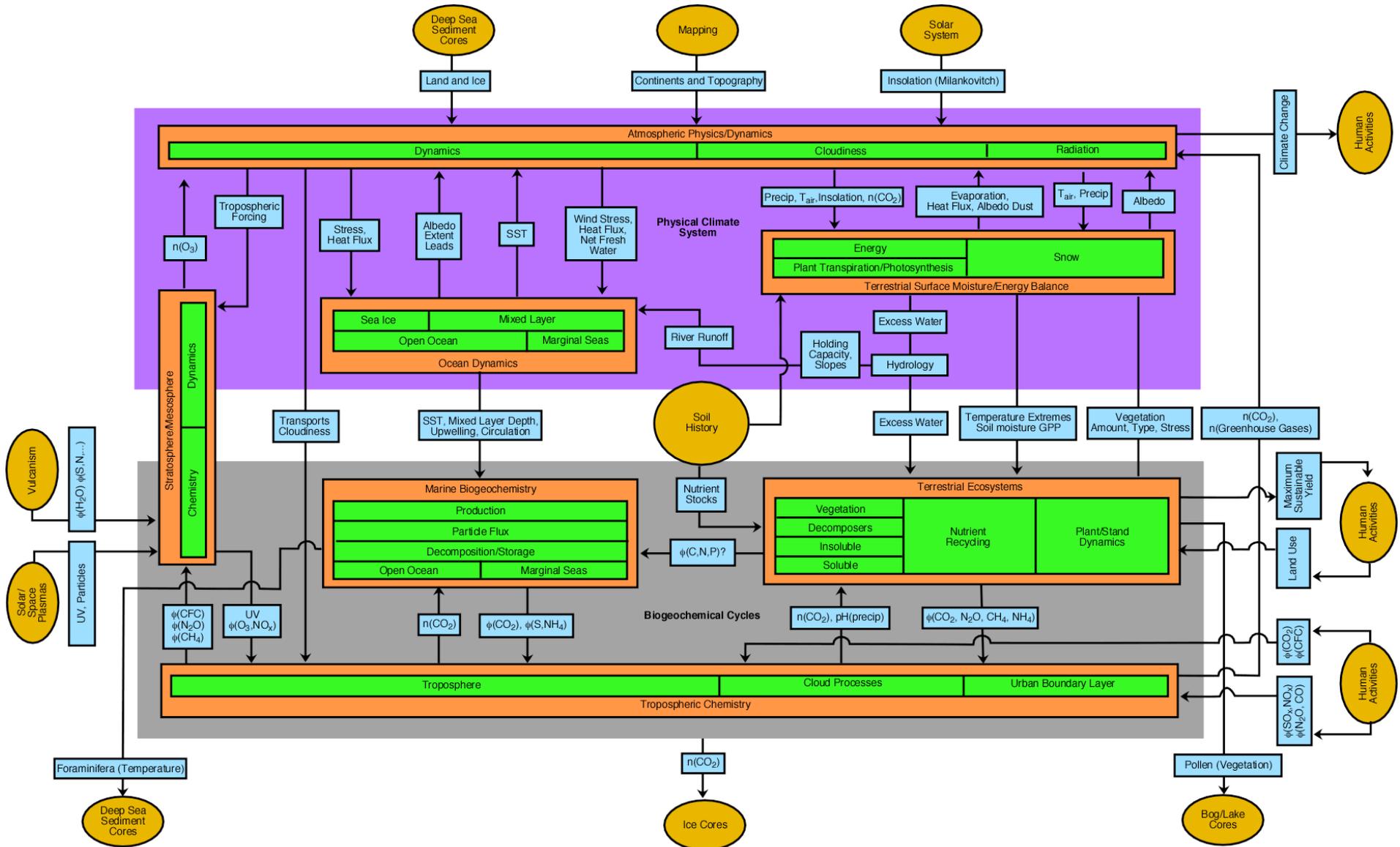The CEDAR-GEM System

Thomas Immel (University of California, Berkeley)

Outline:

•How do you represent a system?

   • a complex, historical example

   • a simpler example

•A CEDAR-GEM system diagram

•Where do we go from here?

