Operational Applications of the VHI for Real-Time Crop Yield Modeling and Assessments at USDA's World Agricultural Outlook Board

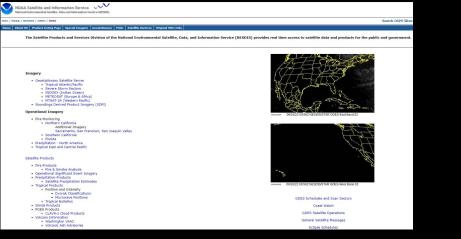
> Eric Luebehusen

Meteorologist USDA/OCE/WAOB

Background & History...

Department of the Environment





FOIA out Us

1993-1999; MDE: Air Quality Modeling and Forecasting.

1999; NESDIS-SAB: Operational Meteorologist using satellite imagery for DVORAK, VAAC, Flooding, Special Events.

covering weather in SOA, SEA, AUS

	Climate Prediction	on Cente	er -
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C Search C search Go	Joint Agricultural V	Veather Faci	ility (JAWF)
VF Home them Hemisphere zil entina them Africa thralia them Hemisphere dco ope b die East a na Asia	This webpage was developed i Agricultural Weather Facility (JAWF). 1 growers, exporters, USDA commodity staff informed of worldwide weather d livestock. NWS & USDA Responsibilities: NWS meteorologists provide global i interpretation of forecast models. USDA agricultural meteorologists me agroduction. The official JAWF Webpage is: https://www.	The Mission of JAW analysts, as well a evelopments and t veather data, product rge the NWS informa to arrive at the weath	F is to keep the Nation's as the Secretary and top heir effects on crops and is, and expertise in tion with climatological ler impact on agricultural
ekty Summary ppt ppt hive ninar Series 0 Schedule sentations DATA . OBS bal	If you have any questions regarding the pro (David, Miskuegnoaa, gov). NOAV National Westher Service NOAA Center for Westher and Climate Prediction Catego Park, Maryland 20740 Catego Park, Maryland 20740 Page Author: Canade Prediction Center Internet Team Page Justin Canade Prediction Center Internet Team Page Justin Catego Park, Sorts	Disclaimer Information Quality Credits Glossary	Pease contact David Miskus Privacy Polic Freedom of Information Act (FOI/ About U Career Opportunitie

Arc

GIS

National Weather Service

1999-2005; NOAA-NWS-CPC: JAWF (@ USDA)

2005-Current: USDA-OCE-WAOB

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World Agricultural Outlook Board

OFFICE OF THE CHIEF ECONOMIST

About Us

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Commodity Markets

WASDE Report

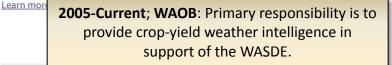
Baseline Projections

About WAOB

WAOB Staff

Economic Analysis

Energy and Environmental Policy The World Agricultural Outlook Board (WAOB) serves as USDA's focal point for economic intelligence and the commodity outlook for U.S. and world agriculture. WAOB coordinates, reviews, and approves the monthly <u>World Agricultural Supply and Demand Estimates (WASDE) report</u> as well as long-term Agricultural Baseline Projections. It is also the focal point for analyzing weather-related impacts on agriculture through the Office of the Chief Meteorologist. In addition, the Board is responsible for coordinating the World Agricultural Outlook Forum, USDA's oldest and largest gathering.







Agricultural Weather Assessments World Agricultural Outlook Board

2005-Current: USDA-OCE-WAOB

WASDE: Market-sensitive document released by the 12th of every month detailing the latest US and global crop situational outlook.

"Trading Places"



Department of World Agricultural Supply Agriculture and Demand Estimates

ISSN: 1554-9089

Office of the	Agricultural Marketing Service		c Research Service
Chief Economist	Farm Service Agency		Agricultural Service
WASDE - 625	Approved by the World Agricultural Outlo	ook Board	June 10, 2022

WHEAT: The outlook for 2022/23 U.S. wheat this month is for increased supplies. unchanged domestic use and exports, and higher stocks. Supplies are raised on higher production with all wheat production projected at 1,737 million bushels, up 8 million from last month. NASS raised winter wheat production to 1,182 million bushels as increases for Soft Red Winter and White Winter more than offset a reduction for Hard Red Winter. The all wheat yield is 46.9 bushels per acre, up 0.3 bushels from last month. Projected 2022/23 ending stocks are raised 8 million bushels to 627 million, still down 4 percent from 2021/22. The projected 2022/23 season-average farm price is unchanged at \$10.75 per bushel, compared to \$7.70 for 2021/22.

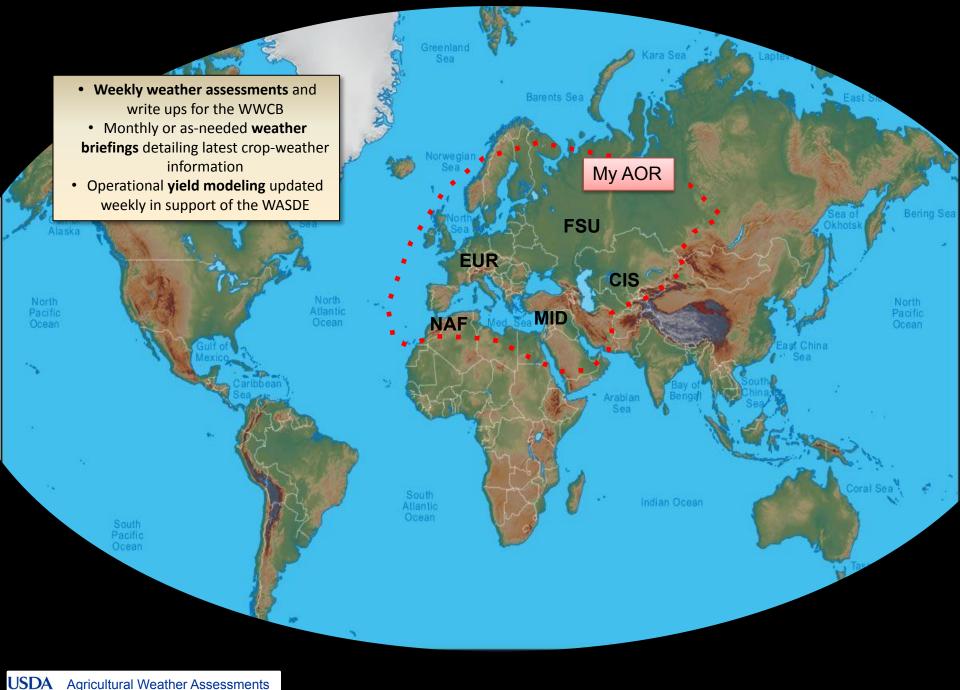
The global wheat outlook for 2022/23 is for lower supplies, reduced consumption, fractionally lower trade, and slightly lower ending stocks. Supplies are decreased by 1.7 million tons to 1.052.8 million as lower India production more than offsets an increase for Russia. India's production is lowered 2.5 million tons to 106.0 million as extreme temperatures in March and April reduced yields during grain fill. Russia's production is raised 1.0 million tons to 81.0 million with all of the increase in winter wheat on generally favorable weather conditions to date. Projected 2022/23 world consumption is reduced 1.5 million tons to 786.0 million mainly on lower feed and residual use for India and less food, seed, and industrial use for Sri Lanka and Argentina.

Projected 2022/23 global trade is decreased 0.3 million tons to 204.6 million as lower exports from India are not completely offset by higher exports from Russia and Uzbekistan. India's exports are reduced 2.0 million tons to 6.5 million as the government intends to restrict exports to some destinations to ensure sufficient domestic supplies. Russia's exports are raised 1.0 million tons to 40.0 million, which would be the second largest on record. Russia's supplies are projected higher for 2022/23 and its export prices are more competitive than most other exporters. Projected 2022/23 world ending stocks are lowered 0.2 million tons to 266.9 million, a six-year low.

COARSE GRAINS: This month's 2022/23 U.S. corn outlook is for larger beginning stocks, slightly higher use, and increased ending stocks. Corn area and yield forecasts are unchanged. USDA will release its Acreage report on June 30, which will provide surveybased indications of planted and harvested area. Beginning stocks are up 45 million bushels mostly reflecting a forecast decline in exports for 2021/22. Exports are lowered 50 million



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Iran Wheat:	2.50	2.24	2.21	0.94	2.21	2.24	2.21 - 2.28	2006-2020	6/16/20)21	2.38	2.28	2.51
Iraq Wheat:	1.93	1.80	1.78	0.86	1.78	1.75	1.72 - 1.78	1999-2020	6/16/20)21	1.86	1.86	2.00
Uzbekistan Wheat:	4.65	4.29	4.17	0.82	4.60	4.73	4.17 - 4.87	2011-2020	6/16/20)21	5.18	4.68	5.11
Turkey Barley:	2.13	1.35	1.64	0.82	1.62	1.72	1.62 - 1.87	2009-2020	8/26/20)21	1.95	1.89	2.19
Syria Barley:	1.27	0.85	0.76	0.99	0.78	0.91	0.76 - 1.24	2014-2020	6/15/20)21	1.35	0.98	1.54
Iran Barley:	2.21	1.76	1.73	0.83	1.73	1.83	1.73 - 1.95	1995-2020	6/15/20)21	2.03	2.04	2.21
Iraq Barley:	1.29	1.18	1.24	0.99	1.23	1.37	1.23 - 1.42	2010-2020	6/16/20		1.44	1.29	1.33
Turkey Corn:	11.45	44.70	44.60		44 72	44 74	-11 10 11 00	- 2000 2020	0/24/20	21	11.82	10.68	11.76
Turkey Sunflowers:	2.17	Over	the past s	several ye	ears, the a	bility to	quantify cro	op stages u	sing	21	2.50	2.30	2.52
Turkey Cotton:	1804.00	Gro	wing Deg	ree Davs	(GDDs) a	nd matcl	h them with	the VHI a	nd	21	1715.00	1657.00	1853.00
Uzbekistan Cotton:	782.00			• •	• •					21	729.00	709.00	871.00
Turkmenistan Cotton:	368.00	VV	eather (v	•			r-expanding	crop-yield	1	21	348.00	433.00	710.00
Tajikistan Cotton:	680.00			mode	ling effort	t at USDA	A-WAOB.			21	639.00	626.00	939.00
Kazakhstan Cotton:	534.00									21	607.00	568.00	849.00
Morocco Wheat:	0.93				120					21	1.83	1.66	2.54
Algeria Wheat:	1.88		•	•	•		nternational	•	•	21	1.77	1.74	1.90
Tunisia Wheat:	2.01	yi yi	eld regres	ssion fore	ecast suite	es (7 fore	casts each v	vorkbook)		21	2.15	2.03	2.44
Morocco Barley:	0.44									21	1.11	1.02	1.83
Algeria Barley:	1.80									21	1.86	1.61	1.95
Tunisia Barley:	1.28			i have	e also add	ea 43 for	r the US.			21	1.42	1.28	1.94

5/3/2022			Quick F	² Stats:		Number at or Above R ² Thresholds:					
Crop	<u>Total</u>	Avg R ²	Median R ²	Best R ²	Worst R ²	0.50	<u>0.70</u>	0.80	0.90		
EUR Barley	12	0.85	0.89	0.96	0.67	12	11	9	5		
EUR Corn	14	0.86	0.90	0.96	0.67	14	12	11	7		
EUR Rapeseed	13	0.84	0.84	0.98	0.58	13	12	10	5		
EUR Soybeans	8	0.84	0.85	0.96	0.76	8	8	6	1		
EUR Sunflowers	10	0.85	0.86	0.98	0.66	10	9	7	4		
EUR Wheat	17	0.88	0.88	0.95	0.79	17	17	16	6		
FSU All	22	0.90	0.91	0.99	0.64	22	21	21	14		
MID All	24	0.90	0.92	1.00	0.69	24	23	23	13		
NAF All	6	0.90	0.88	0.90	0.74	6	6	5	2		
						126	119	108	57		
All Regression:	126	0.87	0.89	1.00	0.58	100% > 0.5	94% > 0.7	86% > 0.8	45% > 0.9		

It all starts with data. The main source of WMO weather data for the WAOB is through a MOU with **NOAA/NWS/CPC**; This is the backbone of our work.

Data is maintained in house at USDA.

