ePTM Calibration

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How Do We Determine Values of Behavioral Parameters?

- Theory
  - Hypotheses about fish behavior
- Trial and Error
  - “Pattern matching” to observed data
- Problems:
  - No uncertainty in parameter estimates
  - Somewhat subjective

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Goals

- Develop methods to fit models to observed data
- Methods should be general
  - Applicable to any model
- Provide parameter estimates + uncertainty
- Allow assessment of different model structures

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Challenges

- The ePTM is computationally burdensome
  - Traditional optimization routines take too long
- Models are stochastic
  - Gradient methods won’t work (e.g., Newton-Raphson)
  - Traditional stochastic methods take too long
- A potential solution
  - Gaussian process model +
  - Markov Chain Monte Carlo (MCMC) optimization

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General Idea

- Build a simple model that predicts ePTM output
  - Orders of magnitude faster than ePTM
- Set ePTM aside, use simple model for calibration
- Run ePTM at best-fit parameters
- Evaluate goodness of fit

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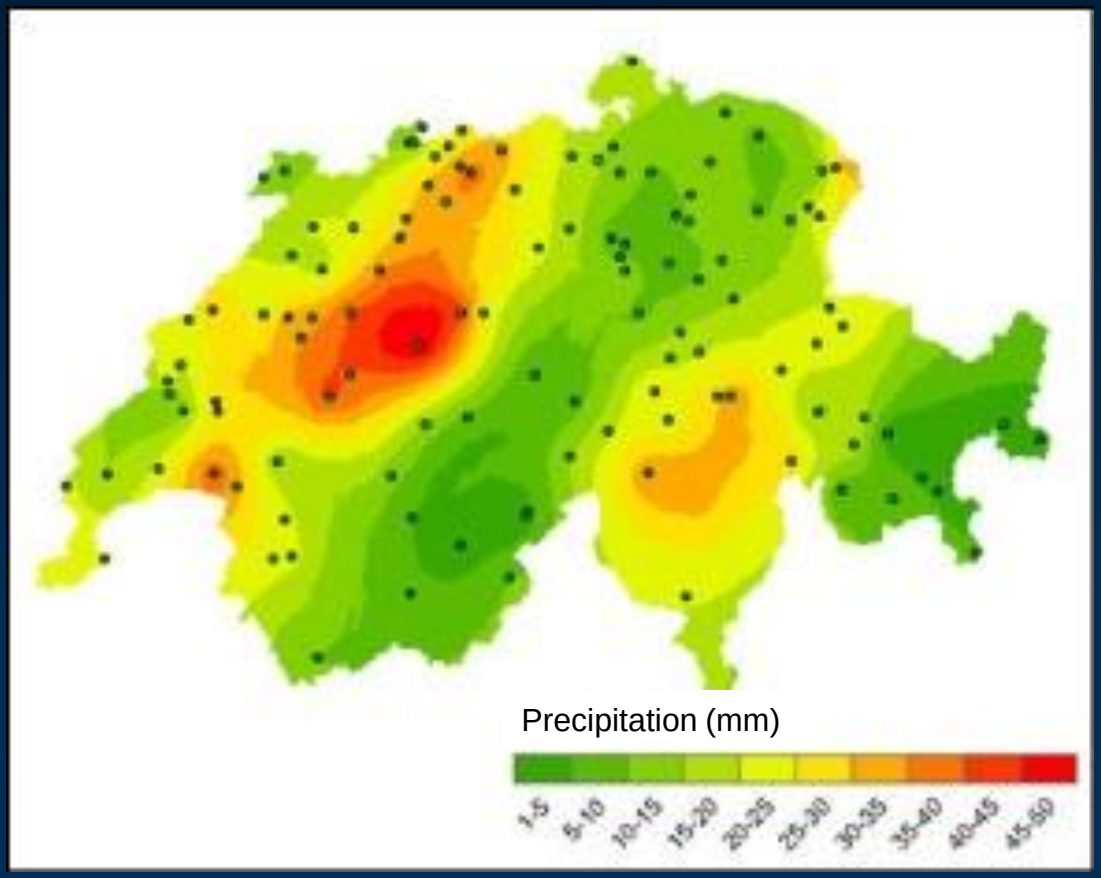
Gaussian Process Models

