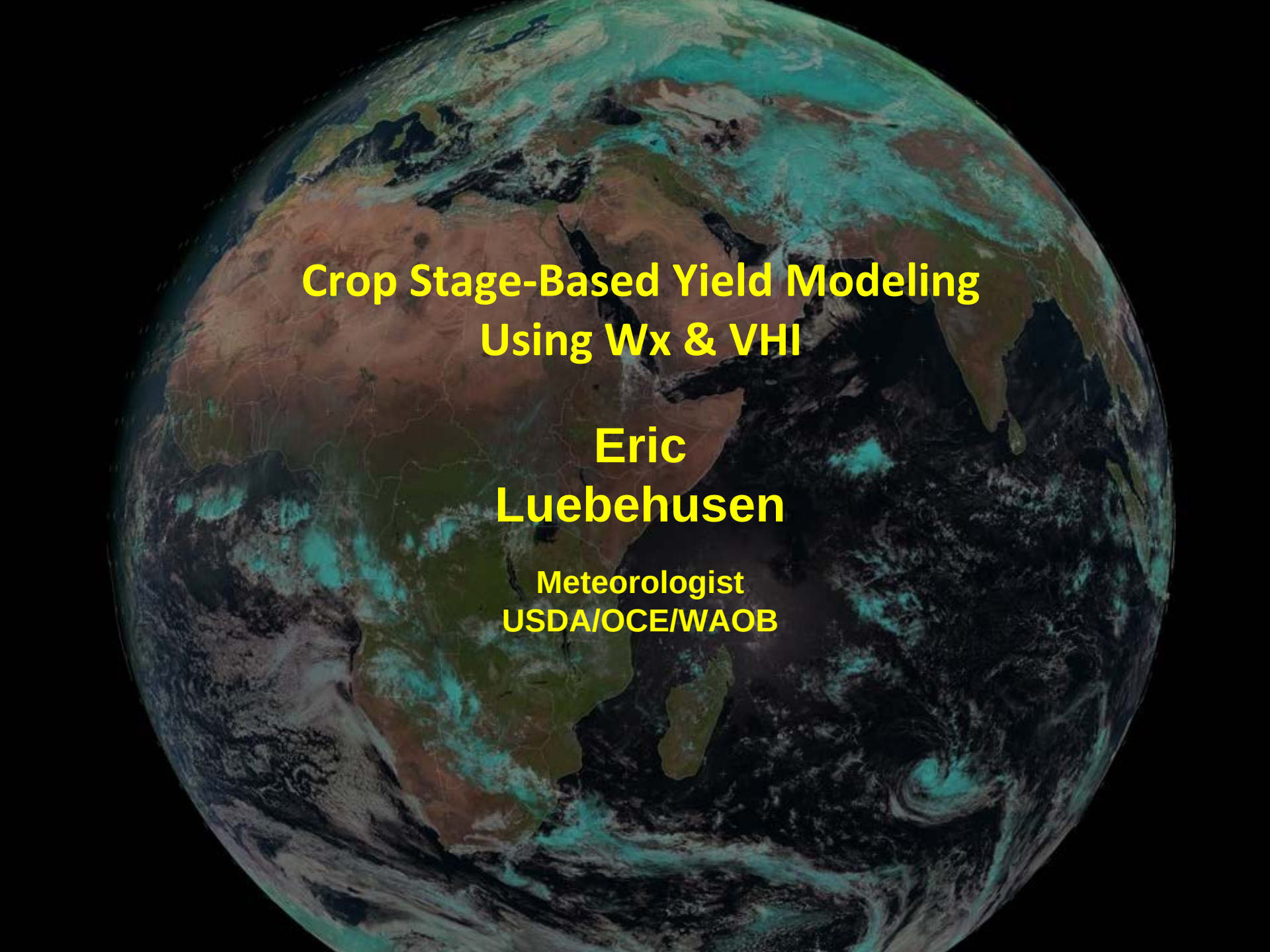
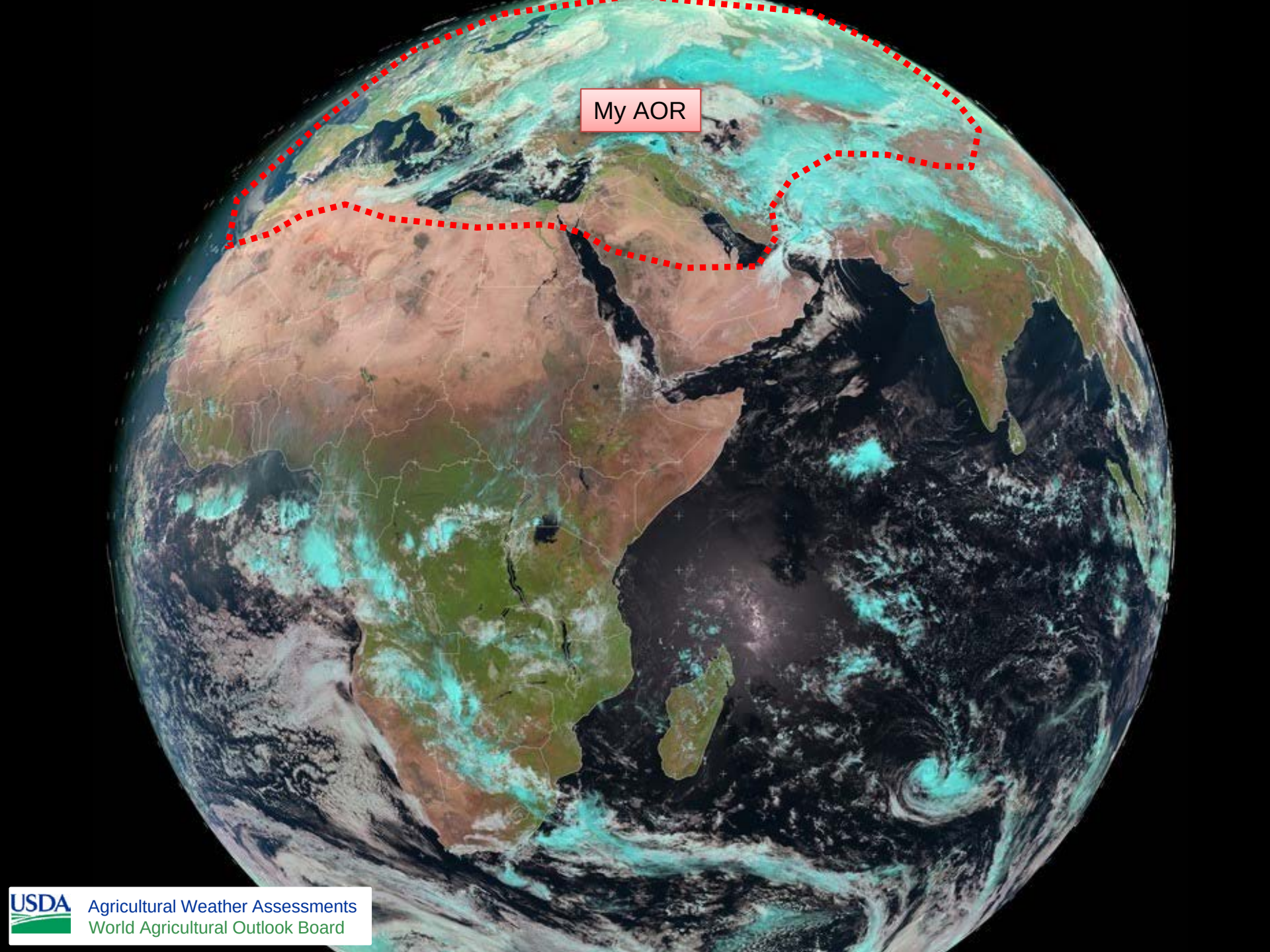


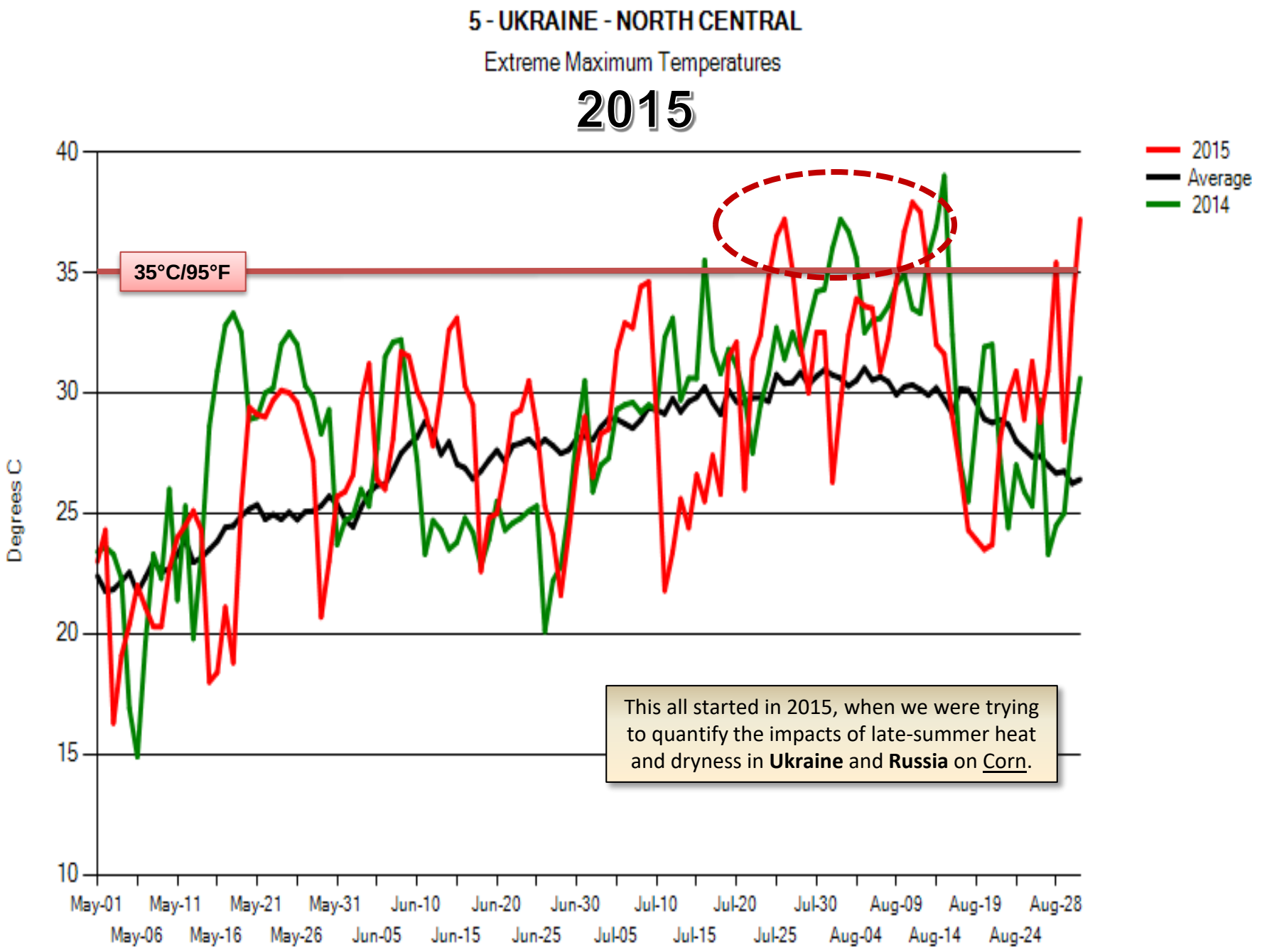
Crop Stage-Based Yield Modeling Using Wx & VHI

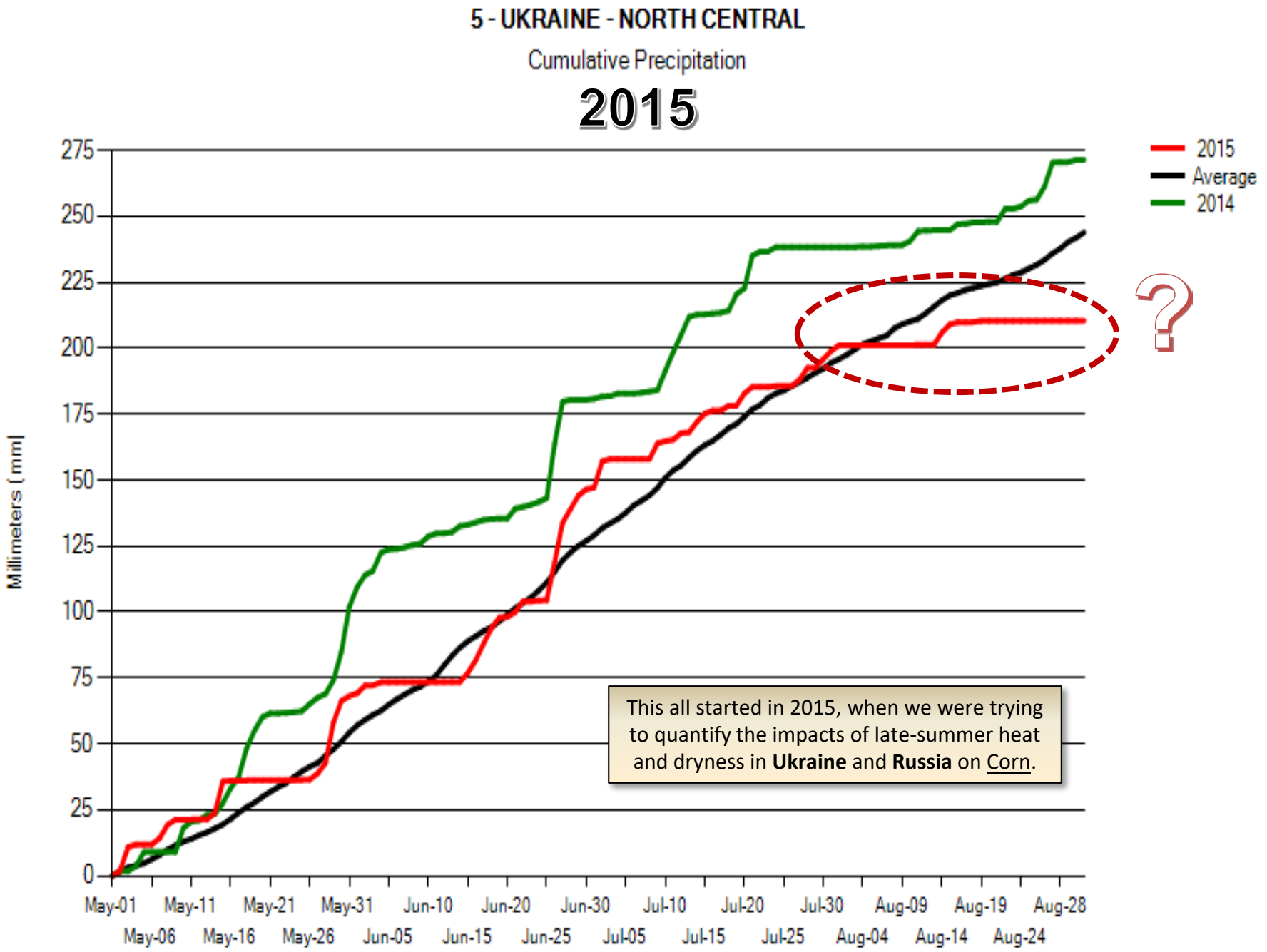
Eric Luebehusen

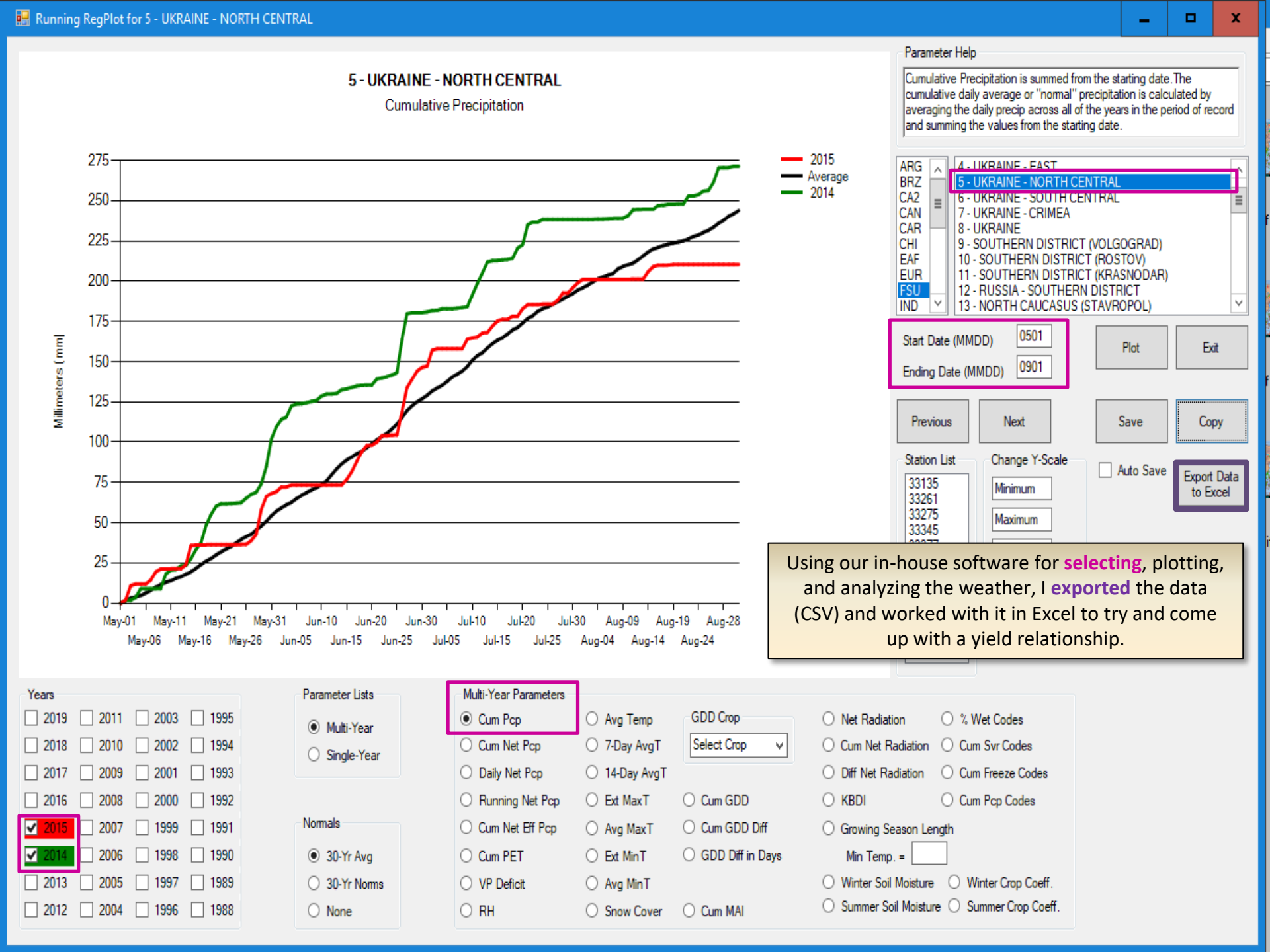
Meteorologist
USDA/OCE/WAOB

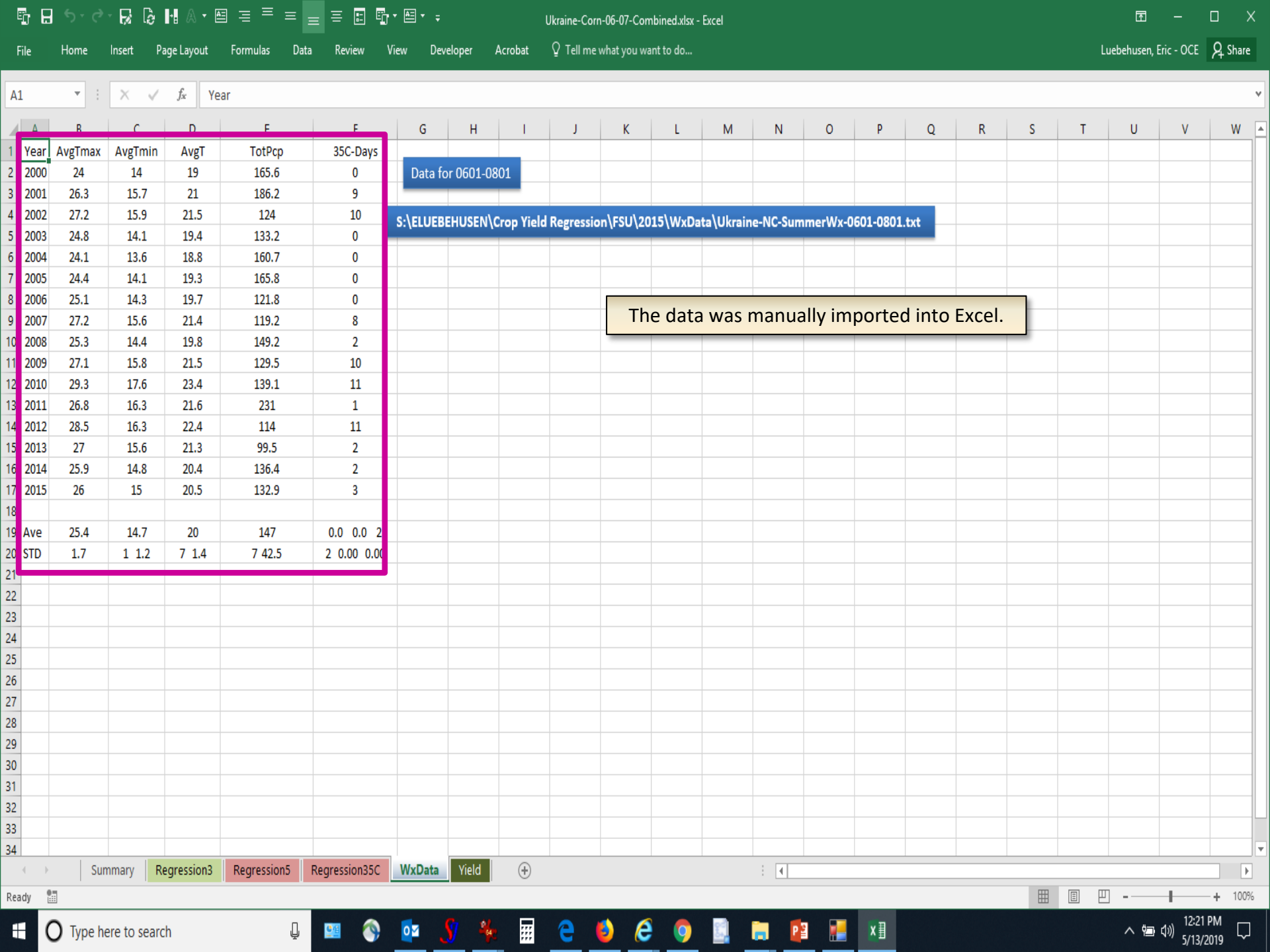


USDA Agricultural Weather Assessments
World Agricultural Outlook Board


5 - UKRAINE - NORTH CENTRAL
Extreme Maximum Temperatures
2015
2015
Average
2014
35°C/95°F
Degrees C
40
35
30
25
20
15
10
May-01
May-06
May-11
May-16
May-21
May-26
May-31
Jun-05
Jun-10
Jun-15
Jun-20
Jun-25
Jun-30
Jul-05
Jul-10
Jul-15
Jul-20
Jul-25
Jul-30
Aug-04
Aug-09
Aug-14
Aug-19
Aug-24
Aug-28
This all started in 2015, when we were trying to quantify the impacts of late-summer heat and dryness in **Ukraine** and **Russia** on Corn.


5 - UKRAINE - NORTH CENTRAL
Cumulative Precipitation
2015
Millimeters [mm]
275
250
225
200
175
150
125
100
75
50
25
0
May-01
May-06
May-11
May-16
May-21
May-26
May-31
Jun-05
Jun-10
Jun-15
Jun-20
Jun-25
Jun-30
Jul-05
Jul-10
Jul-15
Jul-20
Jul-25
Jul-30
Aug-04
Aug-09
Aug-14
Aug-19
Aug-24
Aug-28
2015
Average
2014
?
This all started in 2015, when we were trying to quantify the impacts of late-summer heat and dryness in **Ukraine** and **Russia** on Corn.


Running RegPlot for 5 - UKRAINE - NORTH CENTRAL
5 - UKRAINE - NORTH CENTRAL
Cumulative Precipitation
Millimeters [mm]
2015
Average
2014
Parameter Help
Cumulative Precipitation is summed from the starting date. The cumulative daily average or "normal" precipitation is calculated by averaging the daily precip across all of the years in the period of record and summing the values from the starting date.
ARG
BRZ
CA2
CAN
CAR
CHI
EAF
EUR
FSU
IND
4 - UKRAINE - EAST
5 - UKRAINE - NORTH CENTRAL
6 - UKRAINE - SOUTH CENTRAL
7 - UKRAINE - CRIMEA
8 - UKRAINE
9 - SOUTHERN DISTRICT (VOLGOGRAD)
10 - SOUTHERN DISTRICT (ROSTOV)
11 - SOUTHERN DISTRICT (KRASNODAR)
12 - RUSSIA - SOUTHERN DISTRICT
13 - NORTH CAUCASUS (STAVROPOL)
Start Date (MMDD)
0501
Ending Date (MMDD)
0901
Plot
Exit
Previous
Next
Save
Copy
Station List
33135
33261
33275
33345
Change Y-Scale
Minimum
Maximum
Auto Save
Export Data to Excel
Using our in-house software for selecting, plotting, and analyzing the weather, I exported the data (CSV) and worked with it in Excel to try and come up with a yield relationship.
Years
Parameter Lists
Multi-Year
Single-Year
Normals
30-Yr Avg
30-Yr Norms
None
Multi-Year Parameters
Cum Pcp
Cum Net Pcp
Daily Net Pcp
Running Net Pcp
Cum Net Eff Pcp
Cum PET
VP Deficit
RH
Avg Temp
7-Day AvgT
14-Day AvgT
Ext MaxT
Avg MaxT
Ext MinT
Avg MinT
Snow Cover
GDD Crop
Select Crop
Cum GDD
Cum GDD Diff
GDD Diff in Days
Cum MAI
Net Radiation
Cum Net Radiation
Diff Net Radiation
KBDI
Growing Season Length
Min Temp. =
Winter Soil Moisture
Summer Soil Moisture
% Wet Codes
Cum Svr Codes
Cum Freeze Codes
Cum Pcp Codes
Winter Crop Coeff.
Summer Crop Coeff.



