Why you should (probably) not be doing "uncertainty visualization"

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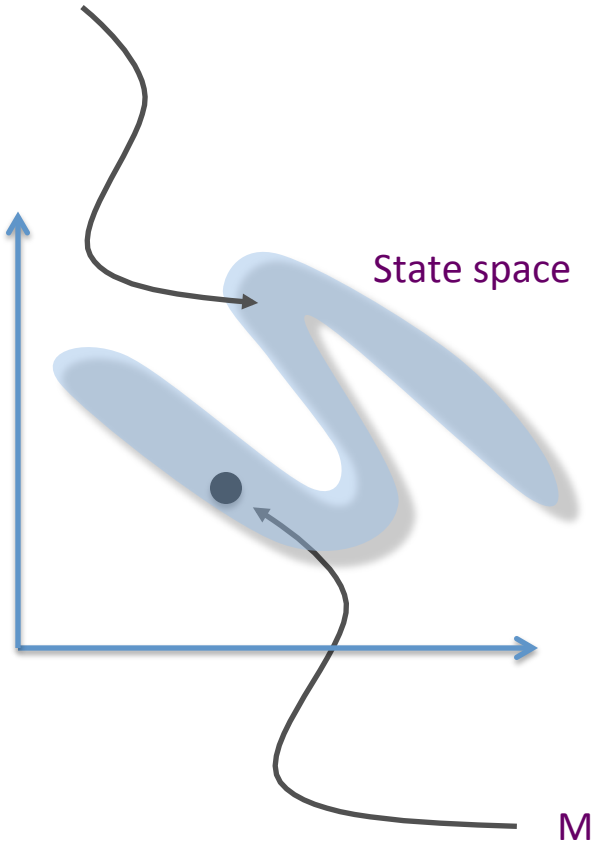
Uncertainty in Measured Data

Set of possible real objects (y)

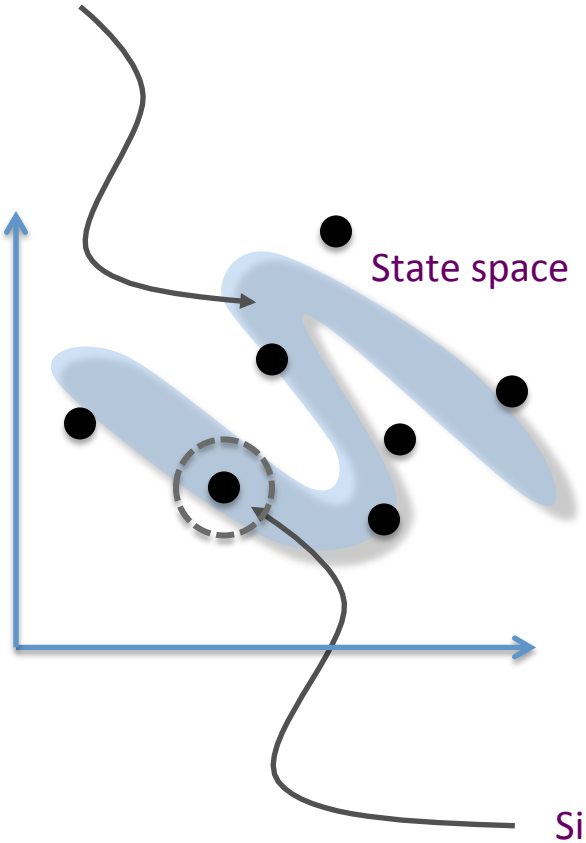


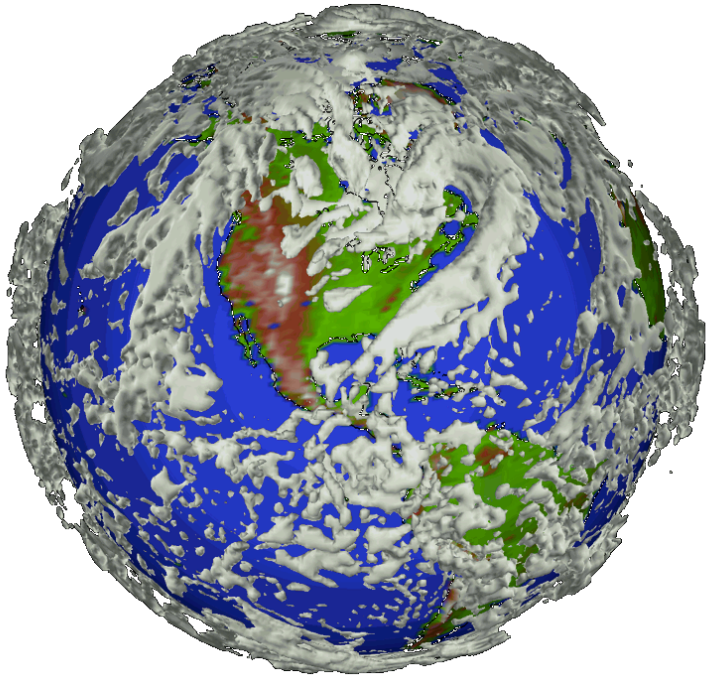
$$P(y|x) = \alpha\ P(x|y)P(y)$$

Typical approach: ignore P(y), visualize the variance of the marginals (assumed independence)

