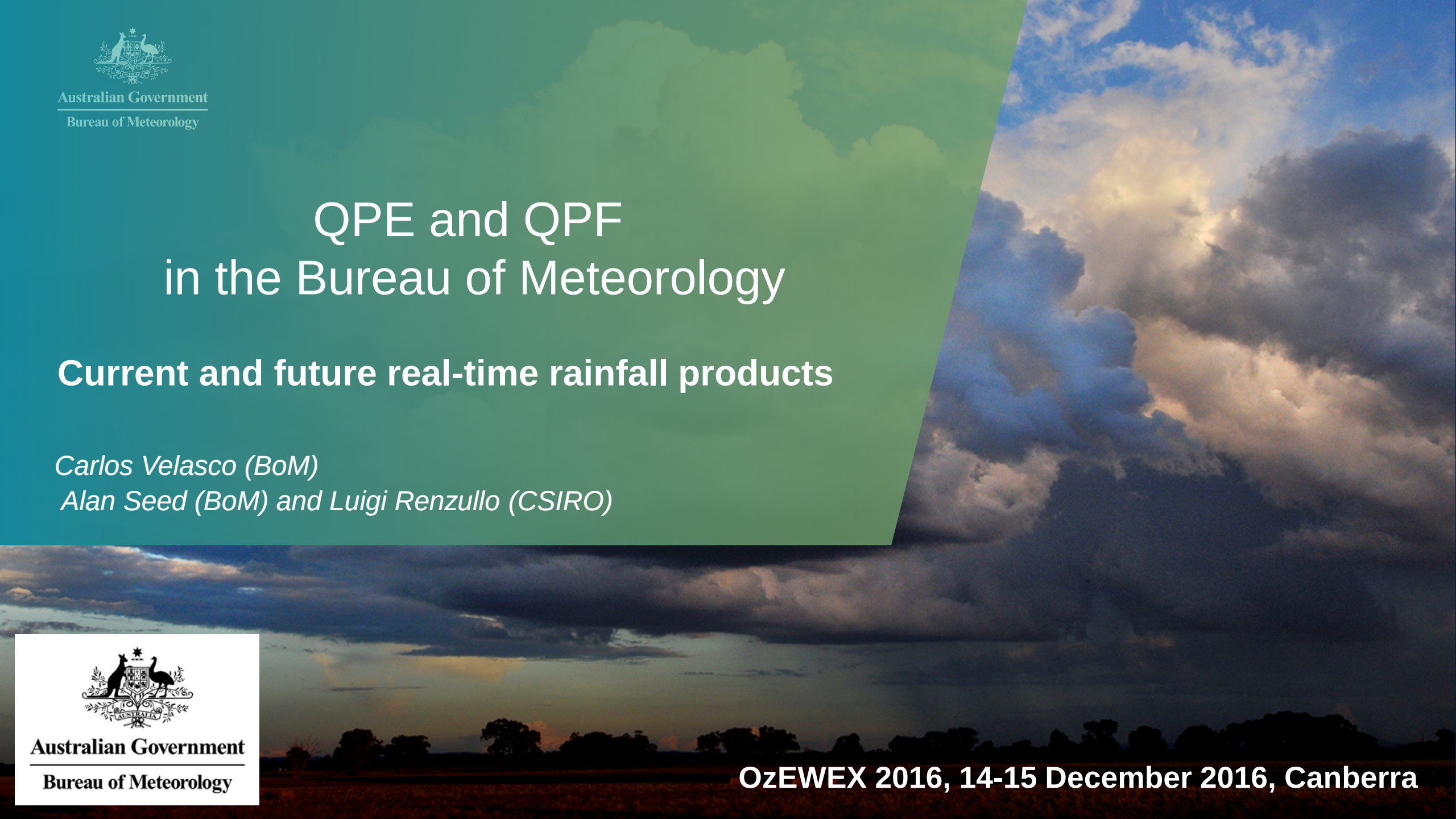


Australian Government
Bureau of Meteorology

QPE and QPF in the Bureau of Meteorology

Current and future real-time rainfall products

Carlos Velasco (BoM)
Alan Seed (BoM) and Luigi Renzullo (CSIRO)

Australian Government
Bureau of Meteorology

OzEWEX 2016, 14-15 December 2016, Canberra

Australian Government
Bureau of Meteorology

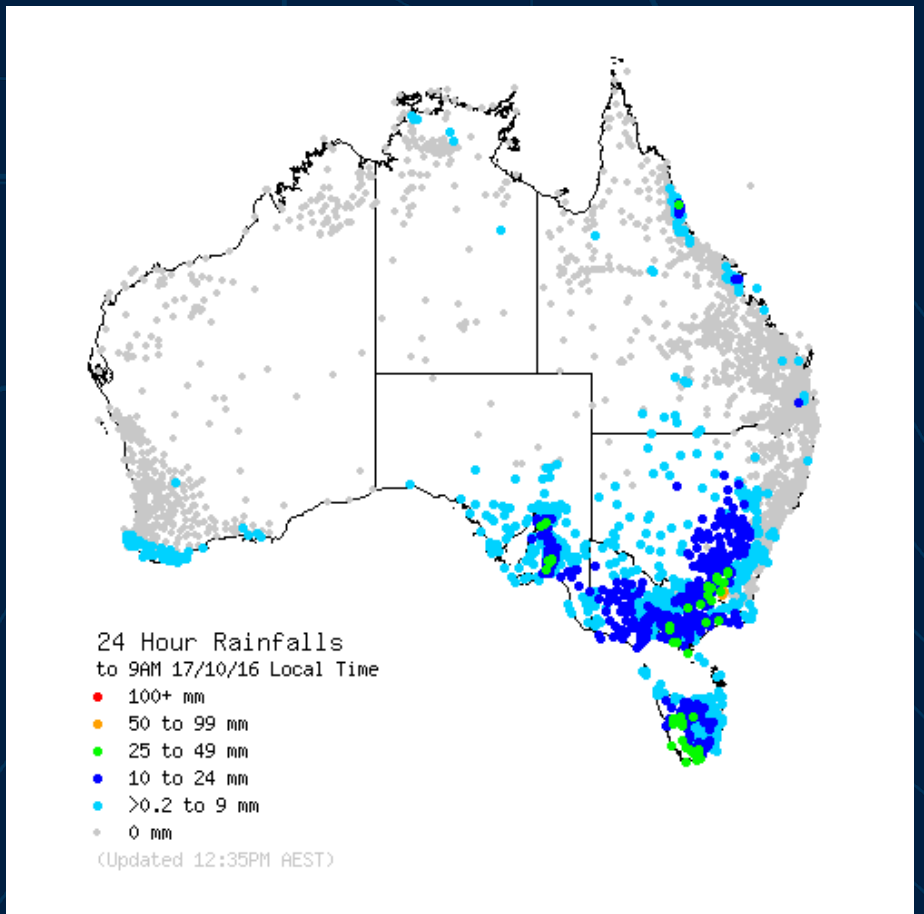
Why do we need real-time rainfall estimations and predictions?

- Provide timely advice to all Australians
- Input for riverine and flash-flood forecasts
- Estimating and predicting storm severity
- Verify NWP models performance

Australian Government
Bureau of Meteorology

How rainfall is measured?

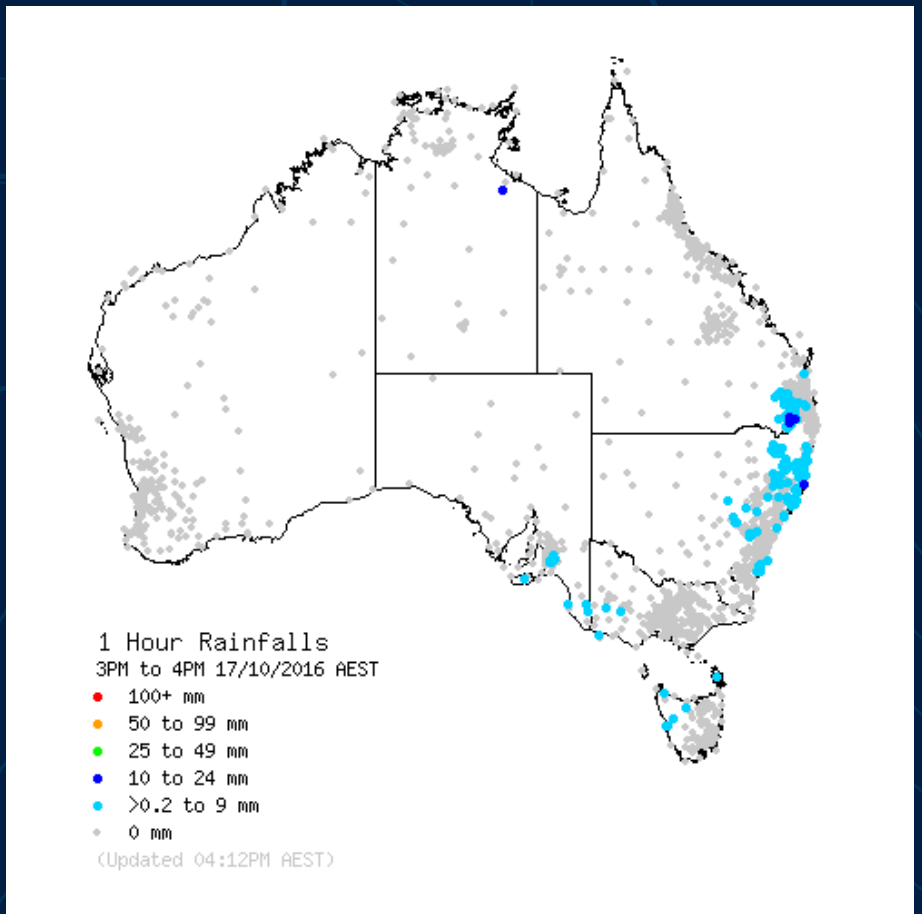
- Rain gauges (manual and automatic)
  - Direct measurement of rainfall at ground
  - Often sparse or inexistent



Australian Government
Bureau of Meteorology

How rainfall is measured?

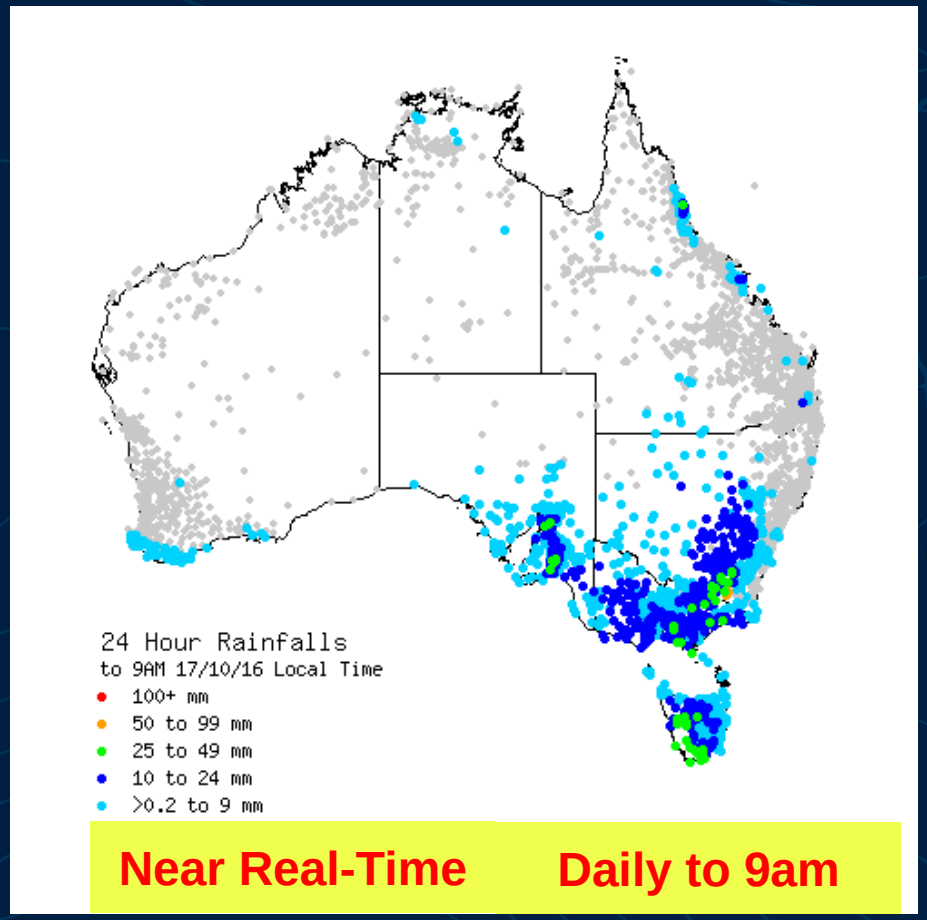
- Rain gauges (manual and automatic)
  - Direct measurement of rainfall at ground
  - Often sparse or inexistent
    - Even more limited in real – time



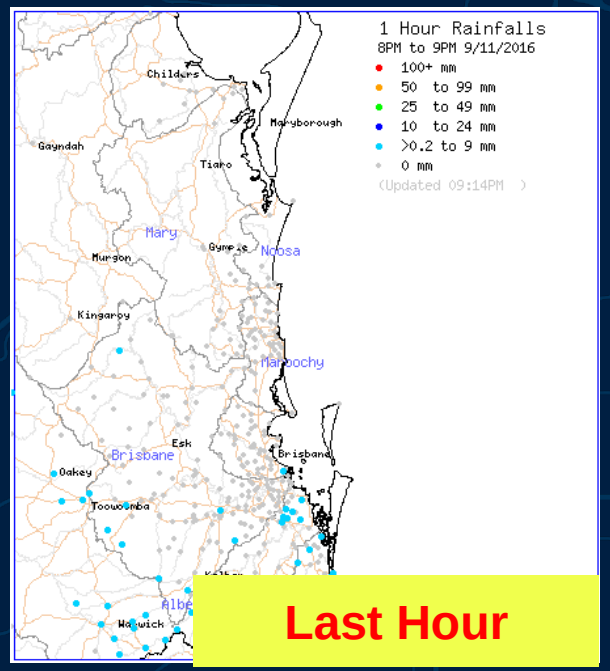
Australian Government
Bureau of Meteorology

National rainfall products available to public

- Rain gauges (only)



Near Real-Time **Daily to 9am**

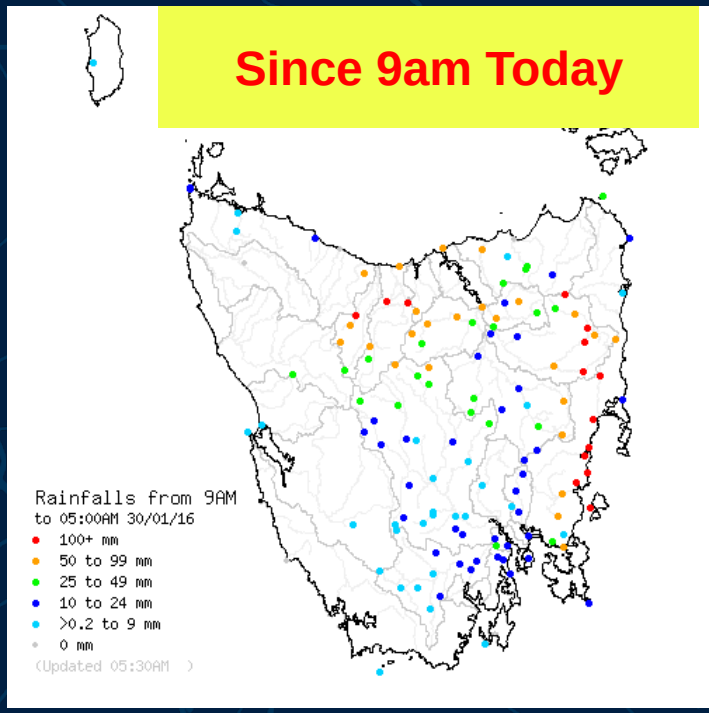


Last Hour

www.bom.gov.au/australia/flood

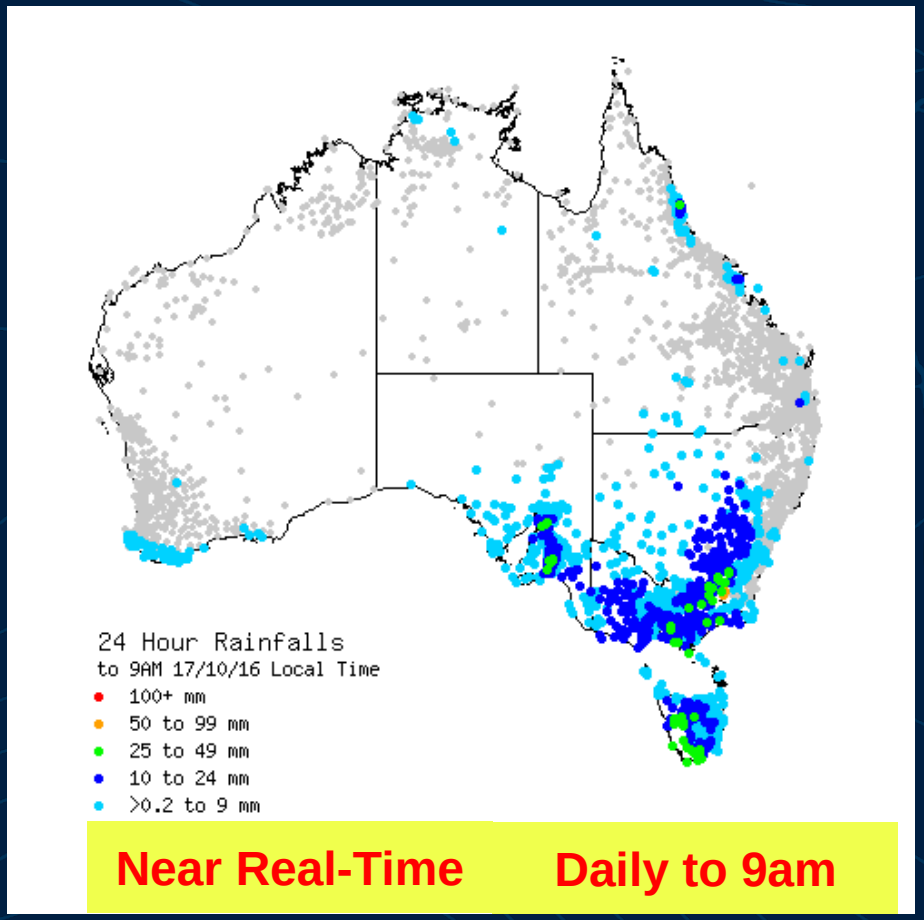
SOUTHEAST COAST

	Date/Time EST	Temp °C	App Temp °C	Dew Point °C	Rel Hum %	Delta-T °C	Wind					Press hPa	Rain since 9am mm
							Dir	Spd km/h	Gust km/h	Spd kts	Gust kts		
Amberley	10/11:00am	27.8	29.0	19.8	61	5.2	N	13	15	7	8	1007.2	0.0
Archerfield	10/11:00am	29.7	29.4	19.1	53	6.9	W	19	28	10	15	1007.3	0.2
Banana Bank	10/11:00am	-	-	-	-	-	N	19	22	10	12	-	-
Beerburrum	10/11:00am	31.6	33.2	18.2	44	8.6	E	7	13	4	7	-	0.0
Beaudesert AWS	10/11:00am	28.2	30.4	19.2	58	5.8	WNW	6	11	3	6	1007.3	0.0
Brisbane	10/11:00am	30.3	33.1	19.6	52	7.0	N	4	9	2	5	1007.2	0.0
Brisbane Airport	10/11:00am	28.4	28.3	21.4	66	4.7	NNE	24	30	13	16	1007.3	0.0
Cape Moreton	10/11:00am	27.5	29.9	23.7	80	2.6	N	17	26	9	14	1007.8	0.0
Coolangatta	10/11:00am	26.0	25.9	21.2	71	3.8	N	28	35	15	19	1006.9	0.0



