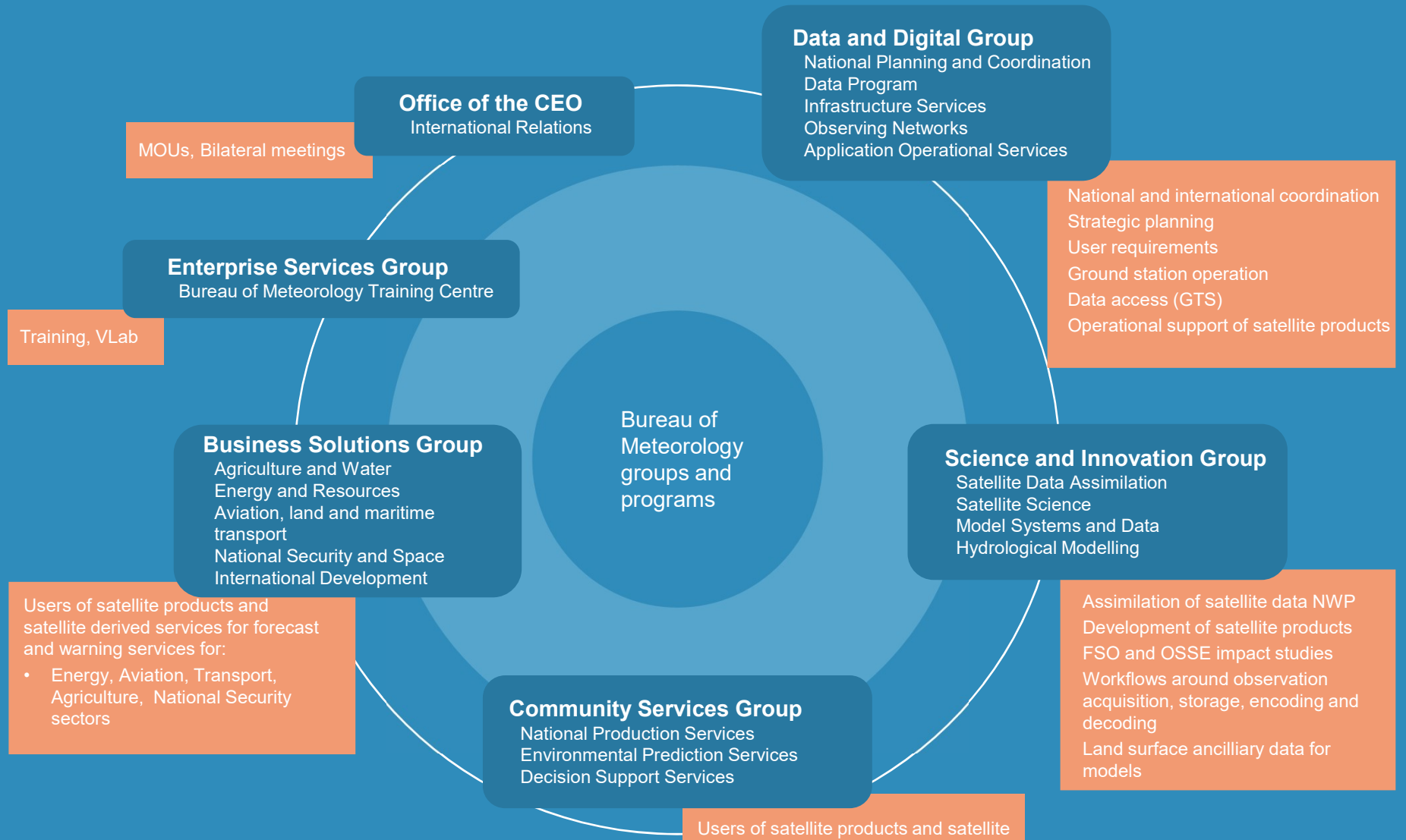
The Bureau of Meteorology

Satellite Activities at the Bureau of Meteorology

Agnes Lane

Ron Wilson, Nahidul Samrat, Chris Rudiger, Leon Majewski, Caroline Poulsen, Jarrad Denman, Luigi Renzullo

Satellite data activities across the Bureau



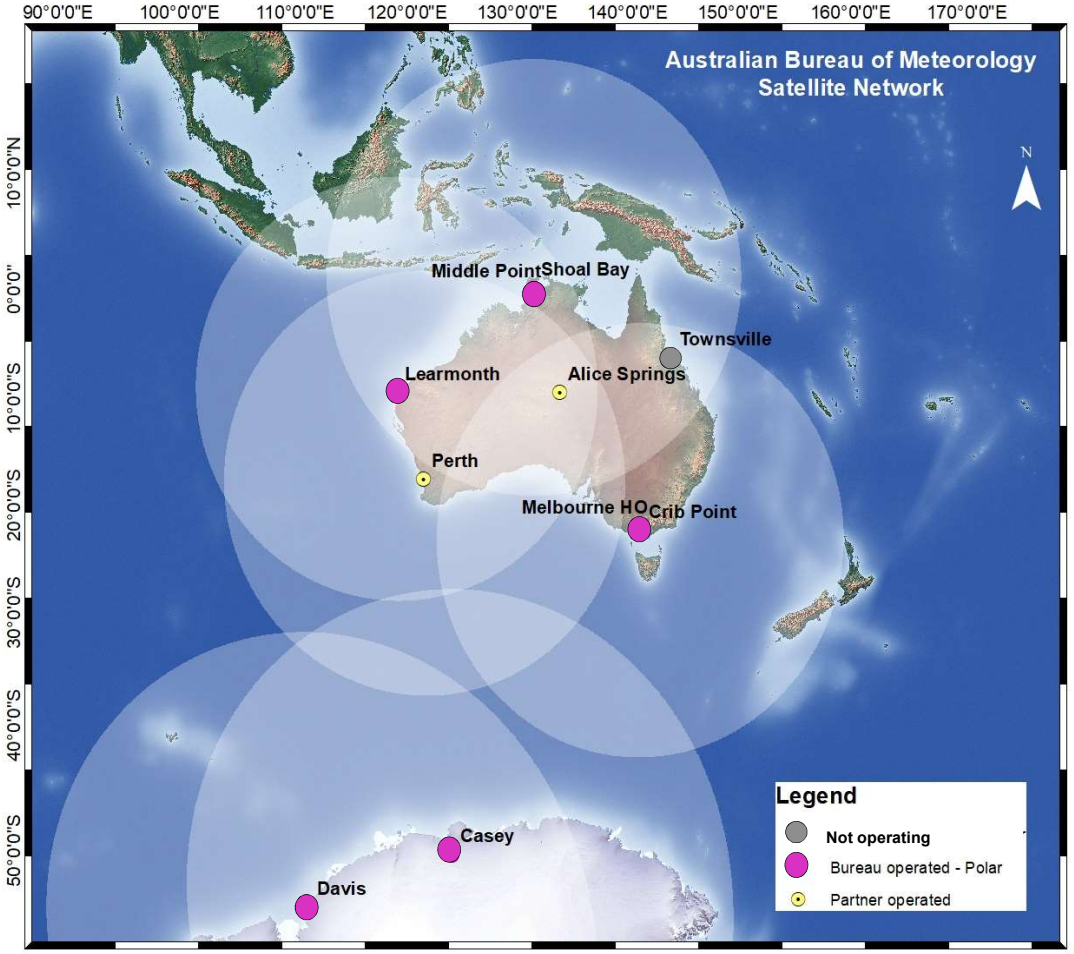
The Bureau's ground station network

Ground network includes:

