New tools for weather forecast verification at the Australian Bureau of Meteorology

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National Operations Centre, Melbourne

Australian Government
Bureau of Meteorology

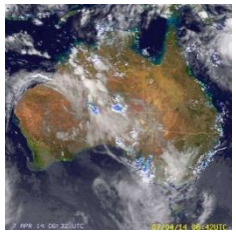
Image: Scottbridle.com

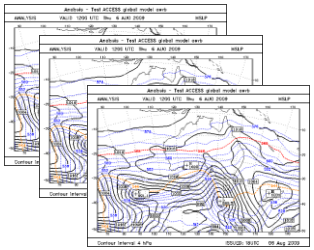
Why verify?

- The Bureau is accountable to its customers and supporters: reporting Key Performance Indicators
- Forecaster learning happens best when there is rapid feedback: verification "situational awareness"
- Innovations should be evidence-based: e.g, Bureau is contemplating forecast automation

Weather forecasting process

Observations

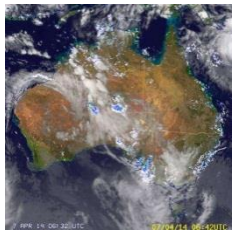




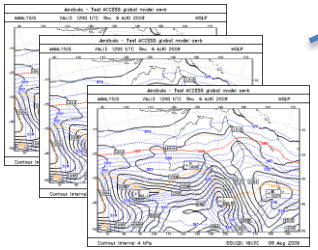
Multiple NWP model outputs

Weather forecasting process

Observations



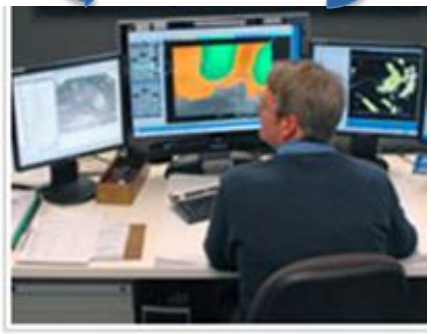
Post Processor



Multiple NWP model outputs

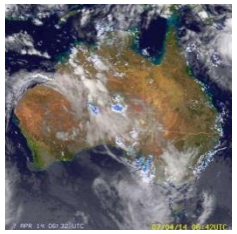
"OCF"

Graphical Forecast Editor



Weather forecasting process

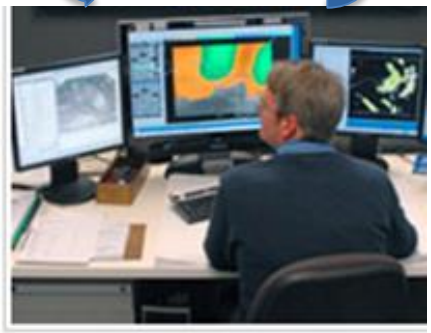
Observations



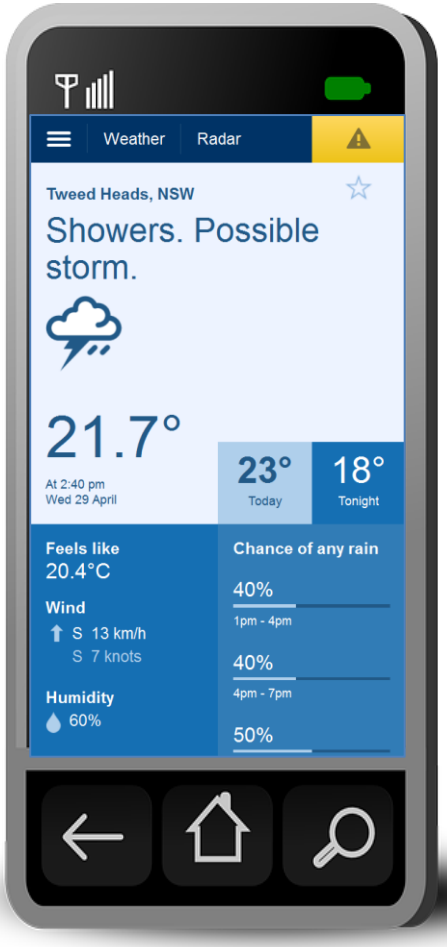
Post Processor

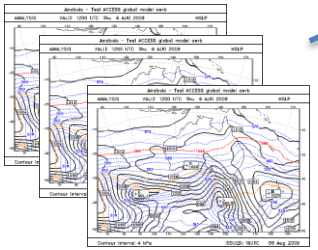
"OCF"

Graphical Forecast Editor



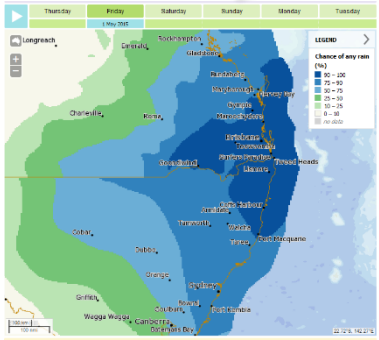
Automated 7 day text forecasts for 650 locations





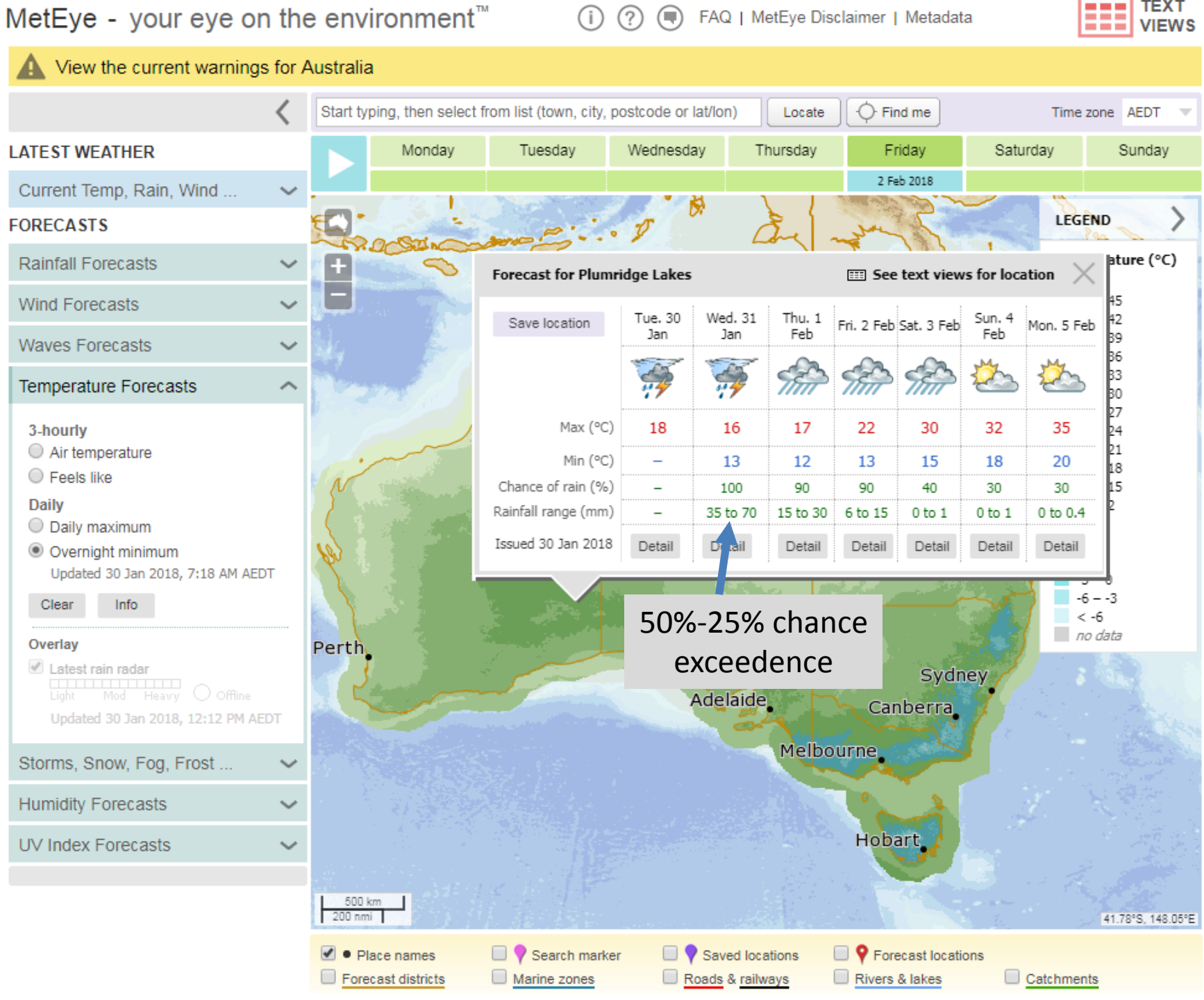
Multiple NWP model outputs

"Official"