Year	AvgTmax	AvgTmin	AvgT	TotPcp	35C-Days
2000	24	14	19	165.6	0
2001	26.3	15.7	21	186.2	9
2002	27.2	15.9	21.5	124	10
2003	24.8	14.1	19.4	133.2	0
2004	24.1	13.6	18.8	160.7	0
2005	24.4	14.1	19.3	165.8	0
2006	25.1	14.3	19.7	121.8	0
2007	27.2	15.6	21.4	119.2	8
2008	25.3	14.4	19.8	149.2	2
2009	27.1	15.8	21.5	129.5	10
2010	29.3	17.6	23.4	139.1	11
2011	26.8	16.3	21.6	231	1
2012	28.5	16.3	22.4	114	11
2013	27	15.6	21.3	99.5	2
2014	25.9	14.8	20.4	136.4	2
2015	26	15	20.5	132.9	3
Ave	25.4	14.7	20	147	0.0 0.0 2
STD	1.7	1 1.2	7 1.4	7 42.5	2 0.00 0.0

J7 0.45250047472575

Year	Yield	AvgT	TotPcp	Year
2000	3.00860047	19	165.6	2000
2001	3.24220837	21	186.2	2001
2002	3.51555929	21.5	124	2002
2003	3.45651081	19.4	133.2	2003
2004	3.85521739	18.8	160.7	2004
2005	4.31746988	19.3	165.8	2005
2006	3.73604651	19.7	121.8	2006
2007	3.89963216	21.4	119.2	2007
2008	4.69139344	19.8	149.2	2008
2009	5.01962662	21.5	129.5	2009
2010	4.50113293	23.4	139.1	2010
2011	6.44413093	21.6	231	2011
2012	4.78764302	22.4	114	2012
2013	6.40414508	21.3	99.5	2013
2014	6.15135135	20.4	136.4	2014
2015	6.04651163	20.5	132.9	2015
Predicted:	6.82			

Ukraine: Corn
North-Central met data
Regression 3

SUMMARY OUTPUT

Regression3: 2005-2014

Regression analyses were run manually on the data.

Regression Statistics	
Multiple R	0.929621
R Square	0.864195
Adjusted R Square	0.796292
Standard Error	0.4525
Observations	10

ANOVA

	df	SS	MS	F	gnificance F
Regression	3	7.817805	2.605935	12.72698	0.005192
Residual	6	1.22854	0.204757		
Total	9	9.046345			

	Coefficients	andard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	pper 95.0%
Intercept	-642.127	112.7956	-5.69284	0.001268	-918.128	-366.127	-918.128	-366.127
AvgT X Variable 1	-0.21181	0.133533	-1.5862	0.163788	-0.53855	0.114933	-0.53855	0.114933
TotPcp X Variable 2	0.010165	0.004116	2.469776	0.048472	9.41E-05	0.020236	9.41E-05	0.020236
Year X Variable 3	0.323543	0.05676	5.700183	0.00126	0.184656	0.462429	0.184656	0.462429

RESIDUAL OUTPUT

Year	Yield	Observation	Predicted Y	Residuals
2005	4.31747	1	4.17301	0.14446
2006	3.736047	2	3.964558	-0.22851
2007	3.899632	3	3.901594	-0.00196
2008	4.691393	4	4.86899	-0.1776
2009	5.019627	5	4.6322	0.387427
2010	4.501133	6	4.650889	-0.14976
2011	6.444131	7	6.289875	0.154256

Ukraine-Corn-06-07-Combined.xlsx - Excel

File Home Insert Page Layout Formulas Data Review View Developer Acrobat Tell me what you want to do... Luebehusen, Eric - OCE Share

B18 =ROUND(J17+(C17*J18)+(D17*J19)+(E17*J20)+(F17*J21)+(G17*J22),3)

	A	B	C	D	E	F	G
1	Year	Yield	AvgTmax	AvgTmin	TotPcp	35C-Days	Year
2	2000	3.00860047	24	14	165.6	0	2000
3	2001	3.24220837	26.3	15.7	186.2	9	2001
4	2002	3.51555929	27.2	15.9	124	10	2002
5	2003	3.45651081	24.8	14.1	133.2	0	2003
6	2004	3.85521739	24.1	13.6	160.7	0	2004
7	2005	4.31746988	24.4	14.1	165.8	0	2005
8	2006	3.73604651	25.1	14.3	121.8	0	2006
9	2007	3.89963216	27.2	15.6	119.2	8	2007
10	2008	4.69139344	25.3	14.4	149.2	2	2008
11	2009	5.01962662	27.1	15.8	129.5	10	2009
12	2010	4.50113293	29.3	17.6	139.1	11	2010
13	2011	6.44413093	26.8	16.3	231	1	2011
14	2012	4.78764302	28.5	16.3	114	11	2012
15	2013	6.40414508	27	15.6	99.5	2	2013
16	2014	6.15135135	25.9	14.8	136.4	2	2014
17	2015	6.04651163	26	15	132.9	3	2015
18	Predicted:	7.057					

Ukraine: Corn
North-Central met data
Regression 5

SUMMARY OUTPUT

Regression5: 2005-2014

Regression Statistics	
Multiple R	0.959996
R Square	0.921593
Adjusted R Squar	0.823584
Standard Error	0.421099
Observations	10

ANOVA

	df	SS	MS	F	gnificance F
Regression	5	8.337046	1.667409	9.403141	0.024819
Residual	4	0.709299	0.177325		
Total	9	9.046345			

		Coefficients	tandard Err	t Stat	P-value	Lower 95%	Upper 95%	ower 95.0%	pper 95.0%
Intercept		-679.14	131.8877	-5.14938	0.006747	-1045.32	-312.961	-1045.32	-312.961
AvgTmax	X Variable 1	-1.27597	0.892673	-1.42939	0.226107	-3.75443	1.202484	-3.75443	1.202484
AvgTmin	X Variable 2	1.413762	0.999505	1.414462	0.230132	-1.36131	4.188831	-1.36131	4.188831
TotPcp	X Variable 3	-0.00174	0.008089	-0.21483	0.840411	-0.0242	0.020722	-0.0242	0.020722
35C-Days	X Variable 4	0.012402	0.083041	0.149351	0.888504	-0.21816	0.242961	-0.21816	0.242961
Year	X Variable 5	0.346581	0.068986	5.023901	0.007365	0.155044	0.538118	0.155044	0.538118

Regression analyses were run manually on the data.

RESIDUAL OUTPUT

Year	Yield	Observation	Predicted Y	Residuals
2005	4.31747	1	4.266184	0.051286
2006	3.736047	2	4.078799	-0.34275
2007	3.899632	3	3.687461	0.212171
2008	4.691393	4	4.63533	0.056063
2009	5.019627	5	4.797877	0.22175

Summary Regression3 Regression5 Regression35C WxData Yield

Ready 100%

Type here to search 12:22 PM 5/13/2019

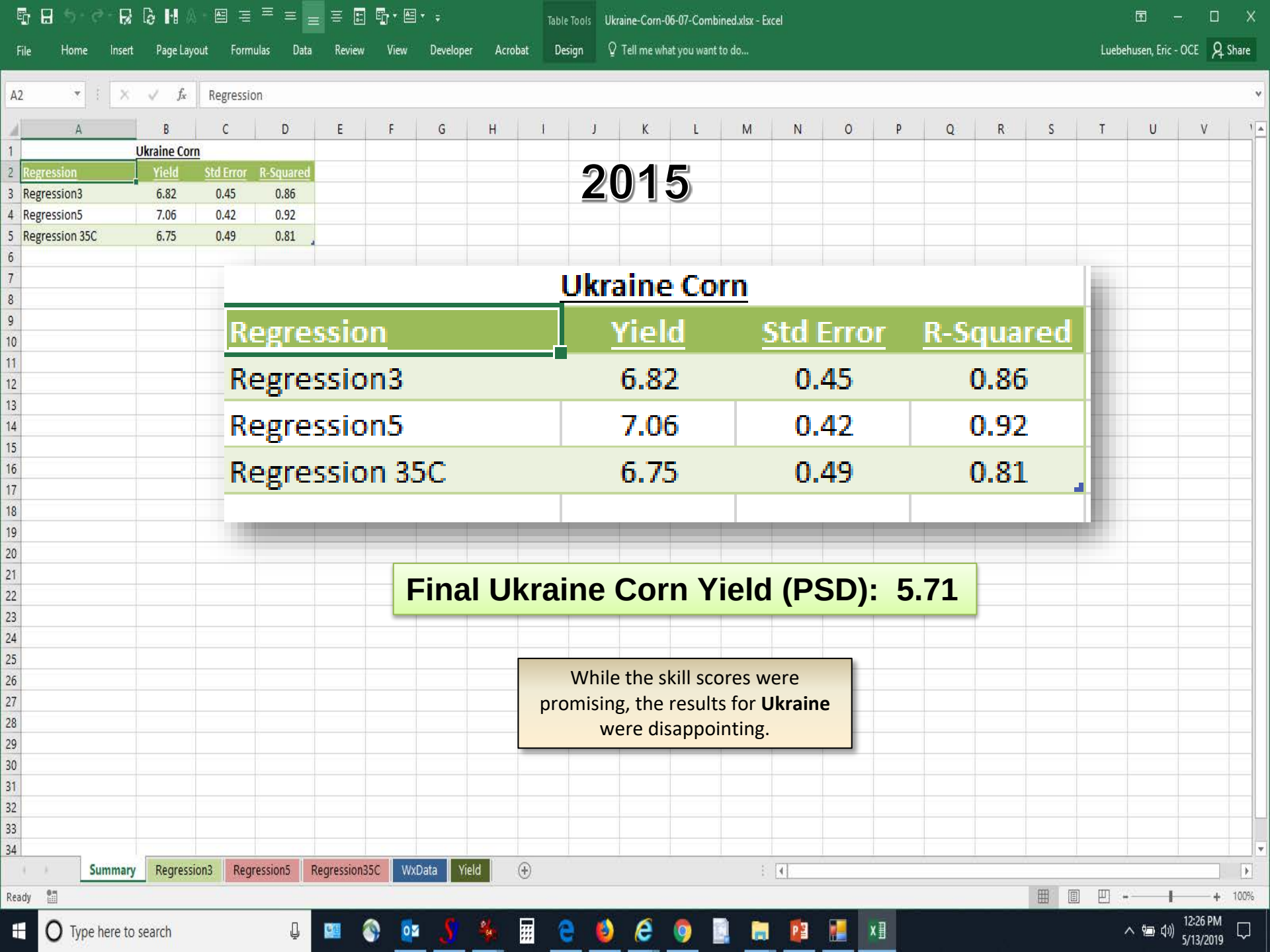


Table Tools
Ukraine-Corn-06-07-Combined.xlsx - Excel
File
Home
Insert
Page Layout
Formulas
Data
Review
View
Developer
Acrobat
Design
Tell me what you want to do...
Luebehusen, Eric - OCE
Share
A2
Regression
Ukraine Corn
Regression
Yield
Std Error
R-Squared
Regression3
6.82
0.45
0.86
Regression5
7.06
0.42
0.92
Regression 35C
6.75
0.49
0.81
2015
Ukraine Corn
Regression
Yield
Std Error
R-Squared
Regression3
6.82
0.45
0.86
Regression5
7.06
0.42
0.92
Regression 35C
6.75
0.49
0.81
Final Ukraine Corn Yield (PSD): 5.71
While the skill scores were promising, the results for Ukraine were disappointing.
Summary
Regression3
Regression5
Regression35C
WxData
Yield
Ready
Type here to search
12:26 PM
5/13/2019

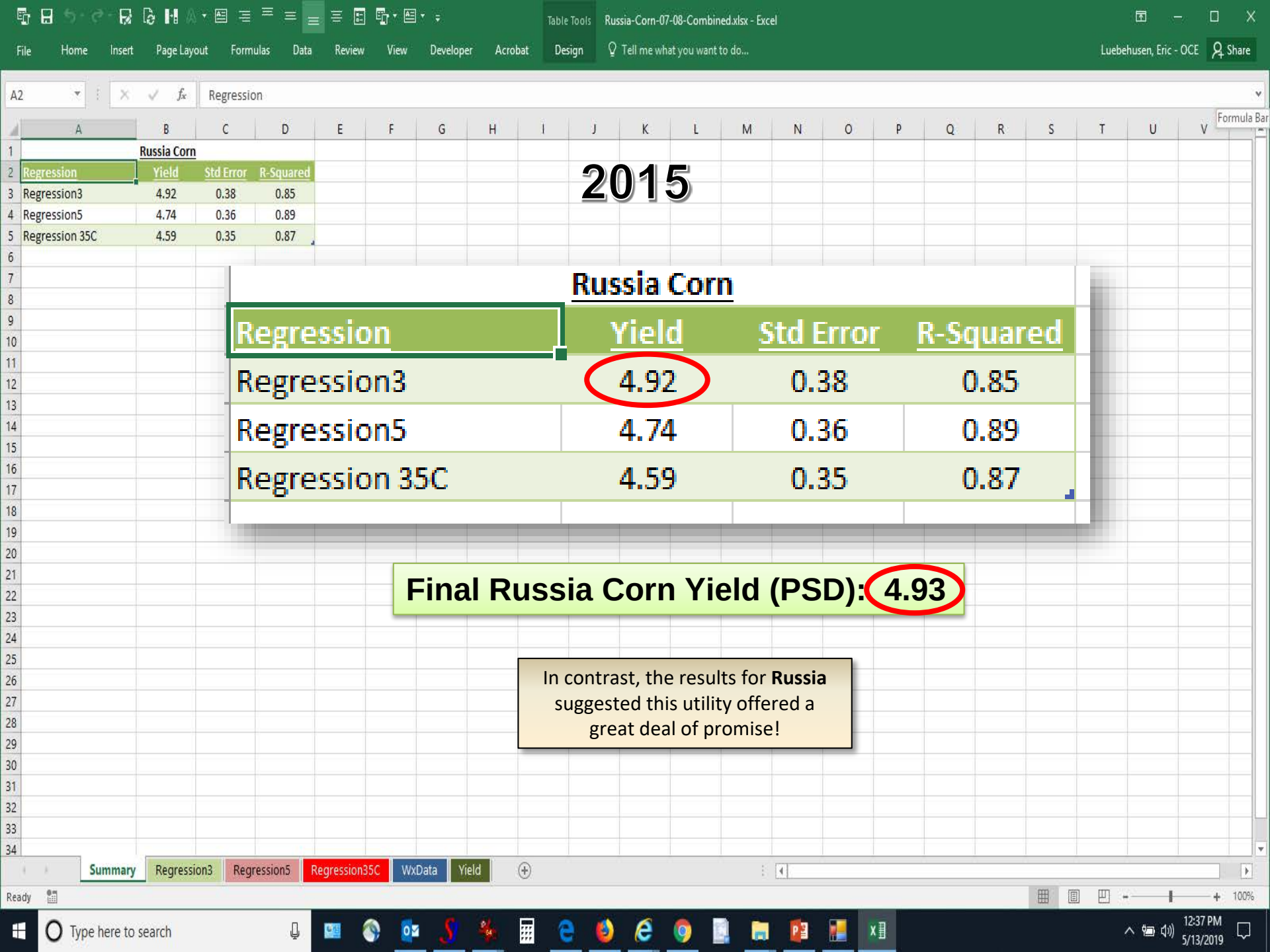
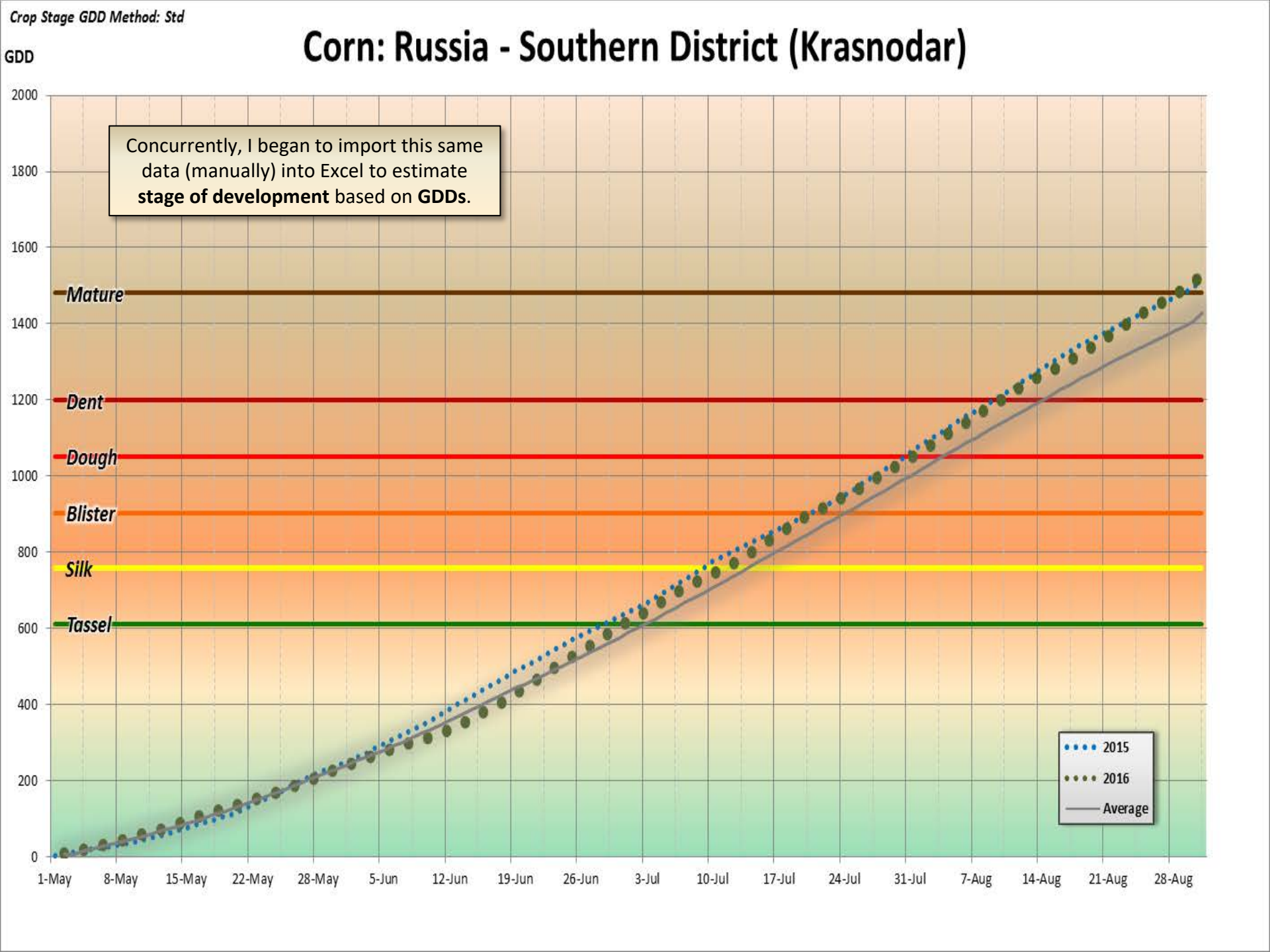


Table Tools
Russia-Corn-07-08-Combined.xlsx - Excel
File Home Insert Page Layout Formulas Data Review View Developer Acrobat Design
Tell me what you want to do...
Luebehusen, Eric - OCE
Share
A2
Regression
Formula Bar
Russia Corn
Regression Yield Std Error R-Squared
Regression3 4.92 0.38 0.85
Regression5 4.74 0.36 0.89
Regression 35C 4.59 0.35 0.87
2015
Russia Corn
Regression Yield Std Error R-Squared
Regression3 4.92 0.38 0.85
Regression5 4.74 0.36 0.89
Regression 35C 4.59 0.35 0.87
Final Russia Corn Yield (PSD): 4.93
In contrast, the results for Russia suggested this utility offered a great deal of promise!
Summary
Regression3
Regression5
Regression35C
WxData
Yield
Ready
100%
Type here to search
12:37 PM
5/13/2019


Crop Stage GDD Method: Std
Corn: Russia - Southern District (Krasnodar)
GDD
Concurrently, I began to import this same data (manually) into Excel to estimate **stage of development** based on **GDDs**.
Mature
Dent
Dough
Blister
Silk
Tassel
2015
2016
Average
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1-May
8-May
15-May
22-May
28-May
5-Jun
12-Jun
19-Jun
26-Jun
3-Jul
10-Jul
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug

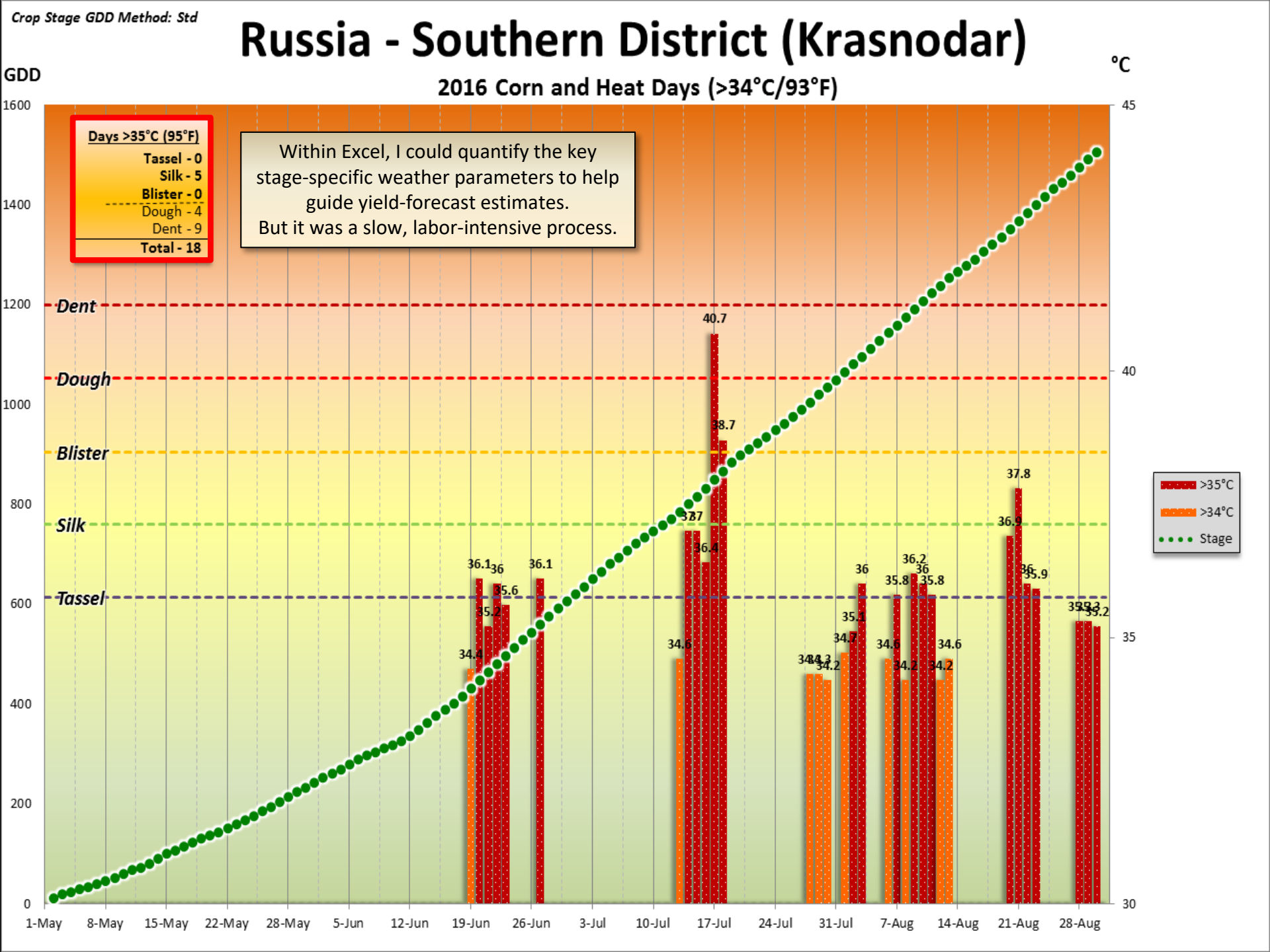

Crop Stage GDD Method: Std
Russia - Southern District (Krasnodar)
2016 Corn and Heat Days (>34°C/93°F)
GDD
°C
Days >35°C (95°F)
Tassel - 0
Silk - 5
Blister - 0
Dough - 4
Dent - 9
Total - 18
Within Excel, I could quantify the key stage-specific weather parameters to help guide yield-forecast estimates.
But it was a slow, labor-intensive process.
Dent
Dough
Blister
Silk
Tassel
>35°C
>34°C
Stage
1-May
8-May
15-May
22-May
28-May
5-Jun
12-Jun
19-Jun
26-Jun
3-Jul
10-Jul
17-Jul
24-Jul
31-Jul
7-Aug
14-Aug
21-Aug
28-Aug

Table Tools Corn-GDD-Wx-Database-FSU.xlsm - Excel

File Home Insert Page Layout Formulas Data Review View Developer Acrobat Design Tell me what you want to do... Luebehusen, Eric - OCE Share

A1 RDATE

	A	B	C	D	E	F	G	H	I	J	K
1	RDATE	TAVG	PRECIP	PNORM	TNORM	EXT_TMAX	EXT_TMIN		GDD	CumPcp	AvgPcp
14939	24-Aug-18	23.0	0.0	1.9	20.3	31.2	12.9		1262.4	262.3	221.4
14940	25-Aug-18	23.7	0.0	1.9	20.1	32.8	12.6		1276.1	262.3	223.3
14941	26-Aug-18	24.0	0.0	1.9	19.9	33.9	12.2		1290.1	262.3	225.2
14942	27-Aug-18	23.9	0.0	1.9	19.8	32.4	17.2		1304	262.3	227.1
14943	28-Aug-18	23.7	0.0	1.9	19.6	33.7	16.0		1317.7	262.3	229.0
14944	29-Aug-18	22.5	0.8	1.9	19.5	30.0	16.4		1330.2	263.1	230.9
14945	30-Aug-18	21.8	0.0	1.9	19.3	31.7	10.4		1342	263.1	232.8
14946	31-Aug-18	22.8	0.0	1.9	19.1						
14947	1-Sep-18	23.9	0.0	1.9	18.9						
14948	2-Sep-18	24.4	0.0	1.9	18.8						
14949	3-Sep-18	25.4	0.0	1.9	18.6						
14950	4-Sep-18	23.5	0.0	1.9	18.4						
14951	5-Sep-18	21.3	4.4	1.9	18.2						
14952	6-Sep-18	19.7	5.8	1.9	18.0	25.8	15.6		1433	273.3	246.1
14953	7-Sep-18	19.5	0.0	1.9	17.8	27.1	13.7		1442.5	273.3	248.0
14954	8-Sep-18	17.8	0.0	1.9	17.6	25.4	11.7		1450.3	273.3	249.9
14955	9-Sep-18	16.4	0.4	1.9	17.4	21.4	11.6		1456.7	273.7	251.8
14956	10-Sep-18	18.2	8.8	1.8	17.3	25.9	14.0		1464.9	282.5	253.6
14957	11-Sep-18	17.6	4.1	1.8	17.1	22.3	14.2		1472.5	286.6	255.4
14958	12-Sep-18	20.2	0.1	1.8	16.9	26.7	12.8		1482.7	286.7	257.2
14959	13-Sep-18	20.2	0.0	1.8	16.7	28.5	11.3		1492.9	286.7	259.0
14960	14-Sep-18	21.4	0.0	1.8	16.5	29.0	11.9		1504.3	286.7	260.8
14961	15-Sep-18	22.1	0.1	1.7	16.4	29.9	12.3		1516.4	286.8	262.5
14962	16-Sep-18	20.5	0.8	1.7	16.2	26.4	15.6		1526.9	287.6	264.2
14963	17-Sep-18	17.3	0.0	1.7	16.0	25.8	6.7		1534.2	287.6	265.9
14964	18-Sep-18	18.2	0.0	1.7	15.8	26.9	7.3		1542.4	287.6	267.6
14965	19-Sep-18	19.2	0.0	1.7	15.6	28.7	8.7		1551.6	287.6	269.3
14966	20-Sep-18	19.7	0.0	1.6	15.5	29.3	8.4		1561.3	287.6	270.9
14967	21-Sep-18	19.9	0.0	1.6	15.3	30.1	7.8		1571.2	287.6	272.5
14968	22-Sep-18	21.6	1.5	1.6	15.1	30.1	11.0		1582.8	289.1	274.1
14969	23-Sep-18	15.4	1.8	1.5	14.9	21.6	9.3		1588.2	290.9	275.6
14970	24-Sep-18	16.8	4.4	1.5	14.8	30.4	10.7		1595	295.3	277.1
14971	25-Sep-18	10.3	2.1	1.5	14.6	16.1	2.1		1595.3	297.4	278.6

The first big breakthrough came when Brian Morris provided a **dynamic link** to our in-house **WMO database** I could use in Excel; I could now work with the updated data within Excel versus having to [SAVE AS] from our data plotter.

