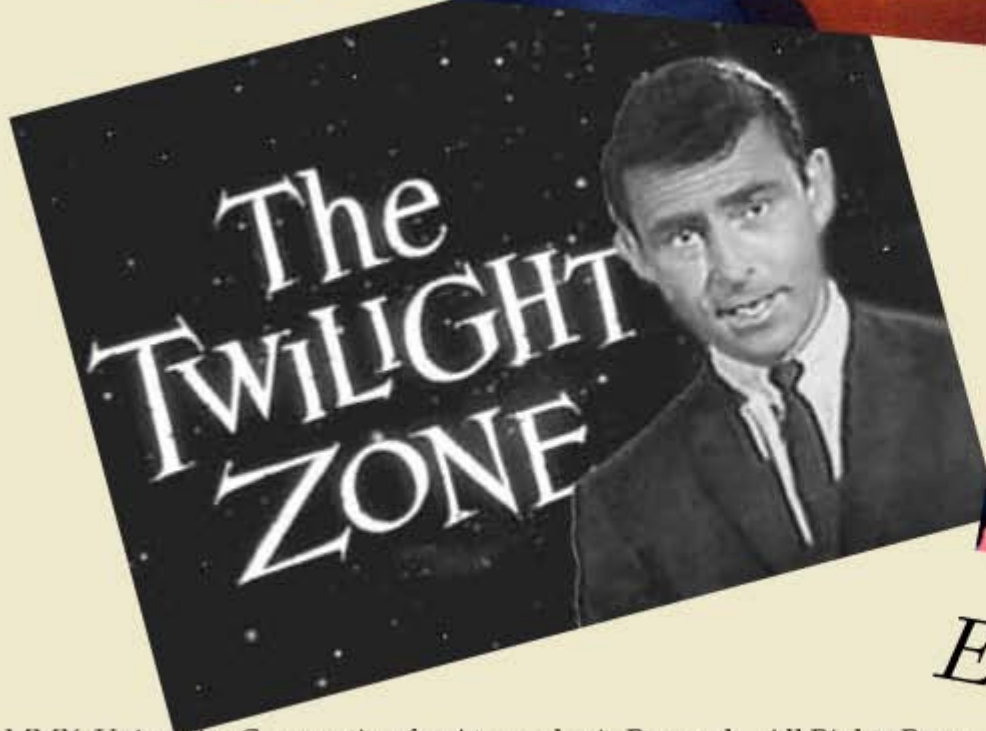
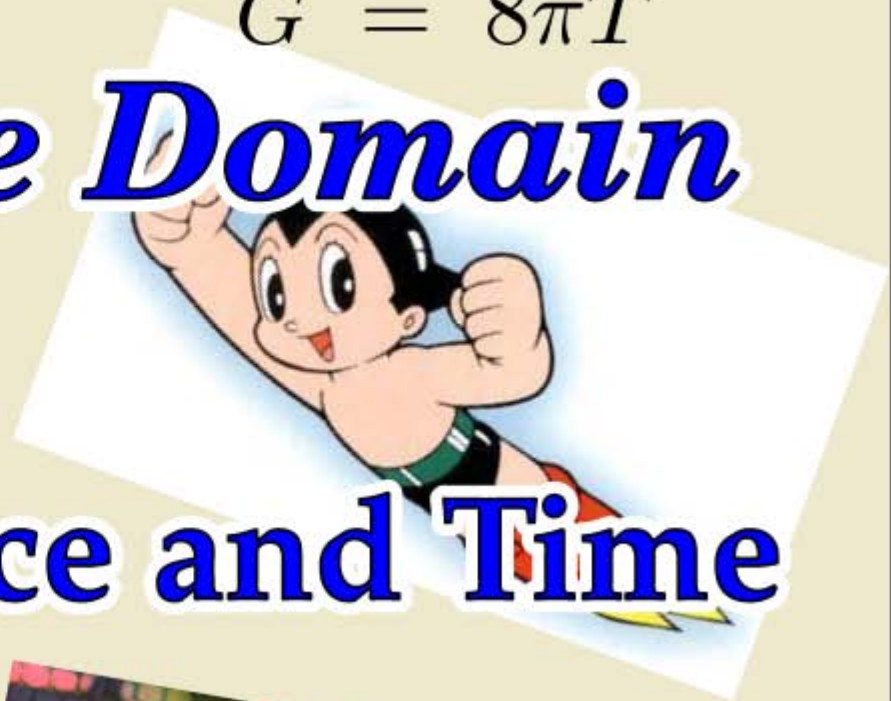