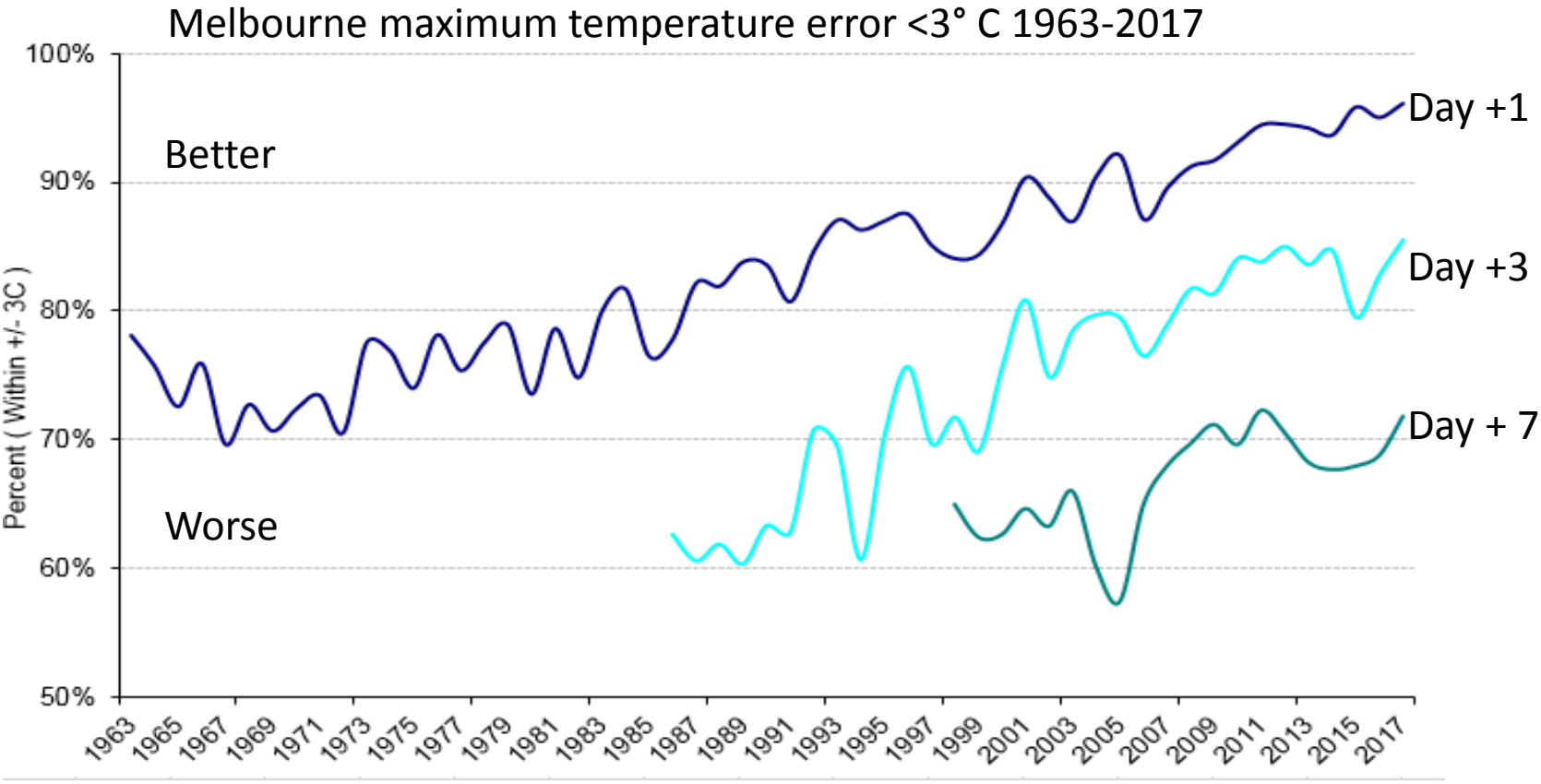


6 km resolution graphical forecasts

Gridded downstream applications


MetEye - your eye on the environment™
FAQ | MetEye Disclaimer | Metadata
TEXT VIEWS
View the current warnings for Australia
Start typing, then select from list (town, city, postcode or lat/lon)
Locate
Find me
Time zone AEDT
LATEST WEATHER
Current Temp, Rain, Wind ...
FORECASTS
Rainfall Forecasts
Wind Forecasts
Waves Forecasts
Temperature Forecasts
3-hourly
Air temperature
Feels like
Daily
Daily maximum
Overnight minimum
Updated 30 Jan 2018, 7:18 AM AEDT
Clear
Info
Overlay
Latest rain radar
Light Mod Heavy Offline
Updated 30 Jan 2018, 12:12 PM AEDT
Storms, Snow, Fog, Frost ...
Humidity Forecasts
UV Index Forecasts
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
2 Feb 2018
LEGEND
Forecast for Plumridge Lakes
See text views for location
Save location
Tue. 30 Jan
Wed. 31 Jan
Thu. 1 Feb
Fri. 2 Feb
Sat. 3 Feb
Sun. 4 Feb
Mon. 5 Feb
Max (°C) 18 16 17 22 30 32 35
Min (°C) – 13 12 13 15 18 20
Chance of rain (%) – 100 90 90 40 30 30
Rainfall range (mm) – 35 to 70 15 to 30 6 to 15 0 to 1 0 to 0.4
Issued 30 Jan 2018
Detail
50%-25% chance exceedence
Perth
Adelaide
Sydney
Canberra
Melbourne
Hobart
500 km
200 nmi
41.76°S, 148.05°E
Place names
Search marker
Saved locations
Forecast locations
Forecast districts
Marine zones
Roads & railways
Rivers & lakes
Catchments

Existing systems



Long-term annual/quarterly statistics

Verification systems
developed incrementally
over about 15 years

Temperature
Precipitation
Wind speed/direction
Ocean wave height
Fire weather (humidity, temperature, wind)

New developments
Dashboards – KPIs – Meteograms

Interactive Dashboards

Audience is Bureau forecasters, used in morning briefings, retrospectives

Data gathering supported by python, visualisation by R-shiny

Temperature
- Daily maximum, minimum

Precipitation
- Daily PoP, mean precip, 75, 50, 25, 10% chance of exceedance

Daily Verification

Date: (end of valid period in UTC)

2017-10-27

Forecast lead day:

1 2 3 4 5 6 7

Region:

Northern Territory

- New South Wales
- Northern Territory
- Queensland
- South Australia
- Tasmania
- Victoria
- Western Australia

HELP

Long-term Verification

Report an issue

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrec | Data tables | Links | Database

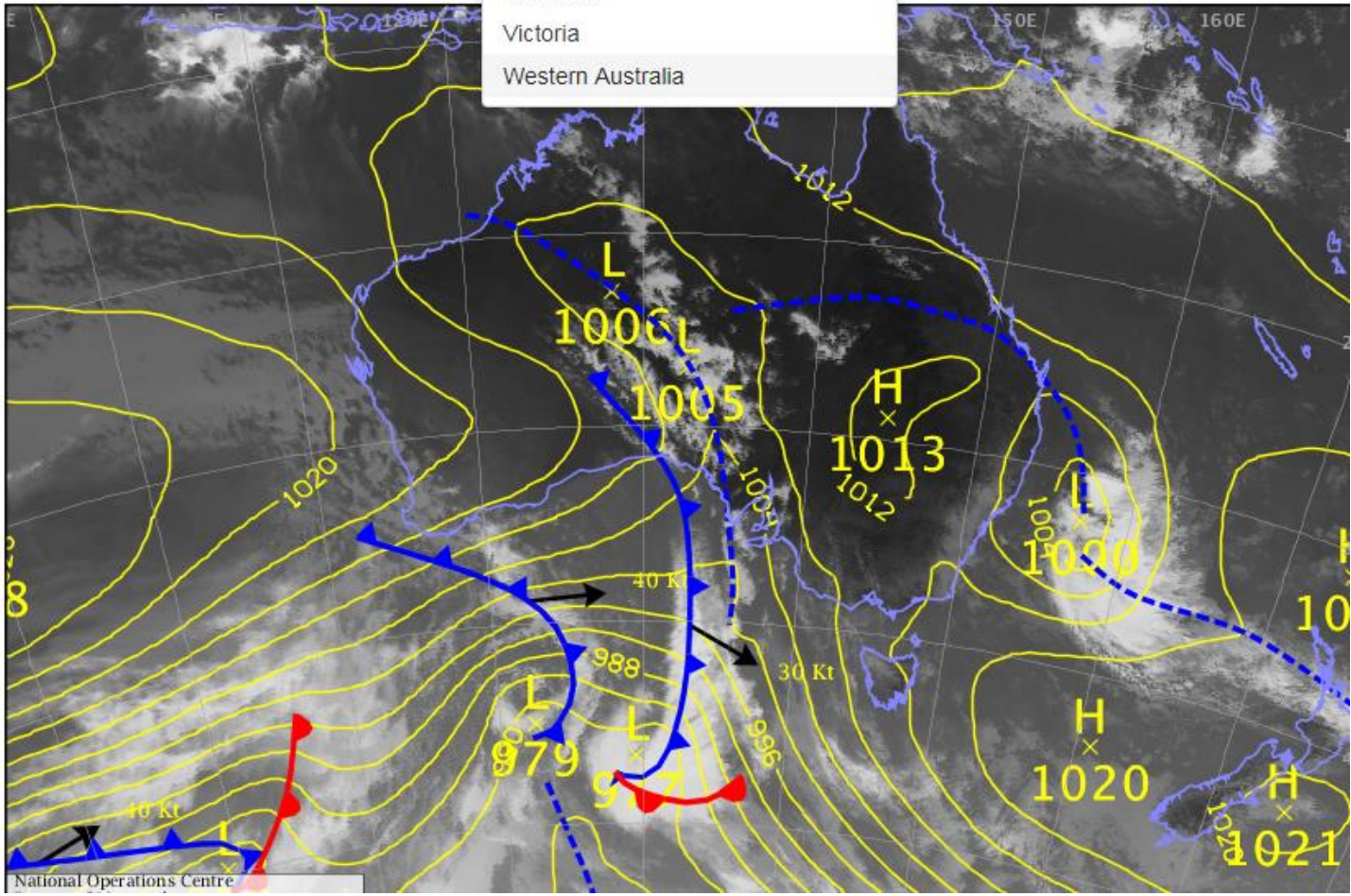
Select a chart

- MSLP
- MSLP with IR
- 850 hPa
- 700 hPa
- 500 hPa
- 400 hPa
- 300 hPa
- 250 hPa
- 200 hPa

Hour (UTC)

- 18z
- 00z
- 06z
- 12z

IR imagery with MSLP overlay from BNOC cha



Daily Verification

Date: (end of valid period in UTC)

2017-10-27

Forecast lead day:

1 2 3 4 5 6 7

Region:

Northern Territory

HELP
Long-term Verification
Report an issue

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

MaxT or MinT

- (•) MaxT
- ( ) MinT

Map type

- (•) Observations
- ( ) Forecast
- ( ) Forecast error
- ( ) Official vs 18z PtOCF

Forecast source

- (•) Official
- ( ) 18z PtOCF

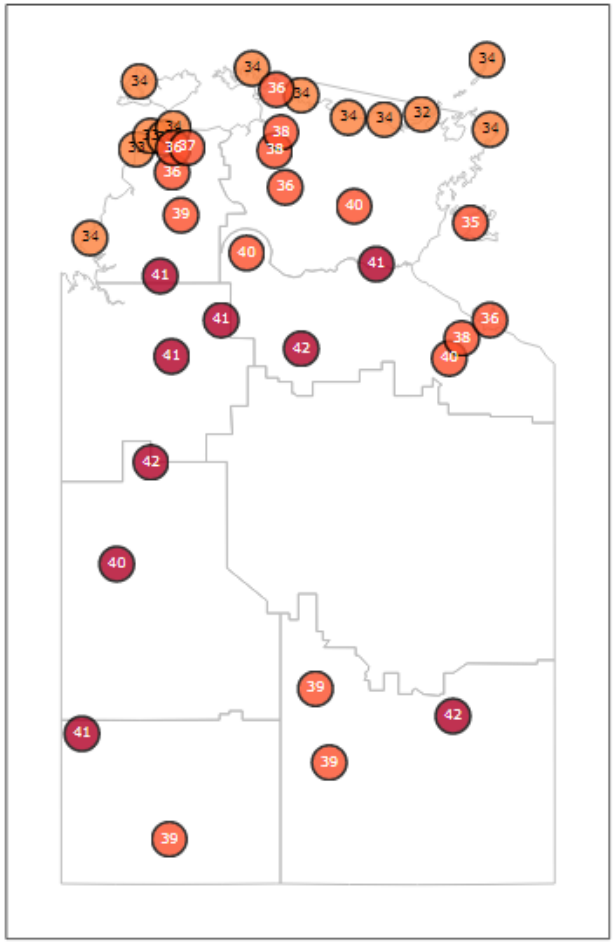
Error and |Score| filter

No filter

Observed

Forecast

Observed MaxT: 2017-10-27



Daily Verification

Date: (end of valid period in UTC)

2017-10-27

Forecast lead day:

1 2 3 4 5 6 7

Region:

Northern Territory

HELP
Long-term Verification
Report an issue

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

MaxT or MinT

- (•) MaxT
- ( ) MinT

Map type

- ( ) Observations
- ( ) Forecast
- (•) Forecast error
- ( ) Official vs 18z PtOCF

