# EVIDENCE-BASED DECISION MAKING AT HEALTHY WATERS:

## RAINFALL FORECASTING SKILL ASSESSMENT FRAMEWORK

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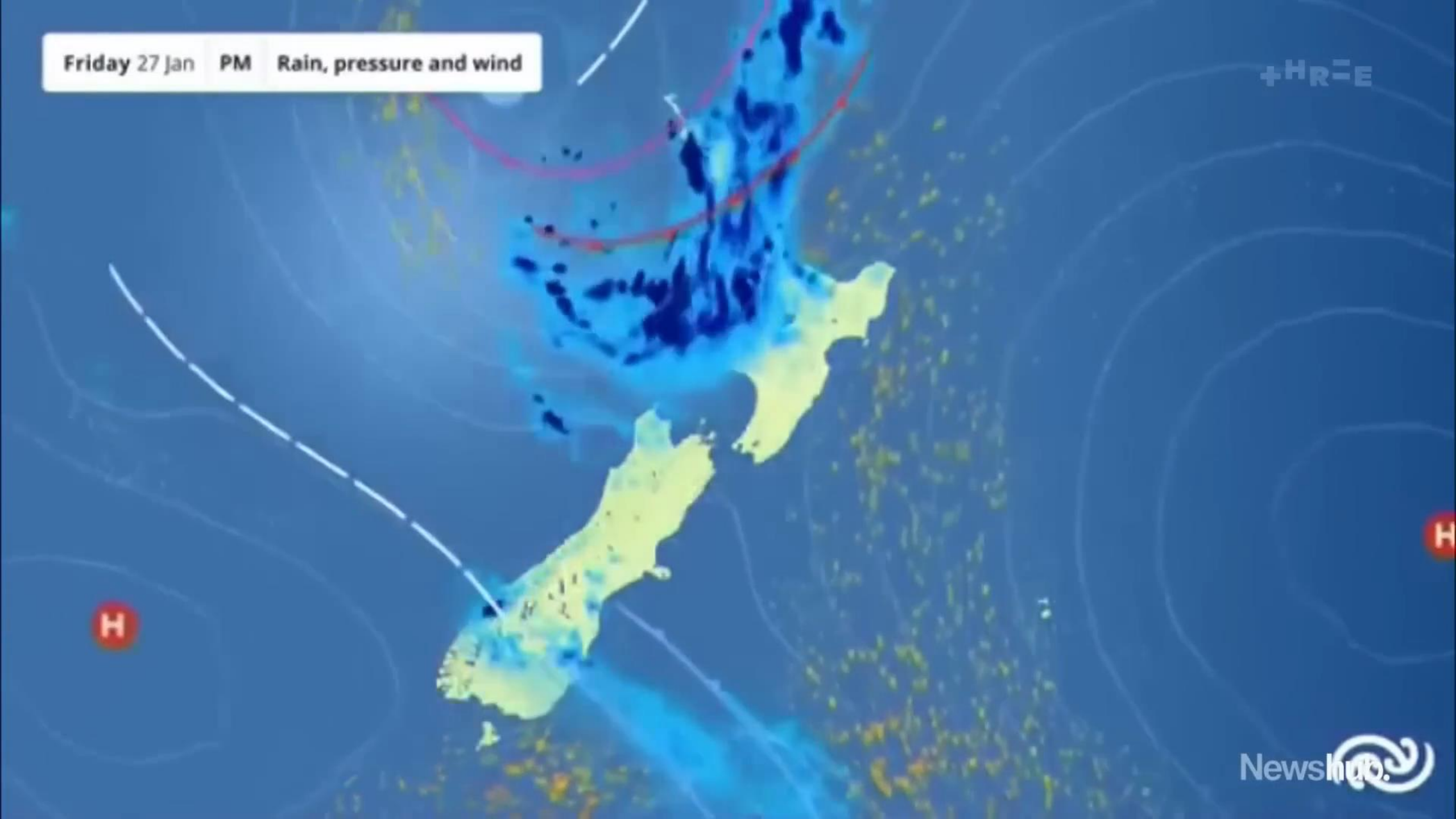
May 2023


Friday 27 Jan
PM
Rain, pressure and wind
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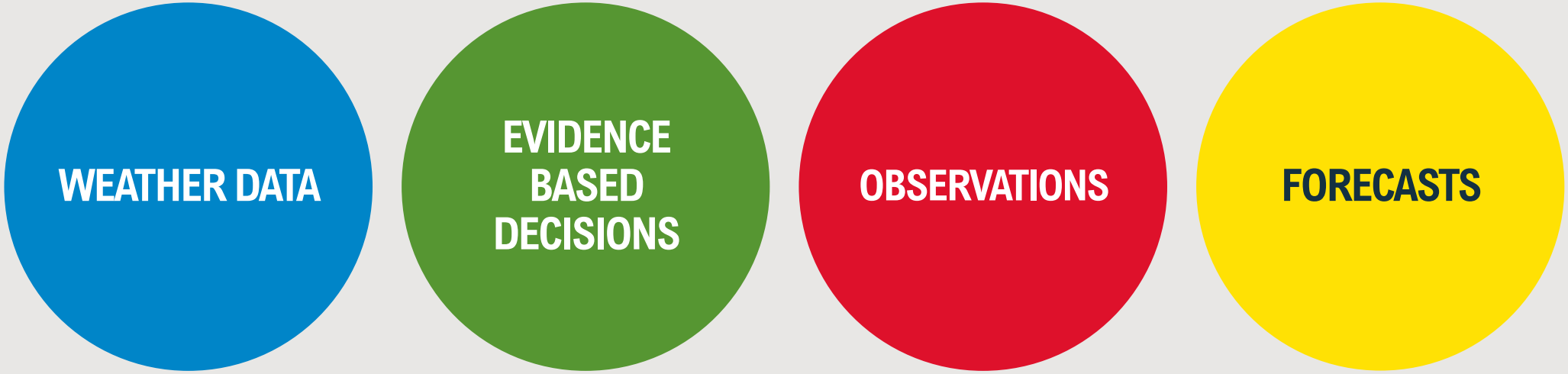
Newshub.

# Motivation




It's the core of everything we do

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

Measurements.

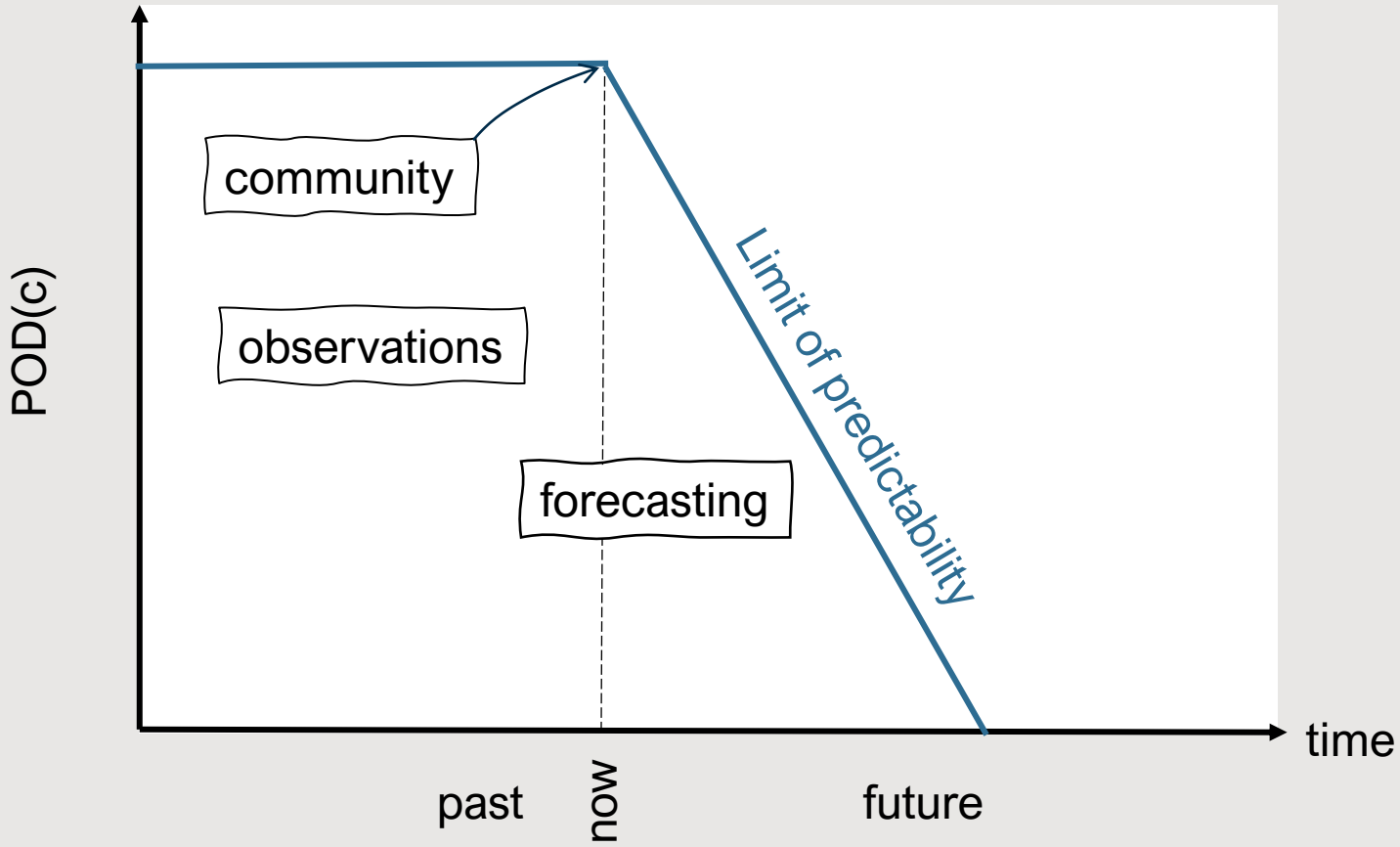
Not Measurements.

Models.

# DECISION MAKING PROCESSES

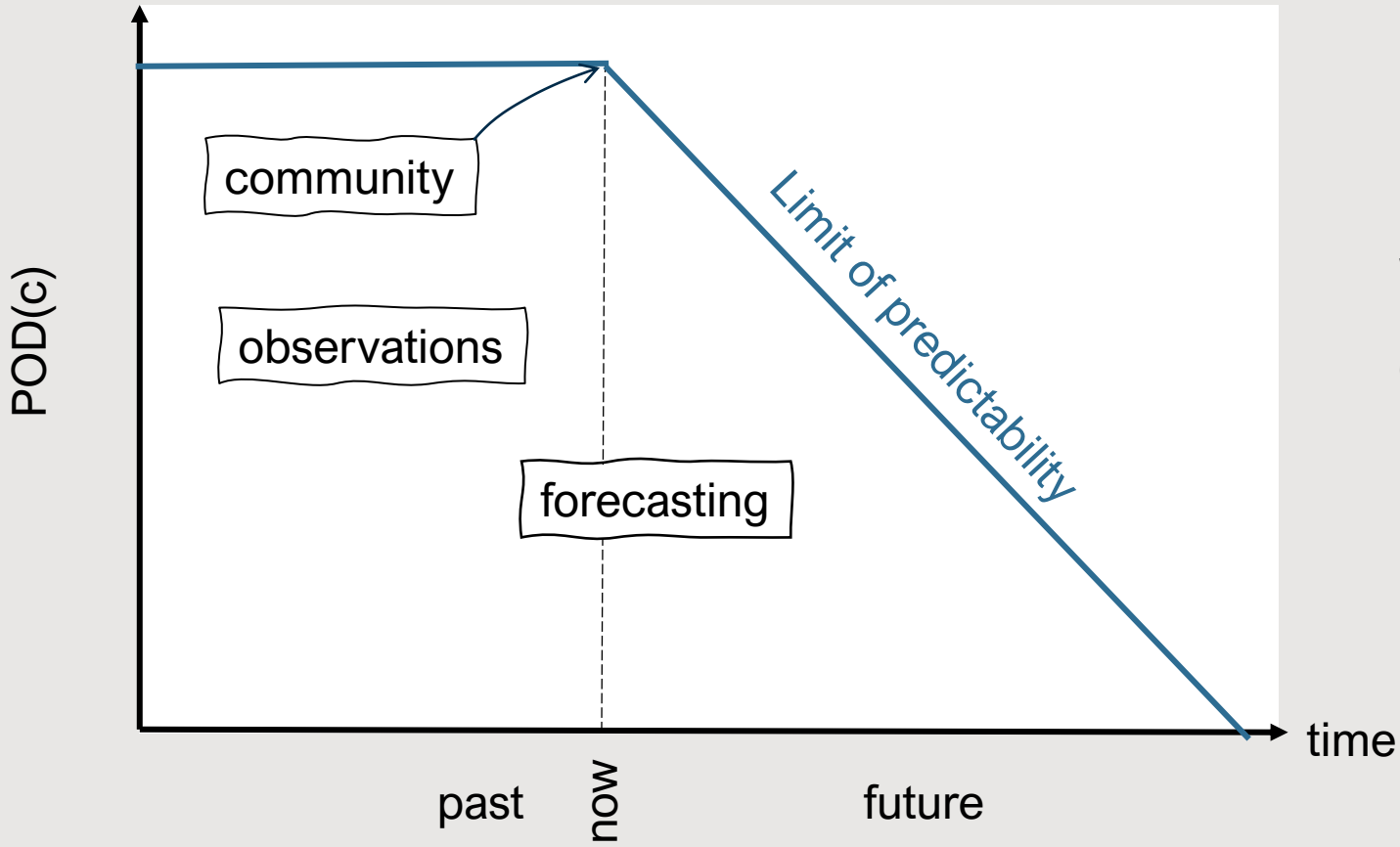
- What is “Weather Data”?
- Having decided what it is, how can me estimate our confidence in it?
- Can we make good, or better, decisions about managing risk, and about investments?

