HYDROLOGICAL RESPONSE OF A BRAZILIAN CATCHMENT TO DIFFERENT LAND USE AND LAND COVER PRODUCTS

Anderson Paulo Rudke, T. Fujita, M. V. B.de Morais, S. A. A. Rafee, R. A. F. de Souza, R. V. A. de Souza, E. D. de Freitas, L. D. Martins, Jorge Alberto Martins.

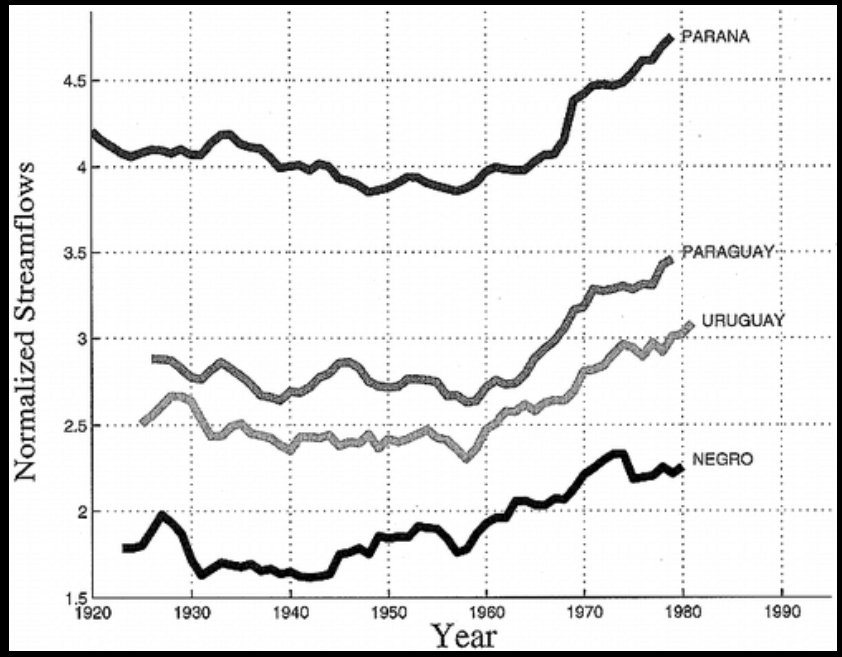
2017 International SWAT Conference in Warsaw, Poland

LA PLATA RIVER BASIN

- DRAINAGE AREA: 3,170,000 km^2;
- LENGTH: 4,500 km;
- WATER DISCHARGE: 28,000 m^3/s.
  - PARANÁ RIVER;
  - PARAGUAY RIVER;
  - URUGUAY RIVER;
  - NEGRO RIVER.

LA PLATA RIVER BASIN

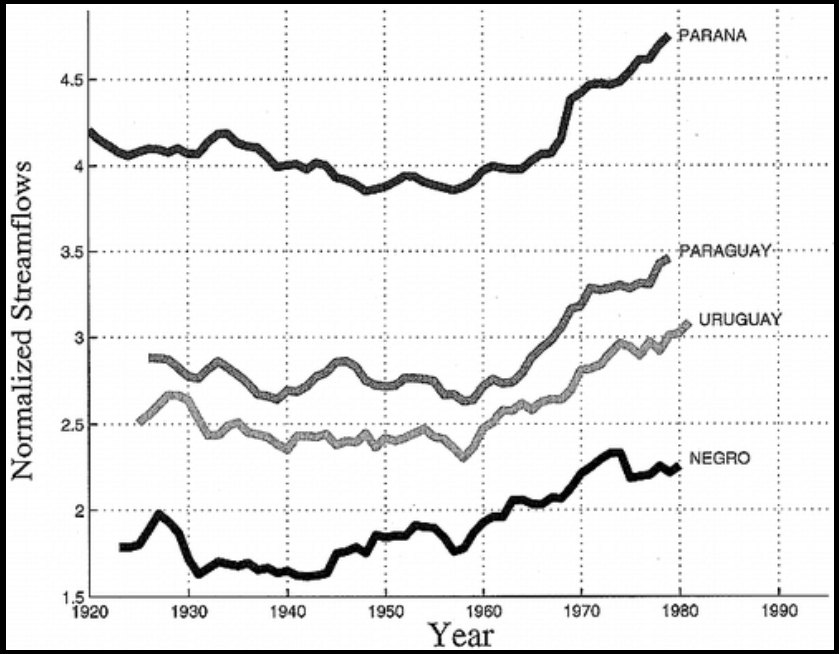
- LONG-TERM TRENDS IN STREAMFLOW



GENTA, J.L., G. PEREZ-IRIBARREN, AND C.R. MECHOSO, 1998: A RECENT INCREASING TREND IN THE STREAMFLOW OF RIVERS IN SOUTHEASTERN SOUTH AMERICA. J. CLIMATE, 11, 2858–2862.

LA PLATA RIVER BASIN

- LONG-TERM TRENDS IN STREAMFLOW
  - PRECIPITATION PATTERNS
    - FREQUENCY AND INTENSITY
    - POSITIVE/NEGATIVE ANOMALIES
  - EVAPORATION PATTERNS
    - LAND USE CHANGES;
    - DEFORESTATION;
  - SURFACE RUNOFF
    - SOIL EXPOSURE



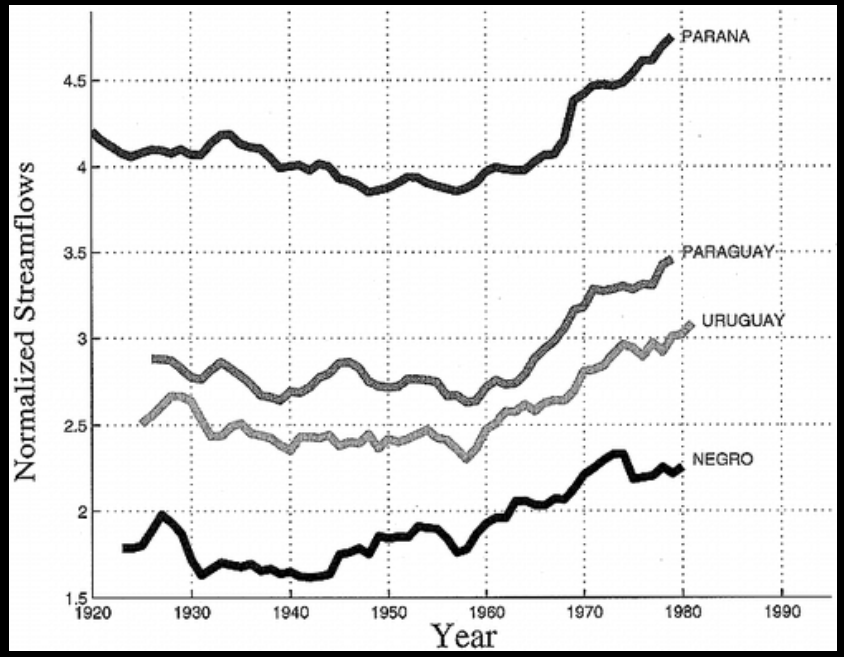
GENTA, J.L., G. PEREZ-IRIBARREN, AND C.R. MECHOSO, 1998: A RECENT INCREASING TREND IN THE STREAMFLOW OF RIVERS IN SOUTHEASTERN SOUTH AMERICA. J. CLIMATE, 11, 2858–2862.

LA PLATA RIVER BASIN

- LONG-TERM TRENDS IN STREAMFLOW
  - PRECIPITATION PATTERNS
    - FREQUENCY AND INTENSITY
    - POSITIVE/NEGATIVE ANOMALIES
  - EVAPORATION PATTERNS
    - LAND USE CHANGES;
    - DEFORESTATION;
  - SURFACE RUNOFF
    - SOIL EXPOSURE

+

=



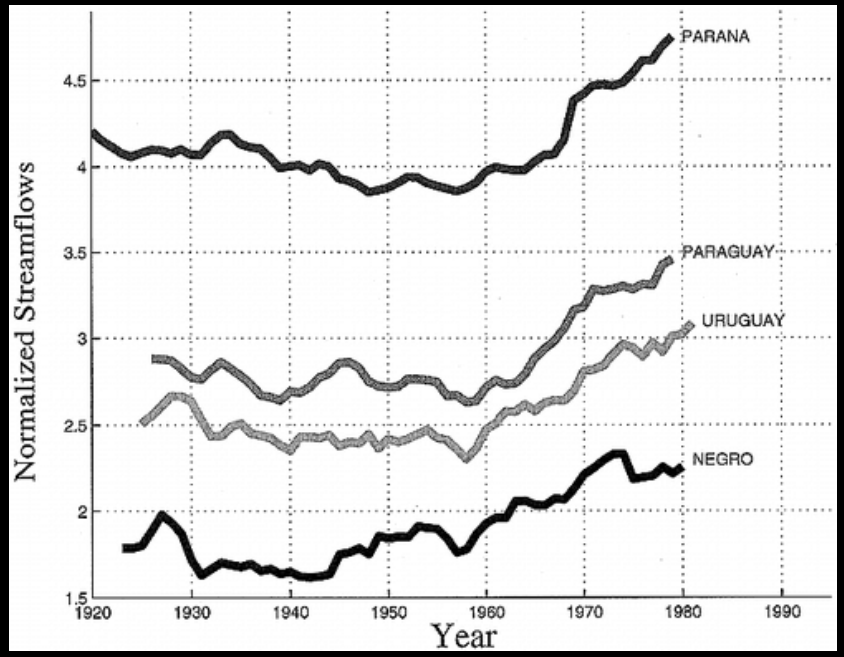
GENTA, J.L., G. PEREZ-IRIBARREN, AND C.R. MECHOSO, 1998: A RECENT INCREASING TREND IN THE STREAMFLOW OF RIVERS IN SOUTHEASTERN SOUTH AMERICA. J. CLIMATE, 11, 2858–2862.