$$e^{\pi i} + 1 = 0$$

$$G = 8\pi T$$

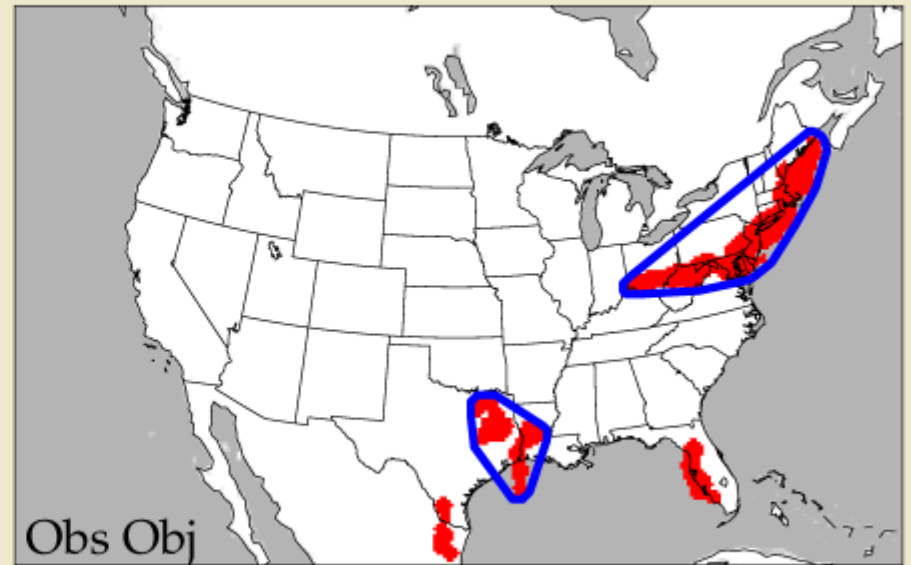
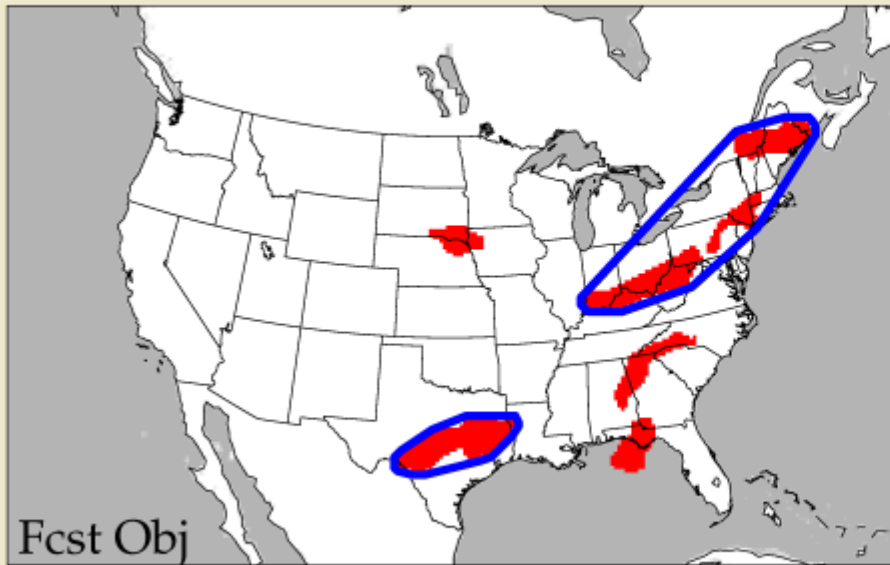
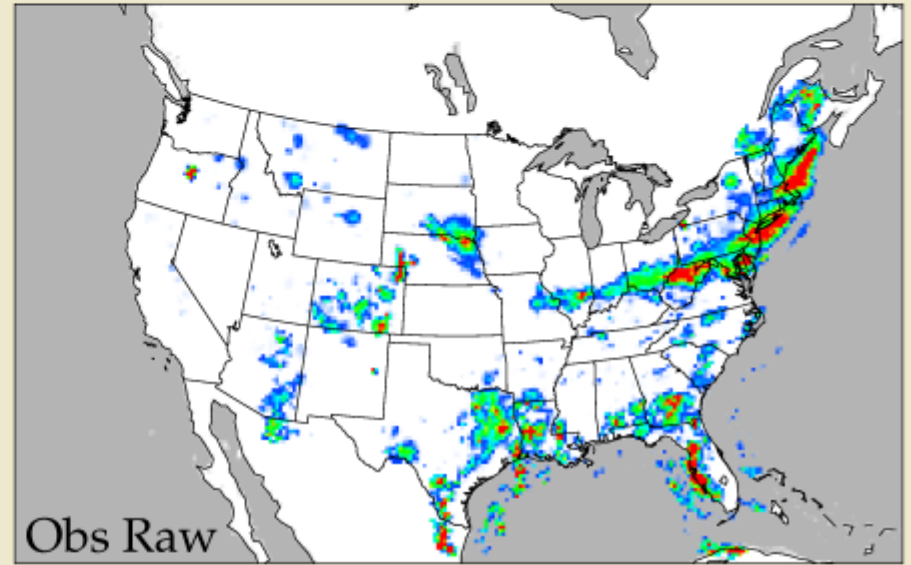
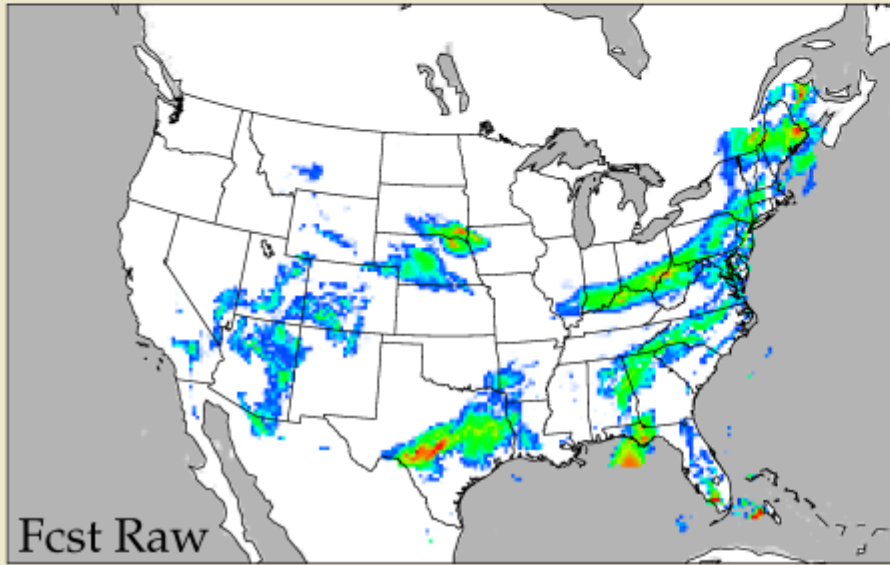
# MODE Time Domain

