Jack Rabbit III Modelers Working Group

FLADIS Geometry and Wind Directions

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Background

At the Jack Rabbit III Modelers Working Group meeting on 3 December 2021, several CFD modeling teams said that they would like to construct a three-dimensional geometry of the FLADIS test site to model the wake effects from buildings located upwind of the release location.

The purpose of this document is to summarize the information available on the FLADIS site geometry and wind directions in Trials 9, 16 and 24.

Maps and location of the FLADIS test site

The FLADIS experiments took place at the test site of Hydro-Care in Landskrona, Sweden.

Maps of the FLADIS test site are given in Figures 1 and 2 below, showing the location of buildings, the release point and the sensor array. The heights of buildings and other obstacles are given in these two figures. Photos of the FLADIS experiments that were distributed with the FLADIS dataset are also shown in Figure 3.

Morten Nielsen (Danish Technical University) kindly provided a KMZ file with the approximate location of the release point, which can be downloaded from the following link:

- https://xnet.hsl.gov.uk/fileshare/public/3385/approximate-fladis-release-point.kmz

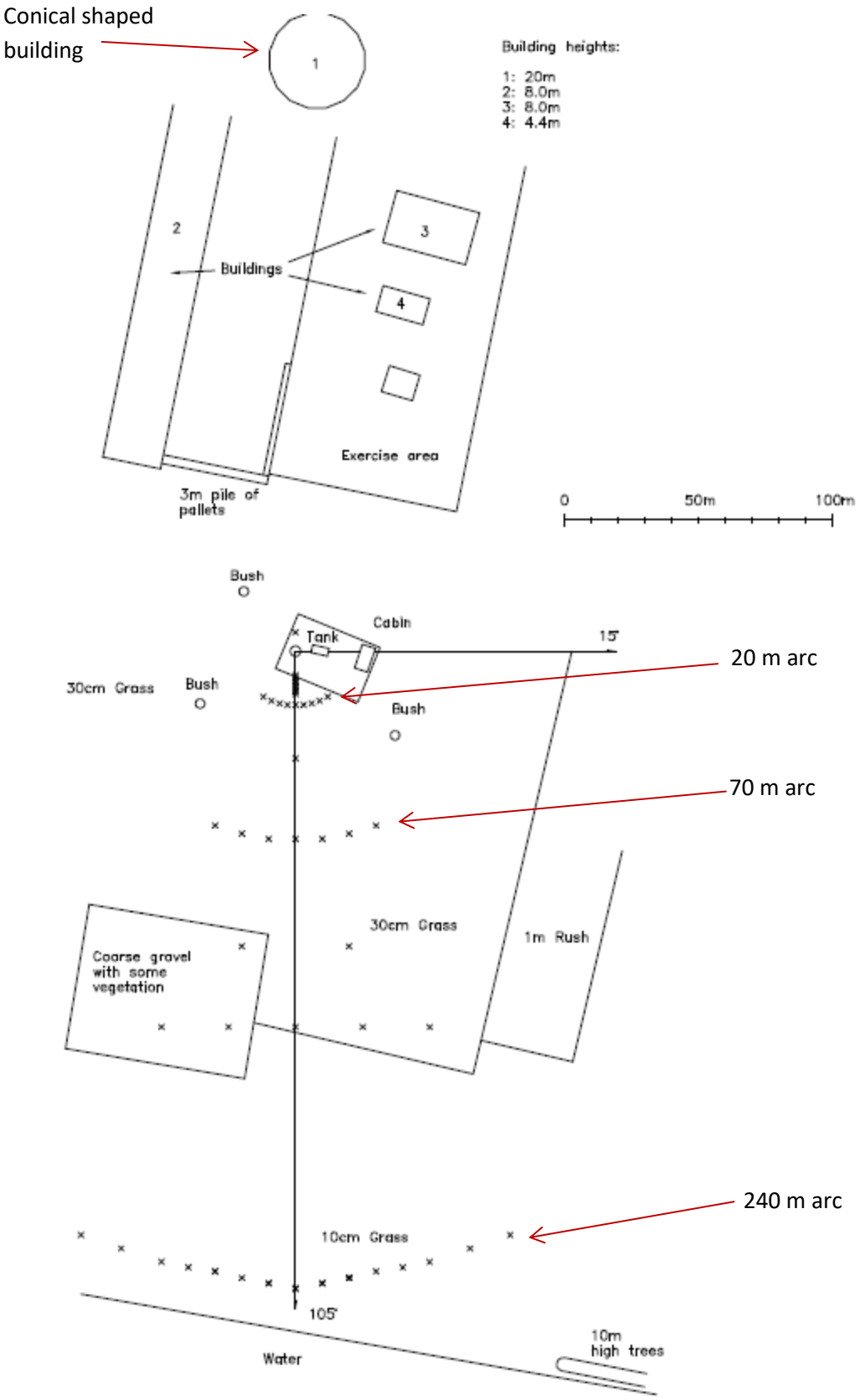

Figure 1 Map of the FLADIS test site including the array of measurement positions and the coordinate system, from Nielsen *et al*. (1994). The building labelled 1 is of a conical shape.

