

## Alberta Climate Information Service (ACIS) Definitions

### Disclaimer

Please note that due to technical difficulties AF's IT team has only committed to having ACIS and Roping the web services achieve a 95% uptime. As a result, frequent outages particularly around weekends do occur more often than they otherwise should.

Alberta Agriculture and Forestry's (AF) and its partners supply this data "as is" with no warranties neither expressed nor implied. The data, derivatives products and services are subject to change at any time. When data is deemed missing or invalid in AF's view, AF attempts to replace these values with estimates using a variety of methods. The user must recognize that such estimated data are not real observations. The user of this data assumes all responsibilities on its usage and for verifying the completeness and accuracy of this data for both critical and non-critical uses and applications. In no event will AF or its partners be in any way held liable to the user or any third parties who use this data or any derivatives, products or services arising from this data, for any damages whether indirect, direct, consequential, special or exemplary.

### Overview

Through this viewer Alberta Agriculture and Forestry (AF), provides weather data from approximately 430 meteorological stations across Alberta. Most of these Alberta stations are owned and operated by AF, Environment and Parks, Meteorological Service of Canada (MSC), and Agriculture and Agri-Food Canada (AAFC). Every attempt has been made by AF to insure that the data and information portrayed here is correct and up to date. However, all data portrayed here has been acquired indirectly through various forms of transmission and is not raw logger data. At times, sensors will malfunction and errors in transmission may occur. Note that raw logger data is considered to be the most reliable source of data but it may contain errors.

AF's Meteorological Applications and Modelling Unit (MAMU) built the ACIS system and also manages stations that end with the suffix AGDM, AEDM, AGCM and IMCIN. Stations not ending in one of these suffixes are not owned and/or operated by this unit and as such are beyond the control of MAMU. MAMU makes no claims, neither expressed nor implied, as to the completeness, accuracy or operational status of stations contained within ACIS. For questions concerning stations not operated by MAMU, users are strongly encouraged to seek clarification directly from the station owners and or the operators of the station or stations of interest.

### Hourly Observations:

#### Notes:

- All hourly time stamps are given in Mountain Standard Time (MST), so it is important to note that during daily light savings time, users should add one hour to each time stamp to convert to Mountain Daylight Time (MDT).
- Data values are subject to change under further review

As raw hourly data is received, it is automatically screened by a process that filters out obvious errors and identifies missing data. It then attempts to fill (estimate) all obvious errors and missing observations. During a second pass, a more rigorous automated process screens all observations and estimates, for less obvious errors and then flags all values that are deemed to be

suspect. These suspect observations are still available online in near-real-time (NRT). During normal working hours (five days a week), each suspect value is then examined by a Quality Assurance and Quality Control (QA/ QC) operator, and marked either valid or invalid. Invalid data is either replaced with estimated values through a filling process, or manually entered at the operator's discretion and subsequently flagged. Note that manual data entry is a last resort. Since QA/QC is an ongoing process, previous data may change as new information comes in, or when less obvious errors are later identified and flagged.

The hourly data feed is derived from several sources, which are updated in Near-Real-Time (NRT) as the data is received. More than 75% of the stations present on ACIS operate on the GOES/NESDIS satellite system or cellular modems, with the most recent data available being only two hours to three hours old. The remainder (25%) of the stations report hourly observations once per day. For the stations that report once per day, the previous day's hourly observations are typically available by about 8:00 am every day. Values are estimated for missing or suspect hourly observations using a variety of filling techniques, or if the filling fails and it is deemed appropriate, the observation may be manually filled. Thus, near real time hourly data consists of both actual transmitted readings, estimated readings that are either computed or manually entered, and occasionally missing values when filling attempts fail.

### **Daily observations:**

Notes:

- All daily time stamps are based on Mountain Standard Time (MST), with hourly values being aggregated between 00:00 and 23:00 hrs. It is important to note that during day light savings time, the day ends at 22:00 hrs MDT.
- Data values are subject to change under further review.

Daily data is derived from the hourly values or in some cases (precipitation only) from 6-hourly values. Daily aggregations are first performed at approximately 4:00 am with roughly 75% of the stations having full daily aggregations from the previous day. At 8:00 am the remaining 25% of the stations will have received the previous day's hourly data and depending on server load, are usually processed within two hours. After the QA/QC process has been completed by the QA/QC operator, usually by 12:00 pm (Monday to Friday), the daily data will then be re-aggregated and are then deemed to be QA/QC'd.

Subsequent changes to historical hourly data will occur from time to time with the daily aggregations being updated. It is important to note that:

- Daily observations are in Mountain Standard Time (MST)
- Daily observations are rolled up from hourly observations with the exception of a few stations that report precipitation as 6-hrly observations.
- When rolling up daily observations from hourly data, readings from 00:00 to 23:00 hrs MST are used to define a day.
- Precipitation accumulations, when rolled up from 6-hrly observations, the readings 06:00 12:00 and 18:00 and 00:00 hrs are used to define a day.

### **Data Flagging Schemes**

**Hourly Data:** hourly observations are available here, on or after Sept 1, 2018. Each hourly observation is flagged indicating whether it was an actual, computed or manual value. Missing

observations that could not be filled are given a time stamp but both the value and the flag are empty. As of May 25, 2010, more detailed flags (comments) were added that indicate how the data was filled.