- 5 polar tracking ground stations (Crib Point, Learmonth, Shoal Bay, Casey, Davis)
- COSMIC-2 (Middle Point)
- FY-2

Satellite data received:

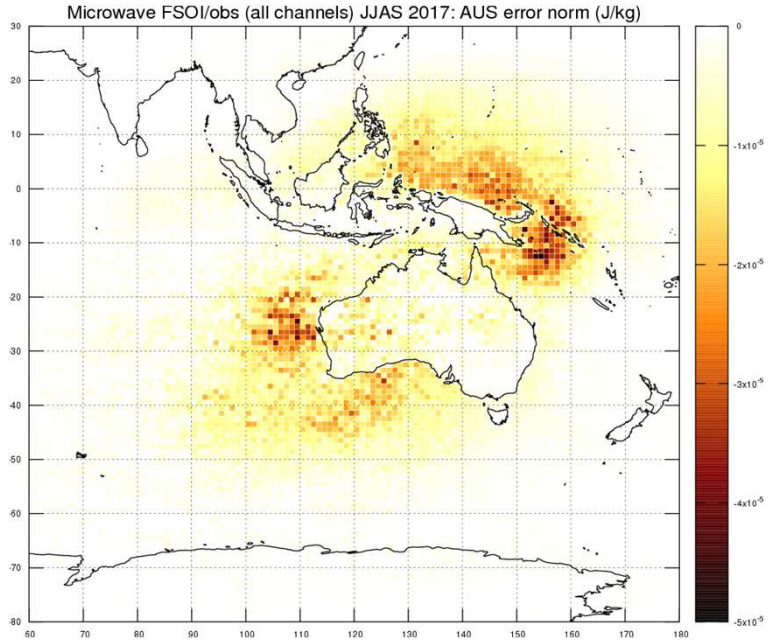
- NOAA-18
- NOAA-19
- NOAA-20
- Terra
- Aqua
- SNPP
- METOP-B
- METOP-C



Direct Broadcast Network (DB-Net)

The Bureau's polar tracking ground stations are part of DB-Net, providing low latency data for NWP. The following sounding instruments are processed at these stations for use in our global (ACCESS-G) and convective scale (ACCESS-C) models:

- ATOVS (HIRS, AMSU-A and AMSU-B or MHS) from NOAA-18, NOAA-19, Metop-B, Metop-C (microwave and limited infrared sounding)
- IASI from Metop-B and Metop-C (hyperspectral infrared sounding)
- CrIS from S-NPP and NOAA-20, soon NOAA-21 (hyperspectral infrared sounding)
- ATMS from S-NPP and NOAA-20, soon NOAA-21 (microwave sounding)



FSOI per observation for microwave sounders aggregated into 1°x1° bins during June to September 2017. The darker areas indicate greater beneficial impact from the observations.

Satellite Data Assimilation: observations & requirements

ACCESS-G
(global model)

NOAA-15
NOAA-18
NOAA-19
DMSP F-17
Aqua
SUOMI-NPP
NOAA-20
METOP-B
METOP-C
GCOM-W1
Himawari-9
GNSS-ground (various)
GOES-16
GOES-17
FY-3C
FY-3D
Meteosat-8
Meteosat-11
Sentinel-3A
Sentinel-3B
ScatSat-1
TerraSAR-X
Tandem-X
GRACE (2 sats)

Locally-received observations from Metop-B/C, NOAA-18, -19, -20, SNPP, Terra, Aqua

OceanMAPS
(ocean model)

Sentinel-3A
Sentinel-3B
Jason-3
SARAL
Cryosat2
Sentinel-6
Various satellite SSTs

Future:
SWOT (wide swath altimetry)

SSMIS and AMSR-2 ice concentration

SAR

AWRA-L
(hydrological model)

SMAP
AMSR2

ACCESS-S2
(seasonal model)

Satellite SSTs

(Initial conditions from ACCESS-G)

Future:
Satellite altimetry

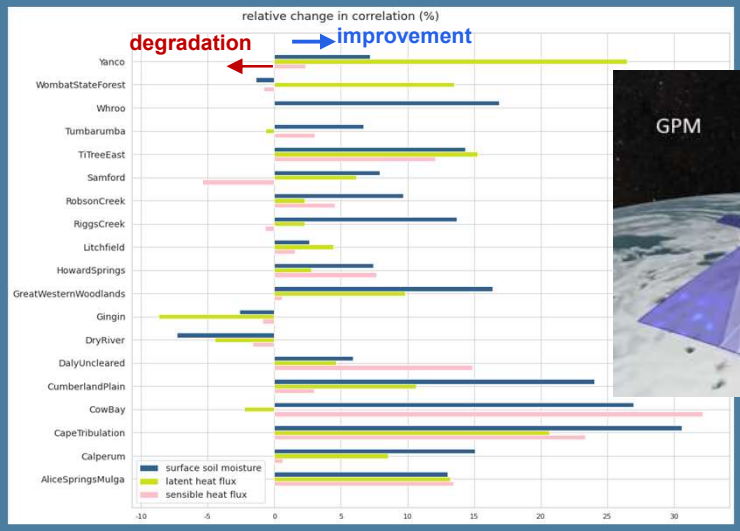
Satellite data requirements are coordinated internationally by the GODEX-NWP

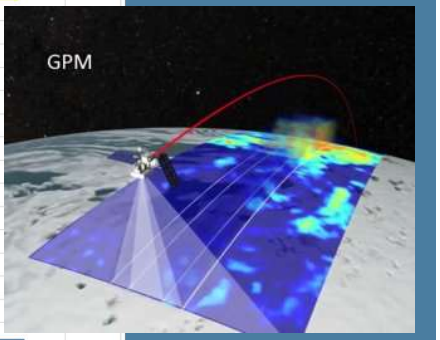
(meeting next week, 14-17 November)

Improving the global model with land data assimilation

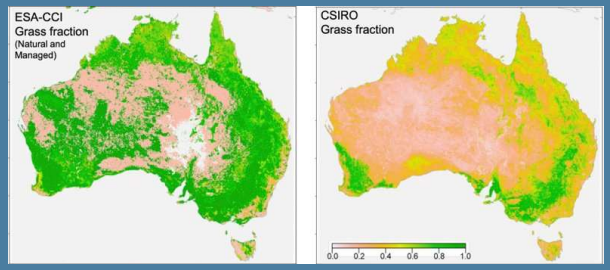
Hydrological Modelling Team

Using **GPM** with Australian Gridded Climate Data (AGCD) for high resolution sub-daily estimates of rainfall. Improvements in soil moisture and heat flux in most test sites

