A Model for Collaborative Learning using Climatological Data, the Virtual Notebook System™ and MATLAB®

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August 5, 1993

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Introduction

In the traditional model for high school assignments, students work individually on an identical set of objectives with little or no contact with their classmates. This model contrasts sharply with the methods commonly used by professional research and development groups in which people collaborate in a structure that merges varied individual objectives into a greater collective whole. The difficulty with using collaborative models in the high school classroom has traditionally been the managerial challenge it places on the teacher to coordinate individual efforts of 25 to 30 teenagers. The Virtual Notebook System (VNS™) is a multi-user, distributed software system that fosters collaborative learning. VNS™ provides a structure that allows students to selectively privatize or publicize their work. It also offers the instructor powerful methods of supervision and interaction.

In addition to its intramural uses, VNS™ provides a forum for intervarsity collaboration. Often students who enter a competitive college or university are shocked by the skills, preparation, and abilities possessed by their new classmates. VNS™ will allow students to interact in close, personal collaboration with their peers in schools around the world while still in high school. This will insure each student the opportunity to be challenged.

While these new technologies have great educational potential, their effectiveness requires the development of new instructional materials and curricula. In particular, students are not accustomed to being given multiple answers to an assignment and asked to further develop or criticize those answers. This paper presents a student-centered application of these technologies to climatological data appropriate for junior high Earth Science or senior high Environmental Science classes.

Overview of the Virtual Notebook System™

VNS™ is designed as a electronic notebook. Like a paper notebook, a VNS™ notebook is a series of pages containing information. As its name implies, the VNS™ maintains a central notebook metaphor, but it is in many ways quite unlike a paper notebook. Information on a VNS™ page is organized into *objects*. These objects may be full color text and drawings, as on a paper notebook, or they may also be audio or video segments, animated images, links to other programs, or even real-time video-telecommunication links. VNS™ pages exist in electronic form, and programs acting on the user's behalf can create, search, or manipulate the pages automatically. VNS™ has *Hypertext* capabilities allowing pages to be cross-referenced among the pages of the same notebook or other notebooks. A single VNS™ page can be accessed by many different people across great distances at the same time. VNS™ pages can be easily modified and any modification is seen simultaneously by all people who are accessing that page.

VNS™ also includes an elaborate scheme of security and options for controlled access. When a user creates a notebook, he or she specifies exactly which other users are not given access, which are given read-only access and which are given read-write access. Anyone with read-write access to a notebook page may choose to *lock* that page. Locked pages may not be modified by anyone other than the person holding the lock. If a person attempts to modify a locked page, the person automatically receives a dialog showing the user-id of the person holding the lock. Backups of any changes made to the VNS™ database are created daily and stored in high security vault.

Overview of MATLAB®

MATLAB® is a high performance programming language for scientific and engineering numeric computation. MATLAB® integrates numerical analysis, matrix computation, signal processing, and graphics in an easy-to-use environment where problems and solutions are expressed just as they are written mathematically. In university environments, MATLAB® has become the standard instructional tool for introductory courses in applied linear algebra, as well as advanced courses in practical engineering and mathematical problems. High school level MATLAB® instructional materials are beginning to be developed.

Example Lessons for Classroom Use

We believe that VNS™ and MATLAB® both have great potential for use in the high school classroom. This article presents a specific application of these technologies to lessons on Climatological data of six Texas cites. In this example, we worked with thirty high school juniors and two science teachers from the Science Academy of South Texas. The students received a short background essay describing the effects of climate on corn plants, and basic instruction on how to use VNS™ and MATLAB®. They were also given open-ended questions and a description of project goals. We present here an edited version of some of the work done by the students and teachers. The intent is, for this example, to form a kind of kernel on which other students will build - NOT an ideal that others should strive to reproduce. New students working with this notebook would have access to the collective work of all those who have preceded them. Students may read what others have done, learn from it, take from it what they like, and expand on it. In some sense, the students who follow have it harder since all of the easy things will already have been done. On the other hand, those who follow will have it easier since many useful organizational and format standards will exist. For example, future users of this particular notebook will notice that adjacent to each graph is printed the MATLAB® commands used to produce the graph. This format was developed by one of the students and later applied to all of the students' work. Central to VNS™ is the principle articulated by Sr. Isaac Newton: "If I have seen farther then others, it is only because I have stood on the shoulders of Giants."

It is not possible to capture the true dynamic nature of a virtual notebook in print. Instead we present a set of black & white "snap-shots" of the notebook. In the particular project presented here, the students were using MacII computers with 12 inch screens. Each student was directed to create two pages: One that was private (could only be read by the student who created it and the teacher), and one that was public (could be read by everyone in the class). Other pages in the notebook were read-only by all of the students, and some pages (such as the "Student Bulletin Board" page) were read-write by all of the students. Their teacher was logged into a MacII-lc with a 21 inch high resolution screen. From the large screen, he could monitor 4 to 6 of their pages simultaneously. The teacher had read-write permission for all of the pages so that he was able to write comments on any student page even as the student was writing on a different object of the same page.

