Climate Change in Established and Emerging Wine Regions of Ontario: Risks and Opportunities

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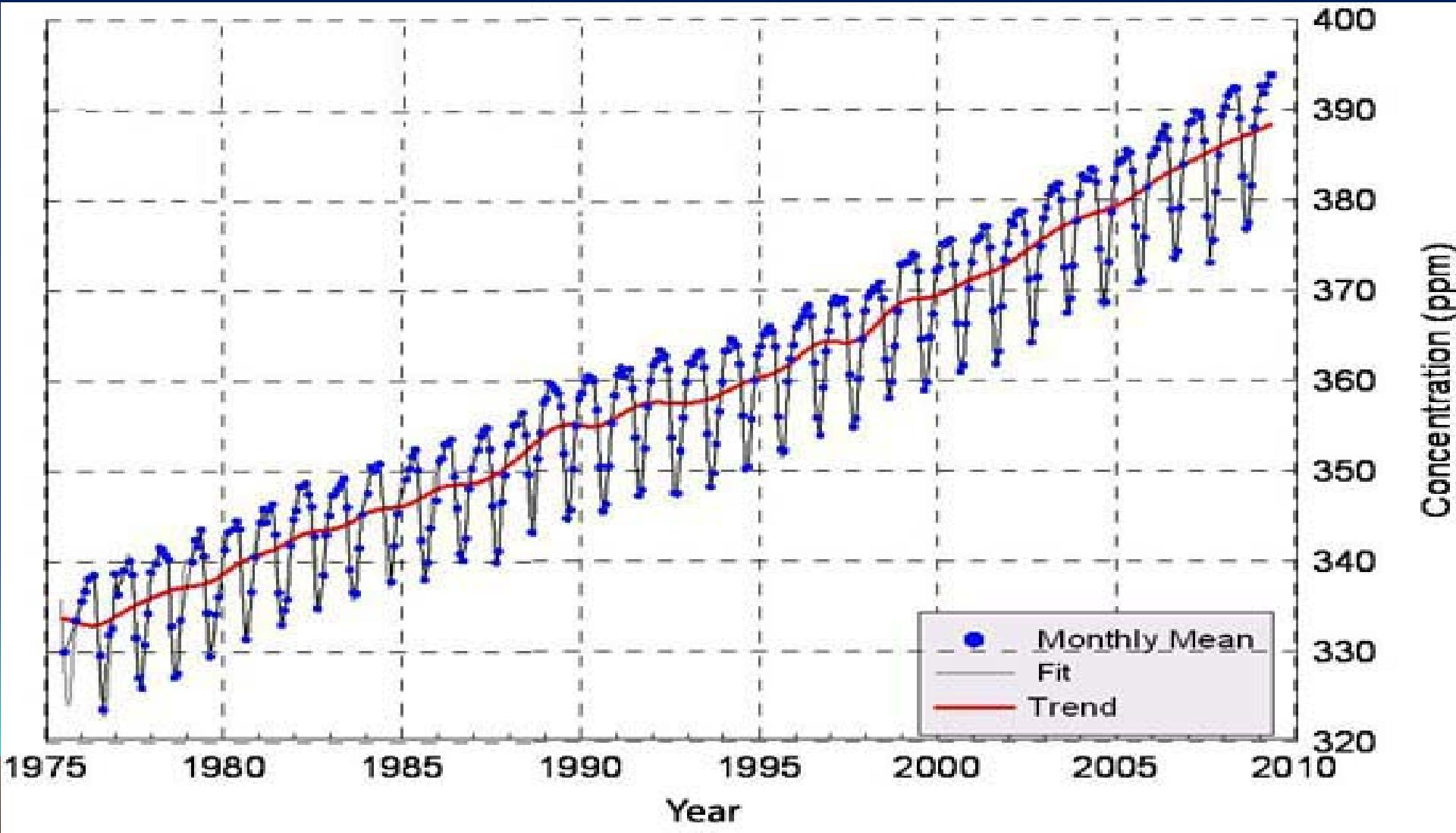
THE MAIN VITICULTURE AND FRUIT GROWING AREAS OF CANADA

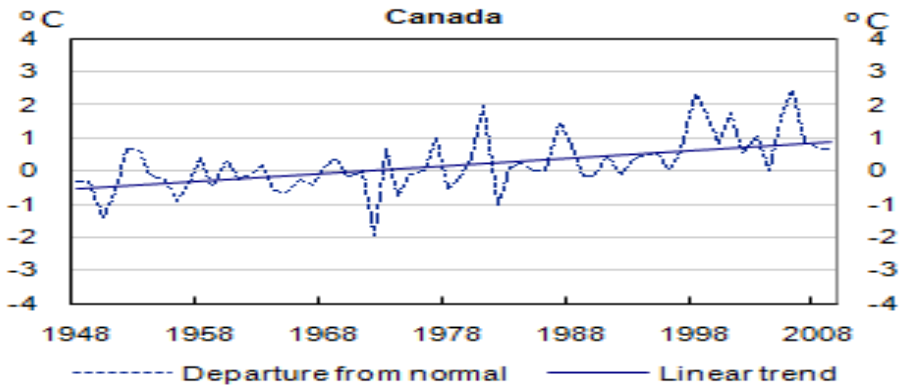
Georgian Bay
Grey
Lake Huron
Durham
P EC
Huron
Lake Ontario
Niagara
Norfolk
Lake Erie
North Shore
© 2012 Cnes/Spot Image
Image © 2012 TerraMetrics
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image NOAA
43°30'27.49" N 79°28'14.74" W elev 31 m
Google earth
Eye alt 872.14 km

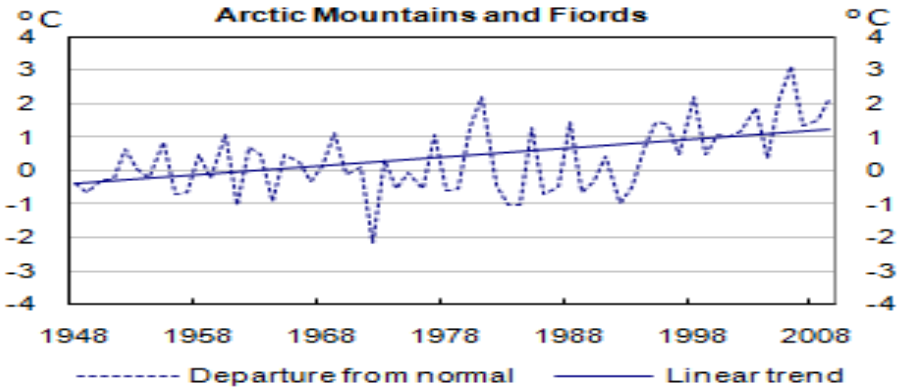
Evidence of Climate Change

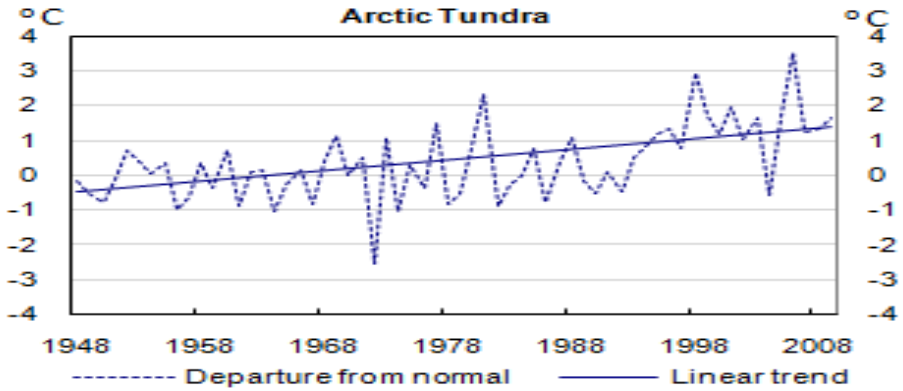
Atmospheric Carbon Dioxide Measure at Alert, Ellesmere Island

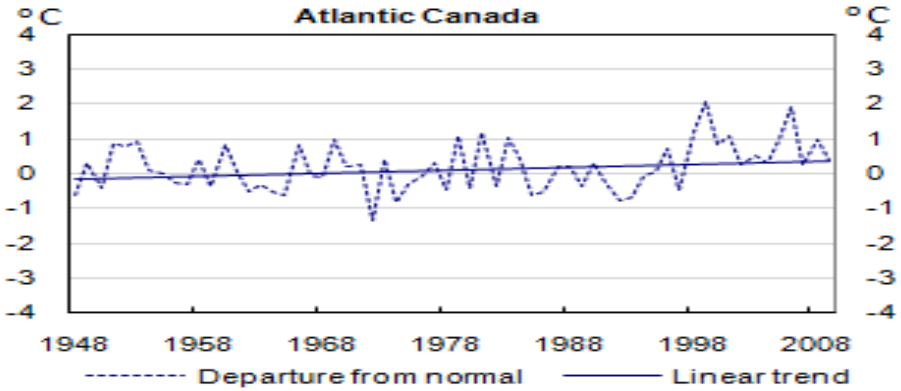


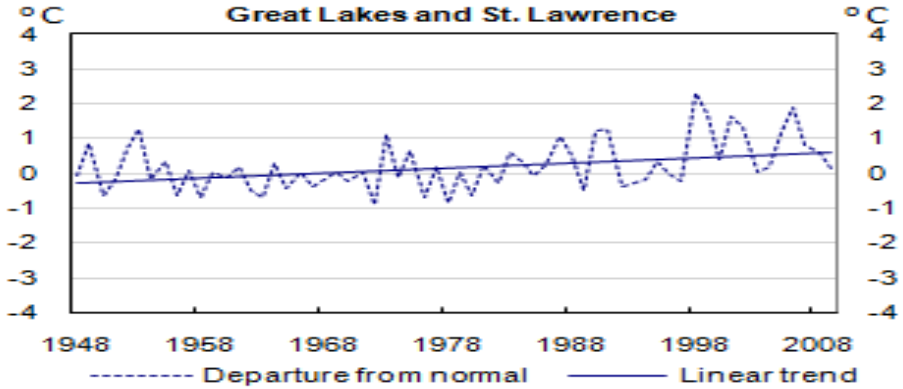
Mean temperature departures from 1961 to 1990 normal and linear trend for Canada and climatic regions,[1] 1948 to 2009

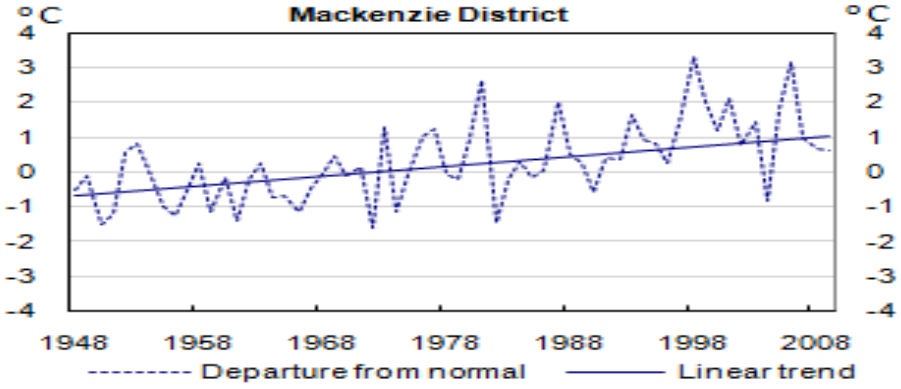


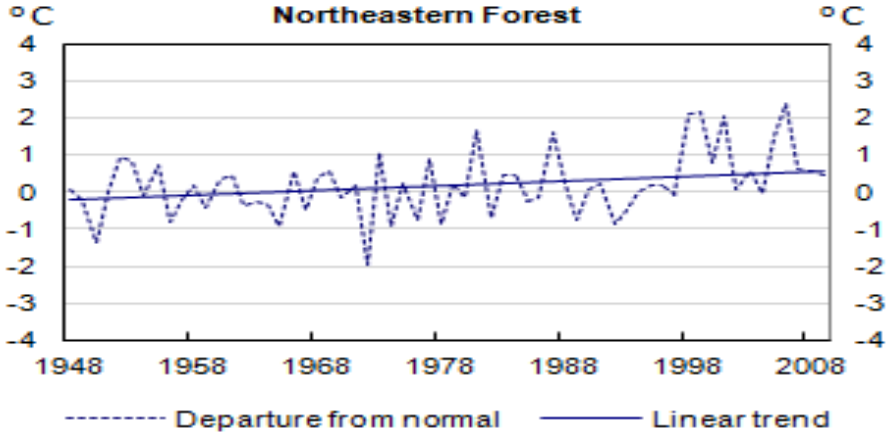


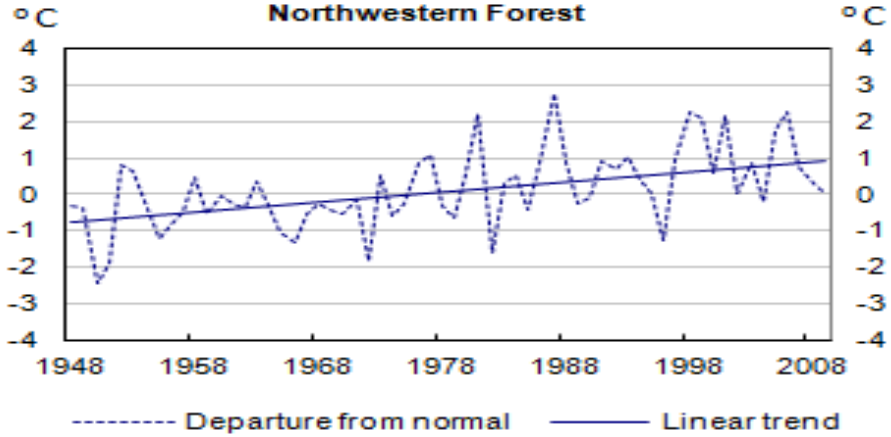


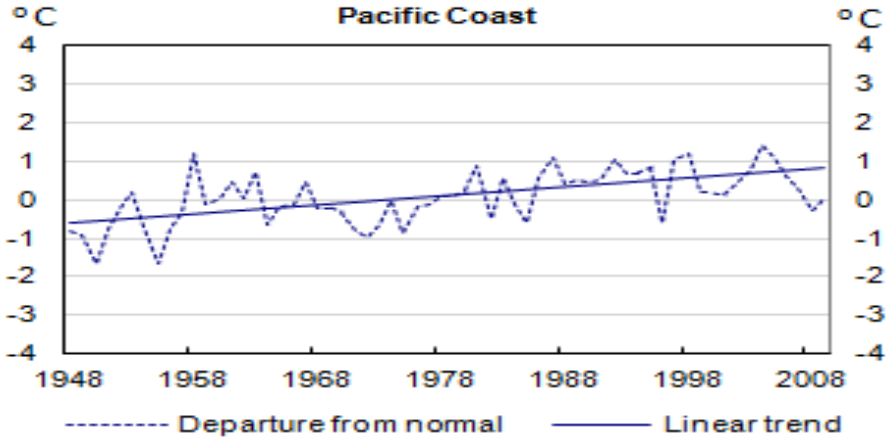


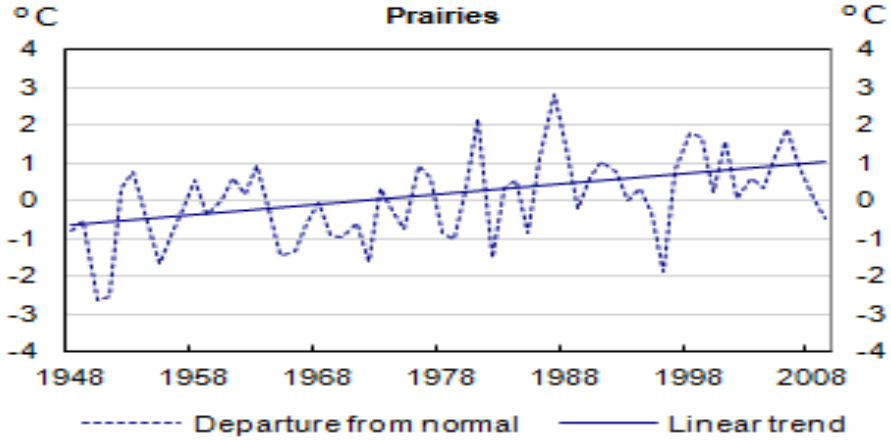


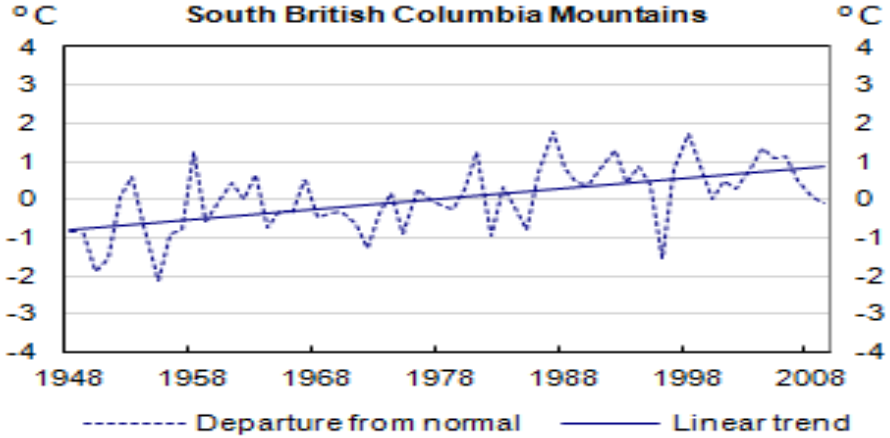


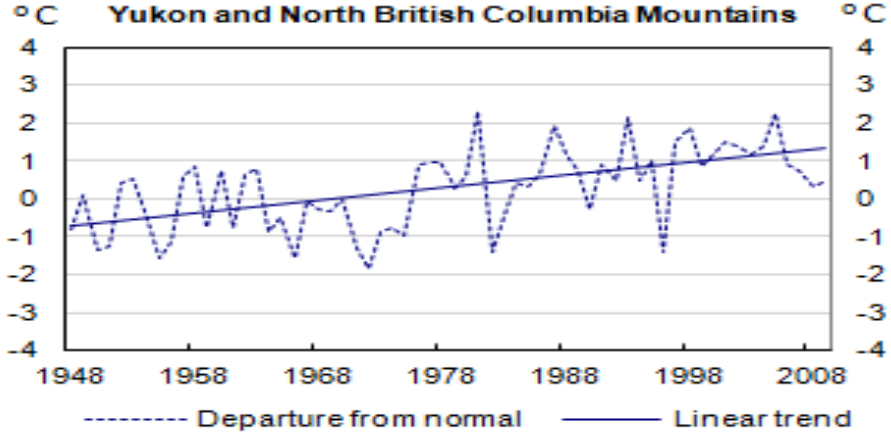

Northeastern Forest
°C
°C
4
3
2
1
0
-1
-2
-3
-4
1948
1958
1968
1978
1988
1998
2008
Departure from normal
Linear trend


Northwestern Forest
°C
°C
4
3
2
1
0
-1
-2
-3
-4
1948
1958
1968
1978
1988
1998
2008
Departure from normal
Linear trend


Pacific Coast
°C
°C
4
3
2
1
0
-1
-2
-3
-4
1948
1958
1968
1978
1988
1998
2008
Departure from normal
Linear trend


Prairies
°C
°C
4
3
2
1
0
-1
-2
-3
-4
1948
1958
1968
1978
1988
1998
2008
Departure from normal
Linear trend


South British Columbia Mountains
°C
°C
4
3
2
1
0
-1
-2
-3
-4
1948
1958
1968
1978
1988
1998
2008
Departure from normal
Linear trend


Yukon and North British Columbia Mountains
°C
°C
4
3
2
1
0
-1
-2
-3
-4
1948
1958
1968
1978
1988
1998
2008
Departure from normal
Linear trend

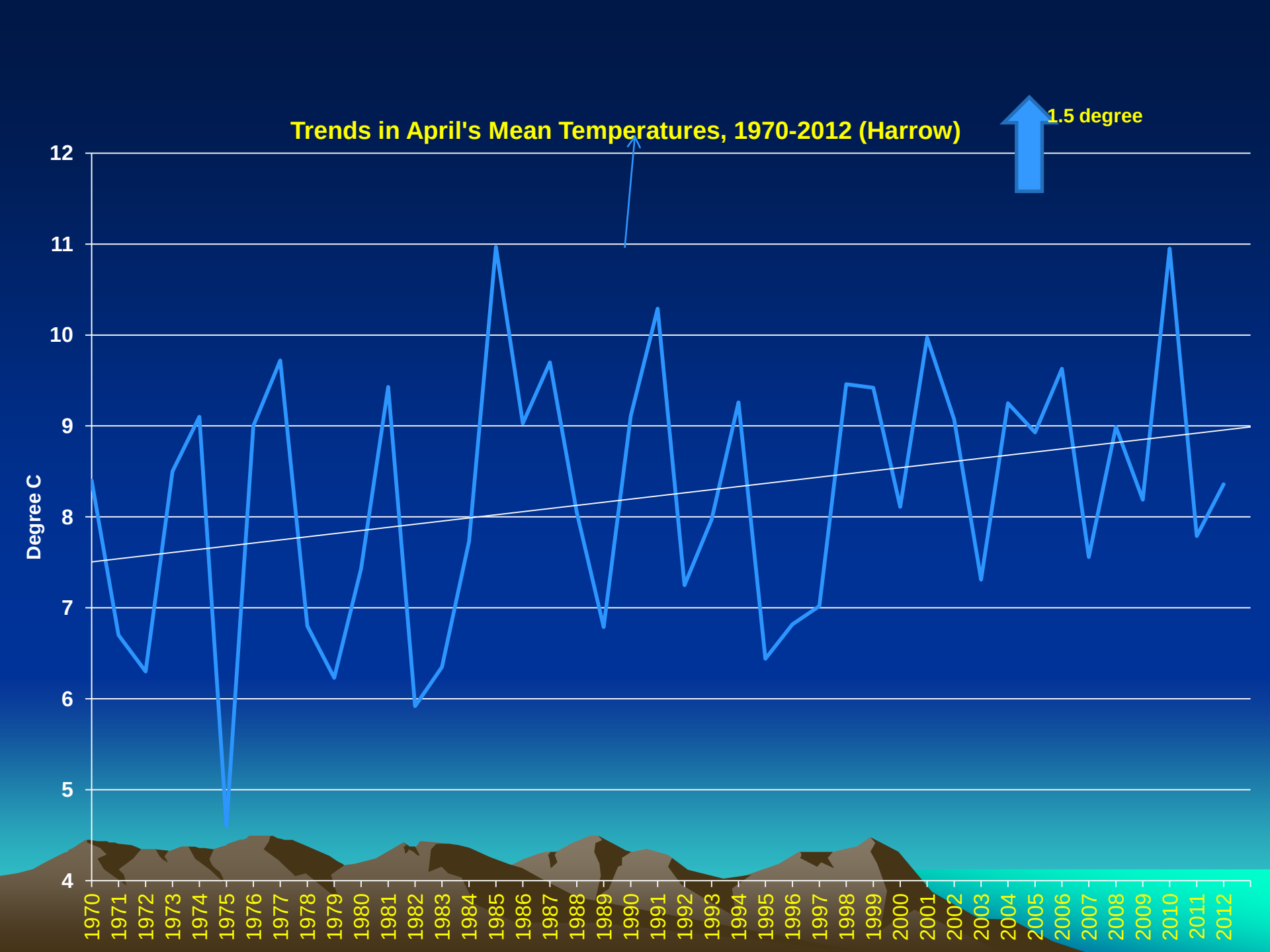
Prince Edward County
Niagara
Peninsula
Finger
Lakes
Lake Erie North Shore
Pelee Island

Lake Ontario
Niagara Peninsula
Lake Erie
Image © 2008 First Base Solutions

Spring

Is it getting warmer and occurring earlier?

Vineyard With Wind Machine


Trends in April's Mean Temperatures, 1970-2012 (Harrow)
1.5 degree
Degree C
12
11
10
9
8
7
6
5
4
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
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1996
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1998
1999
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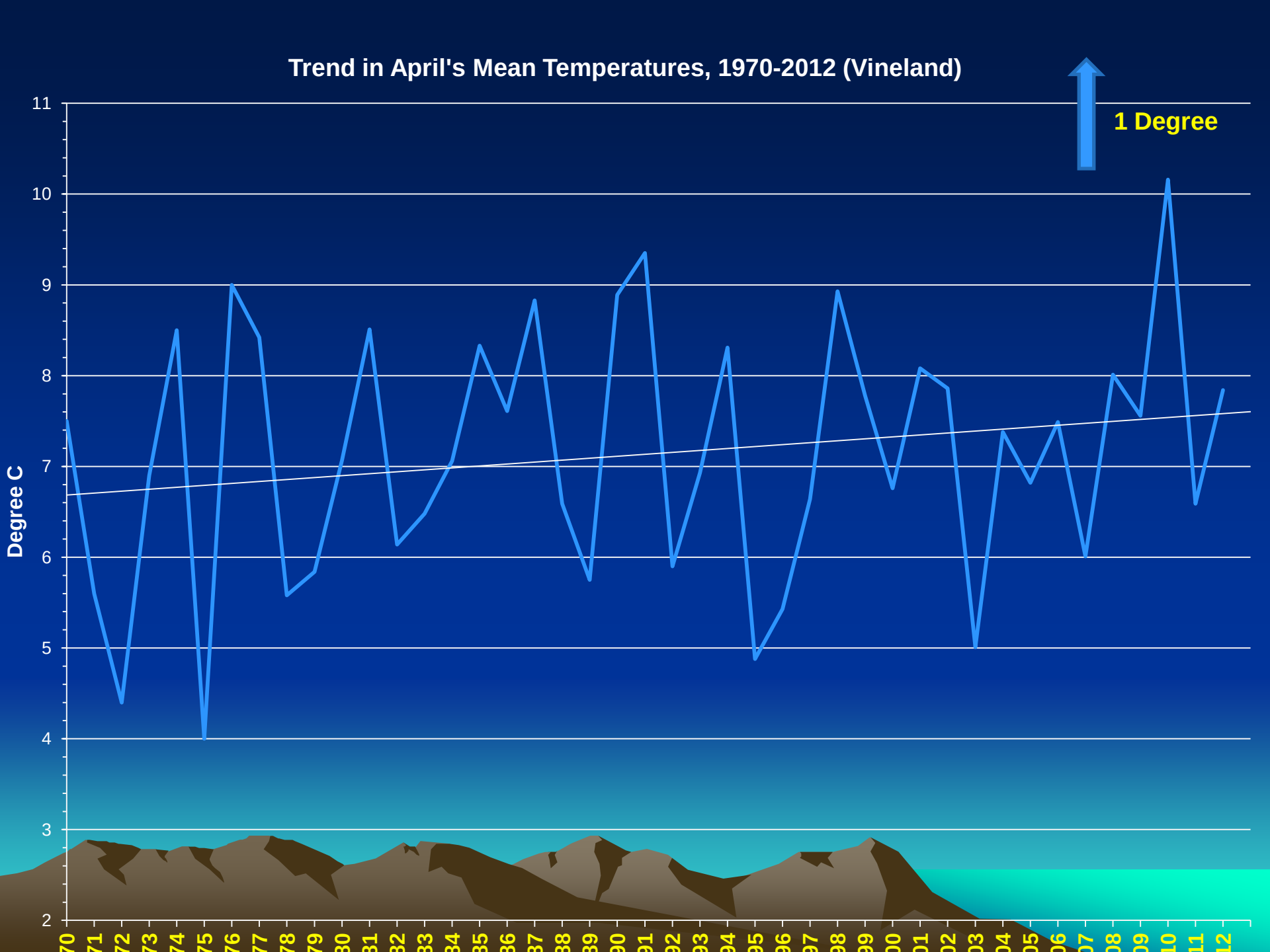
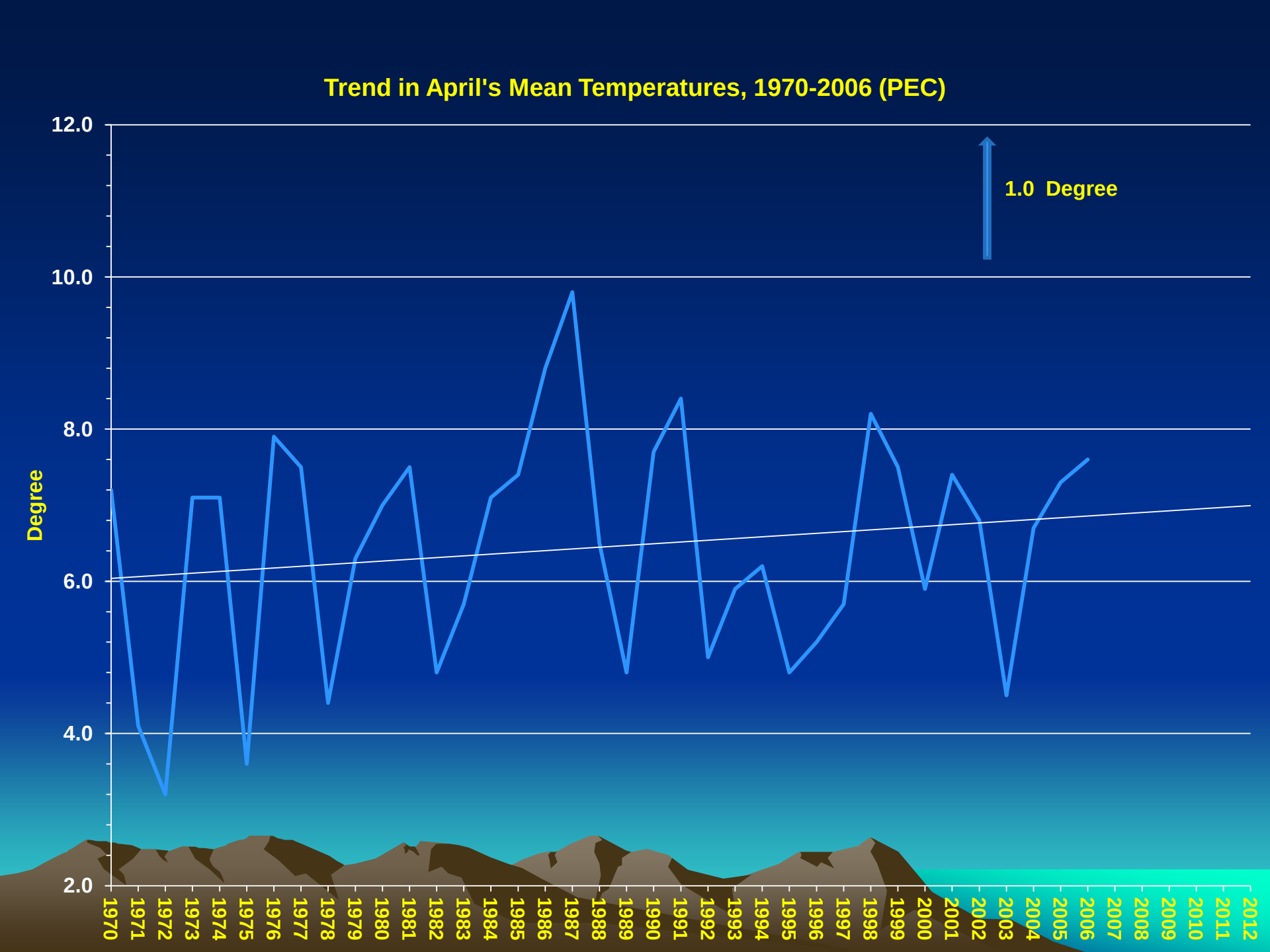
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012