HeatDays-Cur HeatDays-Prev FrzDays-Cur FrzDays-Prev GDD Pcp TMax TMin Yield WxData

Ready 100%

Type here to search 12:57 PM 5/13/2019

Corn-GDD-Wx-Database-FSU.xlsm - Excel

File Home Insert Page Layout Formulas Data Review View Developer Acrobat Tell me what you want to do... Luebehusen, Eric - OCE Share

B4 =LOOKUP(FormData!$N$2,FormData!I:I,FormData!O:O)

Region	FSU
SubReg #	5
Year	2018
Start Date	0515
GDD Base	10
PSD Crop (Yield):	Corn
*Chart Title (region)	Ukraine (Northcentral)
Chart Title (crop):	Corn
Current DB Region	UKRAINE - NORTH CENTRAL

← =YEAR(TODAY())

<Enter as 'MMDD

Select Region: Former Soviet Union

Select Subregion: UKRAINE - NORTH CENTR

UKRAINE - NORTH CENTRA
UKRAINE - SOUTH CENTRA
UKRAINE - CRIMEA
UKRAINE
SOUTHERN DISTRICT (VOL
SOUTHERN DISTRICT (ROS
SOUTHERN DISTRICT (KRA
RUSSIA - SOUTHERN DISTF
NORTH CAUCASUS (STAVF
NORTH CAUCASUS (DAGE
RUSSIA - VOLGA DISTRICT
RUSSIA - VOLGA DISTRICT
RUSSIA - VOLGA DISTRICT
RUSSIA - VOLGA DISTRICT
RUSSIA - CENTRAL DISTRI(
RUSSIA - CENTRAL DISTRI(
RUSSIA - CENTRAL DISTRI(
RUSSIA - NORTHWEST DIS
URALS DISTRICT
RUSSIA - SIBERIA DISTRICT

GoTo Form Data | GoTo DB Wx Data | Refresh Data | Year Wrap | No Year Wrap | GoTo Yield Data

*Chart Title (region) can be changed/set in **Form Data**

=LOOKUP(FormData!$N$2,FormData!I:I,FormData!O:O)

Yield Area Name: Russia

Select Country Yield Data: Russia

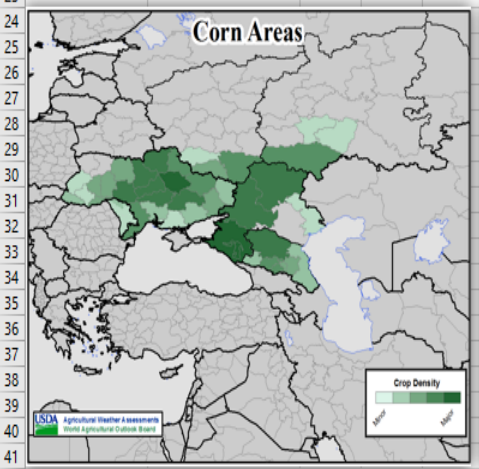
EXPORT PNGs To: (must end with → \ )

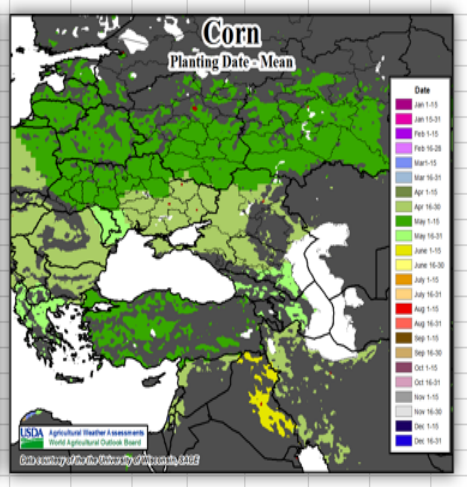
S:\ELUEBEHUSEN\Crop GDD Stages\FSU\CURRENT\SummerCrops\Expo

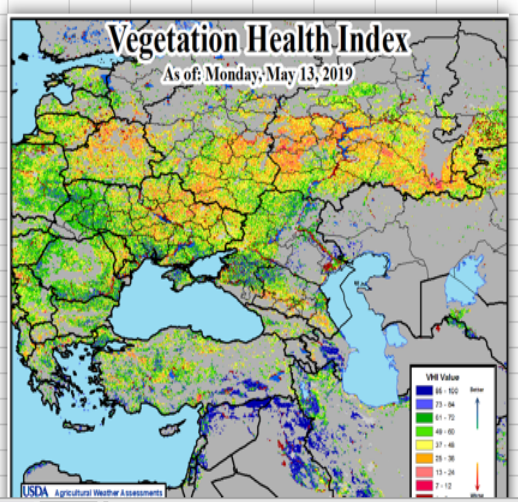
Corn Heat Thresholds during Reproduction (°C)

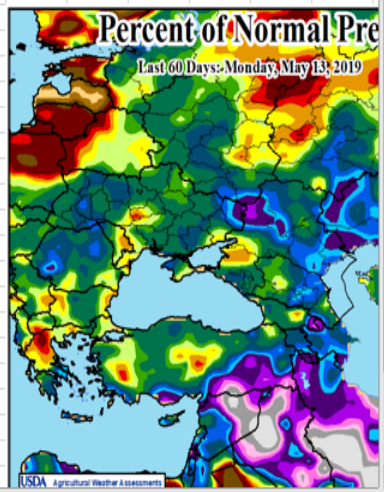
Stress	Damage
32	35

Using the built-in database link, macros, VBA, and Excel's plotting capabilities, the ability to **select and plot weather data** increased by an order of magnitude.









Region | CropStage | Pcp-Cur | Pcp-Prev | HeatDays-Cur | HeatDays-Prev | FrzDays-Cur | FrzDays-Prev | GDD | ...

Ready 80%

Type here to search 1:02 PM 5/13/2019

Corn-GDD-Wx-Database-FSU.xlsm - Excel

File Home Insert Page Layout Formulas Data Review View Developer Acrobat Tell me what you want to do... Luebehusen, Eric - OCE Share

A1

Dat	2018	Averag	2017
Stage Label			
15-May	#N/A	#N/A	#N/A
19-May	35.4	23.0	
20-May	42.1	30.13	18.2
21-May	45.1	37.	
22-May	51.8	45.4	
23-May	60.4	53.7	28.7
24-May	70.3	61.96	37.9
25-May	81.1	69.915	45.5
26-May	89.2	77.525	52.5
27-May	95.2	85.445	58.9
28-May	102.6	93.71	65.4
29-May	112.1	102.2	74.8
30-May	120.5	110.8	86.6
31-May	132.8	119.69	98.4
1-Jun	138.3	127.735	108.5
2-Jun	144.1	134.94	114
3-Jun	151.8	142.215	117.2
4-Jun	162.8	150.075	121.1
5-Jun	174.9	158.61	131.8
6-Jun	181.2	167.265	143.1
7-Jun	184.7	176.29	155.9
8-Jun	192.6	185.725	168.7
9-Jun	203.9	195.46	178.8
10-Jun	212.3	205.65	185.7
11-Jun	220.8	215.86	193.6
12-Jun	232.2	226.32	204
13-Jun	244.1	236.28	214.2
14-Jun	257.2	246.27	221
15-Jun	271	255.99	226.3
16-Jun	283.9	265.7	233.4
17-Jun	297.2	275.085	242.8
18-Jun	309.7	284.385	252.9
19-Jun	322.2	294.145	263.4
20-Jun	336.6	304.29	276.3
21-Jun	349.5	314.33	287.9
22-Jun	364.4	324.14	295.7
23-Jun	373.4	334.21	304.4
24-Jun	378.7	344.795	314.2
25-Jun	384.9	355.495	325.7
26-Jun	393.5	366.085	340.5
27-Jun	404.8	375.995	353.9
28-Jun	418.3	385.89	366.4
29-Jun	431.9	396.13	381.1
30-Jun	444	406.545	397
1-Jul	451.2	416.78	412.4
2-Jul	456.6	427.065	423.7
3-Jul	463.1	437.905	434.1

Yellow: Graph Title/Item

Green/Grey: Macro-set Data/Stage

Method:	Tassel	Silk	Blister	Dough	Dent	Mature
Std	613	760	904	1052	1199	1482

Chart Title---> Corn : Ukraine (Northcentr StageName

Crop Stage GDD Method: Std

2017

EXPORT Charts

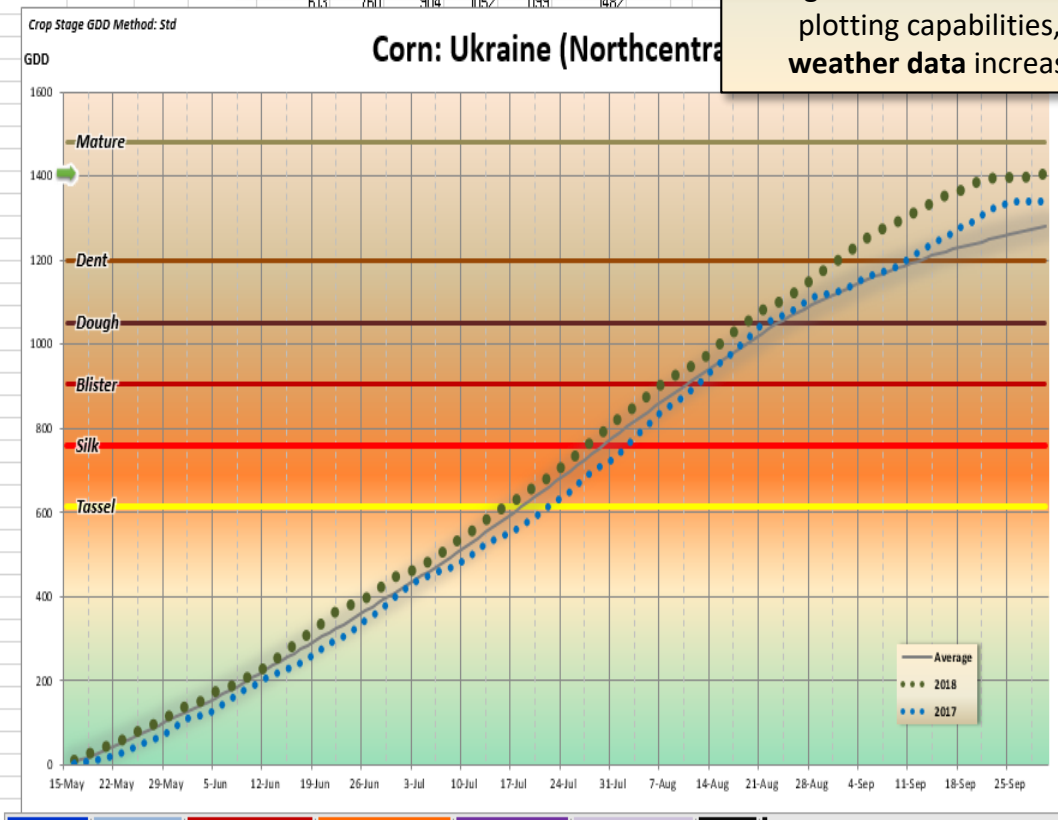
Export Prev Year Charts

GDDs:	1403.1	Corn: Ukraine (Northcentral)	11/11
#N/A	Date:	9/29/2018	43 days ahead of Avg

Tassel	Silk	Blister	Dough
613	760	904	105

760	Silk	
904	Blister	
1052	Dough	
1199	Dent	
1482	Mature	

S:\ELUEBEHUSEN\Crop GDD Stages\FSU\CURRENT\SummerCrops\Export

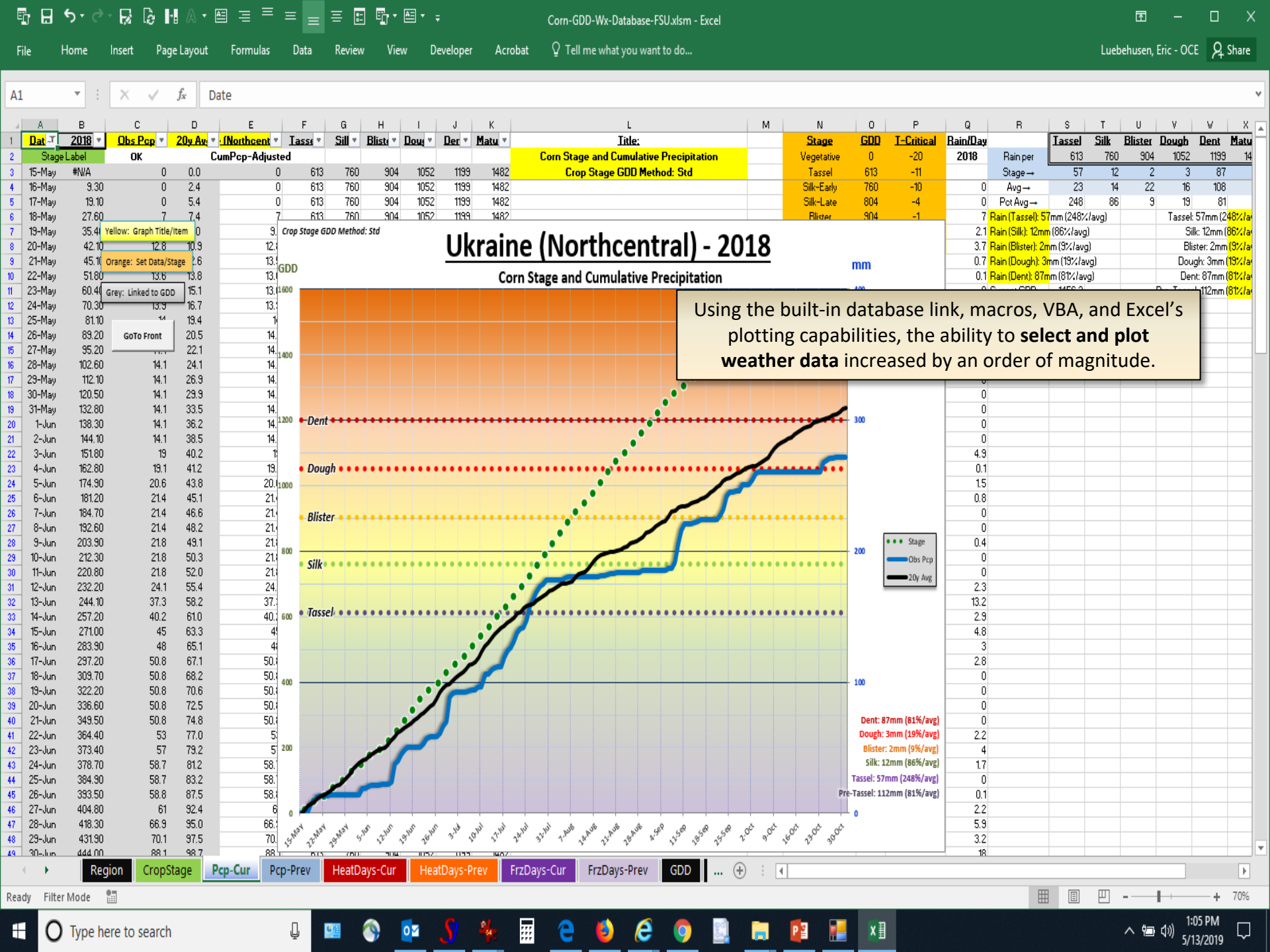


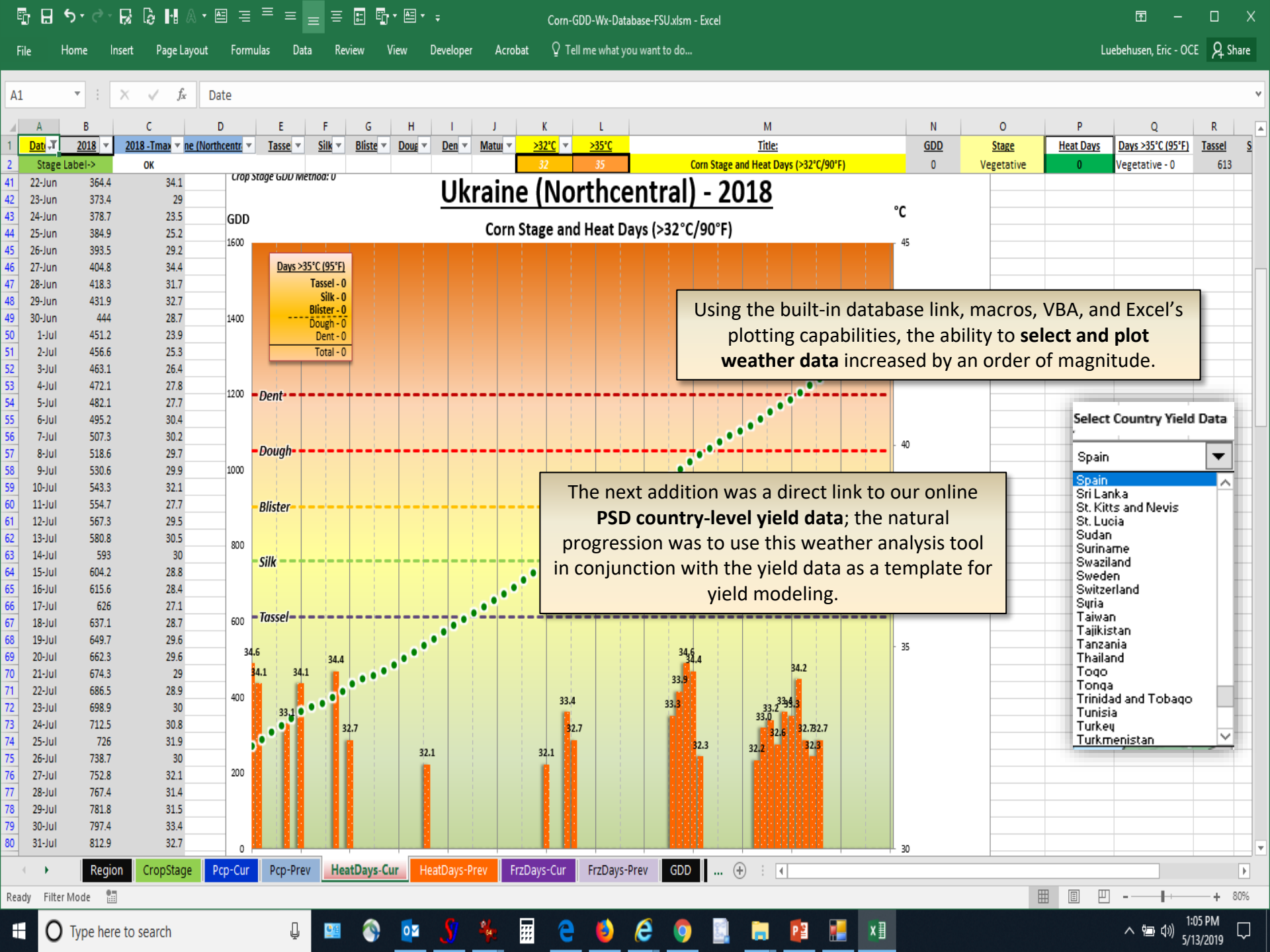
Using the built-in database link, macros, VBA, and Excel's plotting capabilities, the ability to **select and plot weather data** increased by an order of magnitude.

Region CropStage Pcp-Cur Pcp-Prev HeatDays-Cur HeatDays-Prev FrzDays-Cur FrzDays-Prev GDD ...

Ready 70%

Type here to search 1:05 PM 5/13/2019


Corn-GDD-Wx-Database-FSU.xlsm - Excel
Ukraine (Northcentral) - 2018
Corn Stage and Cumulative Precipitation
Crop Stage GDD Method: Std
GDD
mm
Dent
Dough
Blister
Silk
Tassel
Stage
Obs Pcp
20y Avg
Dent: 87mm (81%/avg)
Dough: 3mm (19%/avg)
Blister: 2mm (9%/avg)
Silk: 12mm (86%/avg)
Tassel: 57mm (248%/avg)
Pre-Tassel: 112mm (81%/avg)
Using the built-in database link, macros, VBA, and Excel's plotting capabilities, the ability to **select and plot weather data** increased by an order of magnitude.
Yellow: Graph Title/Item
Orange: Set Data/Stage
Grey: Linked to GDD
GoTo Front
Region
CropStage
Pcp-Cur
Pcp-Prev
HeatDays-Cur
HeatDays-Prev
FrzDays-Cur
FrzDays-Prev
GDD
Ready
Filter Mode
Type here to search
1:05 PM
5/13/2019


Corn-GDD-Wx-Database-FSU.xlsm - Excel
Ukraine (Northcentral) - 2018
Corn Stage and Heat Days (>32°C/90°F)
GDD
°C
Days >35°C (95°F)
Tassel - 0
Silk - 0
Blister - 0
Dough - 0
Dent - 0
Total - 0
Dent
Dough
Blister
Silk
Tassel
Using the built-in database link, macros, VBA, and Excel's plotting capabilities, the ability to select and plot weather data increased by an order of magnitude.
The next addition was a direct link to our online PSD country-level yield data; the natural progression was to use this weather analysis tool in conjunction with the yield data as a template for yield modeling.
Select Country Yield Data
Spain
Sri Lanka
St. Kitts and Nevis
St. Lucia
Sudan
Suriname
Swaziland
Sweden
Switzerland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Region
CropStage
Pcp-Cur
Pcp-Prev
HeatDays-Cur
HeatDays-Prev
FrzDays-Cur
FrzDays-Prev
GDD

Pogodnie - poc | EUMETNET Rac | phenomena24. | Birleştirilmiş, Sc | MIMIC-TPW2 | STAR - Global V | IRI – Internatio | STAR - Glo | Index of /pub/\ | EUMETNET Rac

https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/vh_browseByCountry_province.php?country_code=UKR&province_id=1&year1=1981&year2=2019

NOAA STAR CENTER FOR SATELLITE APPLICATIONS AND RESEARCH

Intranet • Contact • Skip navigation Go

- STAR Home Page
- Vegetation Health Home
- Ancillary Data
- VH from S-NPP/VIIRS Study
- AQUA/MODIS VH
- Validation
- Sensitivity Study

News

NPP first images for land cover was obtained on 11/21/2011

NPP VIIRS 500m GVI data were produced since May 2, 2012 to now

Data and images displayed on STAR sites are provided for experimental use only and are not official operational NOAA products. More information>>

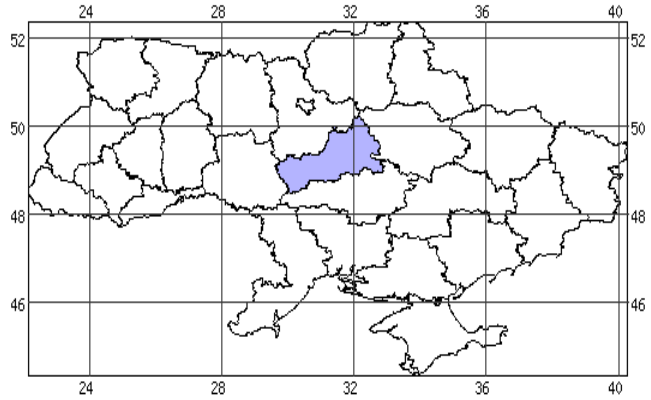
STAR - Global Vegetation Health Products :

You selected the 1th province in *Ukraine*

country/region(191)	province	Year1	Year2
178: Ukraine (UKR)	1: Cherkasy	1981	2019

Cherkasy, Ukraine

Selected Province



Zoom=0.99

The above image highlights the province selected. You may select another province by cursor.

