Environmental Setting Protocol - Example Station Metrics

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The draft Environmental Setting protocol calculates four types of climate metrics using the EnvironmentalSetting toolkit https://github.com/nationalparkservice/EnvironmentalSetting_Toolkit.

- **station-based temperature and precipitation**
- **station-based departures from normal temperature and precipitation**
- grid-based departures from normal temperature and precipitation
- index-based precipitation and drought

The first two metric types are calculated for all stations that intersect the 30km areas of analysis for parks while the latter two metric types are calculated by area of analysis (AOA) bounding box extent. This notebook shows the first two metric types for stations around Agate Fossil Beds NM (AGFO). The climate stations and observation data for areas around and within National Parks are obtained from webservices maintained by NOAA's Regional Climate Centers (RCCs) from a system called ACIS - Applied Climate Information System (http://www.rcc-acis.org/index.html).

Environmental Setting protocol metrics are shown below.

ï..Metric	Description
CGP1	Monthly departures from average monthly average precipitation (% of climate normal)
CGP2	Monthly departures from average monthly minimum precipitation (% of climate normal)
CGP3	Monthly departures from average monthly maximum precipitation (% of climate normal)
CGP4	Snow-Water Equivalent Snowpack Departures from average (% of climate normal)
CGP5	Monthly Palmer Drought Severity Index
CGP6	Standardized Precipitation Index
CGT1	Monthly temperature departures from average monthly average temperature (% of climate normal)
CGT2	Monthly temperature departures from average monthly minimum temperature (% of climate normal)
CGT3	Monthly temperature departures from average monthly maximum temperature (% of climate normal)
CSP1	Heavy Precipitation Days
CSP2	Extreme Precipitation Days
CSP3	Micro-drought
CSP4	Measurable Snow Days
CSP5	Moderate Snow Days
CSP6	Heavy Snow Days
CSP7	Above Normal Precipitation Days
CSP8	Below Normal Precipitation Days
CST1	Hot Days
CST2	Cold Days
CST3	Sub-Freezing Days
CST4	Sub-Zero Days
CST5	Growing Degree Days
CST6	Heating Degree Days
CST7	Cooling Degree Days
CST8	Above Normal Temperature Days
CST9	Below Normal Temperature Days

For formal metric requests for the protocol, the *getStationMetrics()* convenience function is used. To demonstrate metric request capability, this notebook shows direct calls to the *getWxObservations()* function which is called by the convenience function. The *getWxObservations()* function faciliates access to most ACIS parameters, not just those used for Environmental Setting metrics. Similarly, the *findStation()* function requests in this notebook demonstrate the generic park-based station location capability rather than the station-AOA intersection approach. This function also accepts custom bounding boxes.

Station-Based Temperature and Precipitation Metrics

For the protocol, formal metrics are calculated for stations that intersect the 30km park area of analysis. To demonstate the flexibility of the Toolkit, examples shown in this notebook are for stations within 20km of Agate Fossil Beds National Monument (AGFO).

Exploratory plots are shown in this notebook but are not included in the Toolkit functions.

For all metrics, values returned are raw data that include missing values.

Temperature

For the temperature metrics, a set of stations collecting standard temperature parameters (maxt, mint, gdd) is needed. Two distinct stations are returned for each requested parameter - 6 total, 3 replicate sets (by parameter) of 2 stations.

```
# Get stations collecting maxt, mint, pcpn, and gdd with data from last
# 20 years
agfoStations20km <- findStation(unitCode = "AGFO", distance = 20, climateParameters = list("ma
    "mint", "gdd"))
agfoStationsCurrent <- agfoStations20km[agfoStations20km$minDate >= "1998-01-01" &
    agfoStations20km$maxDate >= "2018-05-15", ]
str(agfoStationsCurrent)
```

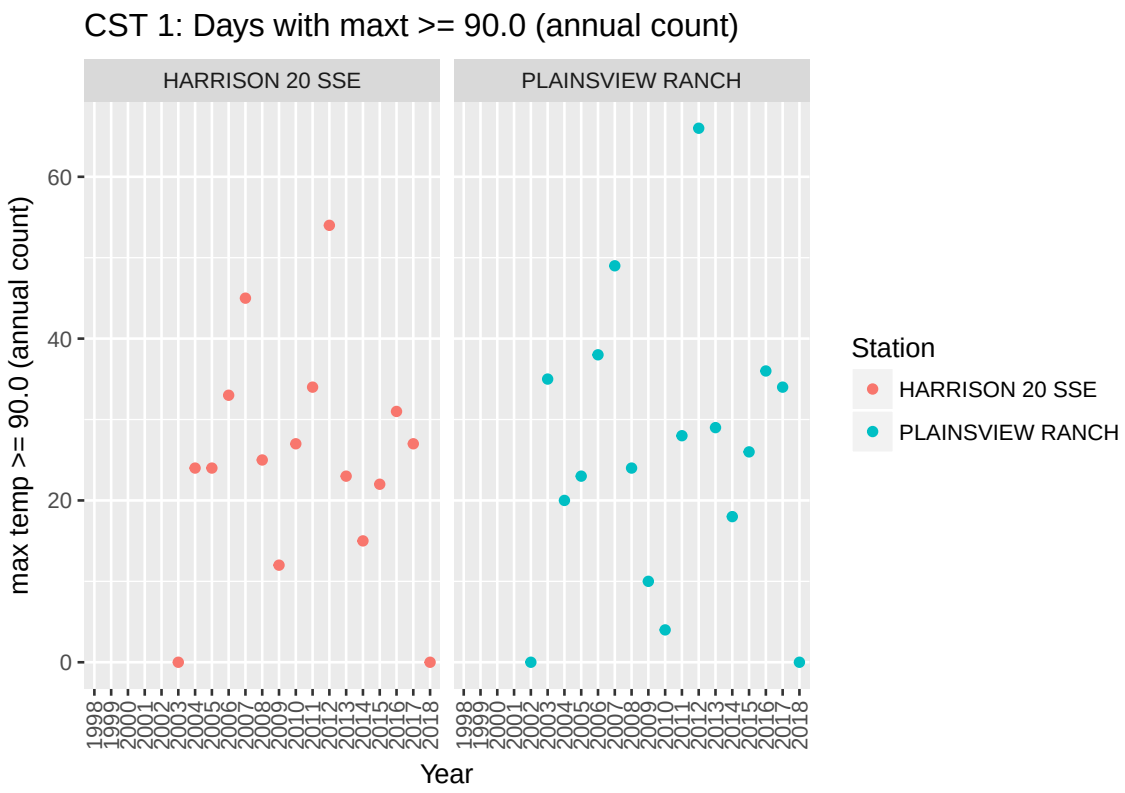
```
## 'data.frame':    6 obs. of  17 variables:
##  $ uid             : num  31465 31702 31465 31702 31465 ...
##  $ name            : chr  "PLAINSVIEW RANCH" "HARRISON 20 SSE" "PLAINSVIEW RANCH" "HARRISON
##  $ longitude       : num  -104 -104 -104 -104 -104 ...
##  $ latitude        : num  42.3 42.4 42.3 42.4 42.3 ...
##  $ sid1            : chr  "256765 2" "94077 1" "256765 2" "94077 1" ...
##  $ sid1_type       : chr  "COOP" "WBAN" "COOP" "WBAN" ...
##  $ sid2            : chr  "USC00256765 6" "253628 2" "USC00256765 6" "253628 2" ...
##  $ sid2_type       : chr  "COOP" "COOP" "COOP" "COOP" ...
##  $ sid3            : chr  "PVRN1 7" "74438 4" "PVRN1 7" "74438 4" ...
##  $ sid3_type       : chr  "NWSLI" "WMO" "NWSLI" "WMO" ...
##  $ state           : chr  "NE" "NE" "NE" "NE" ...
##  $ elev            : num  4680 4406 4680 4406 4680 ...
##  $ isHCNStation    : chr  "N" "N" "N" "N" ...
##  $ minDate         : Date, format: "2002-11-23" "2003-08-28" ...
##  $ maxDate         : Date, format: "2018-05-30" "2018-05-31" ...
##  $ climateParameter: chr  "maxt" "maxt" "mint" "mint" ...
##  $ unitCode        : chr  "AGFO" "AGFO" "AGFO" "AGFO" ...
```

