

Development of a Decision Support System for Estimating Salinity Intrusion Effects due to Climate Change on the South Carolina and Georgia Coast

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Outline

- Problem
- Data
- Model & Decision Support System
- Results
- Conclusion

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Threaten Intakes along SE Coast Due to Climate Change

- **Sea-level rise**
- **Changing streamflow patterns**
- **Inputs from GCMs**



Short Review Salinity Dynamics

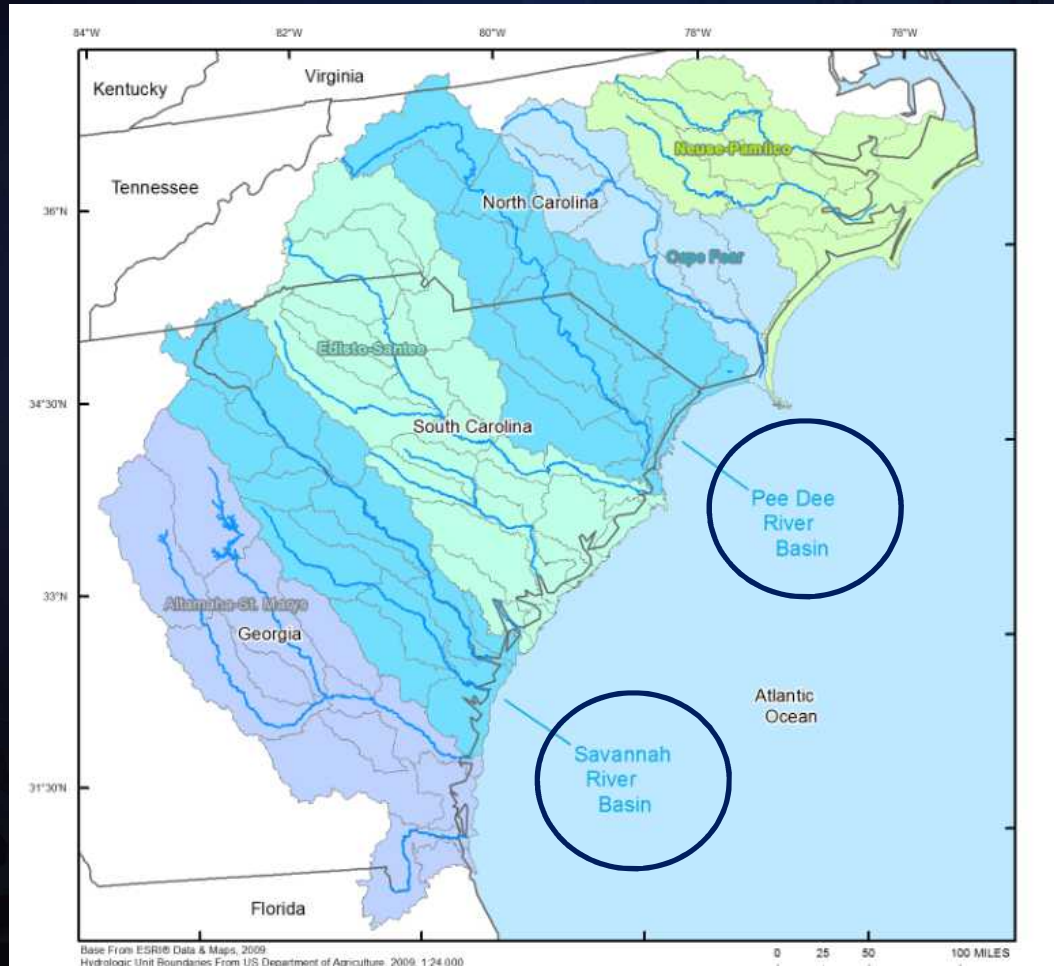


“...estuaries may never really be steady-state systems; they may be trying to reach a balance they never achieve.”

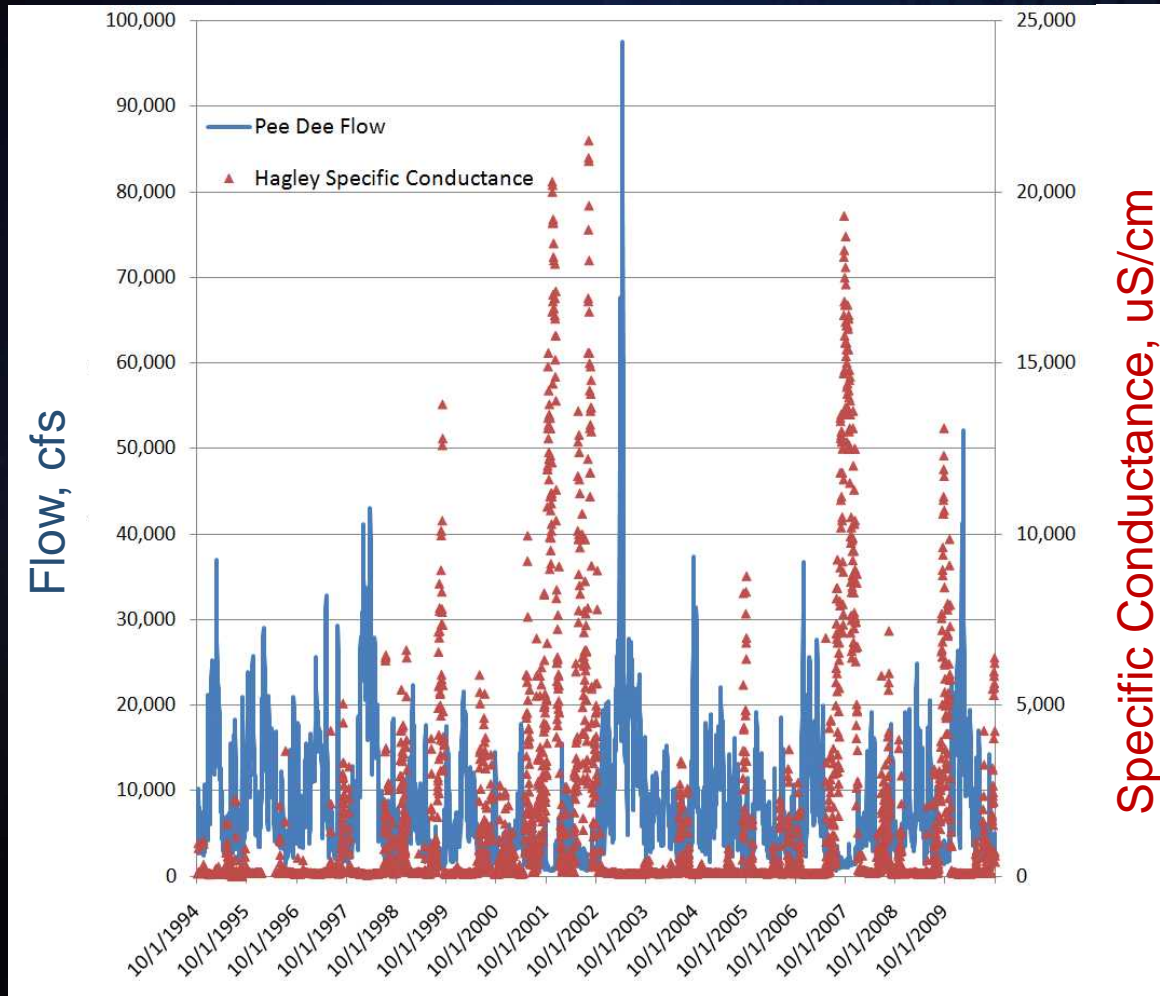
Keith Dyer, from Estuaries – A Physical Introduction (1997)

