Australian Government
Bureau of Meteorology

Land and ocean satellite data products from the Australian Bureau of Meteorology

Second Asia/Oceania Meteorological Satellite Users Conference

Ian Grant, Paul T. M. Loto'aniu, Leon Majewski and George Paltoglou
6 December 2011

Outline

Overview of AuBoM satellite use

Terrestrial data products

- Solar radiation
- AVHRR NDVI
- Grassland curing

Oceanography

- Overview
- AVHRR SST

National collaboration

- Satellite rainfall
- Evapotranspiration
- Data product distribution

Satellite data use in the Bureau

Most of the applications in the Bureau focus on the atmosphere

Weather and Warnings

- Timeliness = key factor
- **Forecasters** mainly use VIS, IR, WV products for nowcasting
  - e.g. cloud images, volcanic ash products, fog detection

Numerical Prediction Models:

- **Temperature and humidity soundings**
  - key sources - microwave and IR polar orbiting satellite data
  - GPS is an emerging data source (Radio Occultation and ground-based water vapour)
- **Wind**
  - scatterometers
  - satellite derived Atmospheric Motion Vectors

Earth-related applications:

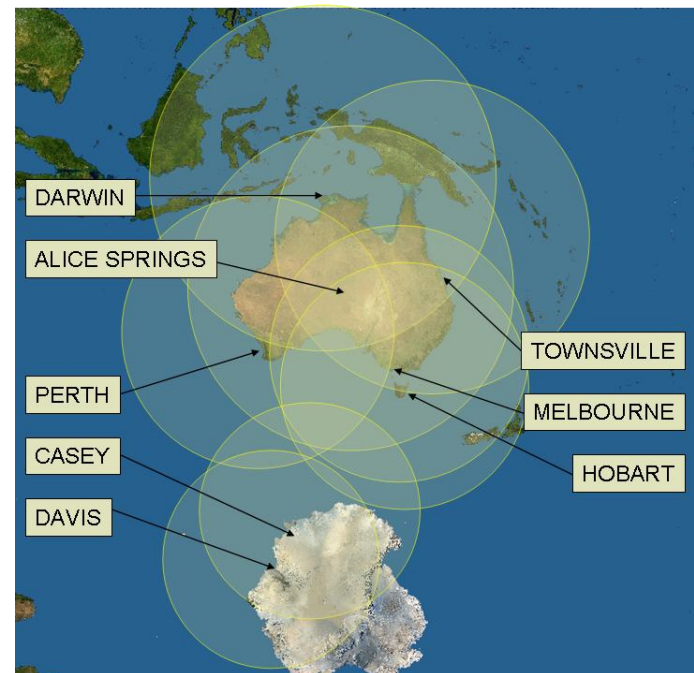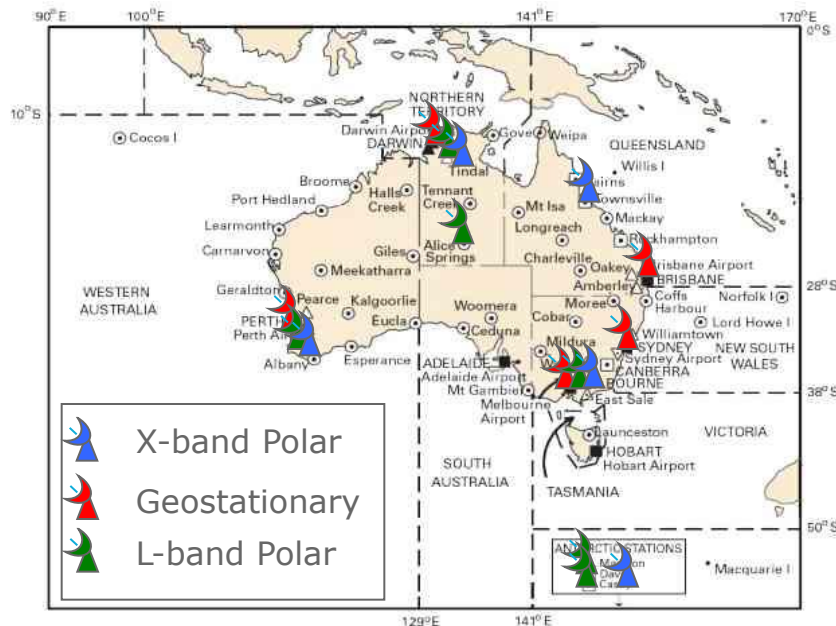- **Sea Surface Temperature, NDVI, Grassland Curing, Solar Radiation**

Direct Reception

Reception stations

- Geostationary (FY-2, MTSAT)
- L-band (NOAA)
- X-band (Terra, Aqua)

Preparing for FY-3, METOP, NPP

X-band Polar

Geostationary

L-band Polar

Operational Product Development

Terrestrial Applications

- Incoming Solar Radiation
- NDVI
- Grassland Curing

Marine Applications

- NOAA Sea Surface Temperatures
- MTSAT Sea Surface Temperature (NOAA Collaboration)

Atmospheric and NWP Applications
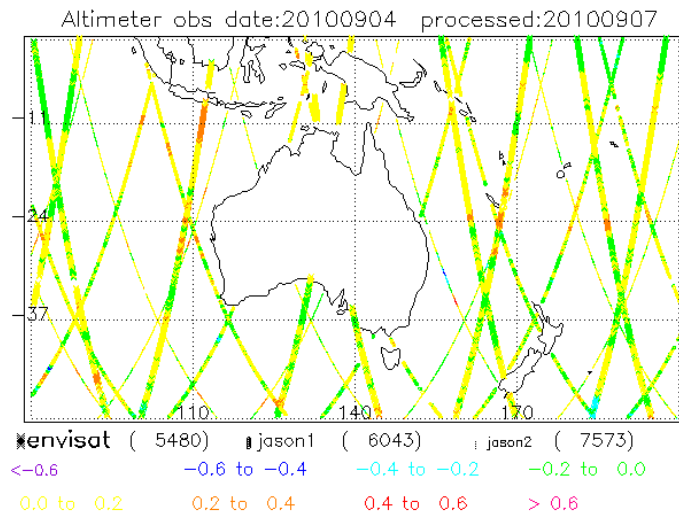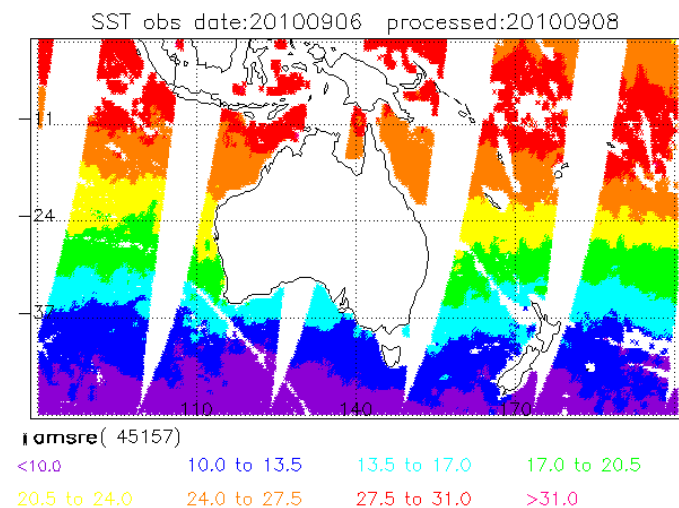
- Atmospheric Motion Vectors

Third party data – indirect reception

- Global sounder data (ATOVS, AIRS, IASI)
- Ocean Surface Topography: Envisat RA-2, Jason-1, Jason-2
- Sea Surface Temperatures: AATSR, AVHRR, AMSR-E
- Scatterometer winds
- Geostationary data from other regions (Meteosat, GOES)