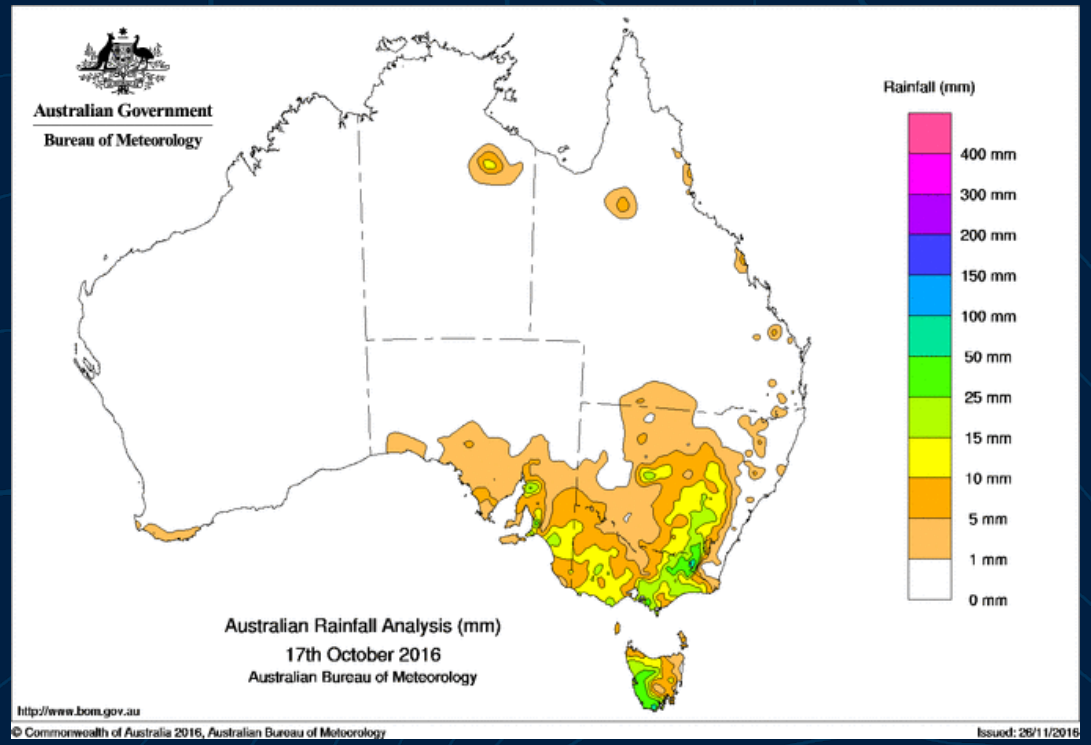
National rainfall products available to public

- Rain gauges (only)



Near Real-Time **Daily to 9am**

AWAP : Daily Gridded Rainfall Analysis (Only Gauges)
www.bom.gov.au/jsp/awap/rain/

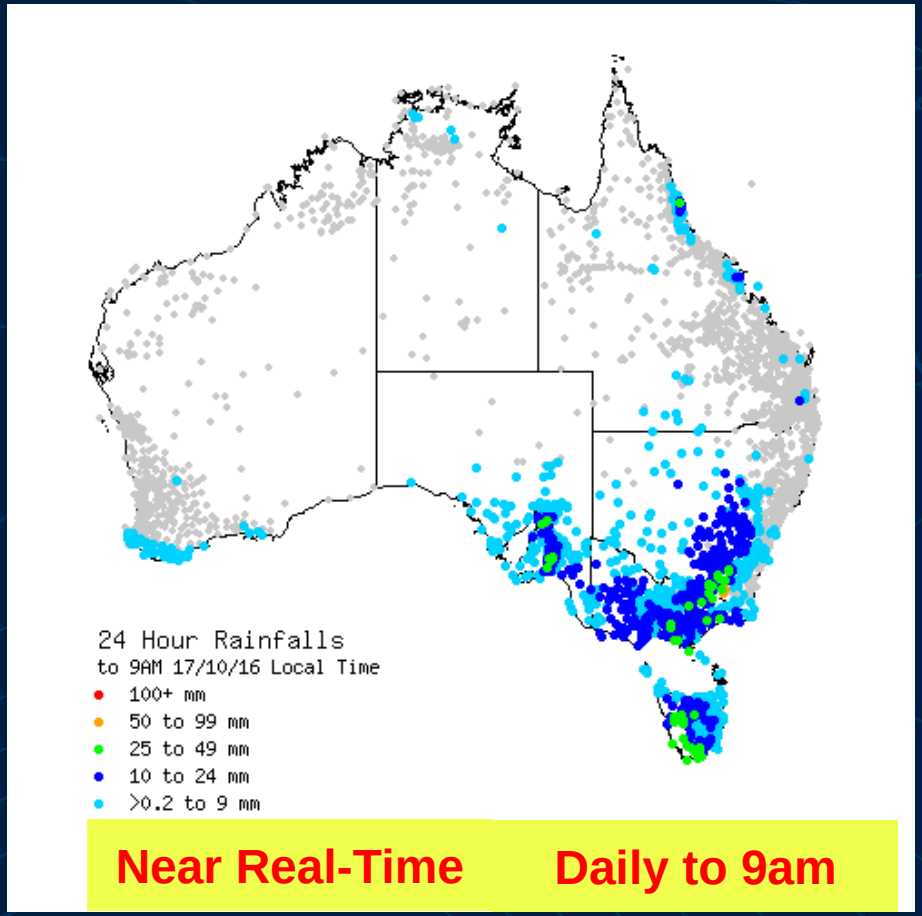


David Jones et al 2009
http://www.bom.gov.au/amm/docs/2009/jones.pdf

Australian Government
Bureau of Meteorology

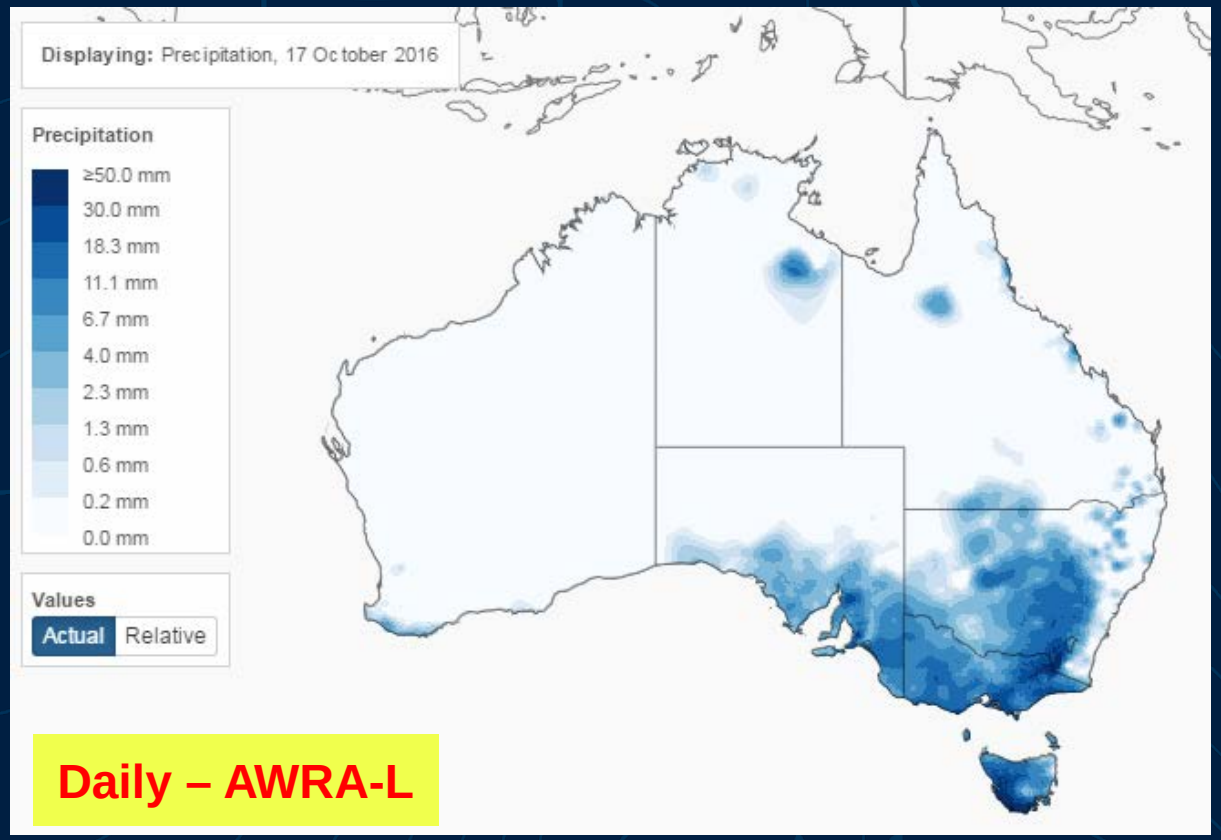
National rainfall products available to public

- Rain gauges (only)



Near Real-Time **Daily to 9am**

AWRA – L: Daily Gridded Rainfall Analysis (Only Gauges)
www.bom.gov.au/water/landscape



Daily – AWRA-L

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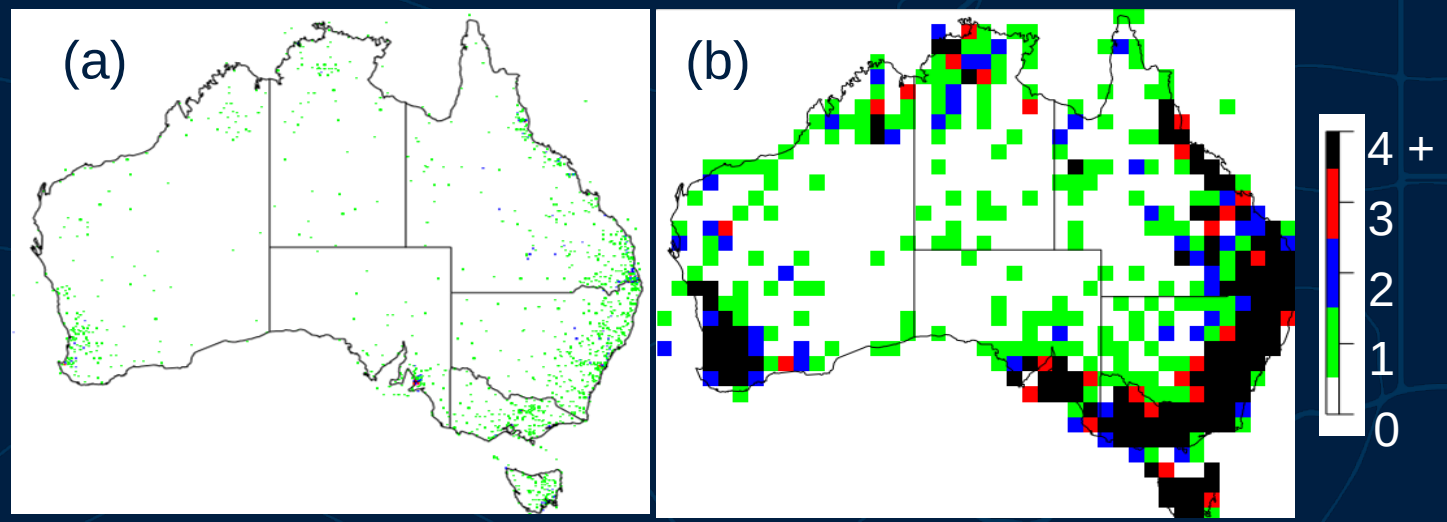
Bureau of Meteorology

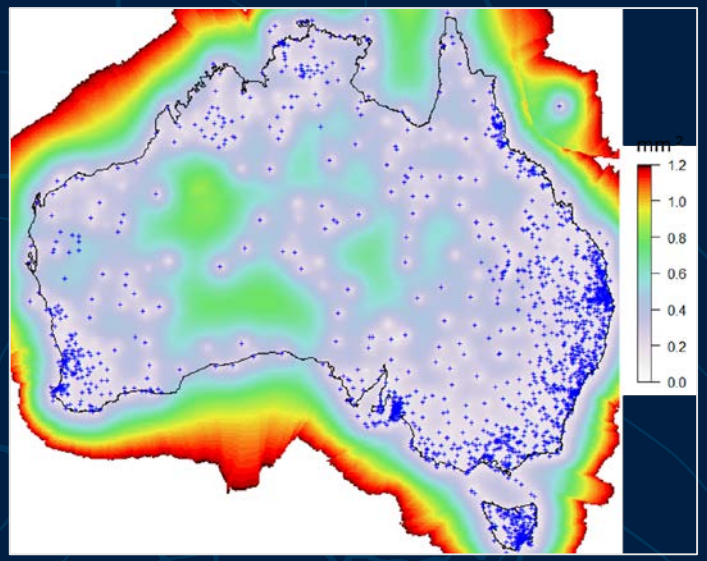
National rainfall products available to public

- Rain gauges (only)

Limited Rain gauges Coverage in Real Time



Density of daily rain gauges reporting in near real-time for the period 1 November 2015 - 15 August 2016: average number of gauges per day per (a) 0.1 ^{o} x 0.1 ^{o} and (b) 1 ^{o} x 1 ^{o} grid cell across Australia.

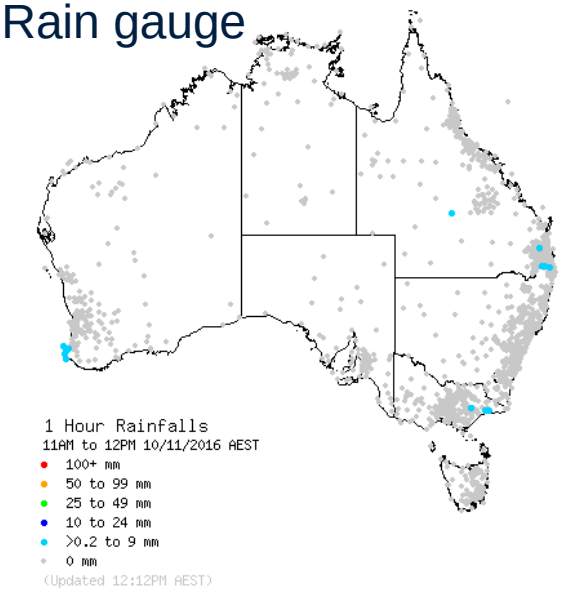


Spatial estimation error variance from ordinary kriging of daily gauge data

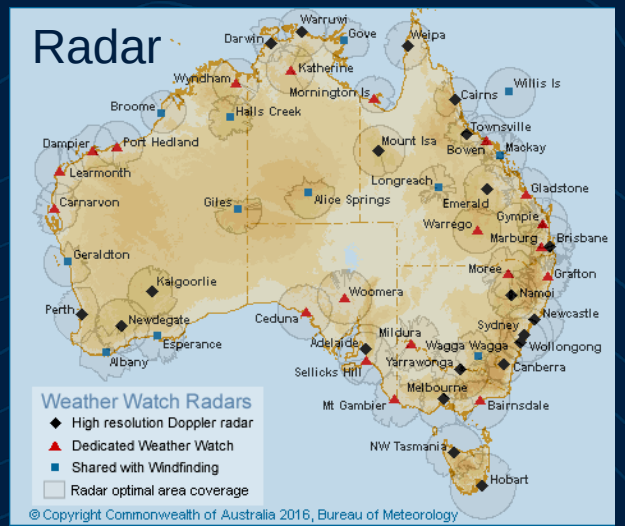
Australian Government
Bureau of Meteorology

Sources of (near) real-time rainfall information

Rain gauge



Radar



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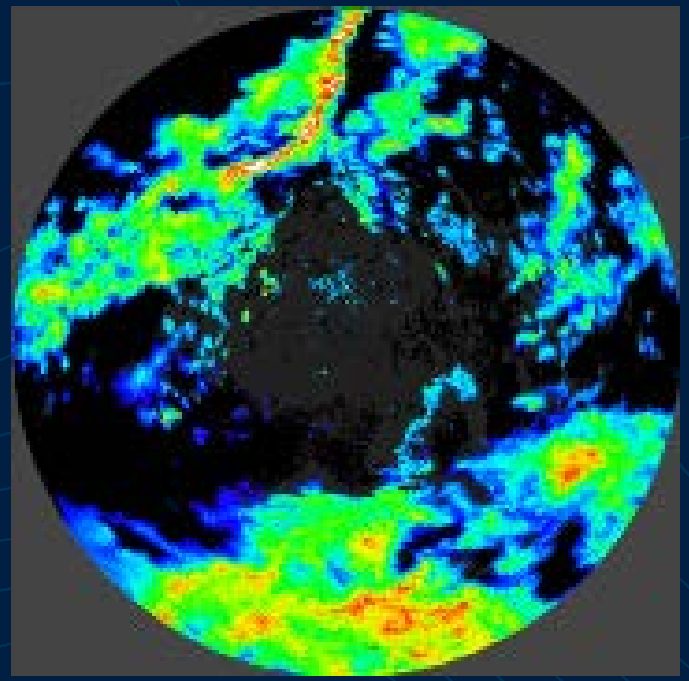
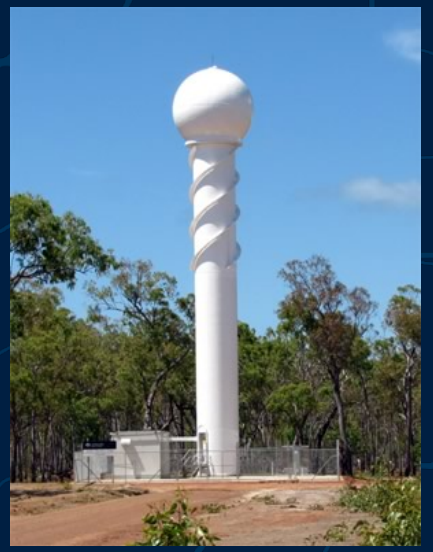
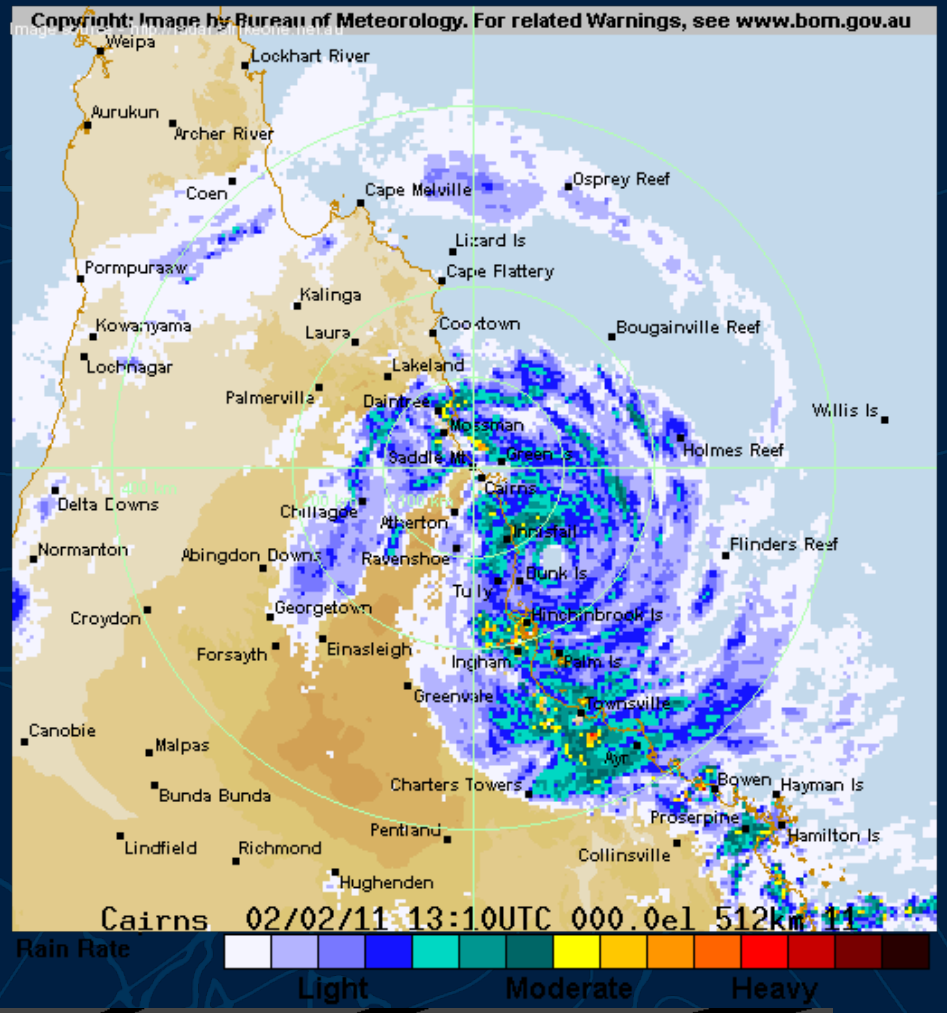
How rainfall is measured?

