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Title:

Unplanned Airborne Releases at Los Alamos National Laboratory: A Comparison between Observations and Model Predictions

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Internal Technical Report

Unplanned Airborne Releases at Los Alamos National Laboratory: A Comparison between Observations and Model Predictions

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Abstract

The MIDAS plume segment model is the primary emergency plume model of the Emergency Operations Center of LANL. The radiological dose associated with four historical releases of tritium oxide recorded by the AIRNET and stack-monitoring network maintained by RRES-MAQ are compared with MIDAS predictions. In the cases of the two largest releases, dose predictions by the plume segment model of MIDAS are greater than what is measured by AIRNET by up to about a factor of ten. The complex terrain model of MIDAS, on the other hand, frequently underestimates release impacts. In the cases of the two smaller releases, AIRNET doses often exceed MIDAS predictions by both the plume segment and complex terrain models but the releases cannot be distinguished from background. MIDAS' tendency to err on the side of caution makes it a safe emergency tool for estimating impacts of airborne releases.

1.0 Introduction

Los Alamos Laboratory (the Lab) was established in 1943 with the mission of developing the world's first atomic bomb under the Manhattan Project. The isolation of the sparsely-populated location 30 miles northwest of Santa Fe, New Mexico made Los Alamos the ideal venue for the secret project. The Laboratory's name has changed twice since the Manhattan Project; in 1947 the Lab became Los Alamos Scientific Laboratory and in 1981 the name was changed to Los Alamos National Laboratory (LANL). LANL is managed by the Regents of the University of California under a contract that is administered by the National Nuclear Security Administration of the Department of Energy (DOE). The mission has evolved and broadened tremendously in its 60 years of existence, but the Lab is still centered on national defense. LANL's directive today is three-fold: 1) ensuring the safety and reliability of the nation's nuclear arsenal, 2) reducing the global threat of weapons of mass destruction, and 3) solving national problems in energy, infrastructure, and health security.

To fulfill its mission, the Laboratory uses a number of hazardous chemicals and radioactive materials including uranium, plutonium, and tritium (a radioactive form of hydrogen containing two neutrons in addition to a proton in the nucleus). Routine operations at the Laboratory release small quantities of these materials to the environment. Rarely are the releases large enough to be considered hazardous by Environmental Protection Agency (EPA) or New Mexico Environment Department (NMED) standards. Small releases may occur several times per year, usually resulting in potential dose exposure that is a small fraction of the limits set by the EPA. The annual accumulated dose at the site boundary is usually about 1 to 2 millirems. The EPA limit for radiological exposure, as prescribed in 40 CFR 61, is 10 millirems per year. For comparison, natural exposure can be expected to be about 300 millirems per year (NCRP 1988), so clearly the EPA's rule of 10 millirems per year pertains to radiation from anthropogenic activity and not to natural background.

Because of the hazardous nature of the materials used and the potential for airborne releases, the Laboratory has developed an extensive meteorology and air quality program, following DOE and Environmental Protection Agency (EPA) requirements, to monitor local meteorology and airborne releases and to measure the impact of releases on LANL workers, the public, and the environment. The LANL group that manages these activities is the Meteorology and Air Quality (MAQ) group of the Risk Reduction and Environmental Stewardship (RRES) division. Emergency Management and Response (EM&R) personnel of LANL's Emergency Operations Center (EOC) train to prepare for, among many things, possible airborne releases.

Part of the EOC's response includes utilization of a plume dispersion model called MIDAS to predict the spatial extent of a radiological, chemical, or biological release, and to predict doses at any given location at several near-future time intervals. MIDAS, which stands for Meteorological Information and Dispersion Assessment System, makes use of weather information that is gathered by RRES-MAQ's meteorological network (see Fig. 1). Weather data from the Technical Area 6 (TA-6), TA-49, TA-53, and TA-54 towers are retrieved by telephone every 15 minutes and made available to MIDAS. MIDAS incorporates temperature, wind speed, wind direction, precipitation, and standard deviation of wind direction from gauges on the four towers at 11.5 meters above ground level (wind) and near the towers at about 1.2 meters above ground level (temperature, precipitation). In addition, MIDAS internally contains a host of general information such as chemical properties, dose conversion factors, etc.

RRES-MAQ and LANL's EOC recently underwent a transition from an obsolete version of MIDAS which ran on a Hewlett Packard workstation to a new version of MIDAS which runs on a PC. The new MIDAS has an added ability to model biological and chemical agents, and has been correspondingly named "MIDAS-AT" (anti-terrorism) by the manufacturer, ABS Consulting (ABS 2001).

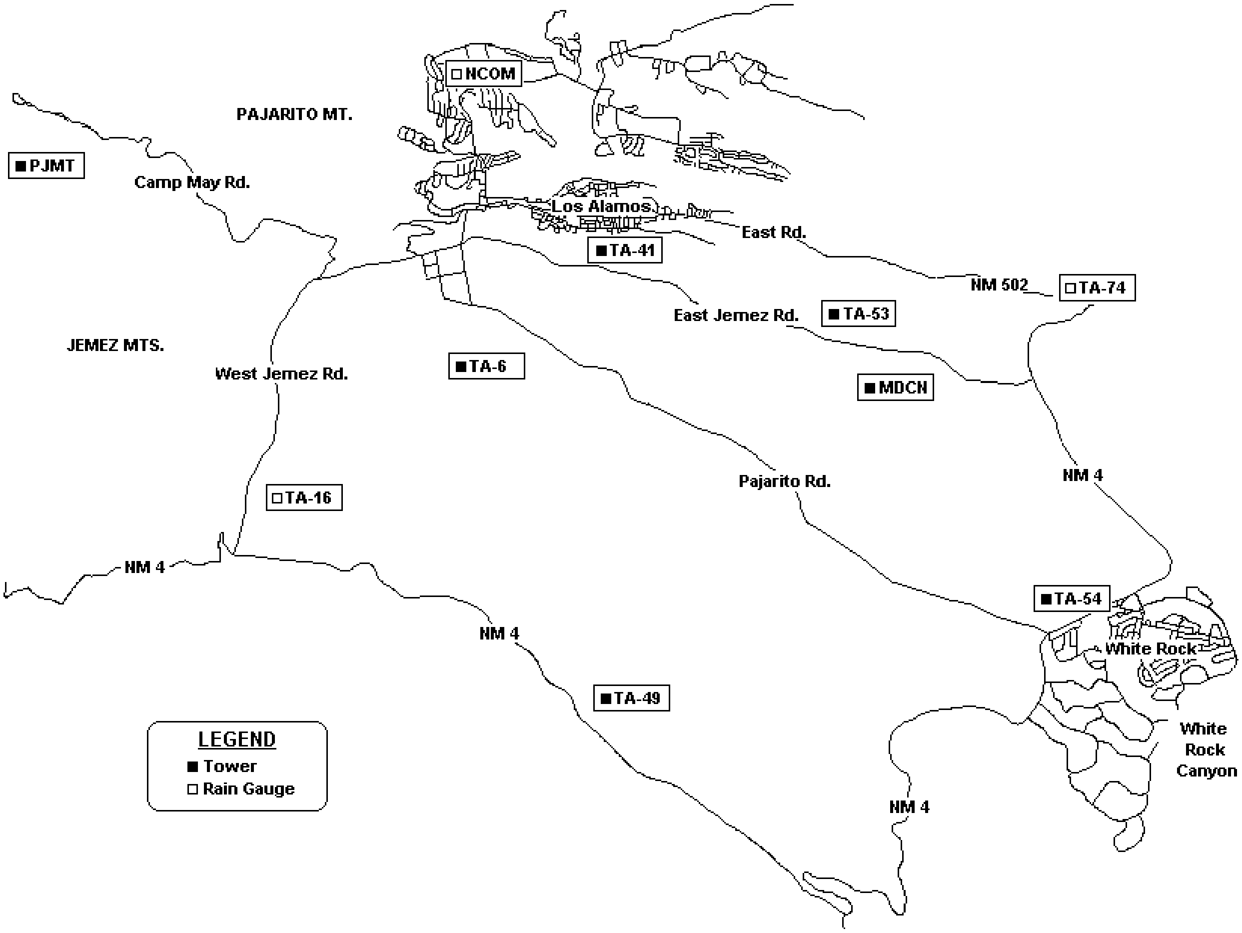
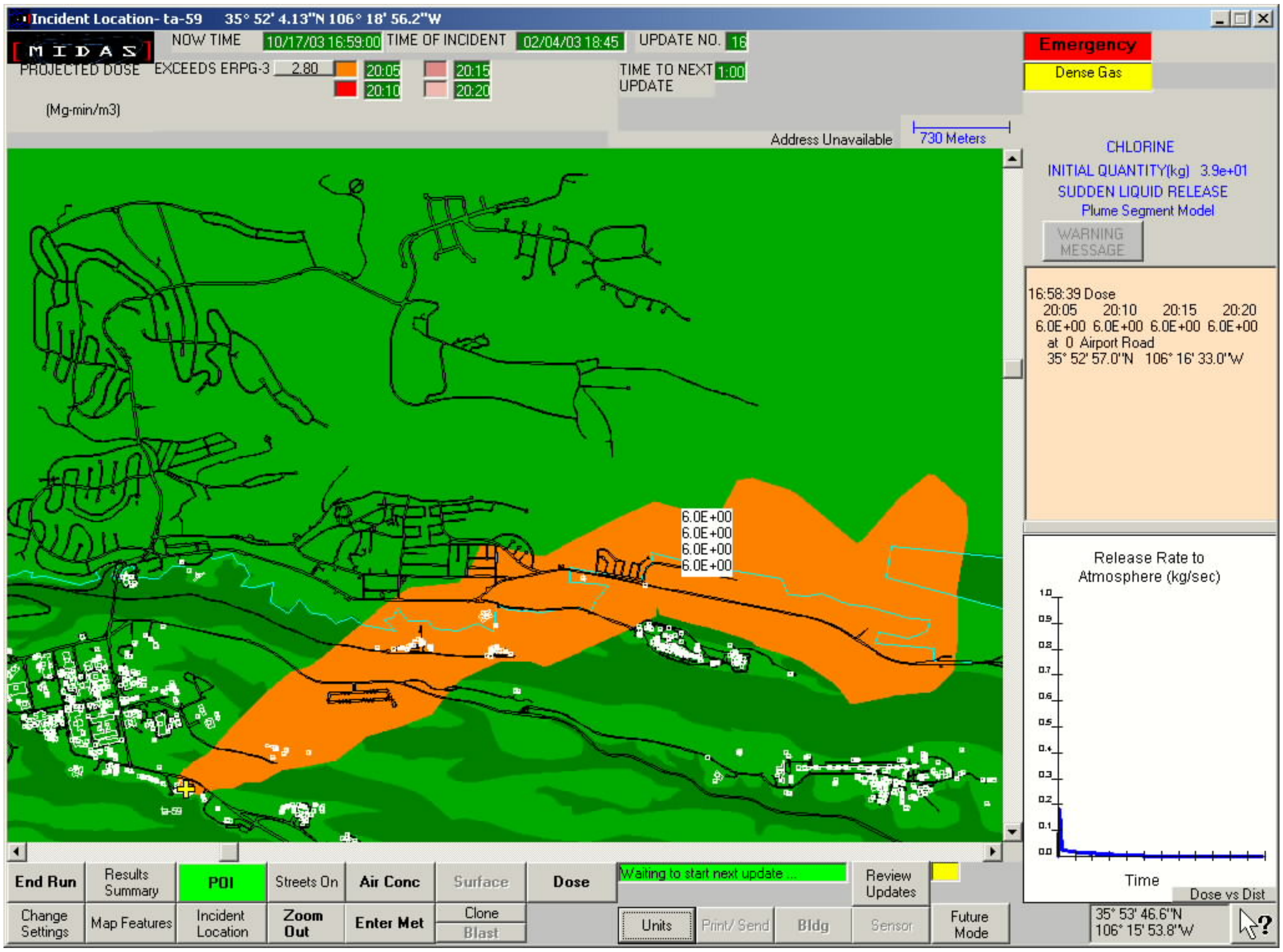


Figure 1. The meteorological monitoring network.

MIDAS-AT is actually composed of two models, the “plume segment” model and the “complex terrain” model. The plume segment model releases “puffs” every minute during the release and follows each puff with a plume track that disperses with a Gaussian shape in the vertical and crosswind directions. The net plume is the superposition of all of the plume tracks, which are updated every five minutes. The plume segment model assumes flat terrain and calculates impacts much more quickly than the complex terrain model. The complex terrain model is much more computationally expensive than the plume segment model, partly because it takes into account variations in terrain elevation. The complex terrain model is also fundamentally different from the plume segment model and does not, for example, assume Gaussian dispersion. Instead, the complex terrain model divides the released quantity into tens of thousands of packets and calculates the path of each packet. Small random perturbations are applied to packet velocities to generate dispersion. Despite the appeal of the complex terrain model given the strongly varying terrain at LANL, the plume segment model is used almost exclusively, primarily due to the fact that even a very brief release takes many minutes to run using the complex terrain model.


Incident Location- ta-59 35° 52' 4.13"N 106° 18' 56.2"W

NOW TIME 10/17/03 16:59:00 TIME OF INCIDENT 02/04/03 18:45 UPDATE NO. 16

PROJECTED DOSE EXCEEDS ERPG-3 2.80 (Mg-min/m3)

🟧 20:05 🟥 20:10 20:15 20:20

TIME TO NEXT UPDATE 1:00

Emergency

Dense Gas

Address Unavailable

CHLORINE
INITIAL QUANTITY(kg) 3.9e+01
SUDDEN LIQUID RELEASE
Plume Segment Model

16:58:39 Dose
20:05 20:10 20:15 20:20
6.0E+00 6.0E+00 6.0E+00 6.0E+00
at 0 Airport Road
35° 52' 57.0"N 106° 16' 33.0"W

Waiting to start next update ...

