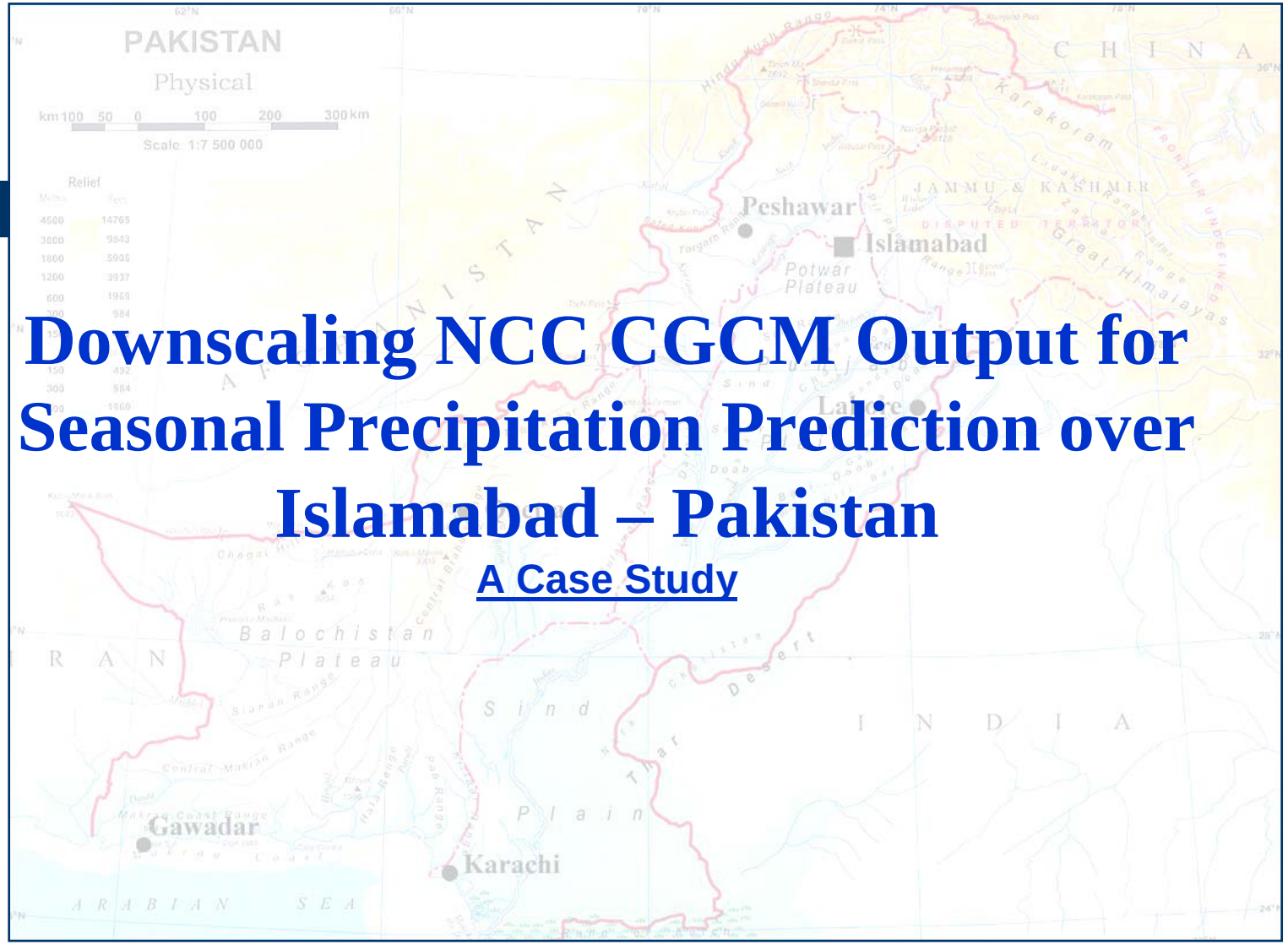
# DOWNSCALLING General Circulation Models' output

**By**

**Muhammad Afzaal Karori**
**Muhammad Hasan Ali Baig**

**Research & Development Division,**
**Pakistan Meteorological Department,**
**P.O Box 1214, Sector H – 8/2, Islamabad – Pakistan**
**afzaalkarori@yahoo.com**




# Downscaling NCC CGCM Output for Seasonal Precipitation Prediction over Islamabad – Pakistan

## A Case Study

## Data used

**Observational seasonal precipitation data of summer (JJA) of Islamabad from 1983 – 2005.**

**Dataset provided by Pakistan Meteorological Department.**

## Large Scale Climate Variables

1. **Global Atmosphere-Ocean Coupled Model (CGCM)**
2. **NCEP Reanalysis data provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA.**

# The Global Coupled Ocean-Atmosphere Model (CGCM)

- ✓ **AGCM named T63L16 AGCM_1.0 which was developed for operational use in National Meteorological Center of China Meteorological Administration (NMC/CMA), Horizontal Resolution 1.875°×1.875°.**

- ✓ **OGCM named GT63L30 OGCM_1.0 which was developed by the State Key Laboratory of Numerical Modeling for Atmospheric Science and Geophysical Fluid Dynamics (LASG) of the IAP/CAS on the basis of the original LASG OGCM, 20 levels in vertical direction, horizontal resolution 4°×5°.**

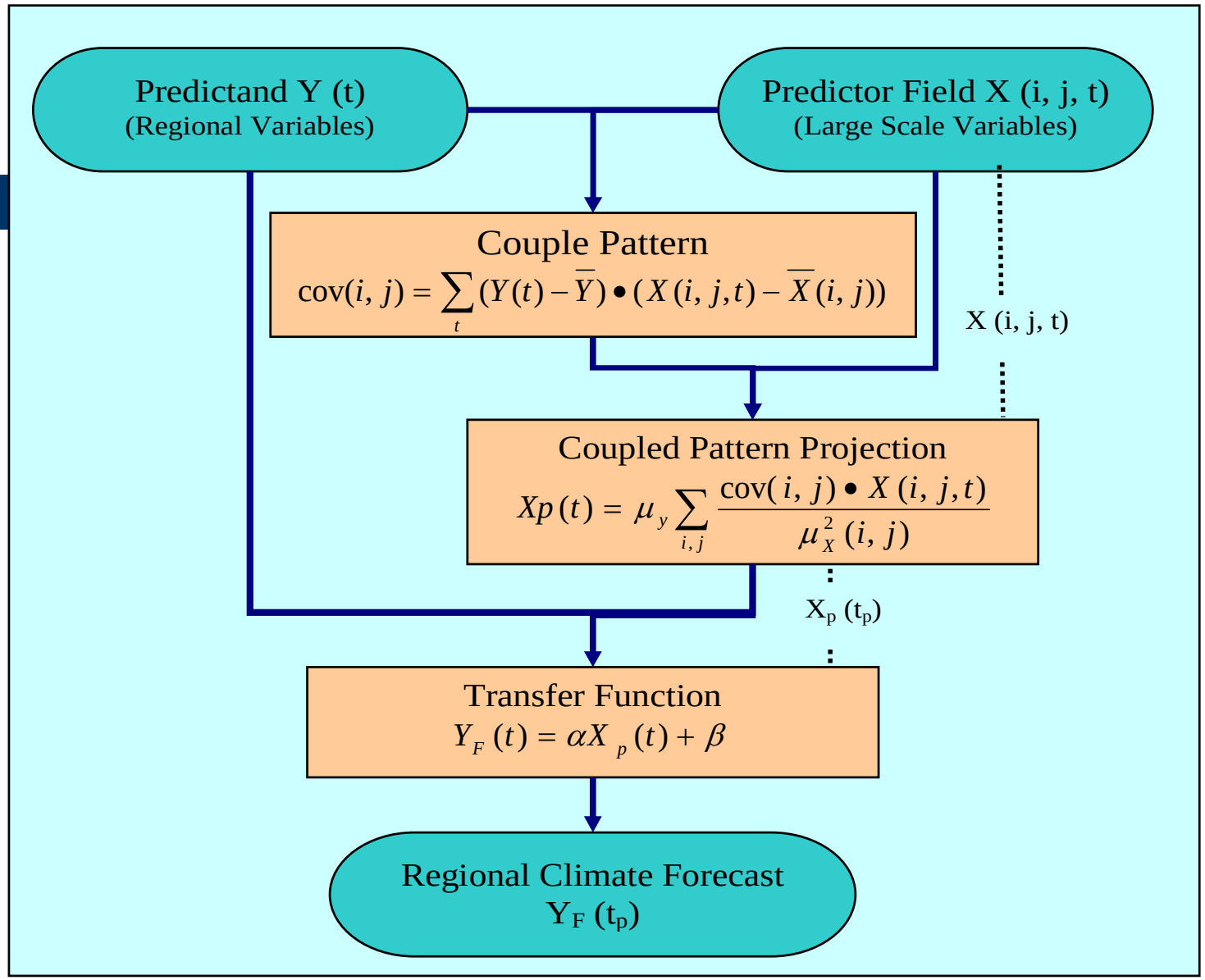
- ✓ **These are coupled through the coupling scheme of the Daily Flux Anomaly on the open sea surface. This model contains large scale variables like SLP, SST, Precipitation and Temperatures at 2M at the resolution 1.875°×1.875°, and H500, H200, T850, U200, V200, U850, V850 at the resolution 2.5°×2.5°.**

# Statistical Model

**Two statistical downscaling models are used for seasonal precipitation prediction:**

1. **Coupled Pattern Projection Model (CPPM)**
2. **Multiple Linear Regression Model (MLRM)**

**CPPM; coupled patterns are achieved from the covariance between each predictor and predictand and projected onto the predictor field and then the value of predictand on local scale using single variable predictor, is calculated**


Predictand Y (t)
(Regional Variables)
Predictor Field X (i, j, t)
(Large Scale Variables)
Couple Pattern
$\mathrm{cov}(i,j) = \sum_t (Y(t) - \overline{Y}) \bullet (X(i,j,t) - \overline{X}(i,j))$
X (i, j, t)
Coupled Pattern Projection
$Xp(t) = \mu_y \sum_{i,j} \frac{\mathrm{cov}(i,j) \bullet X(i,j,t)}{\mu_X^2(i,j)}$
$X_p$ ($t_p$)
Transfer Function
$Y_F(t) = \alpha X_p(t) + \beta$
Regional Climate Forecast
$Y_F$ ($t_p$)