Jason altimetry

Altimeter obs date:20100904 processed:20100907

AMSR-E SST

SST obs date:20100906 processed:20100908

*envisat (5480) jason1 (6043) jason2 (7573)

| <−0.6 | −0.6 to −0.4 | −0.4 to −0.2 | −0.2 to 0.0 |
| 0.0 to 0.2 | 0.2 to 0.4 | 0.4 to 0.6 | > 0.6 |

amsre(45157)

| <10.0 | 10.0 to 13.5 | 13.5 to 17.0 | 17.0 to 20.5 |
| 20.5 to 24.0 | 24.0 to 27.5 | 27.5 to 31.0 | >31.0 |

Solar radiation from GMS/MTSAT

Gridded datasets from GEO

- 0.05° grid over Australian land since 1990
- Validation with Bureau surface radiation network
- Time series: Hourly and daily
- Monthly climatologies: Hourly and daily
- Global horizontal and direct beam

Applications

- Renewable energy, building design and thermal management, agriculture, irrigation, water balance modelling
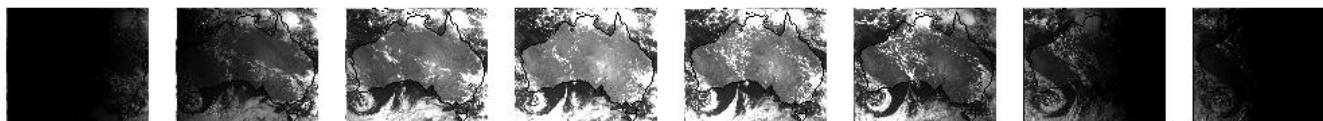

Hourly satellite and 1-minute surface global observations
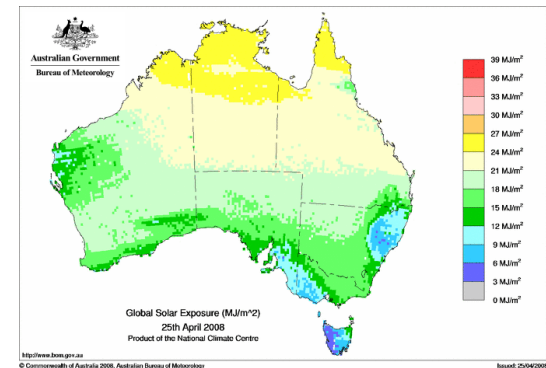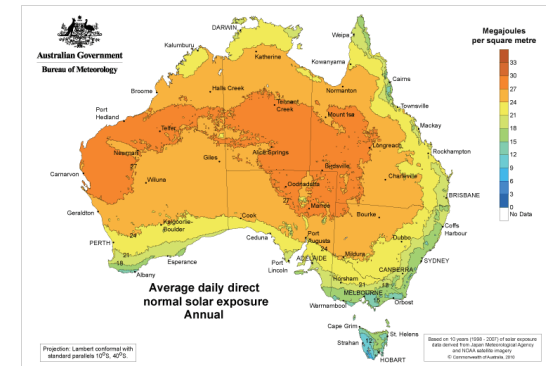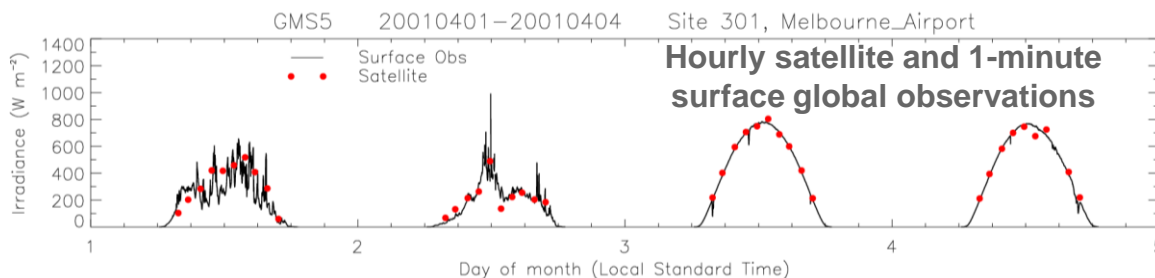
Satellite Solar Processing

Hourly satellite images

Physical model

Hourly global irradiance

Daily integration

Empirical conversion

Daily global exposure
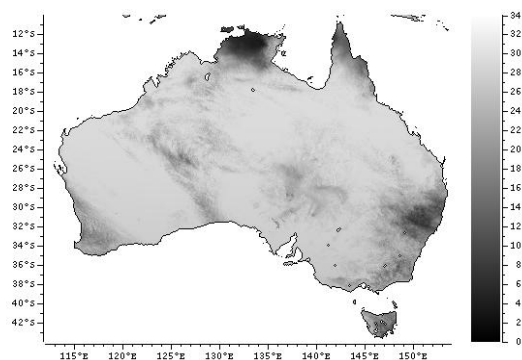
Hourly direct irradiance

432   532   832   932
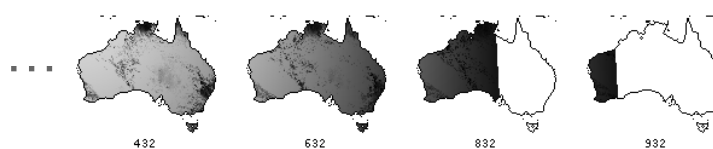
Satellite Solar Product Enhancement

**Integrate satellite and surface data**

- − Tune satellite to surface (e.g. bias removal)
- − Characterise satellite data uncertainties

Processing improvements

- − Detect georeferencing errors and scan anomalies
- − Eliminate bias in modelled global irradiance
- − Extra satellites to increase sampling frequency
- − Improve the global-to-direct model

Prepare for Himawari-8 from 2015

- − 10-minute images
- − Atmospheric and cloud parameters direct from the satellite data
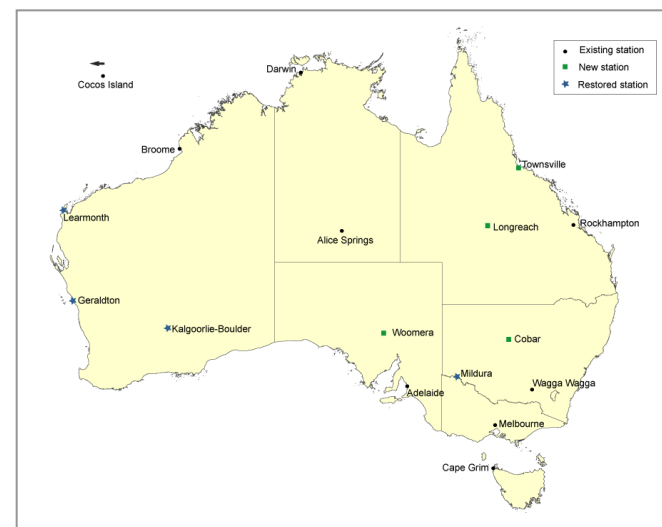
Solar radiation now/forecasting

