

Understanding weather and the weather forecast

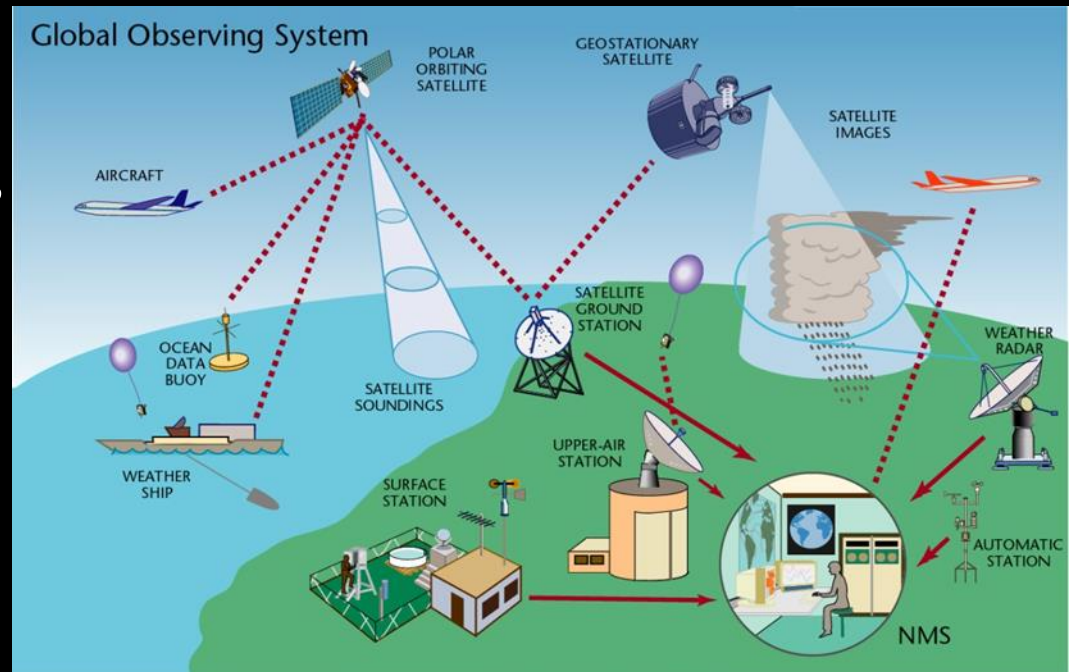
Week 32

Forecasting the Weather
Accuracy and limitations

Terry Hart

Computer Weather Prediction (or Numerical Weather Prediction)

- We have equations that tell how things will change in the atmosphere (e.g. Vilhelm Bjerknes), **but we need to know what the atmosphere looks like to start with.**
- Importance of weather observations and analysis
- Like seeing a doctor – analysis before prognosis and treatment



Climate models are basically the same apart from more details on the ocean, etc. They are long term averages and so do not rely so much on the starting point.

Non-orographic wave drag



Long-wave radiation

Short-wave radiation

O₃ Chemistry
CH₄ Oxidation

Cloud

Cloud

Deep convection

Shallow convection

Subgrid-scale orographic drag



Wind Waves

Long-wave flux
Short-wave flux

Latent heat flux

Turbulent diffusion

Sensible heat flux

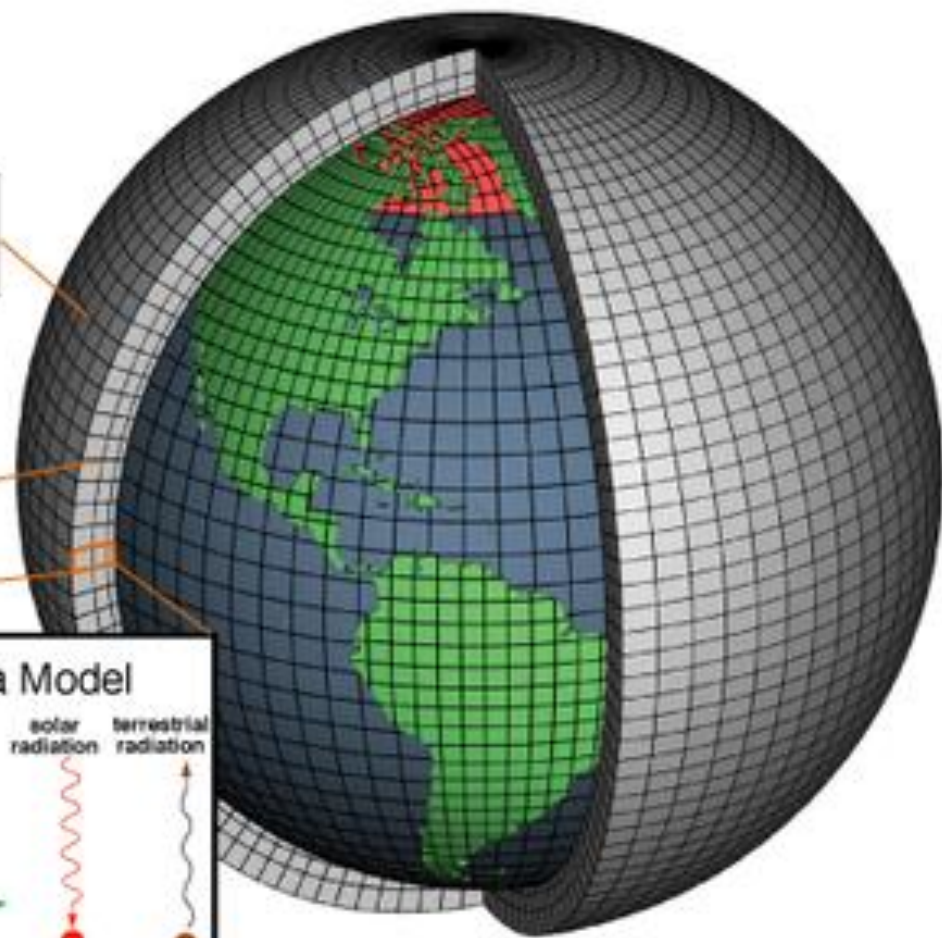
Surface

Ocean model

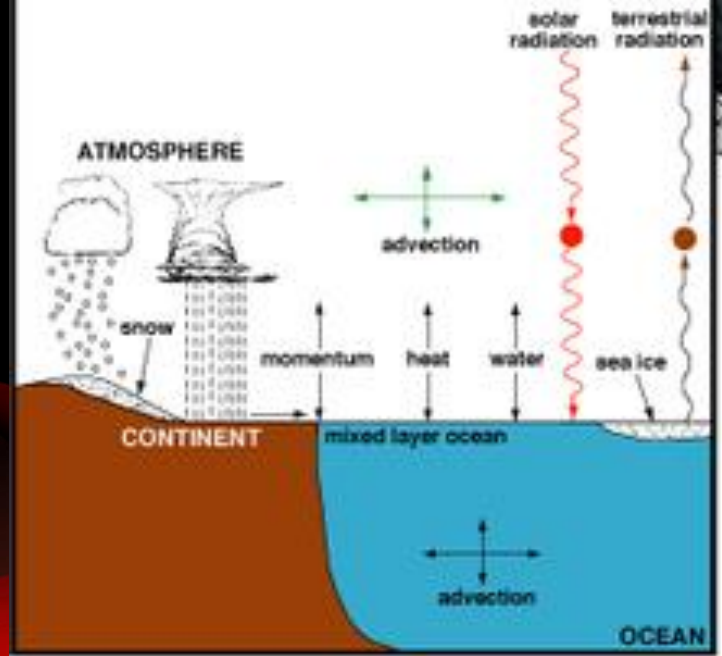
Typical atmospheric processes modelled in a computer weather prediction model

