When the Time is Right:

The impact of weather variations on the contrast in earth resistance data

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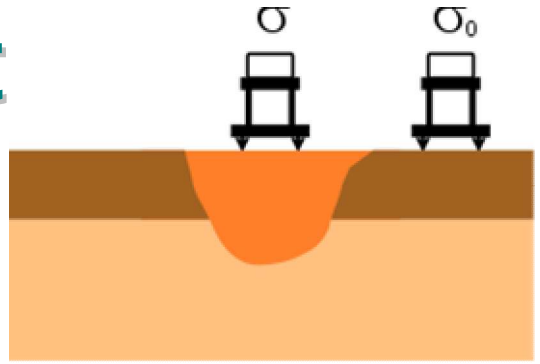
Overview

- Earth Resistance and Soil Moisture
- Conductivity Contrast
- Correlation with Rain
- Prediction of Contrast
- Conclusions

Earth Resistance and Soil Moisture

- Best time for earth resistance survey?
- Measurements = soil electrical conductivity
- Electrical conductivity ↔ soil moisture:
  well researched, known for various soils
- Soil moisture ↔ weather, environmental variables:
  difficult – too many parameters

Conductivity Contrast



- Usual definition of contrast:

$$c = \frac{\sigma - \sigma_o}{\sigma_o}$$

  - higher conductivity ($\sigma > \sigma_0$): *c* between 0 and $+\infty$
  - lower conductivity ($\sigma < \sigma_0$): *c* between -1 and 0

- Symmetric contrast:

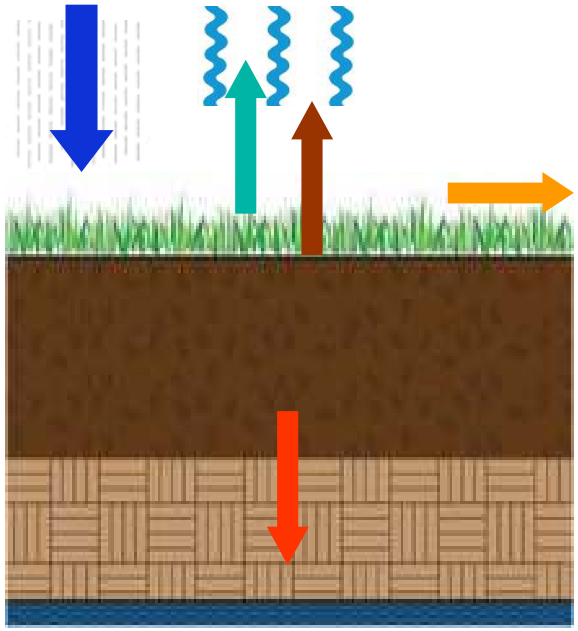
$$c = \frac{\sigma - \sigma_o}{\sigma + \sigma_o}$$

  - higher conductivity ($\sigma > \sigma_0$): *c* between 0 and +1
  - lower conductivity ($\sigma < \sigma_0$): *c* between -1 and 0

- Resistivity contrast is the negative of this symmetric conductivity contrast

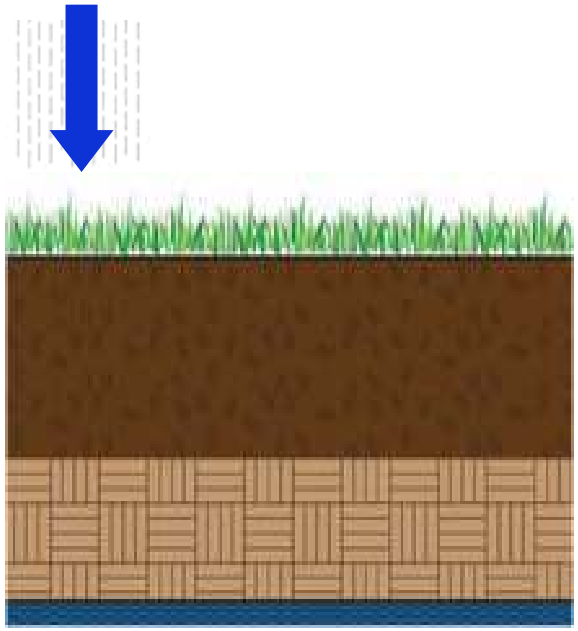
Correlation with Rain

- Net amount of moisture in soil:
  - precipitation that enters the soil
  - evapotranspiration
    - →through crops
    - →through bare soil
  - downward drainage (percolation)