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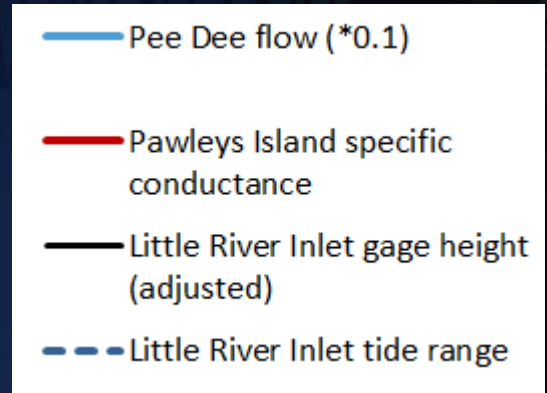
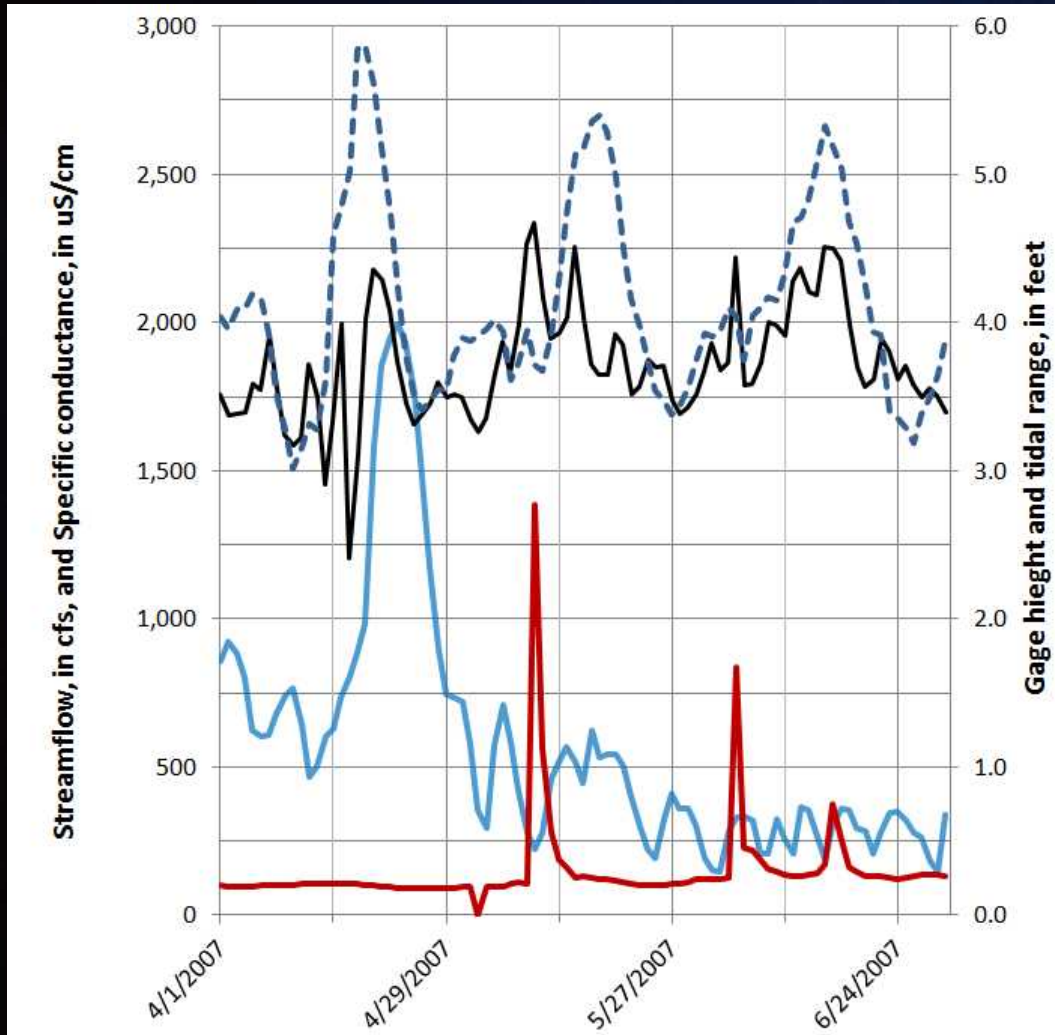
Flow and Salinity Data



