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and O'Brien, J.J.

# Crop Specific Thermal Time: A Comparison of ENSO Climatology, JMA SST Anomalies, and the FSU Regional Climate Model



# Background

- ❖ AgClimate.org and GDD tool
- ❖ ENSO forecasts for thermal time
- ❖ FSU RCM forecasts

# Thermal Time for Agriculture

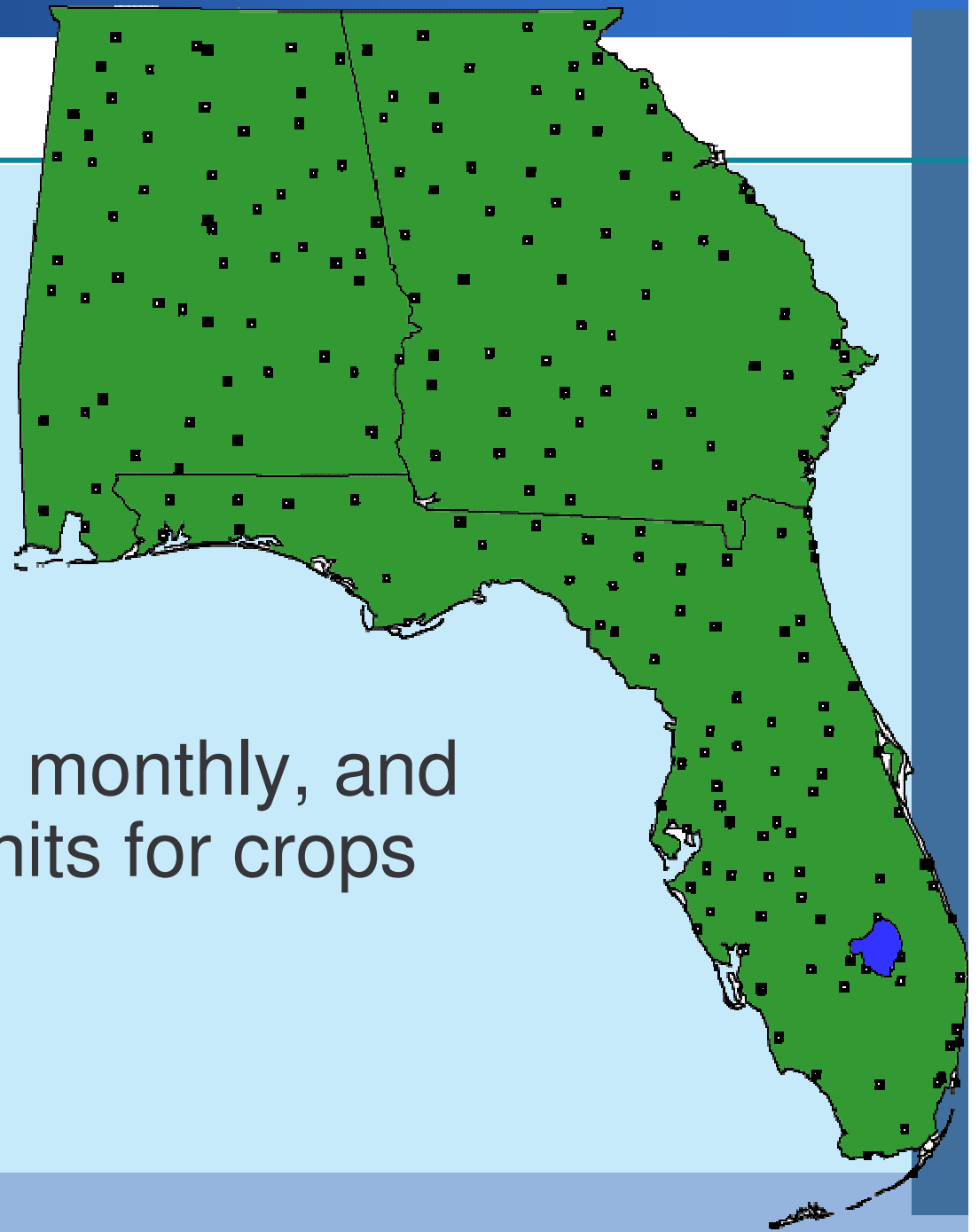
- ❖ Stakeholder interest in thermal time
  - ❖ Winter forage production & rotational grazing
  - ❖ Market opportunities in tomato
  - ❖ Vegetable seedling production
  - ❖ Disease management in cotton
  - ❖ Integrated pest management (IPM)
  - ❖ Management of deciduous fruit
  - ❖ Varietal selections in field crops
  - ❖ Heat stress in poultry, dairy, and cattle operations

# Thermal Time for Agriculture

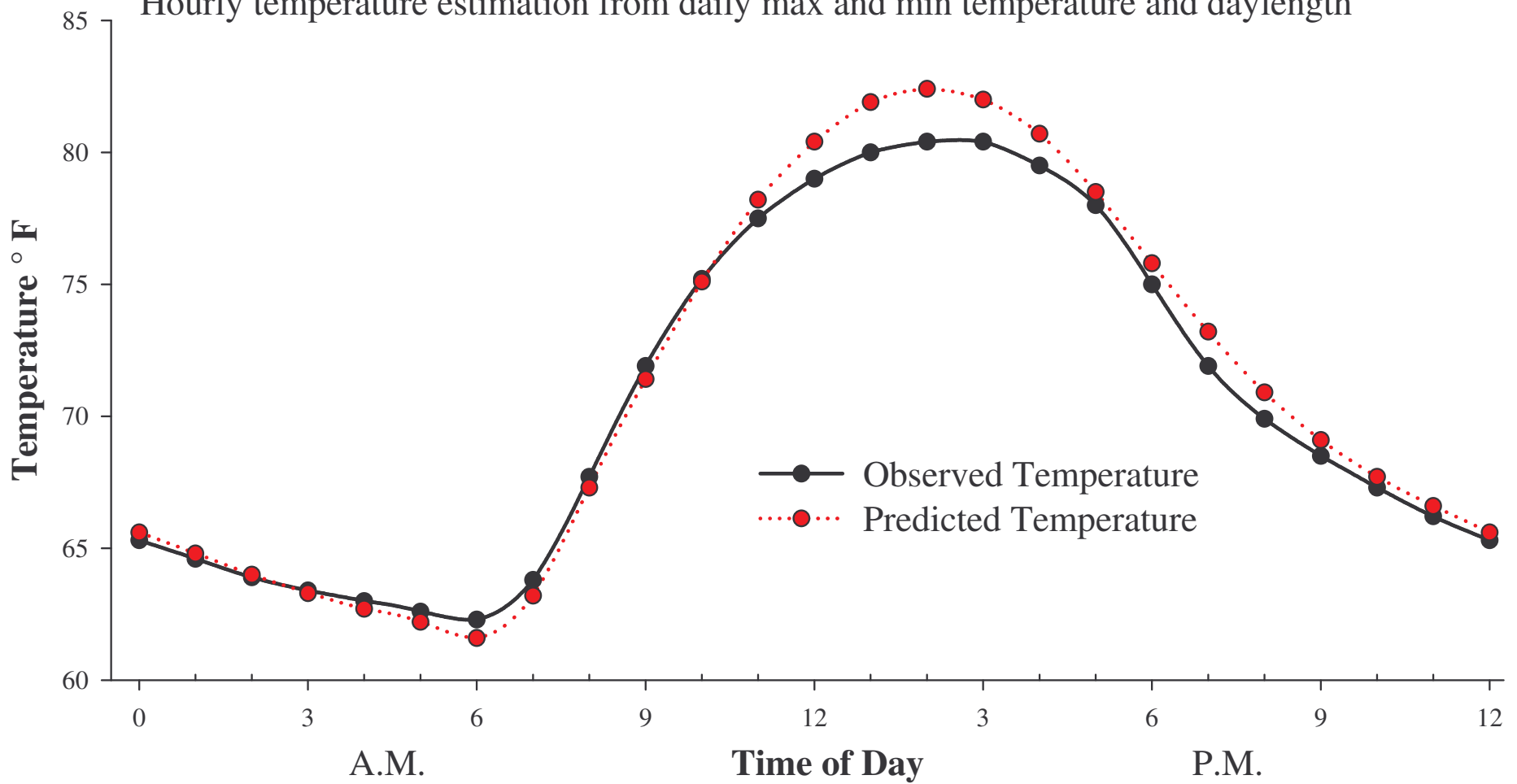
- ❖ Peanut <sub>(10)</sub>
- ❖ Cotton <sub>(33.8-15.6)</sub>
- ❖ Corn <sub>(48-6.2)</sub>
- ❖ Tomato <sub>(55-10)</sub>
- ❖ Broccoli <sub>(20-0)</sub>
- ❖ GDD 86 °-50 °
- ❖ Ryegrass <sub>(30-0)</sub>
- ❖ Wheat <sub>(0)</sub>
- ❖ Heating Degree Days <sub>(18.3)</sub>
- ❖ Cooling Degree Days <sub>(18.3)</sub>
- ❖ Insect Populations <sub>(lots)</sub>
- ❖ Fruit Chill Units
  - ❖ 45 °F Chill hours
  - ❖ Apple <sub>(8-3)</sub> , Pear <sub>(10-0)</sub> ,  
Blueberry <sub>(15-7.2—2.5)</sub> , Peach <sub>(14-6—2)</sub> , &  
Strawberry <sub>(7-0)</sub>

## Methods

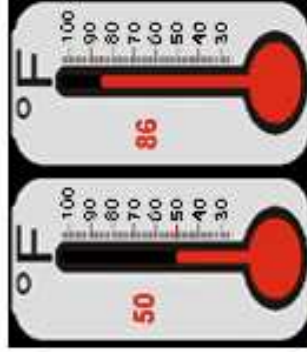
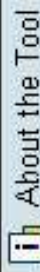
- ❖ TD3200 Coop Data
- ❖ 1948-2006
- ❖ Hourly temperature estimation
- ❖ Calculation of daily, monthly, and seasonal thermal units for crops



## Hourly temperature estimation from daily max and min temperature and daylength



- Hourly temperature estimation from: Latitude & Longitude, Max T, Min T
- Non-linear fit using FAWN hourly data for 9 sites (3 coastal, 6 inland)
- Tested on independent FAWN sites:  $R^2 = 0.92$  ( $n = 6$ )



Crop

Growing \* Days

State

FL

County

ALACHUA  
BAKER  
BAY

Starting Date

Mar 15

- Neutral
- El Nino
- La Nina
- All Years

Avg and Deviation

Probability Distribution

Probability of Exceedance

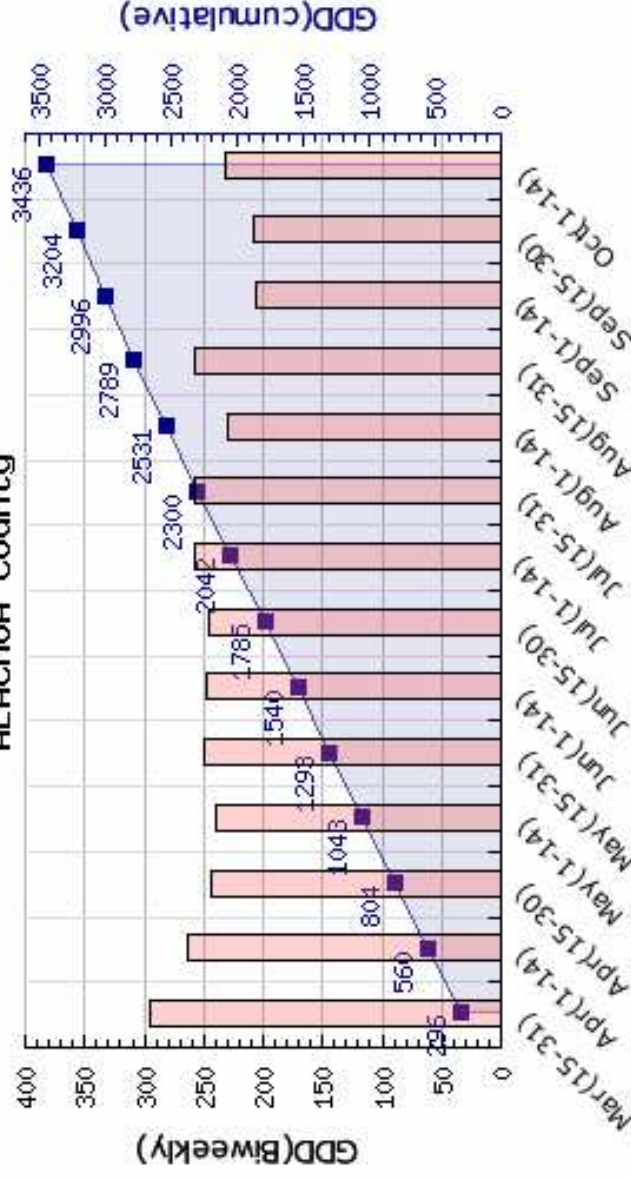
Last 5 Years


### Average and Deviation (from All Years).

	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct	
	15-31	1-14	15-30	1-14	15-31	1-14	15-30	1-14	15-31	1-14	15-31	1-14	15-30	1-14	15-31	1-14
<b>Avg.</b>	296	264.2	244.3	239	249.9	247.2	245.2	257.1	257.5	230.6	257.8	206.7	208	231.7		
<b>Dev.</b>	7	-0.4	-12.6	-13.2	-11.3	0.2	8.9	7.1	-0.6	-5.9	5.4	-9.5	0	5.9		

Statistics are calculated for ALACHUA county.

### Average Accumulation in ALACHUA County



 About the Tool


### Average and Deviation (from All Years).

Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
15-31	1-14	1-14	1-14	1-14	1-14	1-14	1-14
15-30	1-14	15-31	1-14	15-31	1-14	15-31	1-14

<http://www.egclimate.org> - Chill Forecast Tool - Mozilla Firefox

[<< Previous](#)
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## Growing Degree Days Tool User's Guide

- [Overview of growing degree days tool](#)
- [Quick Start](#)
- [Customizing the growing degree days tool](#)
- [Average and deviations tab](#)
- [Probability Distribution tab](#)
- [Probability of exceedance distribution tab](#)
- [Historical data tab](#)
- [Research findings](#)
- [Submit a question](#)

Done

## Growing Degree Days Quickstart Guide

The growing degree days (GDD) tool provide forecasts of the expected number of growing degree days for a generic calculation of GDD with a base temperature of 50 °F and a maximum temperature of 86 °F or a user can select calculations based on other temperatures that are more appropriate for individual crops. You must select a crop or growing degree days from the left side menu.

The forecast is for an individual county, if it is not already selected, users must indicate the state and county that interests them.

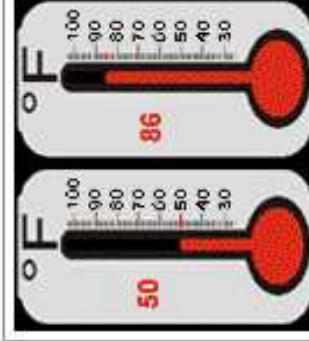
The user must select a starting date for the forecast from the left side menu. Default dates are offered for each crop type but may not be the best dates for all applications.