# Predictability of the Atmospheric State




after Austin et al 1987

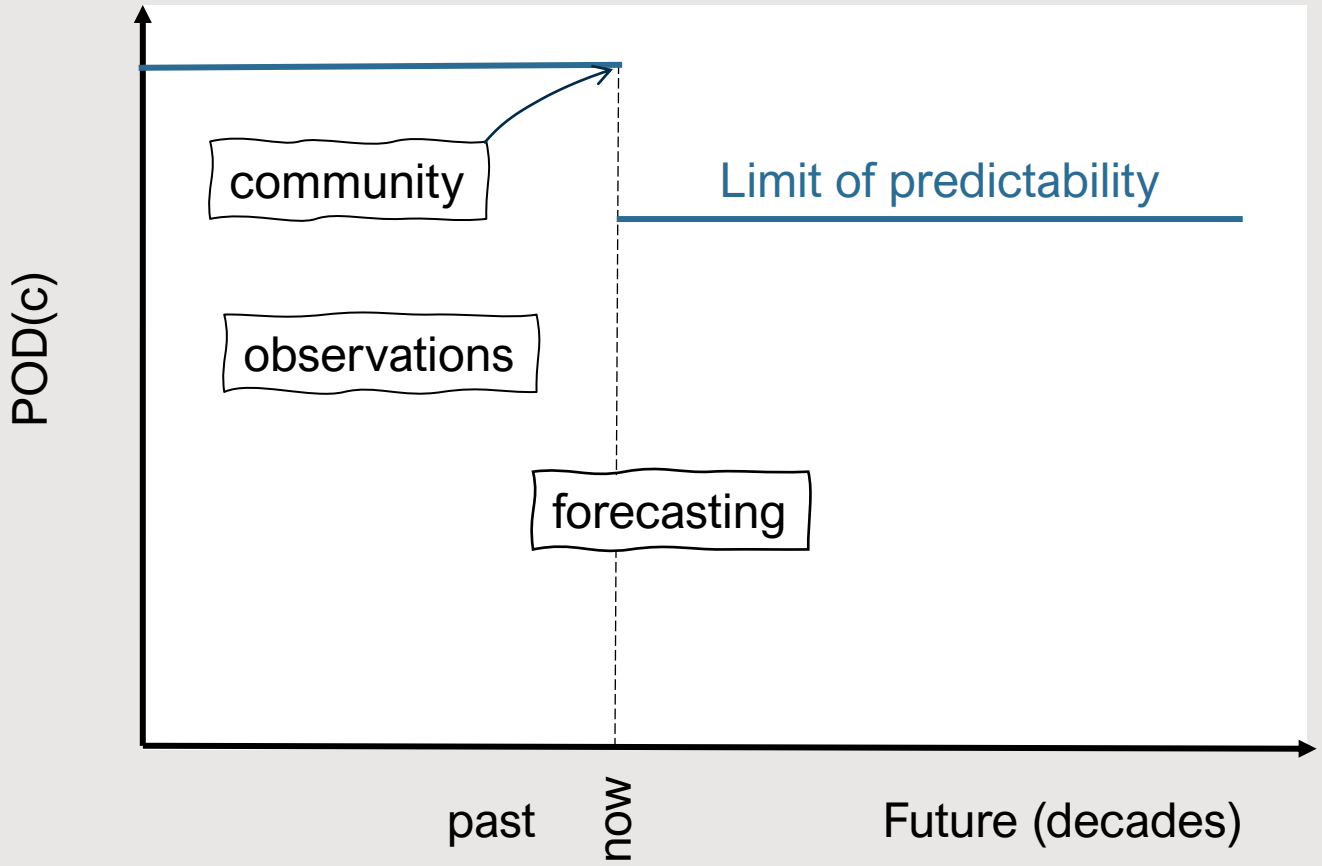
# Predictability of the Atmospheric State




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

after Austin et al 1987

# Predictability of the Atmospheric State



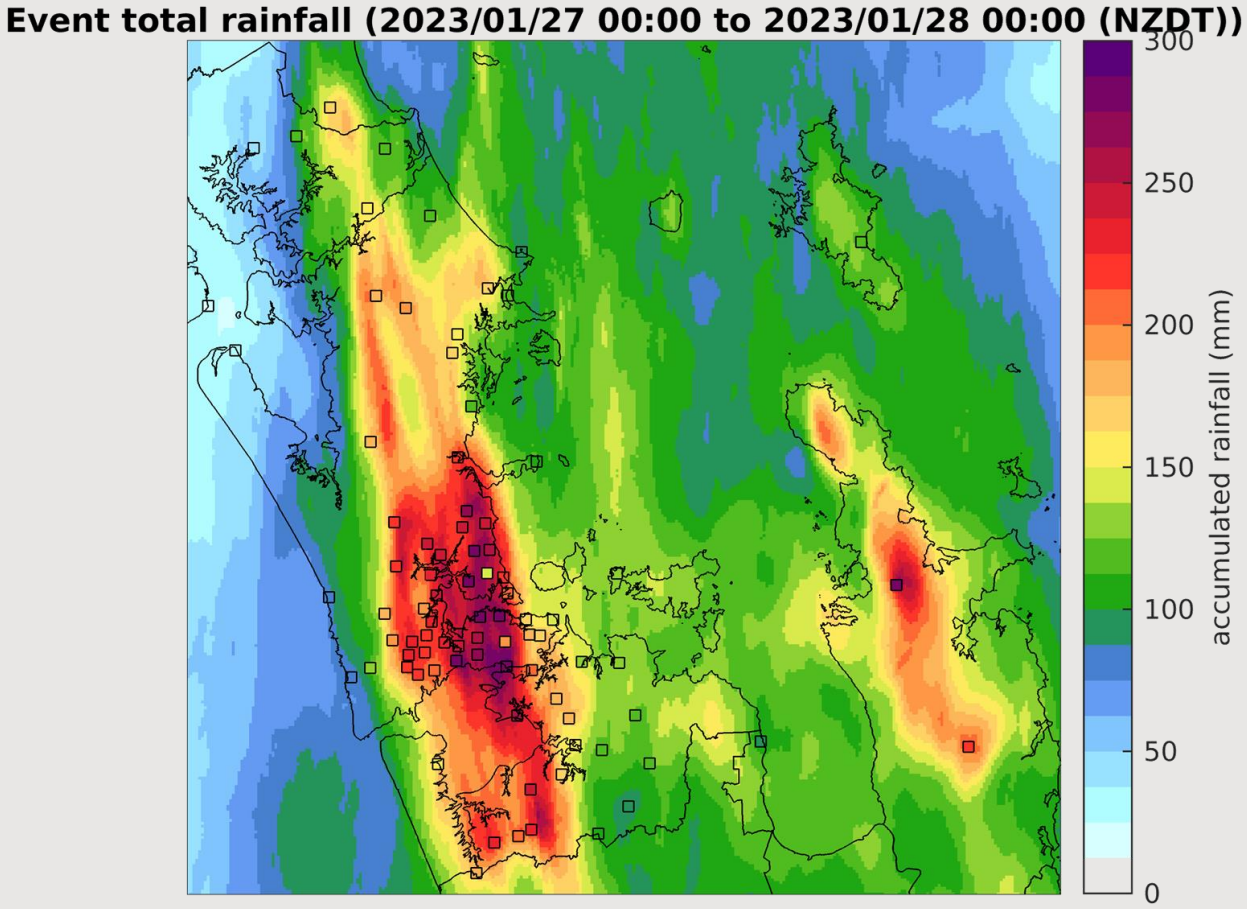

Solutions:
Climate Scales
(Planning Rules)

after Austin et al 1987

# Weather Data systems at Healthy Waters

## Observations (**Now**)

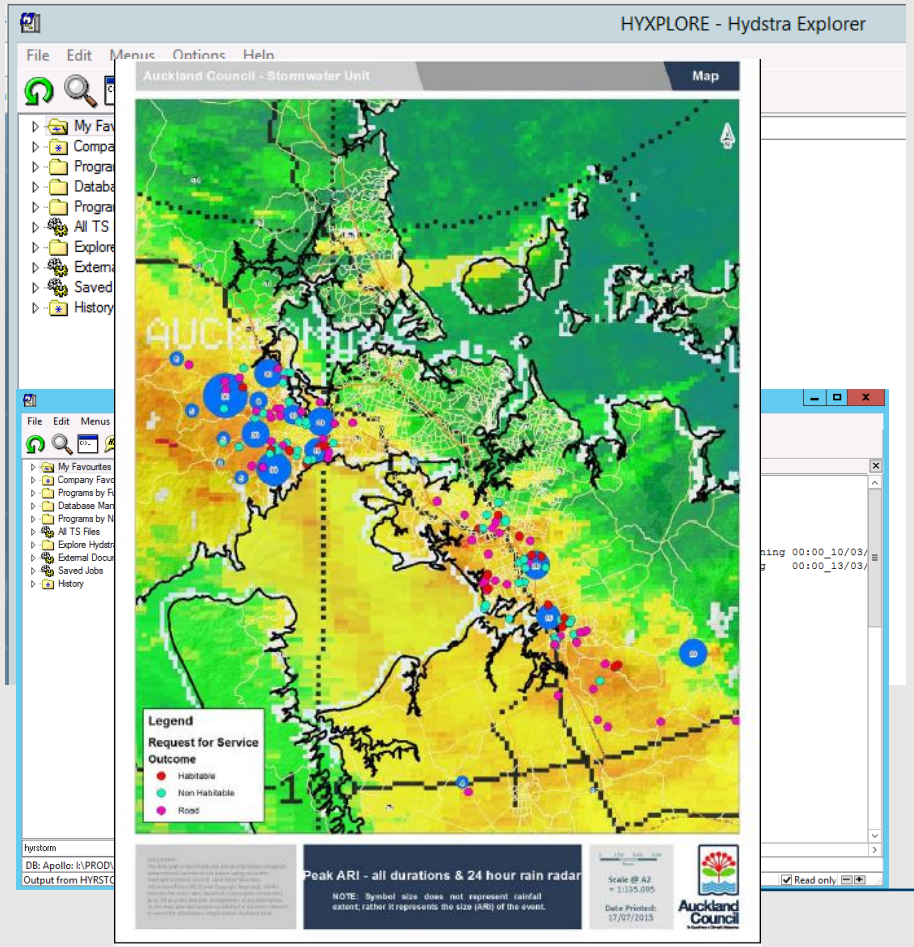
In-situ and remote instrument observations of rainfall (rain gauges, radar etc.)

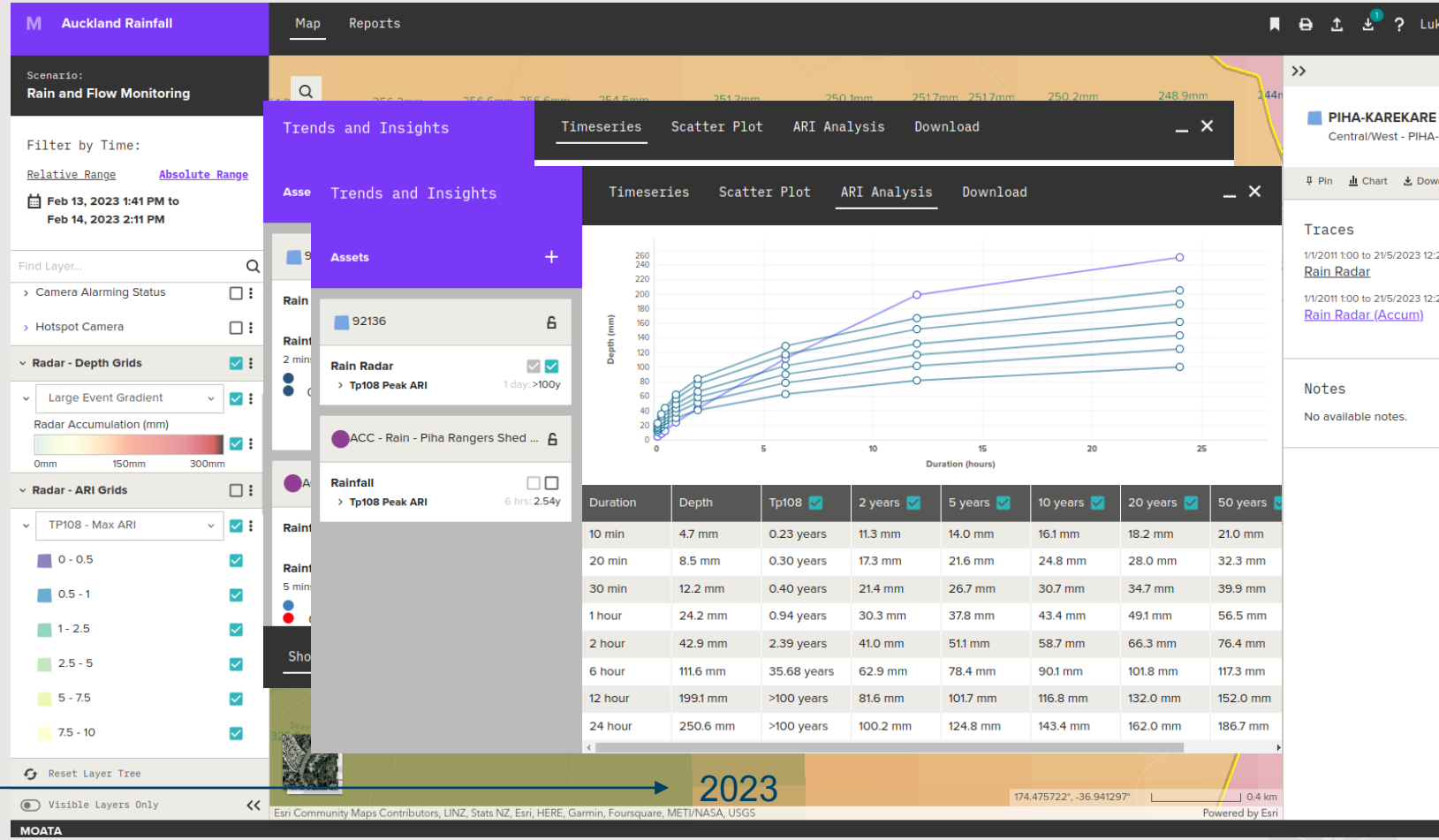



Radar and Gauge are combined in a Rainfall Analysis System (RAS)

# Weather Data systems at Healthy Waters

## Observations (**Now**)

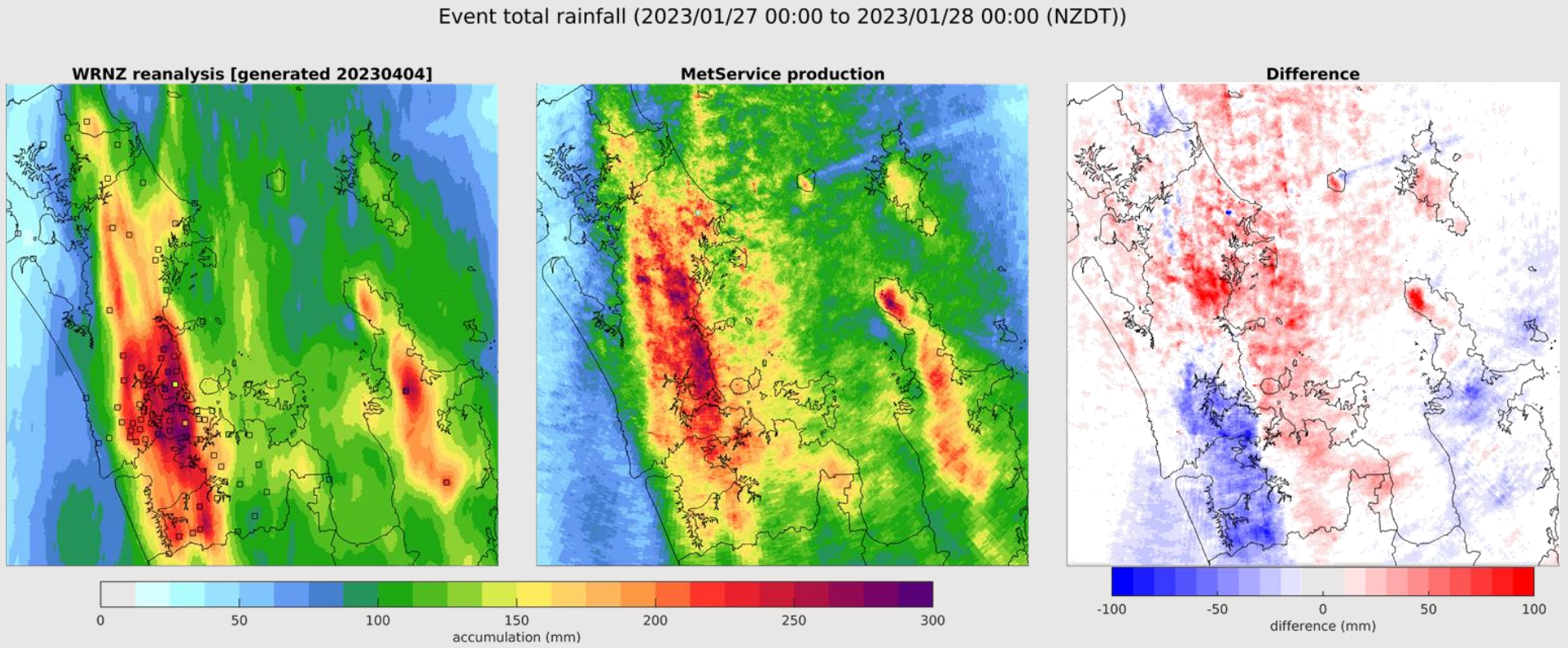


# The RAINFALL ANALYSIS SYSTEM required a significant investment.

## RIGOUR

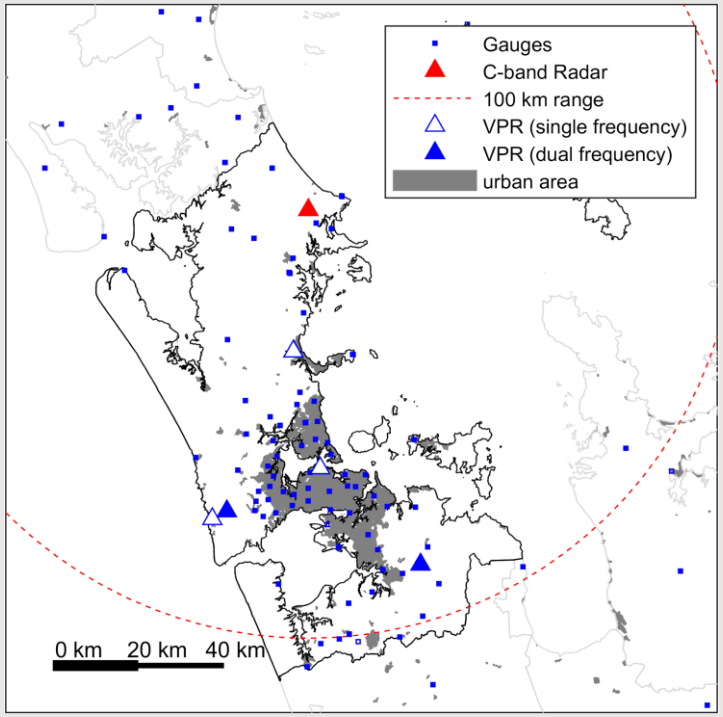
- Quality level of the MetService radar-derived rainfall analysis confounds any attempt to use the data in engineering / EWS applications .
- (discussed in our earlier Stormwater Conference talks!)
- Contemporaneous example:



