

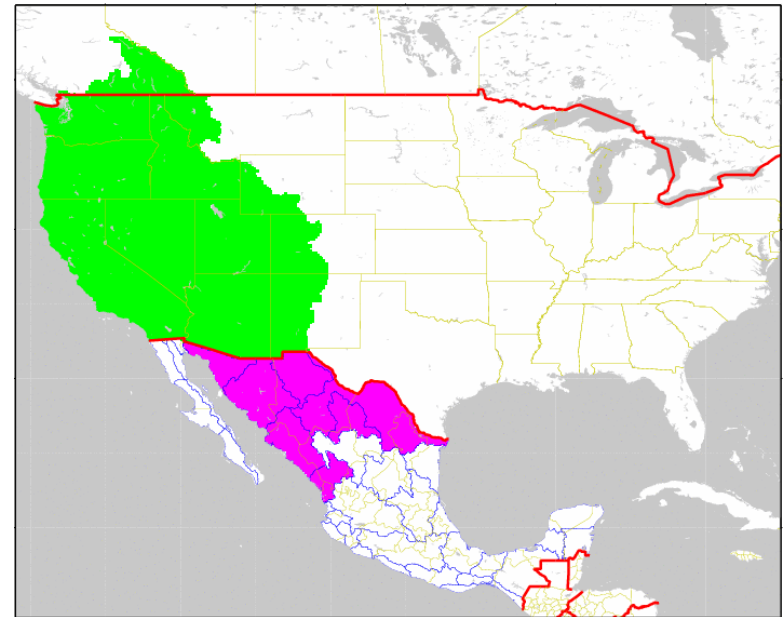
Intraseasonal to Interannual hydrologic forecasting for Mexico: new products and forecasts and their potential uses

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Rene Lobato S., IMTA

with thanks to:

Miguel Cortez & Alejandro Gonzalez, SMN
Chunmei Zhu & Andrew W. Wood, UW

North American Drought Monitor Meeting
D.F., Mexico
18 October, 2006



Announcement:

Union Geofisica Mexicana/American Geophysical Union Joint Assembly: Acapulco, week of 25 May 07

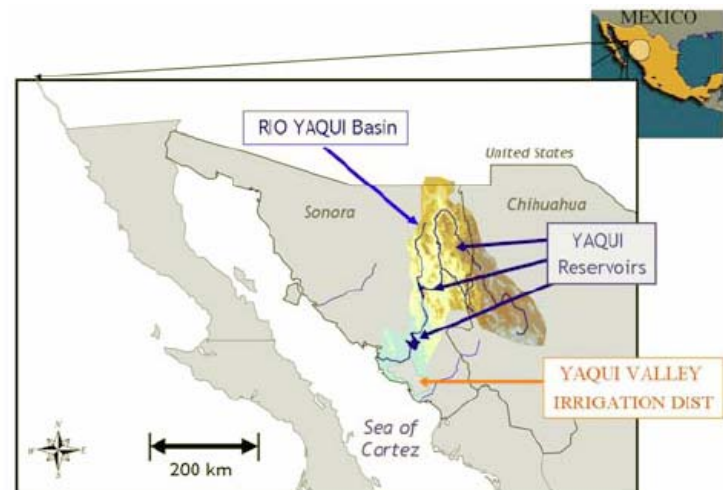
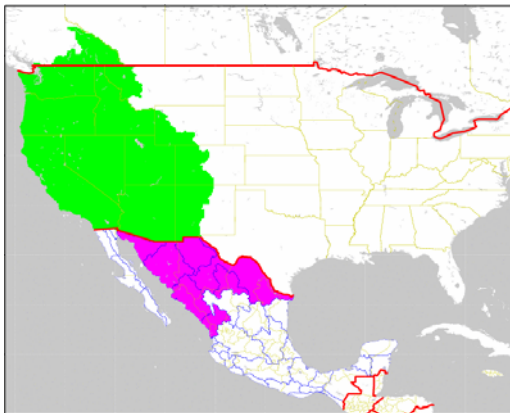
- Session proposed: **Human Dimensions of Climate Variations in the Americas**
- Session will focus on the interaction of climate and society across a range of time scales, and what is known about adaptation and reduction of vulnerability to climate from these studies.
- Invited talks from authors of the IPCC chapters on Impacts, Adaptation, and Vulnerability, and two other important arenas of climate and society interactions: applications of research on the North American Monsoon and the development of the North American Drought Monitor.
- ***We invite submission of papers and posters on:***
 - human dimensions of climate change and variability across the Americas;
 - societal processes related to drought, especially the trans-boundary societal impacts of drought;
 - the interaction of the North American Monsoon System and society; and
 - studies of applications of atmospheric and hydroclimatologic research to societal problems across a range of time scales.

Please inform your colleagues!! Questions??

Andrea.Ray@noaa.gov

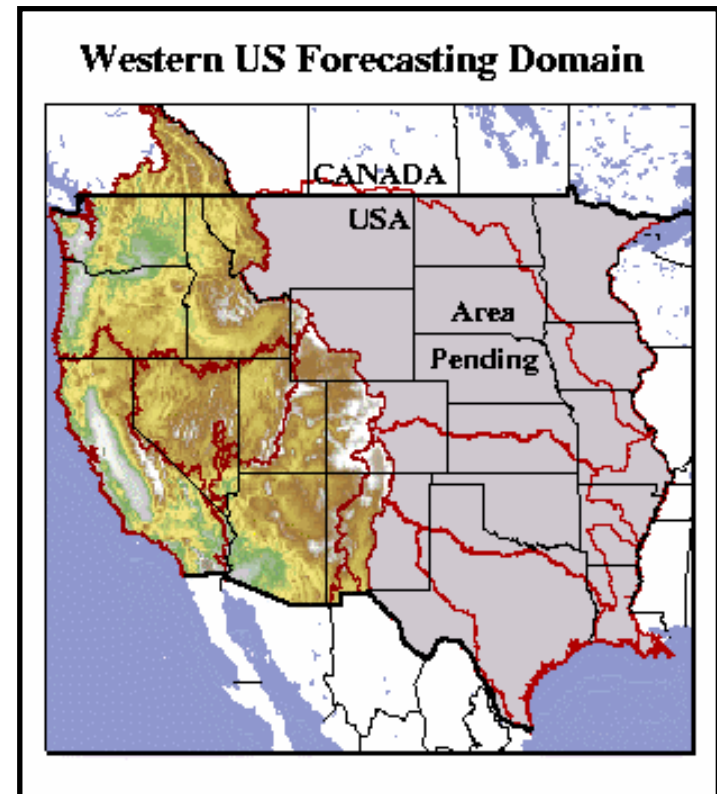
Overview

- Hydrologic forecasting for the North American Monsoon System (NAMS) region – extension of the University of Washington “Westwide Forecast System”
 - Summary of the UW system for the U.S.
 - Surface water monitor, also being implemented for Mexico
 - New 1/8 degree gridded dataset for surface hydrology and energy flux data for Mexico, 1925-2004
- Summary of hydrologic predictions project for Mexico, focus on Rio Yaqui



US “Westwide” hydrologic forecast system objectives

- Demonstrate/evaluate the utility of a regional approach to seasonal streamflow forecasting
- Evaluate the potential to integrate climate forecasts into seasonal (two week to one year) lead streamflow forecasts over the western U.S.
- Evaluate the potential to integrate research advances (including alternative data sources, e.g., remote sensing, and data assimilation) into operational seasonal streamflow forecasting, “testbed” concept



Forecast System Overview

<http://www.hydro.washington.edu/Lettenmaier/Projects/fcst/>

HOME
RESEARCH
PEOPLE
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LINKS

WEST-WIDE SEASONAL STREAMFLOW FORECASTING PROJECT

FORECASTS 12/25/03: Choose a basin...

Current Forecast Status:

- Initial conditions (SWE/SM) done
- ESP runs done
- GSM/NSIPP-1 runs done

FCST SUMMARY

Western US Forecasting Domain

This website presents current monthly-to-seasonal hydrologic, streamflow and reservoir system forecasts for the western U.S. The experimental effort is funded by primarily by NOAA/OGP, the [IRI/ARCS Regional Applications Project](#), and the [NASA Seasonal-to-Interannual Prediction Project \(NSIPP\)](#).

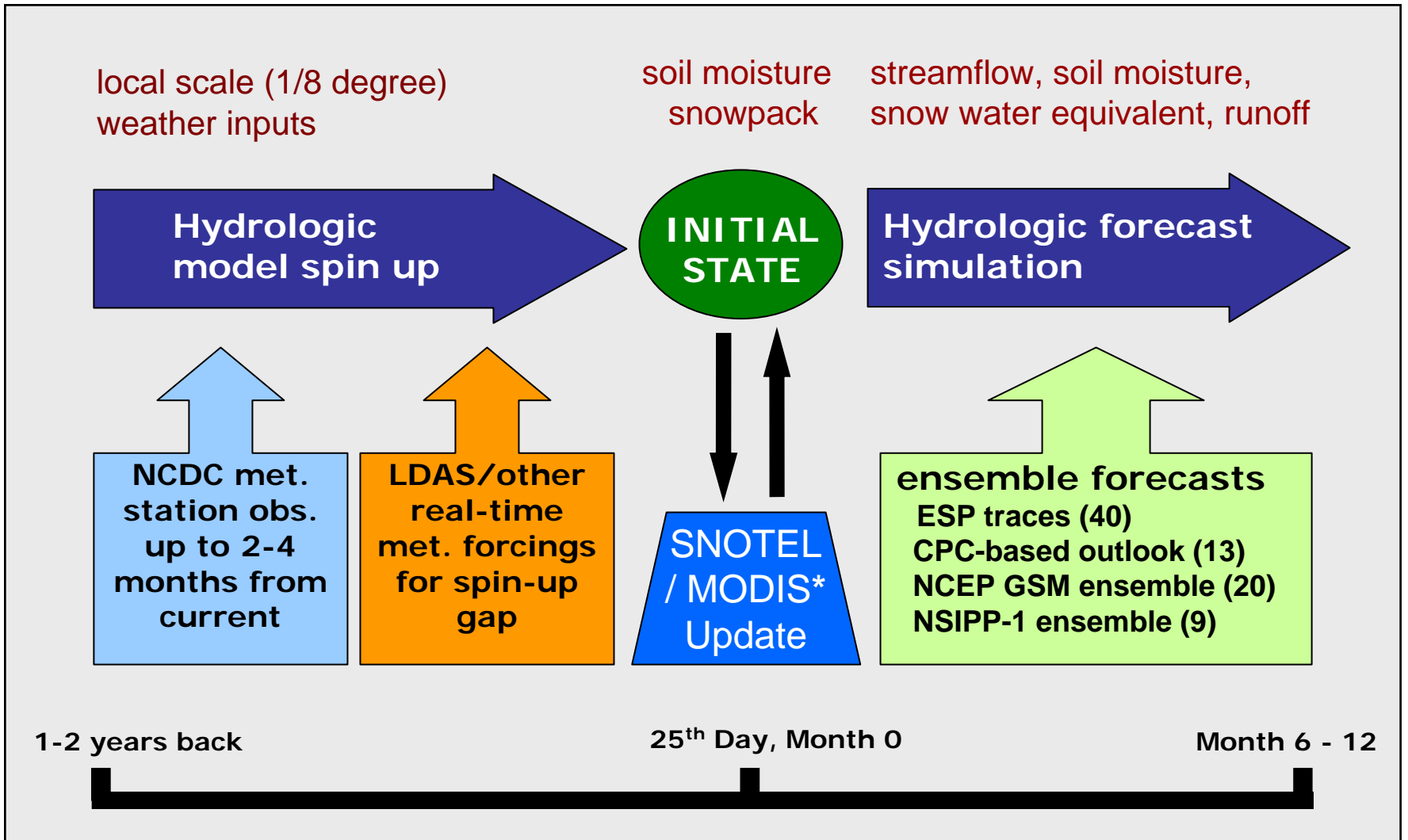
Currently, two forecast approaches are used, both centering on the use of macroscale hydrologic simulation with the [VIC model](#):