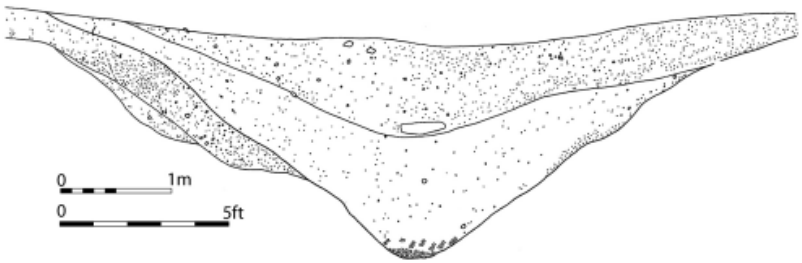
Correlation with Rain

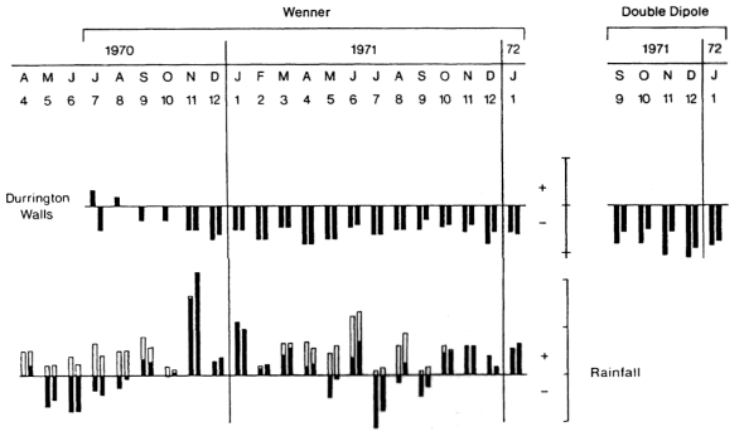
- Simplified model:
  - only based on ***change***
  - evapotranspiration and downward drainage assumed to have approximately constant rate
  - this leaves: ***change in rainfall***

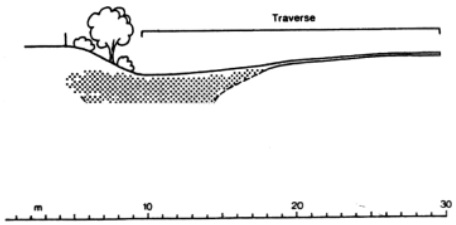


Prediction of Contrast

- Experience: best earth resistance contrast after dry period that follows considerable rain
  - larger pores in ditch retain more total moisture
  - bottom fill traps moisture