## The RAINFALL ANALYSIS SYSTEM required a significant investment.

# PATHWAYS TO IMPROVMENTS

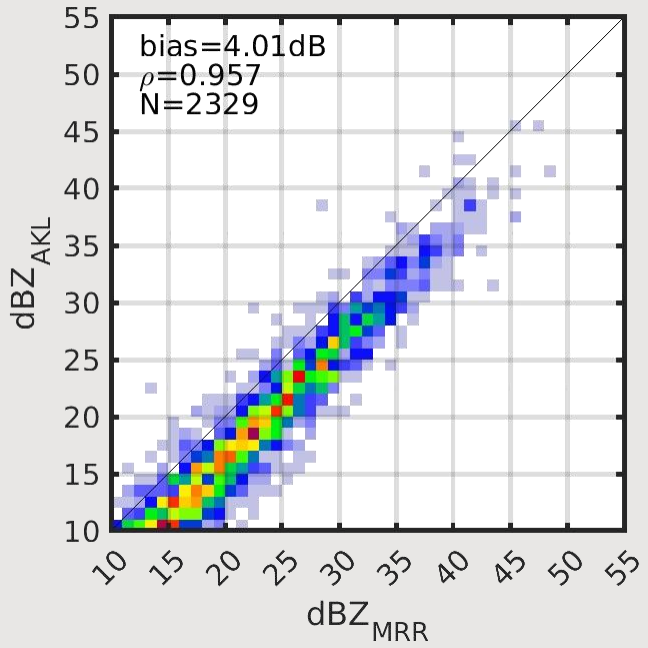
- An investment in science was required to realise a useable Weather Data type from radar

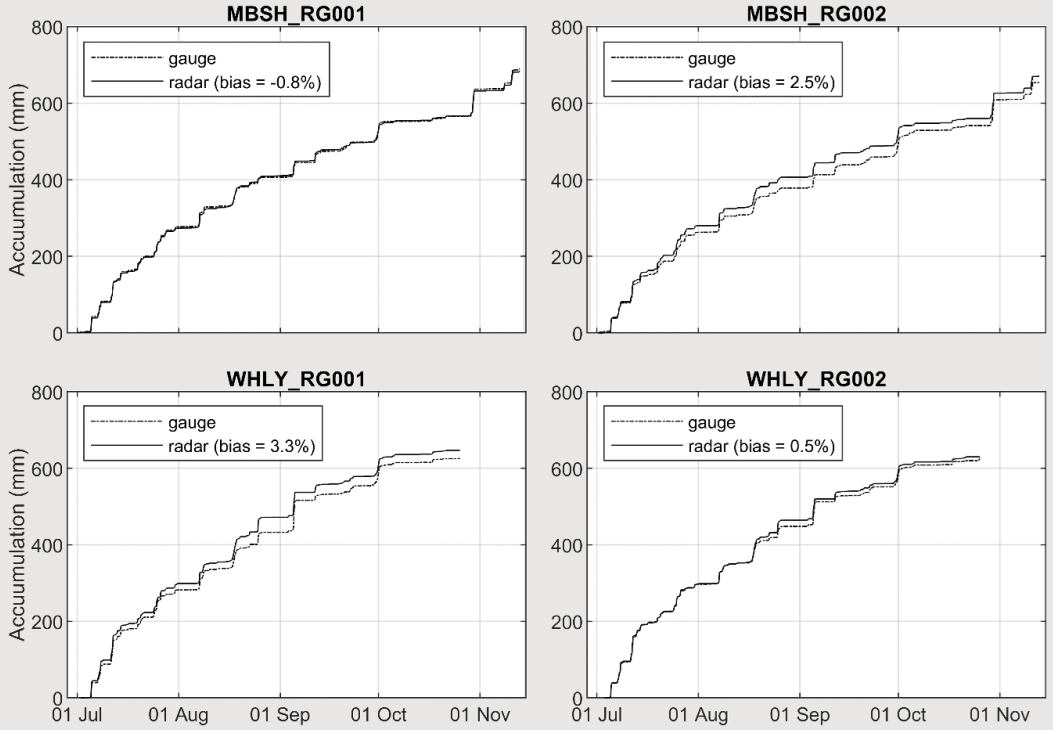


## The RAINFALL ANALYSIS SYSTEM required a significant investment.

# 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

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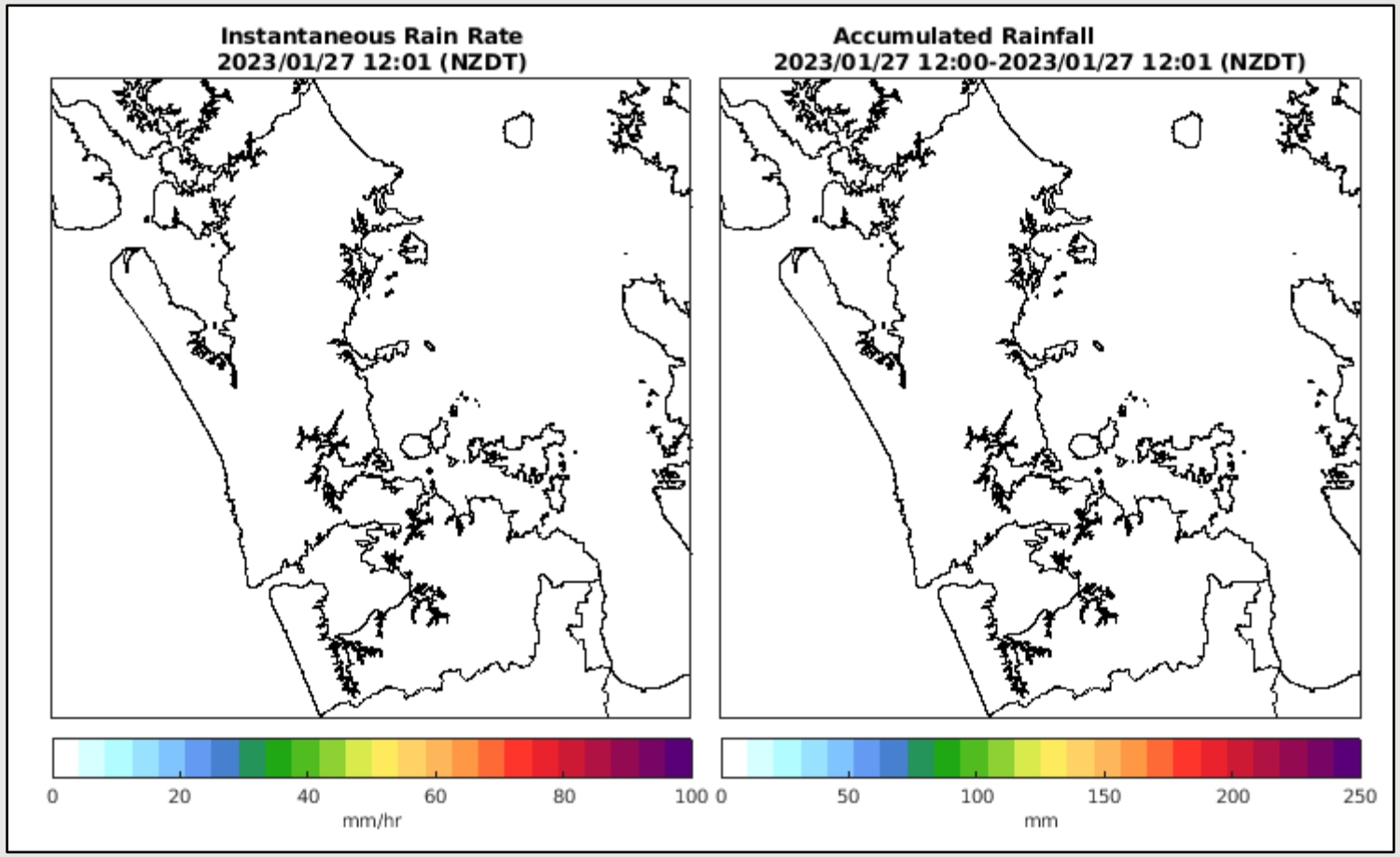

