Crop Yield Outlooks under Extreme Weather: lessons learnt

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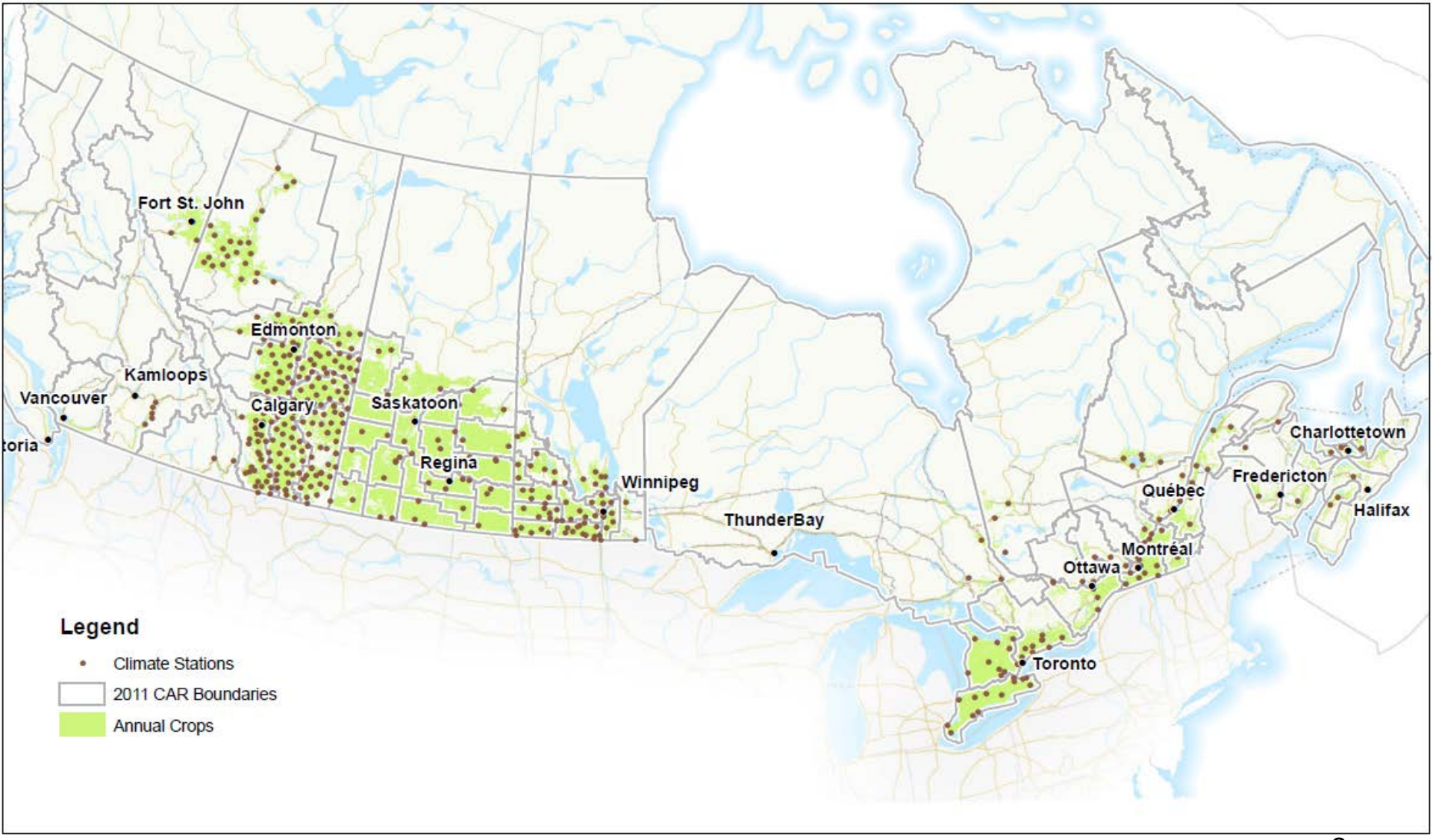
Outline