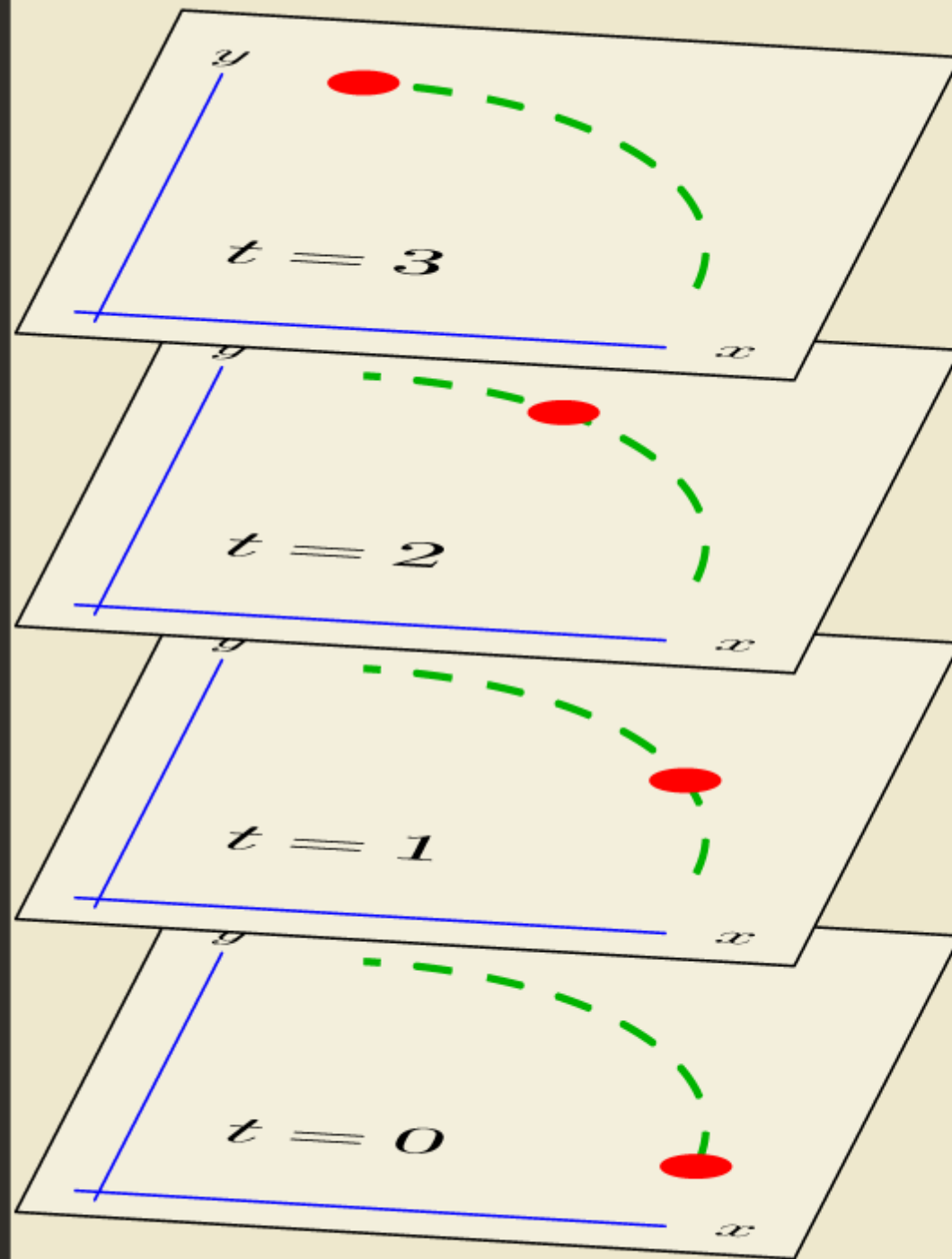
## Objects in Space and Time



$$E = mc^2$$

# MODE 2D

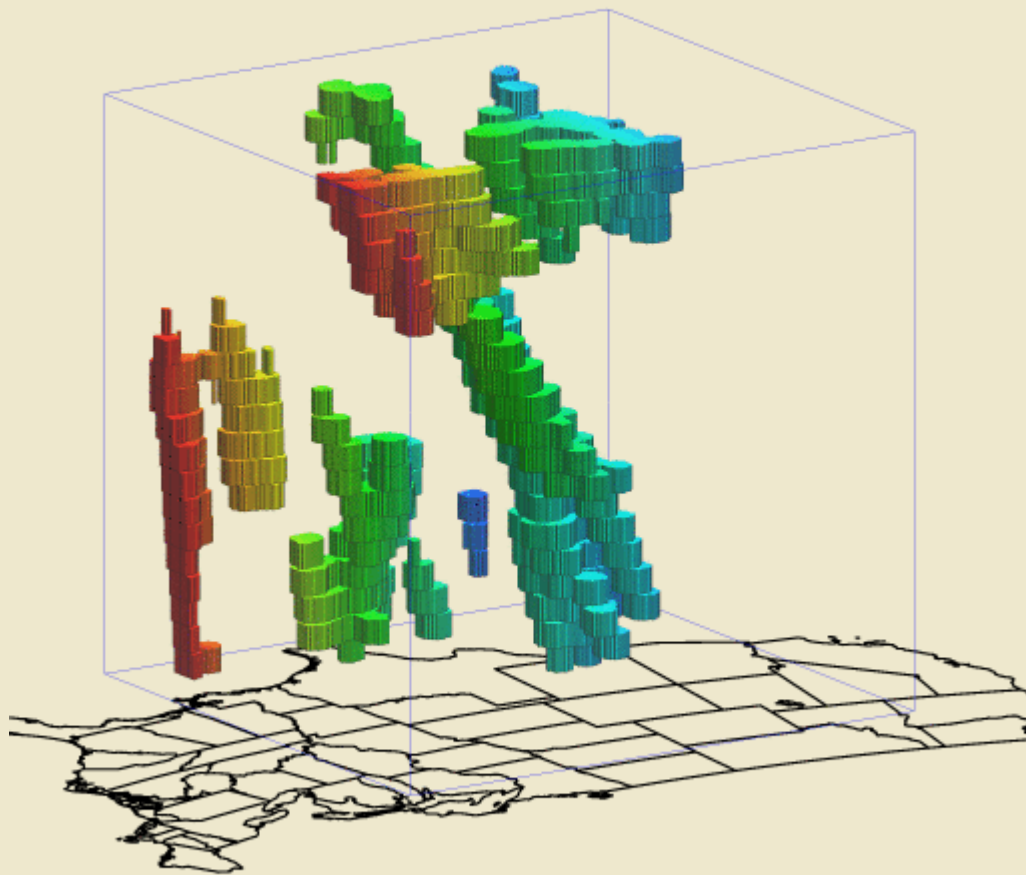




Time Slices  
Stacked Vertically  
Moving 2D Object  
Sweeps Out  
3D Spacetime Object