The pictures below show the time series of drought related indices for this province (*Cherkasy, Ukraine*).

The time series of 'Area-Avegaed' and 'Percentage-Of-Area' data for the plots below are avilable in ASCII format.

Note: The information on this page is for selected provinces/countries. Here is the list of selected provinces and countries

The current week' situtation

The next breakthrough:
In **June of 2017**, I noticed the VHI ascii data was now available to download.
I began to work with the data that summer; this would become a game changer.

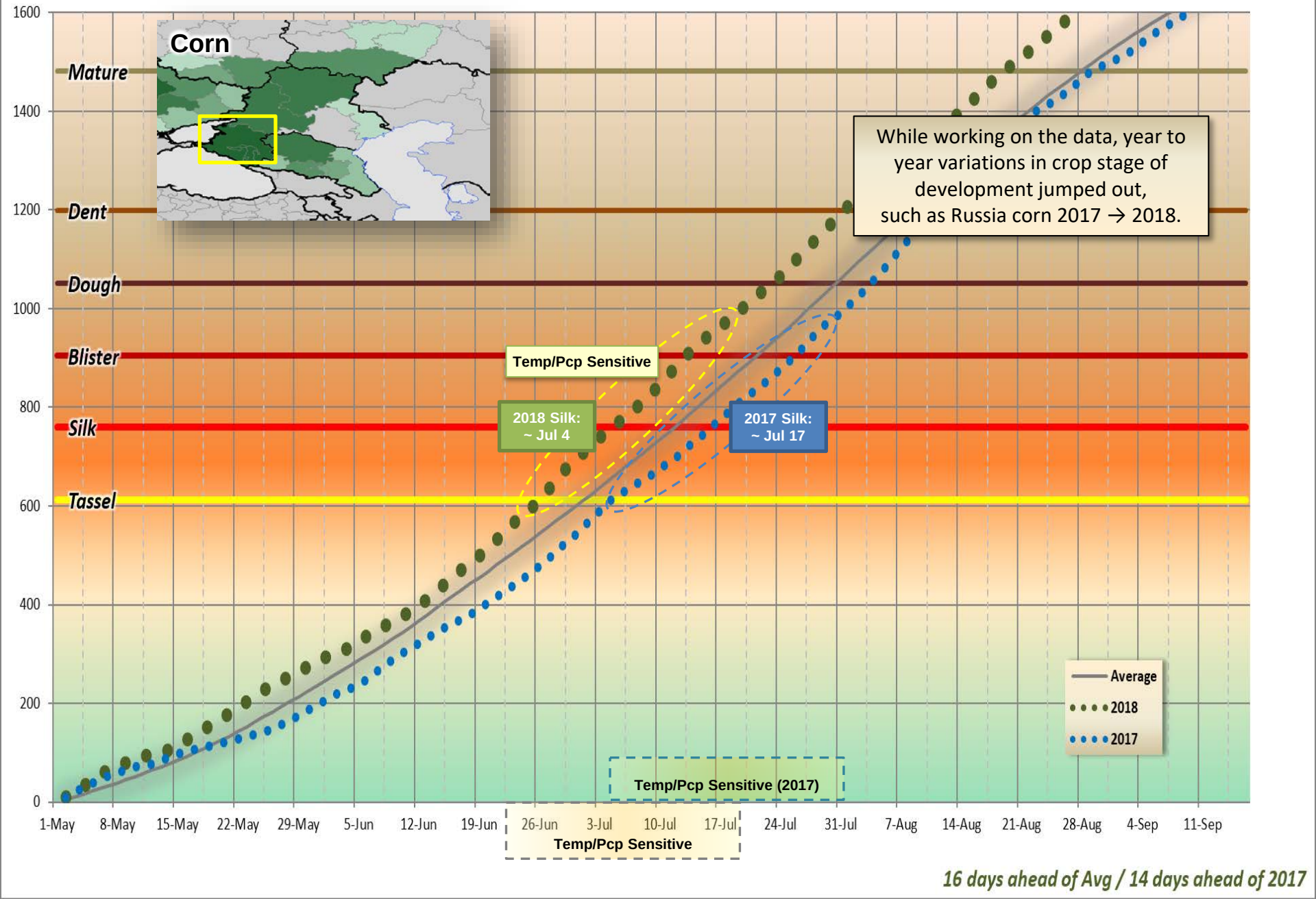
Type here to search

1:15 PM
5/13/2019

Crop Stage GDD Method: Std

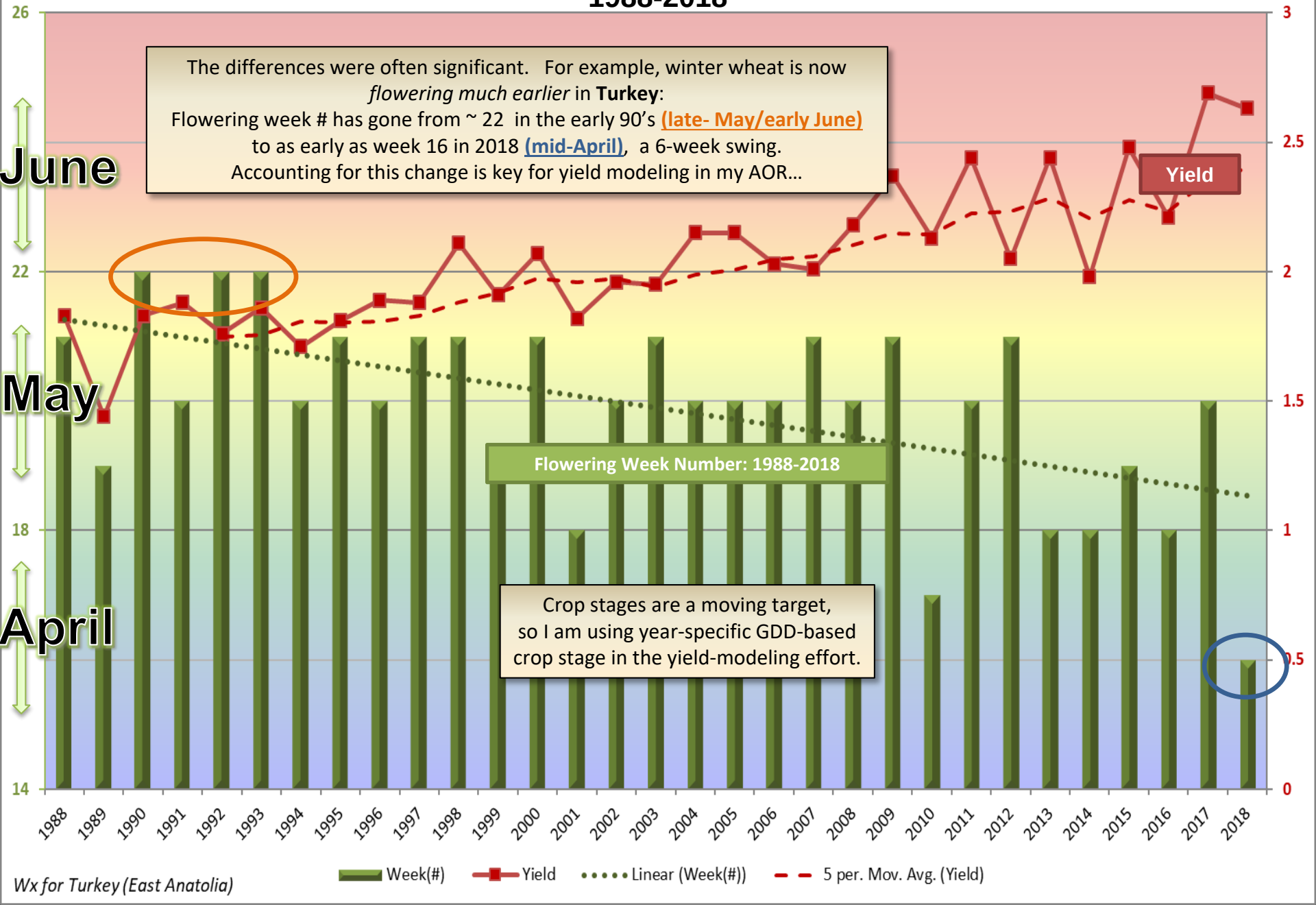
9/3/2018

Corn: Russia (Southern - Krasnodar)



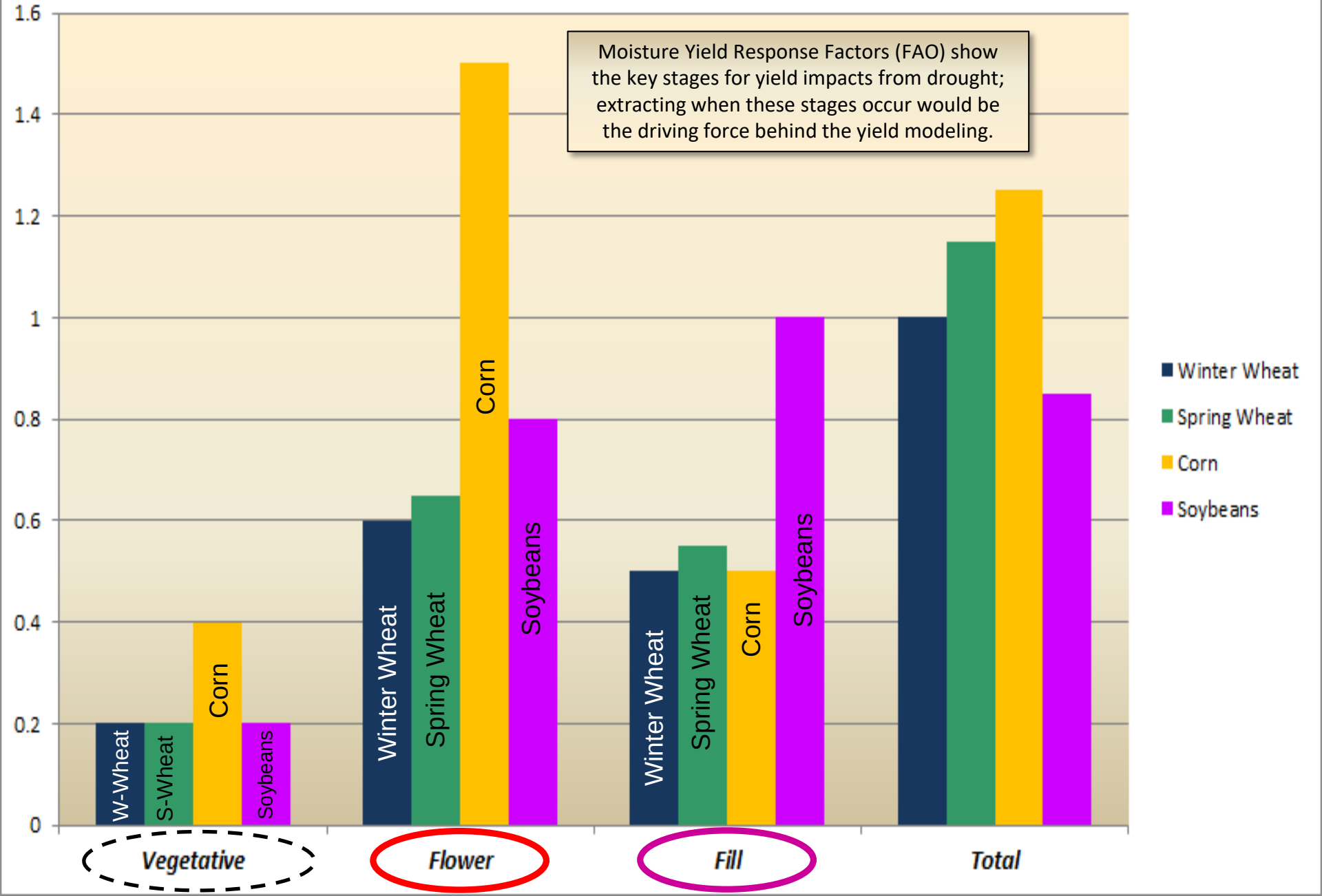
16 days ahead of Avg / 14 days ahead of 2017

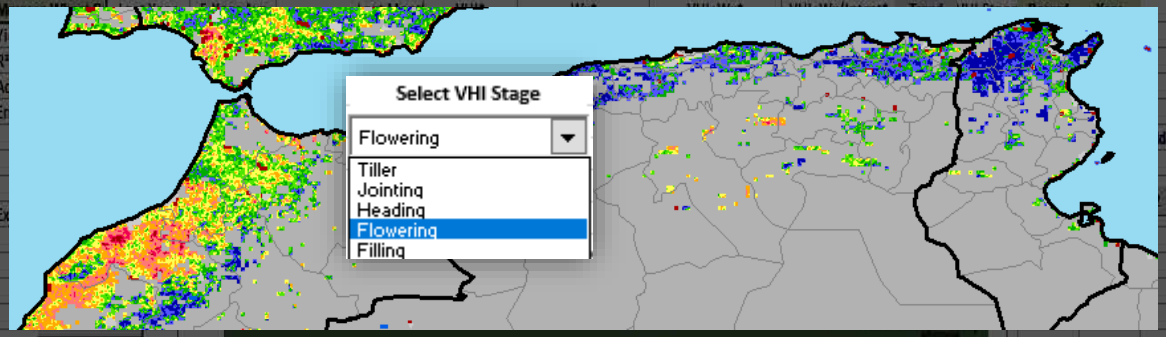
Turkey: Week # for Wheat @ Flowering
1988-2018



Wx for Turkey (East Anatolia)

Water Deficit Yield Response Factors ($ET_{actual}/ET_{measured}$)





Pairing the VHI and WMO databases into Excel and using GDD-based crop stages,

Stage-specific

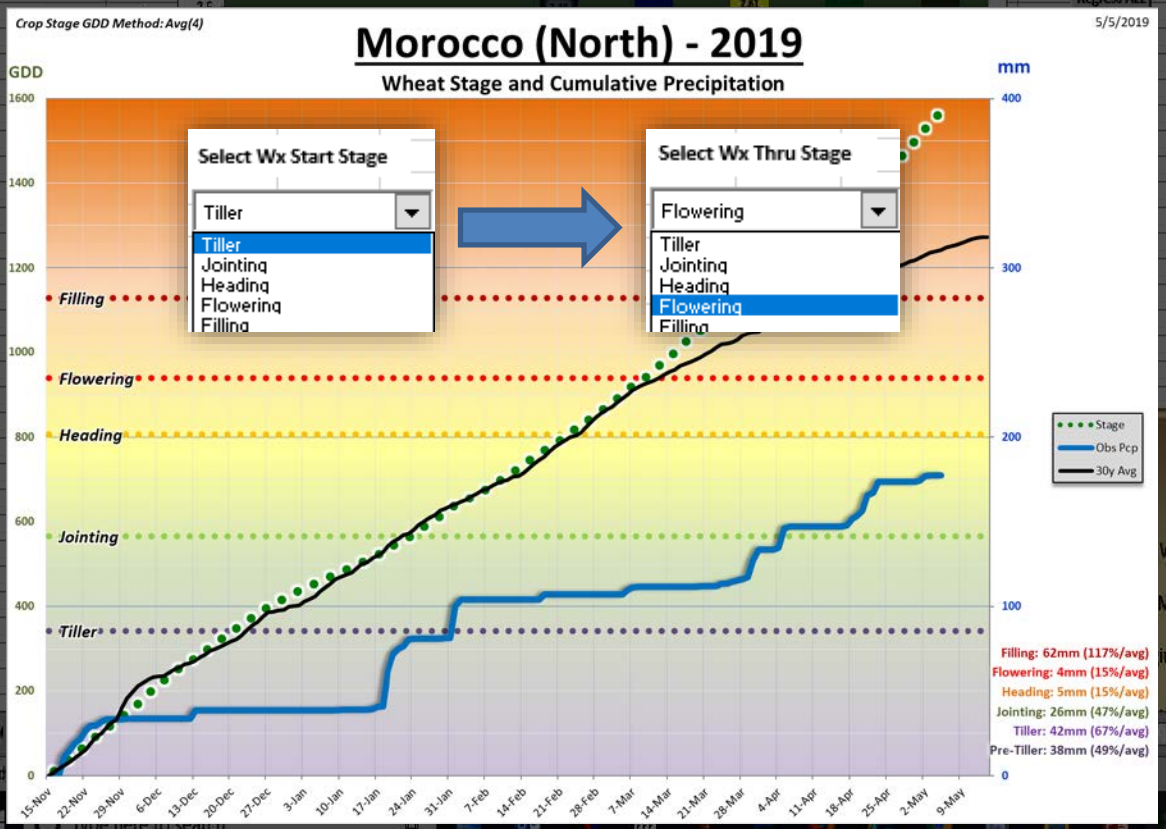
VHI,

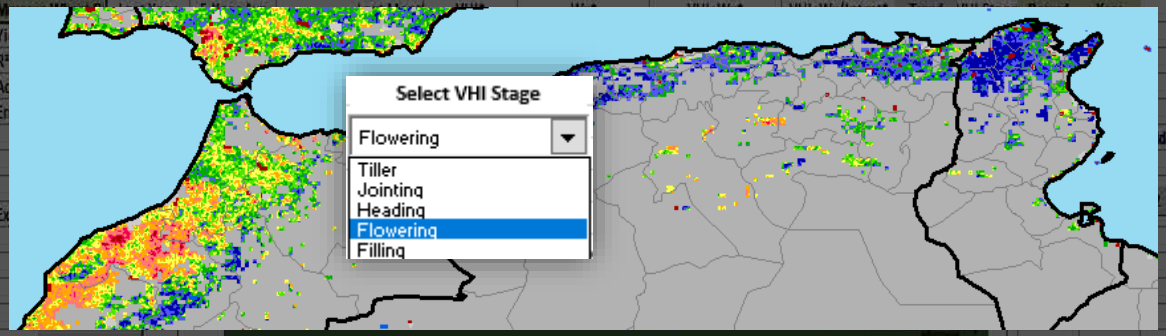
Weather "Start",

& Weather "End"

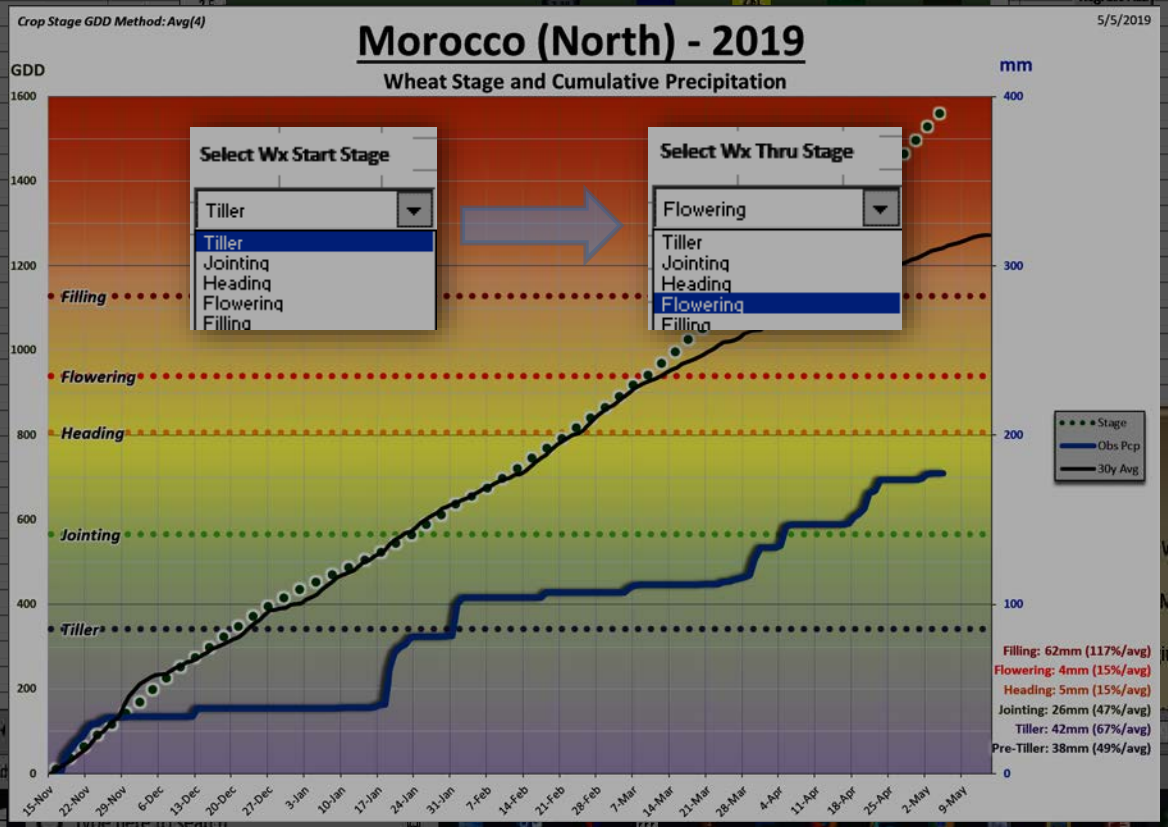
are analyzed.

This ensures year-to-year consistency allows easy testing of different scenarios.

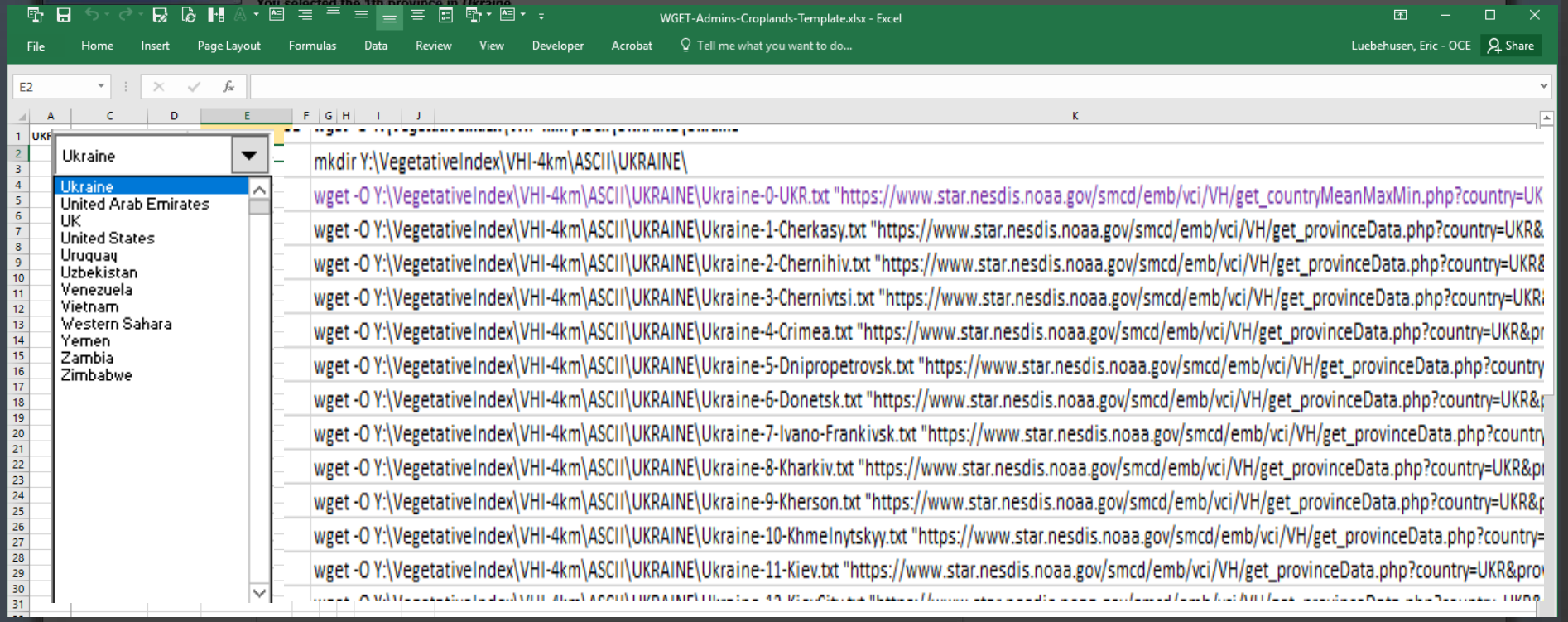


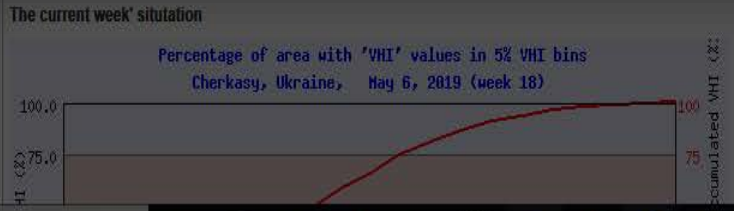


A quick note about the VHI data acquisition methodology….