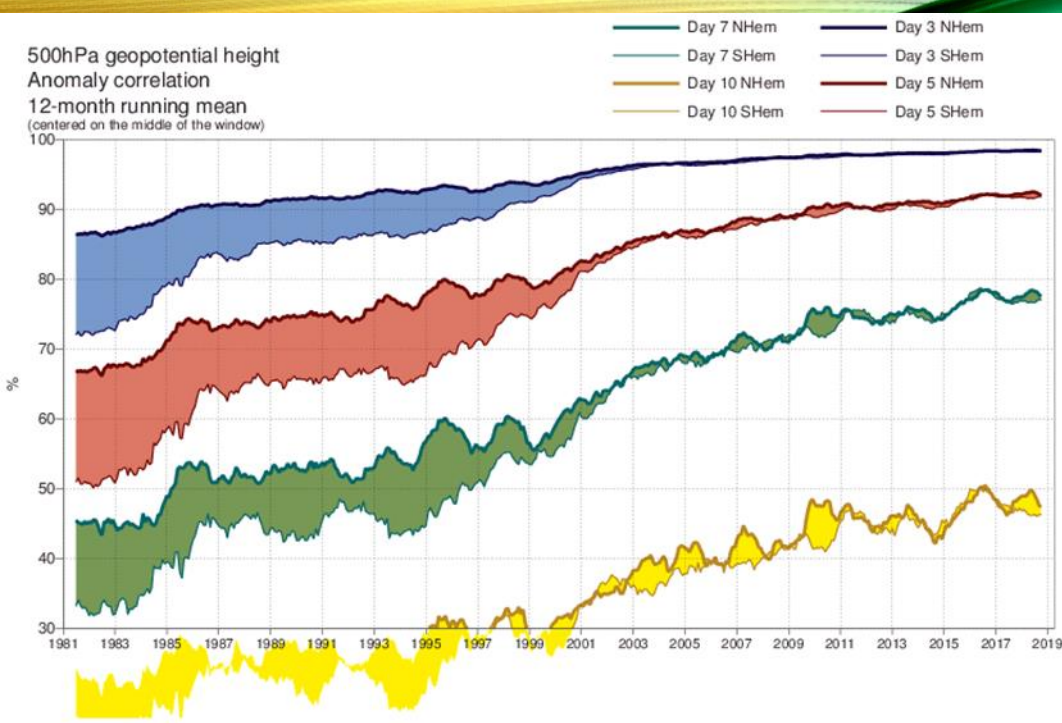
Horizontal Grid
(Latitude-Longitude)

Vertical Grid
(Height or Pressure)



Physical Processes in a Model





Every picture tells a story. There are **two main stories here and a question**.

- The great improvement in weather prediction since the 1980s
- The closing of the gap between the skill of forecasts in the northern and southern hemispheres (mainly due to satellite data and improved analysis techniques)
- The **question** is why does the skill deteriorate at the longer outlook period?

Weather forecasting and chaos theory – the work of Ed Lorenz

https://www.youtube.com/watch?v=bZ6yxt_o_CQ

Forecast Accuracy and Fundamental Limits

Our weekly review of predicted and actual weather charts has shown that, while there is often good agreement out to 7 days, in some cases there are significant differences that affected the accuracy of the forecast.

When rain is forecast the radar images often show a fairly spotty appearance and rain may fall in one suburb and not another.

Thunderstorms – sometimes they are forecast but do not occur, or vice versa. Even when they do occur there can be big variations in where they form and how much rain falls.

Tropical cyclone forecasts – the track map shows a spread of the possible tracks.

Forecast Accuracy and Fundamental Limits

There can be several reasons for an inaccurate forecast:

- There were missing observations or some feature was missed
- Forecasting systems themselves have errors.

But the ideas of chaos theory show that there are **fundamental limits**.

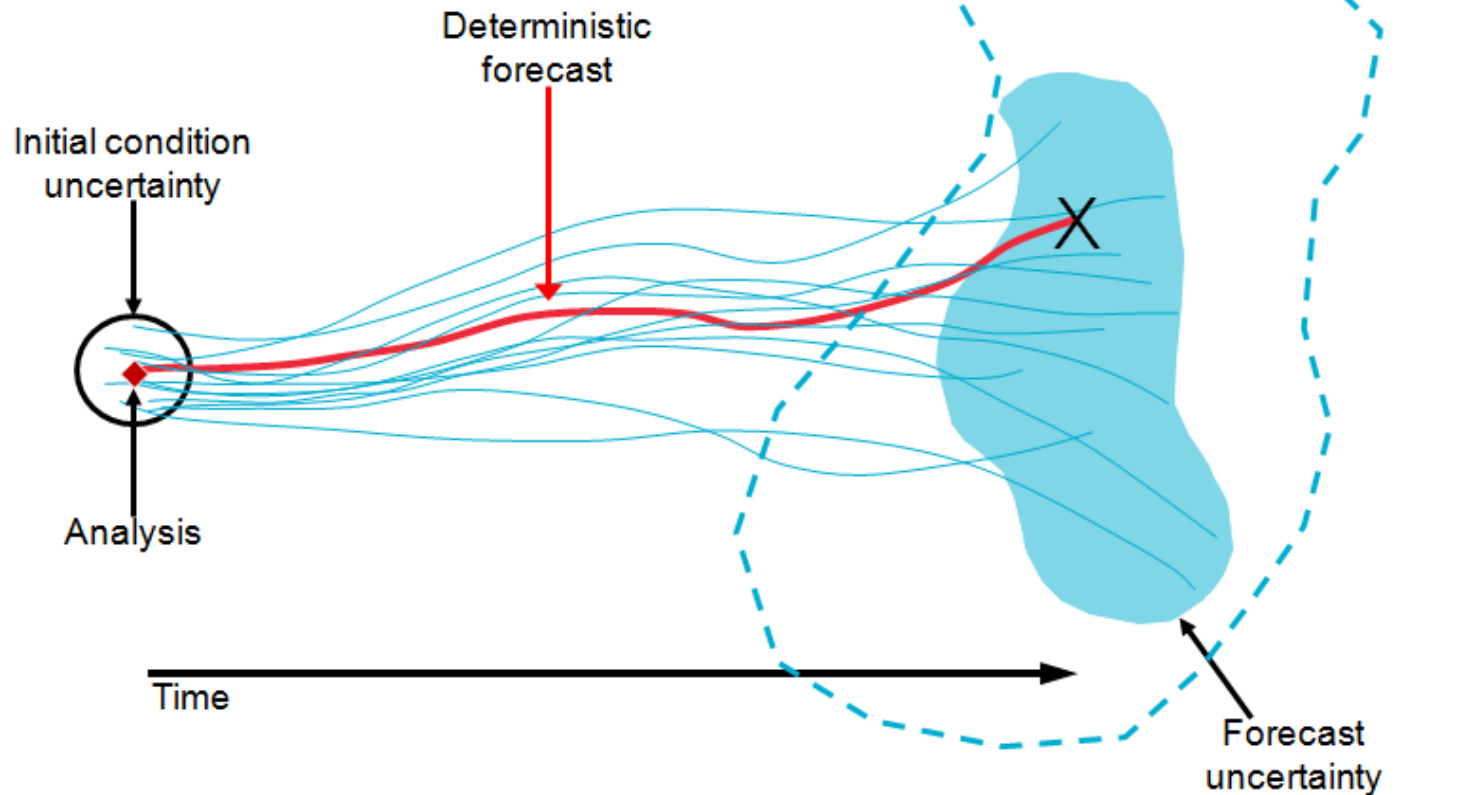
Because we do not know exactly the weather values everywhere, small errors may grow into large differences in the forecast outlook period.

The meteorological community now:

- Accepts that there are fundamental limits
- Tries to give some idea of the confidence they have in the forecast.