Uncertainty in Simulation

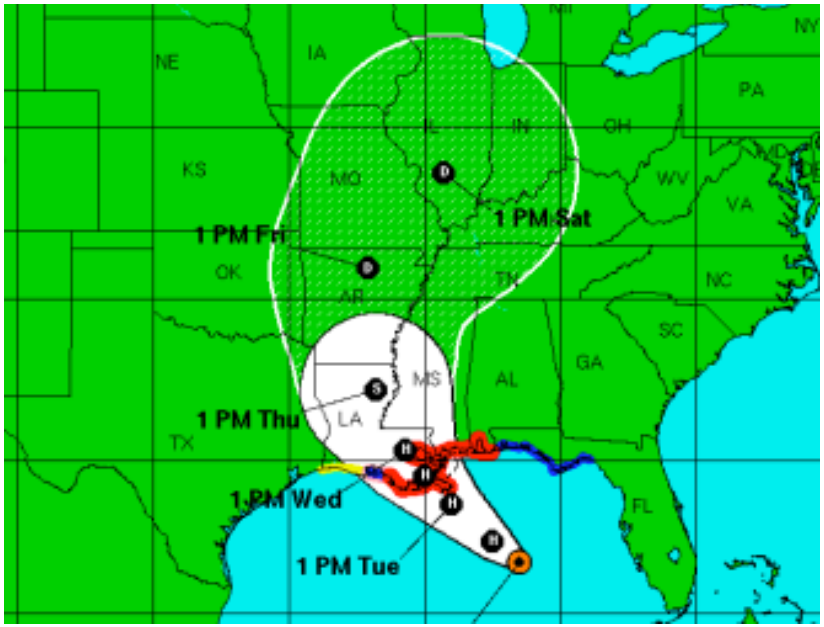
Set of possible real outcomes (y)

