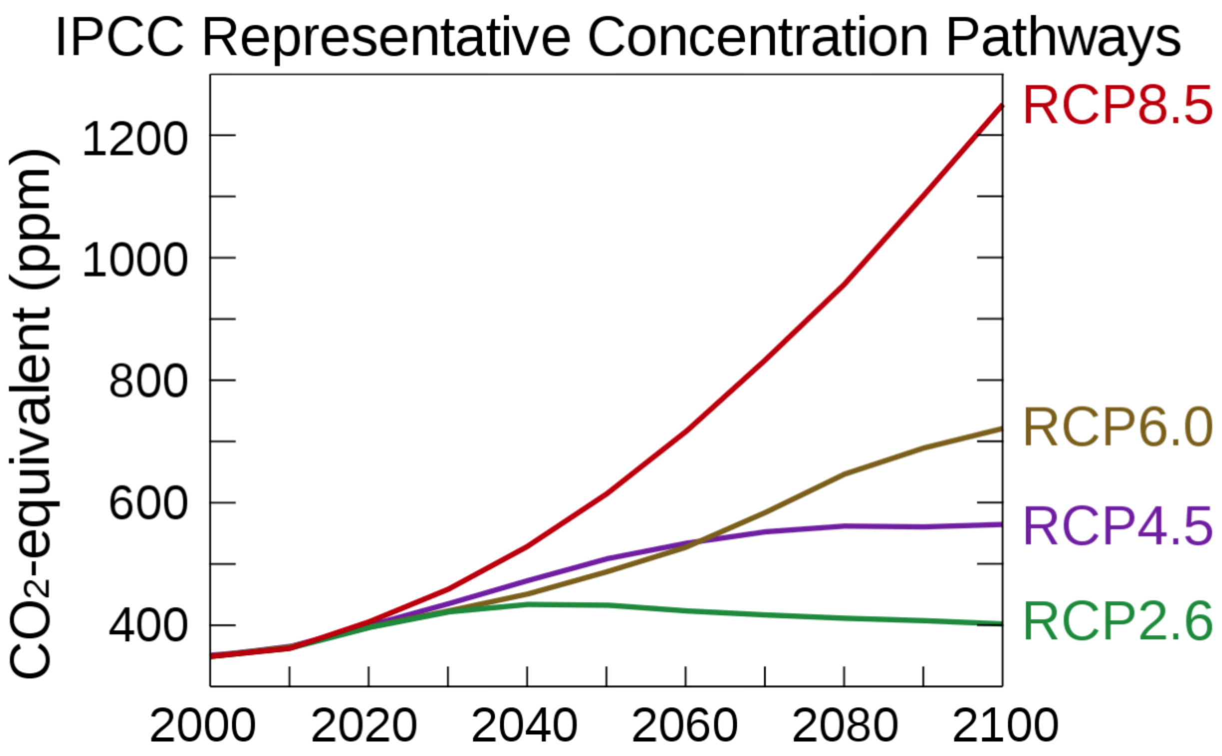
The Climate Change Question: An EAA Modeling Approach to Assessing the Potential Effects of Future Climate in Support of a Long-term EAHCP