- **Brief description of the tool**
- **Model Performance under extreme weather**
- **Solutions**
- **Summary**

Study Area: Climate Stations, CARs and Crop Land



Methodology: Baseline CAR Model

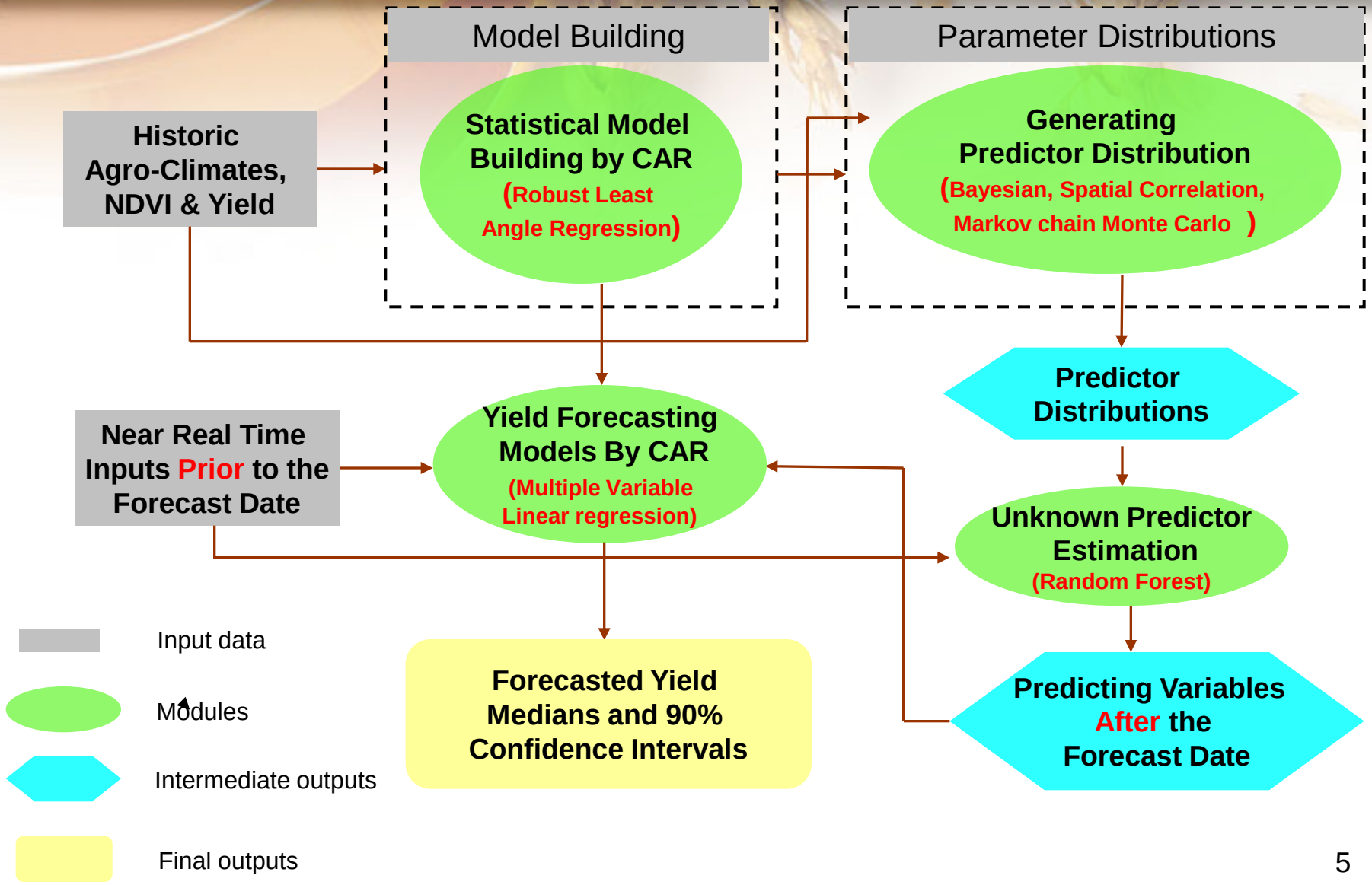
yield at year *t*

linear effects of the top ranked variables (e.g. water deficit)