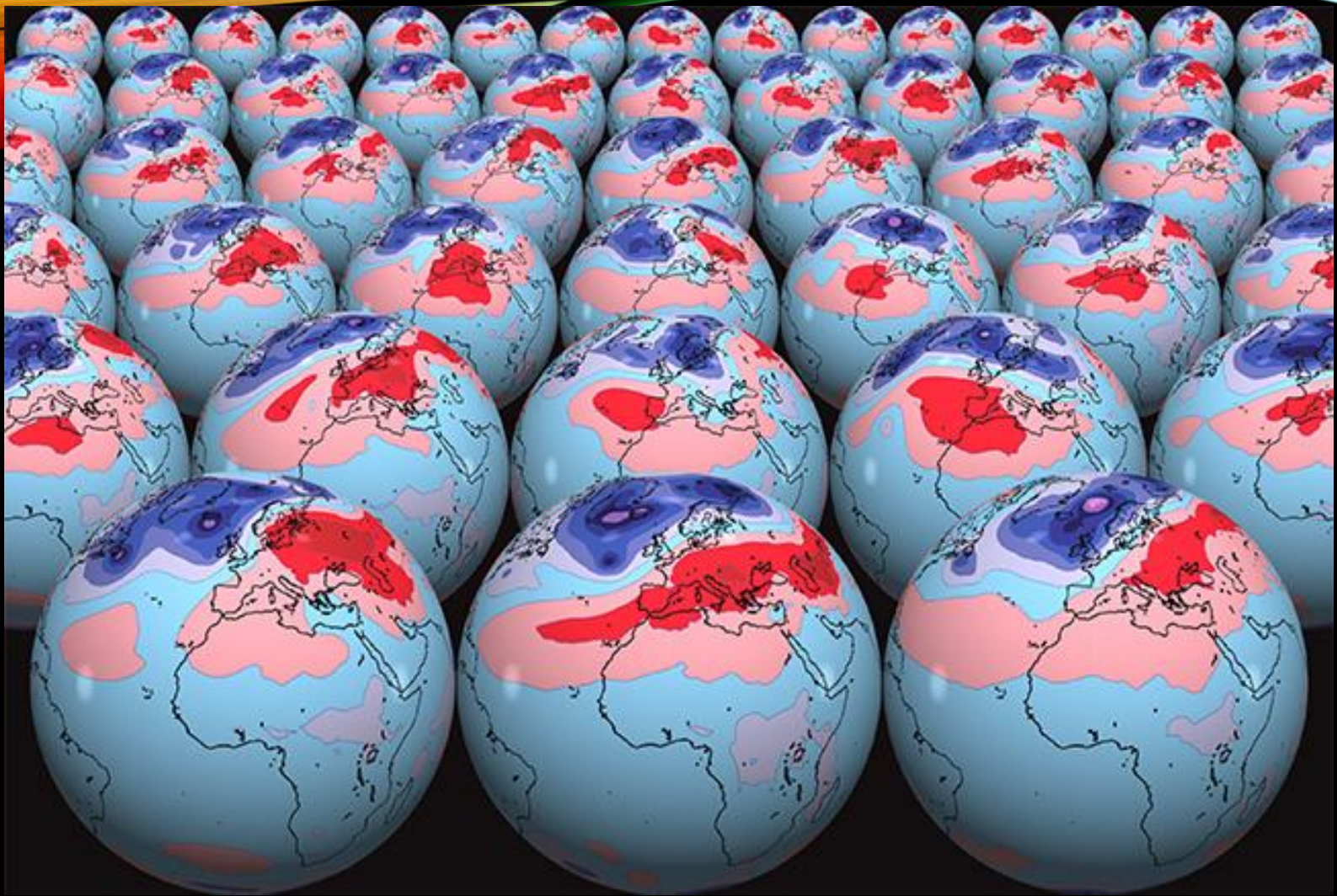
In computer weather prediction that is being tackled by using an ensemble of forecasts, to try to estimate what is the range of possibilities.

Ensembles



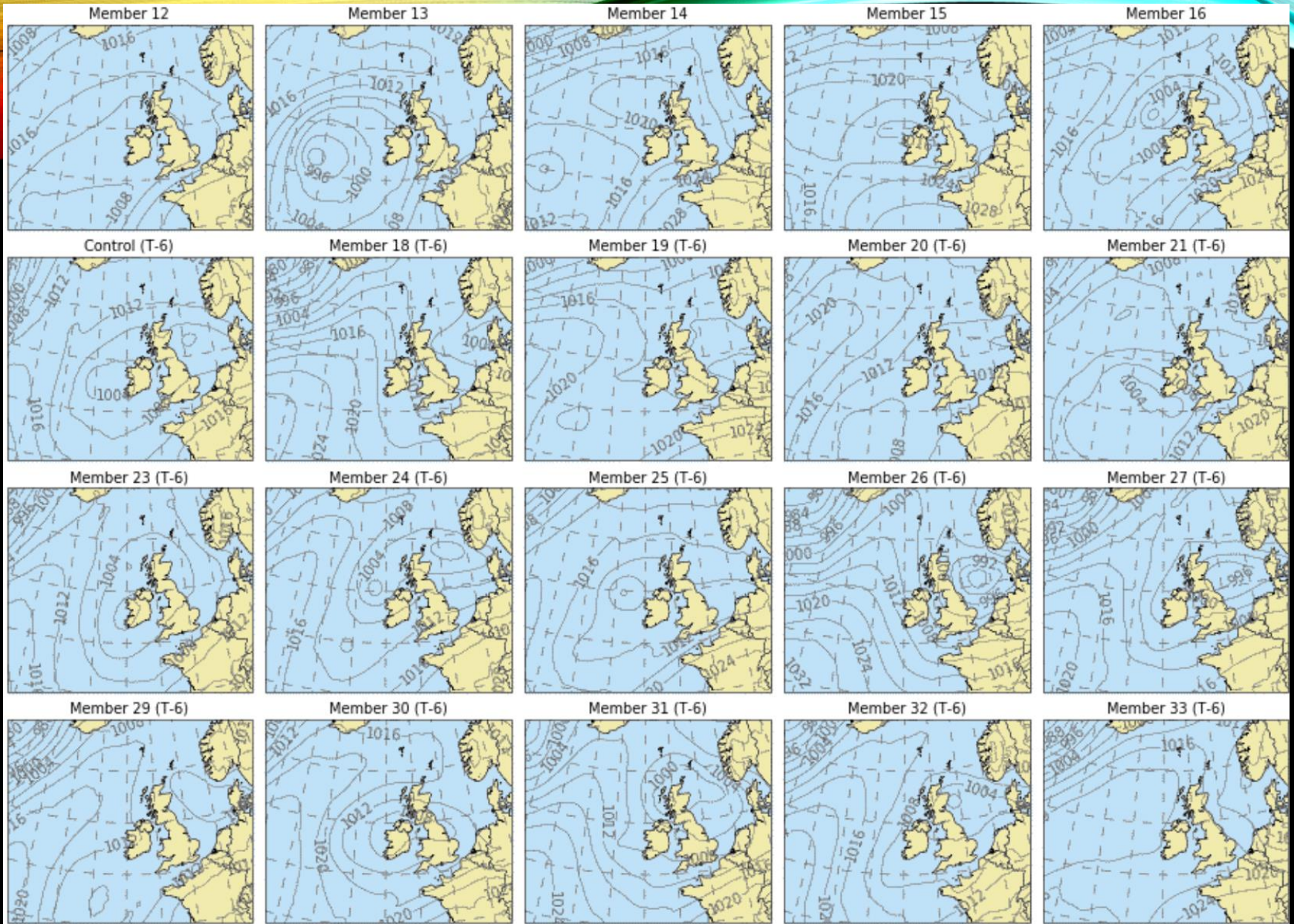
The ensemble can be:

- Pooling together the results of forecasts from various forecast systems from around the world
- Running their own prediction system many times with varying analyses.



