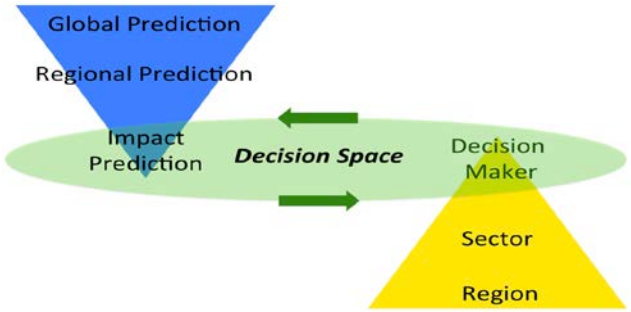
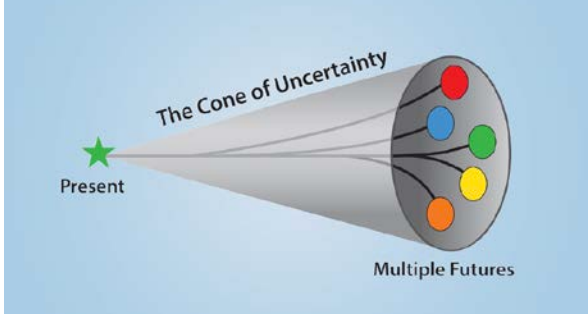


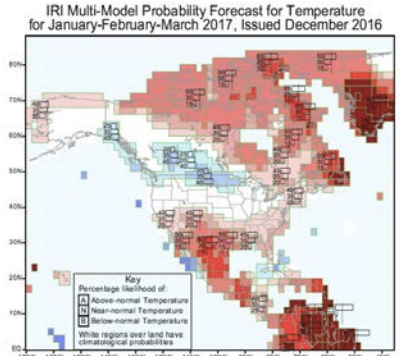


Incorporating decadal climate predictions into water management

Erin Towler, David Yates, &

Debasish PaiMazumder

NCAR



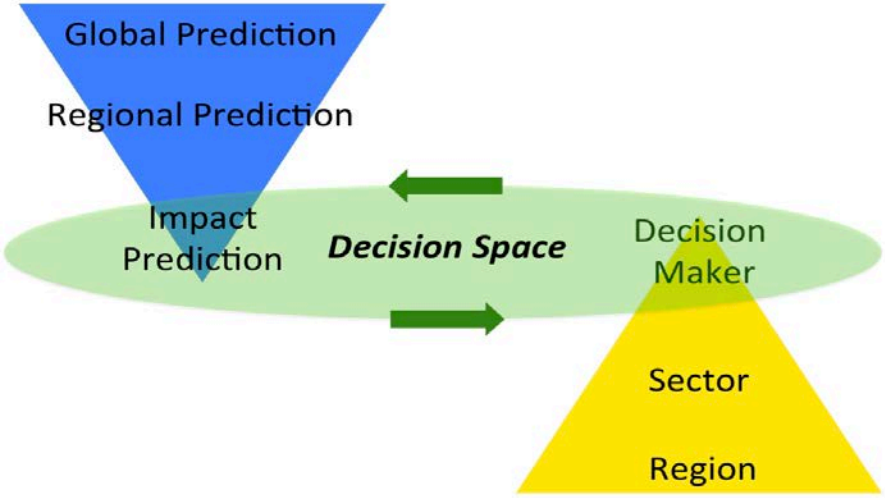
Societal Dimensions Working Group Meeting
Feb 28, 2017

towler@ucar.edu

Understanding Decision-Climate Interactions on Decadal Scales

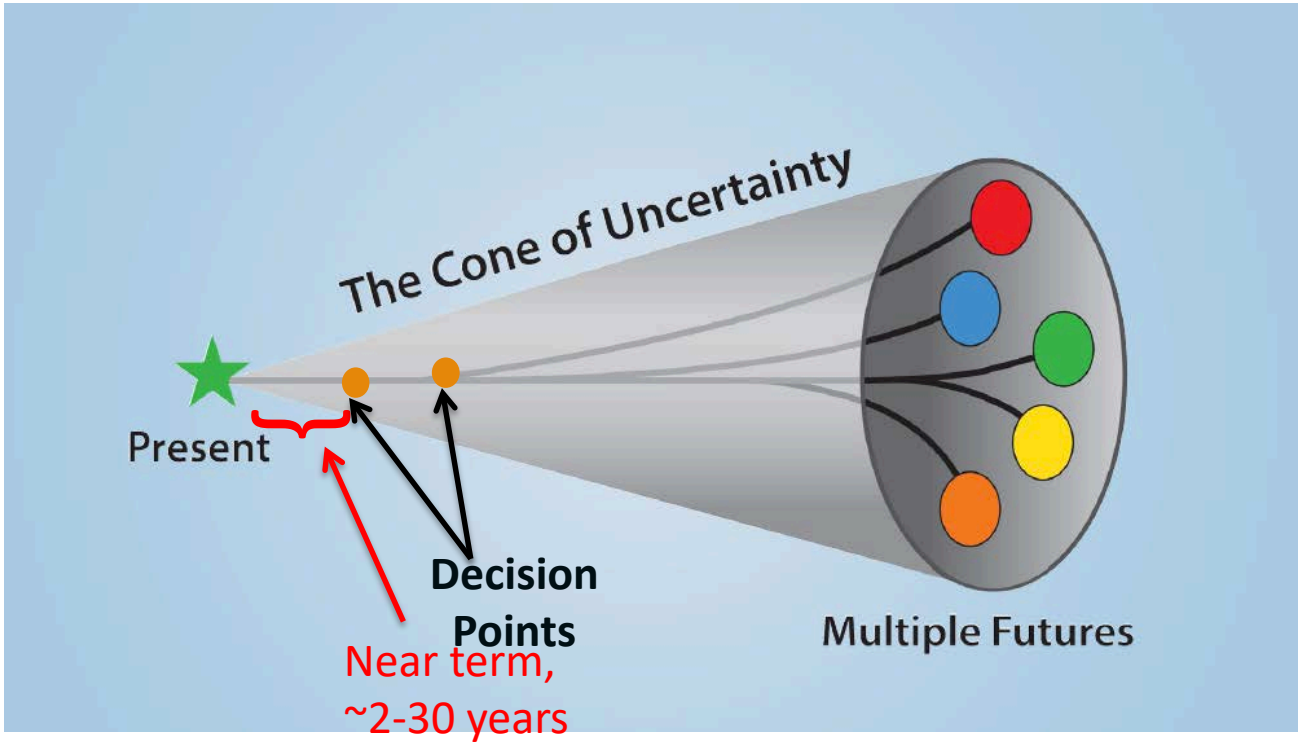
UDECIDE aims to understand the role of decadal climate information for water management decisions.

What information is skillful on decadal scales?

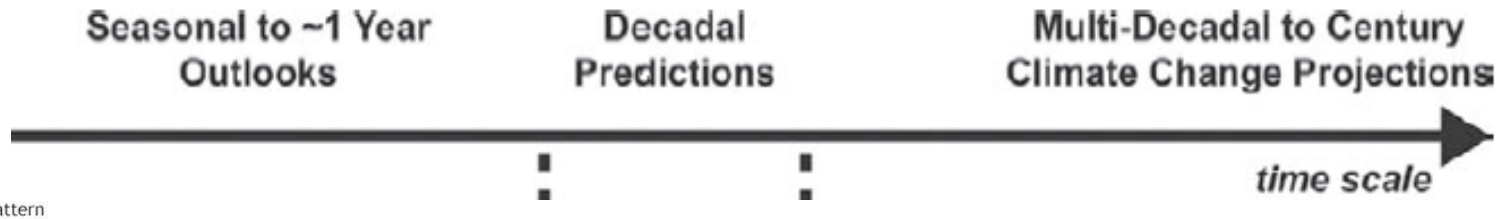


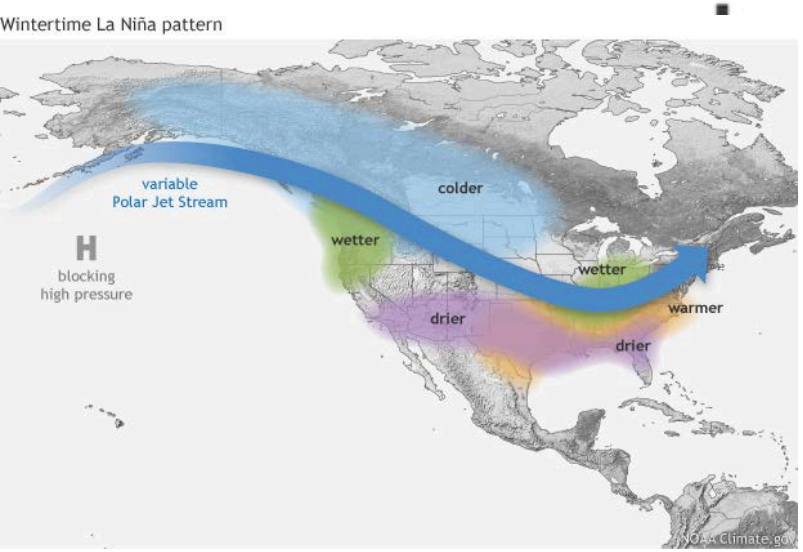
What information is needed on decadal scales?

Water utilities have identified improved climate projections on decadal time scales as a desired need to better fit with their planning horizons (Barsugli et al. 2009, WUCA).

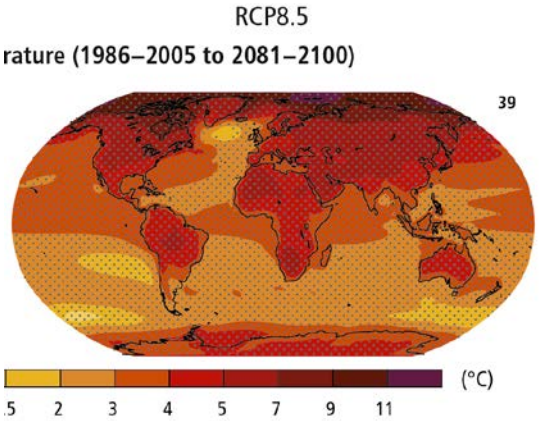


Decadal predictions bridge gap between seasonal forecasting and future climate change projections



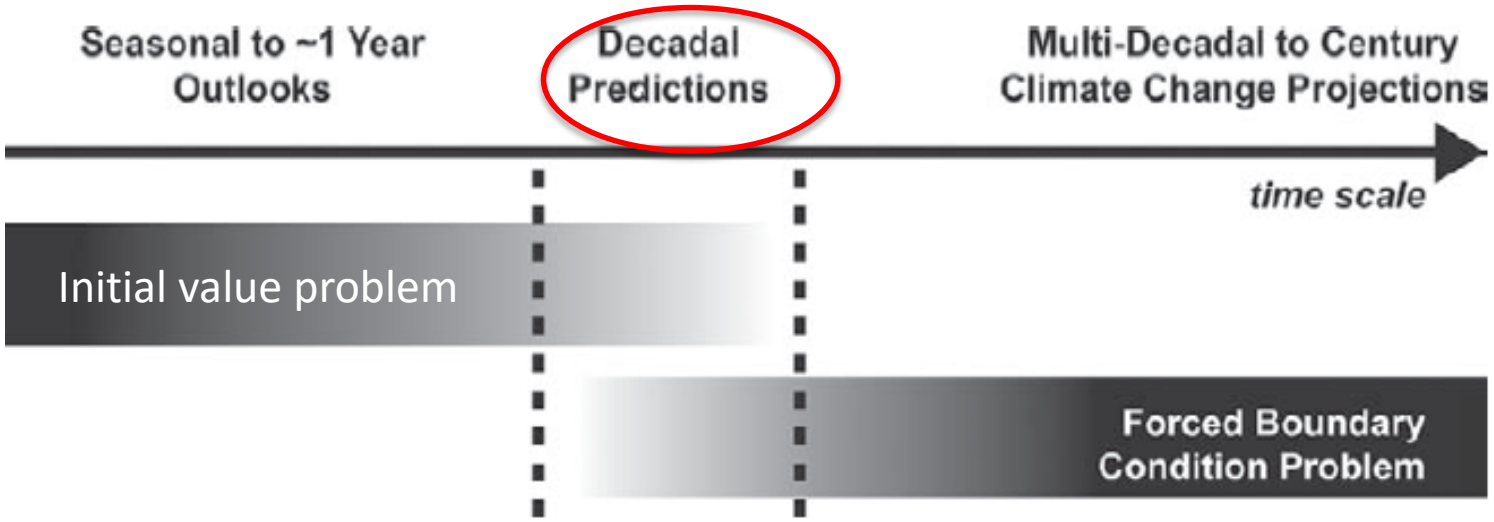


Initial value problem: Climate models are **initialized to current conditions** and run out months to a year

