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Downscaling economic projections of land cover & land use change for carbon management and Earth system modeling: a multi-scalar approach

NORTH AMERICAN CARBON PROGRAM
FOURTH ALL-INVESTIGATORS MEETING
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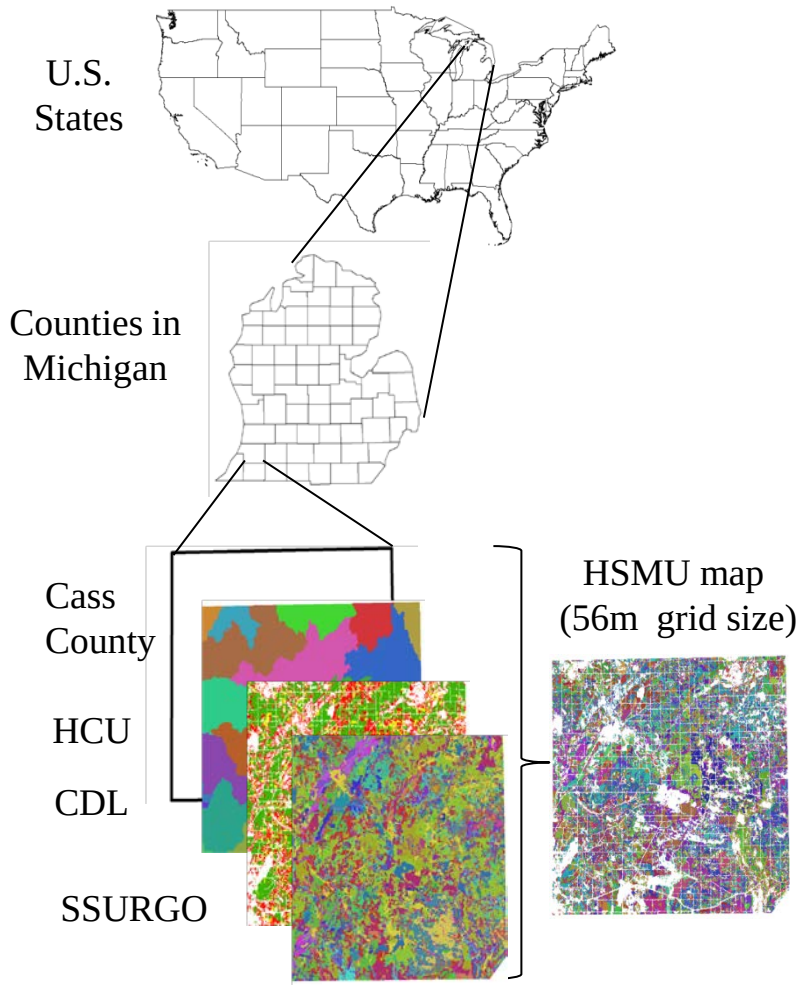
Tris West, Prasad Bandaru, Page Kyle,
Xuesong Zhang, Ben Bond-Lamberty, Allison Thomson
Joint Global Change Research Institute
Pacific Northwest National Laboratory
College Park, Maryland, USA

Carbon management - *defined*

- ***Conducting activities that alter carbon sources or sinks.***
- Usually done to reduce net CO_2 emissions (and other GHG emissions).
- Different from observation or monitoring.
  - Requires knowledge of direct and indirect consequences of human action on carbon dynamics.
  - Often requires higher spatial and temporal resolution for attribution purposes (Duren and Miller 2011).

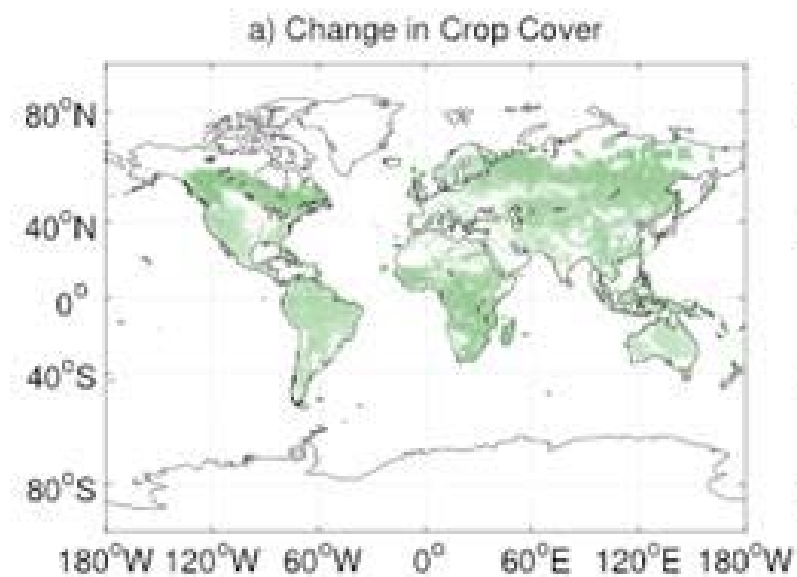
Duren, R.M. & C.E. Miller. 2011. Towards robust global greenhouse gas monitoring. Greenhouse Gas Measurement and Management 1: 80-84.

