Documentation for The New Mexico Tech Catalog of Data from the TCS-08 Field Experiment

October 27, 2009

Contents

1 Introduction

This document describes the web-based catalog hosted at New Mexico Tech (http://patka.nmt.edu/tcs08/catalog.html) of data collected during the field phase of the TCS-08 field experiment. NRL P3 and USAF C130 flight tracks and dropsonde positions are graphically displayed in the planetary frame with corresponding synoptic-scale wind and vorticity information, culled from NCEP's final analysis (FNL) output during the project interval (August-October, 2008). Mesoscale reflectivity and wind vectors from analyses of NRL P3 ELDORA Doppler radar data is presented in the system frame with corresponding P3 flight tracks and relevant P3 and C130 dropsonde positions. Detailed descriptions of these follow.

2 Catalog Structure

The catalog is structured as two nested layers of information: the synoptic-scale and the mesocale. At the top layer (found here), a list of months spanning the project interval is shown: August, September and October. Each month links to a gallery of thumbnail images showing all the synoptic scale plots for the month.

The galleries are organized in a grid format, where each row represents a day of the month, and each column represents one of the four UTC hours 00Z, 06Z, 12Z, 18Z, from left to right respectively. Certain gallery rows have green labels above them indicating that a certain type of data associated with that day exists. Such data is either from a P3 flight (the RF mission number is given), or a C130 flight. Since the C130 flights do not have associated mission numbers, only the fact that a C130 flight has occurred is indicated.

On days where data exists, data is associated with a particular image if observations were made within the 6h interval following the time indicated on the image, i. e. by the column containing the image; such images have black squares in the upper-left corner (see figure 1, below).

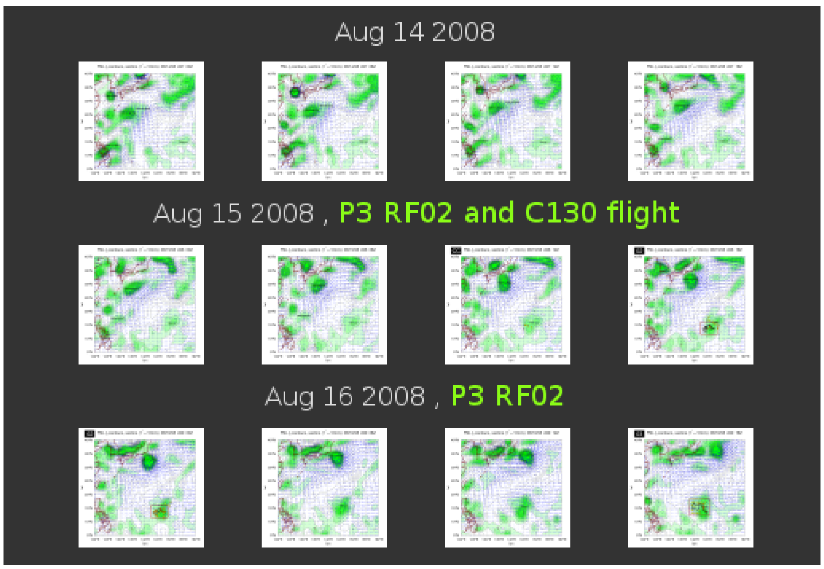

Figure 1: A small section of the August gallery of synoptic-scale thumbnail images. Three consecutive days are shown as three rows. The columns represent 00Z, 06Z, 12Z and 18Z from left to right, respectively. The top row (August 14) has no data associated with it. The middle row has a P3 flight (RF02), and a C130 flight. The bottom row contains the later (past midnight) portion of RF02. Note that certain thumbnails have black boxes in the upper-left corner indicating data exists during the interval represented by the image. For example, the leftmost image on the bottom row has a black box, indicating that on August 16, between 00Z and 06Z, some kind of data was gathered. Only the first RF mission number for a day is shown in the row label; the last image on the bottom row is in fact associated with RF03.

Clicking on any of the thumbnail images presents an enlarged version of the image with navigation links below it. On most browsers the F11 key will toggle a full-screen view of the website, which may help one to see the navigation links, particularly on small laptop screens. Images associated with P3 radar data have an extra navigation link: “Radar Plot”.

Clicking on the “Radar Plot” link brings one to the mesoscale radar analysis associated with the P3 flight during which radar data was collected. Navigation links below each radar analysis allow one to view different height levels of the analysis, toggle markers to be superimposed on the image, read information about the markers, and lastly, to read this documentation. The above-mentioned images are described in greater detail below.

3 Synoptic-Scale Images

Clicking on a thumbnail in one of the image galleries enlarges the image to full size. The images are synoptic-scale plots covering the Western Pacific with coastlines outlined in red. The data is shown in the Earth frame, i. e., each observation is plotted at the actual place and time at which it occured on the rotating planet. Links below each image allow navigation to images 6 hrs earlier or 6 hrs later. Also, a link back to the gallery is provided. On images with associated P3 radar data, a link to the radar image is given. See Figures 2 and 3, below.

