

# EVIDENCE-BASED DECISION MAKING AT HEALTHY WATERS: RAINFALL FORECASTING SKILL ASSESSMENT FRAMEWORK

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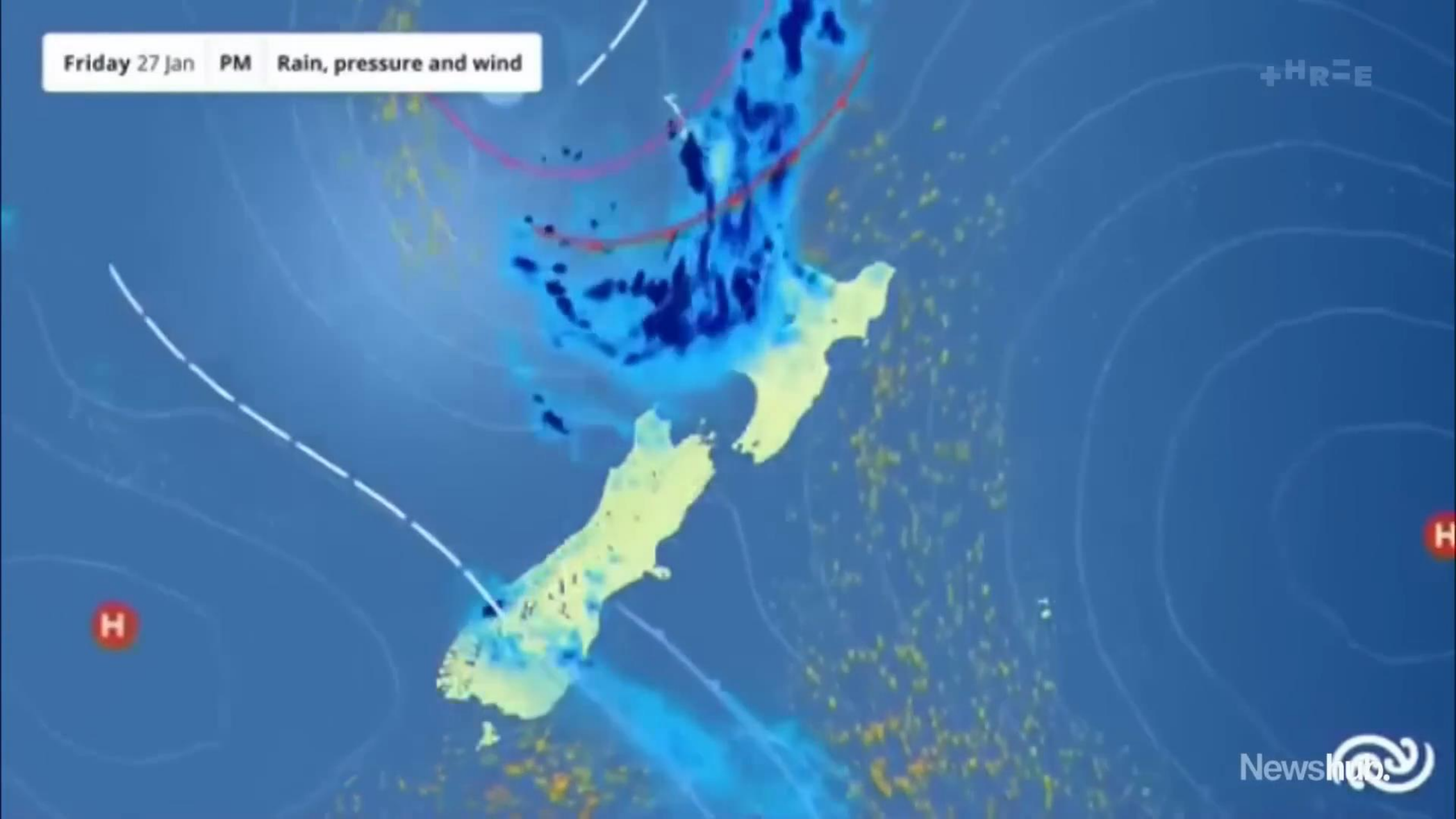
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May 2023



Friday 27 Jan PM Rain, pressure and wind

+HRE



## Motivation

**WEATHER DATA**

It's the core of everything we do

**EVIDENCE  
BASED  
DECISIONS**

1. Understanding currently available Weather Data
2. Understanding what this means for decision making

**OBSERVATIONS**

Measurements.

**FORECASTS**

Not Measurements.  
Models.



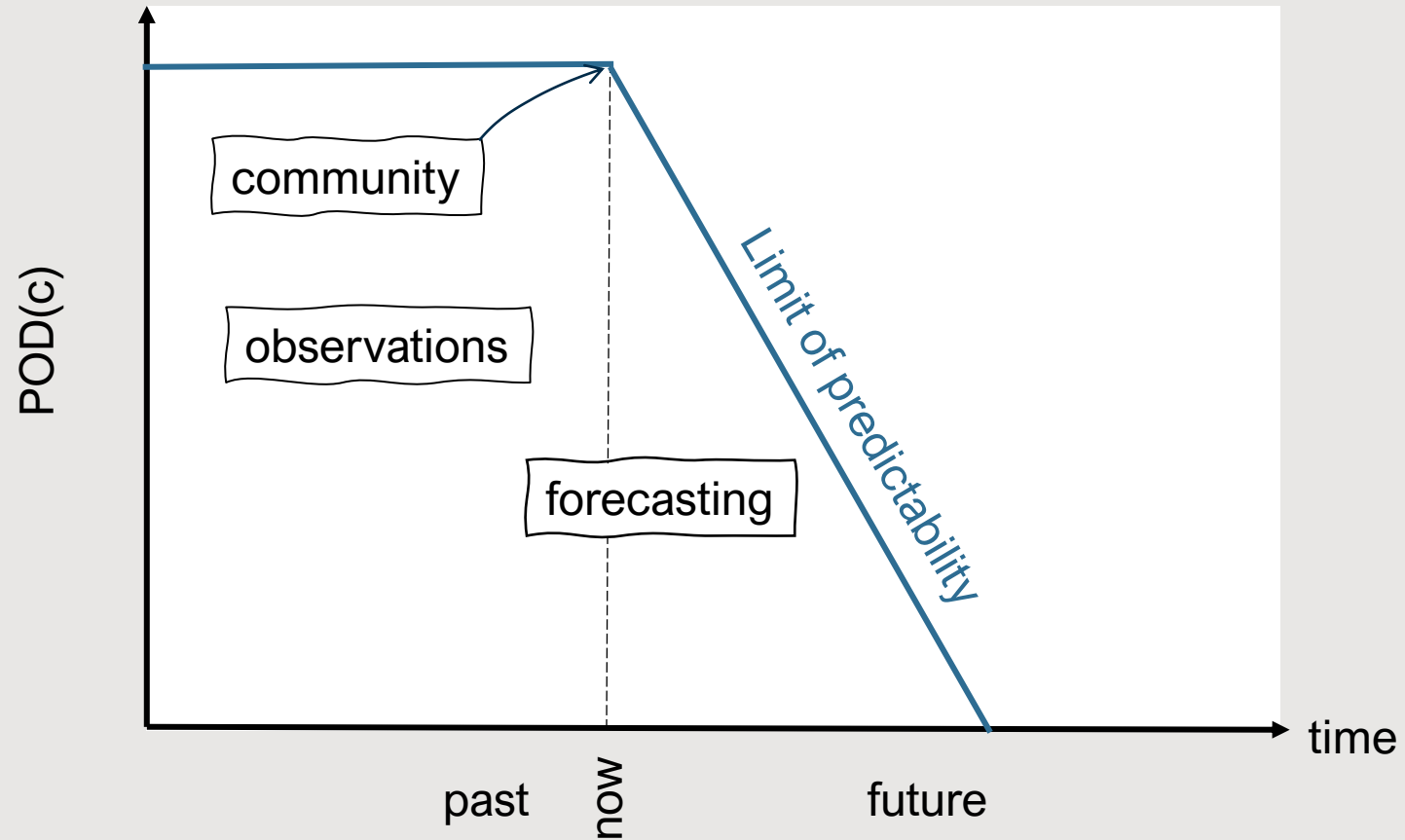
# DECISION MAKING PROCESSES



- What is “Weather Data”?
- Having decided what it is, how can we estimate our confidence in it?
- Can we make good, or better, decisions about managing risk, and about investments?



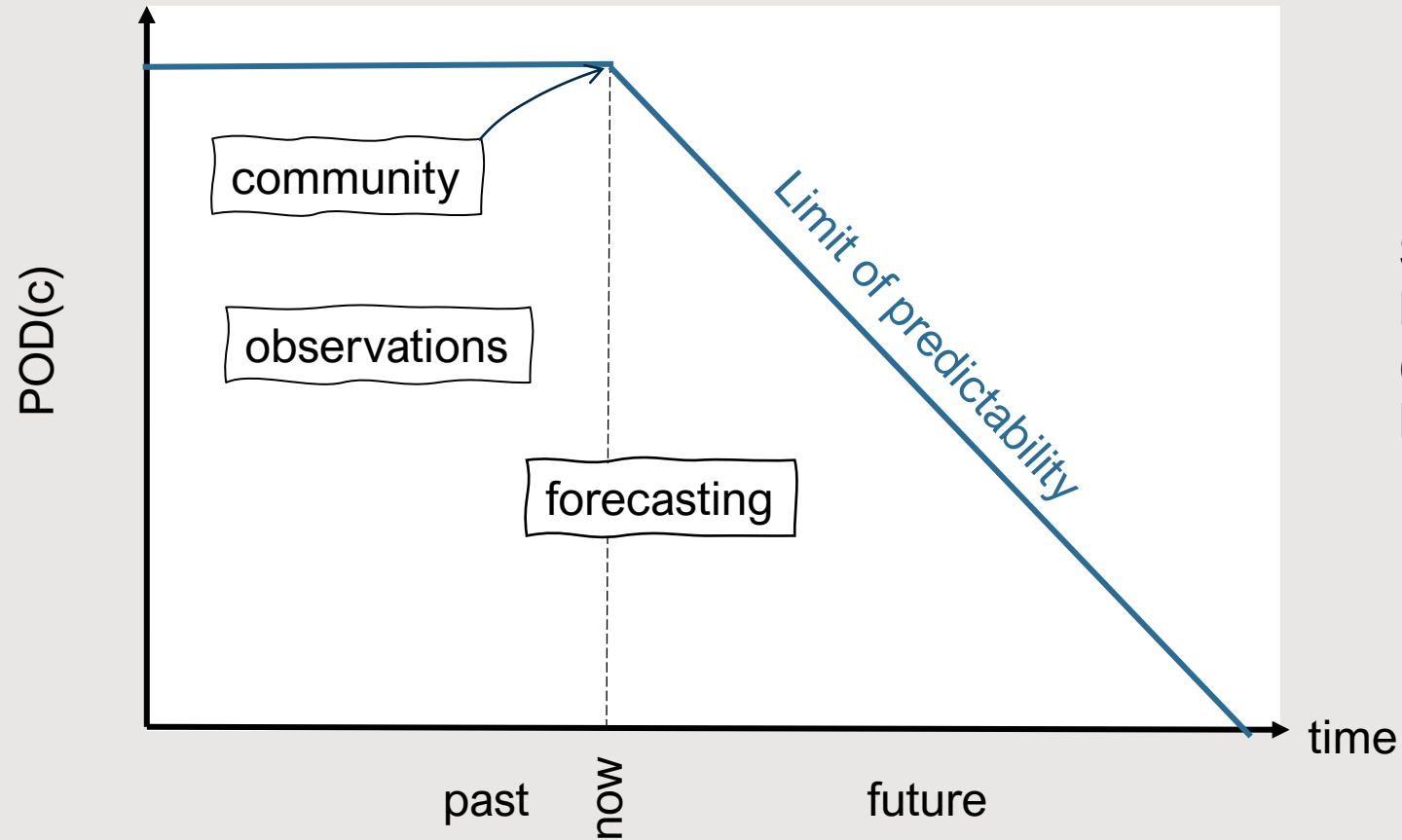
# Predictability of the Atmospheric State



after Austin et al 1987



# Predictability of the Atmospheric State

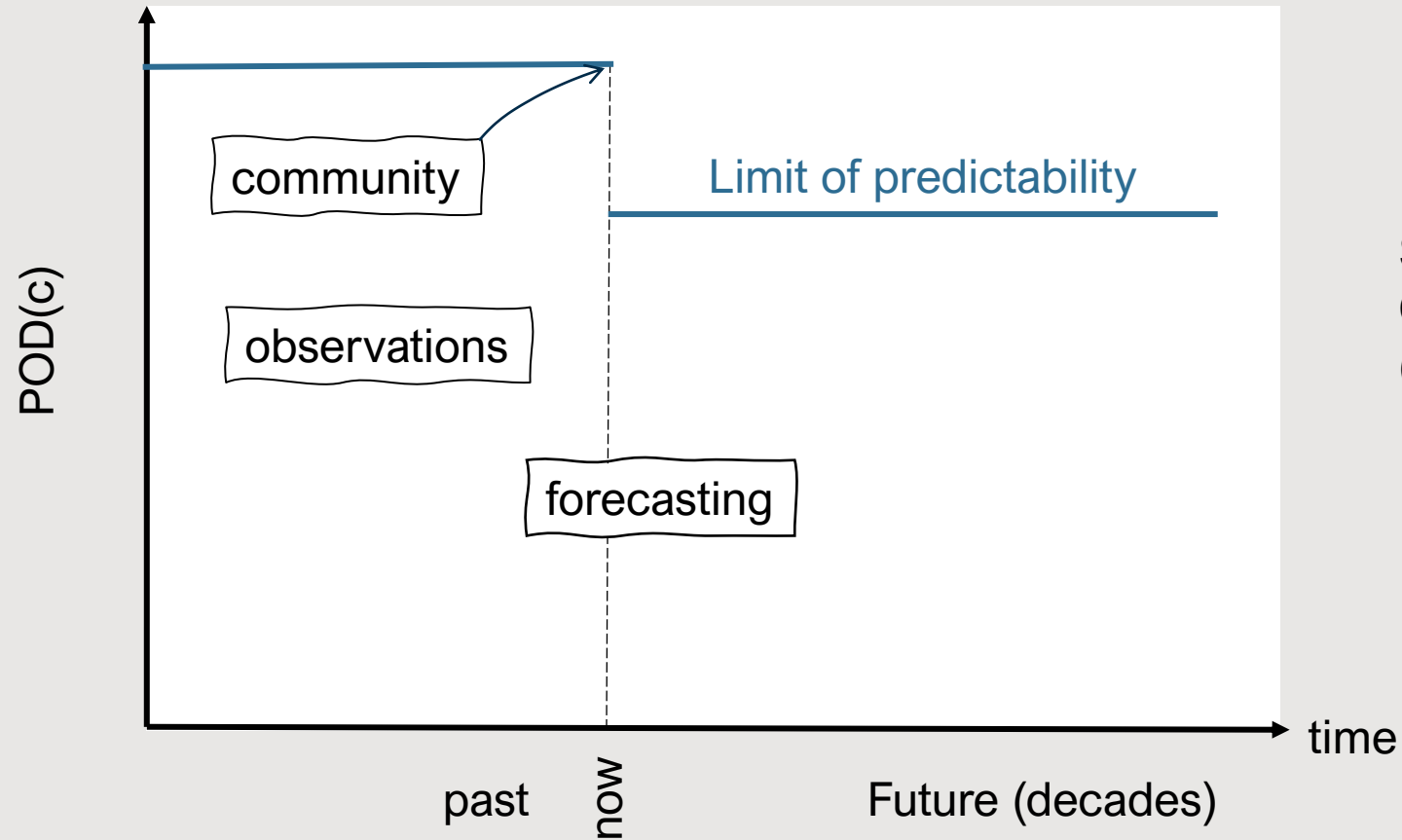


Solutions:  
Less precise language  
(timing, location, confidence)  
Larger Scales