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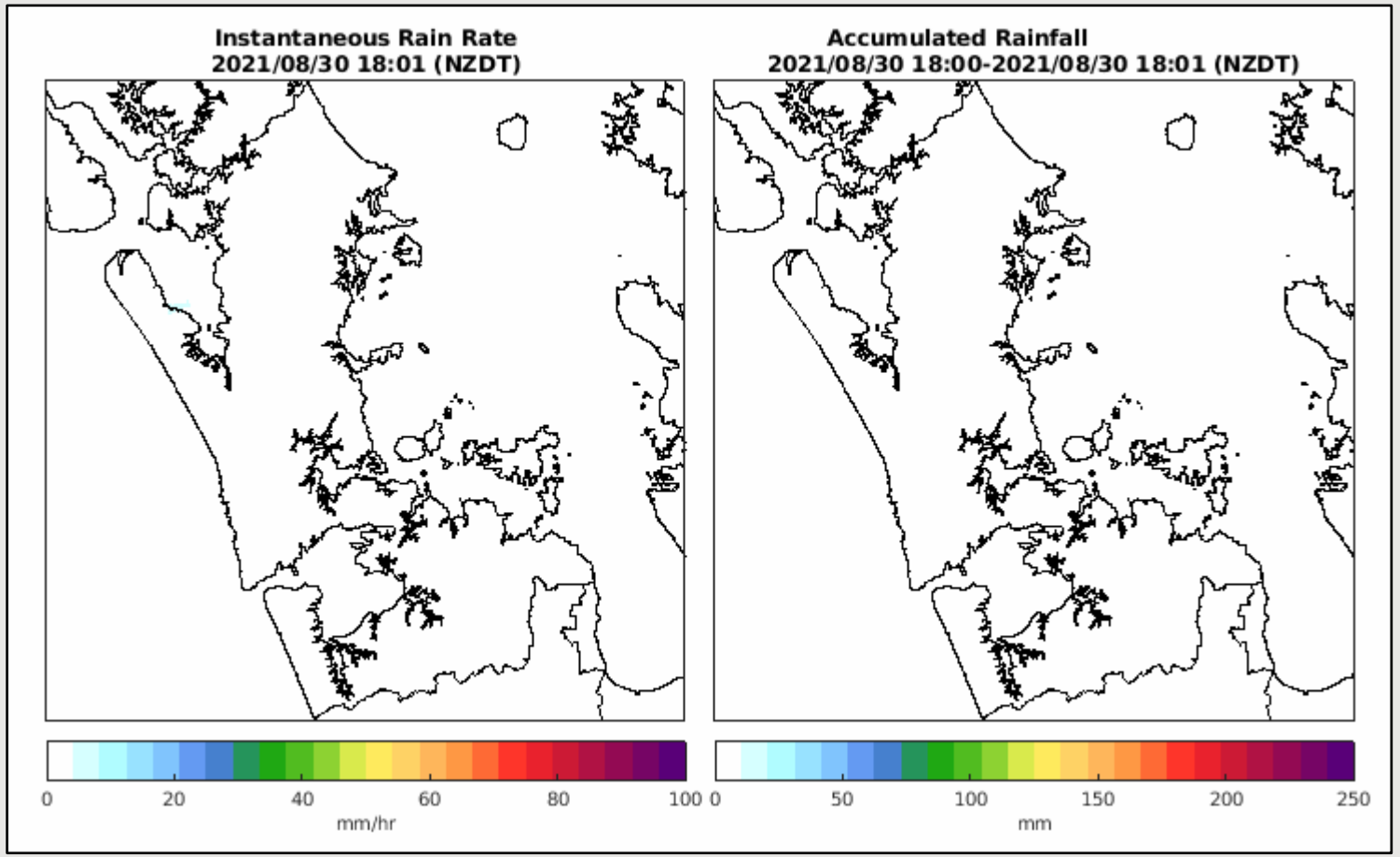
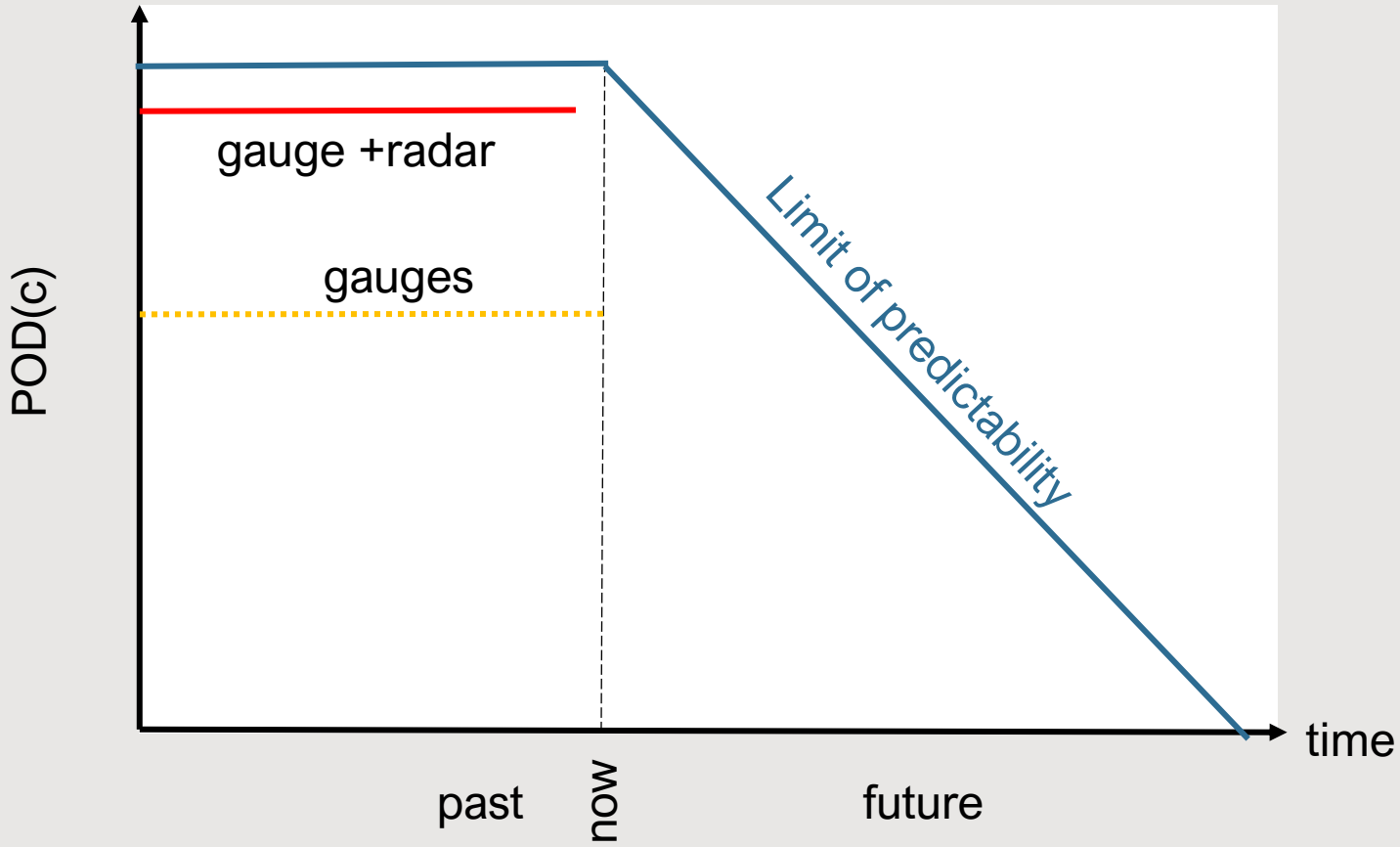
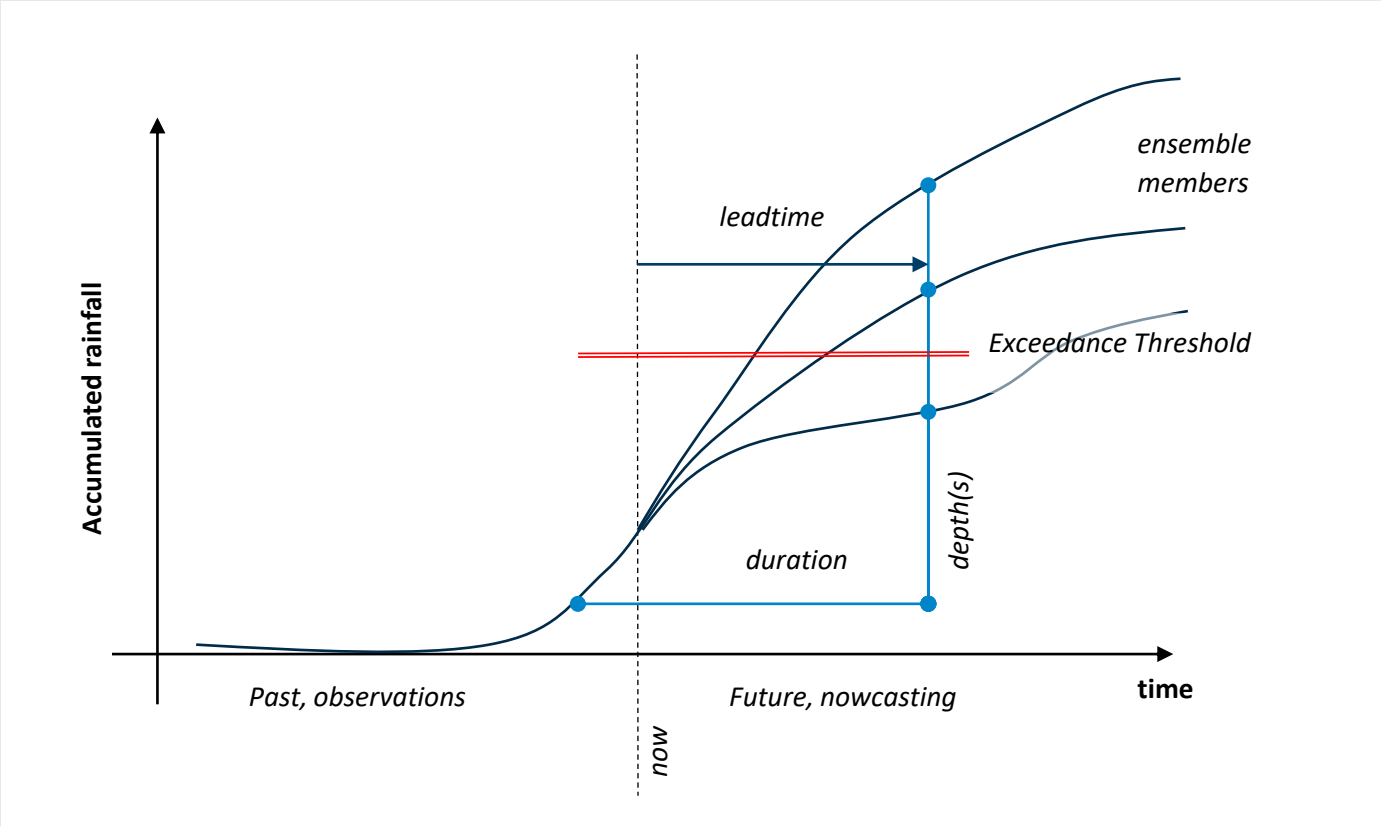


# Predictability of the Atmospheric State




after Austin et al 1987

# OBSERVATIONS ARE INSUFFICIENT TO MANAGE RISK

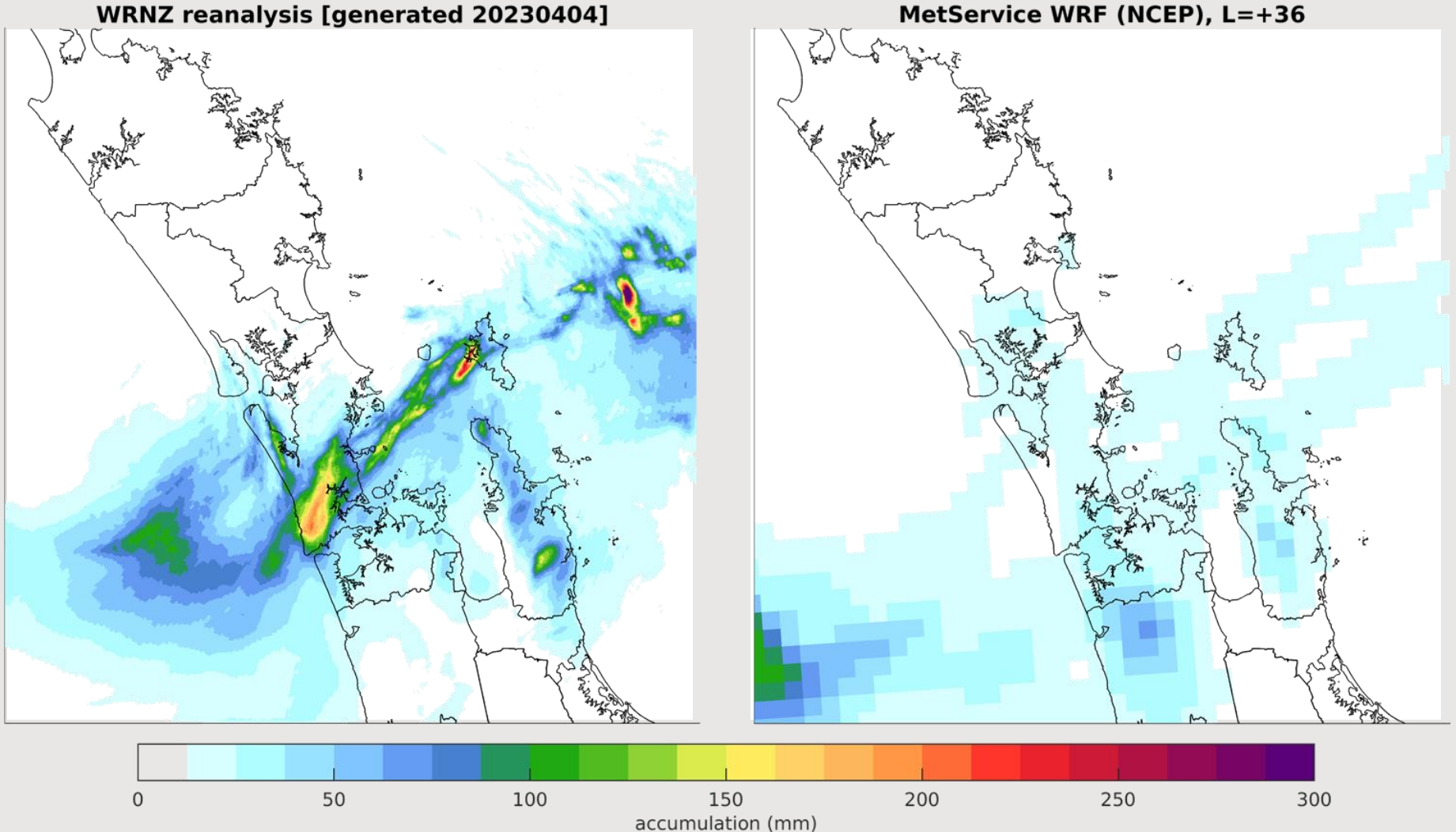



- Probabilistic Forecasting

# Weather Data systems at Healthy Waters

## NWP Forecasts (**Future**)

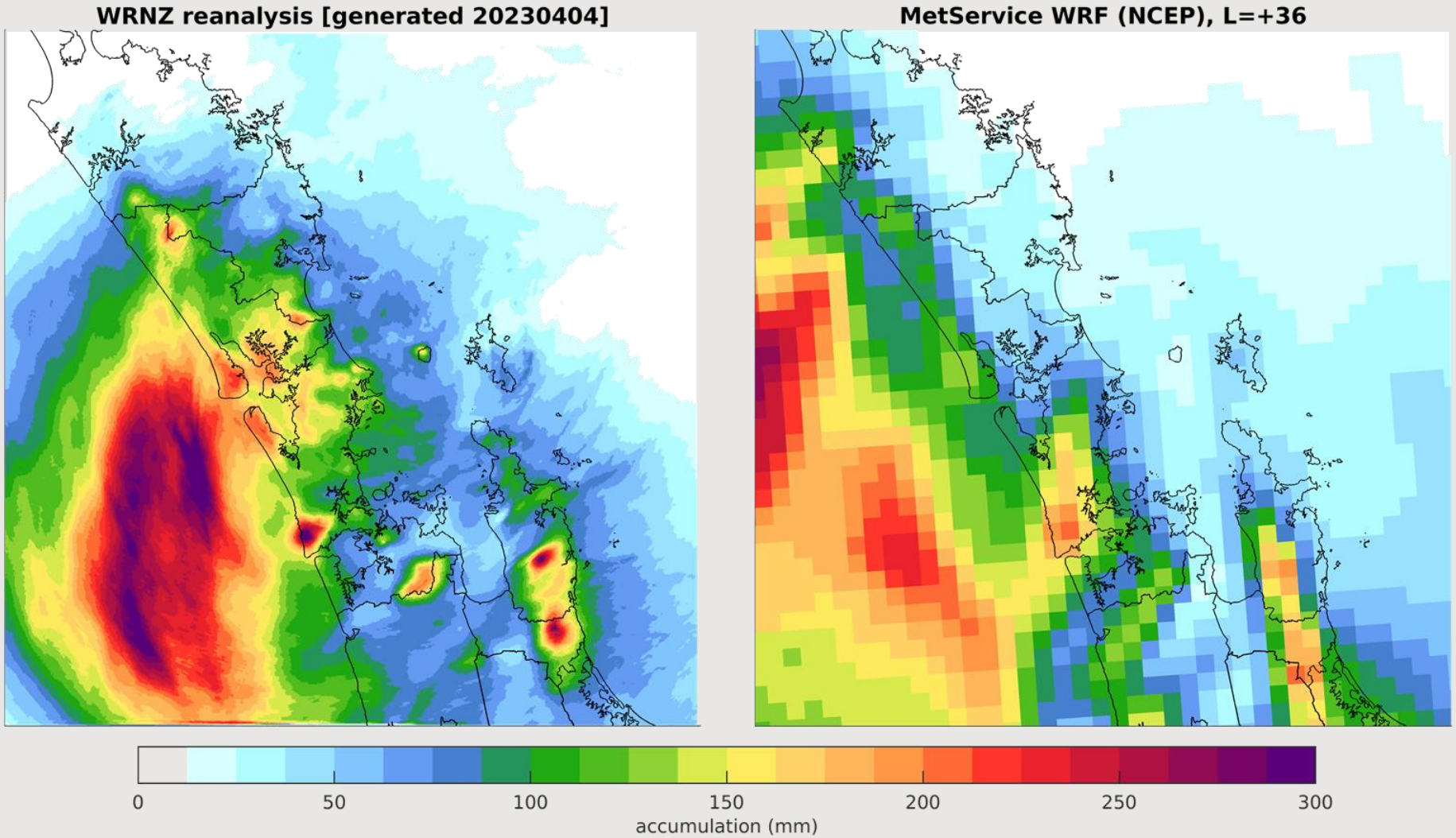
Event total rainfall (2021/08/30 12:00 to 2021/08/31 12:00