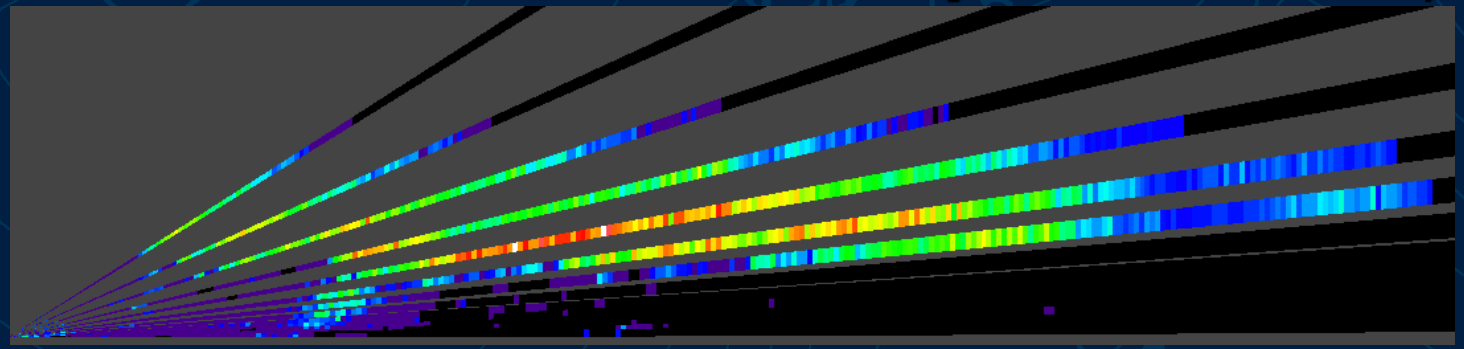
Weather Watch Radars

- Very dense observations
- Reflectivity above the surface









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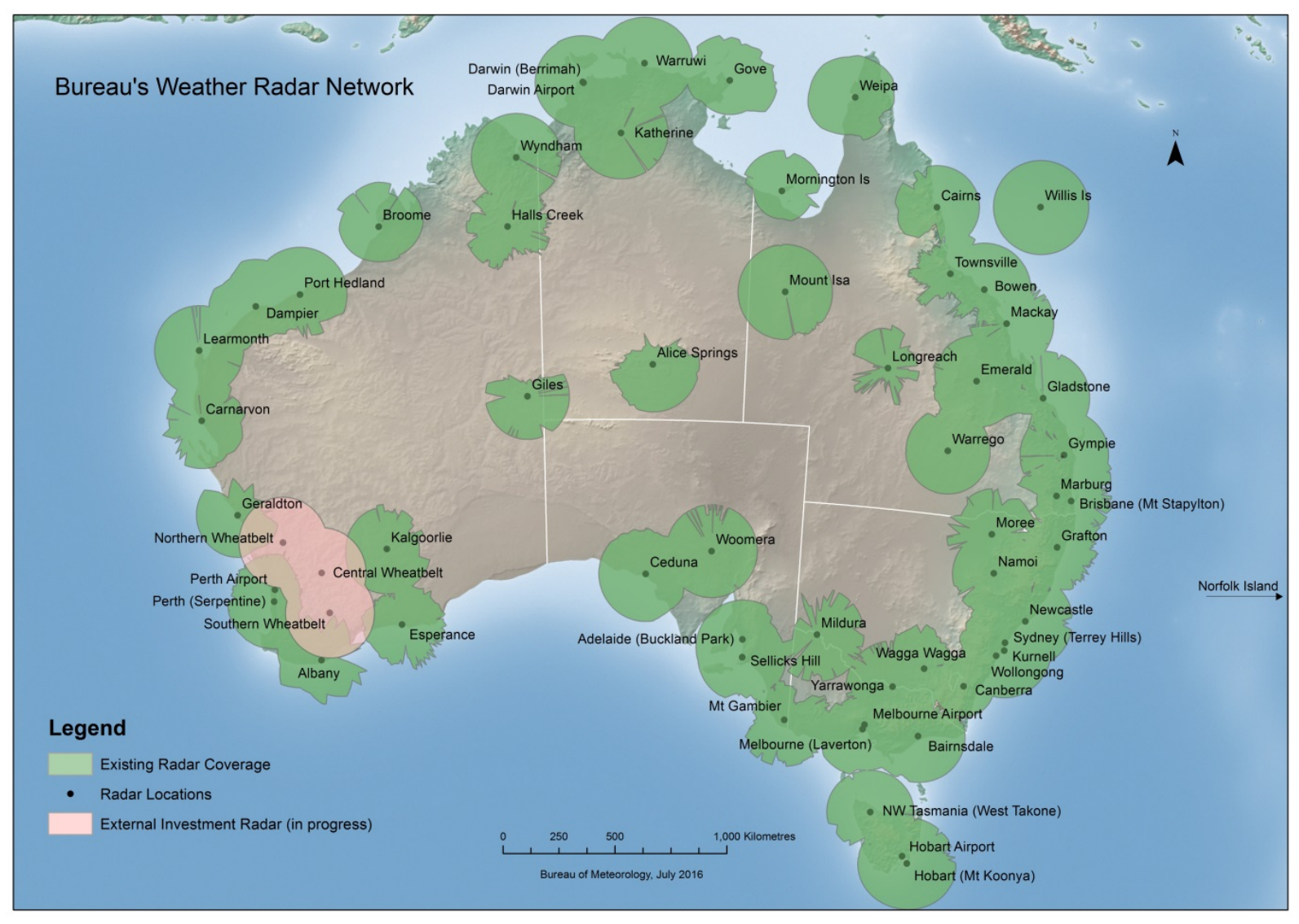
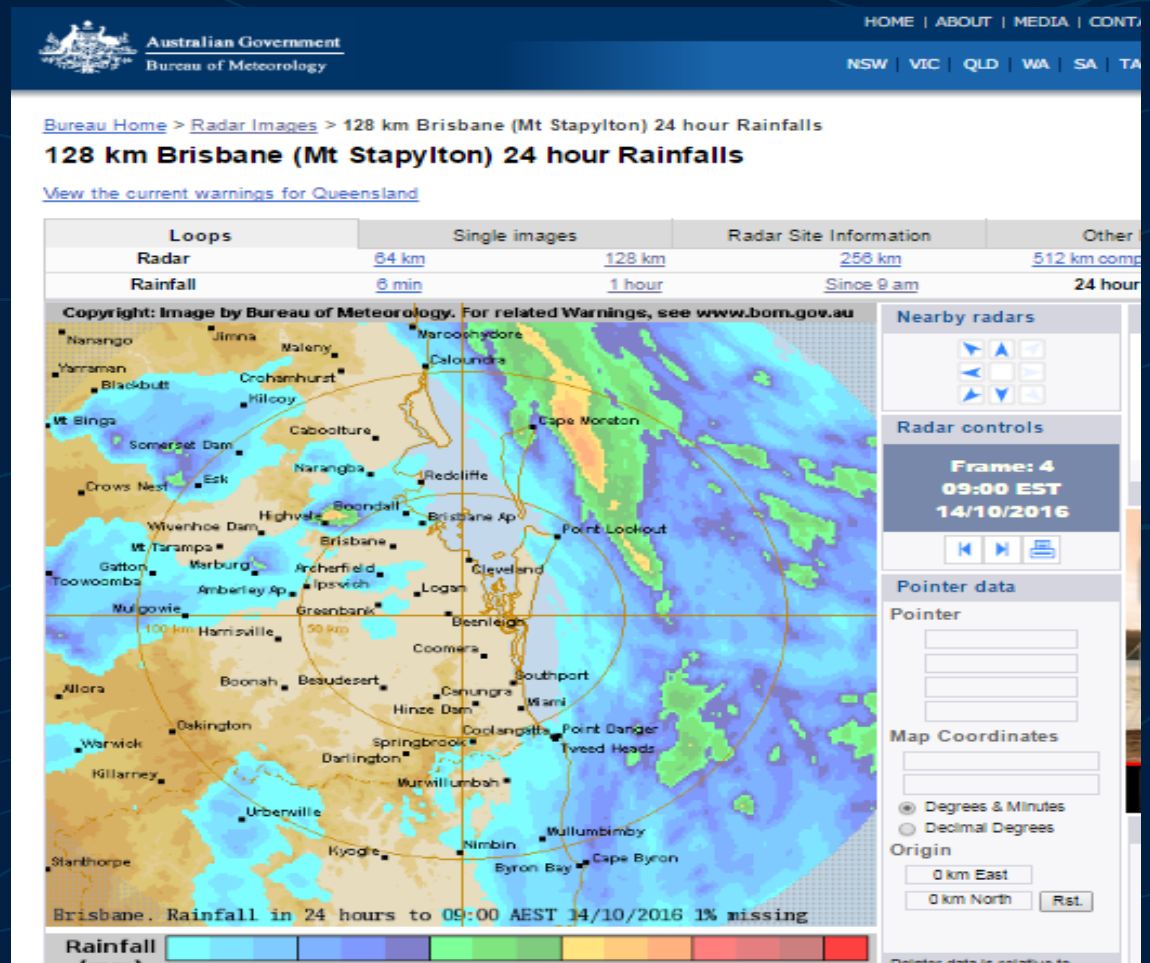
Australian Weather radar network

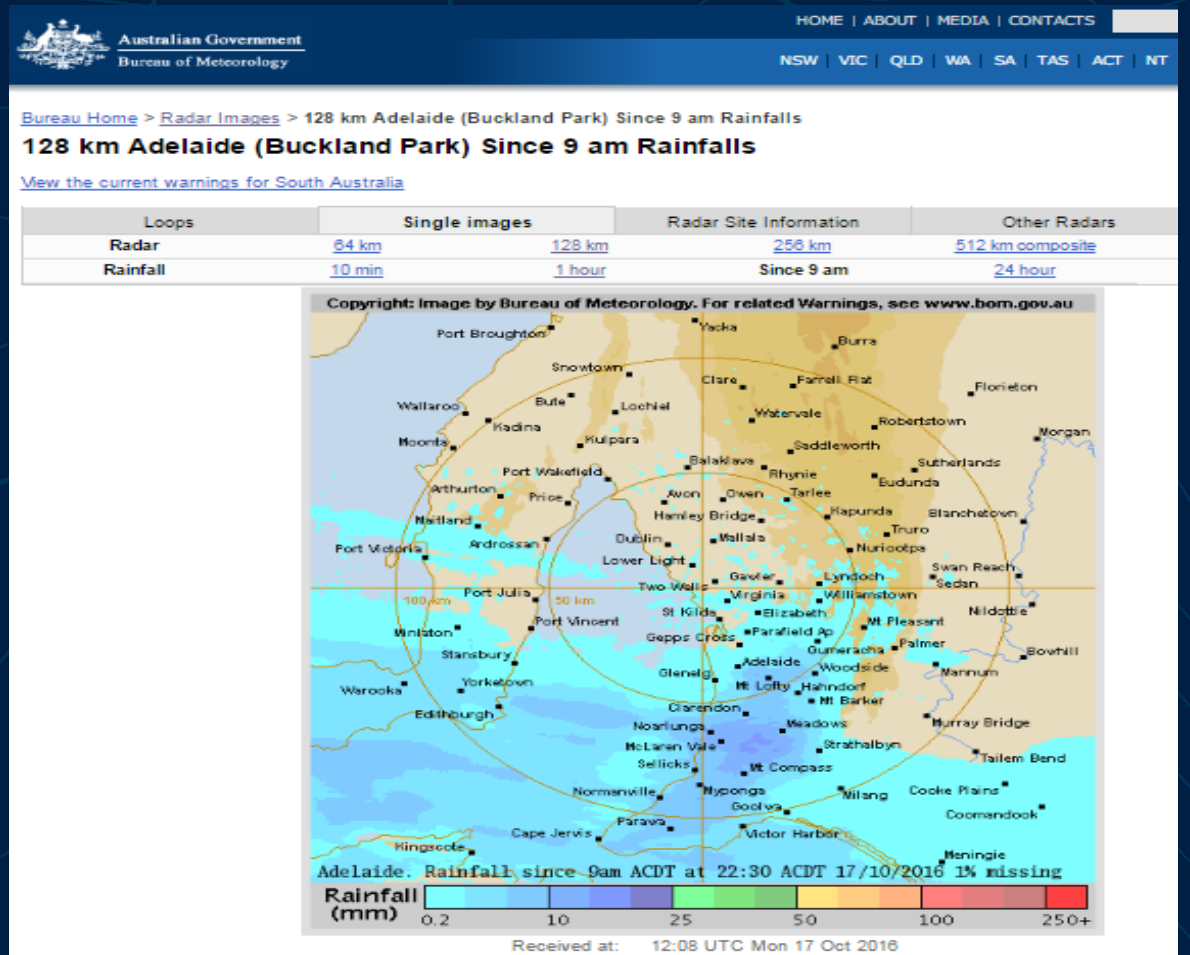


Rainfields – Flexible and scalable radar QC/QPE

Current Operational Version – Rainfields 2.0

- QPE products available in our public website and data for registered users. **Limited set of radars.**





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Rainfields – Flexible and scalable Radar QC/QPE

New Operational Version – Rainfields 3.0 (mid 2017)

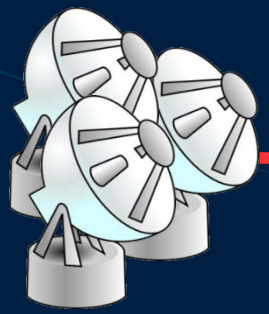
- Enhanced Rainfields Products Portal
  - Quality controlled volume scans (QC added to the volume scan data)
  - Surface radar reflectivity for single and multi-radar domains
  - Instantaneous rain rate (used for accumulations and nowcasts)
  - Rainfall accumulations (6 min to 24 h)
  - Ensemble forecasts
    - 0-12 h, 10 min update over 500 km domains for Melbourne, Sydney, Brisbane
    - 0-90 min, 6 min update, over 50 radar domains

Australian Government
Bureau of Meteorology

Rainfields – Flexible and scalable radar QC/QPE

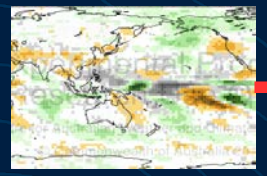
New Operational Version – Rainfields 3.0 (mid 2017)

- Enhanced Rainfields Products Portal



50 radars

1700 rain gauges

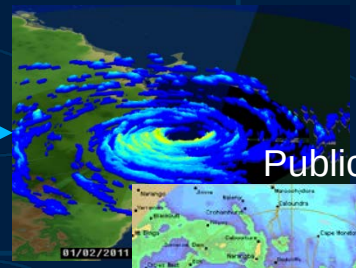


NWP wet bulb freezing levels

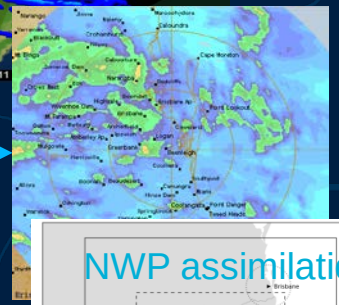
Rainfields
QC/QPE/QPF

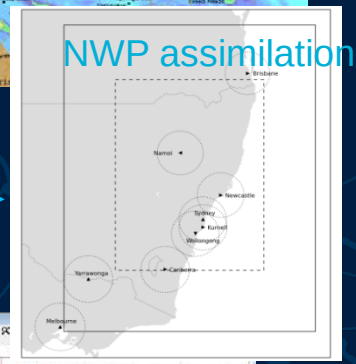
10 000 products per hour

Forecasters

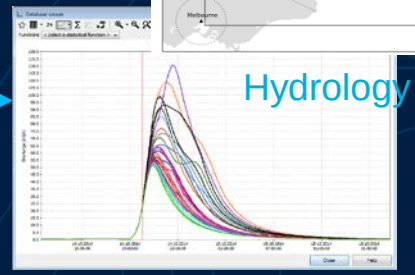


Public weather





NWP assimilation

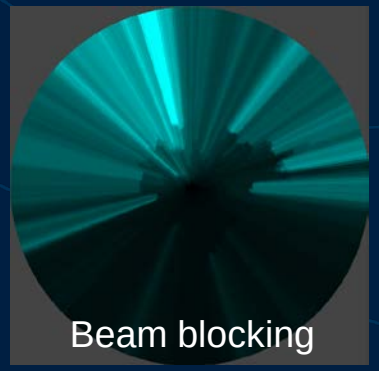


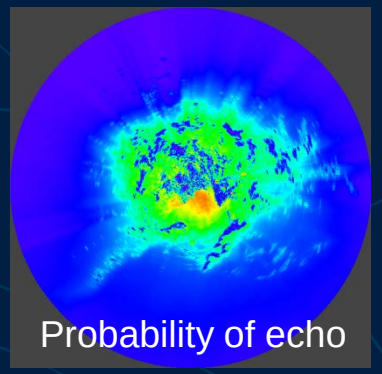
Hydrology

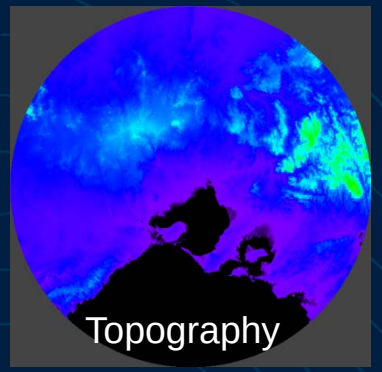
Australian Government
Bureau of Meteorology