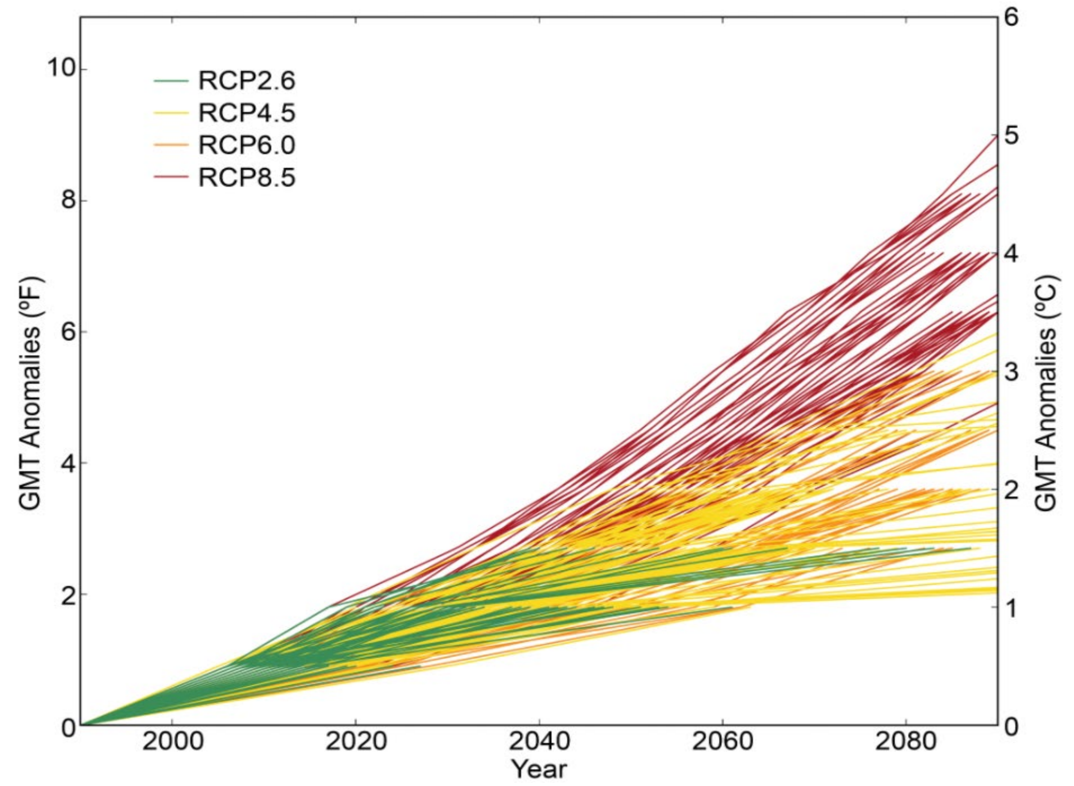
Presented by Jim Winterle to

EAA Board of Directors

January 12, 2021

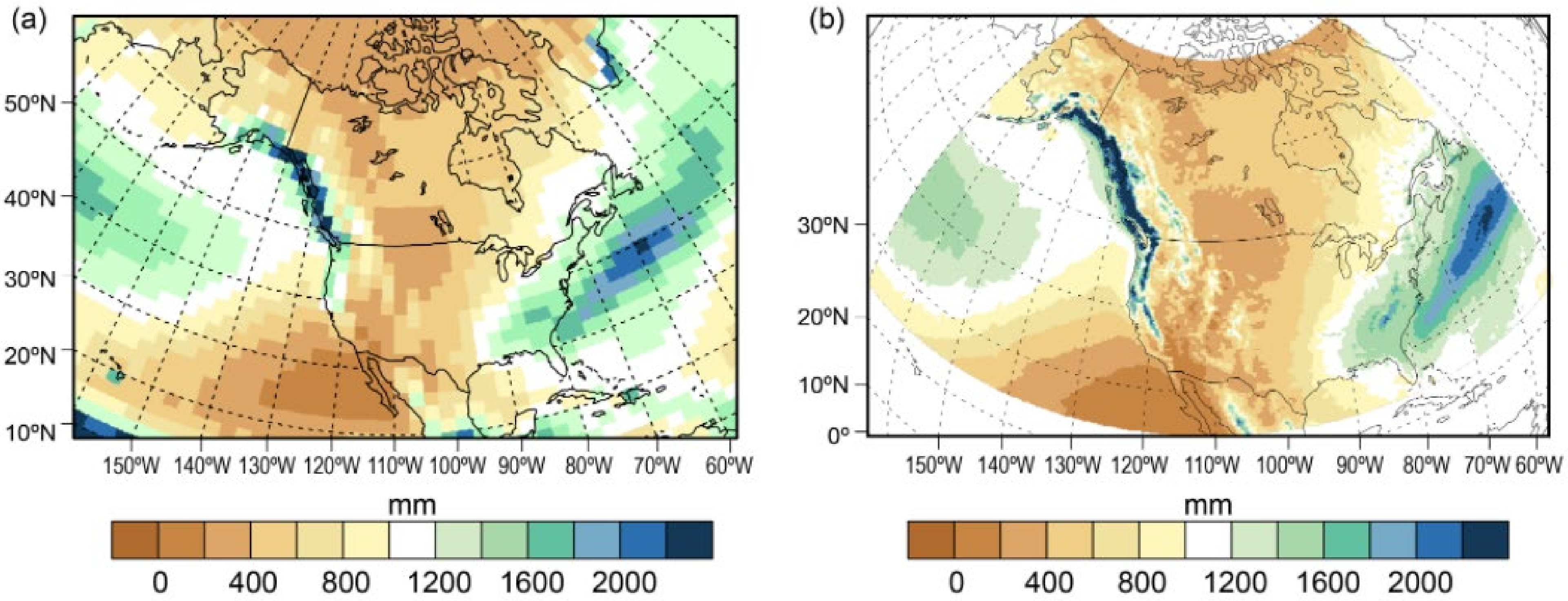
Global Climate Models and Scenarios





- Future temperature projections depend on carbon emission scenario
- 5th Coupled Model Intercomparison Project (CMIP5) evaluated future climate using 34 different models

