Comparison Between Air Temperature and Rail Temperature

Weather is always a popular topic of conversation when you live in one of the temperate zones of the world. Climate Change, like it or not, is affecting our current weather. It's intensifying weather events such as making droughts last longer, making rainfall events more intense, increasing heatwave temperatures and decreasing cold snap temperatures. Climate Change can have a profound effect on our lives and our public infrastructure. In this paper, we will briefly look at the correlation between ambient temperature and rail temperature.

In a previous paper (https://trentrace.com/Research/SunshineOnTheRailways.pdf), ambient, or air, temperature was used from the Irish Weather Service approximately 70km from the installation measuring rail track temperature. The data was taken from a period of particularly warm weather for Ireland in June 2018. There was no precipitation and very little cloud cover for the period in question. A summary of the main points from that study:

- The minimum air and rail temperatures correlate pretty well during darkness hours when it is dry
- The correlation between air and rail temperatures varies during periods of precipitation (it can be inferred that there are clouds present when precipitation occurs, thus affecting direct sunlight on the rail)
- During periods of sunshine, there is a divergence between air and rail temperatures
- There is a small lag in ramp up and ramp down rail temperatures compared with air temperatures (probably due to thermal mass of the ballast/ rail etc.)

Methodology

In this paper, the data was gathered from the warmest period from 2021 in Kildare, Ireland. A dry spell was examined from 9th July 2021 to 31st July 2021. During this period, the air temperature ranged from 9.7°C to 33.8°C; the rail temperature ranged from 9.0°C to 50.0°C. The track orientation was east/ west.

The data was collected using the TrenTrace system consisting of:

- Solar powered Base Unit sending data via Mobile Network
- Weather Station sited approximately 10m from the rail
- Wireless Temperature Sensor clipped on underneath the rail measuring the temperature of the foot of the rail.

The first chart below shows the data collected for rail temperature, air temperature and rainfall amount for the period in question. It can be seen that the dry weather spell last between 11-Jul-2021 and 26-Jul-2021.

Observations from the data:

- There is a more observable pattern in the relationship between the air and rail temperatures when it is dry. This is to be expected
- Under approx. 25°C, the rail and air temperatures match quite closely when warming in the mornings
- Under approx. 25°C, the rail and air temperature match quite closely when cooling but not quite as closely as rising temperatures in the morning
- There seems to be a slightly rising minimum and maximum rail temperature trend the longer the hot dry spell lasts despite relatively steady maximum air temperatures. It is not as pronounced as observed in the 2018 study. The rising trend may be explained by the thermal mass of the ballast. This would require more data to be analysed before a definitive statement could be made.

