

On the use of radar rainfall estimates and nowcasts in an operational heavy rainfall warning service



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Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

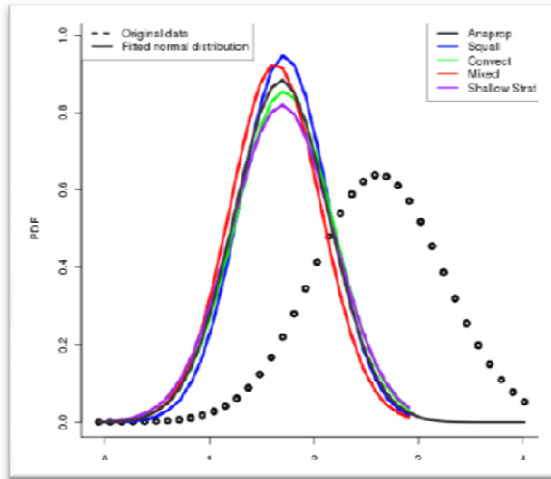


Outline

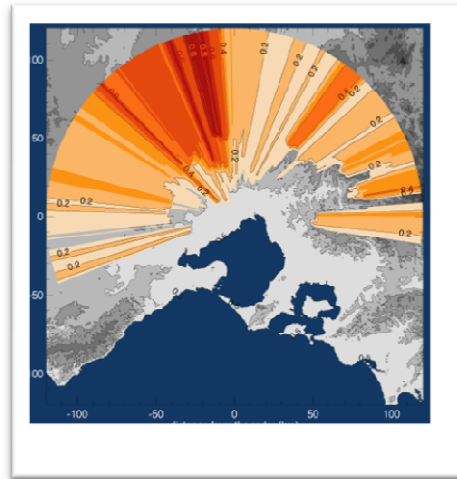


- Radar rainfall and nowcasting systems used
- Heavy Rainfall Warning service
- Making the guidance products

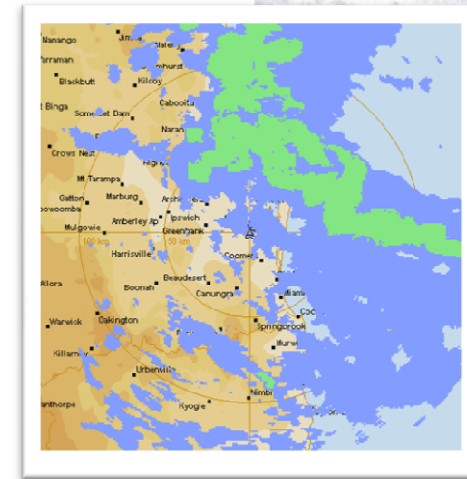
The QPE system - rainfields



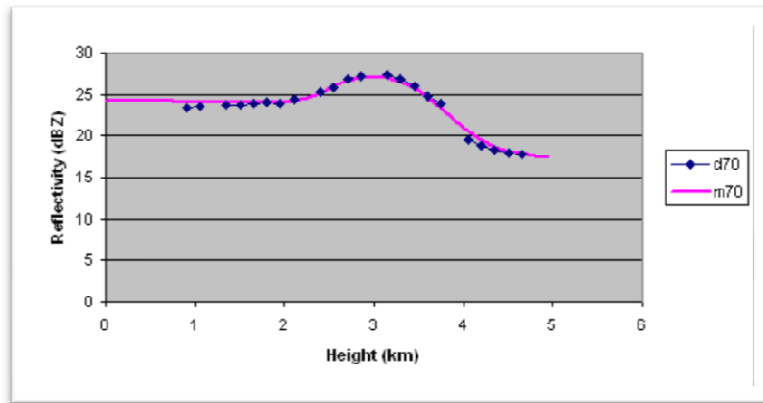
Bayesian Clutter



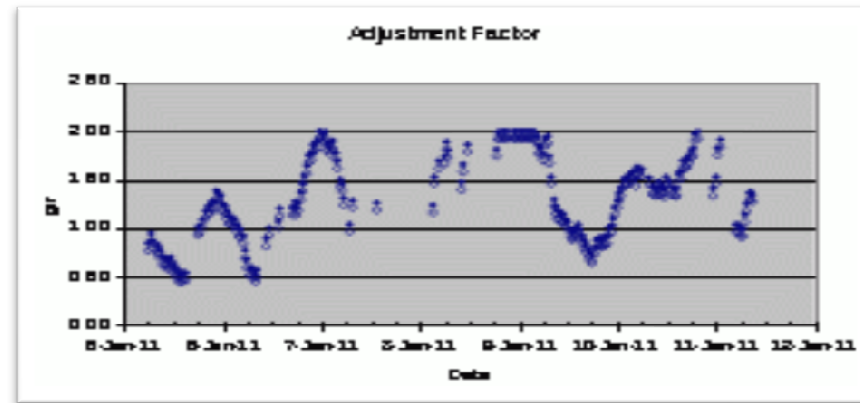
Partial Occultation



Convective/Stratiform ZR

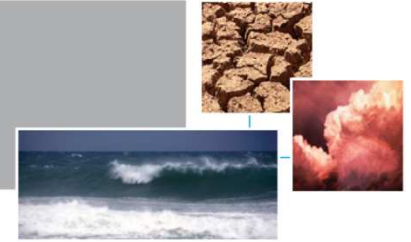


Vertical Profile



Real-time gauge adjustment

The nowcasting system -STEPS



Ensemble nowcasting system using **stochastic** models for

- Radar estimation error
- Advection error
- Development of the rainfall field during the forecast period
- Blending with NWP

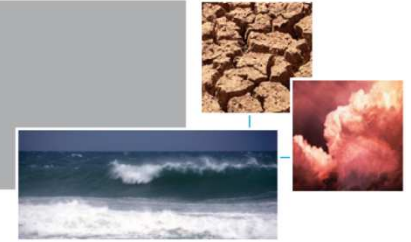
Small domain nowcasts

- 250 x 250 km area- 1 km, 6,10 min resolution
- 9 domains around Australia – single radars
- 40 member ensemble, updated every 6,10 minutes, 2 hour lead time

Large domain nowcasts with NWP blending

- 500 x 500 km area- 2 km, 10 min resolution – radar mosaic
- 3 domains (Melbourne, Sydney, Brisbane)
- 40 member ensemble, updated every 10 minutes, 6 hour lead time

