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Progress Toward the Communication of Low Frequency and Extreme Agrometeorological Events and Their Trends

Delivered by Ted O'Brien

Saskatchewan DRI USER'S WORKSHOP

April 8, 2010



Project partners

- **National Service Office - Agriculture**, Weather and Environment Prediction and Services, Meteorological Service of Canada, Environment Canada (project design, leadership, coordination and indicator development);
- **Climate Data and Analysis Section & Adaptation Impacts Research Section**, Climate Research Division, Science and Technology Branch, Environment Canada (historical trend analysis);
- **Meteorological Research, Atmospheric Science and Technology**, Environment Canada
- **Environmental Health Program**, Eastern Cereal and Oilseed Research Centre, Research Branch, Agriculture and Agri-food Canada (historical analysis, development of risk identification and preparedness advisory service);
- **National Agroclimate Information Service**, AESB, Agriculture and Agri-Food Canada (significant event monitoring);
- **SAGES** “Determining interactions between land use and climate to evaluate impacts and adaptations to climate variability and change.”
- **TBD**, Canadian Meteorological Centre, Meteorological Service of Canada, Environment Canada (forecast);
- **World Meteorological Organization’s Regional Training Centre**, Nanjing, China (Project consultation).



Project team

- **Ted O'Brien, project sponsor, NSO - Agriculture, WEPS-MS-EC;**
- **Aston Chipanshi, project sponsor, project technical team member, NAIS-AESB-AAFC;**
- **Harvey Hill, project sponsor**
- **Sam Gameda, project sponsor, EHP-ECORC-RB-AAFC;**
- **Ted Huffman, project sponsor, EHP-ECORC-RB-AAFC;**
- **Hai Lin, Principle Investigator, SAGES, Meteorological Research**
- **Kai Chen, Project Developer, Past Lead, EC;**
- **Budong Qian, project co-lead, EHP-ECORC-RB-AAFC;**
- **Xuebing Zhang, project technical team member, Trend Analyses, CDAS-CRD-STB-EC;**
- **Yang Feng, computer programmer, CDAS-CRD-STB-EC;**
- **Dirk Anderson, project technical team member, EHP-ECORC-RB-AAFC;**
- **To be determined, project technical team member, CMC-MS-EC;**
- **Heather Auld, (Adam Fenech, Robin Rong) AIRS, S&T, EC**
- **Xiefei Zhi, project consultant, WMO-Regional Training Centre, Nanjing, China;**

