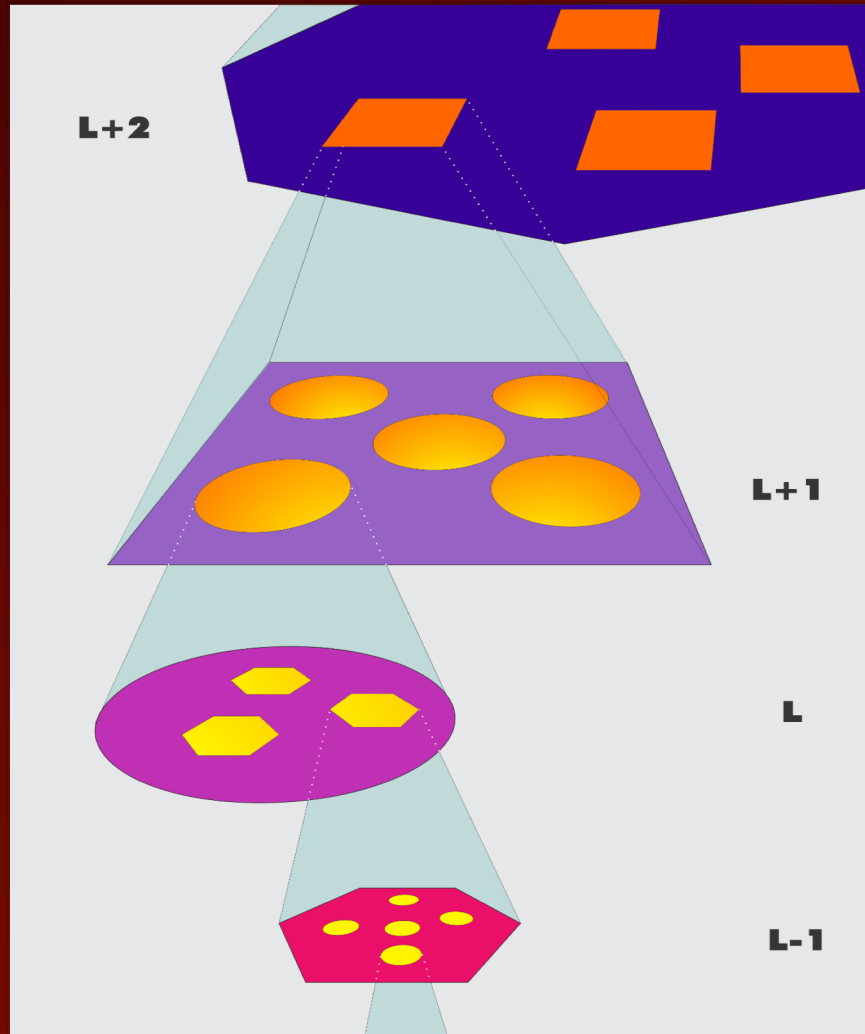


# GENERAL PROPERTIES OF HIERACHICAL SYSTEMS AND INFLUENCES ACROSS LEVELS

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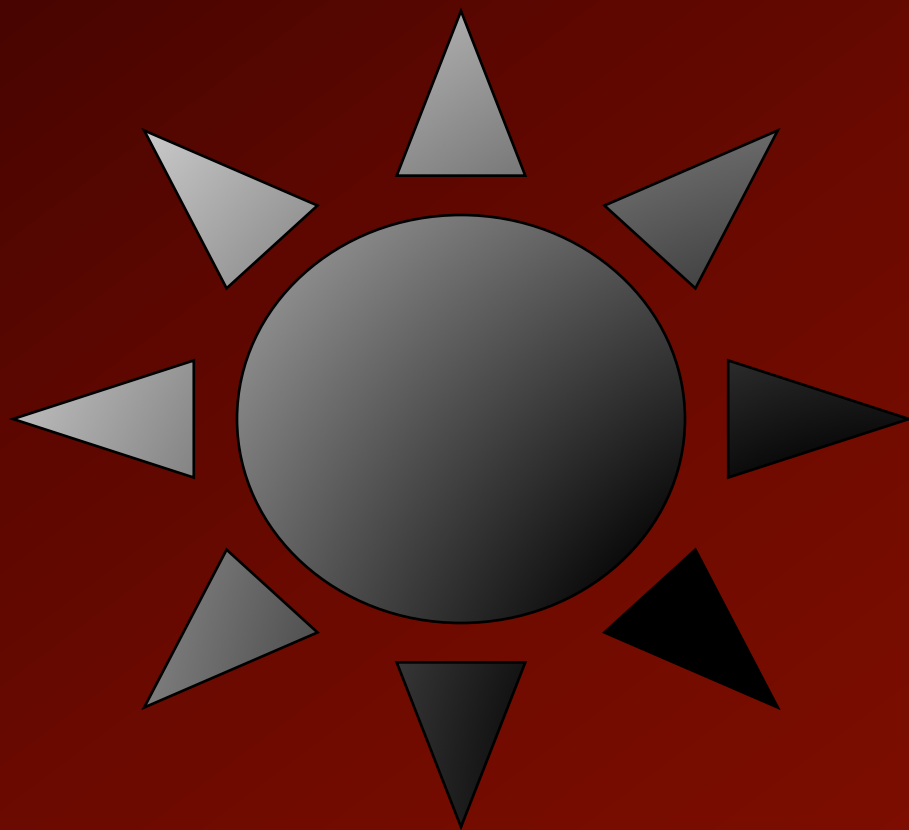
**LARGE-SCALE BEHAVIORAL MODELS OF LAND USE CHANGE**  
**AIMES-GLP Workshop**  
**Arizona State University**  
**September 8-10, 2019**

# HIERARCHICAL SYSTEMS