Tracking Dynamic Land Use Change Using Spatial-Markov Model Based on Spatial Analysis Techniques

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Contents

Background of the study

- Very extensive land use changes have happened in the last decade in China's coastal area,
- as a result, characteristics of landscape pattern have been altered notably in many places,
- it is our purpose to depict the dynamic changes of landscape pattern and to reveal its near-future tendencies more precisely

Background of the study

- We have tried several methods of LUC simulation and forecasting, such as ANN, and CA,
- they obtained very good results in respect of quantitative features and overall spatial patterns (measured by Kappa coefficient)
- however, landscape patterns (measured by multiple landscape indices) have been distorted notably by these models
- therefore, we explore the Spatial-Markov model for short-term LUC forecasting

Methodologies of the Spatial-Markov model

- to divide the whole study area into numerous grids at a certain scale, and
- to forecast land use change by Markov chain theory in each grid,

state matrix
transition probability matrix

formula of P_{ij} determines that the model could be used for short-term forecasting only

$$s_{(t+1)} = P \times s_{(t)}$$

$$P = \begin{pmatrix} P_{11} & P_{12} & \dots & P_{1j} \\ P_{21} & P_{22} & \dots & P_{2j} \\ \dots & \dots & \dots & \dots \\ P_{i1} & P_{i2} & \dots & P_{ij} \end{pmatrix}$$

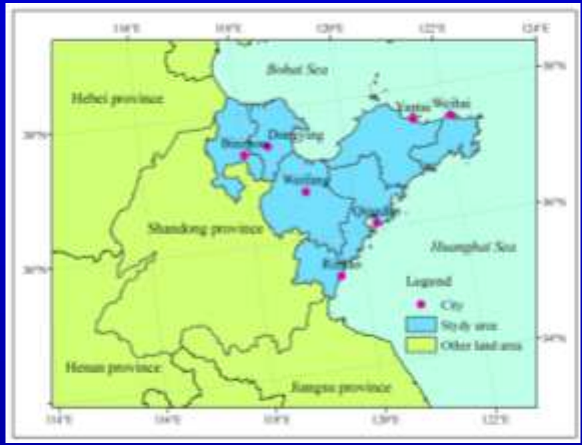
$$P_{ij} = {a_{ij}}/{a_i}$$

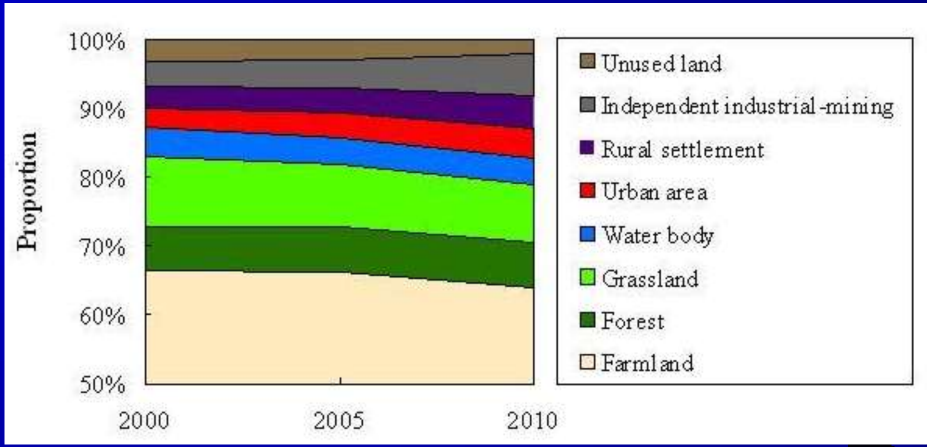
Methodologies of the Spatial-Markov model

