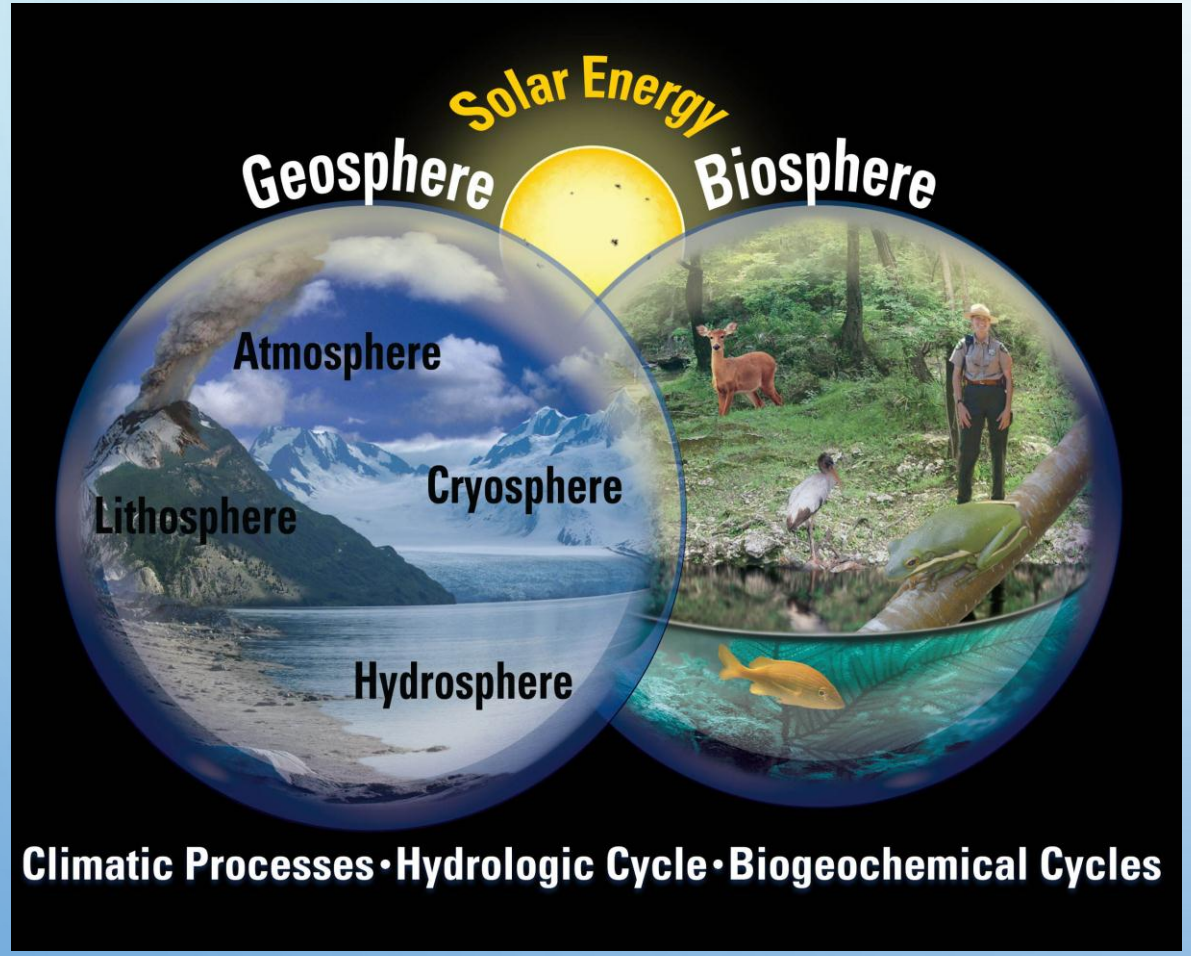
ENV101 - EARTH SYSTEMS

THE HYDROSPHERE AND THE WATER CYCLE

Presented By Ian Lancaster

KSI Land and Water Planning

EARTH SYSTEMS



Before talking about the water cycle there are some things we need to review.

Remember that water is made up of molecules of oxygen and hydrogen atoms, H_2O that are always moving.

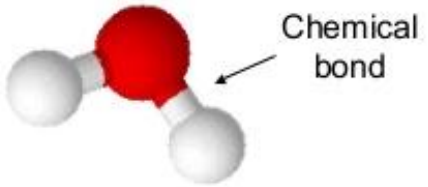
And how fast these molecules are moving determines whether the water will be a solid, a liquid, or a gas.

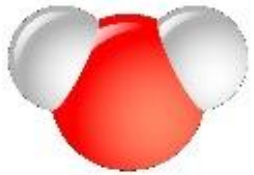
And just how fast these molecules move is determined by heat energy, how hot or how cold they are.

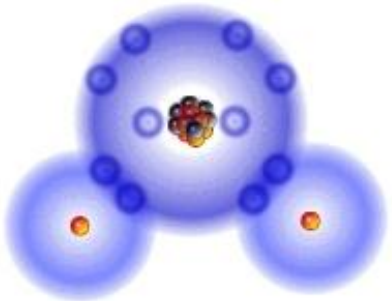
WATER CHEMISTRY

Chemical Formula

- H_2O
- Shows how many and which type of atoms make a single molecule



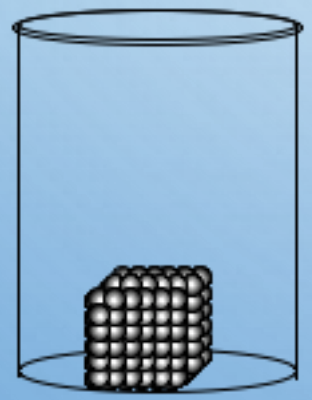




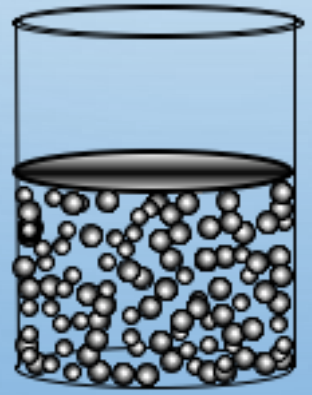
- How many atoms form one water molecule?

•Of course, molecules are way too small to be seen. But if you can visualize the molecules as small balls, molecules of water in the three states of matter might appear something like this:

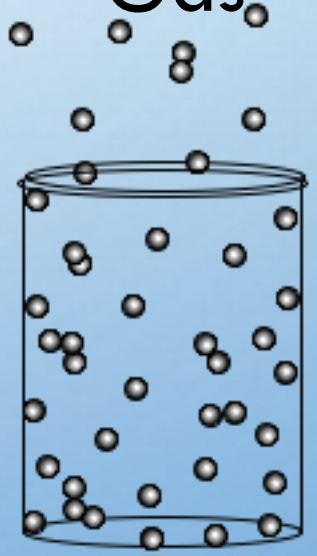
Solid



Liquid



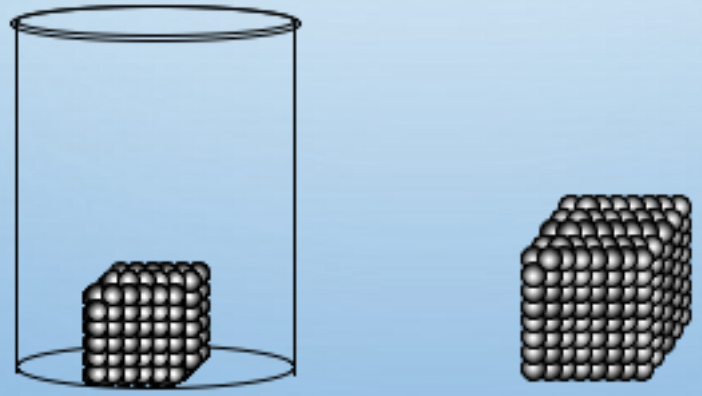
Gas



•We will first look at our model of solid water called "ice." The molecules are tightly packed and vibrating in place.

•When there is only a small amount of heat energy the molecules are packed so tightly together that they form ice.

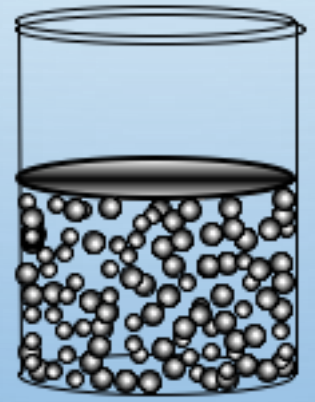
• At sea level, water is transformed into ice, or frozen, at 0 degrees Celsius. This is the solid form.



•Next, we have our model of liquid water molecules.

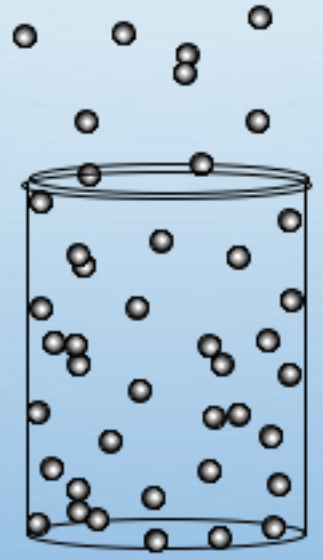
•When there is more heat energy, the molecules move about more vigorously within their container.

• At sea level the liquid form can range between 0 and 100 degrees.



•Finally, we have our model of molecules of gaseous water called “water vapor.”

•There is even more heat energy now, and the molecules are moving rapidly, banging on the walls of whatever container they are in, escaping where ever there is an opening.



- The important thing is that the amount of heat energy determines whether our H_2O molecules are a solid, liquid or gas.
- Adding or subtracting heat energy can cause water to change from one phase, like ice or liquid or gas, to another.
- Water vapor is water in the form of a gas.
- Like most gases, water vapor is invisible.
- Even though we cannot see them, air always contains molecules of water vapor mixed in with molecules of nitrogen, oxygen, argon and carbon dioxide.
- Having learned that there is always some water vapor found in air, we should also understand that:
- The warmer the air the more water vapor molecules there are.
- The cooler the air the fewer water vapor molecules there are.

Water molecules in air do not remain in one state of matter or another; they are constantly changing back and forth between stages.

Stage changes between vapor, liquid and solid happen because of temperature changes.

When liquid water molecules gain heat energy they become water vapor (evaporation): when water vapor molecules lose heat energy they become a liquid (condensation).

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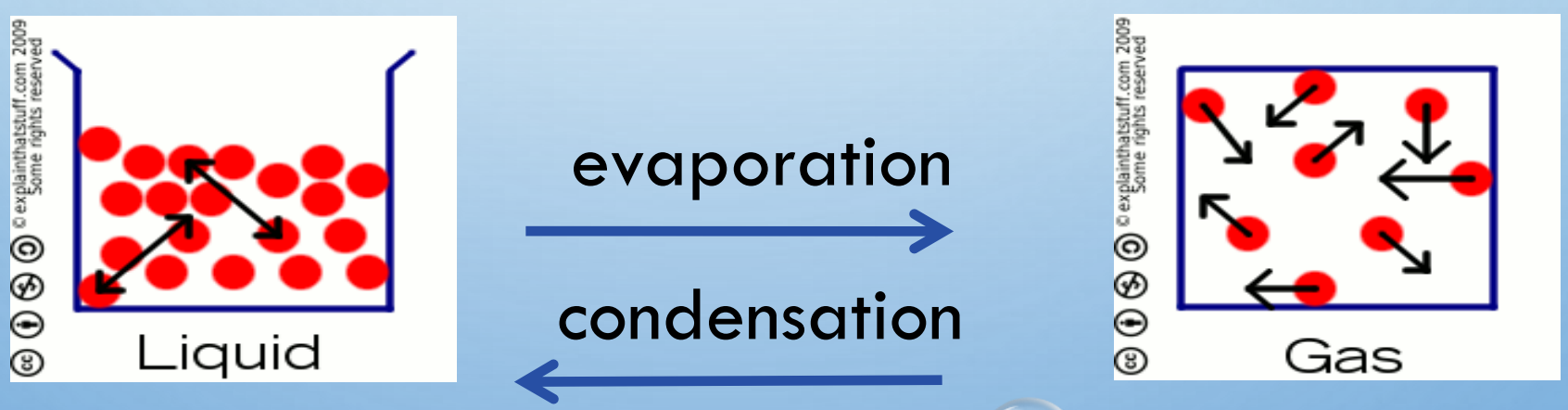
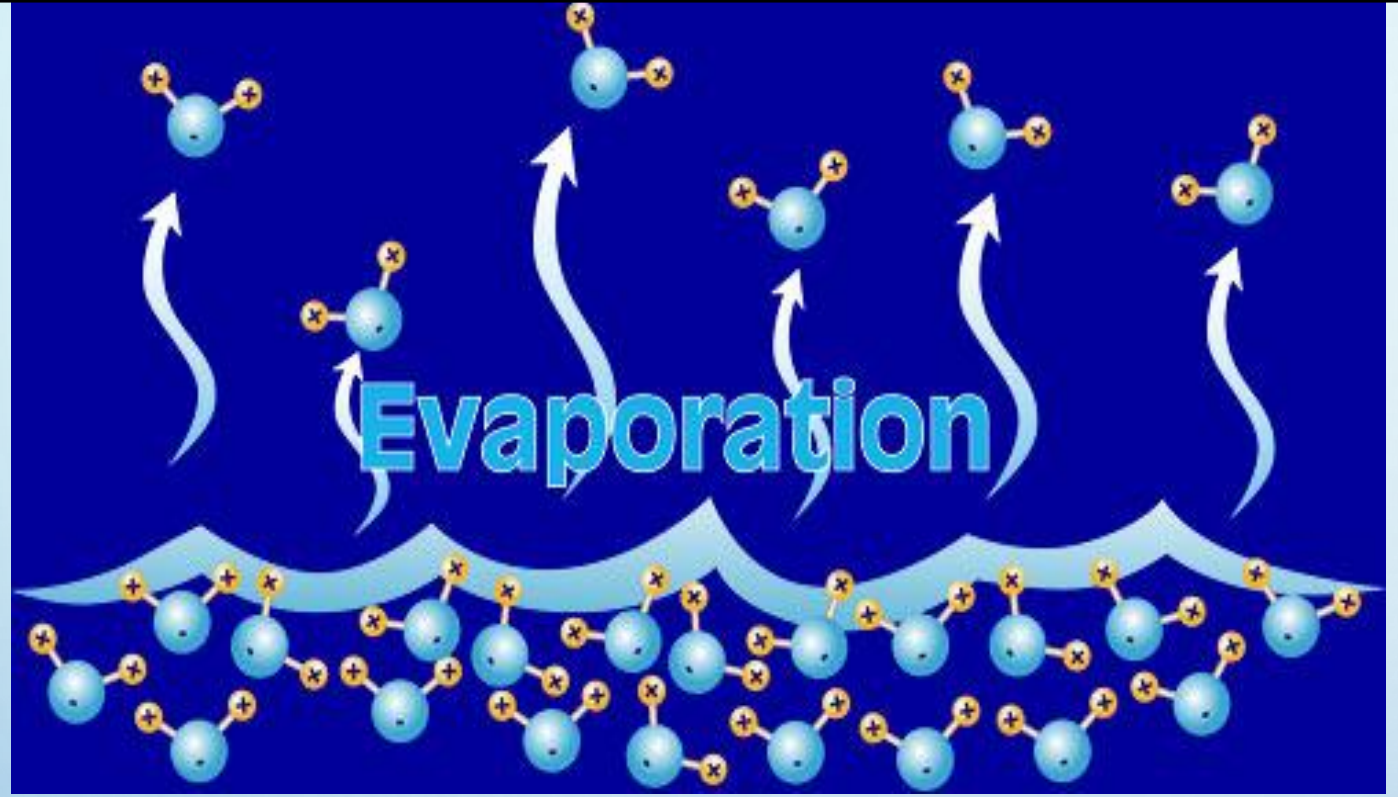


Now let's look at the water cycle.
Although the water cycle is like a circle that has no beginning or end, we will start our study with:
evaporation.

Water on the Earth's surface is continually evaporating—changing from a liquid to the gas called water vapor.

Even on a cool, dull day the energy from the Sun heats the surface of the sea causing some of the water to change from a liquid into water vapor. This process is called EVAPORATION.



Here we see a diagram of some liquid water molecules gaining enough heat energy from the sun to change into molecules of water vapor.

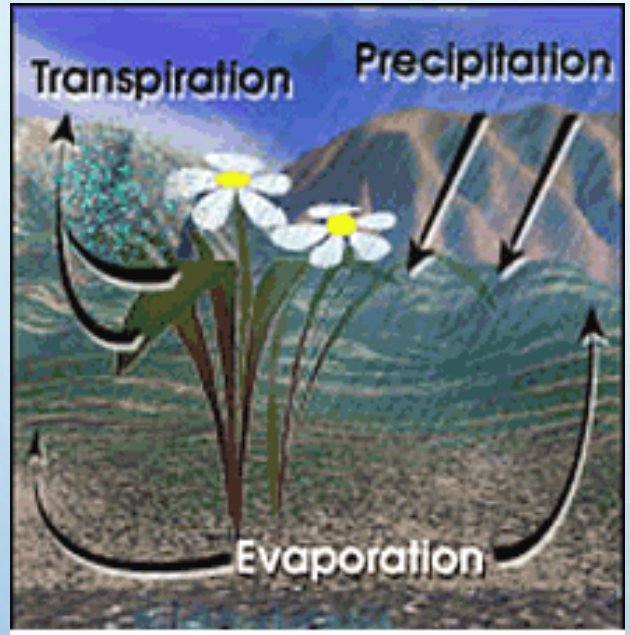
However, remember:

1. Water molecules are too small to see without a microscope
2. Water vapor is invisible

Nearly 90% of the the water vapor in our atmosphere comes from the oceans, seas and other bodies of water (lakes, rivers, streams) through evaporation.

We know that water is evaporating from the water shown above but we cannot see it. Water vapor is invisible.

The remaining 10% of the moisture found in the atmosphere is released by plants through transpiration—release of water vapor from leaves.



Hailey King, NASA, GFSC


Credit: Ming kei College, Hong Kong

While most of the water vapor for the water cycle comes from evaporation, transpiration adds a lot of water vapor. For example, a cornfield 1 hectare in size can transpire as much as 40 kilolitres of water every day.

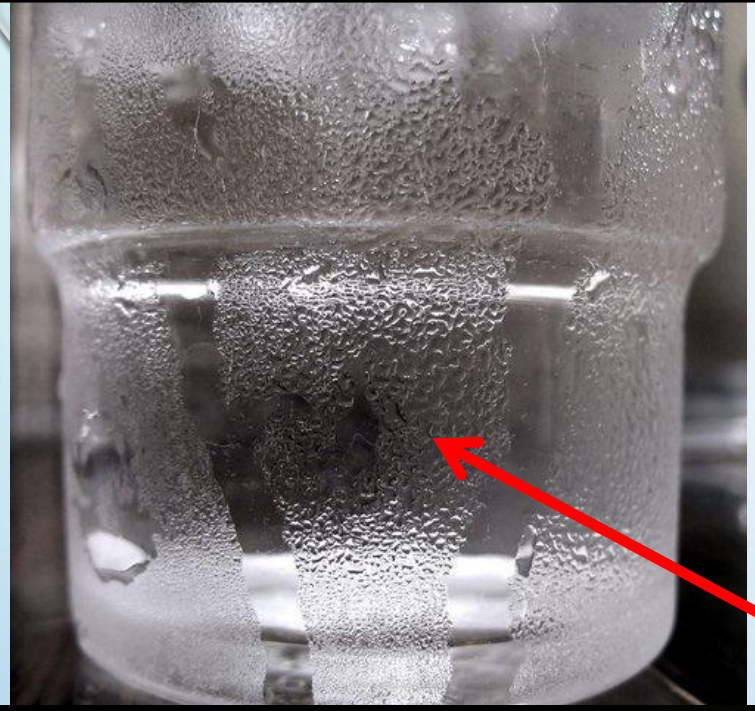
Now that we understand that there is water vapor in the air, the next step to be examined in the water cycle is:
Condensation

Clouds form as the result of condensation—water vapor that is cooled changes to liquid water.

This process of condensation is constantly occurring all around us as water vapor molecules in the air bump into cool surfaces.

Because when water vapor molecules strike a cooler surface, they slow down and sometimes change into tiny droplets of liquid water that look like “fog”.

Over time, these tiny droplets of water join together forming larger and larger drops.



Water vapor hitting the sides of a cold glass or water bottle condenses (changes from a gas to a liquid).

condensation

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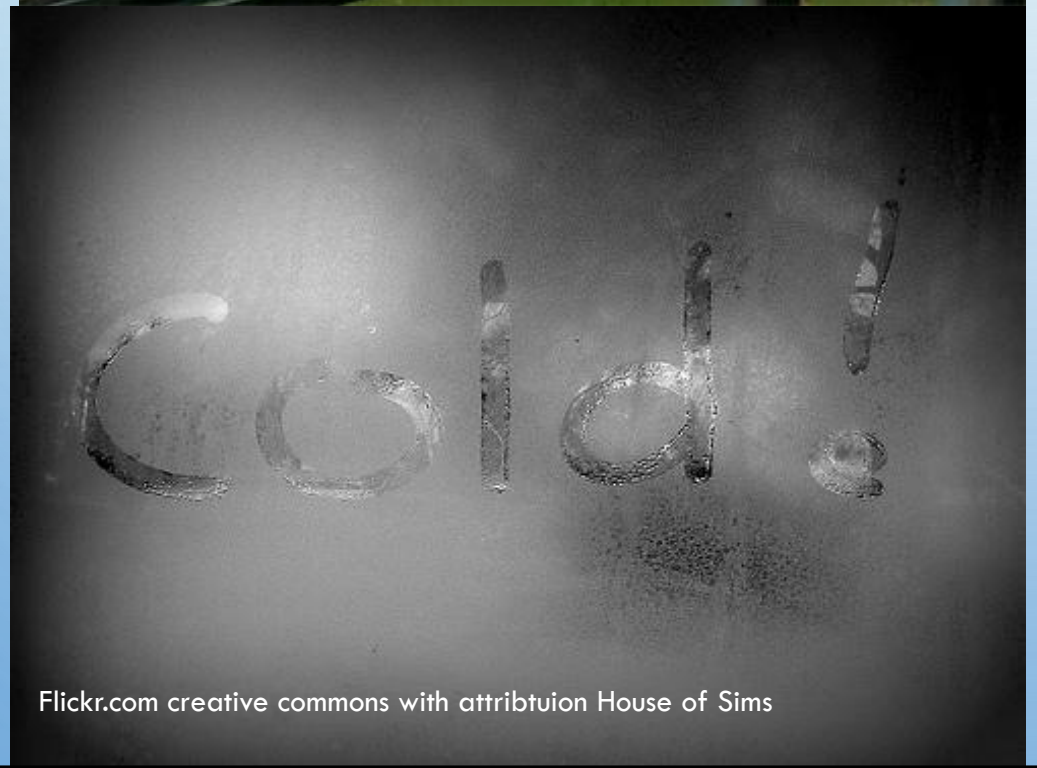
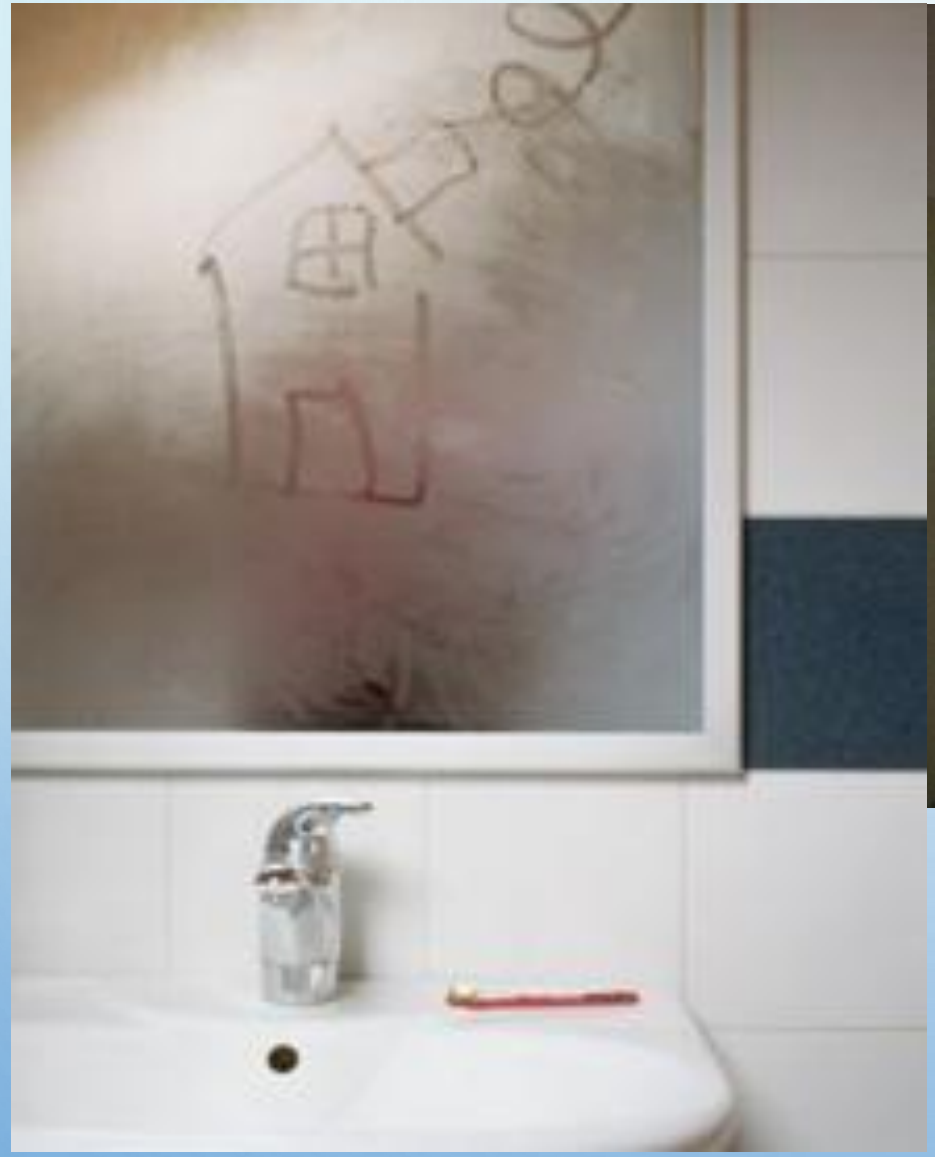
As time passes the water droplets increase in size.

More condensation



Water vapor condensing on a cold window.

More condensation



Water vapor condensing on a cold mirror.

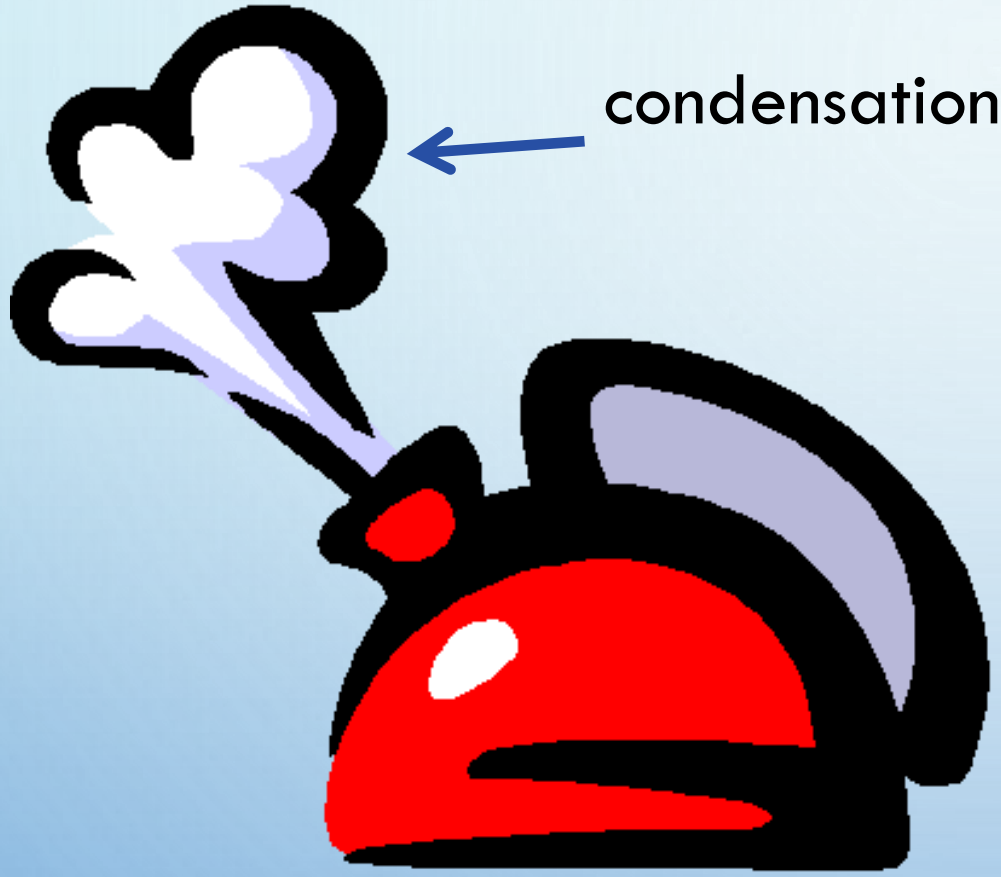
More condensation

Water vapor condensing on the cold car windshield.

More condensation

Water vapor condensing on grass or a spider web--dew.

More condensation



Like the “fog” on the window or mirror, steam is made up of tiny water droplets.

Steam is **not** water vapor.

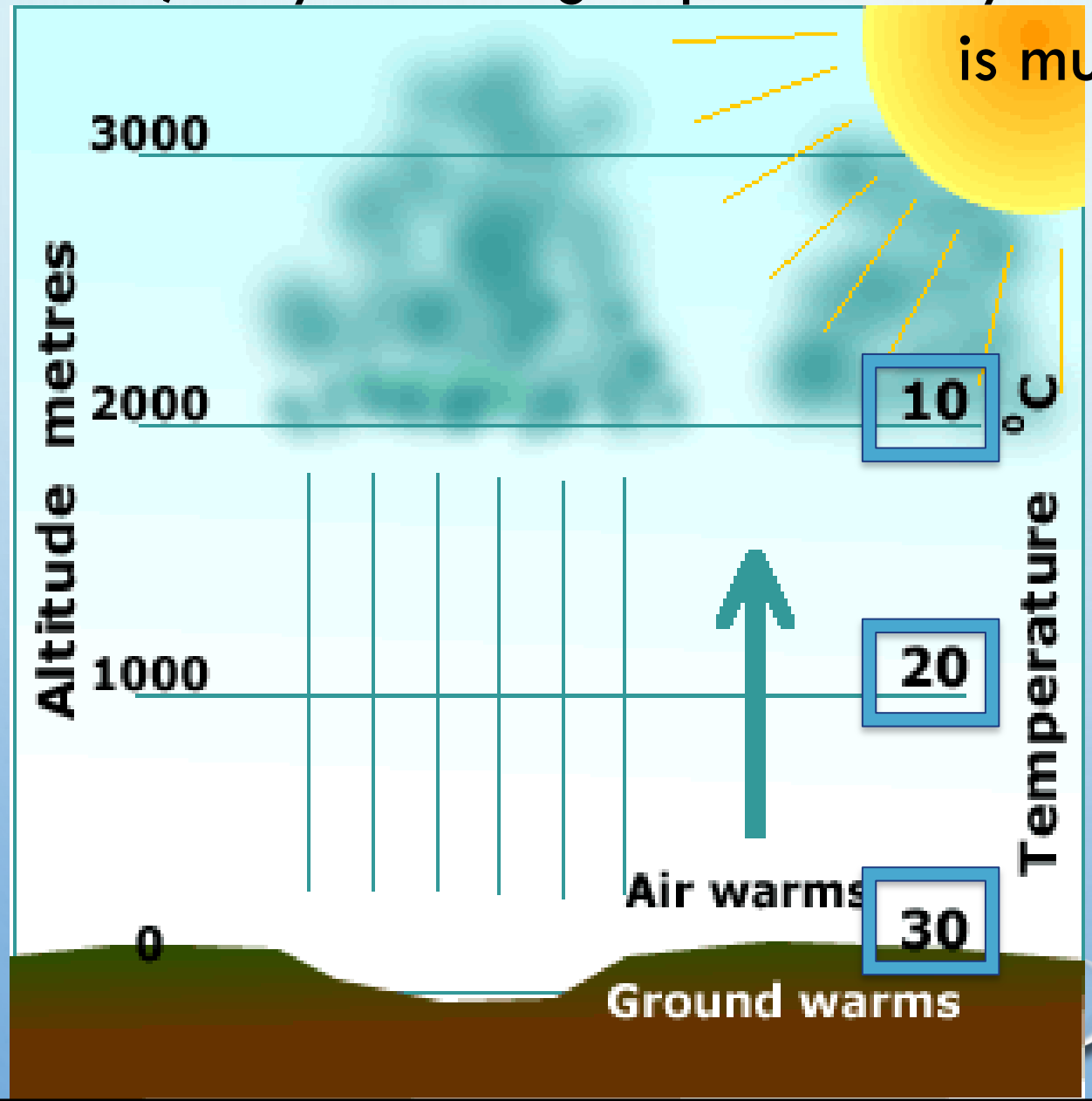
When the water vapor from the boiling water hits the cooler air outside the tea kettle, it condenses as tiny water droplets.

More condensation

At night sometimes, water vapor condenses as it comes in contact with the cool ground creating fog—a cloud on the ground.

Bridge peeking above the fog on the ground.

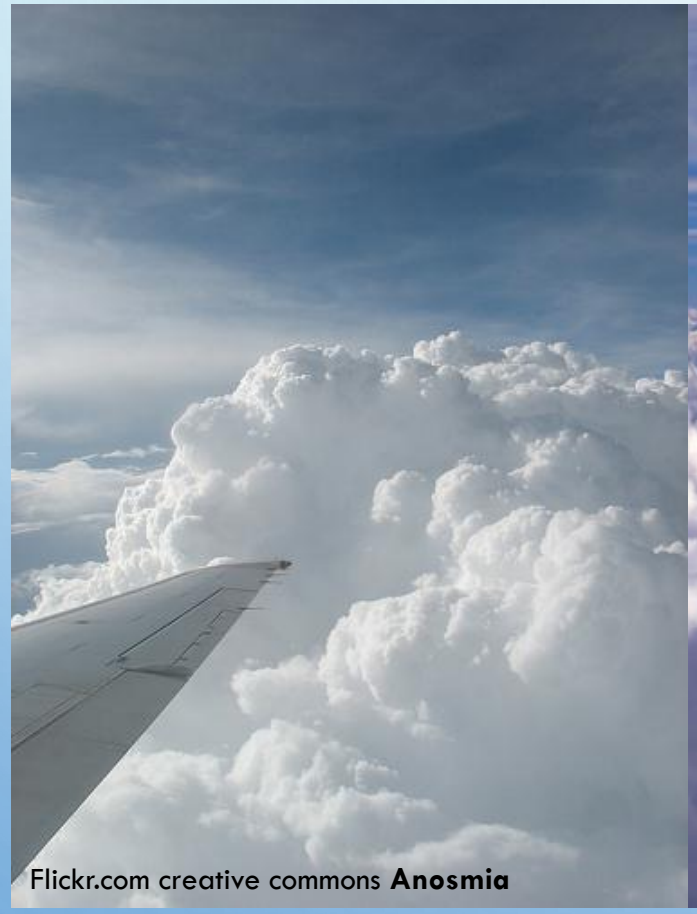
However, unlike fog, most clouds do not form on the ground; they form high up in the sky where the air is is much cooler.



As you move up in the atmosphere it becomes colder and colder.

Clouds—another product of condensation.

As water vapor is cooled high in the atmosphere it condenses into tiny water droplets—a cloud.



Flickr.com creative commons **Anosmia**

Here we see pictures of clouds high up in the sky.

Now we have to ask what causes this warm air that is loaded with water vapor to rise ?

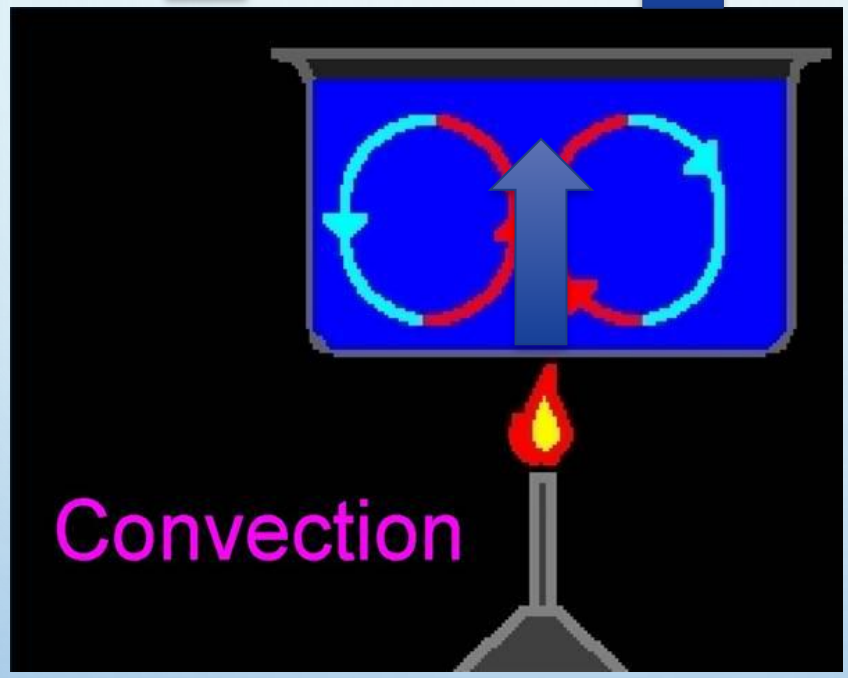
Usually this “lifting” of warm air is caused by another of our “cycles.”

Convection

The tendency of hotter and therefore lighter (molecules further apart) liquids and gases to rise, and for colder, heavier (molecules closer together) liquids and gases to sink.

under the influence of gravity.

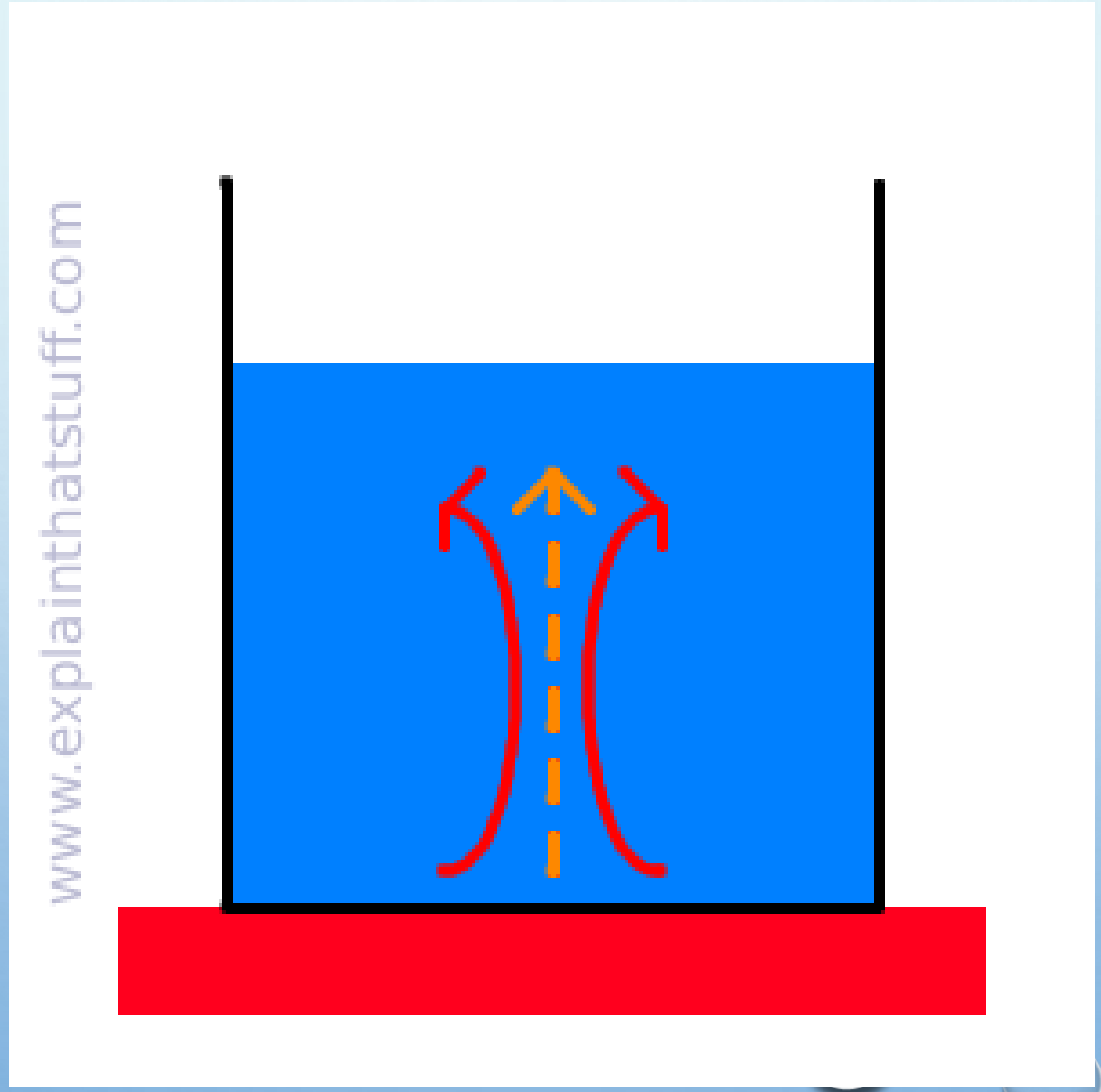
colder, denser (heavier) material sinks



colder, denser (heavier) material sinks

hotter and therefore less dense (lighter) material rises

Here is convection in action.



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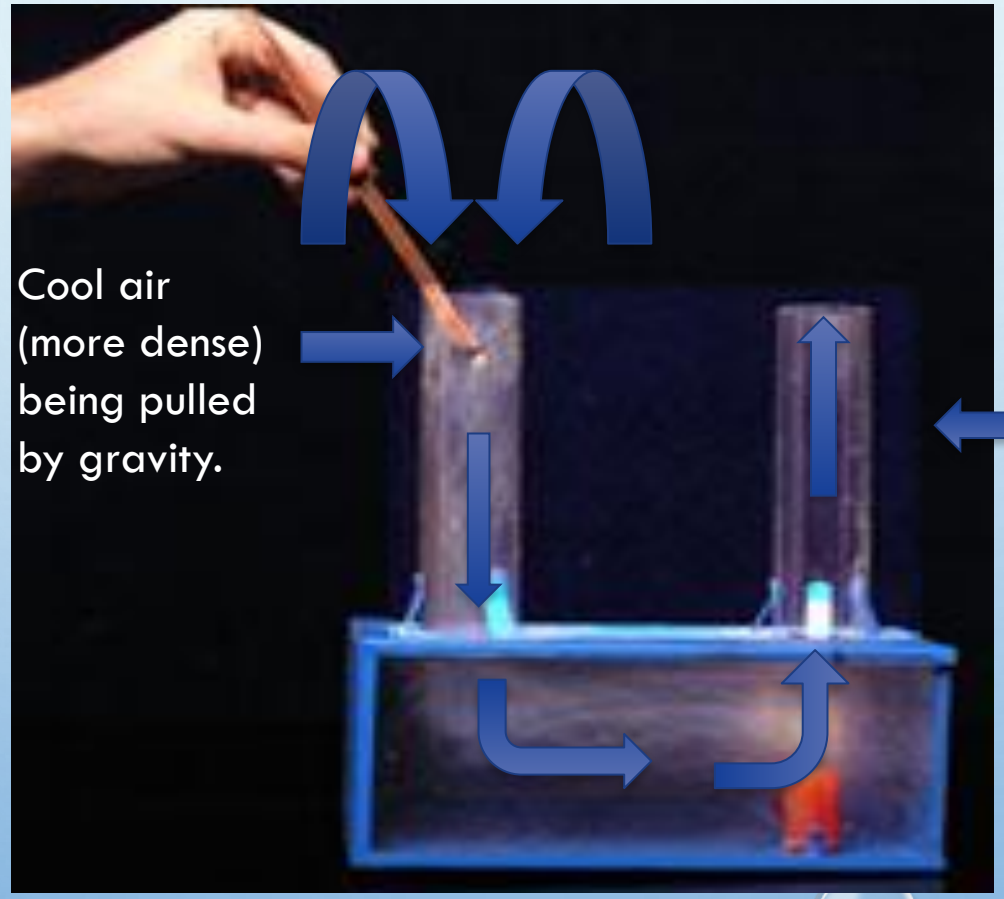
Another demonstration of cool dry air sinking and pushing up warm moist air.

Smoke from burning stick.

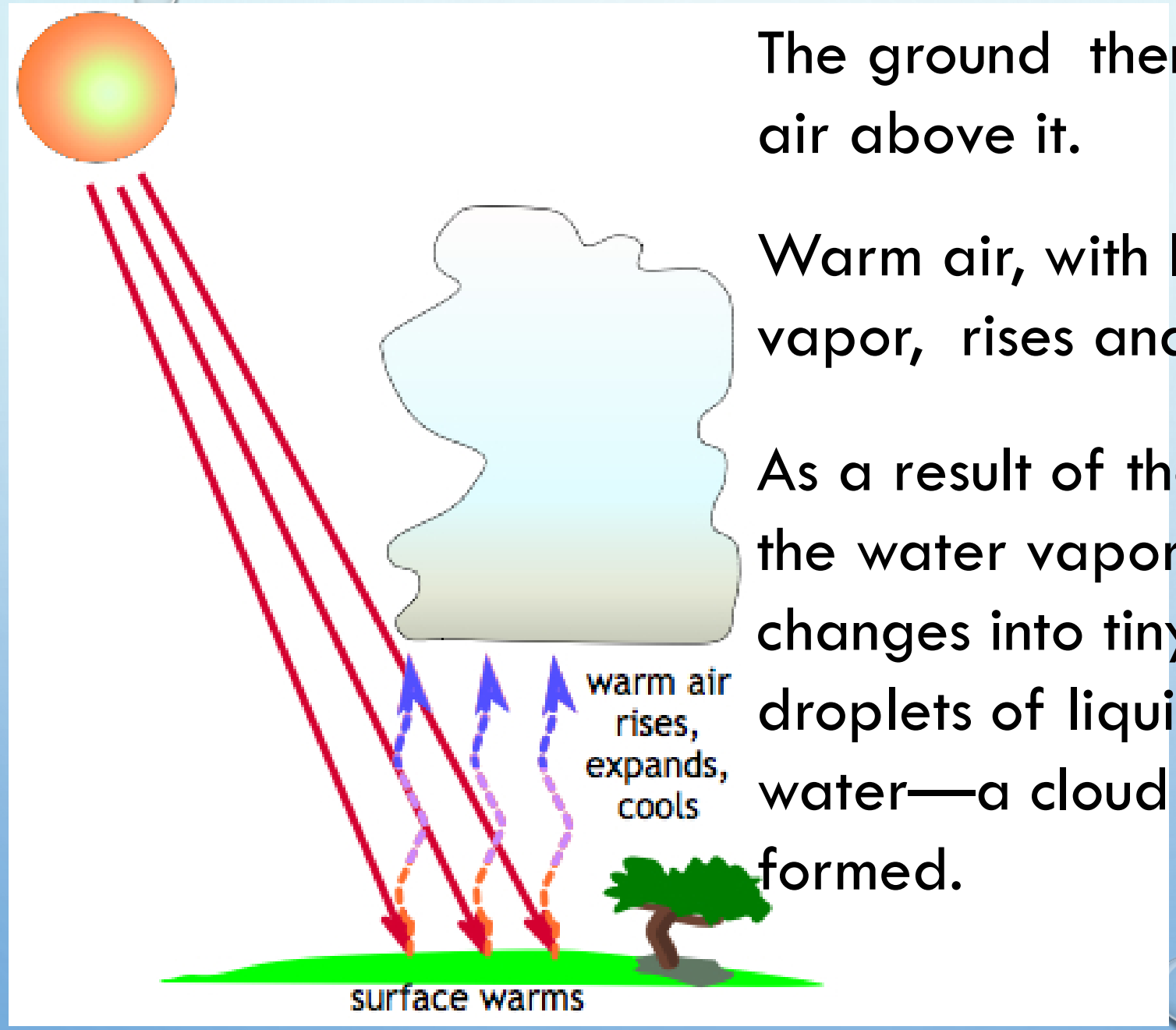


Cool air (more dense) being pulled by gravity.

Warm air (less dense) pulled less hard by gravity and therefore being pushed up by cold air.

Burning candle warming air.

Now let's look at how convection currents on Earth are important in the formation of clouds.

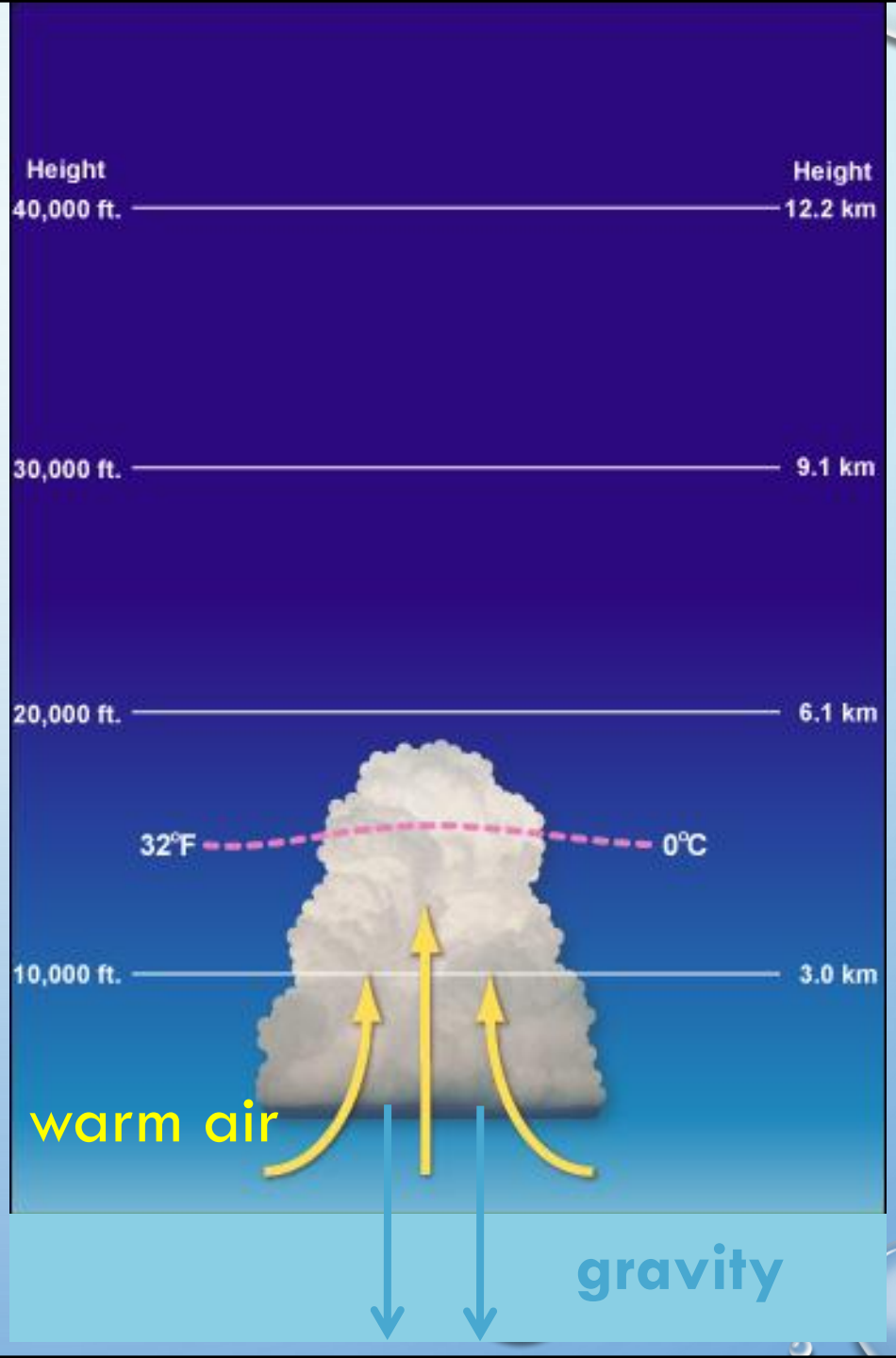


The Sun heats the ground. The ground then warms the air above it.

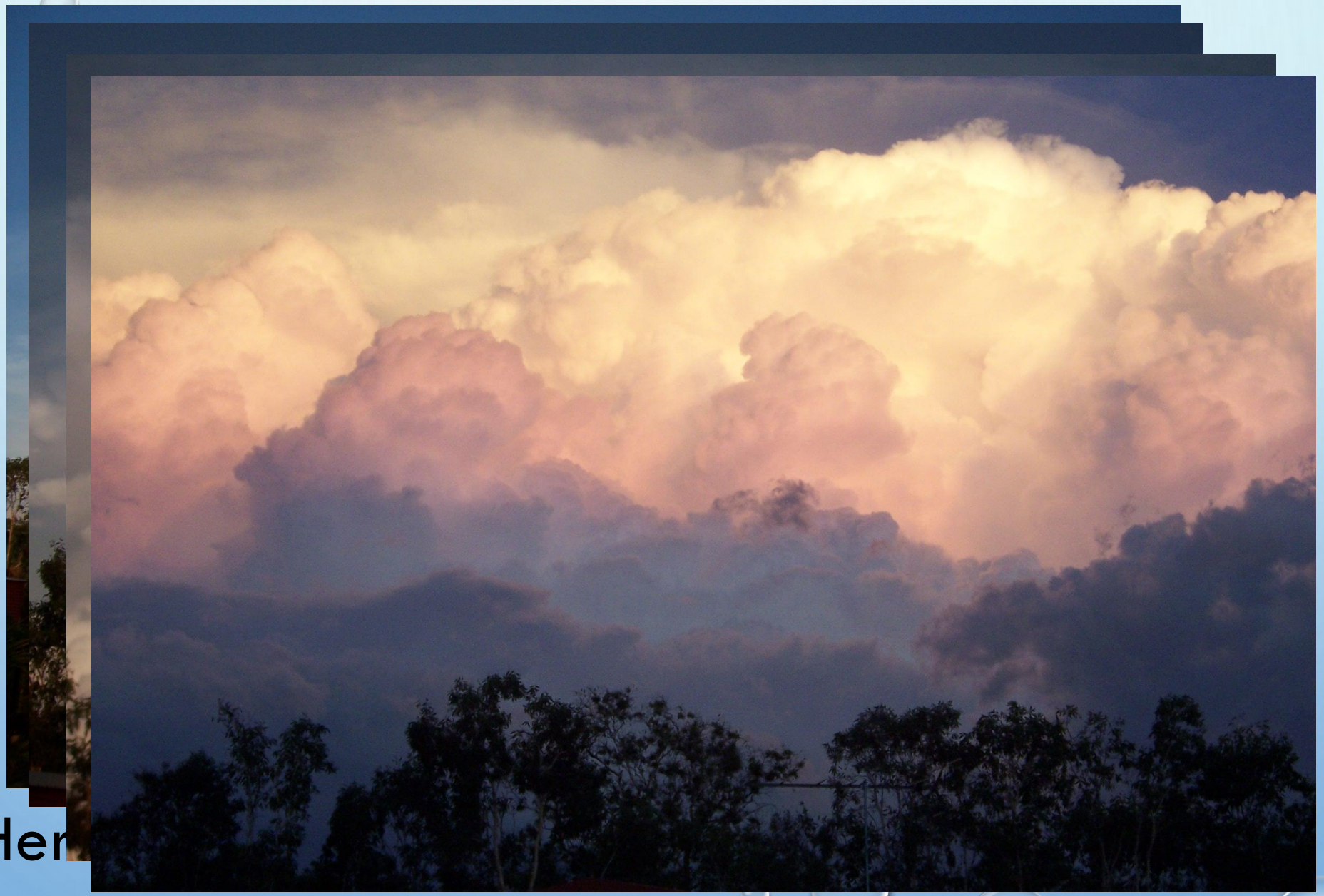
Warm air, with lots of water vapor, rises and cools.

As a result of the cooling, the water vapor in the air changes into tiny water droplets of liquid water—a cloud is formed.

The tiny water droplets making up clouds are big enough to be seen in large groups (like a cloud) but too small for gravity to overcome the rising warm air.



Small, yes. But just how small? The droplets created from condensing water molecules are so small that millions of cloud droplets are needed to produce a single rain drop. They are kept aloft by the slowly rising convection currents.



Her

up a thundercloud.

However, as the tiny droplets inside the cloud collide, they join and droplets grow in size.

Finally water drops form.

Which brings us to the next part of the water cycle,

Precipitation.

When these drops become too large for the rising air to hold them up, they fall as rain (precipitation).

Getting this fallen water (precipitation) back to the rivers, lakes and oceans is also part of the water cycle. Water can take two paths back to larger bodies, one is on the **surface** and the other is **underground.**

Some precipitation that falls on the ground flows over the land to streams and rivers and finally to the ocean.