after Austin et al 1987



# Predictability of the Atmospheric State



Solutions:  
Climate Scales  
(Planning Rules)

after Austin et al 1987





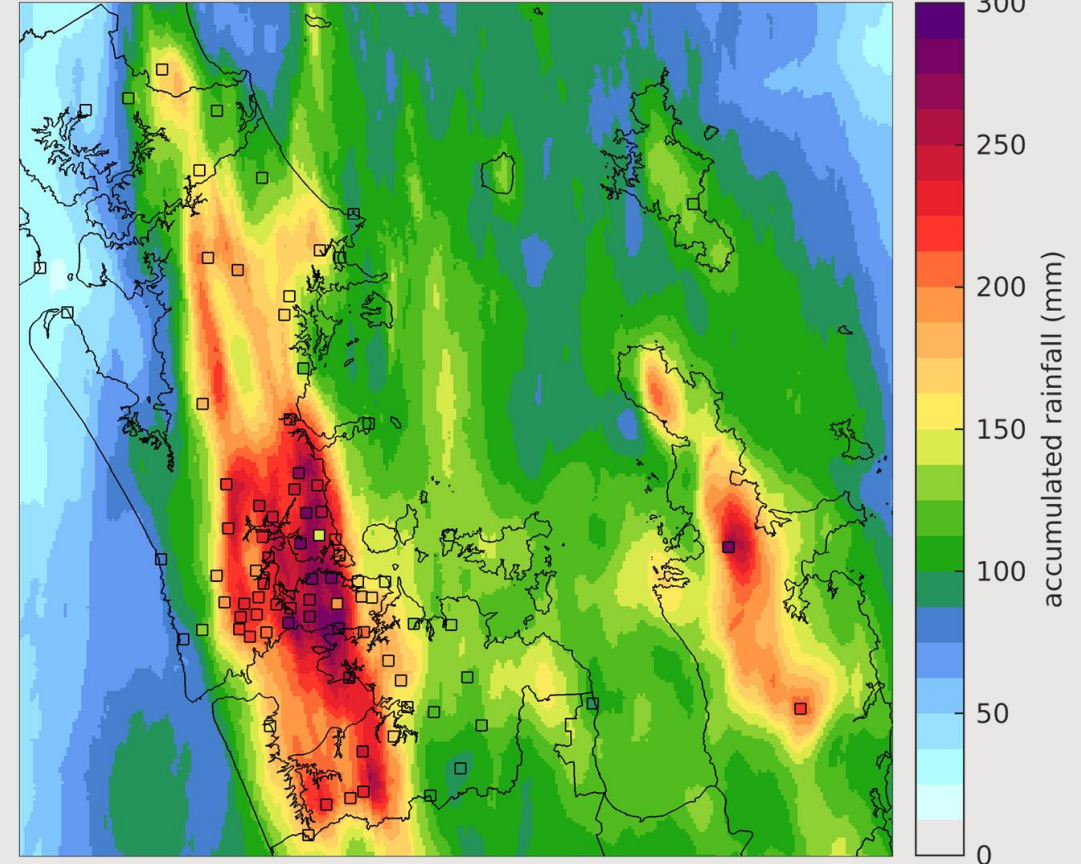
# Weather Data systems at Healthy Waters

## Observations (Now)



In-situ and remote instrument observations of rainfall (rain gauges, radar etc.)

Event total rainfall (2023/01/27 00:00 to 2023/01/28 00:00 (NZDT))



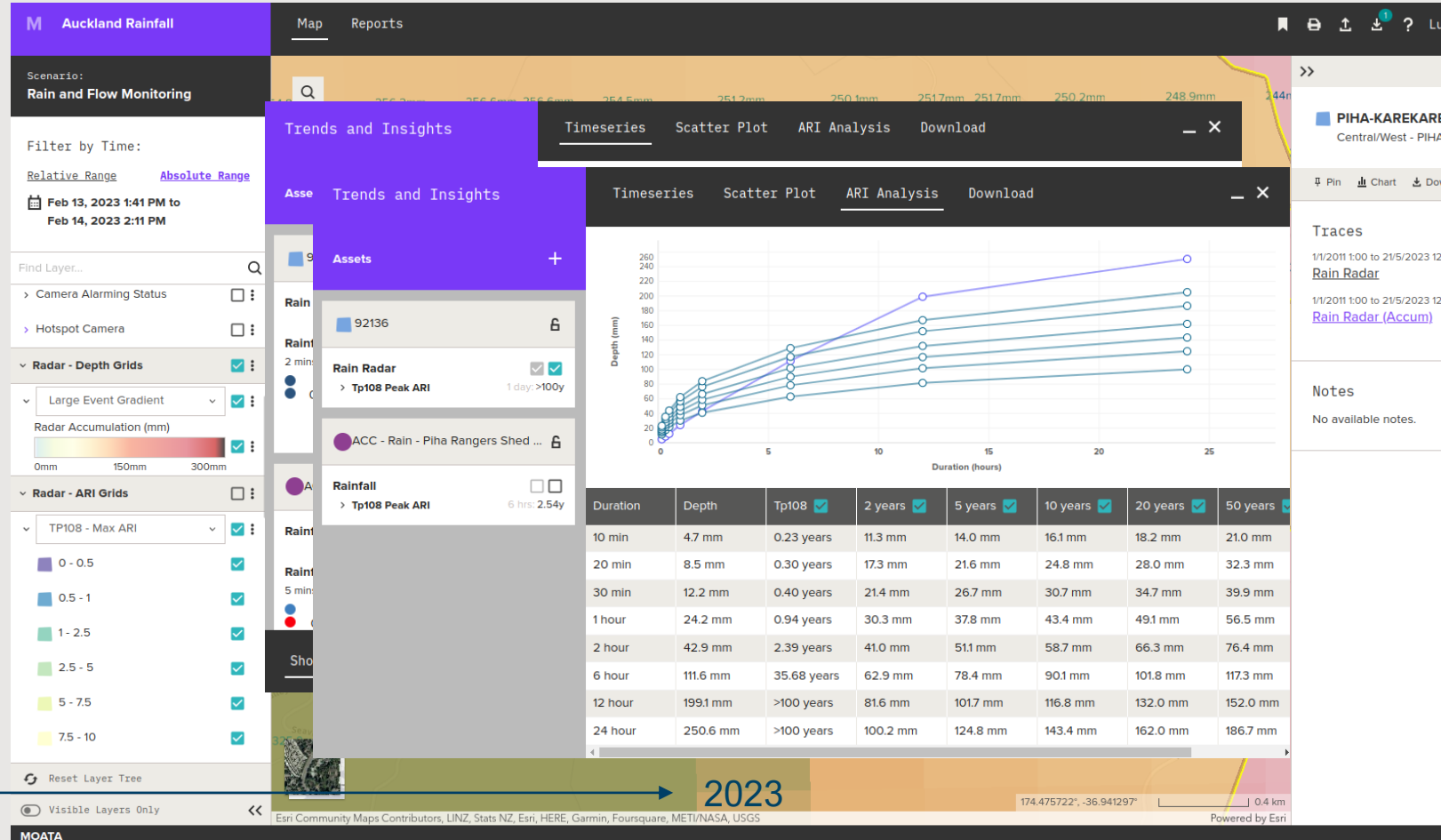
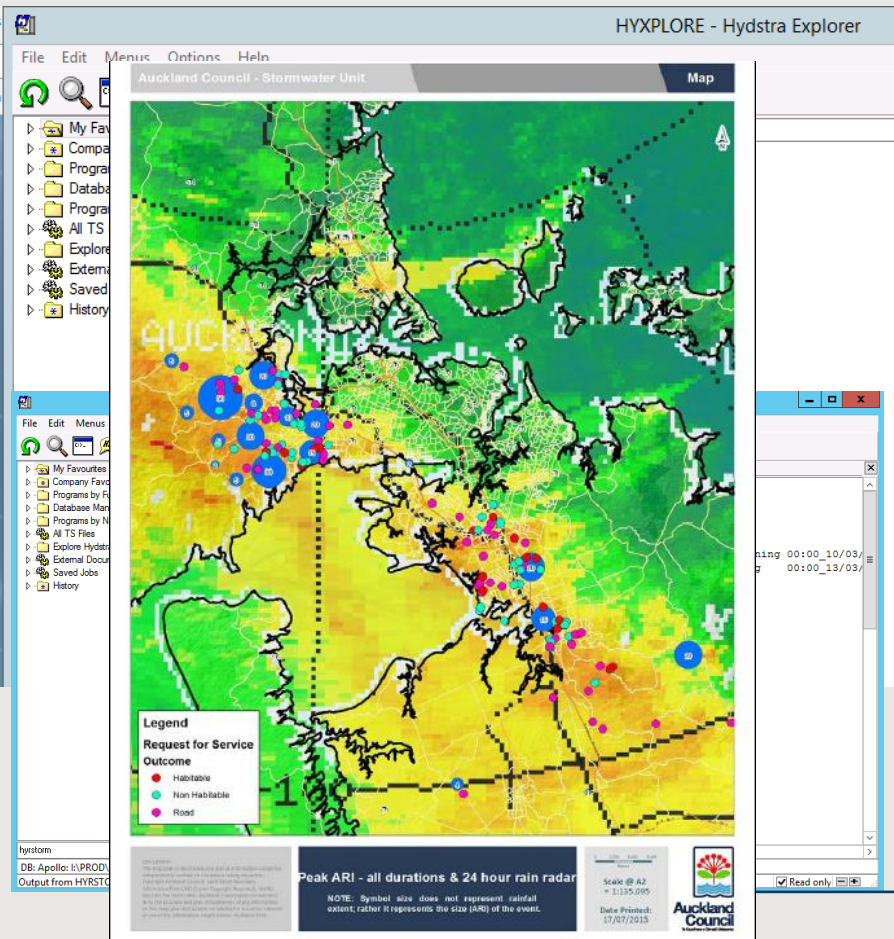
Radar and Gauge are combined in a Rainfall Analysis System (RAS)





# Weather Data systems at Healthy Waters

## Observations (Now)

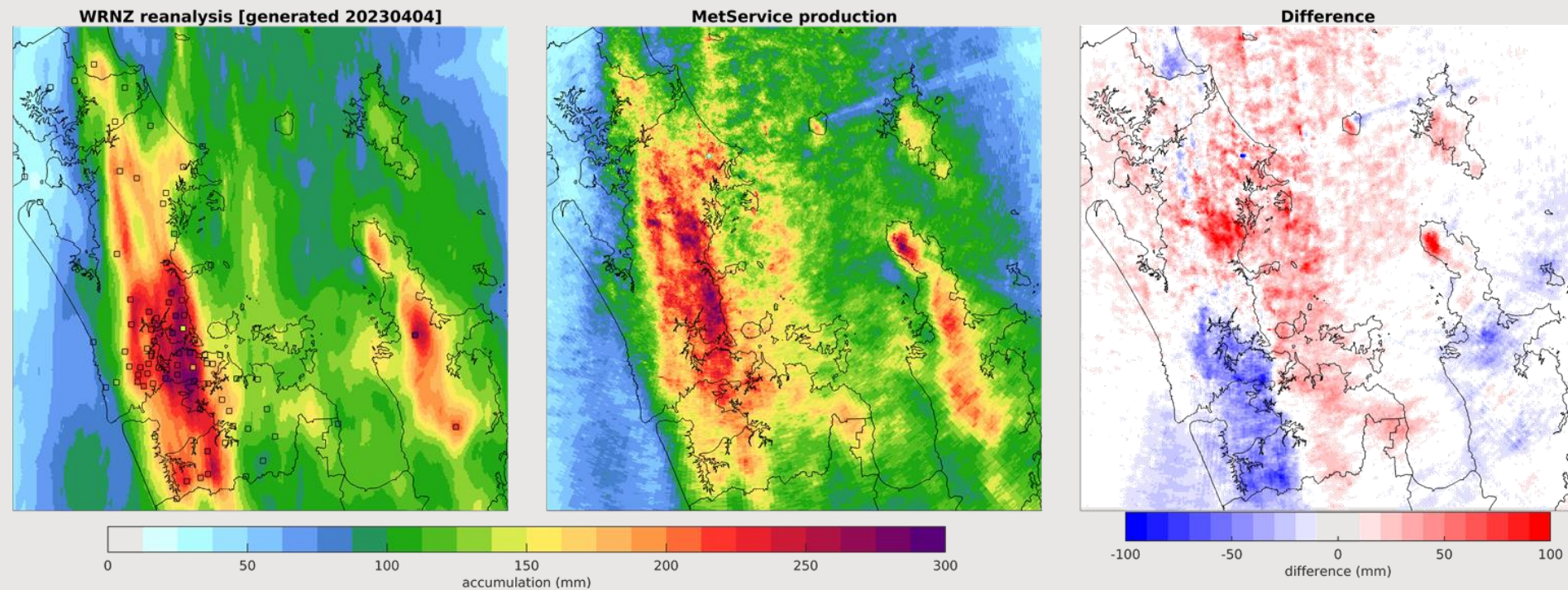


# The RAINFALL ANALYSIS SYSTEM required a significant investment.

## RIGOUR

- Quality level of the MetService radar-derived rainfall analysis confounds any attempt to use the data in engineering / EWS applications .
- (discussed in our earlier Stormwater Conference talks!)
- Contemporaneous example:

Event total rainfall (2023/01/27 00:00 to 2023/01/28 00:00 (NZDT))

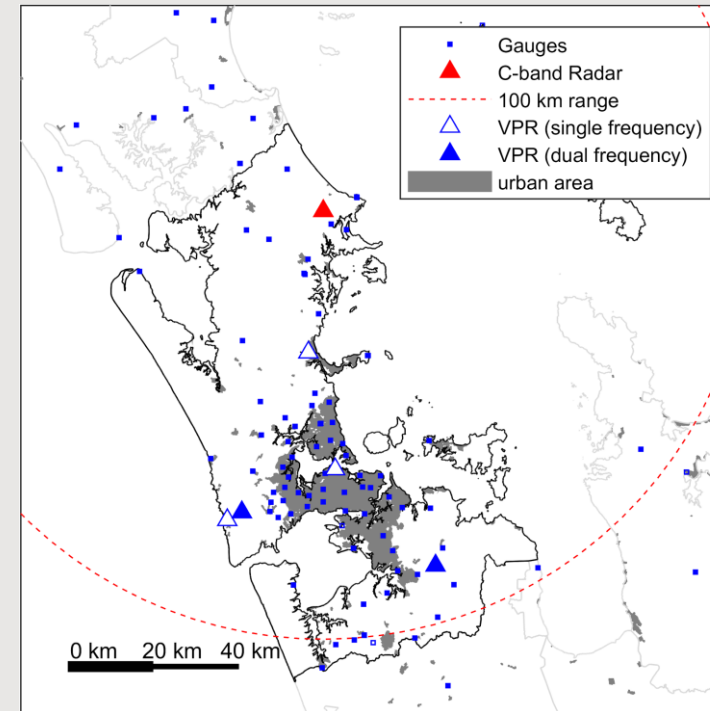




The RAINFALL ANALYSIS SYSTEM required a significant investment.