**Daily Data:** Daily observations from most stations are aggregated from 24-hourly observations with the exception of approximately 20 stations that report precipitation accumulated over the past 6-hours, yielding 4 observations per day. Individual hourly values for each day are either actual, estimated, manual or missing. As of September 1, 2009 a completeness flag is available for each daily value that indicates the percentage of data from that day that were actual observations. For example if a station reported air temperature for only 23 hours during the day, with one value being estimated, the completeness flag would be 95.8% (23/24). If required, the hourly data can be downloaded or viewed, to see which of the hourly values were actual, computed, manual or missing.

In addition to the completeness flag, maximum and minimum values for air temperature and relative humidity use a second flag that indicates if the maximum or minimum value for the day was actual, computed or manual. This was needed because approximately 120 stations only report instantaneous or average hourly air temperatures with the maximum and minimum values being derived from these 24-hourly air temperature readings. The remaining stations have 24-hourly maximum and minimum values, usually derived from 5-second averages. In the case of humidity, stations are only capable of reporting 24-instantaneous or 24-hourly average values, with all of the daily maximums and minimums being derived from these values.

## Elements Tab

### Precipitation (mm)

Precipitation totals (mm) accumulated since the start of the previous interval.

- Hourly option: Selecting the hourly option returns hourly precipitation accumulated during the past hour
- Daily option: Selecting the daily option returns daily precipitation accumulated from that days hourly observations.

**Note:** ACIS tracks precipitation from two main types of precipitation gauges. The type of gauge used at each station can be found in the station metadata by clicking on the camera icon next to the station name, below the map, once the station has been selected.

1. **All season weighing type gauges** (Precip. Weighing (PR)): measure liquid and solid forms of precipitation (rain and snow). Hail is not reliably measured.
2. **Tipping bucket type rain gauges** (Precip. TBRG (P1)): measure only liquid forms of precipitation (rain). Snow falling into the gauge will usually result in a delayed reading when melting occurs. However these measurements are not reliable.

Special Notes:

- Snow falling into the gauge will usually result in a delayed reading when subsequent melting occurs as a result these observations are not reliable. By looking at nearby all season gauges and temperature readings it is possible to estimate if this has occurred. Alternatively, we don't recommend using Tipping bucket data outside the June July August period. Usually in May and September the data is reliable, however not always.

- Stations that have weighing type precipitation gauges employ a large collection bucket that is coupled to a sensitive scale that weighs precipitation accumulations. Since all the captured precipitation is stored in the bucket, total precipitation accumulations occurring over a missing interval can be measured reliably. In contrast, stations that employ tipping bucket style rain gauges rely on counting “tips” from a teeter-totter style bucket-type mechanism. During each “tip”, accumulated precipitation is discarded through drainage ports at the bottom of the gauge. As a result, precipitation accumulations occurring over a missing interval cannot be measured and must be estimated from nearby stations potentially resulting in large estimation errors, particular during convective precipitation events (thunderstorms).

### **Accumulated Precipitation (mm)**

Precipitation totals (mm) accumulated since the selected start date

- Hourly option: Selecting the hourly option returns hourly running totals accumulated since the selected start date.
- Daily option: Selecting the daily option returns daily running totals accumulated since the selected start date.

### **Air Temp. at 2m (°C) Inst.**

Instantaneous ambient air temperature (°C) measured 2-meters above the ground surface.

- Hourly option: This is only available for the hourly option. It is the instantaneous air temperature computed at the top of the hour. For most stations this is the average of the ambient air temperature values recorded during minute 59 to 60, just prior to the top of the hour.

### **Air Temp. at 2m (°C) Ave.**

Average ambient air temperature (°C) measured 2-meters above the ground surface.

- Hourly option: Selecting the hourly option returns the average air temperature recorded over the past hour.
- Daily option: Selecting the daily option returns the average air temperature computed from observations recorded on that day. The method used to compute this value will be dependent on the stations capabilities. The following methods were used, in order of priority.
  1. If the station reports average hourly temperature, then it is the average of the 24-hourly average values.
  2. If the station only reports hourly instantaneous air temperature then it is the average of the 24-hourly instantaneous values.

**Note:** On March 11<sup>th</sup> 2010, the methodology used to compute daily average air temperature values changed at 130 stations. This change yields negligible differences in the computed daily means.

- For all stations, prior to March 11<sup>th</sup>, 2010, daily average air temperature values were computed using instantaneous air temperature values (**Air Temp. at 2m (°C) Inst.**).
- After March 11<sup>th</sup>, 2010, ACIS started to acquire hourly average air temperature values from 130 stations (generally the ARD operated stations).

- A comparison of 15901 average daily values taken from March 11, 2010 to July 5, 2010, from 130 stations, showed that 95% of the time, either method will yield values within  $\pm 0.2$  °C of each other.

### **Air Temp. at 2m (°C) Max.**

Maximum ambient air temperature (°C) measured 2-meters above the ground surface.

- Hourly option: Selecting the hourly option returns the maximum temperature that occurred during the past hour.
- Daily option: Selecting the daily option returns the maximum daily temperature recorded for the day. The method used to compute this value will be dependent on the stations capabilities. The following methods were used, in order of priority.
  1. If the station reports maximum hourly temperature, then the daily maximum is the maximum of the 24-hourly maximum temperatures reported during that day. **Note:** that all stations that report **Air Temp. at 2m (°C) Ave.** also report the maximum hourly temperatures.
  2. If the station only reports hourly instantaneous air temperature then the daily maximum is the maximum of the 24-hourly instantaneous values.

### **Air Temp. at 2m (°C) Min.**

Minimum ambient air temperature (°C) measured 2-meters above the ground surface.