Observation data requests are made with the *getWxObservations()* function, passing in the station list from *findStation()*.

```
# Get CST1: Hot Days (annual count)
CST1Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("maxt"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_ge_90.0", metric = "CST1")
```

```
CST1Data$maxt_F_cnt_ge_90.0[order(CST1Data$name)]
```

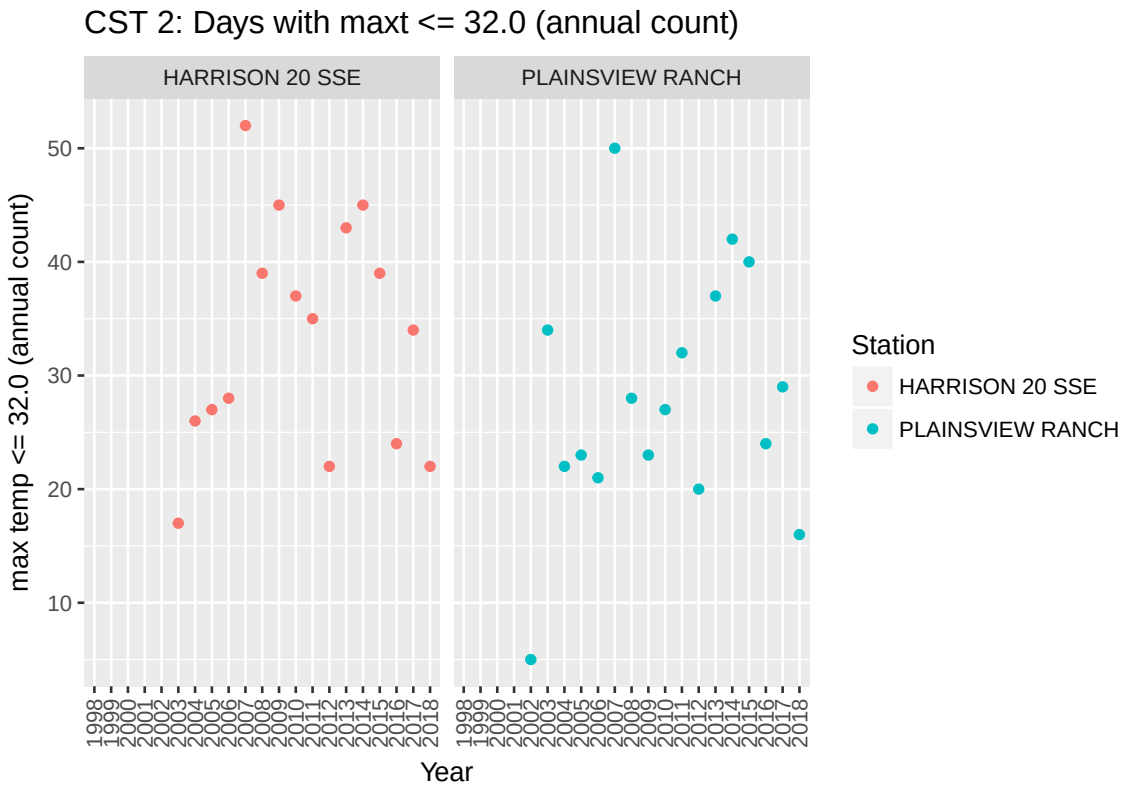
```
##  [1] NA NA NA NA NA  0 24 24 33 45 25 12 27 34 54 23 15 22 31 27  0 NA NA
## [24] NA NA  0 35 20 23 38 49 24 10  4 28 66 29 18 26 36 34  0
```




```
# Get CST2: Cold Days (annual count)
CST2Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("maxt"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_le_32.0", metric = "CST2")
```

```
CST2Data$maxt_F_cnt_le_32.0[order(CST2Data$name)]
```

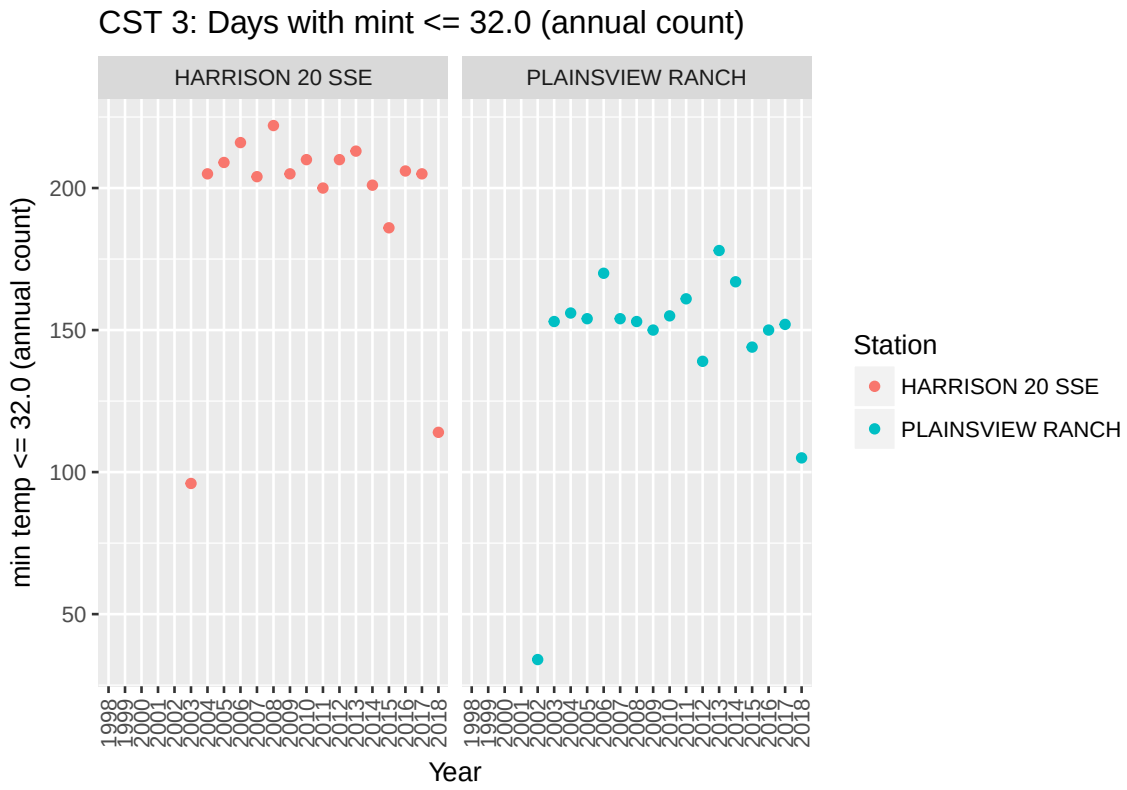
```
##  [1] NA NA NA NA NA 17 26 27 28 52 39 45 37 35 22 43 45 39 24 34 22 NA NA
## [24] NA NA  5 34 22 23 21 50 28 23 27 32 20 37 42 40 24 29 16
```




```
# Get CST3: Sub-freezing Days
CST3Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("mint"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_le_32.0", metric = "CST3")
```

```
CST3Data$mint_F_cnt_le_32.0[order(CST3Data$name)]
```