THEORY



- Scaling-up models of landscapes to the Earth System is  $\gg$  than a scale problem

- ◆ NEAR-DECOMPOSABLE SYSTEMS
- ◆ CROSS-LEVEL INTERACTIONS
- ◆ CONTROL HIERARCHIES



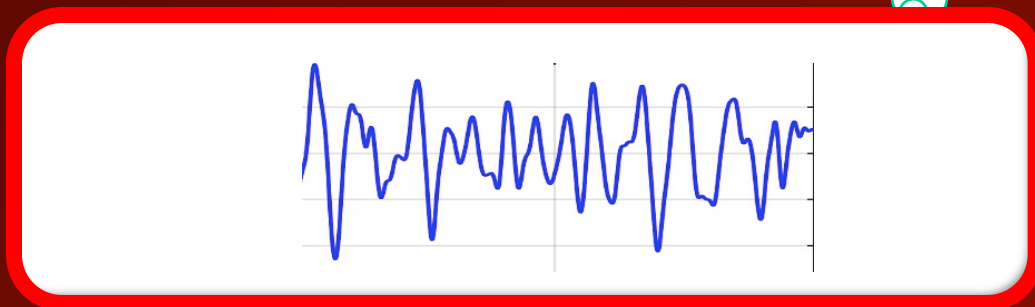
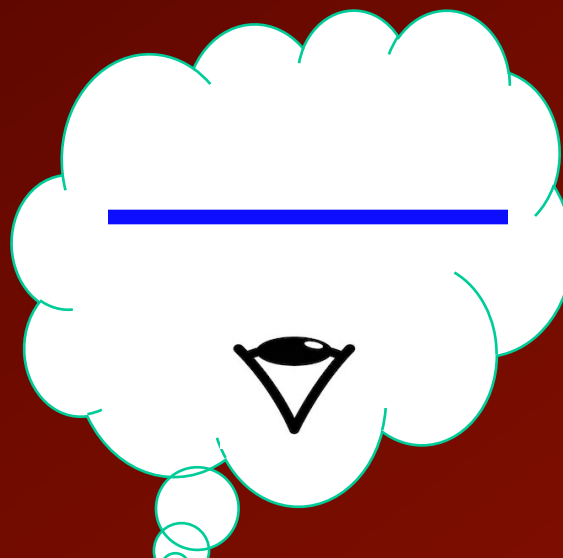
# NEAR- DECOMPOSABLE SYSTEMS: the typical approach:

write dynamical equations for  
one level at a time assuming:

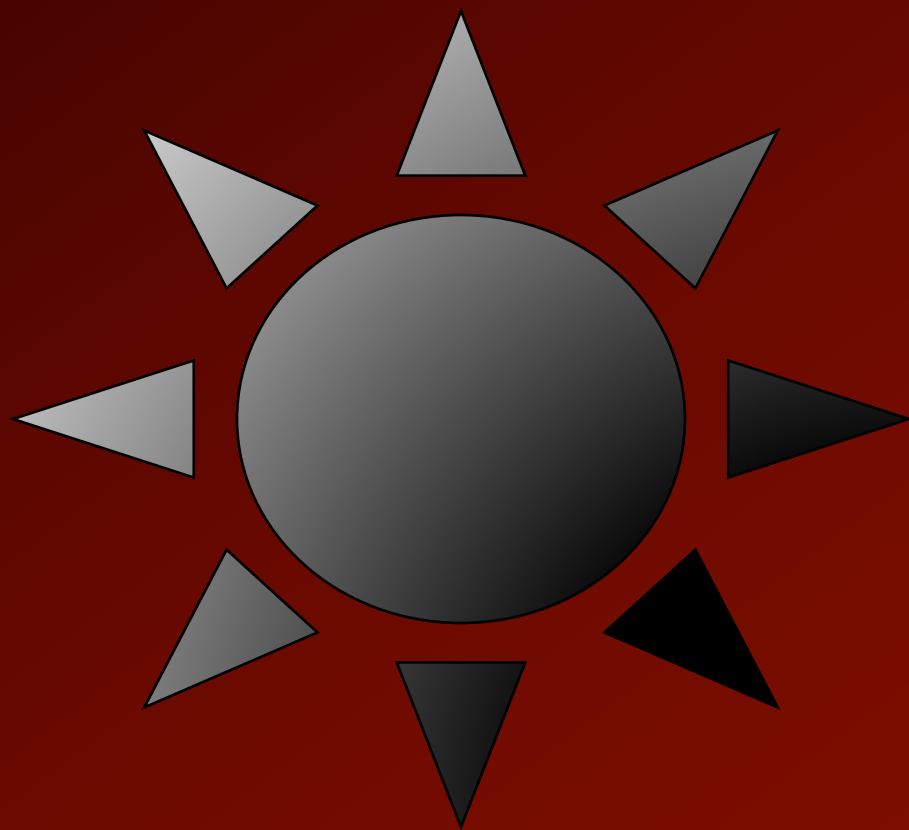
1. the fast motions one level  
down are averaged out
2. the slow motions one level  
up are constant



