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High Impact Weather @ BOM

Beth Ebert

Head, Weather & Environmental Prediction Research

Bureau of Meteorology

Credit: James Ryan, ABC

CLEX Winter School, June 2018

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Outline

- BOM warning services
- Weather information value chain
- Co-development of a new warning service: thunderstorm asthma
- Toward more effective warnings for hazard impacts

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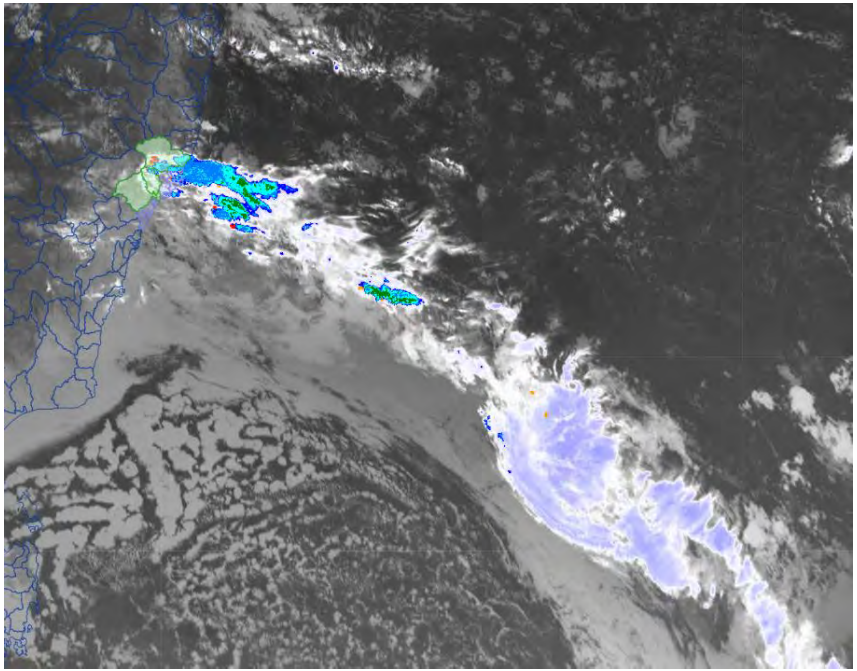
BOM's target: Zero lives lost

- A key responsibility of the Bureau is the provision of warnings to **protect life and property.**
- **Need to provide the right warning products, to the right people, at the right time** with the information they require to effectively project life and property.



March 2018 Mid-North Coast flooding with rainfall streaming into the catchment with severe weather and flood watches and warnings current.

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Hazard warning services @ BOM

Water hazards impacting public safety

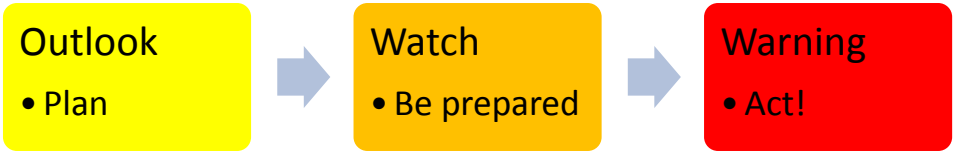
- Riverine flood
- Flash flood
- 7 Day streamflow forecasting
- Tsunami
- Coastal flooding

Weather and marine forecasts

- Public weather
- Agricultural weather
- Marine weather
- Ocean services

Extreme Weather

- Fire weather
- Heatwave
- Tropical cyclone
- Thunderstorm
- Severe weather
- Thunderstorm asthma
- National multi-hazard



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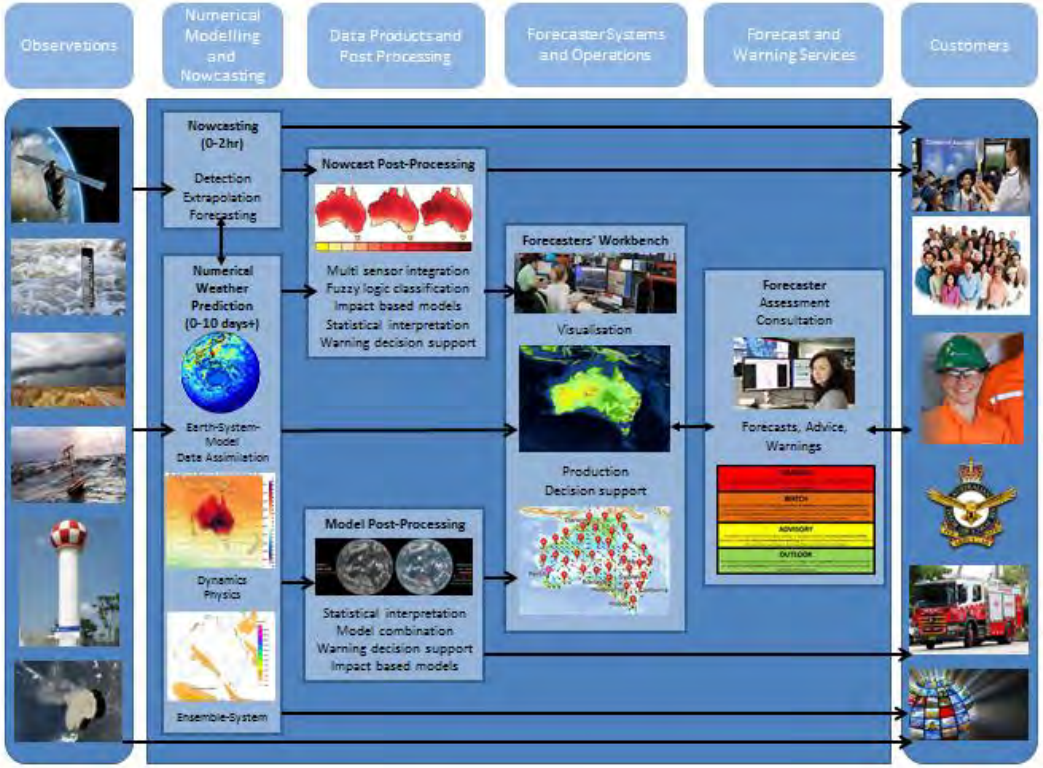
Weather information value chain



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Observations

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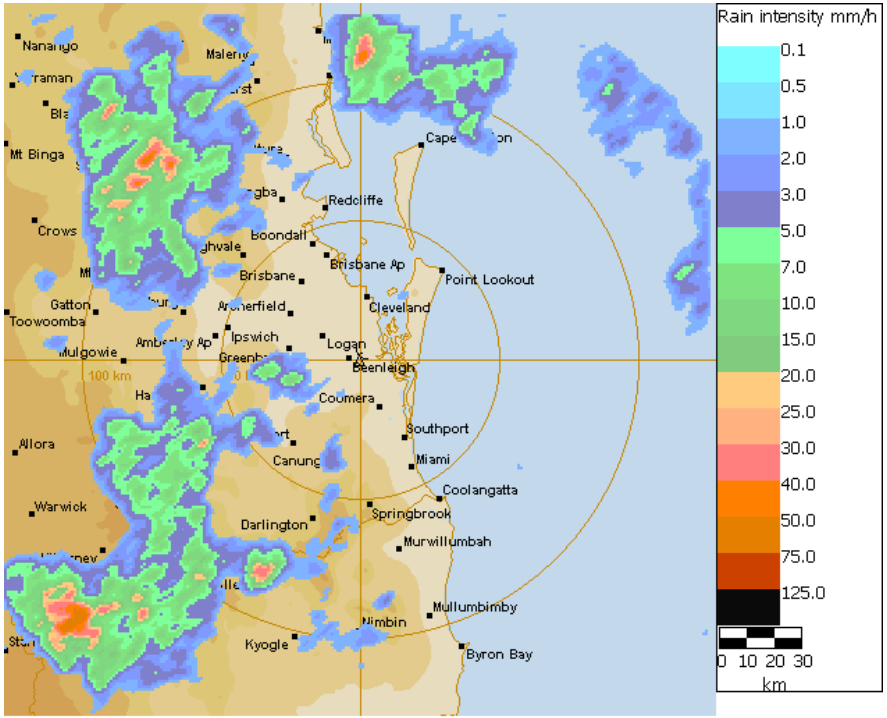
Nowcasting



Data at 10-JAN-2011 01:06:00 UTC

Extrapolation of observations forward in time

- Usually spatial (radar, satellite)
- Minutes to a few hours
- May include very short-term forecasts from high resolution numerical models

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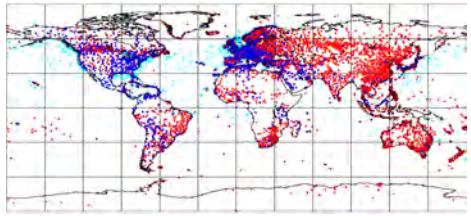
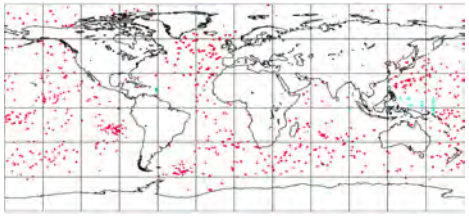
Global observation coverage