How might we model local management options across large scales within a global context?



Zhang et al. 2010. GCB Bioenergy.

?



Jones et al. 2013. Journal of Climate.

Carbon management
- consistency among scales

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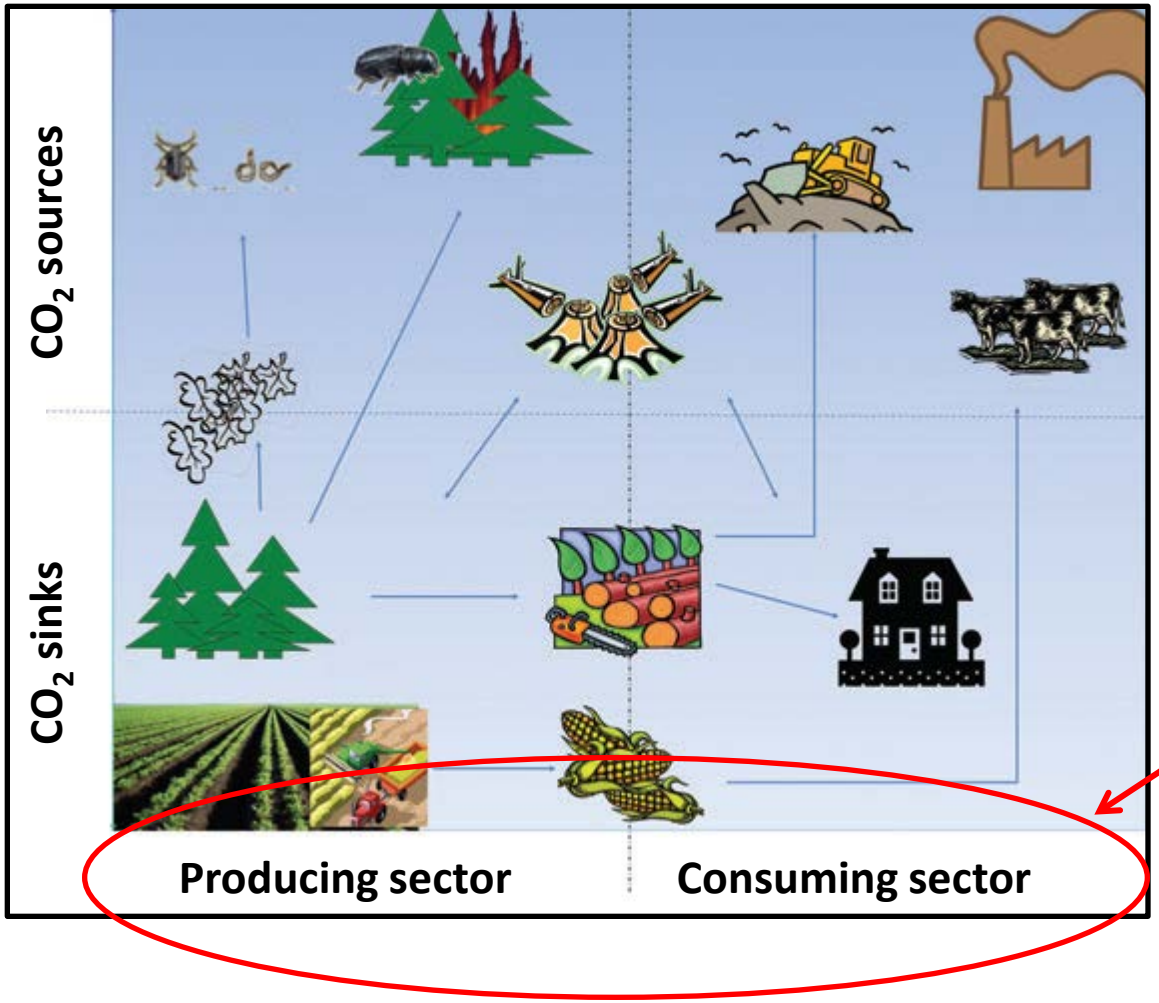
- Consistent land areas:
  - high resolution sums to course resolution;
  - distribution of land classes is similar geographically

- Consistent estimates of C stocks

- understanding drivers of land cover change and adoption of management strategies

- $$$
- See presentation by Thomson et al. (decision support theme)

Conceptual diagram of the North American CO_2 budget: sources, sinks, and lateral movement



Human Dimensions.
Economically driven.
Management and
Adaptation opportunities

From King et al. 2012. Frontiers in Ecology and Environment 10:512-519.

Some current downscaling options
- conducted independently of one another

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Land area and management data (e.g., inventory or model output) can be spatially distributed based on remotely-sensed land cover.