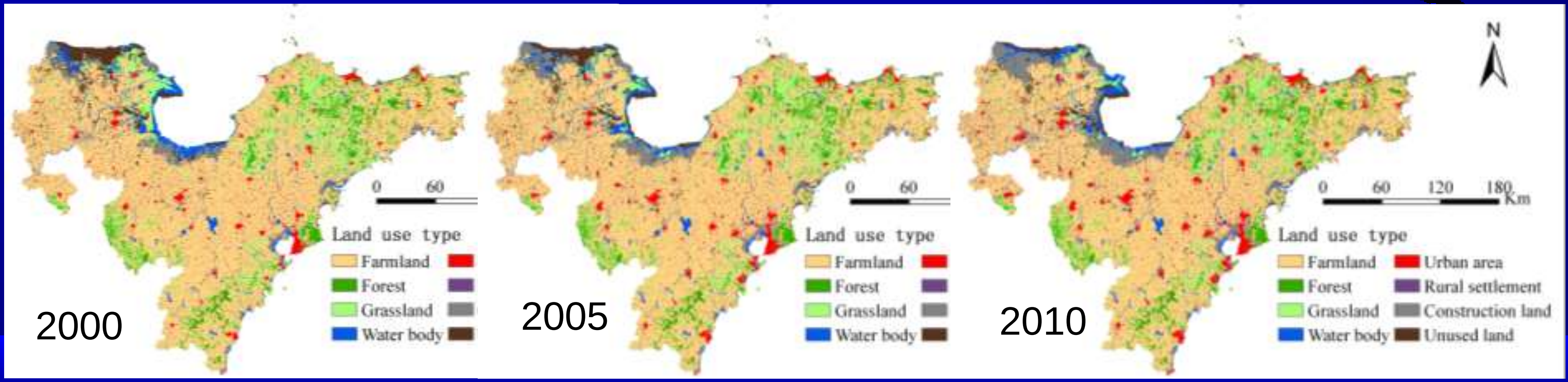
- to reassemble the forecasted results in each grid together, a group of raster maps are obtained (*the initial result*), each map depicts spatial patterns of a land use type,
- the MVC (maximum value composite) method could be used to change the raster maps into a categorical land use map (*the final result*)