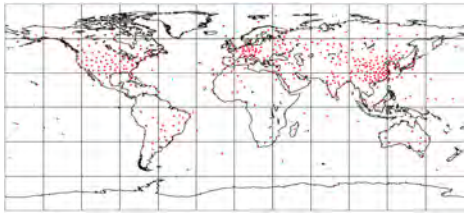
SYNOPS AND SHIPS



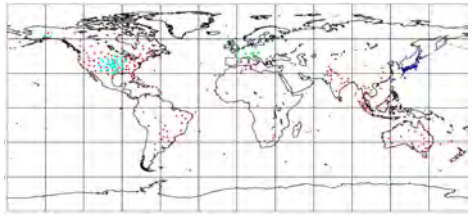
BUOYS



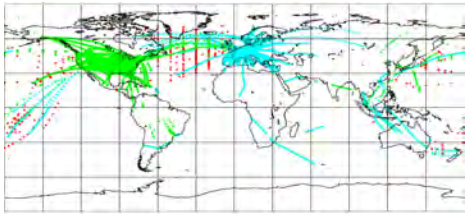
RADIOSONDES



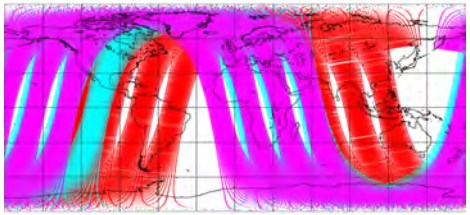
PILOTS AND PROFILERS



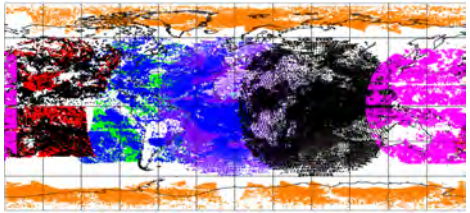
AIRCRAFT



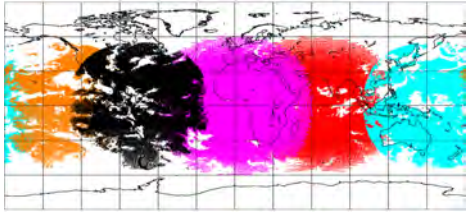
IR AND MW SOUNDERS



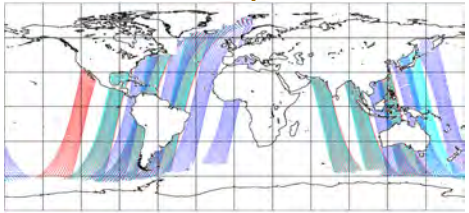
SATELLITE WINDS



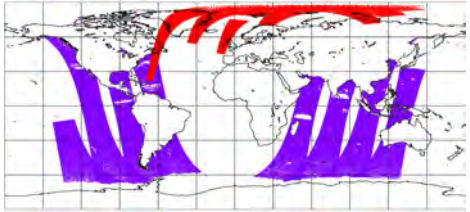
WATER-VAPOUR RADIANCES



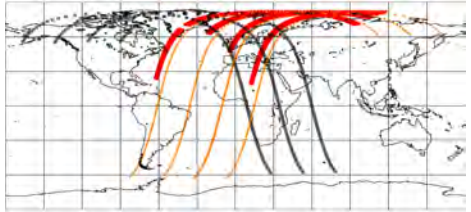
SSM/I



SCATTEROMETER



OZONE



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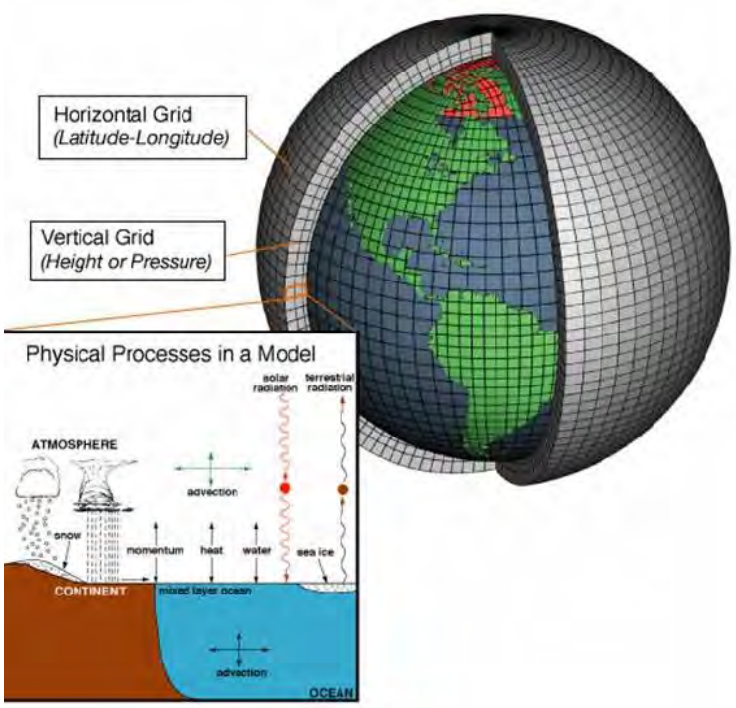
Numerical weather prediction (NWP)

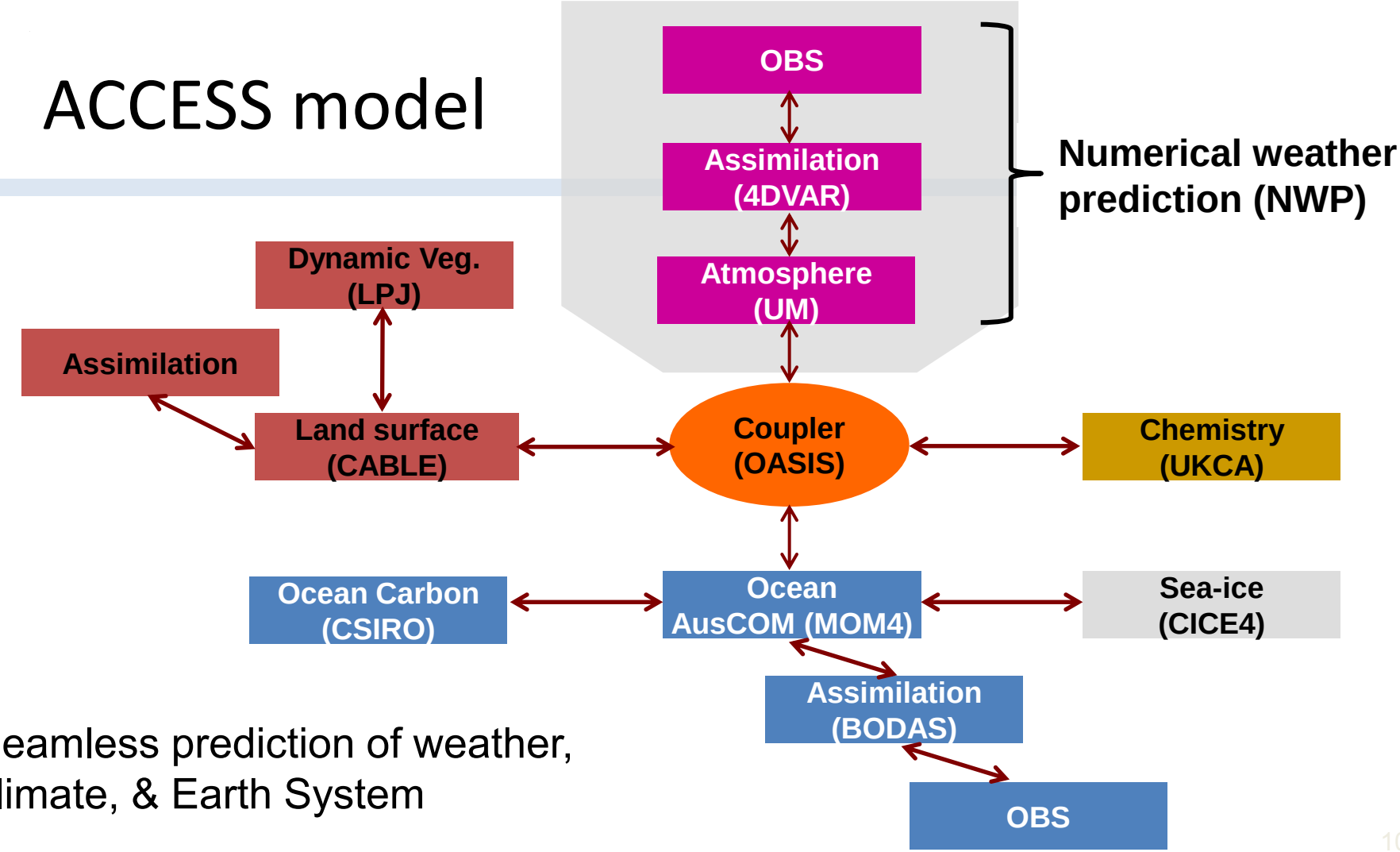


Initialisation

NWP samples the state of the atmosphere at a given time (**initial condition**) and uses the equations of motion to estimate the state of the fluid at a future time.

- The initial condition is generated by entering observation data into the model - this process is called data assimilation
- Modern data assimilation methods are highly complex mathematical algorithms to extract maximum amount of information from the observations
- Assimilation also maintains balance between the mass fields (pressure, temperature) and the wind field
- Improved assimilation methods are responsible of major improvements in weather forecasts

