# SSTs Over and Around Reefs (SOAR) Workshop

Craig Steinberg & William Skirving

27–31 August 2018 Townsville, Australia

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August 27-31 2018, Townsville, Queensland, Australia

The aim of the workshop was to discuss ways to improve SST products in complex shallow-water coastal and coral reef regions.

The goal was to assist the development of improved methodologies for satellite SST retrieval algorithms that are able to meet the needs of the coral reef scientific and management communities.
The goals of the workshop are to:

- facilitate an understanding of end-user problems to the product and algorithm developers;
- help the users understand the current set of solutions available;
- stimulate discussions that will lead to improvements in algorithm development of more suitable SST products for the broader coral reef user community.

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**Introductory talks:**

- **The Influence of SST on Coral Physiology** - *Neal Cantin (AIMS)*
- **What is Remote Sensing? and Overview of Satellite SST** - *William Skirving (NOAA)*
- **The Physical Oceanography of Coral Reefs** - *Craig Steinberg (AIMS)*

**USERS of SST:**

- **Coral Reef Managers' use of SST** - *Mark Read & Jen Dryden (GBRMPA)*
- **Ecological Modellers' use of SST** - *Peter Mumby (UQ)*
- **Biologists' Scientific use of SST** - *Neal Cantin (AIMS)*
- **Physical Scientists/Oceanographers use of SST** - *Madeleine Cahill (CSIRO)*
- **Physical Scientists/Modellers' use of SST** - *Mike Herzfeld (CSIRO)/Clothilde Langlais (CSIRO)*
- **Intermediate users use of SST** - ***Mark Eakin (NOAA)***

*Facilitated Discussion* – What do each of the user groups want? Possible or not? How to deliver?

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## SATELLITE SST – CURRENT STATUS AND GAPS

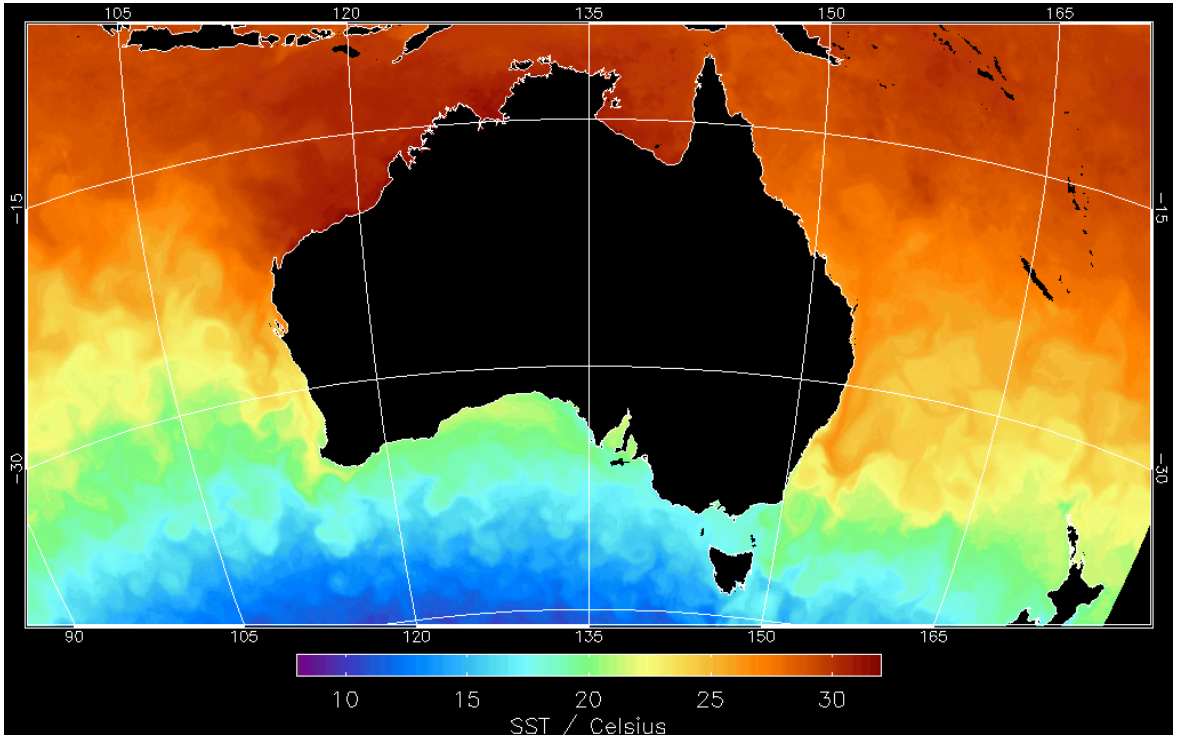
- **Satellite SST products** - *Chris Merchant (U. Reading)*

**Panel discussion on current products, prioritizing new products.**
Chris Merchant (U. Reading), Sasha Ignatov (NOAA), Andy Harris (NOAA), Chris Griffin (BoM), Jonathan Mittaz (U. Reading) *Facilitator: William Skirving*

## IMPROVING SATELLITE SST FOR CORAL REEFS Calibration and Validation

- **In situ cal/val data for the Great Barrier Reef region** *Helen Beggs (BoM)/Jessica Benthuysen (AIMS)/Scott Bainbridge (AIMS)*
- **Cal/val opportunities in the Caribbean** - *Natchanon Amornthammarong "Mana" (NOAA)*
- **Satellite products overview – what currently exists?** - *Helen Beggs (BoM) ) & Gary Corlett (GHRSST, University of Leicester)*

# remarkable view of earth

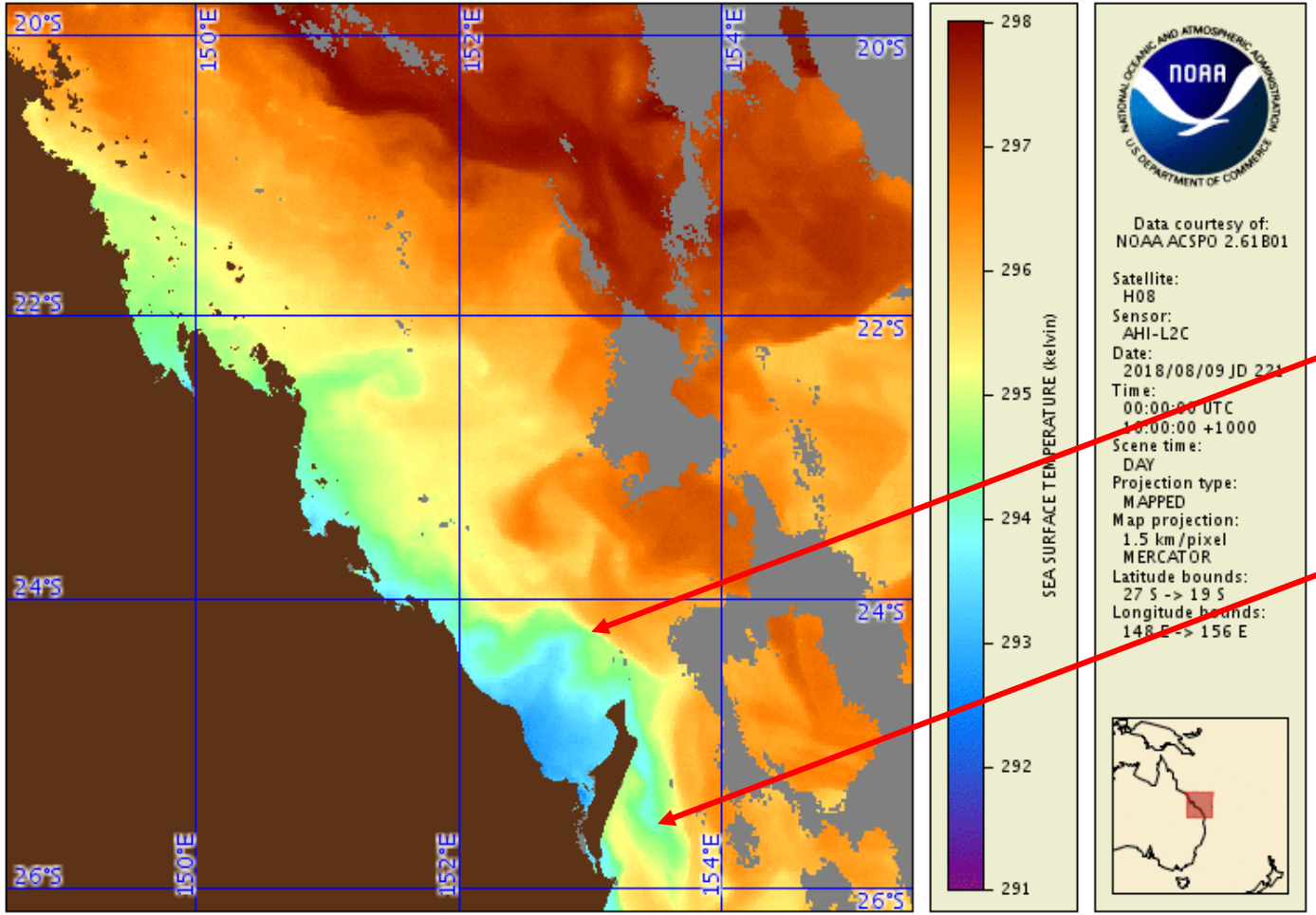



Credit:
Andy Harris
UM/NOAA

Daily data covering 1/4/18 to 31/7/18

0.05° blend

Most SST products are optimized for numerical weather prediction, oceanography and/or climate – 'large-scale applications'