The Heavy Rainfall Warning service



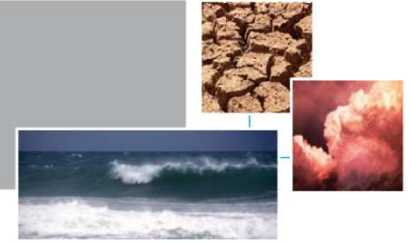
Text warning issued for heavy rainfall

- Australia is quite flat so flooding is slow
- Wide climate range so normalise heavy rainfall as a frequency
- Urban drainage designed for 1:10 year average recurrence interval (ARI)

Existing guidance is based only on rain gauges

A new set of guidance for the main cities is imminent

Removing the road blocks to adopting new products



Products are too complex

- Worked from service requirements to product specification
- Summarised the large number of products efficiently
- Senior Forecasters trialled new products in a series of workshops using case studies

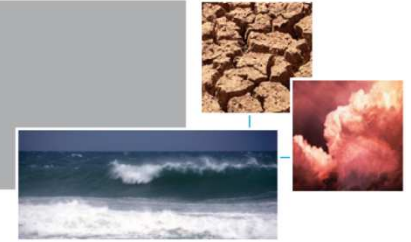
Products not integrated into the forecast system

- Modified the visualisation software to view new fields
- Generated properly geo-referenced netCDF files for all products

Forecaster training

- Generated case studies for each Regional Forecast Office
- Developed a simulator so case studies could be run as if in real time
- Prepared training material and published it on a number of platforms

Making the guidance



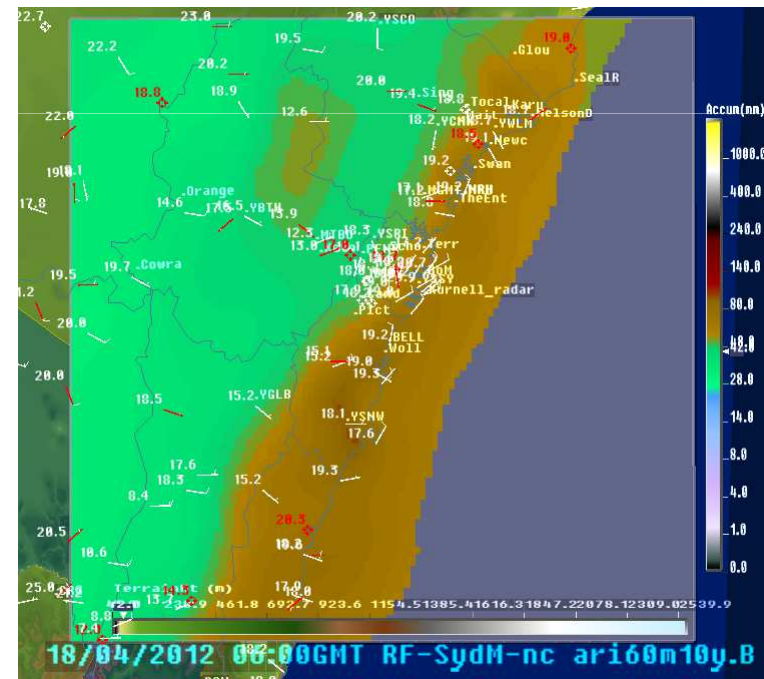
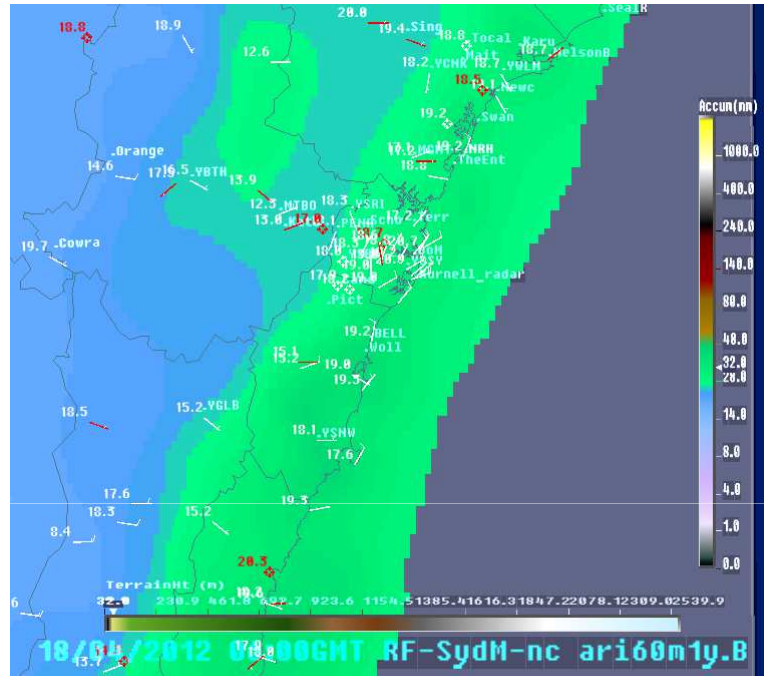
Convert rainfall depth into average recurrence intervals

- The Bureau publishes maps of ARI for a wide range of accumulation periods and frequencies which are used by Engineers Australia for their design standards
- ARI can vary over the area that is covered by a radar, especially in areas of orographic enhancement and rain shadow
- At each pixel calculate the recurrence interval using linear interpolation between maps of ARI (0.5, 1, 2, 5, 10, 20, 50, 100 years)
- Do this for 0.5, 1, 2, 3, 6 hour accumulations
- Update every 6, 10 minutes

Calculate the maximum recurrence interval to be found over the 0.5 to 6 hour accumulation periods

Calculate the probability that the recurrence interval will exceed 1:10 years during the forecast lead time

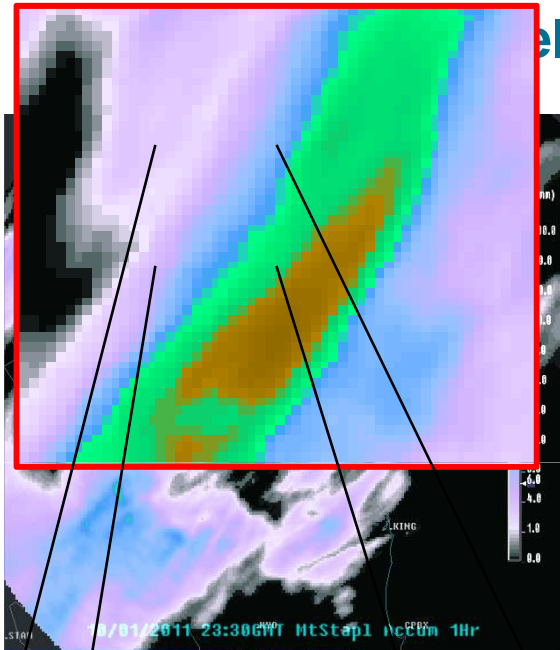
Spatial distribution of 1:1 yr and 1:10 yr ARI hourly rainfall over Sydney