Primary Data Source: WMO through NOAA/CPC

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USDA

Agricultural Weather Assessments World Agricultural Outlook Board

FID	Shape *	WMO	LATITUDE	LONGITUDE	PRECIP	TAVG	TMAX	TMIN	NPRECIP	NTAVG	TANOM	PNP	PANOM		
133	Point	01001	70.93	-8.67	2	-2	2	-6	10	-4	2	20	-8		
134	Point	01002	80.02	16.25	0	-10	-8	-13	-9999	-9999	-9999	-9999	-9999		
135	Point	01003	77	15.5	0	-9	-5	-12	-9999	-9999	-9999	-9999	-9999		
138	Point	01006	78.25	22.83	0	-11	-7	-15	-9999	-9999	-9999	-9999	-9999		
139	Point	01007	78.92	11.93	2	-10	-6	-14	-9999	-9999	-9999	-9999	-9999		
140	Point	01008	78.25	15.47	0	-10	-6	-16	2	-11	1	0	-2		
141	Point	01009	80.67	20.85	0	-11	-5	-13	-9999	-9999	-9999	-9999	-9999		
	Point	01010	69.3	16.15	0	2	6	-2	17	1	1	0	-17		
	Point	01011	80.08	31.38	0	-10	-2	-15	-9999	-9999	-9999	-9999	-9999		
	Point	01015	69.6	17.83	0	2	6	-2	-9999	-9999	-9999	-9999	-9999		
147	Point	01017	69.35	18.08	0	-8	-5	-11	13	1	-9	0	-13		
	Point	01023	69.05	18.55	3	0	7	-9	8	0	0	38	-5		
149	Point	01025	69.68	18.92	4	1	5	-4	14	1	0	29	-10		
150	Point	01026	69.65	18.94	2	1	6	-4	-9999	-9999	-9999	-9999	-9999		
151	Point	01028	74.52	19.02	3	-4	-1	-9	6	-5	1	50	-3		
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ORACLE

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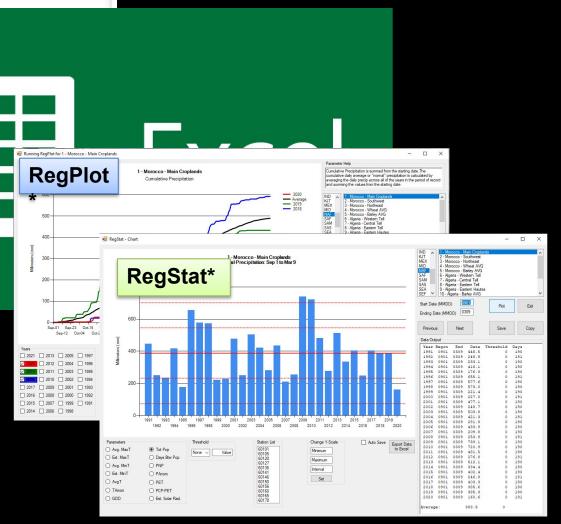
Much of the data analysis and visualization developmental work has been done in *Excel*.

Software for Data Management & Analysis

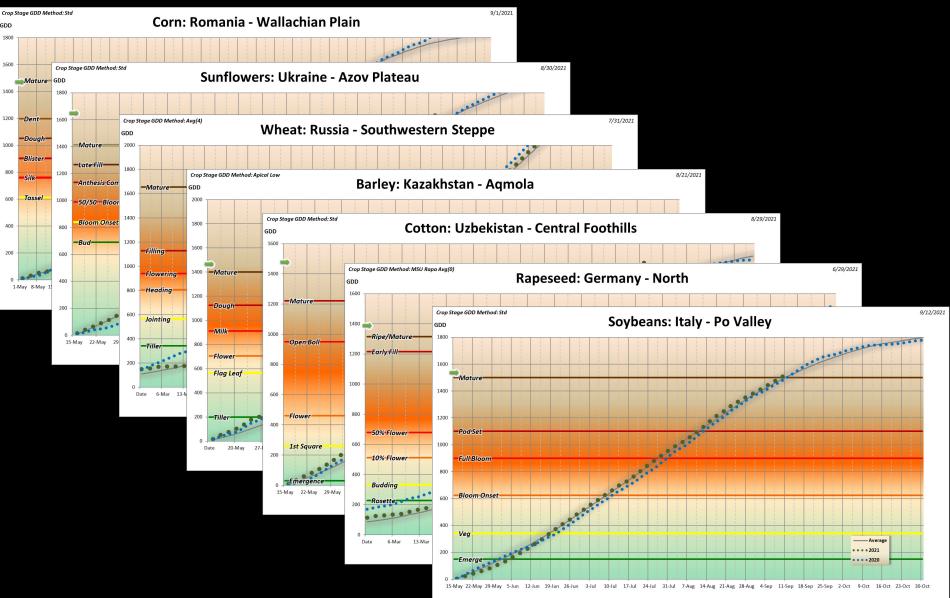
*Software developed, updated, and maintained in-house.



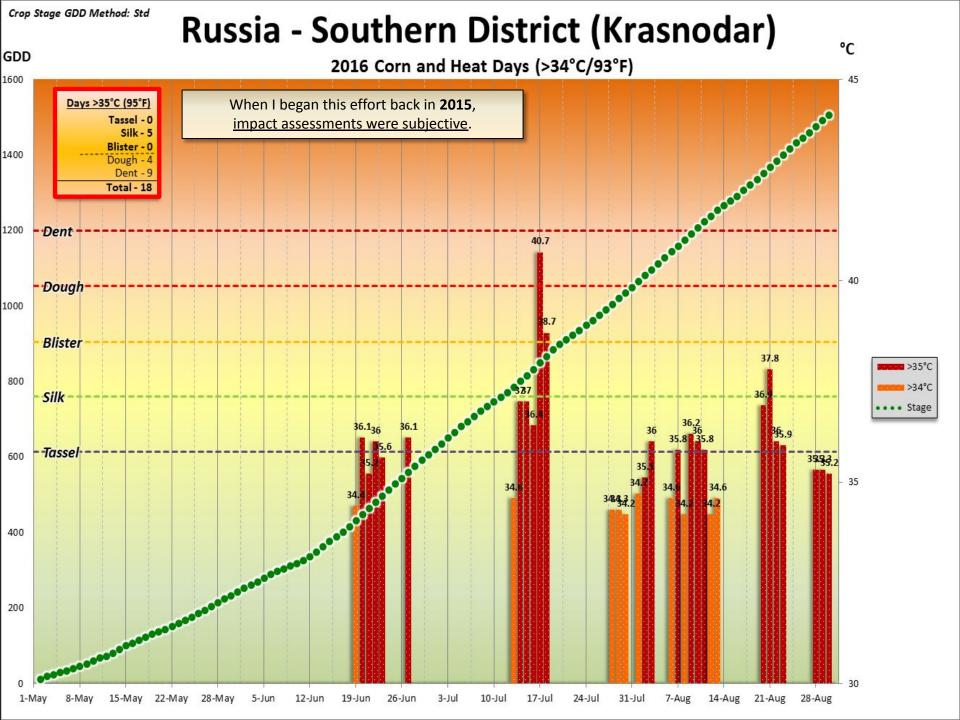
Agricultural Weather Assessments World Agricultural Outlook Board

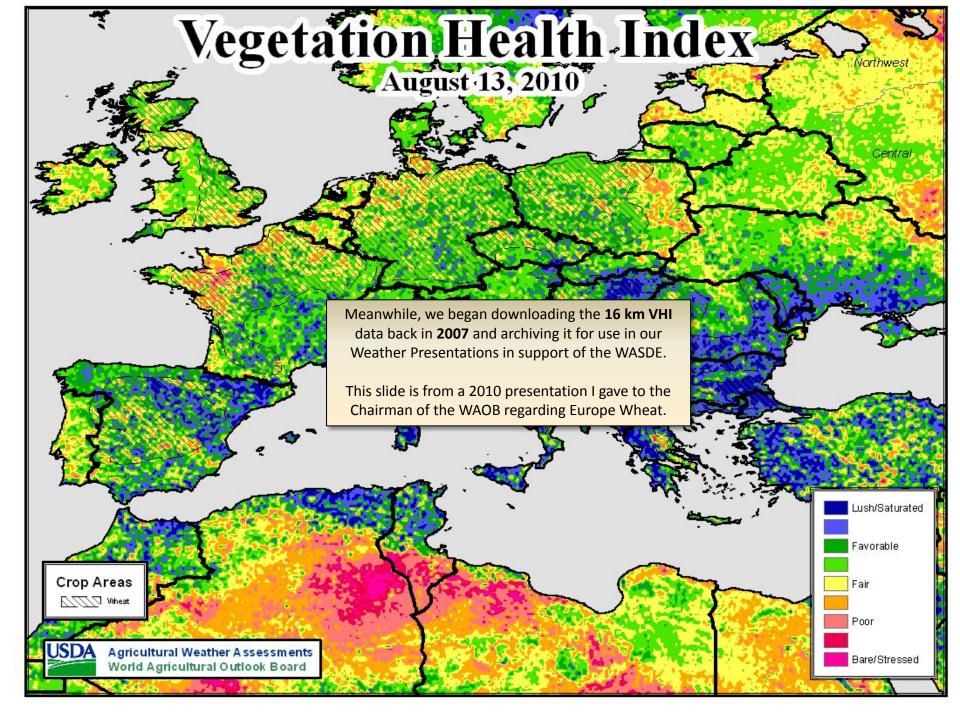


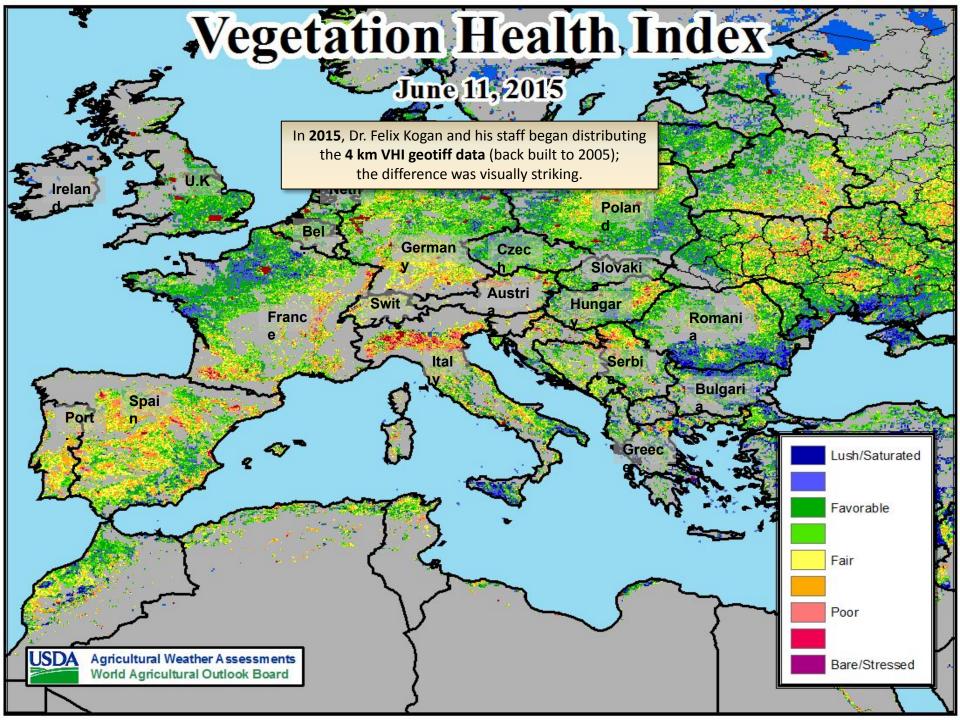
Using established **GDD crop-stage cutoffs**, real-time estimates of *stages of development for crops across the globe* within Excel are possible using our built-in Wx DB links.