Error

Forecast source

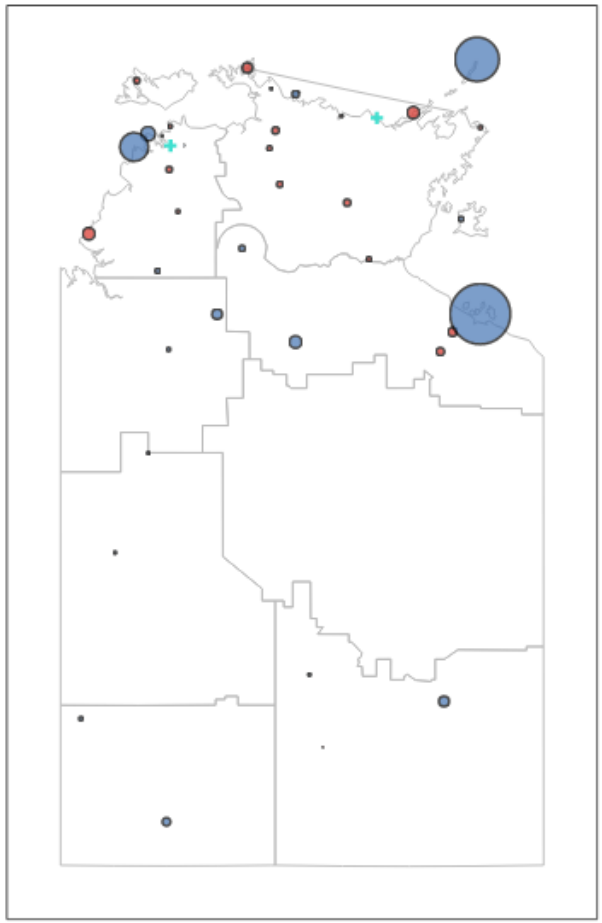
- (•) Official
- ( ) 18z PtOCF

Error and |Score| filter

No filter

- No filter
- > 1C
- > 2C
- > 3C
- > 4C
- > 5C

Official MaxT forecast error:2017-10-27



- Forecast too hot
- Forecast too cold
- Perfect forecast

Daily Verification

Date: (end of valid period in UTC)

2017-10-28

Forecast lead day:

1 2 3 4 5 6 7

Region:

Northern Territory

HELP
Long-term Verification
Report an issue

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

MaxT or MinT
- (•) MaxT
- ( ) MinT

Map type
- ( ) Observations
- ( ) Forecast
- ( ) Forecast error
- (•) Official vs 18z PtOCF

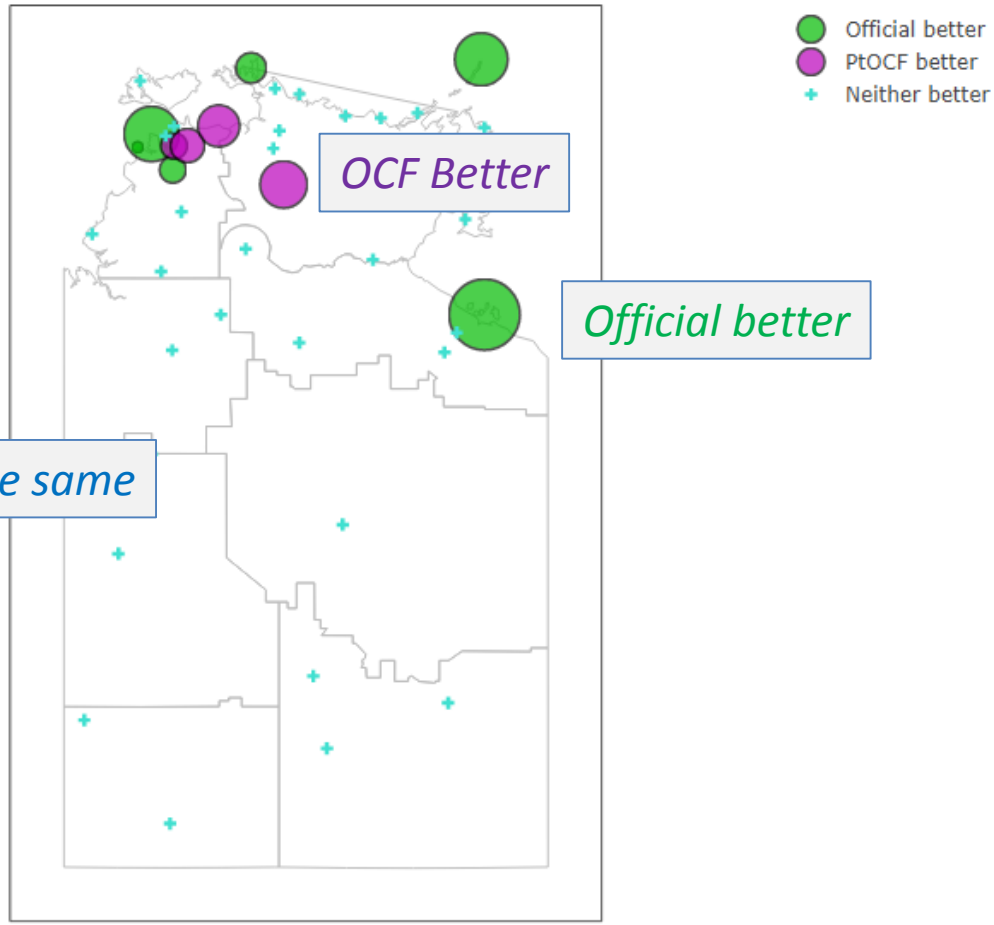
Forecast source
- (•) Official
- ( ) 18z PtOCF

Error and |Score| filter

No filter

Which is better?

Official MaxT vs PtOCF MaxT: 2017-10-28



Long Term Verification

Verification period: 2017-05-01 to 2017-11-25

Forecast lead day: 1 – 7

Region: Northern Territory

HELP
Daily Verification
Report an issue

Get data for selected period

Set a range of dates

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

MaxT or MinT
- (•) MaxT
- ( ) MinT

MaxT

Map type
- ( ) RMSE
- (•) Bias
- ( ) Proportion of errors > X
- ( ) Confidence that Official is better

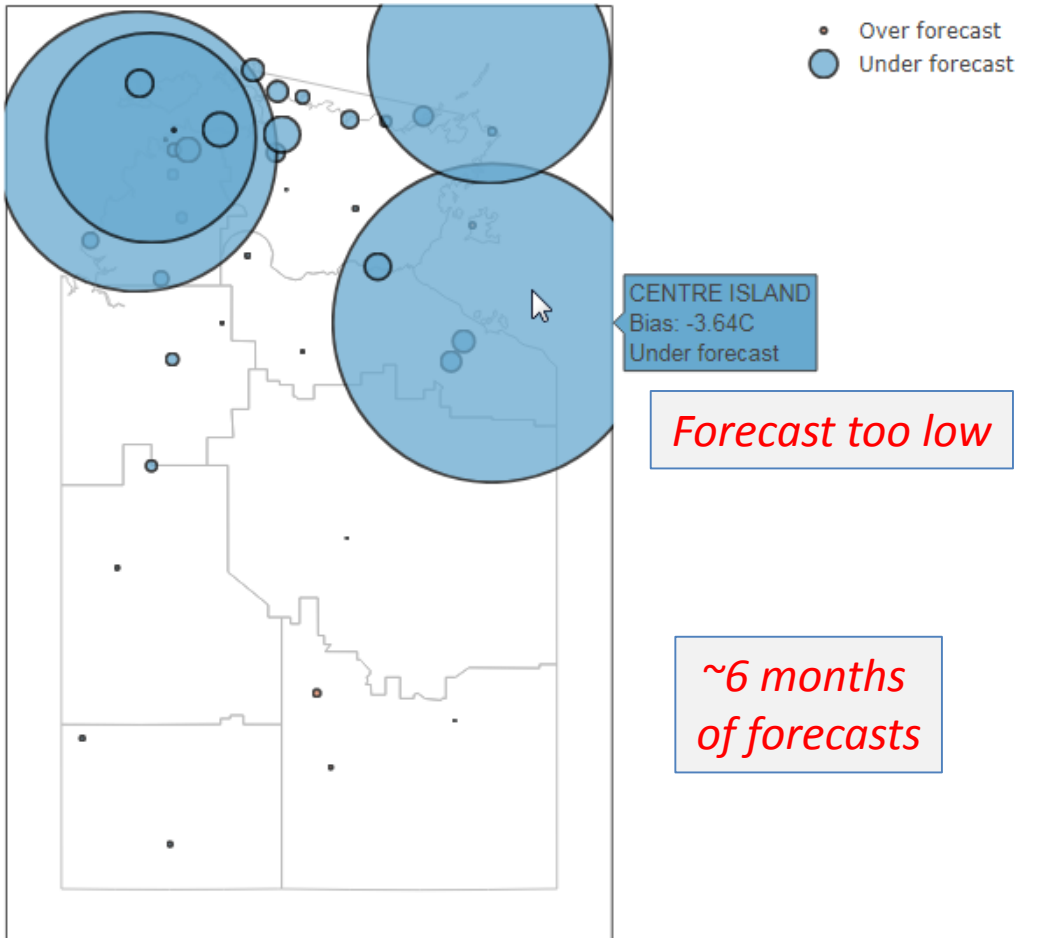
Bias

Forecast source
- (•) Official
- ( ) 18z PtOCF
- ( ) Official vs 18z PtOCF

Error threshold X

0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Official MaxT Bias: 2017-05-01 to 2017-11-25