Yadkin-Pee Dee Basin



Converging Conditions: Waccamaw River Pawleys Island Gage

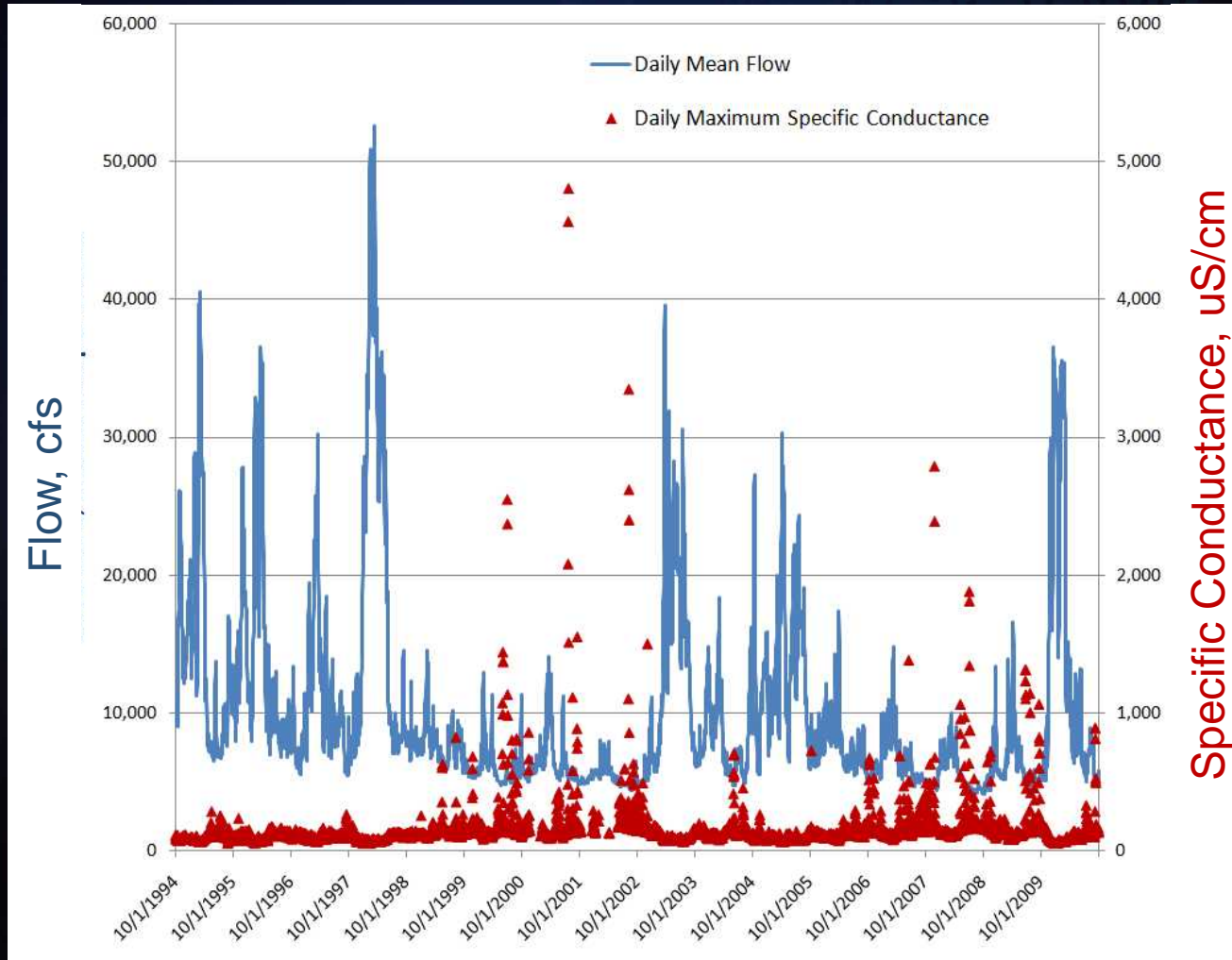


Flows < ~5,000 cfs

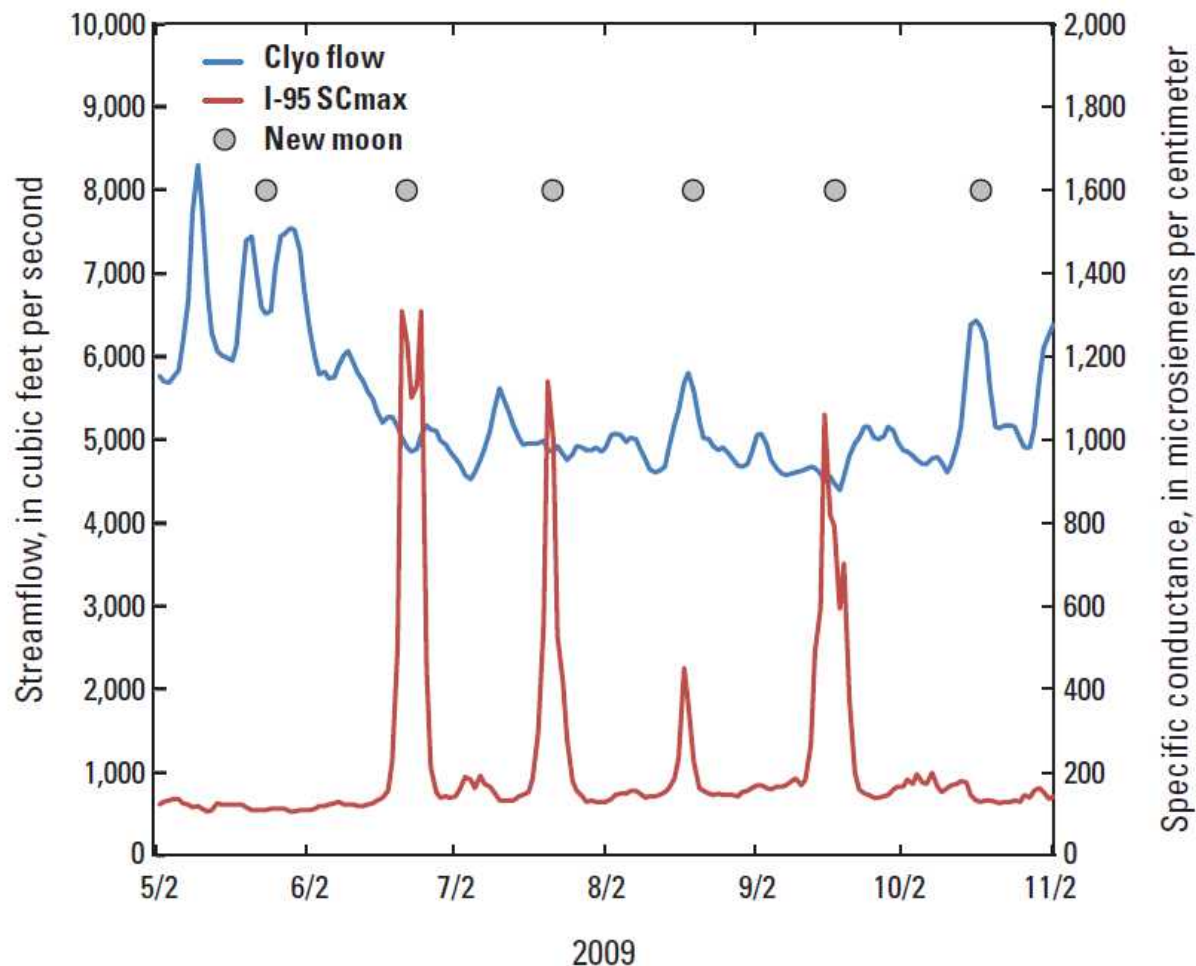
Water levels > ~4.5 ft

Tidal range ~

Savannah River Basin



Converging Conditions: Savannah River



Models & Decision Support Systems

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Data Mining

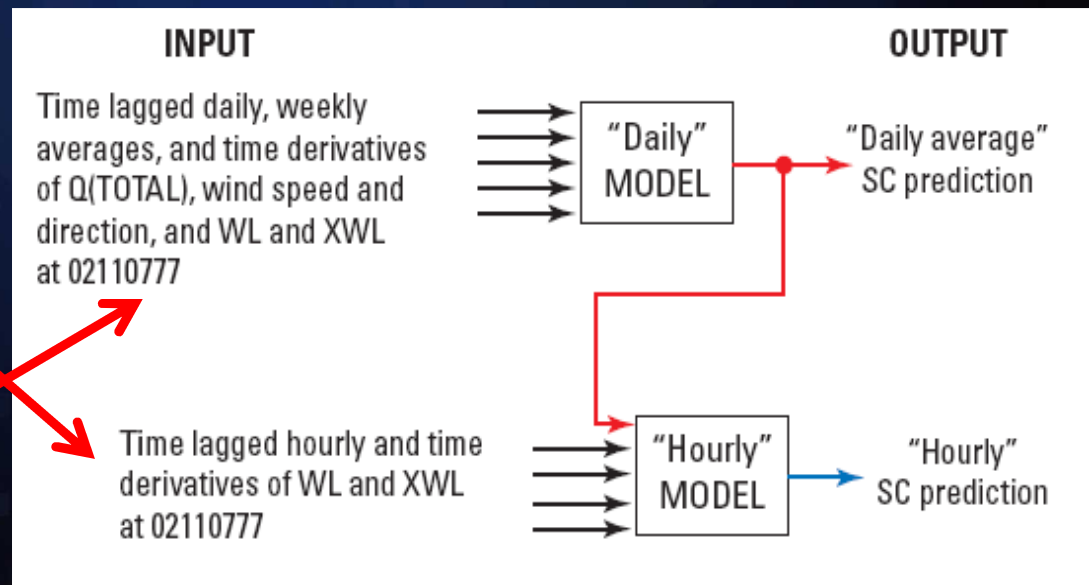
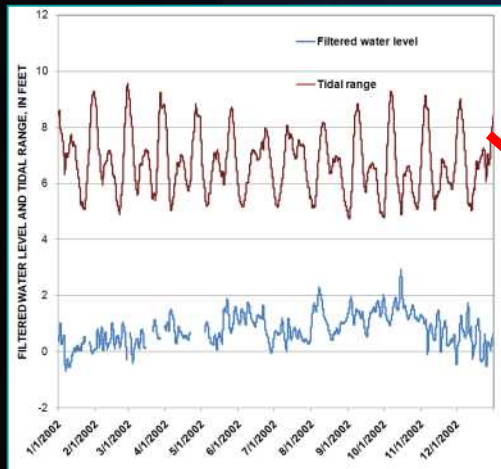
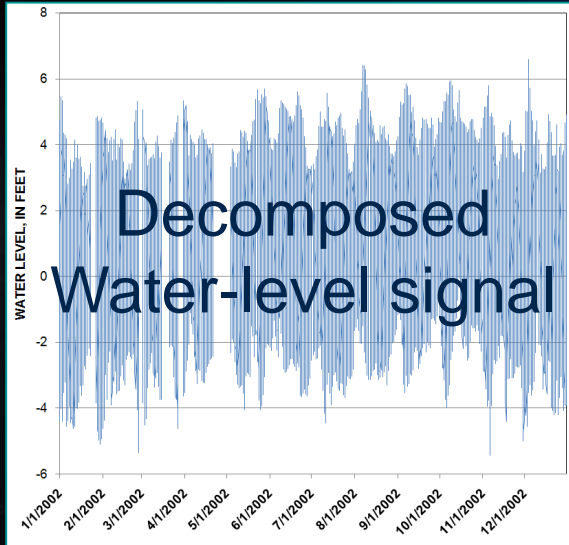
- The physics is manifested in the data
 - Learn/quantify important cause-effect relations
 - Data driven models
 - are “virtual processes”
 - evaluate alternatives

Data  **Information**  **Knowledge**

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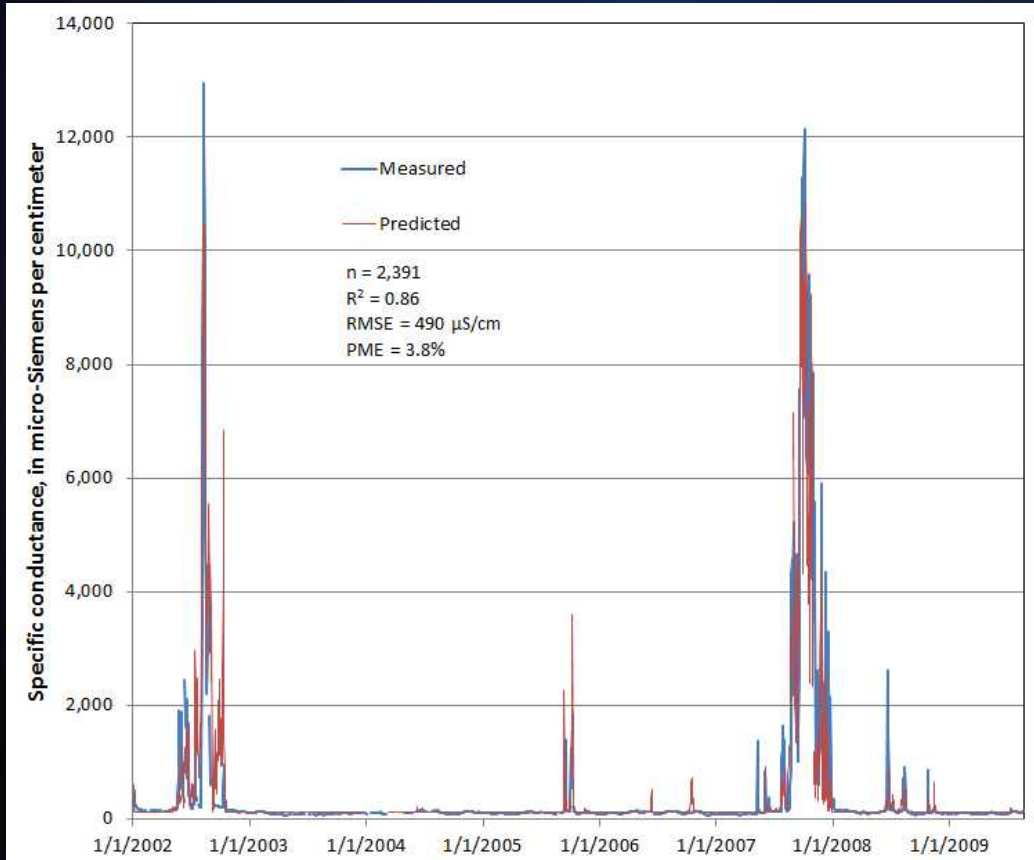
Description of the Salinity Models

- Cascading models
 - 1st Simulates daily SC response
 - 2nd simulates hourly SC response