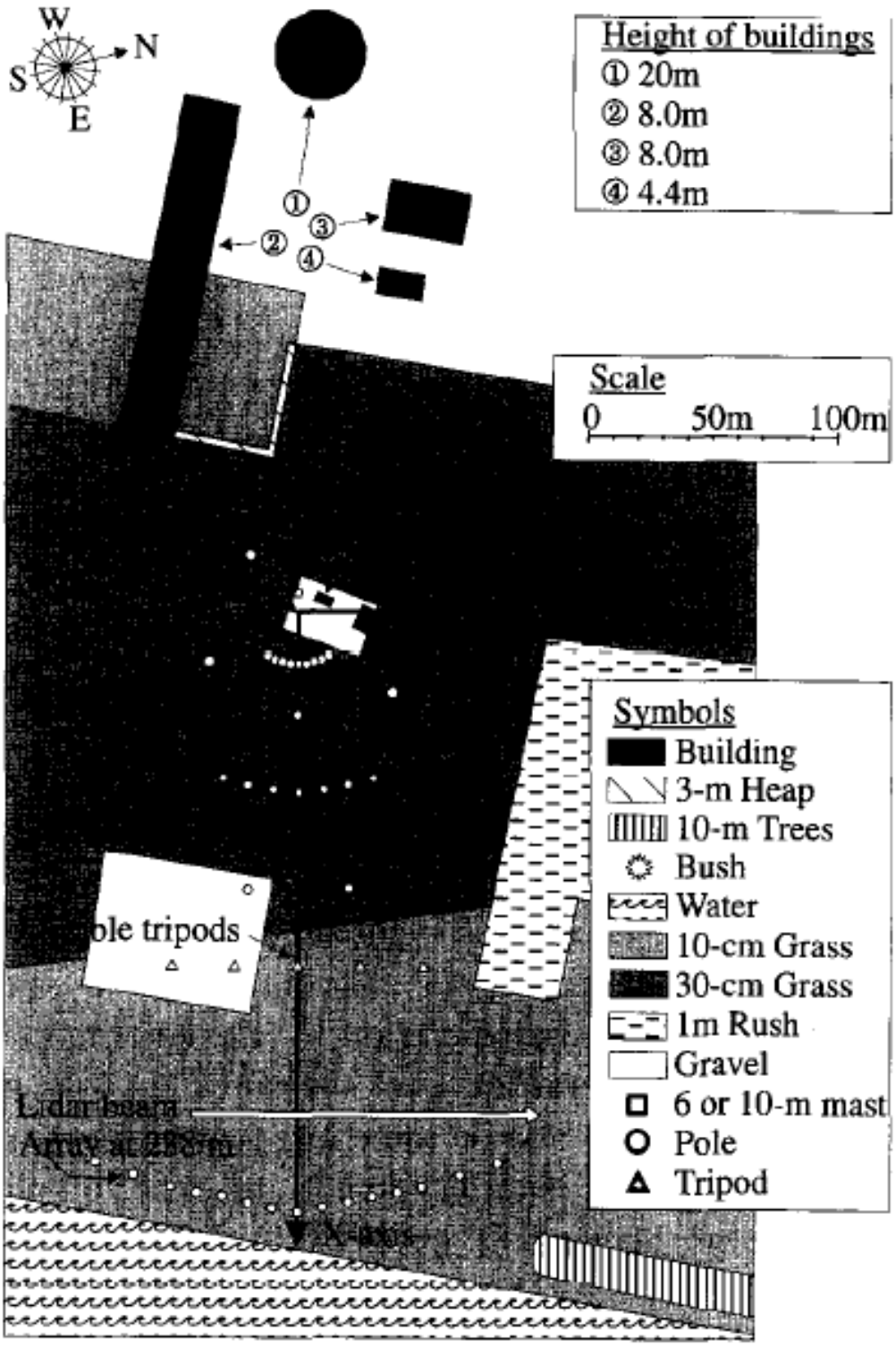

Figure 2 Map of the FLADIS test site showing alignment to North from Nielsen *et al*. (1997)