Trend in April's Mean Temperatures, 1970-2012 (Vineland)
1 Degree
Degree C
11
10
9
8
7
6
5
4
3
2
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
00
01
02
03
04
05
06
07
08
09
10
11
12


Trend in April's Mean Temperatures, 1970-2006 (PEC)
1.0 Degree
Degree
12.0
10.0
8.0
6.0
4.0
2.0
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
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1994
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2000
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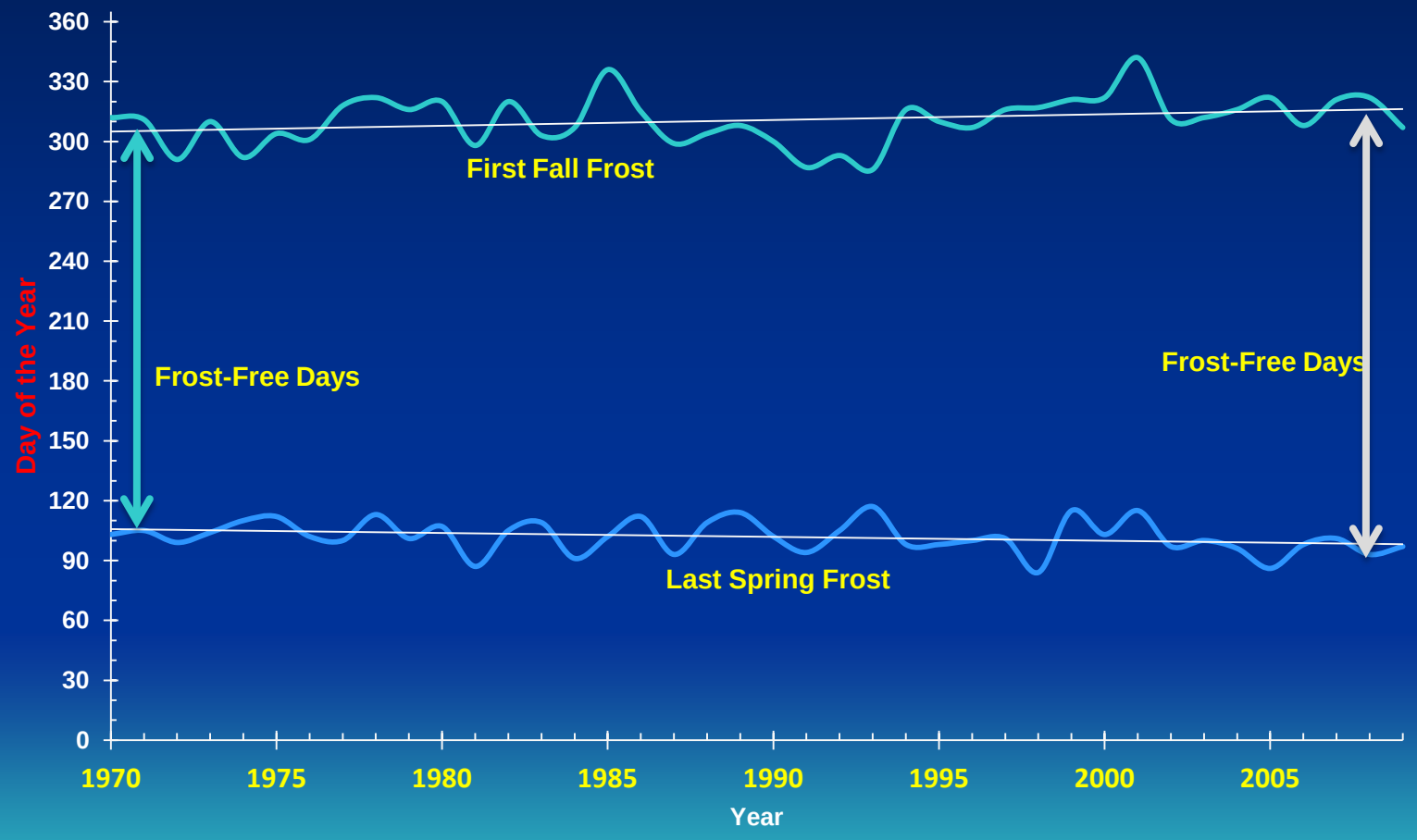
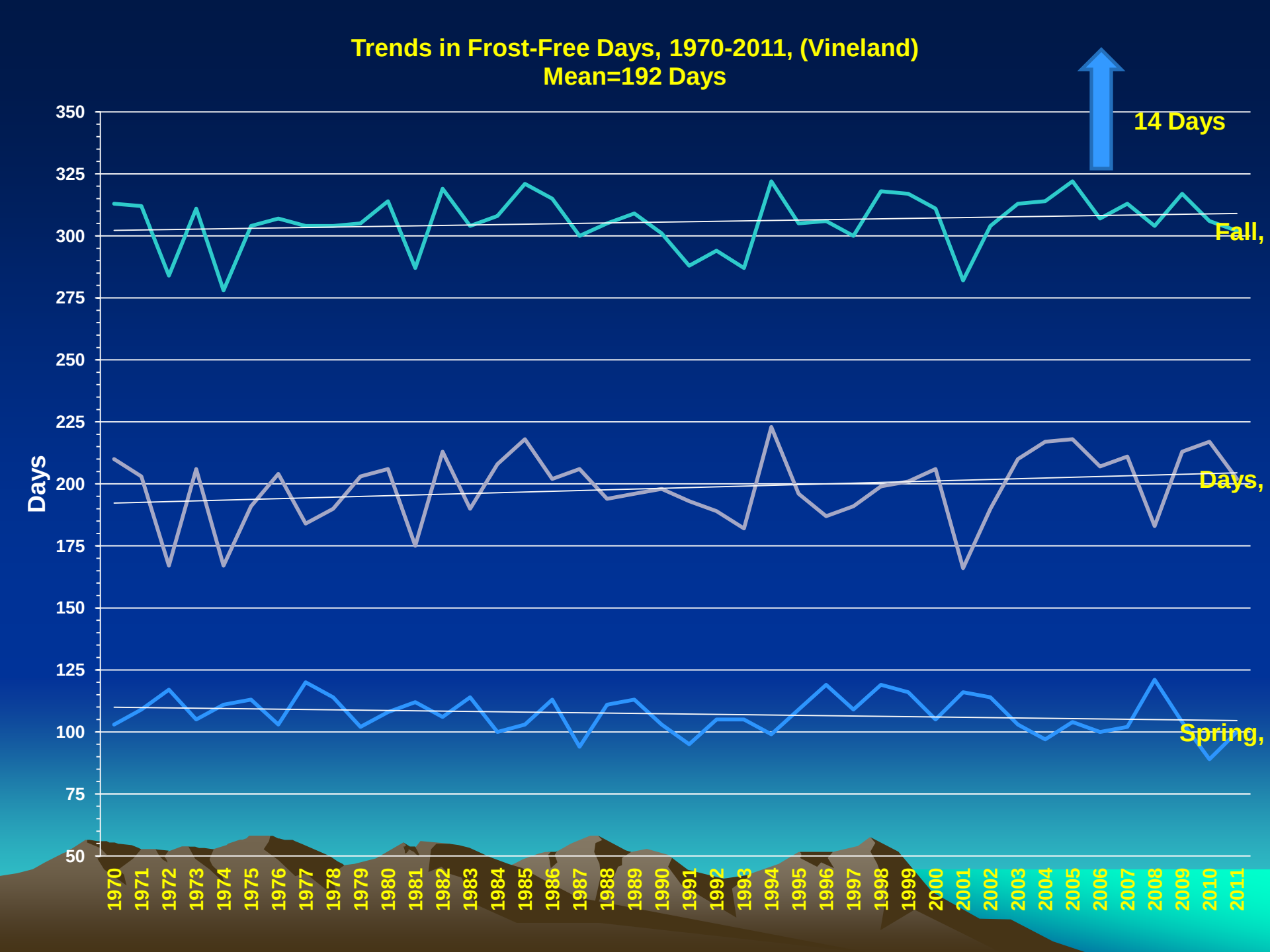
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

First and Last Day of Killing Frost




Trends in Frost-Free Days, 1970-2011, (Vineland)
Mean=192 Days
14 Days
Fall,
Days,
Spring,
Days
350
325
300
275
250
225
200
175
150
125
100
75
50
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
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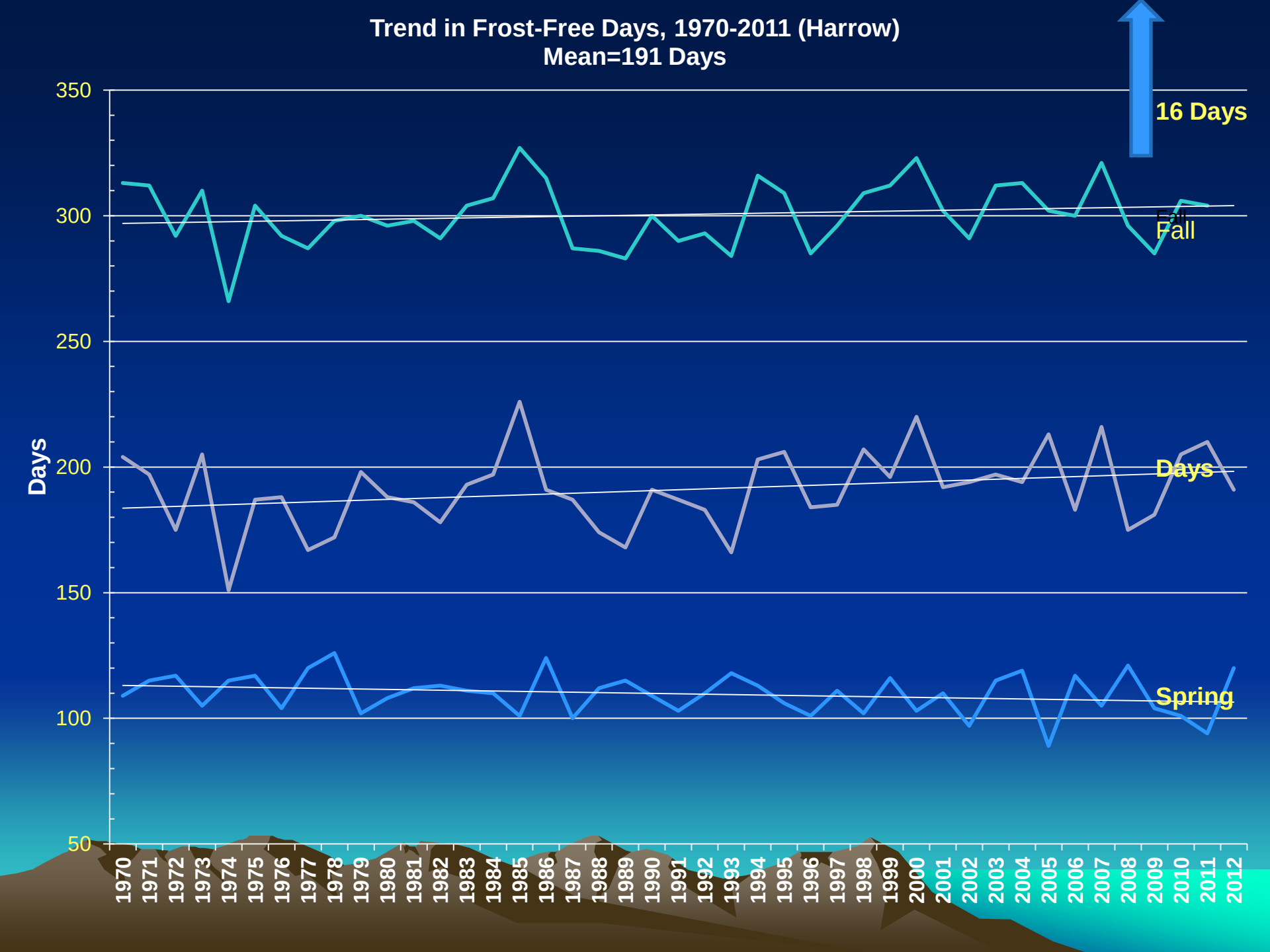
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011


Trend in Frost-Free Days, 1970-2011 (Harrow)
Mean=191 Days
16 Days
Fall
Days
Spring
Days
350
300
250
200
150
100
50
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
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1995
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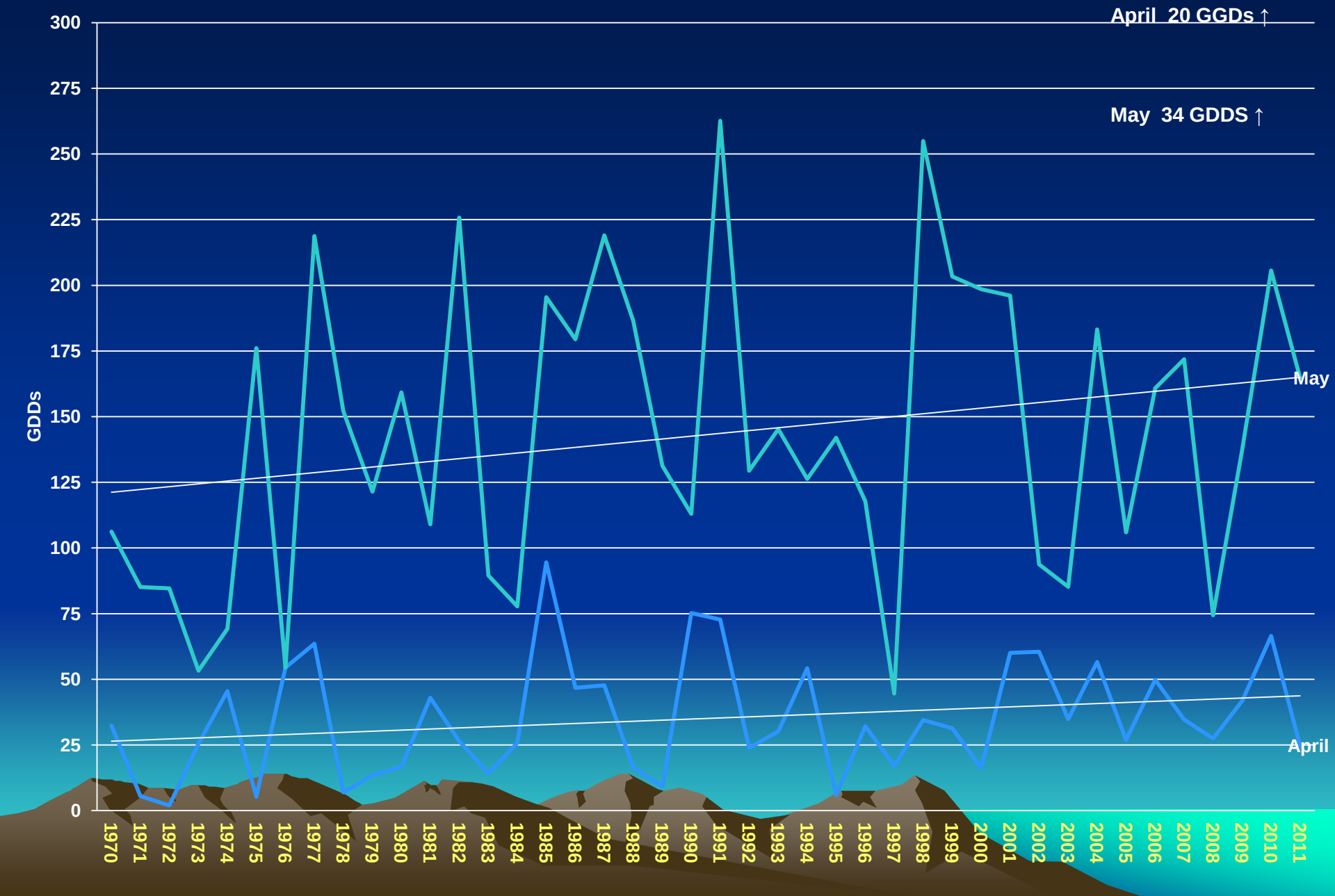
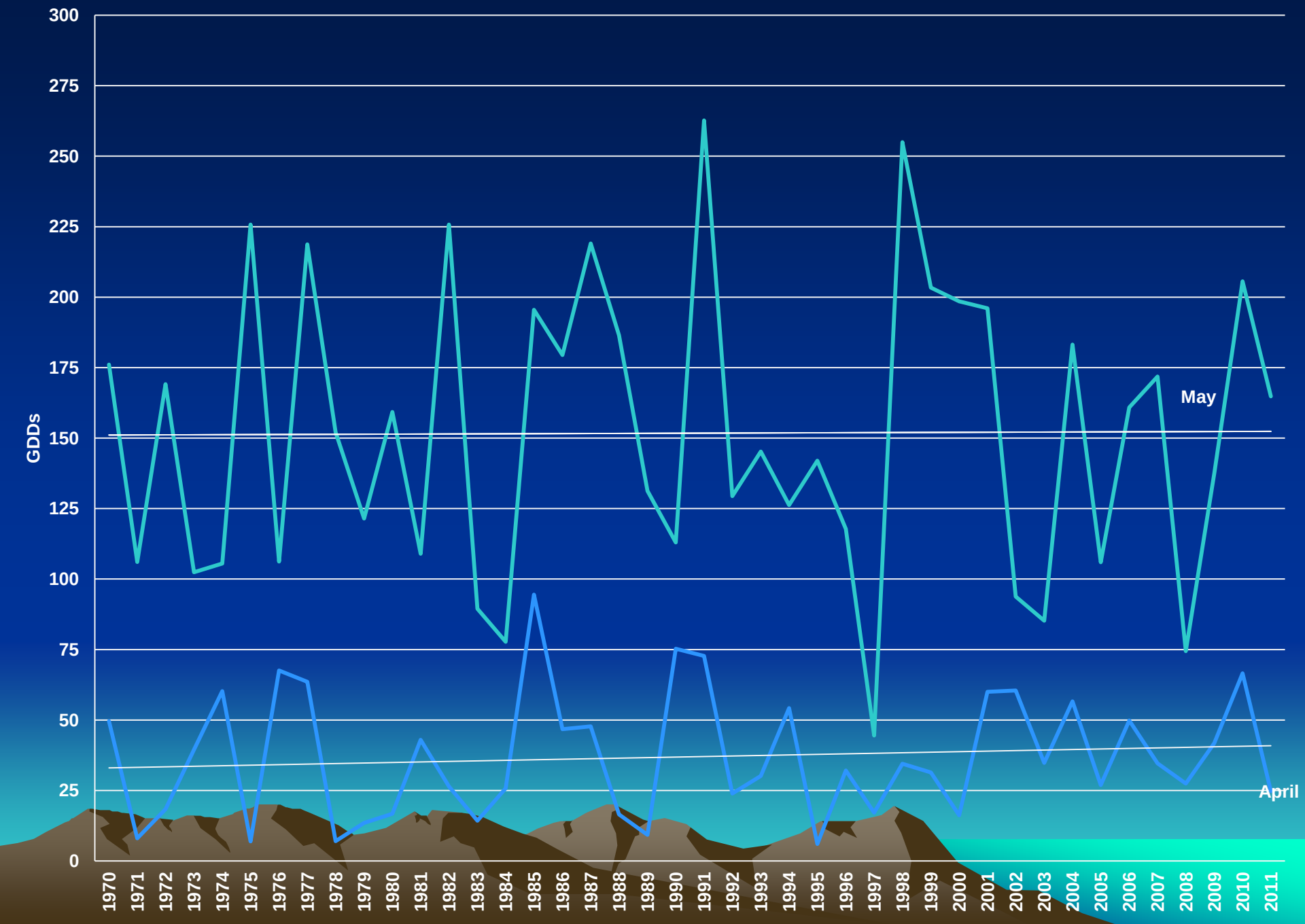
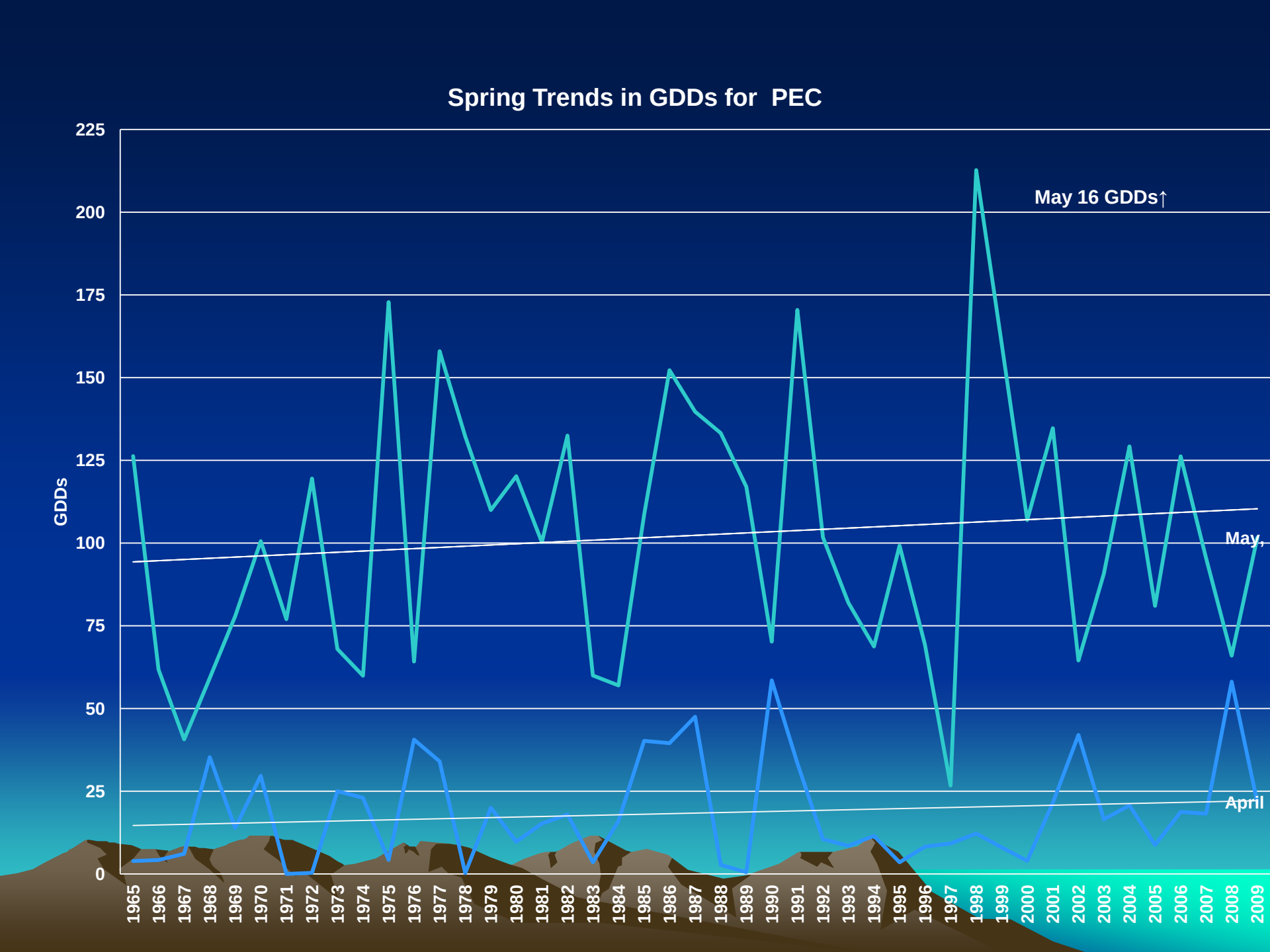
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Spring Trends in GDDs For Niagara



Spring Trends in GGDs For LENS




Spring Trends in GDDs for PEC
GDDs
225
200
175
150
125
100
75
50
25
0
May 16 GDDs↑
May,
April
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
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1997
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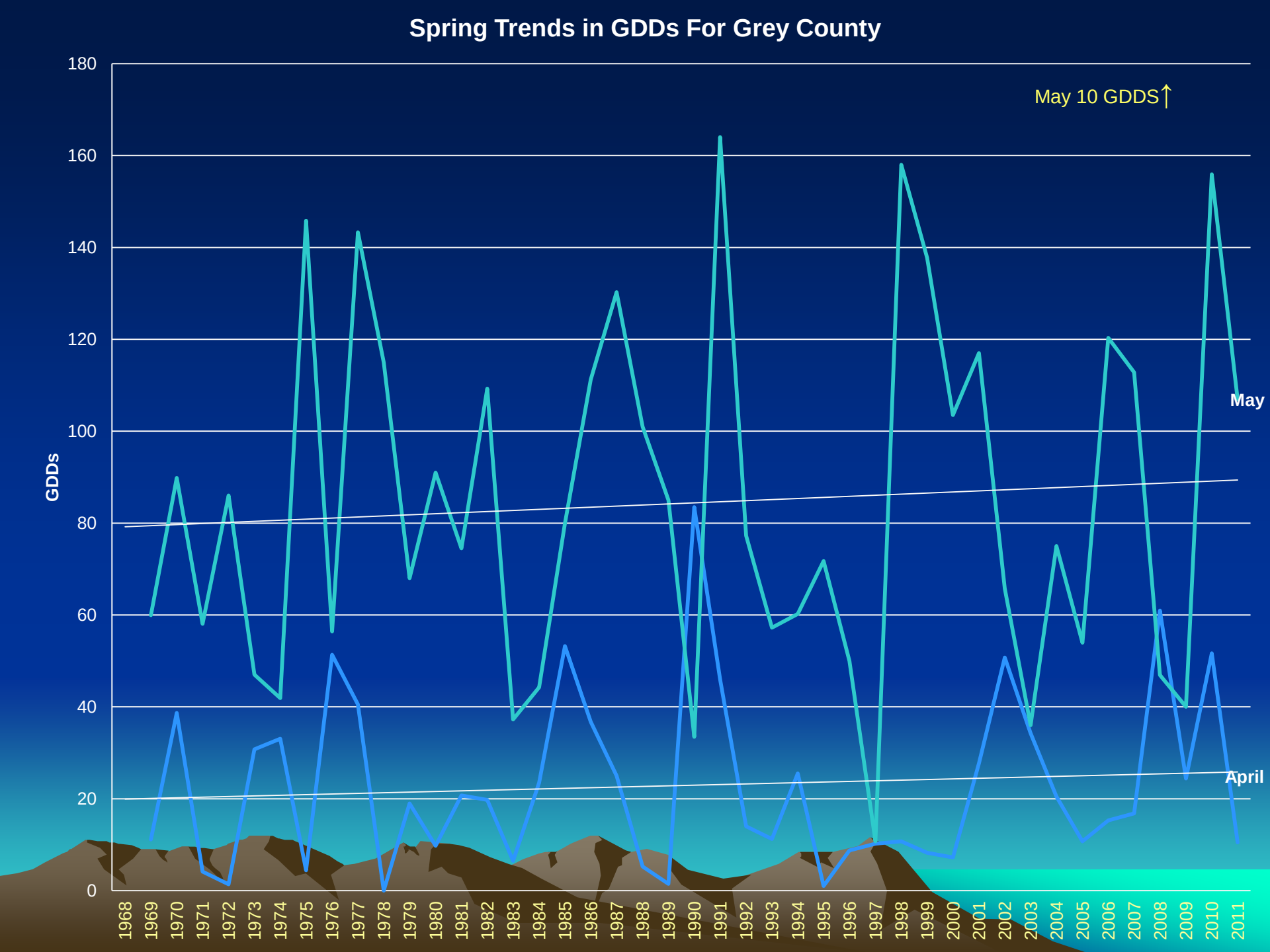
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009


