Information Transport and Synchronization in a Spatially Extended Predator-Prey Model.

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Problem:

- We can't monitor all populations everywhere in a large region.
- Much work has been done on **indicator species** that assess ecological health of a region.
- What about **indicator areas**? Are there some that are **better** (or **worse**) at assessing population in the **region**?

Spatially Extended Predator-Prey Model (Pascual, 1993)

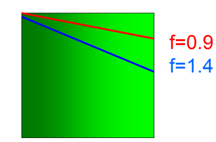
$$\partial p/\partial t = r_x p(1-p) - [ap/(1+bp)]h + d(\partial^2 p/\partial x^2)$$

$$\partial h/\partial t = [ap/(1+bp)]h - mh + d(\partial^2 h/\partial x^2)$$

$$r_x = e - fx$$

(pred. death rate) m = .6, (diffusion coeff.) d = 10^{-4}, (bndry res. Level) e = 5.0, (carrying cap.) b = 2.0 (coupling coeff.) a = 5.0, Two cases: f=0.9, f=1.4

Varying Resource Gradient



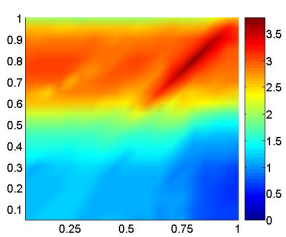
More resources at x=0 fewer at x=1

Jonzen et al (2005) looked at monitoring in a **source/sink** environment. In a **sink,** a population **can't be supported** without diffusion.
In this model the **low-resource end still can support a population**. How might monitoring strategies **differ**?
We will assess strategies using **information flow** and **synchronization** properties of the model.

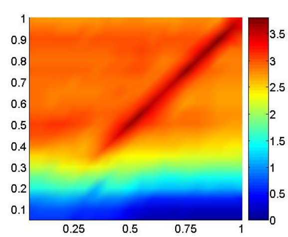
Information Transport: Transfer Entropy (Schreiber, 2000)

$$TE_{Y\to X} = \Sigma p(x_{i+1},x_i,y_j) \log_2(p(x_{i+1}|x_i,y_j)/p(x_{i+1}|x_i))$$

*Transfer Entropy measures the amount of **additional** information about **dynamics** in **X** that **Y** contributes*

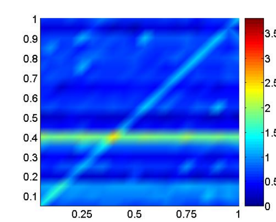


Gradient 0.9



Gradient 1.4

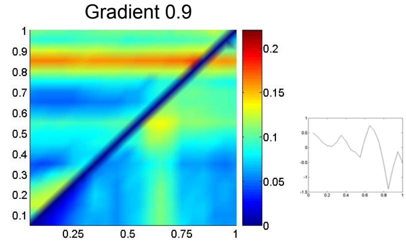
Predator to Prey Transfer Entropy shows **information flow** from high-resource end to low-resource end. The **low** resource end contains **more** information. Without diffusion, there is no "downhill" information flow.



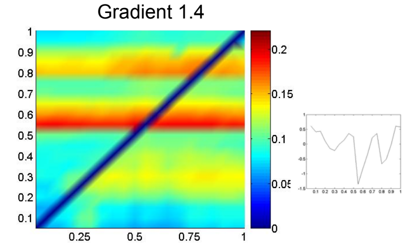
Gradient 1.4, no diffusion

Information flow from one **site** to another (both species). Small plots show *net* information flow (flow out minus flow in). **Peaks** in the graph are areas that contain **more** information about other areas' dynamics… What about the **troughs**? Transfer entropy is **zero** if dynamics are **identical** to another sites'. It is **zero** If the **dynamics** are **independent**. What do we do…?

Gradient 0.9



Gradient 1.4

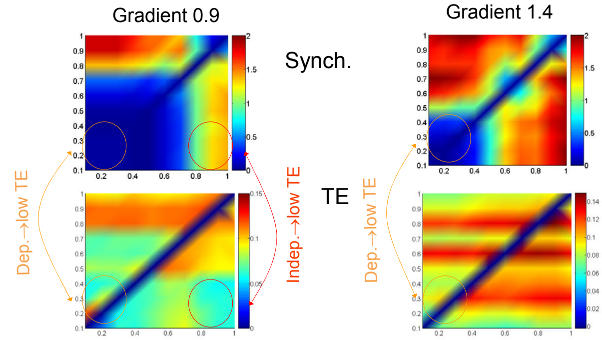


Synchronization: Time-Delayed Continuity

Generalized Synchronization between two sites X and Y is the existence of a continuous function between the two sites. We can also add a time delay in Y to see if the dynamics "flow", that is, they synchronize at some time in the future:

F: X → Y so that F(x) = y(x+t).

We use a variant on the **Continuity Test** found in Nichols et al (2005)
This test indicates why TE is zero – **independence** or **dependence**?



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