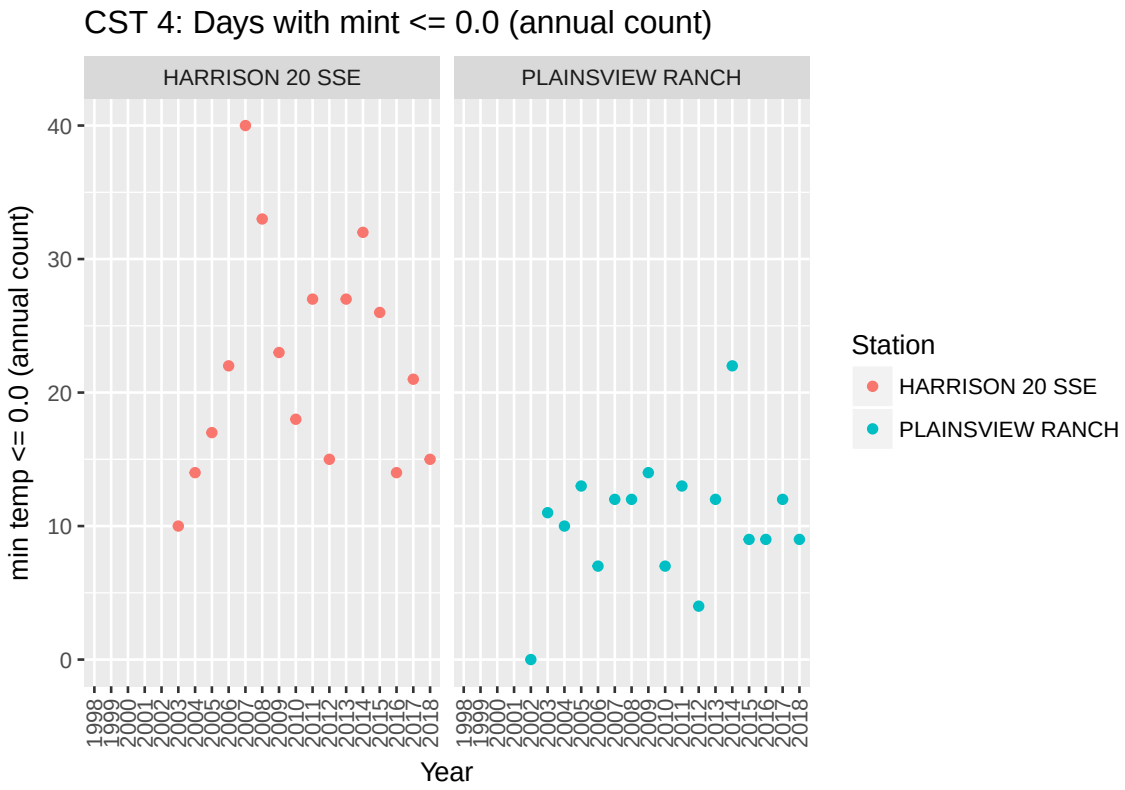
```
##  [1]  NA  NA  NA  NA  NA  96 205 209 216 204 222 205 210 200 210 213 201
## [18] 186 206 205 114  NA  NA  NA  NA  34 153 156 154 170 154 153 150 155
## [35] 161 139 178 167 144 150 152 105
```




```
# Get CST4: Days at or below 0 (annual count)
CST4Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("mint"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_le_0.0", metric = "CST4")
```

```
CST4Data$mint_F_cnt_le_0.0[order(CST4Data$name)]
```

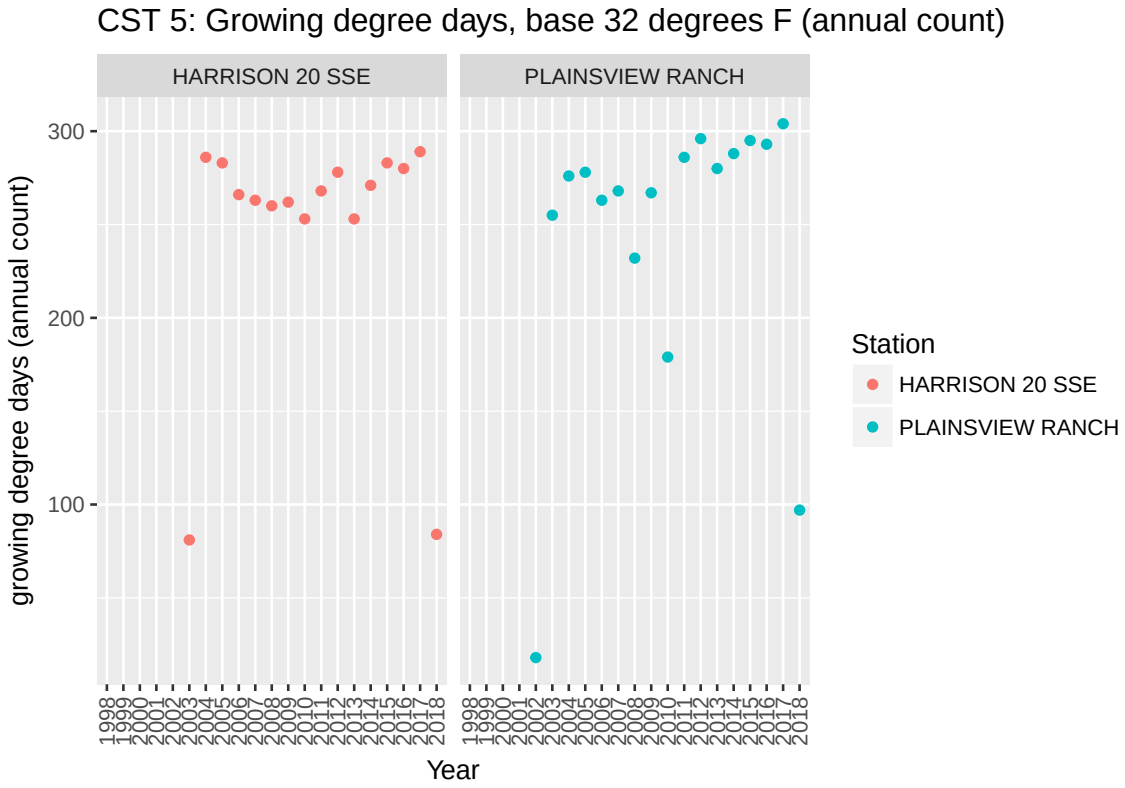
```
##  [1] NA NA NA NA NA 10 14 17 22 40 33 23 18 27 15 27 32 26 14 21 15 NA NA
## [24] NA NA  0 11 10 13  7 12 12 14  7 13  4 12 22  9  9 12  9
```




```
# Get CST5: Growing degree days (base temperature >= 32) (annual count)
CST5Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("gdd32"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_gt_0", metric = "CST5")
```

```
CST5Data$gdd32__cnt_gt_0[order(CST5Data$name)]
```

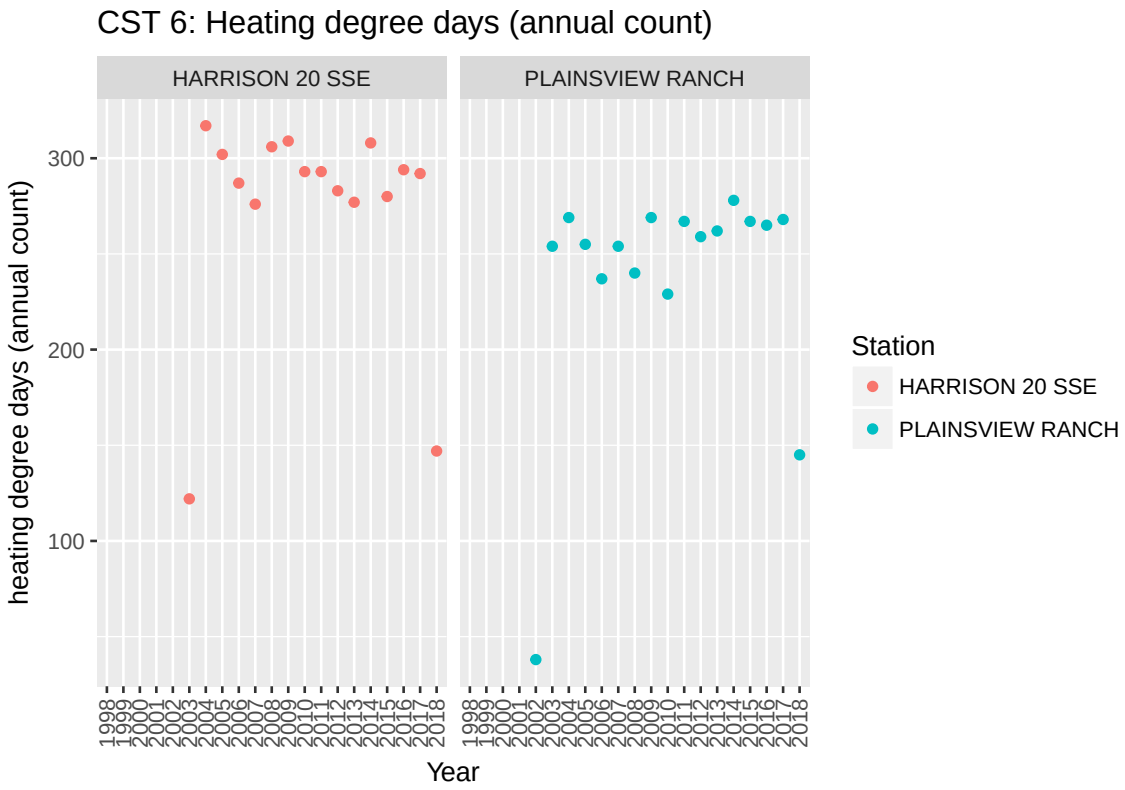
```
##  [1]  NA  NA  NA  NA  NA  81 286 283 266 263 260 262 253 268 278 253 271
## [18] 283 280 289  84  NA  NA  NA  NA  18 255 276 278 263 268 232 267 179
## [35] 286 296 280 288 295 293 304  97
```




```
# Get CST6: Heating degree days (default base temperature >= 65) (annual
# count)
CST6Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("hdd"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_gt_0", metric = "CST6")
```

```
CST6Data$hdd__cnt_gt_0[order(CST6Data$name)]
```