Fact sheet: Ensemble weather forecasting

<https://www.ecmwf.int/en/about/media-centre/focus/2017/fact-sheet-ensemble-weather-forecasting>

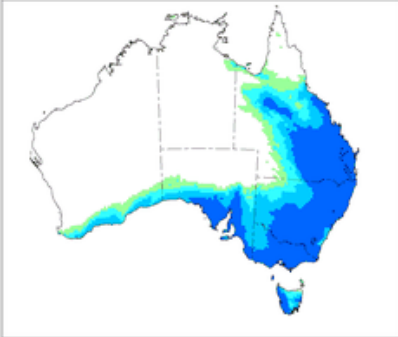


“Postage stamp” view of the weather maps from the ensemble of predictions

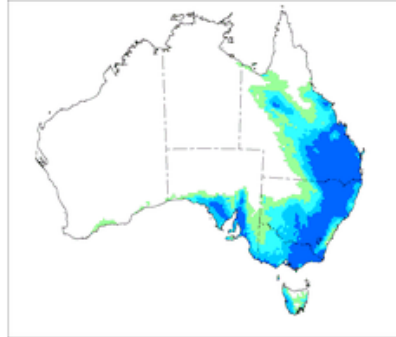
Controls
Map Forecast Rainfall Chance of Rainfall Total Forecast Rainfall
Date 01/11/2022 - Today
Location



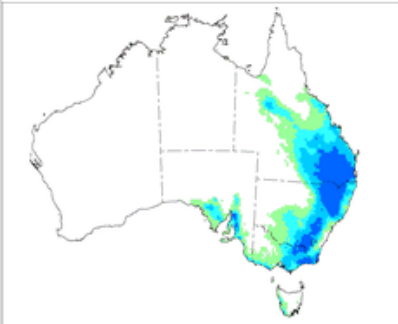
Chance of at least 1 mm



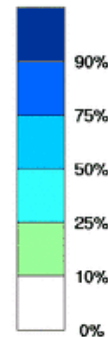
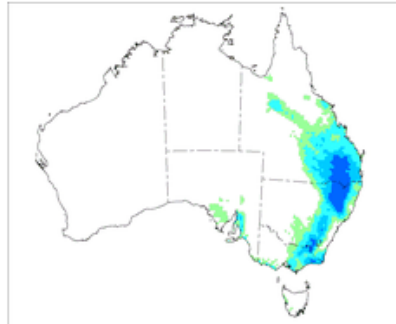
Chance of at least 5 mm



Chance of at least 10 mm



Chance of at least 15 mm



<http://www.bom.gov.au/jsp/watl/rainfall/pme.jsp>

Automated computer model rainfall forecasts

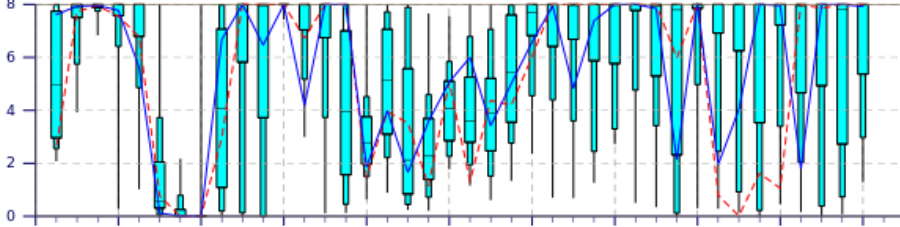
The Water and the Land (WATL) web site provides rainfall forecast maps generated automatically by weather forecast models. Models run by the Bureau of Meteorology and by five international centres are combined to produce the rainfall forecasts. Testing has shown that it easily outperforms a random guess or climatology, and also the forecast from any individual weather model, to at least five days ahead.

ENS Meteogram

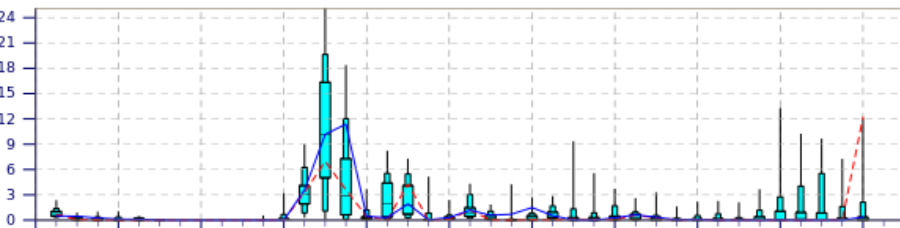
Melbourne - Victoria - Australia 37.88°S 144.96°E (ENS land point) 58 m

High Resolution Forecast and ENS Distribution Wednesday 16 November 2022 00 UTC

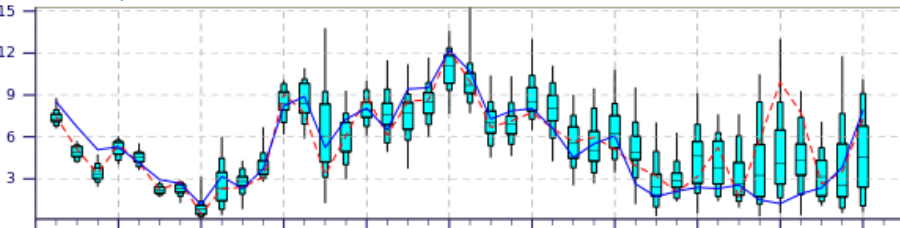
Total Cloud Cover (okta)



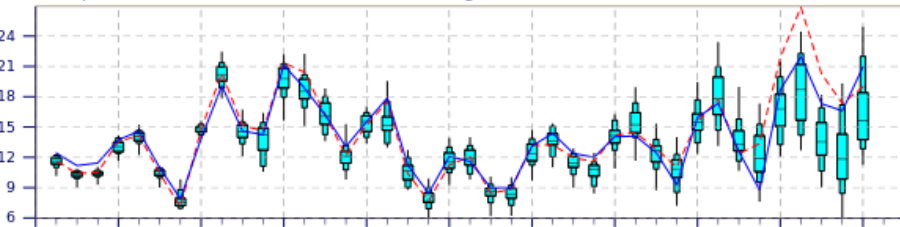
Total Precipitation (mm/6h)



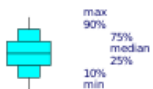
10m Wind Speed (m/s)



2m Temperature(°C) reduced to 58 m (station height) from 18 m (HRES) and 6 m (ENS)



