Introduction to Data Assimilation, Subgrid-Scale Parameterization and Predictability

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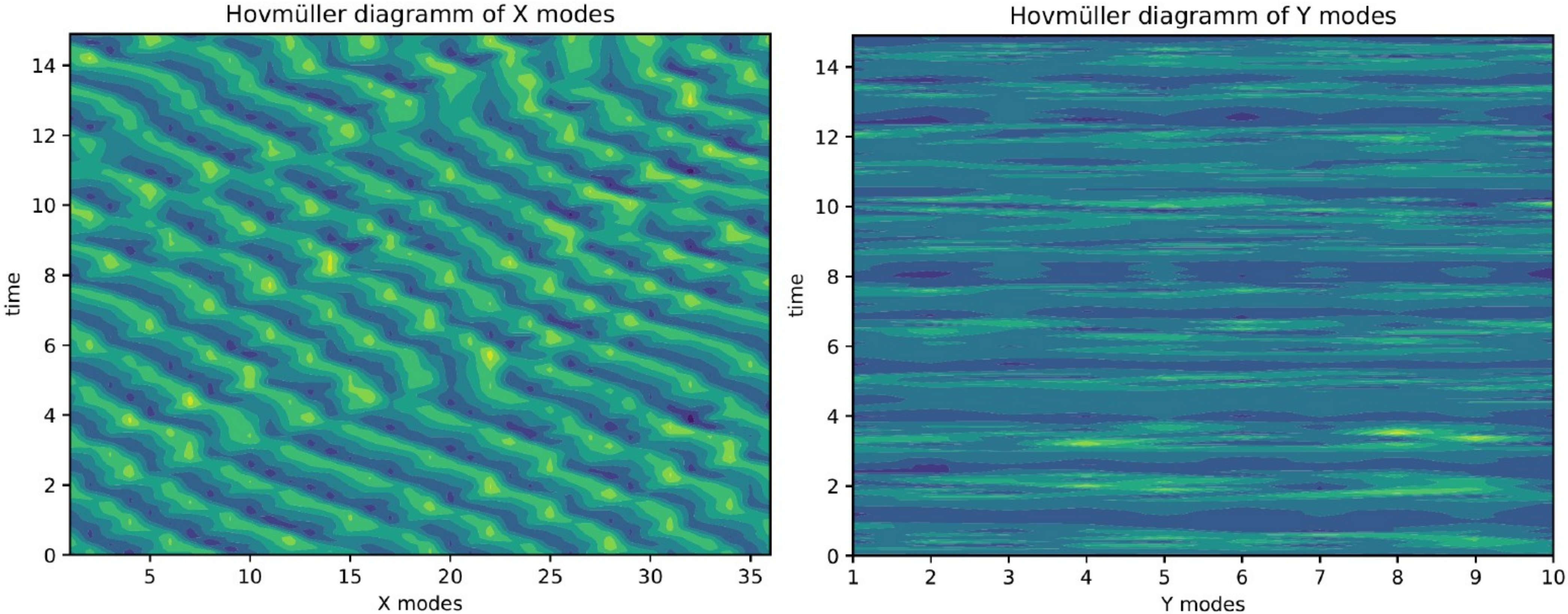
Lorenz 1996 Model

