Paper H15-168

Chlorine and anhydrous ammonia concentrations observed and simulated in the Jack Rabbit field experiment, for releases of 1 or 2 tons in a 30 to 60 second period

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Objectives

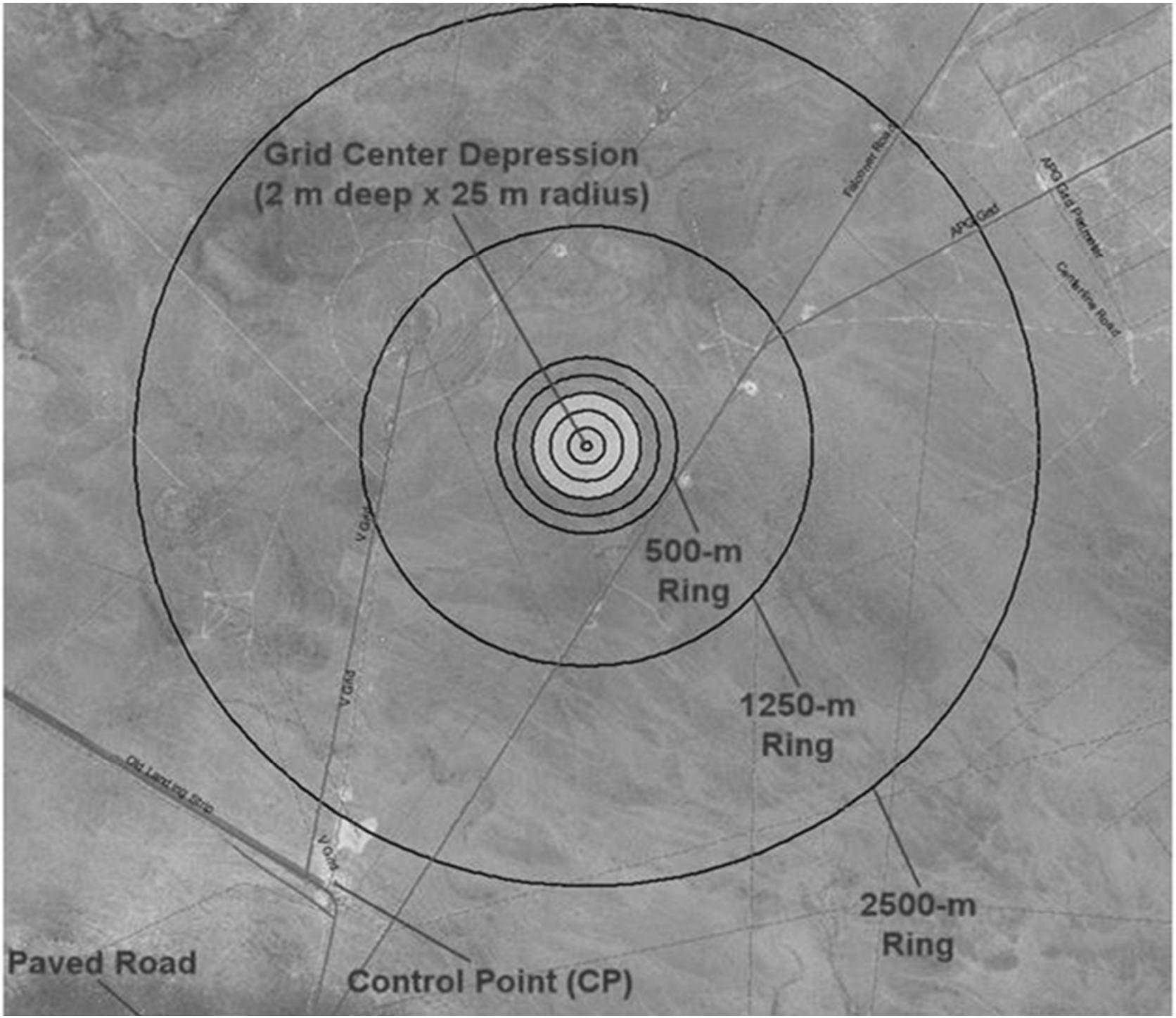
- Describe preparation of QA/QC'd data archive for all ten Jack Rabbit Trials (chlorine and anhydrous ammonia)
- Further confirm Briggs (1990) formulas for cloud hold-up in depression
- Show plots of C(x) for three sampler types