Nov 2022

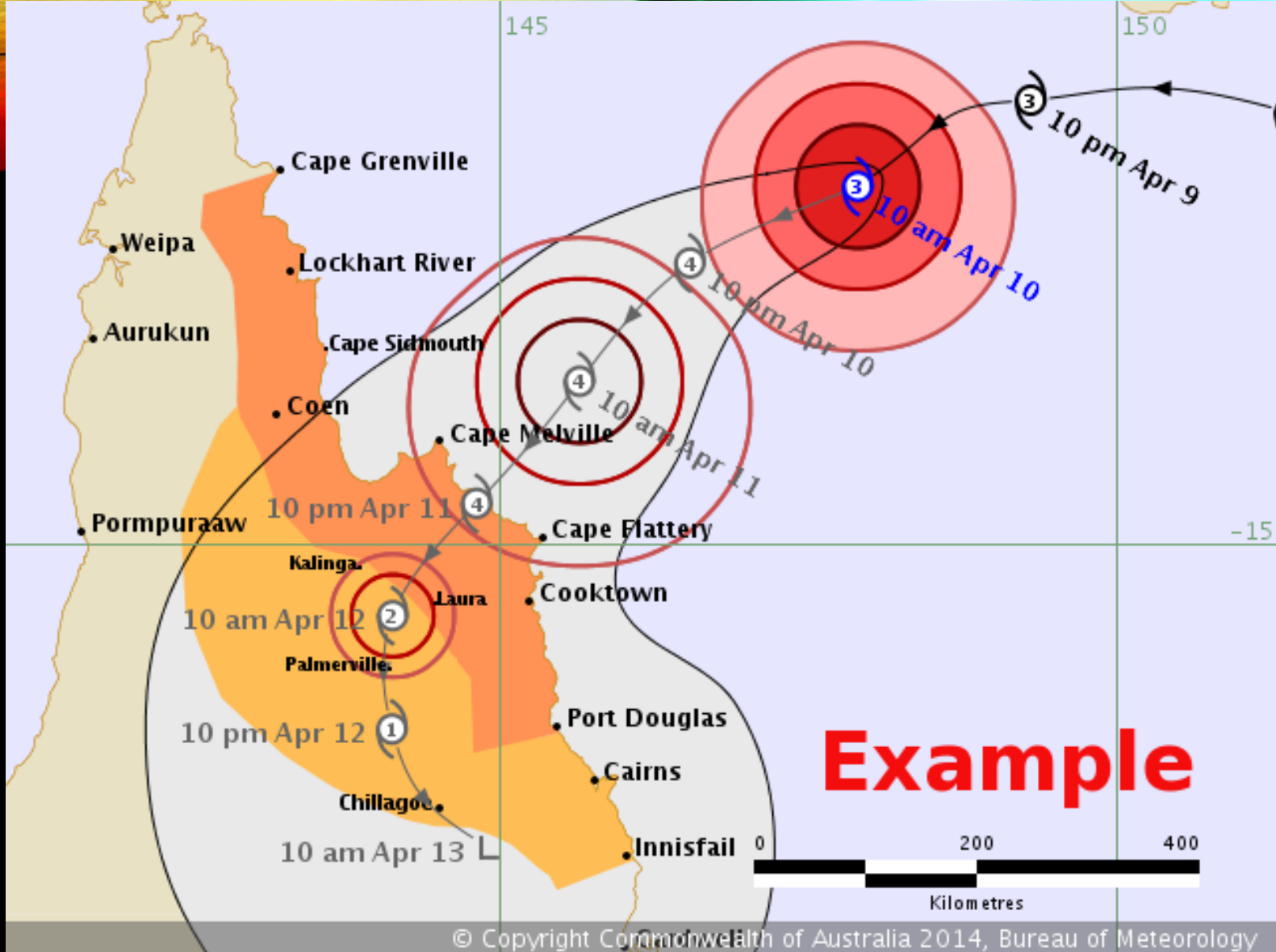


ENS Control(16 km)

High Resolution (8 km)

11 day
“meteogram” for
Melbourne from
ECMWF

https://charts.ecmwf.int/products/opencharts_meteogram



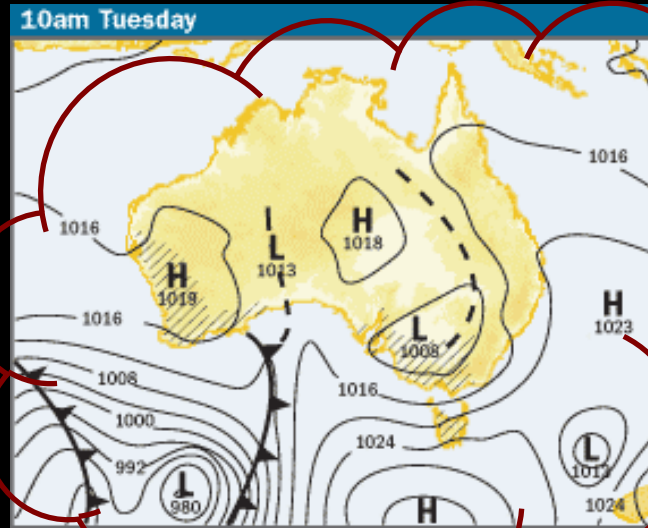
An example of a tropical cyclone forecast track map with its “cone of uncertainty”.

Traditional Forecasting



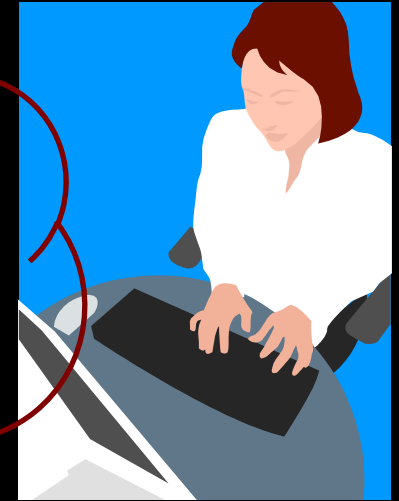
Examine information:

- surface measurements
- satellite and radar images
- computer models



Construct mental picture of how weather will evolve

Statistical guidance and diagnostics

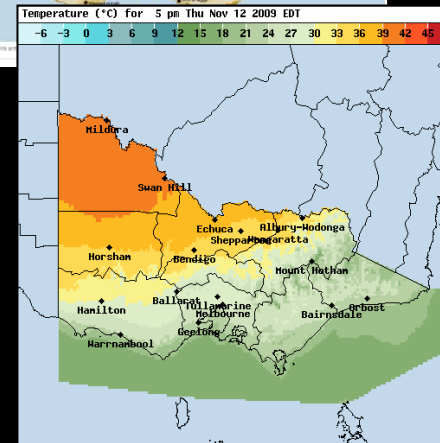
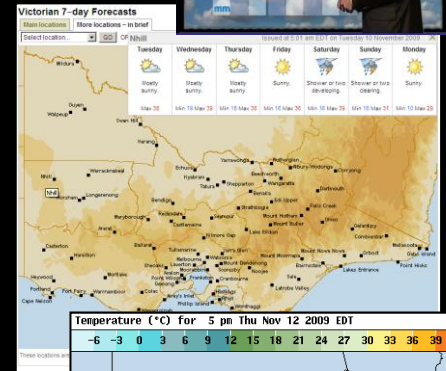
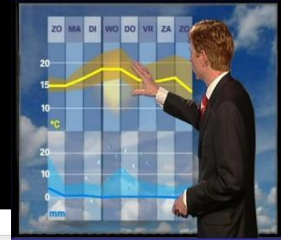
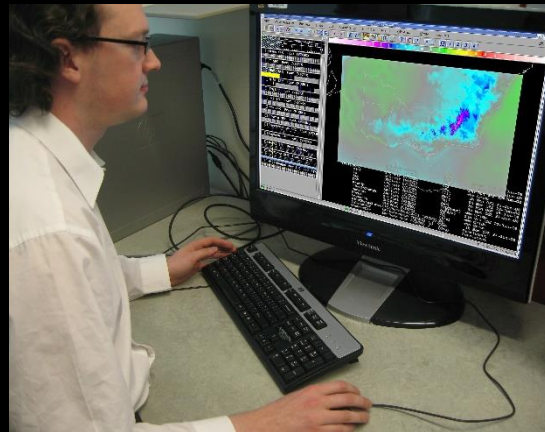


Type forecasts

“Next Generation Forecast and Warning System”

A huge paradigm and cultural change!