This is called **surface run off.**

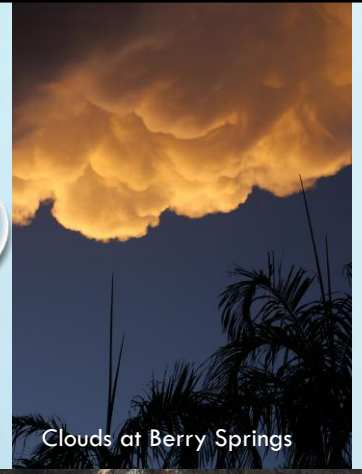
You can easily observe this surface run-off if it is water running down your driveway, along the curb of your street and into a storm sewer.

During a heavy rain, water flows over the soil filling creeks which then flow into streams and finally into rivers. The surface runoff that flows into a creek is beginning its journey back to the ocean.

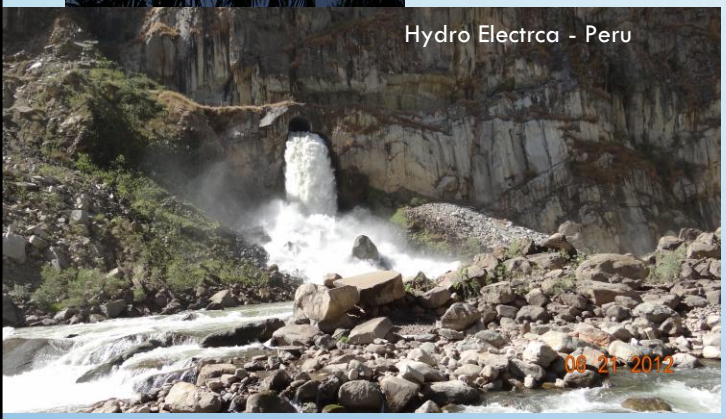
BREAK AND QUESTIONS

The hydrosphere

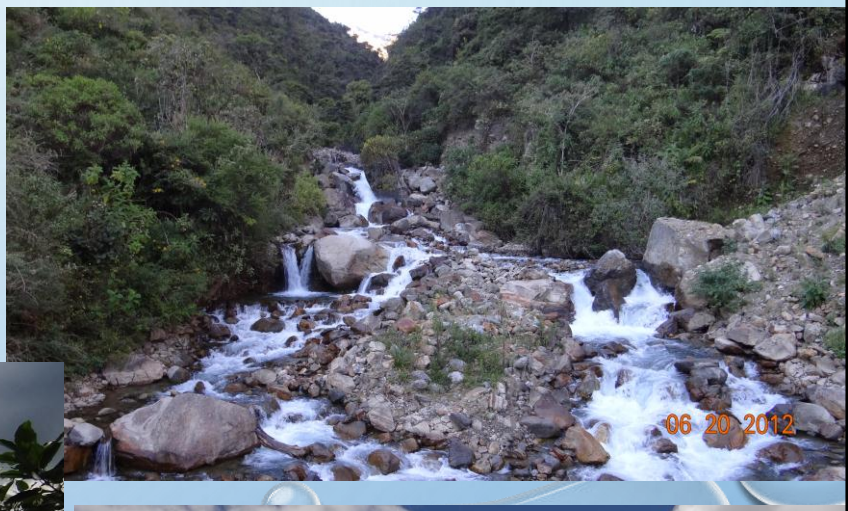
[Blue Planet (5starttv)
https://youtu.be/WBRXJvDk4dQ](https://youtu.be/WBRXJvDk4dQ)


Clouds at Berry Springs


Iguazu Falls - Brasil


Hydro Electrca - Peru

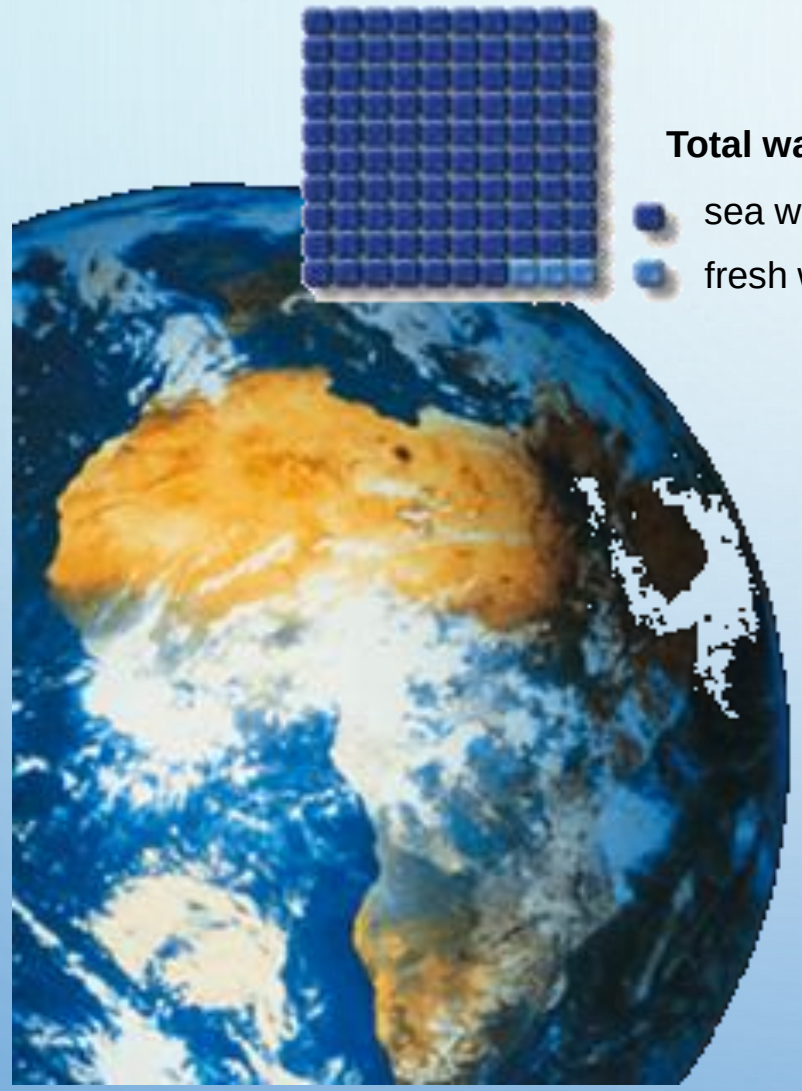

Pacific Ocean - Galapogos


06 20 2012


Lagos Sandoval - Amazonia


Rio Madre - Amazonia
06 05 2012


Salkantay - Peru
06 19 2012

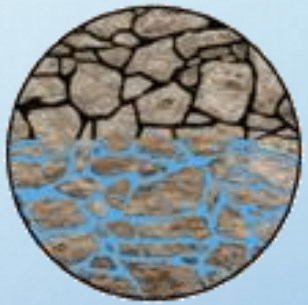


Total water on Earth

- sea water 97 %
- fresh water 3 %

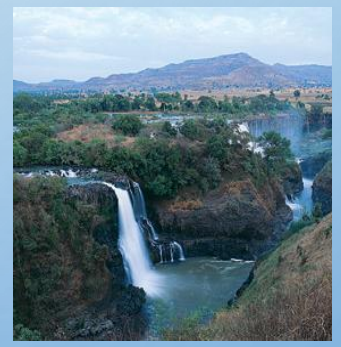
Total fresh water

ice	68.7%
groundwater	30.1%
surface water (liquid)	0.3%
other	0.9%



Total surface fresh water (liquid)

lakes	87 %
swamps	11%
rivers	2%



Origin of the hydrosphere

Primitive atmosphere:
- carbon dioxide
- water vapour

condensation

IS THERE WATER ON OTHER PLANETS?

Temperature

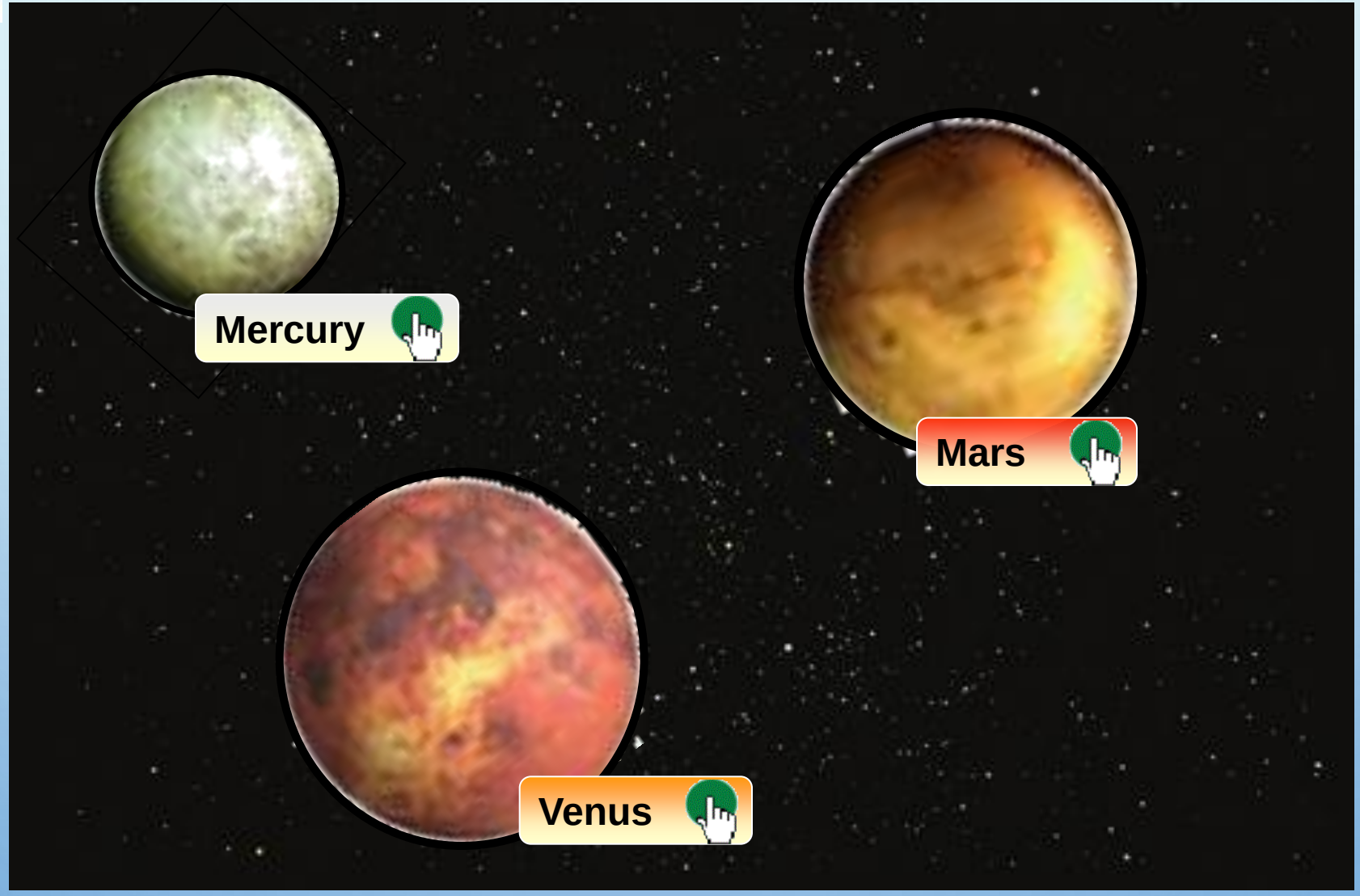
gaseous water

solid water

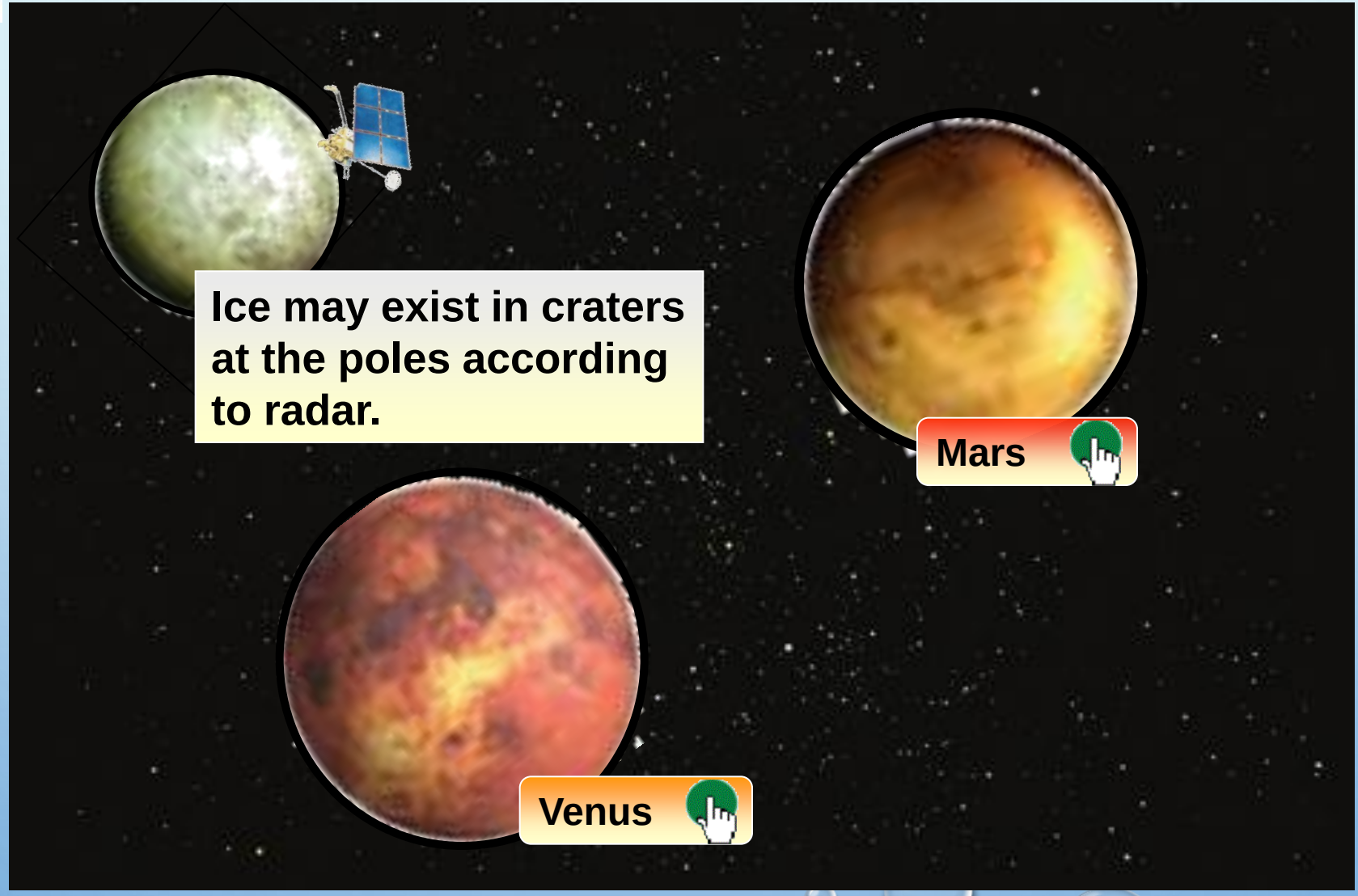
liquid water

4,500 million years ago → Present

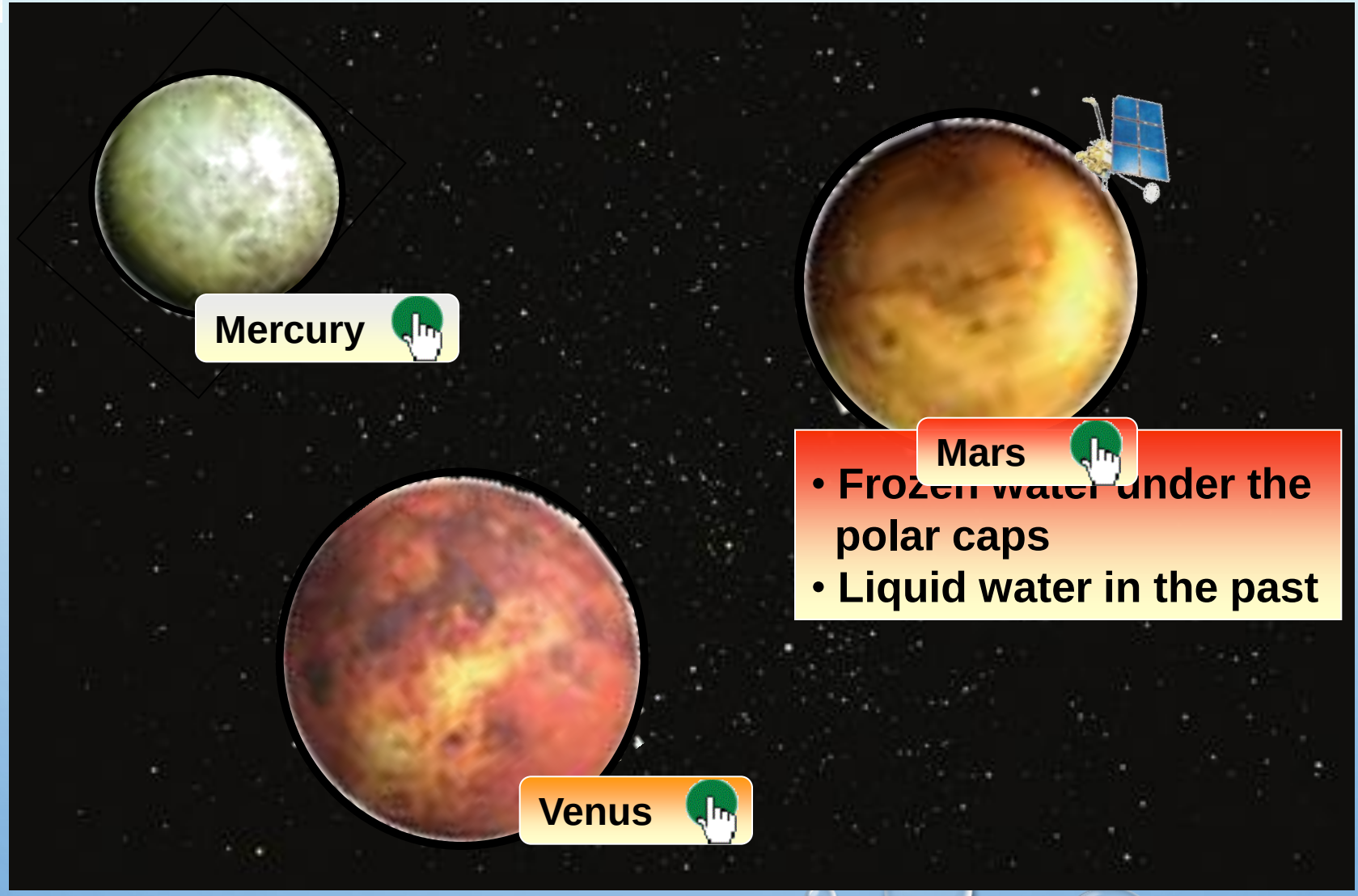
Water on other rocky planets



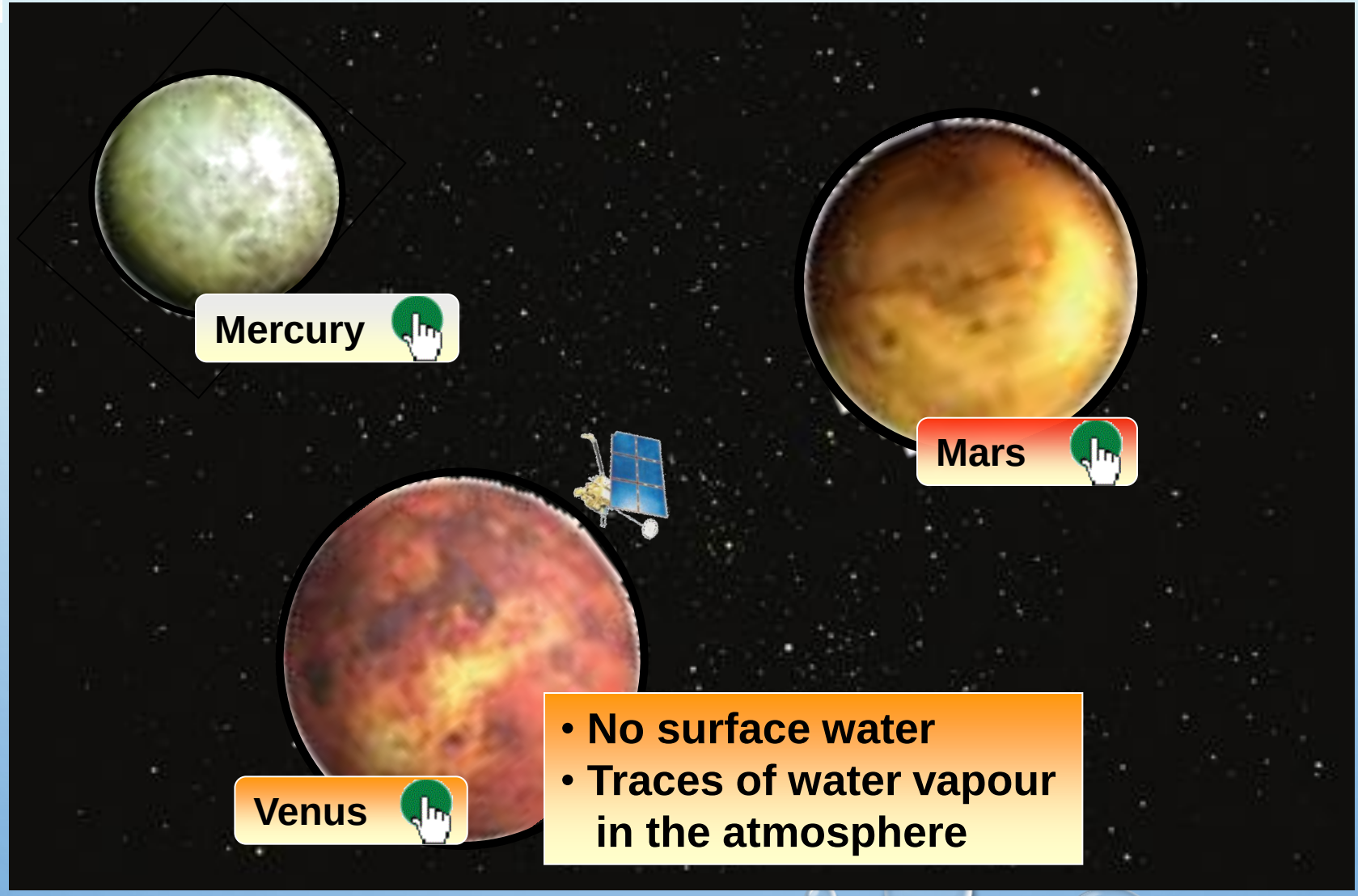
Water on other rocky planets



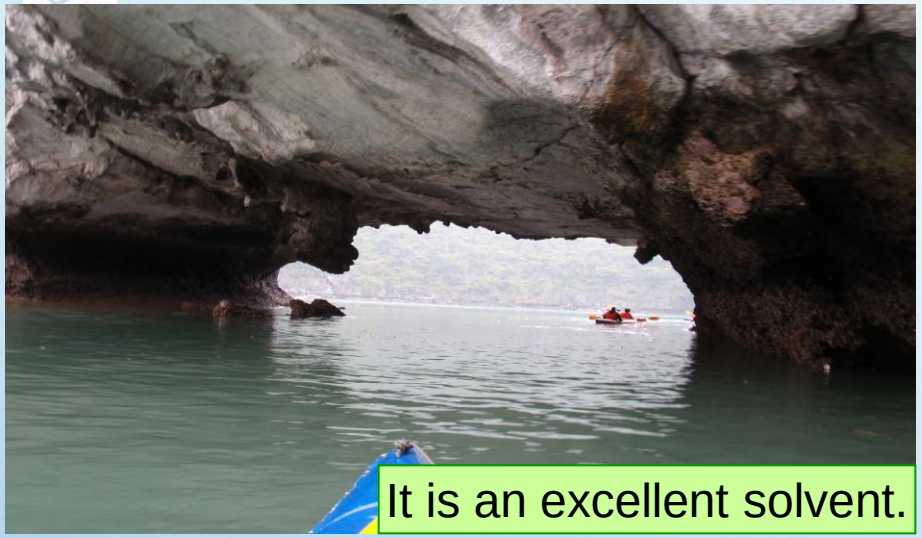
Water on other rocky planets



Water on other rocky planets

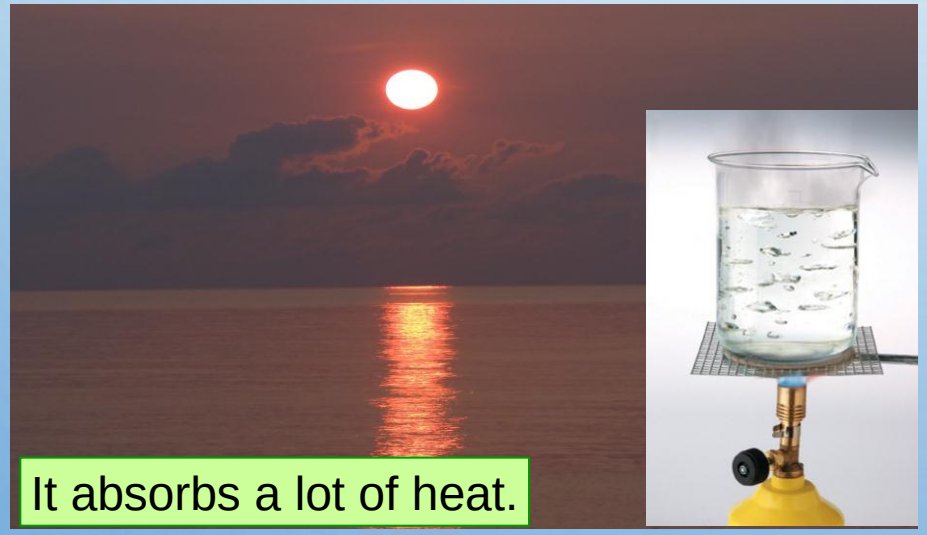


What are some properties of water?



It is an excellent solvent.

It expands on freezing.



It absorbs a lot of heat.

It is highly cohesive and adhesive.

Natural disasters produced by water

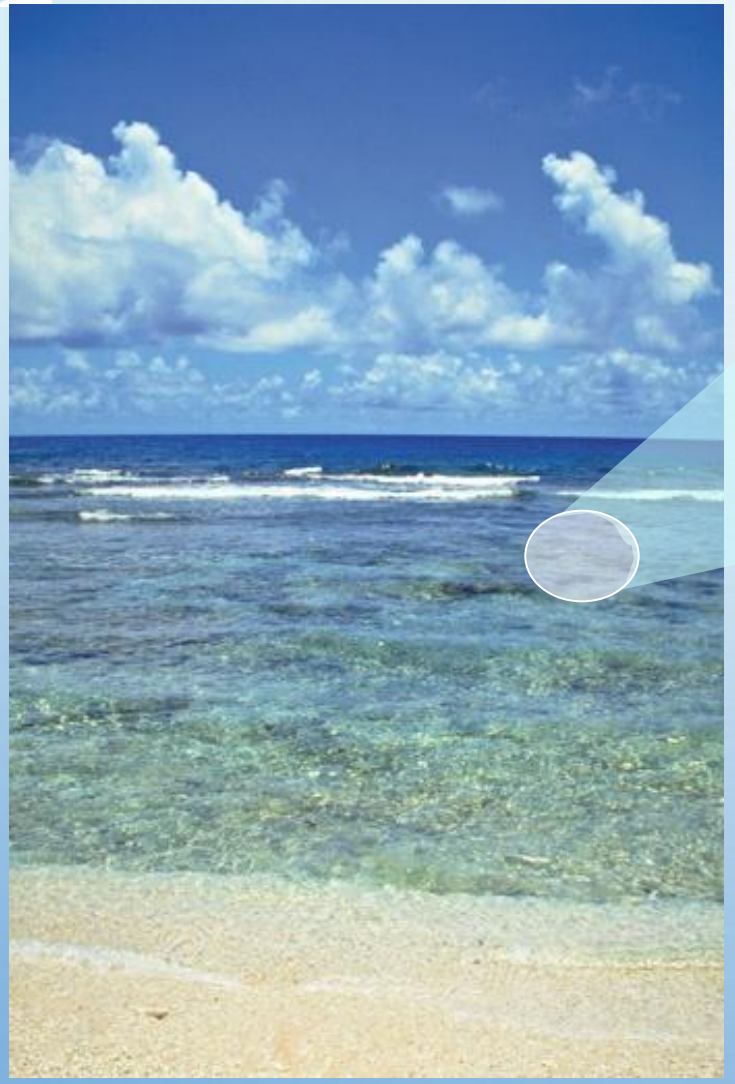
Flash flooding

River flooding

Torrential rain

Tsunamis

What is sea water like?



Proportions of dissolved salts

87 %
chlorides

2 %
others

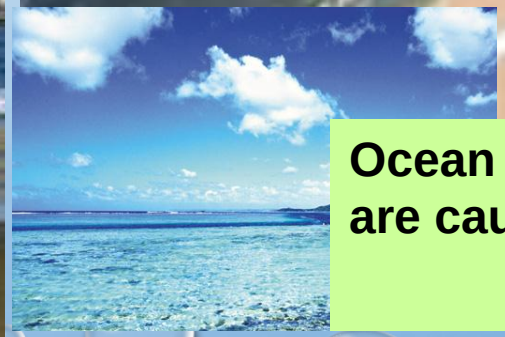
11 %
sulphates

- It is salty.
- It contains dissolved gases from:
  - wave action
  - the activity of aquatic plants and animals
- Temperature varies with depth.

Movements produced in the oceans

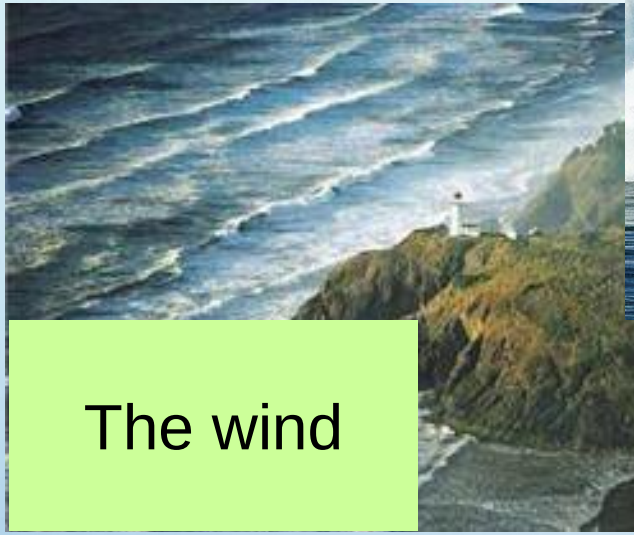
Waves are caused by

Tides are caused by



Ocean currents are caused by

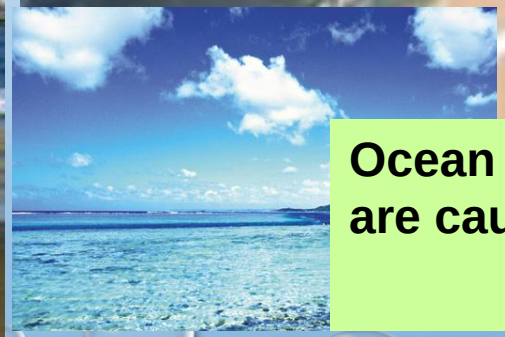
Movements produced in the oceans



The wind

Waves are caused by

Tides are caused by



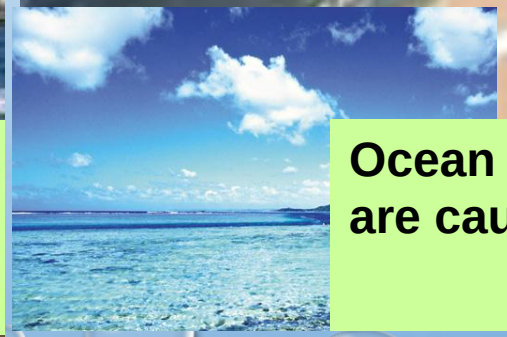
Ocean currents are caused by

Movements produced in the oceans

Waves

Tides are caused by

Gravitational attraction of the Moon and Sun on the water



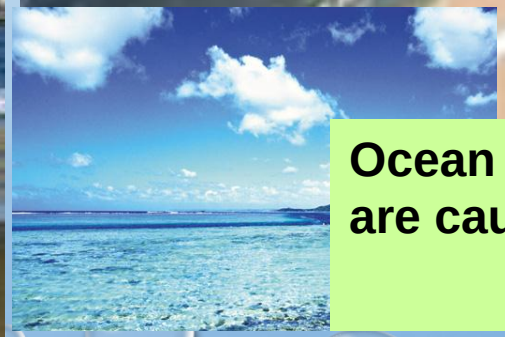
Ocean currents are caused by

Movements produced in the oceans

Waves are caused by

- Winds
- Differences in temperature
- Differences in salinity

Tides are caused by



Ocean currents are caused by

Where is fresh water found?

Lakes

Rivers

Streams or Creeks

Groundwater

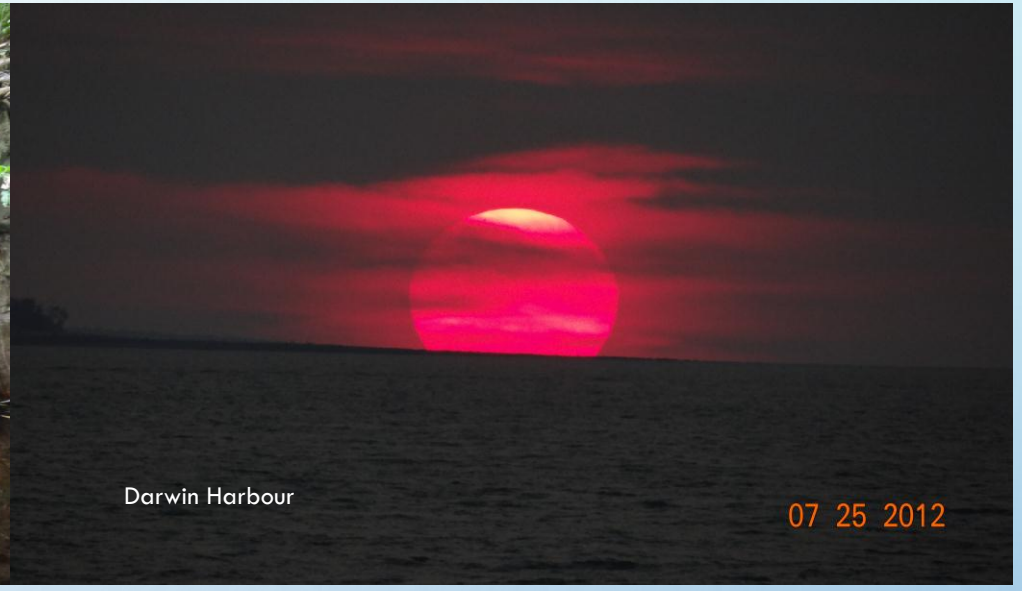
Wetlands

Glaciers

WATER CYCLE REVIEW

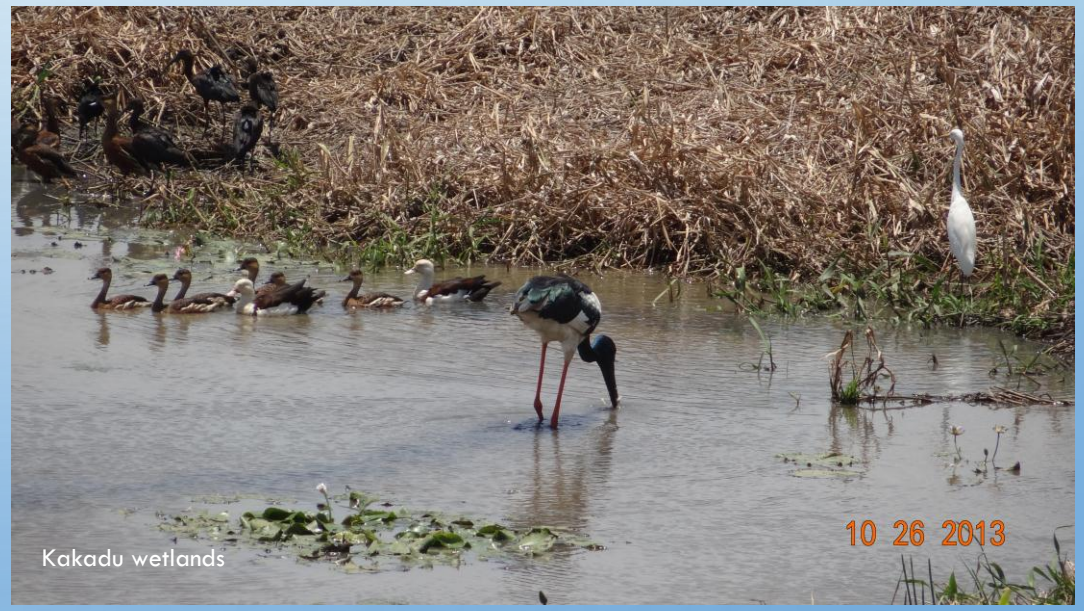

Darwin Sailing Club – 8.3m tide


Tabletop walk - Litchfield



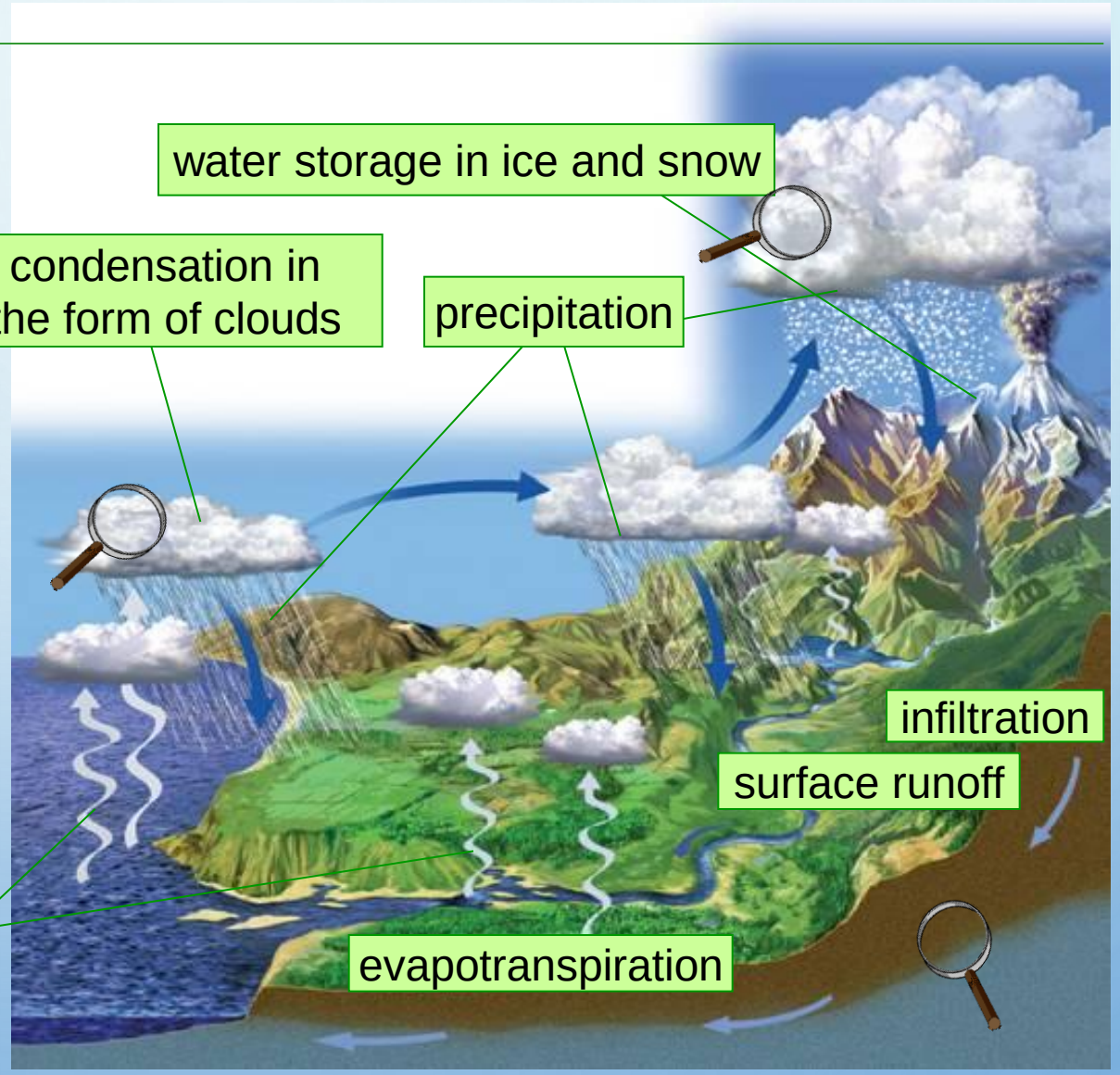
Darwin Harbour

Lunar Eclipse through the clouds



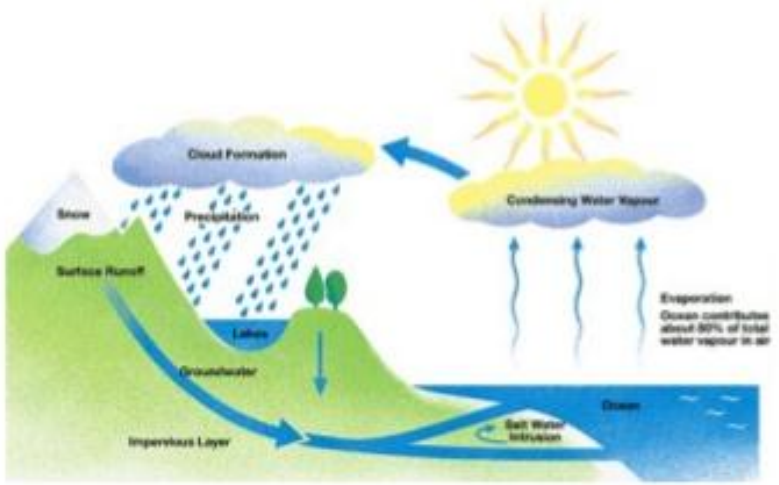
Kakadu wetlands

What is the water cycle?

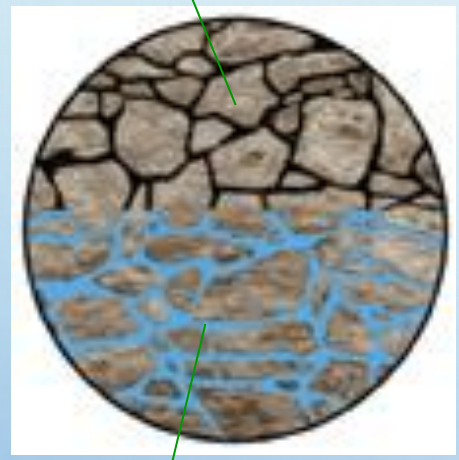


Surface Runoff

- Water flows over the ground instead of sinking into the ground
  - Snow melts, rain runs off surfaces, etc.
  - Streams and rivers carry water back to oceans

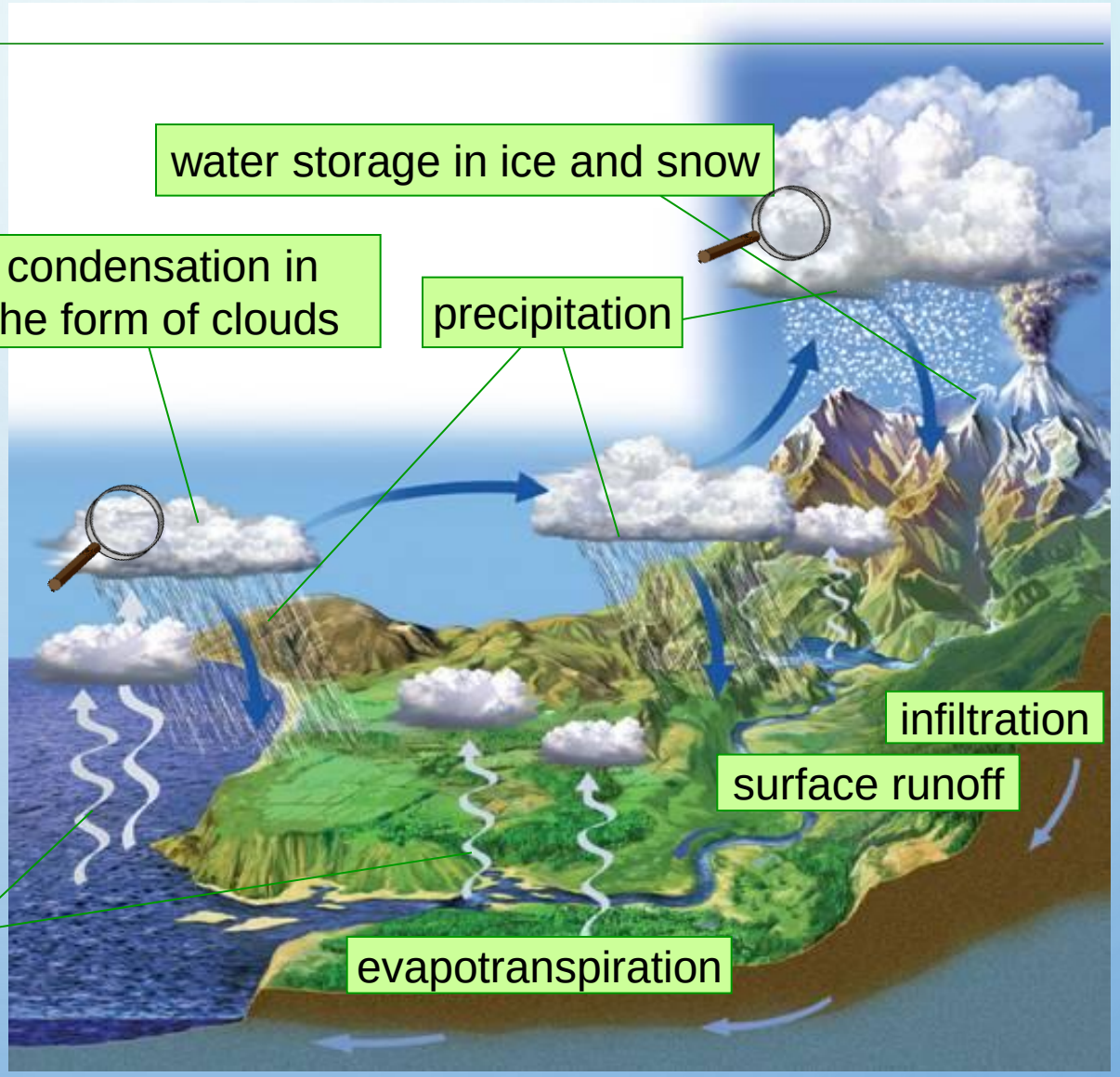


What is the water cycle?



permeable rock

groundwater

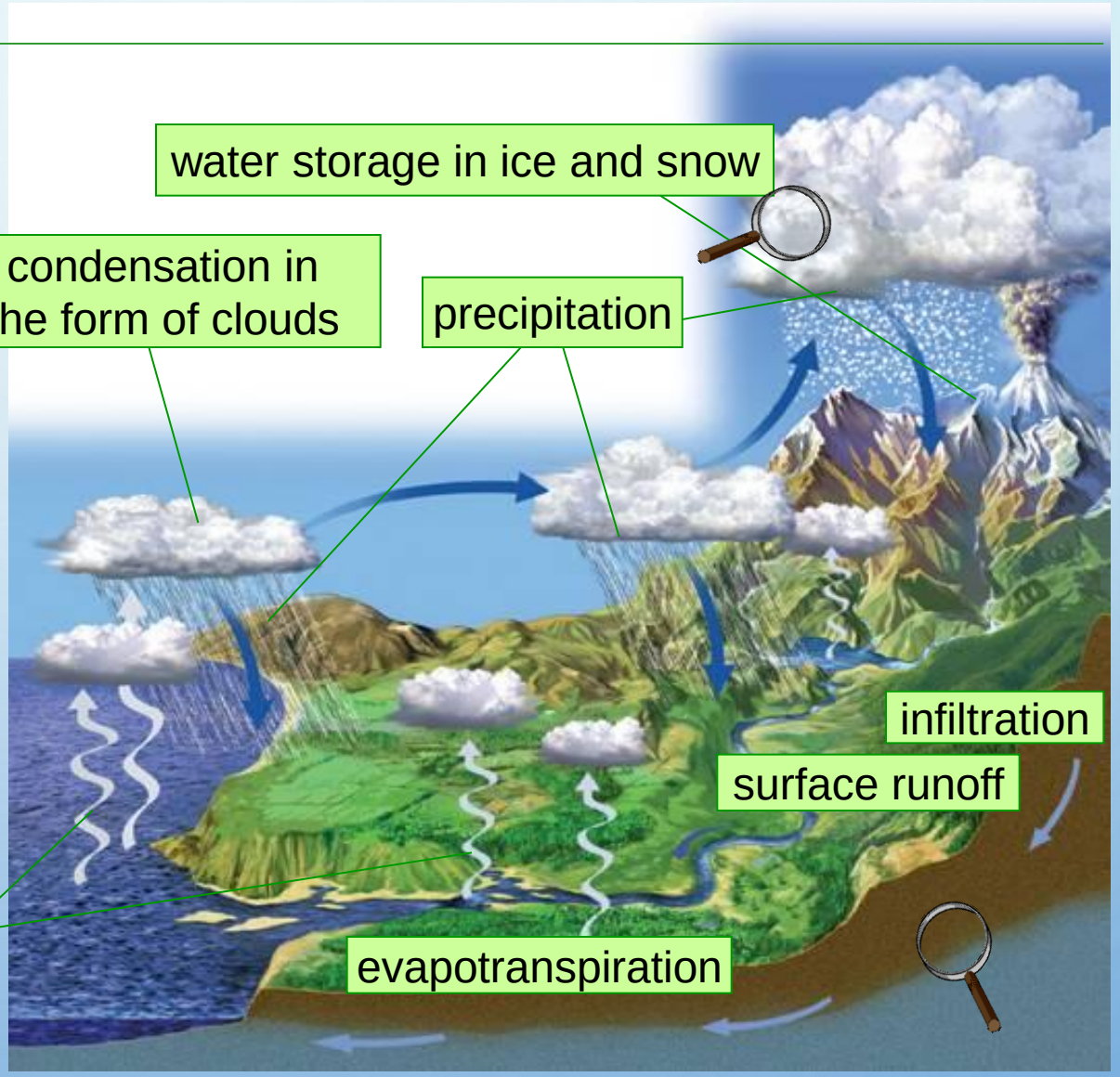


Groundwater

- Precipitation seeps down through soil & rock
- Layers act as filters that trap contaminants
- **Water table:** imaginary line between the water-logged soil and the soil not saturated with water
  - varies with seasonal precipitation, pumping, & geography

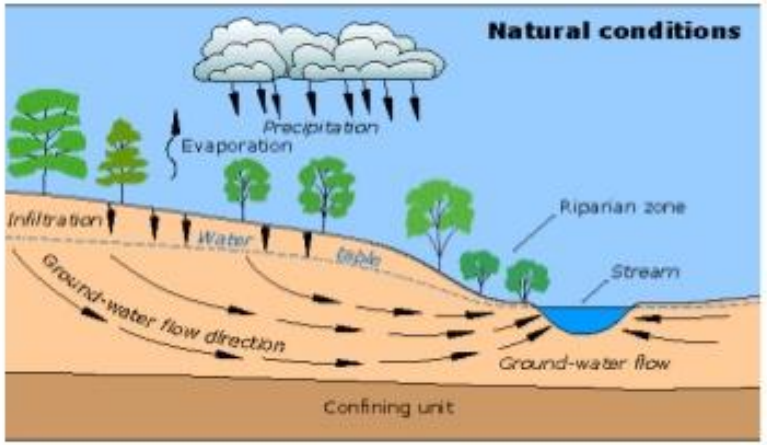
- Two types of **aquifers**:
  - **unconfined**: water supply which has a solid layer of rock under it, but a permeable layer of rocks above it
  - **confined**: water supply sandwiched between two solid rock layers through which water cannot pass
    - pressure builds up and can form an **artesian well**

What is the water cycle?



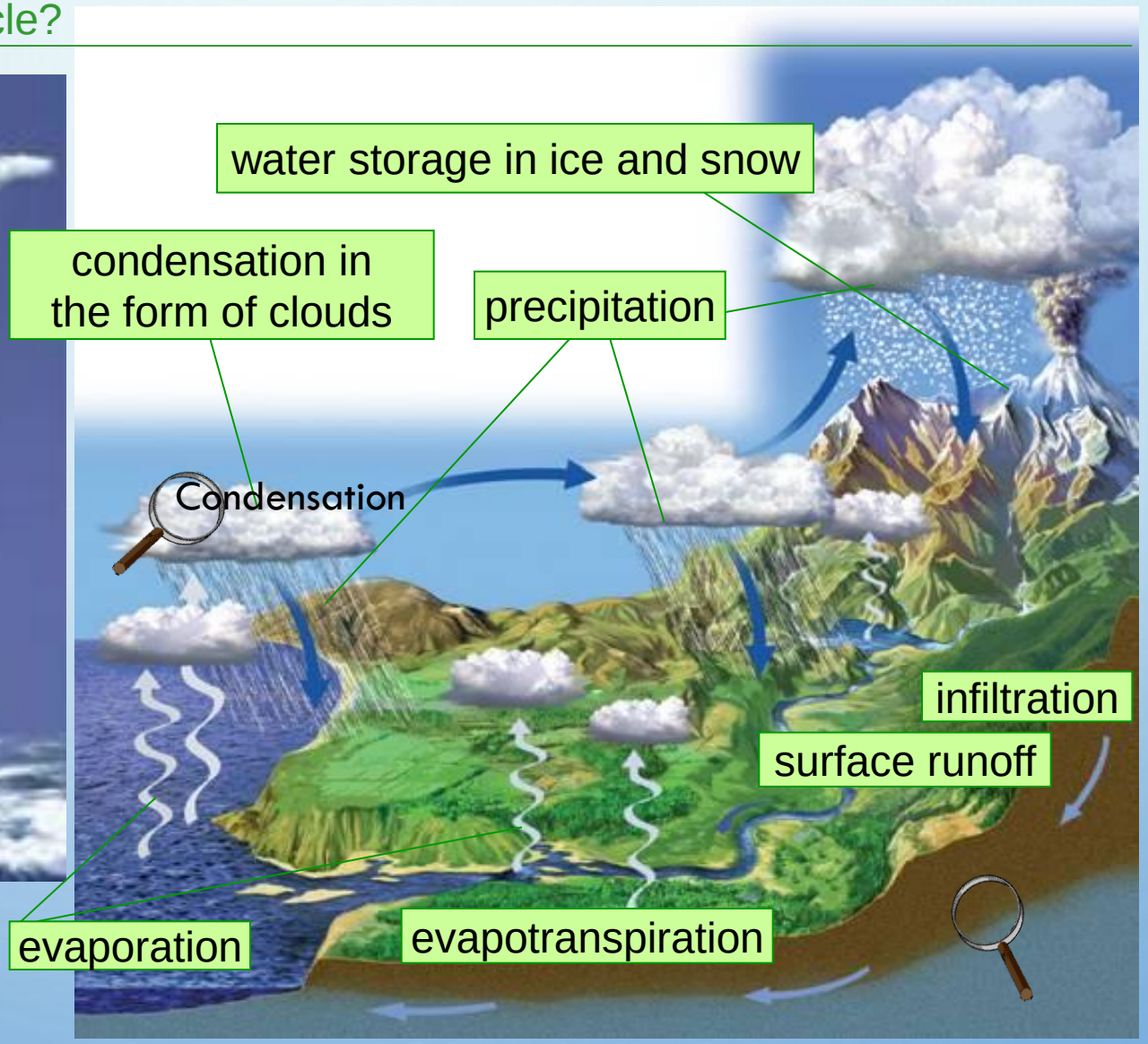
Infiltration

- Water absorbed into subsurface of dirt & rocks
  - Water percolates down between spaces in soil
  - **Groundwater** empties into streams/rivers/oceans or is stored underground in aquifers



- **Saturation** = all the spaces in soil & rock are filled with water
  - Flooding occurs:
    - when soil becomes saturated, or
    - when precipitation falls faster than infiltration can occur

What is the water cycle?