LA PLATA RIVER BASIN

- LONG-TERM TRENDS IN STREAMFLOW
  - PRECIPITATION PATTERNS
    - FREQUENCY AND INTENSITY
    - POSITIVE/NEGATIVE ANOMALIES
  - EVAPORATION PATTERNS
    - LAND USE CHANGES;
    - DEFORESTATION;
  - SURFACE RUNOFF
    - SOIL EXPOSURE

+

=



THE ROLE OF HUMAN ACTIVITIES OVER THE BASIN IS SURROUNDED BY UNCERTAINTIES.

GENTA, J.L., G. PEREZ-IRIBARREN, AND C.R. MECHOSO, 1998: A RECENT INCREASING TREND IN THE STREAMFLOW OF RIVERS IN SOUTHEASTERN SOUTH AMERICA. J. CLIMATE, 11, 2858–2862.

LAND USE AND COVER CHANGES

- STUDIES ON THE EFFECTS OF LUCC ON THE LOCAL AND REGIONAL CLIMATE HAVE FOCUSED THE AMAZON REGION
  - PEER-REVIEWED LITERATURE ABOUT LUCC:
    - AMAZON REGION: 54 STUDIES;
    - NON-AMAZONIAN REGIONS: 19 STUDIES.

LAND USE AND COVER CHANGES

- STUDIES ON THE EFFECTS OF LUCC ON THE LOCAL AND REGIONAL CLIMATE HAVE FOCUSED THE AMAZON REGION
  - PEER-REVIEWED LITERATURE ABOUT LUCC:
    - AMAZON REGION: 54 STUDIES;
    - NON-AMAZONIAN REGIONS: 19 STUDIES.

HISTORICAL AMAZON DEFORESTATION:

0.8 MILLION km^2 (≈17%)

LAND USE AND COVER CHANGES

- STUDIES ON THE EFFECTS OF LUCC ON THE LOCAL AND REGIONAL CLIMATE HAVE FOCUSED THE AMAZON REGION
  - PEER-REVIEWED LITERATURE ABOUT LUCC:
    - AMAZON REGION: 54 STUDIES;
    - NON-AMAZONIAN REGIONS: 19 STUDIES.

HISTORICAL AMAZON DEFORESTATION:

0.8 MILLION km^2 (≈17%)

NON-AMAZONIAN SOUTH AMERICA DEFORESTATION:

3.6 MILLION km^2

4x GREATER

LAND USE AND COVER CHANGES

- STUDIES ON THE EFFECTS OF LUCC ON THE LOCAL AND REGIONAL CLIMATE HAVE FOCUSED THE AMAZON REGION
  - PEER-REVIEWED LITERATURE ABOUT LUCC:
    - AMAZON REGION: 54 STUDIES;
    - NON-AMAZONIAN REGIONS: 19 STUDIES.

HISTORICAL AMAZON DEFORESTATION:

0.8 MILLION km^2 (≈17%)

NON-AMAZONIAN SOUTH AMERICA DEFORESTATION:

3.6 MILLION km^2

4x GREATER

WERE CONVERTED INTO OTHER TYPES OF LAND USE

LAND USE AND COVER CHANGES

- STUDIES ON THE EFFECTS OF LUCC ON THE LOCAL AND REGIONAL CLIMATE HAVE FOCUSED THE AMAZON REGION
  - PEER-REVIEWED LITERATURE ABOUT LUCC:
    - AMAZON REGION: 54 STUDIES;
    - NON-AMAZONIAN REGIONS: 19 STUDIES.

HISTORICAL AMAZON DEFORESTATION:

0.8 MILLION km^2 (≈17%)

NON-AMAZONIAN SOUTH AMERICA DEFORESTATION:

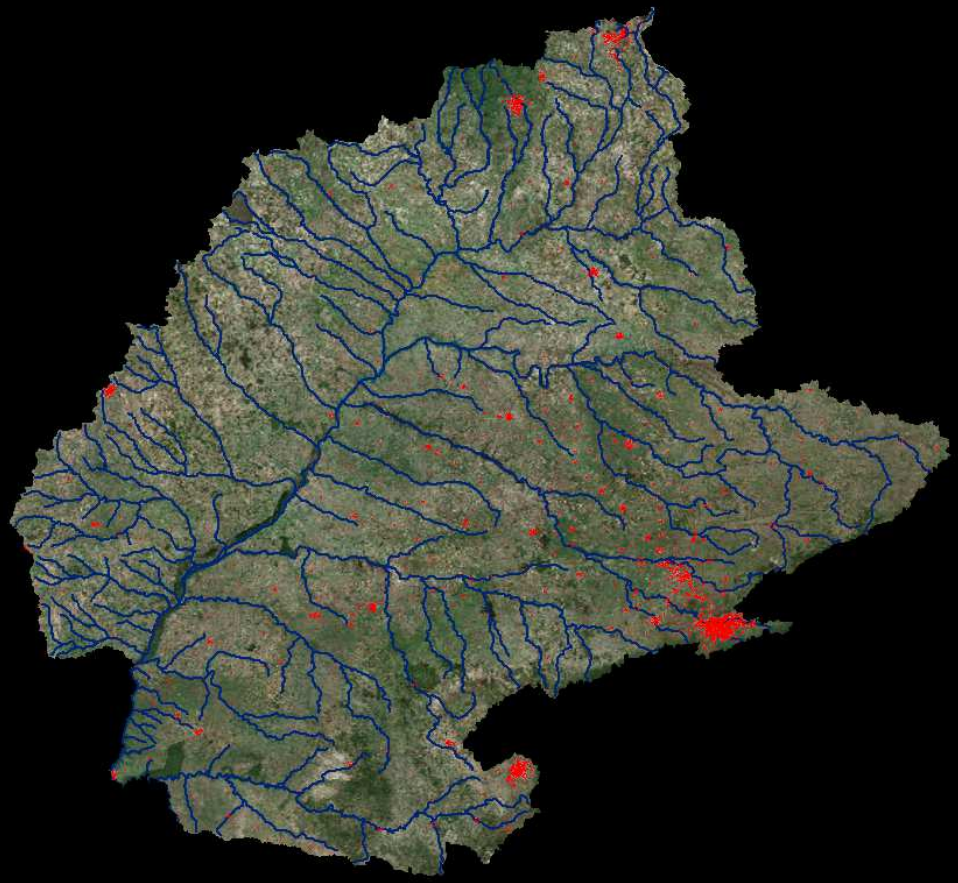
3.6 MILLION km^2

4x GREATER

WERE CONVERTED INTO OTHER TYPES OF LAND USE

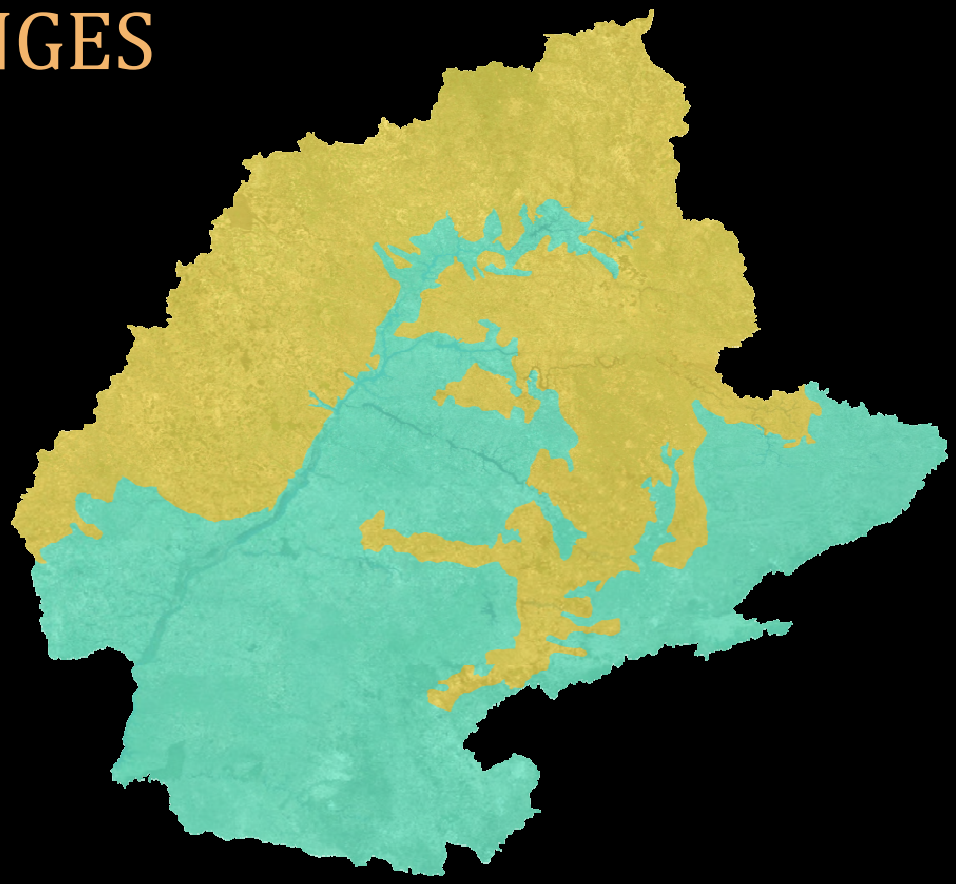
PARANÁ RIVER BASIN

- DRAINAGE AREA: 879,860 km^2
- LENGTH: 1,280 km;
- WATER DISCHARGE: 14,000 m^3/s.