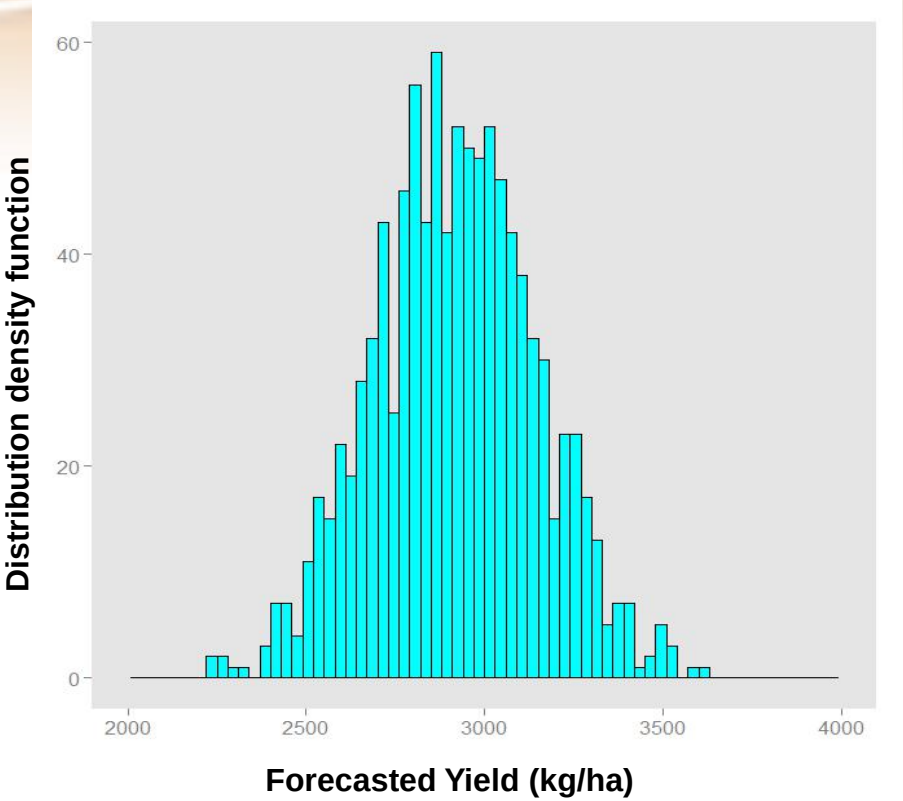
error term

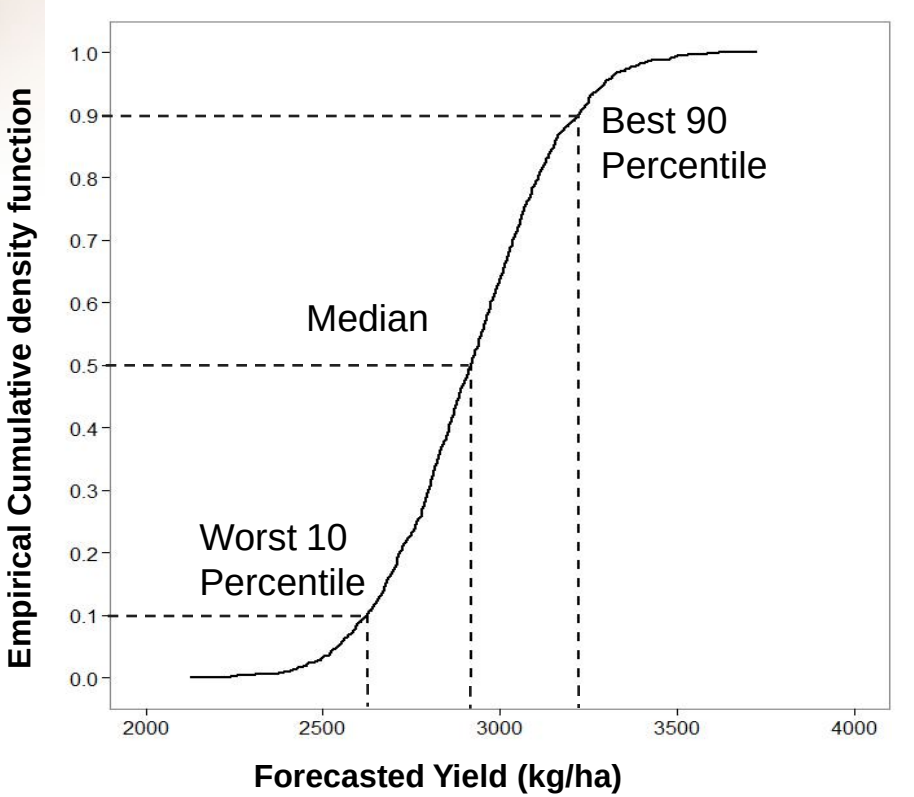
$$y_t = \alpha_0 + \underbrace{\alpha_1 t}_{\text{linear trend (technology)}} + \sum_{i=1}^{I} \beta_i x_{ti} + \varepsilon_t$$