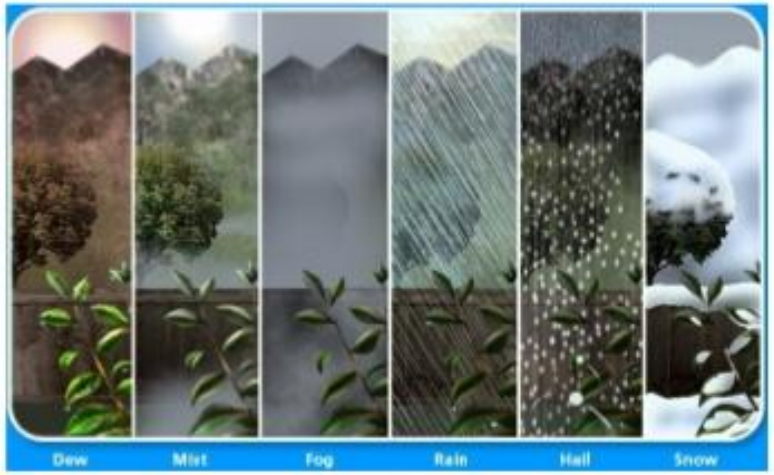


- THE WATER CYCLE (US National Science Foundation)
  HTTPS://YOUTU.BE/AL-DO-HGUIK

- EARTHS WATER CYCLE (NASA)
  HTTPS://YOUTU.BE/OADKPH9YQBS

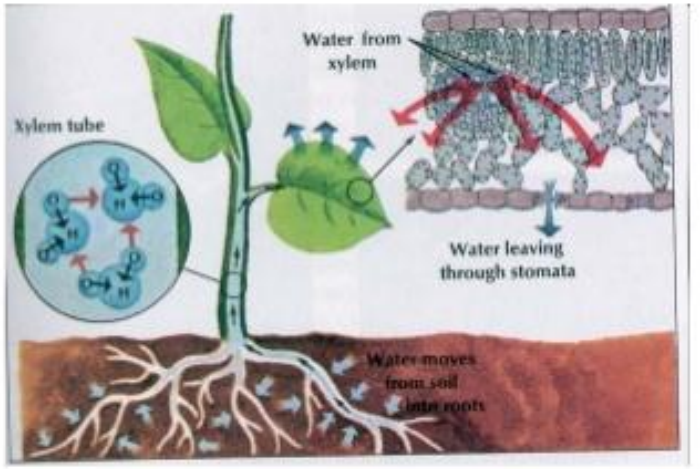
Precipitation

- Water falling from the atmosphere
  - Vapor molecules collide & join to form droplets
  - Falls as rain, snow, sleet, or hail



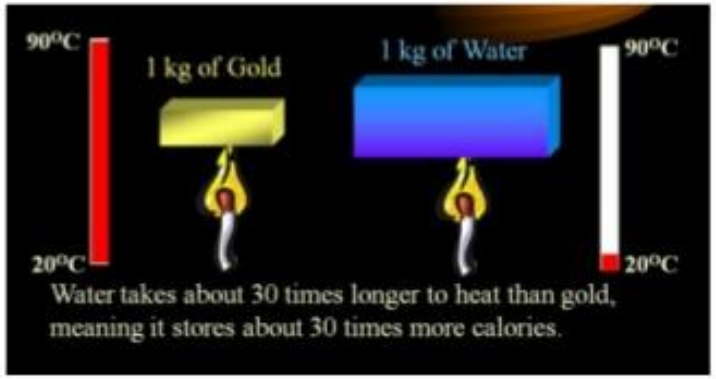
Transpiration

- Emission of water vapor from plants
  - Plants absorb water from soil to use in photosynthesis
  - Water vapor released through stomata (pores) under leaves



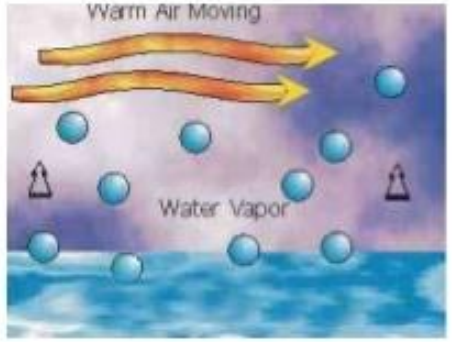
Water Resists Temperature Changes

- Heat = how fast molecules are moving
- Water's polarity makes the molecules both "sticky" and "slippery" (like magnets that attract & repel)
  - stickiness: resistant to vaporizing because of cohesion
  - slipperiness: resistant to freezing because they keep sliding around
- **Specific Heat** = energy needed to raise or lower 1g of anything by 1° C
  - Water has a very high specific heat
- Water stabilizes air temperatures
  - Absorbs/releases large amounts of heat with only a slight change in its own temperature



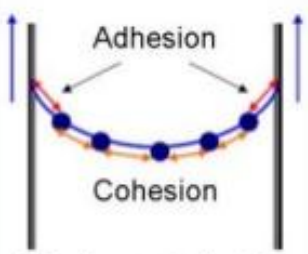
Water Vapor

- Water boils at 100°C (212°F)
  - LOTS of energy to break hydrogen bonds
- Evaporation can occur at much lower temperatures
- Water vapor in atmosphere resists temperature changes
- Evaporation absorbs lots of heat energy
  - Evaporative cooling (sweat, panting, seashore)



Adhesion

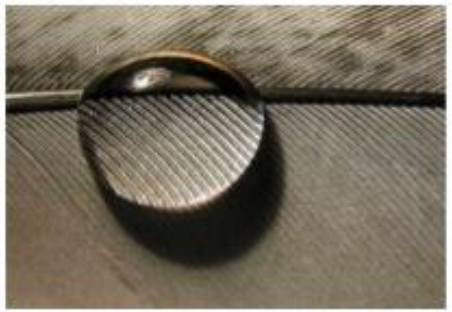
- Attraction between particles of different substances
  - i.e. water and glass
- Explains **capillary action**
  - water molecules will "tow" each other along when in a thin tube
- Transports water against gravity (roots to leaves) in plants



Adhesion > Cohesion

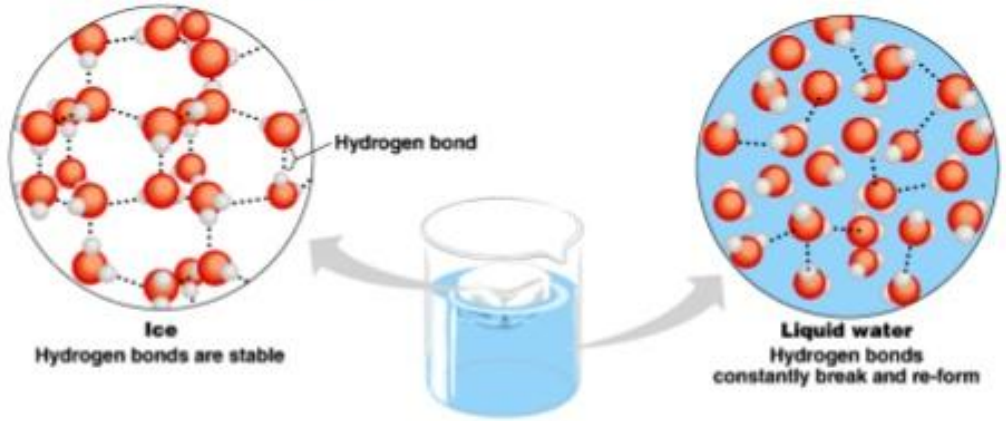
Cohesion

- Attraction between particles of the same substance (i.e. water molecules)
- Results in **Surface Tension**
  - molecules at the surface cling together
  - produces a "film" on top of water that allow some things to remain afloat
  - only at surface



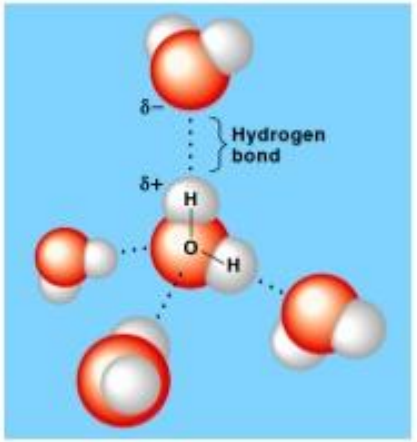
Frozen Water's Density

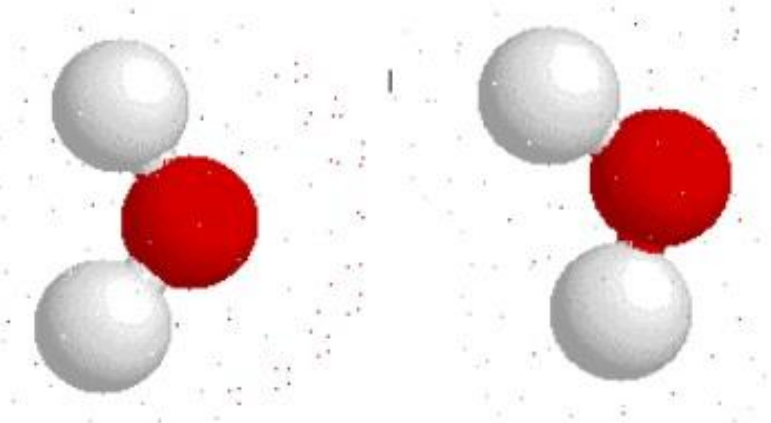
- Water freezes at 0° C (32° F)
- H_2O is most dense at 4° C (as a liquid)
- Crystal lattice formation the result of water's polarity
- Density of solid H_2O is 9% less than liquid H_2O



Hydrogen Bonding

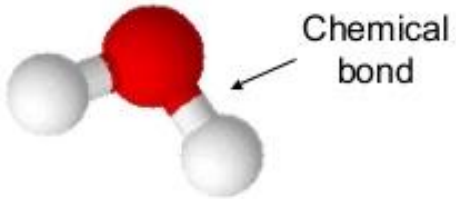
- Attraction between oppositely charged regions of water molecules
- Each molecule can have H-bonds with four other water molecules
- Weak bonds continually break & reform

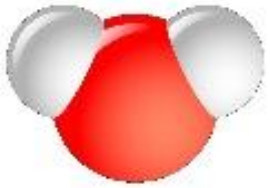


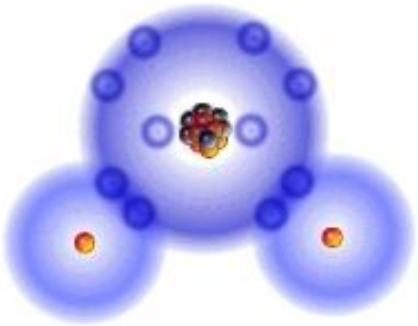


Chemical Formula

- H_2O
- Shows how many and which type of atoms make a single molecule







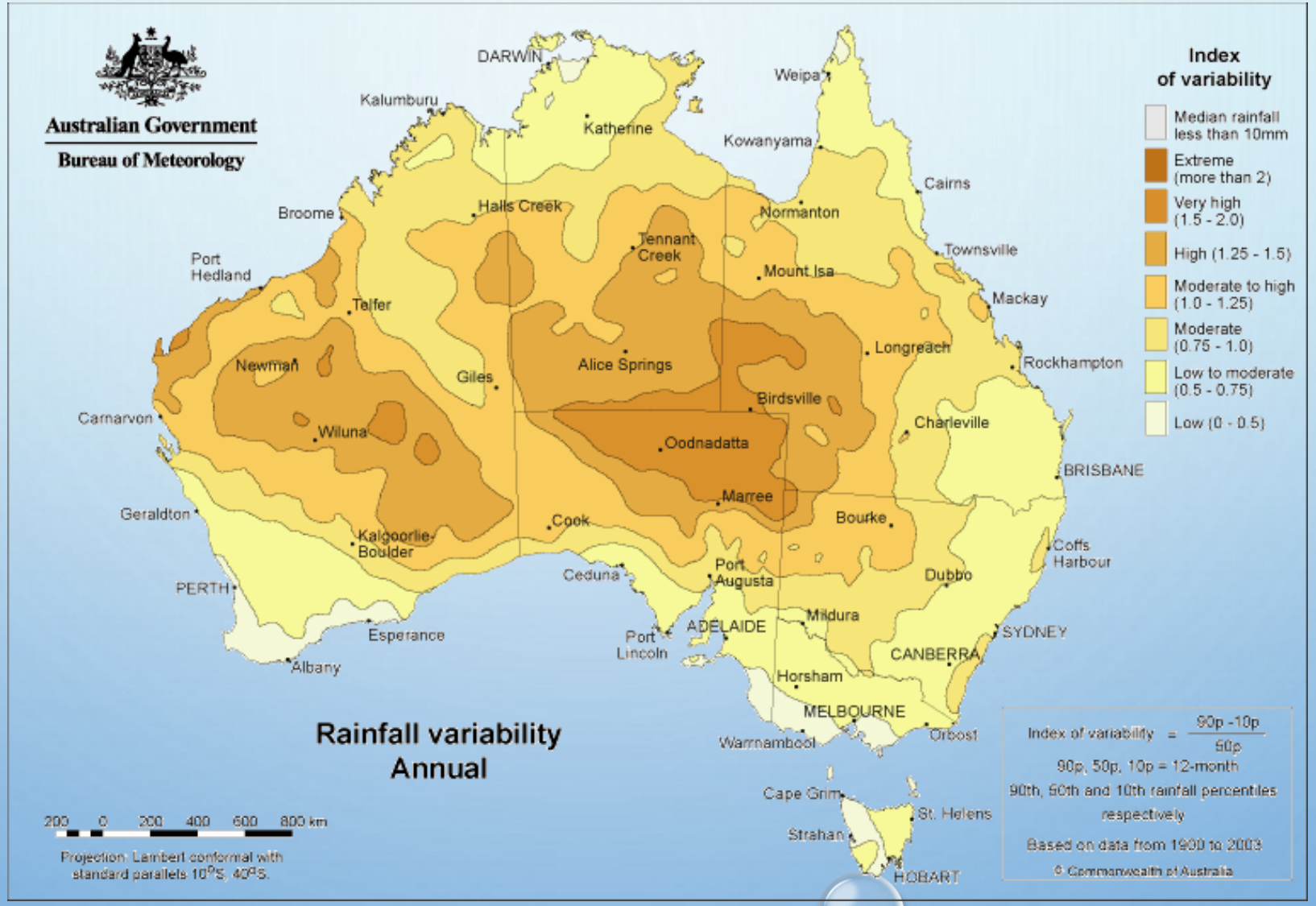
- How many atoms form one water molecule?

BREAK AND QUESTIONS

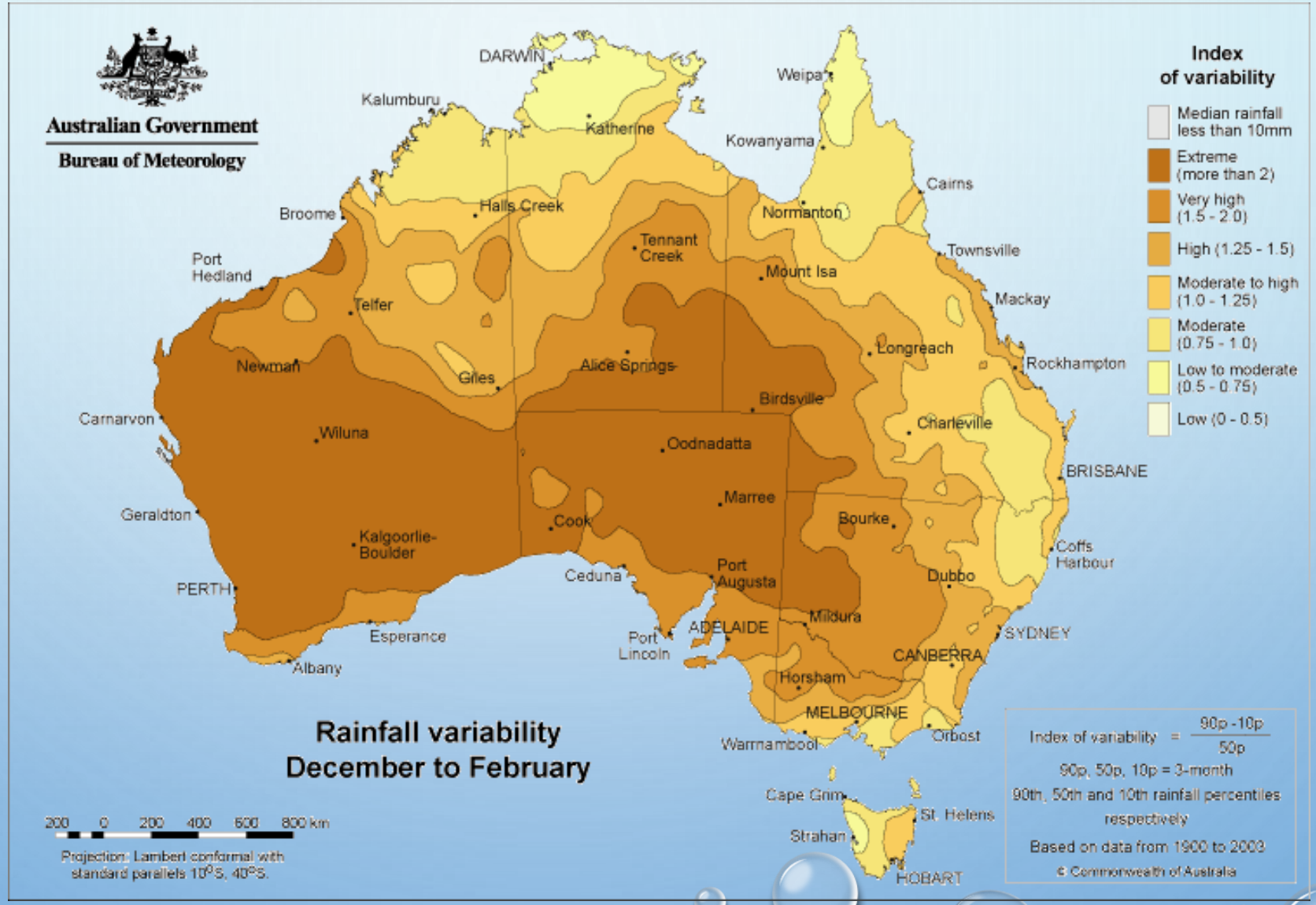
NT Water Resources – Constraints, Opportunities and Climate Change

Ian Lancaster

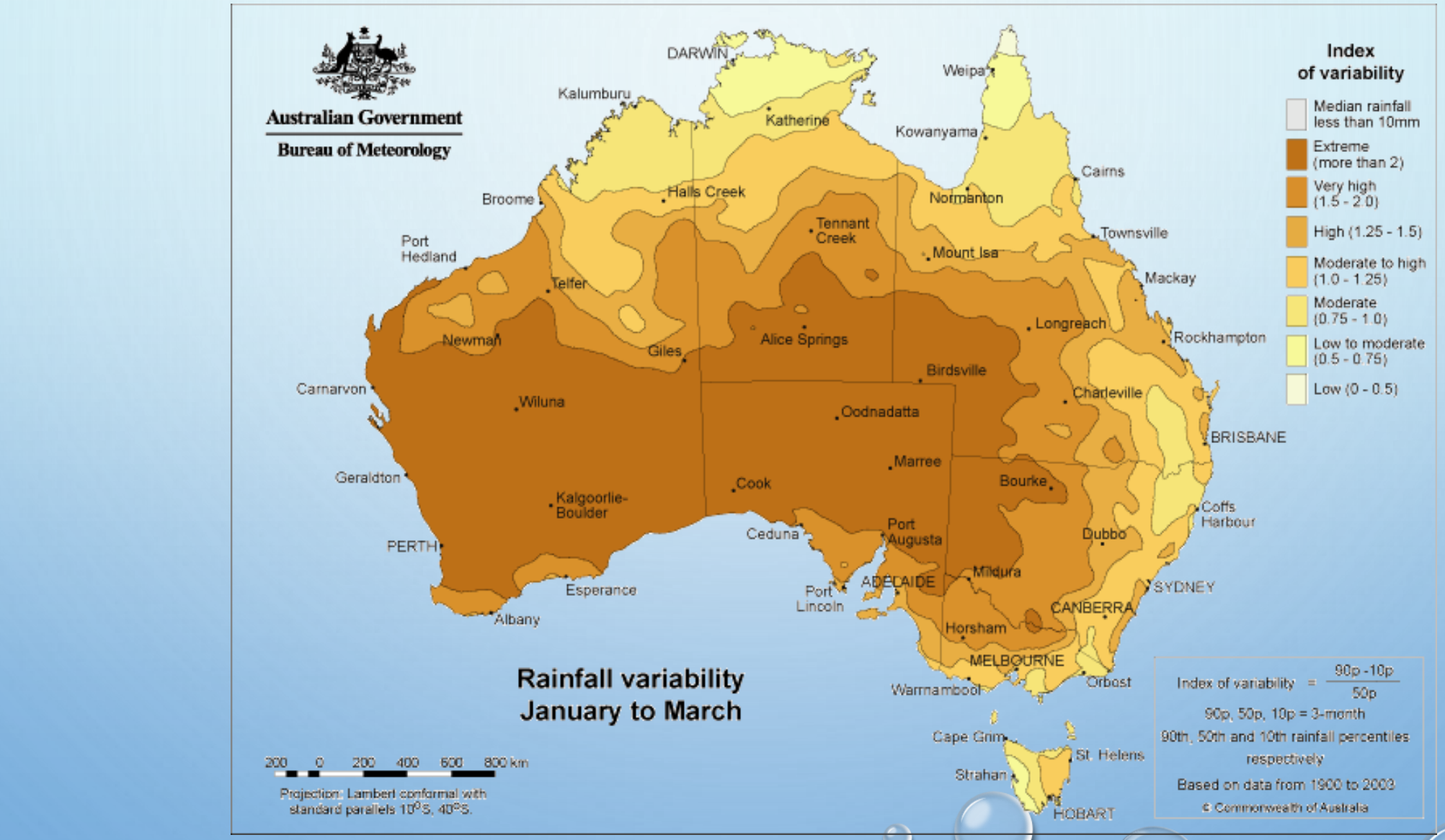
DROUGHT


Australian Government
Bureau of Meteorology
Index of variability
Median rainfall less than 10mm
Extreme (more than 2)
Very high (1.5 - 2.0)
High (1.25 - 1.5)
Moderate to high (1.0 - 1.25)
Moderate (0.75 - 1.0)
Low to moderate (0.5 - 0.75)
Low (0 - 0.5)
DARWIN
Kalumburu
Katherine
Weipa
Kowanyama
Cairns
Broome
Halls Creek
Normanton
Tennant Creek
Townsville
Port Hedland
Mount Isa
Telfer
Mackay
Newman
Giles
Alice Springs
Longreach
Rockhampton
Carnarvon
Birdsville
Wiluna
Charleville
Oodnadatta
BRISBANE
Marree
Geraldton
Cook
Bourke
Kalgoorlie-Boulder
Coffs Harbour
Ceduna
Port Augusta
Dubbo
PERTH
Mildura
ADELAIDE
SYDNEY
Esperance
Port Lincoln
CANBERRA
Albany
Horsham
MELBOURNE
Warrnambool
Orbost
Cape Grim
St. Helens
Strahan
HOBART
Rainfall variability
Annual
200 0 200 400 600 800 km
Projection: Lambert conformal with standard parallels 10°S, 40°S.
Index of variability = 90p - 10p / 50p
90p, 50p, 10p = 12-month 90th, 50th and 10th rainfall percentiles respectively
Based on data from 1900 to 2003
© Commonwealth of Australia

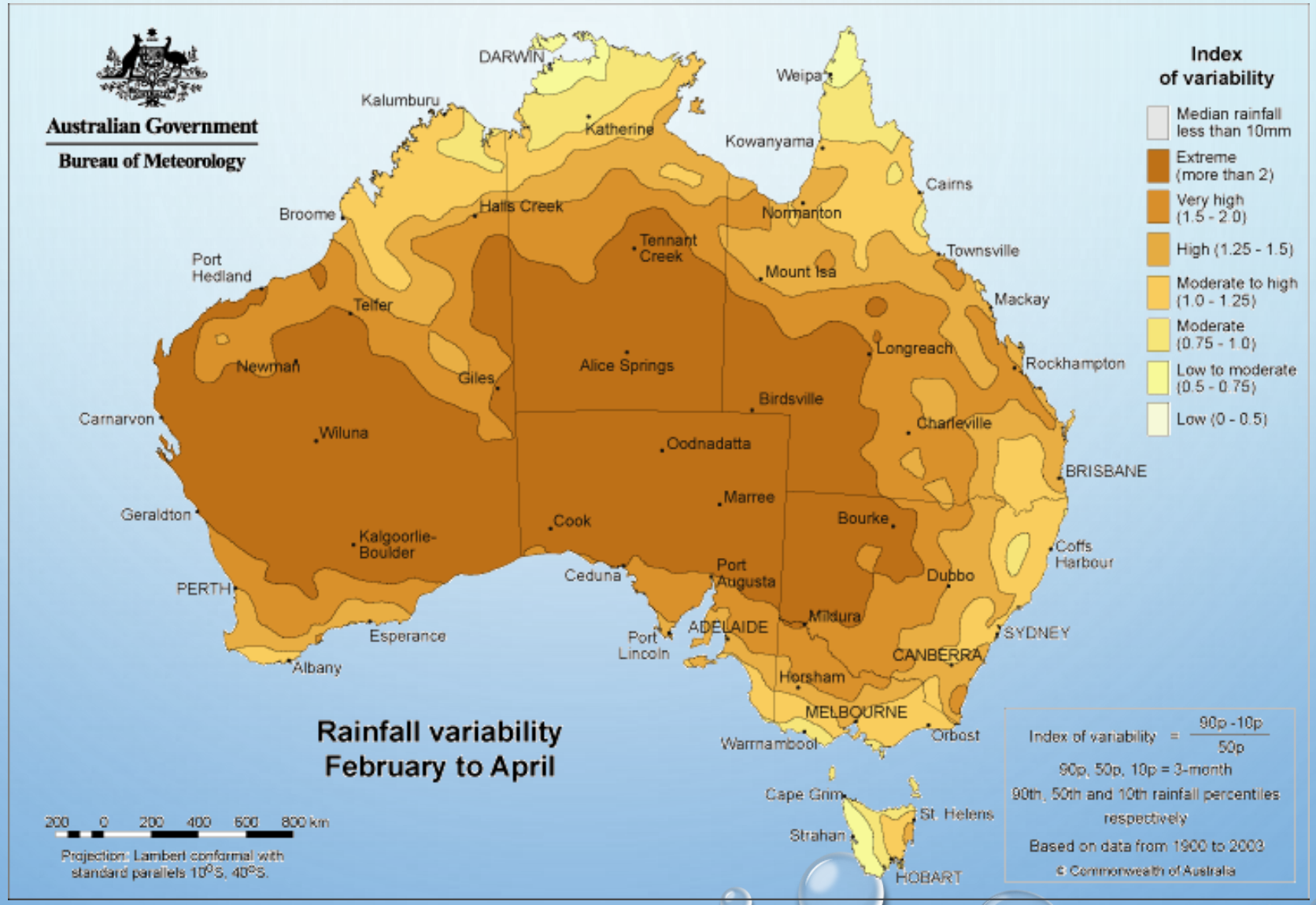
WET – LOW TO MOD VARIABILITY



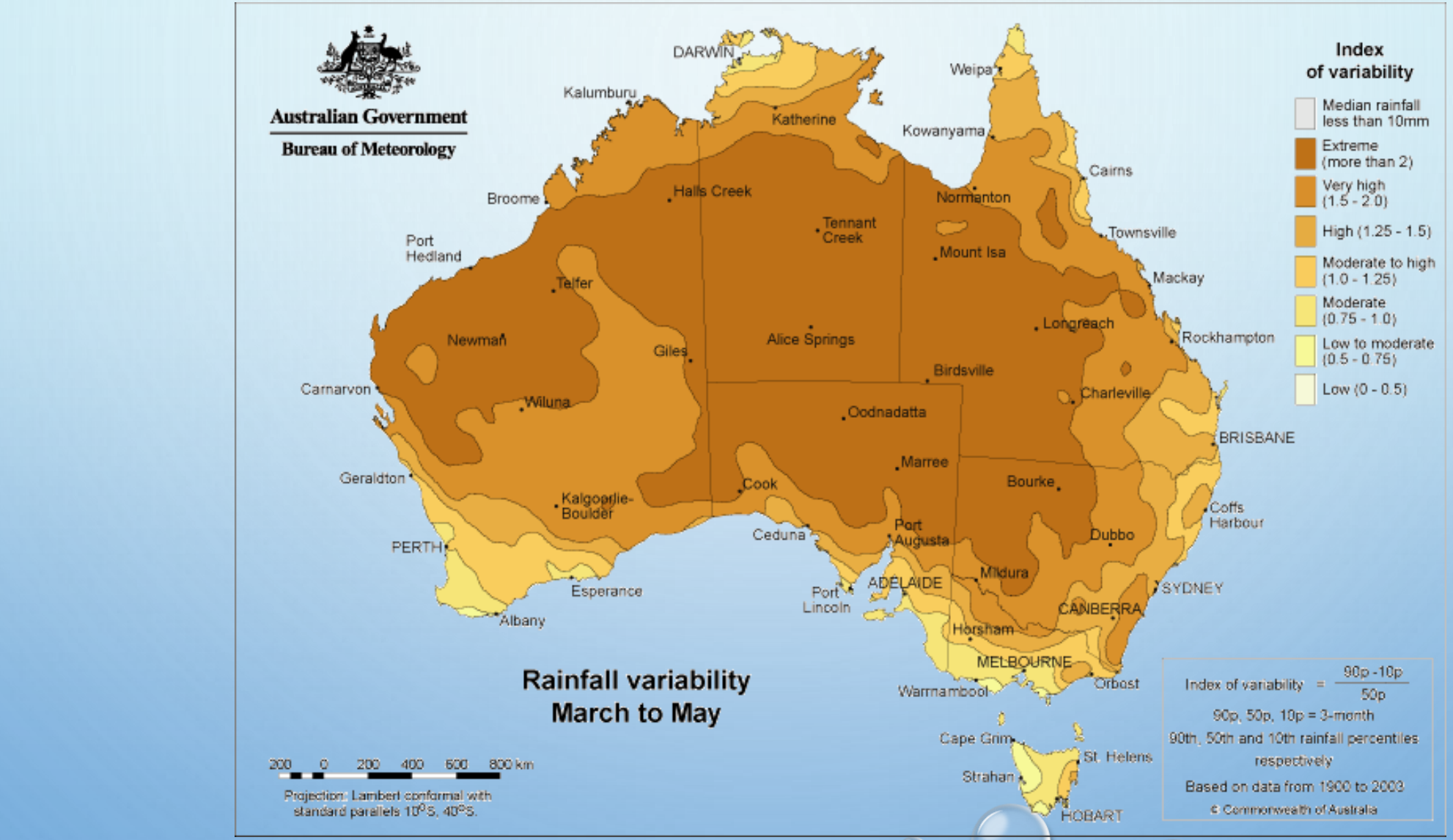
MID WET – LOW VARIABILITY



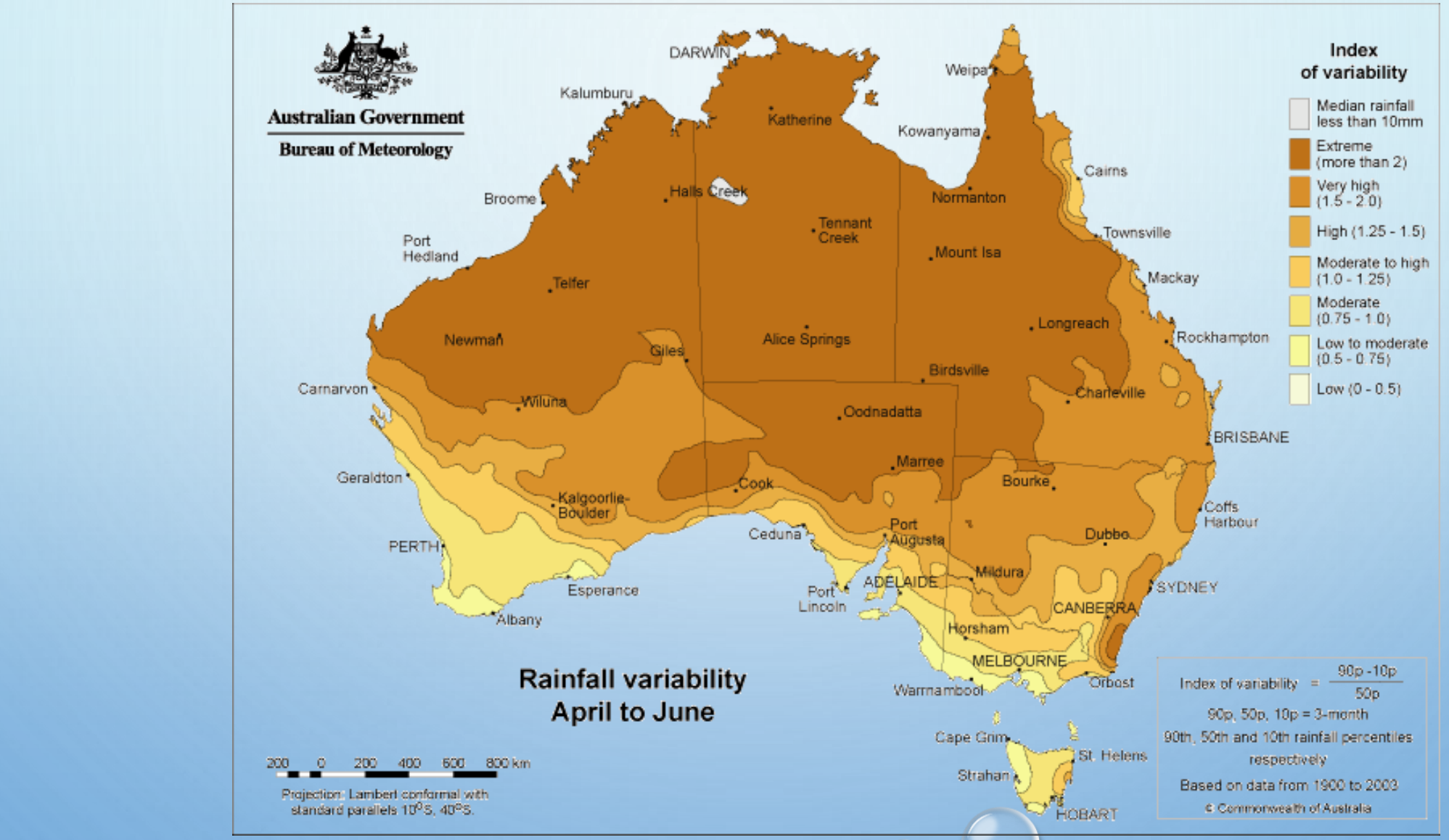
LATE WET – MODERATE VARIABILITY



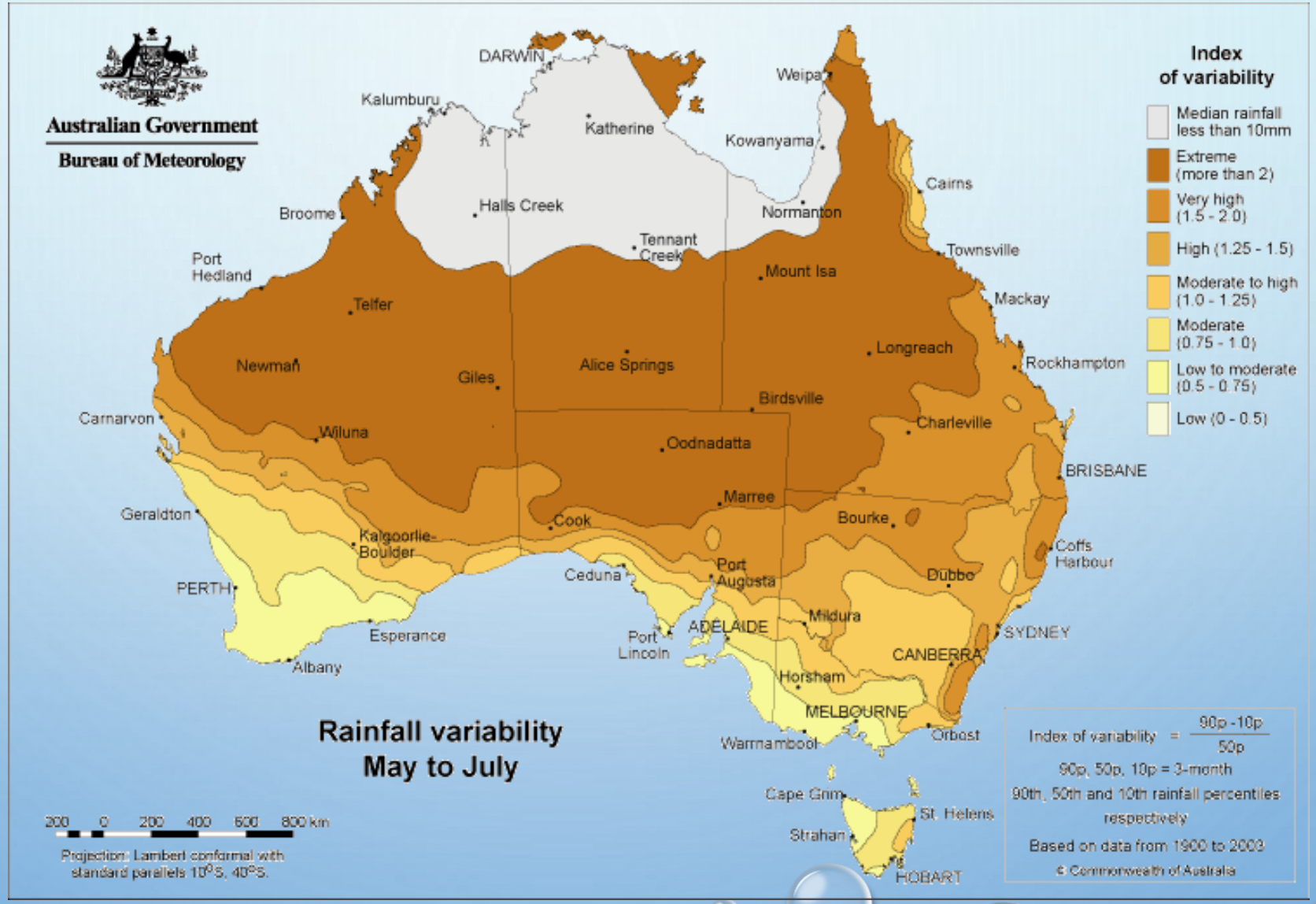
EARLY DRY – MODERATE TO HIGH VARIABILITY



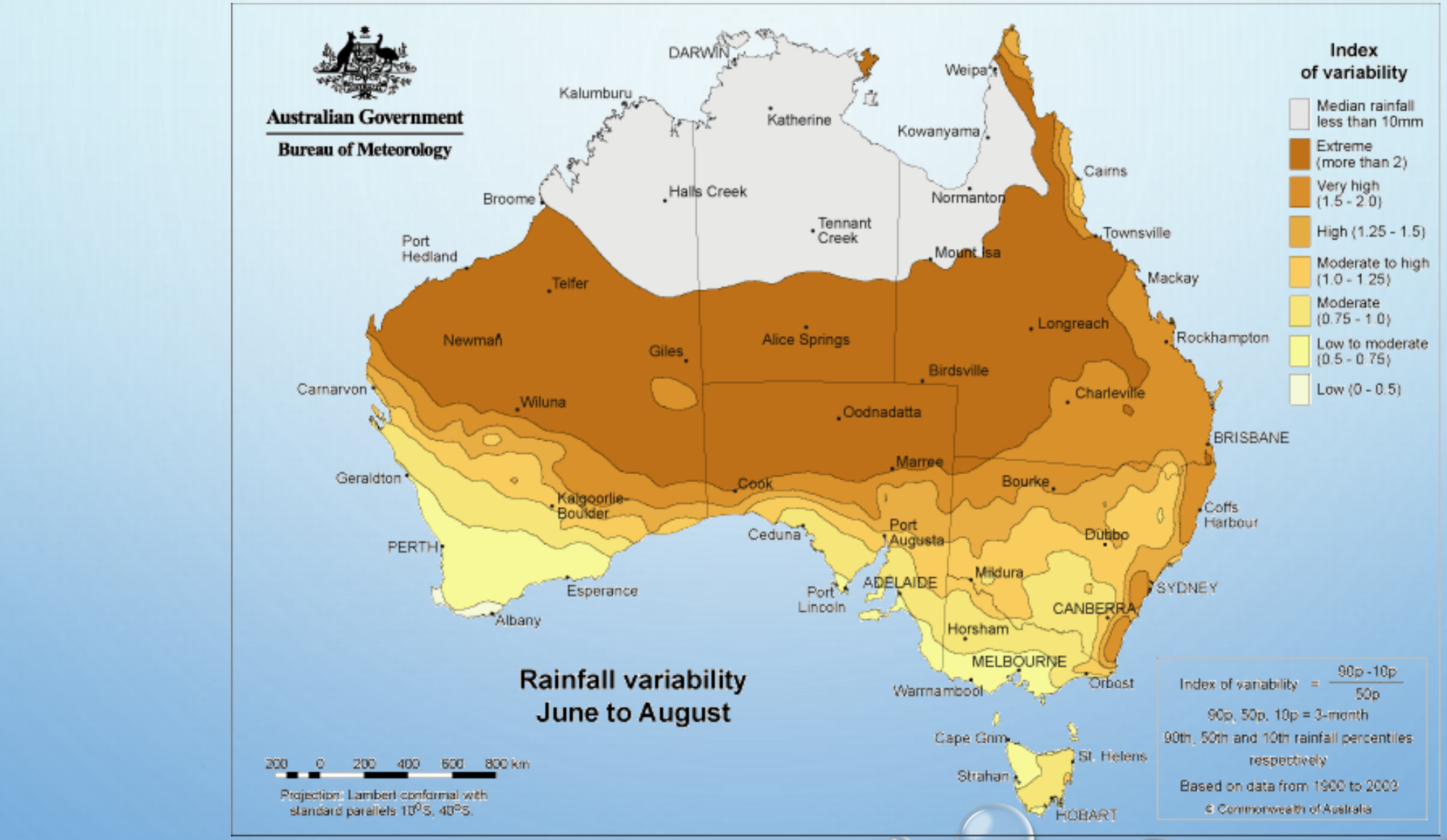
EARLY DRY – EXTREME VARIABILITY



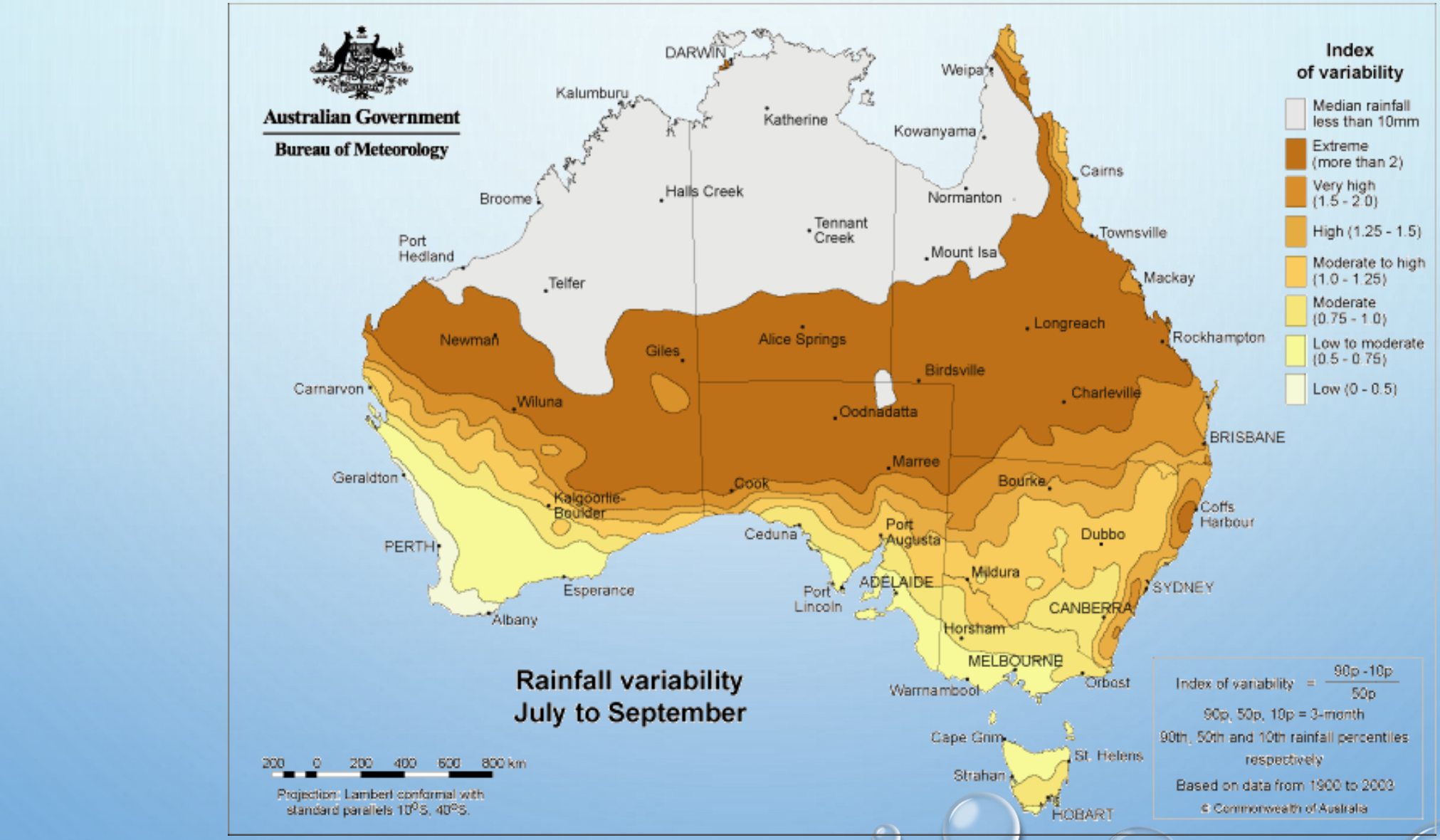
DRY –LOW VARIABILITY >10MM



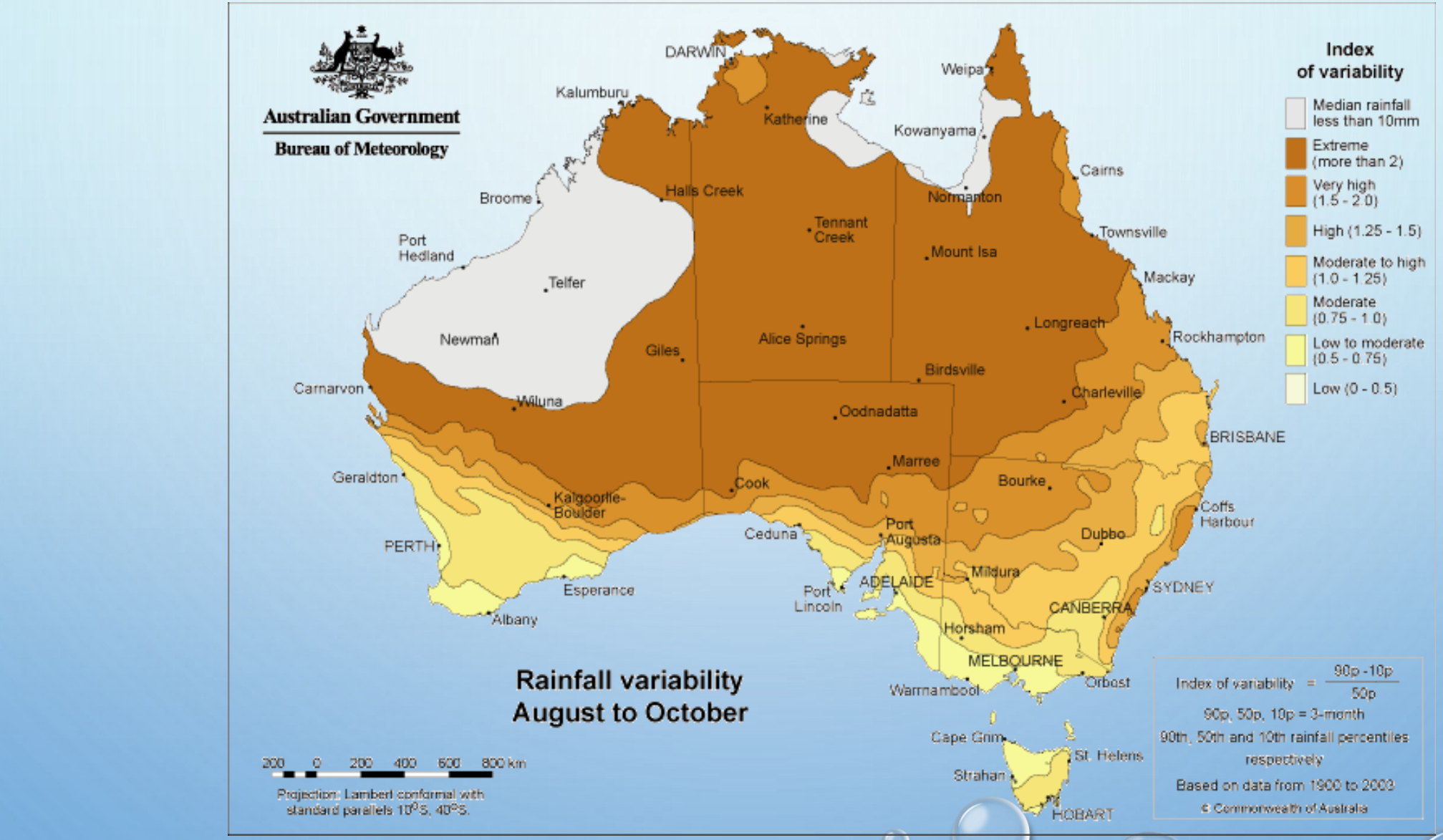
MID DRY – LOW VARIABILITY >10MM



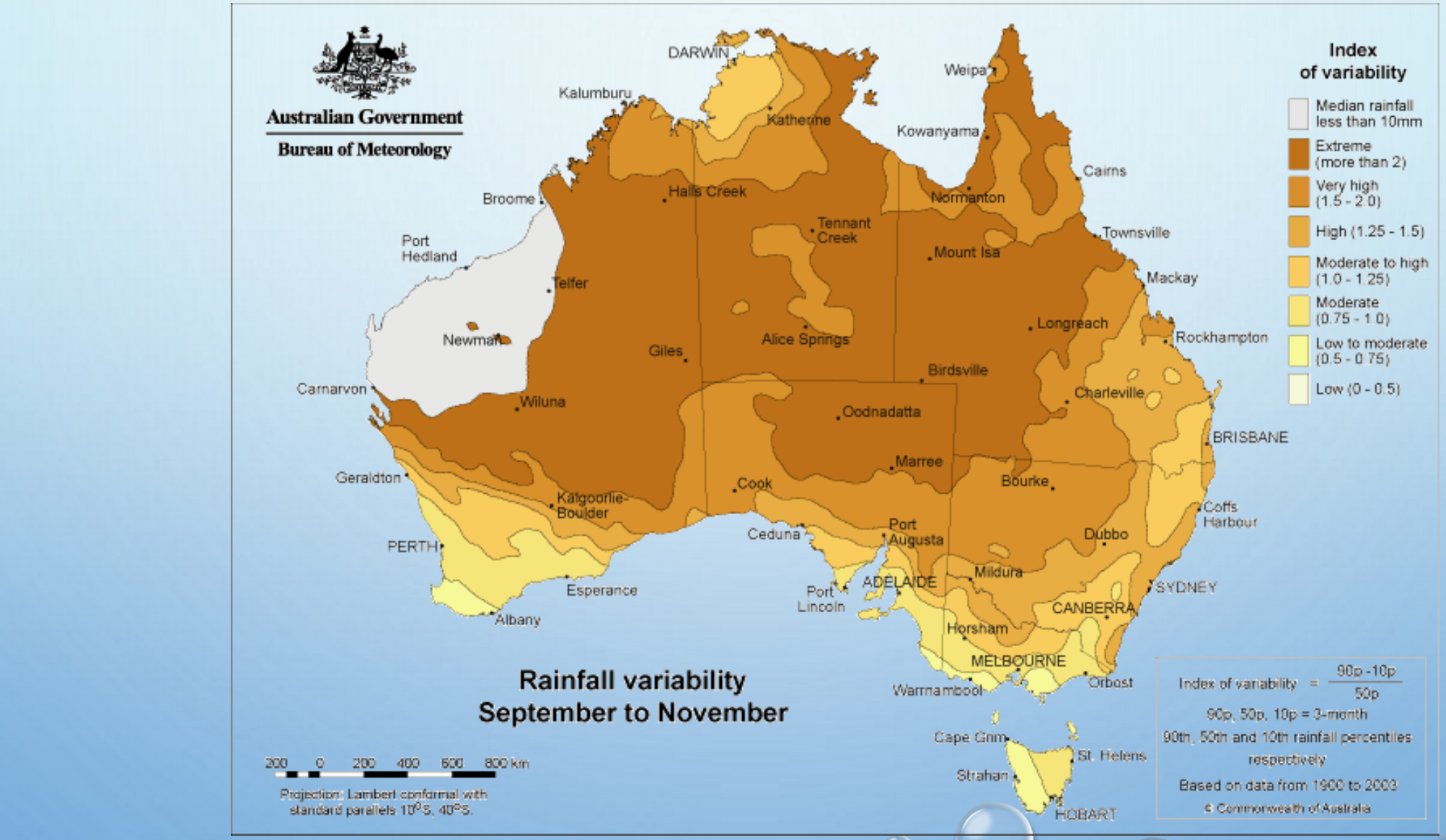
MID DRY – LOW VARIABILITY >10MM



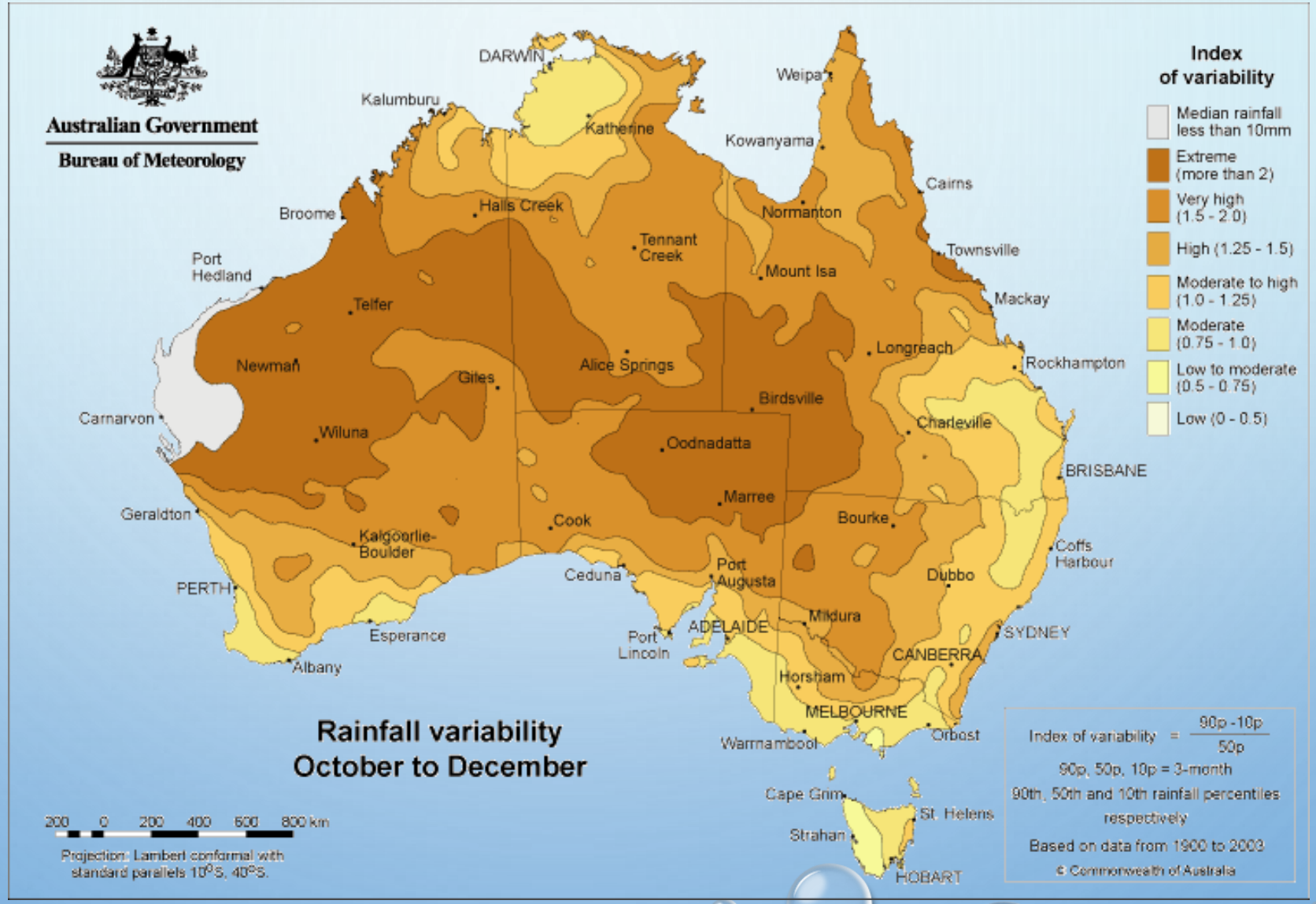
LATE DRY – EXTREME VARIABILITY



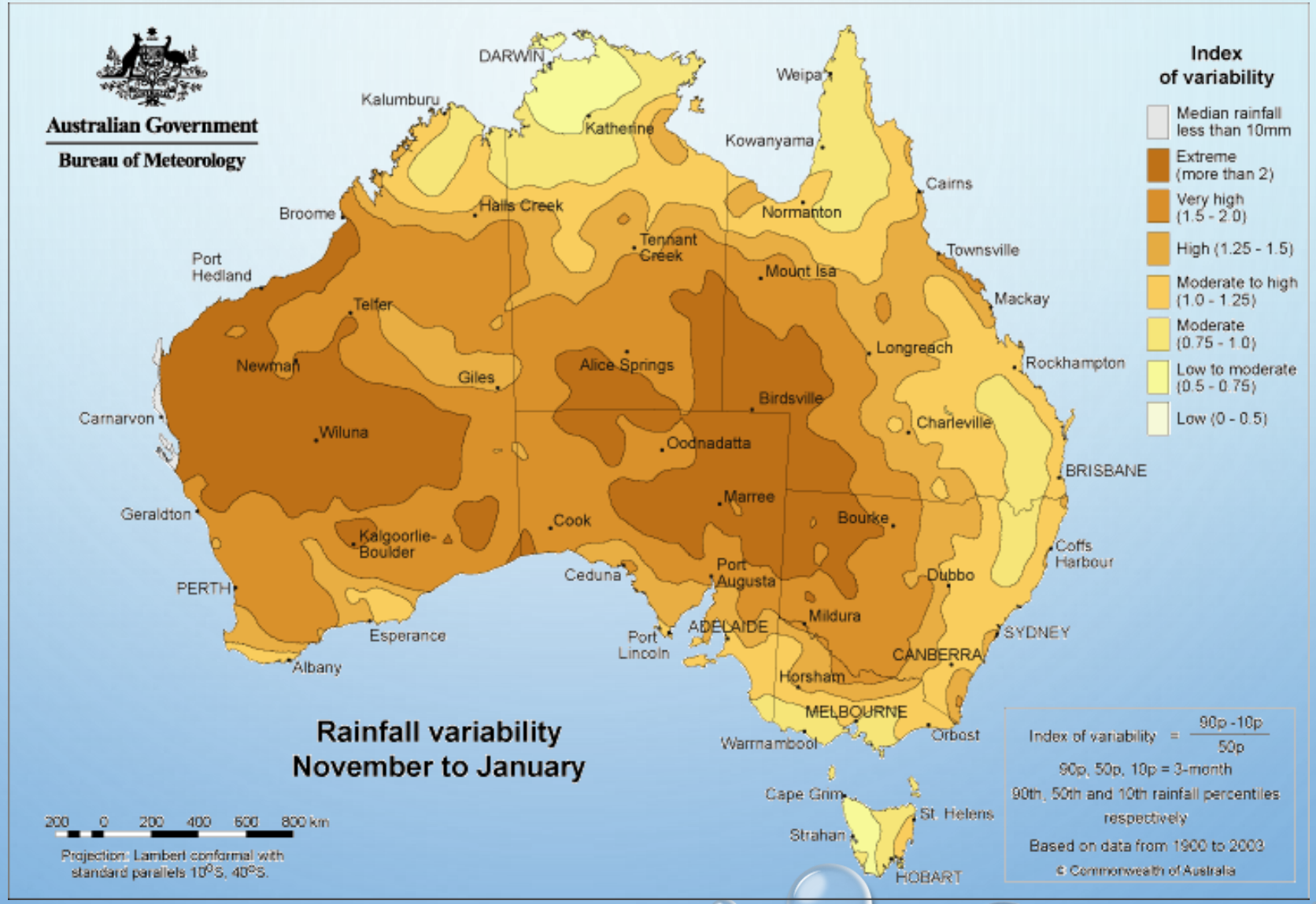
BUILDUP – MOD TO HIGH VARIABILITY



BUILDUP– MODERATE VARIABILITY



EARLY WET – LOW VARIABILITY



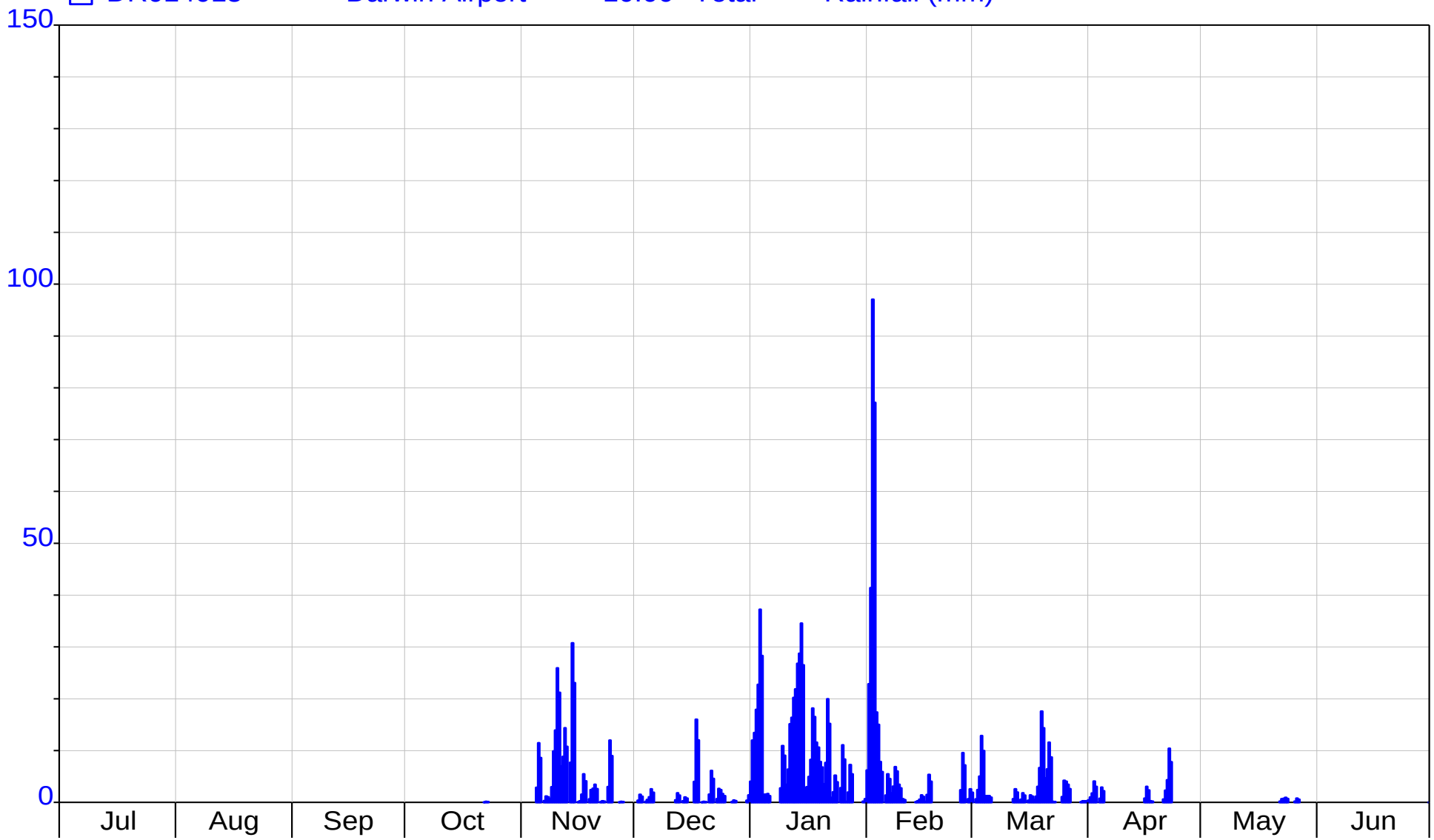
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1941 1941/42