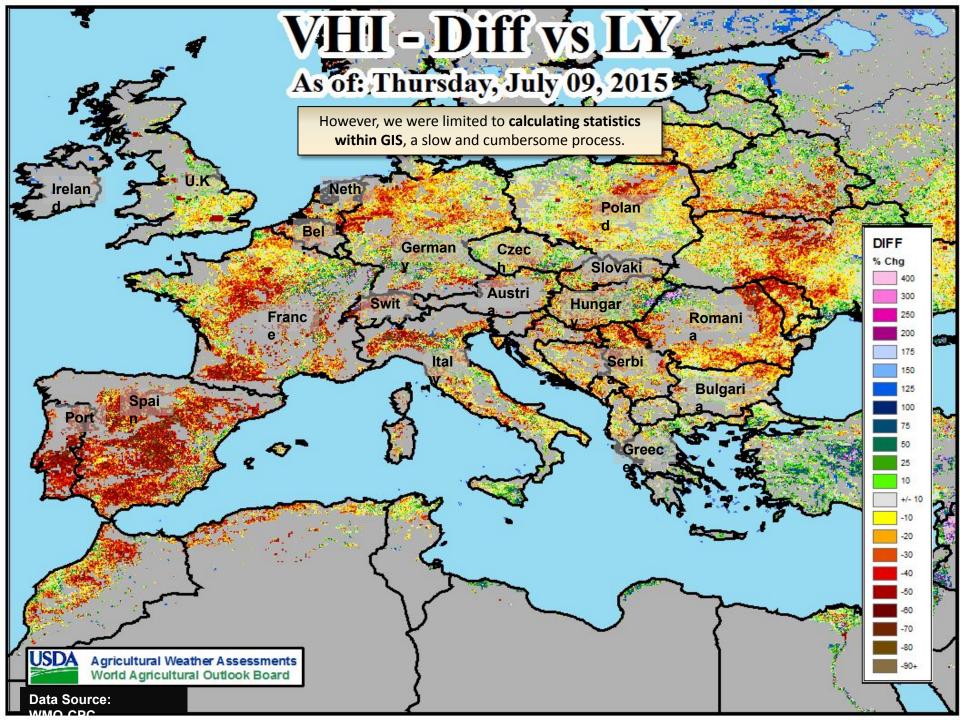


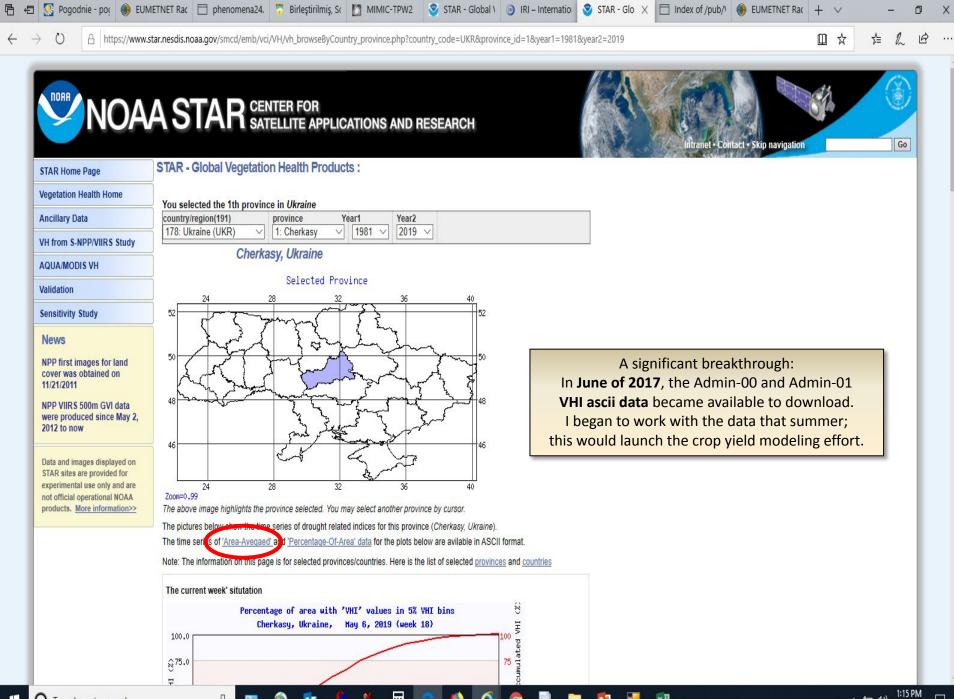
On par with Average / Similar to 2020

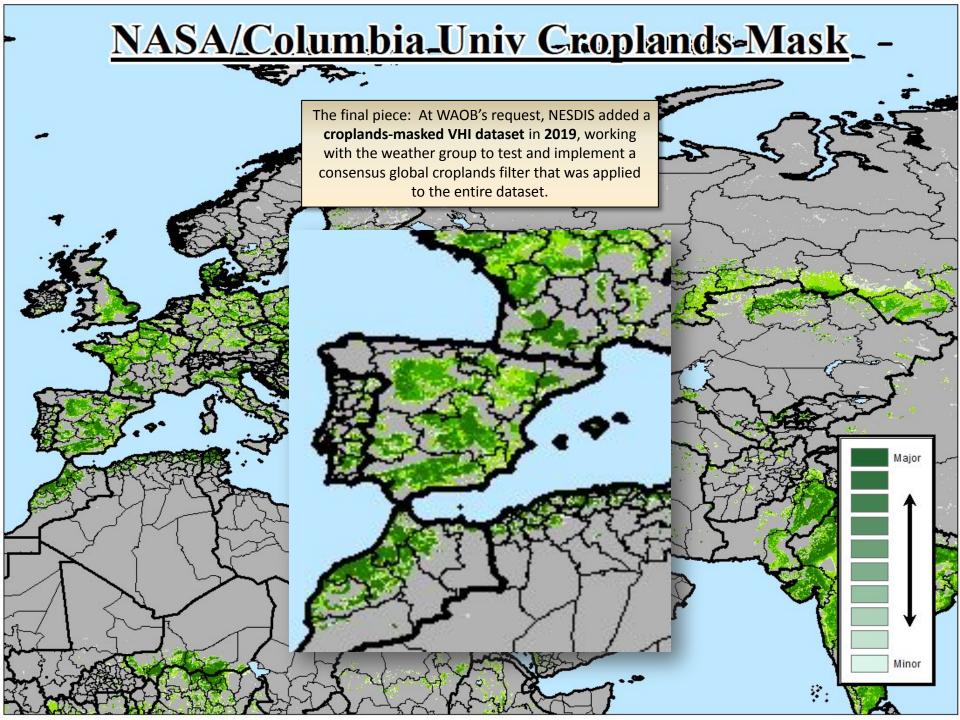




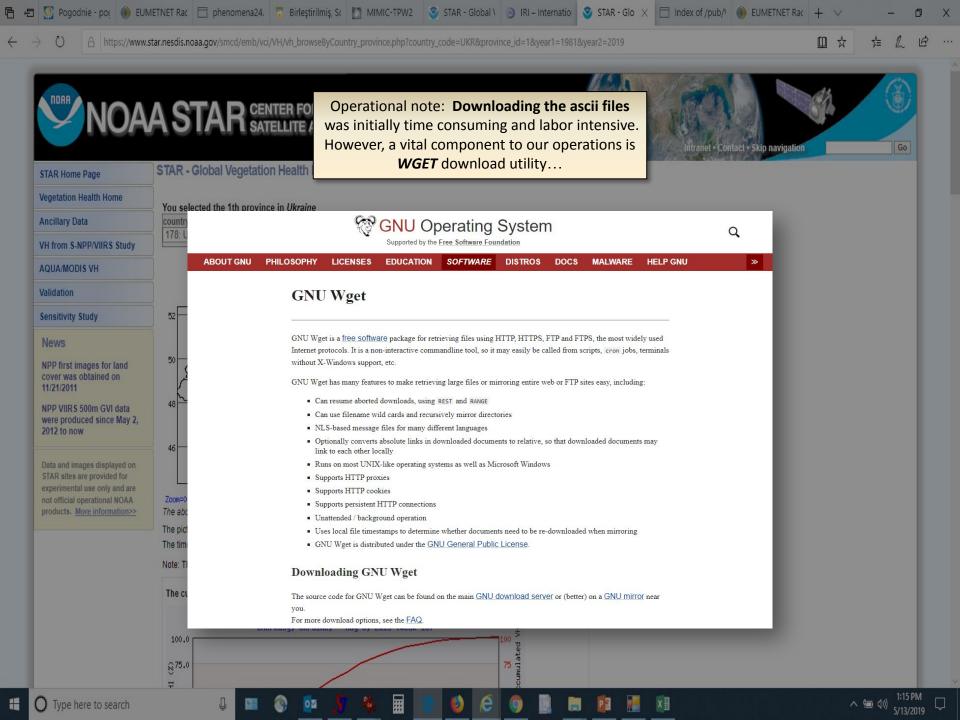








The Process...



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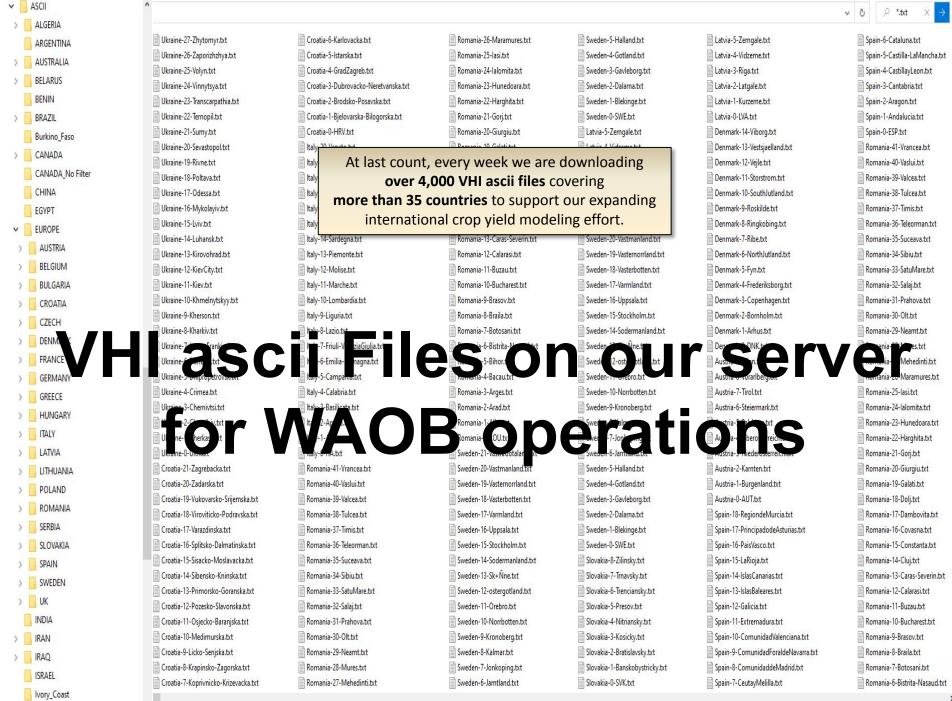
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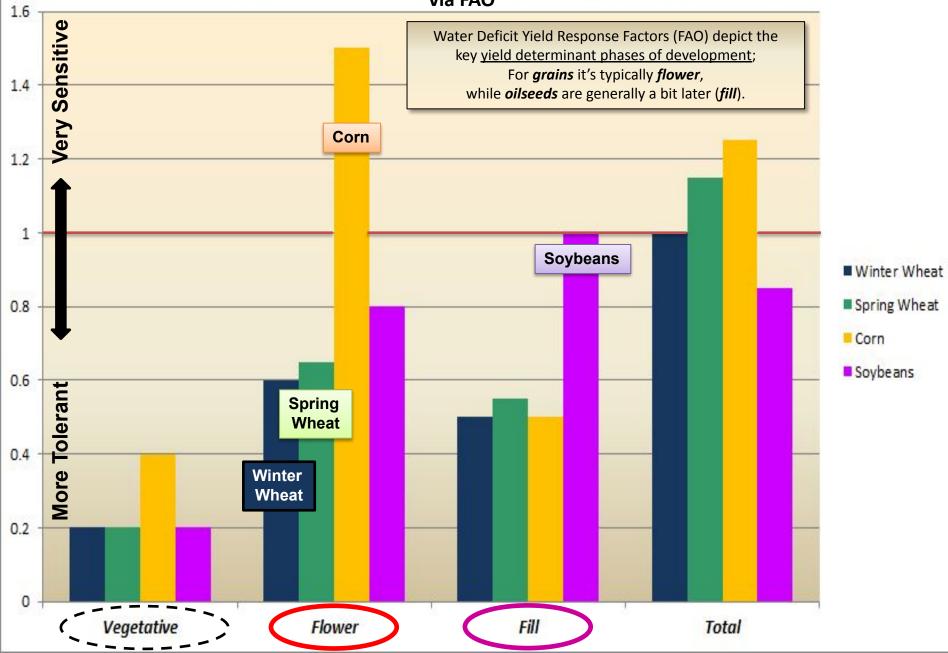
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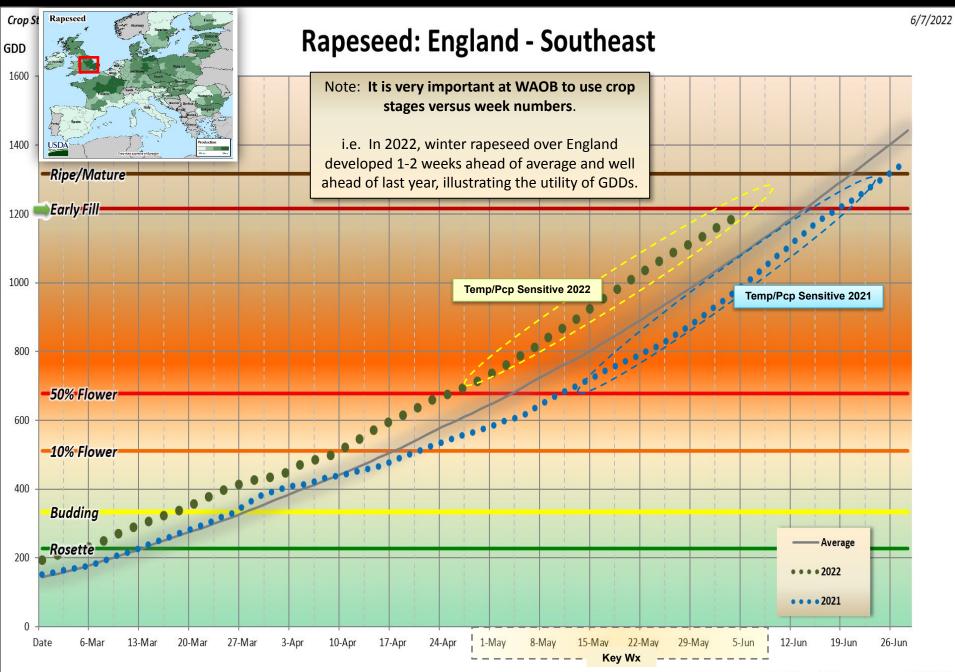
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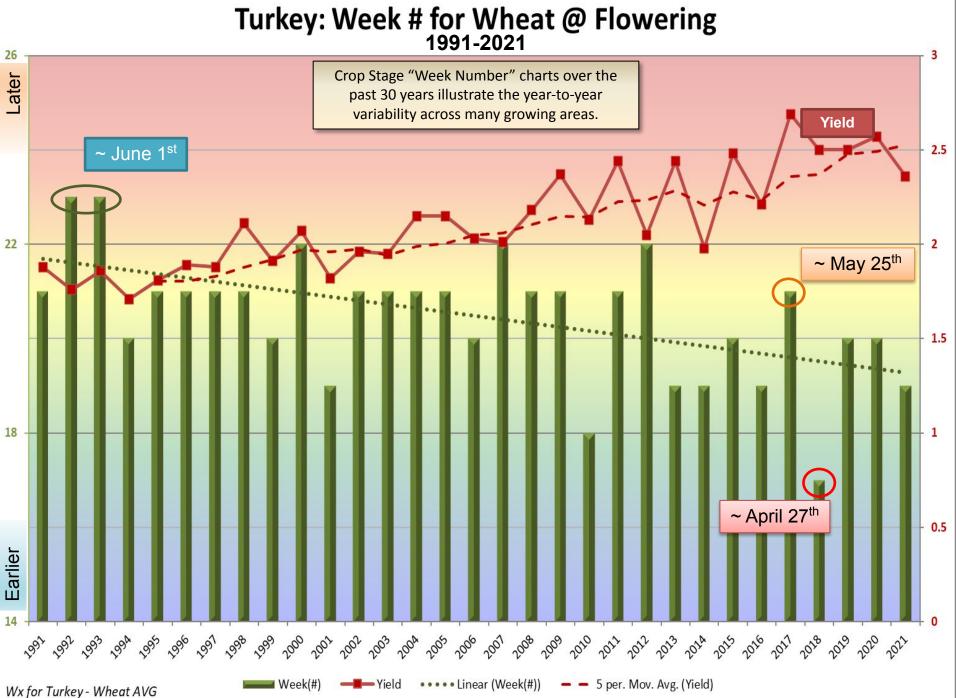
Water Deficit Yield Response Factors (ETactual/ETmeasured)

