Evaluation of Mercury Loads from Climate Change Projections for McTier Creek, South Carolina

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Outline

- Motivation and approach
- Climate projections
- Temperature and precipitation projections
- Flow and load projections
- Summary

Motivation

- Multiple models for McTier
- Downscaled climate projections readily available
- Conflicting climate projections for the SE
- Scale issues with climate projections
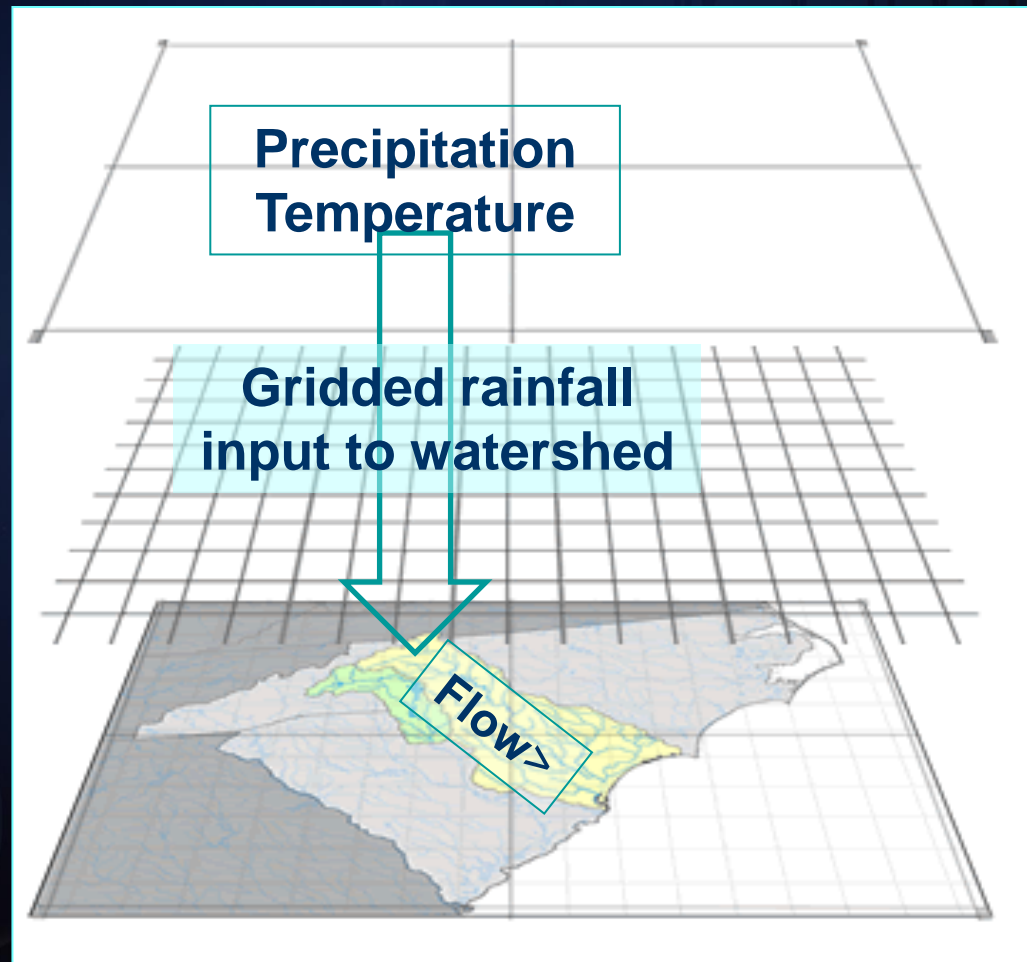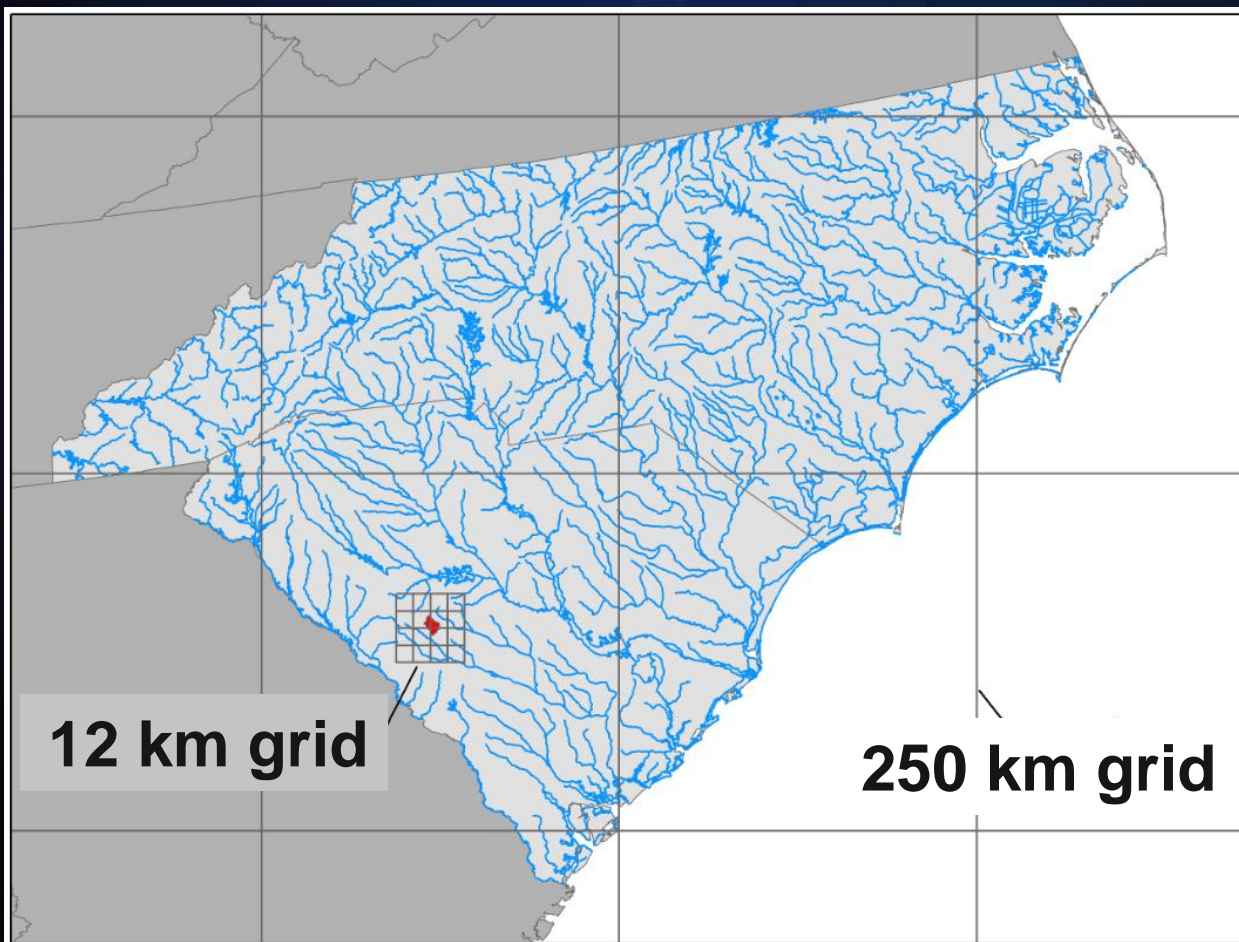- Is there any useful information to be gained?

Approach

Global circulation model (GCM)

Statistical downscaling of GCM Output

Watershed model

Scale issues

12 km grid

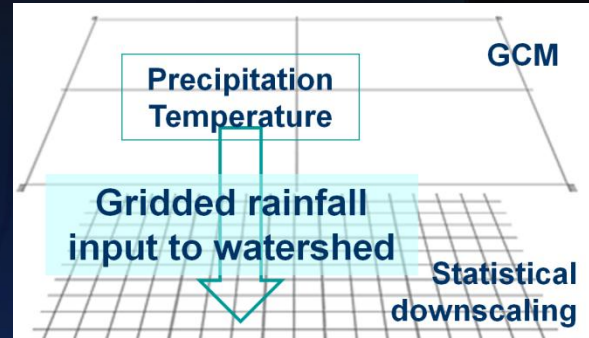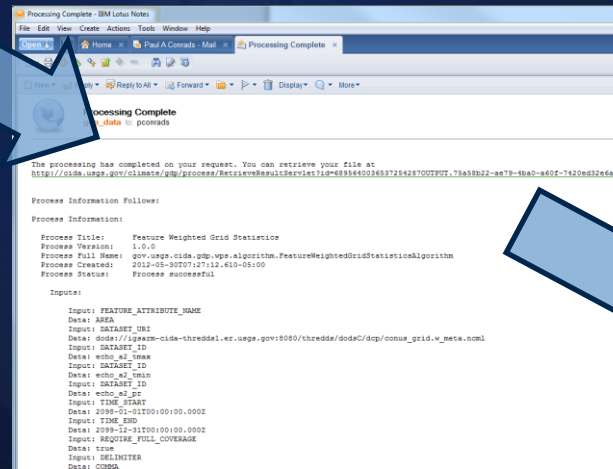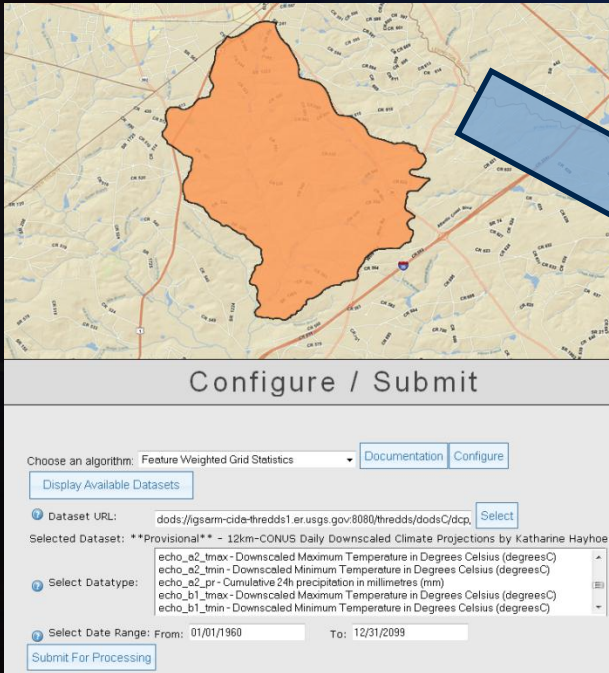250 km grid