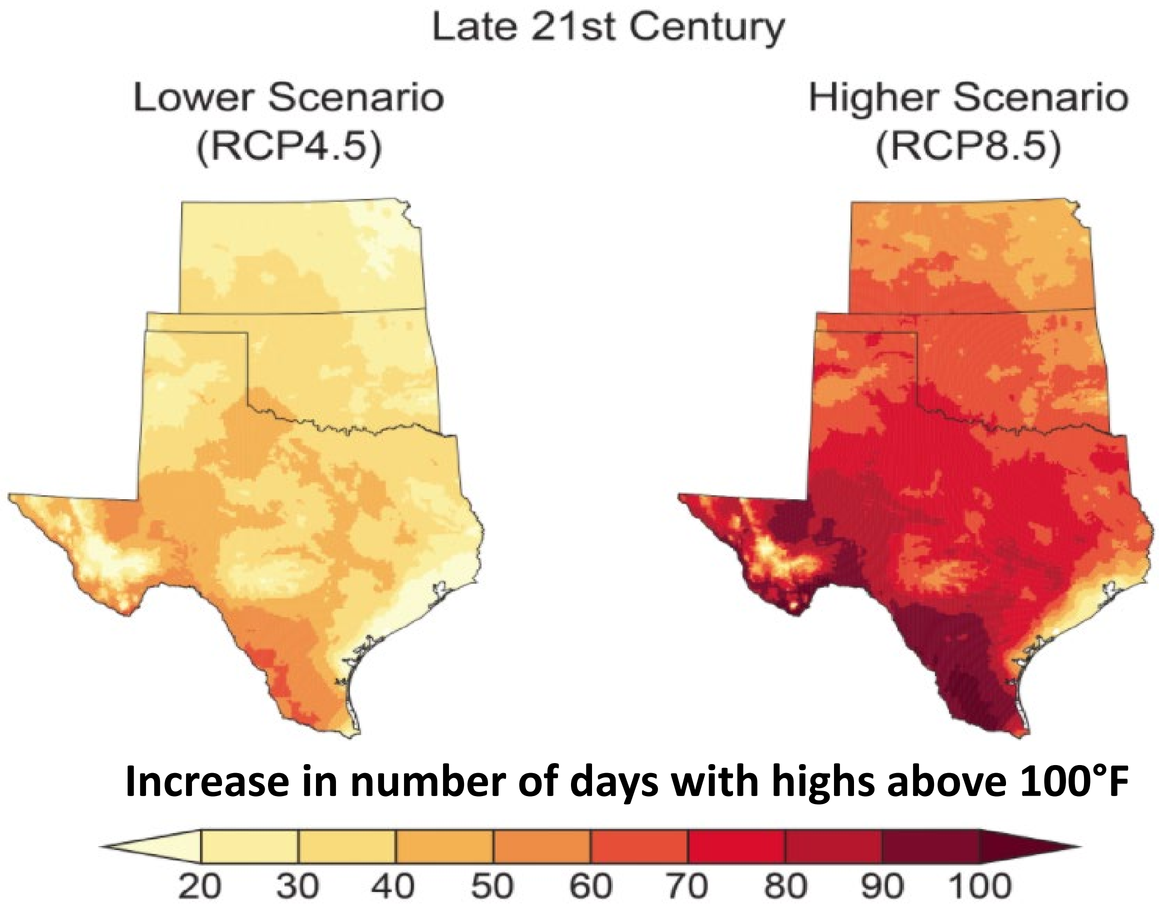
Downscaling from Global to Local



- Coarse grid of global models means predictions are averaged over a large area
- Downscaling uses local observations to calibrate projections to capture smaller scale variability with resolution as small as 4 km x 4 km.