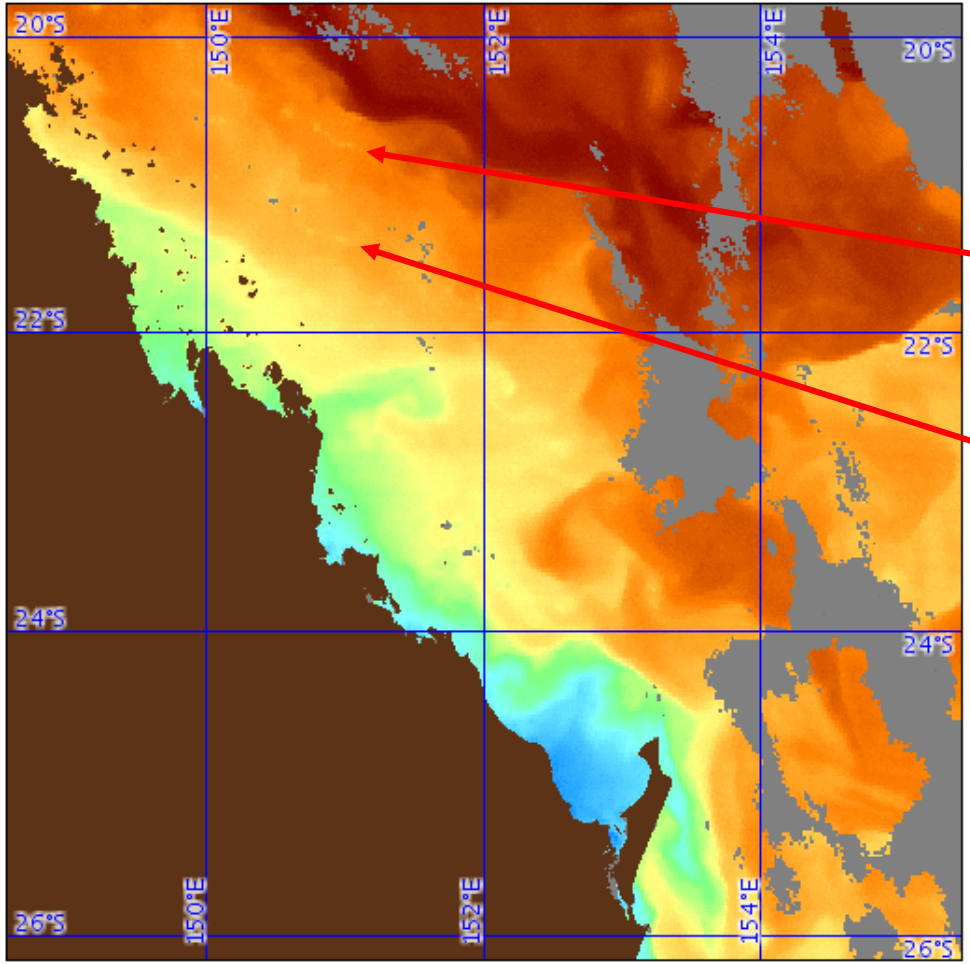


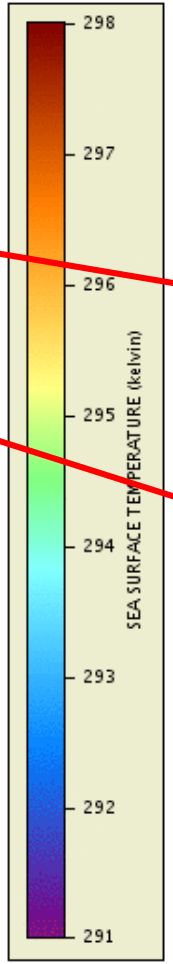

Himawari-8 hourly composites L3C (or L2C)

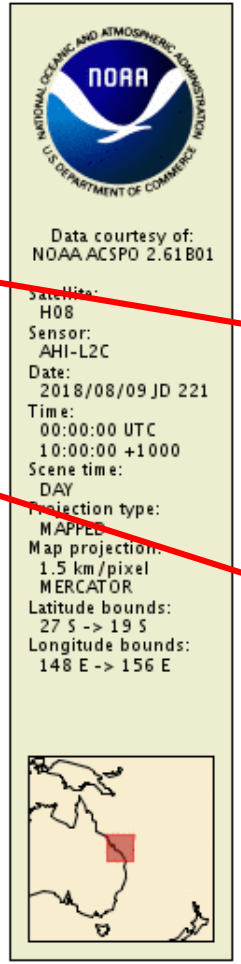
Tidal cycle in front position

Flaws in cloud det'n

Animated by A Harris



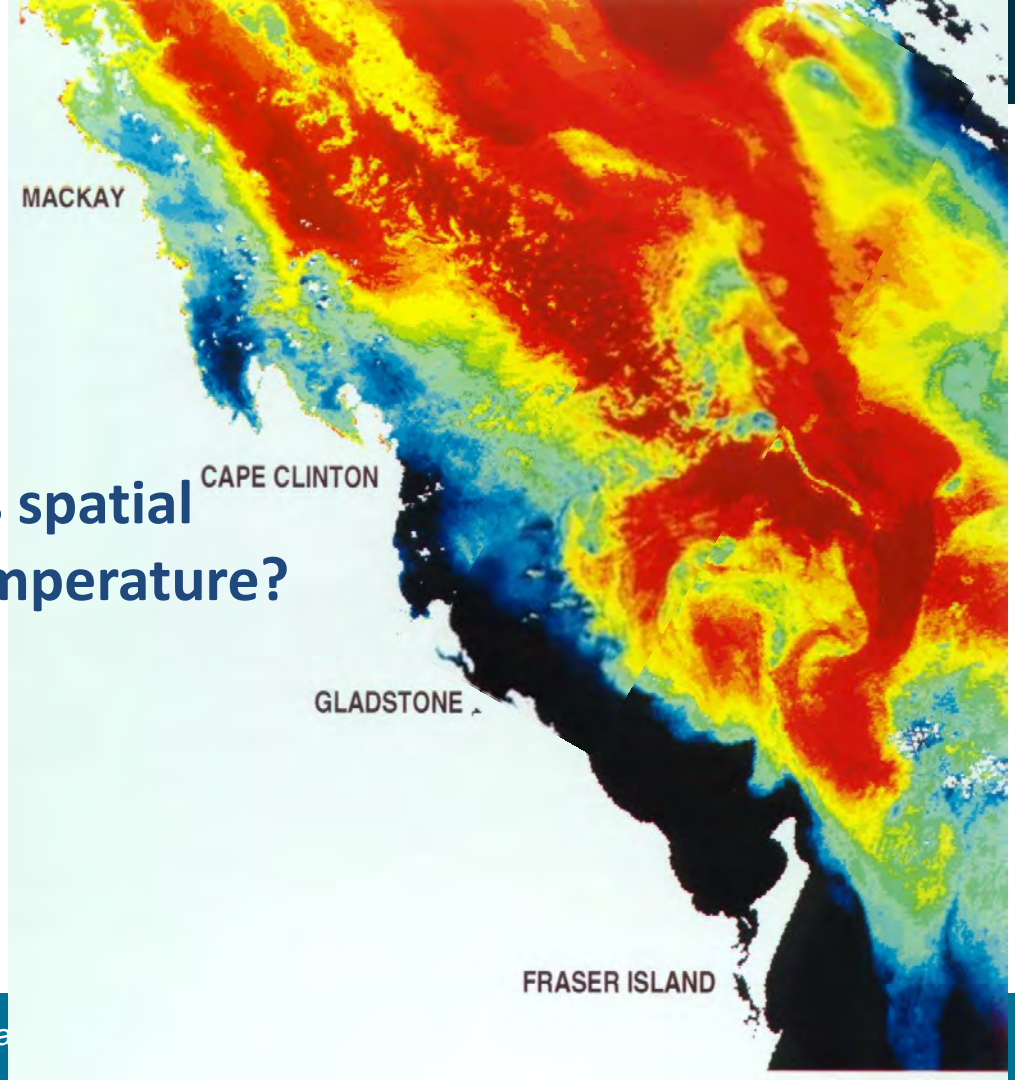

Himawari-8
hourly composites


Google Earth


**Contrast in diurnal cycle of SST**

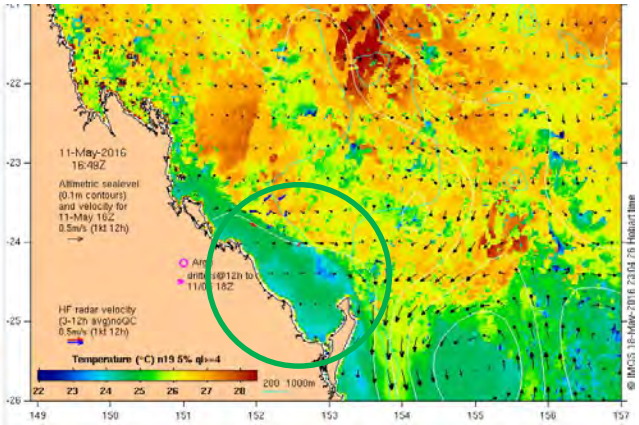
Cooler than ambient mostly, but warmer around 1400 h. Peak insolation coincides with falling low/tide.