## PATHWAYS TO IMPROVMENTS

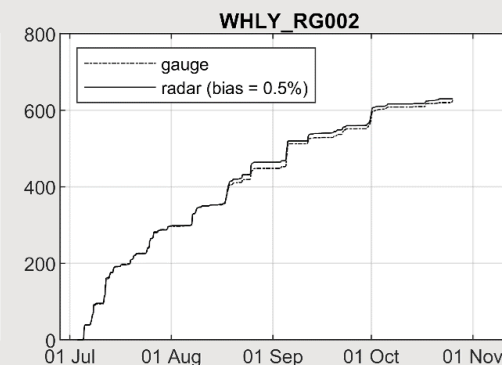
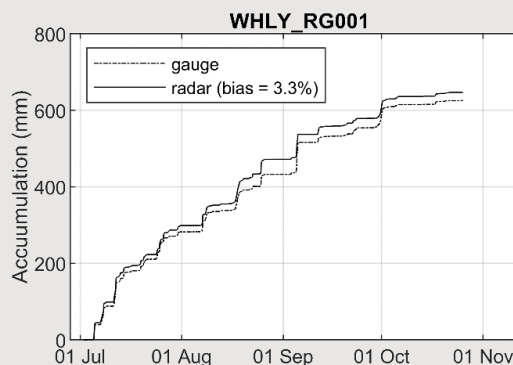
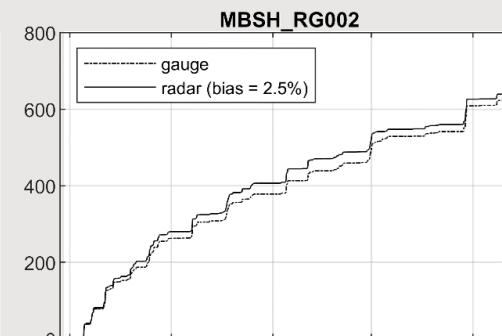
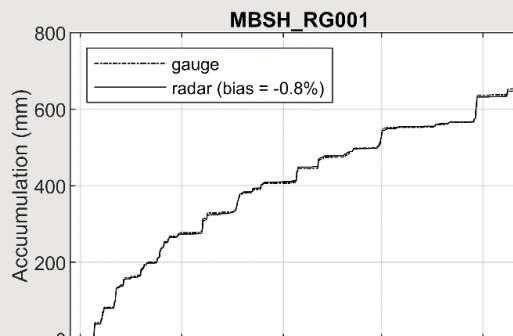
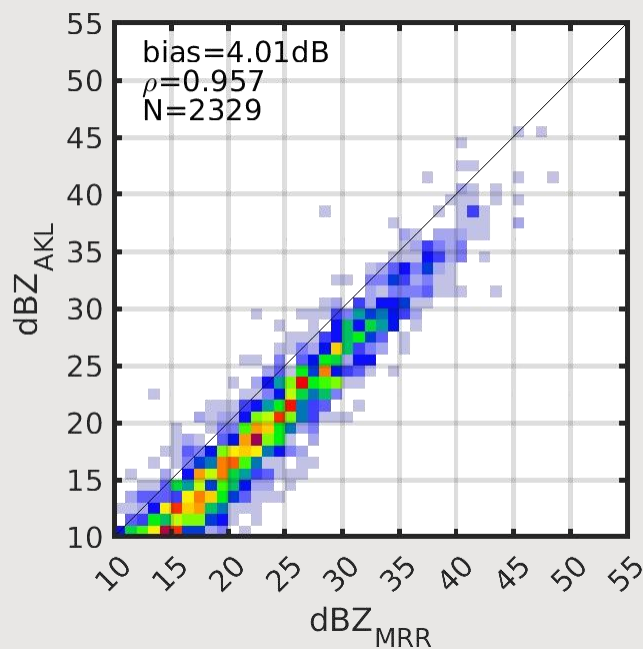
- An investment in science was required to realise a useable Weather Data type from radar



The RAINFALL ANALYSIS SYSTEM required a significant investment.

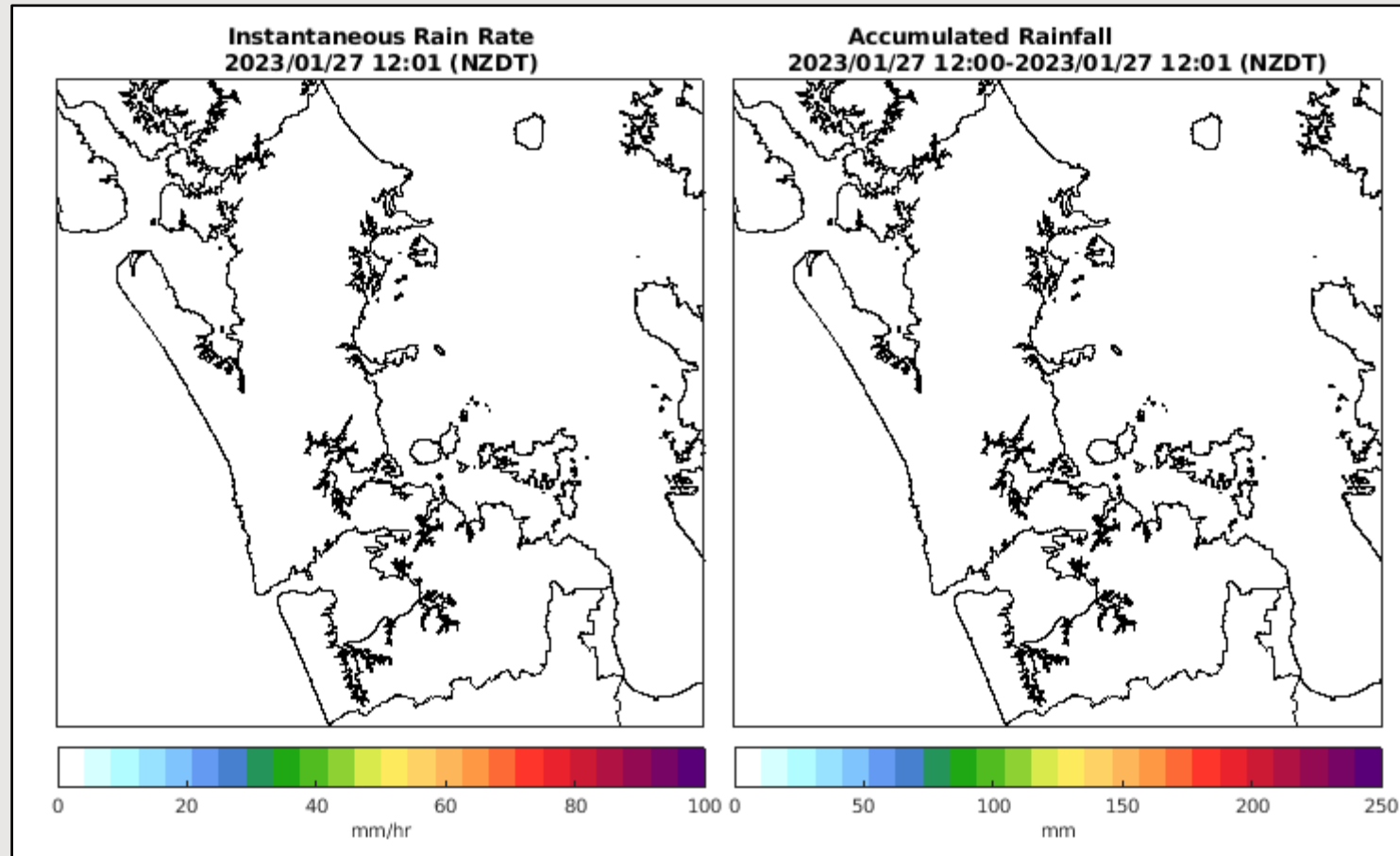
## E.G. ENSURING METSERVICE RADAR CALIBRATION

- MetService Calibration wanders around by up to 60% (probably due to technicians changing settings)
- Results in useable rainfall information, everywhere in the Auckland region.



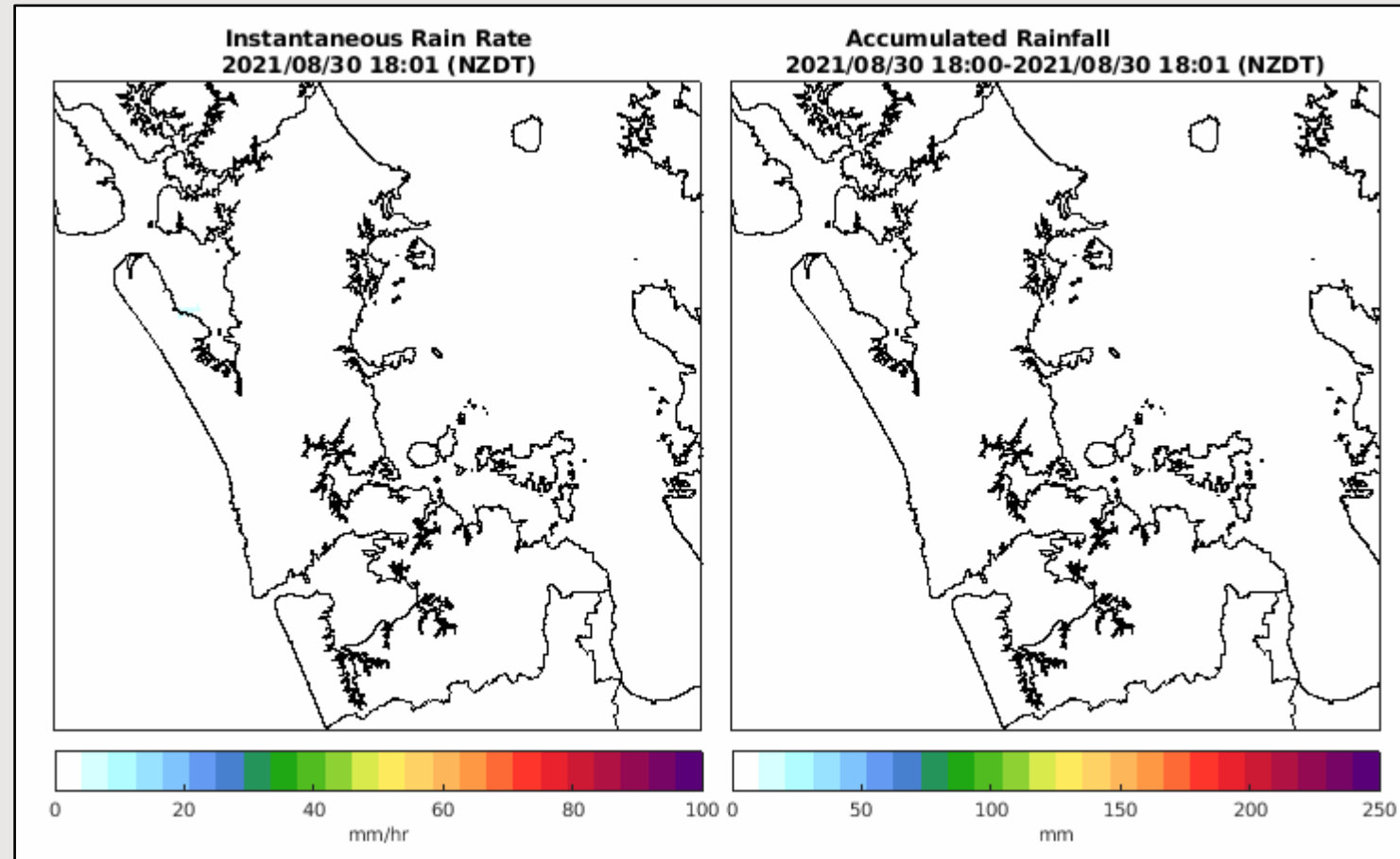
# Weather Data systems at Healthy Waters