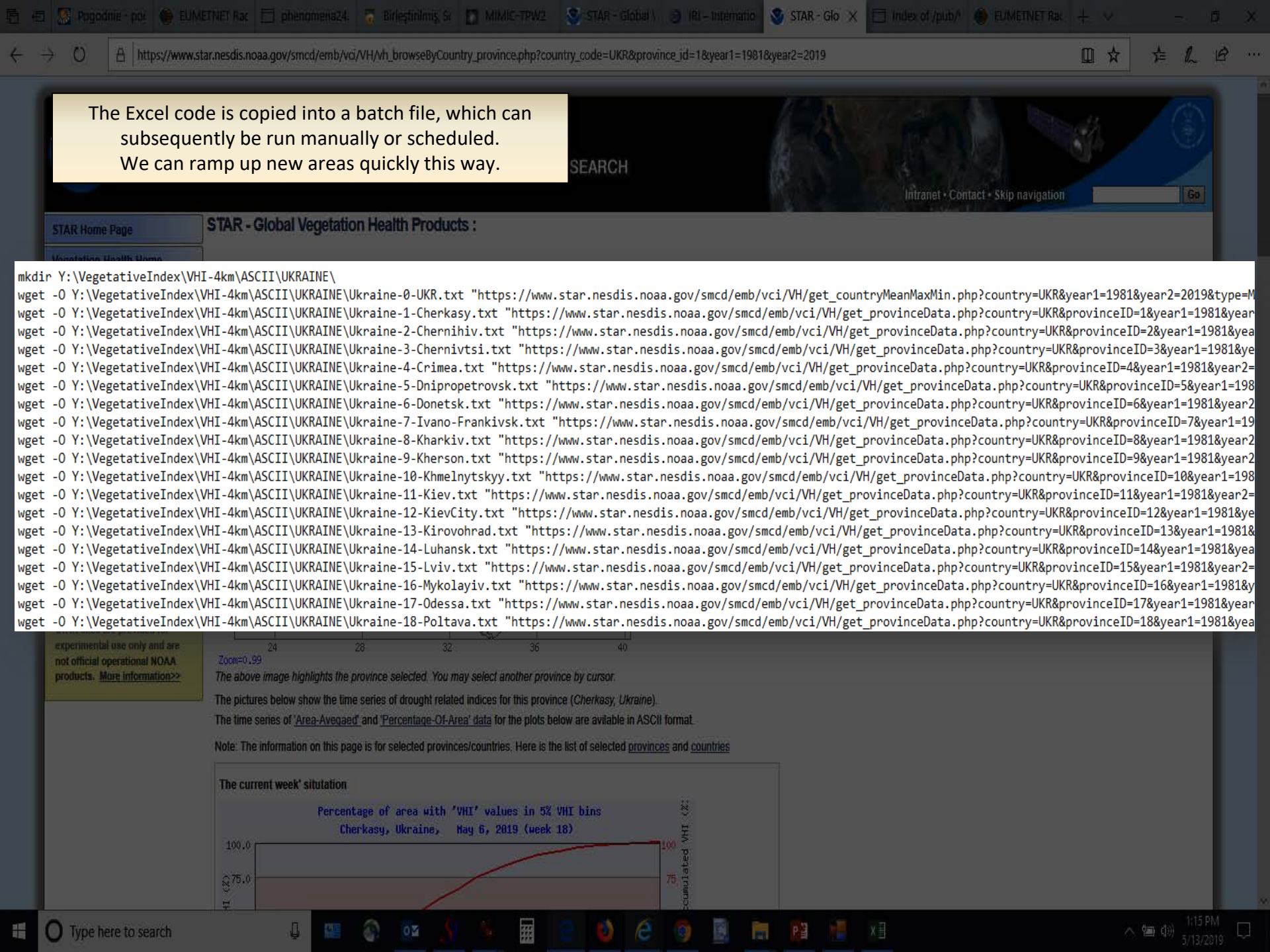
We are downloading the ascii data using **WGET**.
The WGET code is automatically produced for a specific country by using an Excel "assembler"; the user selects the country and then the Excel sheet puts together the code based on the STAR website addresses and structure.



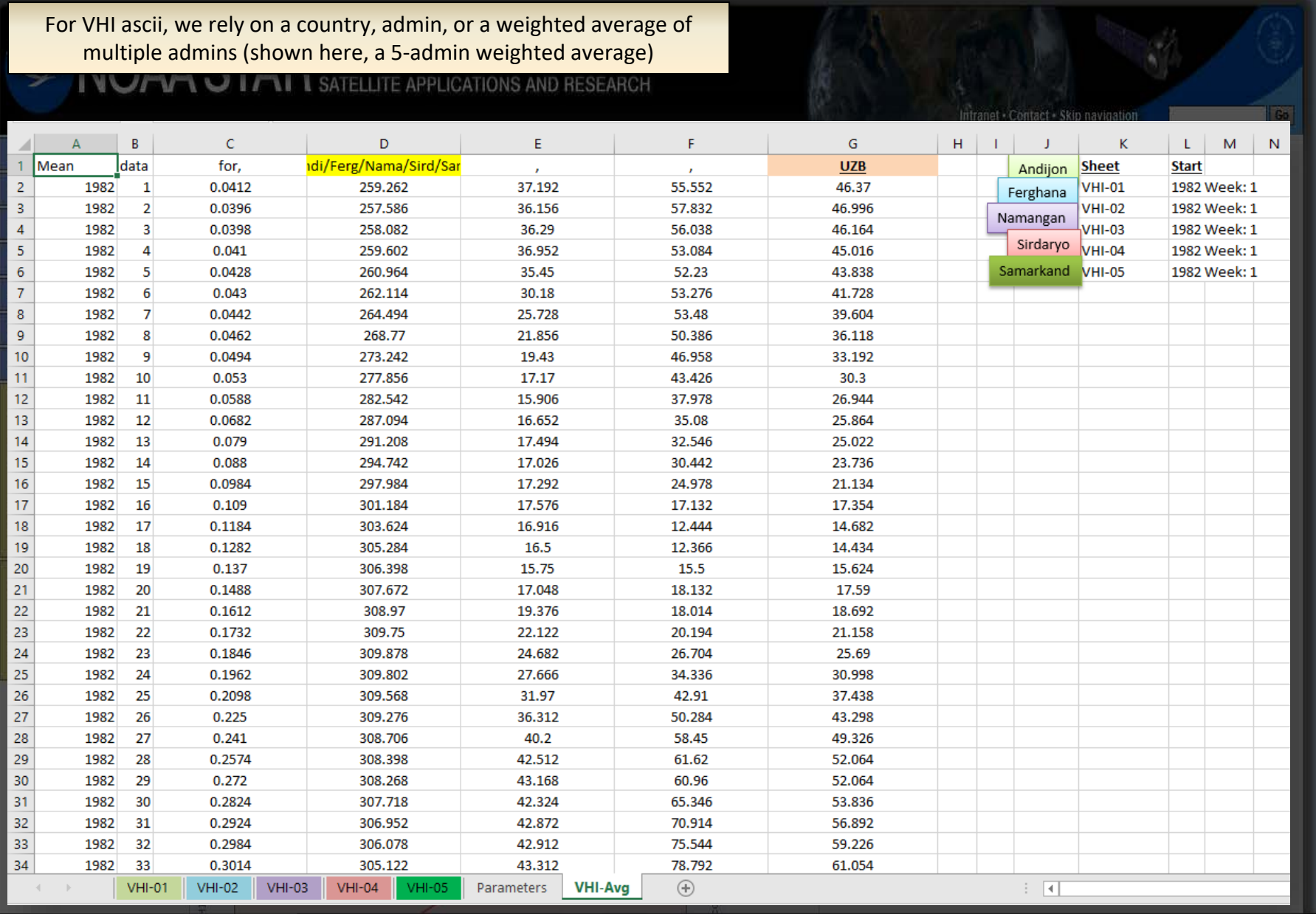


The Excel code is copied into a batch file, which can subsequently be run manually or scheduled.
We can ramp up new areas quickly this way.

```
mkdir Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-0-UKR.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_countryMeanMaxMin.php?country=UKR&year1=1981&year2=2019&type=M
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-1-Cherkasy.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=1&year1=1981&year
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-2-Chernihiv.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=2&year1=1981&yea
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-3-Chernivtsi.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=3&year1=1981&ye
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-4-Crimea.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=4&year1=1981&year2=
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-5-Dnipropetrovsk.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=5&year1=198
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-6-Donetsk.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=6&year1=1981&year2
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-7-Ivano-Frankivsk.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=7&year1=19
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-8-Kharkiv.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=8&year1=1981&year2
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-9-Kherson.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=9&year1=1981&year2
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-10-Khmelnytskyy.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=10&year1=198
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-11-Kiev.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=11&year1=1981&year2=
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-12-KievCity.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=12&year1=1981&ye
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-13-Kirovohrad.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=13&year1=1981&
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-14-Luhansk.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=14&year1=1981&yea
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-15-Lviv.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=15&year1=1981&year2=
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-16-Mykolayiv.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=16&year1=1981&y
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-17-Odessa.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=17&year1=1981&year
wget -O Y:\VegetativeIndex\VHI-4km\ASCII\UKRAINE\Ukraine-18-Poltava.txt "https://www.star.nesdis.noaa.gov/smcd/emb/vci/VH/get_provinceData.php?country=UKR&provinceID=18&year1=1981&yea
```

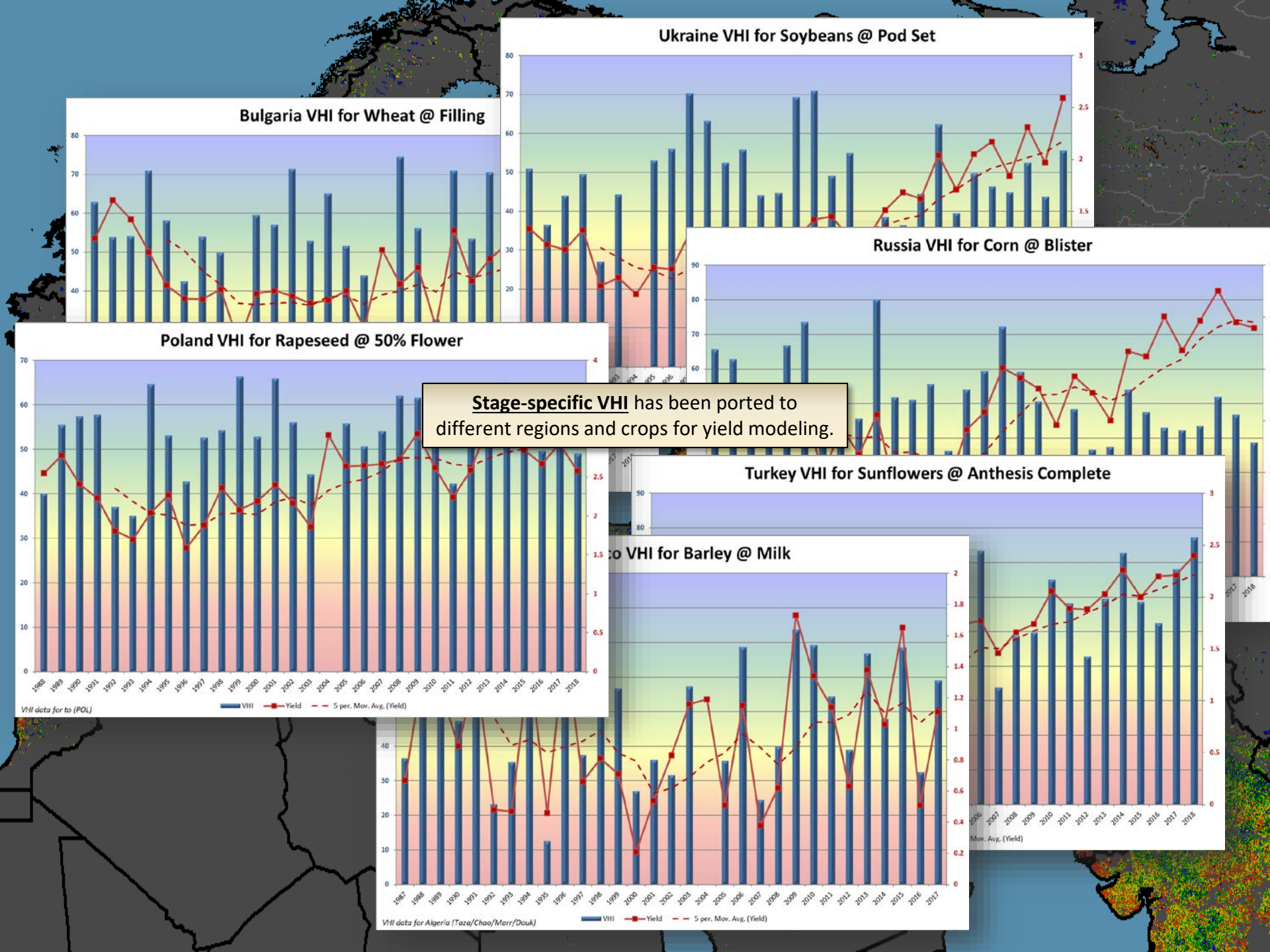


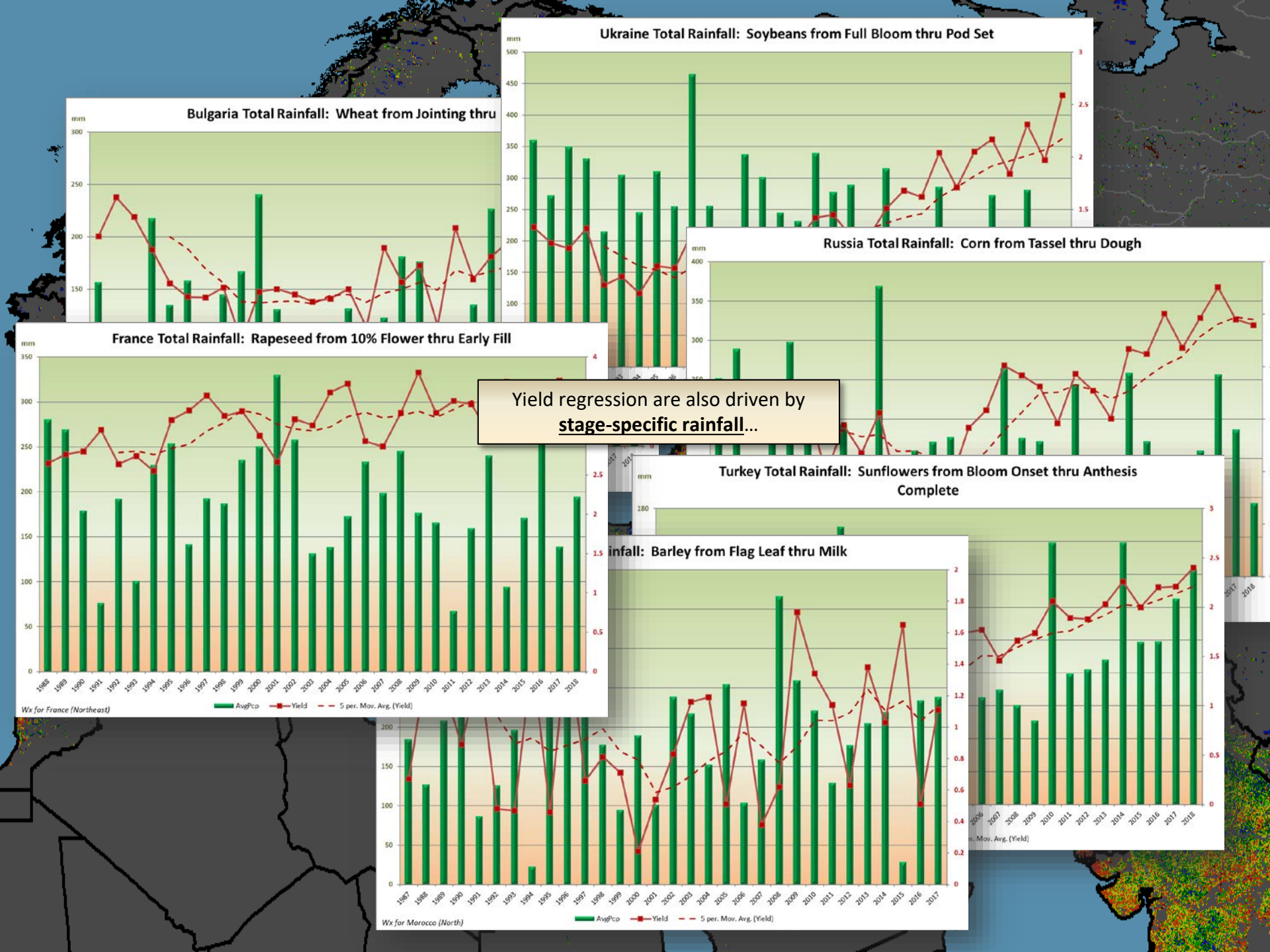
For VHI ascii, we rely on a country, admin, or a weighted average of multiple admins (shown here, a 5-admin weighted average)

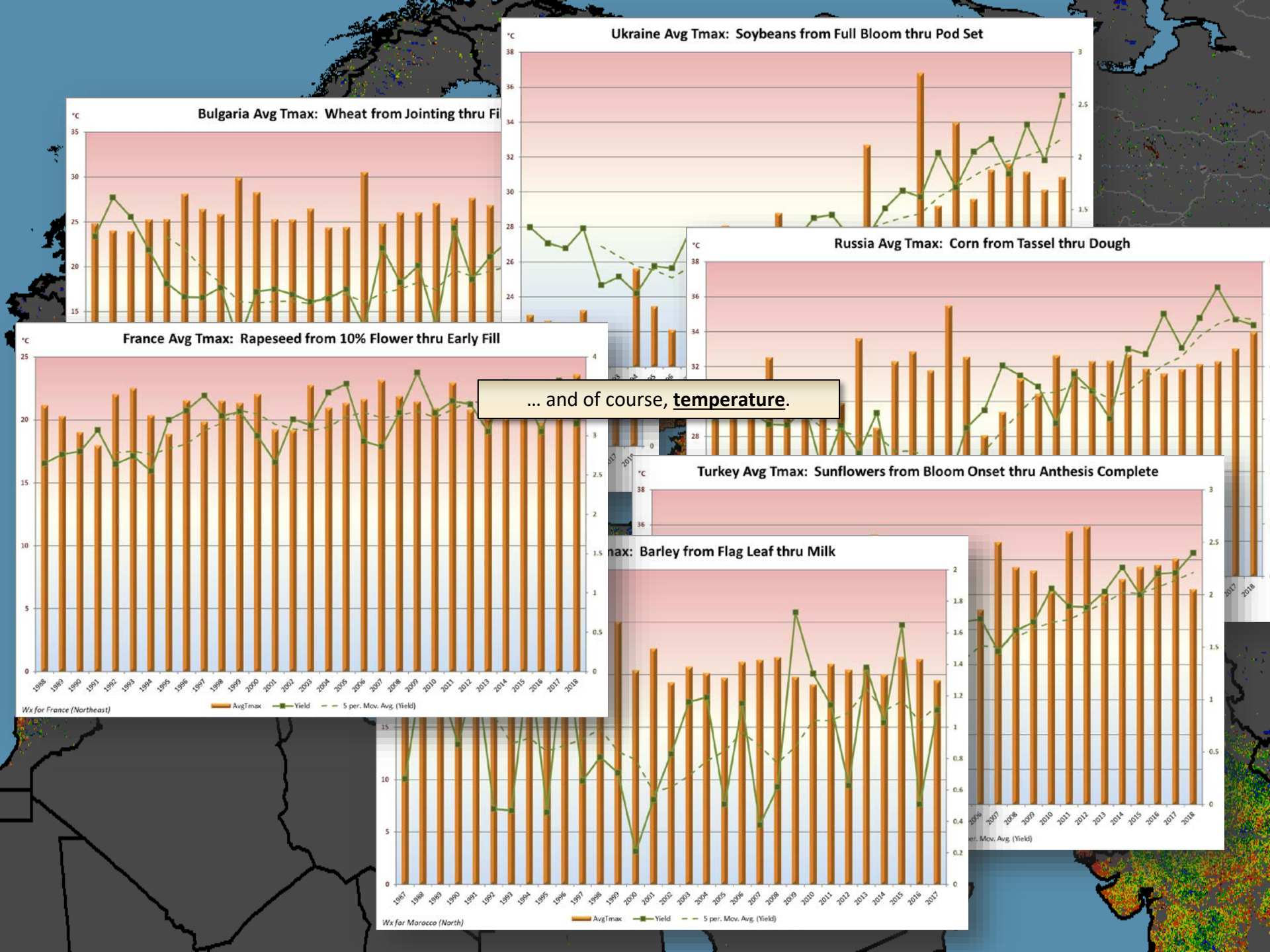


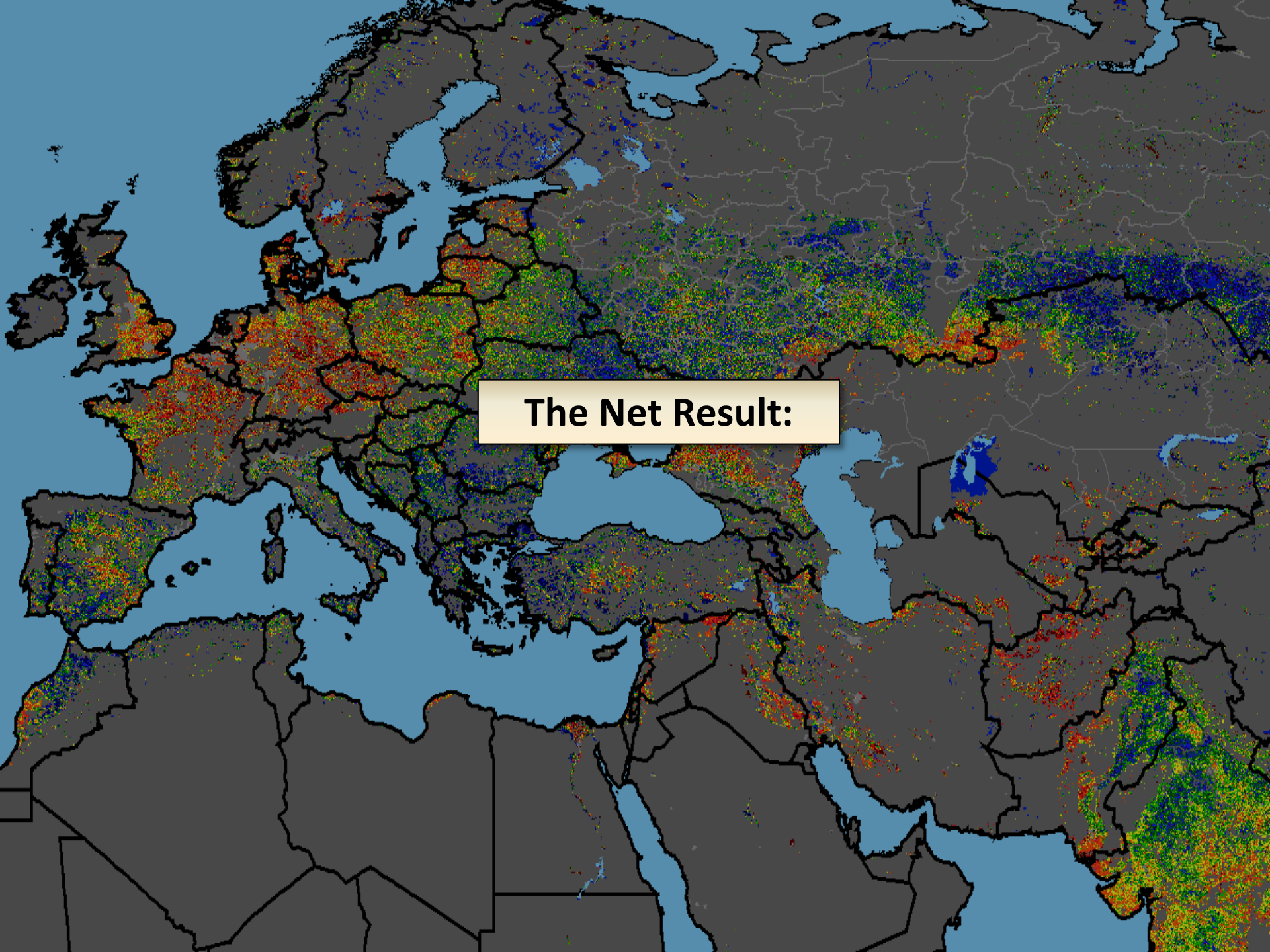
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Mean	data	for,	ıdi/Ferg/Nama/Sird/Sar	,	,	UZB			Andijon	Sheet	Start		
2	1982	1	0.0412	259.262	37.192	55.552	46.37			Ferghana	VHI-01	1982 Week: 1		
3	1982	2	0.0396	257.586	36.156	57.832	46.996			Namangan	VHI-02	1982 Week: 1		
4	1982	3	0.0398	258.082	36.29	56.038	46.164			Sirdaryo	VHI-03	1982 Week: 1		
5	1982	4	0.041	259.602	36.952	53.084	45.016			Samarkand	VHI-04	1982 Week: 1		
6	1982	5	0.0428	260.964	35.45	52.23	43.838				VHI-05	1982 Week: 1		
7	1982	6	0.043	262.114	30.18	53.276	41.728							
8	1982	7	0.0442	264.494	25.728	53.48	39.604							
9	1982	8	0.0462	268.77	21.856	50.386	36.118							
10	1982	9	0.0494	273.242	19.43	46.958	33.192							
11	1982	10	0.053	277.856	17.17	43.426	30.3							
12	1982	11	0.0588	282.542	15.906	37.978	26.944							
13	1982	12	0.0682	287.094	16.652	35.08	25.864							
14	1982	13	0.079	291.208	17.494	32.546	25.022							
15	1982	14	0.088	294.742	17.026	30.442	23.736							
16	1982	15	0.0984	297.984	17.292	24.978	21.134							
17	1982	16	0.109	301.184	17.576	17.132	17.354							
18	1982	17	0.1184	303.624	16.916	12.444	14.682							
19	1982	18	0.1282	305.284	16.5	12.366	14.434							
20	1982	19	0.137	306.398	15.75	15.5	15.624							
21	1982	20	0.1488	307.672	17.048	18.132	17.59							
22	1982	21	0.1612	308.97	19.376	18.014	18.692							
23	1982	22	0.1732	309.75	22.122	20.194	21.158							
24	1982	23	0.1846	309.878	24.682	26.704	25.69							
25	1982	24	0.1962	309.802	27.666	34.336	30.998							
26	1982	25	0.2098	309.568	31.97	42.91	37.438							
27	1982	26	0.225	309.276	36.312	50.284	43.298							
28	1982	27	0.241	308.706	40.2	58.45	49.326							
29	1982	28	0.2574	308.398	42.512	61.62	52.064							
30	1982	29	0.272	308.268	43.168	60.96	52.064							
31	1982	30	0.2824	307.718	42.324	65.346	53.836							
32	1982	31	0.2924	306.952	42.872	70.914	56.892							
33	1982	32	0.2984	306.078	42.912	75.544	59.226							
34	1982	33	0.3014	305.122	43.312	78.792	61.054							

VHI-01 | VHI-02 | VHI-03 | VHI-04 | VHI-05 | Parameters | VHI-Avg


Ukraine VHI for Soybeans @ Pod Set
Bulgaria VHI for Wheat @ Filling
Russia VHI for Corn @ Blister
Poland VHI for Rapeseed @ 50% Flower
Stage-specific VHI has been ported to different regions and crops for yield modeling.
Turkey VHI for Sunflowers @ Anthesis Complete
o VHI for Barley @ Milk
VHI data for to (POL)
VHI data for Algeria (Taza/Chao/Marr/Douk)
VHI
Yield
5 per. Mov. Avg. (Yield)