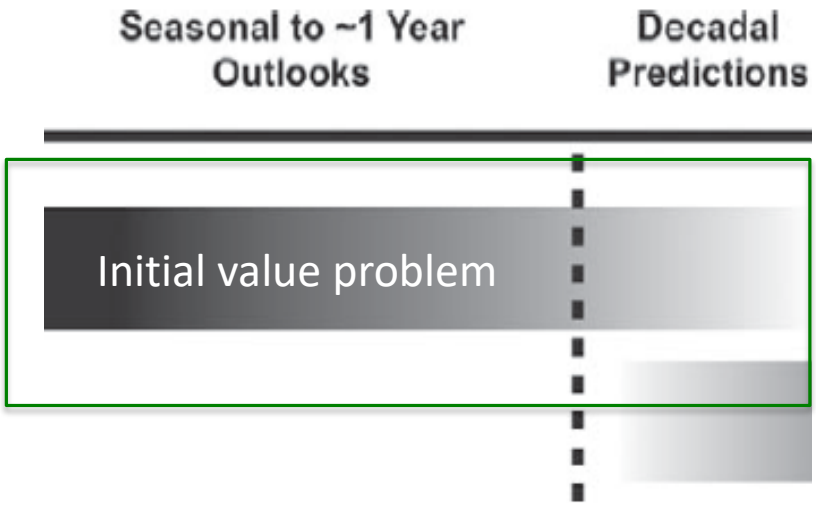


Forced boundary problem: Climate models start in randomly selected preindustrial states and are **forced by greenhouse gas emissions (radiative forcing)**

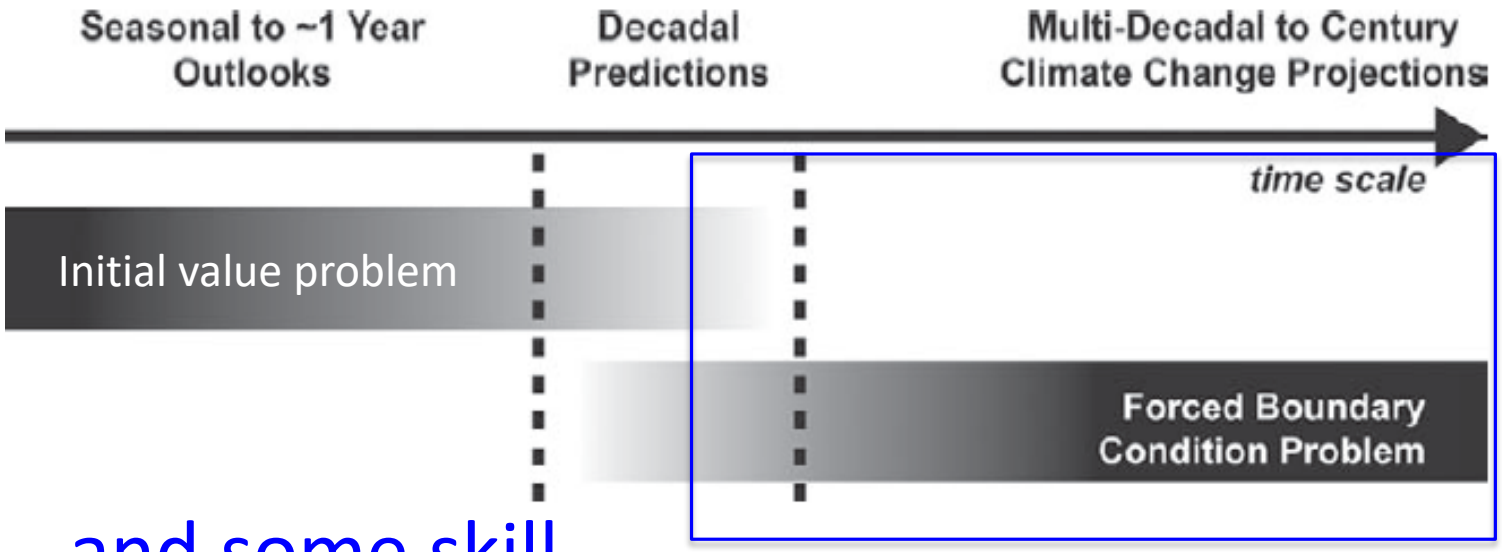
Decadal predictions are both an initial value problem and a forced condition problem



Decadal predictions get some skill from the "initialization"…

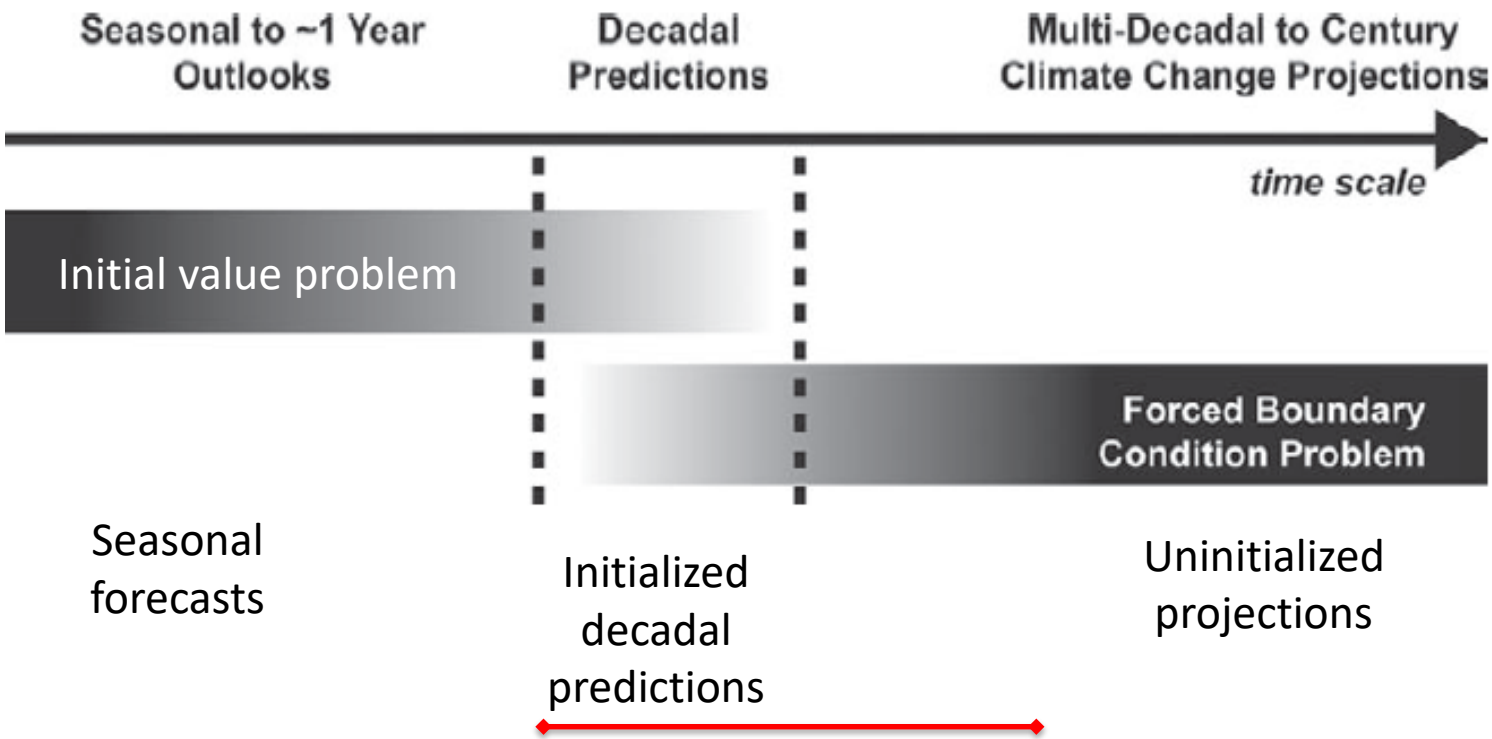


Decadal predictions get some skill from the "initialization"…



… and some skill from the **radiative forcing** (climate change signal)

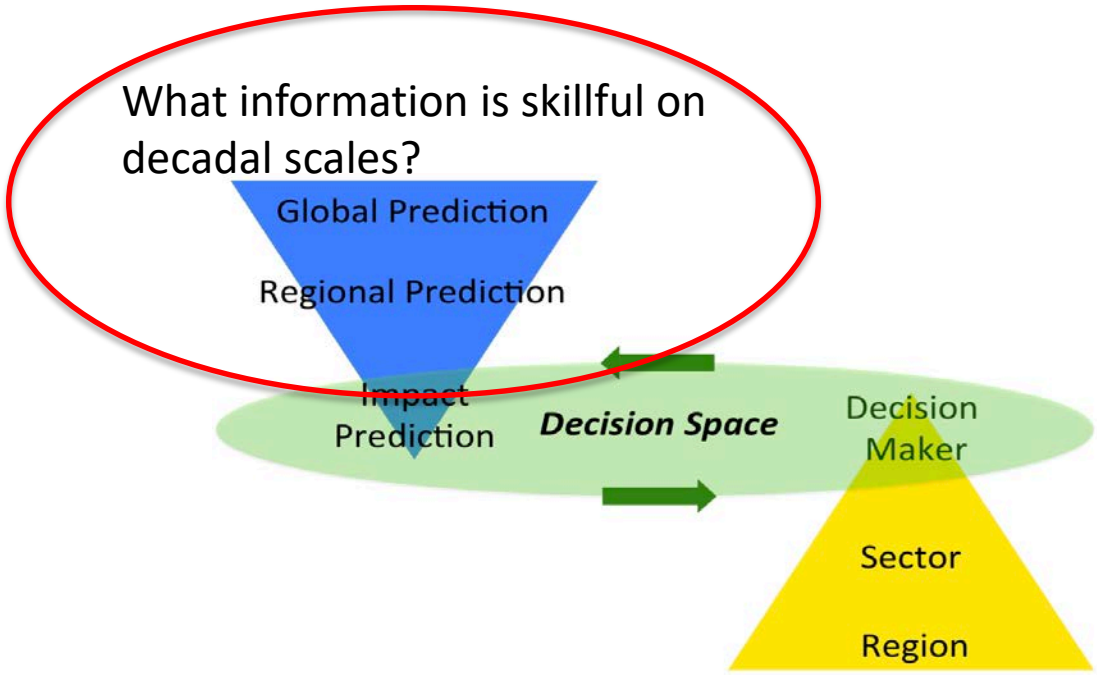
TERMINOLOGY



Near term climate information (~2-30 years) encompasses both predictions and projections.

