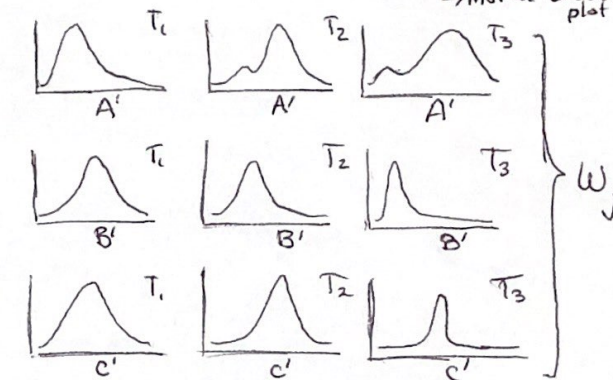
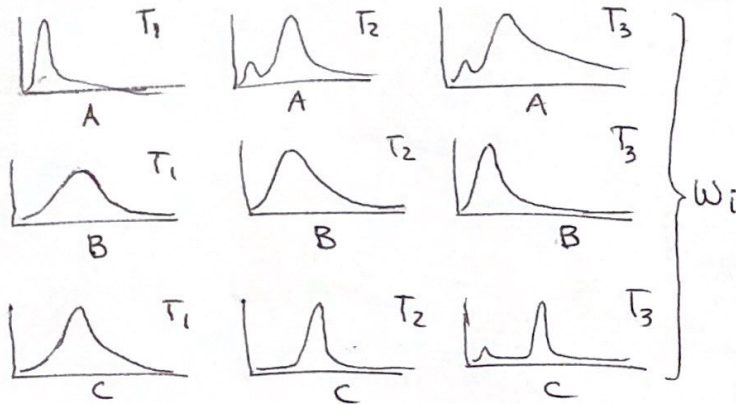


Anomaly Detection

→ Well Frequency Distributions

• See shift in distribution over time

- $\Delta \mu_{\text{Feature}} \quad \{-\Delta Q_1, \Delta Q_2, \Delta Q_3\} \sim \text{normal dist.}$
- $\Delta \sigma_{\text{Feature}} \rightarrow \Delta \sigma_{\text{Feature}}^2$
- num (modes)

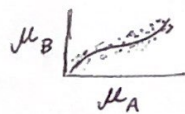


where $A', B', C' \in \mathbb{R}, T_1 < T_2 < T_3$ in well $J(w_j)$

where $A, B, C \in \mathbb{R}, T_1 < T_2 < T_3$ in well $I(w_i)$

1) Proportionality between variables $\{A \leftrightarrow B\}$ in w_i ?

ex. Does one increase if the other increases?
How does it increase? How does it "vary"?



σ_B vs. σ_A
 σ_B^2 vs. σ_A^2
 Mo_B vs. Mo_A

$\mu_X \in \{\mu_X(t) \in A \mid t \in \mathbb{R}\}$
or, in general case

Metric $_X \in \{\text{Metric}_X(t) \in B \mid t_0 \leq t \leq t_f\}$

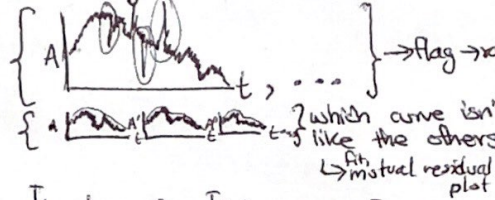
where t_0, t_f are the start/end time frames
Metric is the statistical metric of interest
 X is the label of specific well
 B is the data in a cumulative/moving window

1a) b)

→ TS

→ VAV

3) Change Detection in Time Series



→ Hyper-parameters

- Freq. Distributions
- Bins of Time Intervals

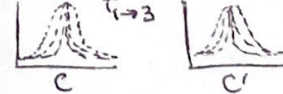
Make sure production date is sorted for observing trends

- Sensitivity ---
- Cumulative Distr.
- Dynamic Distr.
- ruptures

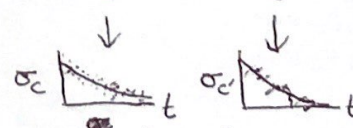
new data test

2) Proportionality between variables $\{A \leftrightarrow B\} + \{A' \leftrightarrow B'\}$ in w_j .

ex. Does one metric in the first well pair transform in the same way as the same metric in another well pair?

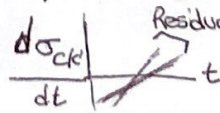


VS. A set where Δ is not shared

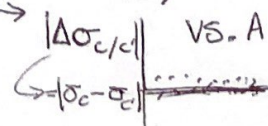


VS. A metric set where Δ is shared

2a)



2b)



VS. A metric \rightarrow deriv \rightarrow residual $\neq 0$
 \rightarrow delta \rightarrow residual $\neq 0$