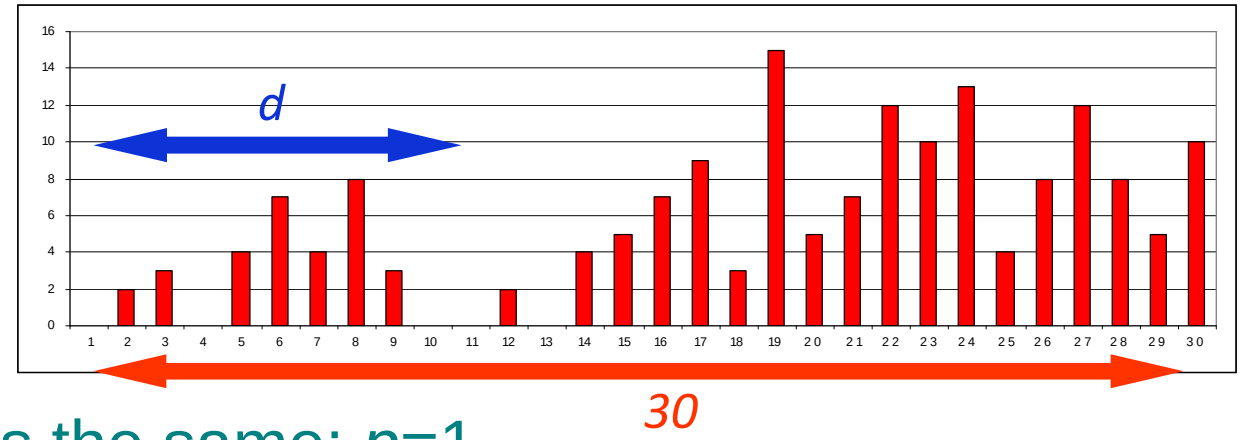




Prediction of Contrast

- Numerical: ‘precipitation ratio’

$$p(d) = \frac{\text{average daily rainfall last } d \text{ days}}{\text{average daily rainfall last } 30 \text{ days}}$$

