A Method of Verifying S-Factor Formula Performance using Ausplume

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IUAPPA 2007 Brisbane

A question for the modellers in the audience...

What happens to the odour criterion contour distance from source when OER is doubled?

a) distance halves

b) distance doubles

c) distance does something else

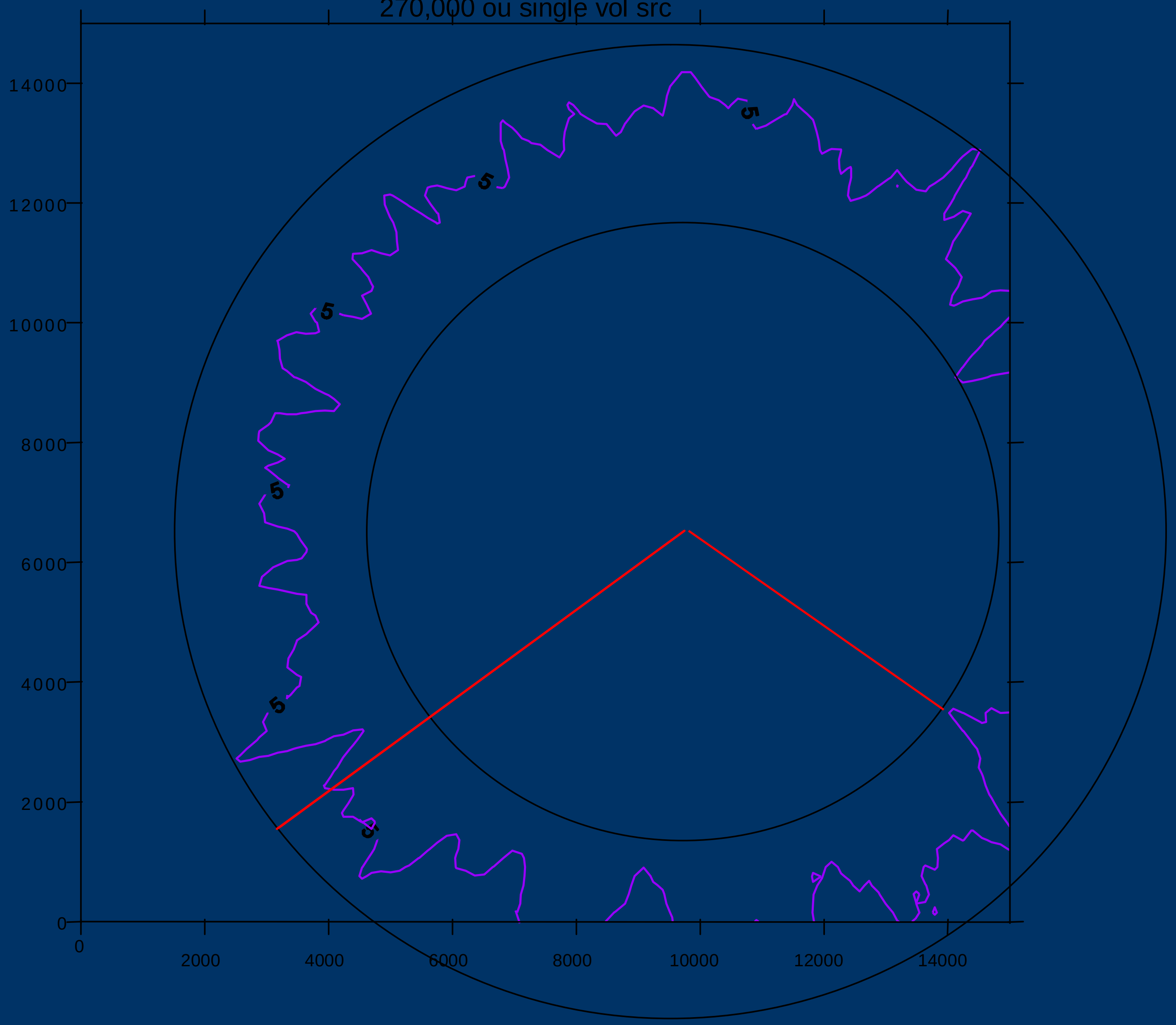
Answer:

- c) The distance does something else
- If you thought it doubled, you are in very good company
- But if it doesn't double, how does it behave?

