Evaluating the Relevance, Reliability, and Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning

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RECLAMATION

Evaluating the Relevance, Reliability, and Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning

Gap(s) Addressed

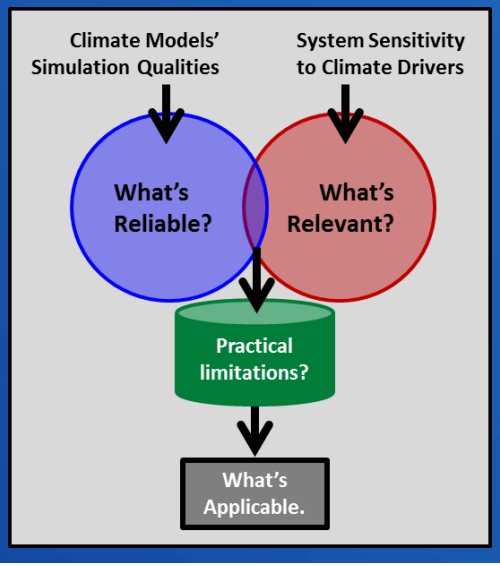
Addresses gaps from long-term needs doc:

3.02: Understanding how to interpret future variability in climate projections …

3.03 Basis for culling or weighting climate projections …

3.05 Guidance on how to jointly utilize the longer-term climate variability from observed records, paleoclimate, and projected climate

Graphic



Research Question:

- How can water and environmental planners assess what climate change information to use in a given study?

Objective:

- Develop and demonstrate a framework for evaluating climate projection information fro water/environmental planning applications based on reliability, relevance, and applicability

Collaborators/Schedule/Source of Support

- **Collaborators:**
  Reclamation, CIRES, NOAA, USACE
- **Schedule:**
  Task 1/3 – CMIP5 evaluation – almost done
  Task 2 – Sensitivity Analysis – April 2014
  Task 4 – Pilot Workshop – May/June 2014

Big Picture

- We have **many methods and datasets** for assessing climate change implications for water management .

- **Recent planning directives** move us to consider method selection from the view of **information applicability**.

- Reclamation, NOAA, CIRES and USACE are partnering to **develop a framework** to guide evaluation of climate projection **relevance, reliability, and applicability** in context of water resources and environmental planning.

Background:

Recent planning directives require consideration of climate change in Federal water resources and environmental planning.

- **Prior Practice:**
  - Use of climate change information in water resources planning was at the **discretion** of individual study teams
- **Current Practice:**
  - Consideration of climate change impacts on water resources is **required** under executive orders, departmental directives, and agency directives and standards.

Background:

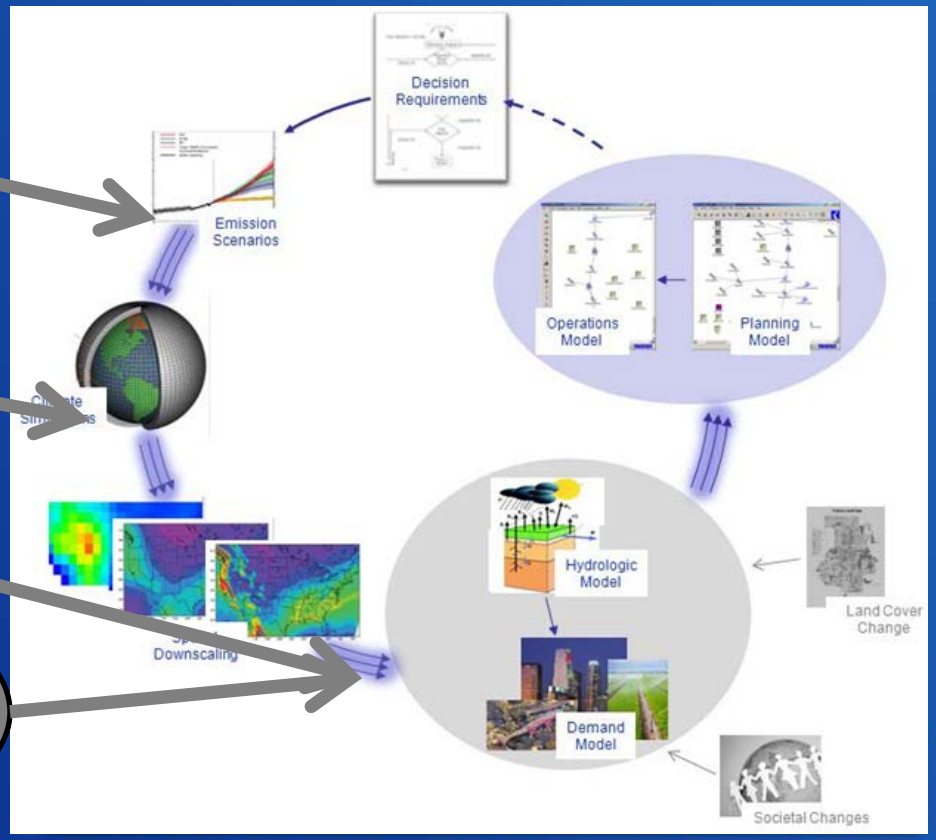
So…how do planners and decision makers determine <u>how to use climate projection information</u> when assessing climate change vulnerabilities, risks, and adaptation needs?

Selection of GCM scenarios and projections

Selection of downscaling/ bias correction method(s)

Selection of hydrology, resource, and impact models

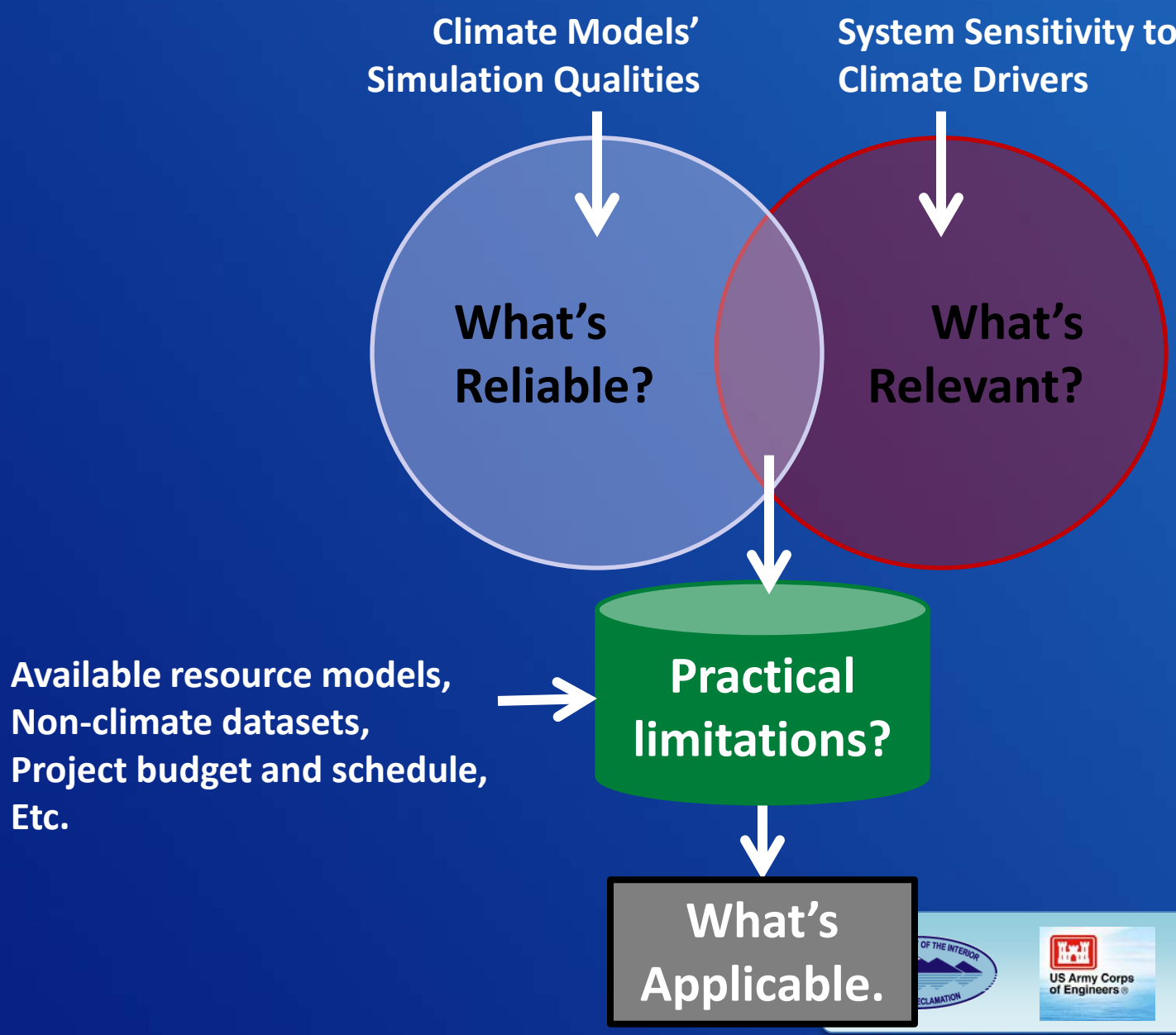
Selection of method to develop model inputs