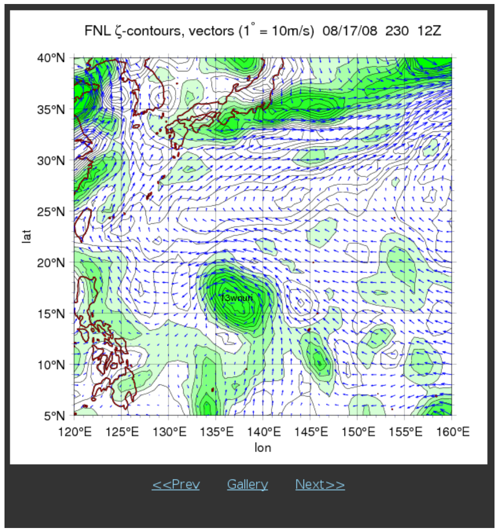

Figure 2: An example of a synoptic-scale image where no flight data occurs. Navigation links are shown below the image. '<<Prev' links to the image 6h previous to the current image, while 'Next>>' links to 6h later. 'Gallery' links back to the associated thumbnail gallery. Green-shaded contours indicate relative vorticity ($white = 0\,ks^{-1}$, $bright\,green \geqslant 0.05\,ks^{-1}$). Horizontal wind vectors describe the regional flow. Coastlines are outlined in red (Japan is at top, Taiwan and the Phillipines are at left). TS Nuri is indicated as 13wnuri, since it had a cyclone number of 13, according to the JTWC.

3.1 Image Title

The title of each image indicates the source of the plotted data (FNL for all images) and the type of data included (vorticity contours and wind vectors, described below). The UTC date and day of the year are displayed in the upper-right corner, followed by the UTC hour. The hour shown indicates the time of the FNL data for the plot, and also the beginning of the 6h interval encompassing any P3 or C130 data locations shown on the plot.

Certain images contain flight track and dropsonde positions in addition to the FNL data described above. These images contain a black box to the left of the title, showing either 'CC', indicating that only C130 dropsonde positions are plotted, or '##', i. e., a two digit number representing the P3 RF mission plotted in the image.

3.2 Wind Vectors

The wind vectors on the plots are derived from the FNL data horizontal wind components and are shown as blue arrows. Vector length (in lon or lat) is proportional to wind magnitude according to the relation $1^\circ = 10\,ms^{-1}$.

3.3 Vorticity Contours

Relative vorticity contours are shown to highlight cyclonic systems. Dark green indicates relative vorticity maxima ($\zeta \geqslant 0.05\, ks^{-1}$), while white indicates zero. Contours are in increments of $\Delta\zeta = 0.01\, ks^{-1}$. Negative vorticity (anticyclonic) regions are not shown. Relative vorticity is calculated from the FNL wind components u, v using:

$$\zeta = \frac{1}{R_e cos(\phi)} \left[\frac{\partial v}{\partial \lambda} - \frac{\partial u cos(\phi)}{\partial \phi} \right]$$

3.4 Storm Labels

Significant systems passing through the plot domain of the synoptic-scale images are labelled using one of the names given to the system by the NRL over the course of the system's lifetime. See the label for 13wnuri in Figure 2, above.

3.5 P3 Flight Tracks

Complete flight tracks of the NRL P3 are indicated on certain synoptic-scale images as black lines, enclosed within red boxes. The boxes define a 1 degree margin around each flight track and serve to highlight the mission region. Dotted portions of the black line indicate the flight segment occuring within the 6 h interval represented by the image. The track positions are taken from the respective in situ data for each flight as given by the NRL P-3 Navigation, State Parameter, and Microphysics LRT (1sps) Data Set retrieved via CODIAC on NCAR's EOL data server. See Figure 3, below.

3.6 Dropsonde Markers

Sondes launched by the P3 and C130 are indicated on certain synoptic-scale images. Orange triangles indicate positions of P3 dropsondes, while yellow triangles indicate C130 sondes (both in the Earth frame). The times and positions are taken from the respective dropsonde data for each flight as given by the TPARC 2008 Quality Controlled NRL-P3 Dropsonde Data Set, and the TPARC 2008 Quality Controlled Air Force C-130 Dropsonde Data Set. Launch times are used to indicate the interval in which the sonde markers appear, while column-averaged lat/lon coordinates are used to give the sonde positions.