S-Factor Formulas

- Attempt to answer opening question
- Designed to calculate conservative screening level nuisance odour boundaries for Intensive Livestock facilities as function of standard stock units
- Conservative means...
  further out than modelled criterion contour
- Include some site specific factors
- Buffer Distance = (S1 * S2 * ... Sj) * X^n
  where
  X = Stock Number (eg SPU)

S-Factor formula should give distances > most conservative model results



- Note that X ~ OER

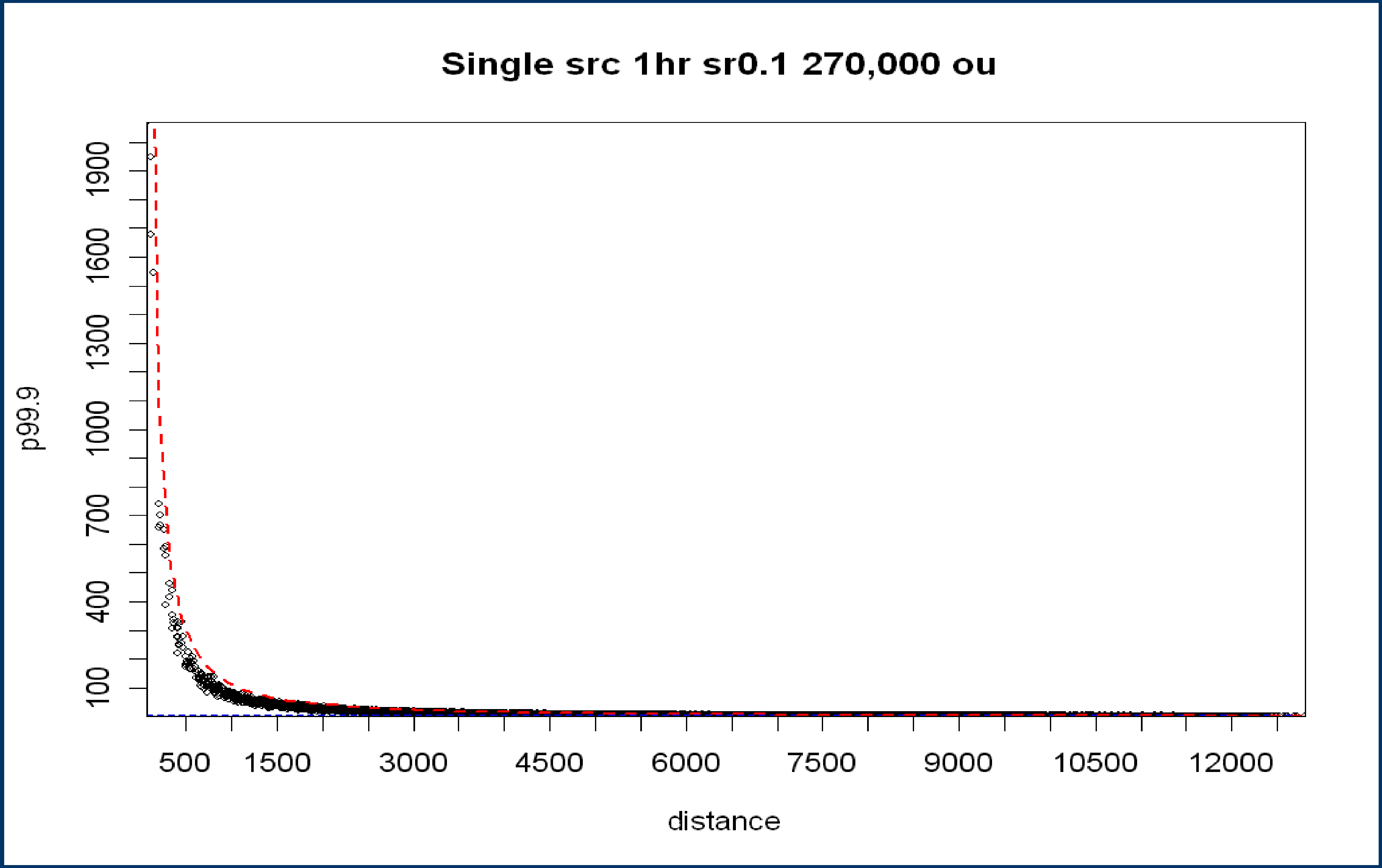
- Some Sj may be proxies for model parameters
eg , Surface Roughness