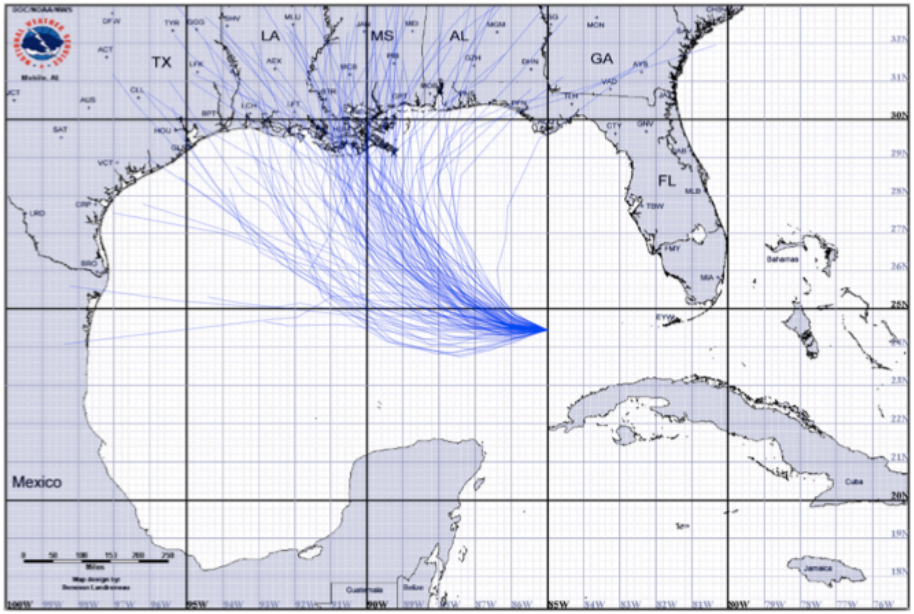




Uncertainty is Not the Main Question

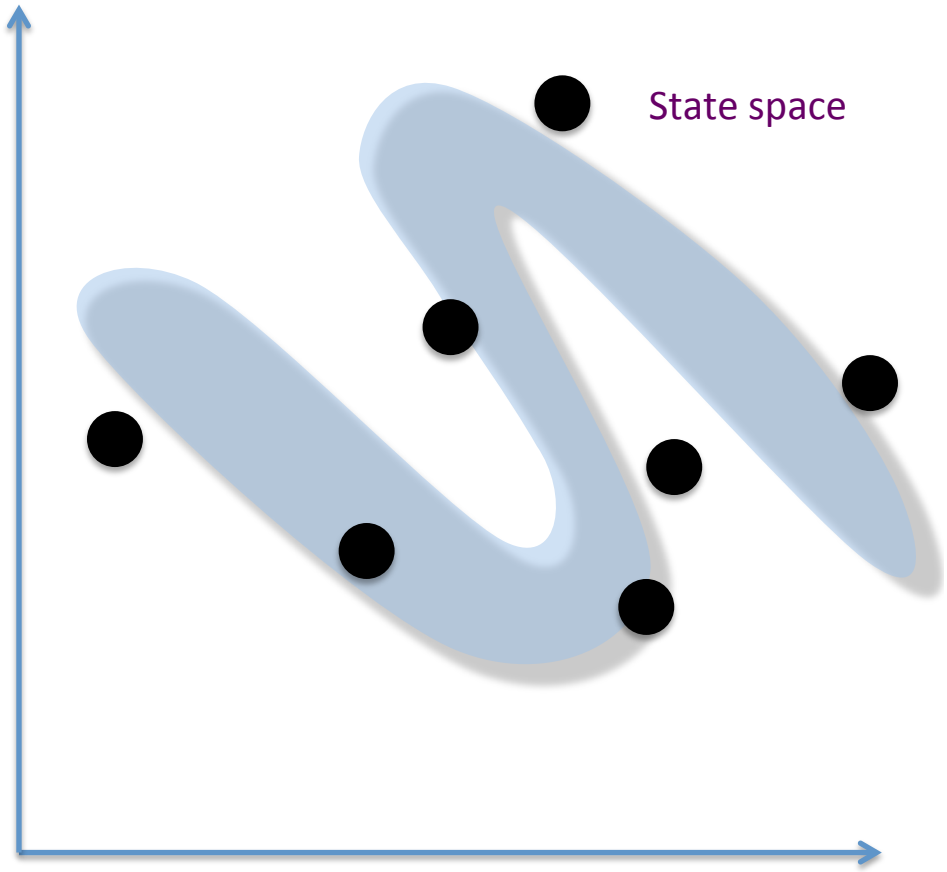
- Understanding the set of possibilities

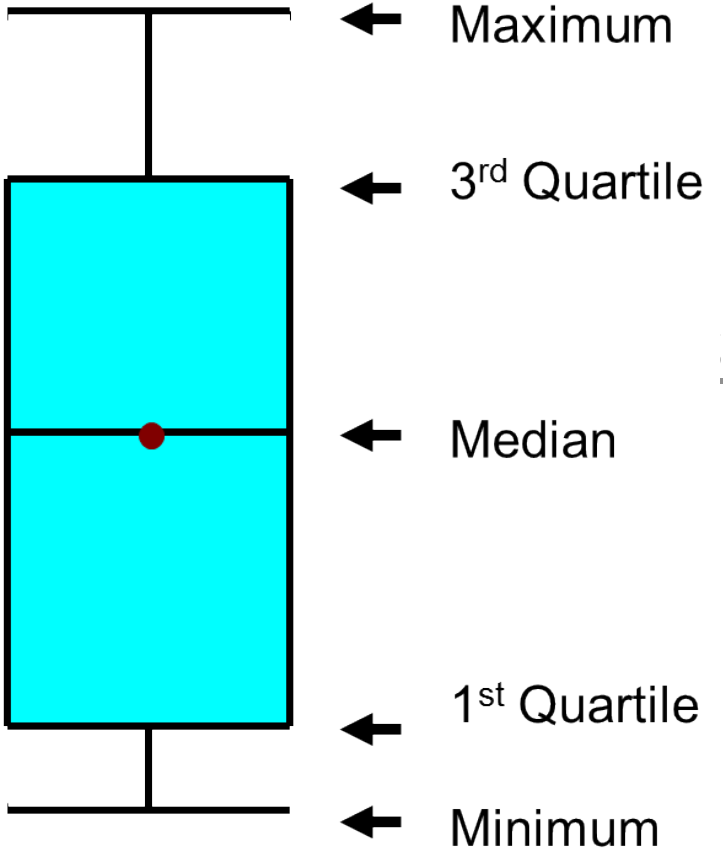




House et. al, 2011

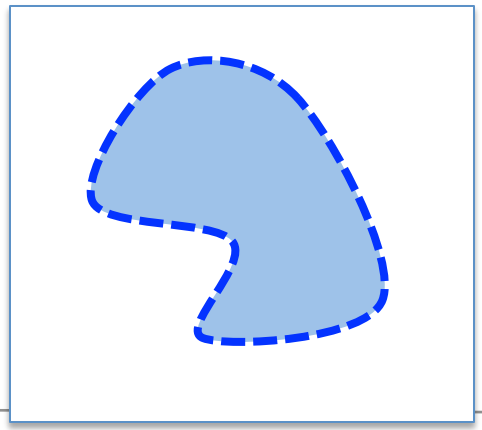
We Want to Visualize This Object
Variability Visualization





User Needs for Understanding Ensembles of Contours

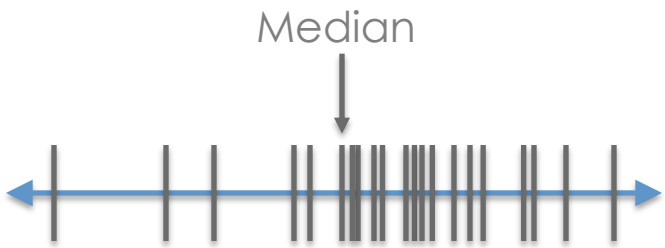
- Informative about *contours*.
- Qualitative interpretation.
- Quantitative interpretation.
- Statistical robustness.
- Aggregation preserves properties.