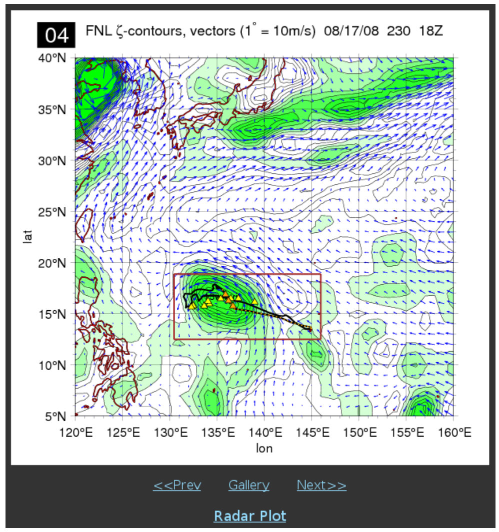

Figure 3: An example synoptic-scale image showing the flight track of P3 mission RF04 with associated P3 (orange triangles) and C130 (yellow triangles) dropsonde positions. Note the black box at upper left, showing the P3 mission number. Also, the dotted (lower) portion of the track is the flight interval that occured within the 6 h interval represented by the image. A link at bottom ('Radar Plot') leads to the associated mesoscale radar analysis for the mission. The flight data in the plot occurs within the image interval, i. e., the 6 hrs from 18Z on 08/17/09 to 00Z on 08/18/09.

4 Mesoscale Images

Clicking on the 'Radar Plot' link at the bottom of a synoptic-scale image shows the mesoscale radar analysis associated with the related P3 mission at $z = 1.5\,km$. Links at the bottom of each plot provide navigation to lower and higher levels of the analysis, ranging from $0\,to\,20.25\,km$ in $0.75\,km$ intervals. Between the '<< Lower Level' and 'Higher Level >>' links is a toggle link ('Toggle Markers') for changing the markers superimposed on the image. Three states exist for each image: 1) only the radar reflectivity, wind vectors and P3 flight track are shown; 2) numbered dropsonde position markers are plotted atop the radar and flight track data; 3) numbered flight track postions are plotted atop the radar data. Below the toggle link is a link to a table of information on the numbered markers superimposed on the images ('Marker Information'). Other links navigate back to the synoptic-scale image and to this document. Detailed descriptions of the various datatypes are given below.

4.1 Image Title

The title of each mesoscale image begins (at left) with the RF number of the P3 mission, followed by the UTC date and the system of interest in the image. The system name is either an NRL TCS number, or the given storm name if it exists. Next, the types of data are listed. Wind vector lengths are proportional to their magnitudes according to $1^\circ = 20\,ms^{-1}$, while radar reflectivity is described by a color gradient image, with a palette showing magnitudes in dBZ. The P3 track is also shown in the image. Lastly, the height of the radar data is shown in km above sea level (See Figure 4, below).

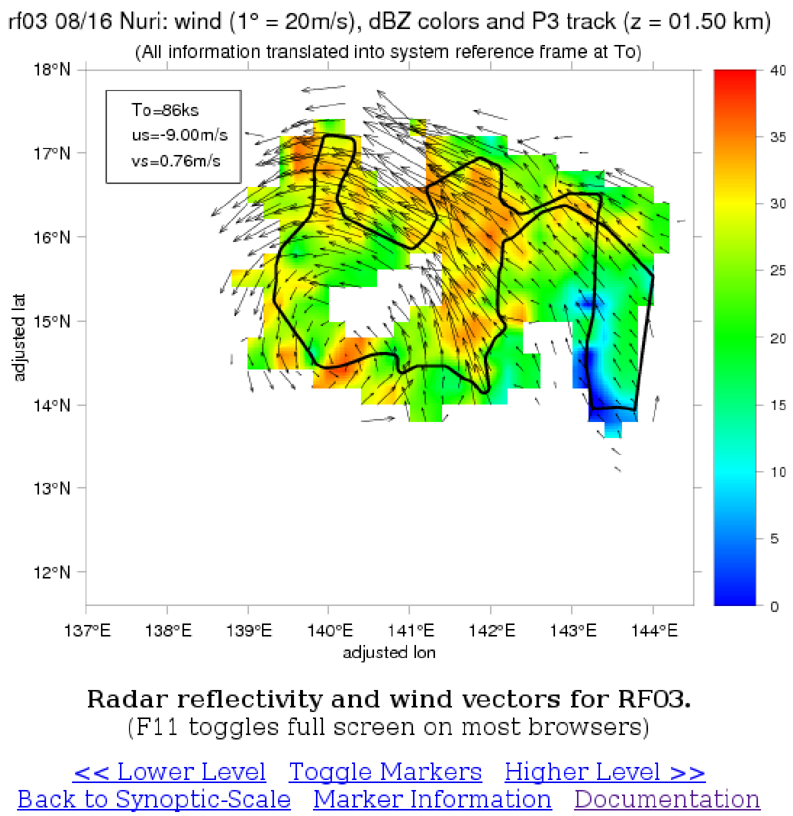

Figure 4: An example radar analysis image from the website. Wind vectors and reflectivity data are shown from RF03 with the associated P3 flight track. The reference time t_0 and the system translation velocity components are indicated in the box at upper left. Links below the image provide navigation to higher and lower levels of the same analysis. The 'Toggle Markers' link causes markers (see Figures 6 and 7) to be superimposed onto the image for dropsonde and flight time information. The 'Marker Information' link provides time and position data corresponding to the markers. Other links lead back to the synoptic-scale plot, and to this document, respectively.