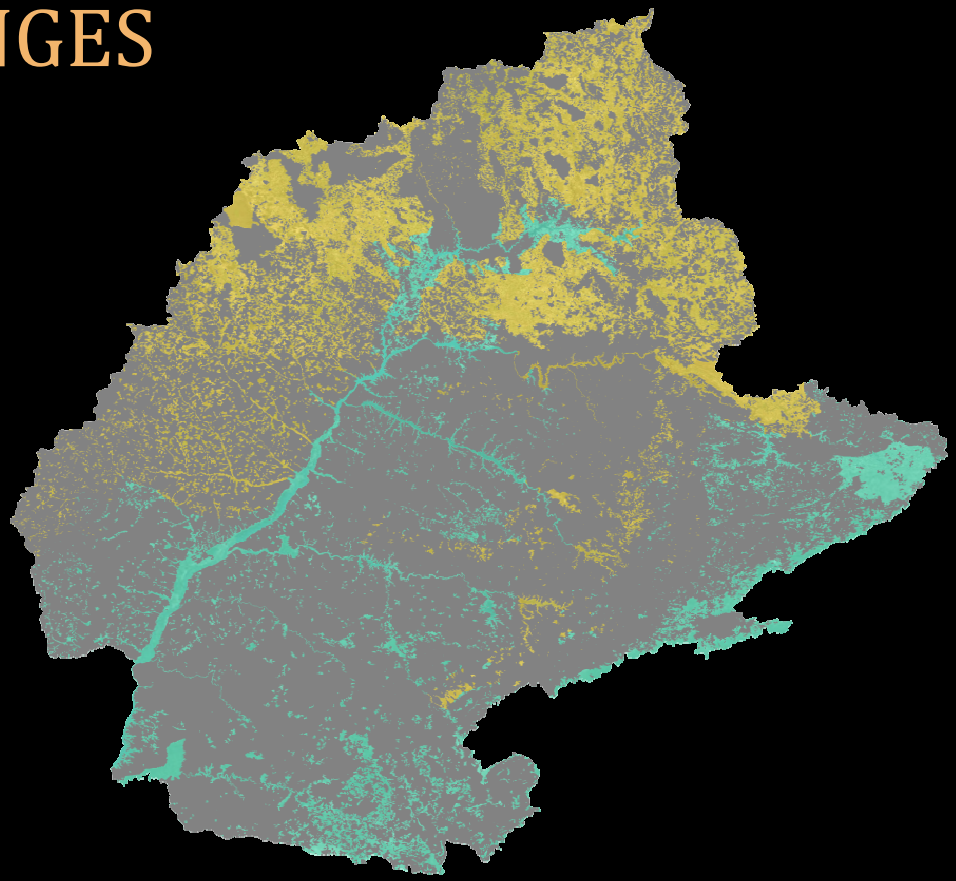
PARANÁ RIVER BASIN
LAND USE AND COVER CHANGES

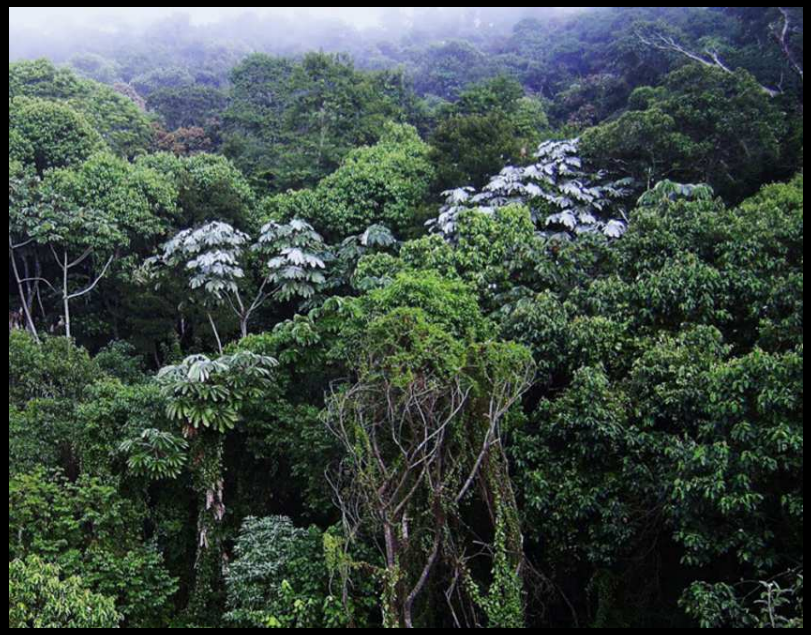
- ORIGINAL ATLANTIC FOREST: 1,500,000 km^2
- ORIGINAL CERRADO: 1,585,000 km^2



PARANÁ RIVER BASIN
LAND USE AND COVER CHANGES

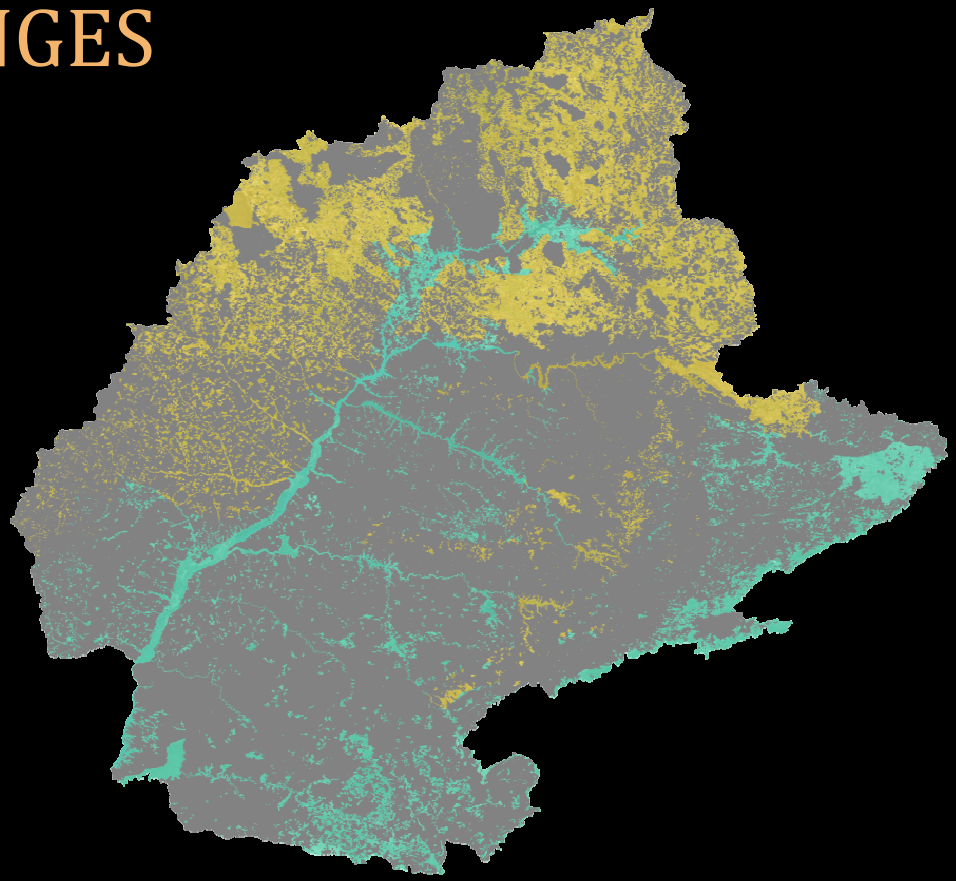
- REMOVAL OF ORIGINAL FOREST COVER;
  - ORIGINAL ATLANTIC FOREST: 1,500,000 km^2
    - 11% REMAINED
  - ORIGINAL CERRADO: 1,585,000 km^2
    - 44% REMAINED





PARANÁ RIVER BASIN
LAND USE AND COVER CHANGES

- REMOVAL OF ORIGINAL FOREST COVER;
  - ORIGINAL ATLANTIC FOREST: 1,500,000 km^2
    - 11% REMAINED
  - ORIGINAL CERRADO: 1,585,000 km^2
    - 44% REMAINED
- DYNAMICS OF THE COVER CHANGES.



LAND USE AND COVER CHANGES
MECHANIZATION [1950 - 1960]

- AGRICULTURAL MACHINERY
  - INCREASE CROP PRODUCTIVITY/EFFICIENCY;
  - LARGE SCALE PRODUCTION;
  - IMPROVE THE QUALITY OF FARM PRODUCT;
  - HIGHER PLANTING DENSITY;

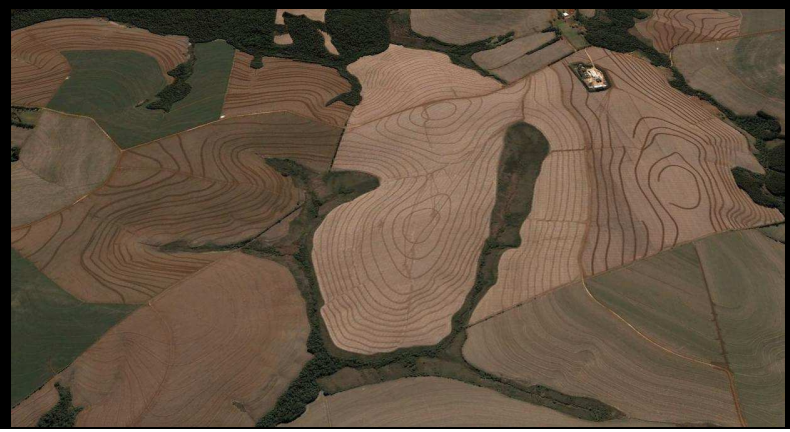
LAND USE AND COVER CHANGES
MECHANIZATION [1950 - 1960]

- AGRICULTURAL MACHINERY
  - INCREASE CROP PRODUCTIVITY/EFFICIENCY;
  - LARGE SCALE PRODUCTION;
  - IMPROVE THE QUALITY OF FARM PRODUCT;
  - HIGHER PLANTING DENSITY;
  - SOIL COMPACTION;
  - EROSION;
  - SEDIMENT RELEASE.