GCM Models and Scenarios

- Two GCM models
  - ECHO-G (Germany/Korea)
  - CCSM3 (NCAR – Community Climate System Model)
- One emission scenario
  - A2 (business as usual)
- Two periods for analysis
  - 1980-2010
  - 2040-2070

Downscaling and Watershed Model

- **Statistical downscaling**
  - Katherine Hayhoe's data
  - Daily projections
- **Watershed model**
  - TOPMODEL (TOPography-based hydrologic MODEL; Bleven and Kirkby, 1979; Wolock, 1993)
  - Monthly simulations
- **Load Model**
  - TOPLOAD (Benedict and others, 2012)
    - Total Mercury (Hg)
    - Mass balance model
   - Monthly simulations

Climate Projections

GCM
Precipitation
Temperature
Gridded rainfall
input to watershed
Statistical
downscaling

Geo-Data Portal

Configure / Submit

Choose an algorithm: Feature Weighted Grid Statistics | Documentation | Configure

Display Available Datasets

Dataset URL: dods://igsarm-cida-thredds1.er.usgs.gov:8080/thredds/dodsC/dcp, | Select

Selected Dataset: **Provisional** – 12km-CONUS Daily Downscaled Climate Projections by Katharine Hayhoe

Select Datatype:
echo_a2_tmax – Downscaled Maximum Temperature in Degrees Celsius (degreesC)
echo_a2_tmin – Downscaled Minimum Temperature in Degrees Celsius (degreesC)
echo_a2_pr – Cumulative 24h precipitation in millimetres (mm)
echo_b1_tmax – Downscaled Maximum Temperature in Degrees Celsius (degreesC)
echo_b1_tmin – Downscaled Minimum Temperature in Degrees Celsius (degreesC)

Select Date Range: From: 01/01/1960 | To: 12/31/2099

Submit For Processing

Data .csv format

	A	B
1	# echo_a2_tmax	
2		7.94E+07
3	TIMESTEP	MEAN(degreesC)
4	2098-01-01T00:00:00Z	18.008774
5	2098-01-02T00:00:00Z	15.456142
6	2098-01-03T00:00:00Z	15.228239
7	2098-01-04T00:00:00Z	20.547836
8	2098-01-05T00:00:00Z	20.494158
9	2098-01-06T00:00:00Z	15.281949
10	2098-01-07T00:00:00Z	13.03721
11	2098-01-08T00:00:00Z	11.479358
12	2098-01-09T00:00:00Z	9.799923
13	2098-01-10T00:00:00Z	11.213561
14	2098-01-11T00:00:00Z	15.969288
15	2098-01-12T00:00:00Z	15.34086
16	2098-01-13T00:00:00Z	15.743985
17	2098-01-14T00:00:00Z	18.670277
18	2098-01-15T00:00:00Z	21.075275
19	2098-01-16T00:00:00Z	12.310971
20	2098-01-17T00:00:00Z	6.44212
21	2098-01-18T00:00:00Z	6.6957593
22	2098-01-19T00:00:00Z	13.900911
23	2098-01-20T00:00:00Z	13.47571
24	2098-01-21T00:00:00Z	4.961596
25	2098-01-22T00:00:00Z	10.136767

- Email notification

- Upload watershed shapefile
- Select GCM, emission scenario, & parameter

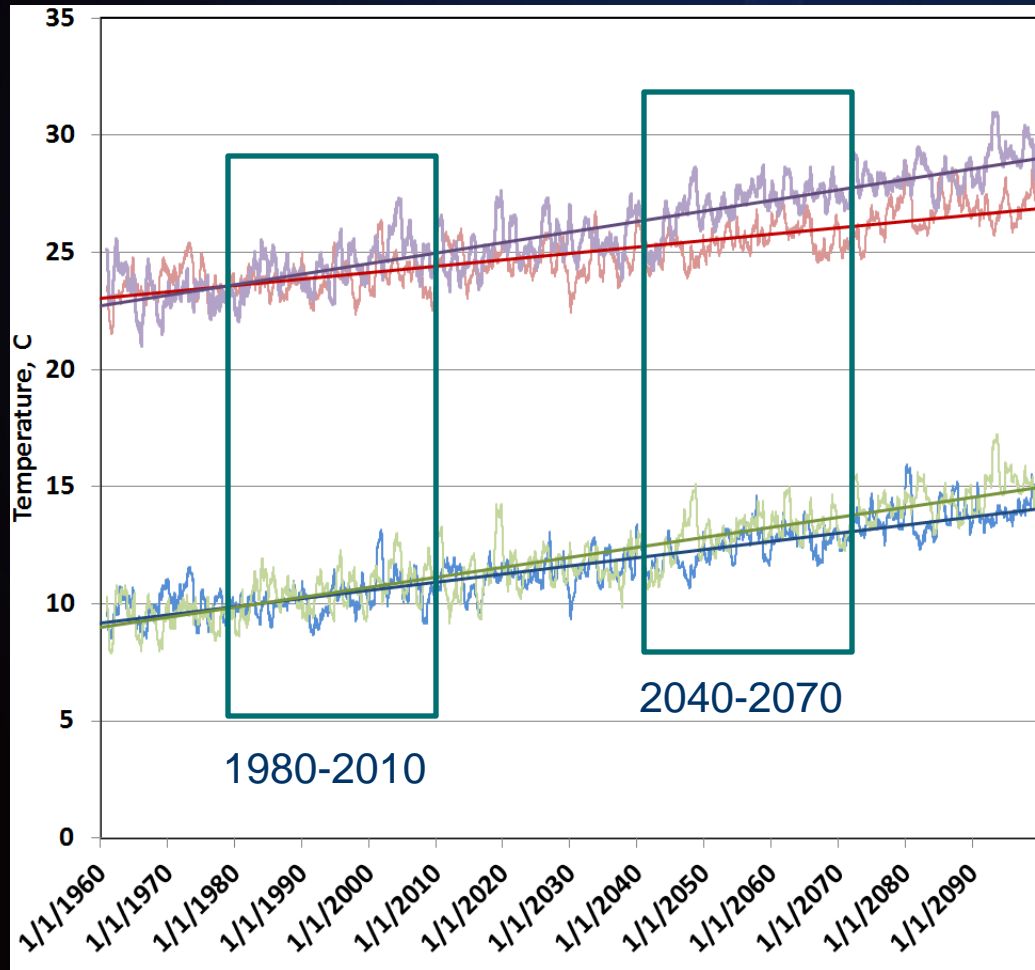URL: cida.usgs.gov

Precipitation projections
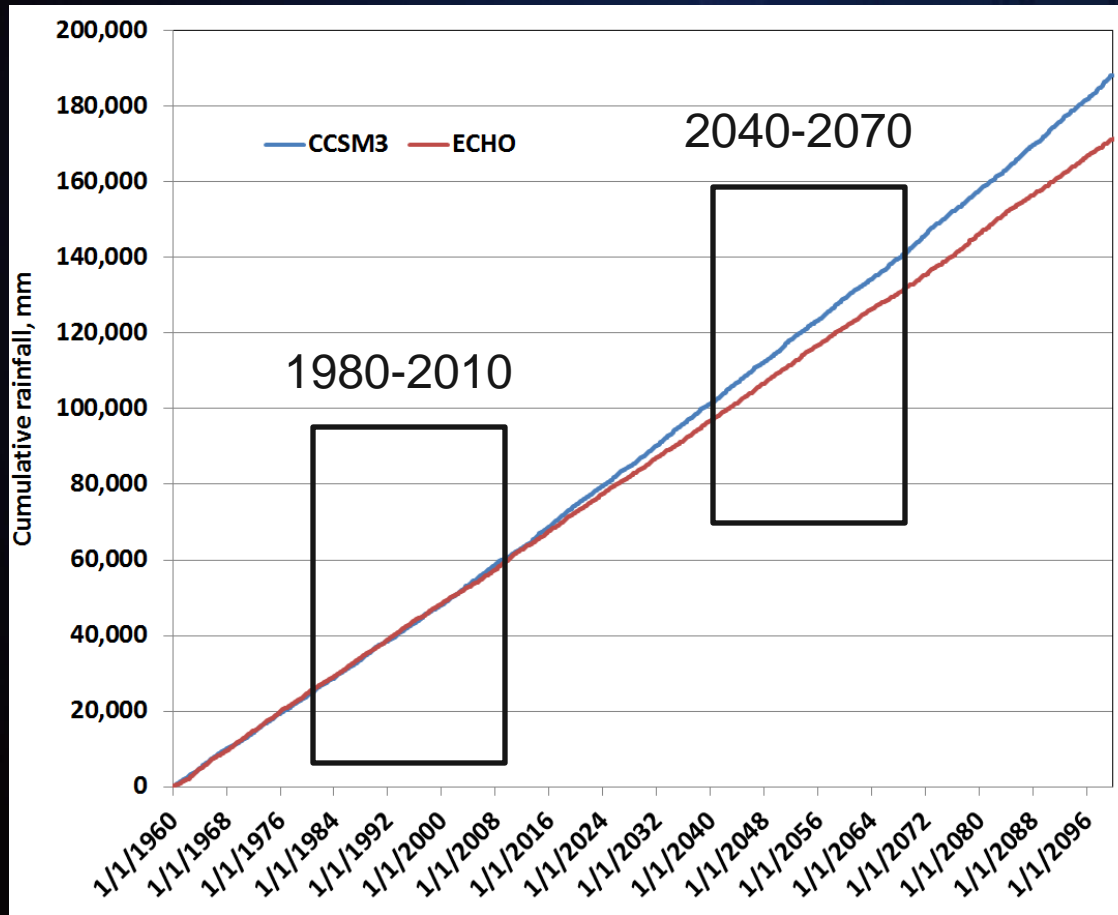
CCSM3 projecting more rainfall than ECHO