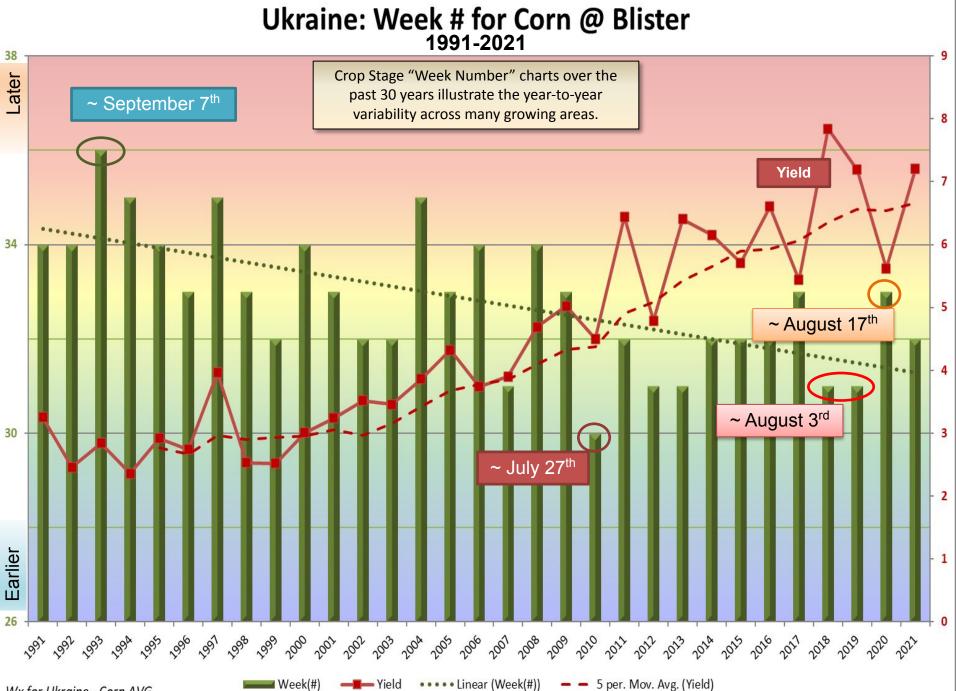
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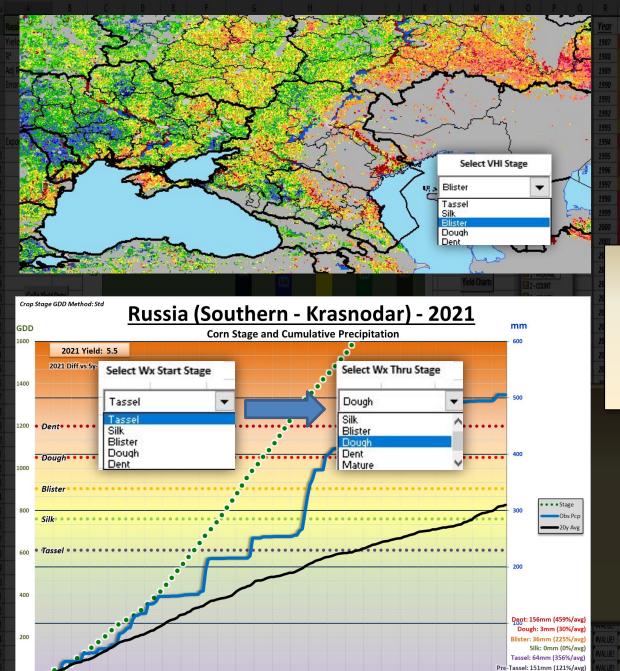
⁸ days ahead of Avg / 12 days ahead of 2021





Wx for Ukraine - Corn AVG

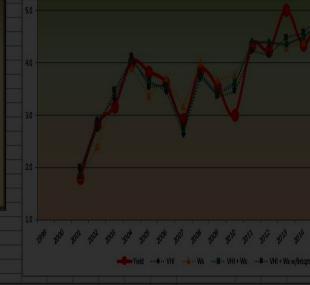
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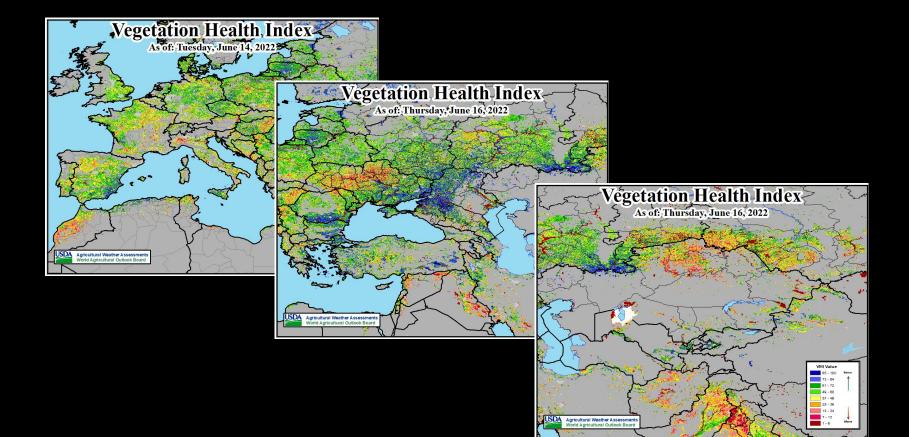
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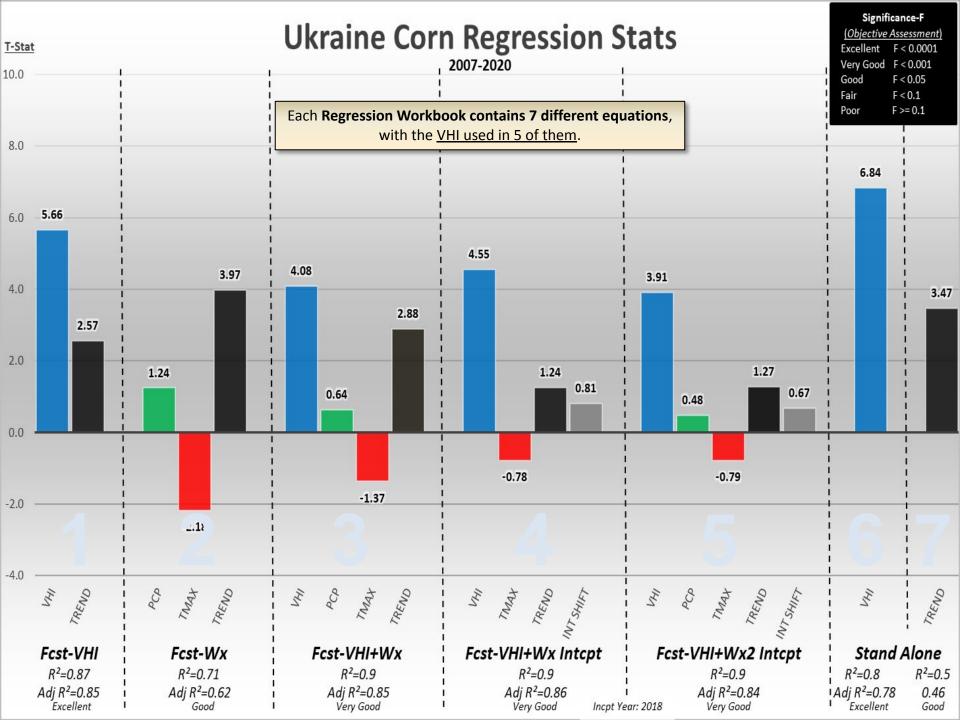
Within Excel, **Crop-Stage-Specific VHI & Weather** are extracted for yield forecasting using regression analysis.

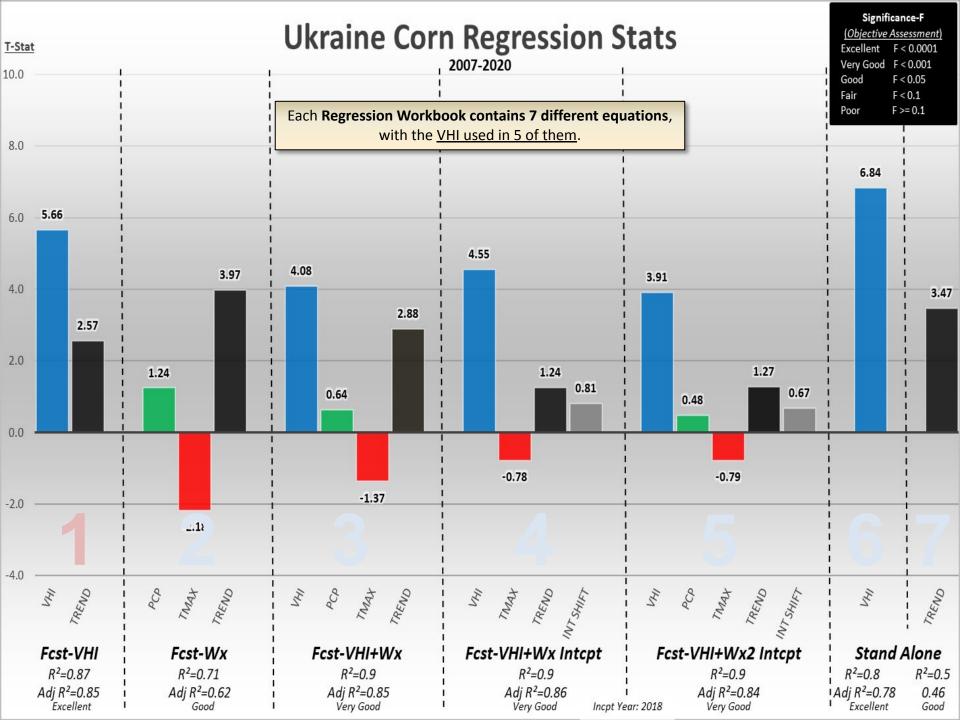
Using crop stages versus static week numbers ensures year-to-year consistency & allows easy testing of different scenarios.

