

# Drought Forecast for Water Resources Management

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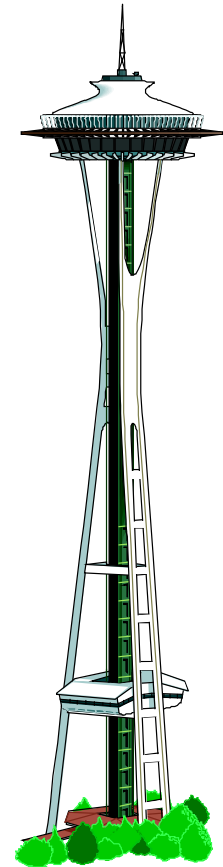


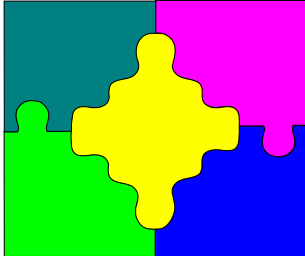
# Overview

- **Research Description**
- **Drought/Drought Indicators**
- **NCEP Forecast**
- **Model Application**
- **EPA BASINS**
- **Analysis Output**
- **Conclusion**
- **Future Work**

# Research Description

- Length of the project
- Funded by Korea Government (KICT)
- Participants
  - Dr. Richard N. Palmer (UW, Seattle)
  - Jae Hyeon Ryu (UW, Seattle)
  - Dr. Sangman Jeong (KNU, Kongju, Korea)
  - Dr. Jooheon Lee (Joongbu, Korea)





# Research Goal

- Generating an operational definition of drought with perfect forecast
- NCEP forecasts as input to drought indicators
- Creating mid-term forecasts of climate variability
- Developing a decision support system for drought management that incorporates these other two features

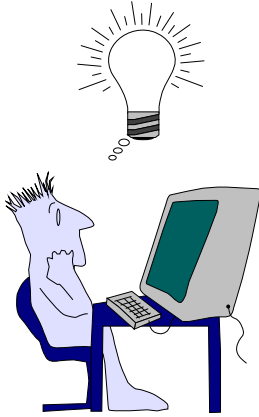
# Drought



- Difficulty of analysis (slow onset, spatial variability, heterogeneous impact, and uncertain management option)
- Meteorological Drought
- Agricultural Drought
- Hydrologic Drought
  - Supply and Demand (Economics)
  - Reliability (Risk analysis)
  - Water Quality (Sociology)
  - Sustainability (Climate, long-term Water Management)

# Talk Flowchart

**1** Define Drought



**2** Look back historic drought



**3** NCEP Forecast

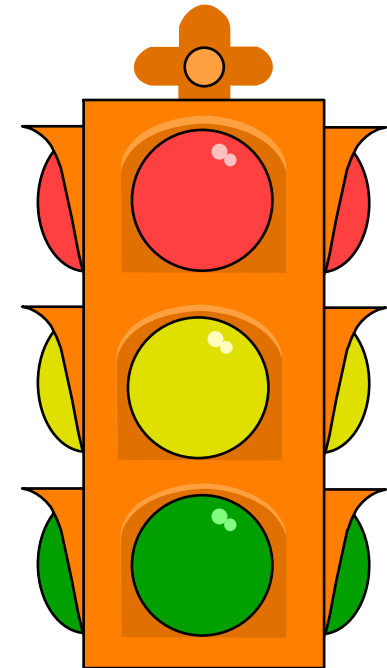


**4** Decision Support System



# Drought Indicators

- Palmer Drought Index (PDSI,PDHI)
- Standard Precipitation Index (SPI)  
3, 6, 12, 24
- Stream flow (Jan – Apr)
- Hydrologic Infrastructure
  - Reservoir capacity
  - Aquifer size
  - Water distribution system

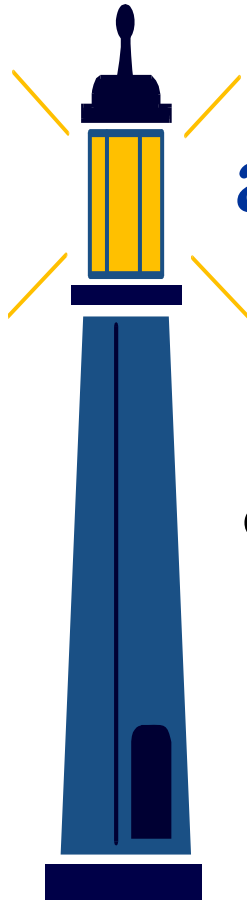


# Drought Indicators and Values

<b>3 Month SPI (Cum. Prob. %)</b>	<b>4 Month Total Inflows (Cum. Prob. %)</b>	<b>Avg. Storage in April (% of Storage)</b>	<b>Indicator Value (1-5)</b>
>80	>80	>80	1 – (very good)
60 – 80	60 – 80	60 – 80	2 – (Good)
40 – 59	40 – 59	40 – 59	3 – (Normal/Warning)
20 – 39	20 – 39	20 – 39	4 – (Drought) ✓
<20	<20	<20	5 – (Severe Drought) ✓



# Standardized Drought Indicators and Values



Is there link to  
drought indicator  
and NCEP  
forecast?

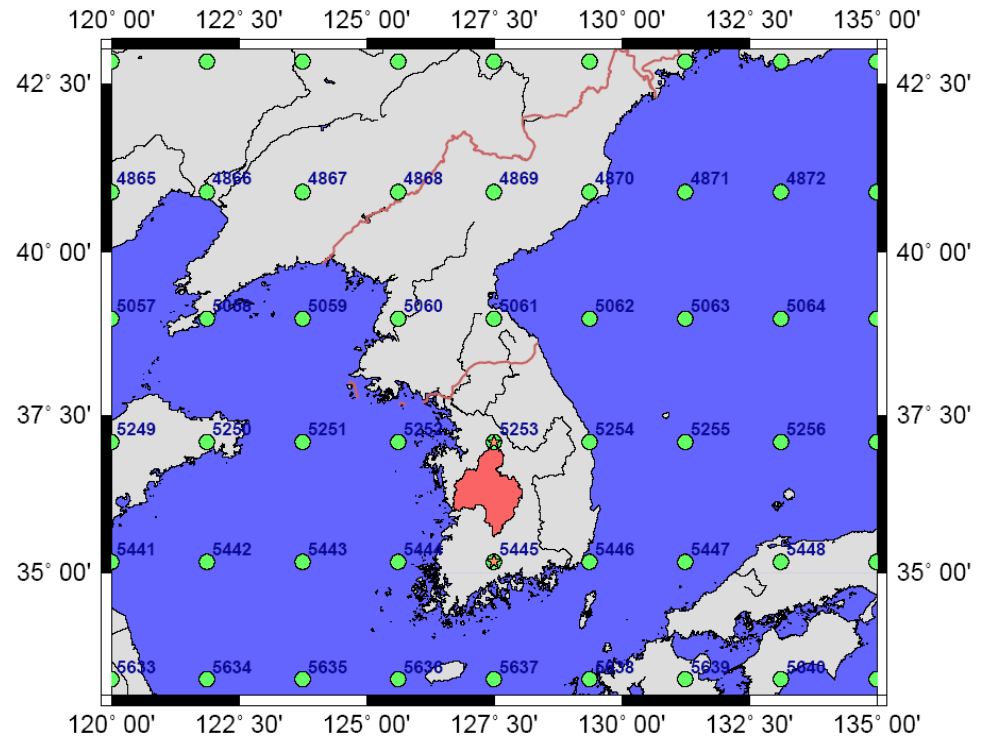
How?