## Observations (Now)

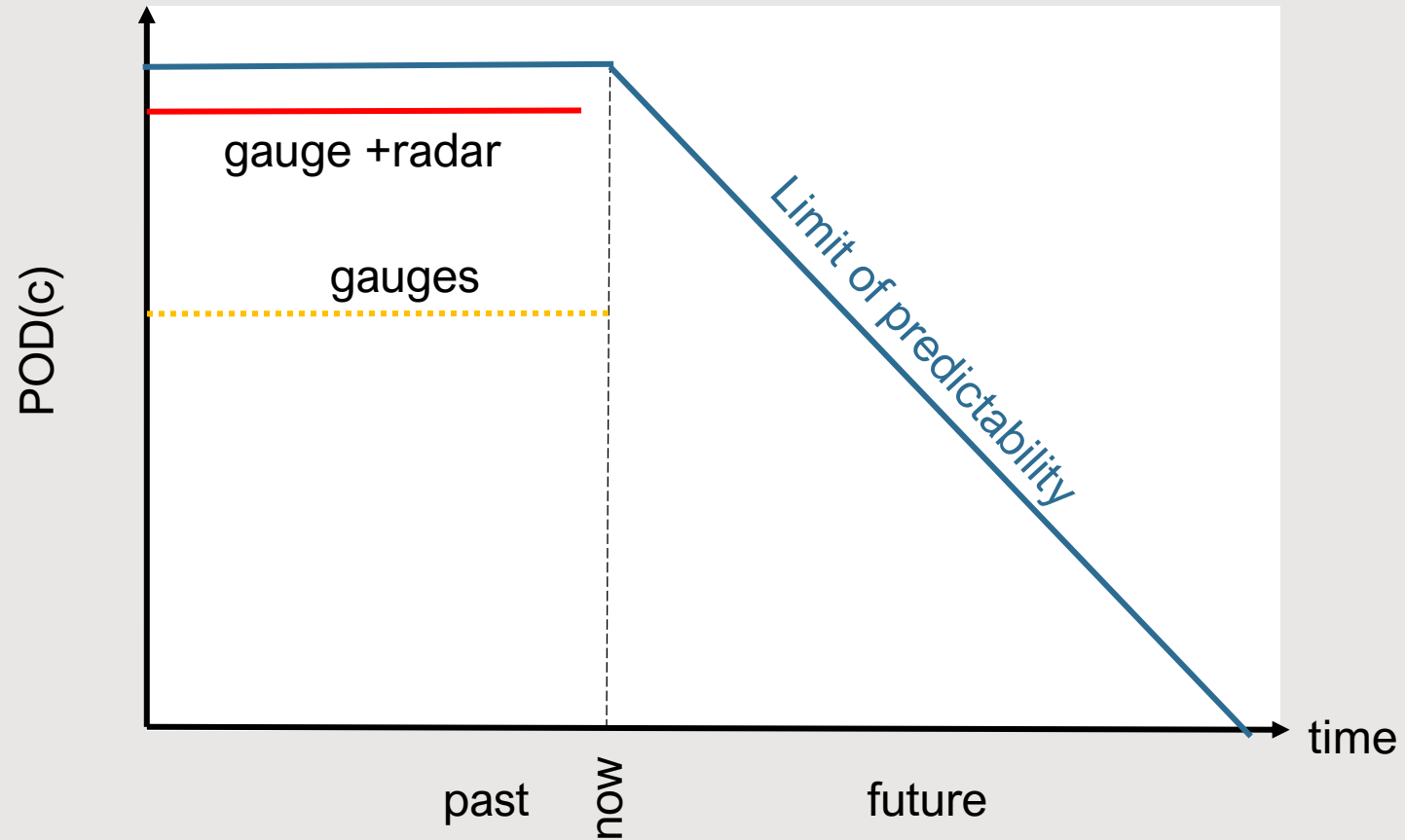


# Weather Data systems at Healthy Waters

## Observations (Now)



# Predictability of the Atmospheric State

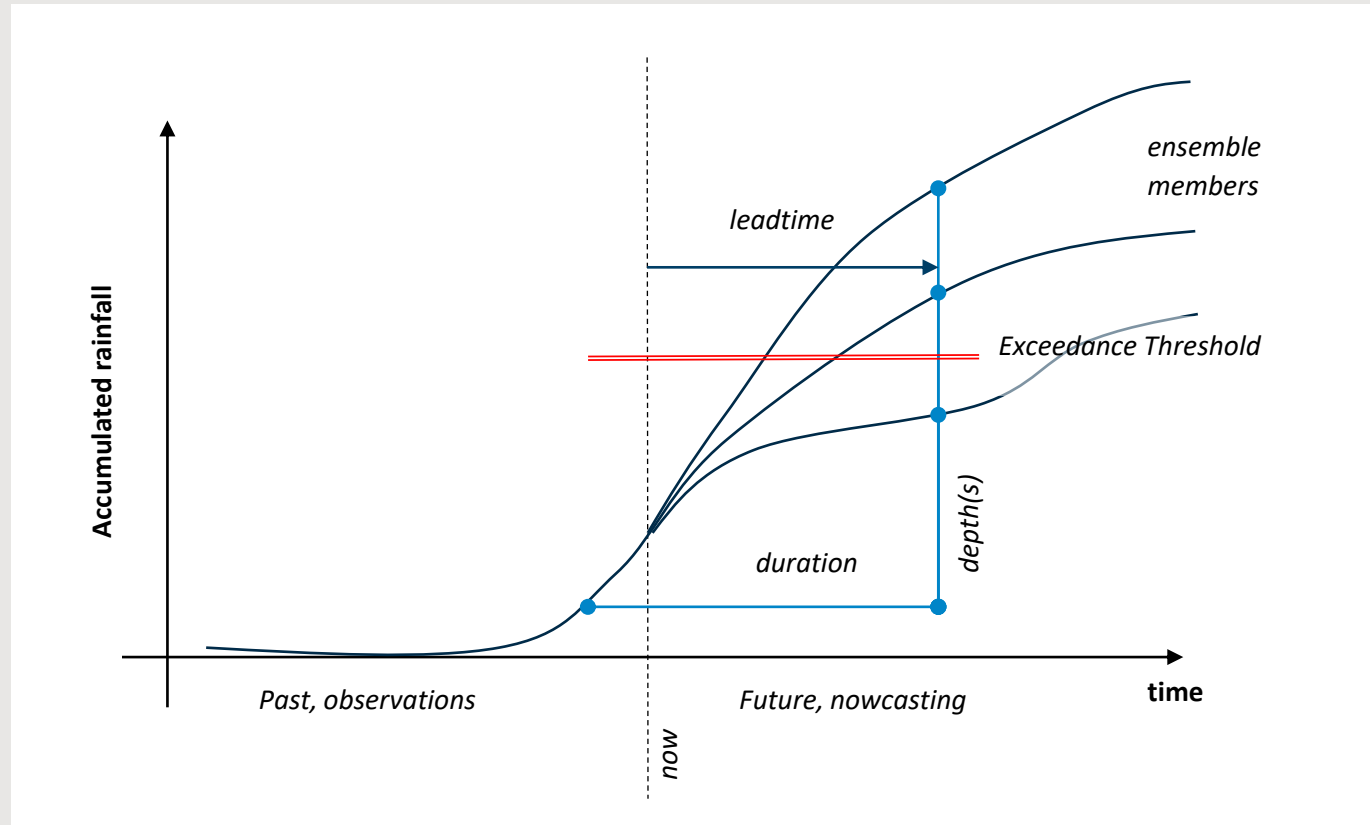


after Austin et al 1987





# OBSERVATIONS ARE INSUFFICIENT TO MANAGE RISK



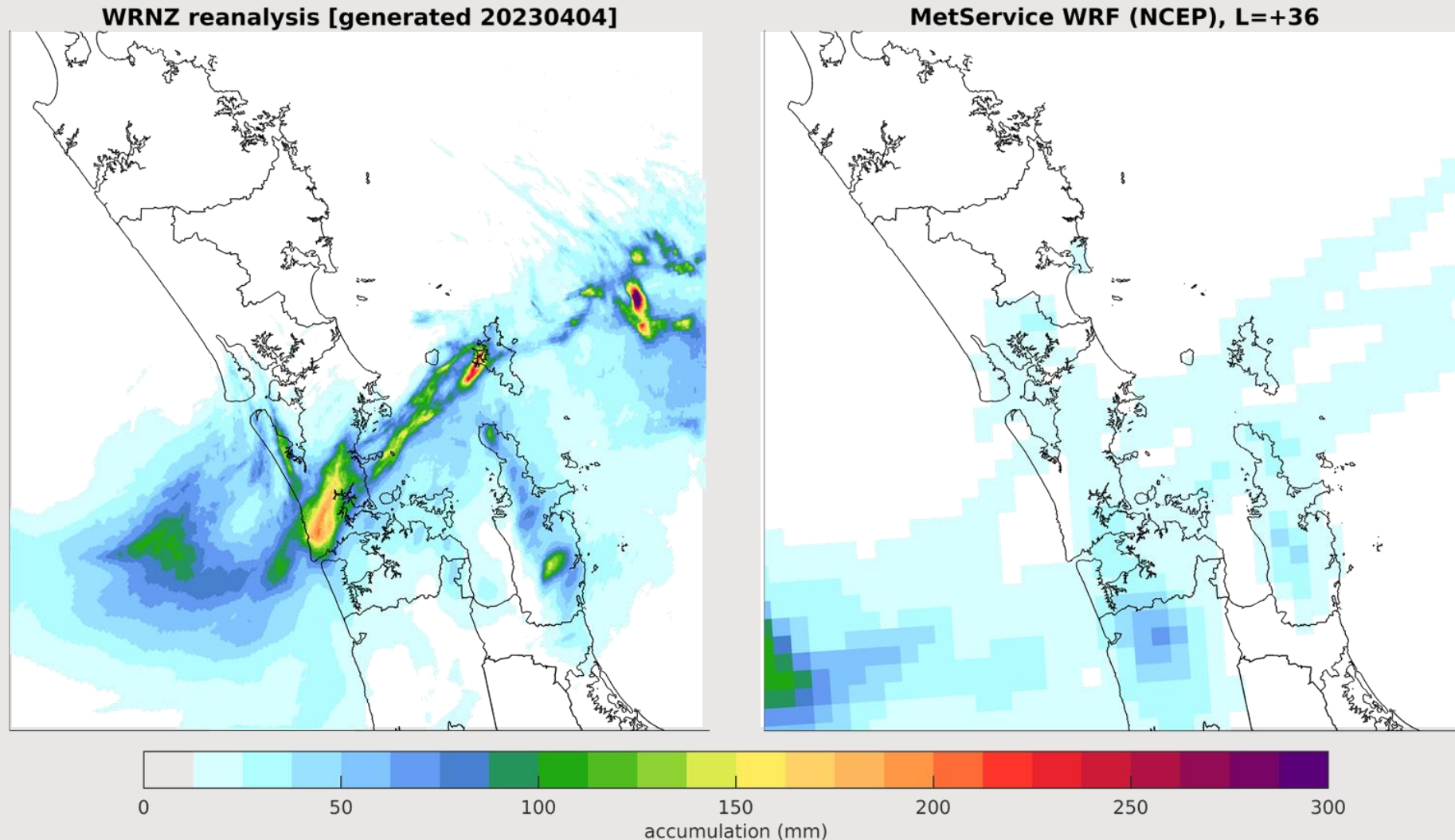
- Probabilistic Forecasting



# Weather Data systems at Healthy Waters

## NWP Forecasts (Future)

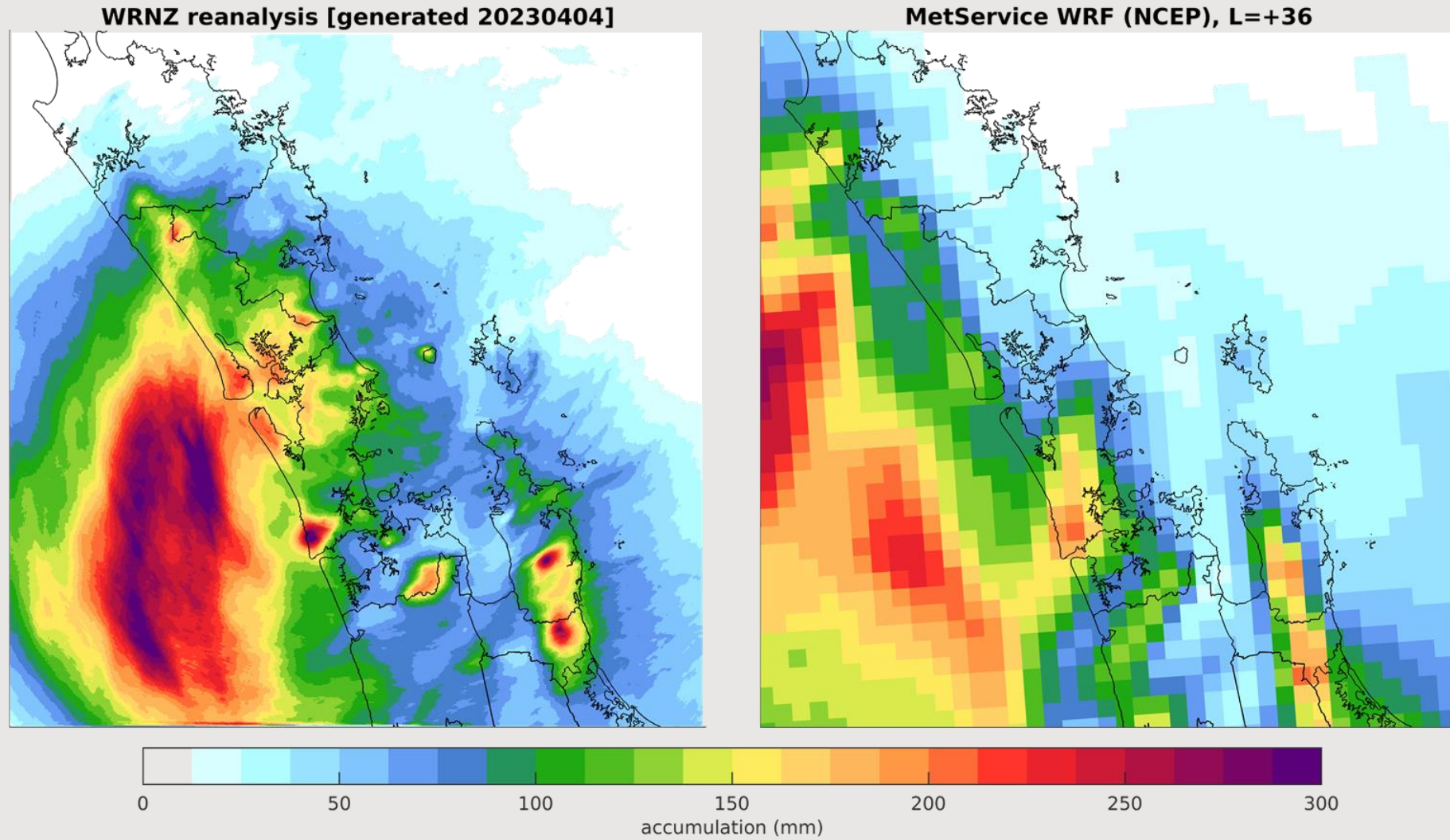
Event total rainfall (2021/08/30 12:00 to 2021/08/31 12:00)



# Weather Data systems at Healthy Waters

## NWP Forecasts (Future)

Event total rainfall (2023/02/13 13:00 to 2023/02/14 13:00)