Release Basin: d = 50 m, h = 2 m

- Release valve is 2 m above ground
- 1 or 2 tons of pressurized liquefied gas in tank
- Two phase jet directed downwards
- Tank empties in 30-60 sec

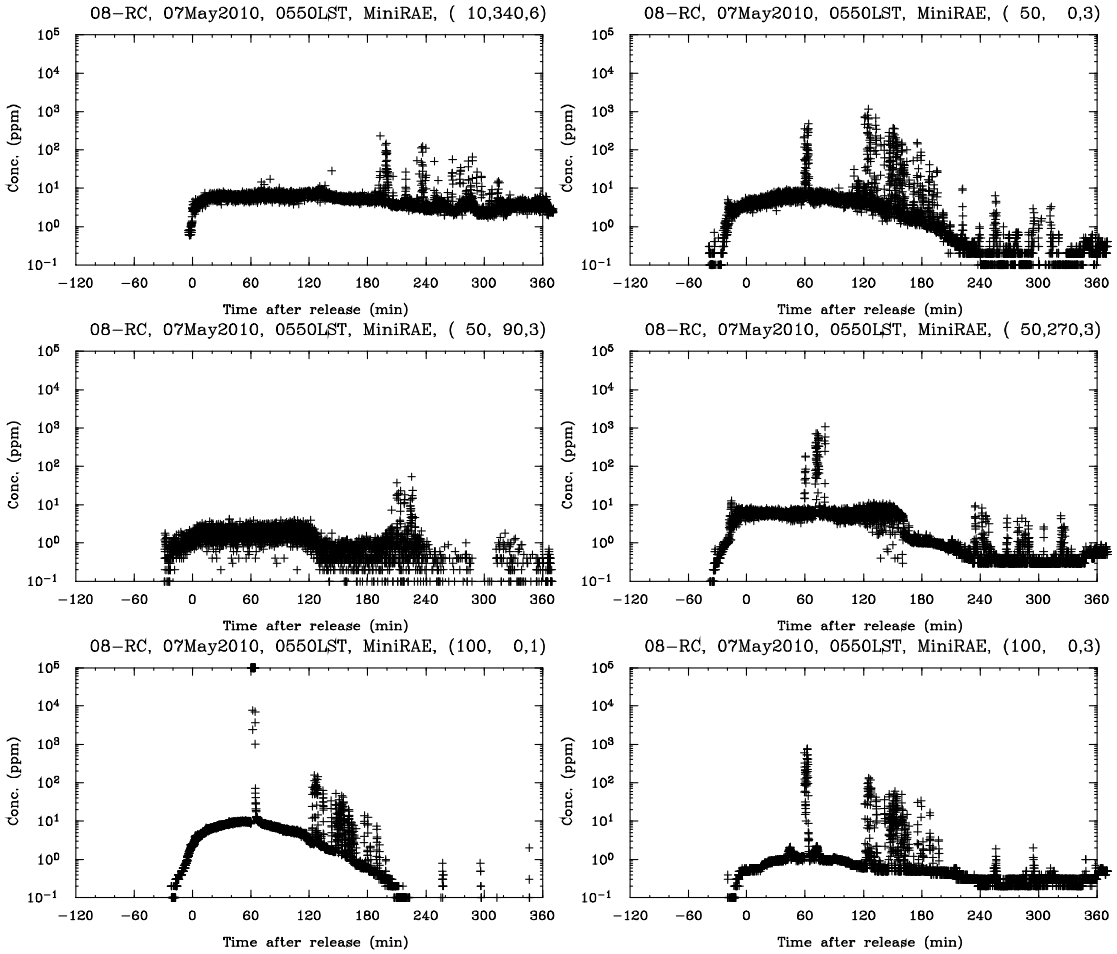
Trial 2-PC 12 sec after release

Trial 2-PC chlorine cloud, at 22 s after the release began. u = 0.6 m/s


Grid Center Depression
(2 m deep x 25 m radius)
500-m
Ring
1250-m
Ring
2500-m
Ring
Paved Road
Control Point (CP)
Old Landing Strip
VGrid
VGrid
VGrid
Fiducial Road
APO Grid
APO Grid Perimeter
Centerline Road

Chlorine Trial 6, u = 6.2 m/s
(at 50 s; not much dense gas slumping)