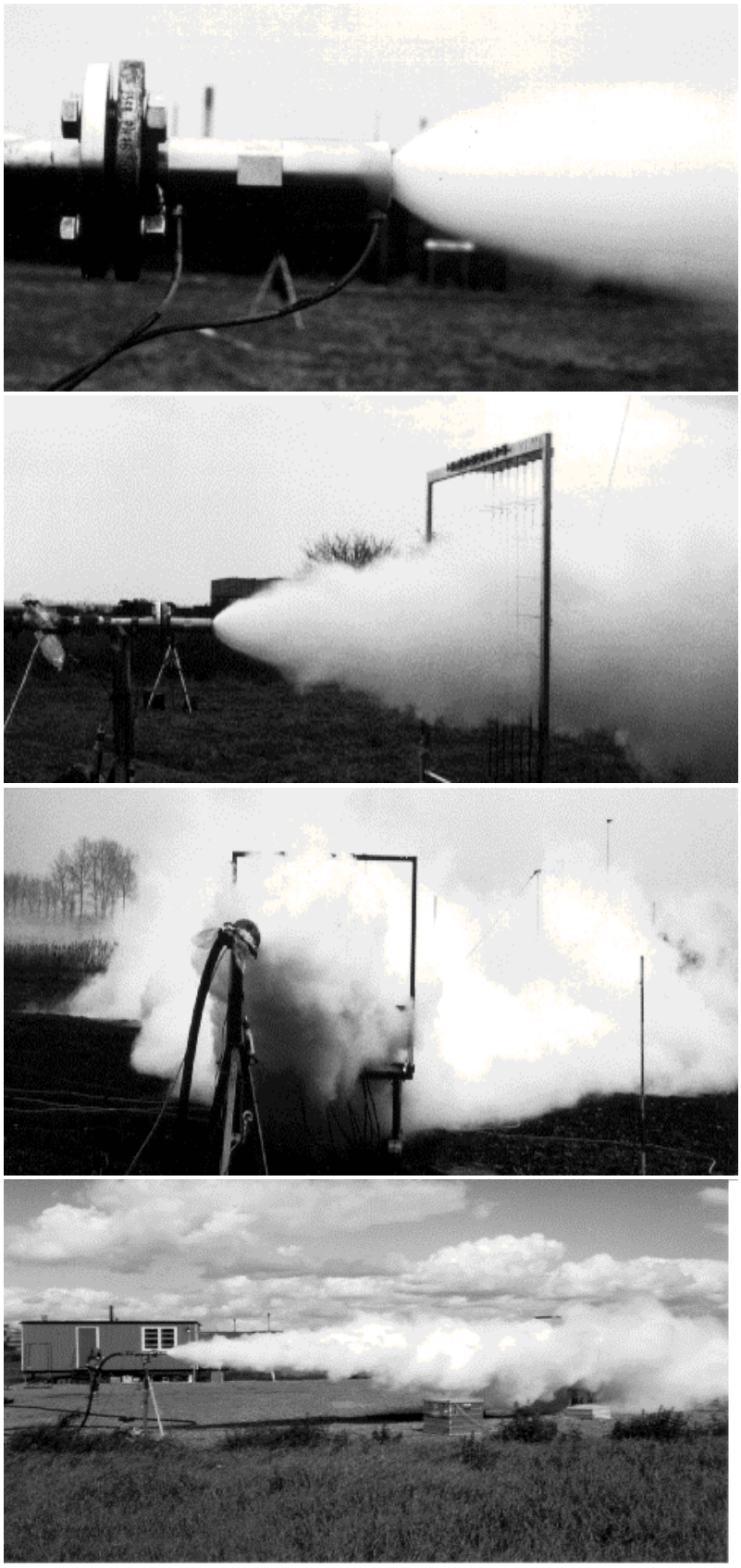

Figure 3 Photos of the FLADIS releases from the FLADIS dataset (source folder: "FLADEXP/DRAWINGS/" and files: "6.BMP", "7.BMP", "8.BMP" and "13.BMP", respectively from top to bottom).

Figure 4 Google earth view of the FLADIS test site. The pin shown is from the file "Approximate FLADIS release point.kmz" provided by Morten Nielsen

Figure 4 shows sample output from Google Earth with the approximate release location given in the KMZ file. Morten noted that since the FLADIS trials were undertaken, the site now appears to have been turned into a soil and container deposit, although the large upwind buildings present during the FLADIS trials are still visible in Google Earth (e.g. the cylindrical building with a conical top). The field towards the water has more bushes now than in the days of the FLADIS experiments.

The approximate latitude and longitude of the FLADIS release point from this KMZ file is:

- Degrees, minutes, seconds (DMS): 55°51'37.0" N 12°50'34.8 E
- Degrees and decimal minutes (DMM): 55.860278 N 12.843000 E

Nielsen *et al*. (1997) provided an alternative location of 55°53' N 12°50' E, but this is for the town of Landskrona and is centered on a housing estate, not the Hydro-Care test site.

Orientation of the test site

The orientation of the FLADIS test site relative to grid North is given different values in three different sources in the literature (see Table 1). For the purposes of the Jack Rabbit III modeling exercise, it is recommended that modelers use the REDIPHEM database value of 110° from grid North.

The difference of 5° or 7° between REDIPHEM value and the other two values is relatively minor. One possible cause for the discrepancy is that Nielsen *et al*. (1994) may have given the magnetic North

whilst REDIPHEM gave grid North (the magnetic declination[1] is approximately 5°). Another possible explanation is that the Nielsen *et al*. (1994) report was written before the experiments were completed and therefore it may have been the design value, whereas the REDIPHEM database gave the actual value. Clarification is currently being sought from Morten Nielsen, but for the moment it is recommended that modelers use 110°.

Table 1 Orientation of the FLADIS test site given in three different sources

Data source	Angle from grid North	Notes
REDIPHEM database	110°	See Table 2
Nielsen *et al*. (1994)	105°	See Figure 1
FLADIS dataset file "FLADEXP/DRAWINGS/ LAYOUT.BMP"	103°	See Figure 5. The value of 283° given in this figure is assumed to be the angle of the negative x-direction

To illustrate the orientation of the FLADIS test site, Figure 6 shows the layout of the test site from Figure 1 rotated around by approximately 110° to align the plot so that grid North is pointing vertically up on the page.

