The RBrel14 Manual

SADIE Red-Blue Analysis With Rbrel14.exe For 32-bit Windows® Operating Systems

by

Kelvin F. Conrad & Joe N. Perry

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What is Rbrel14?

SADIE

SADIE is a acronym for **S**patial **A**nalysis by **D**istance **I**ndic**E**s. The concepts underlying SADIE regard a set of data as represented by regions, within which the observed counts are either arranged effectively at random, or form local neighbourhoods of similarly-sized counts close to one another, termed clusters. In SADIE, spatial pattern is measured locally, at each sampled unit, through an index of clustering. Each unit with a count greater than the overall mean is assigned a patch cluster index, which by convention is positive. Each unit with count less than the overall mean is assigned a gap cluster index, which by convention is negative. Each index is computed to allow for the size of the count (abundance) at each sample unit.

RBrel14.exe

The program RBrel14.exe analyzes the spatial pattern of data that are in the form of spatially referenced counts. These are counts taken at specific spatial locations, for example numbers of moths in light-traps, numbers of plants in selected quadrats, where the two-dimensional location of the traps or quadrats is known. RBrel14.exe measures and detects the degree of clustering in the form of patches and gaps in the data.

The software uses the "red-blue techniques", described in: *Perry, J.N., Winder, L., Holland, J.M. & Alston, R.D., (1999), Red-blue plots for detecting clusters in count data, Ecology Letters, 2, 106-113*. The output of the software may be used in other graphics packages, such as Surfer® or Genstat®, to produce coloured graphical displays and maps of the clustering in the data.

In order to understand the output from the program it is essential to read Perry et al (1999).

Additionally, indices and randomization tests based on previous work are provided, specifically those based on the distance to regularity and the distance to crowding, as described in: *Perry, J.N., (1998), Measures of spatial pattern for counts, Ecology, 79, 1008-1017.*

What's New

On the surface, little has changed between RBRelV13.exe and RBRel14.exe. Perhaps, most visibly, the output has been compacted slightly by removal of blank lines and more stringent formatting of decimal outputs.

Internally, there has been extensive revision, motivated by two main goals:

1. RBRelV13 was an amalgamation of Fortran IV, Fortran 77 and Fortran 90/95 code, which was really only permitted by the now-extinct Microsoft Powerstation Fortran Compiler. The code needed to be rewritten to a Fortran standard.

2. A command-line interface (CLI) is no longer acceptable in these mouse-driven times and the Fortran code needed extensive re-organization toward building a 'dynamic link library' (.dll) from it, so that a more currently-supported language such as Visual Basic or Java might be used to build a modern point-and-click user interface.

A history of the recent modifications appears in Appendix 1.

Changes which should be of immediate interest to the user are as follows:

1. True support for up to 2000 sampling locations.
2. Addition of a rudimentary command-line help system, activated by typing "*rbrel14 -h*" at a command prompt (See Appendix 2).
3. Combination of both the usual analysis and the "non-parametric method" into a single code base. Type "*rbrel14 -r*" at a command prompt to execute a non-parametric red-blue analysis (see below).
4. Addition of an "interactive mode" with prompts for user inputs, activated by typing "*rbrel14 -i*" at a command prompt (See Appendix 3).
5. Using the interactive mode allows specification of an input file other than rbni5.dat, and the use of "project folders" permits reading files from, and writing files to folders other than the one currently containing *RBRel14.exe*
6. The role of *RBno6.dat* has been changed such that it is now more of a log file. It records the name of the input file read, its contents, some basic statistics of the data and any errors that have occurred during execution.
7. The program should now report most common execution errors to the command console (DOS Box) and to *Rbno6.dat.*

Program input

Overview of the program structure

The program uses two files for input. If you aren't using a shell or the interactive mode, the first input file must have the name: *RBni5.dat*; this contains the spatial coordinates with the corresponding raw counts.