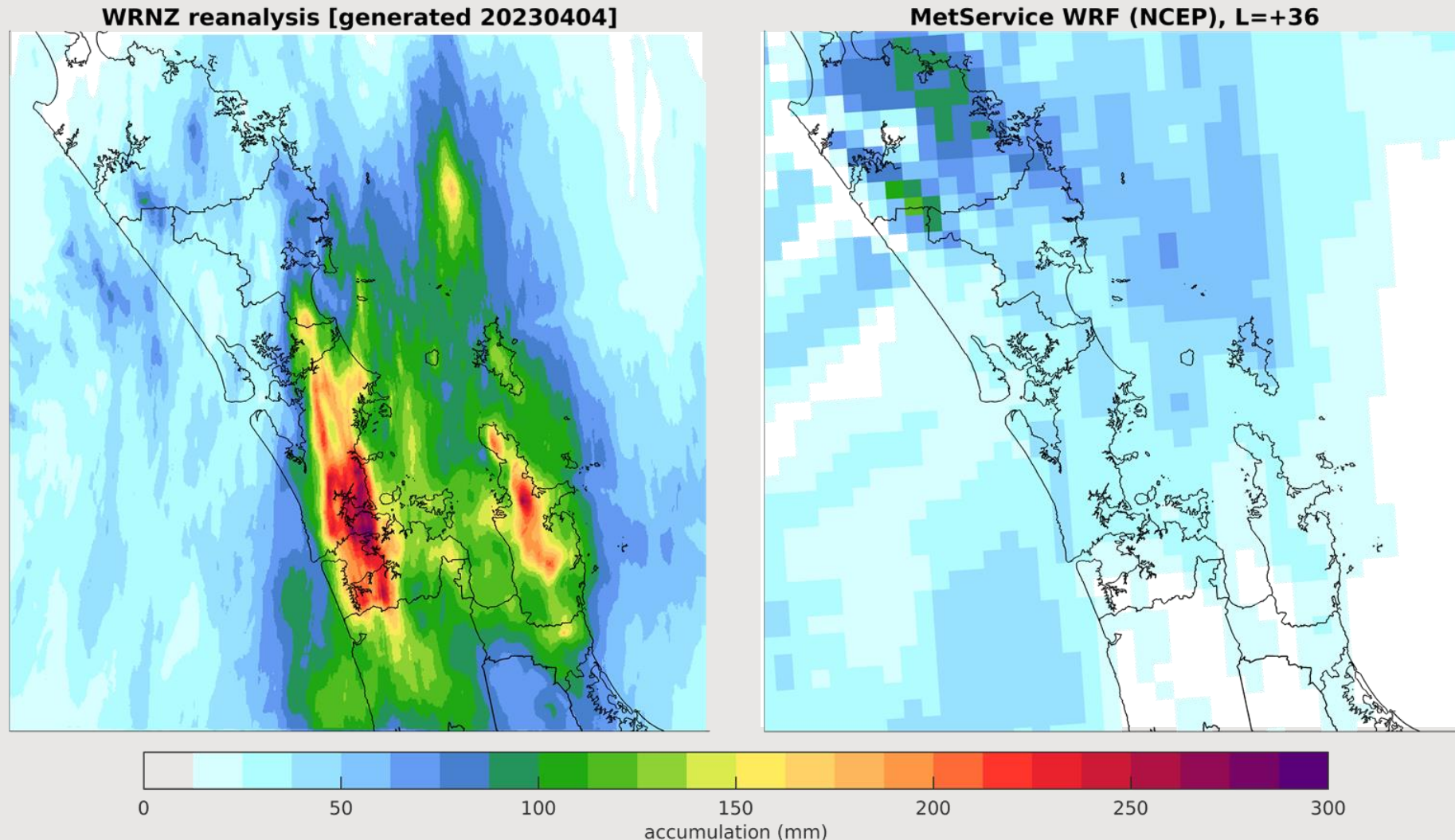




# Weather Data systems at Healthy Waters

## NWP Forecasts (Future)

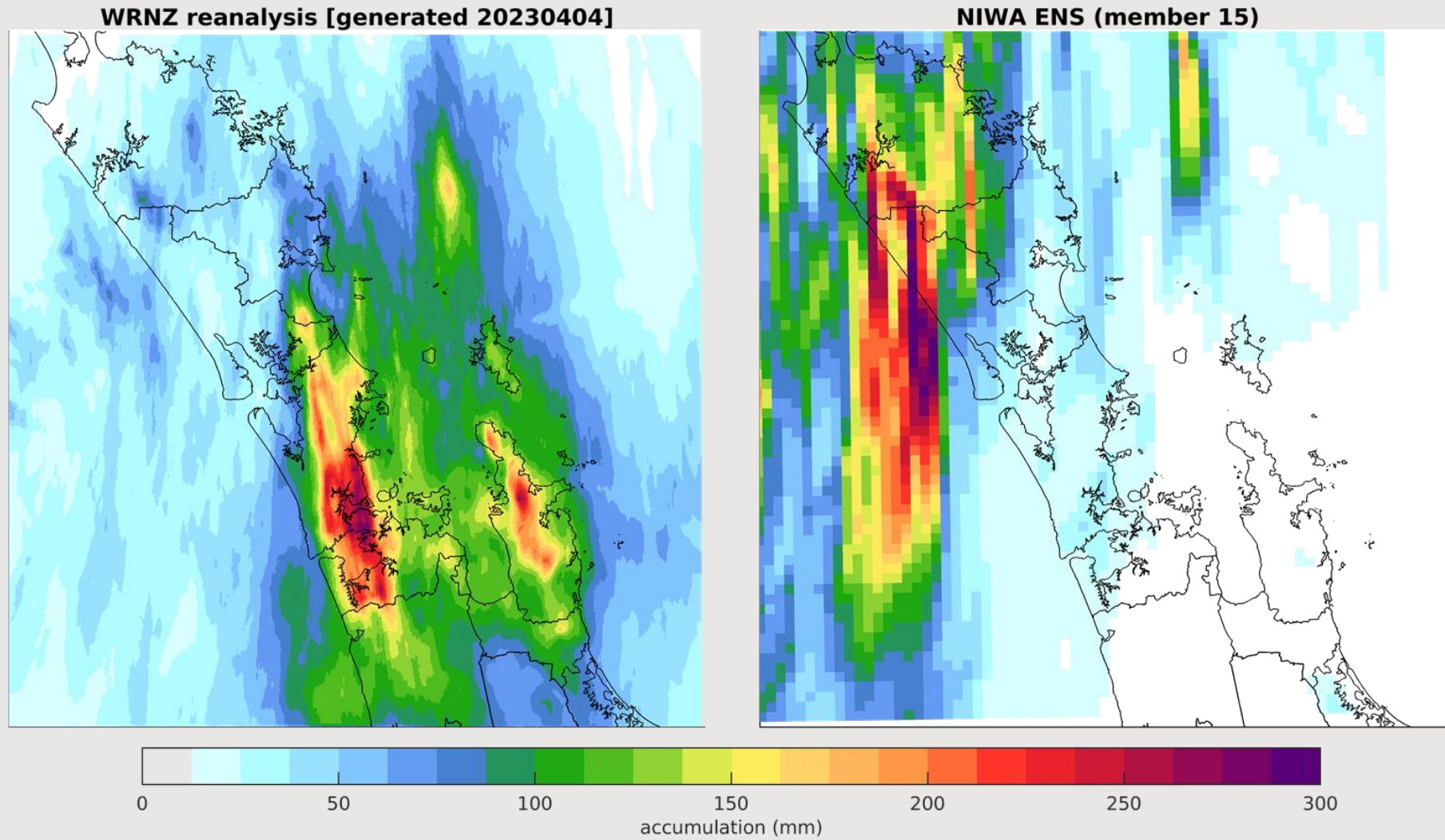
Event total rainfall (2023/01/27 00:00 to 2023/01/28 00:00)



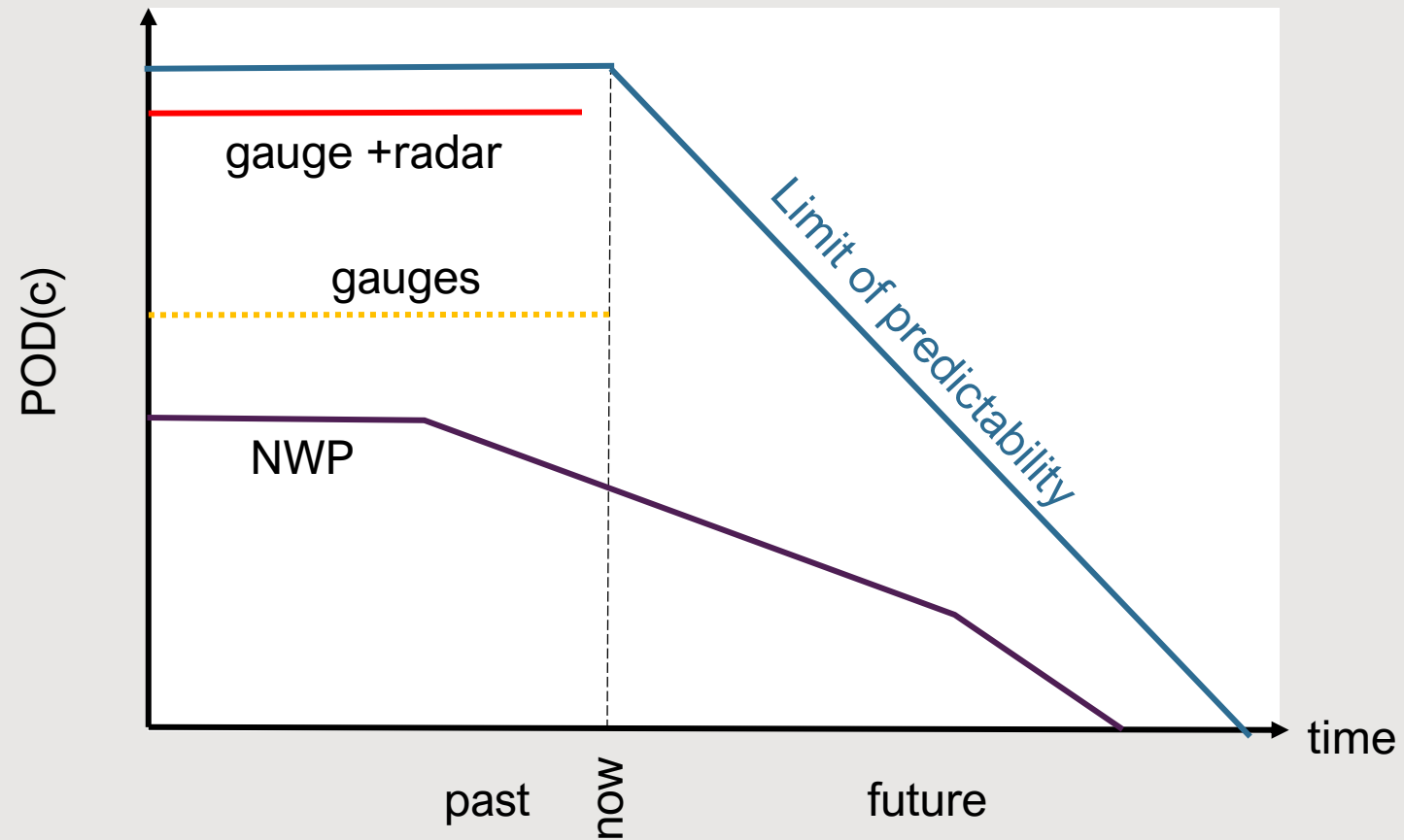
# Weather Data systems at Healthy Waters

## NWP Forecasts (Future)

Event total rainfall (2023/01/27 00:00 to 2023/01/28 00:00 (NZDT))



# Predictability of the Atmospheric State

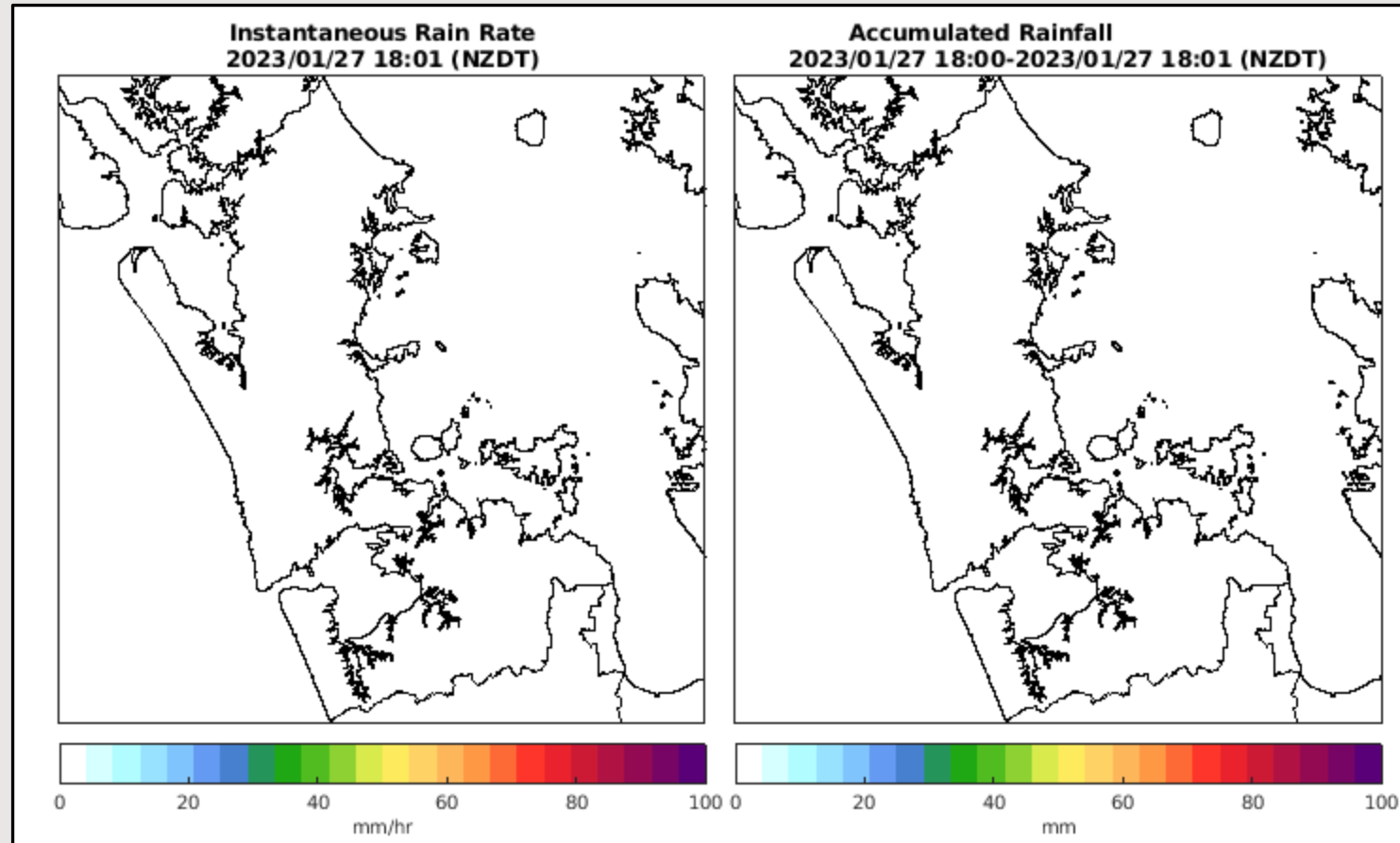


after Austin et al 1987



# Weather Data systems at Healthy Waters

Nowcasting (Leadtime: hours ... often <1!)





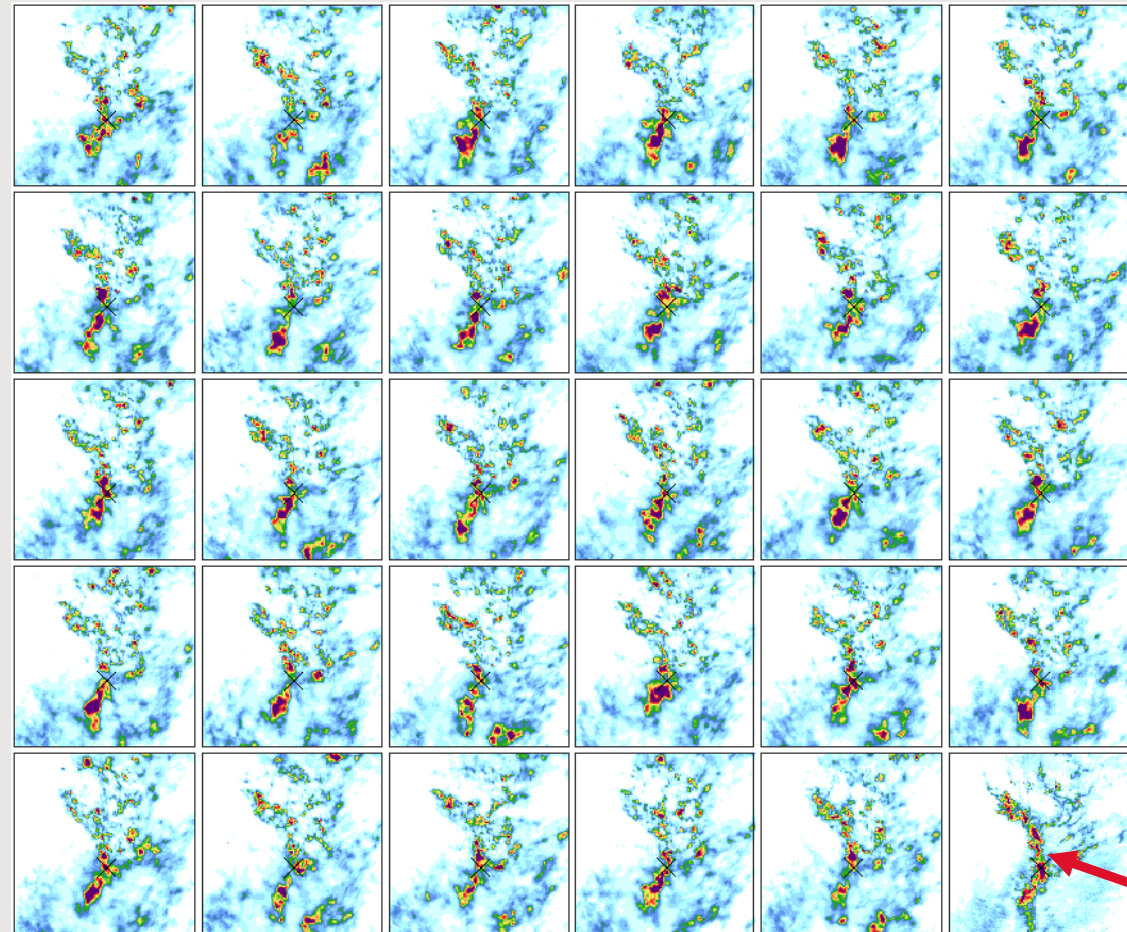
# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours)

Based on the observed velocity  
(speed/direction) and unpredictability  
of the current rain situation.

Same scene as the animation.