Rainfields algorithms

Climatology

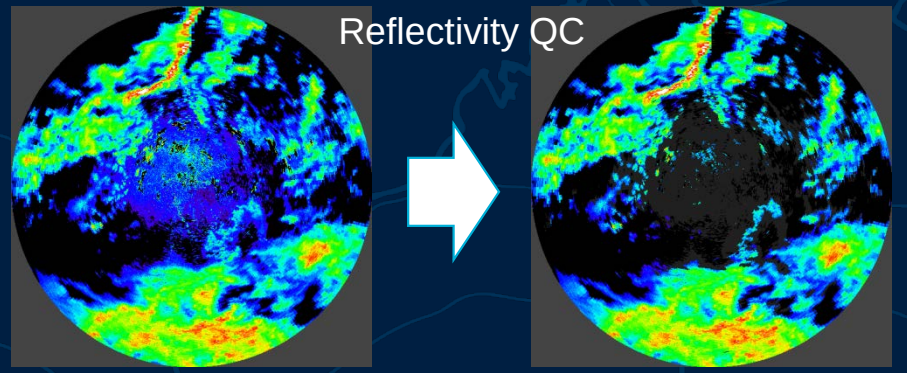




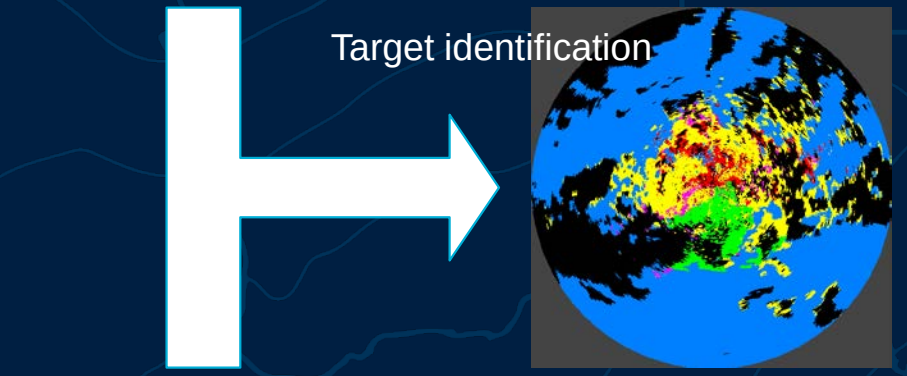


Quality Control

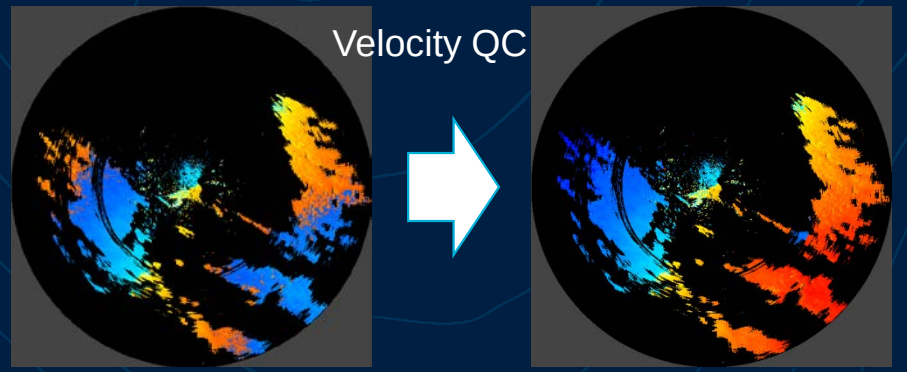
Reflectivity QC



Target identification

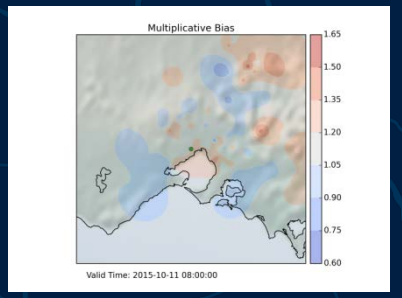


Velocity QC

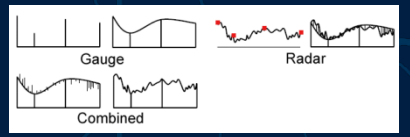


QPE

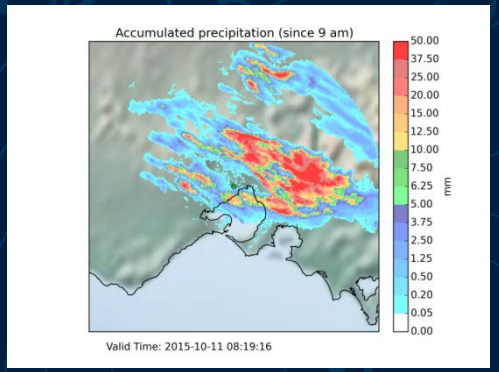
Bias correction



Gauge blending



Rainfall Accumulations



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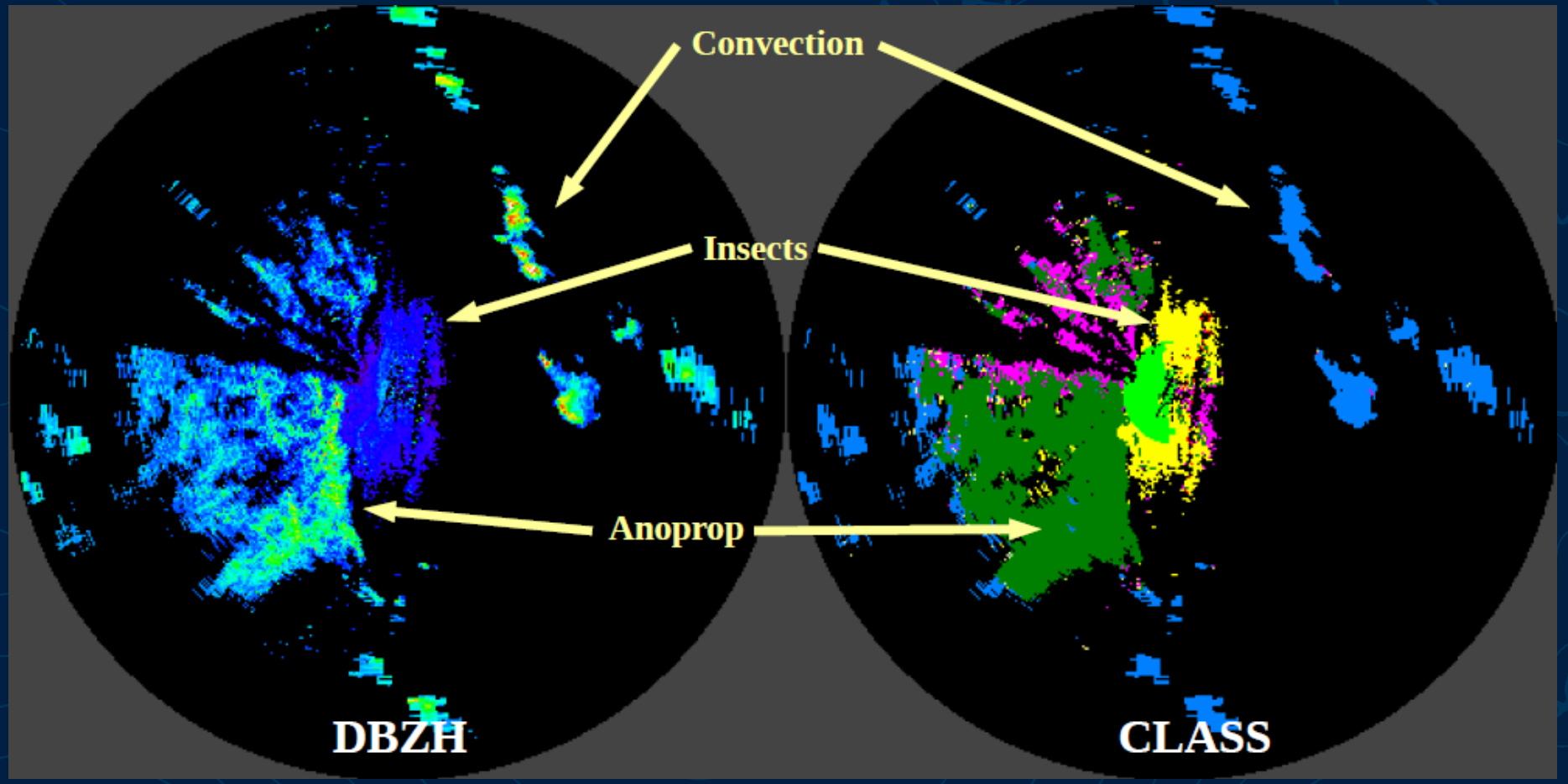
Rainfields algorithms



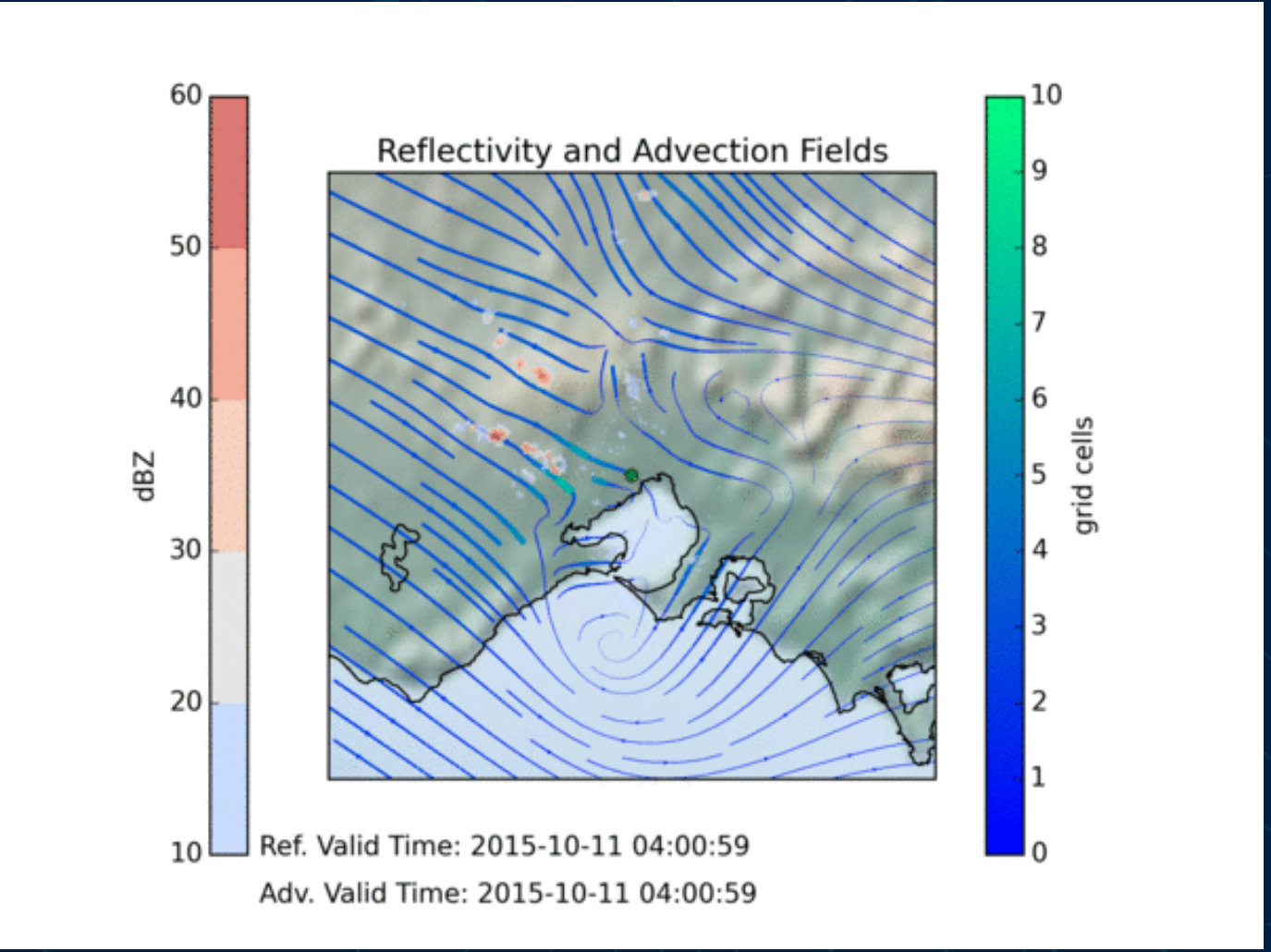
Bayes Target Classification

Australian Government
Bureau of Meteorology

Rainfields algorithms

- Used to simulate 1-minute data when calculating the 6-min accumulations
- Used to correct the different time stamps when making the mosaic
- Used for the nowcasting products

Echo Tracking

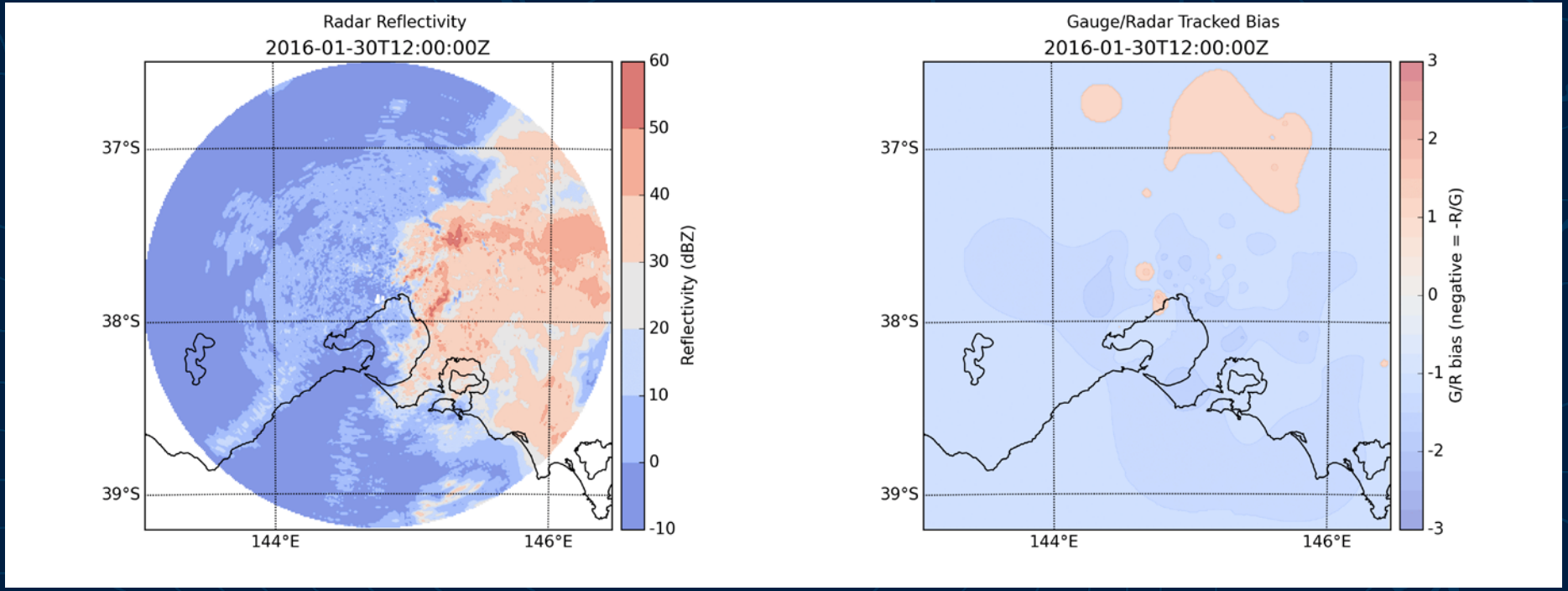


Australian Government
Bureau of Meteorology

Rainfields algorithms

- Mean bias at each gauge is monitored
- Real-time adjustment updated using Kalman filter every 30 mins
- Spatial field estimated using Ordinary Kriging every 30 mins

Dynamic Bias Adjustment



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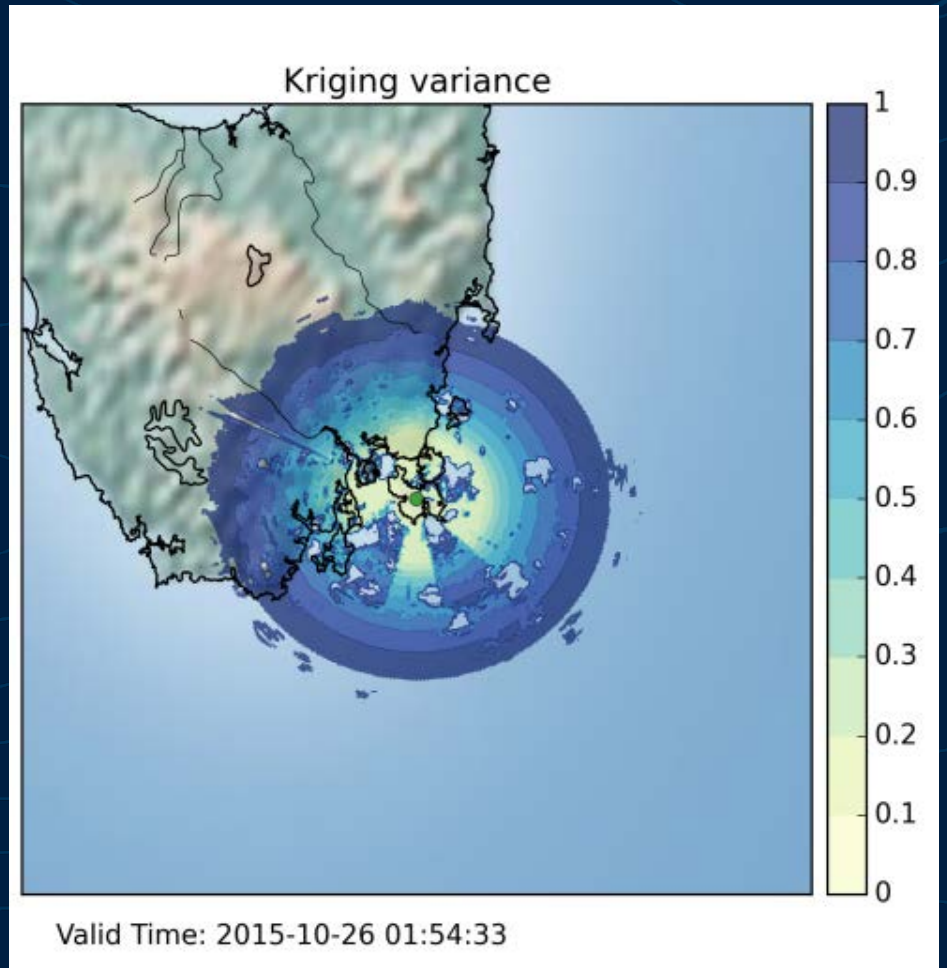
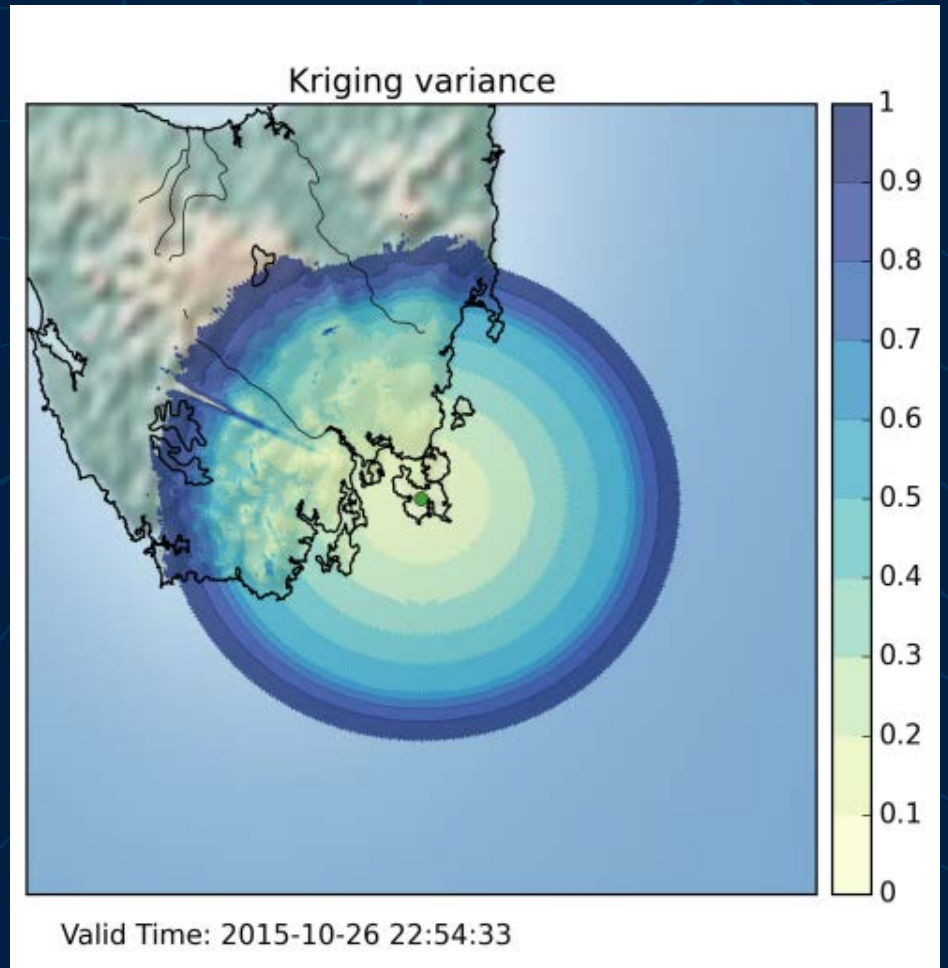
Bureau of Meteorology

Rainfields algorithms

- These plots illustrate that the quality of the radar observations evolve with time for the Koonya radar on October 26, 2015.