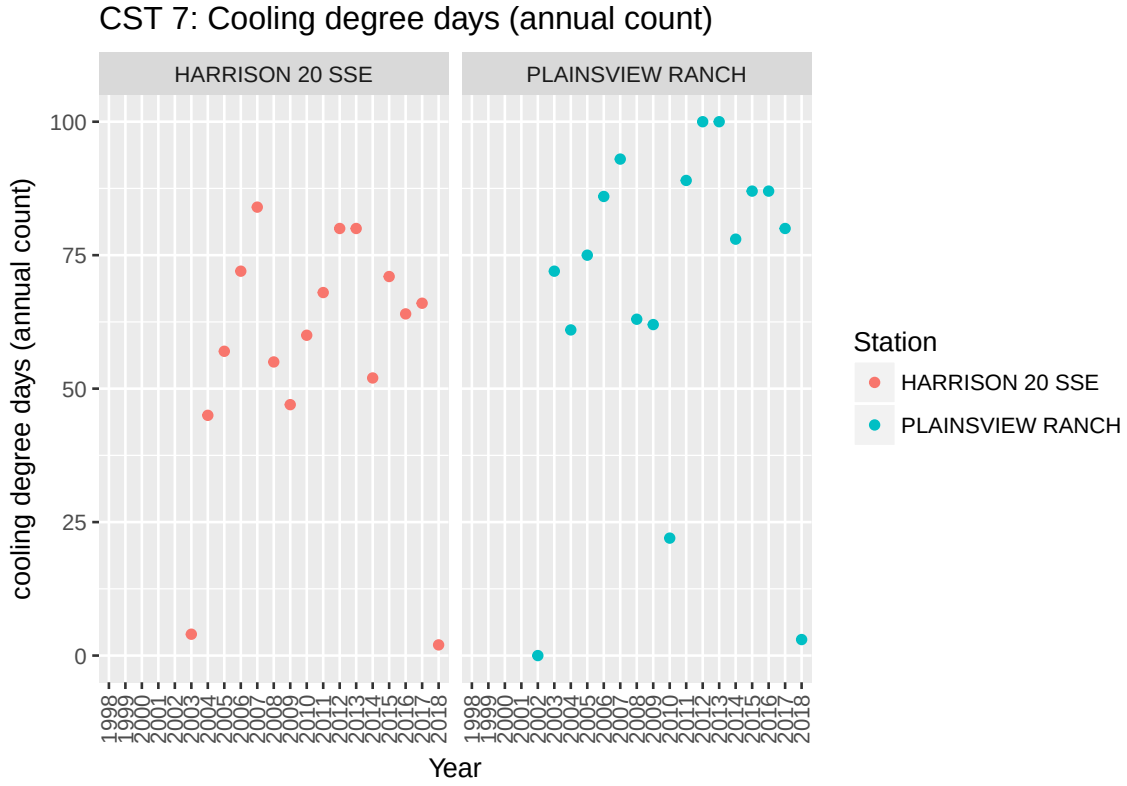
```
##  [1]  NA  NA  NA  NA  NA 122 317 302 287 276 306 309 293 293 283 277 308
## [18] 280 294 292 147  NA  NA  NA  NA  38 254 269 255 237 254 240 269 229
## [35] 267 259 262 278 267 265 268 145
```




```
# Get CST7: Cooling degree days (default base temperature >= 65) (annual
# count)
CST7Data <- getWxObservations(climateStations = unique(agfoStationsCurrent$uid),
    climateParameters = list("cdd"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_gt_0", metric = "CST7")
```

```
CST7Data$cdd__cnt_gt_0[order(CST7Data$name)]
```

```
##  [1]  NA  NA  NA  NA  NA   4  45  57  72  84  55  47  60  68  80  80  52
## [18]  71  64  66   2  NA  NA  NA  NA   0  72  61  75  86  93  63  62  22
## [35]  89 100 100  78  87  87  80   3
```



For the departure-based metrics, a new set of stations collecting average temperature (avgt) is needed which is passed to a new *getWxObservations()* request.

```
agfoStationsBBoxAvgT <- findStation(unitCode = "AGFO", customBBox = "-104.19609745831781, 42.1
    climateParameters = list("avgt"))
agfoStationsCurrentAvgT <- agfoStationsBBoxAvgT[agfoStationsBBoxAvgT$minDate >=
    "1998-01-01" & agfoStationsBBoxAvgT$maxDate >= "2018-01-01", ]
str(agfoStationsCurrentAvgT)
```

```
## 'data.frame':    2 obs. of  17 variables:
##  $ uid              : num  31465 31702
##  $ name             : chr  "PLAINSVIEW RANCH" "HARRISON 20 SSE"
##  $ longitude        : num  -104 -104
##  $ latitude         : num  42.3 42.4
##  $ sid1             : chr  "256765 2" "94077 1"
##  $ sid1_type        : chr  "COOP" "WBAN"
##  $ sid2             : chr  "USC00256765 6" "253628 2"
##  $ sid2_type        : chr  "COOP" "COOP"
##  $ sid3             : chr  "PVRN1 7" "74438 4"
##  $ sid3_type        : chr  "NWSLI" "WMO"
##  $ state            : chr  "NE" "NE"
##  $ elev             : num  4680 4406
##  $ isHCNStation     : chr  "N" "N"
##  $ minDate          : Date, format: "2002-11-23" "2003-08-28"
##  $ maxDate          : Date, format: "2018-05-30" "2018-05-31"
##  $ climateParameter: chr  "avgt" "avgt"
##  $ unitCode         : chr  "AGFO" "AGFO"
```