35° 53' 46.6"N
106° 15' 53.8"W

Figure 2. A hypothetical chlorine release using the plume segment model.

Figure 2 shows a hypothetical release of 25 kg of liquid chlorine from TA-59 building 1 using the plume segment model. The curve in the plume path demonstrates that MIDAS responds to changes in weather as it receives meteorological information (every 15 minutes). The "point of interest" (POI) function has been activated and indicates (in the white window in Fig. 2) a time-integrated air concentration of 6 mg-min per cubic meter of chlorine at the Los Alamos Airport located at the southeast corner of the Los Alamos town site. The POI function produces four values, in this case four identical values, that correspond to dose or concentration at four different future times (e.g. 5, 10, 15, and 20 minutes from now) assuming that the current meteorology remains the same.

In addition to plume modeling, RRES-MAQ monitors stack emissions and maintains the AIRNET system of ambient air monitors located across LANL and around nearby towns. Fig. 3 shows AIRNET stations in the LANL/Los Alamos/White Rock area. Fig. 4 shows a typical AIRNET station, standing about 5 to 6 feet tall.

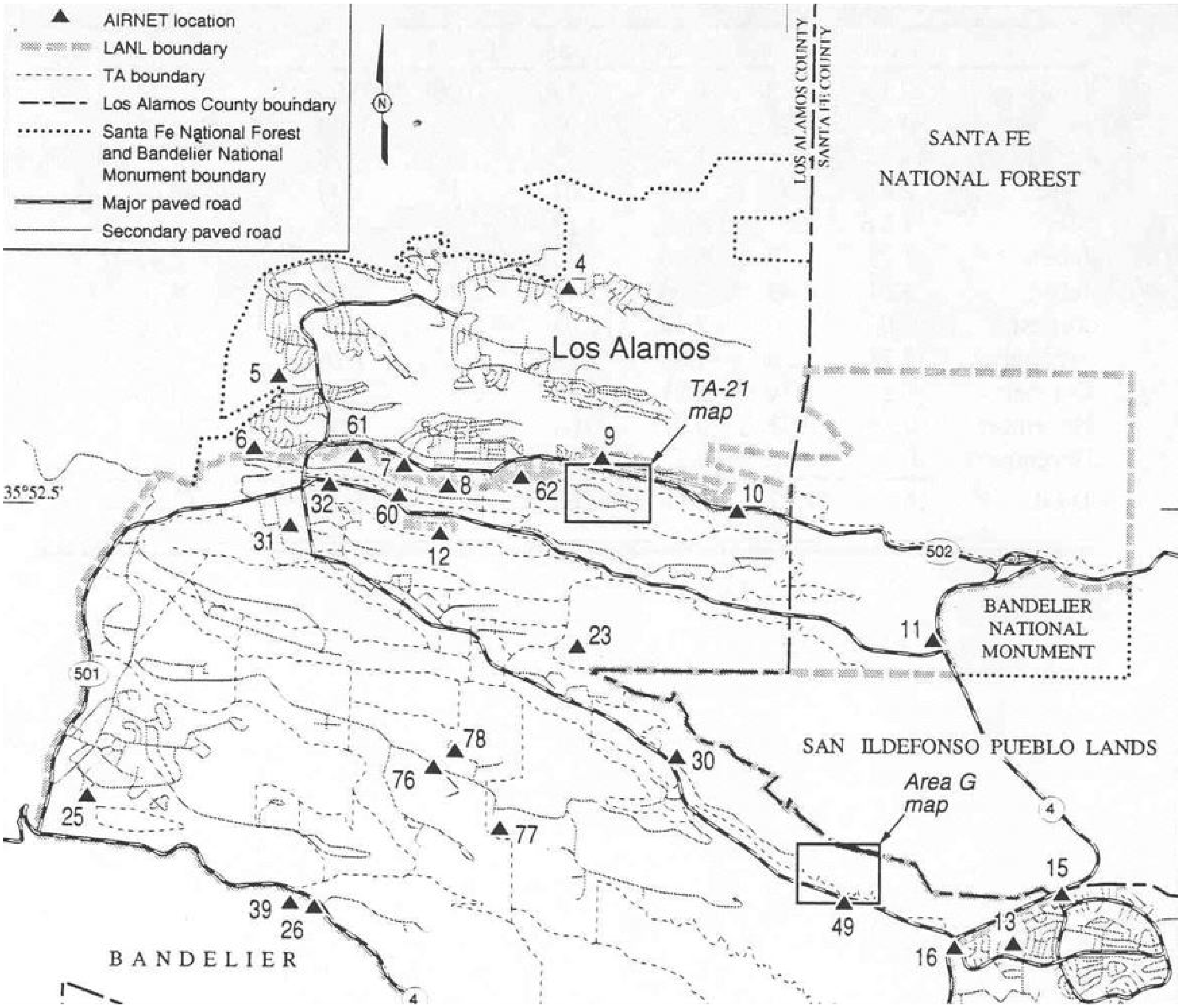


Figure 3. The AIRNET network.

AIRNET stations contain particulate filters and silica gel cartridges and a pump to draw air through the filter and cartridge. As air is drawn through the apparatus, airborne particulates are trapped by the filter and tritium oxide is trapped by the silica gel. The filters and cartridges are removed for analysis and replaced every two weeks. The stack monitors provide an actual record of the amount of radiological substances released from certain facilities while the AIRNET network tells the dose received at AIRNET locations. AIRNET samples are analyzed once every two weeks. Stack samples are analyzed once per week.

Figure 4. An AIRNET station.

The purpose of this study is to compare the doses resulting from actual historical releases as recorded by the AIRNET and stack-monitoring network with the MIDAS model predictions. Model results are compared to observations on a release-by-release basis. Four releases were found for which ample information existed to model the release. Critical information includes the identity and amount of the radionuclide released as well as the exact time span of the release. Unless the correct weather is selected for input to MIDAS, the model can not be expected to mimic the actual plume evolution with any similarity. Hence the importance of knowing the start and end times of the release, preferably to the nearest hour. Three of the four releases for which the time and amount of release were reasonably well known all occurred from a 23-meter stack that ventilates building 209 at TA-21 and involved tritium. The fourth release occurred from TA-21 building 155 and also involved tritium. Fig. 5 shows AIRNET stations located at TA-21.

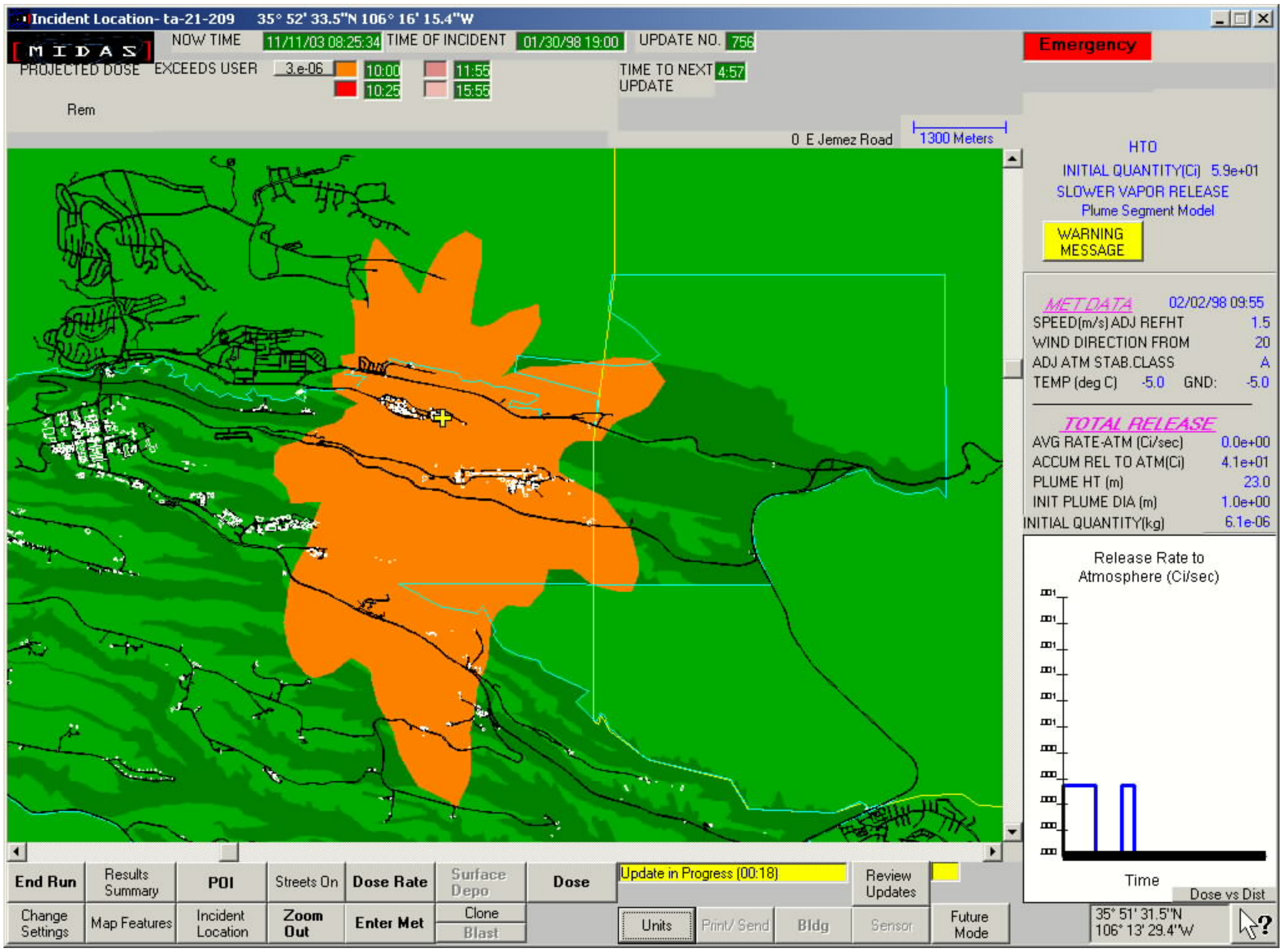
This figure has been removed for operational security purposes. Please contact ENV-MAQ at (505) 665-8855 for a hard copy of the figure.

Figure 5. AIRNET stations at TA-21.

2.0 Release #1: 59 Curies of HTO from TA-21 from 30 January to 2 February 1998

On Friday, January 30th 1998 at about 7 pm, the stack at the Tritium Salt Fabrication Facility (TA-21 building 209) began to release "tritiated" water vapor, or tritium oxide (HTO). The release was noticed and halted on Monday, February 2nd at 7am. The integrating ion chamber stack monitor indicated that about 59 Curies had been released over the weekend. The dose at the site boundary, the highest for all releases investigated here, was orders of magnitude below the 10 millirem EPA standard and was no threat to the public. The release took place over a 60-hour period, so weather conditions varied relatively widely from the start to the end of the release.

Figure 6 shows the plume as calculated by the MIDAS plume segment model. A plume was not calculated using the complex terrain model since any release longer than a few hours can not be modeled using the complex terrain model at this time. The area in orange shows where MIDAS calculates a dose of 0.003 millirems or higher. Although MIDAS predicts doses at present time and three future times such as 5, 30, and 120 minutes from the present, the dose picture usually stops growing within an hour of the end of the release. For this reason, the MIDAS integration (here, and in the rest of the cases studied) is run from the start of the release to one hour beyond the end of the release.



Incident Location- ta-21-209 35° 52' 33.5"N 106° 16' 15.4"W

NOW TIME 11/11/03 08:25:34 TIME OF INCIDENT 01/30/98 19:00 UPDATE NO. 756

PROJECTED DOSE EXCEEDS USER 3.e-06 Rem 10:00 10:25 11:55 15:55

TIME TO NEXT UPDATE 4:57

HTO
INITIAL QUANTITY(Ci) 5.9e+01
SLOWER VAPOR RELEASE
Plume Segment Model

MET DATA 02/02/98 09:55
SPEED(m/s) ADJ REFHT 1.5
WIND DIRECTION FROM 20
ADJ ATM STAB.CLASS A
TEMP (deg C) -5.0 GND: -5.0

TOTAL RELEASE
AVG RATE-ATM (Ci/sec) 0.0e+00
ACCUM REL TO ATM(Ci) 4.1e+01
PLUME HT (m) 23.0
INIT PLUME DIA (m) 1.0e+00
INITIAL QUANTITY(kg) 6.1e-06

Update in Progress (00:18)

35° 51' 31.5"N
106° 13' 29.4"W

Figure 6. Dose plume calculated by the MIDAS "plume segment" model for 59 Curies HTO released from 31 Jan 1998 at 1900 to 2 Feb 1998 at 0700 (release #1).

Figure 7 shows a wind rose that represents the wind activity during the 60 hour release period plus one hour beyond the end of the release. The length of each of the 16 spokes is proportional to the length of time that wind flowed in the direction of each spoke (from the center outward). Wind flowed to the north, for example, about 4.5% of the time, as indicated by the tick-marks.

In addition to providing a histogram of wind direction, a wind rose is also a histogram of wind speed. The length of the rectangles that can be seen along some "spokes" is proportional to the percentage of time that the wind speed was between 2.5 and 5 meters per second (about 6.25 and 12.5 miles per hour, respectively). The portion of each spoke where there is no rectangle has a length proportional to the amount of time that the wind speed was between 0.5 meters per second and 2.5 m/s. For example, while winds were directed to the east about 8% of the time, a little more than half of that time the winds were between 2.5 and 5 m/s. A little less than half the time that wind blew to the east, the wind speed was below 2.5 m/s but was measurable. Wind was calm (below 0.5 meters per second in any direction) for a total of 2.4% of the 61-hour period represented.