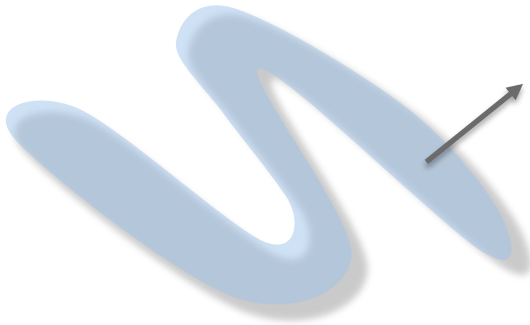


$$C_k = \{x \in \mathcal{D} | f(x) = k\}$$

Data Depth

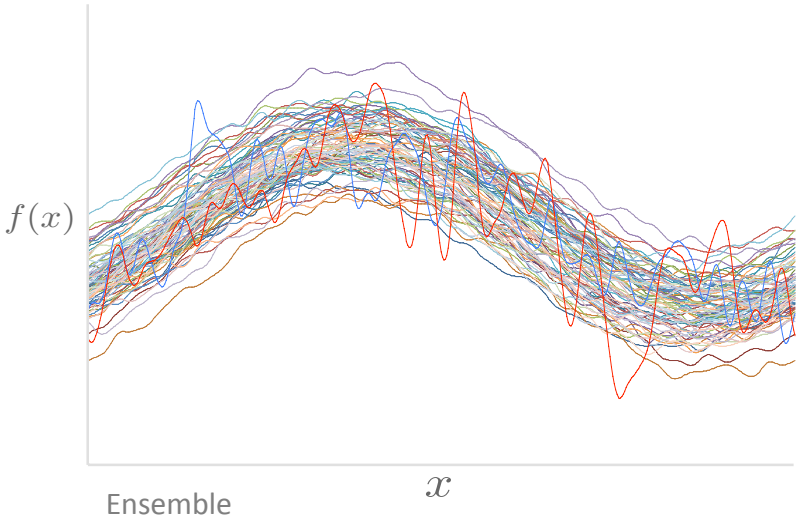
- How far a point has to go to get to P(S)=0



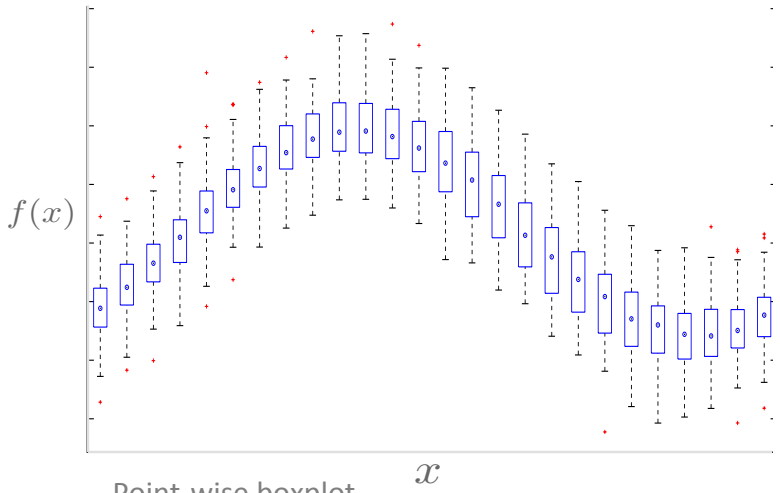


- Robust
- Asymptotically consistent estimators
- Special properties on symmetric distributions