Dynamic Radar Quality Index



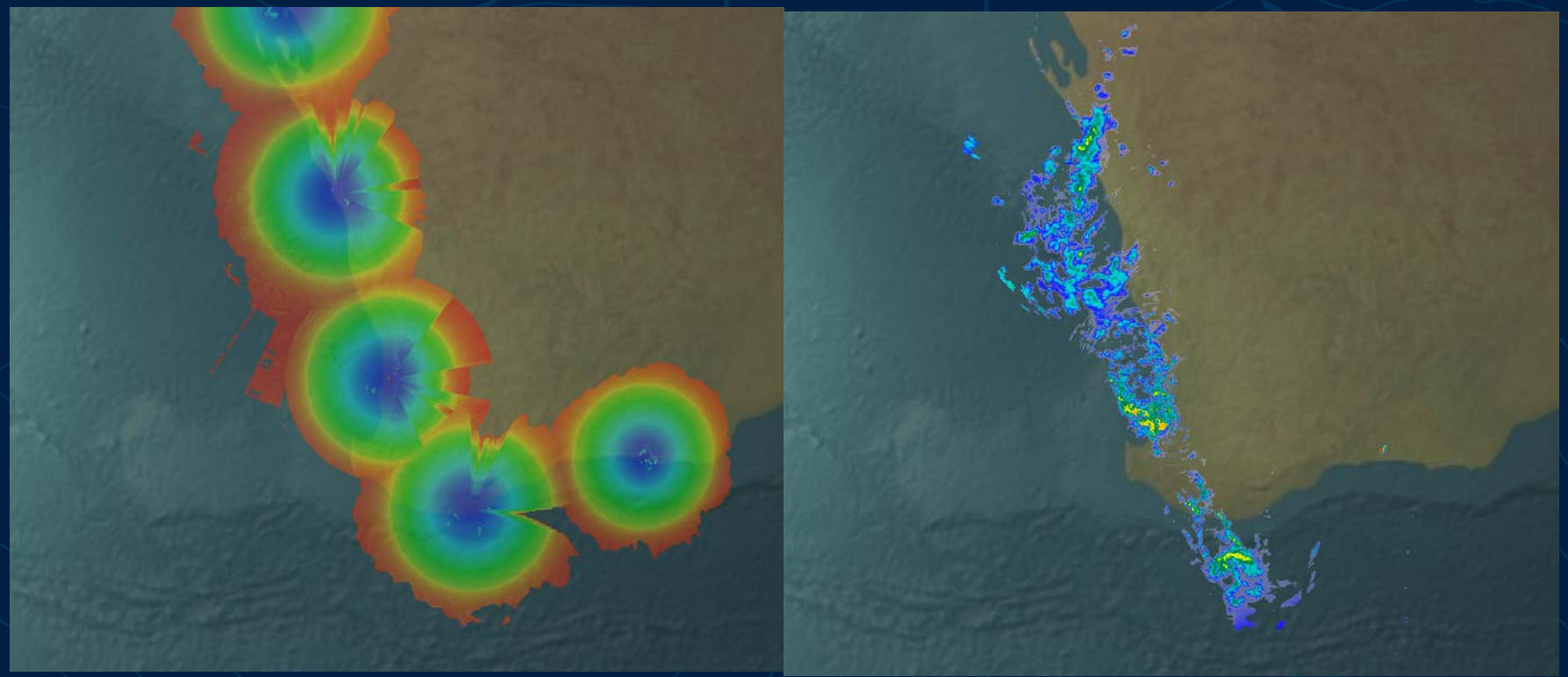


Australian Government
Bureau of Meteorology

Rainfields algorithms

- Use the quality index to calculate the weights for a mosaic product

Multi-radar mosaic



Australian Government
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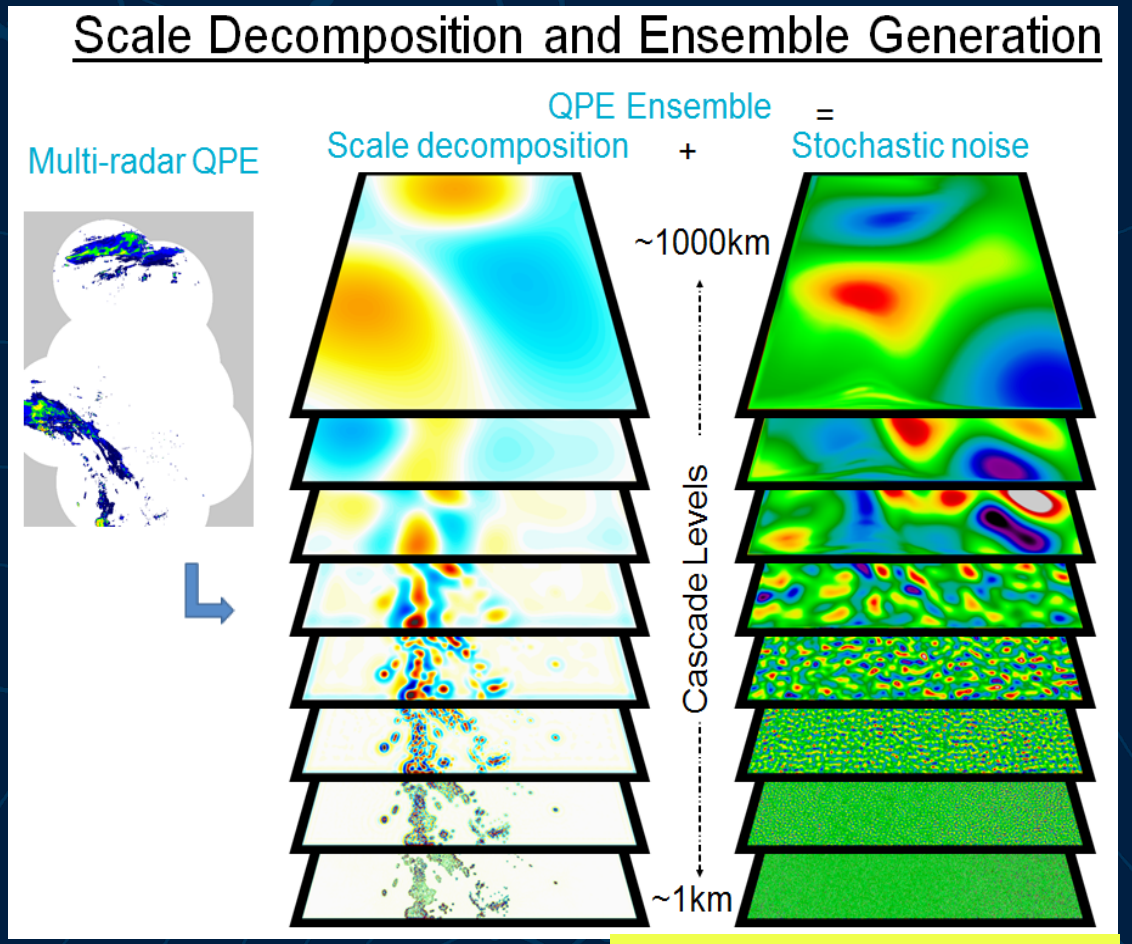
Nowcasting – 0 to 90 minutes

- **STEPS: Short Term Ensemble Prediction System**

- Rainfall fields are usually hierarchical in structure, with smaller areas of higher intensity rain embedded in larger areas of lower intensity rain

- Variability is distributed across a wide range of scales
- Uncertainties in rainfall spatial structure occur on all scales
- Can be modelled as a *predictable* component and a *random* component



Nowcasting STEPS

Australian Government
Bureau of Meteorology

Nowcasting – 0 to 90 minutes

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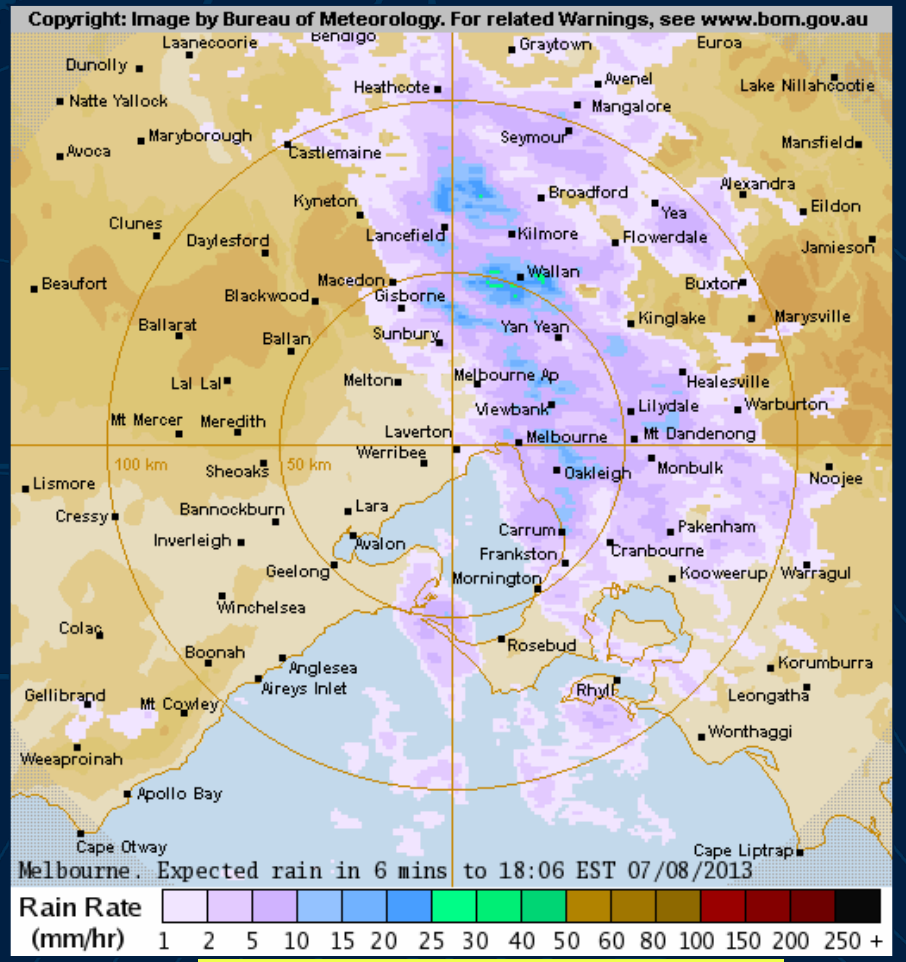
- Uncertainties in rainfall spatial structure occur on all scales
- Can be modelled as a *predictable* component and a *random* component

- The forecast rainfall field looks like rain and can be used to force hydrological models and calculate probabilities

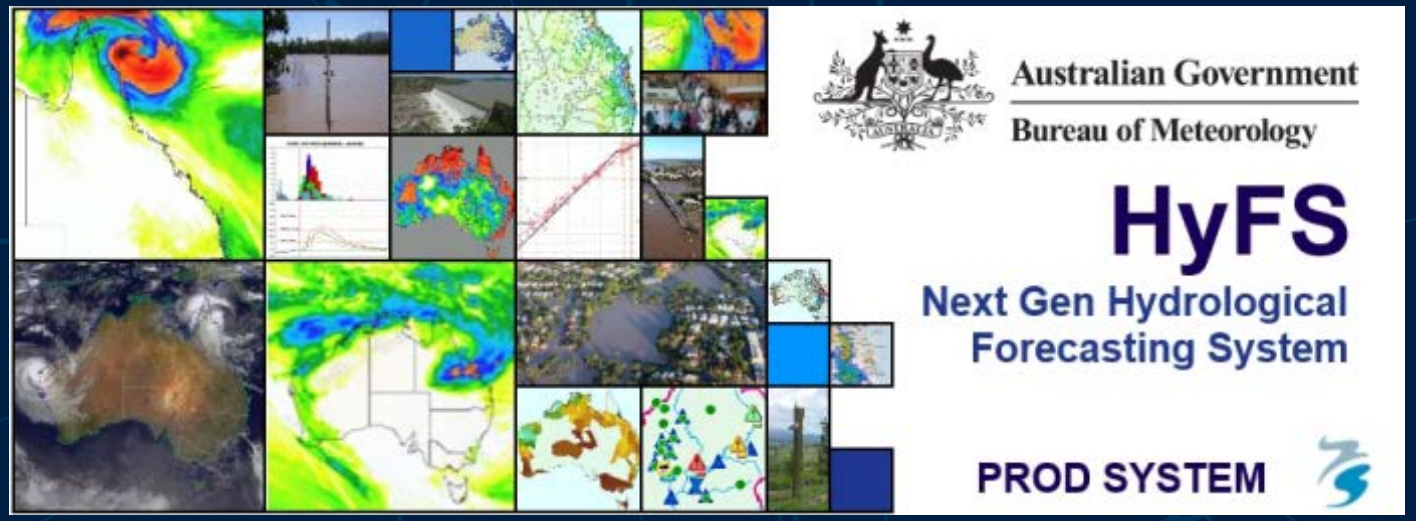


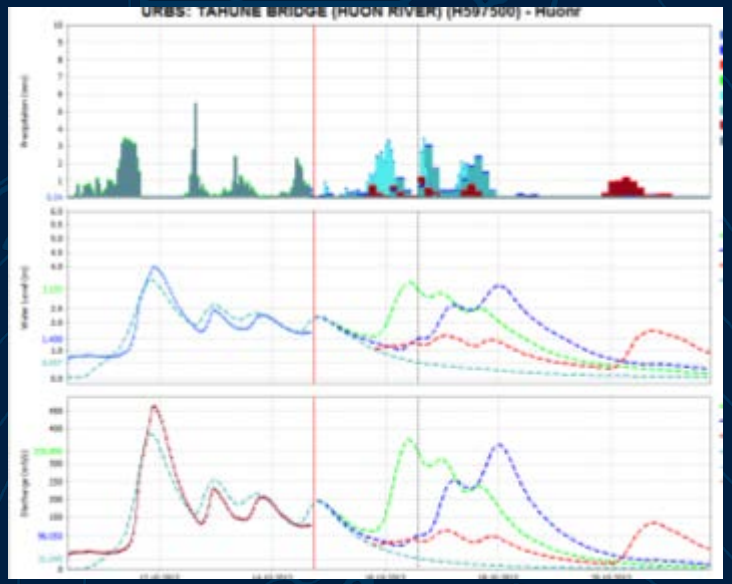
One Ensemble Member

Nowcasting STEPS

Rainfields and Flood Forecasting – HyFS

- HyFS is the Bureau's Next Generation Hydrological Forecasting System
- Implementation of Delft-FEWS platform (Deltares)
- Operational since December 2015
- National Cat-1 System
- Direct use of Gridded Rainfall Estimations and Forecast into Hydrological Models





Australian Government
Bureau of Meteorology

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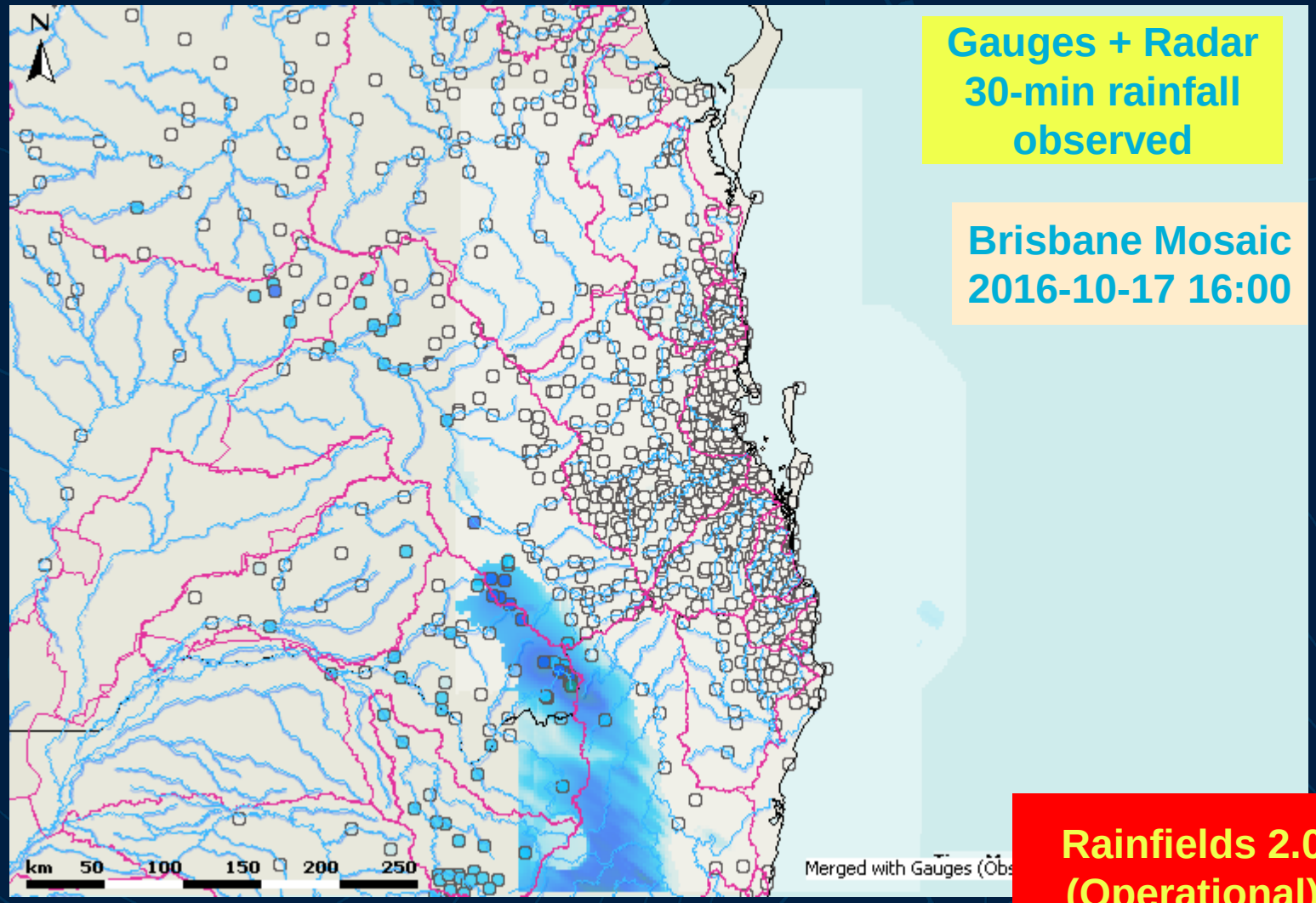

Gauges + Radar 30-min rainfall observed

Brisbane Mosaic 2016-10-17 16:00

Rainfields 2.0 (Operational)

Australian Government
Bureau of Meteorology

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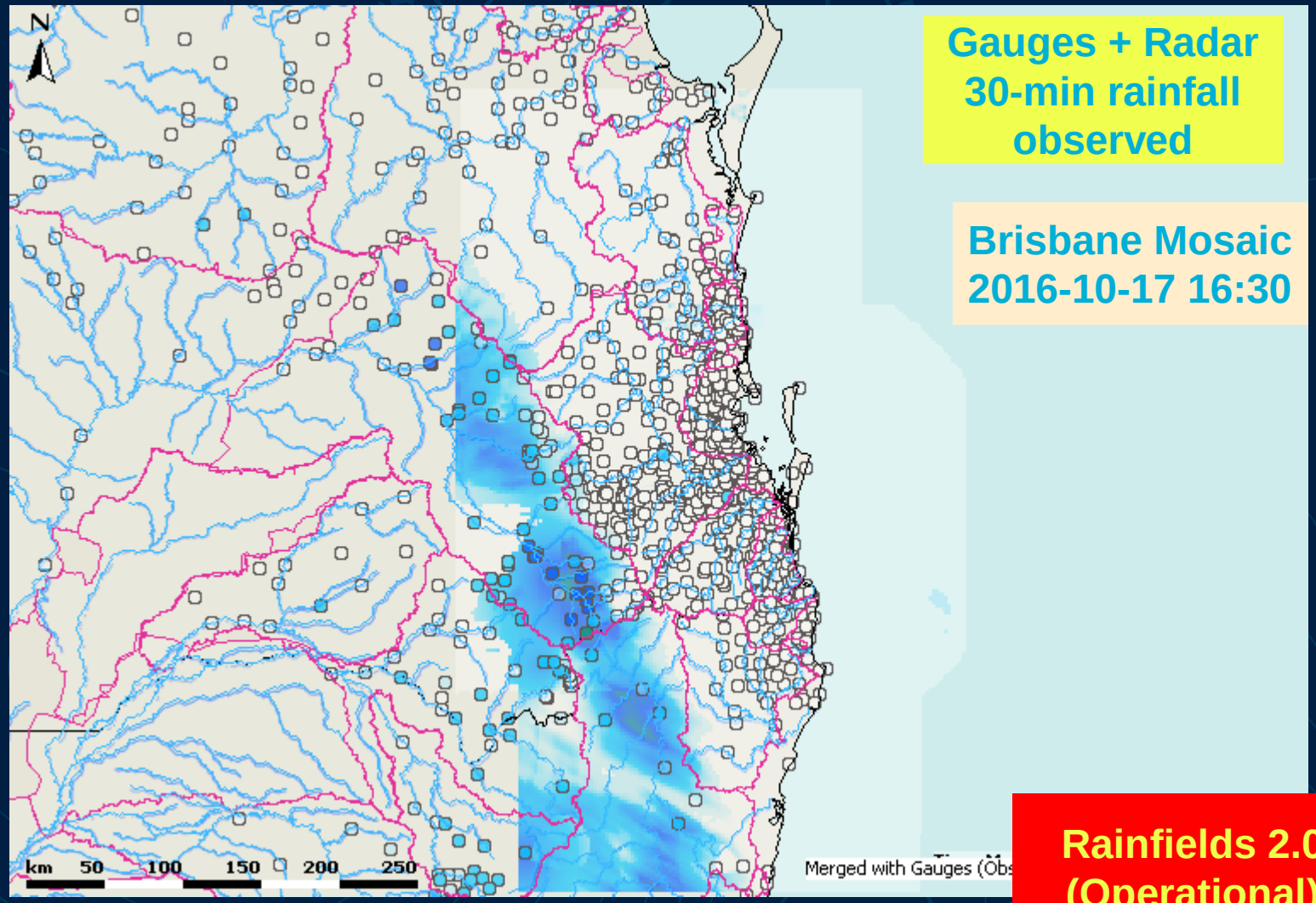