Applications

- Power station and grid operation
- Electricity market operation

Approaches

- Forecasting from satellite observations (0-6 hours)
- Integration of satellite and NWP (0-24 hours)
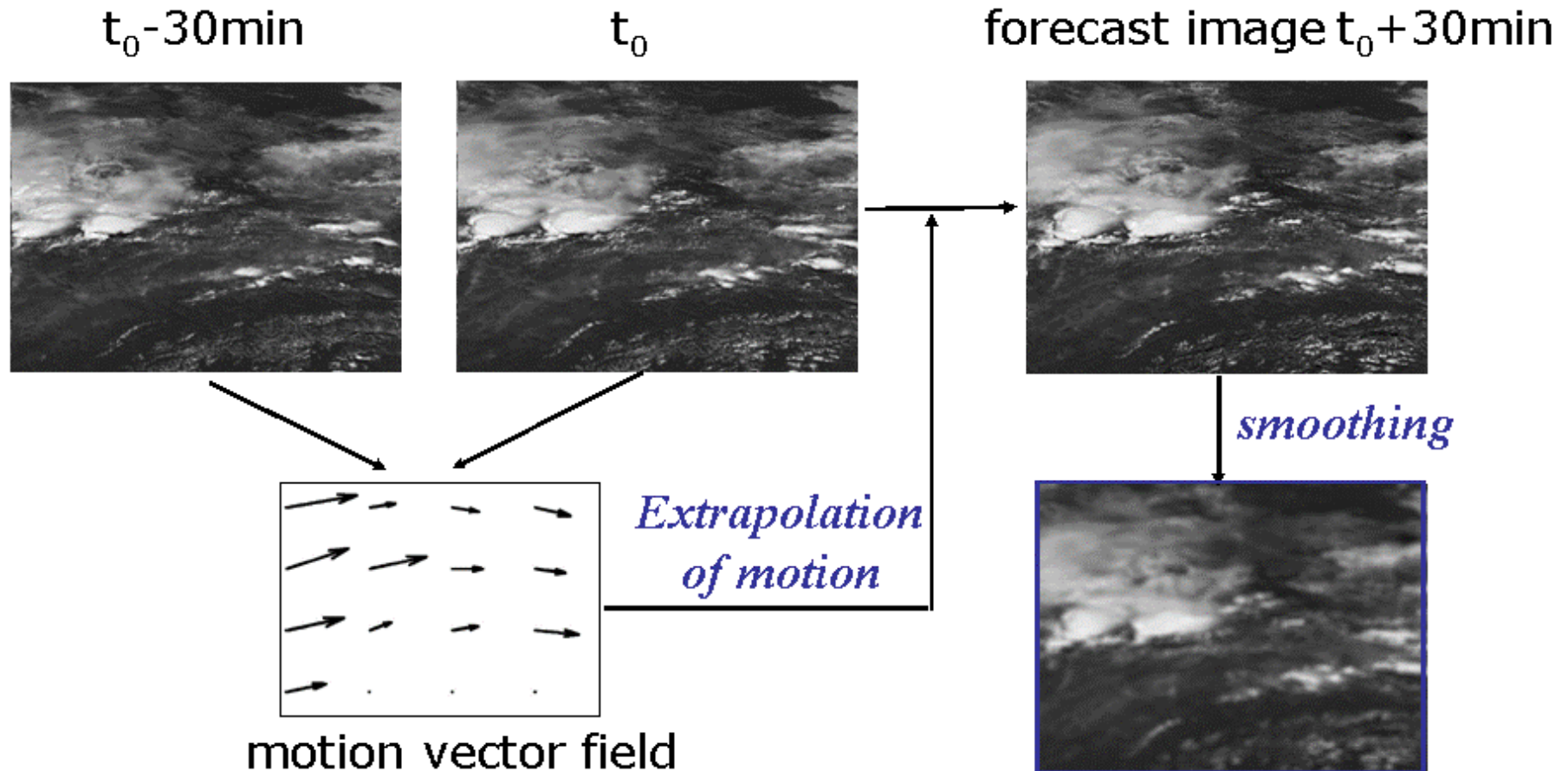- NWP and mesoscale models (1-3 days)

Himawari-8/9

- 10-minute images
- Better information on atmosphere and cloud properties

Forecasting solar radiation from satellite

Source: Univ. Oldenburg

NDVI from NOAA/AVHRR

Current product

- Monthly NDVI from LAC data:
- 1992 - ongoing
- Unified processing of CSIRO archive + BoM NRT
- Calibration drift normalised by assuming invariance of Australian arid sites
- No atmospheric or angular correction yet
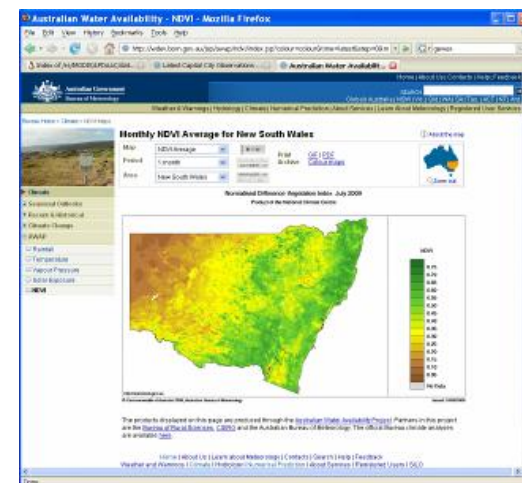
2012 work

- Implement MODIS-like (MOD43 product) processing
  - Atmospheric correction
  - Dynamic angular correction
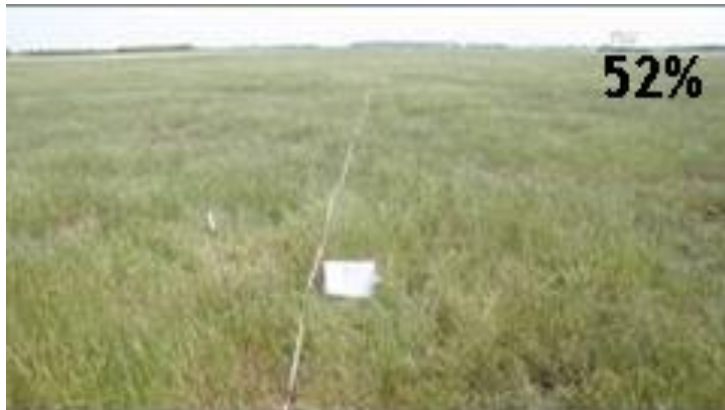- Revise calibration
  - GSICS? LTDR?

Grassland curing

Curing is the percentage dead of grassland / pasture / crop

- Used by bushfire agencies
- Input into fire danger rating system and fire behaviour models
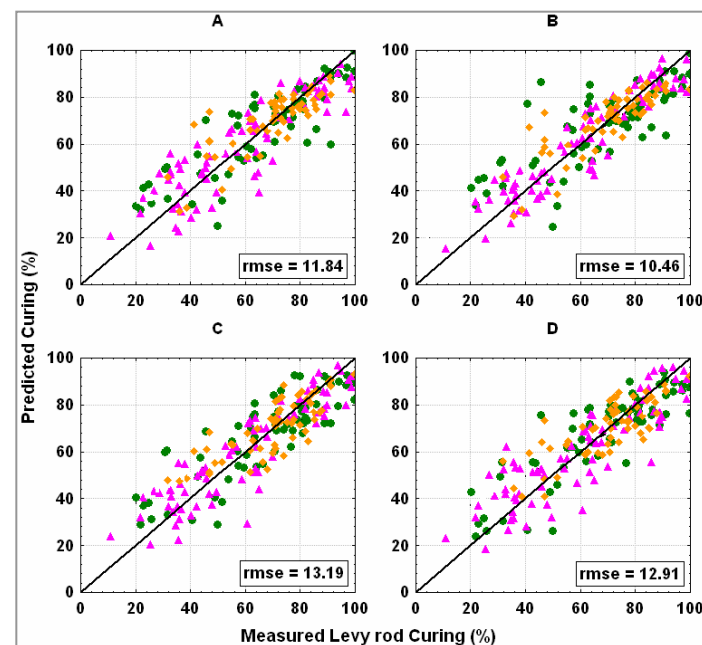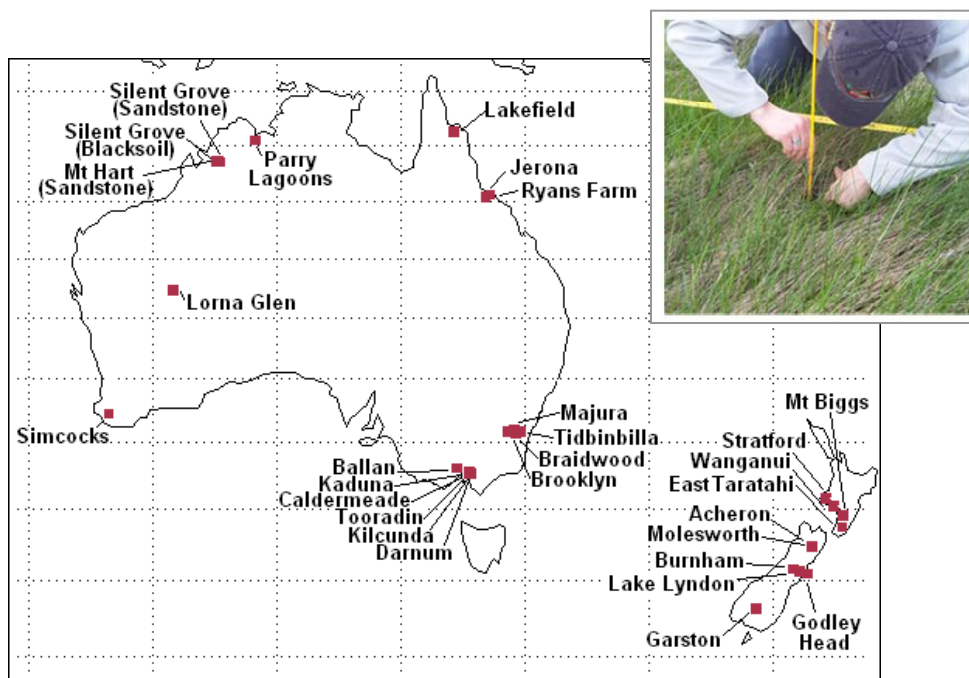- Visual estimates are sparse and can be inaccurate