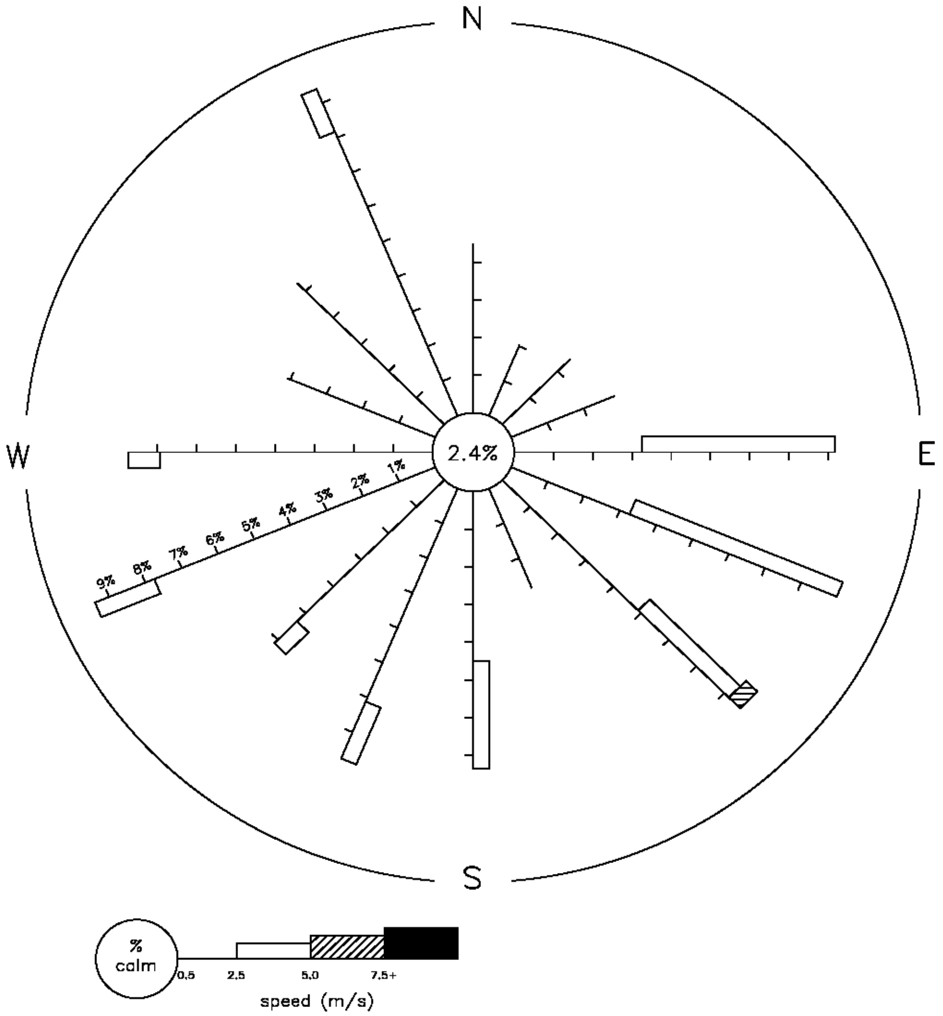
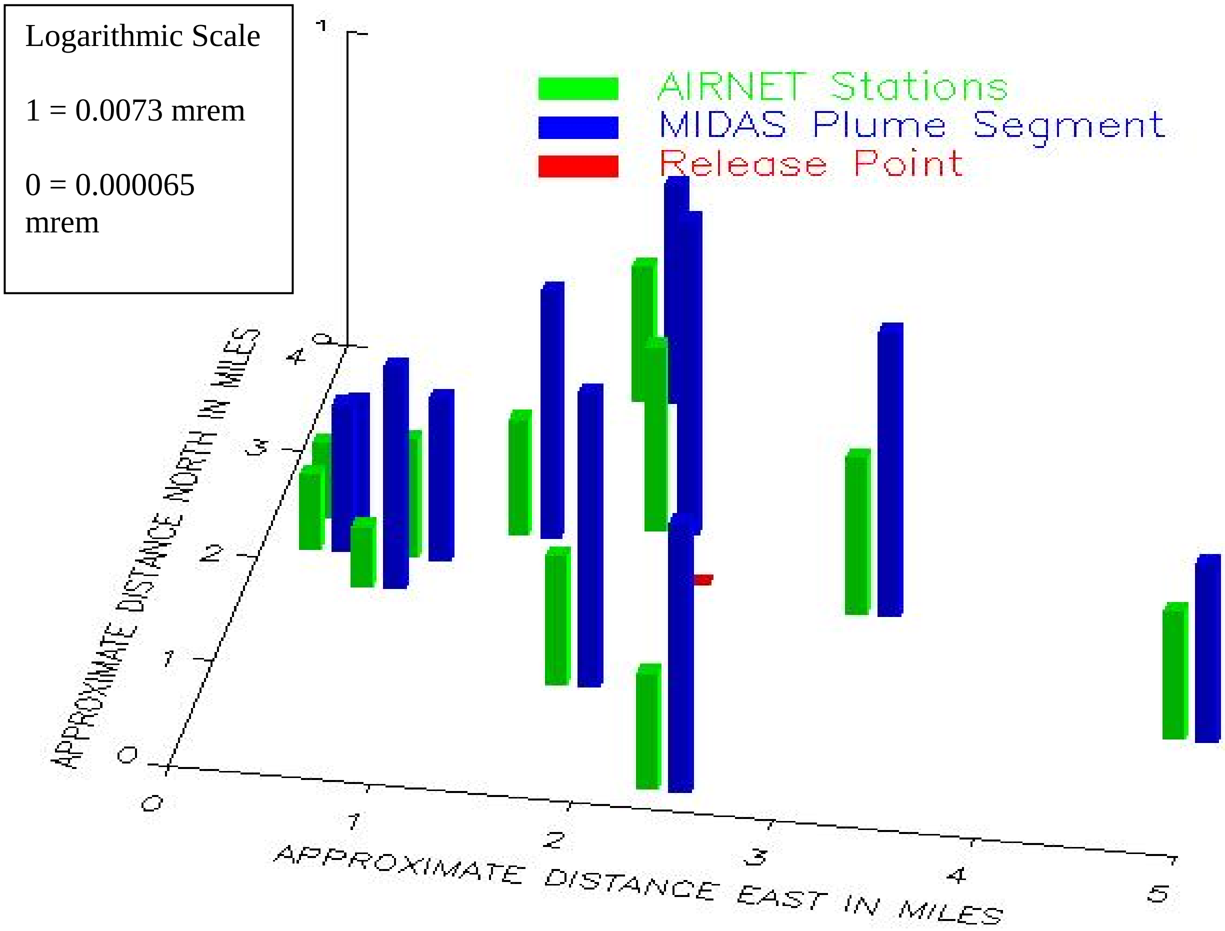


Figure 7. Wind rose for the 61 hour time of MIDAS integration of release #1.

Figure 8 shows a three-dimensional bar graph of the doses as measured at the AIRNET stations (green bars) and as calculated by MIDAS at the AIRNET station locations (blue bars). TA-21 building 209 is represented as a red square. The "point of interest" (POI) function of MIDAS was utilized to determine the dose at AIRNET station locations, as closely as the locations could be estimated. Since the doses as measured differ from the doses as calculated by sometimes more than a factor of ten, the scale of the z-axis is logarithmic. On the bar graph of Fig. 8, Z = 1 is equivalent to 7.3 e-3 millirem and z = 0 is equivalent to 6.5 e-5 millirem. The three-dimensional bar graph is intended to provide a qualitative picture of the spatial pattern of dose measurements and dose calculations so the two can be compared with each other and to the wind rose. A more quantitative comparison will come in Fig. 10. Nonetheless, it is immediately apparent in Fig. 8 that the doses as calculated by MIDAS are always greater than the doses as measured by AIRNET.



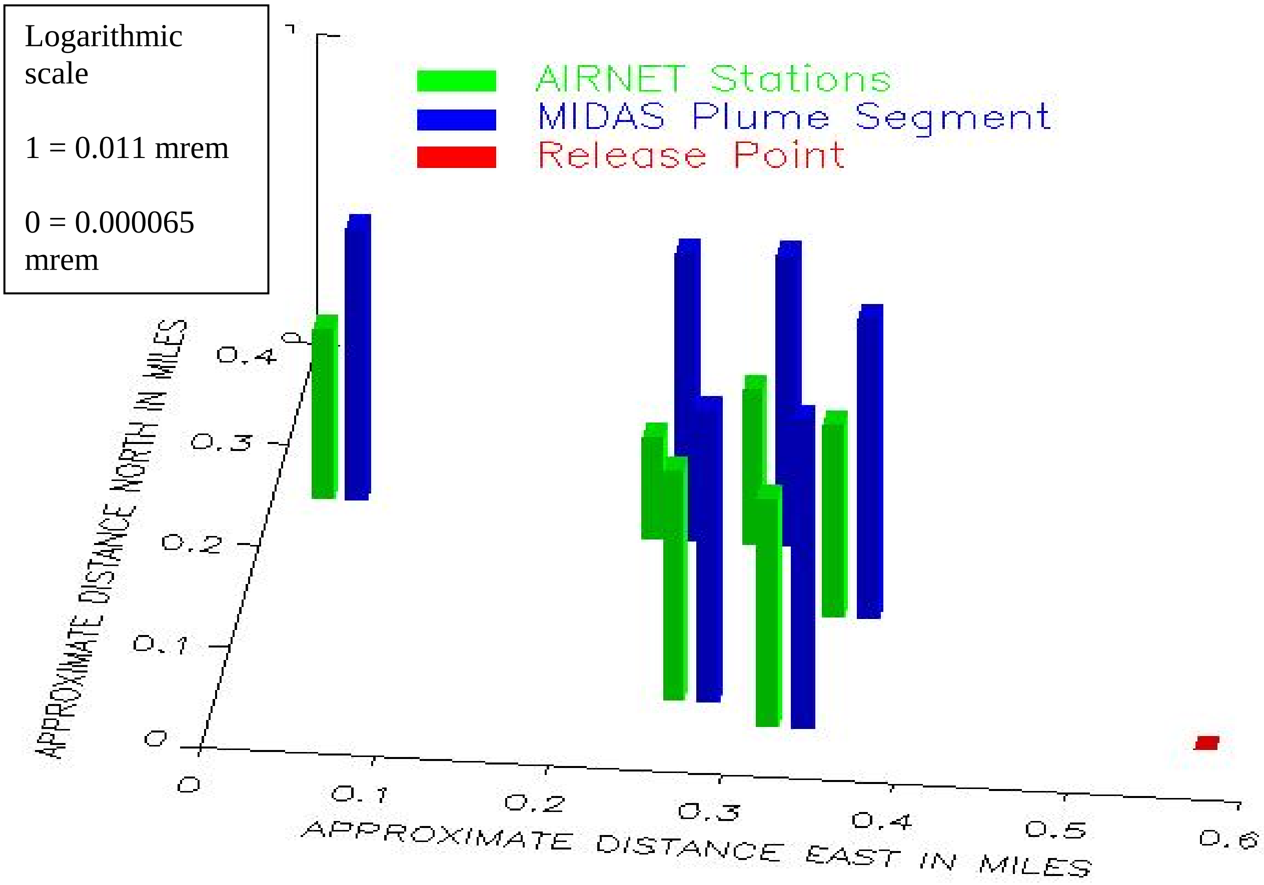
Logarithmic Scale

1 = 0.0073 mrem

0 = 0.000065 mrem

Figure 8. Measured (green) and calculated (blue) doses at AIRNET stations for release #1.

Figure 9 shows a "close-up" of dose comparisons around TA-21. Again, doses as calculated by MIDAS are always greater than the doses that are actually measured.



Logarithmic scale

1 = 0.011 mrem

0 = 0.000065 mrem

Figure 9. Measured (green) and calculated (blue) doses at TA-21 AIRNET stations for release #1.

Figure 10 shows a comparison between the measured dose and calculated dose at all AIRNET stations for release #1. The scale of the graph is logarithmic and the maximum is set to 10 millirem, which is the EPA maximum annual recommended dose. The largest calculated dose is about three lines (or powers of ten) lower than 10 millirem, approximately one tenth of one percent of the EPA standard. The largest measured dose, occurring at TA-21 AIRNET stations 74 and 75, is 2.8 e-3 millirem, or about one fortieth of one percent of the EPA standard. The MIDAS and AIRNET profiles on Fig. 10 track each other fairly well. That is, there is good correlation between the two (correlation = 0.75). This good correlation demonstrates that MIDAS and AIRNET are in fairly good agreement as to the spatial distribution of the dose. Finally, the MIDAS dose calculations clearly exceed the measured doses at every AIRNET location by up to about one order of magnitude. This can partially be explained by the greater dose conversion factor for HTO in MIDAS (96 rem per Curie) than in the literature (about 64 rem per Curie, Eckerman et al. 1988). But this difference amounts to less than a factor of two, so MIDAS appears to be trained to give conservative results, which is not surprising given that MIDAS is intended for use in emergency management where to err on the side of caution is the rule.