Data input:	County NASS or FIA; Regional land-cover change model	FAO; Global land-cover change model
Baseline land cover:	National Land Cover Data; Cropland Data Layer (<100m)	MODIS (>500m; often >0.5 degree)
Receiving model:	EPIC, Century, DNDC	CLM, Earth system models

New downscaling option
- consistent and multi-scalar

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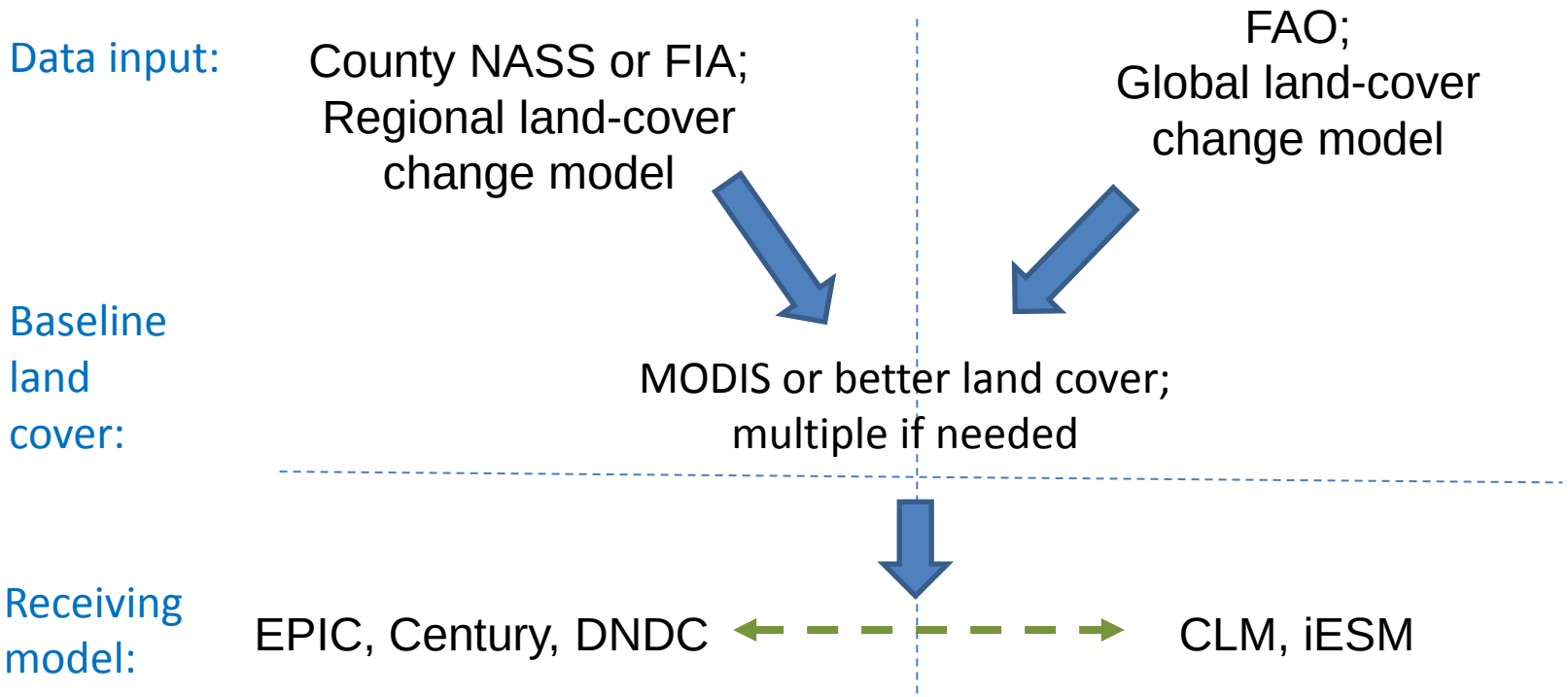
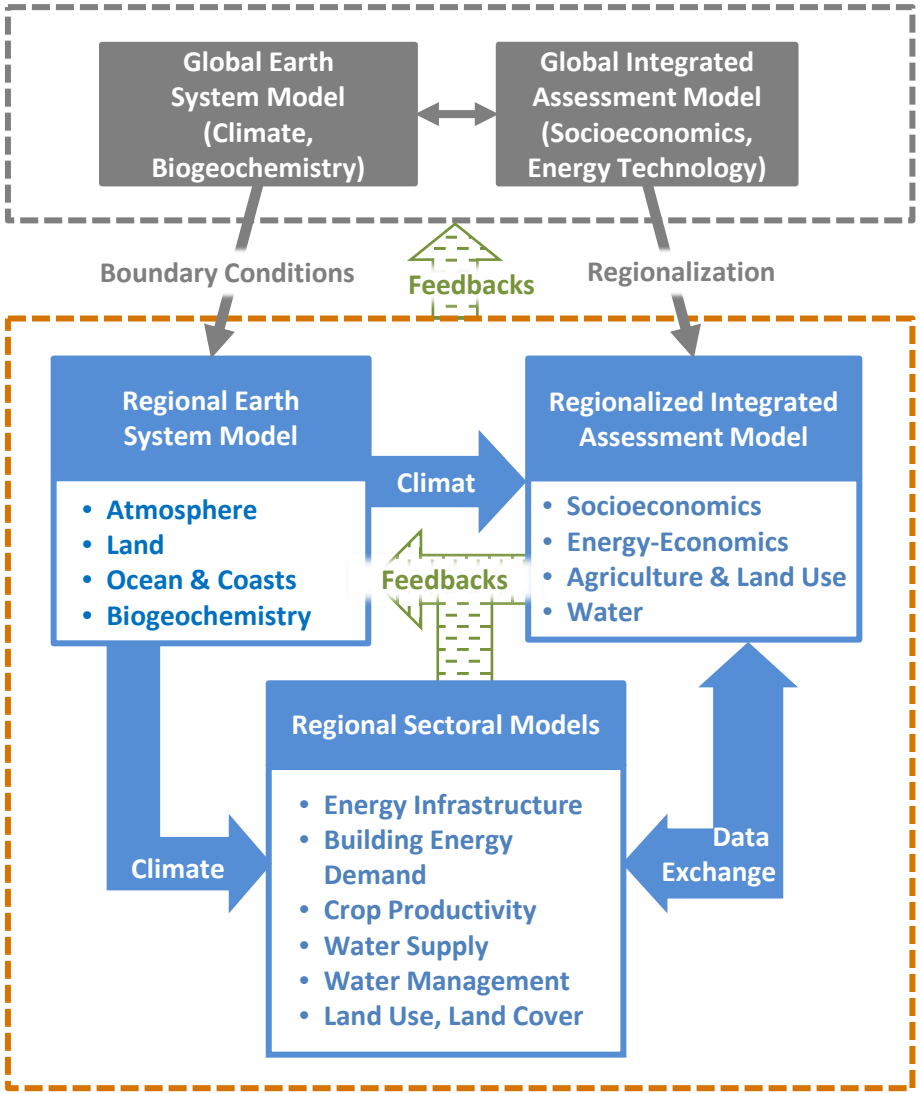