Correlation & Discussion

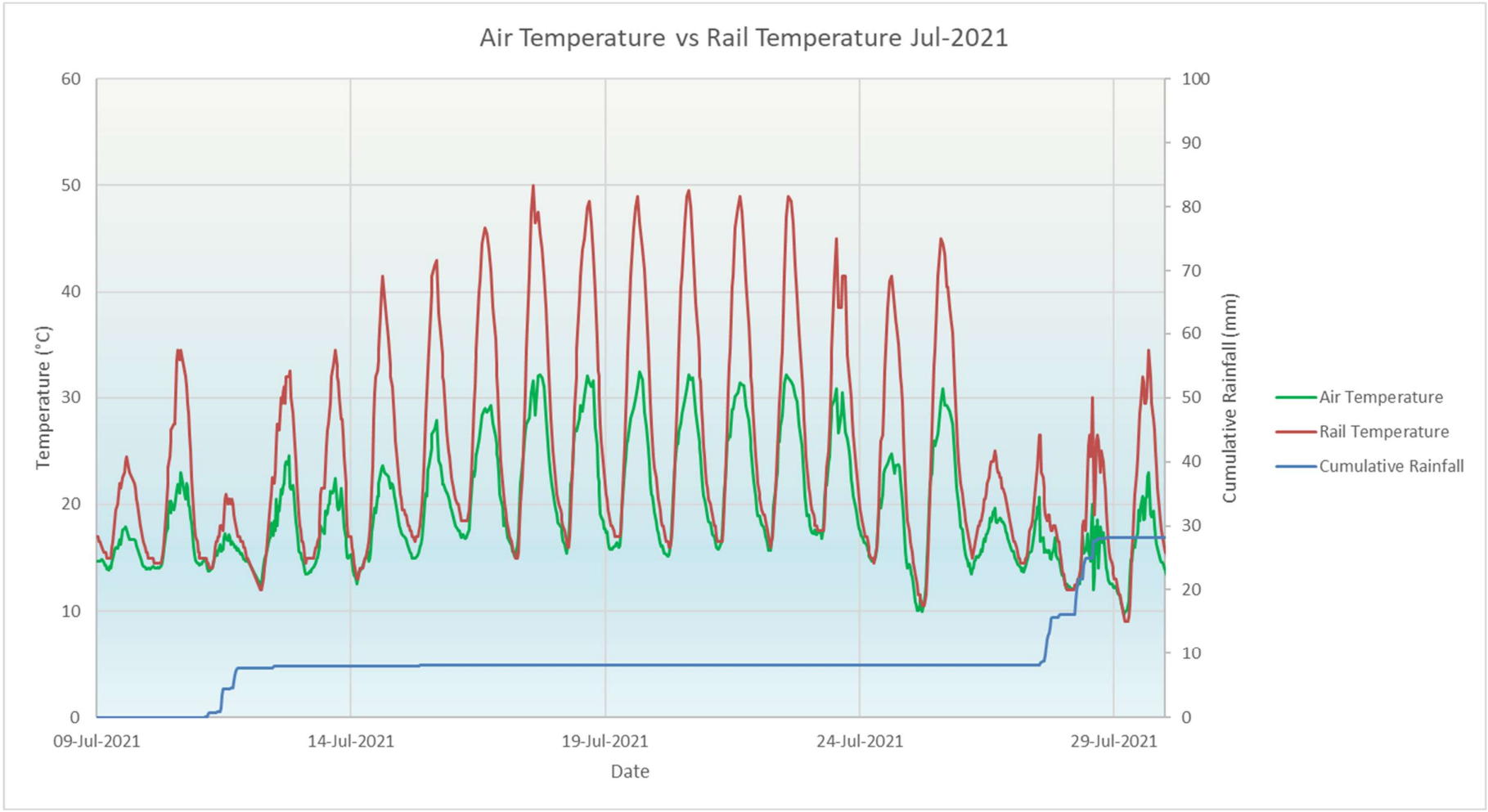
The second chart shows a relationship between the rail temperature and the difference between it and air temperature.