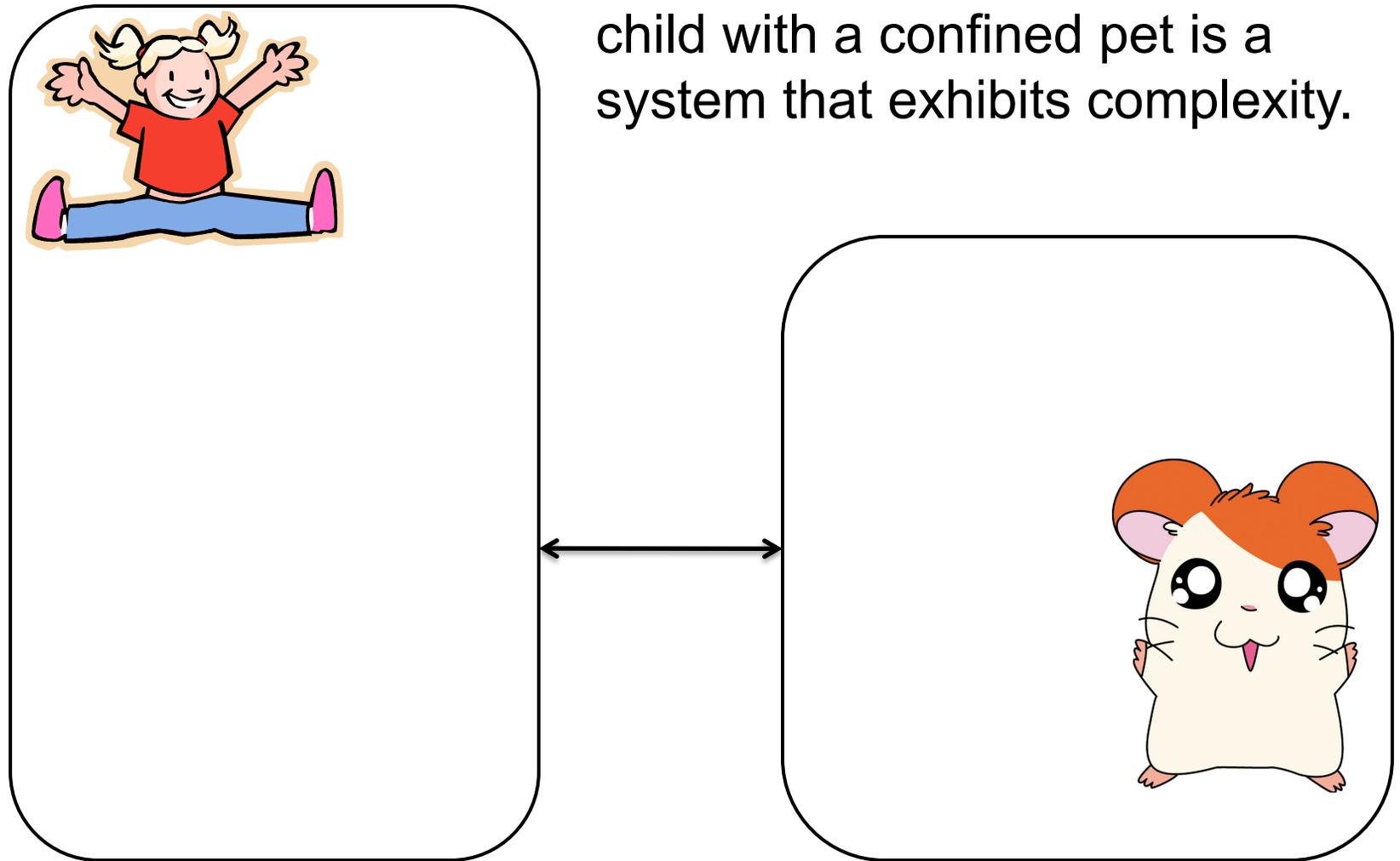# A Complex System: Terrestrial Climate and Biochemistry

Fluid and Biological Earth Processes: Detailed Information Flow
[φ(...)=flux, n(...)=concentration