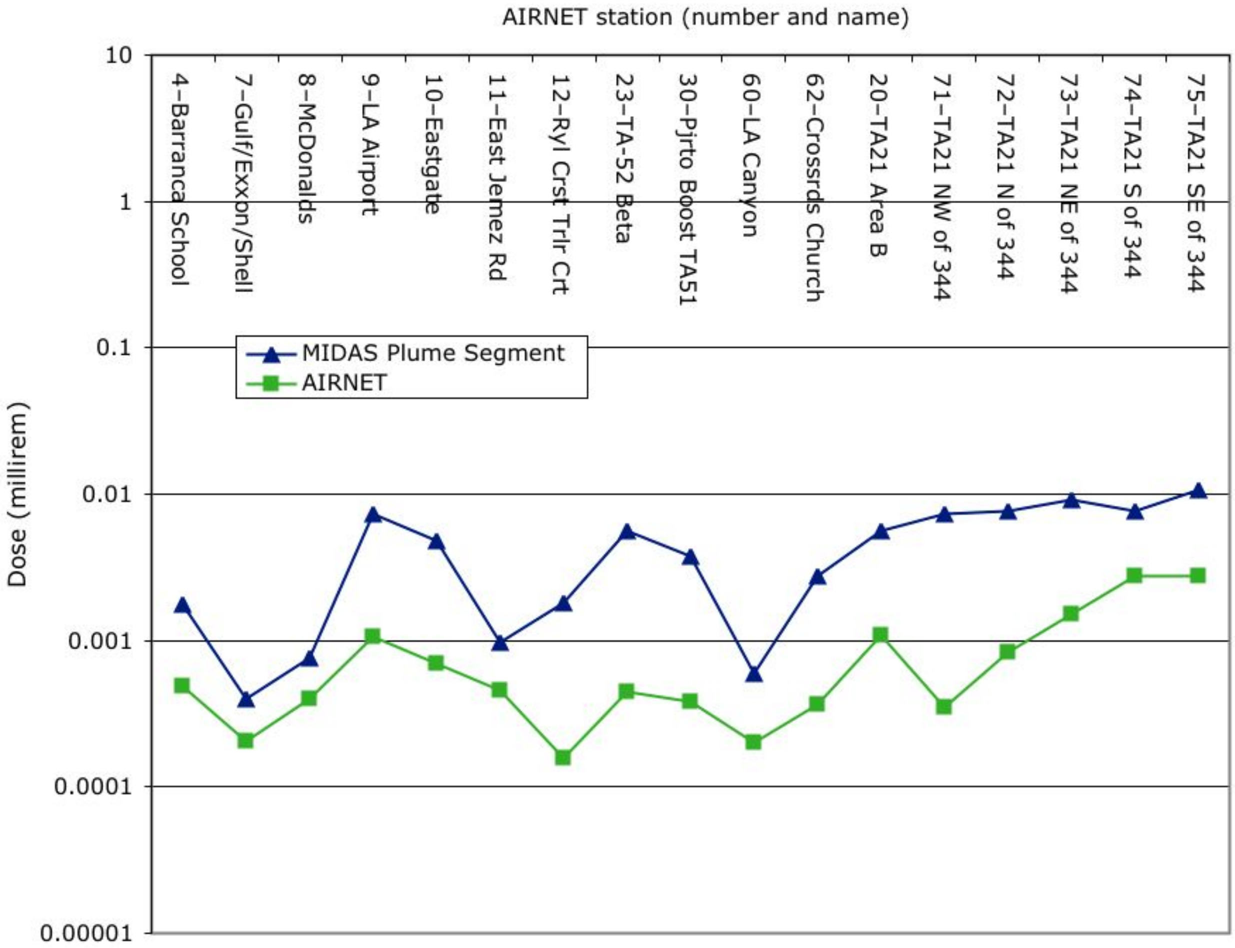
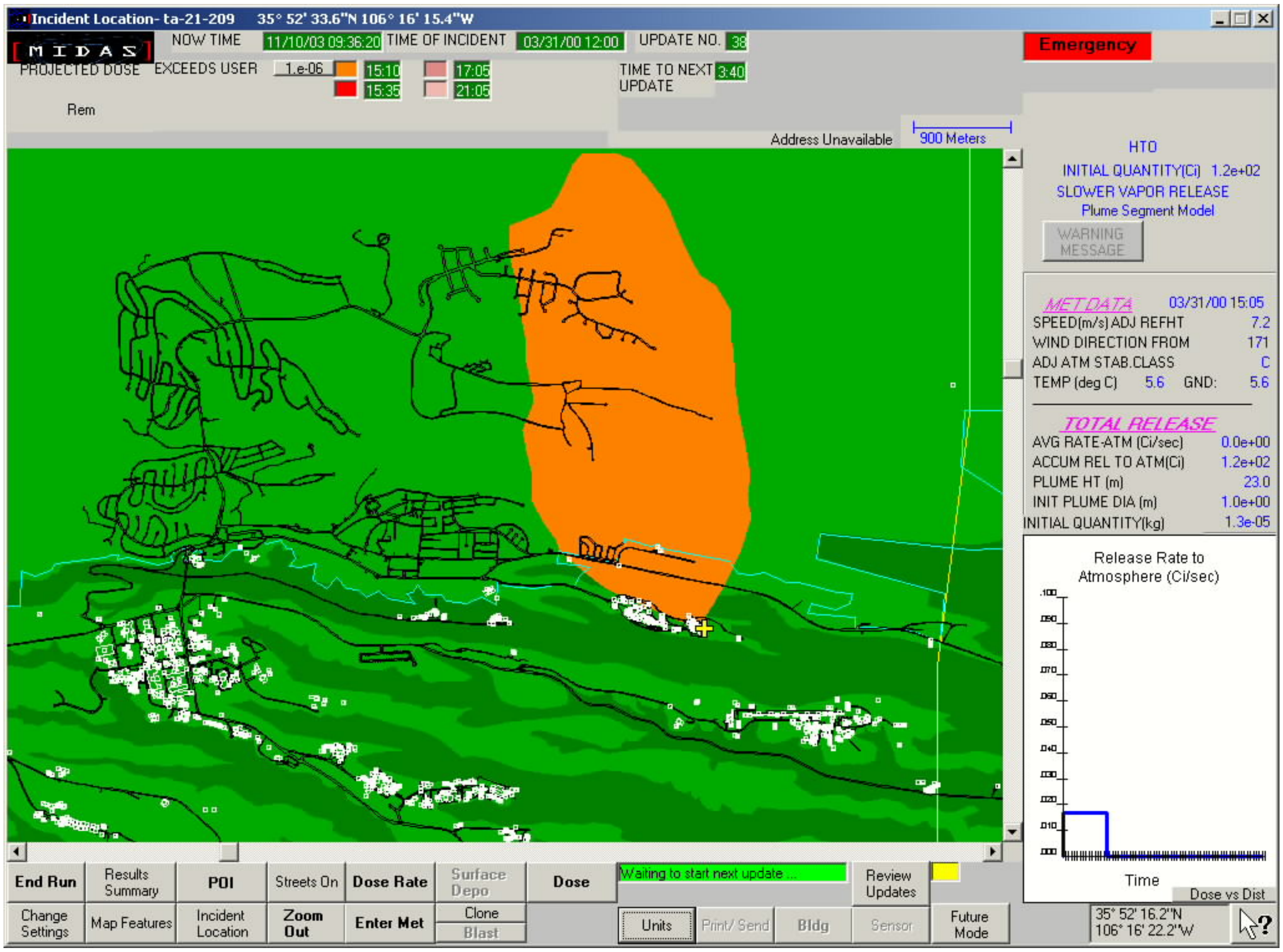


Figure 10. Measured (green) and calculated (blue) doses at all AIRNET stations for release #1.

3.0 Release #2: 122 Curies of HTO and 90 Curies HT from TA-21-209 on 31 March 2000

The MAQ stack monitor at TA-21-209 reported that about 122 Ci of HTO and about 90 Ci of HT were released during the week from March 28th to April 3rd, 2000. This is the largest emission of tritium oxide during any week that I have found at TA-21. A log book from a worker at the time of the release from TSFF noted that the release began at about 12:10 pm on 31 March 2000 and ended about 2 hours later, at 2 pm. No other details about the release were available.

Figure 11 shows the dose plume as calculated by the MIDAS plume segment model for 122 Curies of HTO. The 90 Curies of HT are ignored because HT has a dose conversion factor thousands of times smaller than that of HTO, and hence the released HT does not significantly contribute to the dose. The integration start time was noon on 31 March 2000 and ended at 3 pm (again, about one hour after the end of the actual release). In contrast to the 60-hour release #1, the plume is seen to travel only to the north/northwest. This is in agreement with the winds during the 3-hour integration period shown in Fig. 12.



Incident Location- ta-21-209 35° 52' 33.6"N 106° 16' 15.4"W

NOW TIME 11/10/03 09:36:20

TIME OF INCIDENT 03/31/00 12:00

UPDATE NO. 38

PROJECTED DOSE EXCEEDS USER 1.e-06 Rem

🟧 15:10

🟥 15:35

17:05

21:05

TIME TO NEXT UPDATE 3:40

Address Unavailable

HTO

INITIAL QUANTITY(Ci) 1.2e+02

SLOWER VAPOR RELEASE

Plume Segment Model

MET DATA 03/31/00 15:05

SPEED(m/s) ADJ REFHT 7.2

WIND DIRECTION FROM 171

ADJ ATM STAB.CLASS C

TEMP (deg C) 5.6 GND: 5.6

TOTAL RELEASE

AVG RATE-ATM (Ci/sec) 0.0e+00

ACCUM REL TO ATM(Ci) 1.2e+02

PLUME HT (m) 23.0

INIT PLUME DIA (m) 1.0e+00

INITIAL QUANTITY(kg) 1.3e-05

Waiting to start next update ...

35° 52' 16.2"N
106° 16' 22.2"W

Figure 11. Dose plume calculated by the MIDAS "plume segment" model for 122 Curies HTO released from 1200 to 1400 on 31 March 2000 (release #2).

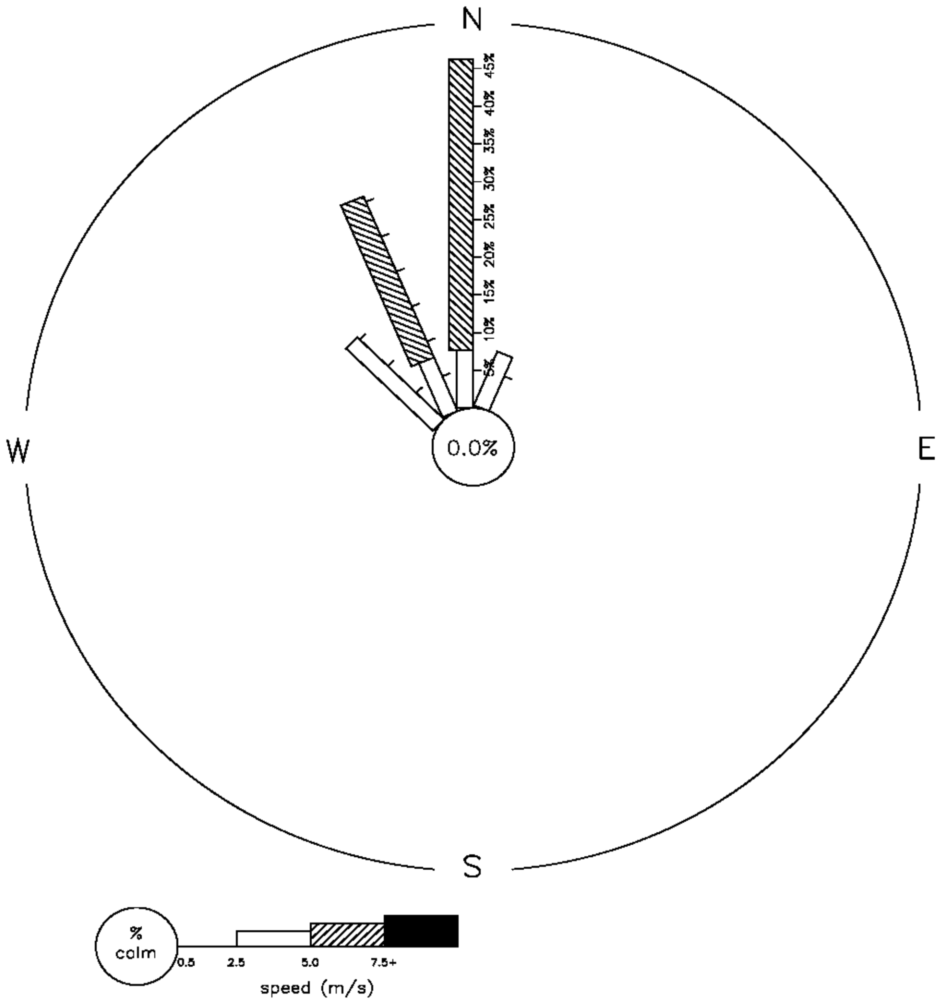
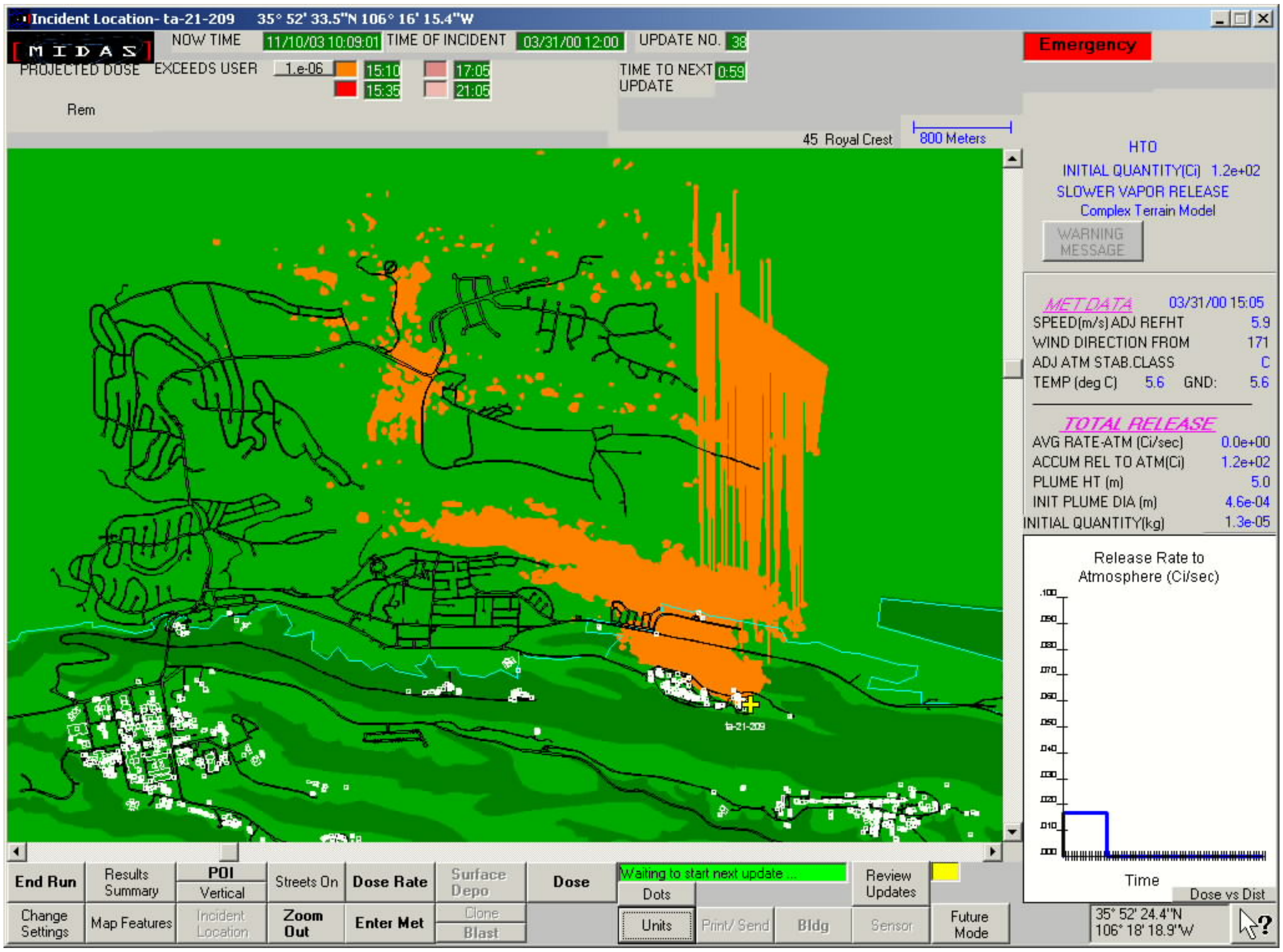