Interval12 Hour Plot End 00:00_01/07/1942

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



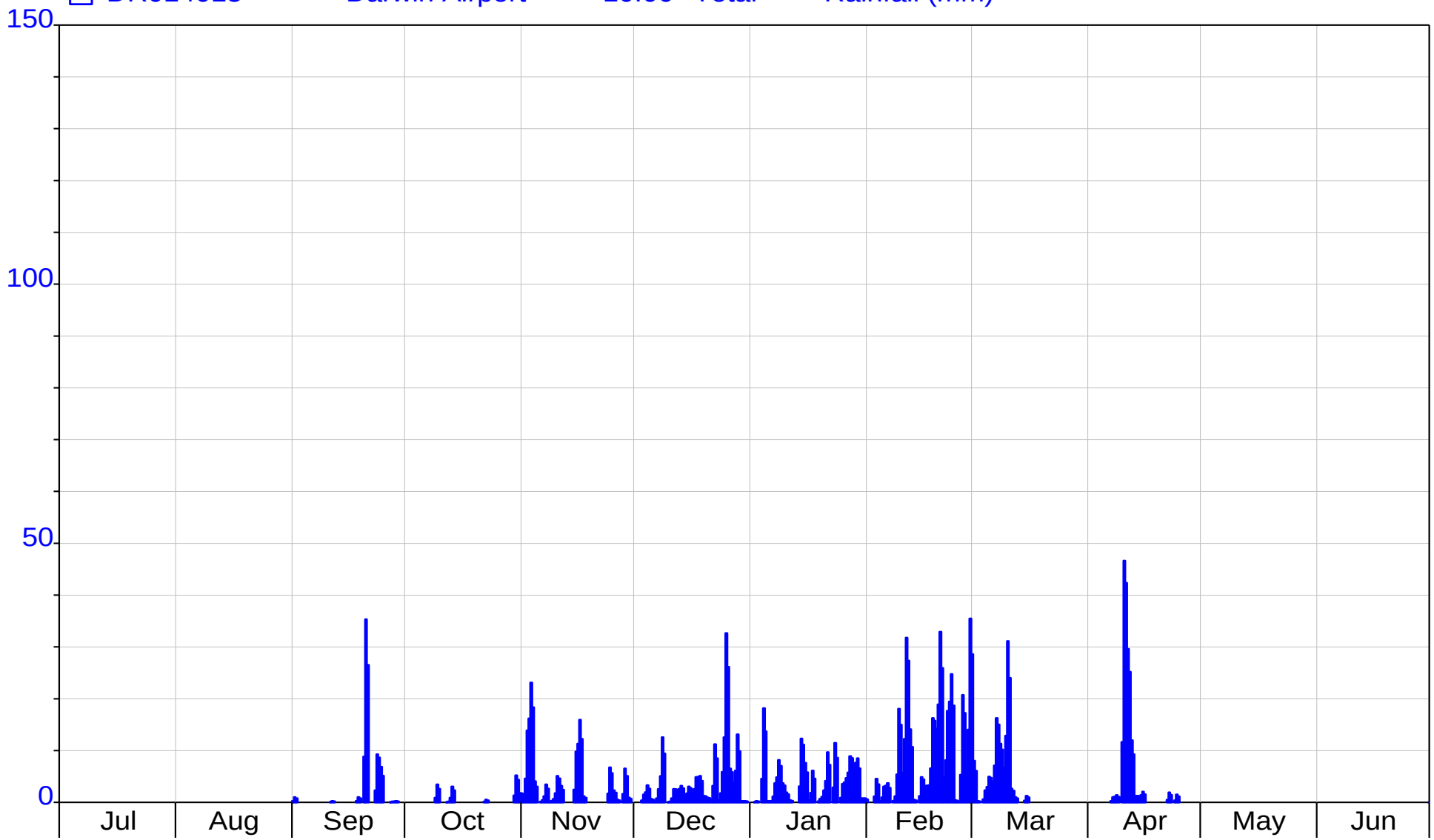
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1942 1942/43

Interval12 Hour Plot End 00:00_01/07/1943

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



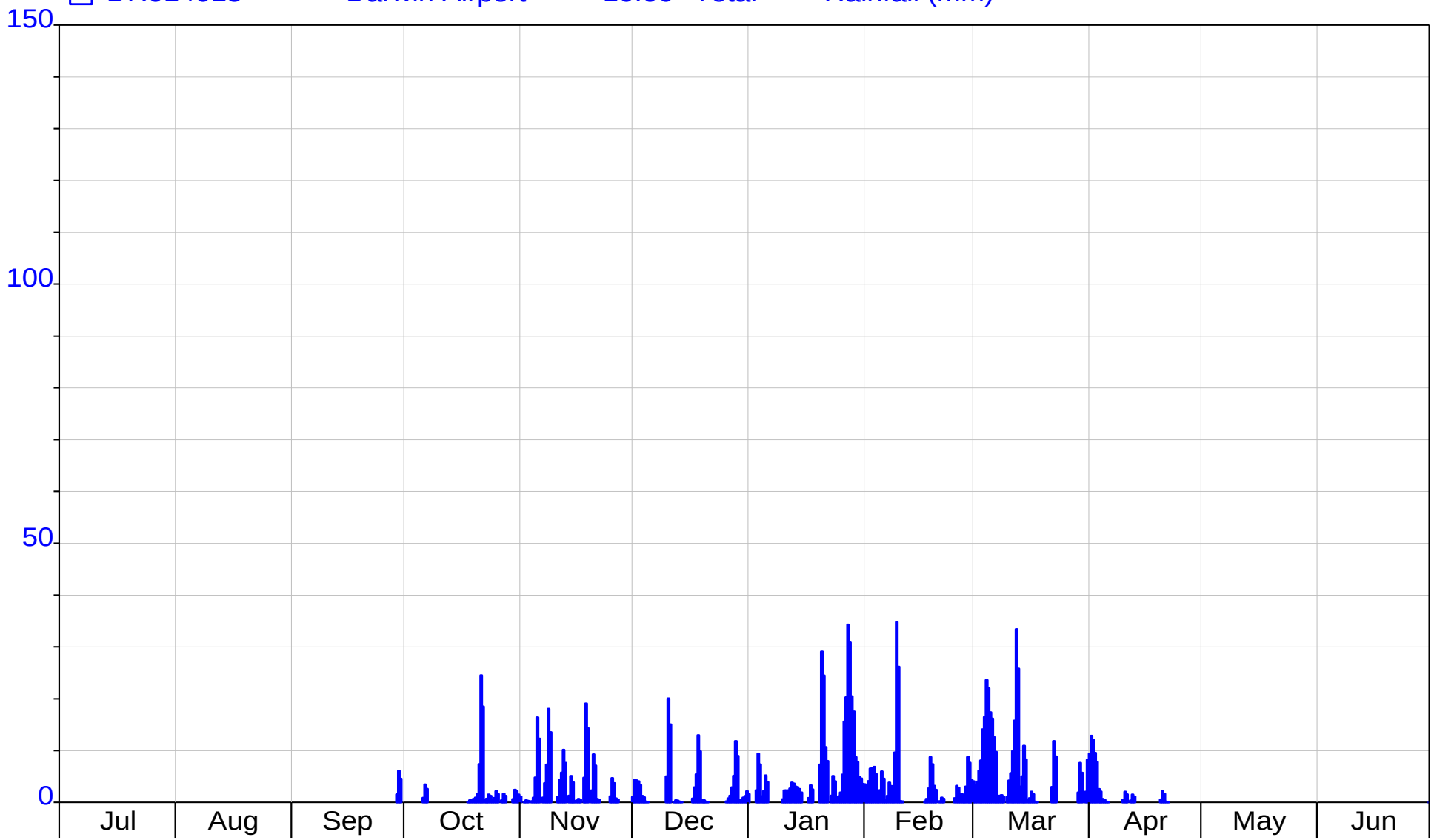
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1943 1943/44

Interval12 Hour Plot End 00:00_01/07/1944

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



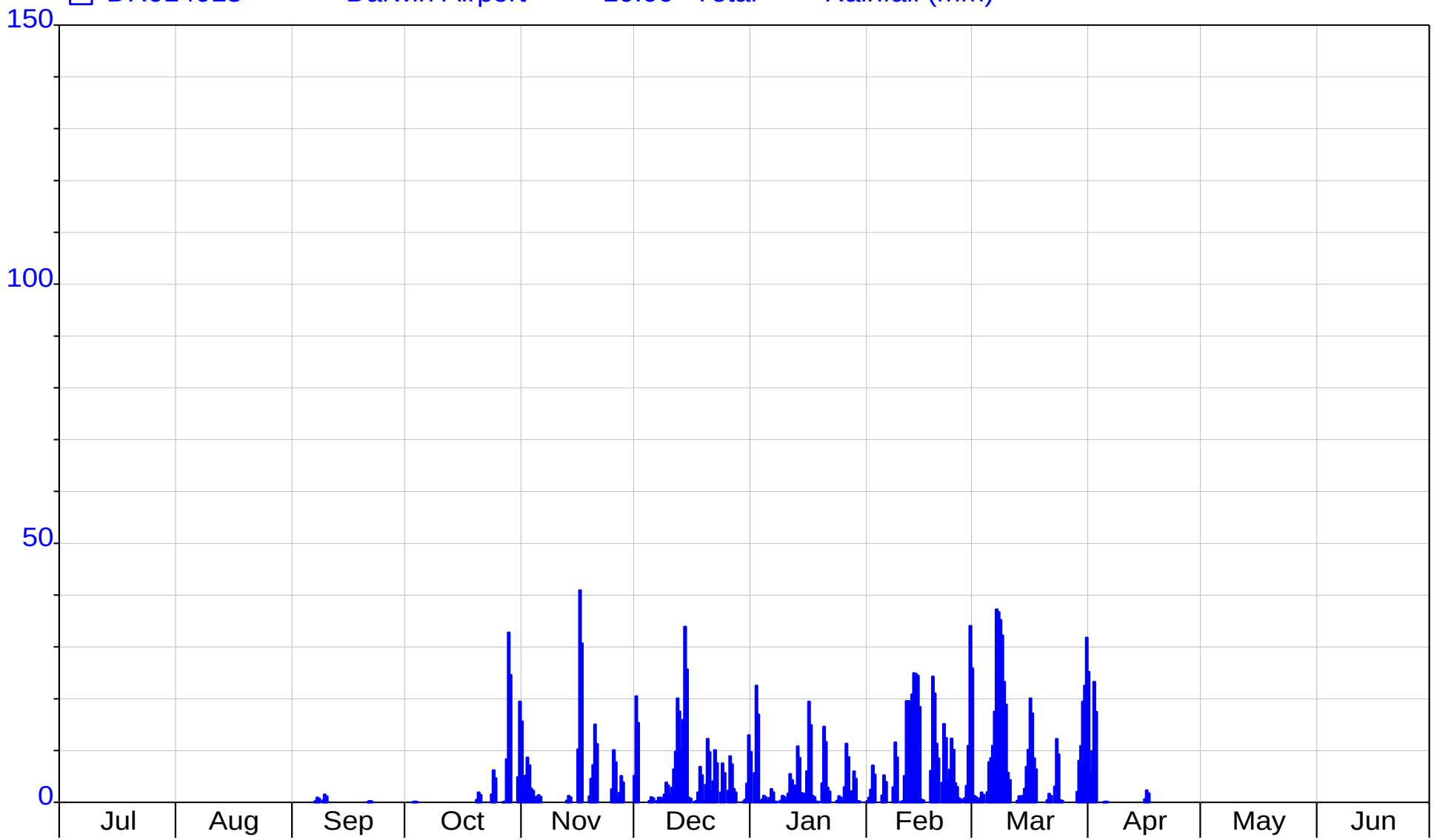
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1944 1944/45

Interval12 Hour Plot End 00:00_01/07/1945

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



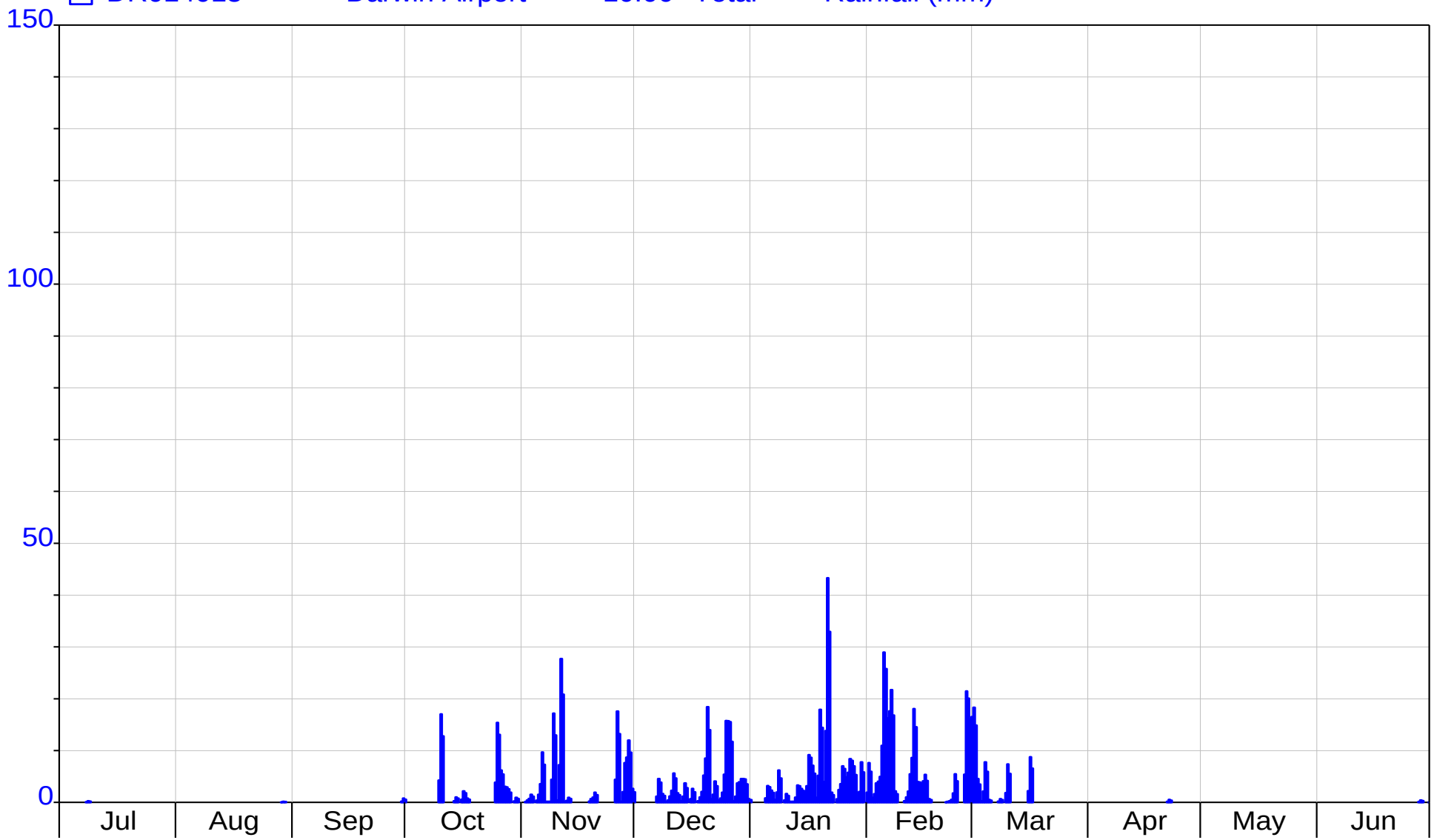
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1945 1945/46

Interval12 Hour Plot End 00:00_01/07/1946

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



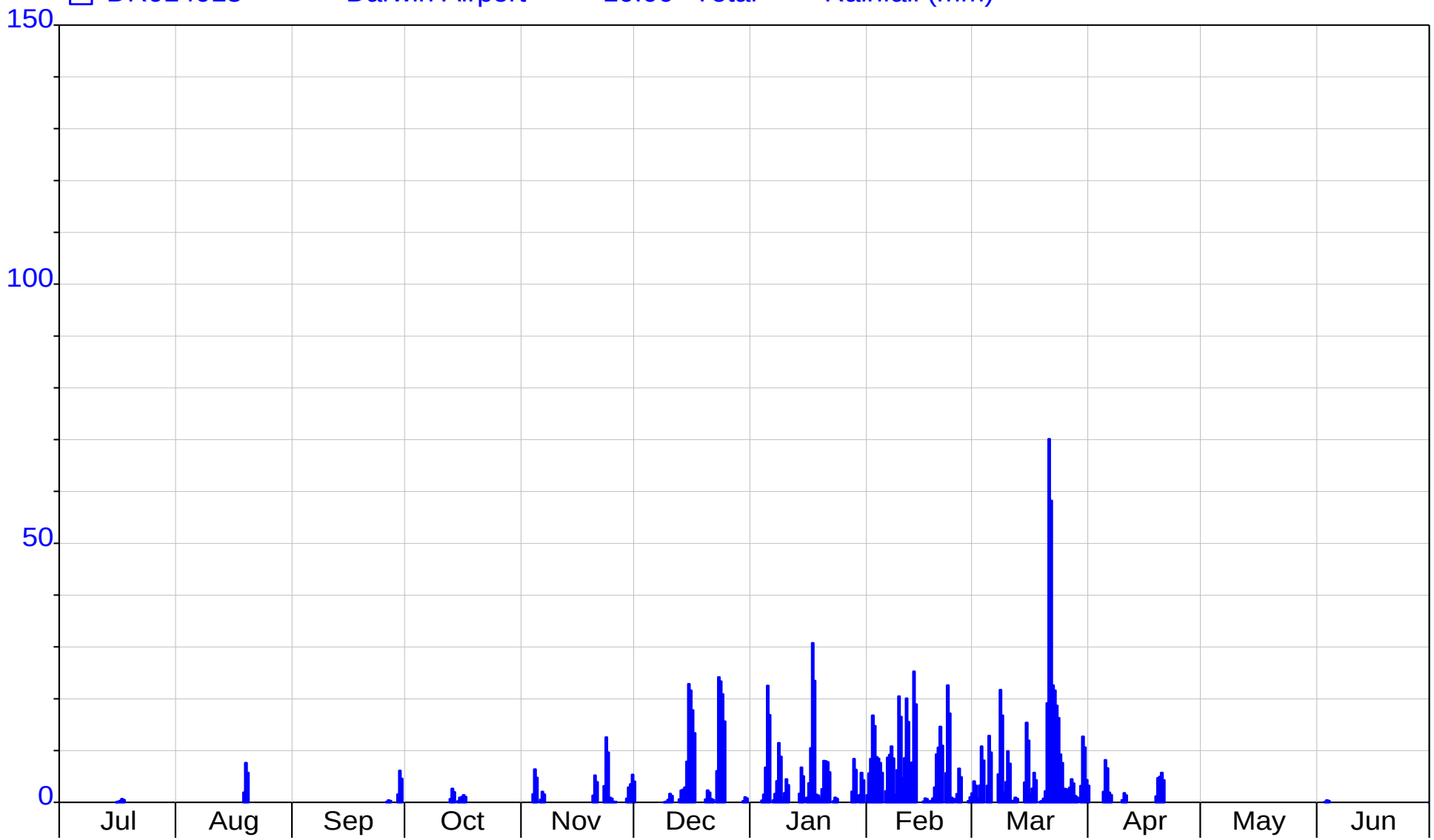
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1946 1946/47

Interval12 Hour Plot End 00:00_01/07/1947

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



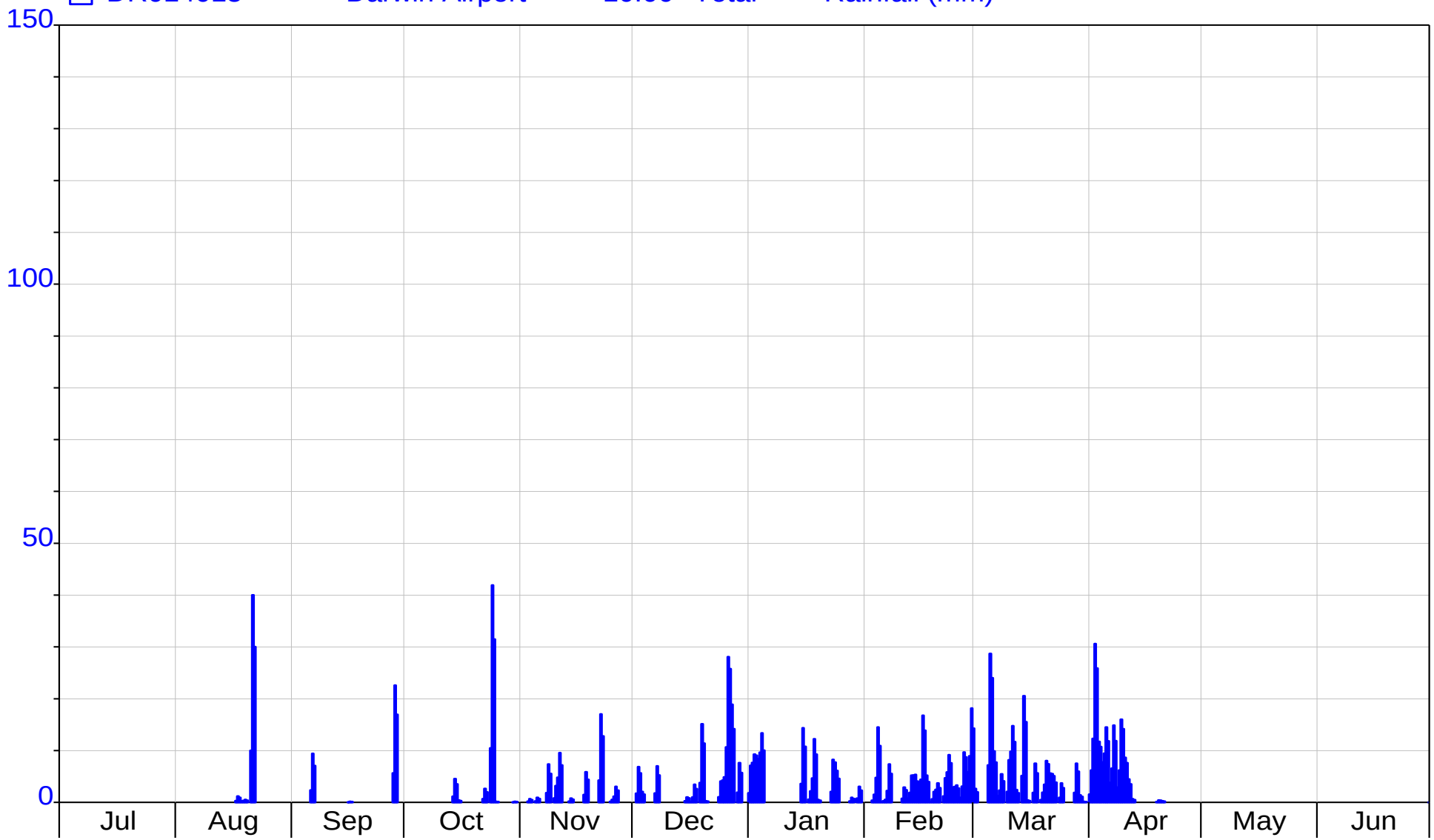
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1947 1947/48

Interval12 Hour Plot End 00:00_01/07/1948

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1948 1948/49

Interval12 Hour Plot End 00:00_01/07/1949

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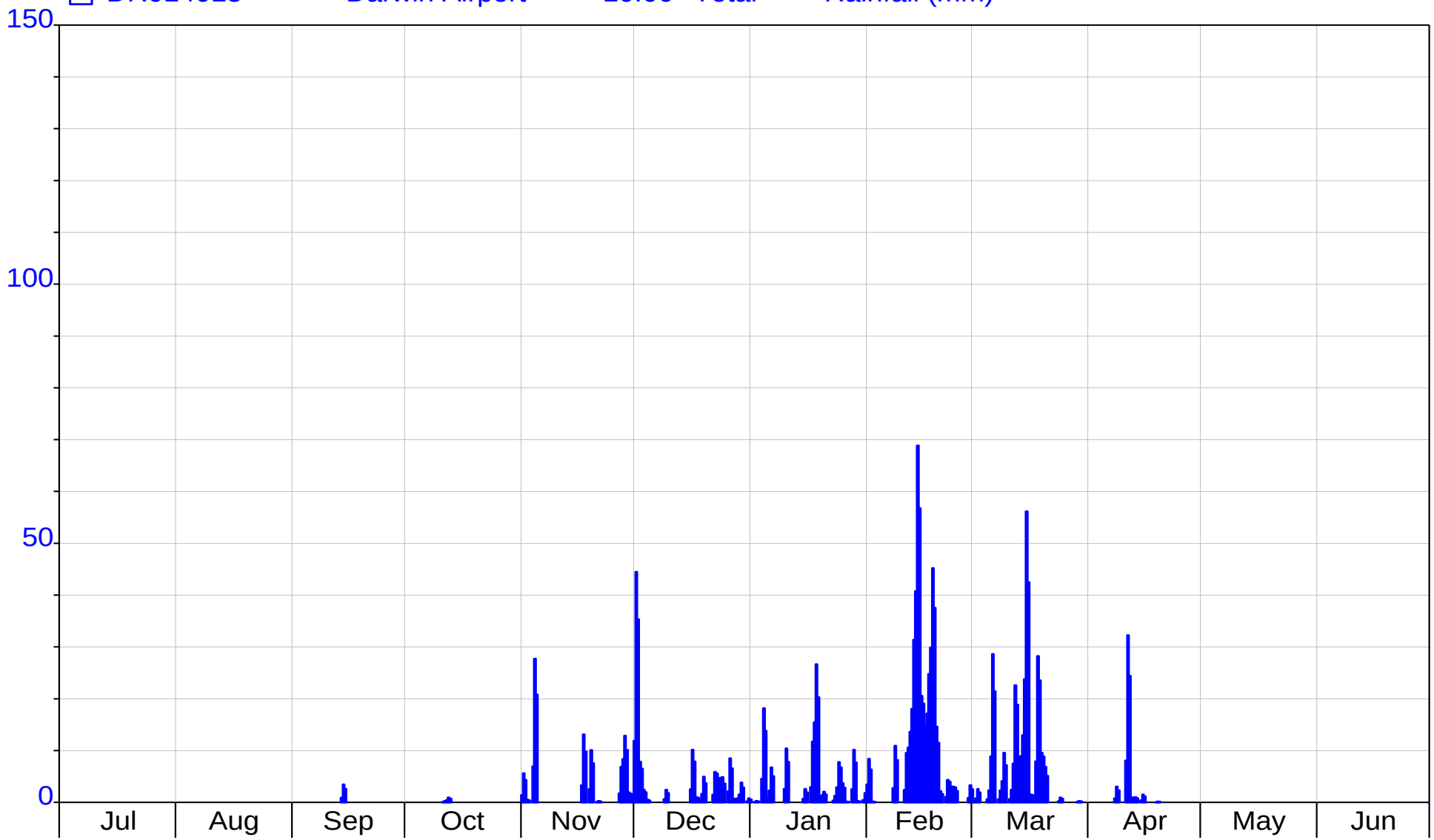


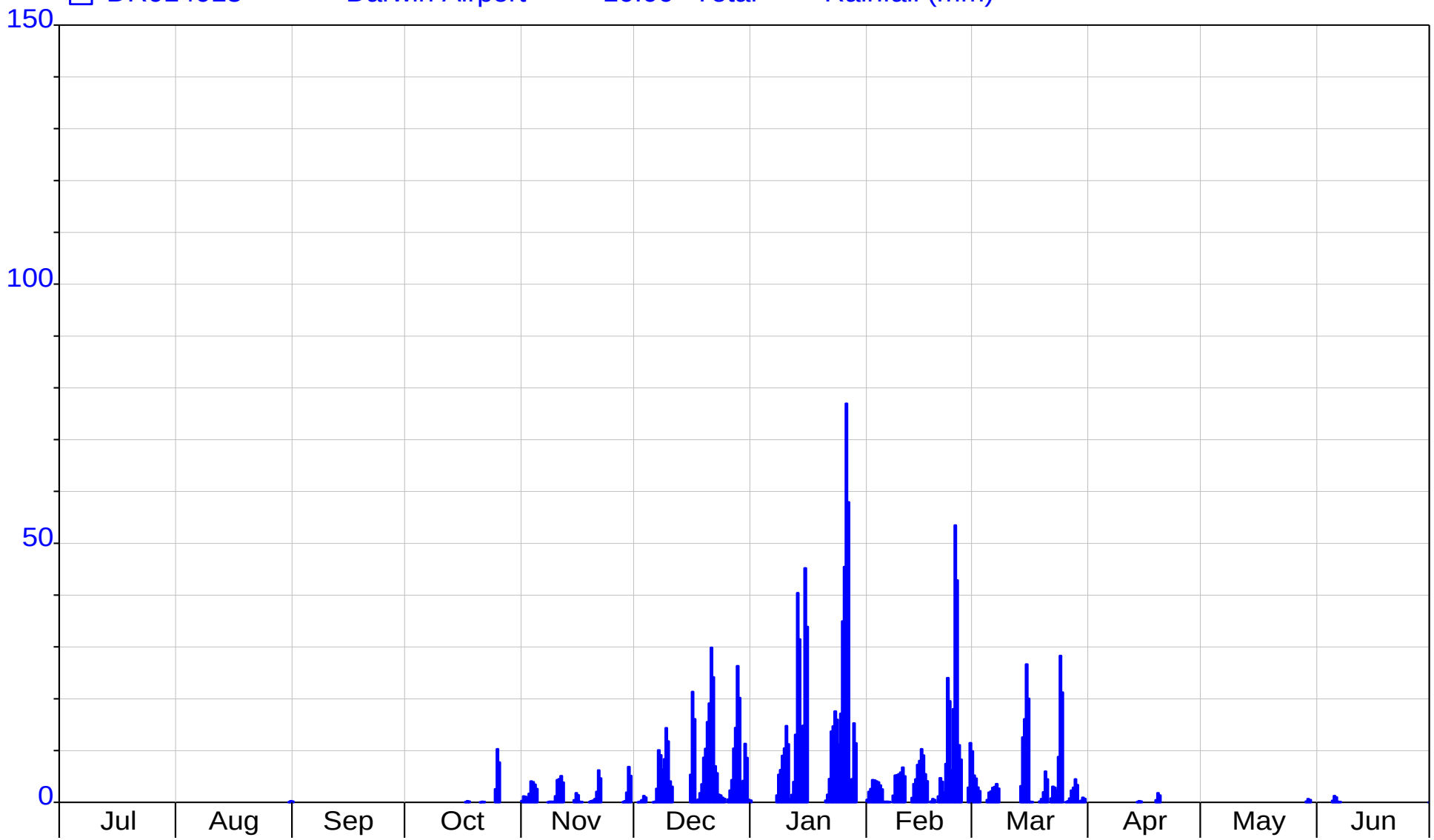
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1949 1949/50

Interval12 Hour Plot End 00:00_01/07/1950

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



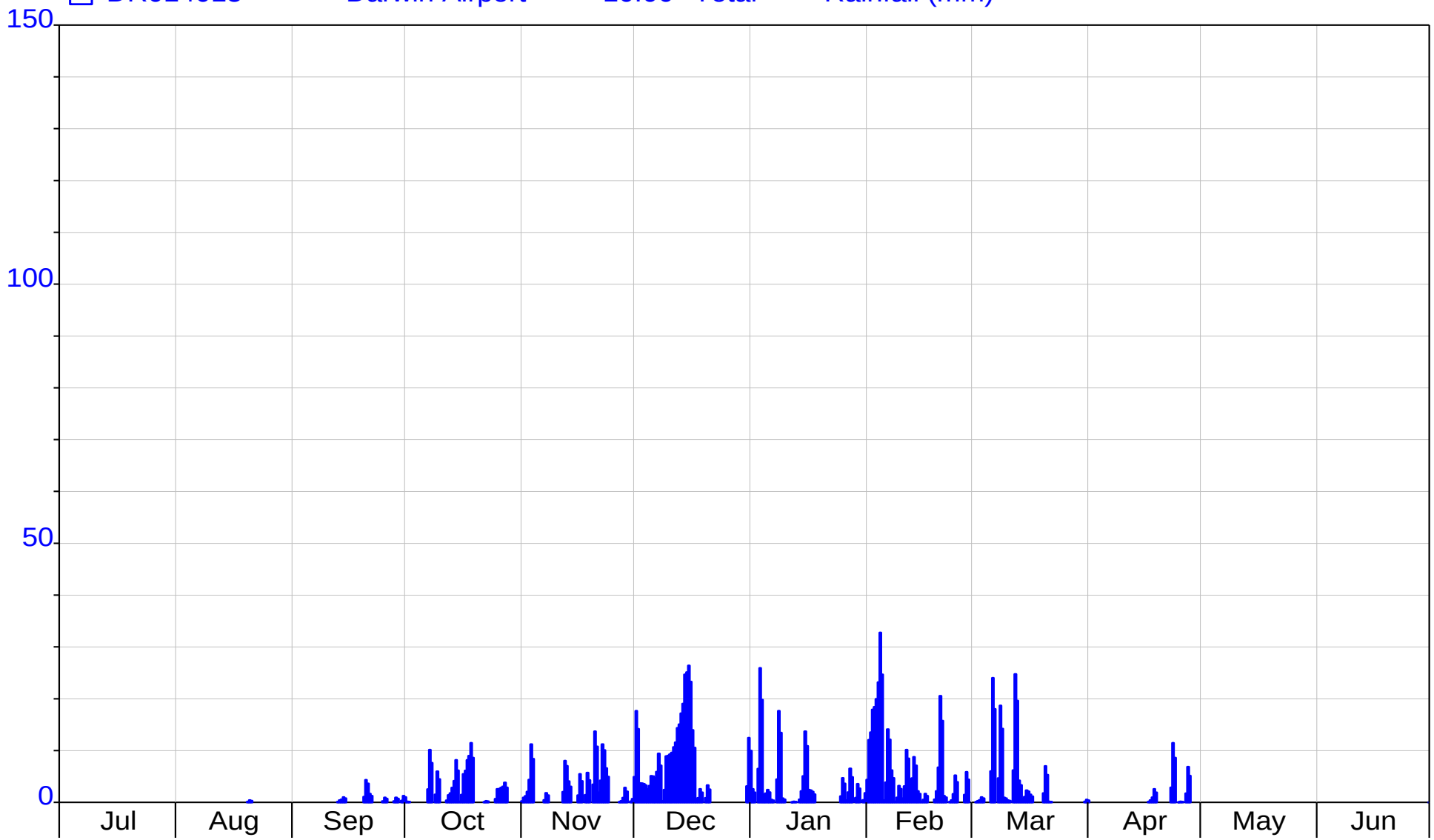
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1950 1950/51

Interval12 Hour Plot End 00:00_01/07/1951

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



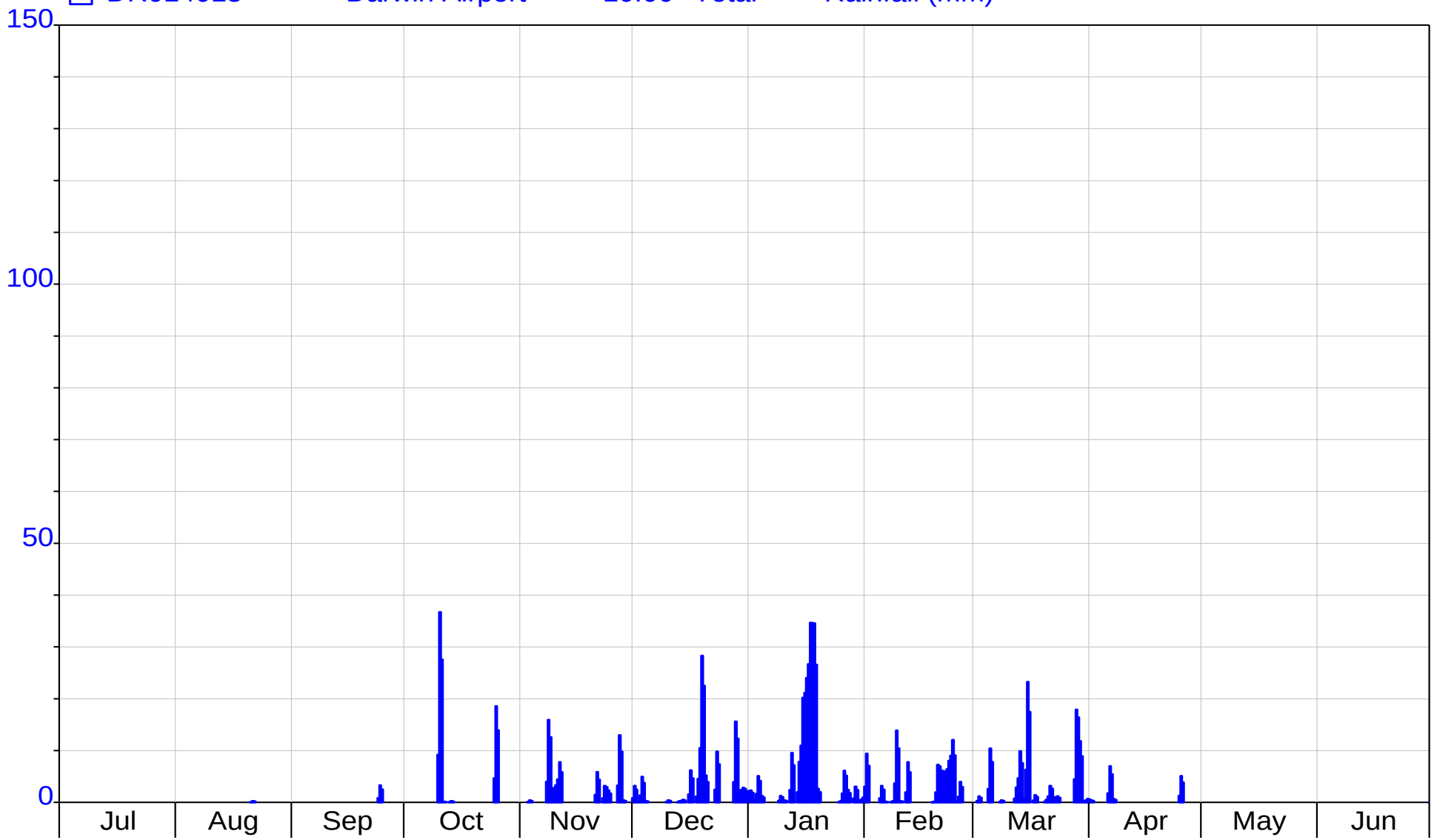
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1951 1951/52

Interval12 Hour Plot End 00:00_01/07/1952

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



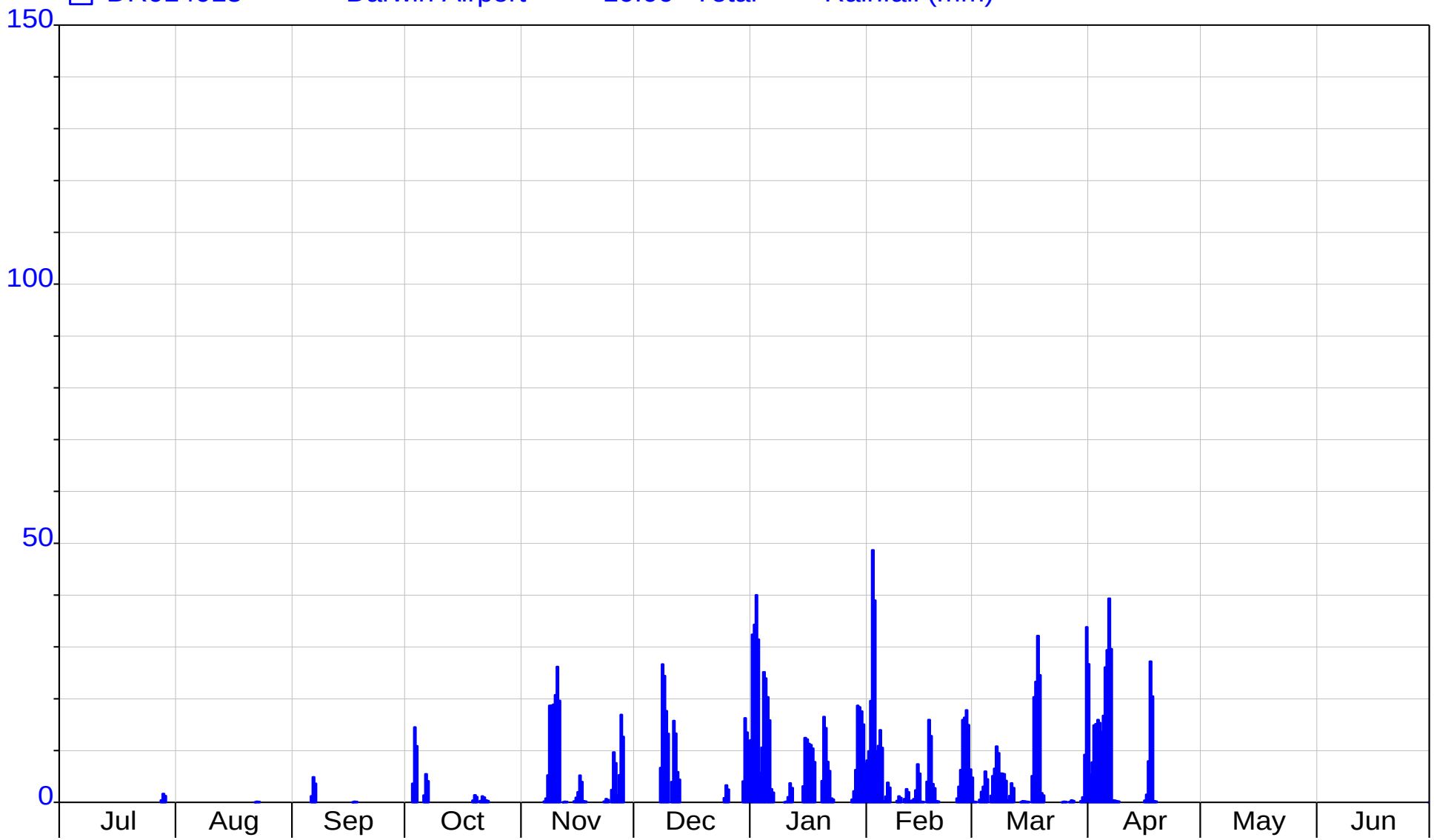
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1952 1952/53

Interval12 Hour Plot End 00:00_01/07/1953

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



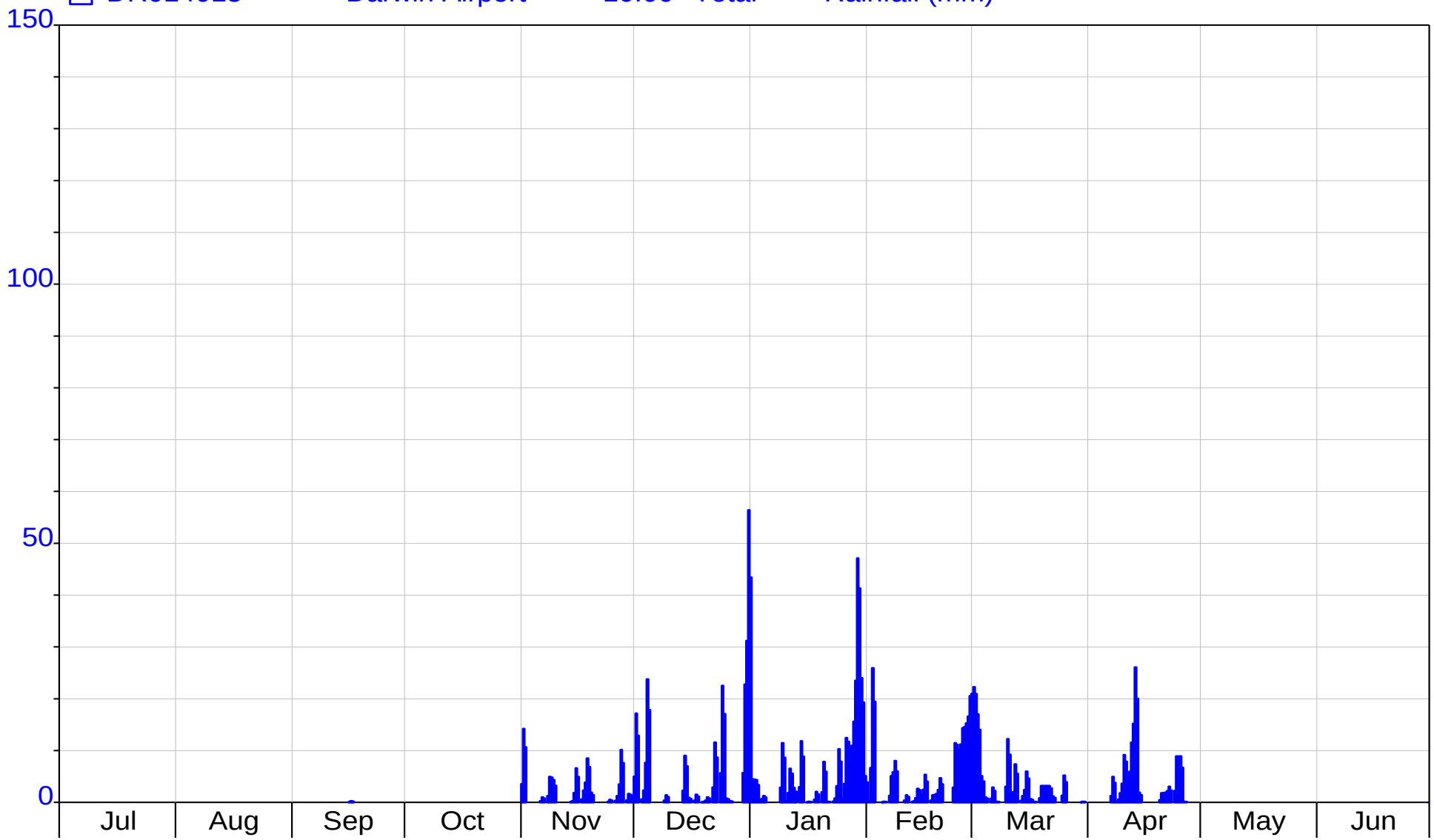
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1953 1953/54

Interval12 Hour Plot End 00:00_01/07/1954

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



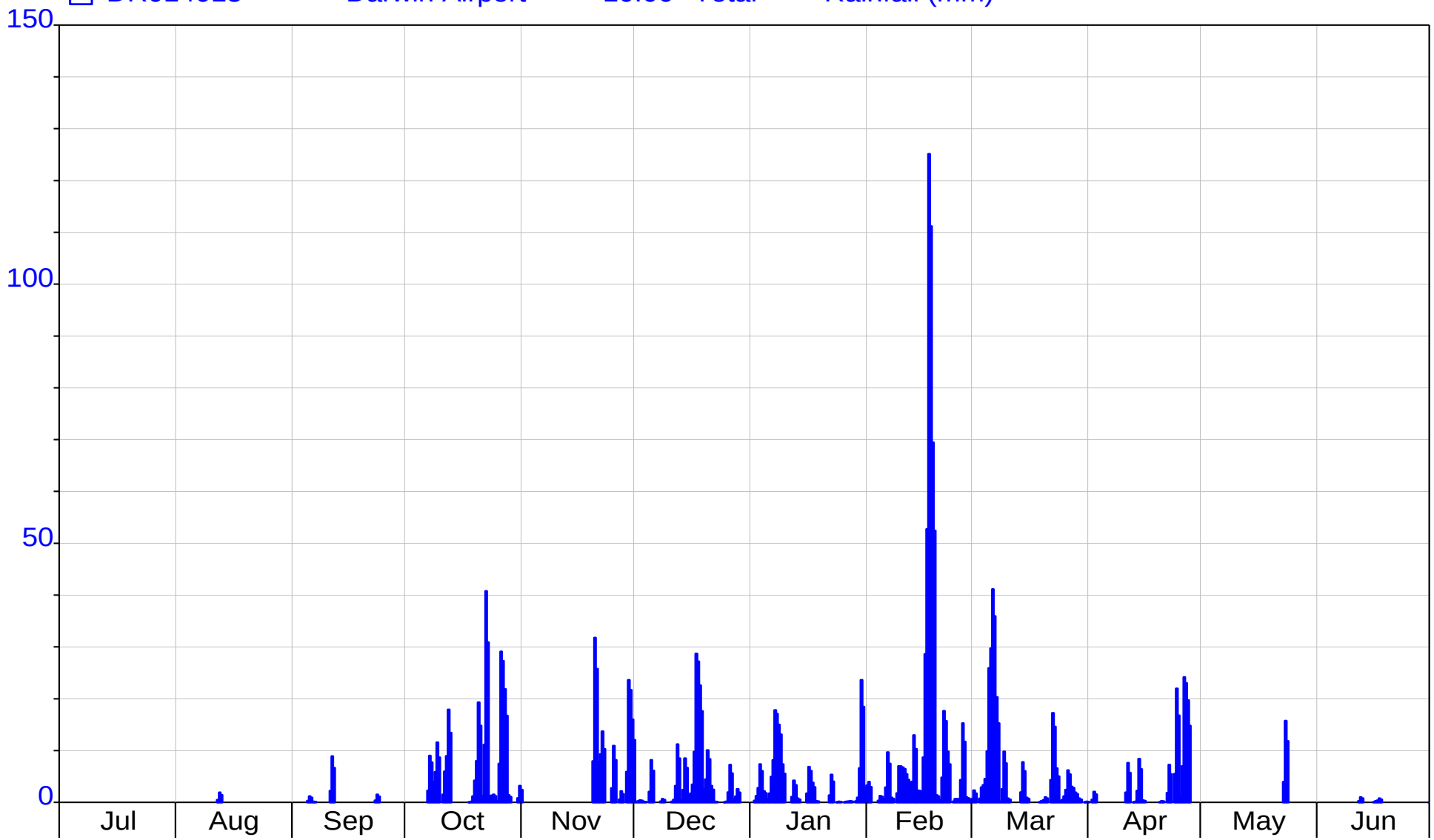
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1954 1954/55