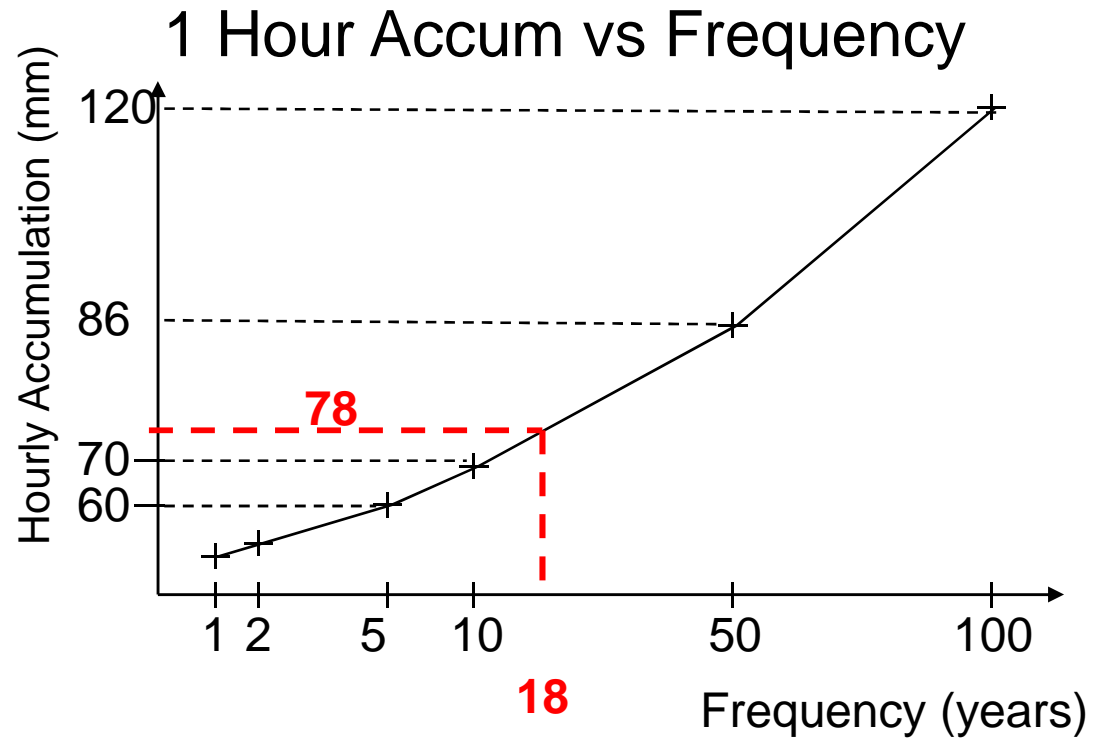
Convert depth into recurrence interval



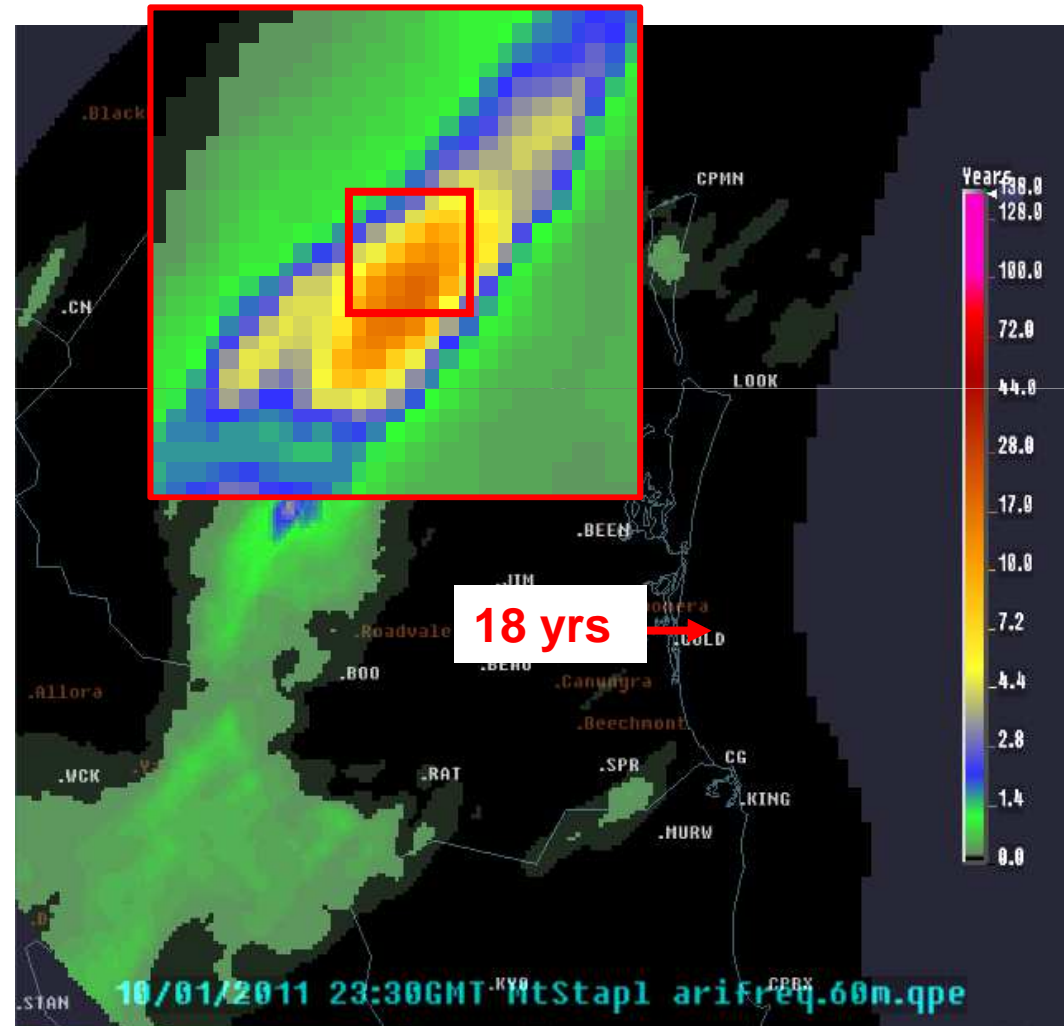
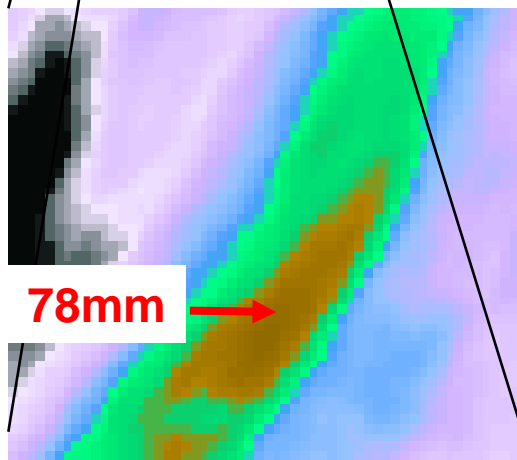
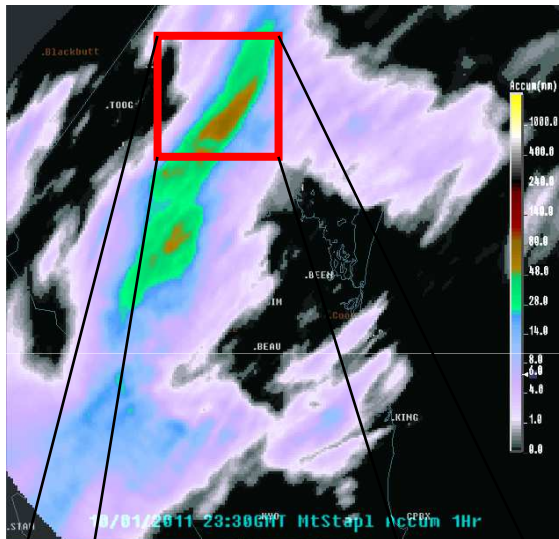
Model in the field:



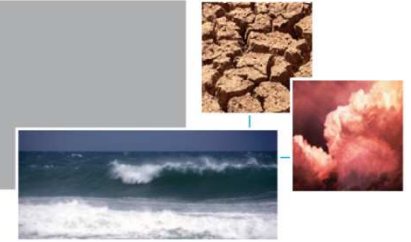
78mm →



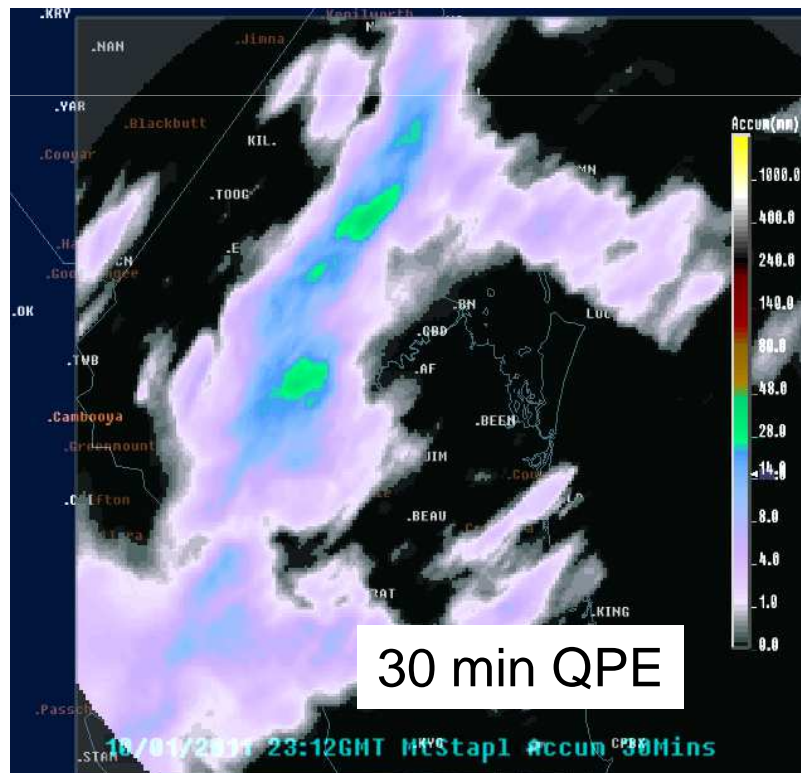
Convert rain depth into recurrence interval



