LA-SUB--95-98

FINAL REPORT TO THE LOS ALAMOS NATIONAL LABORATORY

Subcontract 2944N0014-3H

Desert Research Institute Cloud Droplet Videometer Measurements in Support of MASTEX

13 February 95

1. Abstract

In support of the Monterey Area Ship-Track Experiment (MASTEX) the Desert Research Institute completed modifications to an existing cloud droplet videometer and construction of a second unit for deployment on board the *RV Glorita* during the month of June, 1994. Dr. Randolph Borys accompanied the instrumentation during the period the ship was at sea and assisted in the day-to-day experiments which were conducted on board. Unusually clear conditions and high winds contributed to the lack of opportunities to deploy the new instrument from the ship.

2. Objective

The objective of this project was to operate a modified Desert Research Institute Cloud Droplet Videometer (CDV) from a balloon while at sea on the research vessel *Glorita* off the coast of California near Monterey. Modification of the CDV for use at sea was done prior to the June cruise. Funds were received from LANL at the end of April, 1994 providing a short time frame during which to complete the instrument. The instrument successfully completed laboratory tests prior to being taken into the field on June 1, 1994.

While on board the R.V. Glorita, Dr. Borys prepared the instrument and ground station for use during the cruise. In addition he assisted Dr. Bill Porch of LANL, Dr. Jim Hudson of the Desert Research Institute, and Dr. Ward Hindman of The City College of New York and other investigators in the collection of aerosol particle data and air samples during the study of ship-tracks. The balloon to be used to launch the CDV was lost in high winds early on in the cruise. The final weight of the CDV was greater than originally planned, precluding the use of the instrument under the conditions typically found during the cruise. The aft deck of the ship was unsuitable for launching of the heavy CDV under typical wind conditions and the slow speed capability of the *Glorita*. Modifications were made to the CDV to reduce weight while on board the ship, but these were inadequate. A decision was made early in the cruise that to attempt to launch the CDV under less than ideal conditions would have resulted in a high probability of losing the entire instrument. Because of weather, the launch platform, the ship capabilities and instrument down time, the CDV was not deployed during MASTEX and no stratus cloud droplet data was collected.

3. Results

The contract resulted in the design and completion of a light weight balloon borne cloud droplet videometer that is available for future studies of low-level clouds. Assistance was provided to other investigators during the cruise and in the setup and operation of the aerosol and gas measurements made on board the *RV Glorita*. A complete record of the CN data was maintained. The Appendix is a transcript of the logbook maintained during the cruise.

APPENDIX

MASTEX-94 Logbook record

R. Borys, R.V. Glorita June 1994

6 June

0700- Low stratus and light winds and seas.
Dumped CN data from Campbell Scientific data logger. 70k collected overnight for 9hr 20min. 1 day = 18k or 8 days per disk.

7 June

Final program used for CN data collection is labeled MAST5.dld. Takes A and B from CN counter and calculates CN/cc each 10 sec. where CN = A X 10^B. This program is in operation as of 2000 PST 7 June.

8 June

0550- Sunrise, winds 30 kts from NW (50 min ave). Open fridge on port roll only.

9 June

Heading back to Monterey.
Heavy seas yesterday up to 18 feet. Absolutely impossible to do balloon work on fantail. Crew says these are normal conditions offshore here. Winds are now 30 kts from 340.
0915- In Monterey Bay

10 June

Underway at 1000 to point 50 miles off Pt. Sur.
1030- Did a smoke test on CNC exhaust hose with winds relative to the ship gusting to 25 mph. No back flow was observed.
1430- Connected videometer and captured an image of the calibration grid at 20X. Recorded on tape "MAST TEST" from 00:00 to 55:20. 10X cal recorded at 55:20 to 0:01:55:05. Nebulizer droplet tests collected from 0:01:55:05 to 0:02:16:25, heavy droplet concentration at full film speed.
Did a speed check on film drive. Speed is 24mm/2.62 seconds or 9.16mm/sec. 0.087 seconds are required to "freshen" the impaction surface or 2.6 - 1/30 sec frames.
1830- WX - In fog, very light drizzle. Winds 150 at 5 m/s temp. 12°C. We are heading west @ 7 kts seeking edge of fog/cloud. Relative winds 4 mph.
1955- Rawinsonde launch.
2320- A super tanker passed across our bow heading approx. 360, we are heading 270, winds are estimated NW. Should have plume crossing.
2330- Turned in.

June 11

0630- WX - Fog
0900- First tether launch successful, cloud/fog top at 300m, sounding done to 500m. Winds below inversion are 130 true a 5 m/s, Glorita heading 100.
1440- Lost tether balloon to high winds (>30 kts) while aloft due to a balloon failure. The sonde was lost. This was to be the maiden flight for the videometer.
1900- Clearing. Peaceful.

June 12

No entry.