4.2 Monotime

All times pertaining to radar analyses are in monotime format. Monotime is defined as the number of kiloseconds past 00Z of the day on which the relevant P3 mission began. The relevant P3 mission is the one during which the radar was collected for a given image and the one from which P3 sondes were dropped. For C130 flights, the relevant P3 mission is only defined if the C130 and P3 flew through the same system during the interval defined as ± 10 hours from the beginning and end of the matching P3 flight. Note that monotime gives all associated data events a monotonically increasing timestamp with respect to day0 of the P3 flight, only. For example:

A P3 mission begins one day at 20Z and flies to TC Nuri.
A C130 mission begins on the following day at 02Z and also flies to TC Nuri.
A sonde dropped by the P3 5h into its flight has monotime $= (20h + 5h) * 3.6ks/h = 90.0ks$
A sonde dropped by the C130 1h into its flight has monotime $= (24h + 2h + 1h) * \frac{3.6ks}{h} = 97.2ks$
Sondes dropped simultaneously by the P3 and C130 have identical monotimes.

4.3 The System Reference Frame

Each datatype shown in a mesoscale image (including flight tracks and sonde positions) is located within the Earth frame at its shifted position at a reference time, t_0. That is, all observations are plotted *where they would have occured within the Earth frame, had they been made at* t_0. Assuming the system does not evolve over the observation interval, and assuming a constant system translation velocity V_s over the interval, the data is thus located where it *actually occured within the moving system reference frame*. Since the data spans a large time interval, yet is represented within a single image, the system frame is really a composite of data instances occuring over the observation interval. Therefore, all the data is displayed within the Earth frame at 'adjusted' lat/lon coordinates, though they are positioned with respect to each other within the composite system reference frame. Note that the upshot here is that the flight tracks and dropsonde postitions are *not* where they actually occured within the Earth frame.

The transformation is made according to the system's translational velocity V_s, the actual time the data was collected t and a selected reference time t_0. In short, all of the data associated with a single P3 radar mission is reduced into a contiguous snapshot as though the storm and all requisite data were at the system's location in the Earth frame at the chosen reference time. This concept is illustrated below in Figure 5.

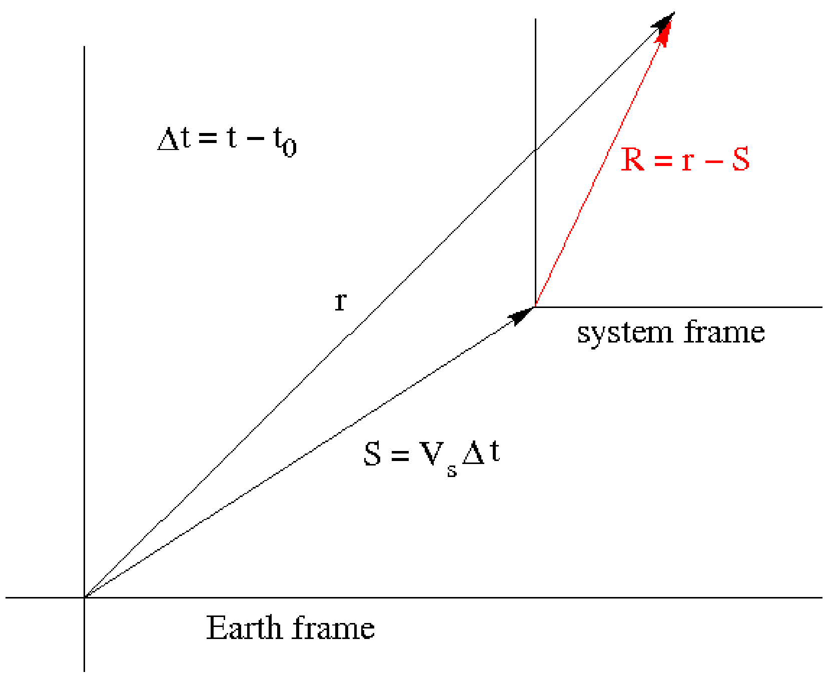

Figure 5: The Galilean transformation of data from the Earth frame to the system frame. The position vector r describes the position of the data within the Earth frame, while the vector R describes the position of the data within the system frame. The system frame is located with respect to the Earth frame according to the vector S, which is dependent on the system translation velocity V_s and Δt. The reference time is t_0 and the actual time the data were observed is t.

4.4 System Translation Velocity

The system translation velocity (assumed constant over the interval spanned by the associated observations) was determined from Best Track-like listings of system postions. The positions were determined by plotting relative vorticity centers using plots similar to the synoptic-scale images shown in Figures 2 and 3, above. For more information, see the storm analysis, and its documentation.

