## Integrating Climate Data Into Forecasting Hydrologic Inflow

## **WESTCAS** June 20, 2018

Tarrant Regional Water District in collaboration with Hydros Consulting







One of 3 Large Raw Water Suppliers in North Central Texas







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- "It's tough to make predictions, especially about the future." – Yogi Berra
- Uncertainty exists in water planning
  - Climate variation
  - Population growth
  - Relatively Short Hydrologic Records
  - Modeling Tools







#### Dallas Fort Worth Monthly Climate Normals



Powered by ACIS



SOURCE: ACIS NOAA REGIONAL CLIMATE CENTER



#### How Much Rain Has Fallen in Texas?

According to the National Weather Service in Fort Worth, Texas, over **35 trillion gallons** of rain have fallen in the month of May. Here's some perspective on that number:

# **35,000,000,000,000** GALLONS



Enough to fill up California's 200 largest surface reserviors

3X to capacity.

Enough to cover the island of Manhattan almost

Empire State Building: 1,250 ft

Enough to supply the entire world's population with

#### 10,000 days

of water if everyone drank eight 8-ounce glasses a day.



Sources: National Weather Service Fort Worth, California Department of Water Resources Credit: Nelson Hsu / NBC 5



Source: United States Drought Monitor, Image Source: LM Otero/AP

### Climate Reanalysis Data

- MERRA-2 Data from NASA
  - Monthly Data (~70,000,000 Data Points)
  - "Assimilated" Observations from Ground, Air, & Space
  - <u>https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/</u>





Image Sources: NASA Global Modeling and Assimilation Office & UCAR COSMIC

#### Atmospheric Variables Used at TRWD

**Parameter Description** 

**Relative Humidity** 

Zonal (E-W) Wind

Meridional (N-S) Wind

**Product of Wind Speed Anomalies** 

Covariance of Relative Humidity and Zonal Wind

Covariance of Relative Humidity and Meridional Wind

**Geopotential Height** 

Temperature



- Wide range of predictors available for each month that correlate to the inflow at TRWD's Reservoirs
- The number of predictors vary from 15 in September to 246 in May







#### Correlations to the Arctic Oscillation (AO) Found in the Predictors







trwd Regional District

#### Correlations to the North Atlantic Oscillation (NAO) Found in the Predictors



+NAO MORE STORN -NAO



Image Sources: Google Earth & Ideo.Columbia.edu

### El Nino Southern Oscillation (ENSO)

The Other Half of the ENSO Equation => Air Pressure

 The changes in ocean temps during El Niño & La Niña are accompanied by even larger changes in air pressure. This is tracked by the Southern Oscillation Index (SOI), and is calculated based on the differences in air pressure anomalies between Tahiti & Darwin, Australia.

#### **December - February El Niño Conditions**







#### Correlations to ENSO Found in the Predictors



**Relative Humidity** 

& Zonal Wind

Image Source: Google Earth



### **RiverWare Implementation**

- Generate Forecast
  - Dry, Avg, Wet, Very Wet
  - Starting Climate State for Simulation
- Select Set of 100 Markov Chain Traces
  - Observed Hydrologic
    Data Resampled Using Initial Forecast Condition
  - Historical Transition Probabilities also Initialized by Forecast
  - Simulate in RiverWare Planning Model
- Review Results





#### **RiverWare Output**





### **Operations Planning and Communication**





#### **RiverWare Studies**

- Climate Variation
  - Realistic versus Disaster
- "Any statistics can be extrapolated to the point where they show disaster." <u>Thomas</u> <u>Sowell</u>



### NOAA Grid Point Map



#### North American Drought Atlas



A History of Meteorological Drought Reconstructed from 835 Tree-Ring Chronologies for the past 2005 years.

#### View Data Values

There are 286 grid point reconstructions. To view the actual PDSI reconstruction data over any grid point:

1. Choose [Select Files] with the link below.

2. From the window on the right move to the desired grid-point then click on a dot.

3. Your browser will direct you to the file containing the requested grid-point data.

#### 1. Select File

• Grid Point

180



#### TREE-RING RECONSTRUCTED DROUGHT GRID-POINTS



Image Credit: NOAA.gov



#### Reconstructed and Instrumental Annual PDSI





### Instrumental PDSI Mapped over Extended Period





#### Developing Extended Hydrologic Record





#### Extended Hydrologic Simulation





#### Multiple Analyses

- Transmission Capacity Limited vs. Water Supply
- Population and Demand Sensitivity
- Operational Policy Changes
- Future Water Supply Options
- Ruleset and Model Changes



### Thank You for The Opportunity

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