Oh Crap! An Exam!

☐ First Takehome Exam (this is the Feb + March Exams).
☐ Issued Monday
☐ Due “Next Wednesday” (after Spring Break, 14 MAR) NO LATE EXAMS!
☐ It Will involve Math.
☐ It Will involve Writing
☐ See and Live my guidelines to writing an essay exam answer.
Lecture 13:  
Endogenous and Exogenous Processes 

“Bull’s Eye Diagrams” 

Accounting for Knowns and Unknowns...  
And what you want from the Data Shoppe
Agenda

- The Bull’s Eye Diagram
  - Endogenous vs Endogenous Inventories

- External Data
  - Data Assimilation
  - Data Forcing

- External Processes
  - “Parameterizations”
So far...

- Our models have been very simple in that we need only give them a small push and off they go.

- Initial Value Problems.

- Most science applications fall beyond this spectrum.
Example: Mono Lake

- Our simulation “assumed” that many variables that we know change from year to year change with time.
  - Potential Evaporation
  - Precipitation
  - Stream flow
  - Regional Water Demands...
Example: Mono Lake

- Physical Processes were also ignored
  - Basin Evaporation from Exposed Lakebed
  - Groundwater Fluxes

- At the time, these rug-sweepings were necessary to create a scenario.

- Similarly, other applications, other approximations will be needed
When I first got into this.

- Susquehanna River Basin Experiment.
  - Multiple Models
  - Different Problem Domains
  - Different Inputs
  - Different Outputs
  - Different Scales

- And no common interface!
And how I came here...
Figure 1

biophysical fluxes
- radiative transfer
- sensible/latent heat
- stomatal physiology
- momentum flux
- soil heat/snow melt
- temperatures

photosynthesis, temperature

biogeochemical fluxes
- maintenance respiration
- growth respiration
- microbial respiration
- net primary production

biomass
- vegetation
  - type
  - height
  - foliage/stem/root
- soil
  - slow
  - fast

soil water
- veg type
- biomass
- CO₂ fluxes
- NPP

ecosystem dynamics
- phenology
  - growing season
  - monthly foliage
- vegetation dynamics
  - growth
  - regeneration
  - mortality
- soil processes
  - decomposition
  - mineralization

water
- vegetation/snow/soil
- wetland/lake/glacier
- groundwater
- river

hydrologic transport
- surface/sub-surface transport
- river flow
- lake/wetland/glacier dynamics

lateral inflow

lateral outflow

lateral inflow

CO₂
- CH₄, NMHC, N₂O

T, u, v, q, CO₂, O₂
- Sₙₐₓ, Lₙₐₓ
- H, λ, E
- Sᵤₜ, Lᵤₜ
- τₓ, τᵧ

precipitation

E, snow melt

vegetation type height LAI water

Figure 1
The “Bullseye Diagram”

- Meadows and Robinson (’85)
  - An inventory of processes explicitly calculated in a model, those provided externally and those totally outside of the model’s mission parameters.
The “Bullseye Diagram”

- This is also called a “Boundary Diagram”
  - It is a useful organizing model by which to arrange your model system between that which you do internally, that which you can get from the outside and that which is just not worth the trouble (or otherwise cannot be simulated)
  - Do NOT confuse this with the term “Boundary Conditions”
The “Bullseye Diagram”

- The model (this data organizing model, that is) is divided into three categories:
  - Endogenous
  - Exogenous
  - Excluded
The “Bullseye Diagram”

- **Endogenous**
  - Model entities that are simulated completely within the simulation
  - Examples (From our previous adventures)
    - Transient Carbon Stocks
    - Bucket and Lake Volumes
    - Wabbits and Fudds
      - (and sometimes carrots!)