Figure 3 from NASA Advisory Council Earth System Sciences Committee, Earth System Science Overview, Washington, D.C., May 1986.
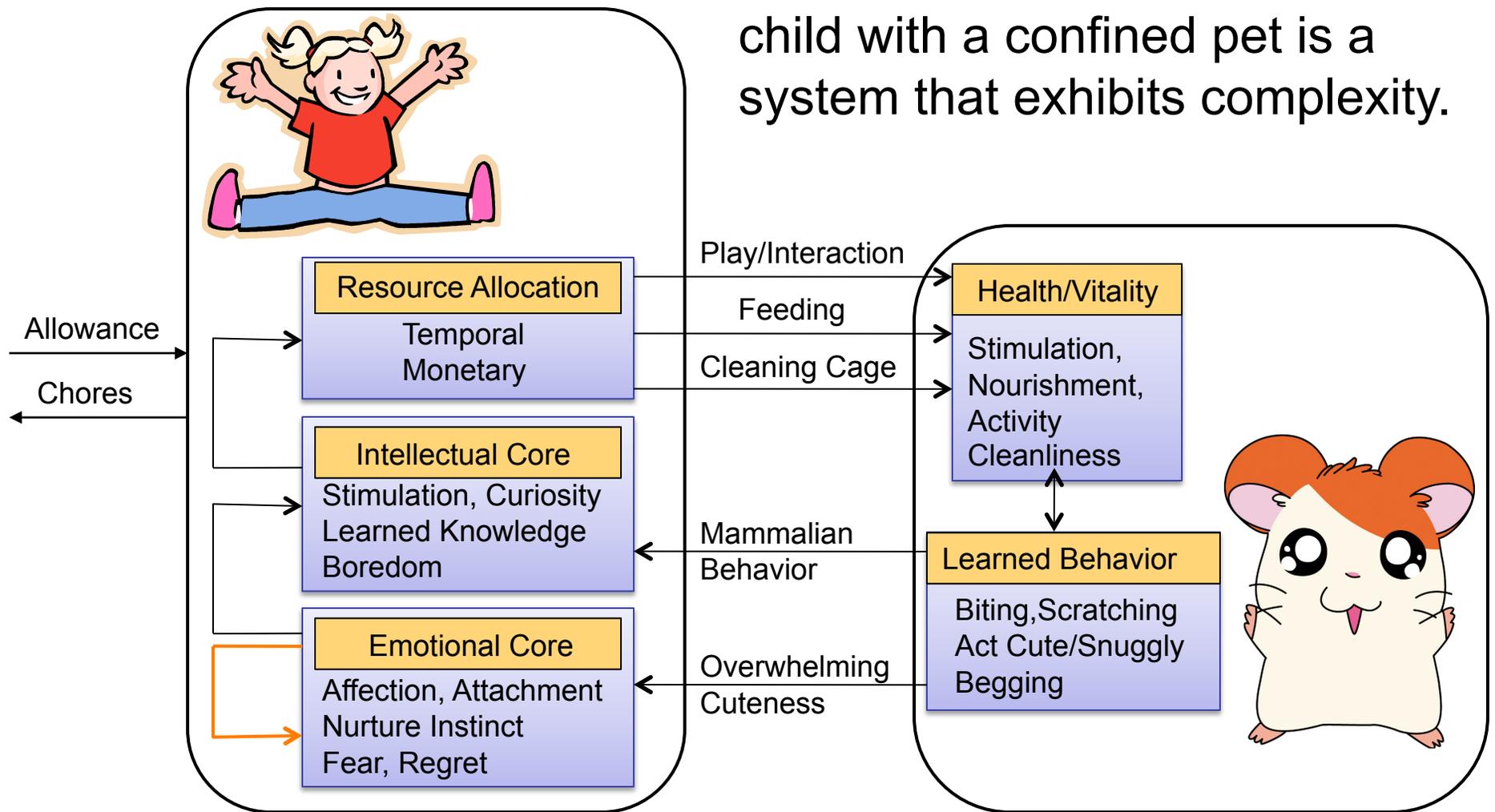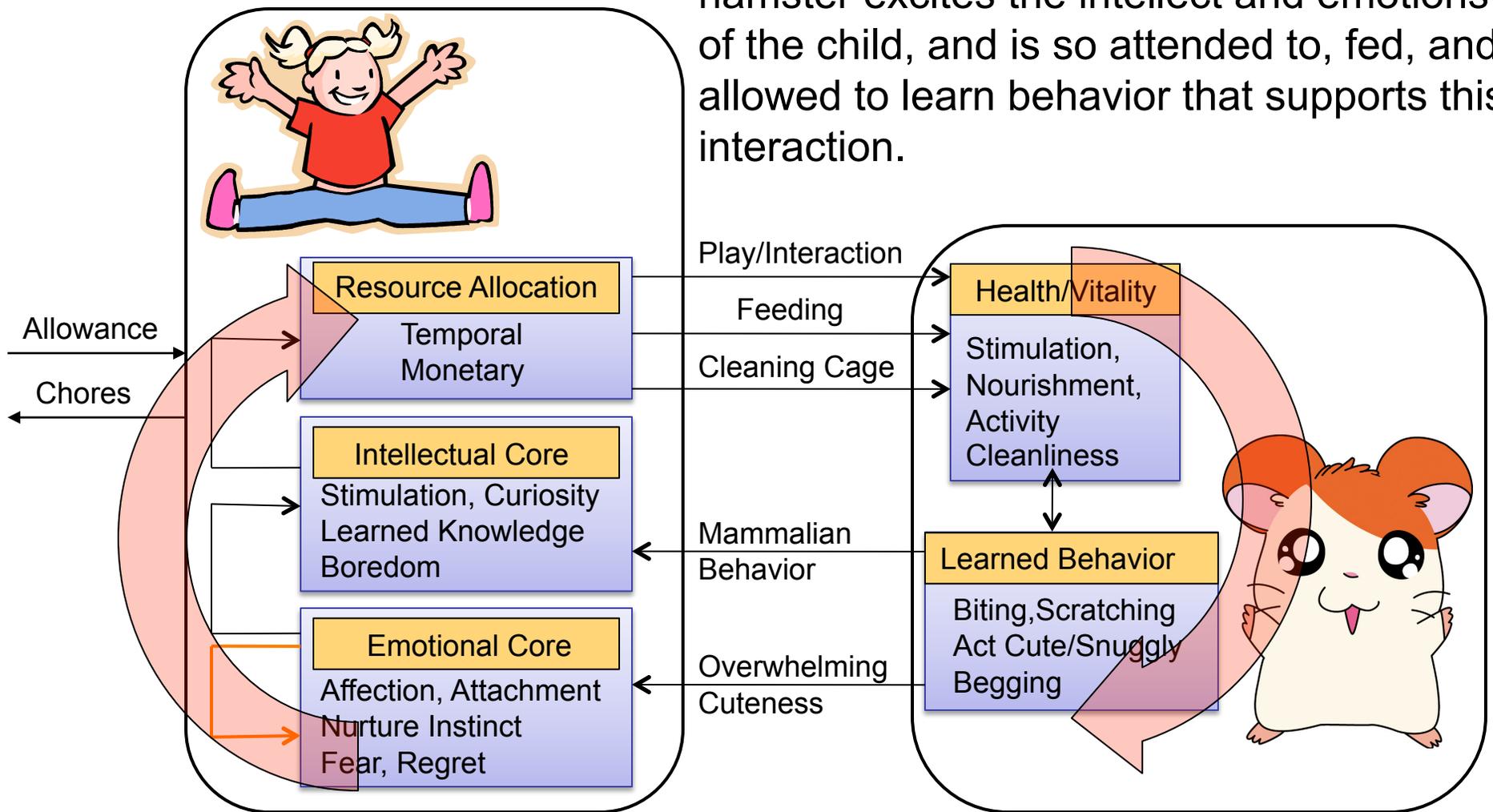
A Simpler System : The Human - Hamster System

The relation/interaction of a child with a confined pet is a system that exhibits complexity.

A Simpler System : The Human - Hamster System

The relation/interaction of a child with a confined pet is a system that exhibits complexity.

Allowance

Chores

Resource Allocation
Temporal
Monetary

Intellectual Core
Stimulation, Curiosity
Learned Knowledge
Boredom

Emotional Core
Affection, Attachment
Nurture Instinct
Fear, Regret

Play/Interaction

Feeding

Cleaning Cage

Mammalian Behavior

Overwhelming Cuteness

Health/Vitality
Stimulation,
Nourishment,
Activity
Cleanliness

Learned Behavior
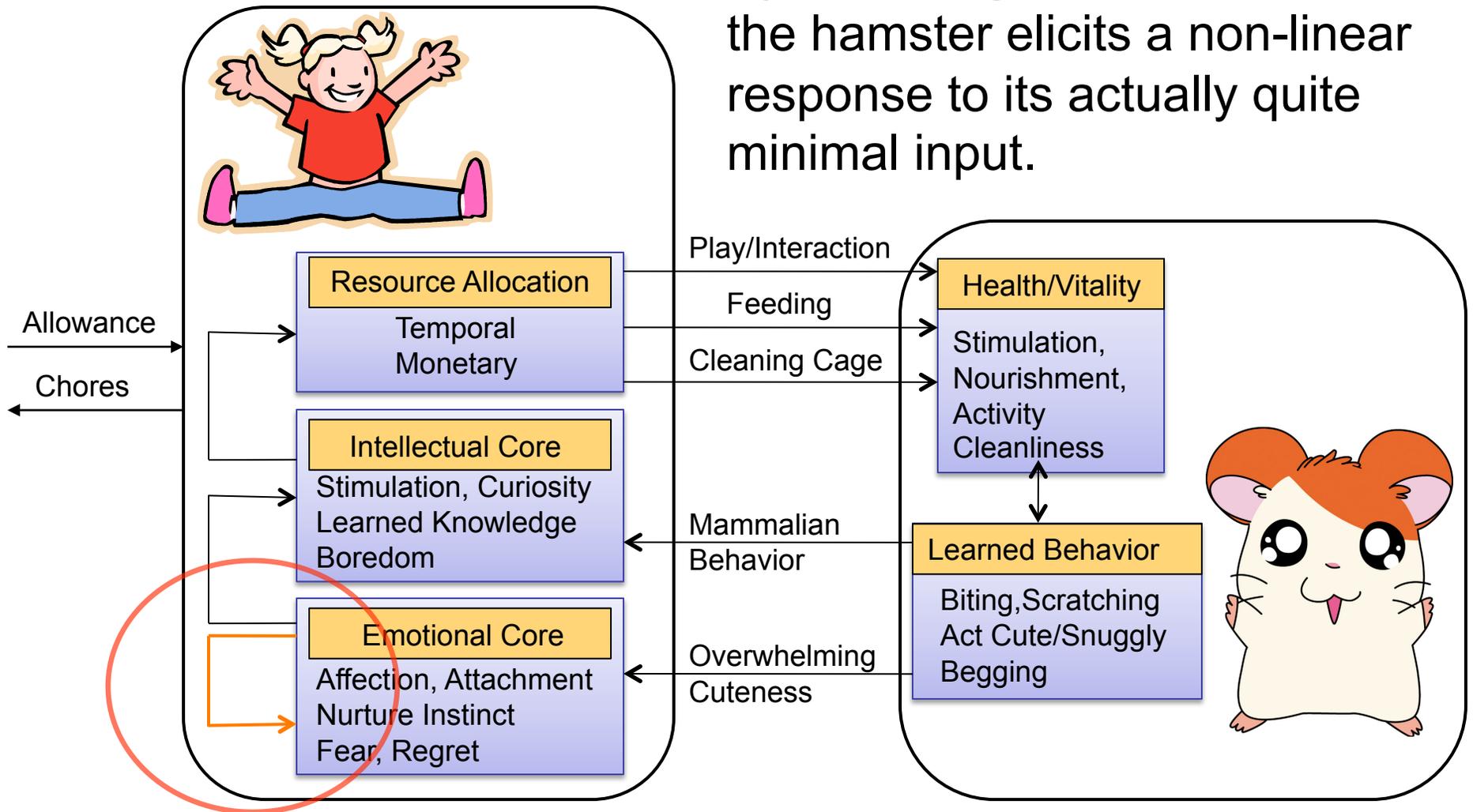Biting,Scratching
Act Cute/Snuggly
Begging

A Simpler System : The Human - Hamster System

A feedback loop exists, whereby the hamster excites the intellect and emotions of the child, and is so attended to, fed, and allowed to learn behavior that supports this interaction.

Allowance

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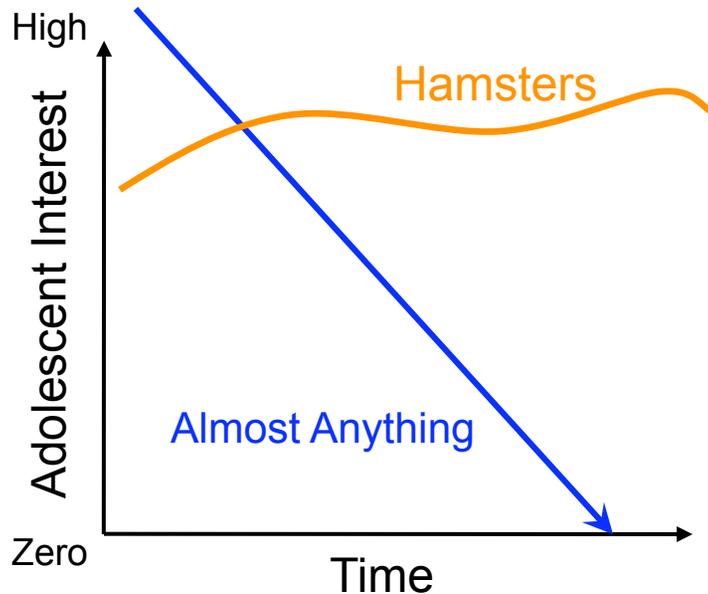Biting,Scratching
Act Cute/Snuggly
Begging

A Simpler System : The Human - Hamster System

By activating human emotions, the hamster elicits a non-linear response to its actually quite minimal input.