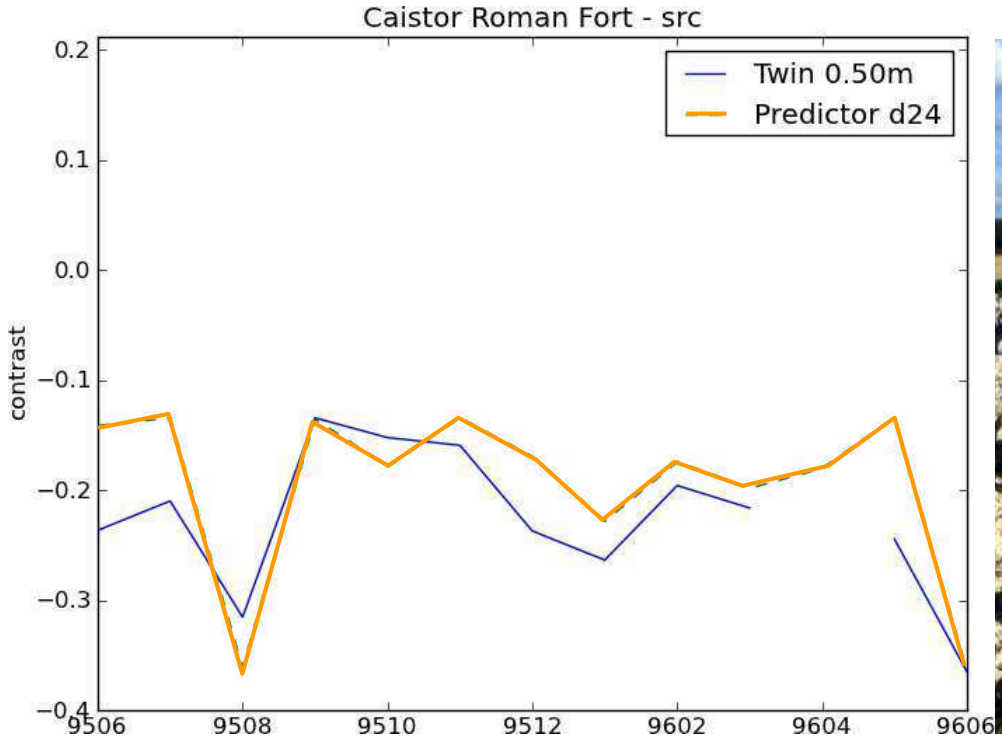


- always the same: $p=1$
- was dry, now wet: $p>1$
- was wet, now dry: $p<1$

Precipitation Ratio

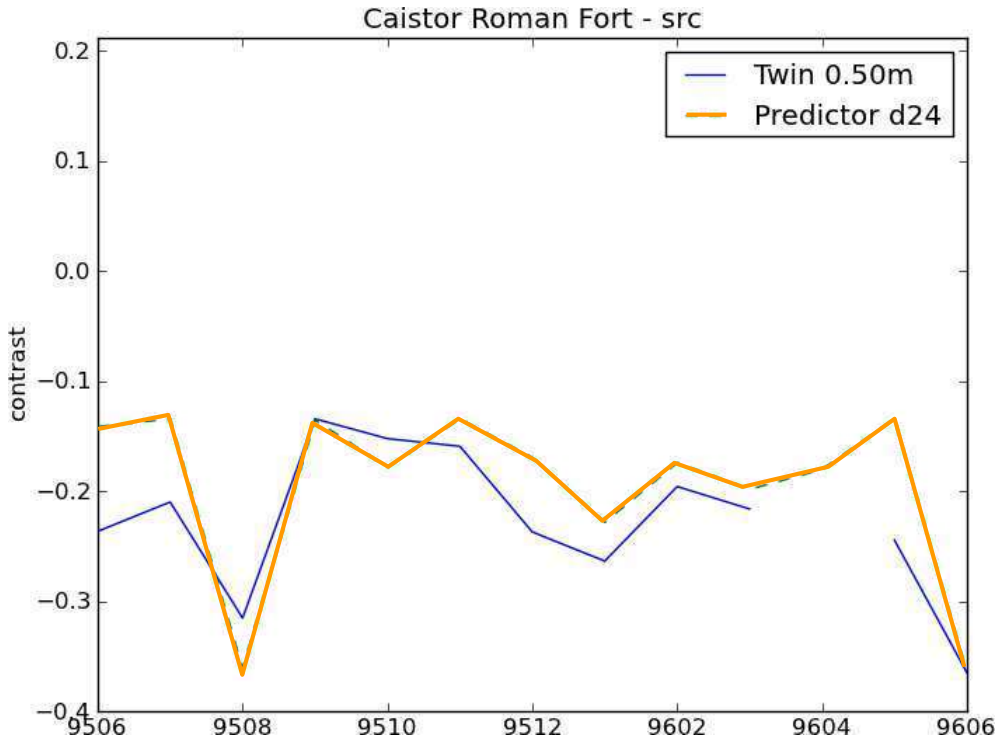
- Caistor Roman fort, main ditch
  - 1995/6: monthly earth resistance measurements ditch *vs.* reference soil → resistivity contrast
  - weather data → precipitation ratio