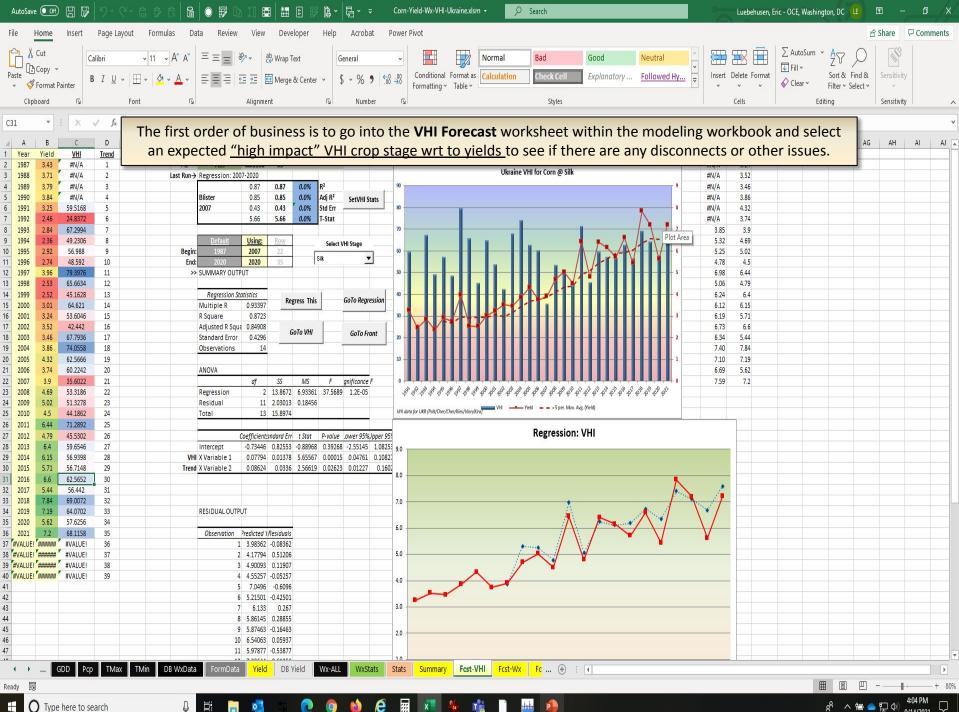


VHI Yield Regression....

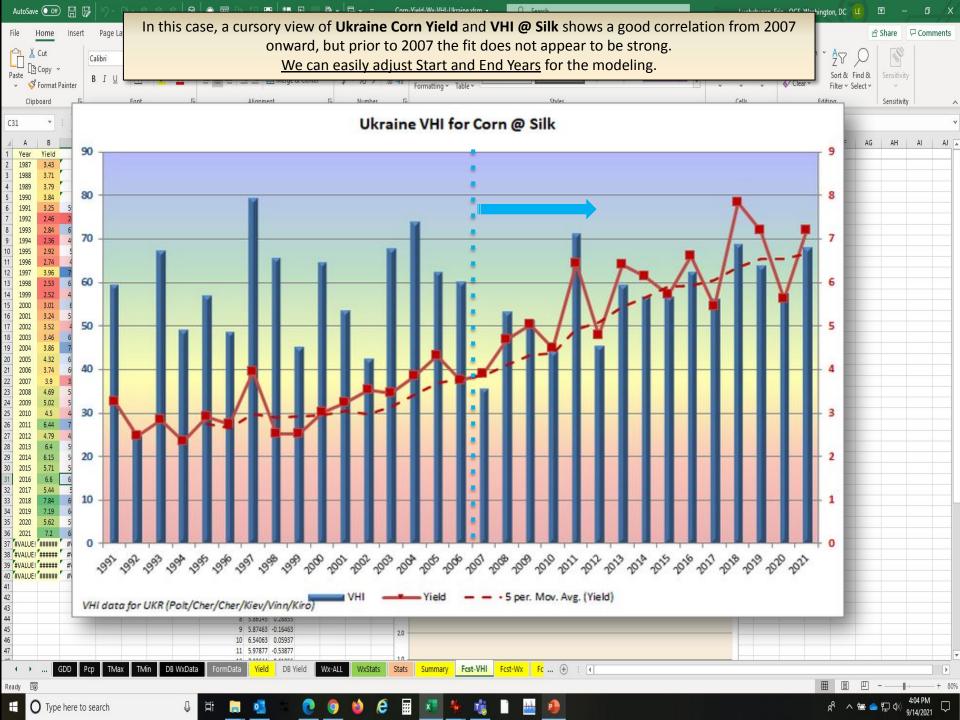


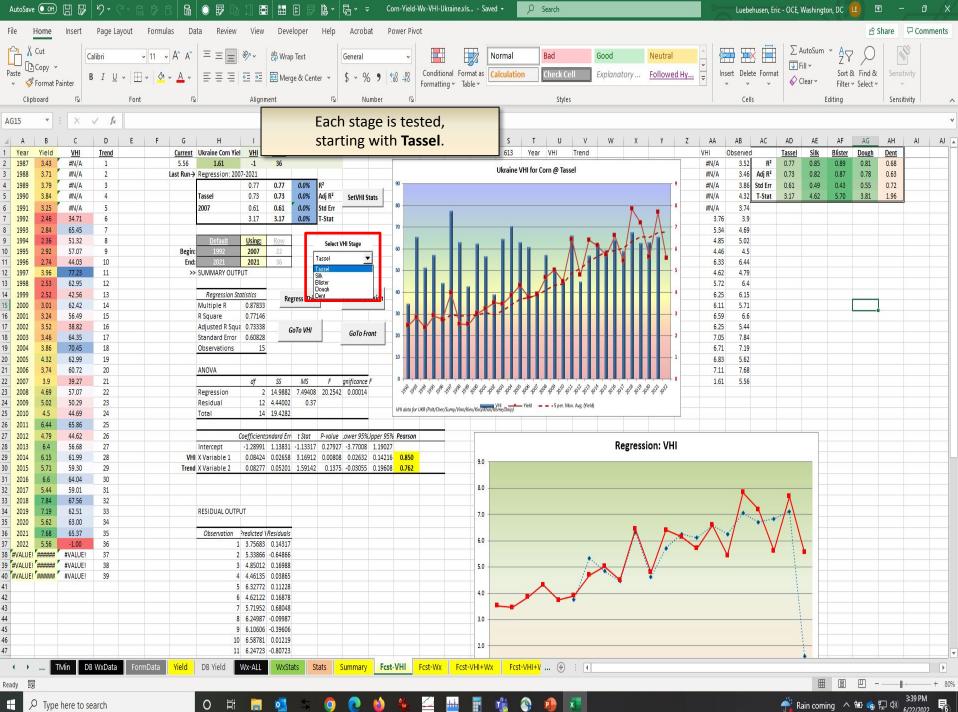




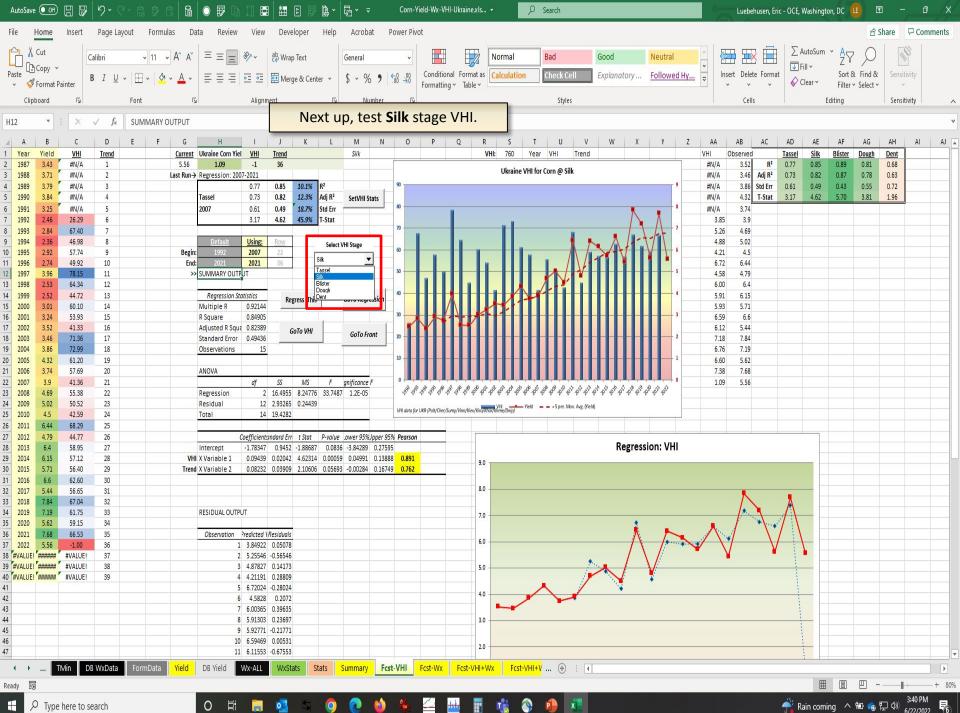


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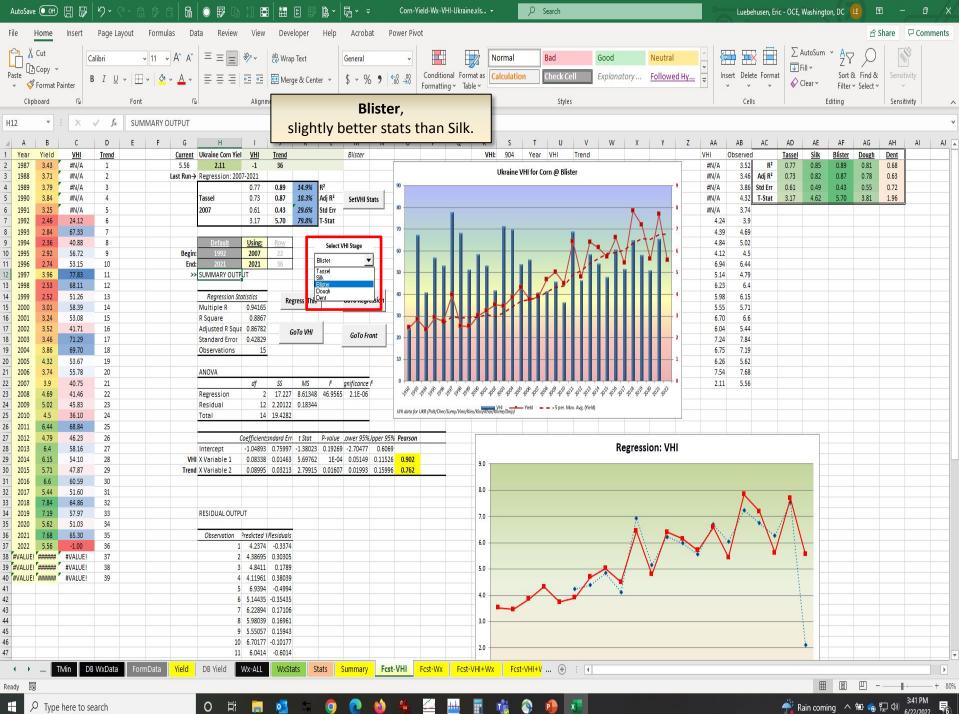




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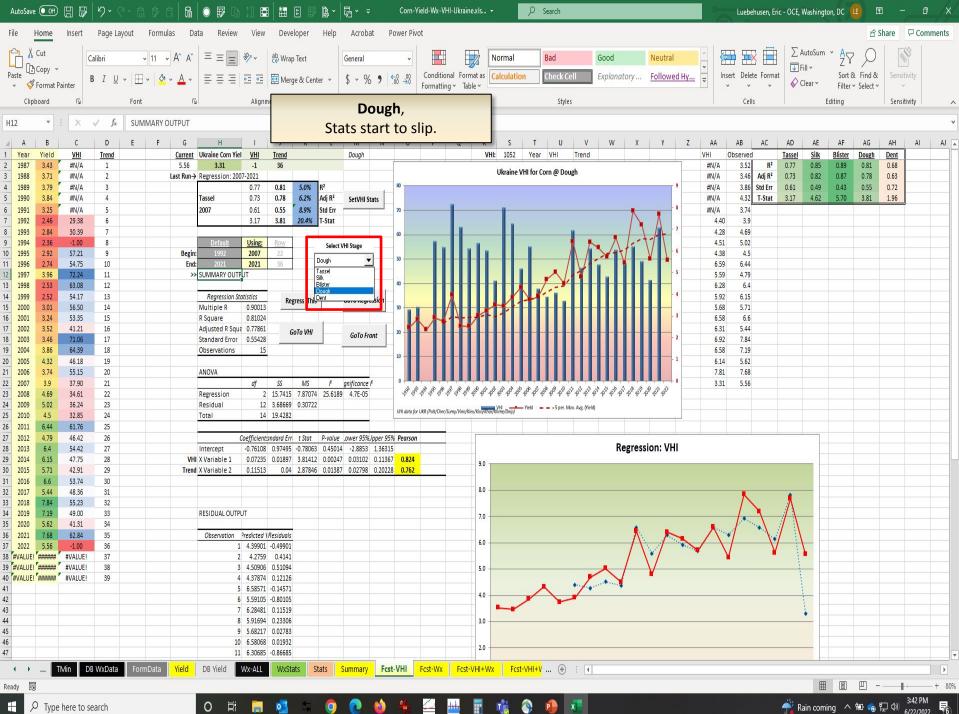