# Weather Data systems at Healthy Waters

## NWP Forecasts (**Future**)

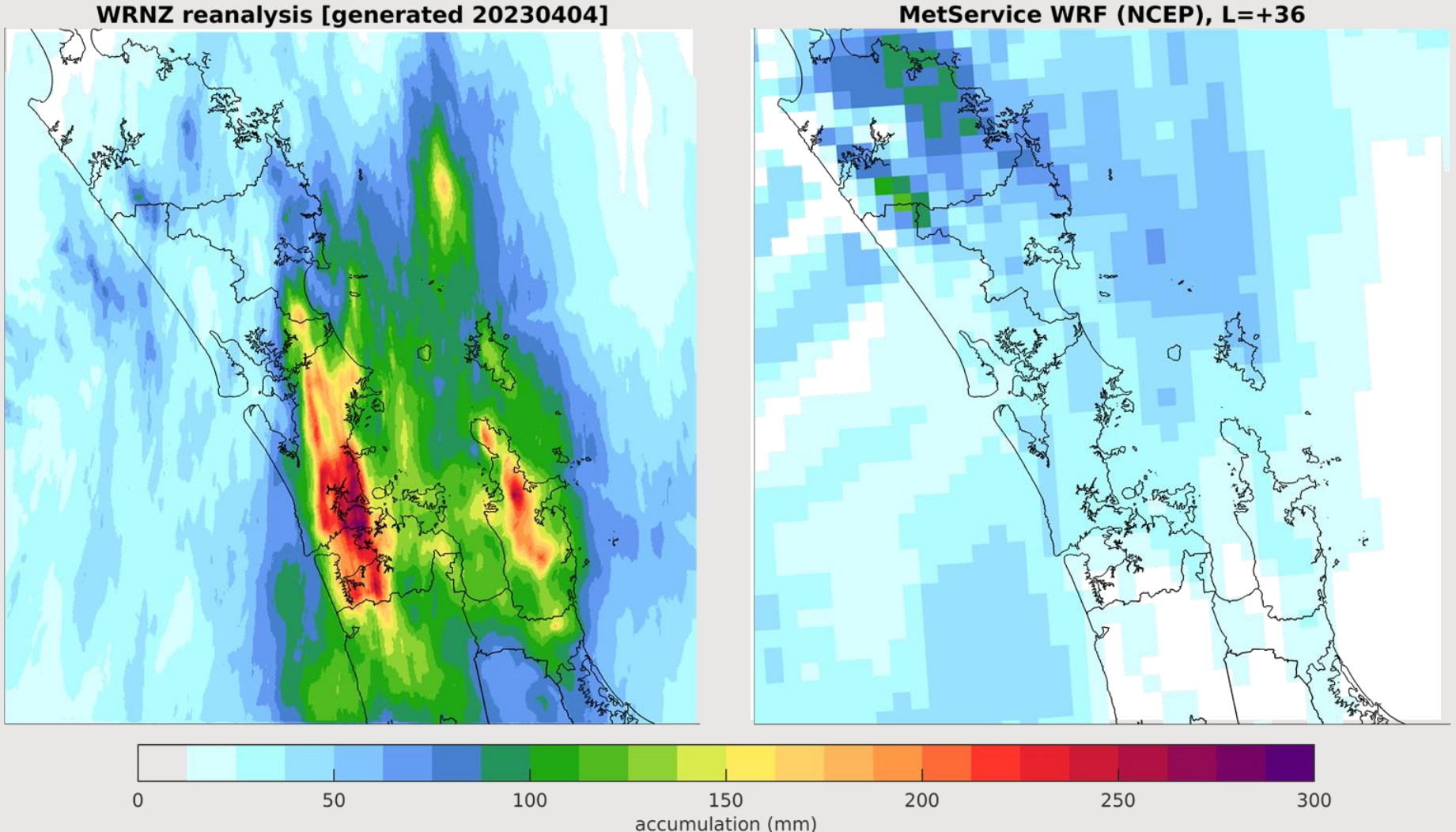
Event total rainfall (2023/02/13 13:00 to 2023/02/14 13:00



# Weather Data systems at Healthy Waters

## NWP Forecasts (**Future**)

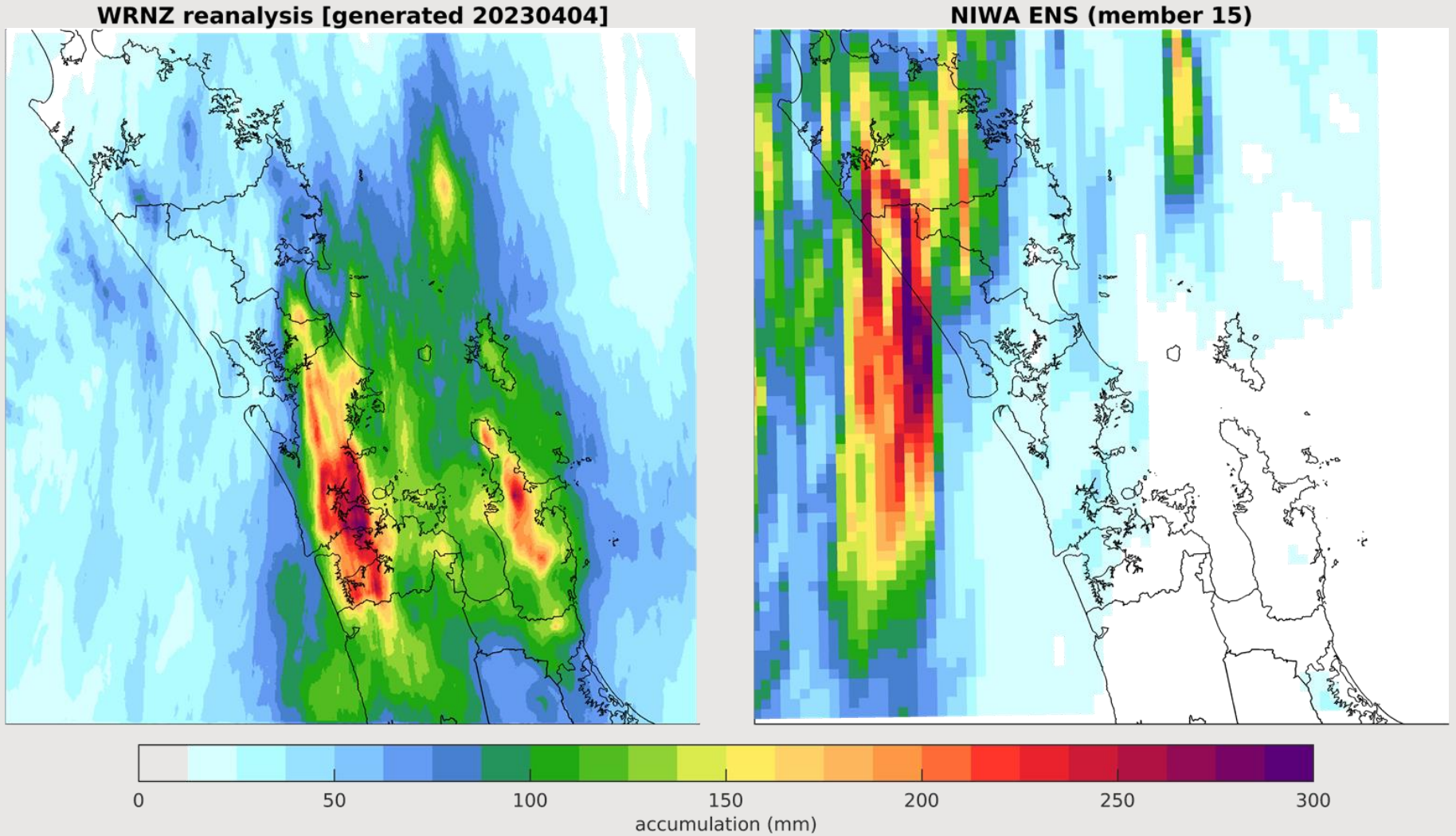
Event total rainfall (2023/01/27 00:00 to 2023/01/28 00:00



# Weather Data systems at Healthy Waters

## NWP Forecasts (**Future**)

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



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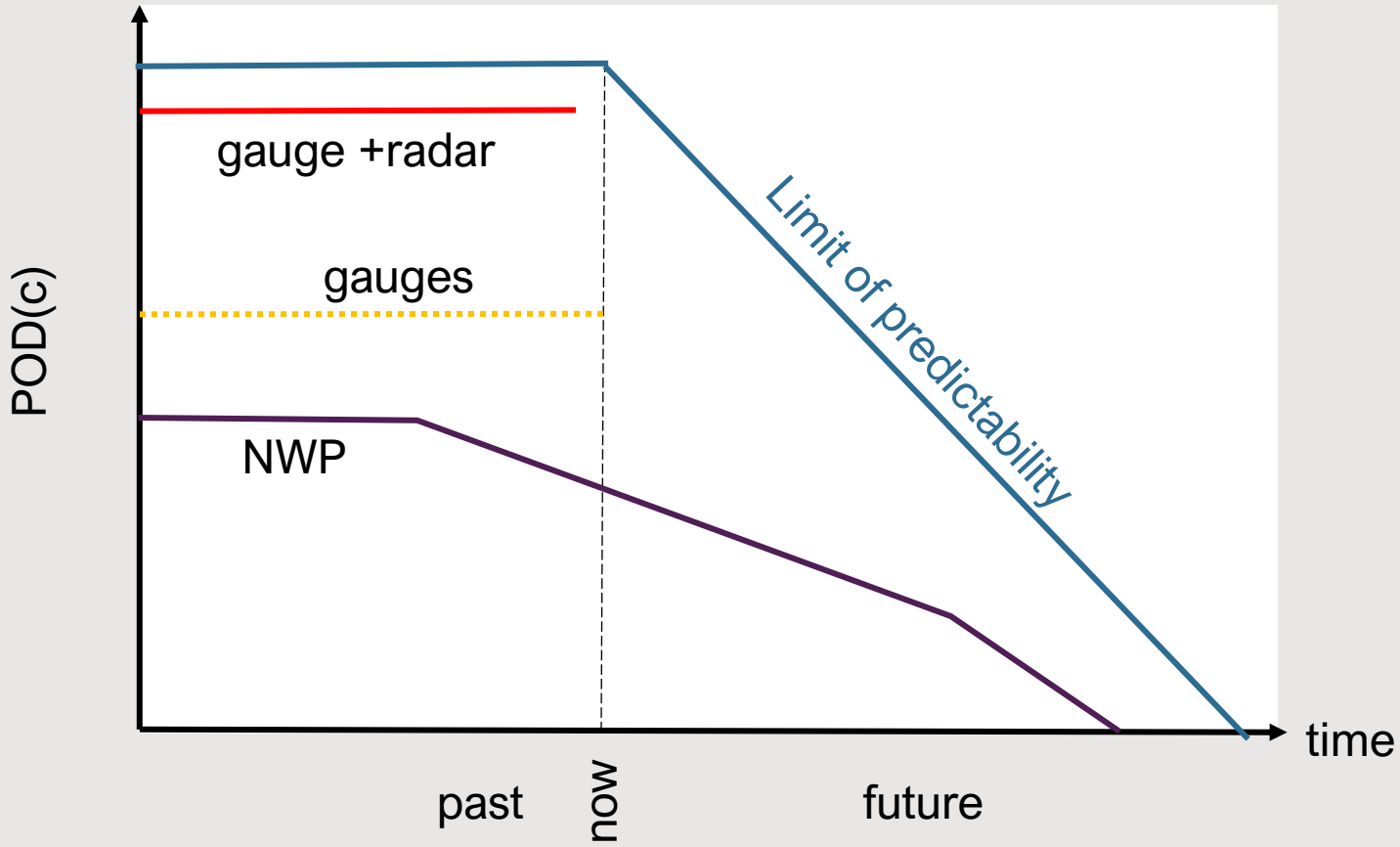
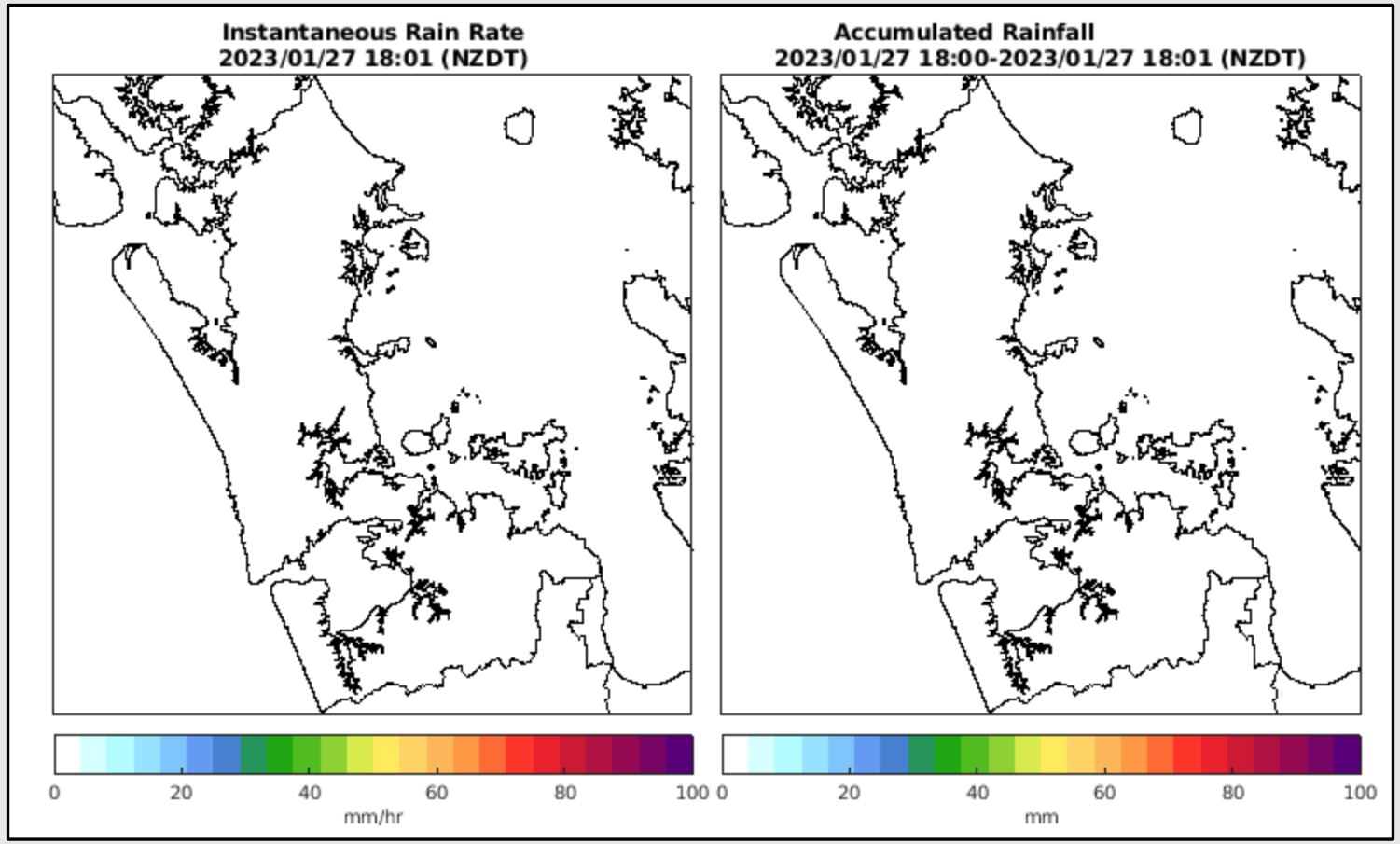



after Austin et al 1987

# Weather Data systems at Healthy Waters

## Nowcasting (Leadtime: hours … often <1!)



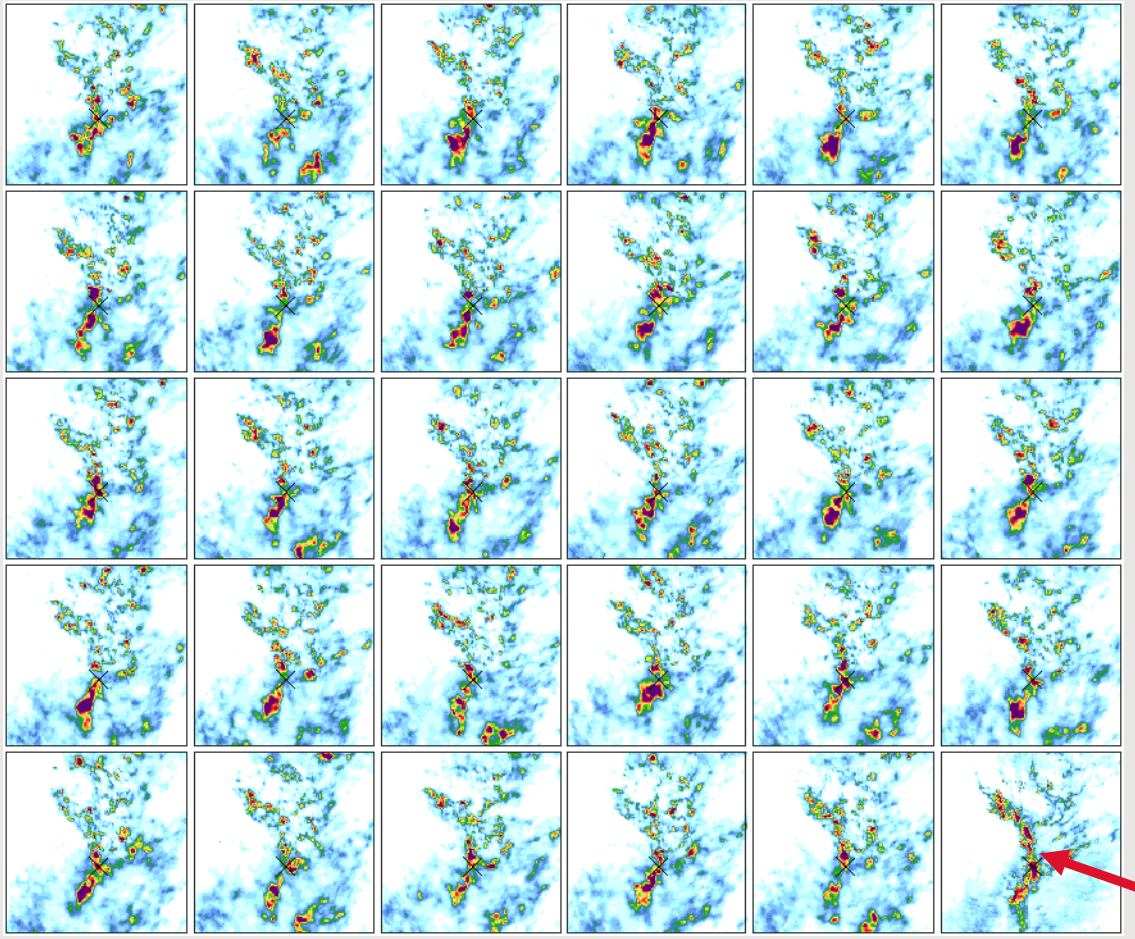
# Weather Data systems at Healthy Waters