The user may select the phase of the ENSO forecast. By default, the current best forecast is selected, but users have the option to evaluate alternate forecasts if desired by selecting the ENSO phase from Neutral, El Niño, or La Niña.

The expected accumulations for 15 day intervals (bars) and the seasonal totals (line curve) are provided in the averages and deviations tab. The forecast in for seven months following the start date. By clicking the deviations row in the data table users can view how the biweekly totals compare with all years. This instantly indicates where during the forecast period, the forecast differs from what is 'normal' for the selected county.

The full probability distributions are available in the probability distribution and probability of exceedance tabs. In both of these forecasts, the user must select an end date within the data table. These forecasts provide forecasts of the amount of growing degree days that will occur during the date range selected.

The final historical record tab is not a forecast but is a record of the most recent five years of



HELP ?

Crop

Growing \* Days

State

GA

County

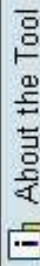
BULLOCH

BURKE

BUTTS

Starting Time

Jan 15



Crop  

  
 — Select Crop —  
 Growing \* Days  
 Corn  
 Tomato  
 Peanut  
 Cotton  
 Rye Grass  
 BAY

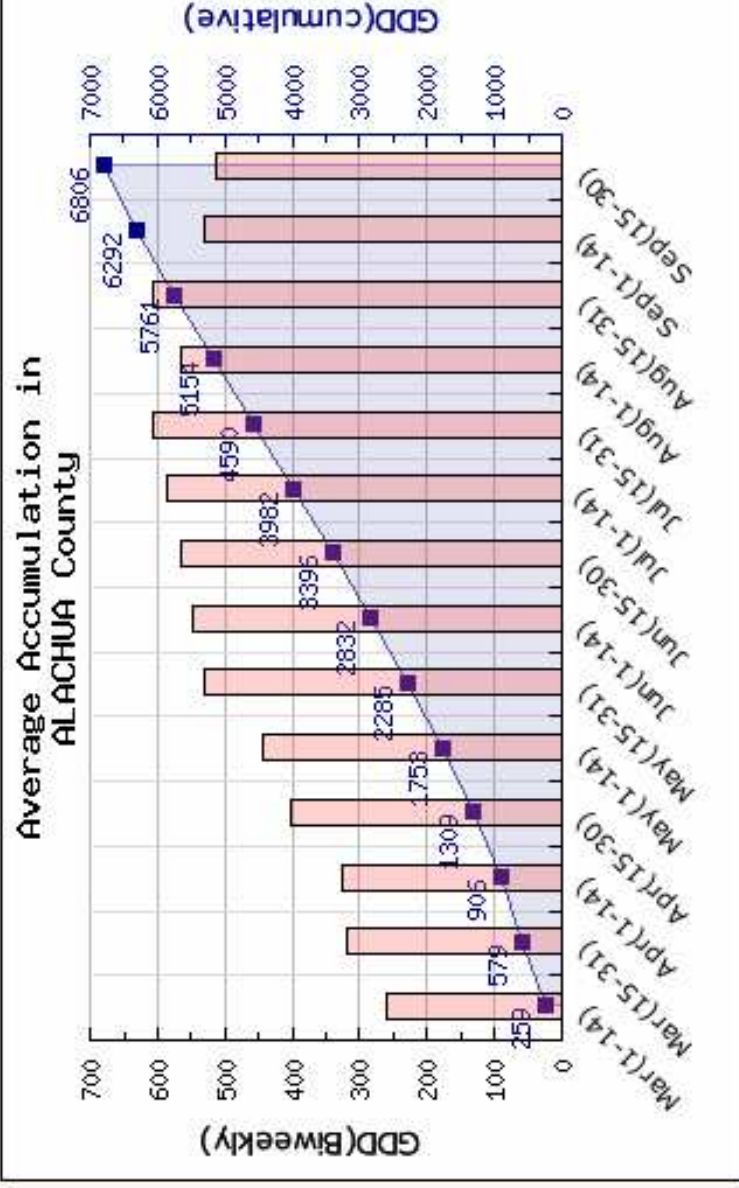
Starting Date

Neutral  
 El Nino  
 La Nina  
 All Years

## Average and Deviation (from All Years).

	Mar		Apr		May		Jun		Jul		Aug		Sep	
	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31
<b>Avg.</b>	259.4	320.1	326.6	403.3	443.8	531.7	547	563.8	585.5	607.5	564.1	606.5	531.3	513.6
<b>Dev.</b>	-6.6	-19.1	-23.3	2.3	-13.6	3.7	5.1	10.3	10.6	-3.2	-3.3	11.1	-6.8	10

Statistics are calculated for ALACHUA county.



About the Tool



Crop

State

County

Starting Date

- Neutral
- El Nino
- La Nina
- All Years

Avg and Deviation

Probability Distribution

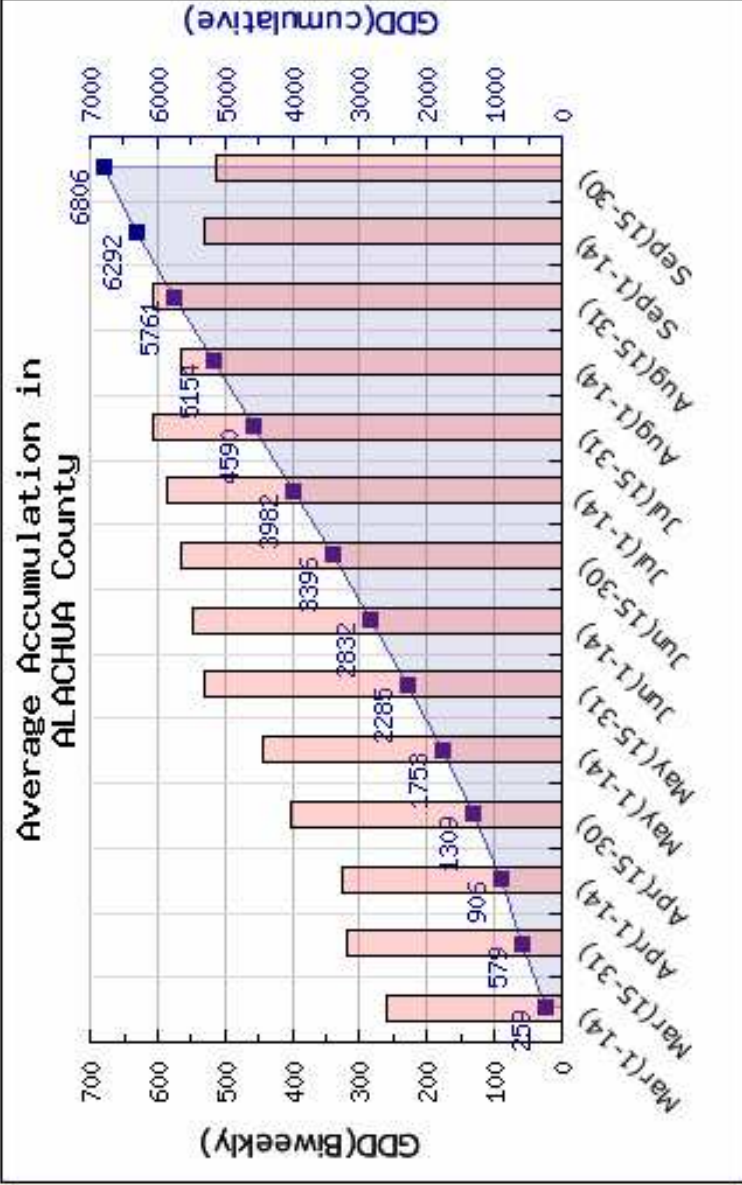
Probability of Exceedance

Last 5 Years

### Average and Deviation (from All Years).

	Mar		Apr		May		Jun		Jul		Aug		Sep	
	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31
<b>Avg.</b>	259.4	320.1	326.6	403.3	443.8	531.7	547	563.8	585.5	607.5	564.1	606.5	531.3	513.6
<b>Dev.</b>	-6.6	-19.1	-23.3	2.3	-13.6	3.7	5.1	10.3	10.6	-3.2	-3.3	11.1	-6.8	10

Statistics are calculated for ALACHUA county.



About the Tool



Crop  
Corn

State  
FL

County  
ALACHUA  
BAKER  
BAY

Starting Date  
Mar 1

Neutral  
 El Nino  
 La Nina  
 All Years

Avg and Deviation

Probability Distribution

Probability of Exceedance

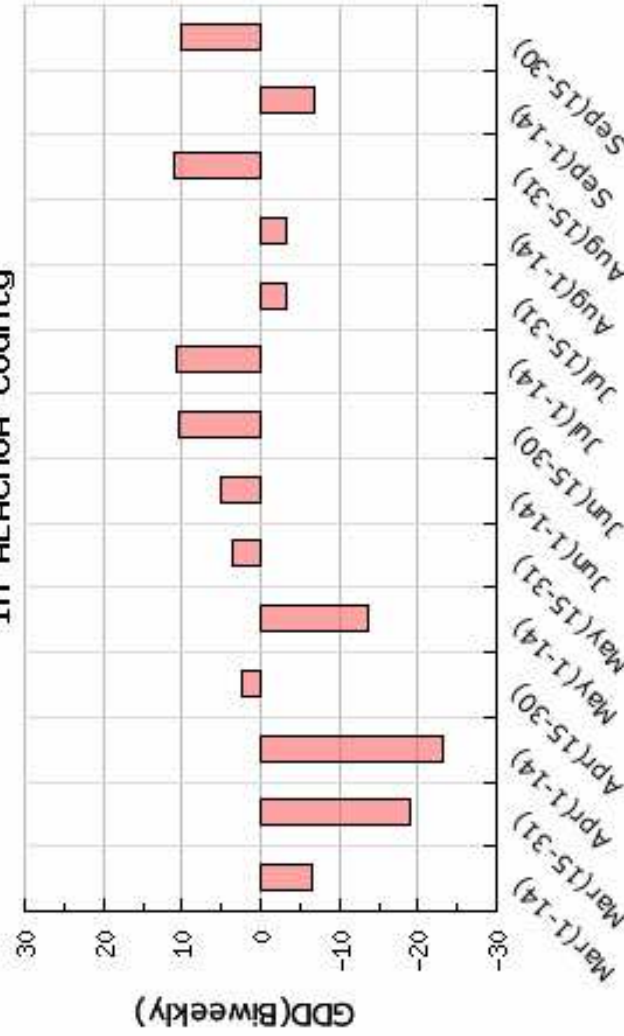
Last 5 Years

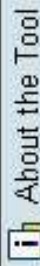
### Average and Deviation (from All Years).

	Mar		Apr		May		Jun		Jul		Aug		Sep	
	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31
<b>Avg.</b>	259.4	320.1	326.6	403.3	443.8	531.7	547	563.8	585.5	607.5	606.5	606.5	531.3	513.6
<b>Dev.</b>	-6.6	-19.1	-23.3	2.3	-13.6	3.7	5.1	10.3	10.6	-3.2	-3.3	11.1	-6.8	10

Statistics are calculated for ALACHUA county.

### Expected Difference due to Climate Phase in ALACHUA County





Crop

State

County

Starting Date

Neutral  
 El Nino  
 La Nina  
 All Years

Avg and Deviation

Probability Distribution

Probability of Exceedance

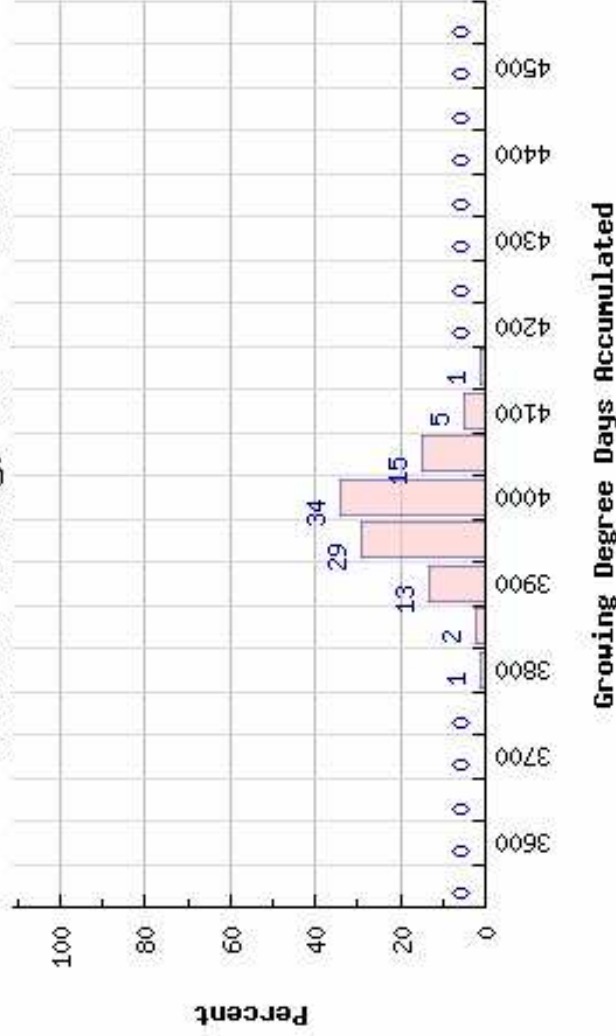
Last 5 Years

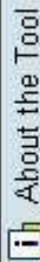
Probability of accumulated GDD for the selected starting date range.  
 Click columns to select end date.

	Mar	Apr	May	Jun	Jul	Aug	Sep
GDD	1-14	1-14	1-14	1-14	1-14	1-14	1-14
	15-31	15-30	15-31	15-30	15-31	15-31	15-30
50	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0

Statistics are calculated for ALACHUA county.  
 X-axis range varies to emphasize non-trivial values

Probability Of Growing Degree Days  
 ALACHUA County, Mar 1 - Jul 14





Crop

State

County

Starting Date

Neutral  
 El Nino  
 La Nina  
 All Years

Avg and Deviation

Probability Distribution

Probability of Exceedance

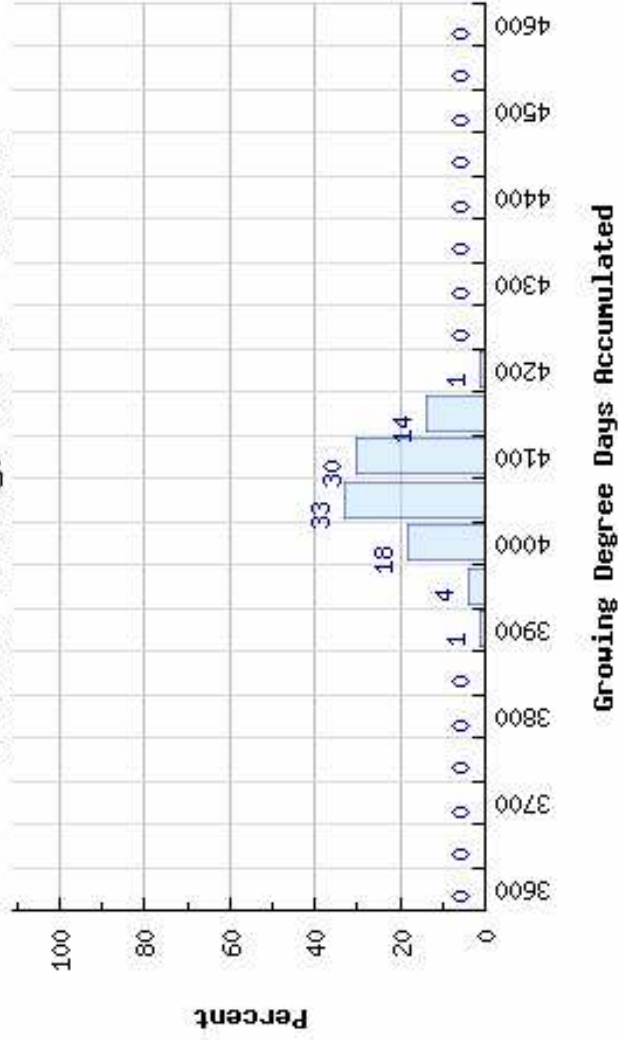
Last 5 Years

Probability of accumulated GDD for the selected starting date range.  
 Click columns to select end date.