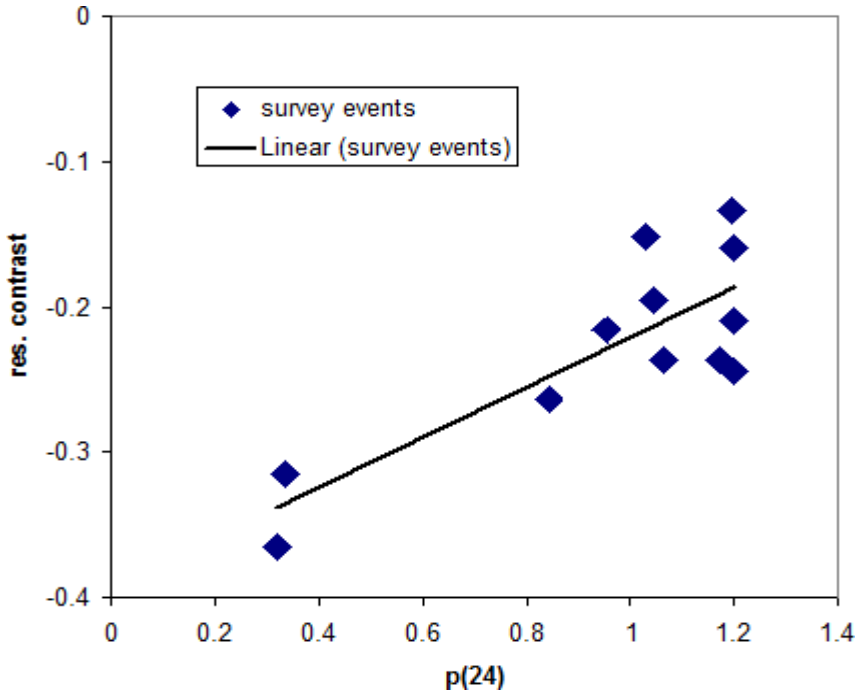
Peter Cott & Arnold Aspinall



Precipitation Ratio

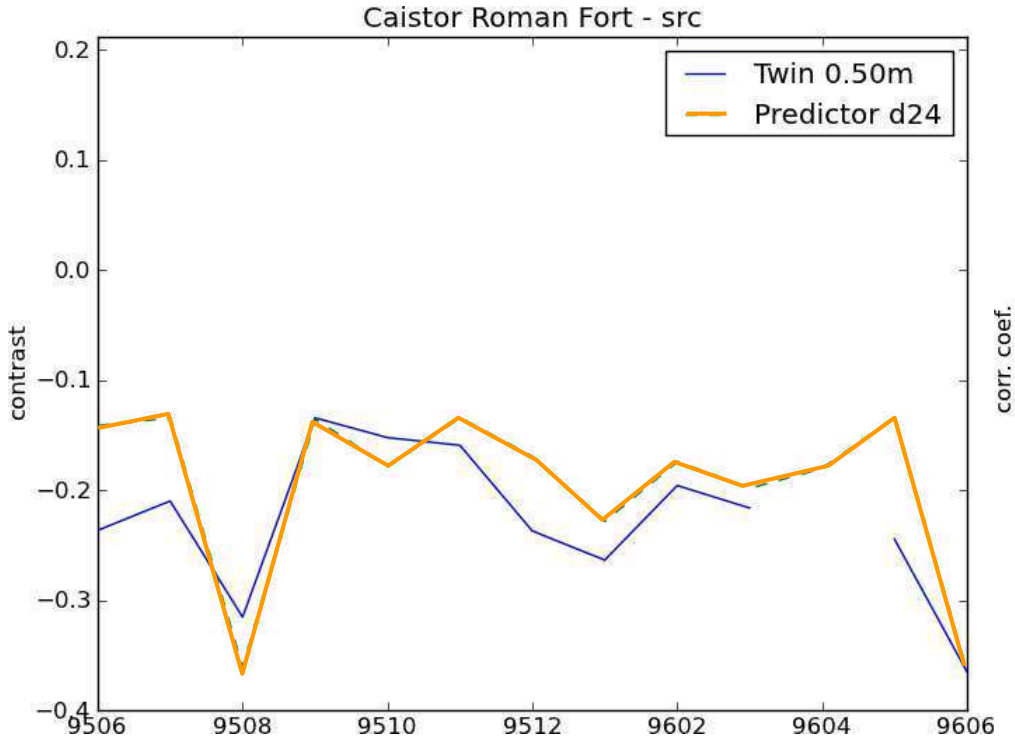
- How to chose number of days *d* for averaging?
  - correlation test: contrast vs. *p(d)* for all survey events