- Distance-weighted interpolation
- Based on multivariate normal distribution
  - e.g., Kriging

Latitude



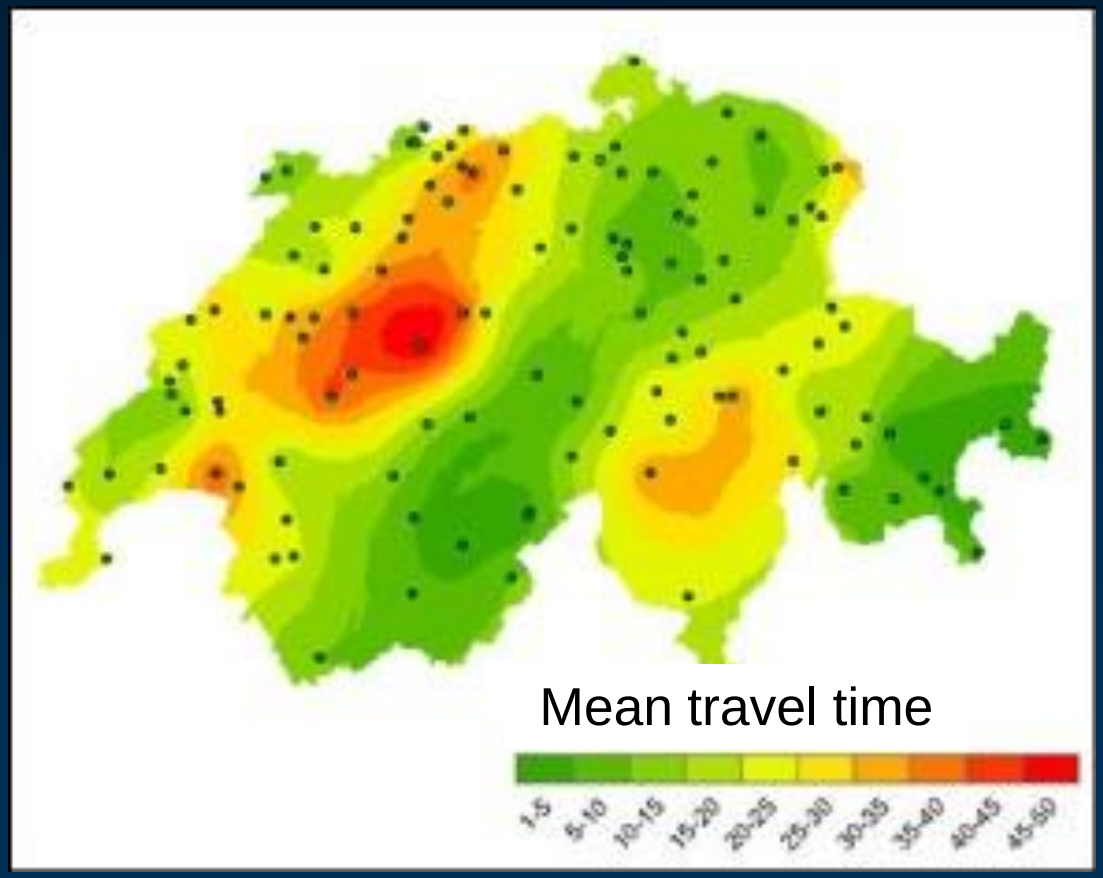
Longitude

Source: http://www.gitta.info/ContiSpatVar/en/image/kriging.jpg

Gaussian Process Models

- Distance-weighted interpolation
- Based on multivariate normal distribution
  - e.g., Kriging

