

# Predicting Network Performance Characteristics

- Introducing Flow Field Forecasting -

Michael Frey  
Bucknell University  
mfrey@bucknell.edu

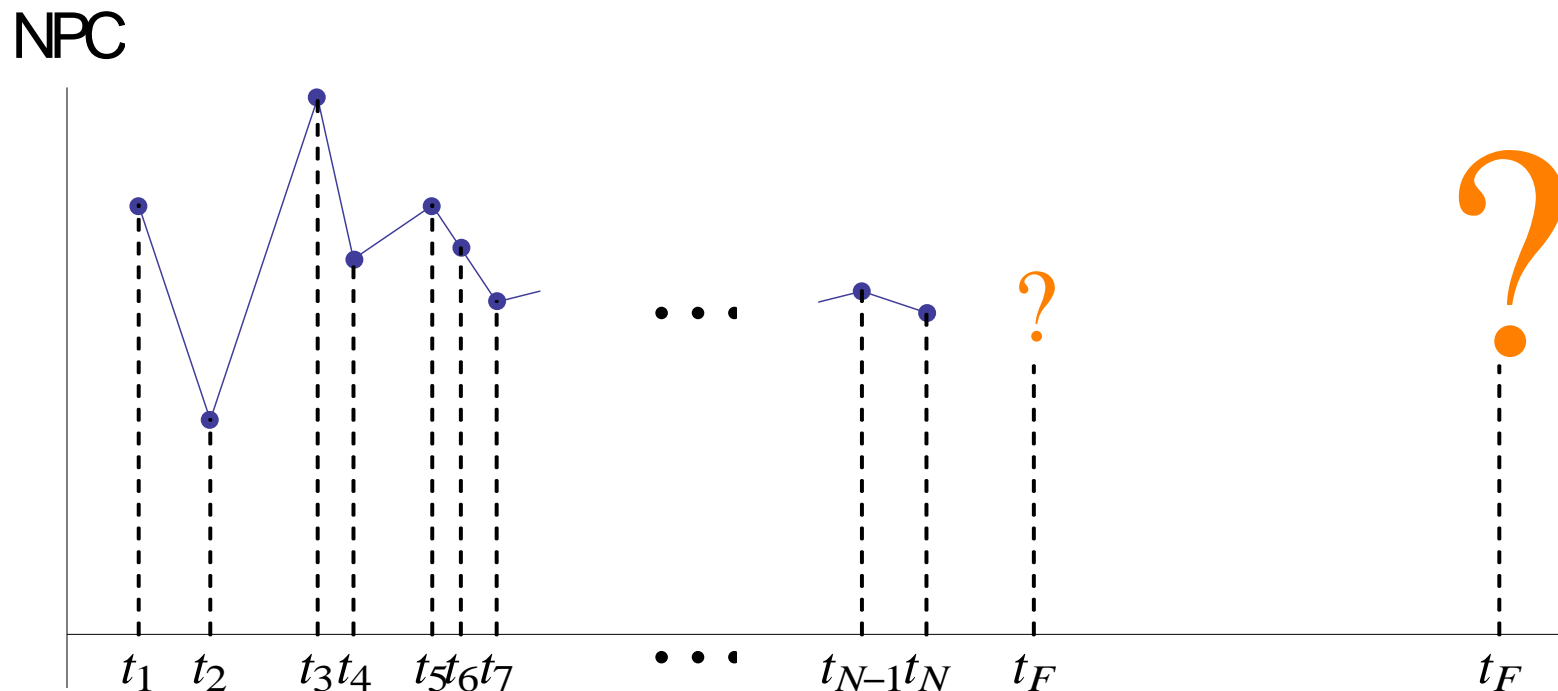
Kyle Caudle  
South Dakota School  
of Mines & Technology

e-Weather Center Project  
- Phil DeMar  
- Brian Tierney

DOE ASCR Program  
- Thomas Ndousse-Fetter

- The NPC forecasting problem
- Standard forecasting tools
- Flow field forecasting
- Demonstrations
- Present status

Given: A sequence of observations of an NPC along a network path with given observation times

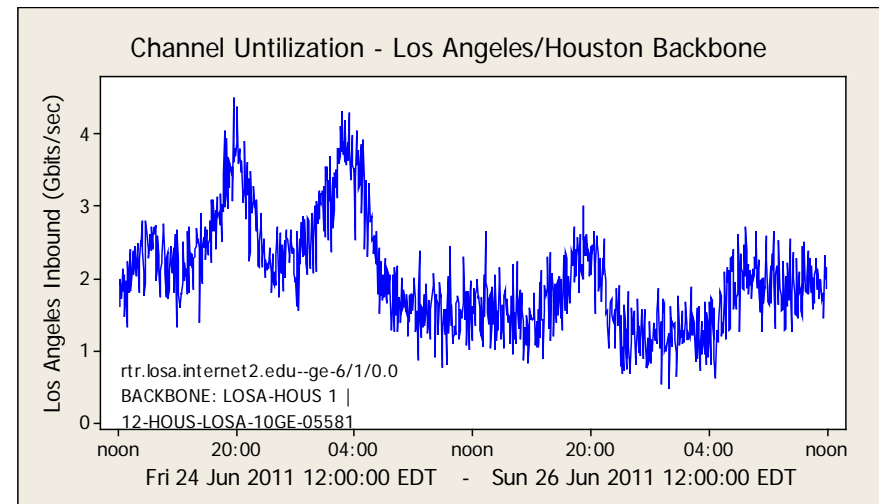
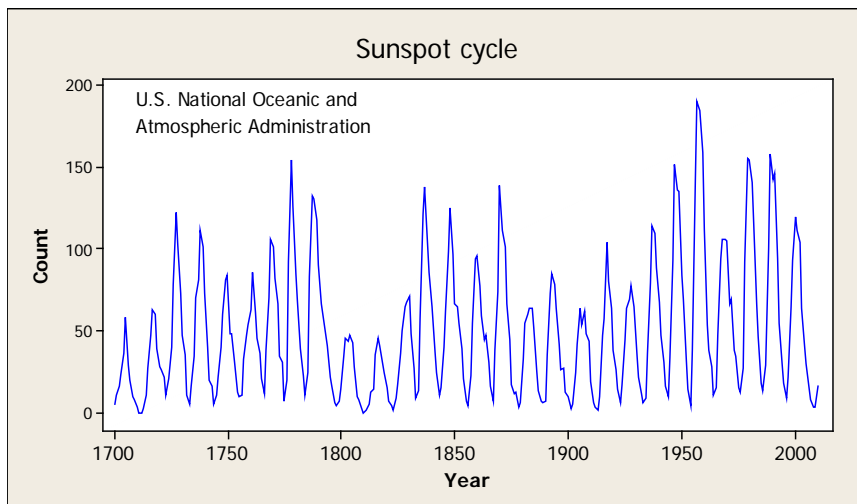
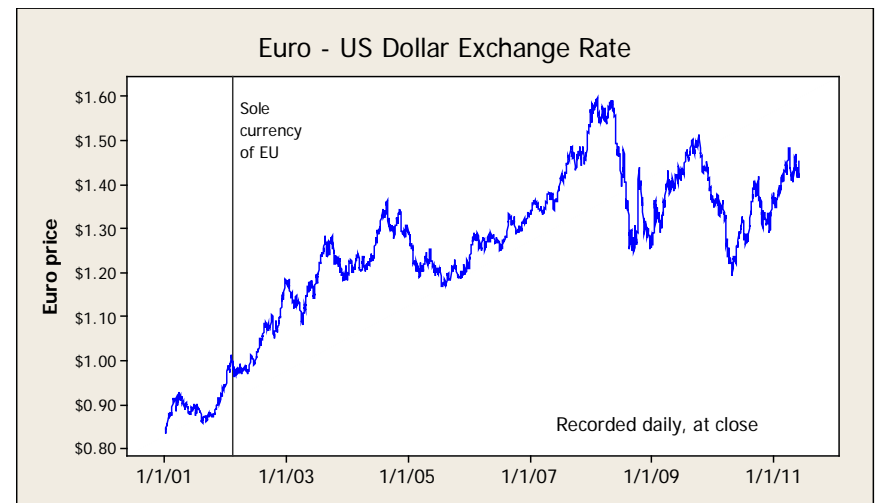
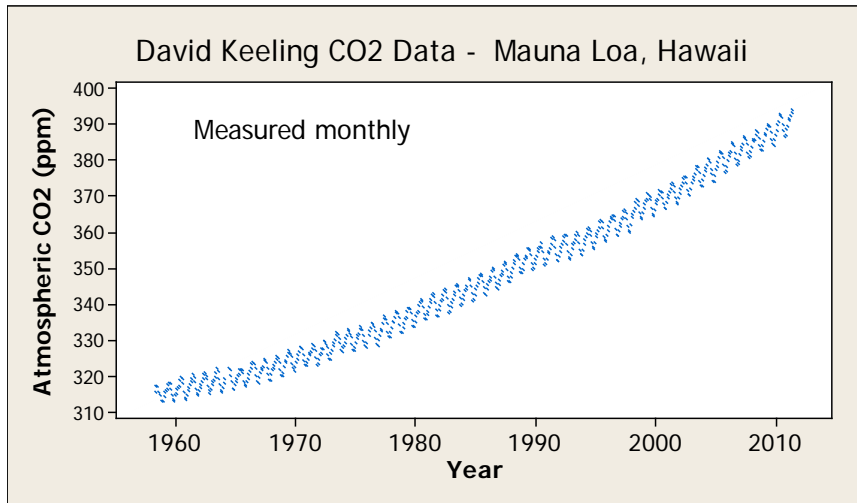


Goal: Predict the NPC *reliably* at time  $t_F$  in the near future  
 Extrapolate *plausibly* at  $t_F$  beyond the near future

# Beyond near future

Stable underlying mechanism  
Reliable prediction beyond near future

Non-stable underlying mechanism  
Unreliable prediction beyond near future



*Error estimate* – reliably estimates near-future prediction error

*Plausible* – plausibly extrapolates beyond near future

*Robust* – accepts non-uniformly spaced observation times

*Autonomous* – no human guidance

*Fast* – computationally efficient; e.g., no multi-dimensional numerical optimizations

*Accommodative* – capable of exploiting “parallel” data

# Available Tools

	Moving averages	Traditional regression	ARIMA forecasting	Neural networks	Semiparametric regression	Spectral/wavelet methods	???
Error estimate	X	✓	✓	X	✓	✓	X
Plausible	X	X	X	X	✓	X	✓
Robust	X	✓	X	✓	✓	✓	X
Autonomous	✓	X	X	✓	X	✓	✓
Fast	✓	✓	X	X	X	✓	✓
Accommodative	X	✓	X	✓	X	X	X

# New Forecasting Method

	Moving averages	Traditional regression	ARIMA forecasting	Neural networks	Semiparametric regression	Spectral/wavelet regression	Flow field forecasting	
Error estimate	X	✓	✓	X	✓	✓	X	✓
Plausible	X	X	X	X	✓	X	✓	✓
Robust	X	✓	X	✓	✓	✓	X	✓
Autonomous	✓	X	X	✓	X	✓	✓	✓
Fast	✓	✓	X	X	X	✓	✓	✓
Accommodative	X	✓	X	✓	X	X	X	✓

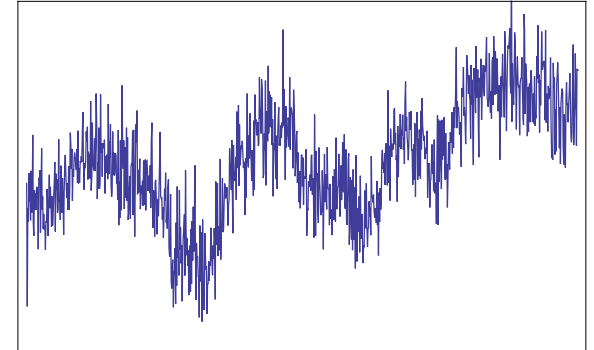
## Step 1: Extract skeleton

$$Y_n = S_n + \varepsilon_n$$

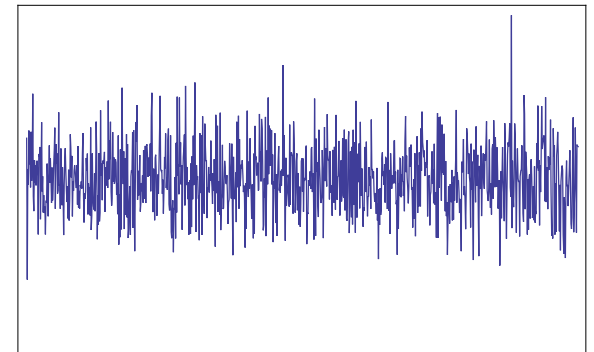
$$\text{Skeleton} = \begin{pmatrix} 0 & \kappa_1 & \kappa_2 & \kappa_3 & \cdots & \kappa_K \\ s_0 & s_1 & s_2 & s_3 & \cdots & s_K \\ \delta_0 & \delta_1 & \delta_2 & \delta_3 & \cdots & \delta_K \end{pmatrix}$$

- Semi-parametric regression
- Use only skeleton for forecast
- Data reduction
- Original time spacing not relevant