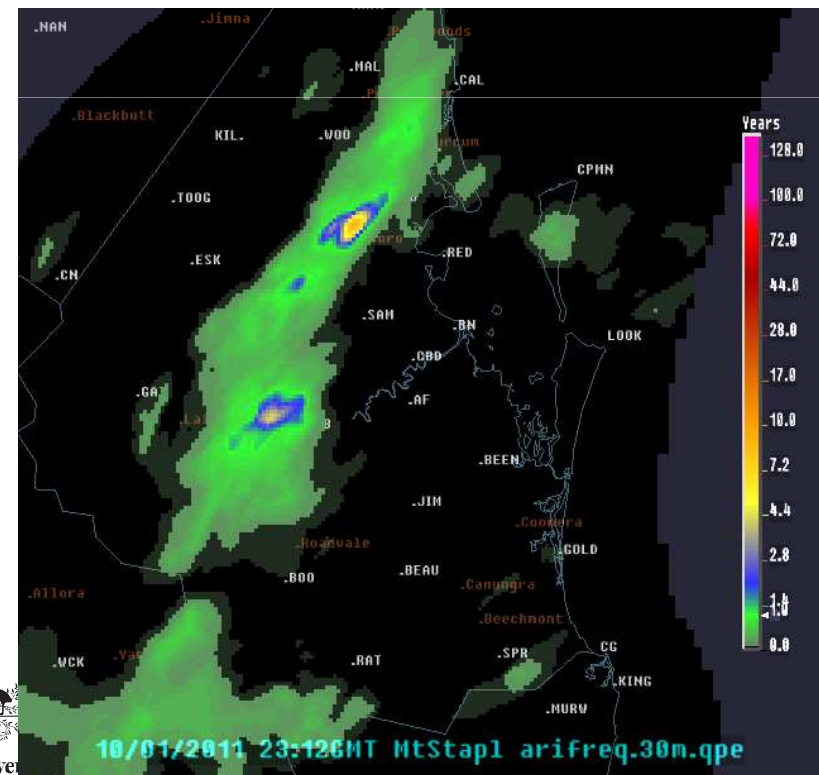
Combine forecast and observed rainfall



Observed rainfall over the last 30 minutes

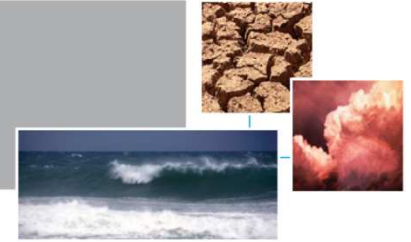


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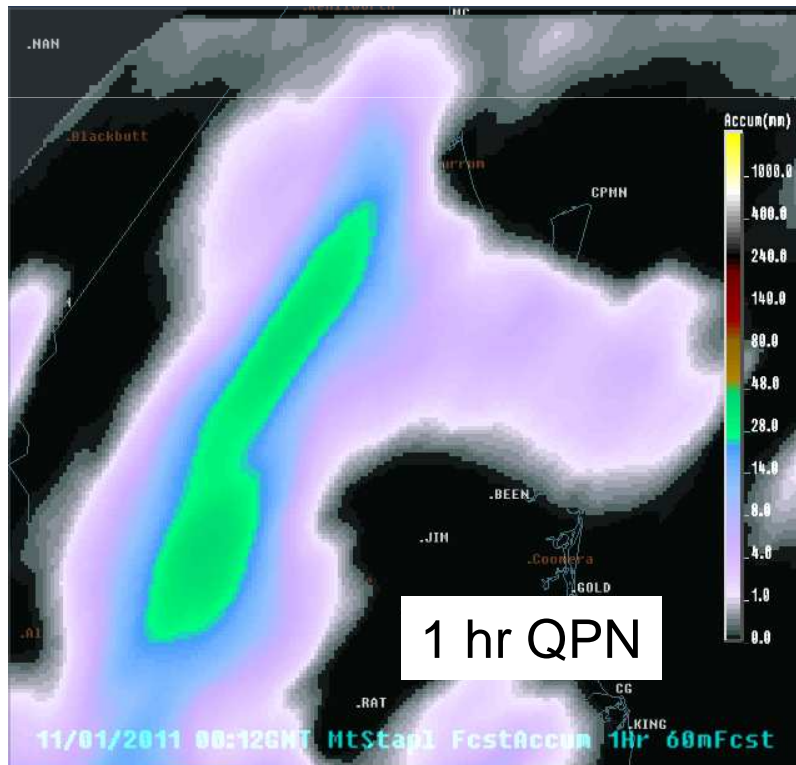


CSIRO

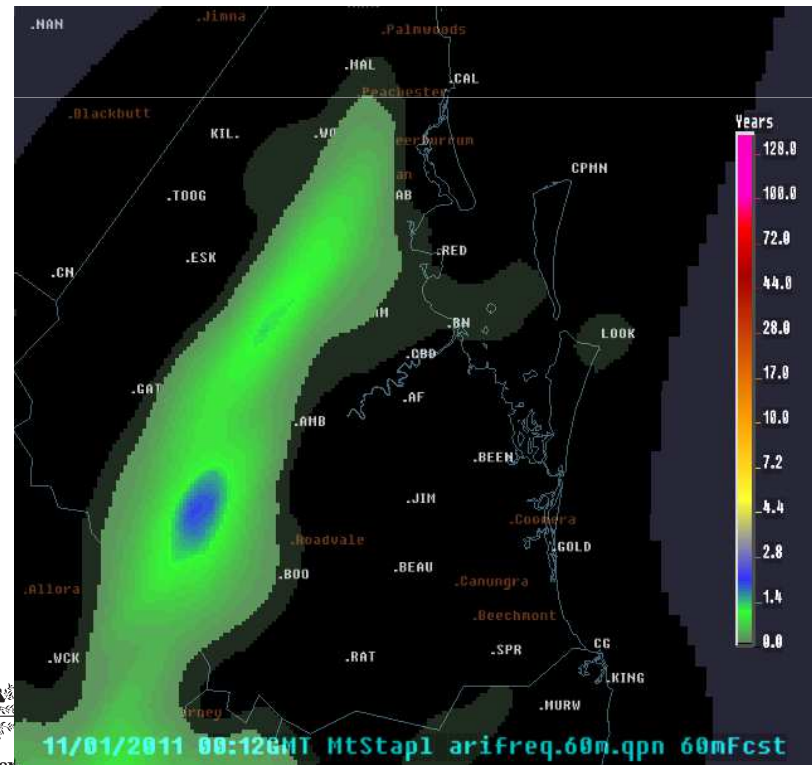
Combining forecast and observed rainfall