- the Ensemble Streamflow Prediction (ESP, formerly Extended Streamflow Prediction) method; and the ESP method conditioned on ENSO and PDO states
- ensemble forecasts downscaled from several climate models (NCEP GSM and NASA NSIPP-1)

Forecast outputs include monthly streamflow ensembles, spatial distributions of snow water equivalent (SWE), soil moisture and runoff, and (*not yet active*) reservoir system storage and flow forecasts. In addition, the analyses of the initial hydrologic state at the forecast date constitute a nowcast of SWE and soil moisture conditions throughout the domain, based on observed meteorology.

<http://www.hydro.washington.edu/Lettenmaier/Projects/fcst>

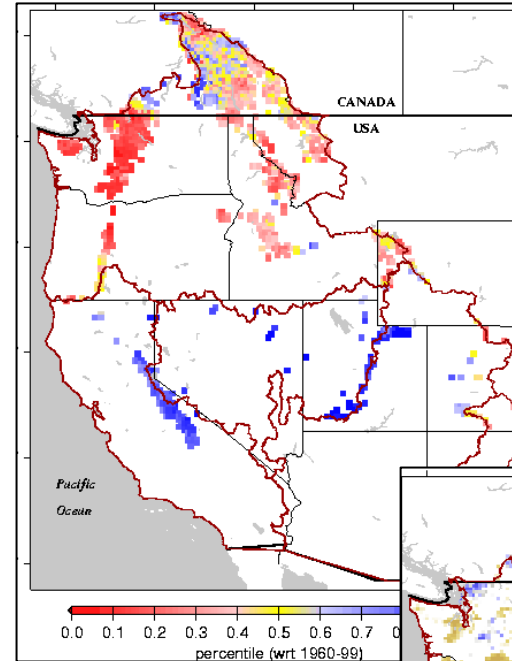
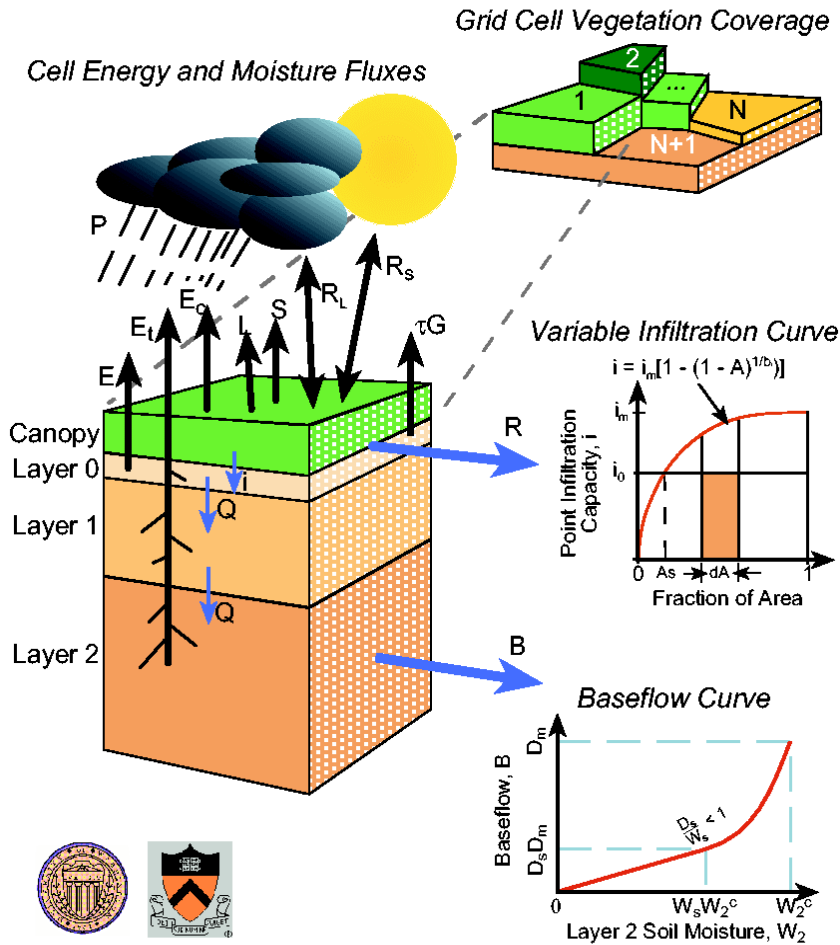
Forecast System Schematic