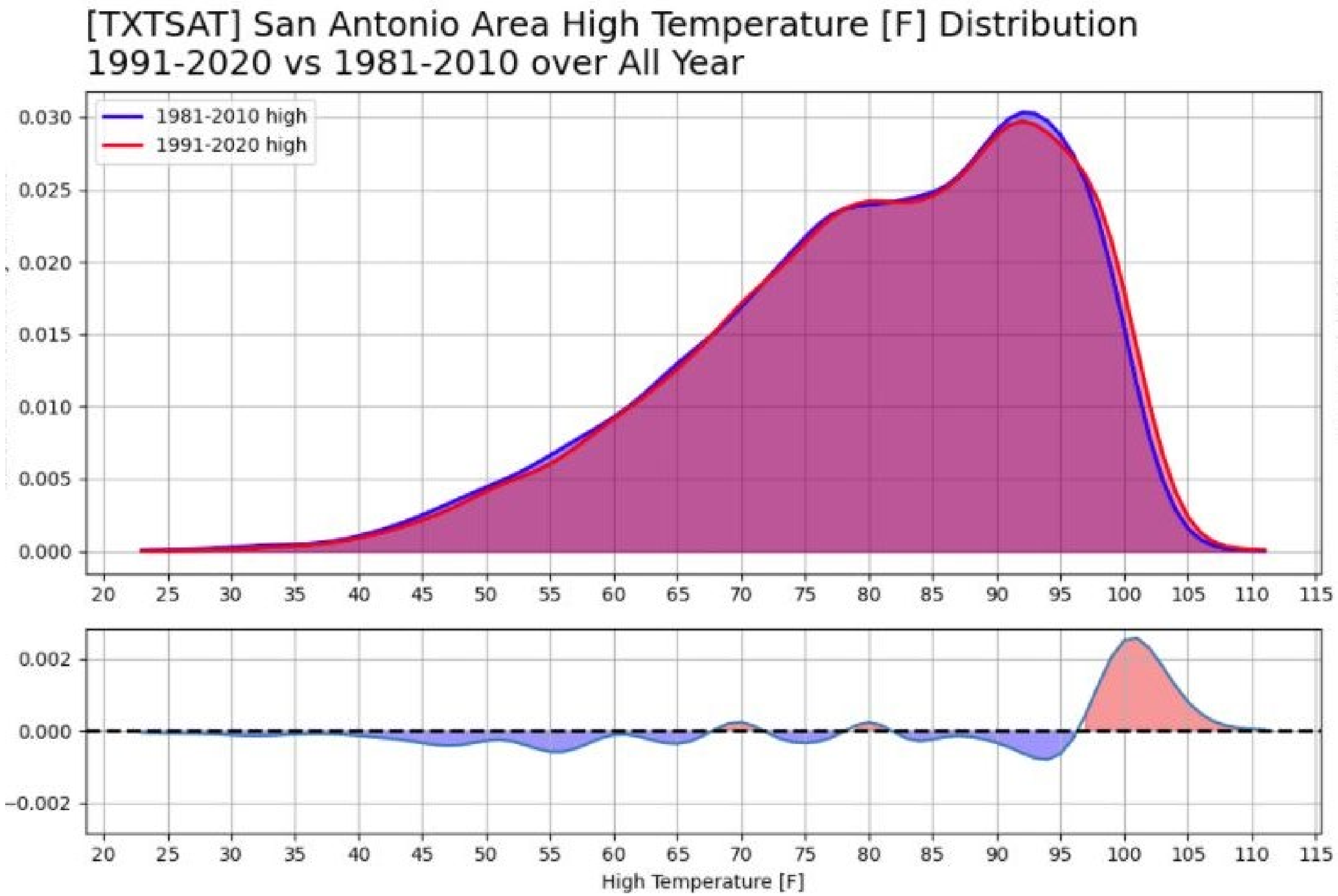
Climate Projections for Southern Great Plains Region

- Multivariate Adaptive Constructed Analogs (MACA) data sets available for 20 selected CMIP5 global models for a historical period from 1950–2005 and a projected period from 2006–2100
- Fourth National Climate Assessment describes climate projections within the United States
- Chapter 23 of the Assessment focuses on Southern Great Plains Region, including Texas
- Projections for the region are that annual average surface **temperatures are projected to increase by 4.4°–8.4°F by 2100**
- Average annual precipitation projections suggest relatively smaller changes in the region, with **slightly wetter winters, drier summers, and more frequent intense storms**



Observed Changes In Local Climate

- National Weather Service determines representative climate conditions based on 30 years of data
- Climate averages updated every ten years at the end of each decade
- Last update, on 01/01/2021 shows increase in daily high temperatures of about 1°F for San Antonio, Austin, Del Rio areas
- Slightly fewer cool days, significantly more days with daily highs above 100°F



http://mesonet.agron.iastate.edu/plotting/auto/?q=215

How Might Climate Affect Spring Flows/Habitat?

- Higher temperatures will increase evaporation rates and decrease soil moisture
- This *could* lead to decrease in distributed recharge in the areas between streams in the contributing and recharge zones

- Greater frequency of high-intensity rainfall *could* lead to more storms that generate runoff to streams and focused recharge in stream beds

- Need to model for several different climate model projections and scenarios

What is the Question We Need to Answer?