Grassland curing

- **MODIS estimation of grassland curing** developed from field data
- Several algorithms tested

Grassland curing

Evaluation by state fire agency

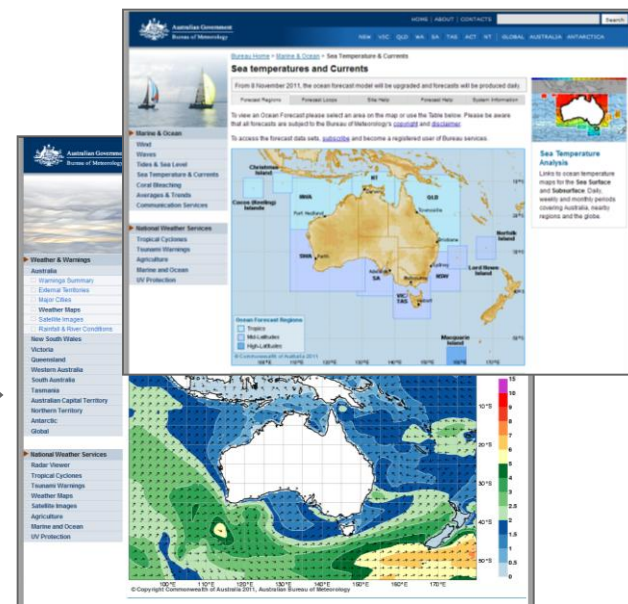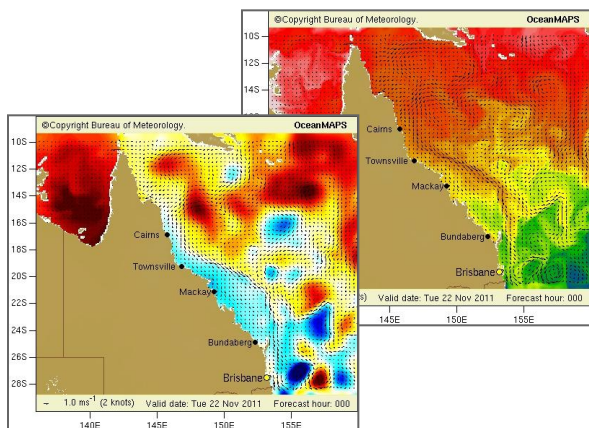**MODIS curing map**

One visual estimate per polygon
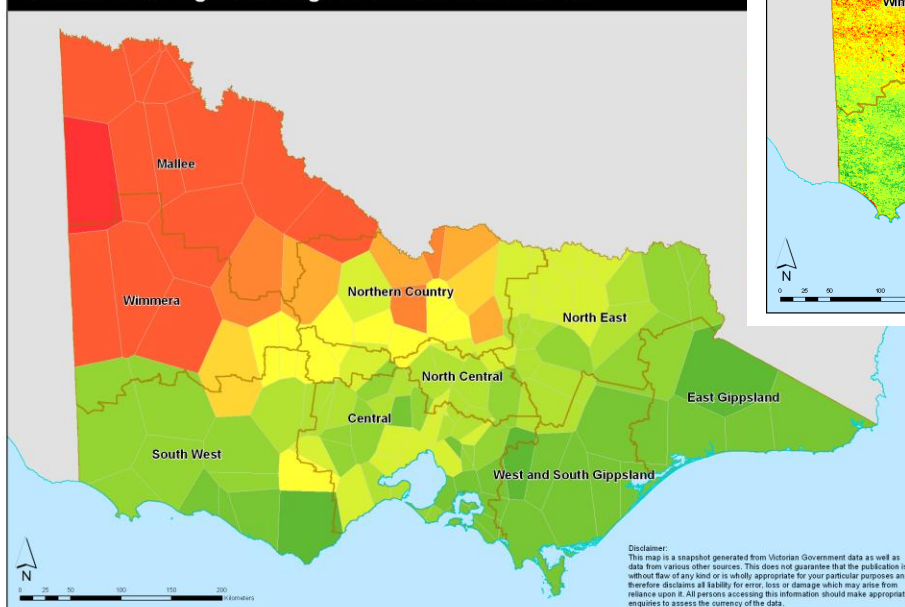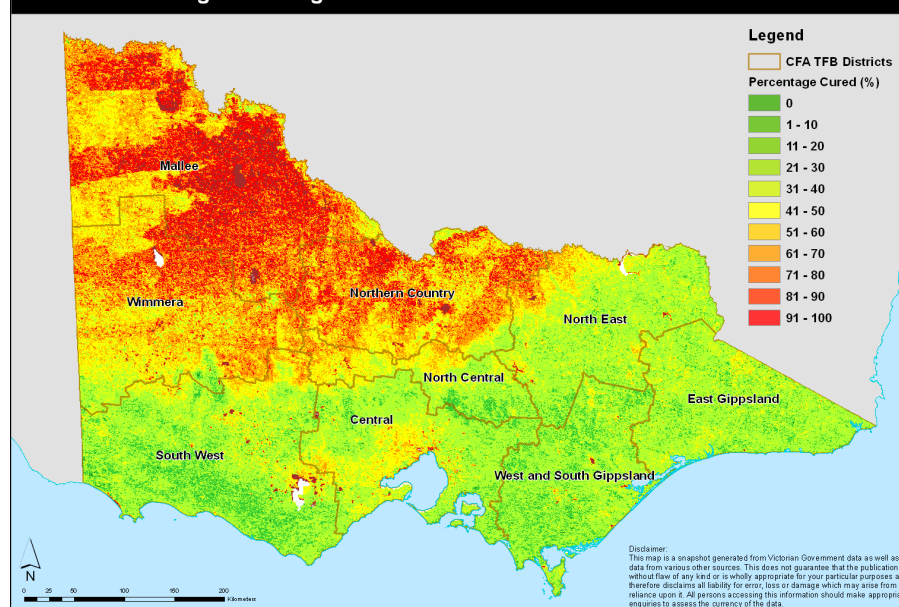
— Other states have sparser visual networks