ACCESS model



Seamless prediction of weather, climate, & Earth System

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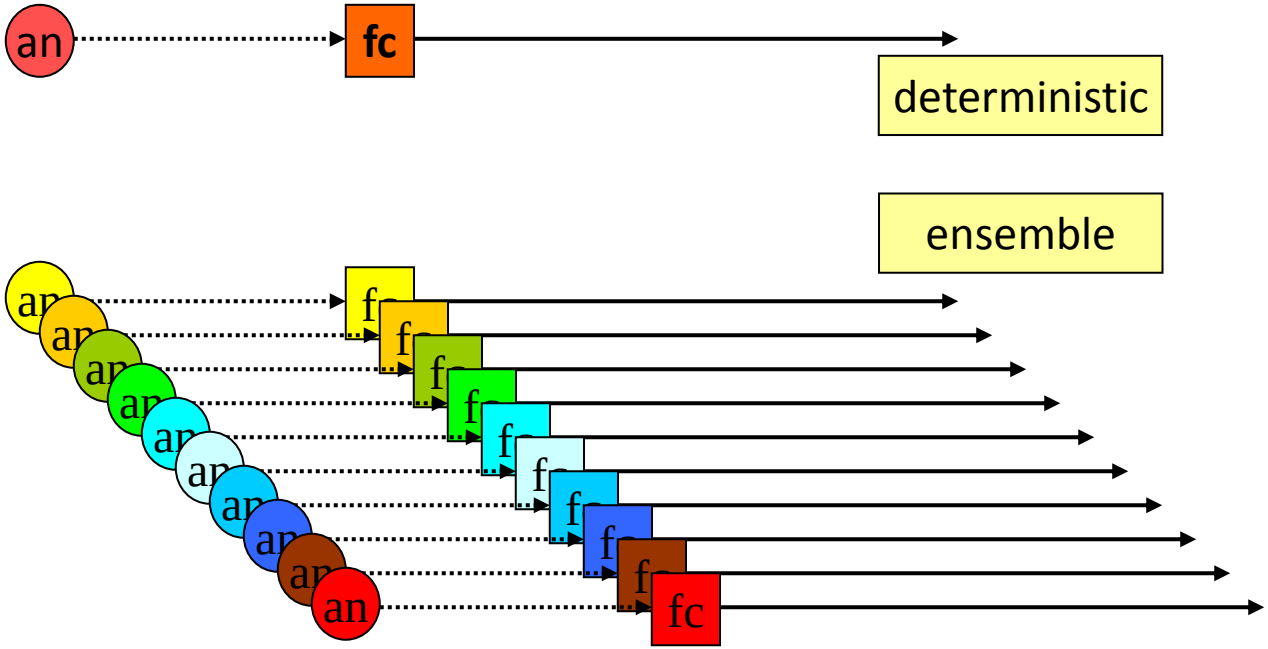
Deterministic & ensemble NWP



Typically 10-50 "members" in a NWP ensemble

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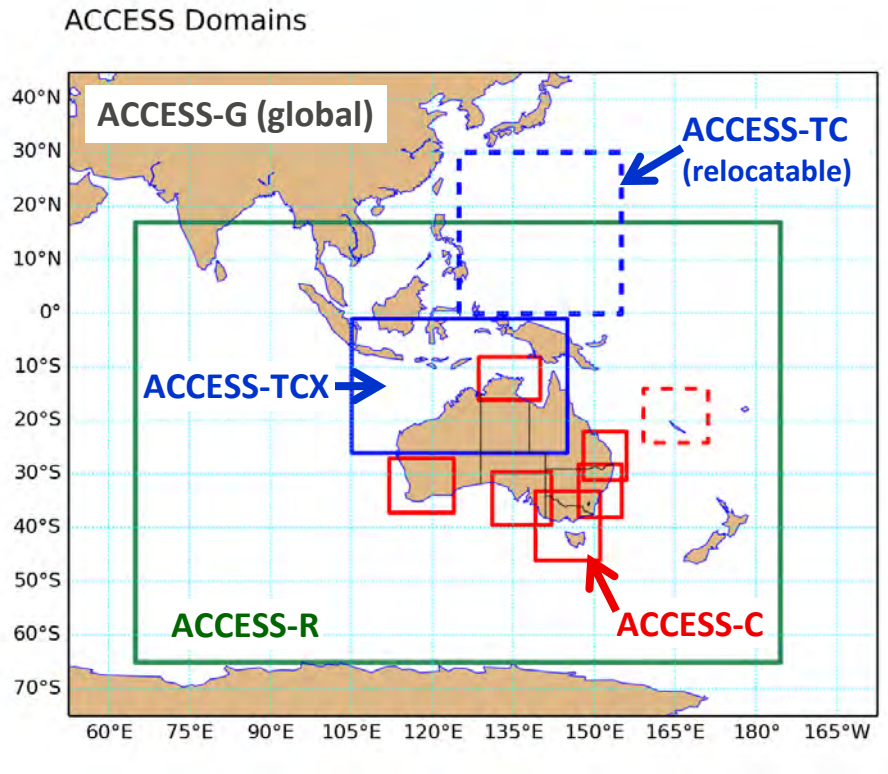
ACCESS NWP
Major developments 2017-18

- ACCESS-C2 (APS2 ACCESS-C)
  - 1.5km resolution, "convection permitting"
- ACCESS-G3 / GE3
  - Major code upgrade (UM10.6+)
  - Major data assimilation upgrades
  - G & GE (ensemble) one system
- ACCESS-C3 / CE3
  - Same base code as G/GE3 (incl. ensemble)
  - Includes data assimilation
  - Focus on short lifecycle phenomena
    - Storms, fire weather, major wind changes
    - More frequent updates to forecasts



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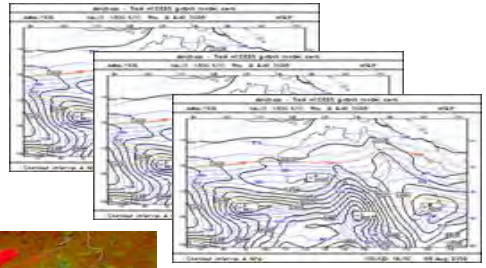
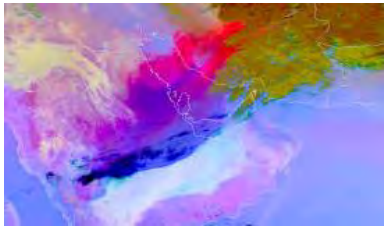
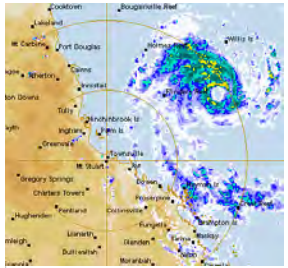
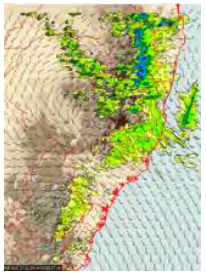
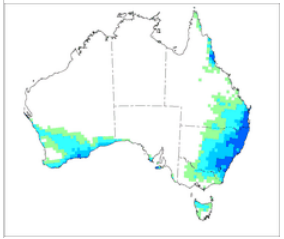
Data products & post-processing











Technical post-processing

- Remapping
- Thinning
- Dissemination

Statistical – dynamical post-processing

- Bias correction
- Downscaling
- Compositing

Product generation

- Charts
- Alerts and warnings
- Probability forecasts

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Forecast systems & operations

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Forecast & warning services

Our services

- Agriculture
- Climate and Past Weather
- Water Information
- Aviation Weather Services
- Marine and Ocean
- UV and Sun Protection
- Environmental Information
- Registered Users and Data Services

News and events

- Latest media releases
- Bureau annual report 2016-17
- Latest ENSO wrap-up
- Service announcements
- Special climate statements
- All news and events

Specialised services

- Climate change
- Business Solutions
- Research
- Defence services
- WMO activities
- Space weather services

Facebook

Youtube

Twitter

Blog

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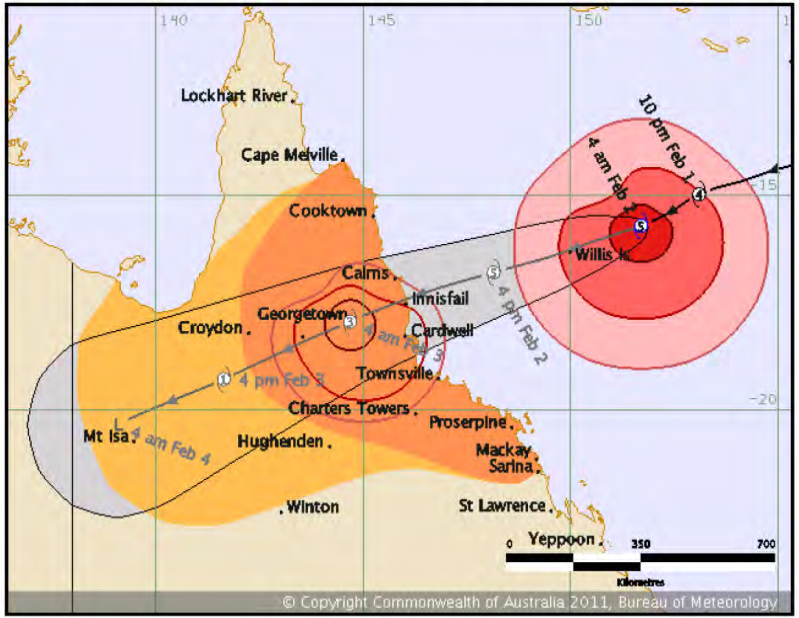
Example: Tropical cyclone

TROPICAL CYCLONE FORECAST TRACK MAP

Severe Tropical Cyclone Yasi

Issued at 5:03 am EST Wednesday 2 February 2011. Refer to Tropical Cyclone Advice Number 11.



Community Threat	Past Cyclone Details
Warning Zone - Gales within 24 hours	Past Location and Intensity Number (3) or L
Watch Zone - Gales from 24 to 48 hours	Past Track and Movement
Current Cyclone Details	**Forecast Cyclone Details** (at 24 and 48 hours from issue)
Current Location and Intensity Number (3) or L	Forecast Location and Intensity Number (3) or L
Very Destructive Winds	Very Destructive Wind Boundary
Destructive Winds	Destructive Wind Boundary
Strong Gale Force Winds	Strong Gale Force Wind Boundary
	Most Likely Future Track
	Range of Likely Tracks of Cyclone Centre

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Example: Tropical cyclone

Australian Government Bureau of Meteorology
Queensland
Tropical Cyclone Warning Centre

Media: The Standard Emergency Warning Signal should NOT be used with this warning.

TOP PRIORITY FOR IMMEDIATE BROADCAST

TROPICAL CYCLONE ADVICE NUMBER 11

Issued at 11:00 am EST on Thursday 10 April 2014

Headline:

Severe TC Ita is currently a Cat 3 system but is expected to intensity to a Cat 4 as it approaches far Nth Qld coast.

Areas Affected:

Warning Zone

Cape Grenville to Port Douglas.

Watch Zone

Port Douglas to Innisfail

Cancelled Zone

None.