Interval12 Hour Plot End 00:00_01/07/1955

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



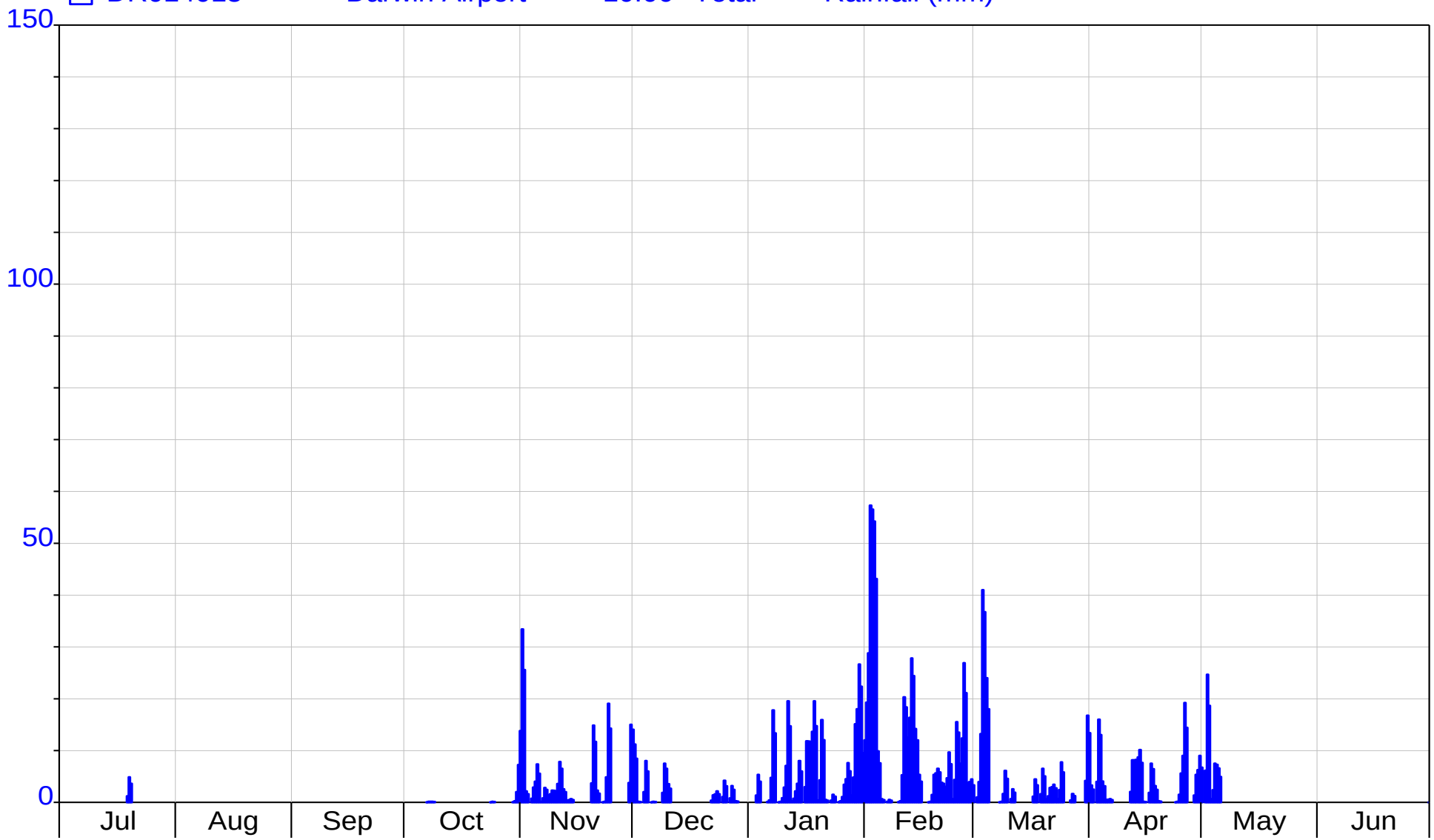
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1955 1955/56

Interval12 Hour Plot End 00:00_01/07/1956

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



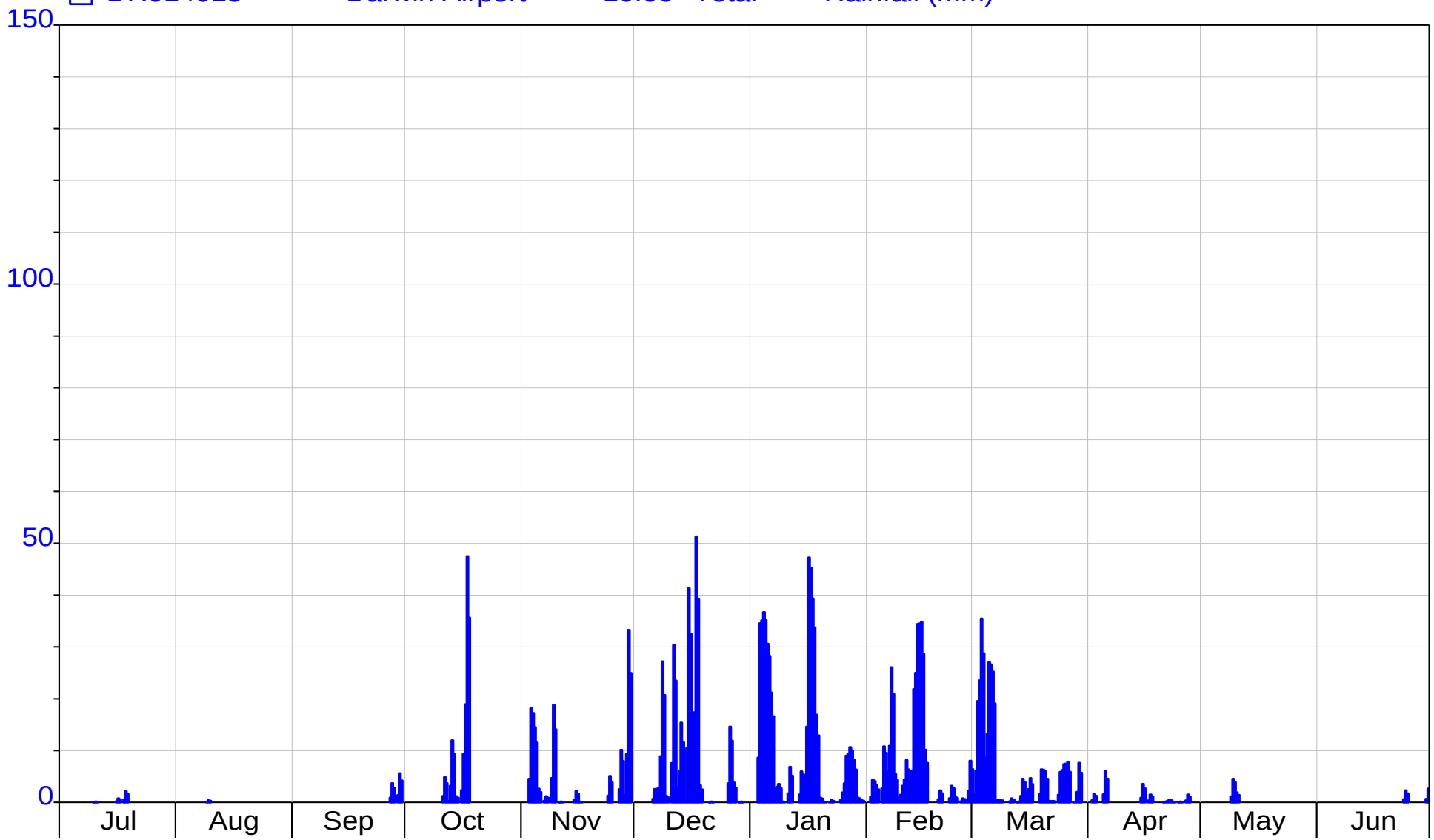
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1956 1956/57

Interval12 Hour Plot End 00:00_01/07/1957

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



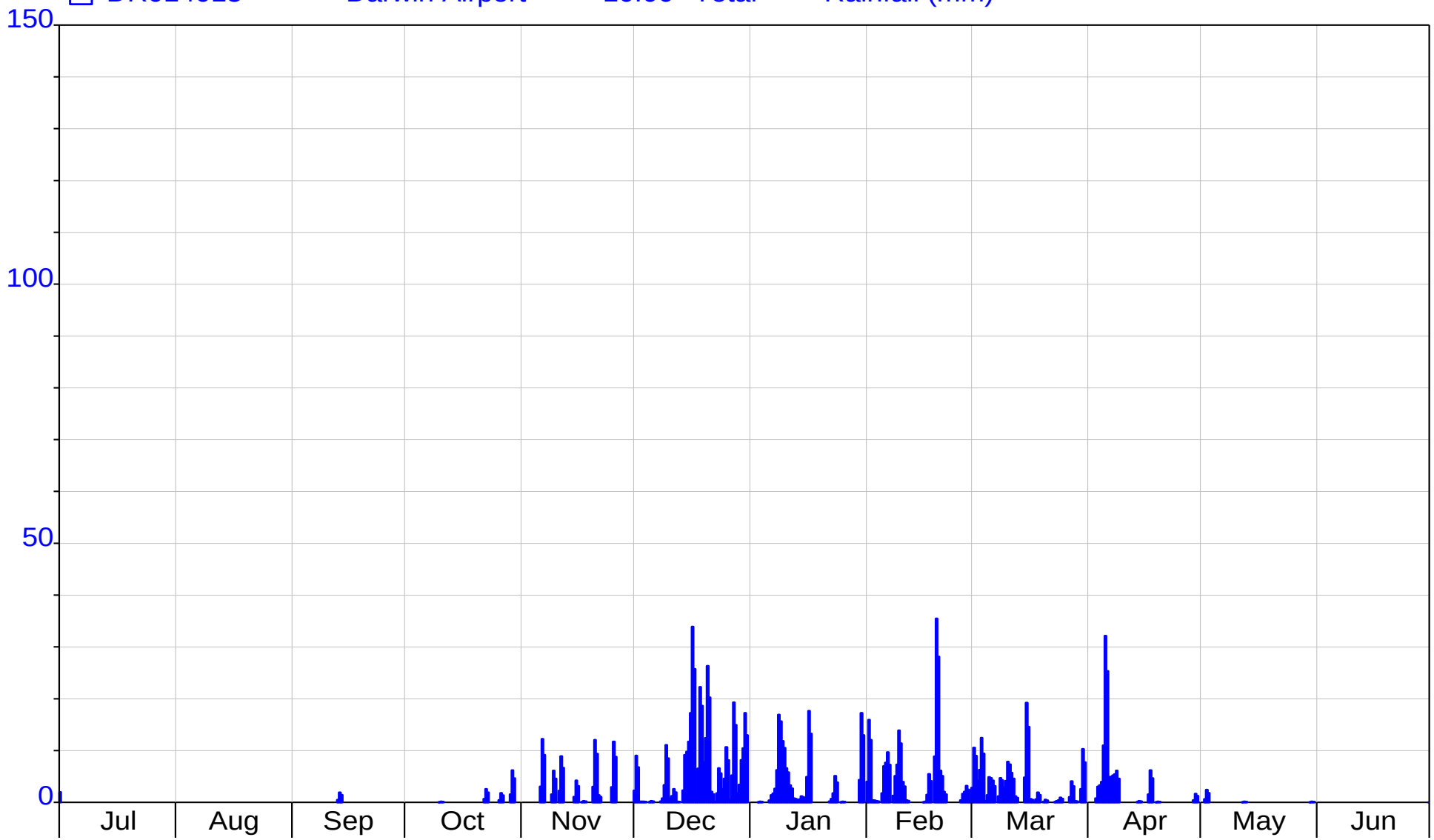
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1957 1957/58

Interval12 Hour Plot End 00:00_01/07/1958

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



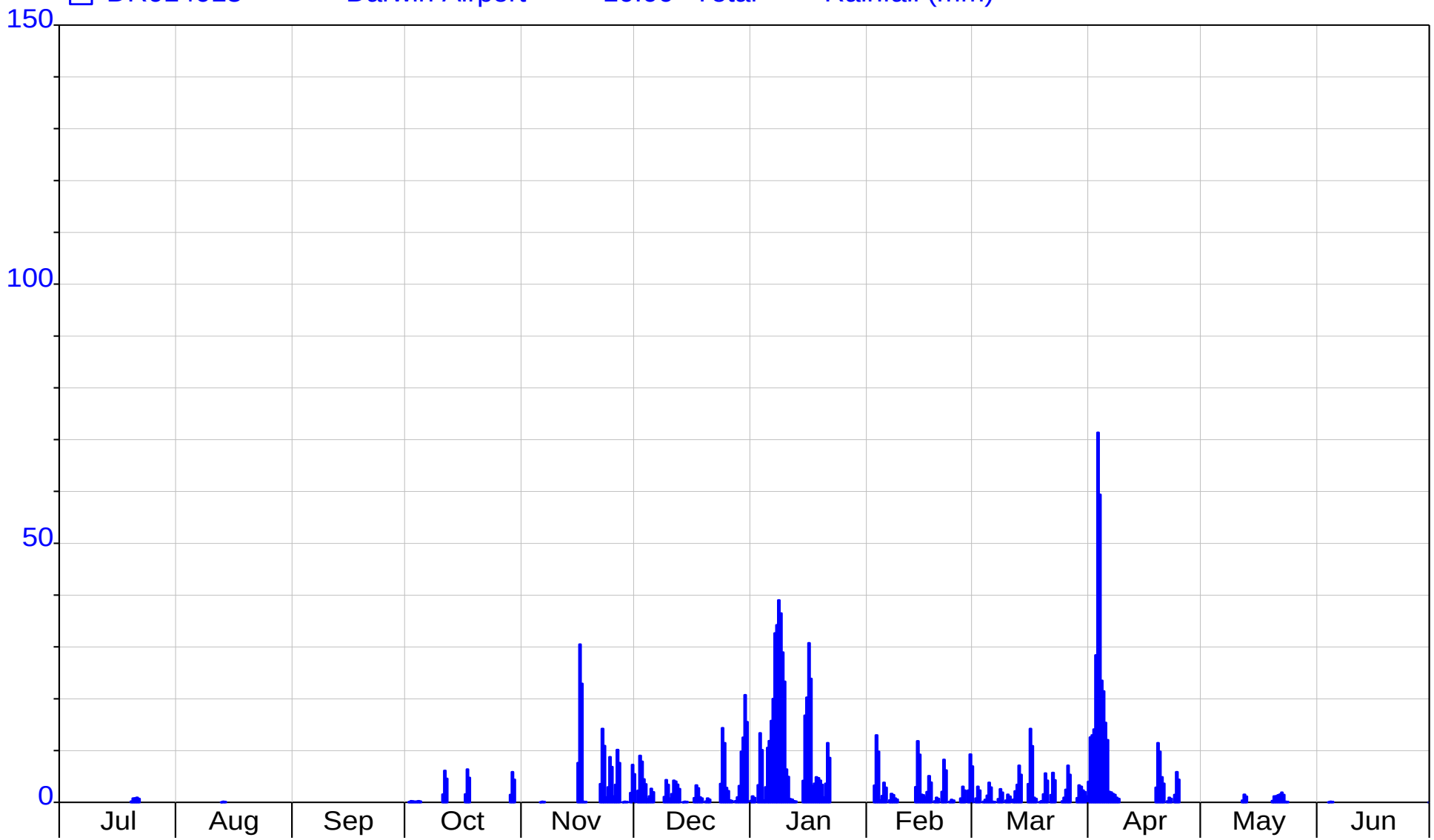
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1958 1958/59

Interval12 Hour Plot End 00:00_01/07/1959

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



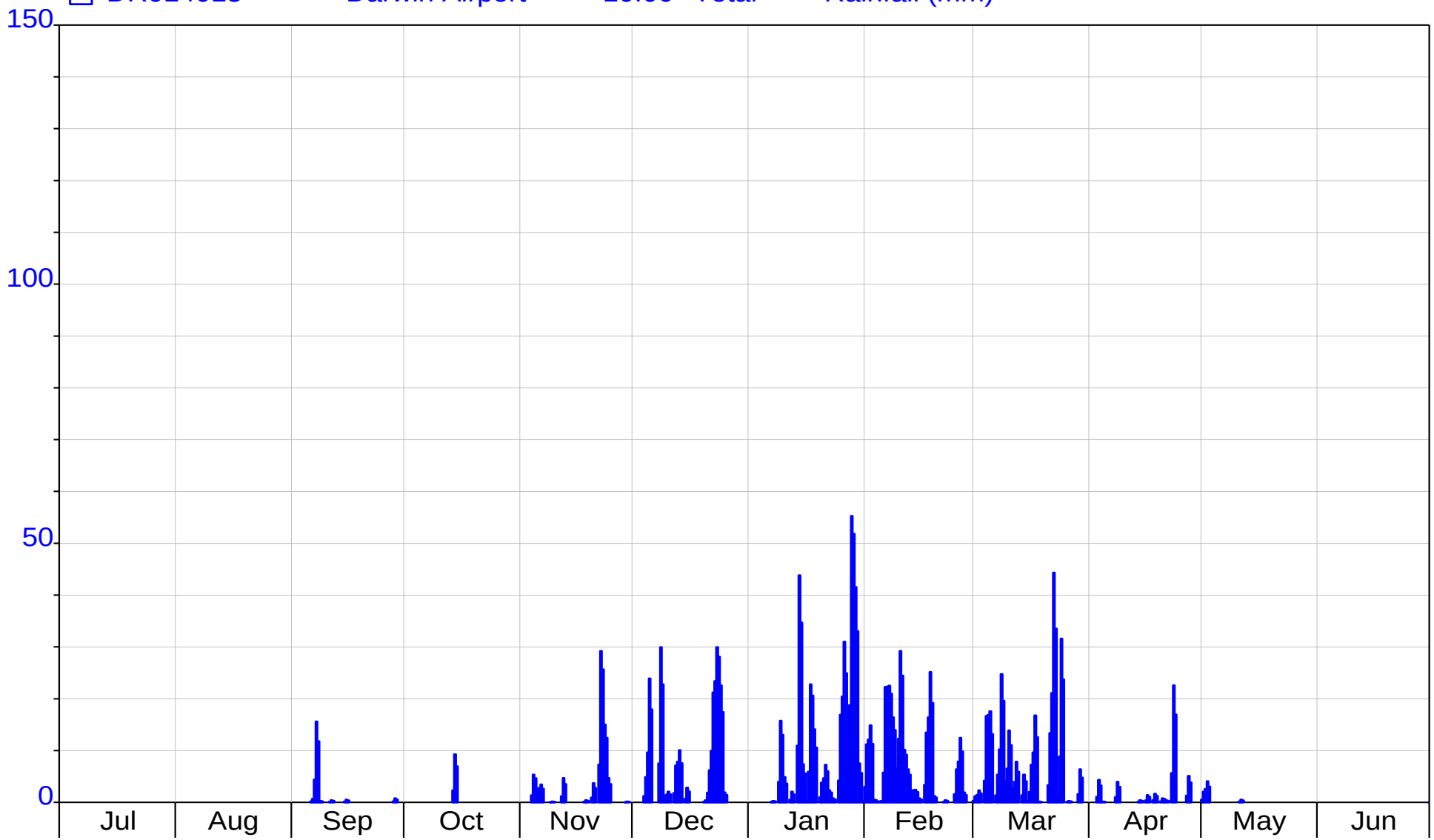
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1959 1959/60

Interval12 Hour Plot End 00:00_01/07/1960

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



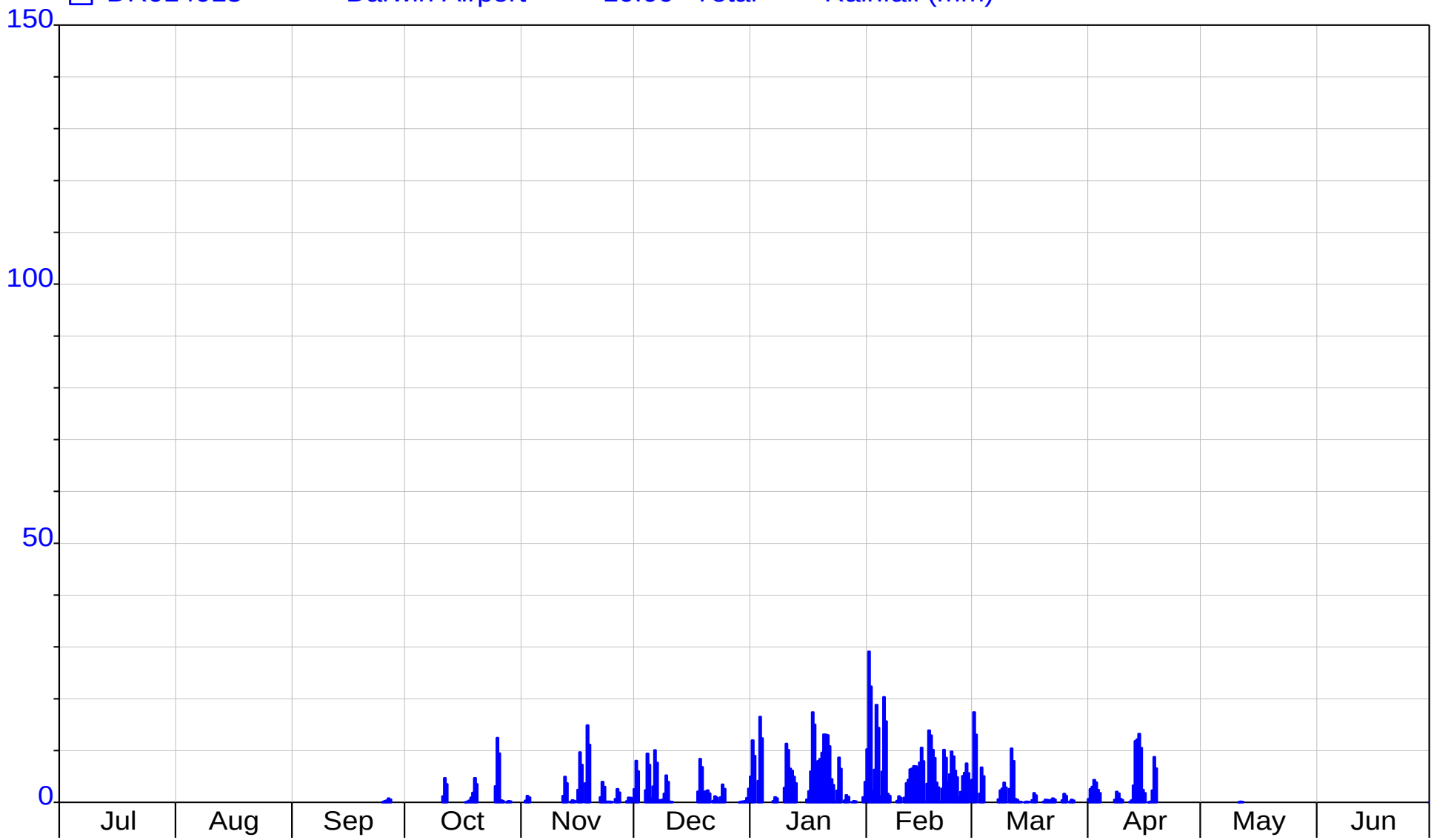
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1960 1960/61

Interval12 Hour Plot End 00:00_01/07/1961

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



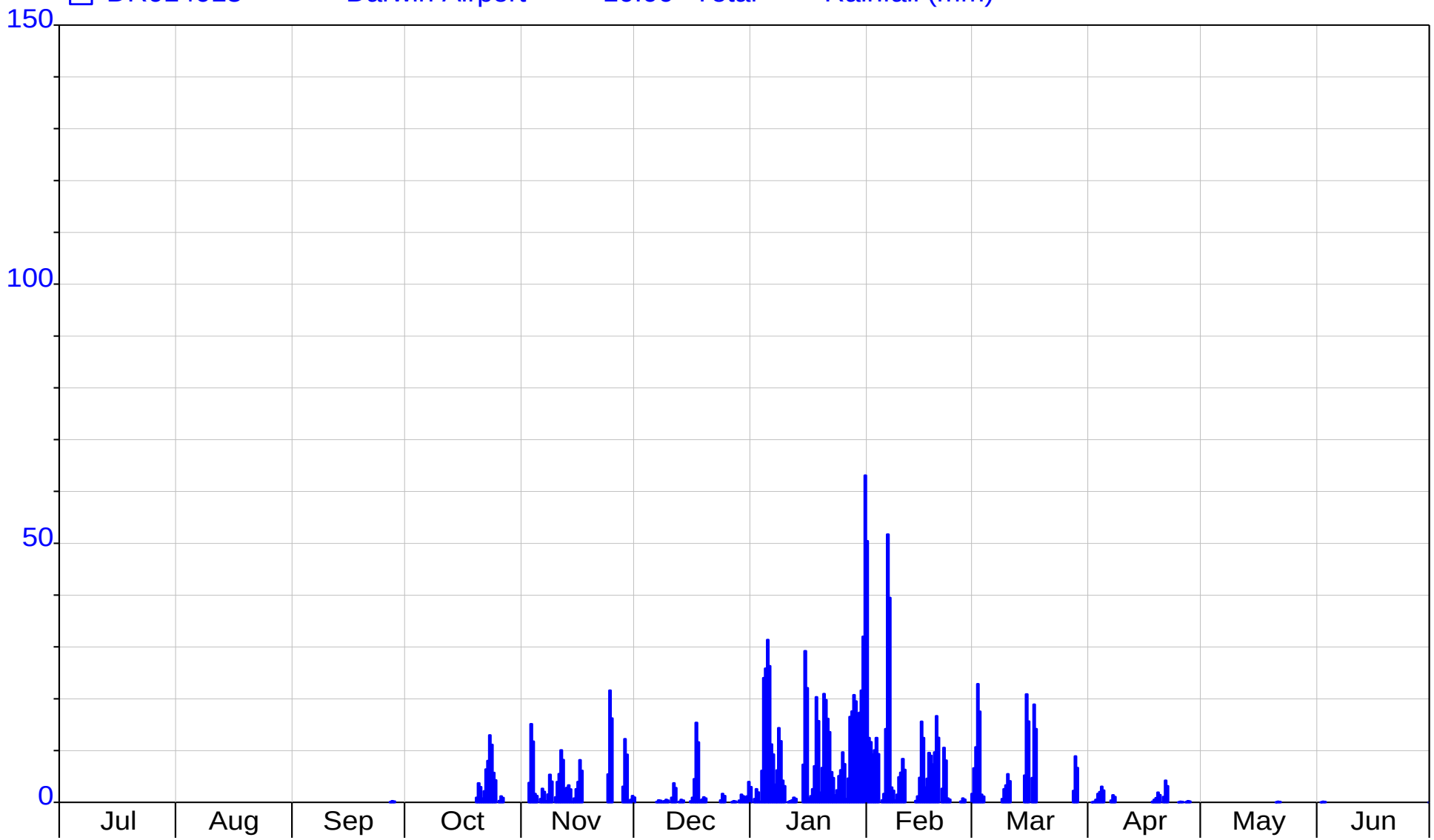
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1961 1961/62

Interval12 Hour Plot End 00:00_01/07/1962

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



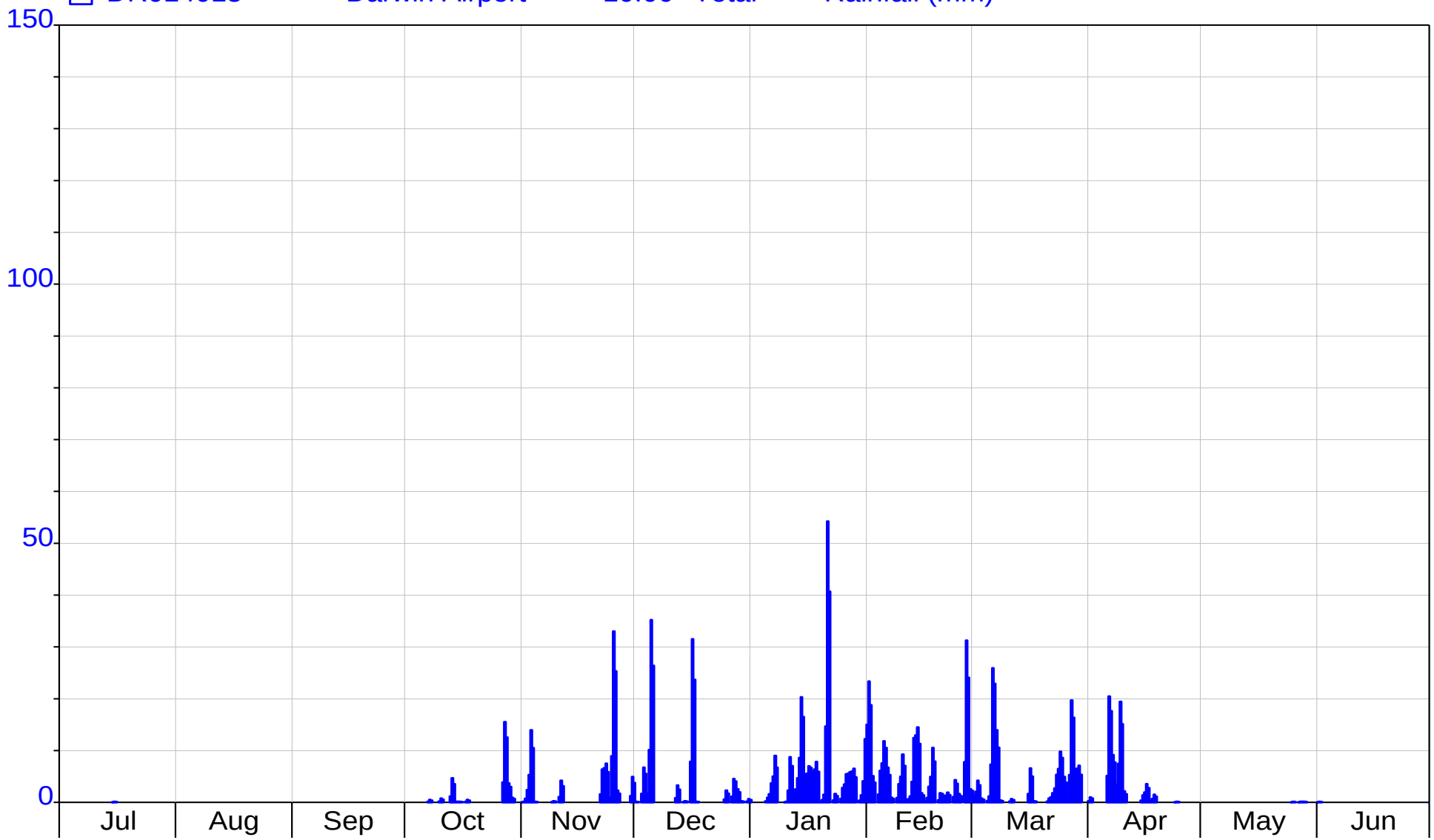
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1962 1962/63

Interval12 Hour Plot End 00:00_01/07/1963

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



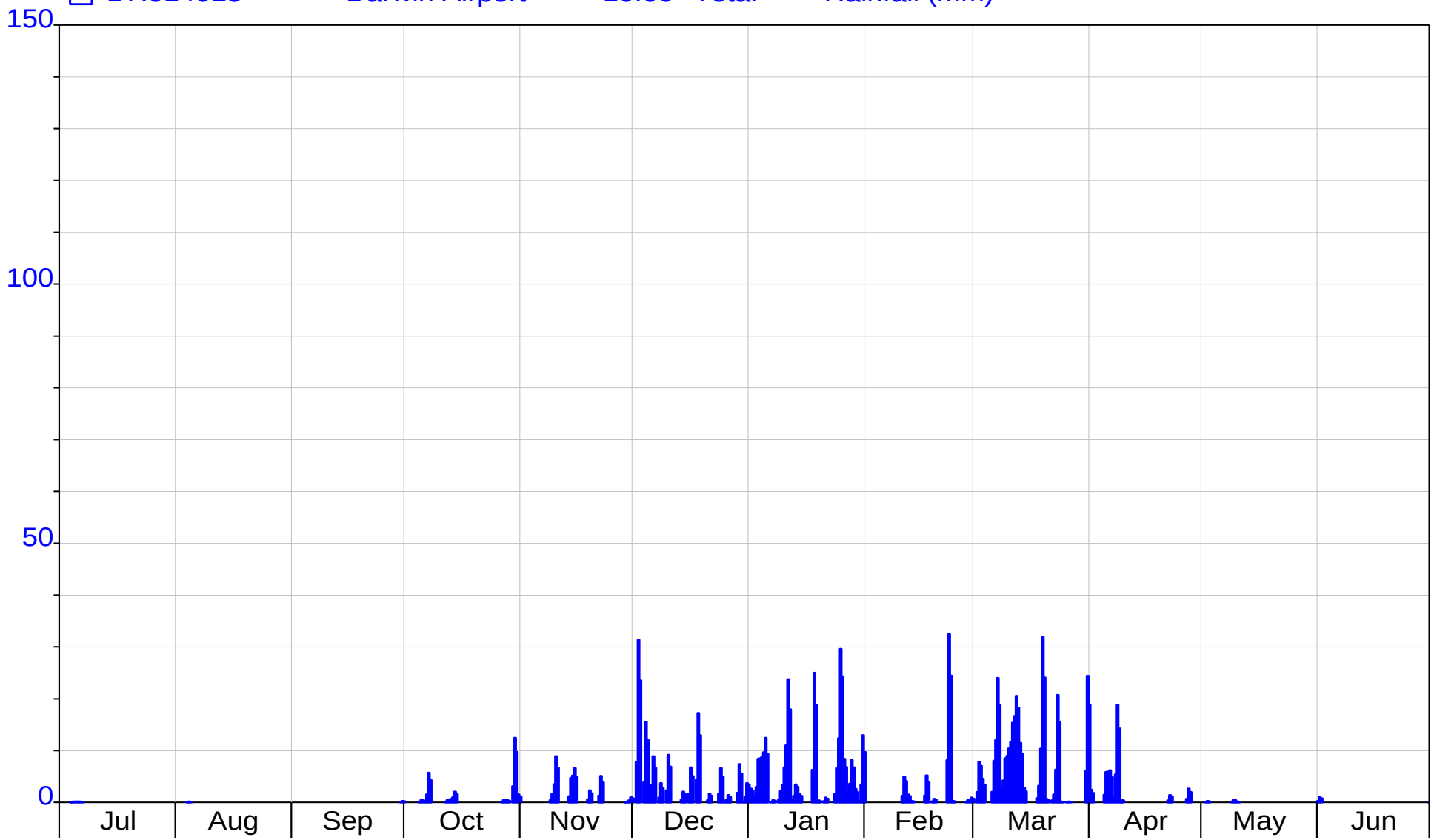
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1963 1963/64

Interval12 Hour Plot End 00:00_01/07/1964

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



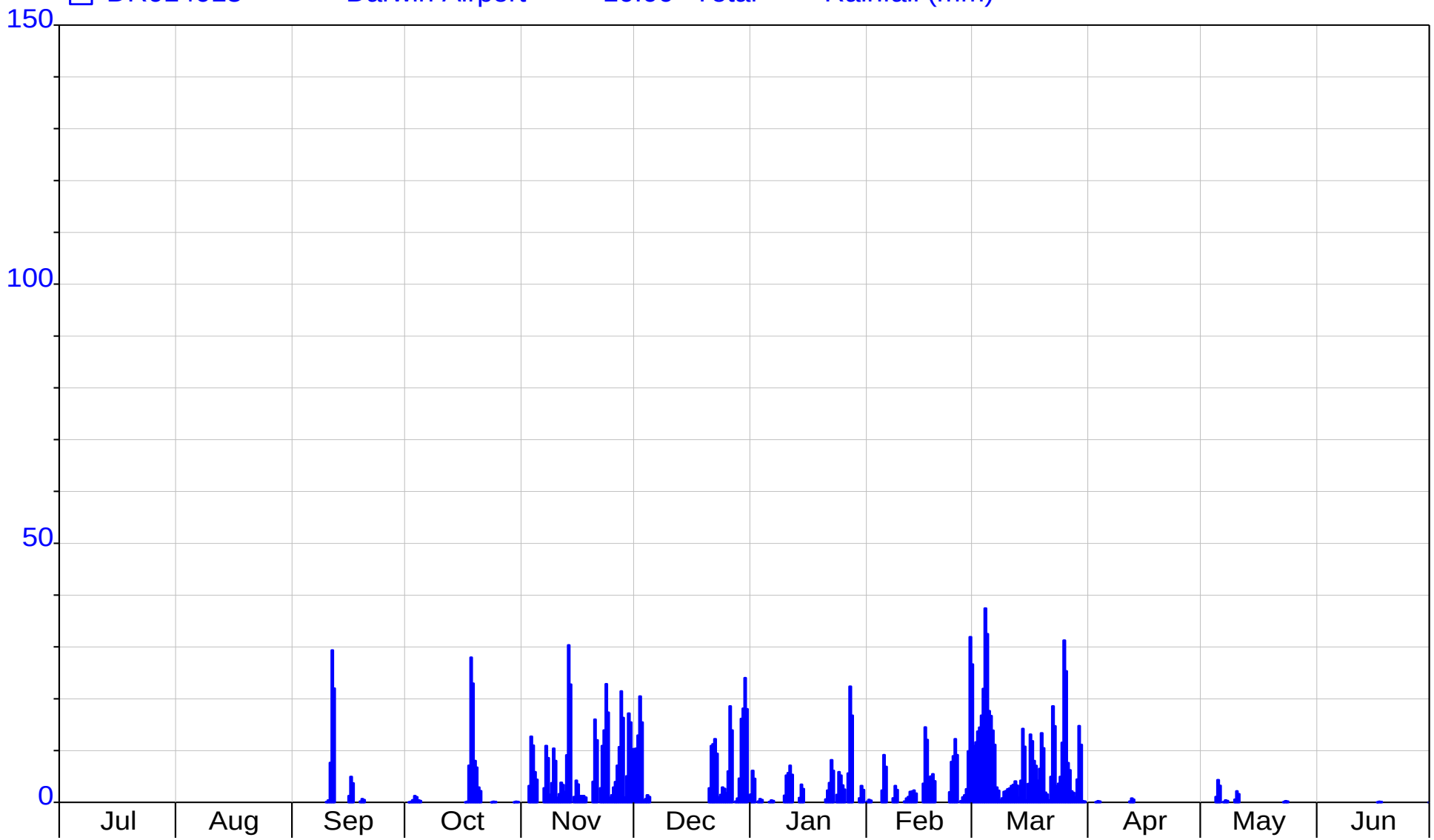
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1964 1964/65

Interval12 Hour Plot End 00:00_01/07/1965

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



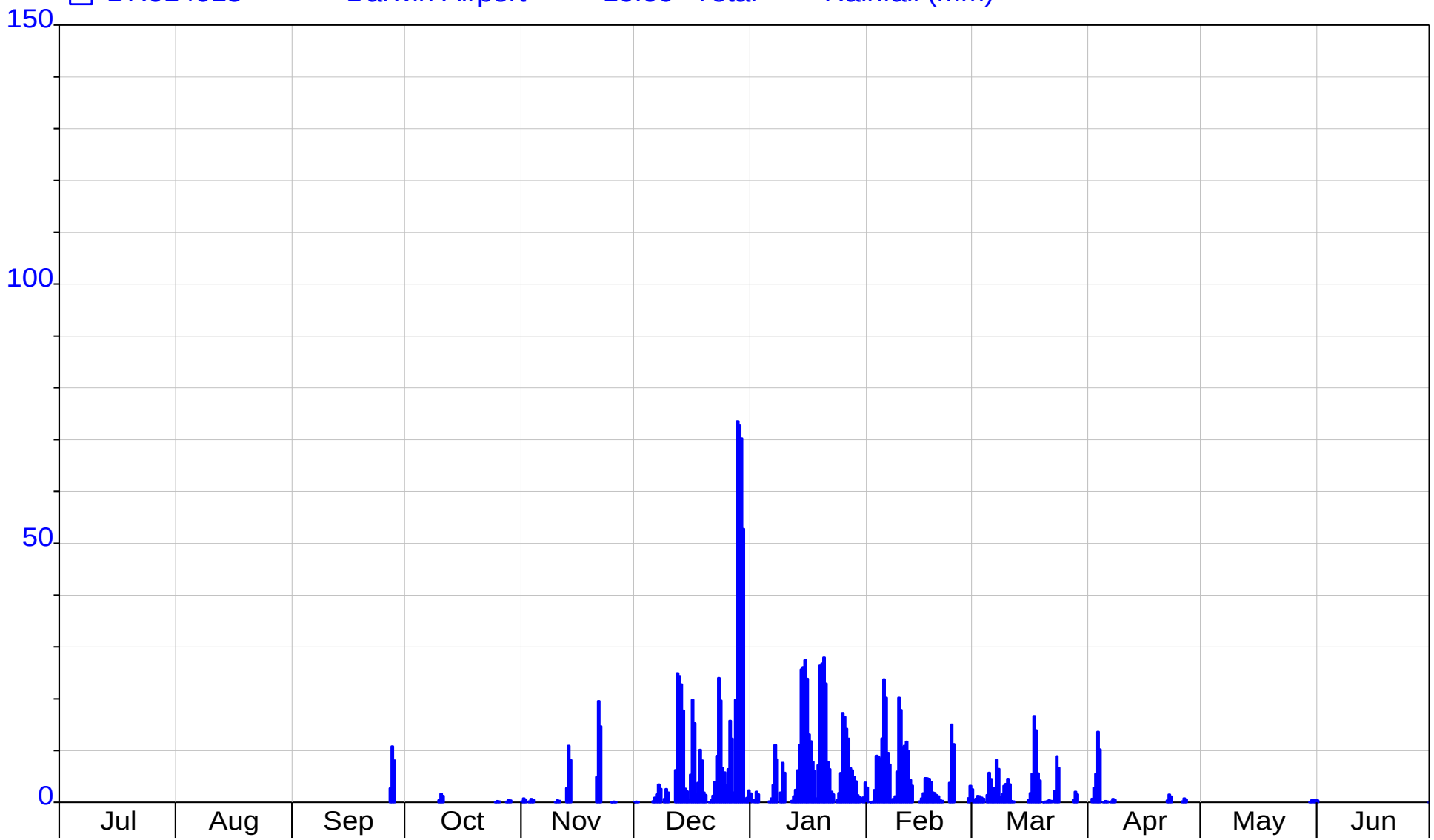
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1965 1965/66

Interval12 Hour Plot End 00:00_01/07/1966

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



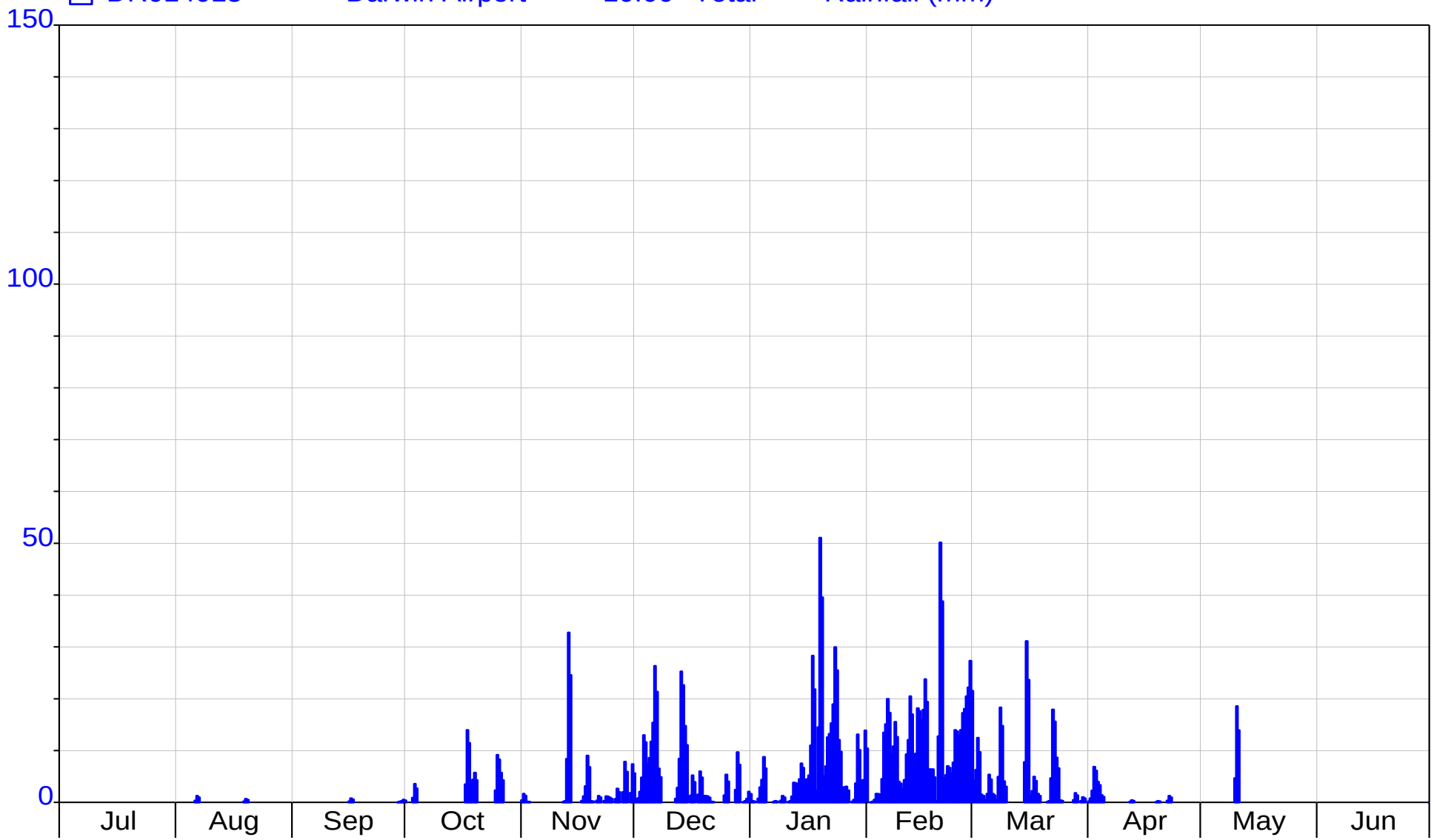
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1966 1966/67

Interval12 Hour Plot End 00:00_01/07/1967

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



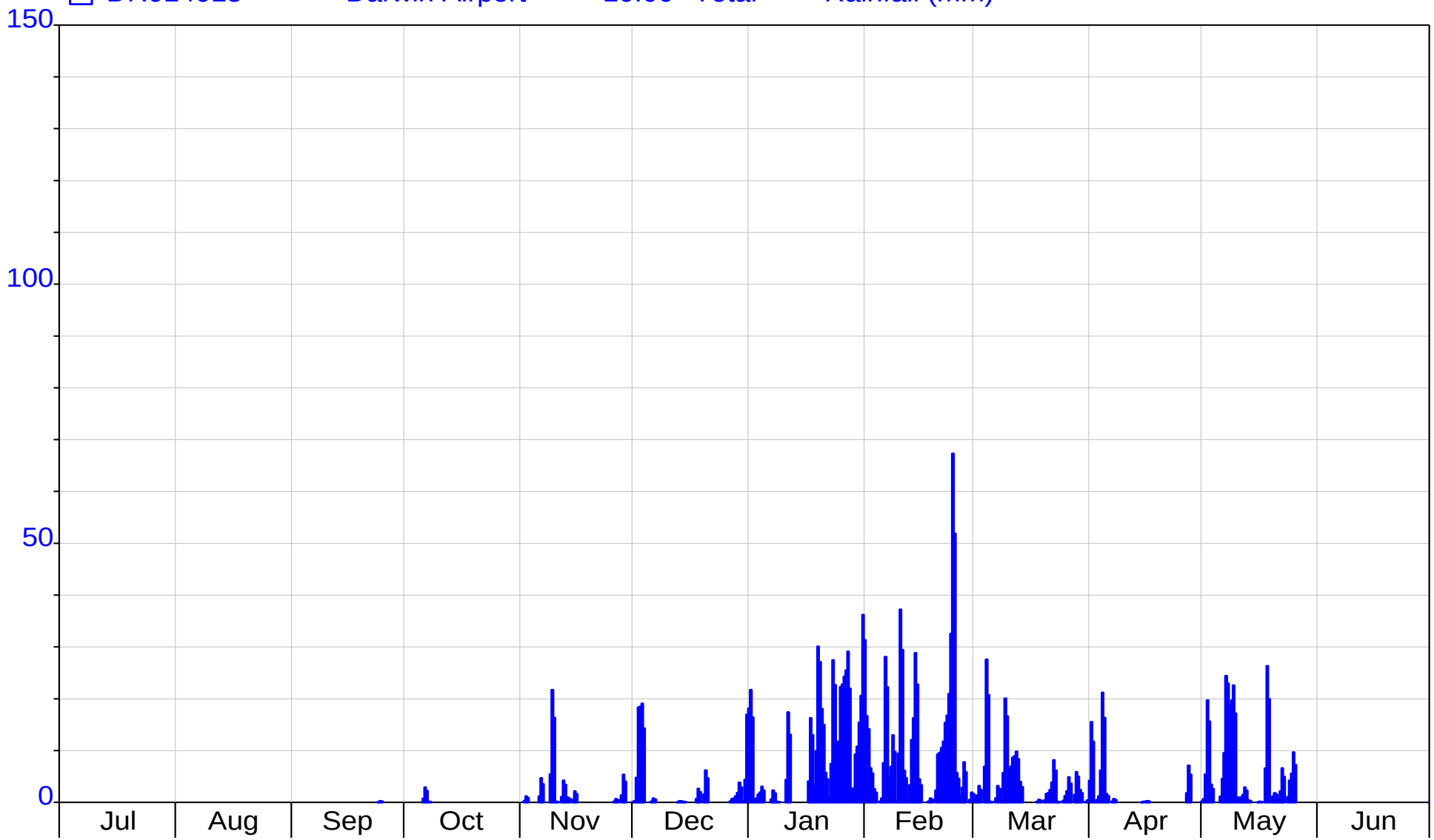
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1967 1967/68

Interval12 Hour Plot End 00:00_01/07/1968

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



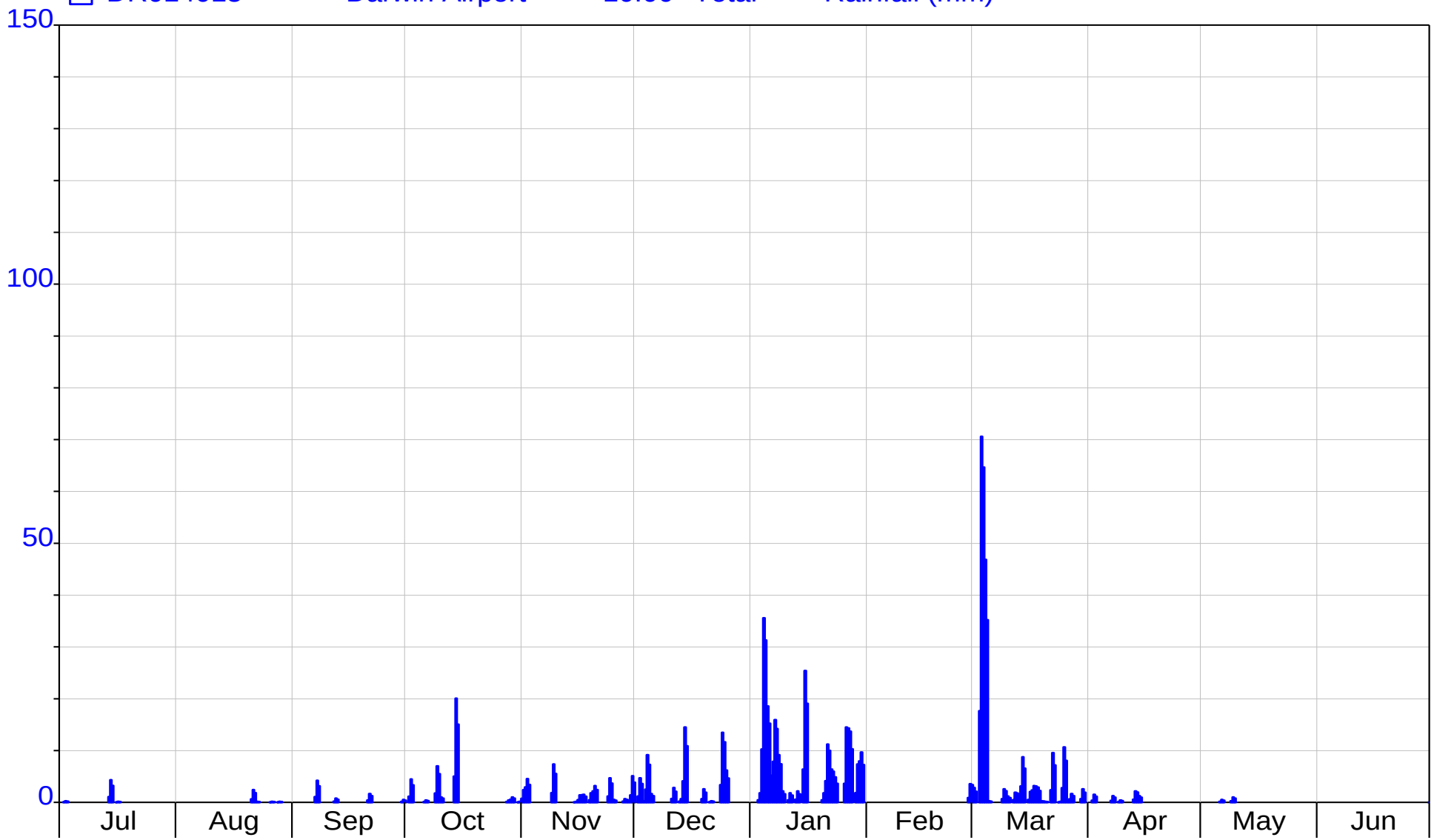
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1968 1968/69

Interval12 Hour Plot End 00:00_01/07/1969

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



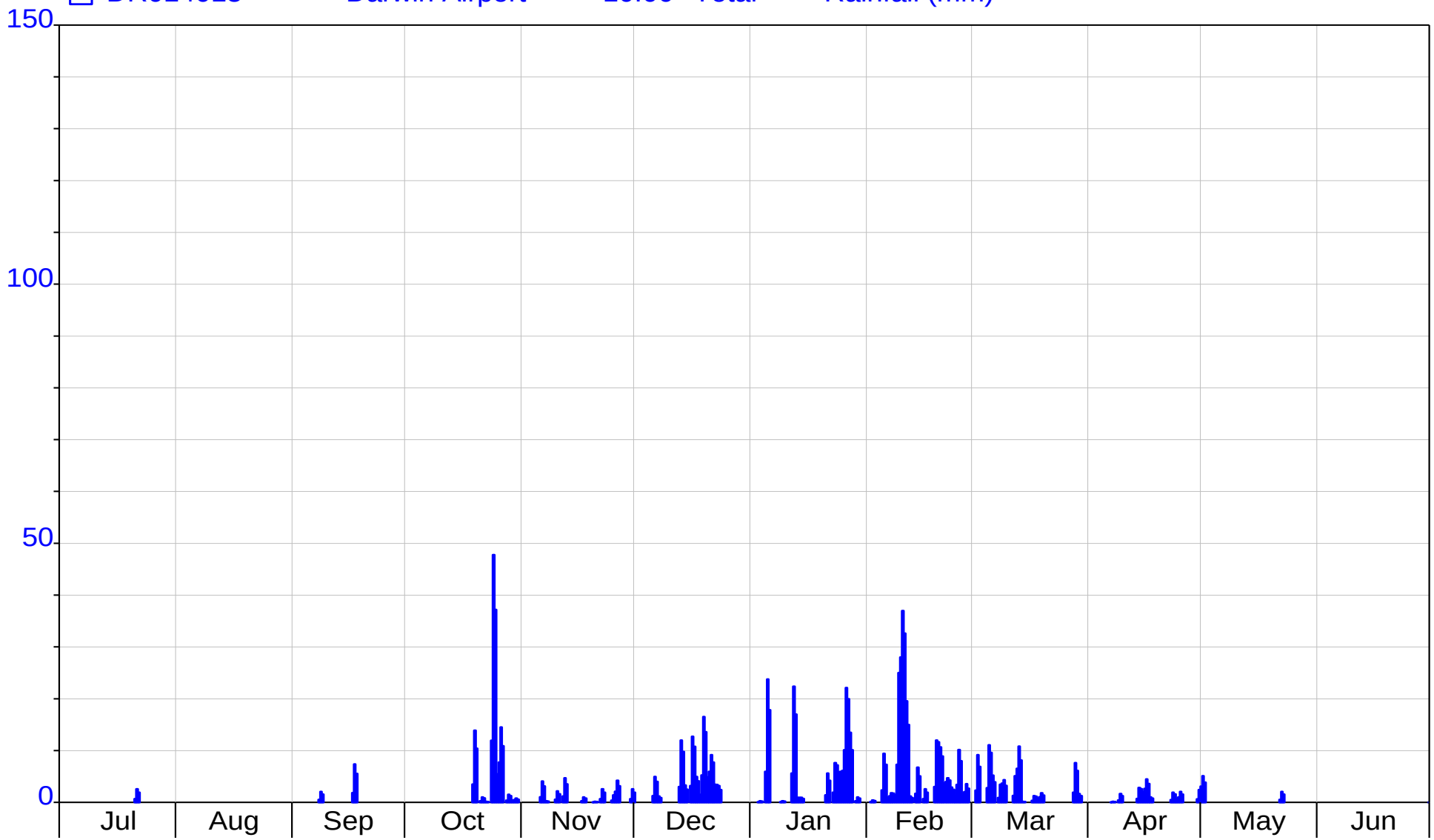
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1969 1969/70