	Mar	Apr	May	Jun	Jul	Aug	Sep
GDD	1-14	1-14	1-14	1-14	1-14	1-14	1-14
	15-31	15-30	15-31	15-30	15-31	15-31	15-30
50	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0

Statistics are calculated for ALACHUA county.  
 X-axis range varies to emphasize non-trivial values

Probability Of Growing Degree Days  
 ALACHUA County, Mar 1 - Jul 14





Crop:

State:

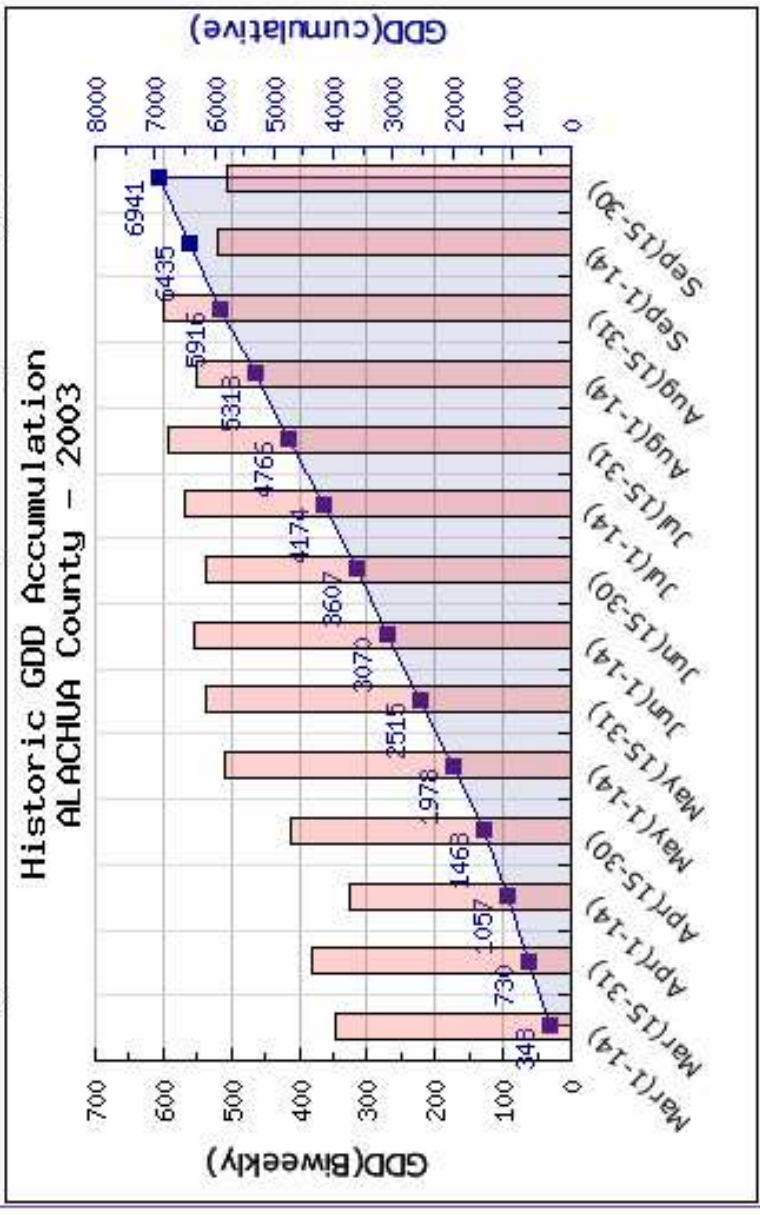
County:

Starting Date:

### Historic GDD accumulation: Last 5 Years in ALACHUA County

Years	Mar		Apr		May		Jun		Jul		Aug		Sep	
	1-14	15-31	1-14	15-30	1-14	15-31	1-14	15-30	1-14	15-31	1-14	15-31	1-14	15-30
2004	299.8	331.1	312.8	382.5	457.2	583.2	570.1	592.4	588	617.3	561.9	611	565.9	520.7
2003	347.7	381.5	327.1	411.1	510.4	536.7	555.3	536.8	567.2	592.4	551.7	598.3	519.2	505.6
2002	263.3	410.2	390.3	504.9	522.7	480.1	567.3	511.6	545.7	620.7	537.2	599.2	554.7	551.5
2001	293.4	268.8	416.1	326.6	415.3	543.4	564.2	538.4	582.1	601.8	561.9	617.5	522.8	450.1
2000	304	371.7	307.6	368.5	472.5	578.2	550.7	562.5	571.3	626.6	580	596.5	536.3	490.8

Color corresponds to ENSO phase at the starting date  
 Phase changes after that are not reflected by color changes in the graph.



About the Tool



Crop

State

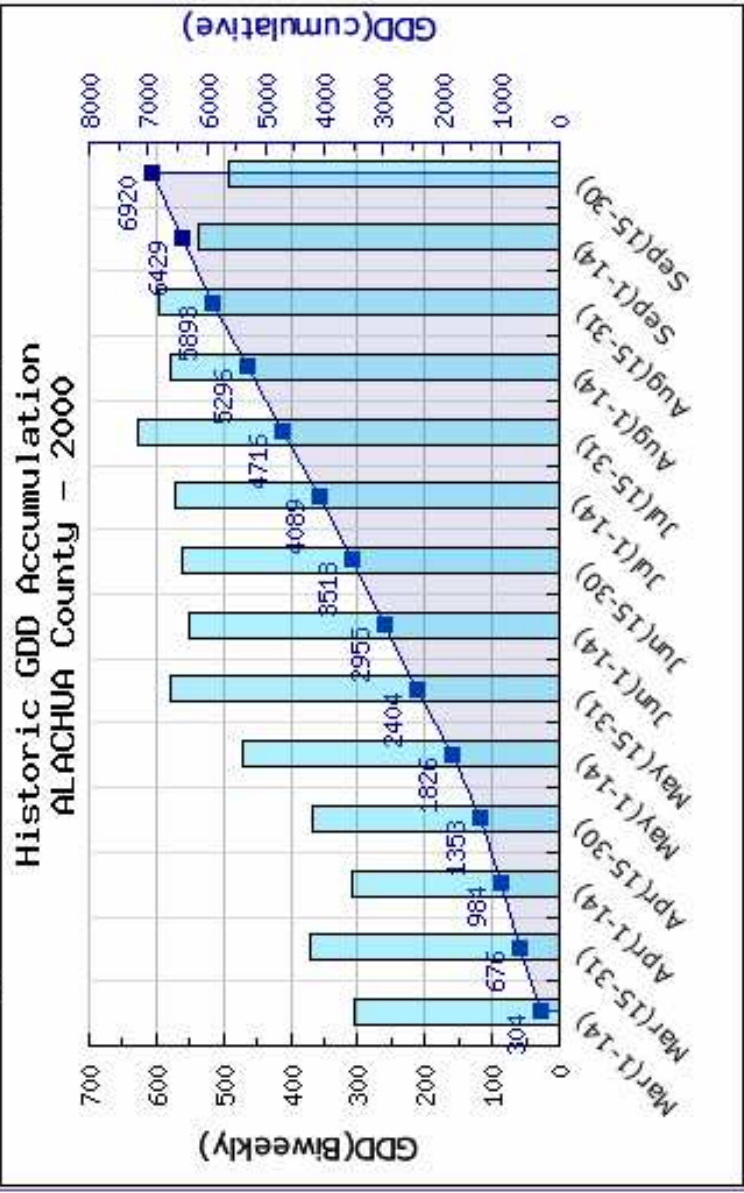
County

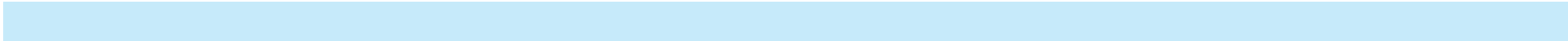
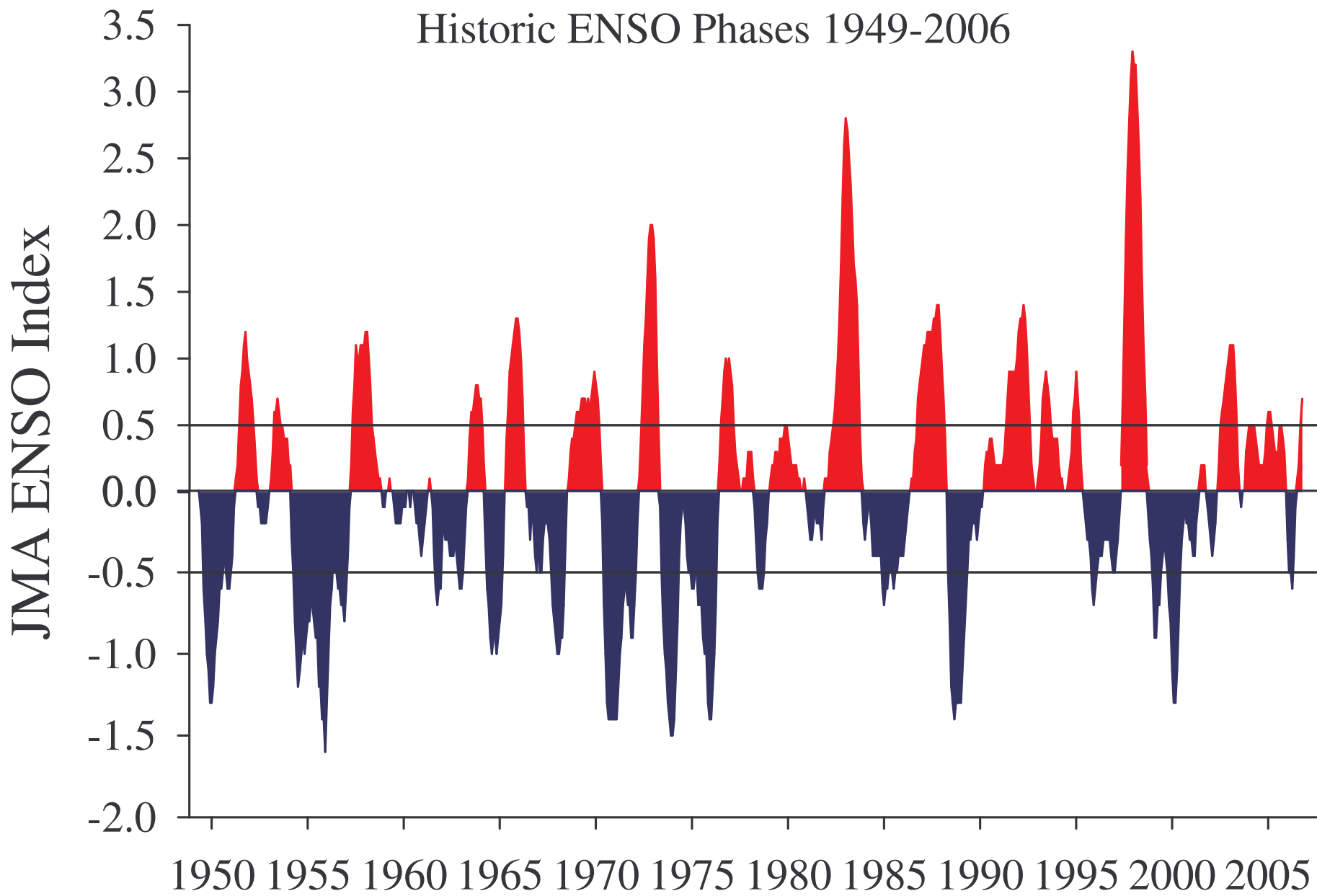
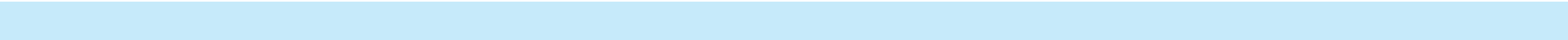
Starting Date

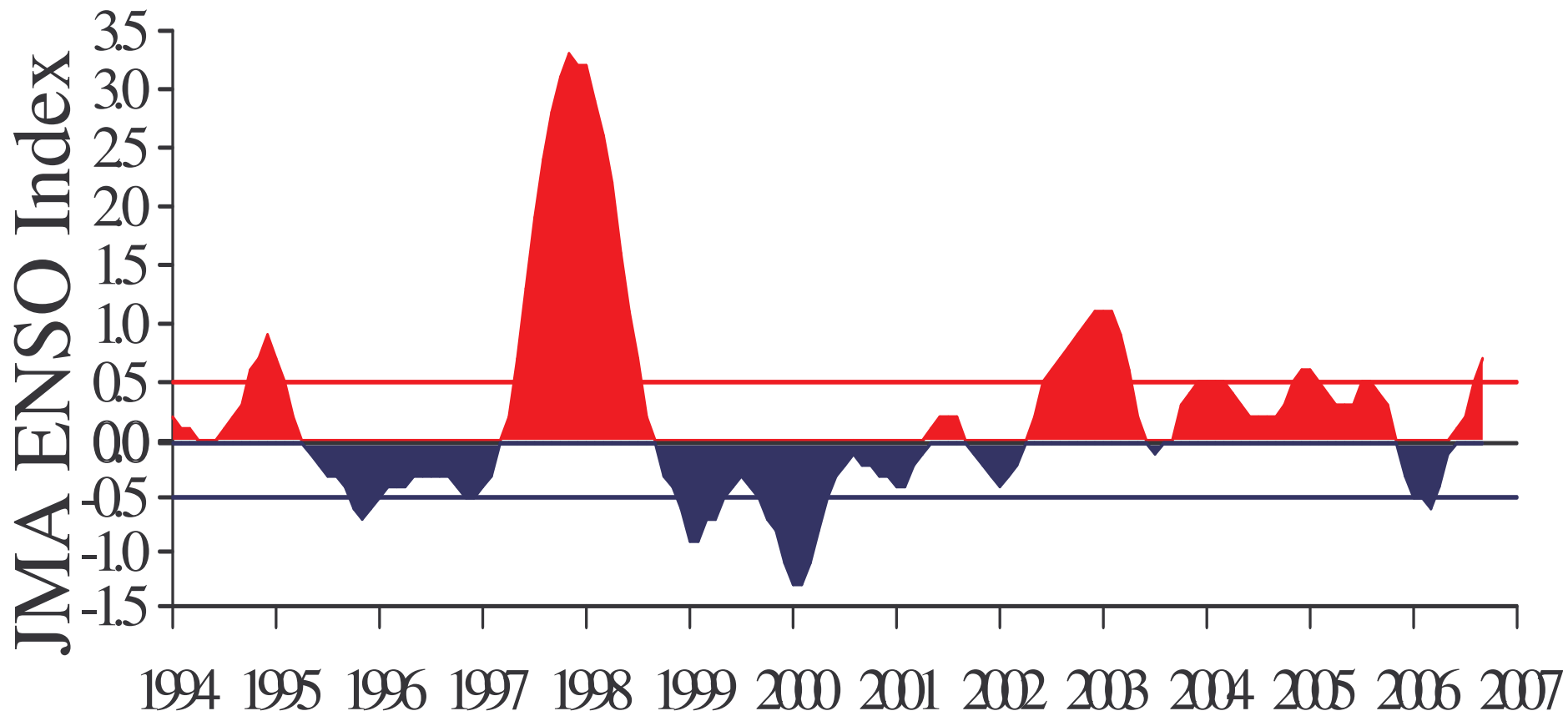
### Historic GDD accumulation: Last 5 Years in ALACHUA County