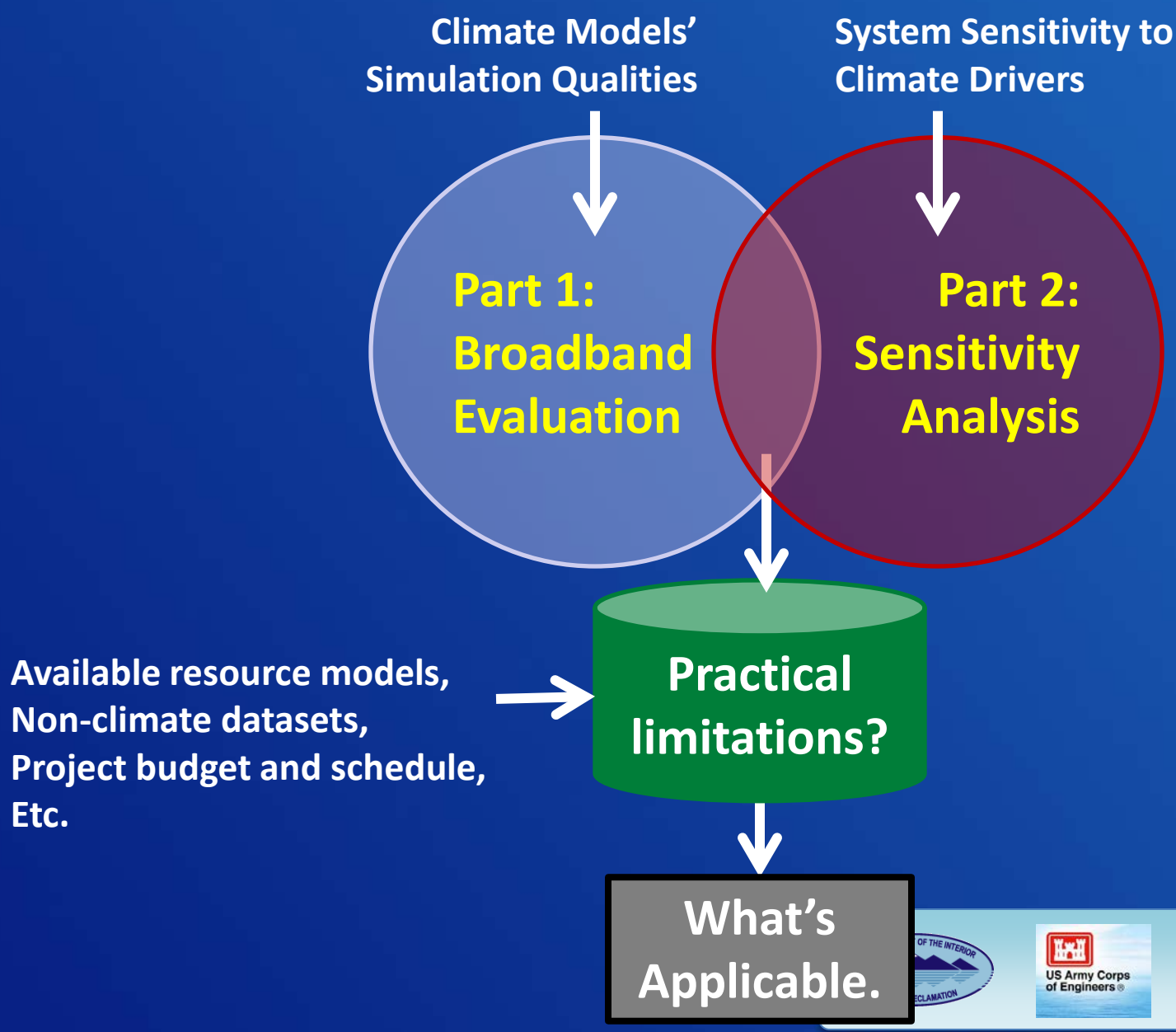
Objective:

Develop and demonstrate a framework for evaluating climate projection information for reliability, relevance, and applicability for water resources and environmental planning and management applications

Applicability Framework:



Applicability Framework:



Part 1: Broadband Evaluation of CMIP5

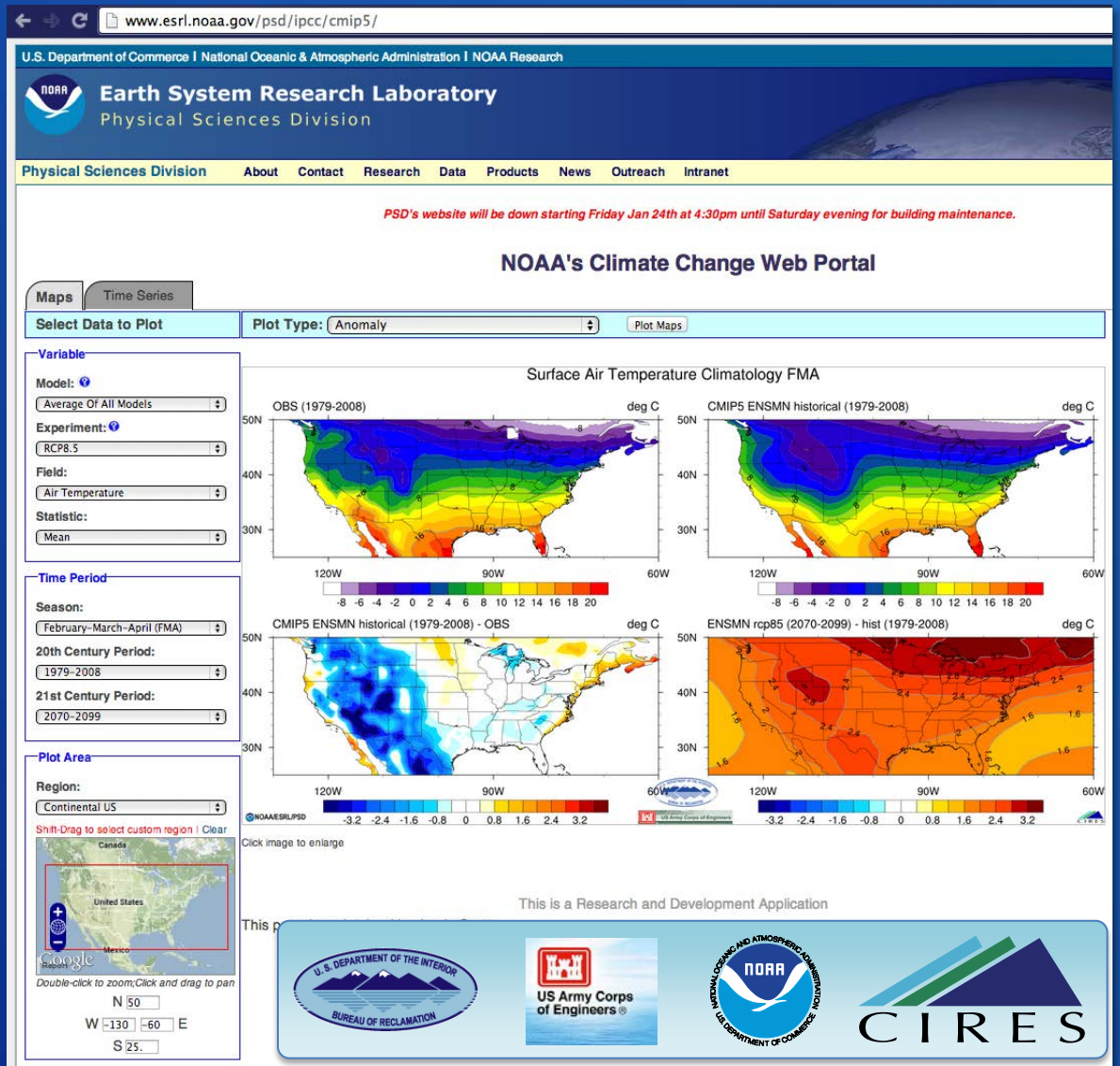
Climate Change Web Portal: esrl.noaa.gov/psd/ipcc/cmip5