Ensemble mean accumulation – the "quantitative" forecast

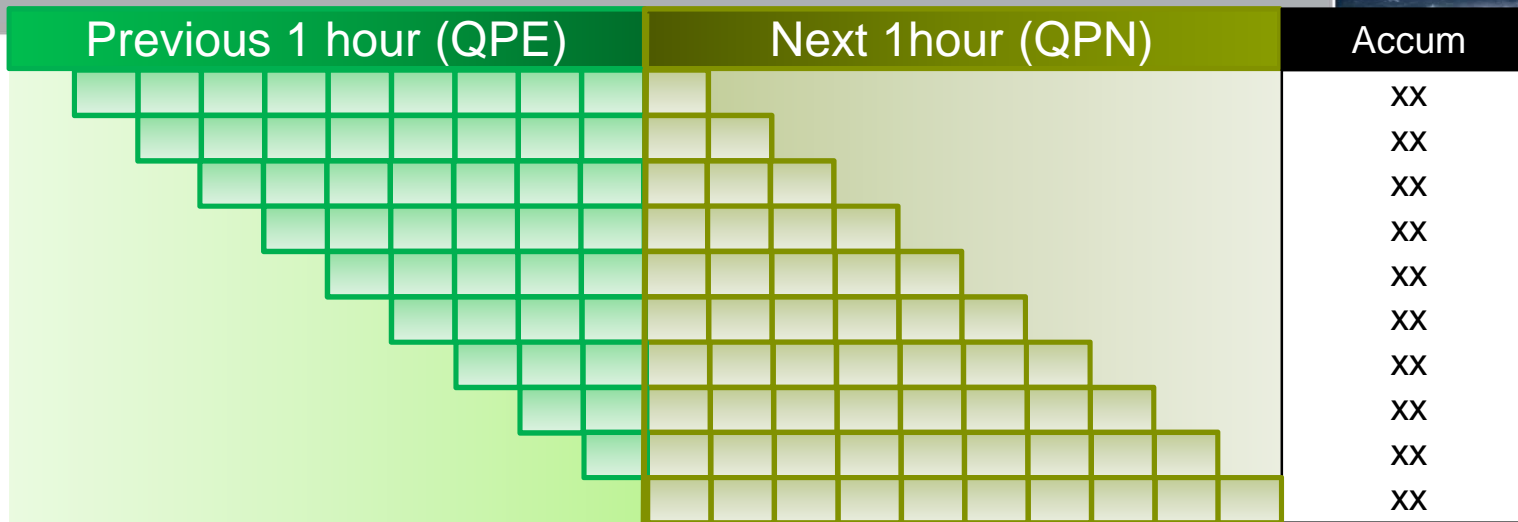


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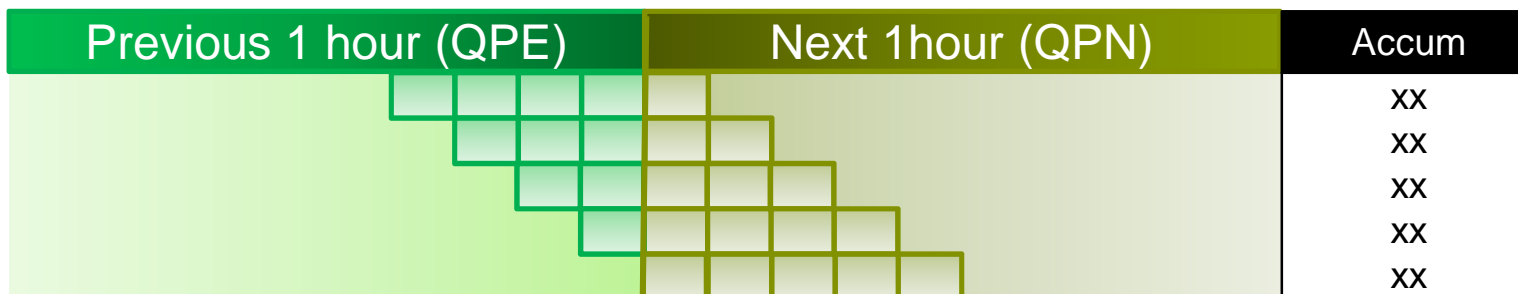


CSIRO

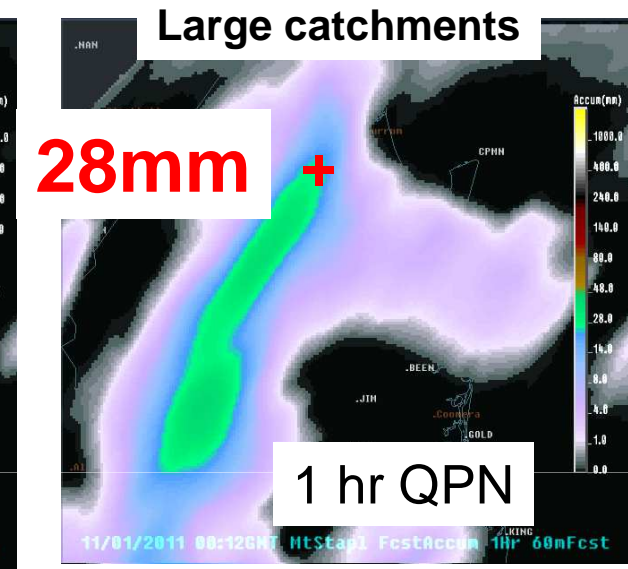
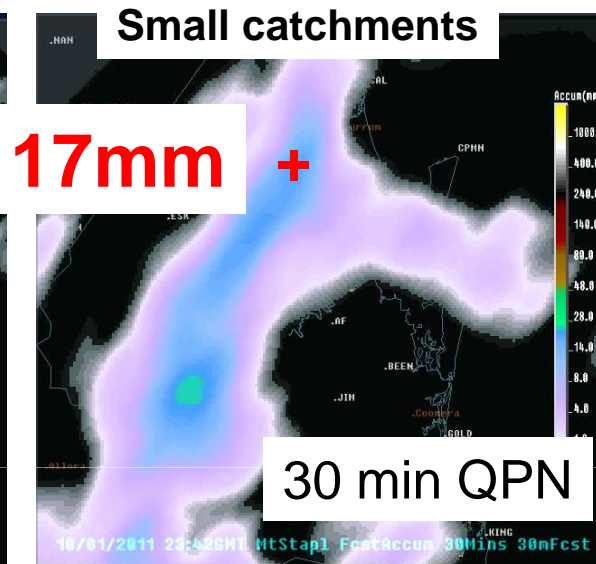
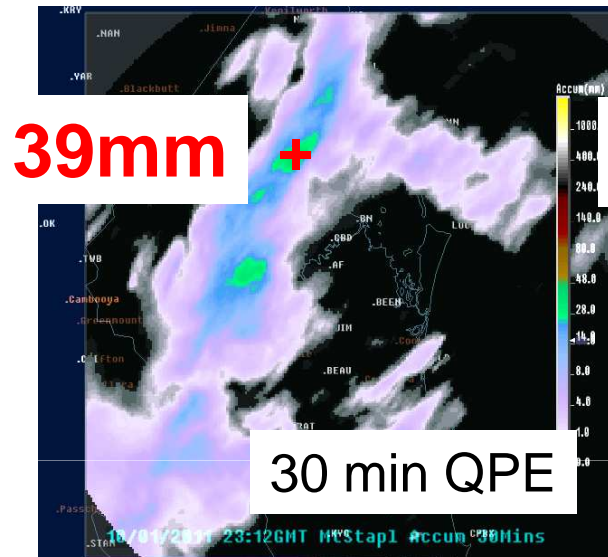
Combine estimated and nowcast rainfall