Details of Severe Tropical Cyclone Ita at 10:00 am EST [9:30 am CST]:

Intensity: Category 3, sustained winds near centre 155 kilometres per hour with wind gusts to 222 kilometres per hour.

Location: within 20 kilometres of 12.1 degrees South 147.9 degrees East, estimated to be 505 kilometres east of Lockhart River and 470 kilometres northeast of Cooktown

Movement: west southwest at 14 kilometres per hour.

Text advisory containing:

- Headline to provide a quick update
- Area covered
- Cyclone name
- Intensity category
- Latest observed location of cyclone centre
- Distance of cyclone to significant locations
- Expected or recent cyclone movement
- Description of potential hazards (destructive winds, storm tide, heavy rain)
- Advice on actions to be taken
- Issue time for next warning

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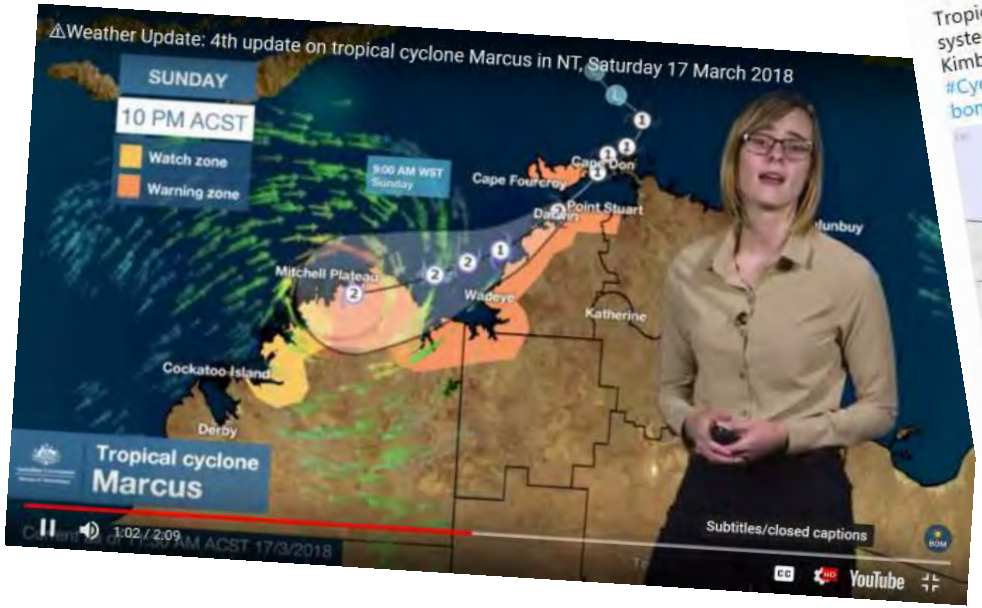
Keeping up with technology



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"Customers" (incl. public)

IMPACT AND VALUE	
Products and services that benefit the Australian community and drive competitive advantage for businesses and industries.	
1.1	Focus on customers in priority sectors, understand their needs and expectations, and deepen and broaden our relationships with them.
1.2	Establish our market positioning, business models, and product and service offerings in priority sectors.
1.3	Amplify our outreach to the parliament, public sector, industry and the community as Australia's most authoritative and trusted source of weather, water, climate and ocean information.
1.4	Build skills, systems and culture across the enterprise to operate in a businesslike way, delivering an outstanding customer experience.
1.5	Measure and monitor the quality, impact and value of our products and services, and drive a culture of continuous improvement.

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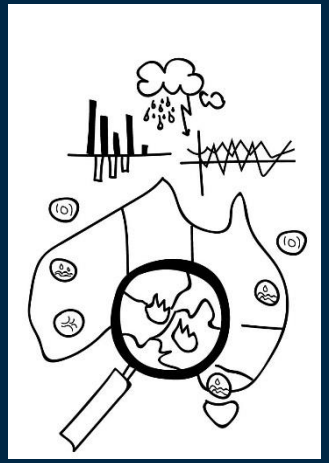
Stakeholders for weather information

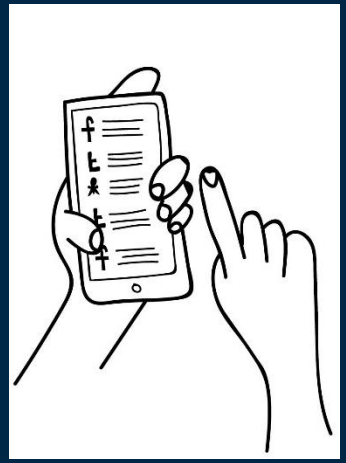
Voice of the Customer

"The Bureau website, I get a bit frustrated. I've got to sit down and think about where to find it and try and navigate to there."
[Senior Manager, NSW RFS]



"All we get from the heatwave service are low-resolution maps with yellow, orange and red blobs. It's really hard to know what areas are affected."
[Senior Manager, NSW Health]

"You're giving information, but not any advice. I think that there's an opportunity to build on the forecast and provide resources, to assist people in identifying hazards and risk."
[Senior Advisor, Yarra City Council]



"We do have a couple of social media sites in the Territory that are quite active, and I'm monitoring those to get a sense of excitement
[Manager, NT Emergency Service]

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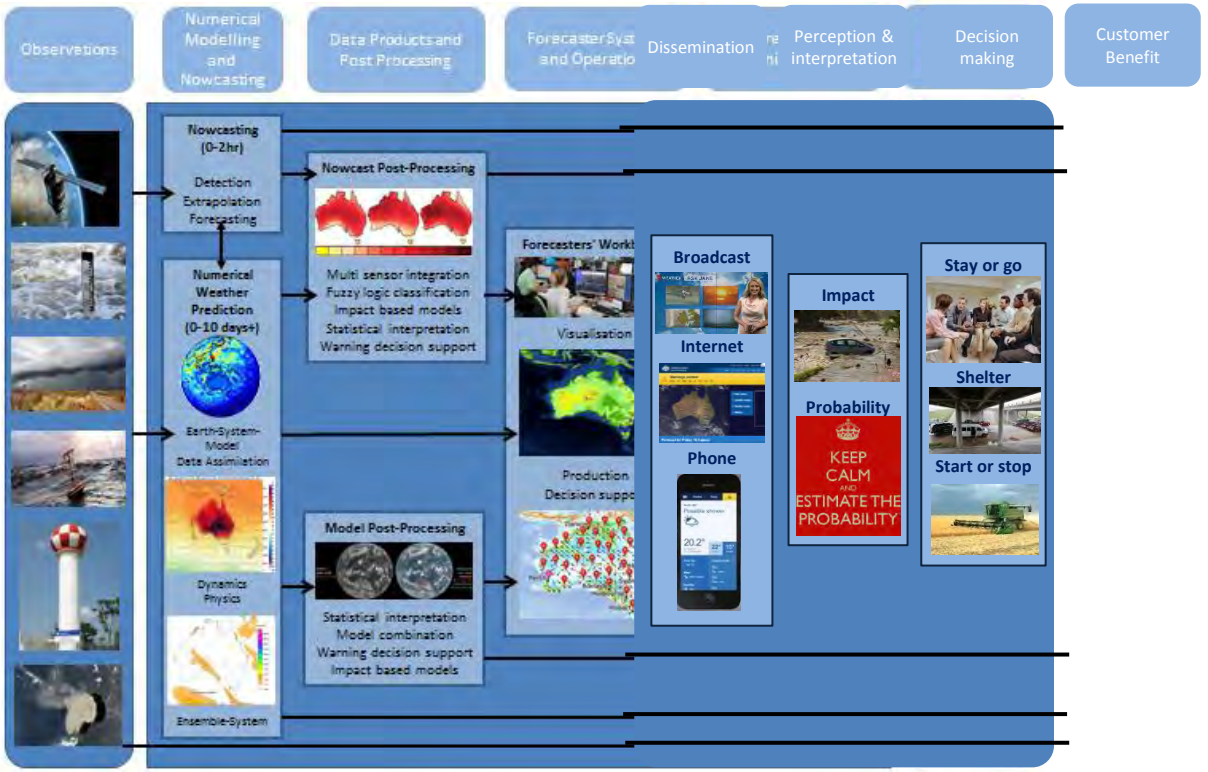
Strengthening the value chain