Temperature projections
360-day average temperature and trends
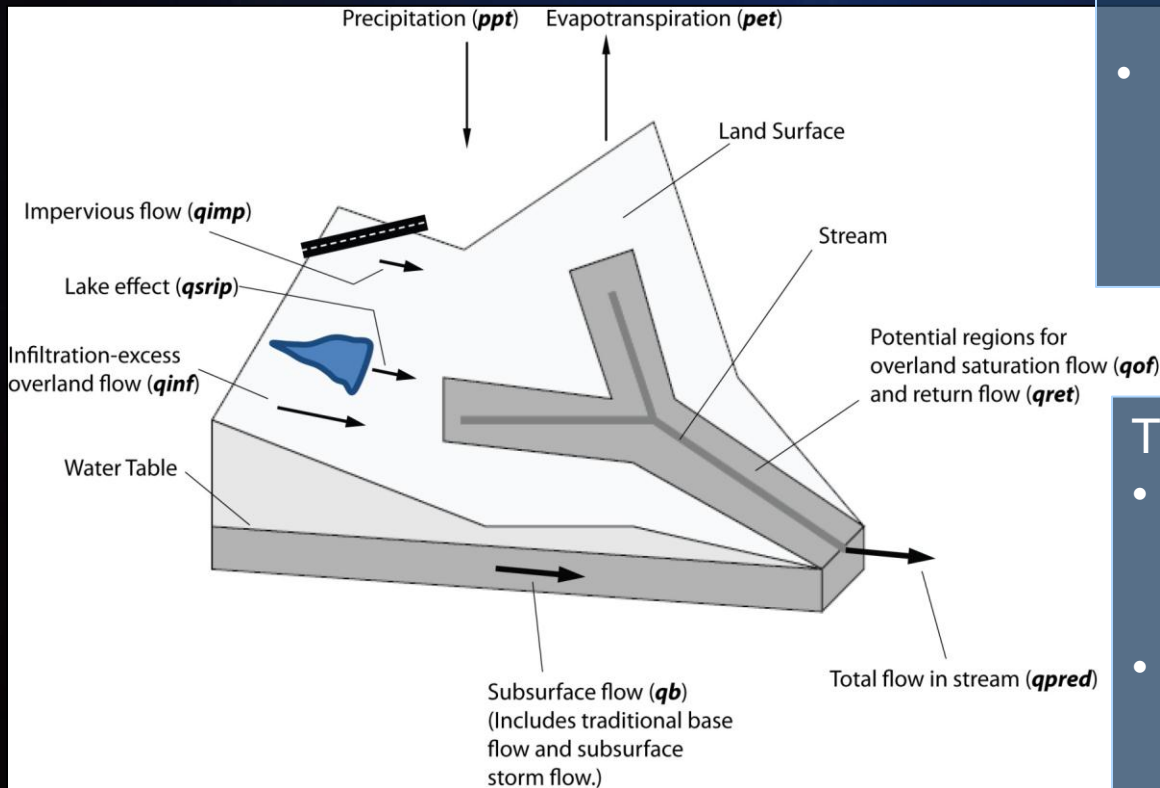

ECHO max

CCSM3 max

ECHO min

CCSM3 min

2040-2070

1980-2010

CCSM3 – wetter and cooler
ECHO – drier and warmer

Flow and Load Model
TOPMODEL and TOPLOAD

Precipitation (**ppt**)   Evapotranspiration (**pet**)

Land Surface

Impervious flow (**qimp**)

Lake effect (**qsrip**)

Stream

Infiltration-excess overland flow (**qinf**)

Potential regions for overland saturation flow (**qof**) and return flow (**qret**)

Water Table

Subsurface flow (**qb**) (Includes traditional base flow and subsurface storm flow.)

Total flow in stream (**qpred**)

TOPMODEL
- variable source area model
- Simulate surface and subsurface flow paths

TOPLOAD
- Assigns concentrations to flow paths
- No Hg dynamics or watershed Hg dynamics

Flow Simulations
GCM data vs. measured conditions
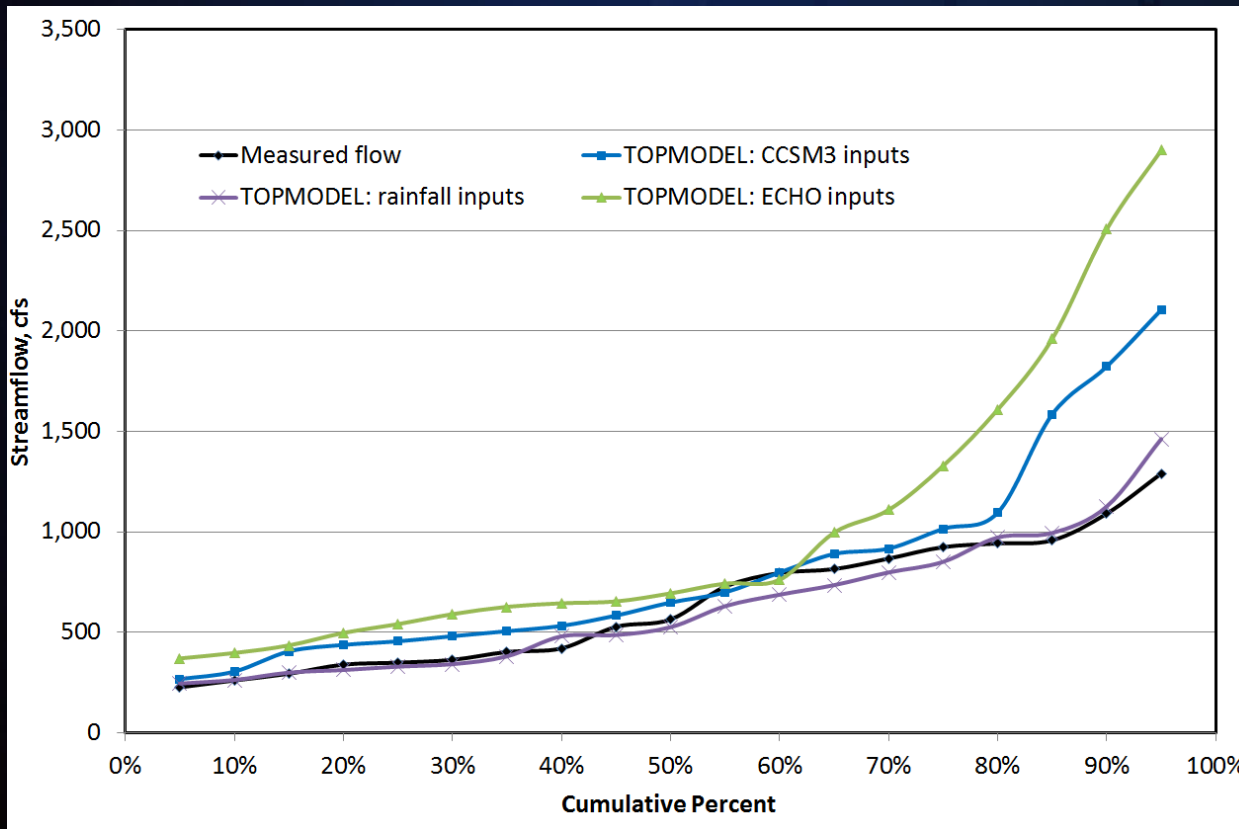
May 2007 – October 2009