- Current conservation measures were developed under the EAHCP based on a standard of maintaining critical spring flows at Comal Springs and San Marcos Springs in the event of a repeat of the drought-of-record (DOR)
- *Will the current conservation measures still be effective through the ITP renewal period under a changing climate?*
- *Or,*
- *Will the standard of protecting to the DOR still meet EAHCP-established measures for spring flow considering projected changes in climate during the ITP renewal period?*

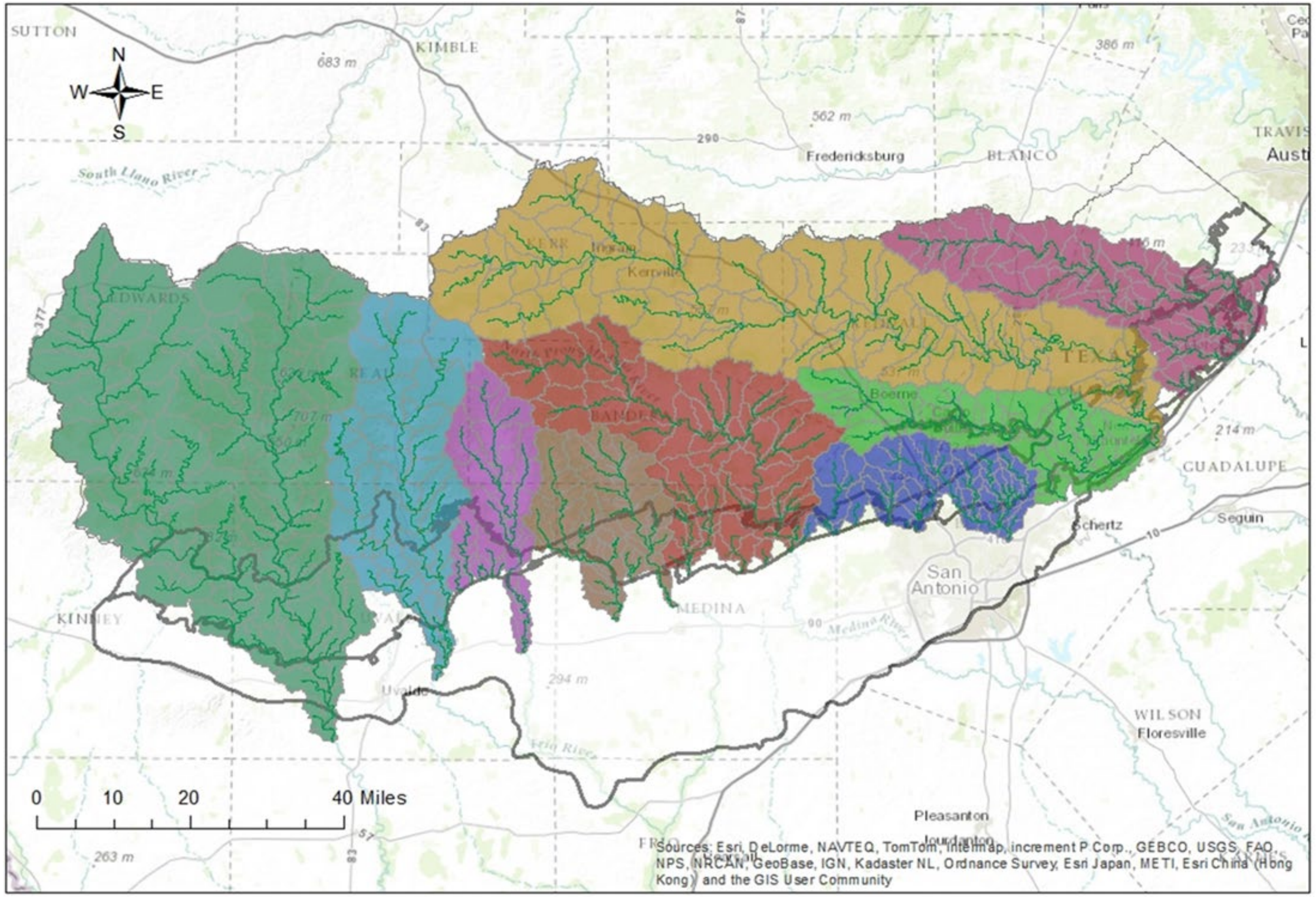
Modeling Approach

- Climate projections are available through 2100
- Focus on ITP renewal period, beginning in 2028
- Renewal period not yet determined, but likely between 15 to 50 years
- Modeling results may affect the renewal period

- Modeling Approaches:
  - HSPF Watershed Modeling
  - Machine Learning-based forecasting