Adapted from the US Weather Service



Examine weather:

- surface measurements
- satellite and radar images
- computer models



**Manipulate
digital
forecast
database**



- **Automatic text forecasts**
- **Graphical forecasts**
- **Point and click forecasts**

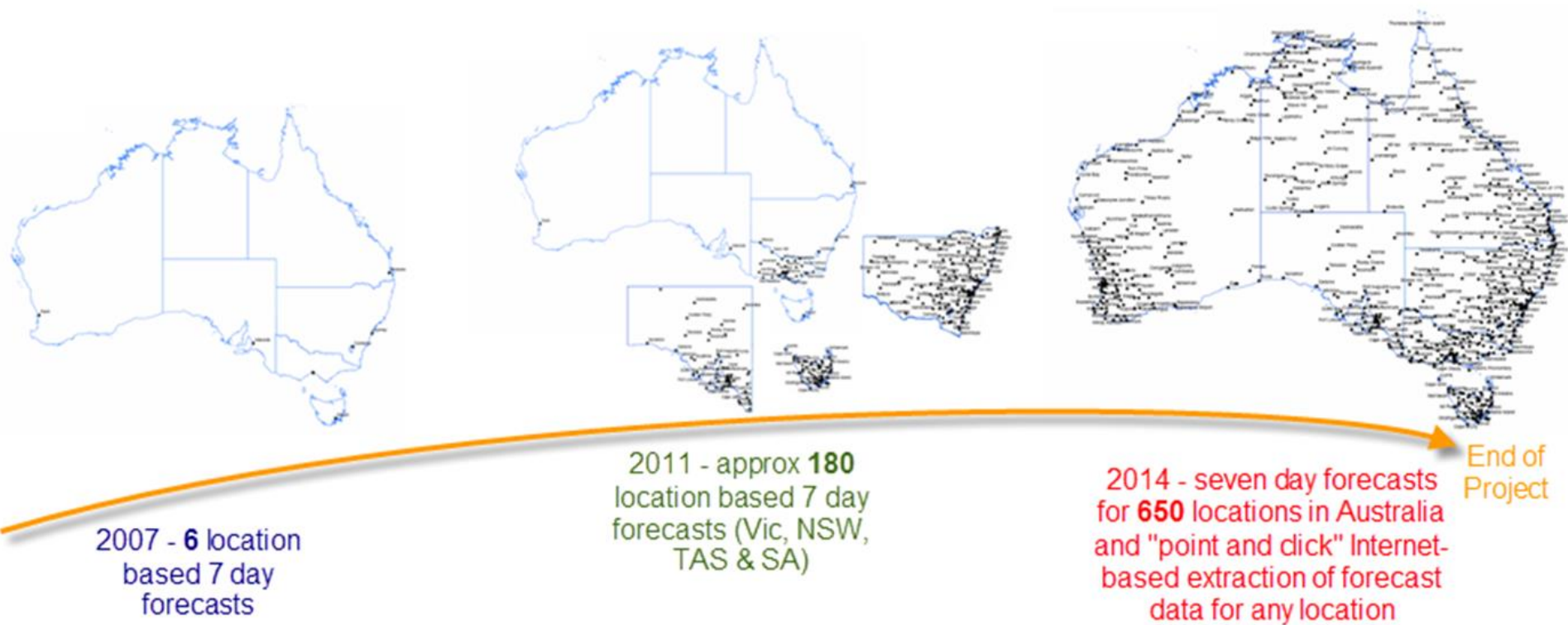
Benefits to the community

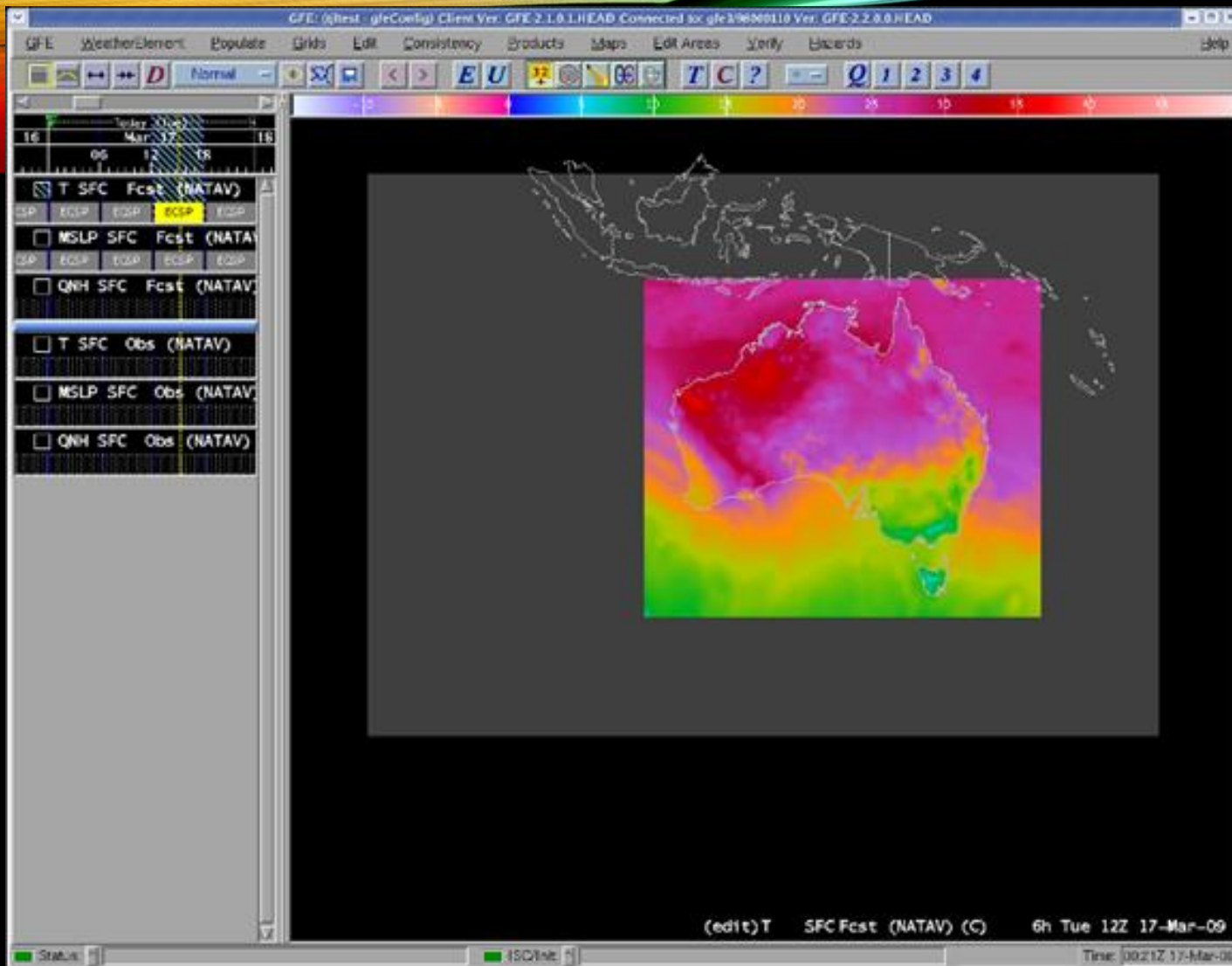
- ❖ Graphical forecasts on the Bureau's website
- ❖ Forecasts available within 3/6km of **any** location
- ❖ Increased detail in worded forecasts and spatial data
- ❖ Locations with 7 day forecasts increases (from 6 to 650)
- ❖ Forecasts available for all times of the day

Benefits to the Bureau

- ❖ A digital forecasting system with high spatial detail (Australian Digital Forecast Database)
- ❖ Ability to apply the latest research to forecasting procedures
- ❖ Allows forecasters to build directly on the excellent guidance provided by computer weather prediction models