Interval12 Hour Plot End 00:00_01/07/1970

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



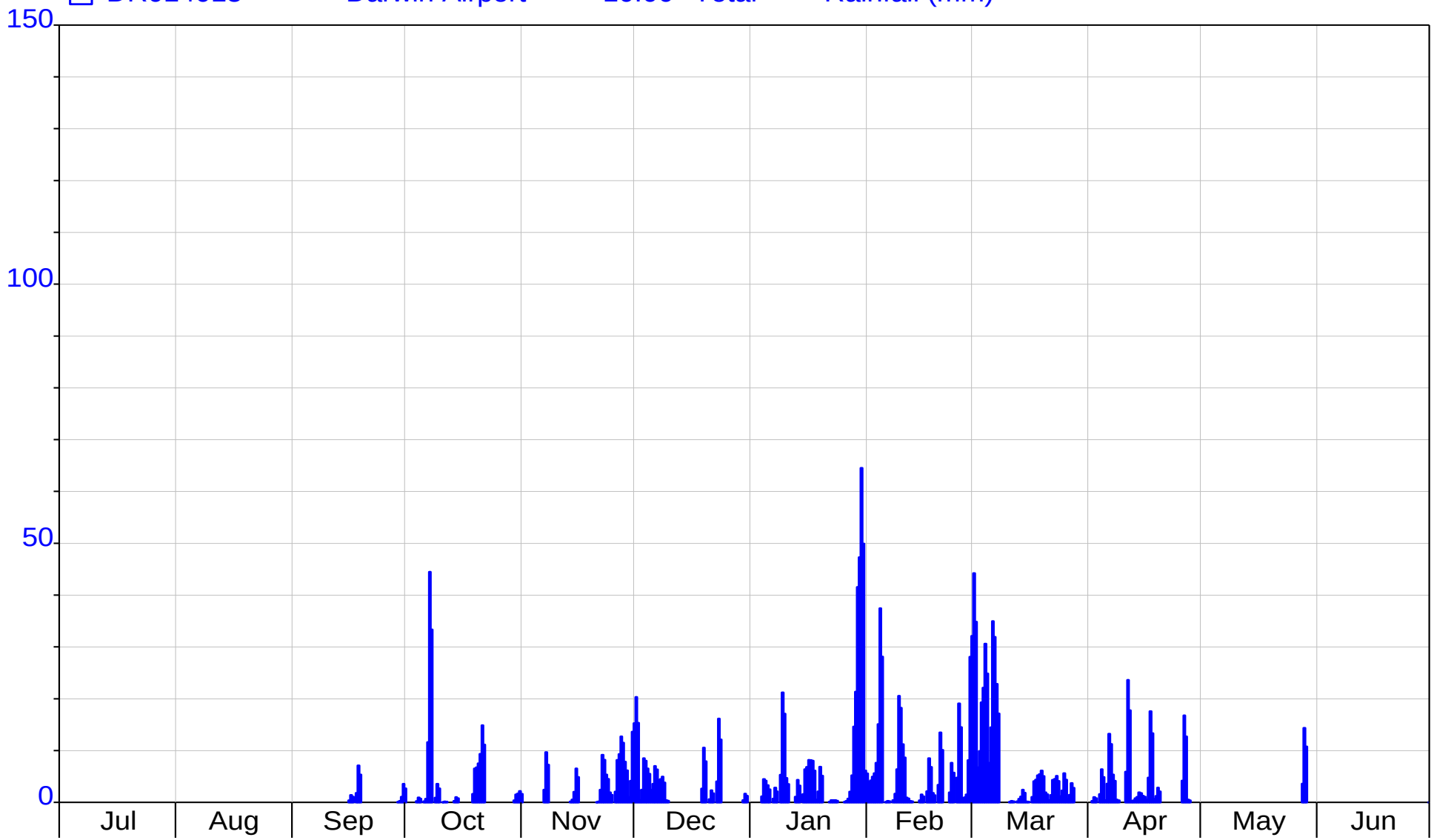
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1970 1970/71

Interval12 Hour Plot End 00:00_01/07/1971

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



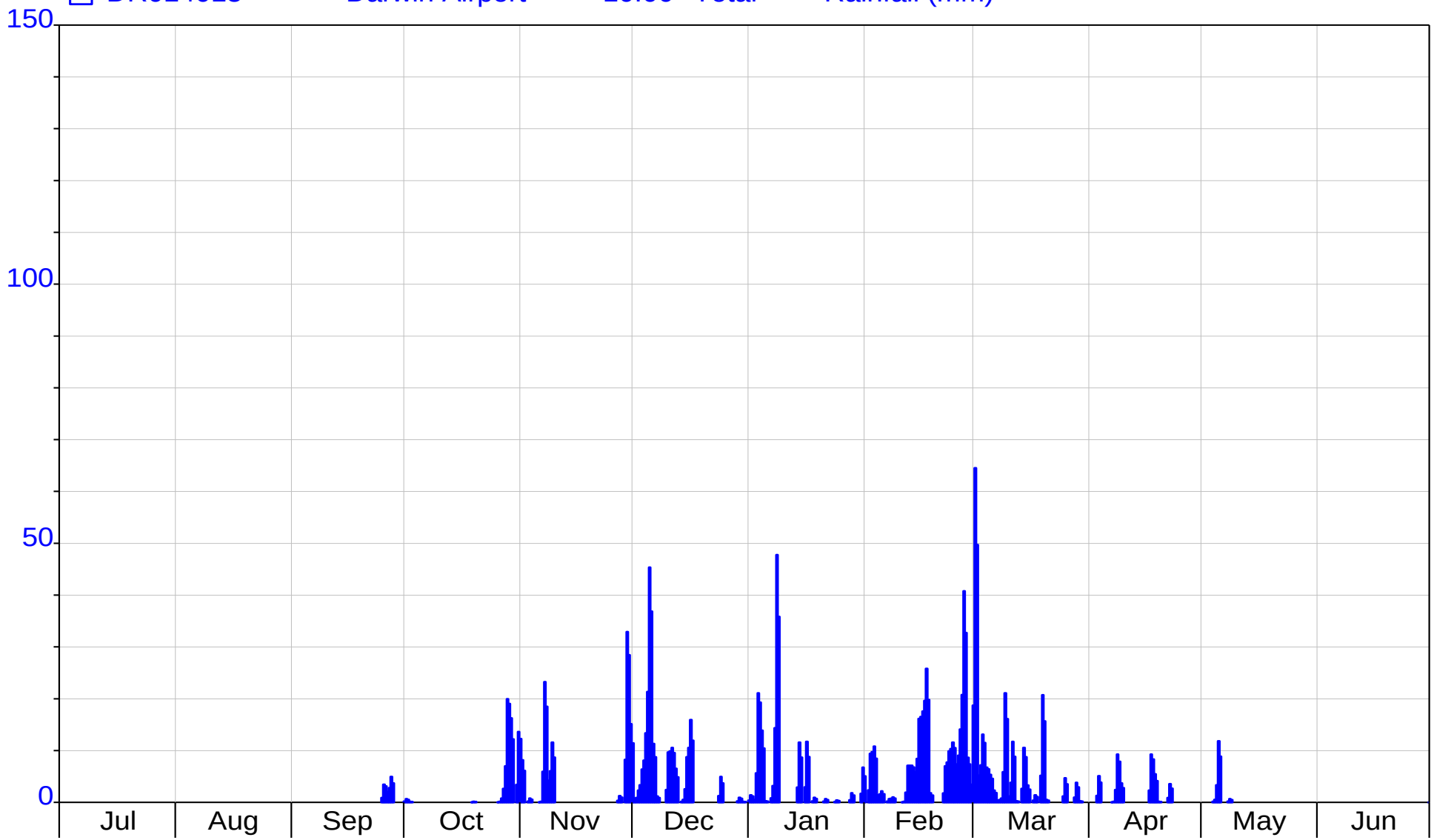
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1971 1971/72

Interval12 Hour Plot End 00:00_01/07/1972

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



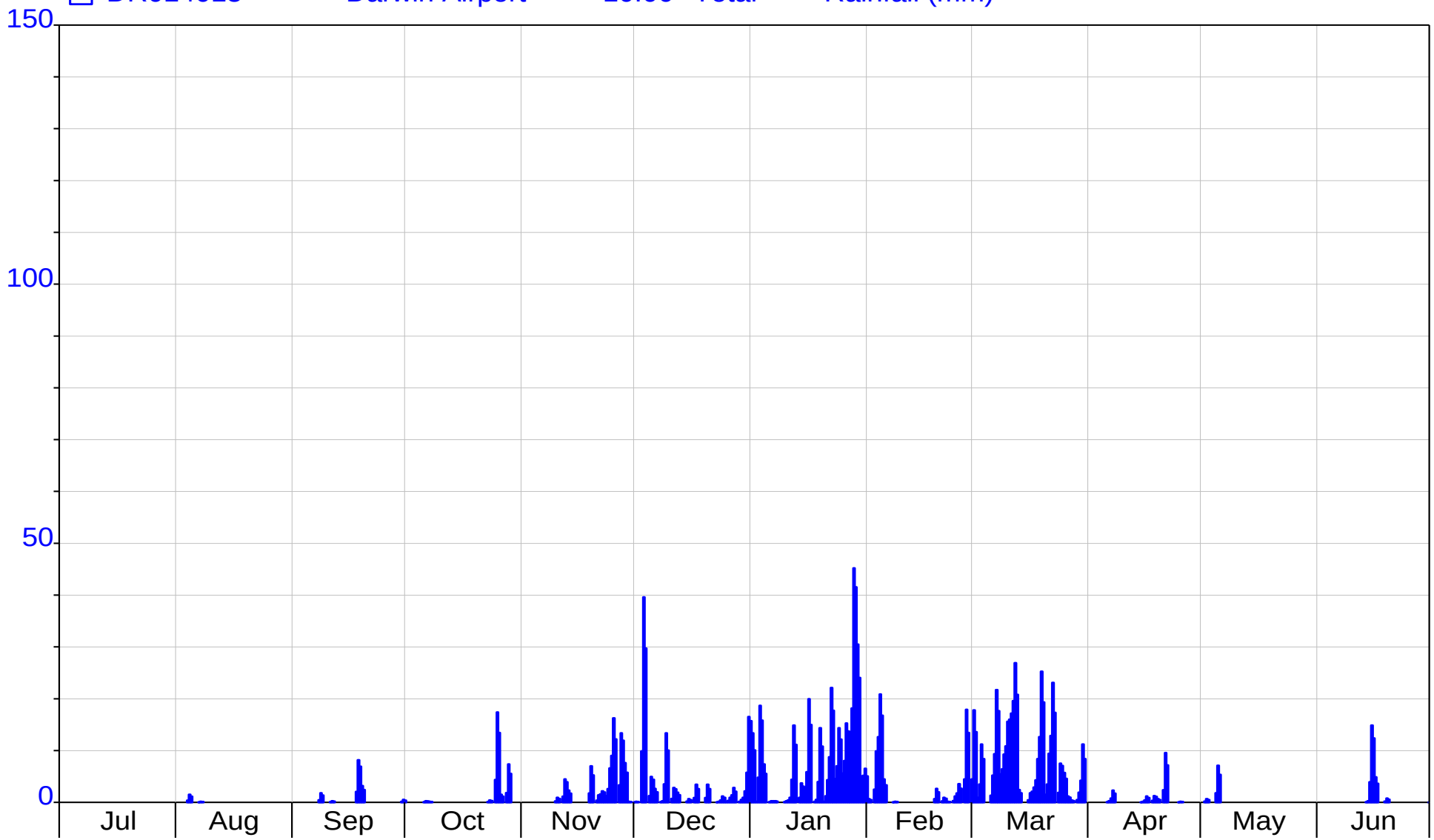
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1972 1972/73

Interval12 Hour Plot End 00:00_01/07/1973

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



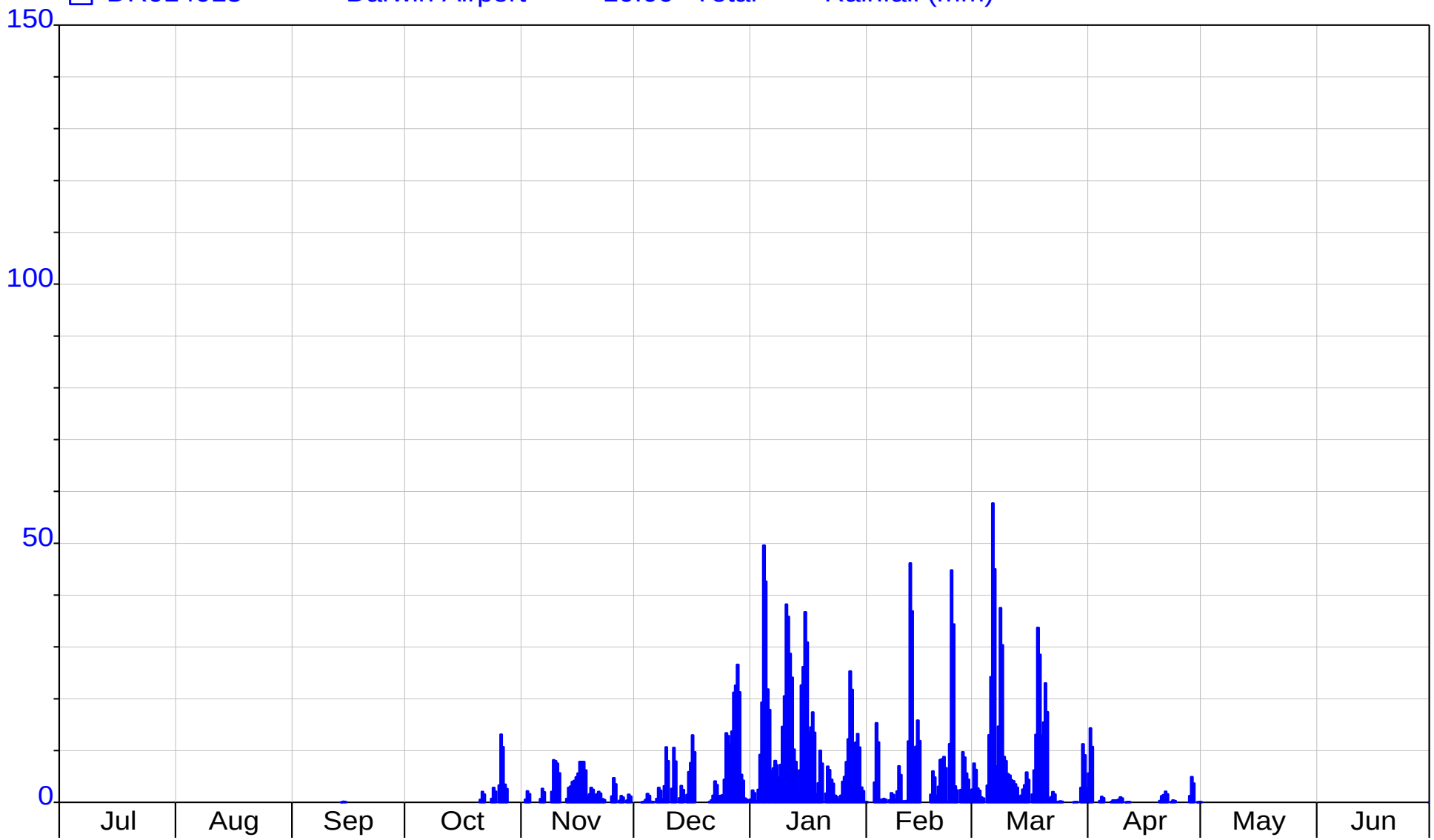
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1973 1973/74

Interval12 Hour Plot End 00:00_01/07/1974

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



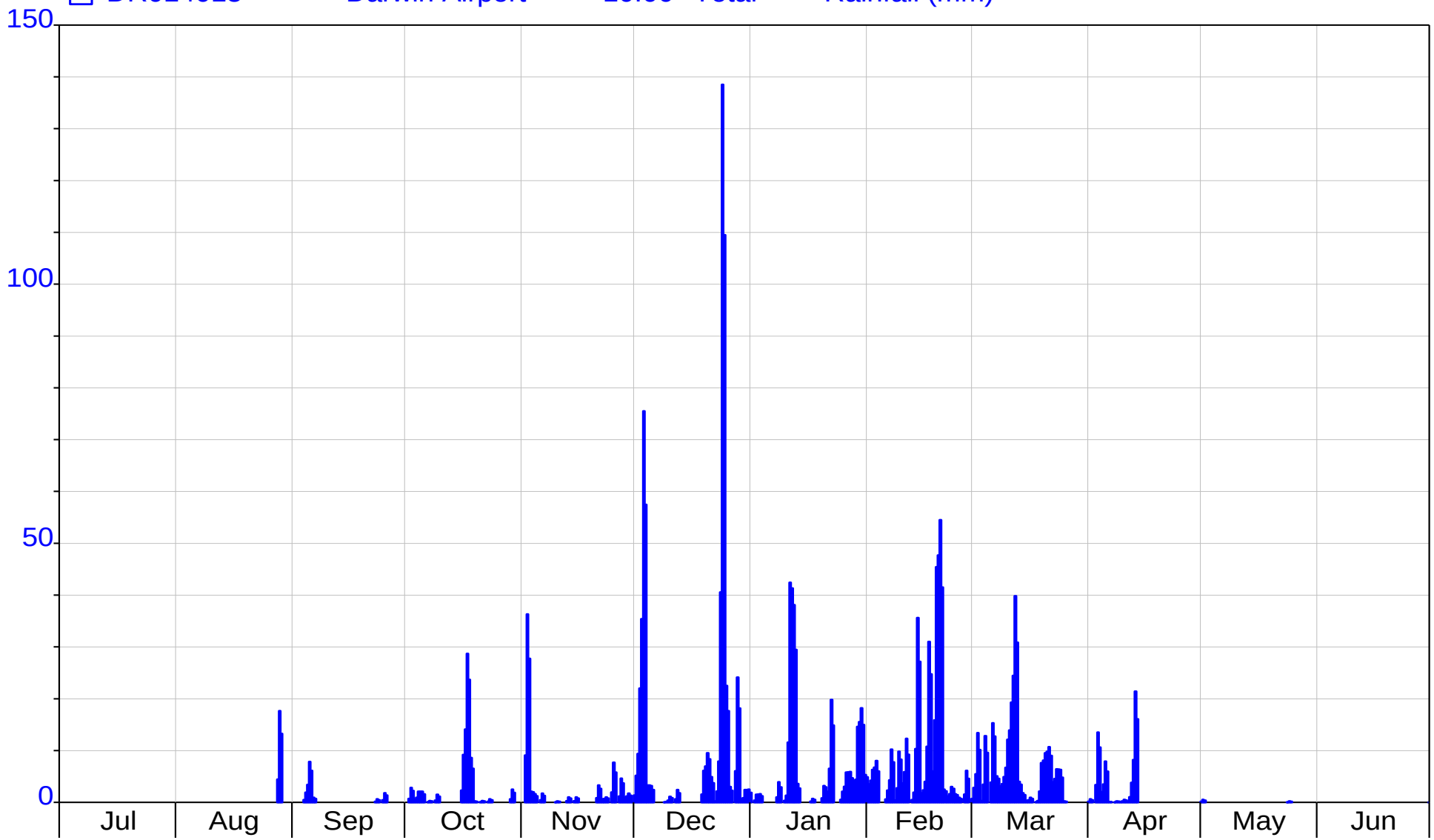
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1974 1974/75

Interval12 Hour Plot End 00:00_01/07/1975

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



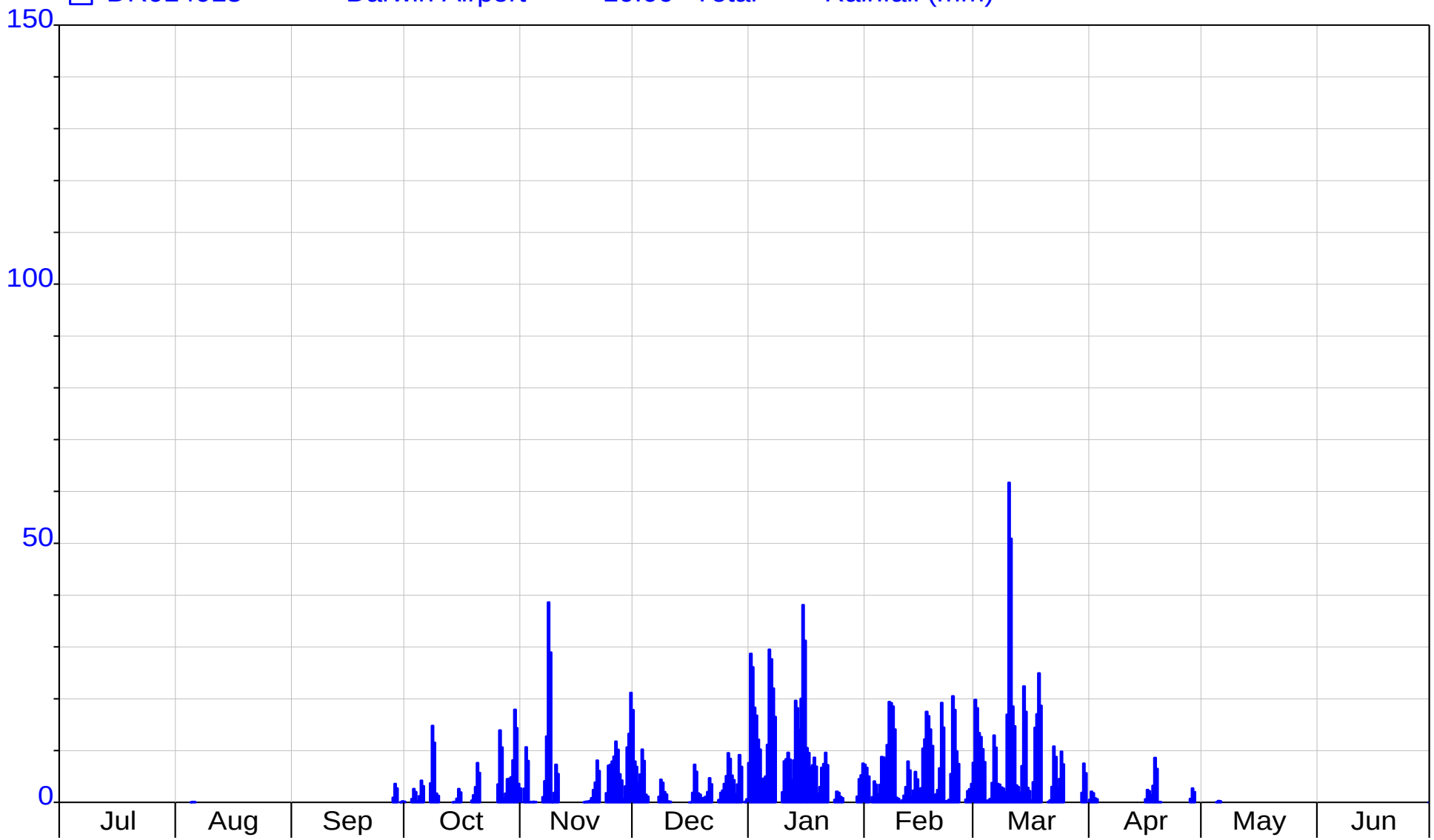
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1975 1975/76

Interval12 Hour Plot End 00:00_01/07/1976

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



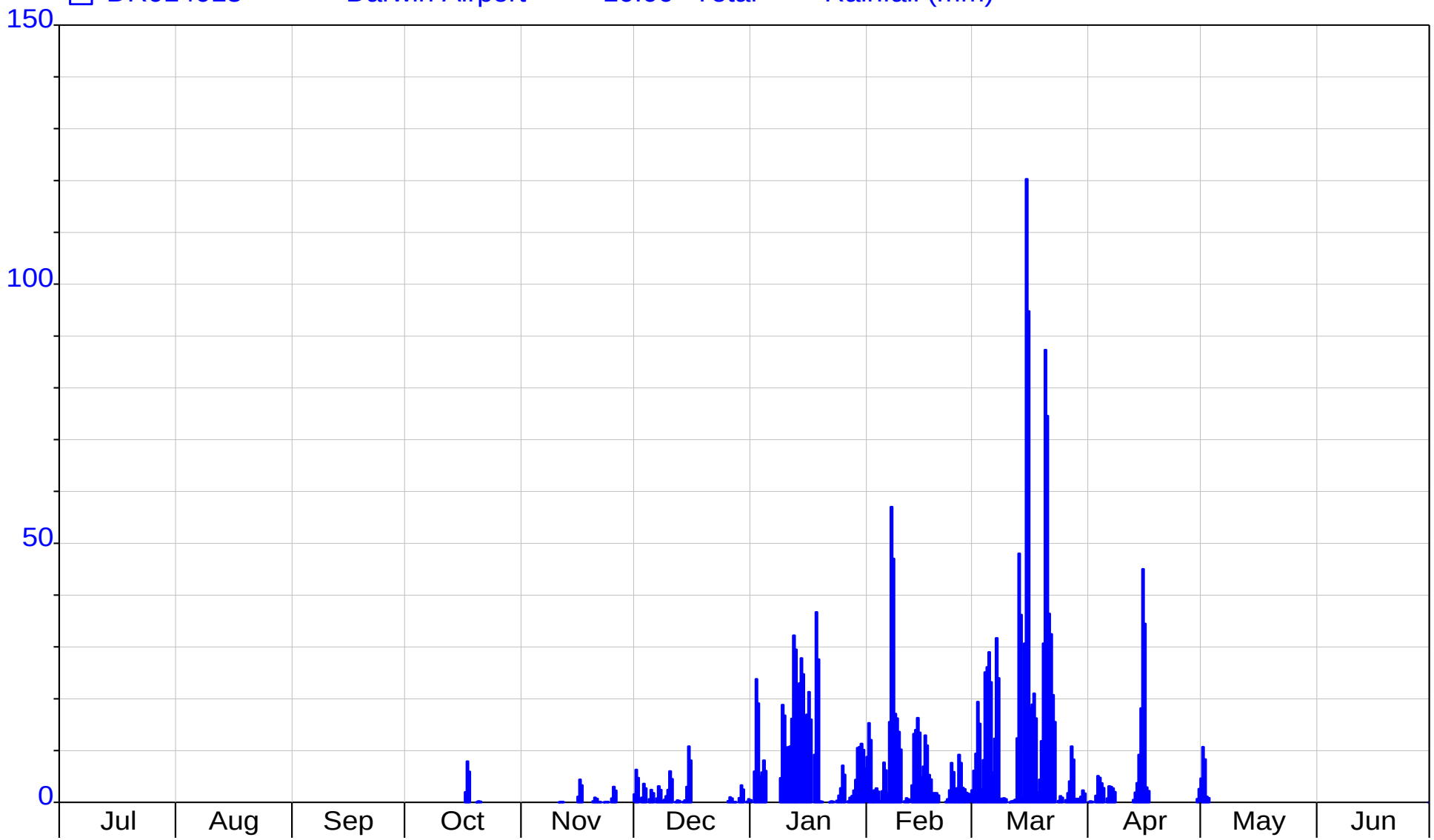
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1976 1976/77

Interval12 Hour Plot End 00:00_01/07/1977

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



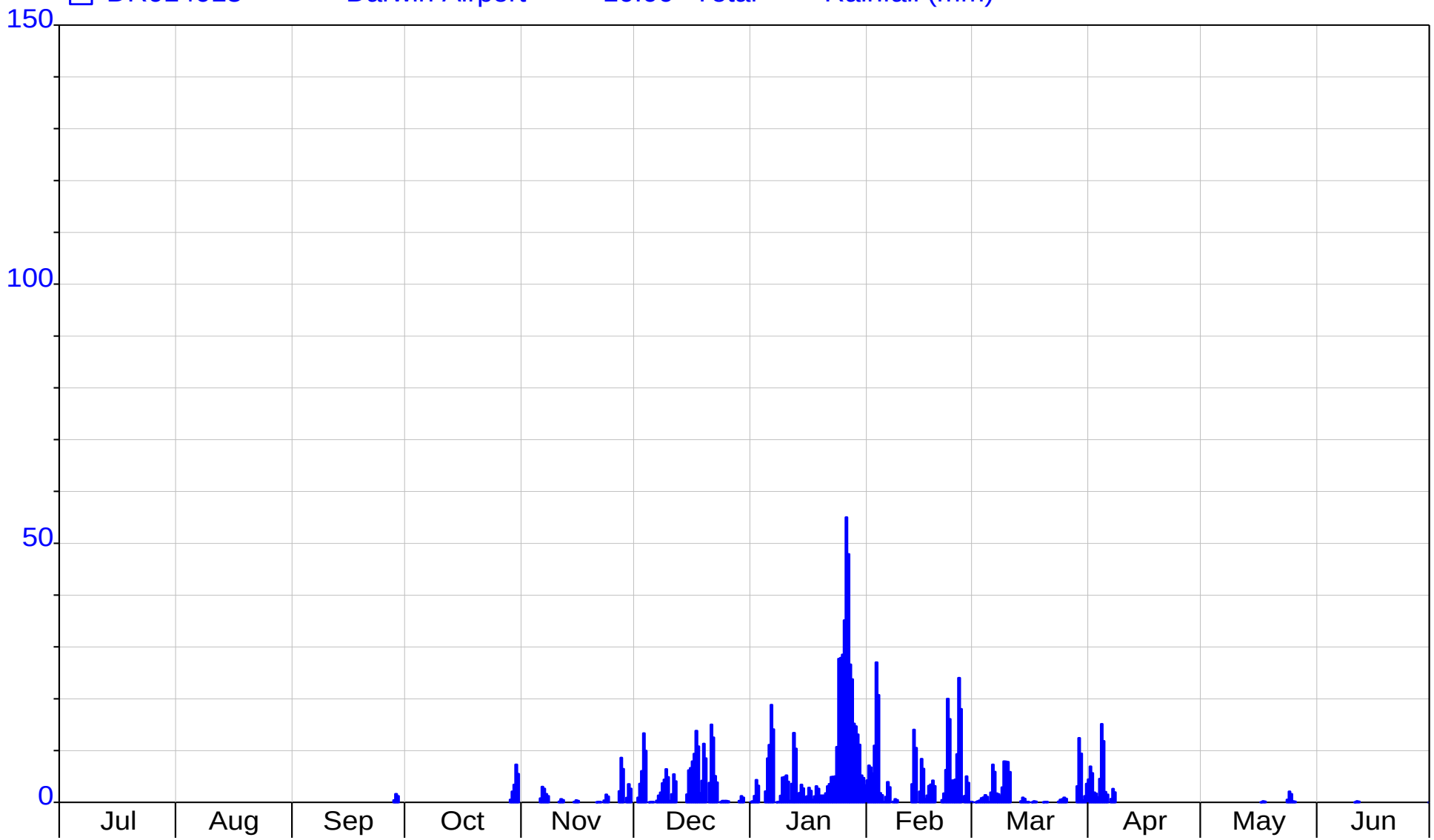
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1977 1977/78

Interval12 Hour Plot End 00:00_01/07/1978

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



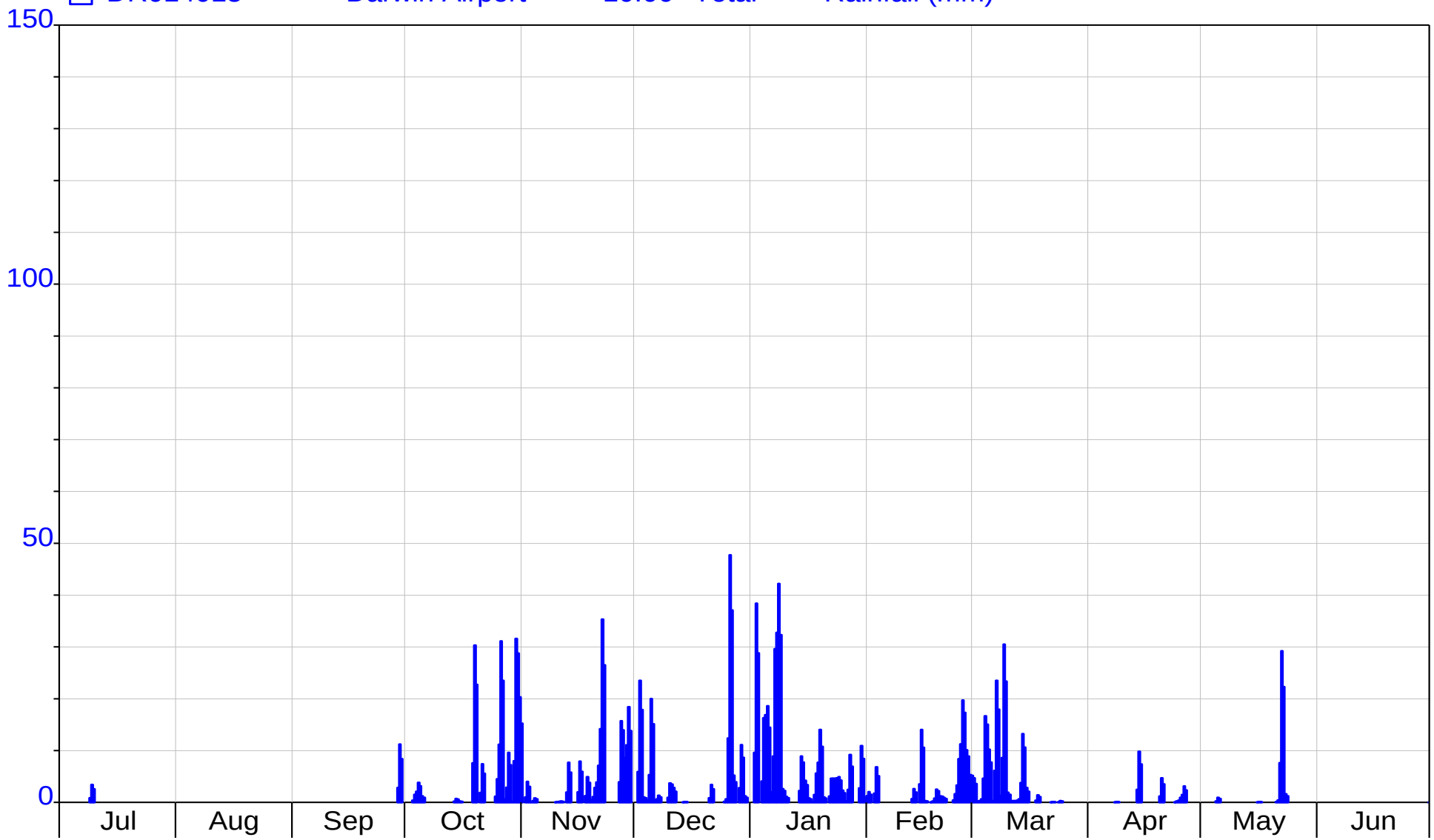
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1978 1978/79

Interval12 Hour Plot End 00:00_01/07/1979

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



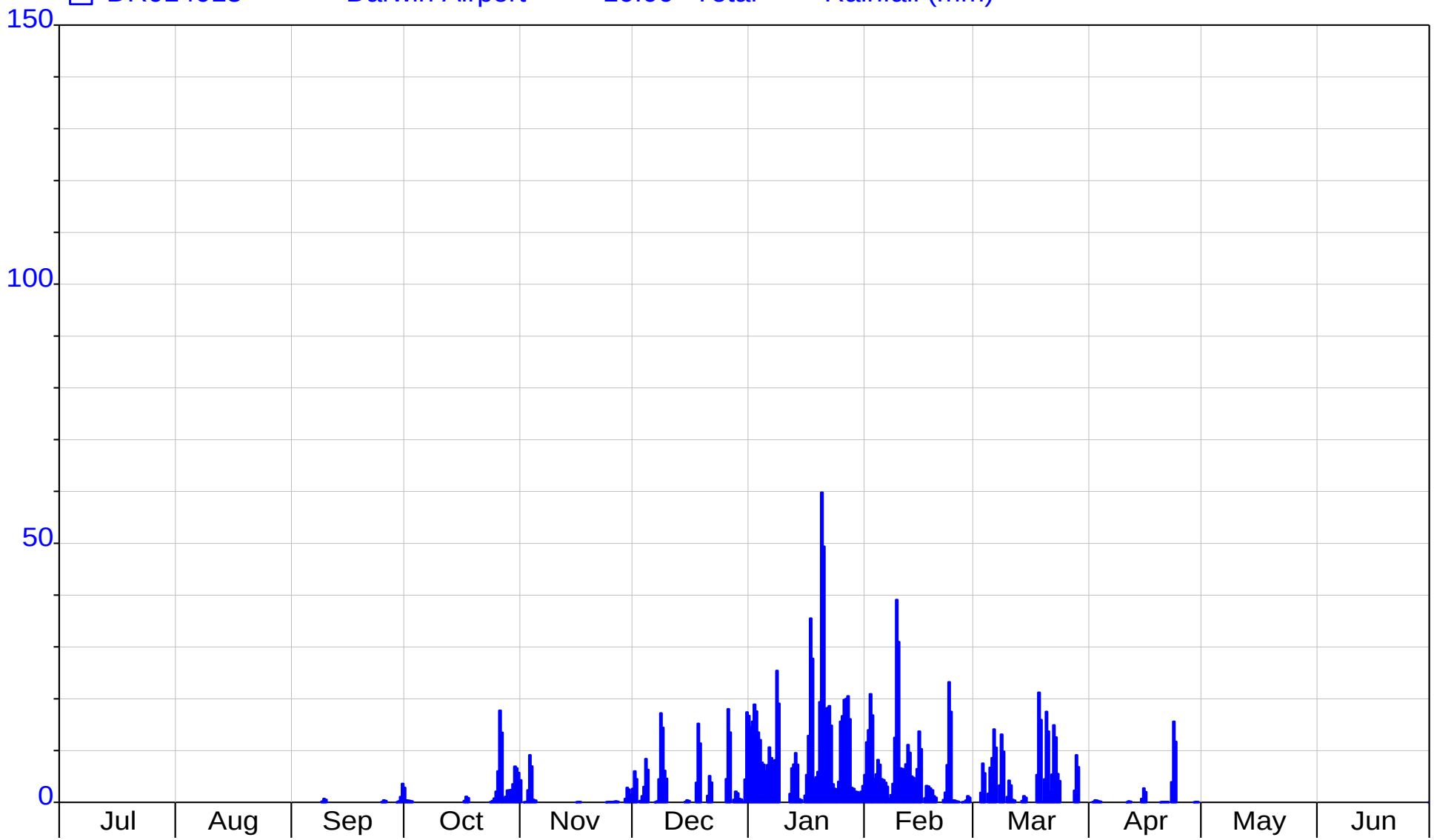
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1979 1979/80

Interval12 Hour Plot End 00:00_01/07/1980

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



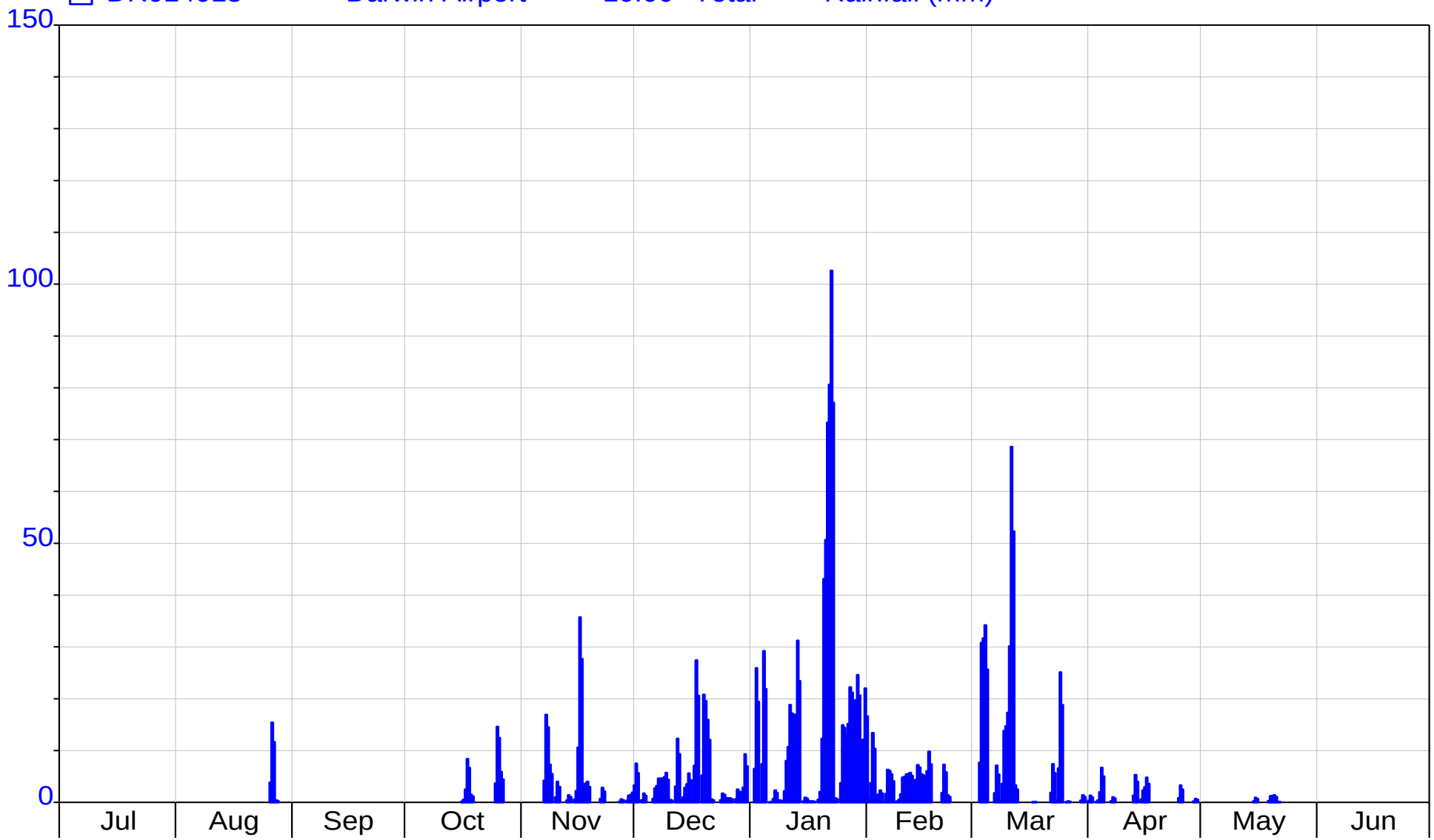
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1980 1980/81

Interval12 Hour Plot End 00:00_01/07/1981

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



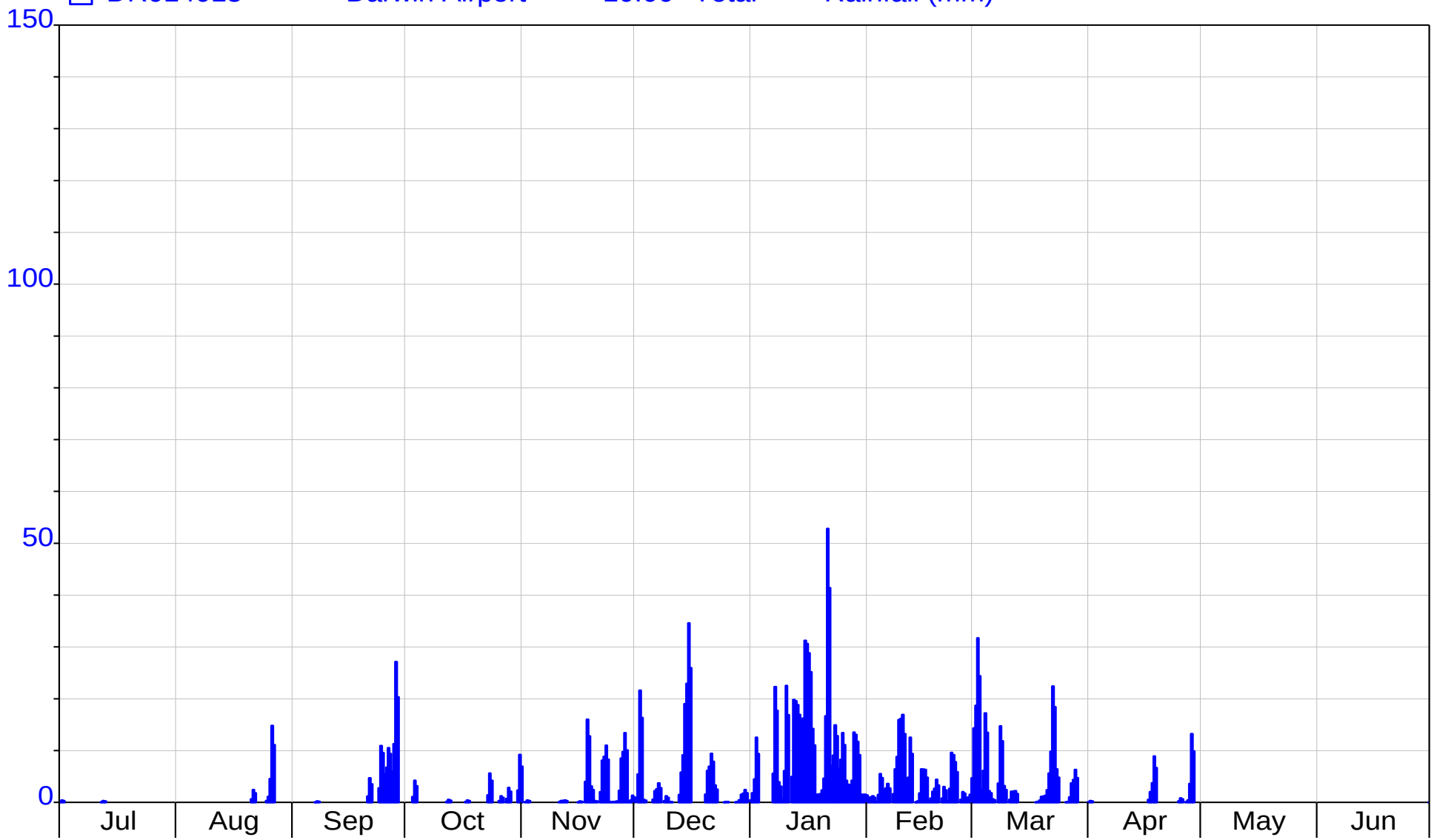
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1981 1981/82

Interval12 Hour Plot End 00:00_01/07/1982

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



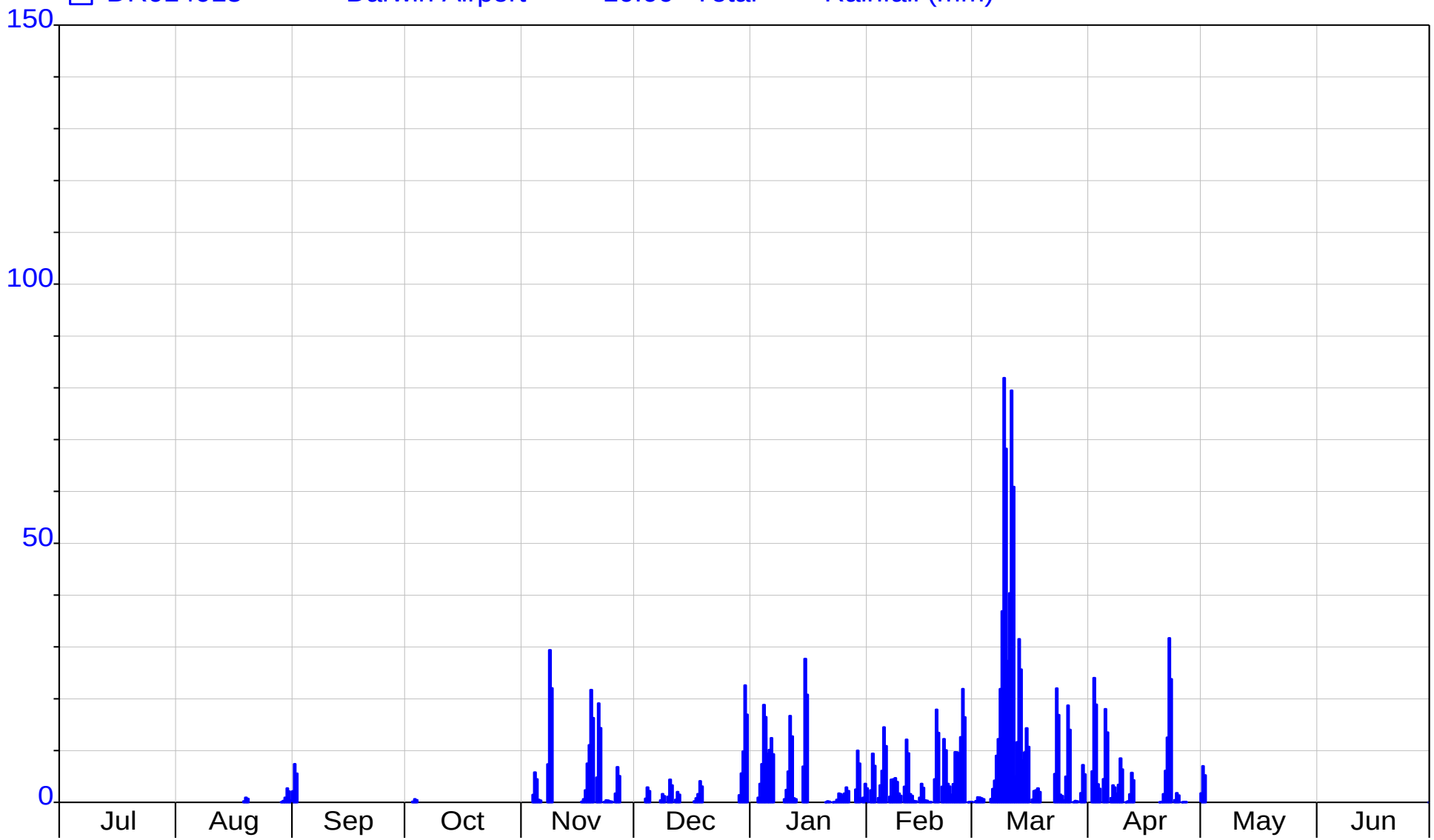
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1982 1982/83

Interval12 Hour Plot End 00:00_01/07/1983

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



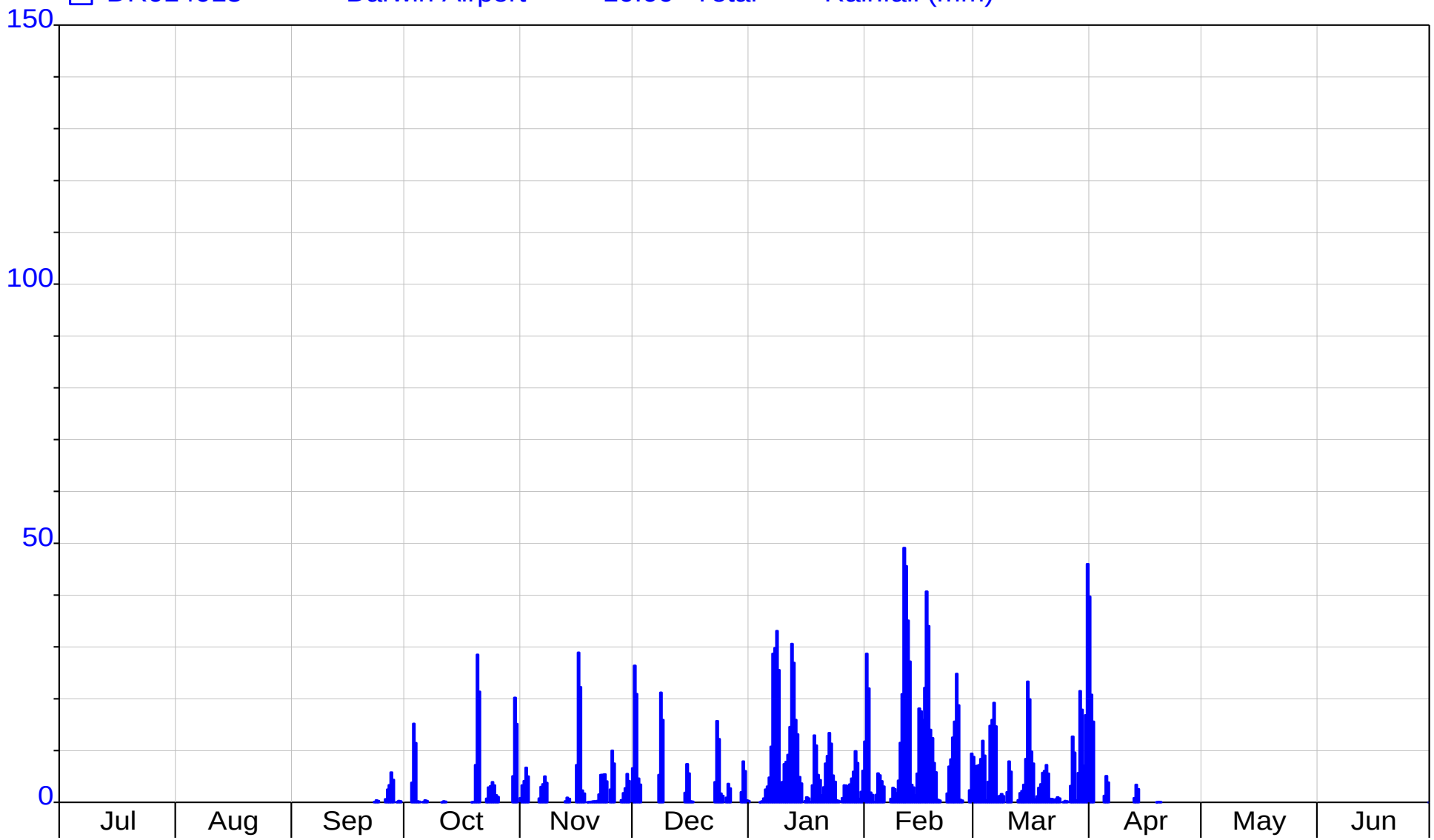
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1983 1983/84

Interval12 Hour Plot End 00:00_01/07/1984

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



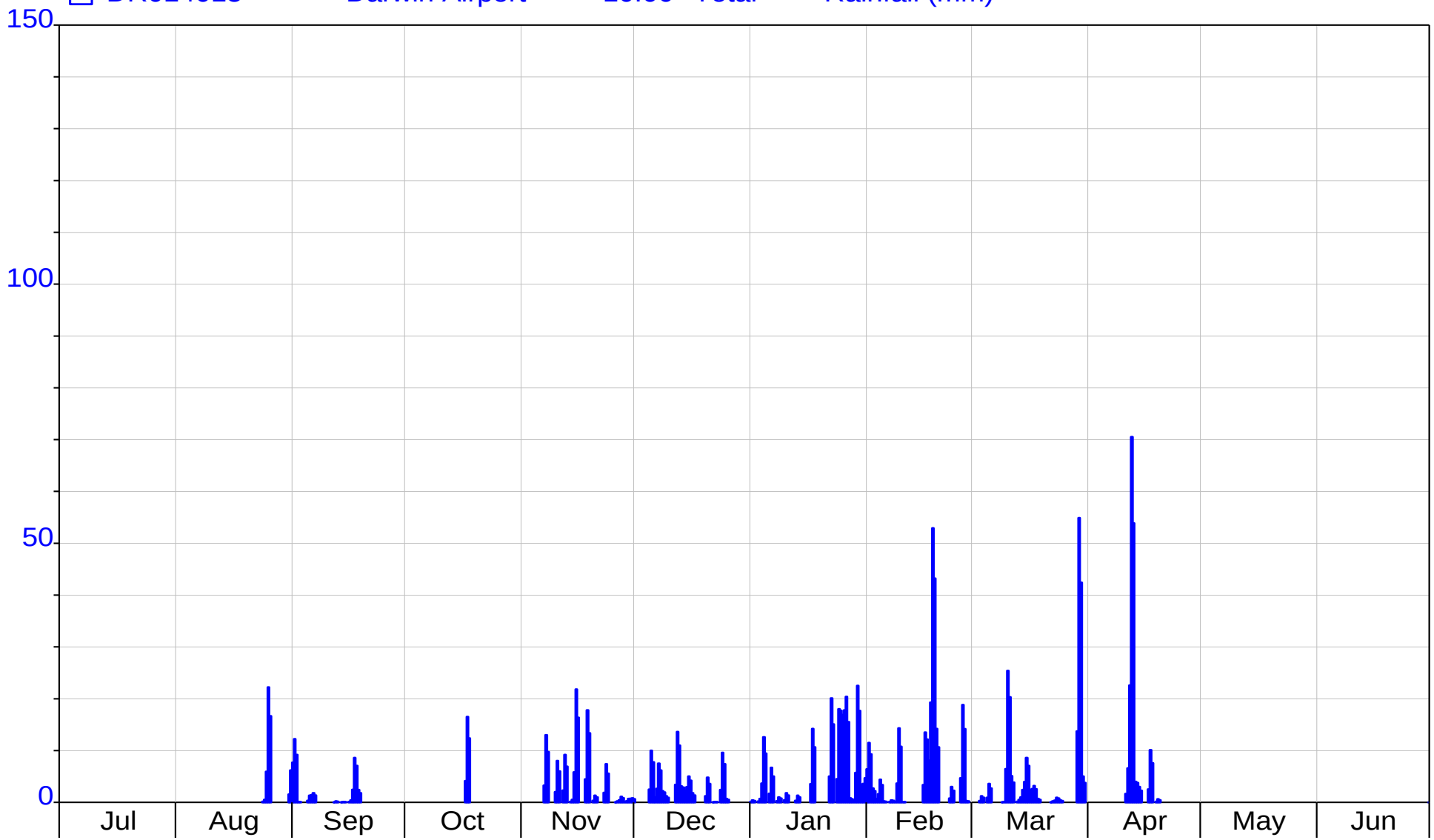
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1984 1984/85