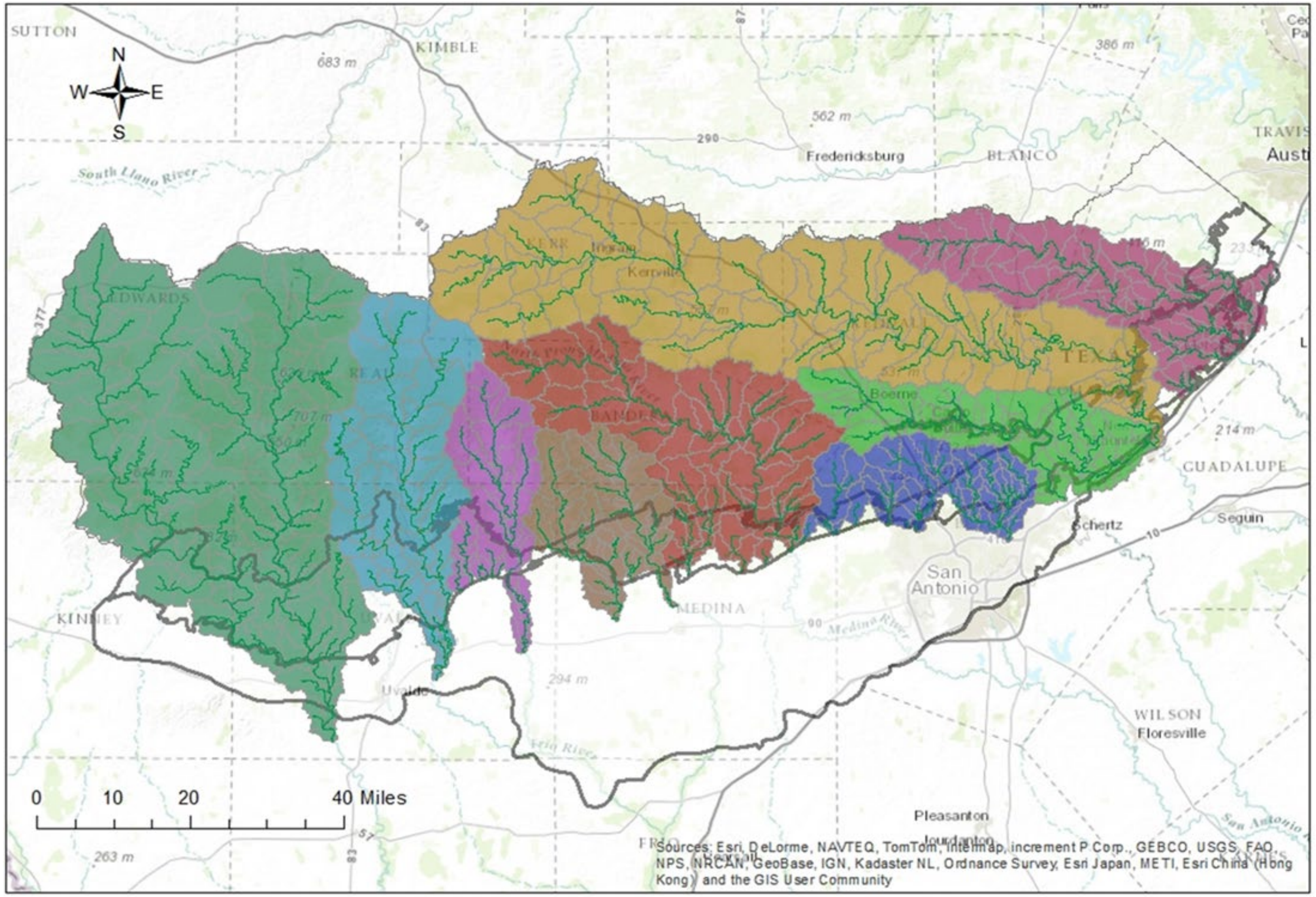
HSPF Watershed Models

- Collaboration with Tetra Tech, Inc.
- Conducted detailed review of Blanco and Frio/Dry Frio models in 2020 and areas for improvements identified
- Updating and recalibrating to match historical observations
- Updated models will be run for future climate using a subset of the 20 MACA downscaled climate projections for input