Allowance →

Chores ←

Resource Allocation
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Monetary

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Cuteness

Thomas Immel (University of California, Berkeley), CEDAR-GEM 2011, Santa Fe

# A Simpler System : The Human - Hamster System

The combination of feedback and non-linear response in the system contribute to childrens' interest in hamsters greater than practically any other thing.
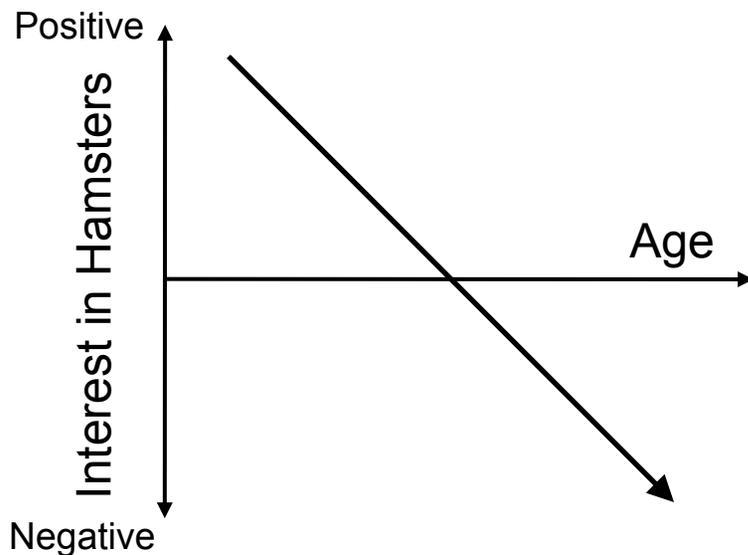
System preconditioning comes in several forms.
• Age of owner (sensitivity to initial conditions (see plot))
• Has the child ever suffered hamster bites? (memory)
• How long has the child been asking for a hamster? (instability)

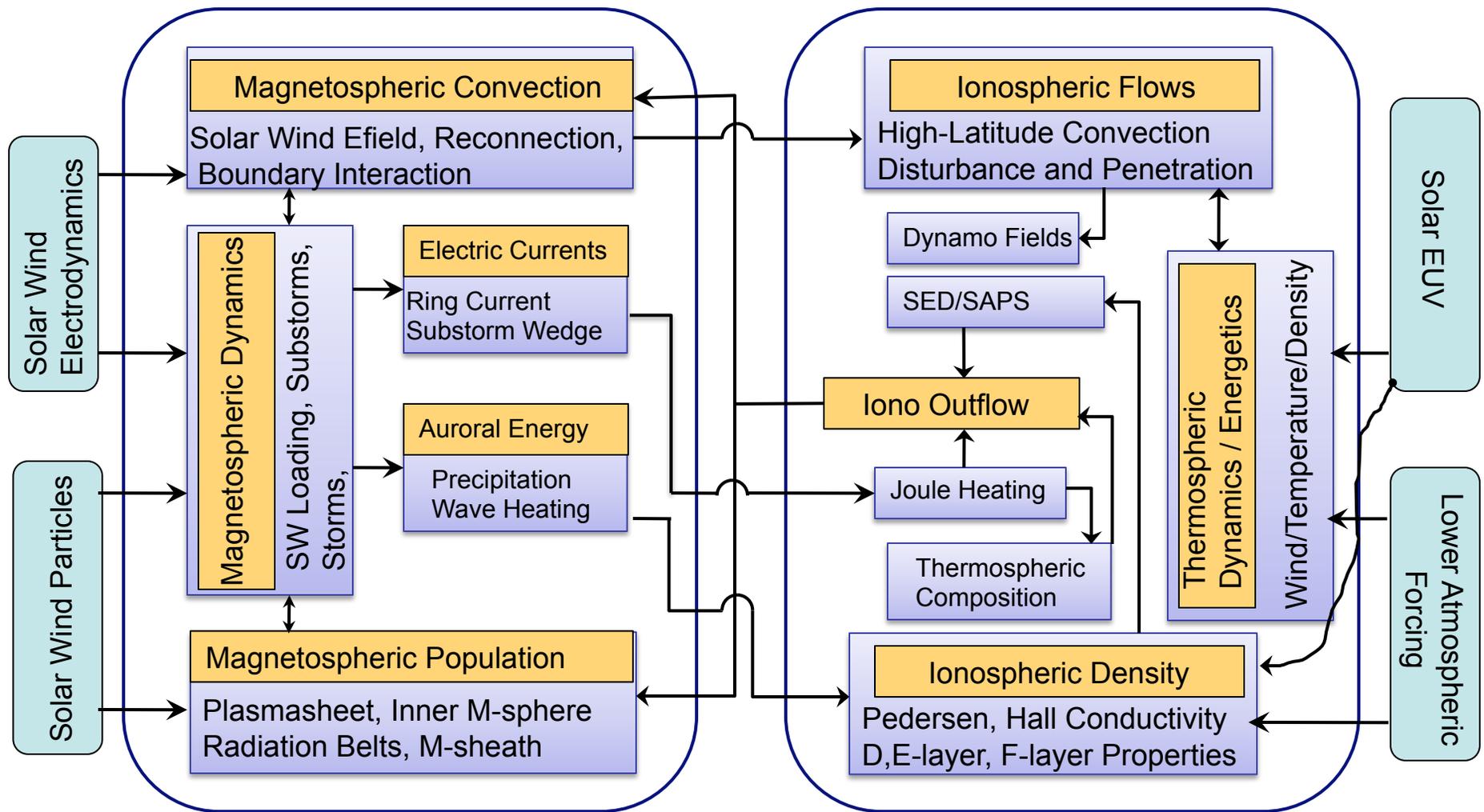Emergent Behavior
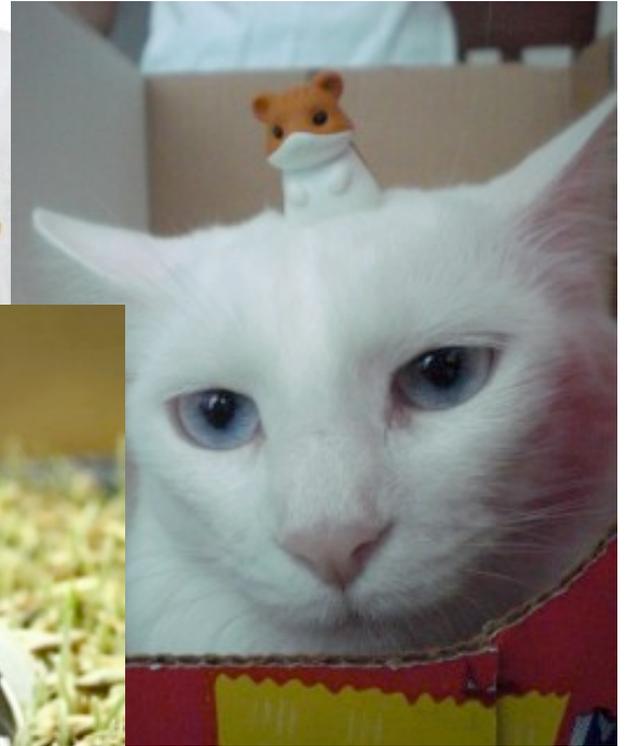
System Diagram Findings

Limitations

• It's difficult to represent time dependence.