Interval12 Hour Plot End 00:00_01/07/1985

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



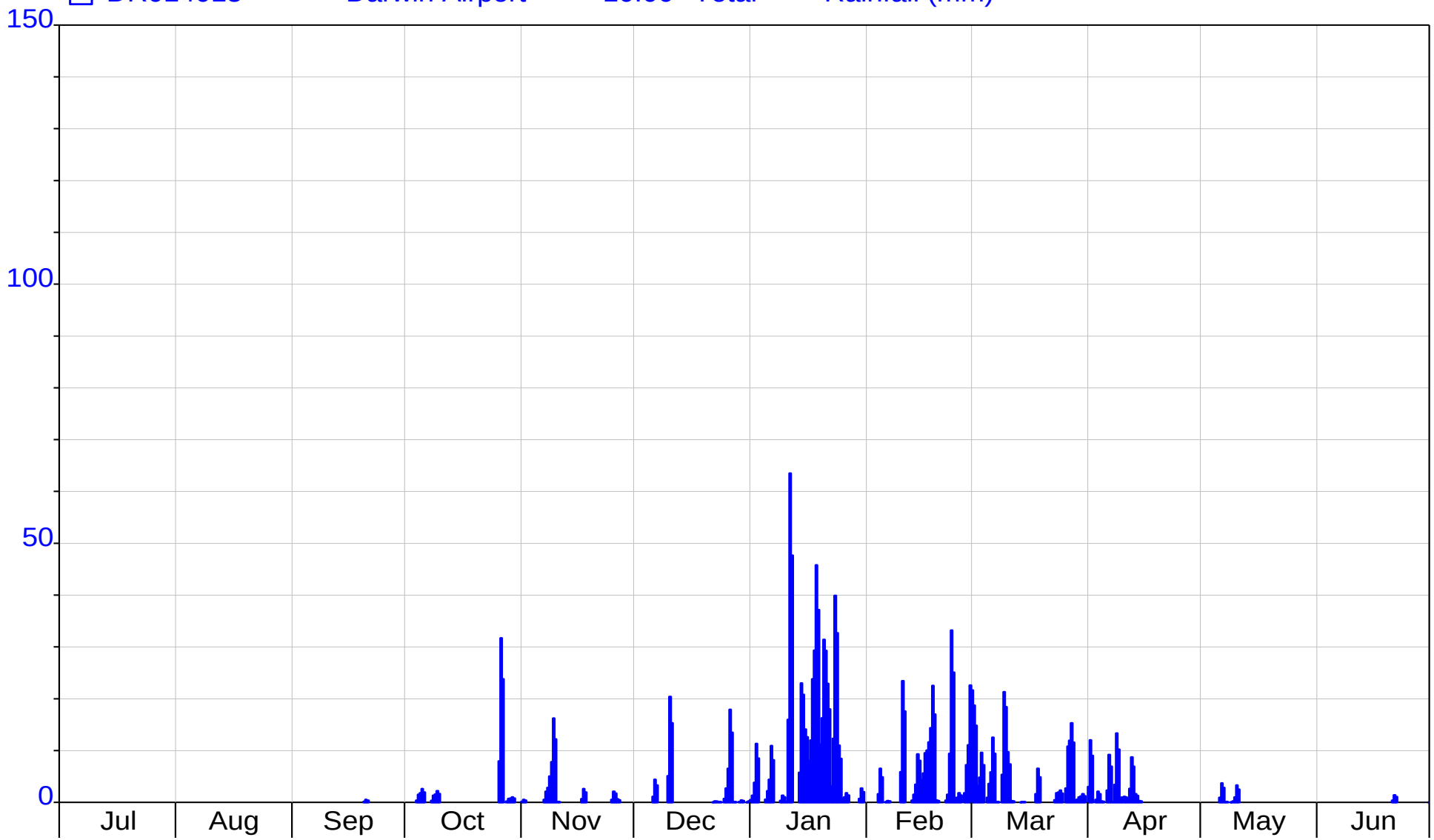
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1985 1985/86

Interval12 Hour Plot End 00:00_01/07/1986

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



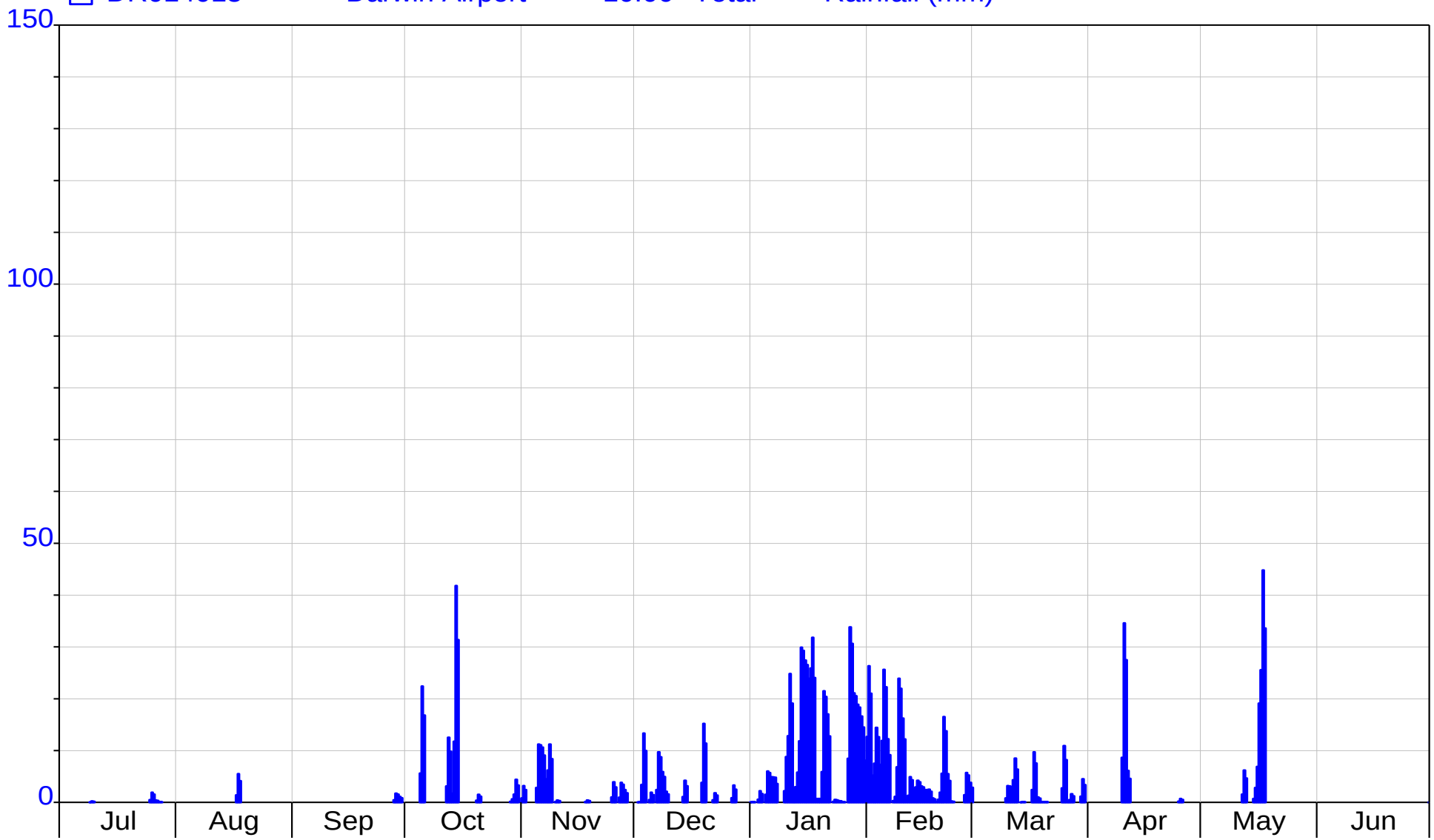
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1986 1986/87

Interval12 Hour Plot End 00:00_01/07/1987

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



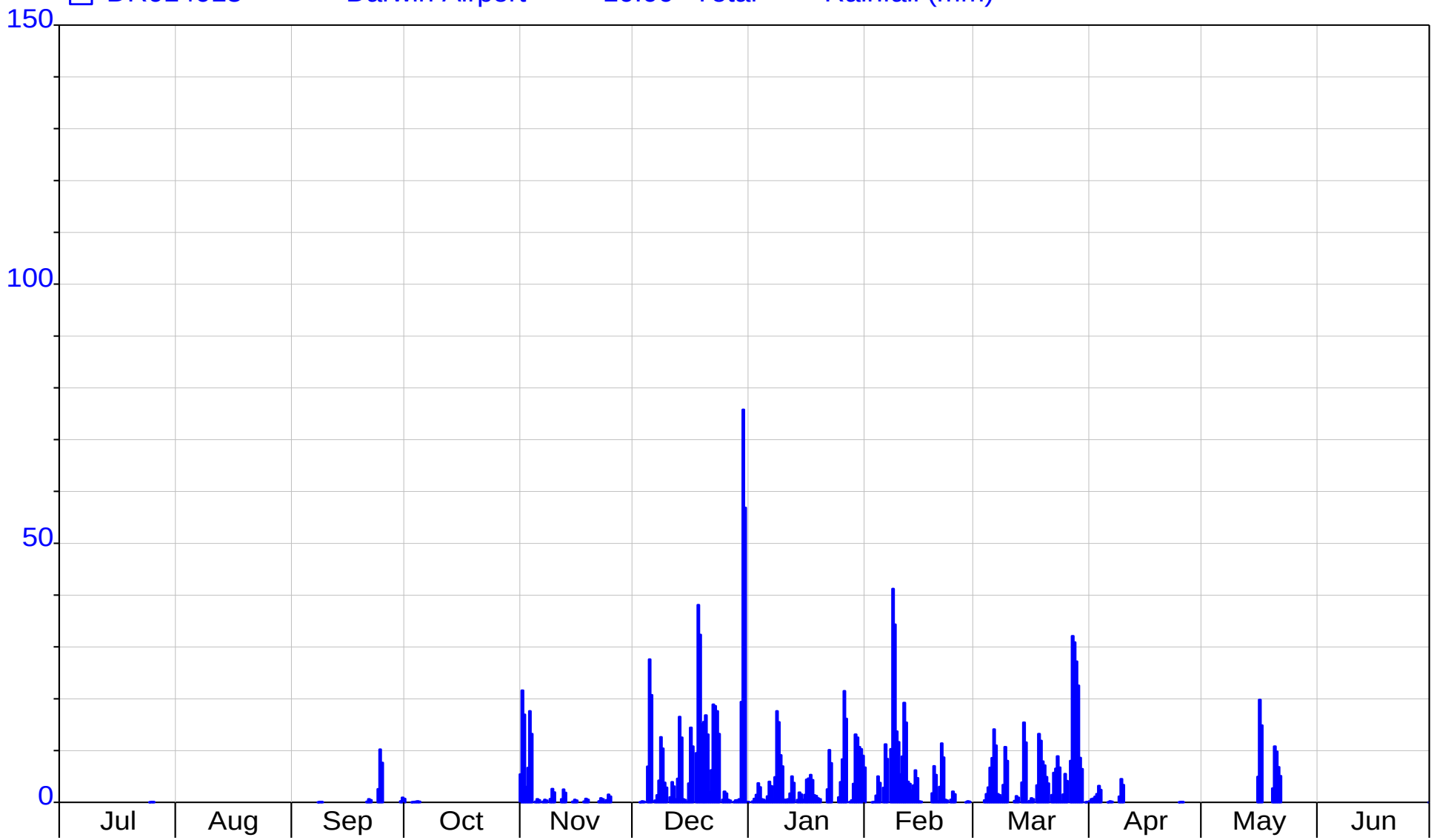
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1987 1987/88

Interval12 Hour Plot End 00:00_01/07/1988

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



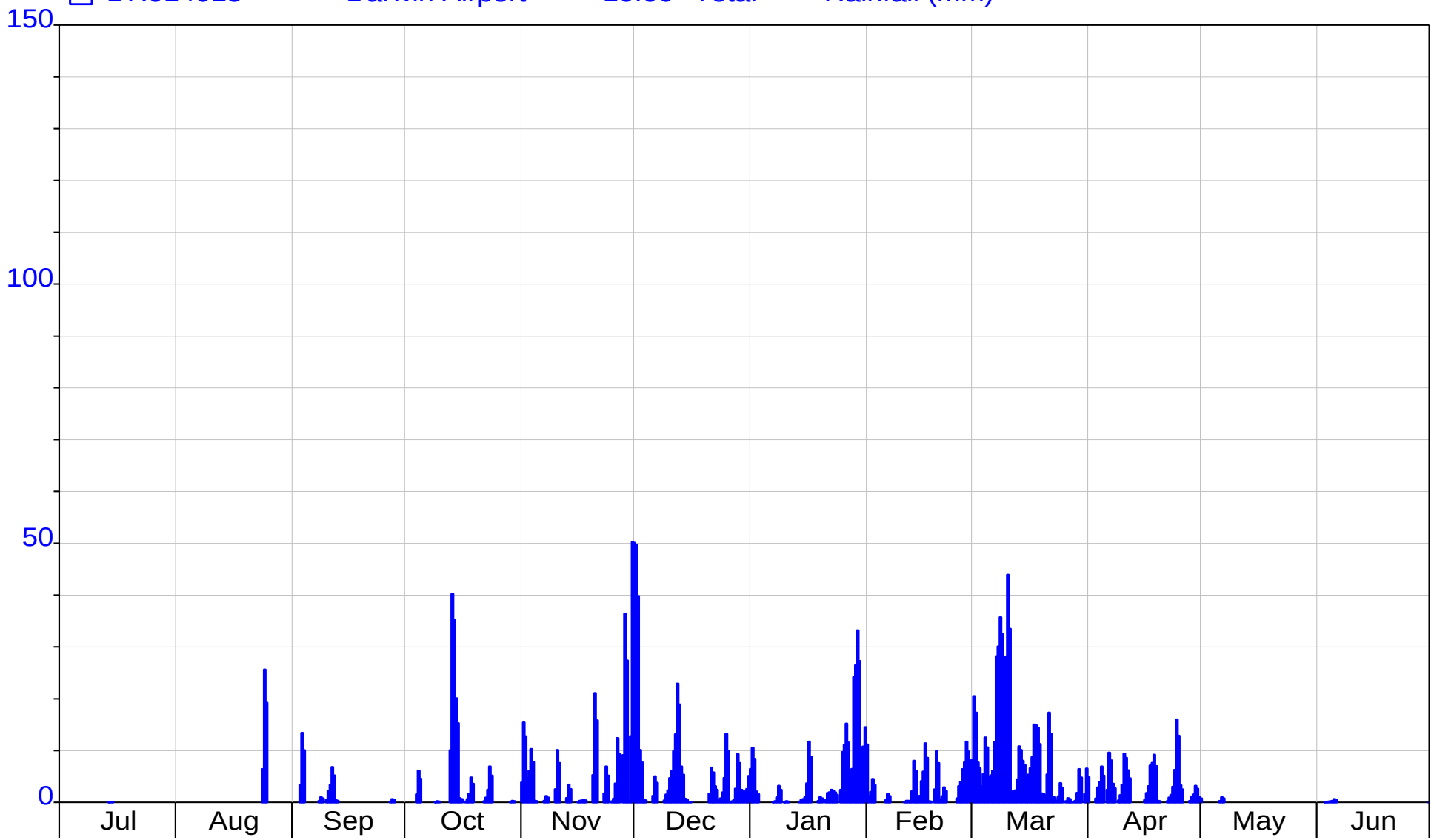
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1988 1988/89

Interval12 Hour Plot End 00:00_01/07/1989

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



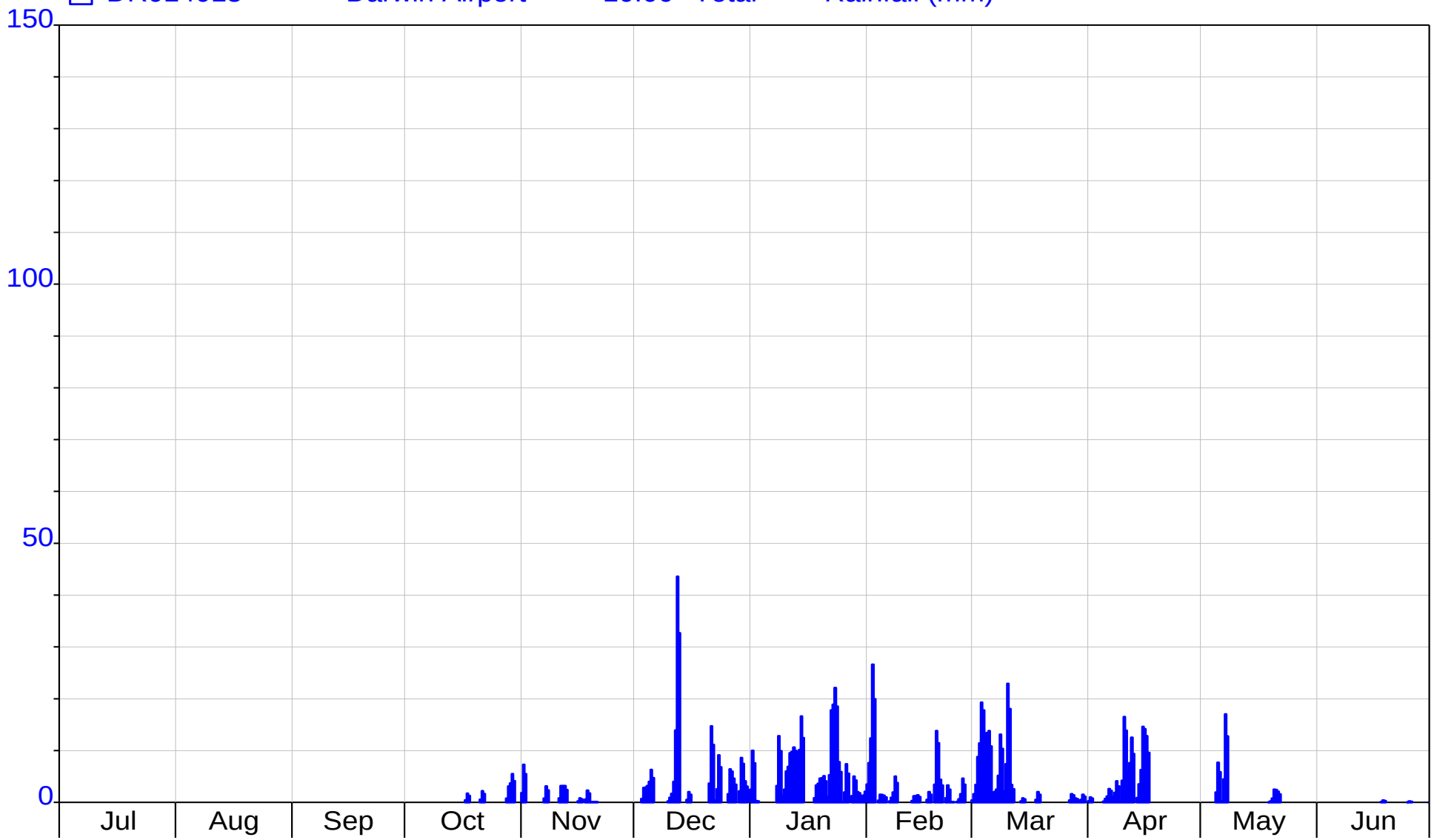
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1989 1989/90

Interval12 Hour Plot End 00:00_01/07/1990

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



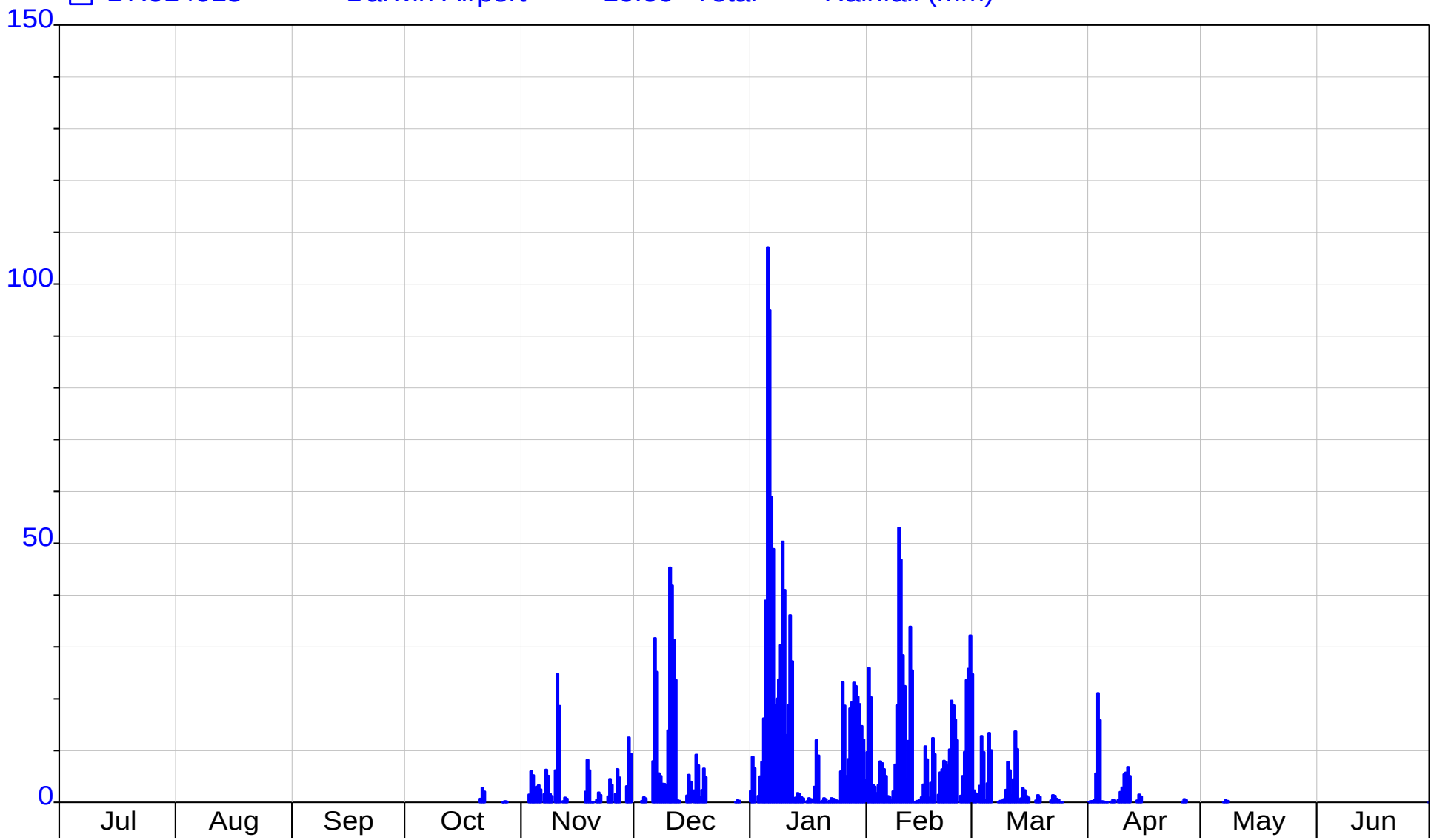
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1990 1990/91

Interval12 Hour Plot End 00:00_01/07/1991

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



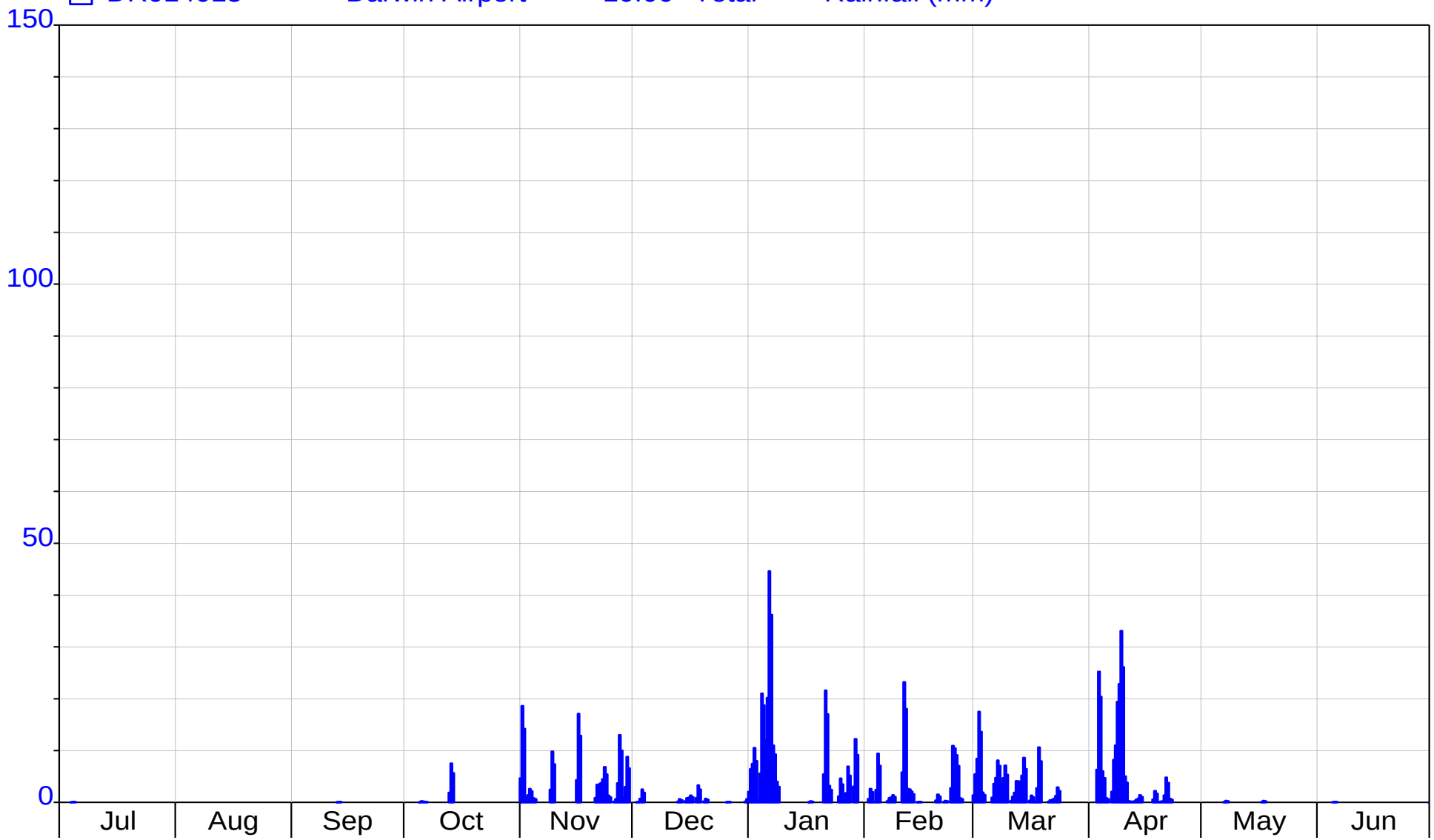
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1991 1991/92

Interval12 Hour Plot End 00:00_01/07/1992

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



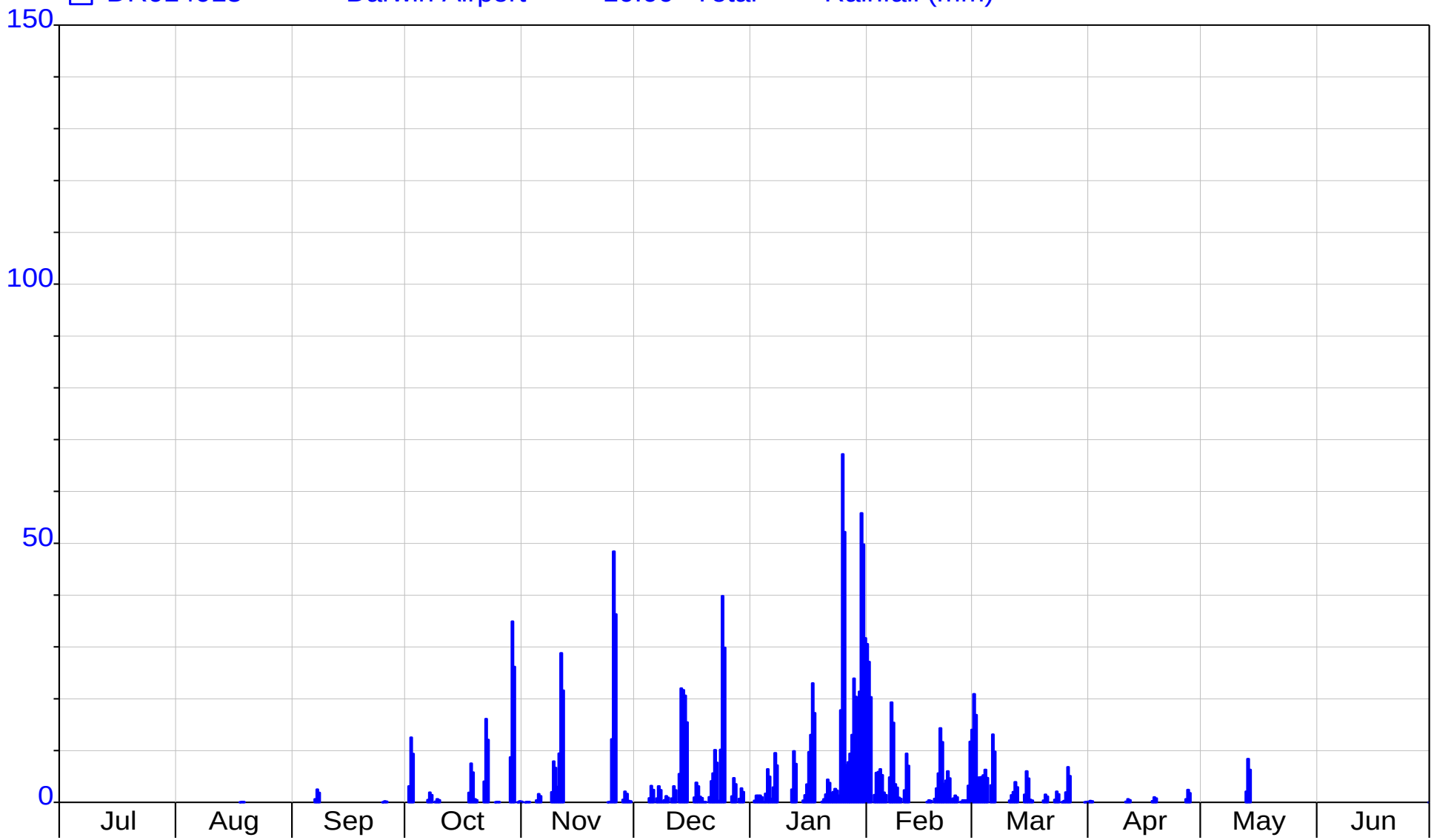
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1992 1992/93

Interval12 Hour Plot End 00:00_01/07/1993

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



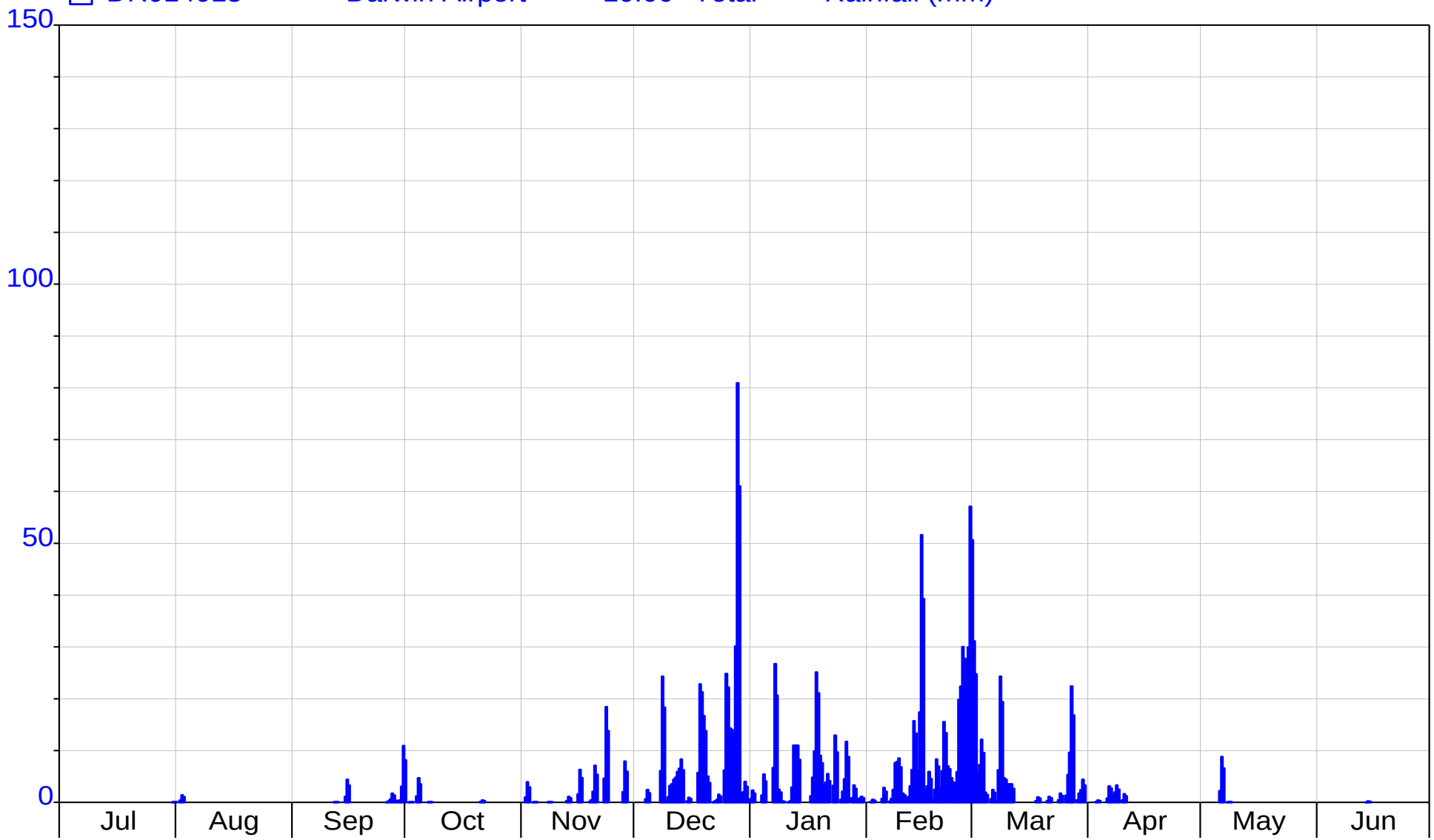
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1993 1993/94

Interval12 Hour Plot End 00:00_01/07/1994

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



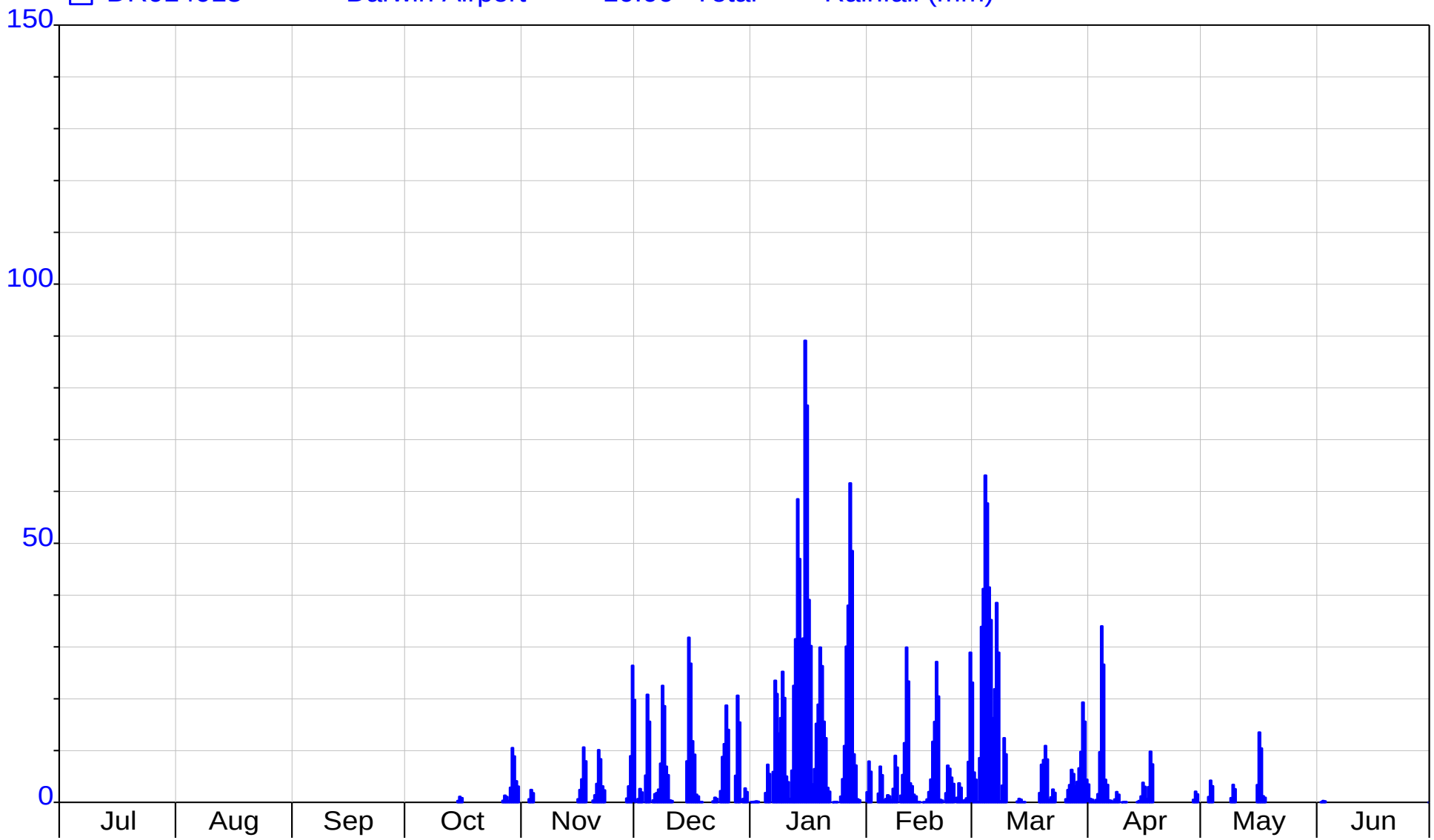
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1994 1994/95

Interval12 Hour Plot End 00:00_01/07/1995

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



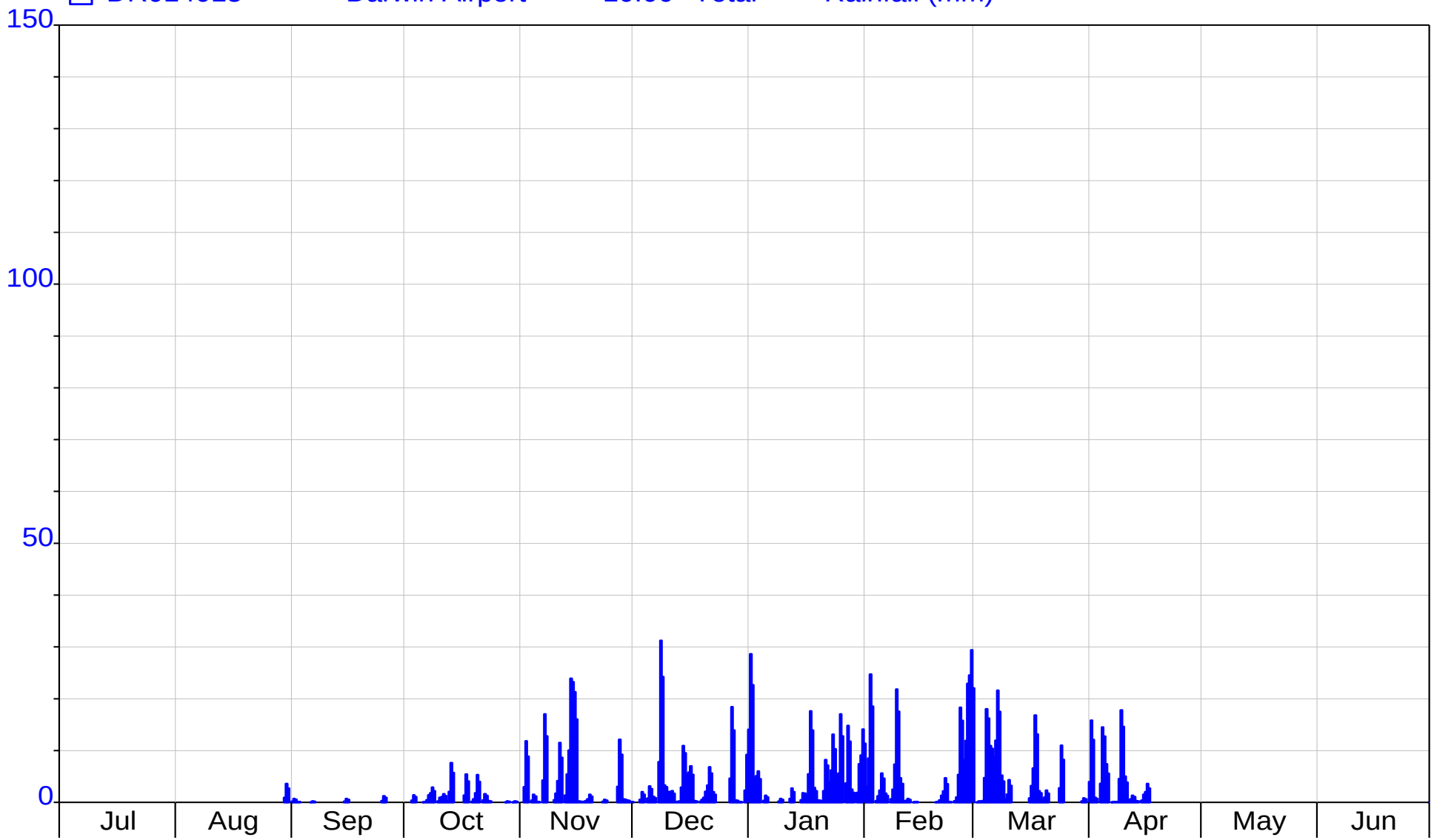
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1995 1995/96

Interval12 Hour Plot End 00:00_01/07/1996

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



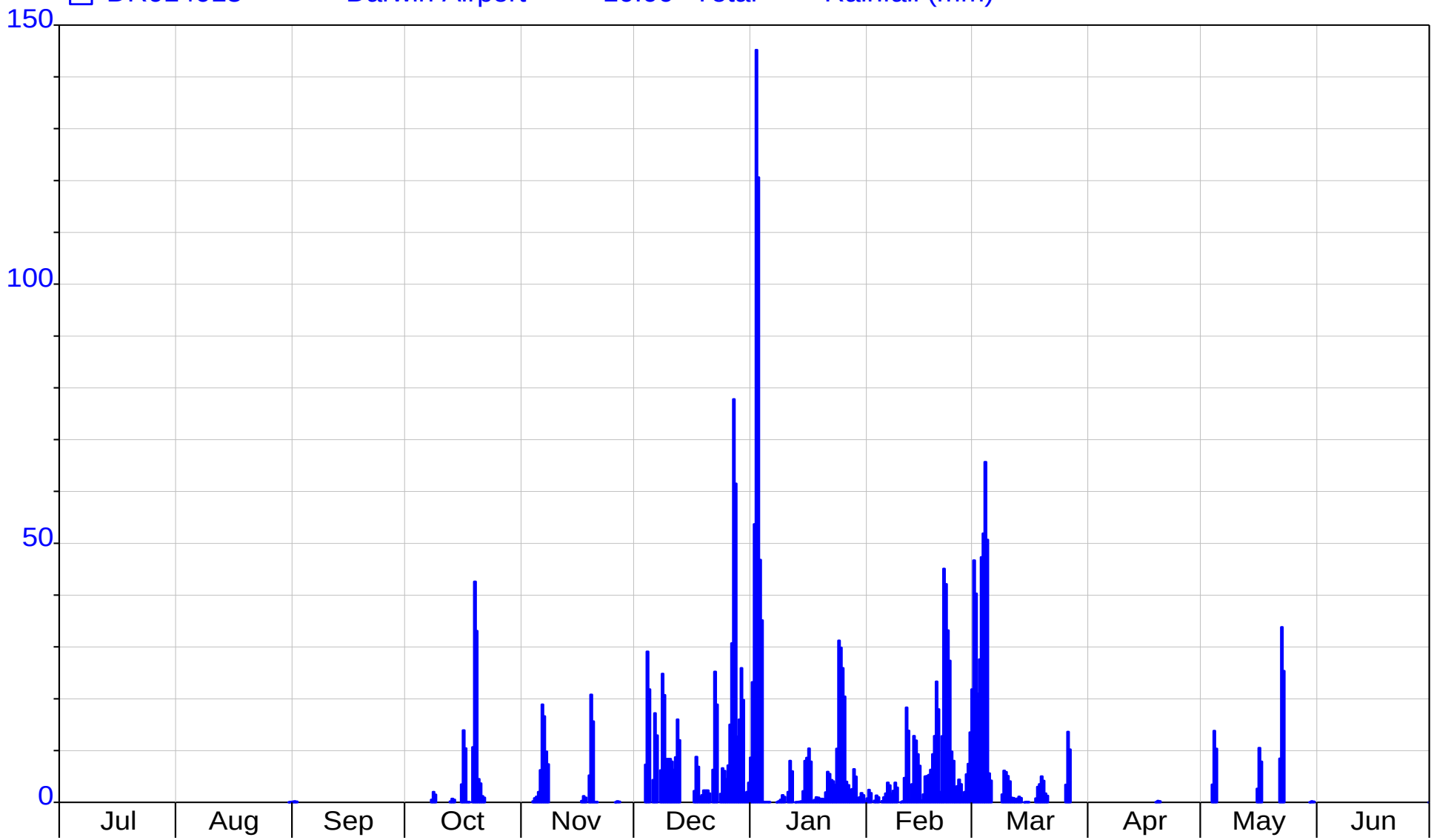
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1996 1996/97

Interval12 Hour Plot End 00:00_01/07/1997

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



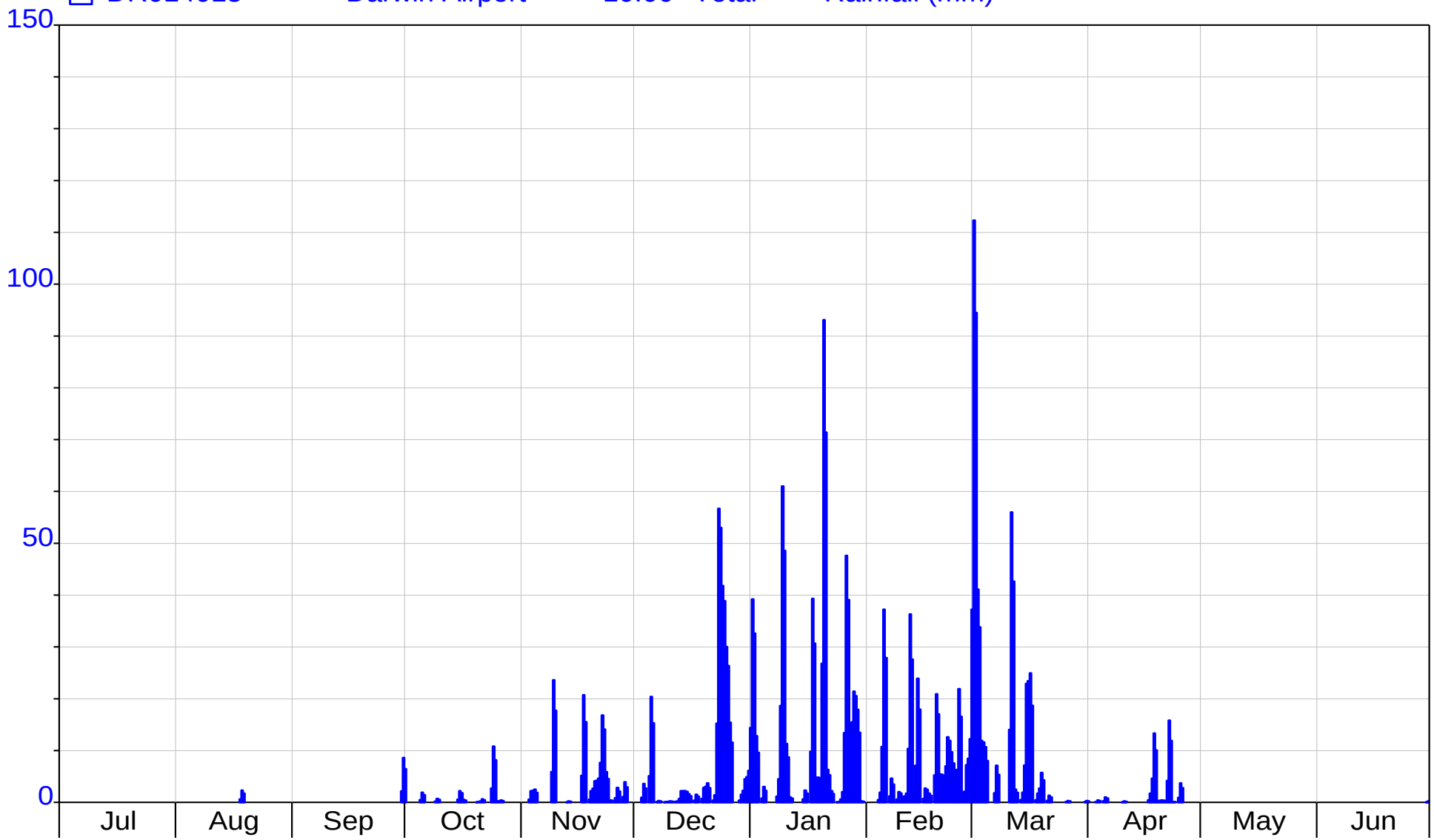
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1997 1997/98

Interval12 Hour Plot End 00:00_01/07/1998

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



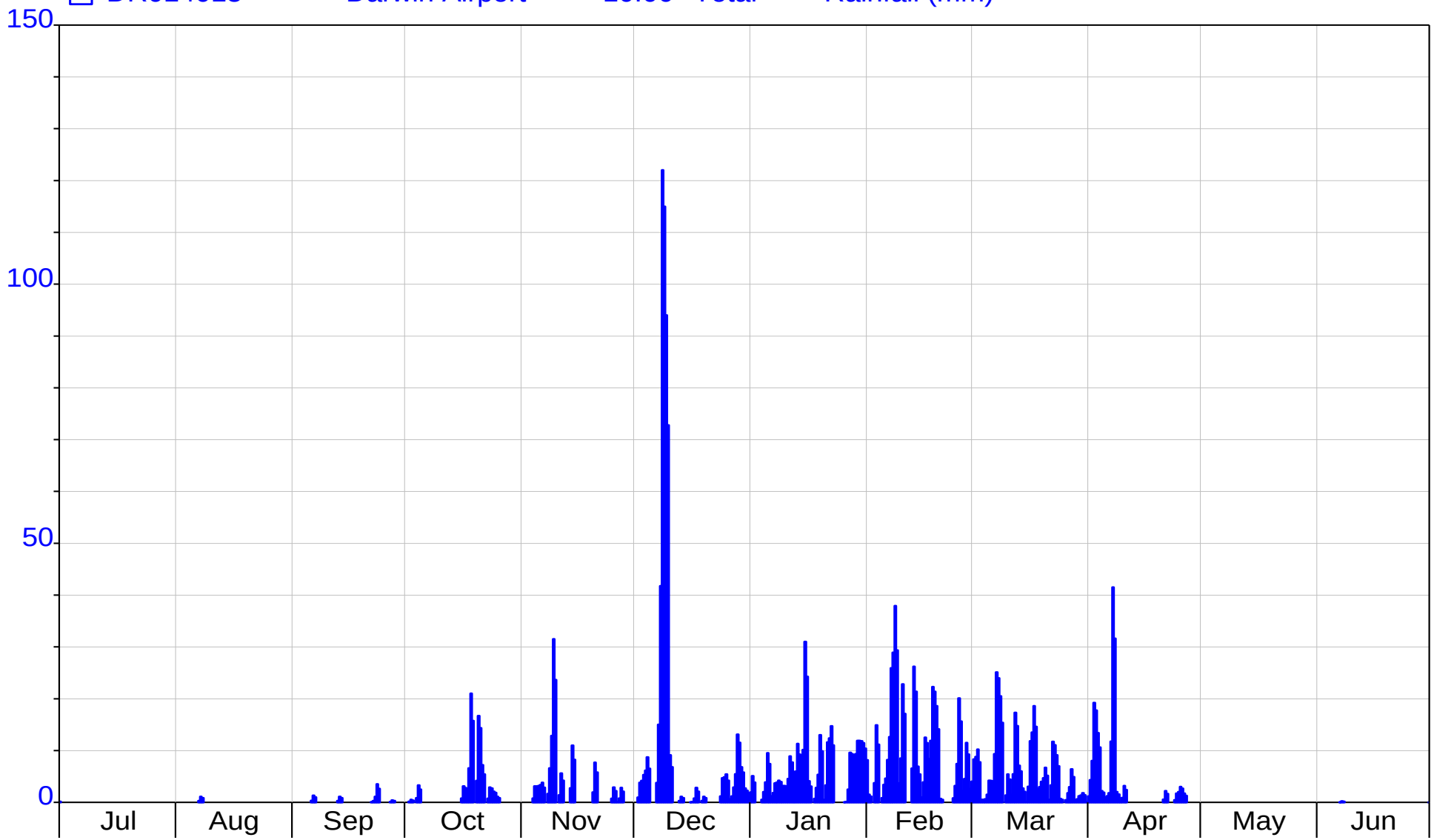
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1998 1998/99

Interval12 Hour Plot End 00:00_01/07/1999

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



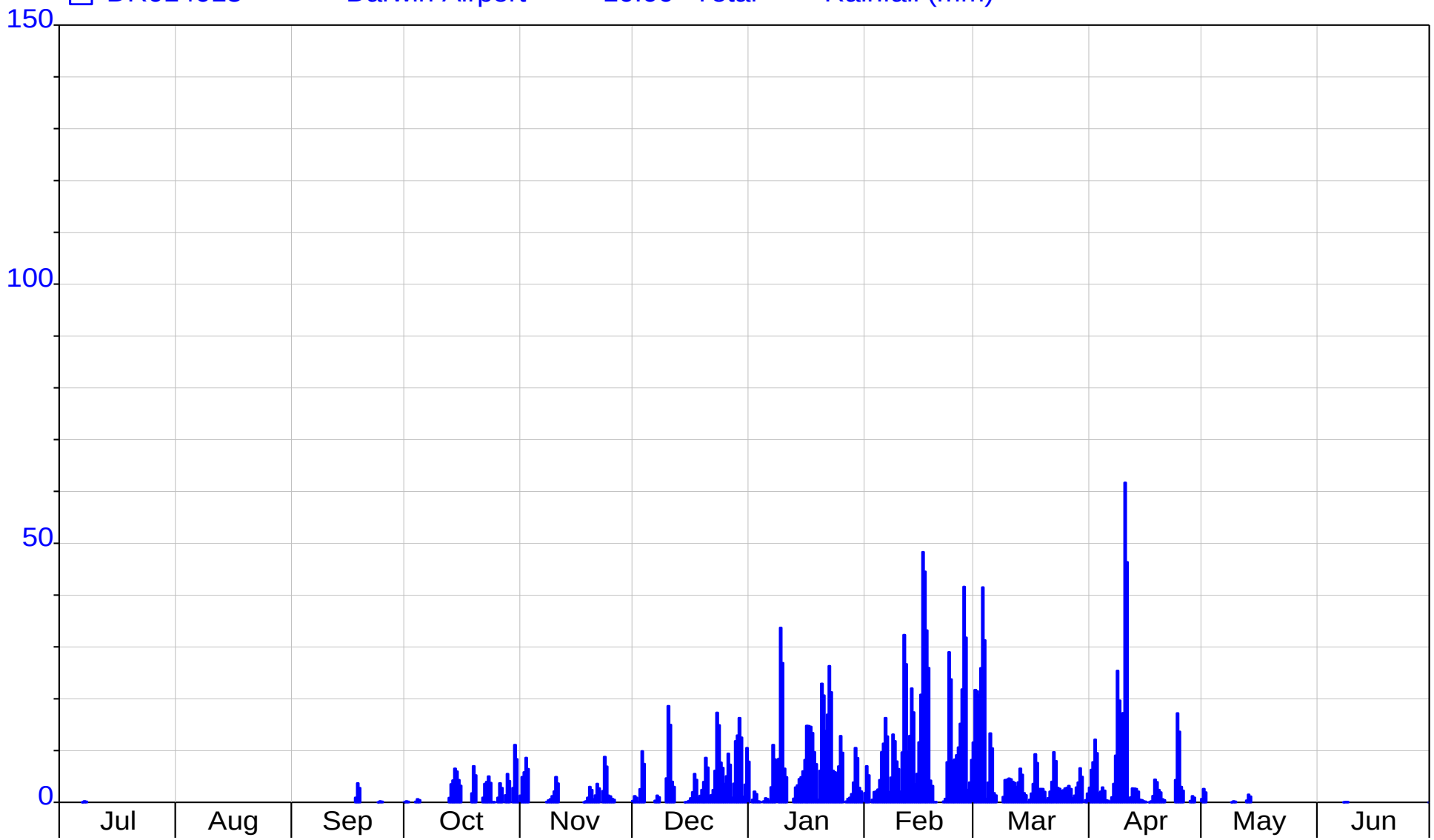
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/1999 1999/00