Forecast too low

~6 months of forecasts

Long Term Verification

Verification period: 2017-05-01 to 2017-11-25

Forecast lead day: 1 – 7

Region: Northern Territory

HELP
Daily Verification
Report an issue

Get data for selected period

A land observation site in an ocean gridcell

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

Select a station

CENTRE ISLAND

Station

MaxT or MinT

- (•) MaxT
- ( ) MinT

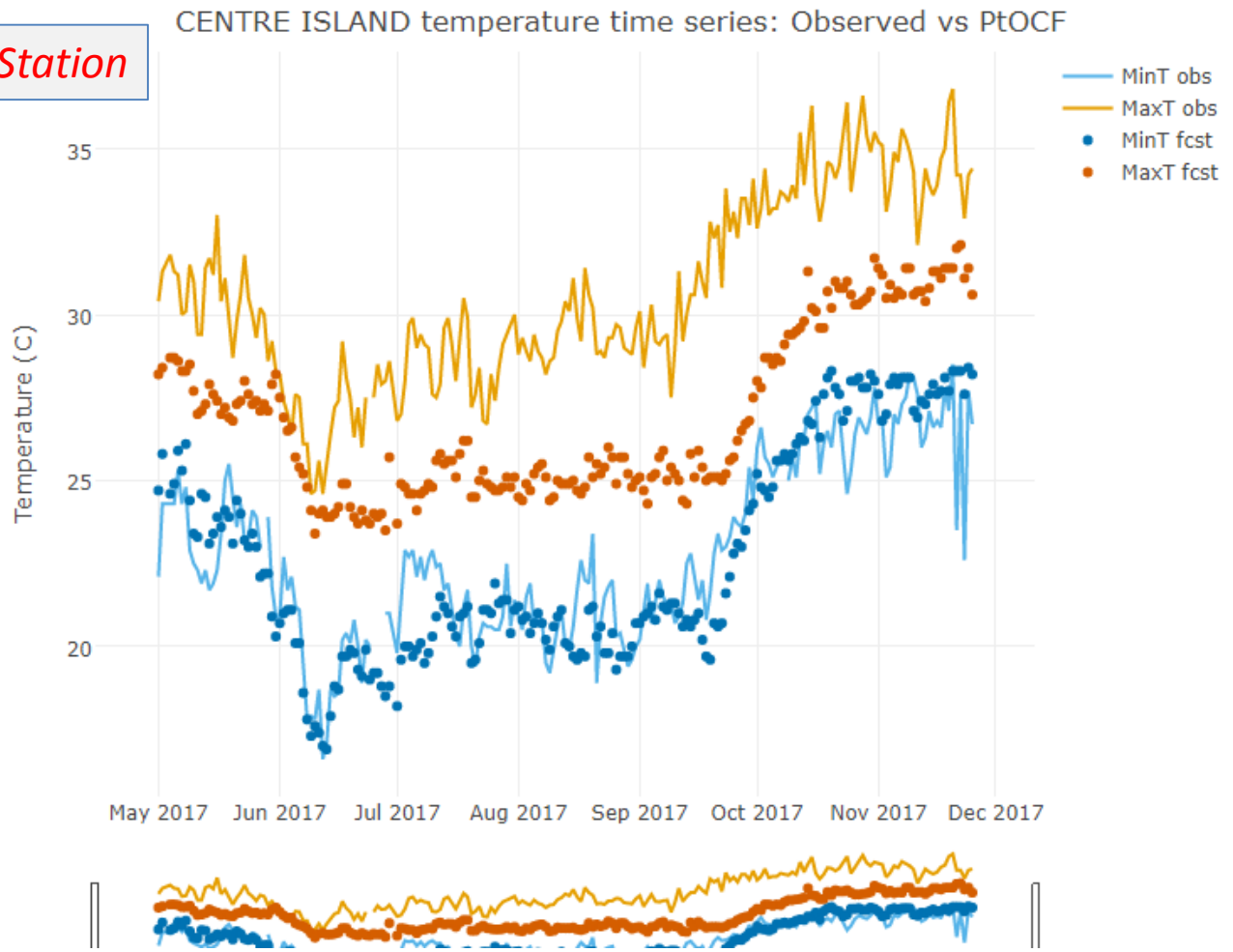
Plot type

- ( ) Obs vs Forecast plot
- (•) Timeseries

Forecast source

- ( ) Official
- (•) 18z PtOCF

OCF



Long Term Verification

Verification period: 2017-05-01 to 2017-11-25

Forecast lead day: 1 – 7

Region: Victoria

HELP
Daily Verification
Report an issue

Get data for selected period

A land observation site on a peninsula

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

Select a station

WILSONS PROMONTORY LIGHTHOUSE

Station

MaxT or MinT

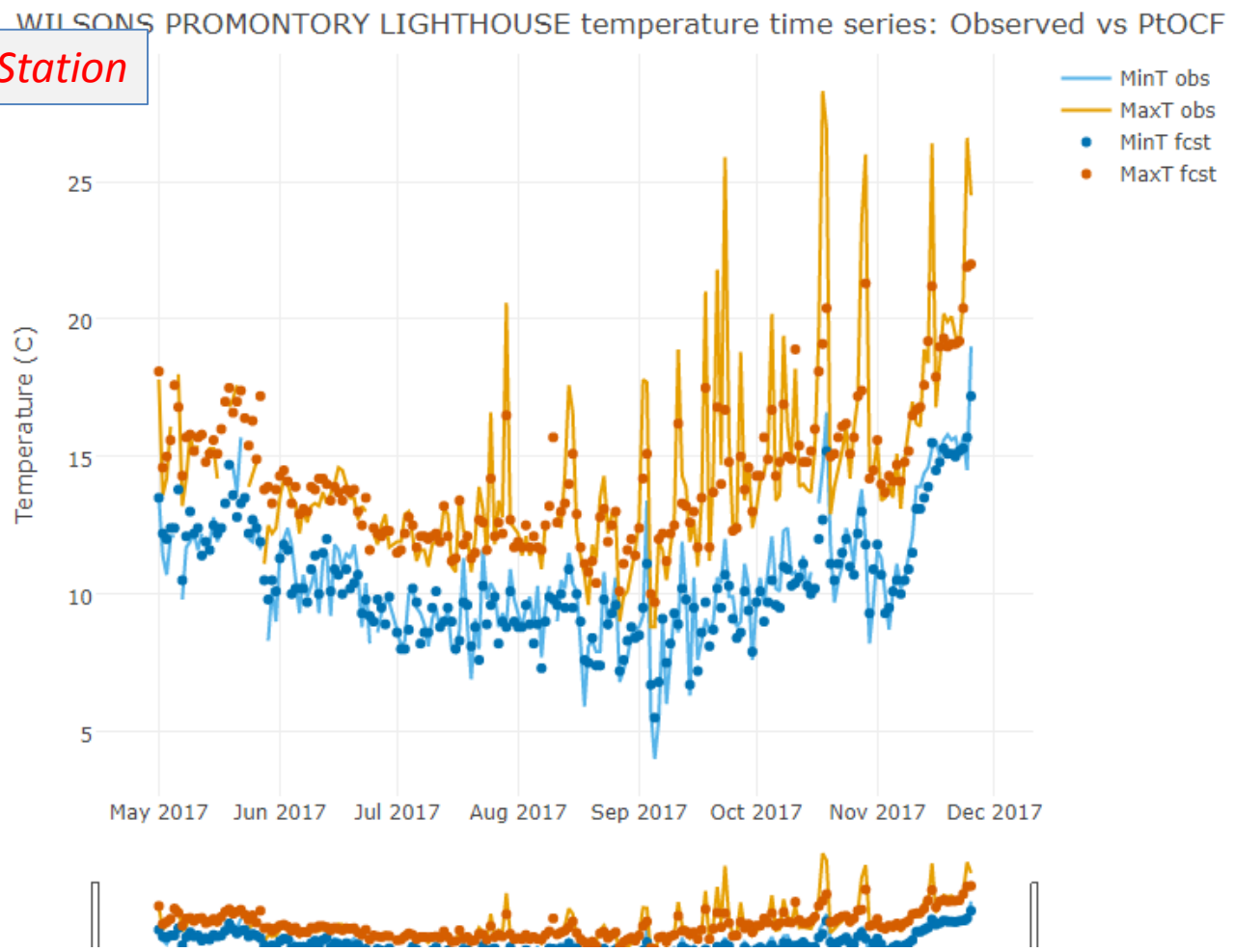
- (•) MaxT
- ( ) MinT

Plot type

- ( ) Obs vs Forecast plot
- (•) Timeseries

Forecast source

- ( ) Official
- (•) 18z PtOCF



Long Term Verification

Verification period: 2017-05-01 to 2017-11-25

Forecast lead day: 1 (1 2 3 4 5 6 7)

Region: Victoria

HELP
Daily Verification
Report an issue

Get data for selected period

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

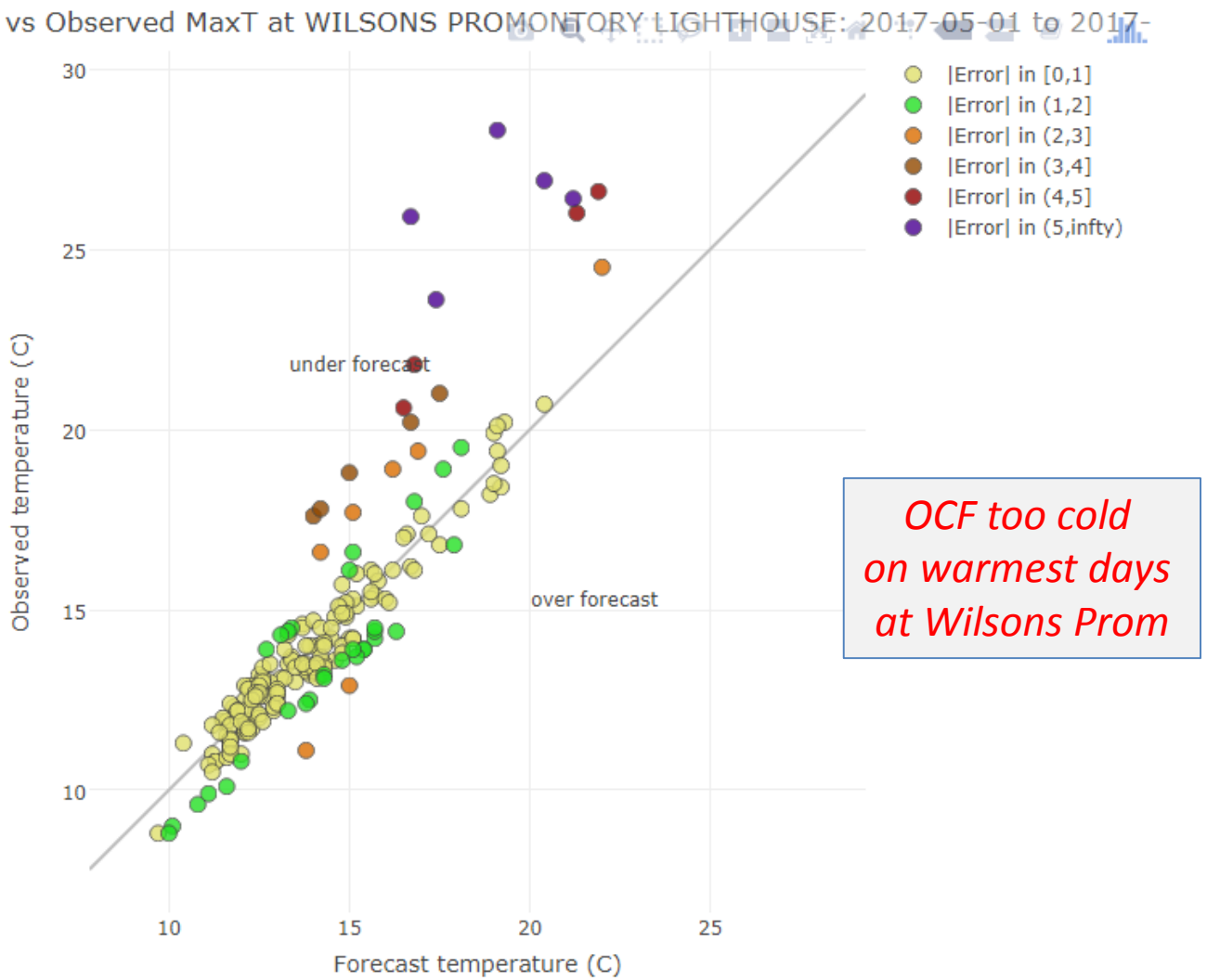
Select a station
WILSONS PROMONTORY LIGHTHOUSE