T7

LAND USE AND COVER CHANGES
EROSION CONTROL [1970 - 1990]

- CONTOUR PLOWING: terraces retain a significant part of the surface runoff.



T7

Contour plowing or contour farming or Contour bunding is the farming practice of plowing and/or planting across a slope following its elevation contour lines. These contour lines create a water break which reduces the formation of rills and gullies during times of heavy water run-off; which is a major cause of soil erosion. The water break also allows more time for the water to settle into the soil.[1] In contour plowing, the ruts made by the plow run perpendicular rather than parallel to slopes, generally resulting in furrows that curve around the land and are level. This method is also known for preventing tillage erosion.[2] Tillage erosion is the soil movement and erosion by tilling a given plot of land.[3] A similar practice is contour bunding where stones are placed around the contours of slopes.

Soil erosion prevention practices such as this can drastically decrease negative affects associated with soil erosion such as reduced crop productivity, worsened water quality, lower effective reservoir water levels, flooding, and habitat destruction.[4] Contour farming is considered an active form of sustainable agriculture.[5]

Thais; 20/06/2017

LAND USE AND COVER CHANGES
EROSION CONTROL [1970 - 1990]

- CONTOUR PLOWING: terraces retain a significant part of the surface runoff.
- DIRECT PLANTING TECHNIQUES: in direct seeding, soil is not tilled before planting and most of the crop residue (straw) remains on the surface.
- AGRICULTURE MACHINERY: succeeded in the 90's with straw cutting discs development.

LAND USE AND COVER CHANGES
PROTECTED AREAS [2000]

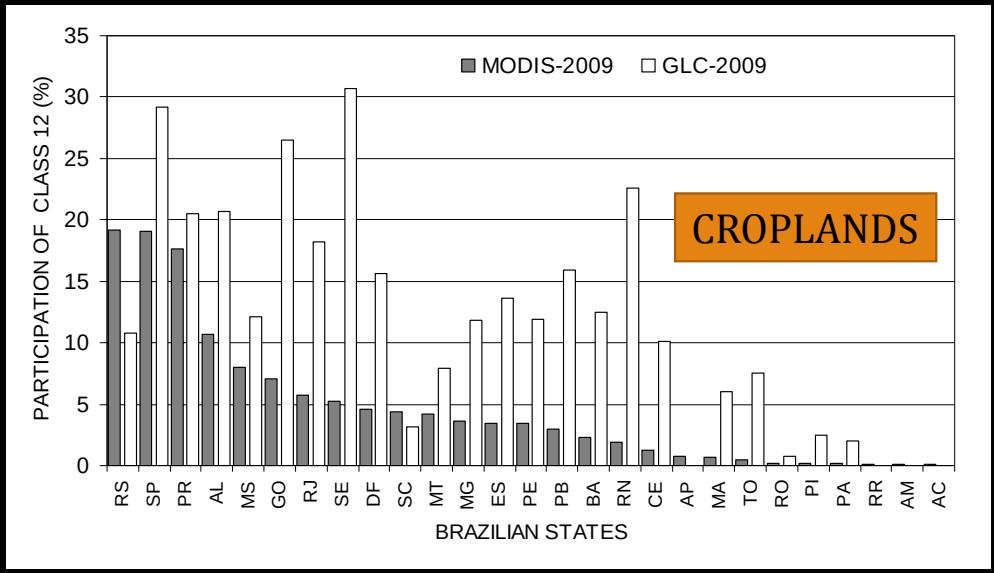
- PERMANET PROTECTED AREAS (PPA): minimum range of 30 meters in each margin, for rivers up to 10 meters wide, widening this range as the width of the river increases.
- CONSERVATION UNITS: protect remaining vegetation.

LAND USE AND COVER CHANGES
URBANIZATION

- RURAL DISPLACEMENT;
- DISORDERED OCCUPATION AND WITHOUT PLANNING;
- PROXIMITY WITH WATER BODIES.

LAND USE AND COVER CHANGES
PRODUCTS DATABASE

- DISAGREEMENT IN THE CLASSIFICATION OF LAND COVER CLASSES;
  - GLOBCOVER vs. MODIS.

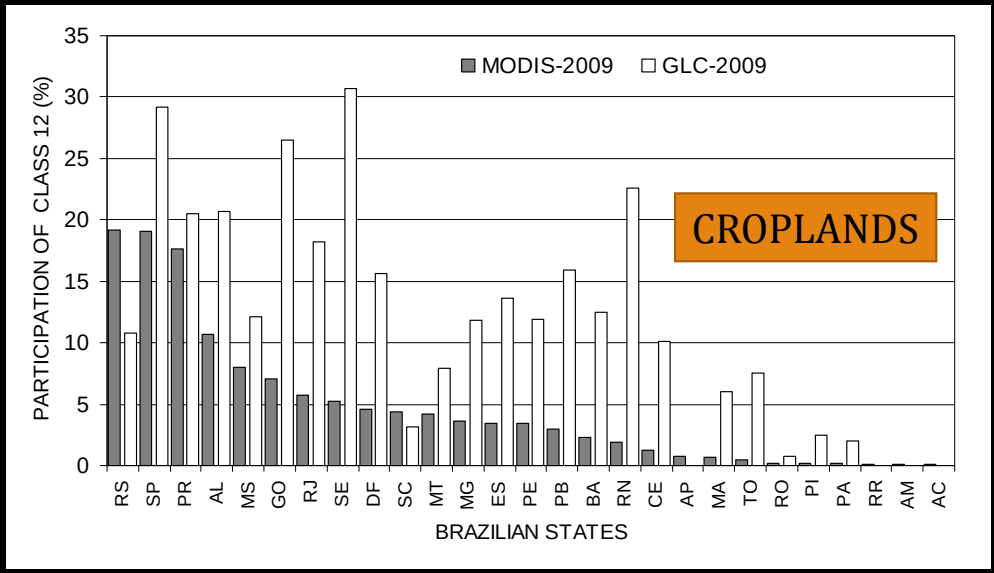


CAPUCIM, M. N. ET AL., 2015. SOUTH AMERICA LAND USE AND LAND COVER ASSESSMENT AND PRELIMINARY ANALYSIS OF THEIR IMPACTS ON REGIONAL ATMOSPHERIC MODELING ATUDIES. IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 8, NO. 3, PP. 1185-1198, DOI: 10.1109/JSTARS.2014.2363368

LAND USE AND COVER CHANGES
PRODUCTS DATABASE

- DISAGREEMENT IN THE CLASSIFICATION OF LAND COVER CLASSES;
  - GLOBCOVER vs. MODIS.
- NUMERICALLY EQUAL vs. SPACIALLY DIFFERENT;

File I		File II	
A	B	B	A
C	D	C	D



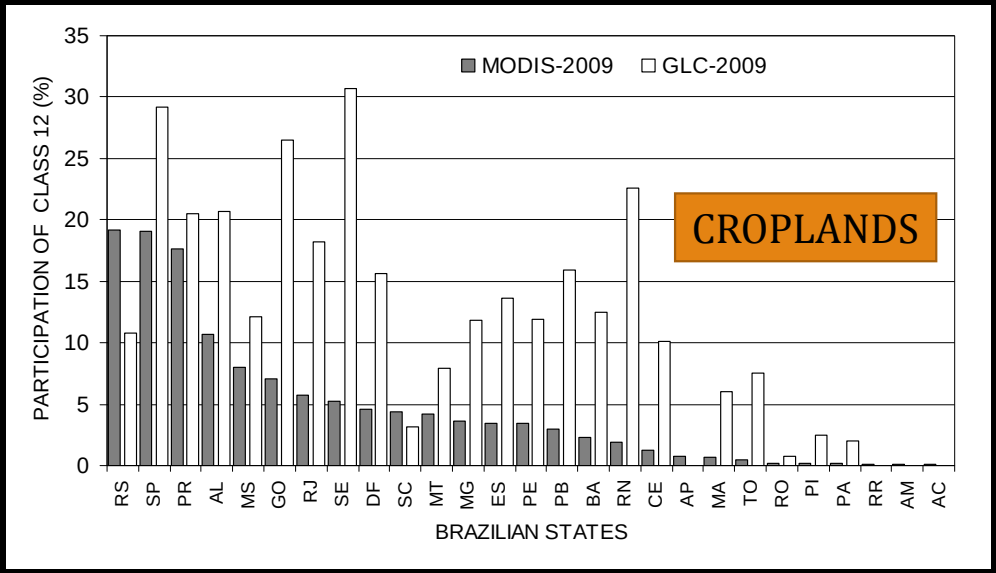
CAPUCIM, M. N. ET AL., 2015. SOUTH AMERICA LAND USE AND LAND COVER ASSESSMENT AND PRELIMINARY ANALYSIS OF THEIR IMPACTS ON REGIONAL ATMOSPHERIC MODELING ATUDIES. IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 8, NO. 3, PP. 1185-1198, DOI: 10.1109/JSTARS.2014.2363368

LAND USE AND COVER CHANGES
PRODUCTS DATABASE

- DISAGREEMENT IN THE CLASSIFICATION OF LAND COVER CLASSES;
  - GLOBCOVER vs. MODIS.
- NUMERICALLY EQUAL vs. SPACIALLY DIFFERENT;

File I		File II	
A	B	B	A
C	D	C	D

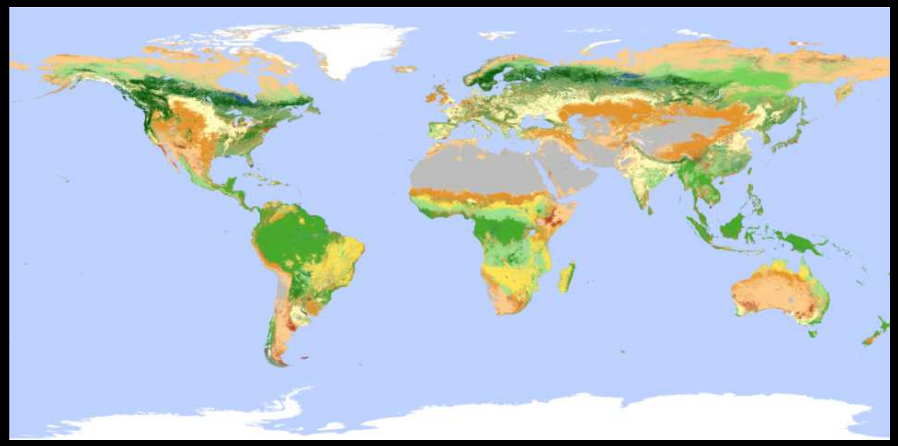
ARE THEY PROPERLY REPRESENTING LUCC?