- **Exogenous**
- **Excluded**
The “Bullseye Diagram”

- **Exogenous**
  - Model entities prescribed outside of the computational realm
  - "Forcings"
  - Examples
    - An imposed transition rate
    - Carbon Entry Rate (a boundary condition)
    - Incoming Energy Rate (solar radiation, and sometimes carrots!)
    - Precip and PE
    - [Initial Conditions of Endogenous values]

- **Endogenous**

- **Excluded**
The “Bullseye Diagram”

- Excluded
  - Entities that are not included in the model at all.
  - Examples
    - LA Lifestyle
    - Climate Variability
    - Wabbit vs Duck “issues”
The “Bullseye Diagram”

- The “Joints”
  - What makes a parameter Endogenous and not Exogenous?
  - What makes a parameter Exogenous but not Excluded
The “Bullseye Diagram”

- **Endogenous vs Exogenous**
  - The “How” Test
    - How do we calculate net profits?
    - How do we calculate rabbit birth rates?
    - How do we represent interannual climate variability?
    - How do we determine predation rates?

- Exogenous
- Excluded
The “Bullseye Diagram”

- **Endogenous vs Exogenous**
  - Here, we are asking ourselves the manner in which a model entity is calculated.
  - Notice the alternatives we have before us:
The “Bullseye Diagram”

- **Endogenous vs Exogenous**
  - We can *prescribe* a value based on reasoned assumptions (Ex)
  - We can *calculate* it on-the-fly from other variables (En)
  - We can *force* it externally by either fixed data or data from a *coupled* model (Ex)
The “Bullseye Diagram”

- Exogenous vs. Excluded
  - The “What” Test (Parse these as you will!)
    - What Sunspot Activity?
    - What'dyamean mean, We have Ducks?
    - What kind of stupid parameter is “Lifestyle?”
Exogenous vs. Excluded

- These are the questions of keeping a process in a model or ignoring it all together
- [These are also the questions you need to be ready to answer!]

The “Bullseye Diagram”
The “Bullseye Diagram”

- Exogenous vs. Excluded
  - Always remember that a model is an hobbled approximation to reality by necessity!
  - The degree of that hobbling is a different matter.
Notebook Assignment

☐ Do an inventory of your pet modeling problems
  ☐ Exogenous
    ☐ Why you need it on-the-fly?
  ☐ Endogenous
    ☐ Criteria for “stepping” it down when there is an option to do it explicitly?
  ☐ Excluded
    ☐ Ditto for the criteria: Why are you excluding/including it.
    ☐ Be reasonable & honest here
      ☐ Cover the obvious issues, not specious road spikes.
      ☐ Butterflies in Bali are not an item to include.
Onto “Forcing”

- What is External Forcing
  - Forcing is the injection of “foreign” data into your model environment.
  - Can be injected across the domain or at the "boundaries" (These are Boundary Conditions)
  - This is often restricted to Dynamic Information, not held constant at initialization but not always
  - Keep your eyes on the user’s context
Onto “Forcing”

- What is External Forcing
  - Forcing is the injection of “foreign” data into your model environment.
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  - Keep your eyes on the user’s context
Exogenous Model Forcing

- What is External Forcing
  - Forcings *can* be imported from a separate model (a coupled model system)
    - This can draw the line between exogenous and endogenous data.
  - How to draw the line?
    - Difficult Question
    - Difficult Example:
Coupled Hydrologic Modeling

Numerical Weather Prediction Model

SURFACE HYDROLOGY COMPONENT

LSM

OFM

CRM

RESERVOIR

WATER FLUXES

HEAD DIFFERENCES

RUNOFF

SURFACE H2O DEPTH

INfiltration

GROUNDWATER RECHARGE

SPRING FLOW & SWALLOW HOLES

SPRAY FLOW

SWALLOW HOLE LOSS & SEEPAGE

CHANNEL FLOW

RESERVOIR

MODFLOW
Exogenous Model Forcing

- When is Exogenous Forcing from an “external” model an Endogenous Coupling?
  - Where do you cut a roast?
    - At the joints.
  - Where do you cut a model?
    - At the disruptions
  - Good Rule of Thumb.
    - Disparate Time Steps?
    - Stop/Start Data Exchanges
Exogenous Model Forcing

- When is Exogenous Forcing from an “external” coupled model an Endogenous Coupling?
  - Good Rule of Thumb for an Exogenous Forcing of an adjacent running model
  - Disparate Time Steps?
    - Is the subroutine in question called periodically? (debatable)
  - Disparate Spatial Scales?
    - Do you have to aggregate or disaggregate dataset?
  - Stop/Start Data Exchanges?
    - Does the execution of a model shell terminate and hold while a “coupled” component’s process is spawned and run? Can be automatic or user-interrupted
Endogenous Coupling?

Numerical Weather Prediction Model

SURFACE HYDROLOGY COMPONENT

LSM

RUNOFF
SURFACE H₂O DEPTH
INfiltration

OFM

CHANNEL FLOW
SWALLOW HOLE LOSS & SEEPAGE

CRM

SPRING FLOW
HEAD DIFFERENCES

RESERVOIR

GROUNDWATER RECHARGE

WATER FLUXES

RESERVOIR

MODFLOW

21 Feb 2007
ATM 515: Intro Env Modeling : Endogenous and Exogenous Data and Processes
Exogenous Forcing?

Numerical Weather Prediction Model

- LSM
  - INfiltration
  - REServoir
  - SURFACE H2O DEPTH
  - WATER FLUXES

SURFACE HYDROLOGY COMPONENT

- OFM
  - CHANNEL FLOW
  - SWALLOW HOLE LOSS & SEEPAGE
  - GROUNDWATER RECHARGE
  - SPRING FLOW & SWALLOW HOLES

- CRM
  - HEAD DIFFERENCES

MODFLOW
Figure 1

**Biophysical Fluxes**
- Radiative transfer
- Sensible/latent heat
- Stomatal physiology
- Momentum flux
- Soil heat/snow melt
- Temperatures

**Column Hydrology**
- Interception
- Throughfall/stemflow
- Snow hydrology
- Infiltration/surface runoff
- Soil water redistribution
- Capillary rise/drainage
- Irrigation
- Lateral inflow

**Photosynthesis, Temperature**

**Biomass**
- Vegetation
  - Type
  - Height
  - Foliage/stem/root
- Soil
  - Slow
  - Fast

**Biogeochemical Fluxes**
- Maintenance respiration
- Growth respiration
- Microbial respiration
- Net primary production
- Soil water
- Veg type
- Biomass
- CO₂ fluxes
- NPP

**Water**
- Vegetation/snow/soil
- Wetland/lake/glacier
- Groundwater
- River

**Hydrologic Transport**
- Surface/sub-surface transport
- River flow
- Lake/wetland/glacier dynamics

**Flux to Ocean**

**CO₂**
- CH₄, NMHC, N₂O

**Ecosystem Dynamics**
- Phenology
  - Growing season
  - Monthly foliage
- Vegetation dynamics
  - Growth
  - Regeneration
  - Mortality
- Soil processes
  - Decomposition
  - Mineralization
Endogenous Coupling!

Catalog this as an “easier” example:
- These two systems are specifically intertwined enough to be considered to be a clearly endogenously-coupled system.
- Stella favors this form of coupling
Does this matter?

- Well... yes.
  - Classifying a model coupling as endogenous or exogenous is important in designing a model
  - What components are absolutely essential for the operation of one range of processes?
  - What components can be made modularly exclusive and stand-alone?
  - How do you test your sub-components
Notebook Assignment II

- What aspects of your system would warrant parameterizations.
  - What endogenous parameters would be required to diagnose and execute them
  - At what spatial and temporal scales would they be needed
  - At what spatial scales could they be represented explicitly
  - At what scales could they be ejected from the model environment as irrelevant.