MaxT or MinT
- (•) MaxT
- ( ) MinT

Plot type
- (•) Obs vs Forecast plot
- ( ) Timeseries

Forecast source
- ( ) Official
- (•) 18z PtOCF

OCF



OCF too cold on warmest days at Wilsons Prom

Long Term Verification

Verification period: 2017-05-01 to 2017-11-25

Forecast lead day: 1 2 3 4 5 6 7

Region: Victoria

HELP
Daily Verification
Report an issue

Get data for selected period

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

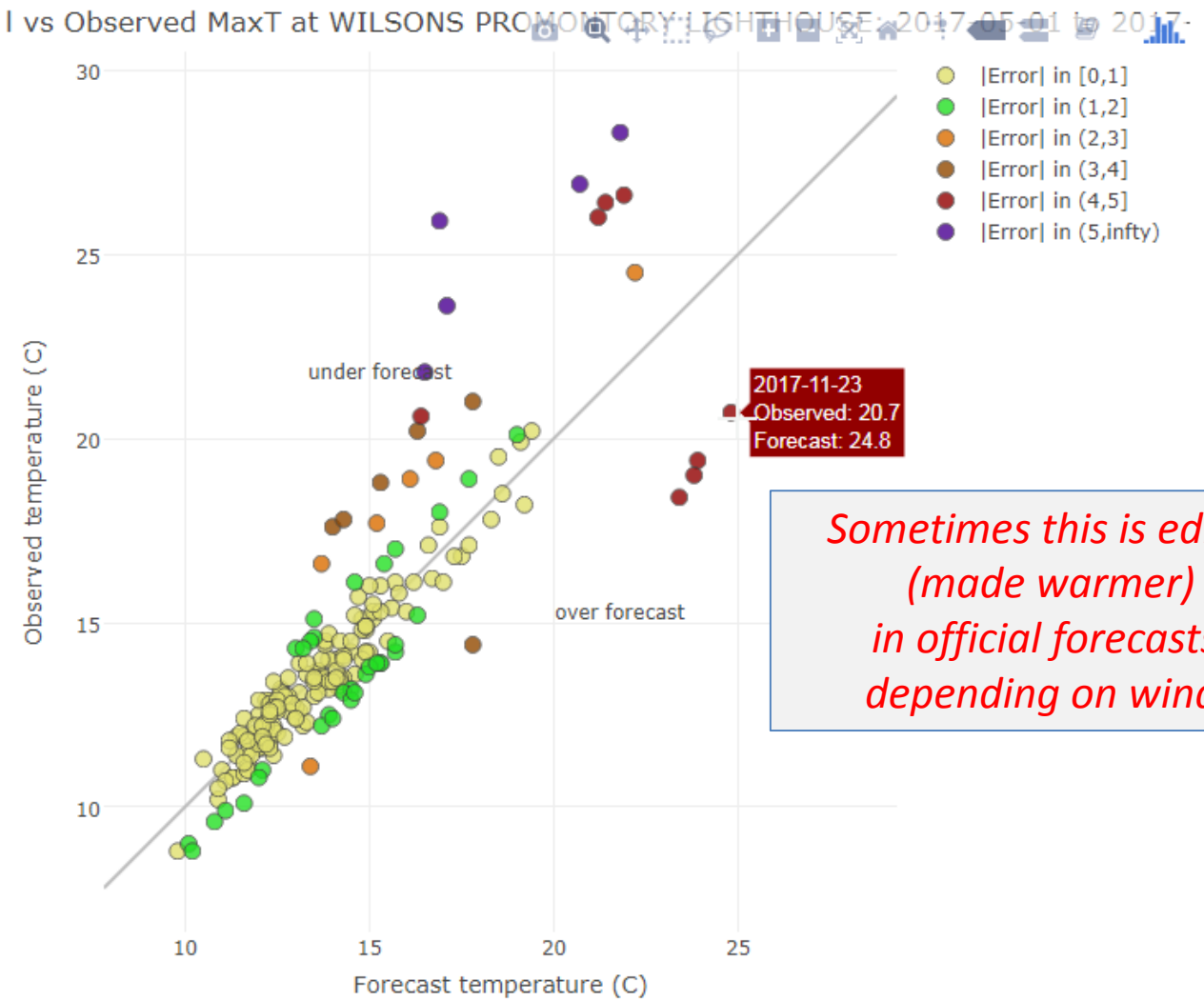
Select a station
WILSONS PROMONTORY LIGHTHOUSE

MaxT or MinT
- (•) MaxT
- ( ) MinT

Plot type
- (•) Obs vs Forecast plot
- ( ) Timeseries

Forecast source
- (•) Official
- ( ) 18z PtOCF

Official



Sometimes this is edited (made warmer) in official forecasts, depending on winds

Daily Verification

Date: (end of valid period in UTC)

2017-09-23

Forecast lead day:

1 2 3 4 5 6 7

Region:

South Australia

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

Map type

- (•) Observed precip
- ( ) Forecast with obs
- ( ) Forecast error
- ( ) Official vs OCF
- ( ) Reliability diagram

Observed

Forecast source

- (•) Official
- ( ) 18z OCF

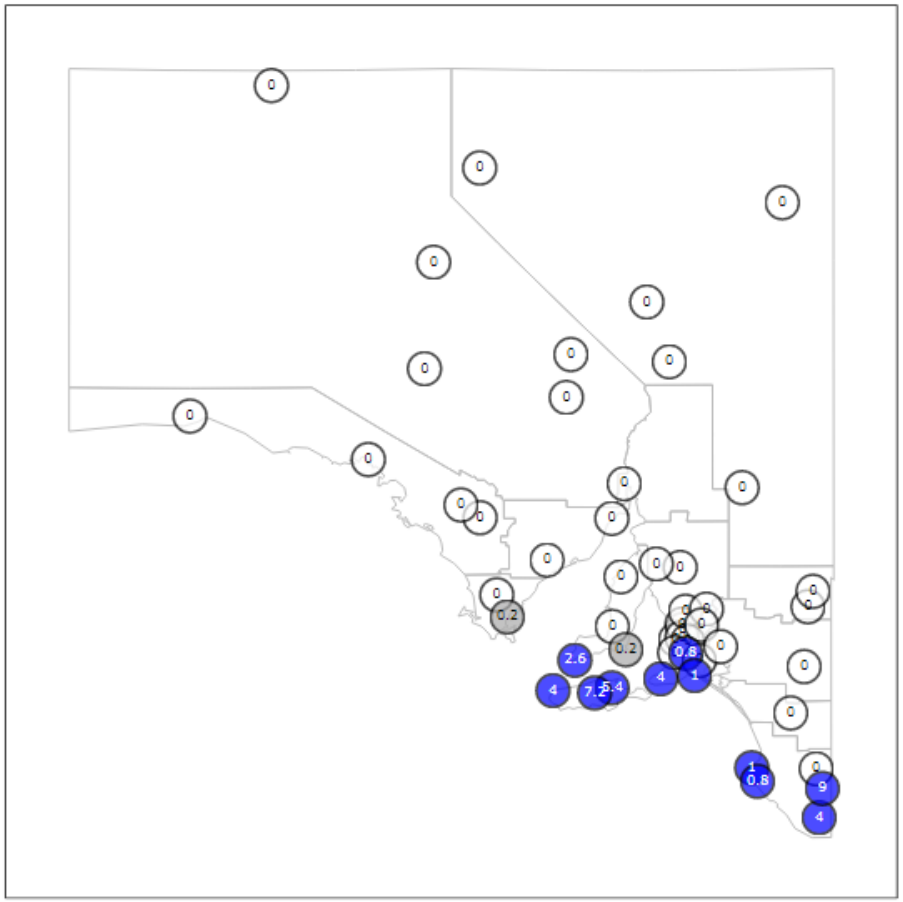
Filter 0.2mm obs

- (•) Yes
- ( ) No

Error and |Score| filter

No filter

Precipitation 15z to 15z:2017-09-23



Daily Verification

Date: (end of valid period in UTC)

2017-09-23

Forecast lead day:

1 2 3 4 5 6 7

Region:

South Australia

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

Map type

- Observed precip
- Forecast with obs
- Forecast error
- Official vs OCF
- Reliability diagram

Forecast PoP

Forecast source

- Official
- 18z OCF

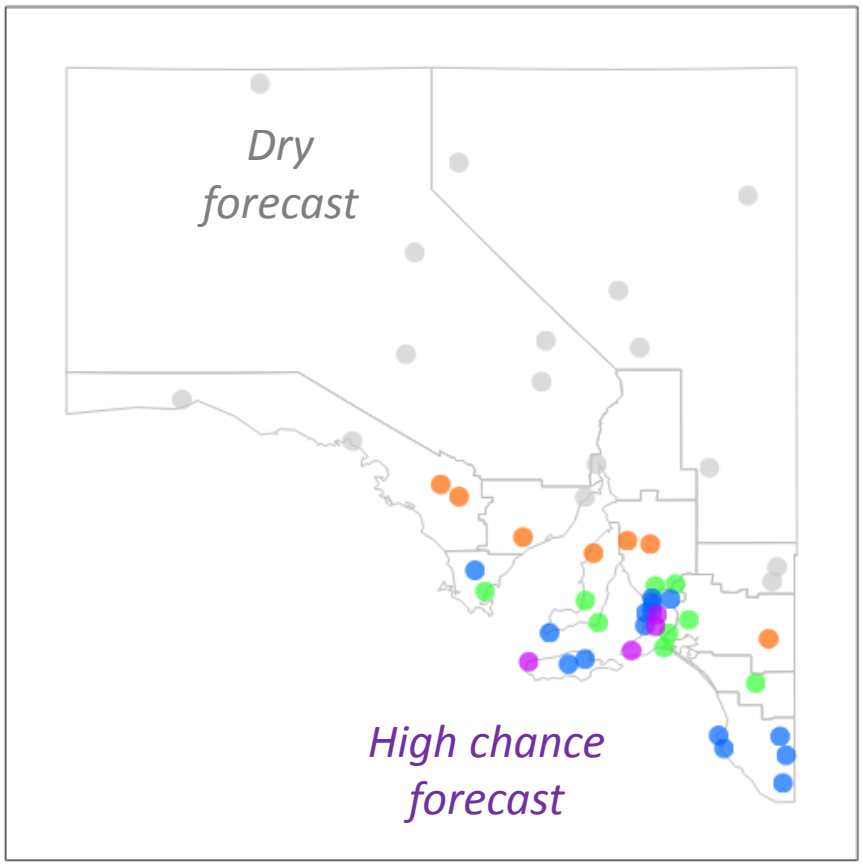
Filter 0.2mm obs

- Yes
- No

Error and |Score| filter

No filter

Official DailyPoP vs Observed Precip: 2017-09-23



Daily Verification

Date: (end of valid period in UTC)

2017-09-23

Forecast lead day:

1 2 3 4 5 6 7

Region:

South Australia

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

Map type

- Observed precip
- Forecast with obs
- Forecast error
- Official vs OCF
- Reliability diagram