Years	Mar		Apr		May		Jun		Jul		Aug		Sep	
	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31	1-14	15-31
2004	299.8	331.1	312.8	382.5	457.2	583.2	570.1	592.4	588	617.3	561.9	611	565.9	520.7
2003	347.7	381.5	327.1	411.1	510.4	536.7	555.3	536.8	567.2	592.4	551.7	598.3	519.2	505.6
2002	263.3	410.2	390.3	504.9	522.7	480.1	567.3	511.6	545.7	620.7	537.2	599.2	554.7	551.5
2001	293.4	268.8	416.1	326.6	415.3	543.4	564.2	538.4	582.1	601.8	561.9	617.5	522.8	450.1
2000	304	371.7	307.6	368.5	472.5	578.2	550.7	562.5	571.3	626.6	580	596.5	536.3	490.8

Color corresponds to ENSO phase at the starting date  
 Phase changes after that are not reflected by color changes in the graph.







# Thermal Time for Agriculture

- ❖ Current : Yearly JMA ENSO (ENSO)

Alternate ENSO classification for months

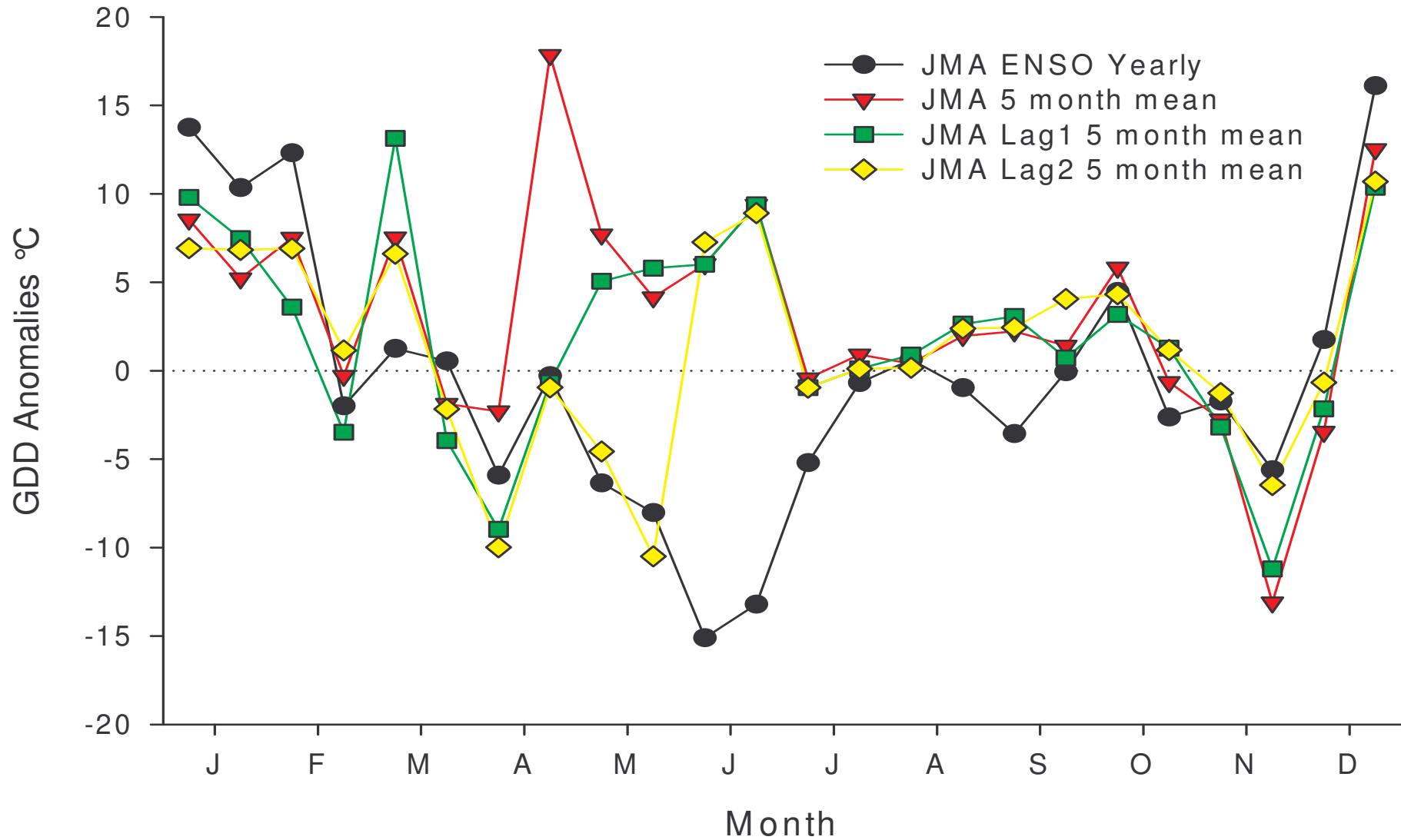
- ❖ Five month running mean of JMA (E5)

- ❖ One month Lag of Enso5 (Lag1)

- ❖ Two month Lag of Enso5 (Lag2)