This webtool makes climate change information more accessible to decision makers

A quick way for users to explore the Coupled Model Inter-comparison Project (CMIP5) experiments and observational counterparts.

Explore different models, variables, climate metrics and seasons.

Choose pre-defined regions or create custom regions



Part 1: Broadband Evaluation of CMIP5

CMIP5 Experiments

- Historical simulations: 1911-2005 (observed CO_2 forcing)
- Future simulations-> RCP8.5 & RCP4.5 : 2006-2100
- Seasonal/annual mean Air Temperature (daily average, Tmax, Tmin), Precipitation, and Sea Surface Temperature
- 37 models used for Air Temperature and Precipitation
- 28 models used for SST, Tmax, Tmin

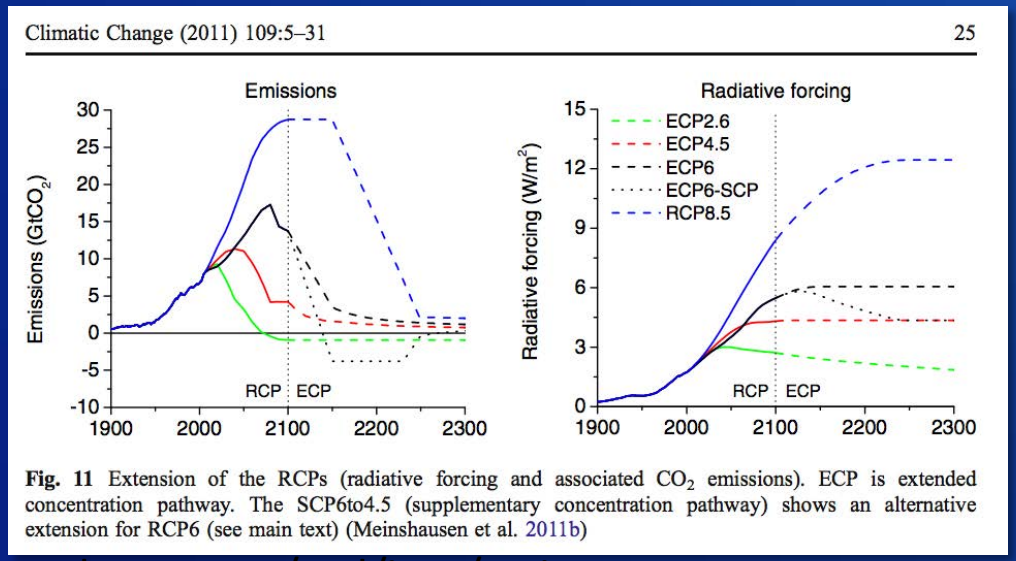


Fig. 11 Extension of the RCPs (radiative forcing and associated CO_2 emissions). ECP is extended concentration pathway. The SCP6to4.5 (supplementary concentration pathway) shows an alternative extension for RCP6 (see main text) (Meinshausen et al. 2011b)

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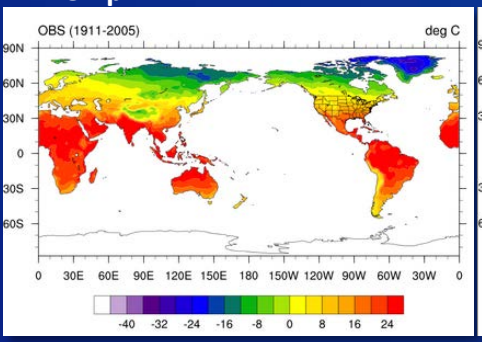
Part 1: Broadband Evaluation of CMIP5

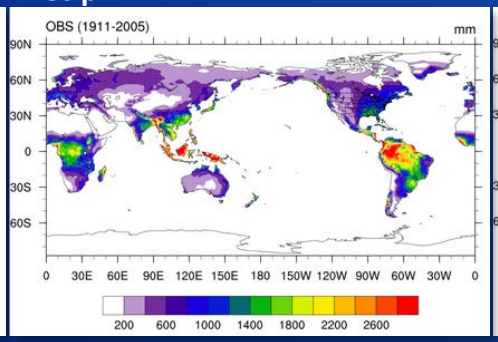
20th Century Observations

- Terrestrial Air Temperature
  - University of Delaware (version 3.01)
- Terrestrial Precipitation
  - Global Precipitation Climatology Centre (WMO, version5)
- Sea Surface Temperature
  - Hadley Centre SST (HadSST2)
- Daily Max/Min Temperature
  - Global Historical Climatology Network – Daily (NCDC)

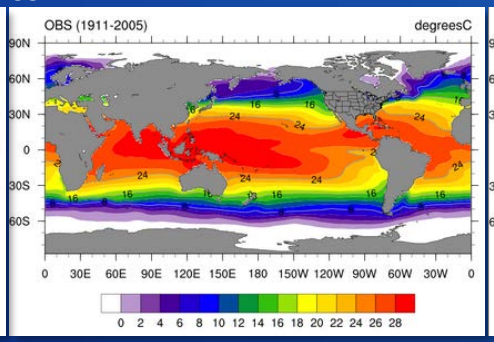
Air Temp



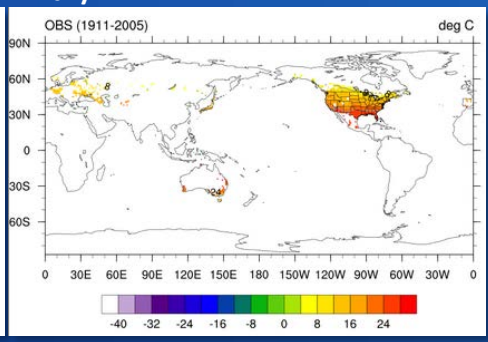
Precip



SST



Tmax/Tmin



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Part 1: Broadband Evaluation of CMIP5