Spring Trends in GDDs For Grey County
GDDs
180
160
140
120
100
80
60
40
20
0
May 10 GDDS↑
May
April
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
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2004
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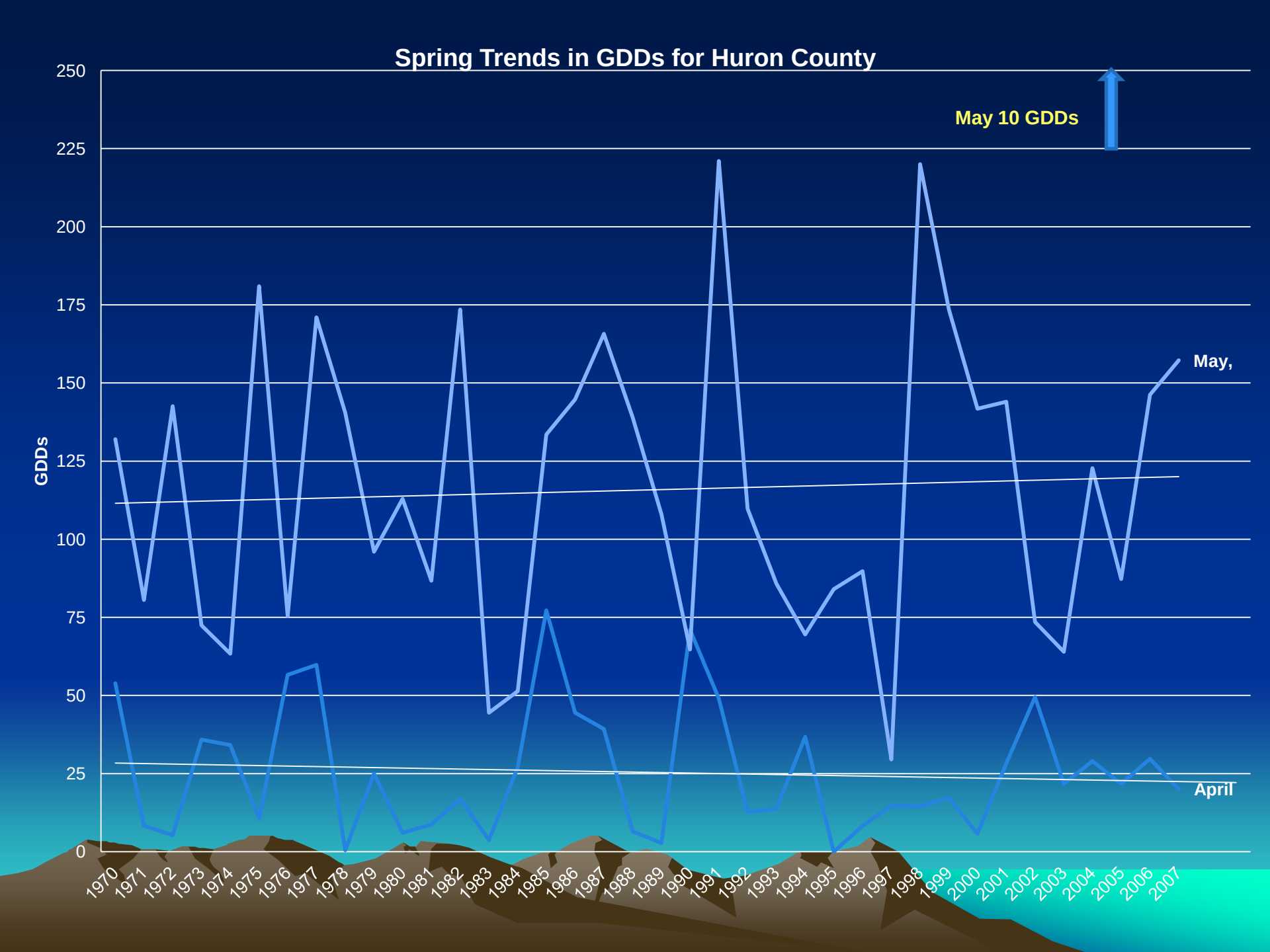
2006
2007
2008
2009
2010
2011

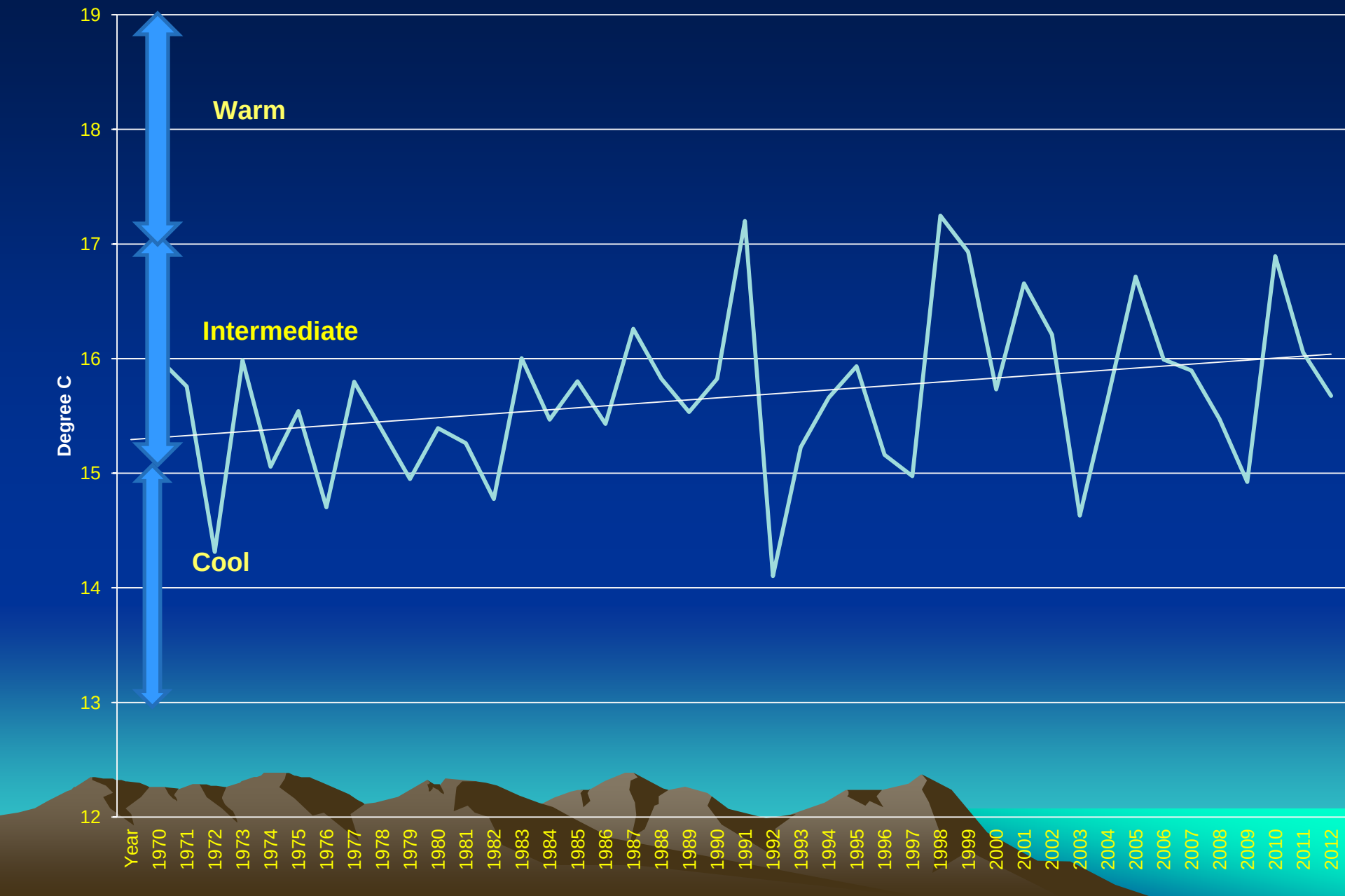

Spring Trends in GDDs for Huron County
May 10 GDDs
May,
April
GDDs
250
225
200
175
150
125
100
75
50
25
0
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

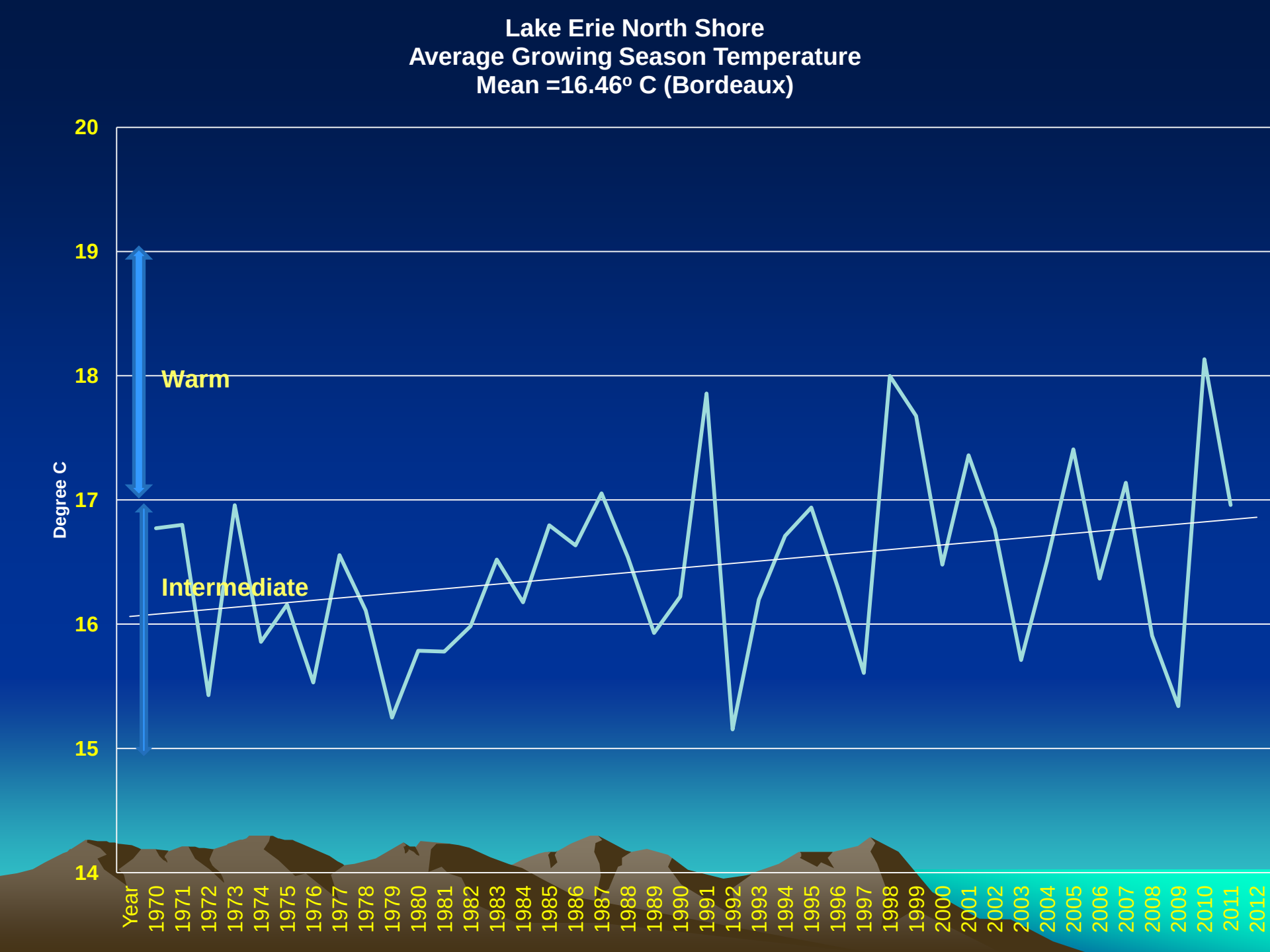
Summer

Is it getting warmer?

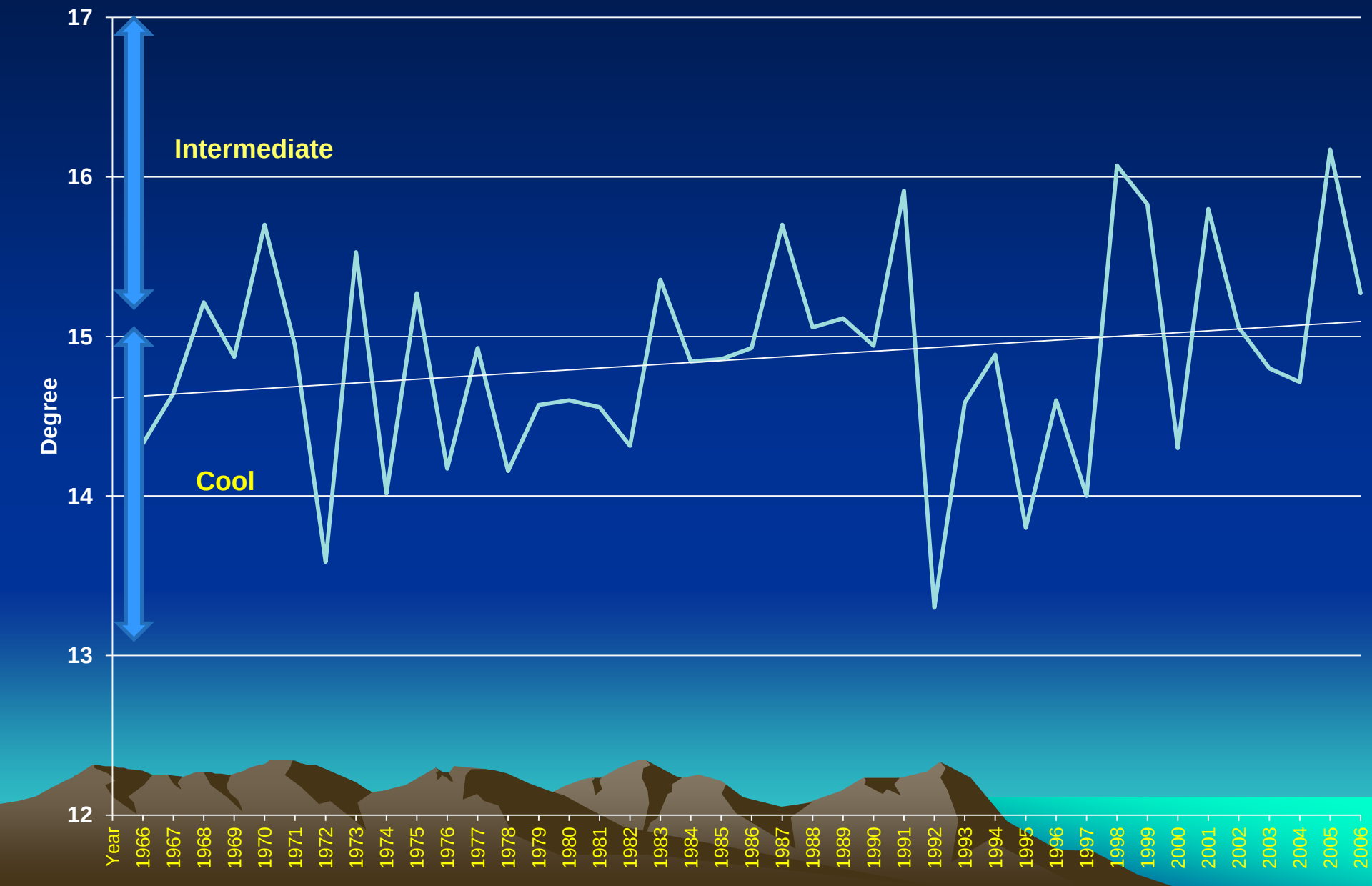
Impacts and Implications For New Varieties, Quality And Emerging Areas

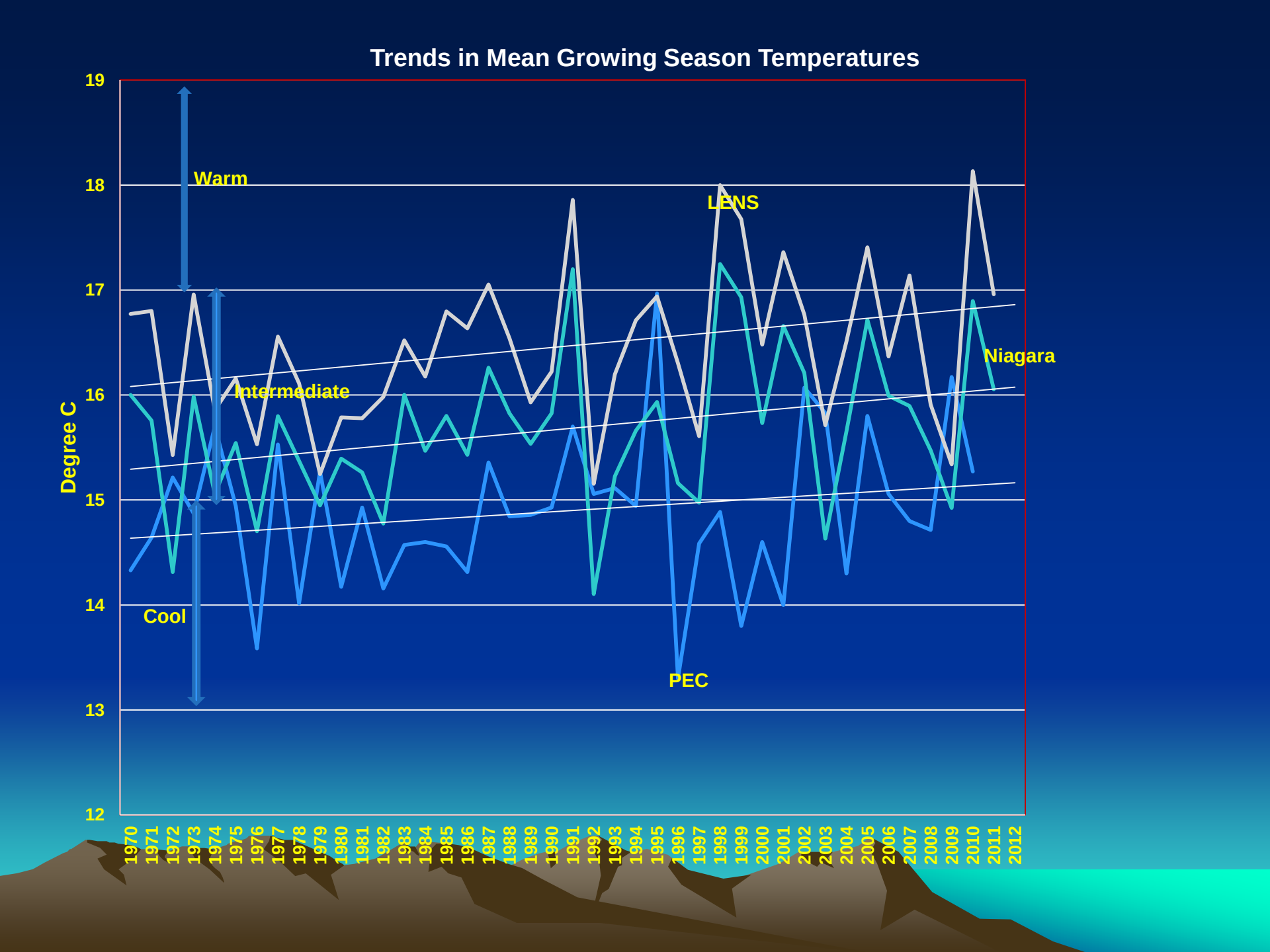
Niagara Region
Average Growing Season Temperature
Mean =15.7 ° C (Burgundy-Beaujolais)




Lake Erie North Shore
Average Growing Season Temperature
Mean =16.46º C (Bordeaux)
Degree C
20
19
18
17
16
15
14
Warm
Intermediate
Year
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Trend in Growing Season Mean Temperature, 1970-2006, PEC Mean=15°C (Rhine Valley, Burgundy)




Trends in Mean Growing Season Temperatures
Degree C
19
18
17
16
15
14
13
12
Warm
Intermediate
Cool
LENS
Niagara
PEC
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
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1996
1997
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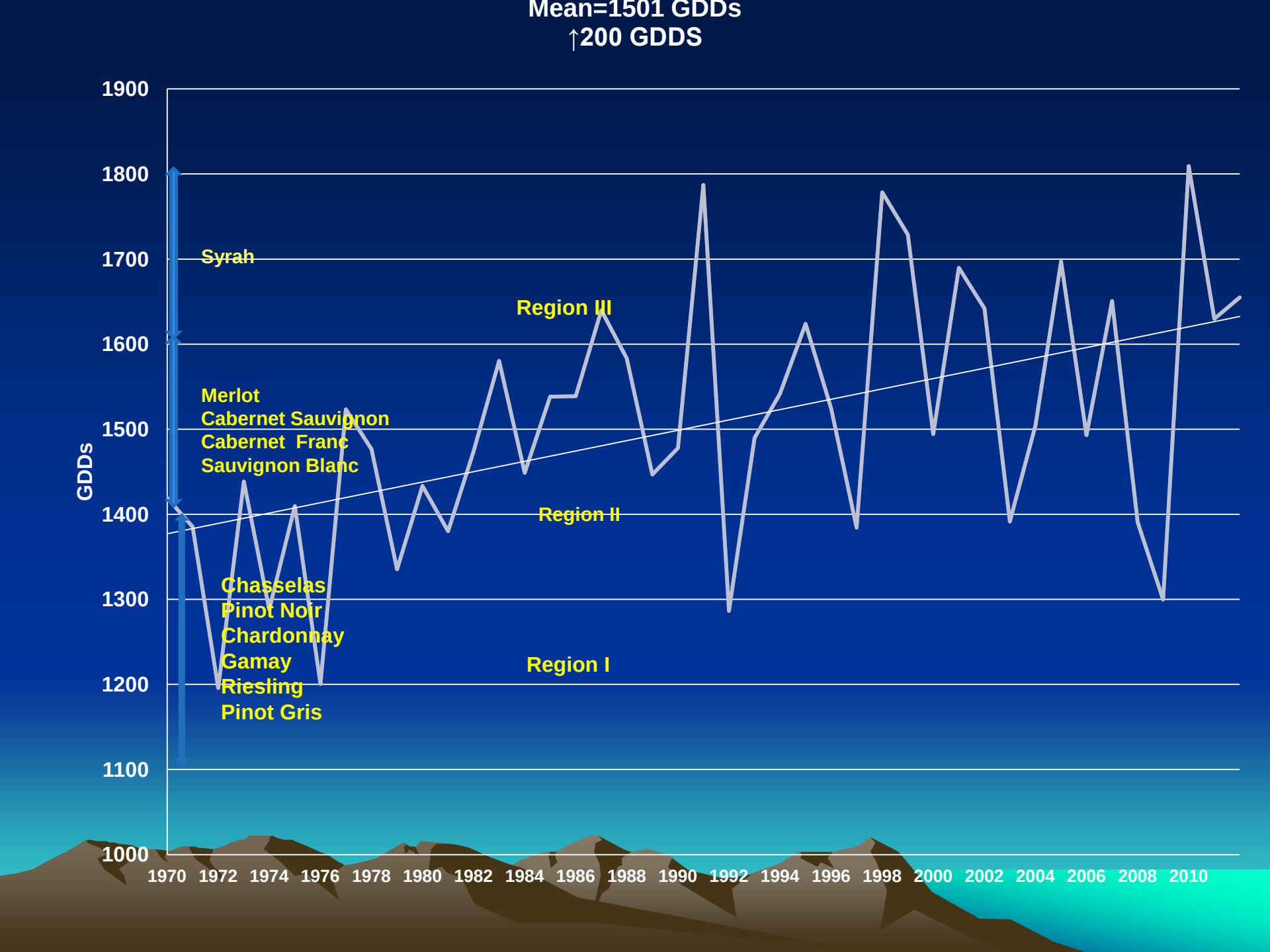
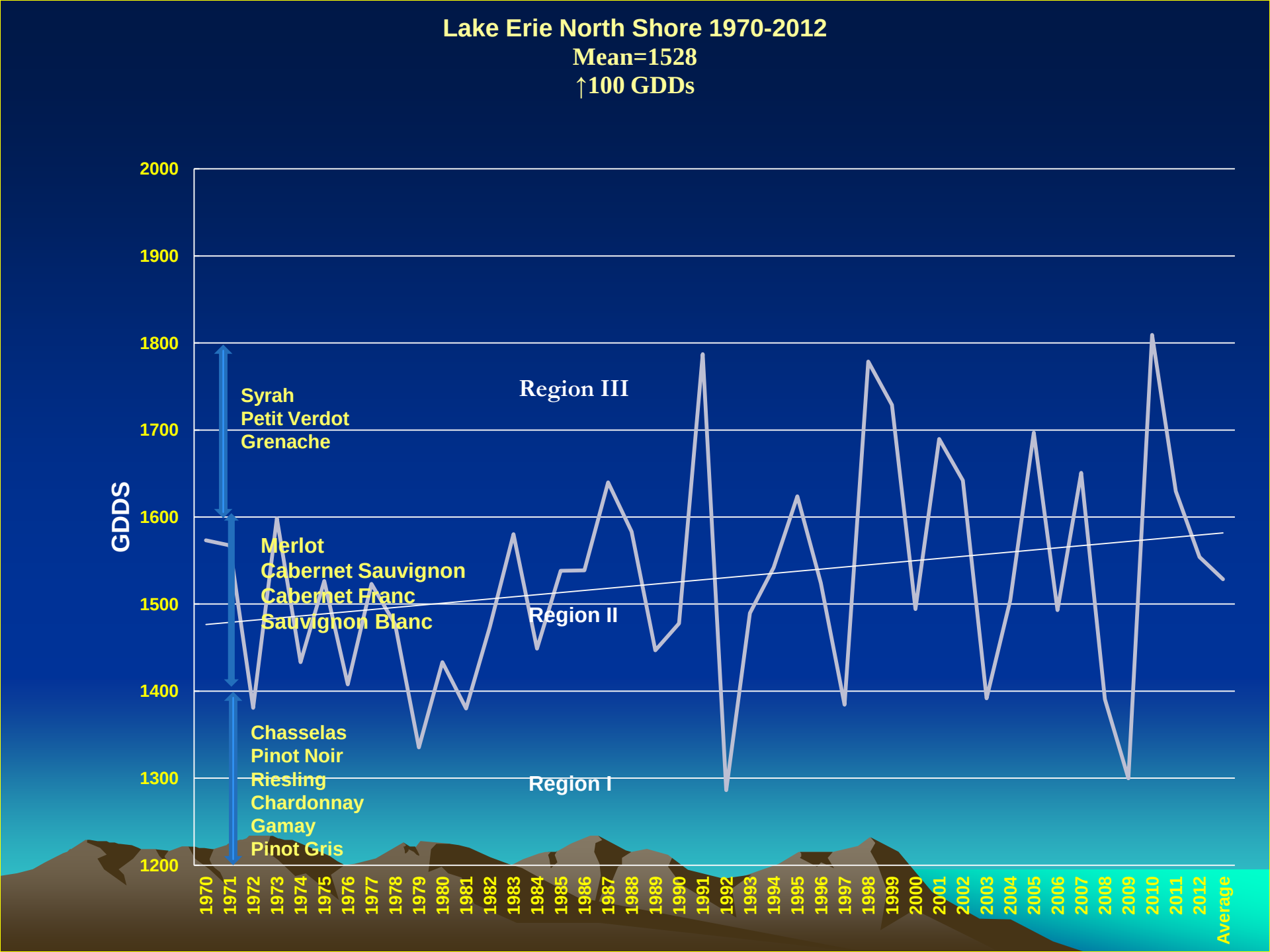
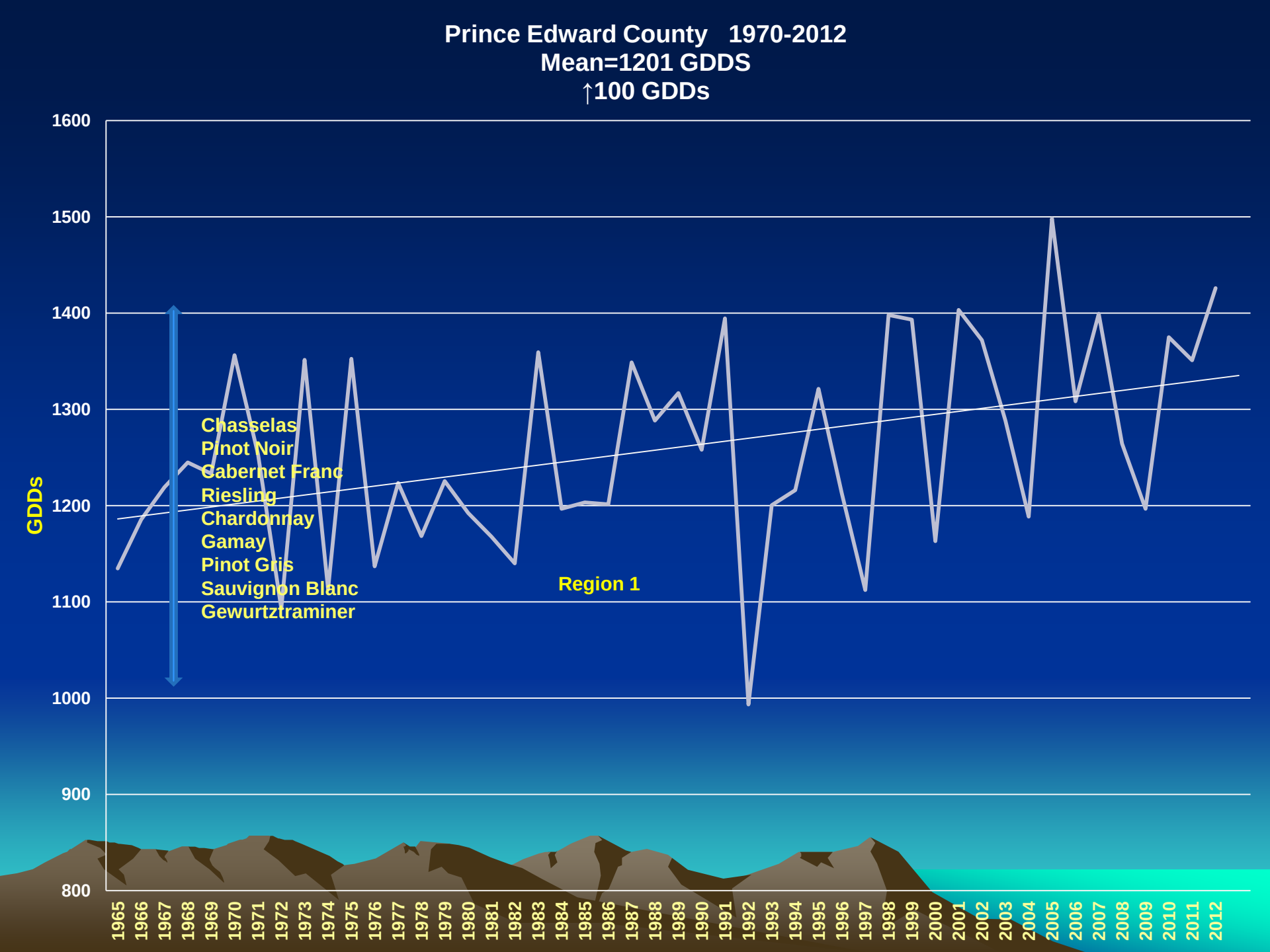
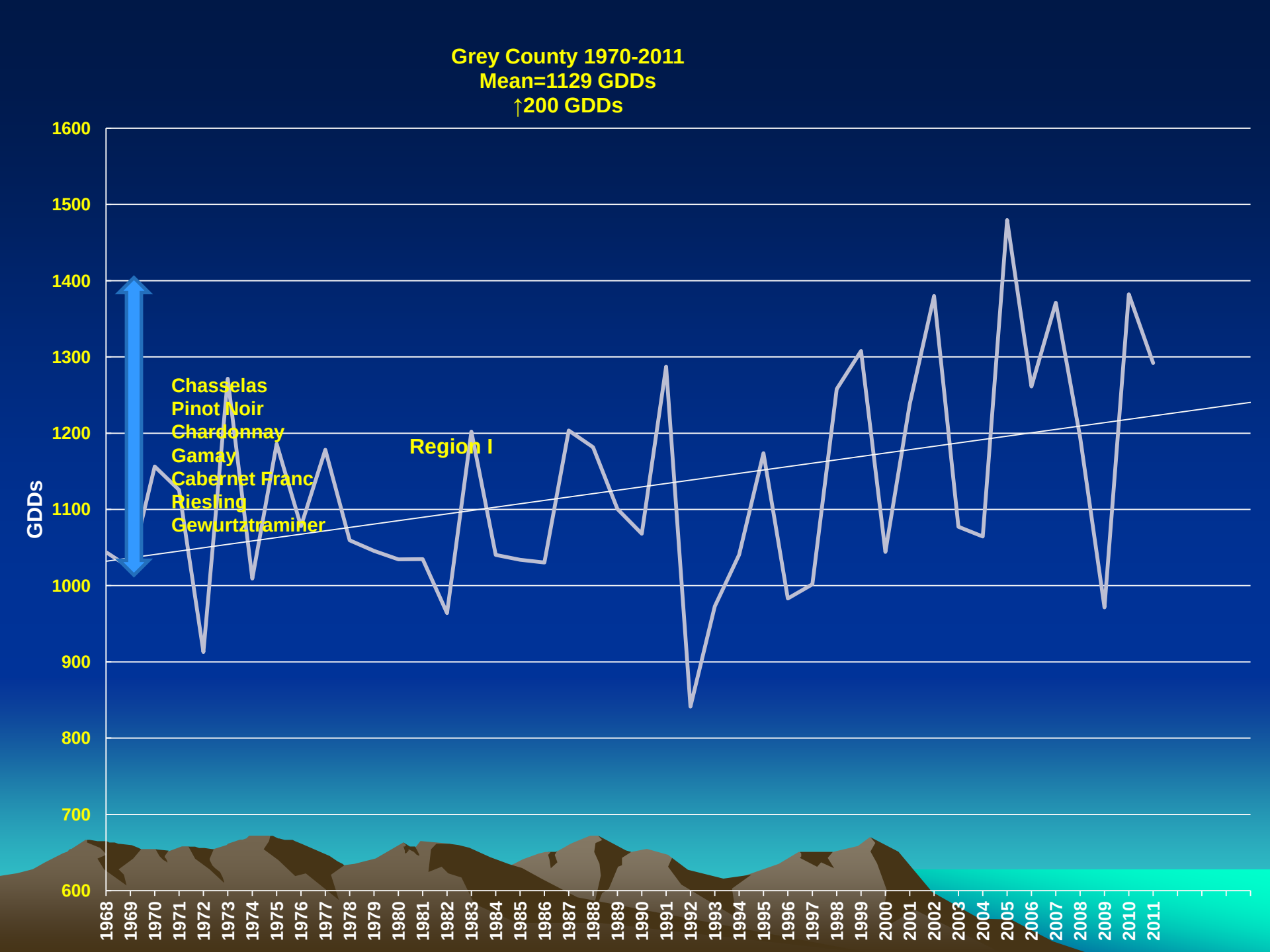
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