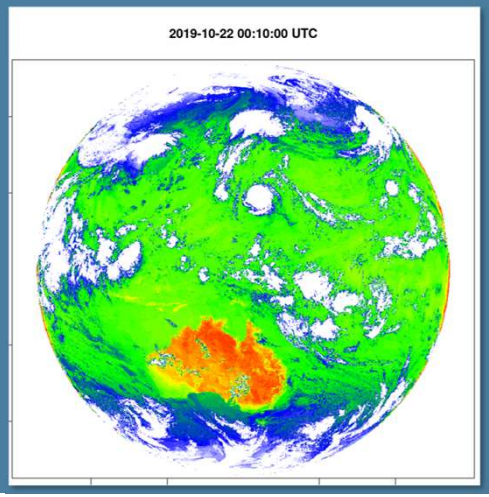




Replacement of ESA land cover maps with **VIIRS, MODIS, Landsat** and ESA CCI to better characterise land cover for Australian conditions



Himawari Land Surface Temperature algorithm (with ANU and UK Met Office)



Assimilating Himawari Radiances in the Bureau regional system

Dr Nahidul Samrat, Satellite Data Assimilation Scientist

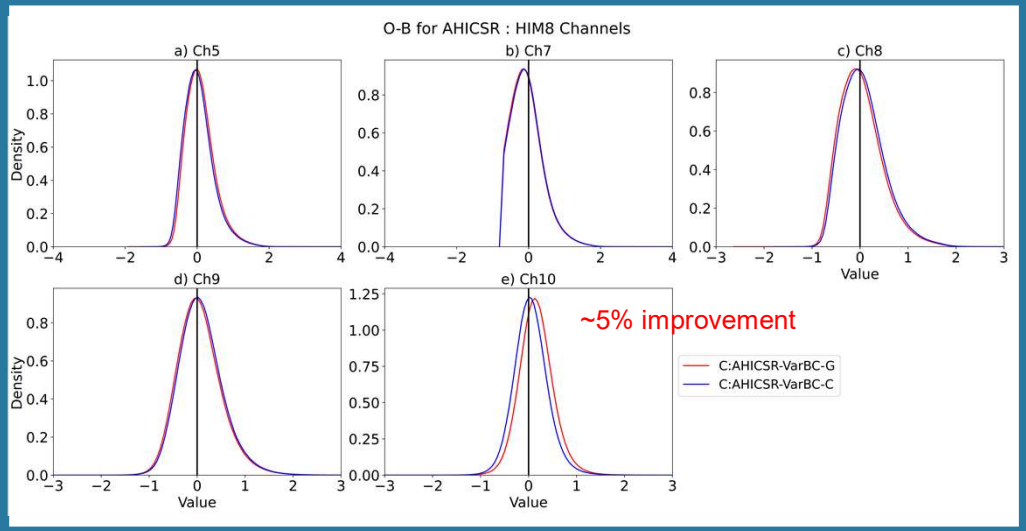
- Himawari delivers enhanced spatiotemporal resolution data compared to other satellites.
- Challenges assimilating these data into the regional (high resolution) model:

  R1) Optimal bias correction framework

  R2) Correlated observation error
- The purpose of this research: to examine the impact of assimilating Himawari CSRs into the regional model

Himawari CSRs can improve the predictability of Australian regional weather forecasts.

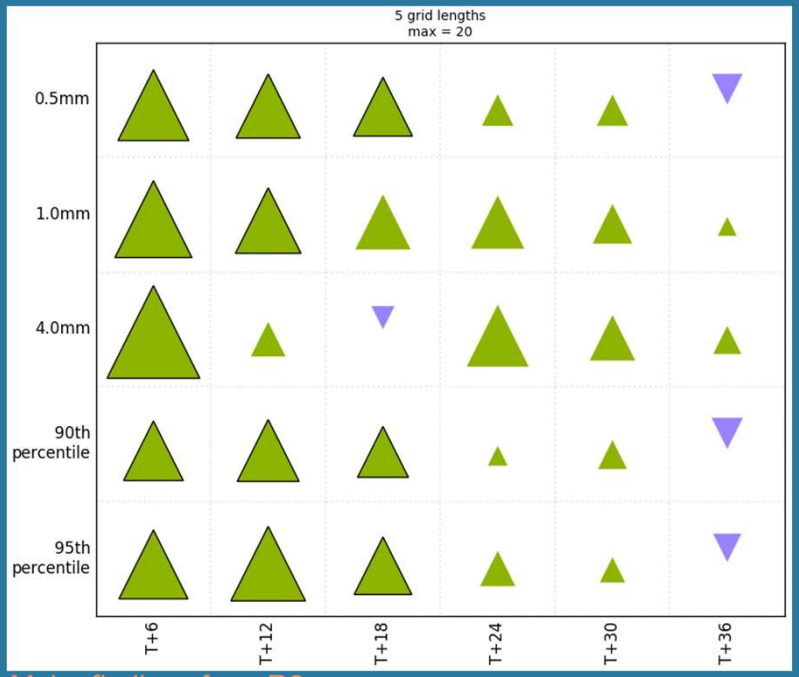
R1: Testing bias correction scheme Observation – Background distribution



Major findings from R1:

After independent bias correction ~5% improvement in channel 10.

R2: Optimal data density to reduce obs. Error ΔFraction Skill score between control vs. test



Major findings from R2:

Forecast impact is positive up to T+18 with statistical significance.

Satellite Science

Develop meteorological & environmental satellite applications

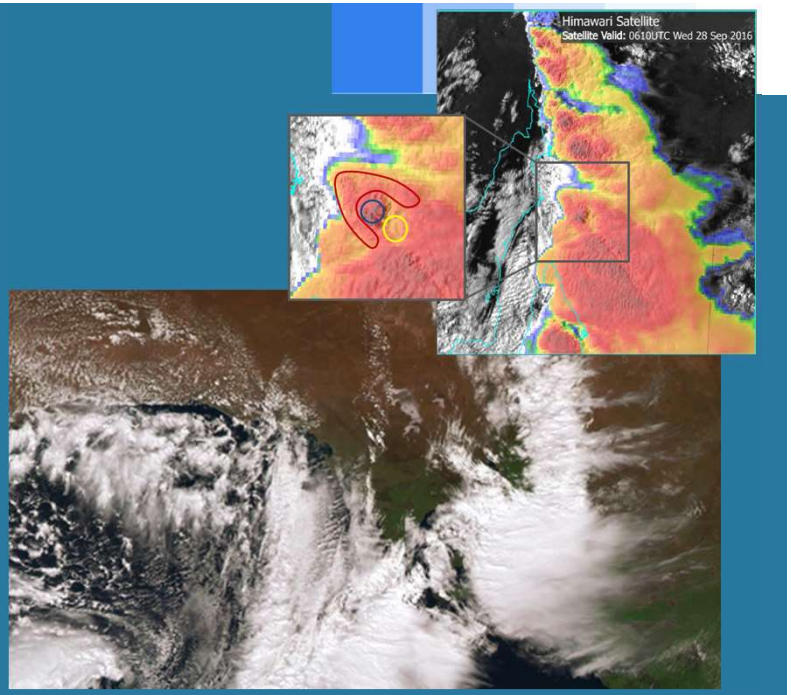
- Remote sensing science (km-scale infrared, optical, wave)
- Data analysis, algorithm development & validation
- Algorithm implementation, scientific software development
- Data services (formats, metadata, distribution, services)
- National and international collaboration and coordination