# What causes spatial variability of Temperature?

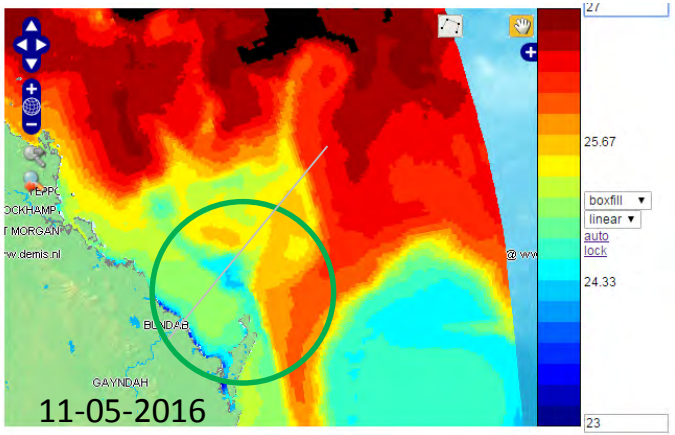



NOAA 9 pass 19422
19 September 1988

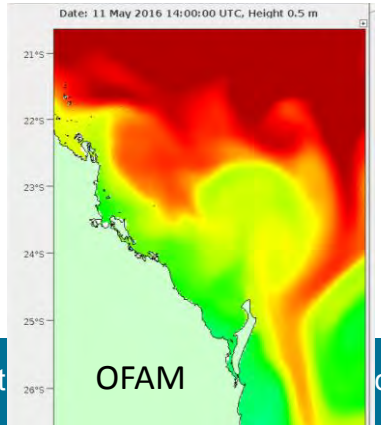
# Upwelling – southern GBR



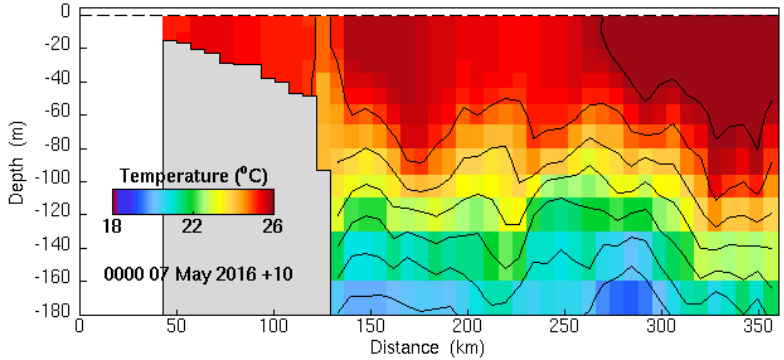

IMOS SST http://oceancurrent.imos.org.au/sst.php



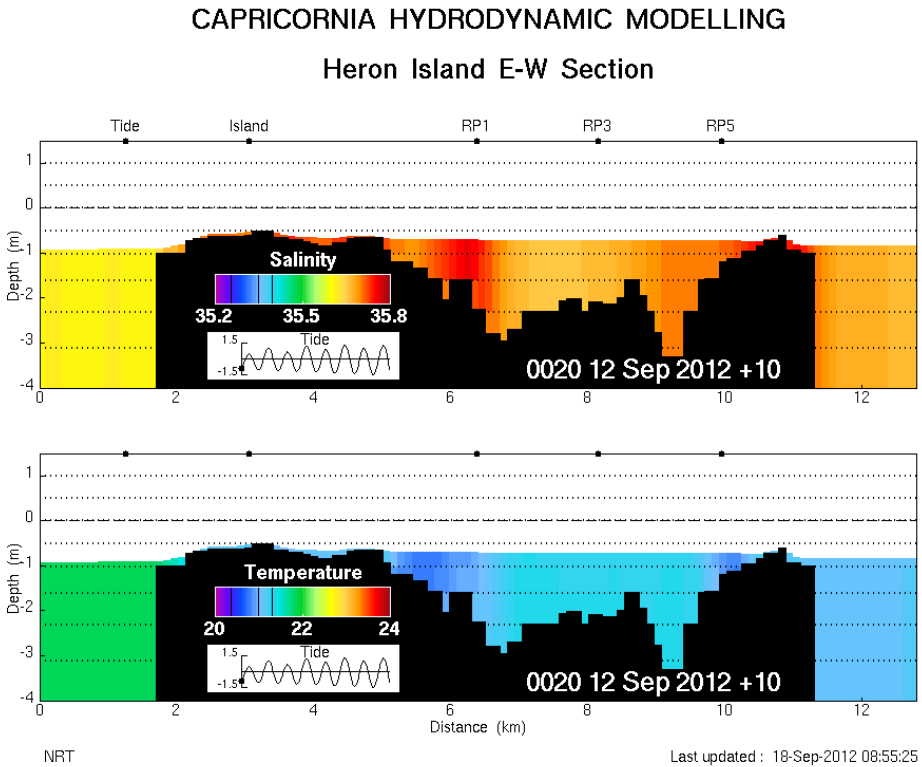

eReefs http://dapds00.nci.org.au/thredds/godiva2/godiva2.html?server=http://dapds00.nci.org.au/thredds/wms/eReefs/model_data/gbr4_1.85.ncml#