Two options:
(1) start with <100m downscaling and grid up to other needed resolutions.
(2) use one consistent method for downscaling to multiple resolutions, thereby maintaining total land areas.

Multi-scalar earth system modeling

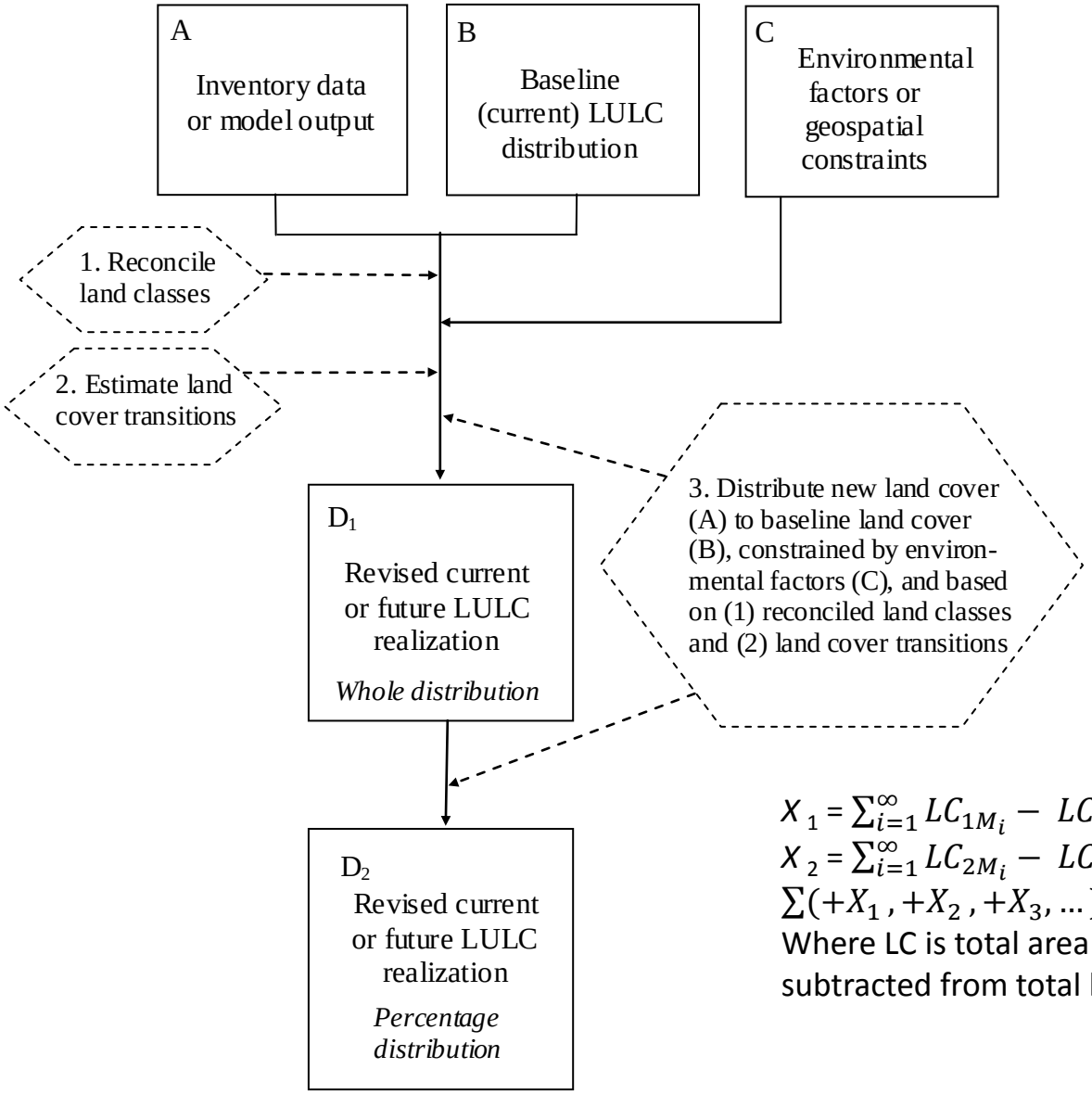


Hibbard and Janetos. 2013. The regional nature of global challenges: a need and strategy for integrated regional modeling. Climatic Change (in press)