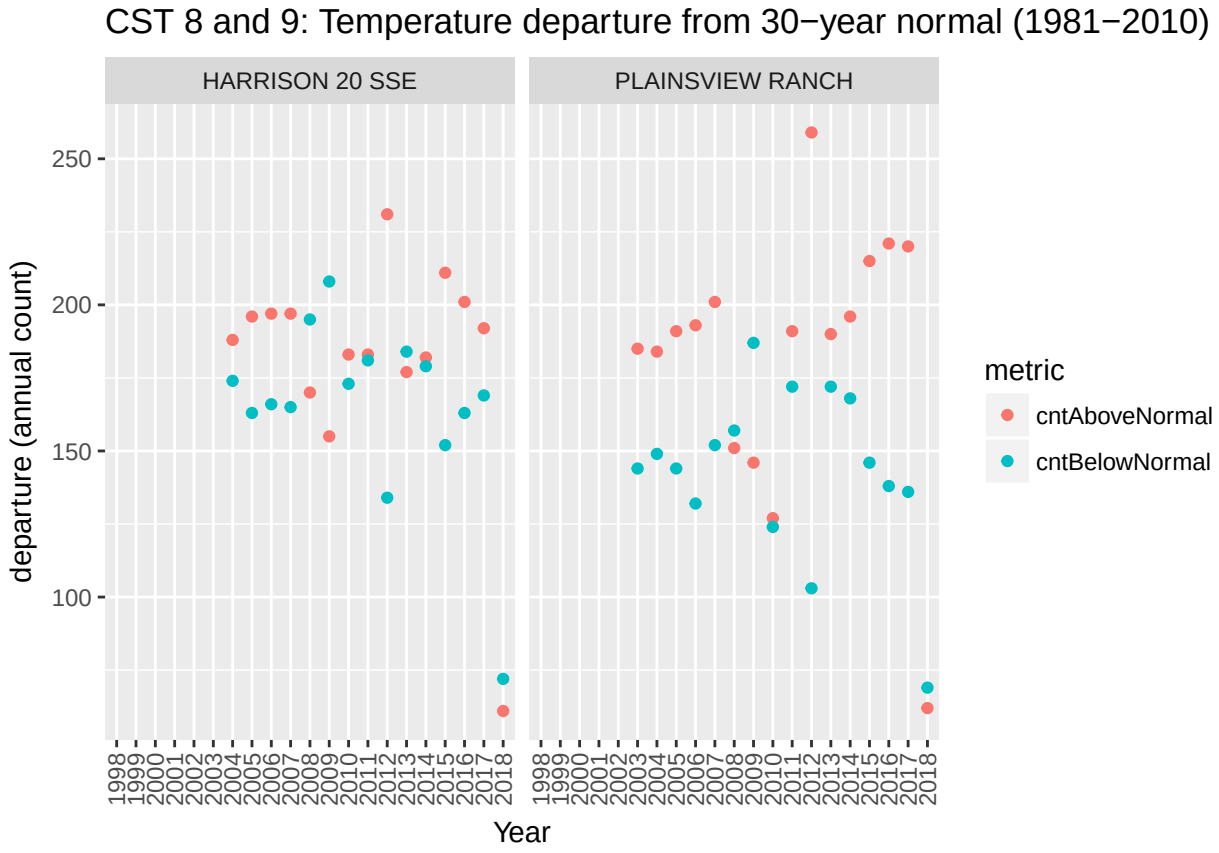
The daily departure data are summarized into annual counts above and below normal using the *getDepartureCounts()* func-

tion.

```
# Get CST8 and 9: Annual count of days above/below 30-year climate normal
# (1981-2010)
CST8and9Source <- getWxObservations(climateStations = unique(agfoStationsCurrentAvgT$uid),
    climateParameters = list("avgt"), sdate = "1998-01-01", edate = "2018-05-15",
    duration = "dly", interval = "dly", normal = "departure", metric = "CST8and9")
```

```
# CST8and9Data$avgt__F_departure str(CST8and9Source)
CST8and9Data <- getDepartureCounts(rawDepartures = CST8and9Source, duration = "yly",
    metric = "CST8and9")
str(CST8and9Data)
```

```
## 'data.frame':    42 obs. of  6 variables:
##  $ uid           : Factor w/ 2 levels "31465","31702": 1 2 1 2 1 2 1 2 1 2 ...
##  $ name          : Factor w/ 2 levels "HARRISON 20 SSE",..: 2 1 2 1 2 1 2 1 2 1 ...
##  $ date          : Factor w/ 21 levels "1998","1999",..: 1 1 2 2 3 3 4 4 5 5 ...
##  $ cntAboveNormal: Factor w/ 26 levels "127","146","151",..: NA NA NA NA NA NA NA NA NA NA
##  $ cntBelowNormal: Factor w/ 27 levels "103","124","132",..: NA NA NA NA NA NA NA NA NA NA
##  $ metric        : Factor w/ 1 level "CST8and9": 1 1 1 1 1 1 1 1 1 1 ...
```



Precipitation

For the precipitation metrics, a new set of stations collecting precipitation (pcpn) is requested. Notice the two additional stations acquiring precipitation and that three of the four stations do not collect snow depth.

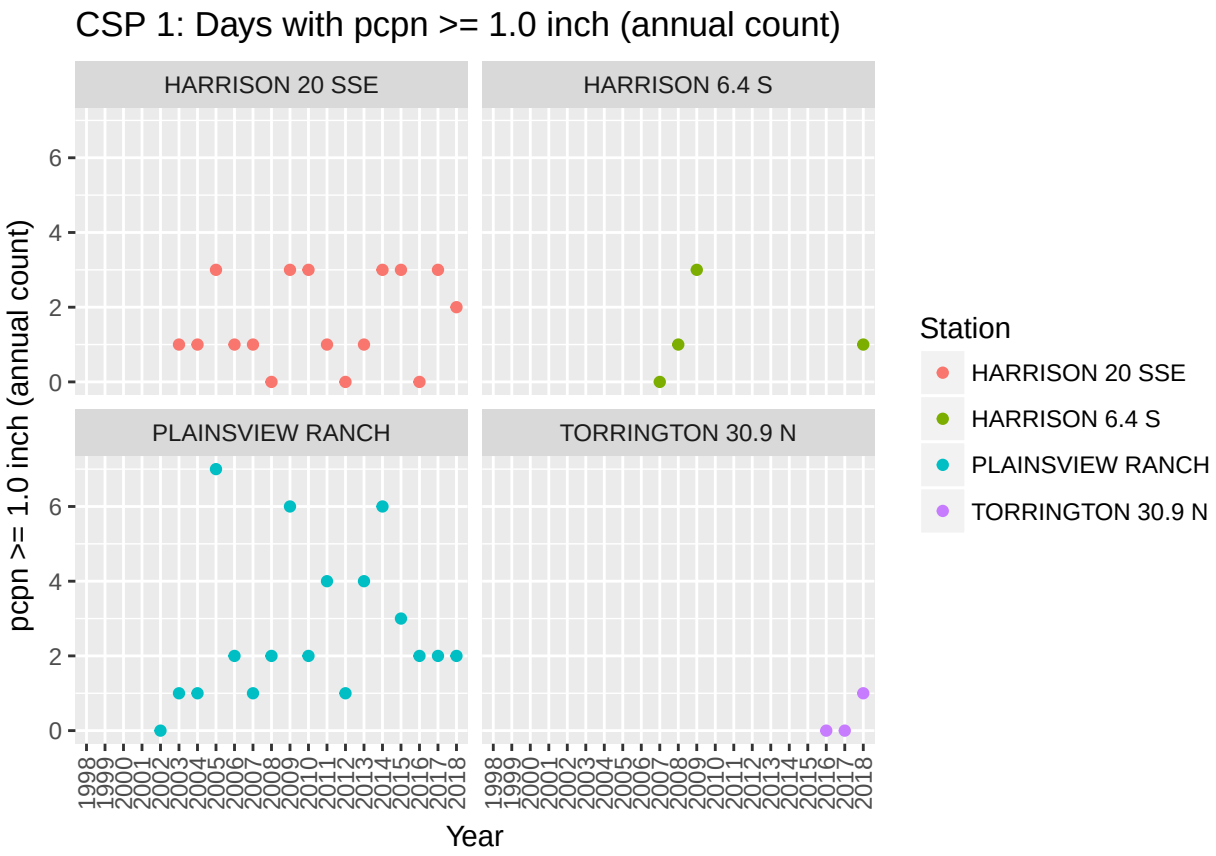
```
agfoStationsBBoxPcpn <- findStation(unitCode = "AGFO", customBBox = "-104.19609745831781, 42.1
    climateParameters = list("pcpn", "snow"))
agfoStationsCurrentPcpn <- agfoStationsBBoxPcpn[agfoStationsBBoxPcpn$minDate >=
    "1998-01-01" & agfoStationsBBoxPcpn$maxDate >= "2018-01-01", ]
str(agfoStationsCurrentPcpn)
```

```
## 'data.frame':    5 obs. of  17 variables:
##  $ uid             : num  81941 31465 31702 62399 31465
##  $ name            : chr  "TORRINGTON 30.9 N" "PLAINSVIEW RANCH" "HARRISON 20 SSE" "HARRISO
##  $ longitude       : num  -104 -104 -104 -104 -104
##  $ latitude        : num  42.5 42.3 42.4 42.6 42.3
##  $ sid1            : chr  "US1WYGS0040 6" "256765 2" "94077 1" "US10siou002 6" ...
##  $ sid1_type       : chr  "GHCN" "COOP" "WBAN" "GHCN" ...
##  $ sid2            : chr  "WYGS0040 10" "USC00256765 6" "253628 2" "0siou002 10" ...
##  $ sid2_type       : chr  "CoCoRaHS" "COOP" "COOP" "CoCoRaHS" ...
##  $ sid3            : chr  NA "PVRN1 7" "74438 4" NA ...
##  $ sid3_type       : chr  NA "NWSLI" "WMO" NA ...
##  $ state           : chr  "WY" "NE" "NE" "NE" ...
##  $ elev            : num  4786 4680 4406 4724 4680
##  $ isHCNStation    : chr  "N" "N" "N" "N" ...
##  $ minDate         : Date, format: "2016-05-13" "2002-11-24" ...
##  $ maxDate         : Date, format: "2018-05-29" "2018-05-30" ...
##  $ climateParameter: chr  "pcpn" "pcpn" "pcpn" "pcpn" ...
##  $ unitCode        : chr  "AGFO" "AGFO" "AGFO" "AGFO" ...
```

```
# Get CSP1: Heavy precipitation days (annual count)
CSP1Data <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("pcpn"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_ge_1.0", metric = "CSP1")
```

```
CSP1Data$pcpn_in_cnt_ge_1.0[order(CSP1Data$name)]
```