Year	Drought index			Value of recalculated composite drought index	Value of recalculated drought index
	P	S	R		
1981	4	4	5	4.3	4
1982	4	5	4	4.2	4
1983	2	3	4	2.8	3
1984	3	5	2	3.2	3
1985	3	4	5	3.8	4
1986	4	4	1	3.1	3
1987	3	2	3	2.7	3
1988	3	5	4	3.8	4
1989	3	3	2	3.2	3
1990	1	2	1	1.2	1
1991	3	3	2	2.7	3
1992	3	4	4	3.5	4
1993	3	4	2	2.9	3
1994	4	5	3	3.9	4
1995	3	5	5	4.1	4
1996	3	5	3	3.5	4
1997	3	5	4	3.8	4
1998	2	2	1	1.7	2
1999	3	3	1	2.4	2
2000	4	5	2	3.6	4
2001	4	4	3	3.7	4

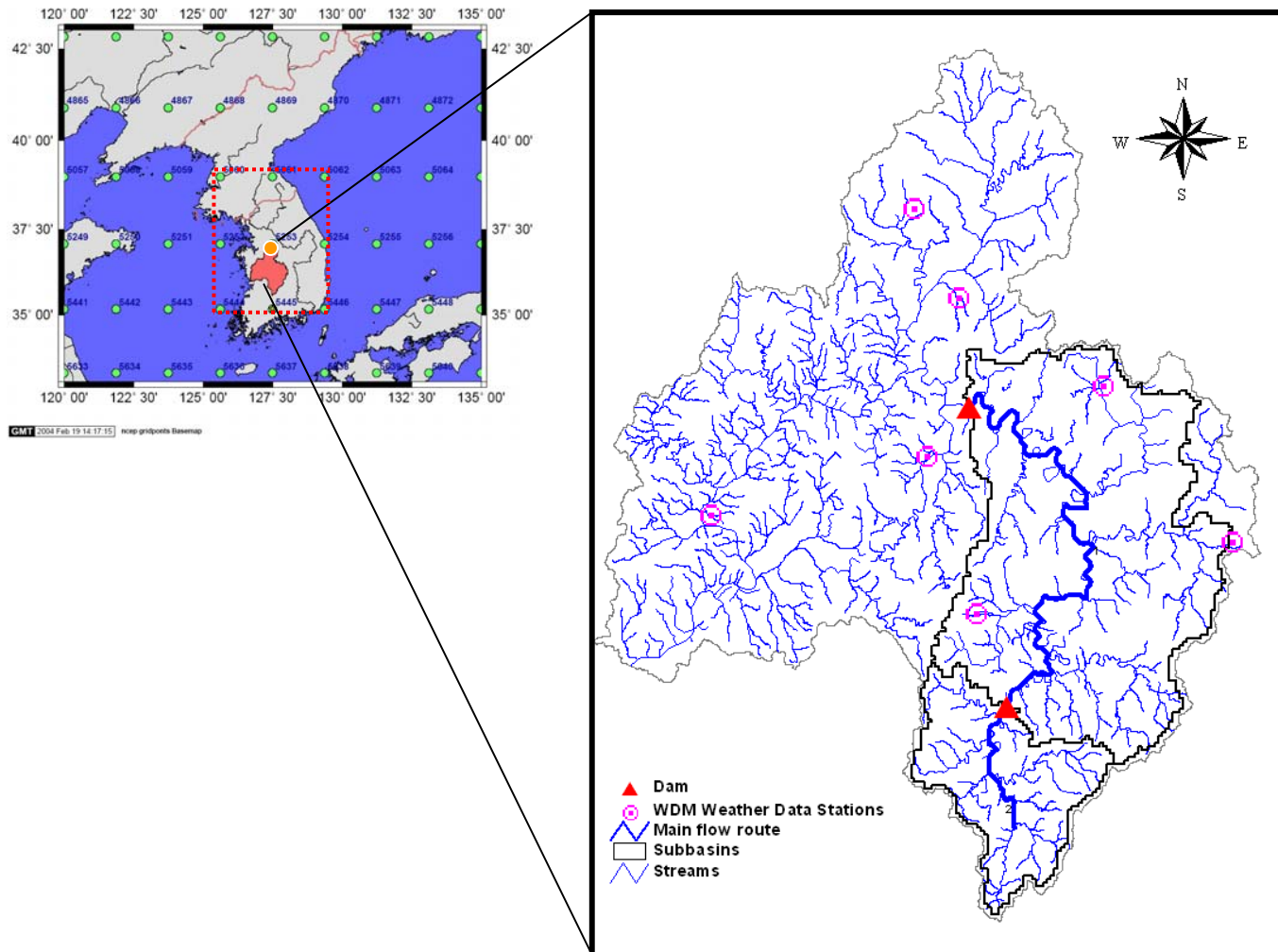
Note: P:3 month SPI,S: four month streamflow into reservoir,  
R: average active storage in April

# NCEP Forecast

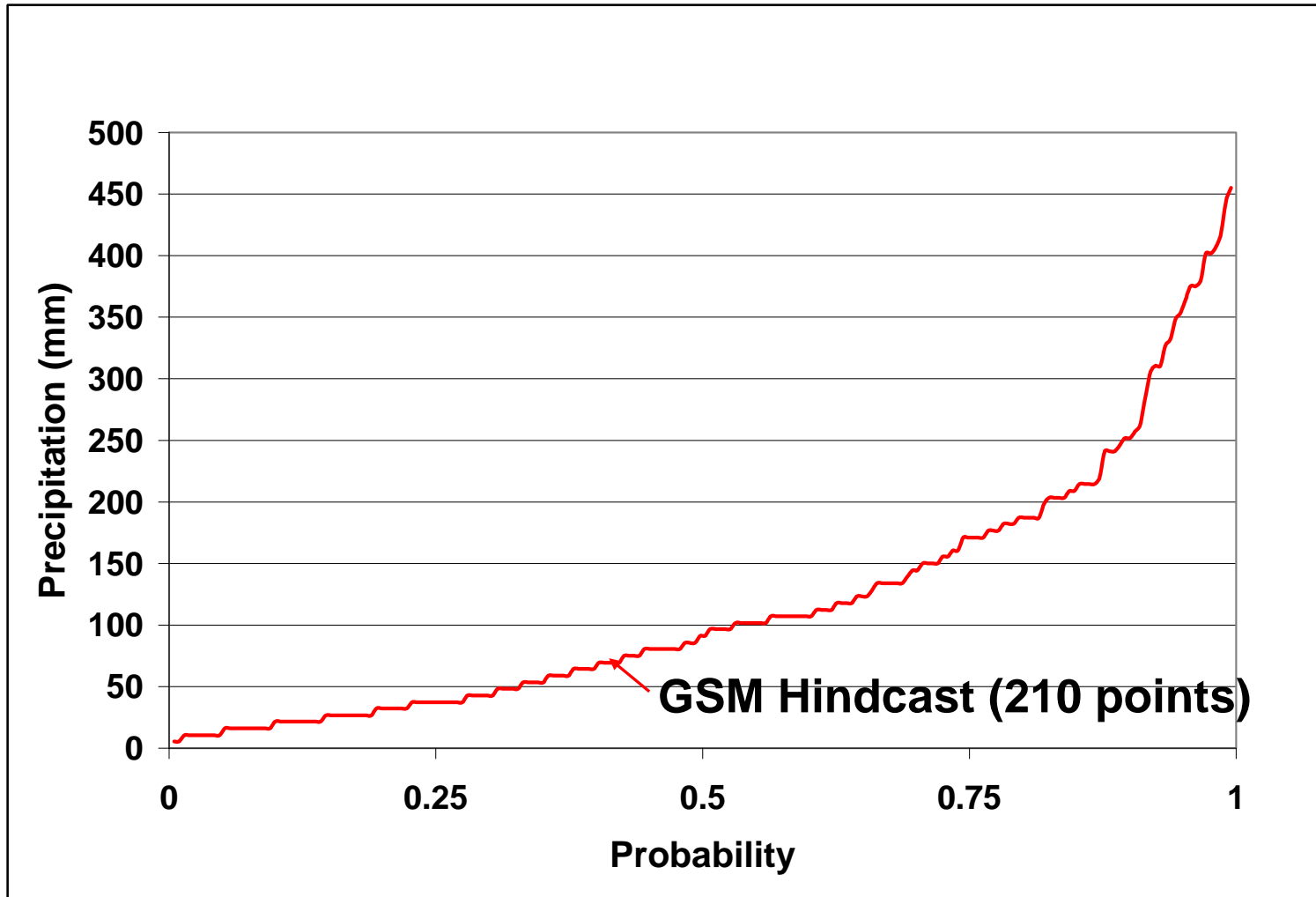
- The National Center for Environmental Prediction (NCEP), NOAA
- Six-month Prediction (Temp. & Prep)
- 1.9 degree resolution (Spatial domain)
- 5 – 15 minutes (Temporal domain)