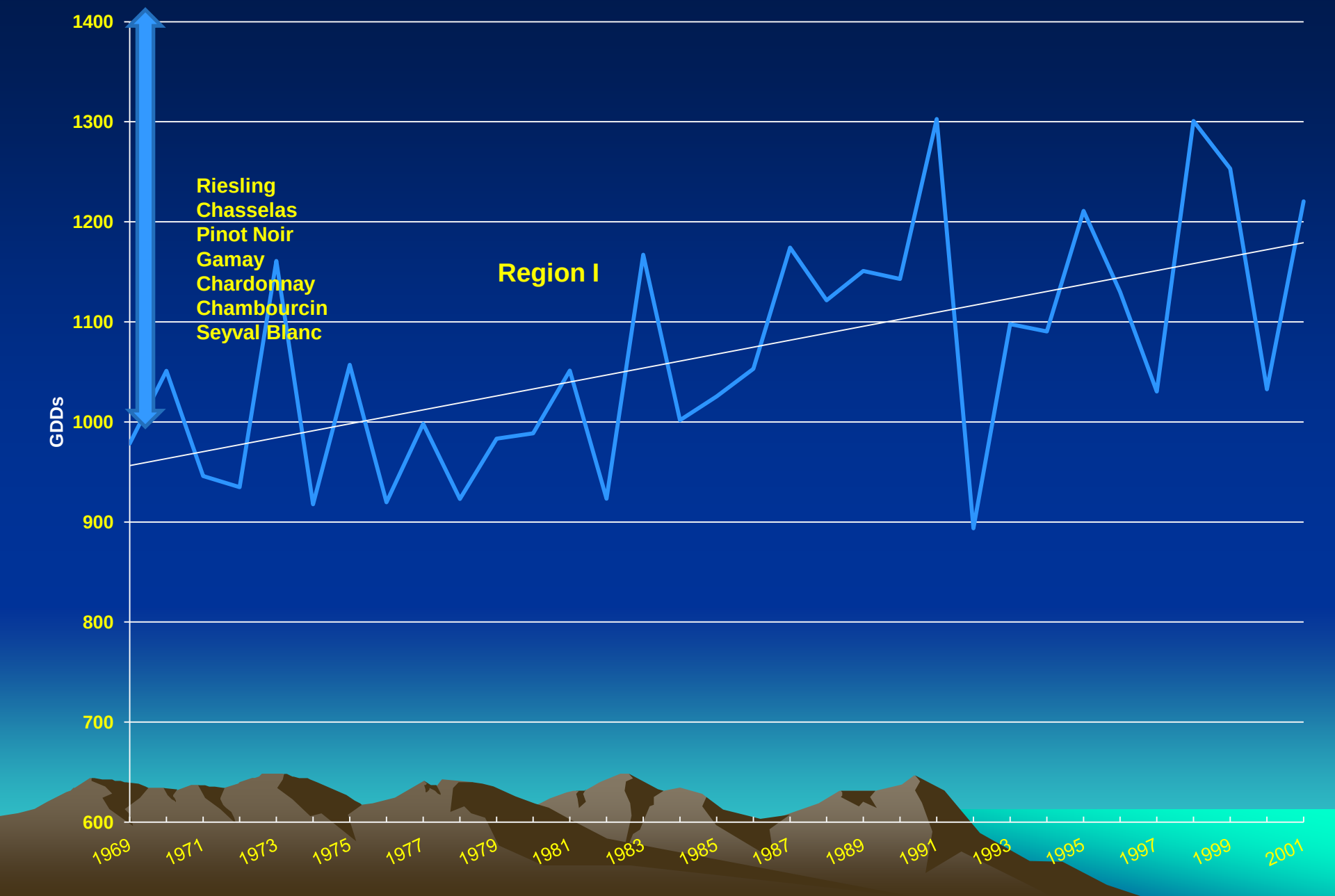

Mean=1501 GDDs
↑200 GDDS
GDDs
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
1970 1972 1974 1976 1978 1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010
Syrah
Region III
Merlot
Cabernet Sauvignon
Cabernet Franc
Sauvignon Blanc
Region II
Chasselas
Pinot Noir
Chardonnay
Gamay
Riesling
Pinot Gris
Region I


Lake Erie North Shore 1970-2012
Mean=1528
↑100 GDDs
GDDS
2000
1900
1800
1700
1600
1500
1400
1300
1200
Syrah
Petit Verdot
Grenache
Merlot
Cabernet Sauvignon
Cabernet Franc
Sauvignon Blanc
Chasselas
Pinot Noir
Riesling
Chardonnay
Gamay
Pinot Gris
Region III
Region II
Region I
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 Average

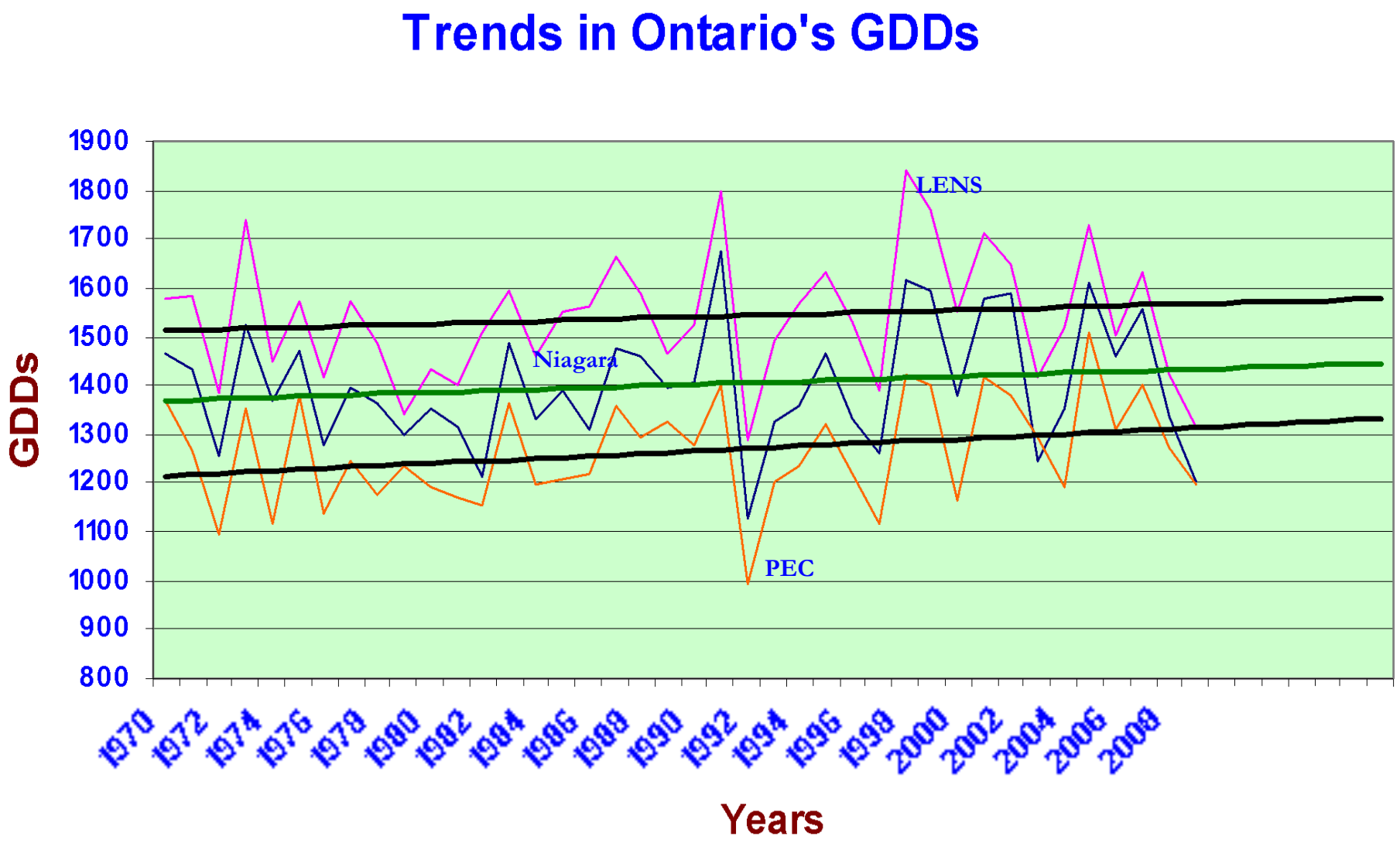

Prince Edward County 1970-2012
Mean=1201 GDDS
↑100 GDDs
GDDs
1600
1500
1400
1300
1200
1100
1000
900
800
Chasselas
Pinot Noir
Gabernet Franc
Riesling
Chardonnay
Gamay
Pinot Gris
Sauvignon Blanc
Gewurtztraminer
Region 1
1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012


Grey County 1970-2011
Mean=1129 GDDs
↑200 GDDs
GDDs
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
Chasselas
Pinot Noir
Chardonnay
Gamay
Cabernet Franc
Riesling
Gewurtztraminer
Region I
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011

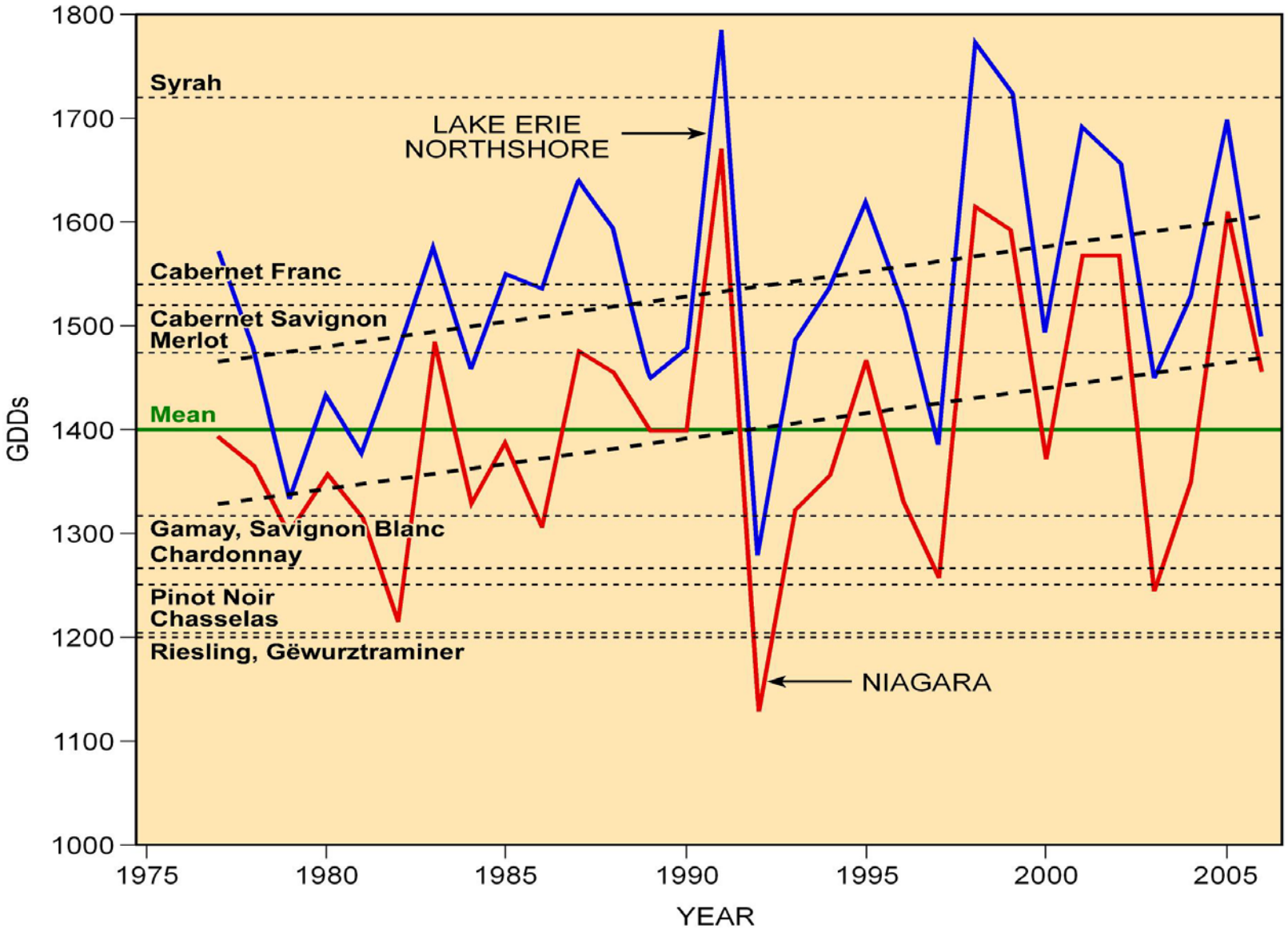
Durham County Total GDDS 1969-2001
Mean=1068 (GEISENHEIM)
↑ 200 GDDs



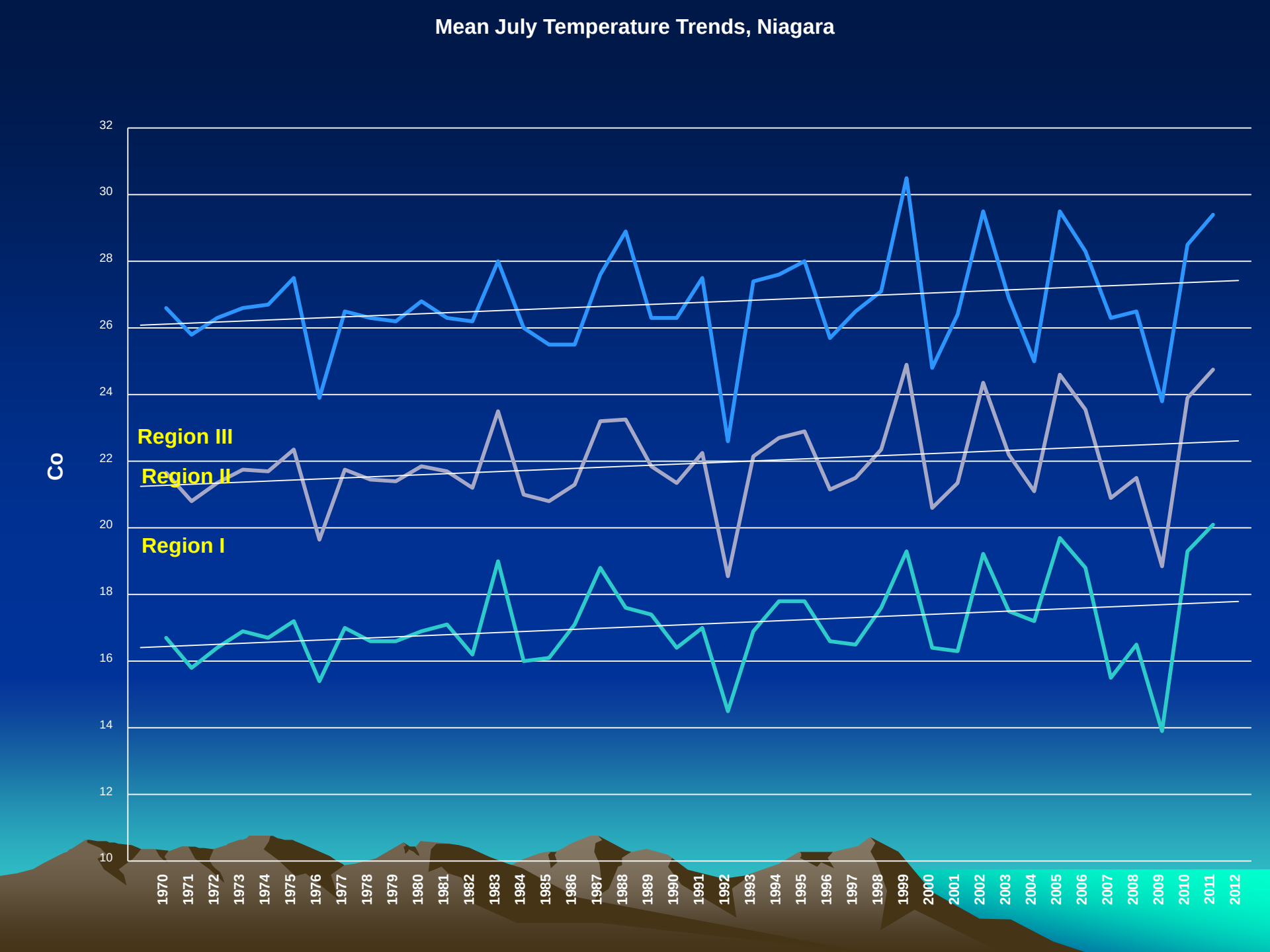
Climate Change



CLIMATIC TRENDS IN GDDs FOR NIAGARA AND LAKE ERIE NORTHSHORE AND VARIETAL SUITABILITY



Mean July Temperature Trends, Niagara

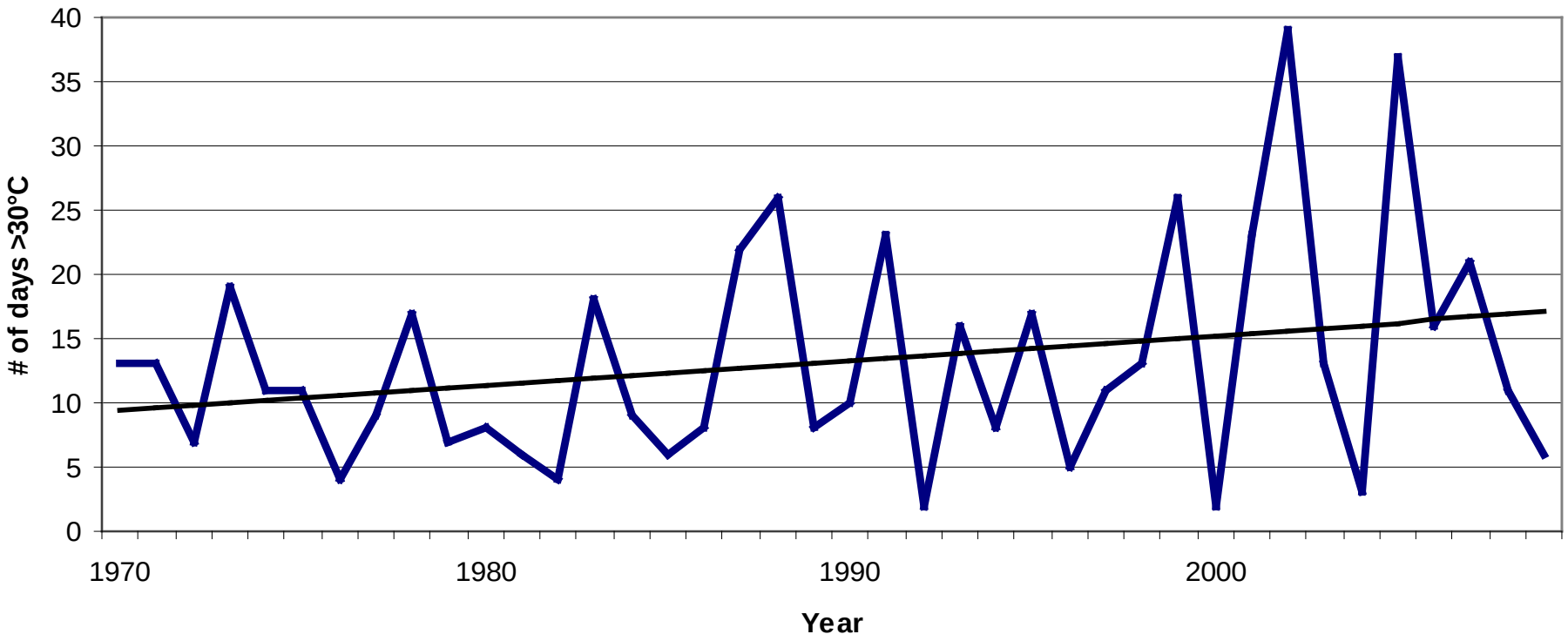


Hot Days

↑8 days/year

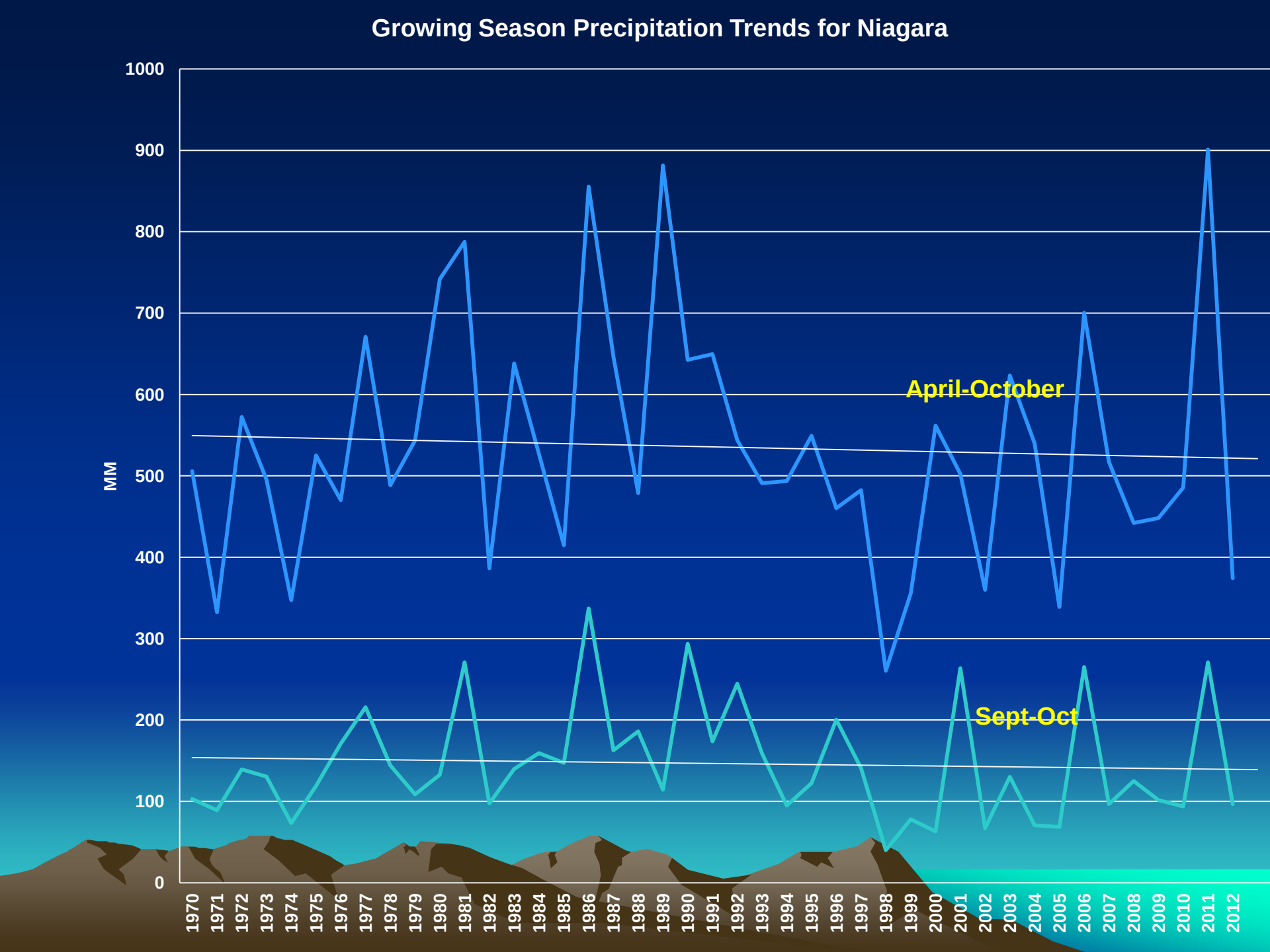
1987, 1988, 1991, 1999

2001, **2002**, 2005, 2007



Ripening Period (Fall)

Is it getting **warmer** and drier?