The second file must be called *RBni8.dat*; this contains two parameters that control program execution. Examples of files *RBni5.dat* and *RBni8.dat* accompany the software. The program produces five files of output called *RBno6.dat*, *RBno7.dat*, *RBno9.dat*, *RBno10.dat* and *cluster.dat*. The file *RBno6.dat* records a copy of the raw data, the parameter values selected, plus some basic summary statistics of the data. It is also used to log the path and name of the file read and to record any error messages from the program. The file *RBno7.dat* contains the minimal output required for an analysis. The file *RBno9.dat* contains output for further graphical analyses that must then be cut and pasted as input to some other package. The file *RBno10.dat* contains the briefest summary of the most important of those indices and probabilities output to *RBno7.dat*. The file *Cluster.dat*, contains x and y coordinates in columns 1 and 2, ordered by the corresponding cluster indices in column 3; you can ignore

column 4; this file can be read straight into the SURFER® mapping program or similar software for mapping and interpolation of the clustering indices. The core of the program is the transportation algorithm for determining the moves to regularity (this was adapted from code kindly supplied by Dr Les Proll of the University of Leeds); the output from this is unnecessary for reporting analyses and its action is made transparent to the user.

Note: (i) both files *RBni5.dat* and *RBni8.dat* must be present in the same folder as RBrel14.exe in order to run the program, unless you are using the interactive mode, AND (ii) none of the files *RBno6.dat*, *RBno7.dat*, *RBno9.dat*, *RBno10.dat* or *Cluster.dat* can be present when the program is run.

In the case that you are using the interactive mode, the files must not be in the project folder. If the files are present, you must rename or delete any existing versions of *RBno7.dat*, *RBno9.dat*, *RBno10.dat* and *Cluster.dat.* The presence of these files could cause *RBrel14.exe* to fail without any obvious error message, although an error message should be logged to *Rbno6.dat.*

Also note that, if present, *RBno6.dat* will be overwritten without warning.

Input File Structure

With the above provisos, running the program is easy! This is what you must do. First, put the *n* records in your data into file rbni5.dat, in the following form:

x co-ordinate 1 y co-ordinate 1 count 1
x co-ordinate 2 y co-ordinate 2 count 2
x co-ordinate 3 y co-ordinate 3 count 3
. . .
. . .
. . .
x co-ordinate n y co-ordinate n count n

Where the *x* & *y* co-ordinates for each pair, (x_k, y_k), k=1,…,n, should be read in as real numbers and the count, c_k, k=1,…,n, should be read in, on the same line, as an integer, with no decimal point. No more than 2000 records can be analyzed in the version supplied.

Secondly, specify two parameters in the file *RBni8.dat* as follows: On line one, specify an integer seed, *iseed*, between 1 and 30,000, for the random number generator. Specifying the same seed in successive runs of the program will generate identical randomizations; specifying a different value will result in different randomizations. On line two, specify an integer value, *k5psim*, between 1 and 153 that will determine the number of randomizations done. The value of *k5psim* relates to how many blocks of 39 randomizations are performed. Within the program, the value of *k5psim* is multiplied by 39 to give the total number of randomizations performed; the result is denoted *nsims* in the output. If you can afford the time required to perform the randomizations, then you should use the largest value of *k5psim* possible, 153. Hence you should put the two values required into file *RBni8.dat* in the following form:

iseed

k5psim

Note: If you are using the interactive mode, you are prompted to enter *iseed* and *k5psim,* and *RBni8.dat* is not used.

Program output

The file *RBno6.dat*, created by the program, is a small file. It first tells you the name of the input file read and the number of records, *n*, there are in your data, and then outputs them, giving each a unique reference number. Then the values of the parameters you have given in file *rbni8.dat* or entered in the interactive mode are output, together with *nsims*, the number of randomizations done. Next, some basic summary spatial statistics of the data are printed. First, the x and y co-ordinates of the centroid of the sample units (the 'middle' of the sample, defined as location *P*, with co-ordinates (x_p , y_p), where $x_p = \Sigma k\ x_k / n$, and $y_p = \Sigma k\ y_k / n$)

Second, the x and y coordinates of the centroid of the counts (the spatial equivalent of the arithmetic mean, defined as location *C*, with co-ordinates (x_c , y_c), where $x_c = \Sigma k\ c_k\ x_k / \Sigma k\ c_k$, and $y_c = \Sigma k\ c_k\ y_k / \Sigma k\ c_k$).