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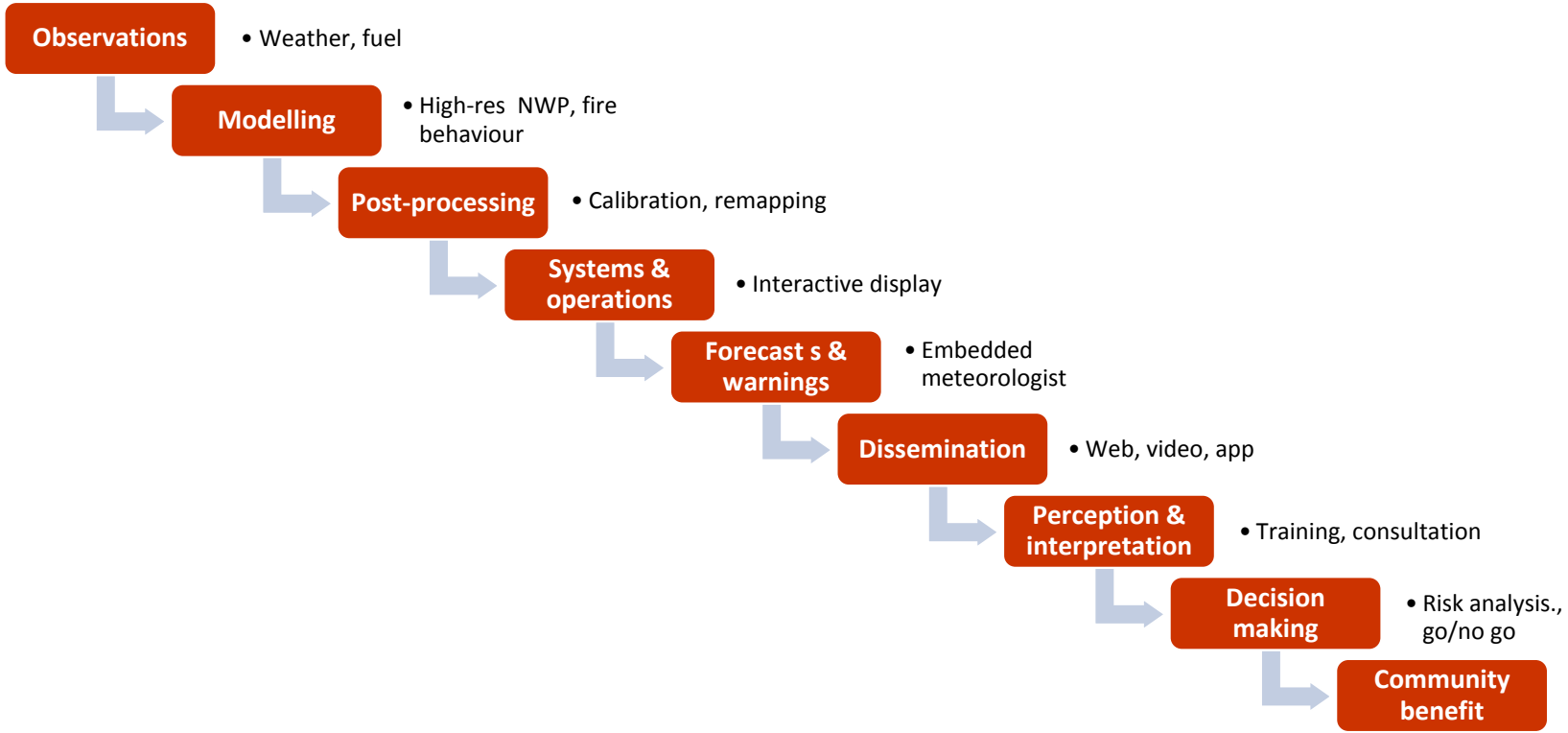
Example value chain for fire weather prediction



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Designing a new warning service

Thunderstorm asthma event, 21 Nov 2016

'Thunderstorm asthma': Two die after Melbourne storm causes spike in respiratory problems

Updated 22 Nov 2016, 5:22pm

Two people have died after experiencing respiratory issues during a "thunderstorm asthma" emergency in Melbourne last night, Ambulance Victoria says.

A severe thunderstorm swept through Melbourne yesterday after the state's hottest day since March, damaging a number of buildings, felling trees and spreading pollen.

Hospitals were swamped with emergency patients, while firefighters and police were called on to help paramedics respond to thousands of calls after the conditions caused breathing problems for Victorians.

Ambulance Victoria emergency operations general manager Mick Stephenson said two people died in Melbourne's western suburbs after reporting respiratory symptoms.

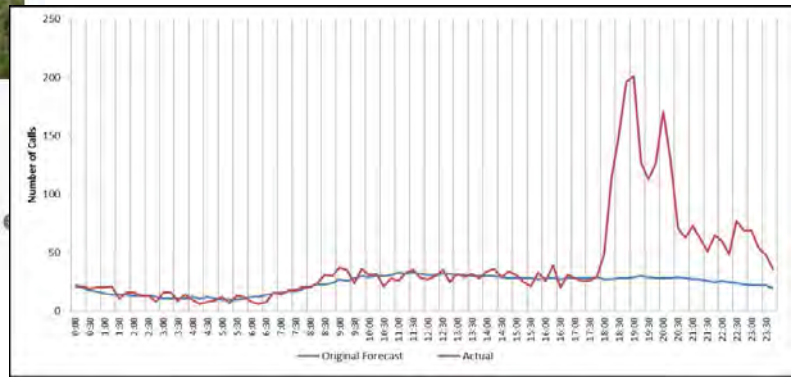
PHOTO: SES volunteers are still responding to calls for assistance after Monday night's storm. (ABC News)

RELATED STORY: Damaging storm hits Melbourne after sweltering temperatures

MAP: Melbourne 3000

- Hospital staff say "they've never seen so many people" in emergency with same condition
- People allergic to rye grass particularly susceptible to thunderstorm asthma
- Hundreds of calls for building damage, mainly in Melbourne's west

Ambulance callouts



(Source: Chief Health Officer's report)

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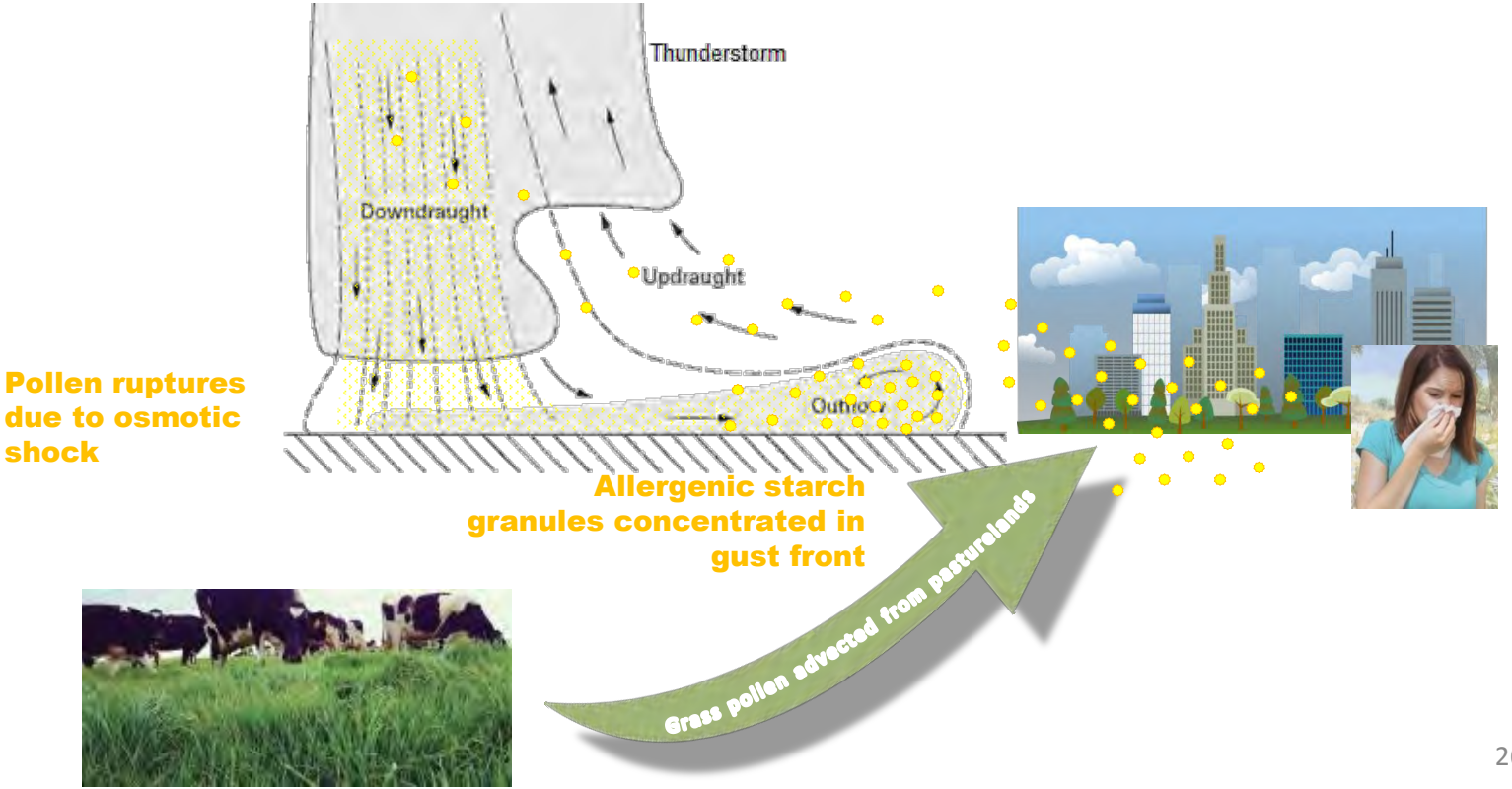
Hypothesised mechanism for thunderstorm asthma



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Exercise: Using the value chain to help design a warning service

Customer: Health Department (DHHS Victoria)

Objective: Enhanced community safety and emergency response during epidemic thunderstorm asthma events