Ukraine Total Rainfall: Soybeans from Full Bloom thru Pod Set
Bulgaria Total Rainfall: Wheat from Jointing thru
Russia Total Rainfall: Corn from Tassel thru Dough
France Total Rainfall: Rapeseed from 10% Flower thru Early Fill
Yield regression are also driven by
stage-specific rainfall…
Turkey Total Rainfall: Sunflowers from Bloom Onset thru Anthesis Complete
infall: Barley from Flag Leaf thru Milk
Wx for France (Northeast)
Wx for Morocco (North)
AvgPcp
Yield
5 per. Mov. Avg. (Yield)

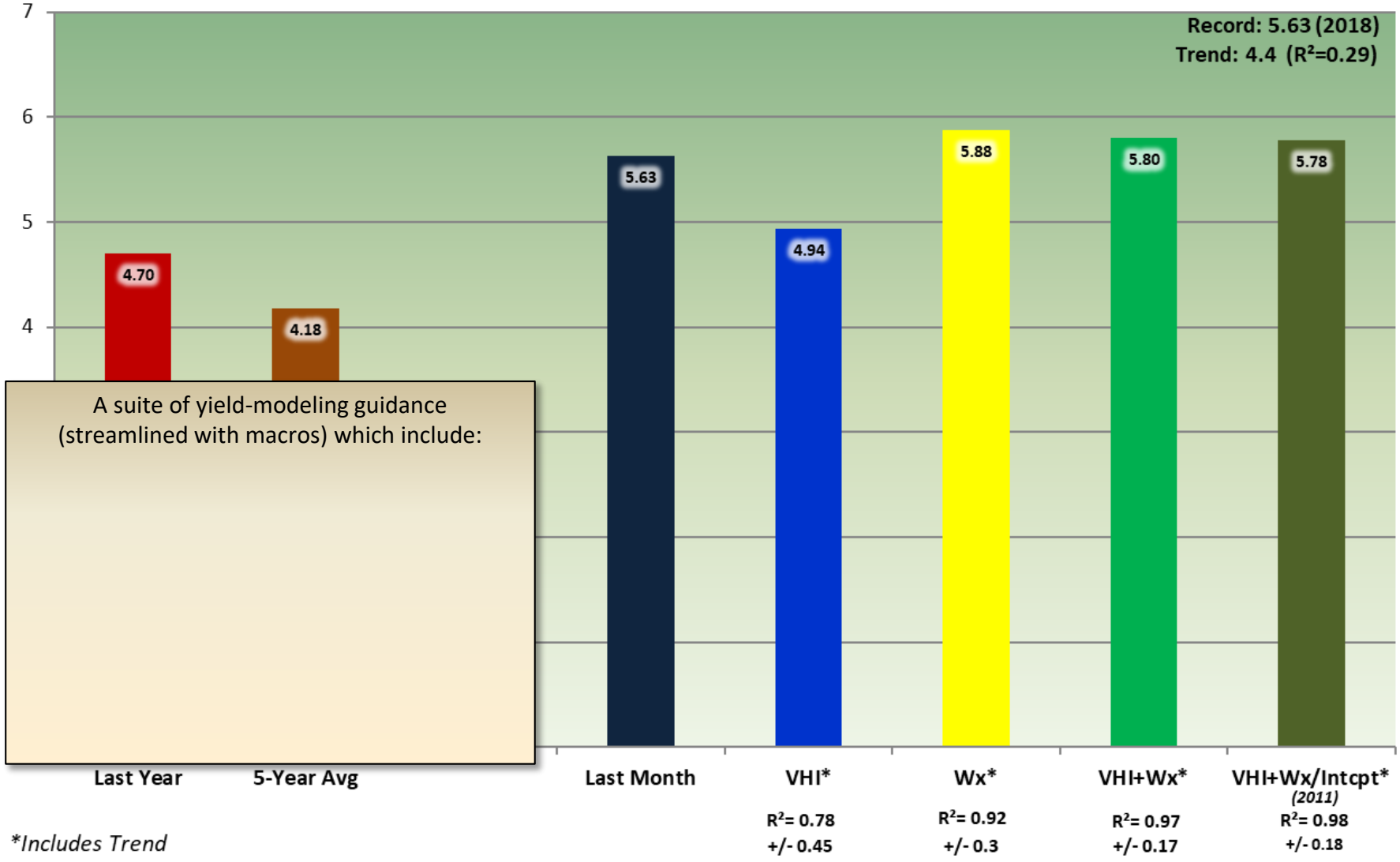

Ukraine Avg Tmax: Soybeans from Full Bloom thru Pod Set
Bulgaria Avg Tmax: Wheat from Jointing thru Fi
Russia Avg Tmax: Corn from Tassel thru Dough
France Avg Tmax: Rapeseed from 10% Flower thru Early Fill
… and of course, temperature.
Turkey Avg Tmax: Sunflowers from Bloom Onset thru Anthesis Complete
ax: Barley from Flag Leaf thru Milk
Wx for France (Northeast)
Wx for Morocco (North)
AvgTmax
Yield
5 per. Mov. Avg. (Yield)


The Net Result:

1/31/2019

Romania Corn Regression

Regression: 2005-2017
Median Regression Yield: 5.79

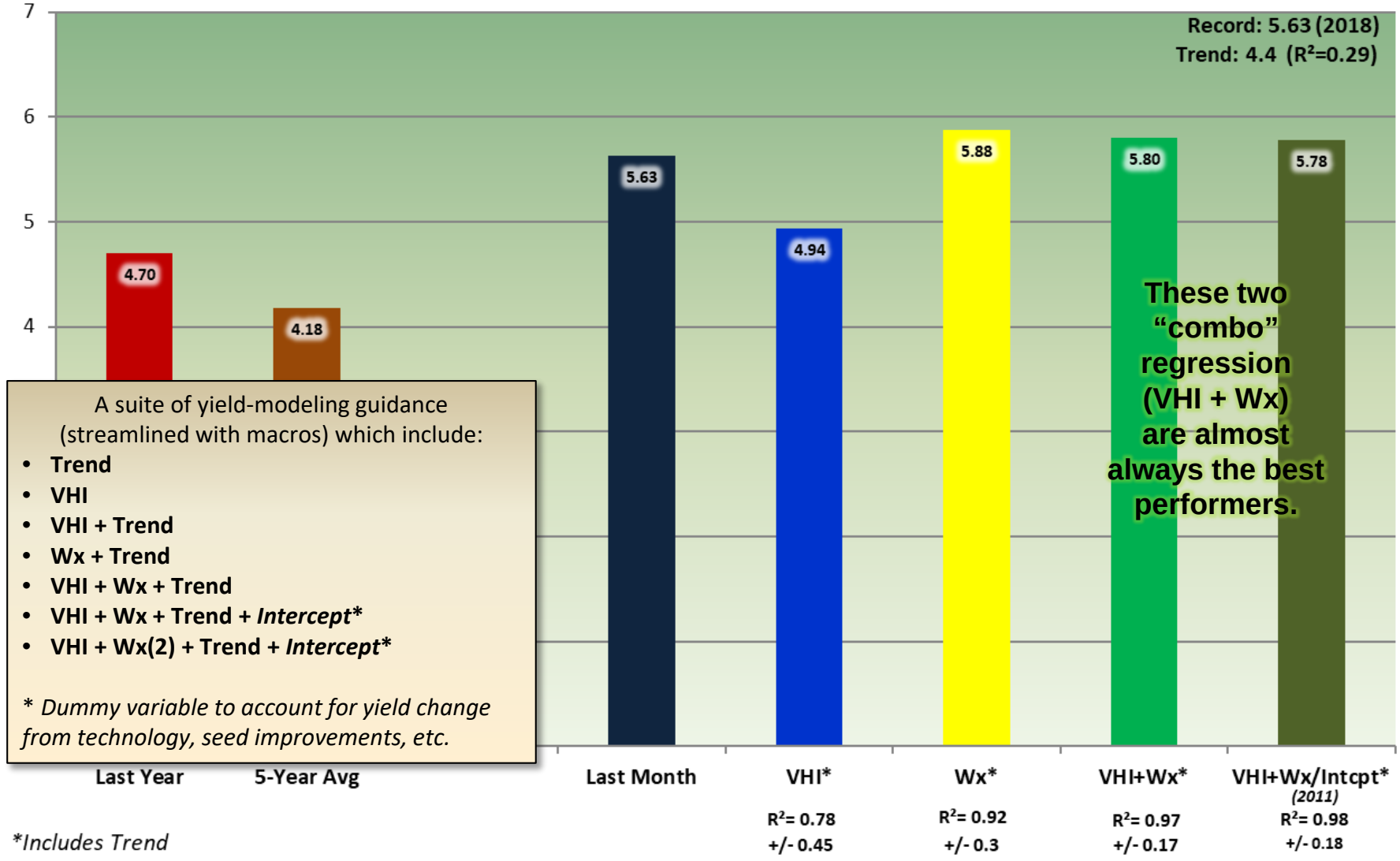


*Includes Trend

1/31/2019

Romania Corn Regression

Regression: 2005-2017
Median Regression Yield: 5.79



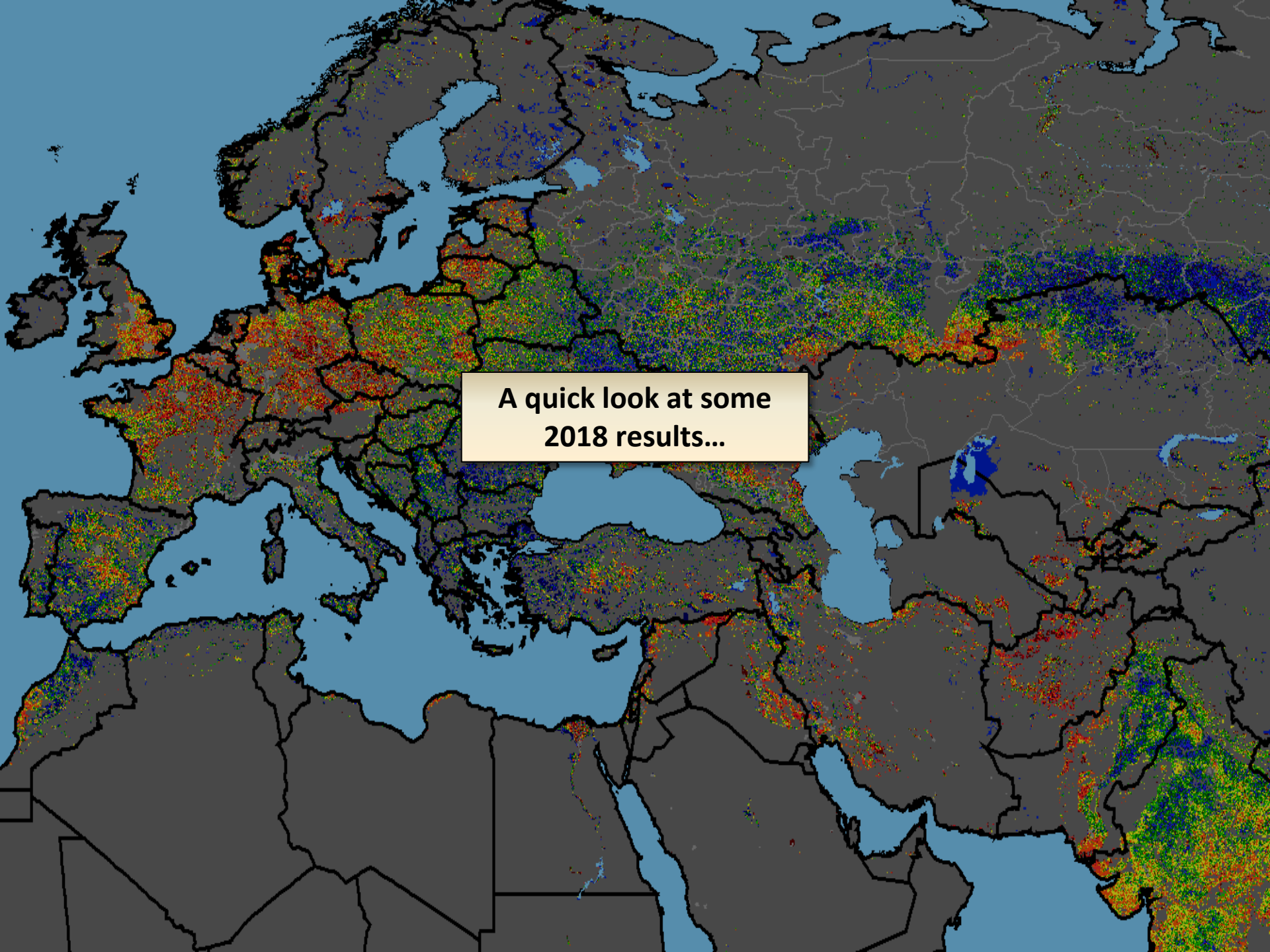
A suite of yield-modeling guidance (streamlined with macros) which include:

- **Trend**
- **VHI**
- **VHI + Trend**
- **Wx + Trend**
- **VHI + Wx + Trend**
- **VHI + Wx + Trend + *Intercept****
- **VHI + Wx(2) + Trend + *Intercept****

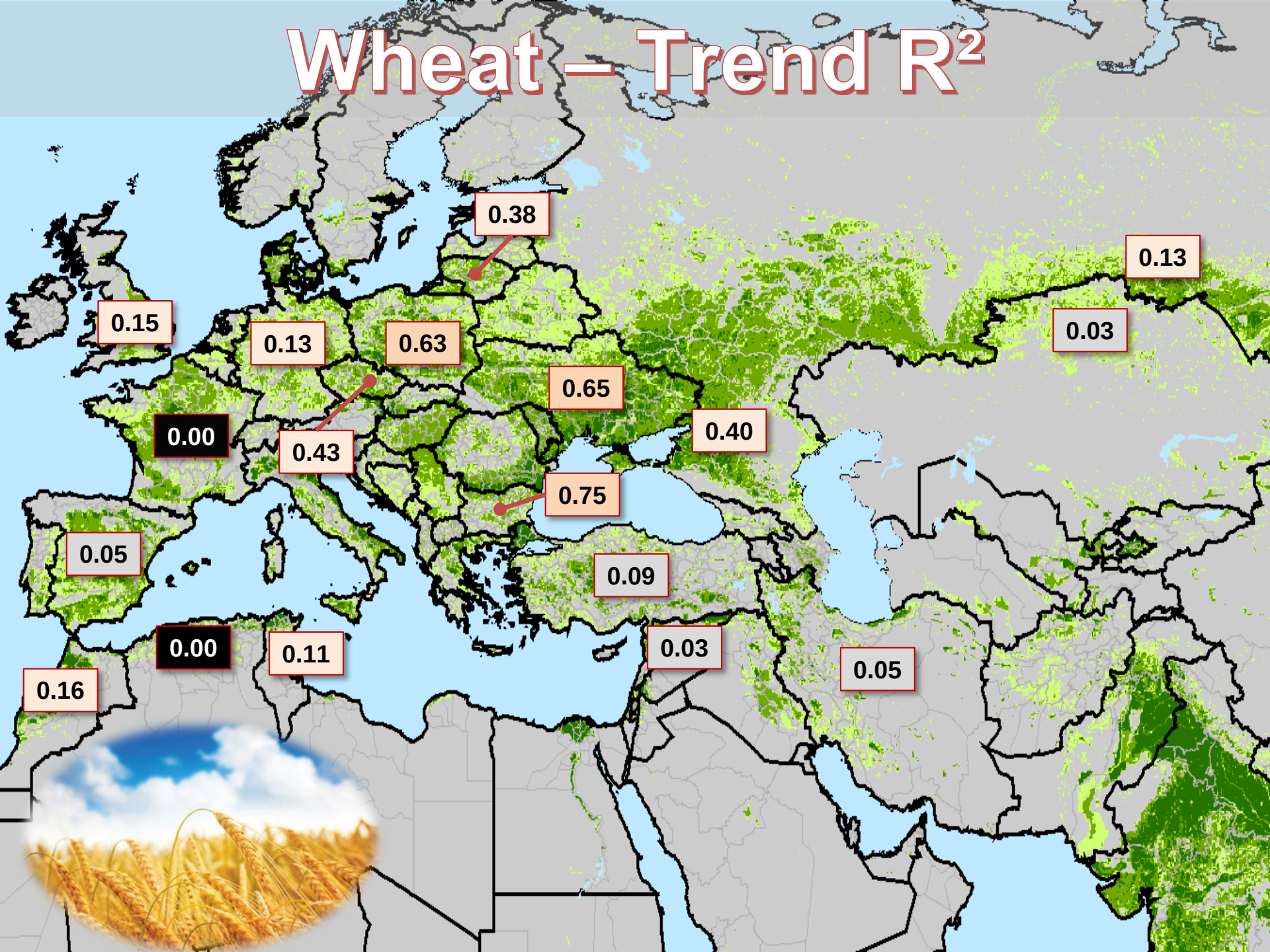
** Dummy variable to account for yield change from technology, seed improvements, etc.*

These two "combo" regression (VHI + Wx) are almost always the best performers.