The example presented here represents "work in progress". For this reason we have captured many cross-references and contradictions. This is practical for the small number of participants represented here, but would clearly become unmanageable with large numbers of participants. It might be, therefore, that each school presents their achievements in a consolidated form. This in itself is an interesting challenge and provides an excellent opportunity for interdisciplinary collaboration between Science and English classes. As you read these examples you will hopefully notice many loose ends - these are perfect areas for further student work.

Popcorn Projects

4) Popcorn Projects - MatLab and Climatological Data:

Goals:

- Find graphical ways of representing the given climatological data as clearly, compactly, and understandably as possible. This is actually an unsolved problem. It is possible for you to develop a creative representation that has never been thought of before and that scientists will find very useful.
- Make use of the various graphs to order (from best to worst) the suitability for Grand-Queen Yellow Pearl popcorn farming in each location.
- Determine the optimal planting time for Grand-Queen Yellow Pearl in each location.
- Discover parts of the collaborative notebook (including this question) that are unclear, incomplete, or apparently contradictory. Then annotate these parts with well articulated enhancements, comments, and/or questions.

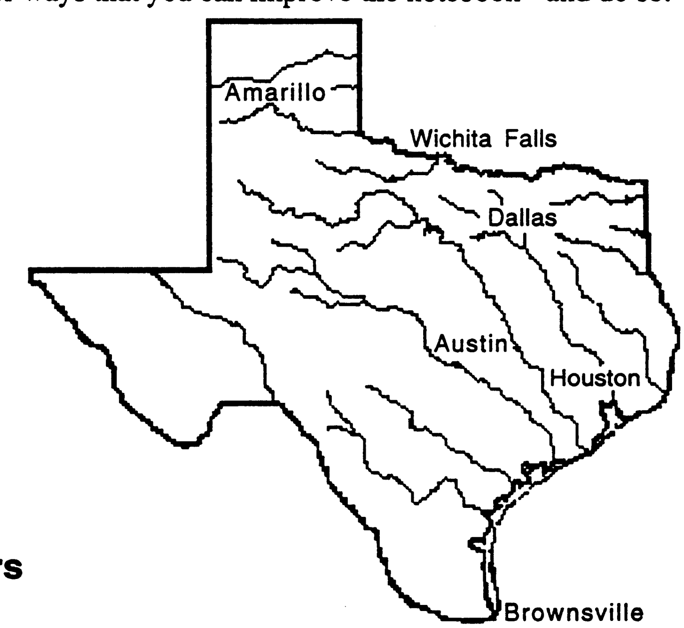
Activities:

(i) Read "Close-Up on Corn Growing" by clicking on the page link below. The close-up page contains information describing the most favorable climatic conditions for growing corn.

(ii) Invoke the MatLab programming language by clicking on the MatLab action link below. This link will cause MatLab to automatically load climatological data for the six locations in Texas shown on the map below.

(iii) MatLab is a very useful tool organizing, analyzing and displaying data. Read the "Student Answers" page. This page contains the names of students and teachers who have already worked on this project. By clicking on one of the names a page containing that person's work will be displayed. Read some of this previous work and try to understand it. Feel free to ask your teacher for help. You can also send a request for help to the person who authored the page you are trying to understand.

(iv) Start creating! Look for ways that you can improve the notebook - and do so.



Close-Up on Corn Growing

MatLab

Student Answers

Close-up on Corn Growing

Drawing by
Cynthia Castellanos

Corn: Thoughts, Comments, & Info. Use this page to include any information or questions that you think would be helpful.

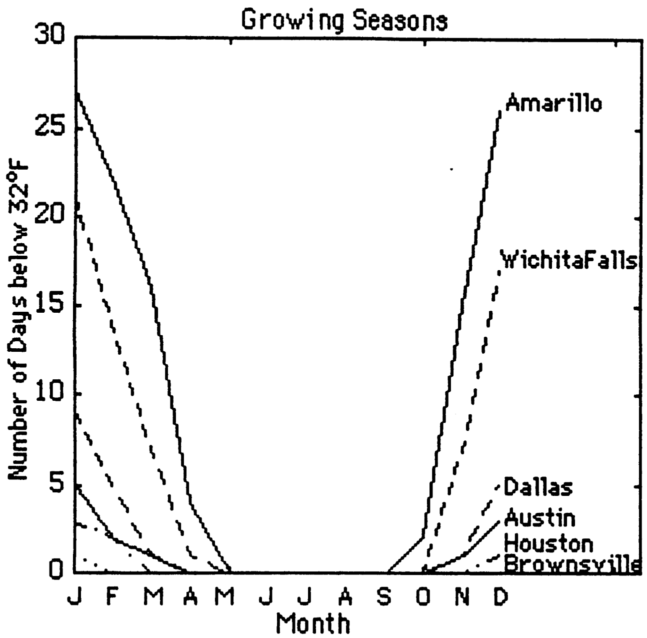
Corn, because of its many varieties, is grown over a wide range of climatic conditions. Some strains grow very short, others very tall, some require 60 to 70 days to mature, and others require 10 to 11 months. There are, however, some general limits. Corn performs best in areas with moderately high summer temperatures, and warm nights. Practically no corn is grown where the mean summer temperature is less than 66°F or where the average night temperature during the three summer months falls below 55°F. Frost is very damaging to corn. Extremely high temperatures (over 100°F), especially when accompanied by low humidity, and direct sunshine, may be injurious to corn. A deep freeze in winter helps to get the soil in good condition by reducing clods and packing caused by machinery or animals, and by reducing the population of some insects that are harmful to corn.