## Statistical Model

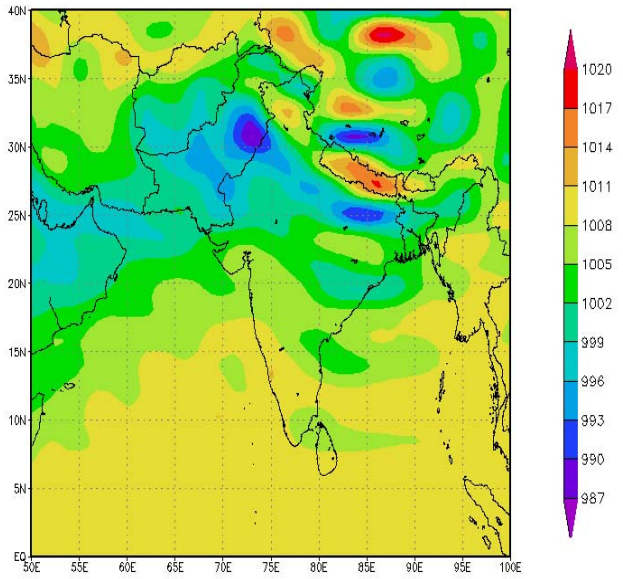
MLRM; More than one predictors are used to have predicted time series

$$Y_F(t) = \mu_y \left[ \alpha_o + \sum_{i=1}^{N} \alpha_i \frac{X_i(t) - \overline{X_i}}{\alpha_{Xi}} \right]$$

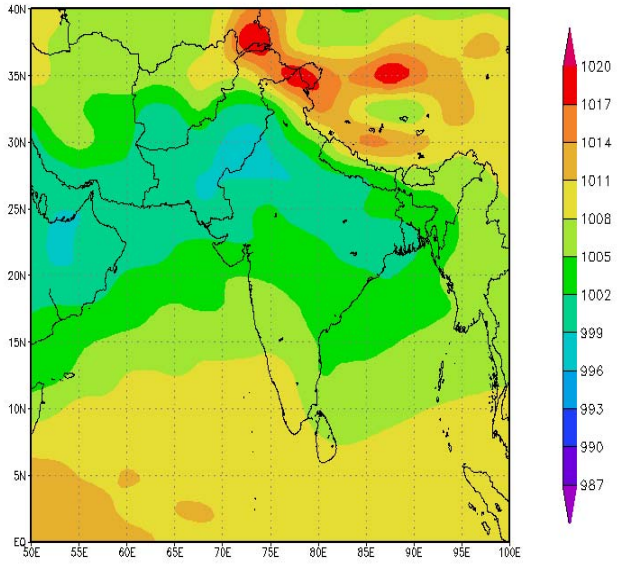
where, $Y_F$ (t) is time series of predictand, $\mu_y$ is standard deviation of predictand, $\alpha_o$ is the regression sum of squares, N is total number of independent large scale variables, $\alpha_i$ is the regression coefficient of ith variable, Xi is the projected time series which is obtained in CPPM. Numerator term is variance of projected time series of ith variable which is divided by the standard deviation of the same variable.