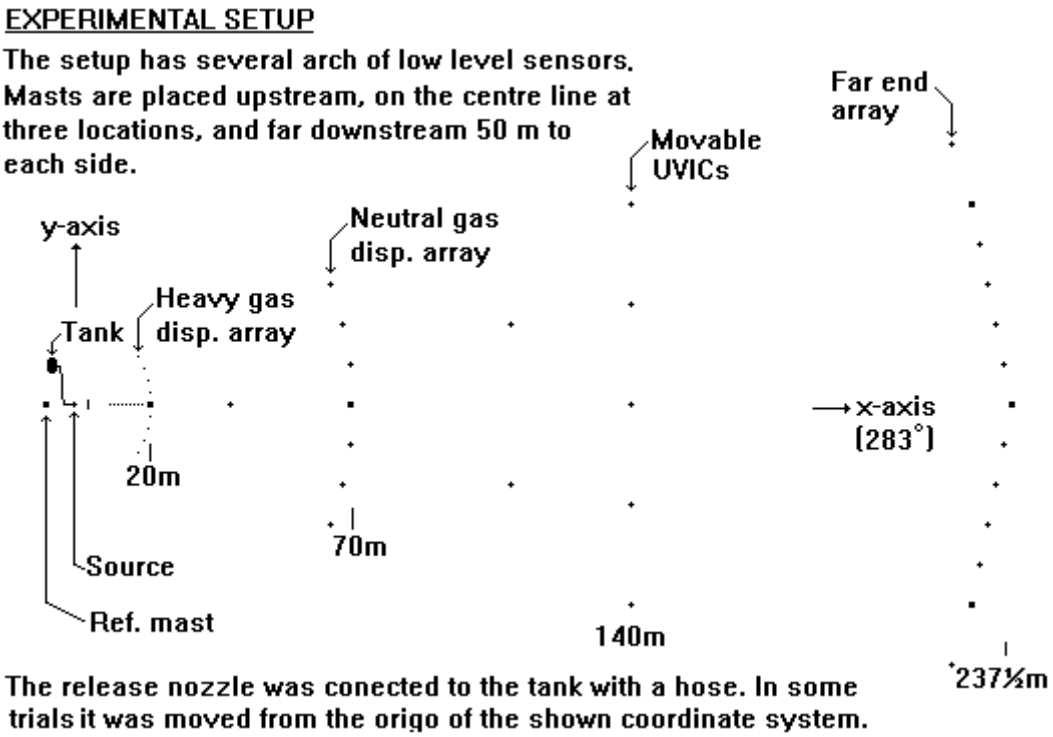

Figure 5 Arrangement of sensors in the FLADIS experiments. Source: FLADIS dataset file "FLADEXP/DRAWINGS/LAYOUT.BMP"