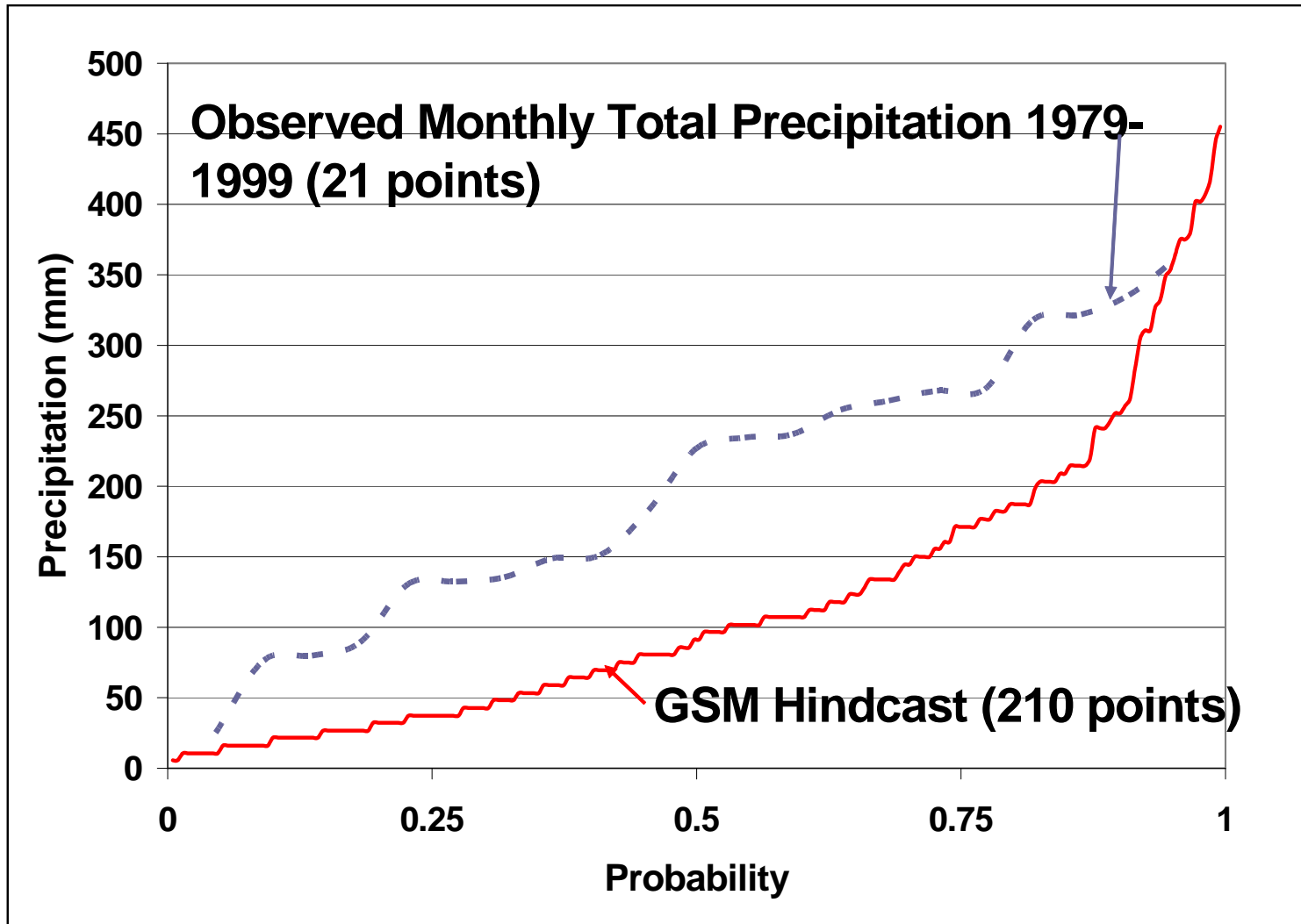
# Model Application



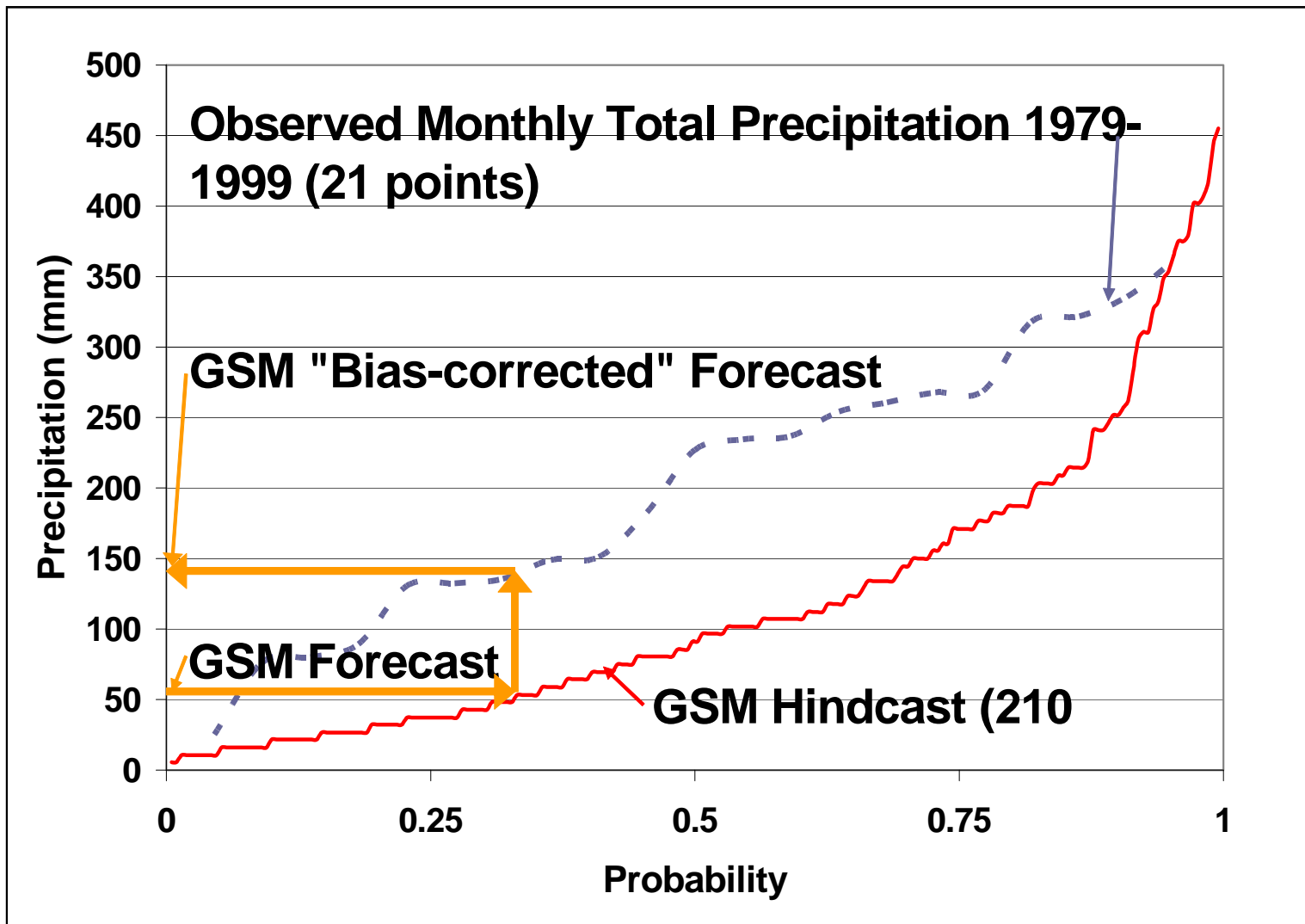
# Bias Correction



# Bias Correction –Cont'd



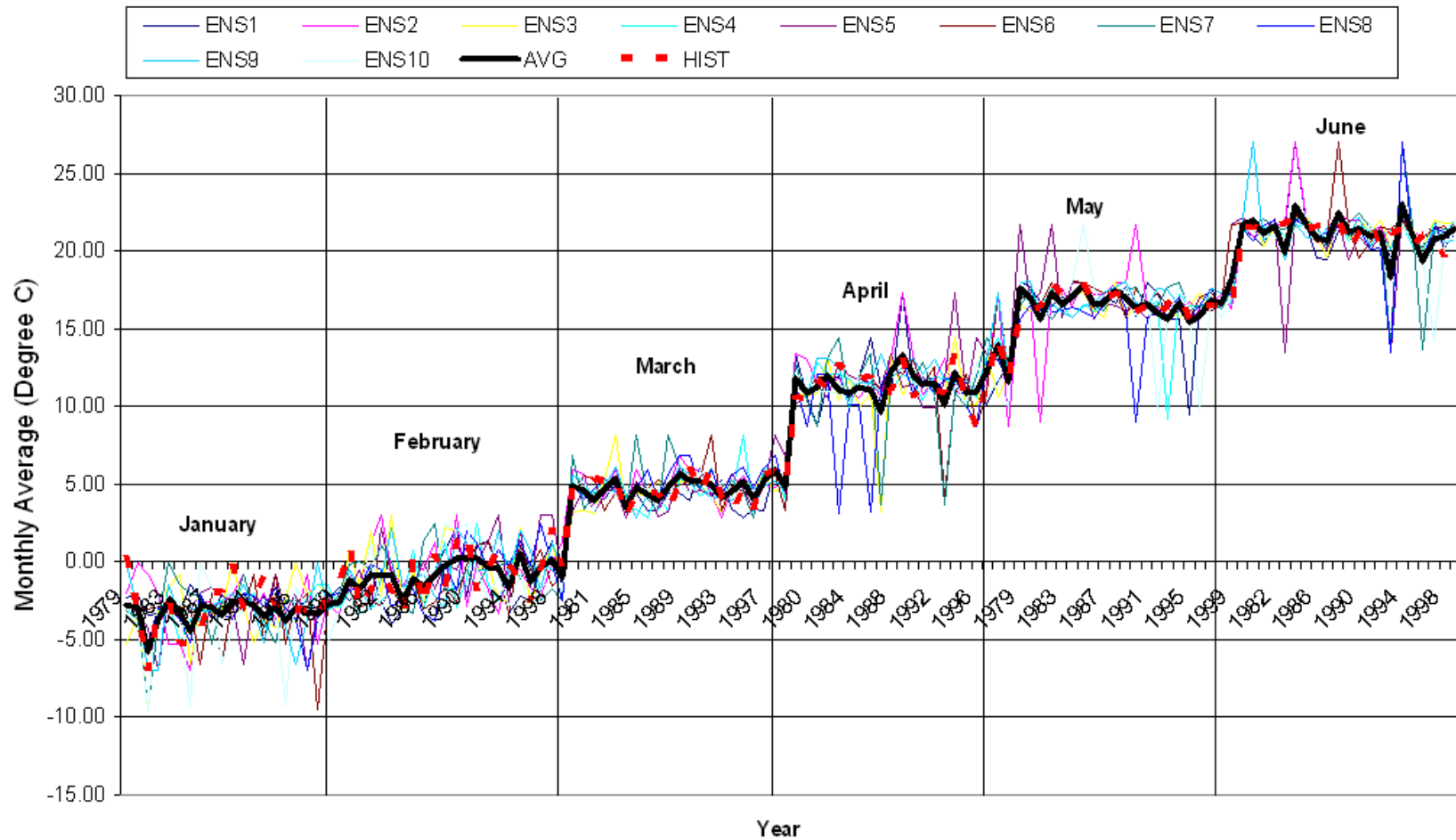
# Bias Correction –Cont'd





# Retrospective NCEP forecast for Temperature

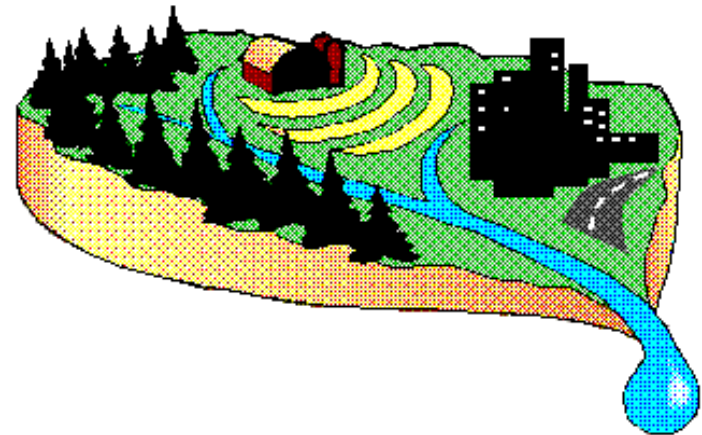
Projected retrospective NCEP forecast for Temperature  
(Guemsan Station 1979-1999)



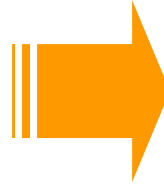
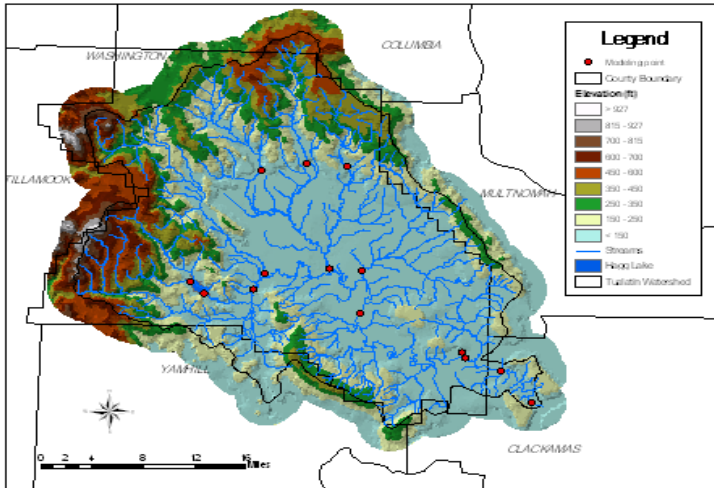


# EPA BASINS

- Arcview GIS Backbone
- Data Management Tools  
WDMUtil, Gensen
- Simulation models
  - HSPF ✓
  - QUAL2E
  - SWAT



# BASINS 3.0 System Overview



**WDMUtil: TUALATIN**

File Tools Scenarios Locations Constituents Time Series Help

Scenarios: 0 of 2 (All None) Locations: 0 of 22 (All None) Constituents: 0 of 3 (All None)

COMPUTED OBSERVED

BEAVERTO  
BUXTON  
FORESTG  
GLEENWOOD  
SCOGGINS

FLOW  
PEVT  
PREC

Time Series - 29 of 29 available time series in list (0 not on WDM file); 1 selected.