Model Performance Pawleys Island

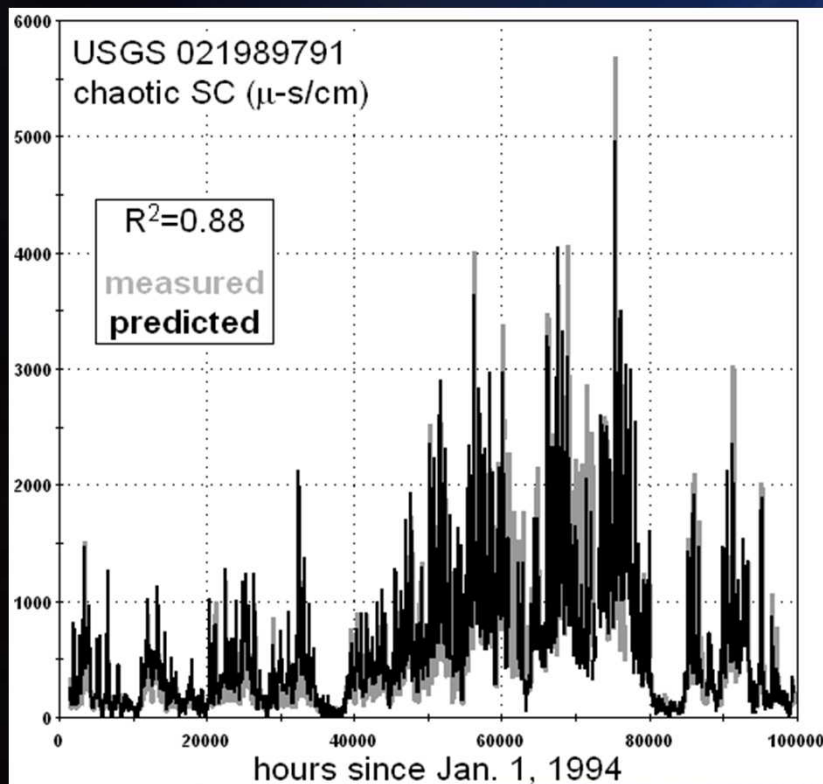
PRISM-2



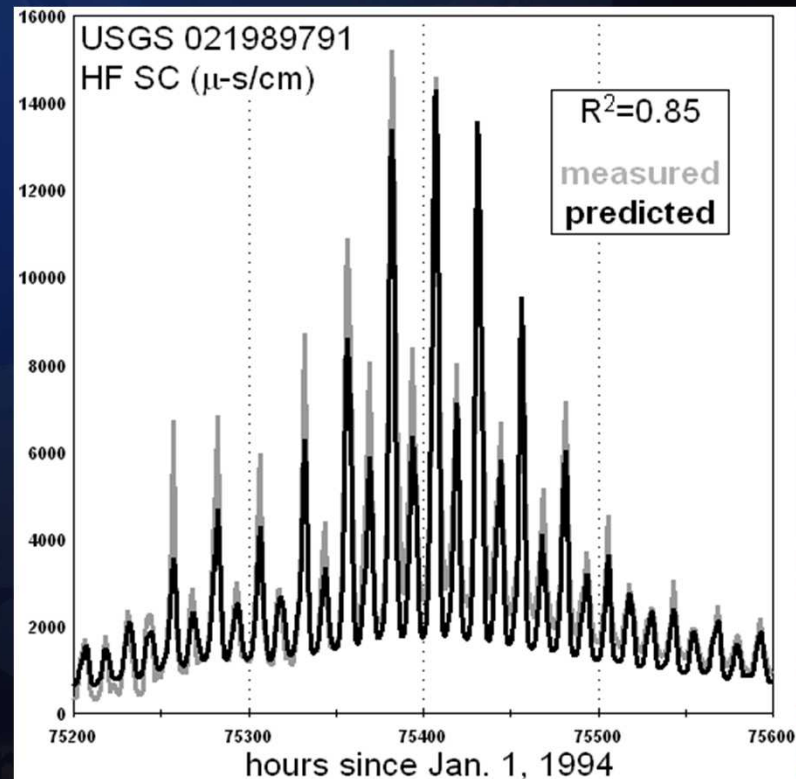
Savannah River ANN Models

M2M-2

Daily Model



Hourly Model



Decision Support Systems

- Models embedded in an Excel application
- Integrates:
 - Historical database
 - Models and model controls
 - Streaming graphics
 - Optimization routines
 - Simulation outputs
- Excel levels the technical playing field

Graphical User Interface

M2M-2

PRISM-2

Where Model Files Are Located: C:\PRISM2

Simulation: Start: 8/12/95, End: 8/21/09, Time Step (hrs): 24, Sim Time: 8/21/09 0:00

Step / Run: << Step, Sim Time=Start, Step >>, RUN, Opt All SC

Output: Graphs ON, Write Output, Clear Output, Abort/Reset: hold escape key, click End, click RESET, RESET

mea	WL777D	13
	WL777H	12
r (hr)	QotherDm	Qoth
-0	1,082	81
-24	1,140	85
-48	1,180	88
-72	1,173	87
-96	1,087	81
-120	1,000	75
-144	826	61

Gage	Q13100D Input Option	Q13100D Inputs By Option				Q13100Du	QtotalDu	SC SP	SCm	SCp(m)	SCp
		%	cfs	usrHyd	Opt						
815 D H	%	2,352	6,000	3,260	0	2,352	3,164	4,000	2,973	2,114	2.5
								4,000	8,850	5,393	6.5
8125 D H	%	2,352	6,000	3,260	0	2,352	3,164	2,000	141	?	?
								2,000	137	?	?
809 D H	%	2,352	6,000	3,260	0	2,352	3,164	700	?	?	?
								700	?	?	?
777 D H	%	2,352	6,000	3,260	3,948	2,352	3,164	10,000	24,627	?	?
								10,000	39,200	?	?
770 D H	%	2,352	6,000	3,260	3,601	2,352	3,164	3,500	4,087	?	?
								3,500	14,500	?	?
755 D H	%	2,352	6,000	3,260	15,000	2,352	3,164	1,000	410	?	?
								1,000	1,490	?	?
760 D H	%	2,352	6,000	3,260	0	2,352	3,164	400	137	146	150
								400	158	?	?

User Controls

Date/Time Controls

Start Date: 1 / 1 / 1995
Stop Date: 11 / 14 / 1996

Hour Time Steps
 Daily Time Steps
 Half Hour Time Steps

Simulation Input Variables Options

% Actual Q8500: 100
 User Q (cfs): 20000
 Percentile Q8500: Select from List
 User Defined Hydrograph(s)

Run Simulation

8840 WL Bias: 0

Writing Output

Select to Write Output (This will open an Output Workbook)

