Understanding Flood Dynamics in East African Wetlands.

Insights from Observational and Model Comparisons.

13.08.25

Hydro-JULES

UK Centre for Ecology & Hydrology

BGS British Geological Survey

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Motivation

- The Sudd is the largest wetland in Africa.

 - Our domain has an area of ≈ 85,000 Km^2

- Since 2019, there's been a large increase in flood extent in the Sudd.

- This has been correlated with an increase in regional methane emissions. (Andy Hardy *et al, 2023*)

Objectives

Compare model output with satellite observations:

- CaMa-Flood (Yamazaki et al 2013,2014) is a river routing and overbank inundation model

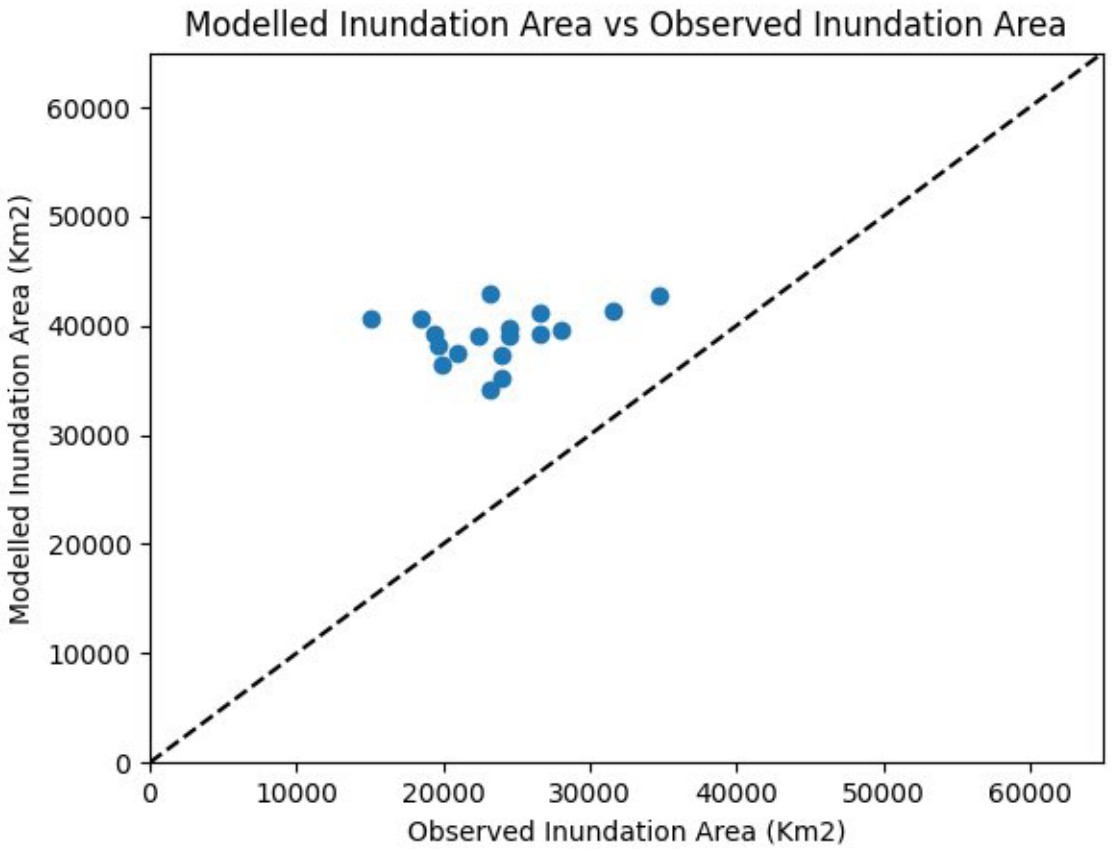
- Observed inundation is derived from the difference between land surface temperature and air temperature.

Assess model sensitivity to different metrics & parameters:

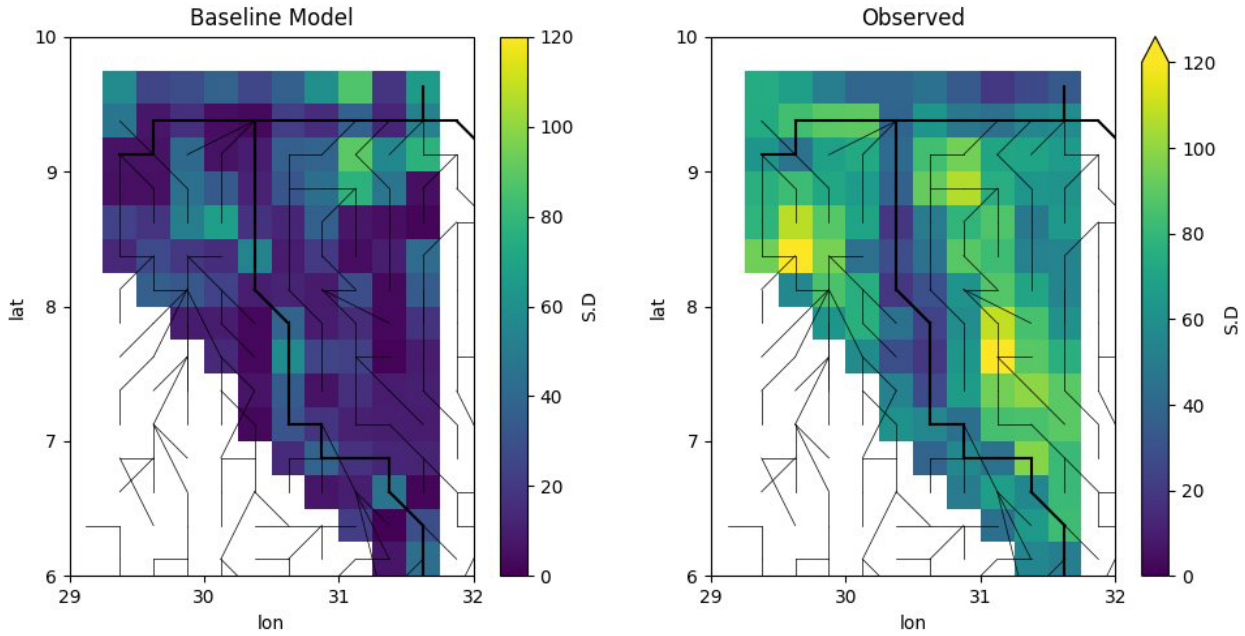
- SPAEF & SPAH4
- KGE
- Root Mean Squared Error(RMSE)
- Fractional Skills Score & other binary metrics