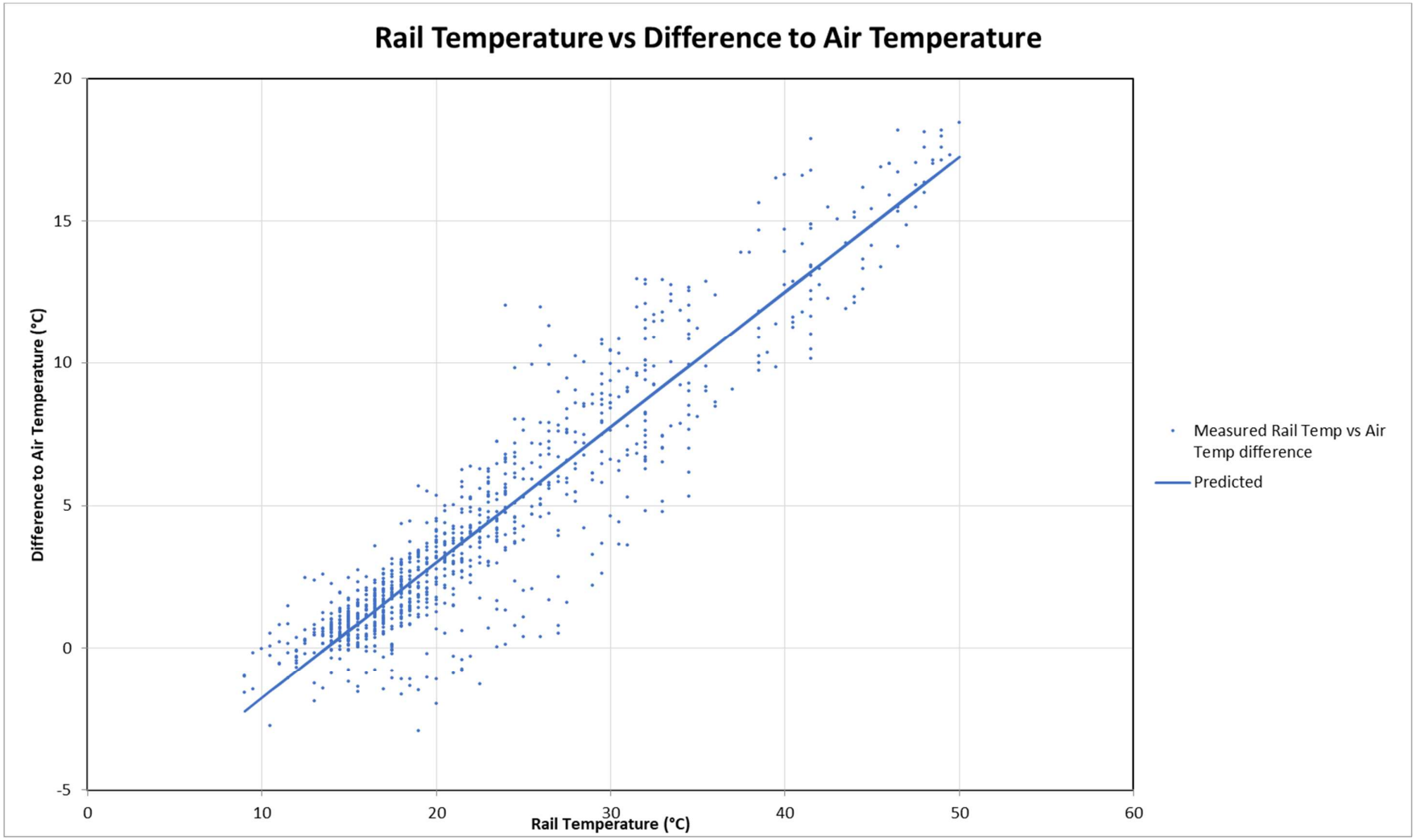
$$t_{rail} - t_{air} = t_{difference}$$

A regression analysis shows an R^2 value of 0.87 and a Standard Error of 1.6°C. This is certainly not an ideal fit but it may be accurate enough to give an indication of possible high rail temperatures given a meteorological/ other air temperature but may not be good enough to predict the actual rail temperature with any degree of accuracy. The main reasons for measuring track temperature are to build a history of min/ max/ mean temperatures for rail stressing, imposition of speed restrictions in cases of high temperatures. These tasks require accurate data to assist in making good engineering decisions. The data used for this short study came from one installation over a short period of good weather. Even given those ideal conditions, the correlation and standard error are relatively high. Some factors that may exacerbate the variation are as follows:

- The time of year: the day length affects the number of hours of sunshine. It will also affect the minimum night time temperature
- The length of the warm weather event: this can affect the temperature of the ballast which acts as a thermal mass, attenuating the night time low temperature
- The orientation of the track: east/ west or north/ south will probably react differently due to different surface areas exposed to the solar radiation
- Cloud Cover: the track temperature can change very quickly in relation to the air temperature when the sun is either exposed to or sheltered from the sun due to clouds

Some further work will be carried out to investigate how/ if the regression coefficient & standard error are affected by some of the above factors in future studies.




Rail Temperature vs Difference to Air Temperature
Difference to Air Temperature (°C)
Rail Temperature (°C)
20
15
10
5
0
-5
0
10
20
30
40
50
60
Measured Rail Temp vs Air Temp difference
Predicted