Visualization

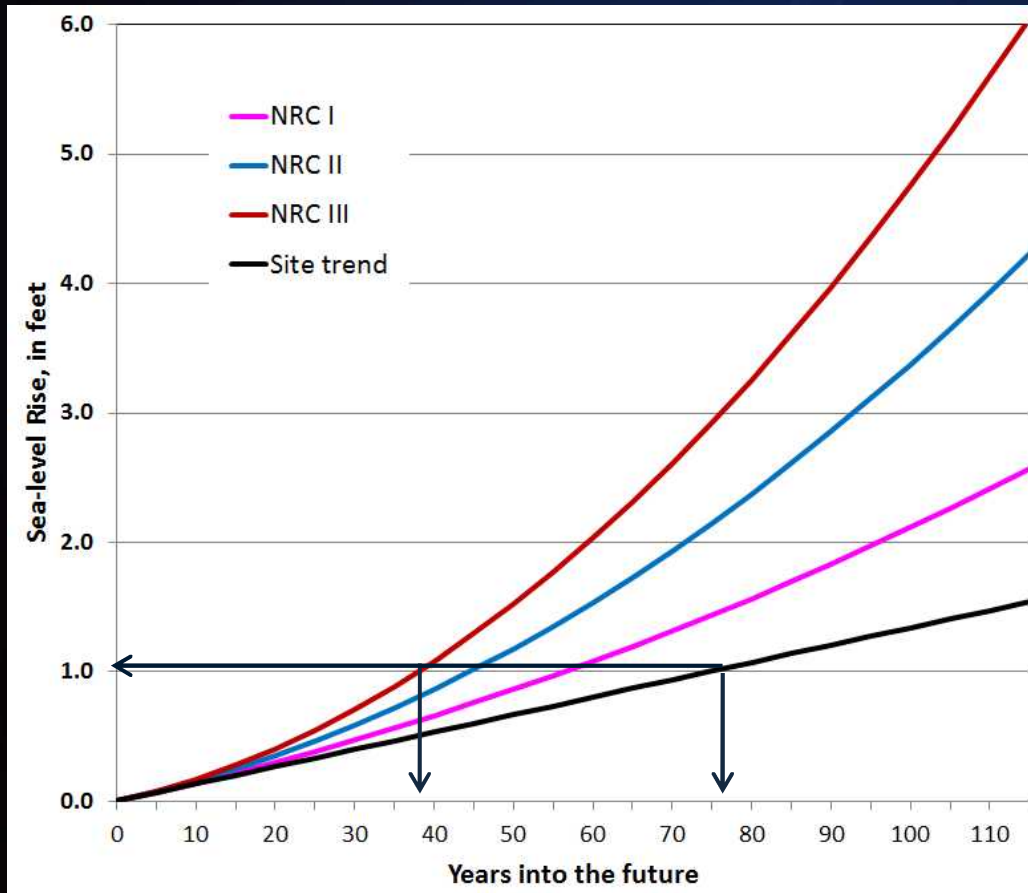
Create Files for Visualization

Results

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Sea-level Rise Projections

Springmaid Pier, Myrtle Beach



Modified NRC-III

Modified NRC-II

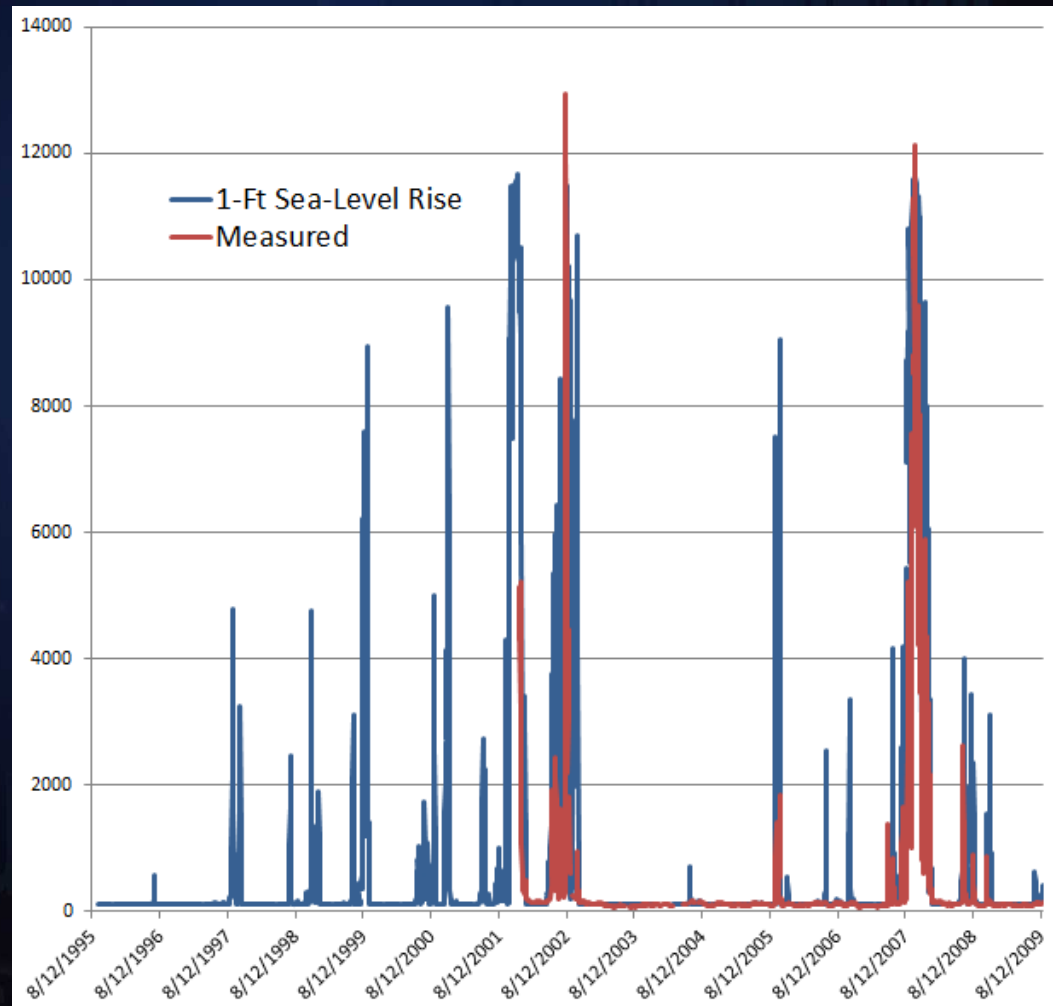
Modified NRC-I

Local Trend

Analysis based on USACE methodology, 2009
National Research Council, 1987

Time series of SLR Plot

- 14 year simulation
- 1- ft SLR

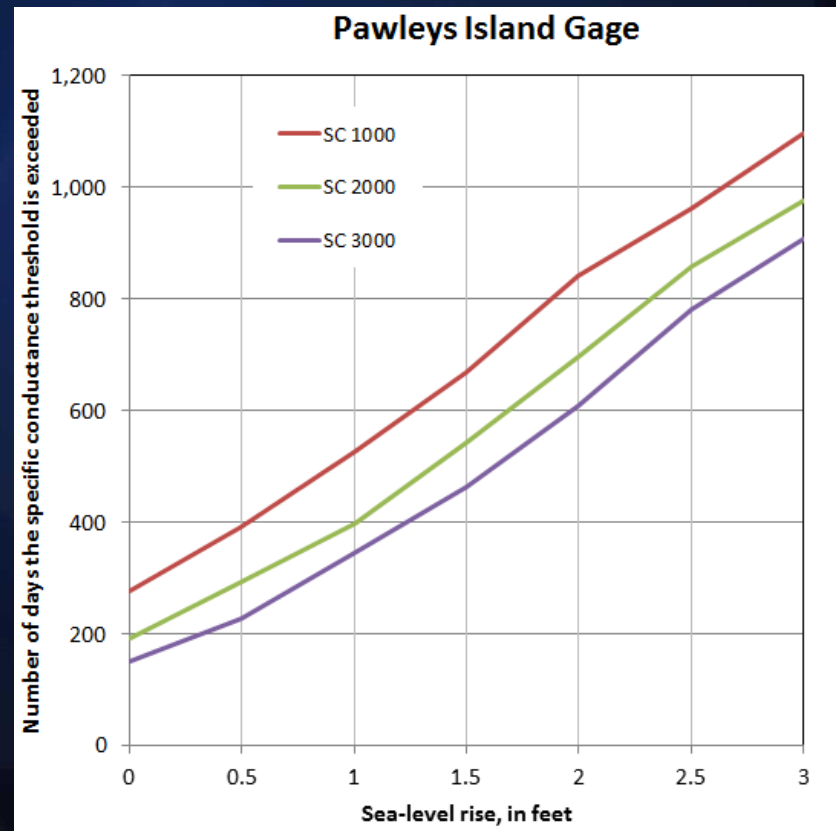


Multiple Model Runs

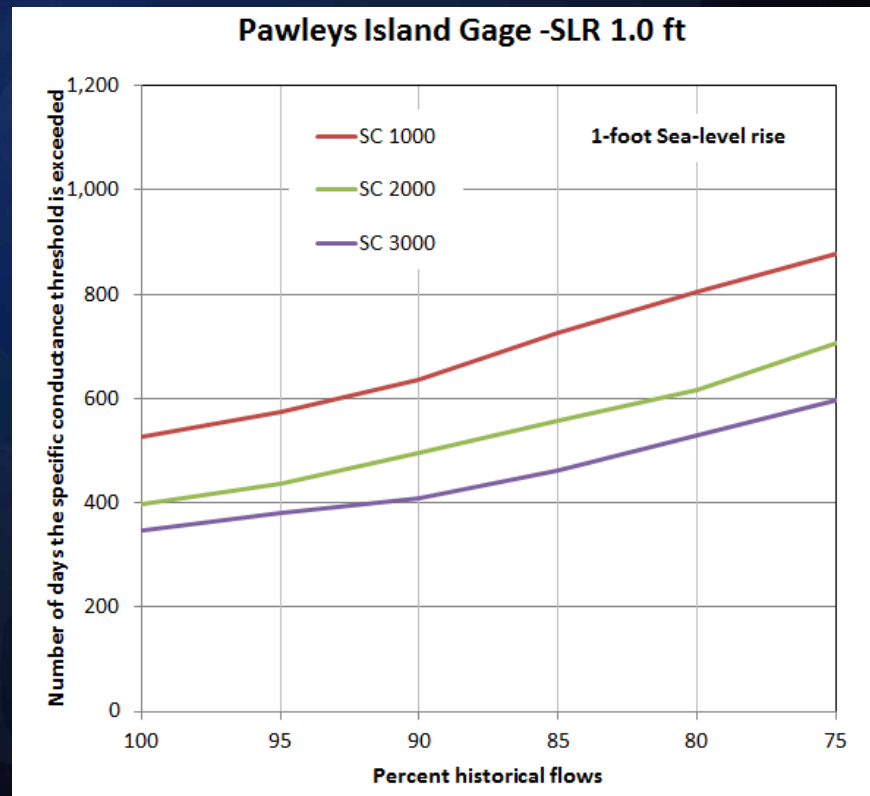
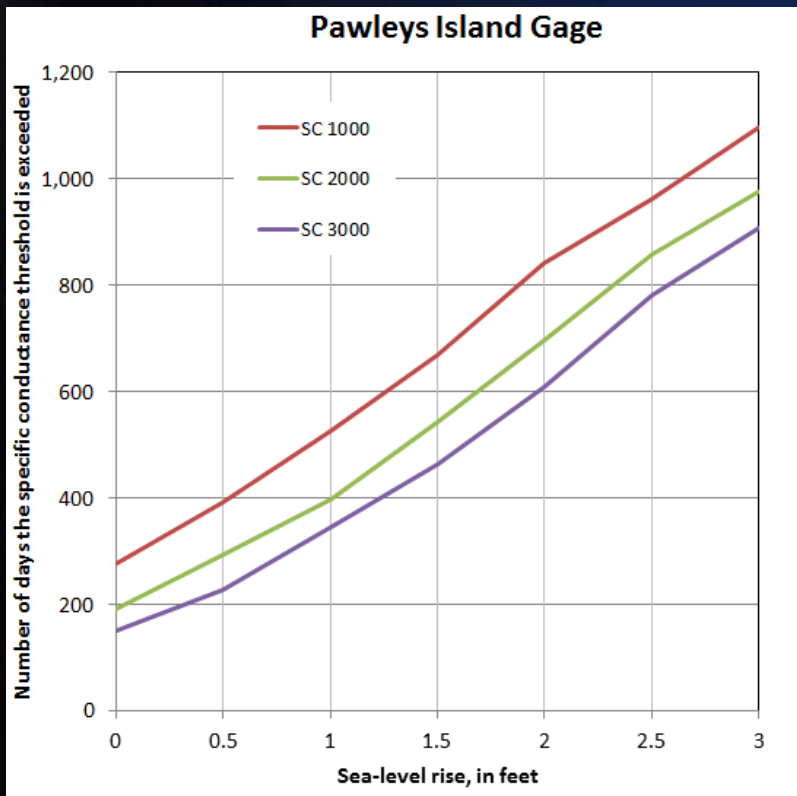
Sea-level rise and flow in combination