Climate Change Flow Projections
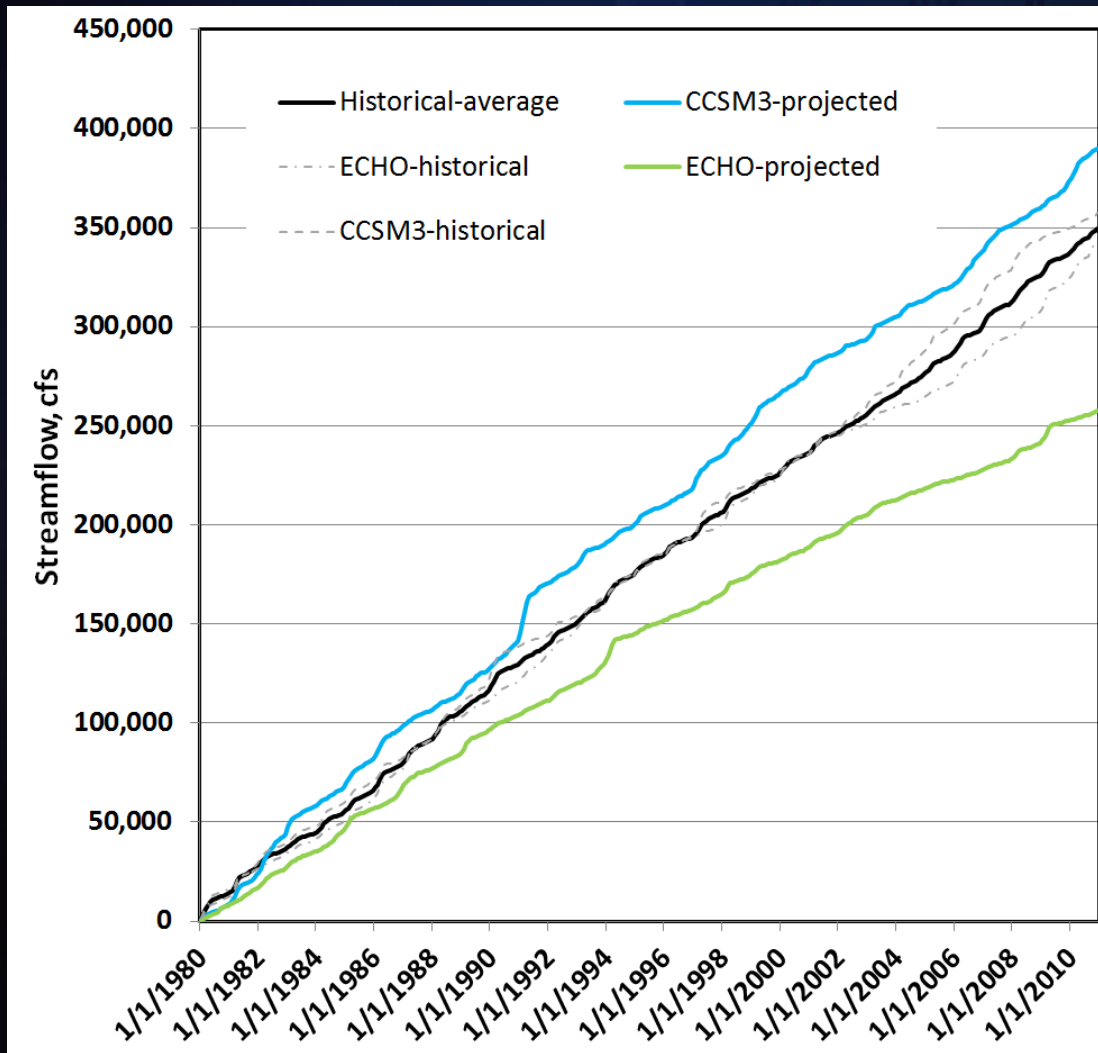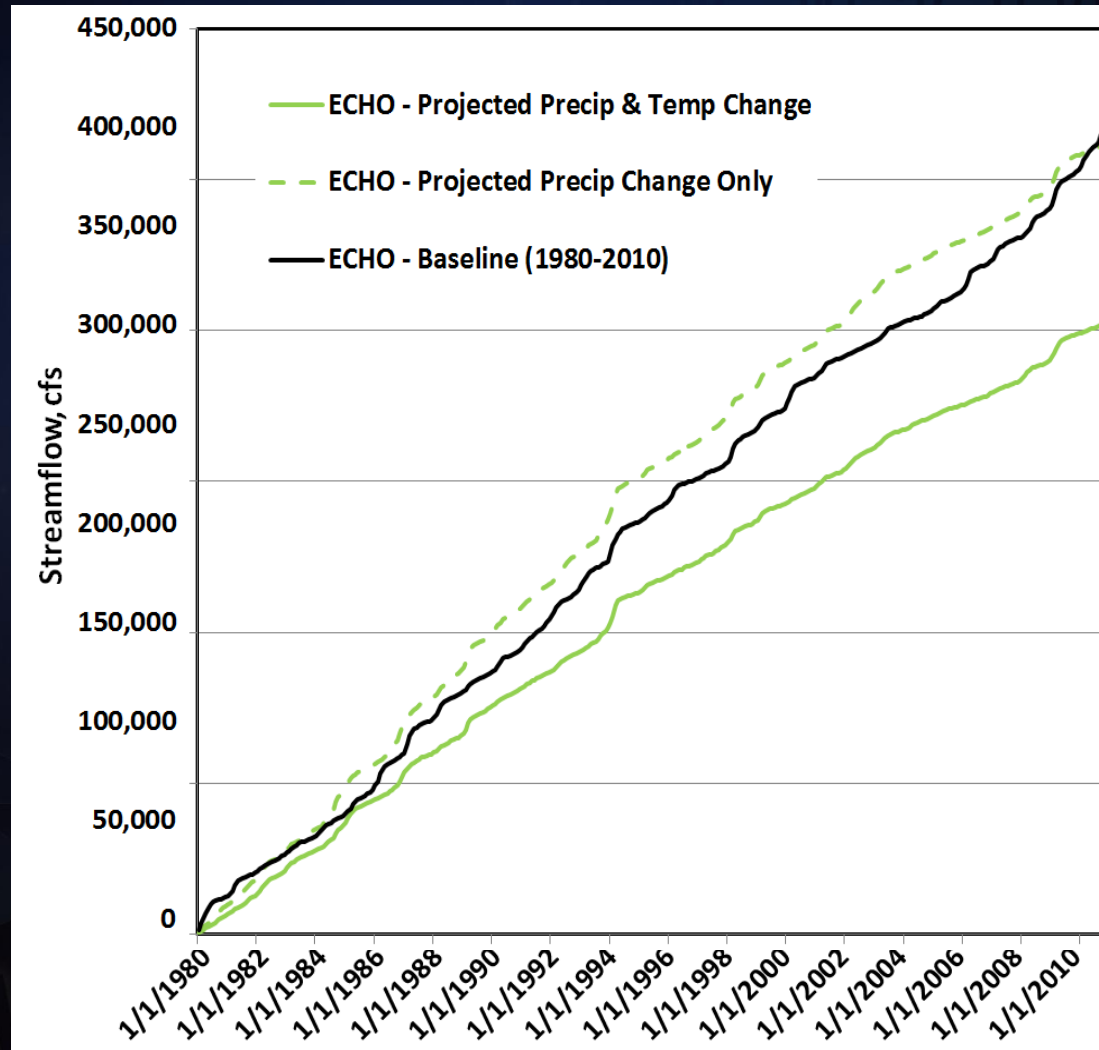
Climate Change Flow Projections
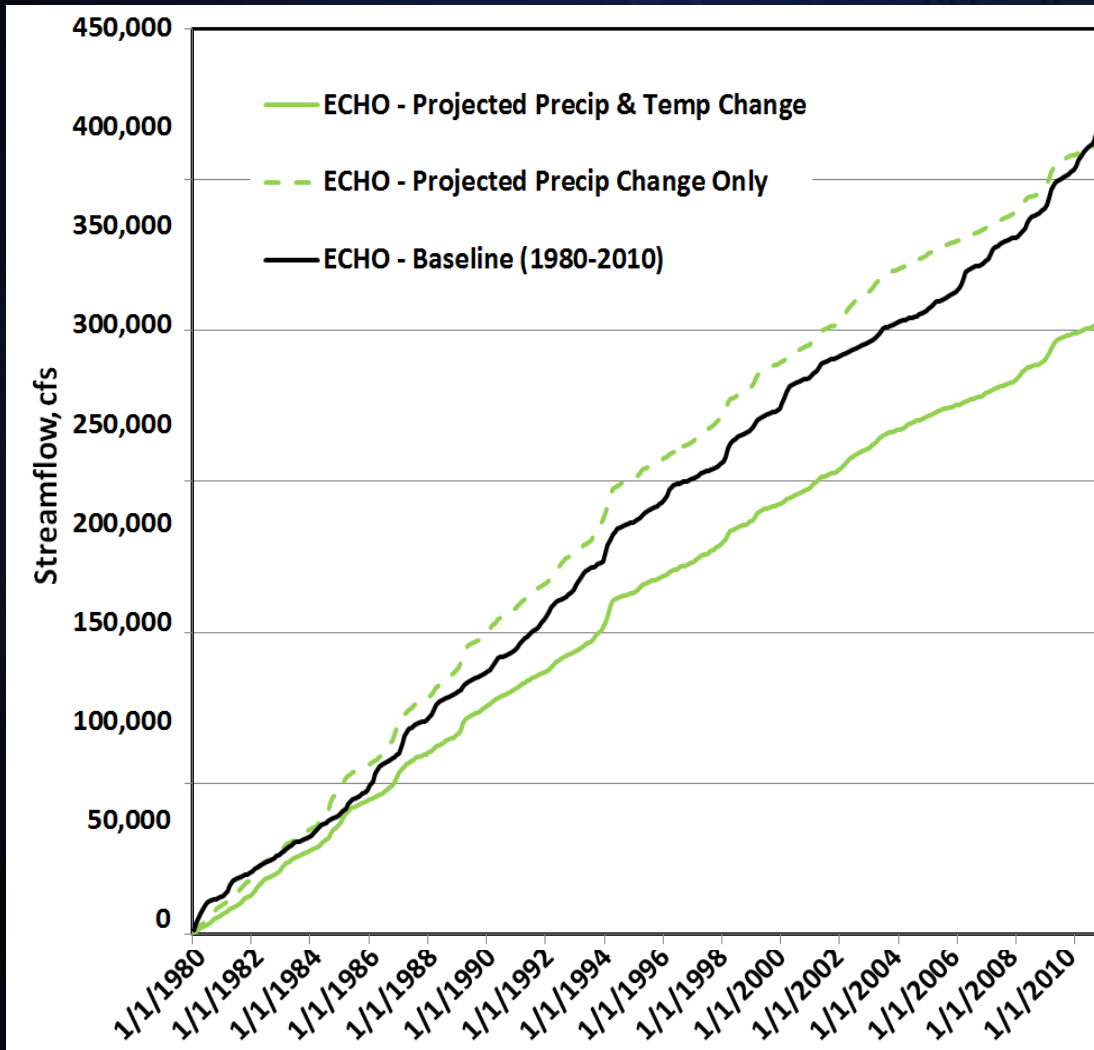
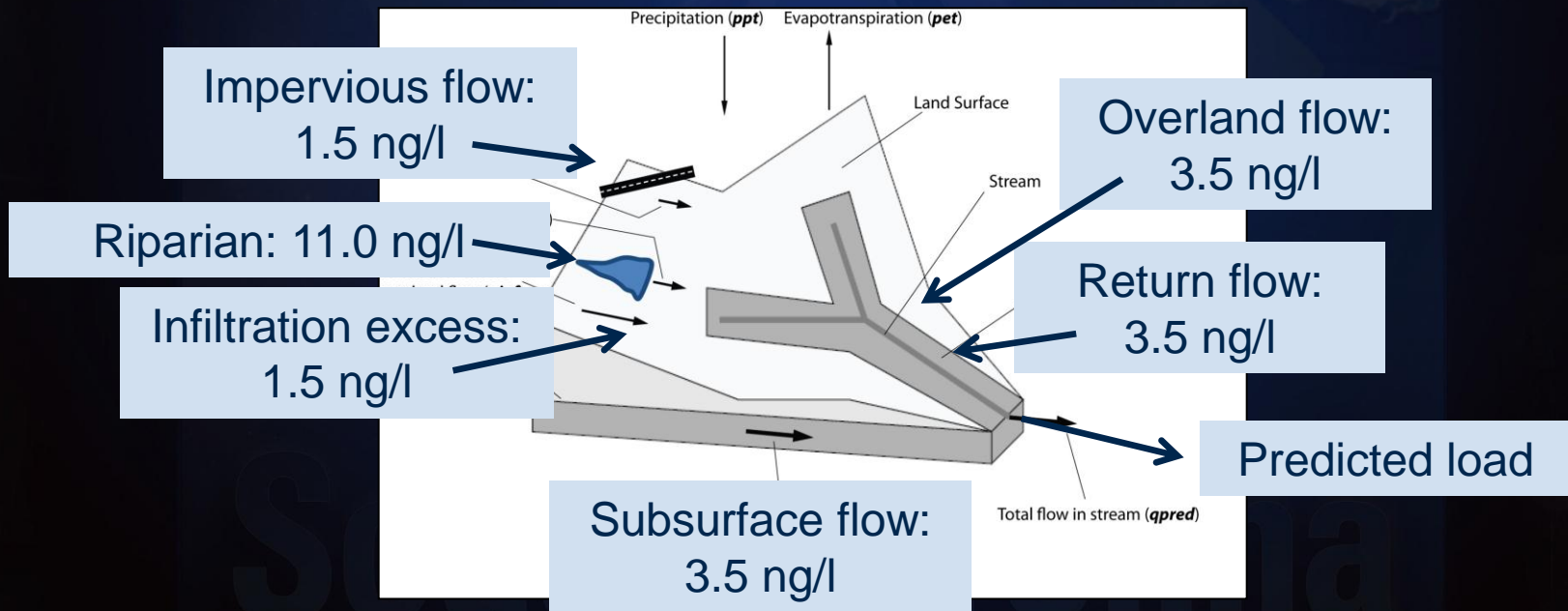# Temperature sensitivity
CCSM3
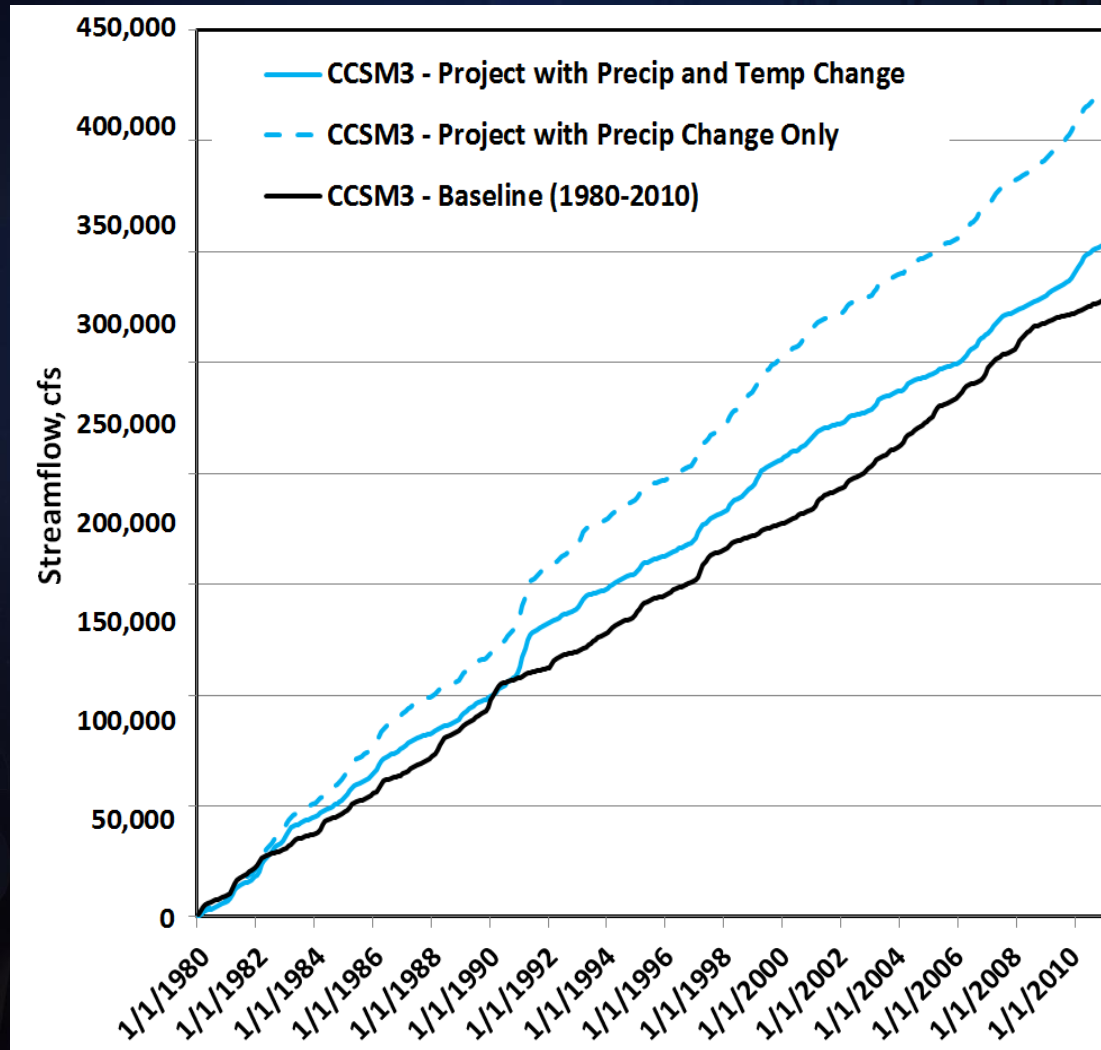
Temperature sensitivity
ECHO
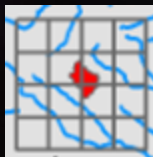
A Look at Loads

Assignment of Concentration for TOPLOAD Model and Selection of Components to be Plotted

Selected Water-Quality Constituent for TOPLOAD Model:		TOPLOAD Load Components					
Total mercury (filtered pus particulate total mercury), in nanograms per liter		**TOPLOAD (qof)	TOPLOAD (qinf)	TOPLOAD (qb)	TOPLOAD (qret)	TOPLOAD (qimp)	TOPLOAD (qsrip)
Concentration (Enter value in cells manually):	ng/l	3.50	1.50	3.50	3.50	1.50	11.00

Impervious flow: 1.5 ng/l

Riparian: 11.0 ng/l

Infiltration excess: 1.5 ng/l

Overland flow: 3.5 ng/l

Return flow: 3.5 ng/l

Predicted load

Subsurface flow: 3.5 ng/l

Concentrations for Total Hg

Measured vs. Predicted Loads

R2 = 0.59
ME = 33 mg/day
RMSE = 169 mg/day
Percent error = 9%
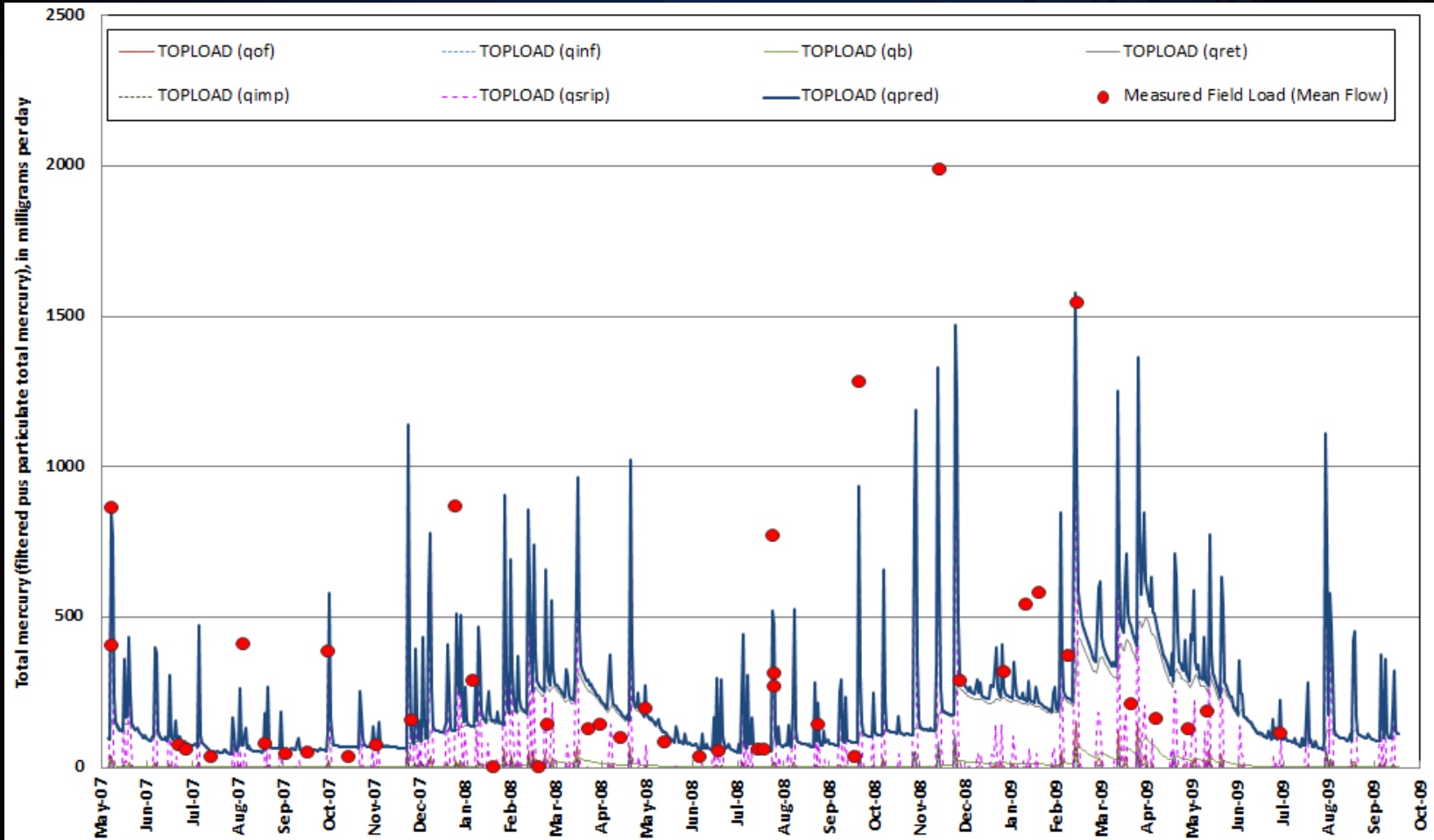
May 2007 – October 2009

Projected Total Hg Load
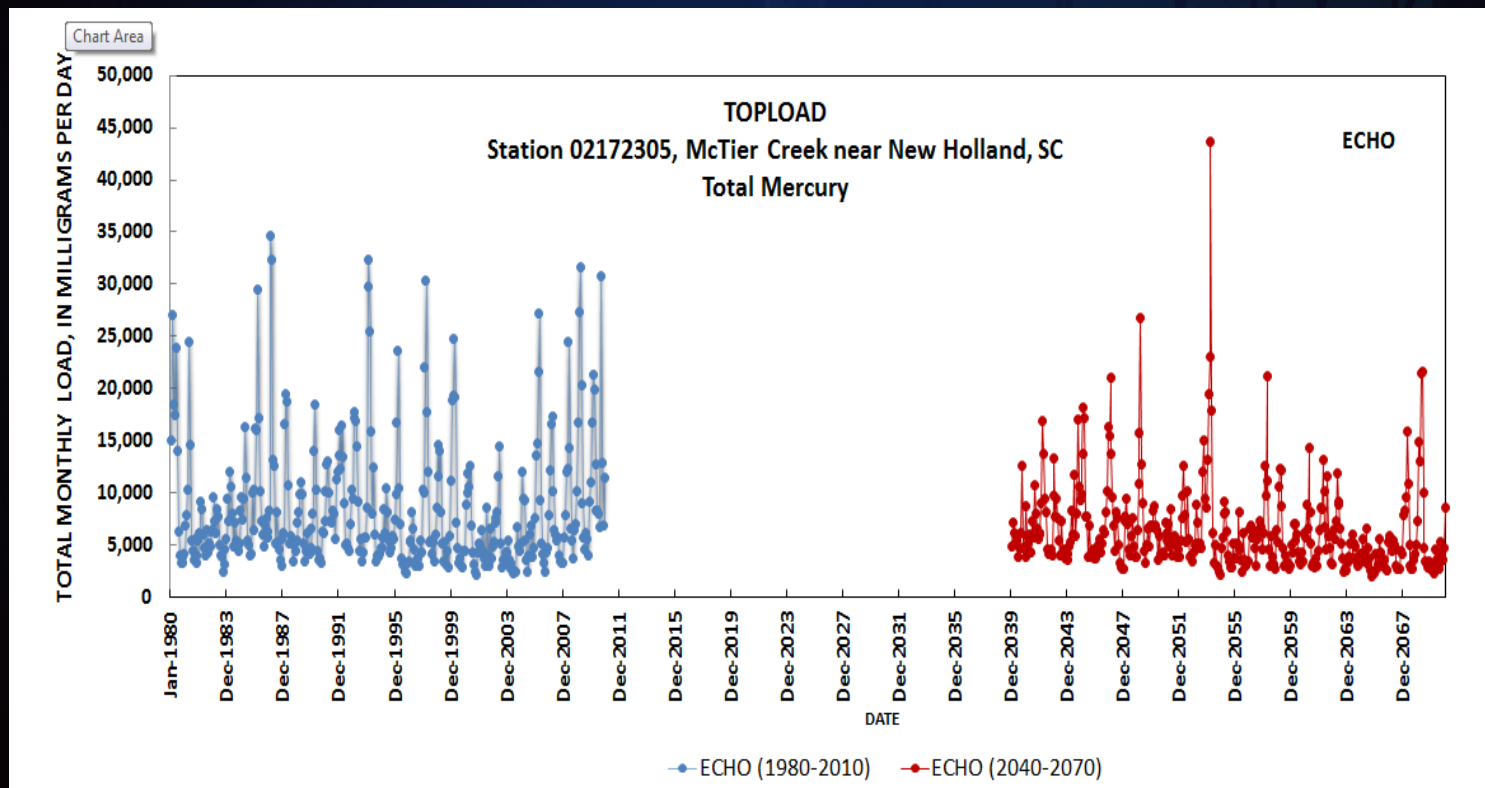
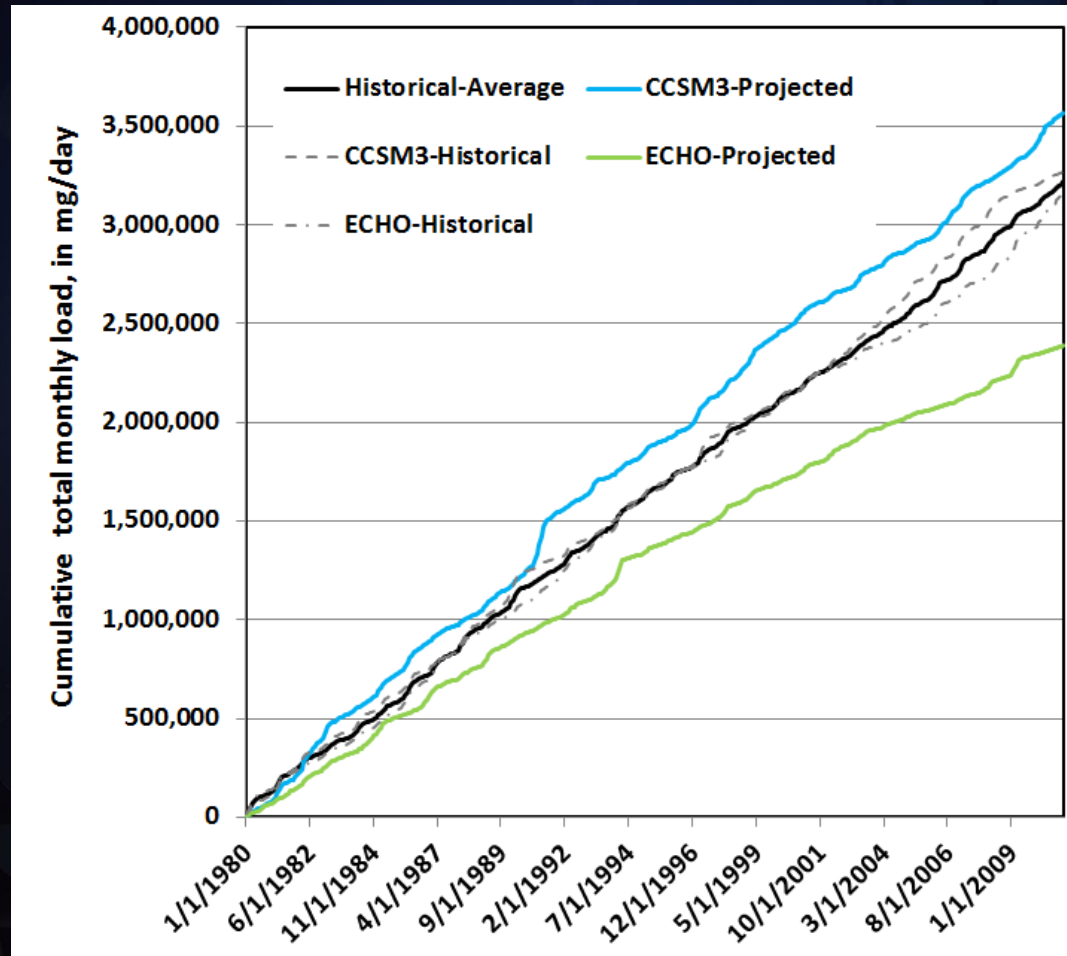1980 - 2010   2040 - 2070
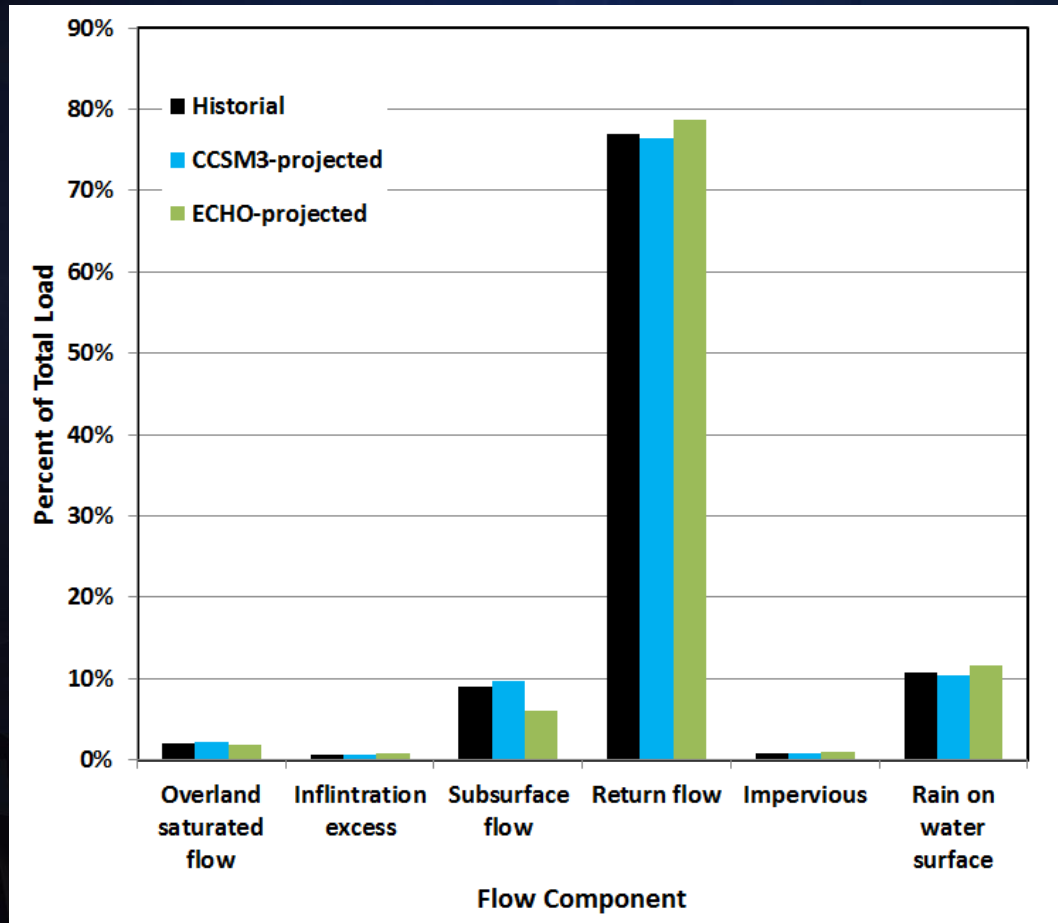
Cumulative Total Hg Load