Core Data and Statistical Modules of ICCYF



Probability Forecast: Yield Distributions

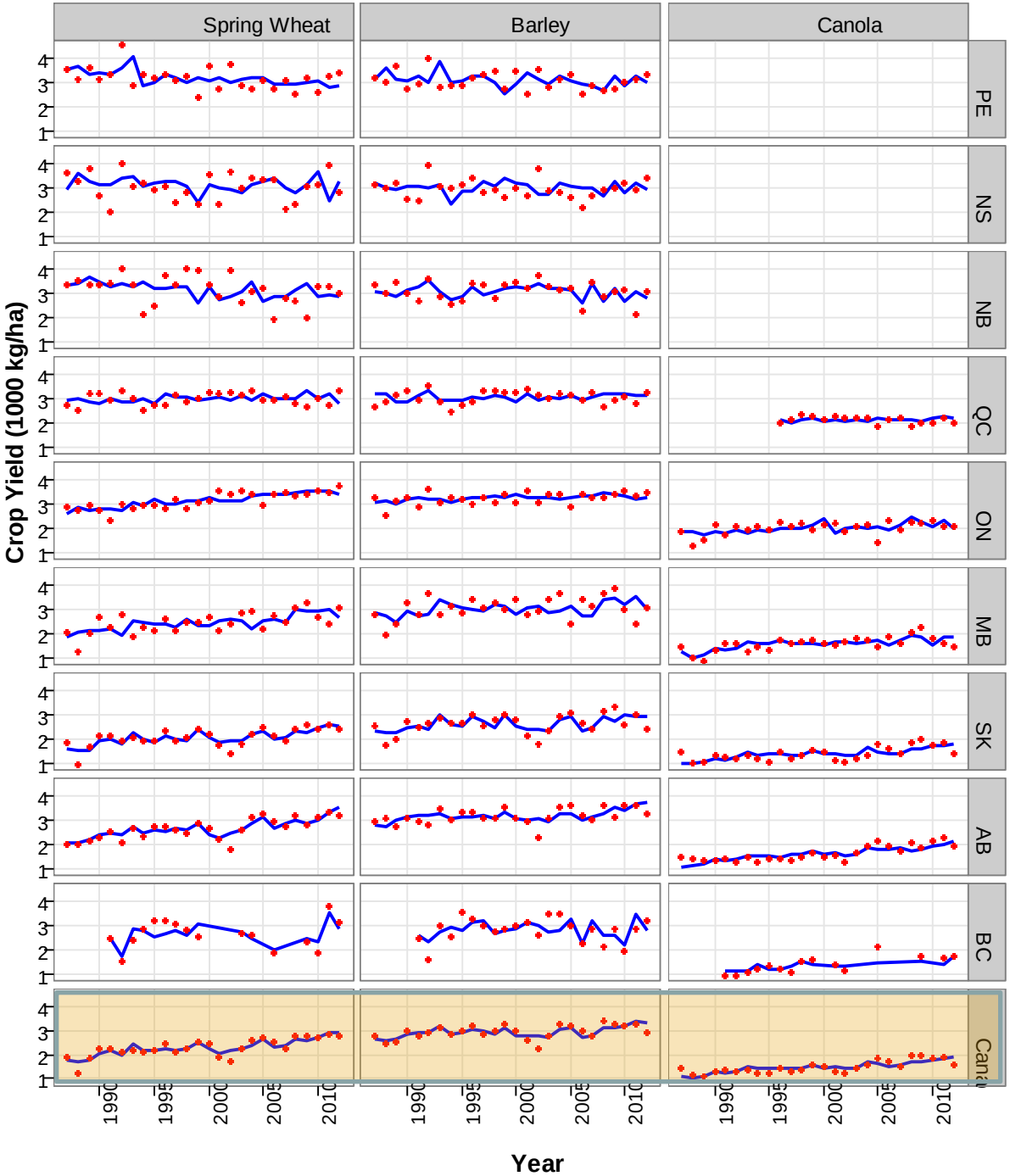




August Forecasted *VS. November* Surveyed Yields at <u>Provincial</u> and <u>National</u> Scales During LOOCV Tests (1987-2012)

Modelled Yield

Surveyed Yield



Definition of extreme weather

1) Extreme dry: AvgSI_68 >1.5 SD

2) Extreme wet: SumPcpn_58 > 1.5 SD

3) Neutral: Outside of 1) and 2)

Avgas: Average
SI : Stress Index: (1-AET/PET))
SD: Standard Deviation

Evaluation of Yield Prediction

1) Overestimate: Yp-Ys >= 1.5 Y_SD
2) Underestimate : Yp-Ys <= -1.5 Y_SD
3) Neutral: 1.5 Y_SD < Yp-Ys < -1.5 Y_SD

Yp: Predicted yield
Ys : Final surveyed yield
Y_SD: Standard deviation of historical yield

Model Performance under extreme weather (Spring Wheat)

Yield outlook compared to survey results	Climate Extreme Type			
	Dry	Average	Wet	Total
Neutral	77 (72%)	823 (90%)	70 (86%)	970
Over estimate	26 (24%)	32 (4%)	8 (10%)	66
Under estimate	4 (4%)	53 (6%)	3 (4%)	60
Total	107	908	81	1096

Model Performance under extreme weather (Canola)

Yield outlook compared to survey results	Climate Extreme Type			
	Dry	Average	Wet	Total
Neutral	85 (79%)	820 (88%)	74 (88%)	979
Over estimate	17 (16%)	51 (5%)	7 (8%)	75
Under estimate	5 (5%)	64 (7%)	3 (4%)	72
Total	107	935	84	1126

Model Performance under extreme weather (Barley)

Yield outlook compared to survey results	Climate Extreme Type			
	Dry	Average	Wet	Total
Neutral	106 (72%)	1197 (92%)	88 (79%)	1391
Over estimate	28 (19%)	63 (5%)	24 (21%)	115
Under estimate	13 (9%)	39 (3%)	0	52
Total	147	1299	112	1588

Model Performance under extreme weather (Corn for Grain)

Yield outlook compared to survey results	Climate Extreme Type			
	Dry	Average	Wet	Total
Neutral	25 (86%)	244 (88%)	14 (74%)	283
Over estimate	4 (14%)	20 (7%)	5 (26%)	29
Under estimate	0 (0%)	12 (5%)	0	12
Total	29	276	19	324

Model Performance under extreme weather (Soybeans)

Yield outlook compared to survey results	Climate Extreme Type			
	Dry	Normal	Wet	Total
Neutral	17 (71%)	232 (93%)	17 (80%)	266
Over estimate	7 (29%)	12 (5%)	2 (10%)	21
Under estimate	0 (0%)	5 (2%)	2 (10%)	7
Total	24	249	21	294

Summary of Model Performance in Extreme Years

- Model generally performed well in years with average weather conditions.
- Model overestimated yields in years with extreme moisture conditions, especially dry years.
- Corn and soybeans were not consistent in their response to extreme events.

Some corrective measures

- Crop specific cover masks were used when deriving climate and NDVI predictors.
- Predicted yields were constrained if predictor variables such as heat stress or frost were experienced .
- Appropriate definitions of heat units for canola, corn etc. were used instead of using GDDs above a fixed threshold.

Improvement With Alternative Climate Indices -- Spring Wheat

Index	R2	MEI (neg. / total)	Mean Percent Error	*R2 increased
Baseline	0.39	7/41	17.0	
EGDD_C_SumHeatD_SumPcpn	0.40	5/41	16.6	22/41
CHU_SumHeatD	0.41	5/41	16.7	29/41

- Variance explained increases when variables are carefully selected
- Model errors drop compared to baseline

Corn Test Results

#	Corn	MEI(neg)	MRE_pct	Indices Selected						
1	Baseline	2/12	11.62	SumEGDD_W	SDGDD5	SumHeatD	SumHEAT_Index	SumPcpn	AvgSI	SumPrcnAWHC
2	EGDD_C	2/12	12.05	SumEGDD_C	SDEGDD_C	√	√	√	√	
3	EGDD_W	1/12	10.65	SumEGDD_W	SDEGDD_W	√	√	√	√	√
4	GDD5	2/12	12.13	SumGDD5	SDGDD5	√	√	√	√	√
5	CHU	1/12	10.95	SumCHU		√	√	√	√	√
6	CHU_SumHeatD	1/12	10.96	SumCHU		√		√	√	√
7	CHU_SumHEAT_Index	1/12	11.69	SumCHU			√	√	√	√
8	EGDD_W_SumHeatD	2/12	11.12	SumEGDD_W	SDEGDD_W	√		√	√	√
9	EGDD_W_SumHEAT_Index	2/12	11.04	SumEGDD_W	SDEGDD_W		√	√	√	√
10	EGDD_W_SumPcpn	2/12	11.41	SumEGDD_W	SDEGDD_W	√	√	√		
11	EGDD_W_AvgSI	2/12	10.95	SumEGDD_W	SDEGDD_W	√	√		√	
12	EGDD_W_SumPrcnAWHC	1/12	11.49	SumEGDD_W	SDEGDD_W	√	√			√
13	CHU_AvgSI_SumPrcnAWHC	1/12	11.21	SumCHU		√	√		√	√
14	CHU_SumPcpn	1/12	10.56	SumCHU		√	√	√		
15	CHU_AvgSI	2/12	11.36	SumCHU		√	√		√	
16	CHU_SumPrcnAWHC	1/12	11.2	SumCHU		√	√			√
17	CHU_HeatD_SumPcpn	1/12	10.74	SumCHU		√		√		

Overall Summary

- **A statistics and GIS based crop yield forecasting tool is used to provide crop yield outlooks during the growing season. The tool integrates climate and NDVI data.**

- **The model results are comparable to observed values at the regional and national scales, however years with extreme dryness were over-estimated.**

- **By forcing the model to select predictors that have physical meaning in years with extreme weather, the variance between model results and observations and their errors were reduced.**

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Thank you!

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