IRT SALH

Stress Accumulator Logger

Software v. 2.05C

Dynamax IRT-SALH Manual

Version 2.05C – Software Version

Fig. 1 IRT-SALH System

10808 Fallstone Road STE 350

Houston, TX 77099 USA

Table of Contents

1. Basic Operation

IRT-SALH: Infra-Red Temperature Stress Accumulator/Logger and Host

The IRT-SALH system consists of one or more wireless IRT sensors, an optional RHT (Relative Humidity and Temperature) sensor, and the SALH: a waterproof coordinator box containing a single-board computer running the Linux operating system, a Zigbee coordinator, and a WiFi USB stick. The user may optionally provide a USB memory stick for saving data files or installing software. The system is controlled either from your smart phone, wireless-enabled tablet, or wireless-enabled laptop computer. All mobile or laptop operating systems and devices are supported as long as you have an Internet web browser and a wireless Internet adaptor. The system can also be connected by wired Ethernet, but this is not recommended unless the SALH is indoors.

For details on the IRT sensor unit, refer to the Dynamax SapIP-IRT Manual.

Power

The SALH runs on 12VDC using a battery and solar charging system. Inside the SALH a 12V to 5V converter supplies 5V power to the computer board and the USB hub. The wireless IRT sensors are charged on 12VDC and have 5V internal batteries. An 110VAC to 12VDC power supply is also provided for indoor use only **(THIS INDOOR POWER SUPPLY SHOULD BE USED BY ITSELF, NOT BE CONNECTED WITH BATTERY OR SOLAR CHARGER).**

For outdoor use, the 300 ma continuous (12V) current requires that the SALH is charged by a 30 W solar panel, and will typically need a 60 to 70 Ahr 12 V deep cycle marine battery. This power requirement is such that all components of the SALH are operational and will continue to log data for a minimum battery charge of 2 weeks with poor , or cloudy weather, for example in North America. Consult Dynamax for other locations.

Installation

After mounting the SALH and applying power, the DC-DC converter (AVRDC in Blue Box) needs to be turned on by sliding the power switch towards the rear of the box. The red light on the power supply should come on. If the computer status lights do not start blinking, press the power-on button at the right-hand side of the computer board. (see page 32). No further installation is required. The computer will automatically detect all nearby sensors, and then wait for a cell phone or laptop computer to establish communication through the WiFi node. The SALH computer will not start logging data until it can set its date and time to the cell phone (or laptop)'s date and time. After that no further help is required and the SALH will begin logging data.

Connecting to the Wi-Fi – to see all data.

The default name for the Wi-Fi node is:

"dyna100".

Using the settings screen of your Android phone or iPhone, connect to the Wi-Fi named "dyna100" and enter the Wi-Fi password which is, by default:

"agridata8" (without the quotes).

The SALH then provides a mini wireless network (2.4 Ghz Wi-Fi) that is compatible with most mobile devices, with all the network services that are normally provided by the Internet. To use the network, enter dyna/dynamax or http://dyna/dynamax/index.html into your web browser. ("dyna" is the domain name of the server). On Android phones or Windows laptops the URL

http://192.168.8.2/dynamax

must be used. The SALH supports all modern web browsers such as Safari, Chrome, Firefox, and IE 10 or later versions. Once you are connected, bookmark or save the URL to your home screen or desktop.

Home Screen

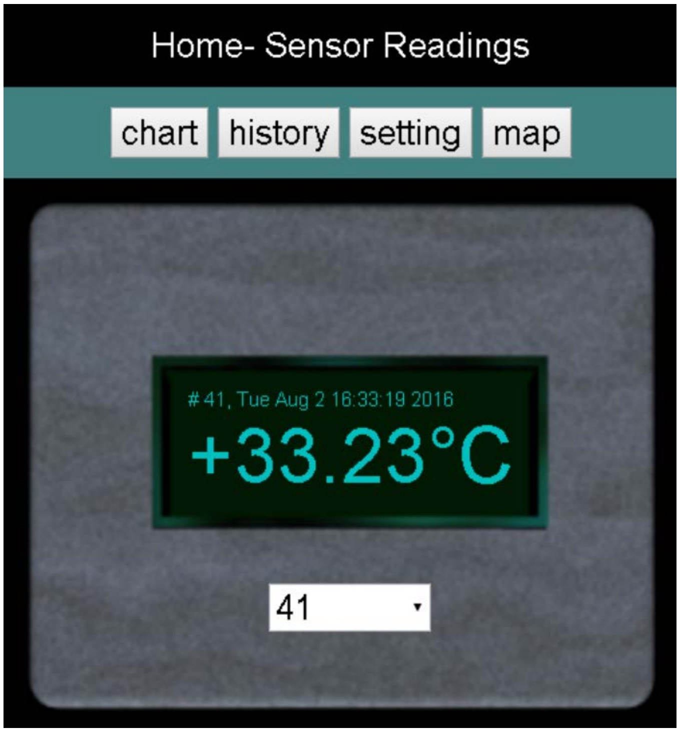


Fig. 2 Home Screen (top)

The Home Screen provides basic information about the system. As one proceeds through the chart screens, settings, or map, one would typically go back to the home screen to proceed to the further information.

The Menu Bar allows you to switch between the Chart, History, Settings, and Map screens.

The gray panel shows the sensor ID, the date and time of the sample, and the latest temperature reading from the first sensor. To select a different sensor, click the drop-down box and select a sensor from the list. The list is populated with all the sensors that are currently reporting. You might need to refresh the screen when new sensors are added to the system. If sensors are turned off or stop reporting, you may continue to see the last reading taken from that sensor.

The date and time will appear yellow if the date and time of the SALH need to be updated from the smartphone. This should only occur in the event of a power failure to the SALH. Refresh the browser to update the date and time and in a few minutes it will turn the normal, blue-green color.

The second panel (Fig. 3 below) shows a diagnostic panel with information such as ambient temperature, sensor battery voltage, and the radio's serial number. Swipe up or scroll down in your browser to view the diagnostic panel:

Diagnostic Panel

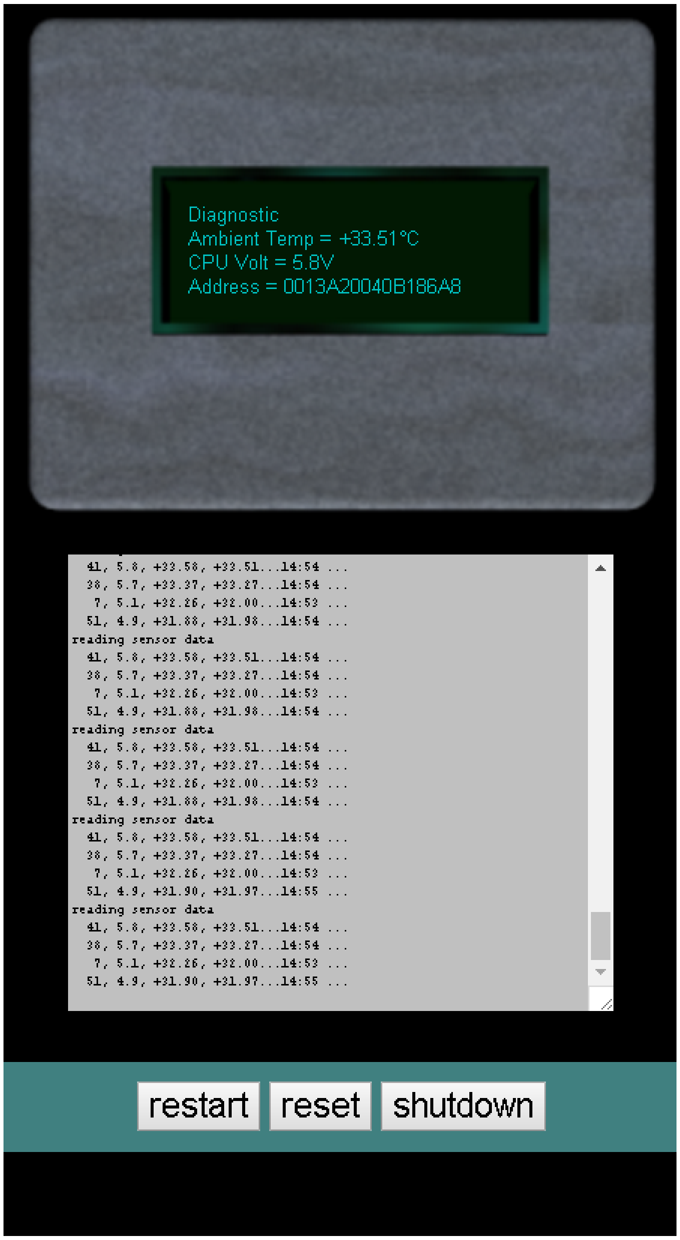
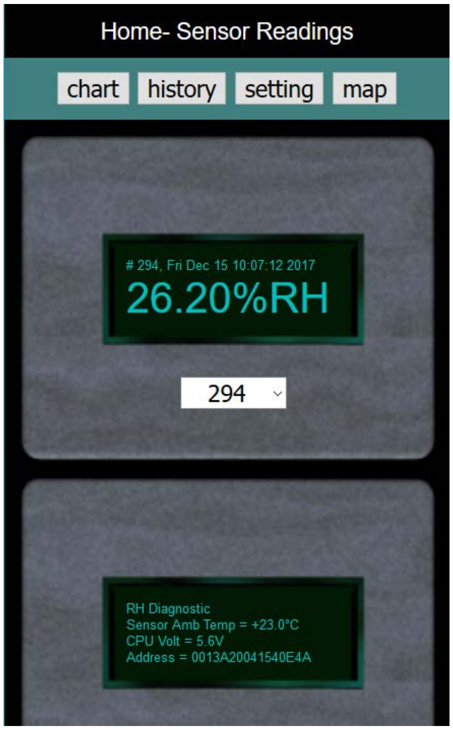


Fig. 3 Home Screen Diagnostic Panels

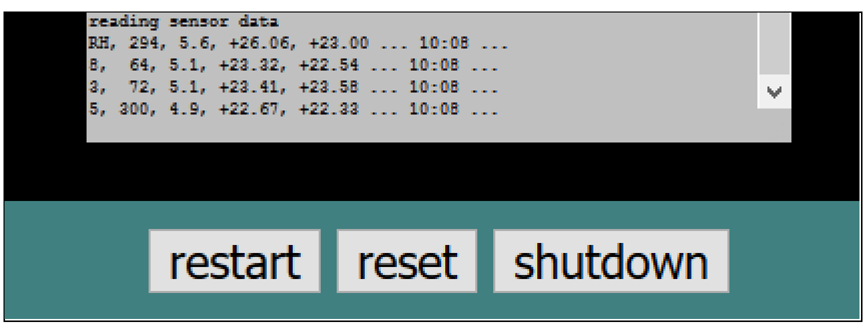
The white text area shown in Fig. 3 is a diagnostic console which shows the latest data from all the sensors in text format. Messages from the JavaScript controller (running on your browser) will also appear in this console.

SAPIP-RHT – Relative Humidity, air temp sensor

The Relative humidity and air temp sensor provides a RH output, and the Air Temp appears in the in the diagnostic details.



The diagnostic panel example show the raw RH sensor Zigbee output, a serialized IRT sensor's output. Below the last panel (diagnostic) are three control buttons:



restart - this button restarts the IRT server program on the SALH. This will cause the coordinator to re-establish communications with all the IRT sensors. After one minute the page will automatically reload to set the date and time. A restart is required when sensors are added. This function is mainly used for maintenance and software upgrades, or when the logging interval or stress settings are changed (see Settings Screen).

reset - this button will reboot the SALH. It takes about 30 seconds to reboot. During that time the web interface will not function and the Wi-Fi will drop out. The browser will automatically refresh the screen after one minute, however if another Wi-Fi hotspot is located nearby, your phone may attempt to switch to this other connection. If so, you may need to use the settings screen of your phone to reconnect to the SALH.

shutdown - this button will shut down the SALH computer. It takes about a minute to shut it down. When shut down is complete, the IRT computer power LED (right below the power connector) will go off. All data logging will be stopped until the SALH Computer is turned on again, by pressing the "power on" button located just under the Ethernet connector on the board. Removing power to the computer with the DC-DC converter power switch, and then turning it back on, will also restart the computer.

