Climate influence on Susquehanna River streamflow dynamics

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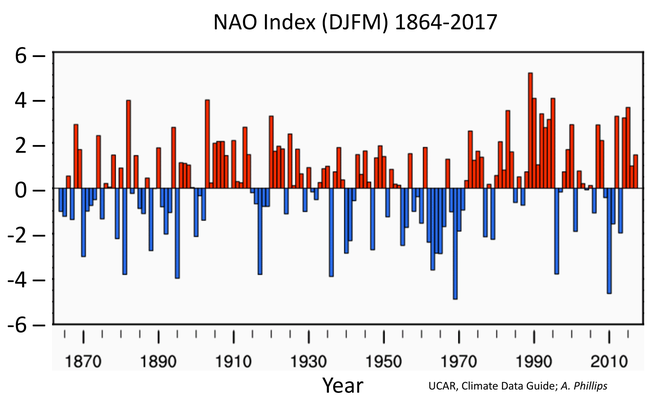
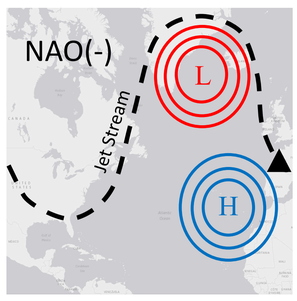
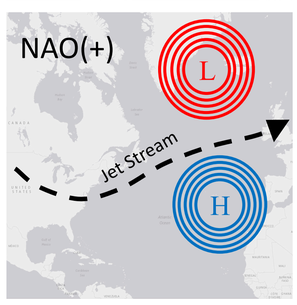
NORTH ATLANTIC OSCILLATION AND STREAMFLOW VARIABILITY

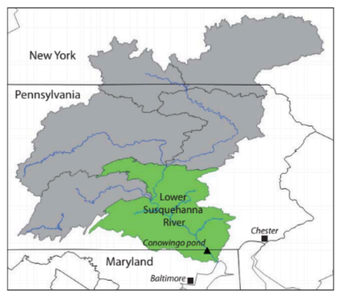
The **North Atlantic Oscillation (NAO)** is the most persistent climate mode, always present in one of its forms day-to-day, either in a neutral, negative, or positive phase. Pressure anomalies at the Subtropical High and Subpolar Low result in different NAO phases. Pressure anomalies with a positive relationship correspond to the positive phase of the NAO and a negative relationship corresponds to the negative phase of the NAO. The time series shows the winter NAO index based on the difference of normalized sea-level pressure between Lisbon, Portugal and Reykjavik, Iceland between 1864 and 2017. Each phase of the NAO results in changes to the flow across the Mid-Atlantic region which results in variations in precipitation quantity and type.

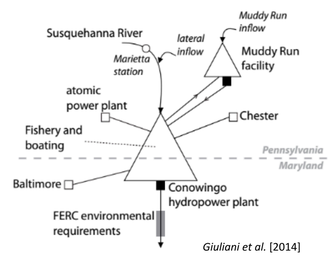
The streamflow record is from Marietta, PA (accessed through the USGS) within the **Susquehanna River Basin (SRB)** and contains daily, continuous streamflow from 1931-Present. Using a streamflow generator, the Dry-Dry, Dry-Wet, Dry-Flood, and all other **transition probabilities** were calculated. The annual flood frequency and **peak over threshold** was calculated from each independent flood.



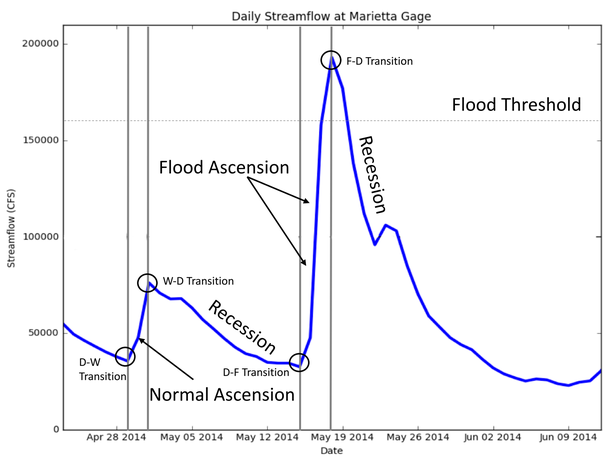








Giuliani et al. [2014]

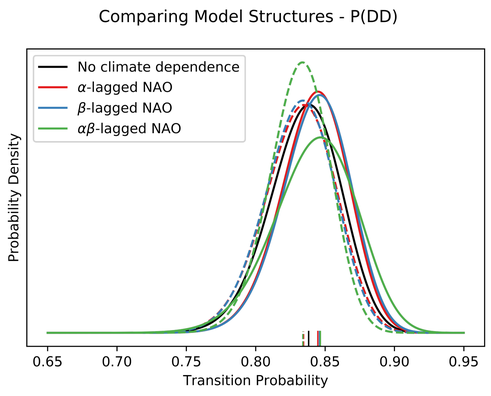


MODEL STRUCTURE

Beta Model
Transition Probabilities

Shape Parameters: α, β

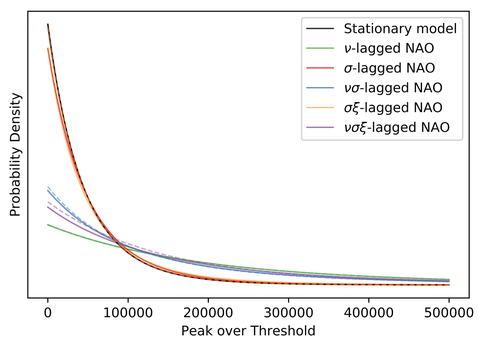
Parameters	Predictors	Predictor Form
Stationary	Annual NAO	Neutral
α	DJFM NAO	Non-neutral
β	Lagged-DJFM NAO	Continuous
$\alpha\beta$		

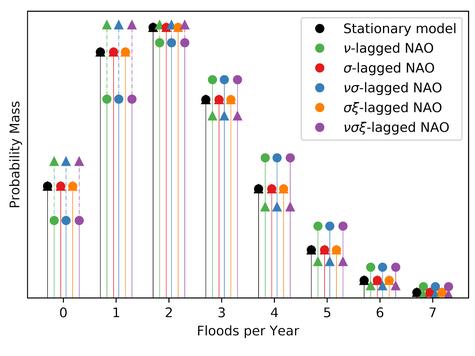


GPD – Poisson Model
Flood Frequency and Magnitude

Event Rate: ν
Shape Parameter: ξ
Scale Parameter: σ

Parameters	Predictors	Predictor Form
Stationary	Annual NAO	Neutral
ν	DJFM NAO	Non-neutral
σ	Lagged-DJFM NAO	Continuous
$\nu\sigma$		
$\sigma\xi$		
$\nu\sigma\xi$		





MODEL SELECTION

Bayesian Information Criterion (BIC) function

$$BIC = k \cdot \ln(n) - 2 \cdot \ln(L)$$

Akaike Information Criterion (AIC) function

$$AIC = 2 \cdot k - 2 \cdot \ln(L)$$

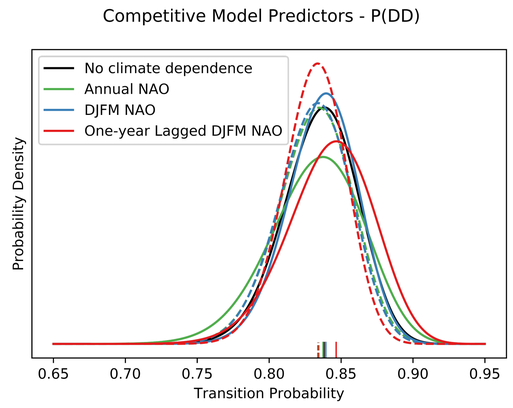
Model	DD-Stationary model*	α(neutral)-lag-DJFM	β(neutral)-lag-DJFM	$\alpha\beta$(neutral)-lag-DJFM
ΔBIC	0	1.243	-0.013	**-0.546**
ΔAIC	0	-1.199	-2.456	**-5.431**

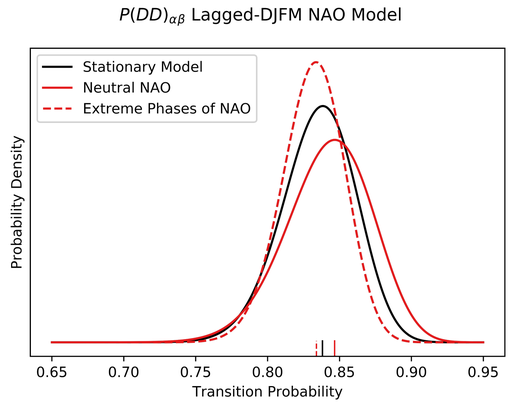
Model	GPD-Poisson Stationary*	ν(neutral)-lag-DJFM	σ(neutral)-lag-DJFM	$\nu\sigma$(neutral)-lag-DJFM	$\nu\sigma\xi$ (neutral)-lag-DJFM
ΔBIC	0.000	7.570	10.343	17.913	28.256
ΔAIC	0.000	**-0.773**	2.000	1.227	3.227

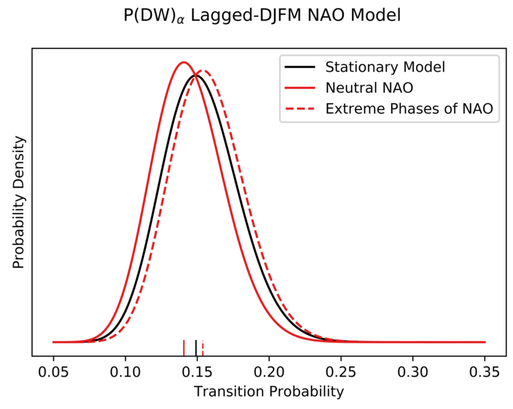
Selected results show how the BIC is biased against more complex models. This led to the decision of using BIC to select the Beta model where model complexity is not a significant metric for each model and AIC is used to select the GPD-Poisson model that had many complex models to choose from.

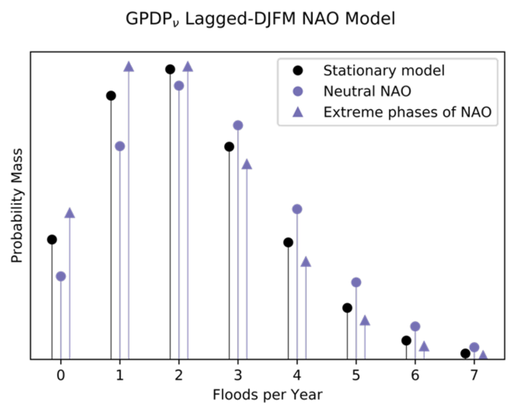
RESULTS AND IMPLICATIONS

(Top Right) The most competitive models of $P(DD)_{\alpha\beta}$ neutral form are dependent on a one-year lagged winter (DJFM) NAO index that is most affected by a NAO dependence. (Bottom Left) The neutral form of the $P(DD)_{\alpha\beta}$ lagged-DJFM is most competitive against the parsimonious (No climate dependence) model noting **an increased chance of dry spell persistence** for the lower SRB. (Bottom Right) The neutral $P(DW)_{\alpha}$ lagged-DJFM model was also very competitive against the parsimonious model and indicates a **smaller possibility of transitioning to a wet period** of streamflow following a neutral lagged-DJFM NAO event.



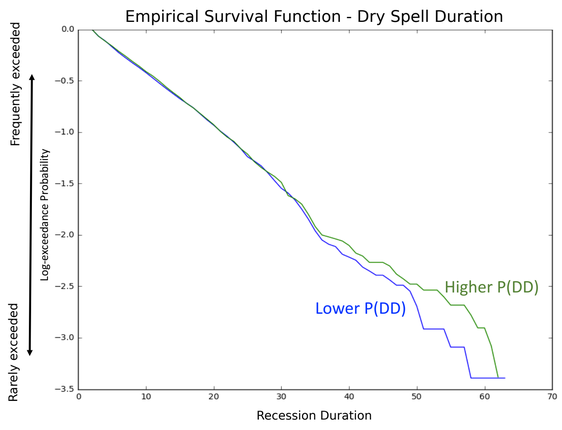






(Left) The neutral $GPDP_{\nu}$ lagged-DJFM NAO model is the only GPD-Poisson model that is competitive against the stationary model using the AIC model selection criterion. This suggests **a higher chance of flood occurrence following a neutral winter (DJFM) NAO**, informing water managers of how to manage the Conowingo Dam in the lower SRB.

(Right) The empirical survival function illustrates the connection between dry-dry transition probabilities and dry spell duration that could affect how droughts are managed. The implications of higher P(DD) must be known to inform water managers. This project developed a climate mode framework that informs a synthetic streamflow generator developed by Dr. Spence of the connection between large-scale climate patterns and daily streamflow dynamics.



ACKNOWLEDGEMENTS

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