June 13

0800- Videometer mounted on deck in fog. No response. All cabling checked. No image.
1420- Called Harold Faretto at DRI. Checked all leads and power supplies. All OK, still not functioning.
1926- End testing.

June 14

AM- Called DRI for assistance. Further testing of videometer with help of Mel Buchenwald. Conclusions: Transmitter may not be working. FEDEXed unit back to DRI for testing.

June 15

0600- Left Monterey, clear day, heading SW to clouds and a rendezvous with a Navy ship. Attempting to install an alarm circuit on CN counter to waken us if a plume is encountered at night.
1921- Spent all day chasing Navy oiler Kansas City, but he's pulled off now. No clouds or ships nearby. Winds are 340 at 30 kts making life difficult. Mounted air intake tube on mast so it self orients into the wind keeping a positive ram pressure on intake.

16 June

Lost 11 hours of data on data logger last night. Unknown reason. Internal memory on data logger should hold 10.72 hours of data.
1330- CN alarm system will not work because data logger's switched power source is only 5 ma at 12 VDC., need 72 ma.
1340- Opened video discriminator on videometer to adjust internal pots. Videometer still not functioning.
2040- Some clouds today. Bill launched the kite/balloon today. Both went down into the sea. Tomorrow we plan to launch my kite.
Changed display of CN counter to enable the visualization of small scale features rather than only strong plumes within 5 miles. We began to see regular oscillations in the CN

concentrations. Suggested that they may be evidence of clouds streets bring down to the surface, CN-rich air from above the MBL.

17 June

1200- Fixed problem of data logger recording only 6999's
2130- Docked in Monterey for 2 days.

18 June

In port.

19 June

In port.

20 June

Stayed up all night with J. Hudson working on his CCNC. 1 hour sleep. WX- Good, overcast, winds NW at 5 kts. Glorita is heading N along coast to intercept the blimp. Theresa is on board in place of Hindman. CCNC will not work as a spectrometer but will function at one supersaturation.

0900- CN and data logger up and running. A small but well defined peak was observed on the CNC about 200 above background where background is 1000/cc. We are approx. 6 nm from the coast. Probably a small boat or our own plume. Winds are NW at 4 kts and we are steaming SW to intercept a plume by 0950.

0926- Peak CN: 2800/cc.

0934- Peak CN: 10,000/cc, 12 mph relative wind. Found cause of peak to be room air entering the CN counter due to loss of power to hair dryer on intake hose.

1016- Another plume contact. Ship 30° off port bow, we are heading 220° @ 10 kts, winds are 320°.

1022- Passing 1/2 mile behind tug w/barge, Target #3.

1026- Plume contact at 1016 was not from ocean tug and barge which we are now pursuing. We will fall behind tug again in approx. 20 minutes.

1027- Picked up narrow plume from tug.

1050- Collected 2 CFC cans, one in plume and one out of plume from tug.

1130- Broke for lunch and two flybys by blimp. No targets.

1600- Notified of a target (#4). We have come about and are heading toward a rendezvous with a Ship Of Opportunity (SOO). encountered a CN peak at 1554, our plume while on a downwind track.

1619- Encountered our plume.

1730- Flow check on Diffusion Battery, OK at 4 lpm.

1900- Ship within 7nm. Target #5.

1915- Target #5 5nm NW. Our heading is 185°, in a position for interception. Winds are on starboard side @ 90°, but CN are at background levels of 400/cc.

2059- CCNC CPU will not boot. Turning in. We are running downwind in our own plume, CN = 35,000/cc.

21 June

0630- Rise. Will rendezvous with the Kansas City @ 0800. Dumped CNC data. A gap in data again. CCNC is down, CPU #1 down.

0820- Sudden increase in CN, saved screen as Monoscr.003

0825- Kansas City is 1/2 mile off port - doing laser scans upwind. We're heading 330° @ 4 kts, winds are 25-35 mph relative or 20-30 kts.

0848- In Kansas City plume, grab sample and Diff/Batt analysis.
5.2 nm aft of ship during plume crossing. Relative winds were 330° at 12 kts at 0800, real winds are 24 kts from 330° at 0900.

0919- Grab air sample. Can 0612 #4110, ambient.

0947- Requested a course change because we are sampling our stack. Course change denied, we must stay south of Kansas City. We are now 090-270 which doesn't work.

1110- Revised program on data logger to give fraction of day in Loc:8, now data file will be: Header,Day,HHMM,SS,FRACDAY,Log CN. will allow easier importation and plotting on SPW.