# Average (JJA) Sea – Level Pressure

- NCC CGCM

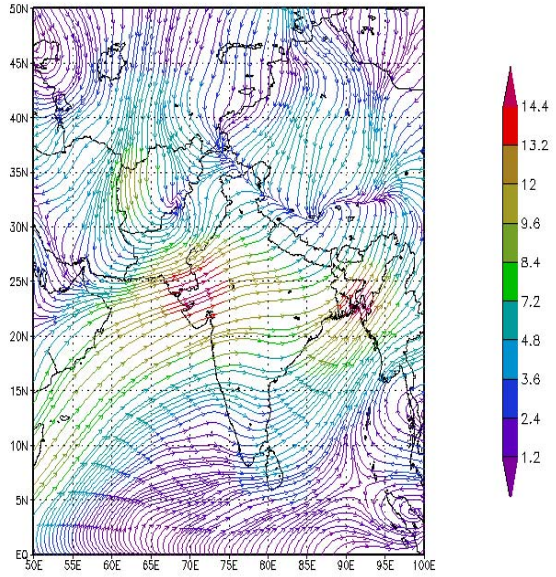



- NCEP Reanalysis

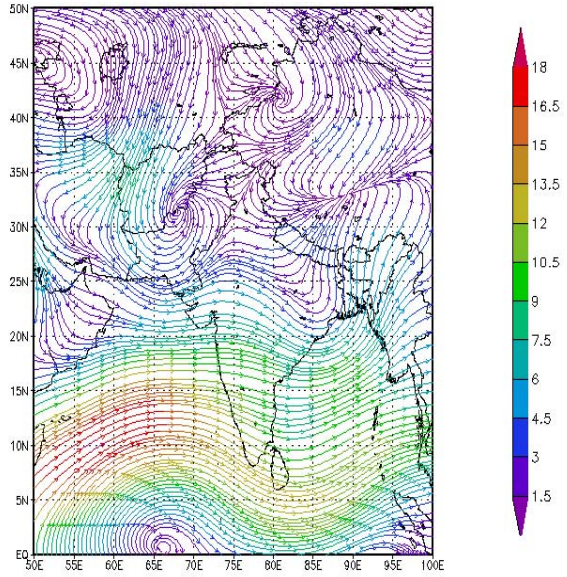


# Average (JJA) Stream Flow at 850hPa Level

- NCC CGCM

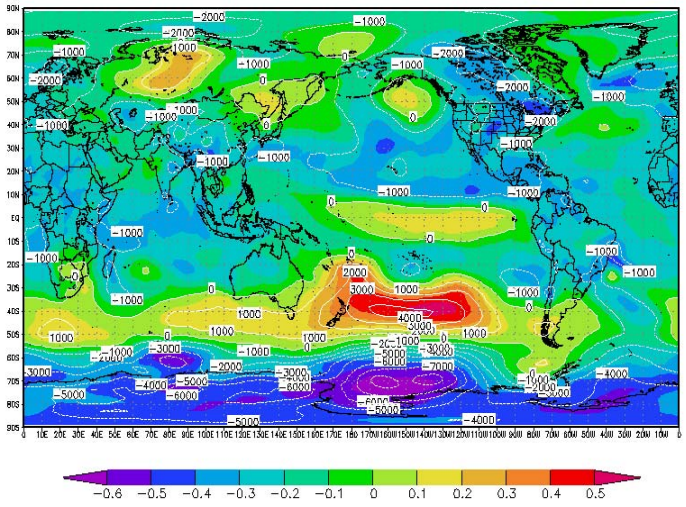



- NCEP Reanalysis

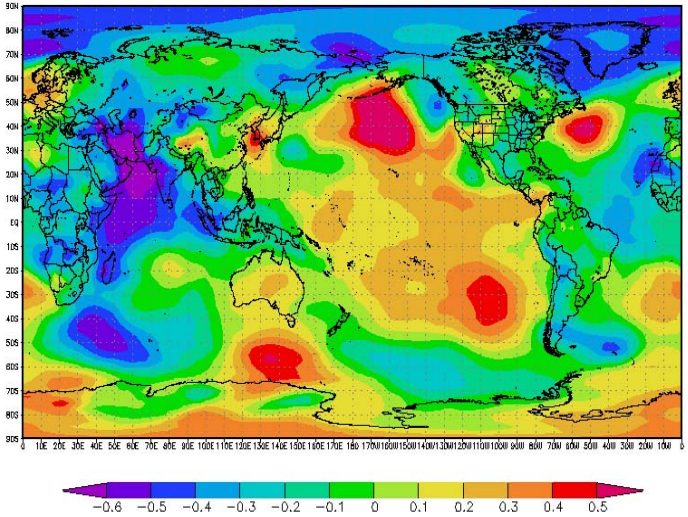


# Correlation Patterns of SLP

- NCC CGCM

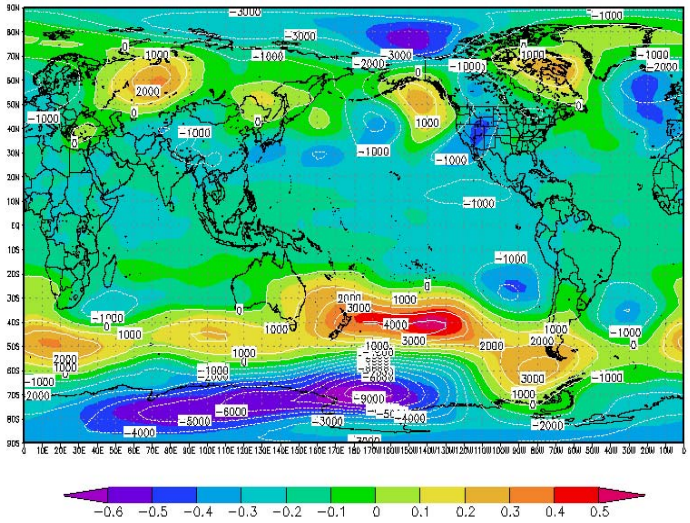



- NCEP Reanalysis

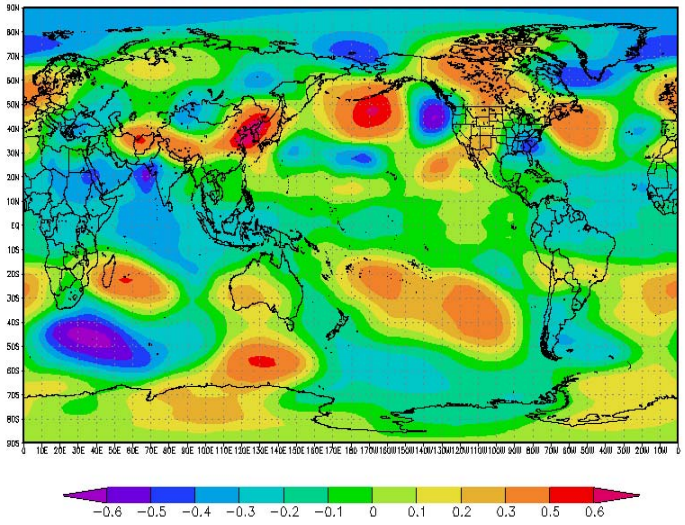


# Correlation Patterns of H500

- NCC CGCM

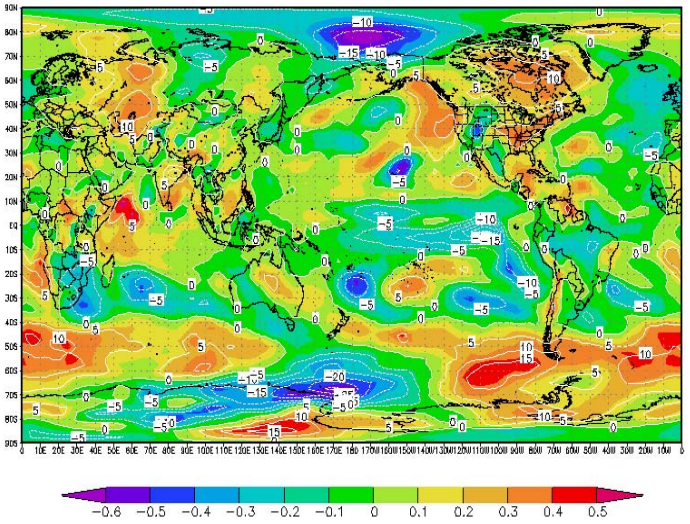



- NCEP Reanalysis

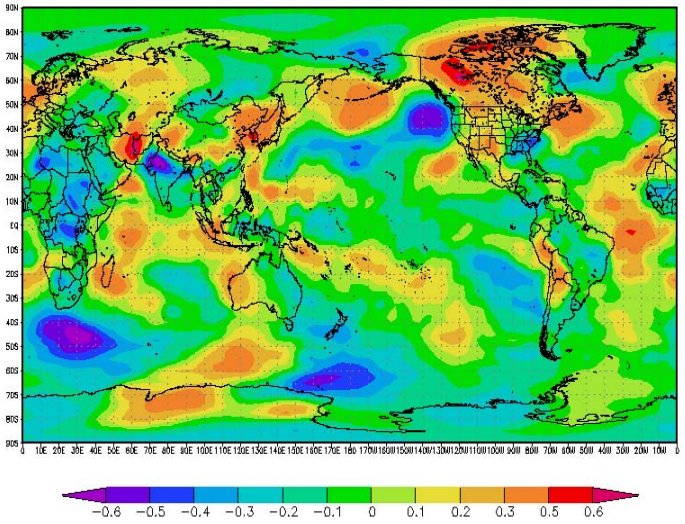