Categorization of current methods

	Spatial Distribution	LULC Classification
Resolution: High	Pure	Homogeneous
Resolution: Low	Mixed	Heterogeneous

Consistent downscaling method



$$X_1 = \sum_{i=1}^{\infty} LC_{1M_i} - LC_{1B} \qquad \text{Eq. 1}$$

$$X_2 = \sum_{i=1}^{\infty} LC_{2M_i} - LC_{2B} \qquad \text{Eq. 2}$$

$$\sum(+X_1, +X_2, +X_3, \ldots) = \xi\left(\sum(-X_1, -X_2, -X_3, \ldots)\right) \qquad \text{Eq. 3}$$

Where LC is total area per land class in model output (M) subtracted from total land area per class in baseline (B) data.

Results - *Pure spatial distribution*

- *Obtain or generate estimates of fields or land parcels*
- Maintain parcel and original grid ID throughout processing
- Set up programming and GIS to work with >2GB files and data input x 10^6
- Follow steps in preceding diagram
- *Regrid parcels with revised land cover, maintaining original grid IDs*

Results - *Pure-homogeneous land realization*

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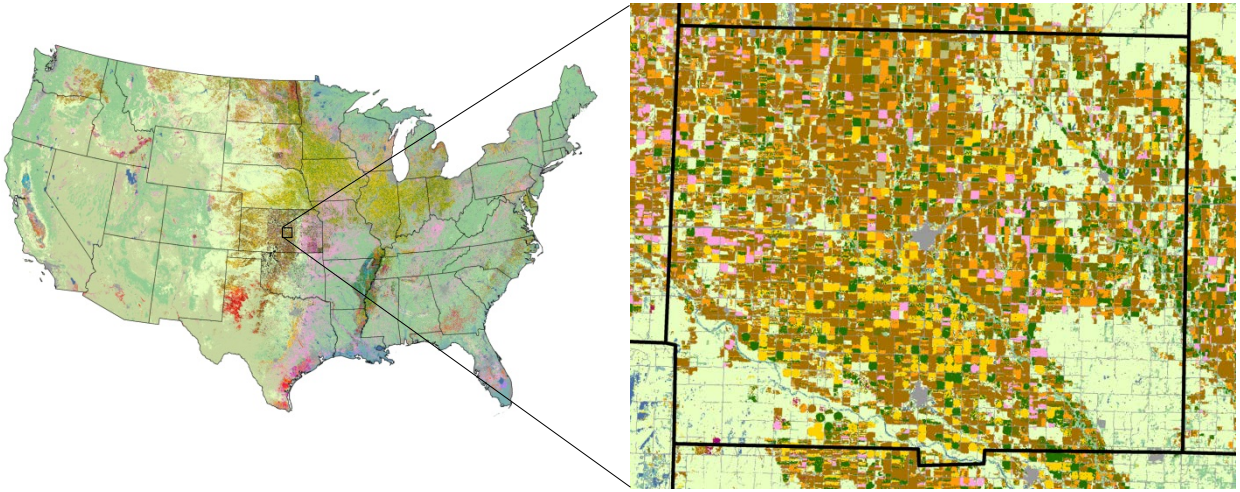
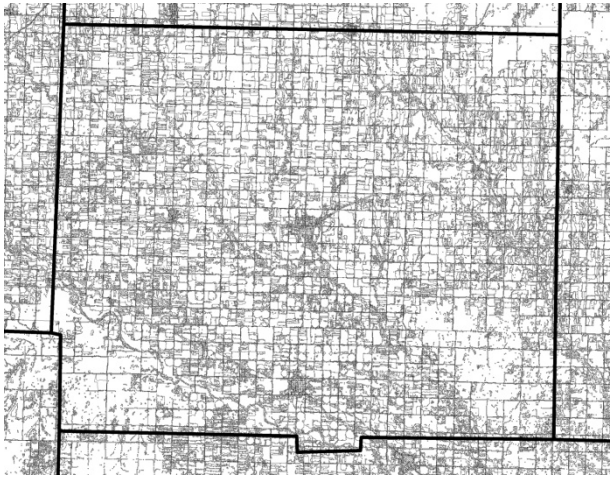
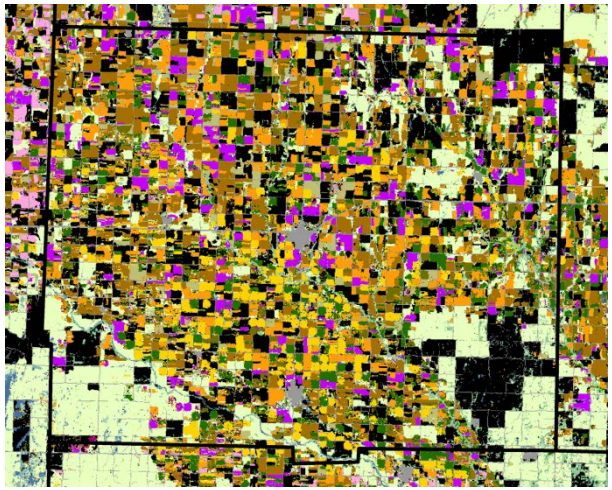
Legend