Baseline Model Performance

High Bias



Low Yearly Variability



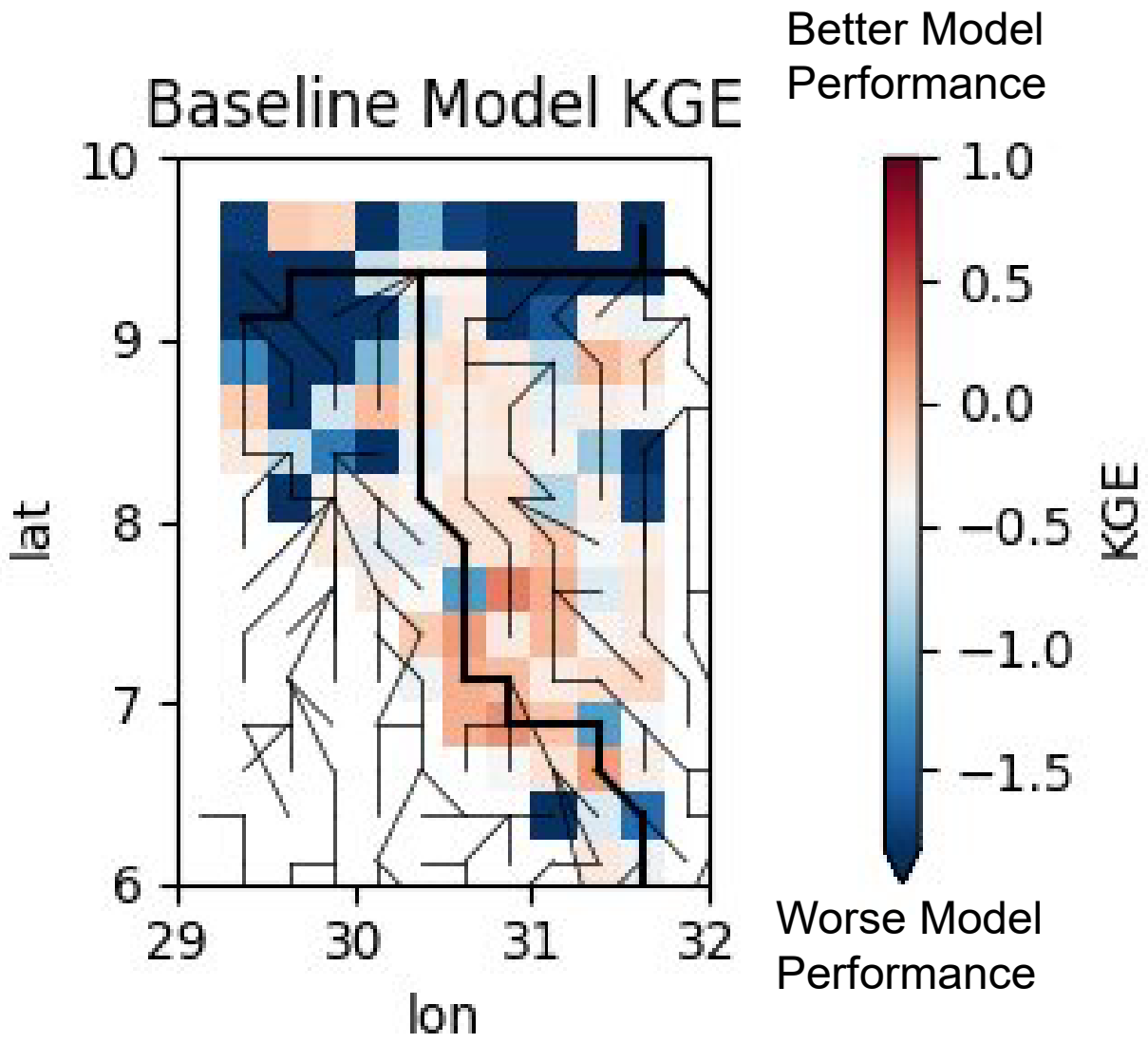
KGE Metric

$$\mathbf{KGE} = 1 - \sqrt{(\alpha - 1)^2 + (\beta - 1)^2 + (\gamma - 1)^2}$$

α = ρ(obs,sim), $\beta = \frac{\sigma_{sim}}{\sigma_{obs}}, \gamma = \frac{\mu_{sim}}{\mu_{obs}}$

Compares time series data –

produces spatial output.