Responsibilities

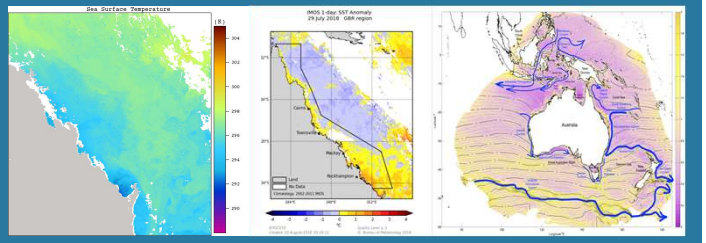
- Satellite imagery and data (Operations + NEWP)
- National Cloud Analysis (geo-cloud), Precipitation (Operations + NEWP)
- Sea surface temperature (Climate + NEWP)
- Solar radiation (Energy sector)
- NDVI Vegetation index
- Grassland curing indices (Agriculture & Emergency services)

Interests

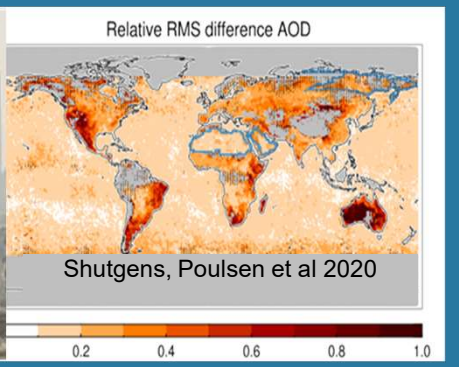
- Increasing space industry capability; new, diverse missions
- Cloud-based data access and analysis; Machine Learning where appropriate (rapidscan, nowcasts, optimisation)



South Australian storms, 2016-09-28



AVHRR & VIIRS | ReefTemp | SSTAARS



Himawari-9 Products

NOAA / U. Wisconsin: GEOCAT

- Cloud Properties (ACHA, DCOMP); Atmospheric Motion Vectors (NOAA)
- Volcanic Ash Cloud (Volcat)
- Fog Detection (UW)

EUMETSAT / NWCSAF: GEO: Himawari-8 and -9 in 2022-12

- Cloud Analysis (CMA)
- Cloud Type (CT), Cloud Top Temp and Height (CTTH)
- Cloud Microphysics (CMIC)
- Convective Rainfall Rate (CRR, CRR-Ph)
- Rapidly Developing Thunderstorms (RDT)*

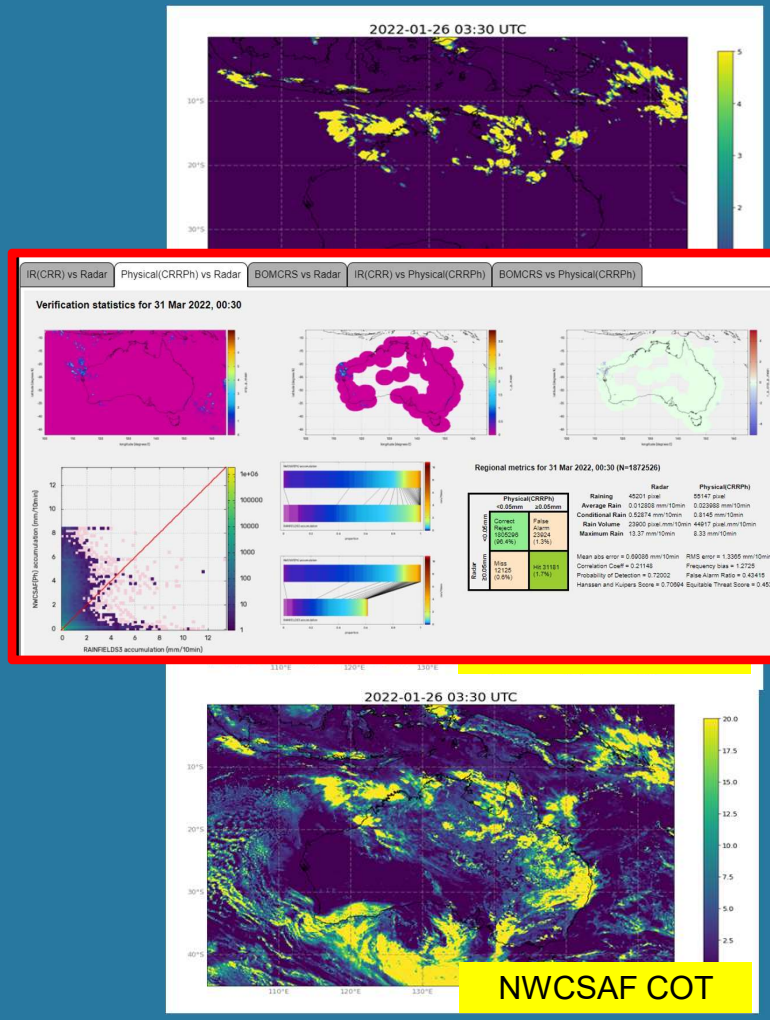
U. Reading: Physical Retrieval: Ocean Skin Tempertures*