The growth in the number of 7 day forecasts as the system is rolled out



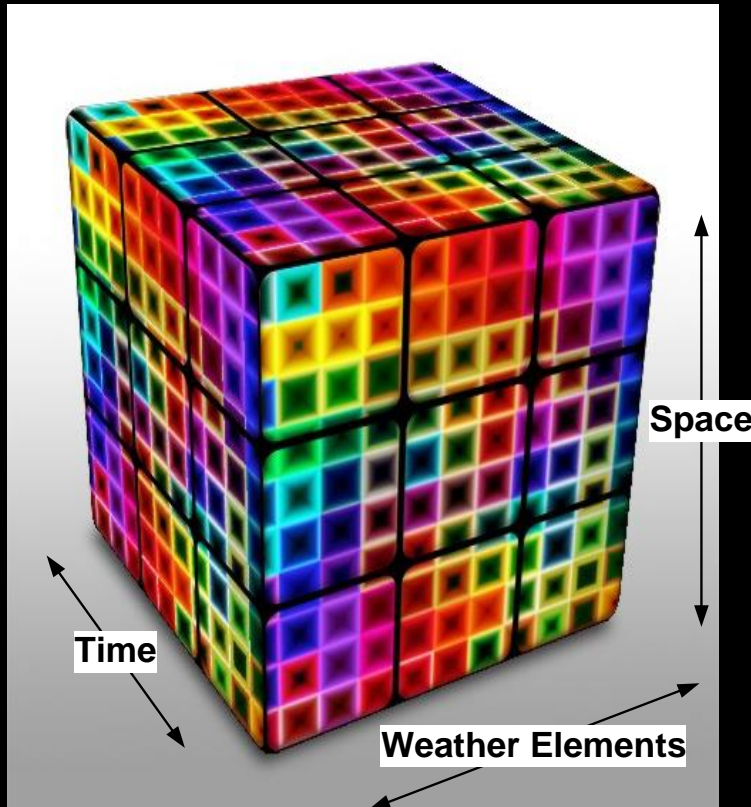


The Graphical Forecast Editor

- Adapted from the US version but with many enhancements and improvements



The Australian Digital Forecast Database



Temporal Resolution

Currently 1-3 hourly out to 7.5 days

Spatial Resolution

Typically 3 – 6km

Weather Elements

Temperature

Dewpoint (Relative Humidity)

Wind speed and direction

Sky cover

Rainfall amount and probability

Weather type (showers, fog, thunder, ...)

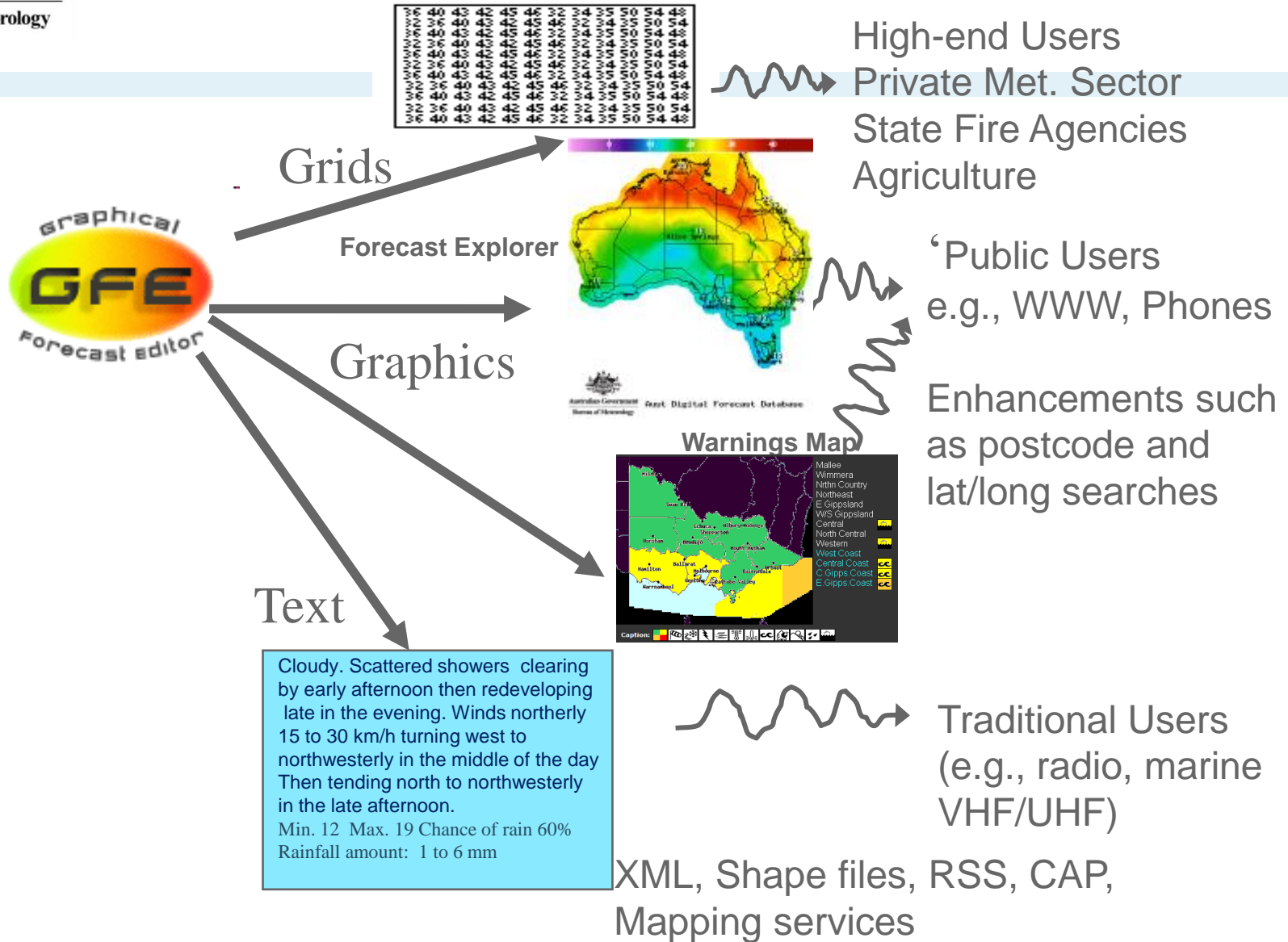
Derived fields – e.g. fire weather indices



Australian Government

Bureau of Meteorology

A Tiered Product Suit



Graphical Products and Forecasts

Australian Government Bureau of Meteorology

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Bureau Home > Weather & Warnings > Victoria > Forecasts > Mount Hotham

Mount Hotham

[View the current warnings for Victoria](#)

Forecast issued at 5:31 am EST on Sunday 21 August 2011.

Forecast for the rest of Sunday

Max 5 Sunny. Light winds.

UV Alert from 9:50 am to 2:40 pm, UV Index predicted to reach 5 (Moderate)

Monday 22 August

Min -2 Max 6 Sunny. Light winds.

Tuesday 23 August

Min -2 Max 5 Sunny. Winds north to northwesterly averaging

- Weather & Warnings
- Australia
- New South Wales
- Victoria
 - Warnings Summary
 - Forecasts
 - Melbourne Metro Forecast
 - Vic. Forecast Areas Map
 - Observations
 - Melbourne Observations
 - All Victorian Observations
 - Rainfall & River Conditions

Central Coastal Waters

[View the current warnings for Victoria](#)

Forecast issued at 5:10 am EST on Sunday 21 August 2011.

Weather Situation

A large high pressure system centred east of Tasmania extends a ridge westwards to the Bight and will move very slowly eastwards across the Tasman Sea during the week. A cold front will approach from the west on Tuesday, but weaken and slide away to the southeast on Tuesday night. A stronger cold front will reach the Bight late Wednesday.

Forecast for Sunday until midnight

Winds North to northeasterly 10 to 15 knots tending east to northeasterly up to 10 knots during the afternoon.

Seas Below 1 metre.

1st Swell Southwesterly

2nd Swell Easterly

Monday 22 August

Winds North to 10 to 15

Seas Below 1

1st Swell Westerly

2nd Swell Easterly

Please be aware

Wind gusts can be 40 percent stronger than the averages given here, and maximum waves may be up to twice the height.