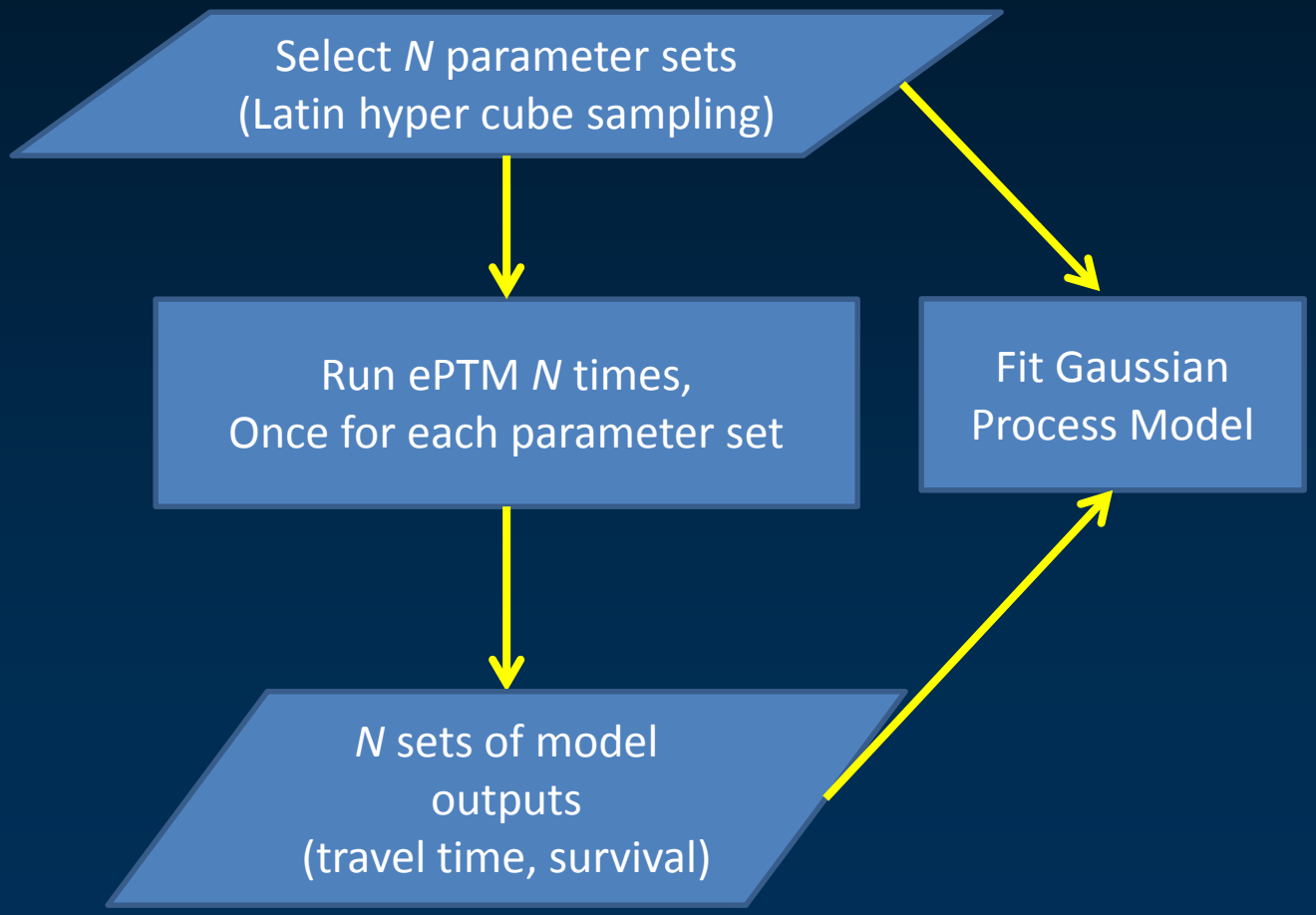
Probability of day-time migration



Swimming Velocity

Source: http://www.gitta.info/ContiSpatVar/en/image/kriging.jpg

Developing Gaussian Process Models (GPM)



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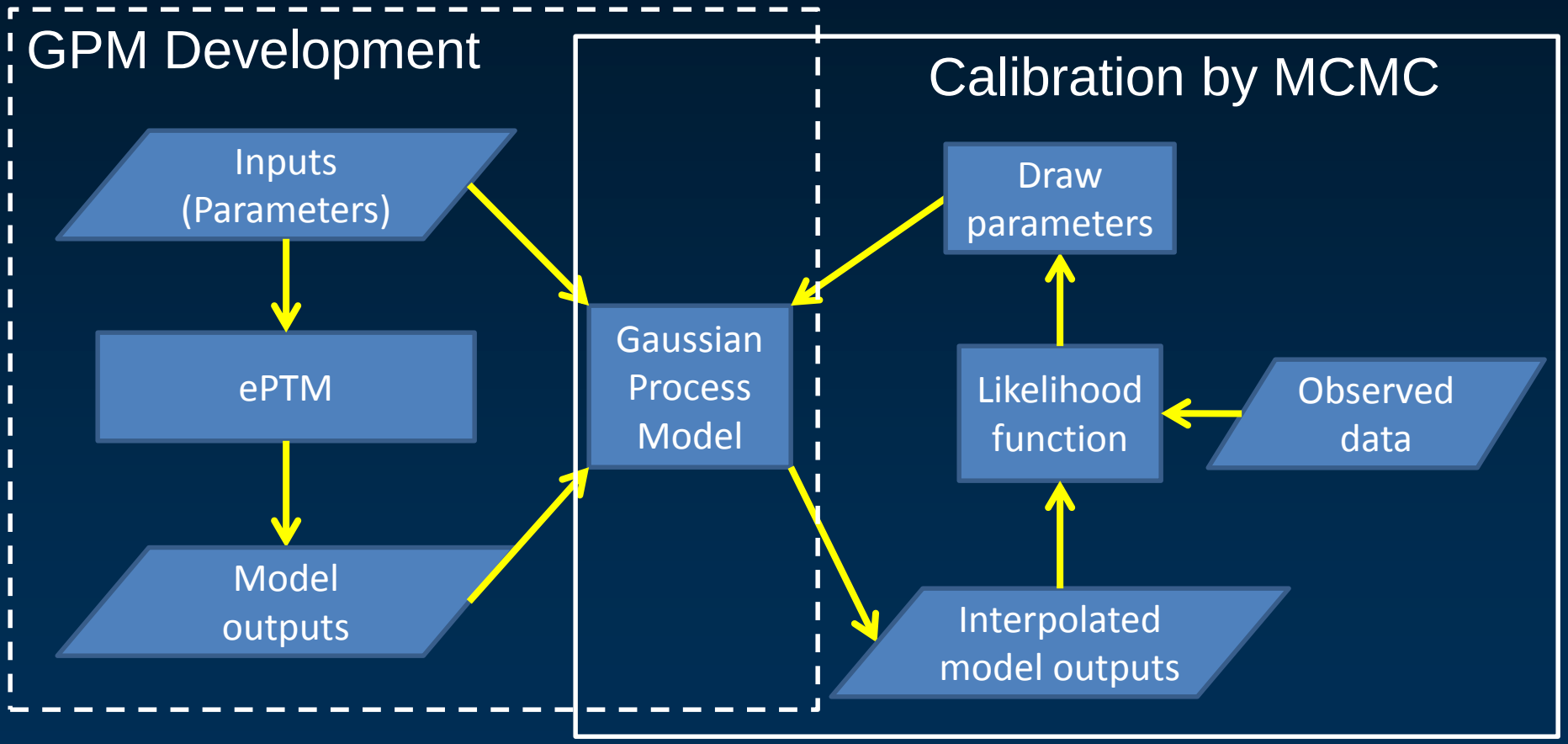
Calibration using Gaussian Process Models (GPM)



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Application to DSM2-ePTM

- 7 parameters (per reach)
- Swimming behaviors
  - Swimming velocity (mean + SD)
  - Daytime holding probability
  - Velocity holding threshold
    - Selective tidal stream transport
  - Probability of mis-assessing downstream direction
    - Function of mean velocity relative to SD velocity
- XT Survival model (Anderson et al. 2005)
  - λ, mean distance between predator-prey encounters
  - ω, random encounter velocity

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Acoustic Telemetry Data

- USFWS (Delta Action 8 study)
- Late-fall Chinook salmon
- Vemco acoustic telemetry
- 1,583 Acoustic tagged fish
- 4 Years (2007 – 2010)
- 8 unique release groups
- 9 reaches
- Migrated between December and February

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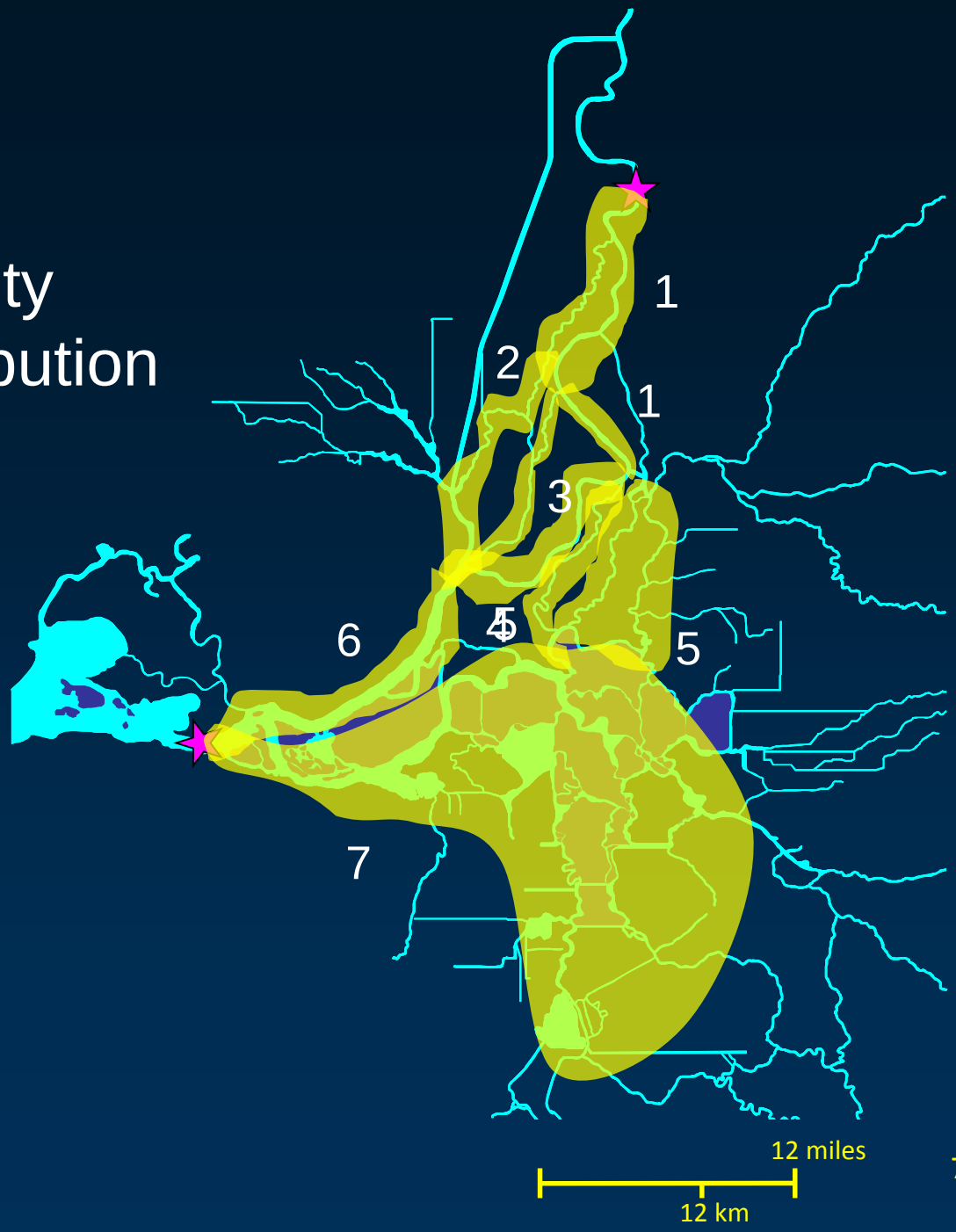
Reaches

For each reach:
- Survival probability
- Travel time distribution



Gaussian Process Model

- 2000 parameter sets
  - Run for each reach and release
  - 144,000 ePTM model runs!
    - Ran in parallel on Amazon cloud

- Model outputs for each reach and release
  - Survival probability
  - Proportion of fish in 20 travel time bins
  - Flexible distribution shapes (e.g., bi-modal)

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Likelihood Function in MCMC Optimization Routine

- Multistate mark-recapture model
  - Perry et al. (2010)
  - Survival, detection, routing
- Multinomial distribution for travel times
  - Proportion of fish in 20 travel time bins
  - Observed number in each bin

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Compare Alternative Models

Coupled physical-biological models

- Physical models
  - Spatially explicit: 1D – 3D hydrodynamics
- Biological models
  - Add “fishy” behaviors to neutrally buoyant particles
    - E.g., swimming velocity, holding during day
- Conduct simulation experiments
  - Water management actions
  - Patterns from fish behaviors and hydrodynamics

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