4.5 Reference Time

The reference time is unique to each mission and is chosen based on the relative importance of the system activity in the region of the P3 during its flight path and also the proximity to the median value of the flight time within the vicinity of the system. The reason for this is to place the shifted data components into the Earth frame at the position nearest the system's median location over the observation interval, and also to place the dropsondes in positions closest to their actual (Earth-frame) locations. This is a compromise, but is relatively unimportant since any given datatype is nevertheless properly positioned within the moving system relative to other data.

4.6 Radar Reflectivity and Wind Vectors

The P3 ELDORA Doppler radar data has been interpolated to a Cartesian grid and translated into the composite reference frame (as described above) using the data utility ngradcart. Reflectivity data is shown as shaded colors ranging from blue to red. The palette to the right of each image shows shows the reflectivity scale in dBz.

Wind vectors are shown as black arrows superimposed onto the reflectivity data.

The initial image one sees when clicking the 'Radar Plot' link from the synoptic-scale image shows the $z = 1.5\,km$ level of the analysis. Reflectivity and wind vectors at other levels can be accessed using navigation links below the image.

4.7 P3 Flight Track

A segment of the total P3 flight track is superimposed onto the radar data to indicate the craft's position within the data image. Since a large portion of most P3 tracks is travel to the system from base and vise versa, much of the track is omitted in many of the mesoscale analysis images. Due to an attribute of the plotting software, the local portion of the track is erroneously shown as a closed loop. However, markers showing monotimes along the track can be toggled on/off to indicate times of portions of the track (see Markers section, below).

4.8 Markers

Markers can be toggled on and off using the 'Toggle Markers' link shown below each image. Markers serve to provide information about flight times and dropsondes. Clicking the link once displays the dropsonde positions. Clicking twice gives positions of known flight times, and a third click removes the markers from the plot (see Figure 6, below).

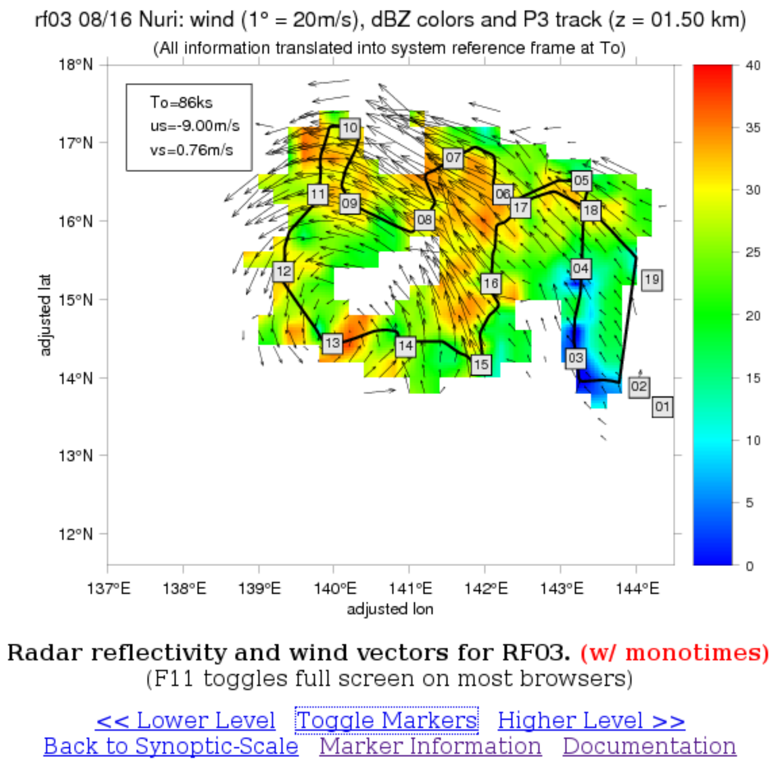

Figure 6: An example mesoscale image showing markers corresponding to times over the flight interval. The markers are toggled on and off using the 'Toggle Markers' link below the image. These markers can be used to determine times of radar and in situ data in the following way: 1) read the marker number in the region of the data or flight track of interest. 2) click on the 'Marker Information' link below the image and find the marker number in the list of 'P3 Positions by Monotime' on that page (see Figure 7). The monotime value at that marker and the adjusted lat/lon coordinates can then be read off the table.

All markers are numbered in the order they occur in time. The numbers correspond to lists displayed using the 'Marker Information' link. Clicking on that link displays information such as the time and position of the sonde or plane corresponding to the marker (see Figure 7, below).