Figure 12. Wind rose for the 3 hours of the MIDAS integration for release #2.



Incident Location- ta-21-209 35° 52' 33.5"N 106° 16' 15.4"W

NOW TIME 11/10/03 10:09:01

TIME OF INCIDENT 03/31/00 12:00

UPDATE NO. 38

PROJECTED DOSE EXCEEDS USER 1.e-06 Rem

🟧 15:10 ▨ 17:05

🟥 15:35 ☐ 21:05

TIME TO NEXT UPDATE 0:59

HTO

INITIAL QUANTITY(Ci) 1.2e+02

SLOWER VAPOR RELEASE

Complex Terrain Model

MET DATA 03/31/00 15:05

SPEED(m/s) ADJ REFHT 5.9

WIND DIRECTION FROM 171

ADJ ATM STAB.CLASS C

TEMP (deg C) 5.6 GND: 5.6

TOTAL RELEASE

AVG RATE-ATM (Ci/sec) 0.0e+00

ACCUM REL TO ATM(Ci) 1.2e+02

PLUME HT (m) 5.0

INIT PLUME DIA (m) 4.6e-04

INITIAL QUANTITY(kg) 1.3e-05

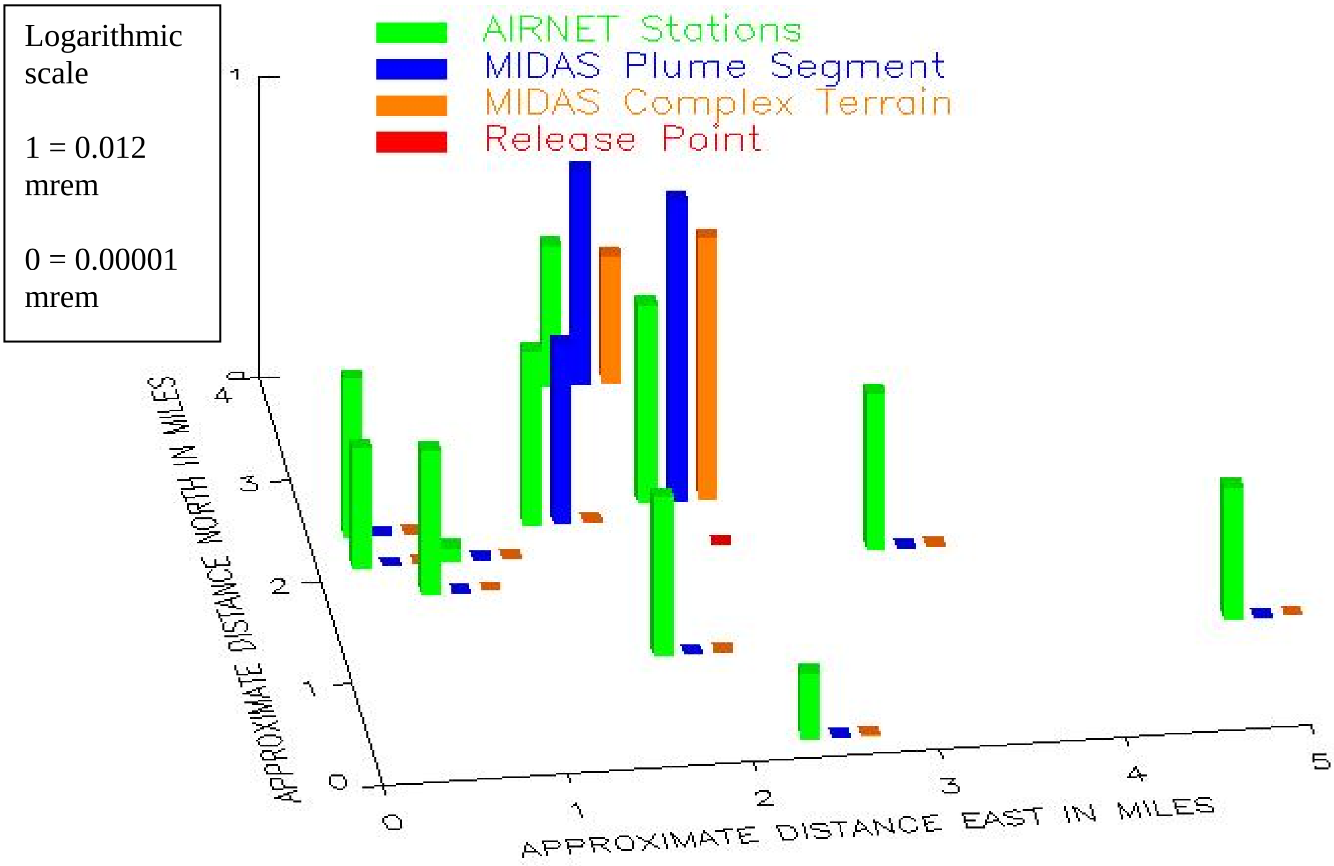
Waiting to start next update ...

35° 52' 24.4"N 106° 18' 18.9"W

Figure 13. Dose plume calculated by the MIDAS "complex terrain" model for 122 Curies HTO released from 1200 to 1400 on 31 March 2000 (release #2).

A three-hour integration is brief enough to be modeled using the complex terrain model of MIDAS as well, and the result is shown in Fig. 13. The packet-following complex terrain model tends to produce a "spotty" dose signature while the Gaussian plume segment model tends to keep the dose together in one large patch or a few patches.

The complex terrain model also tends to have spurious additions to the plume, which manifest (in this particular model run) as vertically-oriented lines running directly north of the release point. One clear advantage of the complex terrain model is the inclusion of terrain elevation, which is apparent in Fig. 13. The plume clearly broadens in the canyon adjacent to and north of the release point. This is evidently due to re-circulation in the canyon as the plume proceeds across it, resulting in a greater dose impact there. The plume then becomes constricted as it travels north across the narrow east-west oriented mesa top where Los Alamos Airport is located. Just north of the Airport, however, is the large and deep Pueblo Canyon. The orange plume marks deep areas and shows a good footprint of Pueblo Canyon extending west to the intersection of several other canyons (the locations of which can be guessed by the absence of streets). The plume can even be seen to branch into Graduation Canyon south of, and parallel to, Pueblo Canyon (near the center of the plume in the east-west direction). Looking further north, the plume again has a greater impact on lower areas and tends to “miss” mesa tops (where streets and residential areas are located).


Logarithmic scale

1 = 0.012 mrem

0 = 0.00001 mrem

Figure 14. Measured (green) and calculated (blue) doses at AIRNET stations for release #2.

The bar graph comparing measured and calculated does levels at the AIRNET stations in shown in Fig. 14. Here we see that MIDAS predicts a dose only to the north/northwest of the release point while AIRNET measures doses at nearly all stations. This highlights an important difference between what is measured by AIRNET and what MIDAS calculates. MIDAS is intended for emergency management and calculates the impact of only the given release while AIRNET will see the sum of everything that is released during the two-week period containing the release incident. TA-21 can be expected to release about 7 Curies of HTO during a two week span so the release incidents that have occurred involve release amounts that are not vastly greater than the “noise”. This means that the smaller the amount released during the modeled incident, the greater the difference between what MIDAS predicts and what AIRNET measures.

Figure 14 shows that the MIDAS plume segment model again appears to be very conservative in comparison to what is actually measured, given the important caveat that MIDAS will only show a plume in the direction that the wind carries it! The complex terrain model, whose calculations are shown by the orange bars, is not as conservative as the plume segment model but produces doses that are closer, on average, to the AIRNET measurements. The same characteristics are apparent as we zoom in to TA-21 in Fig. 15. (Only two AIRNET stations were active at TA-21 during the release, hence only two green bars.) Again, the complex terrain model calculates smaller doses than the plume segment model.

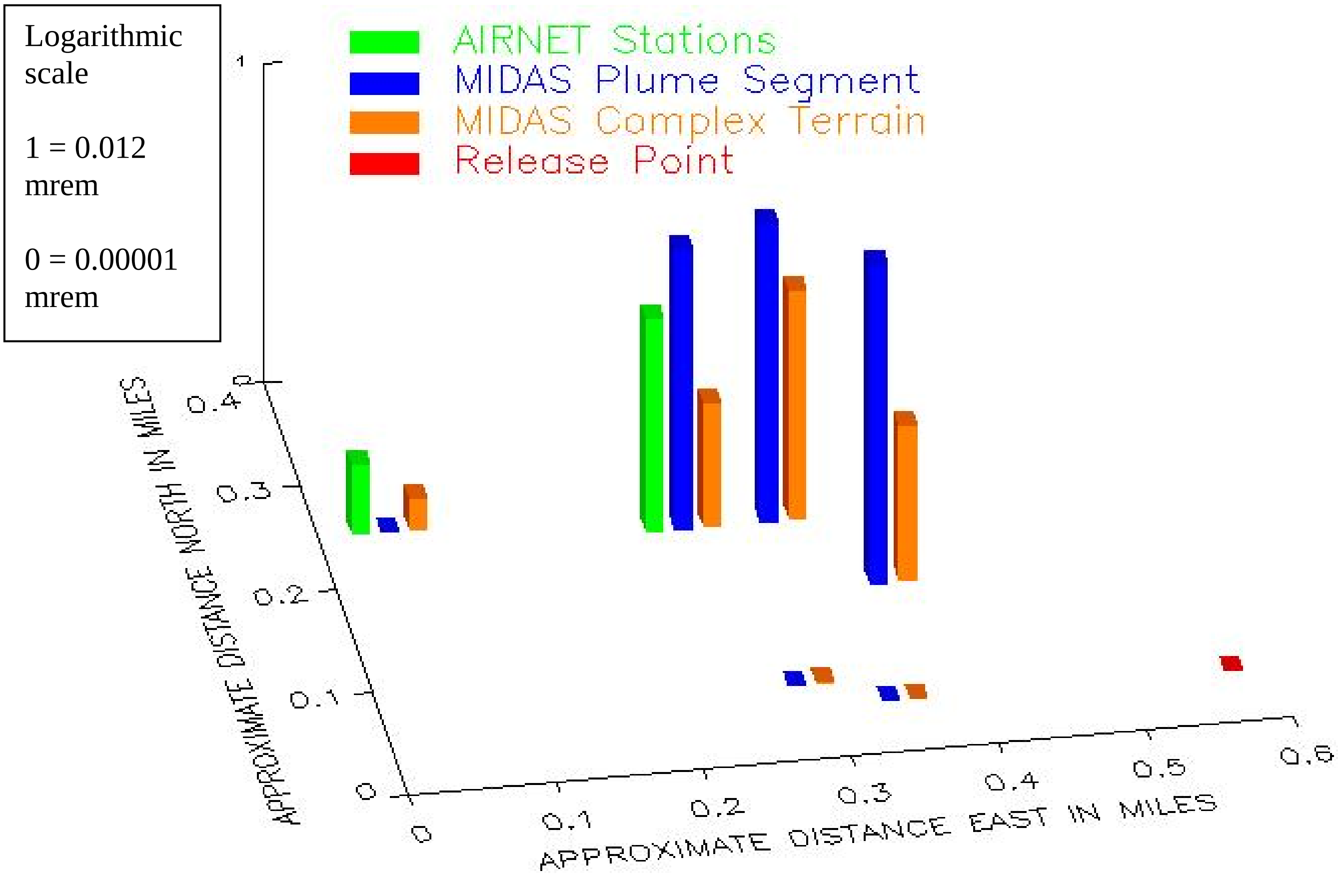


Figure 15. Measured (green) and calculated (blue) doses at TA-21 AIRNET stations for release #2.