* experimental, not yet in real-time product

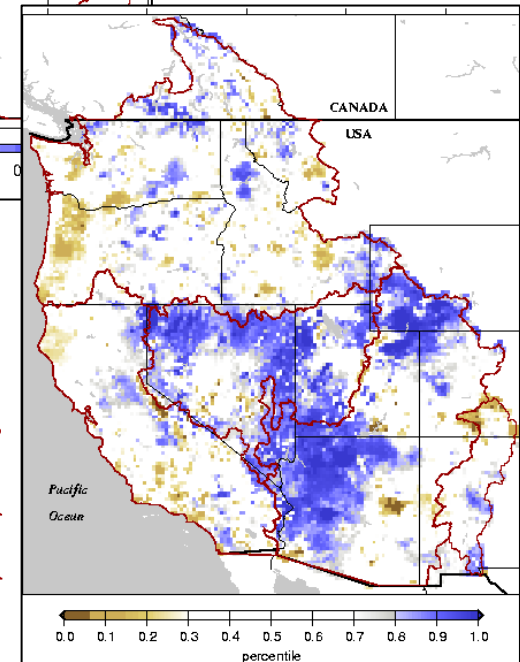
Modeling Framework

Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model

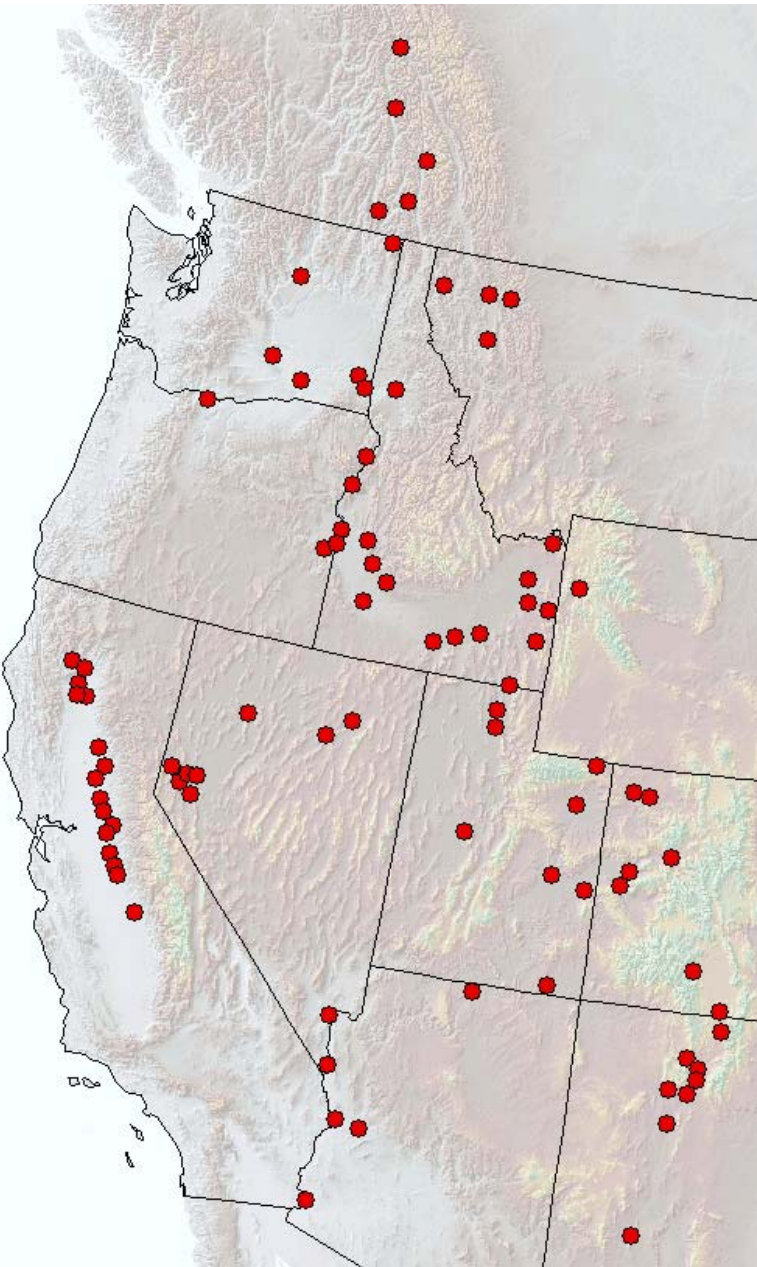


*Snowpack
Initial
Condition*

*Soil Moisture
Initial
Condition*

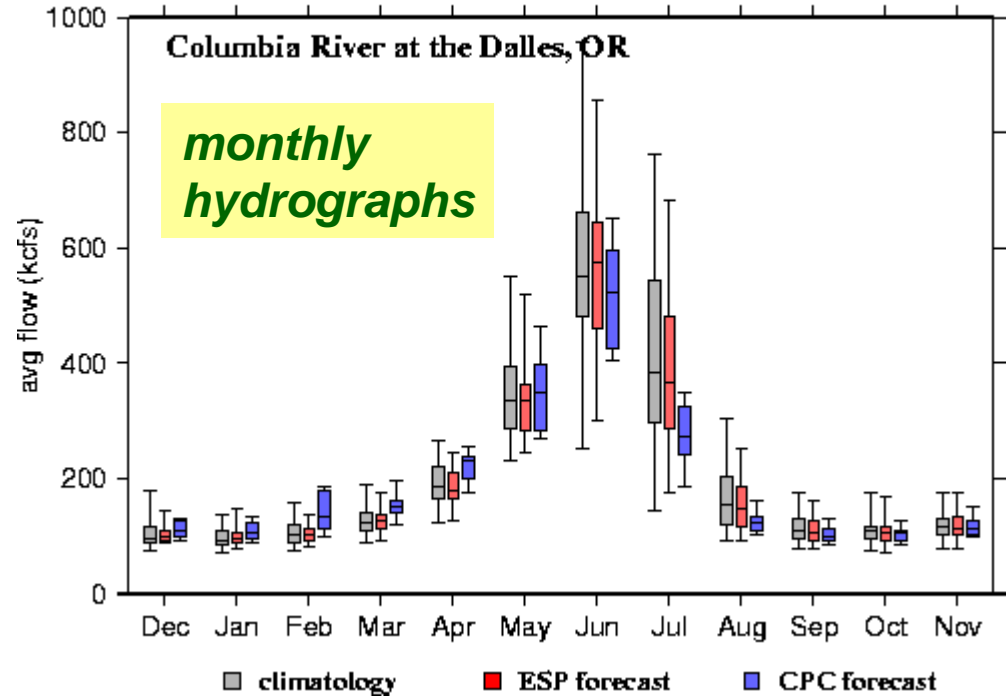


Forecast points and sample streamflow forecasts



PNW Streamflow Forecast vs. Climatology (1960-99)

FORECAST DATE: DECEMBER 1, 2004

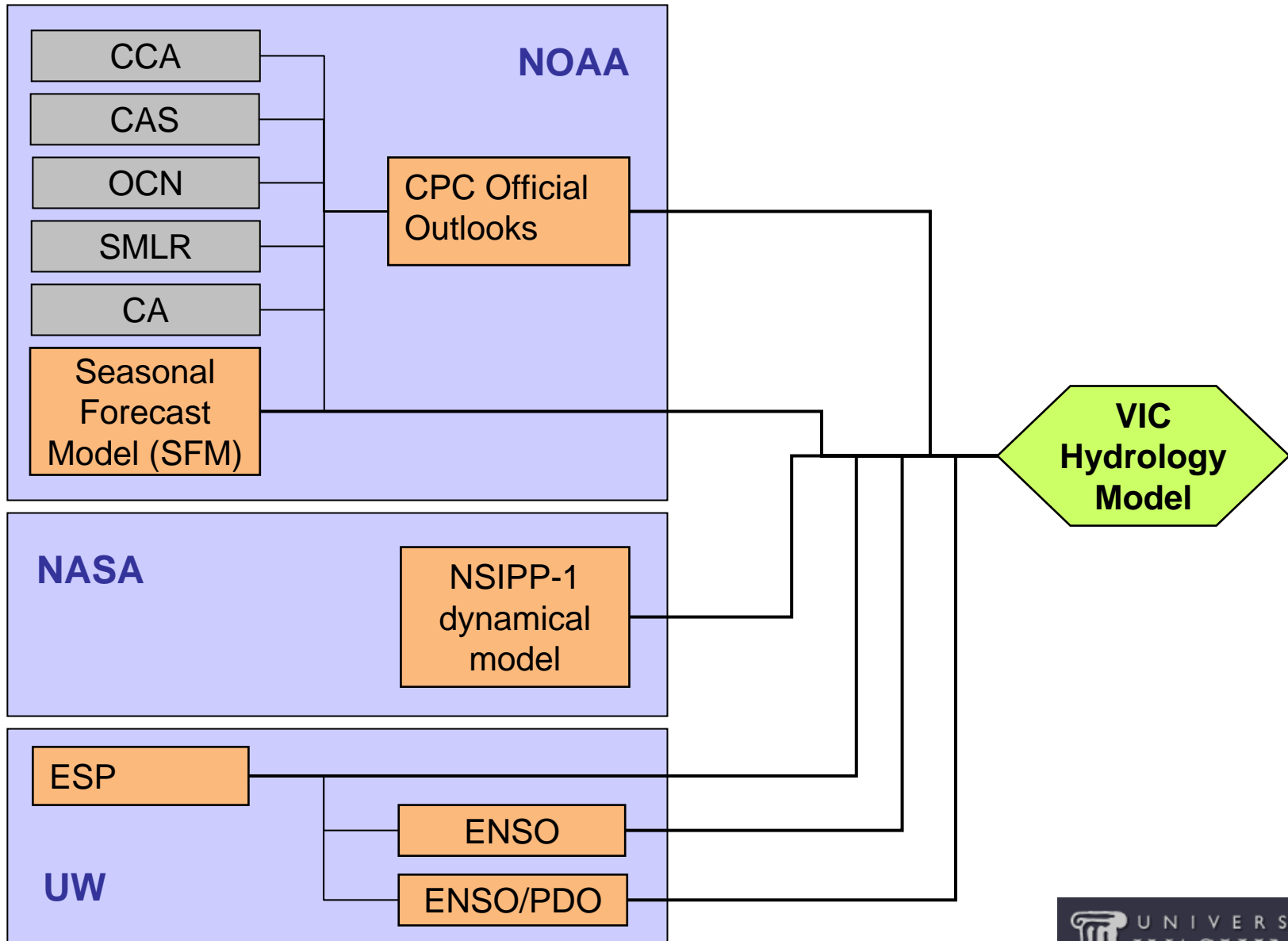


targeted statistics e.g., runoff volumes

Forecast flow percent of average for 2004 APR-SEP average at low, median and high percentiles

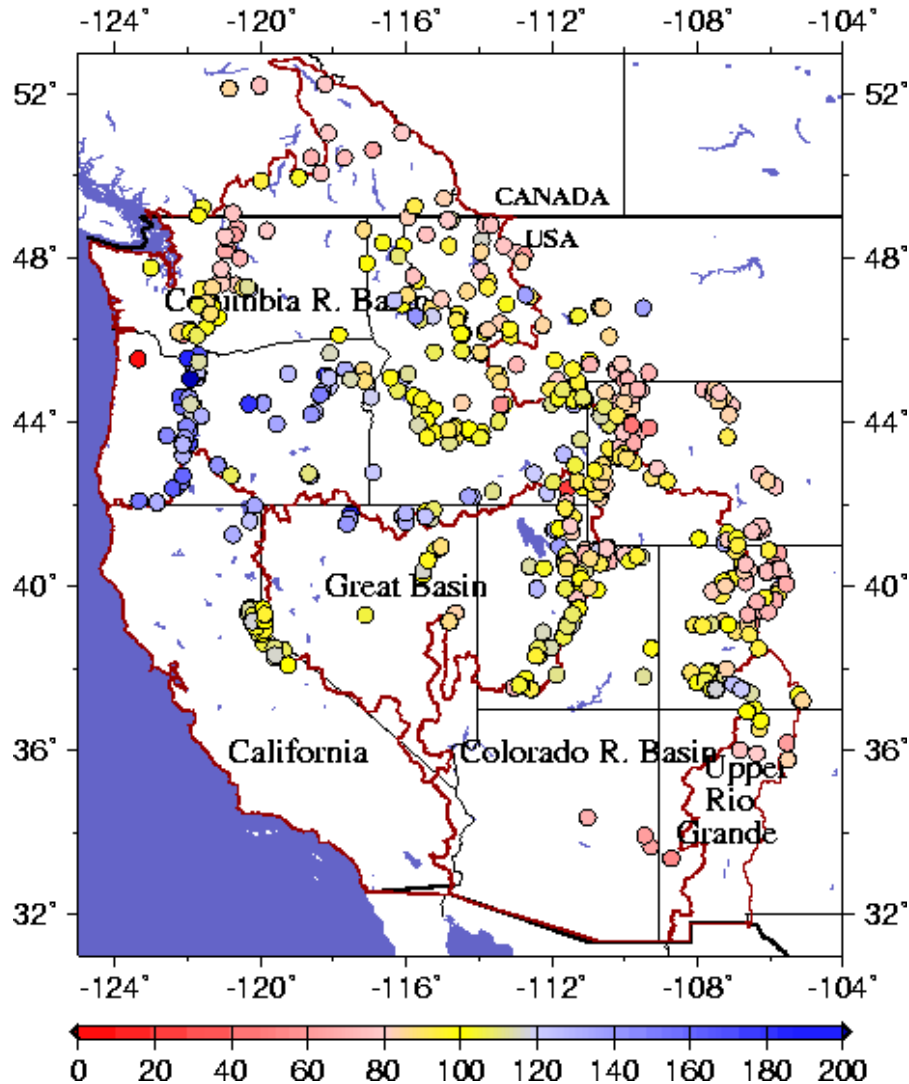
#	NAME	----- unconditional -----			ENSO-Neut 0.5
		0.1	0.5	0.9	
1	MICAA	73	85	97	85
2	REVEL	73	85	98	85
3	ARROW	72	83	97	84

Westwide Forecast System – climate forecast drivers



VIC initial condition estimation: *SNOTEL assimilation*

Snotel/ASP Anomalies (wrt 1990-99 average), 022504



Problem

sparse station spin-up period incurs some systematic errors, but snow state estimation is critical