Climate Change Web Portal Analysis

- Models and Observations interpolated to 1x1 deg grid
- Annual and seasonal mean climate metrics computed for different time periods in 20th, 21st Century
- Metrics of seasonal means for each period:

  mean, median, standard deviation, 10th %, 90th %, linear trend, 1 year lag autocorrelation
- Compare future changes to model bias, historical variability and ensemble spread
- Significance assessment using consensus, Ttest, Ftest
- Time series analysis for US Hydrologic Units
- Global datasets can be explored at regional scales

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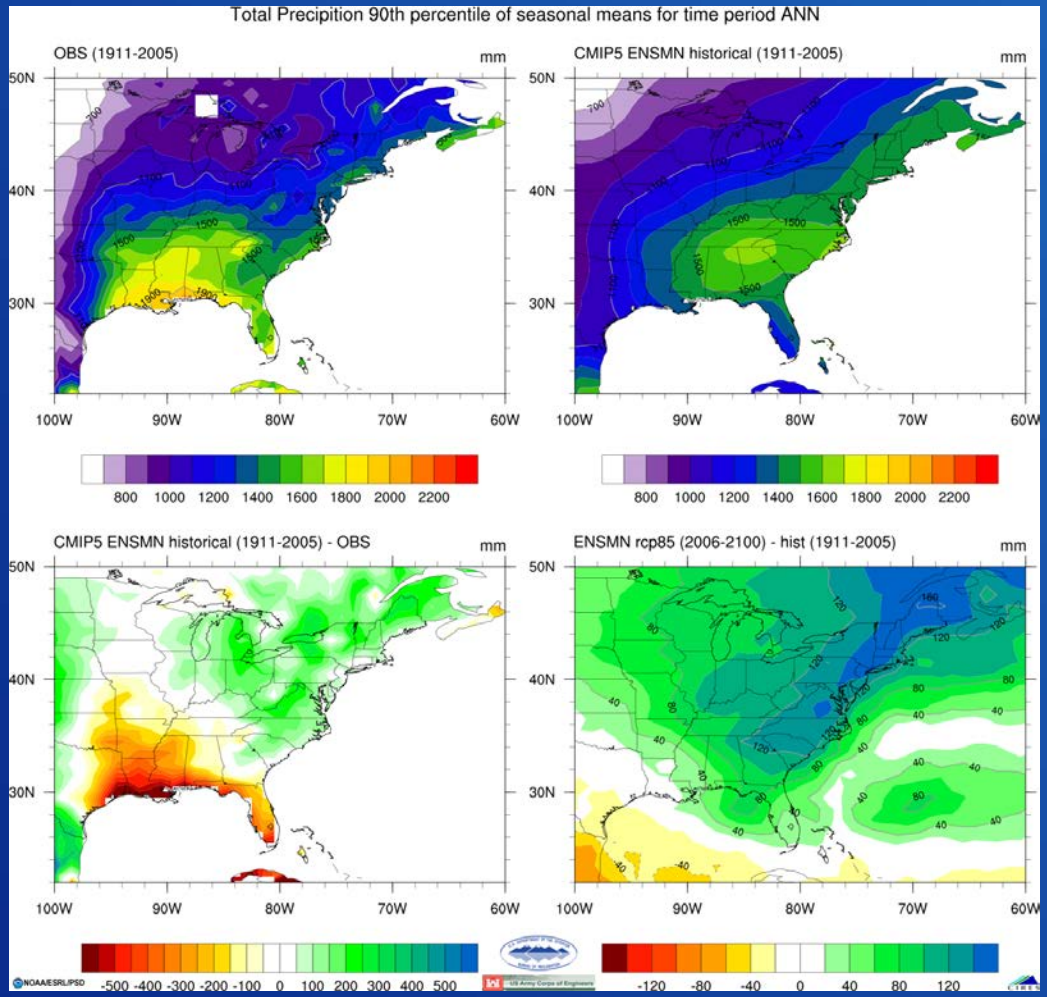
Part 1: Broadband Evaluation of CMIP5

Plottype = Anom (default plot)

90th Percentile for Annual Prec (9th wettest year at each grid)

Observations 1911-2005

Model Bias (Model-Obs) 1911-2005



Simulated Historical 1911-2005

Simulated Change (RCP8.5) 2006-2100

esrl.noaa.gov/psd/ipcc/cmip5

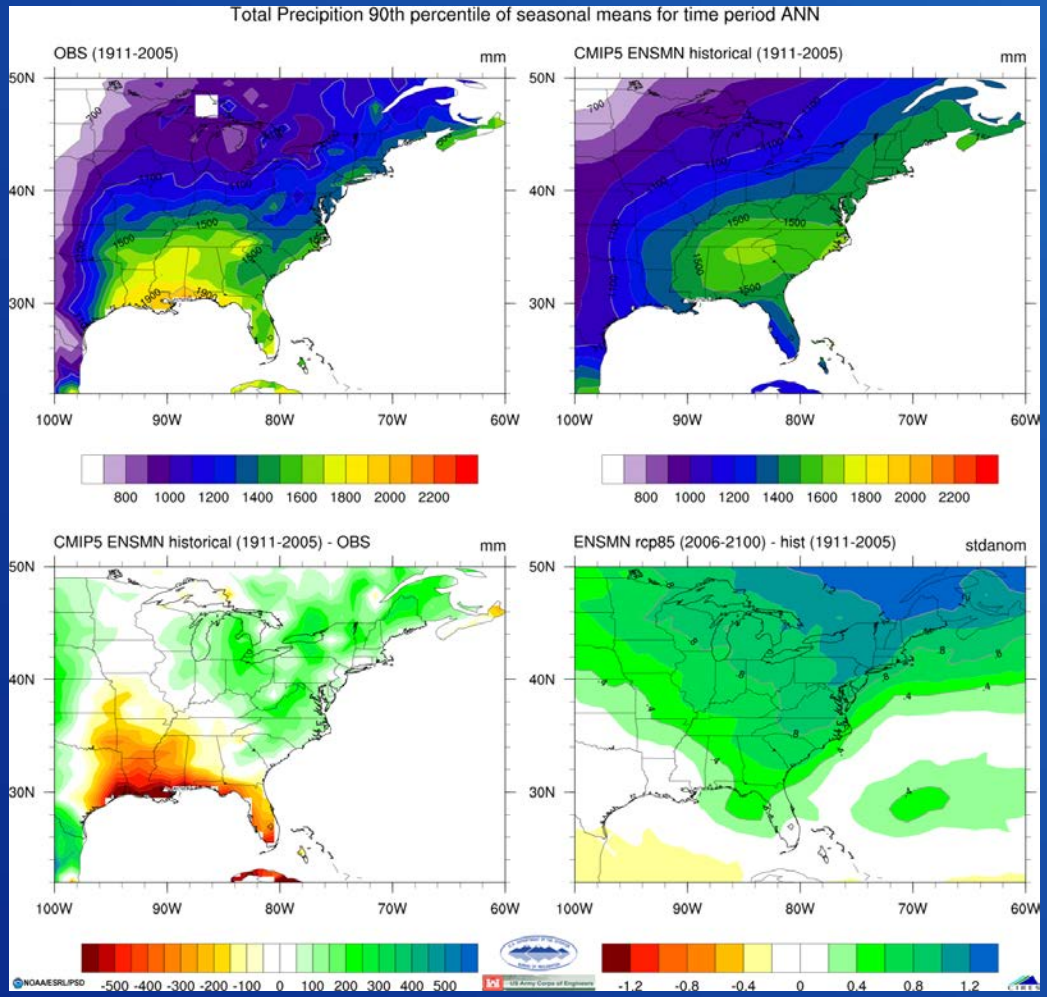
Part 1: Broadband Evaluation of CMIP5

Plottype = Standard Anom

90th Percentile for Annual Prec (9th wettest year at each grid)