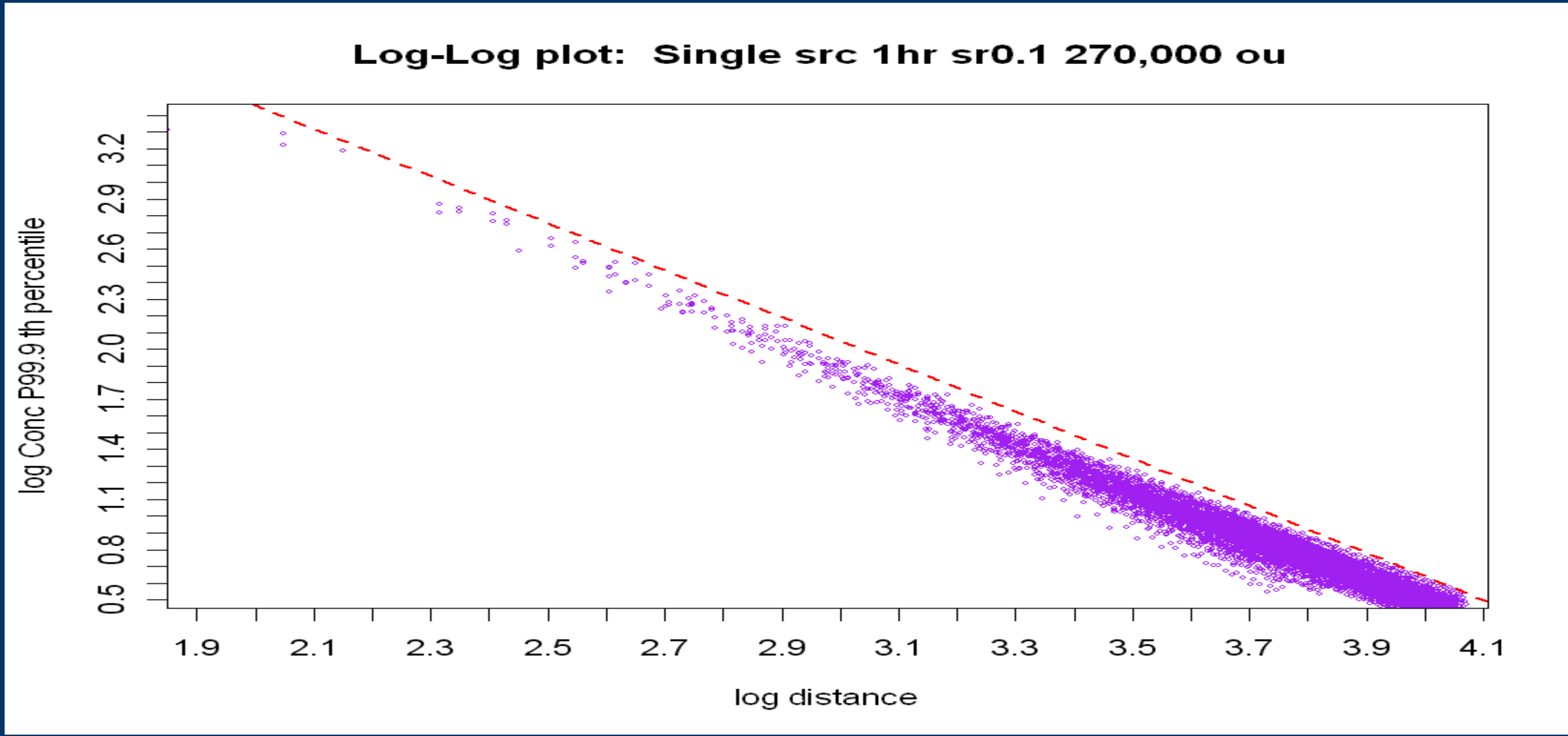
- -> Able to verify performance of
S-Factor formula vs Model output
for these parameters

- Potentially time consuming,
eg multiple model runs for range of source sizes

Deriving an efficient method for verifying S-Factor formula performance:

- Step 1 – take 1 Ausplume output *.sta file...
- Step 2 – preheat oven to...