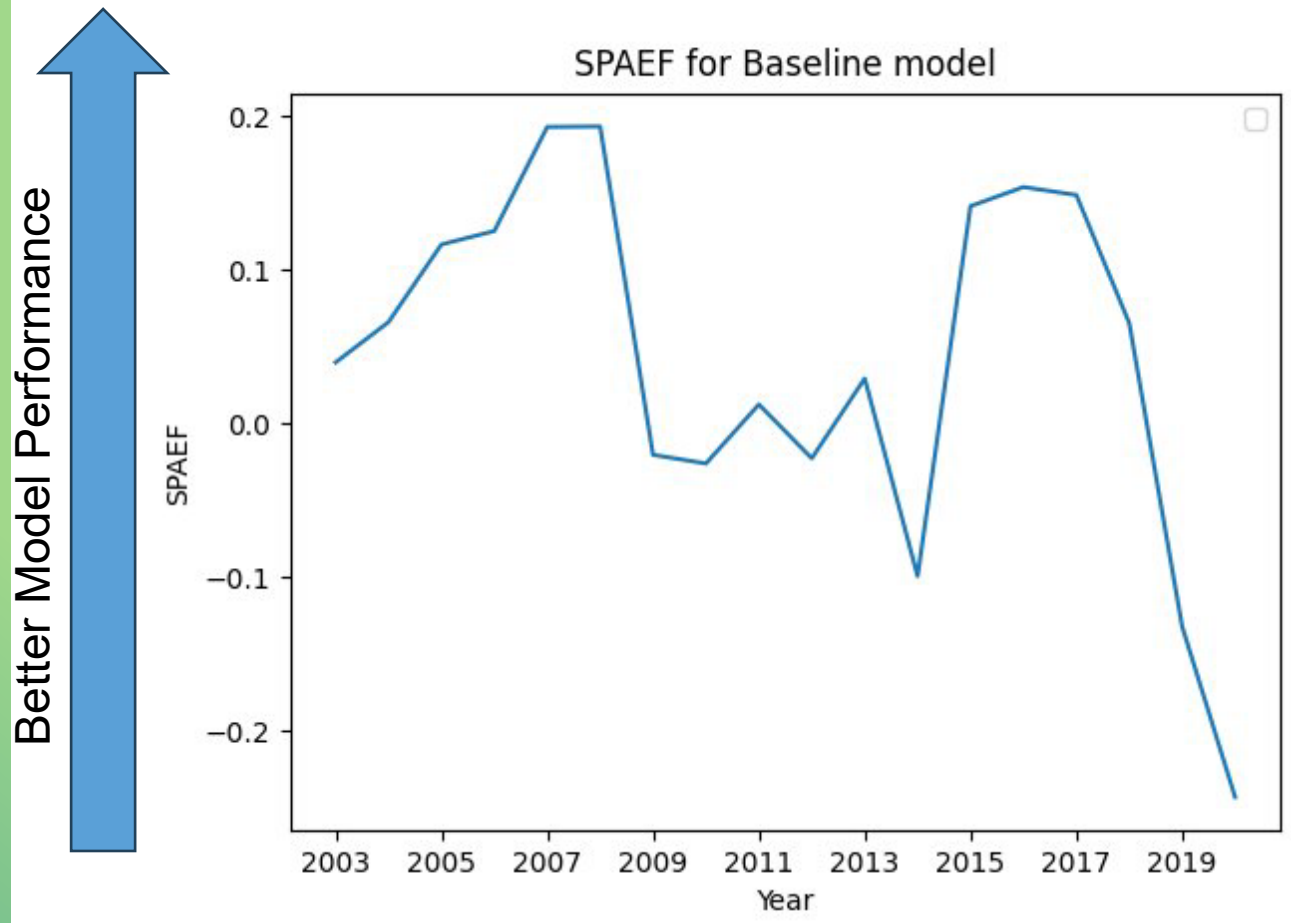
SPAEF Metric

$$SPAEF = 1 - \sqrt{(\alpha - 1)^2 + (\beta - 1)^2 + (\gamma - 1)^2}$$

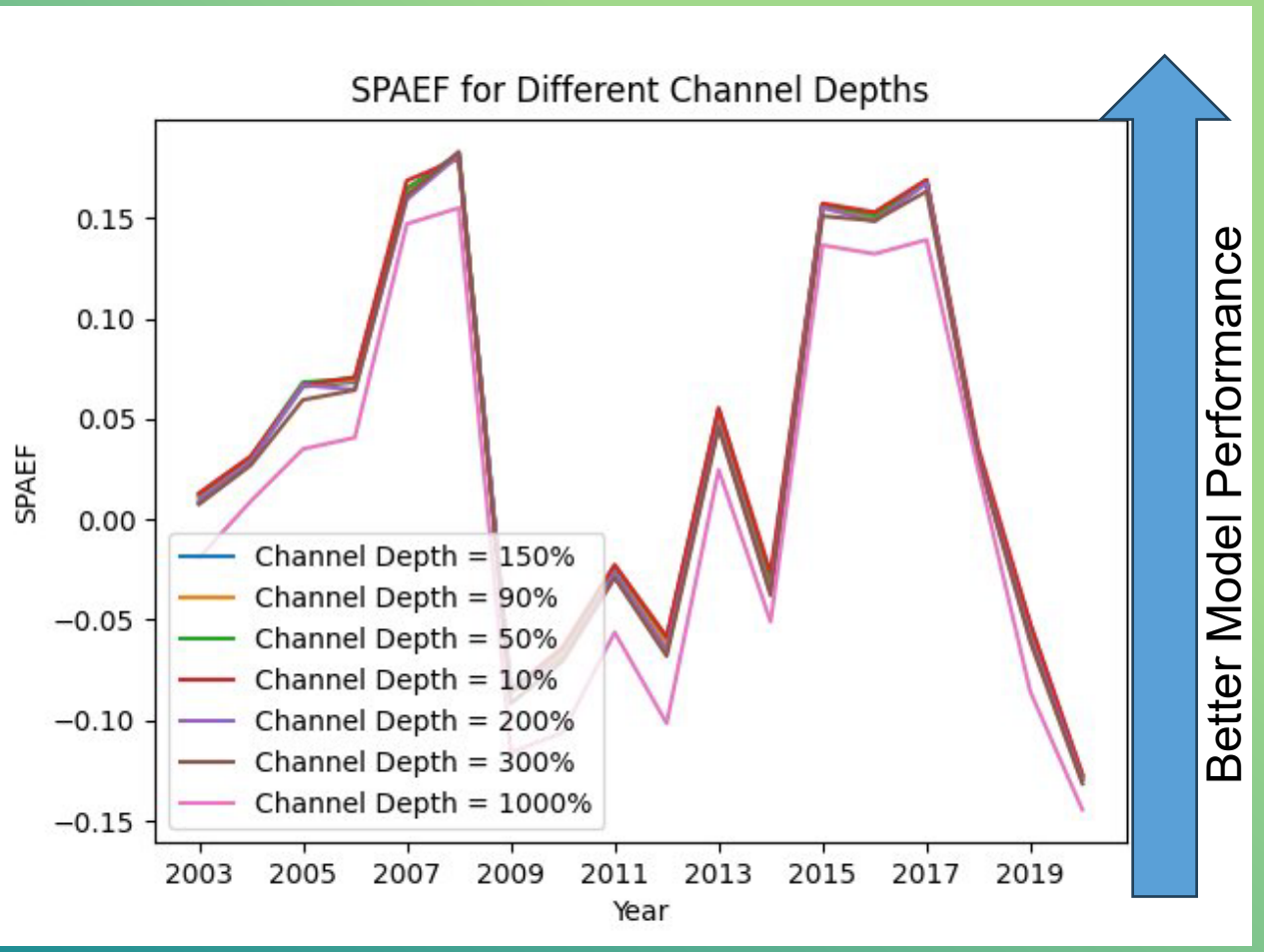
α = ρ(obs,sim), $\beta = \frac{\sigma_{sim}}{\mu_{sim}} \div \frac{\sigma_{obs}}{\mu_{obs}}$, $\gamma = histogram\ overlap$

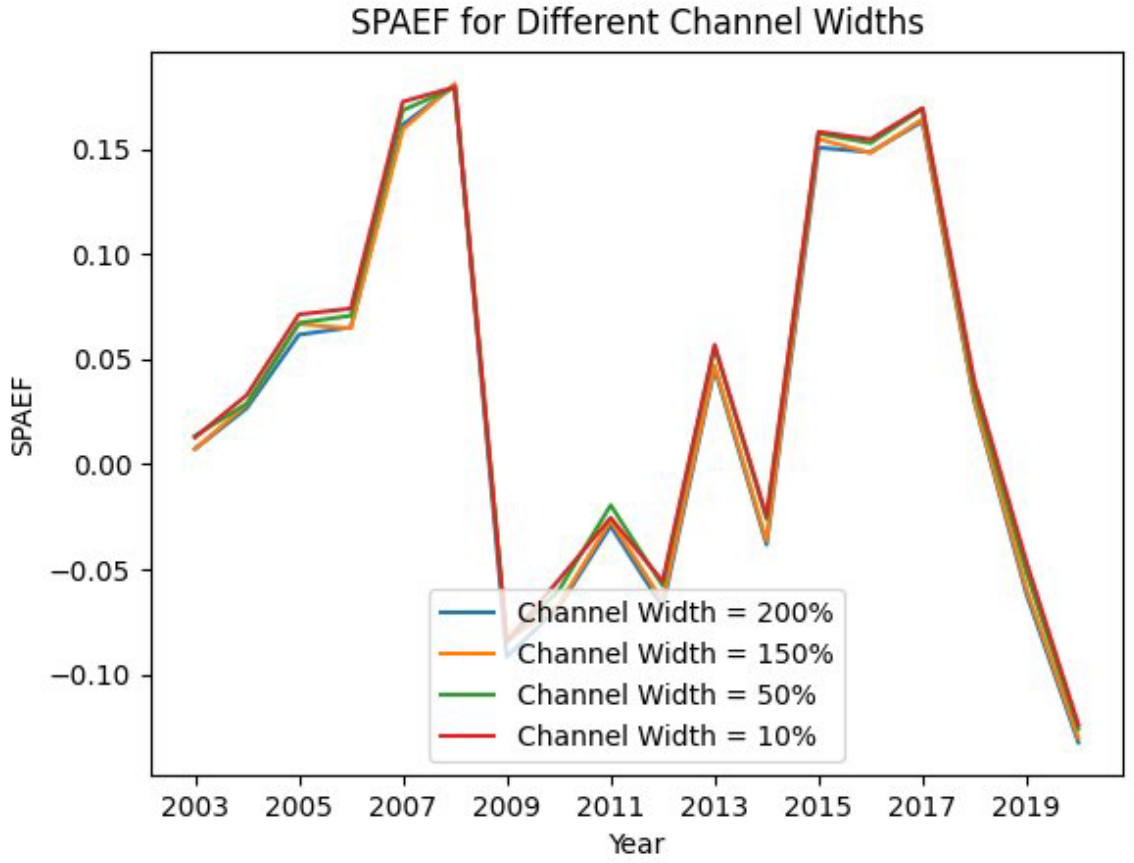
Compares spatial data –

produces a timeseries.



Changing Channel Depth/Width

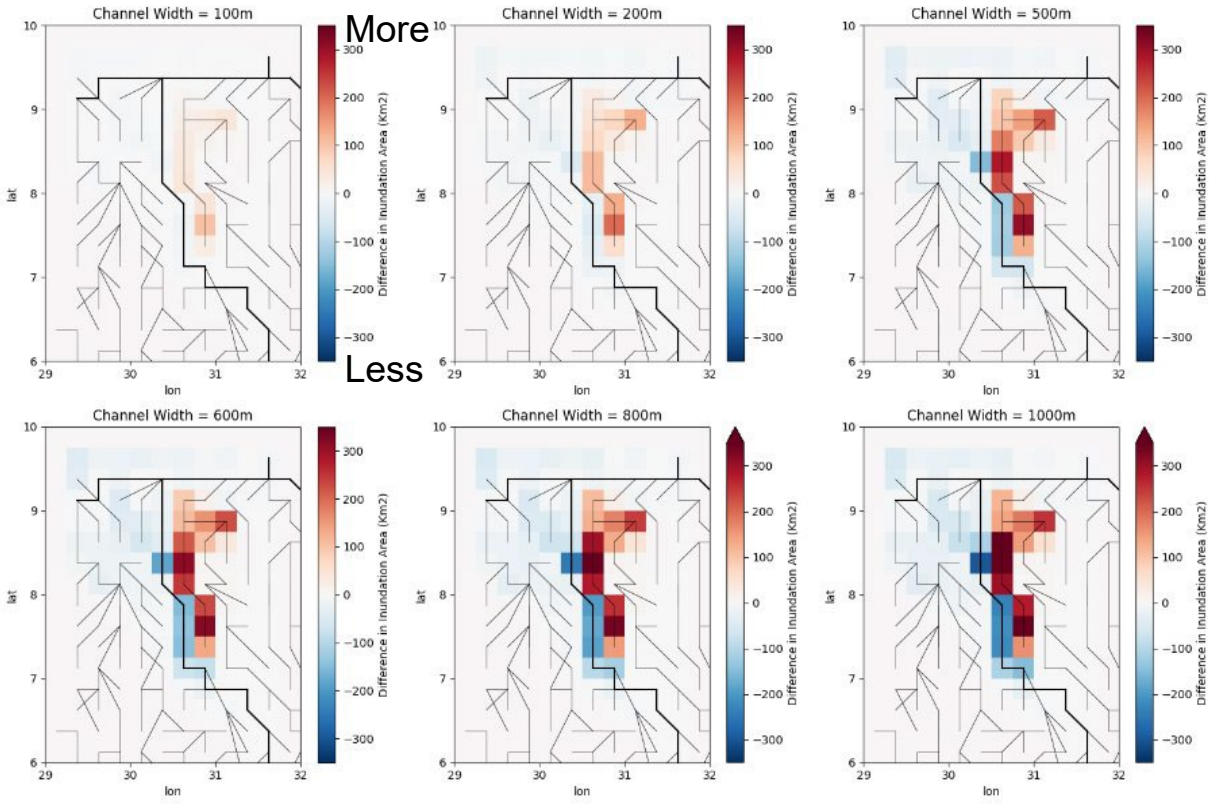




Changing Bifurcation Parameters

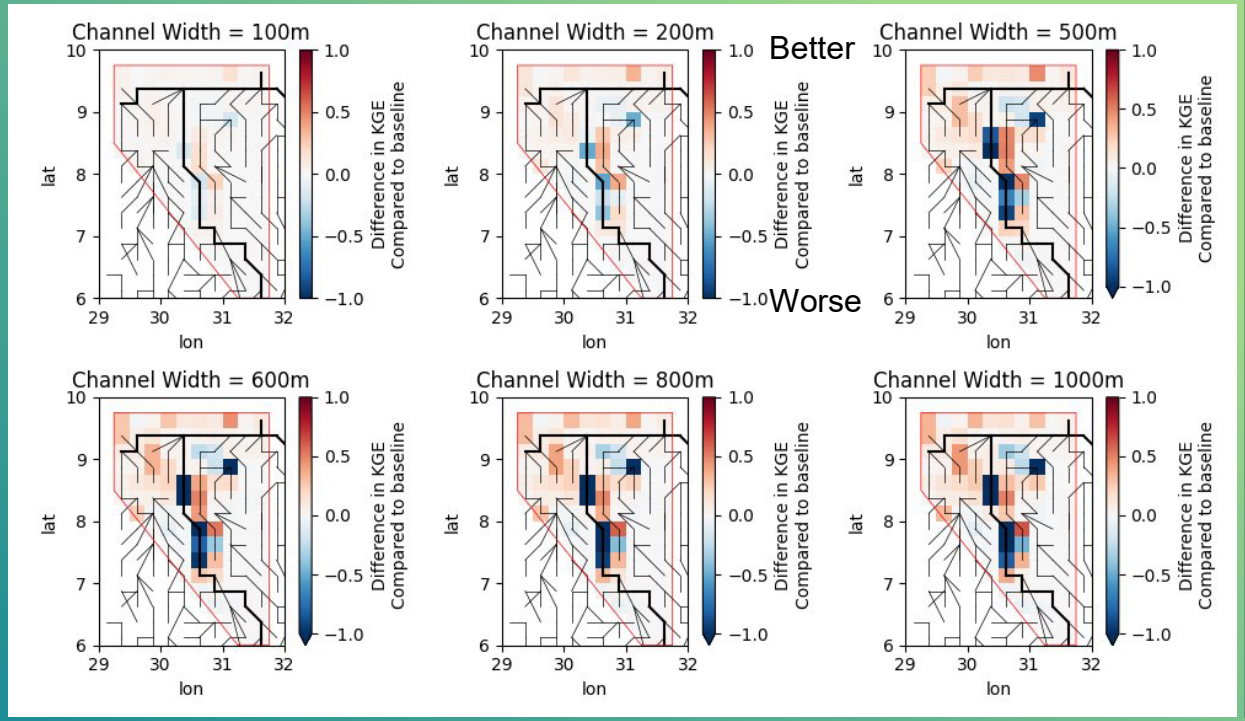
- In wetlands, flow is not constrained to the main channel.
- We can represent this with bifurcations – manually adding connections in.
- We've changed the width of one connection here.

Difference in inundation compared to baseline model

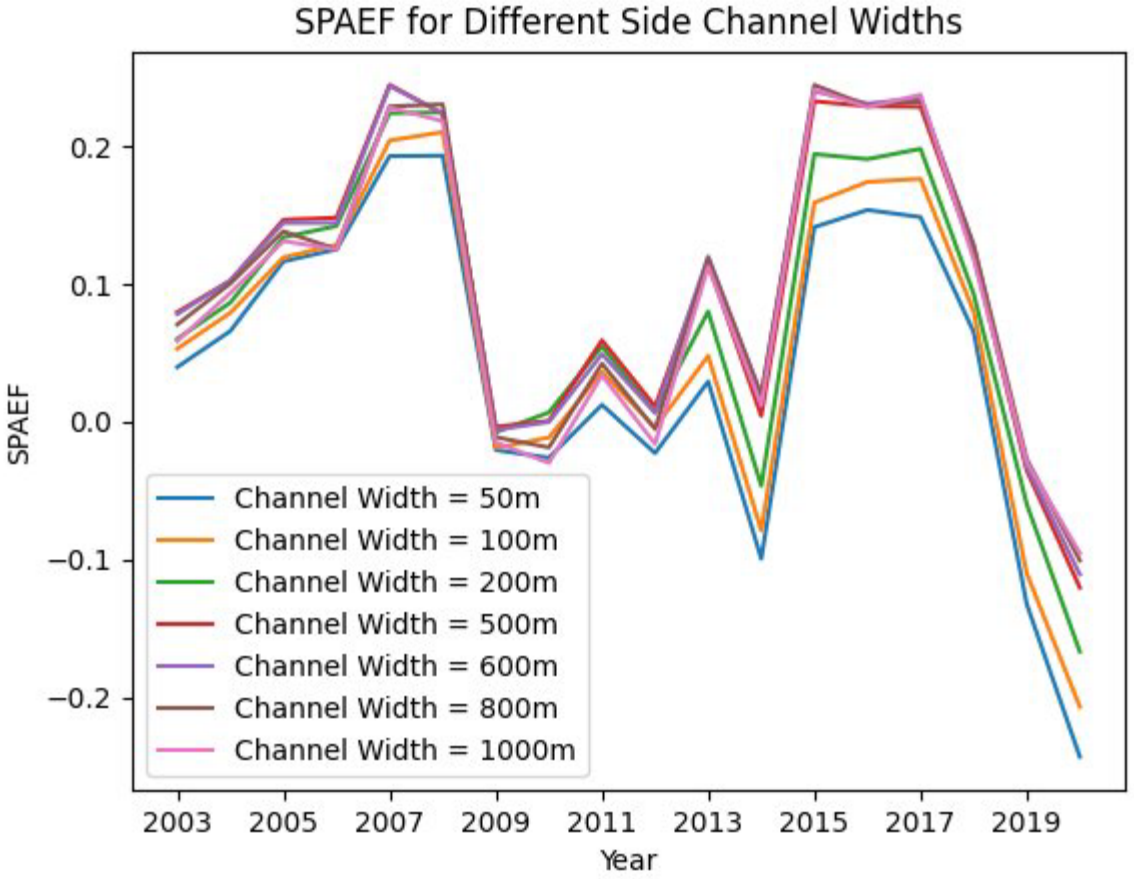


Metric Scores

Difference from baseline KGE



Better Model Performance



Summary

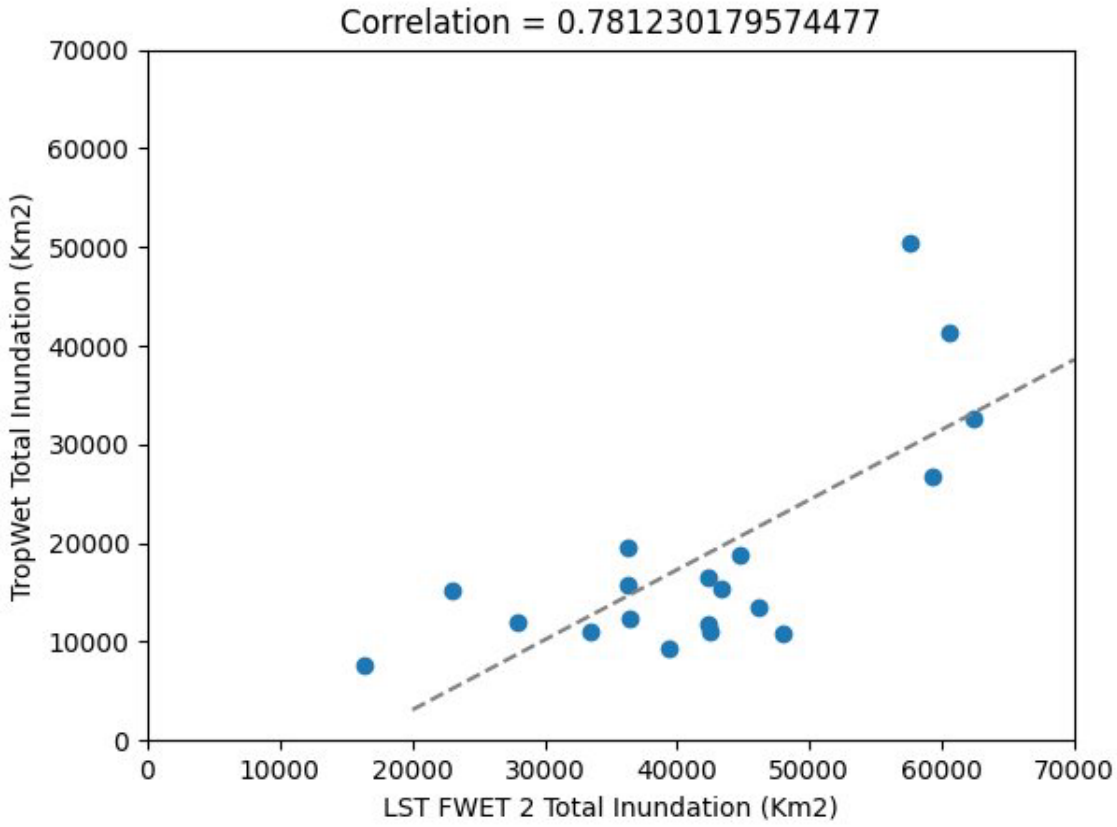
- Different metrics reveal different information.
- The model shows higher sensitivity to bifurcation parameters than to the Nile depth/width.
- The Sudd is a complicated system – it will take time to optimise the model.
- I recommend that future work looks at sensitivity within specific areas of the domain.

Bifurcation KGE Components

Comparing Different Observations.

- TropWet = 7 categories – Based on optical data from LandSat.
- Land Surface Temperature taken from MODIS Aqua.
- So far, we have been using land surface temperature – air temperature <= -2k.

Comparison between (inundated water + open water + inundated vegetation) and Land surface Temperature

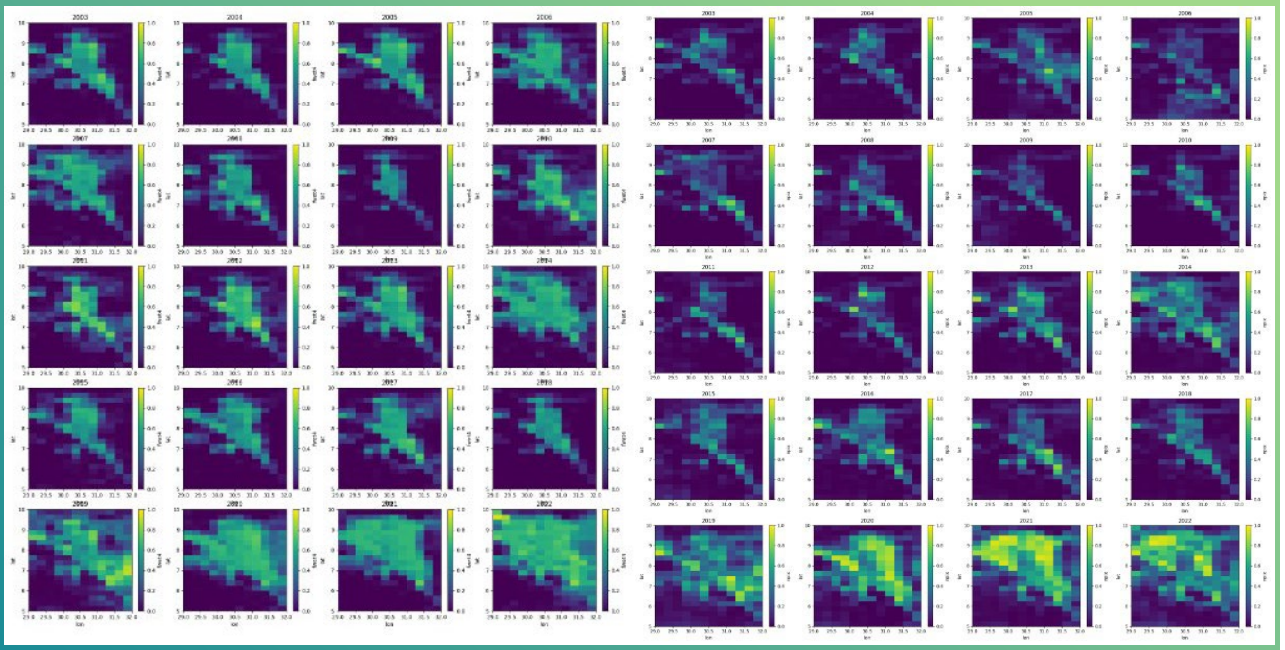


Increasing Land Surface Temperature Threshold.