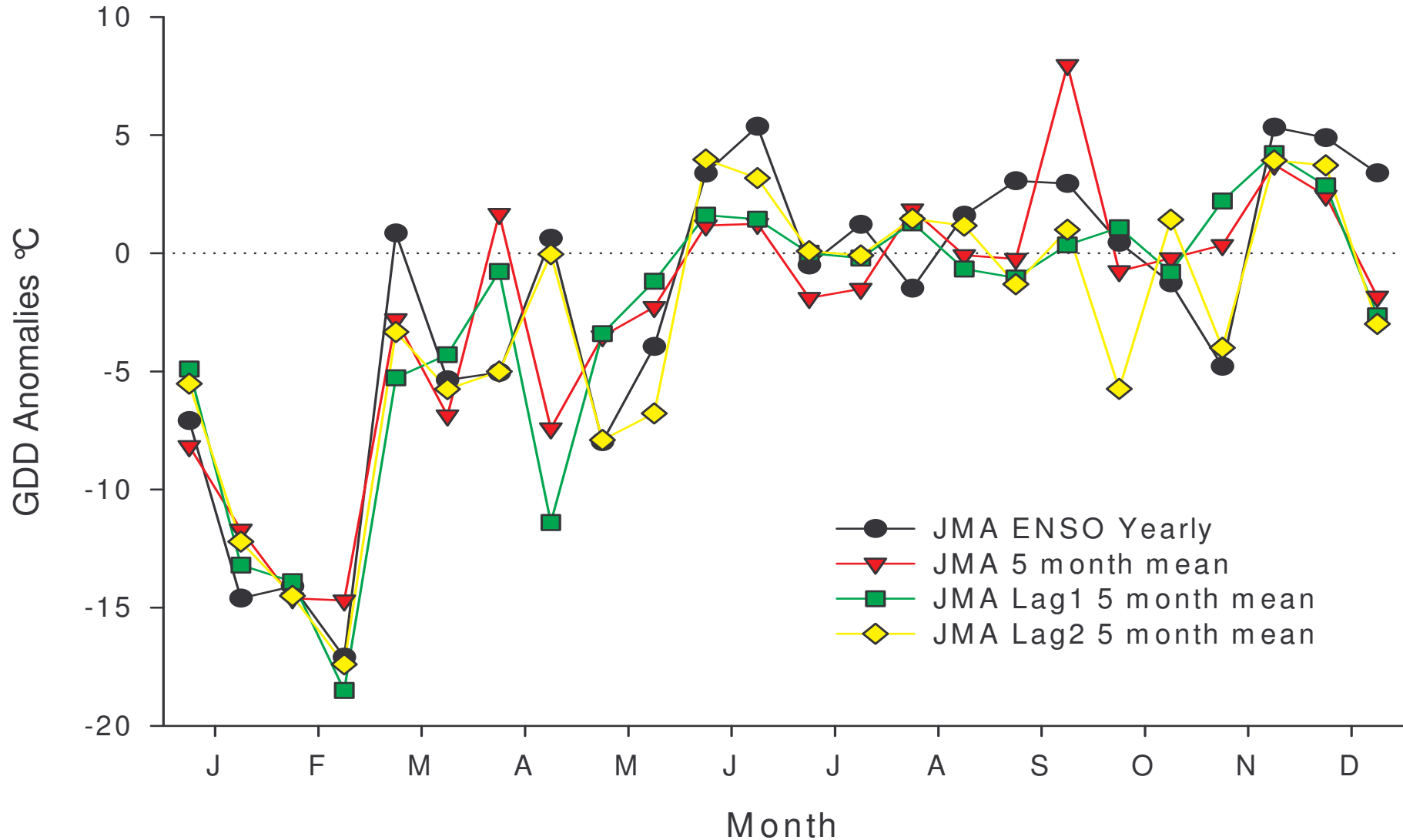
# Growing Degree Days 86-50

La Niña anomalies GDD8650



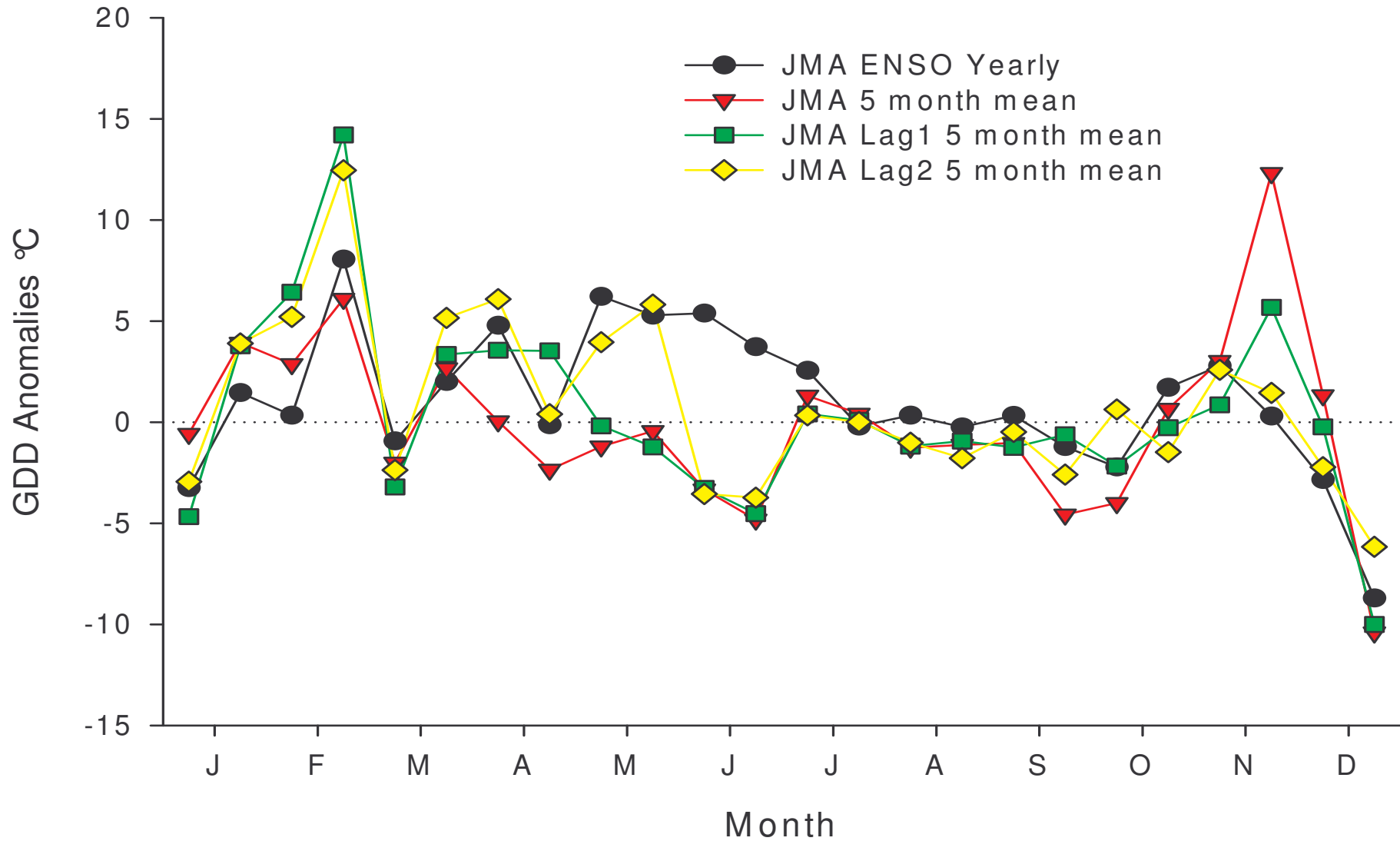
# Growing Degree Days 86-50

El Niño anomalies GDD8650



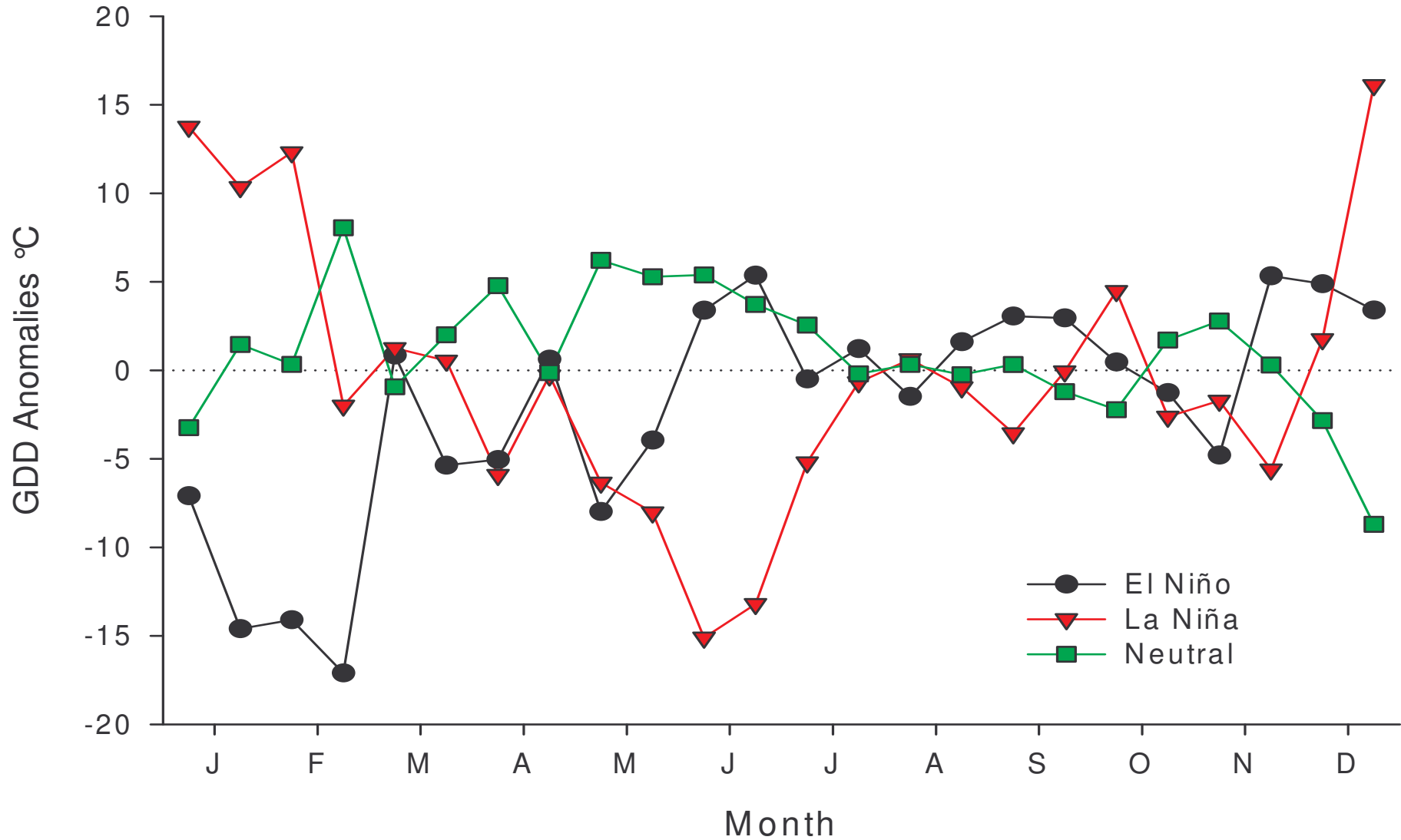
# Growing Degree Days 86-50

Neutral anomalies GDD8650



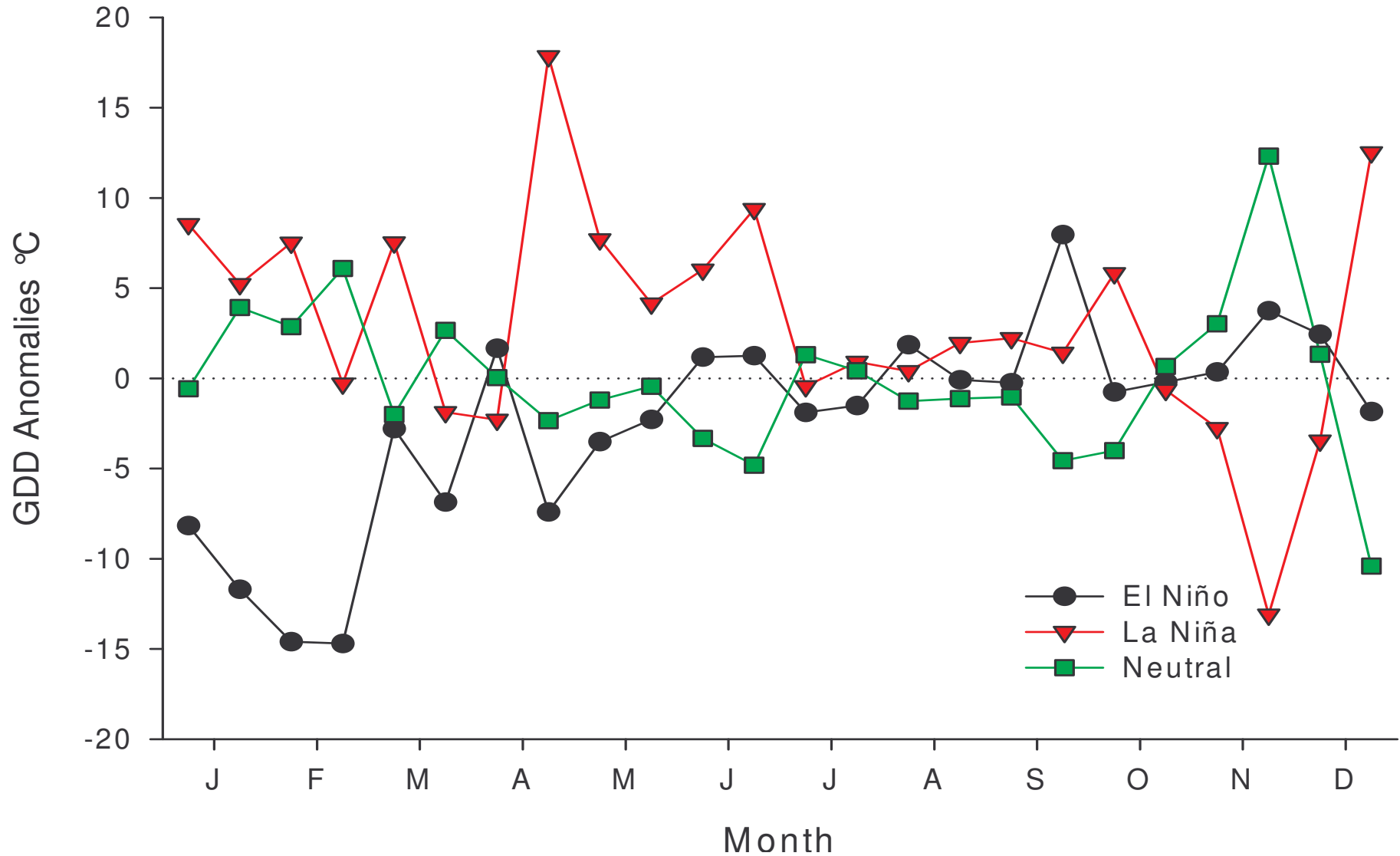
# Growing Degree Days 86-50

JMA ENSO anomalies GDD8650



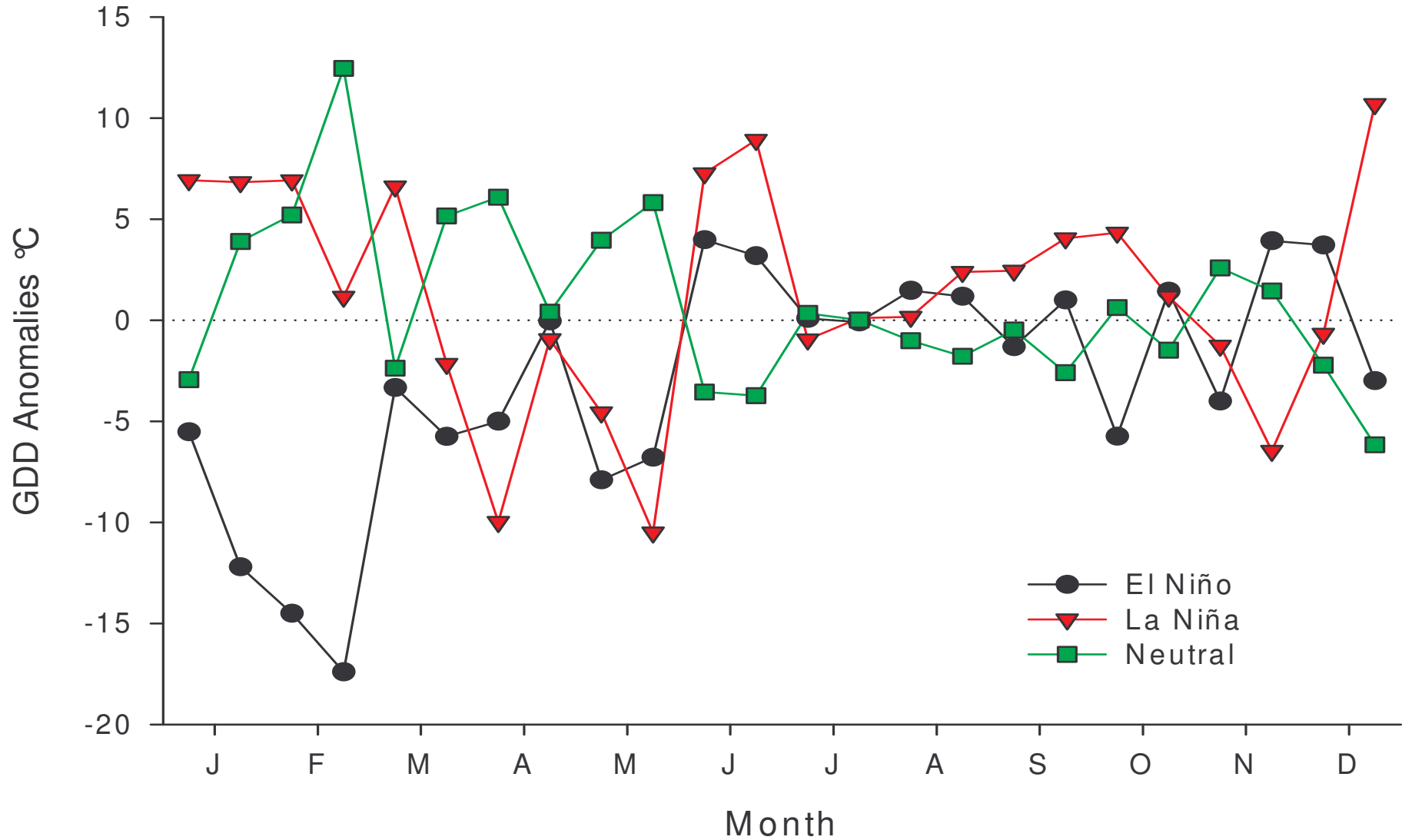
# Growing Degree Days 86-50

JMA E5 anomalies GDD8650