• Actual effects of feedback are left to the reader to guess.

• A limited hierarchy in representation types mixes weak and strong drivers together.

• Complexity involved with preconditioning, memory, instability are best described separately.
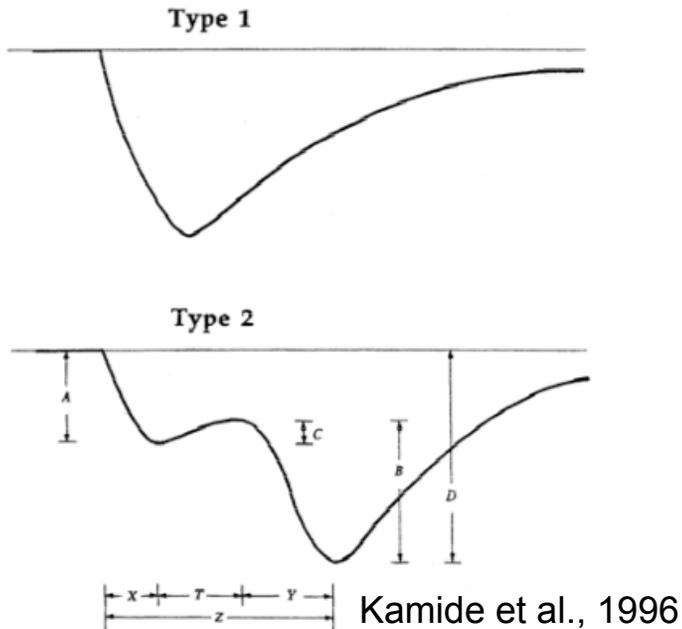
Strengths

• It allows one to convey important aspects of a dynamic system to a wide audience.

• It reduces a system to components that can be identified for focused study.

• Correctly done, it can be an enduring statement and signature of the level of knowledge in a scientific field.
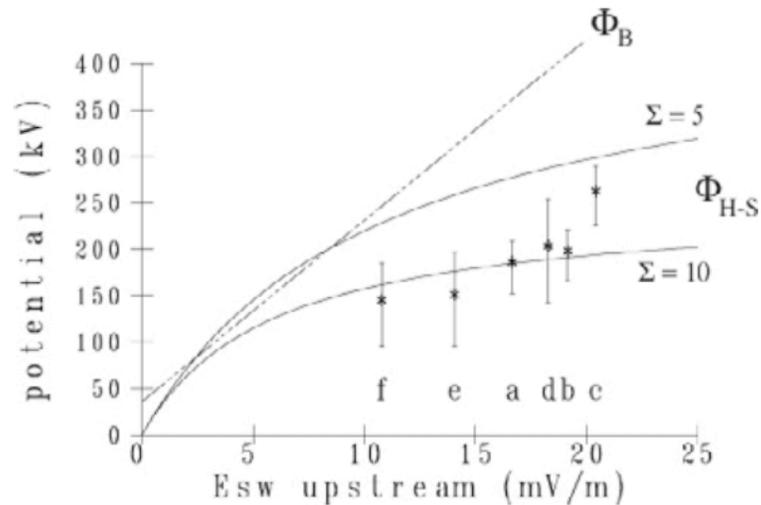
An example CEDAR-GEM system diagram

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The CEDAR-GEM system diagram
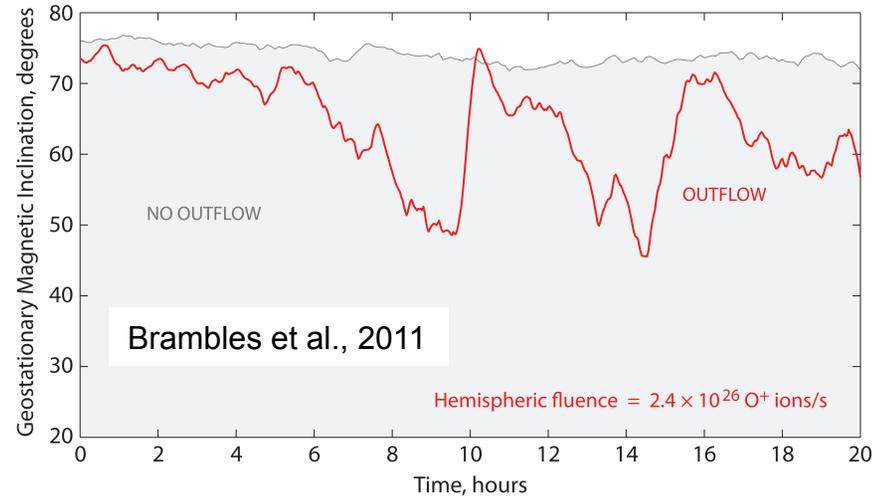
Type 1