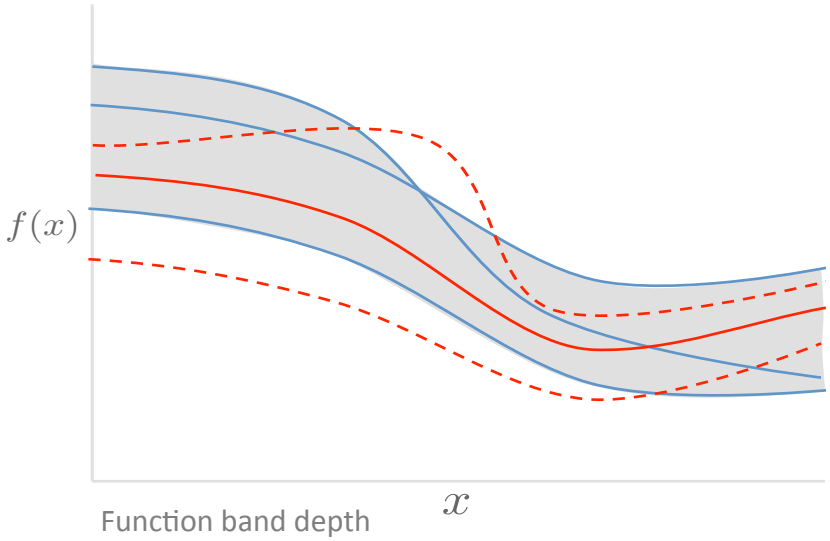
Functional Band Depth



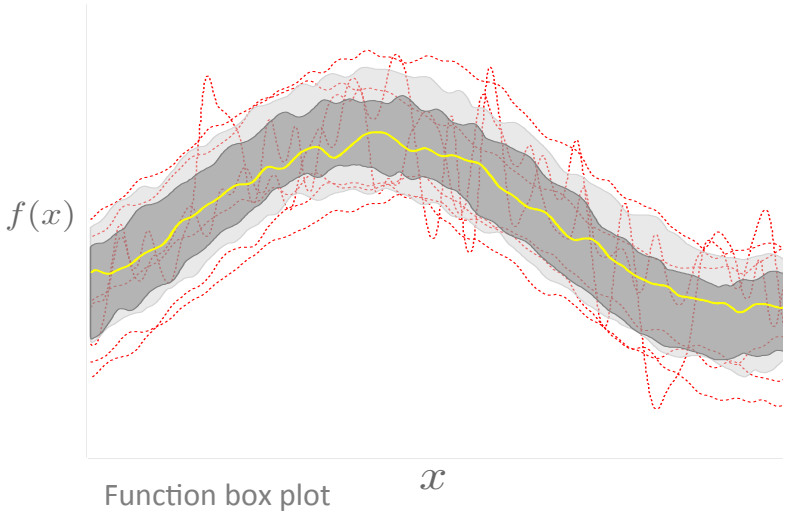
Ensemble



Point-wise boxplot



Function band depth



Function box plot

[Lopez-Pintado and Romo, 2009]

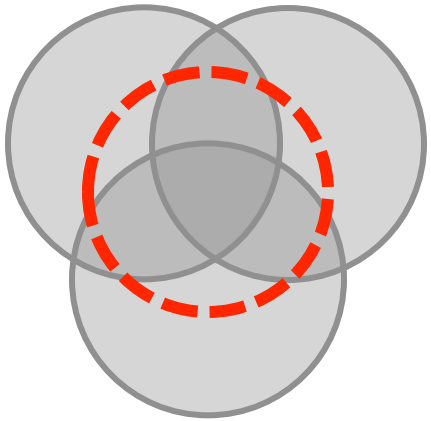
Function box plots, [Sun and Genton, 2011]

Set Band Depth / Contour Band Depth
Whitaker et al., Vis 2013

- Bands formed by sets by union/ intersection

$$S \in \mathrm{sB}\left(S_1, \ldots S_j\right) \iff \bigcap_{k=1}^{j} S_k \subset S \subset \bigcup_{k=1}^{j} S_k$$

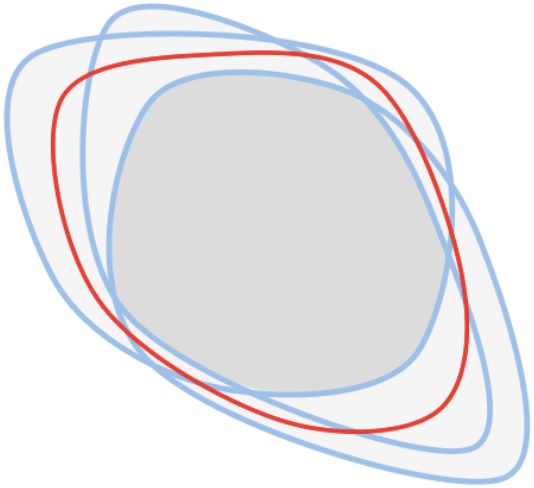
$$\mathrm{sBD}_J\left(S\right) = \sum_{j=2}^{J} P\left[S \in \mathrm{sB}\left(S_1, \ldots S_j\right)\right]$$