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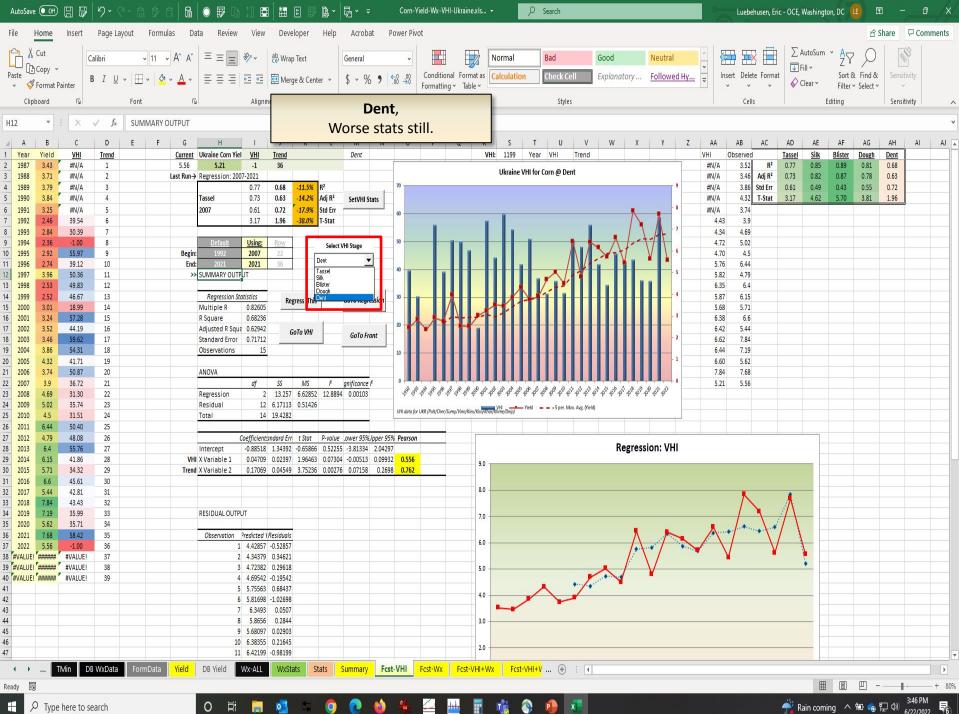


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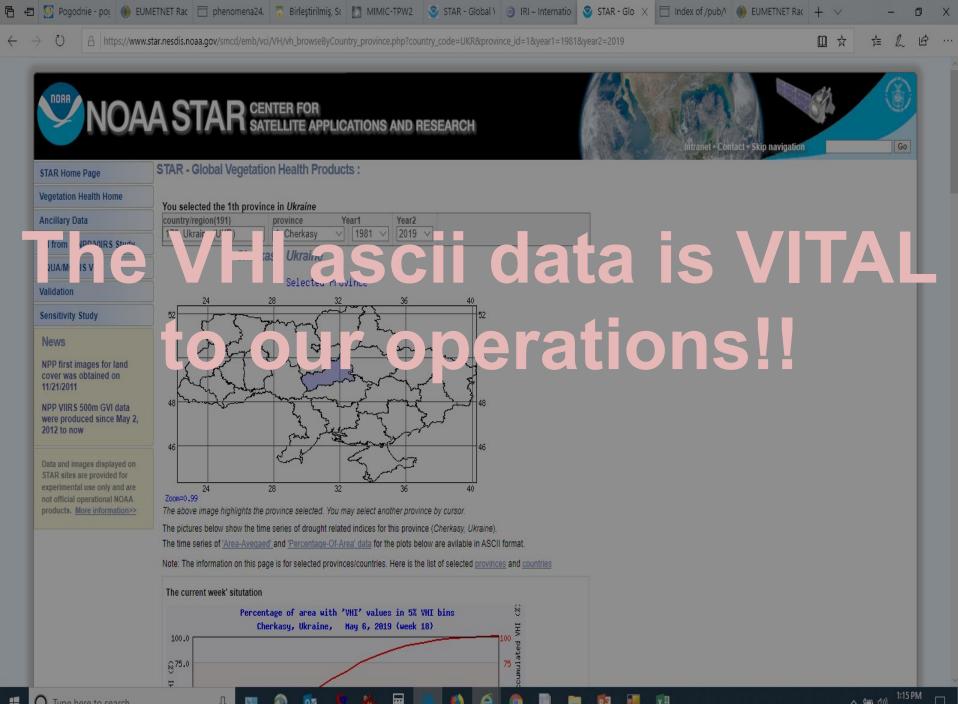
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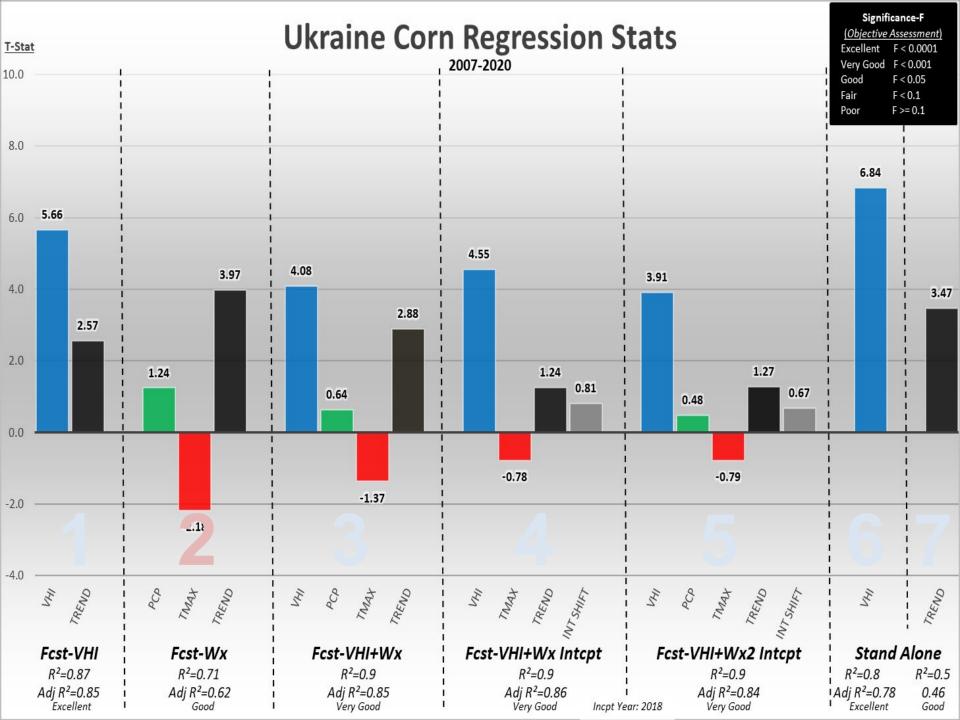
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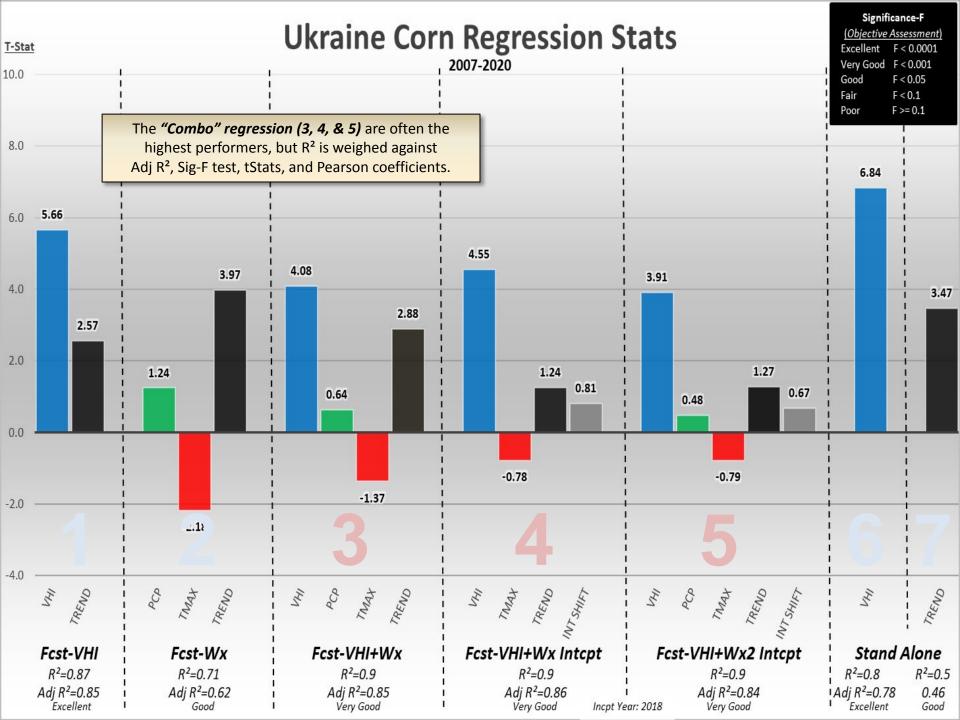
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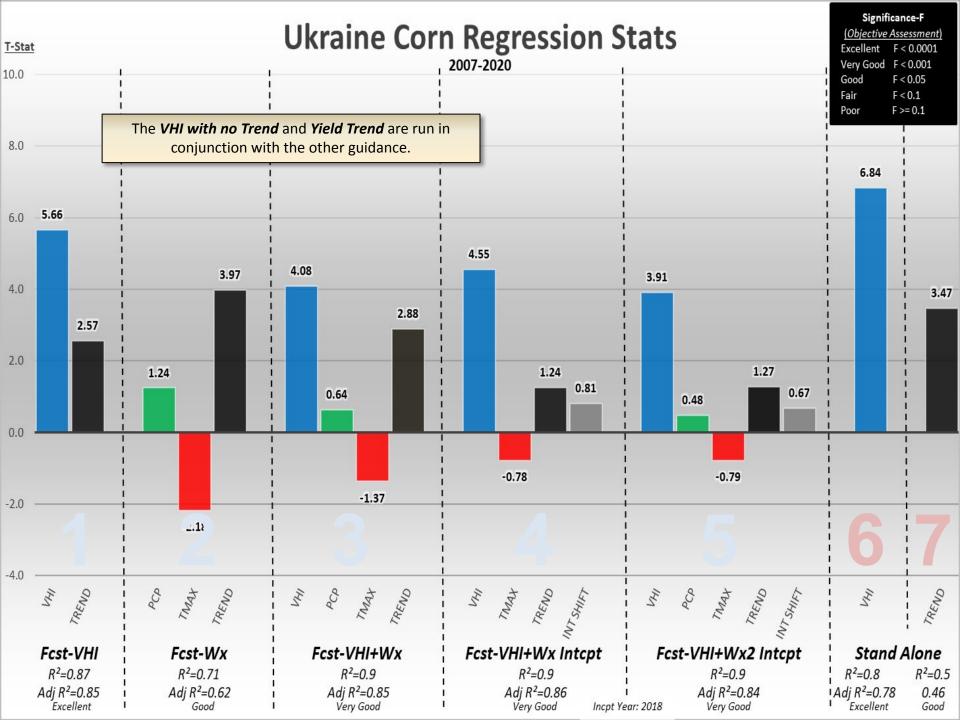
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14	Dough		0.48	0.48	0.46	0.42			Dough		-1.18	-1.04	-0.55	-0.15									-			
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Other Regression....