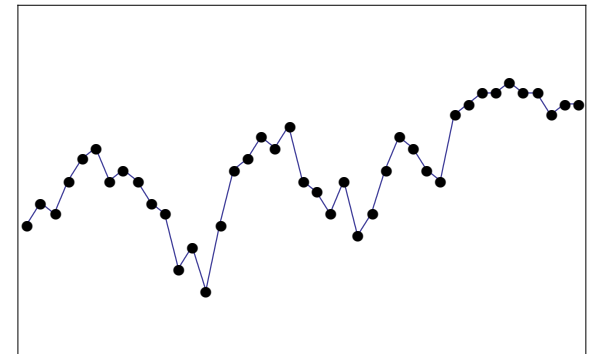
Data



= Noise

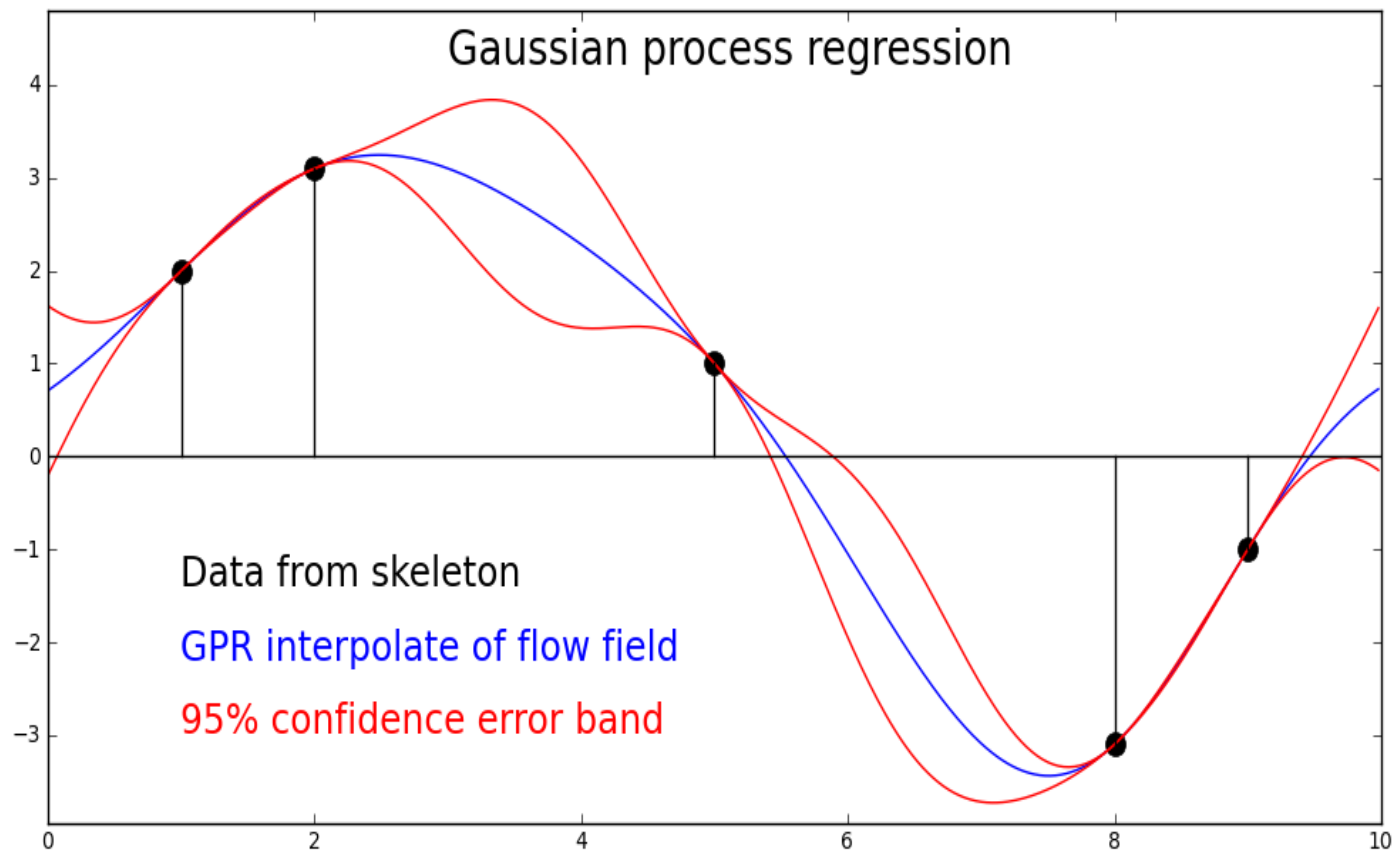


+ Skeleton



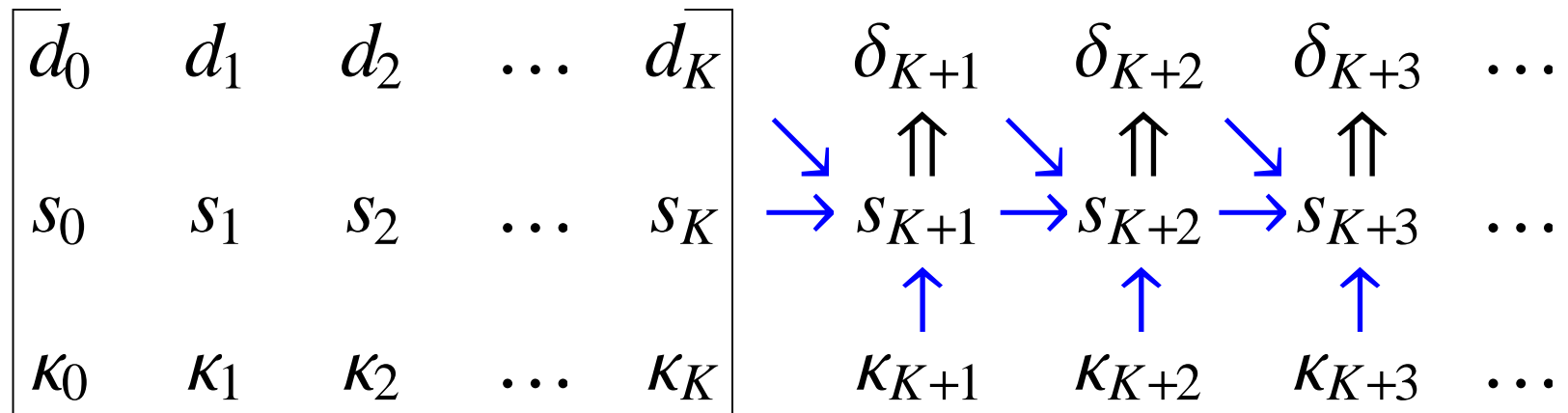


## Step 2: Interpolate flow field



## Step 3: Build to the future

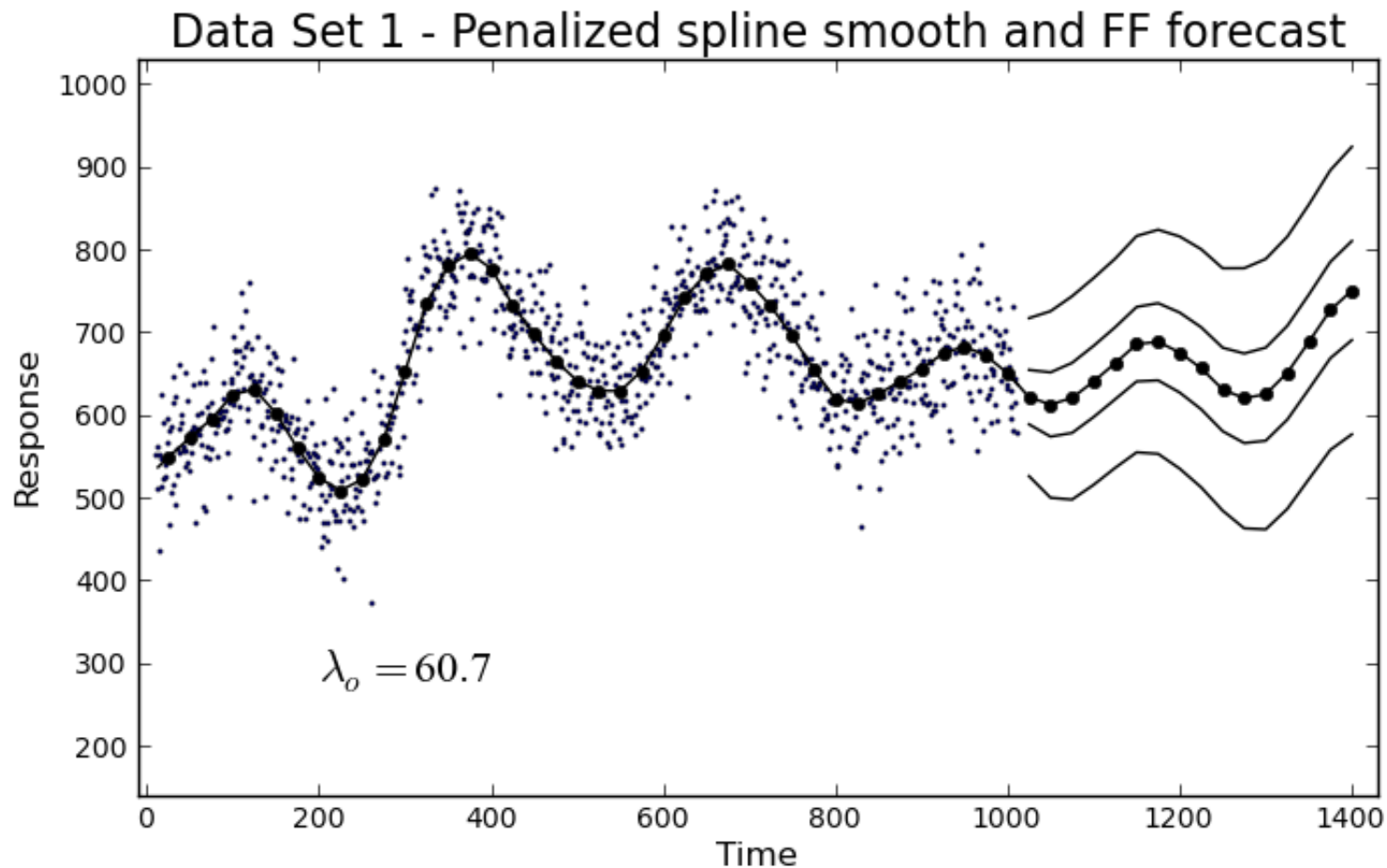