L+1



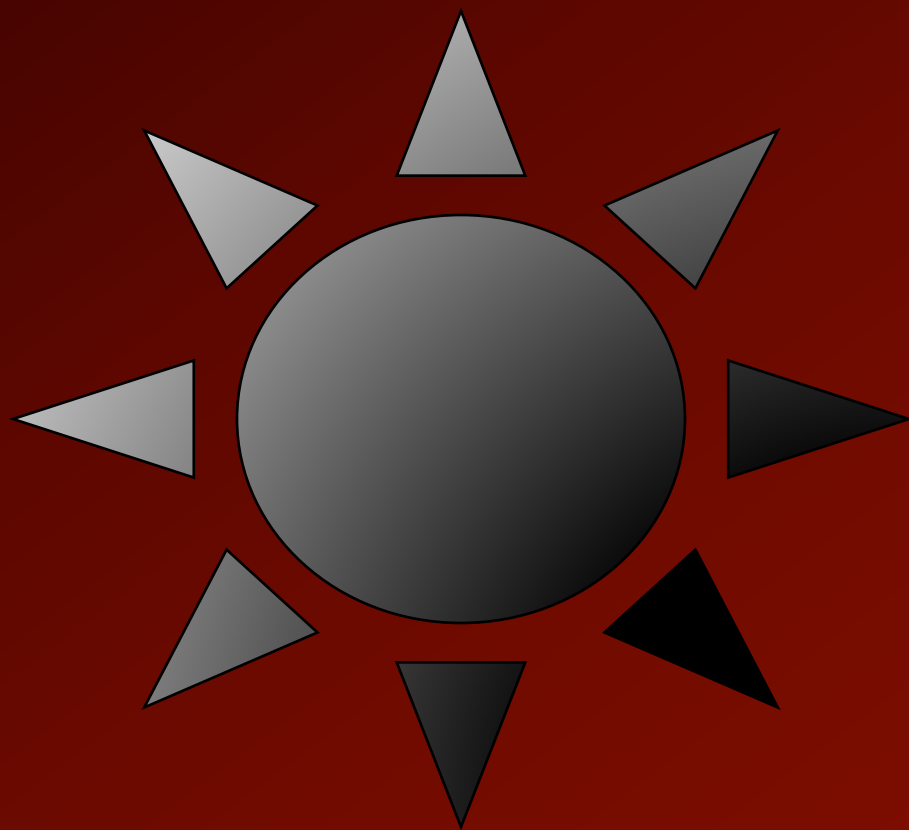
L





# CROSS-LEVEL INTERACTIONS

- If there is a strong dynamic interaction between different levels, asymmetry breaks down → assumption of near-decomposability ceases to hold, and strong nonlinear vertical couplings between subsystems dominate the dynamics of the whole.



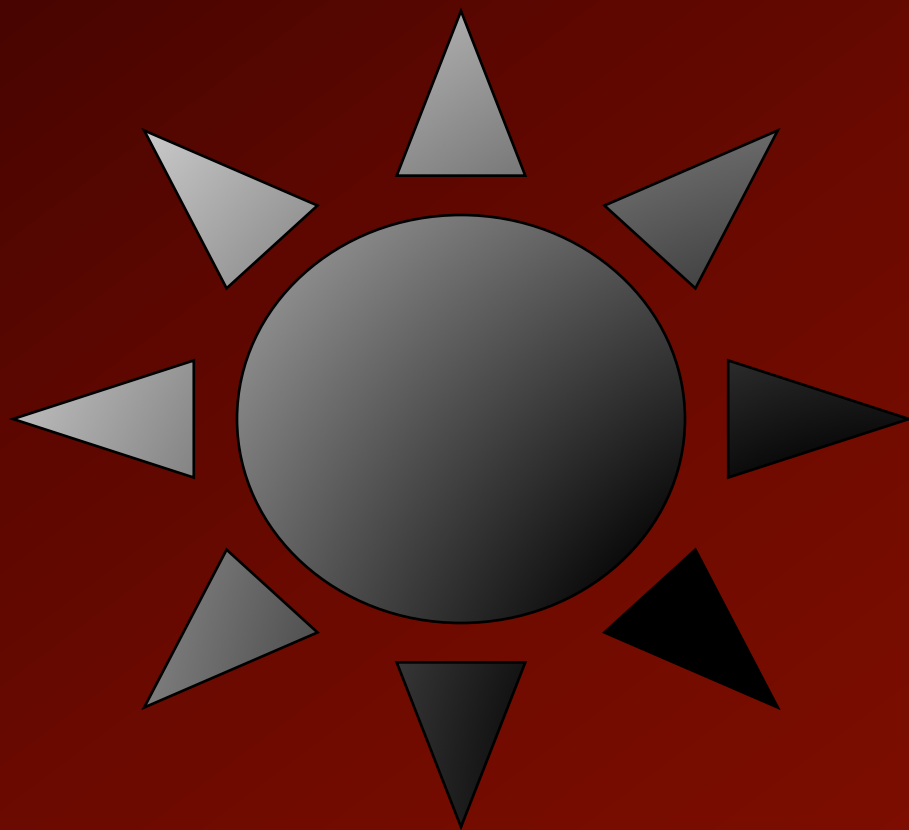
# CONTROL HIERARCHIES

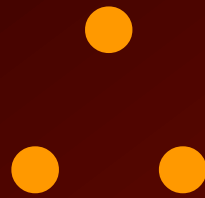
- Where there is a (biophysical or social) control hierarchy (an active authority relation -or a binding influence- of the upper level over the elements of the lower), the assumption of near-decomposability may break-down

- In a **control hierarchy** the upper level exerts a specific constraint on the details of the motion at lower level → the fast dynamics of the lower level cannot simply be averaged out. The upper level now also acts as a constraint on the motions of selected individual subunits.

∴ feedback path between levels

- Then one must take into account at least two levels at a time, and the one-particle approximation fails because the constrained subunits are atypical.





Attention to the relevant time and space scales in the consideration of the interactions between the landscape and the ES

+

Identify possible cross-scale influences that are important for the dynamics of the whole