Reset and Shutdown are needed only for software updates and maintenance (see section on Maintenance). Shutdown is recommended if you need to power off the system for maintenance or to remove any components.

Irrigation Zones and Stress Calculation Methods

The SALH supports multiple irrigation zones and two different methods to calculate water stress. Either method can be selected for a particular irrigation zone.

iDANS – integrated Degrees Above Non-Stressed

Chart Screen iDANS

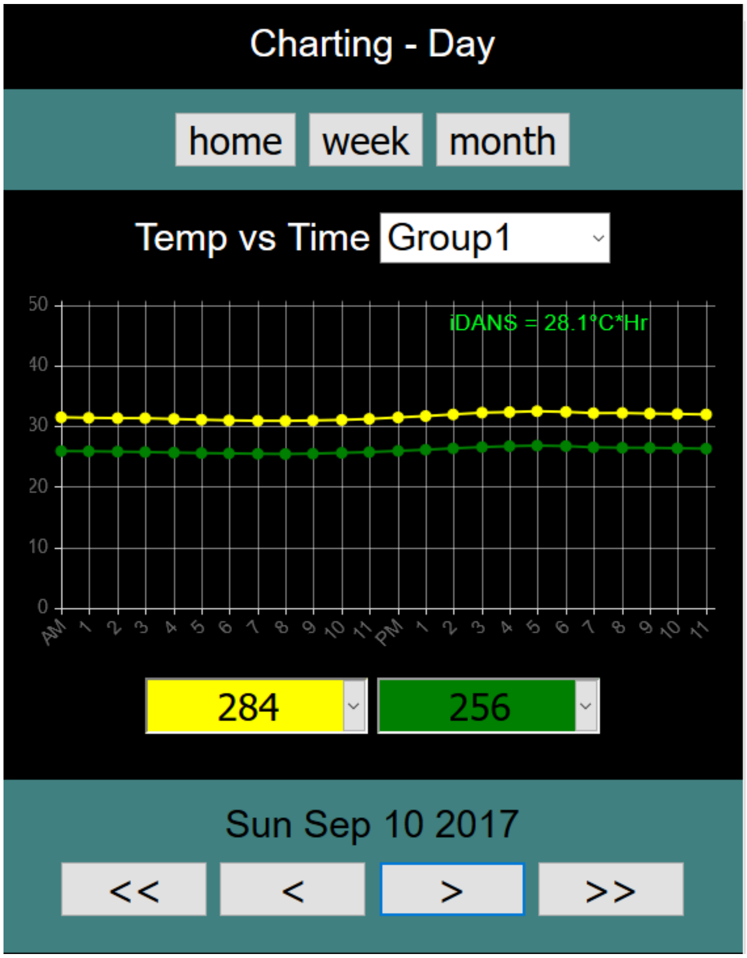
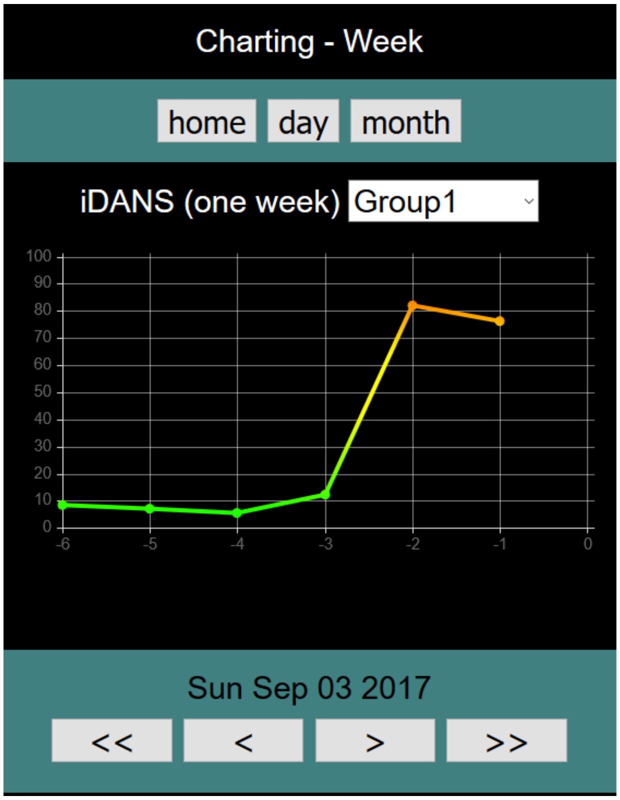


Fig. 4 Chart Screen (Day)

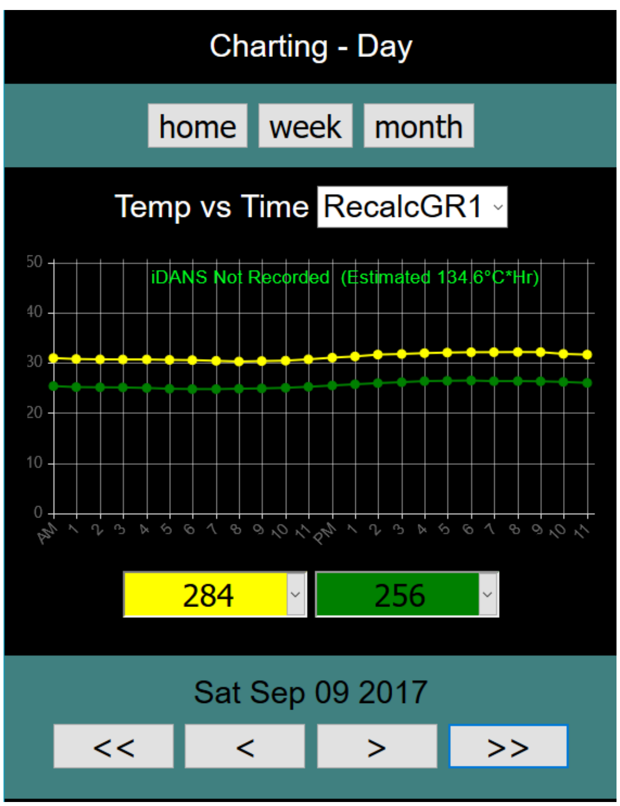
For the iDANS method the SALH system monitors the leaf canopy temperature of stressed plants with an infrared sensor looking down at the leaf canopy, and for comparison, also monitors the leaf canopy temperature of plants in a well-watered or non-stressed field. The difference in temperature is summed over the daylight hours and reported in units of degrees C hours. The value is logged once per day for each zone at the time of your choosing (typically before sunset).

Each day that there is valid data according to the setup screens (Section 2), the iDANS= degree C *hr will be shown. Use the < arrow to proceed to previous days, or the > arrow or follow to the next day. Use the << arrow to proceed to the previous month, at anywhere in the history file of data. The green sensor will always indicate the result for the non-stressed plant.

You can then look at the iDANS values for the past week in a color-coded graph and increase or decrease the water applied to the field as appropriate. See examples below. With this method at least two IRT sensors are required, (at least one non-stressed plant) plus one for each additional zone. A minimum of two sensors may be used for each zone, as one is for stressed and one for non-stressed plants. One may set up multiple sensors which are averaged for stressed, and as well multiple sensors for non-stressed plants.



One may compare a history of any two sensors that has not been computed in real time, by selecting the date at the bottom with the arrow keys, and choosing the yellow as the stressed plant, and the green as the non-stressed plant. Then the chart will specify that the iDANS NOT Recorded will have an estimated value. This applies just to two selected sensors, and not a group of sensors.

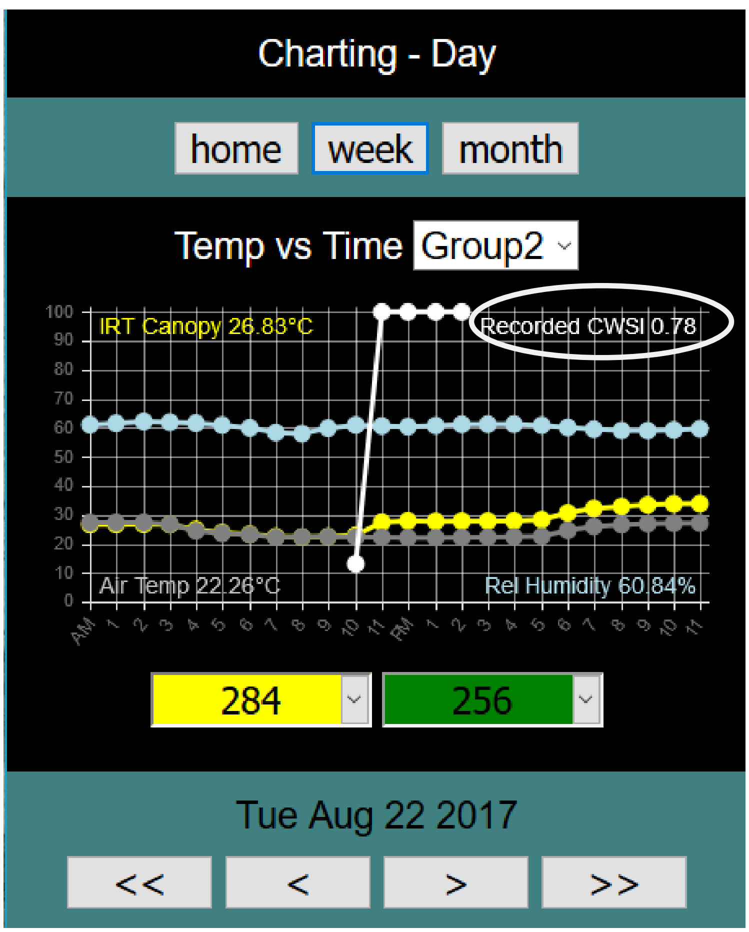


CWSI – Calculated Water Stress Index

CWSI has been established as the "Gold Standard" for water stress calculation by the USDA. The CWSI method requires one wireless relative humidity and air temperature sensor (RHT) for the local climate and at least one IRT sensor for each irrigation zone. The advantage of CWSI is that there is no requirement for a non-stressed field for comparison. CWSI is most accurate on sunny days.

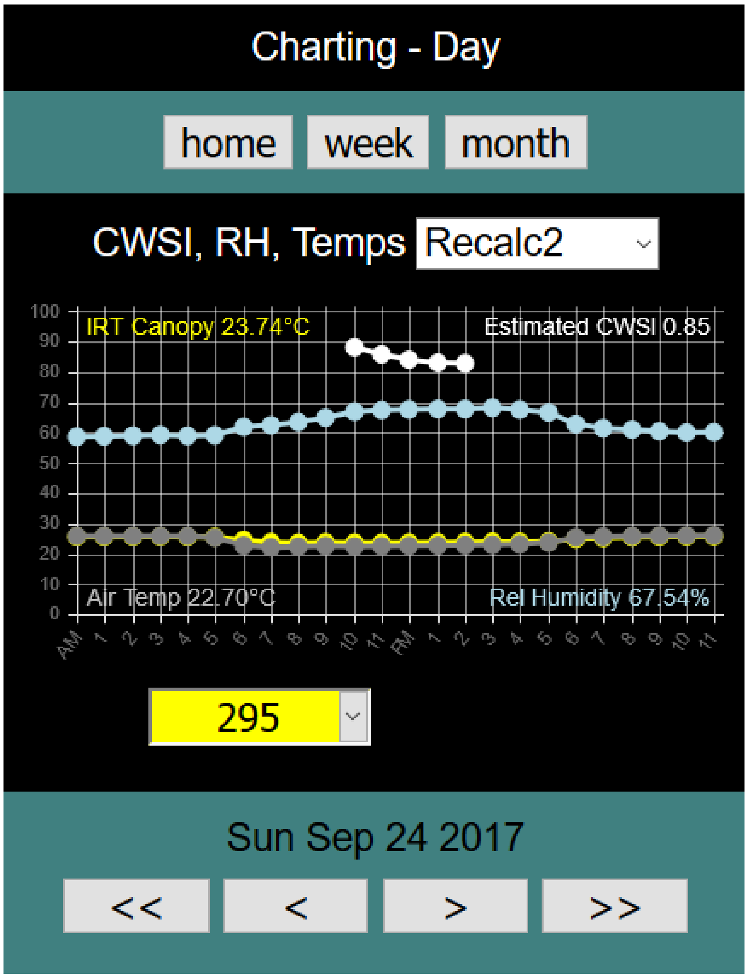
The theory behind CWSI is described in Appendix A (page 44). The basic principle is that water stress has a predictable, straight-line relationship to Vapor Pressure Deficit (the negative water pressure in the air that makes a plant transpire) and leaf temperature. The stress is estimated by two parameters that have been determined by scientists for each type of crop: m (slope) and b (intercept). To use CWSI you must know the m&b values for the type of crop you are growing and the region. Experimentally determined values for some common species of crop plants are provided by the settings screen when you choose the species of crop, or you may use your own pre-determined values. The m&b values may be set differently for each zone. If the m&b values are not known, there is a method to determine their values, see Appendix A (page 44).