Understanding Decision-Climate Interactions on Decadal Scales

UDECIDE aims to understand the role of decadal climate information for water management decisions.



What information is needed on decadal scales?

The CMIP5* included decadal hindcast experiments to understand the potential predictibility and skill

Model/modeling center
BCC-CM1.1 BCC, China
CanCM4 CCCma, Canada
CCSM4 NCAR, United States
CFSv2–2011 NCEP, United States
CFSv2–2011 COLA, United States
CMCC-CM CMCC, Italy
CNRM-CM5 CNRM-CERFACS (France)
EC-Earth (consortium)
FGOALS-g2 LASG-CESS, China FGOALS-s2 LASG-IAP, China
GEOS-5 NASA-GMAO, United States
GFDL-CM2.1 NOAA-GFDL (United States)
HadCM3 Met Office Hadley Centre, United Kingdom
IPSL-CM5A-LR IPSL (France)
MIROC4h, MIROC5 MIROC, Japan
MPI-ESM-LR, MPI-ESM-MR MPI-M, Germany
MRI-CGCM3, MRI, Japan

* Coupled Model Intercomparison Project 5

Research shows **potential and some evidence for prediction skill** on decadal timescales

- Decadal skill depends on phenomenon, time horizon, variable, & region

Kirtman et al. 2013, IPCC;
Meehl et al. 2009;
Meehl et al. 2014

Initialized decadal predictions show widespread skill in temperature

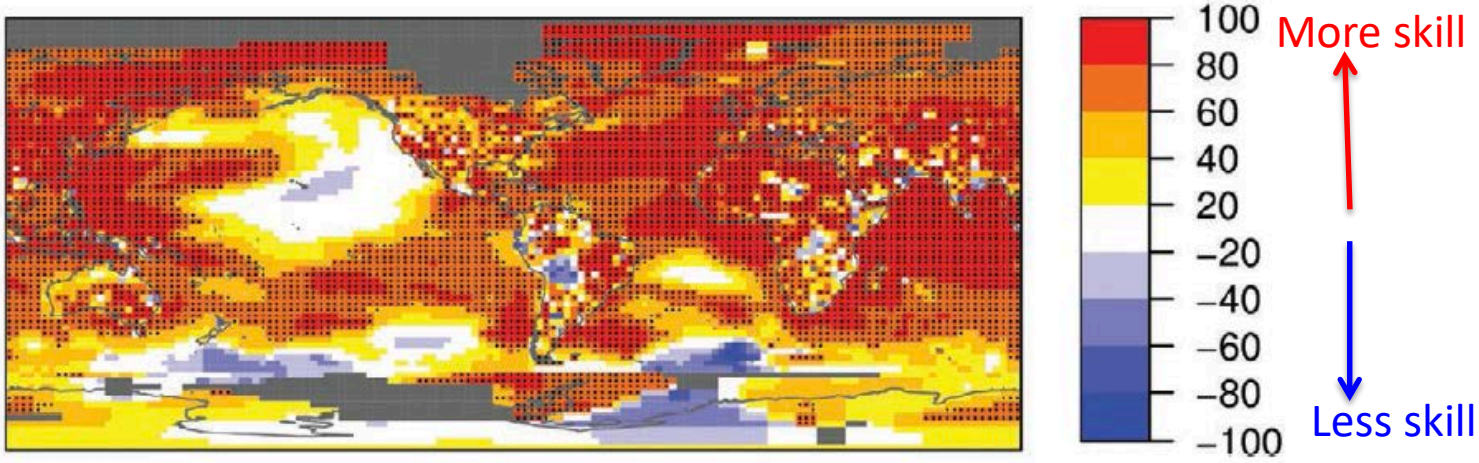
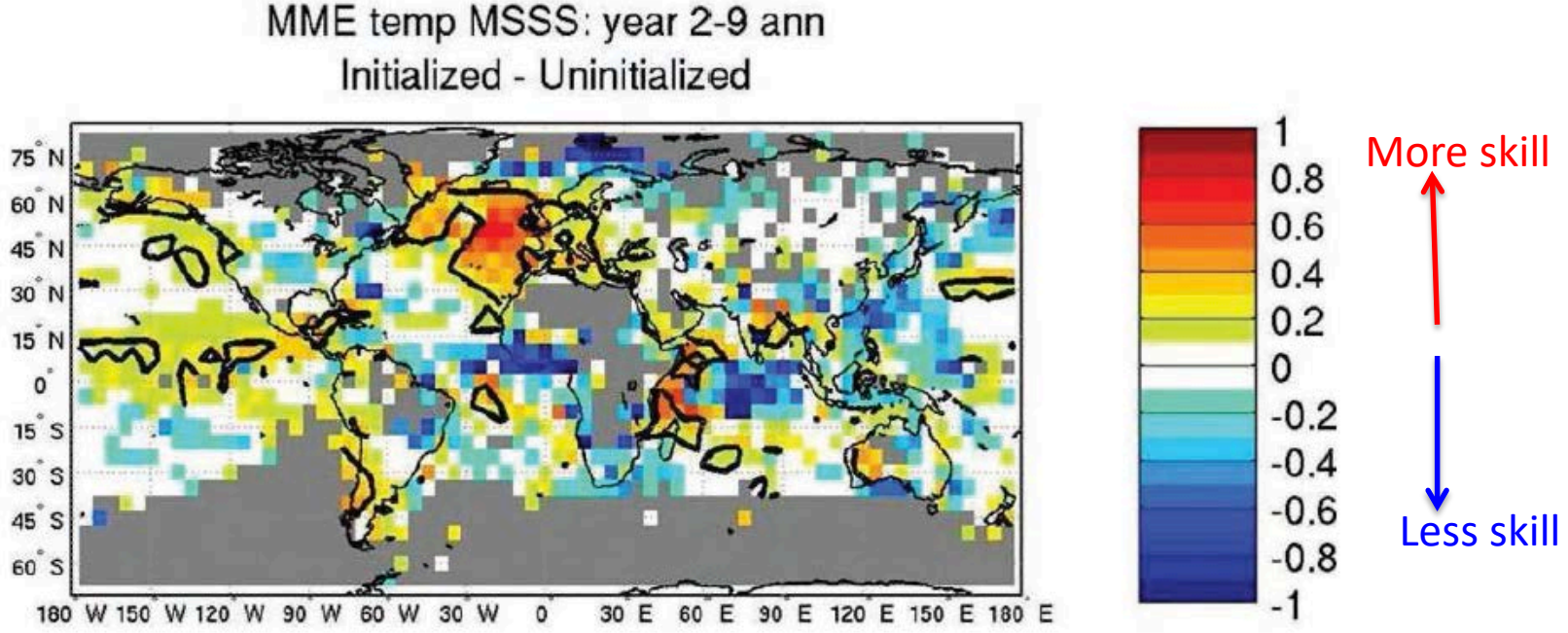


FIG. 4. Surface air temperature predictive skill (correlation with observations), predictions for years 6–9 averages based on CMIP5 multimodel ensemble mean hindcasts (see Table 1 for details). Results are from initialized hindcasts with

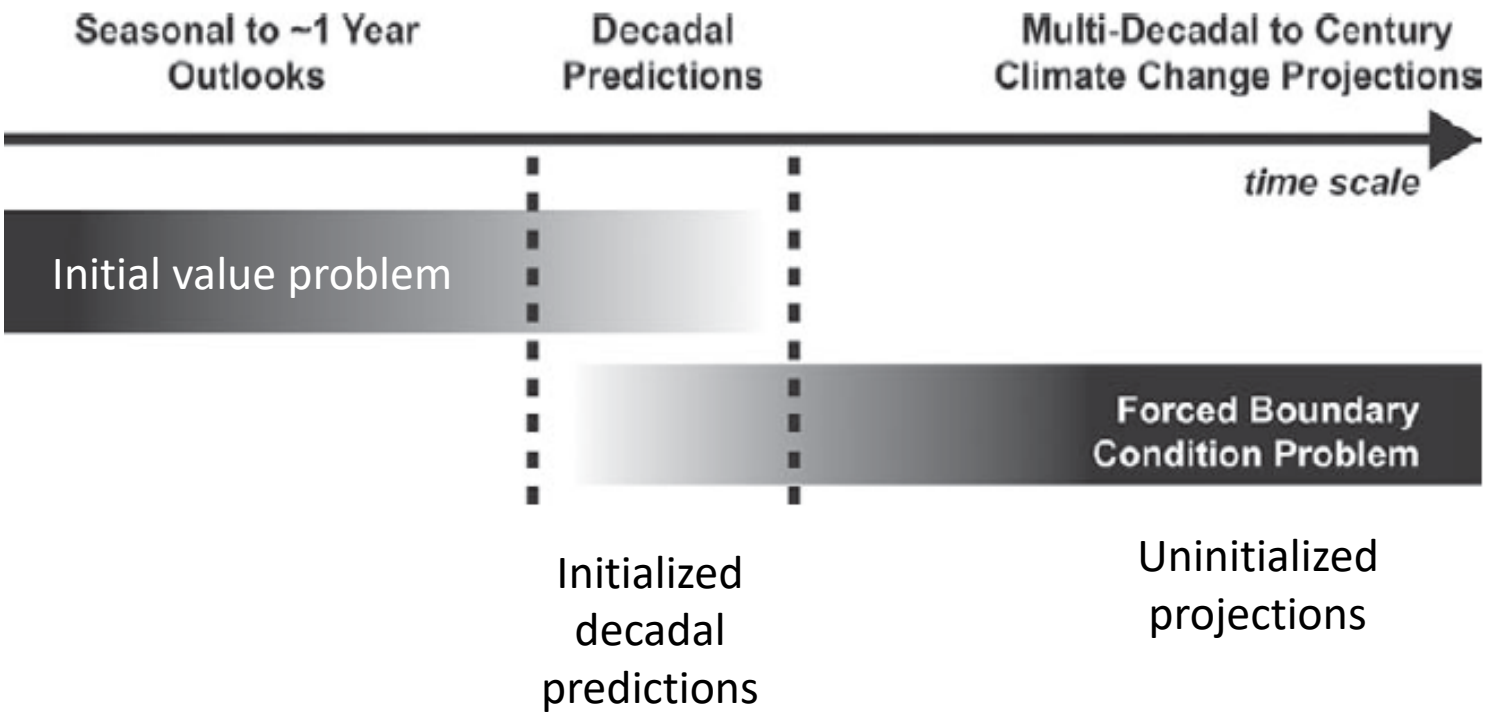
Meehl et al. 2014 BAMS

BUT, most skill is from **climate change signal (forcing)**, skill added from initialization varies spatially



Meehl et al. 2014 BAMS

Both the initialized predictions and uninitialized projections have skill for **temperature**



i.e., Near term temperature (~2-10 years) has skill

Precipitation is less skillful than temp; most skill is from climate change signal (forcing).