Observations 1911-2005

Model Bias (Model-Obs) 1911-2005



Simulated Historical 1911-2005

Simulated change relative to historical standard dev. 2006-2100

esrl.noaa.gov/psd/ipcc/cmip5

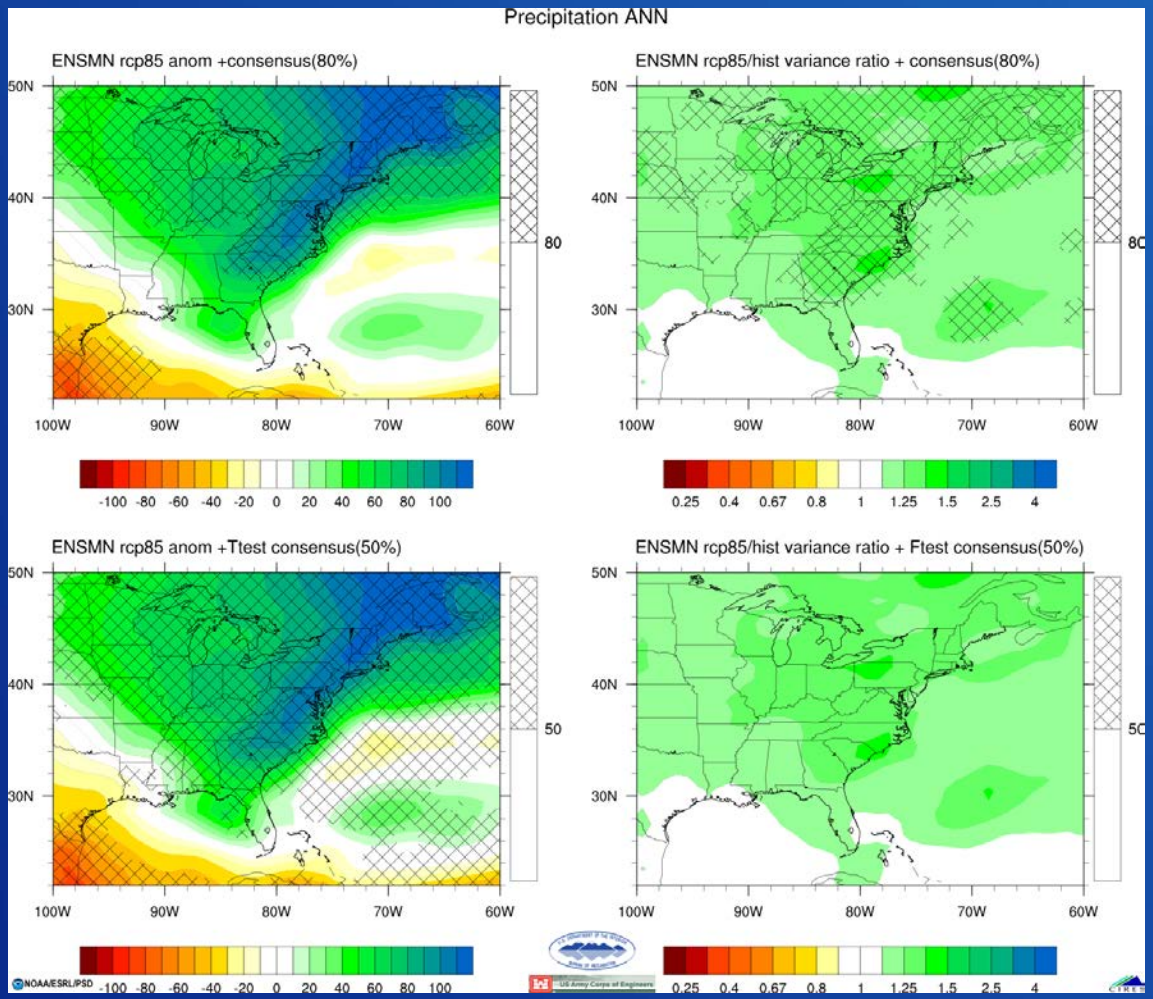
Part 1: Broadband Evaluation of CMIP5

Plottype = Significance Metrics

(2006_2100) – (1911_2005) (2006_2100) / (1911_2005)

Anomaly Consensus
- do models agree (80%) on wetter / drier future climate?

Variance Ratio Consensus
- do models agree (80%) on increased or decreased variability?



Ttest Consensus
- do a majority of models have significant climate changes according to a Ttest (95% level)?

Ftest Consensus
- do a majority of models have significant variance changes according to an Ftest (95% level)?