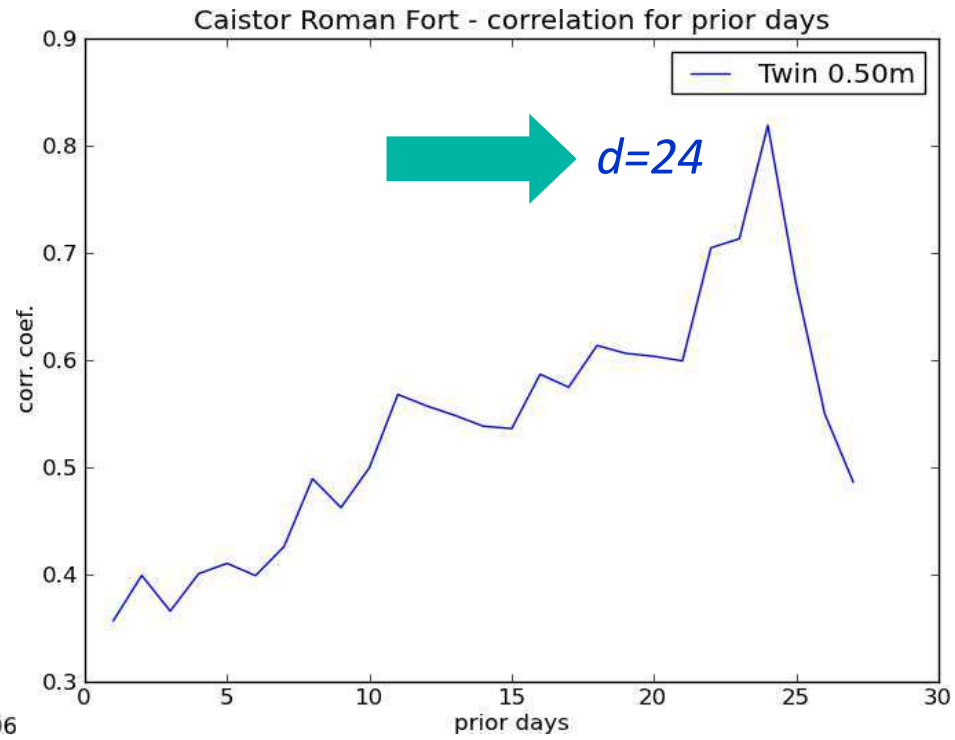




Precipitation Ratio

- How to chose number of days *d* for averaging?
  - correlation test: contrast vs. *p(d)* for all survey events
  - plot correlation coefficient for different *d*
  - chose best *d*