[1] https://www.magnetic-declination.com/Sweden/Landskrona/2426365.html

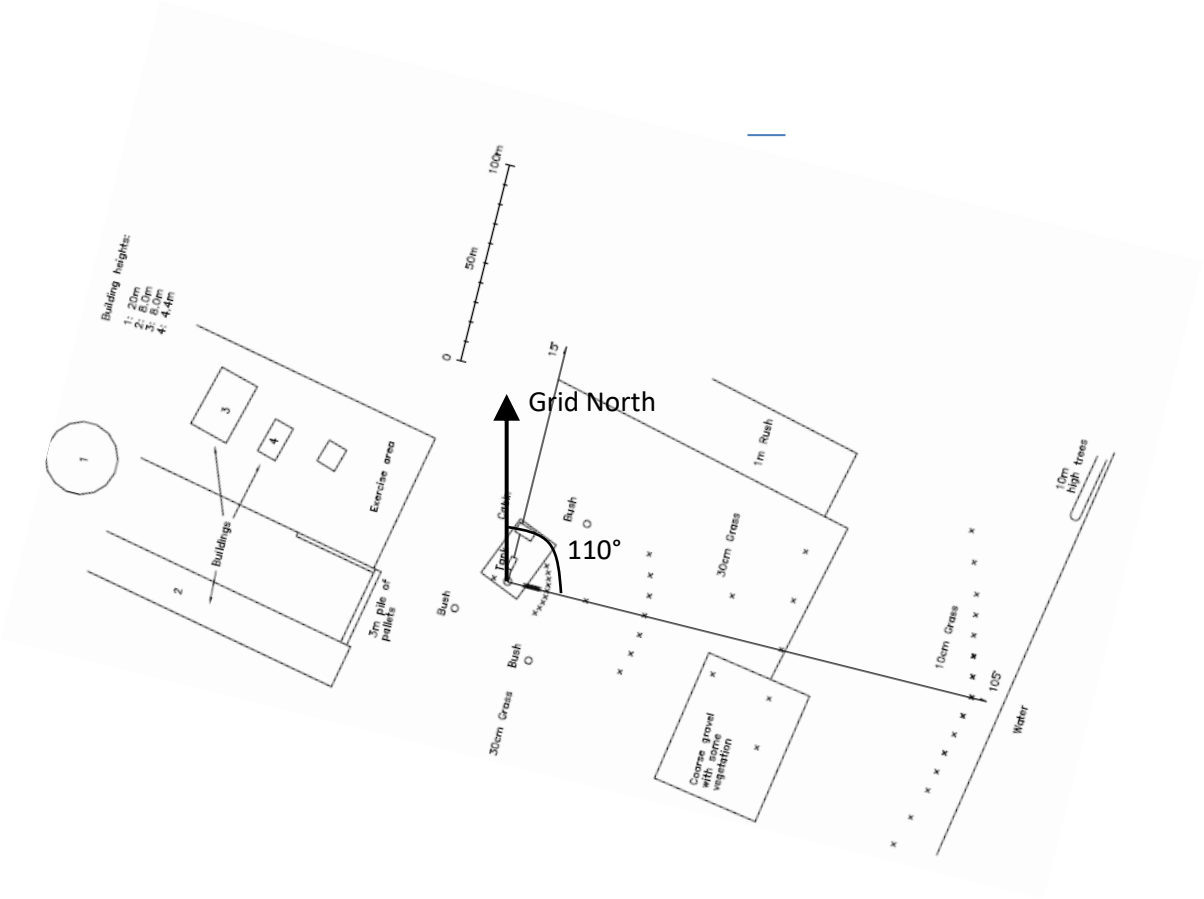

Figure 6 Map of the FLADIS test site oriented with North aligned approximately vertically up the page

Wind direction

Further details of the release orientation and wind direction in the FLADIS trials are given in Table 2, from the REDIPHEM database. Sketches showing the alignment of the wind to the sensor array that should be used in the Jack Rabbit III modeling exercise are shown in Figure 7.

Table 2 Release orientation and wind direction in the FLADIS trials

		FLADIS9	FLADIS16	FLADIS24
Release point: x, y, z	m	0, 0, 1.5	-2, 0, 1.5	0, 0, 1.5
Sensor x-axis orientation	deg from North	110	110	110
Ideal wind direction[a]	deg from North	290	290	290
Release direction	deg from North	110	110	110
	deg relative to x-axis	0	0	0
Site average wind direction[a]	deg from North	296	278	281
	deg relative to x-axis	6 (5)[b]	-12 (-8)[b]	-9 (-6)[b]
Standard deviation of wind direction	deg	14.5 (12.3)[b]	11.6 (9.6)[b]	10.44 (9.7)[b]

Notes:

Values shown here are taken from the REDIPHEM database, as distributed with the FLADIS dataset (files: "FLADEXP\REDIPHEM\DATA\FLADIS\TRIALxxx\SPECS.DAT").

[a] Indicates where the wind was coming from (i.e., pointing upwind).

[b] Values in () parentheses are alternative values of the wind direction and its standard deviation from Nielsen *et al*. (1996a, 1997). For the purposes of the Jack Rabbit III modeling exercise, the REDIPHEM values should be used, i.e., ignore the values in brackets.