Type	File	DSN	Scenario	Location	Constituent	Start	SJ/day	End
WDM	TUALATIN	101	OBSERVED	TIMBER	PREC	1924/7/2	2398	1976/5/2
WDM	TUALATIN	106	OBSERVED	TIMBER	PEVT	1934/1/1	27438	1976/5/3
WDM	TUALATIN	201	OBSERVED	GLEENWOOD	PREC	1934/1/1	27438	2003/3/2
WDM	TUALATIN	206	OBSERVED	GLEENWOOD	PEVT	1934/1/1	27438	2003/3/2
WDM	TUALATIN	301	OBSERVED	SCOGGINS	PREC	1934/1/1	27438	2002/1/2
WDM	TUALATIN	306	OBSERVED	SCOGGINS	PEVT	1934/1/1	27438	2002/1/2
WDM	TUALATIN	401	OBSERVED	BUXTON	PREC	1934/1/1	27438	2002/1/2
WDM	TUALATIN	406	OBSERVED	BUXTON	PEVT	1934/1/1	27438	2002/1/2
WDM	TUALATIN	501	OBSERVED	BEAVERTO	PREC	1934/1/1	27438	2003/9/3
WDM	TUALATIN	506	OBSERVED	BEAVERTO	PEVT	1934/1/1	27438	2003/9/2
WDM	TUALATIN	601	OBSERVED	FORESTG	PREC	1934/1/1	27438	2003/9/3
WDM	TUALATIN	606	OBSERVED	FORESTG	PEVT	1934/1/1	27438	2003/9/3
WDM	TUALATIN	702	OBSERVED	SCOGGIN	PREC	1973/4/1	41773	1985/4/3
WDM	TUALATIN	703	OBSERVED	USBR	FLOW	1940/10/1	29003	2003/9/2
WDM	TUALATIN	801	COMPUTED	US634500	FLOW	1940/10/1	29003	1985/4/3

Dates: Reset Start End TStep Units  
Current: 1924/7/2 to 1976/5/24  
Common: 1924/7/2 to 1976/5/24 Native



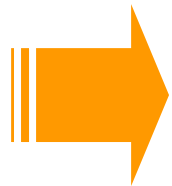
**Hydrological Simulation Program - Fortran (HSPF): tualatin**

File Edit Functions Help

Land Use: Perind Impind, Urban or Built-up, Agricultural Lar, Forest Land, Barren Land, Water, Range Land, Wetlands

Met Seps: RCHRES 12, RCHRES 6, RCHRES 2, RCHRES 13, RCHRES 3, RCHRES 4, RCHRES 8, RCHRES 8, RCHRES 14, RCHRES 7, RCHRES 15, RCHRES 10, RCHRES 11, RCHRES 1

Land Use	Reaches	Impind (Acres)	Perind (Acres)	Total (Acres)
Total		0.0	0.0	0.0



**GenSen: tualatin**

File Scenarios Map Locations Scenarios Constituents Time Series Data Help

Locations: 0 of 3 (All None)

COMPUTED OBSERVED

FLOW  
PEVT  
PREC

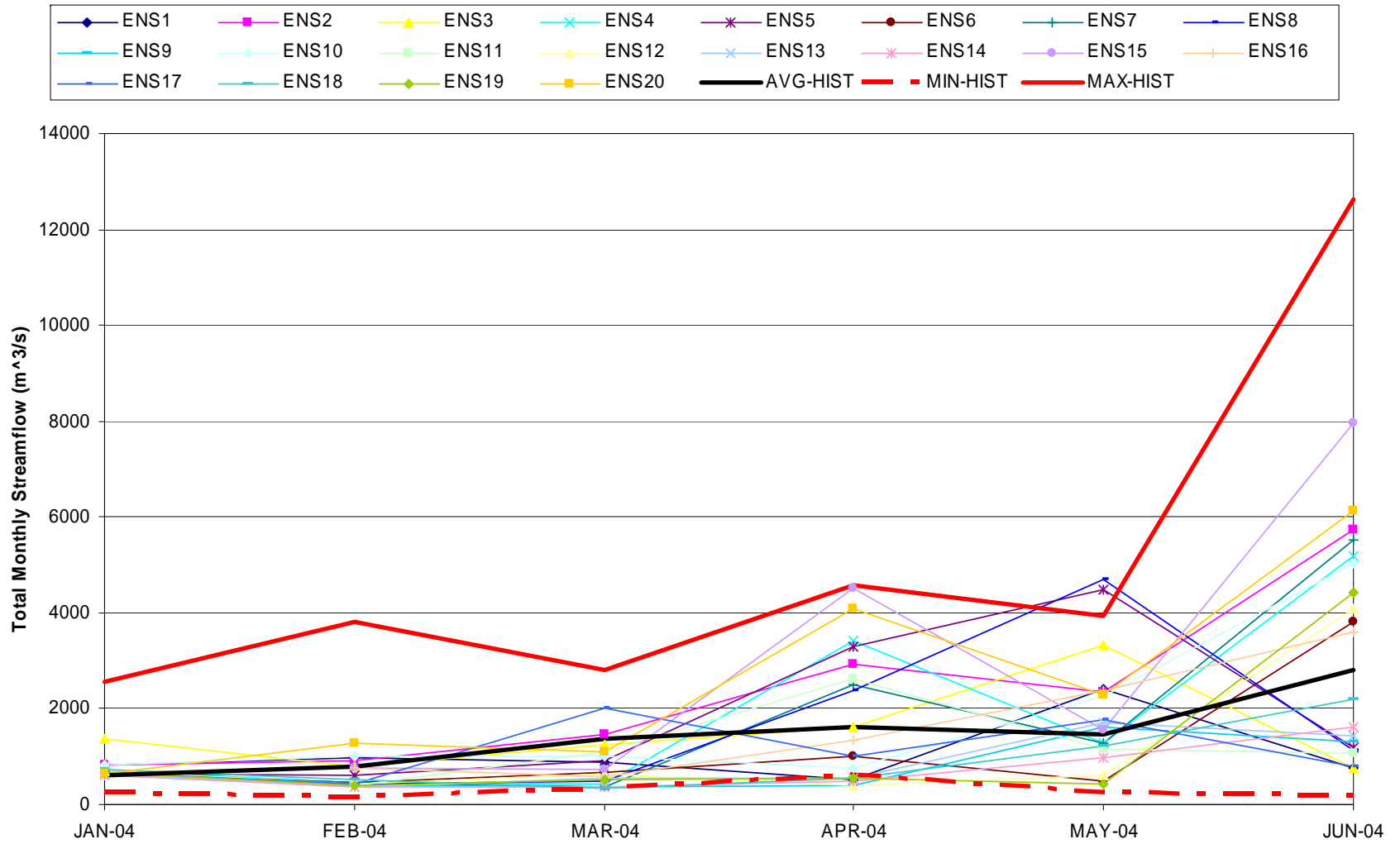
Time Series (29 of 29)