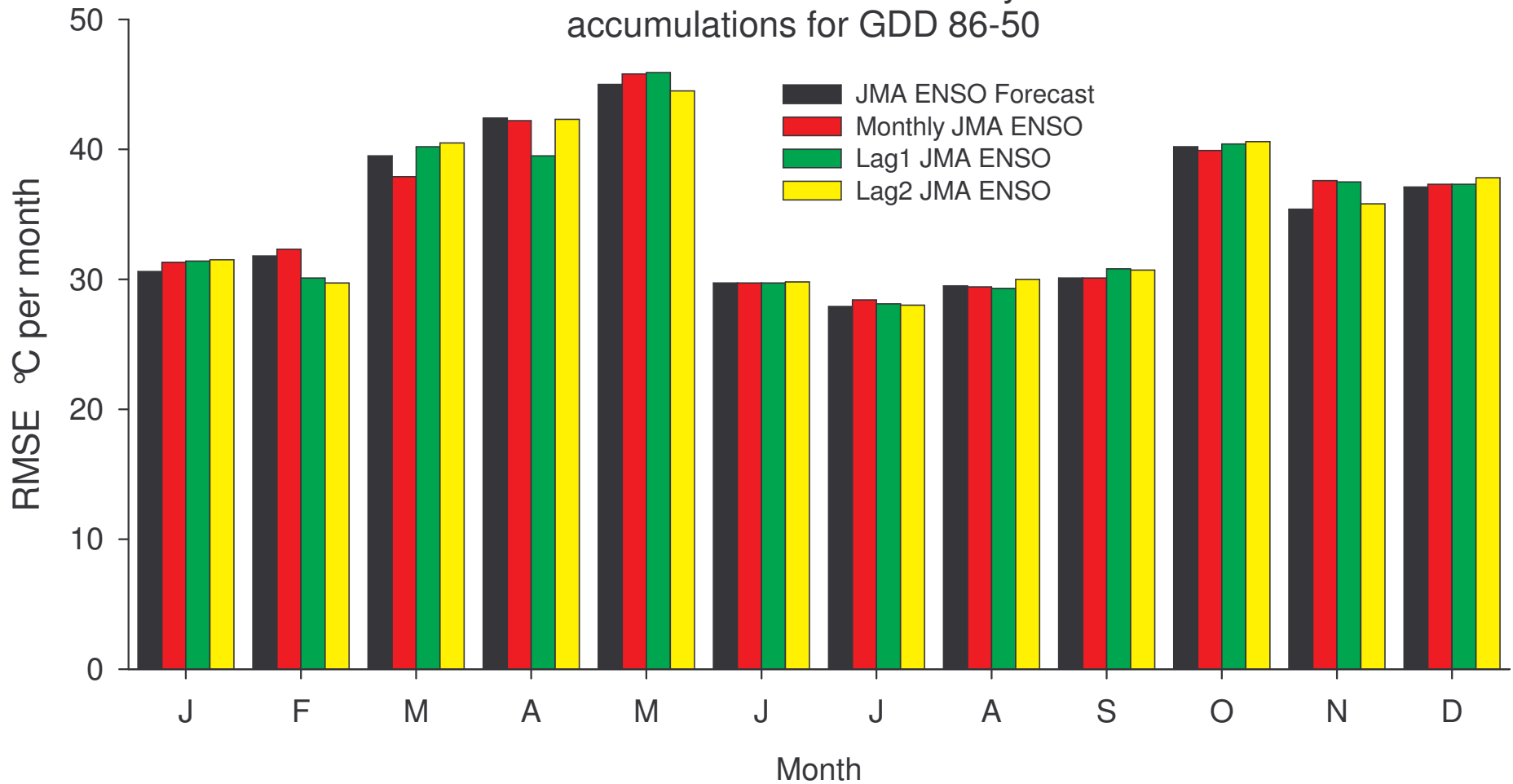
# Growing Degree Days 86-50

JMA Lag2 anomalies GDD8650



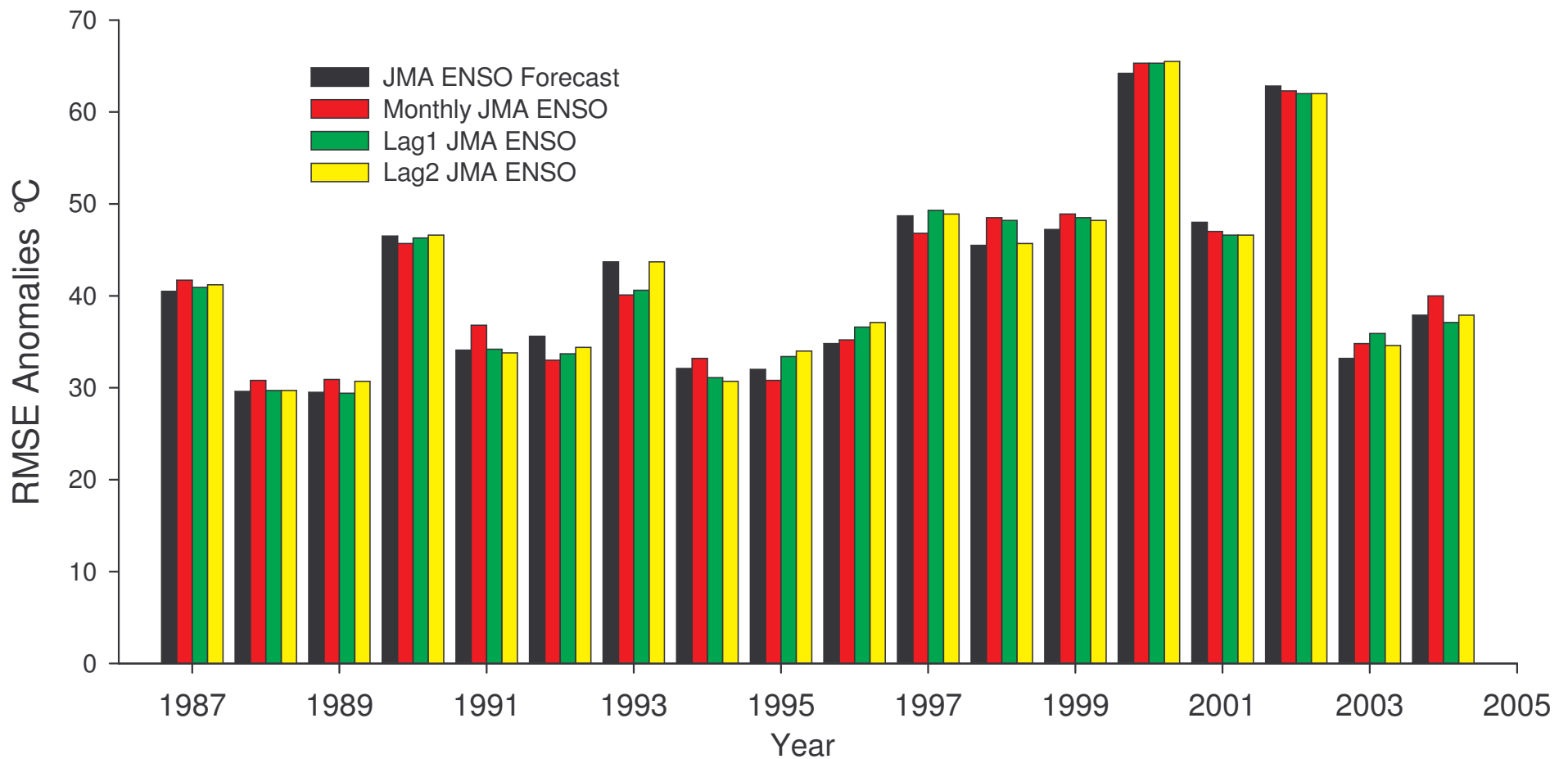
# Months: GDD 86-50

RMSE forecast errors for monthly GDD accumulations for GDD 86-50



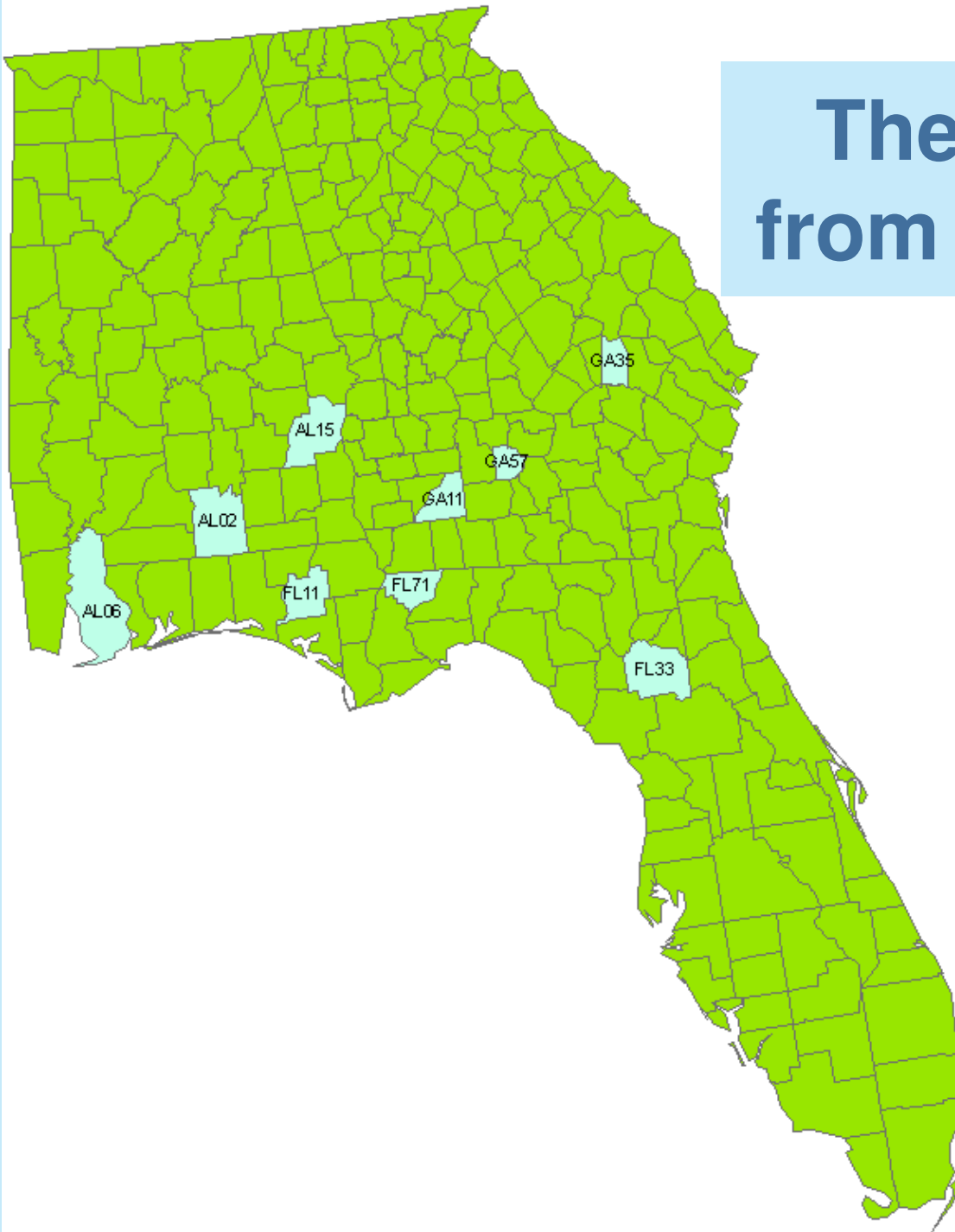
# Years: GDD for Maize

RMSE forecast errors for monthly GDD accumulations for Maize

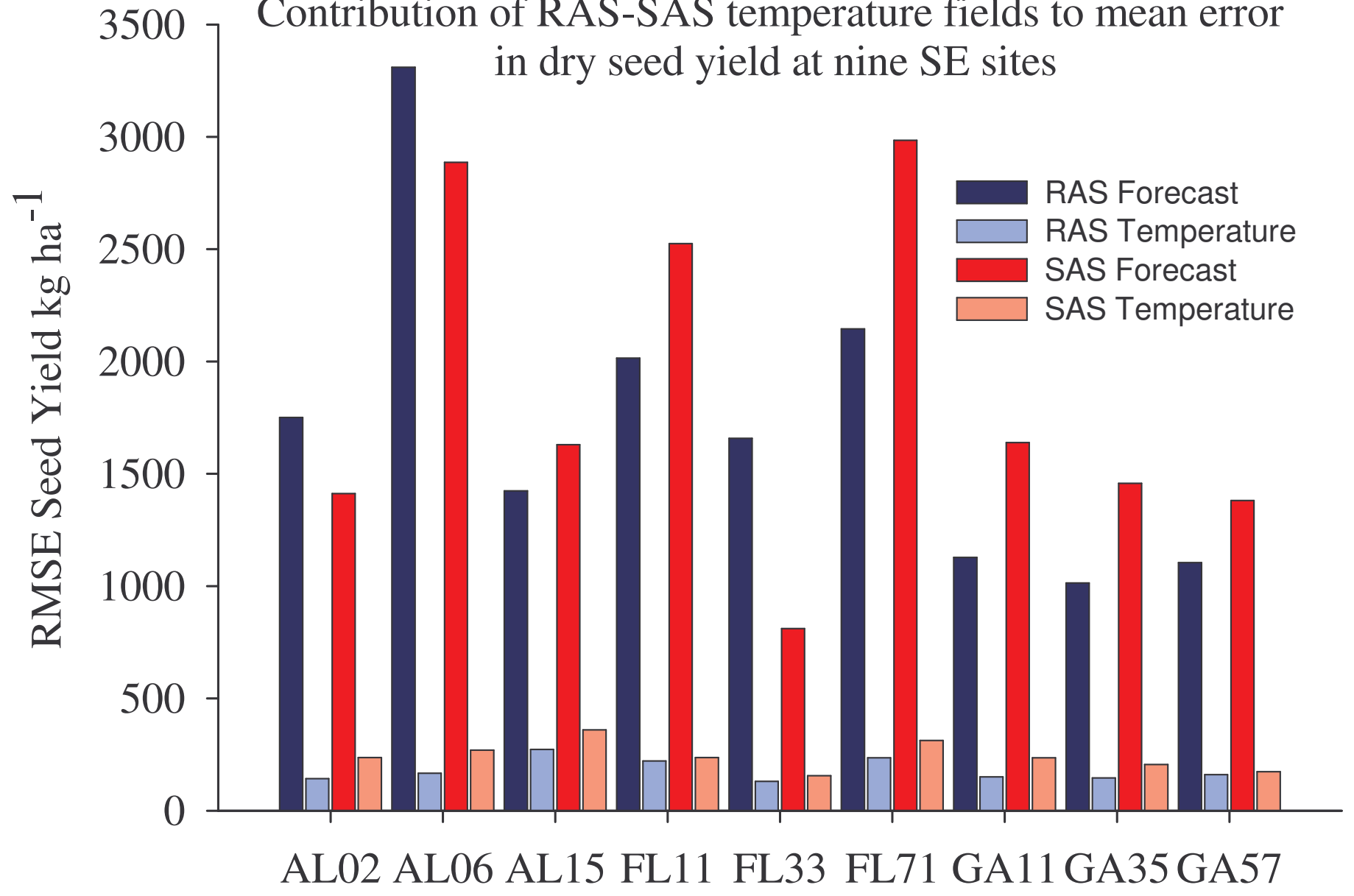


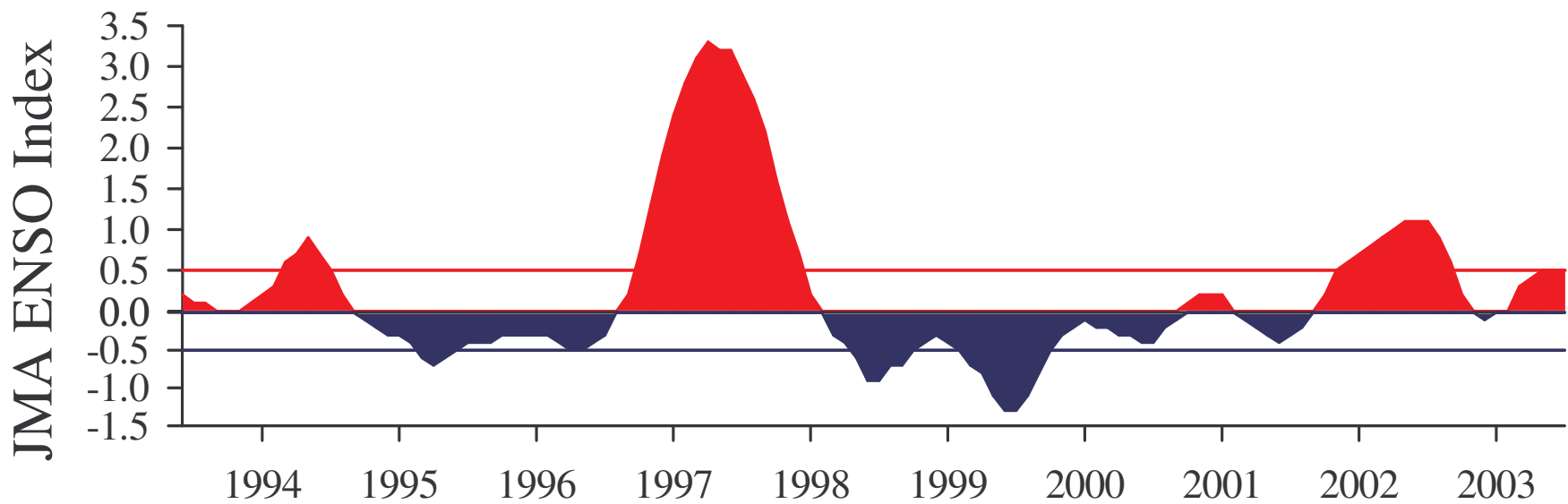
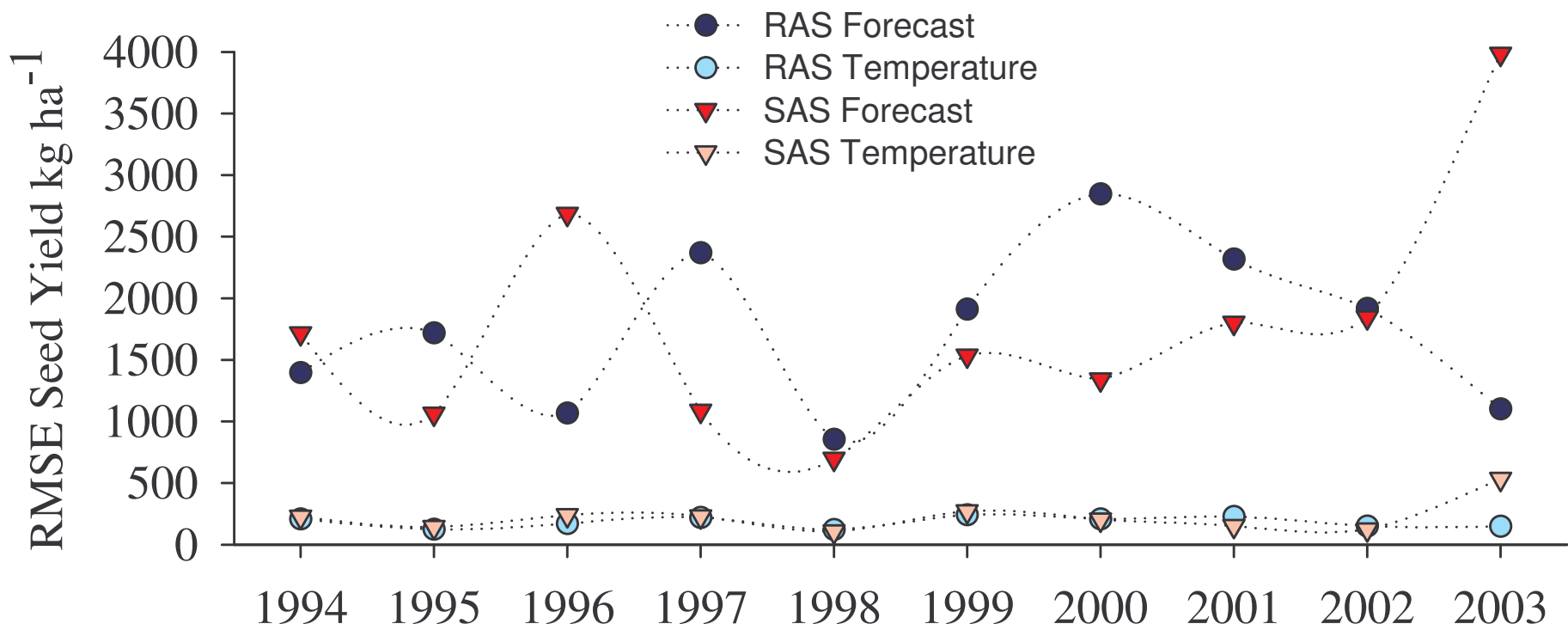
# Thermal time from RCM fields