Examples of C(t) plots for some individual MiniRae samplers



Briggs Theory

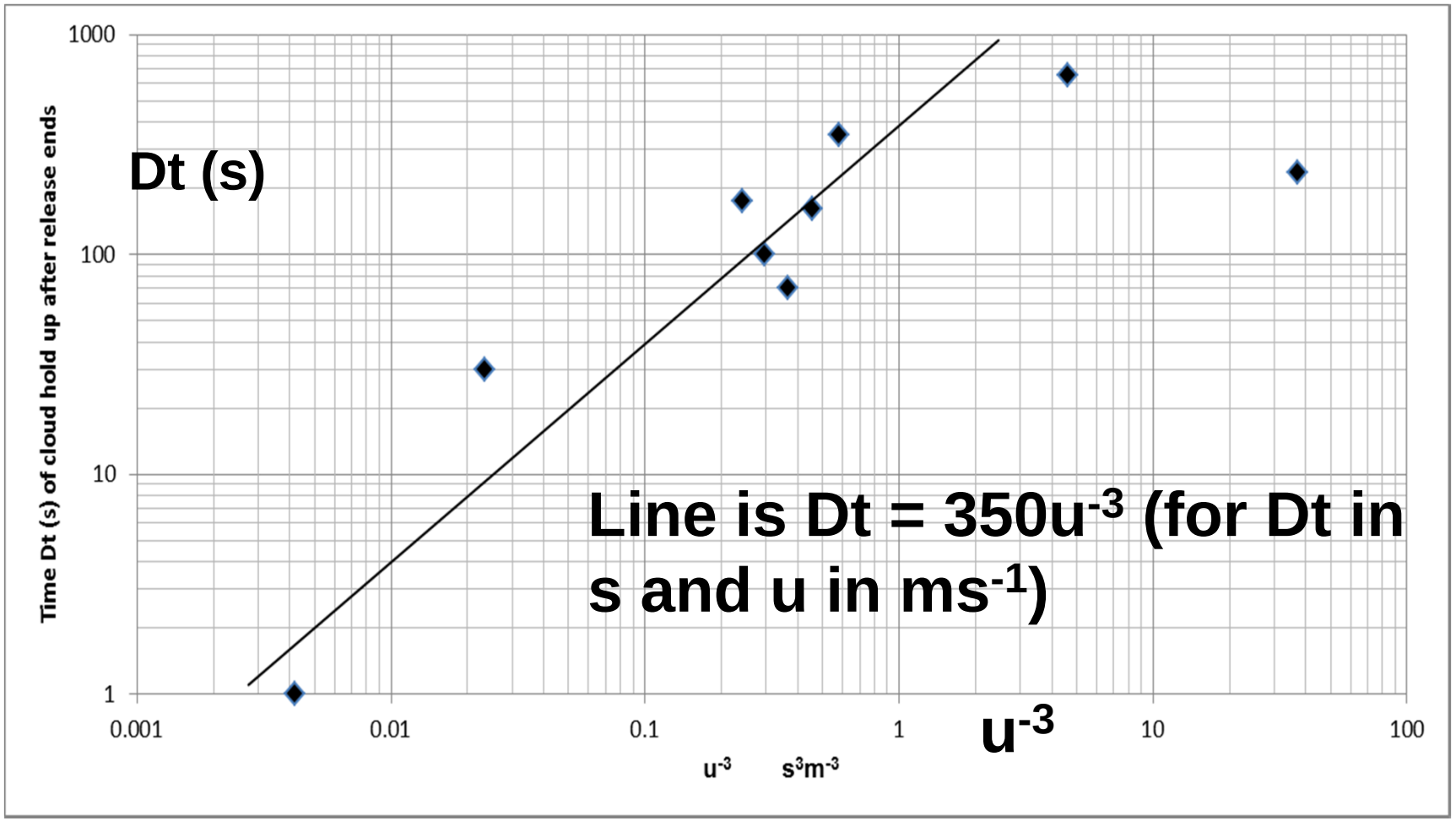
- Assume wind, u, blowing over 2-D depression containing dense gas with $g' = g(\rho_c - \rho_a)/\rho_a$
- Time scale, t_f for cloud hold up is Ag'/u^3 where A is x-z area of cloud in depression
- Assume dimensionless variables $V' = vg'/u^3$ and $T = t/t_f$, where v is 2-D volume flux of emissions from cloud surface
- EPA wind tunnel tests give $V' = 0.06\exp(-0.005t')$
- We use JR observations to "calibrate" constants in formulas for JR 3-D scenario