# Correlation Patterns of T850

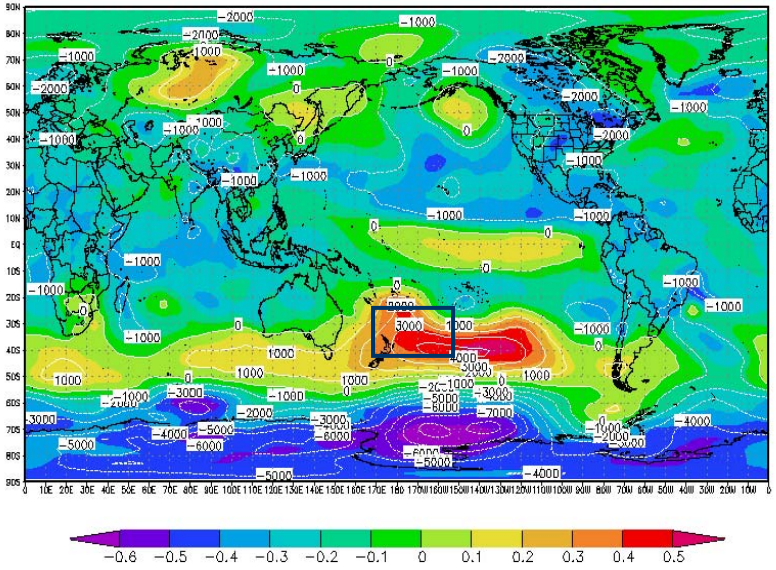
- NCC CGCM



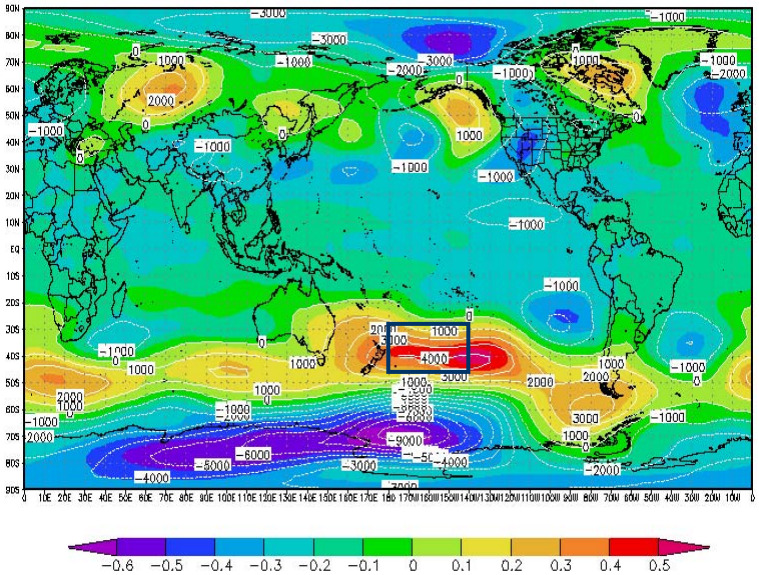

- NCEP Reanalysis



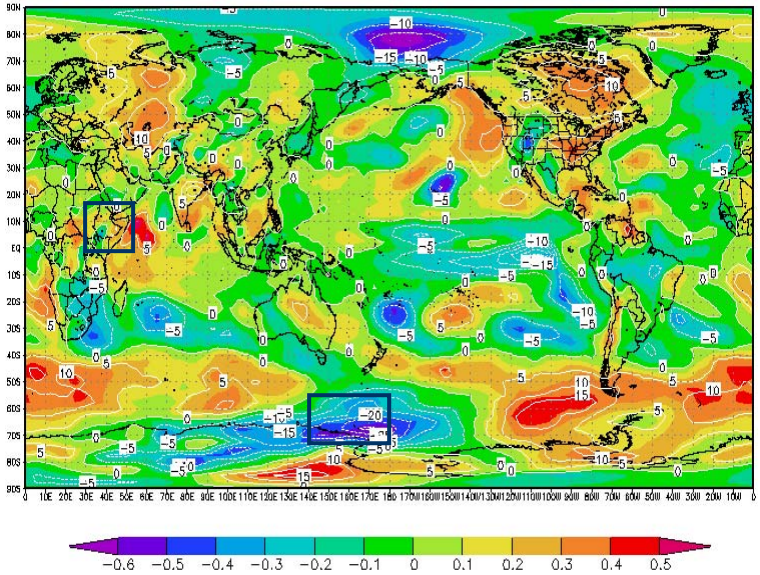
## SLP

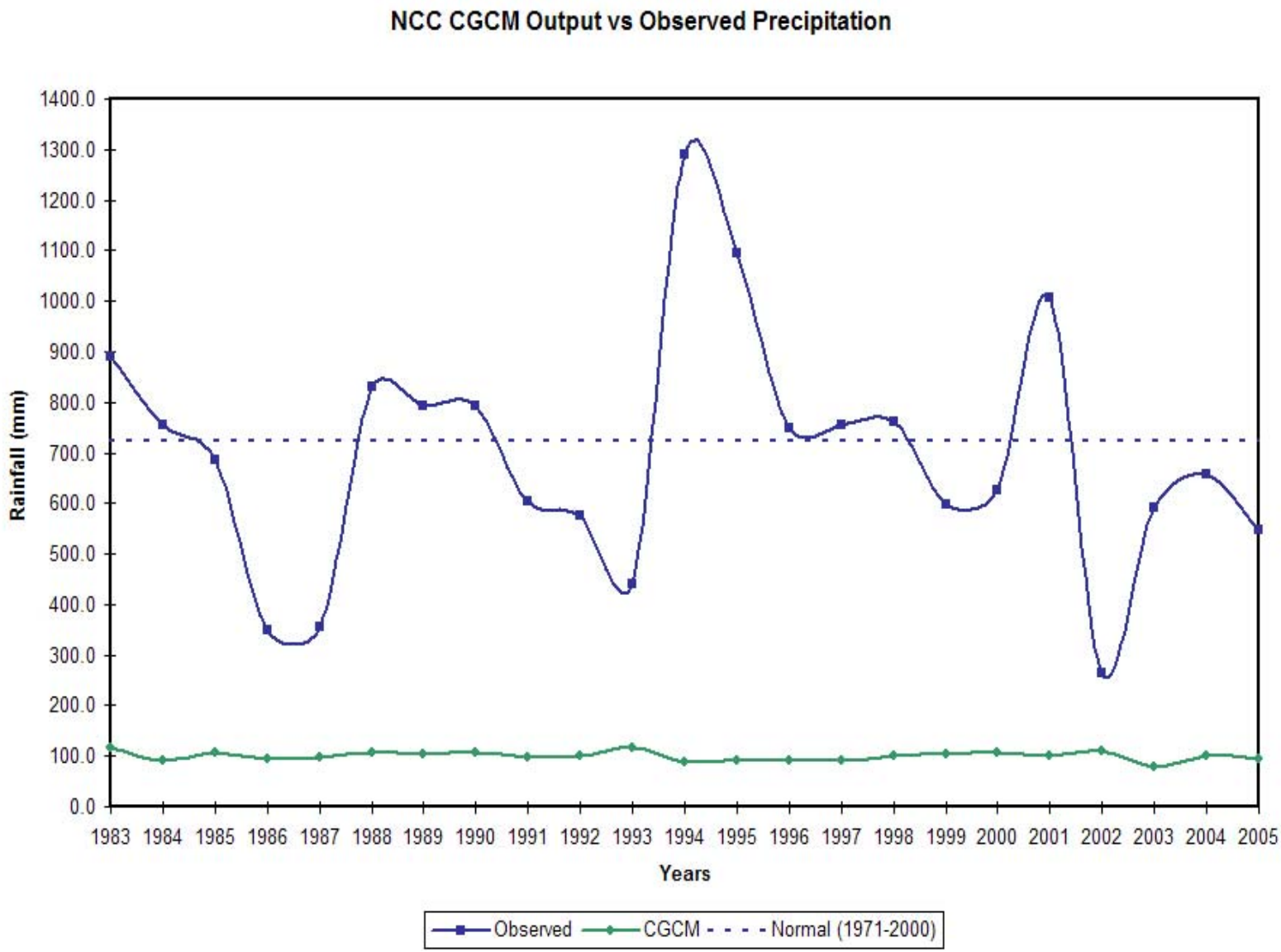



## H500

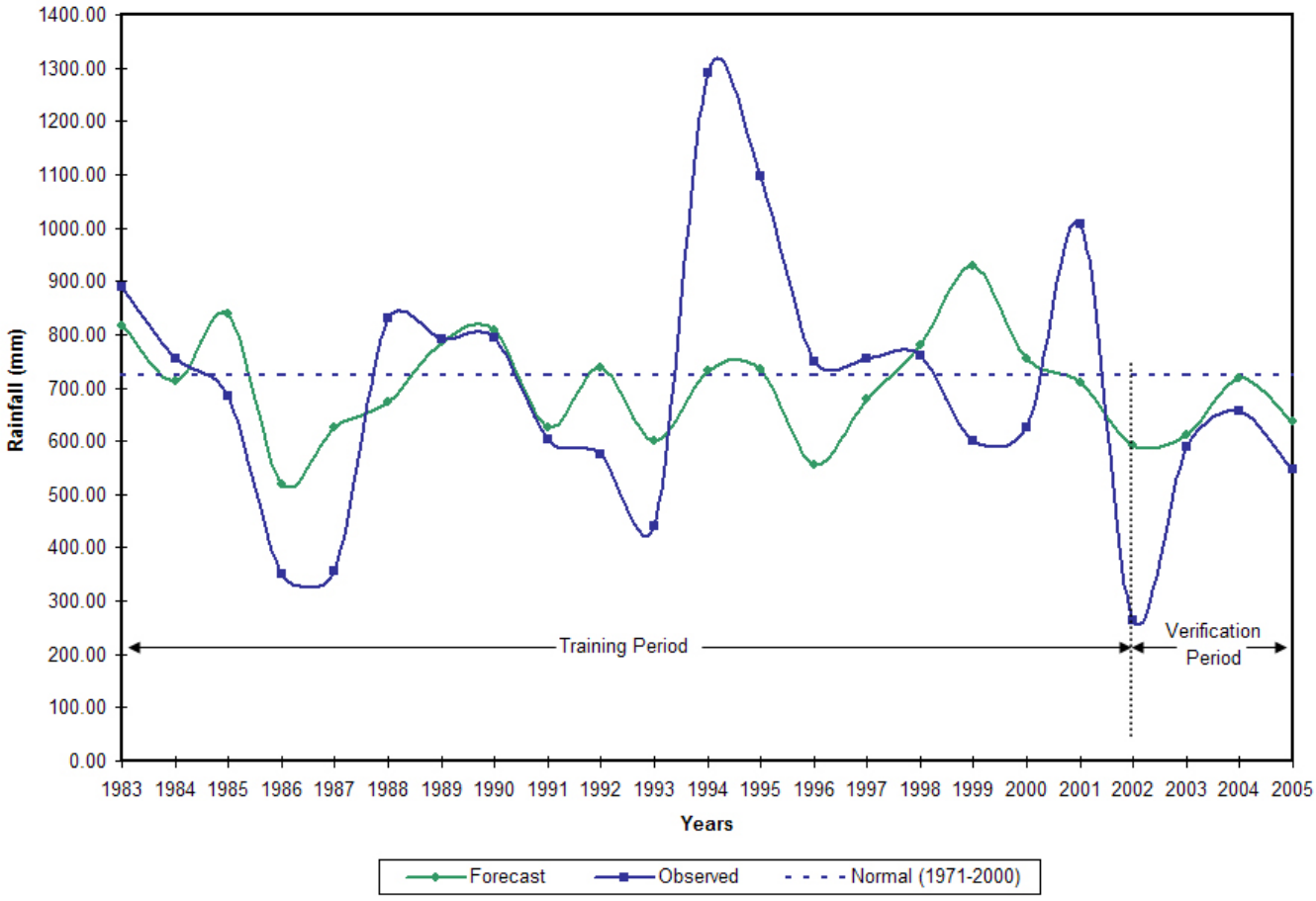



## T850

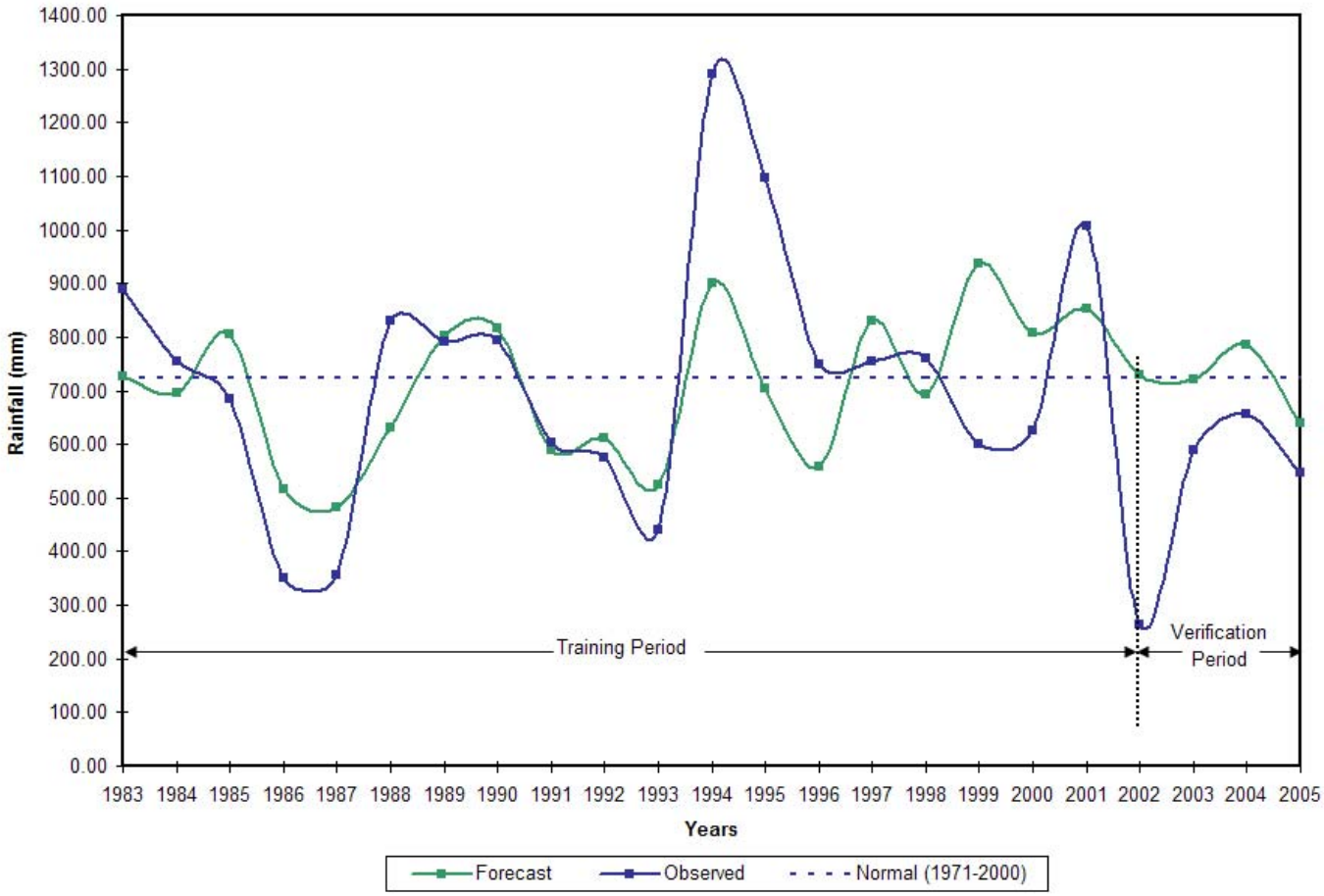



NCC CGCM Output vs Observed Precipitation
Rainfall (mm)
1400.0
1300.0
1200.0
1100.0
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
Years
Observed
CGCM
Normal (1971-2000)

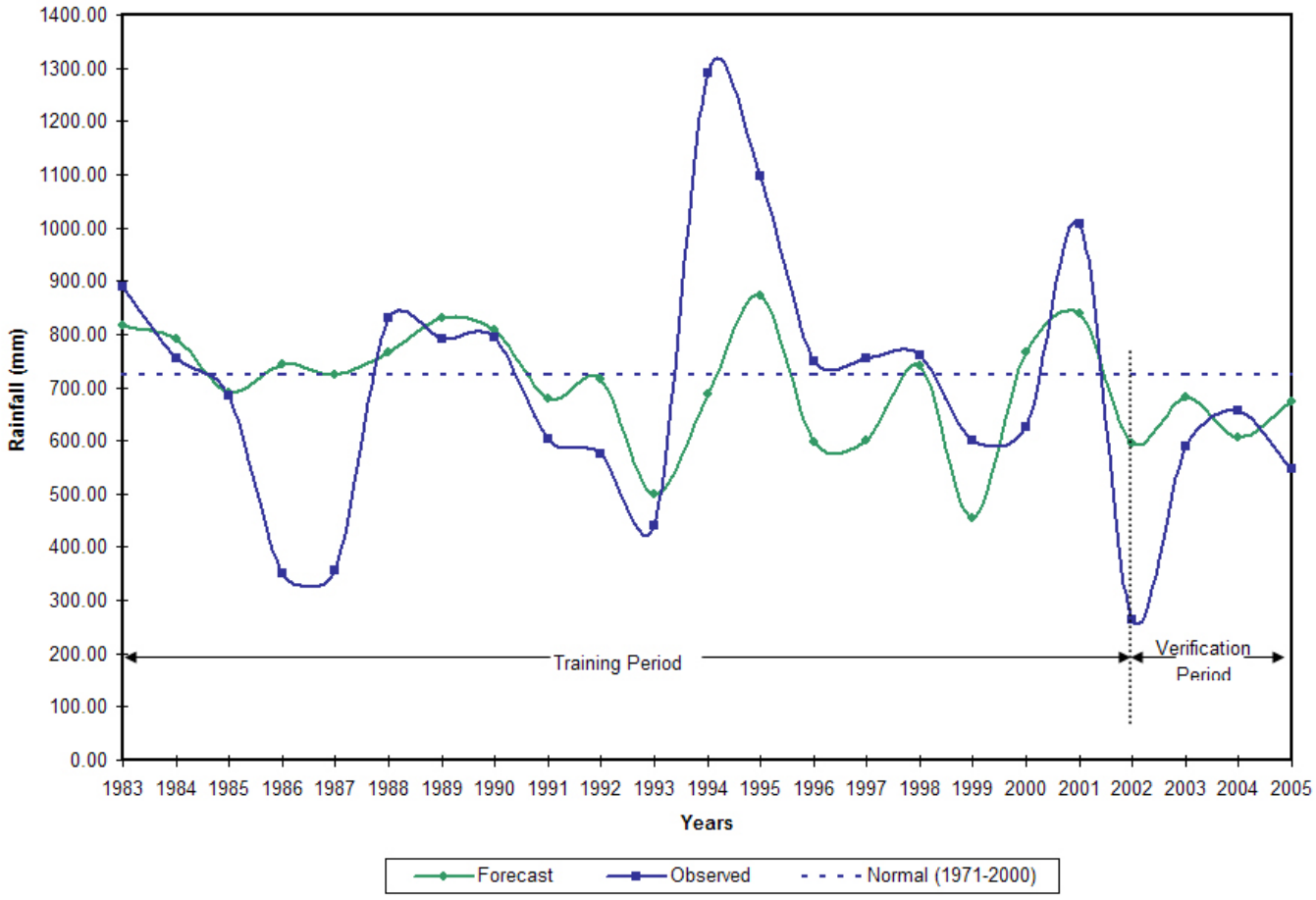
# Predicted Time Series with one Predictor, SLP