Third, the distance, referred to as δ, between these two centroids, i.e. the distance between *P* and *C*. [See also *Perry et al. (1996) Aspects of Applied Biology, 46, 95-102*, or *Perry (1998) Measures of spatial pattern and spatial association for counts of insects. pp. 21-33 in: Population and Community Ecology for Insect Management and Conservation (eds. J. Baumgartner, P. Brandmayr & B.F.J. Manly*). *Balkema, Rotterdam Proceedings of the Ecology and Population Dynamics Section of the 20th International Congress of Entomology, Florence, Italy, 25-31 August 1996. ISBN 90 5410 930 0]*, for further discussion of the importance of the distance δ.

Fourth, for comparison, the maximum distance between any two sample units is given. Next, some basic numerical summary statistics of the data are given: the sample mean, sample variance, the index of dispersion $(n\text{-}1)\ s^2 / m$, and the total number of individuals in the entire sample.

The file *RBno7.dat*, created by the program, is a medium-sized file that contains all the important results from the analysis of clustering and spatial pattern. It first gives the sample mean of the *n* counts. Next come some results from the analysis based on the distance to regularity. Firstly, *D*, the value for the observed data. Secondly, the value of P_a, the probability that the observed counts are arranged randomly among the given sample units. Thirdly, the mean distance to regularity over the randomizations, i.e. the quantity denoted as E_a in Perry (1998). Fourthly, the index, I_a, computed from $I_a = D / E_a$.

Next comes a longer section, devoted to the measurement and detection of clustering. First, several values are given for each unit, with notation that follows that in Perry et al. (1999). There is a row for each unit, ordered by the observed average flow distance, with inflow units, □j, given above and outflow units, □i, given below. The most important value is the standardized clustering index, ν_i or ν_j, given in column five. (An ordered copy of this information is given in the output file *cluster.dat*. Other columns are annotated and should be self-explanatory.) Second, the mean of these clustering indices over inflows and over

outflows, ν_i and ν_j, respectively, mentioned in the discussion of Perry et al. (1999) are given, together with the equivalent value for all flows. Thirdly, the results of the formal randomization tests of these mean clustering indices are given, also mentioned in the discussion of Perry *et al*., and again done separately for inflows, outflows and all flows. Fourthly, results are given relating to the distribution of clustering indices under the null hypothesis of a random distribution of the observed counts amongst the sample units, i.e. the clustering indices produced by the randomizations. These are as follows. Percentiles are given of the entire set of (*nsims* x number of counts in observed data) randomized clustering indices, so that the observed indices may be assessed against objective criteria. Then, percentiles are given for the distribution of the *nsims* values of the maximum clustering index (both for inflows and outflows), where the distribution is formed from the single value found for each randomization. Finally, following a caveat that should be taken seriously, some results are given from the analysis based on the distance to crowding, if they are required, in similar format to that for regularity, described above.

The file *RBno9.dat*, created by the program, is a large file that contains various statistics and results to enable further graphical output. The file begins with the data required to graph the so-called 'initial-and-final' plot (see both papers referenced above). First, all the flows are given in a single block, in arbitrary order, with the total number of flows at the end; then the flows are given again, but now on a unit by unit basis. Note that the flows referred to in these two sections of output have been almost always been scaled to achieve integer values - to get back to the actual values on the original scale of the counts just divide the scaled flows by n, the number of sample units.

Next, information is given, unit by unit, to allow the drawing of the so-called 'vector flow' plot in Fig. 6 of Perry et al. (1999). Again the flows are scaled as above. The important information is given in the final two columns, which give the x- and y- components of the vector for each unit, respectively.

Next, information is given concerning the observed distance to regularity, *D*, and the corresponding value for each of the *nsims* randomizations, as they were generated. The next block of values in three columns facilitates the drawing of the most important contour map of clustering, such as that in Fig. 3 of Perry et al. (1999). The information is essentially the same as that given in file *RBno7.dat*, i.e. the standardized clustering indices, ν_i or ν_j, given as column three, together with the corresponding x and y co-ordinates of each unit in the first two columns of the block. The next block of values gives information to draw the E.D.F. plots given as Figs. 4 & 5 of Perry et al. (1999). These plots are, however, probably less useful than those formal probability tests given in file *RBno7.dat*, that used the means of the clustering indices.