Start with the objective in mind

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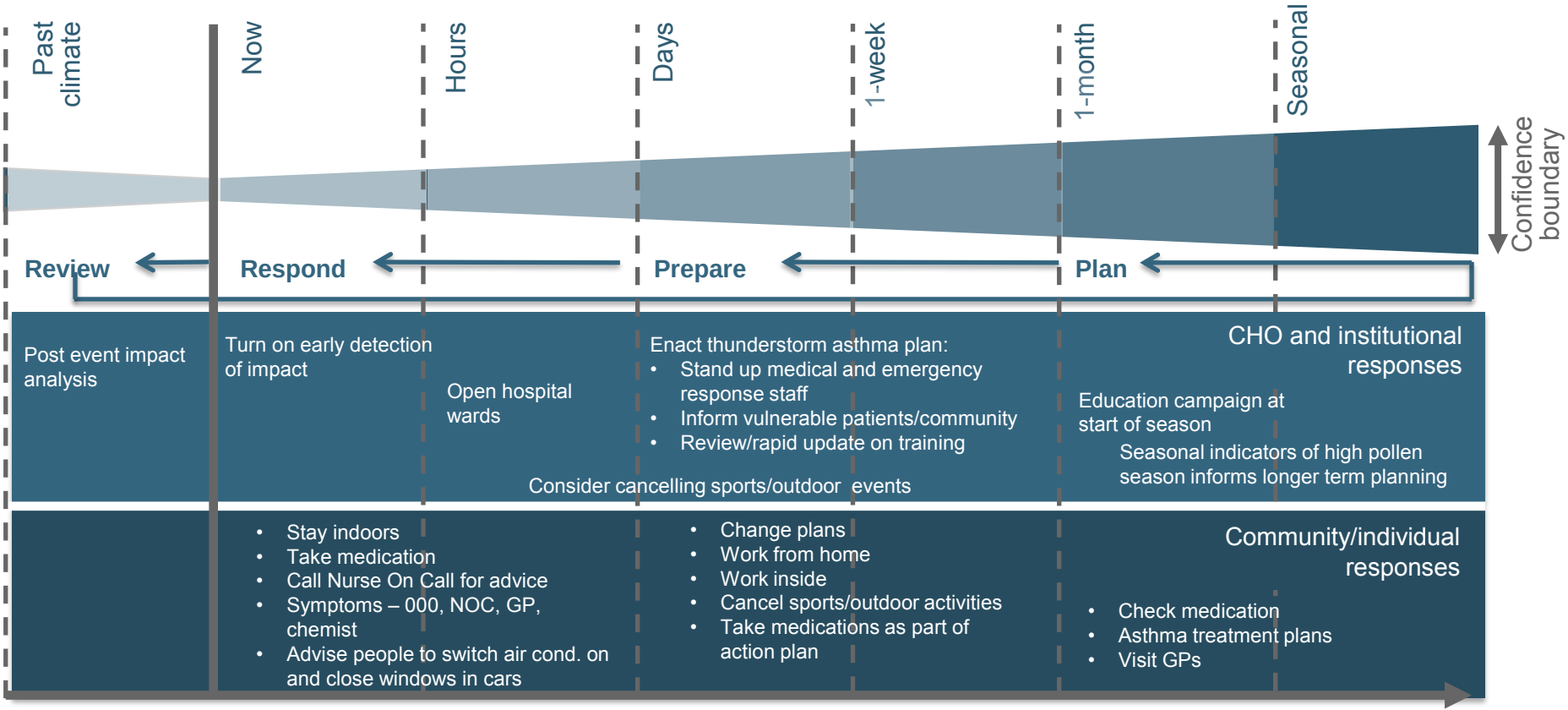
Thunderstorm asthma forecast service – timescales for critical responses



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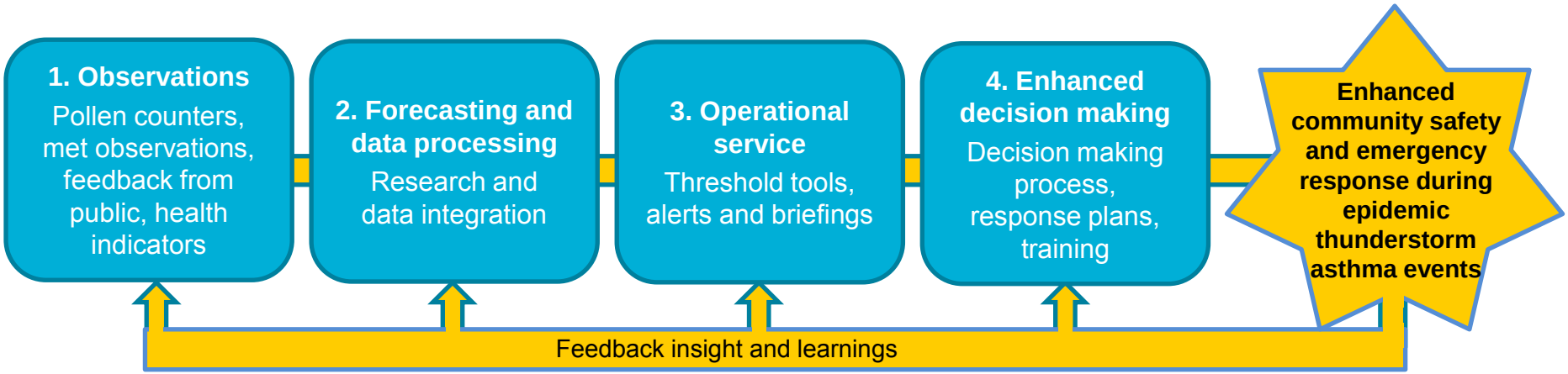
Epidemic thunderstorm asthma forecast service



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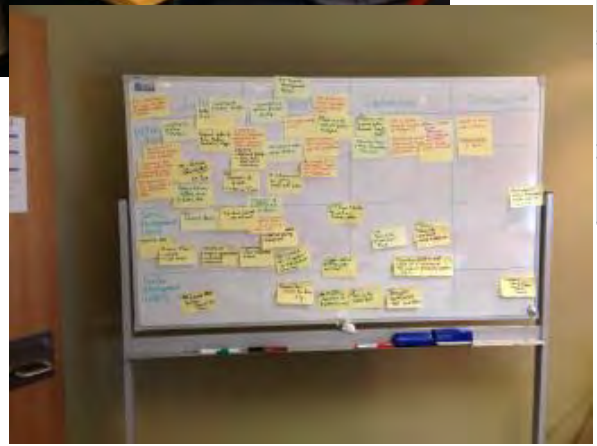
Co-development of a warning service



Multi-disciplinary partnership

Epidemic Thunderstorm Asthma Decision Matrix 2017-18			
Weather factors affecting at least one third of a district			
>30% (Likely) chance of thunderstorms causing gusts >= 50kts (squall line potential adds to risk)	Low	Moderate	High
>30% (Likely) chance of thunderstorms with 35< gust < 50kts or ICON (measure of convergence) >=20	Low	Low	Moderate
<30% (Chance) or nil chance of thunderstorms or ICON (measure of convergence) <20	Low	Low	Low
District Pollen Forecast (m^{-3})	**Low (0-19)**	**Moderate (20-49)**	**High/Extreme (≥50)**

Used by BOM forecasters to predict risk of epidemic thunderstorm asthma during pollen season (Oct-Dec)

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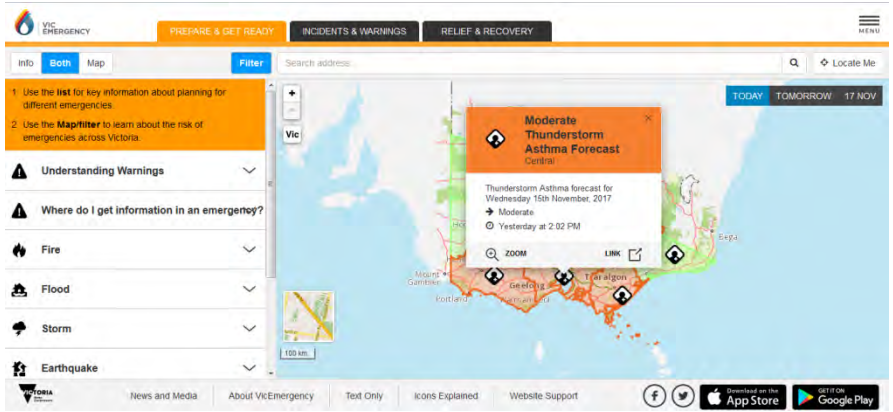
Thunderstorm asthma forecasting

Pilot services

- Enhanced pollen observations
- Forecasts to DHHS during Oct-Dec
- Issued to public via Vic Emergency



Research

- Improved thunderstorm forecasting
- Pollen observation and prediction
  - Vegetation state from satellite and "phenocam"
  - Statistical pollen forecasting
  - Pollen emissions, transport & dispersion modelling
  - Pollen size distribution

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Toward more people-centred warnings

1. Severe thunderstorms are expected with wind gusts exceeding 90 km/h.	Weather forecast and warning (**Hazard only)**
2. Severe thunderstorms with gusts over 90 km/h will result in damage to trees and power lines.	Impact-based forecast and warning (**Hazard and Vulnerability**)
3. Extensive delays in Kensington may occur due to the risk of large trees downing power lines and blocking roads as a result of thunderstorms.	Impact forecasts and warnings (**Hazard, Vulnerability and Exposure**)

Not just what the weather might be, but ***what the weather might do and how that might affect you.***

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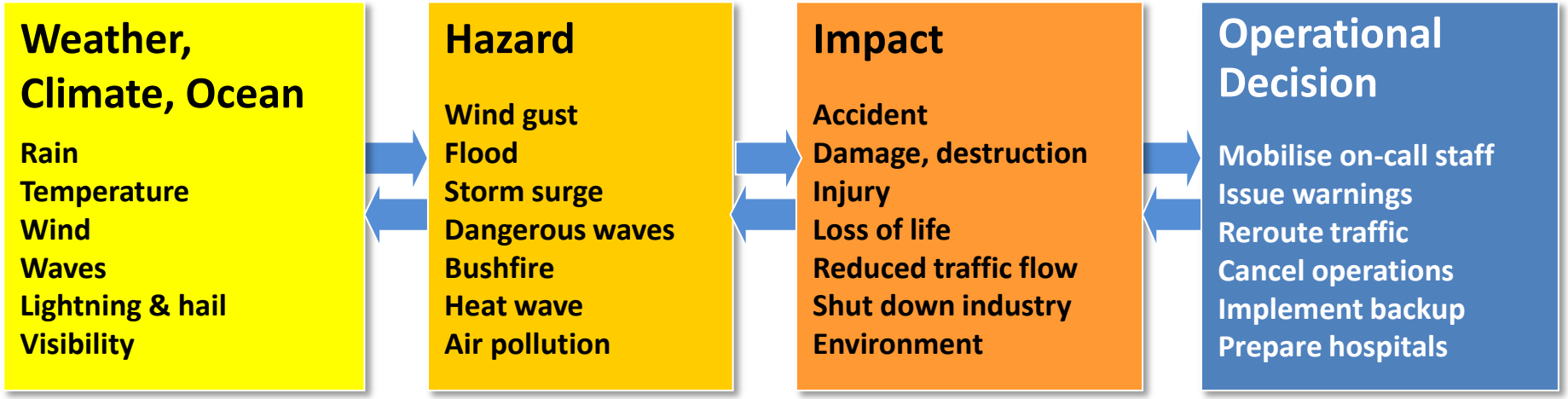
Predicting impacts

Coupling weather information to hazard and impact models

- Bushfire, flood, inundation, air pollution, etc.
- Structural damage, economic loss, public health, etc.