NOAA / George Mason University: Flood / standing water*

Paris Mines Tech: Heliosat-4: Solar Radiation

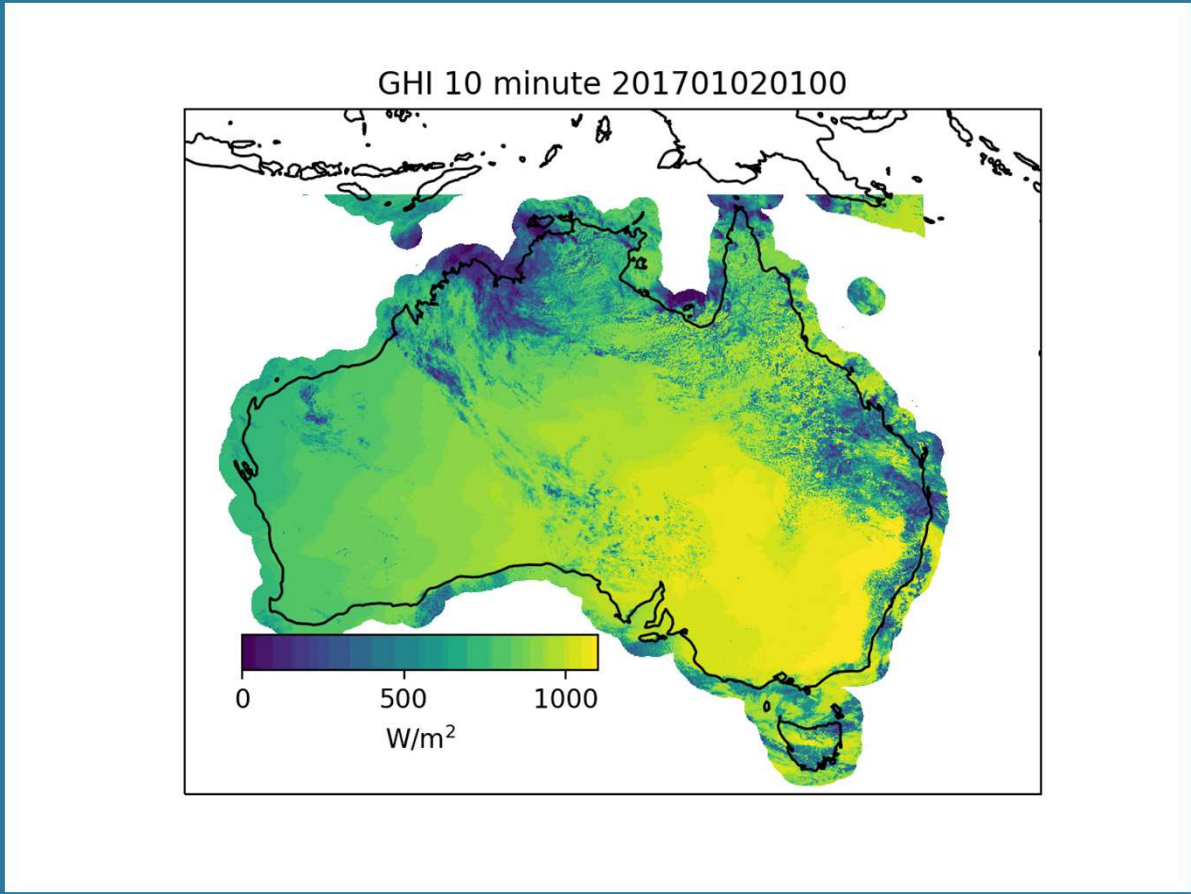
NASA: MAIAC: Aerosols*

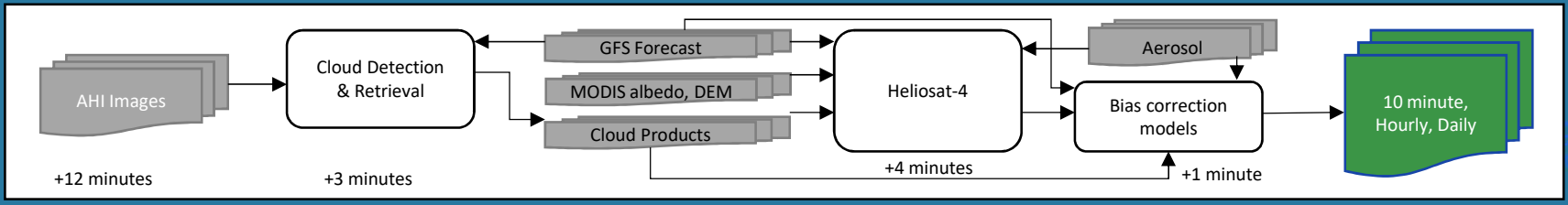
Every 10 minutes



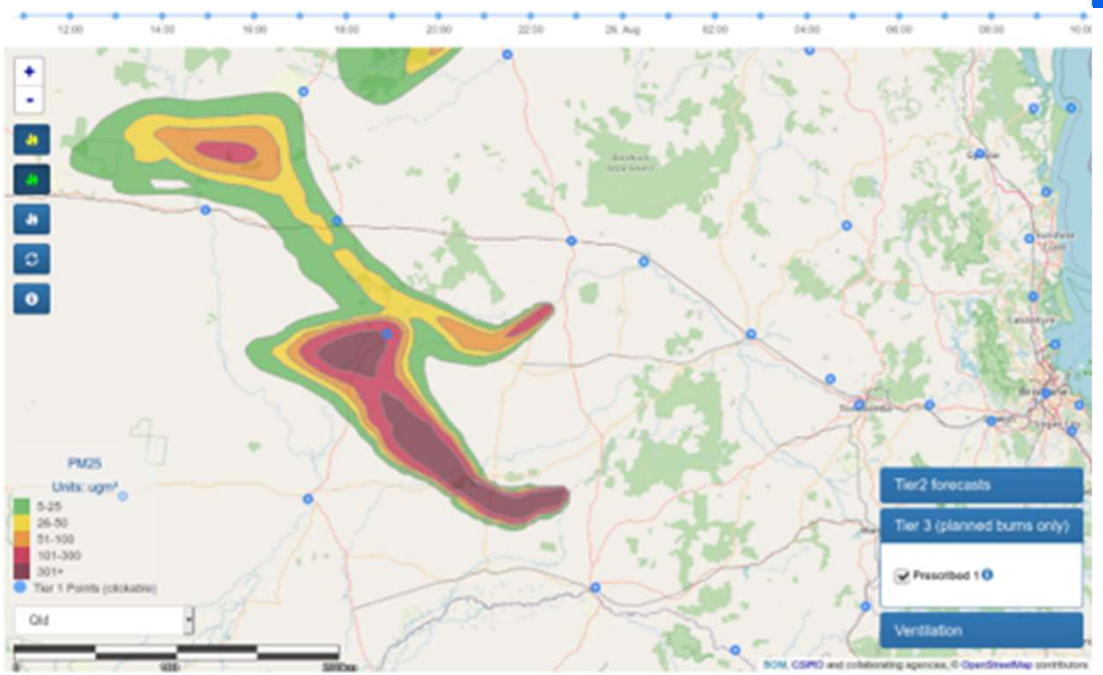
* development/assessment

Solar radiation



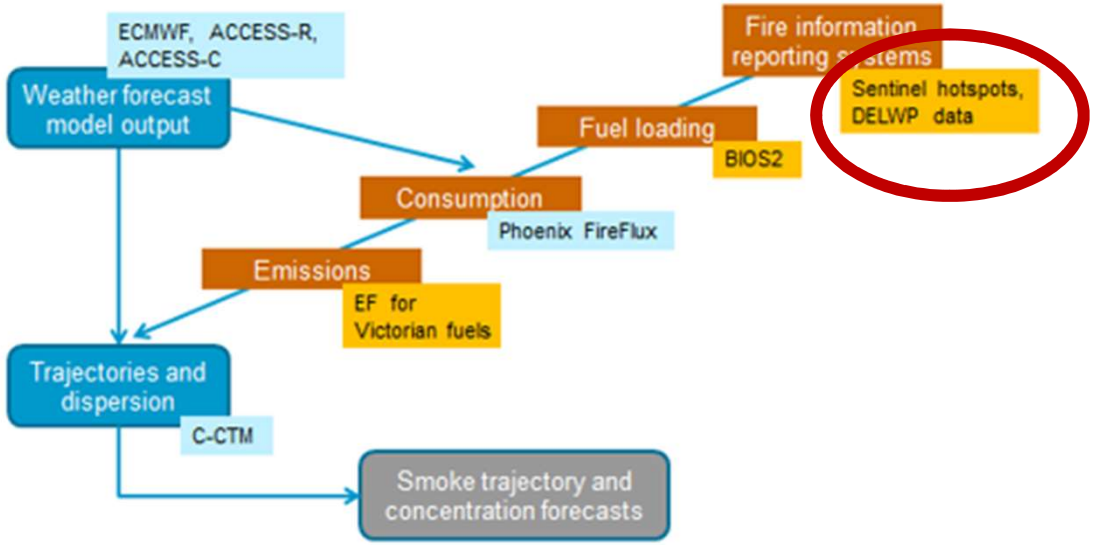


Australian Smoke Dispersion System (ASDS)