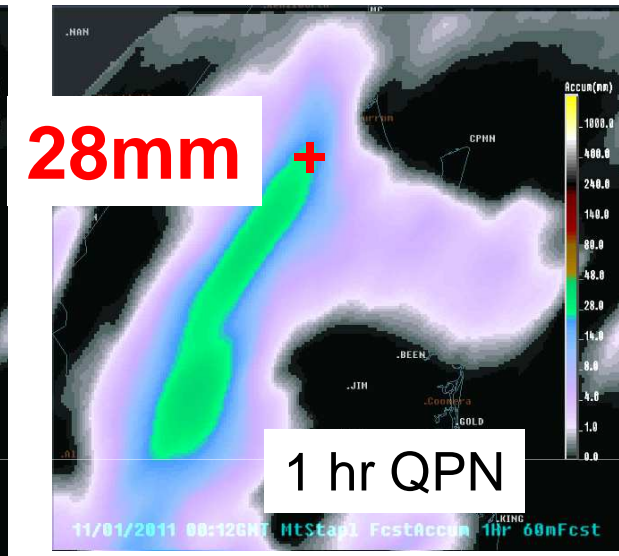
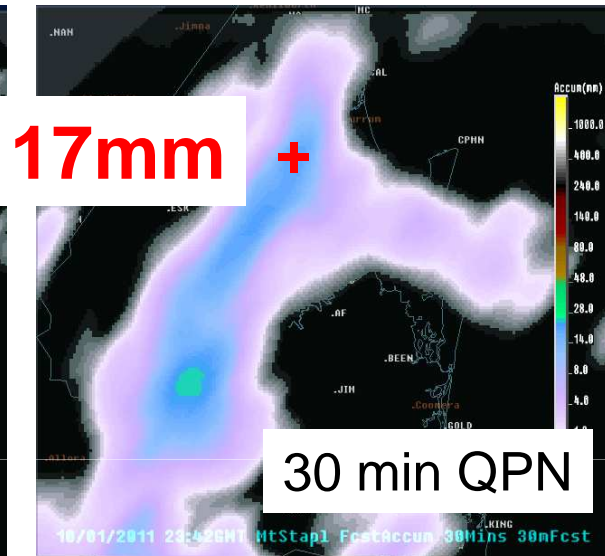
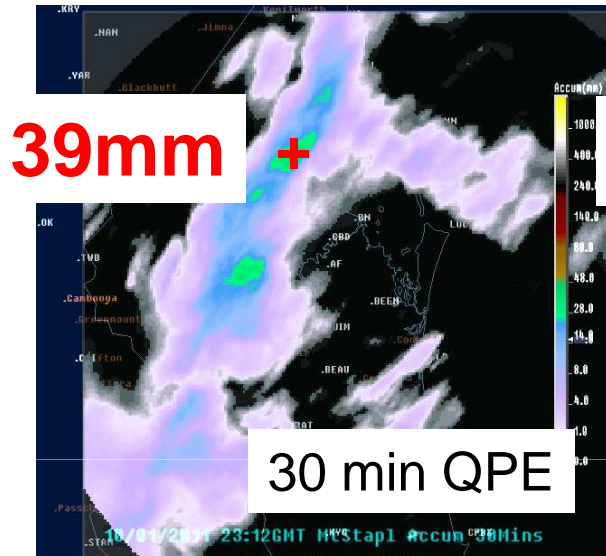
And for 30 minute accumulations



Calculate the max recurrence interval for all combinations of QPE & N



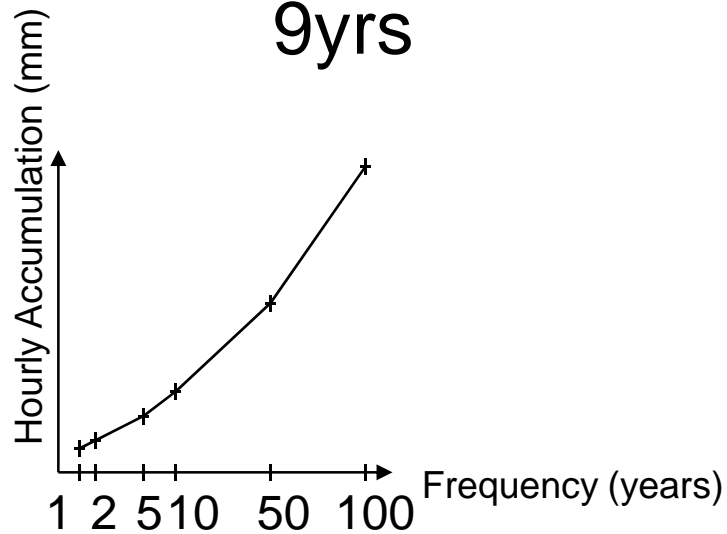
Calculate the max recurrence interval for all combinations of QPE & N



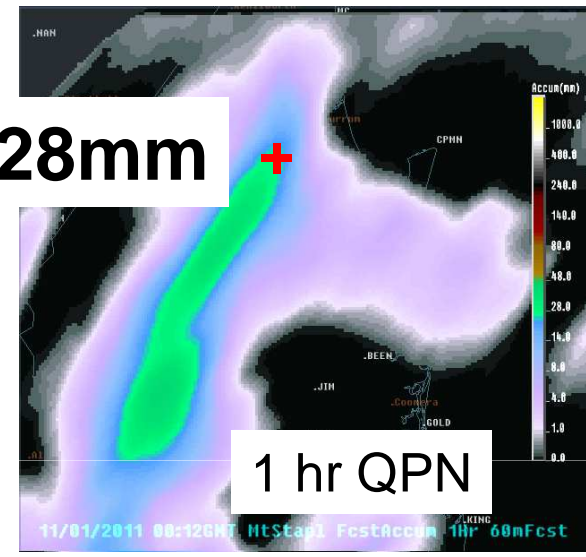
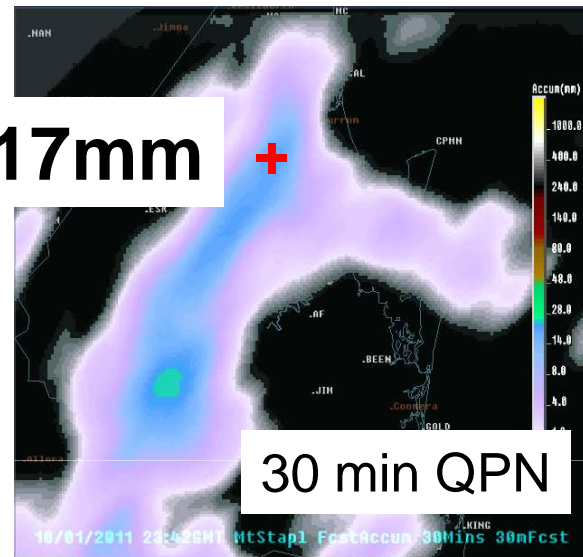
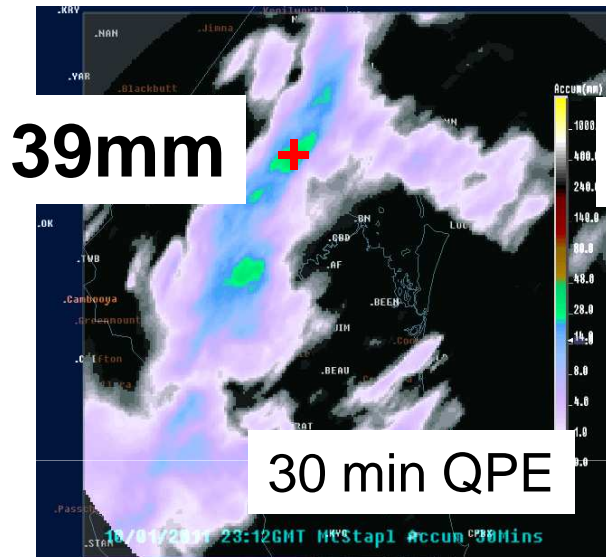
9yrs