Corn is grown in areas where annual precipitation ranges from 10 inches to over 200 inches. A summer rainfall of 8 inches is about the lower limit for corn production without irrigation, although if evaporation is not excessive an even smaller summer rainfall will suffice. As rainfall approaches this lower limit, the plants must be spaced farther apart. Excessive rainfall causes leaching of soil nutrients and may also increase incidence of certain diseases. Corn performs best when rains are evenly distributed throughout the growing season. Rains prior to planting are important in determining soil moisture reserves.

The development of the corn plant can be divided into three stages. The first stage goes from planting to about knee-high growth. Corn is most sensitive to excessive moisture during this time. The second stage is a rapid growth period during which the plant reaches its full height, the small male flowers in the tassels release pollen, and the silks receive the pollen. During this period, the plant is most sensitive to drought, heat, and chill damage. The final stage, from silking to maturity, lasts about 2/5 of total growing time. This final stage is the least sensitive of temperature variation. After harvesting, the rate of drying of corn is favored by increased wind, sunshine, and warm dry days.

Grand-Queen Yellow Pearl is a variety of popcorn that matures 125 days after planting given an optimal 24-hour average temperature of 80°F (145 days for 73°F). Optimal rainfall during the growing season is about 17 inches.

Patrick: Growing Season




```
MatLab Commands:

axis([1,16,0,30])
plot(1:12,cold32)
x = 12*ones(6,1)
y = cold32(:,12)
text(x,y,name)
```

I think that this is an important graph because it shows the growing seasons for each location. Corn cannot be planted until after the last freeze of winter and must be harvested before the first freeze of the next winter. It also shows which locations get a deep winter freeze. The Close-up on Corn Growing page says that "a deep freeze helps to get the soil in good condition by reducing clods and packing caused by machinery of animals, and by reducing the population of some insects that are harmful to corn."

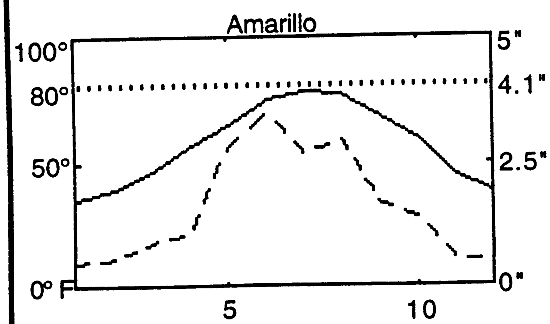
Grand-Queen Yellow Pearl Popcorn requires over 4 months to grow which is longer than the growing season in Amarillo. The other 5 locations all have sufficiently long growing seasons. Wichita Falls and Dallas might be the best of these places for the Grand-Queen because they also have deep winter freezes.

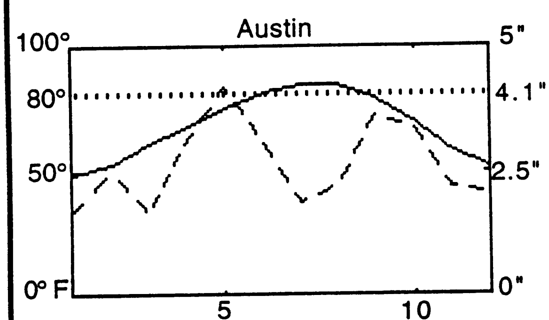
I just read Brenda's "Everything Graphs" and found something that wasn't everything. The vertical dotted lines that she drew to indicate the planting and harvesting time are always spaced 125 days apart. However, if the average temperature is less then 80°F, then the Grand-Queen's growing time is longer then 125 days . Anyway, I thought this table would be helpful:

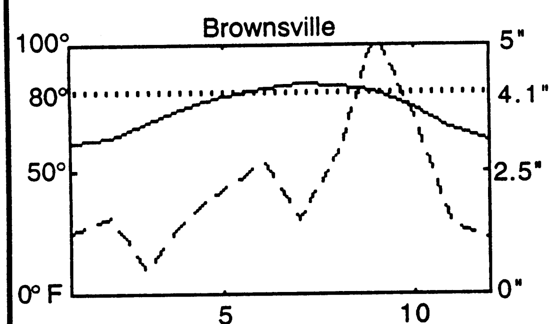
	Avg Temperature °F		
Location	**Apl-Jul**	**May-Aug**	**Jun-Sep**
Amarillo	68.9	74.1	75.1
Austin	77.5	81.5	82.5
Brownsville	80.4	82.6	83.3
Dallas	77.0	81.9	83.3
Houston	76.9	80.4	81.3
WichitaFalls	75.5	80.5	81.8

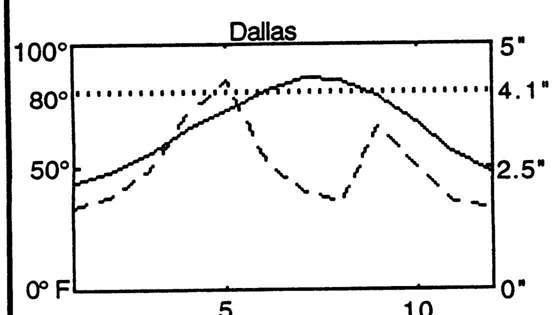
```
MatLab Commands:
a = (high + low)/2;
b = sum(a(:,4:7)')/4;
c = sum(a(:,5:8)')/4;
d = sum(a(:,6:9)')/4;
[b; c; d]'
```

Cynthia: Climatagrams









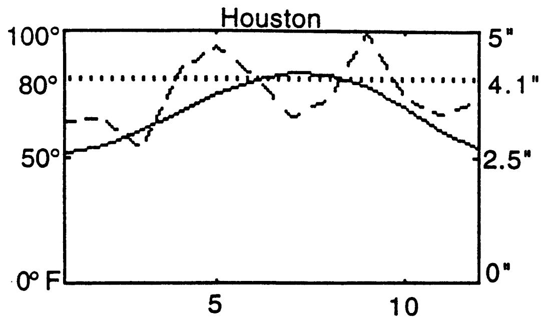
** Climatagrams **

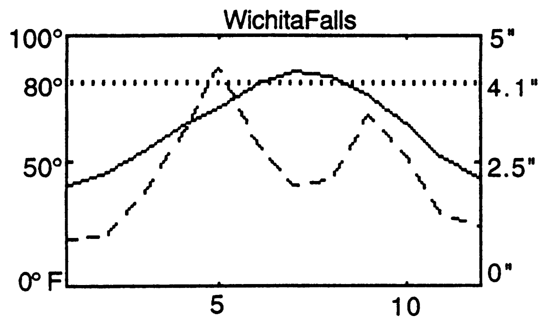
For each location, I am making a graph that shows the average monthly temperature (red) and the average monthly rainfall (green). These are called (I think) climatagrams and determine the climate zone of the area.

I calculated the average temperature by finding (low + high)/2. The real hard part was getting both the temperature and rainfall to show up on the same graph. In order to do this I multiplied all of the rainfall numbers by 20.

The two dotted lines (which are so close that they look like the same line) show the Optimal average daily temperature and the optimal monthly rainfall for Grand-Queen Yellow Pearl. The Close-up on Corn Growing page gives the optimal rainfall as 17 inches for the growing season. The way that I calculated 4.1 inches per month was to divide 17 by the number of days in the growing season (125) and multiply by the number of days in a month (30).

In these Climatagrams, the left axis is °F, the right axis is inches of rain, and the bottom axis is months.





MatLab Commands:

```
avgtemp=(low+high)/2
r20 = rain*20
```

Now create an M-File of the the commands below and then to call it with different values of n (1 through 6):

```
hold off
axis ([1,12,0,100])
plot (1:12,avgtemp(n,:))
hold on
plot (1:12,r20(n,:),'-g')
plot ([1 12], [80 80], ':')
plot ([1 12],[4.1*20 4.1*20],
':')
title (name(n,:))
```

My Interpretations:

All of the locations experience a drought in July - not good since this is the middle of the growing season.

Brownsville's rainfall curve is very bad. Brownsville averages only about 2 inches of rain from April through August. Then in September it gets flooded. I think August would be the best time to plant the Grand-Queen in Brownsville. This would take maximum advantage of the rain since August, September and October all receive over 2.5 inches of rain. Also, the floods would hit just when the popcorn is doing most of its growing. Planting in August implies harvest in early December which is OK for Brownsville since the average temperature at that time is above 60°F and corn is least sensitive to temperature variations in the last 2/5ths of its growth. Overall, I think Brownsville would be one of the worst places for the Queen.

Houston is the best place for the Grand-Queen. It is not as hot as Brownsville, but it gets lots more water. In Houston I would plant the popcorn in late June. This would mean that the corn would have the least rain during its first stage of growth (when it is most sensitive to over watering). During the rapid growth stage, the rainfall will be on the increase.

Amarillo, Dallas, Austin and Wichita Falls all seem to be about the same for growing the Queen. Of the four, Amarillo gets the most summer rain, but is a little too cool. I think that Wichita Falls is the best of the four since it is warmer than Amarillo and gets more summer rain than Dallas, or Austin. In all four of these places, the planting time should be in mid May.

And that is all that I have to say about corn.

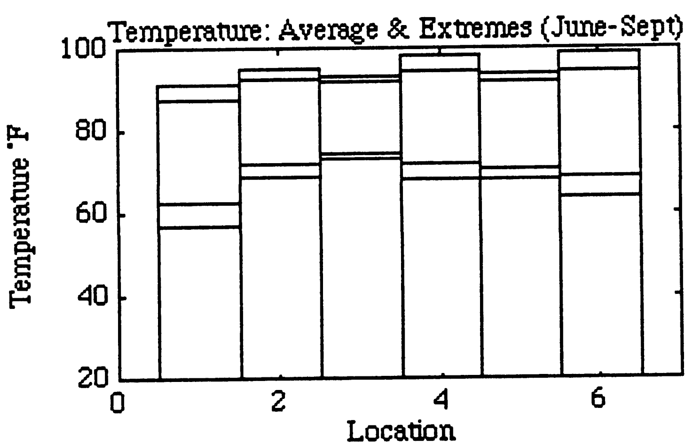
Yadira: Average and Extreme Temperature

I really like Cynthia's Climatagrams but I have two points of comment:

1) She claimed that she could find the average daily temperature for each month by finding (low + high)/2. I think that during the long days of summer that a large part of the day would be near the daily high, and that only the few hours before sunrise would be near the daily low. Therefore, the true daily average would be higher than the average of the daily low and high.

2) The Close-up on Corn page says that corn grows best with "moderately high summer temperatures and warm nights". Therefore, I think we should graph both the high and low separately instead of averaging them. This will give an indication of how much the temperature fluctuates.

The graph below shows an average of the Average Monthly Low & High Temperatures for the four summer months (June through September). The graph also shows the hottest and coldest single monthly average of the four months. All four values for each location are graphed on a single bar of the bar graph.



MatLab Commands:

```
hi2=high(:,6:9);
lo2=low(:,6:9);
avghi=sum(hi2')/4;
avglo=sum(lo2')/4;
hiest=max(hi2');
loest=min(lo2');

bar(avghi)
hold on
bar(avglo)
hold on
bar(hiest)
hold on
bar(loest)
```

Key:
1: Amarillo
2: Austin
3: Brownsville
4: Dallas
5: Houston
6: Wichita Falls

Top line: Hottest Monthly Average High Temperature.
2nd line: Average Monthly Average High Temperature.
3rd line: Average Monthly Average Low Temperature.
Bottom line: Coldest Monthly Average Low Temperature.

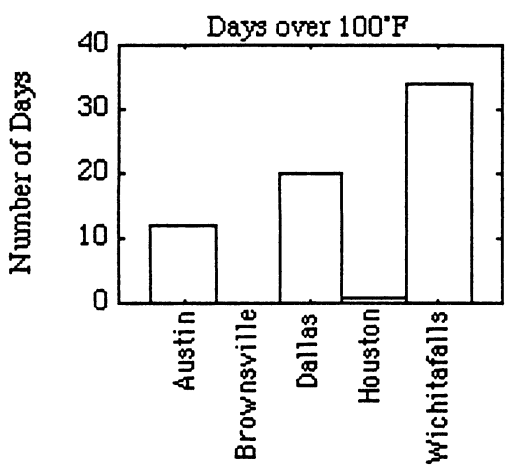
My graph shows that Brownsville is better for growing corn then Cynthia predicted since it is warm and almost the same temperature in both the day and the night. My graph also shows that Wichita Falls and Amarillo are worse then Cynthia predicted. Wichita Falls has very hot days and cold nights. Amarillo is probably the worst place for corn since it has very cold nights.

Eveth: Hot Hot Sun!!!

I like the way Patrick expressed the growing season. In particular, he showed that Amarillo has too short a growing season to grow Grand-Queen Yellow Pearl. In my mind, this completely cuts Amarillo out of the race so I do not understand why other people are still including it in their graphs and discussions of rainfall etc.

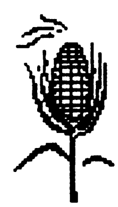
I also like Yadira's graph of the extreme temperatures except that she uses the word "average" too much! Cynthia, in her Climatagrams, put each location's rainfall data on separate graphs. This makes it very hard to compare the data. Furthermore she put rainfall and temperature on the same graph. This does not make sense to me because it is like comparing apples to oranges.