Nationally consistent smoke forecasting system

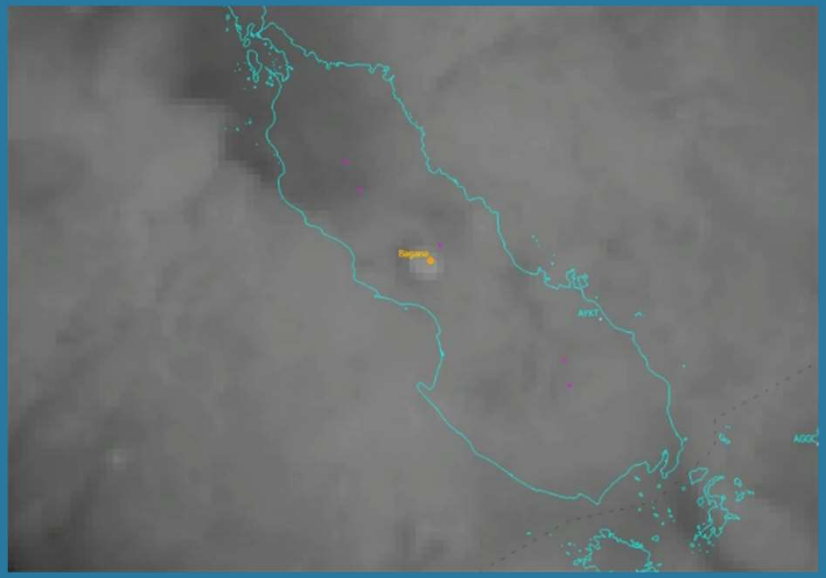
Produces 1-day forecasts of hourly mean concentrations of fine particles associated with smoke for all proposed burns



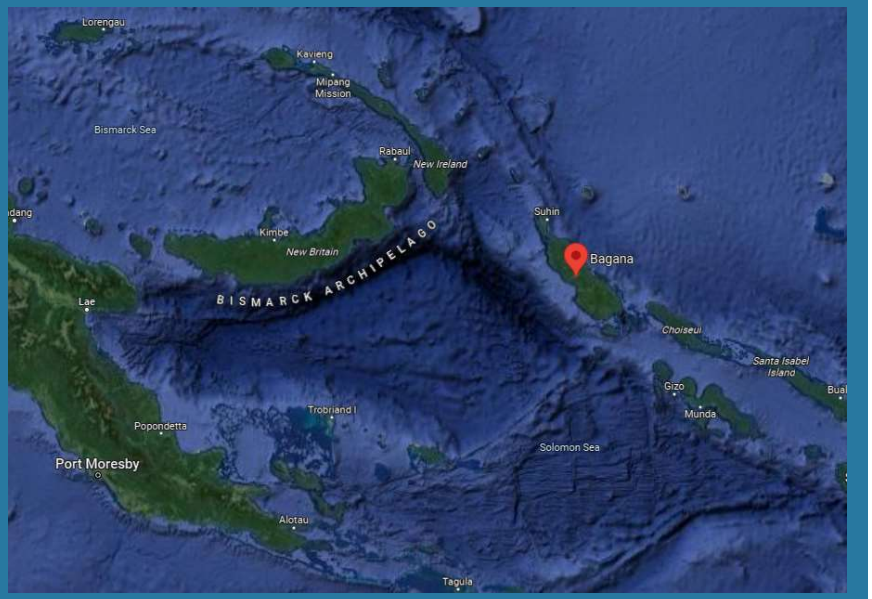
Volcanic Ash applications

Bagana eruption, 7 July 2023

- Volcanic ash is challenging to detect in cloudy conditions
- Forecasters have access to a suite of satellite products and other observations

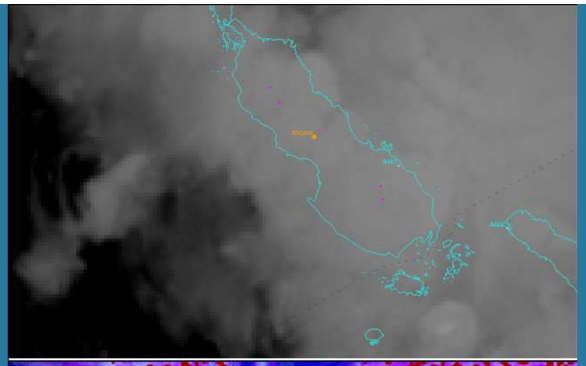


07 July 1210 UTC: suspicious cloud formation identified on Himawari-9 imagery

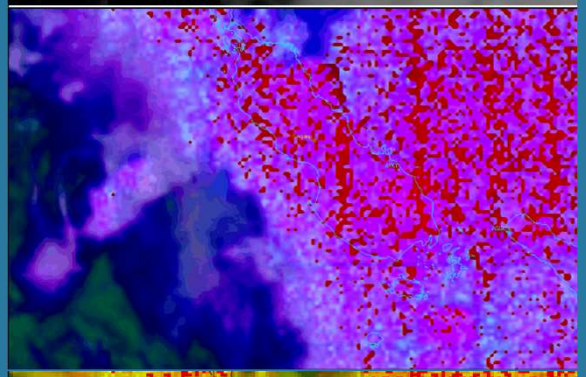


Top image: Image of Bagana 7 August 2023.

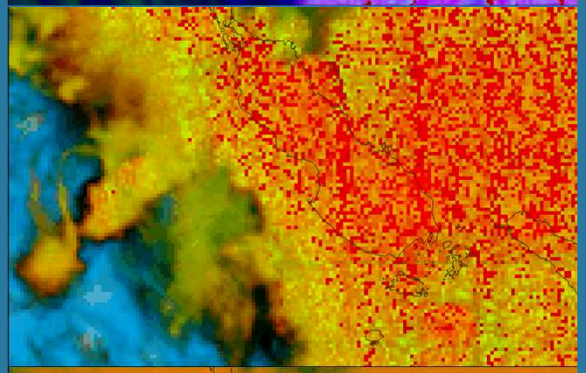
Bottom image: Google location for Bagana.