- Hourly option: Selecting the hourly option returns the minimum temperature that occurred during the past hour.
- Daily option: Selecting the daily option returns minimum daily temperature recorded for the day. The method used to compute this value will be dependent on the stations capabilities. The following methods were used, in order of priority.
  1. If the station reports minimum hourly temperature, then the daily minimum is the minimum of the 24-hourly minimum temperatures reported during that day. **Note:** that all stations that report **Air Temp. at 2m (°C) Ave.** also report the minimum hourly temperatures
  2. If the station only reports hourly instantaneous air temperature then the daily minimum is the minimum of the 24-hourly instantaneous values.

### **Relative Humidity at 2m (%) Inst.**

Instantaneous Relative Humidity (%) as measured at height of 2-meters above the ground surface.

- Hourly option: This is only available for the hourly option. It is the instantaneous relative humidity computed at the top of the hour. For most stations this is the average of the relative humidity values recorded during minute 59 to 60 just prior to the top of the hour.

### **Relative Humidity at 2m (%) Ave.**

Average relative humidity (%) measured 2-meters above the ground surface.

- Hourly option: Selecting the hourly option returns the average relative humidity recorded over the past hour.
- Daily option: Selecting the daily option returns the average relative humidity computed from observations recorded on that day. The method used to compute this value will be

dependent on the stations capabilities. The following methods were used, in order of priority.

1. If the station reports average relative humidity, then it is the average of the 24-hourly average values.
2. If the station only reports hourly instantaneous relative humidity then it is the average of the 24-hourly instantaneous values.

**Note:** On March 11<sup>th</sup> 2010, the methodology used to compute daily average relative humidity values changed at 130 stations. This change yields negligible differences in the computed daily means.

- For all stations, prior to March 11<sup>th</sup>, 2010, daily average relative humidity values were computed using instantaneous relative humidity values (**Relative Humidity at 2m (%) Inst.**).
- After March 11<sup>th</sup>, 2010, ACIS started to acquire hourly average relative humidity values from 130 stations (generally the ARD operated stations).
- A comparison of 15901 average daily values taken from March 11, 2010 to July 5, 2010, from 130 stations showed that 95% of the time, either method will yield values within  $\pm 1\%$  of each other.

#### **Relative Humidity at 2m (%) Max.**

Maximum relative humidity (%) measured 2-meters above the ground surface.

- Hourly option: For hourly data, this value is currently not available
- Daily option: Selecting the daily option returns the maximum relative humidity recorded for the day. The method used to compute this value will be dependent on the stations capabilities. The following methods were used, in order of priority.
  1. If the station reports hourly average relative humidity, then it is the maximum of the 24-hourly average values.
  2. If the station reports instantaneous relative humidity, then it is the maximum of the 24-hourly instantaneous values.

#### **Relative Humidity at 2m (%) Min.**

Minimum relative humidity (%) measured 2-meters above the ground surface.

- Hourly option: For hourly data, this value is currently not available.
- Daily option: Selecting the daily option returns the minimum relative humidity recorded for the day. The method used to compute this value will be dependent on the stations capabilities. The following methods were used, in order of priority.
  1. If the station reports hourly average relative humidity, then it is the minimum of the 24-hourly average values.
  2. If the station reports instantaneous relative humidity, then it is the minimum of the 24-hourly instantaneous values.

#### **Solar Rad. at 2m (W/m<sup>2</sup>) Ave.**

Average global solar radiation measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is an average of five minute averages recorded over the past hour in W/m<sup>2</sup>.

**Solar Rad. at 2m (MJ or W/m<sup>2</sup>) Max.**

Maximum global solar radiation measured 2-meters above the ground surface.

- Hourly option: For the hourly option this is not available.
- Daily option: For the daily option this is the maximum of the 24-hourly global solar radiation values expressed in W/m<sup>2</sup>.

**Solar Rad. at 2m (MJ or W/m<sup>2</sup>) Tot.**

Total Global solar radiation measured 2-meters above the ground surface.

- Daily option: For the daily option this is the sum of the 24-hourly average global solar radiation reported, in MJ.

**Wind 2m Ave Sp.**

Average wind speed (km/hr) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is the wind speed computed as the average wind speed recorded over the past hour.
- Daily option: For the daily option this is the average of the 24-hourly average wind speed values.

**Wind 2m Ave Dir.**

Average wind vector direction (° azimuth) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is mean wind vector direction computed as the average of the wind vector directions recorded over the past hour.
- Daily option: For the daily option this is computed using the unit vector average of the 24-hourly average wind vector direction values.

**Wind 2m Peak Sp.**

Peak wind speed (km/hr) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is maximum wind speed that occurred during the past hour, sampled once every 5-seconds
- Daily option: For the daily option this is the maximum wind speed that occurred during the past day, sampled once every 5-seconds.

**Wind 2m Peak Dir.**

Peak wind speed direction (° azimuth) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is wind direction measured at the time the peak wind speed occurred, during the past hour.
- Daily option: For the daily option this is the wind direction measured at the time the peak wind speed occurred, during the past day.

**Wind 2m Peak Time.**

Peak wind speed Time (hh:mm) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is minute in which the peak wind speed occurred, during the past hour.
- Daily option: For the daily option this is minute in which the peak wind speed occurred, during the past day.

### **Wind 10m Syno. Sp.**

Synoptic wind speed (km/hr) measured 10-meters above the ground surface.