Measured and calculated doses at all AIRNET stations are shown together in Fig. 16. As with release #1 (involving about half as much HTO), the highest calculated dose at any AIRNET station amounts to about one tenth of one percent of the EPA standard of 10 millirems per year. The highest measured dose (green AIRNET profile) is about one one-hundredth of one percent of the EPA standard. How can it be that the highest measured dose, given that the release was twice the amount of HTO as in release #1, is about the same as the highest measured dose in that case (compare Fig. 10)? The answer is probably that release #2 occurred only during daylight hours, during the time of day when solar heating of the ground causes warm air to rise resulting in an upward expansion of the well-mixed layer adjacent to the ground to an altitude of perhaps several kilometers. Release #1, although it involved a smaller release, occurred partly during nighttime when the atmosphere near the ground is relatively stable. In that case, an airborne release would remain closer to the ground, resulting in a higher dose.

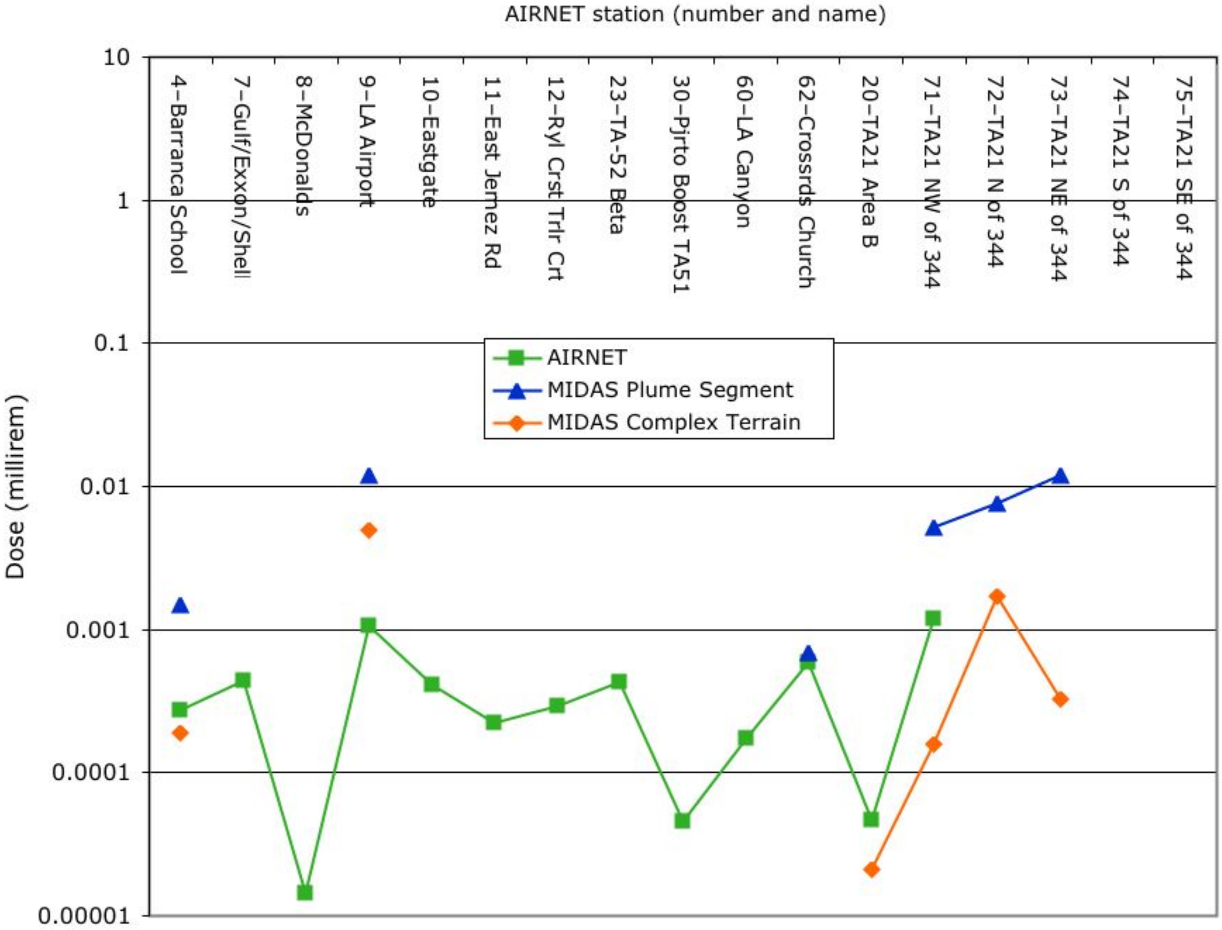


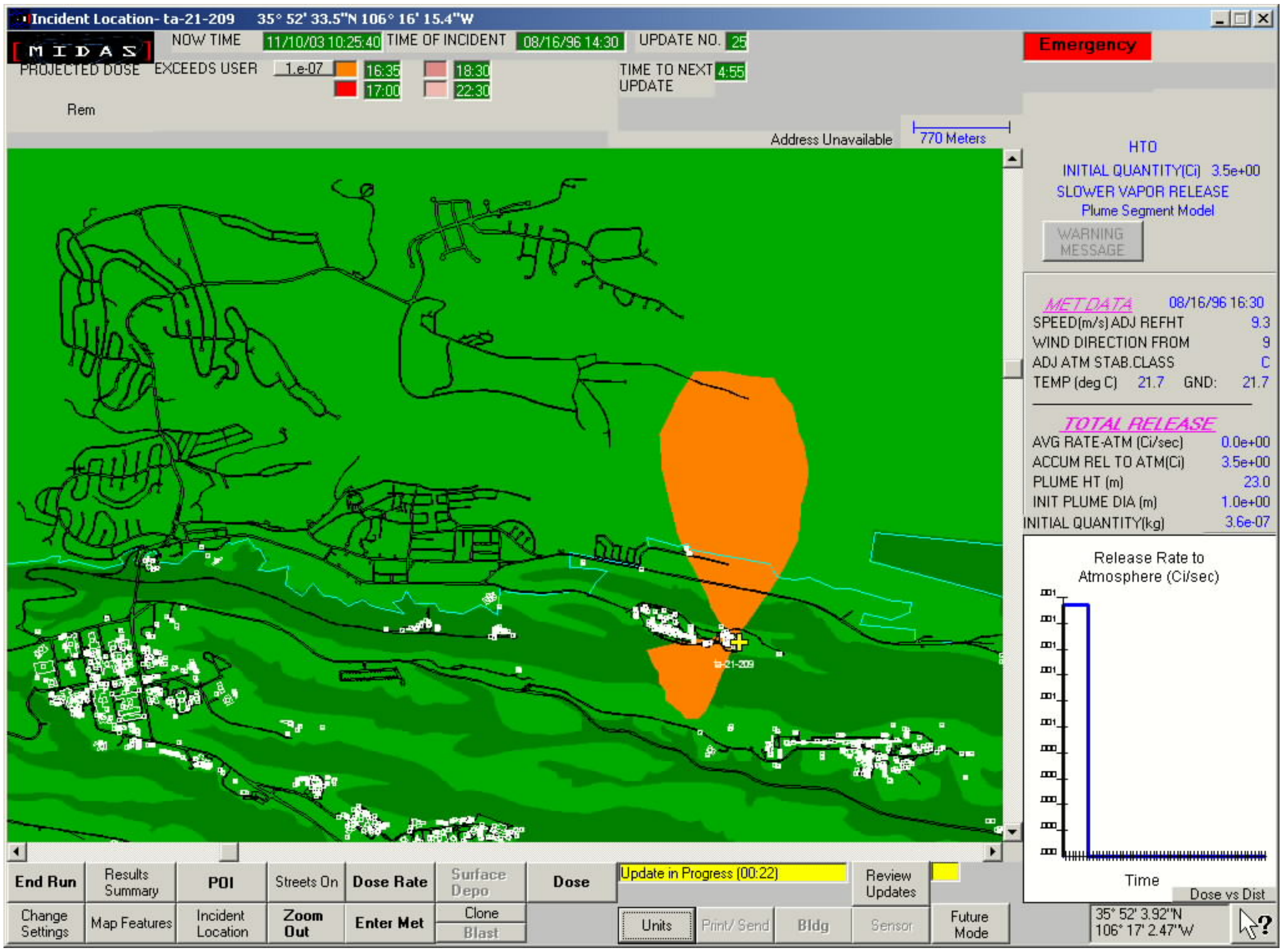
Figure 16. Measured (green) and calculated (blue) doses at all AIRNET stations for release #2.

4.0 Release #3: 3.5 Curies of HTO from TA-21-155 on 16 August 1996 from 3:30 to 4:30 pm

On August 16, 1996, between 3:30 and 4:30 pm (Mountain Daylight Time), during tritium processing operations at the Tritium Systems Test Assembly (TSTA) facility (TA-21 building 155), approximately 3.5 curies of tritium-oxide were accidentally released into the main tritium process room (room 5501) and then out the main exhaust stack for TSTA. This release is described in occurrence report ALO-LA-LANL-TSTA-1996-0001.

The resulting plume, as calculated using the plume segment model of MIDAS, is shown in Fig. 17. The accompanying wind rose is shown in Fig. 18. The southward travel of the plume is to the southwest, not to the south or southeast as the wind rose might suggest. This discrepancy can be due to the fact that the wind directed to the south and southeast was faster. Faster wind produces more dispersion of the plume, reducing the dose. Note that the slowest wind was directed to the north, and this is where the majority of the plume can be found.

The dose signature as calculated by the complex terrain model, shown in Fig. 19, again shows some spurious behavior (north-south lines) and a tendency toward higher doses in canyons.



Incident Location- ta-21-209 35° 52' 33.5"N 106° 16' 15.4"W

NOW TIME 11/10/03 10:25:40

TIME OF INCIDENT 08/16/96 14:30

UPDATE NO. 25

PROJECTED DOSE EXCEEDS USER 1.e-07 Rem

🟧 16:35 🟥 17:00 18:30 22:30

TIME TO NEXT UPDATE 4:55

Address Unavailable

770 Meters

HTO

INITIAL QUANTITY(Ci) 3.5e+00

SLOWER VAPOR RELEASE

Plume Segment Model

MET DATA 08/16/96 16:30

SPEED(m/s) ADJ REFHT 9.3

WIND DIRECTION FROM 9

ADJ ATM STAB.CLASS C

TEMP (deg C) 21.7 GND: 21.7

TOTAL RELEASE

AVG RATE-ATM (Ci/sec) 0.0e+00

ACCUM REL TO ATM(Ci) 3.5e+00

PLUME HT (m) 23.0

INIT PLUME DIA (m) 1.0e+00

INITIAL QUANTITY(kg) 3.6e-07

Update in Progress (00:22)

35° 52' 3.92"N
106° 17' 2.47"W

Figure 17. Dose plume calculated by the MIDAS "plume segment" model for 3.5 Curies HTO released from 1530 to 1630 on 16 August 1996 (release #3).