Satellite Oceanography

Operational Satellite Oceanography Products for Ocean Observation, Analysis & Prediction (OOAP) and Weather and Warnings

- Ocean Surface Vector Winds
- Ocean Surface Topography
- Sea Surface Temperature

Ocean Analysis & Prediction   Forecaster Systems   Public Guidance

AVHRR Sea Surface Temperature

Australian Government
Bureau of Meteorology

BoM has achieved a substantial reduction in SST bias and std dev over existing AVHRR products

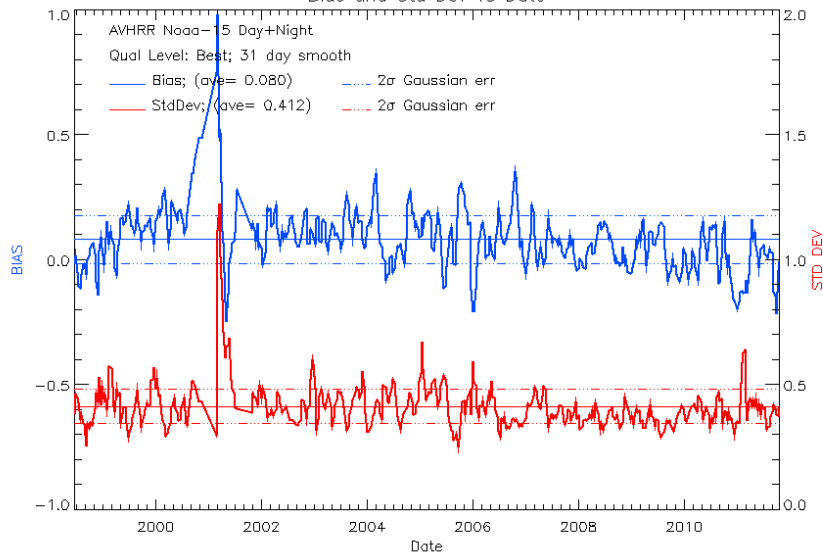Purely empirical approach, comparing AVHRR to drifting buoy SST

- Improved SST algorithm: SST = f(BT, airmass)
  - Used evolutionary algorithms to confirm best formalism
  - Ensured there are no pathologies as a function of latitude or satellite view angle (minimal southern latitude SST bias!)

- Reduced cloud contamination
  - Novel yet simple cloud masking method that reduces misidentification

- Improved long term stability
  - Empirical SST transform based on 'noise-immune' coefficients so that calibration is temporally stable
  - E.g. Achieved bias variations < $0.1°C$ over the lifetime of NOAA-17 (a tribute to the fine engineering of the AVHRR instrument)

SST std dev ~ 0.26°C night-time and ~0.35°C daytime for NOAA-17, 18 and 19 from > 50,000 high quality match-ups with drifting buoy SST
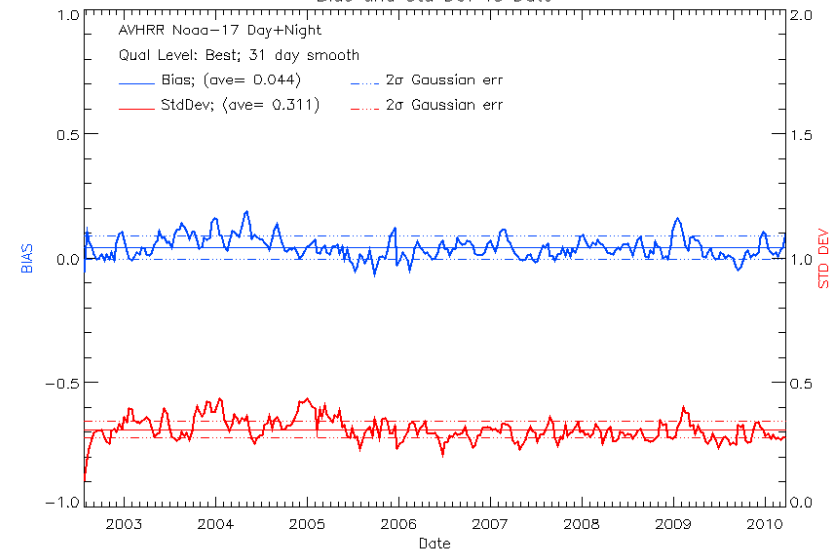
Day + Night Combined Statistics wrt Drifting Buoy SST
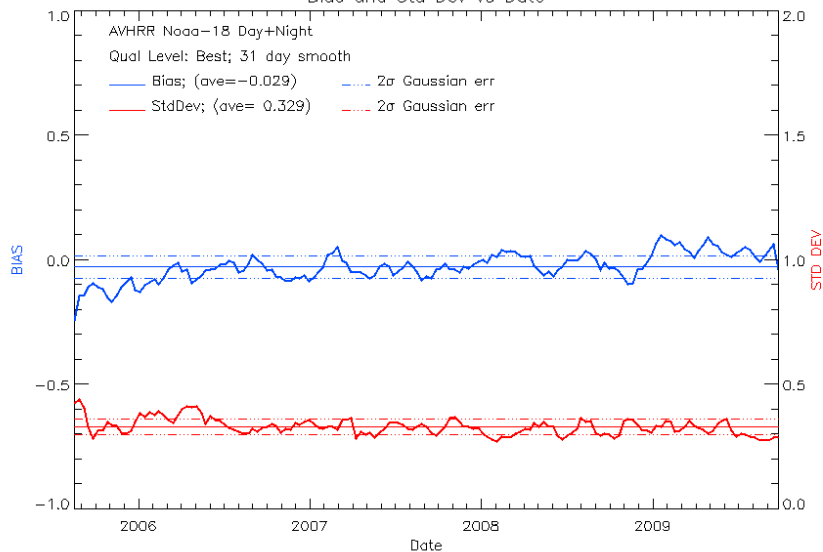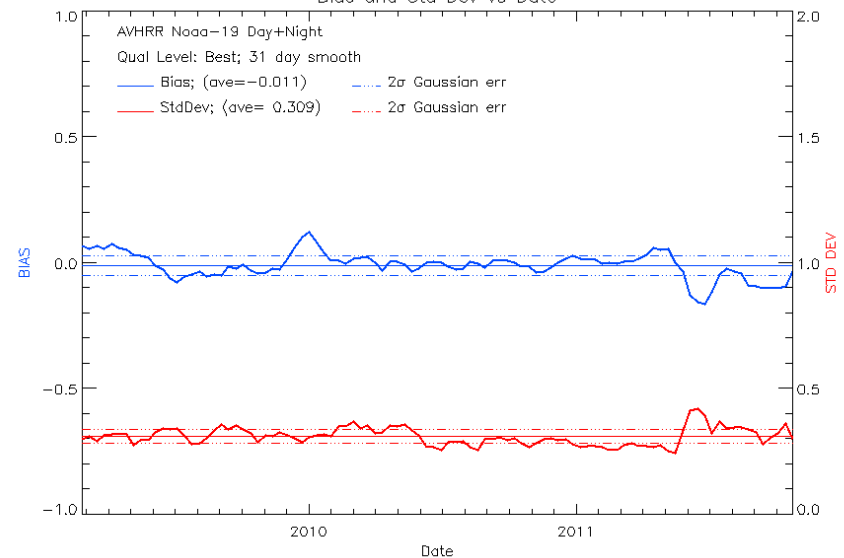
NOAA-15

Bias and Std Dev vs Date

AVHRR Noaa-15 Day+Night
Qual Level: Best; 31 day smooth
Bias; (ave= 0.080)   2σ Gaussian err
StdDev; (ave= 0.412)   2σ Gaussian err

NOAA-17

Bias and Std Dev vs Date

AVHRR Noaa-17 Day+Night
Qual Level: Best; 31 day smooth
Bias; (ave= 0.044)   2σ Gaussian err
StdDev; (ave= 0.311)   2σ Gaussian err