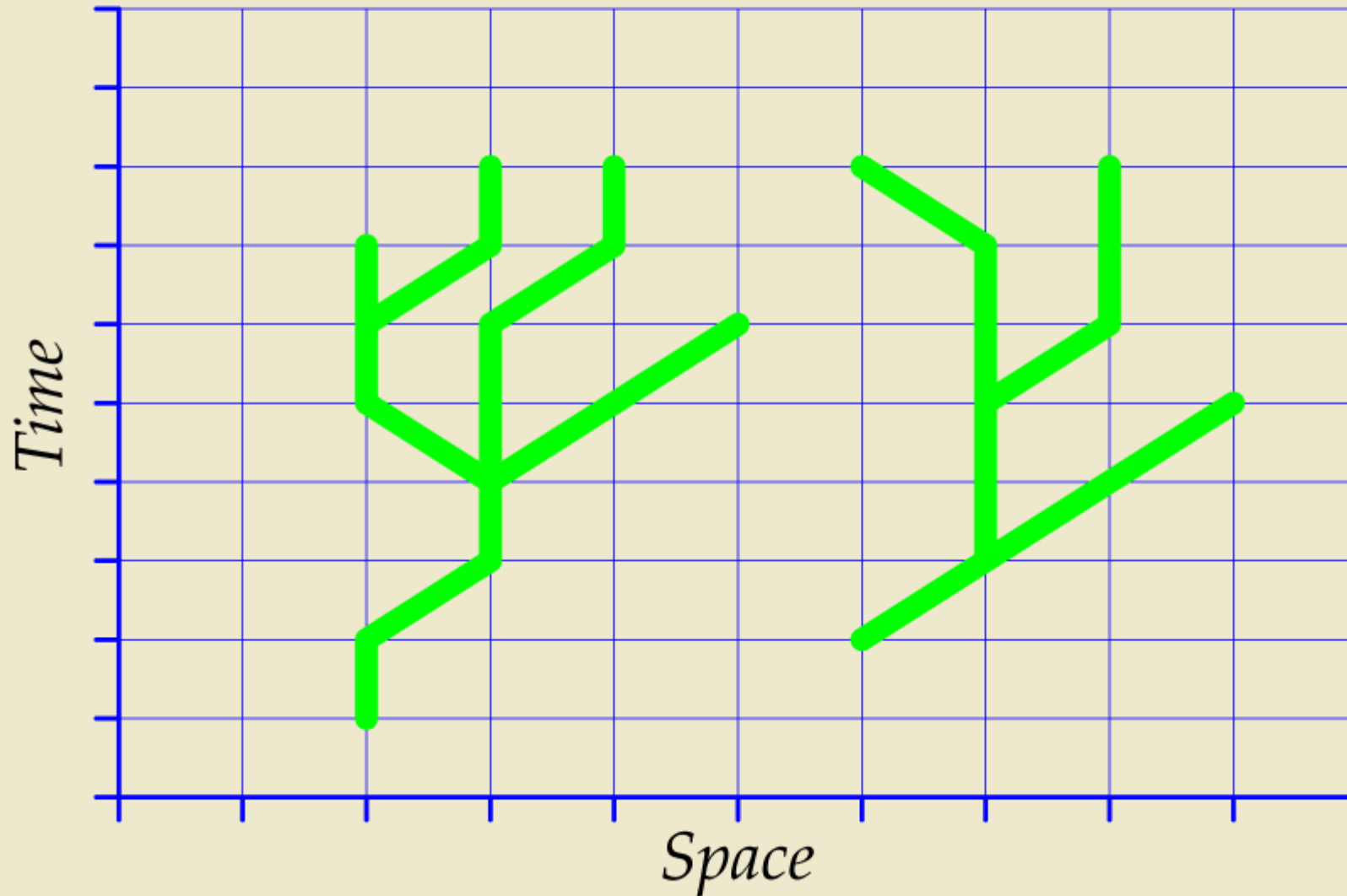
# 3D Objects

June 15, 2002  
IHOP Precip Data



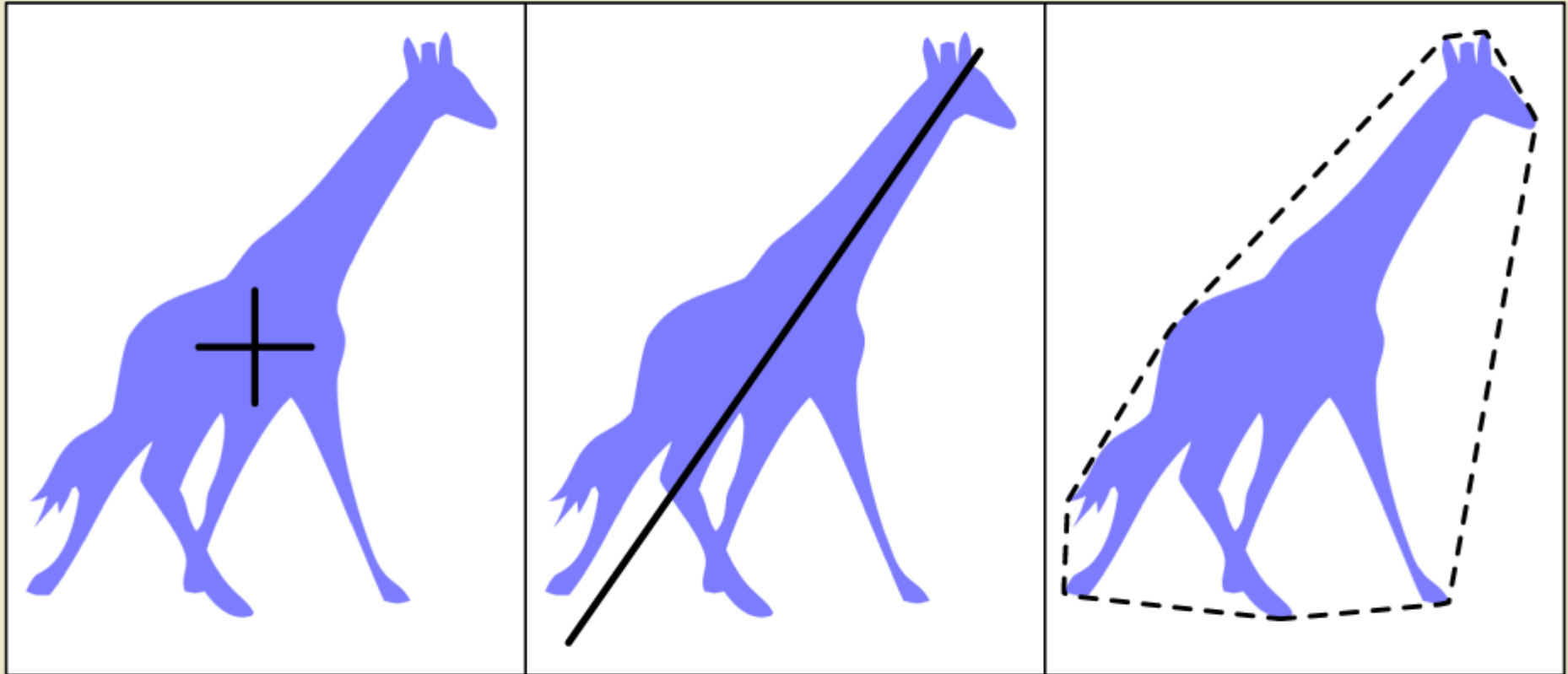
Vertical Dimension  
is Time

3D Objects will often form trees.