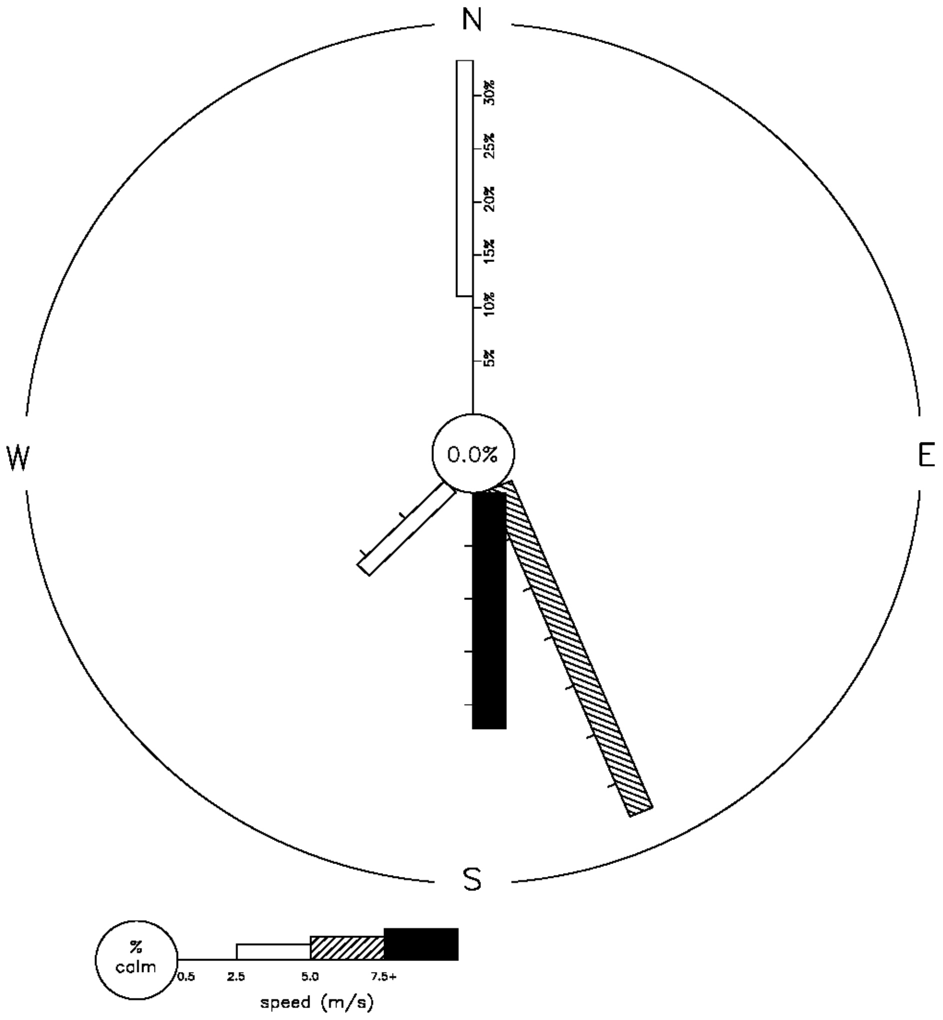
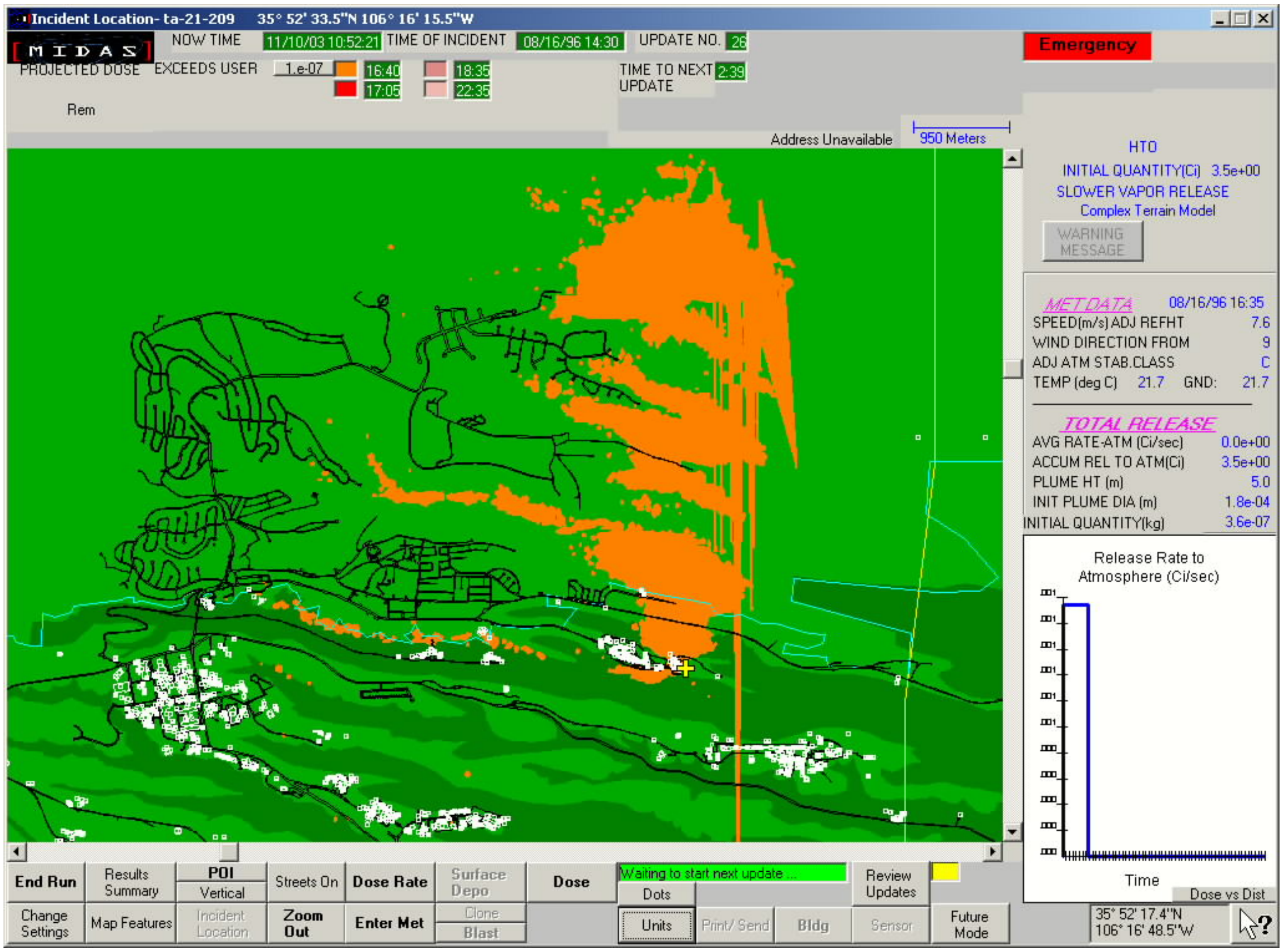


Figure 18. Wind rose for the 2 hour time of MIDAS integration for release #3.


Incident Location- ta-21-209 35° 52' 33.5"N 106° 16' 15.5"W

NOW TIME 11/10/03 10:52:21

TIME OF INCIDENT 08/16/96 14:30

UPDATE NO. 26

PROJECTED DOSE EXCEEDS USER 1.e-07 Rem

🟧 16:40 ▨ 18:35

🟥 17:05 ▨ 22:35

TIME TO NEXT UPDATE 2:39

Address Unavailable

HTO

INITIAL QUANTITY(Ci) 3.5e+00

SLOWER VAPOR RELEASE

Complex Terrain Model

MET DATA 08/16/96 16:35

SPEED(m/s) ADJ REFHT 7.6

WIND DIRECTION FROM 9

ADJ ATM STAB.CLASS C

TEMP (deg C) 21.7 GND: 21.7

TOTAL RELEASE

AVG RATE-ATM (Ci/sec) 0.0e+00

ACCUM REL TO ATM(Ci) 3.5e+00

PLUME HT (m) 5.0

INIT PLUME DIA (m) 1.8e-04

INITIAL QUANTITY(kg) 3.6e-07

Waiting to start next update ...

35° 52' 17.4"N 106° 16' 48.5"W

Figure 19. Dose plume calculated by the MIDAS "complex terrain" model for 3.5 Curies HTO released from 1530 to 1630 on 16 August 1996 (release #3).

The profiles of measured and calculated doses at all AIRNET stations are shown in Fig. 20. In this case, the MIDAS calculations of dose are almost always lower than the measured doses. This can be due to the fact that the released amount of 3.5 Curies HTO is "in the noise". This small one-hour release as treated by MIDAS can not be directly compared to the two-week integration of releases that AIRNET measures. This is a clear case of MIDAS "apples" versus AIRNET "oranges".

In an attempt to make MIDAS results more comparable to AIRNET, the background noise associated with the AIRNET network was estimated. AIRNET dose measurements for three sample periods previous to the sample period of interest were averaged together with three sample periods following the release period. It was checked that no significant releases occurred during the six AIRNET sampling periods used to estimate the average AIRNET "no incident" dose measurement. This average was then subtracted from the green AIRNET profile in Fig. 20, producing the brown "AIRNET minus background" profile at each station. Where stations are missing from the brown profile, the estimated background equaled or exceeded the AIRNET dose measurement at that station during the two-week sample period containing the August 16th release, so AIRNET minus background was treated as zero.

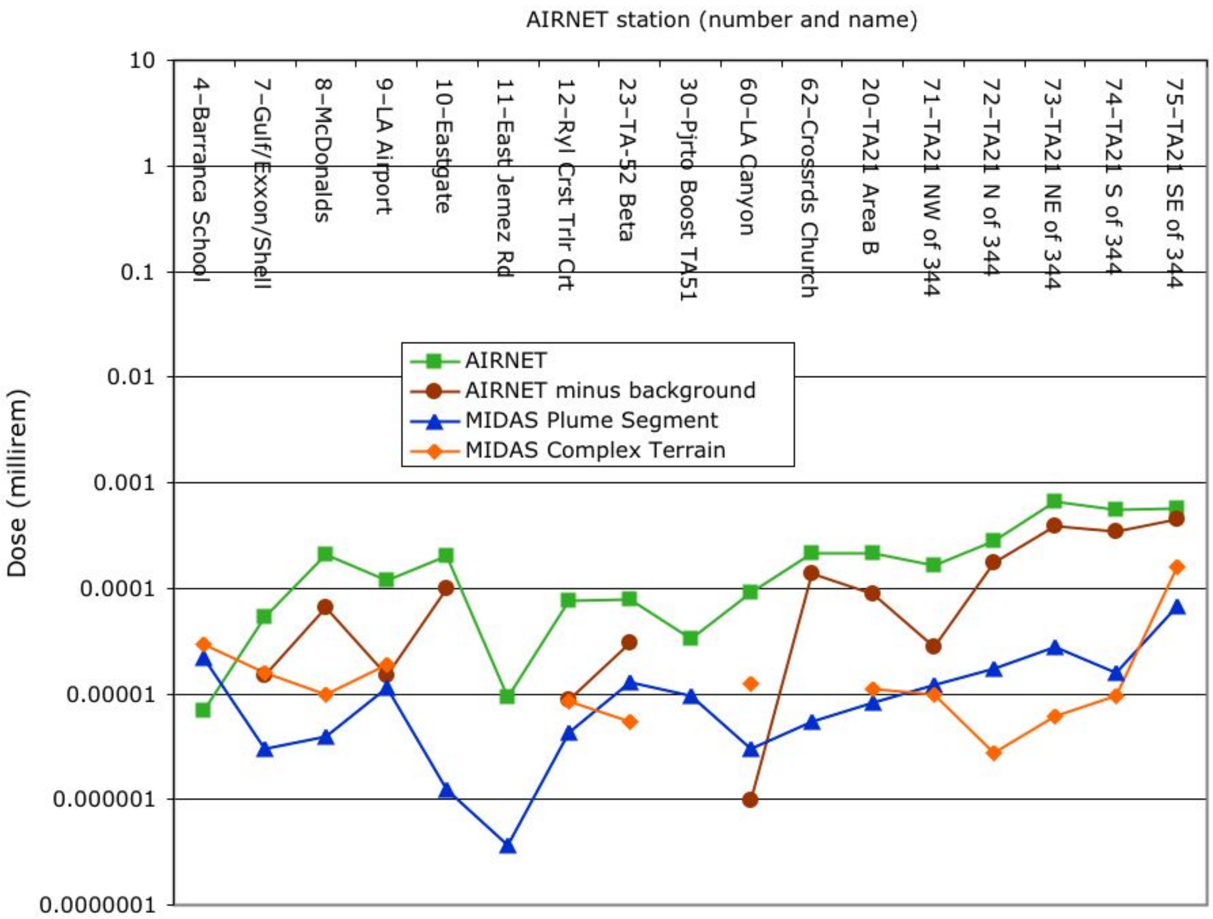
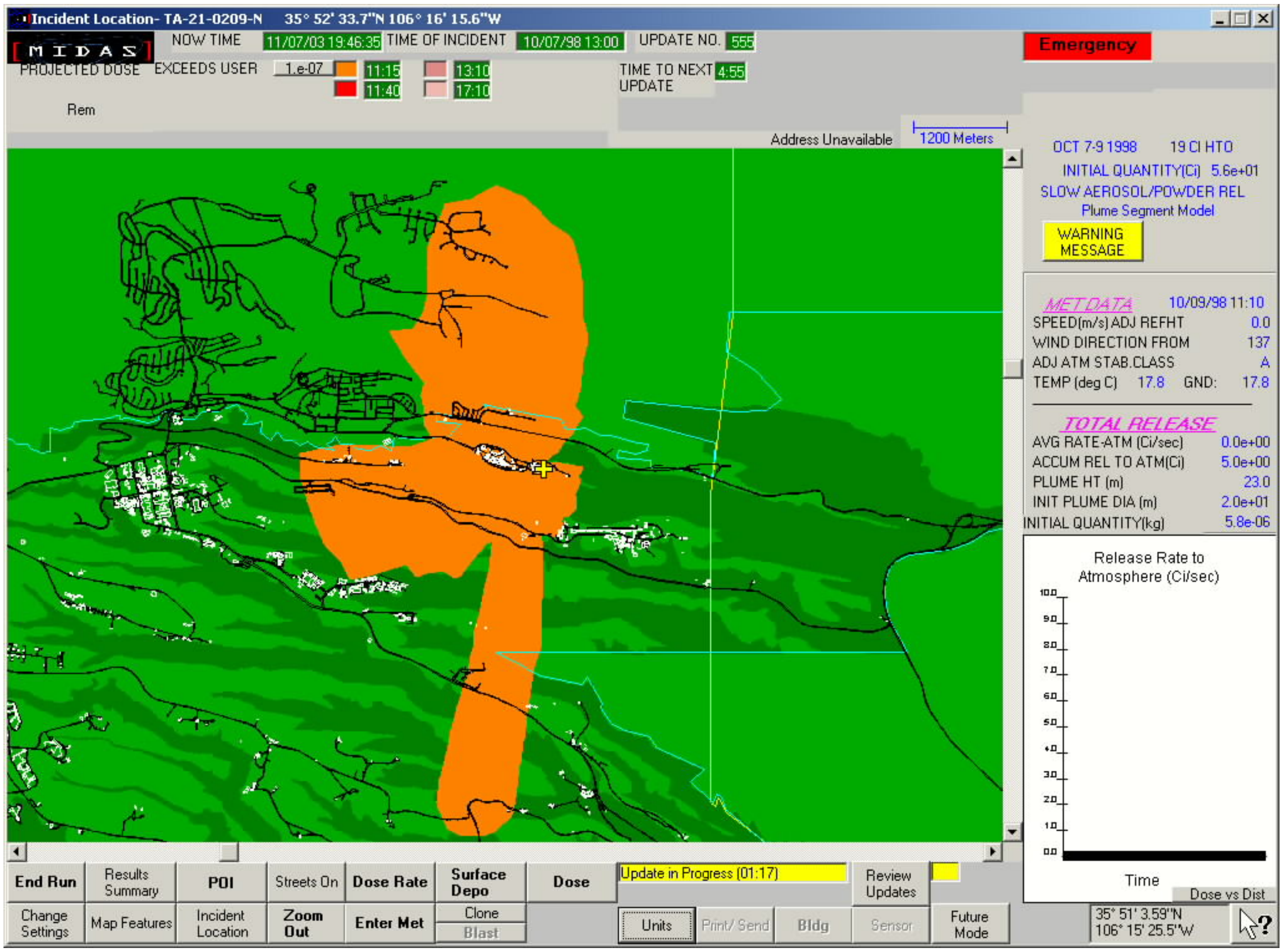


Figure 20. Measured (green) and calculated (blue) doses at all AIRNET stations for release #3.