esrl.noaa.gov/psd/ipcc/cmip5

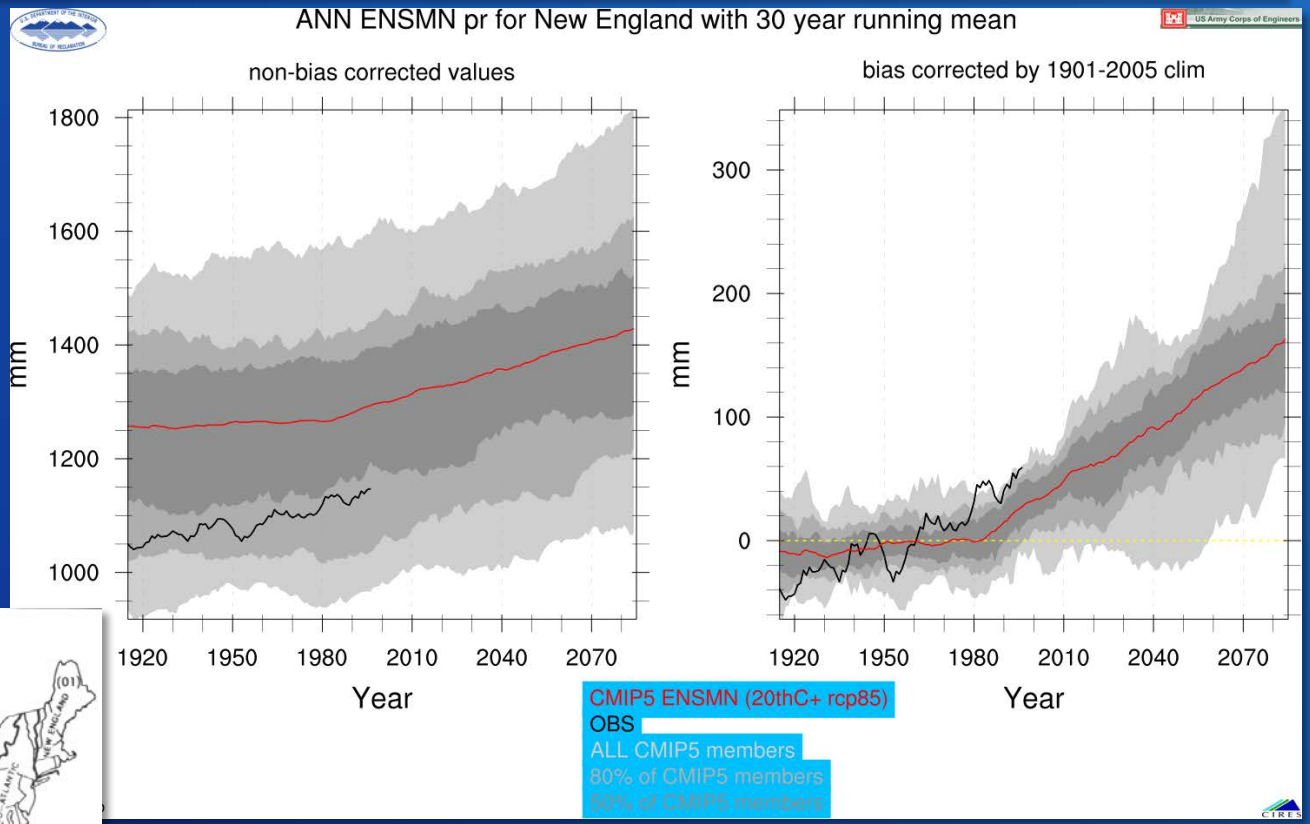
Part 1: Broadband Evaluation of CMIP5

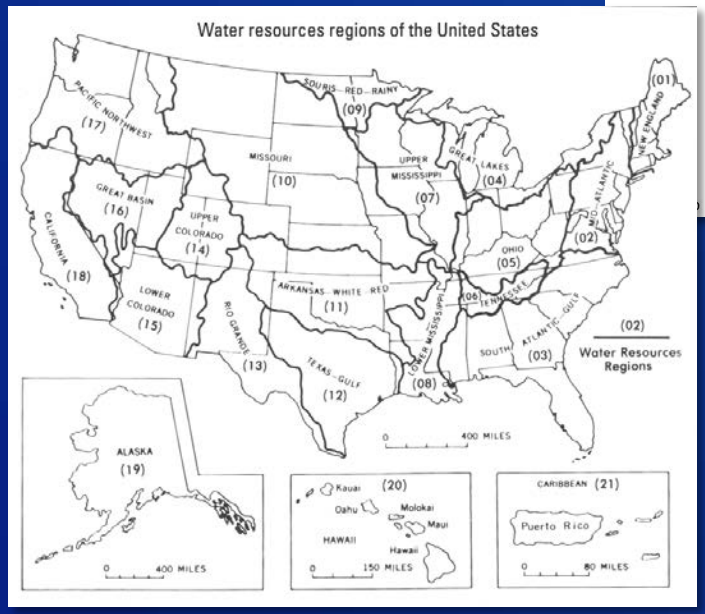
Time Series Tab

Time series analysis for 18 US Water Resource Regions

Model spread, single models and observations

5, 10, 20, 30 year running avg





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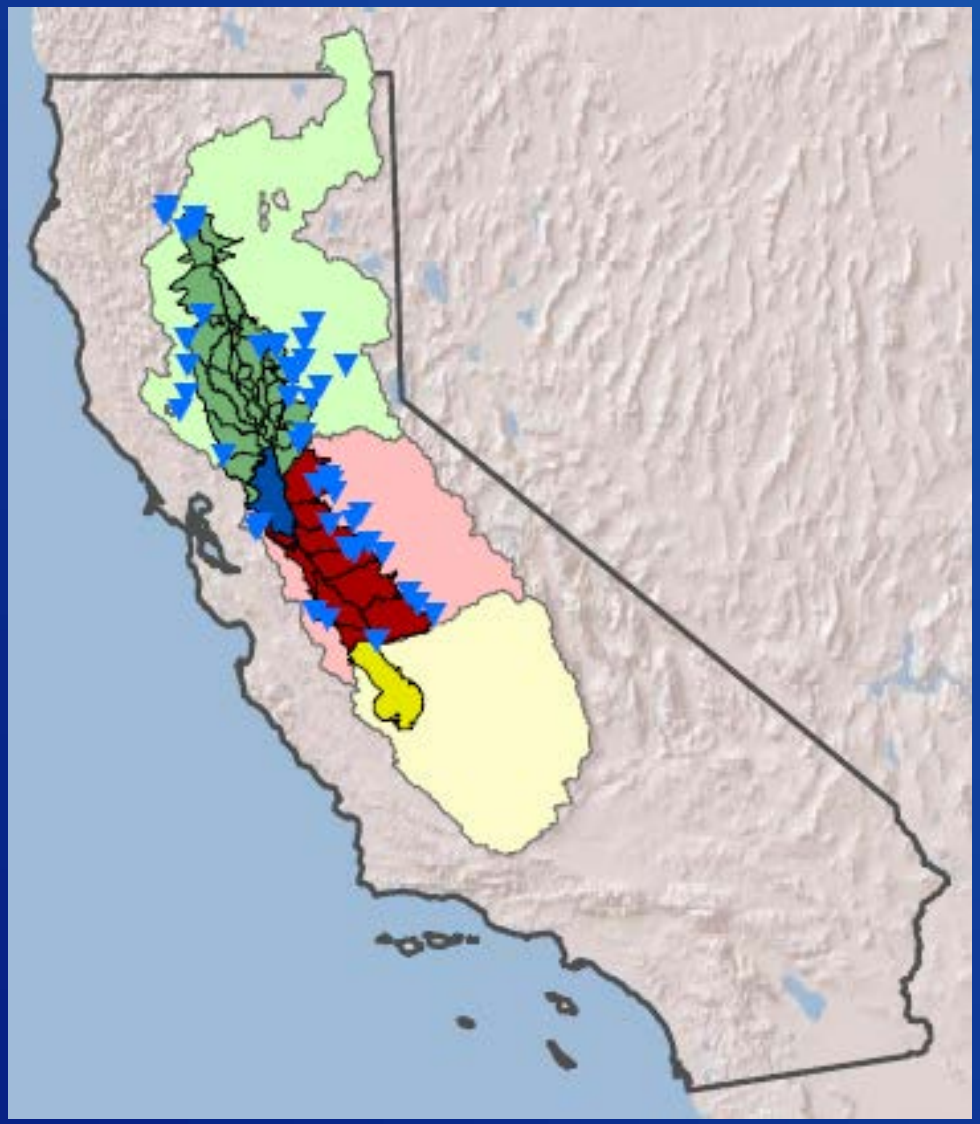
Part 2: System Sensitivity Analysis

Central Valley Project + State Water Project



Sacramento River (green)

- 27,500 mi^2
- 22 MAF

San Joaquin River (red)

- 15,600 mi^2
- 4.5 MAF

Tulare Basin (yellow)

- 16,200 mi^2
- Flow to SJR only in flood
- Avg ~ 142 TAF; Max ~ 2.37 MAF

Part 2: System Sensitivity Analysis

Water Resources System Model:

CalSim3.0

Model Nodes	
Storage Nodes	~45
Demand Nodes	~250
Conveyance Nodes	~725
Miscellaneous	~75
Total	**>1100**