All angles are assumed to be measured clockwise from grid North.

Nielsen and Ott (1996a) gave the following description of the wind direction in the trials as follows:

> "*Trial 16, 20, 23, 24, 25, and 27 are probably the best ones for model comparison, since these had long release duration and favourable wind directions. The wind direction of trial 9 had a fine average but a distinct trend, moving the plume from one side of the array to the other one.*"

The FLADIS dataset provides further notes on the wind direction in the trials, as follows[2]:

> Trial 9: "*During the release period the wind direction slowly turned clockwise and the plume centre line shifted from the left to the right hand side of the ideal centerline*."
>
> Trial 16: "*The mean wind direction was less than 5 degrees off the ideal centerline with the plume sweeping between the centerline mast and the left hand mast in the far end concentration sensor array. Thus the profile of fast concentration sensors at the centerline mast measured both periods from the plume edge and from the plume interior.*"
>
> Trial 24: "*As in the proceeding trial, the wind direction was favourable*".

[2] These excerpts are taken from files "FLADEXP/TRIALxxx/DOC/INFO.TXT" for each of the FLADIS trials. The same notes are also available in the REDIPHEM database.

There are minor discrepancies between the above statement in Trial 16 about the wind direction and the value given in Table 2. It is recommended that modelers use the wind direction given in Table 2 for the purposes of the Jack Rabbit III modeling exercise.