- Corn
- Cotton
- Rice
- Sorghum
- Soybeans
- Sunflowers
- Tobacco
- Barley
- Other Small Grains
- Winter Wheat/Soybeans Double-Cropped
- Rye
- Oats
- Sugarcane
- Sweet Potatoes
- Switchgrass
- Fallow/Idle Cropland
- Developed/Open Space
- Developed/Low Intensity
- Developed/Medium Intensity
- Developed/High Intensity
- Barren
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Woody Wetlands
- Herbaceous Wetlands
- Wheat
- Hay
- Pasture
- Coppice wood
- Noncoppice wood
- High yield sorghum

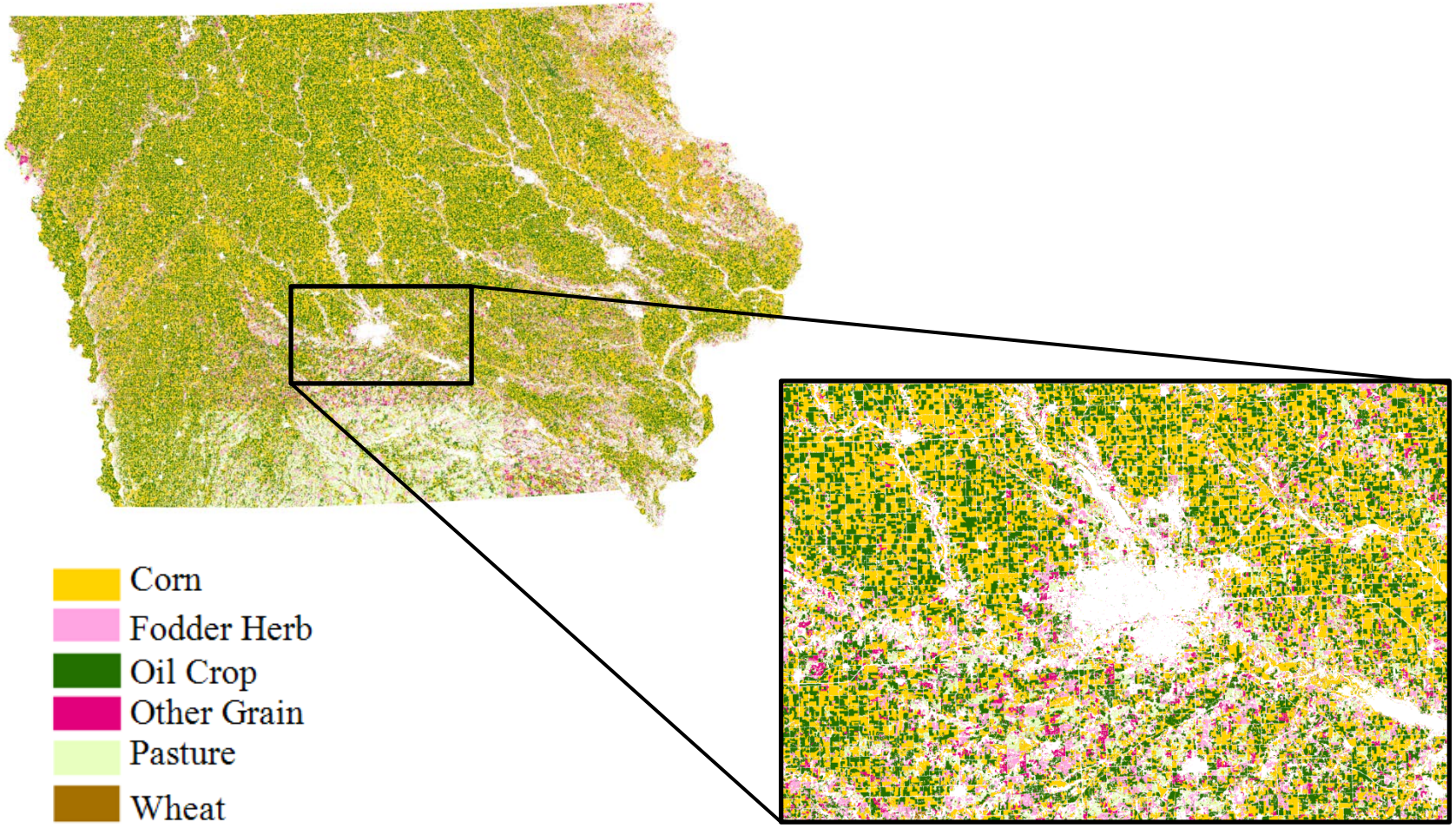






POLYSYS 2030 land realization based on meeting EISA 2007 cellulosic ethanol mandate