Type 2

Kamide et al., 1996
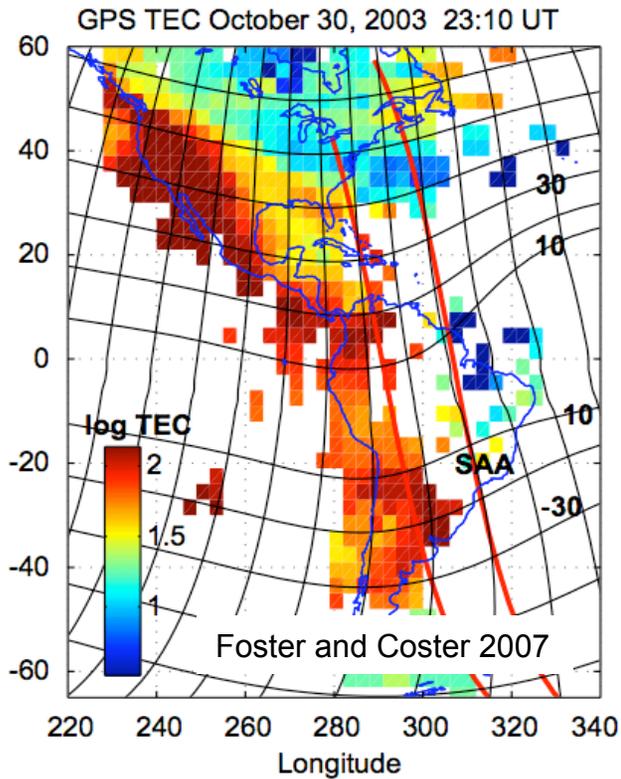
System preconditioning and memory is believed responsible for the susceptibility of the magnetosphere to 2-stepped geomagnetic storms.

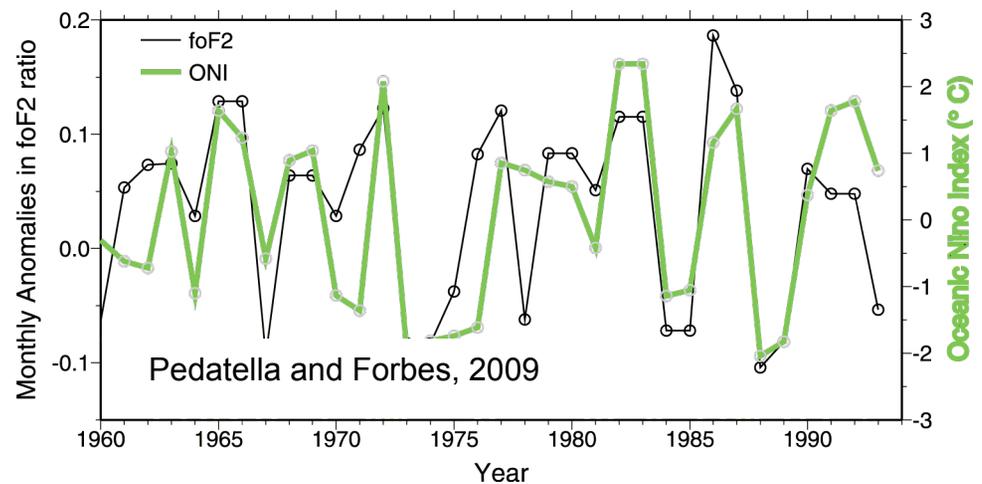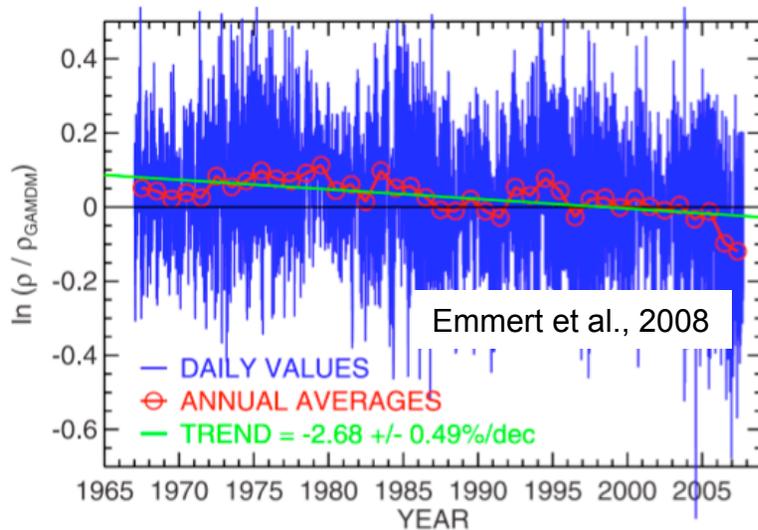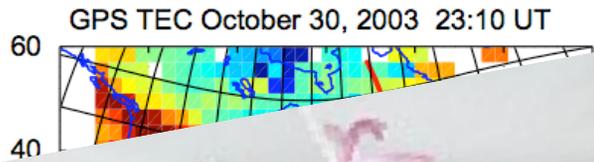The non-linear response of the cross-polar-cap potential to the imposed potential in the solar wind may be due in part to feedback in the system.
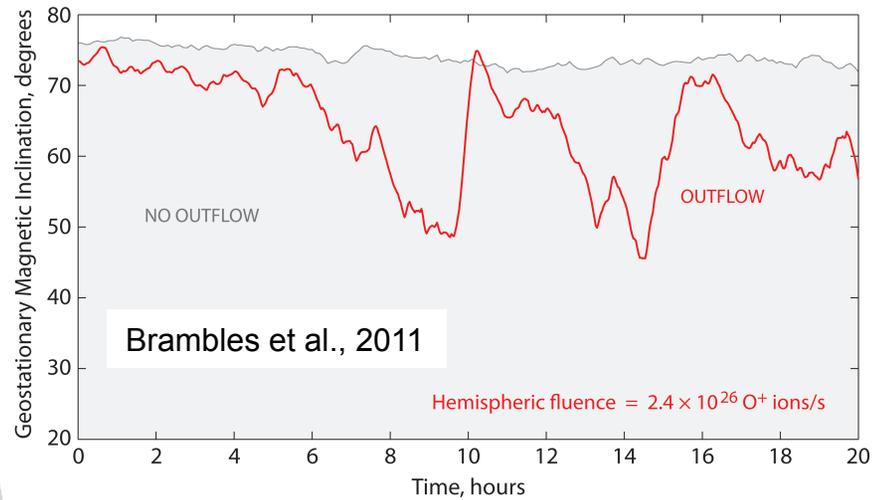
Hairston et al., 2003

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Emergent Behavior?