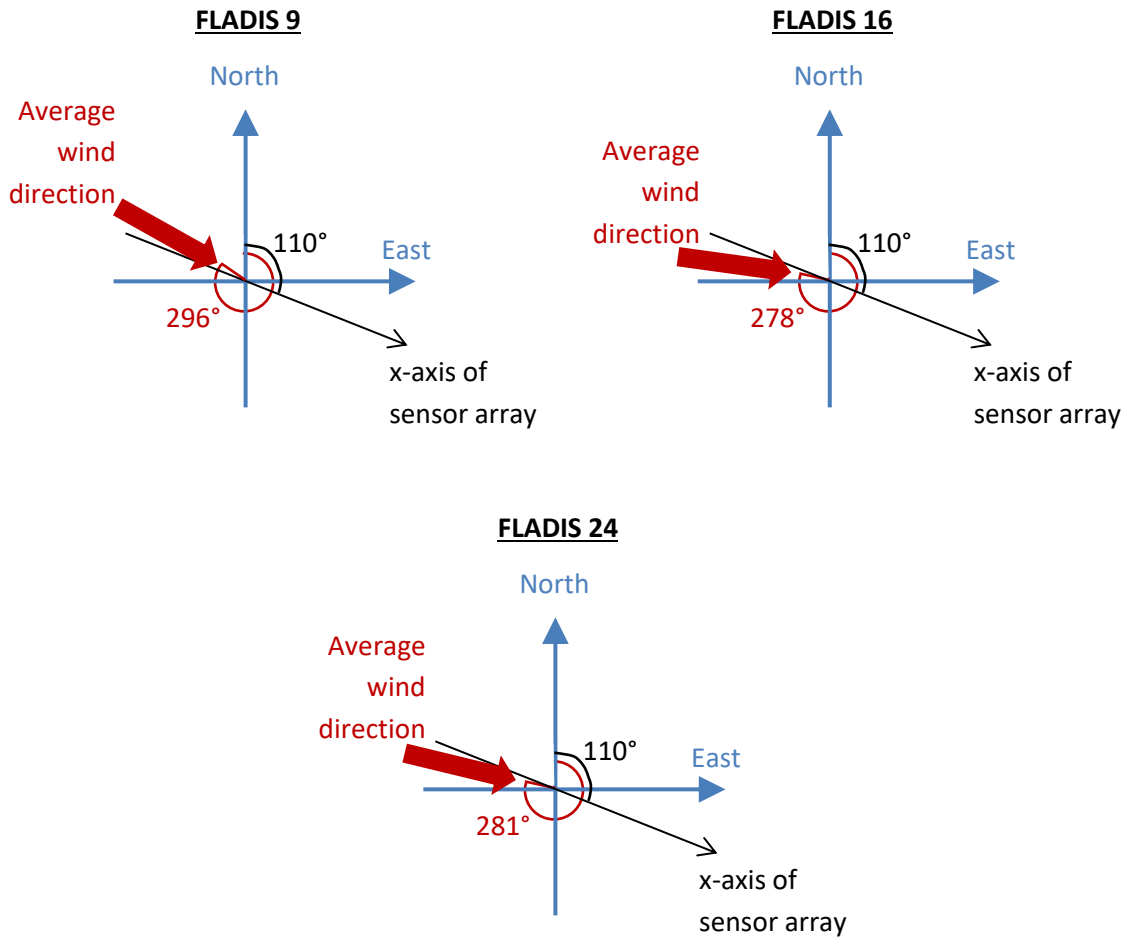

Figure 7 Sketches showing the alignment of the sensor array and the average wind direction in the FLADIS trials, using values taken from Table 2

Access to FLADIS dataset

Morten Nielsen kindly provided the following link where the full FLADIS dataset can be downloaded from, for those interested:

- https://files.dtu.dk/u/ljPATmUzwHmEM8BK/FLADEXP?l (the link will expire in August 2022)

Notes are provided below on how to unzip the data files and run the DOS executable programs on a Windows 10 computer:

- Download and install the x86 emulator software DosBox (https://www.dosbox.com/) which allows you to run DOS programs in Windows 10.
- Create a folder on your C: drive called C:\DOSPROGS
- Create a folder on your C: drive called C:\FLADIS
- Download the pkunzip.exe program from here: https://archive.org/details/PKUNZIP_1020 and copy it into C:\DOSPROGS
- Copy all the FLADIS zip files from the download link above into C:\DOSPROGS
- Start the DosBox program from the Windows 10 start menu
- Type the following commands into the DosBox command window:
    - mount c c:\dosprogs
    - mount d c:\fladis
    - c:
    - pkunzip r3_tools.zip
    - install3.exe (This opens a DOS program)
        - Press F1 to toggle the Source drive until it says C:
        - Press F2 once to toggle the Destination drive to D:
        - Press enter to unpack all the FLADIS files (this will take several minutes)
    - d:
    - cd FLADEXP\TOOLS\
    - copy ..\REDIPHEM\DPMI16BI.OVL .\