# Example 2D Attributes

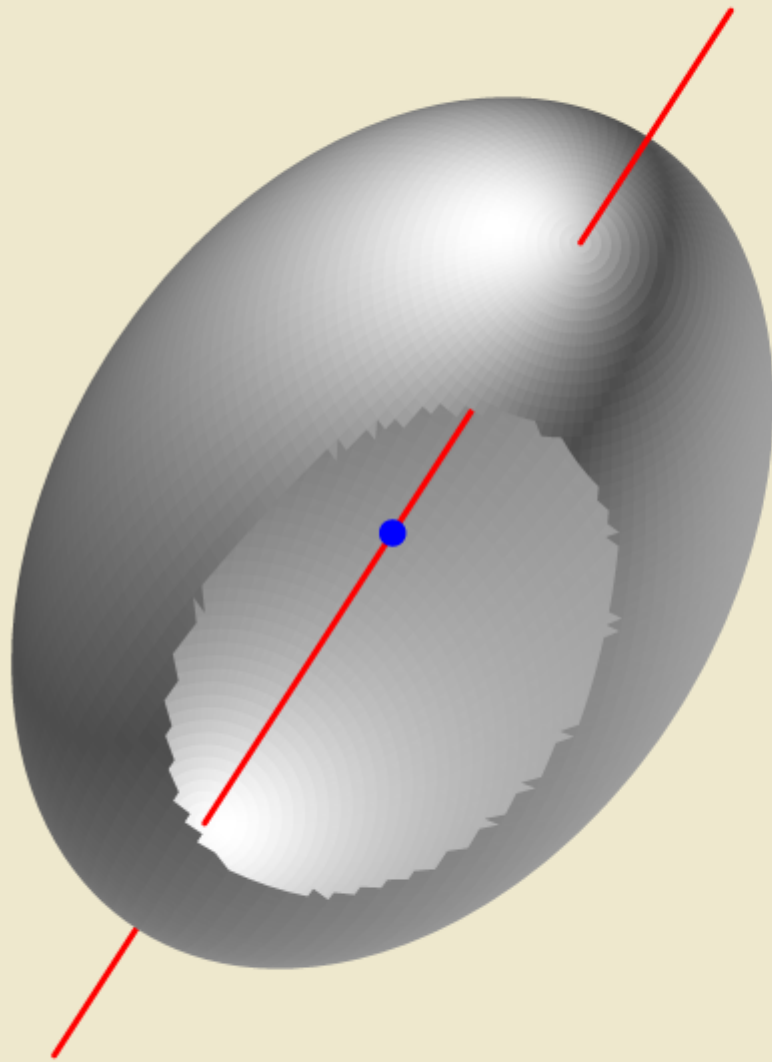


Centroid

Axis

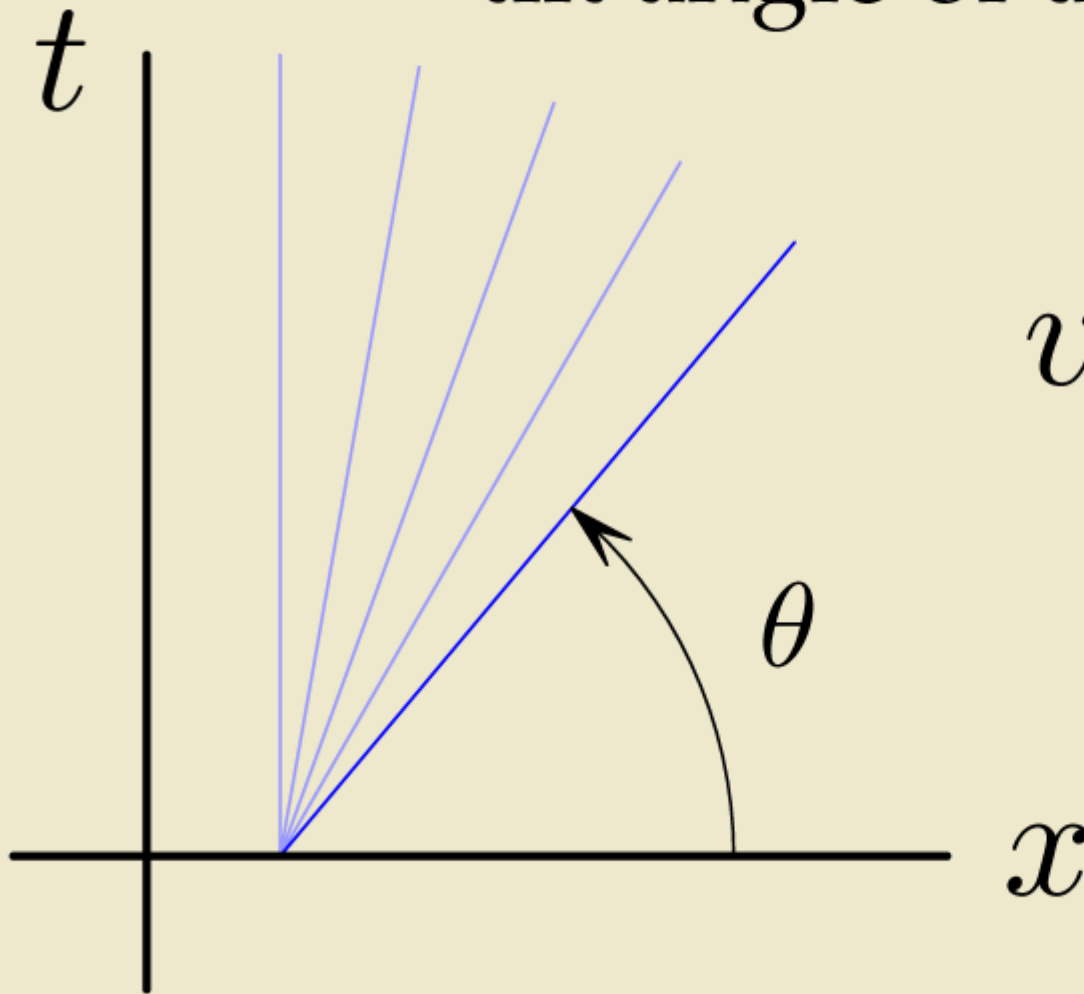
Convex Hull

Most attributes  
for 2D objects  
generalize easily  
to the 3D case



Here we see the centroid  
and axis calculated for this  
3D ellipsoidal object, which  
we call the "potato"

Velocity is related to the  
tilt angle of the axis



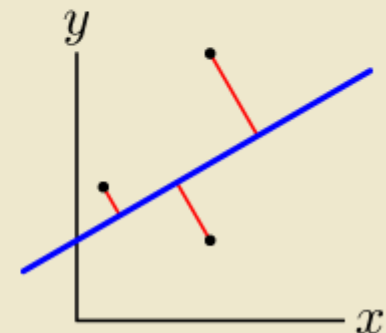
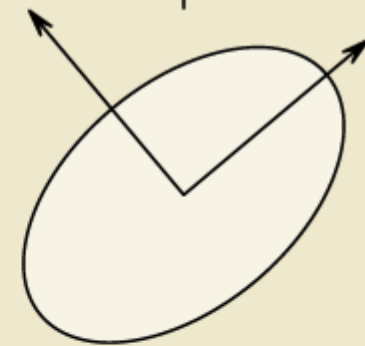
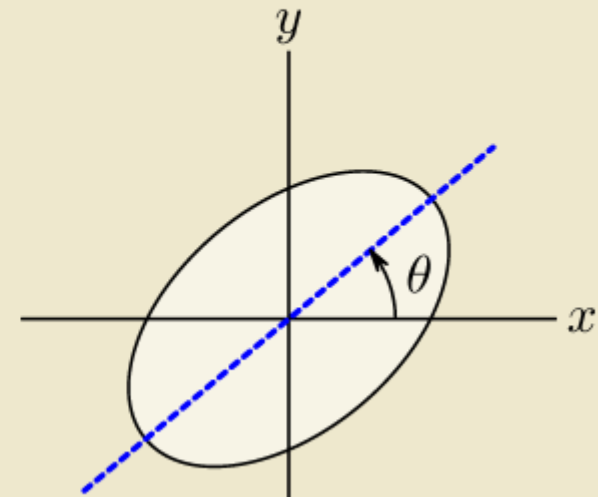
$$v \propto \cot \theta$$