Forecast PoP

Forecast source

- Official
- 18z OCF

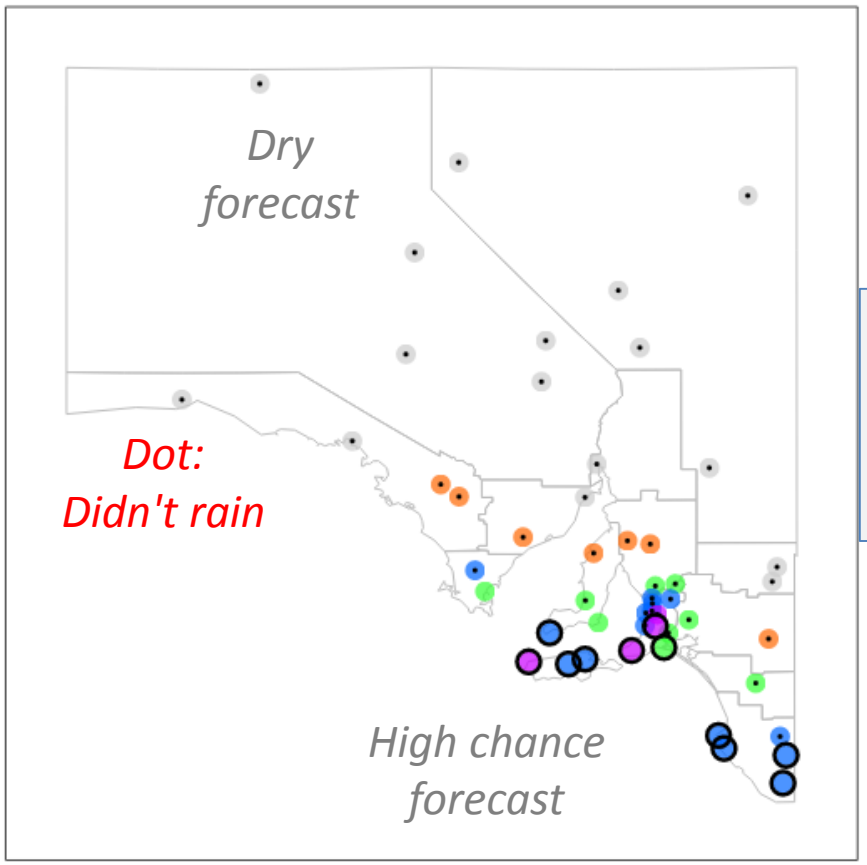
Filter 0.2mm obs

- Yes
- No

Error and |Score| filter

No filter

Official DailyPoP vs Observed Precip: 2017-09-23



- Near zero (< 15%)
- Slight (15% to 34%)
- Medium (35% to 64%)
- High (65% to 84%)
- Very High (>= 85%)
- > 0.2 mm
- 0.2 mm
- 0 mm

Any legend is clickable to make parts appear or disappear

Circle: Rained > 0.2mm

Daily Verification

Date: (end of valid period in UTC)

2017-09-23

Forecast lead day:

1 2 3 4 5 6 7

Region:

South Australia

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

Chart type

- DailyPrecipYPct forecast map
- DailyPrecipYPct forecast vs obs map
- DailyPrecipYPct reliability graph

Forecast

Y percentage threshold

75 50 25 10

25%ile

Forecast source

- Official
- 18z OCF

Filters

Forecast DailyPrecip >=

0.5

Observed Precip >=

0

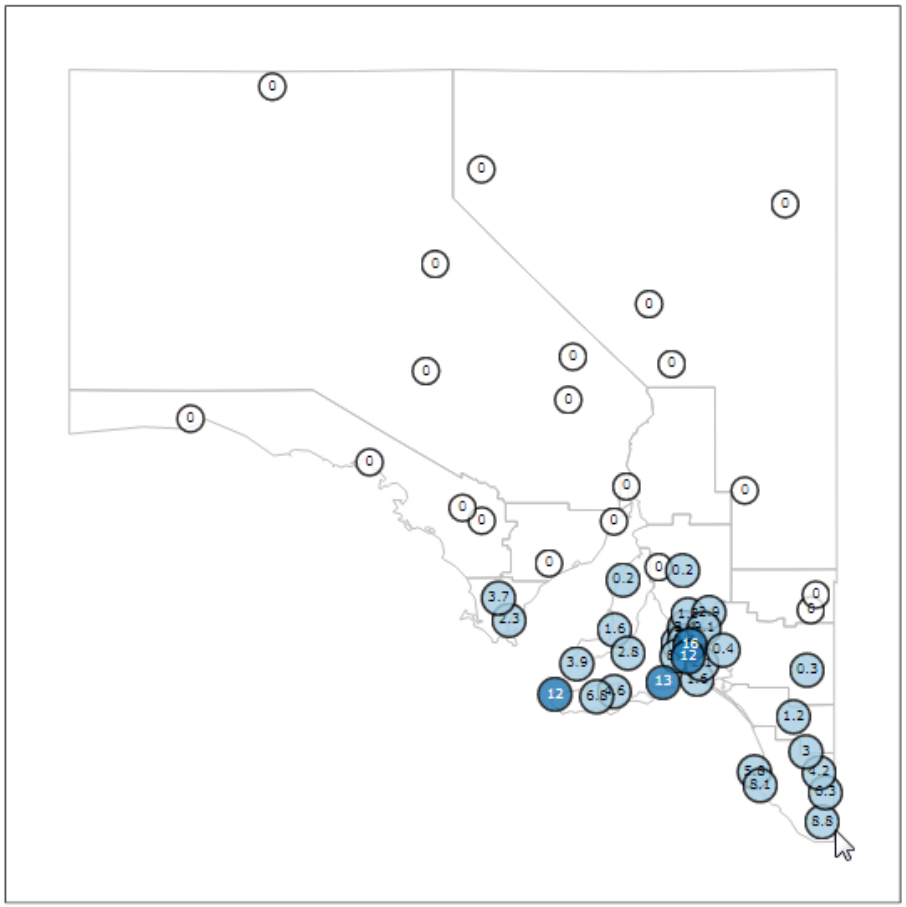
DailyPoP >=

0

District (Ctrl+click for multiple selections)

All districts

Official forecast DailyPrecip25Pct: 2017-09-23



Daily Verification

Date: (end of valid period in UTC)

2017-09-23

Forecast lead day:

1 2 3 4 5 6 7

Region:

South Australia

Charts | Radar | Policy/GPATS | Temp Maps | DailyPoP Maps | DailyPrecip | DailyPrecipYPct | Precip 3hrly | Data tables | Links | Database

Chart type

- DailyPrecipYPct forecast map
- DailyPrecipYPct forecast vs obs map
- DailyPrecipYPct reliability g

Y percentage threshold

75 | 50 | 25 | 10

Forecast source

- Official
- 18z OCF

Filters

Forecast DailyPrecip >=

0.5

Observed Precip >=

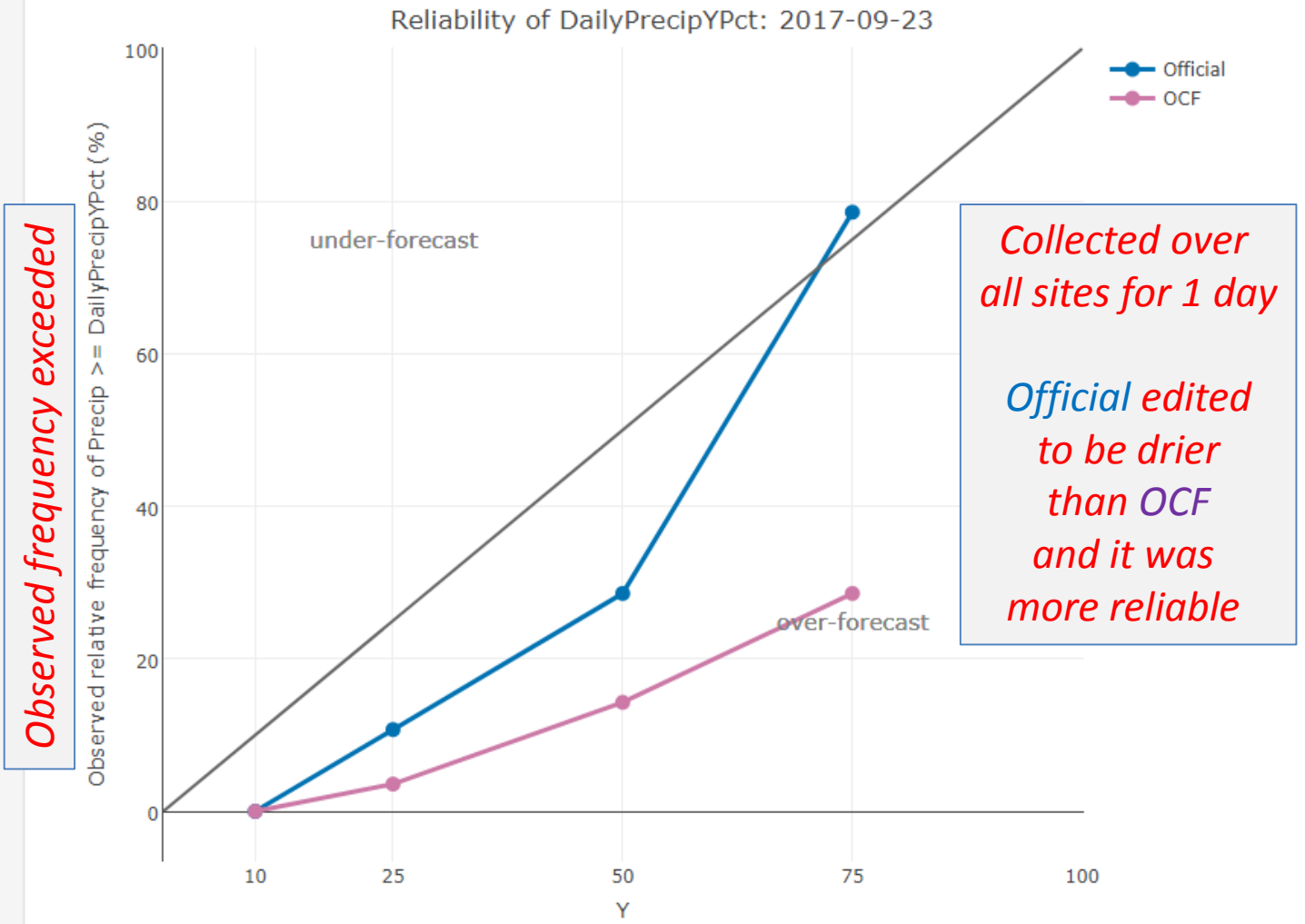
0

DailyPoP >=

0

District (Ctrl+click for multiple selections)

All districts



Observed frequency exceeded

Collected over all sites for 1 day

Official edited to be drier than OCF and it was more reliable

Forecast % chance of exceeding

Long Term Verification

Verification period: 2016-11-26 to 2017-11-25

Forecast lead day: 1 2 3 4 5 6 7

Region: Victoria

HELP
Daily Verification
Report an issue

Get data for selected period

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

Select a station

MELBOURNE (OLYMPIC PARK)

Plot type

- DailyPrecip Forecast vs Obs plot
- DailyPrecip time series
- DailyPoP reliability
- DailyPrecipYPct reliability

