How to Use the Crop-Specific Algorithms provided with the GreenSeeker® RT200 System

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These instructions are intended to be used by individuals with knowledge of the RT200 system and RT Commander Software. Please consult other documents for more information:

- Details on algorithm equations may be found in NTech document: *Algorithm Definitions for RT200 Systems*
- *Operation of RT Commander and the RT200 are described fully in the RT200 System M*

Summary

The GreenSeeker® RT200 Variable Rate Application and Mapping System has the ability to run different crop specific algorithms. These algorithms are equations that determine the amount of material to apply based upon specific GreenSeeker® sensor values. These algorithms are developed by the institutions in their names, not by NTech Industries, Inc.

Below are general instructions for use. Any questions about the operation of the algorithms not answered in this document should be directed to the originating organization. As new algorithms are made available for the GreenSeeker® RT200, they will be available for download on our website at the address below. For your reference, we have compiled a list of web sources for regional Cumulative Growing Degree Days data, which is used by some of the algorithms. All of this is at www.ntechindustries.com/software. An explanation of GDD is in Appendix A.

Adjusting Algorithms

Please note that most algorithms are based upon typical years for temperature, rainfall and planting conditions. While the goal of algorithms is to work under a broad range of conditions, if you re-plant, or observe recommended rates from the algorithm that do not seem appropriate, it's possible that you'll have to adjust per consideration of your local conditions. (For example, if the average temperatures after planting are substantially higher for a sustained period than they have been for 20 years, you may want to adjust the Nitrogen Use Efficiency value or your GDD value.)

Use the RT200 in Measurement mode to collect average and peak value of N-Rich Strip (Ref area) and also an adjacent area that has not received a high N rate (Non Ref). If the *Ref Peak* NDVI value is significantly higher than the average values, consider re-running the N-Rich Strip to confirm data. Note the values as you traverse the area watching for an anomalous spot.

N-Rich Strip (reference area) Data

It is also important where you collect data on your N-Rich Strip (NRS) or Reference Strip. This applies to all of the algorithms. (Refer to the section at the end of this document for more details.) Sensor height should be 3 ft ±1 from the crop canopy.

To avoid skewing your peak and average values, you must only collect data over an appropriate area. Specifically, you must avoid "bad" areas like high spots, sink holes, and avoid head rows where seed may have been double planted, and areas of bumpy or steep terrain which cause the boom to fluctuate very high or low with respect to the crop.

Algorithm	Source of Alg	Ver.	Comments	Environment
Winter Wheat Dryland	OKstate	v1.4	updated coeffs 2008	GD_40F
Winter Wheat soft red*	VTech	v1.0	release	DFP
Spring Wheat Rainfed E.AU 2006	OKstate	v1.0	release, for Richard Heath	DFP
Spring Wheat Irrig Mexico	OKstate	v1.3	for 2007	DFP
Spring Wheat Canada	AgCan	v1.0	release	cumGDD_0C
Spring Wheat Canada/N.Cent US	AgCan	v1.0	release	CumGDD_32F
Durum Wheat	OKstate	v1.0	release	DFP
Corn GreatPlains [DFP]	OKstate	v1.1	release	DFP
Corn GreatPlains	OKstate	v1.3	2007 update: INSEY and cumGDD	CumGDD_50F
Corn Minnesota Region, ContCorn	OKstate	v1.0	release	CumGDD_50F
Corn Ohio Region	OKstate	v1.0	release	CumGDD_50F
Corn Rainfed V6-7	UofMO	v1.0	none	None
Corn Rainfed V8-10	UofMO	v1.0	none	None
Corn Coastal Plains*	VTech	v1.0	release	DFP
Sorghum Kansas	KSU-OSU	v1.3	release	DFP
Canola Rainfed	AAFCan	v1.1	update 2007-08; use NUE=0.5	CumGDD_0C
Cotton	OKstate	v1.0	release, use between 60 & 80 days after planting, bales weight 480 lbs	CumGDD_60F

**requires RTCommander v1.3.6 or higher*

Algorithms for 2008, summarizing Vegetation Index and Environmental Input.
Note that it is important to use the correct Base Temperature for Cumulative GDD

Winter Wheat: Nitrogen Topdress

Oklahoma State University

These algorithms require an N-Rich Strip. See section at the end of this document. General use notes: Use the RT200 in Measurement mode to collect average and peak value of N-Rich Strip, and an adjacent area that has not received a high n rate (Non Ref).