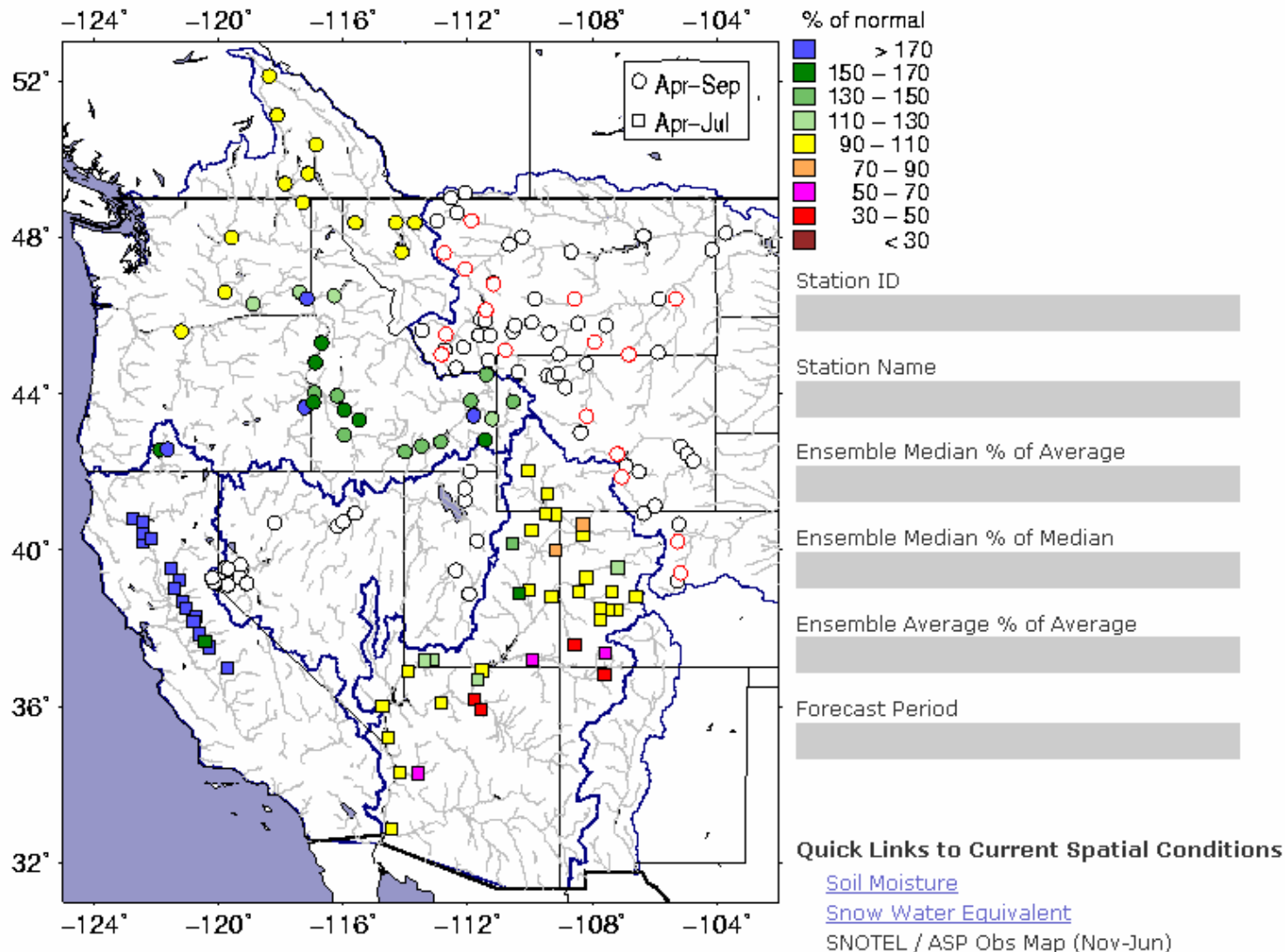
Solution

use SWE anomaly observations (from the 600+ station USDA/NRCS SNOTEL network and a dozen ASP stations in BC, Canada) to adjust snow state at the forecast start date

In Mexico, soil moisture is probably more important!!

Example of Forecast: May 1, 2006

Western US Streamflow Forecasts initiated MAY 1, 2006
Seasonal Volume (Fcast Ensemble Average % of Average)



Wood & Lettenmaier, 2006, *A testbed for new seasonal hydrologic forecasting approaches...*, BAMS, in press; available at: <http://www.hydro.washington.edu/> under publications

Another new tool: UW Surface Water Monitor

- Produces nowcasts of drought/hydrologic conditions across continental US (CONUS)
 - domain to be extended to include Mexico
- Directly related to *retrospective drought reconstruction* Andreadis et al. (“Twentieth Century drought in the conterminous U.S., Jour Hydrometeorology, Dec. 2005) and westwide forecast system
- Enabled by recent NOAA Nat’l Climatic Data Center (NCDC) extension of digital data archives back to 1915
 - places current droughts in historic context
- Forecasts that can be used in drought *outlook* type analysis
- Now used in US Drought Monitor development

<http://www.hydro.washington.edu/forecast/Monitor>

Monitor Webpage

daily updates

1-2 day lag

soil moisture & SWE percentiles

1/2 degree resolution

archive from 1915-current

uses ~2130 index stns

<http://www.hydro.washington.edu/forecast/Monitor>

UW Experimental Surface Water Monitor - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.hydro.washington.edu/forecast/monitor/

Experimental Surface Water Monitor for the Continental U.S.

UW Civil & Environmental Engineering

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Current Conditions
Grid Plots
Change since:
[1 week ago](#)
[2 weeks ago](#)
[1 month ago](#)

Archive (1915 -)
Grid Plots

Powered by **ACIS**
NO AA, Regional Climate Centers

The plots below show the current percentiles for soil moisture and snow water equivalent (SWE) with respect to the climatological period 1960-2003. These update daily by 2 pm PST, and have a lag of 1-2 days.

Soil Moisture Percentiles (wrt/ 1960-2003)

20050511

48° 44° 40° 36° 32° 28° 24°

-120° -112° -104° -96° -88° -80° -72°

0 1 5 10 20 30 70 80 90 95 99 100 percentile

Snow Water Equivalent Percentiles (wrt/ 1960-2003)