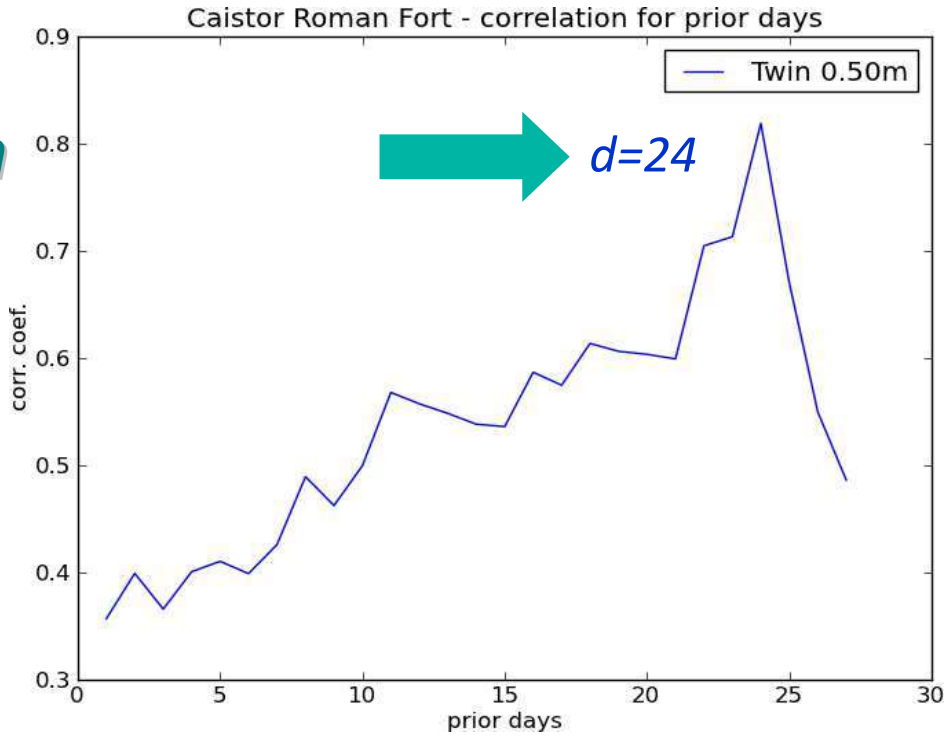




Precipitation Ratio

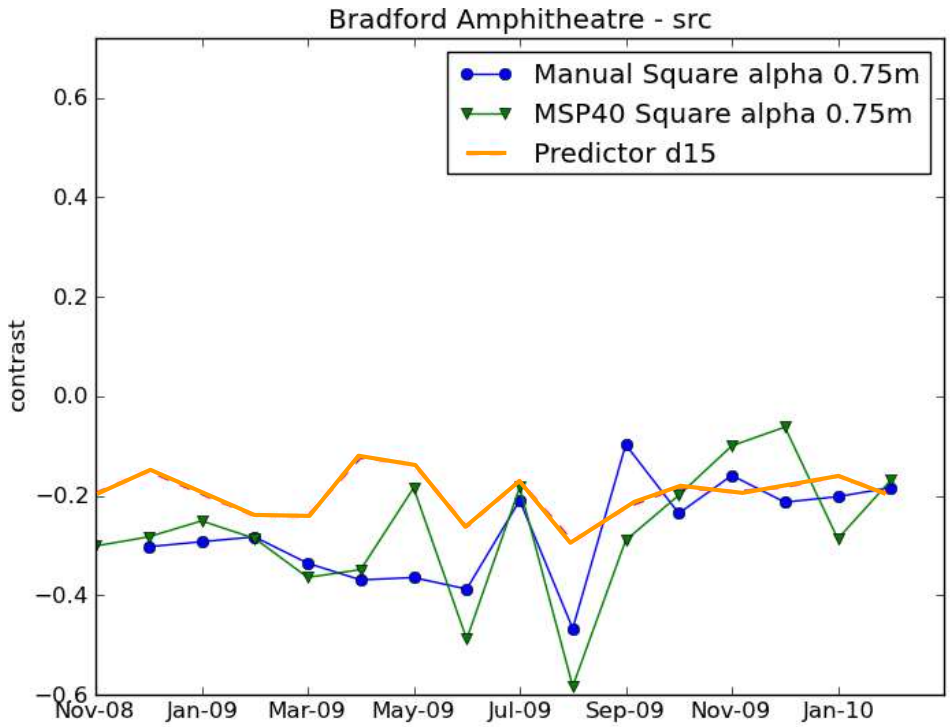
- How to chose number of days *d* for averaging?
  - correlation test: contrast vs. *p(d)* for all survey events
  - plot correlation coefficient for different *d*
  - chose best *d*

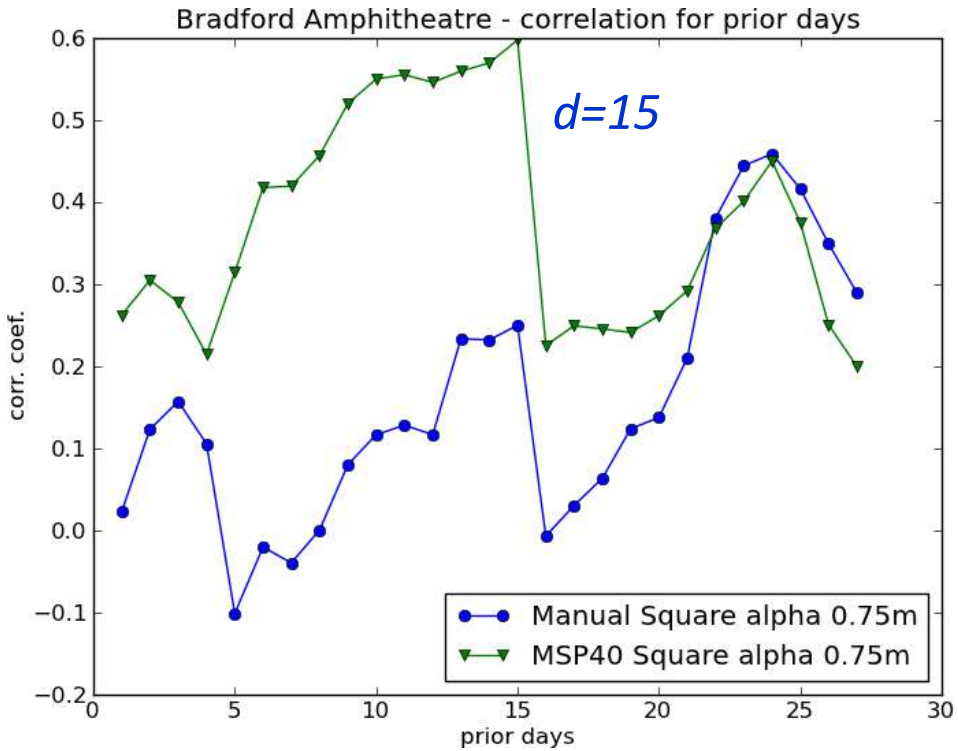
- *"if less average rainfall in last 24 days than in days 25-30, then ditch has pronounced lower resistivity"*