15-minute nowcast



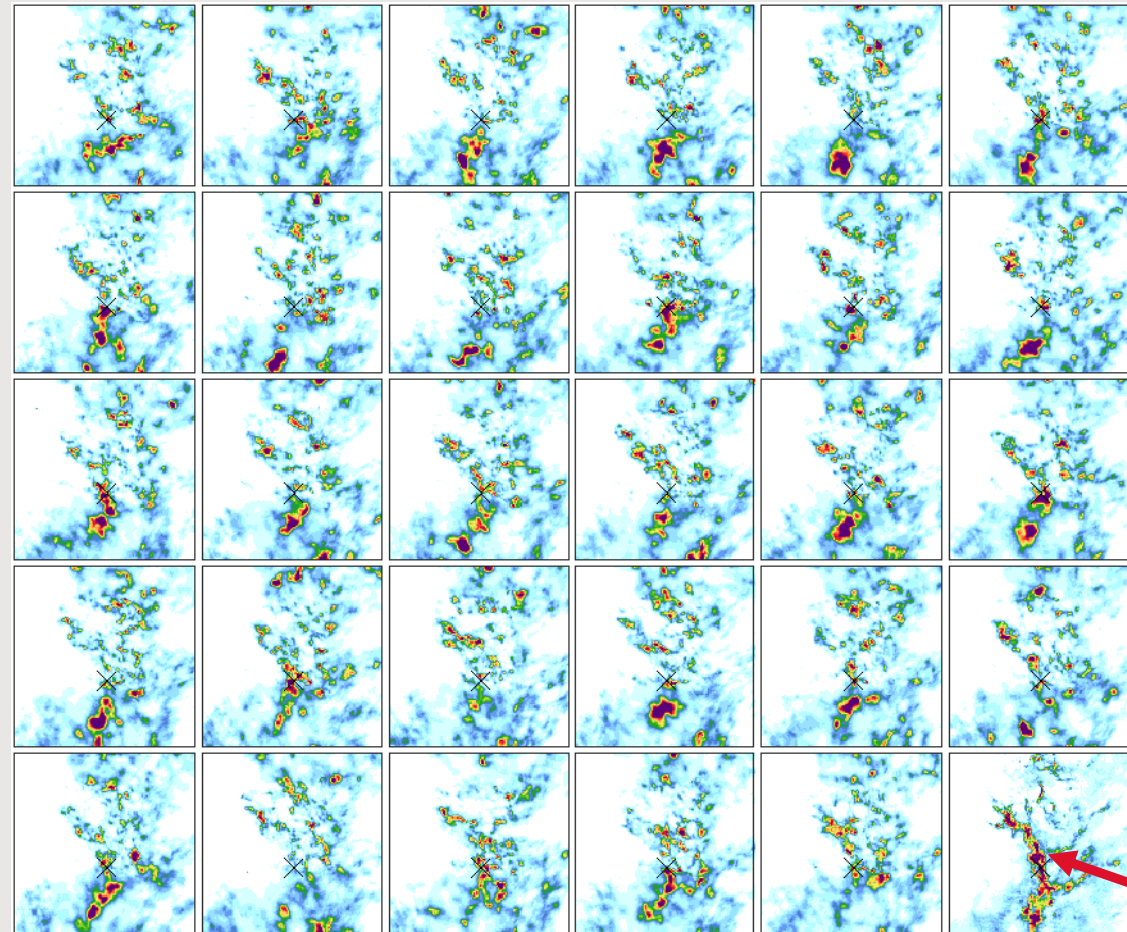
# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours)

Based on the observed velocity  
(speed/direction) and unpredictability  
of the current rain situation.

Same scene as the animation.

30-minute nowcast



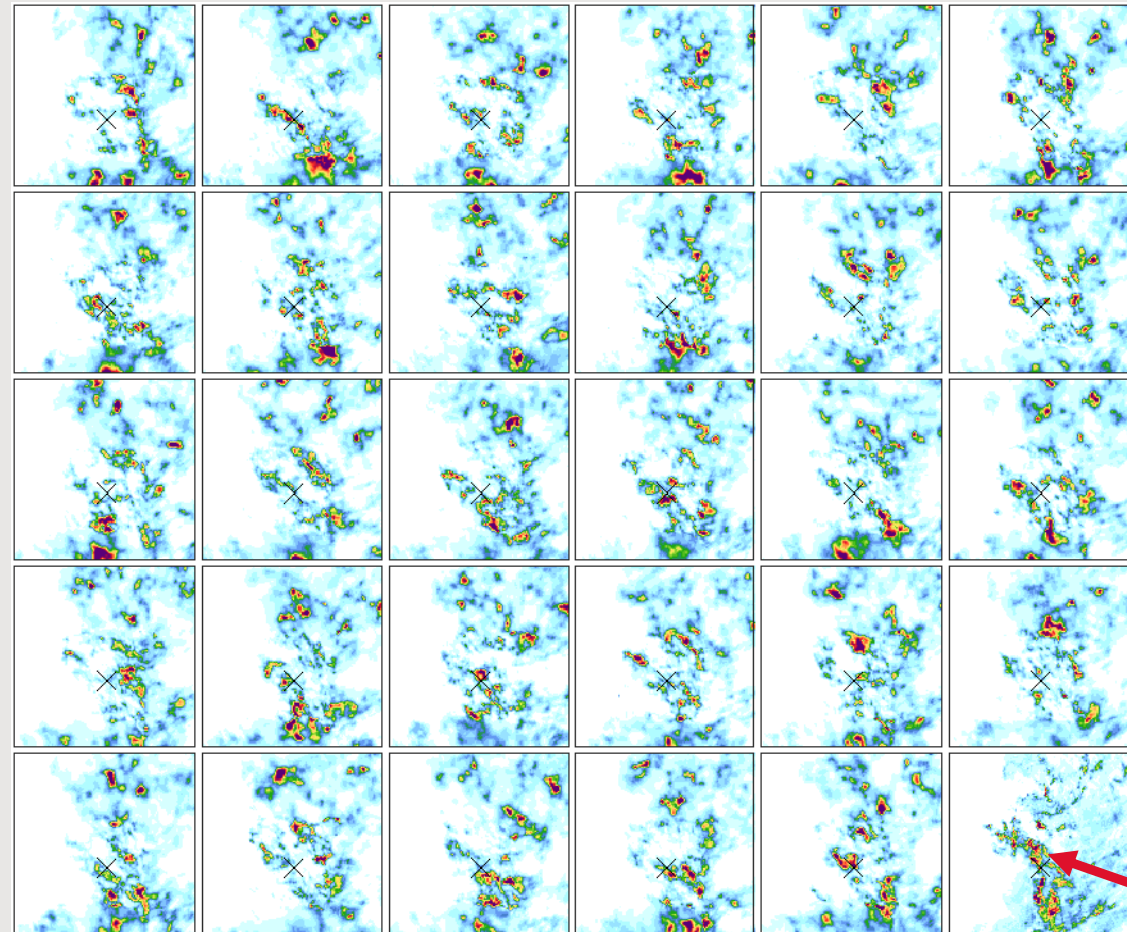
# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours)

Based on the observed velocity  
(speed/direction) and unpredictability  
of the current rain situation.

Same scene as the animation.

60-minute nowcast



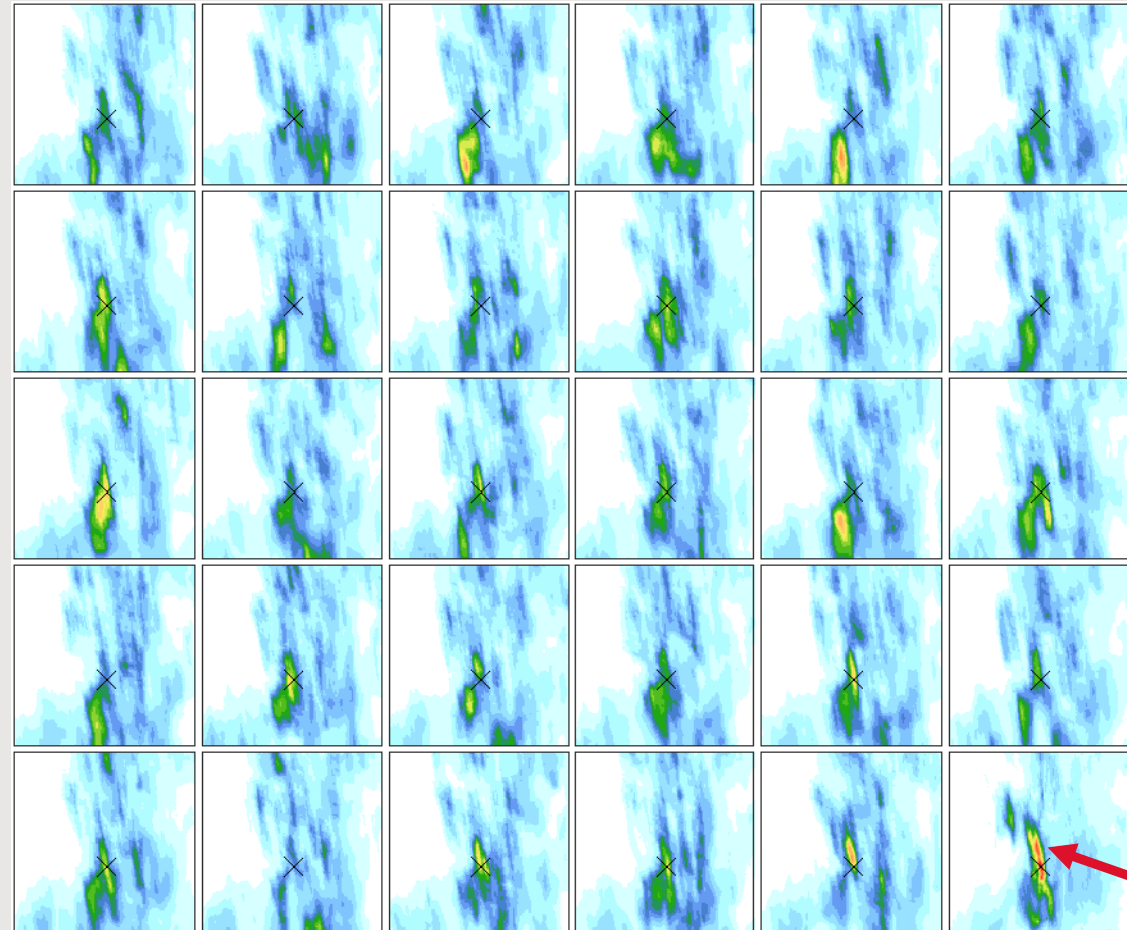
# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours)

Based on the observed velocity  
(speed/direction) and unpredictability  
of the current rain situation.

Same scene as the animation.

60-minute nowcast





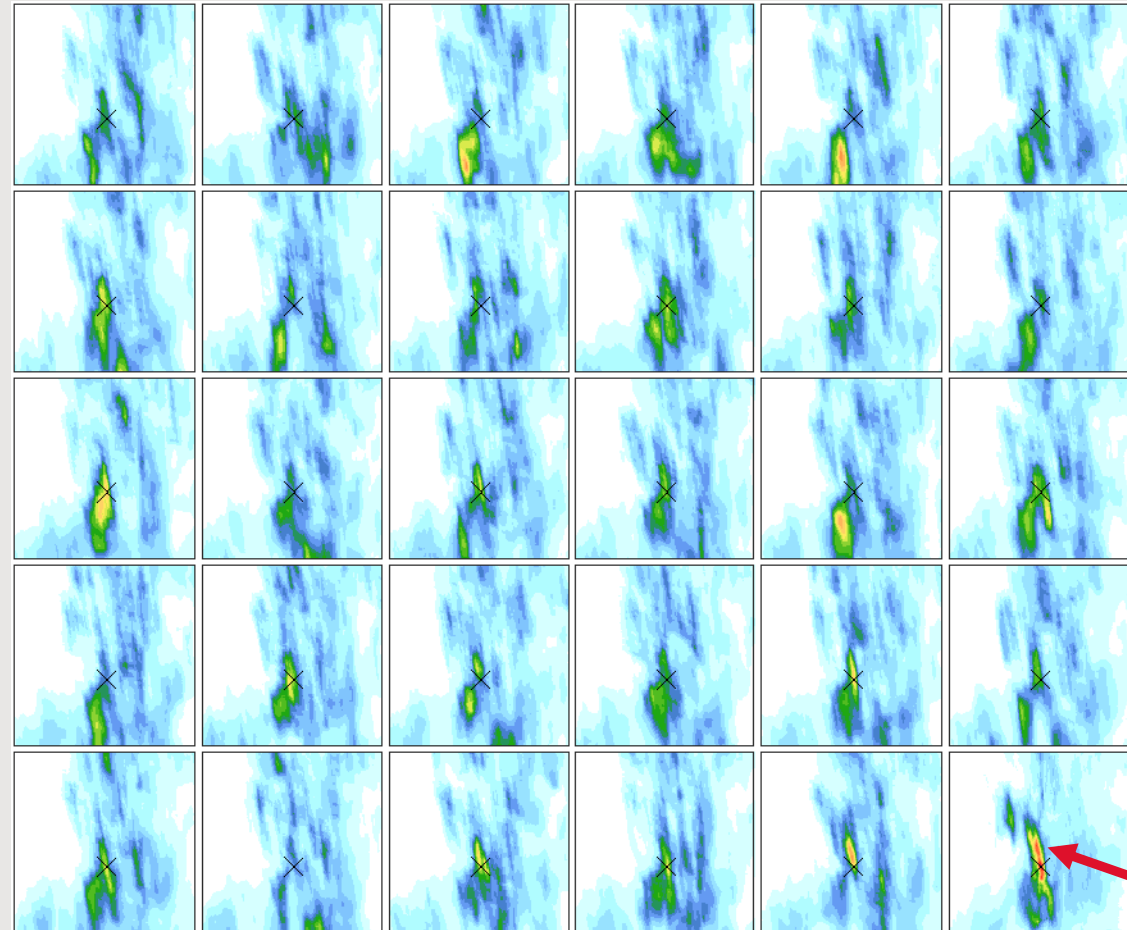
# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours)

Based on the observed velocity  
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Same scene as the animation.