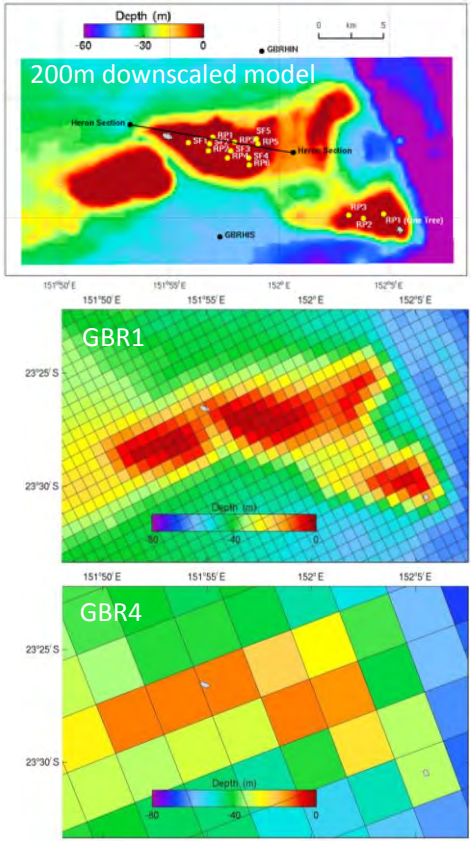



OFAM

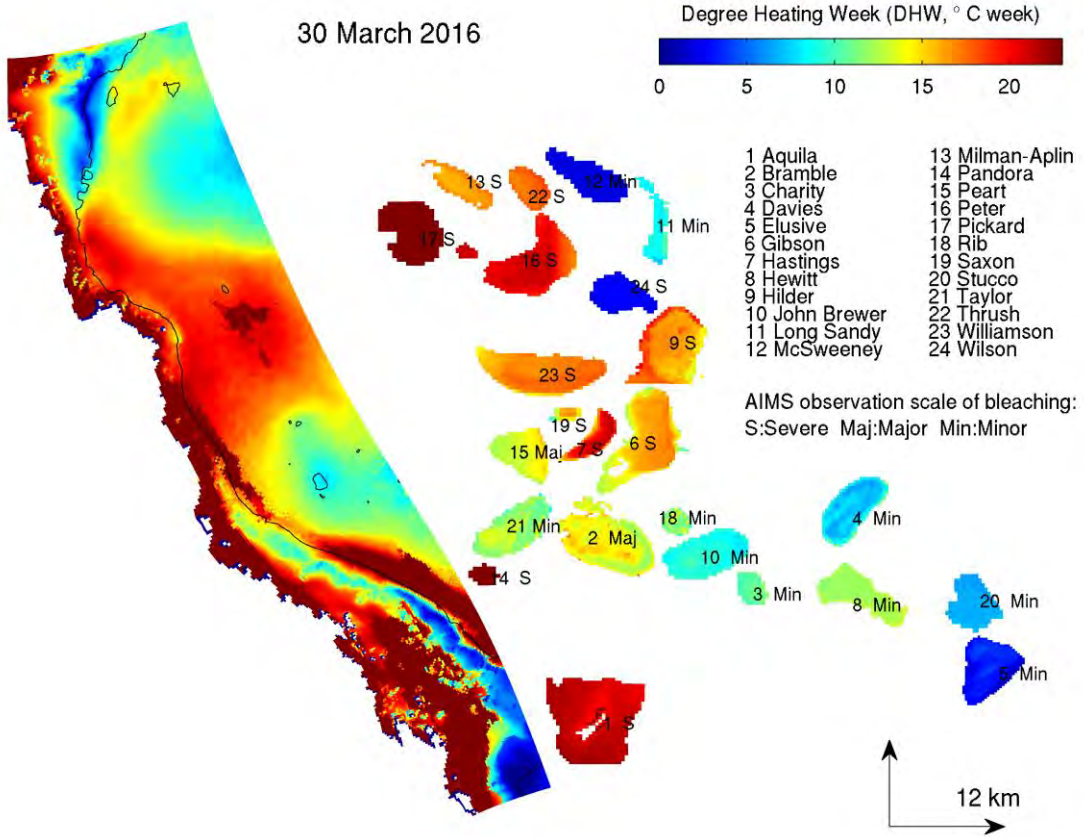


# Differential heating on drying reefs



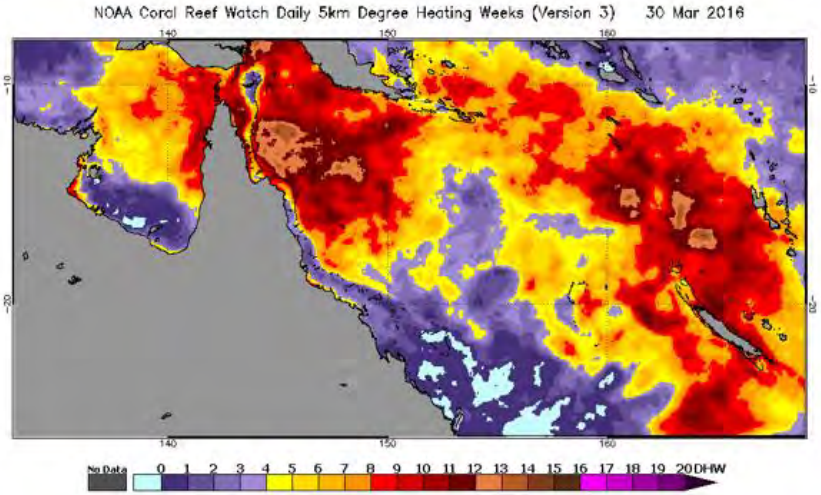
# eReefs RECOM DHW






Elofer & Baird, CSIRO & Cantin AIMS

# Coral Bleaching 2016 & 2017



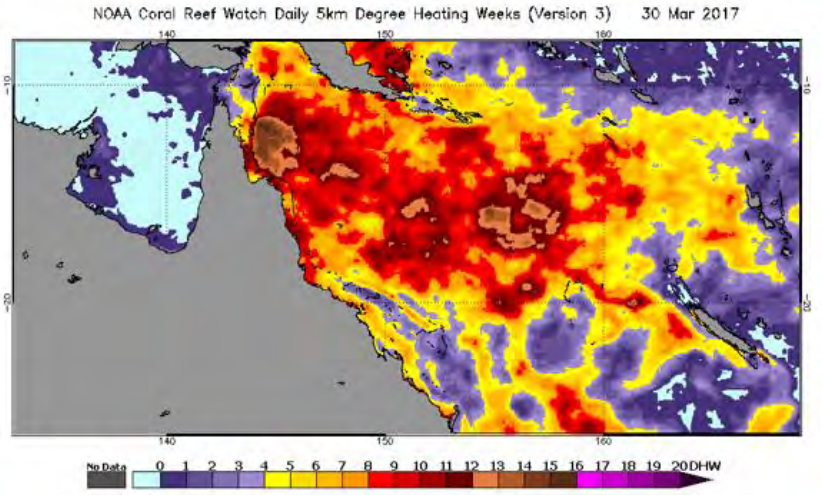
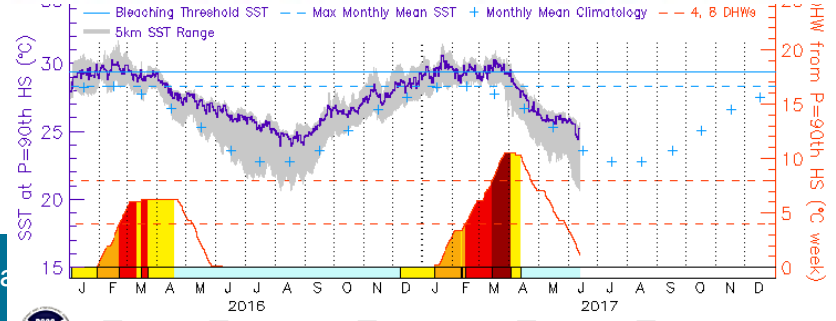
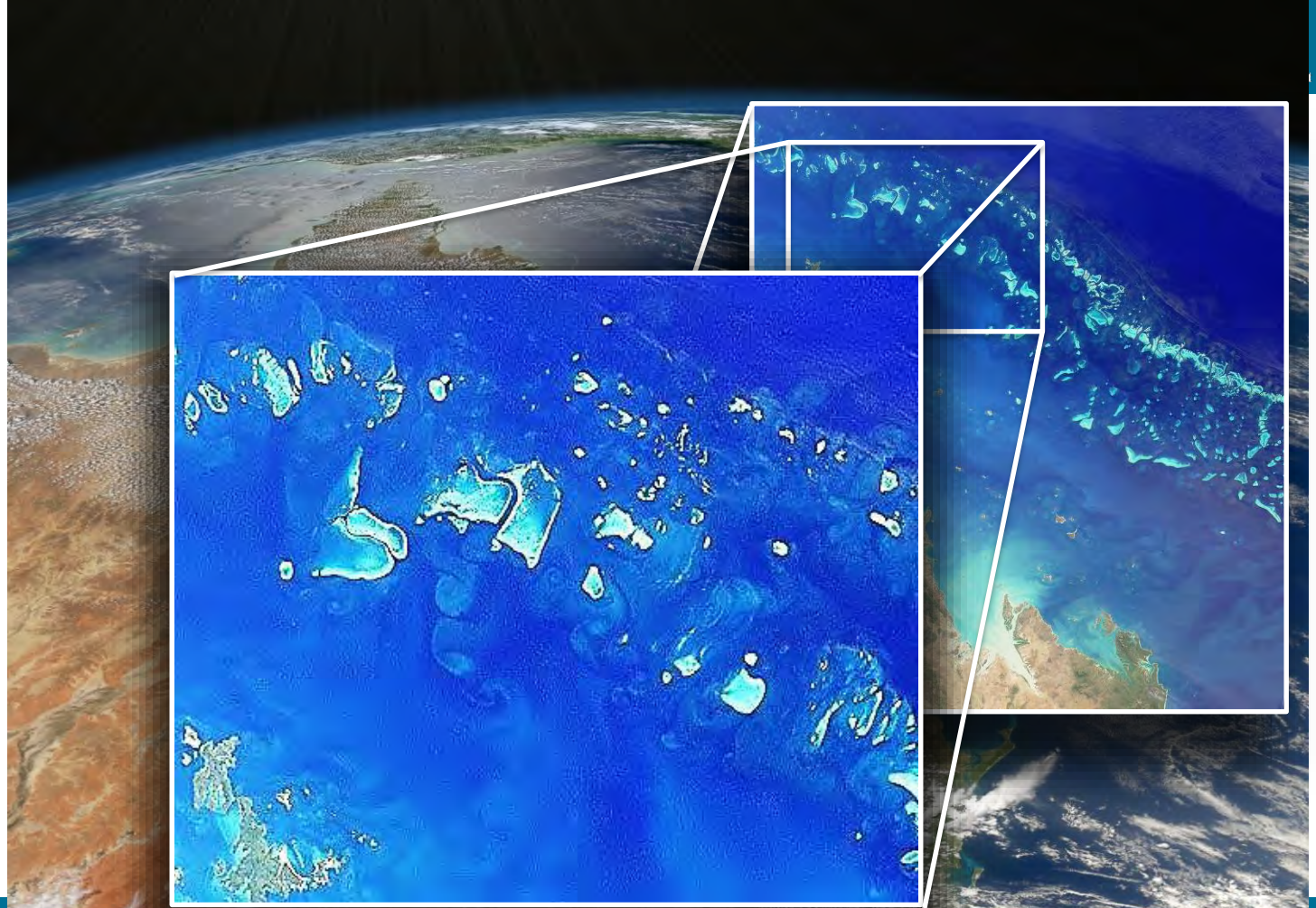




**Figure** 1 –Satellite derived heat accumulation (Degree Heating Week) observed in the Coral Sea for as at March 30 for 2016 (left) and 2017 (right) summers.



# Mixing in the GBR

"Big whirls have little whirls,
That feed on their velocity;
And little whirls have lesser whirls,
And so on to viscosity."
**Lewis Fry Richardson**

Landsat 8 Image enhancement courtesy of Gene Feldman NASA

# 2018-19 wet season – strong monsoons and Burdekin Flood


Matt Curnock
GBRMPA

# The Influence of SST on Coral Physiology and Bleaching Tolerance


DR NEAL CANTIN

Australian Government

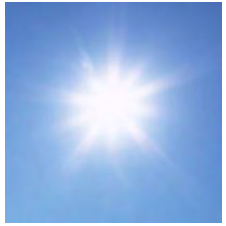
Australian Institute of Marine Science

National Environmental Science Programme

TROPICAL WATER QUALITY HUB

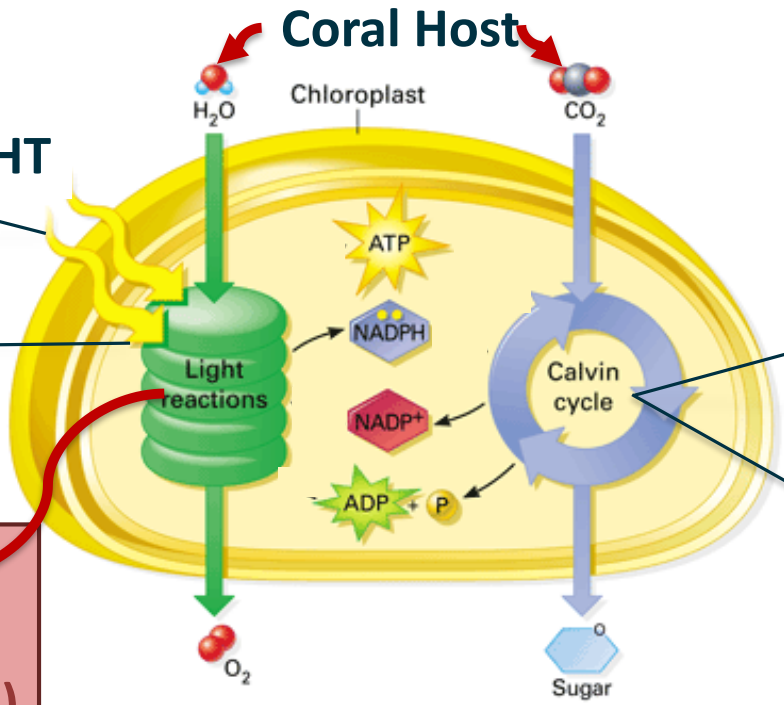
@gbr_neal

# CORAL BLEACHING & SYMBIONT PHOTOSYTHESIS



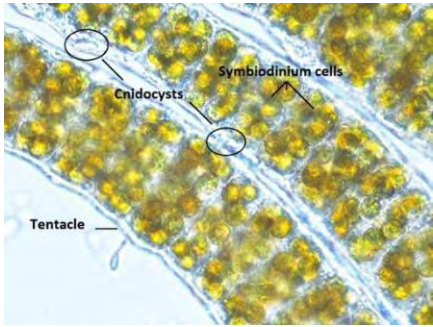
LIGHT

2: Excess Photons




HEAT

1: Degrades Enzymes

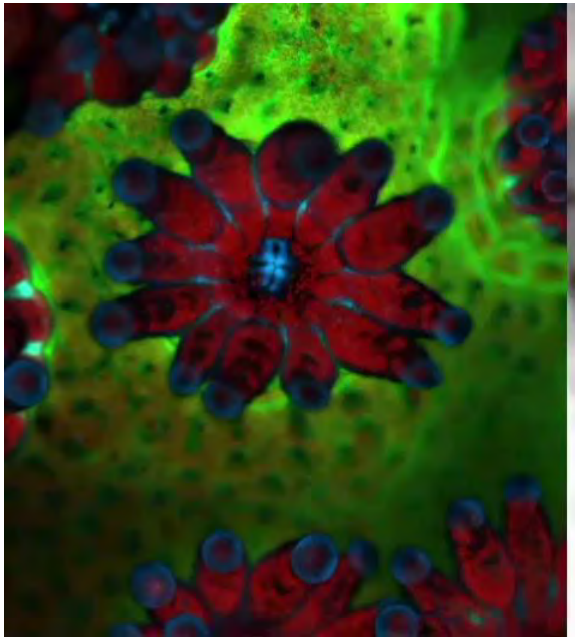



3: TOXIC REACTIVE OXYGEN (ROS)