# Three Approaches to Calculating the Axis in 2D

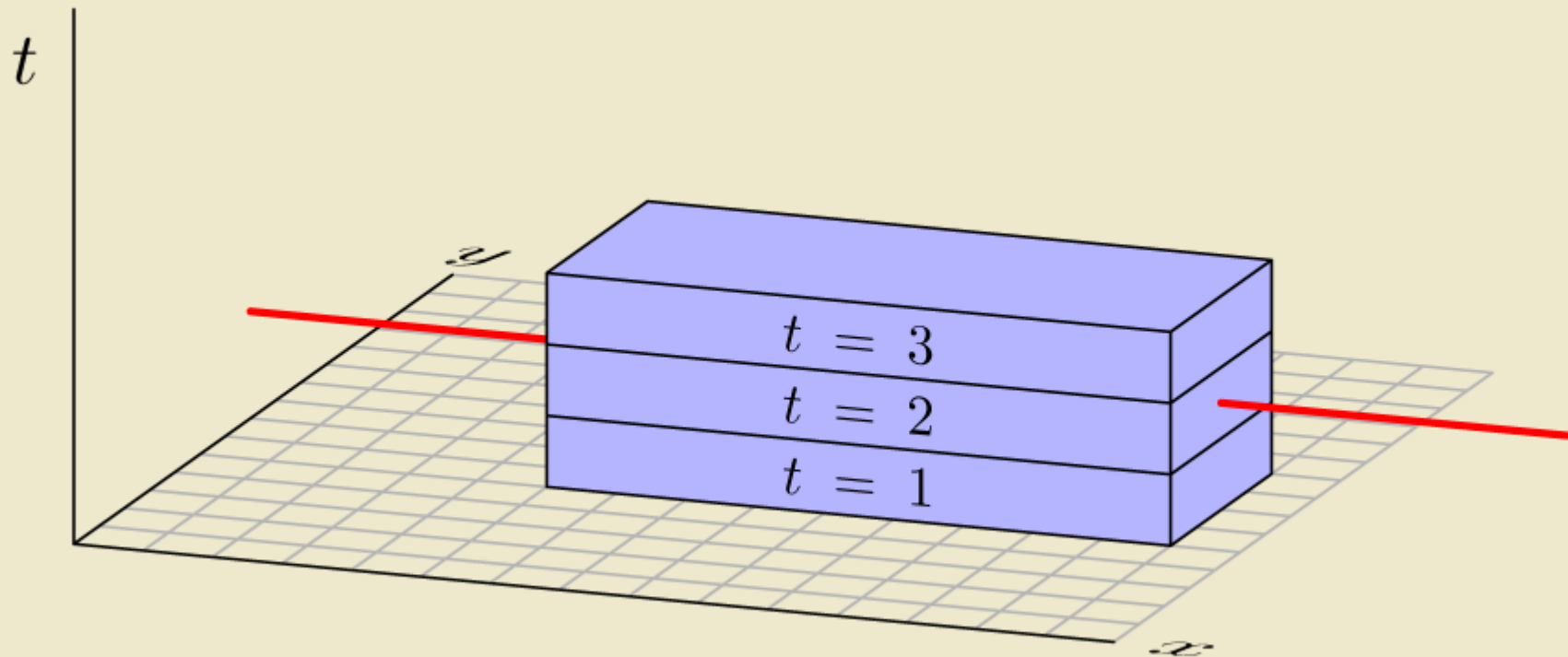
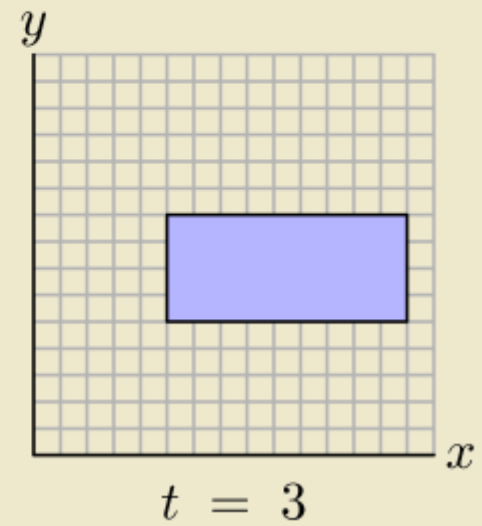
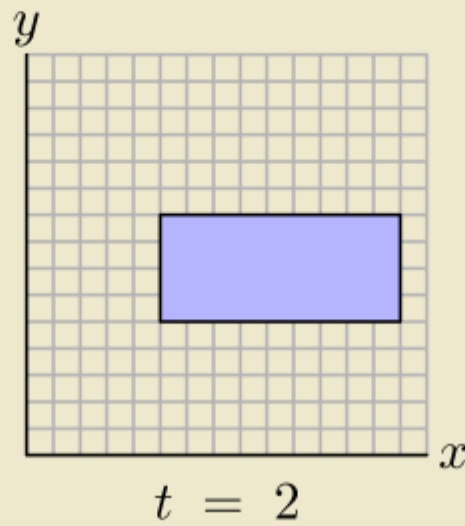
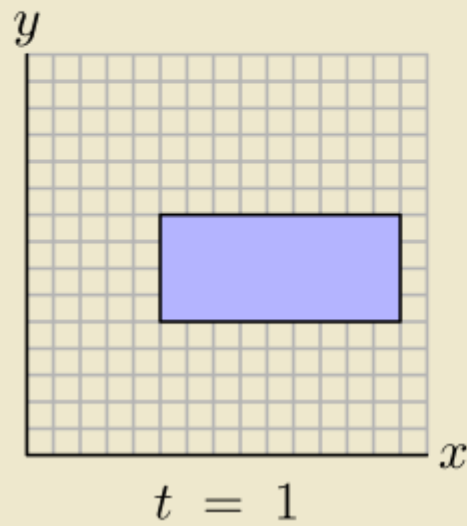
- Maximize second moments

- Principal Components

- Total Least Squares



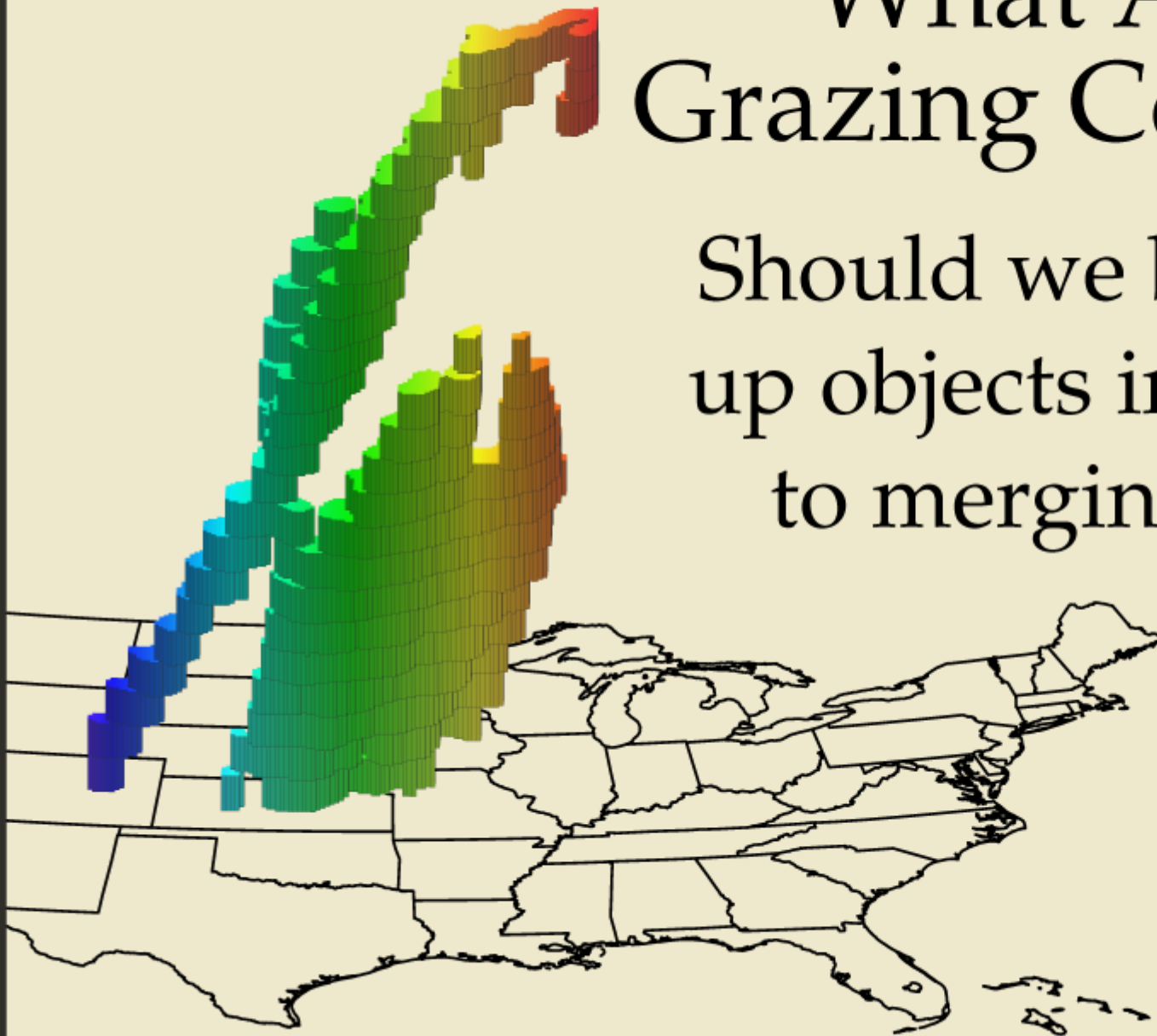
# Trouble with Principal Components



# What About Grazing Collisions?

Should we be cutting  
up objects in addition  
to merging them?