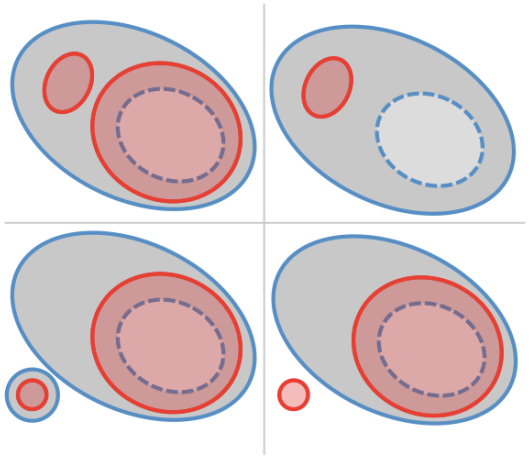


- Application to isocontours
  - Sets = regions of domain above/below isovalue

Contour Box Plots

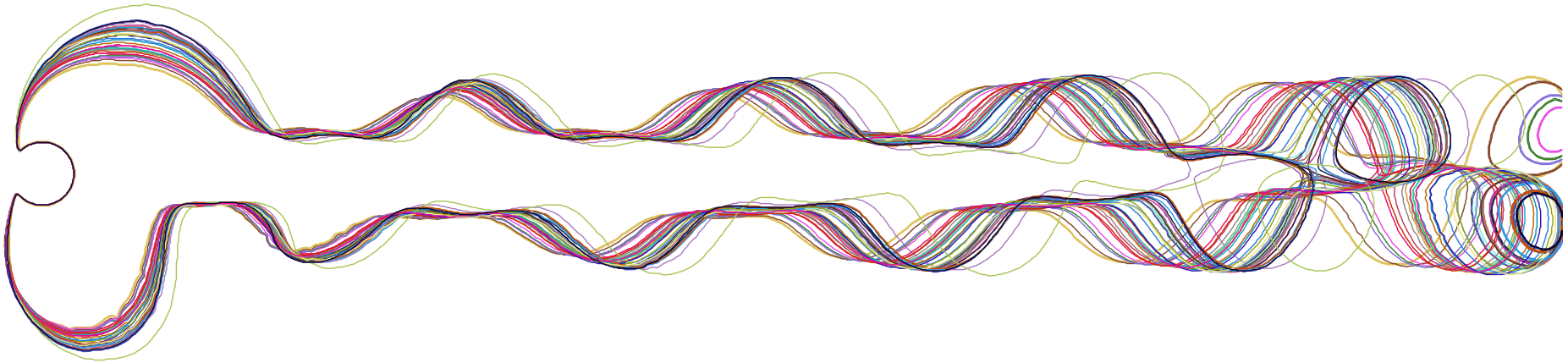
- Generalize band depth methodology for *sets*
- Apply set band depth to contours/regions





Eddy Lines in Fluid Simulations

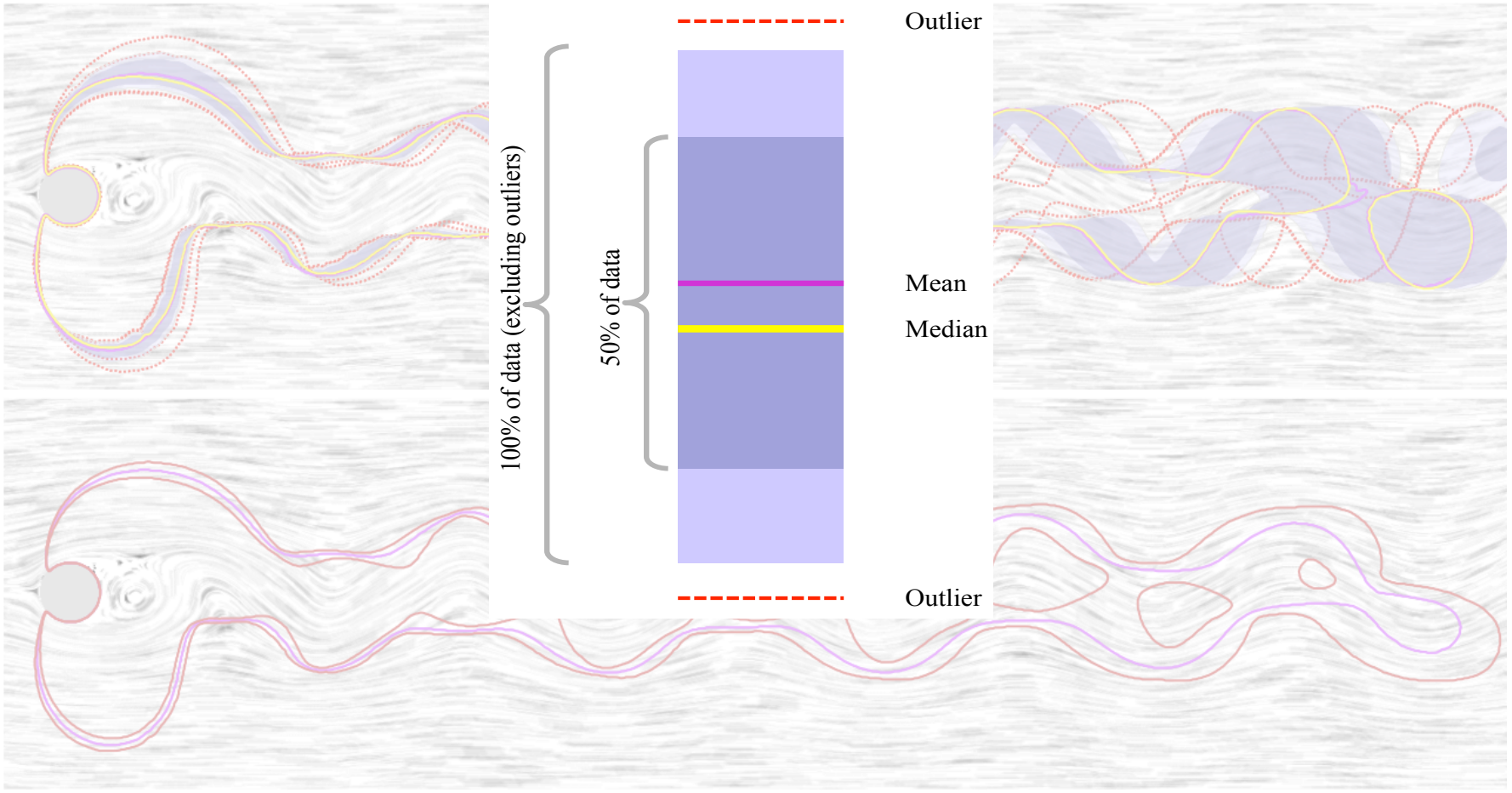
- Perturbations in boundary conditions and viscosity give rise to ensemble