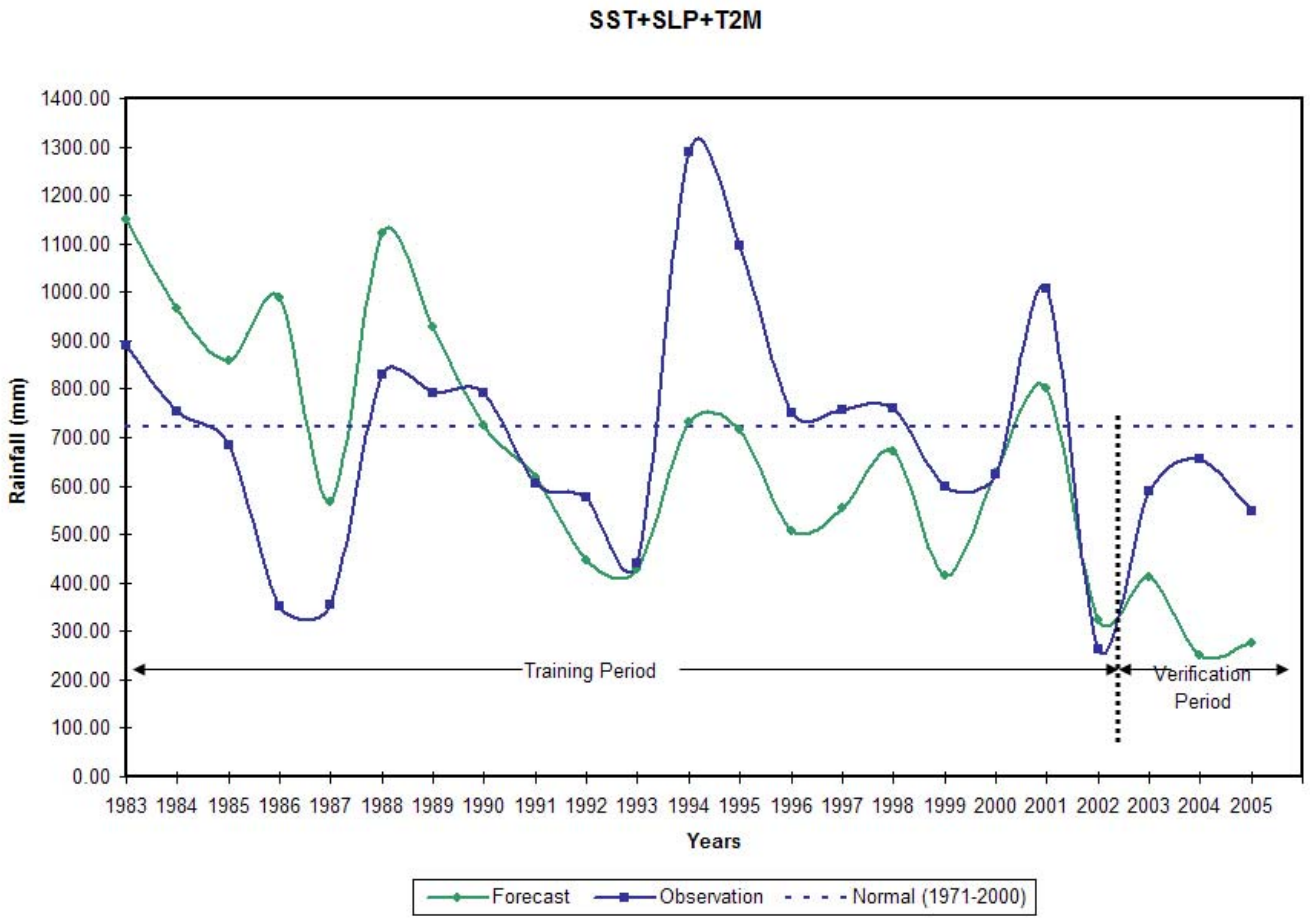
# Predicted Time Series with one Predictor, H500



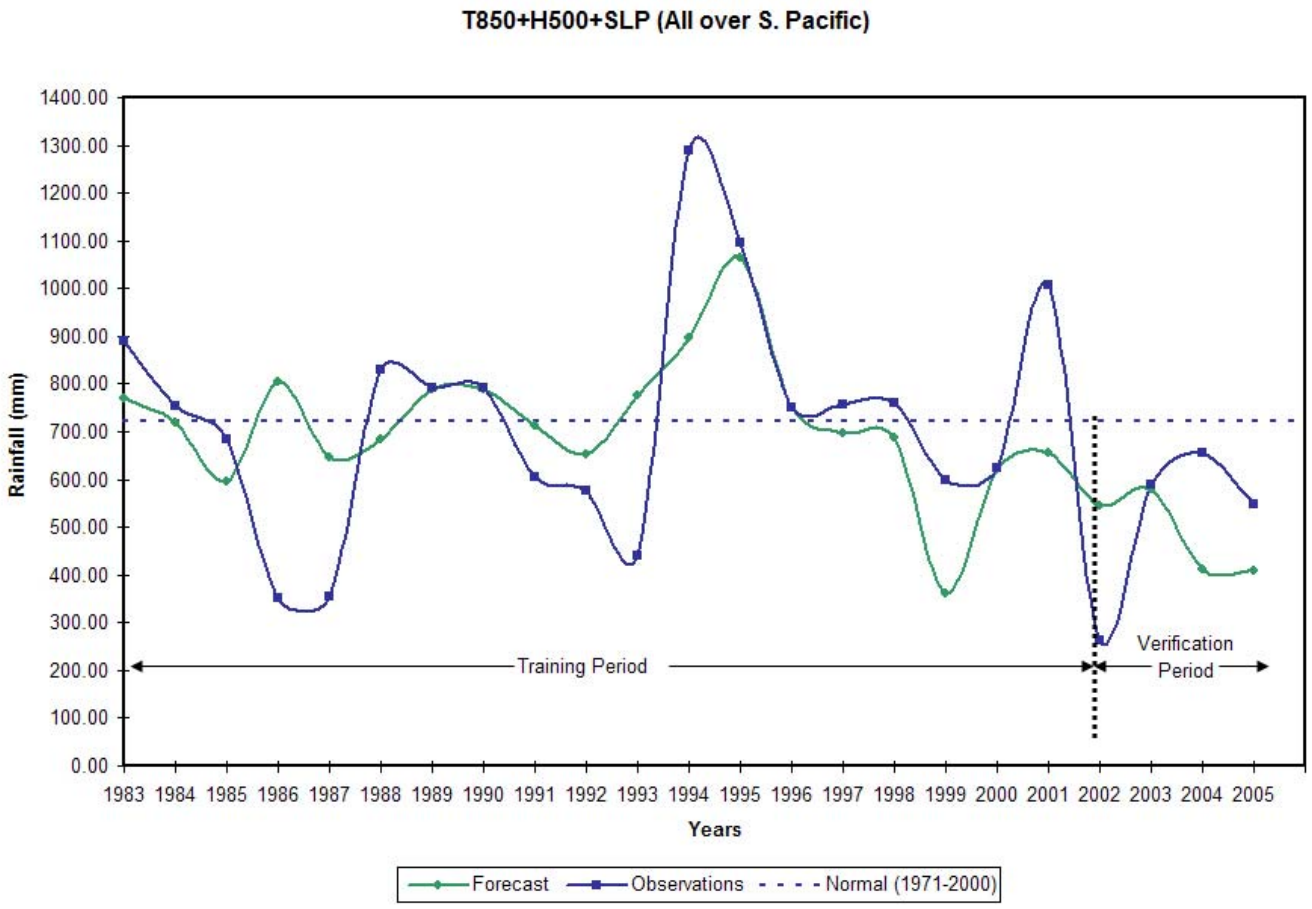
# Predicted Time Series with one Predictor, T850



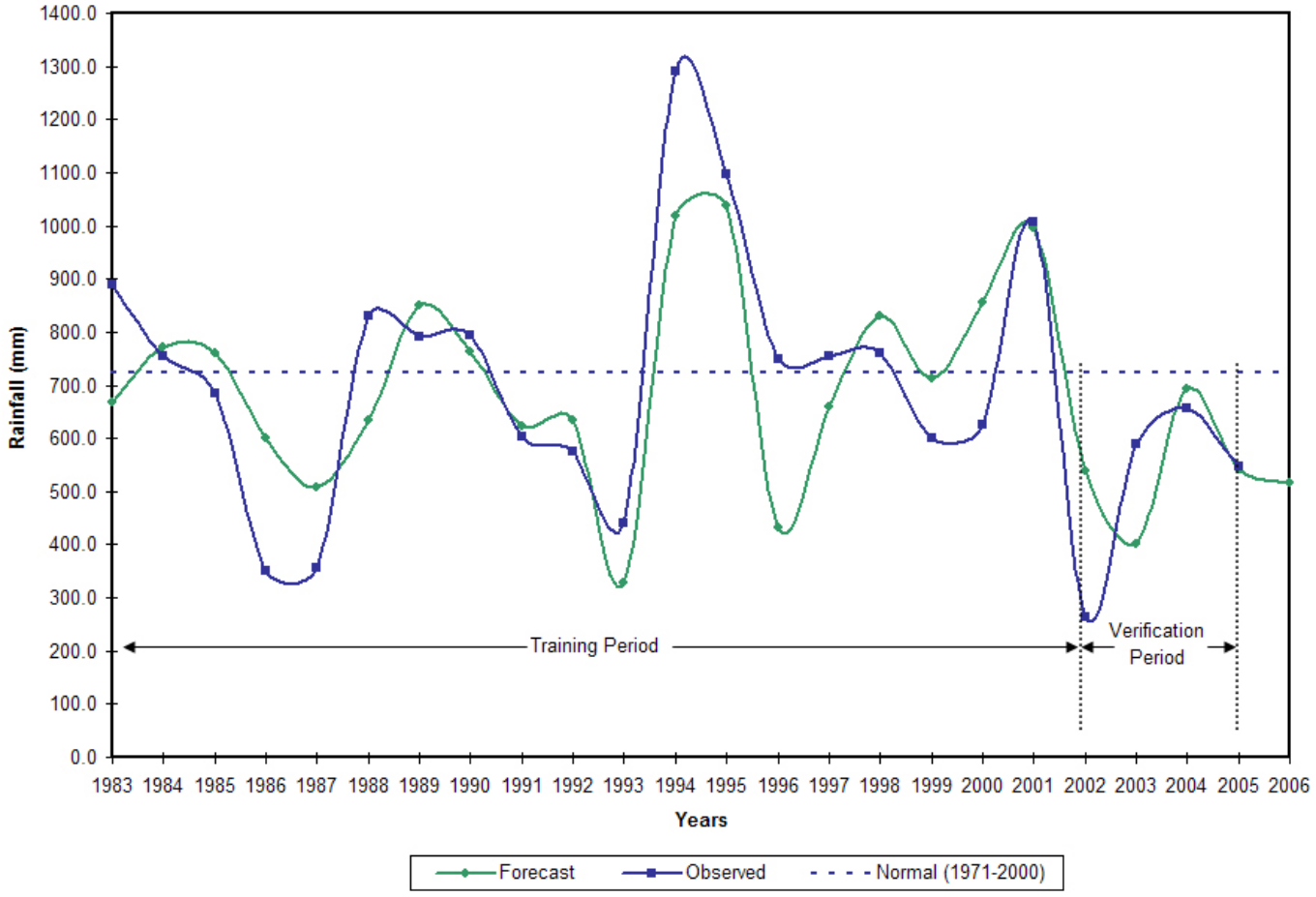
# Predicted Time Series with Three Predictors