Jack Rabbit Trial	Release date (2010) and time UTC	Time when visible jet ends (s)	Dt for cloud seen through[1] (s)	Wind Speed u m s^{-1}
1-PA	4/7 1400	65	**235**	0.3
2-PC	4/8 1345	65	**655**	0.6
3-RA	4/27 1315	118	**162**	1.3
4-RA	5/1 1420	110	**70**	1.4
5-RC	5/3 1320	64	**176**	1.6
6-RC	5/4 1340	56	**1**	6.2
7-RC	5/5 1405	60	**always[2]**	1.4
8-RC	5/7 1250	69	**351**	1.2
9-RA	5/20 1245	40	**100**	1.5
10-RA	5/21 1250	40	**30**	3.5

[1]Dt = (time when mist can be seen through) – (time when visible jet ends)

[2]In Trial 7-RC the cloud never was opaque

Cloud hold-up time Dt vs u^{-3}

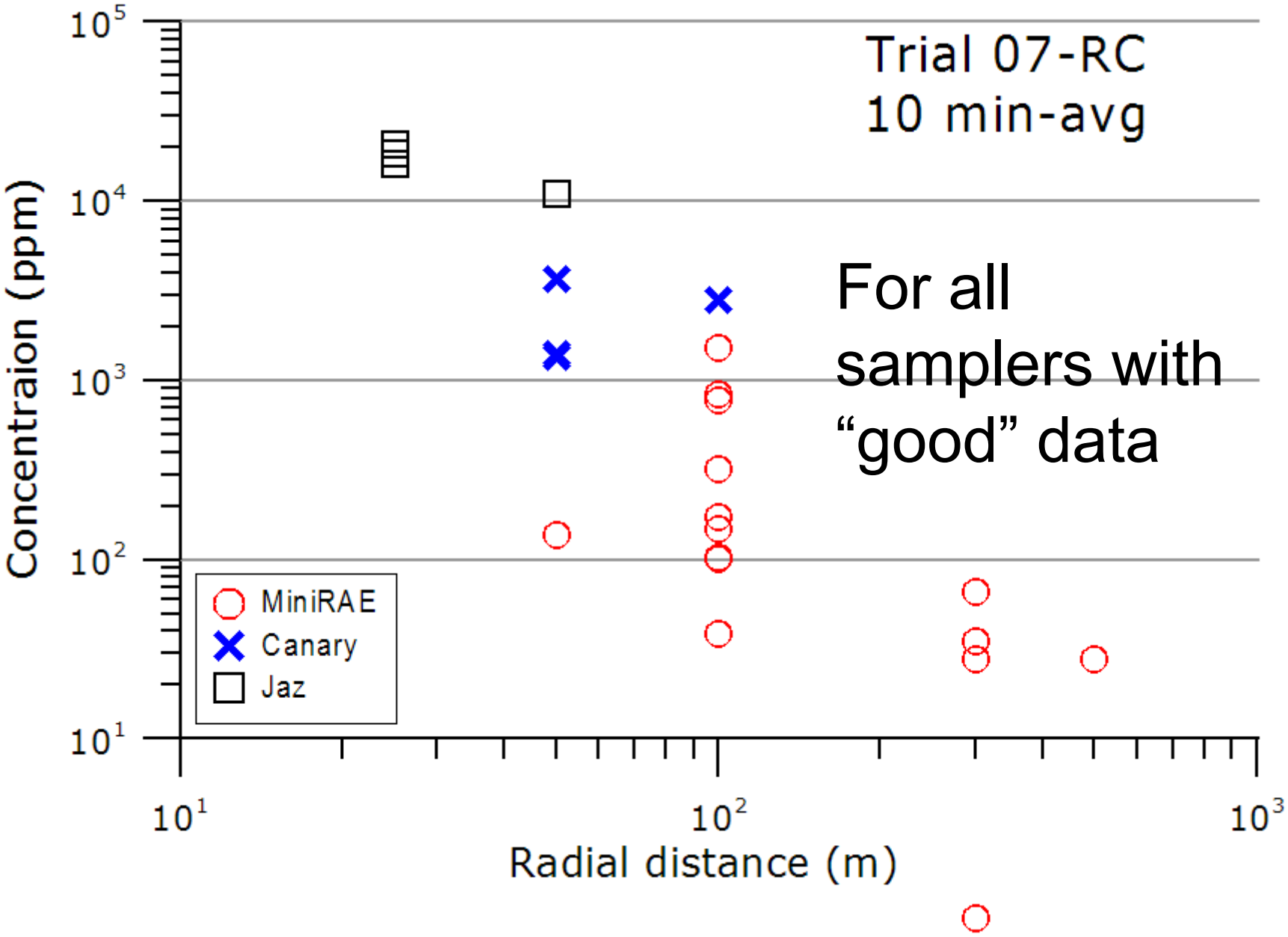


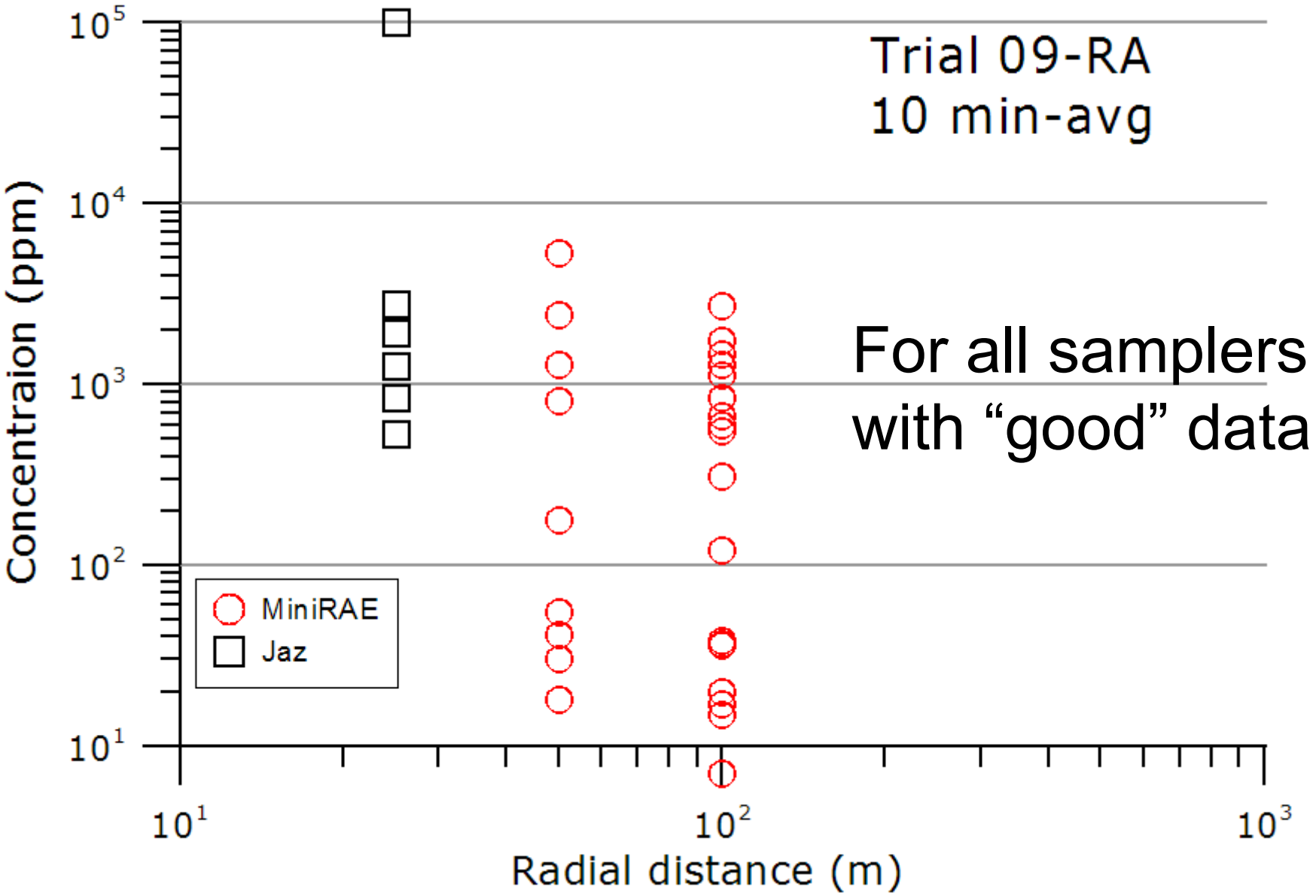
Example of results of “calibration”

- EPA wind tunnel tests give V’ = 0.06exp(-0.05t’)
- JR observations suggest that “0.05” is more likely in the range from 0.07 to 0.4