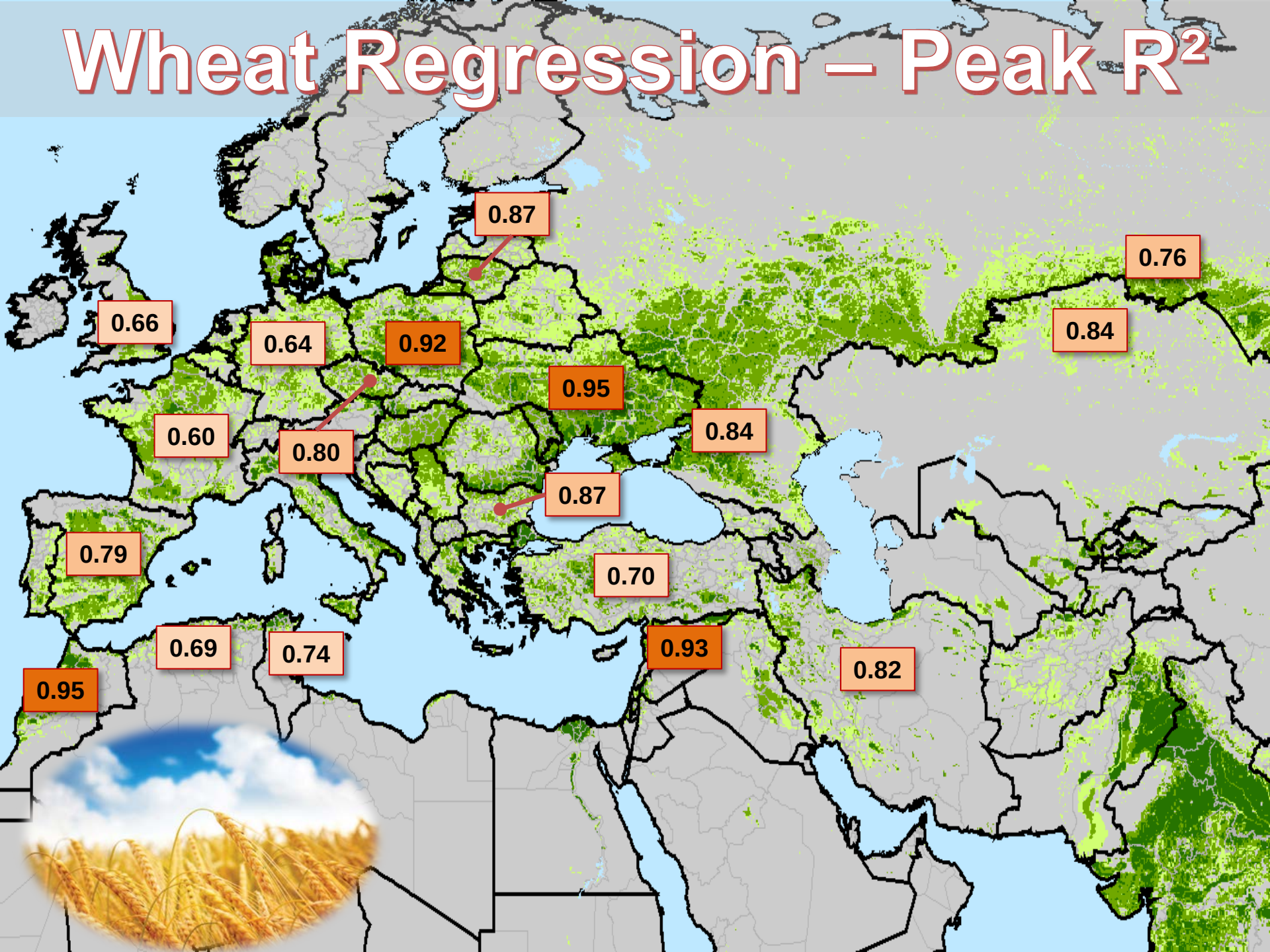
**Includes Trend*


A quick look at some
2018 results…

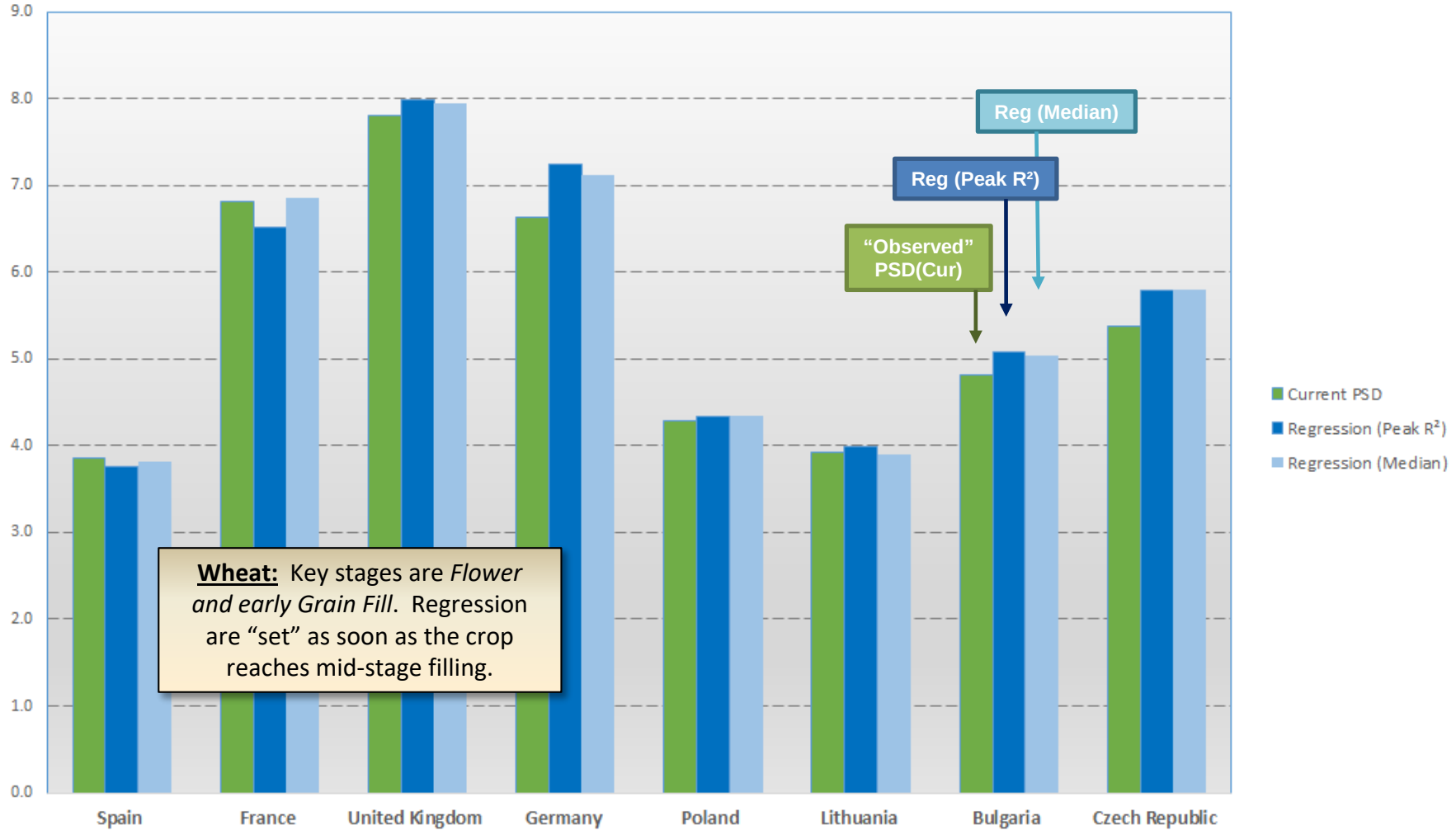
Wheat – Trend R^2



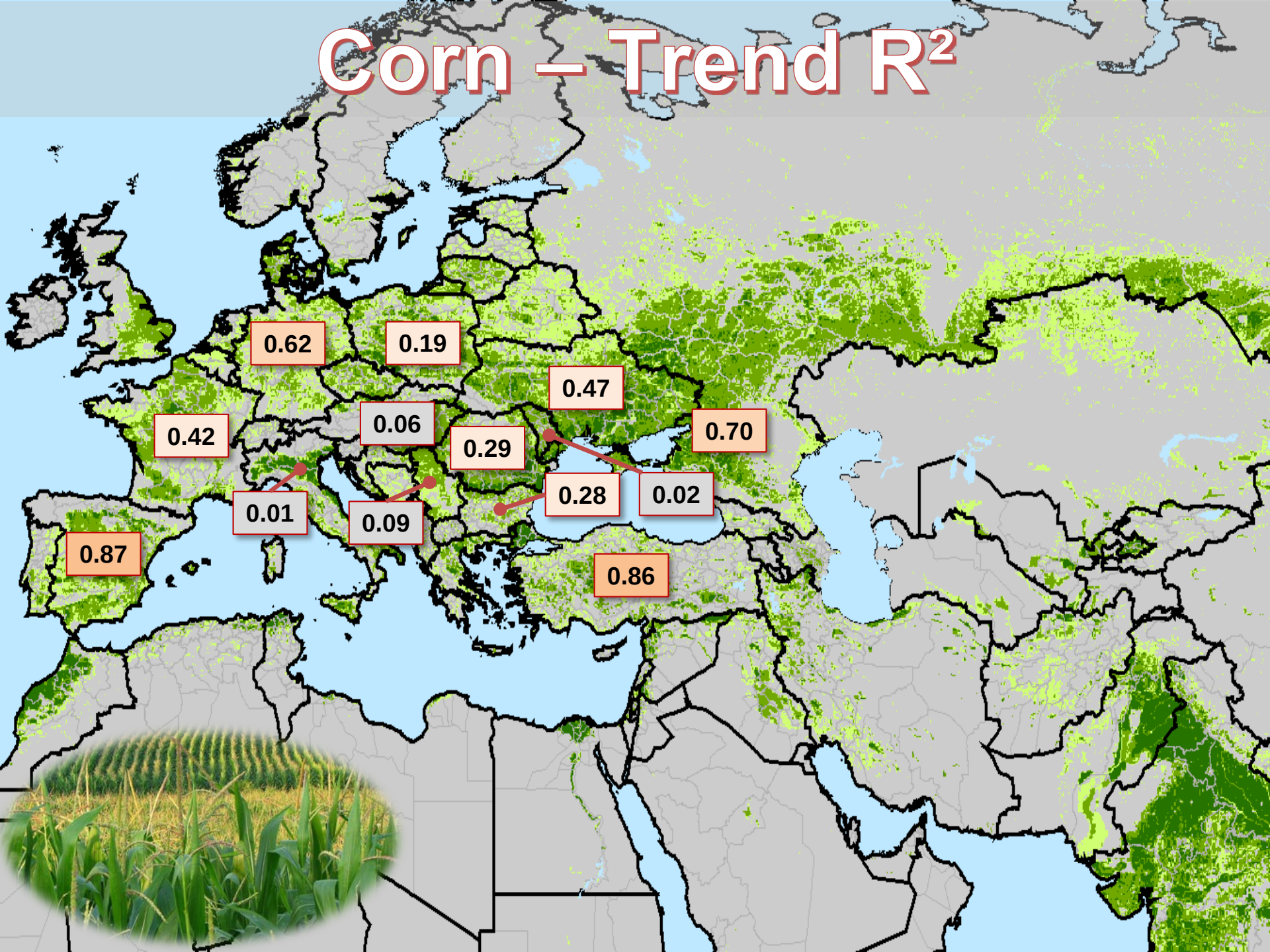
Wheat Regression – Peak R^2



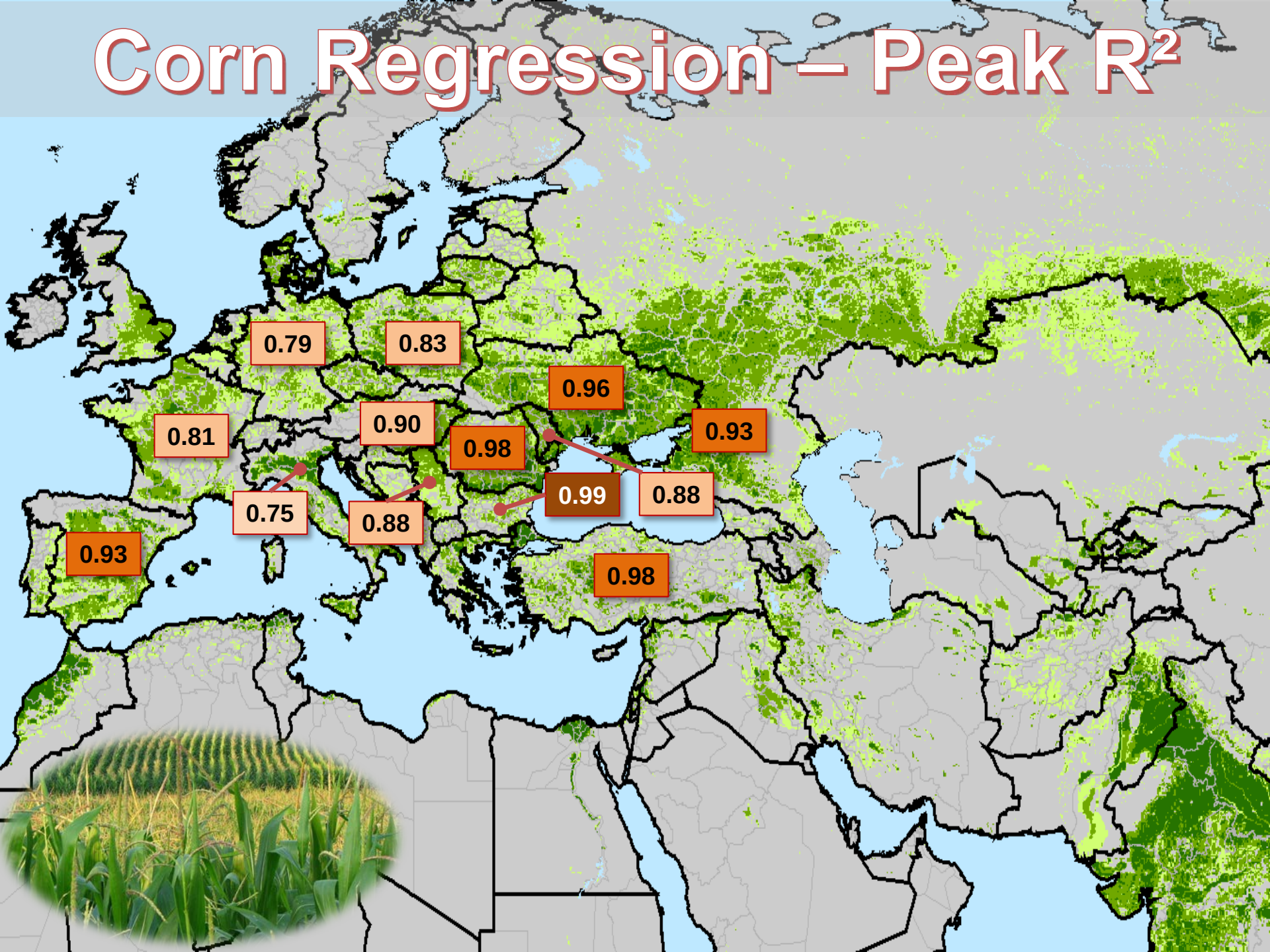
Europe Wheat Regression (2018)



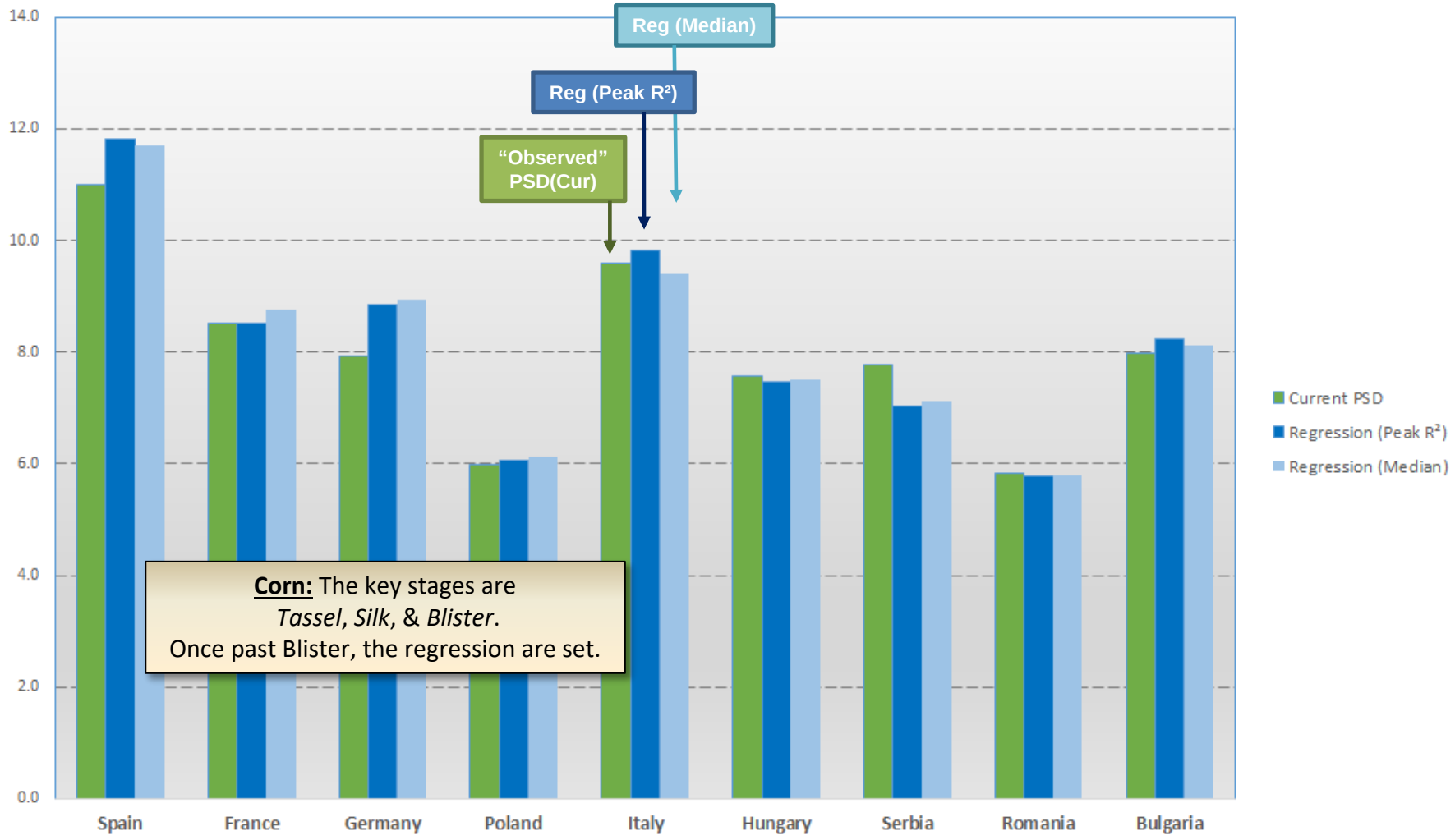
Corn – Trend R^2



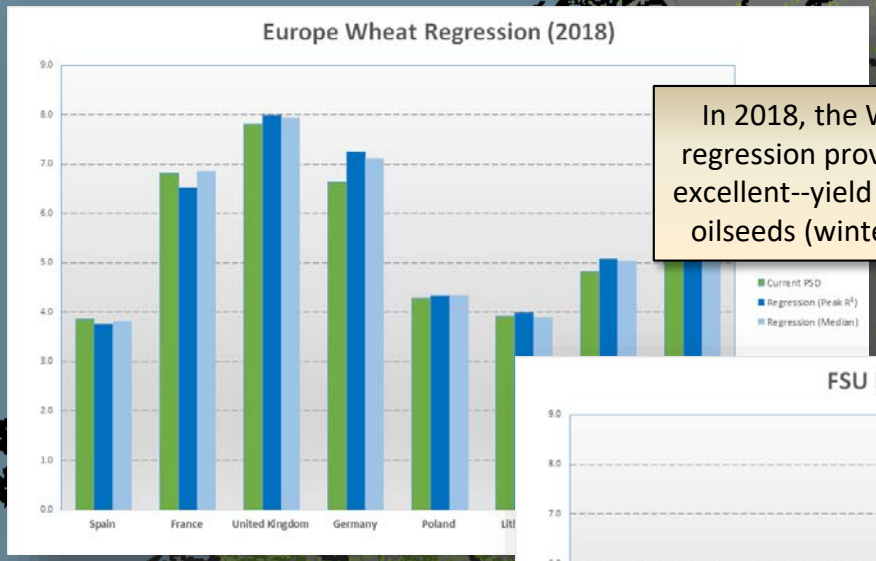
Corn Regression – Peak R^2

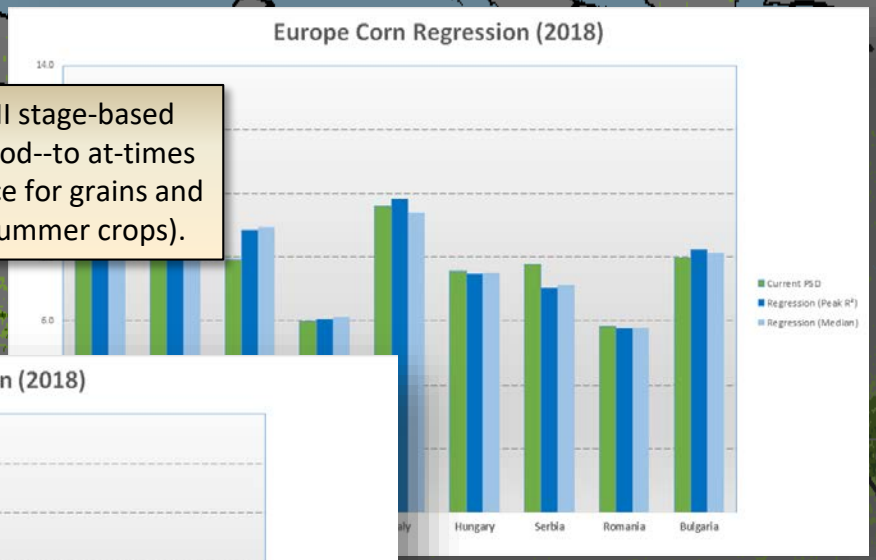


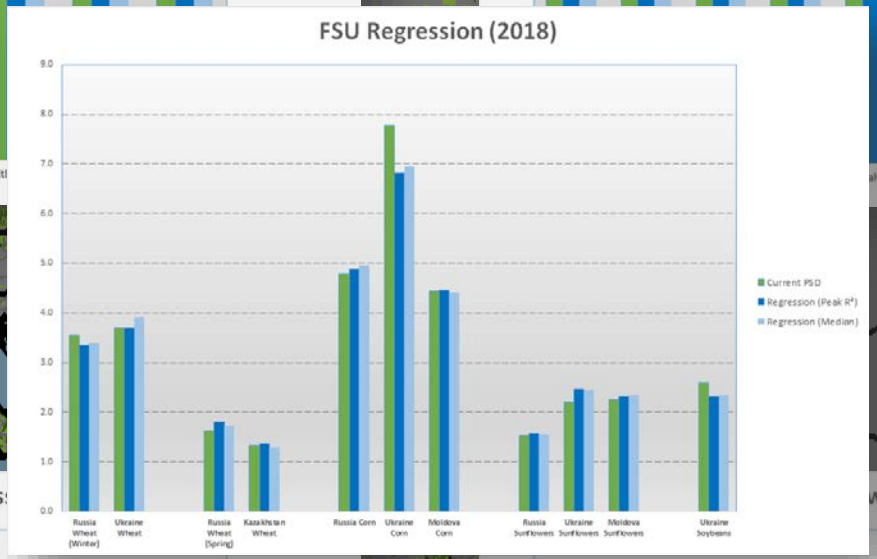
Europe Corn Regression (2018)

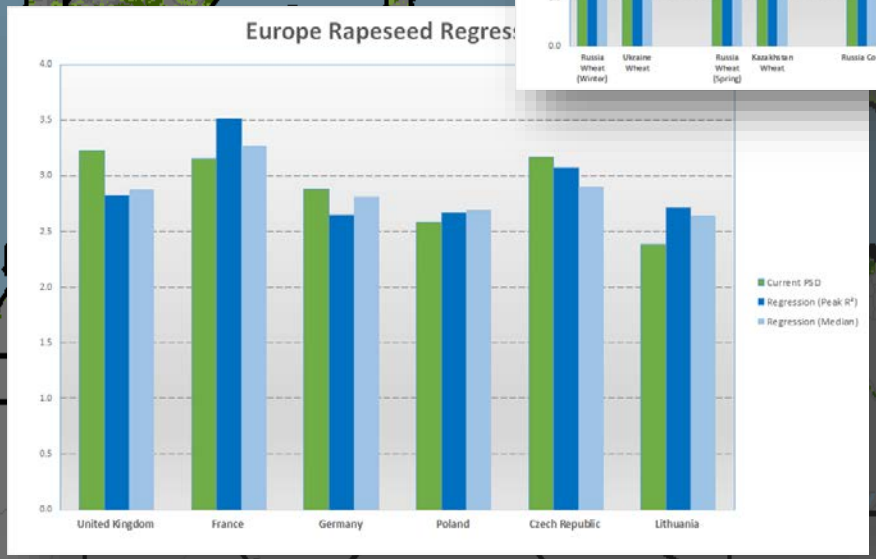


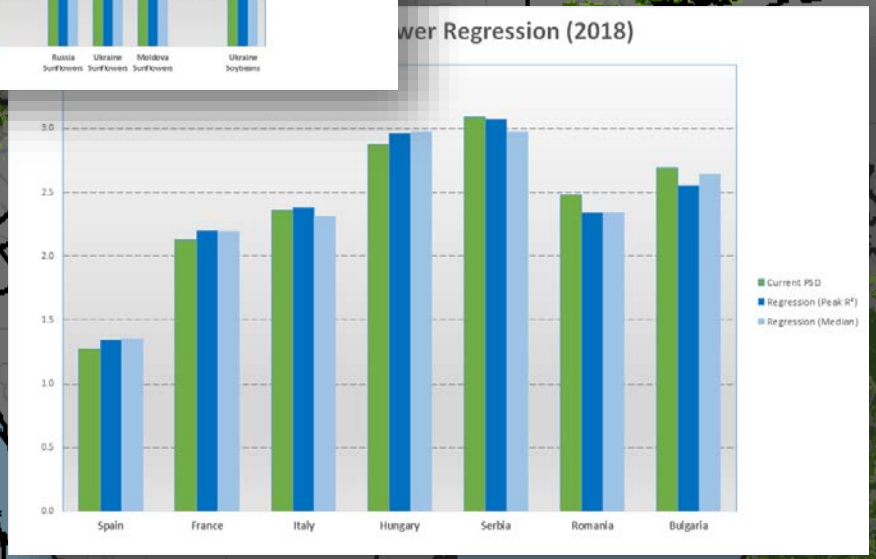
In 2018, the Wx & VHI stage-based regression provided good--to at-times excellent--yield guidance for grains and oilseeds (winter and summer crops).

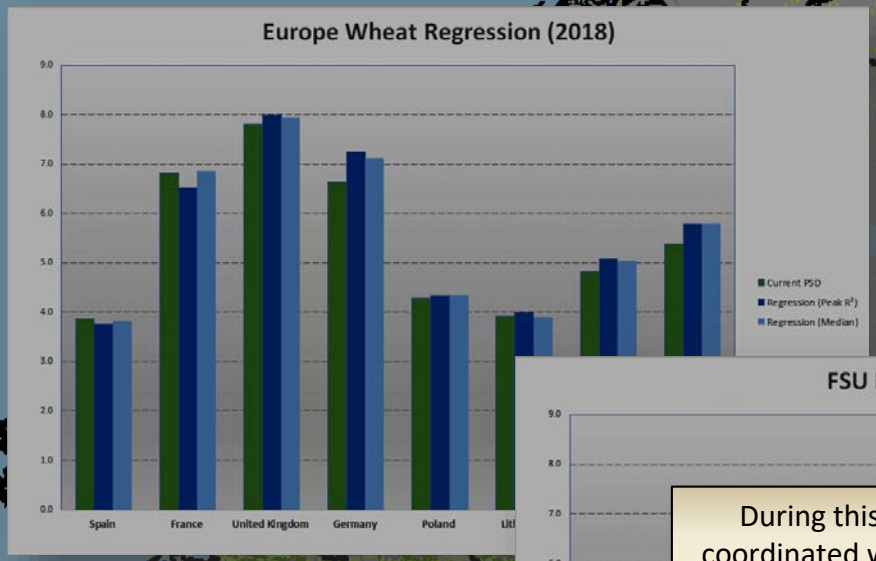


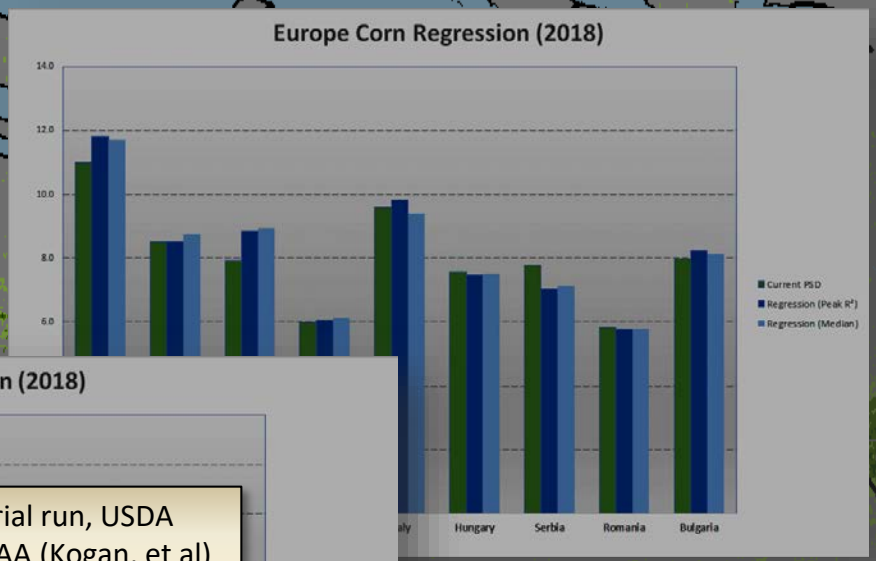


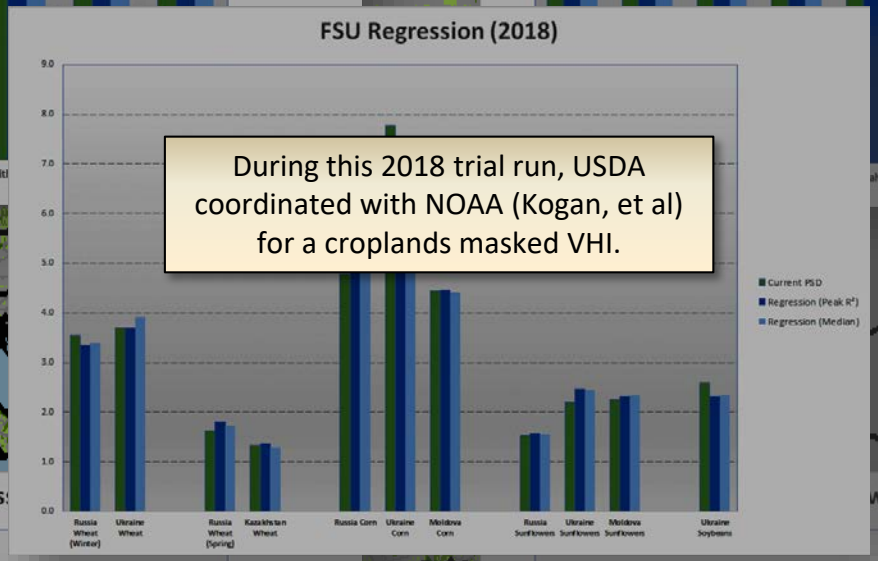




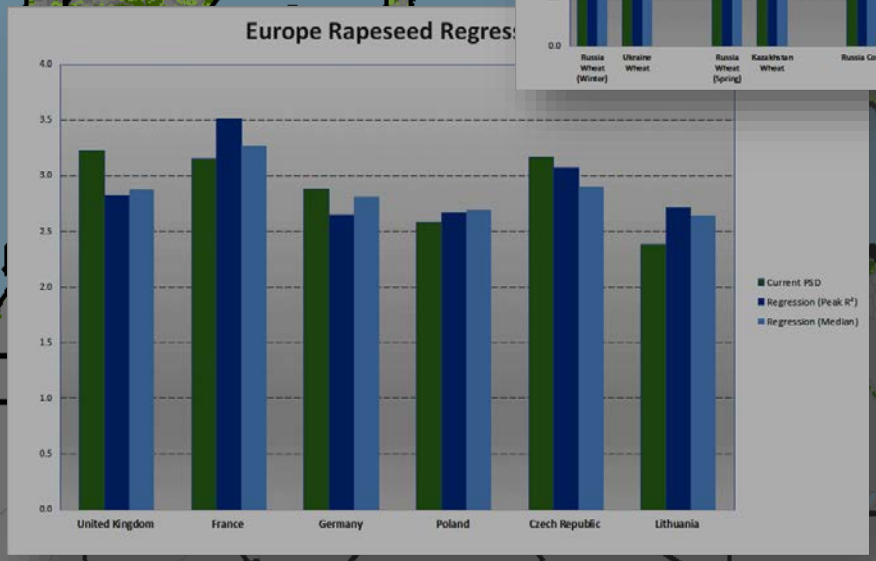


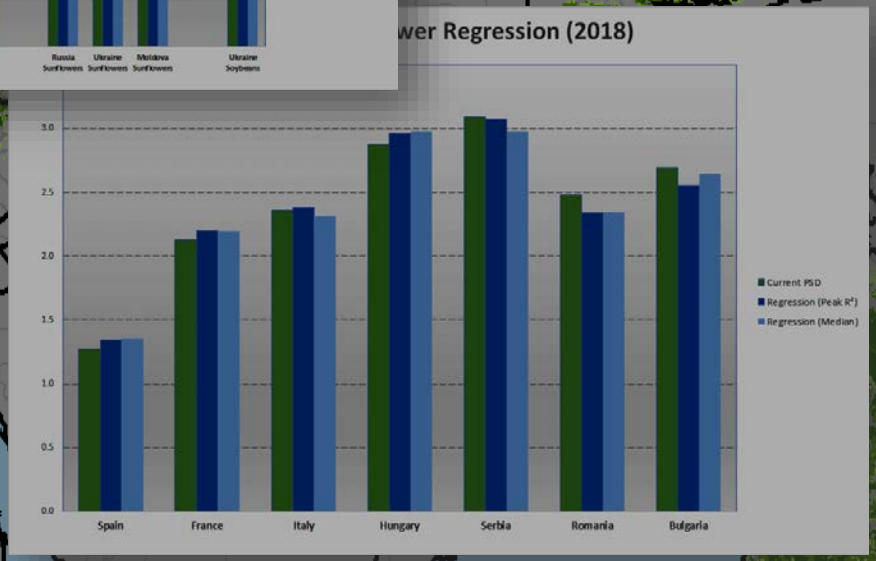


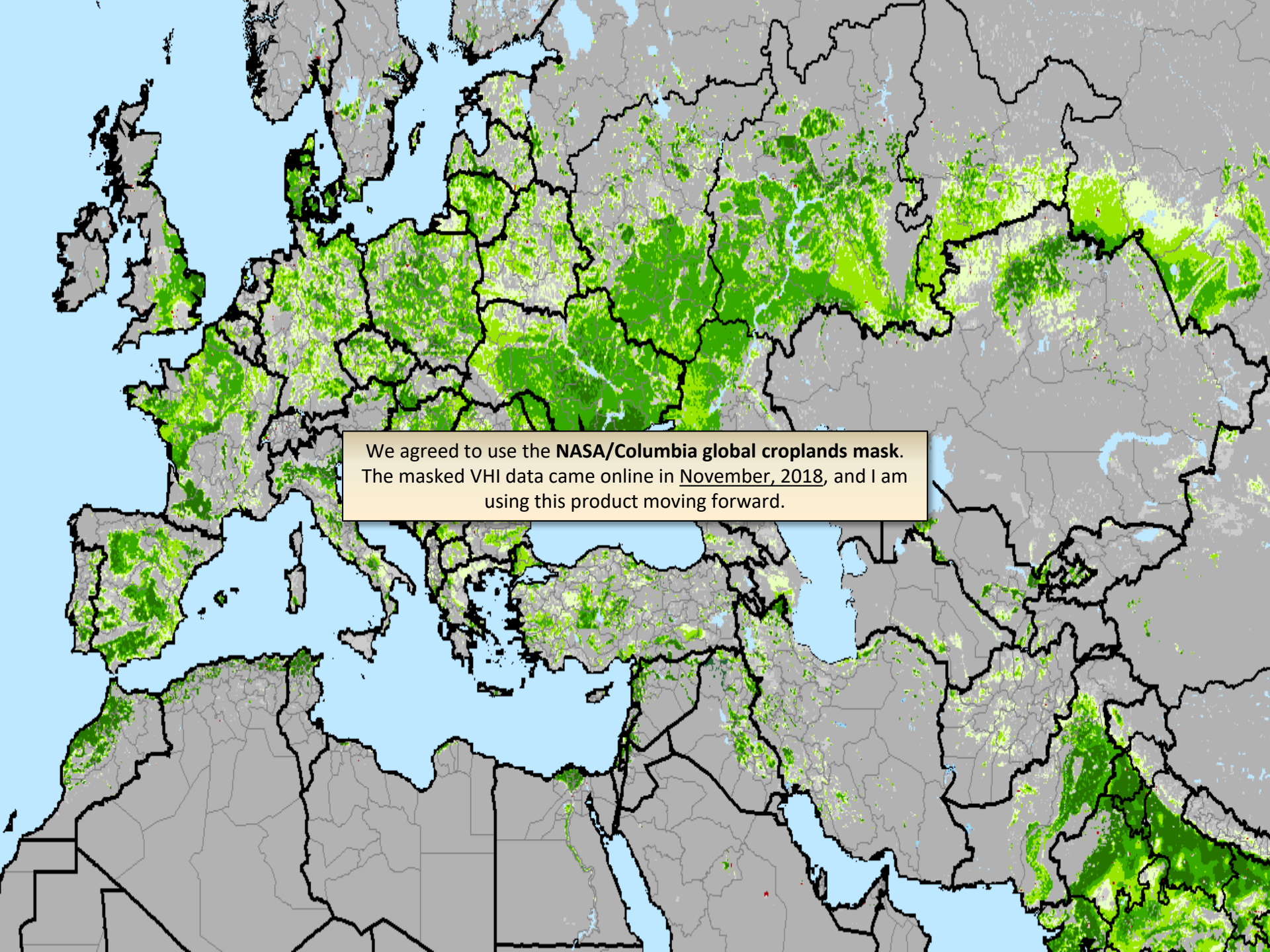




During this 2018 trial run, USDA coordinated with NOAA (Kogan, et al) for a croplands masked VHI.