Growing Season Precipitation Trends for Niagara
MM
1000
900
800
700
600
500
400
300
200
100
0
April-October
Sept-Oct
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
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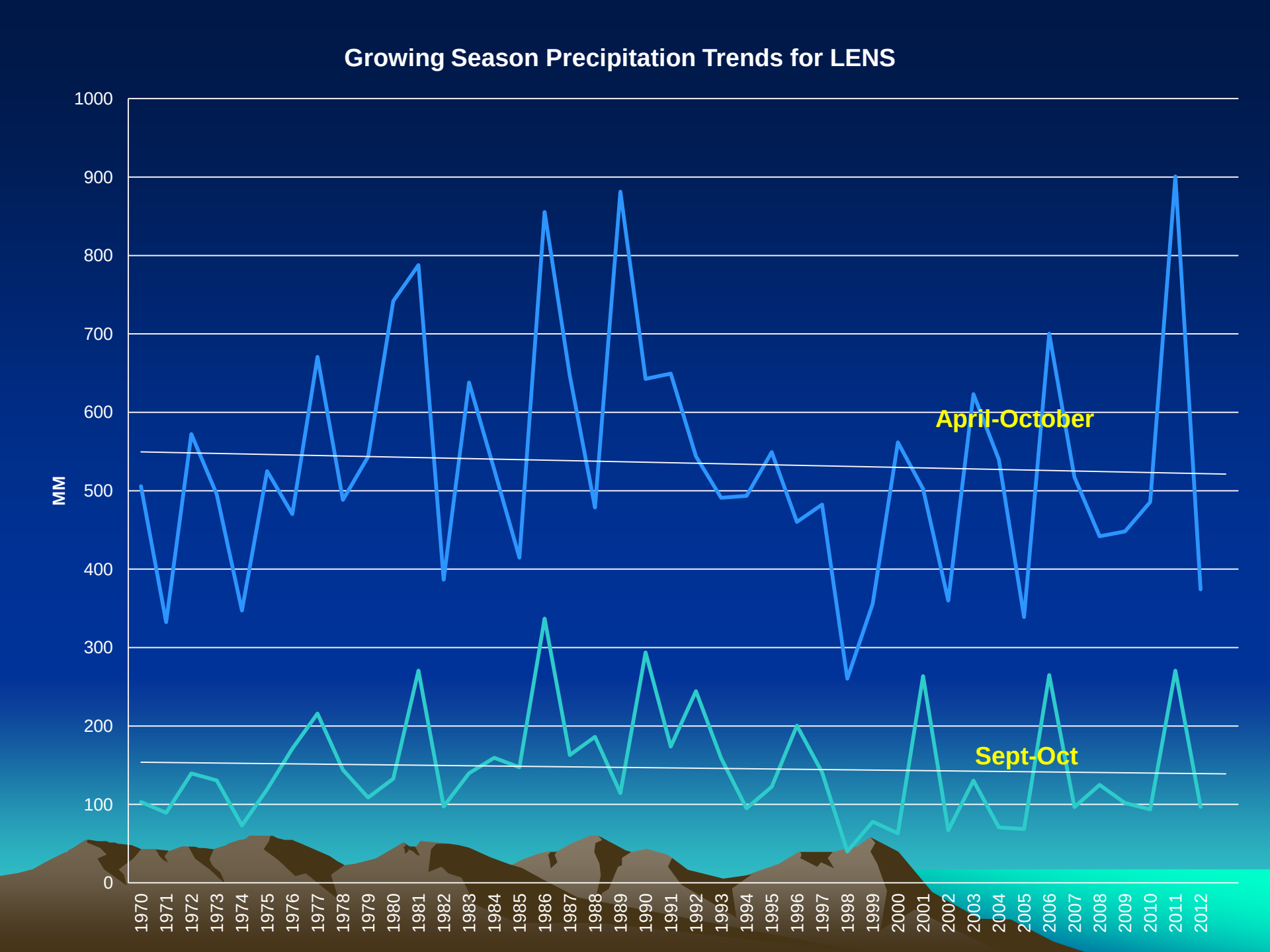
2007
2008
2009
2010
2011
2012


Growing Season Precipitation Trends for LENS
MM
1000
900
800
700
600
500
400
300
200
100
0
April-October
Sept-Oct
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
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1991
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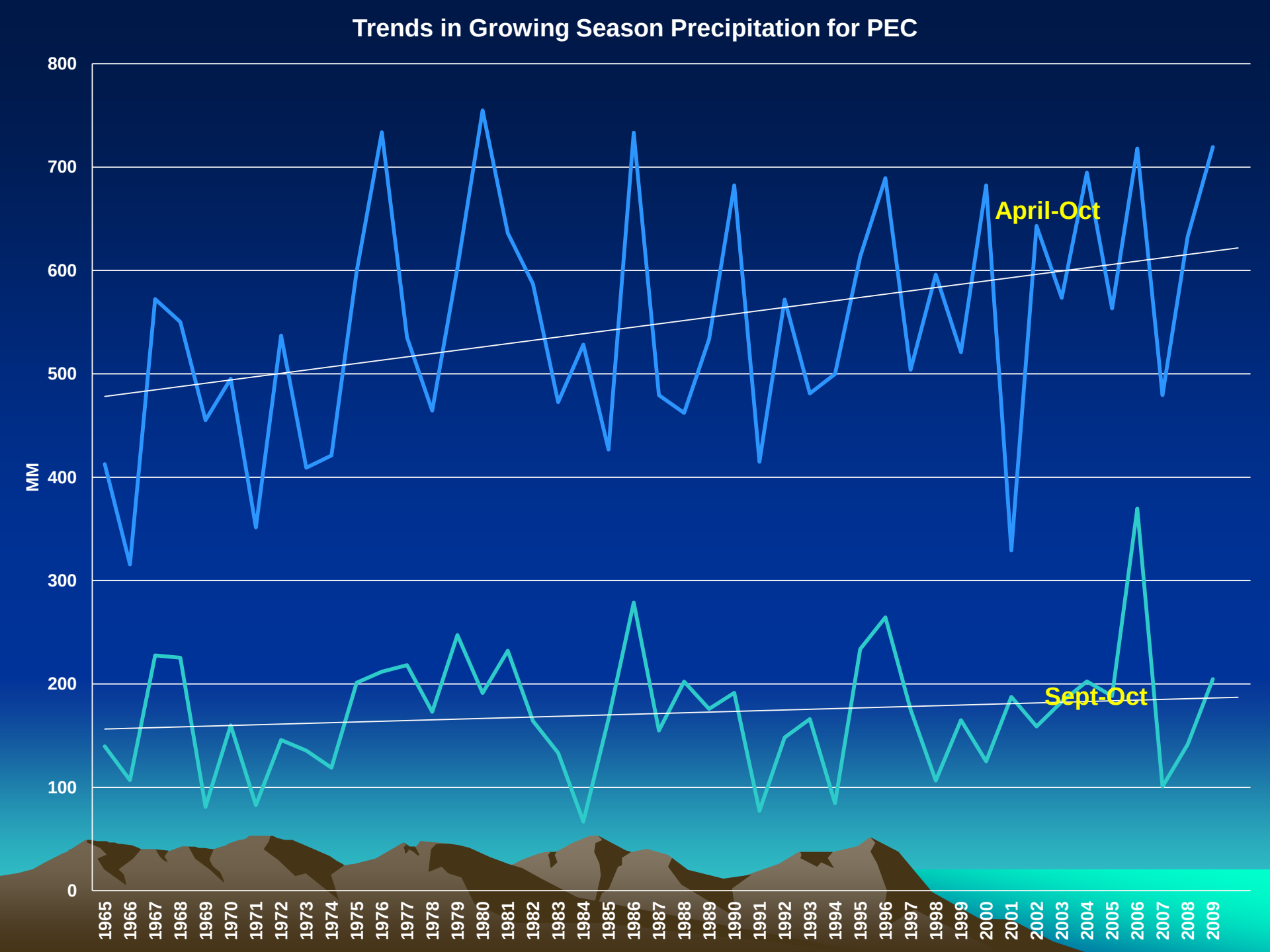
2008
2009
2010
2011
2012


Trends in Growing Season Precipitation for PEC
MM
800
700
600
500
400
300
200
100
0
April-Oct
Sept-Oct
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
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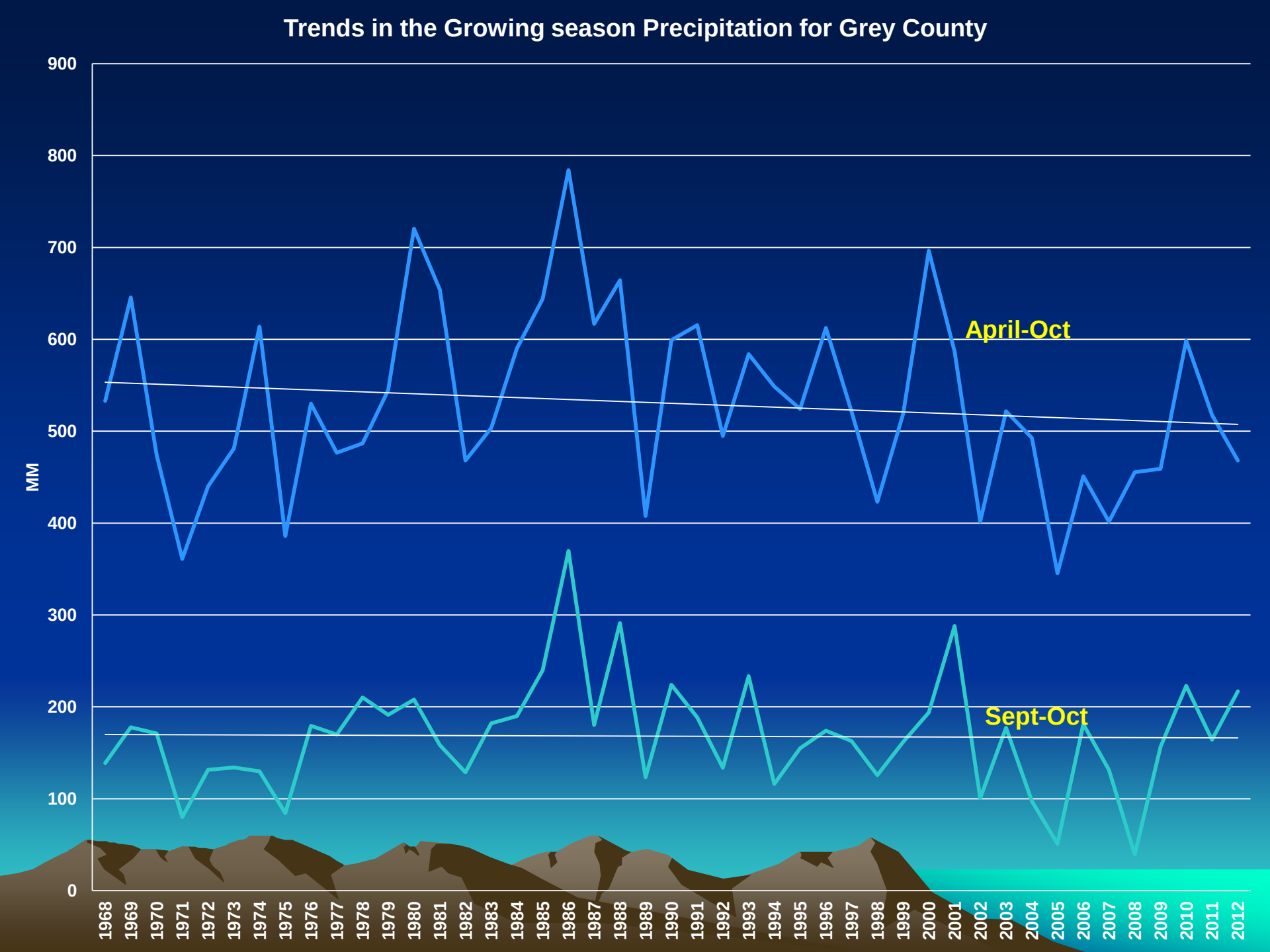
2008
2009


Trends in the Growing season Precipitation for Grey County
MM
900
800
700
600
500
400
300
200
100
0
April-Oct
Sept-Oct
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
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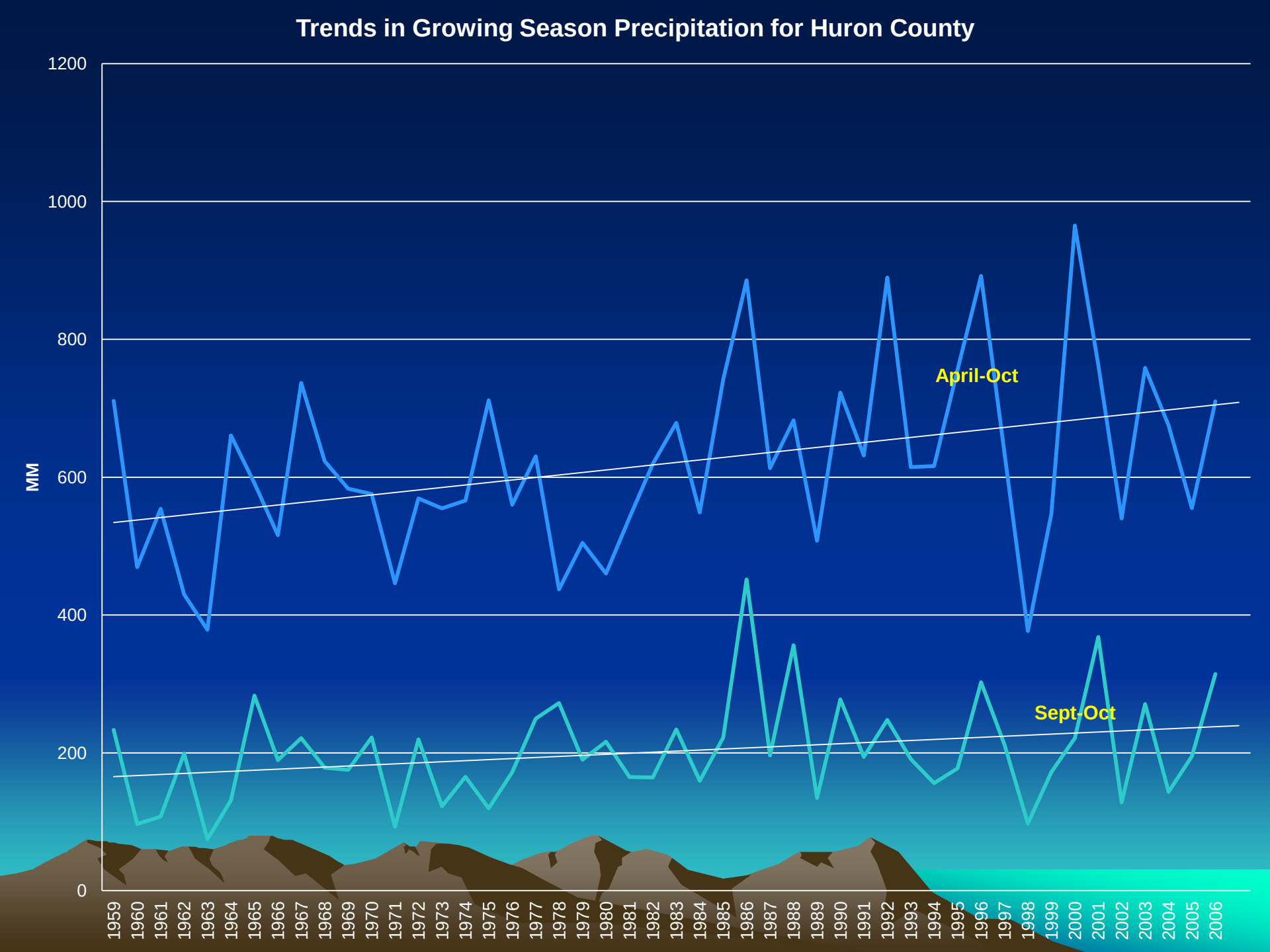
2008
2009
2010
2011
2012


Trends in Growing Season Precipitation for Huron County
MM
1200
1000
800
600
400
200
0
April-Oct
Sept-Oct
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
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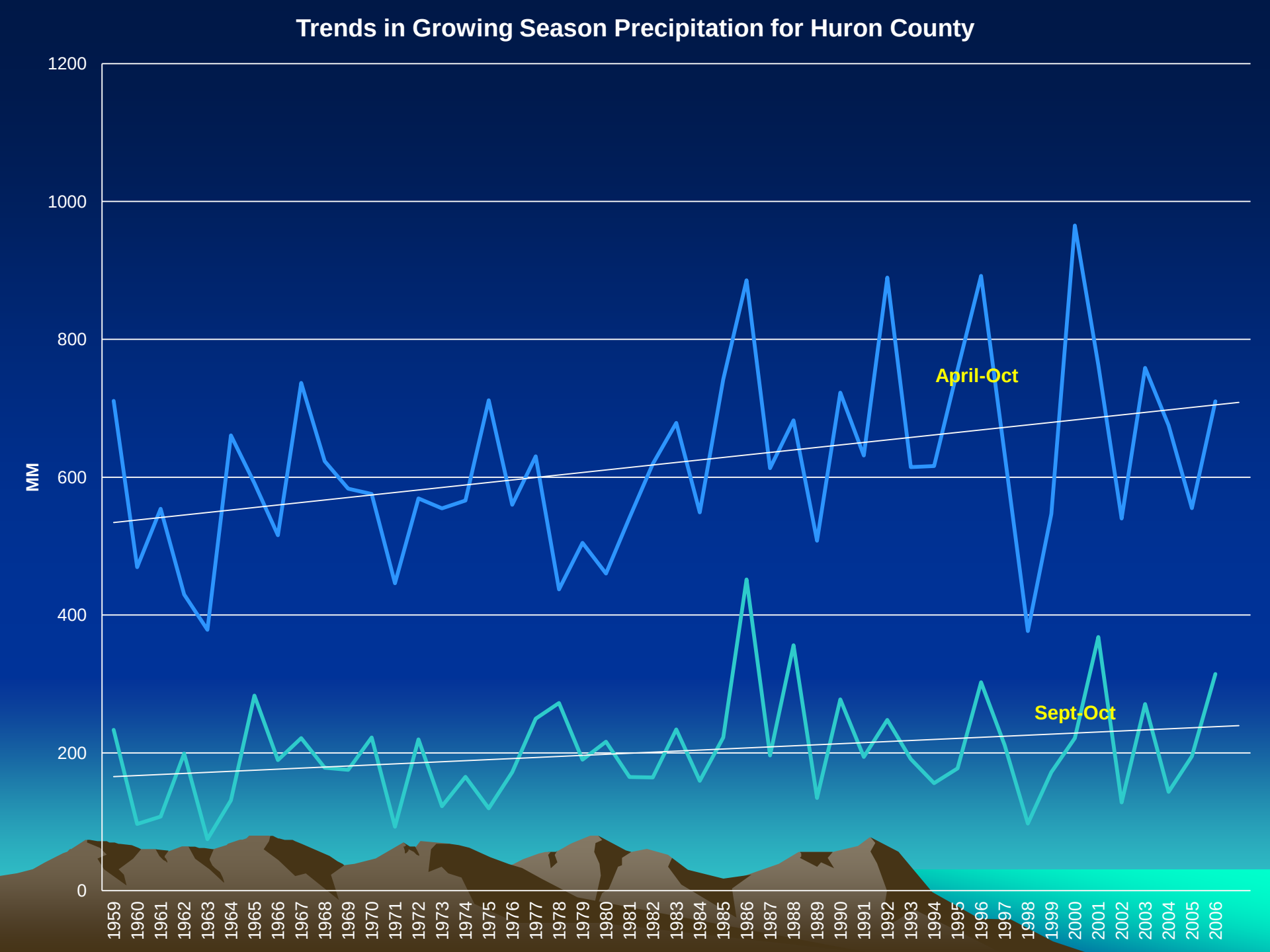
2004
2005
2006


Trends in Growing Season Precipitation for Huron County
MM
1200
1000
800
600
400
200
0
April-Oct
Sept-Oct
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
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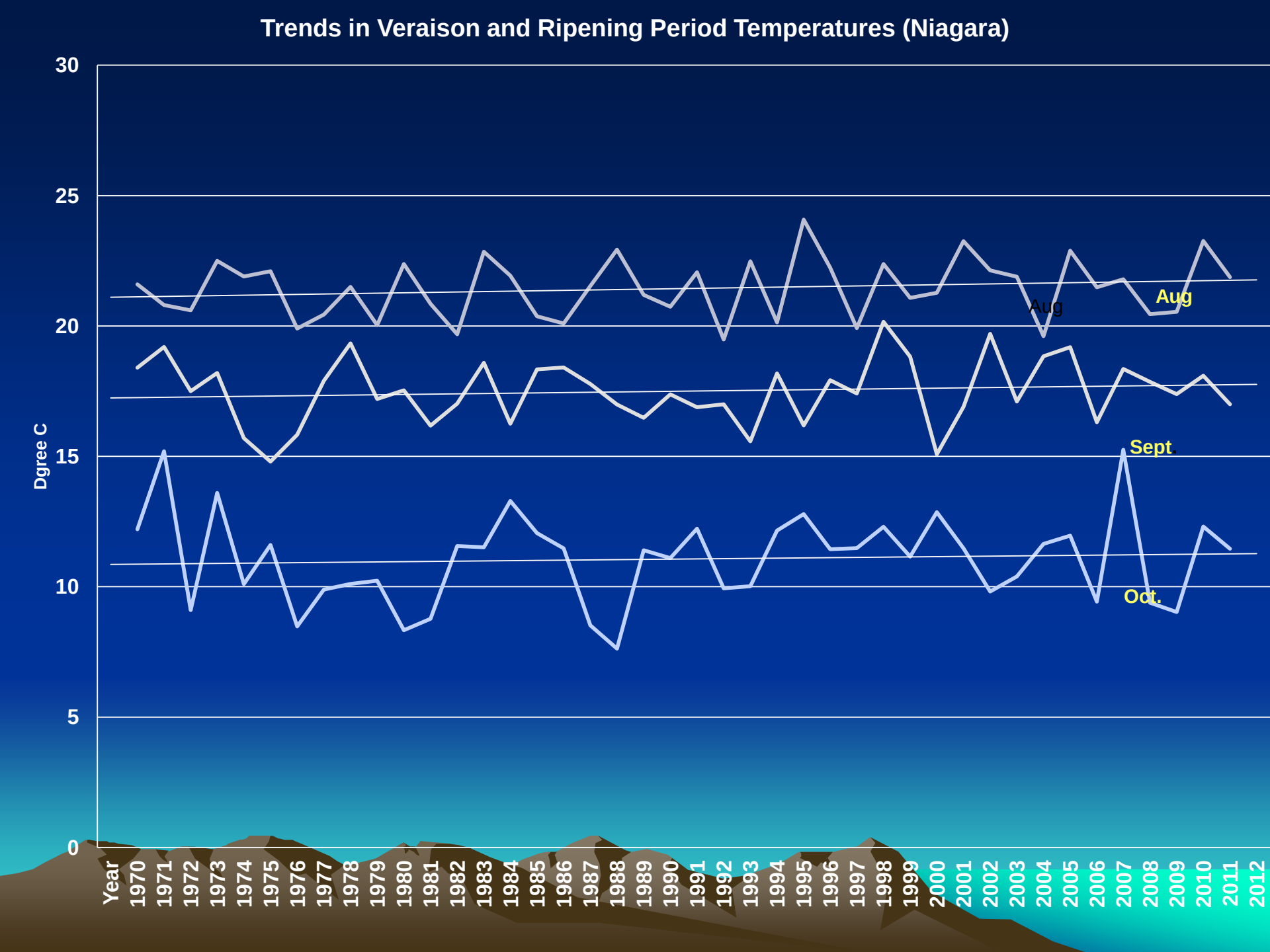
2004
2005
2006


Trends in Veraison and Ripening Period Temperatures (Niagara)
Dgree C
30
25
20
15
10
5
0
Aug
Aug
Sept
Oct.
Year
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
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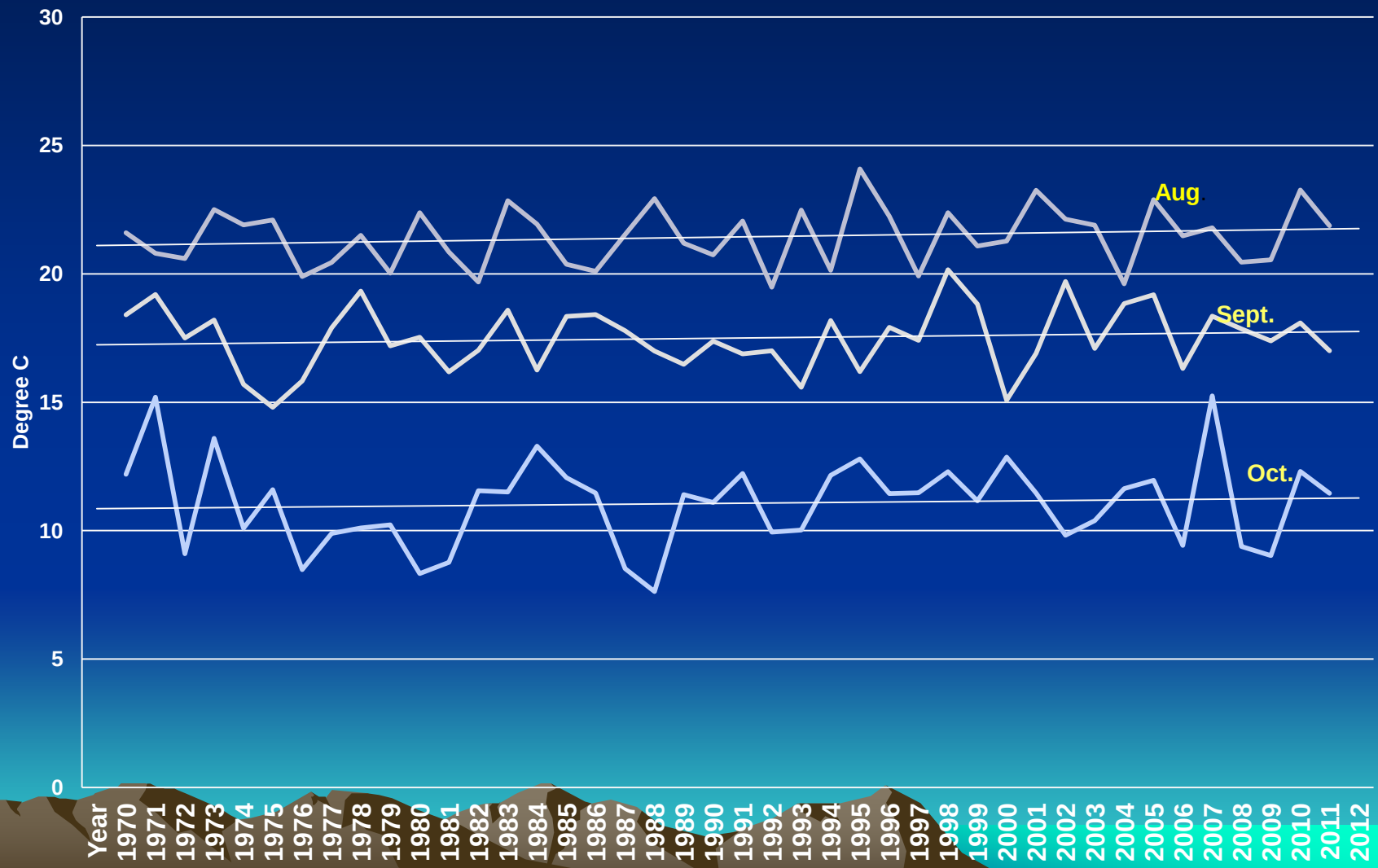
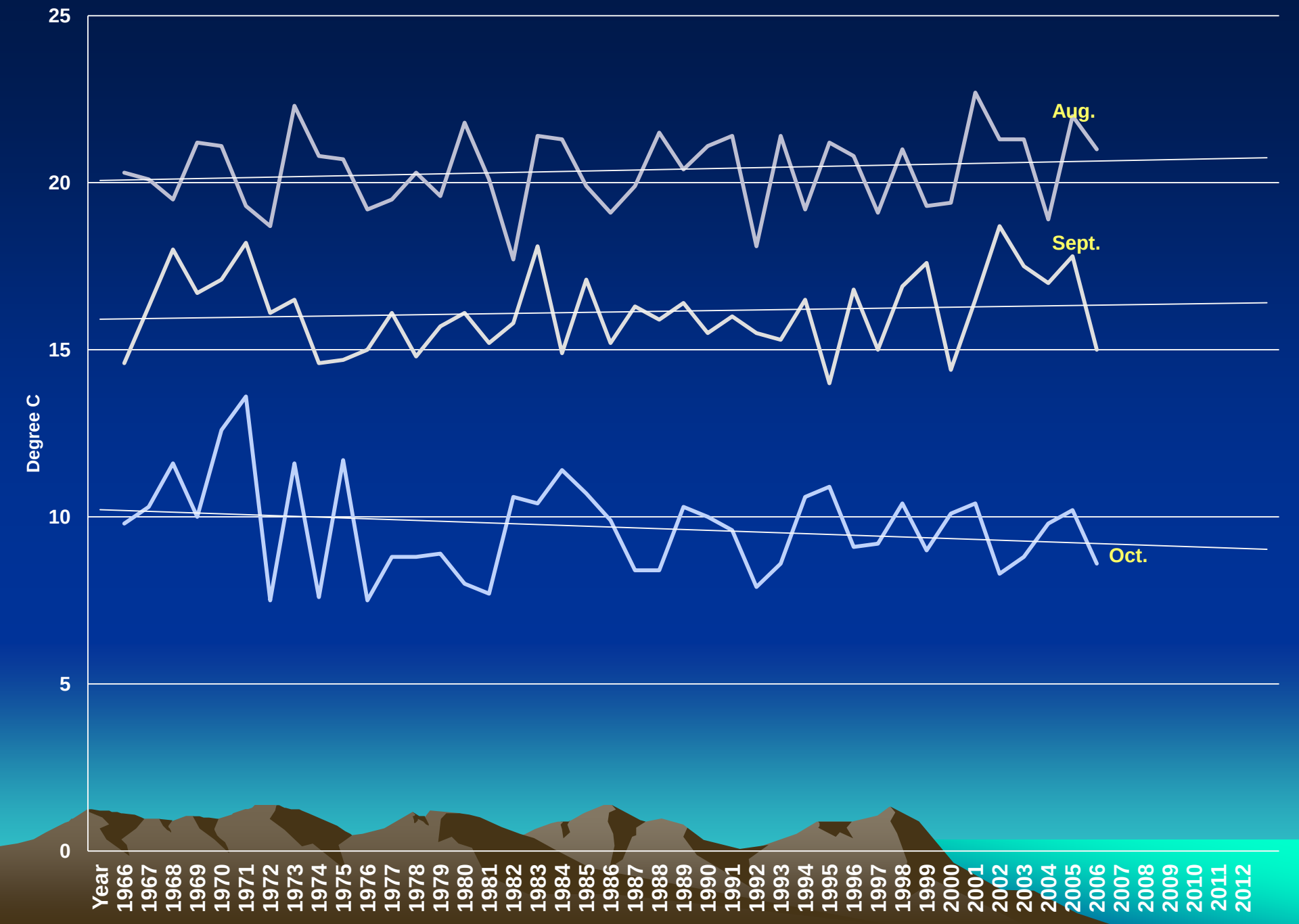
2005
2006
2007
2008
2009
2010
2011
2012