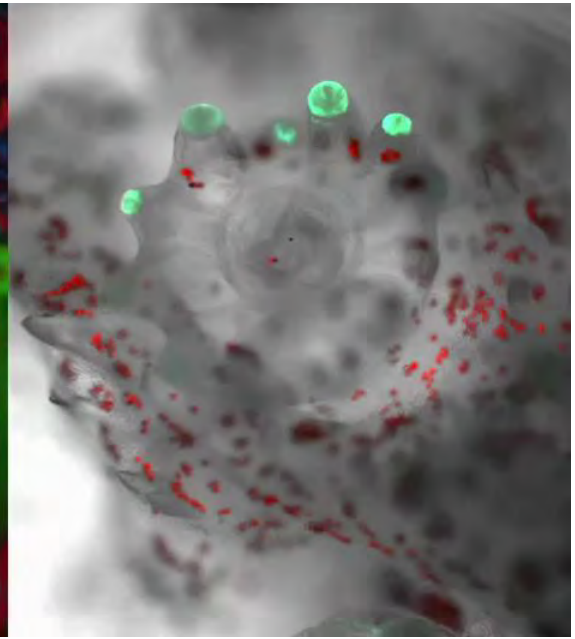
OXYGEN

ENERGY

Healthy Coral Polyp ☺



Bleached ☹

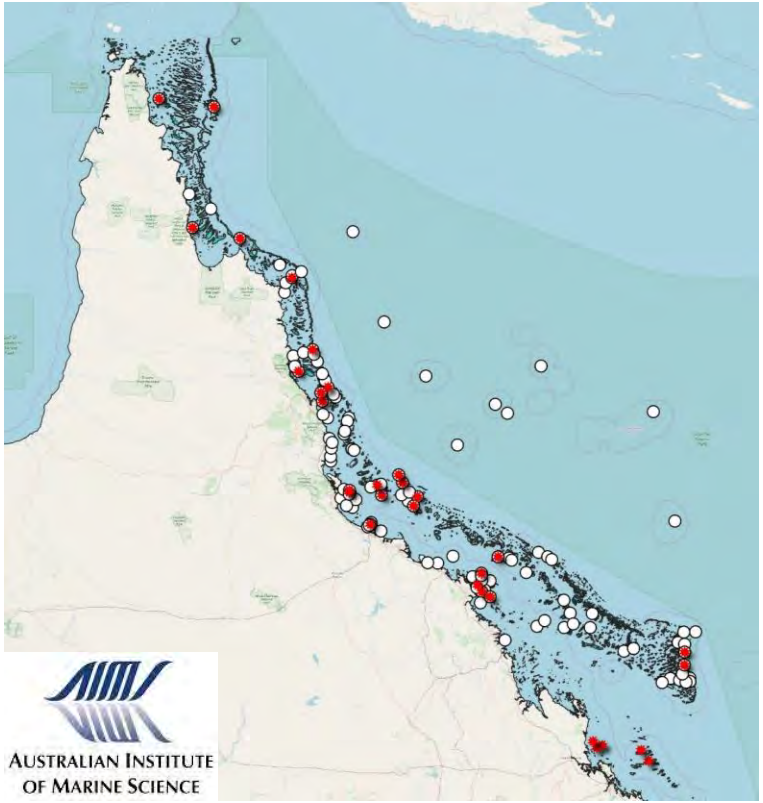


# Biological Applications of SST

- Long-term evidence of ocean warming (HADISST, ERSST, NOAA CRW etc.)
- Understand how temperature influences physiology
- Environmentally relevant experimental profiles
- Assess adaptation potential of corals
- Bleaching event Predictions for Survey Response

**THERMAL THRESHOLDS FOR HEALTHY REEFS**

# IN SITU TEMPERATURE VS NOAA SST



IN SITU TEMP LOGGERS

- Reef Flat (2m)
- Reef Slope (7-9m)

Australian Government
Great Barrier Reef Marine Park Authority

# Uses of sea surface temperature (SST) information for marine park management

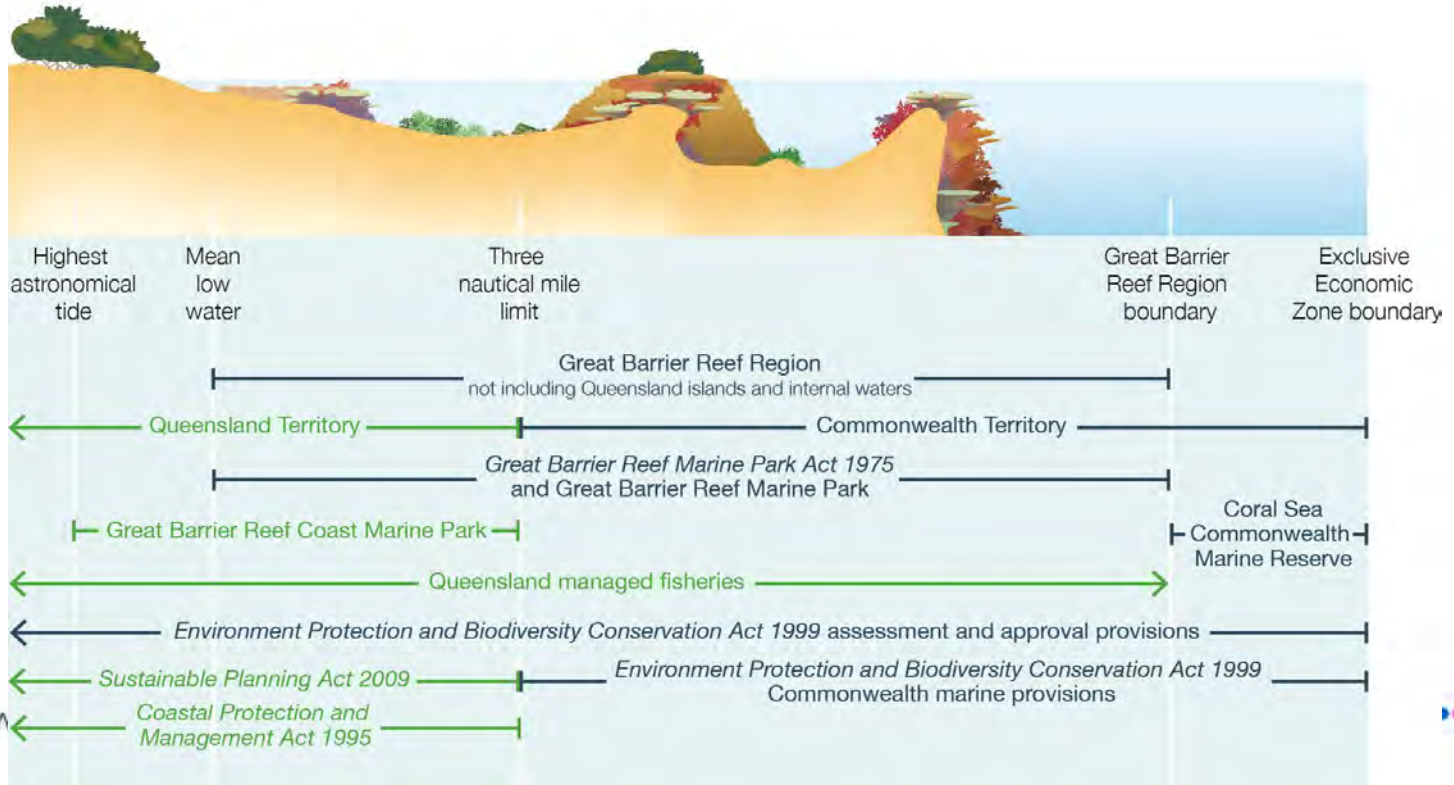
**Presented by Jen Dryden**
Great Barrier Reef Marine Park Authority

SSTs Over and Around Reefs (SOAR) Workshop
August 2018

*Traditional artwork by Patricia Galvin*

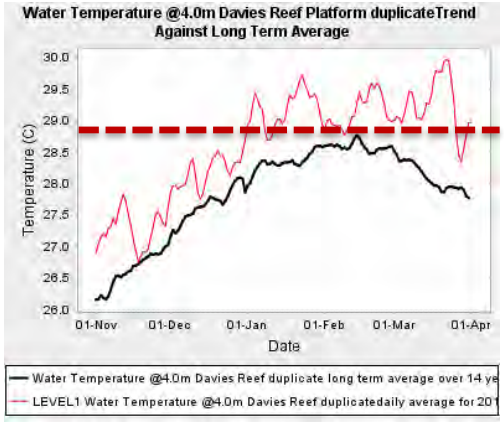
# Multiple use marine park

# Jurisdictionally complex



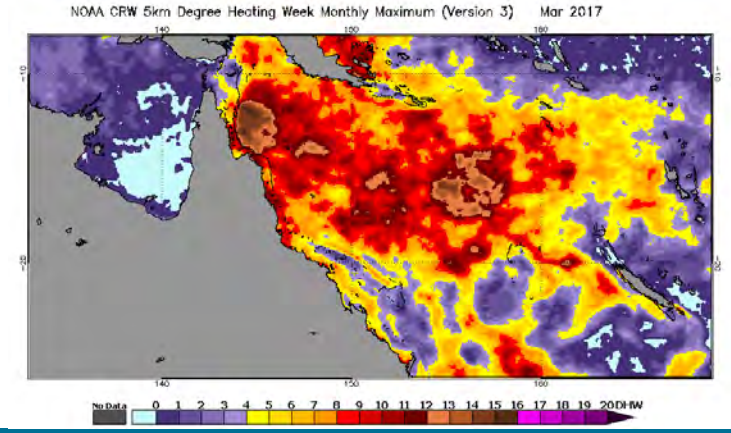
# HEAT ACCUMULATION PREDICTS MASS BLEACHING






MMM

HISTORIC THERMAL RANGE




NOAA DHW

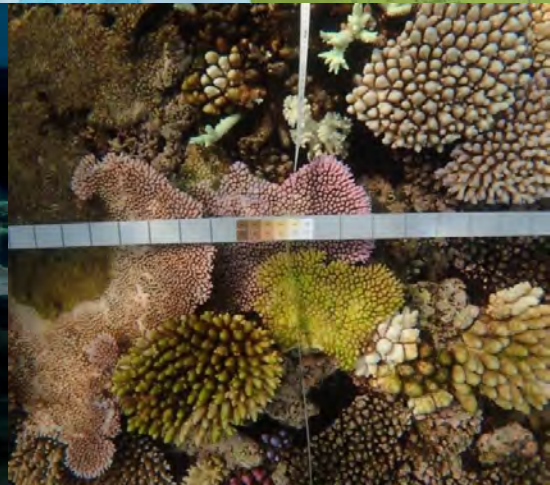
AIMS: Australia's tropical marine research agency.