My graph shows the number of days in each location that are over 100°F. I copied Yadira's idea about only graphing June thorough September. My graph makes it easier to see which locations are too hot for corn.

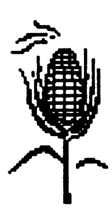


MatLab Commands:

```
hothot = hot100(2:6,6:9)
totalhot = sum(hothot')
bar(totalhot)
```



Ode To Corn Part1
oh corn, oh corn,
oh corn, oh corn
The End



Ode To Corn Part 2
Oh! How sweet thy corn is
Sweet corn, Sweet corn,
Sweet corn!
The End.

Brenda: Everything Graphs

I have tried to combine the information in Cynthia's Climatagrams, Patrick's Growing Season, and Yadira's Average & extreme Temperature pages together with the Humidity and Sky Conditions data (while not to make too much of a mess).

I begin by graphing each location's average rainfall and temperature during the location's growing season (not during the whole year). The way I did this was to set the rainfall and temperature equal to zero for all months of all locations that have an average of at least one freezing day. This has the advantage of making the length of each location's growing season starkly visible. This also has the advantage of removing lots of irrelevant data (in my option, temperature and rainfall data during the freezing months is not important to corn growth). The key step of my great inspiration was the squiggle (~). In MatLab, this is called the "NOT" operator. It makes all non-zero elements of a matrix equal to zero, and all zero elements equal to one.

The humidity data only included four months (Jan, Apr, Jul, Oct). I averaged the July humidity data for 6 am, 12 noon, and 6 pm. This average is shown as a "*" on each graph.

I also tried to express the amount of sunshine received by each location. I did this by multiplying the number of clear days times 3 and adding this to the number of partly cloudy days. I calculated this value for July in each location and plotted it as a "+".

Finally, I used MatLab to plot a pair of vertical lines spaced 125 days apart (the growing time for Grand-Queen Yellow Pearl Popcorn). I made six copies of the line pairs and used VNS to position them on the graphs. The lines indicate the planting and harvesting time that I judge to be best for each location.

MatLab Commands:

```
a = ~(cold32);
rr = a .* (rain*20);
hh = a .* high;
ww = a .* low;
u1 = hum(:,9:11)
u2 = sum(u1')/3
kk = sky(:,7)*3 + sky(:,8)

hold off
axis ([1,12,0,100])
plot (1:12,hh(n,:))
hold on
plot (1:12,ww(n,:))
plot (1:12,rr(n,:),'-g')
plot ([1 12], [80 80], ':')
plot ([1 12],[50 50], ':')
plot ([1 12],[4.1*20 4.1*20], ':')
plot (7,u2(n), '*')
plot (7,kk(n), '+')
title (name(n,:))
```

Key:

The Left axis shows °F.

The Right axis shows Inches of Rain.

The Bottom axis shows the Month of the Year.

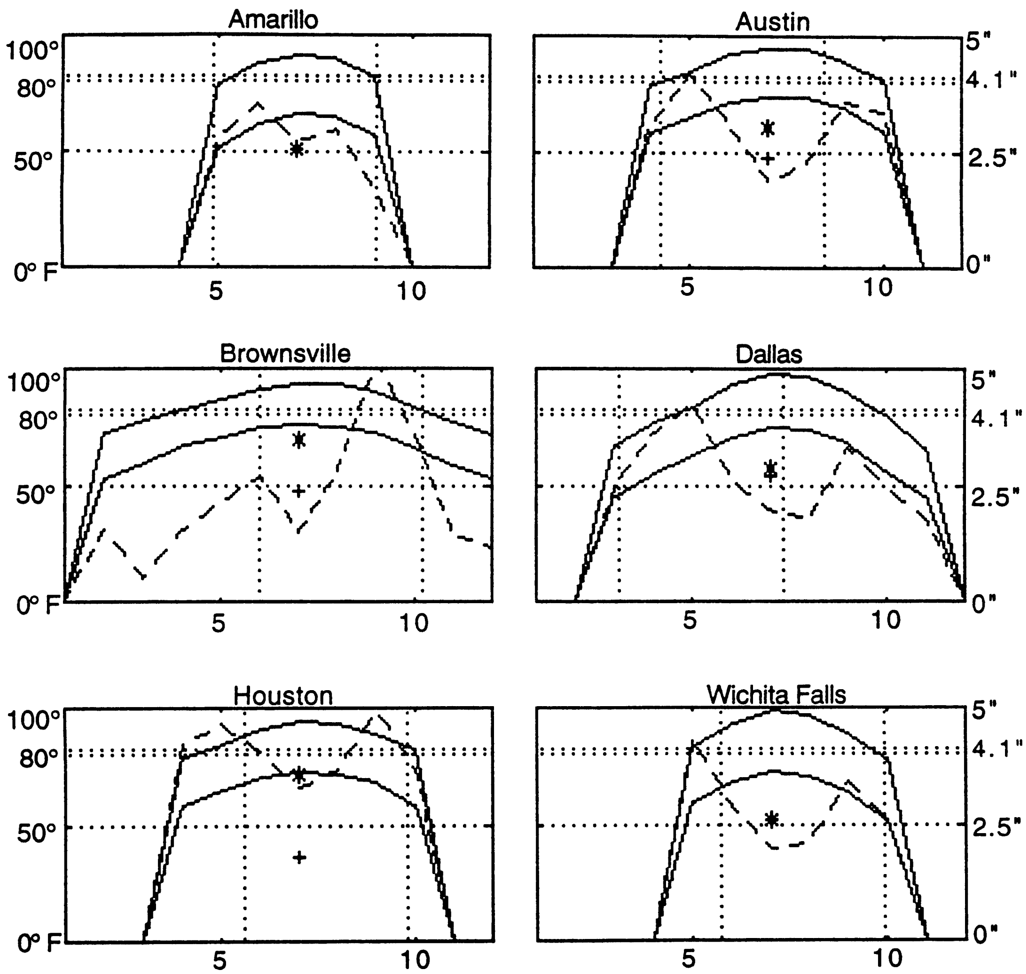
Red solid lines represent average High and Low Temperature.