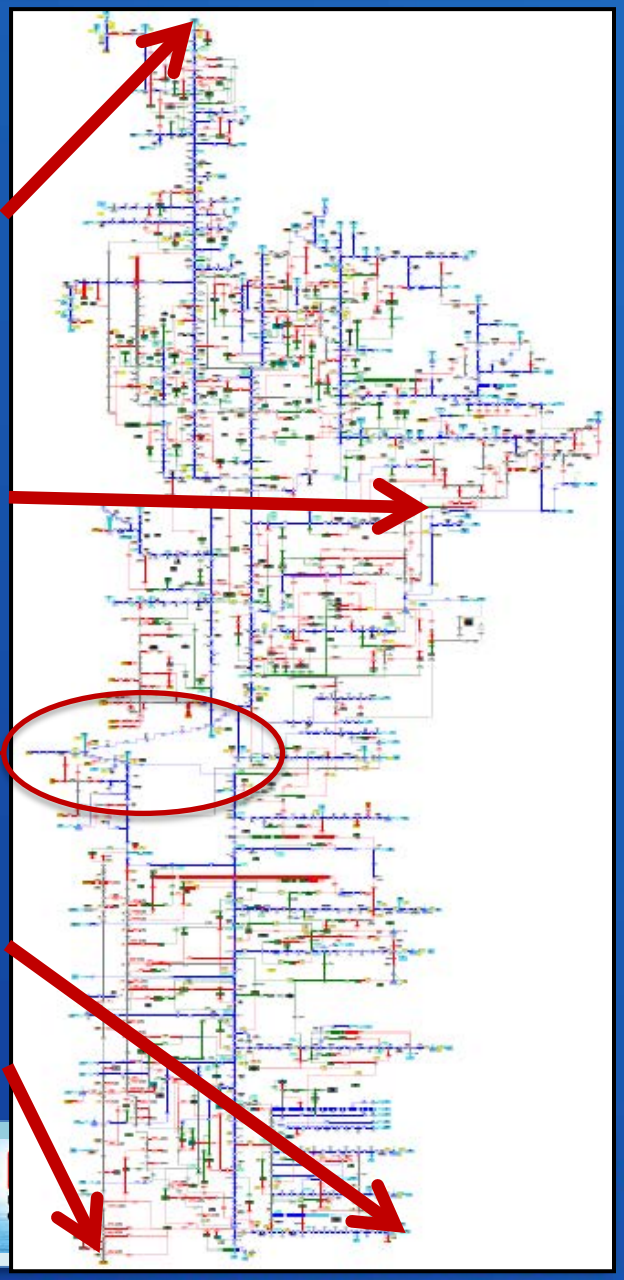
Lake Shasta

Folsom Lake

Delta

Millerton Lake

California Aqueduct to SoCal



Part 2: System Sensitivity Analysis

- **Climate Perturbation Approach**

➢ Systematic, idealized perturbation of historical precipitation and temperature

Variable decomposed into mean, standard deviation, and standardized anomaly…

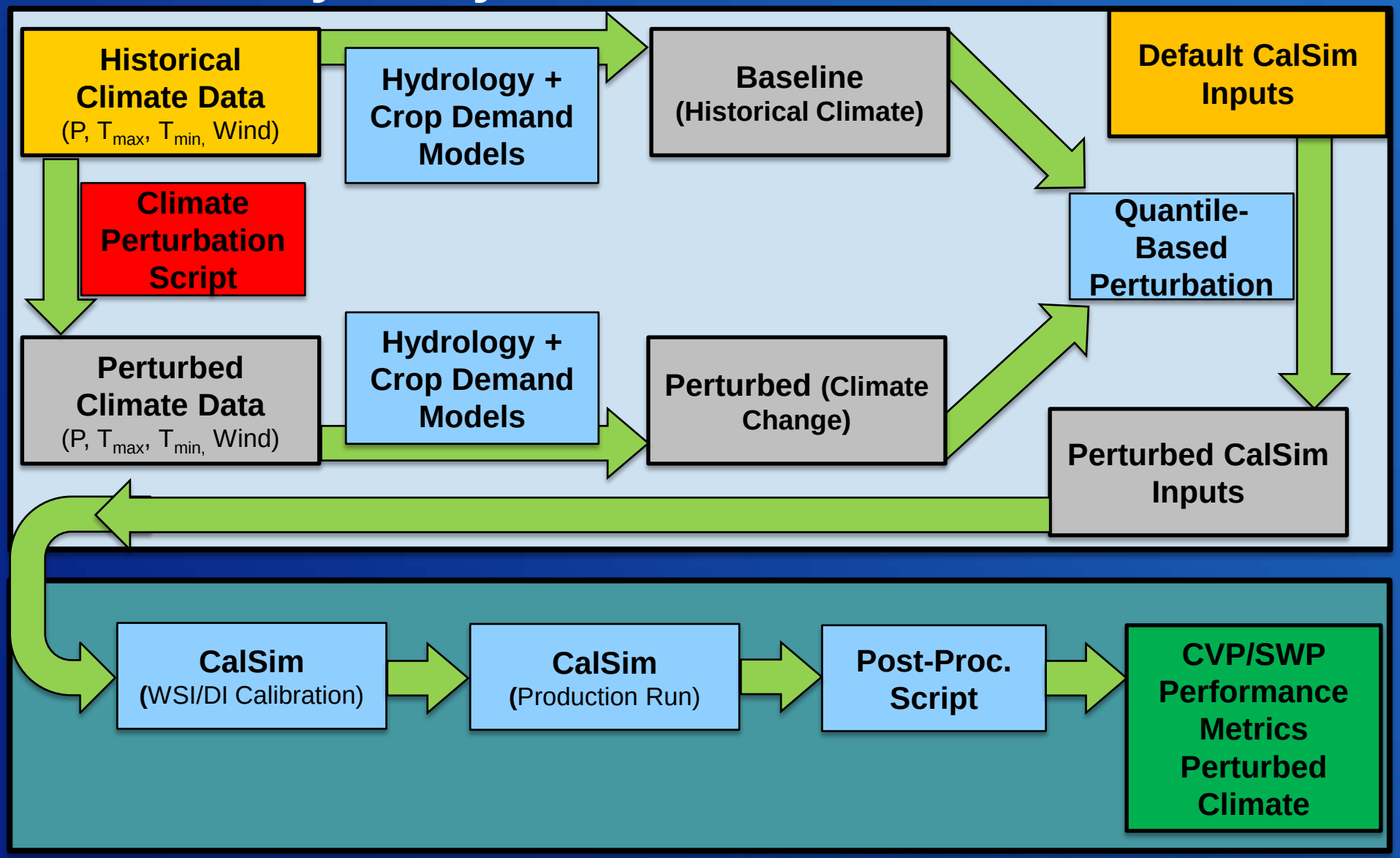
$$\Pi_{ym} = \left(\overline{\Pi}_m\right) + \left(\sigma_{\Pi_m} \cdot \Pi'_{ym}\right)$$

Perturbation applied to mean and/or variance for selected months of the year…

$$\Pi_{ym}^{perturb} = a_m\left(\overline{\Pi}_m\right) + b_m\left(\sigma_{\Pi_m} \cdot \Pi'_{ym}\right)$$