Back to Radar Images

P3 Positions by Dropsonde Number

drop#	monotime	lon	lat
11)	81.7776	143.22	14.96
12)	82.2874	143.27	15.58
13)	83.3242	143.19	16.51
15)	85.2422	141.50	16.77
16)	86.9098	140.54	16.06
19)	90.4867	139.44	15.04
20)	91.9037	140.75	14.60
21)	93.4330	141.93	14.48
24)	96.5088	143.61	15.92

C130 Positions by Dropsonde Number

drop#	date	monotime	lon	lat
13)	8/16	74.0966	142.96	17.09
14)	8/16	75.0038	141.69	17.09
15)	8/16	75.7642	140.36	17.06
16)	8/16	76.5331	139.19	17.05
17)	8/16	77.5613	139.25	15.62
18)	8/16	80.1187	138.47	17.02
19)	8/16	80.8877	138.53	16.01
20)	8/16	82.0454	138.64	14.24
21)	8/16	82.9440	138.72	13.02
22)	8/16	83.6957	139.81	13.01
23)	8/16	84.3350	140.85	13.01
24)	8/16	84.9917	141.89	13.03
25)	8/16	85.7434	141.96	14.03
00b)	8/17	86.4000	142.01	15.03
01b)	8/17	87.0394	142.05	16.01
02b)	8/17	87.6787	141.08	16.00
03b)	8/17	89.2080	140.24	13.97

P3 Positions by Monotime (dt = 1 ks)

mark#	monotime	lon	lat
01)	79.20	144.35	13.62
02)	80.20	144.04	13.87
03)	81.20	143.20	14.24
04)	82.20	143.27	15.39
05)	83.20	143.28	16.51
06)	84.20	142.24	16.34
07)	85.20	141.58	16.80
08)	86.20	141.20	16.01
09)	87.20	140.21	16.22
10)	88.20	140.21	17.18
11)	89.20	139.79	16.34
12)	90.20	139.33	15.35
13)	91.20	139.98	14.43
14)	92.20	140.95	14.39
15)	93.20	141.95	14.16
16)	94.20	142.08	15.20
17)	95.20	142.47	16.17

Figure 7: An example table of marker information. These pages can be accessed by clicking on the link 'Marker Information' below each radar plot. Each box describes the numbered markers of a different datatype: 1) P3 dropsonde launch positions; 2) C130 dropsonde launch positions; 3) periodic P3 flight positions. The first column in each box gives the label on the relevant marker displayed on the radar plot: either the dropsonde number, or a flight interval number. Next, monotimes are given corresponding to the sonde launch time or the P3 flight time. A date column is also given for the C130 sondes, since they are not associated with unique mission numbers and are thus sorted according to the date they were dropped. Lastly, lat/lon coordinates are listed for each marker showing the adjusted positions in the reference frame shown in the radar plot.

4.9 Dropsondes

Sondes launched from the P3 and C130 are indicated as marked positions on the radar plots (see Figure 8, below). The sondes are translated into the system frame in the same way that the radar data and flight tracks are.

An added assumption here is that the system translation velocity is constant, not only over the P3 flight interval, but also over the extended interval that includes the C130 flight and associated sondes. Since the C130 sometimes flew at radically different times than the associated P3, one should especially check the C130 sonde times when correlating data with any of the other data shown in the analysis.

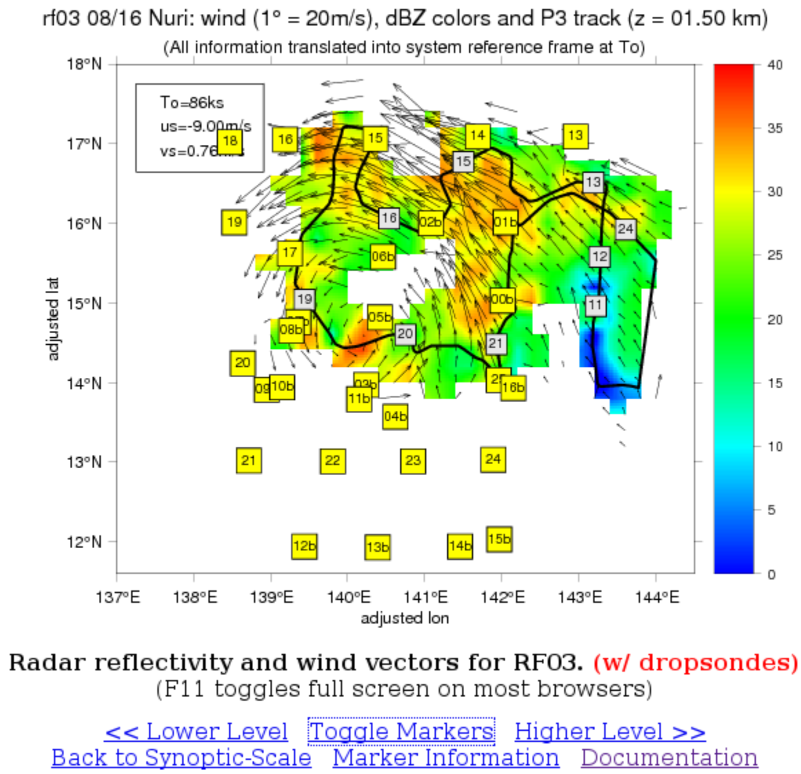

Figure 8: An example mesoscale image showing dropsonde position markers. The markers are toggled on/off using the 'Toggle Markers' link at the bottom of the plot. The yellow markers show the adjusted positions of the C130 sondes at the time of launch, while the white markers represent the P3 sondes. The dropsonde markers are numbered according to dropsonde number for each craft and are numbered sequentially from the start of each flight. Note that some sonde data was unusable, and thus are not included in the numbering scheme. The marker numbers correspond to the numbered rows in the 'Marker Information' table, shown above in Figure 7.