1242- Another series of "plateaus" have been observed on the CN record, going from 240/cc to 680/cc. Saved screen as Monoscr.004
Note: @ 1235 ship changed course from 150° to 322°, then at 1250 changed to 305° and 295° at 1258. Could we be crossing a front? Or airmass boundary? Examples:
Between 1130 and 1230 - in clean air
0830 and 0930 - in dirty air
0730 and 0830 - in clean air
Discussion with Mark (Penn State) suggests that clean air occurred during high

reflectivity on their radar indicating drizzle, and dirty air occurred during low reflectivity or no drizzle. Changes in air quality likely due to scavenging efficiency differences. Clean = 1/3 Dirty in [CN].

1323- Kansas City is 60 nm North and upwind

1340- Heading toward wind line of Kansas City now, plume interception any time.
1445-1448- Saw a 60/cc rise in CN concentration. Plume? Notified bridge. We're turning to 020° to at 1452, approximately 22 nm out from Kansas City. Blips seen in record between 1457-58 are due to adjustments being made on flow to CNC.

1506- Changed course to 335°, directly toward Kansas City which is coming directly downwind at us. Kansas City is 8 nm ahead.

1514- Released a toy balloon, drifted starboard of our stern. Therefore we will not intercept the Kansas City plume as he passes to our starboard.

1641- 25 minutes to plume interception behind the Kansas City. He is circling us at the moment to head upwind.

1657- Plume crossing of Kansas City produced 15,000 CN/cc. Collected one CFC bottle in and one out of plume, DIFF/BATT done on plume grab sample, 2.5 nm out from Kansas City.

1921- Plume crossing of Kansas City. Plume emitted 5.4 nm ahead, winds are 28 kts from 325°, plume CN max was 3,000/cc.

22 June

0700- All plans have changed. Heading south looking for SOO's.

0900- Launched Tethersonde.

1030- Found data logger battery dead. Connected power supply. Lost data from 0910 to 1100.

1213- Forgot to reset clock on data logger until 1213. Also found flow on CNC too high resulting in CN concentrations which are 30/cc. These are incorrect. Ignore. No SOO's nearby. Doing Tethersondes.

1330- On a course of 035, heading up to shipping lanes. Tethersonde is down and parked. Skies clearing, seas are light, 2-4 feet, no SOO's in sight. Will collect CFC sample, can #0606 - 4206. Winds 335° at 18 kts. Partly cloudy and clearing.

1418- About 30 minutes ago we passed through a ship plume. Currently target is approx. 10 nm at a bearing of 310°. We may try to re-intercept,
Theresa is ready at the LUNG.

1455- Encountered plume from ship 10 nm upwind, more or less pacing us. CN concentration is up 40%, 700/cc from 500/cc. Theresa is working the DIFF/BATT.

1630- Unanimous decision to go back to Monterey ASAP. We will head in on 045° to get in by 0900 Thursday.

1740- Collected an ambient CFC sample.

1935- Chicken crepes, mixed veggies w/Dijon wine, Moalou sauce, salad, followed by a raspberry tart. Clear, steaming NE, nice swell, pretty sunset. Will prepare for early fog measurements along the coast. CN flat at 500/cc all afternoon.

2010- Sudden increase in CN concentrations, unknown source, sudden decrease at 1938 to <100 also, unknown cause.

23 June

0630- Awoke to sunny and clear conditions from Monterey to China. Due in Monterey @ 1730. SOO approaching. We are off Pt. Sur.

0915- Ship passed approx. 18 nm North of us, no plume detected, expected plume passage at 0900.

1330- Smooth steady increase in CN concentrations as we approach Monterey. Concentration is 1630/cc now.

1450- We are downwind into Monterey.

1535- We are at the dock.

24 June

In port.

25 June

2130- Departing Monterey. CNC started.

26 June

0800- CN varied regularly between 1000 and 10,000/cc all night like clockwork. Had refilled/flushed alcohol reservoir last night. Instrument zero's fine. It turns out it the regular variation in CN concentration was due to the vacuum line to the CCNC being disconnected and allowing room air into the CNC.

0825- Connected CNC to CCNC intake with the vacuum line closed off. CNC concentration

stabilized at 5,000/cc. Room air is about 9,200/cc. There appears to be air leaks in the CCNC. Outside CN are 200/cc.

0830- Possible ship plume about 5 minutes wide and up to 3,000/cc. No target seen on radar. We are heading 240° in a 335° wind, possible ship contamination? Unlikely. Conducted flow checks on the videometer. Flow is 12.1 cc/sec resulting in a residence time in the intake tube of 0.004 sec.

1048- Connected and started CCNC, peak CN due to room air intrusion into manifold.

1531- CFC grab sample: Bottle #0623 Can 4008.

1610- Sea Temp 15.2
Air temp 15.24
Wind speed 12 m/s from 347°
Lat 35° 01.62 Long 123° 43.80

1640- Slow steady rise in CN concentrations over last 2 hours. Now at 396/cc. CCNC variable. No ships today. Plan to change course from 215° to 305° at 1700.

1936- Start of CCN calibration. CN off line.