CAPUCIM, M. N. ET AL., 2015. SOUTH AMERICA LAND USE AND LAND COVER ASSESSMENT AND PRELIMINARY ANALYSIS OF THEIR IMPACTS ON REGIONAL ATMOSPHERIC MODELING ATUDIES. IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 8, NO. 3, PP. 1185-1198, DOI: 10.1109/JSTARS.2014.2363368

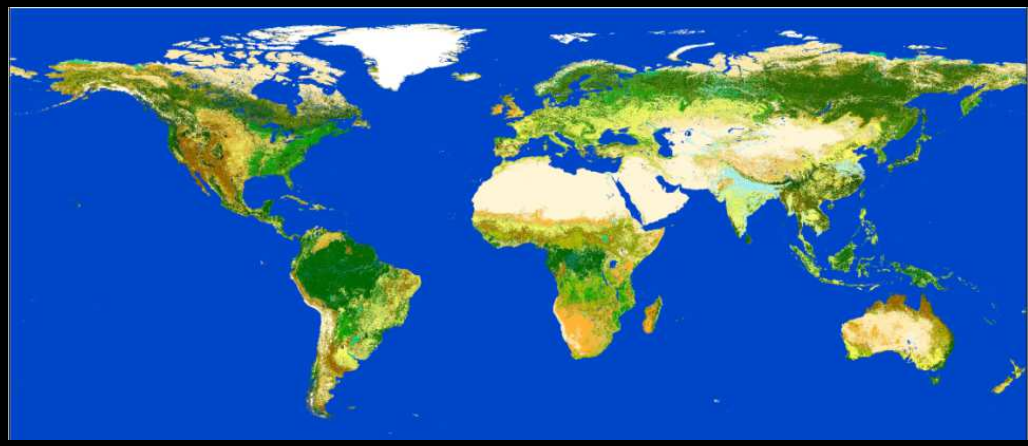
LAND USE AND COVER CHANGES
PRODUCTS DATABASE – GLOBAL SCALE

MODIS - 500m (FRIEDL et al., 2010)



- MODIS SENSOR;
- 17 LAND COVER CLASSES;
- SUPERVISED CLASSIFICATION:
  - 1860 TRAINING SITES; (ONLY 6 IN THE BASIN)
- OVERALL ACCURACY - 74.8%;
- CLASSIFICATION YEAR – 2009.

GLOBCOVER - 300m (ARINO et al., 2008)

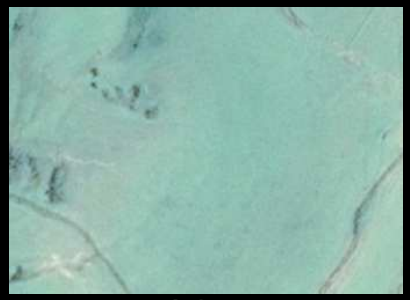


- MERIS SENSOR;
- 22 LAND COVER CLASSES;
- UNSUPERVISED CLASSIFICATION;
- OVERALL ACCURACY - 67.5%
- CLASSIFICATION YEAR – 2009.

LANDSAT DATABASE – 30m

MIXED FOREST

AGRICULTURE



PASTURE

SHRUBLAND

WATER

URBAN

BARREN

CERRADO

LANDSAT DATABASE

LANDSAT	MODIS	GLOBCOVER
Mixed Forest	Evergreen Needleleaf Forest (1)	Closed Needleleaved Evergreen Forest (70)
	Evergreen Broadleaf Forest (2)	Closed to open Broadleaved Evergreen or Semi-deciduous Forest (40) Closed to open Broadleaved Forest Regularly Flooded - Fresh or Brackish Water (160) Closed Broadleaved Forest or Shrubland Permanently Flooded - Saline or Brackish Water (170)
	Deciduous Needleleaf Forest (3)	Open Needle-leaved Deciduous or Evergreen Forest (90)
	Deciduous Broadleaf Forest (4)	Closed Broadleaved Deciduous Forest (50)
	Mixed Forest (5)	Closed to open Mixed Broadleaved and Needle-leaved Forest (100)
Agriculture	Croplands (12)	Rainfed Croplands (14)
	Cropland/Natural Vegetation Mosaic (14)	Mosaic Cropland/Vegetation (20) Mosaic Vegetation/Cropland (30)
Pasture	Grasslands (10)	Closed to open Herbaceous Vegetation (140)
Water	Water (0)	Water bodies (210)
	Permanent Wetlands (11)	Closed to open Grassland or Woody Vegetation on Regularly Flooded or Waterlogged Soil - Fresh, Brackish or Saline Water (180)
Urban	Urbanand Built-Up (13)	Artificial Surfaces and Associated Areas (190)
Barren	Barren or Sparsely Vegetated (16)	Bare Areas (200)
Shrubland	Closed Shrublands (6)	Mosaic Forest or Shrubland/Grassland (110)
	Open Shrublands (7)	Sparse Vegetation (150)
Savanna	Woody Savannas (8)	Open Broadleaved Deciduous Forest/Woodland (60)
	Savannas (9)	Mosaic Grassland/Forest or Shrubland (120) Closed to open Shrubland (130)

Agriculture	Croplands (12)	Rainfed Croplands (14)
	Cropland/Natural Vegetation Mosaic (14)	Mosaic Cropland/Vegetation (20) Mosaic Vegetation/Cropland (30)
Pasture	Grasslands (10)	Closed to open Herbaceous Vegetation (140)

FRIEDL, M.A.; SULLA-MANESHE,D.; TAN, B.; SCHNEIDER, A.; RAMANKUTTY, N.; SIBLEY, A.; HUANG X. MODIS COLLECTION 5 GLOBAL LAND COVER: ALGORITHM REFINEMENTS AND CHARACTERIZATION OF NEW DATASETS. REMOTE SENSING OF ENVIRONMENT, V.114, N.1, P. 168-182, 2010.

CAPUCIM, M. N. ET AL., 2015. SOUTH AMERICA LAND USE AND LAND COVER ASSESSMENT AND PRELIMINARY ANALYSIS OF THEIR IMPACTS ON REGIONAL ATMOSPHERIC MODELING ATUDIES. IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 8, NO. 3, PP. 1185-1198, DOI: 10.1109/JSTARS.2014.2363368

LANDSAT DATABASE OF UPPER GRANDE RIVER BASIN

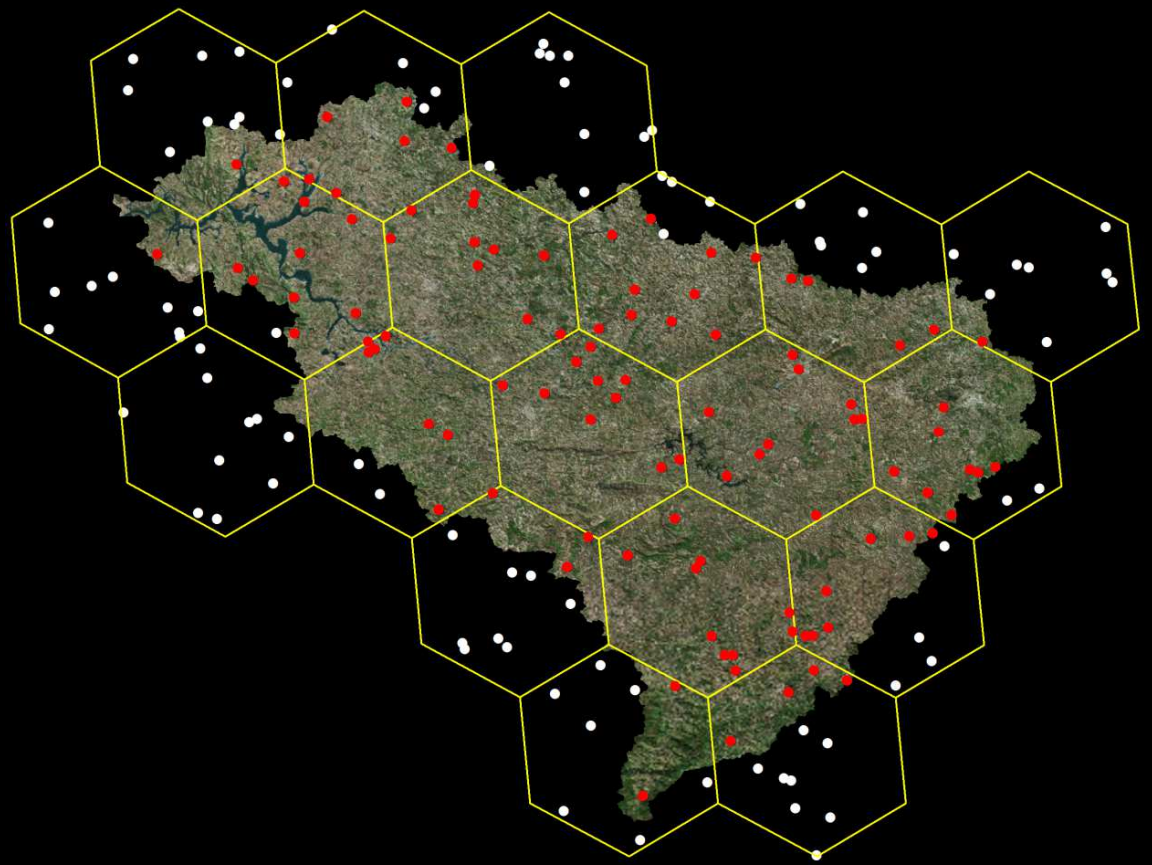
- DRAINAGE AREA: 26,490 km^2;
- AVERAGE STREAMFLOW: 420 m^3/s;