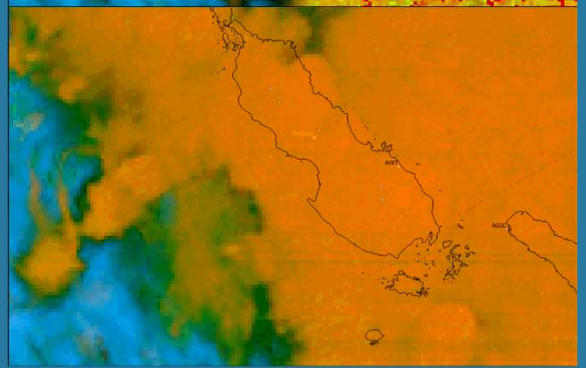
IR



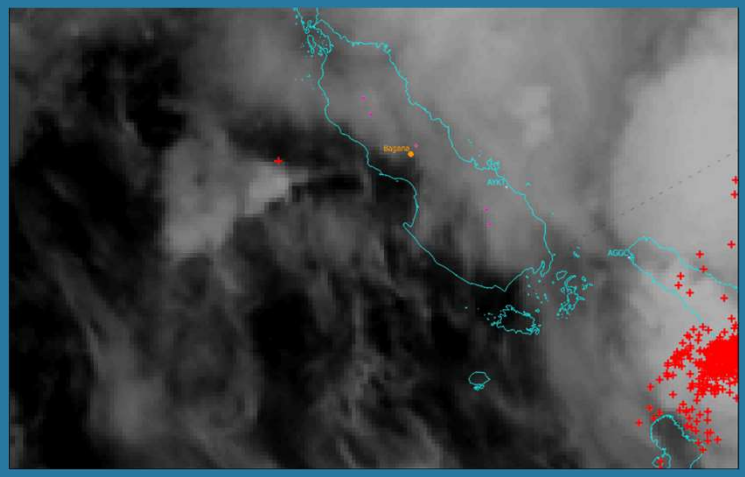
RGB 3.9 µm



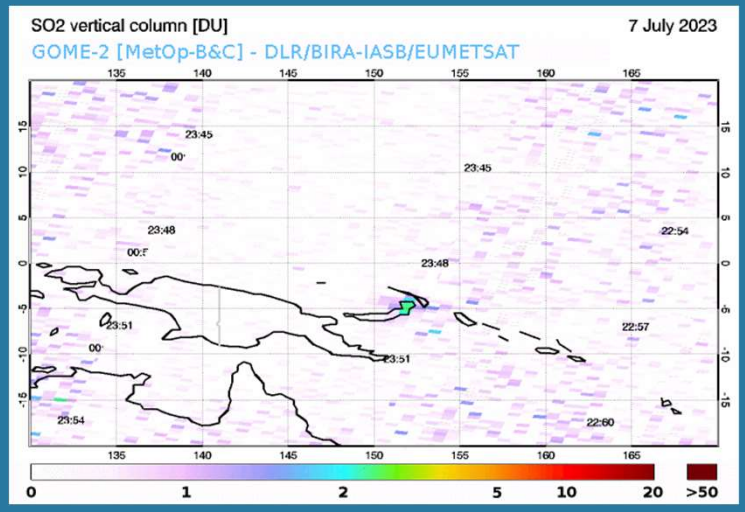
RGB 3.9 µm VOLCAT version



RGB 8.5 µm VOLCAT version



Lightning observations from the World-Wide Lightning Location Network (WWLLN)

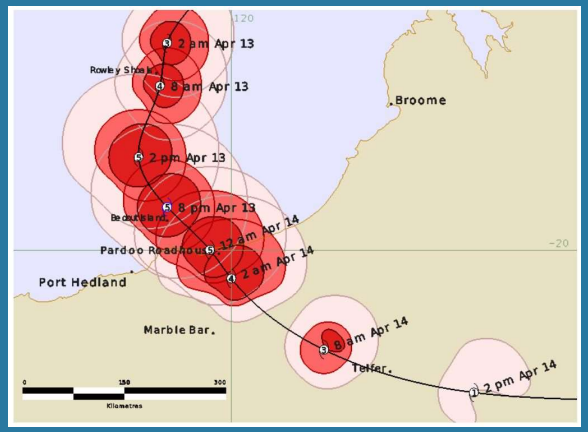


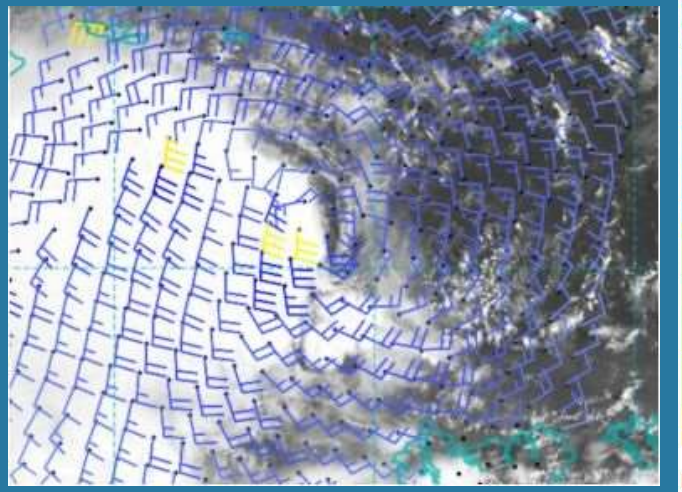
Sulphur dioxide observations available the day after the eruption: https://sacs.aeronomie.be/