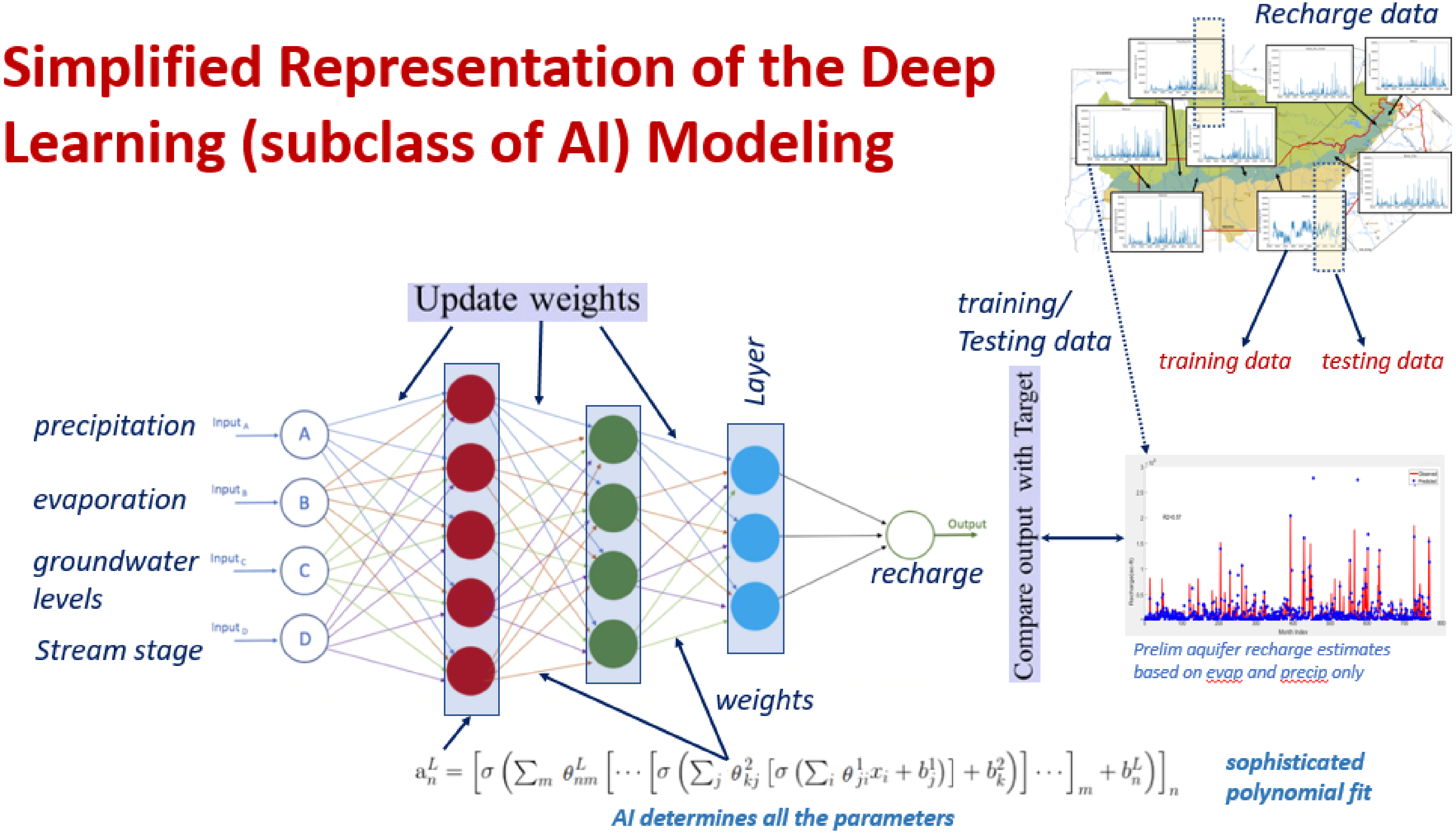
HSPF Watershed Models

- Look at 3-year, 5-year, and 10-year rolling average recharge estimates for each watershed and compare to the drought of record
- Compare to USGS estimates to identify and adjust for any biases
- RCP 4.5 and RCP 8.5 future climate scenarios will be considered



Machine Learning Methods

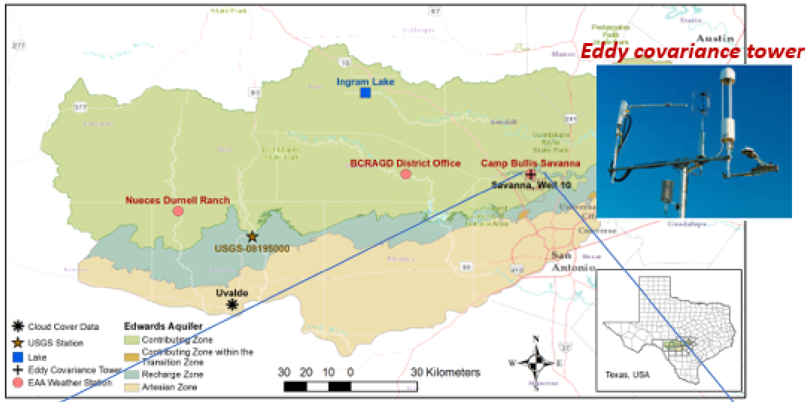
Simplified Representation of the Deep Learning (subclass of AI) Modeling