LANDSAT DATABASE OF UPPER GRANDE RIVER BASIN

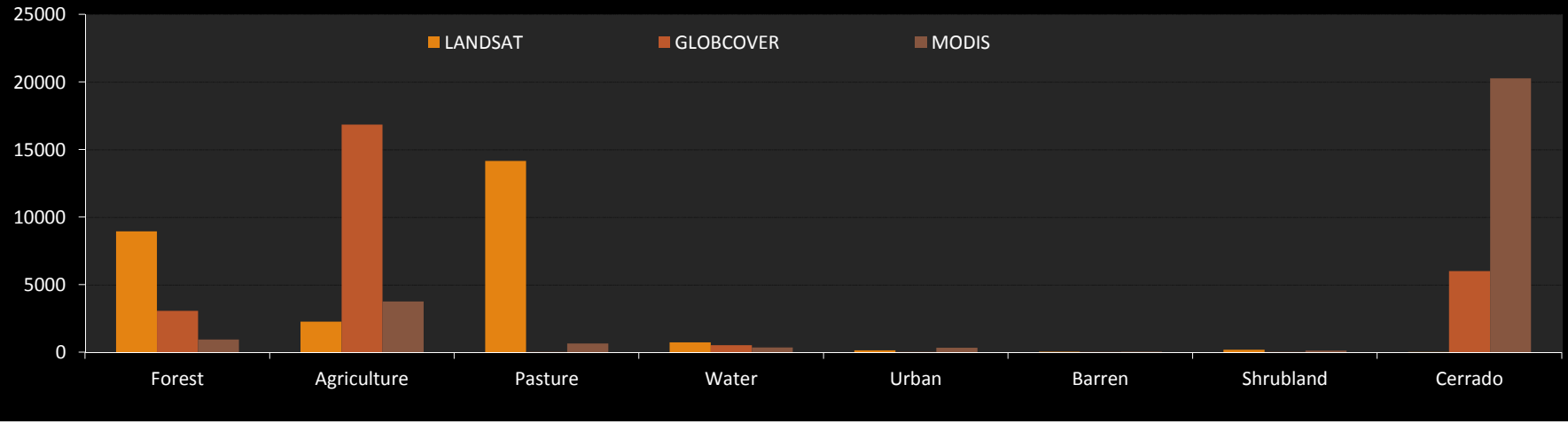
- DRAINAGE AREA: 26,490 km^2;
- AVERAGE STREAMFLOW: 420 m^3/s;
- DESCRIPTION:
  - LANDSAT SCENES – 5;
  - SUPERVISED CLASSIFICATION – 350 TRAINING SITES;
    - SUPPORT VECTOR MACHINE (SVM);
  - CLASSIFICATION YEAR – 2010;

LANDSAT DATABASE OF UPPER GRANDE RIVER BASIN

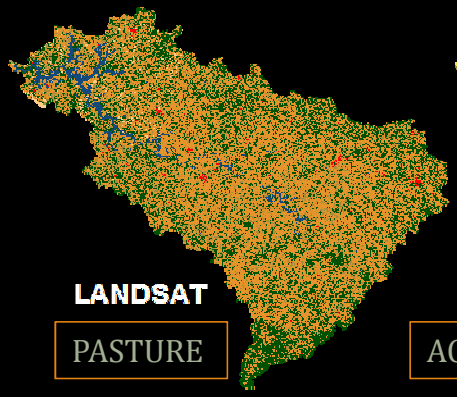
- DRAINAGE AREA: 26,490 km^2;
- AVERAGE STREAMFLOW: 420 m^3/s;
- DESCRIPTION:
  - LANDSAT SCENES – 5;
  - SUPERVISED CLASSIFICATION – 350 TRAINING SITES;
    - SUPPORT VECTOR MACHINE (SVM);
  - CLASSIFICATION YEAR – 2010;
- ACURACY ASSESSMENT POINTS:
  - 19 HEXAGONS
    - 10 RANDON POINTS FOR EACH
  - 103 POINTS WITHIN THE BASIN
    - 94 CERTAIN POINTS



LUCC DATABASE OF UPPER GRANDE RIVER BASIN



LUCC DATABASE OF UPPER GRANDE RIVER BASIN

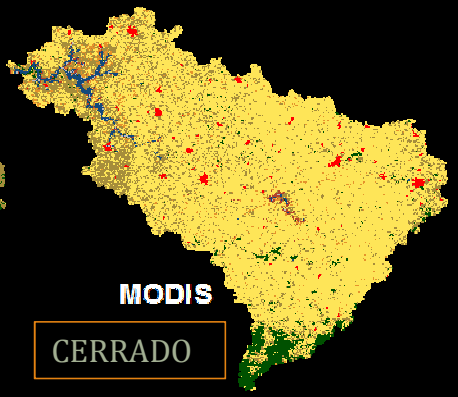


LANDSAT

PASTURE

GLOBCOVER

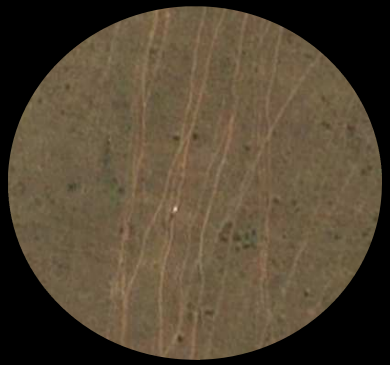
AGRICULTURE



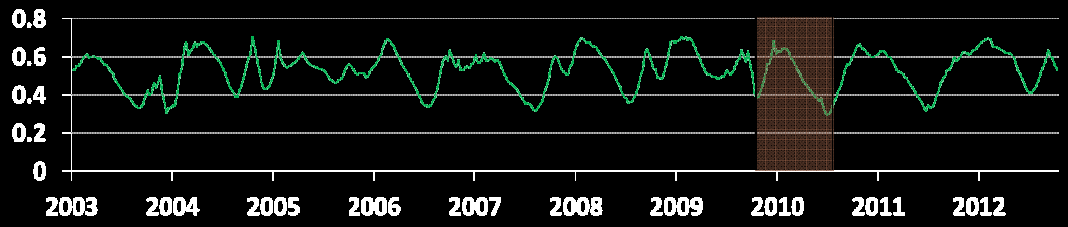
MODIS

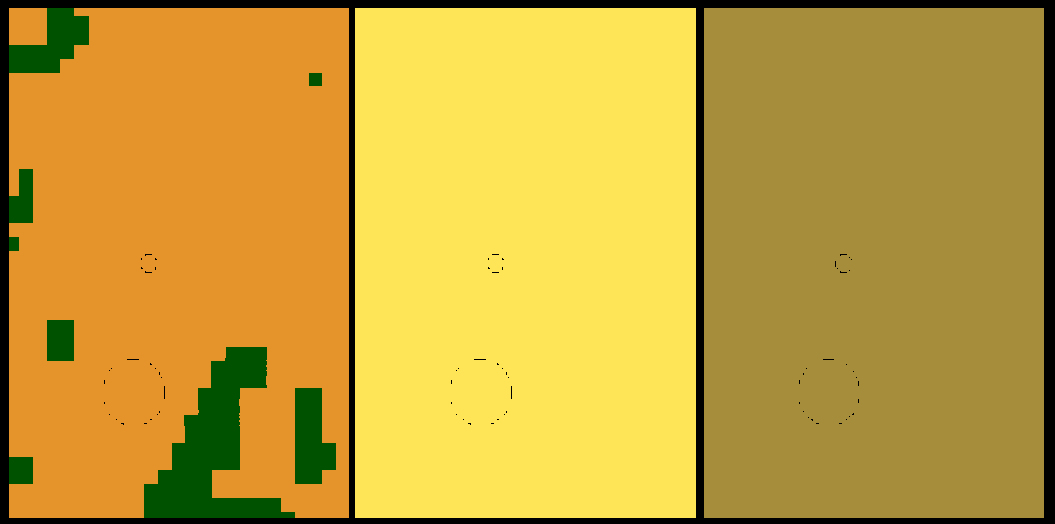
CERRADO

LUCC DATABASE OF UPPER GRANDE RIVER BASIN



NDVI = Normalized Difference Vegetation Index





PASTURE

LANDSAT

AGRICULTURE

GLOBCOVER

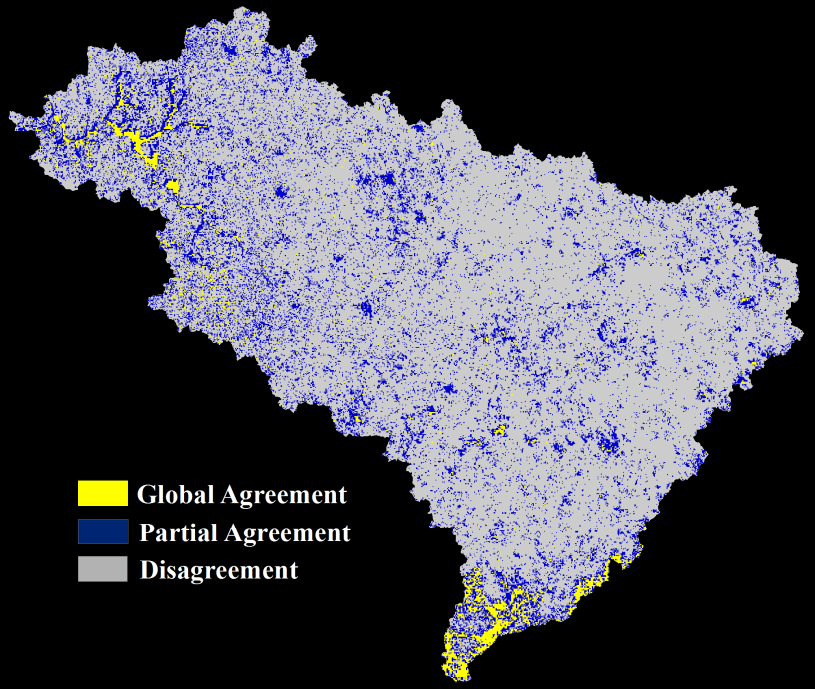
CERRADO

MODIS

LUCC DATABASE OF UPPER GRANDE RIVER BASIN

Table 1 – Accuracy evaluation.