Lorenz 1996 Model – Waves, hence Hovmoeller diagramm



Lorenz 1996 Model

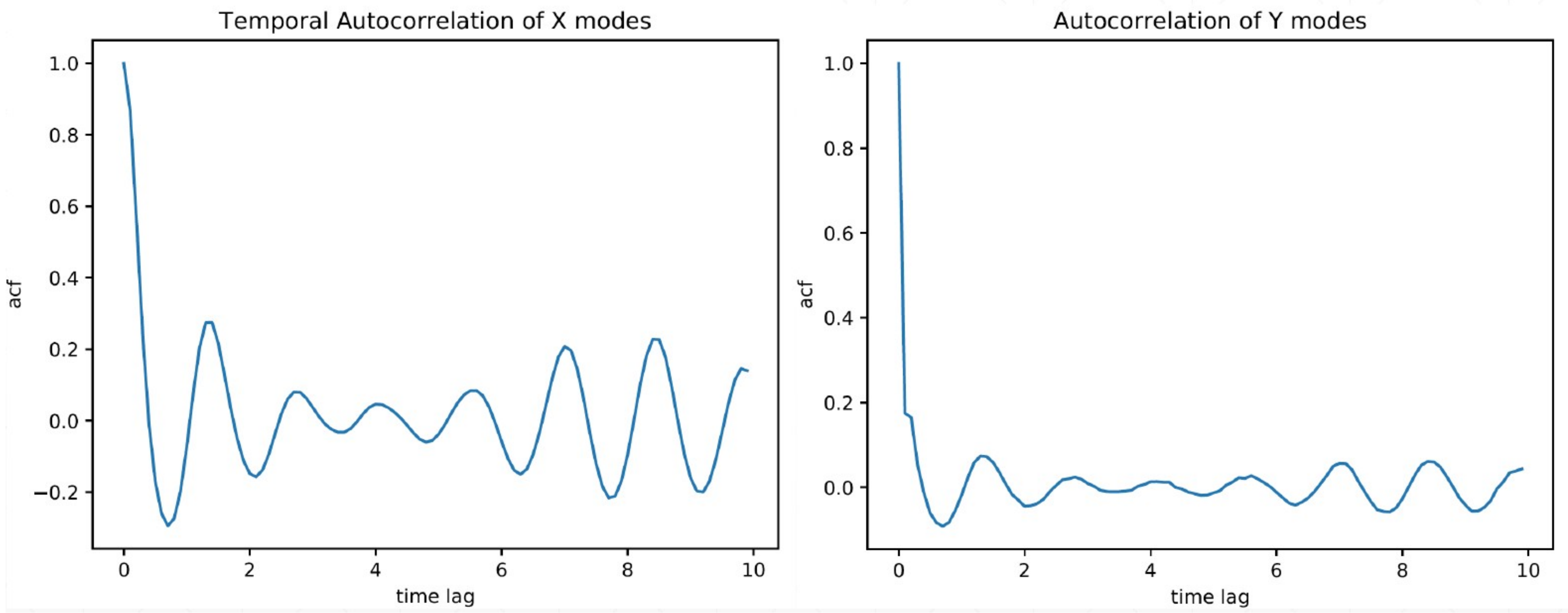
Definition: $$Autocorr(\tau) = \frac{E\left[(X_t - \mu)(X_{t+\tau} - \mu)\right]}{\sigma^2}$$

- Spatial Autocorrelation along X modes or Y modes averaged in time
  ➔ Lag τ is here spatial quantity

- Temporal Autocorrelation along time for each X modes, Y mode and than averaged
  ➔ Lag τ is a time