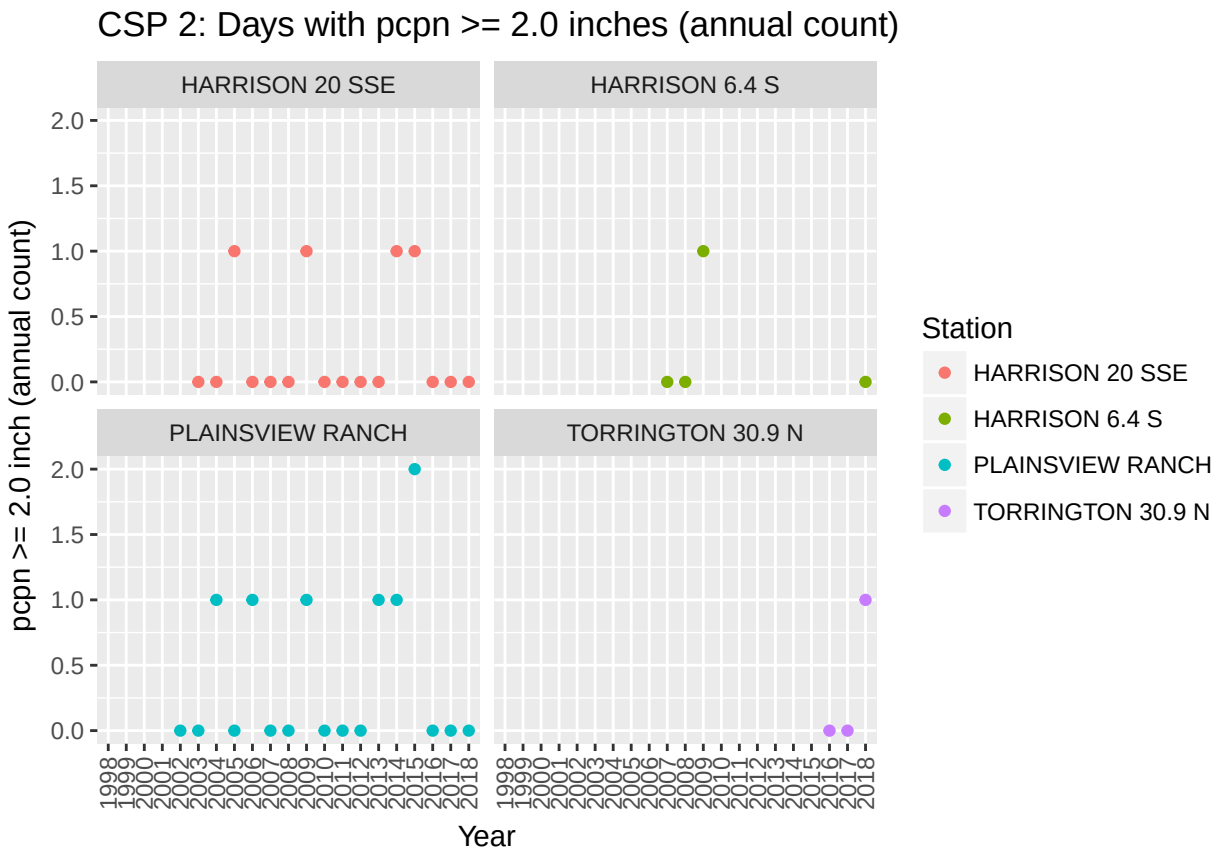
```
##  [1] NA NA NA NA NA  1  1  3  1  1  0  3  3  1  0  1  3  3  0  3  2 NA NA
## [24] NA NA NA NA NA NA NA  0  1  3 NA NA NA NA NA NA NA NA  1 NA NA NA NA
## [47]  0  1  1  7  2  1  2  6  2  4  1  4  6  3  2  2  2 NA NA NA NA NA NA
## [70] NA NA NA NA NA NA NA NA NA NA NA NA  0  0  1
```




```
# Get CSP2: Extreme precipitation days (annual count)
CSP2Data <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("pcpn"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_ge_2.0", metric = "CSP2")
```

```
CSP2Data$pcpn_in_cnt_ge_2.0[order(CSP2Data$name)]
```

```
##  [1] NA NA NA NA NA  0  0  1  0  0  0  1  0  0  0  0  1  1  0  0  0 NA NA
## [24] NA NA NA NA NA NA NA  0  0  1 NA NA NA NA NA NA NA NA  0 NA NA NA NA
## [47]  0  0  1  0  1  0  0  1  0  0  0  1  1  2  0  0  0 NA NA NA NA NA NA
## [70] NA NA NA NA NA NA NA NA NA NA NA NA  0  0  1
```