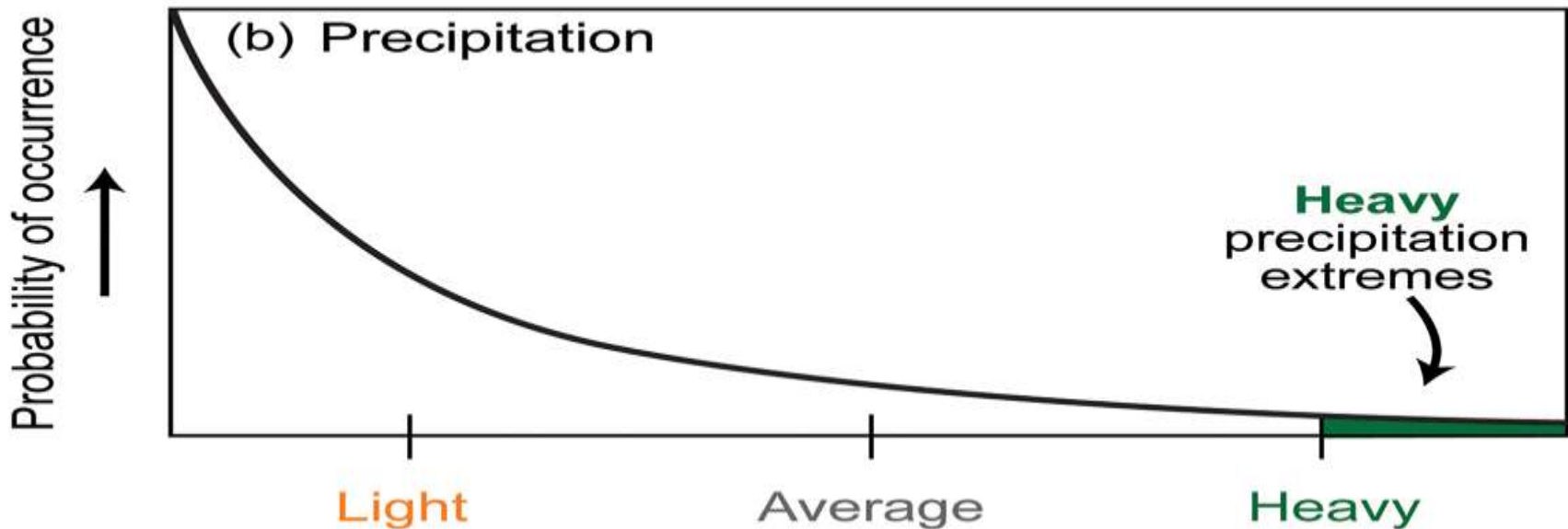
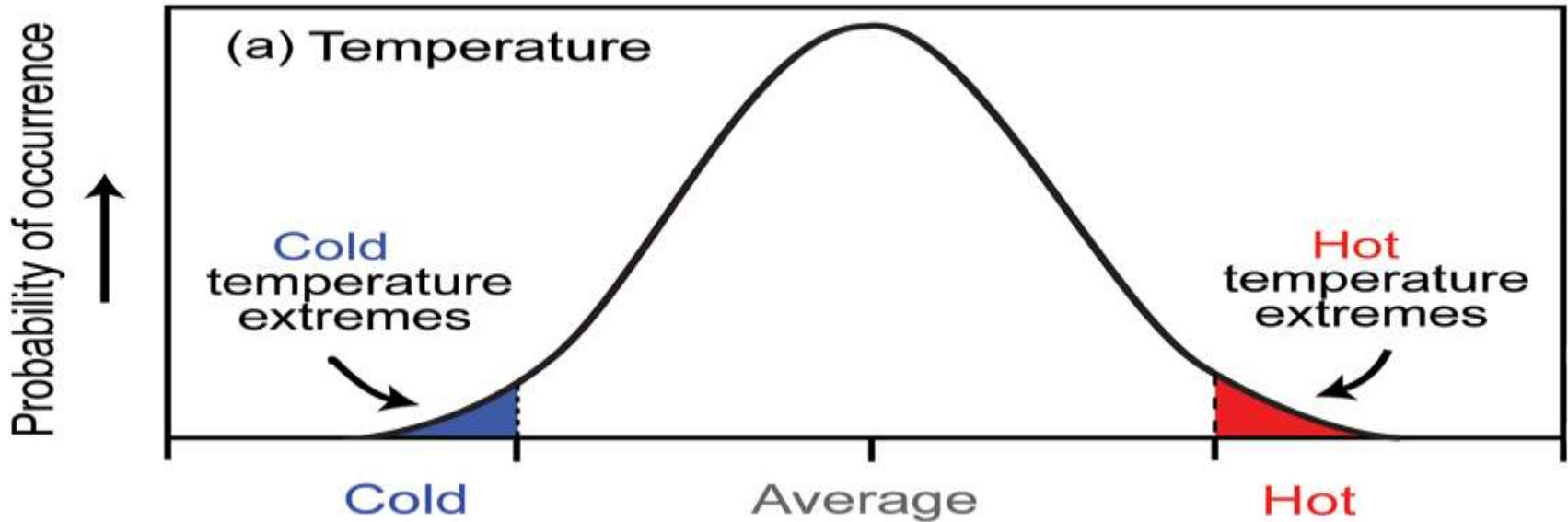


Phases of the project

- Phase I - **Research User Needs, project planning and development** of the extreme agrometeorological indices
- Phase II - **Historical trend and variability analysis** on extreme agrometeorological events in Canada,
- Phase III - **Monitor** significant extreme agrometeorological events in all agricultural regions,
- Phase IV -
 - Research the Forecast Potential
 - **Forecast significant extreme agrometeorological events across the country,**
- Phase V – **Continue User Needs Assessment** and **communicate information about the risks and opportunities** to the Canadian agricultural sector.



What Is an Extreme?



Targeted extreme agrometeorological factors

- **extremely high or low air temperature,**
- **abnormally heavy or low precipitation,**
- **destructive freeze events,**
- **destructive wind events, and**
- **cumulative heat-energy indices.**

Targeted crop types

- **Cool season crops** -- wheat (*Triticum aestivum* and *Triticum durum*), barley (*Hordeum* ssp.), canola (*Brassica napus*), oat (*Avena* ssp.), rye (*Secale cereale*), etc.
- **Warm season crops** -- bean (*Phaseolus* spp.), corn (*Zea mays*), pea (*Pisum* spp.), potato (*Solanum tuberosum*) and soybean (*Glycine max*), etc.
- **Over-wintering crops** -- biennial and perennial herbaceous plants (strawberry, alfalfa, timothy, and other forage crops) and woody fruit trees (apple, pear, peach, cherry, plum, apricot, chestnut, pecan, grape, etc.).

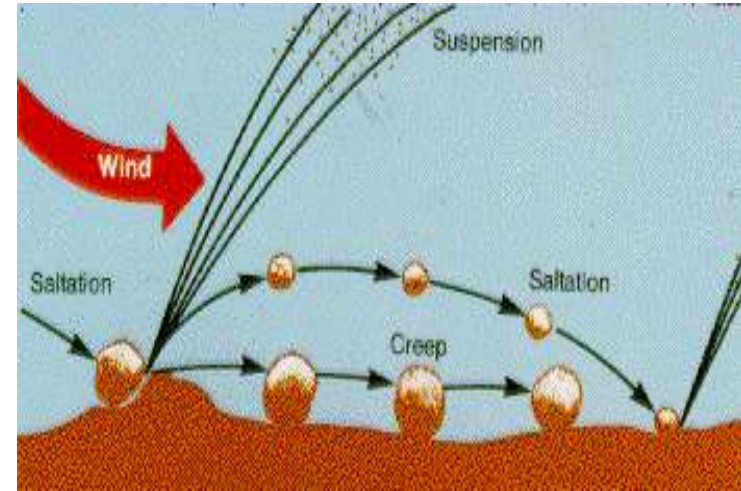
Identified indices and indicators (1)

- Temperature-based indices:
 - Days of cool wave (DCW),
 - Days of heat wave (DHW);
 - 7 & 14 day; 30 days, 4 months
- Precipitation-based indices:
 - Greatest daily precipitation (P1D),
 - Greatest 10-day precipitation (P10D);
 - 14 day



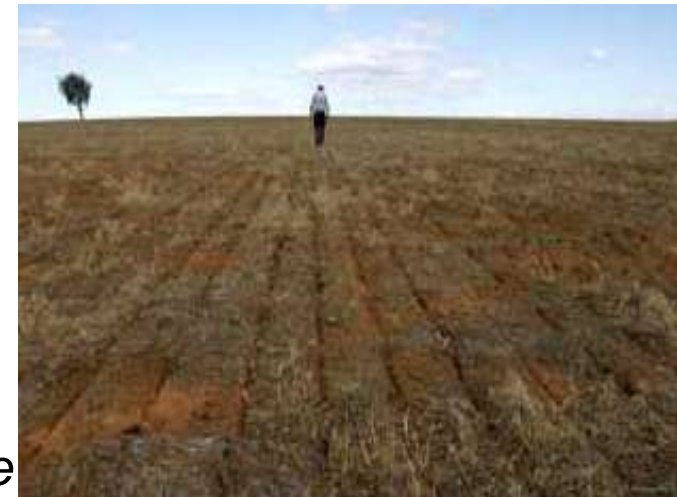
Identified indices and indicators (2)

- Wind-based indices:
 - Maximum daily wind speed (MDWS),
 - Number of strong wind days (NSWD);
 - 14 day
- Freeze-based indices:
 - Number of frost-free days (NFFD),
 - 14 day, 30 day, season
 - Number of ice-freeze days (NIFD);
 - 30 day and seasonal

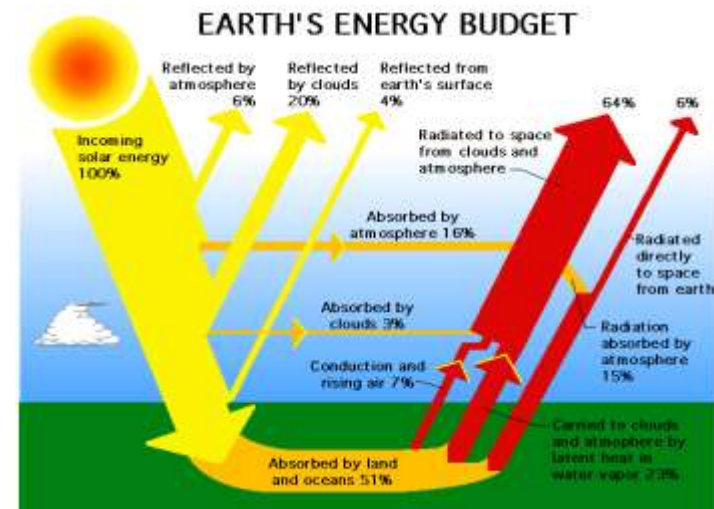


Identified indices and indicators (3)

- Moisture-based indices:
 - Standardized precipitation index (SPI),
 - 30 day and 120 day
 - Seasonal water deficit (SWD, i.e., PE-P);
 - *Under discussion also soil moisture*



- Heat energy-based indices:
 - Effective growing degree days (EGDD),
 - Cumulative crop heat unit (CCHU),
 - 7 day, 14 day, 30 day, seasonal



Summary of Current Status

- Twelve indicators and evaluation methods and techniques of extreme agrometeorological events have been identified and developed.
- Criteria for cardinal temperature and growing season starting and ending dates have been established for the proposed three types of field crops in Canada.
- Criteria for drought and excessive wetness three types of field crops during crop growing season have been established.
- Criteria for critical frost and ice-freeze killing temperatures have been established for three types of field crops during an agricultural year.
- Conducted historical trend and variability analyses of extreme agrometeorological events in Canadian agricultural regions for all but the wind-based elements.

Cardinal temperature criteria for selected types of field-crop growth during the growing season

Crop type	CT_{min} (°C)	T_{opt} (°C)	CT_{max} (°C)
Cool season crops	5.0	25.0	30.0
Warm season crops	10.0	30.0	35.0
Over-wintering crops	5.0	25.0	35.0



Traditionally fixed time frames of crop growing season and agricultural year in Canada*

Type of field crops	Crop growing season	Agricultural year
Cool season crops	Apr. 1 to Aug. 31	Sep. 1 to Aug. 31
Warm season crops	May 1 to Sep. 30	Oct. 1 to Sep. 30
Over-wintering crops	Apr. 1 to Sep. 30	Oct. 1 to Sep. 30

* The time period beyond crop growing season is considered as non-growing season in an agricultural year.

DRAFT – Page 13 – April 19, 2010



Crop cardinal temperature-based time frames for growing season start (GSS) and growing season ending (GSE) dates

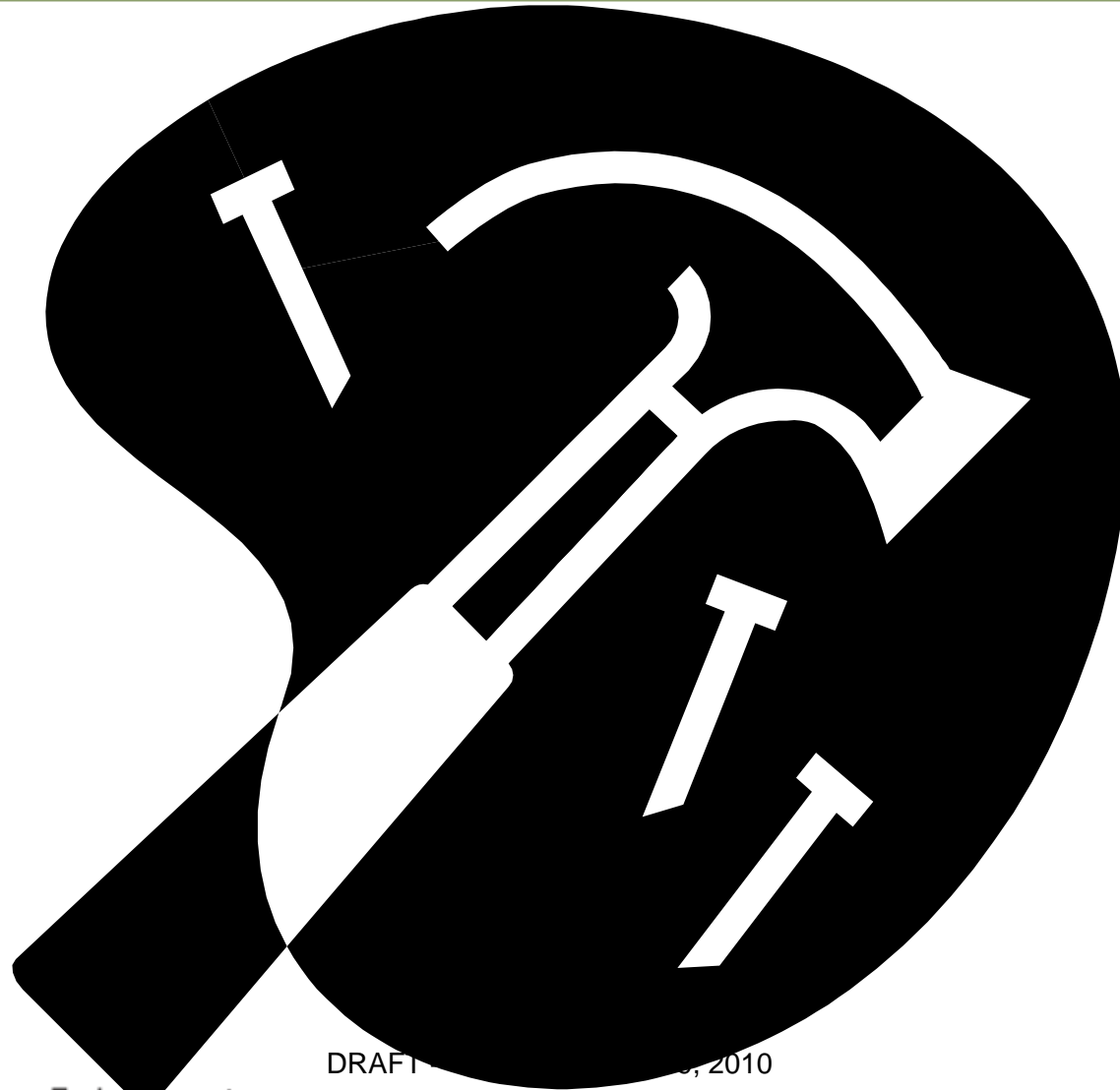
Type of field crops	GSS = CT_{min}	GSE = CT_{min} , or CT_{max} , or Fixed date
Cool season crops	GSSc - 10 consecutive days with $T_{mn} = 5.0\text{ }^{\circ}\text{C}$	GSEc = $30\text{ }^{\circ}\text{C}$, or Aug. 1 at the earliest / Aug. 31 at the latest
Warm season crops	GSS - 10 consecutive days with $T_{mn} = 10.0\text{ }^{\circ}\text{C}$	GSEw less than $10.0\text{ }^{\circ}\text{C}$
Over-wintering crops	GSSo - 10 consecutive days with $T_{mn} = 5.0\text{ }^{\circ}\text{C}$	GSEo = $5.0\text{ }^{\circ}\text{C}$

Criteria for Standardized Precipitation Index (SPI) values and extreme agrometeorological events

SPI value (mm)	Agrometeorological event	SPI value (mm)	Agrometeorological event
-0.50 to -0.01	Not dry	0.50 to 0.01	Not wet
-0.80 to -0.51	Incipient dryness	0.80 to 0.51	Incipient wetness
-1.30 to -0.81	Slight drought	1.30 to 0.81	Slight wetness
-1.60 to -1.31	Moderate drought	1.60 to 1.31	Moderate wetness
-2.00 to -1.61	Severe drought	2.00 to 1.61	Severe wetness
≤ -2.01	Extreme drought	≥ 2.01	Extreme wetness



Criteria for Seasonal Water Deficit (SWD=PE-P) values and extreme agrometeorological events



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Criteria for Critical Frost Killing Temperature of field crops during the growing season

Crop type	Critical frost killing temperature
Warm season crops	0.0 °C
Cool season crops, and over-wintering crops	-2.0 °C

Number of frost-free days required for field crops to maturity on the Prairies

Crop type	Cool season crops Base 5.0 °C					Warm season crops Base 10 °C		
Crop name	Wheat	Buck wheat	Oat	Barley	Canola	Corn	Bean	Soy-bean
Range	83 to 103	70 to 90	82 to 98	70 to 90	85 to 102	100 to 120	85 to 100	105 to 120
Criteria	On an average, cool-season crops: 87 days					On an average, warm-season crops: 105 days		