20050511 threshold = 50 mm

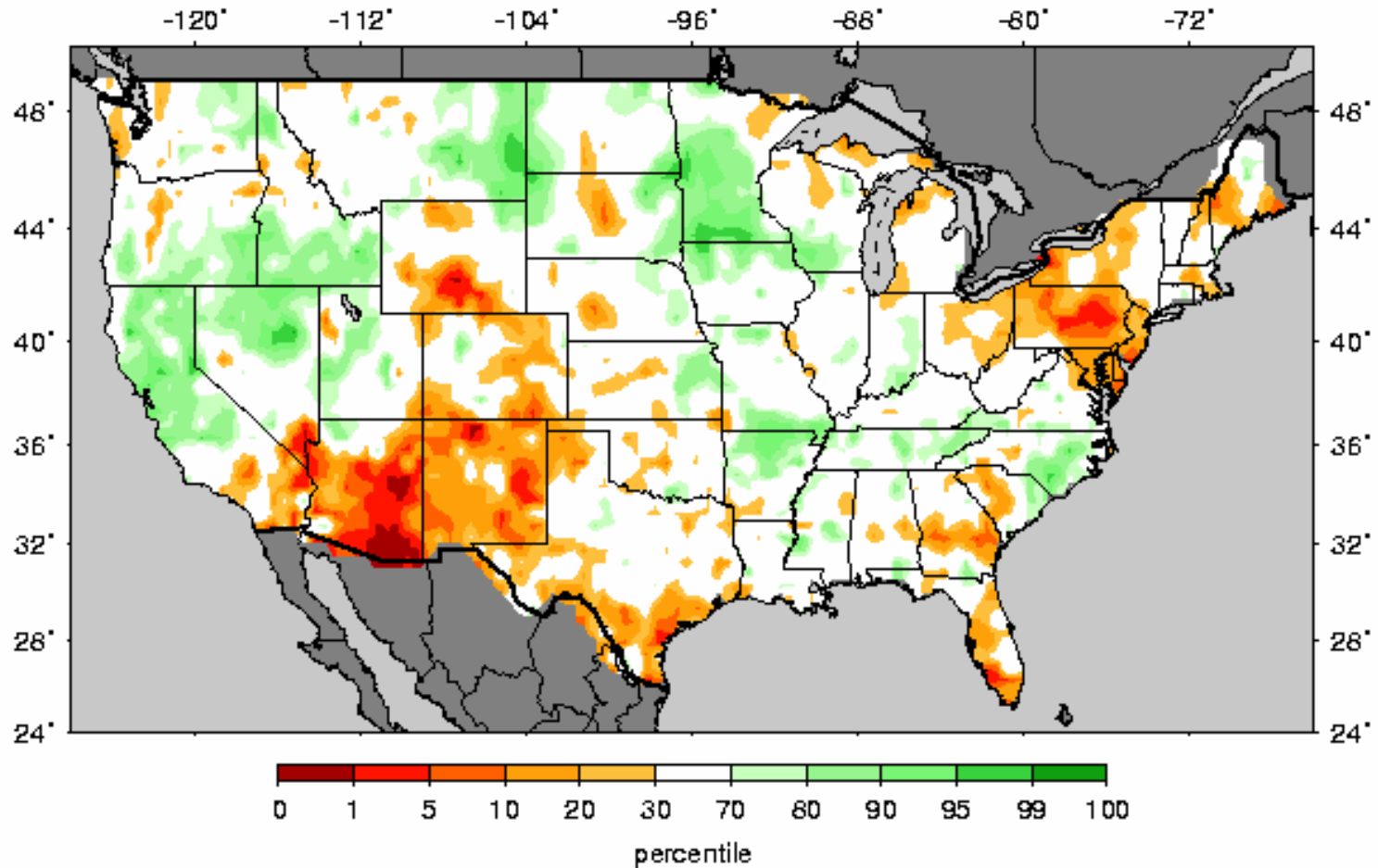
48° 44° 40° 36° 32° 28° 24°

-120° -112° -104° -96° -88° -80° -72°

0 1 5 10 20 35 65 80 90 95 99 100 percentile

Example product: May 1, 2006

Soil Moisture Percentiles (wrt/ 1915-2003)
20060508



<http://www.hydro.washington.edu/forecast/Monitor>

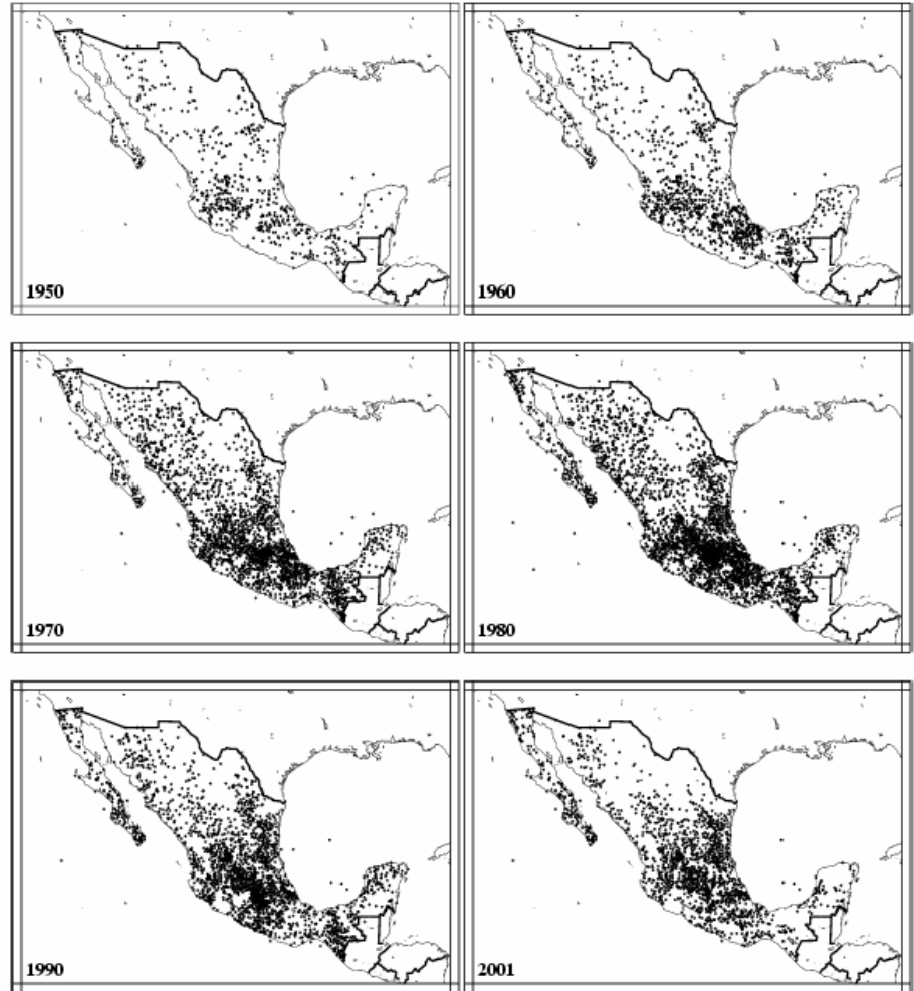
Need for retrospective precipitation and land surface data sets to implement streamflow forecasting

- **Climatology (1925-2004)**

Zhu, Lettenmaier et al, 2006,
*Long-term climate and derived
surface climatology....*, J.Climate,
in press

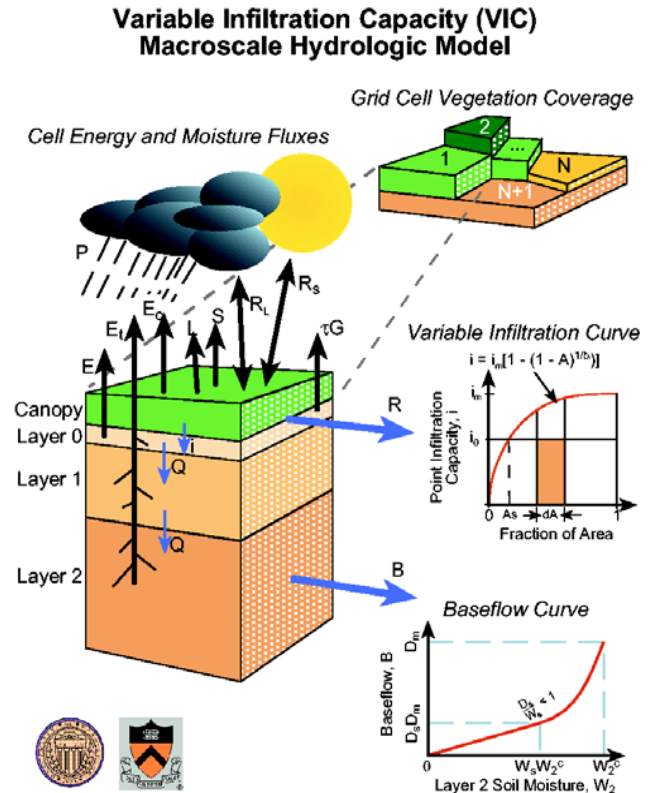
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<http://www.hydro.washington.edu/>
under publications



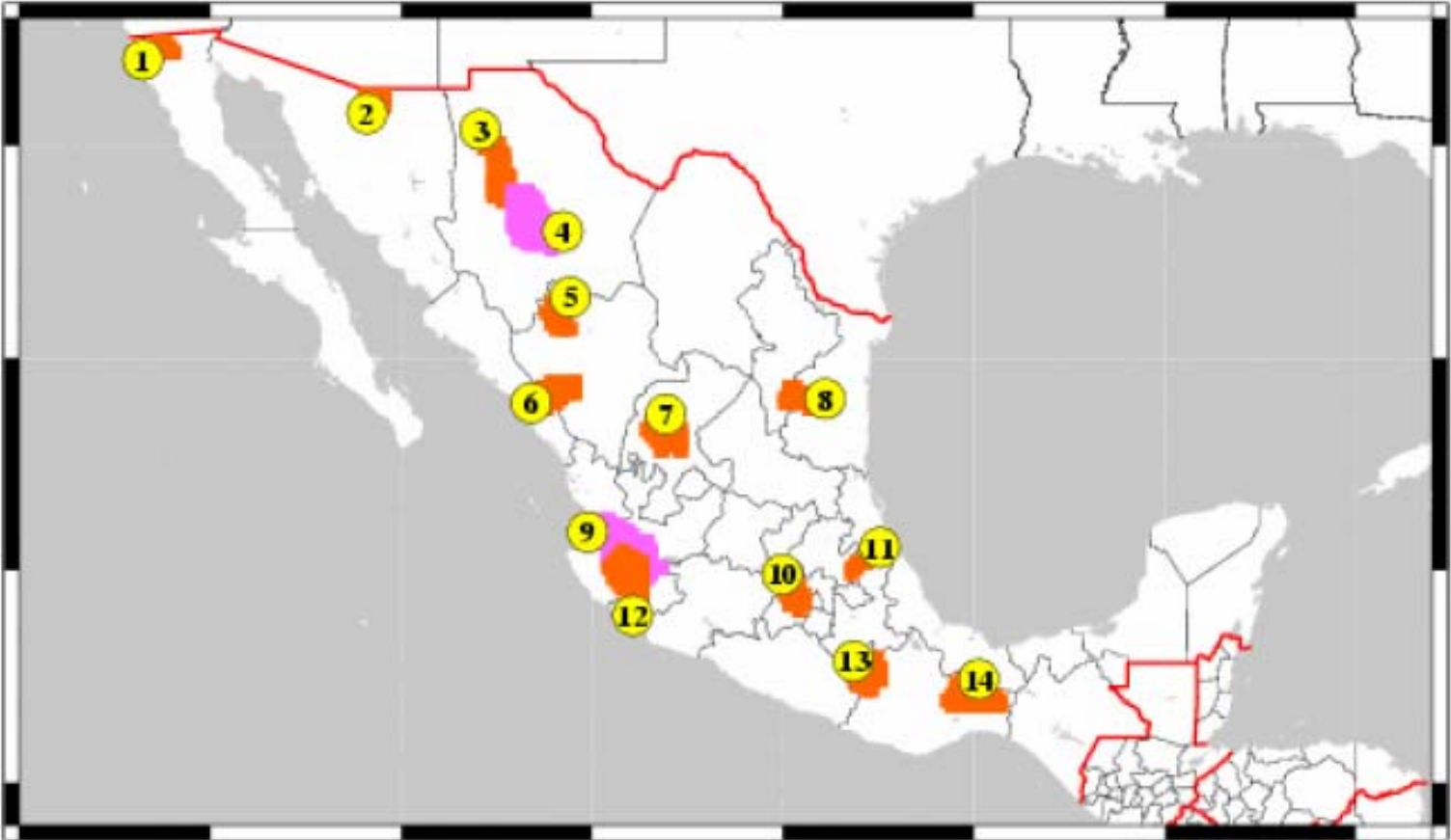
Gridded Long-Term Land Surface Data Set Climatology (1925-2004)

- **Surface forcing data:** Daily precipitation, maximum and minimum temperatures
- **SMN daily precipitation, surface air temperature data (pre-1940 - 2003)** produced by SMN (Ing. Alejandro Gonzales S.) over 5000 stations.
- **SMN daily precipitation data (1995 - near realtime)** provided courtesy of Miguel Cortez V.of SMN, around 1,000 stations.
- Quality controlled, weighted inverse square dataset
- New gridded 1/8 degree dataset



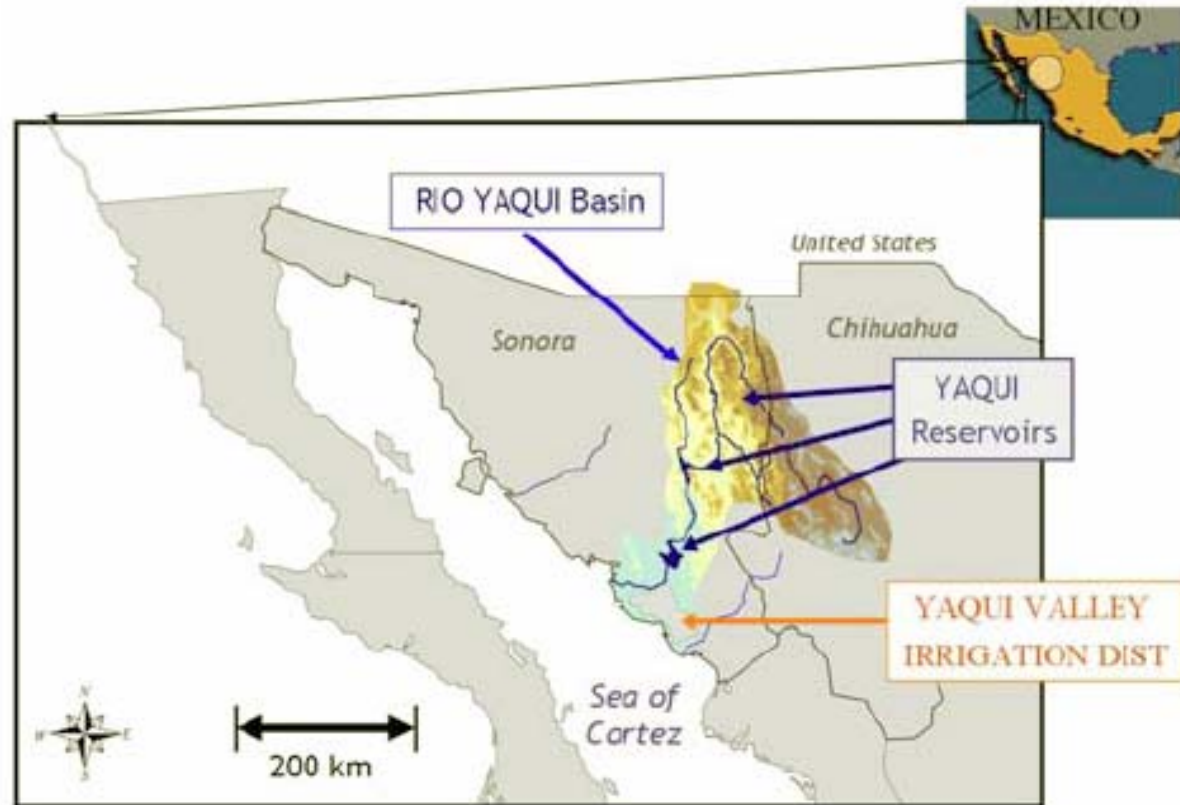
NW Mexico NAME Event Rainage Network (NERN) precipitation daily data (2002 -) provided courtesy of David Gochis, 86 station cross Sierra Madre Occidental