CWSI is reported in a dimensionless unit that is equal to zero for no water stress, and 1.0 for maximum theoretical stress (a dead plant with no transpiration). The CWSI is calculated every hour starting at 10am and an average value is logged once per day at the time of your choosing, typically 2pm. Using your smart phone you can chart the hour-by-hour values, or the past one-week history of daily averages in a color-coded graph. See examples below.



Each hour all of the variables for temp and RH are averaged, and the CWSI is computed. Then at the assigned time (2 pm) the **Recorded CWSI is** computed as the average from 10 am to the ending time 2 pm. Typically this total is referred to as the integrated iCWSI value.

The Daily Chart Screen for the CWSI mode is shown above in Fig. 5. Four plots are shown, white for the hourly calculated CWSI, yellow for the stressed canopy temperature in degrees C, grey for the ambient air temperature in degrees C as measured by the humidity probe, and the relative humidity in percent. In order for a single scale to be used for all of these graphs, the CWSI in this chart is multiplied by 100 so it ranges from 0 to 100.



The estimated CWSI value is calculated from the sensor that you select with the left-hand drop-down list (yellow) and the current settings for m and b, but a recorded CWSI value is determined by the settings when the stress value was calculated on that day.

Chart Screen Operation – Overview

The Chart Screen is used to graph IRT data on the cell phone or laptop screen. To use it, select one sensor from the yellow drop-down list for the canopy temperature, and another sensor from the green list for the non-stressed canopy. The second sensor is optional. If two sensors are selected, the chart will also display an iDANS value for that day, in degree-hours, if it has been calculated for that day, or an estimated value based on the data so far. The estimated value is calculated from the sensors that you select with the two drop-down lists, but a recorded value is determined by the sensors selected in the settings when the stress value was calculated on that day.

To select a different day use the arrow buttons to go forward or backward in time. You can change the date by one day (single arrows) or by one month (double arrows).

The log data available through the Wi-Fi connection covers approximately two year's worth of data (730 days) divided by the number of sensors.

More data is available using the USB memory stick. If a memory stick is attached to the USB hub inside the SALH, all readings are recorded and saved until the memory stick runs out of space. This is about 25,000 days divided by the number of sensors, for each 1GB of capacity.

The memory stick **must be formatted FAT32 using the volume name STICK**, and attached to the USB hub to collect data.

The chart screen will enlarge to show more detail if you turn the smartphone to a horizontal position.

Relative Humidity and Ambient Temperature Chart

If the optional RHT sensor is selected on the left-hand drop-down list, the daily chart will display the day's relative humidity in percent and for the CWSI method it will also plot the ambient air temperature as measured from the same sensor in degrees C (see Fig 6 above) if the RHT sensor is also selected on the right-hand list. The scale for both is zero to 100 (% and degrees C, respectively).

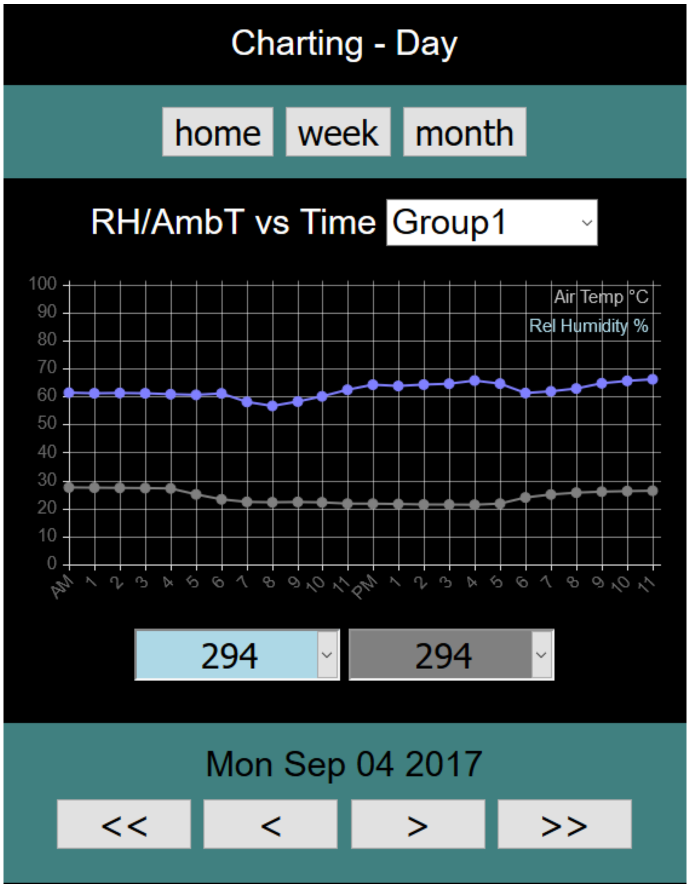


Fig. 6 RHT Daily Chart

To select the monthly chart, click on the **month** button.

Monthly Chart

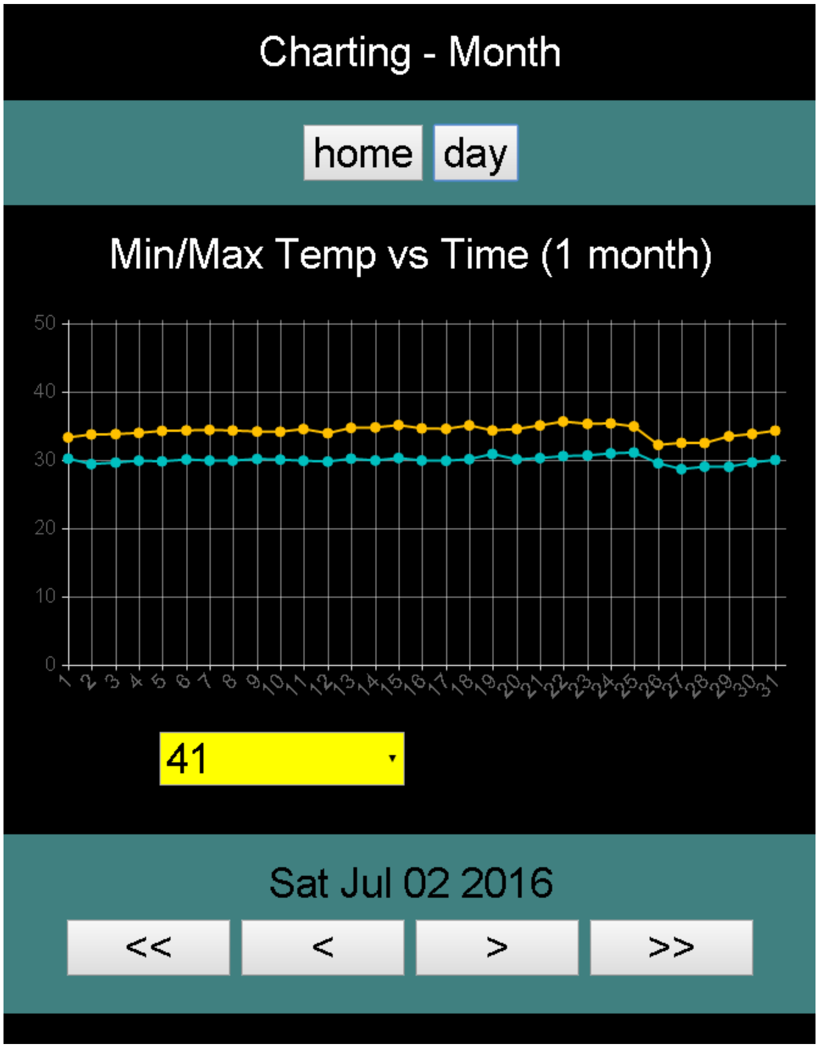


Fig. 7 Chart Screen (Monthly)

The monthly chart screen shows the high and low temperatures for each day of the month for the selected sensor. The high temperature is charted in orange and the low temperature is charted in blue. Click on the day button to switch back to the daily view. Click on the double-arrow buttons to select a different month. The monthly view is useful for finding past months with data, or days when there were temperature extremes.

Weekly Chart

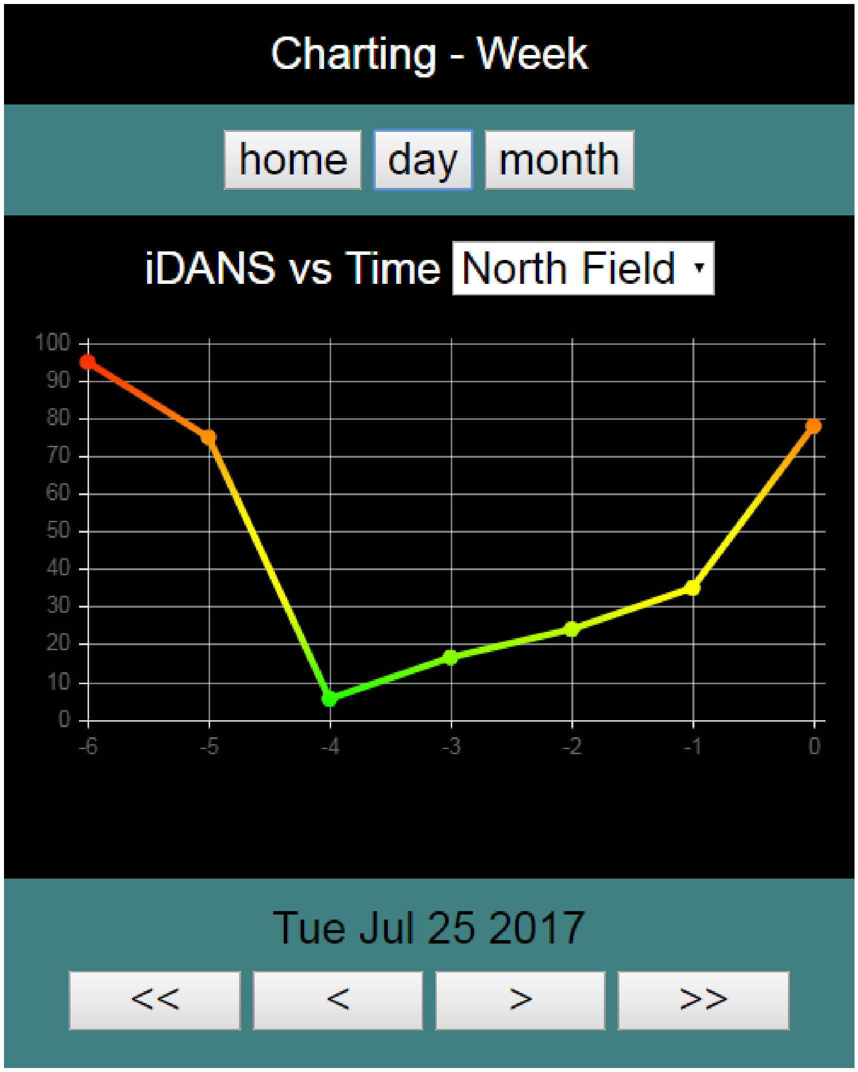


Fig. 8 Weekly Chart – iDANS

The weekly chart is best for determining water stress trends or adjusting the amount of irrigation to a field. The chart is color coded with a gradient to suggest the danger levels of water stress. The color bands in the gradient are user selectable. In the above chart the colors levels chosen are Red = 100, Yellow = 50 and Green = 0.

The zones, color levels, iDANS/CWSI selection and other parameters are controlled in the Settings screen, see Section 2.