Nearby Coastal Waters



Melbourne Local Waters Forecast

[About marine weather services](#) | [Safety](#) | [Definitions](#) | [Marine website feedback](#)

Map Controls

Select Map Type **Swell Height and Direction**

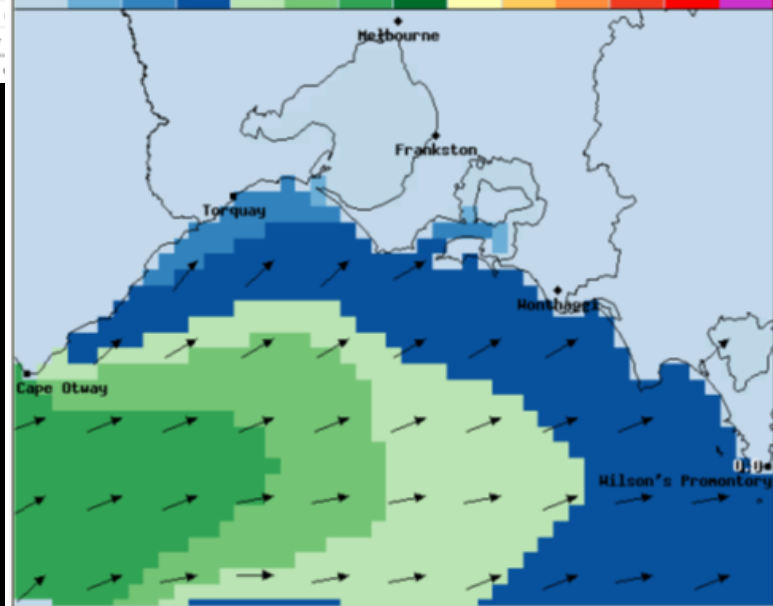
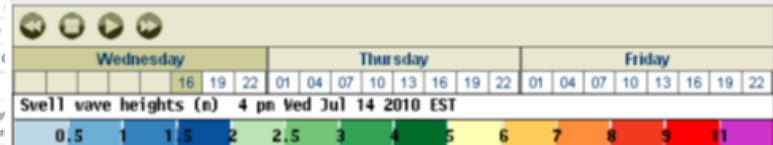


Image created 05 pm Wednesday 14 July 2010 (local time).
Australian Digital Forecast Database

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Victorian 7-day Forecasts

Click locations on map to display summary forecast

Bairnsdale

Issued at 5:01 am EST on Sunday 21 August 2011.

Detailed Bairnsdale Forecast

	Sun. 21 Aug	Mon. 22 Aug	Tue. 23 Aug	Wed. 24 Aug	Thu. 25 Aug	Fri. 26 Aug	Sat. 27 Aug
	Morning fog then sunny.	Sunny.	Morning fog then mostly sunny.	Sunny.	Sunny.	Possible shower.	Possible shower.
Max. Temperature	17°C	18°C	20°C	22°C	22°C	19°C	16°C
Min. Temperature		3°C	4°C	4°C	6°C	9°C	7°C





Australian Government
Bureau of Meteorology

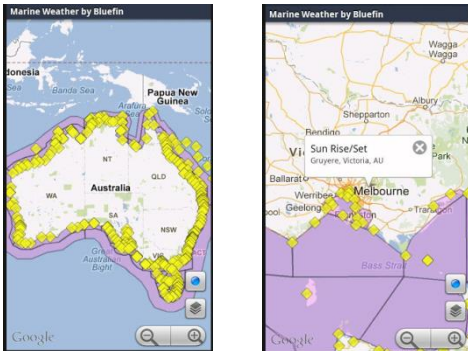
The Bureau's spatial weather data sets feed mobile applications

pocketweather
australia



<http://www.shiftyjelly.com/ios/pocketweatherau>

Marine Weather
by Bluefin



<https://itunes.apple.com/au/app/marine-weather-plus-by-bluefin/id551638799?mt=8>



Water Storage iPhone™ app

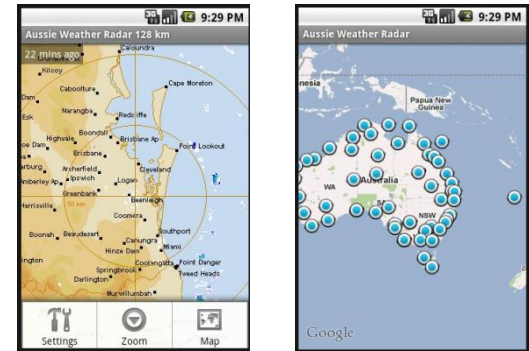



EmergencyAUS



<http://www.emergencyaus.info/discover/app/>

Aussie Weather Radar



<https://play.google.com/store/apps/details>



MetEye - your eye on the environment™



View the current warnings for Australia

Start typing, then select from list (town, city, postcode or lat/lon) Time zone: AEDT

LATEST WEATHER

Current Temp, Rain, Wind ...

FORECASTS

Rainfall Forecasts

Wind Forecasts

- Wind speed and direction (km/h)
- Wind speed and direction (knots)
Updated 8 Nov 2021, 7:38 PM AEDT
- Mixing height

Overlay

- Latest rain radar
Updated 8 Nov 2021, 8:37 PM AEDT
- Mean Sea Level Pressure (hPa)

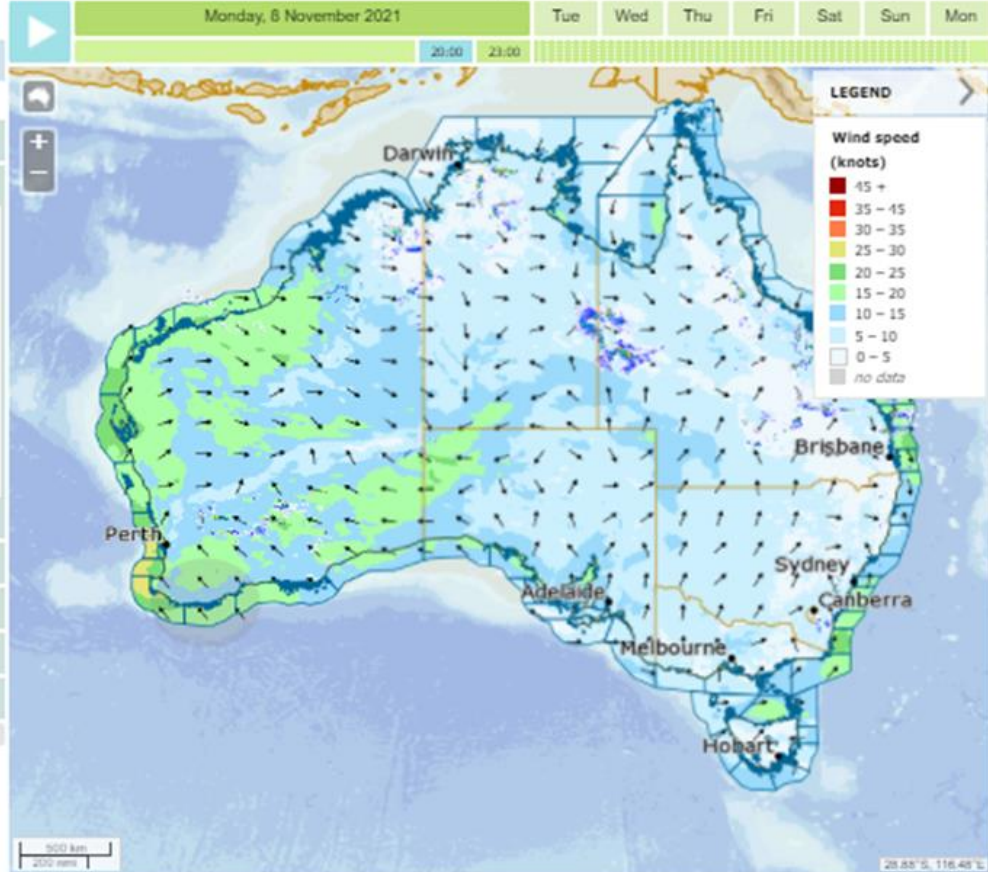
Waves Forecasts

Temperature Forecasts

Storms, Snow, Fog, Frost ...

Humidity Forecasts

UV Index Forecasts



- Place names
- Search marker
- Saved locations
- Forecast locations
- Forecast districts
- Marine zones
- Roads & railways
- Rivers & lakes
- Catchments

MetEye - A map-based viewer available on the Web