Y = intercept + slope * X

Fair estimates of intercept and slope obtained with pencil, ruler

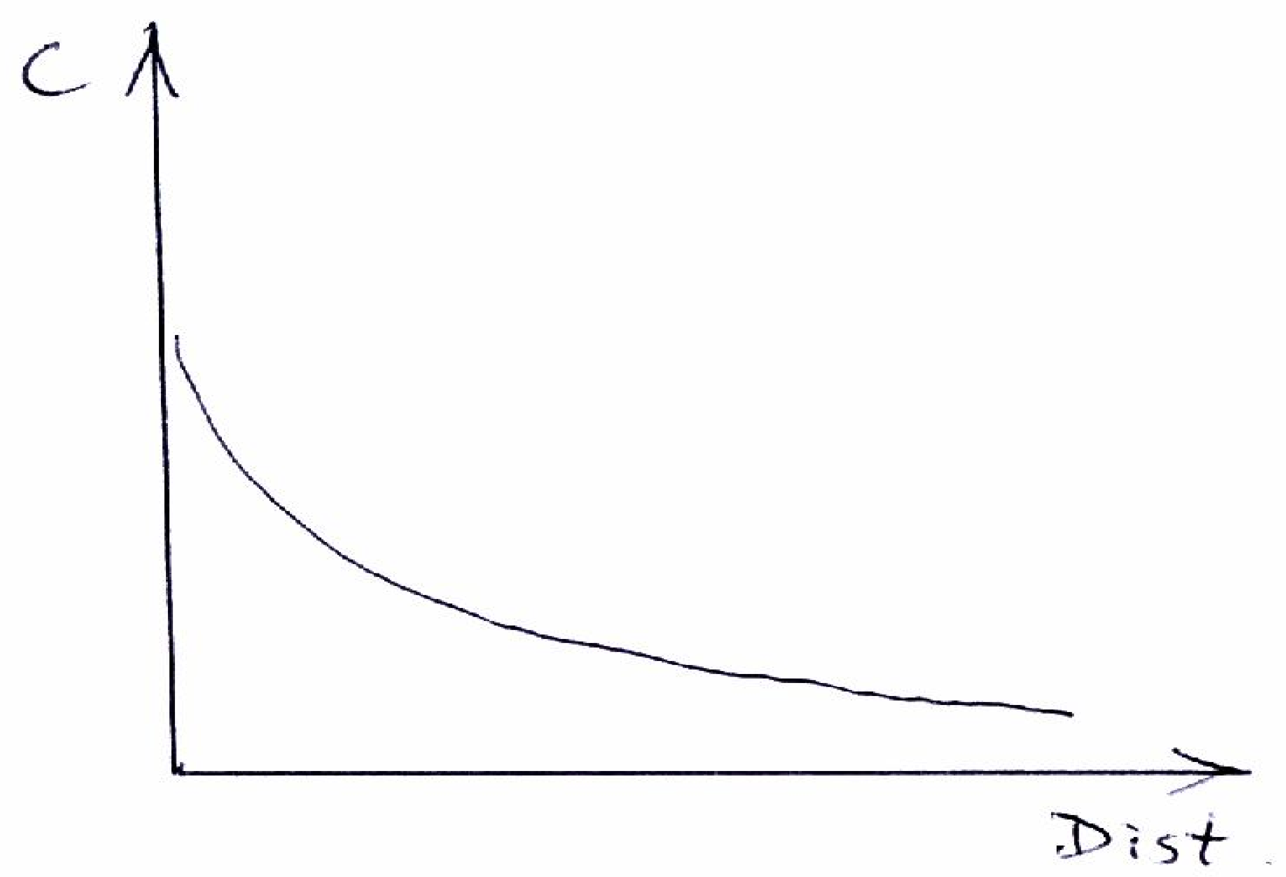
Conc = $10^{\text{intercept}}$ * distance $^{\text{slope}}$

(where dist calculated from x,y grid coords in *.sta file)