Type	File	DSN	Scenario	Location	Constituent	Start	SJ/day
WDM	TUALATIN	506	OBSERVED	BEAVERTO	PEVT	1934/1/1	27438
WDM	TUALATIN	601	OBSERVED	FORESTG	PREC	1934/1/1	27438
WDM	TUALATIN	606	OBSERVED	FORESTG	PEVT	1934/1/1	27438
WDM	TUALATIN	702	OBSERVED	SCOGGIN	PREC	1973/4/1	41773
WDM	TUALATIN	703	OBSERVED	USBR	FLOW	1940/10/1	29003
WDM	TUALATIN	801	COMPUTED	US634500	FLOW	1940/10/1	29003
WDM	TUALATIN	802	COMPUTED	US650001	FLOW	1972/9/30	41650
WDM	TUALATIN	803	OBSERVED	US635900	FLOW	1940/9/29	29003

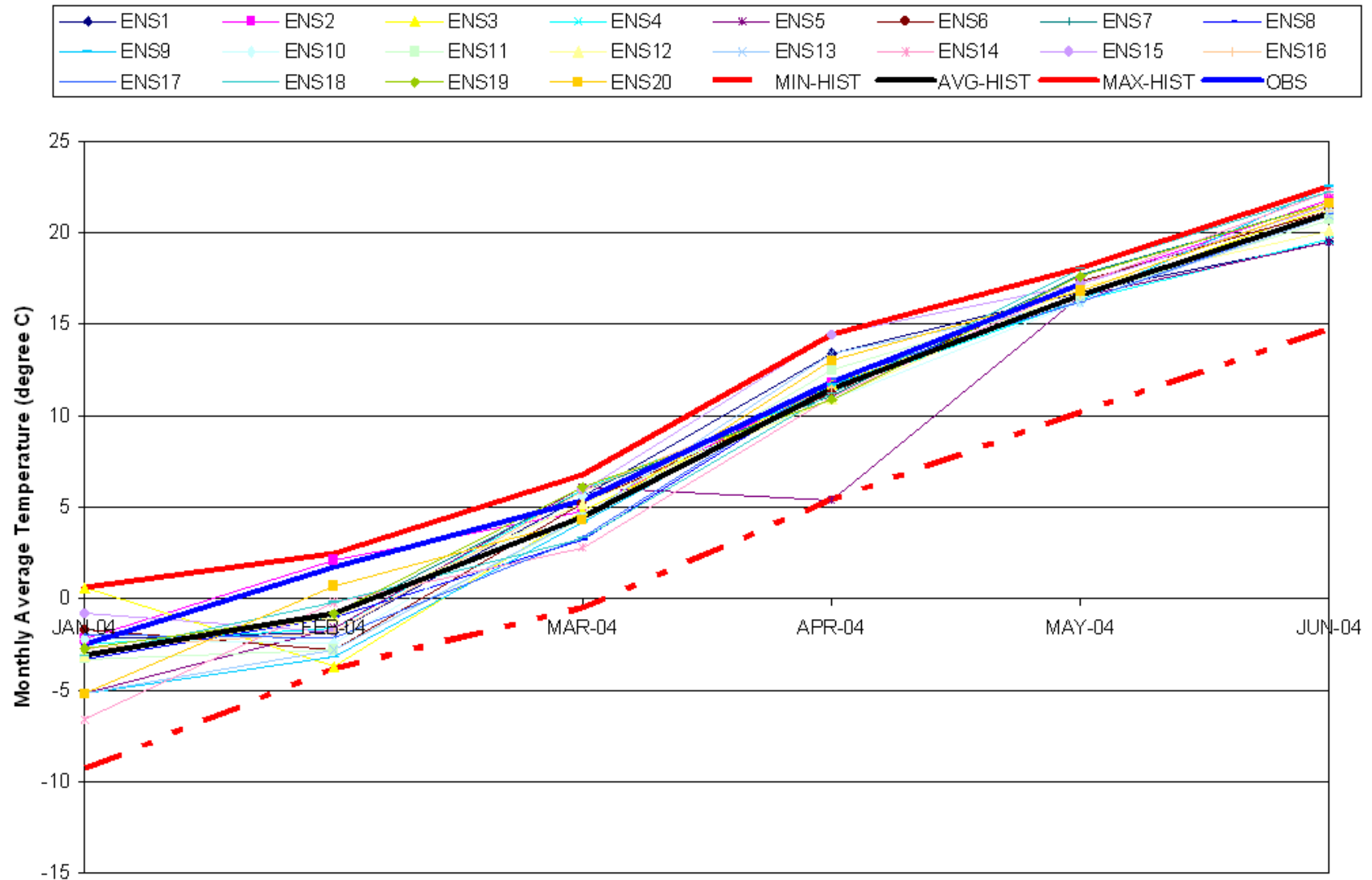
Dates: Reset Start End TStep Units  
Current: 1940/7/2 to 1990/9/30  
Common: 1924/7/2 to 2003/9/30 Native

Analysis: 111/222

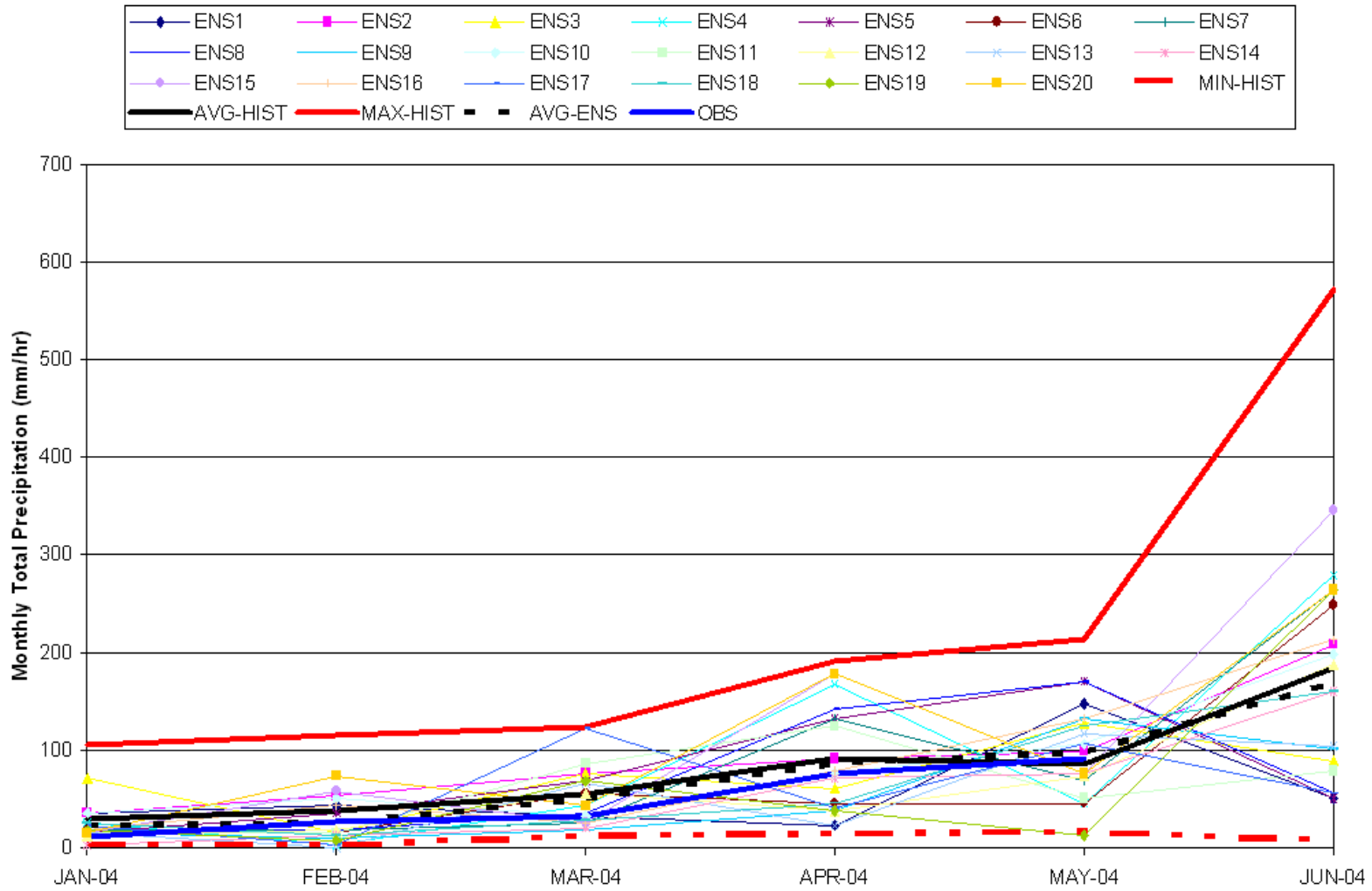
# Projected Inflow into Daechong Reservoir from Jan to Jun