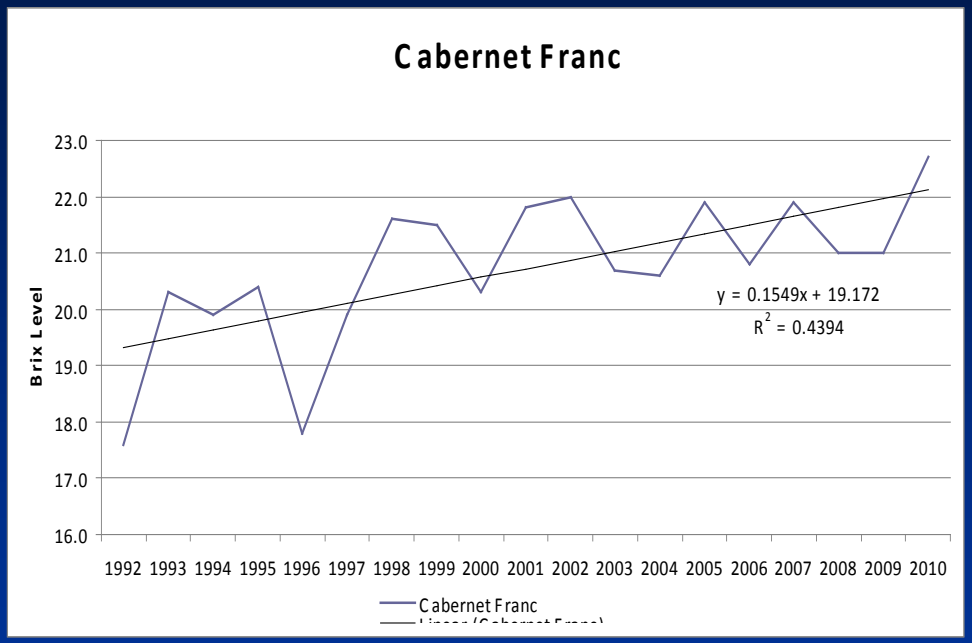
Trends in Veraison and Ripening Period Temperatures (Harrow)

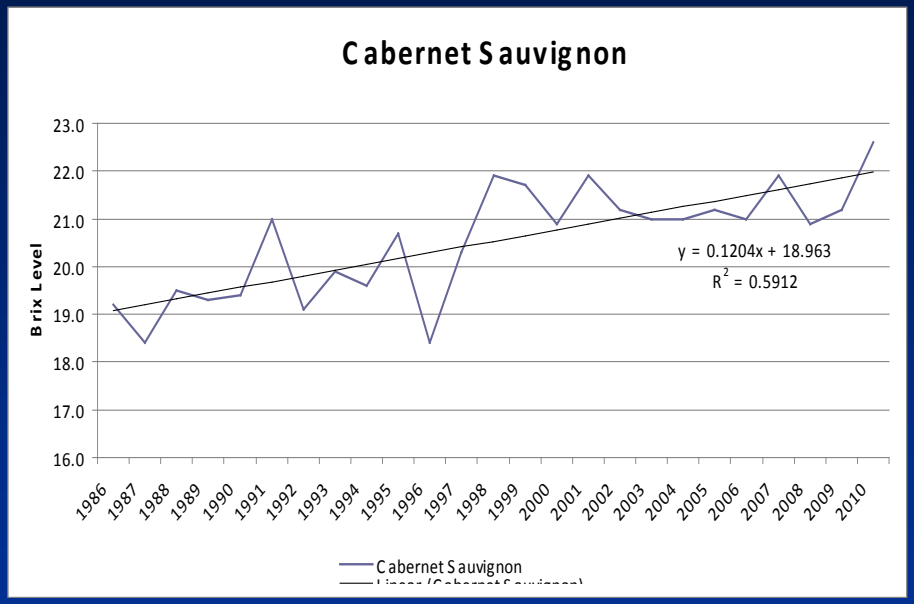


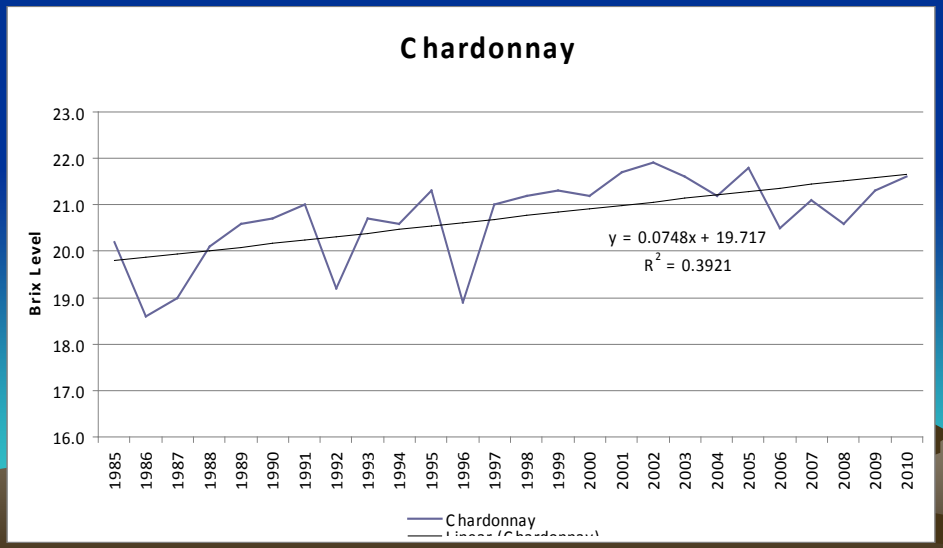
Trends in Veraison and Ripening Period Temperatures (PEC)

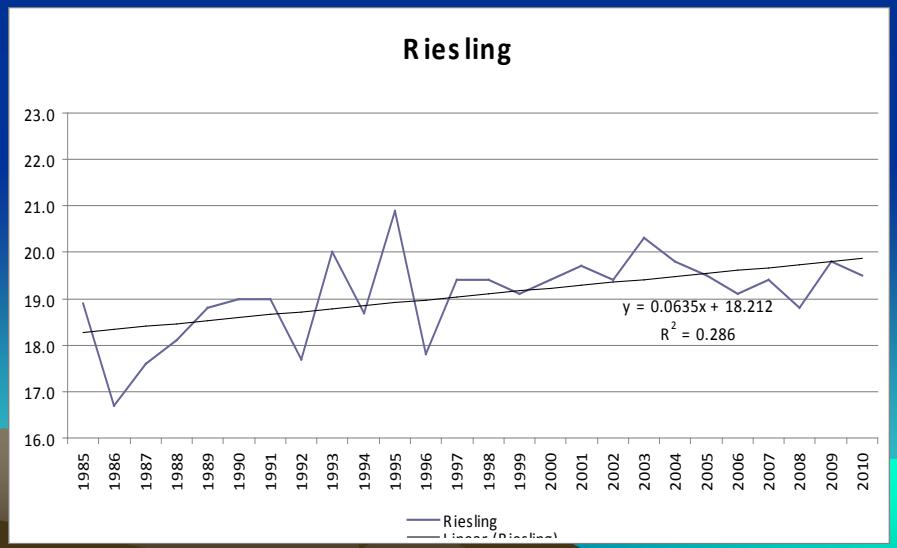


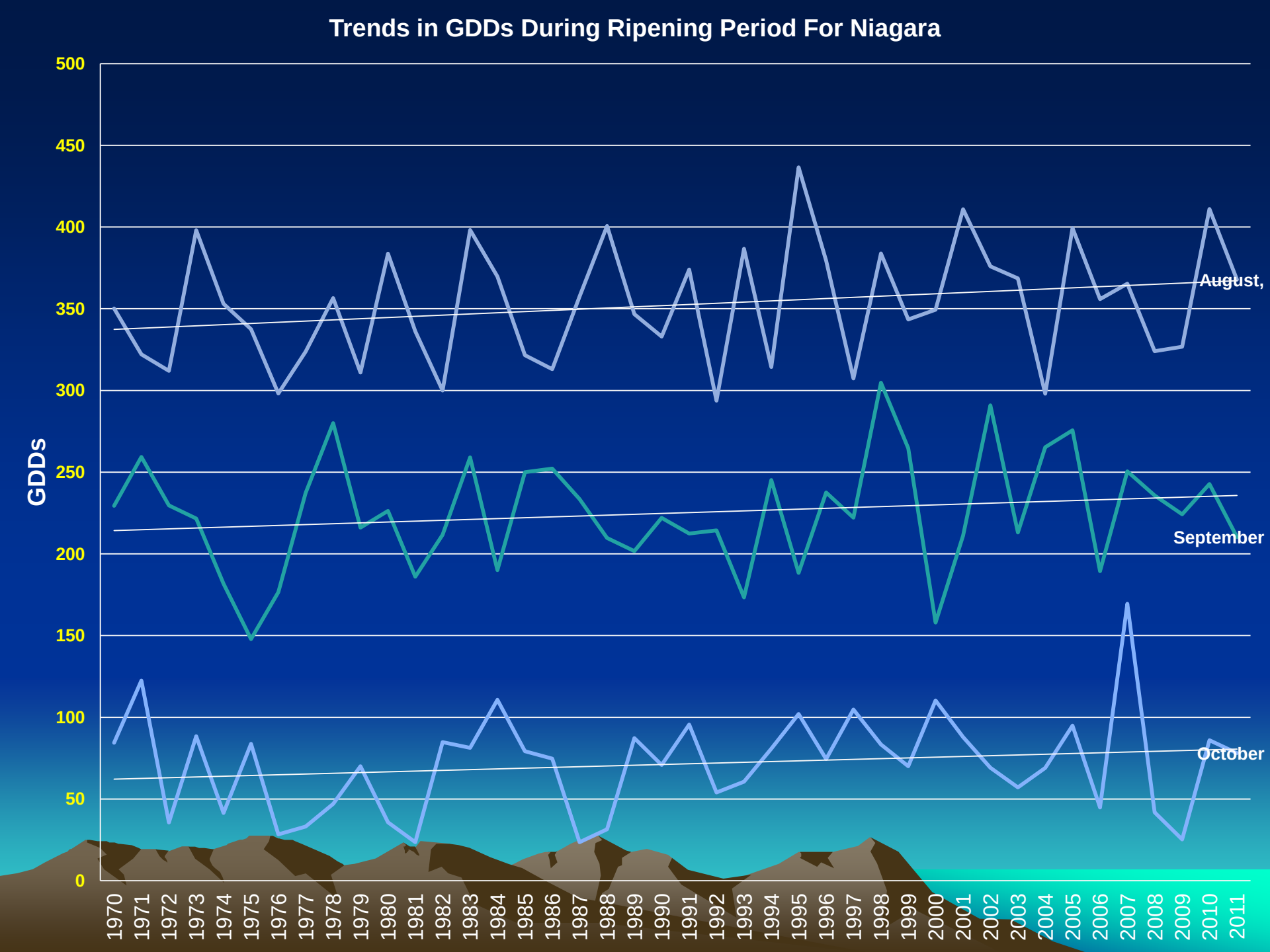
Trends in Brix (Sugar) Levels










Trends in GDDs During Ripening Period For Niagara
GDDs
500
450
400
350
300
250
200
150
100
50
0
August,
September
October
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
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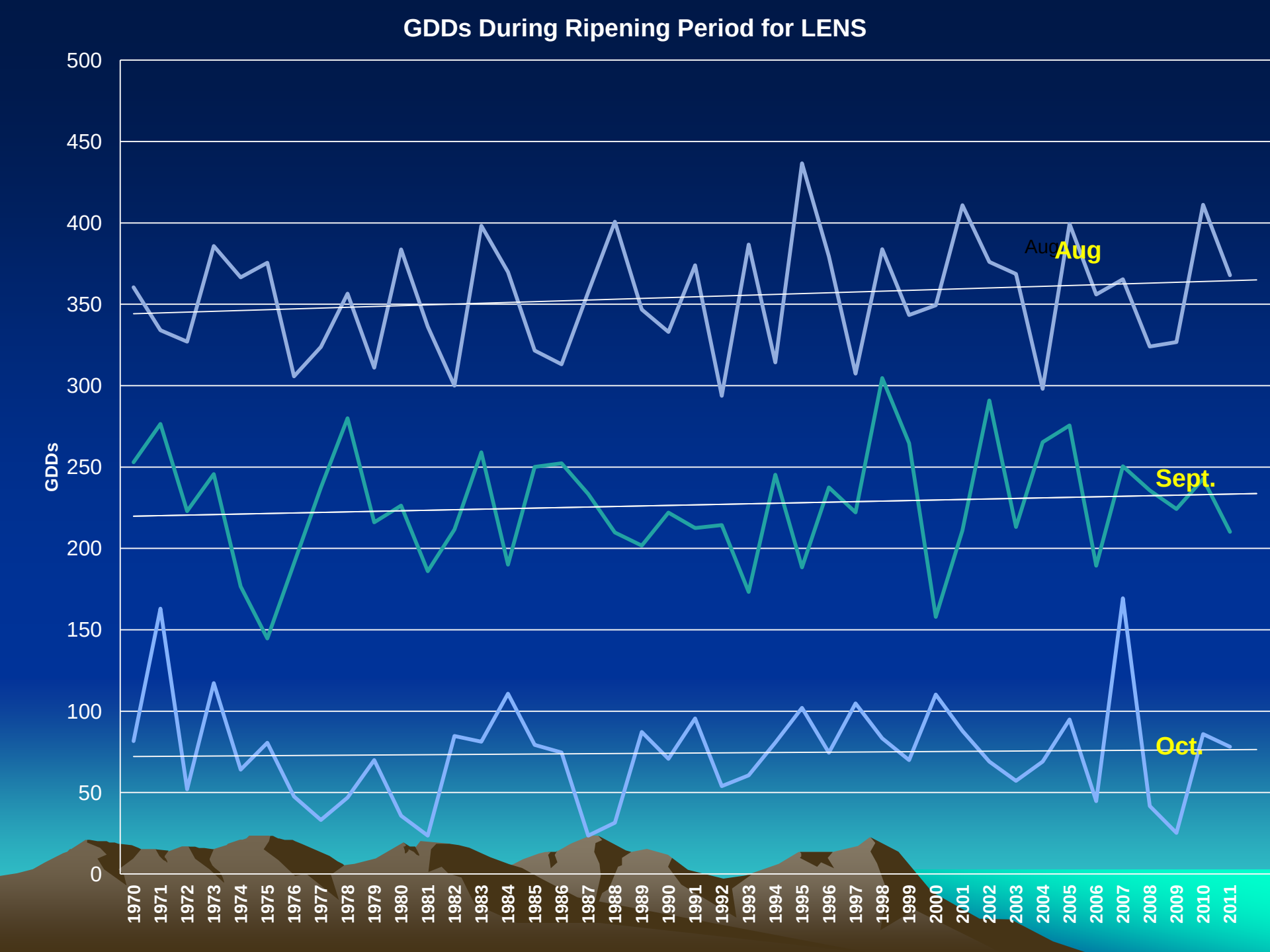
2007
2008
2009
2010
2011


GDDs During Ripening Period for LENS
GDDs
500
450
400
350
300
250
200
150
100
50
0
Aug
Aug
Sept.
Oct.
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
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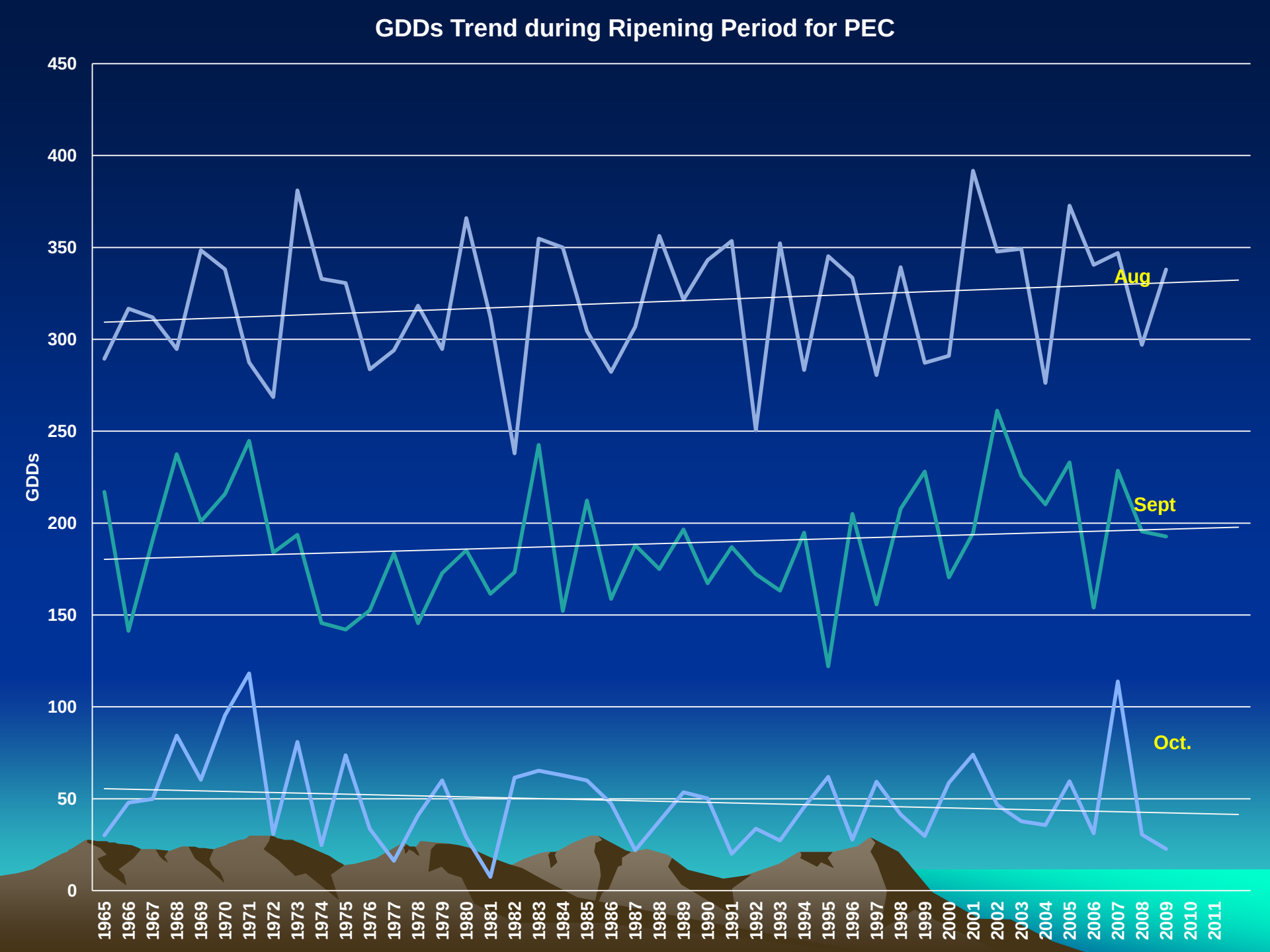
2009
2010
2011


GDDs Trend during Ripening Period for PEC
GDDs
450
400
350
300
250
200
150
100
50
0
Aug
Sept
Oct.
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
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1979
1980
1981
1982
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1986
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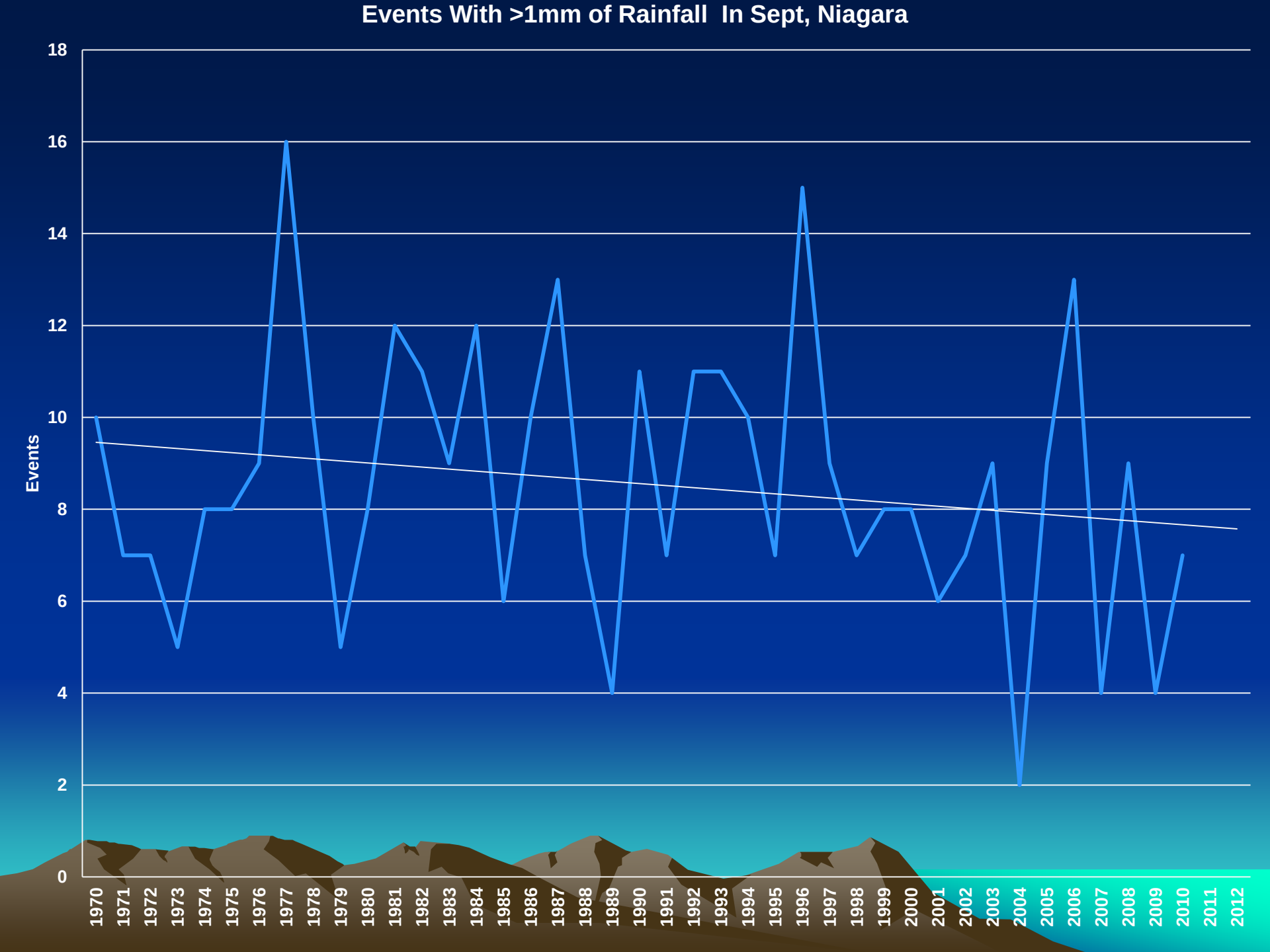
2007
2008
2009
2010
2011


Events With >1mm of Rainfall In Sept, Niagara
Events
0
2
4
6
8
10
12
14
16
18
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
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1991
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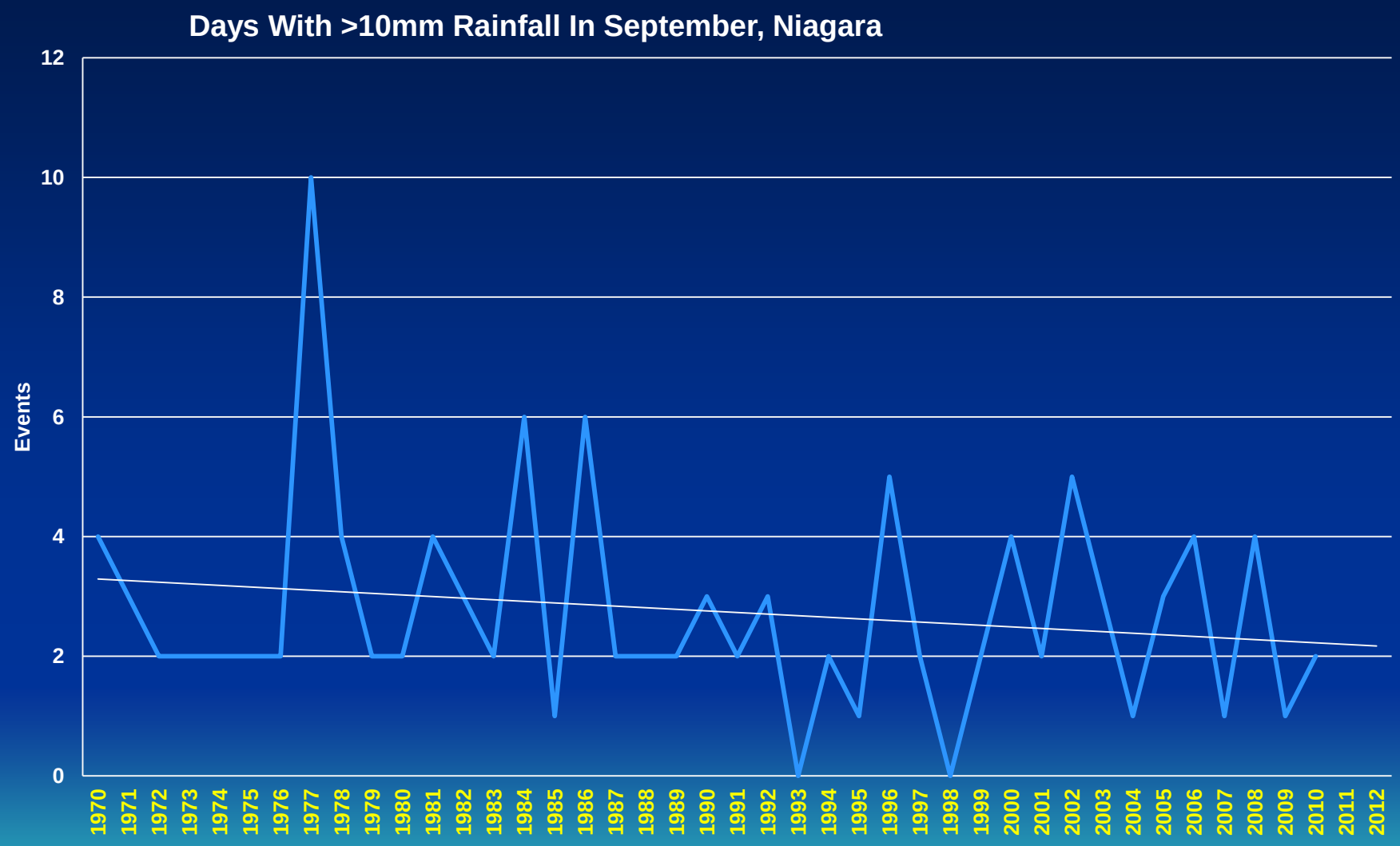
2008
2009
2010
2011
2012


Days With >10mm Rainfall In September, Niagara
Events
0
2
4
6
8
10
12
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
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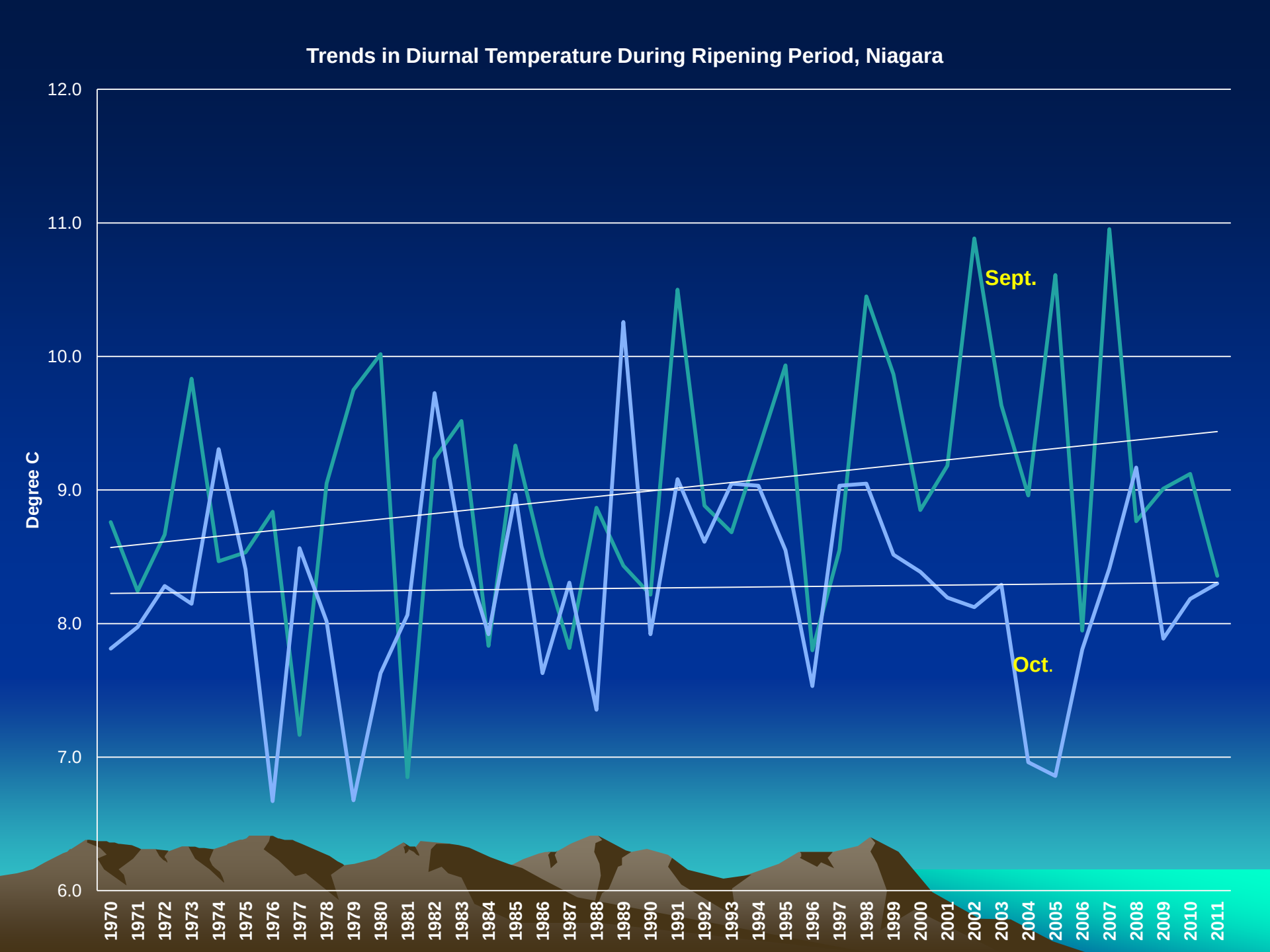
2008
2009
2010
2011
2012


Trends in Diurnal Temperature During Ripening Period, Niagara
Degree C
12.0
11.0
10.0
9.0
8.0
7.0
6.0
Sept.
Oct.
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
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1994
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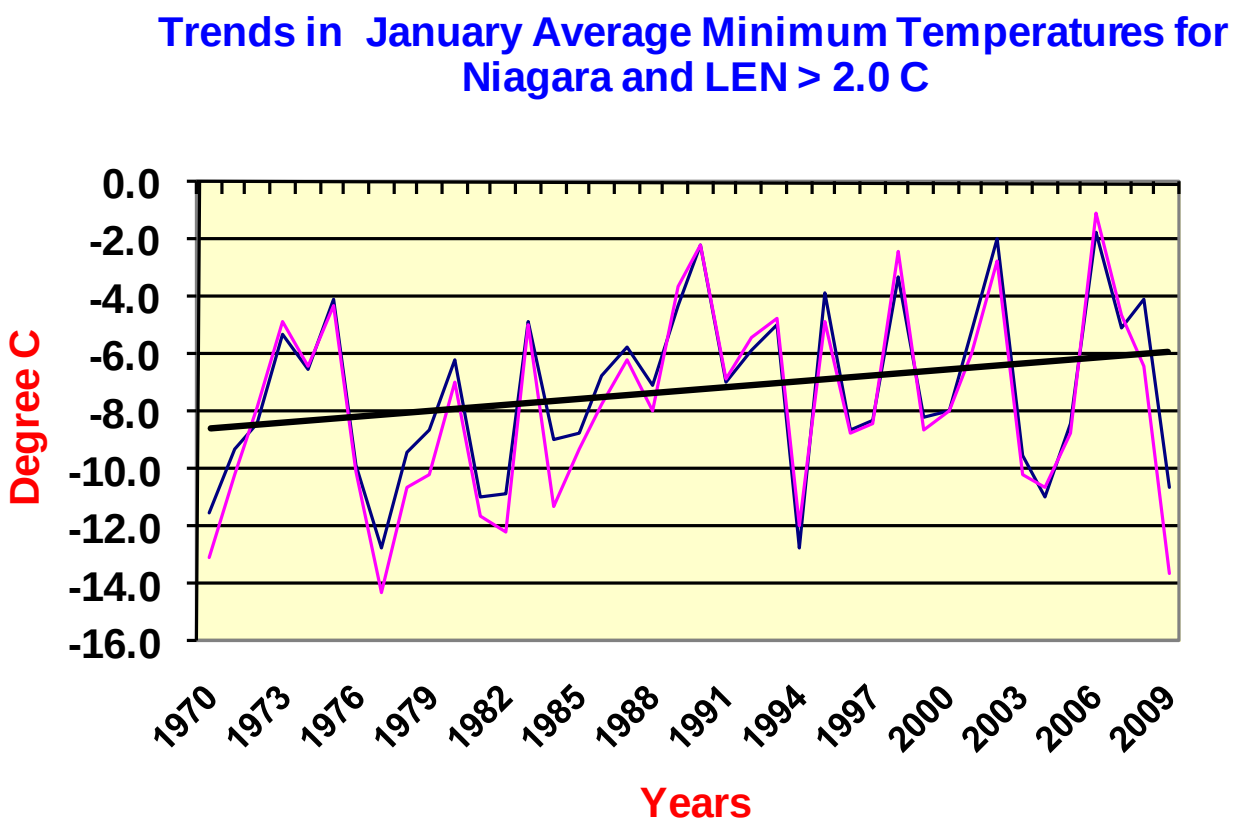
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011

Winter
Is it getting warmer?