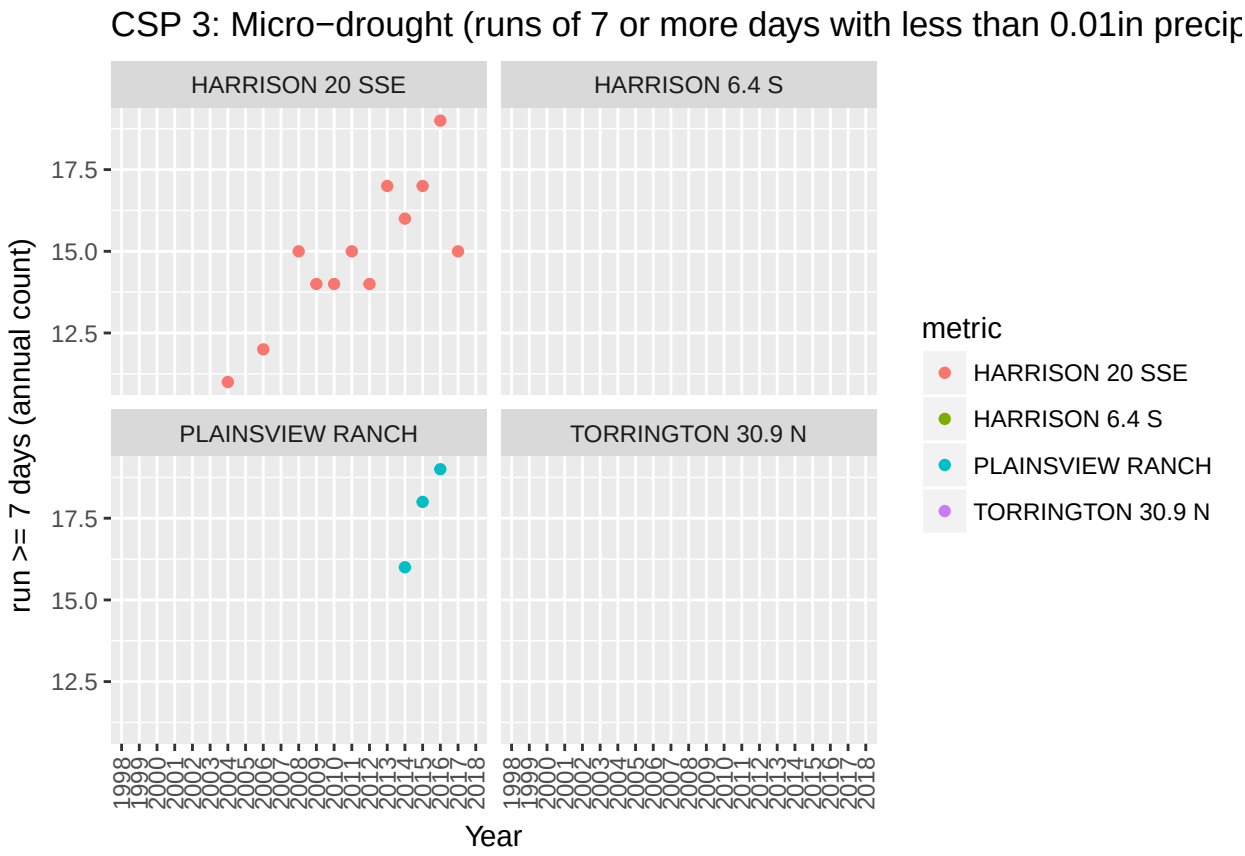

```
# Get CSP3: Micro-drought - runs of 7 or more days with less than 0.01in
# precip (annual count)
CSP3Source <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("pcpn"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "run_le_0.01", metric = "CSP3")
```

```
CSP3Source$pcpn_in_runYear[order(CSP3Source$name)]
```

```
##  [1] "1998" "1999" "2000" "2001" "2002" "2003" "2004" "2005" "2006" "2007"
## [11] "2008" "2009" "2010" "2011" "2012" "2013" "2014" "2015" "2016" "2017"
## [21] "2018" "1998" "1999" "2000" "2001" "2002" "2003" "2004" "2005" "2006"
## [31] "2007" "2008" "2009" "2010" "2011" "2012" "2013" "2014" "2015" "2016"
## [41] "2017" "2018" "1998" "1999" "2000" "2001" "2002" "2003" "2004" "2005"
## [51] "2006" "2007" "2008" "2009" "2010" "2011" "2012" "2013" "2014" "2015"
## [61] "2016" "2017" "2018" "1998" "1999" "2000" "2001" "2002" "2003" "2004"
## [71] "2005" "2006" "2007" "2008" "2009" "2010" "2011" "2012" "2013" "2014"
## [81] "2015" "2016" "2017" "2018"
```

```
CSP3Data <- getRunCounts(rawCounts = CSP3Source, runLength = 7, metric = "CSP3")
CSP3Data$cntGERunLength_7[order(CSP3Data$name)]
```

```
##  [1] <NA> <NA> <NA> <NA> <NA> <NA> 11   <NA> 12   <NA> 15   14   14   15
## [15] 14   17   16   17   19   15   <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA>
## [29] <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA>
## [43] <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA>
## [57] <NA> <NA> 16   18   19   <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA>
## [71] <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA> <NA>
## Levels: 11 12 14 15 16 17 18 19
```

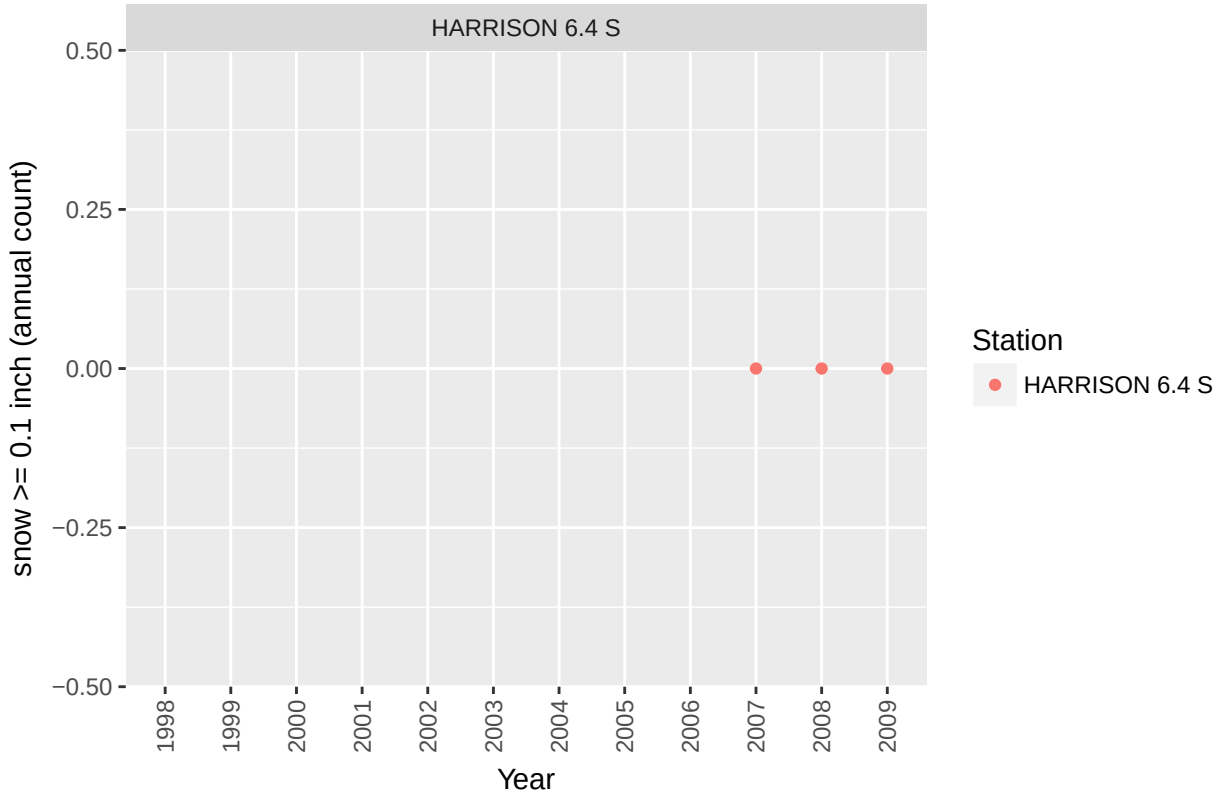


Although one station returns observations for snow depth, the value of 0 measureable snow days may indicate issues with that sensor.

```
# Get CSP4: Measurable snow days (annual count)
CSP4Data <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("snow"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_ge_0.1", metric = "CSP4")
```

```
CSP4Data$snow_in_cnt_ge_0.1[order(CSP4Data$name)]
```