**Pan-Mexican index river basins:
Used to calibrate the dataset**



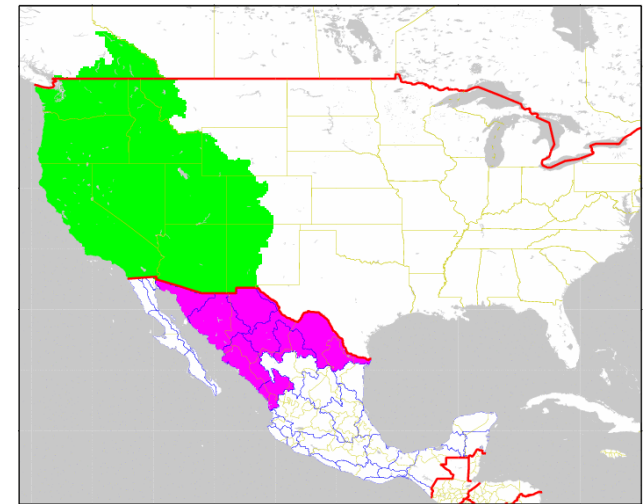
Project to extend hydrologic forecast system to Mexico

- Grant from NOAA as part of the North American Monsoon Experiment (NAME), focus on Rio Yaqui basin, possible work on Rio Conchos
- Plan to transfer the forecast system to IMTA and make it available to other MX water agencies

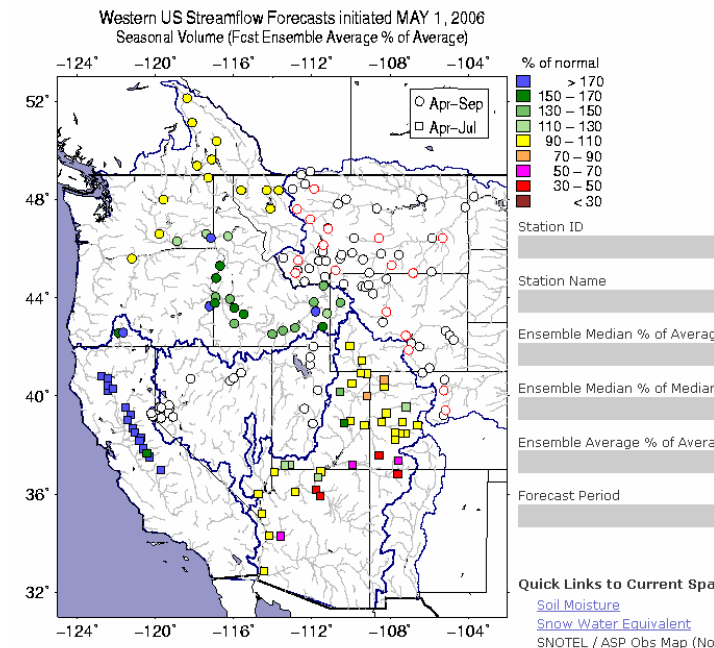


Strategy for extension of forecast system over Mexico

- Implement seasonal streamflow prediction, extend domain to MX
 - Real-time precipitation from SMN (linked to index stations for climatology as in western U.S.)
 - Real-time surface air temperature and surface wind from EDAS (NOAA Eta Data Assimilation System)
 - Other downward fluxes (solar, longwave) and surface variables (vapor pressure deficit) derived from Tmin, Tmax
 - Surface air temperature climatology from NARR (North American Regional Reanalysis)

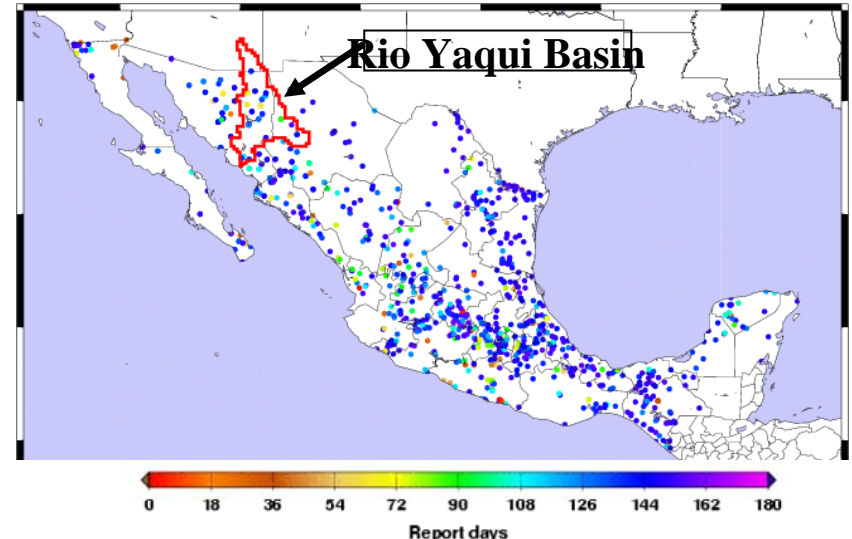
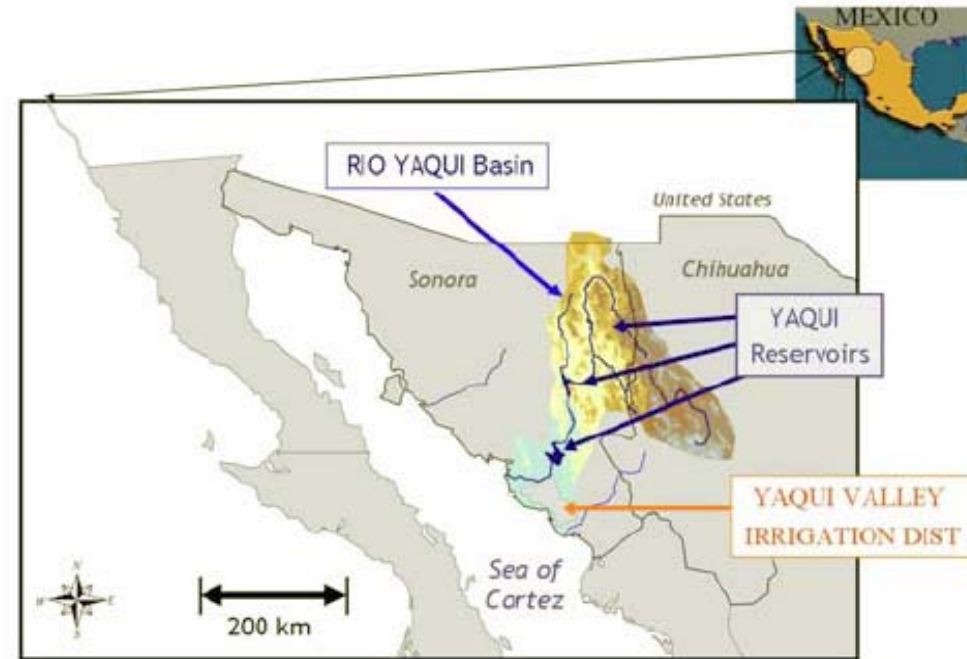


- Hydrologic predictability analysis
 - Evaluate methods for forecasting, e.g. monsoon precipitation, soil moisture
 - Zhu, Cavazos & Lettenmaier, 2006. *Role of antecedent land surface conditions in warm season precipitation over NW Mex.* J.Climate, in press, available at: <http://www.hydro.washington.edu/> under publications



Rio Yaqui model adaptations

- Existing IMTA Fortran model represents major and smaller reservoirs, monthly time step, simulation for planning and operations decisions
- Implement model in “Power-Sim Studio 2003” programming language with some advantages over Fortran: provides graphic and other user interfaces
- Update model to allow it to use and evaluate utility of long lead streamflow forecasts
- Improve representation of reservoir operating rules and demands



Project for hydrologic forecasting for MX: Applications and iteration with users

- Applications and user feedback
 - Meet with CNA/D.F. and Obregon, others to assess current uses of weather/climate/streamflow products, needs and cultivate their interest in the project
 - Iterate with them to ensure that product suite is appropriate
 - Appropriate delivery, e.g. presentation of forecasts as graphs, maps, geo-spatial formats
- Enhancements to forecast system delivery
 - Ensemble streamflow prediction (ESP), PDO, ENSO, two climate models
 - Soil moisture probably more important in MX; snow is critical in western U.S.
 - Create a user-focused website (vs. research-focused)
- Evaluate system performance and forecast capabilities
- Transfer to IMTA and other MX water agencies as desired

Discussion

- *New dataset and water monitor products intended to be useful by water management agencies and others*
 - New gridded dataset intended for use in:
 - more realistic initial conditions for weather and climate forecasting;
 - climate change and trend analysis of simulated hydrologic variables;
 - model diagnostic studies;
 - evaluation of land-surface interactions in the monsoon region
 - US Surface Water Monitor results used in U.S. Drought Monitor
 - How can these products and forecasts be developed as a contribution for MX in MX side of NADM? e.g. surface water monitor, gridded datasets, streamflow outlooks

Andrea J. Ray, NOAA/ESRL

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Open access to products from UW hydro group web site

www.hydro.washington.edu/forecasts

New users welcome!