Green dashed lines represent average Rainfall.

Vertical Dotted lines represent a "good" choice of Planting and Harvesting.

+ shows amount of Sunshine in July.

* shows average day-time Humidity in July.



Cynthia claimed that Brownsville would not be very good for Grand-Queen pop because it does not get much rain until August; however, Brownsville has a high humidity and therefore a low evaporation rate.

My graphs also make it very clear that Austin is much better for the Queen than Dallas or Wichita Falls. As Cynthia pointed out, all three locations have a drought in July; however, this drought is less server in Austin because Austin has a higher humidity, less sunshine and a cooler day high temperature.

Houston has the most rain, the least sunshine and a high humidity. I think that the Queen would rot in Houston.

Corn: Thoughts, Comments, & Info.

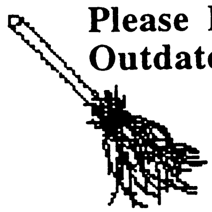
Corny Sex

The Close-up says that the corn silks are female pollen receiving organs. I know that there are lots of silks on each ear of corn. Is there exactly one silk to each kernel? This would mean that the kernels on a single ear are brothers and sisters, but not twins. In fact, most kernels, living and growing together in the same ear, would probably have different fathers! So my question is this: Why aren't some of the kernels on an ear of corn half white, some half yellow, some half blue, and some half Indian? -Patrick

Growth Rate and Tempareture

The close-up says the Grand-Queen takes 125 days to grow at 80°F and 145 days at 72°F. Well, how about if the temperature was 85°F or 90°F - would the corn grow even faster or would it burn up or would it just grow the same? Likewise, if the temperature was 64°F, would the

Student Bulletin Board



Please Delete Your Own Notices When They Are Outdated!

Patrick...
How do you get MatLab to label the axis of a graph? -Yadira

Dear Yadira,
Use the "label" command from the "graph" menu. Note: the "graph" menu only appears when the graph window is active.

Yadira, can you give me a ride home today?
- Brenda

There is water flowing
under.
The rocks and stones.
After the money is gone.
Off in the blue again.
Same as it ever was.
-Talking Heads

```
To Cynthia.....
Please read my "Average and
Extreme temperature" page.
I wrote some comments about
```

TO BRENDA!!!!
I have found a hole in your loop. Read the bottom part of my "Growing Seasons" page for total illumination. - Patrick