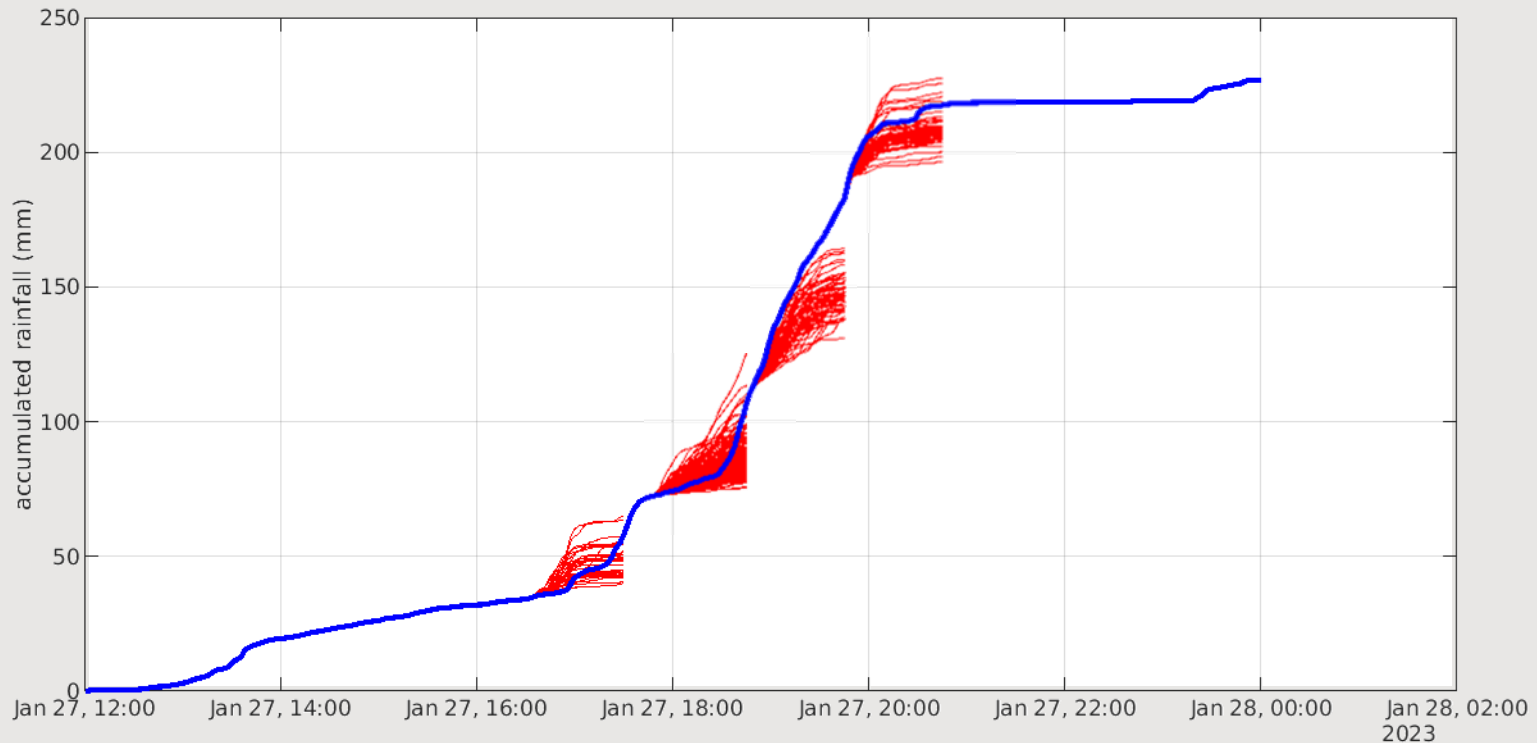
60-minute nowcast



# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours)

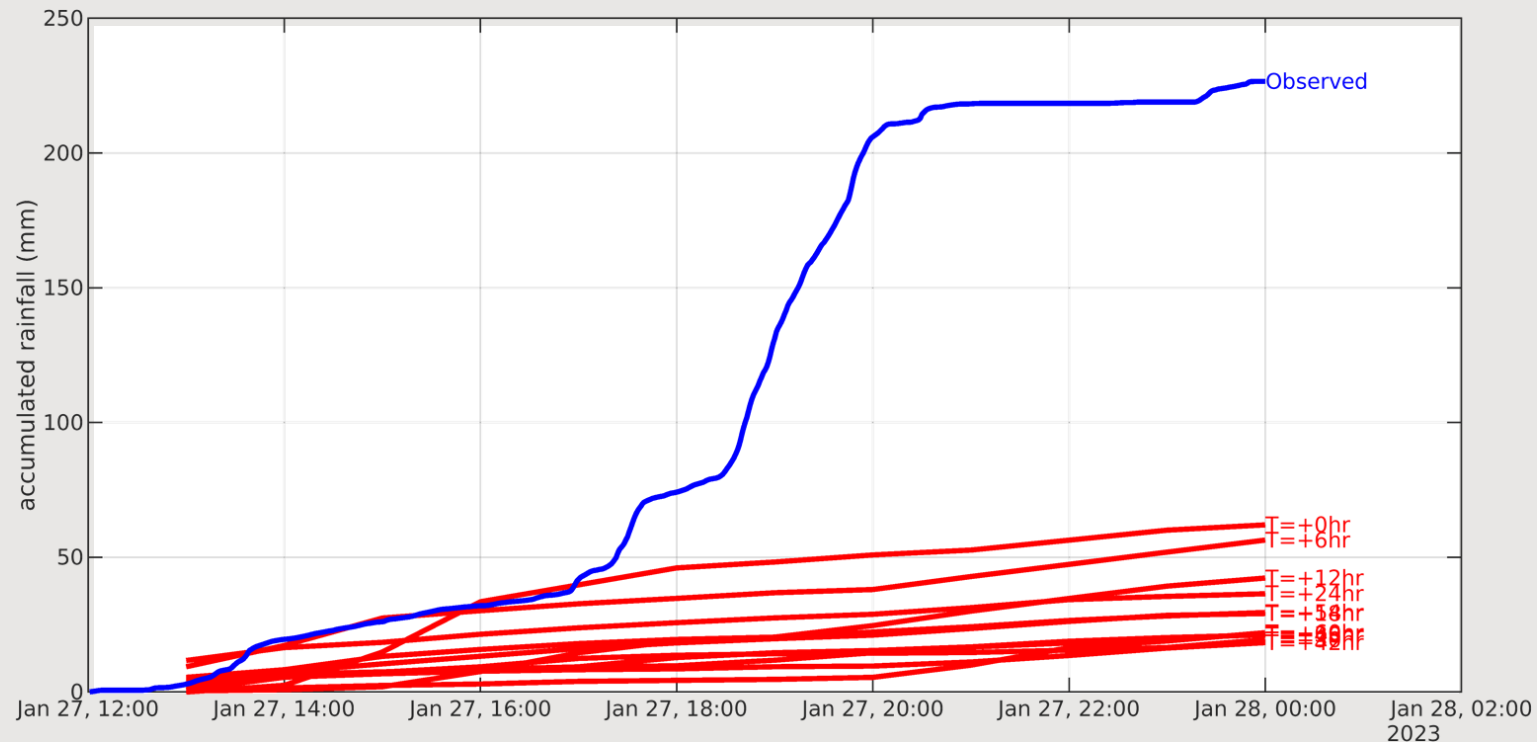
27 January 2023: Albert Park Rainfall Nowcast and Observations



# Weather Data systems at Healthy Waters

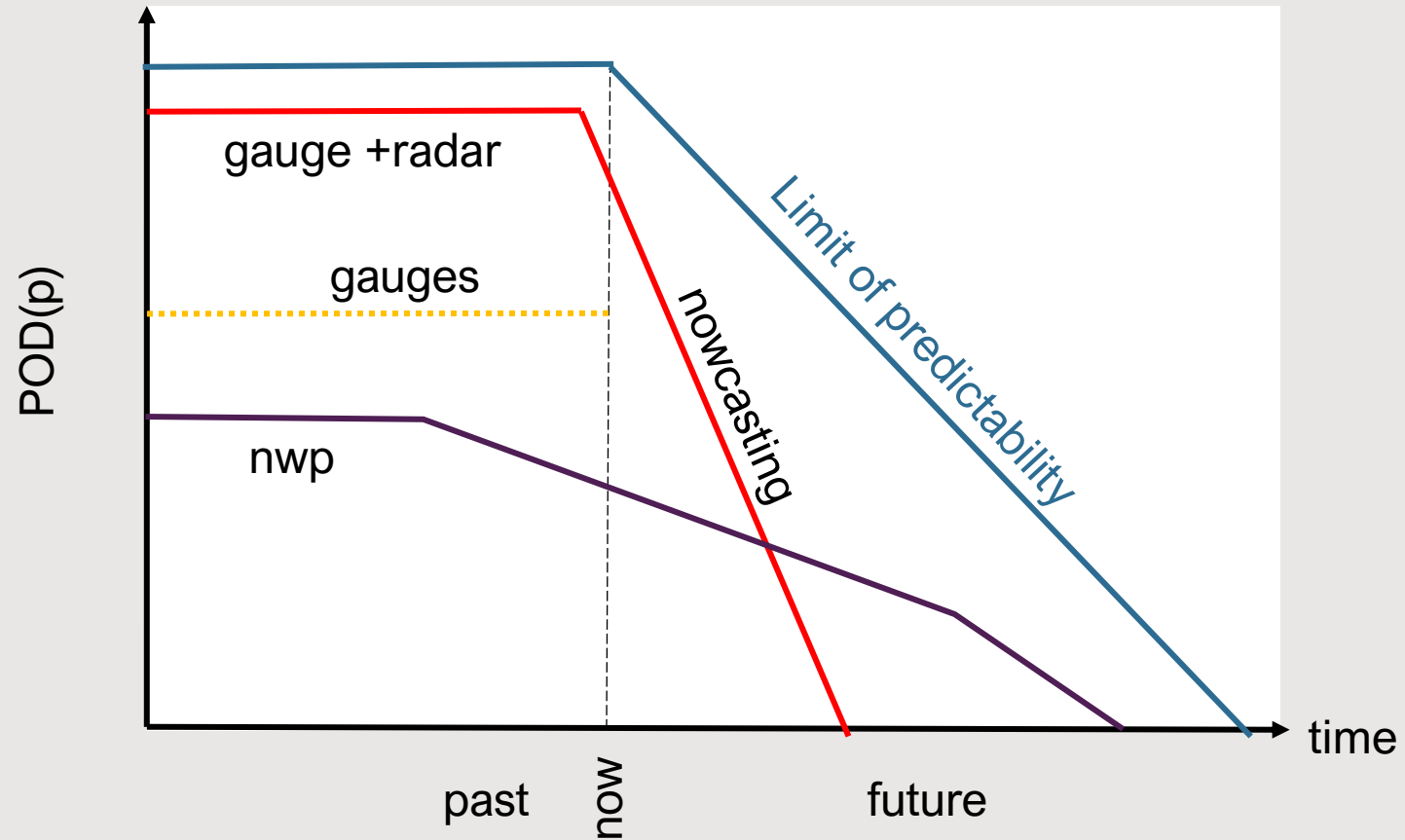
## NWP Forecasting (Leadtime: days)

27 January 2023: Albert Park Rainfall Forecast and Observations (MetService, 8km, NCEP)





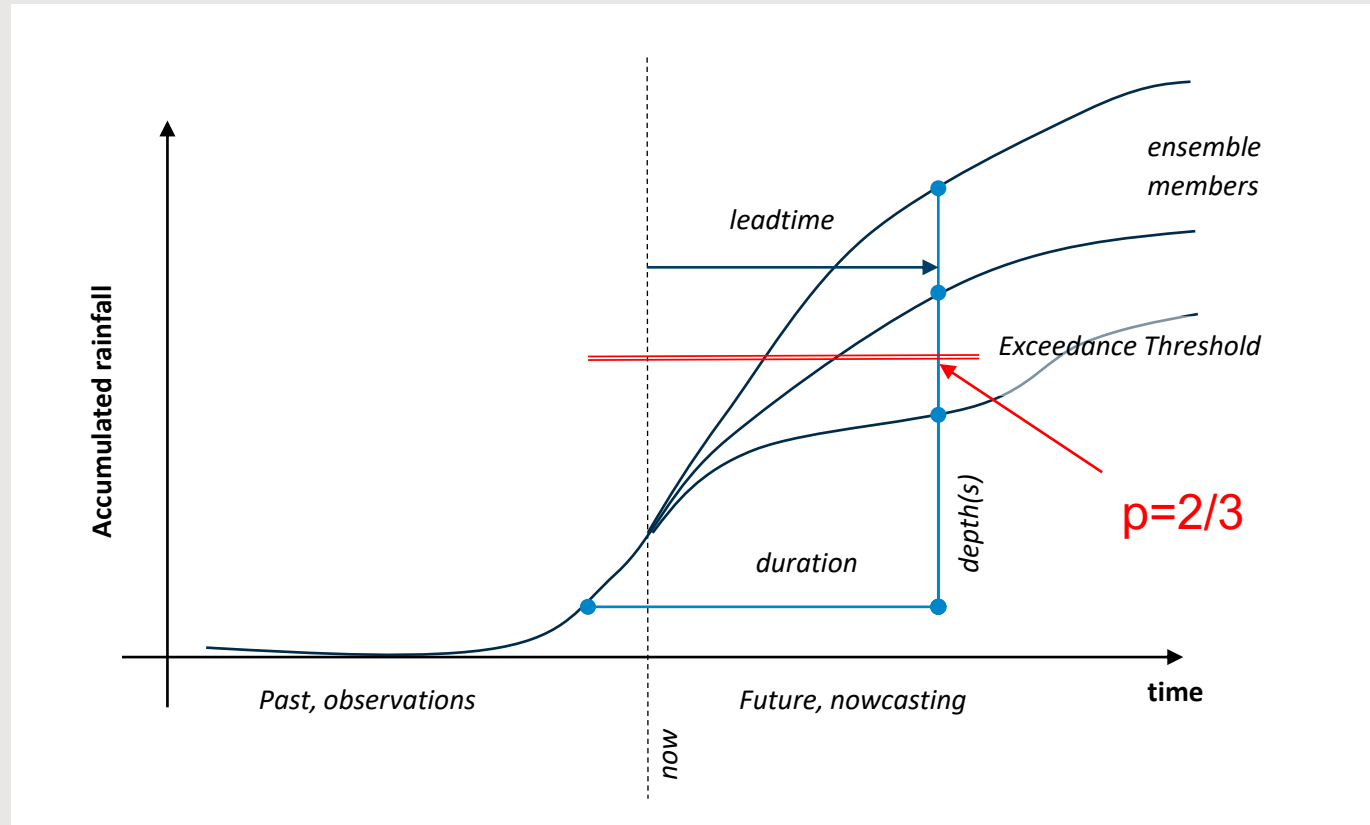
# Predictability of the Atmospheric State



after Austin et al 1987



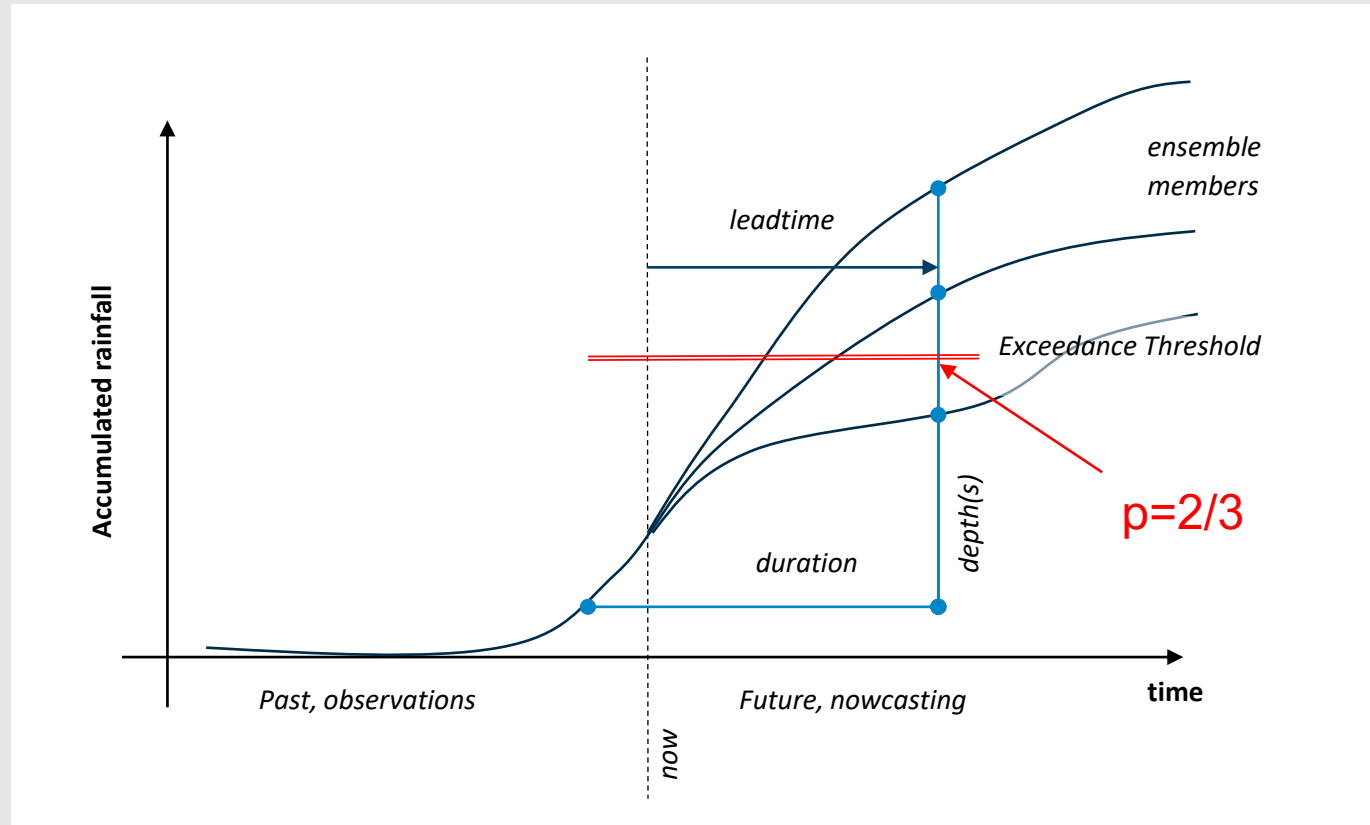
# PROBABILISTIC FORECASTING



- To Quantify Forecast Skill: we need to define the events we are interested in forecasting (Depth, Duration, Frequency, Area)
- Skill is then usefully defined by two statistics: Reliability and Probability of Detection.