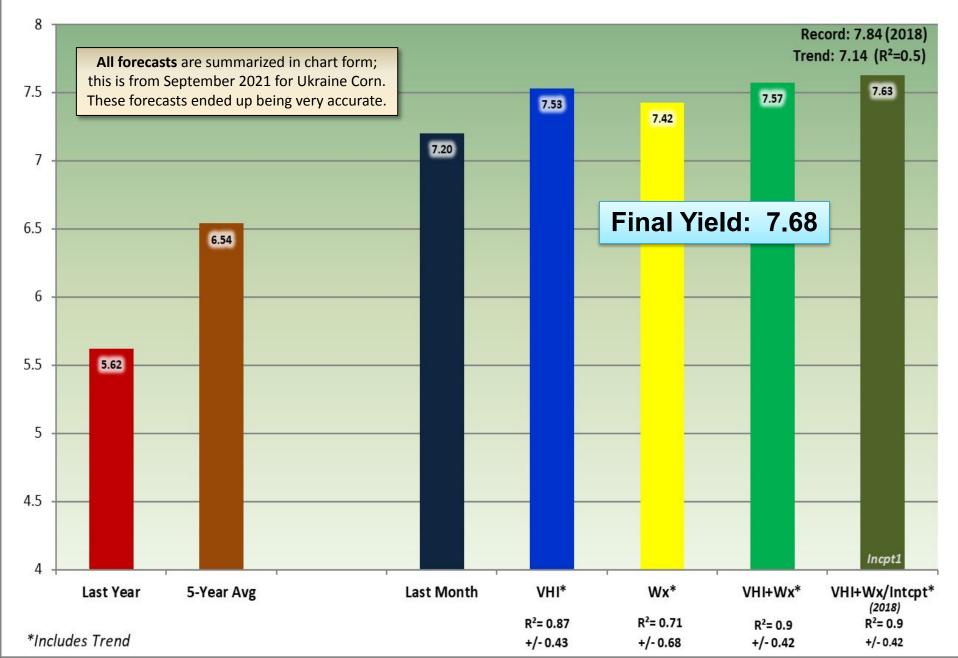


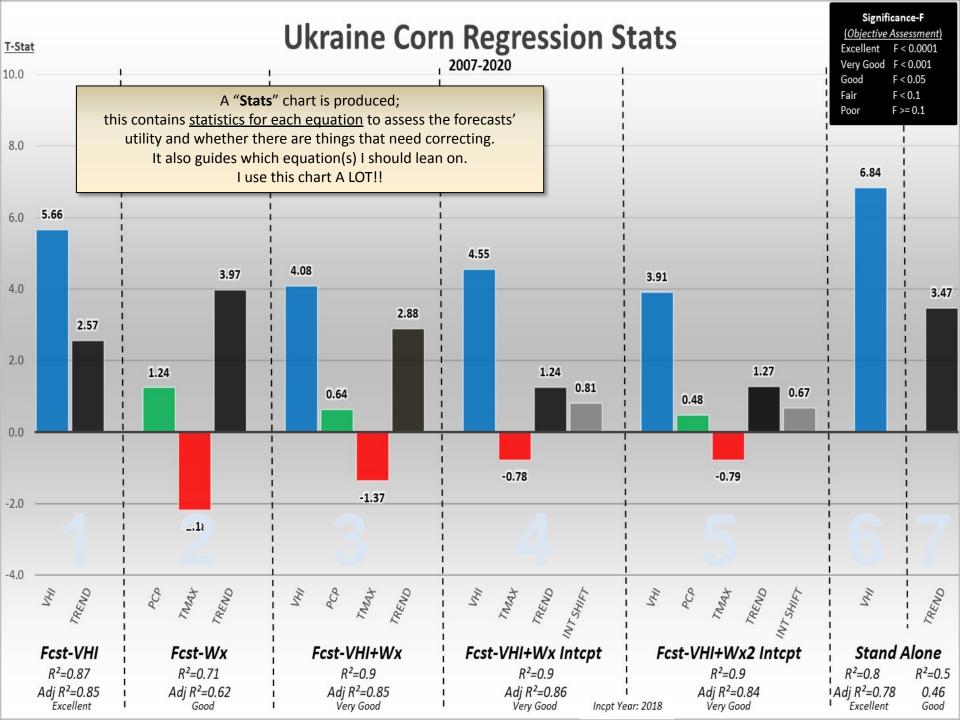


Output....

9/15/2021

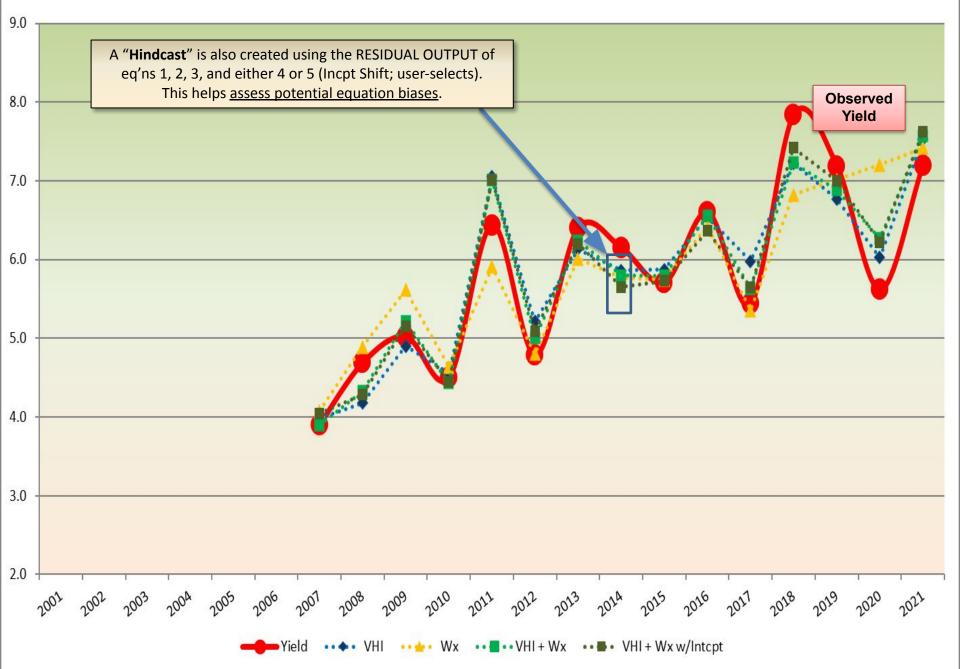
Ukraine Corn Regression





9/15/2021

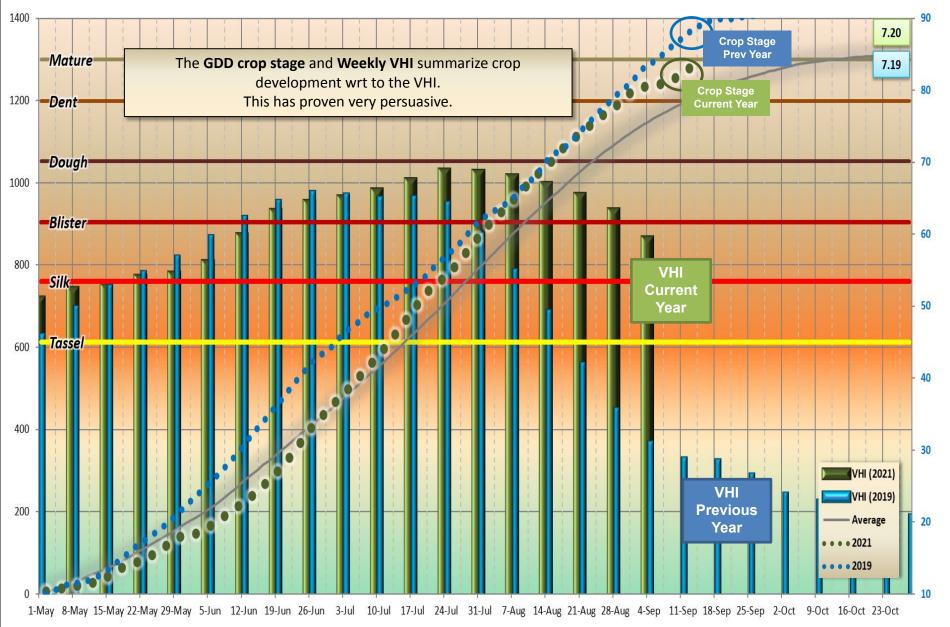
Ukraine Corn: Regression Hindcast vs Observed



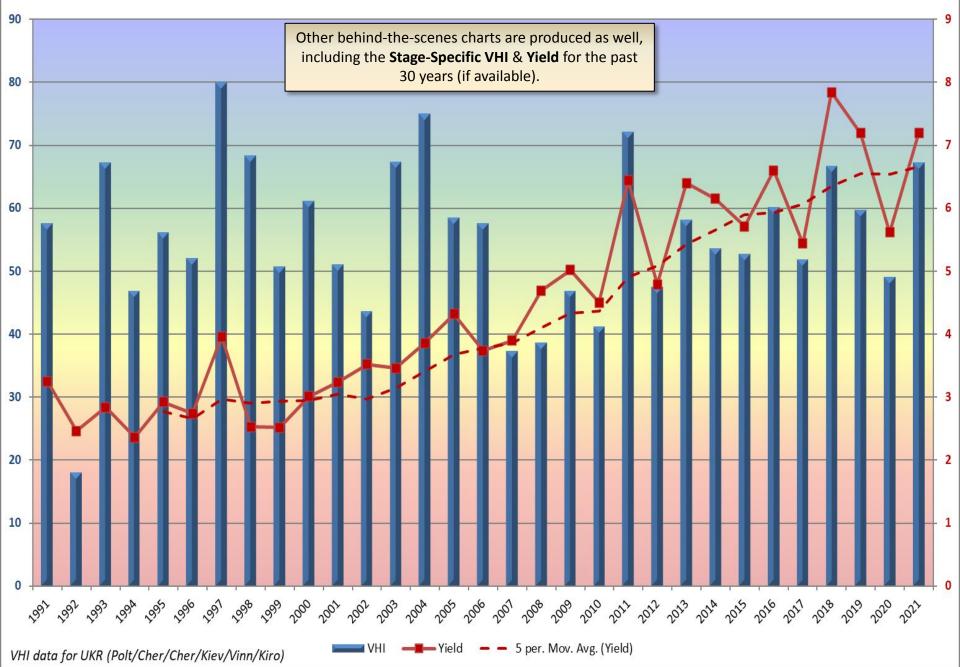


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Corn: Ukraine - Corn AVG



Ukraine VHI for Corn @ Blister



9/15/2021 <u>Wheat</u>	<u>Last Year</u>	PSD <u>Last Month</u>	Suggestion	<u>(E)</u>	Peak <u>(R²)</u>	Regression (Peak R ²)	Regression <u>Median</u>	Regression <u>Range</u>	Regression <u>Years</u>	Last <u>Updated</u>	<u>Trend (R²)</u>	<u>5y</u>	<u>Record</u>	Wx <u>Set?</u>	Suggestion <u>vs Trend</u>
Russia Wheat (Winter):	3.77	3.32	3.60	↑	0.89	3.99	3.94	3.8 - 4.05	1993-2020	8/22/21	3.72 (0.65)	3.73	4.17 (2017)	Yes	-3.2%
Ukraine Wheat:	3.71	4.46	4.60	↑	0.94	4.59	4.68	4.59 - 4.79	2003-2020	8/22/21	4.30 (0.63)	3.96	4.46 (2021)	Yes	7.0%
Moldova Wheat:	1.89	4.00	4.25	↑	0.96	4.23	4.39	4.21 - 4.59	2003-2020	8/22/21	3.30 (0.29)	3.10	4.03 (1993)	Yes	28.8%
Russia Wheat (Spring):	1.88	1.72	1.70	Ξ	0.83	1.69	1.65	1.55 - 1.72	1998-2020	9/15/21	1.75 (0.47)	1.76	1.89 (2017)	Yes	-2.9%
Kazakhstan Wheat:	1.18	0.98 A	summa	-				en down by	- ·		here) is	<u>1.17</u>	1.66 (2011)	Yes	-25.2%
<u>Barley</u> Ukraine Barley (Winter):	3.08	3.89		þ	ubiisn	eu anu se	ent to the	different co	inmoulty §	groups.		3.20	3.89 (2021)	Yes	11.3%
Moldova Barley:	2.25	3.83			•			ation; many				2.86	3.83 (2021)	Yes	22.9%
				-		·		ard during t			_				
Russia Barley (Spring):	2.53	2.32	2.30	=	0.89	2.33	2.28	2.24 - 2.33	2007-2020	9/15/21	2.41 (0.22)	2.38	2.62 (2017)	Yes	-4.6%
Kazakhstan Barley: Com	1.34	1.14	1.15	=	0.88	1.17	1.24	1.17 - 1.29	1997-2020	9/15/21	1.53 (0.36)	1.50	1.71 (2011)	Yes	-24.8%
Russia Corn:	5.08	5.54	5.60	=	0.95	5.69	5.72	5.55 - 5.76	2001-2020	9/15/21	5.63 (0.75)	5.20	5.70 (2019)	Yes	-0.5%
Ukraine Corn:	5.62	7.20	7.55	↑	0.90	7.57	7.55	7.42 - 7.63	2007-2020	9/15/21	7.14 (0.5)	6.54	7.84 (2018)	Yes	5.7%
Moldova Corn:	2.65	4.80	5.05	1	0.88	5.07	5.05	4.16 - 5.96	2004-2020	9/15/21	3.48 (0.09)	3.58	5.02 (1989)	Yes	45.1%
Belarus Corn:	6.00	5.31	5.35	=	0.72	5.67	5.38	5.22 - 5.67	2010-2020	9/15/21	5.95 (0.09)	5.91	6.59 (2011)	Yes	-10.1%
<u>Oilseeds</u> Russia Sunflowers:	1.59	1.67	1.65	=	0.99	1.65	1.66	1.64 - 1.72	2005-2020	9/15/21	1.71 (0.78)	1.60	1.83 (2019)	Yes	-3.5%
Ukraine Sunflowers:	2.01	2.50	2.55	=	0.93	2.39	2.48	2.39 - 2.64	2006-2020	9/15/21	2.48 (0.77)	2.23	2.58 (2019)	Yes	2.8%
Moldova Sunflowers:	1.31	2.33	2.50	1	0.97	2.32	2.50	2.32 - 2.58	2006-2020	9/15/21	2.26 (0.65)	1.94	2.33 (2021)	Yes	10.6%
Kazakhstan Sunflowers:	1.23	1.20	1.20	=	0.90	1.06	0.99	0.94 - 1.06	1997-2020	9/15/21	0.99 (0.65)	1.04	1.23 (2020)	Yes	21.2%
Ukraine Rapeseed:	2.31	2.70	2.95	1	0.96	2.92	3.22	2.92 - 3.34	2000-2020	9/15/21	3.01 (0.86)	2.67	2.85 (2018)	Yes	-2.0%
Ukraine Soybeans:	2.05	2.43	2.57	↑	0.93	2.56	2.58	2.37 - 2.69	2007-2020	9/15/21	2.45 (0.66)	2.24	2.58 (2018)	Yes	4.9%
Russia Soybeans:	1.59	1.59	1.55	↓	0.94	1.56	1.61	1.56 - 1.62	2005-2020	9/15/21	1.64 (0.89)	1.50	1.59 (2020)	Close	-5.5%
	1.59			↓											

