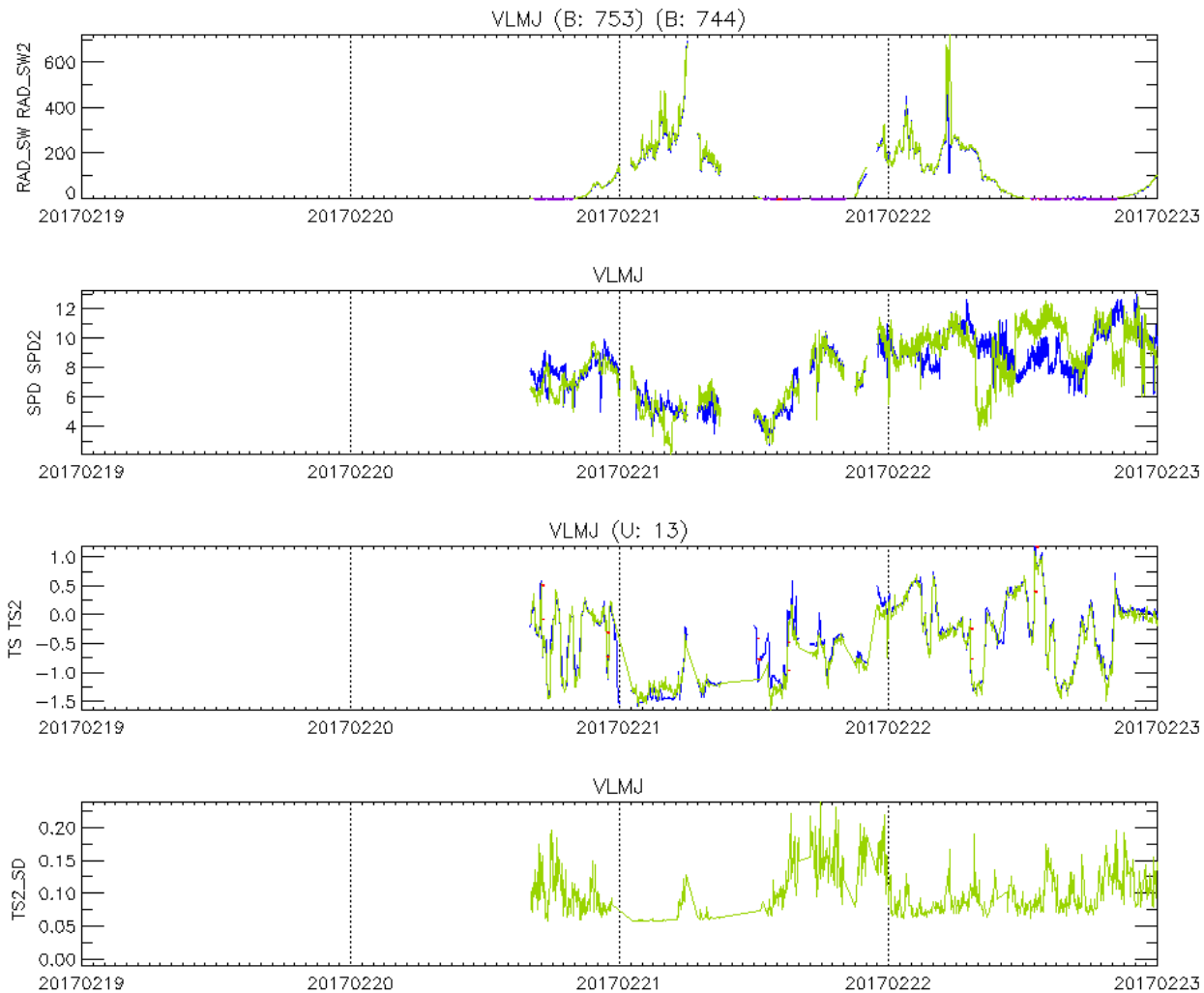


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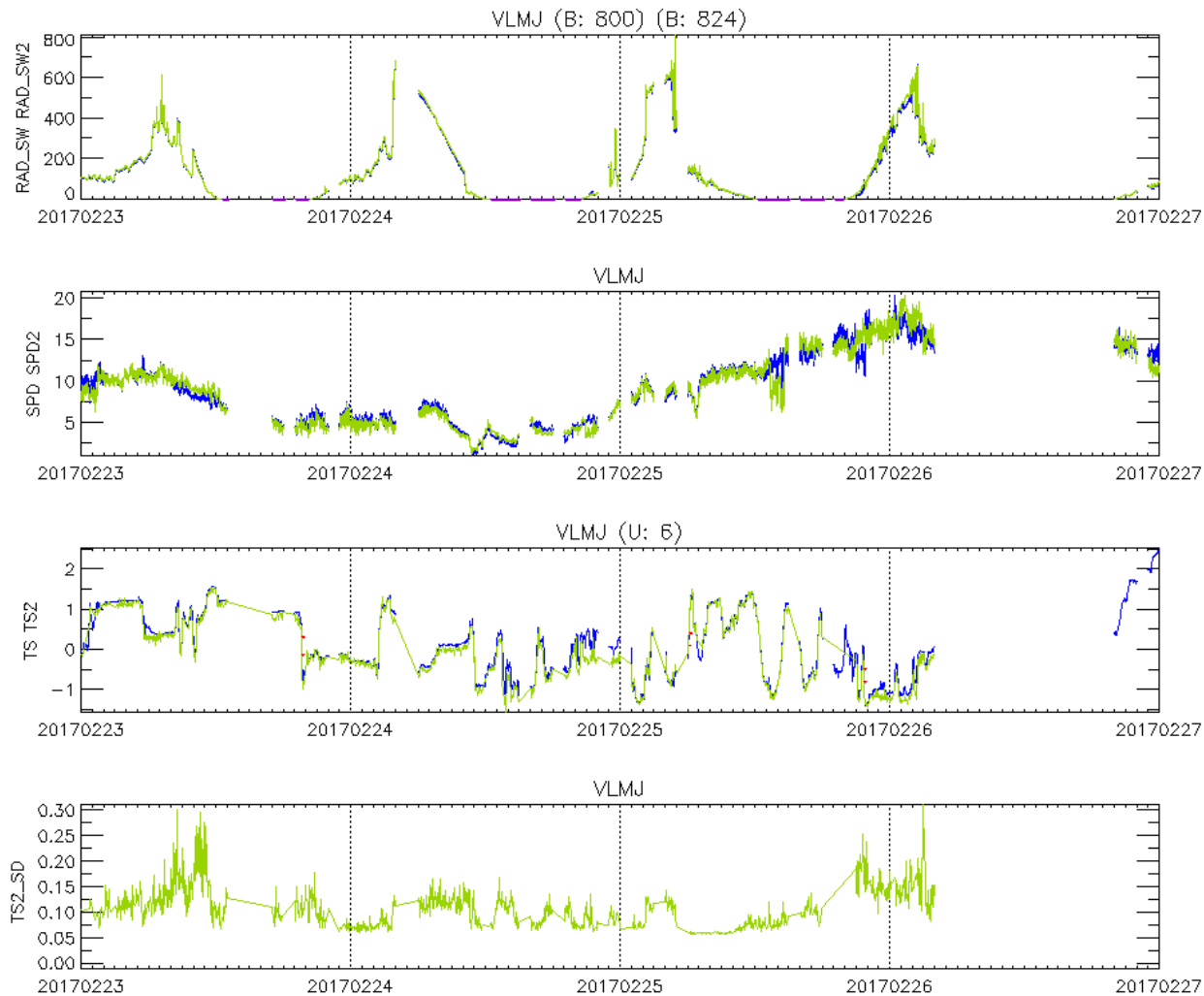
RV Investigator SSTskin and SSTdepth

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