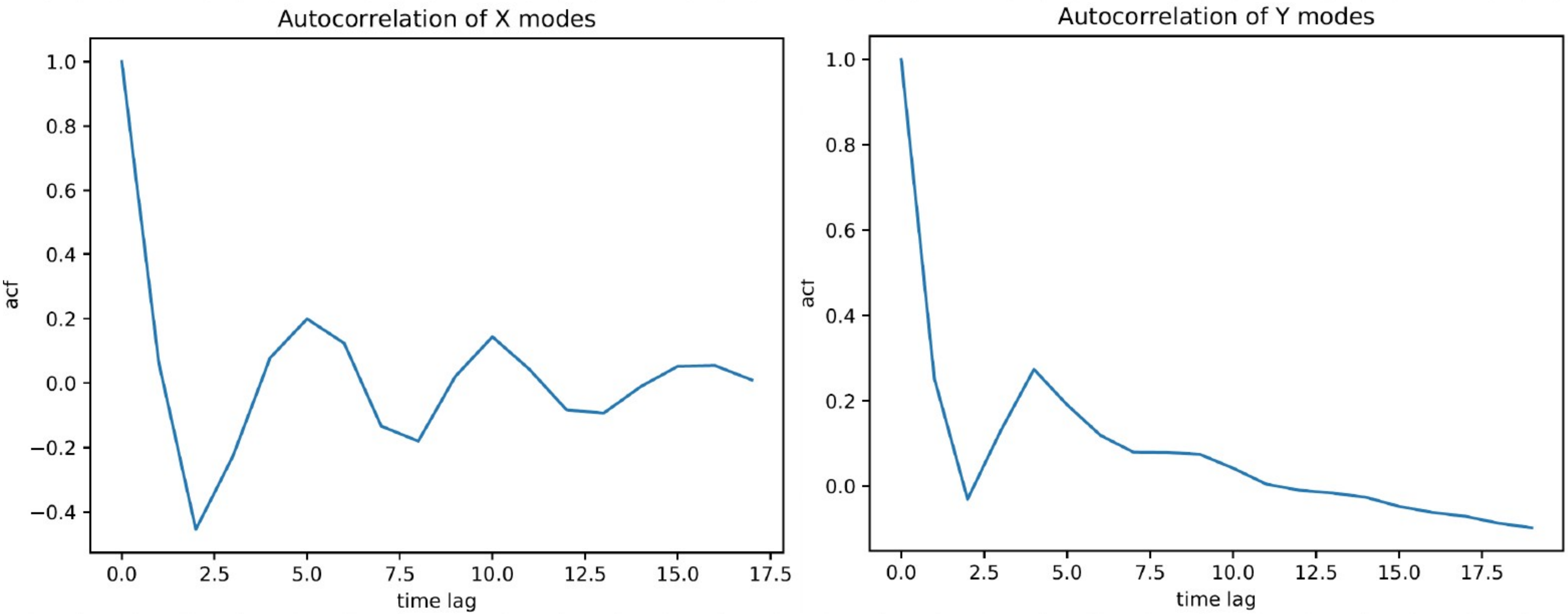
Lorenz 1996 Model

Temporal Autocorrelations



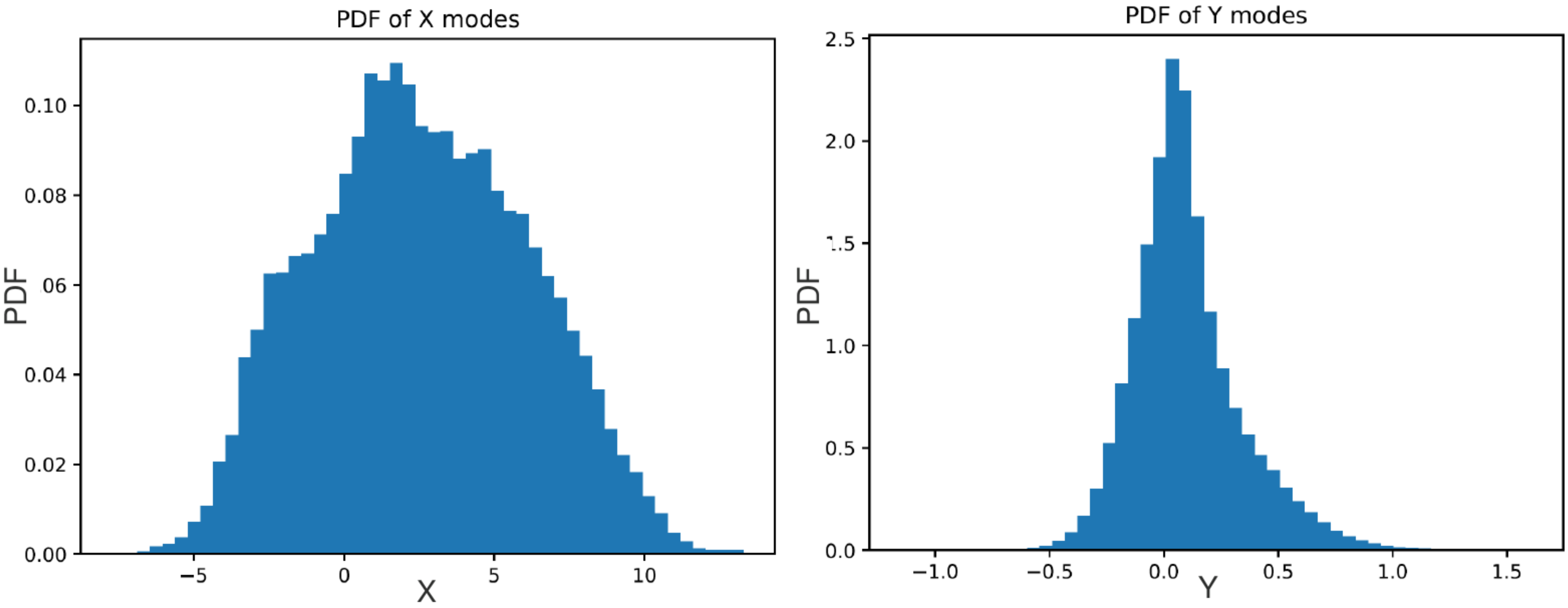
Lorenz 1996 Model

Spatial Autocorrelations



Lorenz 1996 Model

Lorenz 1996 Model – Probability Density of X and Y Modes



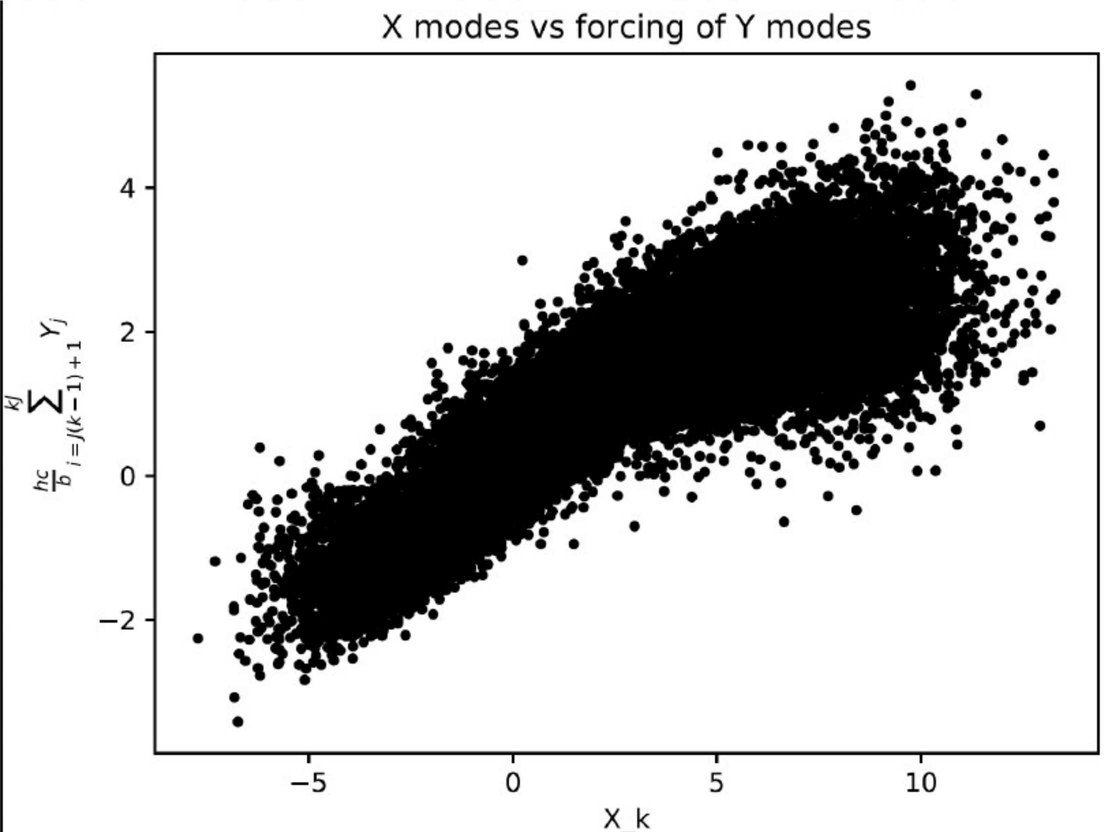
Lorenz 1996 Model

Lorenz 1996 Model – Forcing of Y modes onto X modes

- preparation for the Wilks 2005 “”
- Question: “Can the forcing by the Y modes on the X modes be simplified?”

x axis X_k

y axis $\frac{hc}{b}\sum_{i=J(k-1)+1}^{kJ} Y_j$



Lorenz 1996 Model

Energy definition

$$E_X = \frac{1}{2}\sum_{k=1}^{K} X_k^2$$

$$E_Y = \frac{1}{2}\sum_{j=1}^{JK} Y_j^2$$

"Momentum" definition

$$M_X = \sum_{k=1}^{K} X_k$$

$$M_Y = \sum_{j=1}^{JK} Y_j$$

Energy tendency equations

$$\partial_t E_X = -E_X + F\,M_X - \frac{hc}{b}\sum_{k=j=1}^{K,J} X_k Y_j$$

$$\partial_t E_Y = -cE_Y + \frac{hc}{b}\sum_{k=j=1}^{K,J} X_k Y_j$$

Total Energy tendency equation

$$\begin{aligned}\partial_t E &= \partial_t E_X + \partial_t E_Y \\ &= -E_X - cE_Y + F\,M_X\end{aligned}$$

Lorenz 1996 Model

1) Write routines for plotting:
- PDF
- Autocorrelation
- Hovmoeller diagramm
- Plot Y Forcing on X modes
- energy cycle terms

2) Error Growth
- Do many integrations over short time with different time steps but same initial state
- Compare with a log-log plot
  - X axis: time
  - Y axis: averaged error wrt integration with the smallest timestep