Gauges + Radar 30-min rainfall observed

Brisbane Mosaic 2016-10-17 16:30

Rainfields 2.0 (Operational)

Australian Government
Bureau of Meteorology

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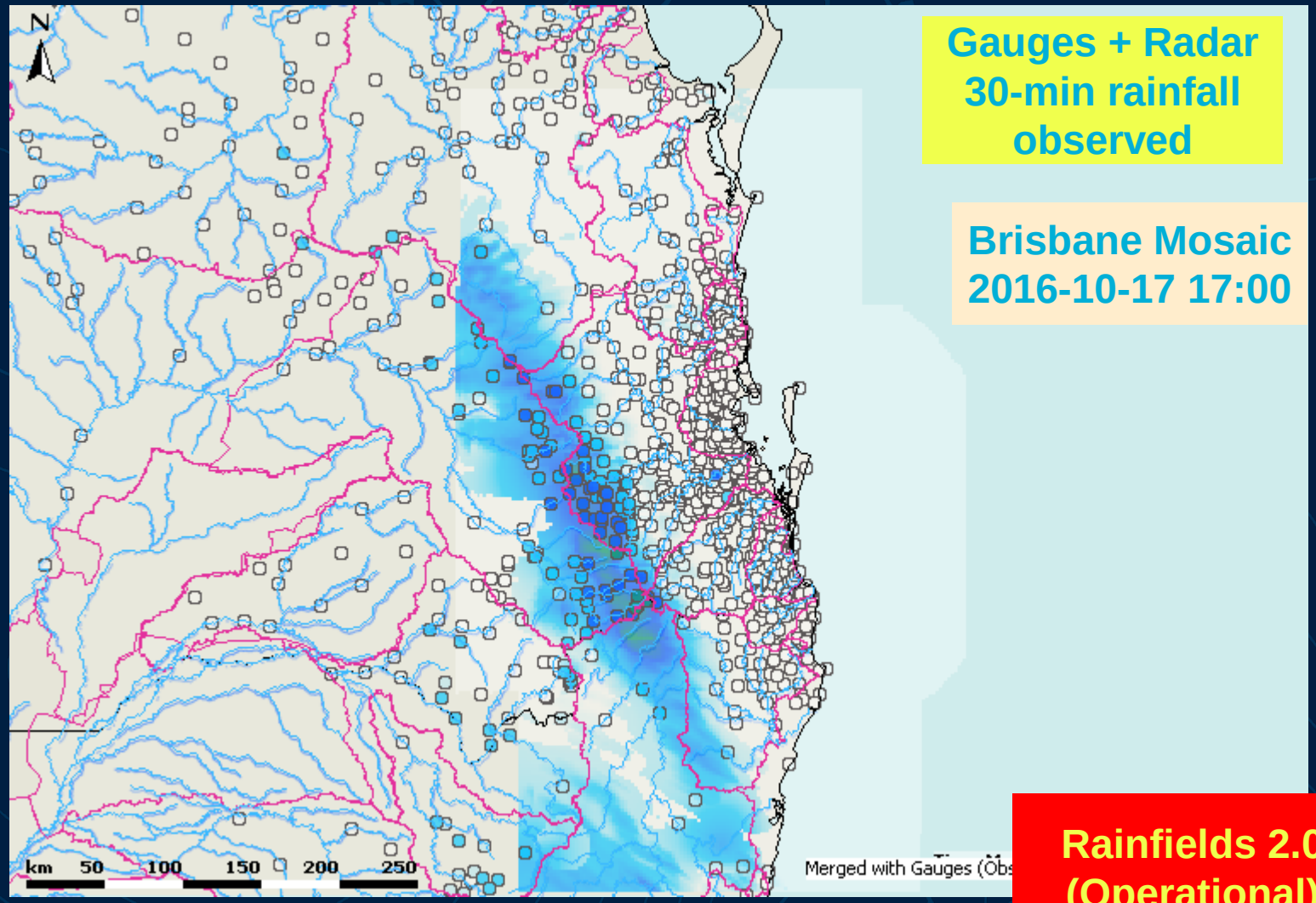

Gauges + Radar 30-min rainfall observed

Brisbane Mosaic 2016-10-17 17:00

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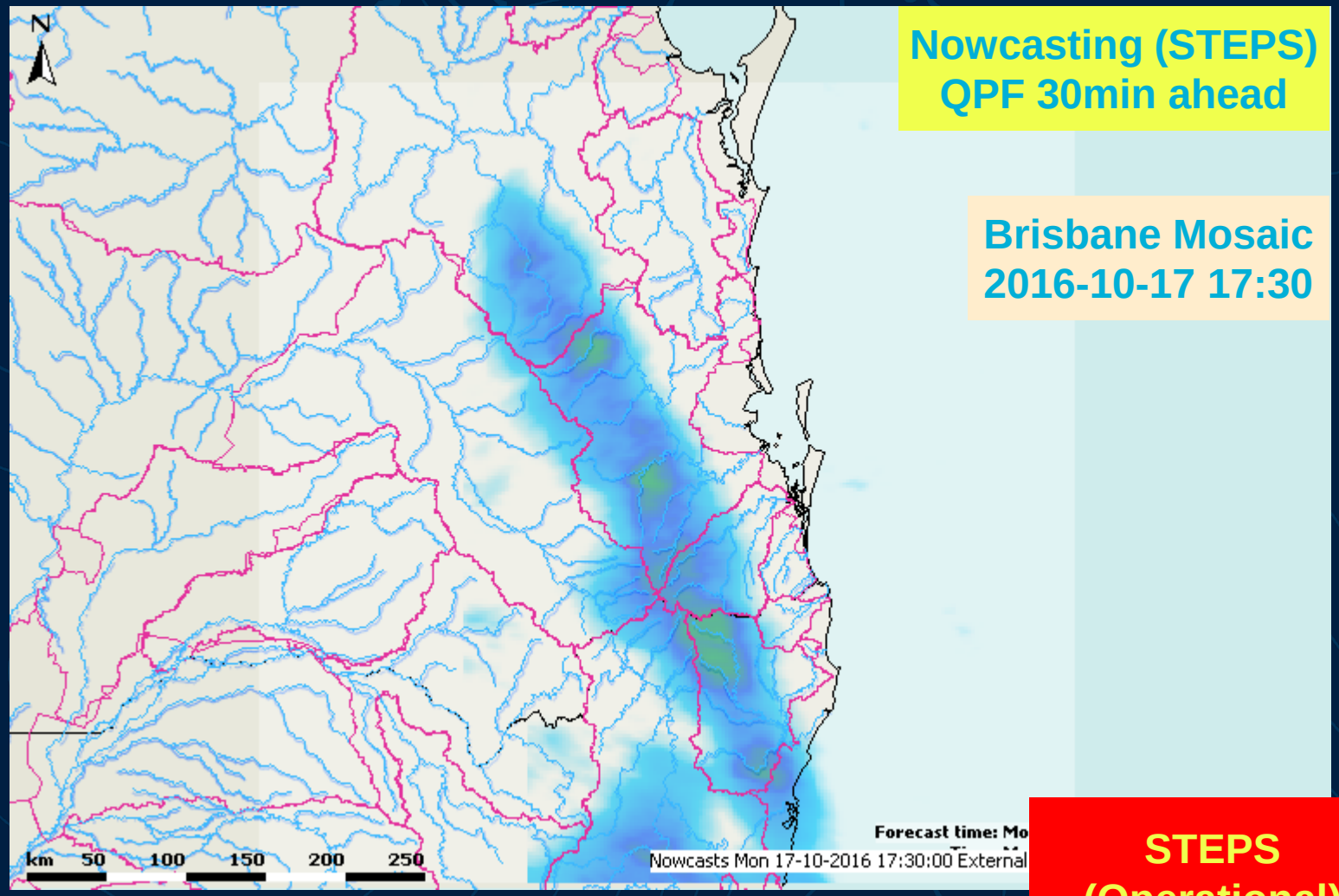

Australian Government
Bureau of Meteorology

Rainfields and Flood Forecasting – HyFS

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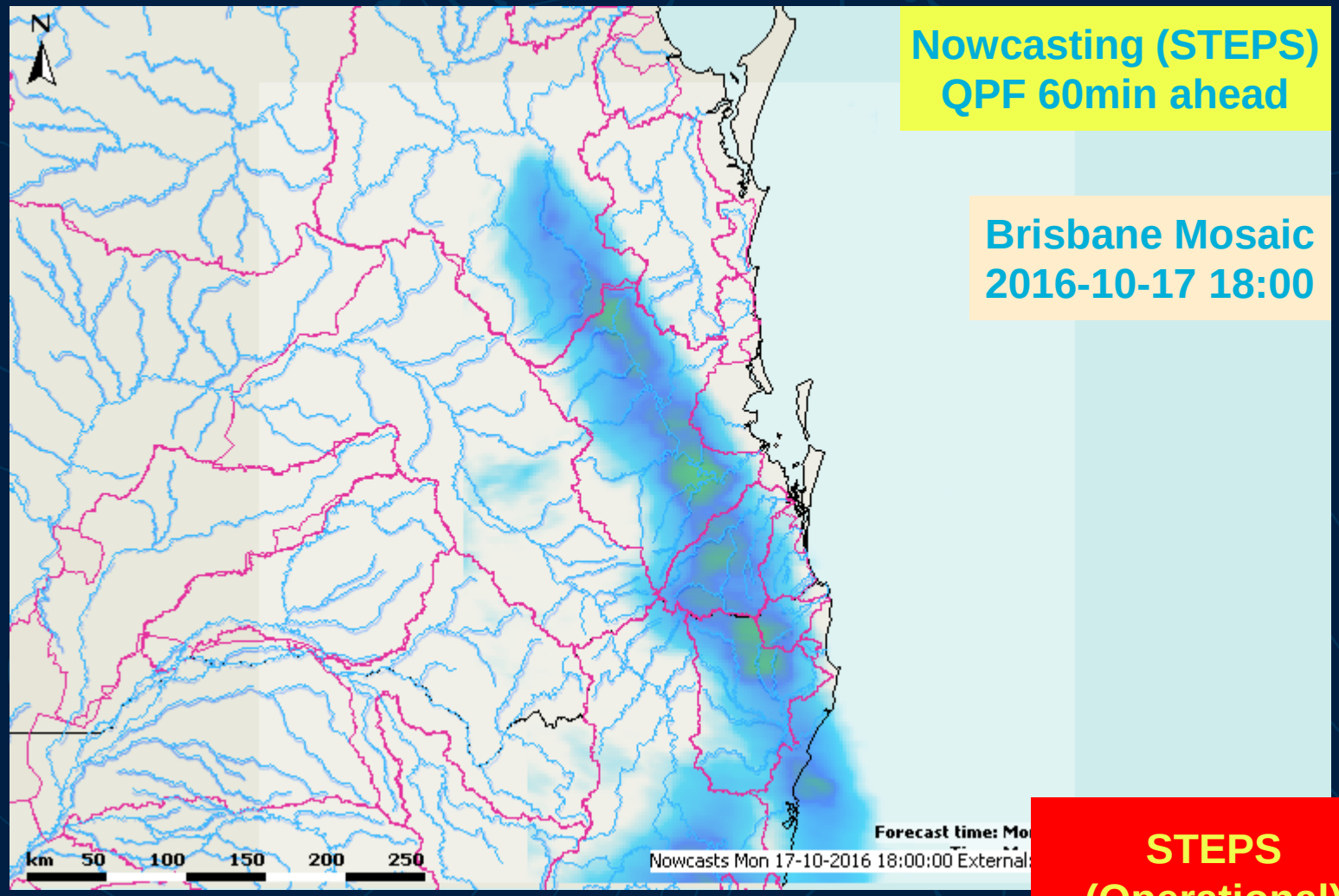

Nowcasting (STEPS)
QPF 60min ahead

Brisbane Mosaic
2016-10-17 18:00

STEPS (Operational)

Australian Government
Bureau of Meteorology

Rainfields and Flood Forecasting – HyFS

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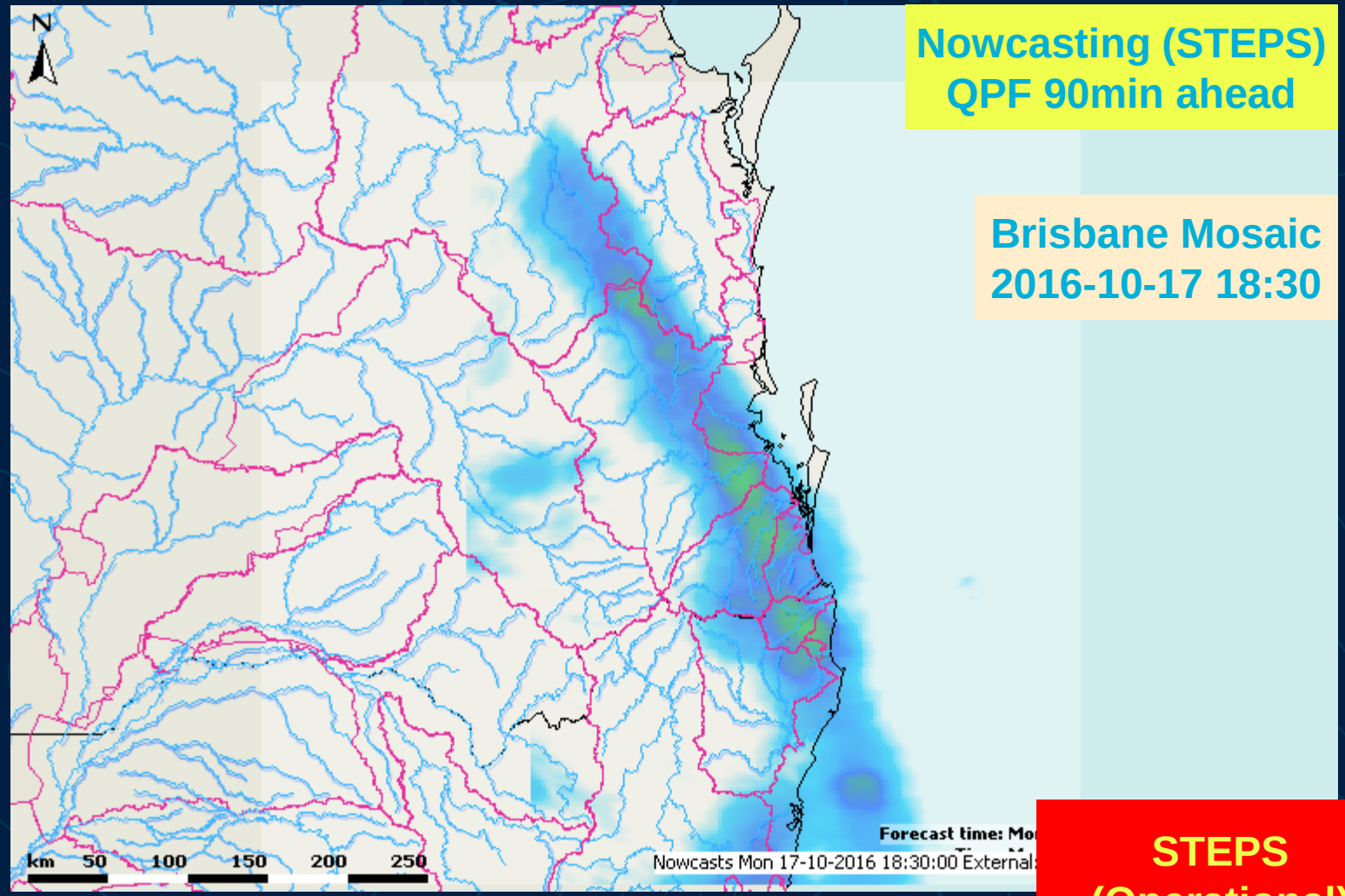

Nowcasting (STEPS)
QPF 90min ahead

Brisbane Mosaic
2016-10-17 18:30

STEPS (Operational)

Australian Government
Bureau of Meteorology

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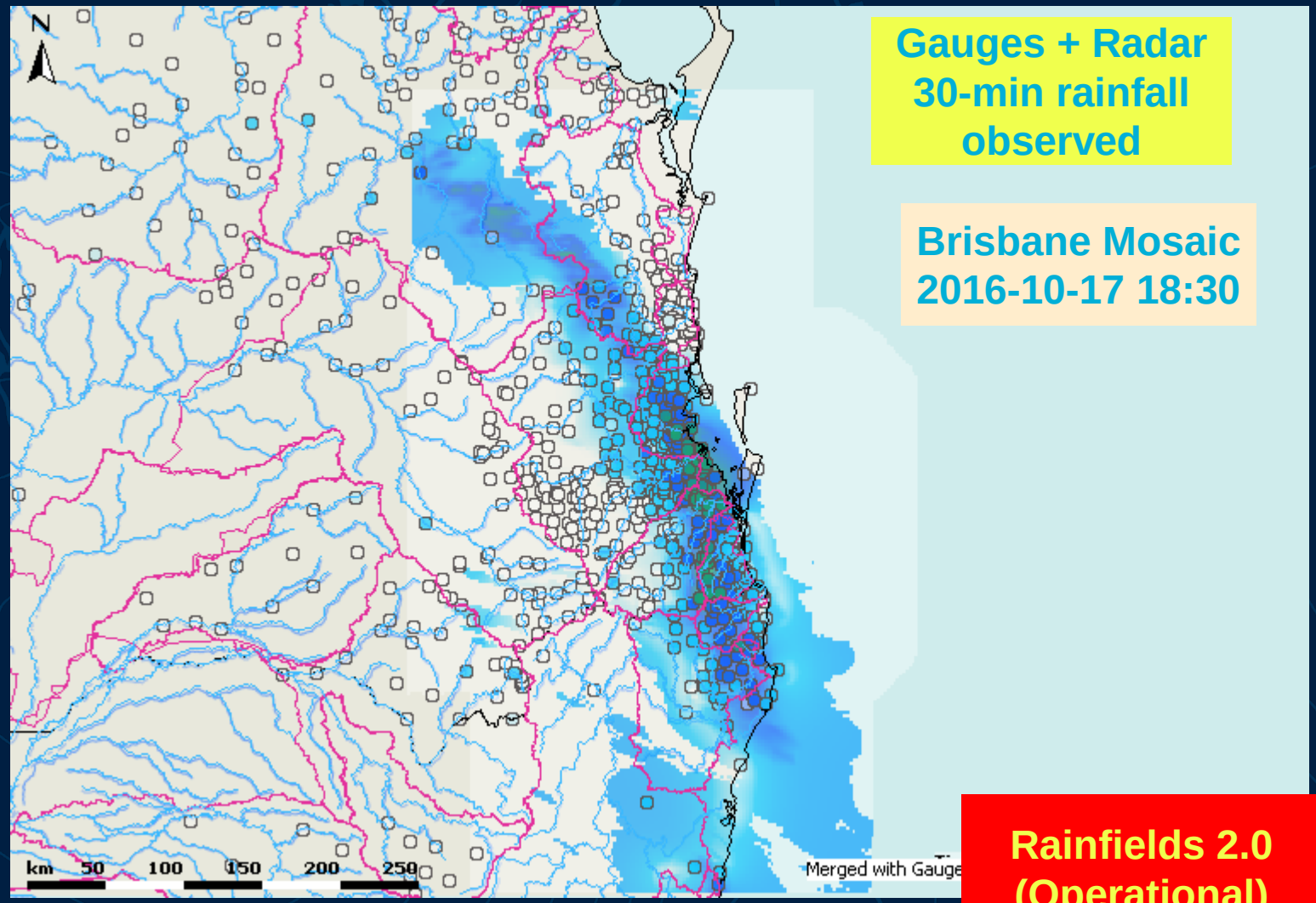