# PROBABILISTIC FORECASTING



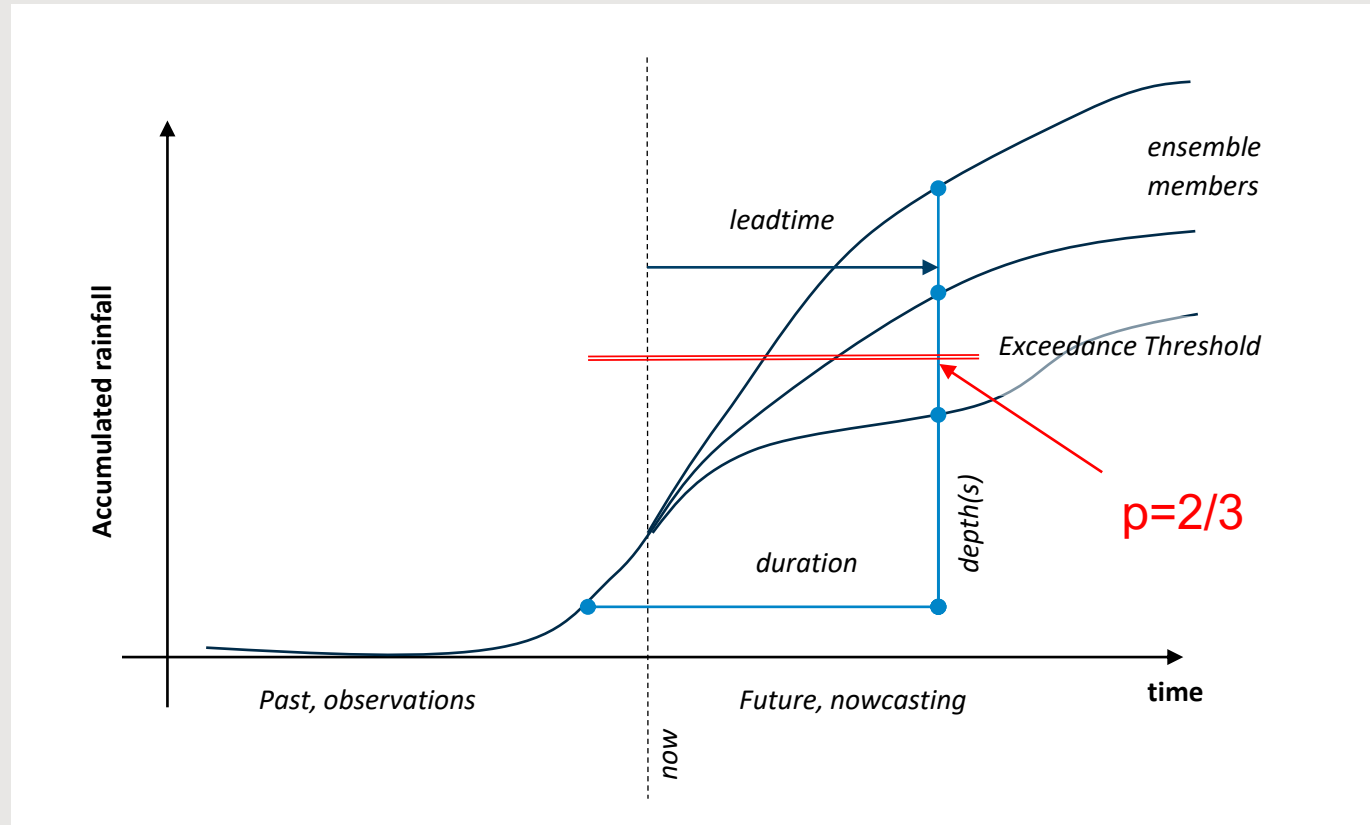
- Reliability: in the long run, do the probabilities issued by the forecasting system match the occurrence frequency of an event.

Above example- probability of the event is  $2/3$ ,

on average, events should occur 66.6% of the time following  $p=2/3$  events.



# PROBABILISTIC FORECASTING



- Probability of Detection: Given some acceptable probability (or confidence level), what proportion of events can be detected in advance.

Say for taking some action, an acceptable probability (confidence) of an event occurring is  $2/3$ . For all events, how many were actually preceded by a forecast with a probability of  $2/3$  or better?



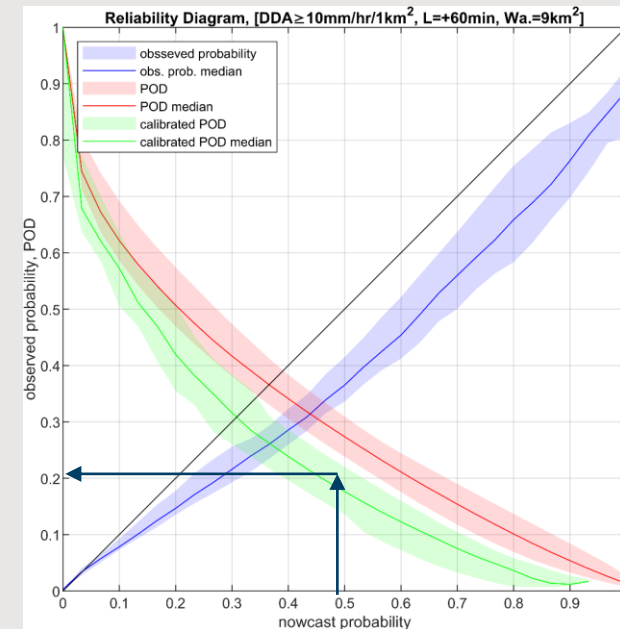
# Reliability and Probability of Detection

Statistics are prepared by tabulating over a 10 year record of radar observations and nowcasts.

Tables are generated for any definition of an event of interest (Depth/Duration/Area) and Leadtime.

Reliability is assessed, then bias correction can be applied. This results in an unbiased estimate of POD(p)

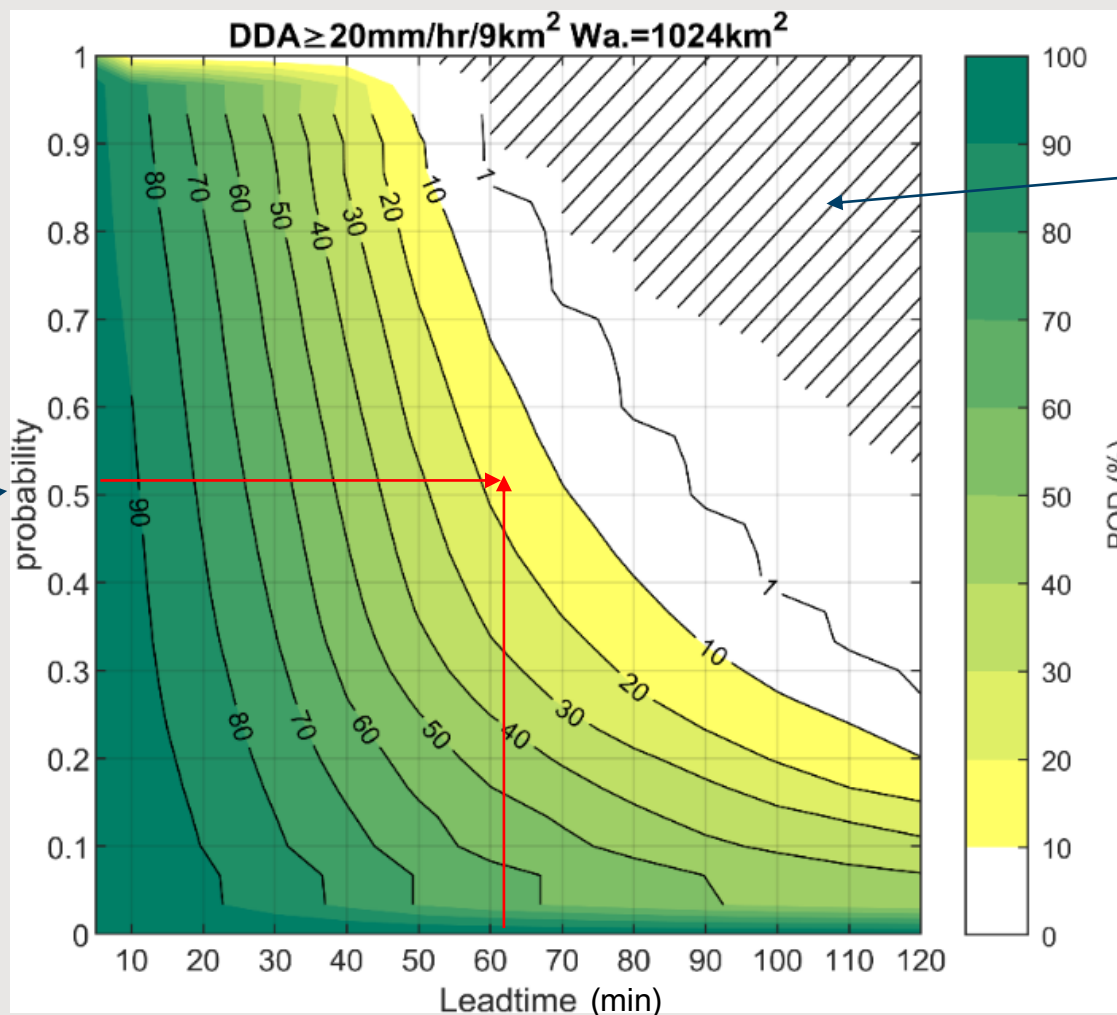
Number of ensemble members >10mm	Nowcast Theoretical Probability	Number of nowcast predicted exceedances	Number of observed exceedances	Observed (Bias corrected) probability	Long term Probability of Detection of an exceedance when alarming at or above this probability	Long Term False Alarm Ratio when alarming at or above this probability
0*	0.00	213434185*	129113	*0.00		
1	0.03	1166202	42057	0.04	0.78	0.86
5	0.17	155365	22439	0.14	0.57	0.67
10	0.33	58064	15669	0.27	0.40	0.52
15	0.50	31035	13408	0.43	0.27	0.39
20	0.67	18379	10729	0.58	0.17	0.29
25	0.83	12210	8877	0.73	0.09	0.20
30	1.00	9612	8755	0.91	0.01	0.09



# TABLES.

DDA = Depth/Duration/ Area Covered, W.a. =  
localization of the event e.g. somewhere in 32x32km

Probability =  
(bias corrected)  
fraction of  
ensemble  
members in  
agreement an  
event is going to  
occur. Can be  
thought of as  
confidence an  
event will  
happen.



Event not  
predictable at  
this level of  
localisation

POD =  
Probability of  
Detection  
(fraction of  
events of this  
size detected in  
advance)

How long in the  
future



**WEATHER DATA**

Should have a  
probability attached  
to it.

**WEATHER DATA  
TYPES**

Will be able to be compared  
for  
“Reliability”  
AND  
“Probability of Detection”

**ENGINEERS**

Deterministic  
modelling doesn't  
work for extreme  
events

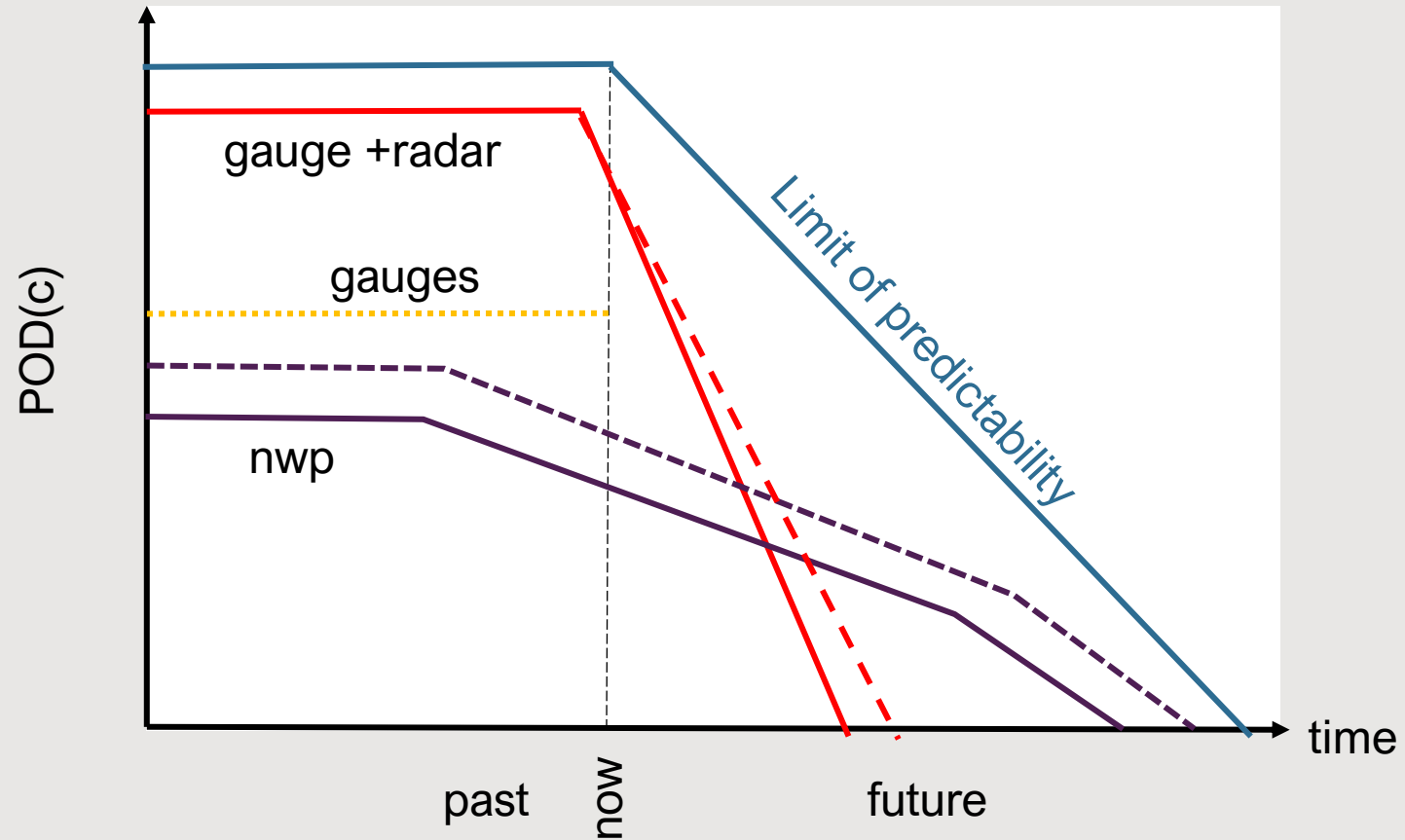
**GOOD NEWS**

Deterministic models  
can be run  
probabilistically.





# Predictability of the Atmospheric State



after Austin et al 1987