Tropical Cyclones

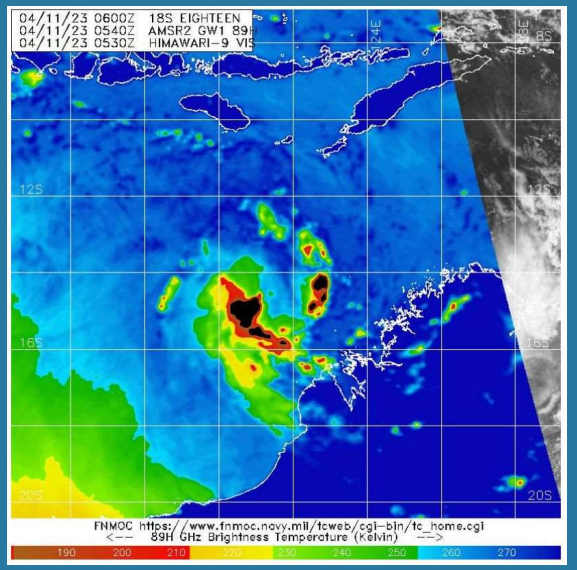
Severe Tropical Cyclone Ilsa

Images courtesy NRL: https://www.nrlmry.navy.mil/TC.html

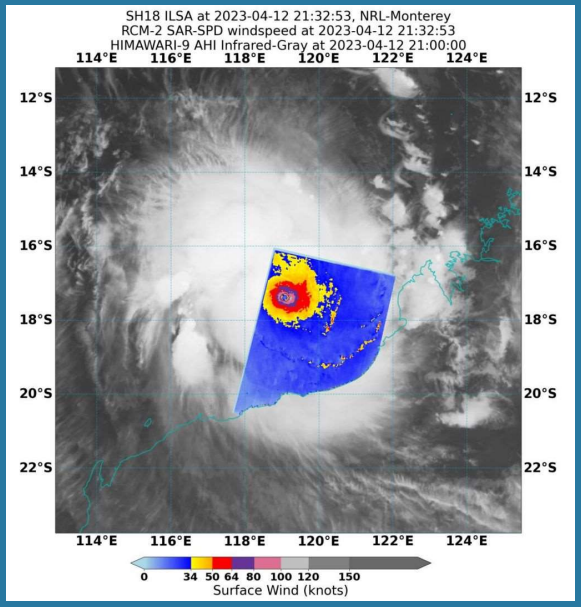




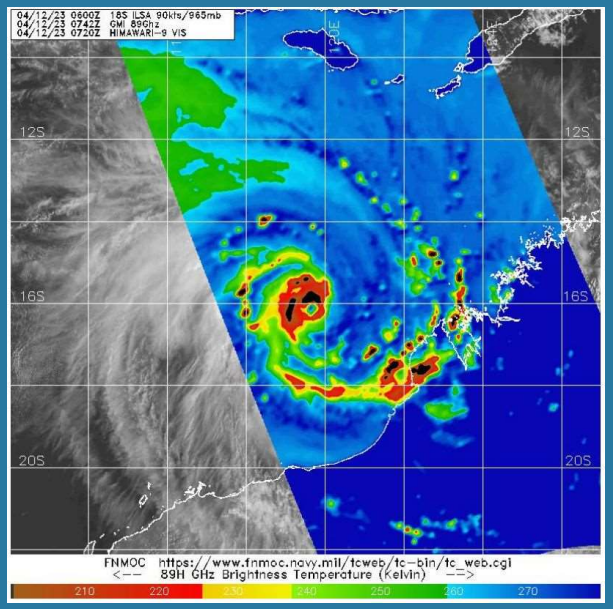
ASCAT, 8 April 2023



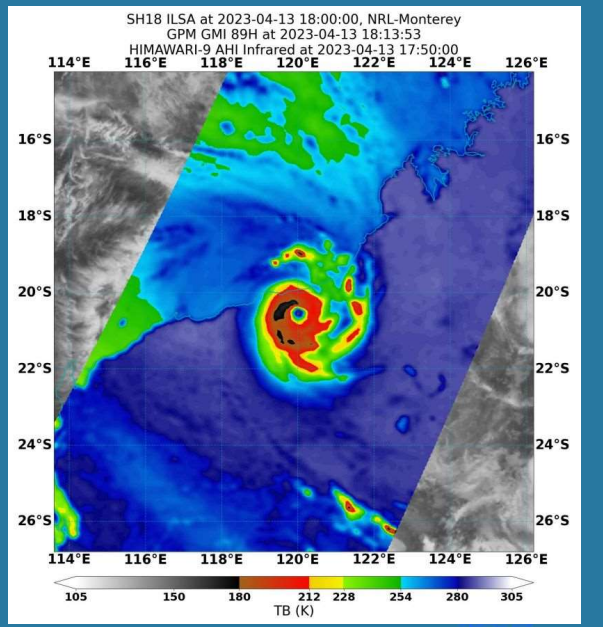
AMSR-2 + Himawari-9, 11 April 2023



SAR + Himawari-9, 12 April 2023



GPM GMI + Himawari-9, 12 April 2023



GPM GMI + Himawari-9, 13 April 2023

National Space Mission for Earth Observation (NSMEO)

The NSMEO was co-designed by the Australian Space Agency, the Bureau of Meteorology, Geoscience Australia, and CSIRO.

As part of this program, the Bureau explored the feasibility of Australian-developed weather satellites.

NSMEO closed June 2023

NSMEO Science Program: Mission Studies

Purpose: to develop high level concept designs for three meteorological satellites: SAR, microwave sounder, lightning sensor.

Leads: Caroline Poulsen (lightning), Luigi Renzullo and Helen Beggs (SAR), and Fiona Smith (microwave sounder).

- **September 2022**: The lead scientists developed user requirements for the 3 missions
- **October 2022**: Three workshops were conducted with experts and UNSW's Australian National Concurrent Design Facility (ANCDF)
- **November 2022**: ANCDF delivered first draft of the Pre-Phase A Mission Studies report
- **October 2023**: Final reports available

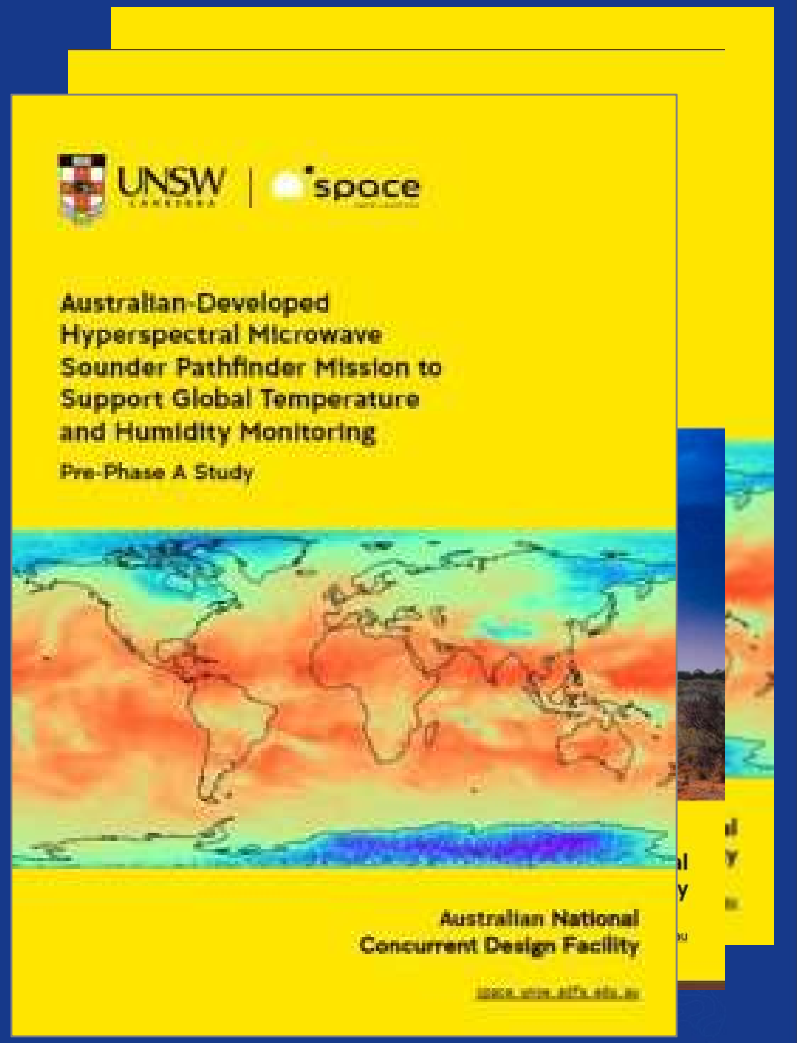
SAR workshop, October 2022, UNSW Canberra Space ANCDF

NSMEO achievements: Mission studies (x 3)

Australia has the skills to develop **meteorological smallsats** that could provide complementary observations and develop capabilities in Australia.

LEO smallsats can be built and launched for between ~$20-100 million (depending on the satellite).

Will require international and national collaboration.



NSMEO achievements: R&D to assess value and impact of new observations

Impact studies

- The Bureau currently operates **Forecast Sensitivity to Observations (FSO)** to determine impact of observations on the error of a forecast. Only works for existing observations in NWP.
- NSMEO commenced development of an **Observing System Simulation Experiment (OSSE) capability** to quantitatively assess the impact of new observations (i.e. those that are not currently assimilated) on the accuracy of the Bureau's forecasts.
  - generates synthetic observations and measures the impact of the simulated observations by the effect on ensemble spread
  - used successfully by ECMWF
  - current work focussed on satellite observations

The Bureau of Meteorology

Thank you