The next block repeats those same observed mean clustering indices, given in file *RBno7.dat*, and, immediately underneath, gives the equivalent values from each of the *nsims* randomizations. These are the raw values used in the comparison between observed and randomized values that was summarized in the formal randomization tests of clustering given in file *RBno7.dat*.

Finally, information is given concerning the observed distance to crowding, and the corresponding value for each of the *nsims* randomizations, as they were generated.

The file *RBno10.dat*, created by the program, is a very small file that contains the three most important indices and their probabilities under the null hypothesis of a random distribution of the observed counts amongst the sample units.

The file *Cluster.dat* contains approximately ordered cluster indices in column 3 and corresponding x and y values in columns 1 and 2; you can ignore column 4. This file can be read straight into the SURFER® mapping program for mapping and interpolation of the clustering indices.

The "Non-Parametric" Method

SADIE is, by definition, a non-parametric method

There is no statistical model underlying SADIE, so the method *is always* non-parametric. But the term as used here applies to the set of data, not the method.

Why is a non-parametric version of SADIE needed?

When a set of counts is very skew, with a variance much greater than its mean, there may be relatively very few counts greater than the mean. For example, in the set of counts {0,0,1,2,4,9,16,63,904}, the mean is 111, so eight of the nine counts are less than the mean and only one, 904, is greater than the mean. The variance, 88832, greatly exceeds the mean. In the SADIE system, for this set of data, only one sample unit, the one with count 904, is a 'donor' unit and could possibly be assessed as being within a (red) patch. All the eight other units are 'receiver' units and are therefore potential (blue) gap units. This clearly limits the ability of the method to discriminate spatial pattern if it exists.

What is the idea behind the non-parametric approach?

To yield greater discrimination, consider replacing the actual counts with their non-parametric ranks, and, for technical reasons, first multiply each rank by 2. The above set would then be transformed to: {3,3,6,8,10,12,14,16,18}. Now, this set is the non-parametric equivalent of the original. The mean is now 10, and there are four units with count smaller than this and four units with count larger. This new set of counts may be used as input to SADIE, exactly as the original counts would have been. With the new set, there are thus four potential patch units and four potential gap units and the ability of the new data to discriminate spatial pattern is therefore enhanced. Note that the arrangement of the original set, defined by the coordinates of its sample units is retained; it is just the counts that are different.

Hence, if the original data had coordinates:

x	y	count
1.0	1.0	0
2.0	2.0	0
1.0	2.0	1
2.0	1.0	2
2.0	2.0	4
.	.	.
.	.	.
5.0	6.0	904

the new, transformed, equivalent non-parametric data would have the same coordinates, but ranks replace the counts:

x	y	count
1.0	1.0	3
2.0	2.0	3
1.0	2.0	6
2.0	1.0	8
2.0	2.0	10
.	.	.
.	.	.
5.0	6.0	18

In summary, the non-parametric approach addresses the problem, for very skew data, that there may be relatively few counts greater than the mean, and therefore an inherent difficulty for the method to detect clustering in the form of patchiness. It does this by “centering” the data about the median. The median of the (old) parametric data becomes the mean of the (new) non-prarametric equivalent data, so, by definition, there are as many values greater than the new mean than there are less than it. However, crucially, in transforming the data it retains the information in the arrangement of the counts relative to one another.

When should the non-parametric version of SADIE be used?

If you believe that the order or rank of the counts relative to one another are as, or more important, as their actual magnitude. This is especially useful with data that is highly skew and for which the variance far exceeds the mean.

How can I run a non-parametric analysis?

If you are using the command-line version, you may either specify the "-r" option (rbrel14 -r), or invoke the interactive mode with "rbrel14 -i" and enter "y" when prompted whether you wish to use the non-parametric method.

Note that if you choose the non-parametric option there is no need for you to do anything to your data prior to input; the program generates the transformation to the non-parametric version of your data automatically. The output in *RBno6.dat* will be slightly different and will explain how the data have been transformed.

How do the results differ when I run a non-parametric analysis?