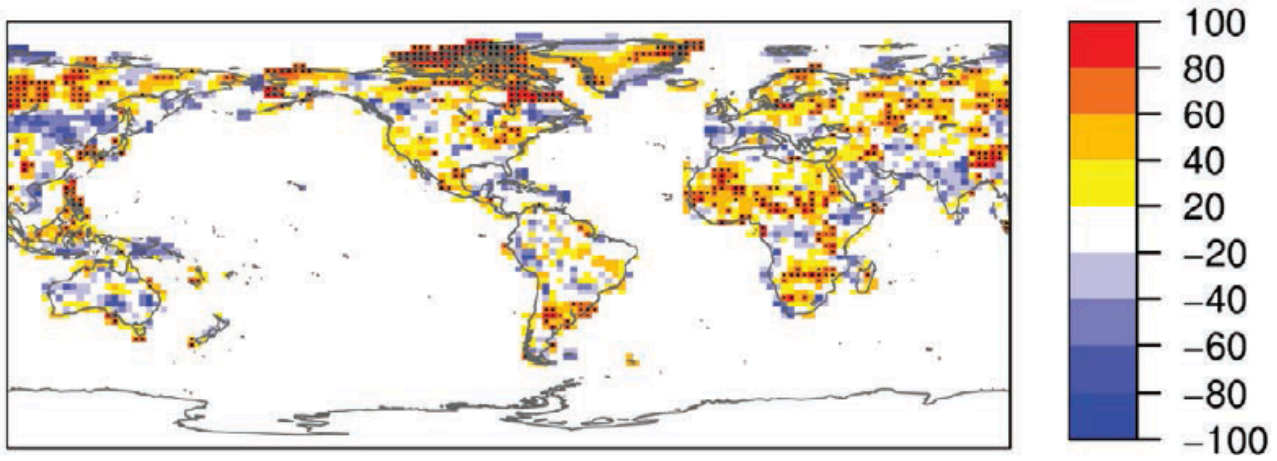


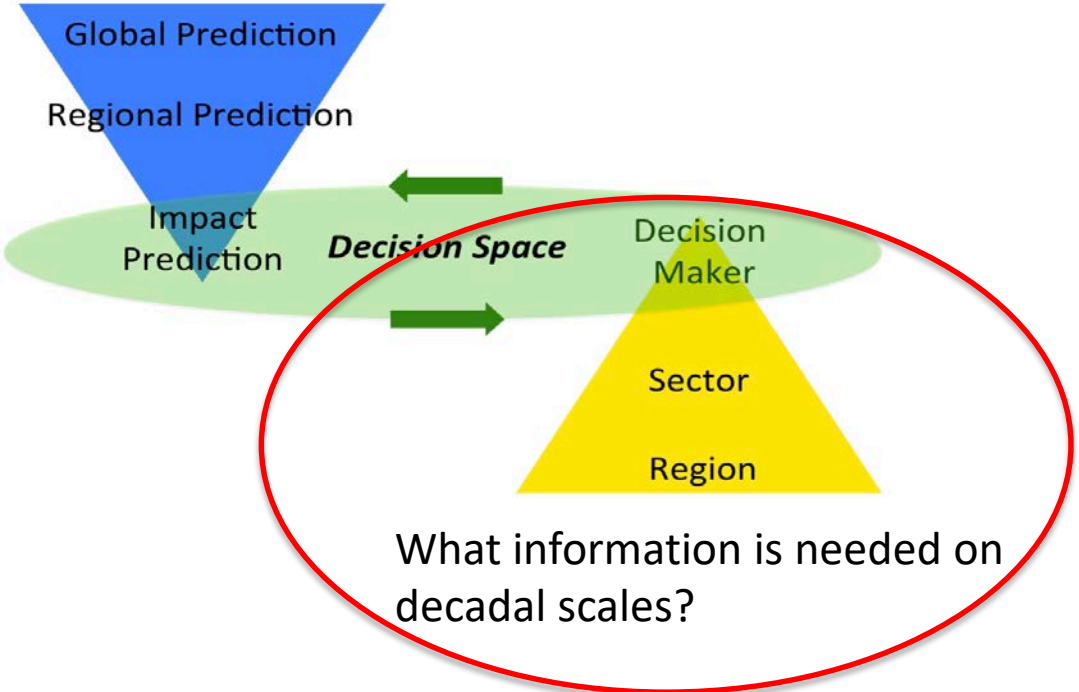
FIG. 8. Precipitation predictive skill (correlation with observations), predictions for years 6–9 averages based on CMIP5 multimodel ensemble mean hindcasts (see Table 1 for details). Results are from initialized hindcasts with 5-yr intervals between start dates from 1960 to 2005. Correlations are

Meehl et al. 2014 BAMS

Understanding Decision-Climate Interactions on Decadal Scales

UDECIDE aims to understand the role of decadal climate information for water management decisions.

What information is skillful on decadal scales?

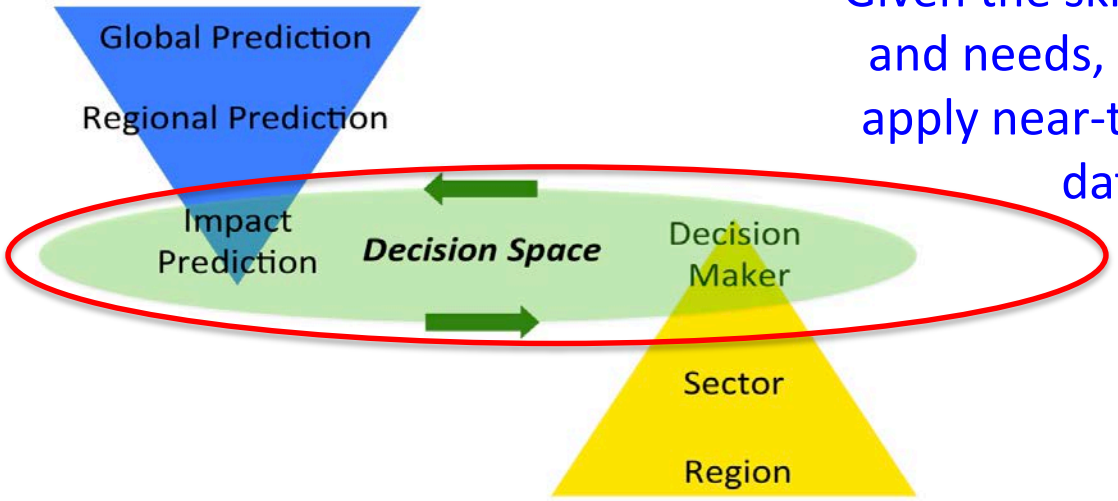


20 interviews with water managers in Colorado to explore potential of decadal information

Understanding Decision-Climate Interactions on Decadal Scales

UDECIDE aims to understand the role of decadal climate information for water management decisions.

What information is skillful on decadal scales?



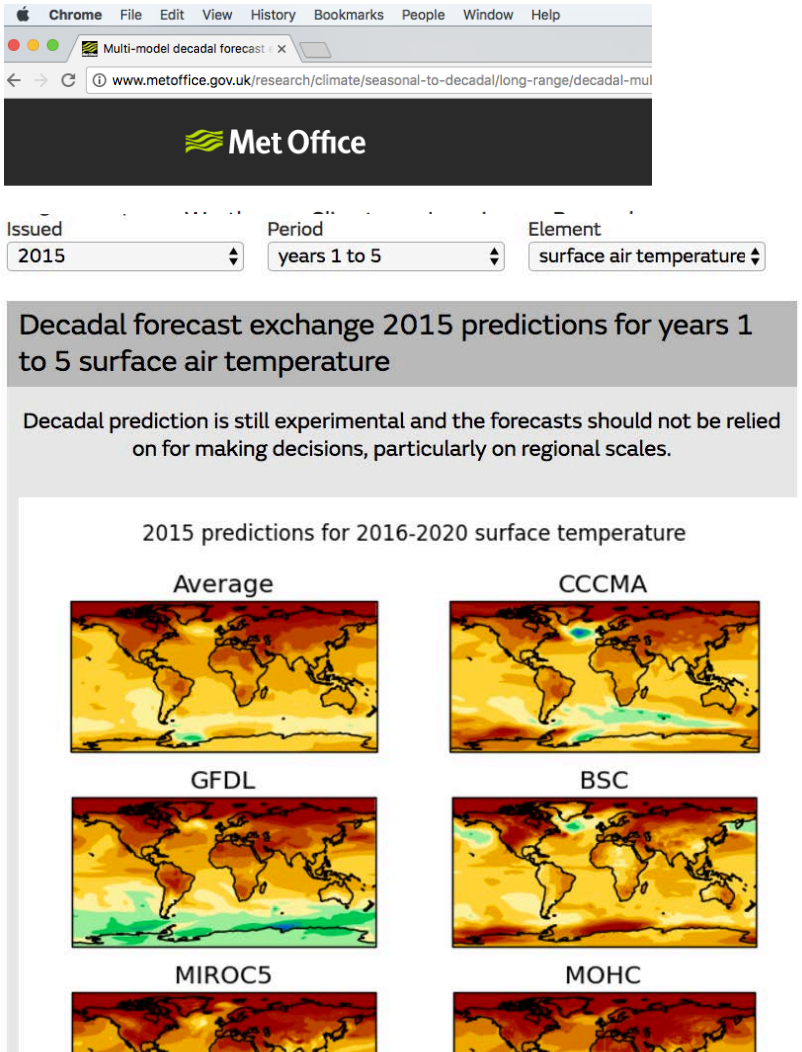
Given the skill, limitations and needs, how can we apply near-term climate data?

What information is needed on decadal scales?

Decadal predictions are not considered “operational”

- “decadal predictions… are in an exploratory stage” (Taylor et al. 2012 BAMS)
- “… very much an experimental and nascent activity.” (Goddard et al. 2010 Clim Dyn)

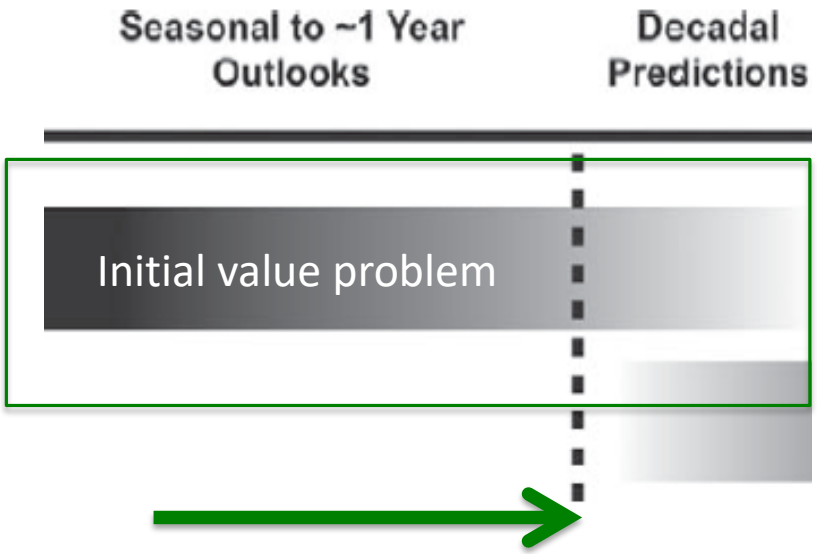
But, real-time decadal climate predictions are available (Smith et al. 2013)



Creating an urgent research need to :