<u>27 June</u>

0700- My God! There is stratus!! Big flurry of activity!
Will did a canister. Theresa is already got the CCN fired up. % minutes ago I was in bed. There was a gentle peak in CN as Theresa turned on the CCNC, no known ships in the area.

0730- Cloud base - 400m
Temp 15 C
Winds 338 @ 10 m/s
We've slowed to 4 kts and are heading into the wind, we are seeing contamination from our own stacks.

1025- Expect plume passage from SOO at 1040-1100. Ready, no balloons.

1052-1113 The first <u>confirmed</u> ship track-
Lidar - cloud base up
Radar - Thinning of return #4
CN - up by 80%
No contact of ship on radar.

1206 - Likely above ship track was new ship. Still expecting track #3 @ 1300-1400+. Shortened plotting time of GT to 10s. CCN displayed conc. less channels 1-14:
27 18

30 24
26 25
43 31
27 35

28.6 +- 6.8

1335- No sign of plume as yet.

1342- !GOOOOOOOOOOOOOL! Got a gas sample in and out of track. Saved plot as monoscr.005

1612- All's quiet on the Western Front.

1737- CN background has risen to 900/cc. Cloudy, 8.9 m/s from 345 Sea Temp = 15.6 Air Temp = 15.6. Lat 35.14.47, long 124.50.7

28 June

Tried a night launch of videometer. Got a sonde up to 550m, ran out of line. Were about to launch the Videometer, but surface winds were up to 10 m/s. Sonde died and quit @ 0045

0730- Ship (?) approaching on the port side, will make passes ahead of us as it proceeds to AC area. We will bag at least 2 grab samples from her.
(?) Mt Vernon
Winds, 9 m/s 350, we are heading 335. Plume will not strike us.
CCN BKGD approx. 336, 176, 215, 146, 215, 121, 189, 216, 100, 70 = 163 +/- 88
CN = 460
CCN MED 63-73
Temps. 14.2 Air Temp.

CCN in Mt. Vernon plume = 129, 174, 90, 121, 88
data went off scale on display, therefore CCN is responding.

0939- Mt. Vernon + Truxten are way north playing w/AC. We're off line until 1400 for dedicated ships and possibly on-line at anytime for plumes of opportunity. Currently winds on bow of ship are 20-28 mph (18-25 kts) Wind speed true is 9 m/s or 18 kts, ship speed is 6 kts. If ship goes down wind can reduce relative wind to 6 m/s or 12 kts or 15 mph. However to launch balloon need winds on side so can't reduce ambient winds at all.

1024- SOO track CN peak - 200/cc above ambient. We put a zero filter on CCNC and got counts don to 161/cc in sum of channels > 14. However, the CCN are now > CN by about 100/cc.

1145- Possible Truxten/Mt. Vernon plume in 10-15 min.

1230- Changed Butanol in CNC to see if counts go up to exceed CCNC. Answer - NO.

1245- Smoke test

Blazed a match directly into intake on mast. CN has 20 sec delay. 1 min 53 sec delay for CCN. It took 1min 40 sec for CN to return to normal and 5 min 40 sec for CCN to return to normal.

1555-Plume of Truxten passage. 5 nm upwind passage 10 m/s

CCN = 45, 51, 56, 22, 22, 34, 44, 29, 36, 40, 70, 38, 42, 29, 40, 39, 52, 56, 59, 65, 45, 33, 75, 55, 27, 26, 46, 46, 43, 56, 35.

We have ceased to attempt to measure the Truxten plume.

1630- An announced encounter with a plume.

1750- Waited for last Truxten plume due 1715. - Did not occur. Passage 3 nm upwind. Saved as MONSCR.007.

1855- Turned to a heading of 150 - Back to Huehuene? Aerosol sampling only our own stack.

2130- Lost port engine. Limping home downwind on one lung, no spares.

2200- Bed.

29 June

0700- Up

Engine back. 120 mi from Huehueme, should be in 0700 tomorrow. Winds 12 m/s 345, course 115 @ 8 kts. Winds are from starboard side, waves are 11 feet. Dave was washed don the deck last night. We are in our own exhaust. Requested Satellite info on tracks of opportunity. J. D. does not want to deviate from course..

1025- Moved intake hose to bridge-level upwind railing. We have a SOO off our starboard bow headed NW, about 50 nm away, expect he will cross our bow and provide a track to study. Moving intake hasn't helped much. CN now about 1200.

1040- No improvement on intake, I will move back to mast. Air at deck level is > 10,000 so it may be real background, we are nearing the coast.

1540- Up from nap. Calming down, up from nap.

1606- Mexican freighter passes 1 nm off port side, coming around 40 degrees into the wind.

1609- Plume encounter. Did a DIFF BAT on plume, probably some contamination from GLORITA. We turned from 115 degrees. to 080.

1930- Shut all systems Down. END MAST.