Interval12 Hour Plot End 00:00_01/07/2000

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



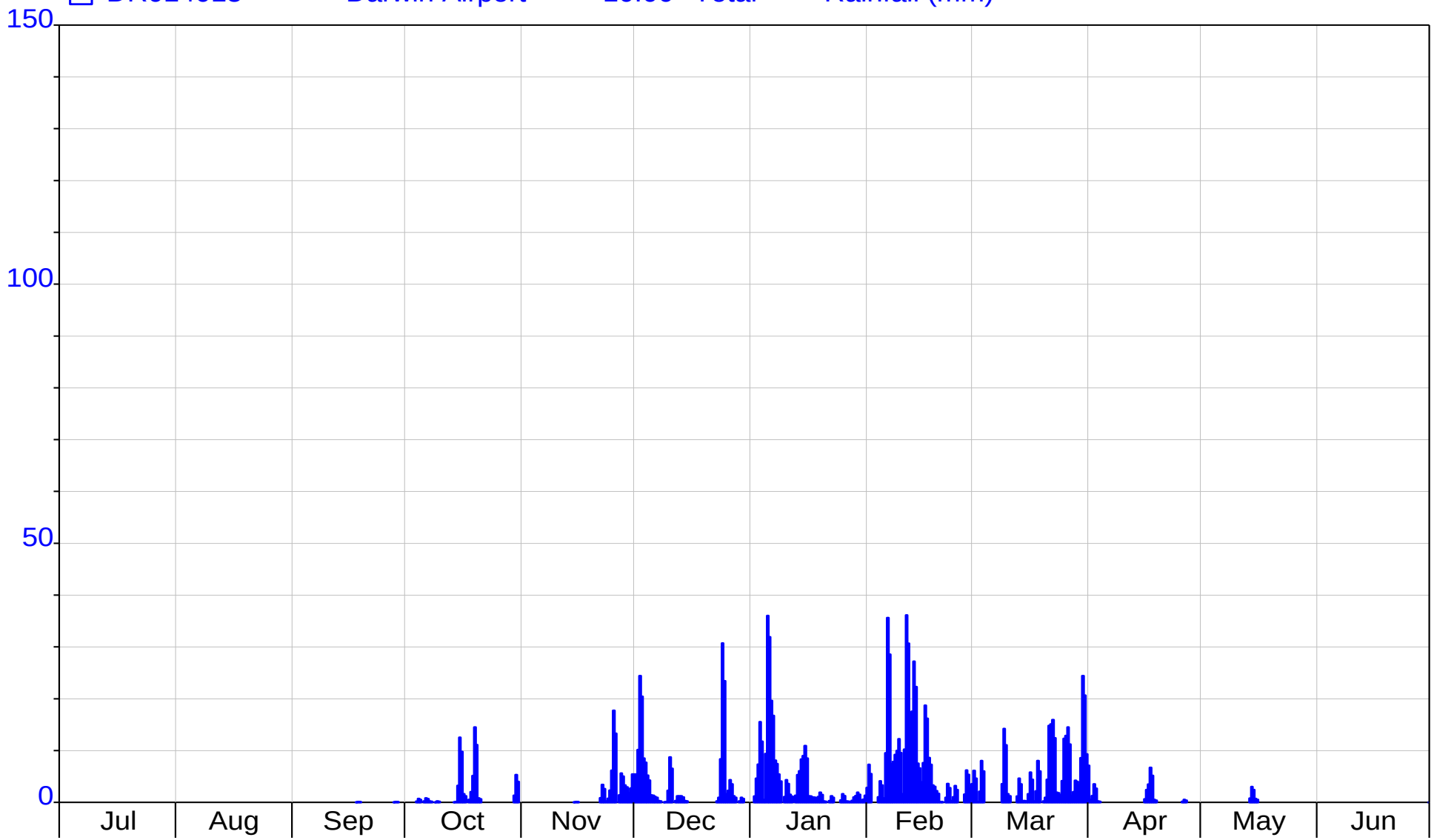
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/2000 2000/01

Interval12 Hour Plot End 00:00_01/07/2001

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



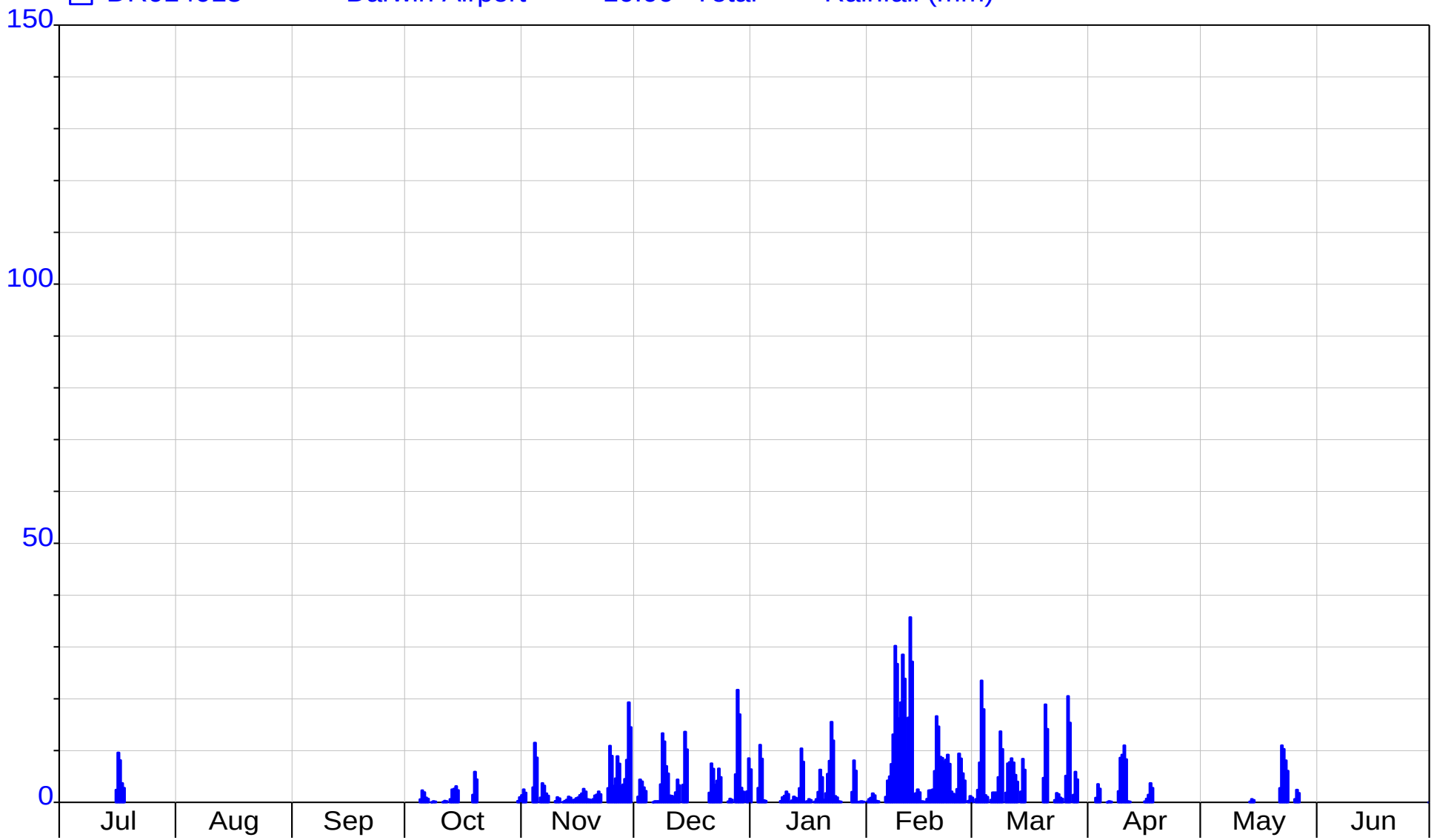
NT Water Resources

HYPLOT V130 Output 05/05/2008

Period 1 Year Plot Start00:00_01/07/2001 2001/02

Interval12 Hour Plot End 00:00_01/07/2002

DR014015 Darwin Airport 10.00 Total Rainfall (mm)



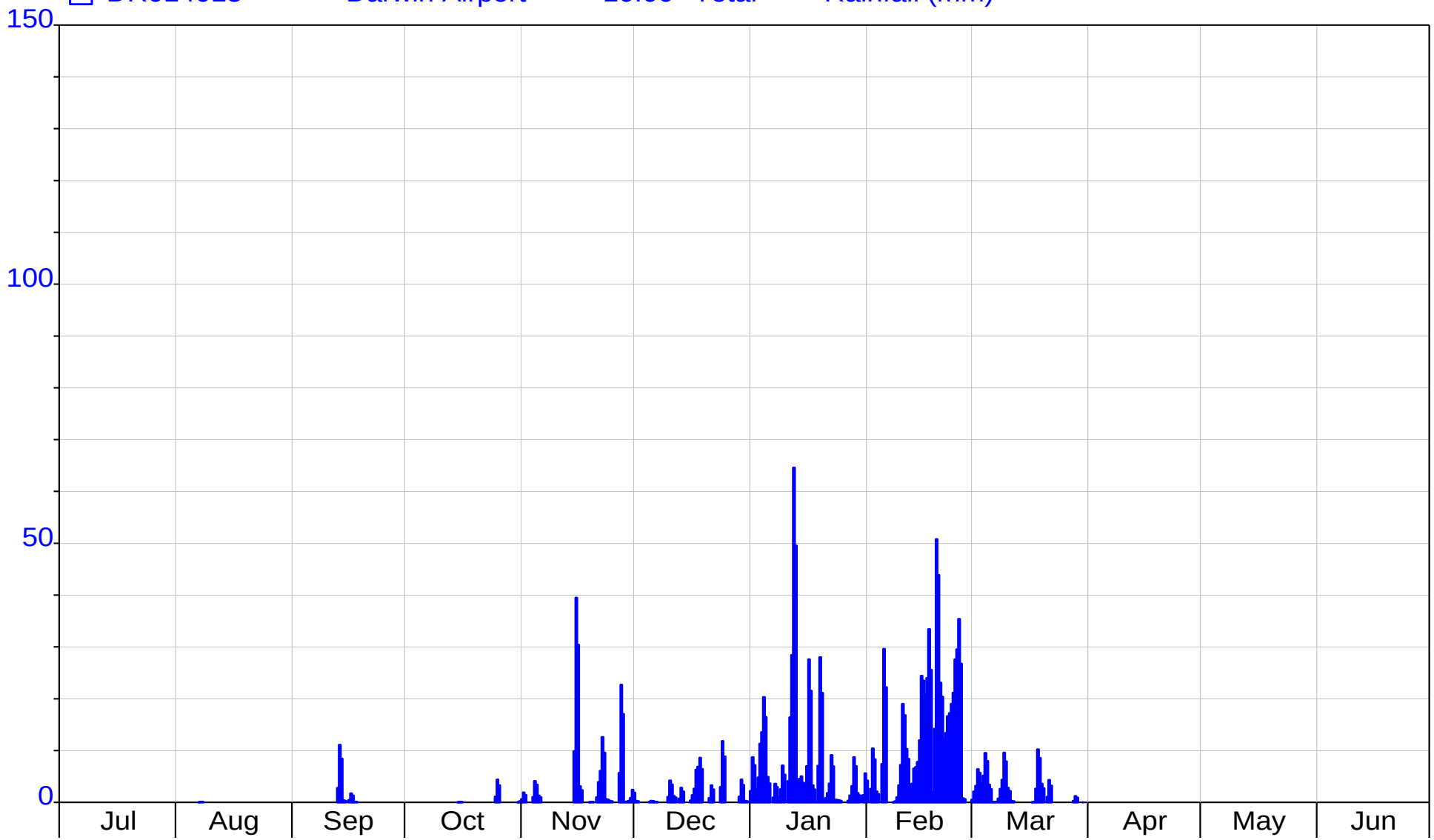
NT Water Resources

HYPLOT V130 Output 05/05/2008

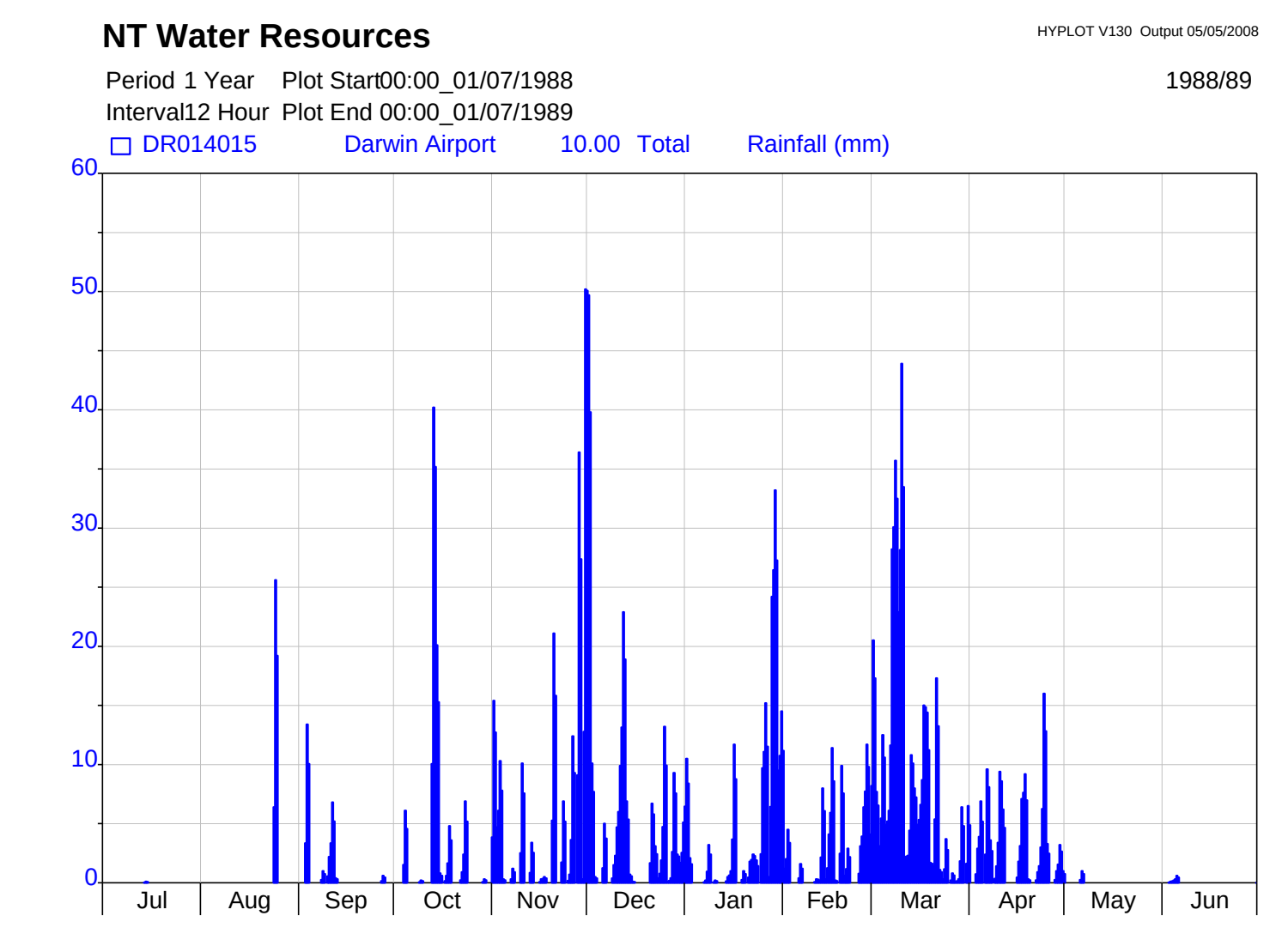
Period 1 Year Plot Start00:00_01/07/2002 2002/03

Interval12 Hour Plot End 00:00_01/07/2003

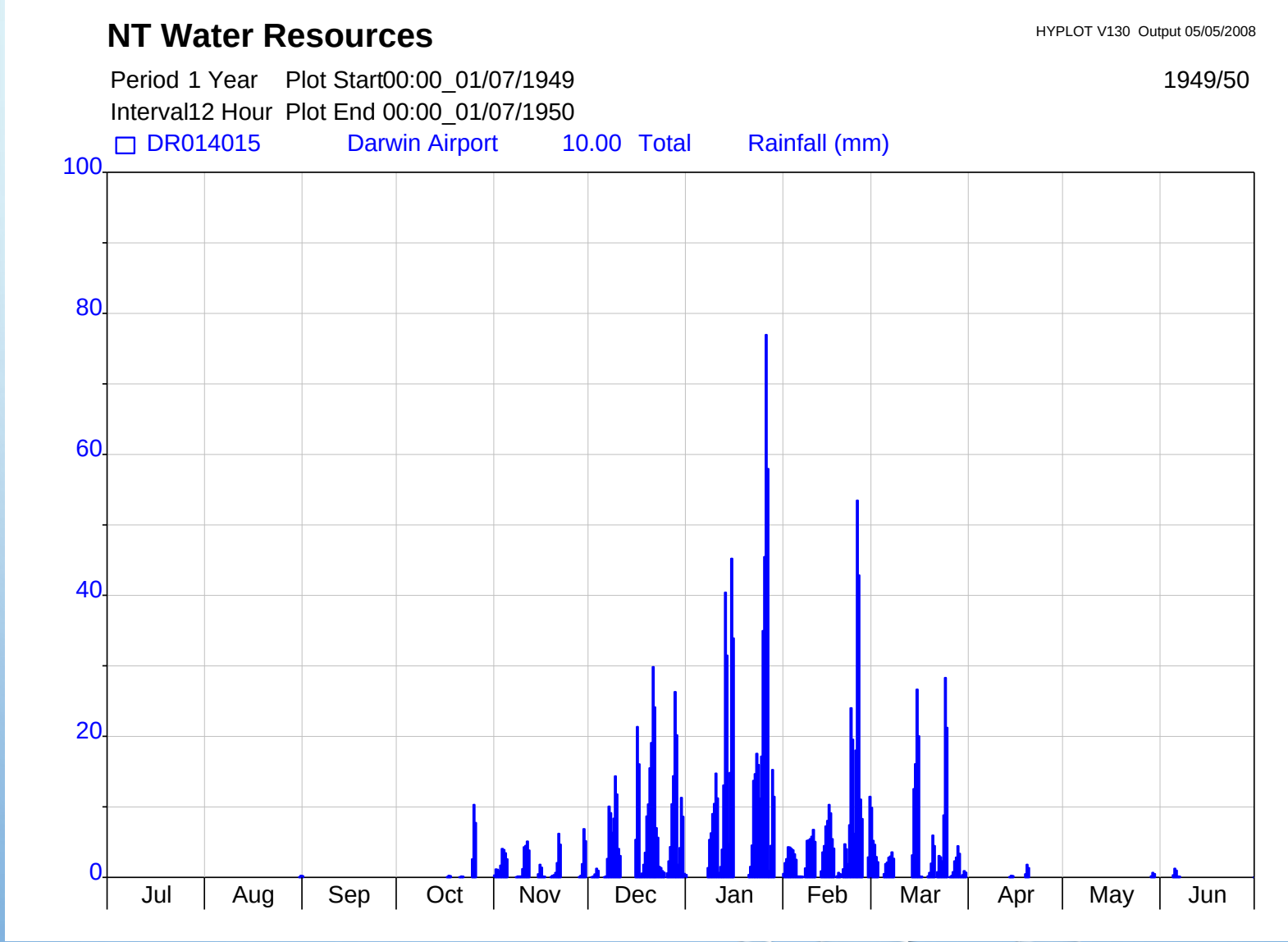
DR014015 Darwin Airport 10.00 Total Rainfall (mm)



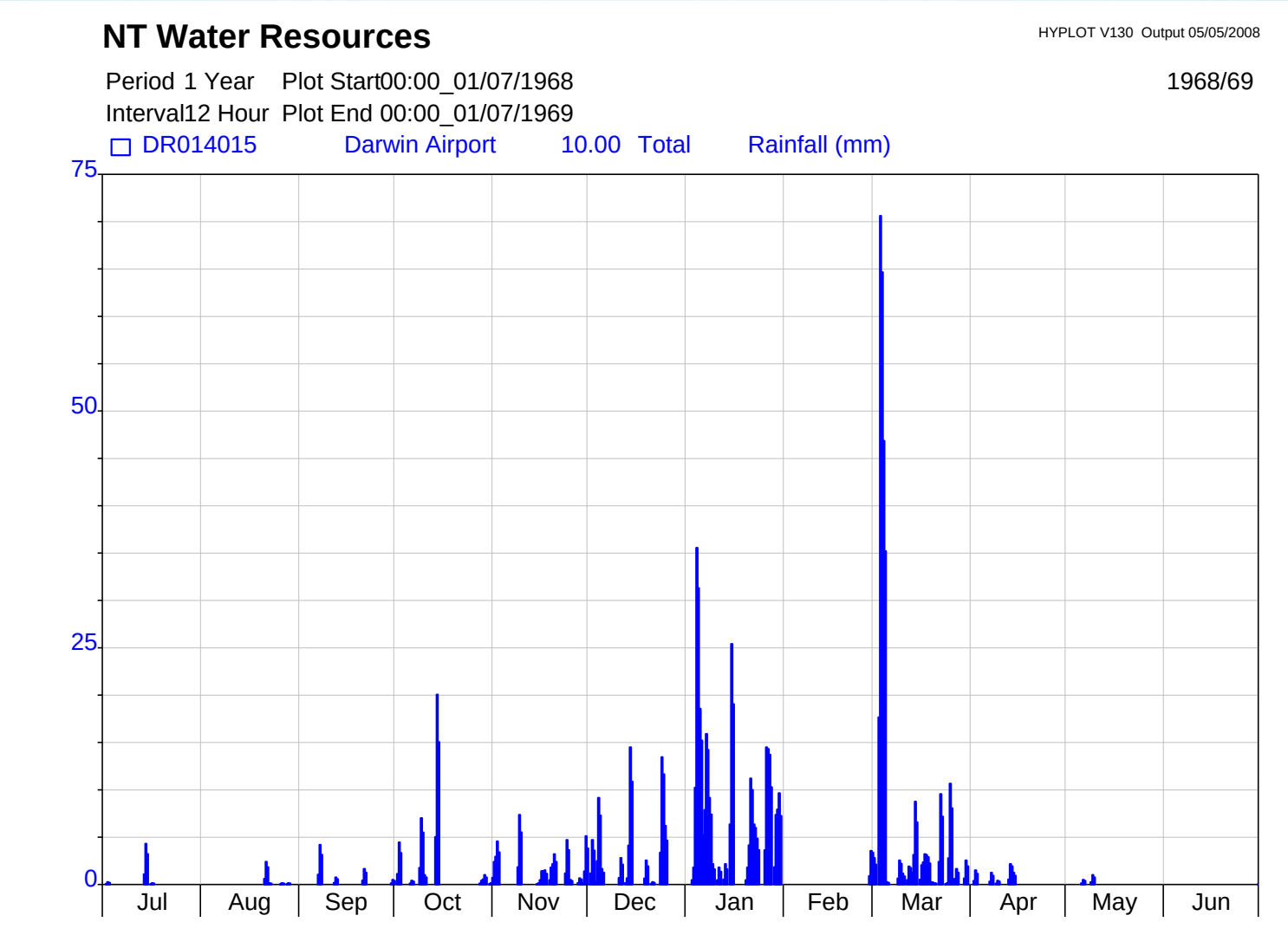
1988/89 A LONG WET



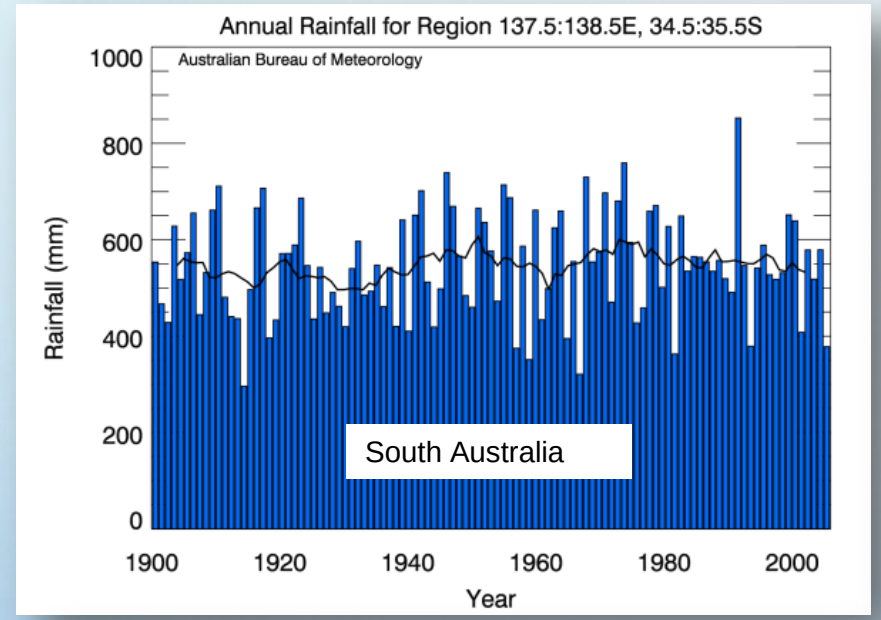
1949/50 A SHORT ONE

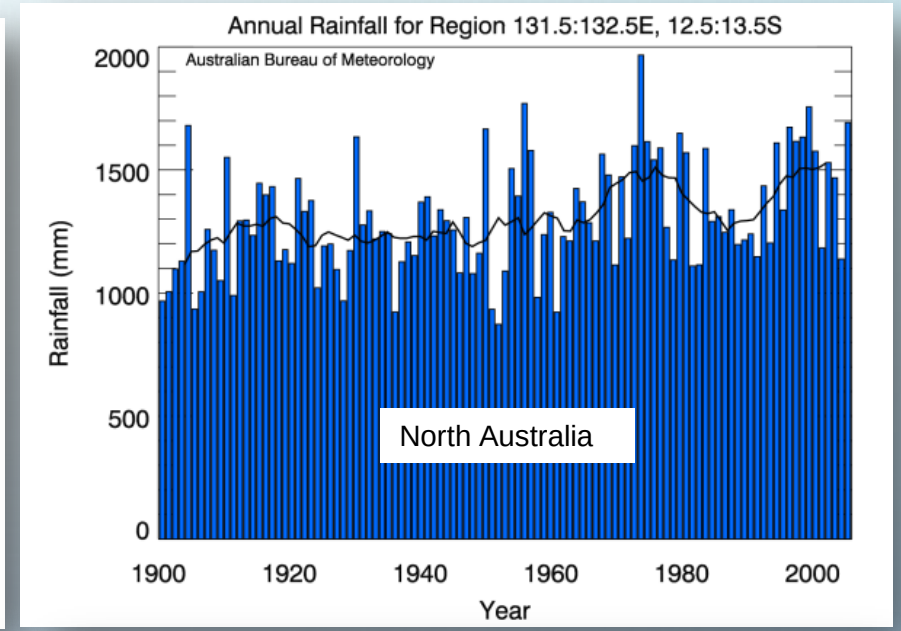


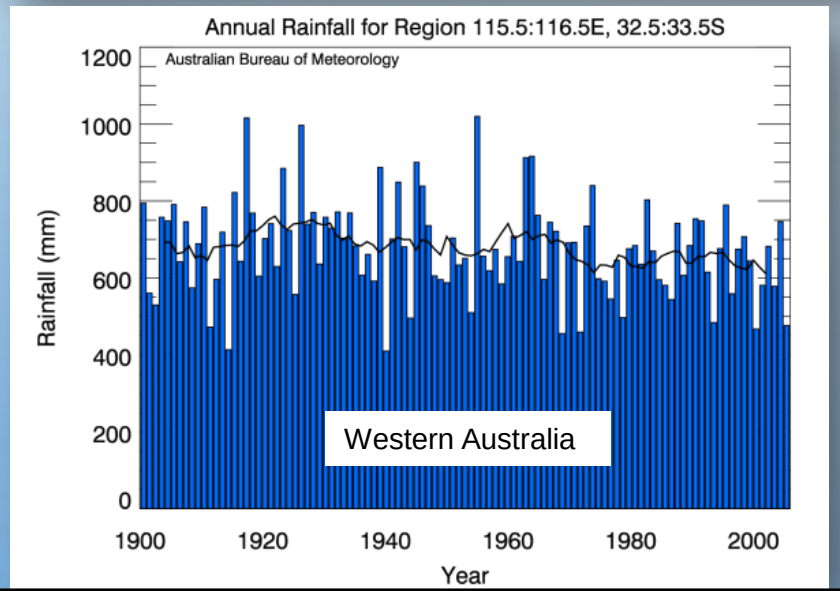
1969 A DRY FEBRUARY

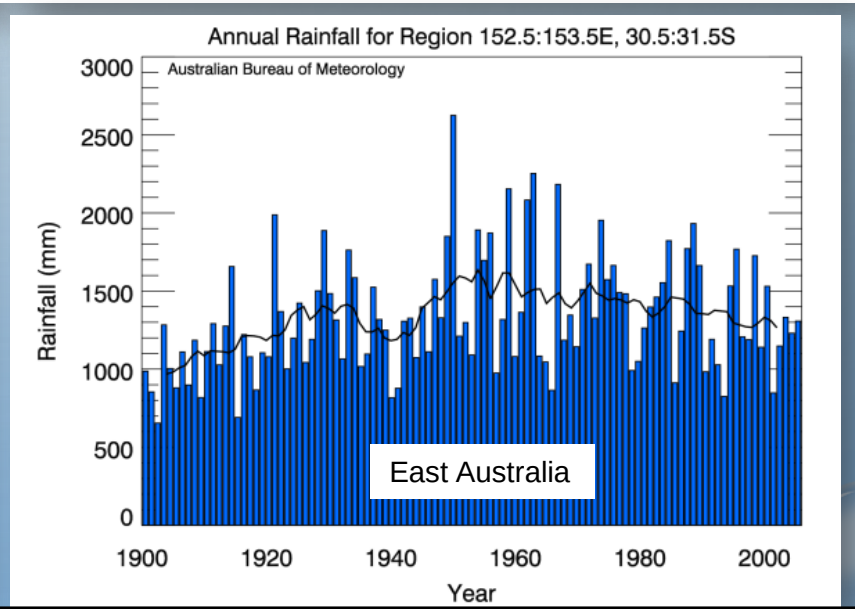


LONG TERM VARIABILITY









DRY TIMES AT WILDMAN

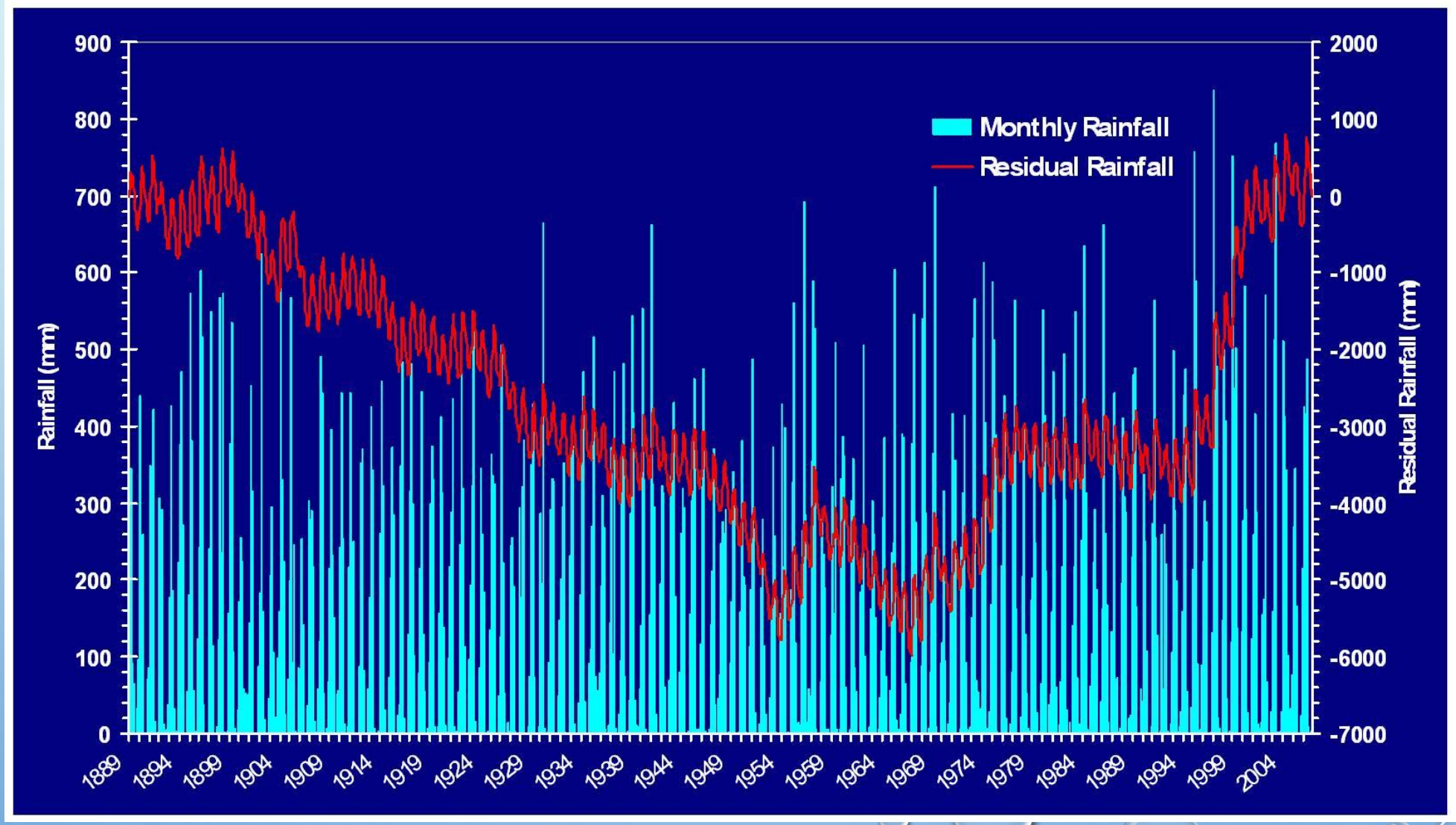
WET TIMES AT WILDMAN

WET DRY IN ARNHEM LAND

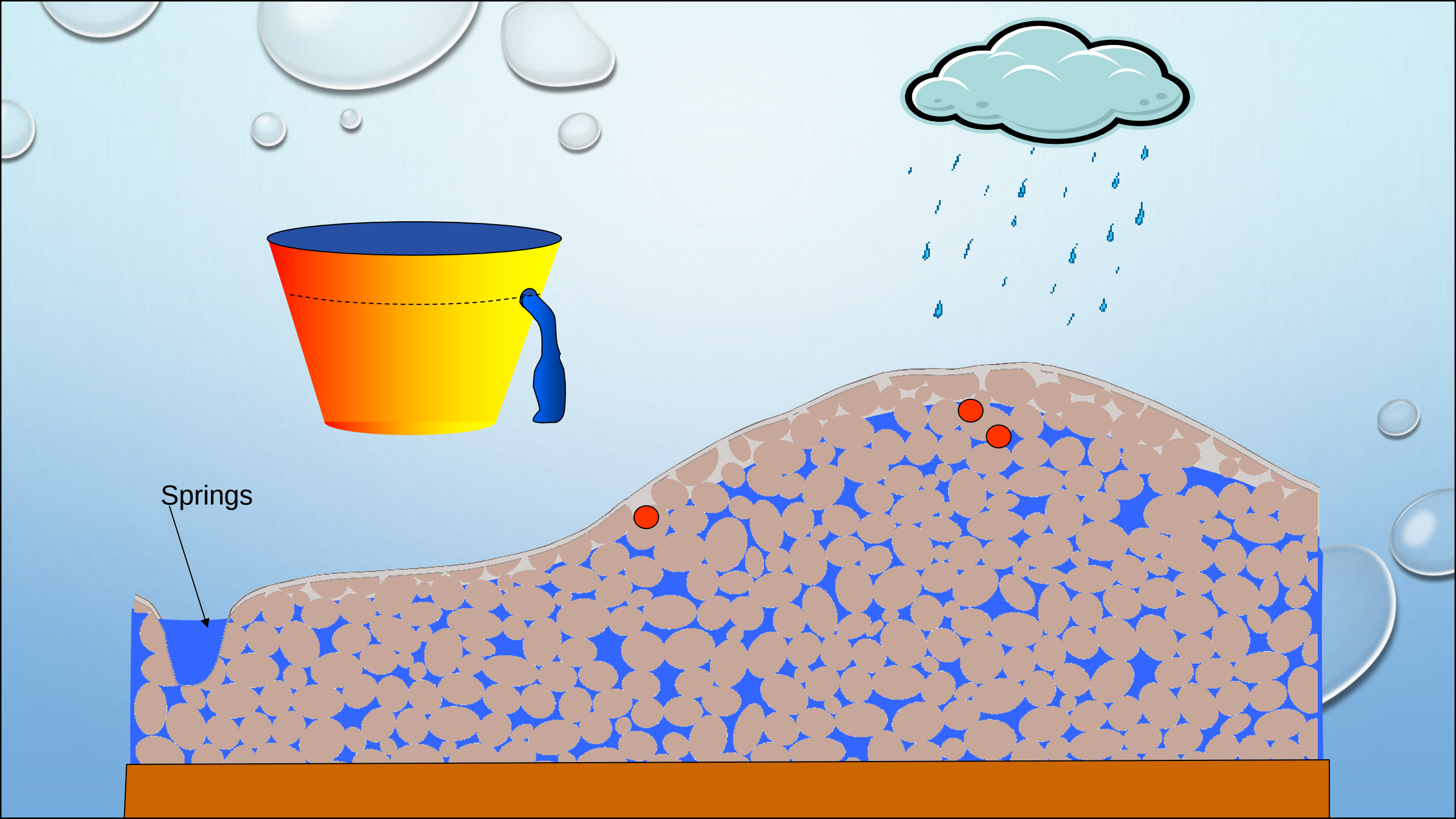
Calvert River – August 1984 500 L/S

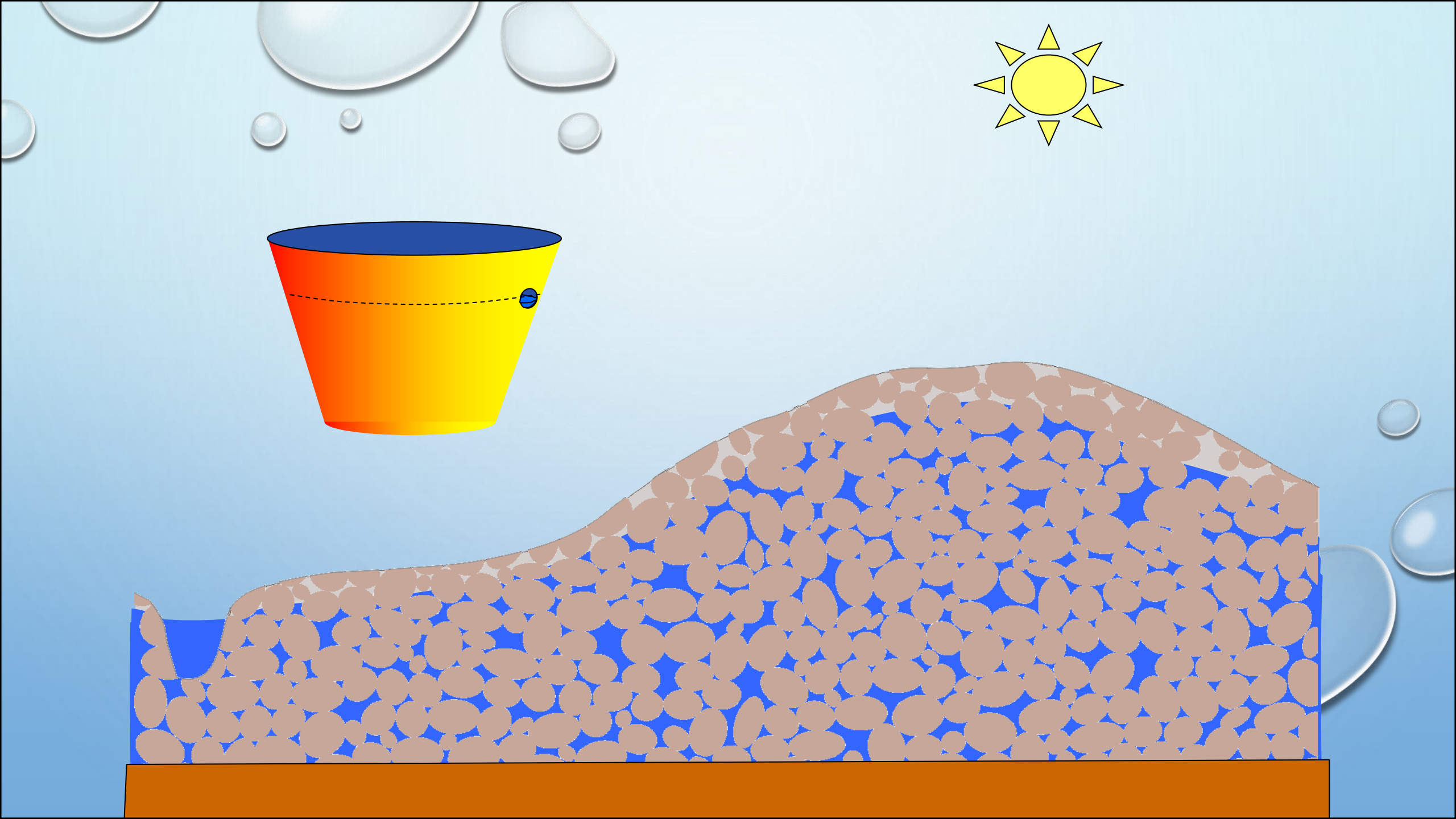
Calvert River – November 2007 3643 L/S

LONG TERM RAINFALL TREND

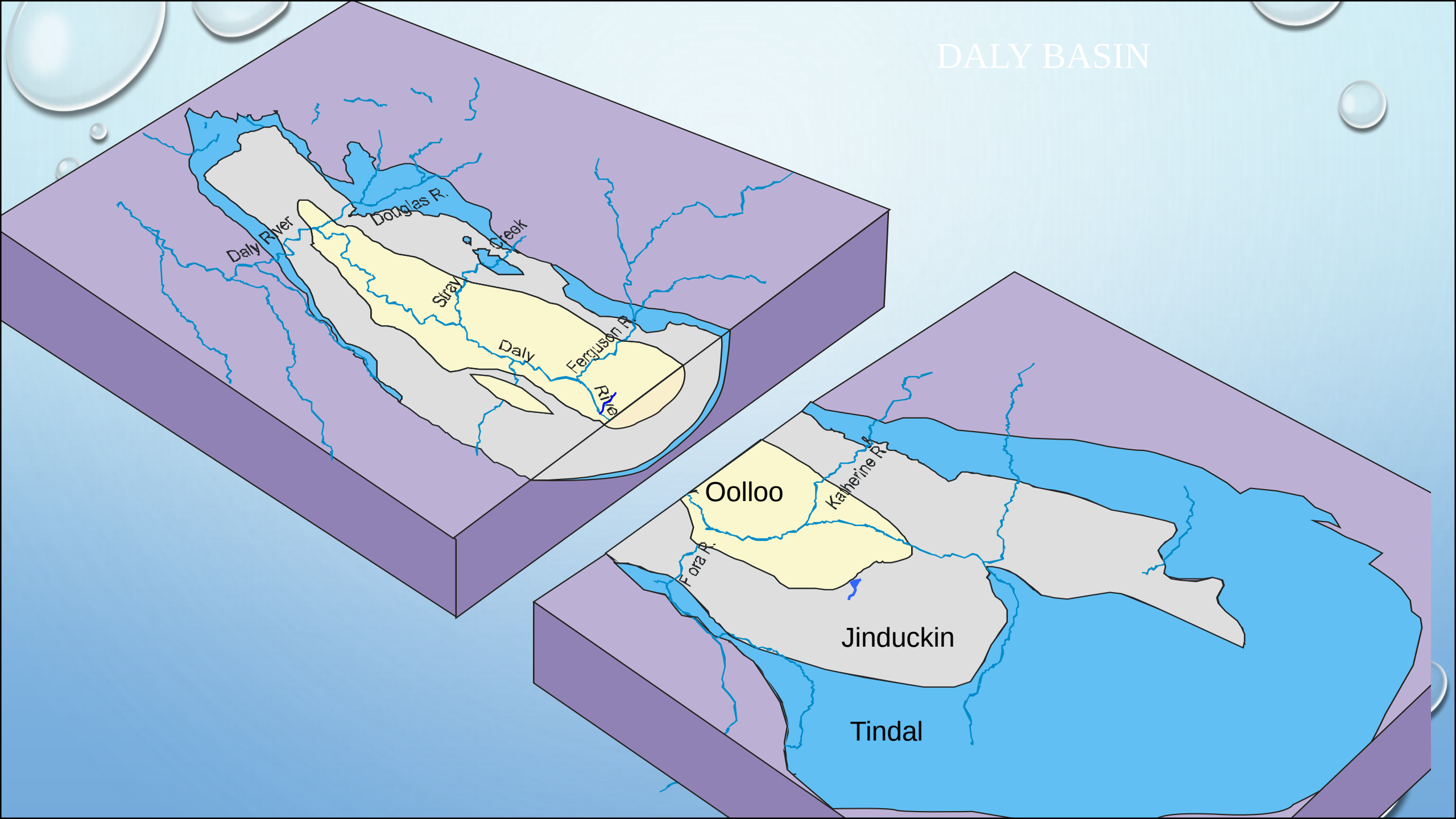


CONSTRAINTS AND OPPORTUNITIES

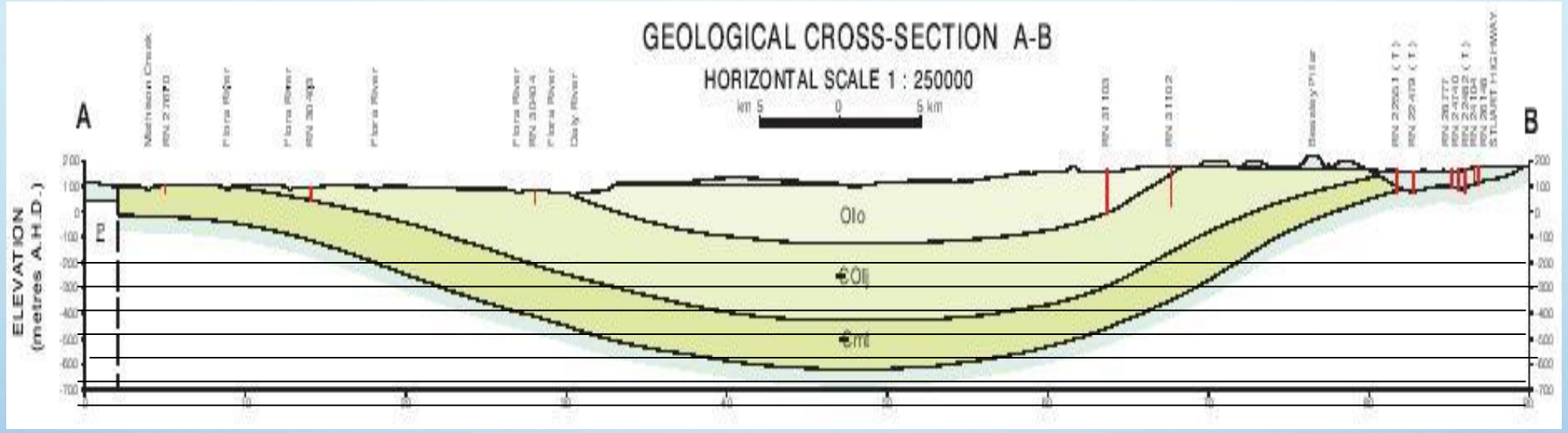

Springs



DALY BASIN


Daly River
Douglas R.
Creek
Stray
Daly
Ferguson R.
Oolloo
Katherine R.
Fora R.
Jinduckin
Tindal

GDE- KATHERINE RIVER



The low Level- Katherine River

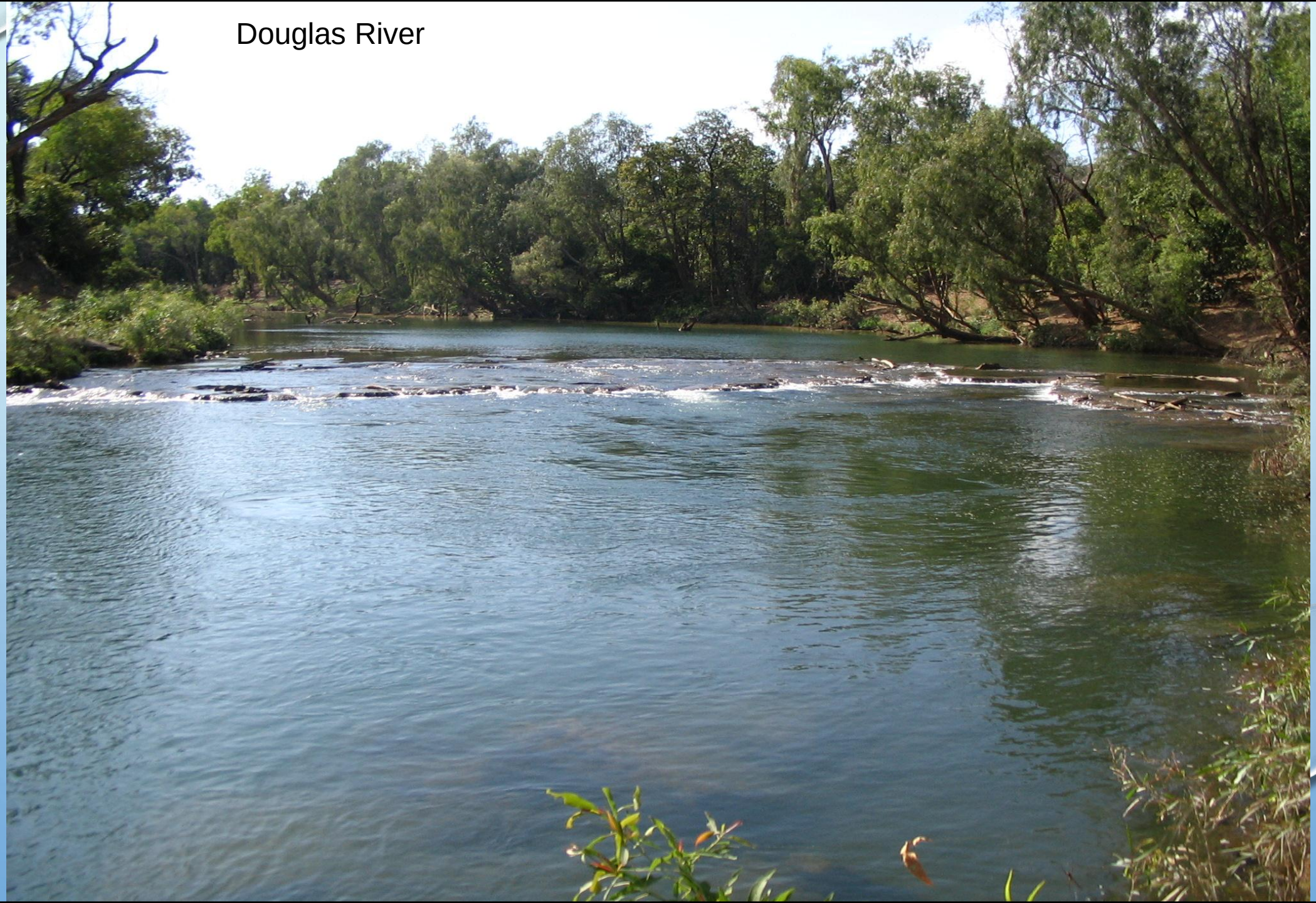
Sinkhole discharge

GDE- Dry Season at Katherine River

KATHERINE HOT SPRINGS

DALY RIVER SPRING

Douglas River



Dorrisvale Xing – Daly River

Daly River – Bank slumping

AGRICULTURAL TIMELINE IN THE NT

YEAR	MILESTONE	COMMENT
2008	MAJOR LAND USE CHANGE IN DALY	MIS FORESTRY
2007	BANANA PRODUCTION STOPS	PRIMARILY DUE TO PANAMA DISEASE
2006	REVIEW SHOWS 156 CROPS TRIALED BY NT	
2002	TABLE GRAPES DECLINE	NEMATODES
2001	MANGO SEA FREIGHT TRIALS	TO HONG KONG
1999	DOUBLING VALUE OF HORT EVERY 5 YEARS STOPS	INDUSTRY GROWTH PLATEAUS
1997	PANAMA DISEASE IN BANANAS	
	MAJOR SLUMP IN LIVE CATTLE	MAJOR GROWERS EFFECTED
1996	CONSERVATION FARMING SYSTEM	NO TILL PLUS LEGUME ROTATION
1995	TIWI ISLAND FORESTRY PROJECT	ACACIA MANGIUM FOR PULP IN PARTNERSHIP WITH TLC STARTS
1993	CITRUS CANKER OUTBREAK	
1992	LARGE SCALE BANANA PRODUCTION	
1991	LIVE CATTLE EXPORTS AFTER BTEC	RESURGENCE
1990	MELONS - THRIPS PALMII	INDUSTRY COLLAPSES
	KENAF RESEARCH CEASES	
1989	TABLE GRAPES START AT TI TREE	

AG TIMELINE CONTINUED

YEAR	MILESTONE	COMMENT
1988	CUT FLOWER INDUSTRY STARTS	
	NURSERY SECTOR EXPANDS	
	BRUCELLOSIS FREEDOM	
LATE 80S	KENAF RESEARCH STARTS	
1984	KATHERINE MEATWORKS CLOSE	UNION DISPUTE
1980S	MOST CATTLE SOLD FOR US HAMBURGER MARKET	
1980	MANBALLOO MANGOES START	SINGLE LARGE PLANTING
1975	BUFFALO EXPORTS RECOMMENCE	BRUNEI
MID 70S	CATTLE PRICES FALL, LIVE CATTLE TRADE RESTARTS	
1970	BTEC START	CULLING OF TB INFECTED STOCK
1968	RICE OPERATIONS CEASE AT TORTILLA	
1967	TIPPERARY BOUGHT BY TEXANS	THOUSANDS OF HA OF SORGHAM
1960S	ORD RIVER SCHEME DEVELOPED	
1964	LARGE SCALE SOWING OF IMPROVED PASTURES	
1955	TERRITORY RICE LTD	LASTED 15 YEARS @ COASTAL PLAINS AND TORTILLA
1940/50	LEGUME HAY FARMING DEVELOPED	

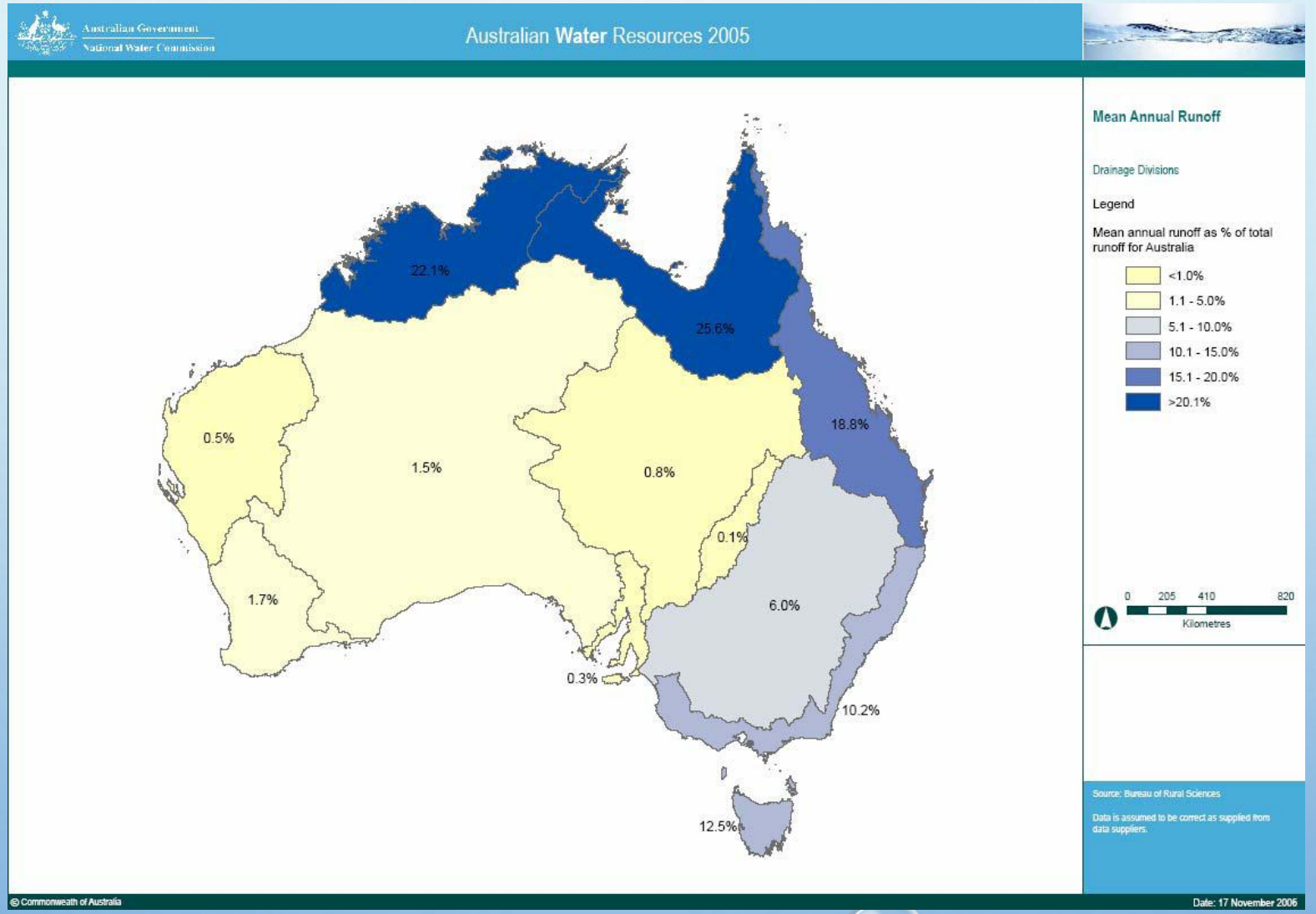
RICE FARMING AT HUMPTY DOO

HARVESTING AT HUMPTY DOO

RICE CULTIVATION IN THE NORTH

OPPORTUNITIES – WET SEASON HARVESTING

SURFACE WATER DRAINAGE



OFF-STREAM STORAGE

OPPORTUNITIES – WET SEASON CROPPING

Opportunities – Forestry

OPPORTUNITIES - RESOURCE UTILISATION

STARK REALITIES OF A MODERN WORLD

A REMINDER

Photo by Arthur Mostead. Sourced from the Murray Darling Basin Commission.

Photo by Arthur Mostead. Sourced from the Murray Darling Basin Commission.