# Projected average temperature at Guemsan station



# Projected Monthly Total Precipitation at Guemsan station



# GUI for Drought Indicators and values (STELLA 7.0)

**KumKang SPI (Standard Precipitation Index)**

**Drought Indicators**

3 Month SPI Input Panel

Daechon ▼

ChongJ	145
BoEun C	161.62
ChooPo	174.89
KumSan	174.04
BooYeo	179.6
KunSan	164.77

Daechong 3 Month SPI

ChungJu	<input type="text" value="-0"/>	KumSan	<input type="text" value="0"/>
BoEun	<input type="text" value="0"/>	BooYeo	<input type="text" value="0"/>
ChooPoongRyung	<input type="text" value="0"/>	KunSan	<input type="text" value="0"/>

Standard Precipitation Index SPI

Total Inflow From Jan to Apr Inflow

Average Storage in April Storage

**Inflow And Storage**

Inflow/Storage ▼

Daechong Infl	4292.27
Daechong Cur	60

Daechong Inflow Jan to Apr

Probability of Inflow

Percentile of Storage

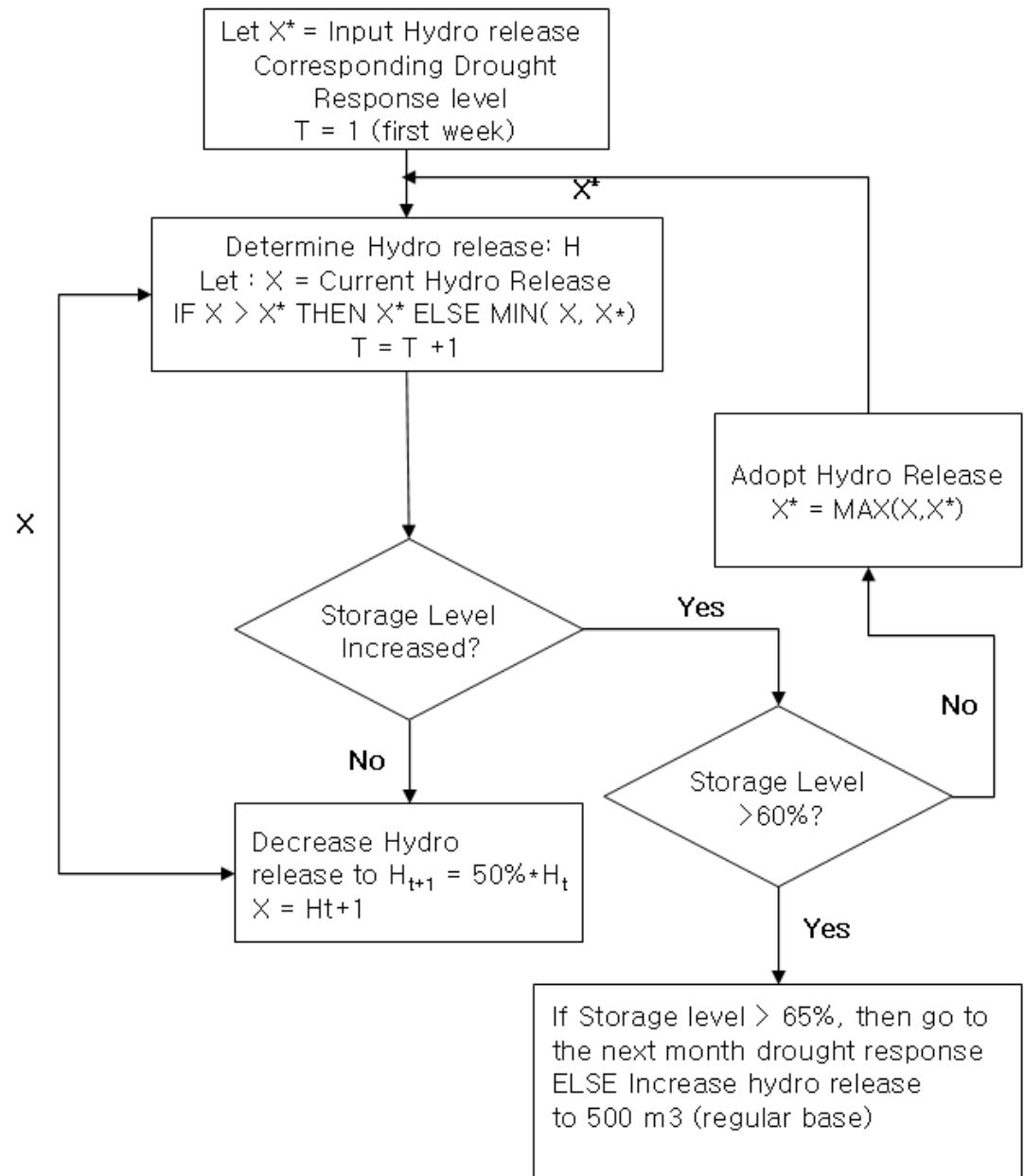