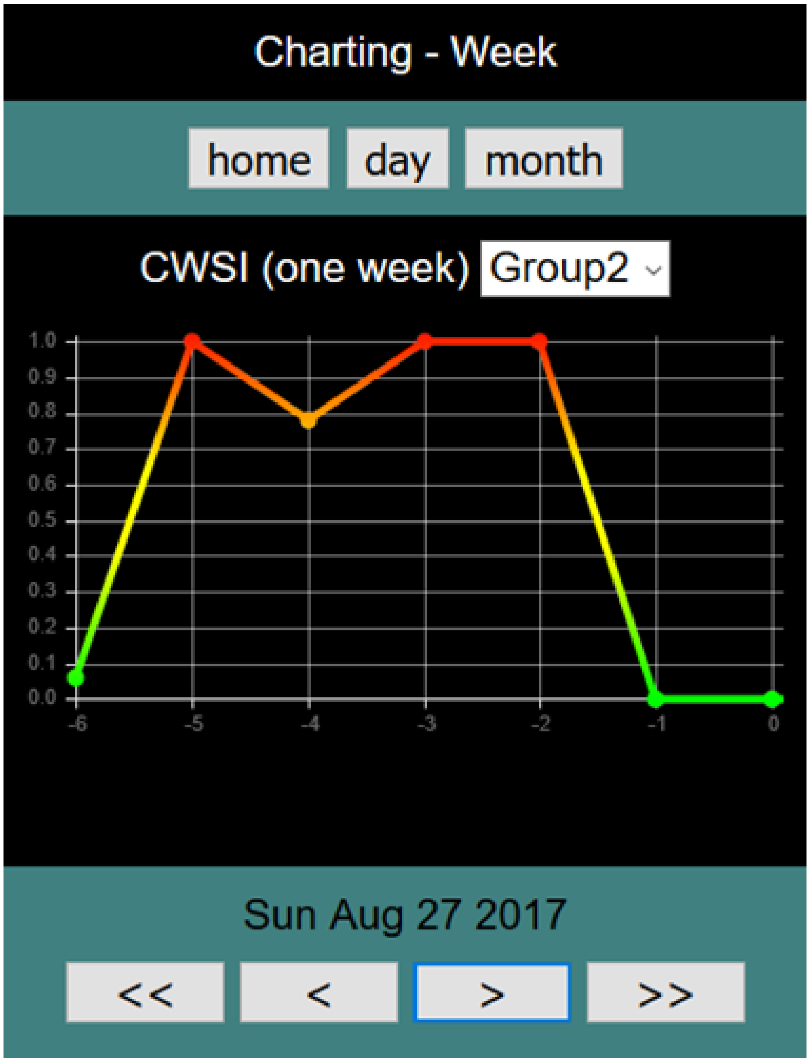


Fig 9 Weekly Chart of CWSI

Fig. 9 shows a weekly chart for the CWSI method. The color band values here are Red = 1.0, Yellow = .5 and Green = 0.0.

Map Screen

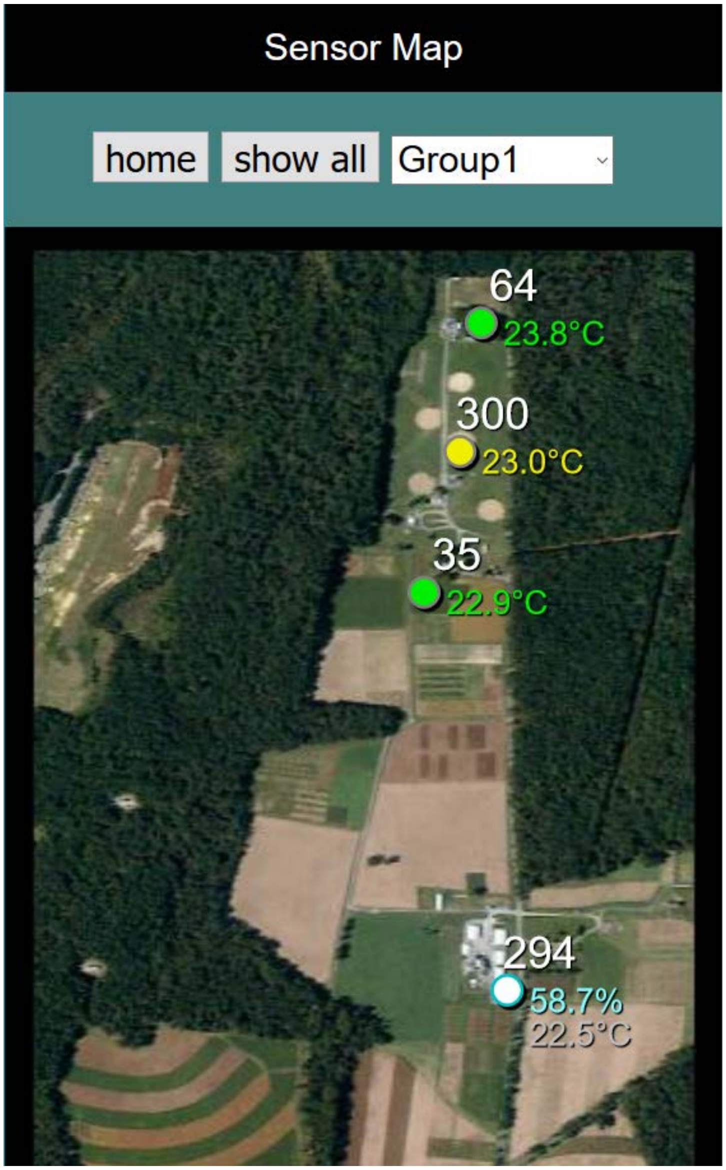


Fig 10. Map Screen (image nasa.gov)

To keep track of which sensor is where, a Map Screen is provided. The position of each sensor along with the latest reading is plotted against an aerial photo or screen grab from Google Maps, Apple Maps, or Google Earth. Use the upload image button to upload a picture from your camera, or a screen grab from your photo library (see **Upload Map Image Screen** below for details). Then you position the sensors where they are located in the map.

To position each sensor, touch the sensor once to pick it up, and then touch the screen again to place it down. The positions are recorded in the SALH Computer's flash memory so the system will remember the positions until they are moved. When a new sensor is added, it will appear in a random position until you place it.

Note that some pictures will not display properly if they are not in portrait format, although the browser will try to resize the image to fit the window. In some cases problems can be fixed by cropping or rotating the picture using your phone's picture editing function. At this time, only vertical format (portrait) pictures can be used. The approximate image size should be 500 pixels high by 300 pixels wide.

The sensors are color coded yellow for designated stressed plants, green for non-stressed plants, blue for RHT sensors, and blue-white for all other sensors.

The home button will switch you to the home screen.

The show all button will display all active sensors.

Upload Map Image Screen

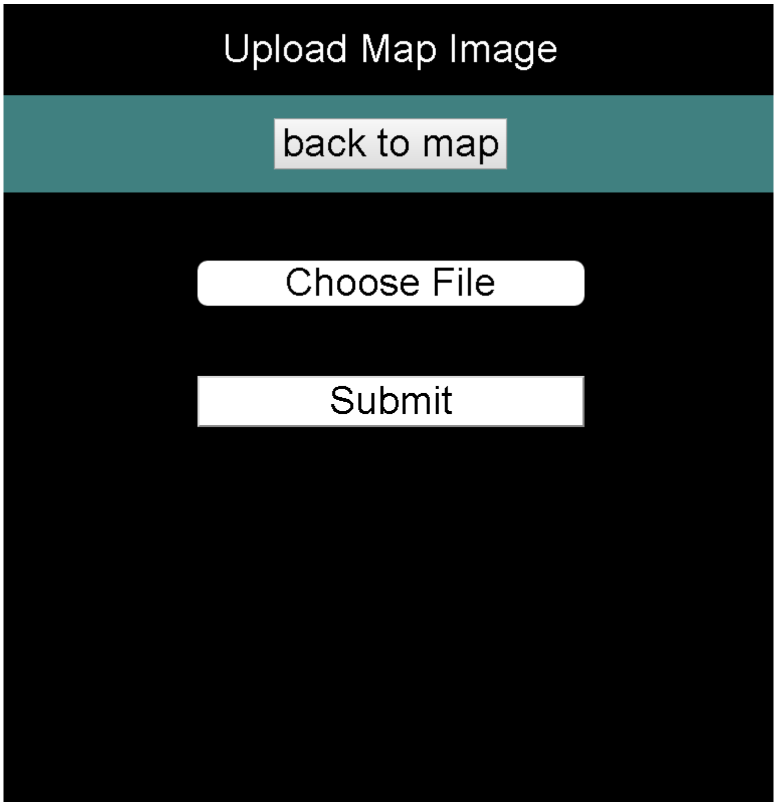


Fig. 11 Upload Map Image Screen

The Upload Map Image screen is used to copy an image file from the smart phone's memory (or the laptop's hard drive) to the SALH so it can be displayed on the map screen.

You can take your own picture, or use a picture from a map application (such as Google Maps or Apple Maps), or use a picture downloaded from the Internet.

The first step is to capture the picture you want to use either with your camera, or by doing a screen capture while running a mapping application. The method used to capture the screen varies with each phone, but on many Android phones it's done by simultaneously holding down the volume down and the power button. On the iPhone it's done by holding down the power button and quickly pressing the home button. Once the image is captured you can use the phone's image editing functions to rotate or crop the image. It must be in the vertical (portrait) format.

From the SALH Upload Map Image Screen click the Choose File button, and chose either the phone's camera or an image from your image library. For a laptop, choose an image file from your hard drive. After the file is selected, click the Submit button to upload the image and the SALH will then display the map screen with the new image.

History Screen – Saving Data to a Server or to the Laptop

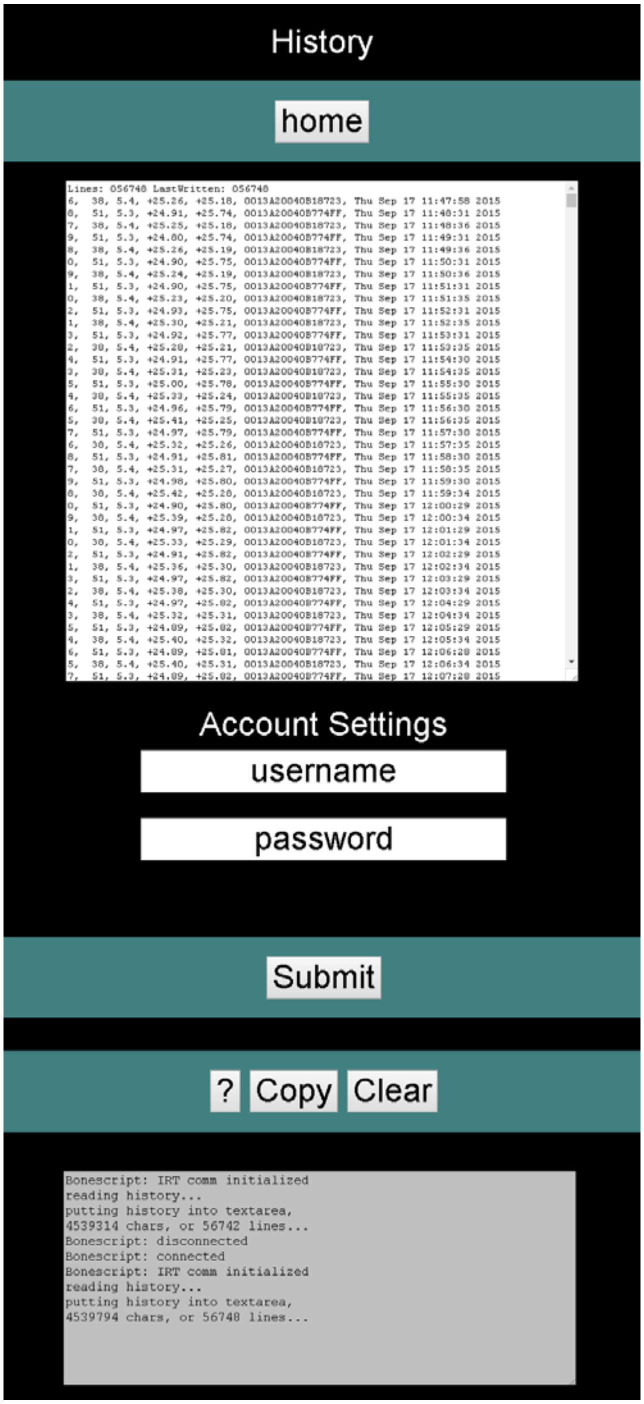


Fig 12. History Screen

The History Screen is used to transfer data from the SALH Computer to a laptop computer or to a computer on the Internet. It will take a few seconds to download the historical data and it will appear in the window. To save the data to a server on the Internet, connect your phone to the cellular data network by turning **off** the Wi-Fi. And then press the Submit button. Right now the data is stored at a server in Austin, Texas called dvfilm.com. The account name and password are not used. After the data is uploaded, a link will appear to display the data on your phone, or on your computer in the home or office (the link is http://dvfilm.com/upload/IRThistory.txt).