In general, if the count data are skewed, the mean count will be larger than the median count. Values between the median and mean count will switch from being "receiver" (potential gap) units to being "donor" (potential patch) units. So, if the red-blue plot for the parametric analysis shows moderate gaps and few patches, then the non-parametric analysis will display moderate gaps and moderate patches. These are qualitative changes. They occur in addition to the purely quantitative numerical changes in the data brought about by the transformation. It is important to realize that, for a non-parametric analysis, the data change, and therefore the results must also change.

Known Problems

1. RBRel14 now exits "gracefully" if the output files *RBno6.dat*, *RBno7.dat*, *RBno10.dat* or *Cluster.dat* already exist in the project folder. The one exception occurs if *RBno6.dat* is "locked" for editing by another program (e.g. Microsoft Word). RBRel14 will exit with a mysterious system error, which will only be seen if it was run in a "DOS Box" manually from a command prompt. Unfortunately, while Rbrel14.exe should be able to test if the file is locked, the act of testing seems to cause the same error, so the only current workaround is to make sure *RBno6.dat* is not locked by another application.
2. In interactive mode, RBRel14 does not create Project Folders. You must enter an existing folder name.

Frequently-Asked Questions

What is all this RBni and RBno stuff?

The original red-blue analysis software was written in Fortran 77, with bits and pieces of Fortran IV and Fortran 90 code. It provided no user interface and read input directly from Fortran file units 5 and 8 and wrote output directly to file units 6, 7, 9, 10, and 11. Consequently the input files were named with 'RB' (Red-Blue), 'i' for input and the file unit: *RBni5.dat* and *RBni8.dat*. The original program ran only if these input files were present

Similarly, the output file names contained an 'o' for output and the file unit number: *RBno6.dat*, *RBno7.dat*, *RBno9.dat* and *RBno10.dat*. Cluster.dat is an excerpt from RBno7.dat containing the local cluster scores to simplify transferring the data to graphics packages and other analyses. The original program worked only when these output files were absent (existing versions couldn't be overwritten and the program crashed)

Why is there so much output?

The original Red-Blue analysis program was written as much to study the mathematical properties of Red-Blue analysis as it was to provide a means of analyzing data. The output was made very detailed to show how the analysis performed on different data sets and understand how the results reflected properties of the data. This meant, however, that the results that were important to ecological researchers were difficult to extract, so specific output to *RBno10.dat* and *Cluster.dat* was added.

Researchers have now created tools, macros and protocols to deal with the extensive output and extract the crucial portions. Tradition now dictates continued production of the extensive output, or these tools may be broken.

In any case, minimal output is satisfactory when an analysis goes well, but the extensive output is still essential to understanding unusual patterns in the data.

Why do I need a project folder? Why can't I pick the names and folders of the output files?

RBrel14 still outputs the four traditional *RBno* output files plus *Cluster.dat*. While it would not be difficult to allow the user to choose a name for each of these files, running multiple SADIE analyses and selecting six separate file names each time would become very tedious. It would also be possible to write all of the output to a single file, but this file would be unwieldy. The simplest solution is to write all five files to a project folder and organize output from multiple analyses according to project folder names, rather than individual output file names.

What is the smallest sample size I can analyze?

There has been no rigorous testing of minimum sample sizes for a SADIE analysis. Extensive experience with small data sets suggests something in the range of 25-30 rows of data is the practical minimum for reliable analysis. Certain spatial configurations in small data sets can also mean that the transportation algorithm at the heart of the SADIE red-blue method

cannot find a unique solution and the analysis will fail, often after displaying seemingly bizarre results.

If you do use small data sets, make use of the extensive output and study the results carefully.

What is the largest sample size I can analyze?

The current version of RBrel14 is designed to analyse up to 2000 rows of data. However, it is worth noting that if you plan to use the output (i.e. *Cluster.dat*) as input for SADIE Association Analysis (N_A15.exe or N_AShell), the software for Association Analysis supports only 1005 rows of data.

When using large (>800?) data sets, it is also worth checking the bottom of RBno6.dat for error messages regarding 'arcs', which may indicate RBrel14 is not capable of handling the particular combination of sample size and spatial pattern.