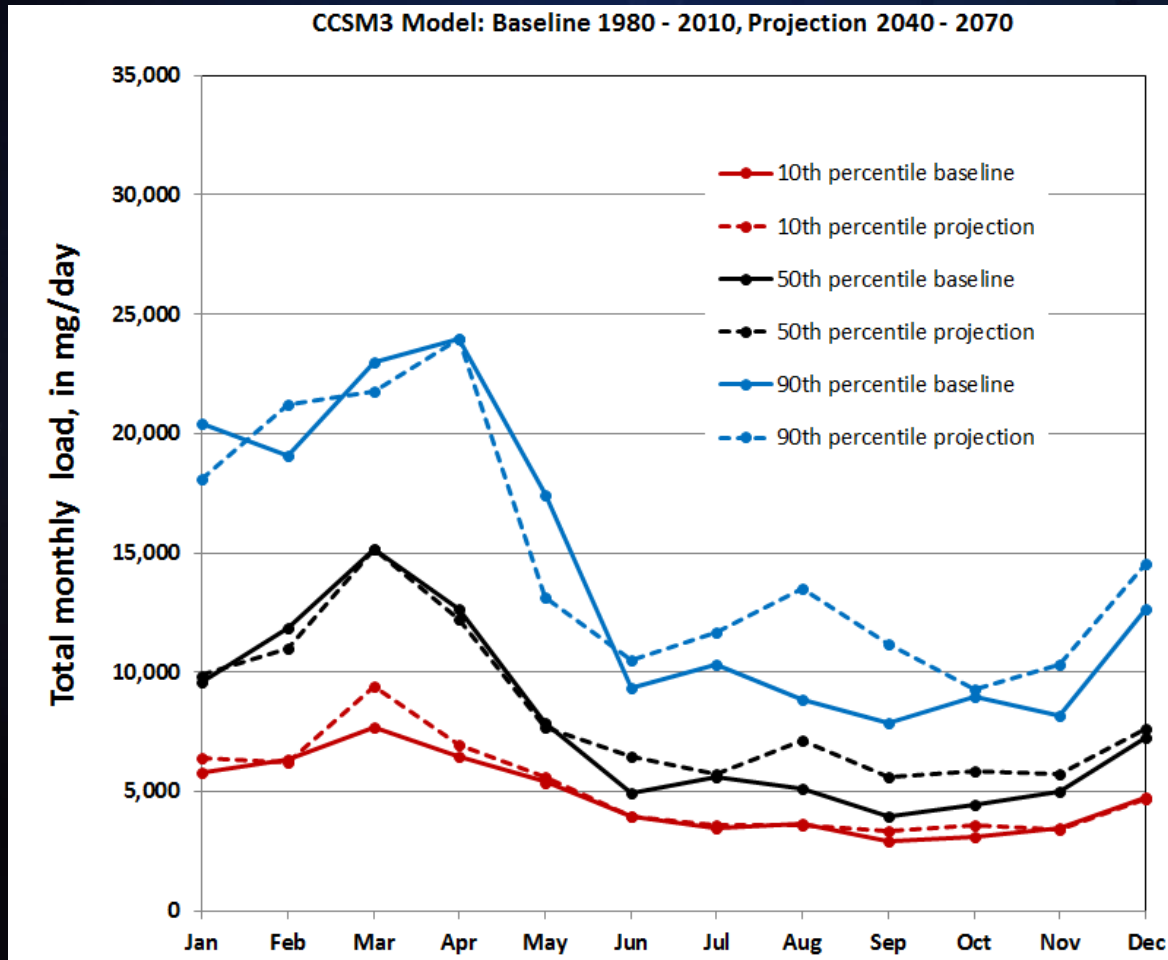# Flow Components Percent of Total Load

CCSM3
Monthly Durations -Total Load

CCSM3 Model: Baseline 1980 - 2010, Projection 2040 - 2070

CCSM3
Monthly Durations –Return Flow

CCSM3 Model: Baseline 1980 - 2010, Projection 2040 - 2070

CCSM3
Monthly Durations: Subsurface

CCSM3 Model: Baseline 1980 - 2010, Projection 2040 - 2070
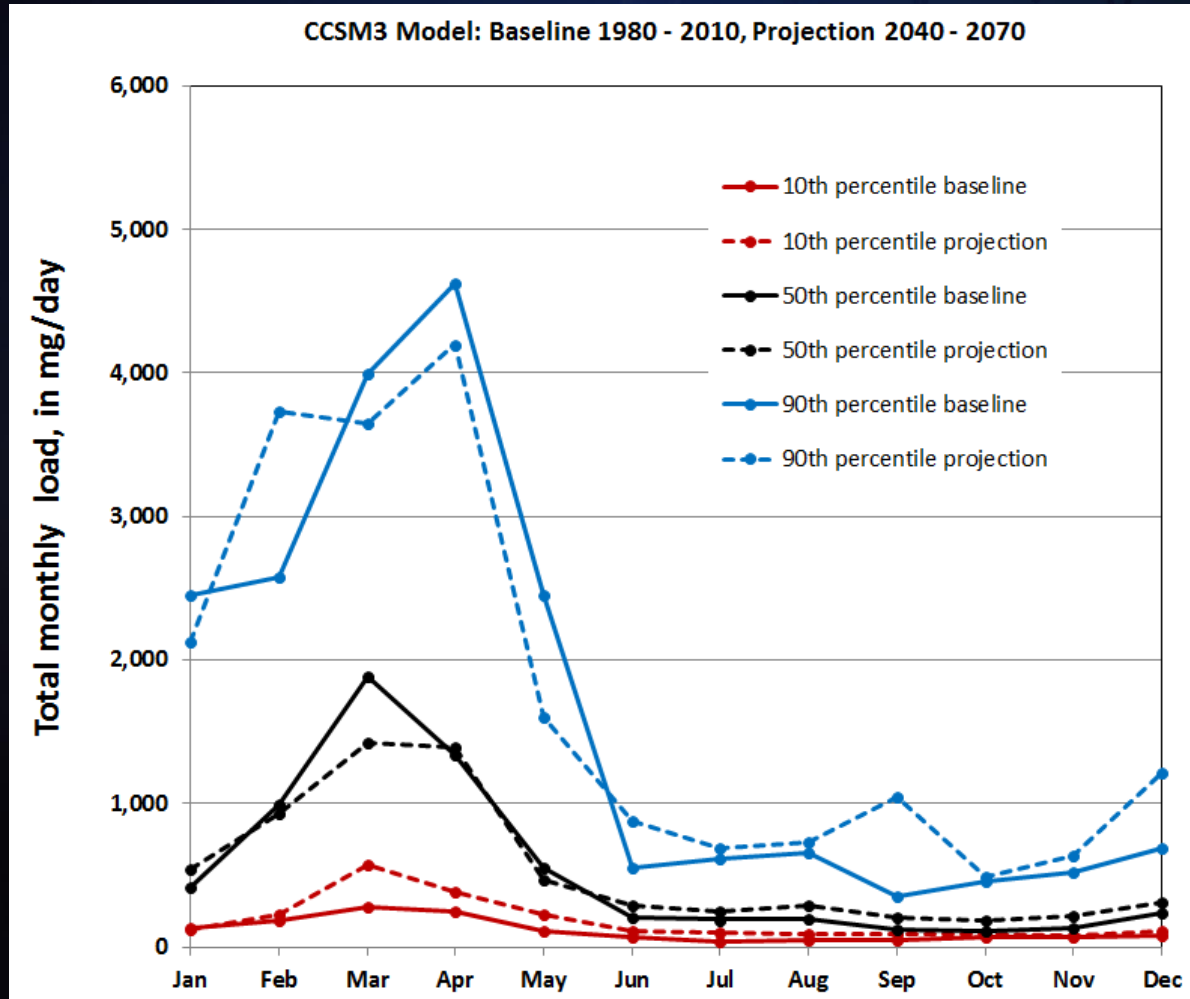
ECHO – Monthly Durations: Total Load