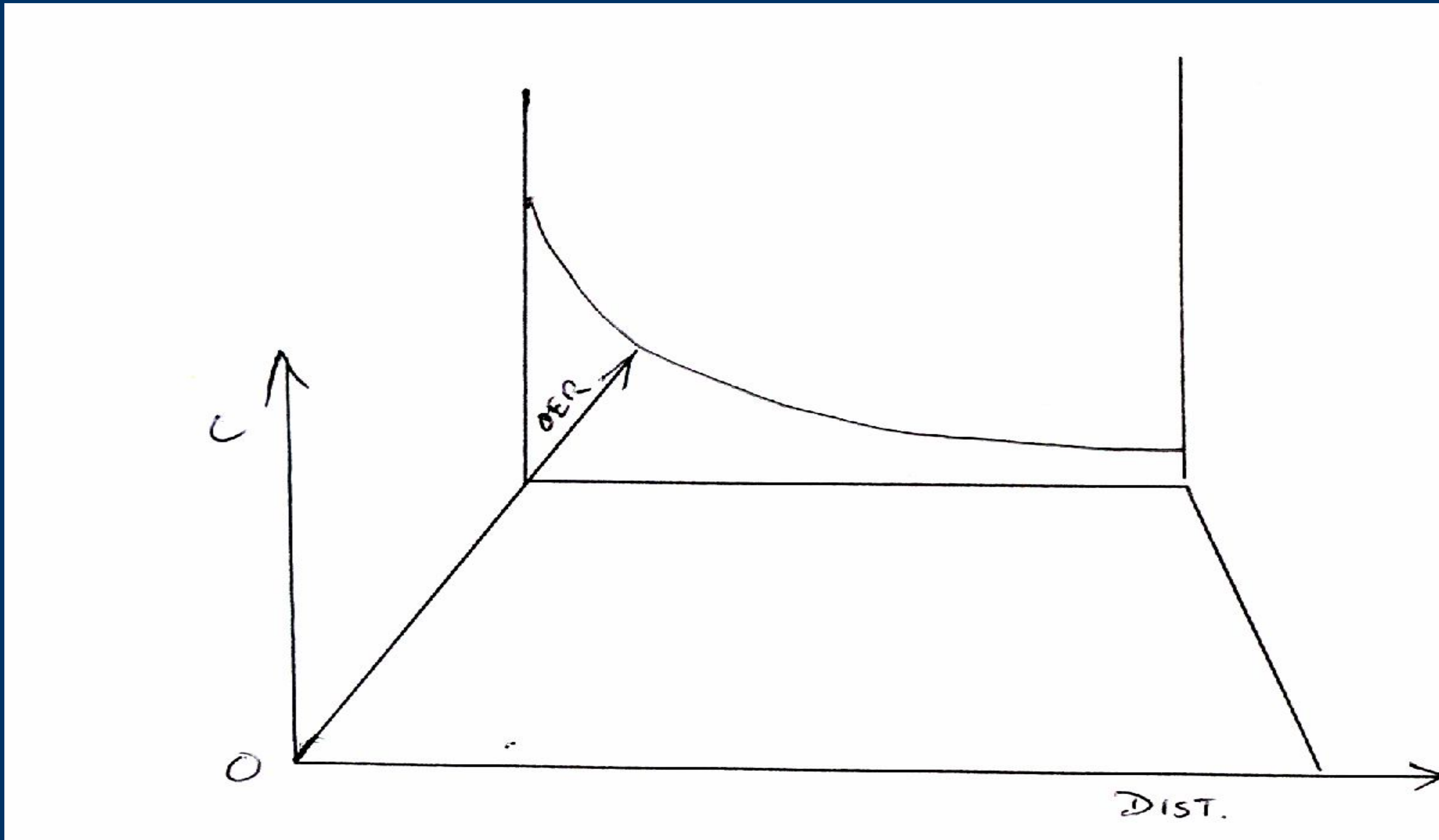
* Does not work well for distances < ~ 300m (ie v. small facilities)

$$Conc = 10^{intercept} * distance^{slope}$$

Equation describes Ausplume model results remarkably well (dist > ~ 300m)