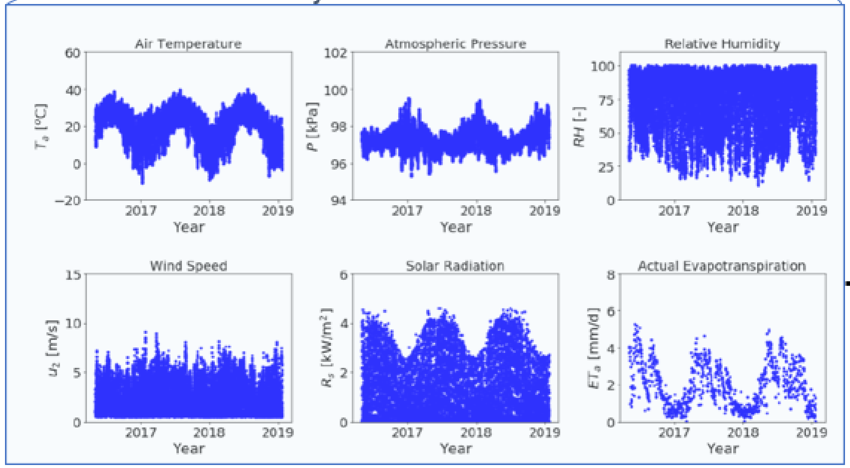
$$a_n^L = \left[\sigma\left(\sum_m \theta_{nm}^L \left[\cdots\left[\sigma\left(\sum_j \theta_{kj}^2 \left[\sigma\left(\sum_i \theta_{ji}^1 x_i + b_j^1\right)\right] + b_k^2\right)\right]\cdots\right]_m + b_n^L\right)\right]_n$$

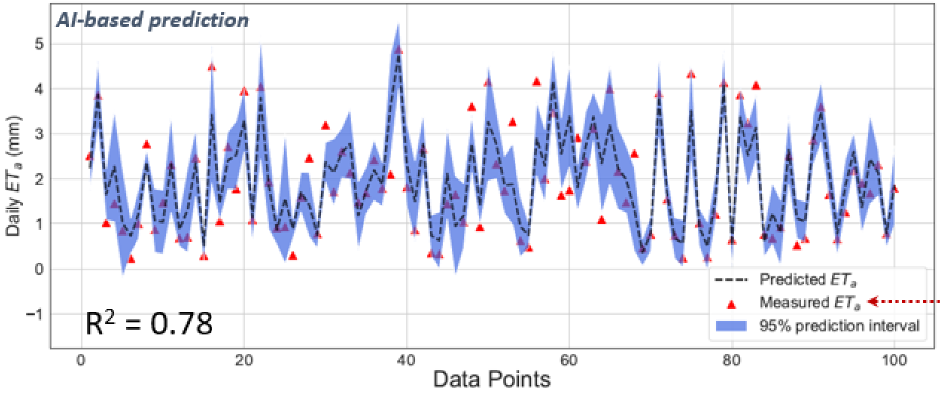
Machine Learning Methods

AI-Based Prediction of “Actual” Evapotranspiration



measured data from EAA weather station

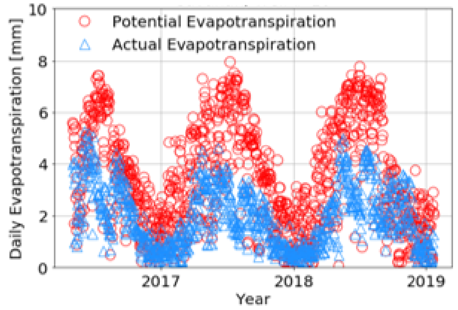




AI-based prediction of daily actual evapotranspiration (ET_a) and its comparison against measured ET_a through the eddy covariance tower (ETC). AI-predicted daily ET_a are mostly within 95% confidence interval of the measured ET_a. AI effectively offsets high capital and maintenance costs of ETC. 80% of the computed ET_a and was used for training. The plot above shows the robust and accurate prediction of 3-months of ET_a data (note that less measured ET_a was available for AI modeling than computed ET_a).

Computed daily and monthly potential evapotranspiration (ET_o) Using Penman-Monteith Equation

$$ET_o = \frac{0.408\triangle(R_n - G) + \gamma\frac{37}{T_a+273}u_2(e^o - e_a)}{\triangle + \gamma(1 + 0.34u_2)}$$



Machine Learning Methods

- Collaboration with UTSA

- Work conducted to date has involved developing machine learning algorithms to predict
  - potential and actual evaporation rates based on data collected at EAA weather stations, and
  - water levels at the J-17 index well based on historical and projected precipitation and temperature inputs

- Several analyses have been submitted for publication in peer-reviewed journals

Other Supporting Activities

- Literature reviews to improve internal knowledge of global climate models, model scenarios and assumptions, available model outputs, and methods for downscaling model outputs to local scales

- Networking with outside agencies and stakeholders (e.g., South Central Climate Adaptation Science Center, University of Texas at San Antonio, Oklahoma State University) who are facing similar issues

- Developing software applications and utilities to format climate model outputs in a manner that is appropriate for input to watershed models or other analytical methods that will be used to assess potential environmental impacts

- Evaporation sutdies to better understand how various climate parameters affect ET rates spatially and temporally.

- Soliciting peer reviews from recognized experts as EAA's methodology develops and results are obtained

Questions?