N	Winter Wheat Dryland	OKstate	v1.4	updated coeffs 2008	GD_40F	NDVI

Virginia Tech

General use notes: The user may supply a max N Rate (GPA), and *must* supply a yield estimate (Bushels/acre) and the amount of N applied earlier, GS_25N (lbs/acre), on the algorithm parameters screen. Details for using this may be found at at www.grains.cses.vt.edu/wheat_algorithm.htm.

N	Winter Wheat soft red	VTech*	v1.0	release	DFP	NDVI

Spring Wheat: Nitrogen Topdress

Oklahoma State University & Agricultural and Agri-Food Canada

These algorithms require an N-Rich Strip. General use notes: Use the RT200 in *Measurement mode* to collect average and peak value of N-Rich Strip (Ref area) and also an adjacent area that has not received a high N rate (Non Ref).

N	Spring Wheat Irrig Mexico	OKstate	v1.3	for 2007	DFP	NDVI
N	Spring Wheat Canada	AgCan	v1.0	release	CumGDD_0C	NDVI
N	Spring Wheat NorthCentral US	AgCan	v1.0	release	CumGDD_32F	NDVI
N	Durum Wheat	OKstate	v1.0	release	DFP	NDVI

Canola: Nitrogen Topdress

Agricultural and Agri-Food Canada

These algorithms require an N-Rich Strip. General use notes: Use the RT200 in *Measurement mode* to collect average and peak value of N-Rich Strip (Ref area) and also an adjacent area that has not received a high n rate (Non Ref).

The recommended growth stages for using this algorithm is 3.1 – 4.1 on the *Harper and Berkenkamp scale. Growth Stage Info:* Bolting/Bud Initiation to <10% flowering

N	Canola Rainfed	AAFCan	v1.1	update 2007-08; use NUE=0.5	CumGDD_0C	NDVI

Corn: Nitrogen Sidedress

Oklahoma State University

Oklahoma State University recommends using the v1.3 corn algorithm, which uses *cumulative GDD*. If you cannot obtain this data for your region, use the v1.1 algorithm with *Days From Planting* entered in the GDD field of the Crop Measurement Parameters screen. Used with corn at stages V8-V12.

N	Corn GreatPlains [DFP]	OKstate	v1.1	release	DFP	NDVI
N	Corn GreatPlains	OKstate	v1.3	2007 update: INSEY and cumGDD	CumGDD_50F	NDVI
N	Corn Minnesota Region, ContCorn	OKstate	v1.0	release	CumGDD_50F	NDVI
N	Corn Ohio Region	OKstate	v1.0	release	CumGDD_50F	NDVI

University of Missouri

These algorithms require an N-Rich Strip.

N	Corn Rainfed V6-7	UofMO	v1.0	none	None	iRVI
N	Corn Rainfed V8-10	UofMO	v1.0	none	None	iRVI

General use notes: The vegetative index iRVI (inverse Ratio) is used. iRVI varies from 0.0 to 1.0, but is a high value for a small plant and a low value for a larger plant, (opposite of NDVI). The use of iRVI is automatic and will not require any user adjustments with the RT200. *You must select the appropriate algorithm based upon average growth stage of field.* Use RT200 in *Measurement mode* to collect *average* value of N-Rich Strip (Ref area). The Missouri algorithms *do not* require measurement of the non reference area like some algorithms, and also uses the *average* of the complete N-Rich strip reference area, not a peak value.

The Max Ref field indicates an iRVI constraint value in the algorithm. Comparing with the iRVI value of your N-rich strip, the Missouri algorithm will use the lower of the two values to compute rates.

Virginia Tech

This algorithm requires an N-Rich Strip. The v1.0 corn algorithm uses DFP. General use notes: The user may supply a max N Rate (GPA), and *must* supply a yield estimate (Bushels/acre) and the amount of N applied previously at or near preplant (lbs/ac) on the algorithm parameters screen. Details for this are at. www.grains.cses.vt.edu/corn_algorithm.htm.

N	Corn CoastalPlains	VTech*	v1.0	release	DFP	NDVI

Sorghum: Nitrogen Sidedress

Oklahoma State University

These algorithms require an N-Rich Strip. General use notes: Use RT200 to in Measurement mode to collect average and peak value of N-Rich Strip (Ref area) and also adjacent area that has not received high n rate (Non Ref).