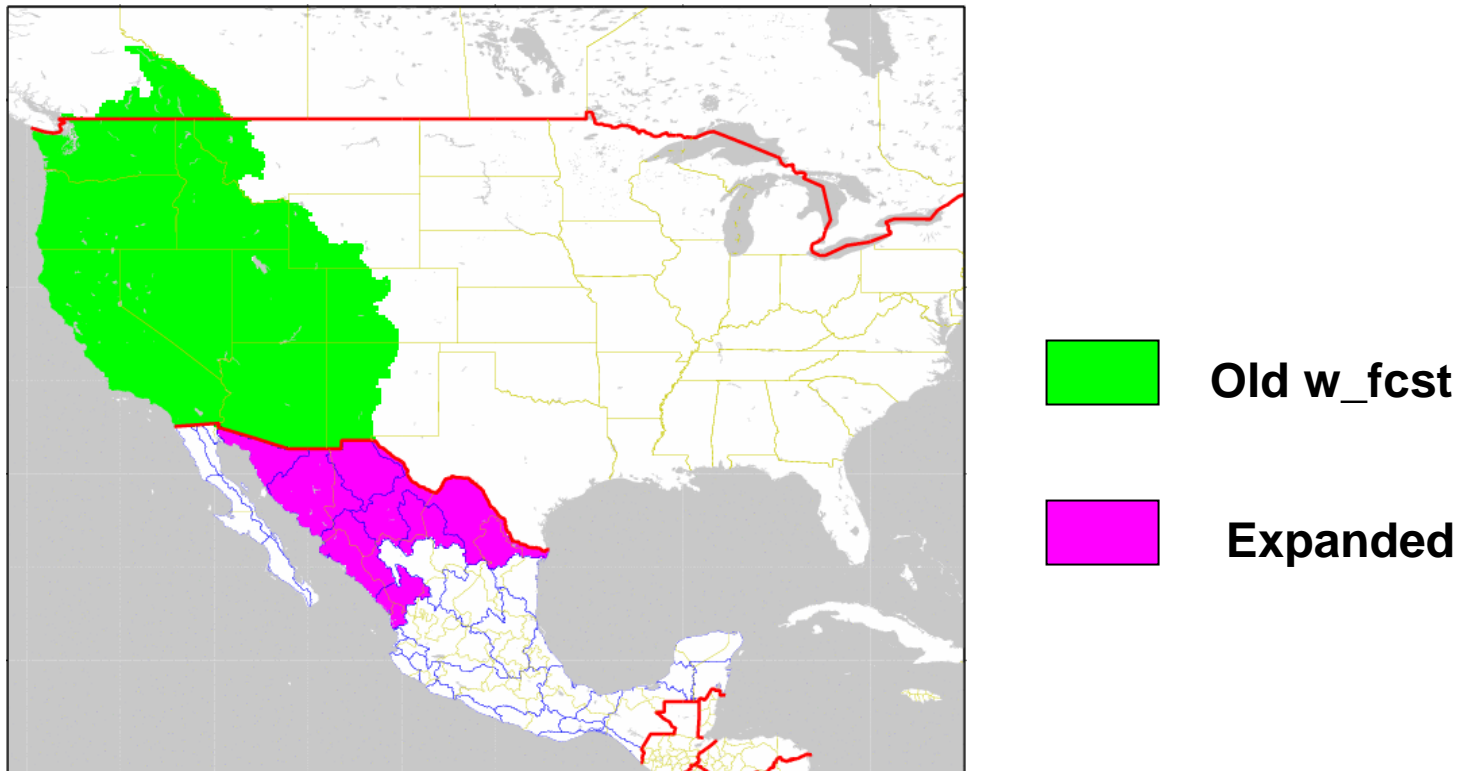
Thank you! Muchas gracias!



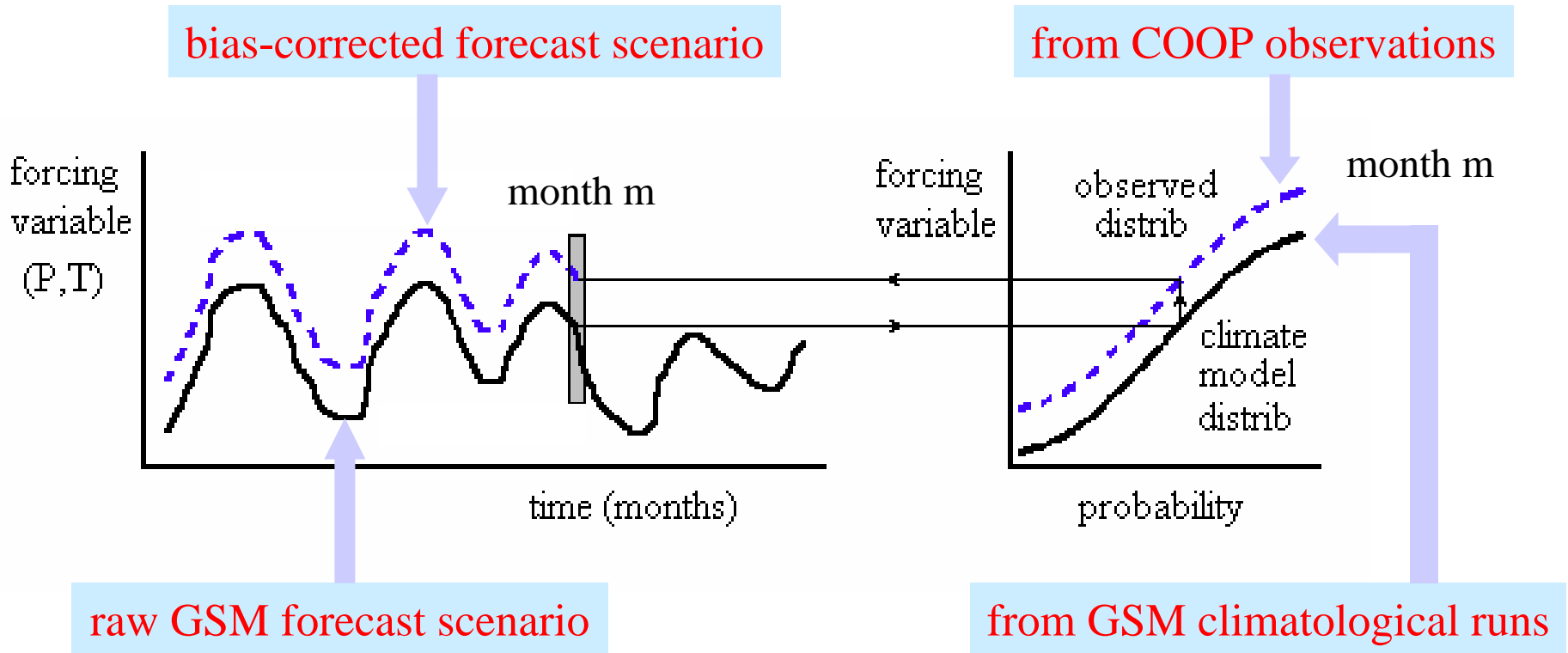
Extra slides

- **XX**

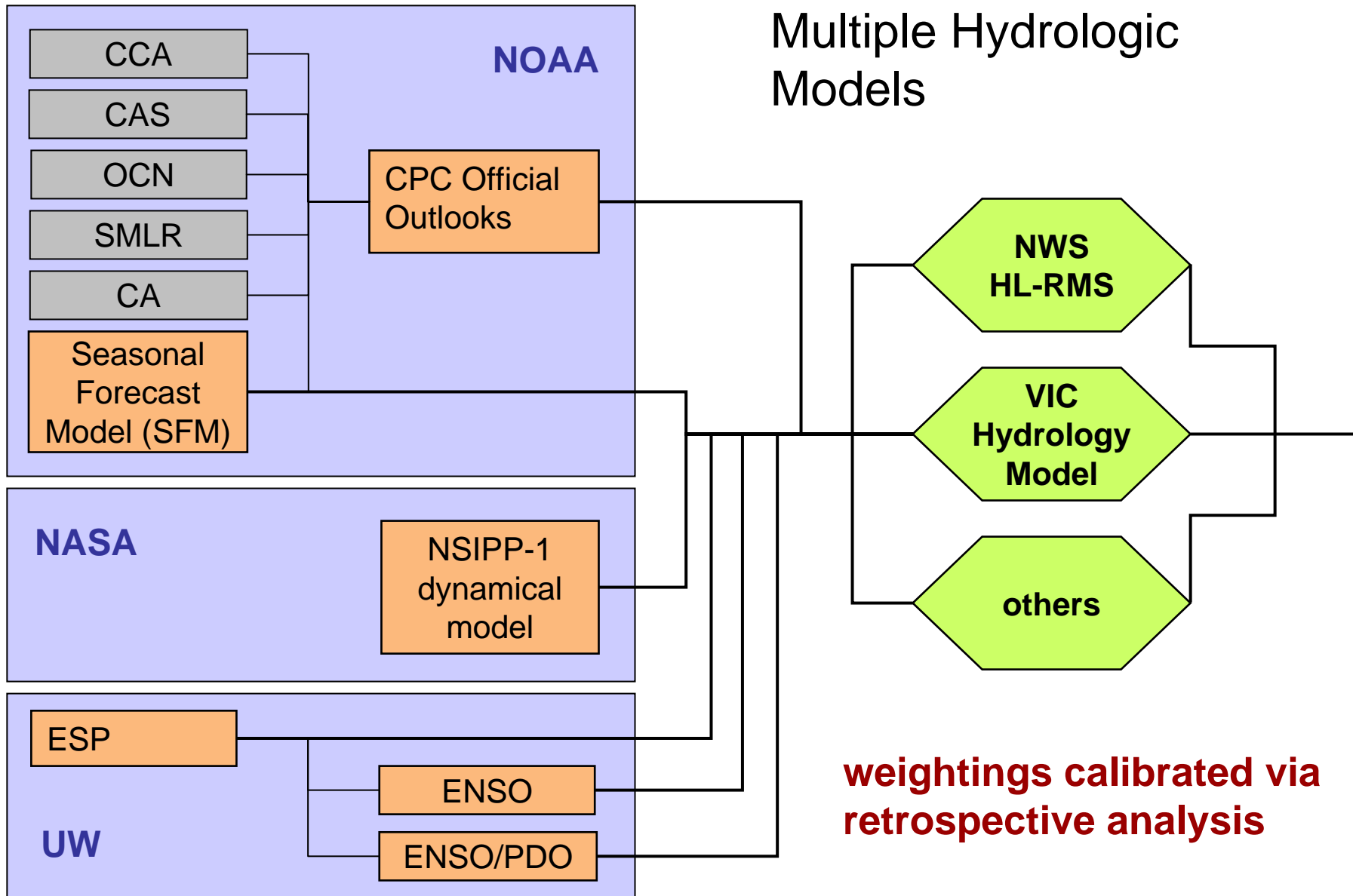
Spatial Domain for Expanded West-wide Seasonal Hydrologic Forecast System