- Hourly option: For the hourly option this is the wind speed averaged between minutes 50 to 60 of the past hour.
- Daily option: For the daily option this is the average of the 24-hourly instantaneous wind speed values.

### **Wind 10m Ave. Sp.**

Average wind speed (km/hr) measured 10-meters above the ground surface.

- Hourly option: For the hourly option, this is the wind speed computed as the average wind speed recorded during the past hour.
- Daily option: Selecting the daily option returns the average wind speed computed from observations recorded on that day. The method used to compute this value will be dependent on the stations capabilities. The following methods were used, in order of priority.
  1. If the station reports average hourly wind speed, then it is the average of the 24-hourly average values.
  2. If the station only reports hourly instantaneous wind speed then it is the average of the 24-hourly instantaneous values.

**Note:** On March 11<sup>th</sup> 2010, the methodology used to compute daily average wind speed values changed at 62 stations. This change yields negligible differences in the computed daily means.

- For 62 stations, prior to March 11<sup>th</sup>, 2010, daily average wind speed values were computed using synoptic wind speed values (**Wind 10m Syno. Sp.**)
- After March 11<sup>th</sup>, 2010, ACIS started to acquire hourly average wind speed values from 62 stations.
- A comparison of 15901 average daily values taken from March 11, 2010 to July 5, 2010, from 130 stations, showed that 95% of the time, either method will yield values within  $\pm 1.2$  km hr<sup>-1</sup> of each other.

### **Wind 10m Syno. Dir.**

Synoptic wind vector direction (° azimuth) measured 10-meters above the ground surface.

- Hourly option: For the hourly option, this is mean wind vector direction computed as the average of the wind vector direction recorded between minutes 50 to 60 of the past hour.
- Daily option: For the daily option this is computed using the unit vector average of the 24-hourly instantaneous wind vector direction values.

**Note:** On March 11<sup>th</sup> 2010, the methodology used to compute daily average wind direction values changed at 62 stations. This change yields relatively small differences in the computed daily means.

- For 62 stations, prior to March 11<sup>th</sup>, 2010, daily average wind direction values were computed using synoptic wind direction values (**Wind 10m Syno. Sp.**)
- After March 11<sup>th</sup>, 2010, ACIS started to acquire hourly average wind direction values from 62 stations.

- A comparison of 7146 average daily values from 62 stations from March 11, 2010 to July 5, 2010, showed that 95% of the time, either method will yield values within  $\pm 19.4$  degrees azimuth of each other.

### **Wind 10m Ave Dir.**

Average wind vector direction ( $^{\circ}$  azimuth) measured 10-meters above the ground surface.

- Hourly option: For the hourly option, this is mean wind vector direction computed as the average of the wind vector directions recorded over the past hour.
- Daily option: For the daily option this is computed using the unit vector average of the 24-hourly average wind vector direction values.

### **Wind 10m Peak Sp.**

Peak wind speed (km/hr) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is maximum wind speed that occurred during the past hour, sampled once every 5-seconds
- Daily option: For the daily option this is the maximum wind speed that occurred during the past day, sampled once every 5-seconds.

### **Wind 10m Peak Dir.**

Peak wind speed direction ( $^{\circ}$  azimuth) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is wind direction measured at the time the peak wind speed occurred, during the past hour.
- Daily option: For the daily option this is the wind direction measured at the time the peak wind speed occurred, during the past day.

### **Wind 10m Peak Time.**

Peak wind speed Time (hh:mm) measured 2-meters above the ground surface.

- Hourly option: For the hourly option, this is the minute in which the peak wind speed occurred, during the past hour.
- Daily option: For the daily option this is minute in which the peak wind speed occurred, during the past day.

### **Soil moisture (%)**

Soil moisture as a % by volume at four depths below the ground surface (5-cm, 20-cm, 50-cm and 100-cm)

- Hourly option: For the hourly option this is soil moisture averaged during the past hour
- Daily option: For the daily option this is the average of the 24-hourly average soil moisture values

### **Soil Temperature ( $^{\circ}$ C)**

Soil temperature ( $^{\circ}$  C) at four depths below the ground surface (5-cm, 20-cm, 50-cm and 100-cm)

- Hourly option: For the hourly option this is soil temperature averaged during the past hour
- Daily option: For the daily option this is the average of the 24-hourly average soil temperature values

## Weather Derivatives Tab:

The number of available options on this page will increase in the future and is intended to include a variety of calculations and model values based on data collected for the various elements at a weather station. Coming soon are Evapotranspiration, Drying index, Potato Degree days (P-Days) and other useful information. Drop us a line and let us know what you would like to see here (phone number is at the bottom of the web page).

### Dew Point Temperature:

The dew point temperature is the temperature at which a given parcel of air must be cooled, at constant pressure and water vapor content until saturation occurs. It is computed based on Magnus -Tetens formula using air temperature (T) over a range of 0 to 60 0C and relative humidity (RH) over a range of 1 to 100%. The dew point temperature (Td) equation in 0C is given by:

$$(1) T_d = \frac{b * \alpha}{a - \alpha}$$

Where

$$a = 17.27$$

$$b = 237.7$$

$$(2) \alpha = \frac{a * T}{b + T} + \ln(RH)$$

### Growing Degree Days

Growing degree days are a heat index that relates the development of plants, insects, and disease organisms to environmental air temperature. ACIS will compute them anytime between April 15 and Oct 15. Before April 15 and After Oct 15 they are assumed to be 0. Users can set the start date for the calculation by selecting a start date and end the calculation by selecting an end date. If the weather station experiences frost, the average growing degree days will still continue to accumulate, but will be 0 on the frost date. This gives the user full control over local frost conditions and does not force and end to the computation. In the event that a frost date is unknown, simply plot the minimum temperature along with the growing degree days and then manually determine the frost date and then readjust the end date accordingly. Growing Degree days are computed on a daily basis for a variety of base temperatures using the following equations:

$$(3) \text{ Growing Degree days (0)} = \left( \frac{T_{\max} + T_{\min}}{2} \right) - 0, \text{ If negative} = 0$$

$$(4) \text{ Growing Degree days (2)} = \left( \frac{T_{\max} + T_{\min}}{2} \right) - 2, \text{ If negative} = 0$$

$$(5) \text{ Growing Degree days (5)} = \left( \frac{T_{\max} + T_{\min}}{2} \right) - 5, \text{ If negative} = 0$$

Where:

Tmax = Maximum Daily temperature (°C)

Tmin = Minimum daily temperature (°C)

### Corn Heat Units

Corn Heat Units are similar to growing degree days and are temperature-based units that are related to the rate of development of corn. ACIS will compute them anytime between April 15 and Oct 15. Before April 15 and after Oct 15 they are assumed to be 0. Users can set the start date for the calculation by selecting a start date and end the calculation by selecting an end date. If the weather station experiences frost, the average corn heat units will still continue to accumulate, but will be 0 on the frost date. This gives the user full control over local frost conditions and does not force and end to the computation. In the event that a frost date is unknown, simply plot the minimum temperature along with the corn heat units and then manually determine the frost date and then readjust the end date accordingly. Note that from the selected start date, corn heat units will **start** accumulating only after three consecutive days where average daily air temperatures are  $\geq 12.8$  (°C). Prior to April 15<sup>th</sup> they will be 0 regardless of the temperature. Corn Heat Units are computed on a daily basis using the following equation:

$$(6) \text{ Corn Heat Units} = \frac{CHUX + CHUY}{2}$$

Where:

$CHUX = 1.8 \times (T_{min} - 4.4)$ , *If negative = 0*

$CHUY = 3.33 \times (T_{max} - 10) - 0.084 \times (T_{max} - 10)^2$ , *If negative = 0*

Tmax = Maximum Daily temperature (°C)

Tmin = Minimum daily temperature (°C)

### ET. Standard Grass

Evapotranspiration (ET) represents the loss of water from the earth's surface through the combined processes of evaporation from soil, plant surfaces and transpiration from plants.

Potential or Reference Evapotranspiration is the rate of Evapotranspiration from an open surface, covered with actively growing, short vegetation, similar to grass, under moist soil conditions.

### Methodology

The ASCE standardized reference potential ET equation for a grass reference surface (ET<sub>os</sub>) is the simplified and reduced form of the ASCE Penman-Monteith equation as described in the ASCE Manual 70, 1990. ET<sub>os</sub> is defined as the ET rate from an extensive uniform grass or short vegetation (0.12 m height), actively growing and not short of soil water. For an explanation of the calculations used in, a summary of the ASCE reference ET standardization procedures check the following [click here](#).

### Importance of reference conditions at weather stations

When using the ET<sub>os</sub> equation the assumption is that the input weather data is collected from stations maintained within a reference environment. That is, ideally the area in and surrounding

the weather station is vegetated with actively growing short grass under moist soil conditions. Under these conditions, relative humidity and temperatures regimes are buffered from extremes that may otherwise occur when it is hot and dry. Most of the weather stations in the agricultural areas of the province are located on open, rain-fed grassed areas where moisture can be limiting at certain times of the year. Additionally, some are also located adjacent to cultivated lands, and others outside of the agricultural areas may be in more rugged terrain i.e., forested or transitional environments. Therefore, strictly speaking, some stations and their surroundings do not conform to the reference condition. Under arid conditions where vapour deficits are extreme (days with low humidity and extreme temperatures), ET estimated using the  $ET_{os}$  equation may be overestimated by as much as 25% during certain hours (Temesgen et al. 1999). Under these conditions, adjustments can be applied to temperature and humidity observations, bringing them closer to reference conditions, but such adjustments have not been attempted here. Therefore, care should be taken in using  $ET_{os}$  estimates, particularly on days when humidity is low and temperatures are extreme. Note that these effects will become even more pronounced as wind speeds increase.

### **$ET_{os}$ computation during non growing seasons**

Due to freezing temperatures and snow cover, conditions for a reference surface may not exist at a station during most, or parts of the cold or non growing season (November to end of March). In general, ET estimated using  $ET_{os}$ , during the non growing season tends to be less than reference ET due to the increased surface resistance and a higher reflectance by dormant vegetation as well as from snow covered surfaces. Exceptions are when wet surface conditions exist from precipitation or the melting of snow, during early fall and spring periods, where the ET from evaporation can be substantial. Because, most stations are covered by snow during much of the cold season, the current  $ET_{os}$  equation for the cold season (October to March) uses a surface reflectance value of 0.57 which is the averaged Albedo for grass covered surfaces during the winter season. In general  $ET_{os}$  values during most of the cold season are small and as such do not represent measureable values using current methods. However, they can be used as an **index** of evaporative power of the environment under reference conditions.

### **Estimating solar radiation for stations not having solar radiation sensors.**

For those stations not equipped with an incoming solar radiation sensor, solar radiation is estimated using daily maximum and minimum temperatures, date, station latitude and station elevation. For these stations, the Hargreaves and Samani (1982, 1985) equations were used with an adjustment coefficient of 0.16. Estimated solar radiation using this simple model have shown good agreement ( $r^2 = 0.87$ ) with measured daily solar radiation data at most of the ARD stations that measure solar radiation.