### Skeleton



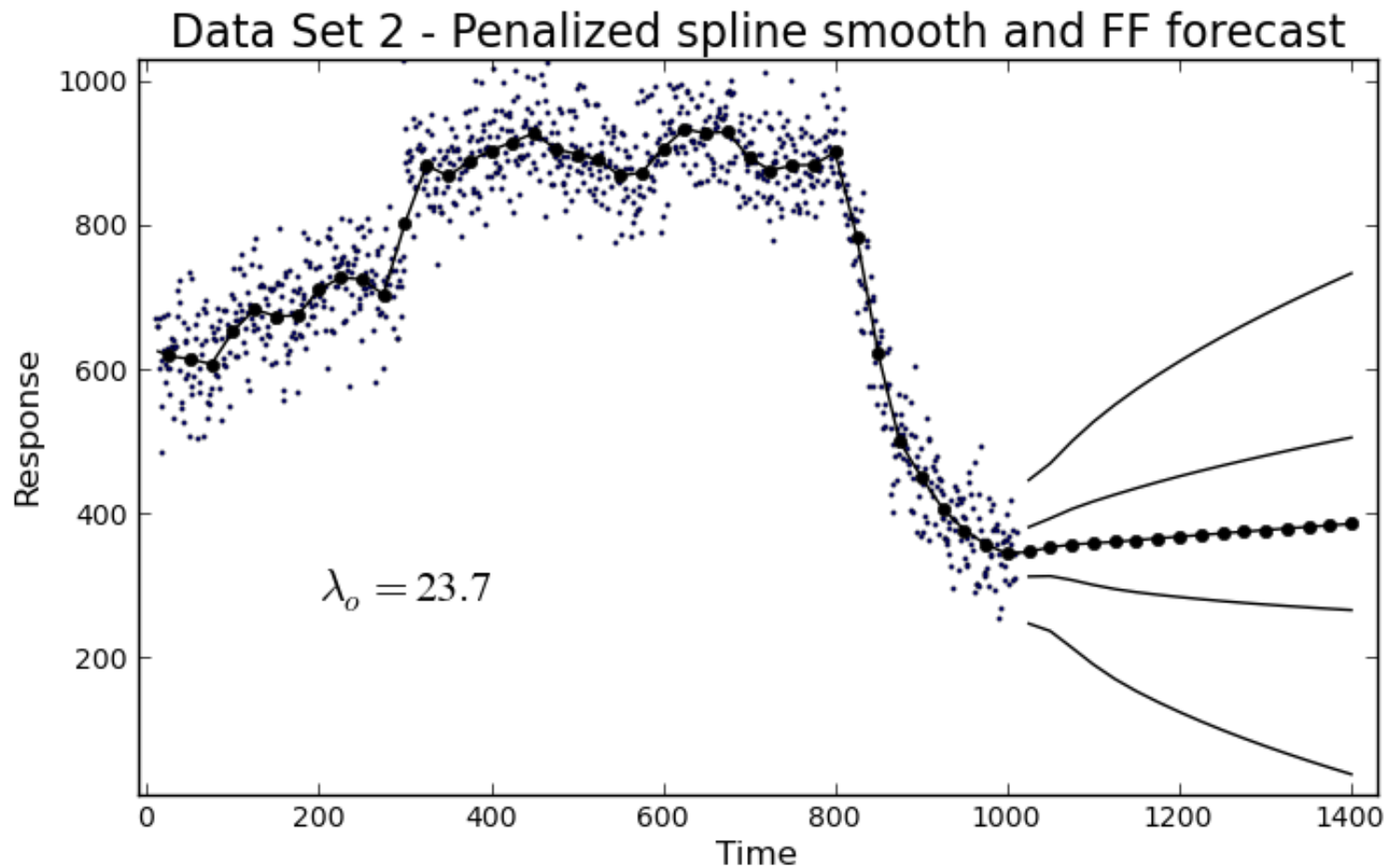
$\uparrow\uparrow$  = flow field interpolation

# Demonstration 1

- Flow field contains much applicable information
- Prediction error builds slowly



- Flow field contains little applicable information
- Prediction error builds quickly



## Current Status

- Python code undergoing final testing

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- Integration with e-Weather Center  
can begin in September 2011

- “Introducing Flow Field Forecasting”  
by Frey and Caudle

For a copy ► [mfrey@bucknell.edu](mailto:mfrey@bucknell.edu)