DRAFT – Page 18 – April 19, 2010



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Criteria for Critical Ice-Freeze Killing Temperature of over-wintering crops in an agricultural year

Season	Physiological status of plant	Time-period	Group of over-wintering field crops	Critical ice-freeze killing temperature
Growing season	Growing	Apr. 1 to Sep. 30	All over-wintering crops	-2.0 °C
Non-growing season	Non-dormant	Mar. 1 to Mar. 31, and Oct. 1 to Nov. 30	Biennial or perennial herbaceous crops	-5.0 °C
			Woody-like deciduous fruit-tree crops	-10.0 °C
	Dormant	Dec. 1 to Feb. 28/29	Biennial or perennial herbaceous crops	-15.0 °C
			Woody-like deciduous fruit-tree crops	-30.0 °C

Effective growing degree days (EGDD) for different field crops in Canada

Crop type	Cool season crops Base 5.0 °C				Warm season crops Base 10 °C		
	Wheat	Oat	Barley	Canola	Corn	Bean	Soybean
EGDD Range	1538 to 1680	1483 to 1750	1269 to 1540	1152 to 1445	1173 to 1779	1100 to 1300	1186 to 1719
Criteria	On an average, cool-season crop: 1485				On an average, warm-season crop: 1375		

Long-term trends (EGDD and CHU)

Percentage of stations showing a significant positive trend(++) or a significant negative trend (--)

	1895-2007				
Indices	#	++	+	-	--
EGDD _c	124	53.2	44.4	2.4	0.0
EGDD _o	124	64.5	29.8	5.6	0.0
EGDD _w	124	62.9	29.8	7.3	0.0
CHU _w	124	58.9	34.7	6.5	0.0



Long-term trends (EGDD and CHU)



EGDD over-wintering crops

CHU warm season crops

Median value of the trends: 153 degree-days and 228 units/100yrs



Long-term trends (SPI and SWD)

Percentage of stations showing a significant positive trend(++) or a significant negative trend (--)

Indices	1895-2007				
	N	++	+	-	--
SPI _c	81	35.8	48.1	16.0	0.0
SPI _o	80	31.2	48.7	20.0	0.0
SPI _w	81	29.6	54.3	14.8	1.2
SWD _c	80	0.0	22.5	50.0	27.5
SWD _o	80	1.2	17.5	43.7	37.5
SWD _w	81	0.0	25.9	48.1	25.9



Long-term trends (SPI and SWD)



SPI over-wintering crops



SWD over-wintering crops

Extreme Variables include (some GCMs):

- 2 m Air Temperature Range (C)
- Consecutive Dry Days (days)
- Days with Rain > 10 mm/d (days)
- Fraction of Annual Total Precip > 95th percentile (%)
- Fraction of Time < 90th percentile min temp (%)
- Number of Frost Days (days)
- Maximum Heat Wave Duration (days)
- Maximum 5 Day Precipitation (mm)
- Simple Daily Intensity Index (mm/day)
- Growing Season Length (days)

Next steps

- Report on historical trend and variability analyses of extreme agrometeorological events in Canadian agricultural regions. Including Fact Sheets for the agriculture sector.
- Establish collaboration with AAFC-AESB-NAIS to develop the application of these elements for monitoring future significant extreme agrometeorological events in Canada.
- Research the forecast potential for these indicators **(SAGES)**.
- Obtain approval (dependent on budget and priorities) to establish collaboration with EC-MS-CMC for forecasting the agrometeorological elements where forecast skill has been demonstrated and can be verified.
- Research user needs and the design of a risk communication service for the agriculture sector with EC, AIRD; AAFC-RB-ECORC-EHP and NAIS; and provincial agriculture departments.
- Support NAIS in the communication of agrometeorological extremes, risks and opportunities and preparedness advice to the Canadian agricultural sector.

Goals

- Significant extreme agrometeorological event risks and opportunities will be identified for the future Canadian agricultural sector.
- Occurrence of the risk indices will be monitored in near real time for agricultural regions of the country.
- Potential occurrence or continuation of these weather and climate risks will be forecasted.
- Timely information will be enhanced for the Canadian agricultural sector through public sector agriculture departments (AAFC and provincial agriculture) with support from EC. This will ensure science-based advice and useful information is available for the identification of risks and opportunities, preparedness, response and adaptation to future extreme agrometeorological events.