My data are not integers (counts). Can I still use SADIE analysis?

If you can get your head around the philosophical issues of having clusters of continuous measures, such as, say, pH, rather than counts, then all you need to do is transform your data from real numbers to integers and proceed as usual. In fact, this can be a useful way to detect spatial association between counts of a species and physical measurements. The variable entered in the Count column of the input file does not need to be a count, but it does need to be an integer.

I 'misplaced' my original input file. Can I re-run an analysis from the project folder?

All of the information necessary to re-run a particular Red-Blue analysis is stored in the *RBno6.dat* file. The easiest thing to do is to cut and paste the contents of the 'X, Y, Count, Ref. No'. table to a spreadsheet, delete the 'Ref. No.' column and save the file as a Tab-Separated or Comma-Separated text file to serve as your new input file.

The values of *iseed* and *k5psim* can also be obtained from *RBno6.dat*.

I've analyzed four 25-row data sets (n = 25) and although the I_a are all different, the *P*-values for significance are all identical. Is there something wrong?

When you run analyses on similar, small, identically-sized data sets, all with the same iseed, *P*-values may indeed be identical across several analyses. This is a valid outcome of the randomization tests used, but is suspicious-looking. In this case, use a different *iseed* to run each data set and the *P*-values should then differ just slightly from each other.

I don't have/ can't afford/ don't want Golden Software's Surfer® Software. Can I do Red-Blue analysis without it? And do you guys get a commission from Golden Software?

One of the most important features of SADIE analysis is the availability of local clustering indices – a bit like a patch or gap membership score for each sampling point. Surfer® provides a relatively simple means to interpolate, grid and contour map local clustering indices, along with statistics to validate the interpolation method. The result is the nicely

coloured, contoured "Red-Blue" plot to visualize clustering in a data set. There are many other statistical and GIS packages that can perform interpolation and contour plotting. Also, if visualization of the local clustering indices is your primary concern, these can be plotted in many different programs with a little creative thinking. For example, plotting the absolute value of the indices as two series (one for patches and one for gaps) of a 'Bubble Plot' in Excel® will often illustrate patch and gap sampling points very well, if the sampling points are well-spaced.

Although we like Surfer very much, we are not affiliated with Golden Software in any way. No fat brown envelopes stuffed with cash ever appear in our mailboxes as a result of our admiration of Surfer and we even have to pay full price for it just like everyone else.

Selected References

Papers that explain methods

Cluster indices and red-blue plots

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Simulation of spatial data

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Appendix 1: History of modifications

2 JUNE 1999 – Original version by J. N. Perry

29 OCT 2007 – Recoded to avoid use of EQUIVALENCE of NODE and ARC in the TRANSP subroutine

- Removed BLOCK DATA and DATA statements and used simple assignment to initialize variables.
- Replaced the varible FLOOR with TFLOOR b/c FLOOR is a reserved word
- Replaced the varible XOR with TXOR b/c XOR is a reserved word
- Replaced the bubble sorts in SORT2K, SORT6K, SORT78K and DTSORT with slightly faster Shell sorts (all could be replaced eventually with one SBR)

30 OCT 2007 – Replaced the bubble sort in ICSORT with a slightly faster Shell sort

- Replaced the bubble sort in AVFLPP with a slightly faster Shell sort
- Declared TEMP and ITEMP explicitly in AVFLPP, which may have caused rounding errors in EDF in previous versions

28 NOV 2007 – Changed Holerith variables to characters and NAME to a character array

29 NOV 2007 – Reduced sorting sbr (sort2k,sort6k,sort78k) to use one universal one

30 NOV 2007 – imposed IMPLICIT NONE on all sbr and explicitly declared all variables

02 DEC 2007 – added initialization of CAT(J100) = 0 in sbr INDAT

- Moved STFROM(2000),STTO(2000),STFLOW(2000) to a common block
- Increased the dimension of DUMFRO,DUMTO,TNF,DINCX, DUMFLO,DINCY,DUMDIS,DINCL in AVFLPP from 2000 to 4000 to account for the fact that they could require indices up to 2*NOP (=TNN)
- NOTE: program now tested successufully with 1300 sampling points

30 DEC 2007 – Revised code to provide both parametric and non-parametric versions from one code base using RFLAG (=TRUE when non-parametric analysis needed)

- Added the command-line parameter -r to switch to the "non-parametric" mode

30 JAN 2008 – Revised ERRMES so that errors from the transportation algorithm are written to *RBno6* as well as the console window

- Increased the allowable number of arcs from 444444 to 2600000. A better estimate of the max arcs is needed.