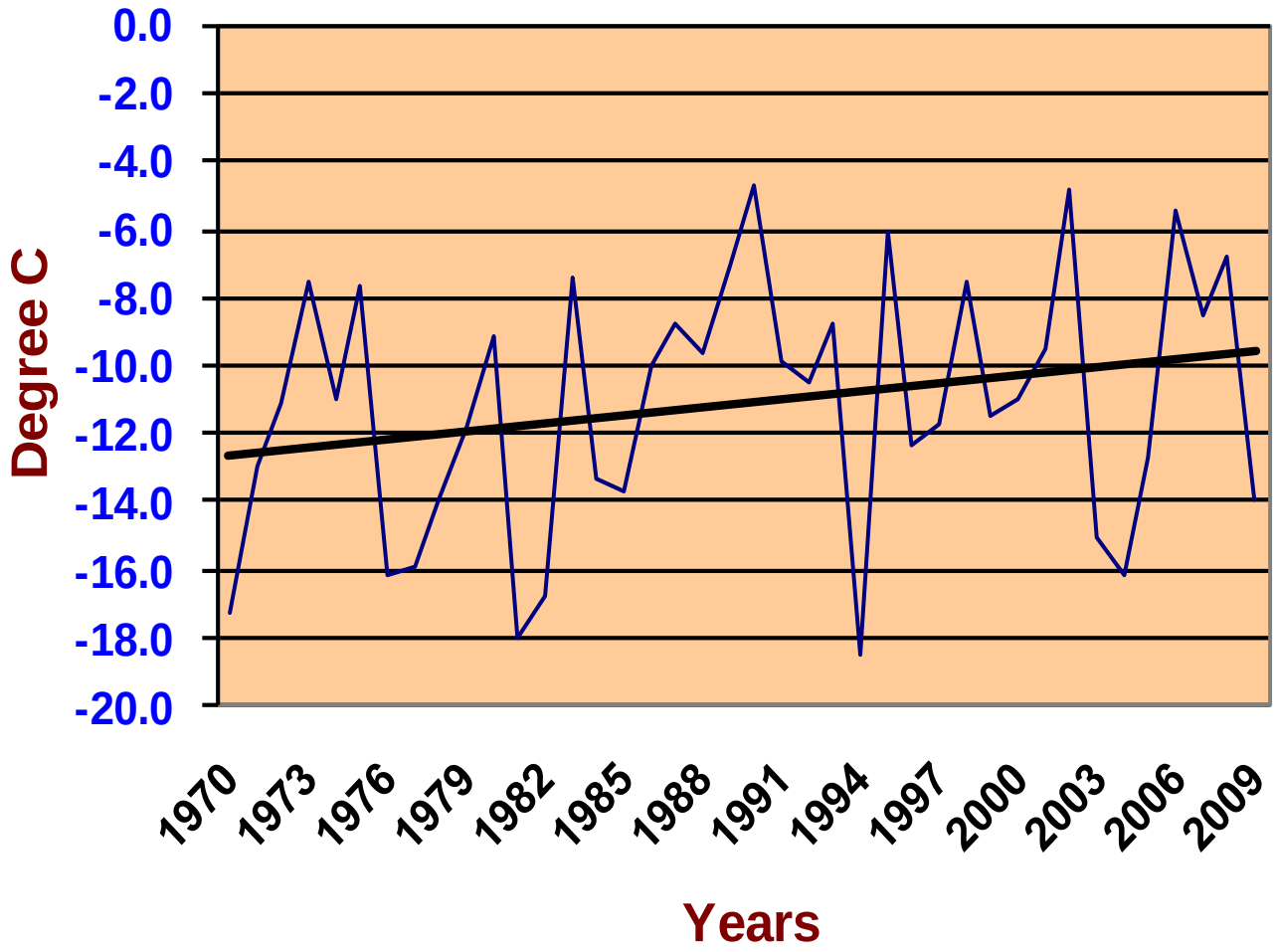
Romantic View

Climate Change

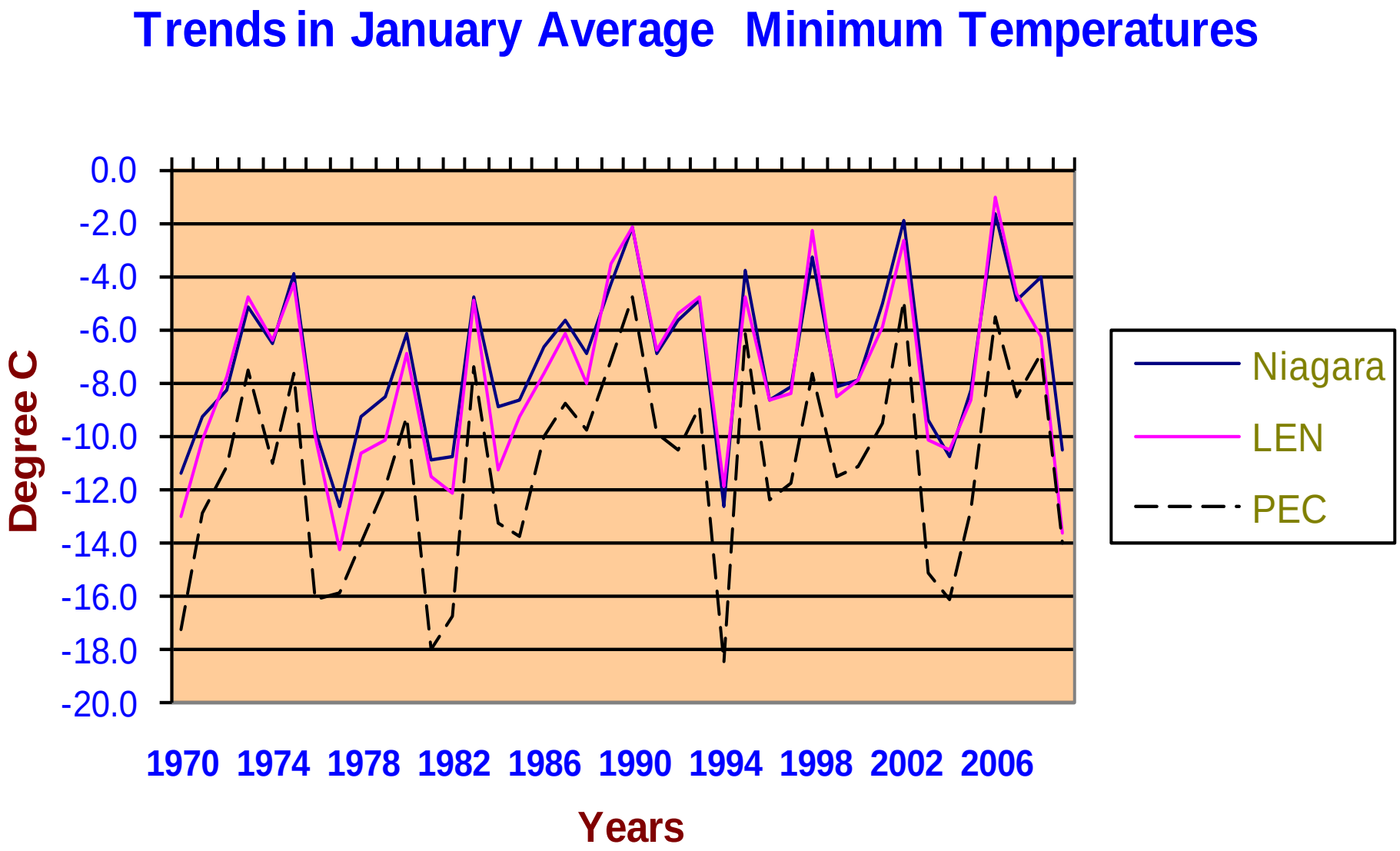


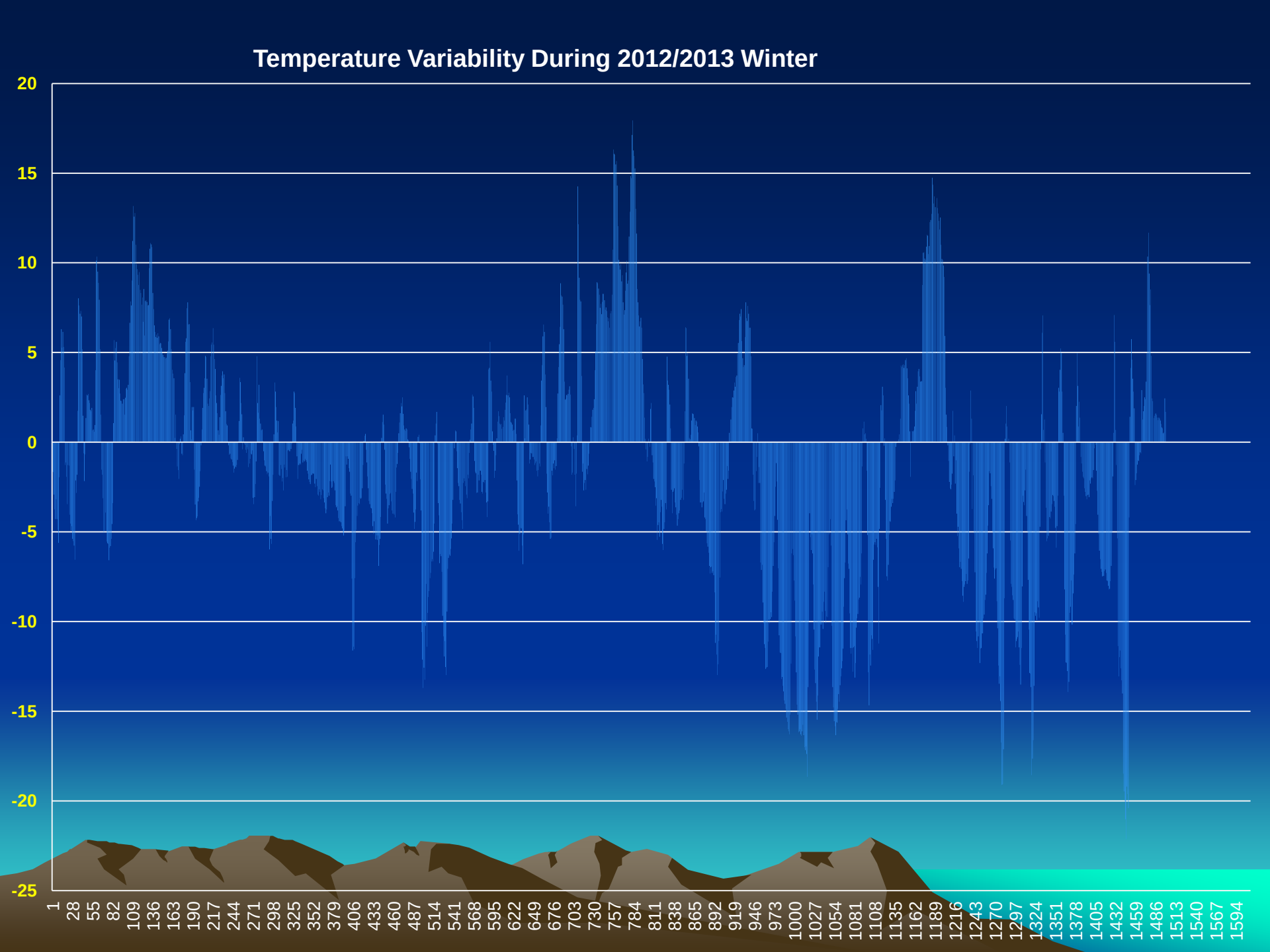
Climate Change

Trends in January Average Minimum Temperatures for PEC

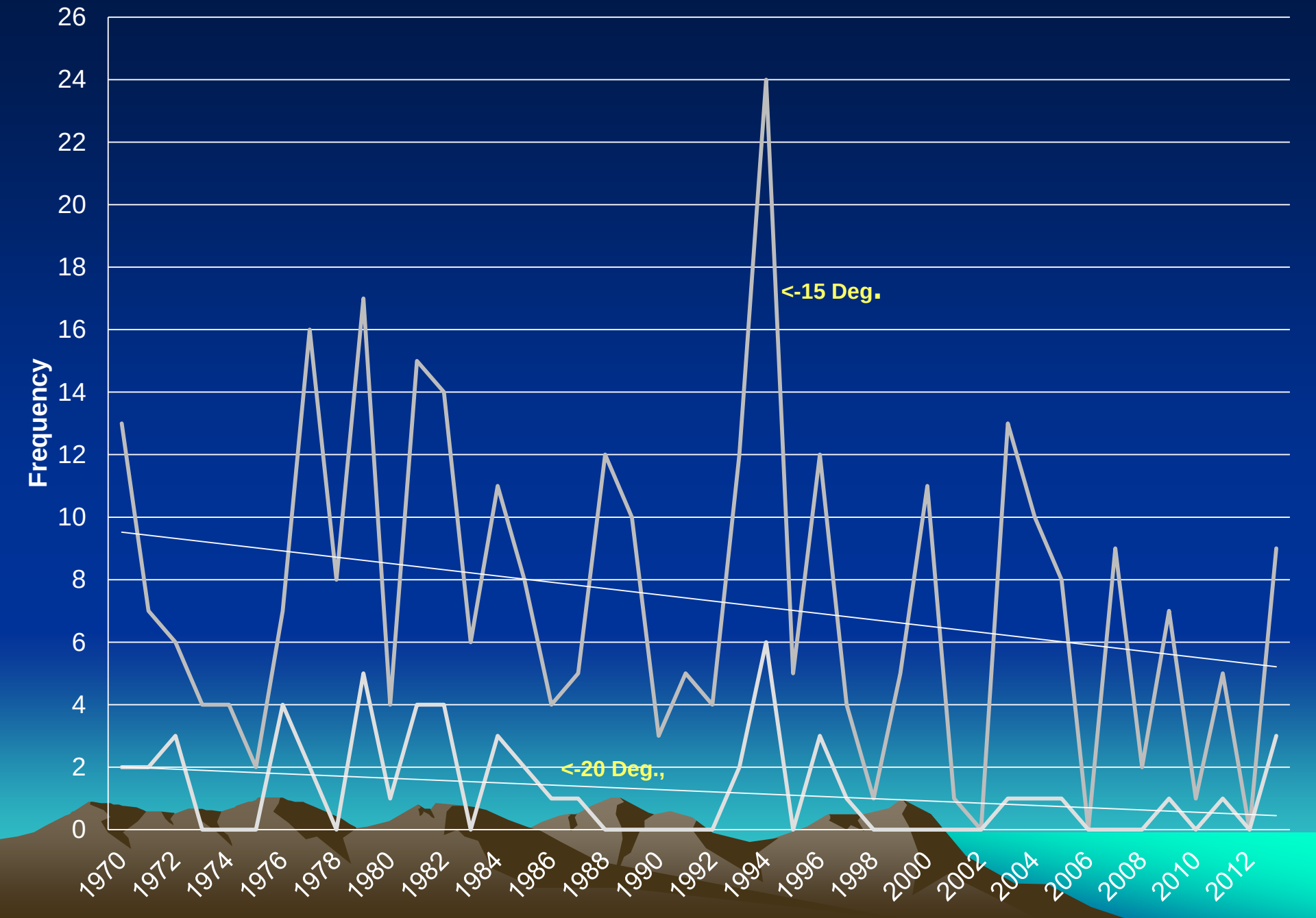


Climate Change

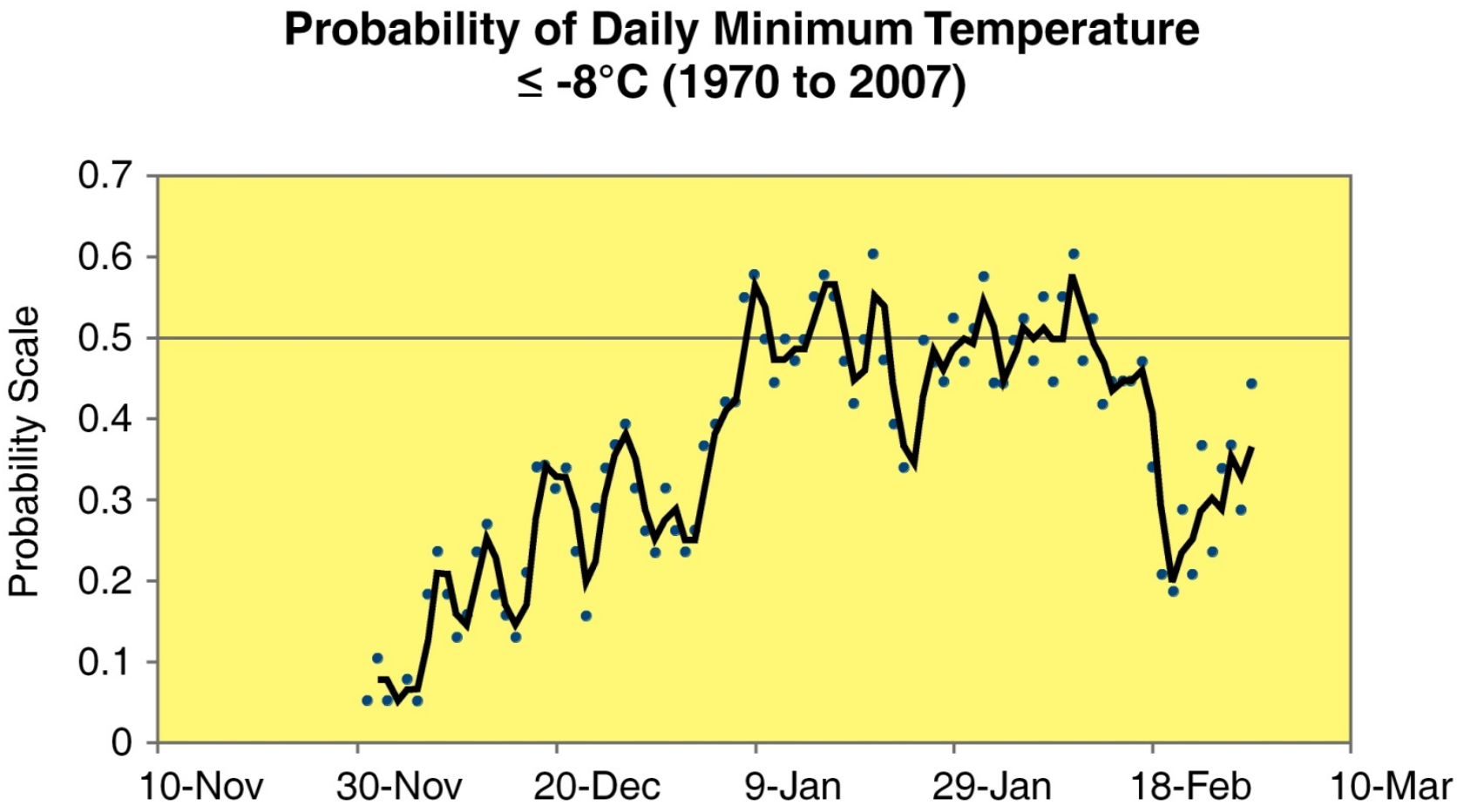



Temperature Variability During 2012/2013 Winter
20
15
10
5
0
-5
-10
-15
-20
-25
1
28
55
82
109
136
163
190
217
244
271
298
325
352
379
406
433
460
487
514
541
568
595
622
649
676
703
730
757
784
811
838
865
892
919
946
973
1000
1027
1054
1081
1108
1135
1162
1189
1216
1243
1270
1297
1324
1351
1378
1405
1432
1459
1486
1513
1540
1567
1594

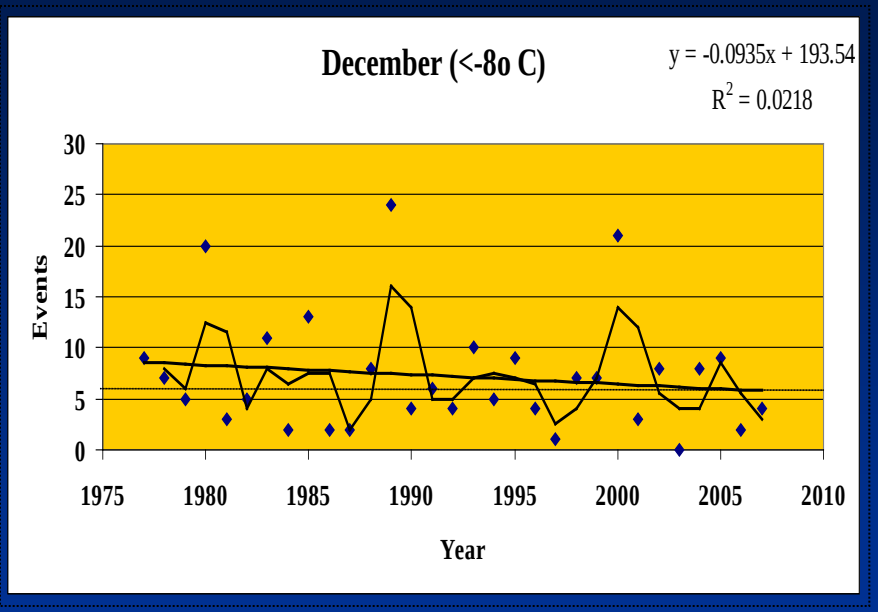
Potentially Damaging Winter Temperatures, Niagara

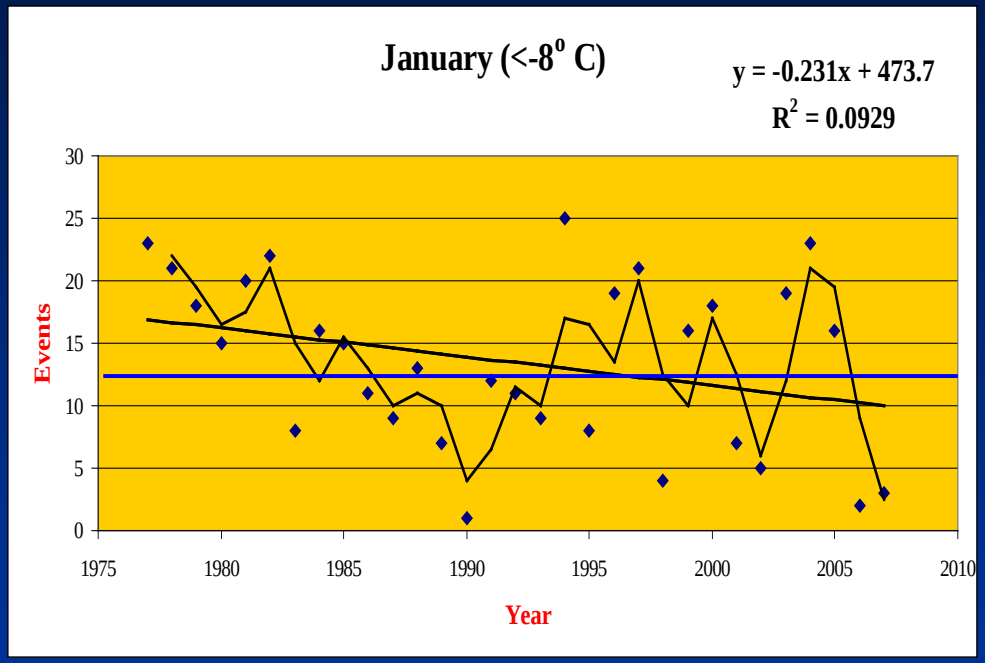


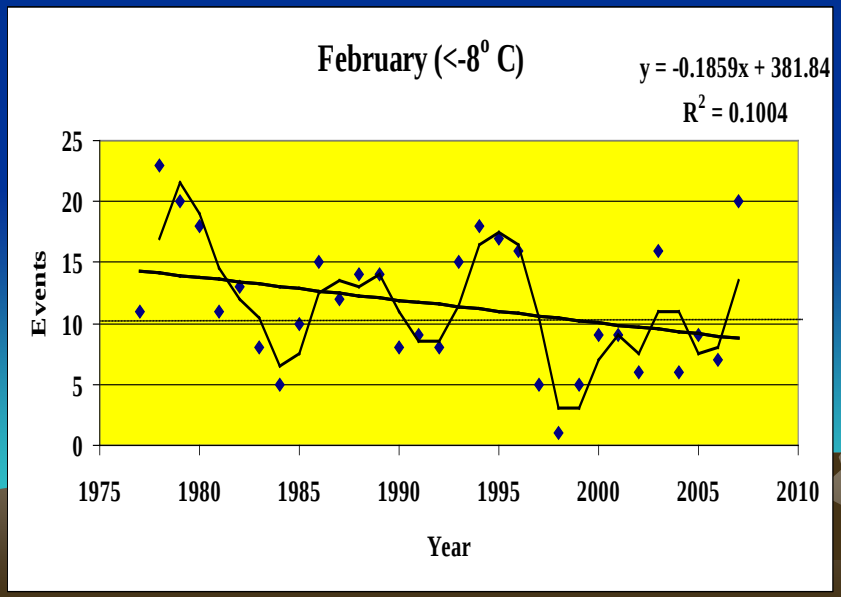
ICEWINE


Probability of Daily Minimum Temperature
≤ -8°C (1970 to 2007)
Probability Scale
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10-Nov
30-Nov
20-Dec
9-Jan
29-Jan
18-Feb
10-Mar