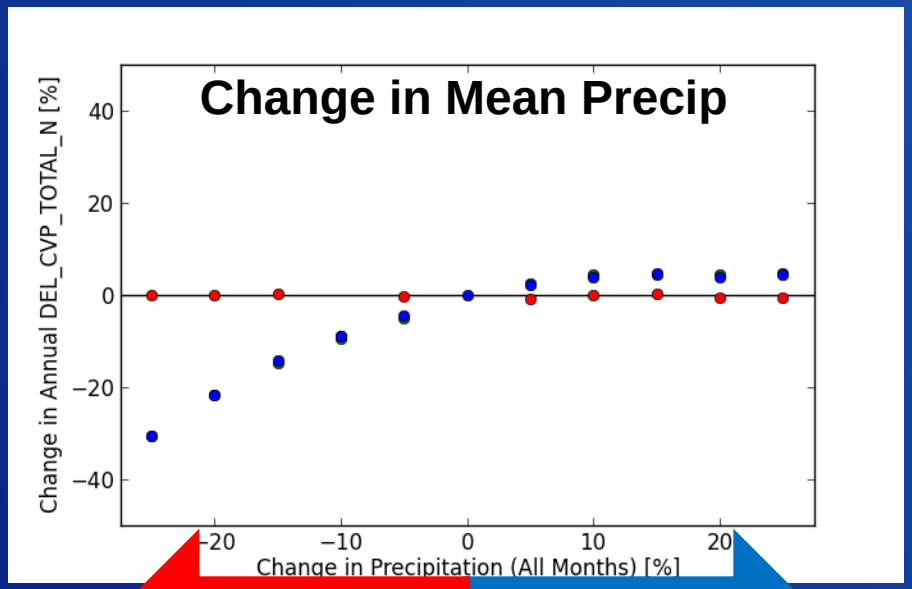
Part 2: System Sensitivity Analysis

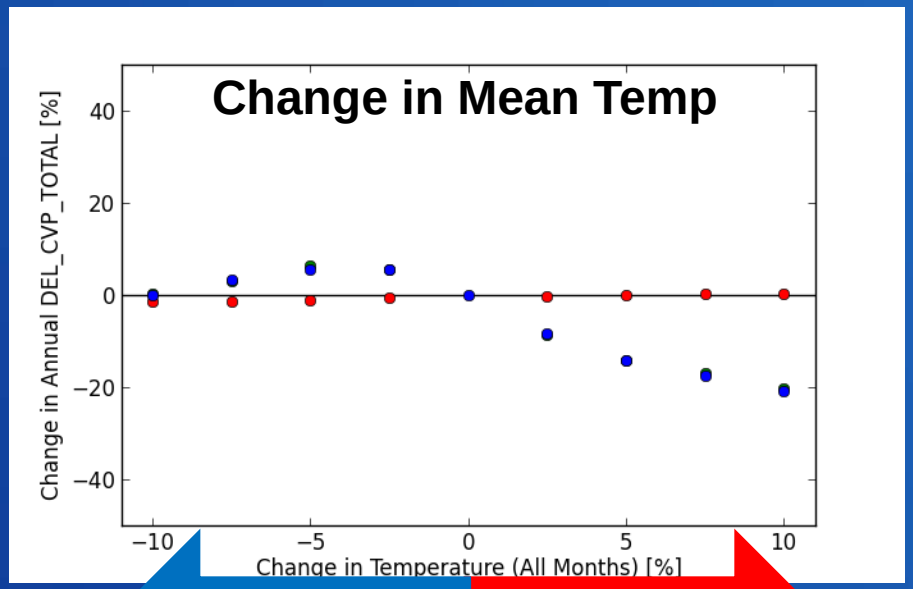
- **Sensitivity Analysis Workflow**



Part 2: System Sensitivity Analysis

- **Climate sensitivity…**
  Total North-of-Delta CVP Deliveries





Drier Wetter

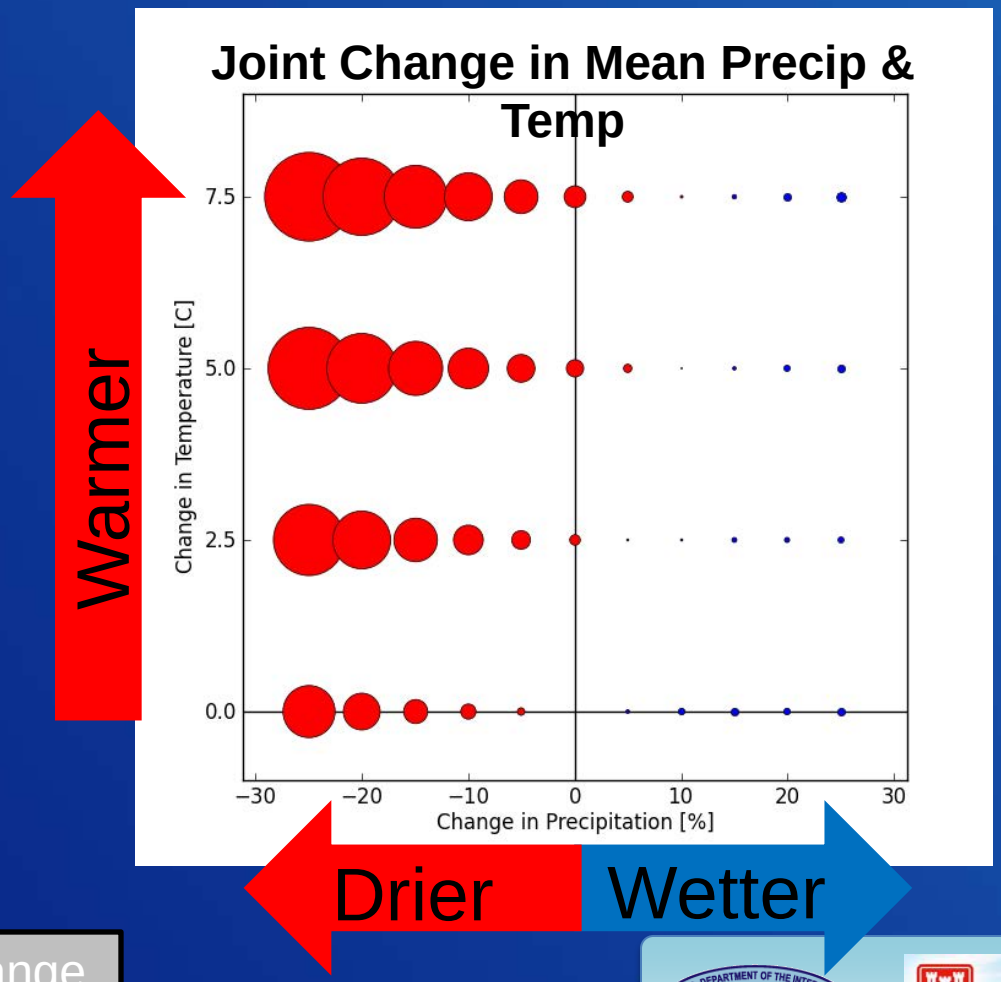
Cooler Warmer

- Valley Inputs
- Rim Inputs
- All Inputs

Part 2: System Sensitivity Analysis

- **Climate sensitivity…**

  Total North-of-Delta CVP Deliveries



Negative Change
Positive Change

Next Steps

- **Pilot workshop – mock scoping session**
  - Engage with key planners and decision makers
  - Observe how planners use reliability and relevance information in scoping major planning study
  - Get feedback from planners regarding information and framework
  - Use input from workshop to improve/finalize framework

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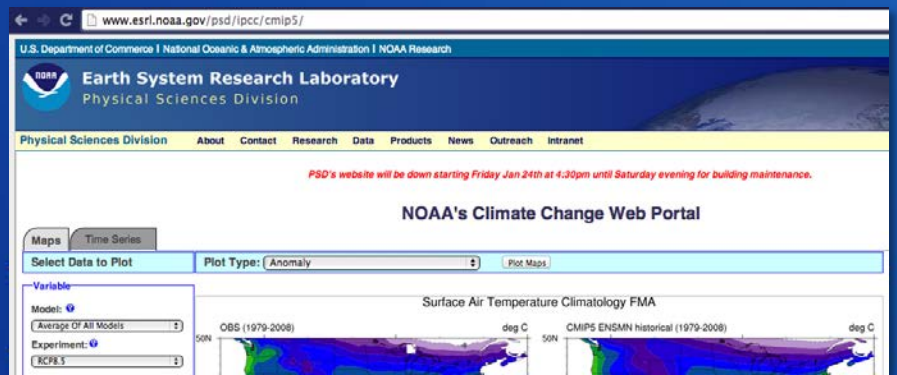
Summary

- Project develops and applies a new framework for evaluating climate change information for water/environmental planning applications
- Climate Change Web Portal – quick and easy resource for planners (etc.) to evaluate CMIP5
- Sensitivity Analysis – insight into CVP/SWP climate sensitivity for broad array of metrics
- Pilot Workshop – apply and hone framework

Key Lessons Learned

- Applying climate perturbations to water resources system models in a consistent and comprehensive manner is extremely challenging!
- Distilling the complex results of CMIP5 experiments into simple, yet useful metrics for assements in environmental planning is a difficult balancing act.

Next Steps/Future Work

- **Wrap Up – evaluation, sensitivity analysis**
- **Pilot Workshop – mock scoping session**
  - Engage with key planners / decision makers
  - Observe how planners use reliability and relevance information in scoping major planning study
  - Get feedback from planners regarding information and framework
  - Use input from workshop to hone framework
- **Documentation and publication of results**

Visit the Web Portal: →
esrl.noaa.gov/psd/ipcc/cmip5