N	Sorghum Kansas	KSU-OSU	v1.3	release	DFP	NDVI

Cotton: Nitrogen Sidedress

Oklahoma State University

These algorithms require an N-Rich Strip. General use notes: Use RT200 to in Measurement mode to collect average and peak value of N-Rich Strip (Ref area) and also adjacent area that has not received high n rate (Non Ref). Application time should be between 60-80 days from planting.

N	Cotton	OKstate	v1.0	release, best when used 60 - 80 days after planting	CumGDD_60F	NDVI

Setting up an N-rich reference area in your field

Before the GreenSeeker applicator can be utilized to apply nitrogen (N) across a field, a nitrogen rich reference strip (N-Rich Strip or NRS) must be established prior to or shortly after planting. This reference strip is used primarily to determine the amount of nitrogen being made available to the plant by the environment (mineralization, etc). The ideal NRS would run the length of the field, but it should at least be 400 ft long. Establish the NRS in a representative portion of the field (i.e. not in a poor-performing region such as a high spot or sink hole). *Avoid locations that include a terrace or other terrain condition that could adversely effect sensor height when the RT200 is used to take calibration data in the NRS.* The rate of N necessary to establish a NRS is crop and region dependent, and should be equivalent to the highest rate necessary to satisfy crop needs throughout the growing season. For example, if it typically takes 150 pounds of nitrogen fertilizer from all sources to raise 200 bu/ac corn, then you might want to apply at least 120% of the total N requirement, ~180 total pounds of N in the NRS.

Disclaimer

These algorithms are developed by the institutions in their names, not NTech Industries, Inc. For details about their operation or implementation, and possible risks associated with using them for your specific application, please contact the institution developers directly. NTech Industries Inc. has made every effort to implement and document them accurately for use with GreenSeeker® products, but NTech and its distributors make no guarantees regarding the results you may obtain from the use of these algorithms or our equipment, and will not be liable for any consequential damages incurred by the use of NTech products, including loss or reduction of crop yields or changes in the amounts and expenses or crop fertilizers or other input materials.

Appendix A: Defining Growing Degree Days

There are various methods of defining an environmental variable for weather and agronomy uses which reflects the amount of heat energy present on a given day. It also called *cumulative growing degree days.* It has several variations, all of which try to quantify the heat energy available to plants. When temperatures are too hot or too cold, plants stop growing. Note that it may be calculated in Fahrenheit or Celsius. It is often referred to generically as Growing Degree Days or GDD. Our published algorithms use one of the following definitions:

- Cum GDD Base X°F — Cumulative Growing Degree Days using equation: (Tmax – Tmin)/2 – X *where Tmax, Tmin were highest and lowest temperatures that day, and X is the base temperature.*
- Note: — Different base temperatures may be used for particular crops. For these algorithms, the Base is 40F,50F & 60F for Wheat, Corn and Cotton respectively.
- Cum GDD Base 0°C — Cumulative Growing Degree Days (°C), using equation: (Tmax – Tmin)/2 – 0. Used for Eastern Canada crops. A base of 10°C is also common.
- GD >40°F — number of calendar days from planting when the temperature exceeded 40°F (OKstate, Mesonet)
- DFP — number of calendar days from planting. Also called *days after planting* (DAP)

Use the published GDD for your region.

*(If your information source publishes GDD °C, you can convert GDD to °F directly, using the conversion °F = °C * 9/5 + 32. or conversion °C = (°F -32) * 5/9*

Any temperature below the baseline is set to the baseline before calculating the average. Likewise, the maximum temperature is usually capped at 30 °C because most plants and insects do not grow any faster above that temperature.

Growing Degree Days [days]

In the wheat, sorghum, and corn algorithms of 2003 - 2006 supplied by Oklahoma State University, GDD is defined differently: simply the total number of *Days From Planting*, but with the qualification that the temperature exceeded 40°F for a given day. (Values for this index are available on line at www.mesonet.org). In the 2008 season, it is now identified as GD (Growing Days) in NTech's RTCommander.

Days From Planting [DFP or DAP]

A simple variable is just the number of elapsed days, and is often a sufficient measure for crops growing in Spring and early Summer.