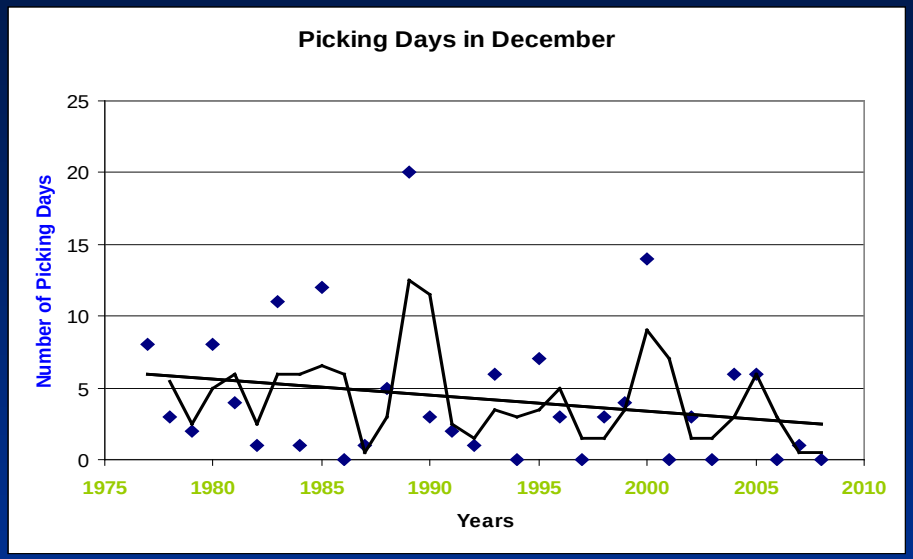
Ice Wine Events For Niagara

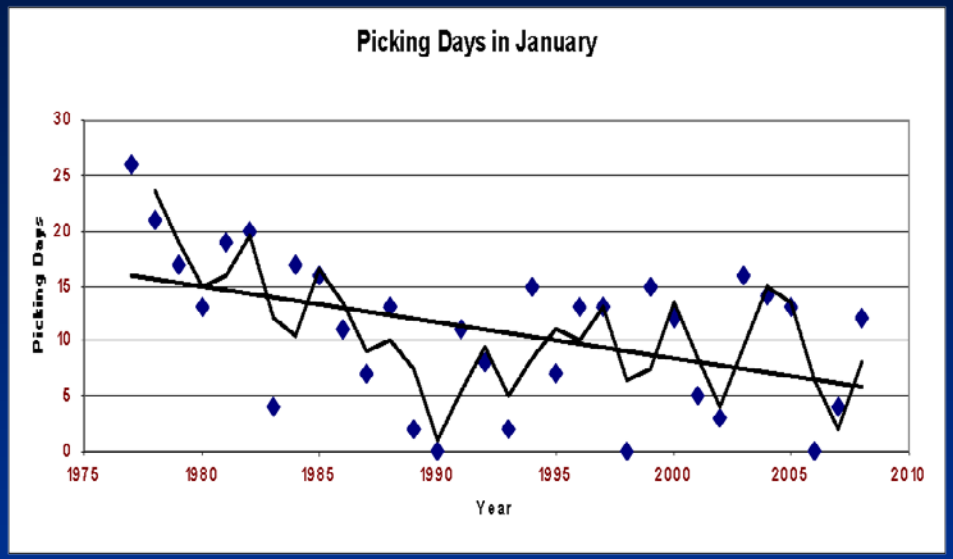


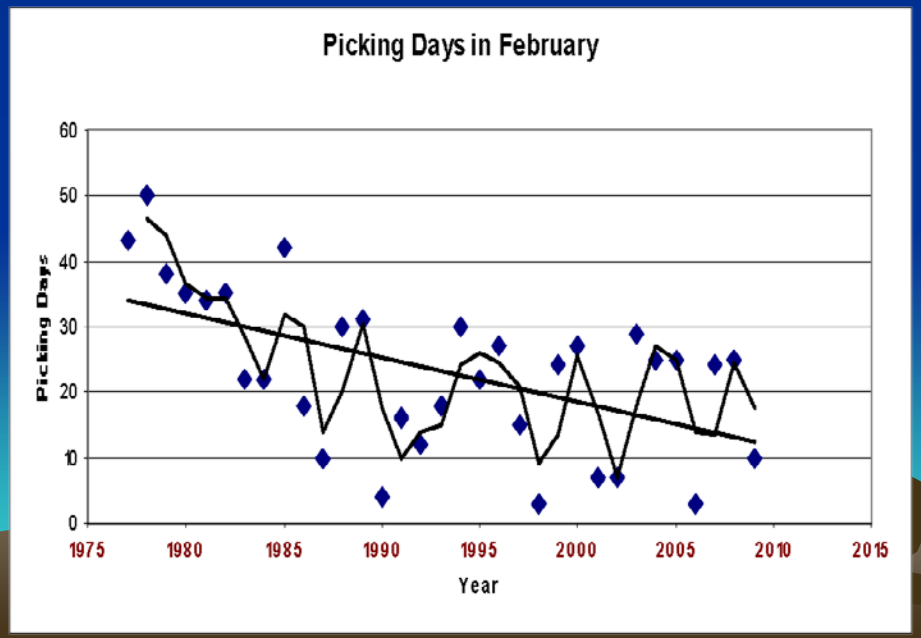


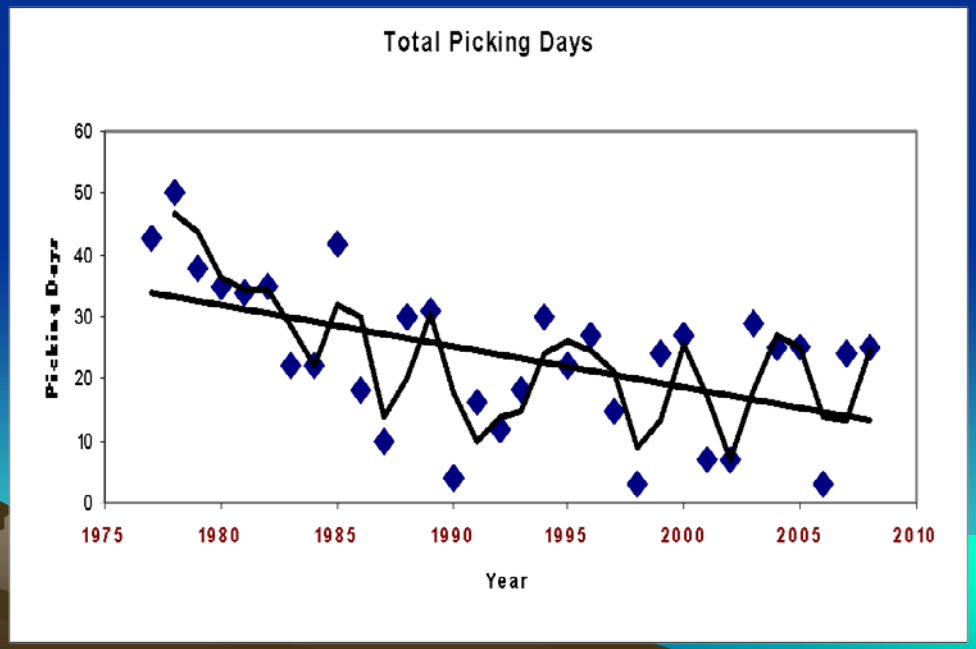


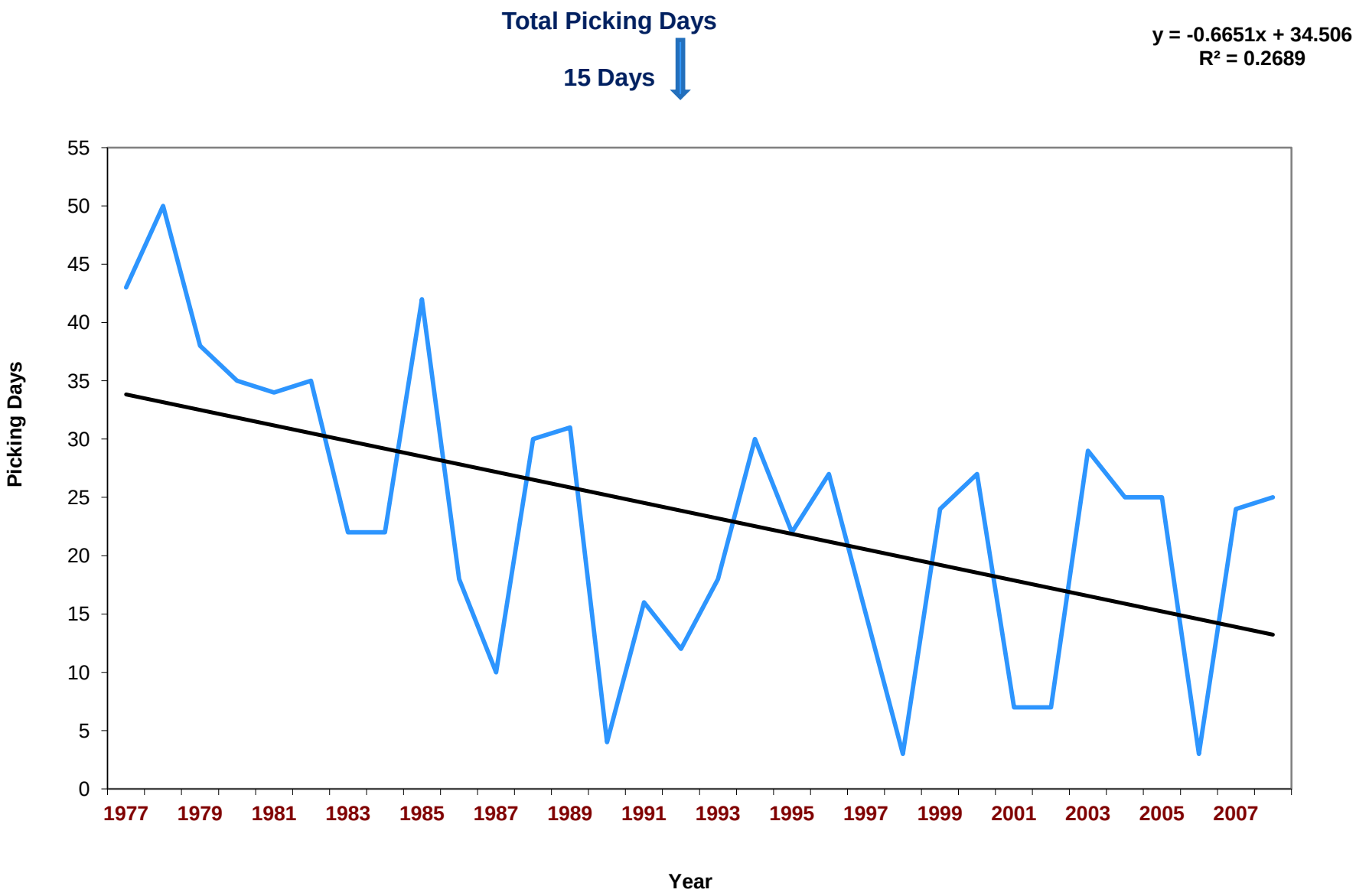
Icewine Events in Lake Erie Northshore



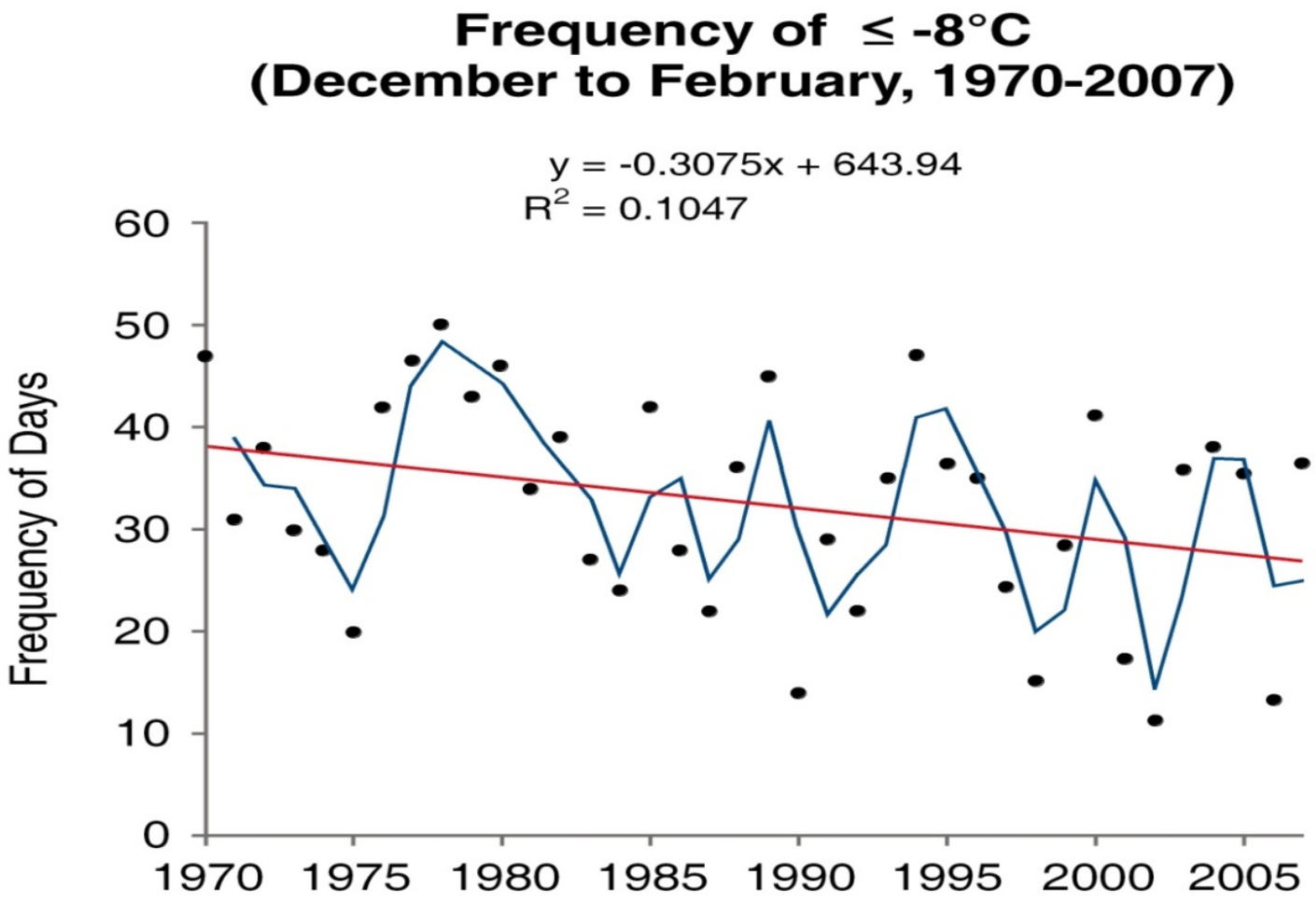






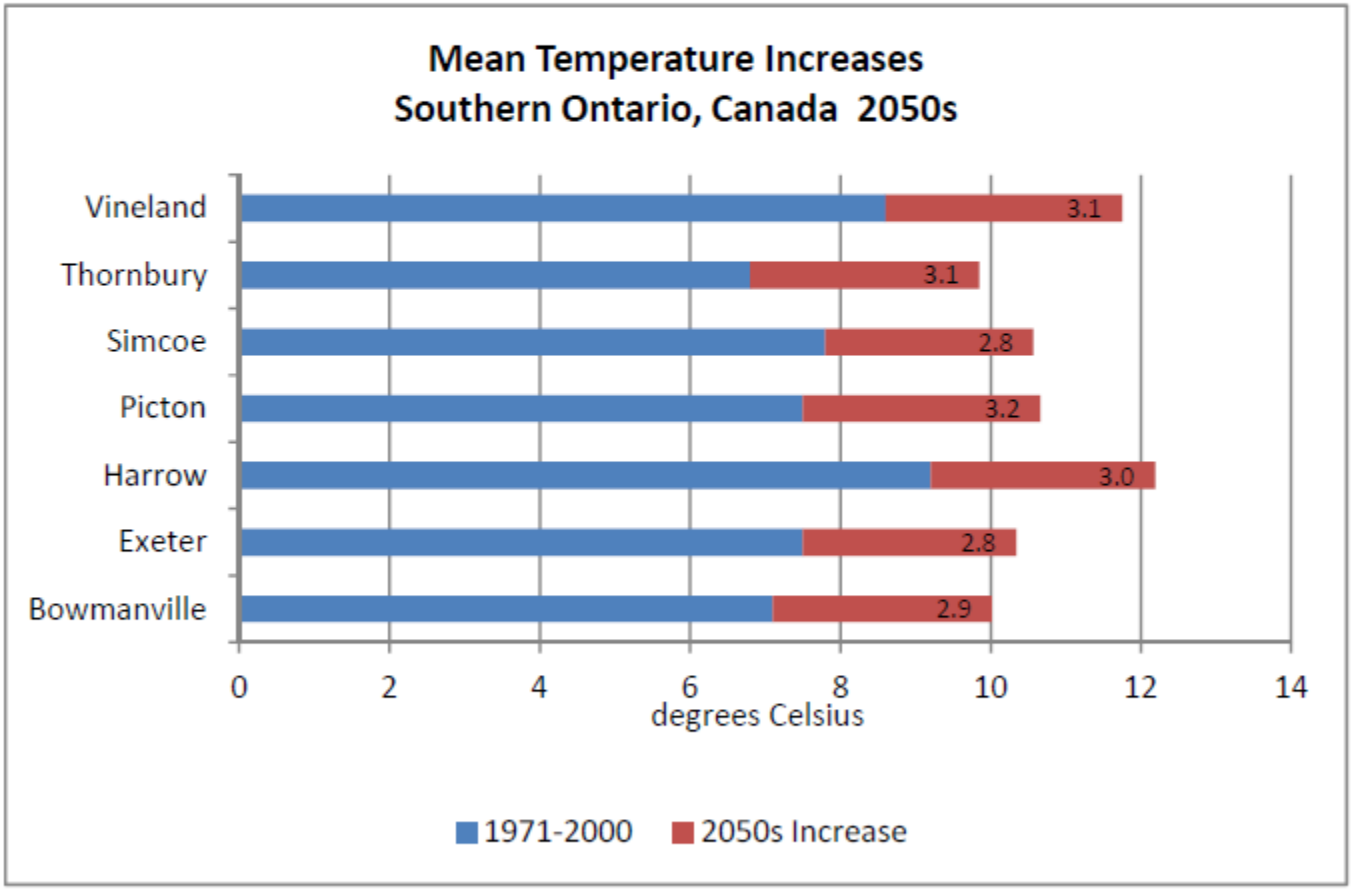

Total Picking Days
15 Days
y = -0.6651x + 34.506
R² = 0.2689
Picking Days
55
50
45
40
35
30
25
20
15
10
5
0
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year

ICEWINE

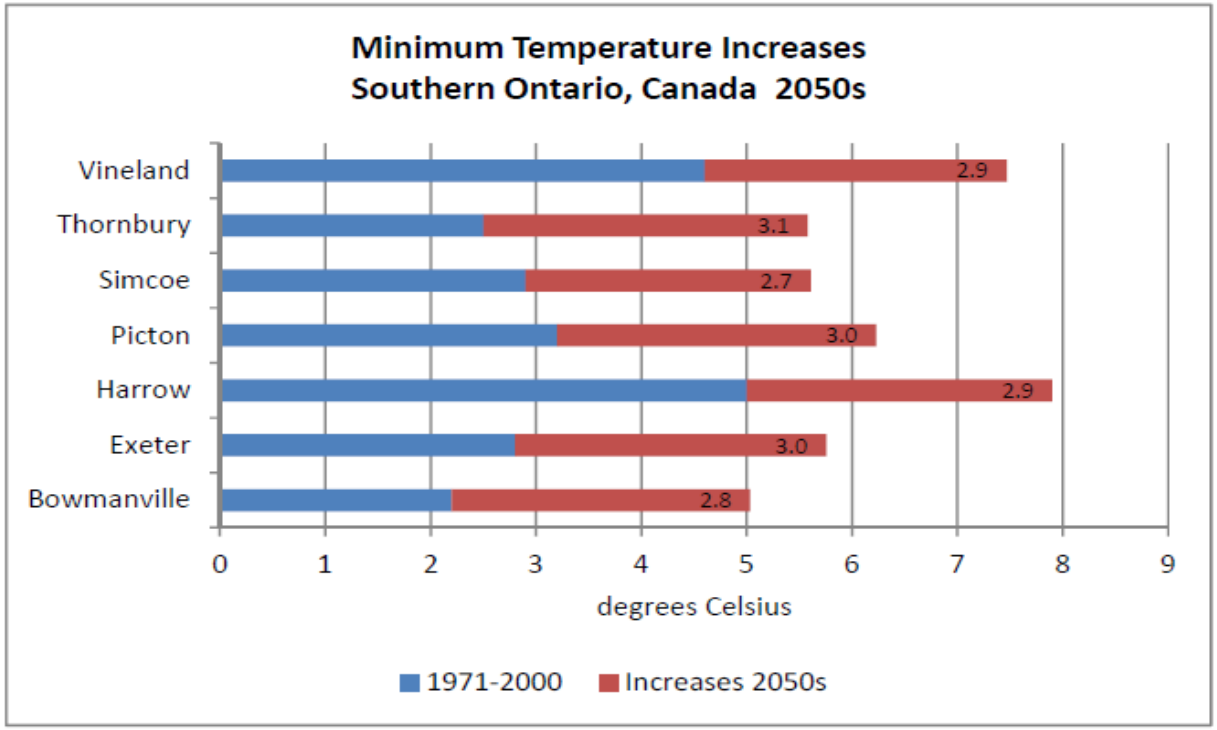

Frequency of ≤ -8°C
(December to February, 1970-2007)
y = -0.3075x + 643.94
R2 = 0.1047
Frequency of Days
60
50
40
30
20
10
0
1970
1975
1980
1985
1990
1995
2000
2005

Projected Changes In Temperature and Precipitation to 2050s

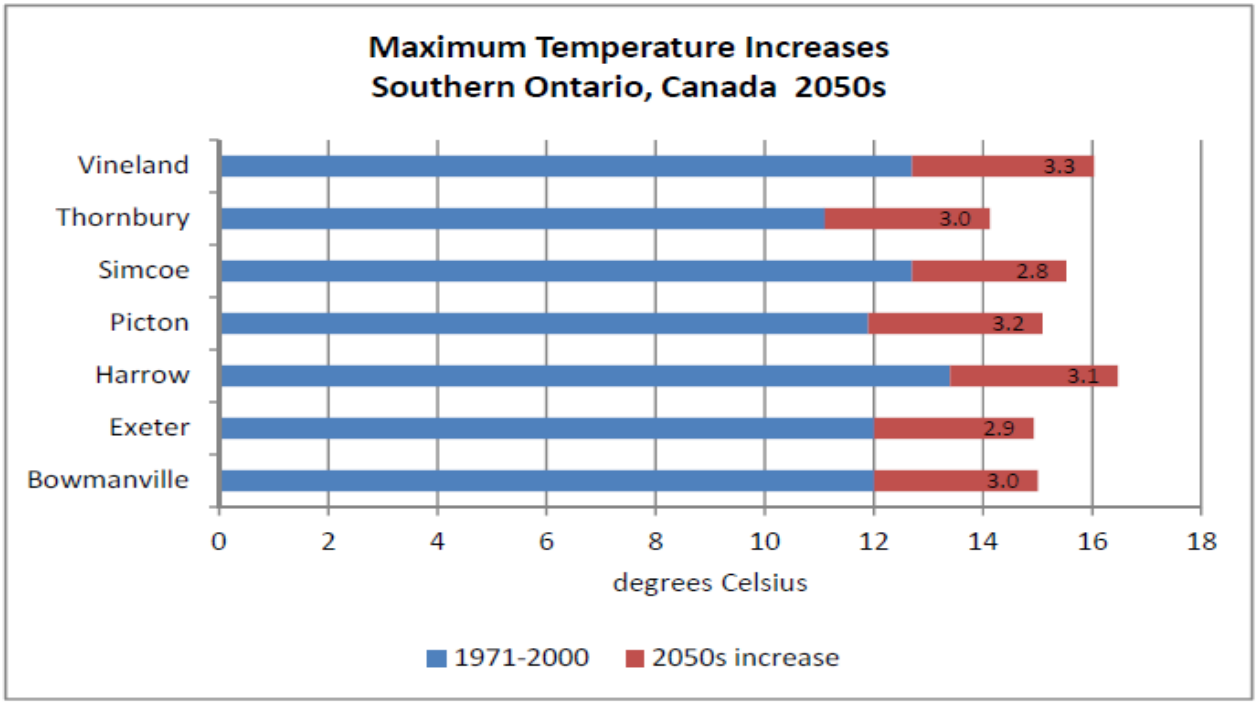
	Bowmanville	Exeter	Harrow	Picton	Simcoe	Thornbury	Vineland
Tmean	10.0	10.3	12.2	10.7	10.6	9.9	11.7
71-2000	7.1	7.5	9.2	7.5	7.8	6.8	8.6
Diff	2.9	2.8	3.0	3.2	2.8	3.1	3.1



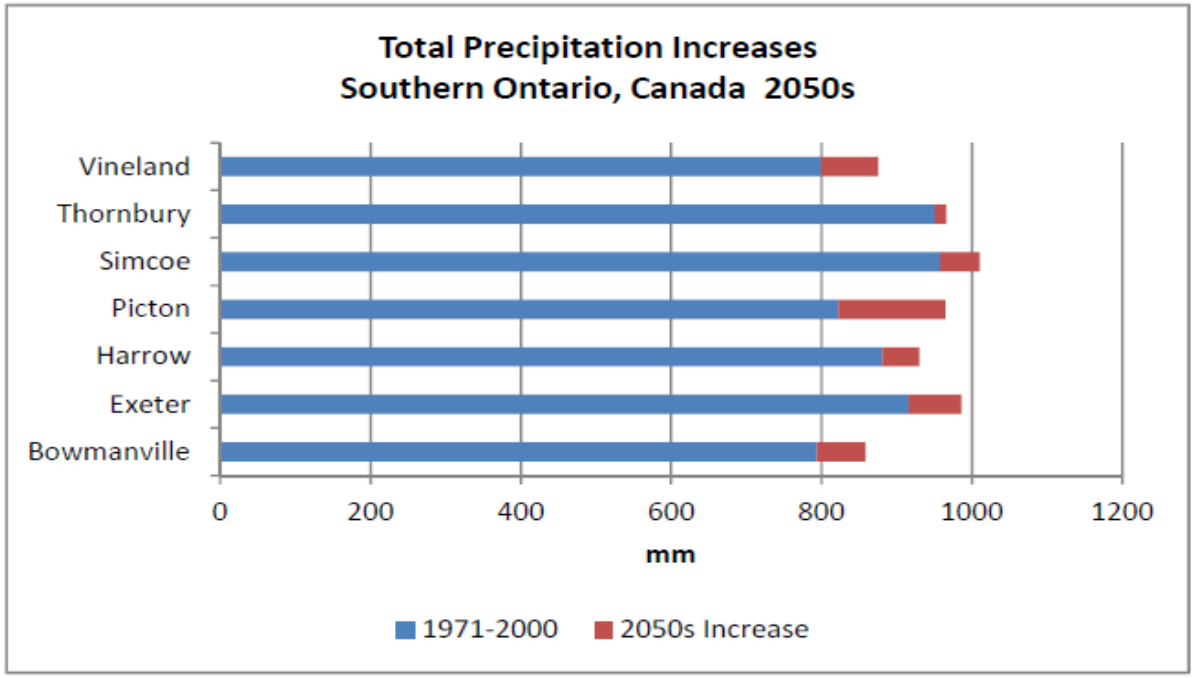
	Bowmanville	Exeter	Harrow	Picton	Simcoe	Thornbury	Vineland
Tmin	5.0	5.8	7.9	6.2	5.6	5.6	7.5
71-2000	2.2	2.8	5.0	3.2	2.9	2.5	4.6
Diff	2.8	3.0	2.9	3.0	2.7	3.1	2.9



	Bowmanville	Exeter	Harrow	Picton	Simcoe	Thornbury	Vineland
Tmax	15.0	14.9	16.5	15.1	15.5	14.1	16.0
71-2000	12.0	12.0	13.4	11.9	12.7	11.1	12.7
Diff	3.0	2.9	3.1	3.2	2.8	3.0	3.3



	Bowmanville	Exeter	Harrow	Picton	Simcoe	Thornbury	Vineland
Ptotal	858	986	930	965	1010	966	875
1971-2000	794	916	880	822	958	950	799
2050s Increase	64	70	50	143	52	16	76
% increase	8	7	5	15	5	2	9



Impacts and Implications For New Varieties, Quality And Emerging Areas

Implication for Viticulture

Impact on Varieties

- Shifts away from whites to high quality reds (Cabernet Sauvignon, Cabernet Franc, Merlot and Syrah) in some areas (Lake Erie North Shore, Pelee Island and Niagara Region)
- Shifts to less cold-hardy whites such as Sauvignon blanc
- A greater diversity of wine styles
- Expansion in the range of terroirs or appellations

Impact on geographic distribution of viticulture areas

- Expansion of viticulture areas northwards, but in preferred snow belts areas of the Great Lakes

Impact on Phenology of Pests

- Likely increase in pests and diseases due to milder winters

Climate Change Impacts

- **Impacts on Climate**

- Winters are getting warmer
- Summers are getting warmer
- Higher frequency of days with extreme maximum temperatures
- Greater volatility of weather in general
- Highly variable, but a likely decrease in precipitation in spring and summer months for some regions

- Winter damage could actually increase in Ontario's wine regions due:
- Reduced cold hardening during the fall
- An increase in the frequency of winter freeze-thaw events followed by cold snaps
- A decrease in protective snow cover.
- These can significantly affect the health of the vines and consequently, substantially reduce yields. Finally, climate change research generally suggests that extreme weather conditions are likely to increase in the future resulting in higher volatility of weather conditions.

Implications for Viticulture in the Long-Term

- **Impact on Vine Phenology**
- Earlier bud break and flowering
- Earlier veraison and ripening
- **Impact on Quality**
- Accelerated ripening for early season varieties
- Lower acidity and higher sugar and alcohol levels due to higher daytime and night time temperatures
- Full maturity of mid to late season varieties (Merlot and Cabernet Sauvignon)

Climate Change

- **Viticulture Practices In a Warming Climate**
- Plant new varieties
- Move into new areas
- Develop water conservation measures
- I*mplement* effective irrigation techniques, such as drip
- irrigation
- Develop canopy management practices to conserve moisture
- Effectively mulch the soil and plant mid row crops in order to absorb more water
- Invest in crop insurance
- Develop cold resistant varieties to accommodate cycles of freeze and thaw
- Develop disease resistant varieties

Climate Change

Conclusions

- Potential benefits are not clearly evident
- The changes may be imperceptible to most people
- More controversial, are the uncertainties
- Even more controversial: What strategies should we adopt

Thank You