## 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



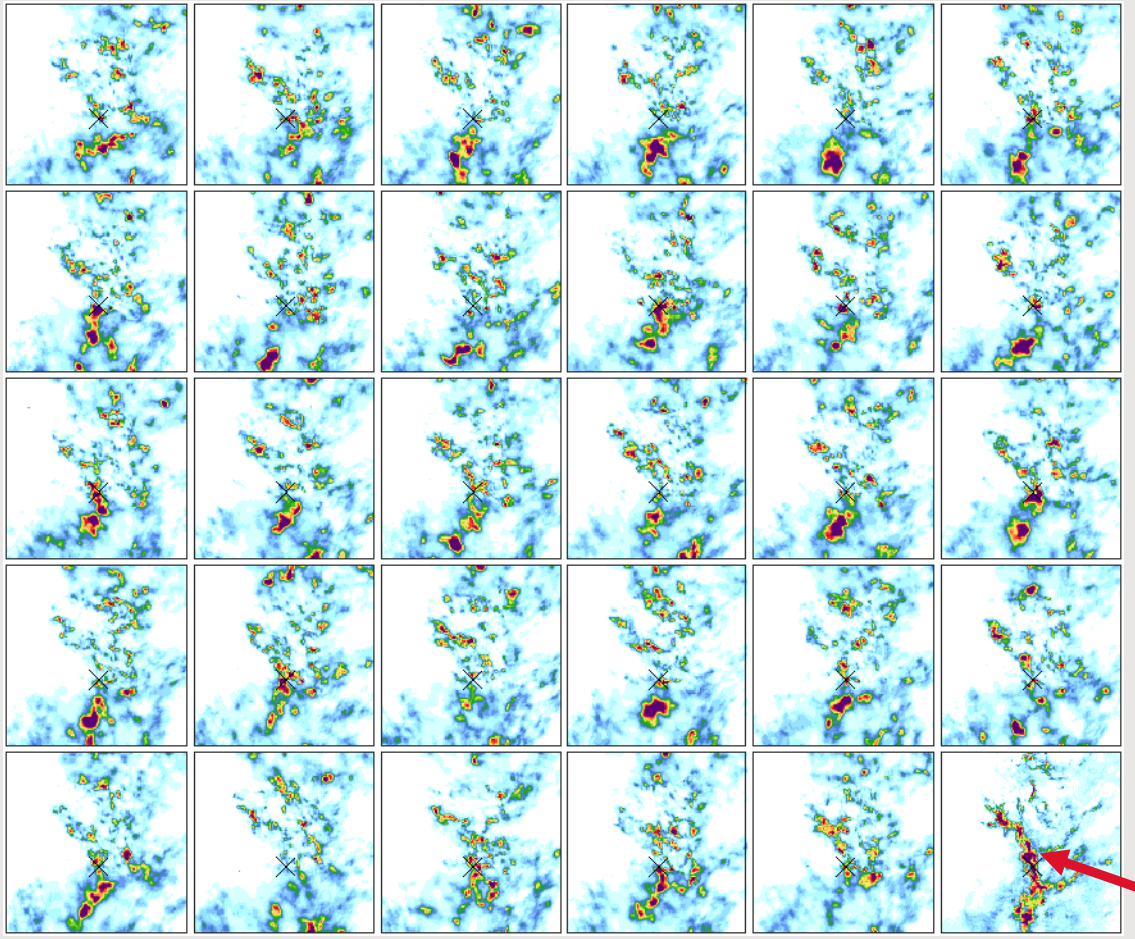
# Weather Data systems at Healthy Waters

## 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



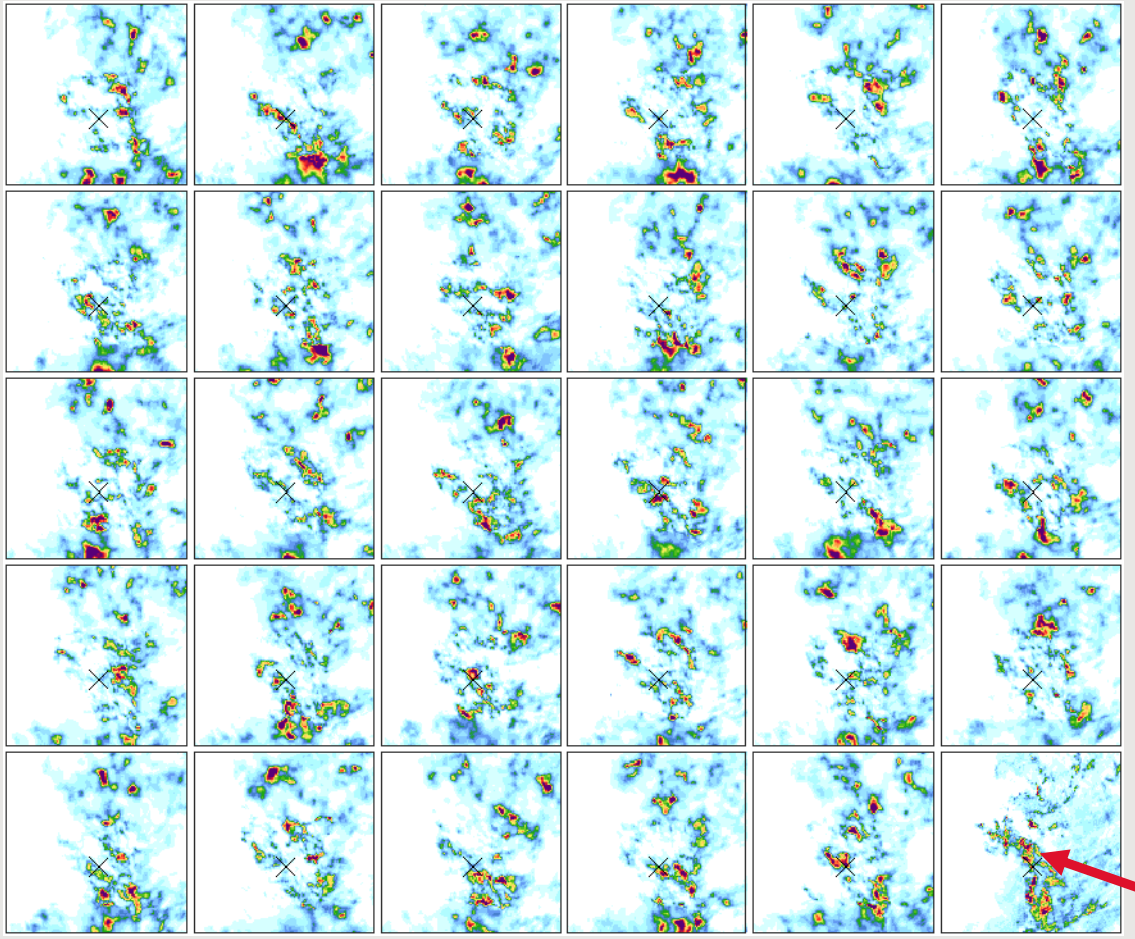
# Weather Data systems at Healthy Waters

## 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



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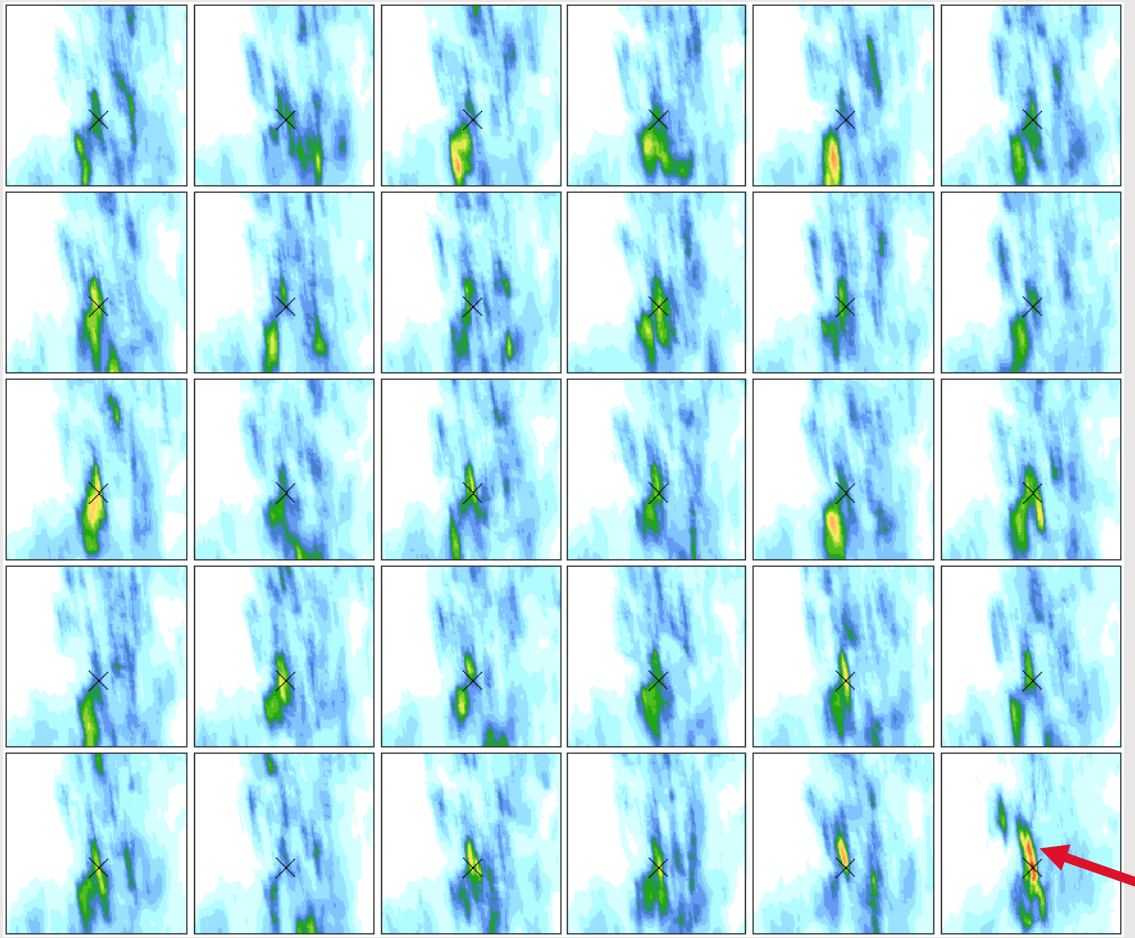

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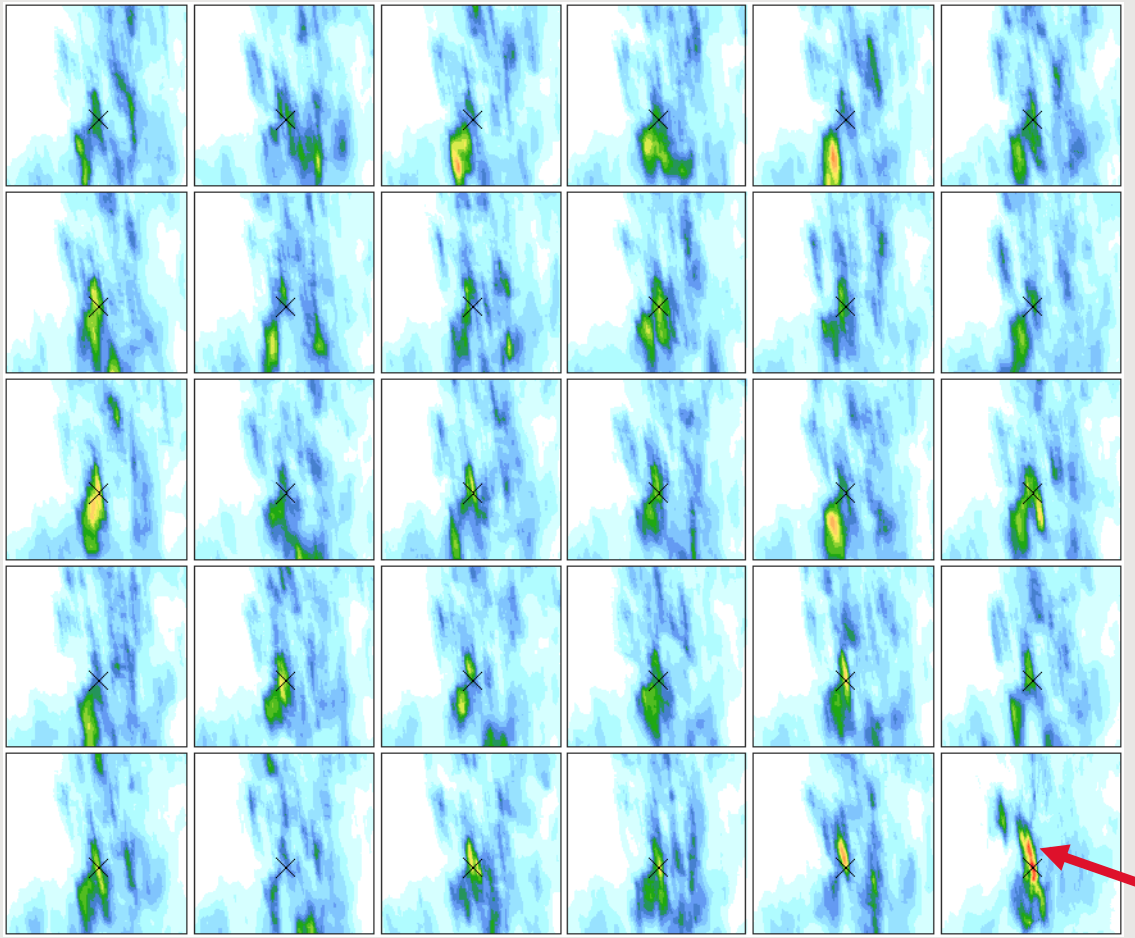