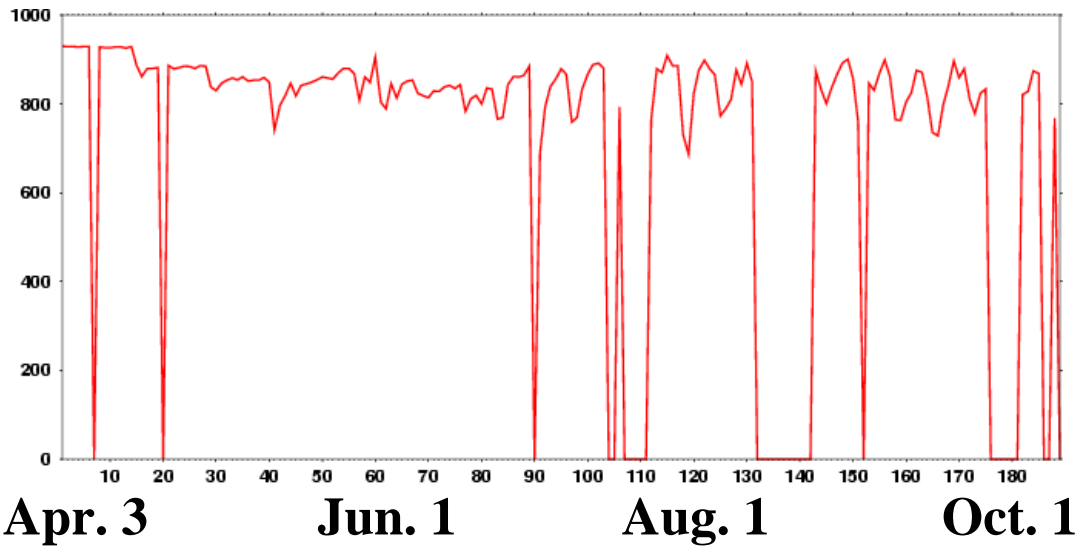
Climate forecast bias correction scheme



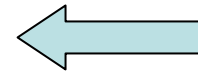
Expansion to multiple-model framework



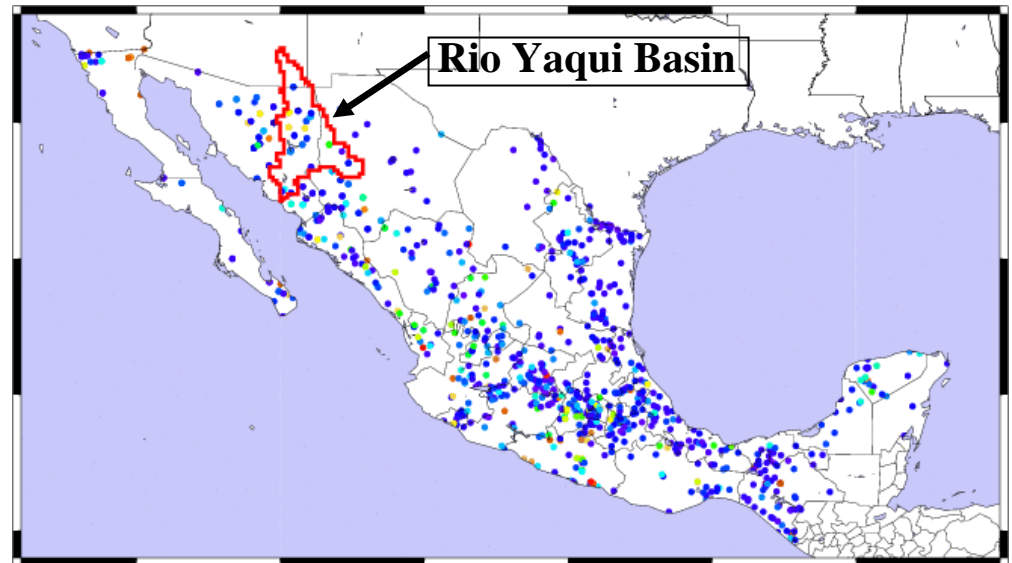
SMN real-time precipitation availability



Reporting station number
since Apr. 3rd, 2006



Reporting days over last
6 months

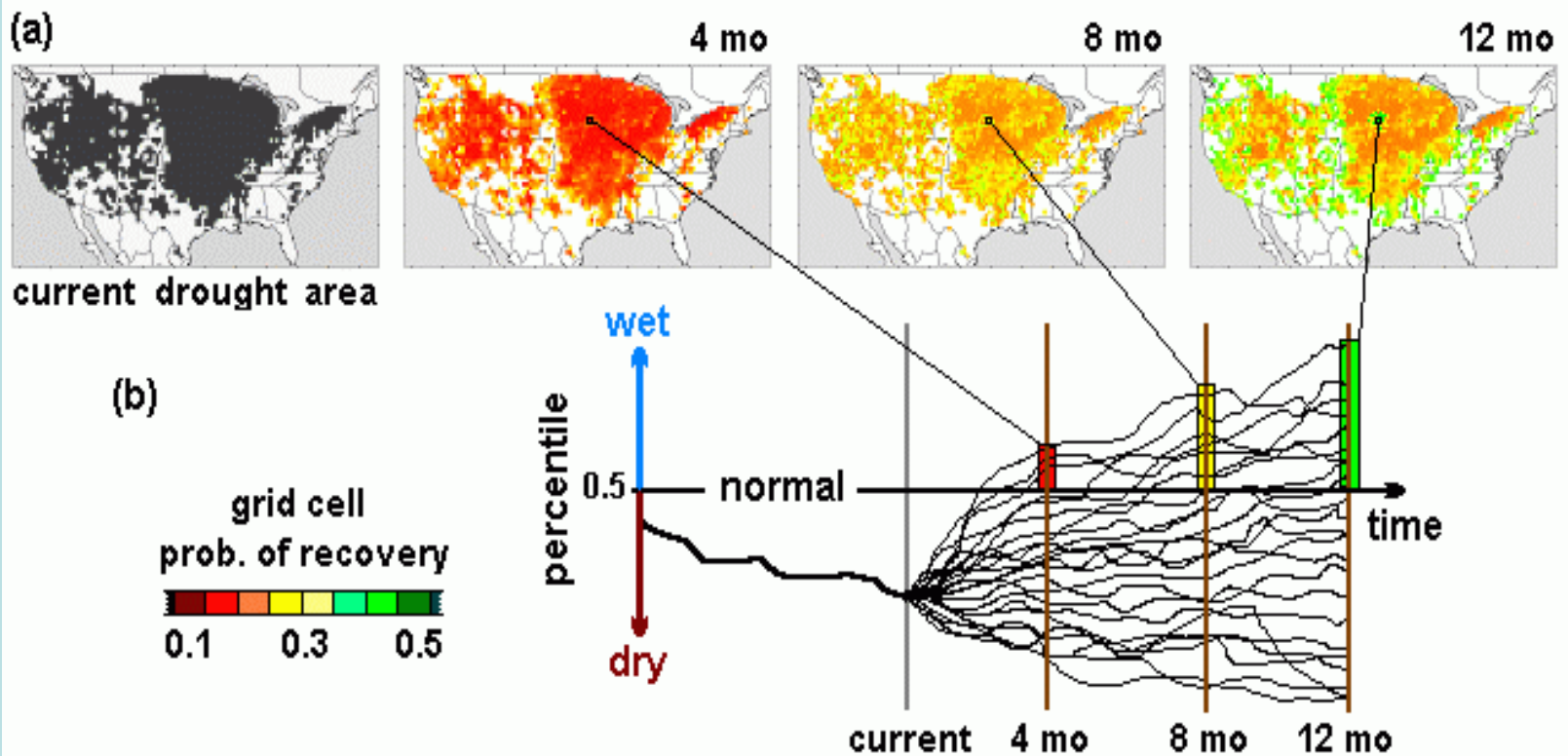


Report days

Ongoing work

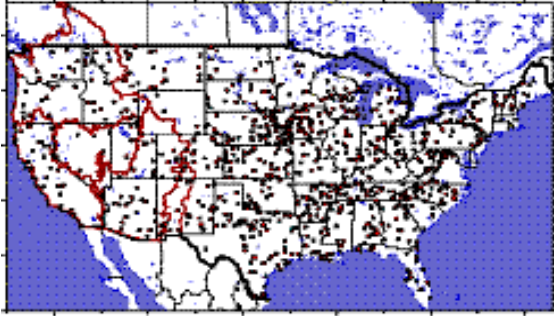
- Improved data assimilation (snow cover extent, SNOTEL)
- 2-week forecasts
- Multi-model ensemble (hydrology and climate)
- Forecast domain expansion
- Augmented forecast products (e.g. nowcasts in real-time)

Scheme for drought recovery/persistence analysis (planned)

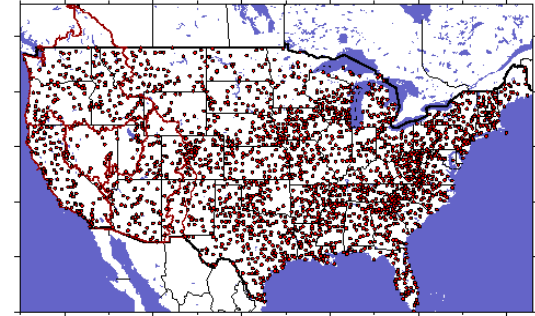


SW Monitor Information Flow

1930s



1955+



NOAA ACIS
Precp Tmax Tmin
Coop Stations

Index Station Method Gridded Forcing Creation

VIC Retrospective Simulation
Daily, 1915 to Near Current

Hydrologic
State

VIC Real-time
Simulation
(~1 month long)

Hydrologic
State
(-1 Day)

Hydrologic values,
anom's, %-iles w.r.t.
retrospective PDF

climatology (PDF)
of
hydrologic values
w.r.t. defined period

vals, anom's
%-iles
w.r.t. PDF

First focus area: Rio Yaqui basin