Grand Strand – Pawleys Island Gage

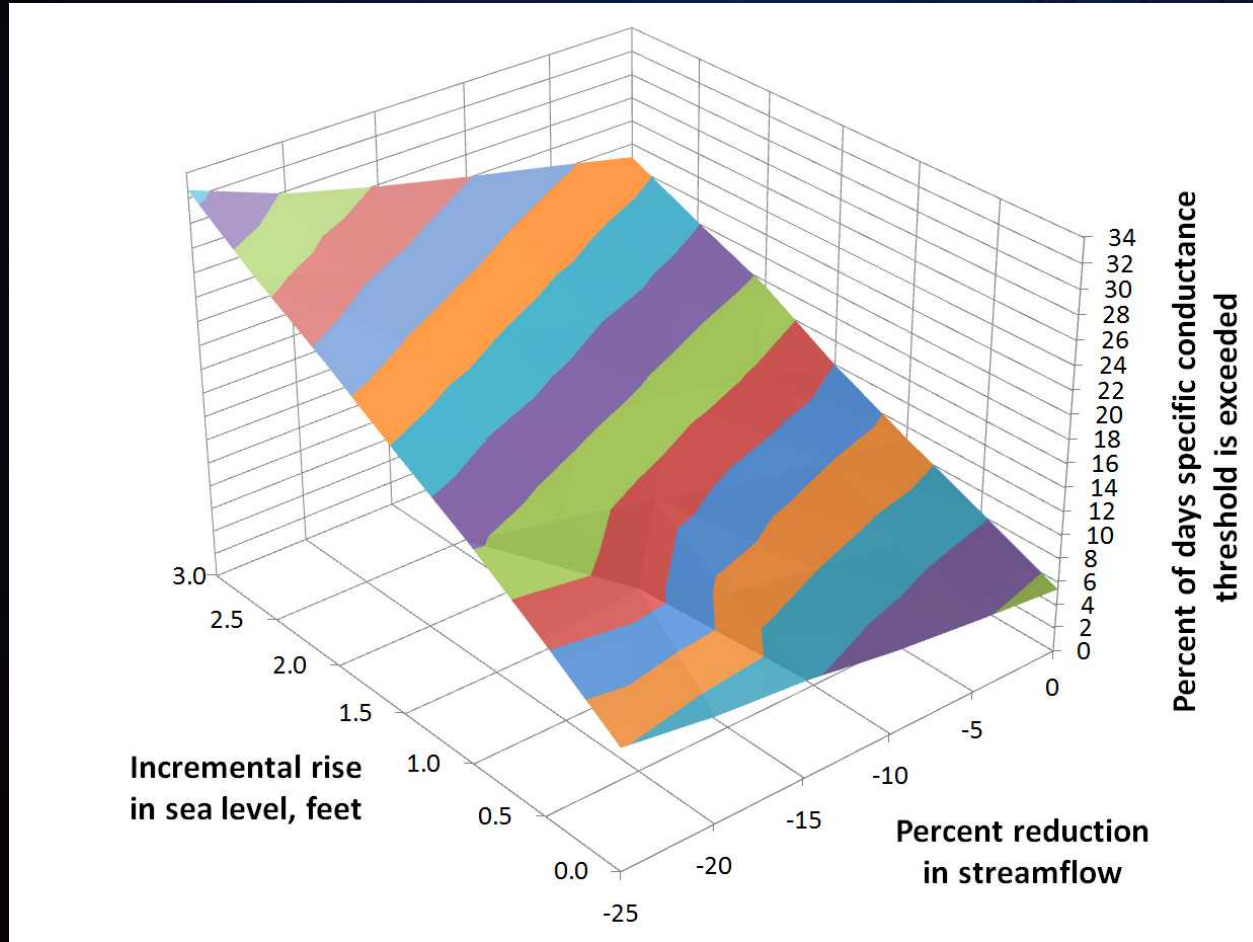
- 14 year simulation
- 0.5 ft incremental SLR up to 3 ft
- 5 % reductions in streamflow