Eddy Lines with CBPs vs Field Averaging

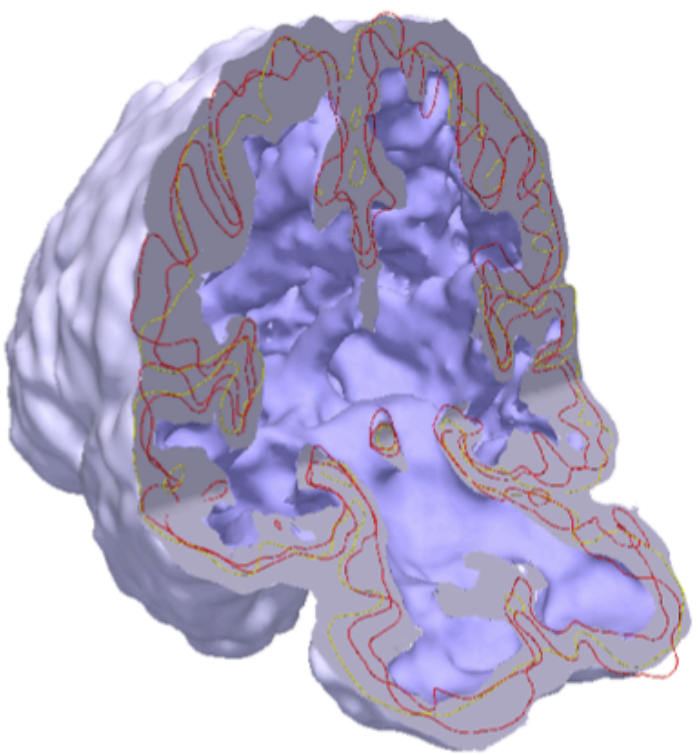
Contour box plot

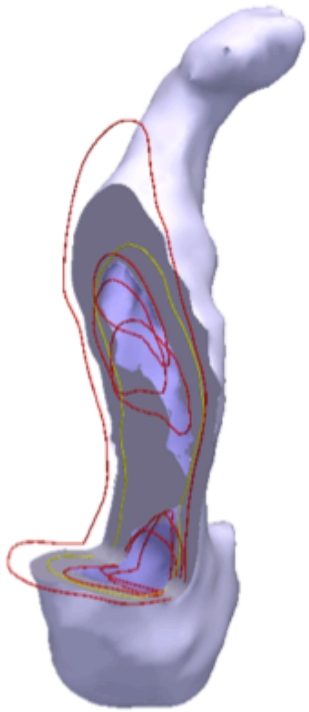
Average +/-std



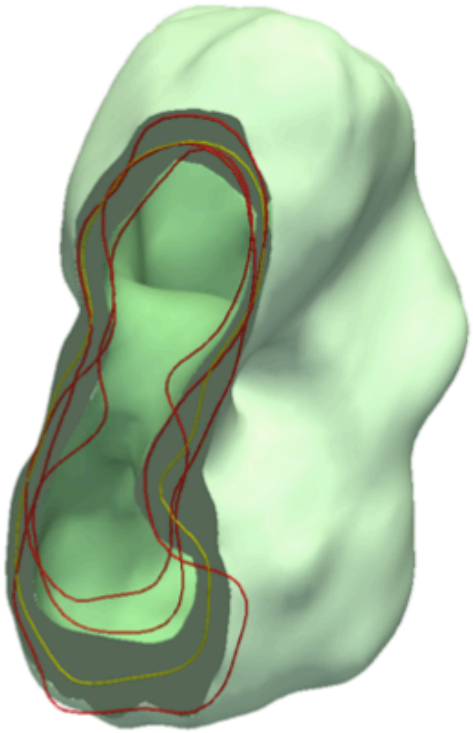