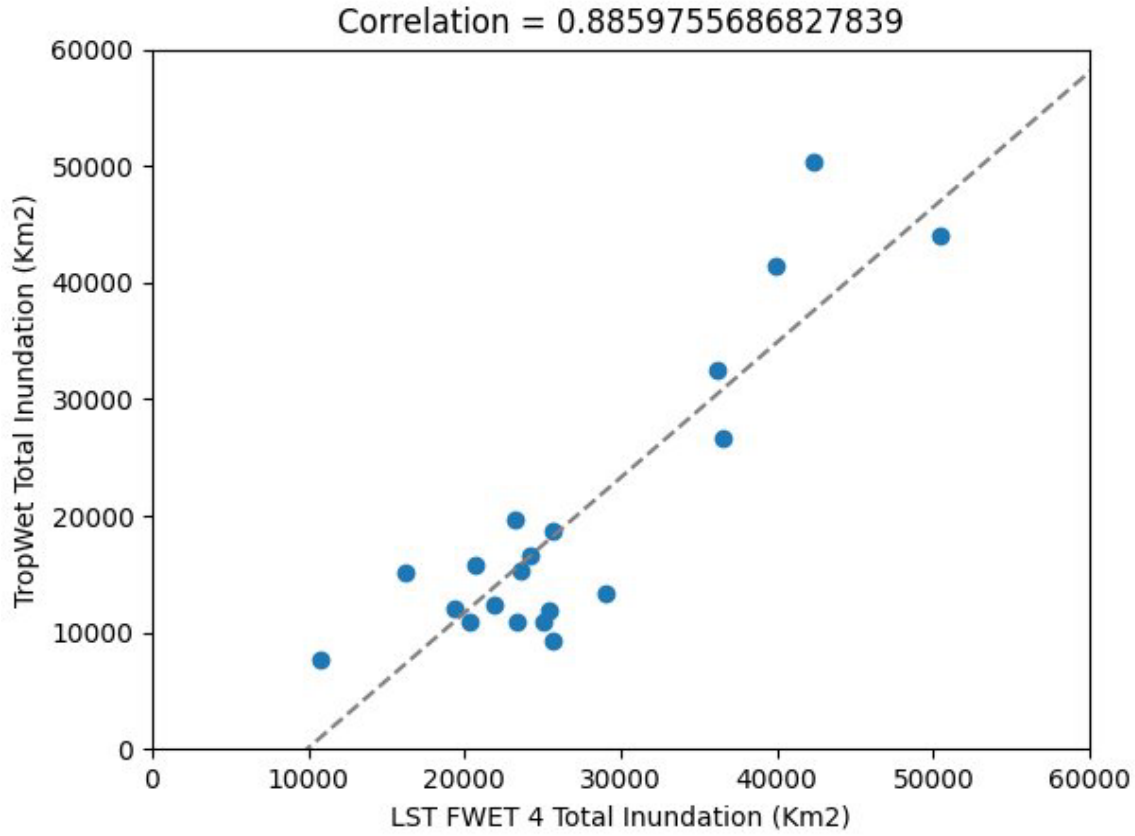
Land Surface Temp – Air Temp <= -4K

Land Surface Temperature

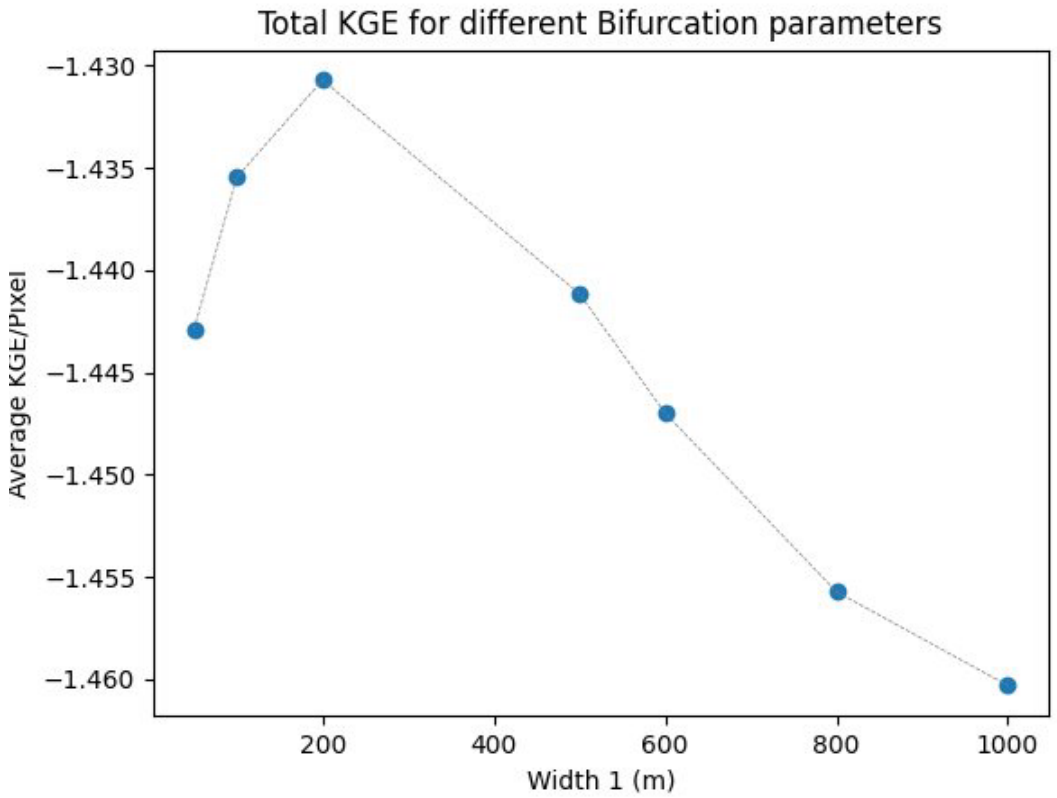
TropWet

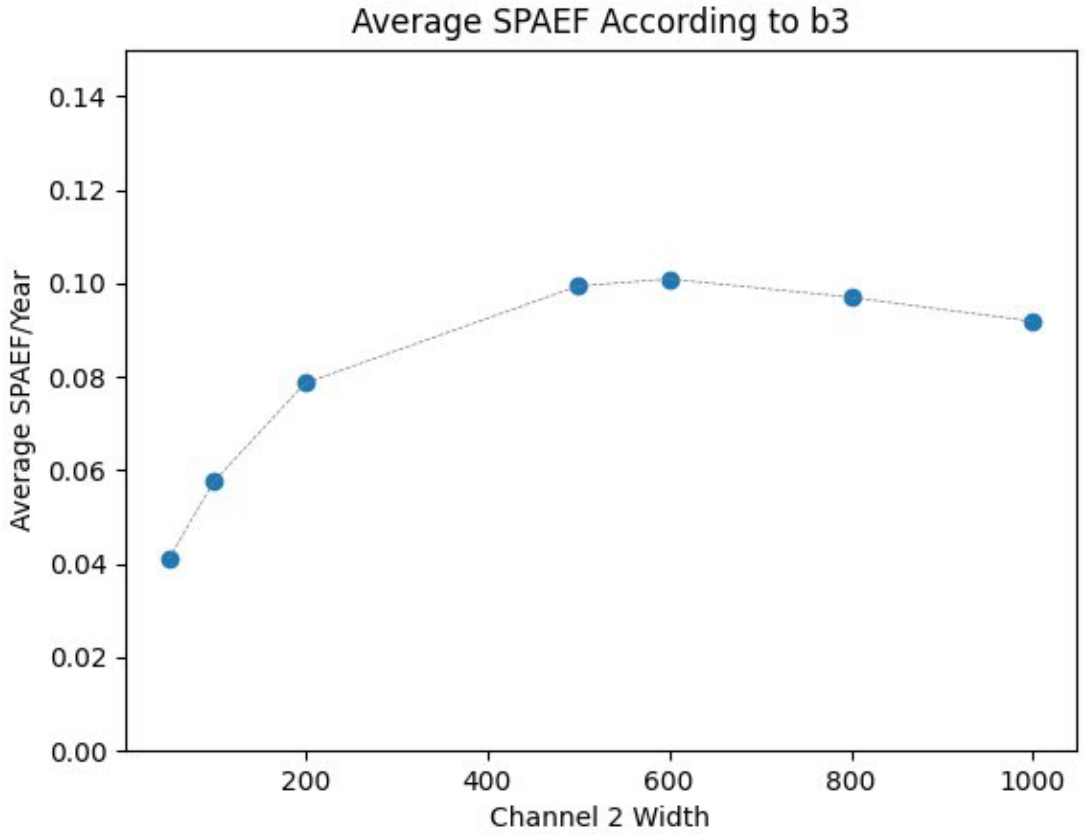


Correlation between the TropWet and the new threshold.



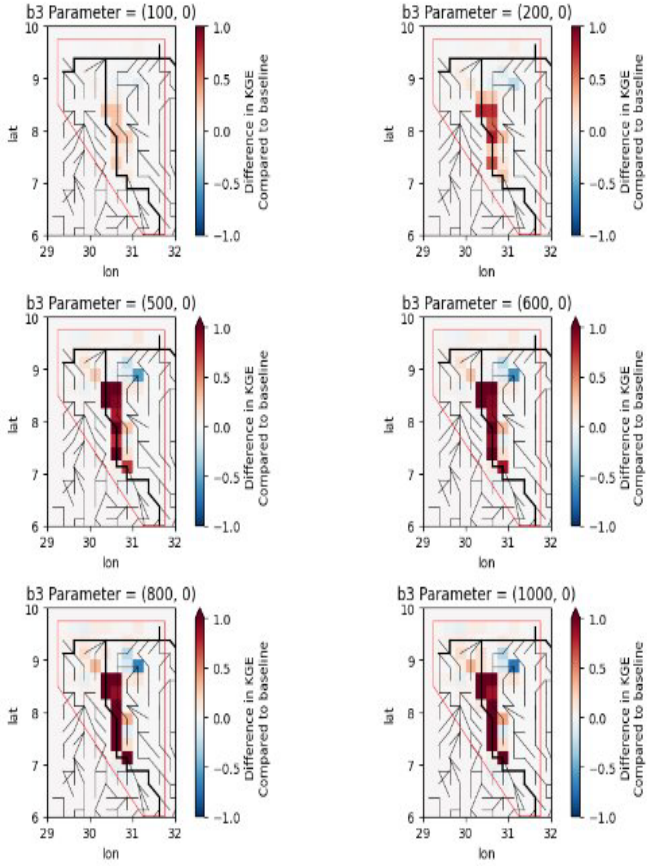
Total KGE/SPAEF





Difference in B3 KGE Components (1 Channel)

Ratio of S.D.



Bias