Bias
Std Dev

NOAA-18

Bias and Std Dev vs Date

AVHRR Noaa-18 Day+Night
Qual Level: Best; 31 day smooth
Bias; (ave=-0.029)   2σ Gaussian err
StdDev; (ave= 0.329)   2σ Gaussian err

NOAA-19

Bias and Std Dev vs Date

AVHRR Noaa-19 Day+Night
Qual Level: Best; 31 day smooth
Bias; (ave=-0.011)   2σ Gaussian err
StdDev; (ave= 0.309)   2σ Gaussian err
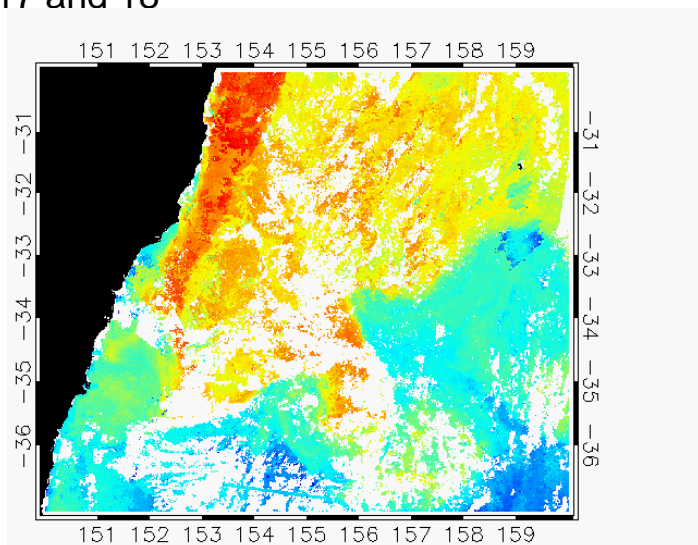
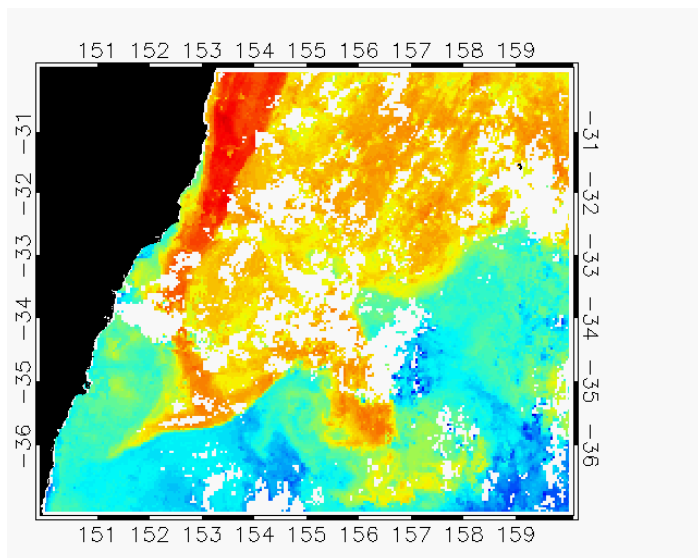# Different Australian HRPT AVHRR SST products for 9-11 Apr 2010

Legacy BoM 0.01° AVHRR Mosaic **L3** SSTblend from NOAA-17 and 18

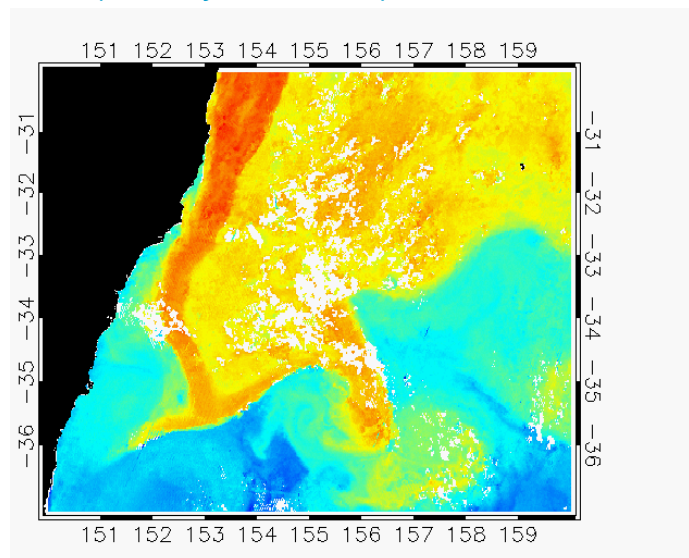**IMOS-BoM** 0.02° AVHRR **L2P** SSTskin from NOAA-17, 18 and 19 (Quality_level 5)

CSIRO 0.04° AVHRR **L3** SSTblend from NOAA-17 and 18
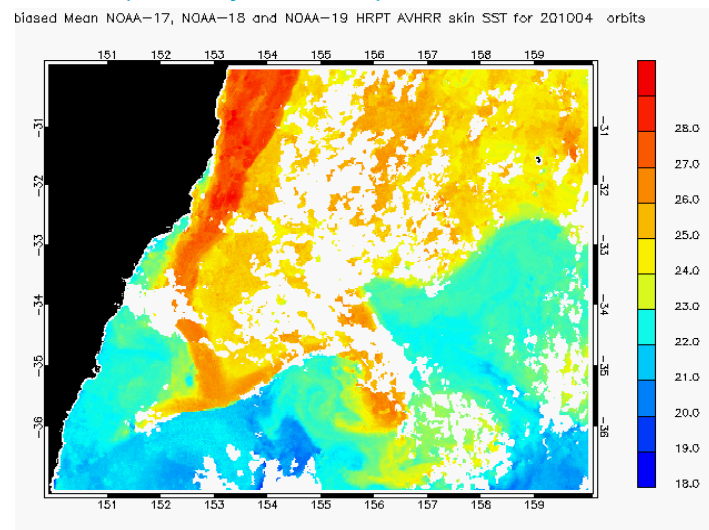
IMOS-BoM 0.02° AVHRR **L2P** SSTskin from NOAA-17, 18 and 19 (Quality_level > 2)

NOAA-15,-18,-19 6-day L3S Composite
70° W-170° E, 20° N-70° S
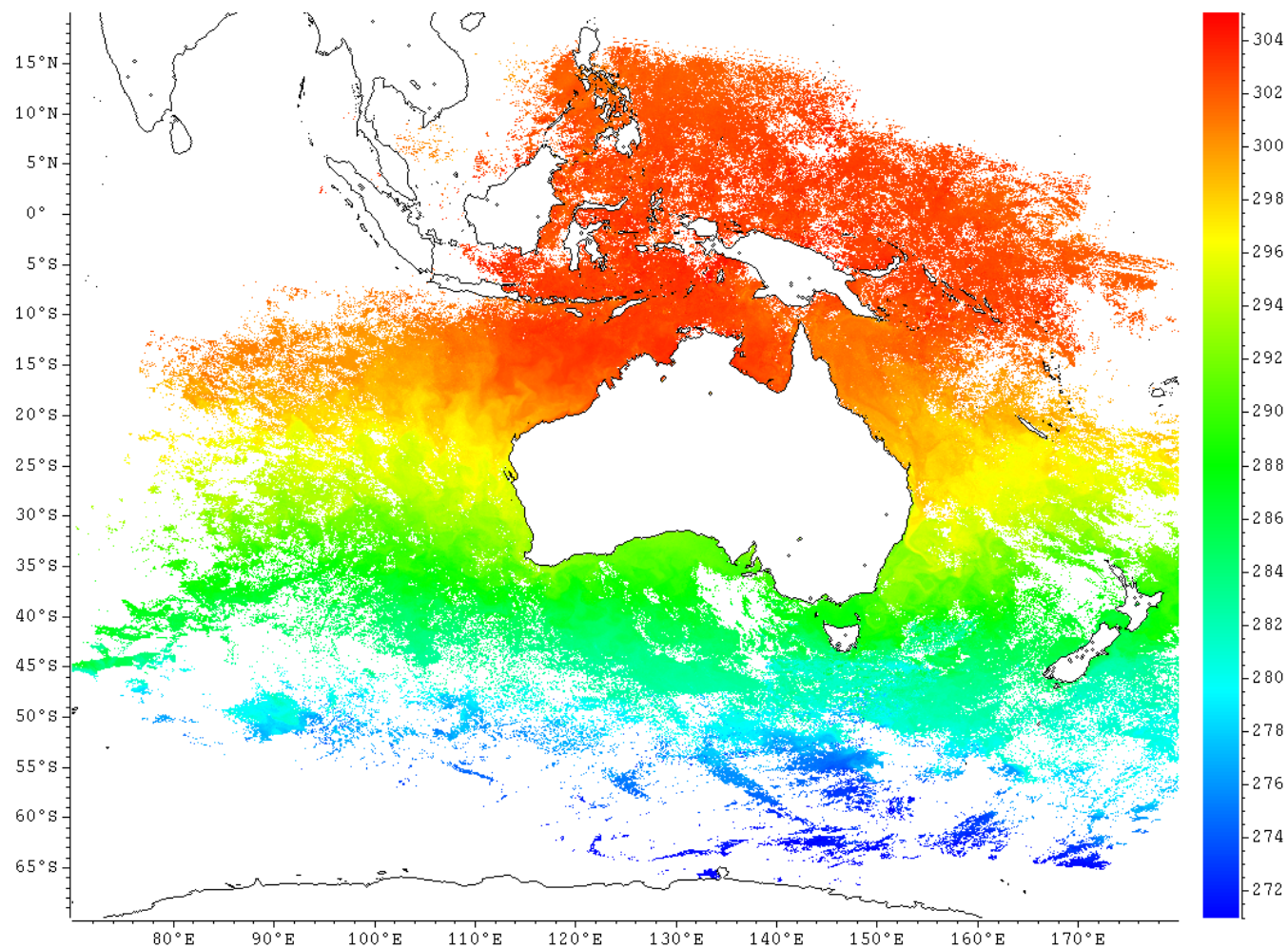
NOAA-19 1-day L3C composite
North-West Australian Coast
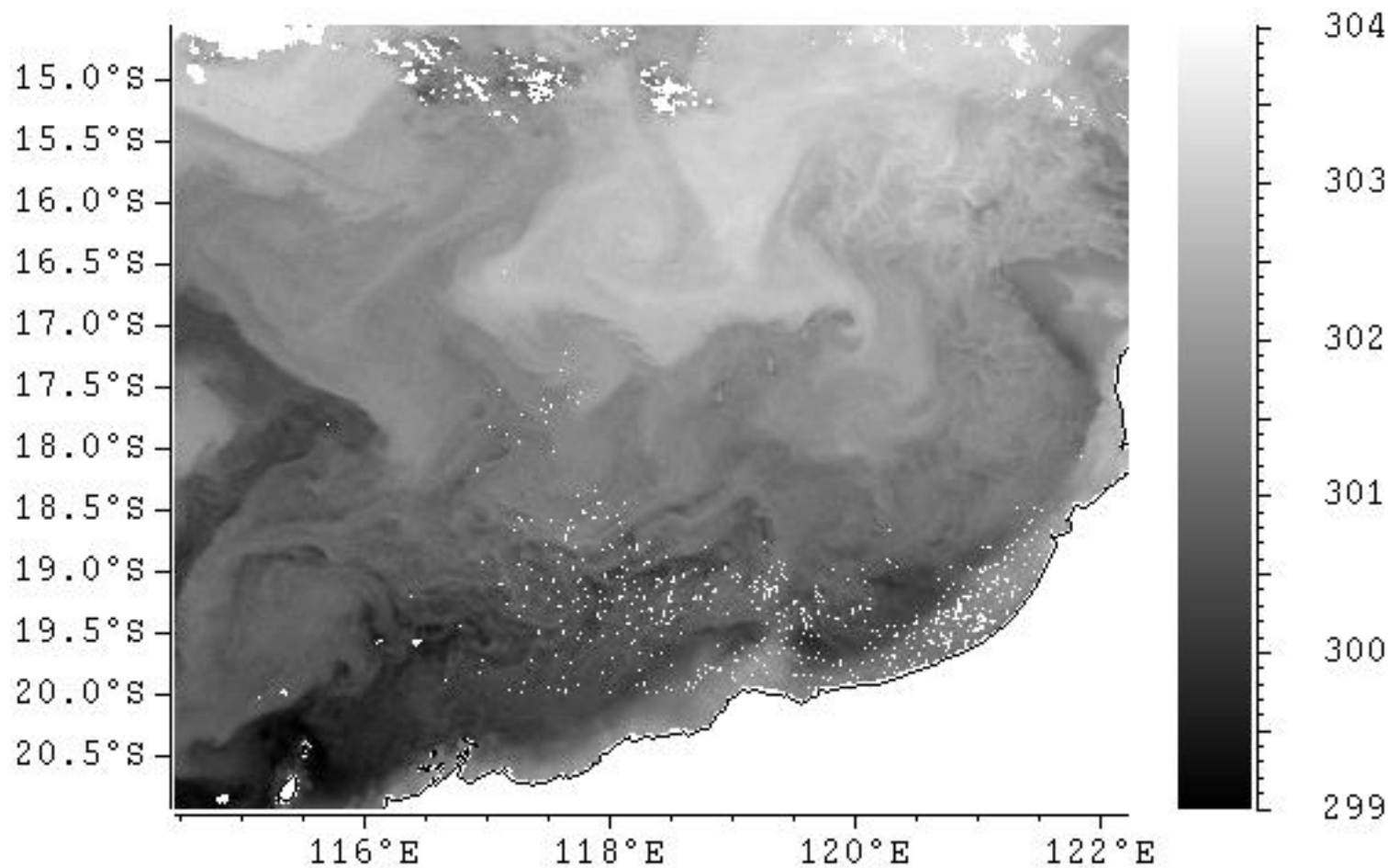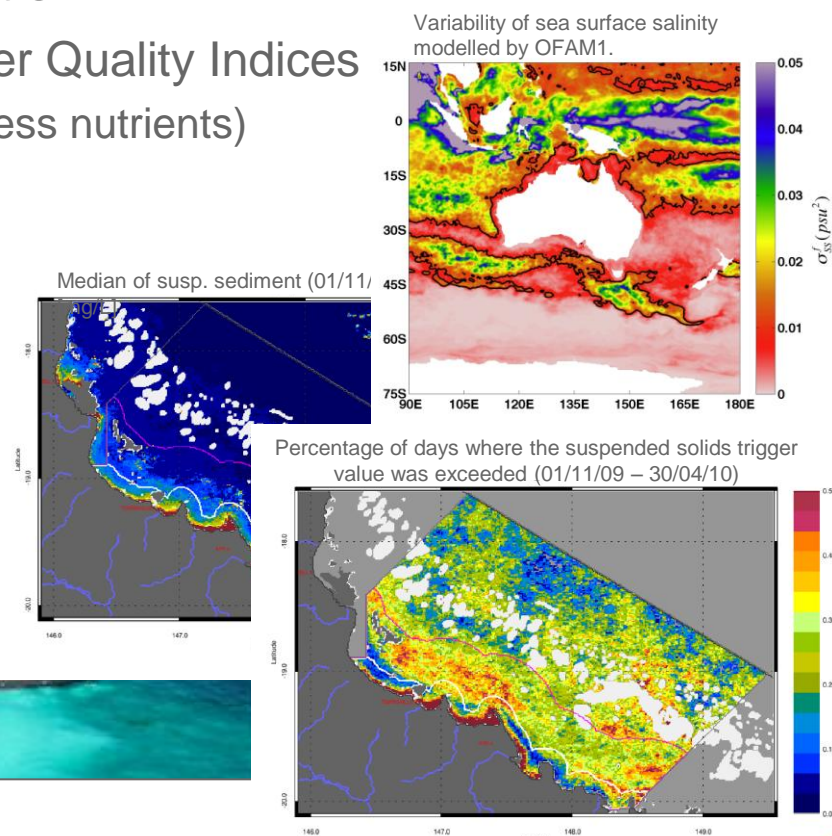
Satellite Oceanography