Results – SLR & Reduced flow Grand Strand – Pawleys Island Gage

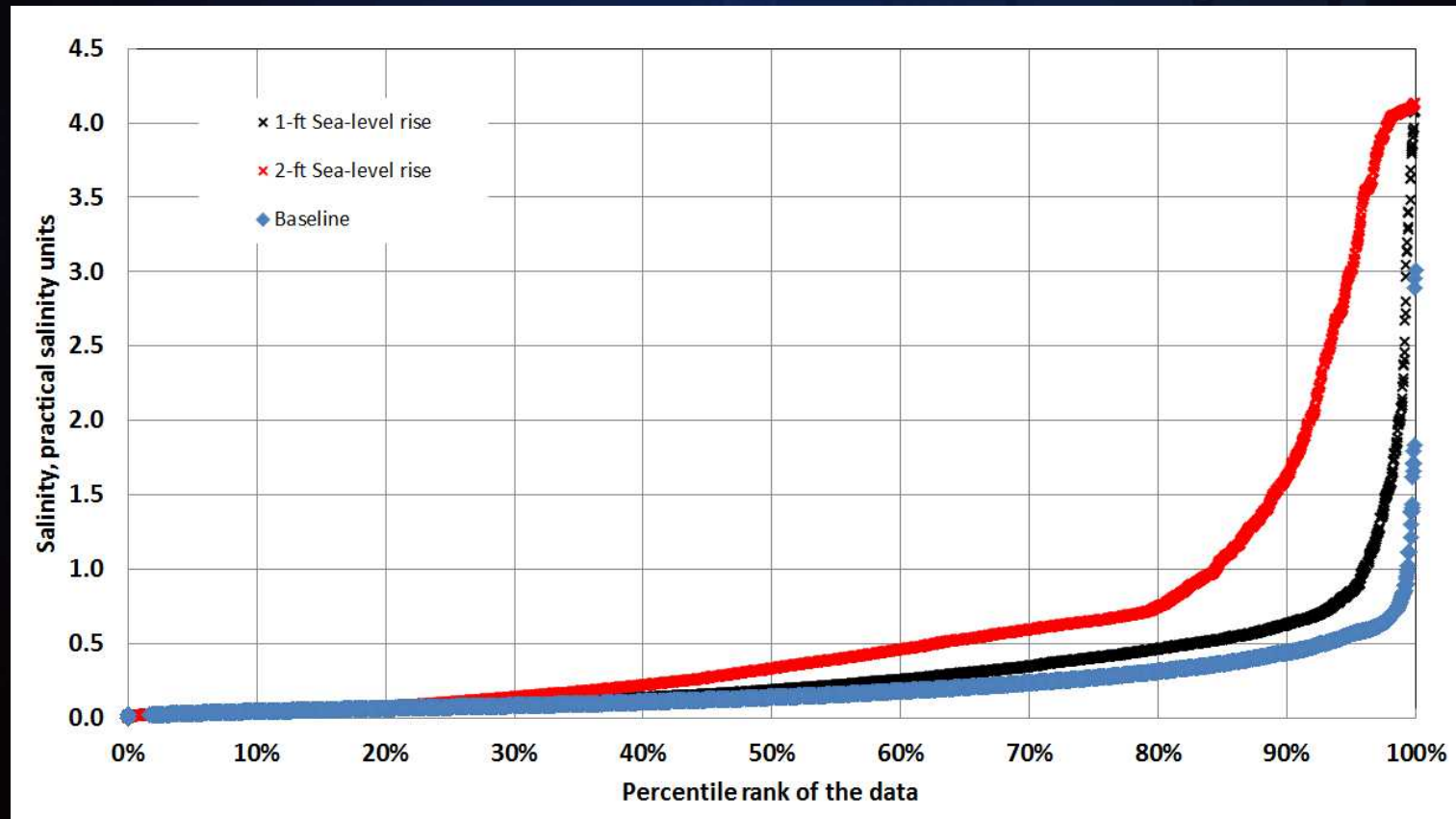


3D Response Surface of Results



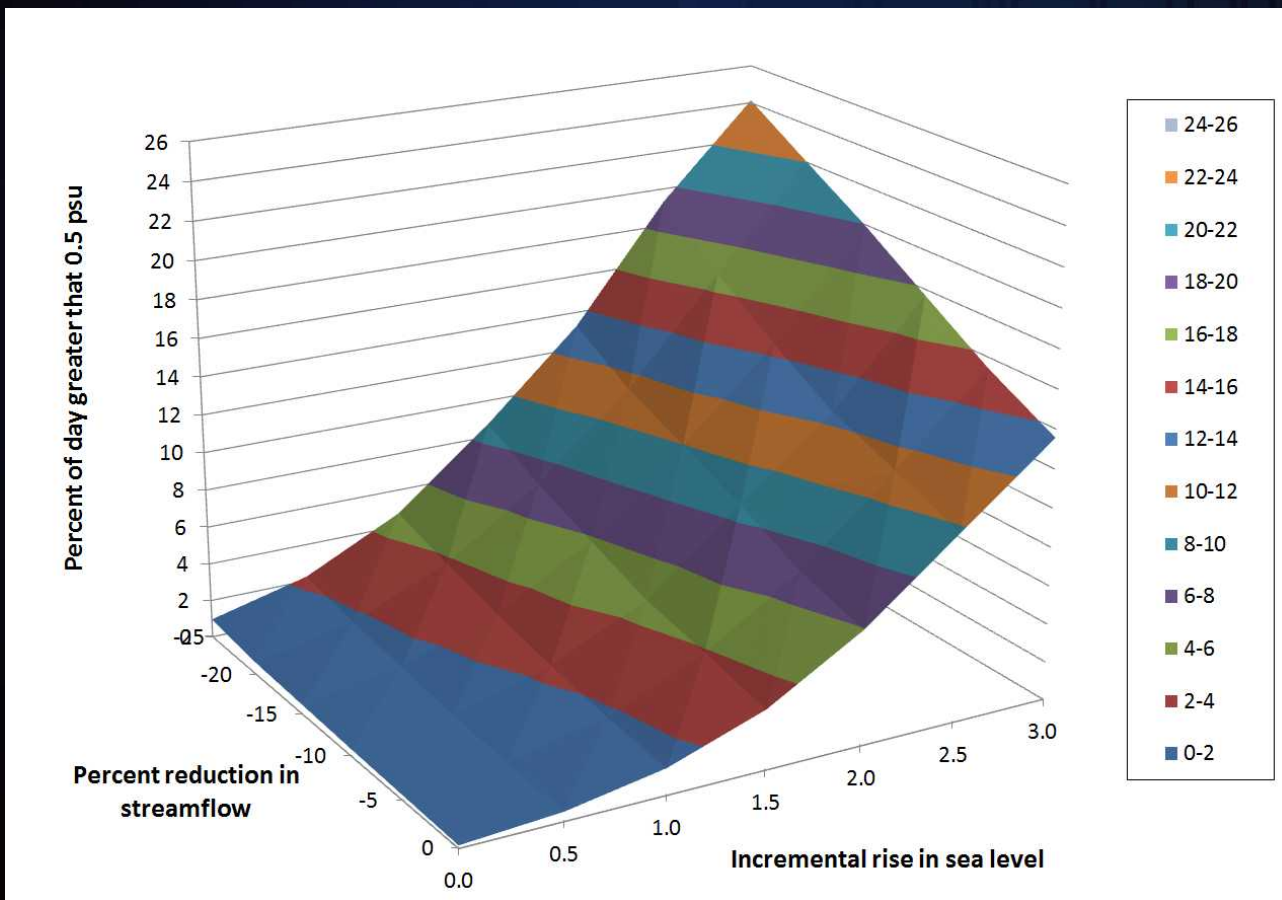
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Savannah National Wildlife Refuge Little Back River



Eleven year simulation 1994- 2005

SLR & Flow Results at I-95



Threshold = 0.5 psu (~1,000 $\mu\text{S}/\text{cm}$)

Climate Model Derived Flows

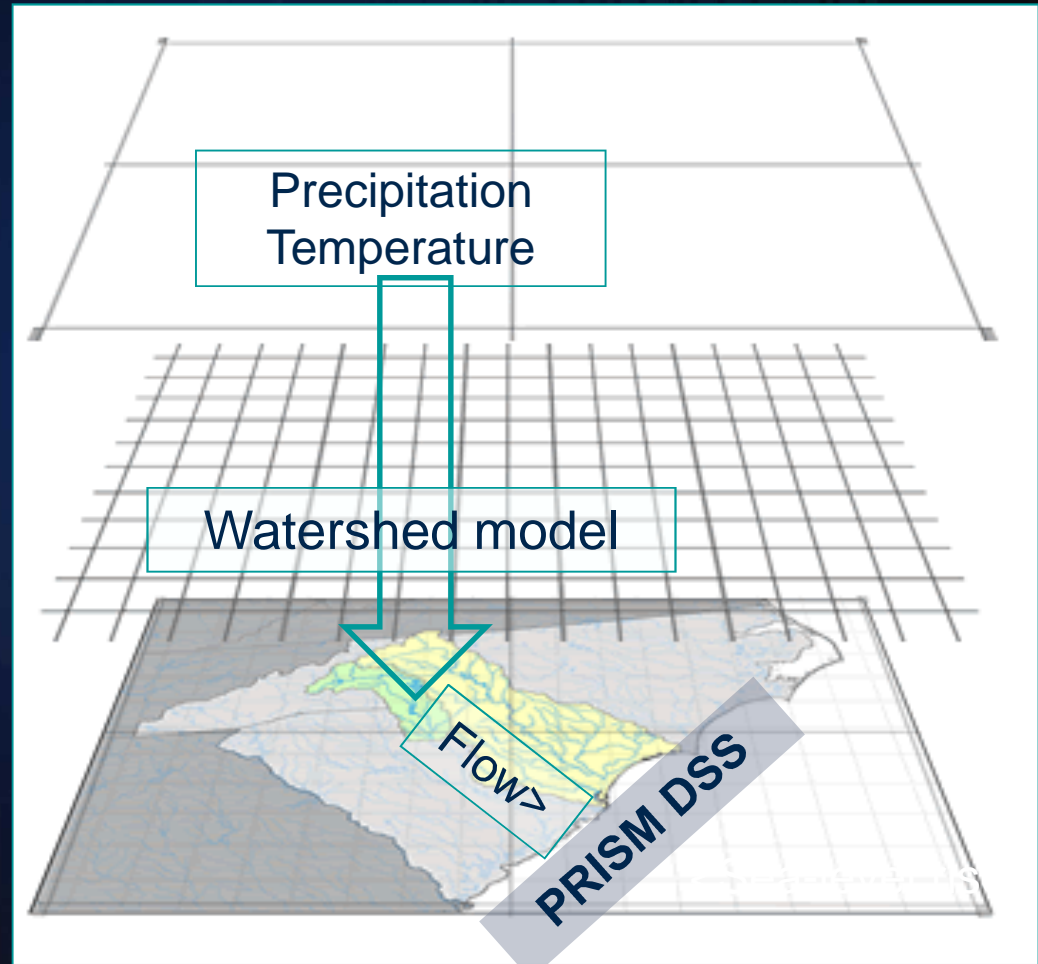
**Global & regional
circulation models**