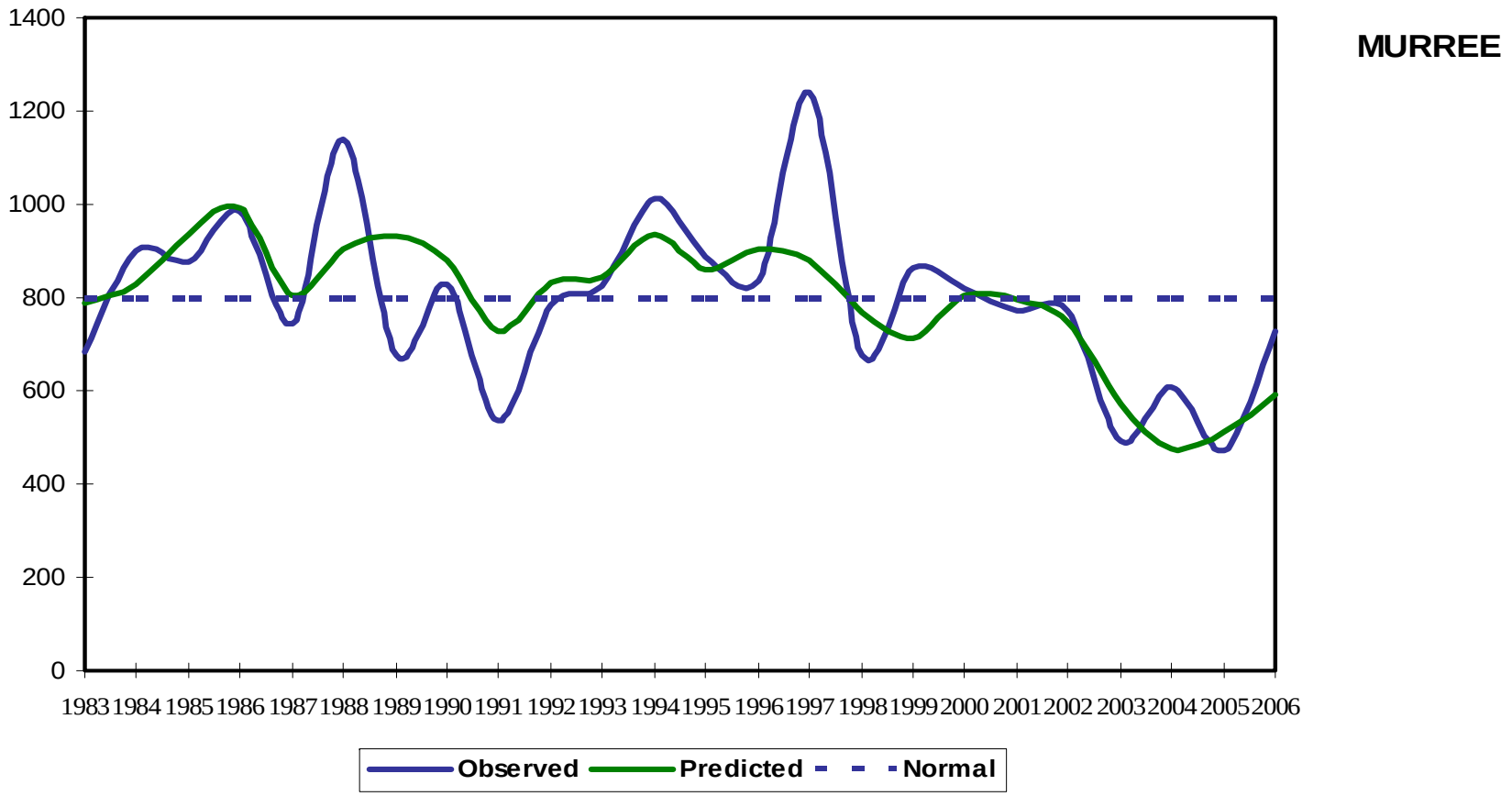
# Predicted Time Series with Three Predictors