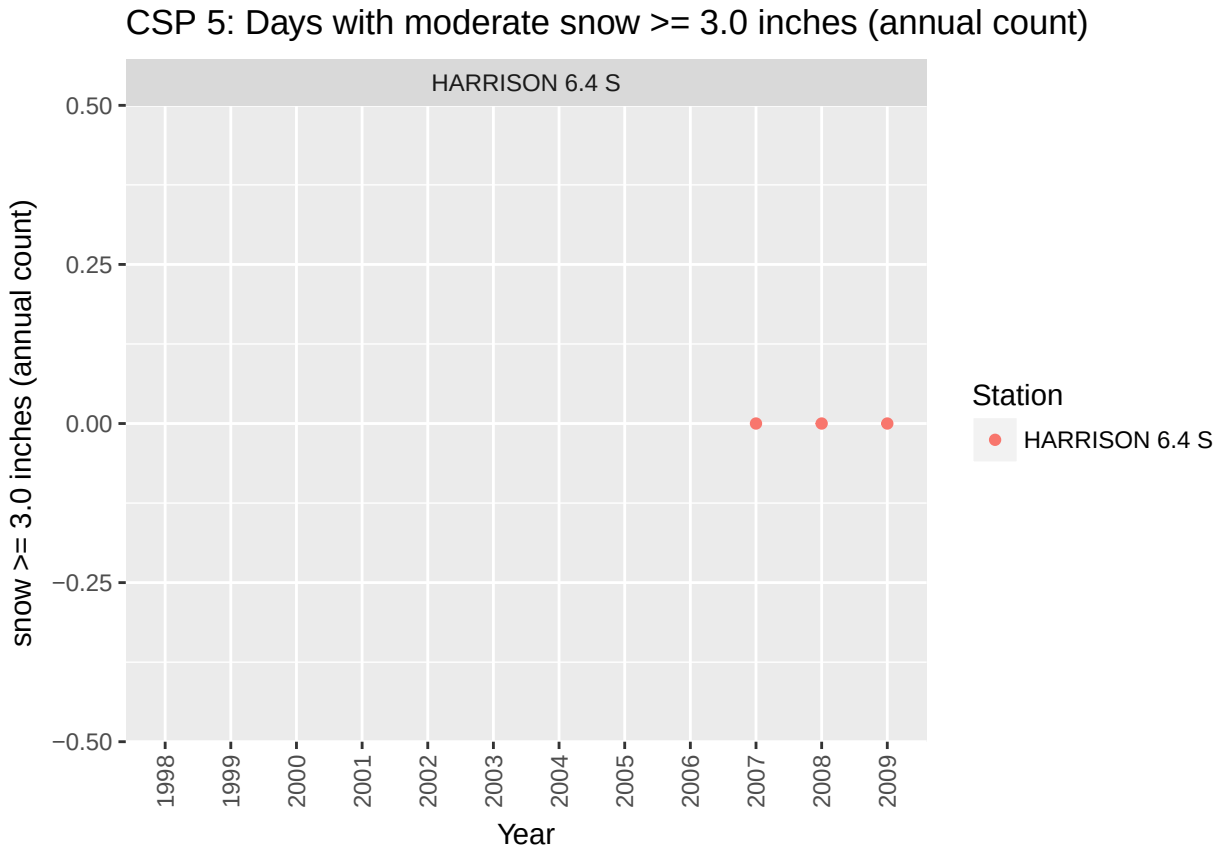
```
##  [1] NA NA NA NA NA NA NA NA NA  0  0  0
```




```
# Get CSP5: Moderate snow days (annual count)
CSP5Data <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("snow"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_ge_3.0", metric = "CSP5")
```

```
CSP5Data$snow_in_cnt_ge_3.0[order(CSP5Data$name)]
```

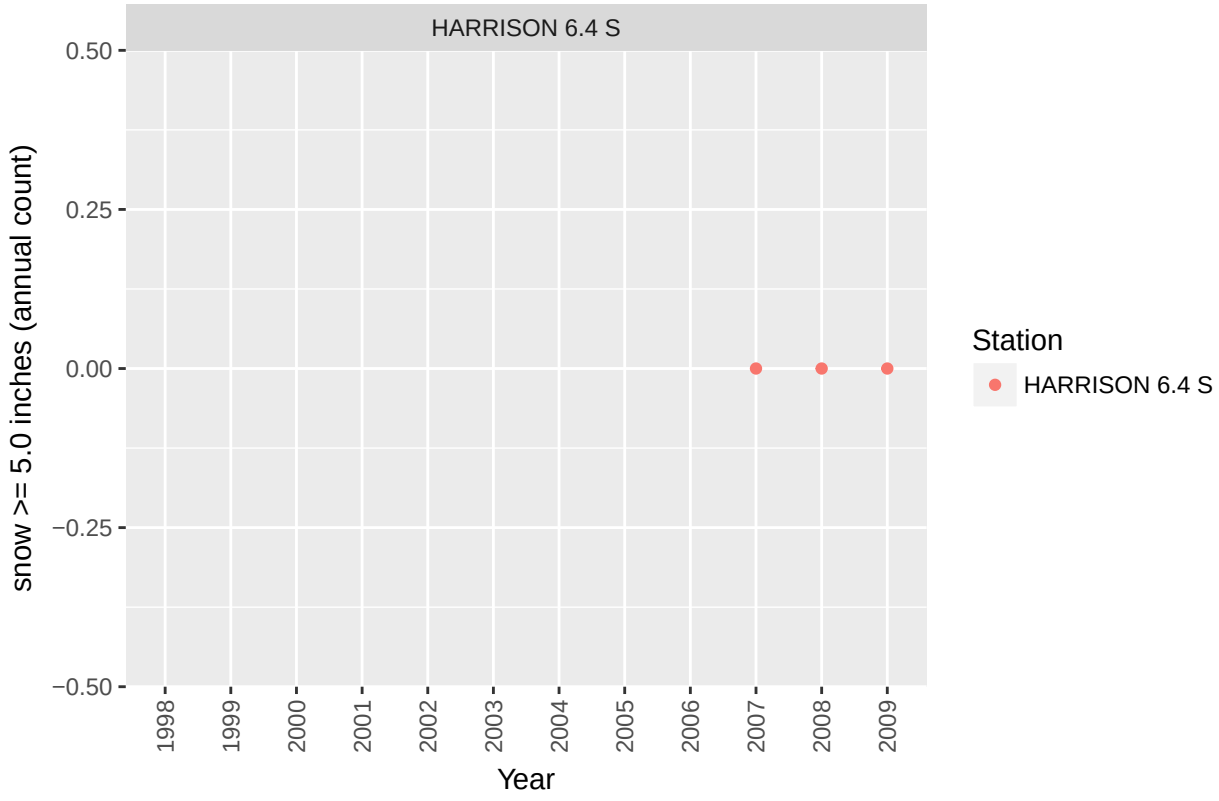
```
##  [1] NA NA NA NA NA NA NA NA NA  0  0  0
```




```
# Get CSP6: Heavy snow days (annual count)
CSP6Data <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("snow"), sdate = "1998-01-01", duration = "yly",
    interval = "yly", reduceCodes = "cnt_ge_5.0", metric = "CSP6")
```

```
CSP6Data$snow_in_cnt_ge_5.0[order(CSP6Data$name)]
```

```
##  [1] NA NA NA NA NA NA NA NA NA  0  0  0
```




```
# Get CST8 and 9: Annual count of days above/below 30-year climate normal
# (1981-2010)
CSP7and8Source <- getWxObservations(climateStations = unique(agfoStationsCurrentPcpn$uid),
    climateParameters = list("pcpn"), sdate = "1998-01-01", edate = "2018-05-15",
    duration = "dly", interval = "dly", normal = "departure", metric = "CSP7and8")
```

```
# CST8and9Data$avgt__F_departure str(CST8and9Source)
CSP7and8Data <- getDepartureCounts(rawDepartures = CSP7and8Source, duration = "yly",
    metric = "CSP7and8")
str(CSP7and8Data)
```

```
## 'data.frame':    84 obs. of  6 variables:
##  $ uid           : Factor w/ 4 levels "31465","31702",..: 4 1 2 3 4 1 2 3 4 1 ...
##  $ name          : Factor w/ 4 levels "HARRISON 20 SSE",..: 4 3 1 2 4 3 1 2 4 3 ...
##  $ date          : Factor w/ 21 levels "1998","1999",..: 1 1 1 1 2 2 2 2 3 3 ...
##  $ cntAboveNormal: Factor w/ 21 levels "22","24","28",..: NA NA NA NA NA NA NA NA NA NA ...
##  $ cntBelowNormal: Factor w/ 22 levels "106","209","283",..: NA NA NA NA NA NA NA NA NA NA
##  $ metric        : Factor w/ 1 level "CSP7and8": 1 1 1 1 1 1 1 1 1 1 ...
```

CSP 7 and 8: Precipitation departure from 30−year normal (1981−2010)