**Gridded rainfall
input to watershed
model**



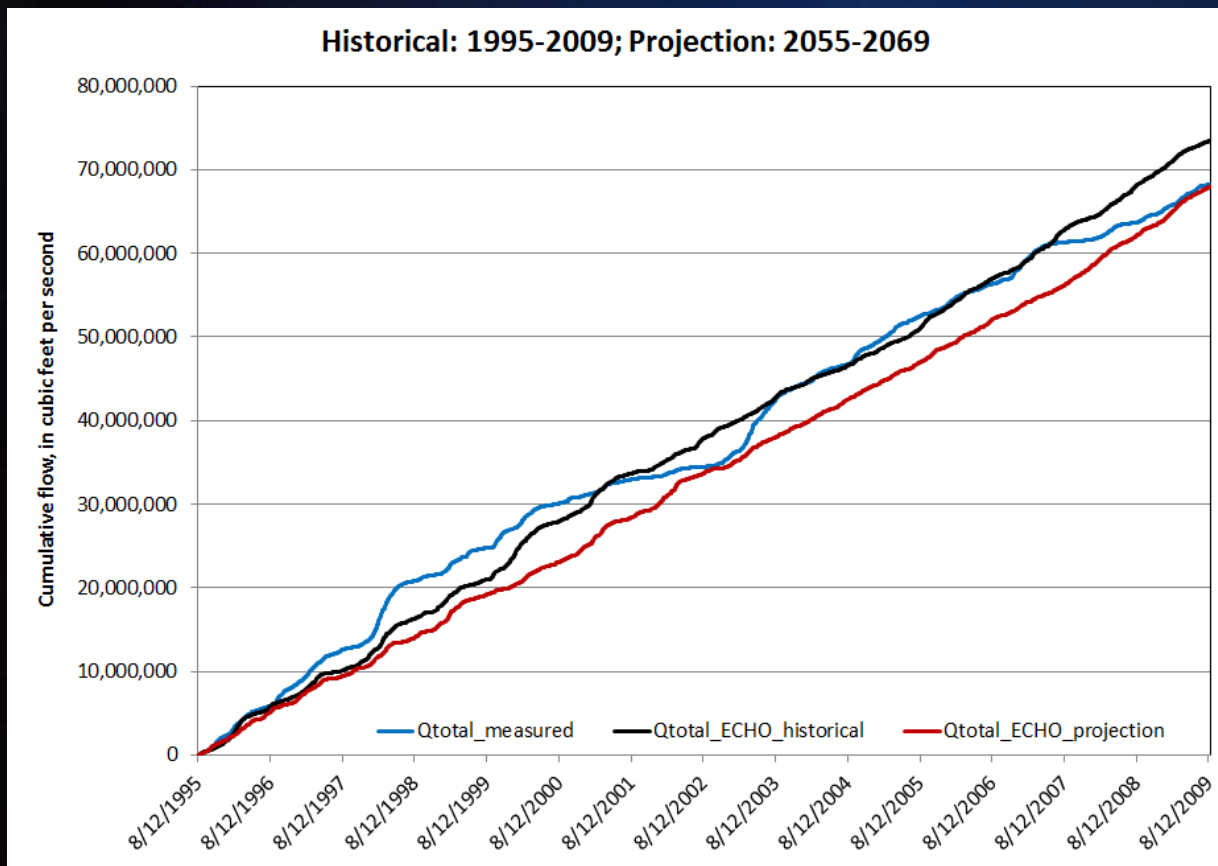
**Salinity intrusion
model**



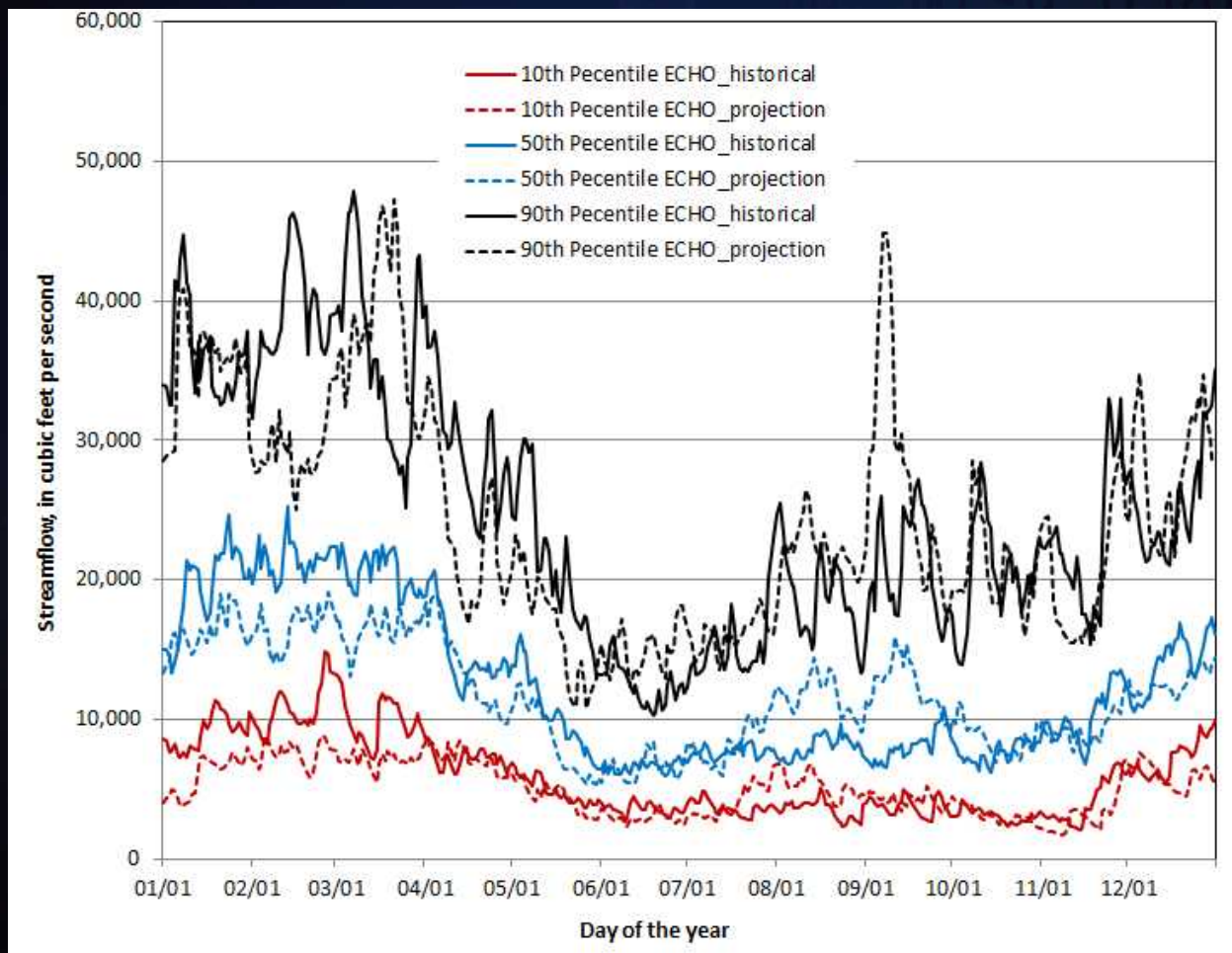
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GCM Inputs to Rainfall/Runoff Model

- ECHO-G Global Circulation Model
- Statistically downscaled precipitation and temperature inputs (Hayhoe)
 - HSPF watershed model



Duration Hydrographs of Projected Flows

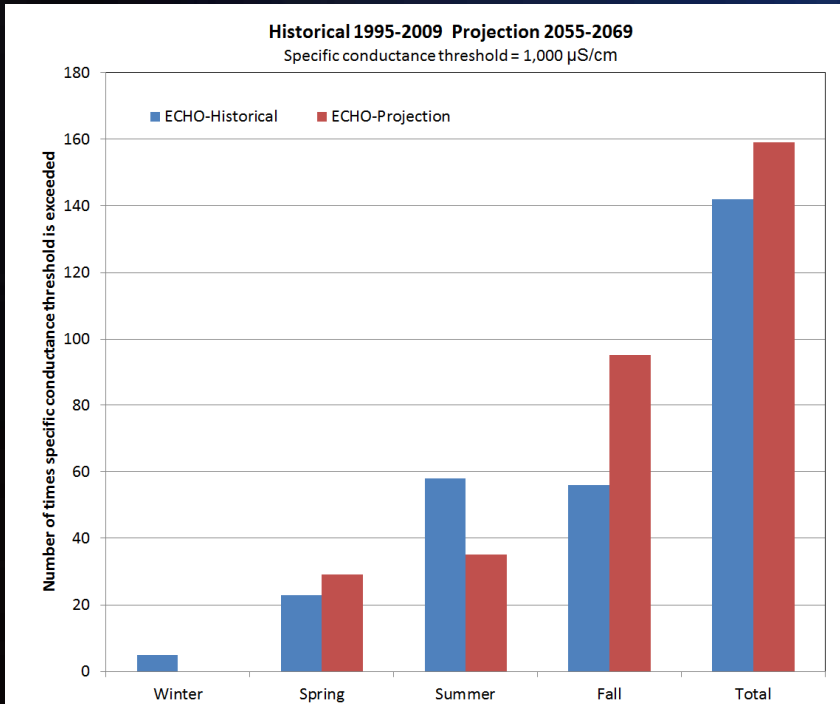


Historical 1980-2010, Projection 2040-2070

Projected Seasonal Change in Salinity Intrusion

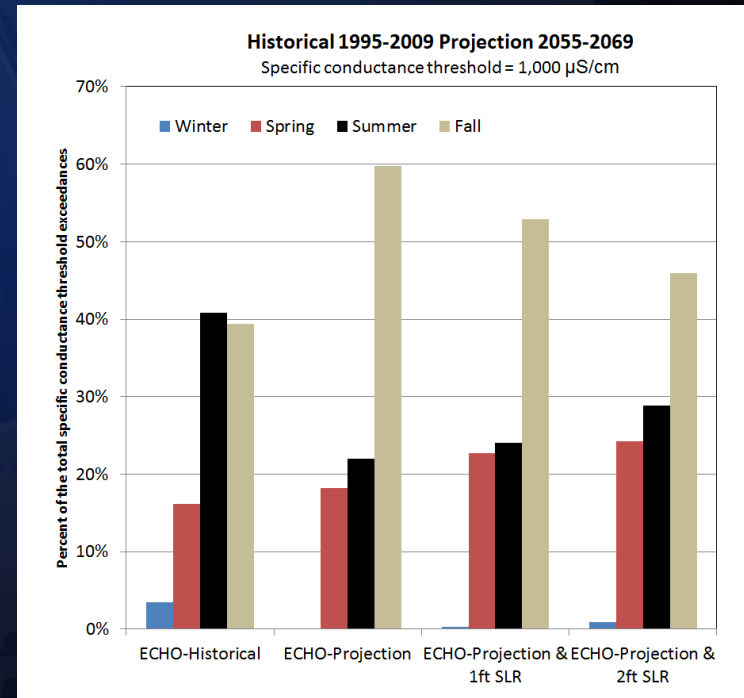
Historical 1995-2009, Projection 2055-2069
 Specific conductance threshold = 1,000 $\mu\text{S}/\text{cm}$

Number of days SC threshold exceeded



Winter Spring Summer Fall Total

Percent of the total SC threshold exceedances



ECHO Historical ECHO Proj. ECHO 1 SLR ECHO 2 SLR

Conclusions

- Accurate models developed directly from the data
- Models & database delivered in Excel
- DSS allows a variety of climate change scenarios
- Climate changes project **not** prescribed by the DSS

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