More cloud seeding

Note Title 5/14/2004

How to carry out experiment ?

Option 1

- Decide on number n_s of clouds that will be seeded.
- whenever cloud is deemed suitable for seeding, toss coin; "h" → seed cloud, "t" → don't seed
- Stop experiment when n_s clouds have been seeded

Problem: Total # N of clouds in experiment is random
what to do if $N = n_s$? How likely is that ? What is the distribution of N ?

Option 2

- Fix total # n of clouds to be observed, and # n_s of seeded clouds
- Choose random placement of n_s balls into n holes

Problem: Conditional probability that i-th cloud will be seeded depends on how many clouds have been seeded so far.
This could result in bias

Option 3 :

- Fix total # n of clouds to be observed
- Whever cloud is deemed suitable for seeding, toss coin.
- Stop after n clouds have been deemed suitable for seeding.

Problem: # N_s of seeded clouds is random:

$$N_s \sim \text{Binomial}\left(n, \frac{1}{2}\right)$$

$$E(N_s) = \frac{n}{2} \qquad V(N_s) = \frac{n}{4}$$

$$n = 52 \Rightarrow E(N_s) = 26$$
$$V(N_s) = 13$$
$$Sd(N_s) = 3.6$$

$$P(19 \leq N_s \leq 33) \approx 0.95$$

In our analysis we will consider n, n_s to be fixed at the observed values ($n = 52$, $n_s = 26$)

Justification: Later

A mini example: $n = 5$, $n_s = 2$

Observed rainfalls

100	U	unseeded
500	S	seeded
200	U	
400	S	
300	U	

median (seeded) − median (unseeded)
= 450 − 200 = 250

Suppose that the null hypotheses H_0: "seeding has no effect" was true.

In this case we can write down the values of our test statistic

T = median (seeded) − median (unseeded)

that we would have obtained for all possible assignments of labels "seeded" and "unseeded" to clouds

100	200	300	400	500	T
S	S	U	U	U	150 − 400 = −250
S	U	S	U	U	200 − 400 = −200
S	U	U	S	U	250 − 300 = −50
S	U	U	U	S	300 − 300 = 0
U	S	S	U	U	250 − 400 = −150
U	S	U	S	U	300 − 300 = 0
U	S	U	U	S	350 − 300 = 50
U	U	S	S	U	350 − 200 = 150
U	U	S	U	S	400 − 200 = 200
U	U	U	S	S *	450 − 200 = 250

* Actually observed assignment gives largest difference between medians

Two possible explanations

- The null hypotheses is false
- We were lucky in picking clouds to be seeded.

Probability of being that lucky - choosing the assigment that gives largest difference between medians – is only 0.1

We reject H_0 at level 0.1
The p-value of the test is 0.1