Forecast source

- Official
- OCF

Filter for DailyPoP reliability

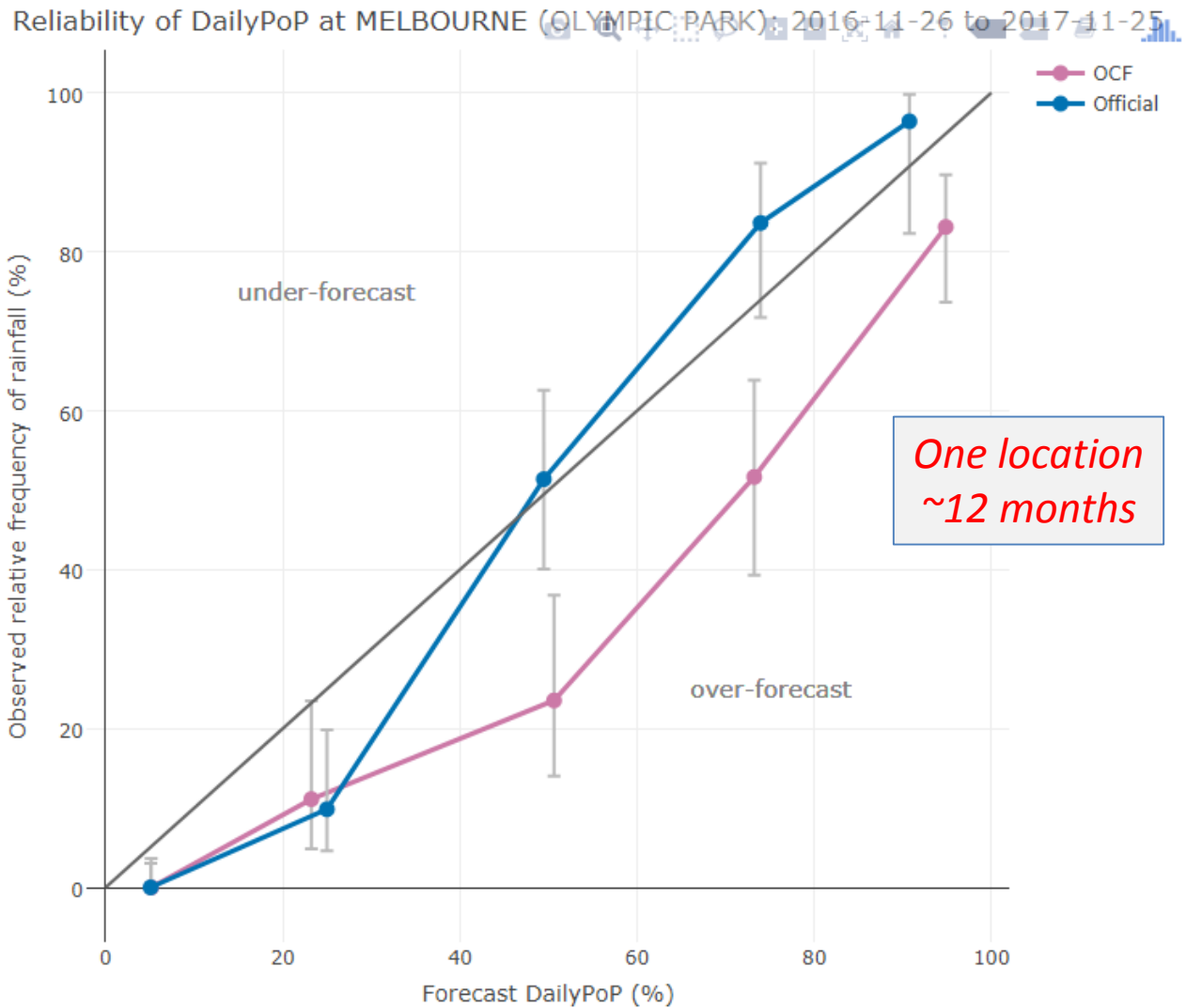
- Include 0.2mm observations

Filters for DailyPrecipYPct reliability

Forecast DailyPrecip >= 0.5

Observed Precip >= 0

DailyPoP >=



One location ~12 months

Long Term Verification

Verification period: 2017-07-01 to 2018-01-29

Forecast lead day: 1 – 7

Region: Victoria

HELP
Meteograms
Daily Verification
Report an issue

Get data for selected period

Precip skill maps

Temp maps | Station Temp Plots | DailyPoP maps | DailyPrecip maps | Station DailyPoP/Precip Plots

Select a station

MELBOURNE (OLYMPIC PARK)

Plot type

- DailyPrecip Forecast vs Obs plot
- DailyPrecip time series
- DailyPoP reliability
- DailyPrecipYPct reliability

Forecast source

- Official
- OCF

Filter for DailyPoP reliability

Include 0.2mm observations

Filters for DailyPrecipYPct reliability

Forecast DailyPrecip >=

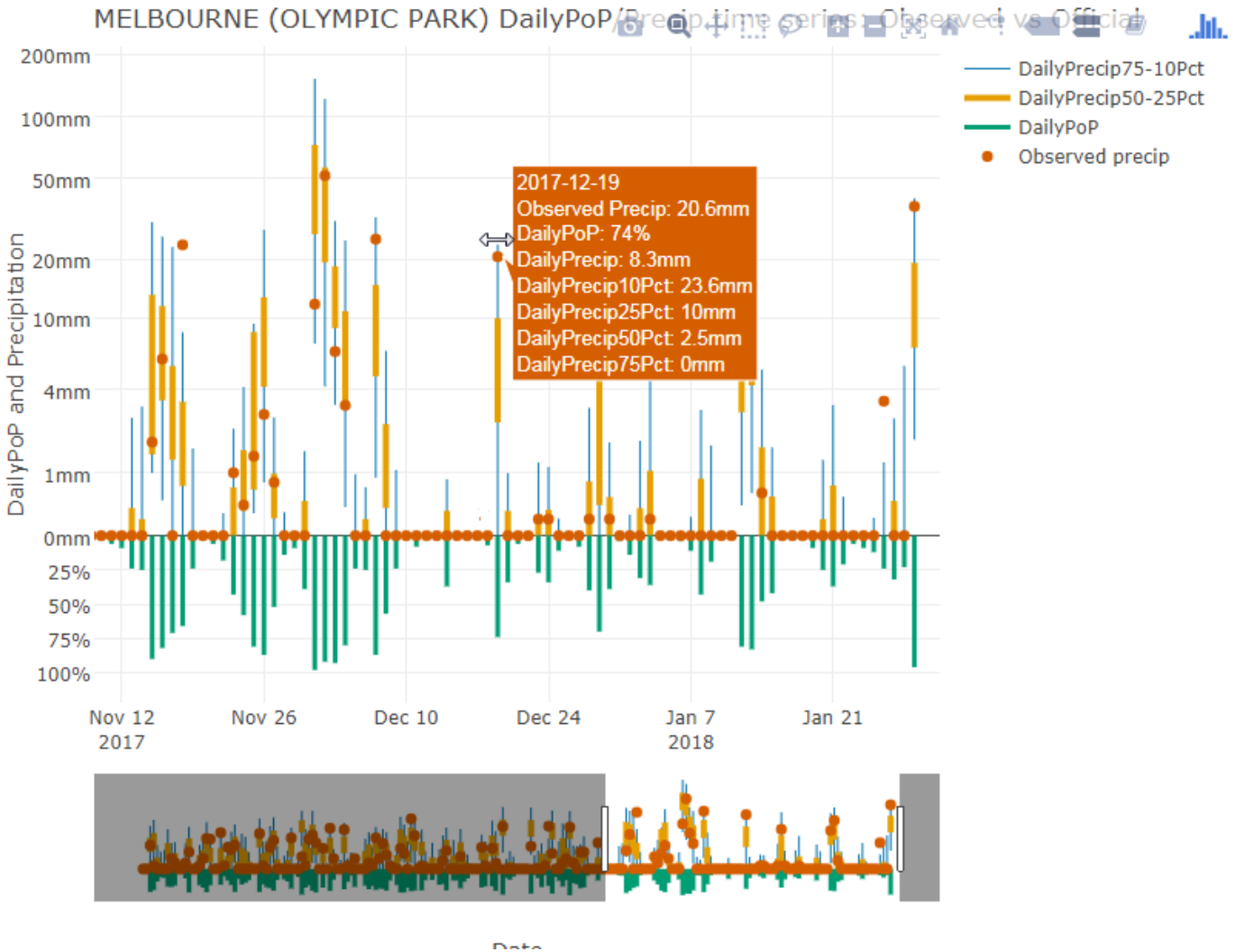
0.5

Observed Precip >=

0

DailyPoP >=

0



New developments

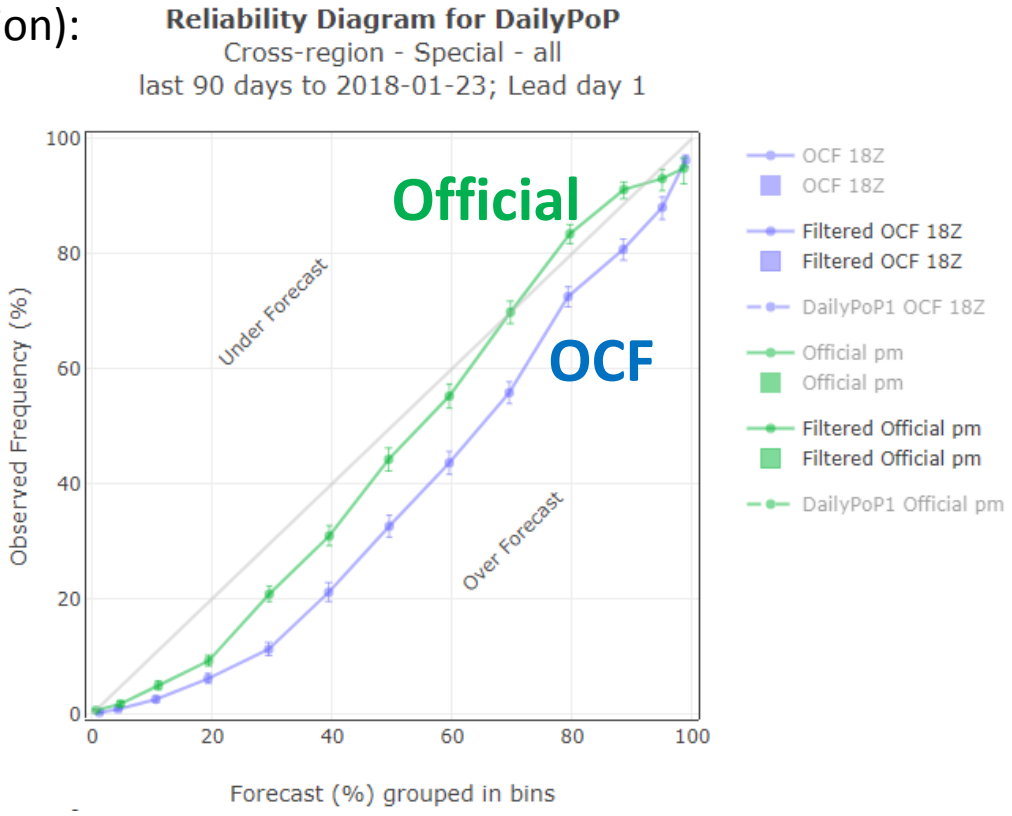
Dashboards – **KPIs** – Meteograms

Key Performance Indicators

Temperature (daily maximum and minimum)
% forecasts within 2 degrees C

Precipitation (daily probability of precipitation):
Reliability diagram

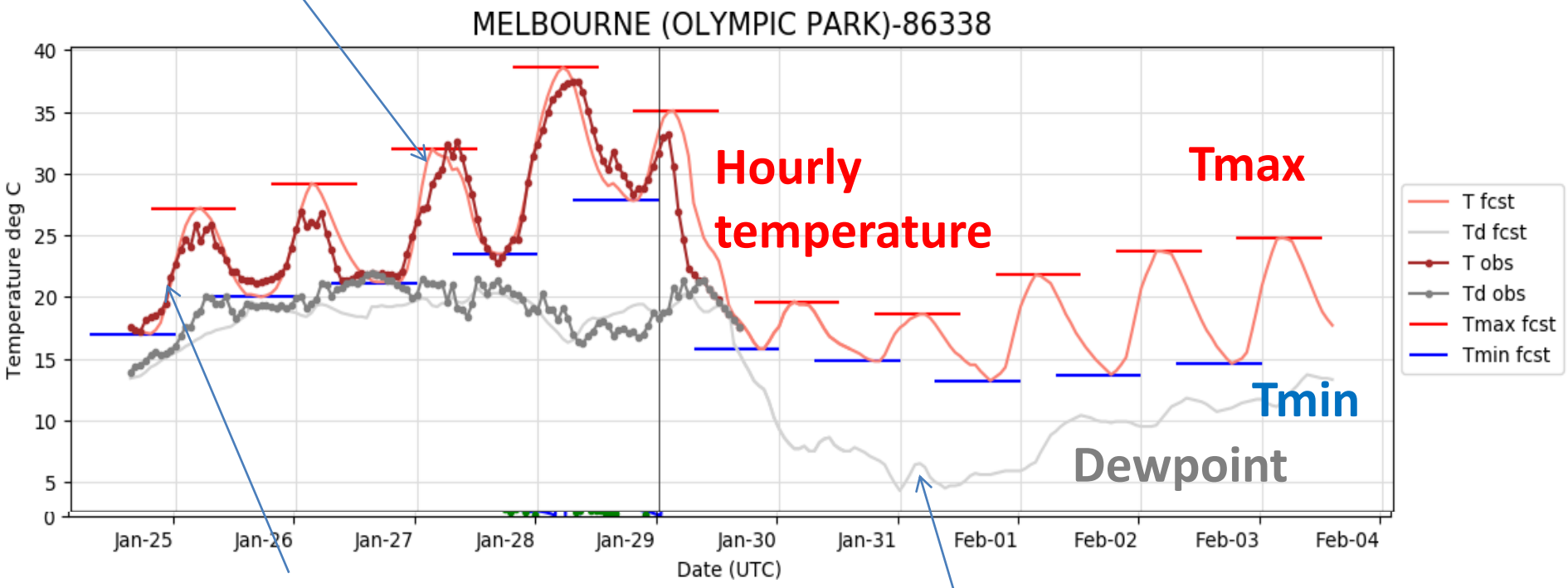
Wind (at ~4 pm):
% forecasts within 5 knots
% within 30 degrees direction



New developments

Dashboards – KPIs – **Meteograms**

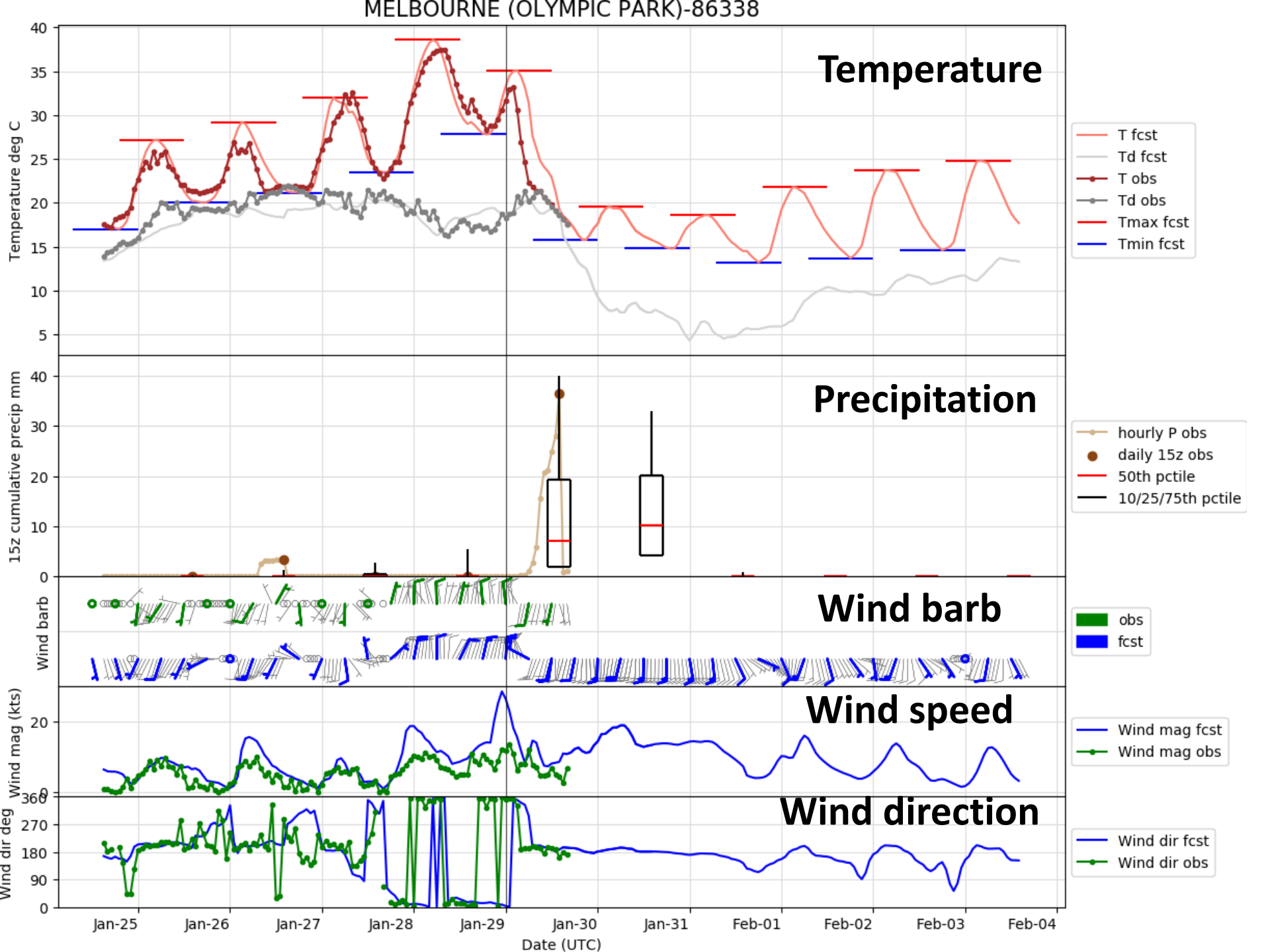
Past forecasts
(1 day leadtime)



Observations

"Now"

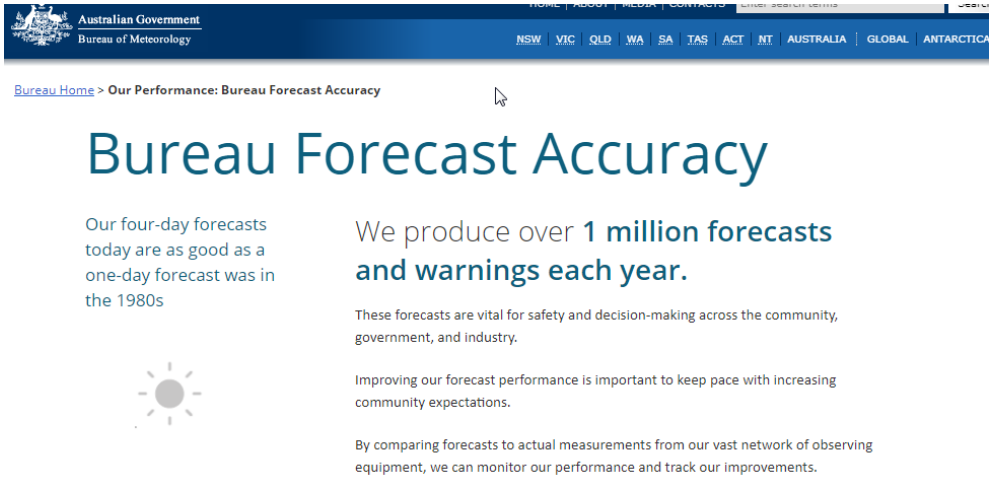
Latest forecast
(multiple leadtimes)

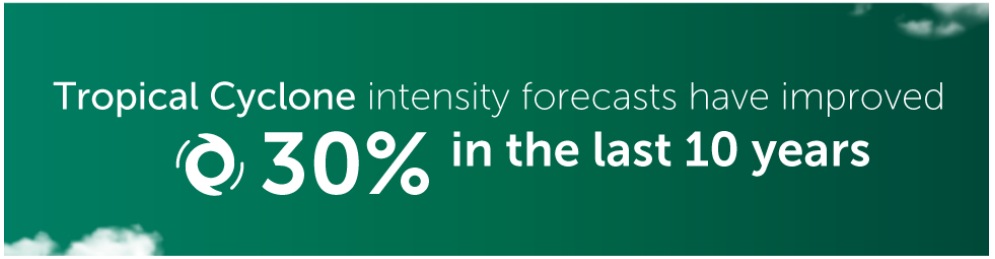

MELBOURNE (OLYMPIC PARK)-86338
Temperature
Precipitation
Wind barb
Wind speed
Wind direction
Temperature deg C
15z cumulative precip mm
Wind barb
Wind mag (kts)
Wind dir deg
T fcst
Td fcst
T obs
Td obs
Tmax fcst
Tmin fcst
hourly P obs
daily 15z obs
50th pctile
10/25/75th pctile
obs
fcst
Wind mag fcst
Wind mag obs
Wind dir fcst
Wind dir obs
Jan-25
Jan-26
Jan-27
Jan-28
Jan-29
Jan-30
Jan-31
Feb-01
Feb-02
Feb-03
Feb-04
Date (UTC)

Plans and challenges

- Expansion of dashboards for wind, waves, humidity, fire weather
- Push alerting for large/persistent errors (in testing now)
- Evaluation against competitors e.g. weather.com
- Better performance indicators for the public
- Understandable, relevant and defensible rainfall metrics are elusive

Public webpage



tompagan@bom.gov.au

Thanks: Rob Taggart, Michael Foley, Ioanna Ioannou, Lex Hider, Aihong Zhong, Denis Margetic, Forecaster Consultative Team