ECHO –
Monthly Durations: Return Flow

ECHO Model: Baseline 1980 - 2010, Projection 2040 - 2070

ECHO
Monthly Durations: Subsurface

ECHO Model: Baseline 1980 - 2010, Projection 2040 - 2070
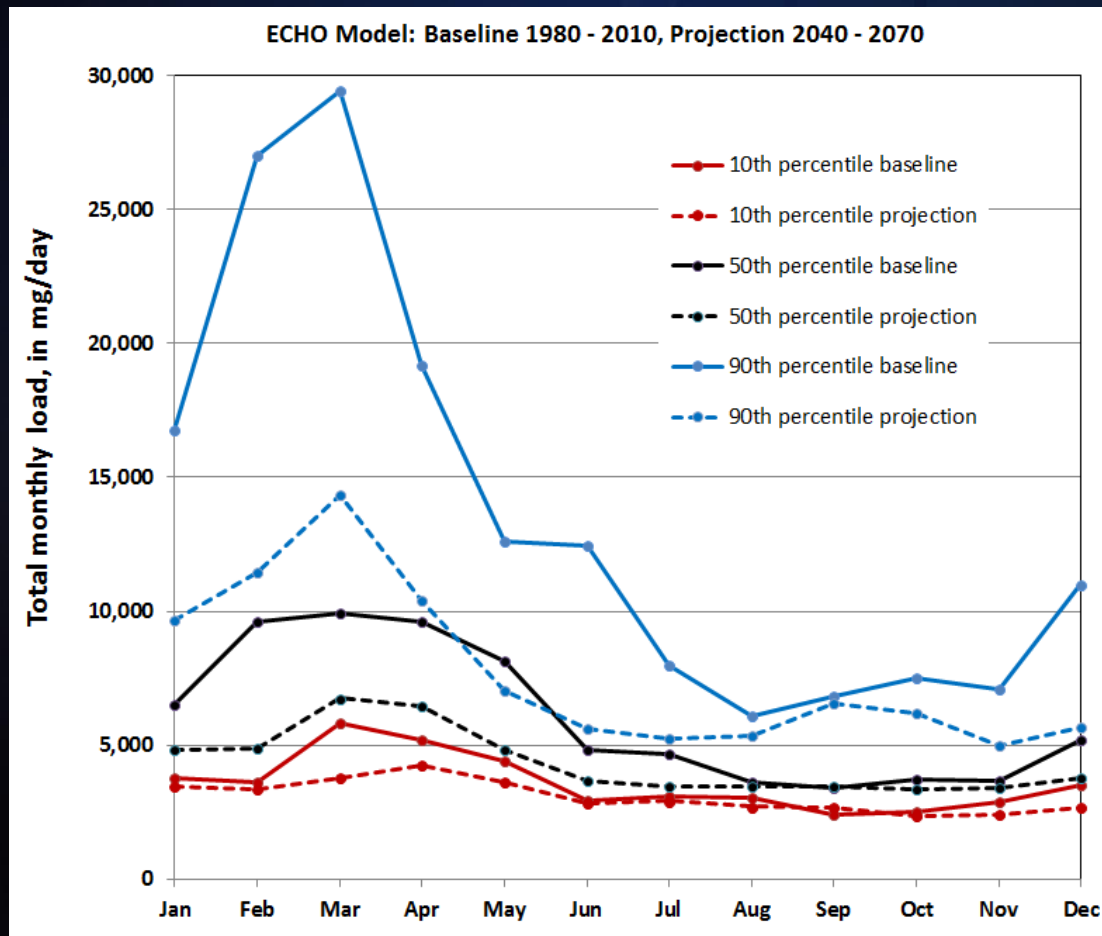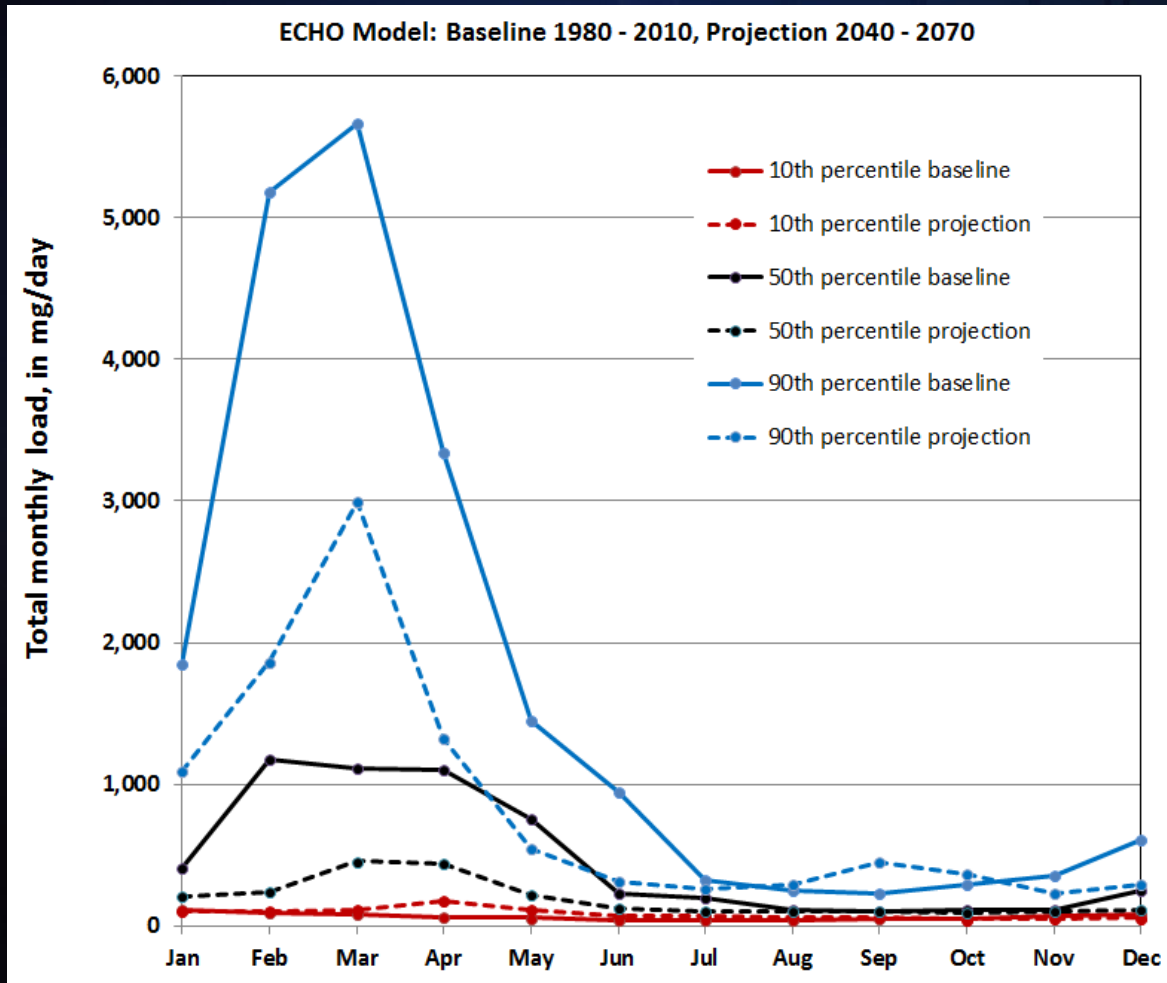
Summary

- GCM conflicting precipitation projections
- Consensus between GCMs on some seasonal Total Hg loads
  - Decreasing Winter and Spring load
- GCM differ on Summer and Fall loads
  - CCSM3 - increase in loads
  - ECHO – decrease in loads

Summary

- Multiple models offers approach to constraining potential climate change projections effects

- From this limited analysis, scale of McTier vs. GCM did not appear to be an issue

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