# Predicted Time Series with Three Predictors SLP,H500,T850

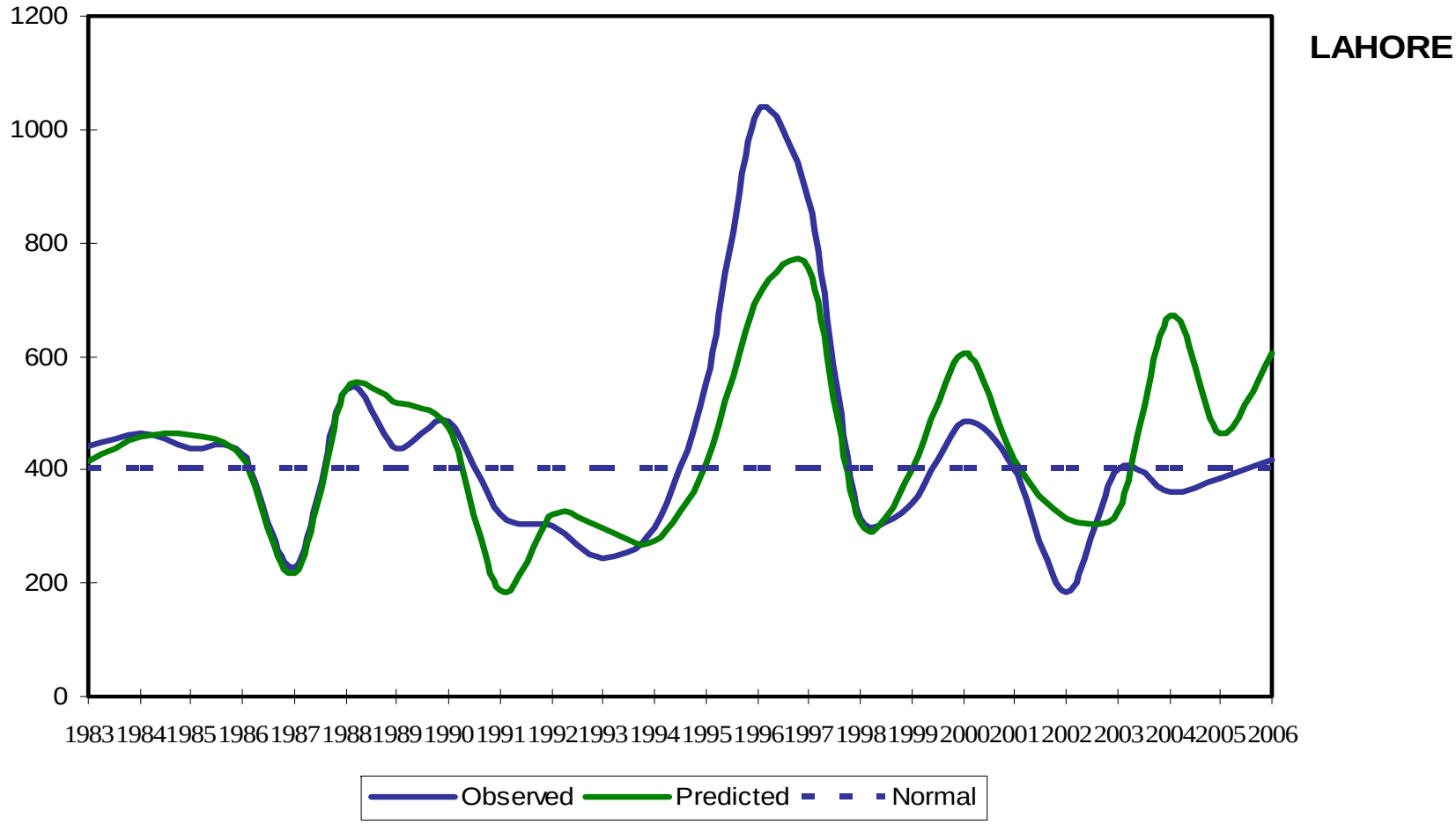


# Predicted Time Series with Three Predictors SLP, SST, TEMP

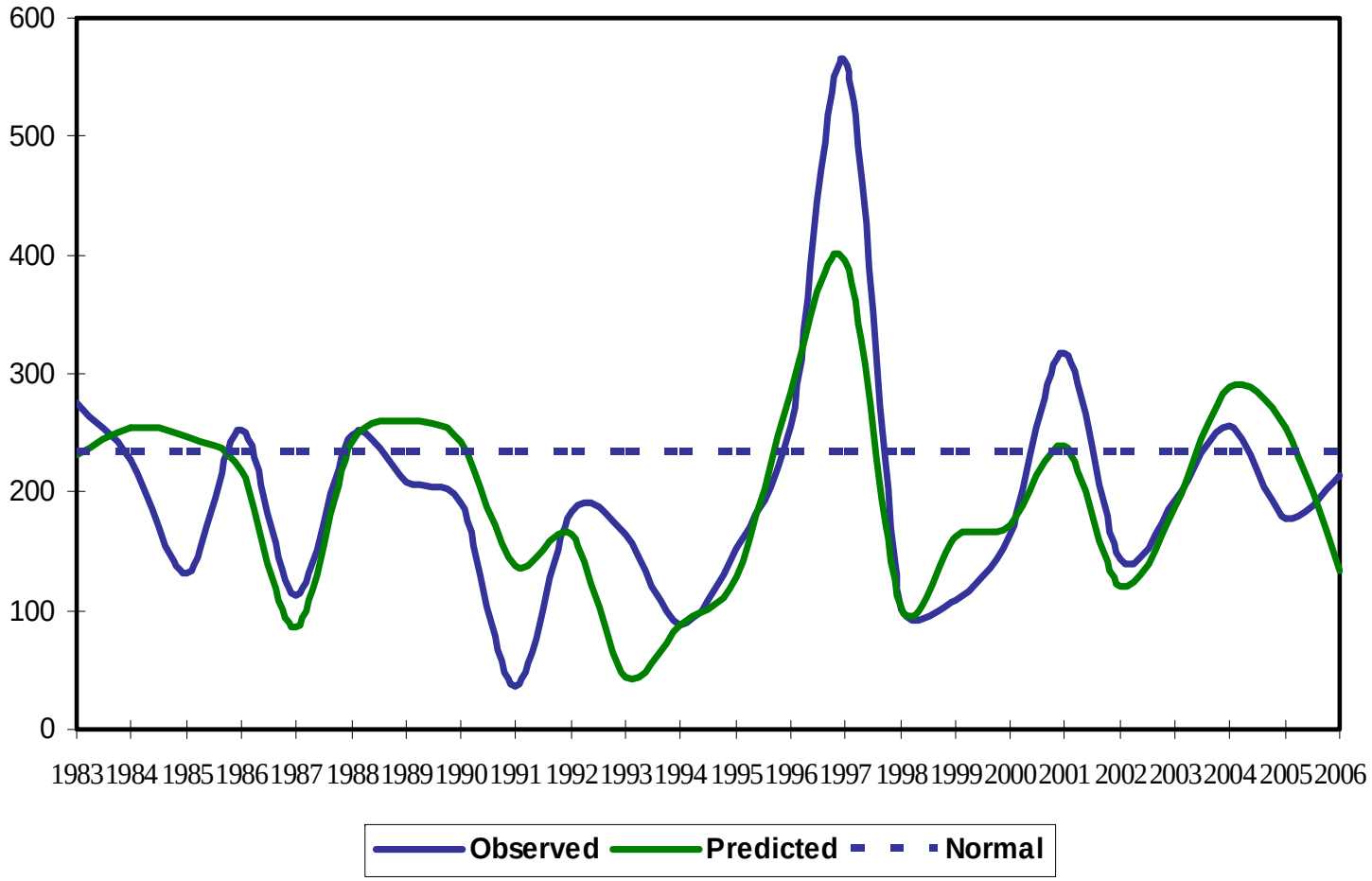



**MURREE**

# Predicted Time Series with Three Predictors U200, SST, T850

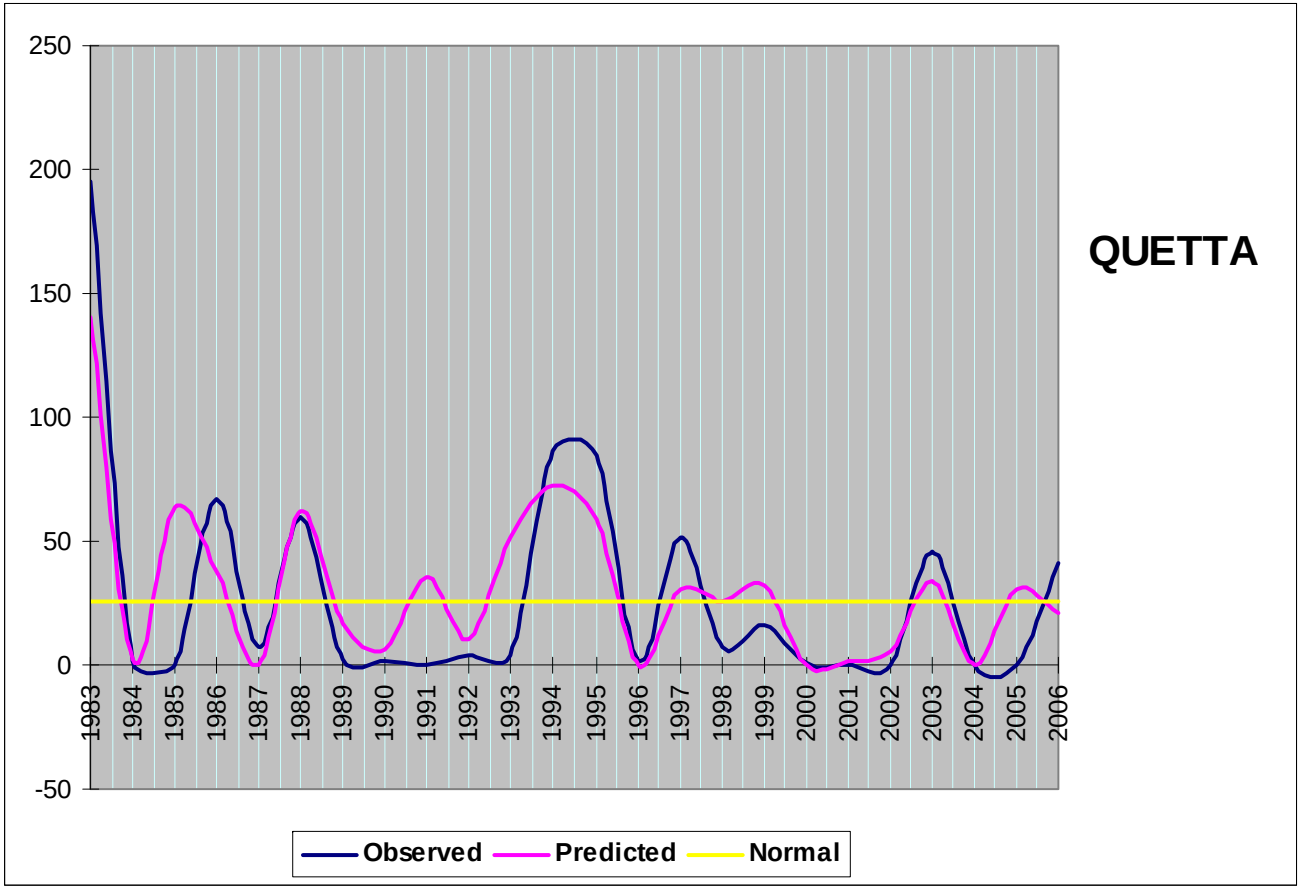


## Predicted Time Series with Three Predictors U200, V200, U850

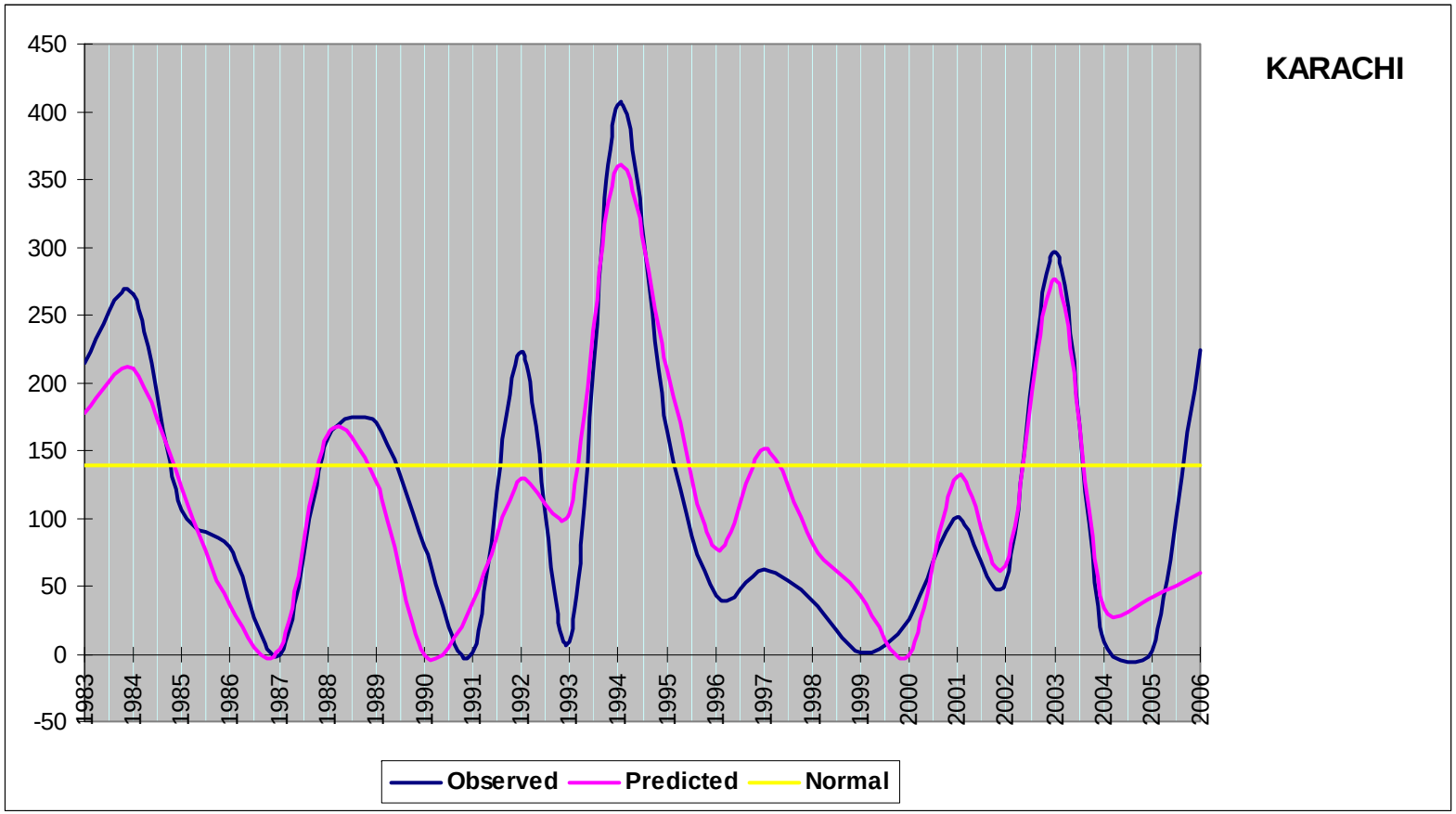



**FAISALABAD**

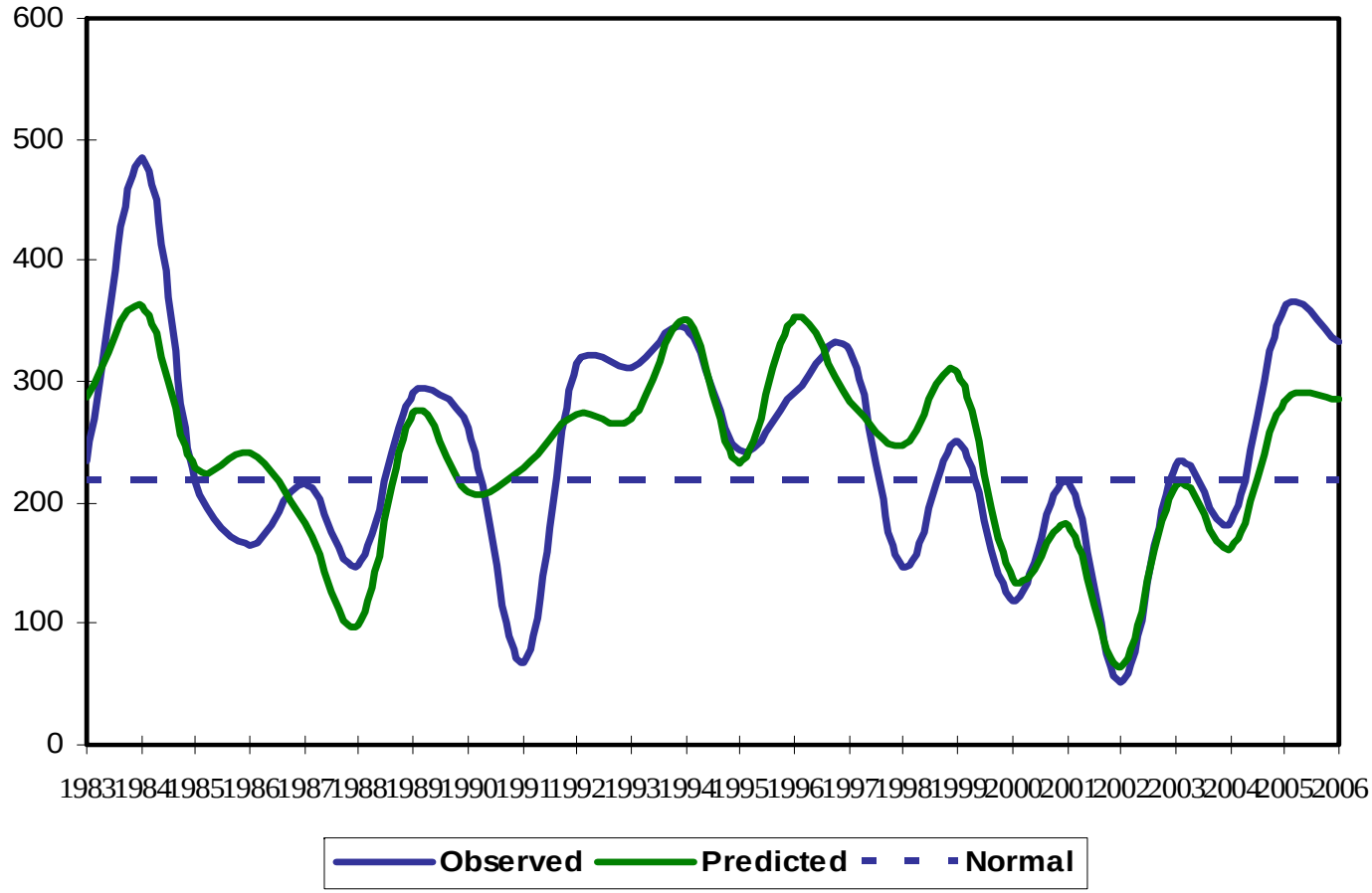
## Predicted Time Series with Three Predictors U200, V200, TEMP



# Predicted Time Series with Three Predictors U200, V200, TEMP



## Predicted Time Series with Three Predictors U200, V200, TEMP




**BARKHAN**

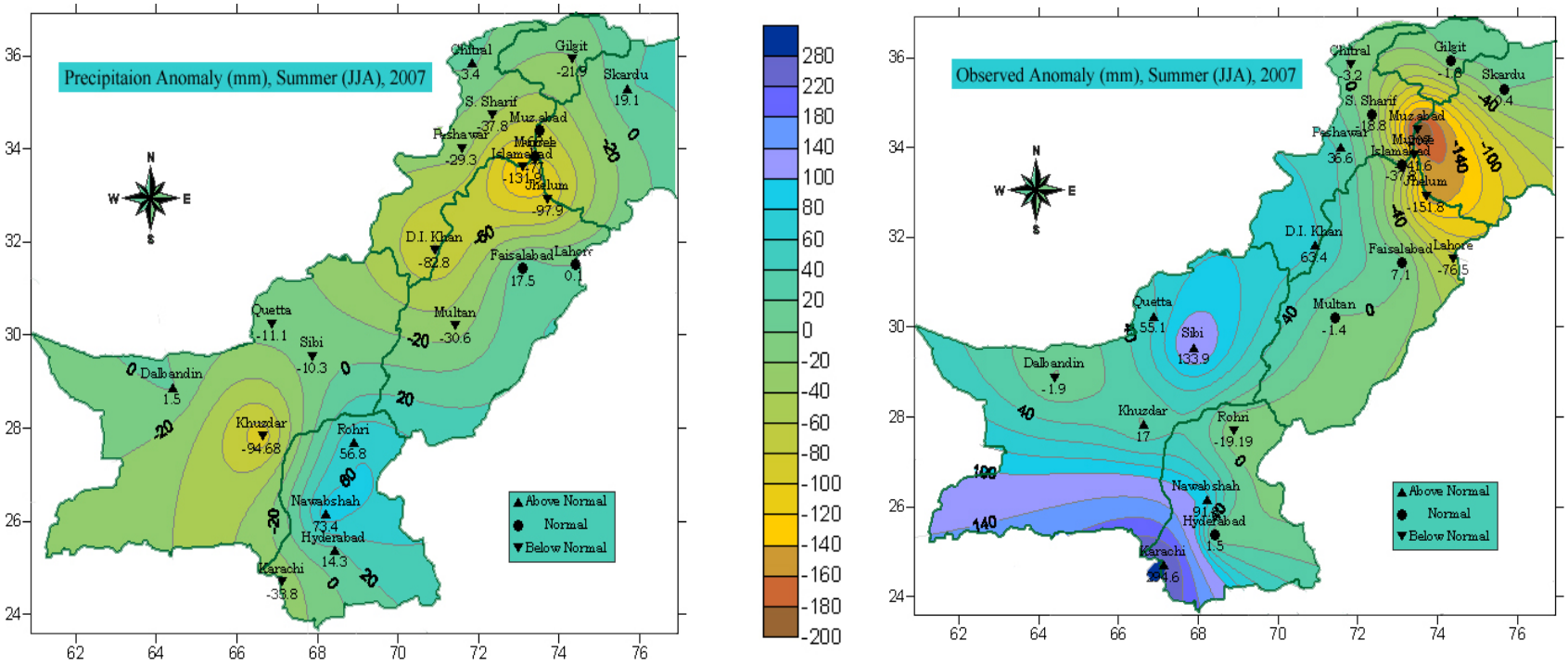
# CONCLUSION

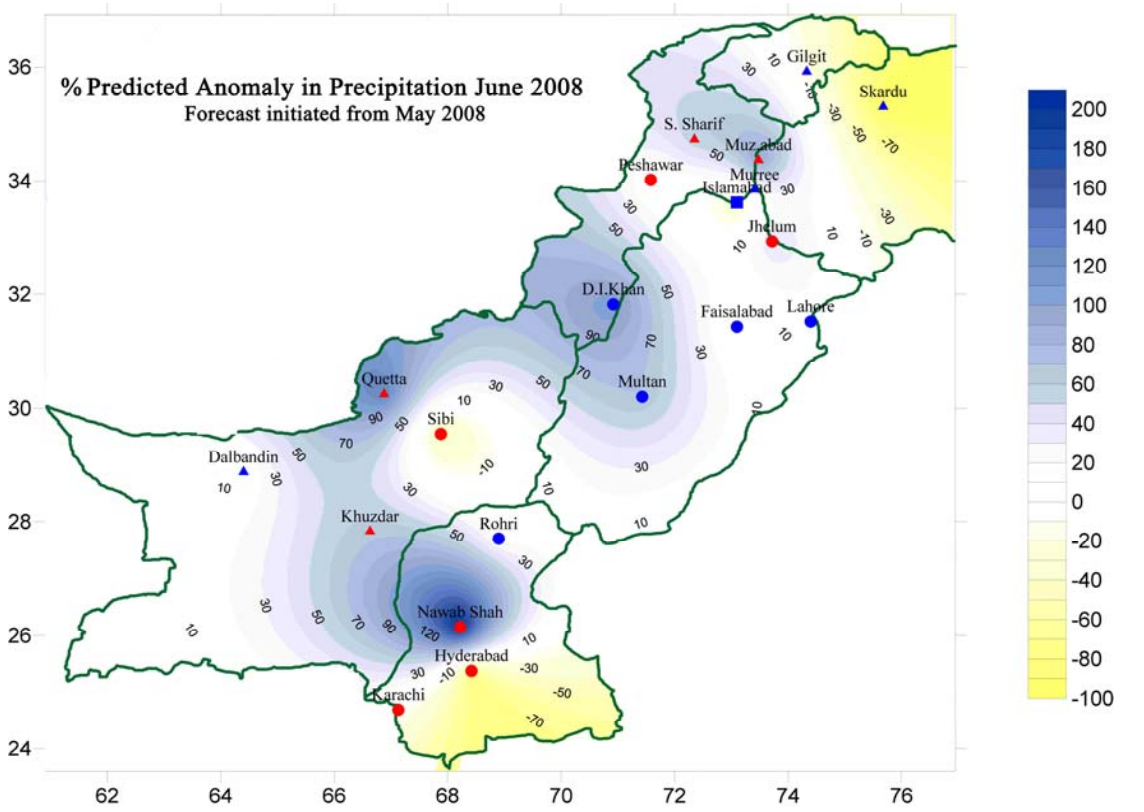
- ✓ The correlation coefficient between observed and predicted precipitation by the statistical downscaling of NCC CGCM output is 0.74, which means that the prediction is in well accordance with the observed precipitation
- ✓ The statistical model performed well in terms of regenerating the precipitation at station/regional scale from large scale variable
- ✓ This technique is a good tool for seasonal precipitation prediction. However, some outliers exist in the predicted time series.

# JJA Rainfall

| Station | Normal | Observed | Predicted |
|---|---|---|---|
| Faisalabac | 175.1 | 213.4 | 134 |
| Lahore | 402.3 | 417 | 606.6 |
| Murree | 796.5 | 728 | 592.6 |
| Karachi | 158.4 | 224.5 | 59.3 |
| Quetta | 25.9 | 41 | 21.3 |
| Barkhan | 218.4 | 332 | 284 |

# Prediction for Monsoon 2007




% Predicted Anomaly in Precipitation June 2008
Forecast initiated from May 2008
Gilgit
Skardu
S. Sharif
Muz abad
Peshawar
Murree
Islamabad
Jhelum
D.I.Khan
Faisalabad
Lahore
Quetta
Multan
Sibi
Dalbandin
Khuzdar
Rohri
Nawab Shah
Hyderabad
Karachi
36
34
32
30
28
26
24
62
64
66
68
70
72
74
76
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100

# Thank You Very Much!