4.10 A Look at Dropsonde Positions

It is important to realize that the Galilean transformation rearranges the positions of the dropsondes, since sondes are dropped at various times over the observation period. For example, two sondes dropped at the same location in the Earth frame but at different times will be represented in different locations in the adjusted system frame, since the system will have moved according to its translation velocity during the interval. Thus, the sondes are effectively dropped in two different locations of the (assumed static, yet translating) storm structure. This behavior becomes extreme when two sondes that are respectively arranged east-west in the Earth frame, become arranged west-east in the system frame. This can occur when two sondes are nearly collocated in the Earth frame and are dropped on either side of the reference time. If the first sonde is dropped before the reference time, it is shifted westward (since the system is generally moving west), while the second sonde, dropped after the reference time, is shifted to the east.

This scenario is illustrated in the following figures:

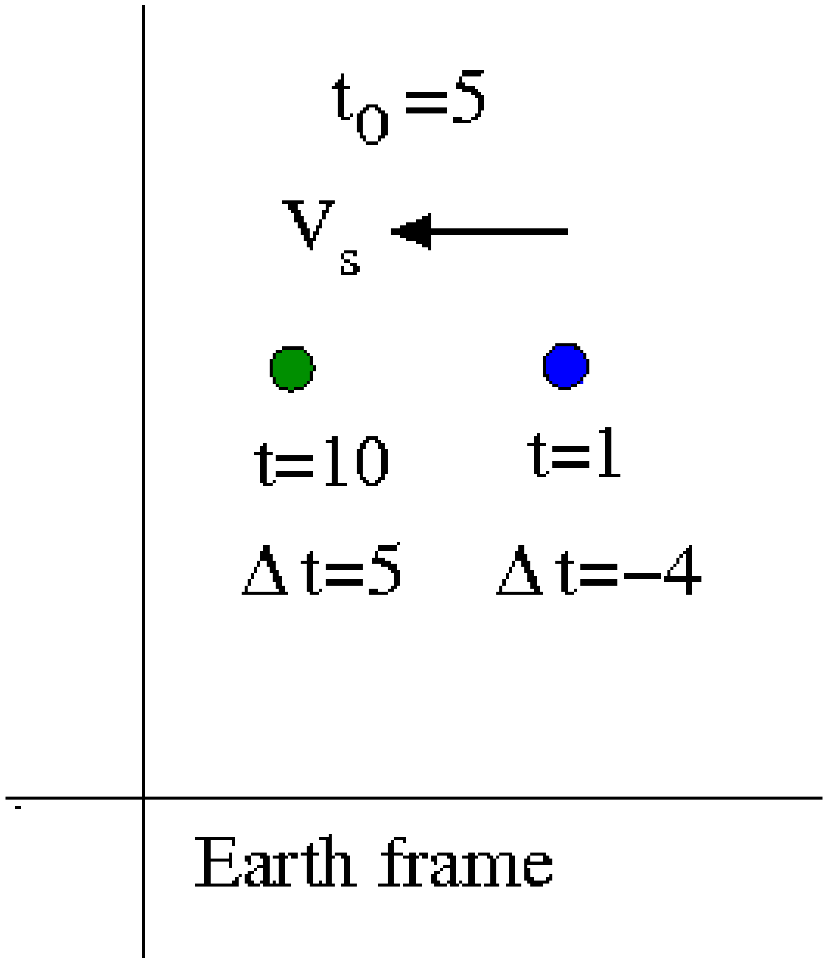

Figure 9: In this image, the system is translating to the left at V_s. A green sonde was dropped to the left of a blue sonde, but $9\,ks$ later. The reference time is at 5 ks, so Δt for the green sonde is $+5\,ks$, while that for the blue sonde is $-4\,ks$. This means they will be translated in different directions, according to the Galilean transformation described, above.