Case study - coastal areas in Shandong province, China

- Land use maps in 2000, 2005, 2010 were created based on Landsat TM/ETM+ images

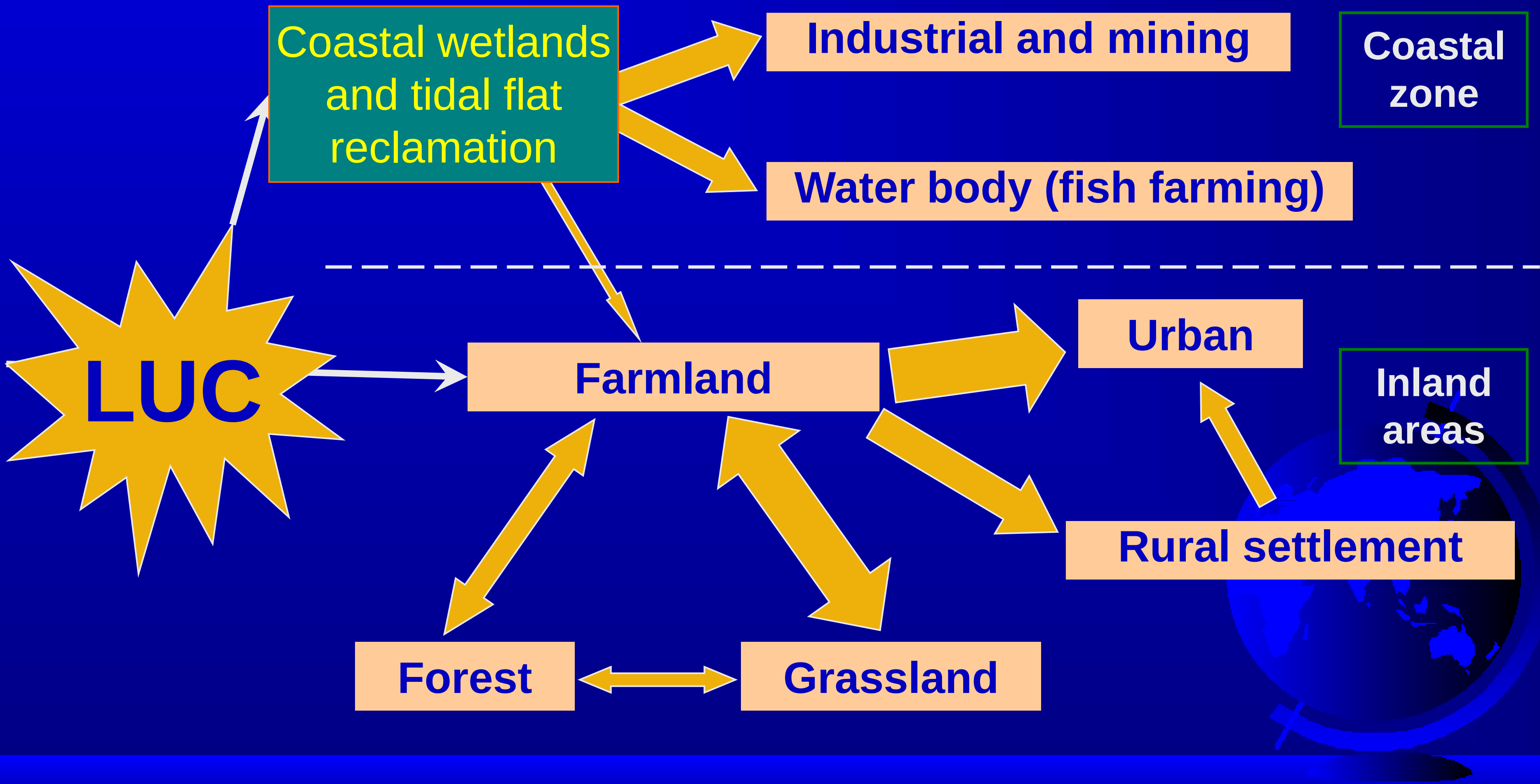






Case study - coastal areas in Shandong province, China

- Dynamics of regional LUC from 2000 to 2010

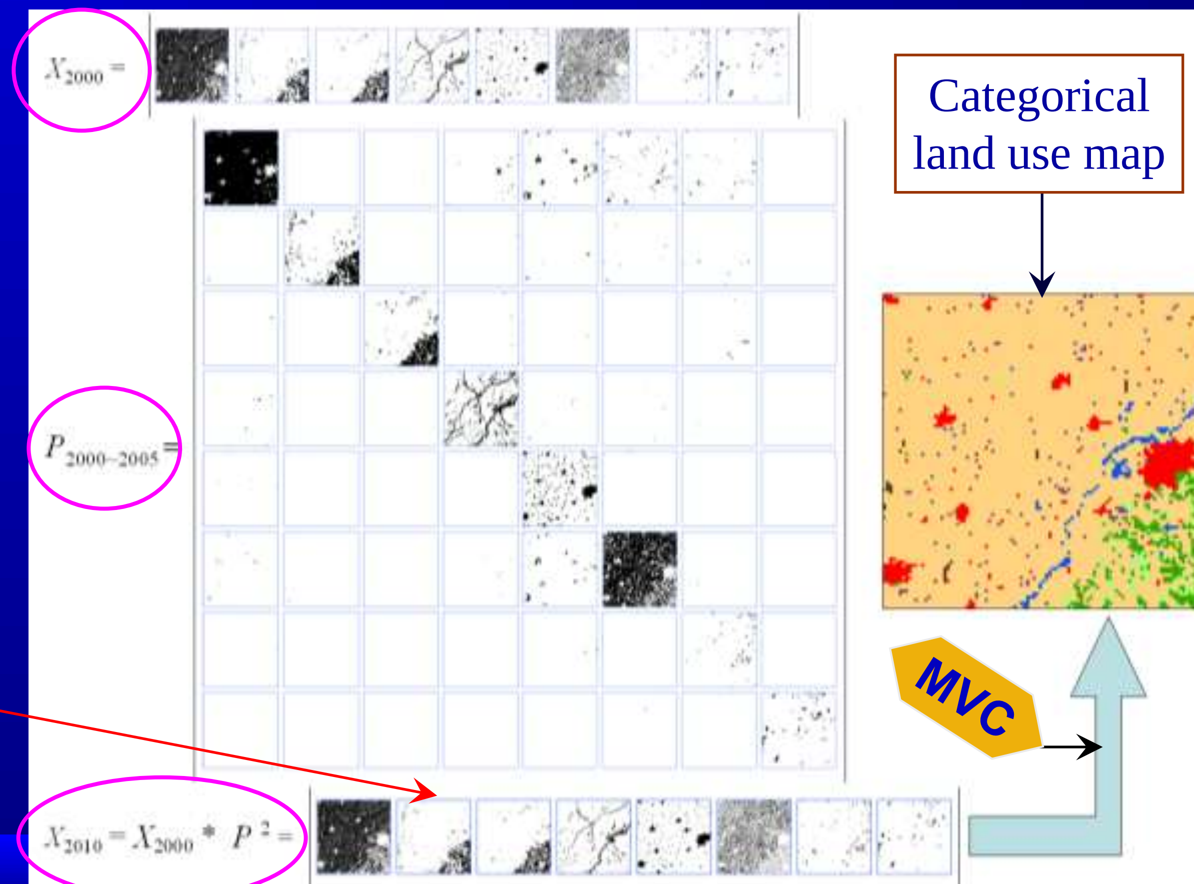