GPS TEC October 30, 2003 23:10 UT

log TEC

SAA

Foster and Coster 2007

Brambles et al., 2011

NO OUTFLOW

OUTFLOW

Hemispheric fluence = 2.4×10^{26} O$^+$ ions/s

Do any aspects of the GEM-CEDAR system exhibit behavior that could reasonably be termed "emergent"?

— foF2
— ONI

Pedatella and Forbes, 2009

$\ln(\rho / \rho_{GAMDM})$

— DAILY VALUES
⊖ ANNUAL AVERAGES
— TREND = -2.68 +/- 0.49%/dec

Emmert et al., 2008

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Emergent Behavior?

Is it more "emergent" than a hamster in a party hat?

GPS TEC October 30, 2003 23:10 UT

Brambles et al., 2011

NO OUTFLOW

OUTFLOW

Hemispheric fluence = 2.4×10^{26} O$^+$ ions/s

Geostationary Magnetic Inclination, degrees

Time, hours

foF2

ONI

Oceanic Nino Index (°C)

Pedatella and Forbes, 2009

Year

YEAR

$\ln (\rho / \rho_{GAMDM})$

Thomas Immel (University of California, Berkeley), CEDAR-GEM 2011, Santa Fe
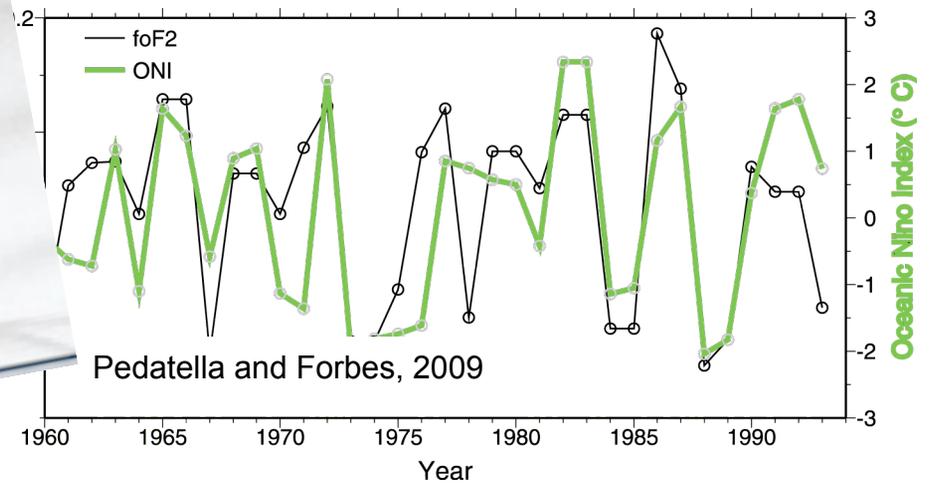
Where do we go from here?
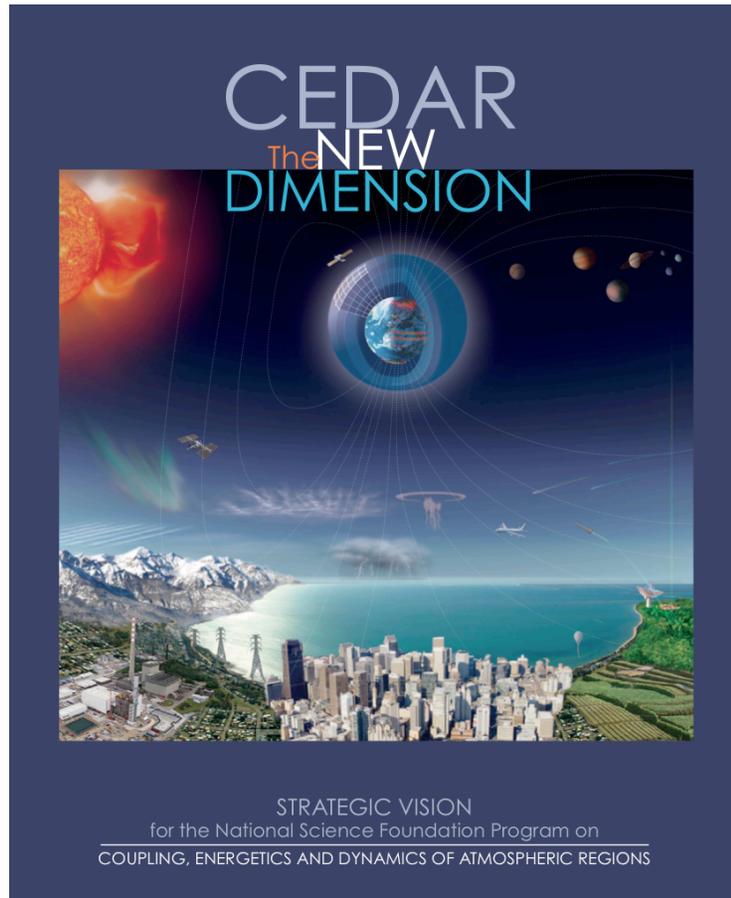
Share and discuss your views on the utility of a systems view for our fields.

Contributions to system diagram ideas are very welcome.

Damp non-linear emotional responses, or you may develop your own emergent behavior

Thomas Immel (University of California, Berkeley), CEDAR-GEM 2011, Santa Fe