Appendix I: Climatological Data File

```
disp('Data based upon reports by the U.S. Dept of Commerce, 1951-1984.

disp('Name of location')
name = [  'Amarillo      '
          'Austin        '
          'Brownsville   '
          'Dallas        '
          'Houston       '
          'WichitaFalls  '];

disp('Average number of days < 32°F (Jan, Feb, ... Dec).')
cold32 = [ 27   22 16 4 0 0 0 0 0 0 2 15 26
            9    5  1 0 0 0 0 0 0 0  1  5
            1    0  0 0 0 0 0 0 0 0  0  0
            3    2  0 0 0 0 0 0 0 0  0  1
            5    2  1 0 0 0 0 0 0 0  1  3
           21   14  7 1 0 0 0 0 0 0  7 17];

disp('Average number of days > 100°F (Jan, Feb, ... Dec).')
hot100 = [ 0 0 0 0 0 2  2  1 0 0 0 0
           0 0 0 0 0 1  4  6 1 0 0 0
           0 0 0 0 0 0  0  0 0 0 0 0
           0 0 0 0 0 2  9  8 1 0 0 0
           0 0 0 0 0 0  0  1 0 0 0 0
           0 0 0 0 1 5 15 12 2 0 0 0];

disp('Average precipitation in inches (Jan, Feb, ... Dec).')
rain = [  .46  .57  .87 1.08 2.79 3.50 2.70 2.95 1.72 1.39  .58  .49
         1.60 2.49 1.68 3.11 4.19 3.06 1.89 2.24 3.60 3.38 2.20 2.06
         1.25 1.55  .50 1.57 2.15 2.70 1.51 2.83 5.24 3.54 1.44 1.16
         1.65 1.93 2.42 3.63 4.27 2.59 2.00 1.76 3.31 2.47 1.76 1.67
         3.21 3.25 2.68 4.24 4.69 4.06 3.33 3.66 4.93 3.67 3.38 3.66
          .93 1.00 1.82 2.99 4.34 2.85 2.00 2.14 3.41 2.61 1.42 1.22];

disp('Average monthly low temperatures °F (Jan, Feb, ... Dec).')
low = [ 22  26  32  42  52  62  66  65  57  46  32  25
        39  42  49  58  65  72  74  74  69  59  48  41
        51  53  60  67  71  75  76  75  73  66  58  53
        34  38  45  55  63  71  75  74  68  56  45  37
        41  43  50  58  65  70  73  72  68  58  49  43
        28  33  40  51  59  68  73  71  64  52  40  32];

disp('Average monthly high temperatures °F (Jan, Feb,... Dec).')
high = [ 49 53 61 71 79 88 91 90 82 73 59 52
         59 64 72 79 85 92 95 95 89 81 69 63
         70 73 78 83 87 91 93 93 90 84 77 72
         54 59 67 77 84 93 98 97 90 80 66 58
         62 66 72 79 85 91 94 93 89 82 72 65
         52 58 67 77 84 93 99 97 89 78 64 56];

disp('Average number of days with various sky conditions')
disp('     January         April           July          October')
disp('   Cr  PC  Cd     Cr  PC  Cd     Cr  PC  Cd     Cr  PC  Cd')
sky = [ 12   7  12     12  8   10     13  12  6      17   7   7
         9   6  16      8  7   15     11  14  6      13   9   9
         6   8  17      5 11   14     11  15  5      12  12   7
        10   5  16      9  7   14     15   9  7      14   8   9
         7   5  19      8  6   16      7  15  9      12   9  10
        11   6  14     11  7   12     14  10  7      16   7   8];

disp('Average relative humidity (%)')
disp('     January           April             July              October')
disp('   6am 12 6pm 12     6am 12 6pm 12     6am 12 6pm 12     6am 12 6pm 12')
hum = [ 70 51 47 64       67 38 31 54       73 42 38 60       70 41 40 61
        79 61 58 73       83 58 54 76       87 50 46 74       83 54 53 75
        87 68 74 86       87 60 68 85       90 55 63 85       88 59 69 85
        80 61 60 74       84 58 54 74       80 48 44 66       82 53 54 73
        88 67 72 85       92 60 63 89       93 58 63 88       93 56 71 91
        81 57 57 74       81 49 47 72       77 42 38 65       83 50 53 73];
```

Appendix II:
System Requirements

VNS Requirements for Connection with the Outside World:

Each school will need a single, dedicated file server and at least a 9600 bps external telephone line. Increasing the transmission rate to 14400 bps or higher will offer a very noticeable improvement in performance.

Minimum requirements for VNS on individual work stations :

Macintosh Computers:

MacII with System 7 or higher, 8 MB of RAM, an EtherNet card, MacTCP, and 10 MB of free disk space.

PC Compatible Computers:

A 386, 486 based PC with Microsoft Windows version 3.1 or greater, an EtherNet card, PCNFS or ChameleonNFS, VGA graphics, 8 MB of RAM, and 10 MB of free disk space.

UNIX Systems:

X-windows R4 or better. Also, IRIX, SUNOS, ULTRIX, AIX or SOLARIS.

Most useful upgrades for individual work stations:

Additional RAM is the most important upgrade over the minimum requirements (16 MB would be ideal). A 16 inch (or larger), high resolution color monitor is also a very noticeable improvement. Additional disk space (20MB to 40MB) is useful for temporary storage of video segments and also for reducing network traffic.

Appendix III:
Availability and Additional Information.

VNS™ was first developed at Baylor College of Medicine and is available from The ForeFront Group, Inc. 1360 Post Oak Boulevard, Suite 1660, Houston, Tx 77056.

MATLAB® is available from the MathWorks, Inc. Cochituale Place, 24 Prime Park Way, Natick, MA, 01760

Additional applications of both VNS™ and MATLAB® to high school education are available free of charge by writing to Joel Castellanos, CITI Rice University, Houston Tx, 77251-1892.