- ❖ FSU Global Spectral Model
  - ❖ T63 – 200 km<sup>2</sup> or 1.8°
- ❖ FSU Regional Climate Model
  - ❖ 20 km grid
  
- ❖ Two convection schemes
- ❖ With Bias Correction



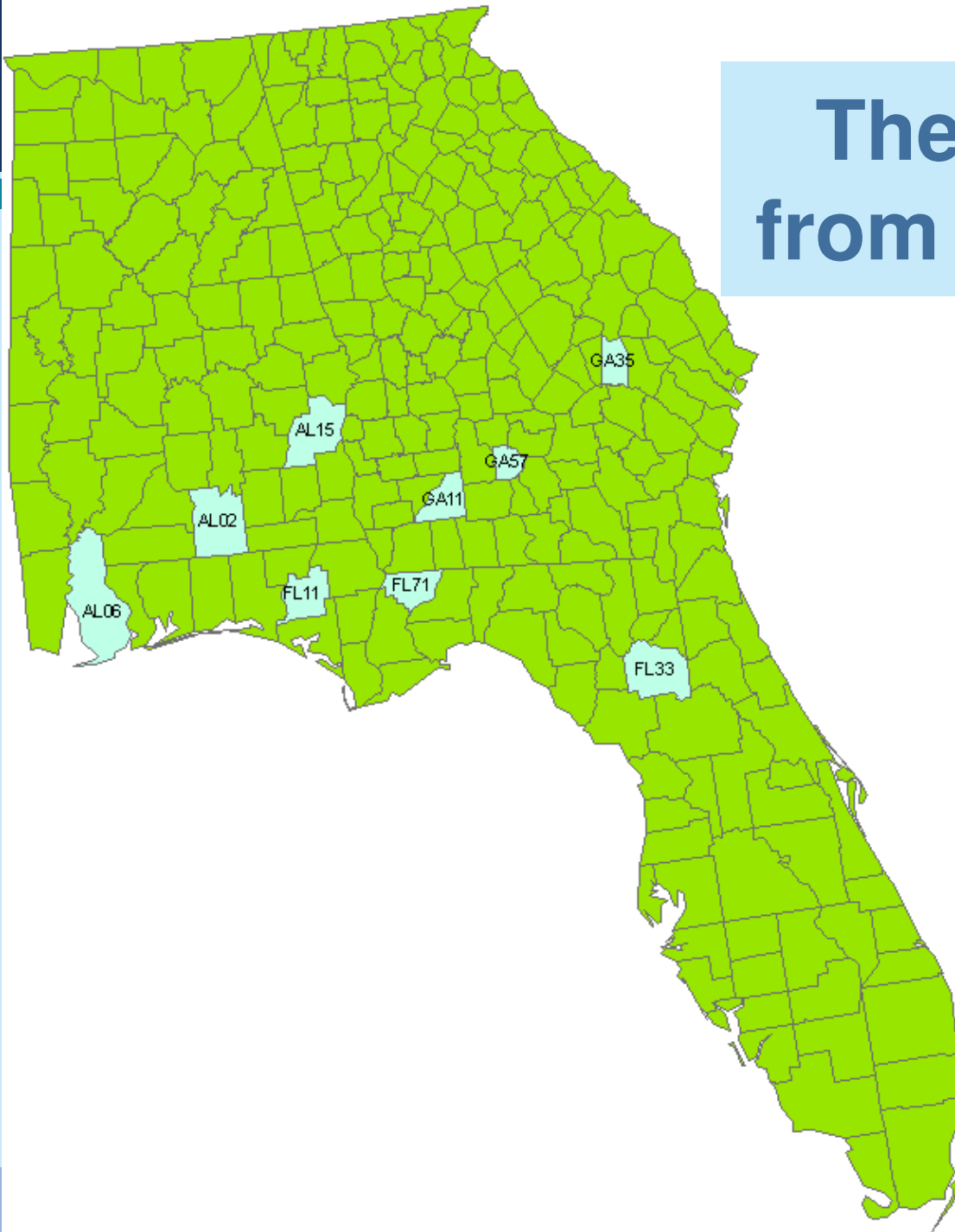
Contribution of RAS-SAS temperature fields to mean error in dry seed yield at nine SE sites



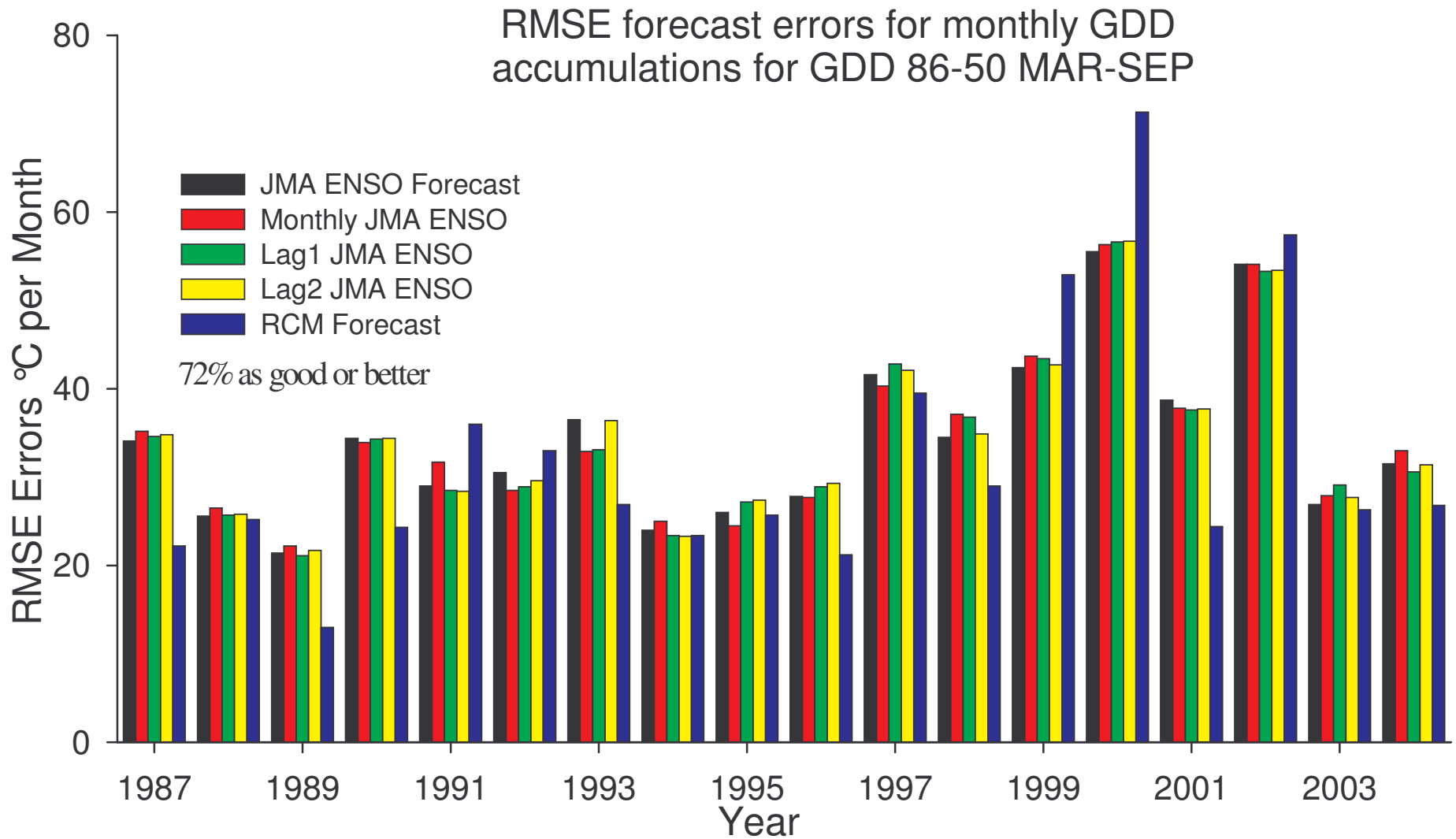


# Thermal time from RCM fields

- ❖ Hindcast data from 20 ensemble members
- ❖ 1987-2004
- ❖ Daily Tmax, Tmin
- ❖ 1 Mar – 30 Sep
  
- ❖ Hourly T estimation
- ❖ Daily thermal time estimates
- ❖ Bi-weekly & Monthly accumulations