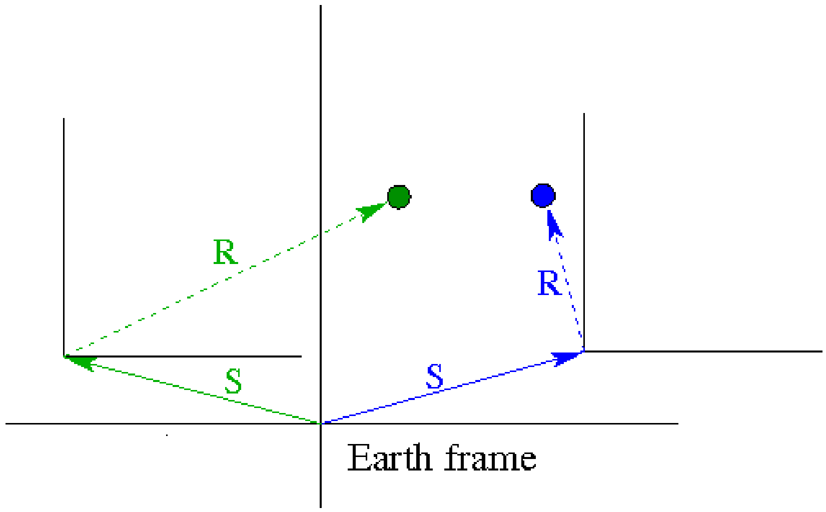

Figure 10: In this figure, the system frames for the two sondes are shown, with their respective position vectors, S. Since the blue sonde had a negative Δt value, its system frame is translated to the right in the Earth frame. The sondes' position vectors R with respect to each system frame are shown.

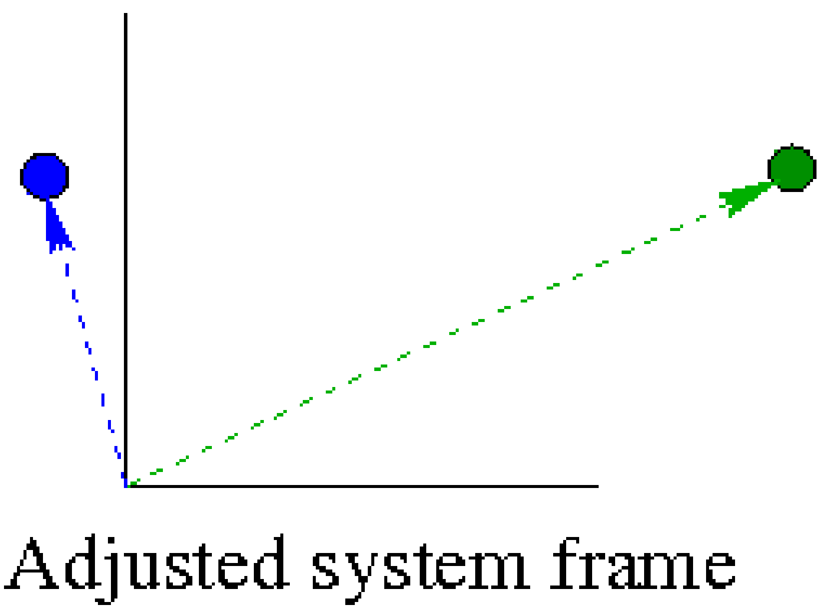

Figure 11: The adjusted system frame, which is the composite system frames of the two sondes is shown here. The blue sonde is now on the left of the green sonde, since its position vector R in the adjusted system frame points to the left.

4.11 Caveats

The following assumptions behind the mesoscale images should be heeded: 1) the system does not evolve over the flight interval; 2) the system's translation velocity is constant over the flight interval.

The above caveats can be avoided in practice by thresholding the output of ngradcart according to quality flags representing the feasibility of the velocity vectors based on goodness of fit and the standard deviation of times for nearby datapoints. Furthermore, if one keeps in mind the meaning of the refectivity and wind data, one can avoid drawing innacurate conlcusions from the images.

For instance, convective-scale behavior of the system can probably be seen in isolated regions of reflectivity where a single pass of the P3 gathered data over a short time interval, though the mesoscale behavior is not necessarily captured there. Conversely, in regions of the reflectivity map where one or more passes of the P3 combine to fit the data over large time intervals, the convective scale data is almost certainly unknown, but the mesoscale information may be well represented, since the compound data sources have been effectively averaged over a large time interval (See Figure 6, above).

Note that markers 06 and 17 in Figure 6 appear collocated on the plot. Although they are collocated in the reference frame of the system, they occur 11ks (~4.25 h) apart in time, as evinced by Figure 7, above. Thus, the wind/reflectivity information in the region is effectively averaged over 4.25 h and therefore decribes the mesoscale flow, but probably not the convective-scale flow. In contrast, the P3 traversed the distance from markers 13 and 14 in 1 ks (~20 minutes). Thus, the strong reflectivity feature above marker 13 and its associated cyclonic winds can be taken as actually describing the convective-scale phenomena at the time the P3 passed by.

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5 Links

A project report by Patrick Harr of the Naval Postgraduate School

Naval Postgraduate School TPARC/TCS-08 site

TPARC/TCS-08 Field Catalog

NRL Monterey Marine Meteorology Division Tropical Cyclone Page

ngradcart manual page

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