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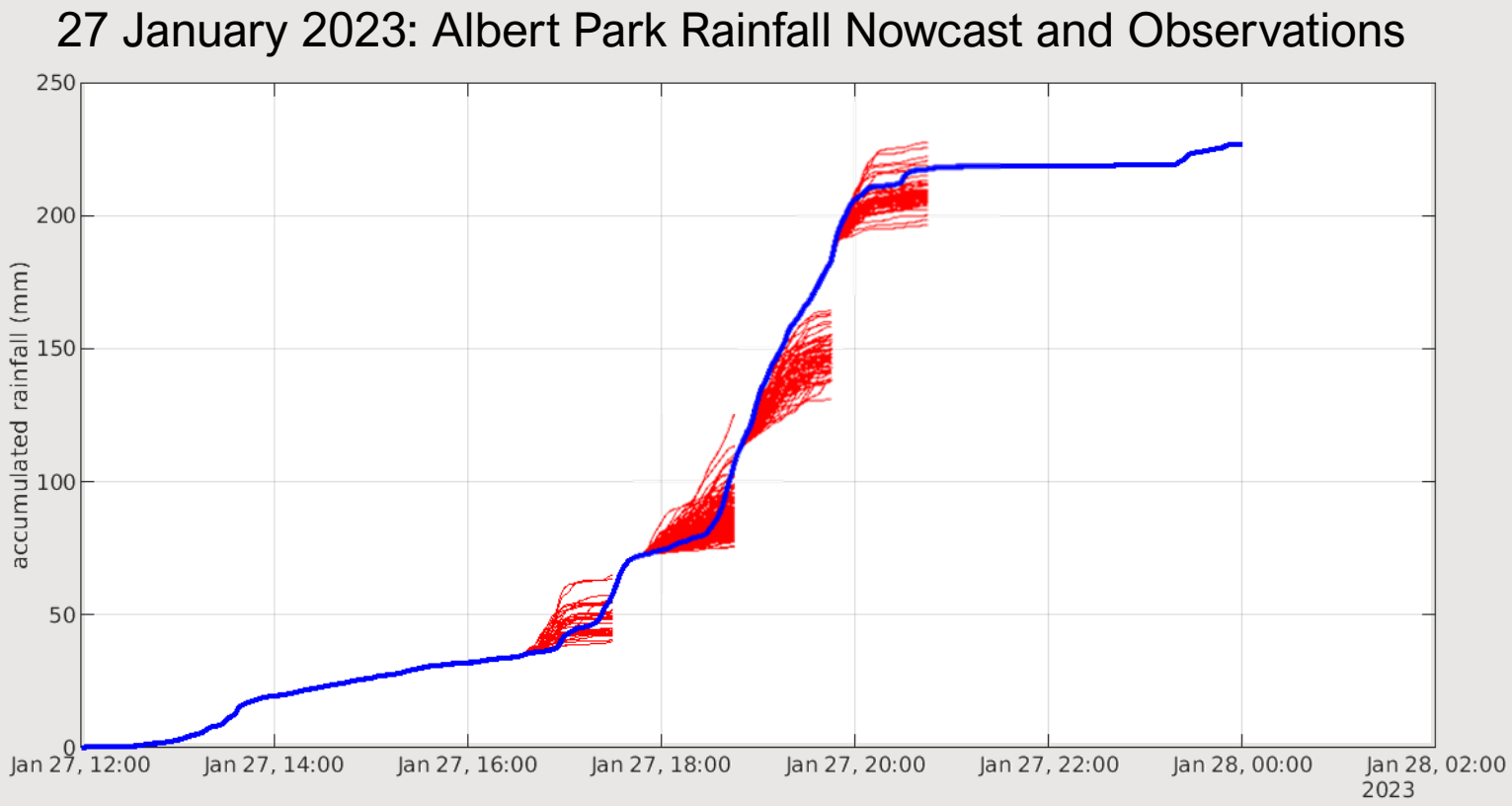
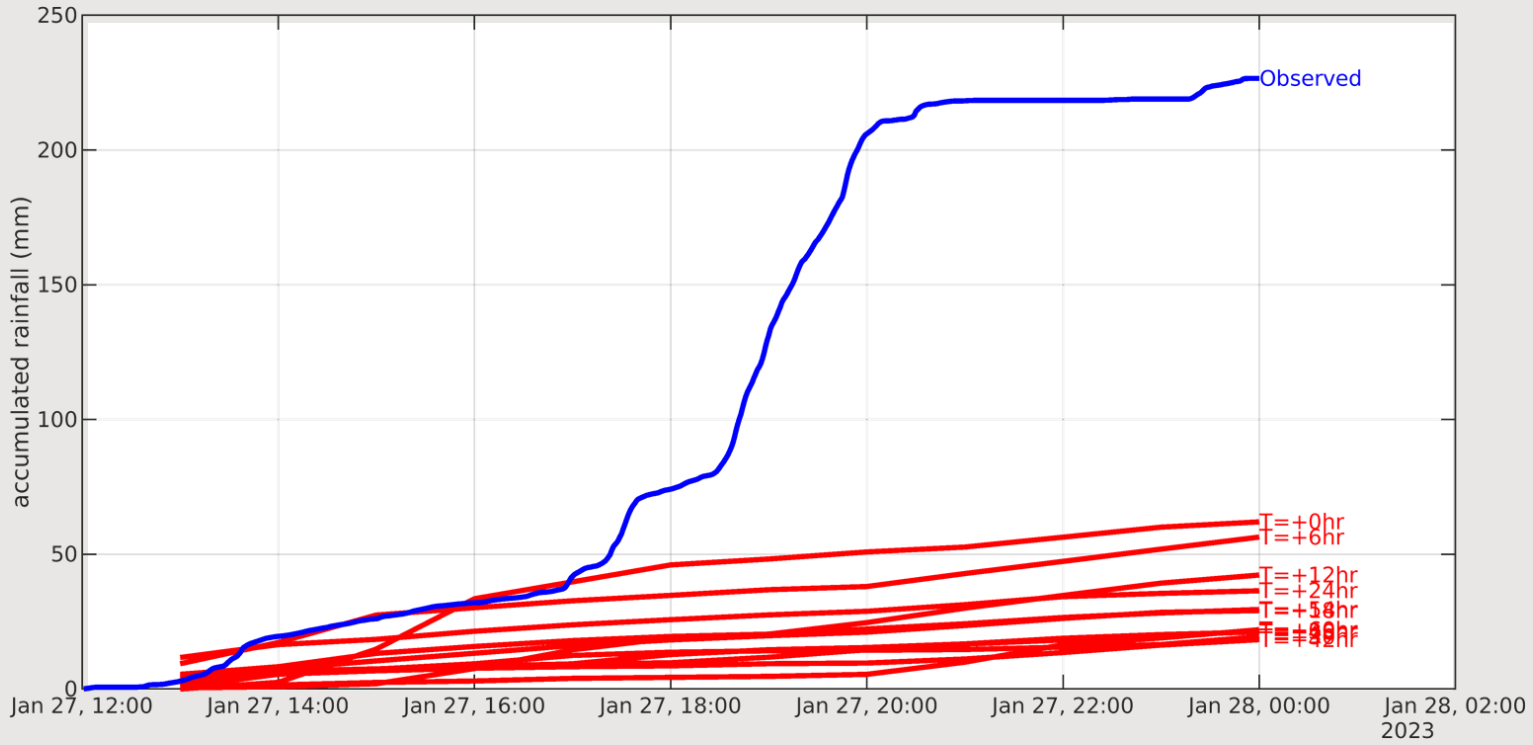


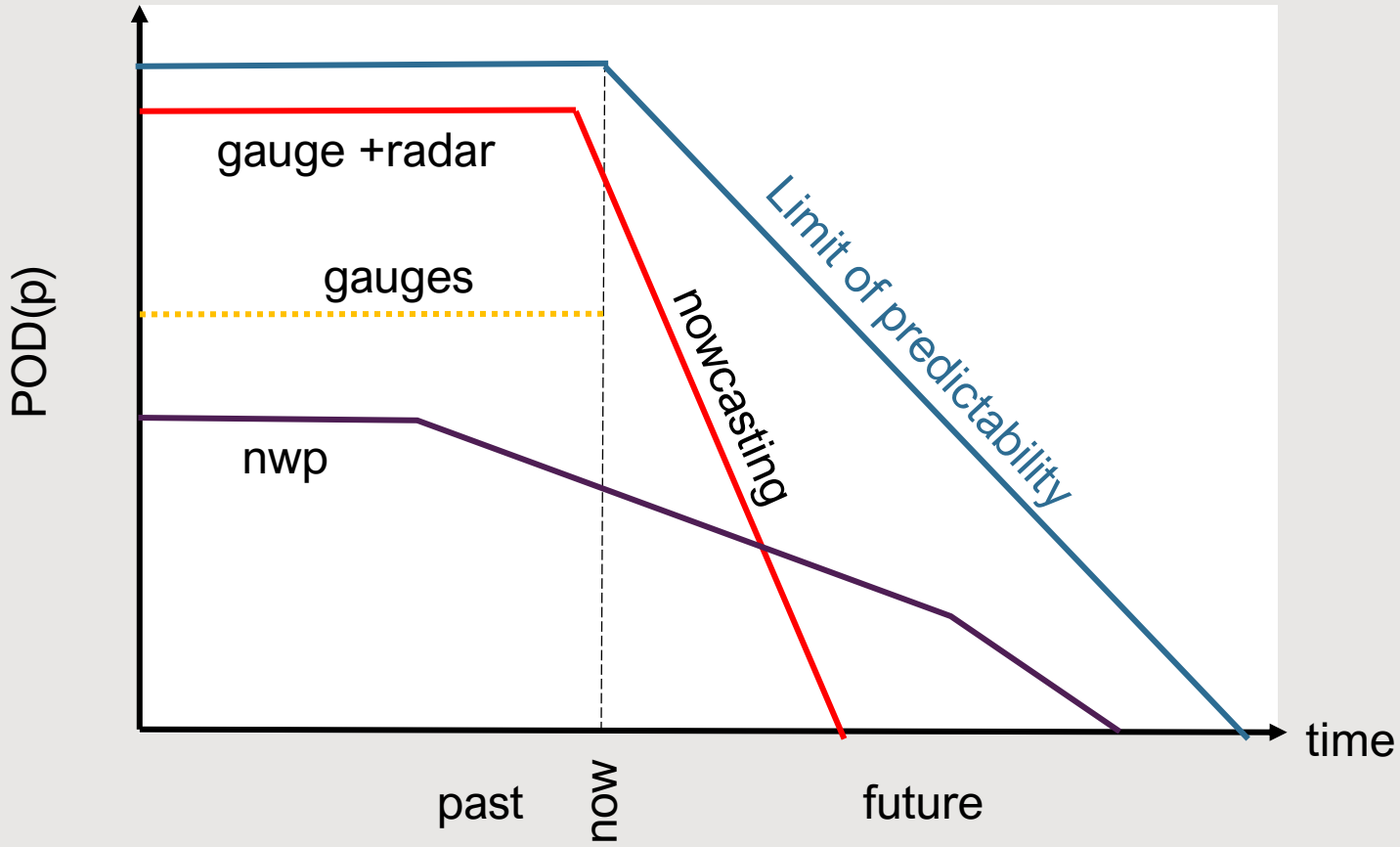
# Weather Data systems at Healthy Waters