Data Saved to Laptop

Alternatively, you can connect to the SALH using a laptop computer with a wireless adaptor. After the history screen is loaded, press the Copy button instead of Submit . The raw data will appear full screen in a .txt file and you can then use the browser's "Save As..." function to save it to your hard drive. See Fig 6 below using Google Chrome and the right-click “Save As…” function:

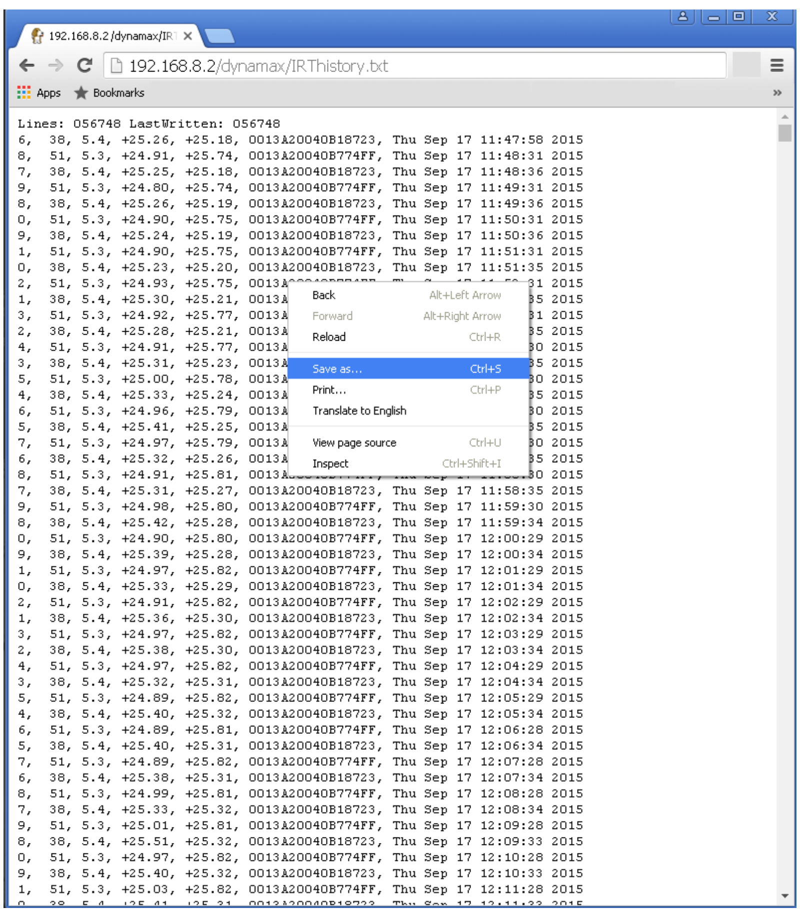


Fig. 13 Saving the History File to a local Disk.

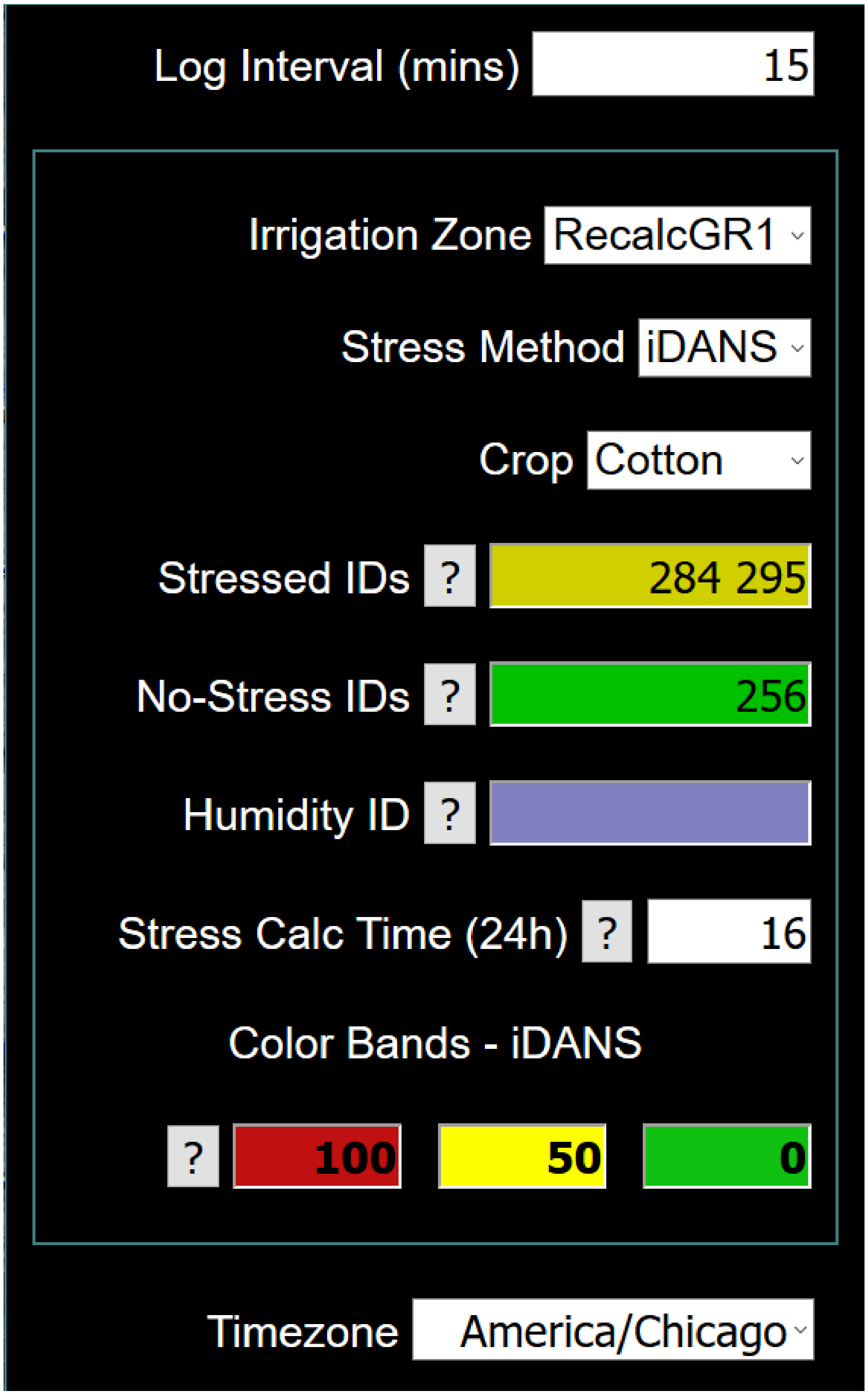
Note that most cellular smartphone browsers do not have a "Save As" function, this works only on a laptop browser such as Chrome or Firefox.

One more option exists for saving the data.

Readings will be logged to an external USB memory stick if one is connected to the SALH Computer. The memory stick must be formatted with the FAT32 disk format and have the volume name STICK. The memory stick must be connected while the logging takes place. To make a copy of the data, first shut down the SALH by using the shutdown button on the SALH home screen. Remove the memory stick and plug it in to your laptop or desktop computer. Copy the file called "IRThistory.txt" which will appear in the root folder, and then delete it off the memory stick after you have checked the data. Re-insert the memory stick into the USB hub of the SALH Computer for further logging. Then power the SALH back on by pressing the Power On button.

2. Settings Screen

The settings screen allows you to set logging parameters and options for the calculation of iDANS or CWSI. See Fig. 14 below.



Typically you will average every 15 minutes, all data is logged.

Set a new zone for each crop or test area.

iDans is simple

Optional – but needed to track data

List of stressed sensor – plant locations. (list separated by space or by comma.)

Can be 2 or more, but at least one plant is well watered.

Not used on iDans

Hour to compute iDans, should be 16:00, or 4 pm. Some farms may want to track later in the day.

Hours*degrees above well-watered. Each crop will develop a variety of ratings

Needed to synchronize to local time.

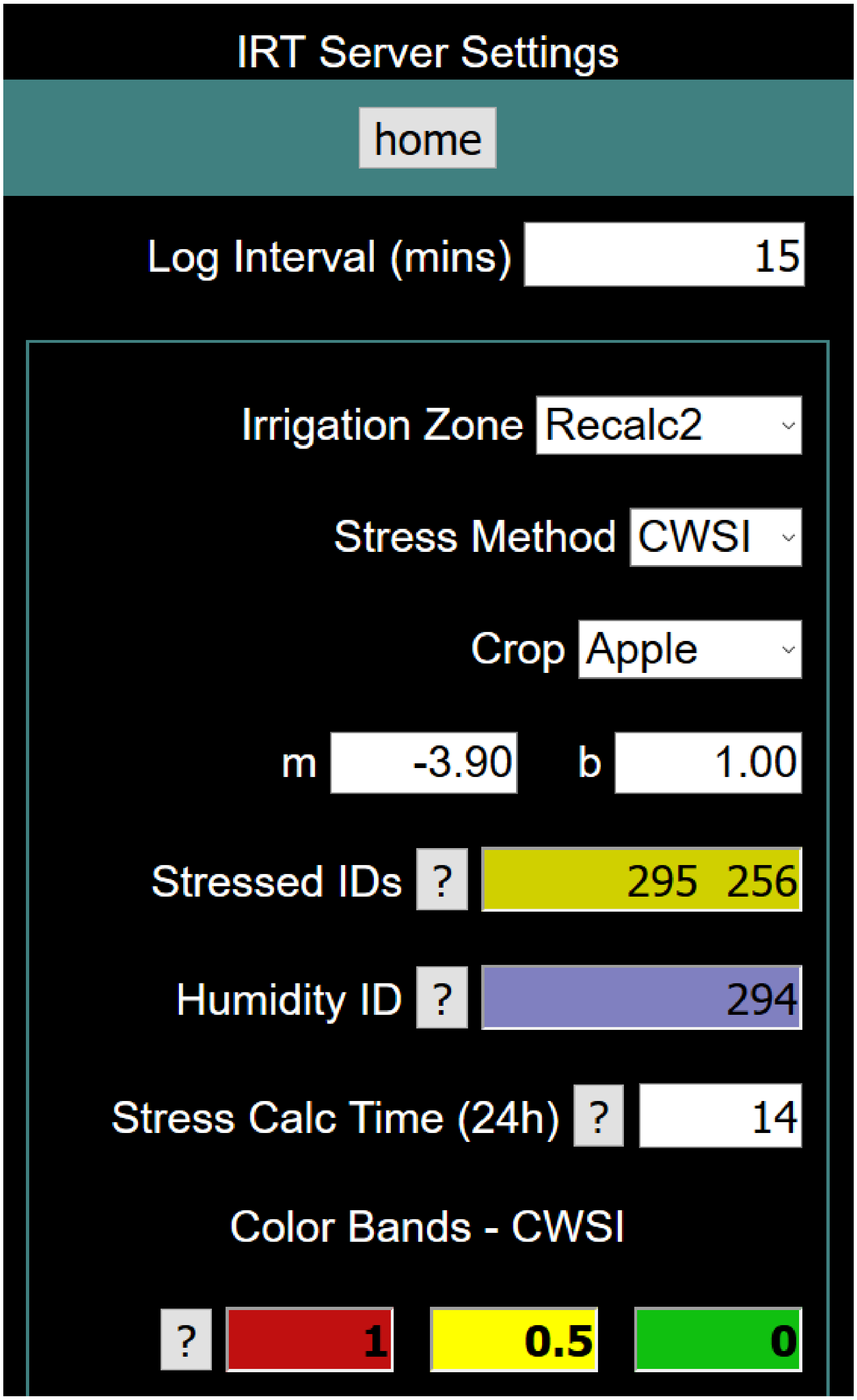


Fig. 14 Settings Screen

Log Interval

The Log Interval is the period of time, in minutes, between readings of a particular sensor, that are logged to the flash memory of the SALH, and recorded in the IRThistory.txt file. Although each IRT sensor may report at a faster rate, not every reading is recorded in the history file. The Log Interval determines how often they are recorded.

The exception to this is the USB memory stick, which (when installed) does record every reading from the sensors regardless of the Log Interval setting.

Zone

The Zone field shows the selected zone for which you are changing the settings. To add a zone, select **Add Zone** from the drop-down list, enter the zone name, and click Return. To delete a zone click the Delete button at the bottom of the screen. To change zones, select the zone from the drop-down list. Each zone is logged separately and has its own settings. Zones may share sensors and may even use the same set of sensors, as a way to run two different stress methods on the same field.

Stress Method

The **Stress Method** drop-down list allows you to choose iDANS or CWSI for each zone.

Crop

The **Crop** drop-down list allows you to select one of several common crop varieties. When a crop is selected the default m and b values are drawn from a list of standard values contained within the JavaScript user interface software. The values can be changed by typing in a new value. The values do not take effect until the **Set** button is clicked. If the crop you are growing does not appear in the list you can select **Other** and enter in custom settings for m&b.

The m and b Values (CWSI only)

The m and b values are used in the straight-line approximation of temperature rise in the leaf vs. the Vapor Pressure Deficit (VPD). These values must be supplied by the user for the CWSI method. Default values from USDA research are provided when you select the **Crop** parameter.

Stressed IDs

Stressed IDs are the ID strings (hexadecimal codes) of each sensor pointed at a stressed plant canopy. The IDs must be separated by blanks or commas. You may designate up to 25 sensors. The readings of each stressed sensor are averaged together when calculating the Water Stress Index.

Non-Stress IDs (iDANS only)

Non-Stress IDs are the ID strings (hexadecimal codes) of each sensor that is pointed at a non-stressed plant canopy (an area of plants that get all the water they need). The IDs must be separated by blanks or commas. You may designate up to 25 sensors. The readings of each non-stressed sensor are averaged together when calculating the iDANS value.

Humidity ID

Humidity ID is the ID string for the relative humidity sensor used for this field. More than one ID can be listed, in which case the SALH server averages the values together when calculating CWSI.

Stress Calc Time

The Stress Calc Time is the time of day, in hours of a 24-hour clock, when the water stress is calculated by the SALH and recorded in the history file IRThistory.txt. The water stress is logged only once a day. If the stress has been calculated and logged, it will not do so again until after midnight or until the SALH is restarted. For best accuracy for iDANS the Stress Calc Time should be after sunset. For CWSI the standard time to calculate and log the CWSI is at 2pm. Some areas will use 4 pm (after max stress).

The values in the settings screen do not take effect until you click the set button and then restart the SALH using the restart button on the home screen.

Time Zone

The time zone must be set for the sensor readings to be logged accurately and the water stress calculation to be logged at the proper local time, since the settings and charts all use local time. The SALH gets the Universal Coordinated Time from the smart phone and translates it into the correct time zone for the SALH. After the smart phone disconnects from the SALH, it maintains the current date and time accurately on its own.

Select the timezone for the nearest city that shares your time zone and daylight savings time. The setting takes effect after you press the set button.

3. iDANS and CWSI Calculation

The iDANS water stress value is calculated as follows:

a. For each hour of the day from midnight up until the Stress Calc Time, an hourly stress in degrees C is computed by subtracting the average of all the stressed temperature sensor readings in that hour minus the average of all the non-stressed temperature sensor readings in that hour. If the result is negative, it is set to zero.

b. The stresses from each hour that are calculated in step (a) are summed together. The result is iDANS which is in units of degrees C hours.

The CWSI value is calculated once per hour starting at 10am and the last value at the Stress Calc Time (typically set to 2pm). The average of the hourly calculations is then logged at the Stress Calc Time. For more information on CWSI theory of operation see Appendix A (page 44).

When comparing data, it is certainly possible to create recalculation zones, or hypothetical zones where the sensors for an iDans target is also used in the CWSI zones, and then record. In this case, the user will need to purchase a SAPIP-RHT sensor, Relative Humidity and Temp sensor, just create a new zone, and and then link the idANS sensor to a group or irrigation zone that has the RHT sensor.

For trial cases, enter a new zone, then give it a new name. Insert the sensor configuration, and set up the IRT and RHT sensors. Test the new configuration, by going through the history, and check the stress numbers. Each sensor will have an estimated iDans or estimated CWSI result.

4. Maintenance and Technical Info

Software Updates

A simple procedure exists for updating the software on the SALH Computer. Copy the files provided from Dynamax onto a blank USB memory stick that is formatted FAT32 and uses the volume name STICK. Insert the stick into the SALH Computer's USB hub (power should remain on). Go to the home page of the user interface and press **restart**. The SALH Computer will automatically detect the "update.sh" script file on the USB stick and execute the installation program, which will copy over the files to the appropriate places in the system's flash drive. The SALH server and web interface will then automatically start with the new software and no further action is required. The first time you connect to the Wifi interface, you will see a pop-up message on the home screen that identifies the software update. You can then remove the USB stick.

PAN and SC Channel Information – Maintenance

Each SALH has an assigned channel (007) – actually 3 of the 12 channels available, and an assigned PAN ID – default is 100. Once the system and the sensors are moved next to another SALH, or to another group of IRT – all the channels and PAN ID on the older system need to be changed. This will keep the sensors from trying to cross networks, and keep data straight on the SALH.

Each time there is a service for an IRT, or buy a new IRT for an existing network, please let us know what the PAN and SC channels are. If we need to reprogram, or service the RF chip, we will need the “home” coordinator address, PAN, and SC data to send as the data destination. The inside lid of the SALH has a marking area with all of the PAN and the SC channels written on the box. The password and the Wi-fi information are there as well.

LED Status Lights

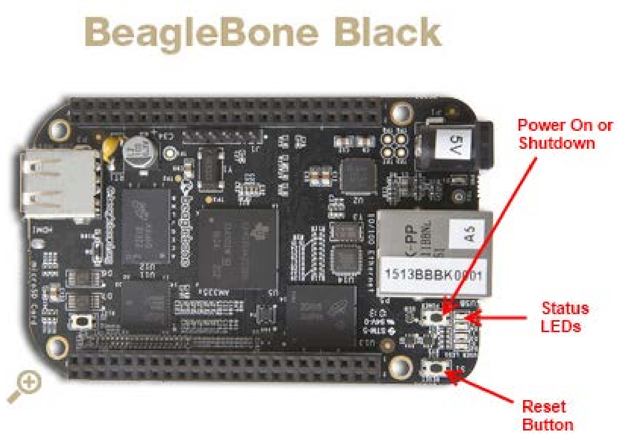


Fig. 15 Computer Board Layout

The LEDs will show basic information about what the SALH Computer is doing.

Four LEDS Flickering - this occurs while the computer is starting and running the startup scripts. For more information about the lights during this startup state see http://www.beagleboard.org

Two Lights Flashing - one second on, one second off - waiting to connect to Zigbee Radio.

LEDS 1-4 flash together for 1 sec - a message is received from one of the IRT sensors

LEDS 2,3,4 - lights flash in a cascade up, then down, once every 5 seconds - the monitor task of the IRT server program is running and waiting for commands from the smart phone web interface

No lights - IRT server is stopped or computer is shutting down

Computer Command Line interface

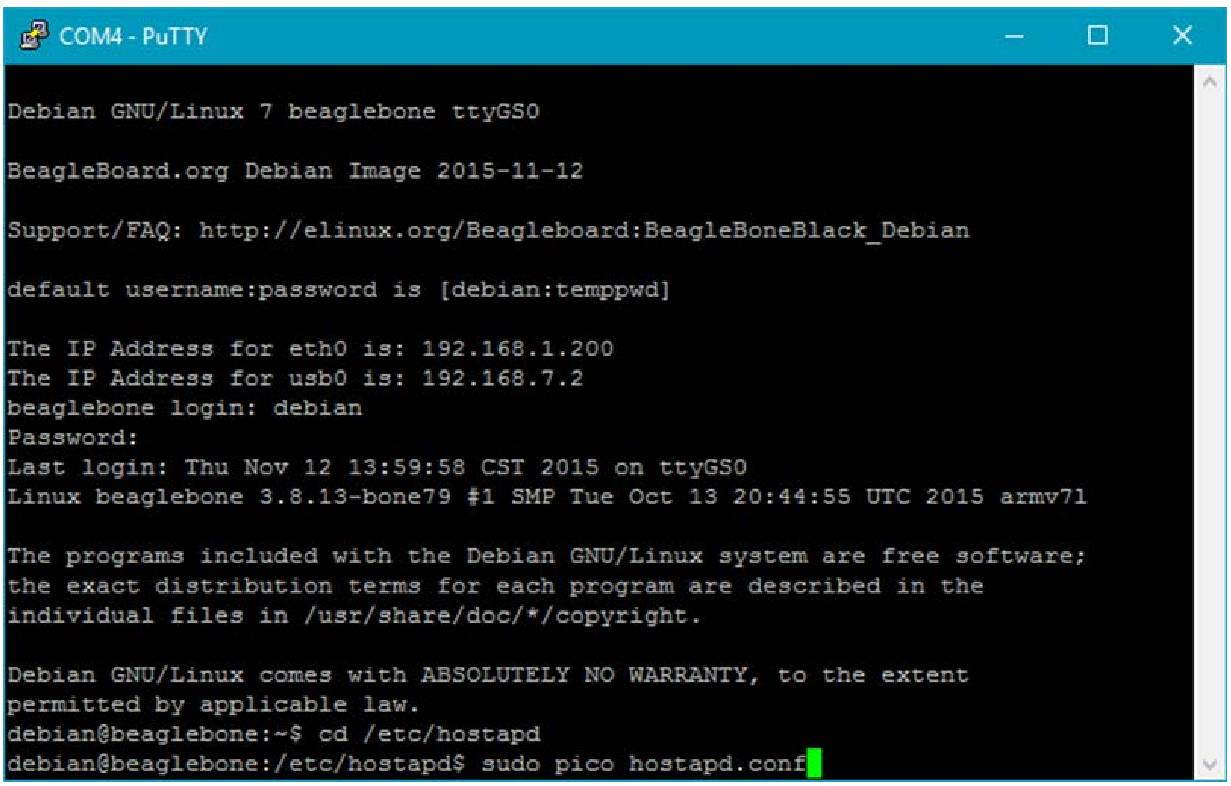
The Linux command line interface (see http://linux.org) is available over the Wi-Fi, mini USB or the Ethernet. Use a laptop running a secure shell (SSH) application like Putty (download free at http://putty.org). Run the app and use the SSH interface using IP address 192.168.8.2 and port 22. Login with username "debian" and the default password is "defcon3".

Changing Wi-Fi Password or Name or Channel

Login to putty with debian username.

Type ***cd /etc/hostapd*** hit enter.

Then type ***sudo pico hostapd.conf*** hit enter.

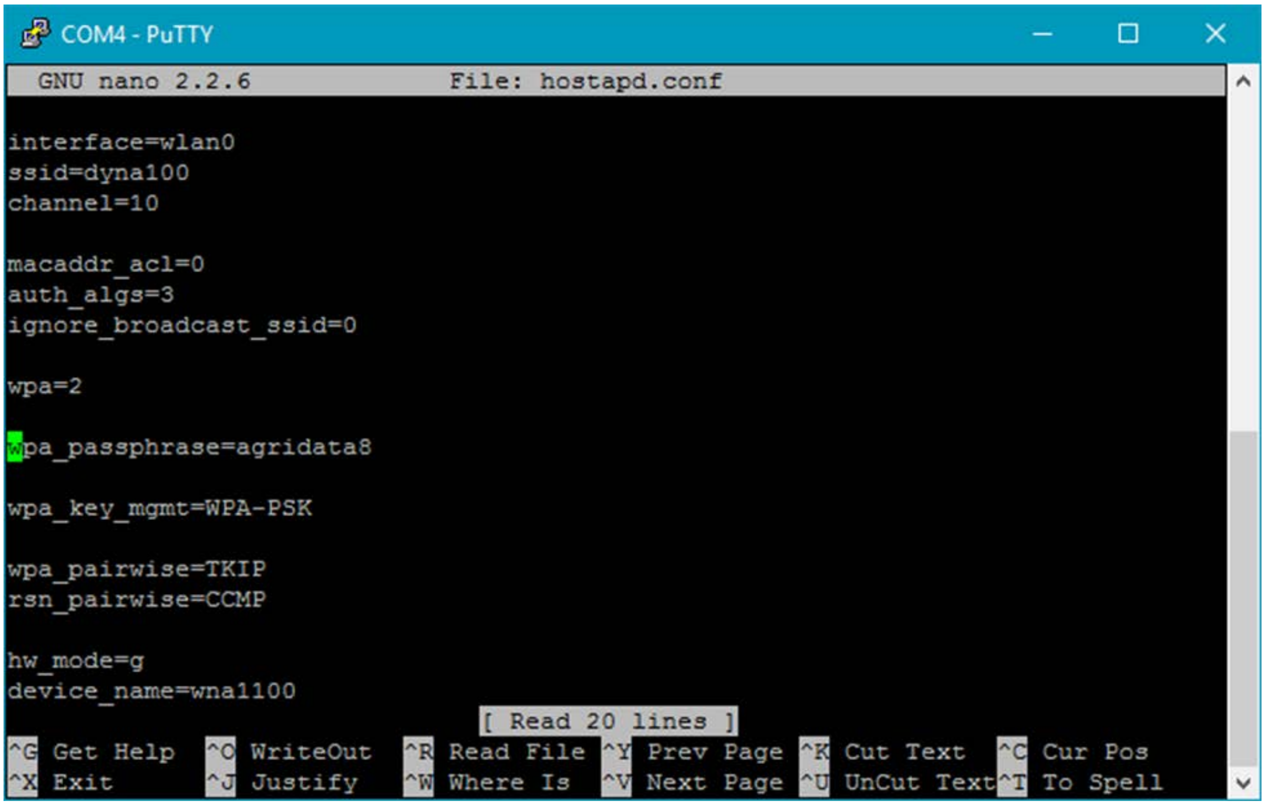


Change the Wifi password under the **wpa_passphrase=agridata8.**

To change the name of the Wifi Name, change the name on the **ssid=dyna100**

To change the Wifi channel, change the settings on the **channel=10**

On the keyboard press control-O and then Enter, and then control-X to save and quit.



Search linux.org for more information about hostapd (Host Access Point Daemon). Dynamax can also provide a document that further explains how the wireless network is implemented and how to diagnose problems with the Wifi, Hostapd, and DNSMASQ (the Domain Name Server program).

The Linux password can be changed with the command

sudo passwd

You will be prompted for the old password and the new one.

Changing the IP Addresss for SALH

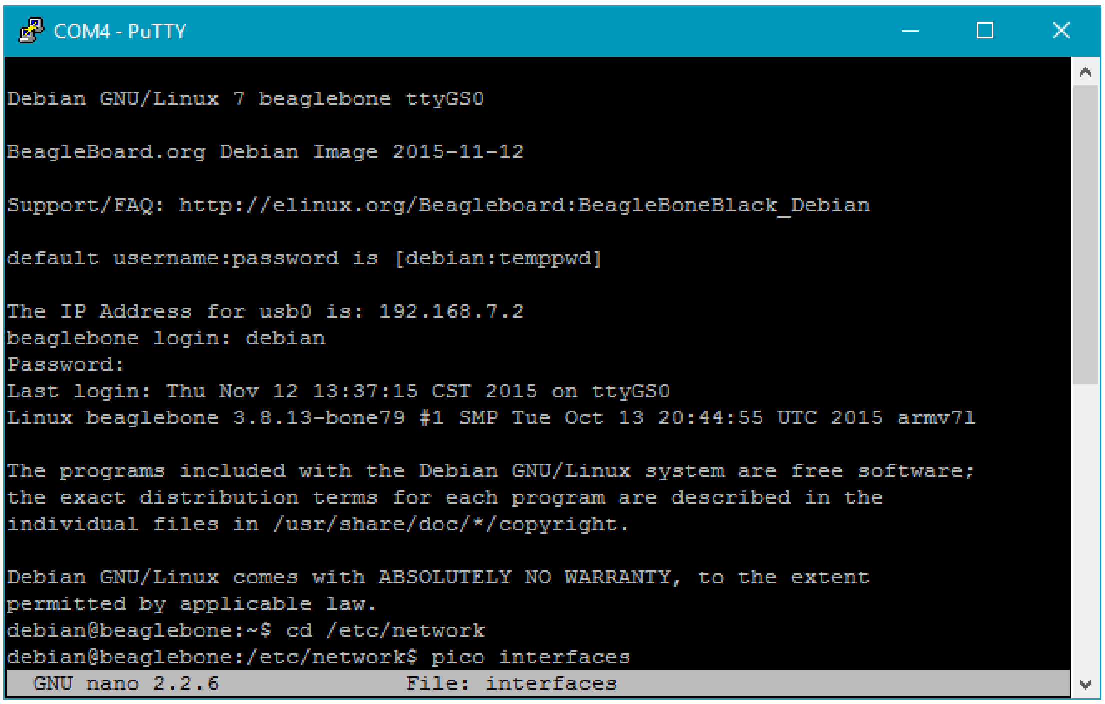
(NOTE: This step requires help from the IT department)

The default IP address for the beagle board is 192.168.1.200. You can add that to your network and it will work**.**

If you need to change the IP address to accommodate your network, you'd need to do the following:

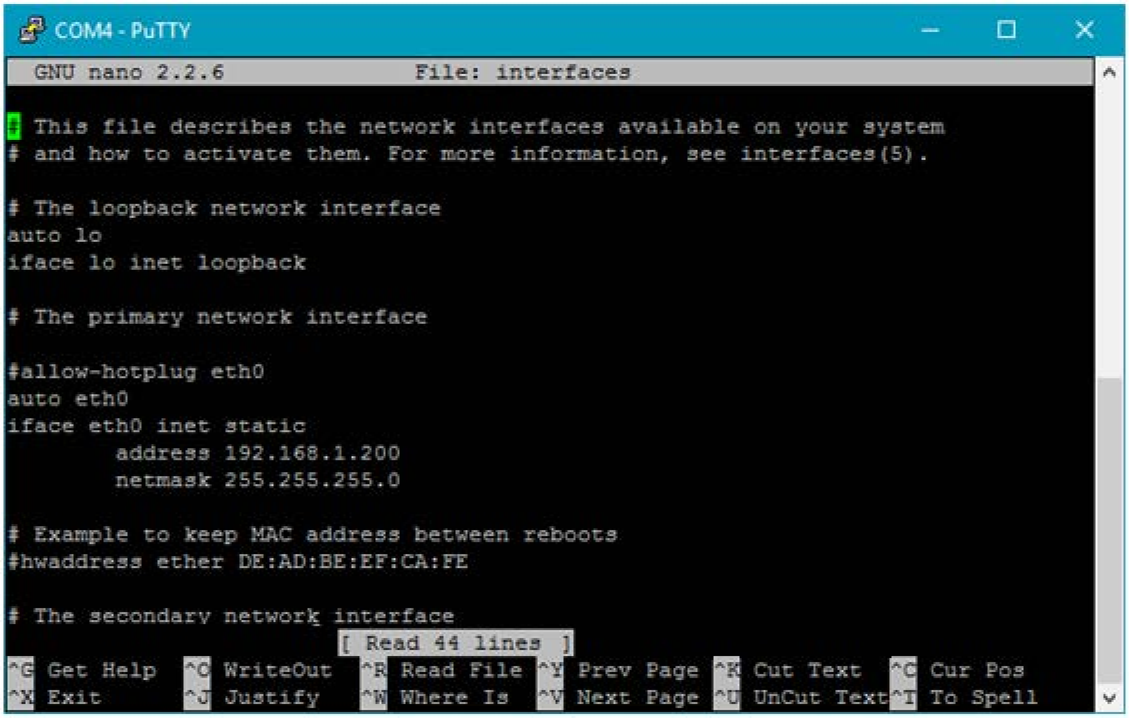
Type ***cd /etc/network*** hit enter

Then type ***sudo pico interfaces*** hit enter



You should see the following screen.

On this screen you will need to change the IP address under the ***iface eth0 inet static.***
Again, the default is 192.168.1.200



Looking at Log Files

The IRT server creates two log files, log1.txt (for the monitor task) and log2.txt (for the polling task). The software installation script creates the installLog.txt file. All these files are written to the USB memory stick if provided. Otherwise no logs are created so the flash memory on the SALH Computer does not fill up.

Looking at History File

The IRThistory.txt file, the same one that is accessible through the wireless user interface, is located in the /home/debian/dynamax folder, along with these other files:

IRTreadings.txt - latest readings

IRTserver - the IRT server program, compiled from C++

sensorPositions.txt - the sensor positions for the Map Screen

quit - this file, if present, commands the IRTserver to stop

command.txt - this file, if present, contains a command from the user interface

start.txt – this file, if present, contains the date and time from the cell phone

version.txt – the latest version number of the IRT server

If the History file needs to be edited, you can do so with these commands:

First, stop the IRTserver:

cd /home/debian/dynamax

touch quit

Wait for the quit file to disappear by using

ls –lrt

The IRTserver will not quit until at least one message is received from the ZigBee interface. In a situation where no sensors are connected, you can force a quit by using these commands:

ps ax | grep IRT

The computer will reply with the active processes for the IRT, look for the ones marked as "IRTserver". There should be two of them.

Use the kill command with the process IDs (decimal values) from the first column:

sudo kill -9 <process ID>

After you've confirmed both IRT server tasks have stopped, then edit the history file:

sudo pico IRThistory.txt

For information on pico see http://www.guckes.net/pico/. If you need to delete the history file to start a new history, use this command:

sudo rm IRThistory.txt

Restart the IRTserver in the background:

sudo ./IRTserver &

Looking at Web Interface Source Files

The source files for the Web Interface are located at /var/lib/cloud9/dynamax, /var/lib/cloud9/static and /var/lib/cloud9/autorun. Cloud9 is the integrated development environment for the JavaScript and Node.js webserver source code. Cloud9 is available over the Wi-Fi at http://192.168.8.2:3000/ide.html. If you make a change to the JavaScript source code using Cloud9, the procedure to test the changes is as follows:

Use File->Save in the Cloud9 user interface

Refresh the webpage being tested in your browser

To debug the Javascript source code, for example by using Google Chrome, open the "Developer Tools" from the Chrome menu and set breakpoints, etc.

Programming the Zigbee Radios

The Zigbee Coordinator (XBIB module) may be attached with a USB converter cord, and plugged into a laptop PC and reprogrammed (to set a different PAN ID for example) using the XCTU program from Digi.com. This also allows you to reprogram the IRT/RHT Sensor radios as well. Refer to the XCTU documentation at Digi.com. An extensive method is available to reprogram the IRT Zigbee radios from the laptop and XBIB, but not from the SALH itself. Settings are available to change the SC – scan channels, and the PAN ID. Please contact Dynamax for further assistance.

Important Radio Settings

In the XCTU settings screen, you can change the settings of each radio on the network (see XCTU guide at Digi.com). However some setting changes may cause the wireless network to stop working. For example the PAN ID must be the same across all IRT or RHT sensors and on the Coordinator (the Zigbee radio that is plugged in to the SALH Computer). Here are the most important settings:

Coordinator (SALH Computer):

Firmware version = 21A7 (Coordinator API mode) for Rev B radio,

Firmware version = 405E (ZIGBEE TH PRO) for Rev C radio.

Pan ID (ID) = 100

Scan Channels (SC) = 7

Scan Duration (SD) = 3

Zigbee Stack Profile (ZS) = 0

Node Join Time (NJ) = FF

Coordinator Enable (CE) = Enabled [1] -- Applies to Rev C radio only

Destination Address High (DH) = 0

Destination Address Low (DL) = FFFF

Node Identifier (NI) = e.g. HOME (will vary)

Maximum Hops (NH) = 1E

Broadcast Radius (BH) = 0

Many-to-One (AR) = FF

Device Type Identifier (DD) = 30000

Node Discovery Backoff (NT) = 3C

Node Discovery Options (NO) = 0

PAN Conflict Threshold (CR) = 3

Power Level = Highest [4]

Power Mode = Boost Mode Enabled [1]

Encryption Enable (EE) = Disabled [0]

Sleep Mode (SM) = No Sleep (Router) [0]

Baud Rate (BD) = 9600 [3]

API Output Mode [AO] = Native [0]

API Mode [AP] = One [1]

All other options set to their default values.

Note that the SALH uses the coordinator in API mode. This is different from the IRT Watcher (Dynamax's PC-based application) which requires the coordinator to be in AT mode.