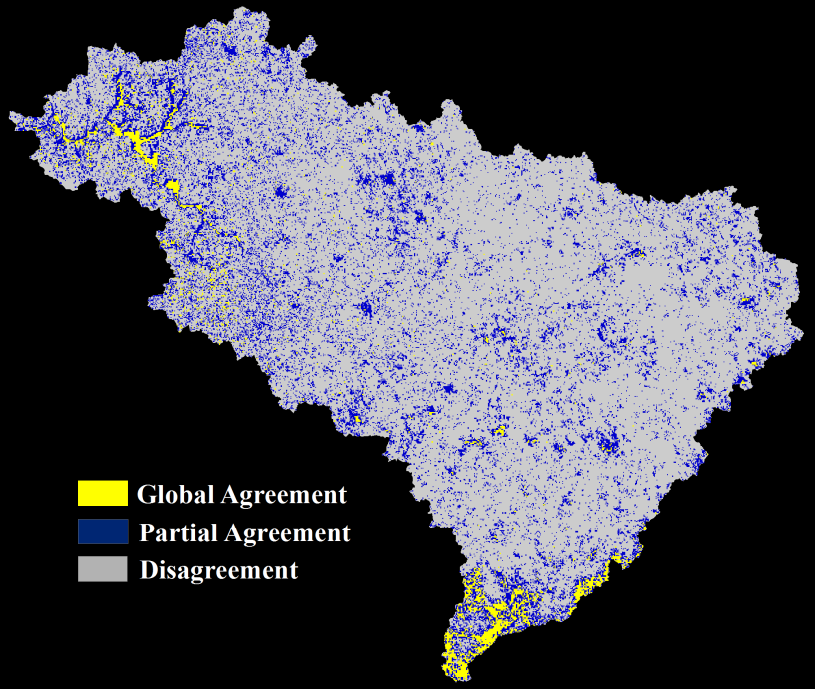
	LANDSAT	GLOBCOVER	MODIS
Precisão Global	0,830	0,181	0,064
Índice Kappa	0,713	0,067	0,010



LUCC DATABASE OF UPPER GRANDE RIVER BASIN

Table 1 – Accuracy evaluation.

	LANDSAT	GLOBCOVER	MODIS
Precisão Global	0,830	0,181	0,064
Índice Kappa	0,713	0,067	0,010

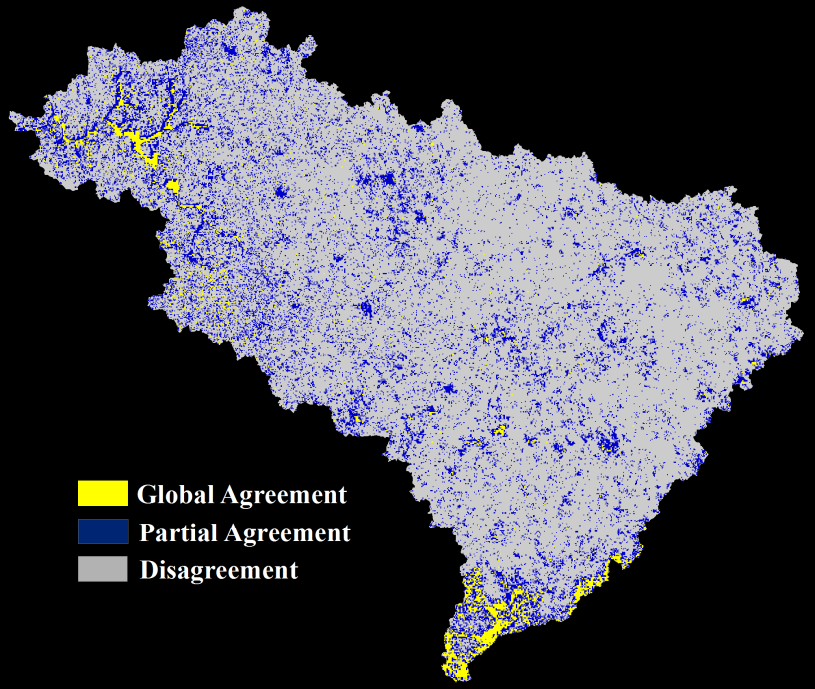


LUCC DATABASE OF UPPER GRANDE RIVER BASIN

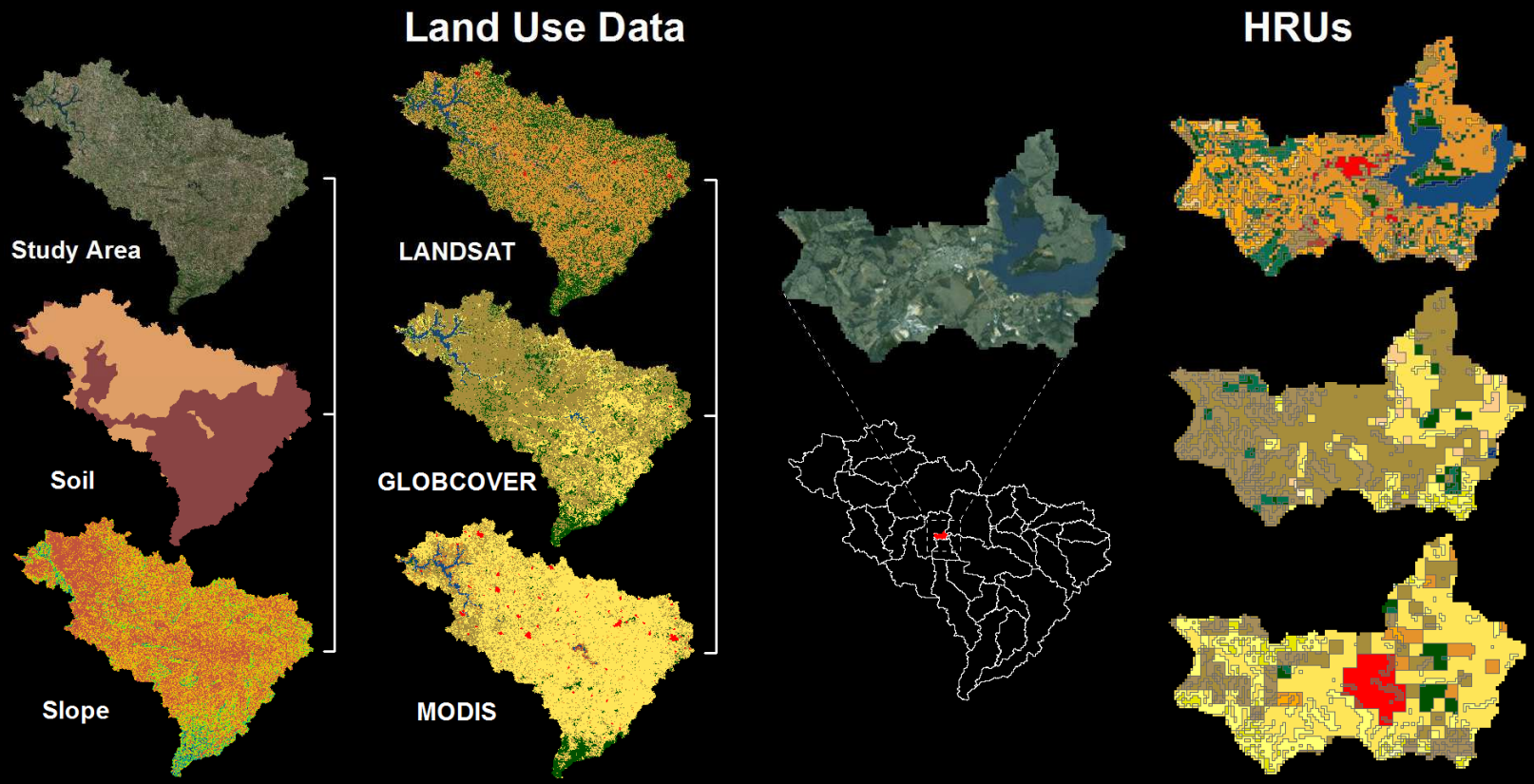
Table 1 – Accuracy evaluation.

	LANDSAT	GLOBCOVER	MODIS
Precisão Global	0,830	0,181	0,064
Índice Kappa	0,713	0,067	0,010

MODIS CONSIDERED MOST AREAS AS SAVANNA INSTEAD OF PASTURE… BETTER INDEXES!?