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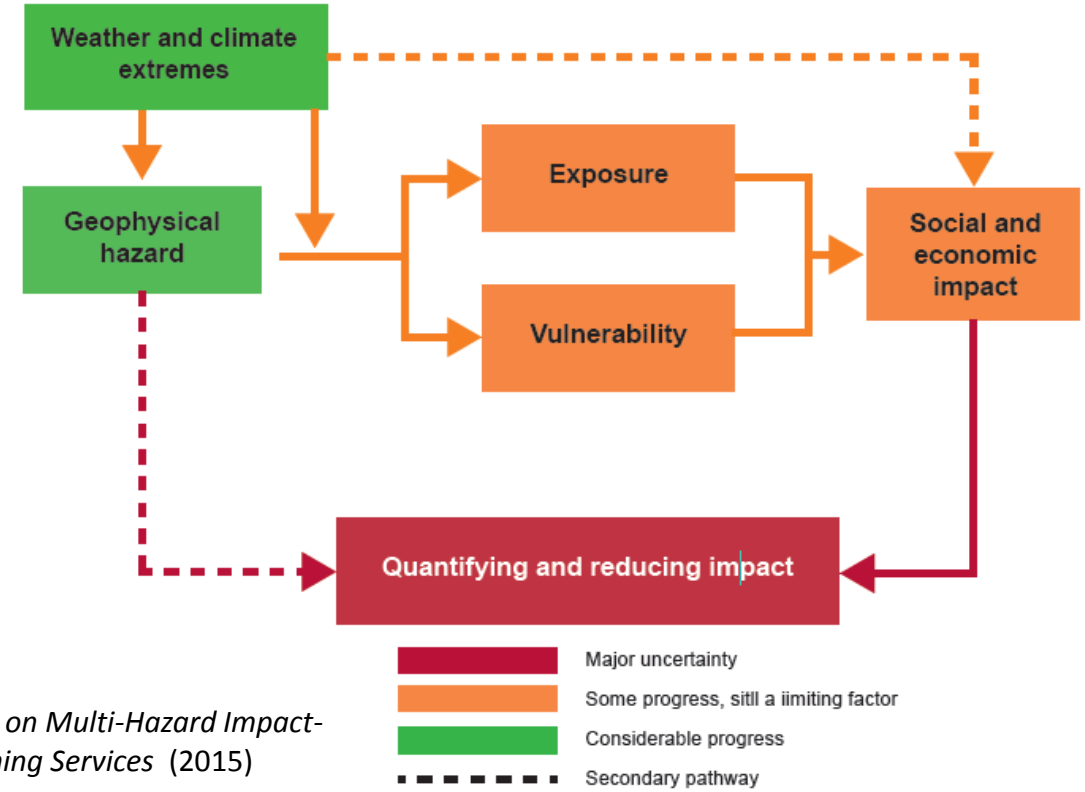
Key elements of an impact forecast system

Ensembles and/or probabilities are best!



Source: *WMO Guidelines on Multi-Hazard Impact-Based Forecast and Warning Services* (2015)

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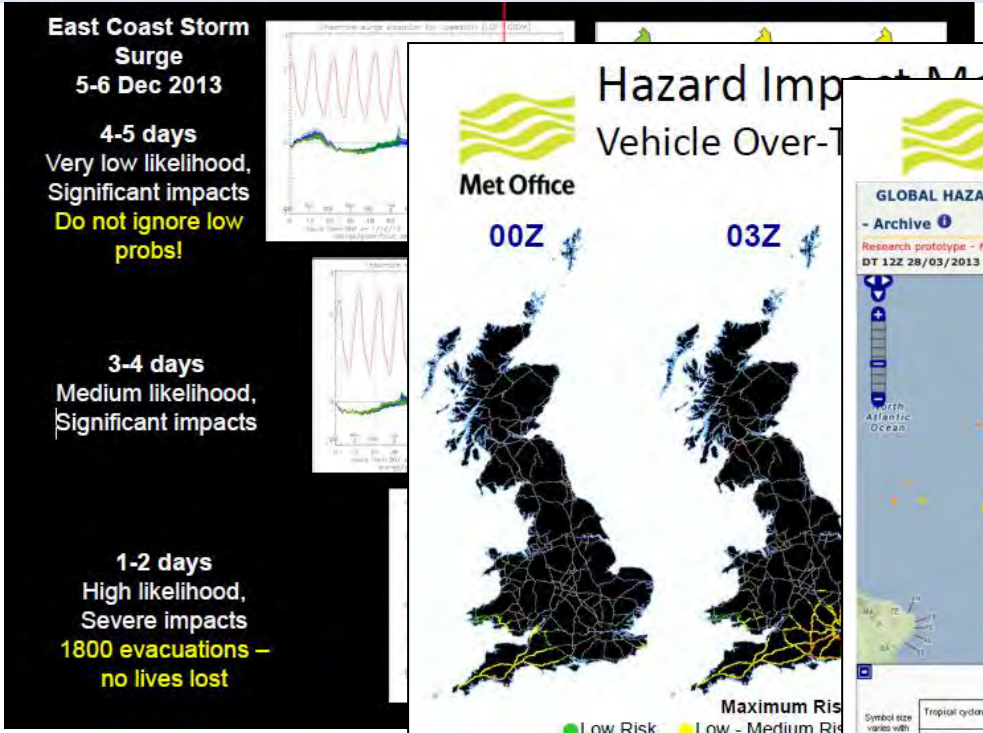
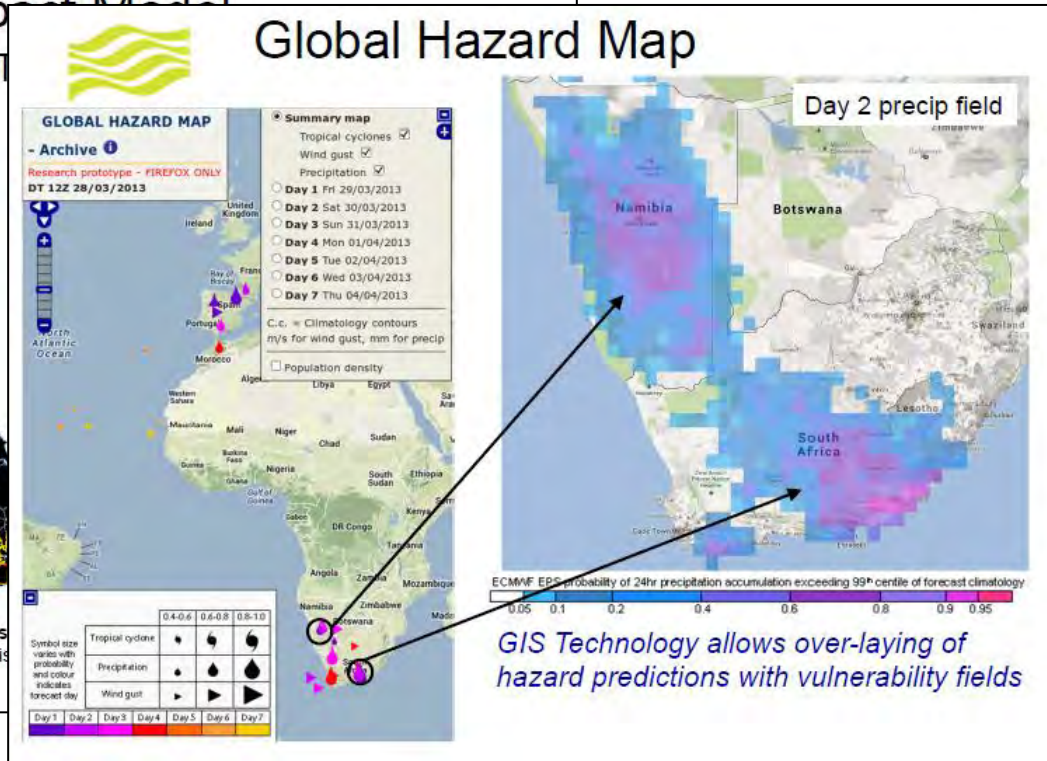
Impact prediction – UK examples





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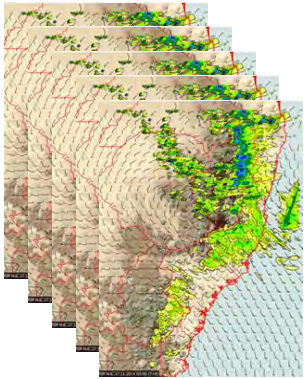
BOM & GA hazard impact forecast development (early days!)