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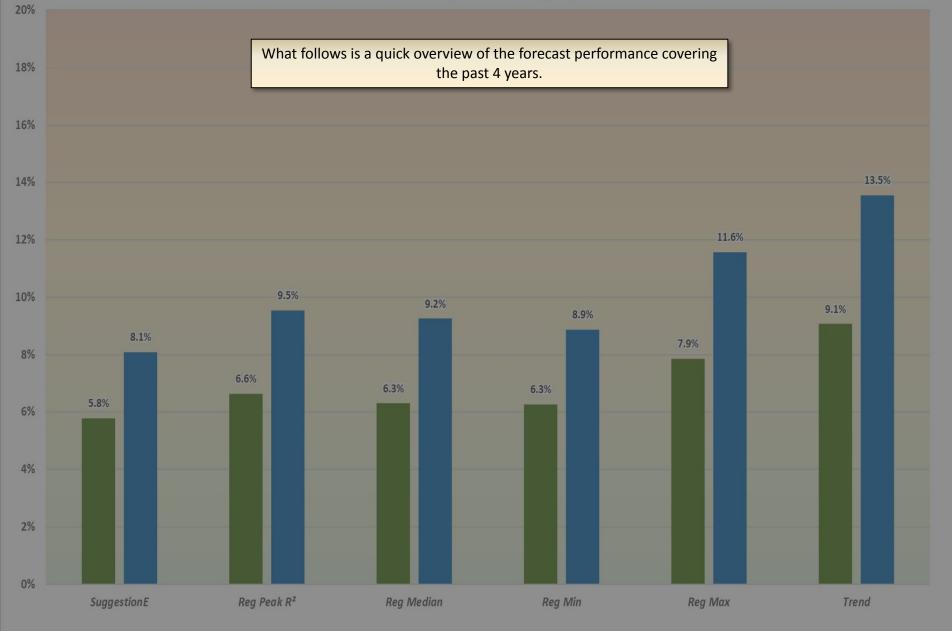
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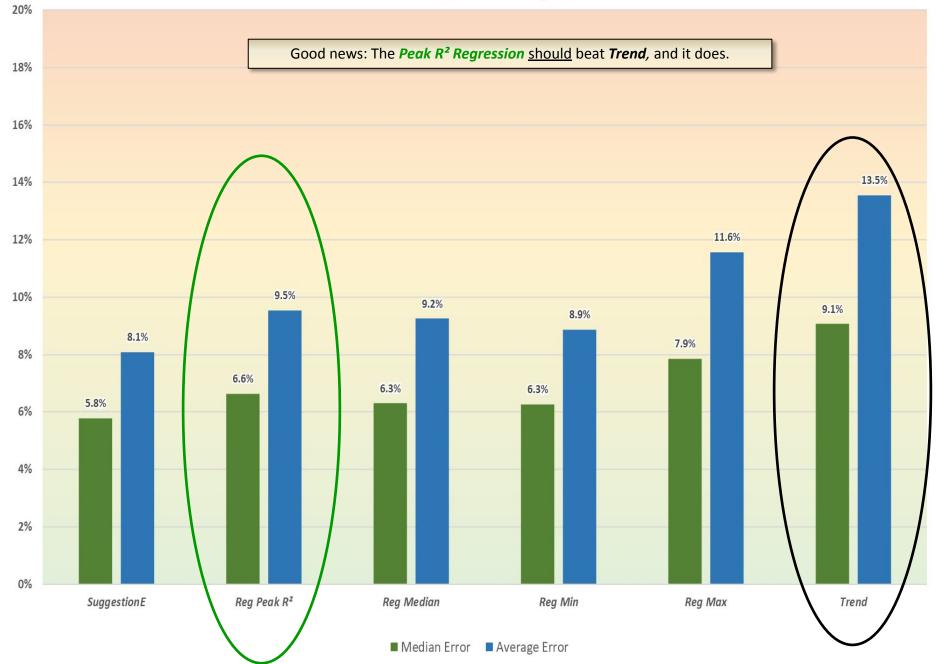
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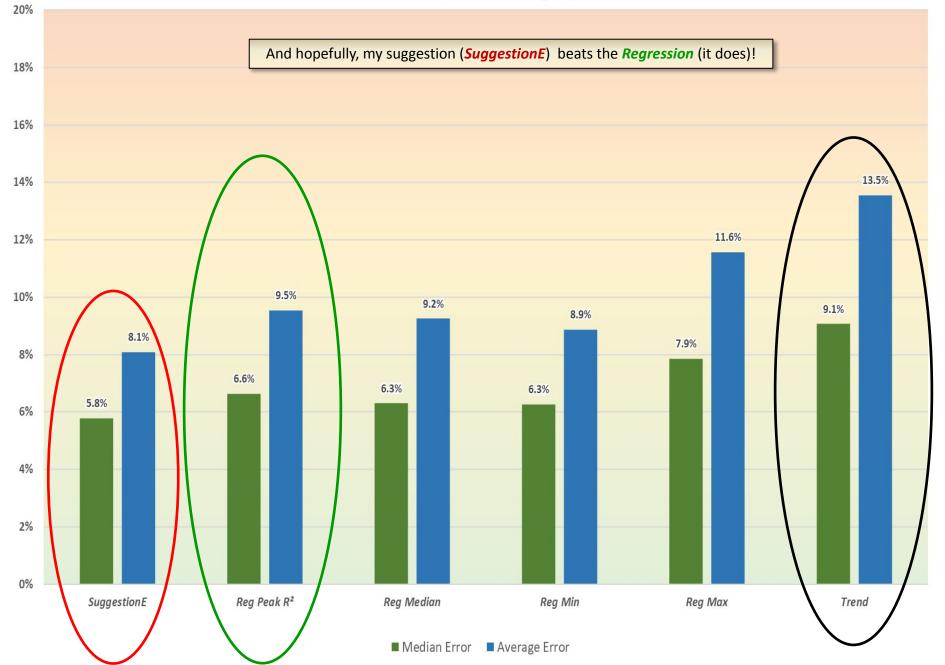
Errors - All Areas, All Crops, 2018-2021



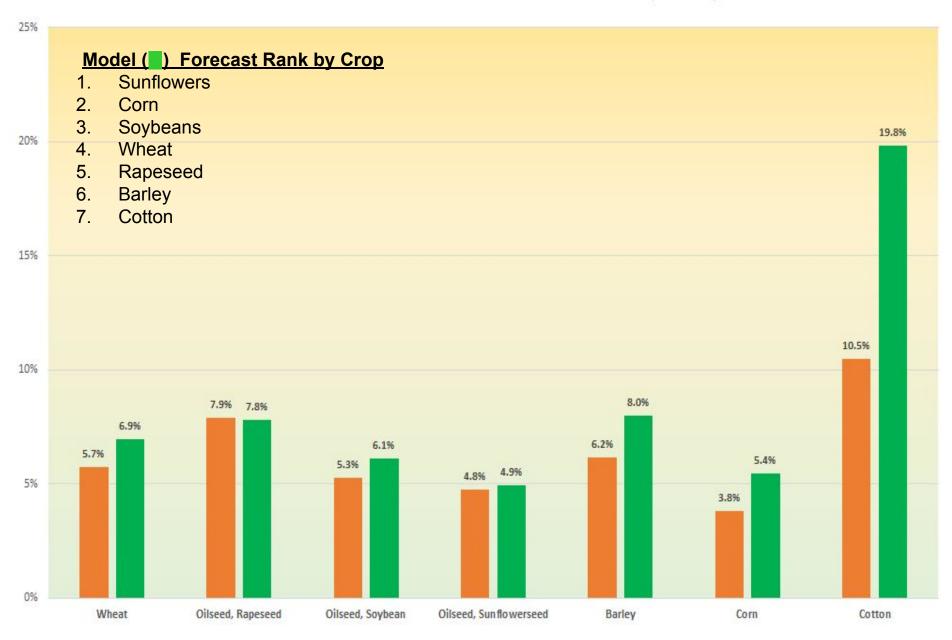
Errors - All Areas, All Crops, 2018-2021



Errors - All Areas, All Crops, 2018-2021



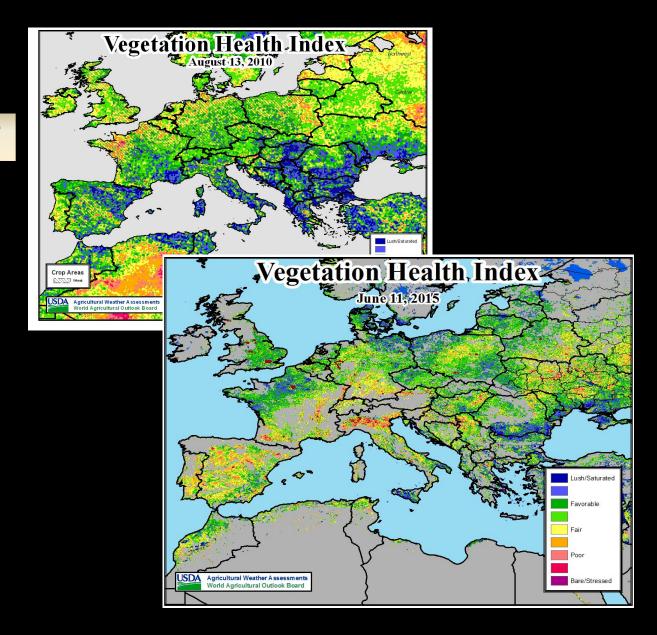
2018-21 Median Forecast Error - By Crop



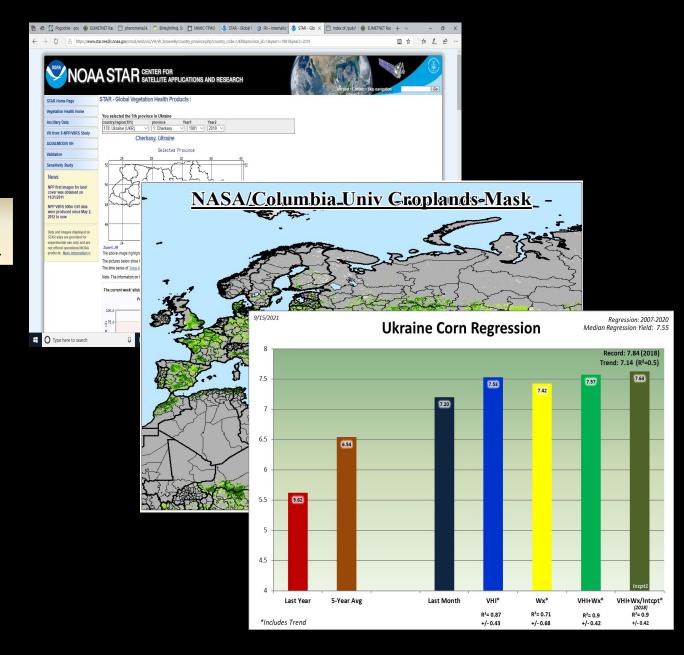
SuggestionE Peak R² Fcst

Conclusions....

We have been using the VHI in some form operationally since 2007.



The VHI ascii data and croplands masked ascii data were game changers for USDA-WAOB operations.



Russia Corn Regression