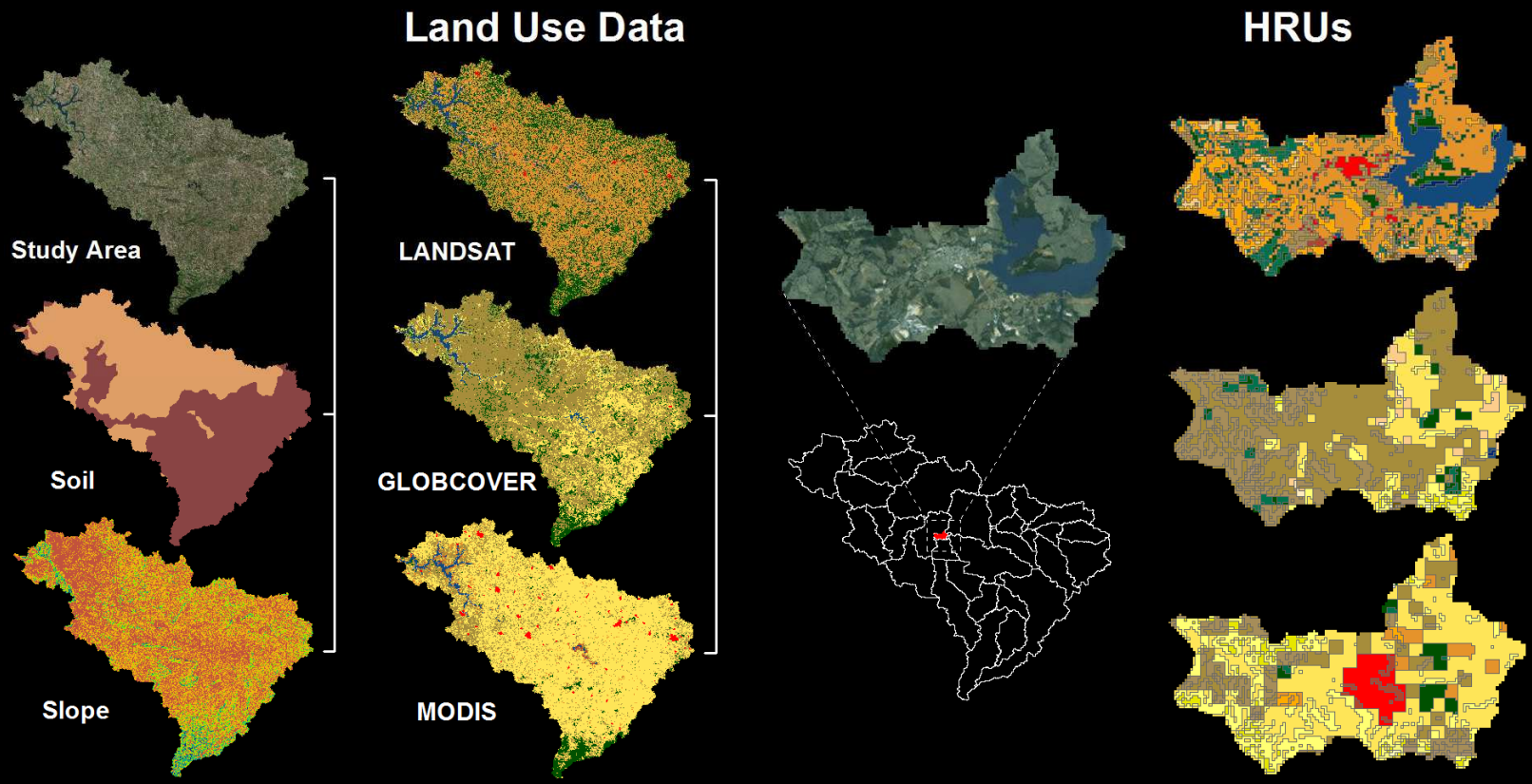


LUCC DATABASE OF UPPER GRANDE RIVER BASIN

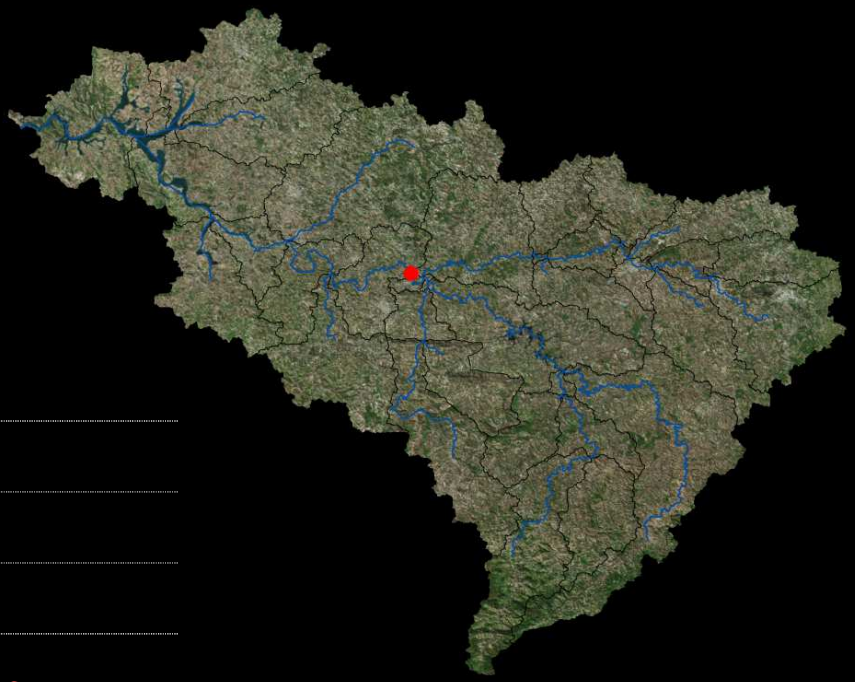


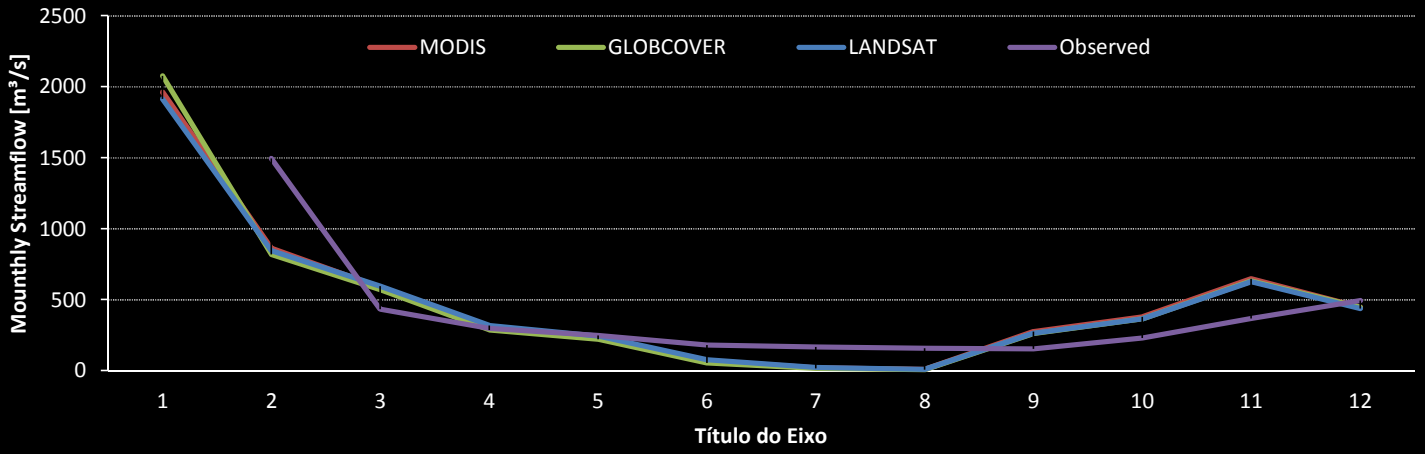
LUCC DATABASE OF UPPER GRANDE RIVER BASIN

	TOTAL_HRUs	HRU	RESOLUTION
LANDSAT	1277	21	30
GLOBCOVER	919	19	300
MODIS	1215	18	500



LUCC DATABASE OF UPPER GRANDE RIVER BASIN





Observed – 312 m^3s^{-1}
LANDSAT - 369.9 m^3s^{-1}
GLOBCOVER - 379.5m^3s^{-1}
MODIS - 379.1m^3s^{-1}

	LANDSAT	MODIS	GLOBCOVER
E	-1.01	-1.16	-1.44
R^2	0.57	0.56	0.54

LUCC DATABASE OF UPPER GRANDE RIVER BASIN

- NEXT STEPS:
  - PARAMETER SENSITIVITY ANALYSIS;
    - Does the Landsat product reduce uncertainties?
    - Does the calibration is more efficient?
  - CALIBRATE AND VALIDATE;
  - PRODUCE PRODUCT DATA FOR THE WHOLE AREA – 2010;
    - 1975
    - 1980
    - 1985
    - 1990
    - 1995
    - 2000
    - 2005
    - 2015
  - MAKE THIS LANDSAT PRODUCT AVALIABLE!

THANK YOU!

DETECTION OF THE ROLE IN CLIMATE CHANGE AND LAND USE AND LAND COVER CONDITIONS IN THE PARANA RIVER BASIN HYDROLOGY

[1] PAST LULC CHANGES AND THE IMPACT ON HYDROLOGY

[2] POTENTIAL IMPACTS OF CLIMATE CHANGE SCENARIOS

[3] EFFECTS OF LARGE-SCALE CLIMATE VARIABILITY

CAPES

ANA
AGÊNCIA NACIONAL DE ÁGUAS

rudke@alunos.utfpr.edu.br

[1] Federal University of Technology – Paraná, PR, Brazil

[2] University of São Paulo, SP, Brazil

[3] State University of Amazonas, AM, Brazil