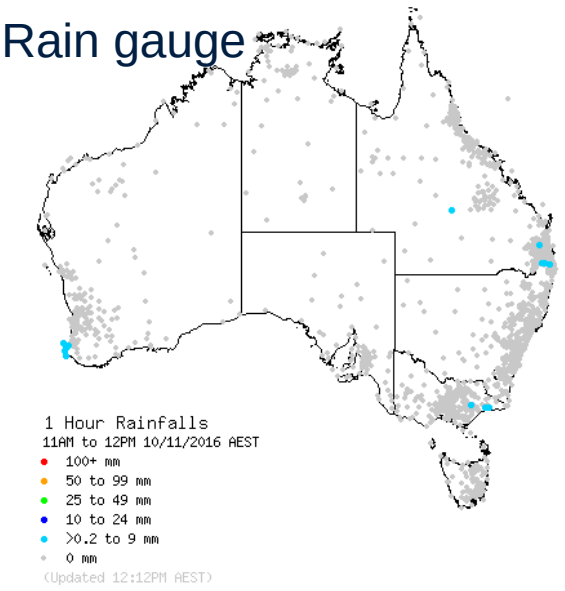
Gauges + Radar 30-min rainfall observed

Brisbane Mosaic 2016-10-17 18:30

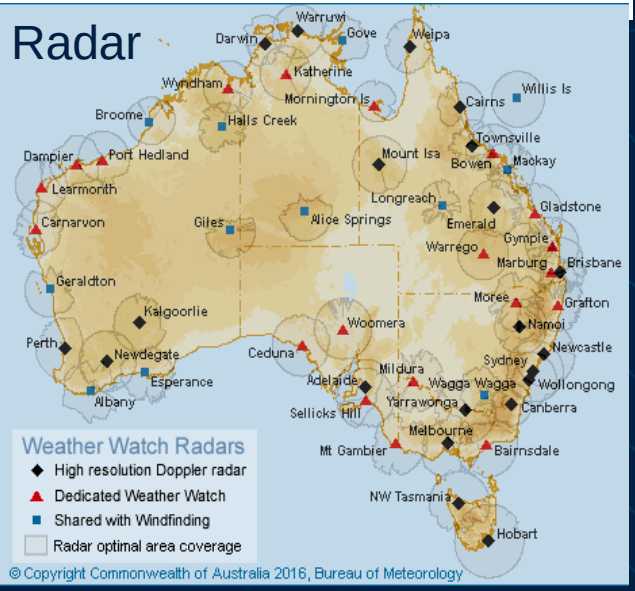
Rainfields 2.0 (Operational)

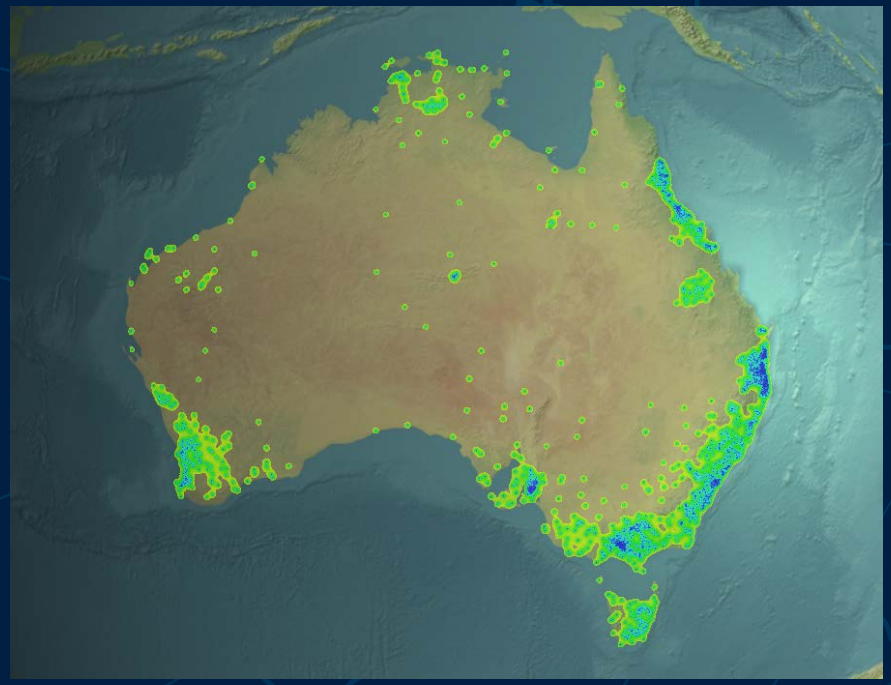
Australian Government
Bureau of Meteorology

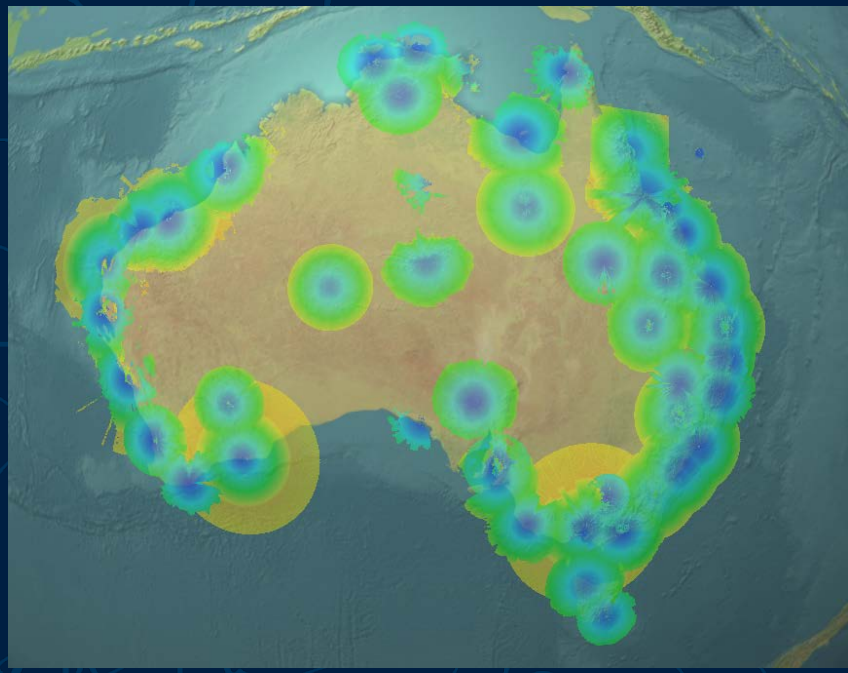
Rain gauge



Radar



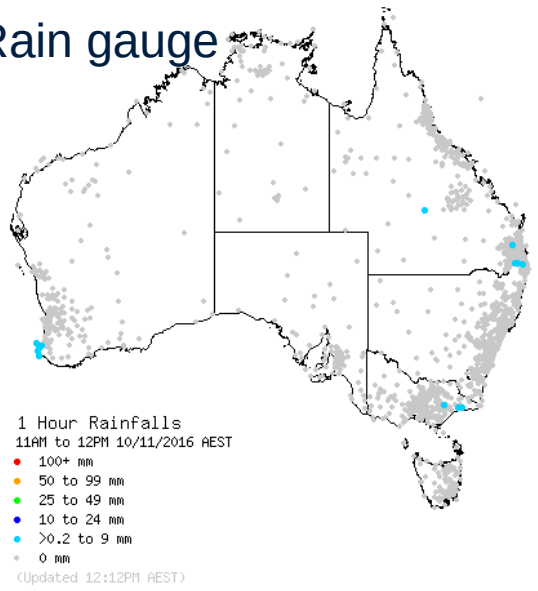




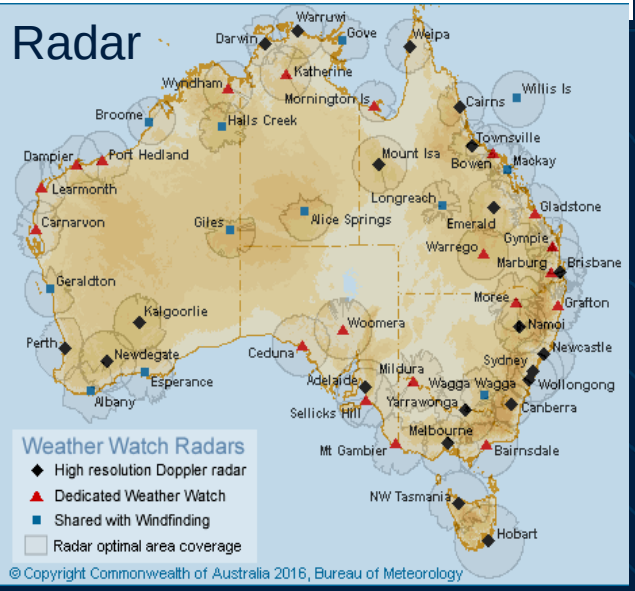
Limited Rain gauges and Radar Coverage in Real Time

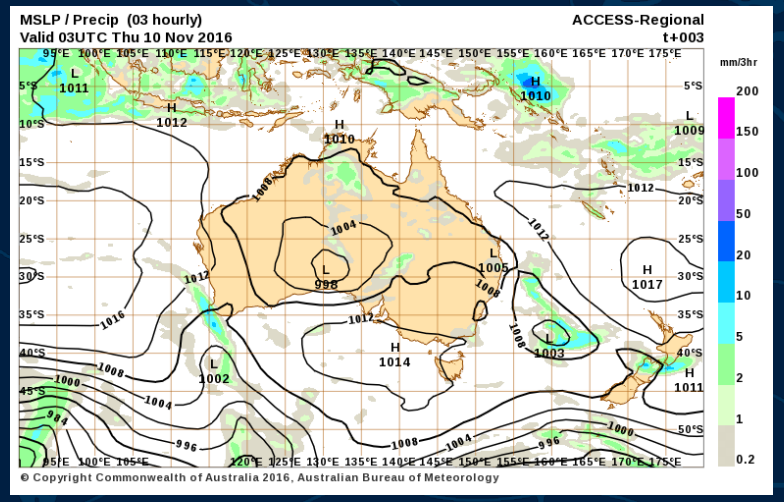
Australian Government
Bureau of Meteorology

Rain gauge



Radar

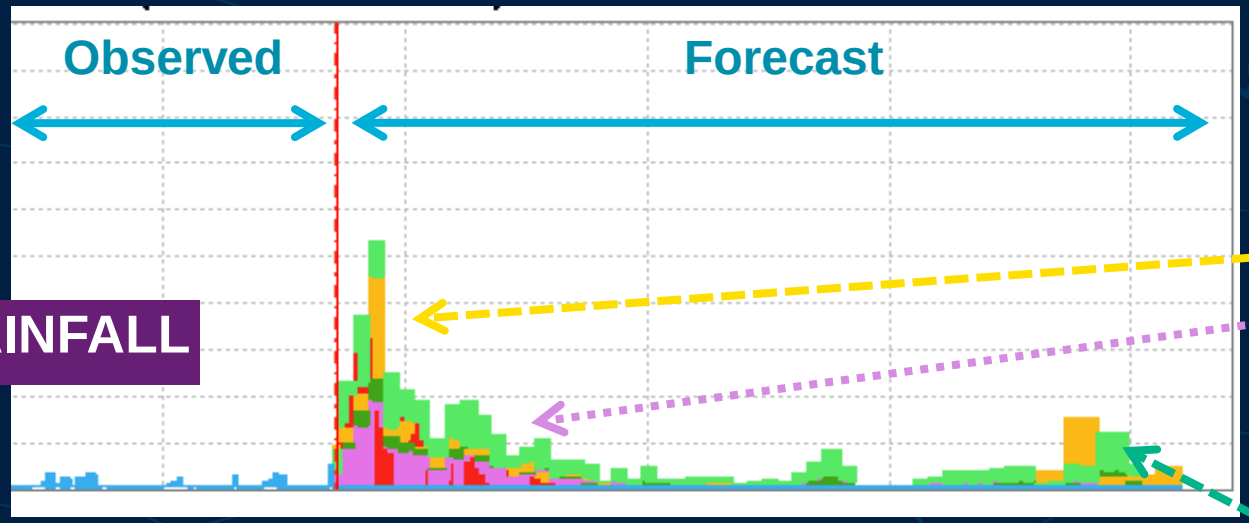


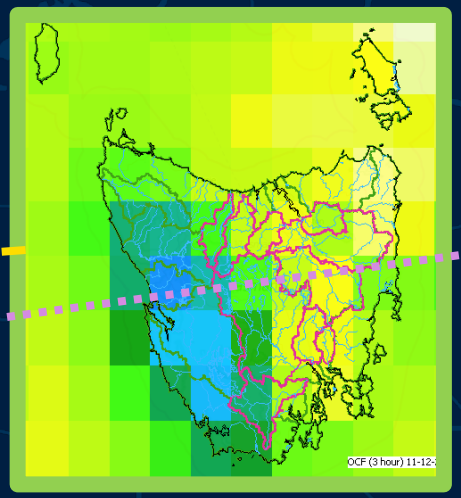


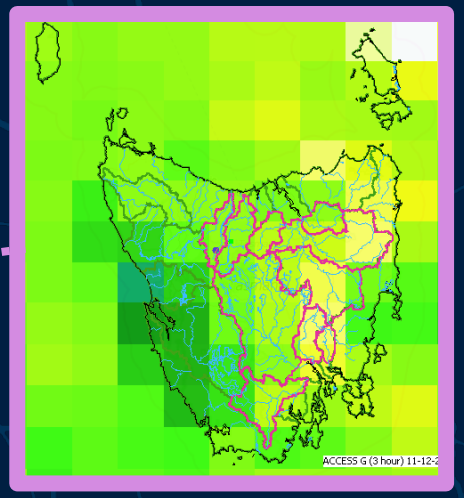
Short range numerical model forecasts

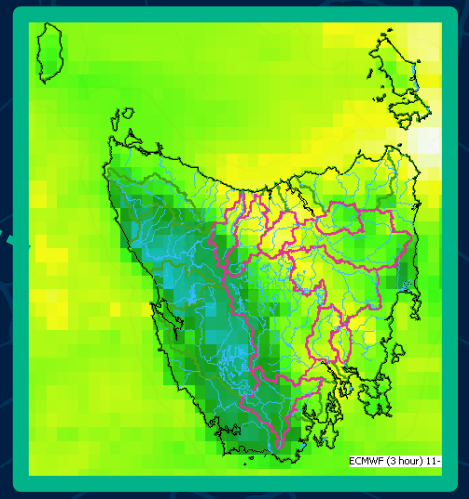
Australian Government
Bureau of Meteorology

HyFS – Operational Flood Forecast System



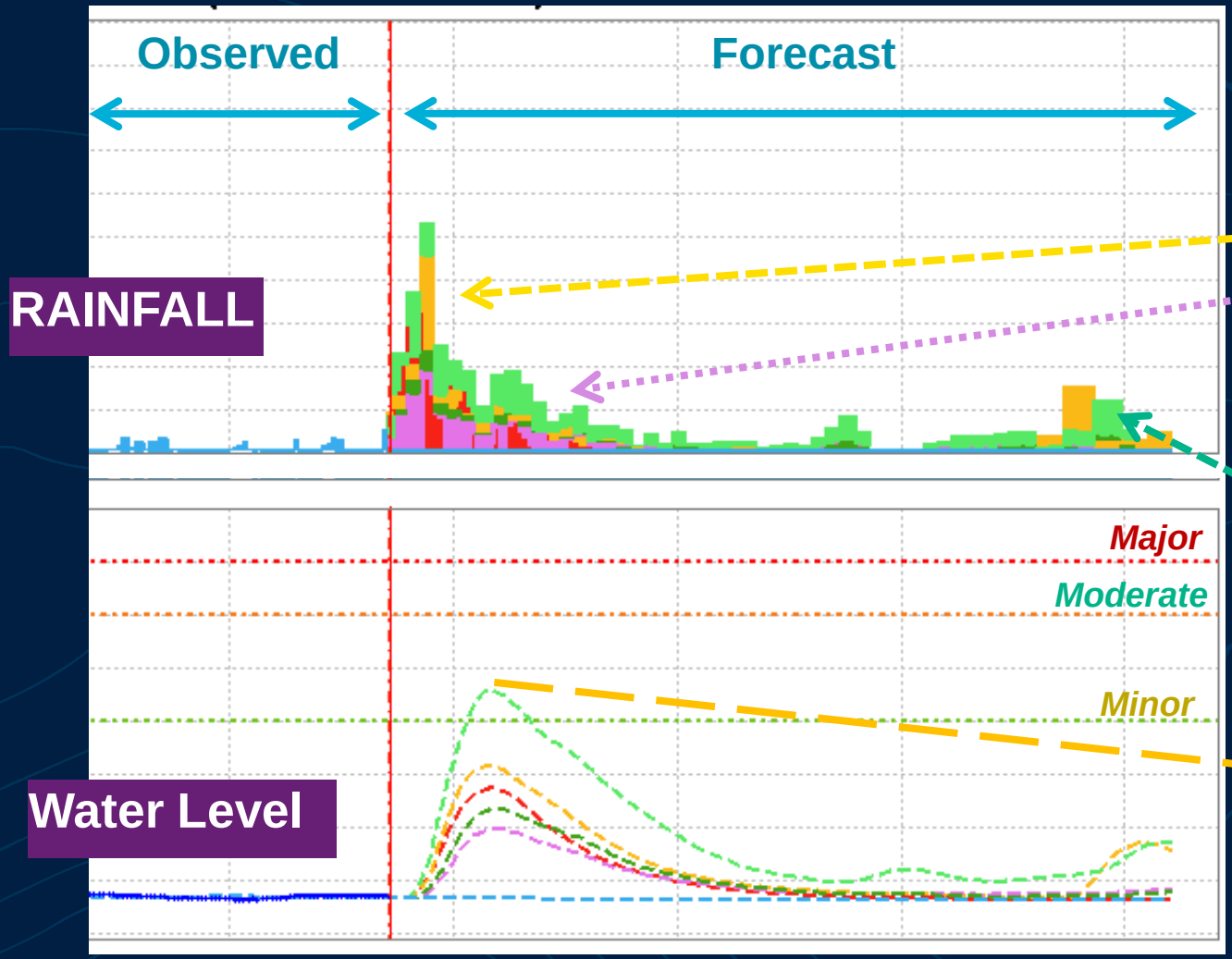


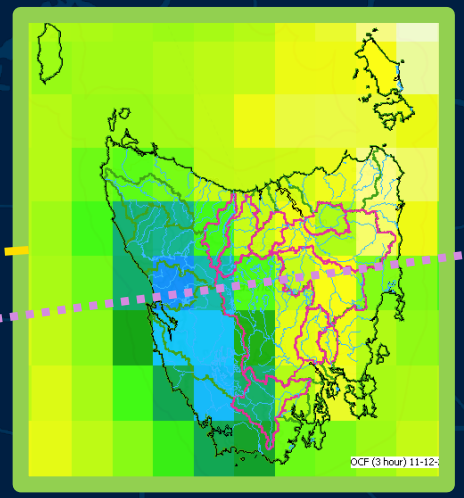


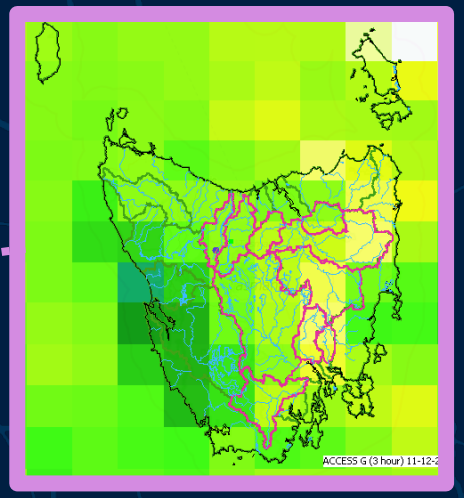


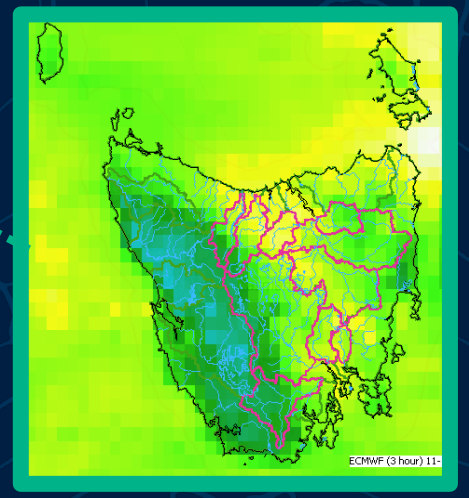
Australian Government
Bureau of Meteorology