Even with the subtraction of an estimated background, the AIRNET doses do not appear to be comparable to MIDAS results. The fault is probably not that MIDAS fails when releases become “too small” since MIDAS simply scales down the results as the size of the release becomes smaller. Instead, it appears that we are unable to identify and remove the portion of the AIRNET measurement during the two week sampling period that is not associated with the small release that occurred on August 16th 1996. In conclusion, this release unfortunately does not allow for a useful comparison between the measurements and the model.

5.0 Release #4: 19 Curies of HTO from TA-21-209 from 7 to 9 October 1998

The last release studied is actually a three-part release from the Tritium Salt Fabrication Facility taking place on: 7 October 1998 from 2:00 to 5:00 pm Mountain Daylight Time (MDT) when 6 Ci of HTO were released, 8 October 1998 from 10:00 am to noon MDT (10.5 Ci of HTO were released), and 9 October 1998 from 8:00 to 11:00 am MDT (2.5 Ci of HTO were released). The dose plume according to the MIDAS plume segment model is shown in Fig. 21.



Incident Location- TA-21-0209-N 35° 52' 33.7"N 106° 16' 15.6"W

NOW TIME 11/07/03 19:46:35 TIME OF INCIDENT 10/07/98 13:00 UPDATE NO. 555

PROJECTED DOSE EXCEEDS USER 1.e-07 Rem

🟧 11:15
🟥 11:40
▨ 13:10
▨ 17:10

TIME TO NEXT UPDATE 4:55

Address Unavailable

1200 Meters

OCT 7-9 1998 19 CI HTO
INITIAL QUANTITY(Ci) 5.6e+01
SLOW AEROSOL/POWDER REL
Plume Segment Model

MET DATA 10/09/98 11:10
SPEED(m/s) ADJ REFHT 0.0
WIND DIRECTION FROM 137
ADJ ATM STAB.CLASS A
TEMP (deg C) 17.8 GND: 17.8

TOTAL RELEASE
AVG RATE-ATM (Ci/sec) 0.0e+00
ACCUM REL TO ATM(Ci) 5.0e+00
PLUME HT (m) 23.0
INIT PLUME DIA (m) 2.0e+01
INITIAL QUANTITY(kg) 5.8e-06

Release Rate to Atmosphere (Ci/sec)

Update in Progress (01:17)

35° 51' 3.59"N
106° 15' 25.5"W

Figure 21. Dose plume calculated by the MIDAS "plume segment" model for 19 Curies HTO released in three intervals between 2 pm on 7 October and 11 am on 9 October 1998 (release #4).

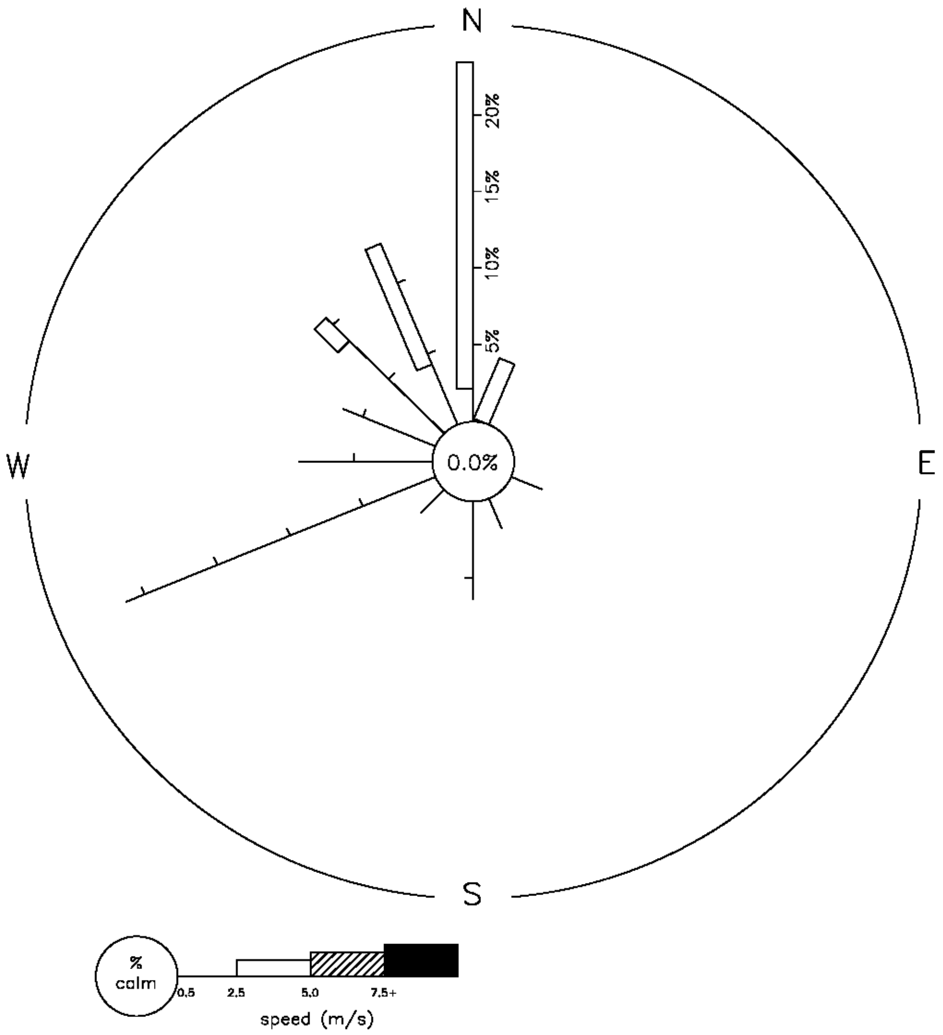


Figure 22. Wind rose for the 11 hours of time from the beginning to one hour past the end of three release intervals on 7 to 9 October 1998 totaling 19 Curies of HTO (release #4).

The wind rose shown in Fig. 22 includes wind information from the start of the October 7th release to one hour past the end of the October 7th release (four hours) plus similar wind sets for the October 8th (three hours) and October 9th (four hours) releases for a total of eleven hours of wind, three hours more than the total duration of the release (eight hours). There is good agreement between the wind rose and the plume produced by MIDAS, as would be expected.

The measured and calculated doses are compared at all AIRNET stations in Fig. 23. Even with the subtraction of background from AIRNET (estimated in the same way as in release #3), there is not very good agreement between AIRNET and MIDAS. The 19 Curies that were released apparently did not constitute a large enough exposure to be separable from the noise. MIDAS's tendency to only show a plume where the wind carries it also contributes to the difference between MIDAS and AIRNET. As with release #3, it appears that this release is not useful for a comparison between AIRNET and MIDAS.

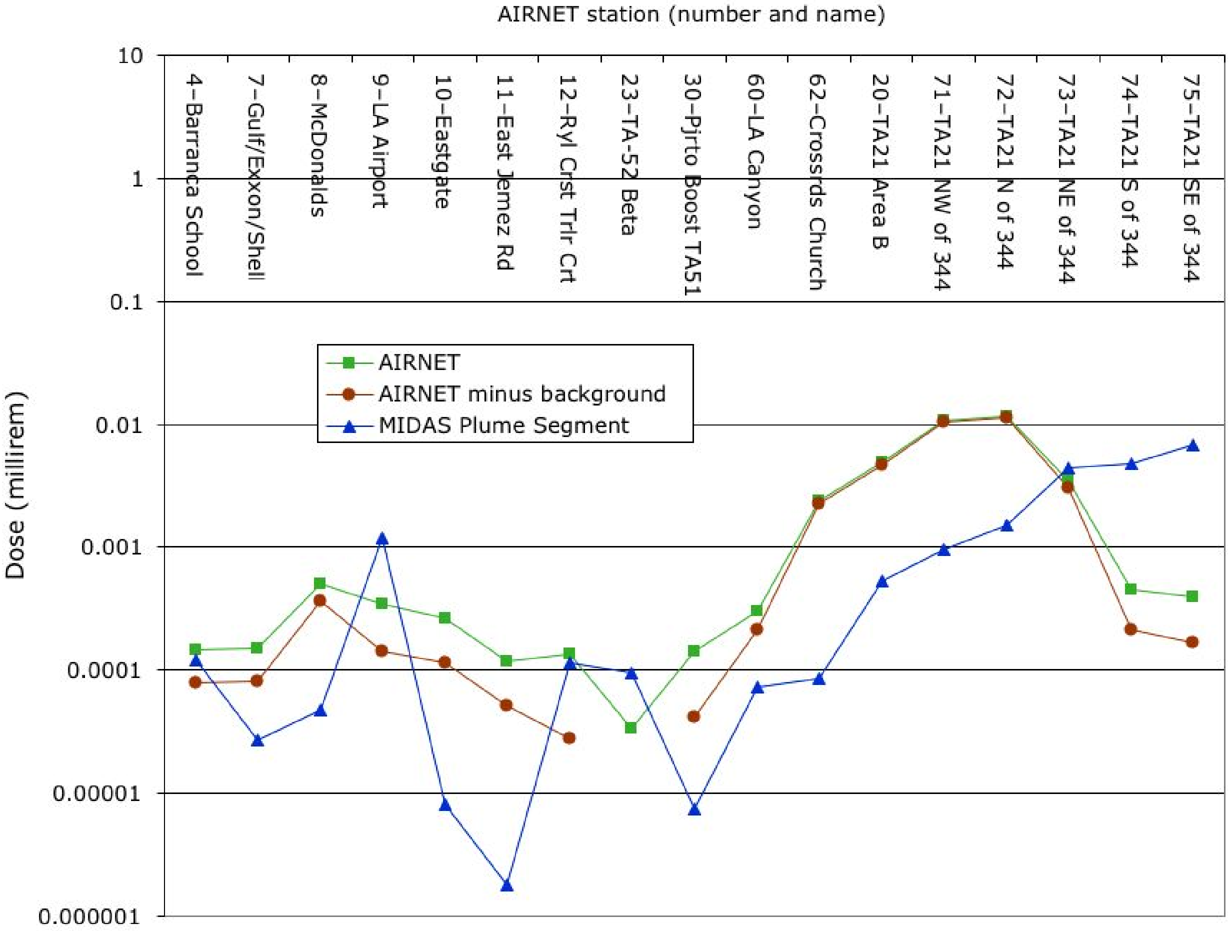


Figure 23. Measured (green) and calculated (blue) doses at all AIRNET stations for release #4.

6.0 Conclusions

Of the four releases that could be modeled using MIDAS, only the two largest ones appear to provide a useful verification of the predictions of LANL's primary emergency plume model versus the measurements using AIRNET. In these two cases, it is found that predictions by the plume segment model of MIDAS, which is currently the mainstay of the emergency management program at LANL, are typically conservative. The plume segment model calculates doses that are always greater than what is actually measured based on analyses of the AIRNET silica gel cartridges by up to a factor of ten or so.

It is important to note also that MIDAS shows significant impact only in regions where wind carries the plume. If a release is carried north, for example, MIDAS can be expected to predict no impact to the west, south, and east. Although this is probably accurate, there is no way to demonstrate it by comparing MIDAS to AIRNET, given the background noise.

The terrain around LANL, composed of mesas and canyons, is strongly varying. Thus, it would be preferable to employ an emergency response plume model that takes terrain into account. The MIDAS complex terrain model appears to do so. At present, however, the complex terrain model runs too slowly (and produces spurious plume signatures) and so can not be applied during an emergency. In addition, the complex terrain model is unlike the plume segment model in that it frequently underestimates release impacts. This issue should be given more attention, along with the problems with the complex terrain model that have been identified, before the complex terrain model is adopted to replace the plume segment model as LANL's first response airborne release model.

At this time, the MIDAS plume segment model appears to be an effective emergency management tool. It is entirely contained by LANL's EOC and is therefore invulnerable to communication breakdown (e.g. telephone, internet). The plume segment model's tendency to err on the side of caution makes it a safe instrument for estimating impacts of airborne releases.

REFERENCES

ABS, 2001: MIDAS-AT Technical Description, ABS Consulting, Inc. 4 Research Place, Suite 200A Rockville, MD 20850.

Eckerman, K. F., C. B. Richardson, and A. B. Wolbarst, 1988: Limiting Values of Radionuclide Intake And Air Concentration and Dose Conversion Factors for Inhalation, Submersion, And Ingestion. Federal Guidance Report No. 11, United States EPA Report 520/1-88-020.

NCRP, 1988: Exposure of the Population in the United States and Canada from Natural Background Radiation, National Council on Radiation Protection and Measurements, ISBN 0-913392-93-6.