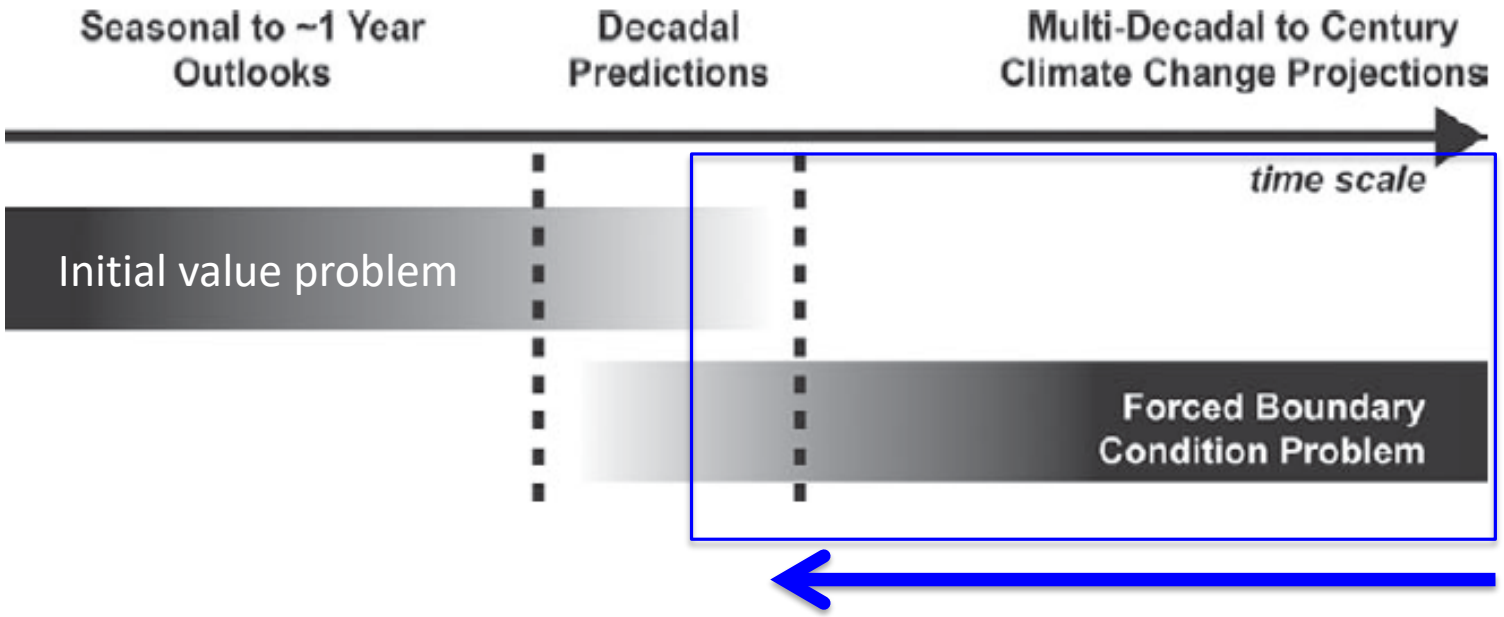
Develop an approach for communicating (Taylor et al. 2015) and incorporating near-term climate information in water resources applications.

Case Study Application:
Test application of near-term predictions using a seasonal forecasting approach



Case Study Application:

Test application of near-term predictions using a seasonal forecasting approach

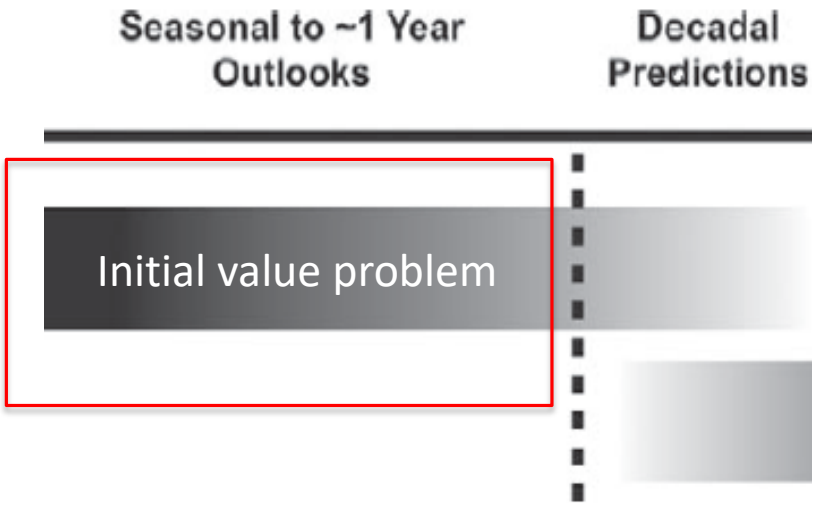


… and using a climate change projection approach.

Case study: Use near term climate information to estimate inflows into Cheesman Reservoir in South Platte, CO using WEAP model

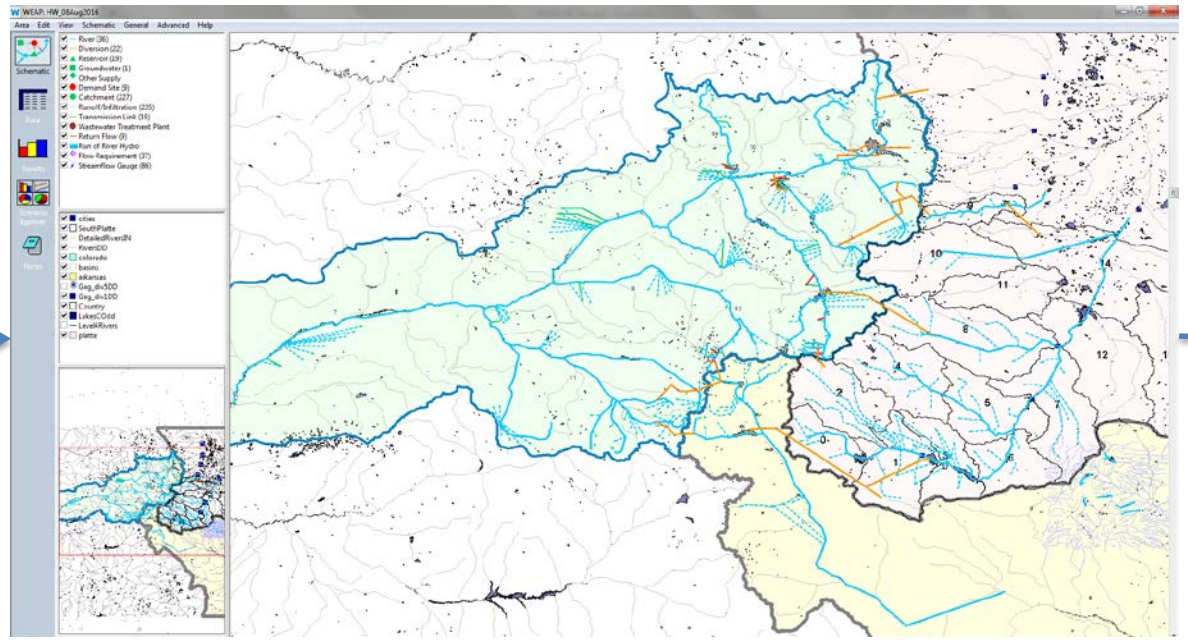
Cheesman inflow Case Study Application:

Already have seasonal forecasting research we can leverage



2016 Seasonal Forecast Experiment: WEAP to model inflows to Cheesman Reservoir

Temp & Precip

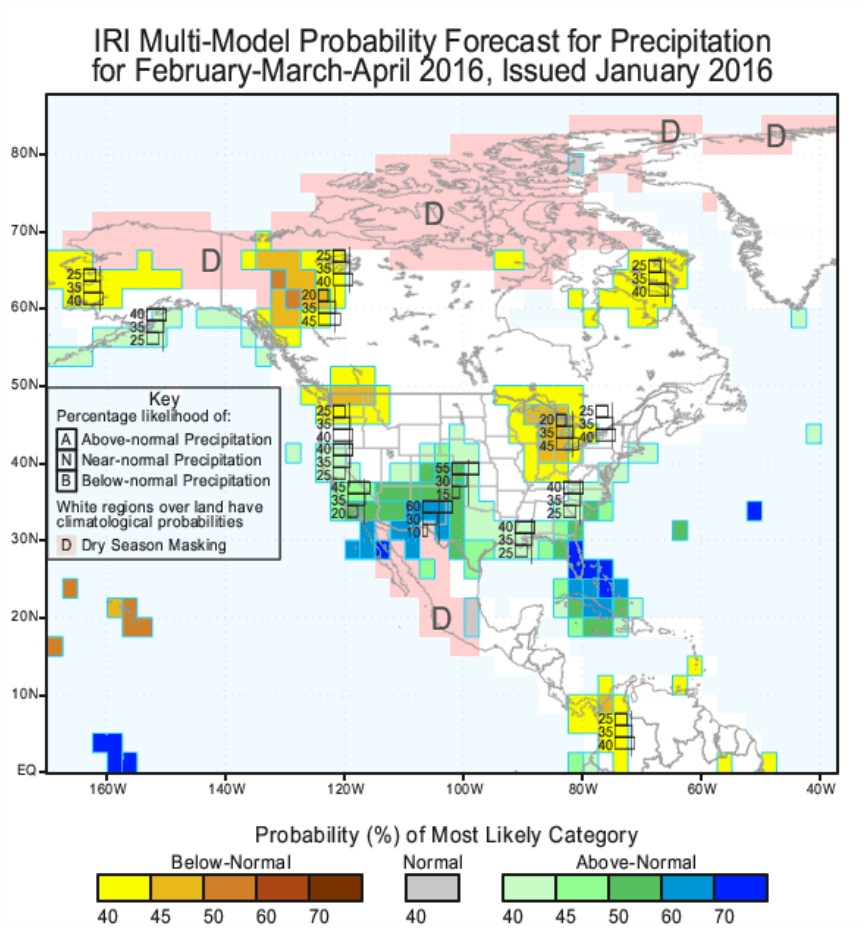


Reservoir inflows

Reservoir management, drought planning, etc.

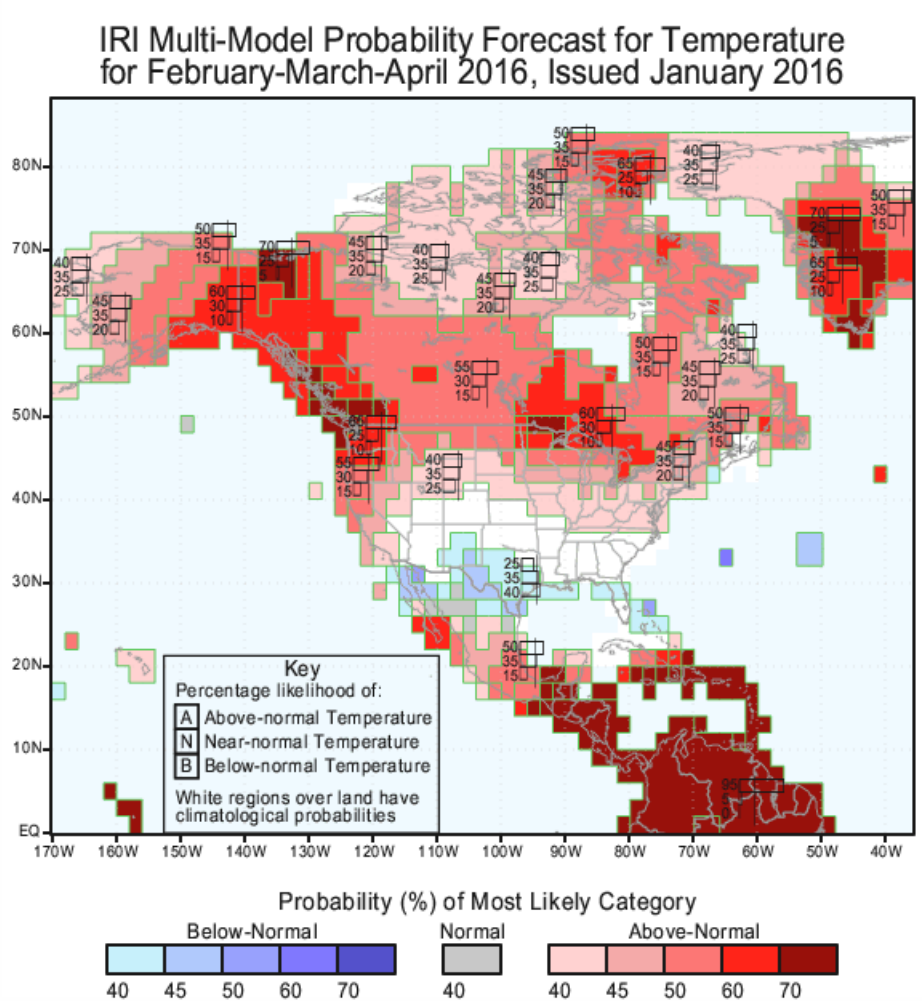
WEAP Application (Hydrologic model)
Courtesy David Yates, NCAR