The equation is given by:

$$(7) \quad R_s = Kt * Ra * (T_{max} - T_{min})^{0.5}$$

Where:

- $R_s$  = estimated solar radiation in [ $MJ \ m^{-2} \ day^{-1}$ ],
- $R_a$  = extraterrestrial radiation [ $MJ \ m^{-2} \ day^{-1}$ ],
- $T_{max}$  = daily maximum air temperature ( $^{\circ}C$ )
- $T_{min}$  = daily minimum air temperature ( $^{\circ}C$ )
- $Kt$  = adjustment coefficient ( 0.16)

Extraterrestrial radiation ( $Ra$ ) is computed as:

$$(8) \quad Ra = \frac{1440}{\pi} G_{sc} * dfr \left( nws * \sin(lat) * \sin(ndec) + \cos(lat) * \cos(ndec) * \sin(nws) \right)$$

$$(9) \quad dfr = 1 + 0.033 * \cos(2 * \pi * Jday / Ndays)$$

$$(10) \quad nws = ar \cos(-\tan(lat) \tan(ndec))$$

$$(11) \quad ndec = 0.409 \sin \left( \frac{2\pi Jday}{Ndays} - 1.39 \right)$$

Where:

- $G_{sc}$  = solar constant [ $\text{MJ m}^{-2}\text{day}^{-1}$ ] (0.082)
- $dfr$  = inverse relative distance
- $Jday$  = Julian day
- $Ndays$  = number of days in a year (366 in a leap year)
- $nws$  = sunset hour angle
- $ndec$  = solar declination angle
- $elev$  = station elevation [m]
- $lat$  = station latitude in radians

### Data Flagging Schemes:

Ideally a station should have daily measurements of maximum and minimum temperature, humidity, solar radiation and wind speed at 2m, derived from hourly observations. However, not all stations measure these elements in the same way, nor do all stations have solar radiation or 2 meter wind speed measurements. The following is a list of all possible elements that were used to drive ETos calculations: Numbers preceding the element were given first priority if that element existed at a given station.

#### Air temperature

- (1) Hourly average
- (2) Hourly instantaneous (2 minute average of min 58 – 60)

#### Humidity

- (1) Hourly average humidity
- (2) Hourly instantaneous humidity (2 minute average of min 58 – 60)

#### Solar Radiation

- (1) Hourly average
- (2) Estimated

#### Wind Speed

- (1) 2-meter hourly average
- (2) 2 meter synoptic wind speed (10 minute average of min 50 – 60)
- (3) 10-meter hourly average
- (4) 10 meter Synoptic wind speed (10 minute average of min 50 – 60)

For those stations that do not measure solar radiation, equation (8) was. If a station did not have a 2-meter wind speed then the 10-meter wind speed was converted to a 2-meter wind speed using:

$$(12) \quad WS_2 = \frac{\left( WS_{10} \times \frac{1000}{3600} \times 4.87 \right)}{\ln(67.8 \times 10 - 5.42)}$$

Where:

$WS_2$  = Wind speed at 2-meters (km hr<sup>-1</sup>)

$WS_{10}$  = wind speed at 10-meters (km hr<sup>-1</sup>)

Unfortunately, not all stations on ACIS have exactly the same parameter suit, but despite this  $ET_{os}$  can still be reliably computed at many stations with the caveat that not all stations have a completely ideal element suite. To add transparency to  $ET_{os}$  calculations, a flagging scheme was developed to inform the user as to what elements were used in the computation of  $ET_{os}$ . When data is downloaded, each daily observation is accompanied by a coma separated, three-part-flag. For example an observation flagged “*solar-EST,10m-conv-2m wind, Syno.*”, means that solar radiation was estimated (*solar-EST*), the station did not have a 2m wind speed, so a 10 meter wind was converted to a 2 meter wind (*10m-conv-2m wind*) and the source of the 10 m wind speed was the average of the 24-houlyr synoptic values (*Syno.*). All possible values of each part of the flag are listed below:

Part 1: Describes whether or not solar radiation was an actual or estimated value

- *Solar-ACT* = Actual solar radiation values were used
- *Solar-EST* = Estimated solar radiation values were used using equation (8)

Part 2: Describes the height at which the wind was measured, either 2 meter or 10 meter.

- *2m* = 2-meter wind speed (daily average of the 24-hourly average or synoptic values)
- *10m-conv-2m* = 10-meter wind speed was converted to 2-meter wind speed winds using equation (12)

Part 3 Describes what hourly wind value was used in computing average daily wind speed.

Either it was the average of the 24- hourly average values or the 24 synoptic values.

- *Ave.* = Average daily values were derived from 24- hourly average values
- *Syno.* = Average daily values were derived from 24- hourly synoptic values

Note that for air temperature and humidity, there is usually very little difference between daily values that were derived using the true hourly average values or the hourly instantaneous values. As a result, it was felt that it was not necessary to include this information in the flagging scheme.