Case study - coastal areas in Shandong province, China

- the Spatial-Markov model was developed based on lu2000, lu2005 to simulate lu2010 at 500m spatial scale

Sketch map of the Spatial-Markov model

The initial result



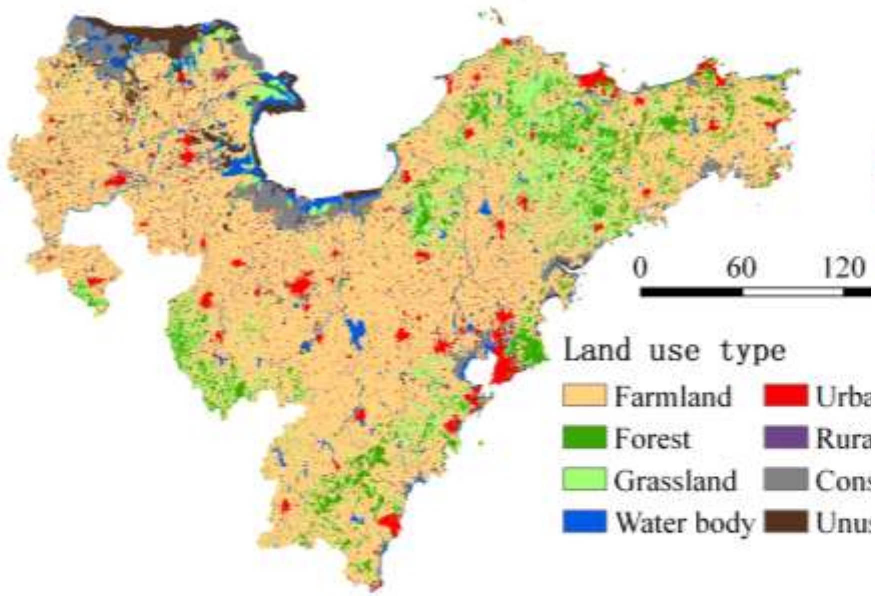
Case study - coastal areas in Shandong province, China