2016 Forecast Experiment: Jan 2016 showed a wet forecast over Colorado



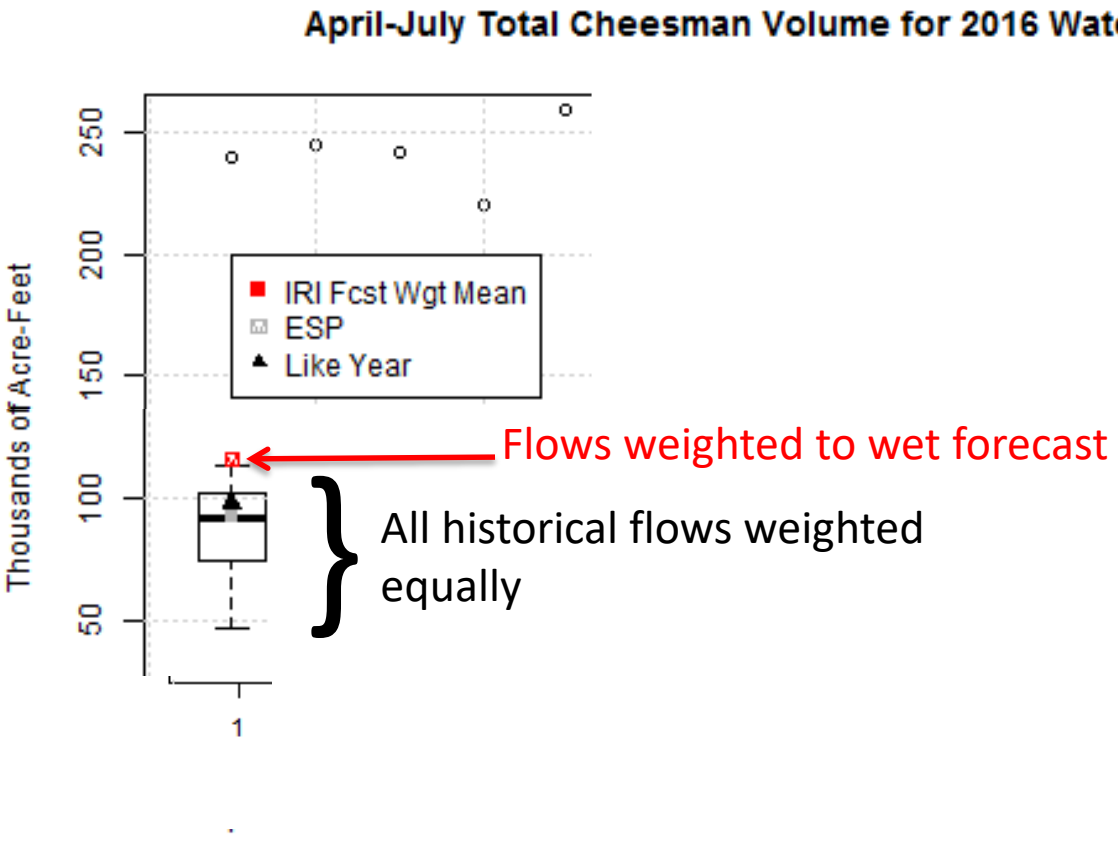
Precip: 55% above average, 30% normal, 15% below average
55/30/15

2016 Forecast Experiment: Jan 2016 showed near-normal temps over CO



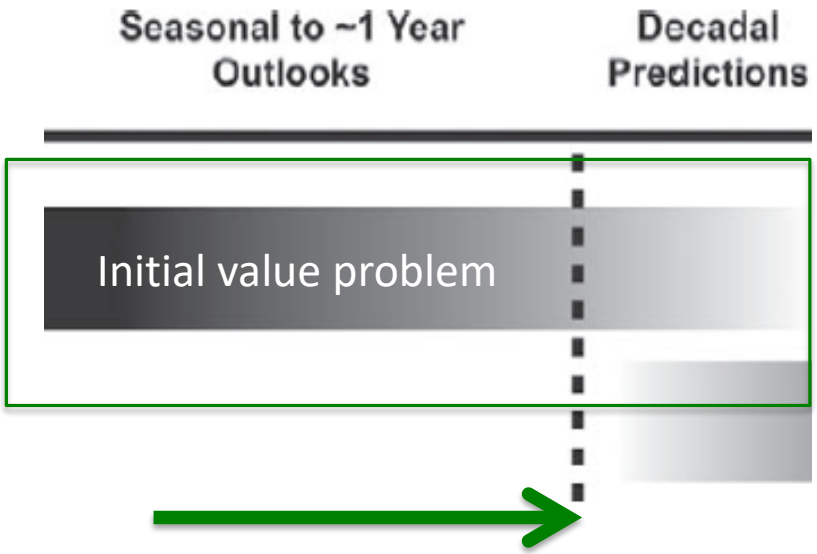
Temperature: 33/33/33 (Climatology)

2016 Forecast Experiment: Inflows to Cheesman Reservoir are weighted towards forecast



Courtesy David Yates, NCAR

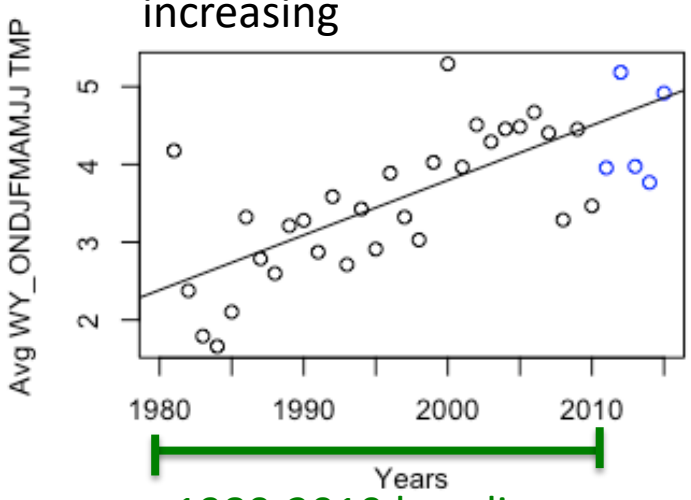
Case Study Application:
Test application of near-term predictions using a seasonal forecasting approach



2011-2015 Hindcast Experiment

** Only look at temperature because that is where there is skill

Water year temperature over the watershed is increasing



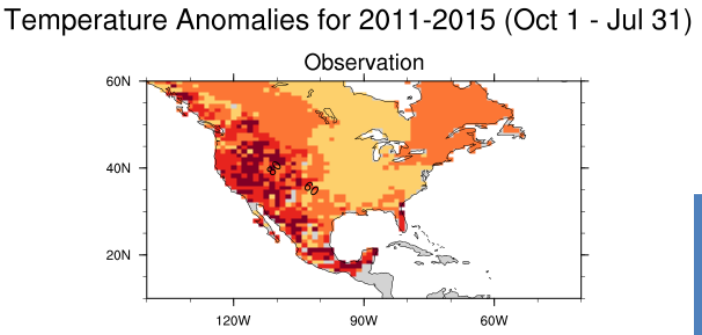
1980-2010 baseline

2011-2015 Hindcast Experiment

Data: NCAR's CCSM4 initialized decadal predictions (10 ensembles) and uninitialized projections (5 ensembles)

Model/modeling center
BCC-CM1.1 BCC, China
CanCM4 CCCma, Canada
CCSM4 NCAR, United States
CFSv2–2011 NCEP, United States
CFSv2–2011 COLA, United States
CMCC-CM CMCC, Italy
CNRM-CM5 CNRM-CERFACS (France)
EC-Earth (consortium)
FGOALS-g2 LASG-CESS, China FGOALS-s2 LASG-IAP, China
GEOS-5 NASA-GMAO, United States
GFDL-CM2.1 NOAA-GFDL (United States)
HadCM3 Met Office Hadley Centre, United Kingdom
IPSL-CM5A-LR IPSL (France)
MIROC4h, MIROC5 MIROC, Japan
MPI-ESM-LR, MPI-ESM-MR MPI-M, Germany
MRI-CGCM3, MRI, Japan

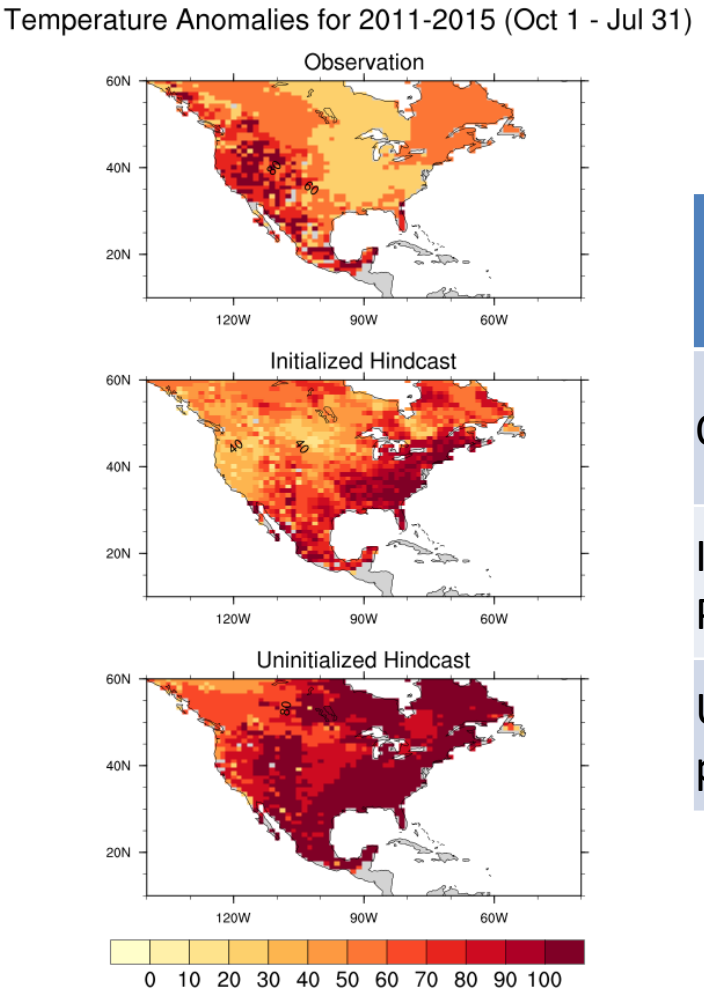
Probabilistic hindcast shows likelihood of being above average tercile



	A (A/N/B)
Observation	**50** (i.e., 50/35/15)