### **Normals Tab (1961-2018):**

Most of the stations that are available through ACIS do not have a long enough period of record to develop long term normal's, and of those that do, many have numerous missing observations within their period of record. This makes it difficult to compare normals between stations at different locations. Thus, the long term normals available here (1961-2018), are **estimates of the long term normal's** for each station, based on a gridded weather data product called the

Alberta Climate Database <http://agriculture.alberta.ca/acis/township-data-viewer.jsp>. This database was created by interpolating the historical daily weather data for stations in Alberta as well as from neighboring provinces, to a grid that uses township centers as grid points. Note, since the township grid does not exist in the Mountain Parks, these stations do not have estimated normals. The interpolation scheme used a combination of the hybrid method of inverse-distance weighting and nearest station assignments (Shen et al, 2001). Basing the interpolation on township centers yields a manageable database with enough detail and without undue redundancy.

Daily weather data for each day from January 1, 1901 to December 31, 2018, was interpolated to the center point of each of the 6900 townships in Alberta. The interpolation for any given day was based only on those stations that reported weather values for that day. For each township center on each day, the closest eight stations within a 60 km radius for precipitation and 200 km radius for other elements, were used to inverse distance weight the value for the township. If no stations had data for a particular element within the 60 or 200 km radius, then the nearest station was used regardless of its distance from the township center. For the purposes of calculating the long term normal's given here, the period from 1961 to 2018 was chosen since, prior to 1961, station density was not sufficient to make meaningful regional and local weather related time series. Air temperature, wind speed, wind direction, solar radiation and humidity were inverse distance weighted using a linear weighting scheme. Precipitation was inverse distance weighted using the cube of the inverse distance, with the inverse distance monthly totals redistributed proportionally, relative to the nearest station with a complete monthly record. This resulted in more weighting to the nearest station and for precipitation, the redistribution of the monthly totals, imposed a more natural precipitation pattern.

Note that for all the interpolated elements, it is extremely important to realize that the interpolation scheme tends to “smooth” the data and as such, only approximates the extreme occurrences at each station. In addition, since the interpolation looks out to 60 km for precipitation and 200 km for other elements, there tends to be more estimation error where local variability for a particular element is high. This is particularly true for areas near the mountains or foot hills and/or where local elevation changes rapidly or large bodies of water are present. More details on the interpolation method can be found at:

<http://agriculture.alberta.ca/acis/docs/methodology-and-data-sources-for-interpolated-data-y2019-m03-d27.pdf>

#### **Precipitation Ave. (mm)**

- Daily Option: This is the average daily precipitation accumulated for the period ranging from 1961 to 2018.
- Monthly Option: This is the average monthly precipitation based on the period ranging from 1961 to 2018.

#### **Air Temp. Ave (°C)**

- Daily Option: The average daily air temperatures for the period ranging from 1961 to 2018.
- Monthly Option: The monthly average daily air temperature for the period ranging from 1961 to 2018.

#### **Air Temp Ave. Max. (°C)**

- Daily Option: The average maximum daily air temperature for the period 1961 to 2018

- Monthly Option: The monthly average maximum daily air temperature for the period ranging from 1961 to 2018.

#### **Air Temp. Highest Max (°C)**

- Daily Option: The estimated maximum daily air temperature for the period 1961 to 2018. Note that these are not record maximum station temperatures as these values were estimated using data from 1 or more nearby stations.
- Monthly Option: The estimated maximum daily air temperature that occurred during the month for the period 1961 to 2018. Note that these are not record maximum station temperatures as these values were estimated using data from one or more nearby stations.

#### **Air Temp Ave. Min (°C).**

- Daily Option: The average minimum daily air temperature for the period 1961 to 2018
- Monthly Option: The average monthly minimum daily air temperature for the period ranging from 1961 to 2018

#### **Air Temp. Lowest Min. (°C)**

- Daily Option: The estimated minimum daily air temperature for the period 1961 to 2018. Note that these are not record minimum station temperatures as these values were estimated using data from 1 or more nearby stations.
- Daily Option: The estimated minimum daily air temperature that occurred during the month for the period 1961 to 2018. Note that these are not record minimum station temperatures as these values were estimated using data from one or more nearby stations.

#### **Growing Degree Days**

Daily Option: Average daily accumulated growing degree days from the period 1961 to 2018

Monthly Option: Average monthly accumulated growing degree days from the period 1961 to 2018.

Growing degree days are a heat index that relates the development of plants, insects, and disease organisms to ambient air temperature. ACIS will compute them anytime between April 15 and Oct 15. Before April 15 and After Oct 15 they are assumed to be 0. Users can set the start date for the calculation by selecting a start date and end the calculation by selecting an end date. If the weather station experiences frost, the average growing degree days will still continue to accumulate, but will be 0 on the frost date. This gives the user full control to over local frost conditions and does not force and end to the computation. In the event that a frost date is unknown, simply plot the minimum temperature along with the growing degree days and then manually determine the frost date and then readjust the end date accordingly. Growing Degree Days are provided for a variety of base temperatures, and they are computed on a daily basis using the following equations:

$$\text{Growing Degree days (0)} = \left( \frac{T_{\max} + T_{\min}}{2} \right) - 0, \text{ If negative} = 0$$

$$\text{Growing Degree days (2)} = \left( \frac{T_{\max} + T_{\min}}{2} \right) - 2, \text{ If negative} = 0$$

$$\text{Growing Degree days (5)} = \left( \frac{T_{\max} + T_{\min}}{2} \right) - 5, \text{ If negative} = 0$$

Where:

Tmax = Maximum daily temperature (°C)

Tmin = Minimum daily temperature (°C)

### Corn Heat Units

Daily Option: Average daily accumulated corn heat units from the period 1961 to 2018

Monthly Option: Average monthly accumulated corn heat units from the period 1961 to 2018.