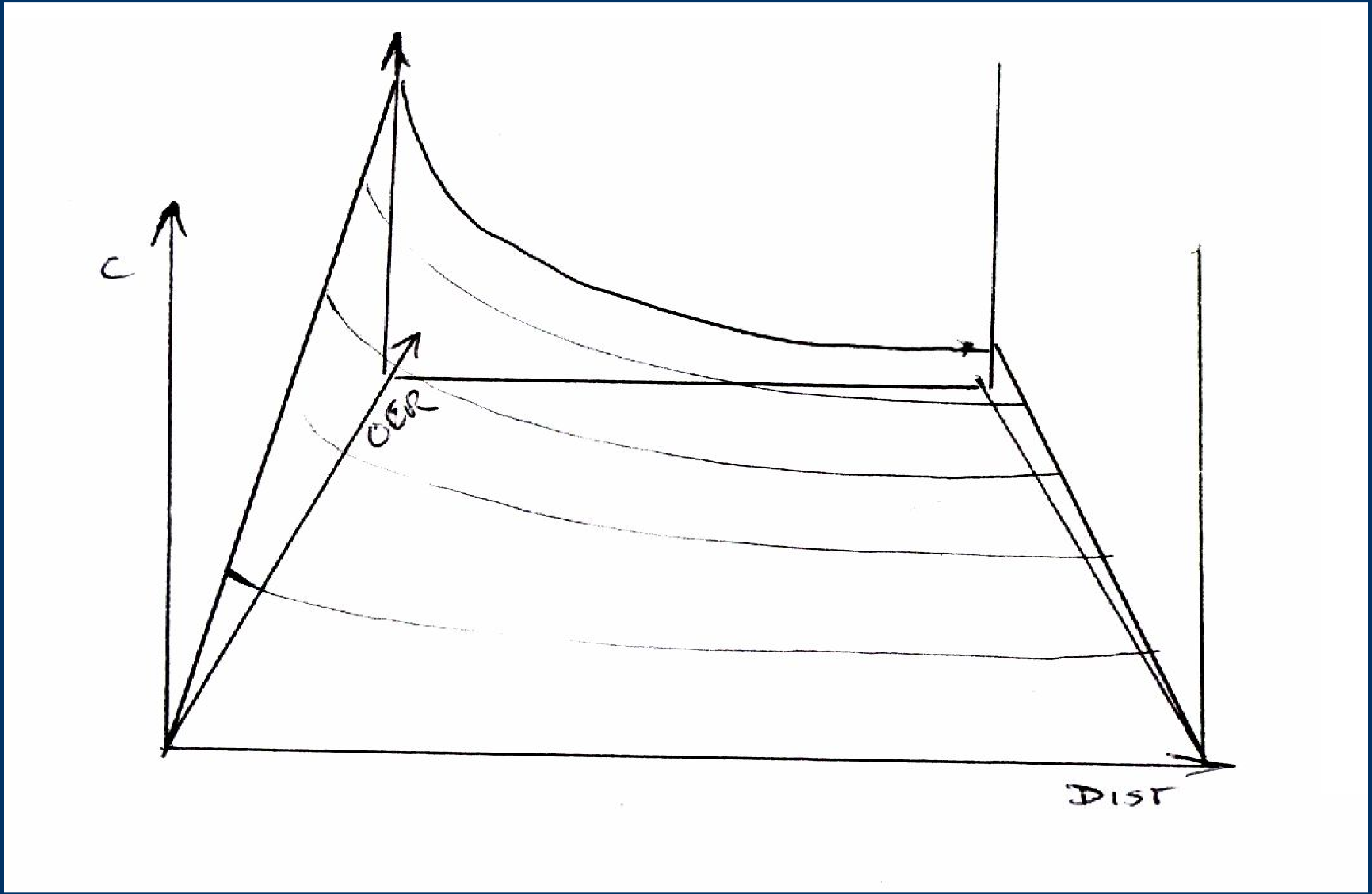
Adding the OER dimension



Making use of Guassian plume Conc vs OER relationship

$$Conc = 10^{intercept} * dist^{slope} * OER/OER1$$

where OER1 = OER for orginal C vs D model run



Rearranging equation from previous slide:

$$dist = (OER1/10^{intercept})^{(1/slope)} * (Conc^{1/slope}) * OER^{-1/slope}$$

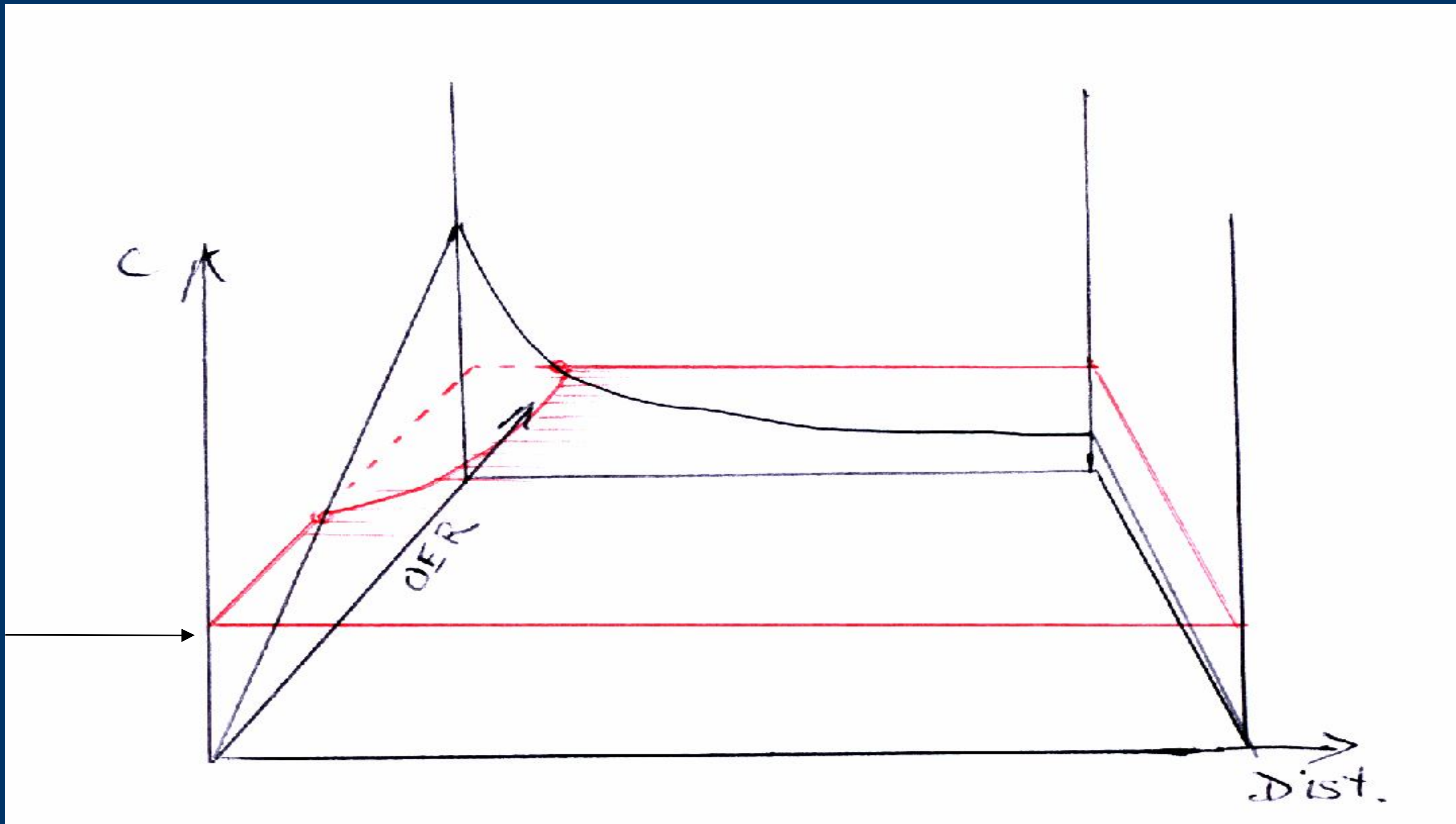
$$dist = const * Conc^{1/slope} * OER^{-1/slope}$$

ie from Ausplume *.sta file have generated 3-D surface linking concentration, OER and distance

Fixing Concentration (eg at criterion conc) -> plane

Intersection with surface gives desired distance = f(OER) relationship

Criterion conc.



For fixed concentration, the complex formula

$$dist = (OER1/10^{\text{intercept}})^{(1/slope)} * (Conc^{1/slope}) * OER^{-1/slope}$$

simplifies to:

$$\mathbf{dist = const * OER^{N}}$$

which is directly comparable to S-Factor formula

$$dist = S * X^{n}$$

Different %iles, surface roughness, Ausplume (one dataset) ->

$0.65 < N < 0.72$

compared to some common (?) S-Factor equation exponents

$n = 0.5$ or 0.55

S-Factor equations at first appear to be unconservative and not match model results well, but ...

can be compensated for by S = S1...Sj scaling.

Example:

- Caversham 1994 met data
- Choose 99.9th %ile to represent annoyance
- Criterion Concentration = 5ou
- Surface Roughness = 0.1 (conservative val)
- Single vol src (conservative config)

log-log plot of Ausplume *.sta gives:

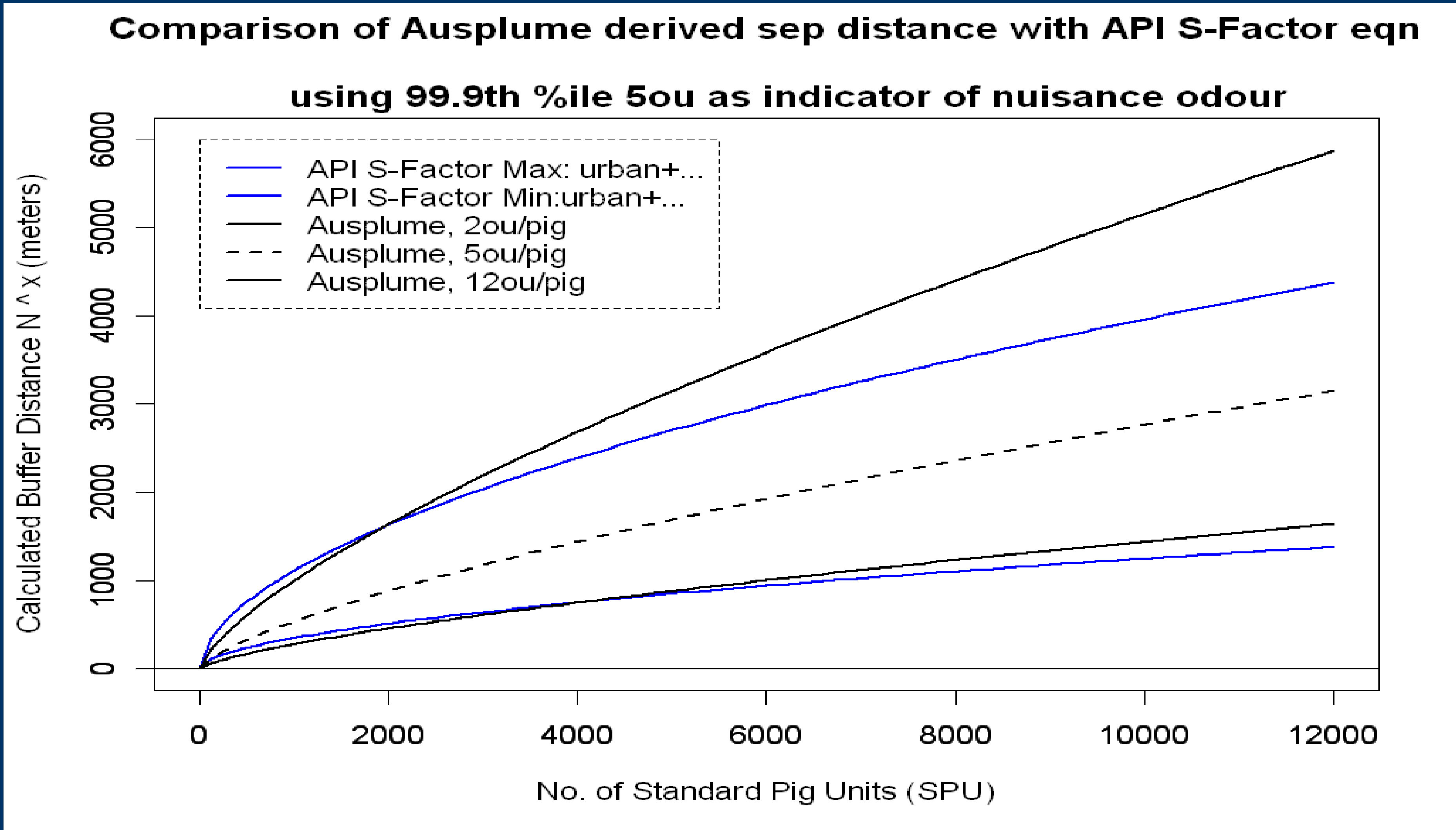
slope = -1.41

intercept = 6.28

-> **Dist = 1.28 * OER $^{0.71}$**

API formula

$$Dist = S * X^{0.55}$$



Summary

- Simple formula able to be easily obtained for a given criterion %ile, and concentration in form dist = f(OER,conc),

  $\text{dist} = (\text{OER1}/10^{\text{intercept}})^{(1/\text{slope})} * (\text{Conc}^{1/\text{slope}}) * \text{OER}^{-1/\text{slope}}$

- approximates Ausplume model results remarkably well for dist > ~300 m

- Directly comparable to S-Factor equations for given dataset, surface roughness setting
  (Exponent n = -1/slope)

- Useful in other contexts, eg back of envelope dist range calcs for given OER for frequently used met datasets

Early results suggest

- room for tuning some S-Factor formula exponents
- S-factors relating to OER may work better if included with exponent term, ie
  $\text{Buffer Distance} = S1 * S2 * (\ldots Sj * X)^n$

Additional note

- Expect most datasets to have at least one direction in which 99.9th %ile is ~ F class 0.5 ms-1

  Therefore derived example equation is expected to work reasonably well for most datasets
  (SR = 0.1 99.9th %ile)