(Maybe ...)



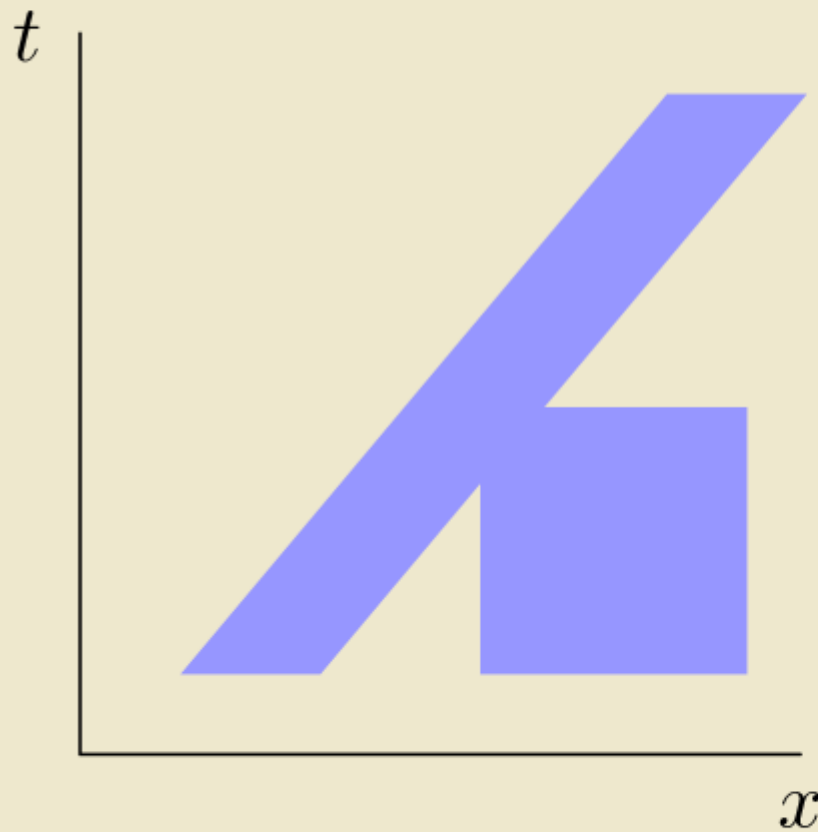
# PQRS

- Skeletonization may help us determine cut points.
- Need algorithm to perform cuts intelligently.

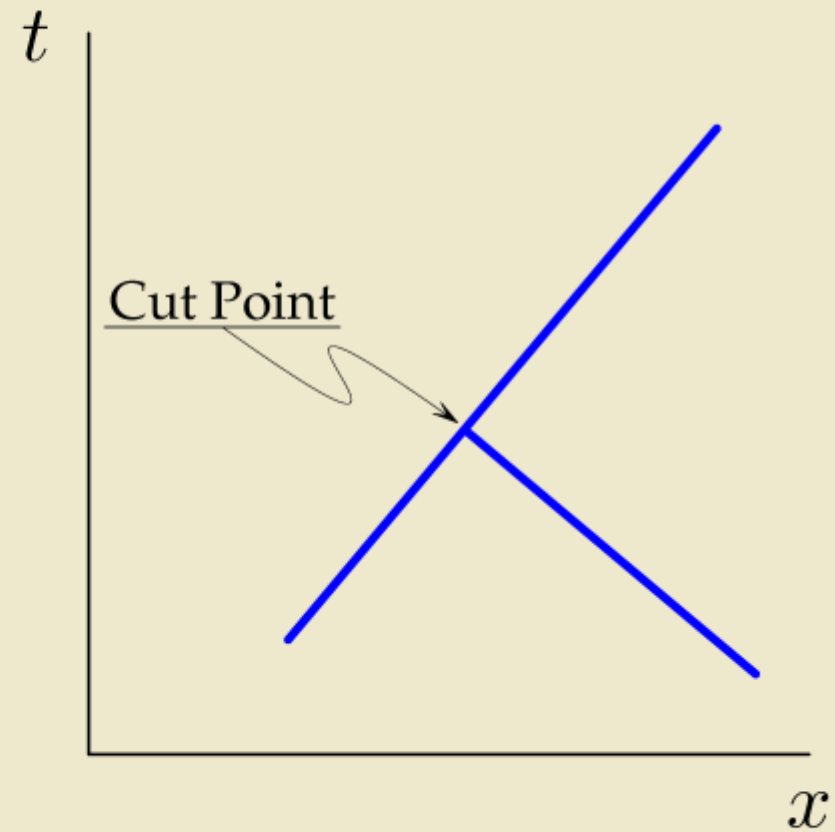
# Making the Cut

---

Original Object



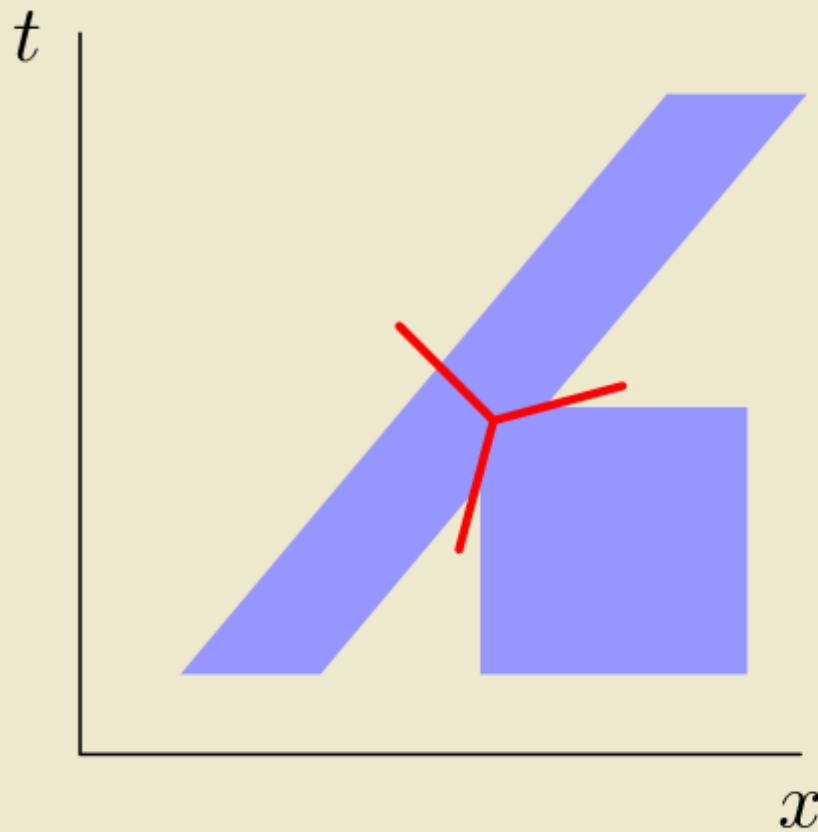
Skeletonized



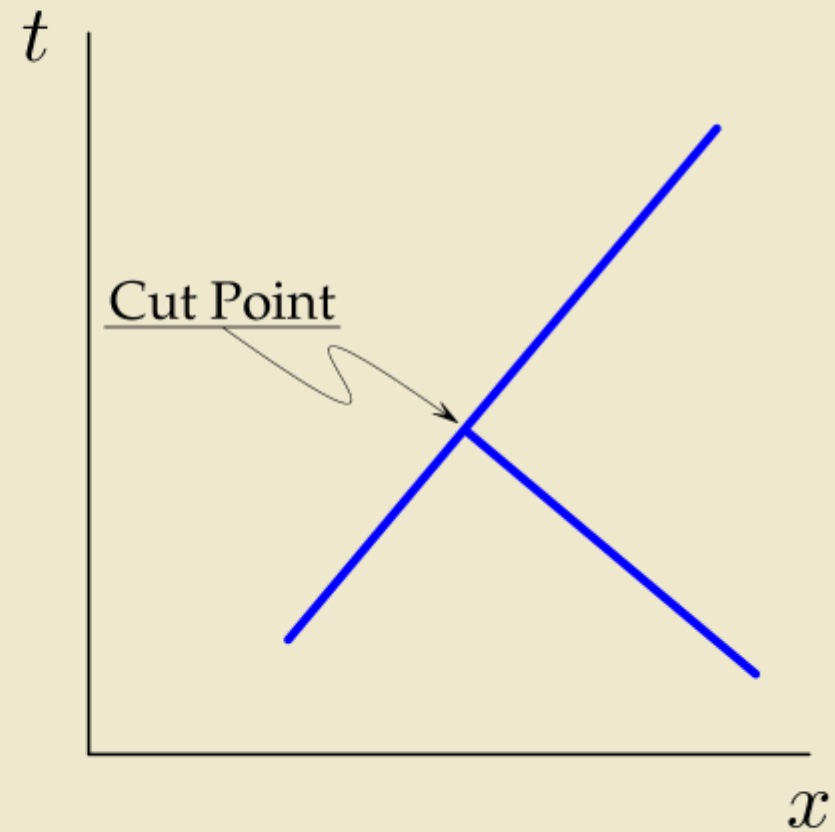
# Making the Cut

---

Original Object



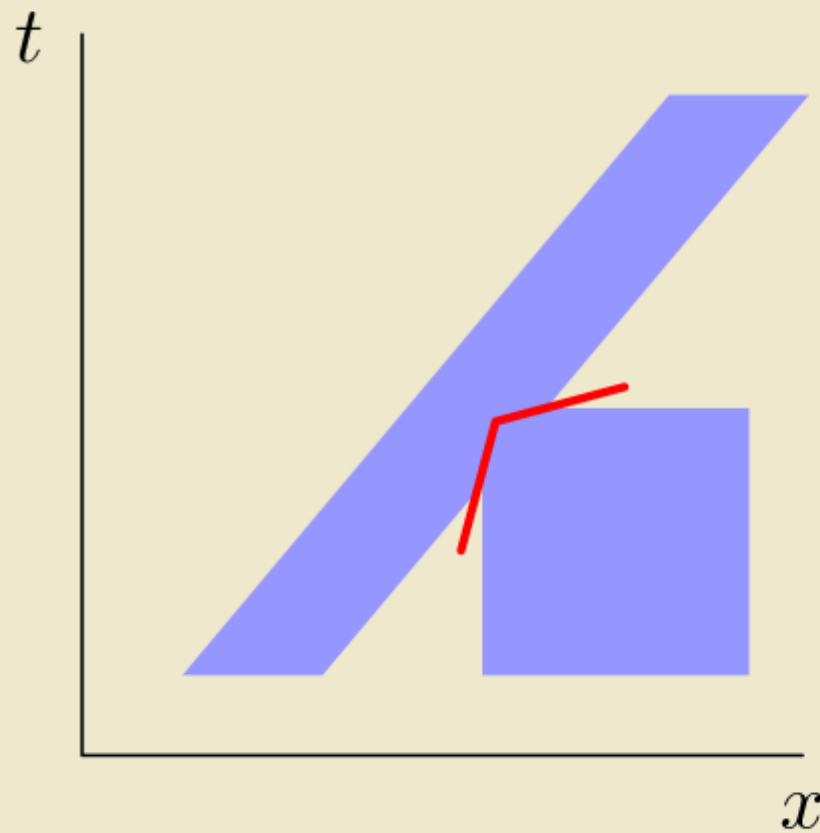
Skeletonized



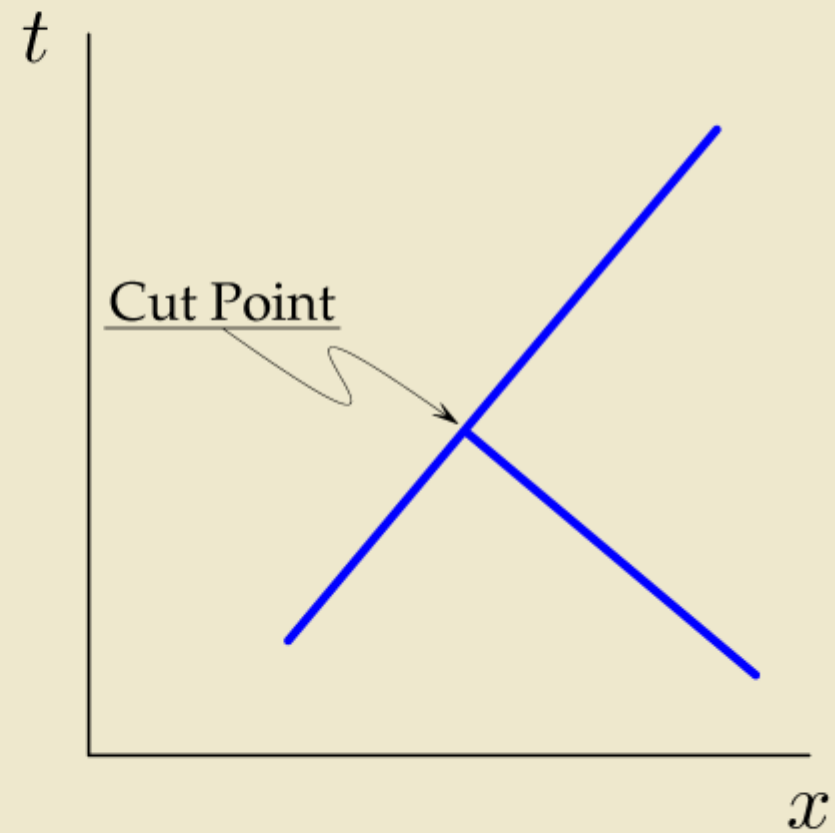
# Making the Cut

---

Original Object



Skeletonized



# Summary

- MODE 3D is a generalization of MODE 2D that incorporates the time dimension.
- Object matching and merging are done with a fuzzy-logic engine, as in the 2D case.
- Because one of the dimensions is not spatial, some object attributes have new interpretations.
- The addition of the time dimension produces a few new wrinkles.

# Summary

- Object tracking over time is a freebie.
- Spacetime graphs may give some measure of storm complexity.
- Plan to adapt algorithms and data structures from image analysis and computational geometry to this situation.
- Lots of both meteorology and computer science in this project.

# Acknowledgements

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- Barb Brown, Chris Davis

- Boris Karloff