End Device (IRT or RHT Sensor):

Firmware Version = 29A7 (End Device API mode) for Rev B radio

Firmware version = 405E (ZIGBEE TH PRO) for Rev C radio.

Pan ID (ID) = 100

Scan Channels (SC) = 7

Scan Duration (SD) = 3

Zigbee Stack Profile (ZS) = 0

Node Join Time (NJ) = FF

Join Notification (JN) = Disabled [0]

Coordinator Enable (CE) = Disabled [0] -- Applies to Rev C radio only

Destination Address High = 0

Destination Address Low = 0

Node Identifier (NI) = e.g. 20049 (will vary)

Maximum Hops (NH) = A

Broadcast Radius (BH) = 0

Device Type Identifier (DD) = 30000

Node Discovery Backoff (NT) = FF

Node Discovery Options (NO) = 0

PAN Conflict Threshold (CR) = 3

SleepMode (SM) = Pin Sleep [1] (End Point Node)

Power Level = Highest [4]

Power Mode = Boost Mode Enabled [1]

Encryption Enable (EE) = Disabled [0]

Baud Rate (BD) = 9600 [3]

API Output Mode [AO] = Native [0]

API Mode [AP] = One [1]

All other options set to their default values.

5. Specifications for SALH

Power

Voltage: Requires 12VDC at 300mA max Solar Panel: 30 W for 5 solar hours. 70 to 80 Amp-Hr Deep Cycle Marine Battery	Accessory Provided: 110VAC with optional AC/DC converter. 12 V DC/ User supplied User Supplied

Sensors

- 25 IRT and RHT sensors maximum
- Each 9 sensors requires a Router / relay device

Works with up to 25 Dynamax wireless IRT (Infra-Red Temperature) or RHT (Relative Humidity and Temperature) sensors.

Refer to the Dynamax IRT data sheet for accuracy details.

The SALH logs temperatures	.01 °C resolution
Displays on the home screen	.01 °C
Map Screen and	.1 °C

Range : The chart screen can plot temperatures from 0 to 50 °C.

Relative Humidity is always recorded in .01 % RH, and Air is recorded in .01 C. reported in percent Relative humidity and is accurate to about 1%, and temperature is accurate in 0.1 C.

Placement of RHT Sensor

The RHT sensor probe must be outside, but is fitted into a shaded ventilated shield. Dynamax supplies the SAPIP-RHT sensor only with the ventilated shield.

It should be in a well ventilated, shaded area away from hot surfaces that might influence the air temperature reading. The RHT sensor is required only if you are using the CWSI method to estimate water stress.

Operating Temperature

The SALH box must be shaded and not exposed to direct overhead sunlight, in very hot areas. The computer or other electronics may fail if subjected to very hot conditions.

Recommended Ambient Temperature: –20 to +50 deg.C.

Radio Range

There are two radios to transmit data – the Zigbee and the Wi-fi:

Zigbee data : IRT and RHT sensors must be in line-of-sight, and within 300 ft. of the SALH. In 2017 the SALH was upgraded with a weather proof, high gain 5 dBi antenna. The router will extend the range of the Zigbee RF. Please check the SAPIP-IRT Instruction Manual for more range information on low and high gain antennas.

Wi-Fi data: The Wi-Fi range to the user's smartphone is 100ft and line-of-sight from the SALH. A Zigbee Wireless Router may be used to extend the range.

Logging

The SALH can log up to 65,536 temperature readings in the internal flash memory (non-volatile memory) before overwriting the oldest data. The logging interval is chosen by the user and can vary from 1 to 60 minutes. Logging can be extended by plugging in a 2 GB memory stick. This new feature was added by Dynamax in spring 2017.

Appendix A. Theory of Operation: Calculated Water Stress Index (CWSI)

CWSI is based on the Vapor Pressure Deficit (VPD).

VPD in kilopascals for a plant is calculated from the relative humidity in percent and air temperature (T) in degrees C with an exponential approximation as follows (see Wikipedia article on "Tetens Equation"):

$$VPD = (1\text{-}RH/100\%)\, e^{(17.27(T\ /\ (T + 273.0)))}$$

The error in this approximation is less than .06% for temperatures from 0 to 50 degrees C.

The Vapor Pressure Gradient is the small change in VPD when the temperature is raised slightly from T to T_2

$$VPG = e^{(17.27(T_2\ /\ (T_2 + 273.0)))} - e^{(17.27(T\ /\ (T + 273.0)))}$$

Through experiment with various crops and climates, the m (slope) and b(intercept) values in the linear approximation y=mx+b, have been used to convert VPD and VPG to a maximum and minimum ΔT, the expected maximum and minimum difference between the canopy temperature and the air temperature, for a given VPD:

$$\Delta T_{max} = (m)VPD + b$$

$$\Delta T_{min} = (m)VPG + b$$

The CWSI, which is defined as a fraction of 1 (ranging from 0.0 to 1.0), is the difference between the current ΔT and ΔT_{min}, divided by the difference between ΔT_{max} and ΔT_{min}:

$$CWSI = (dT - \Delta T_{min}) / (\Delta T_{max} - \Delta T_{min})$$

The calculated CWSI can then be used to judge how stressed a crop is at the current conditions of canopy temperature, air temperature, and relative humidity. The CWSI is 0.0 for an unstressed crop (has all the water it needs) to 1.0 for a crop that is dying or dead.

References

Crop	Upper Limit / Lower Limit	Article - Ref
Apple	a value: -3.90 b value: 1.00	Andrews, P.K.; Chalmers, D.J.; Moremong, M. Canopy-air temperature differences and soil water predictors of water stress of apples grown in a humid, temperate climate. *J. AM. Soc. Hortic. Sci.* **1992,** *117*, 453-458.
Almond	a value: (N/A) b value: (N/A)	Udompetaikul, V.; Upadhyaya, S.K.; Slaughter, D.; Lampinen, B.; Shackel, K. Plant water stress detection using leaf temperature and microclimate information. *ASABE*. **2011**.
Corn	Several	Taghvaeian, S.; Chavez, J.L.; Baush, W.C.; DeJonge, K.C.; Trout, T.J. Minimizing instrumentation requirement for estimating crop water stress index and transpiration of maize. *Irr. Sci.* **2013**.
Cotton:	Several	Many 25+ (Hattfield, Idso, Reginato, Wanjura)

Crop	Upper Limit / Lower Limit	Article - Ref
Grapevine	a value: -1.39 b value: 2.16	Bellvert, J.; Zarco-Tejada, P.J.; Marsal, J.; Girona, J.; Gonzales-Dugo, V.; Fereres, E. Vineyard Irrigation scheduling based on airborn thermal imagery and water potential thresholds. *Aust. J. Grape Wine Res.* **2015.**
Mandarin	a value: -0.50 b value: 4.06	Gonzales-Dugo, V.; Zarco-Tejada, P.J.; Fereres, E. Applicability and limitations of using the crop water stress index as an indicator of water deficits in citrus orchards. *Agr. For. Meteor.* **2014**, *198-199*, 94-104.
Olive	a value: -2.05 b value: 3.97	Bellvert, J.; Zarco-Tejada, P.J.; Girona, J,; Gonzoles-Dugo, V.; Fereres, E. A tool for detecting crop water status using airborne high-resolution thermal imagery. In *Sustainable Irrigation and Drainage V: Management Technologies and Policies*; WIT Transactions on Ecology and The Environment: Poznan, Poland 2014; pp. 25-31.
Orange	a value: -0.38 b value: 4.58	Gonzales-Dugo, V.; Zarco-Tejada, P.J.; Fereres, E. Applicability and limitations of using the crop water stress index as an indicator of water deficits in citrus orchards. *Agr. For. Meteor.* **2014**, *198-199*, 94-104.
Peach	a value: -1.71 b value: 3.87	Bellvert, J.; Marsal, J.; Girona, J.; Gonzales-Dugo, V.; Fereres, E.; Ustin, S.L.; Zarco-Tejada, P.J.; Airborne thermal imagery to detect the seasonal evolution of crop water status in peach, nectarine and saturn peach orchards. *Agr. For. Meteor.* **2016.**
Pistachio	a value: -1.33 b value: 2.44	Testi, L.; Goldhamer, D.A.; Iniesta, F.; Salinas, M. Crop water stress index is a sensitive water stress indicator in pistachio trees. *Irrig. Sci.* **2008**, *26*, 395-405.

Reference/Author	Subject – topic - Crop	Name Article
Bellvert, J.; Marsal, J.; Girona, J.; Gonzales-Dugo, V.; Fereres, E.; Ustin, S.L.; Zarco-Tejada, P.J.; Airborne thermal imagery to detect the seasonal evolution of crop water status in peach, nectarine and saturn peach orchards. *Agr. For. Meteor.* **2016.**	Peaches, Nectarines	Airborne Thermal Imagery to Detect the Seasonal.pdf
Gonzales-Dugo, V.; Zarco-Tejada, P.J.; Fereres, E. Applicability and limitations of using the crop water stress index as an indicator of water deficits in citrus orchards. *Agr. For. Meteor.* **2014**, *198-199*, 94-104.	Mandarin, Oranges	TBD
Testi, L.; Goldhamer, D.A.; Iniesta, F.; Salinas, M. Crop water stress index is a sensitive water stress indicator in pistachio trees. *Irrig. Sci.* **2008**, *26*, 395-405.	Pistachio	CWSI is a sensitive water stress indicator in pistachio.pdf
Osroosh, Y.; Peters, R.T.; Campbell, C.S.; Daylight crop water stress index for continuous monitoring of water status in apple trees. *Irrig. Sci.* **2016**, *34*, 209-219.	Apples	Oosrooh CWSIinApples.pdf

Reference/Author	Subject – topic - Crop	Name Article
Gardner, B.R.; Nielsen, D.C.; Shock, C.C. Infrared thermometry and the crop water stress index. II. Sampling procedures and interpretation. *J. Prod. Agri.* **1992**, 5: *466-475*.	All crops	All-Crops-CWSI-1992 Gardner JPA.pdf
Paltineanu, C.; Chitu, E.; Tanasescu, N. Using the crop water stress index in irrigation scheduling in apple orchards on southern Romania. **2016.**	Apples	Paltineau-Apple_CROP WATER STRESS INDEX IN IRRIGATION SCHEDULING.pdf
Bellvert, J.; Zarco-Tejada, P.J.; Marsal, J.; Girona, J.; Gonzales-Dugo, V.; Fereres, E. Vineyard Irrigation scheduling based on airborn thermal imagery and water potential thresholds. *Aust. J. Grape Wine Res.* **2015.**	Grapevine	Mapping CWSI in Pinot Noir.pdf
Udompetaikul, V.; Upadhyaya, S.K.; Slaughter, D.; Lampinen, B.; Shackel, K. Plant water stress detection using leaf temperature and microclimate information. *ASABE.* **2011.**	Almond, Walnut, Grapevine vs. SWP	Plant Water Sress Detection Using Leaf Temp and Micro Climate Almond Walnut.pdf
Tormann, H. Canopy temperature as a plant water stress indicator for nectarines. *Fruit and Fruit Technology Research Institute.* **2017**	Nectarine	Canopy temperature as a plant water stress indicator for nectarines.pdf

Reference/Author	Subject – topic - Crop	Name Article
Bellvert, J.; Marsal, J.; Girona, J.; Gonzales-Dugo, V.; Fereres, E.; Ustin, S.L.; Zarco-Tejada, P.J.; Airborne thermal imagery to detect the seasonal evolution of crop water status in peach, nectarine and saturn peach orchards. *Agr. For. Meteor.* **2016.**	Peaches, Nectarines	Airborne Thermal Imagery to Detect the Seasonal.pdf
Taghvaeian, S.; Chavez, J.L.; Baush, W.C.; DeJonge, K.C.; Trout, T.J. Minimizing instrumentation requirement for estimating crop water stress index and transpiration of maize. *Irr. Sci.* **2013**.	Corn	Taghvaeian - 2013 - IrrigSci - Instrumentation CWSI maize.pdf
Alderfasi, A. A.; Nielsen, D.C. Use of crop water stress index for monitoring water status and scheduling irrigation in wheat. *Agri. Water. Mana.* **2001**. 69-75.	Wheat	Alderfasi-Nielson_crop_water_stress_index_for_monitoring_water_status_and_scheduling_irrigation_in_wheat.pdf
1982 Jackson		