Weather Forecasts with CBPs

Contour Boxplots in 3D



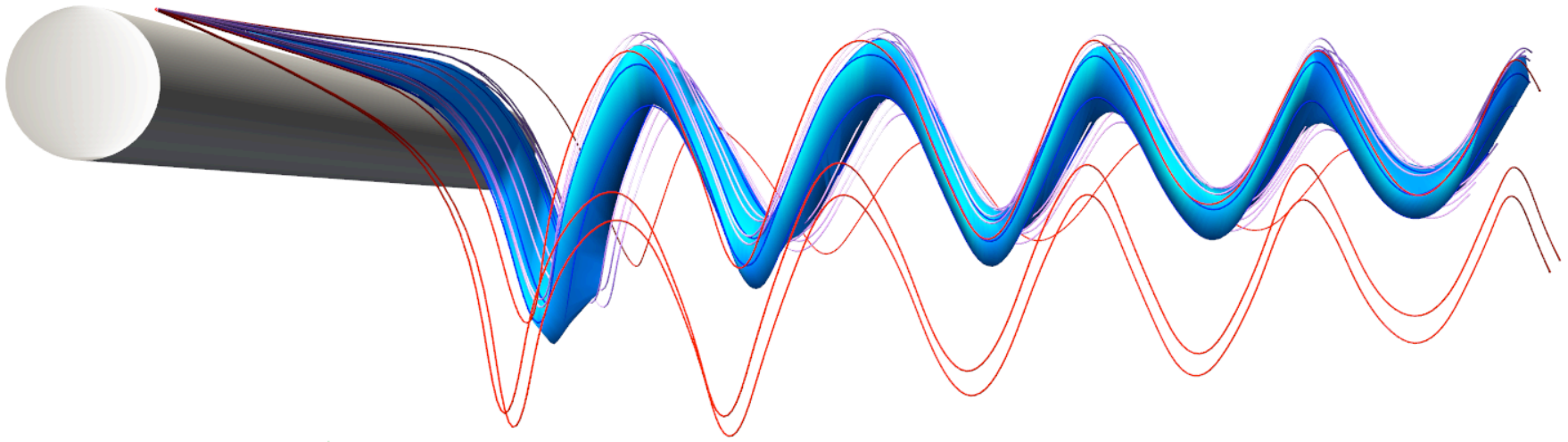


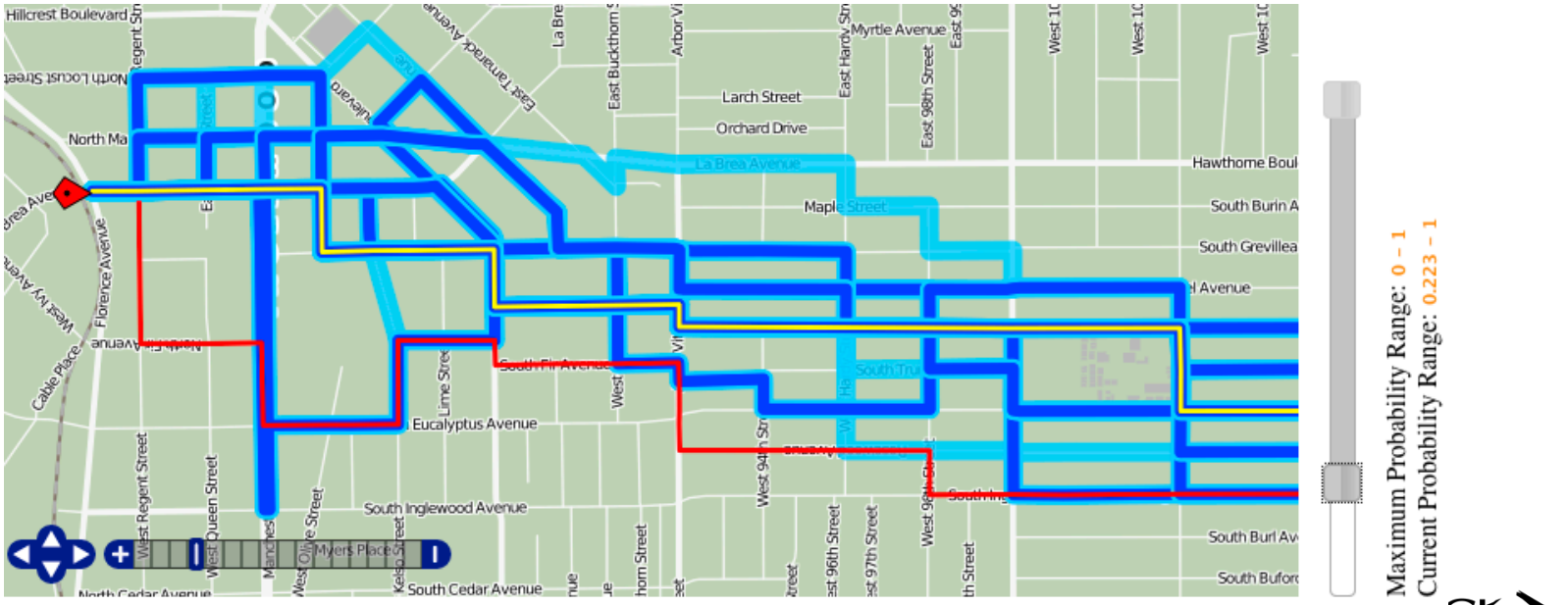
Brain Atlases



Molecular Dynamics

Other Directions





Das Ende