- The increase might be because JR is 3-D while Briggs theory used 2-D data
- The “0.06” constant is more difficult to refine because JR did not take sufficient downwind concentrations in height and cross-wind

Development of Concentration Data Archive

- Three types of Cl_2 and NH_3 samplers – MiniRae, Jaz, and Canary, different contractors
- Basic averaging time of a few seconds
- Different thresholds varying in time
- Plotted C time series and estimated thresholds and “good” data for all samplers and trials
- Calculated C for avg times from 10 s to 30 min
- Made summary plots as on next page
- Ongoing analysis


Trial 07-RC
10 min-avg
For all samplers with "good" data
Concentraion (ppm)
10^5
10^4
10^3
10^2
10^1
MiniRAE
Canary
Jaz
10^1
10^2
10^3
Radial distance (m)


Trial 09-RA
10 min-avg
For all samplers
with “good” data
Concentraion (ppm)
10^5
10^4
10^3
10^2
10^1
MiniRAE
Jaz
10^1
10^2
10^3
Radial distance (m)

Conclusions from C(x) plots

- Plots of C(x) “look reasonable”
- $C = ax^{-2}$ with $a = 10^8$ ppm-m^2 provides fair overall agreement with max C (x) for 10 min avg time
- Problems with max C at large C > 10,000 ppm, where samplers “maxed out”. Must remember this for future experiments with these samplers.

Preliminary Conclusions

- The analysis of ten JR trials is ongoing
- Briggs' theory of dense cloud hold-up in a depression is confirmed and scaling "constants" have been revised
- An improved QA/QC'd concentration data archive has been produced; the data plots "look good" and analysis is continuing, with comparisons with dense gas model simulations