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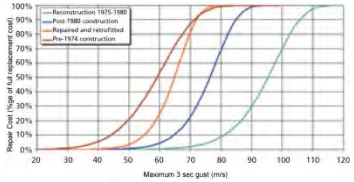

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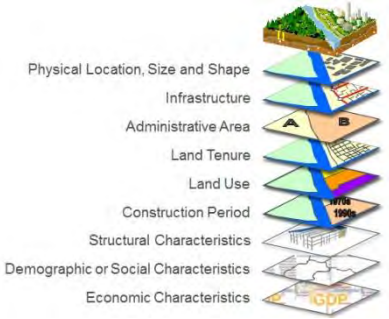

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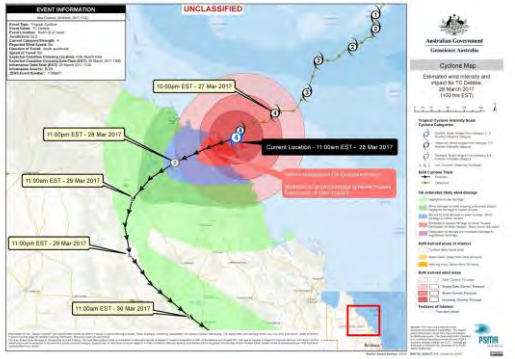

Hazard: Heavy rain and strong wind (gusts) from high-res ensemble NWP

Vulnerability: Relationship between wind gusts and building damage

Exposure: NEXIS National Exposure Information System

Hazard impact risk forecast (spatial, probabilistic)

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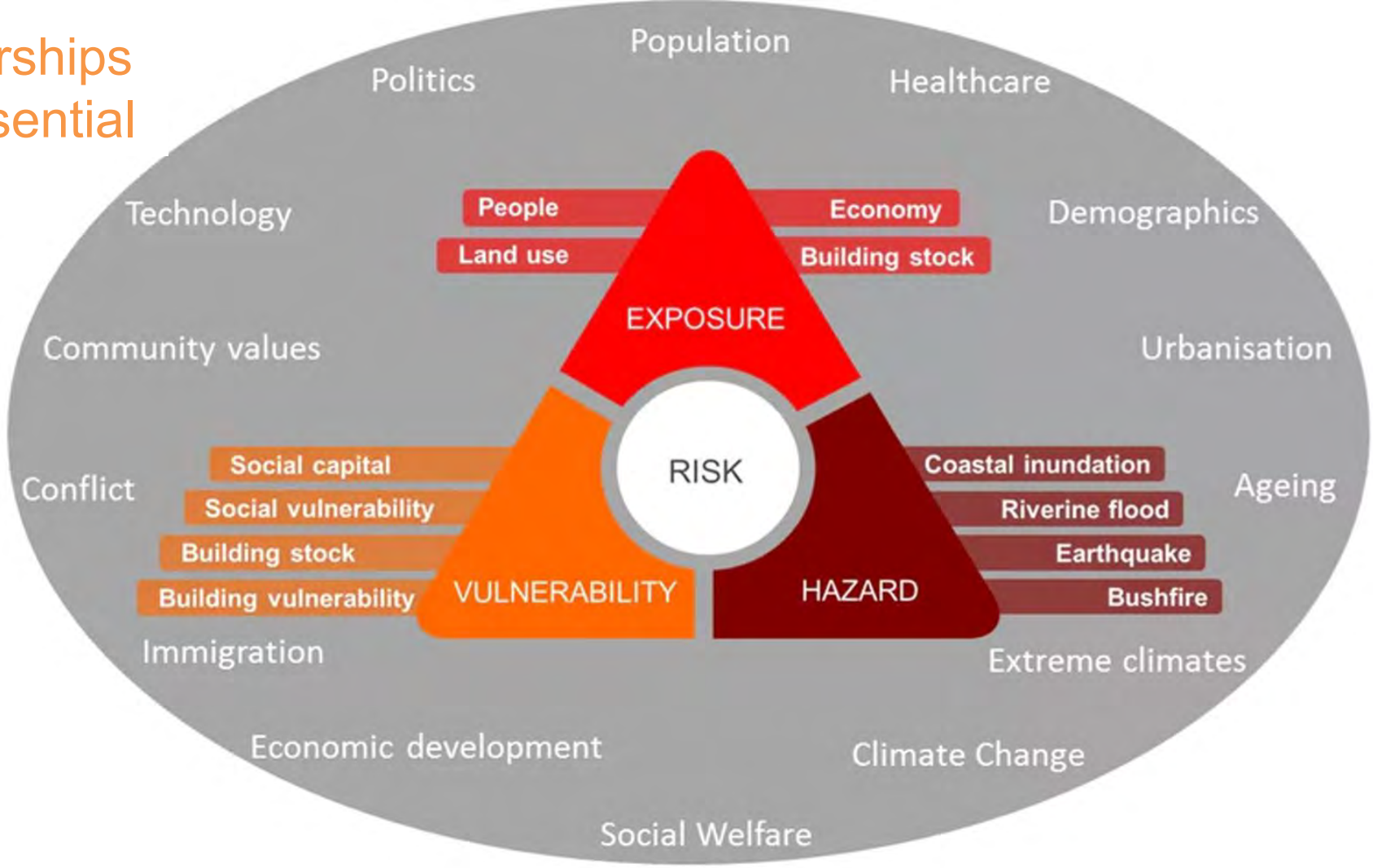
Impact modelling challenges

- Diversity of impacts and vulnerabilities
- Poorly understood mechanisms
- Coupling with social sciences
- Lack of consistent observations
- Rare events
- Inconsistent reporting
- …poor data for calibration, training, verification
- Shortage of vulnerability datasets

Partnerships are essential



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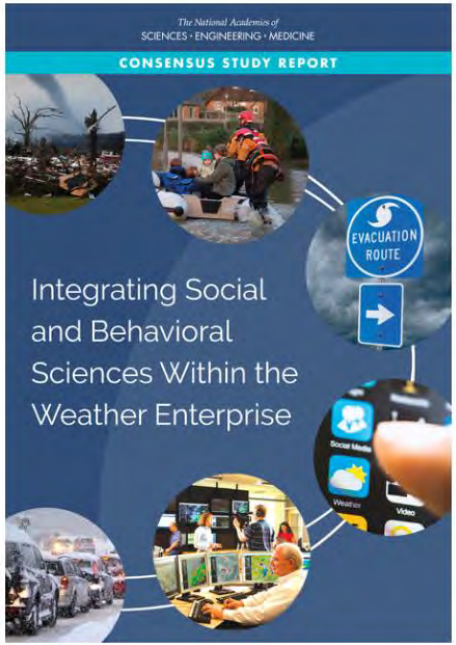
Australian high impact weather partnerships

- Bureau of Meteorology
- State and Commonwealth Governments
- World Meteorological Organization
- Universities
- National research organisations (CSIRO, GA, NCI, ...)
- Bushfire & Natural Hazards CRC
- Agency and industry users (fire, health, energy, …)
- Technology industry (e.g. IBM) for additional capability

Work in Progress

Integrating social science within weather agencies



Disaster risk knowledge

Detection, monitoring, analysis and forecasting of the hazards and possible consequences

Warning dissemination and communication

Preparedness and response capabilities

Four elements of end to end, people-centred multi-hazard early warning system: MHEW WMO 2018

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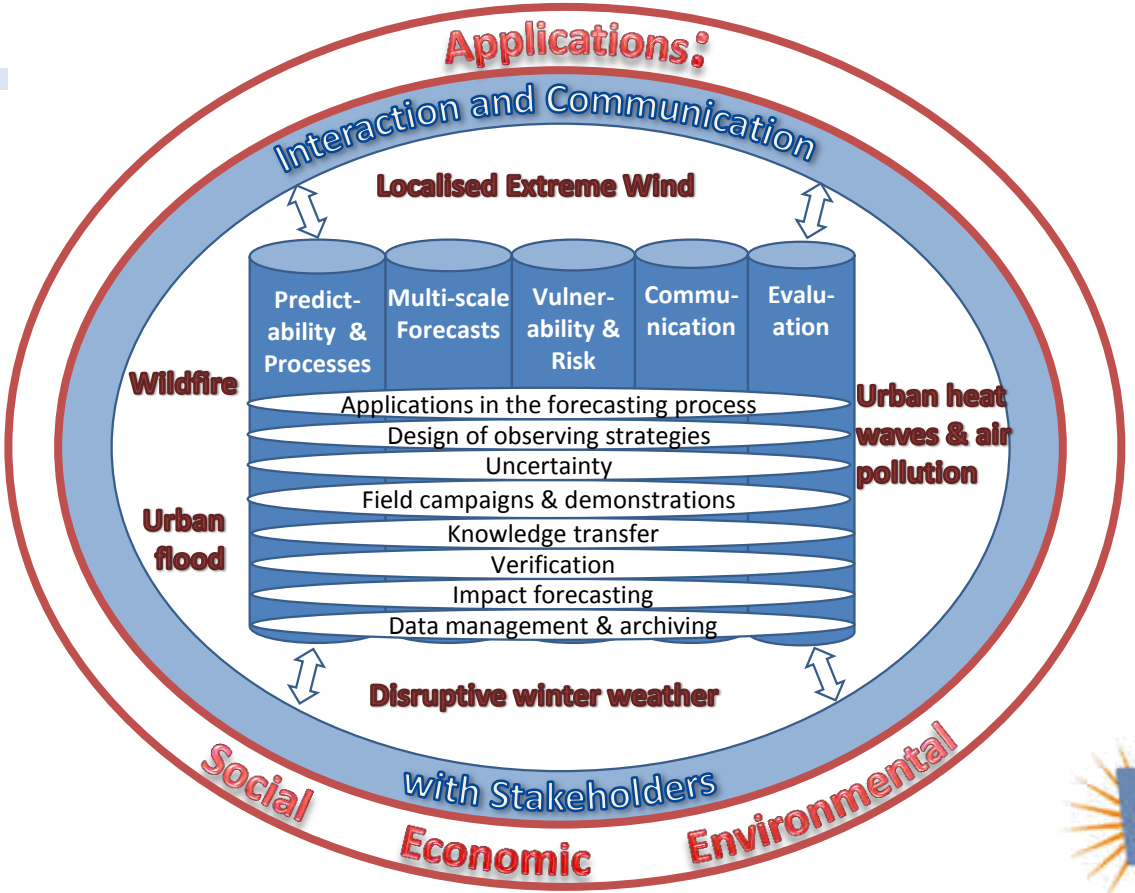
High Impact Weather (HIWeather) project



WWRP
WORLD WEATHER RESEARCH PROGRAMME

Australian Government
Bureau of Meteorology

Australian Meteorological & Oceanographic Society

AMOS Workshop on High Impact Weather Predictability and Processes

1:00 pm – 5:30 pm, Tuesday 10 July 2018

University of Melbourne, McCoy Building (Earth Sciences)

253-275 Elgin Street, CARLTON, VIC 3053