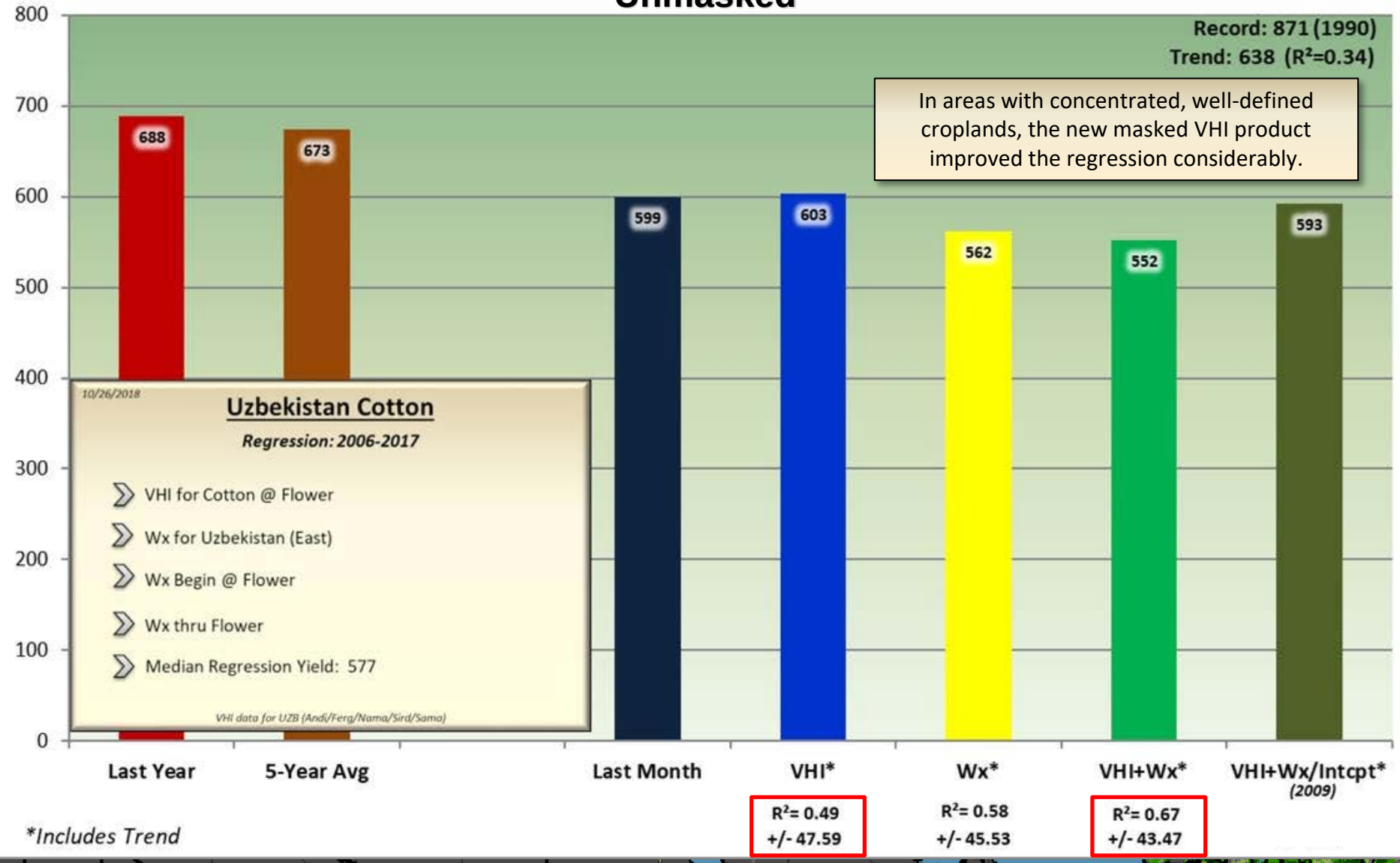



We agreed to use the **NASA/Columbia global croplands mask**. The masked VHI data came online in November, 2018, and I am using this product moving forward.

10/26/2018

Uzbekistan Cotton Regression
Unmasked

Regression: 2006-2017
Median Regression Yield: 577

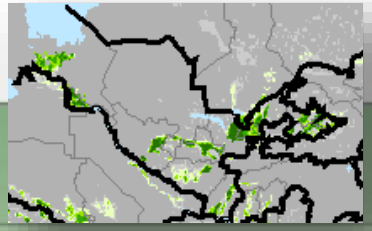


*Includes Trend

11/29/2018

Uzbekistan Cotton Regression
Masked

Regression: 2006-2017
Median Regression Yield: 557



Record: 871 (1990)
Trend: 633 (R^2=0.38)

In areas with concentrated, well-defined croplands, the new masked VHI product improved the regression considerably.

11/29/2018

Uzbekistan Cotton

Regression: 2006-2017

- VHI for Cotton @ Flower
- Wx for Uzbekistan (East)
- Wx Begin @ Flower
- Wx thru Flower
- Median Regression Yield: 557

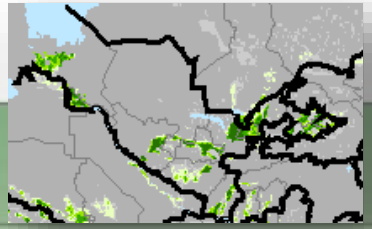
VHI data for to (UZB)

**Includes Trend*

11/29/2018

Uzbekistan Cotton Regression

Regression: 2006-2017
Median Regression Yield: 557



Record: 871 (1990)
Trend: 633 (R^2=0.38)

Not all areas saw this type of improvement, but in some it made a notable difference.

800
700
600
500
400
300
200
100
0

672 | 670 | 599 | 556 | 557 | 524 | 563

11/29/2018

Uzbekistan Cotton

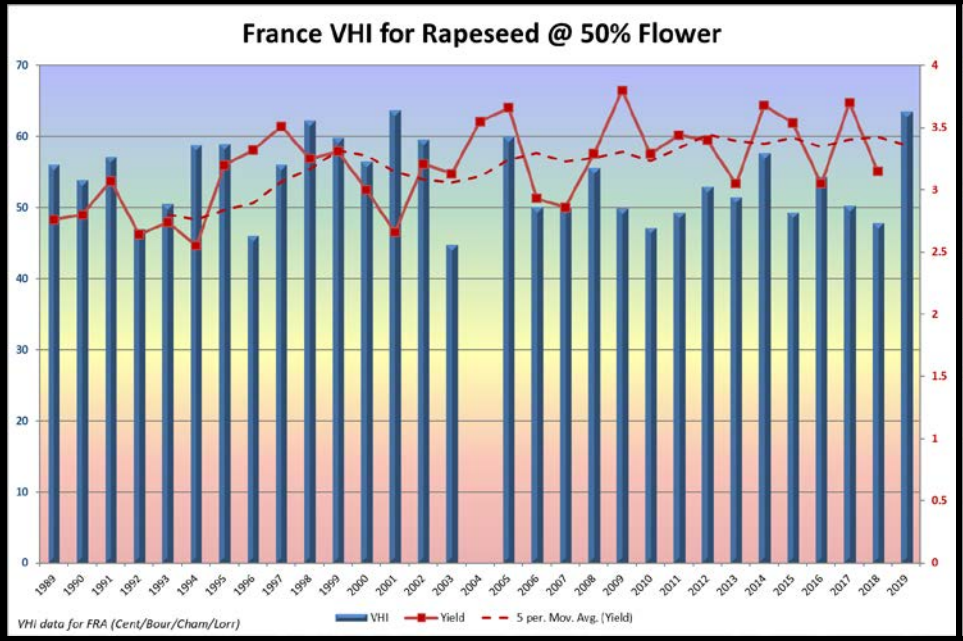
Regression: 2006-2017

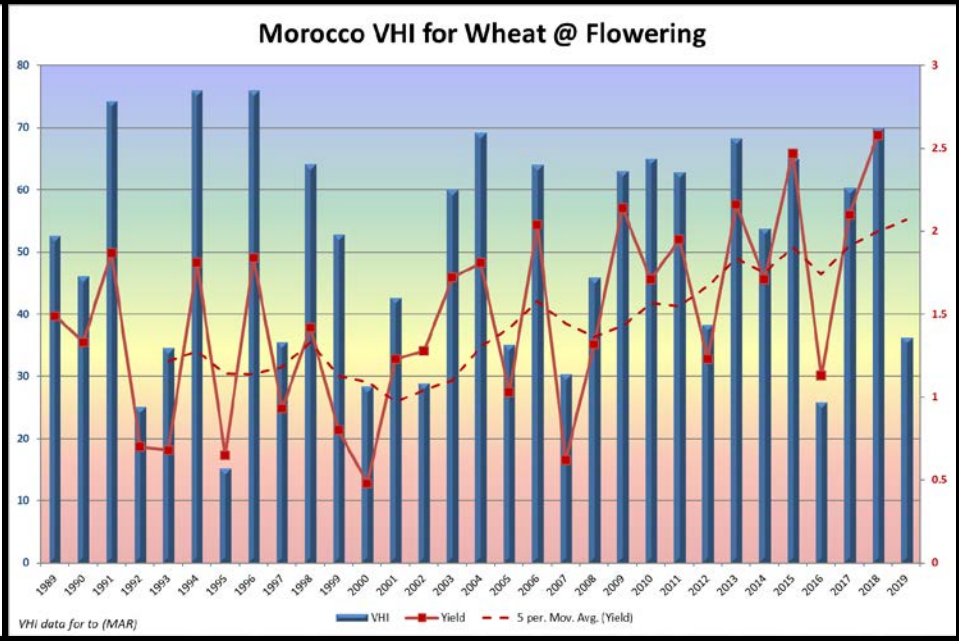
- VHI for Cotton @ Flower
- Wx for Uzbekistan (East)
- Wx Begin @ Flower
- Wx thru Flower
- Median Regression Yield: 557

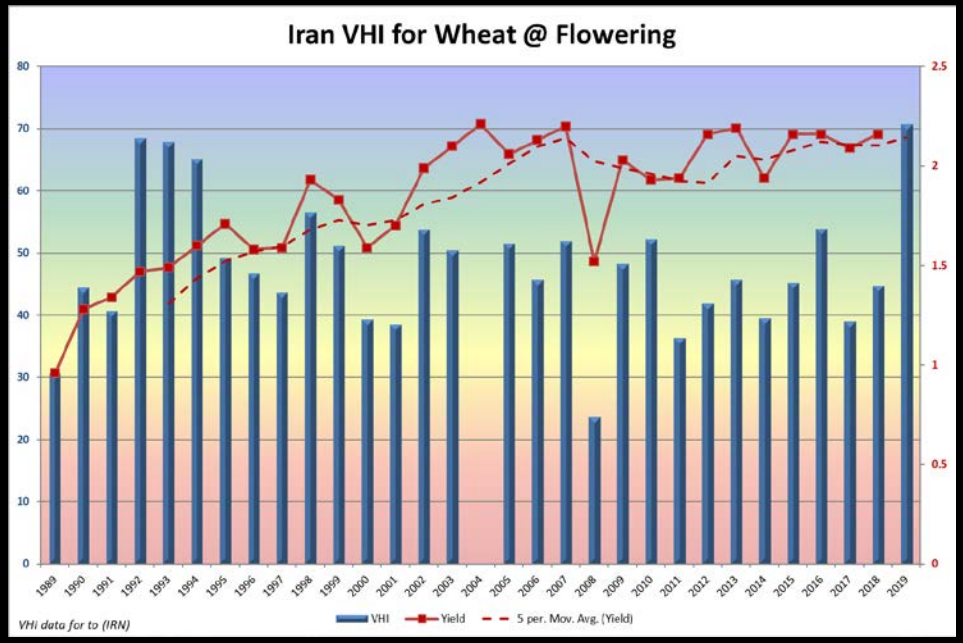
VHI data for to (UZB)

Last Year	5-Year Avg	Last Month	VHI*	Wx*	VHI+Wx*	VHI+Wx/Intcpt* (2009)
		Masked	R^2= 0.72 +/- 35.44	R^2= 0.61 +/- 44.52	R^2= 0.83 +/- 31.23	
		Unmasked	R^2= 0.49 +/- 47.59	R^2= 0.58 +/- 45.53	R^2= 0.67 +/- 43.47	

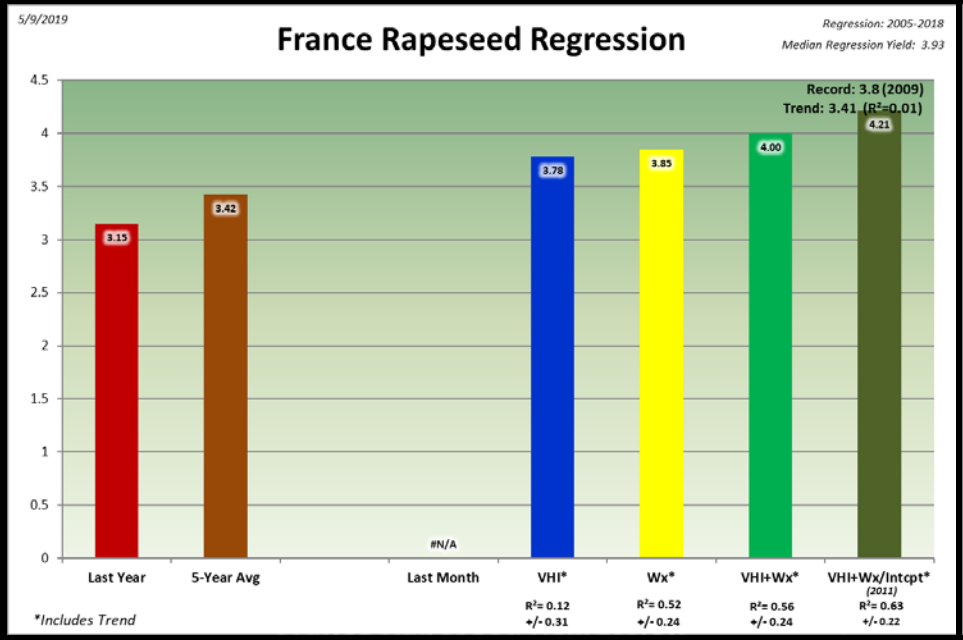
**Includes Trend*

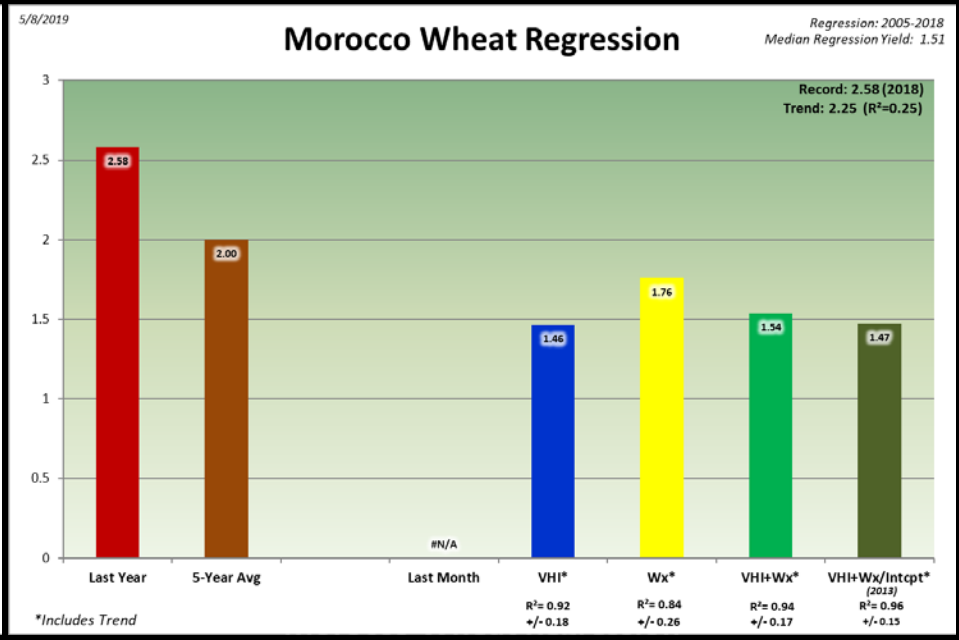


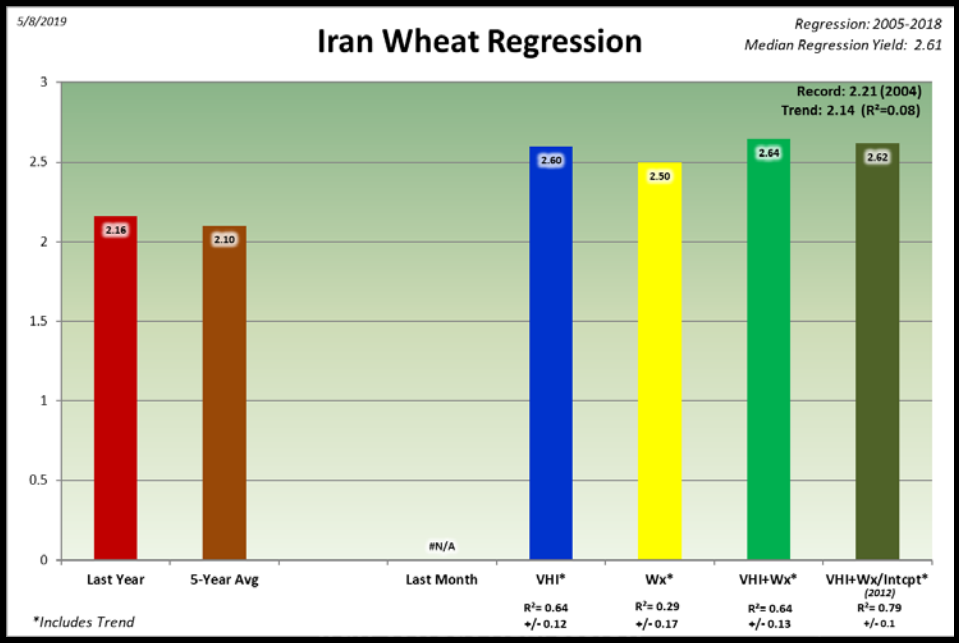




In the most recent WASDE (May, 2019), VHI & Weather data were featured prominently in my analysis, my presentation to the WAOB, and the subsequent slides **used by the WAOB Chairman in the Secretary's Briefing** the following morning.







For this month's WASDE, WAOB and FAS staff directly referred to the regression results to help determine the latest yield forecasts.

Rapeseed Regression Summary Table – May, 2019

5/9/2019	Last Year	Last Month	Suggestion (E)	Peak R^2	Regression (Peak R^2)	Regression Median	Regression Range	Regression Years	Date	Trend (R^2)	5y	Record
United Kingdom Rapeseed:	3.23	#N/A	3.9	0.79	4.39	3.89	3.8 - 4.39	2007-2018	5/9/19	3.57 (0.05)	3.56	3.94 (2017)
France Rapeseed:	3.15	#N/A	3.9	0.63	4.21	3.93	3.78 - 4.21	2005-2018	5/9/19	3.41 (0.01)	3.42	3.80 (2009)
Germany Rapeseed:	2.88	#N/A	3.9	0.85	4.95	5.06	3.71 - 5.21	2003-2018	5/9/19	3.54 (0.01)	3.58	4.48 (2014)
Poland Rapeseed:	2.58	#N/A	2.8	0.72	2.76	2.75	2.55 - 3.41	2007-2018	5/9/19	2.88 (0.02)	2.89	3.44 (2014)
Denmark Rapeseed:	2.61	#N/A	3.6	0.84	3.62	4.40	3.62 - 5.59	2008-2018	5/9/19	3.52 (0.03)	3.69	4.29 (2014)
Lithuania Rapeseed:	2.38	#N/A	2.8	0.93	3.07	3.13	2.83 - 3.45	2006-2018	5/9/19	3.02 (0.64)	2.72	3.17 (2017)
Czech Republic Rapeseed:	3.17	#N/A	3.4	0.87	2.54	3.04	2.54 - 4.74	2007-2018	5/9/19	3.38 (0.12)	3.38	3.95 (2014)
Slovakia Rapeseed:	2.88	#N/A	4.1	0.89	4.12	4.18	3.35 - 4.76	2007-2018	5/9/19	3.46 (0.52)	3.24	3.59 (2017)
Hungary Rapeseed:	2.95	#N/A	3.7	0.91	3.65	3.73	3.31 - 3.89	2007-2018	5/9/19	3.42 (0.59)	3.19	3.60 (2016)
Romania Rapeseed:	2.36	#N/A	3.6	0.96	3.36	3.62	2.96 - 4.05	2007-2018	5/9/19	3.35 (0.63)	2.98	3.65 (2016)
Bulgaria Rapeseed:	2.79	#N/A	3.2	0.92	3.13	3.12	2.97 - 3.32	2006-2018	5/9/19	3.07 (0.65)	2.81	3.05 (2016)

Pct Diff Tolerance: 5

Red = Record

In fact, the **Chairman of the Oilseeds Committee** and his assistant used this "*Summary Table*" to calculate the range of rapeseed production possibilities within the EU.


EU Wheat:
Spain
Italy
France
UK
Denmark
Germany
Poland
Lithuania
Czech Republic
Hungary
Serbia
Romania
Bulgaria
EU Rapeseed:
UK
France
Germany
Poland
Denmark
Lithuania
Czech Republic
Slovakia
Hungary
Romania
Bulgaria
EU Corn:
Spain
France
Germany
Poland
Italy
Hungary
Serbia
Romania
Bulgaria
EU Sunflowers:
Spain
France
Italy
Hungary
Serbia
Romania
Bulgaria
FSU:
Russia Winter Wheat
Ukraine Winter Wheat
Russia Spring Wheat
Kazakhstan Spring Wheat
Ukraine Corn
Russia Corn
Moldova Corn
Ukraine Sunflowers
Russia Sunflowers
Moldova Sunflowers
Ukraine Soybeans
Uzbekistan Cotton
Kazakhstan Cotton
Wx- & VHI-driven regression are being run operationally for nearly 70 different country-crop pairs in my AOR alone! Many of these were specific requests from WAOB Economists or FAS personnel.
MIDEAST:
Turkey Wheat
Syria Wheat
Iran Wheat
Turkey Barley
Iran Barley
Turkey Corn
Turkey Sunflowers
Turkey Cotton
NW Africa:
Morocco Wheat
Algeria Wheat
Tunisia Wheat
Morocco Barley
Algeria Barley
Tunisia Barley

Final VHI Thought: "ROPE"

Reliable (*Established, Peer Reviewed, Quality Controlled, Updated*) ✓

Operational (*Timely, Routine, What Ifs, Back Ups (data & personnel)*) ?

Portable (*Global, Amin 00 & Admin 01, Universal Cropland, Uniform Format, Compatible*) ✓

Expedient (*Openly Available, Easily Acquired, Simple, "Schedule-able"*) ✓ & ?

Thank you!

USDA Agricultural Weather Assessments
World Agricultural Outlook Board