Corn heat units are similar to growing degree days and are temperature-based units that are related to the rate of development of corn. ACIS will compute them anytime between April 15 and Oct 15. Before April 15 and After Oct 15 they are assumed to be 0. Users can set the start date for the calculation by selecting a start date and end the calculation by selecting an end date. If the weather station experiences frost, the average corn heat units will still continue to accumulate, but will be 0 on the frost date. This gives the user full control to over local frost conditions and does not force and end to the computation. In the event that a frost date is unknown, simply plot the minimum temperature along with the corn heat units and then manually determine the frost date and then readjust the end date accordingly. Note that for the each year during the period of record (1961-2018) corn heat units **started** accumulating after April 15 of each year, only after three consecutive days where average daily air temperatures are  $\geq 12.8$  (°C) and they were zero prior to this day. They are computed on a daily basing using the following equations:

$$\text{Corn Heat Units} = \frac{CHUX + CHUY}{2}$$

Where:

$CHUX = 1.8 \times (T_{\min} - 4.4)$ , *If negative = 0*

$CHUY = 3.33 \times (T_{\max} - 10) - 0.084 \times (T_{\max} - 10)^2$ , *If negative = 0*

Tmax = Maximum Daily temperature (°C)

Tmin = Minimum daily temperature (°C)

after the selected start date, corn heat units will **begin** accumulating only after three consecutive days where average daily air temperatures are  $\geq 12.8$  (°C) and they are zero prior to this day.

### Frost Probabilities

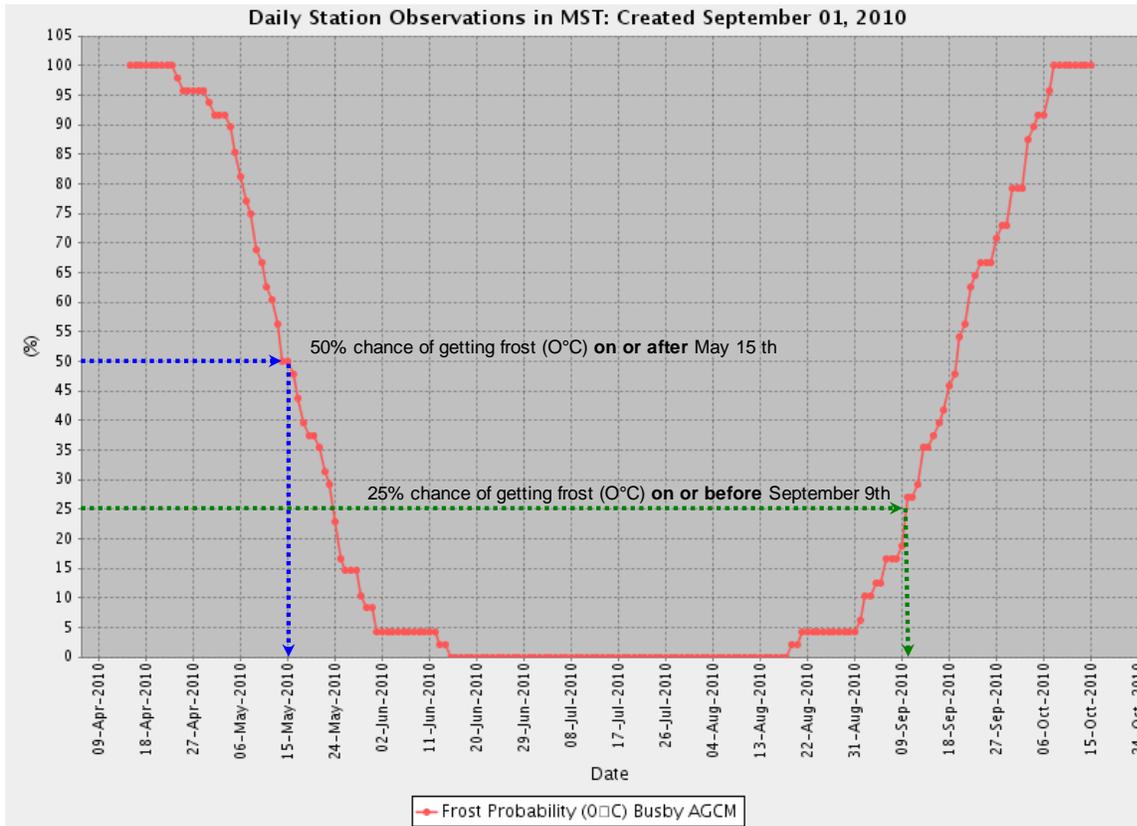
Daily option: The estimated probability of getting a frost **after** a given date in the spring or **before** given date in the fall.

The frost probabilities presented here are based upon interpolated station data from the 1961 to 2018 period, representing 48 years of observations. It is important to realize that they are generalizations based on interpolated station data. Local variations will exist and be largely dependent on landscape characteristics that affect air drainage and day time heating. Therefore, the frost probabilities presented here should only be used as a general guide.

Frost probabilities can be generated for various frost thresholds ranging from 0 °C to – 5 ° C.

For example, in the spring, after what date is there a 50% chance of receiving frost? Using Figure 1, we can see that for Busby AGCM this date is May 15<sup>Th</sup>. Similarly, in the fall, on what

date is there a 25% chance that frost will have occurred? Using Figure 1, we can see that for Busby AGCM that date is September 9<sup>th</sup>.



**Figure 1.** Probability of getting spring or fall frosts, for Busby AGCM, using 0 °C as the definition for frost

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