## NWP Forecasting (Leadtime: days)

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

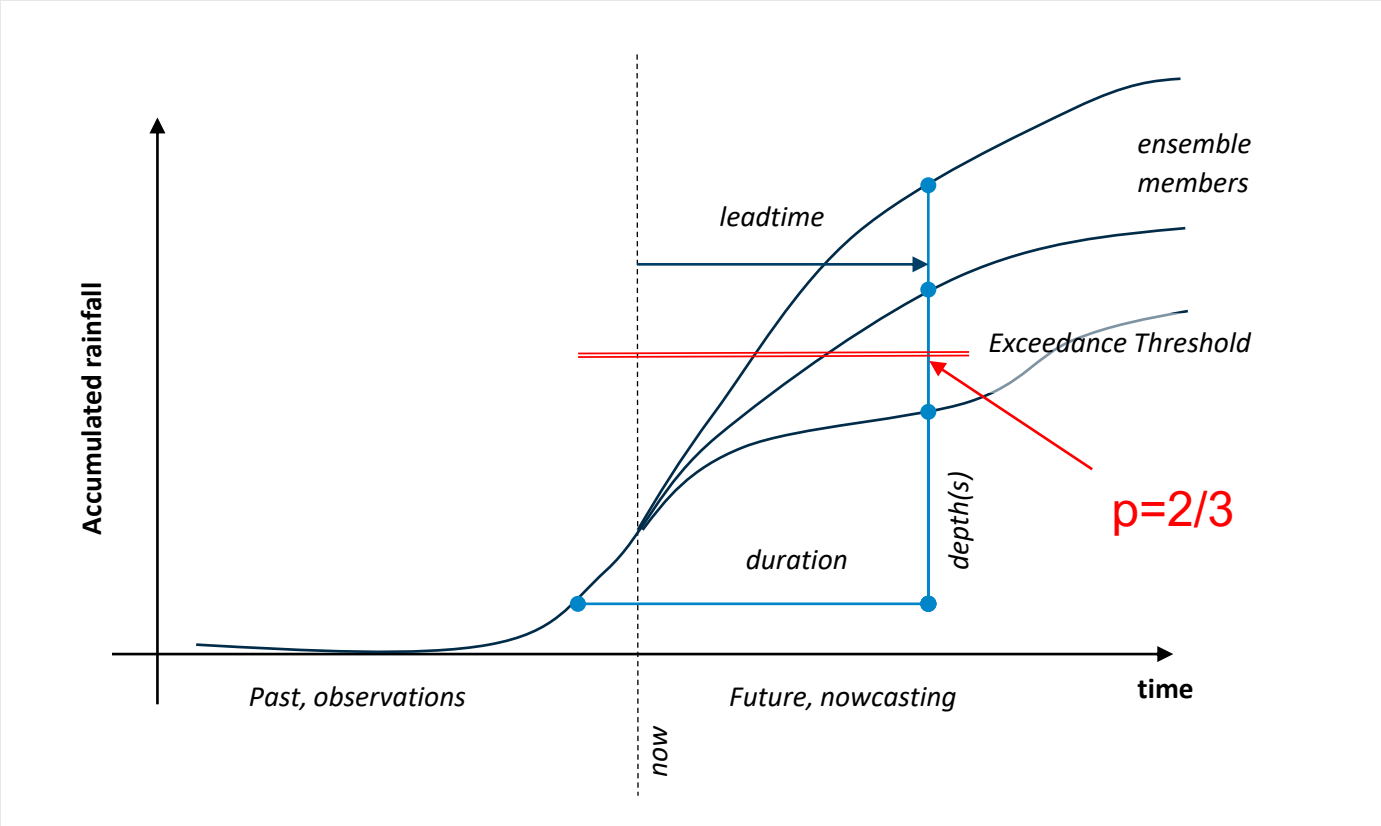


# Predictability of the Atmospheric State



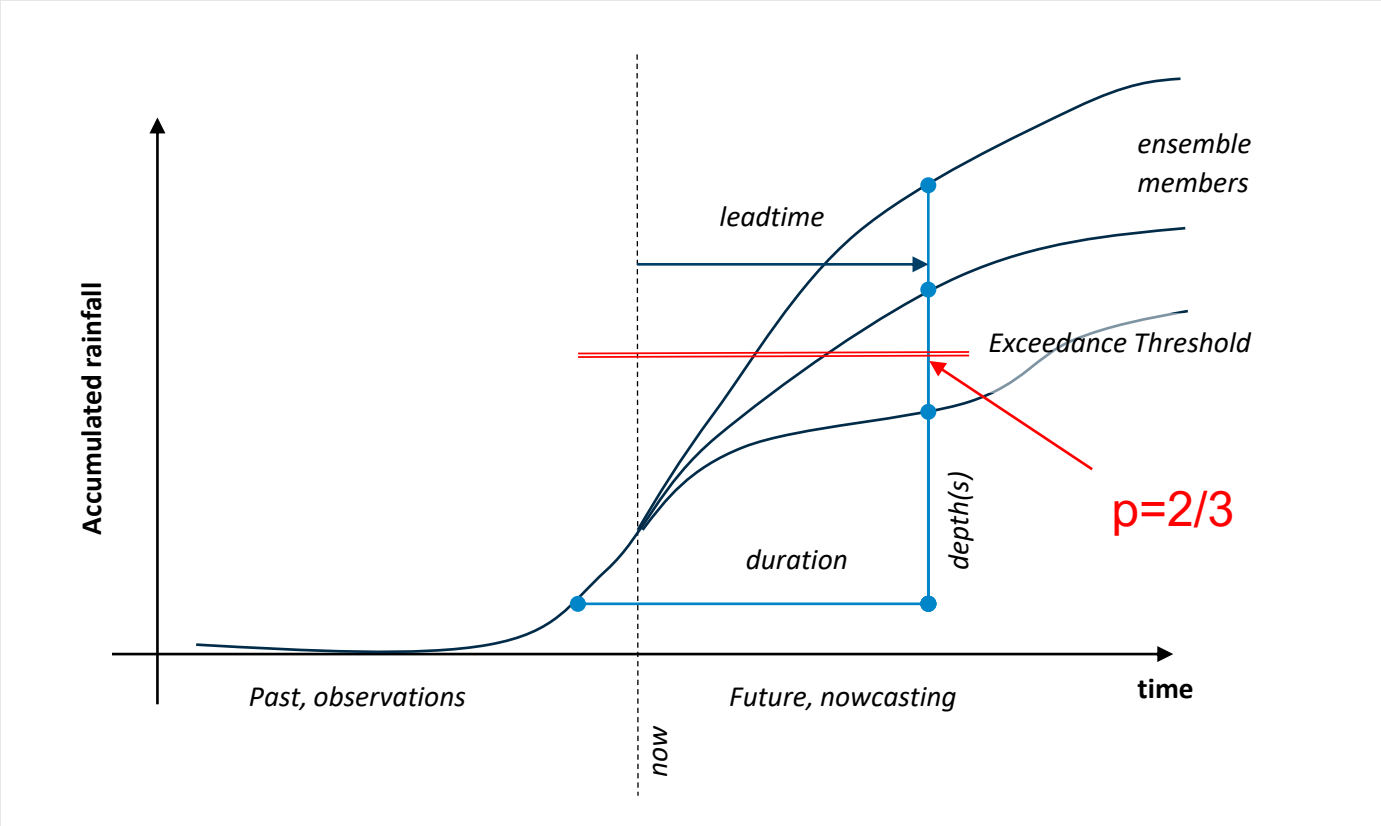

after Austin et al 1987

# 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

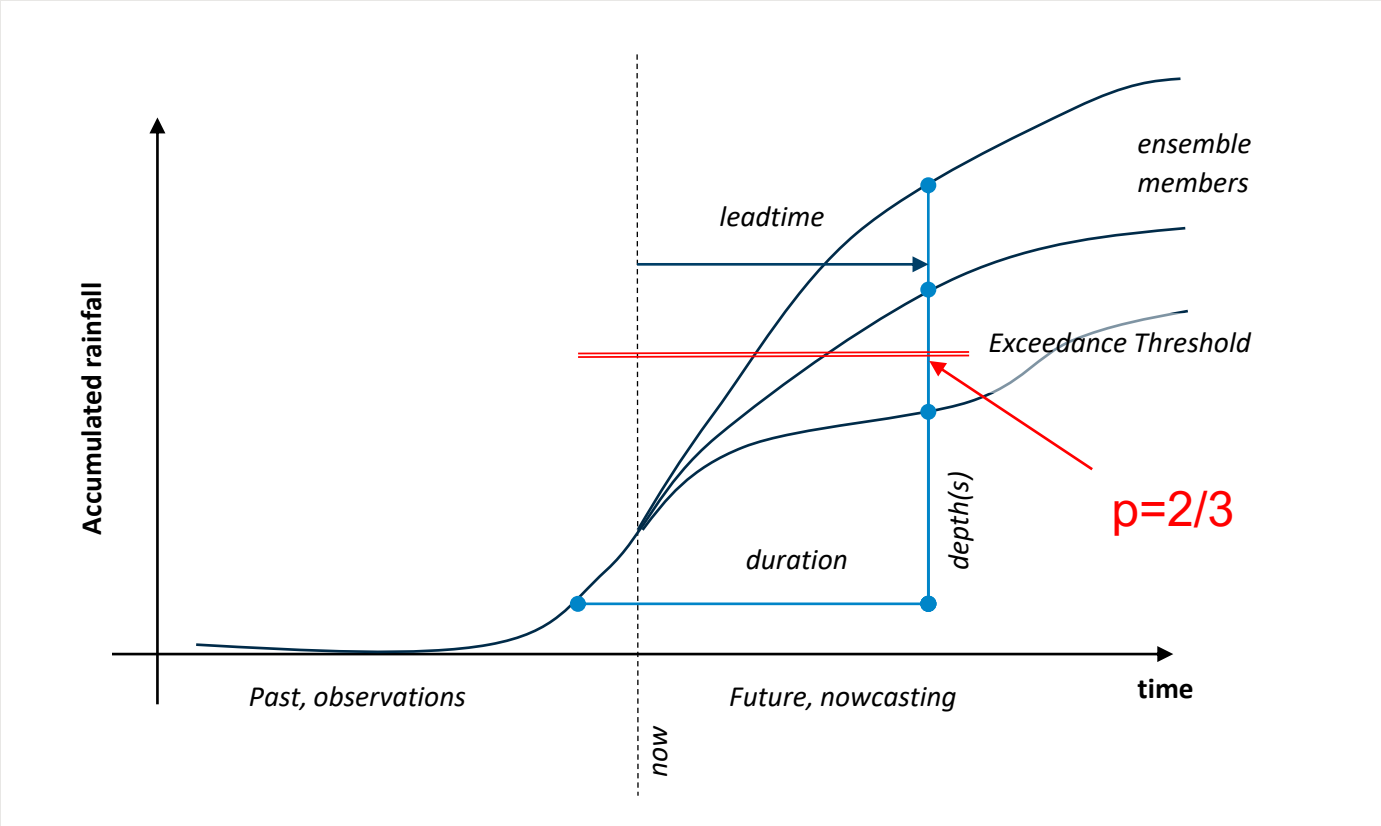



- Reliability: in the long run, do the probabilities issued by the forecasting system match the occurrence frequency of an event.

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?

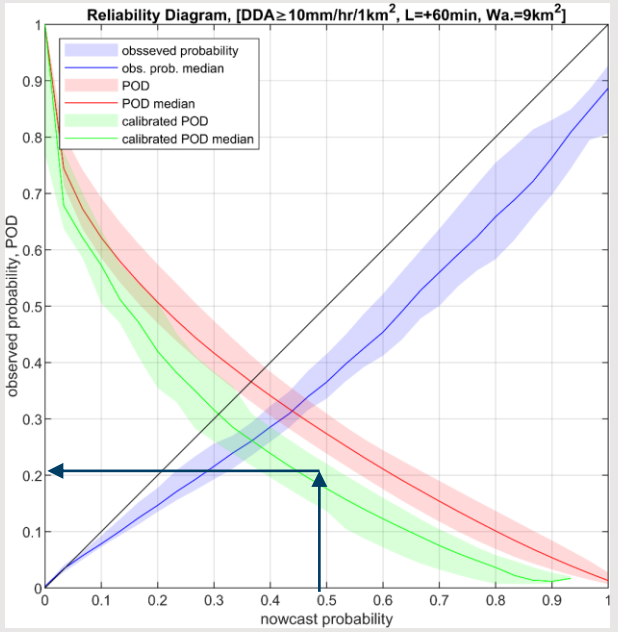
# Reliability and Probability of Detection

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.

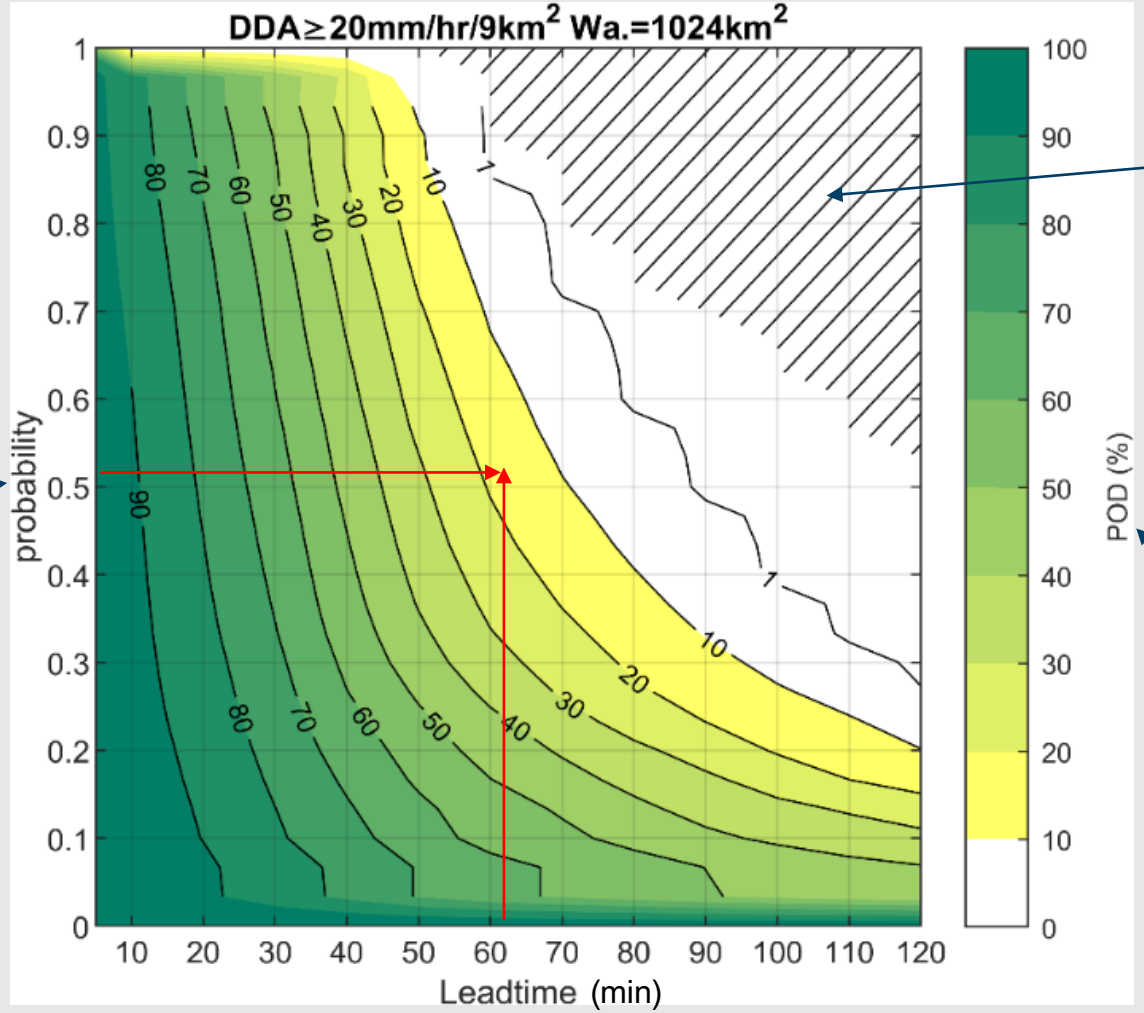
Reliability is assessed, then bias correction can be applied. This results in an unbiased estimate of POD(p)

| 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”

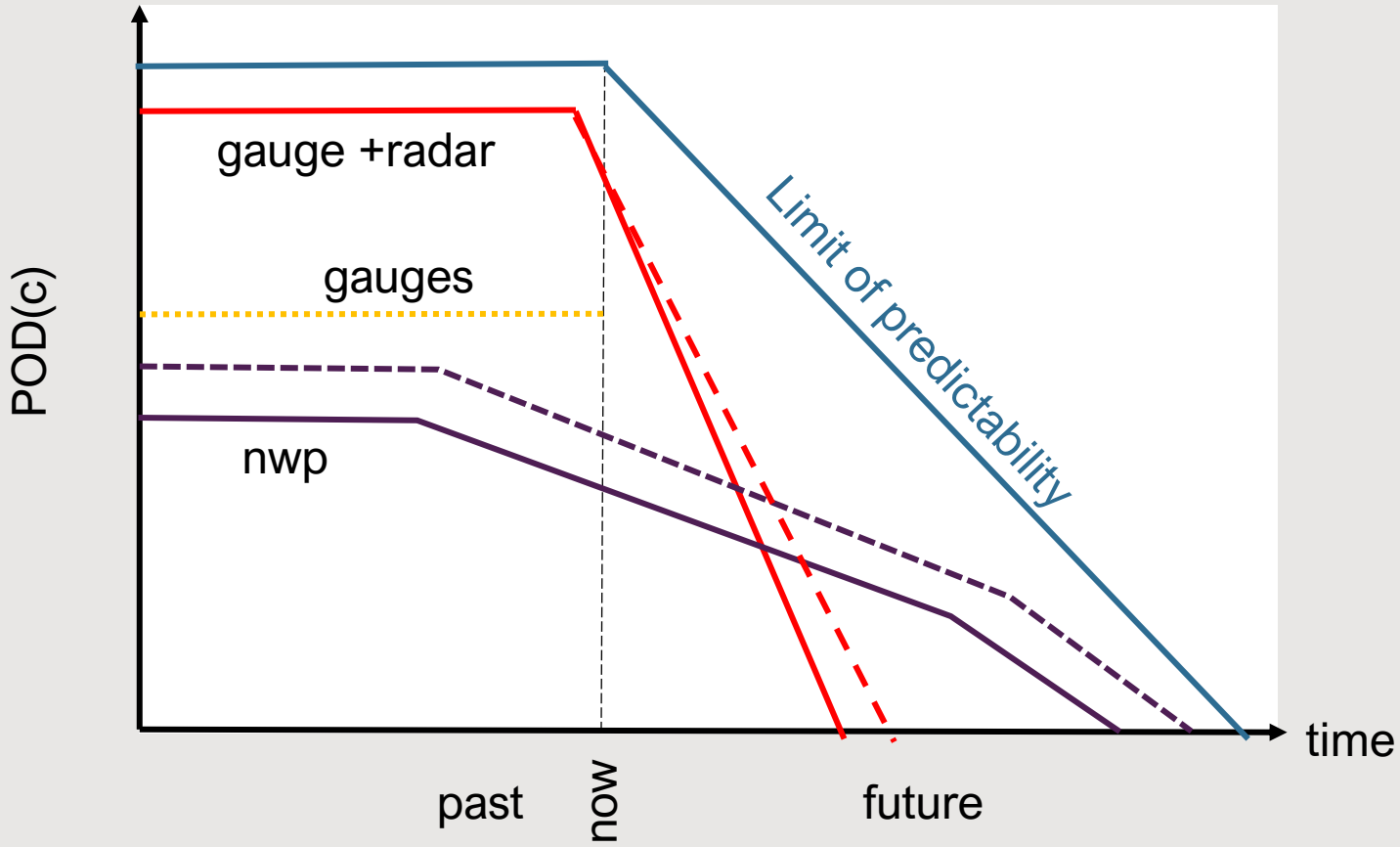
## ENGINEERS

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