Precipitation Ratio

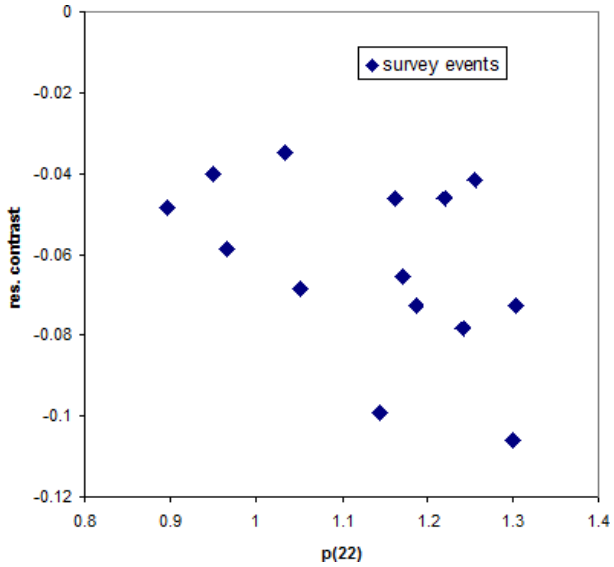
- University of Bradford ‘amphitheatre’
  - ‘best’ *d* is not always the biggest

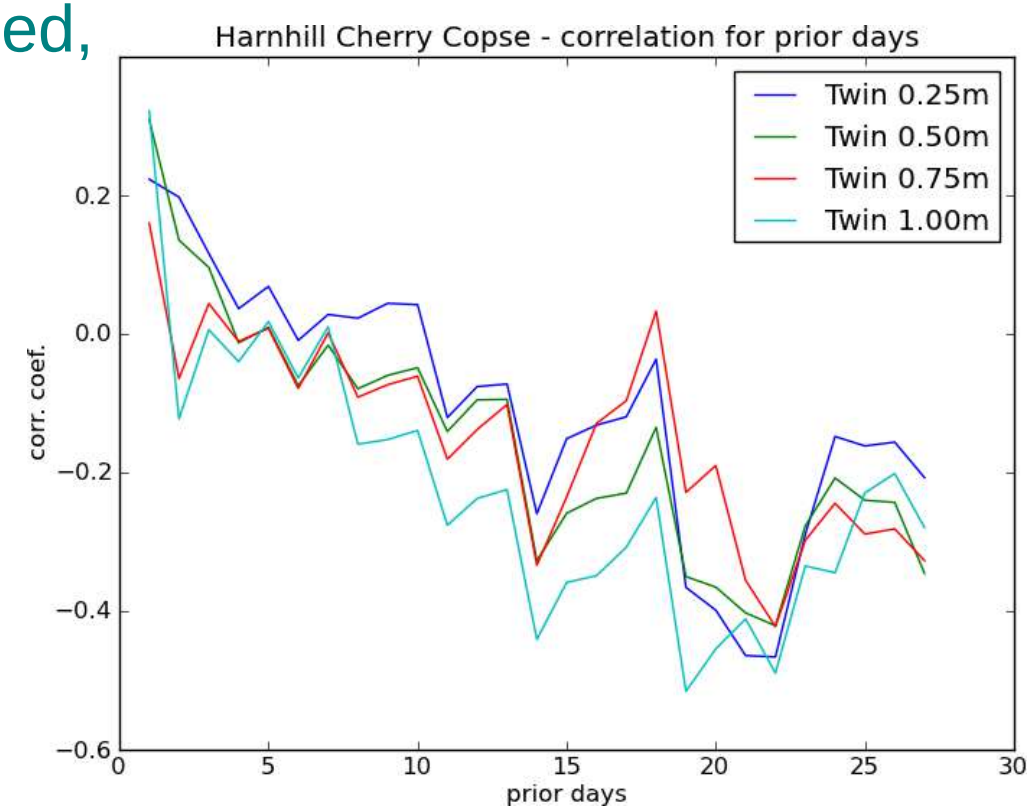




Precipitation Ratio

- Harnhill Cherry Copse
  - correlation negative
  - low resistivity ditch if last few days were very wet
  - extremely well drained, ditch and surrounding matrix





Conclusion

- calculate precipitation ratio for prior 15 days
- from rain data
- then predict earth resistance contrast for ditches

- approximation, not for all sites

- simple method

- needs easy tool