▶ Run

|| Pause

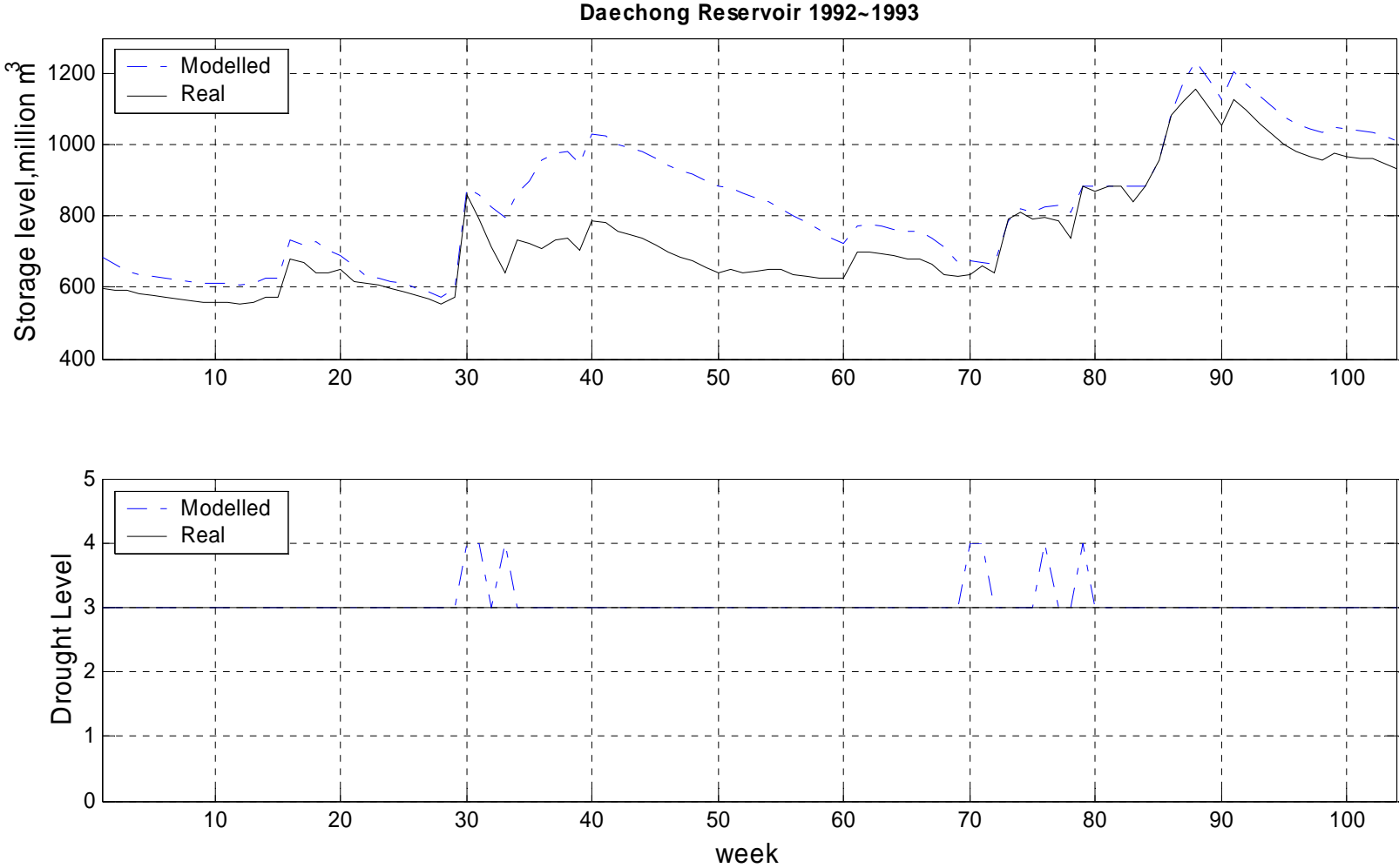
■ Stop

**Control Panel**

# Drought Response Procedure



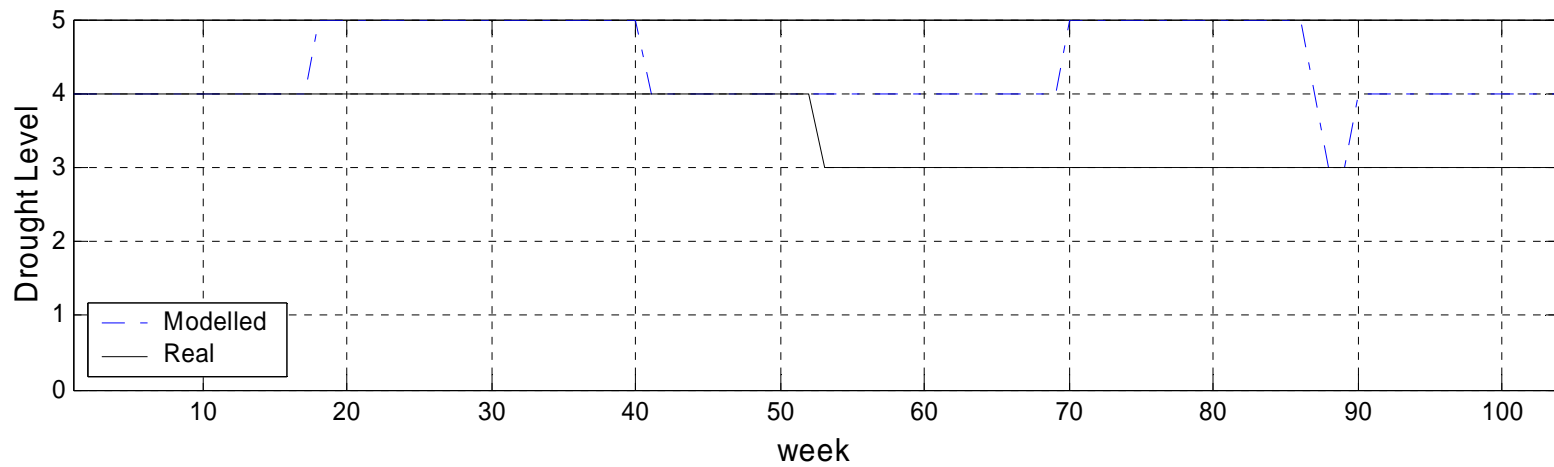
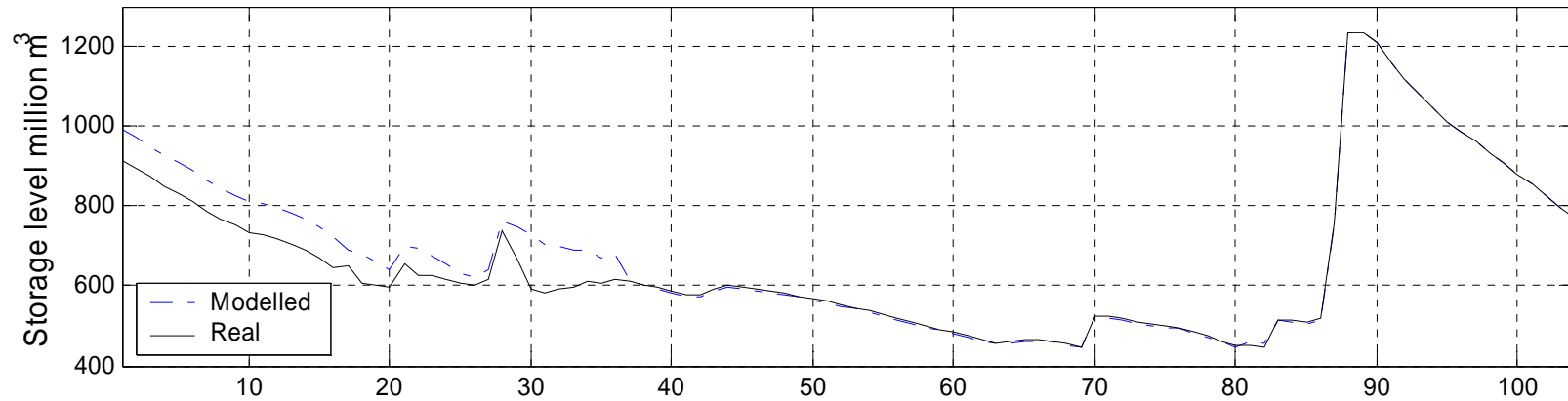
# Drought Management Model





# Drought Management Model – Cont'd

Daechong Reservoir 1994-1995



# Conclusion

- Drought indicator well represented historic drought condition
- Drought management model responds normal condition as a function of storage volume
- The model should include other variable (system wide-conservation, restriction, etc) to manage drought during severe condition
- 6 month lead-time NCEP forecast represents that this year is normal condition for study area

# Future Work

- Apply forecast data into drought management model
- Development of a local climate forecast model
- Compare the result between local forecast and NCEP forecast
- Forecast accuracy study



Question !!!