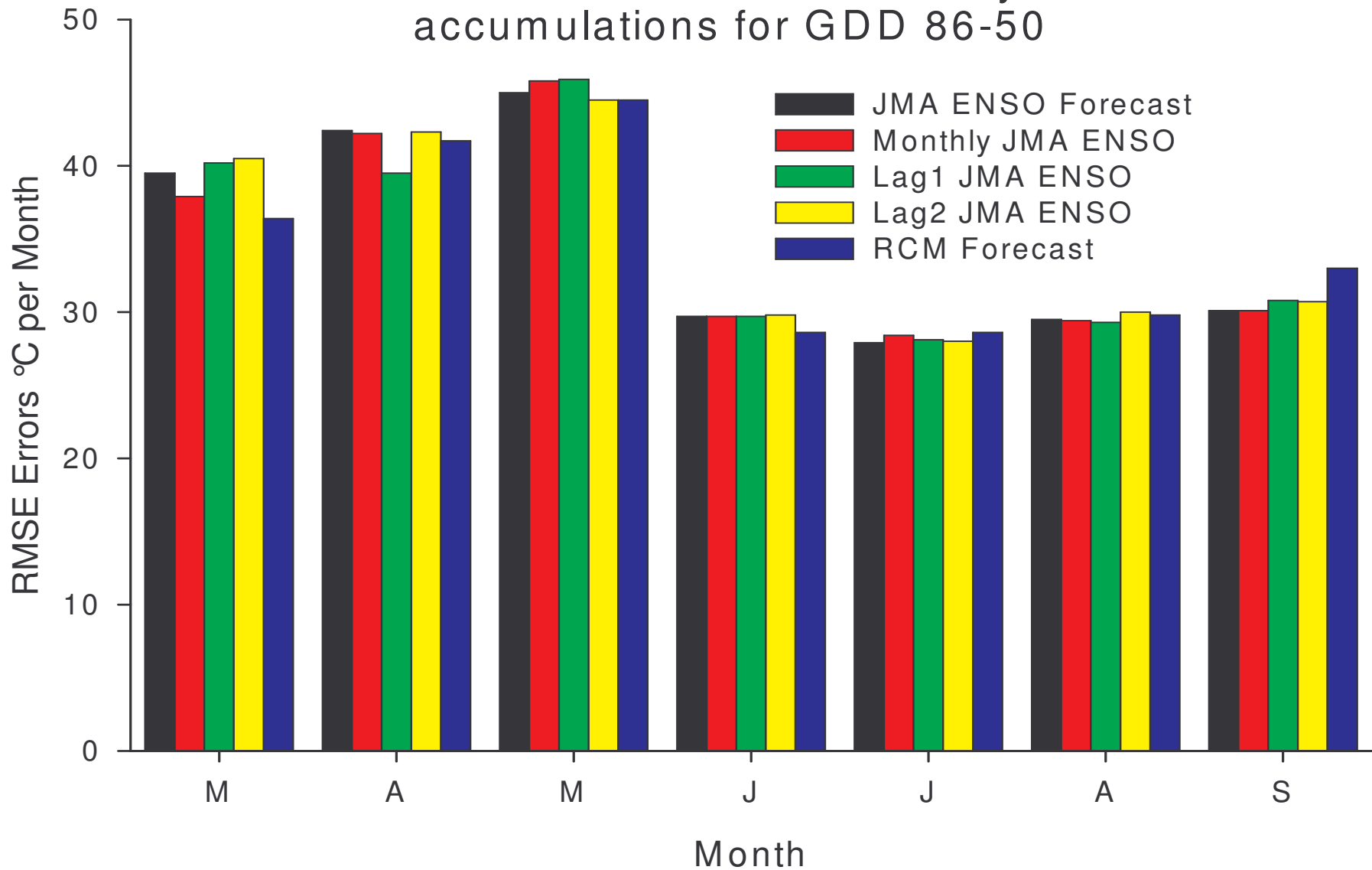


# FSU RCM model hindcast

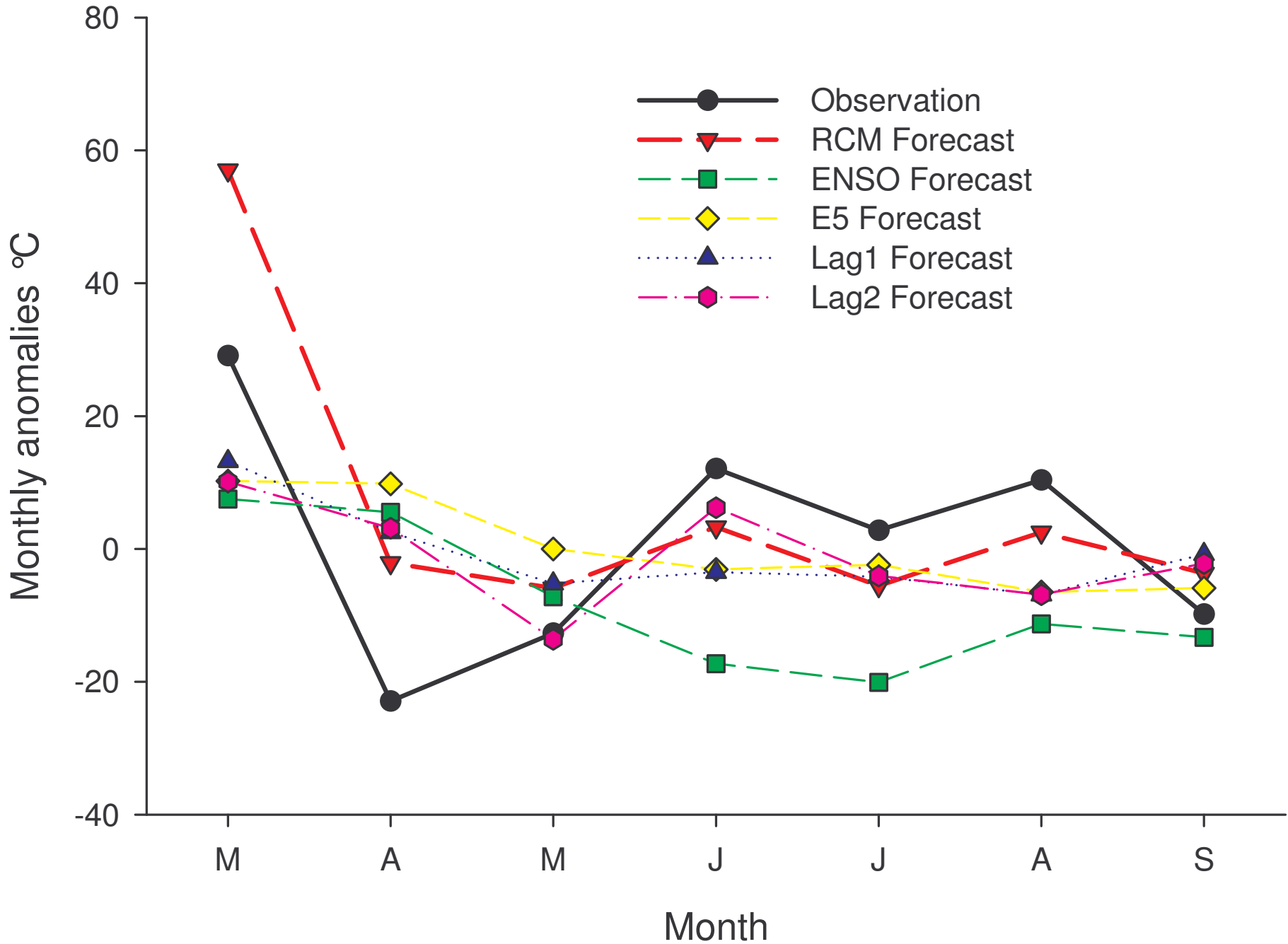


# FSU RCM model hindcast

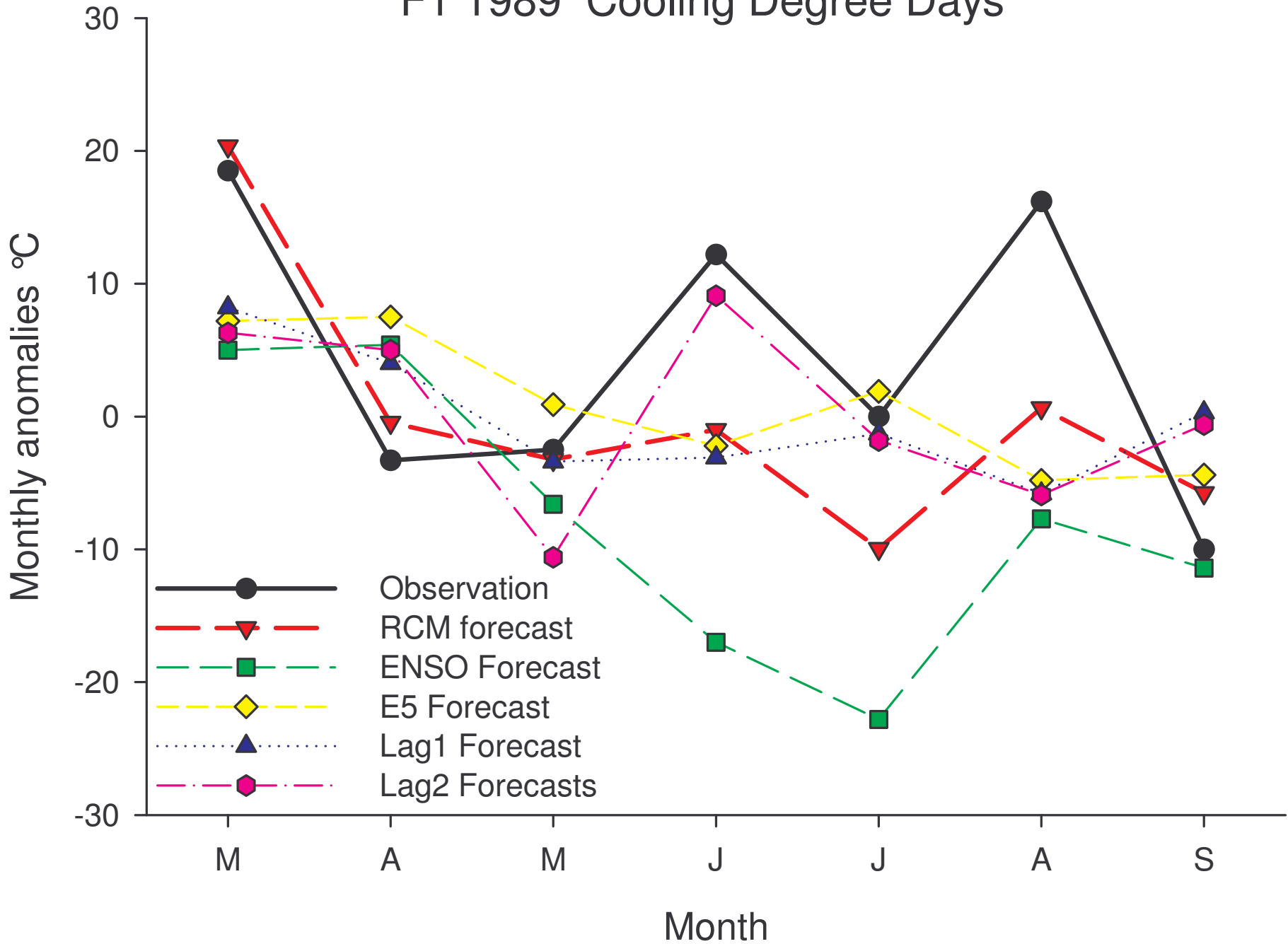
RMSE forecast errors for monthly GDD accumulations for GDD 86-50



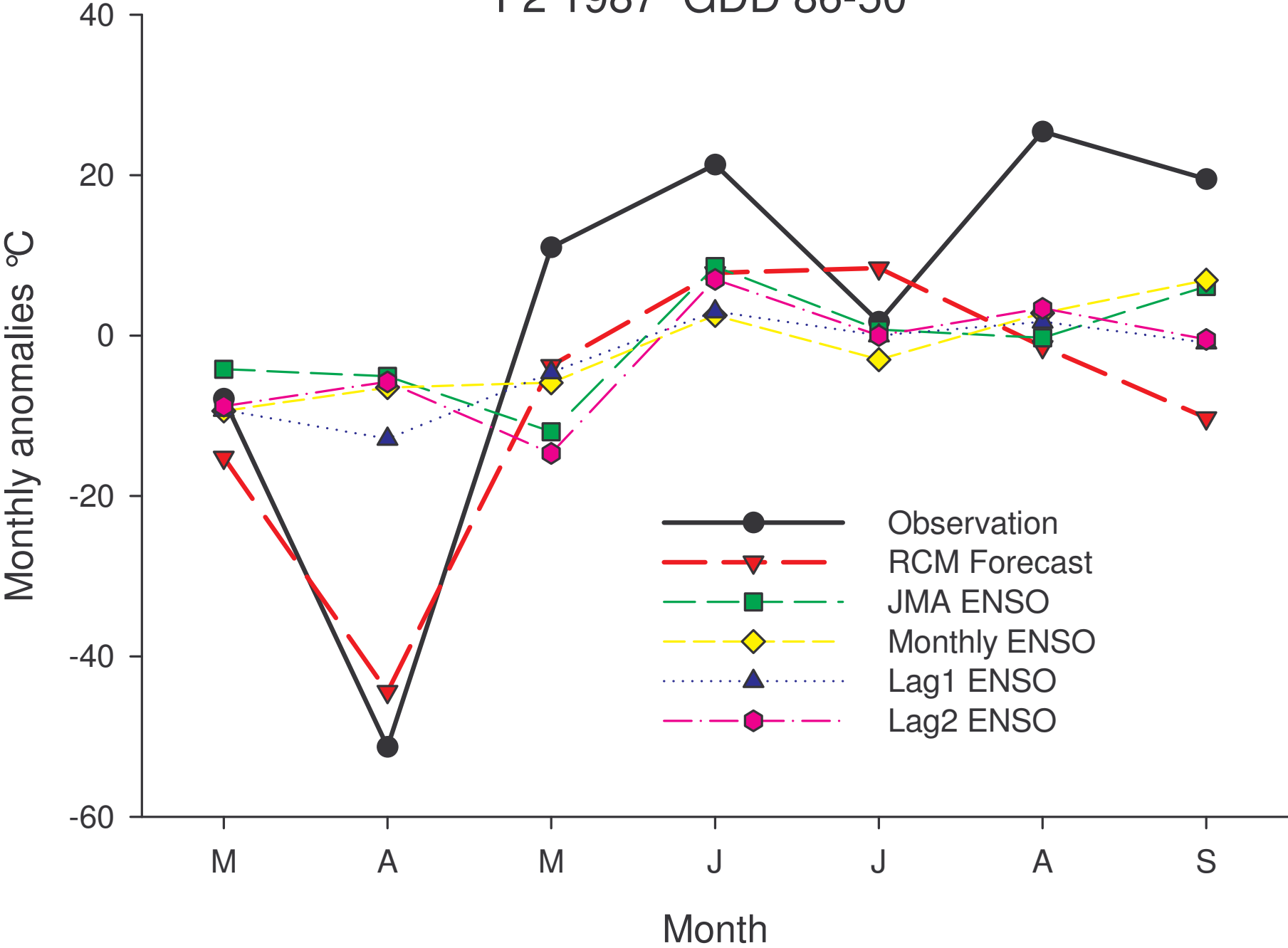
# F1 1989 Growing Degree Days 86-50



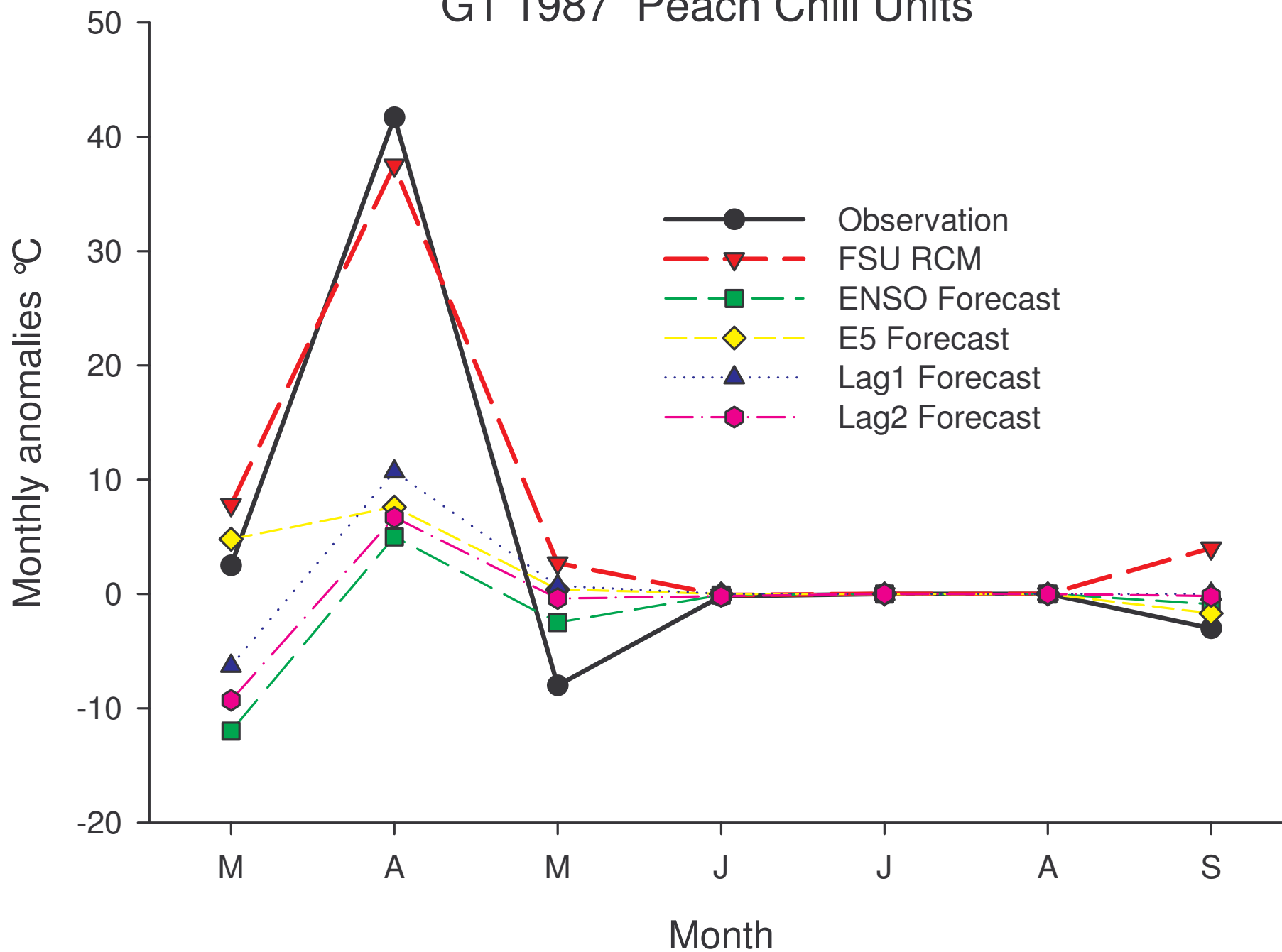
# F1 1989 Cooling Degree Days



# F2 1987 GDD 86-50



# G1 1987 Peach Chill Units



# Conclusions

- ❖ Yearly ENSO-based tool provides a probabilistic forecast that can be accessed and used by stakeholders
- ❖ Alternate forecast techniques based on ENSO classification are not clearly superior but certainly no worse
- ❖ Alternate methods provide different view of late spring and early fall ENSO signals
- ❖ Currently more questions than answers
- ❖ FSU RCM predicts monthly thermal time accumulations with less error than ENSO classifications during the warm season particularly under JMA ENSO neutral events

# Future Directions

- ❖ When to employ alternate ENSO class.?
- ❖ Cool season performance of FSU RCM?
- ❖ How best to apply multi-ensemble info?
- ❖ Performance evaluation through specific cropping seasons
- ❖ Translation of applications to other regions with strong ENSO signals