Courtesy of Deb PaiMazumder

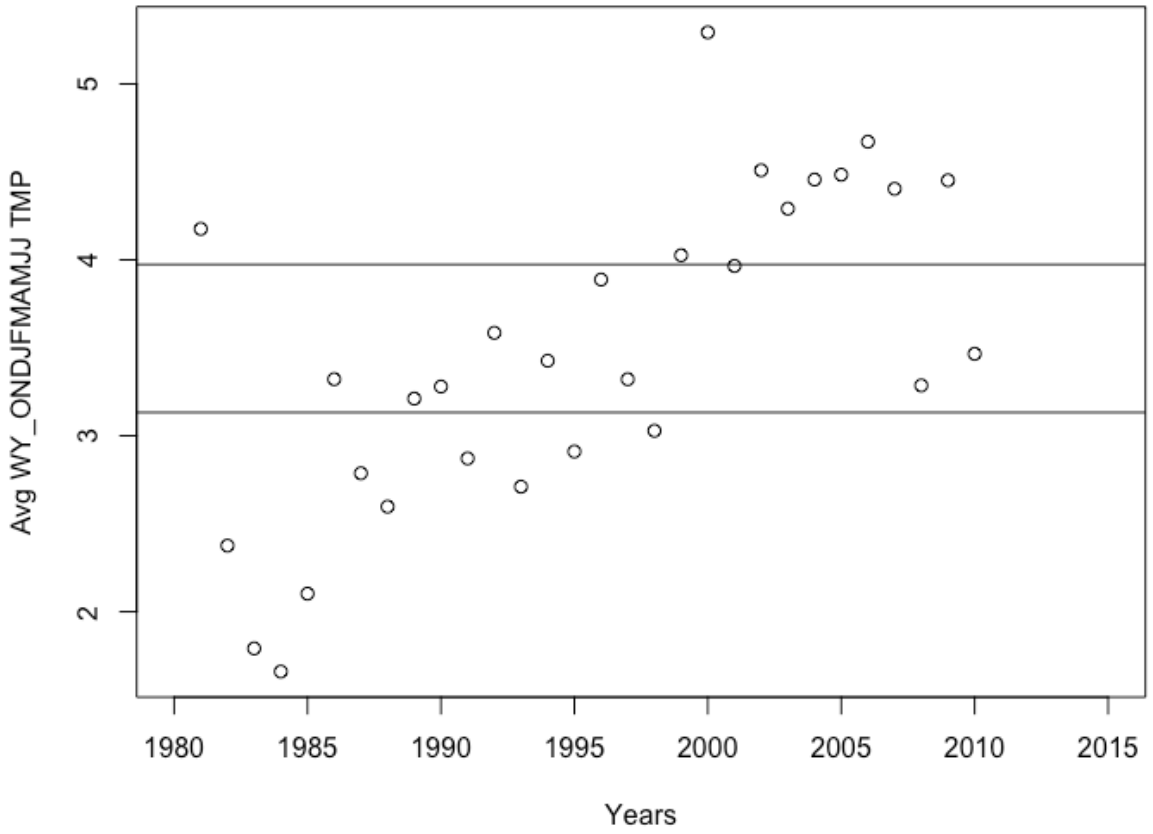
Probabilistic hindcast shows likelihood of being above average tercile



	A (A/N/B)
Observation	**50** (i.e., 50/35/15)
Initialized Prediction	**60** (i.e., 60/30/10)
Uninitialized projection	**100** (i.e., 100/0/0)

Courtesy of Deb PaiMazumder

Resample historical years weighted towards decadal forecast



Above normal

Near normal

Below normal

Create synthetic forecasts to do sensitivity analysis of increasing probability of above average temperatures.

	Temp
	A/N/B
Clm33	**33**/33/33
Wrm40	**40**/35/25
Wrm50	**50**/35/15
Wrm60	**60**/30/10
Wrm70	**70**/25/5
Wrm80	**80**/15/5
Wrm90	**90**/7/3
Wrm100	**100**/0/0

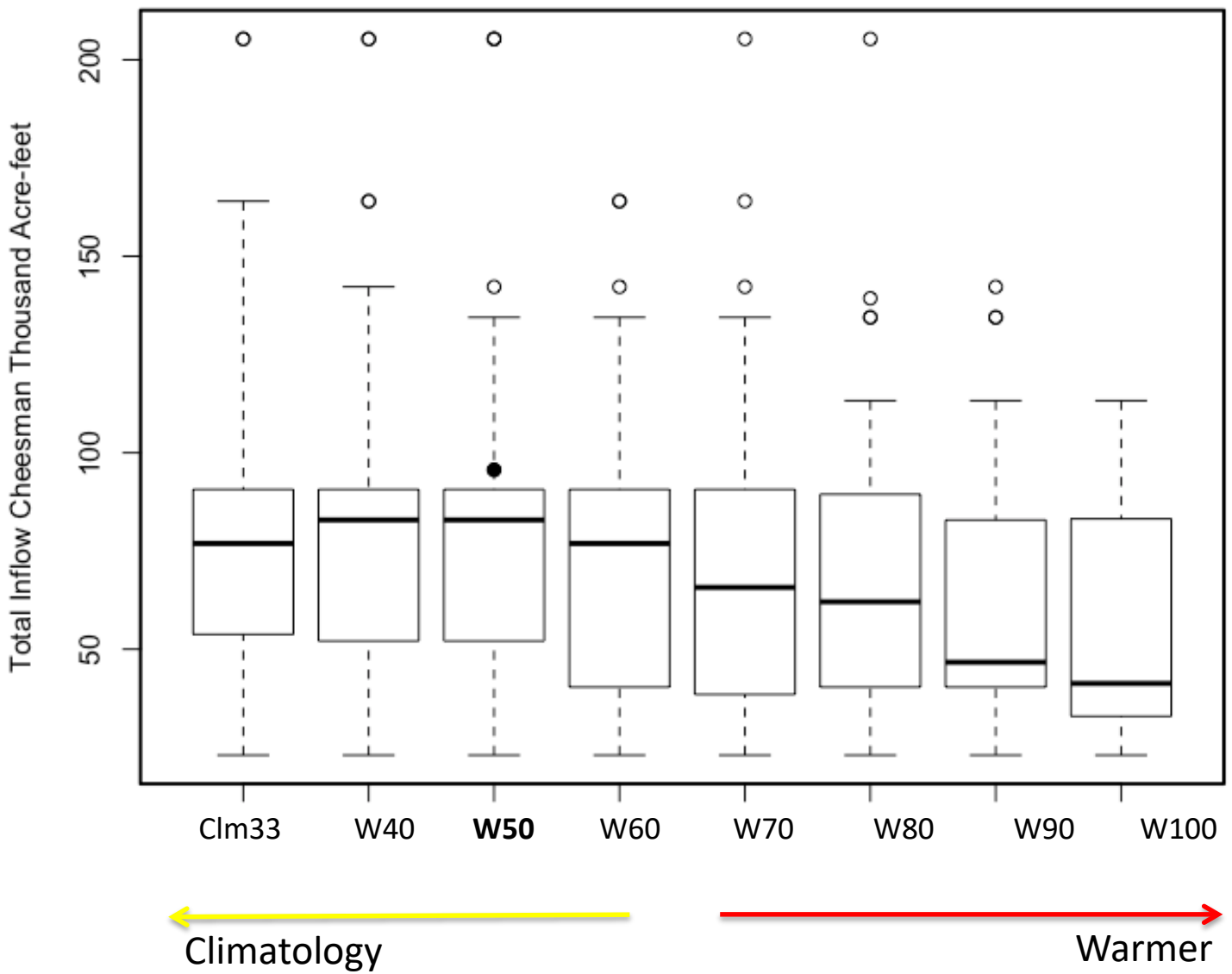
Climatology

Obs 2011-2015 hindcast scenario

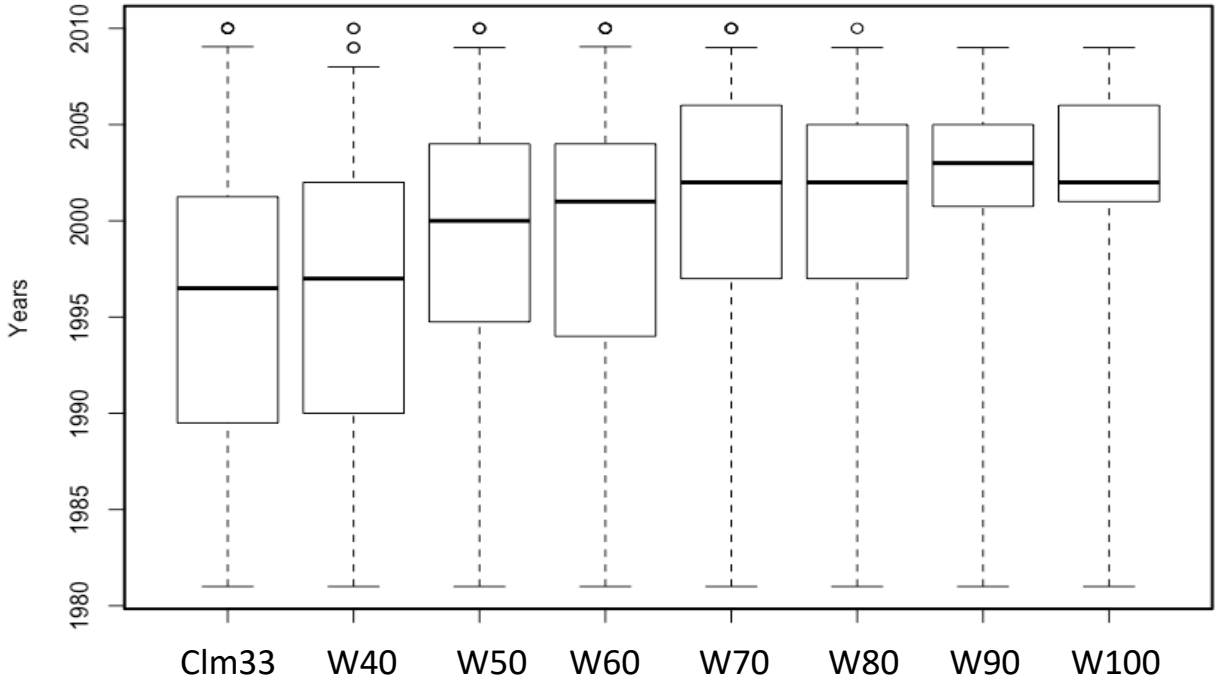
Initialized prediction 2011-2015 hindcast

Unitialized projection 2011-2015 hindcast

Inflows to Cheesman Reservoir show decrease with warming temperature scenarios



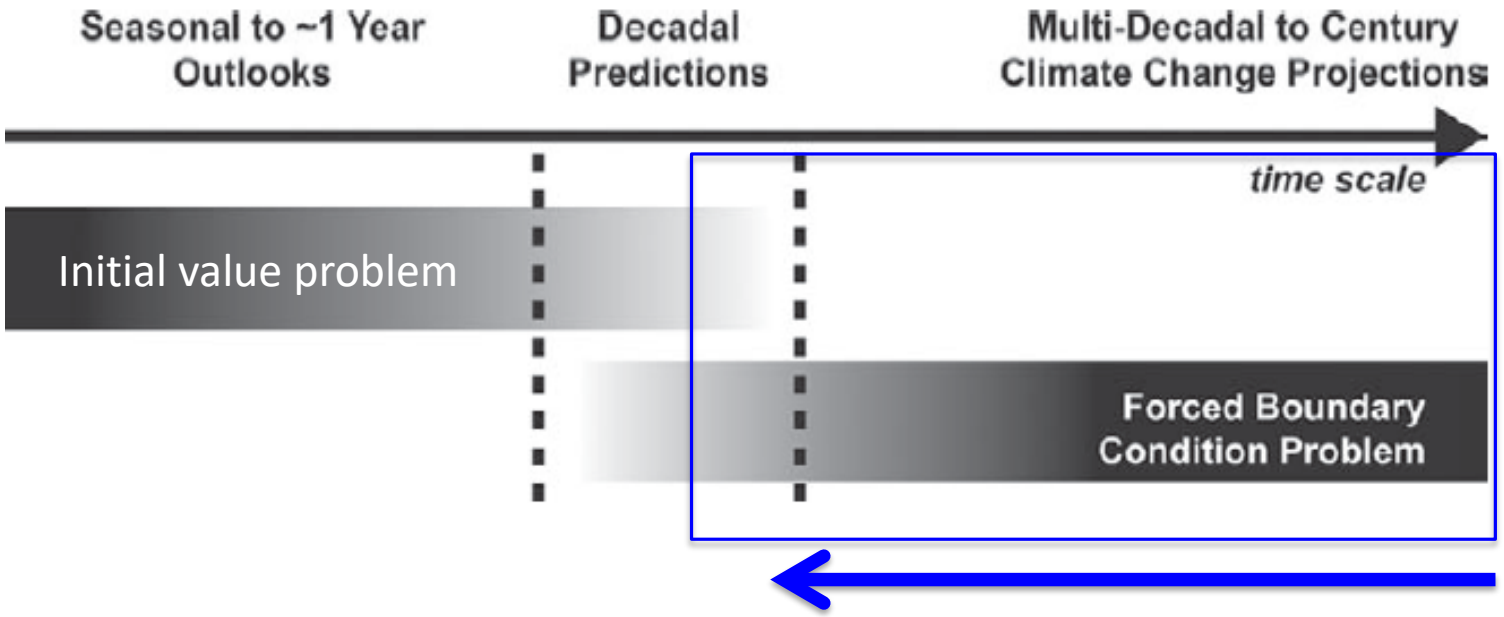
As expected with trend, increased warming likelihood tends to skew ensemble towards recent years



Limitation is that your resample is limited to years you have already seen.