# Bleaching Response Action

Australian Government | Australian Institute of Marine Science

## AERIAL SURVEYS


## IN WATER SCUBA SURVEYS


Vision:

A coordinated and integrated monitoring, modelling and reporting framework for the Great Barrier Reef and its catchment, explicitly linked to the outcomes in the Reef 2050 Plan

# SSTs Over and Around Reefs (SOAR) Workshop

**August 27-31, 2018, Townsville, Queensland, Australia**

## Recommendations:

The most urgent unmet requirements and potential improvements to cater for them were identified:

- Compatibility between multiple sources of data, e.g. standard climatologies
- Higher temporal and spatial resolution of data
- Estimates of diurnal and vertical temperature variations
- Uncertainty information

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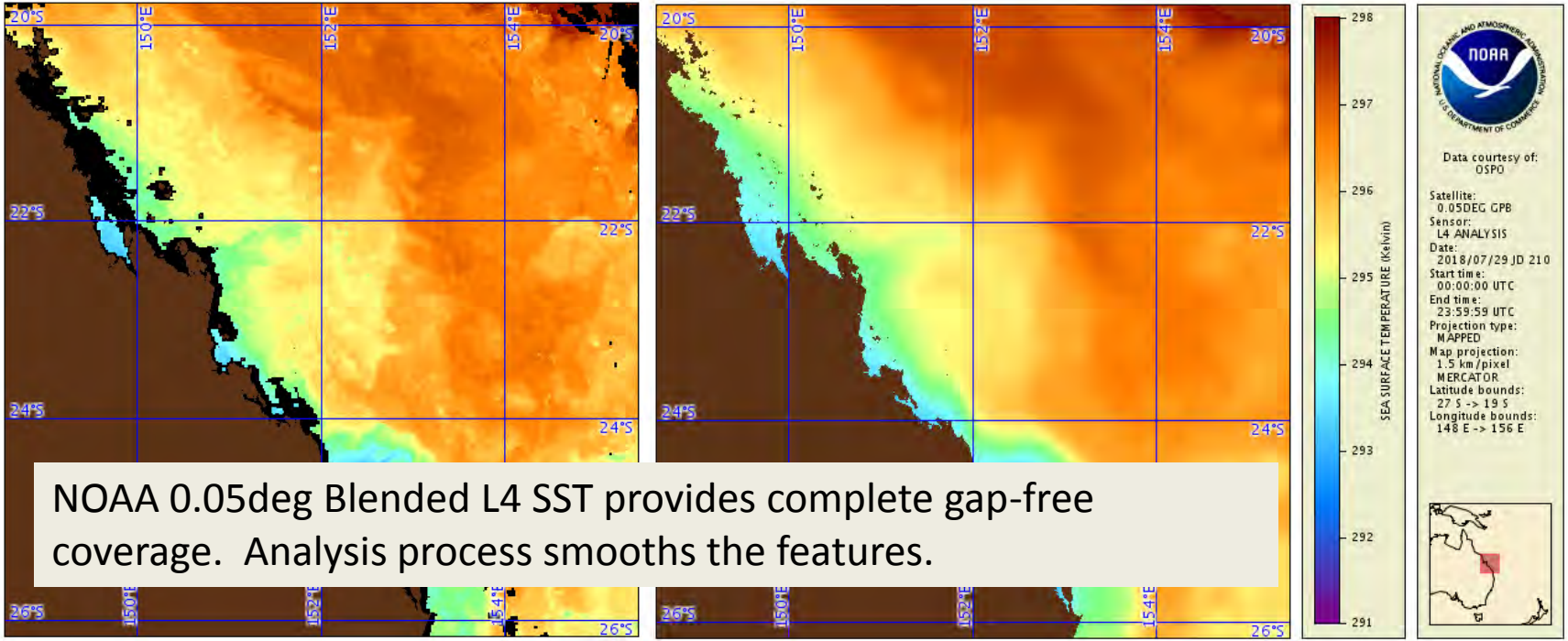
GBR Marine Park Authority Priorities:

- Consistent maintenance of products
- Consistent frequency of information updates
- Importance of three dimensionality of the reef system considered and incorporated
- Any new products should have an option for GBR (or other regions) specific view/query
- Simple explanations of product strengths, weaknesses and limitations

# 29 July 2018 – BoM AVHRR 0.02deg L3S  NOAA 0.05deg Geo-Polar Blend L4

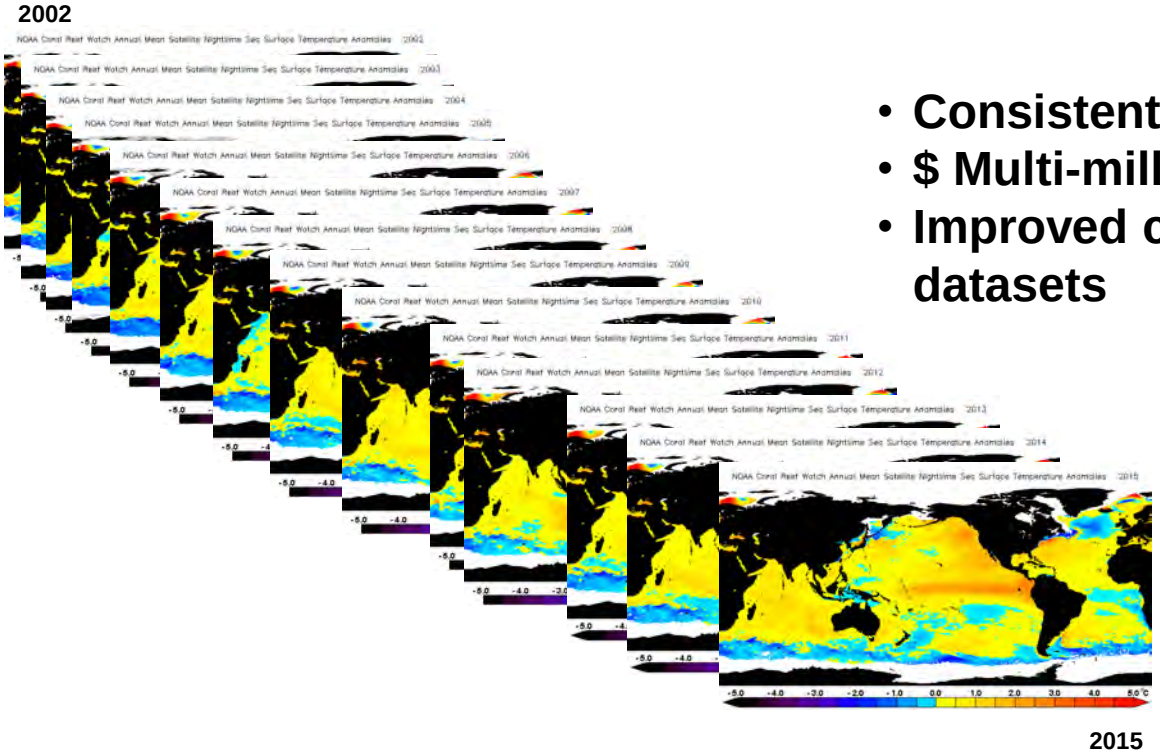
Helen Beggs, BoM




NOAA 0.05deg Blended L4 SST provides complete gap-free coverage.  Analysis process smooths the features.

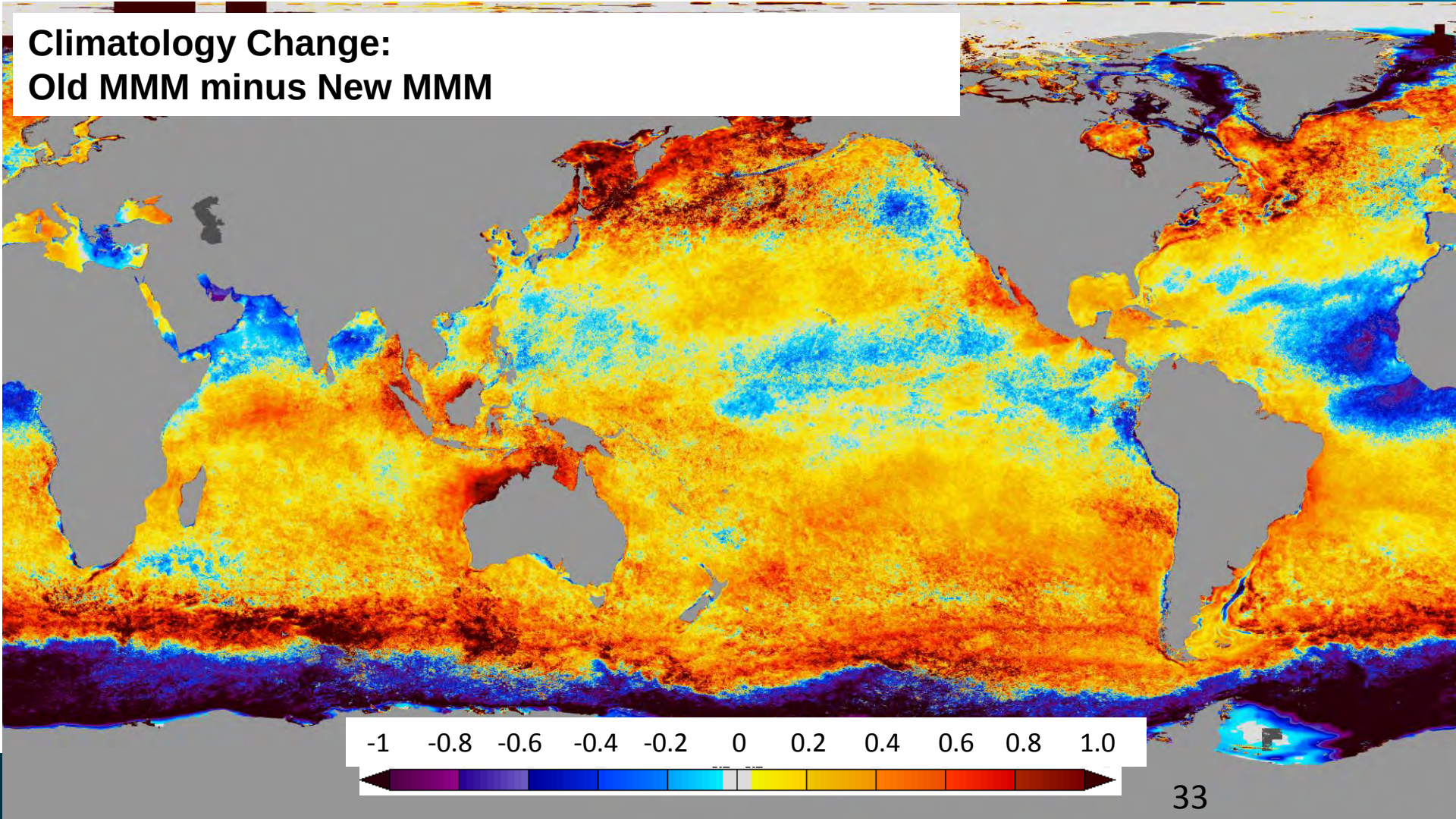
BoM collates IMOS HRPT AVHRR SSTs from NOAA-18/19 and VIIRS SST a into night-only L3S, multisensory. Testing as input for ReefTemp NextGen Coral Bleaching Nowcasting System.

# 5 km Geo-Polar Reprocessing

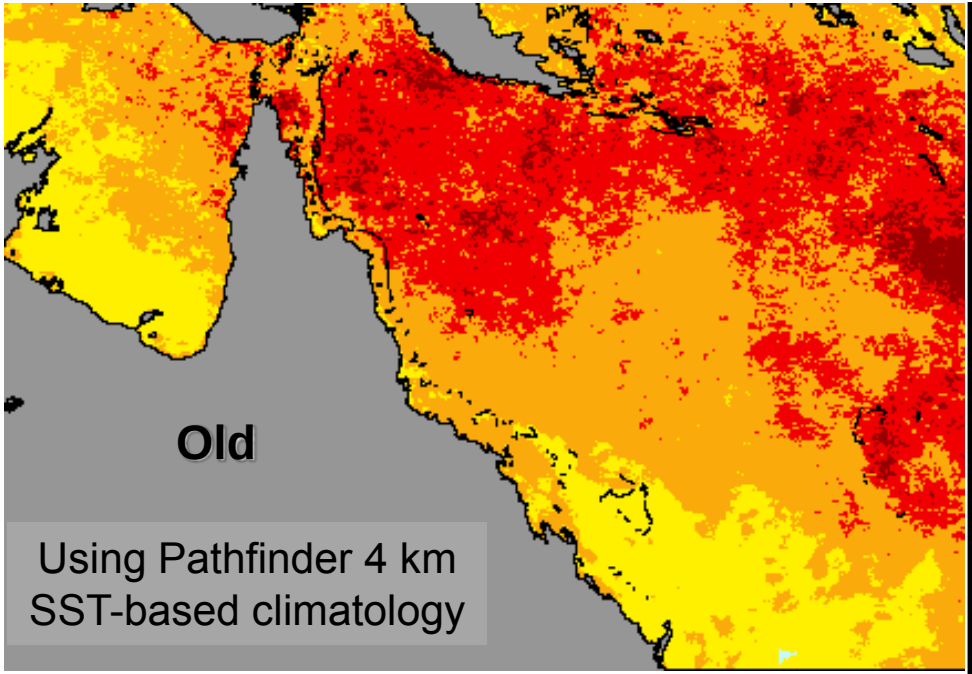


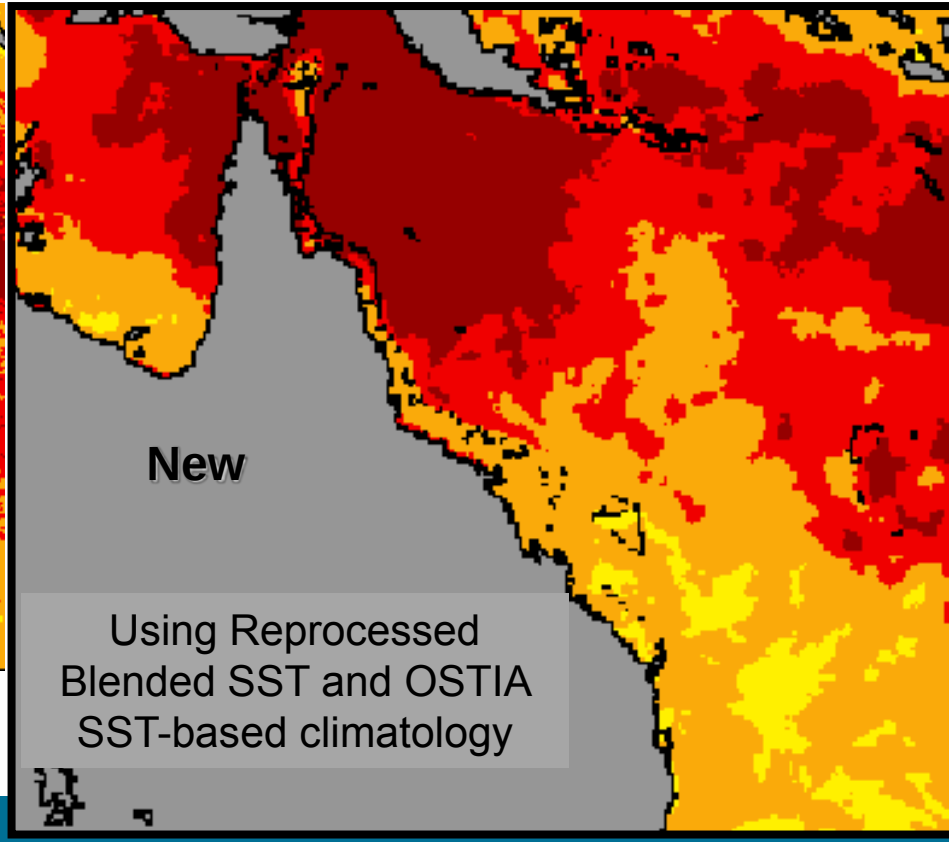

- **Consistent dataset 1994-2015**
- **$ Multi-million effort**
- **Improved climatology and datasets**

# Climatology Change:
# Old MMM minus New MMM



# Heat Stress using Improved 5 km Climatology



Australian Government
Bureau of Meteorology

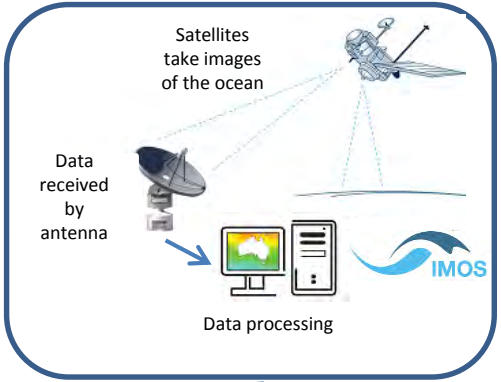
# Australian Satellite SST Products Suitable for Great Barrier Reef Studies

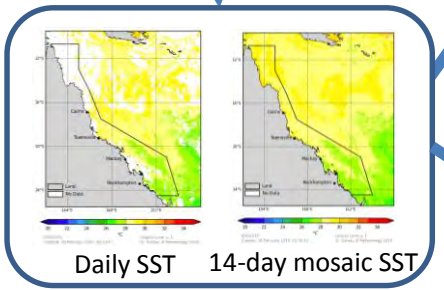
Helen Beggs[1], Christopher Griffin[1], Pallavi Govekar, Leon Majewski[1], Susan Wijffels[2,3], Madeleine Cahill[2], Edward King[2], Yuwei Hu[4] and Rob Johnson[1]

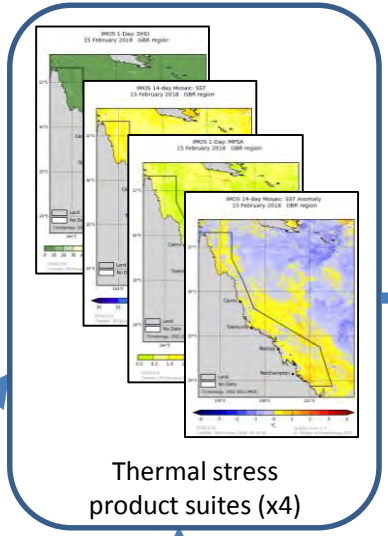
[1]Bureau of Meteorology, Melbourne, Australia
[2]CSIRO Oceans and Atmosphere Flagship, Hobart, Australia
[3]CSIRO Woods Hole Oceanographic Center, Woods Hole, USA
[4]University of New South Wales, Canberra, Australia

SST Over and Around Reefs Workshop, Townsville, Australia, 27th – 31st August 2018

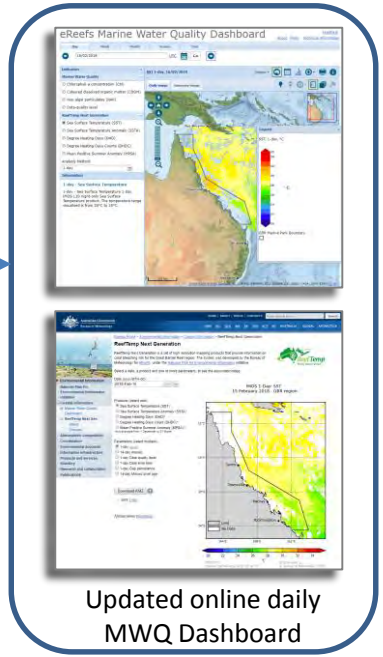
# ReefTemp Next Generation




IMOS AVHRR L3S
SST climatology
*2002-2011*

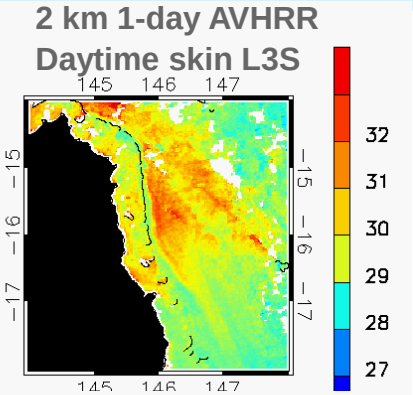


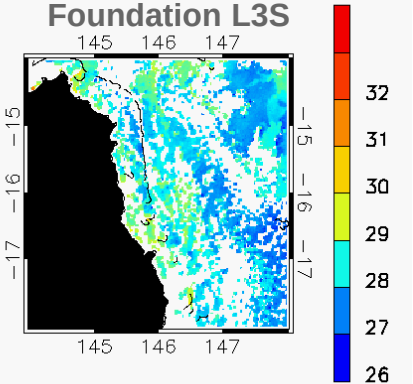

eReefs is a collaboration between:
GREAT BARRIER REEF foundation
Australian Government Bureau of Meteorology
CSIRO
Australian Government
AUSTRALIAN INSTITUTE OF MARINE SCIENCE
Queensland Government
Supported by funding from:
CARING FOR OUR COUNTRY
Queensland Government
SCIENCE AND INDUSTRY ENDOWMENT FUND
bhpbilliton resourcing the future
BMA BHP Billiton Mitsubishi Alliance

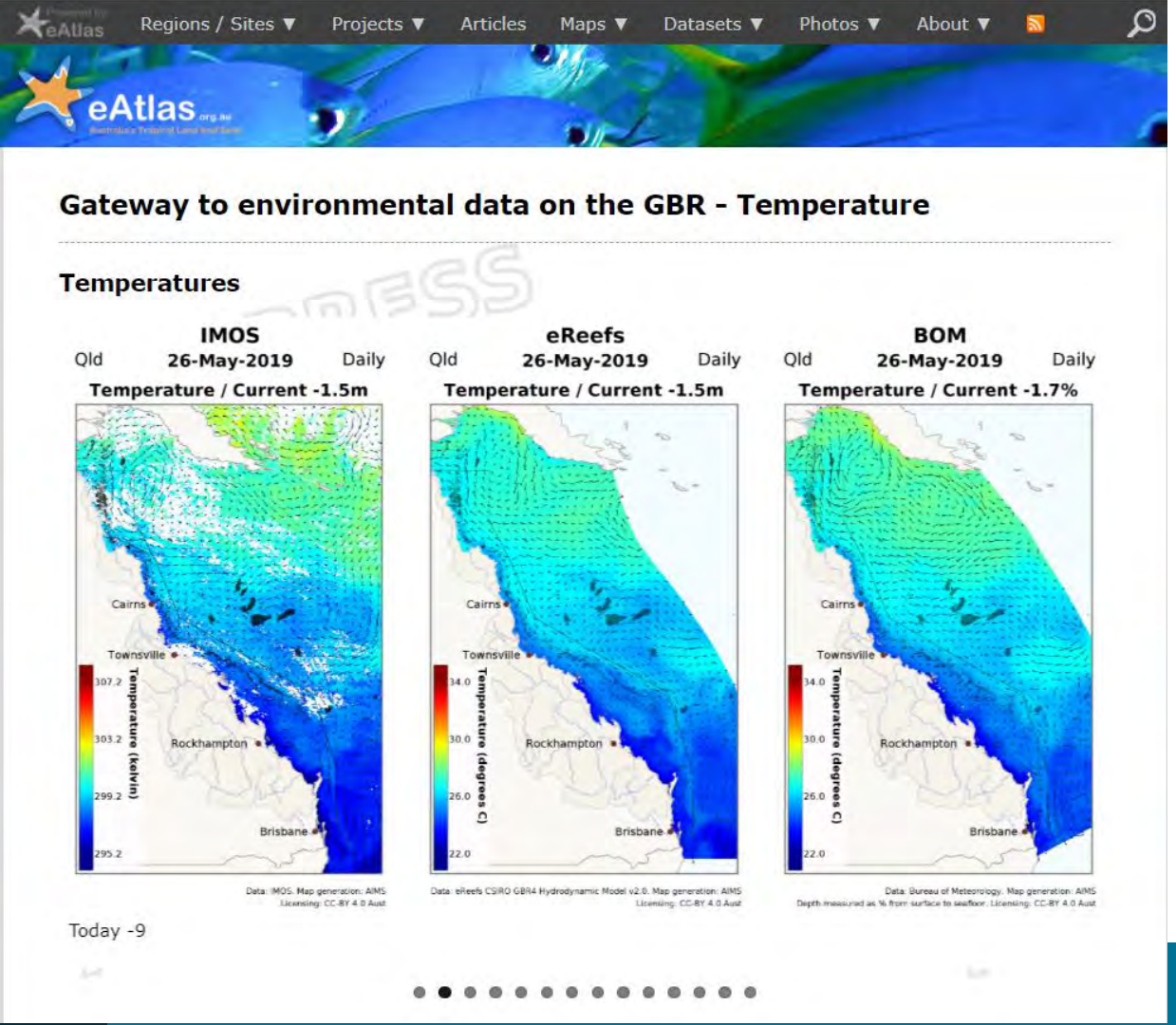
Australian Government
Bureau of Meteorology

# Things to consider when choosing an SST product…

- Depth – skin (~10μm), sub-skin or foundation (~10m)?
- Time – length/timeliness, local time of measurement
- Temporal resolution – what is characteristic time period of process?
- Spatial resolution of feature/process
- Spatial coverage – L3 composite vs L4 gap-free?
- Do you need microwave data to measure SST under cloud?
- Quality level (cloud contamination)
- Geolocation accuracy – native projection or gridded?
- SST accuracy – with respect to what reference?
- Stability of sensor and orbit



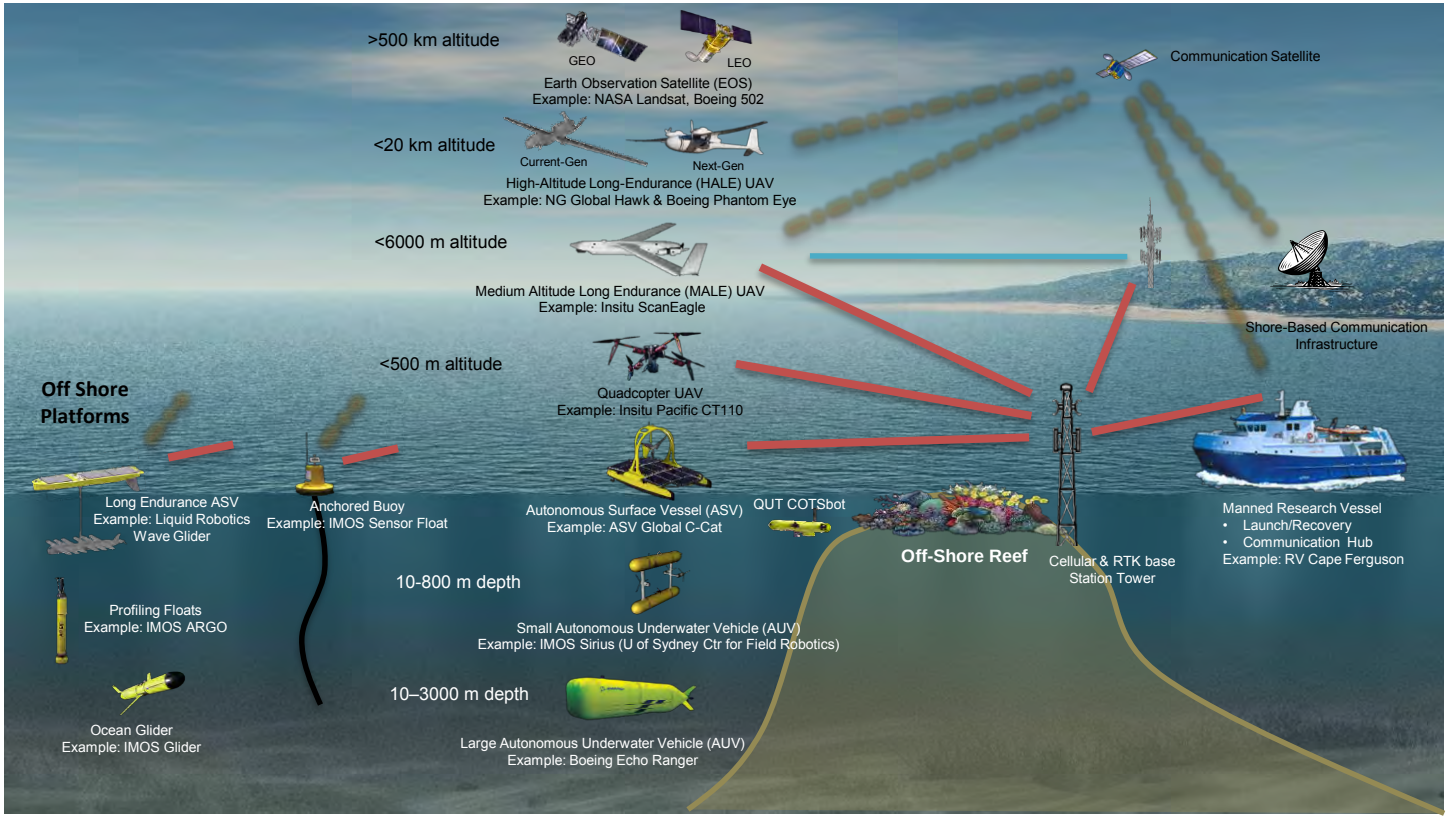



Observations and Model intercomparisons:

Products are often found on different locations with different ranges and colourbars

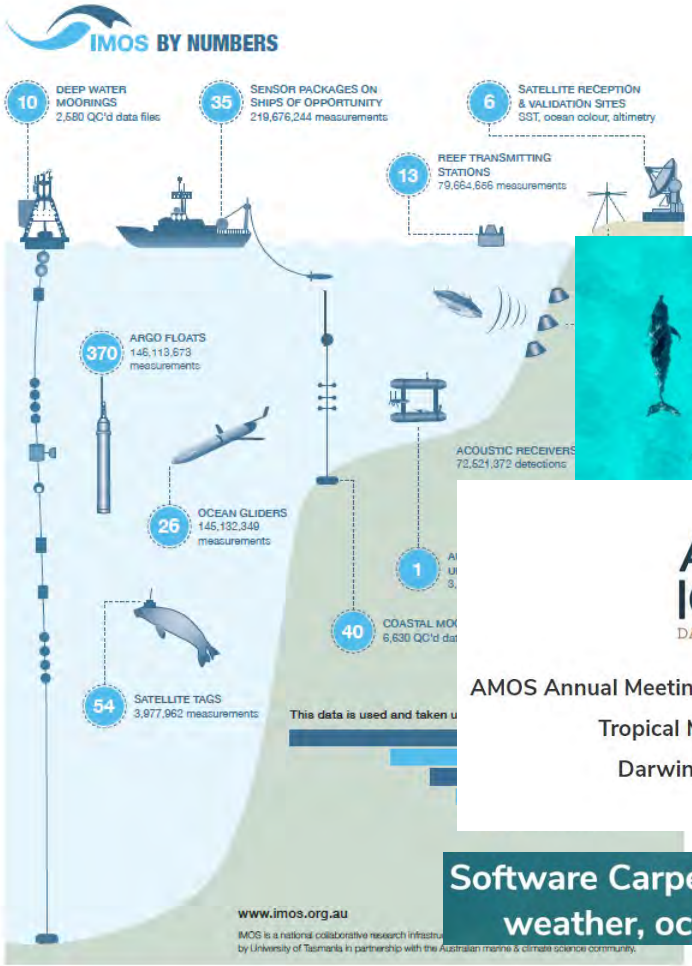
We can put them side by side and more readily compare them

# Layered Marine Observation System



IMOS Integrated Marine Observing System

Australian Government | Australian Institute of Marine Science





AMOS ICTMO 2019
DARWIN AUSTRALIA

AMOS Annual Meeting 2019 and the International Conference on Tropical Meteorology and Oceanography

Darwin Convention Centre, Australia

11-14 June 2019*

**http://imos.org.au/calendar/events/amsaimos2018**

Contact: c.steinberg@aims.gov.au
Location: Engineering & Maths Sciences Building, Room EMG06 at the University of Adelaide, The University of Adelaide, North Terrace Campus

AMSA 2018 ADELAIDE CANYONS TO COAST

AMSA 2019 MARINE SCIENCE FOR A BLUE ECONOMY 7-11 July 2019 Fremantle, Perth.

**Software Carpentry: Python masterclass for weather, ocean and climate scientists**

# SSTs Over and Around Reefs (SOAR) Workshop

**August 27-31, 2018, Townsville, Queensland, Australia**

# Thank you to all the participants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http://www.bom.gov.au/environment/doc/marine-heatwave-2016.pdf