1yr

1.9yrs



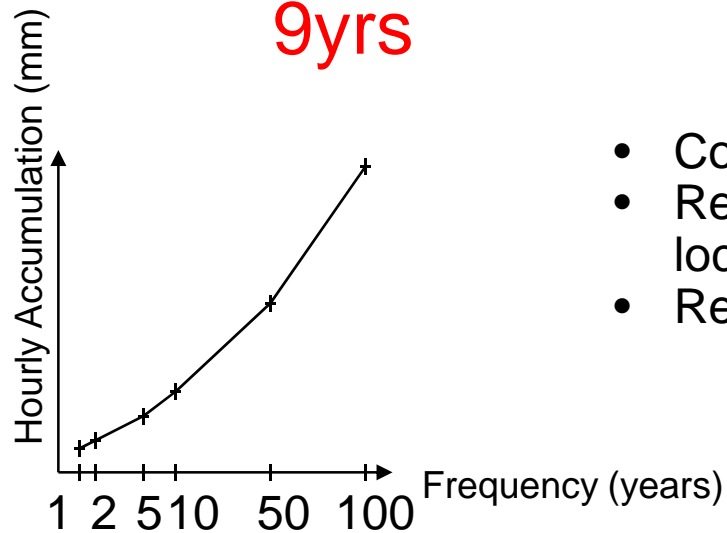
Calculate the max recurrence interval for all combinations of QPE & N



9yrs

1yr

1.9yrs



- Convert each accumulation to a recurrence interval (yrs)
- Record the maximum recurrence interval for that pixel location for all combinations
- Repeat for other pixel locations

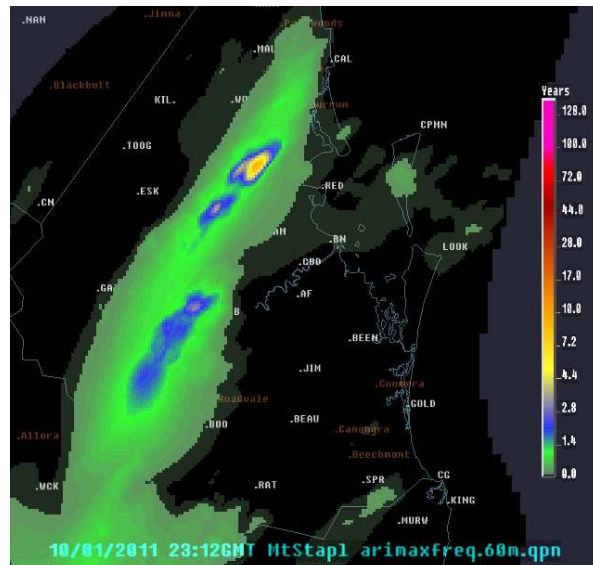
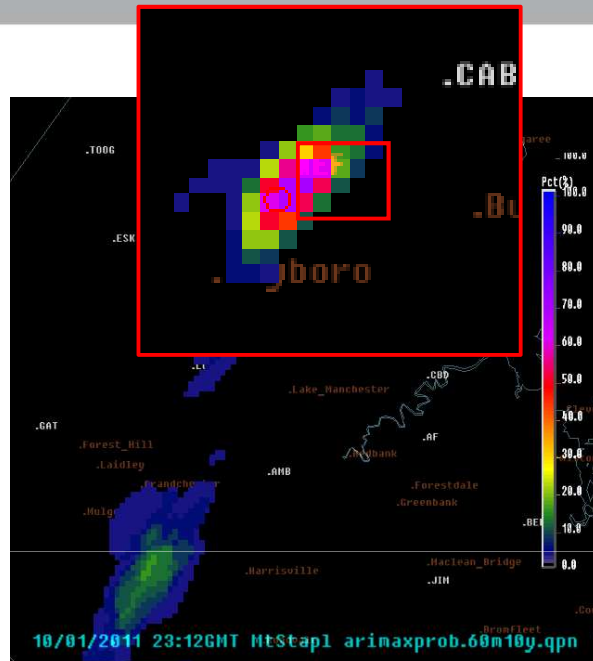
Use the ensemble to create probabilities

	Previous 1 hour (QPE)	Next 1 hour (QPN)	Accum	
1		60 min accumulation 40 ensemble members	XX	
2			XX	
3			XX	
4			XX	
5			XX	
6			XX	
7			XX	
8			XX	
.				
.				
.				
33			XX	
34			XX	
35			XX	
36			XX	
37			XX	
38			XX	
39			XX	
40			XX	

Probability of exceeding 1/X year Average Recurrence Interval = $\frac{\text{No. of ensemble members} > \text{threshold}}{\text{Total no. of ensemble members}}$

Determine for ARI = 1, 2, 5, 10, 50, 100 years

Benefits

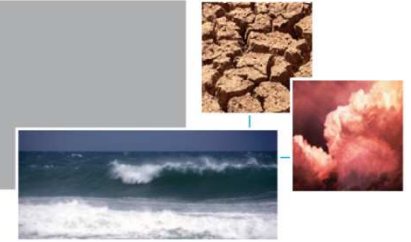


- Frequency close to a warning threshold in 2 areas...?

- May show one area more likely to occur

- Could provide some more lead-time than just the Frequency products

Thresholds to use for issuing a warning



Start Getting Nervous

- Frequency ≥ 10 %

Review all thresholds in time
with verification statistics

Warning!

Frequency ≥ 20 %

Rapid rate of change per
scan... warn earlier

Is it going to continue to
worse?

Area greater than 1 pixel



Conclusions



It is not enough to simply generate the quantitative precipitation forecasts and estimates and expect them be used operationally

Need to convert the products into something that delivers guidance for the operational service

- Products need to be relevant
- Integrated into the system that is used to generate the warning
- Forecasters need to be trained on how to use the new guidance