    - copy ..\REDIPHEM\RTM.EXE .\
- You can then run executable files by entering commands like the following:
    - jet trial016

The time-varying data files (e.g. velocities at the reference mast) are saved in binary files. There is a program called "CONVERT.EXE" to convert these into ASCII files but it does not seem to work. Instead, it just outputs a *.DAT file in the EXPORT folder with header information (device name, measurement, location, frequency, units) and not the actual time-varying data. To convert the binary file to ASCII you can instead use a MatLab or Octave program with the following command: A = fread(fileID,'float32'). It is necessary to specify 'floating point 32 bits' for the precision, instead of the default.

References

Nielsen M. Bengtsson R., Jones C., Nyrén K., Ott S. and Ride D. (1994) Design of the FLADIS field experiments with dispersion of liquefied ammonia, Report Risø-R-755(EN), Risø National Laboratory, Roskilde, Denmark, June 1994

Nielsen M. and Ott S. (1996a) FLADIS field experiments: final report, Risø-R-898(EN), Risø National Laboratory, Roskilde, Denmark, July 1996

Nielsen M. and Ott S. (1996b) A collection of data from dense gas experiments, Risø-R-845(EN), Risø National Laboratory, Roskilde, Denmark, March 1996.

Nielsen M., Ott S., Jørgensen H.E., Bengtsson R., Nyrén K., Winter S., Ride D. and Jones C. (1997) Field experiments with dispersion of pressure liquefied ammonia, Journal of Hazardous Materials, 56, p59-105.