01 FEB 2008 – Reduced CONTINUES in the Transportation algorithm by restructuring DO and IF...GOTO statements

- Removed Arithmetic IF statements

18 FEB 2008 – Recoded sections of the Transportation Algorithm for g77 and gfortran compliance

- Reduced redundant common blocks
- Reduced redundant variable declarations
- Converted GOTOs in the Transportation Algorithm to IF...THEN structures
- Tarted up the code

12 MAR 2008 – Added SAVE subroutines

- Tried to enforce stricter formatting of output

21 MAR 2008 – Changed *RBno6* from I/O unit 6 to unit 12 to avoid conflicts with console output

- Changed *RBno6* from STATUS=NEW to STATUS=REPLACE so it can be used for logging errors
- Consolidated and simplified (??) error-handling by moving error handling to the end of the main prog.
- Also added the /errs/ common block to share error messages among modules

23 MAR 2008 – Changed *RBni5* from I/O unit 5 to unit 15 to avoid conflicts with console output

- Added the -i command-line option to prompt the user for the input file and *iseed* and *k5psim*

26 MAR 2008 – Implemented rudimentary support for project folders

- Note that no folders can be created and there is no checking validity of project folders
- Added the filename read to *RBno6*
- Note that implementing folder handling means that code is no longer portable between MS Fortran and g77 (and linux) b/c the system and CHAR functions are non-standard Fortran

23 July 2008 – Re-defined INTEGER as INTEGER*4

- Removed SAVE from main routine DTSORT, DISCRO; Switched from Shell to Bubble sort in AVFLPP; These changes removed discrepancies with distance to crowding compared with RBRELV13.
- Verified rounding error discrepancies caused by previously inplicitly defined TEMP in AVFLPP: TEMP now declared DOUBLE PRECISION

Appendix 2: Command-line help

```
Program RBRel14

Usage: rbrel14 [-r] [-h] [-i]

Performs a Red-Blue SADIE analysis

Optionally uses input files rbni5.dat rbni8.dat

Optional command-line parameters:

  -r Analyses ranks of counts rather than the counts
     (The "non-parametric method")

  -i Enters interactive mode with prompts for input

  -h Displays this text

Only one option may be used at a time
```

Appendix 3: Interactive mode

The following prompts are displayed on the screen in interactive mode (using the -i option). User responses, here shown in bold, are entered after the -->. On the screen, the prompts appear one at a time and the program waits at the --> for each user response.

```
 *** Program Red-Blue version 1.4 ***

 Enter project path for output files
 Use . for current directory
 --> .

 Enter the file name for input
 (full pathnames permitted)
 --> rbni5.dat

 Use non-parametric method? (y/n)
 --> n

 Enter a seed for the random number generator (1 < seed <
30000)
 --> 3000

 Enter a number for k5psim (max=153)
 --> 3

 Program running ...


 Program executed successfully!
```

Appendix 4: Error codes

1	rbno6 I/O error
2	Input file I/O error
3	Error: negative counts in the data
4	Too many sampling points
5	Error reading unit 5
6	No numbers in data
7	Error creating output files
8	Value of ISEED too large
9	Too many simulations
10	Error reading unit 8
11	Total supply <> total demand
12	Number of neg, zero and pos nodes do not equal total number of units
13	All data values identical
14	Two units have same coordinates
15	Invalid number of arcs
16	Too many arcs for this version
17	Problem infeasible - lower bounds on arc flow cannot be met
18	Too many nodes for this version
19	Too many arcs for this version
20	Supply/demand already specified for node
21	Problem infeasible - demand exceeds supply
22	Improper bounds on arc flow
23	Too many arcs for this version

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Version 3, 29 June 2007

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