- Logistic-CA-Markov model was developed to simulate lu2010 at 500m spatial scale for model comparison,
  - 11 variables were selected for Logistic regression analysis and the results were used as the suitability maps in CA-Markov,
  - ROC curve method was used to test the Logistic regression analysis, it varied from 0.9260 to 0.9840 in this study,
  - a contiguity filter of 5 × 5 pixels was applied in CA-Markov,

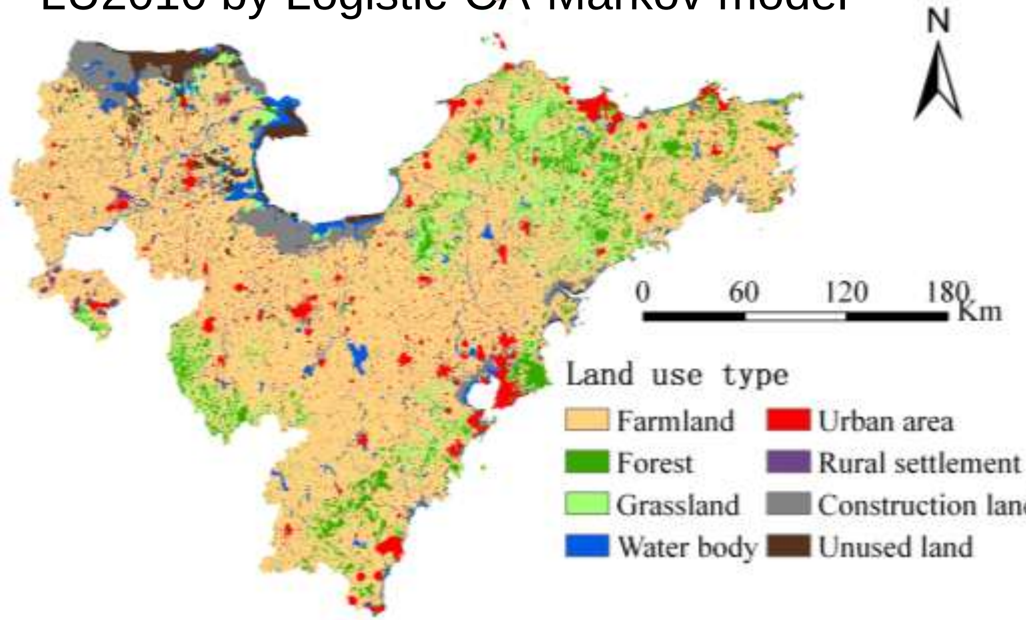
Results evaluation & model comparison

- both Kappa coefficient and eight landscape indices (LI) at landscape level were used to assess the simulation results of lu2010 by the two models

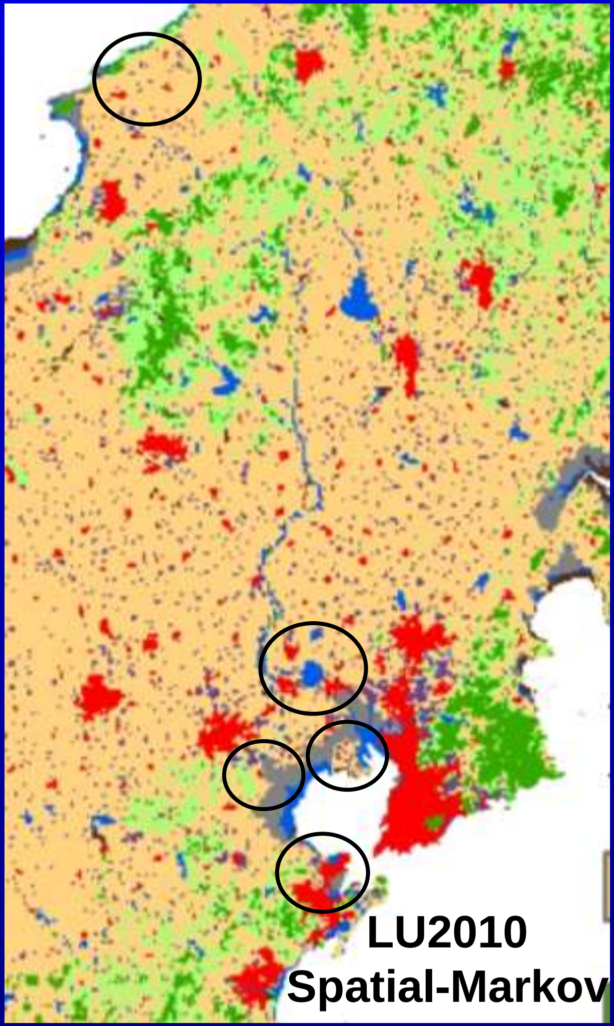
LU2010 by Spatial-Markov model

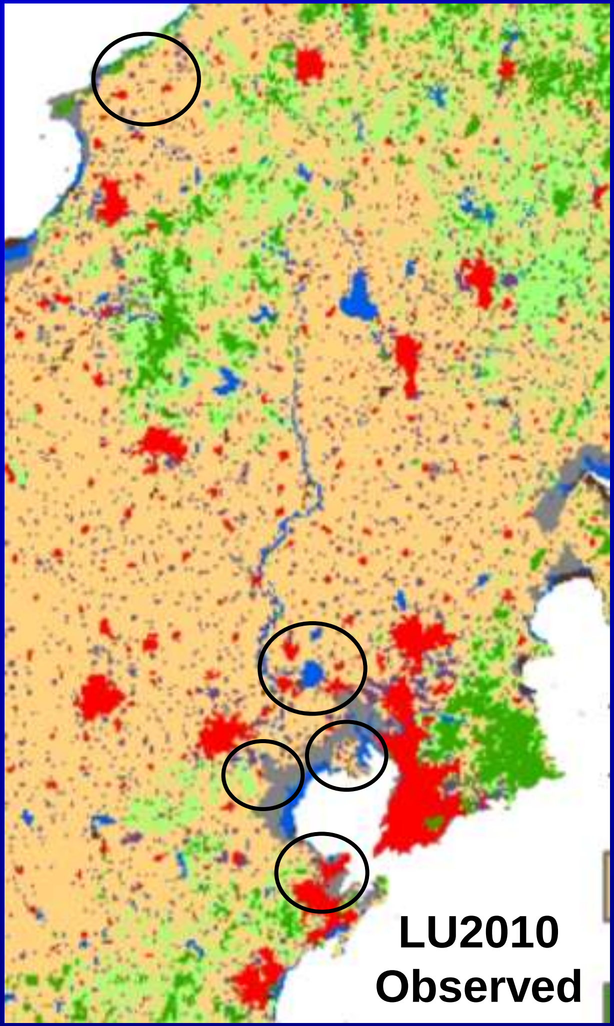


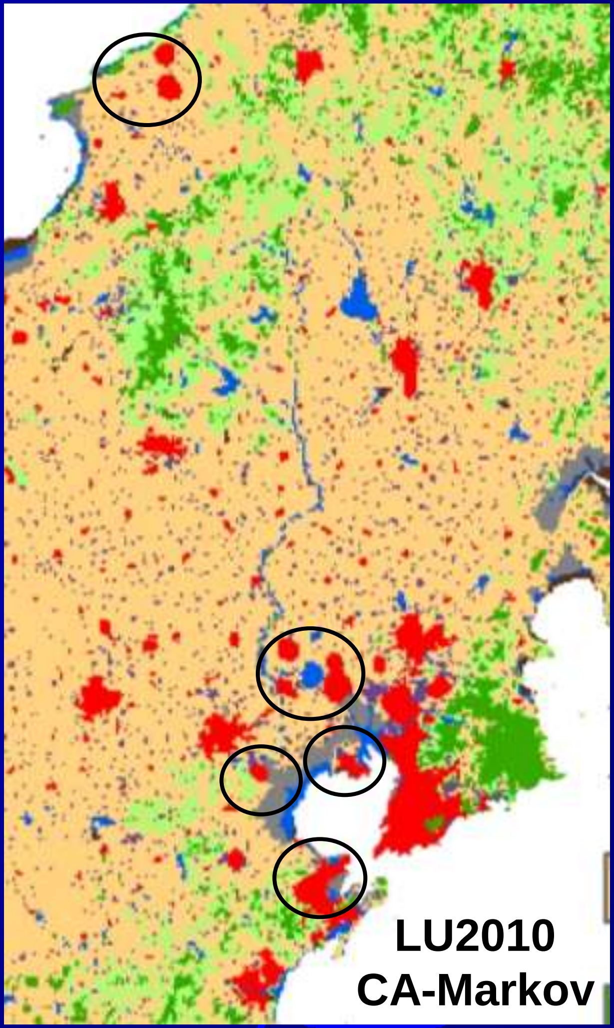
LU2010 by Logistic-CA-Markov model



Results evaluation & model comparison







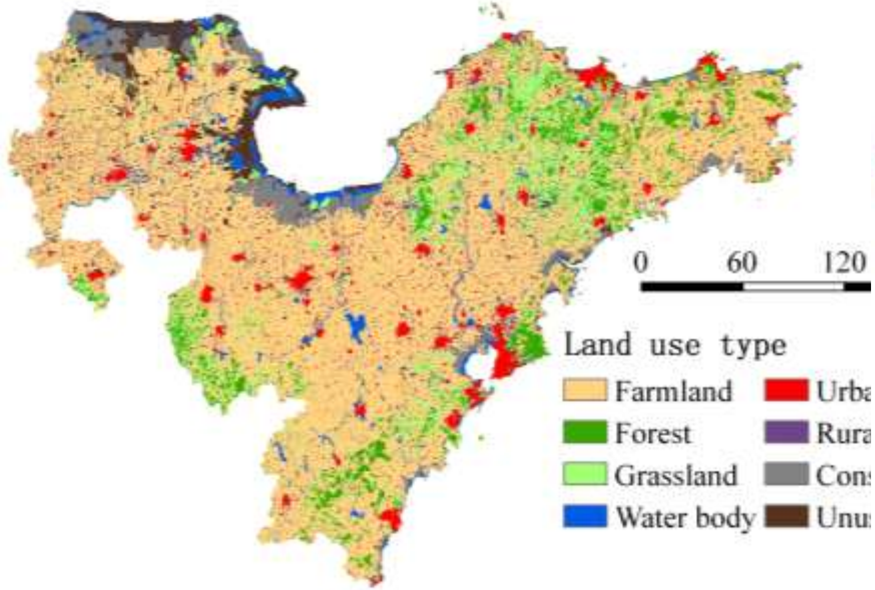
Results evaluation & model comparison

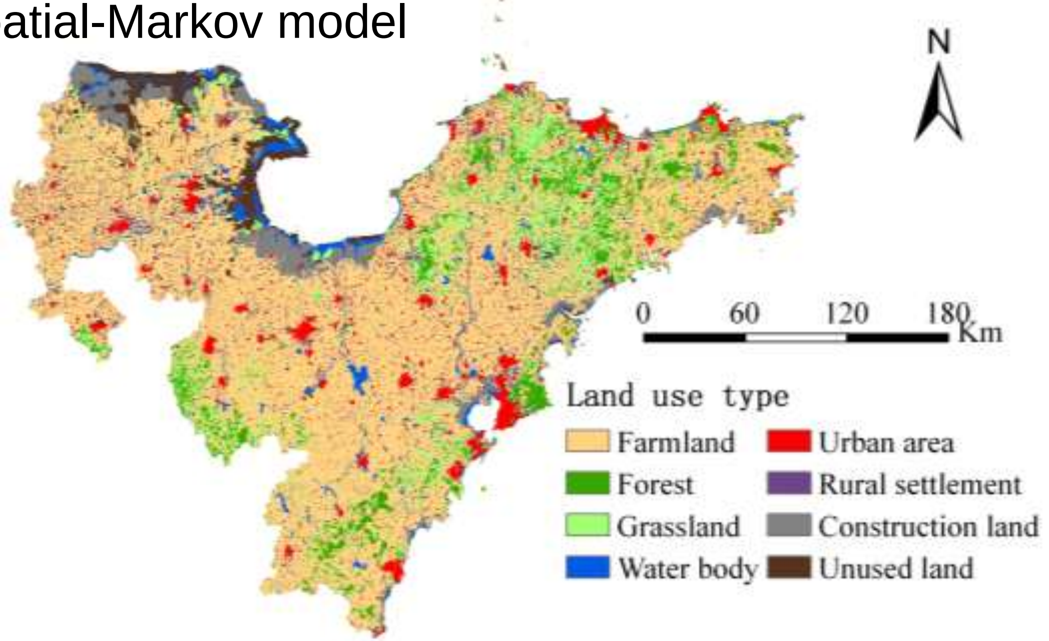
Kappa coefficients of the two simulated LU2010s

	Overall	Farmland	Forest	Grassland	Waters	Urban	Rural	Construction	Unused
CA-Markov	**0.8530**	0.9279	0.9628	0.8555	0.6590	0.8476	0.7425	0.7044	0.7235
Spatial-Markov	**0.8872**	0.9608	0.9656	0.9457	0.7233	0.8462	0.7613	0.6761	0.8834

- performance of Spatial-Markov is a little bit better than that of CA-Markov

LU2015 and LU2020 forecasted by Spatial-Markov model





Results evaluation & model comparison

- **Landscape indices used to evaluate the modeling results**

  NP——patch numbers

  MPS——mean patch size

  PAFRAC——perimeter-area fractal dimension

  CONTAG——contagion

  AI——aggregation index

  LPI——largest patch index

  SHDI——Shannon's diversity index

  SHEI——Shannon's evenness index

Results evaluation & model comparison

Landscape indices at landscape level

Time-LU map	NP	MPS (hm^2)	PAFRAC	CONTAG (%)	AI (%)	LPI (%)	SHDI	SHEI
Obs2000	14864	463.31	1.4731	51.28	76.69	64.66	1.2568	0.6044
Obs2005	14908	462.07	1.4726	50.66	76.40	64.50	1.2731	0.6122
Obs2010	16059	429.79	1.4699	48.53	75.45	54.62	1.3329	0.6410
Sim2010a by Spatial-Markov	15033	459.13	1.4706	50.12	76.29	63.90	1.2889	0.6198
Sim2010b by CA-Markov	13430	2331.27	1.4510	77.45	95.09	78.00	0.8100	0.3686
Deviation degree of **Sim2010a**, %	*-6.39*	*6.83*	*0.05*	*3.28*	*1.11*	*16.99*	*-3.30*	*-3.31*
Deviation degree of **Sim2010b**, %	*-16.37*	*442.42*	*-1.29*	*59.59*	*26.03*	*42.80*	*-39.23*	*-42.50*
Sim2015 by Spatial-Markov	17083	404.01	1.4701	46.96	74.22	61.23	1.3658	0.6568
Sim2020 by Spatial-Markov	17571	392.79	1.4724	46.19	73.57	53.65	1.383	0.6651

- **performance of Spatial-Markov is far better than that of CA-Markov**

Conclusions by this case study

- It's necessary to evaluate spatial explicit LUC models with landscape indices even if its results obtain very high Kappa coefficients.
- The Spatial-Markov model has notable advantages in short-term LUC forecasting because it has good performance in respect of both Kappa coefficient and landscape indices.

This is just the beginning …

Thanks for your attention!

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