Case Study Application:

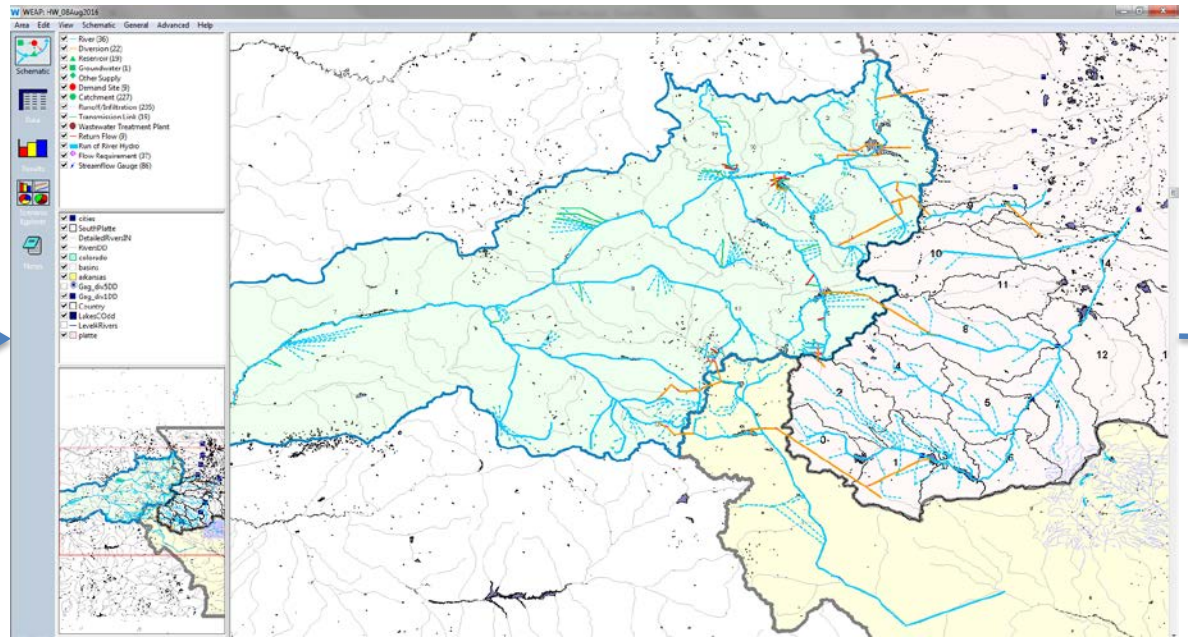
Test application of near-term predictions using a seasonal forecasting approach



… and using a climate change projection approach.

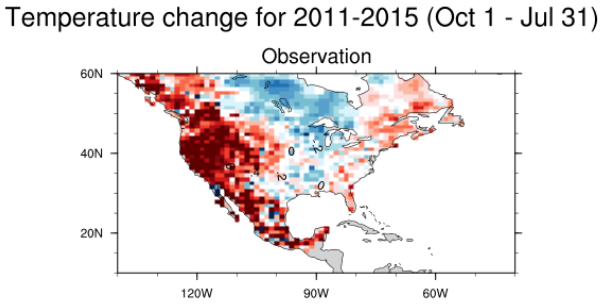
Can add “delta” like a traditional climate change approach

Temp + **DELTA** & Precip →



→ Reservoir inflows

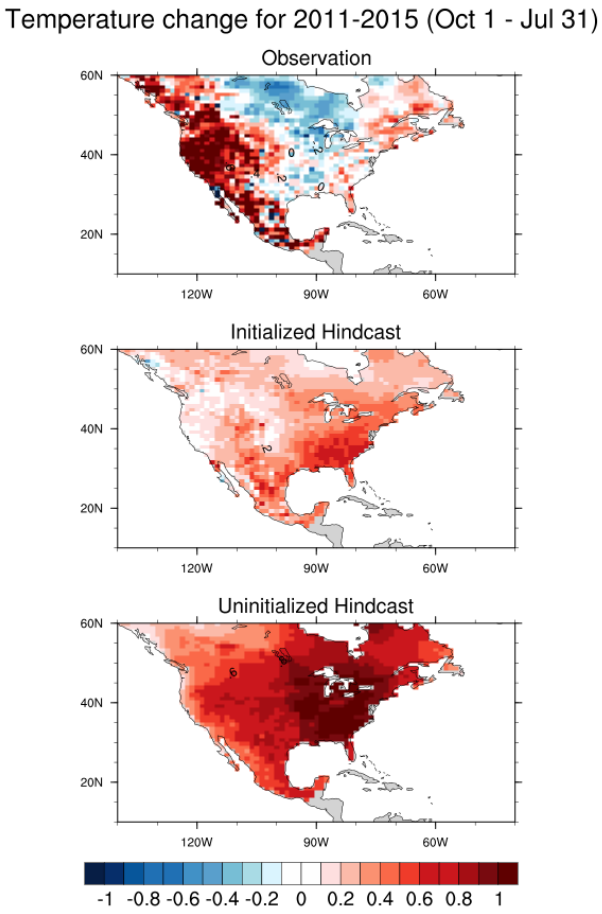
Observed delta showed warming in the West



	Oct-Jul (°K)
Observation	0.5

Courtesy of Deb PaiMazumder

Uninitialized showed more uniform and widespread warming than initialized; use to create delta scenarios



	Oct-Jul (°K)
Observation	0.5
Initialized	0.2
uninitialized	0.8

Courtesy of Deb PaiMazumder

Next steps:

- Run decadal hindcasts through WEAP to see Cheesman inflow impacts using delta approach
- Get feedback on framework and potential usability of near-term climate information.
- Look at multi-model ensemble (not just CCSM4)

Conclusions

- Although decadal predictions are experimental, they are available and in demand, creating an urgent research need to explore their usability.
- Near-term temperature has skill, but interviews indicate that neither decadal predictions nor projections have been utilized in decision-making.
- Where seasonal forecasts or climate change projection information is already compatible with hydrologic models and decision-making, near-term climate information can be readily incorporated.

Thank you!

towler@ucar.edu

Exploratory 2014-2023 Outlook

- Looked at **2014-2023 decadal prediction ensemble over Colorado (n=10)** to explore ideas around contextual acceptability.

Communication of decadal predictions depends on context

Contextual Acceptability **-** Water managers need a way to communicate scientific evidence to boards, government officials, public tax payers, regulatory agencies etc. for near-term planning decisions, project funding, etc.

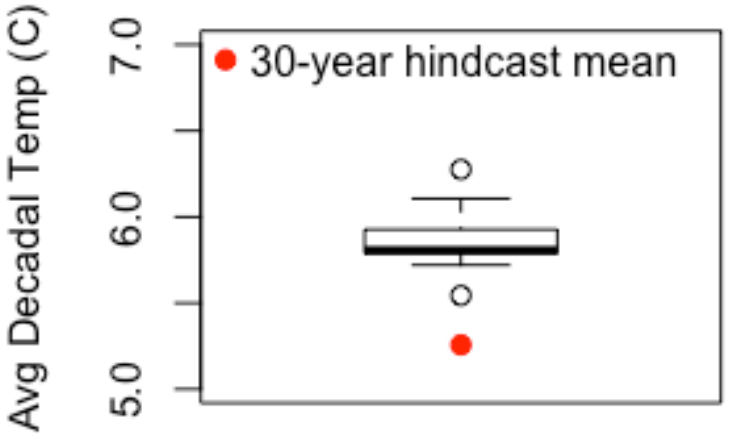
CCSM4 Colorado 2014-2023 probabilistic prediction:

Probabilistic Prediction

P(Above Normal) = 100%

P(Near Normal) = 0%

P(Below Normal) = 0%



Contextual Acceptability – Colorado 2014-2023 probabilistic prediction shows "maintaining current or historic conditions" of temperature (using 1980-2010 baseline) over next 10 years to be highly unlikely

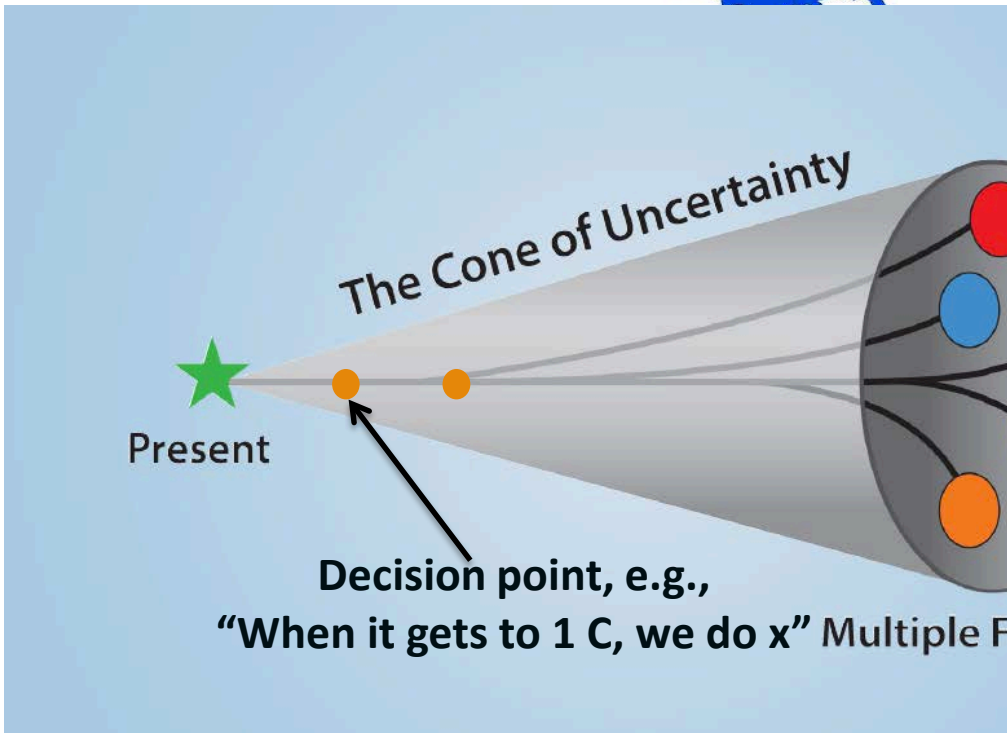
CCSM4 Colorado 2014-2023 delta prediction:

B) Delta

Max Change = 1.0 C

Mean Change = 0.61 C

Min Change = 0.29 C



Contextual Acceptability – Colorado 2014-2023 delta prediction can show how swiftly approaching decision points

Contextual Acceptability **–** Colorado 2014-2023 prediction can show how **rate of warming** will change compared to baseline rate.

C. In relation to 30-year trend: