Is the Speed of Ocean Surface Currents Weibull Distributed?

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INTRODUCTION

- Ocean surface currents are crucial for:
  - regulating Earth's climate by **transporting heat.**
  - **movement of marine life** across the world and regulating temperature of marine ecosystems.
  - determining the **course of navigation** while traversing the ocean.
- Underlying causes: wind stress, buoyancy fluctuations, tides, wave dynamics etc.
- **Nontrivial** to understand piece-wise contribution of each.
- Very little known about the shape and behaviour of their statistical distribution in time. But WHY would we want to know anything about it?

MOTIVATION

- Ocean surface currents are also a potential source of electric energy, possibly **better than winds.**
- Accurate information about these distributions can be utilised as a bench mark for improved **ocean and climate modelling**

AGENDA

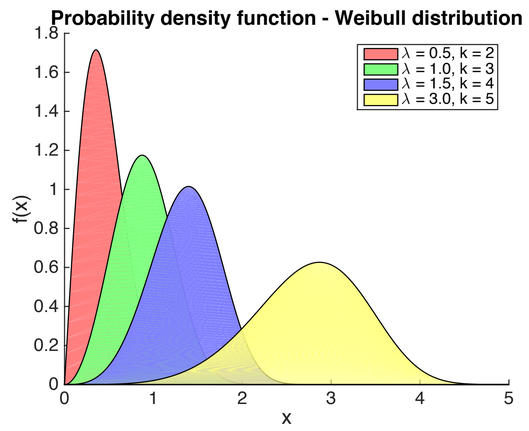
- Test the long standing hypothesis that the pdfs under consideration are **Weibull** distributed.
- If the hypothesis is rejected, test whether the alternate, the **Generalised Gamma** distribution is better suited for the pdfs.

WEIBULL DISTRIBUTION

Shape parameter

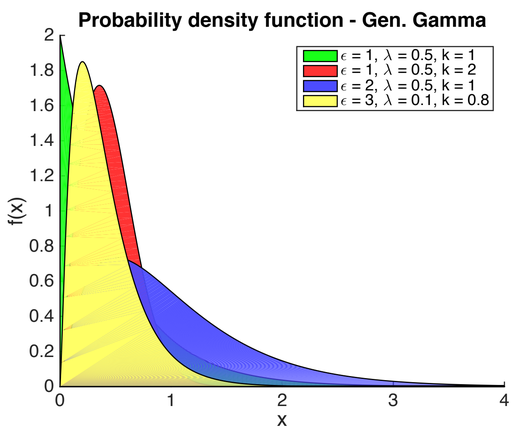
$$f(x;k,\lambda) = \frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{(k-1)} e^{-\left(\frac{x}{\lambda}\right)^k}$$

Scale parameter



GENREALISED GAMMA DISTRIBUTION

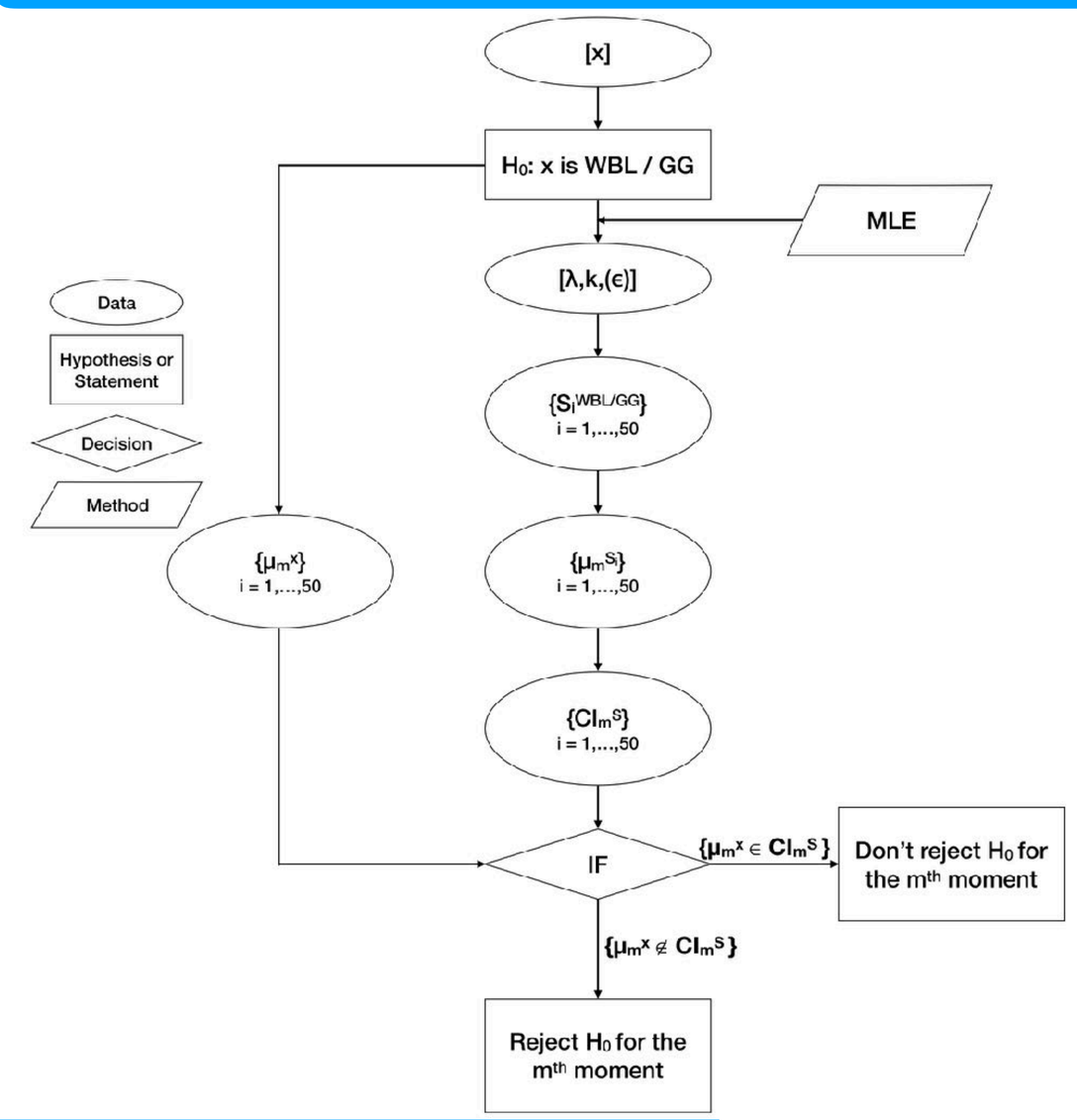
$$f(x;k,\lambda,\epsilon) = \frac{1}{\Gamma(\epsilon)}\frac{k}{\lambda}\left(\frac{x}{\lambda}\right)^{\epsilon k-1} e^{-\left(\frac{x}{\lambda}\right)^k}$$



Generalised Gamma distribution behaves as:

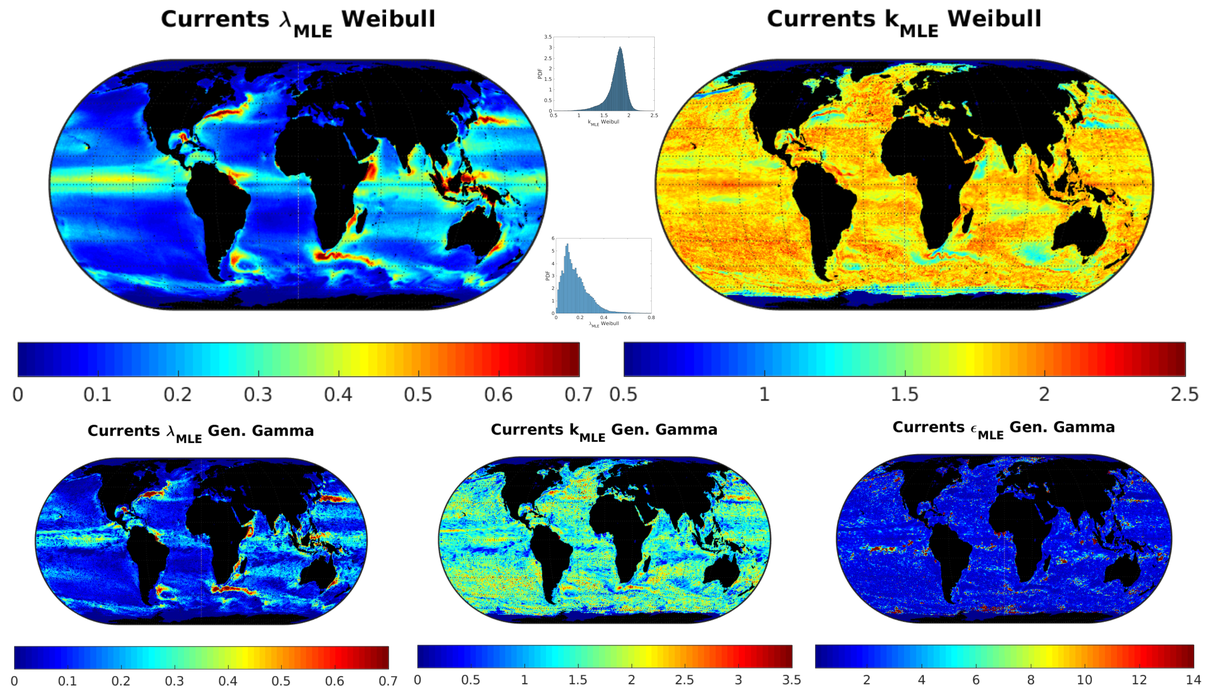
- Exponential ~ ε = 1.0, k = 1.0
- Weibull ~ ε = 1.0
- Gamma ~ k = 1.0

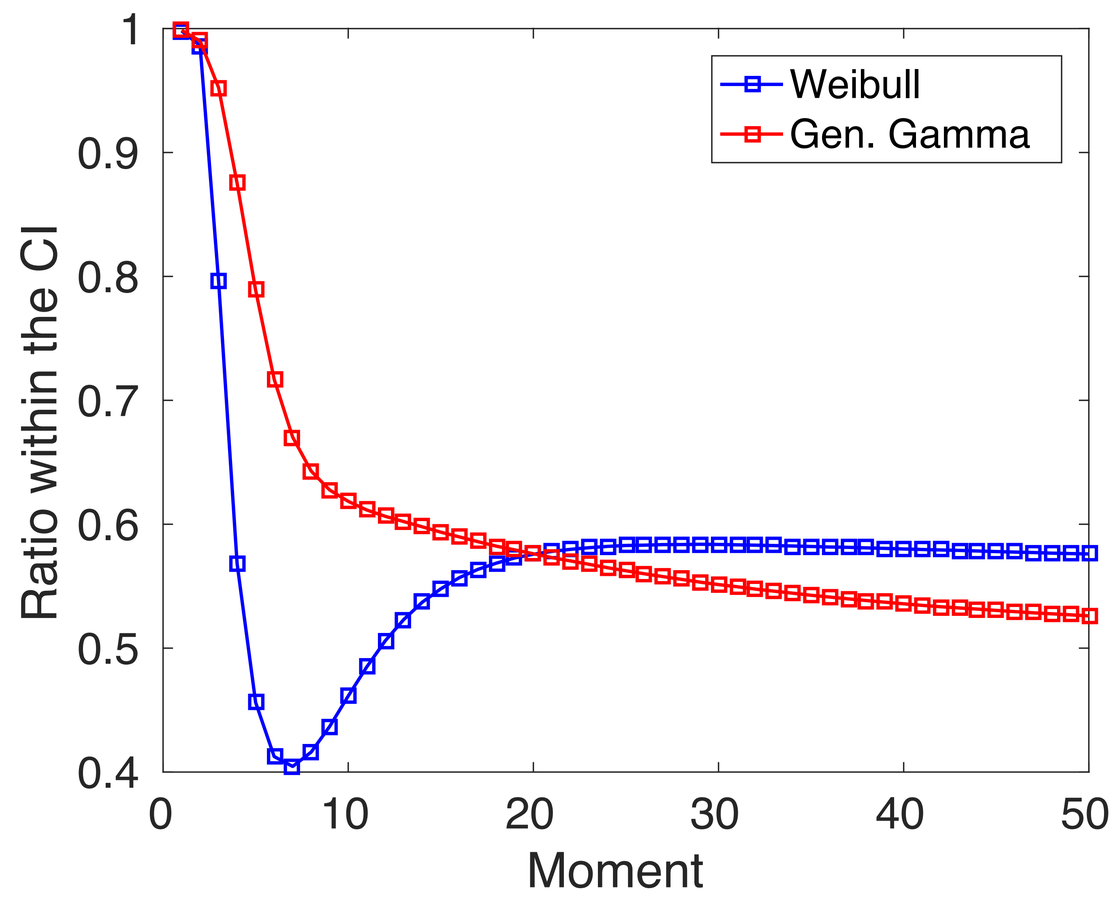
METHOD

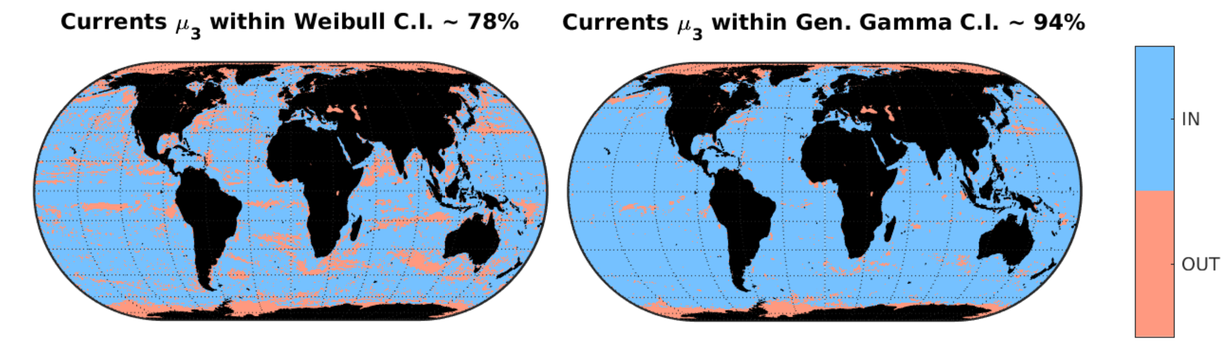


The analysis starts by assuming
i) the sample at hand (x) are Weibull (WBL) /Gen. Gamma (GG) distributed; therefore,
ii) the MLEs λ, k, (ϵ) of x are calculated.
iii) using the estimated parameters, generate a set of random WBL/GG surrogate series $\{S^{WBL/GG}\}$
iv) calculate up to the 50th moment for each surrogate distribution; v) estimate the confidence interval for each moment of the surrogates.
vi) calculate up to the 50th moment of the original sample x; finally;
vii) benchmark the values of the moments of x against the boundary levels of the corresponding confidence interval if the moment is within its confidence interval, then conclude that x is WBL/GG for that moment else its not.

RESULTS







CONCLUSION

- Successful statistical analysis of the available time-series.
- **Current speeds are not ALWAYS Weibull distributed** over the global marine surface.
- **Generalised Gamma distribution is a better approximation** for a larger number of the global marine surface time series in comparison to the Weibull.
- The **Generalised Gamma distribution gives a better estimate of μ_3** (the third moment) for time-series of the Currents.
- This is relevant because for many applications, for example, the electric power available from these currents ~ $A\rho\langle U^3\rangle/2$.

DISCUSSION

- A similar analysis was carried out by Dr. Salvatore Campisi-Pinto for time-series of winds over the global surface and the results were consistent.
- Other methods were also used to further validate the hypothesis for both the winds and the currents and the results are robust.

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