Australian Government
Bureau of Meteorology

Experimental Products for Ocean Observation, Analysis & Prediction (OOAP) and Environmental Information
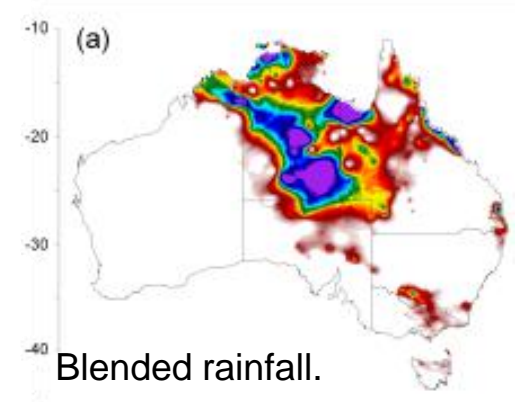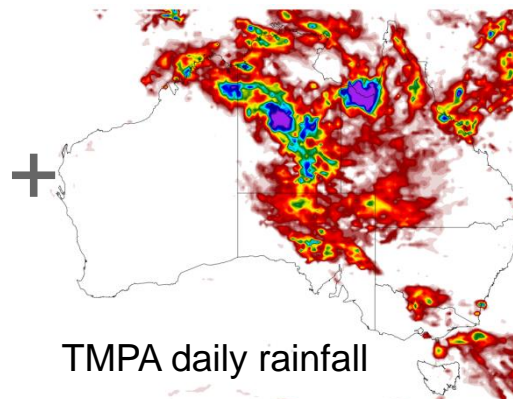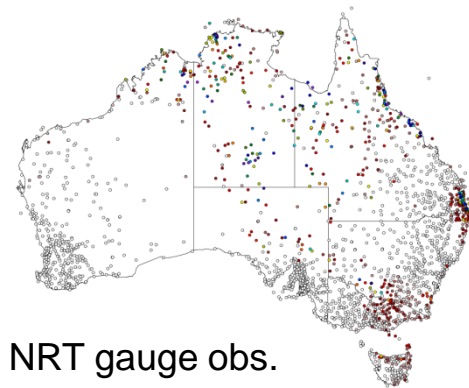
- Ocean Surface Reflectance for Water Quality Indices
  - Sediments and run off (tannins; excess nutrients)
  - Phytoplankton abundance
  - Light availability
- Sea Surface Salinity
  - Aquarius validation work

Variability of sea surface salinity modelled by OFAM1.

Median of susp. sediment (01/11/

Percentage of days where the suspended solids trigger value was exceeded (01/11/09 – 30/04/10)

CSIRO: Brando et al, 2010, Reef Rescue Marine Monitoring Program

National water accounting
- Surface-satellite blended rainfall

Merging rain gauge and TRMM rainfall
(CSIRO Land & Water - Luigi Renzullo)

NRT gauge obs.

+

TMPA daily rainfall

Blended rainfall.

Evapotranspiration estimation from MODIS (1-km, 8-day data)
(CSIRO Land & Water – Juan-Pablo Guerschman)

- Inflow event with dynamic surface water movement and vegetation response
- Requires spatial and temporal resolution of satellite data

300 km x 300 km in W. Qld from Feb. 2004

Modelled AET (Blue → Red)
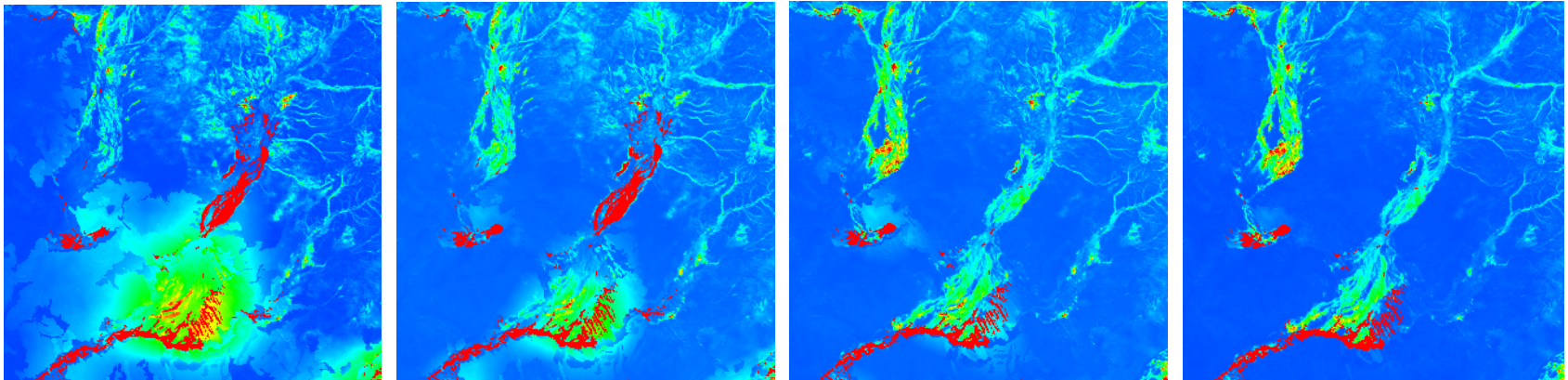
Terrestrial Ecosystem Research Network - AusCover

Terrestrial Remote Sensing and Spatial Data Facility

**Remote Sensing Data Delivery Backbone**
- Issues of data formats, interoperability, data-policy,
- Physical storage, efficient delivery to end-users etc.

Data Production Network
- Nationally-consistent, standard biophysical data products
- Metadata and technical support documents
- Specialised space-borne, airborne & in-situ data

Ground Validation Program and Instrumentation
- Set national standards & field validation protocols
- Sites/transects etc.
- International Benchmarking (eg CEOS WGCV LPV)
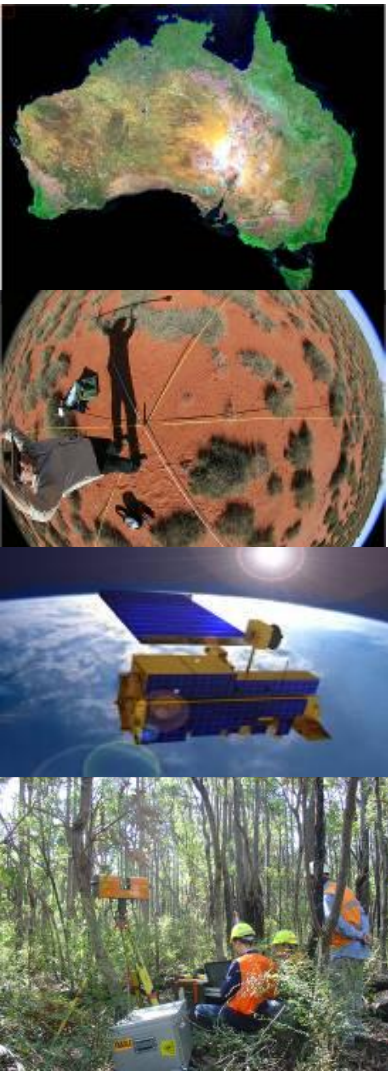
Thank you…

Presenter's name
Presenter's phone number
Email@bom.gov.au