Results – *Pure-heterogeneous land realization*

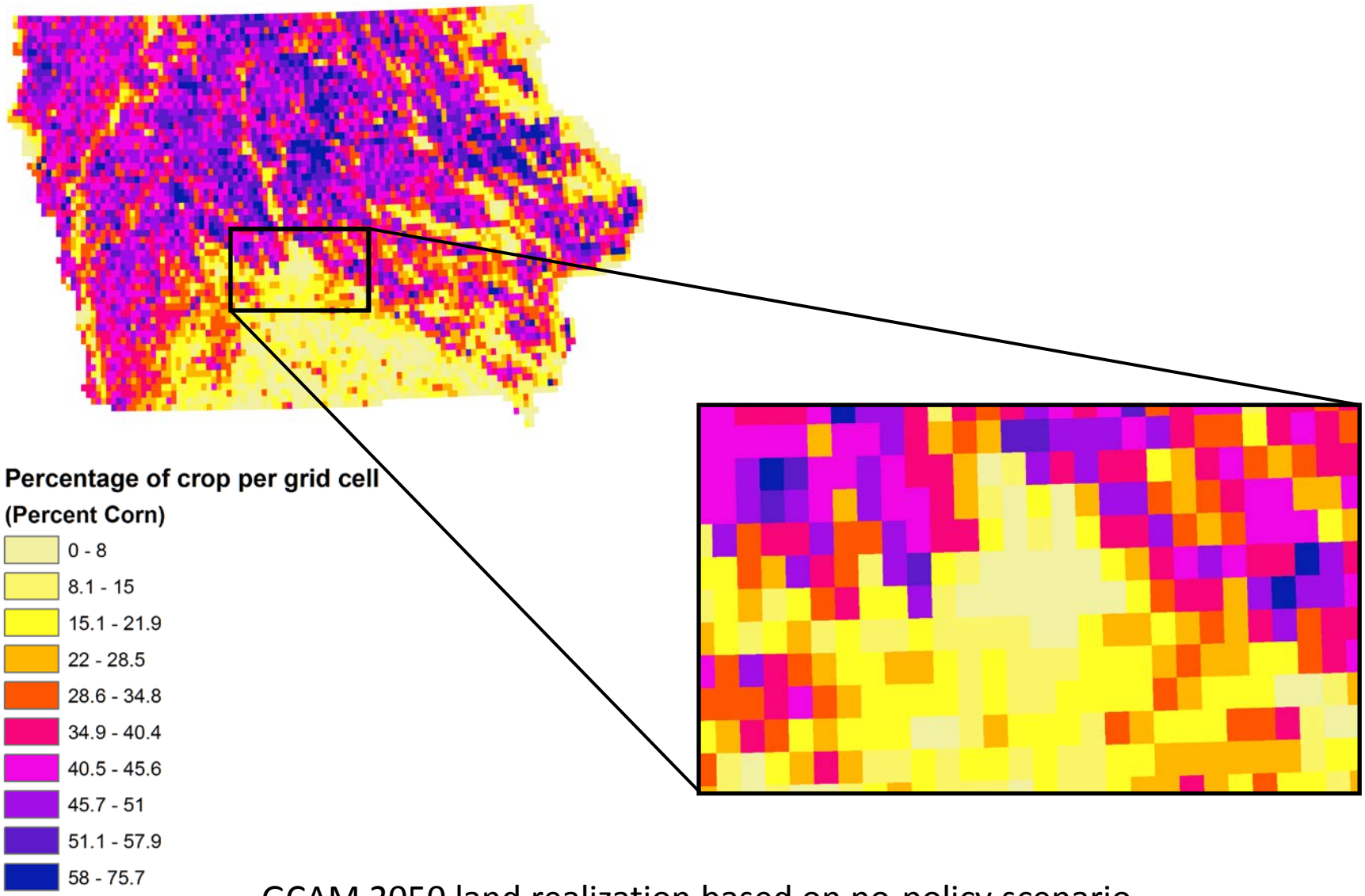


GCAM 2050 land realization based on no-policy scenario

Results – *Mixed spatial distribution*

- *Export table of all grid cells and attribute (not attribute summary table)*
- Maintain original grid ID throughout processing
- Follow steps in preceding diagram

