

Problem 4

Designing an optimal weather radar network for Ireland

Weather radar are a valuable source of information for national meteorological services. They play a crucial role in the monitoring and forecasting of rainfall and weather systems.

The weather radar work by transmitting pulses of microwave energy. The waves are scattered and reflected by precipitation such as rain, snow or hail. By measuring the returning echoes, the radar can “see” this precipitation. The radar transmitters rotate through 360 degrees on the horizontal plane, repeated over a number of elevation angles, to build up a three-dimensional picture.

Currently Met Éireann operates two radar, located at Dublin and Shannon airports.

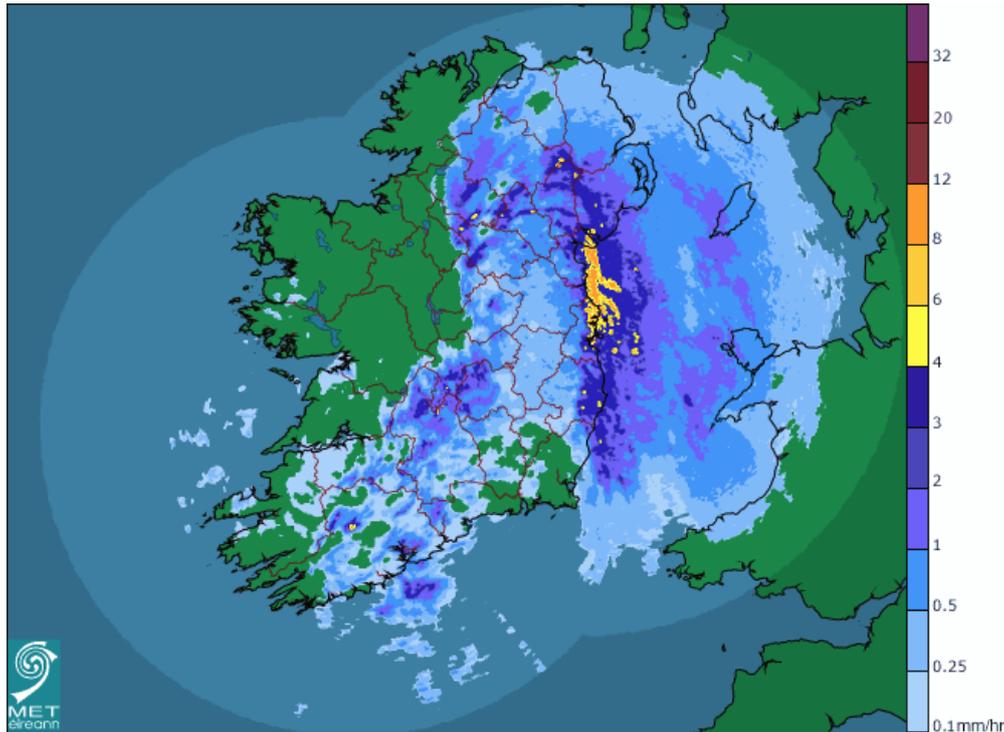


Fig.1: Radar coverage from Dublin and Shannon airports
(<http://www.met.ie/news/display.asp?ID=411>)

While this network appears at first sight to provide adequate coverage for Ireland, there are some shortcomings. The radar often report echoes from nearby mountain ranges (such as the Wicklow or Mourne mountains), mistaking the terrain for precipitation. Blocking by mountains can also create a radar shadow on the far side, a region in which nothing is detected. In addition, distance from the radar is an issue. Measurements are accurate up to ~100km, with a rapid decline in performance beyond this, and the distance between Shannon and Dublin is more than 200km.

Ideally, therefore, we would have a network consisting of many more radar covering the whole country sufficiently, to overcome these issues and allow for loss of coverage due to breakdowns etc.

However, given the high costs involved in building and maintaining such a network, the problem is to model an optimal network for Ireland such that

1. a minimal number of radar towers are needed, and
2. their locations are chosen to maximise radar coverage

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Some further information

- A brief introduction to radar meteorology may be found here: <http://www.met.ie/news/display.asp?ID=411>
- As mentioned above, the radar performance declines with distance from the tower, with a maximum range of 240 km. The decline is not linear, but can be better modelled with a cubic function.
[See, for example, Section 5.2 of the following Technical Note, which also provides a useful background and introduction to radar: <http://edepositireland.ie/handle/2262/70547>]
- As well as distance and the position of mountain ranges, a further consideration might be to ensure reliable coverage in areas where we can expect the most rainfall; see Fig. 2 below from <http://www.met.ie/climate-ireland/rainfall.asp>

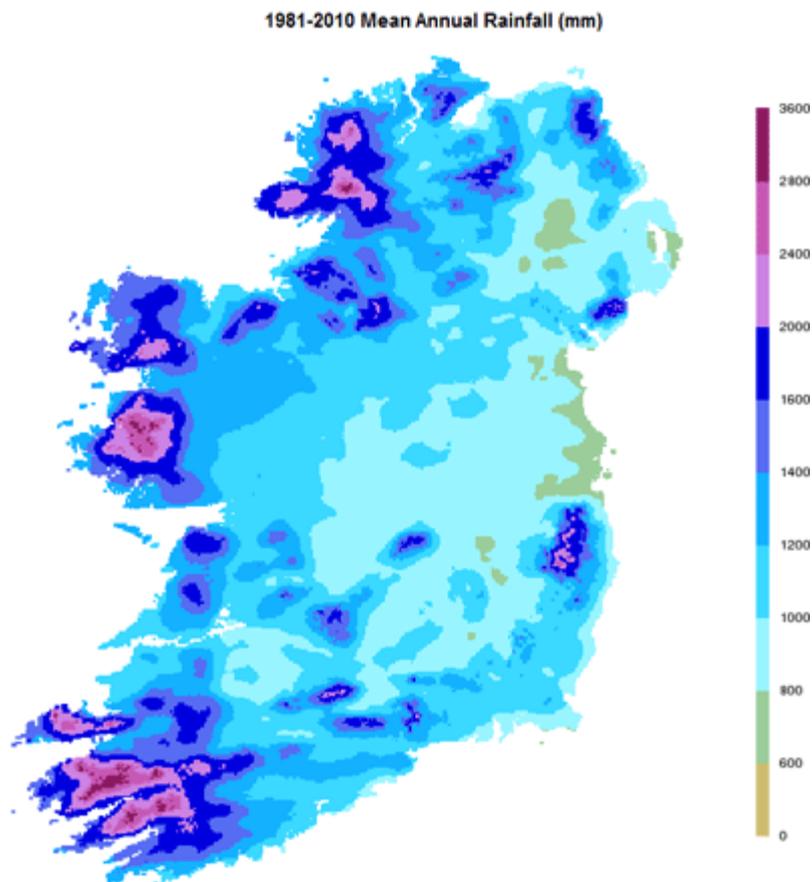


Fig. 2: Rainfall climatology of Ireland.

- An example of the denser UK network may be seen here: http://www.metoffice.gov.uk/binaries/content/gallery/mohippo/images/research/weather/observations/radar-systems/radar_graphic5th.jpg