HyFS – Operational Flood Forecast System





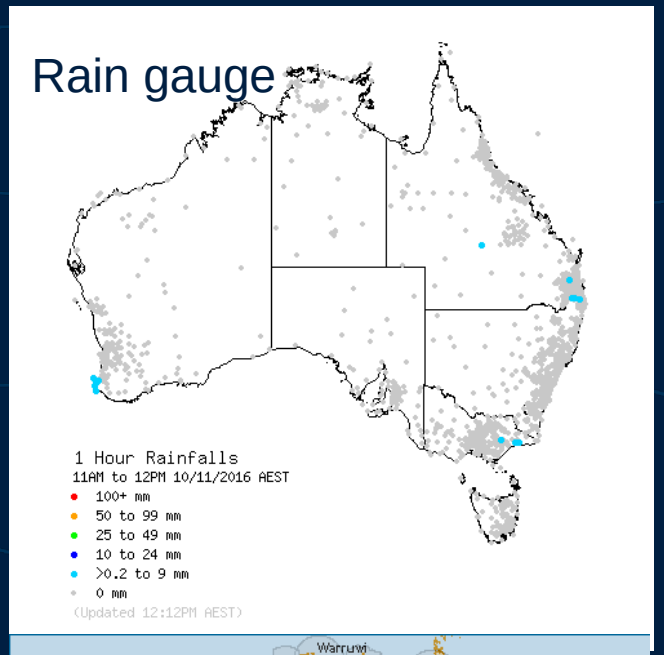


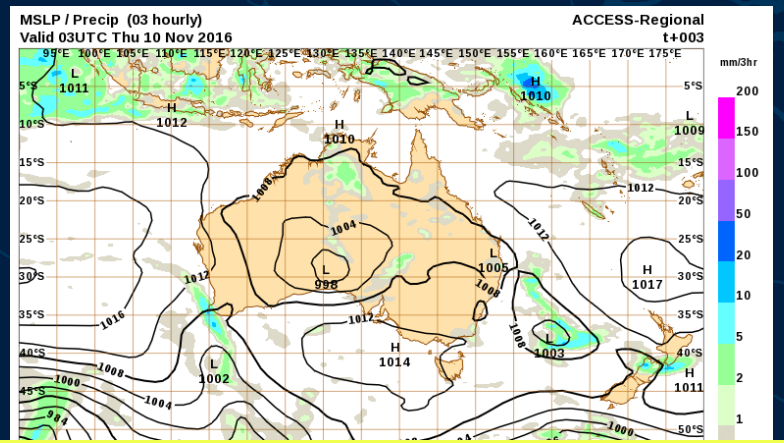


Flood Warning

Australian Government
Bureau of Meteorology

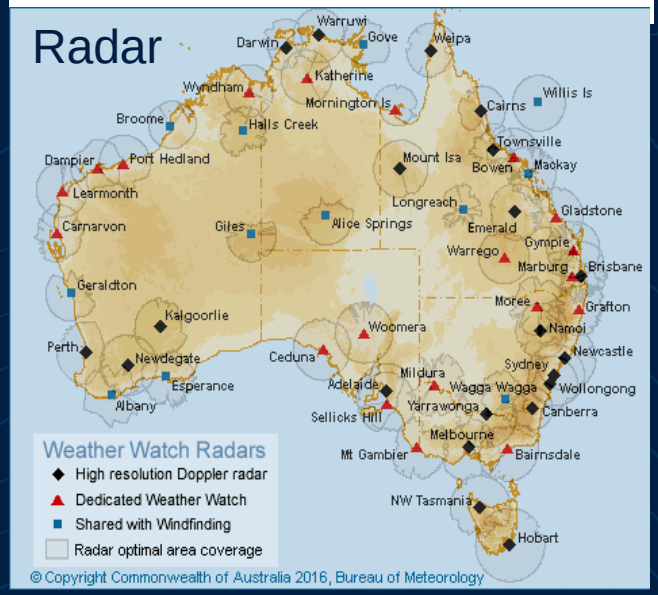
Real-time multi-sensor national rainfall

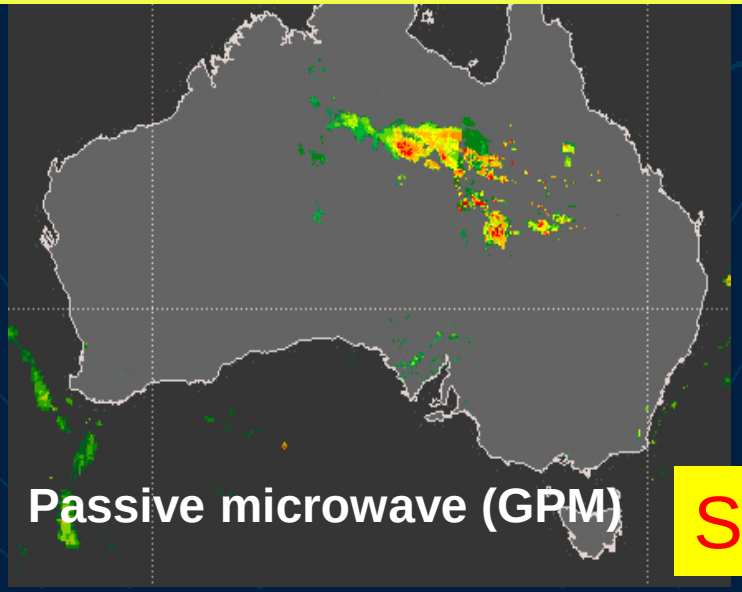


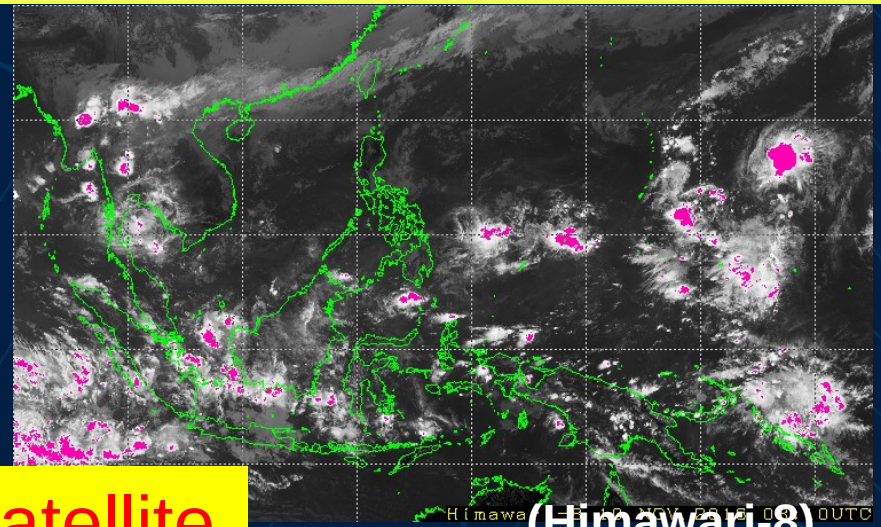


Short range numerical model forecasts

Real-time multi-sensor national rainfall project (part of WIRADA)





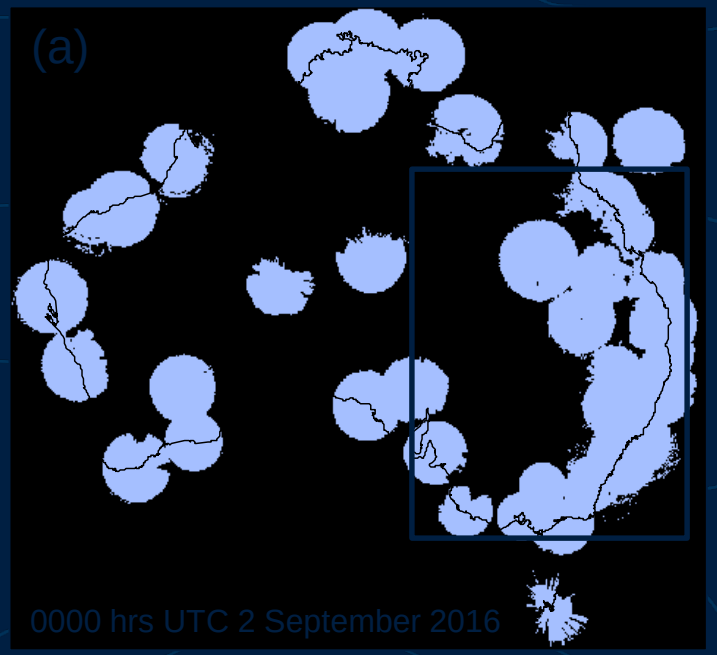


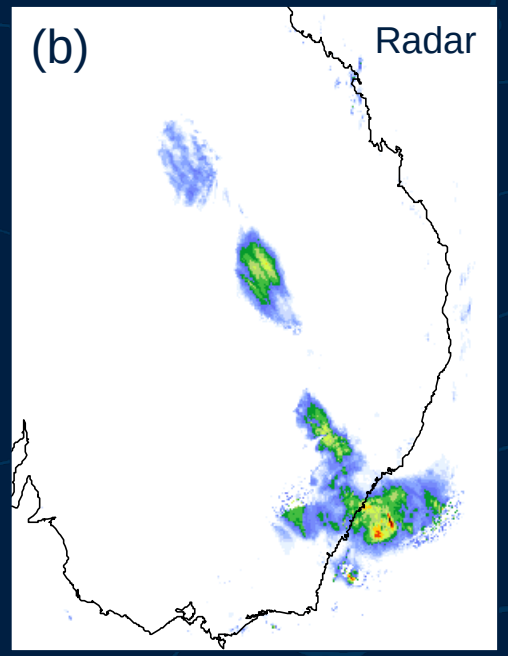
Satellite (Himawari-8)

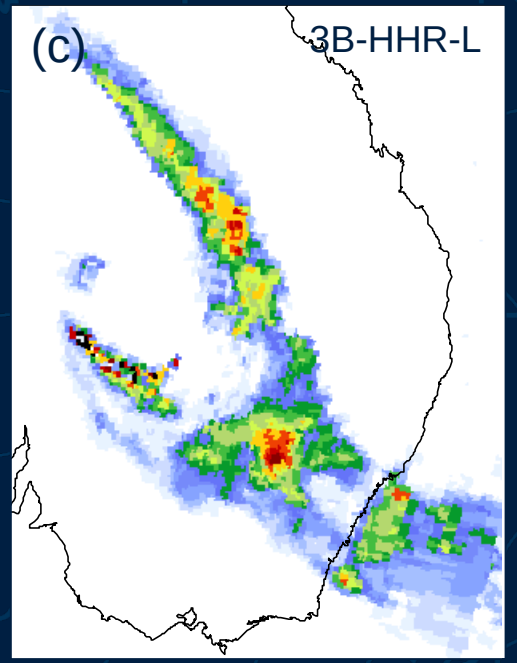
Australian Government
Bureau of Meteorology

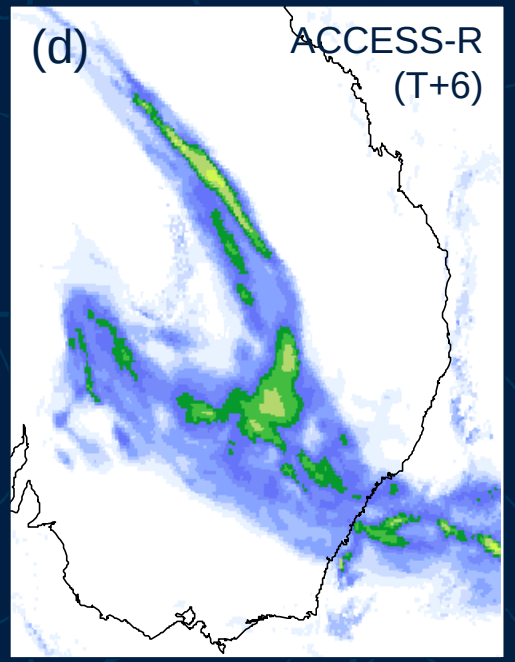
Real-time multi-sensor national rainfall project

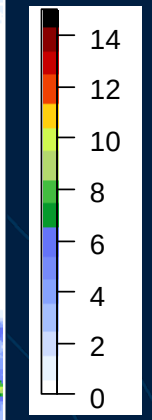
Hourly Rainfall Estimations











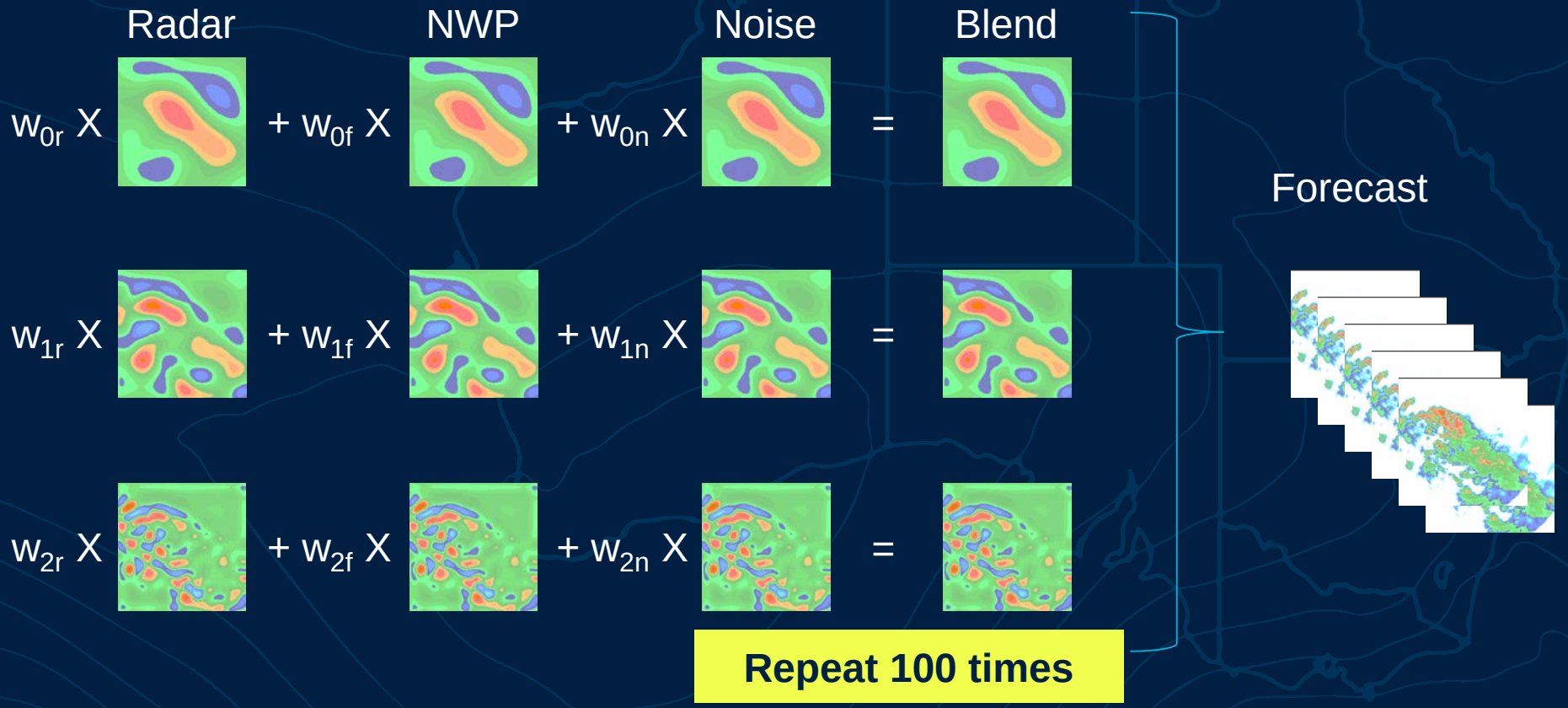
Radar Coverage | **Radar** | **Satellite** | **NWP**

Rainfall data has large uncertainties.
Blending method must preserve the fine spatial structure captured by the radar and gauges whilst extending estimation capability across Australia beyond the radar network

Australian Government
Bureau of Meteorology

Real-time multi-sensor national rainfall project

Hourly Rainfall Estimations

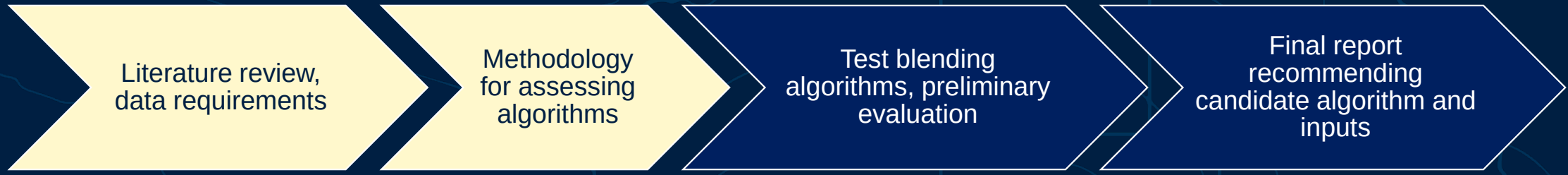


Scale – dependent Weighted blending - STEPS

HOURLY QPE ANALYSIS - ENSEMBLE

Australian Government
Bureau of Meteorology

Real-time multi-sensor national rainfall project



Quantifying errors in inputs: Radar, Satellite, NWP

Explore the use of Himawari rainfall products

User feedback to specify and refine product suite

Next year – implementation based on recommendations this project

Australian Government
Bureau of Meteorology

Summary

- **AWAP and Flood maps**
  - Only gauges Analysis
  - Available in the public Bureau's website as images and data
  - Mainly Daily information
- **Rainfields 2.0**
  - Current Operational Radar and Gauges Rainfall estimation system
  - Limited number of areas where rainfall products are available
  - Rainfall products available in the public Bureau website as images and data for registered users
- **Rainfields 3.0 (mid 2017)**
  - the next generation operational radar rainfall estimation and nowcasting system
  - Processes data from 50 radars
  - Massively enhanced radar QC and QPE algorithms
  - Will use STEPS algorithms to generate 30-member nowcast ensemble for each of the 50 radars (6 min updates)
  - Generates 10000 QPE&QPF products an hour
- **National multi-sensor rainfall analysis (under research stage – a WIRADA project)**
  - Assess the usage of Satellite and NWP models rainfall estimations to complement Rainfields QPE

Australian Government
Bureau of Meteorology

Thank you

Any questions?

Carlos Velasco – carlos.velasco@bom.gov.au