Results – Mixed-heterogeneous realization



GCAM 2050 land realization based on no-policy scenario

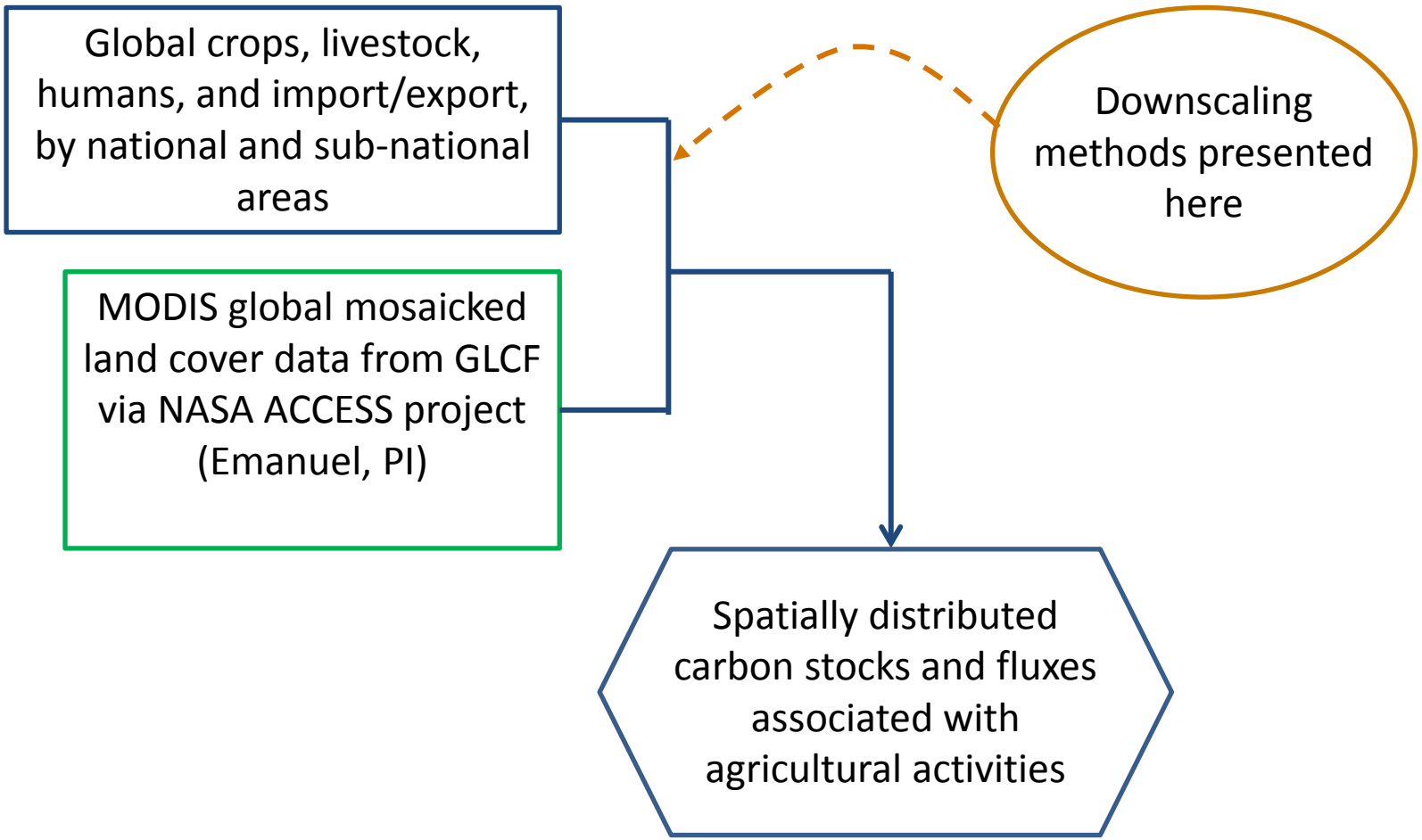
Results

Grid cell value	Corn	Other grain	Oil crop	Wheat	Fodder (herbaceous)	Pasture
1.0	19.4	0.2	32.2	0.5	4.0	31.9
2.0	41.1	0.3	29.4	0.0	5.0	13.5
3.0	39.1	0.1	38.1	0.0	5.6	10.0
4.0	55.7	0.0	29.5	0.0	1.0	2.6
5.0	47.1	0.1	33.8	0.0	2.4	9.2
6.0	53.2	0.6	30.4	0.0	2.2	4.3
7.0	43.8	0.1	42.4	0.0	0.6	4.4
8.0	44.2	0.1	36.0	0.0	1.7	7.7
9.0	42.1	0.1	28.3	0.0	6.4	15.4
10.0	39.3	0.1	46.2	0.0	2.4	5.7

Sample of grid attribute table showing the percentage of land classes for first ten grid cells. Total number of grid cells in a 0.05 degree grid for Iowa equals 6396. Percent area does not equal 100, because many other classes that are represented in the grid (e.g., urban area, water, forest) are not included in this table.

Current/Future: CMS Phase 2 Flux Project

Estimating Global Inventory-based Net Carbon Exchange from Agricultural Lands (West, PI)



Future: Research

- Similar distributions for crops, forests, urban area.

- Similar distributions for NPP. Also examining how spectral reflectance can be used in the distribution process.

Conclusions

- Regional (management) to global (climate) link.
- Attribution (needed for carbon monitoring and management)
- Improved carbon source / sink estimates
- Improve ability to assess management options, mitigation, adaptation.

Acknowledgments

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NASA - Carbon Monitoring System

PNNL – Laboratory Research and Development Program

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PRIMA:
Platform for Regional Integrated Modeling and Analysis

North American Carbon Program