

Spatial overlay & spatial coincidence concept

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Spatial coincidence

- Landscape genomics mainly uses one of the six concepts of spatial analysis
- In order to connect genetic information with geo-environmental data, we utilize **spatial coincidence** analysis
- This approach associates information levels and is able to compare across them thanks to their common geographical coordinates
- We need a geo-referenced data set comprising one or more environmental variables describing the sampling location and a geo-referenced molecular marker data set for the study individuals or population(s)

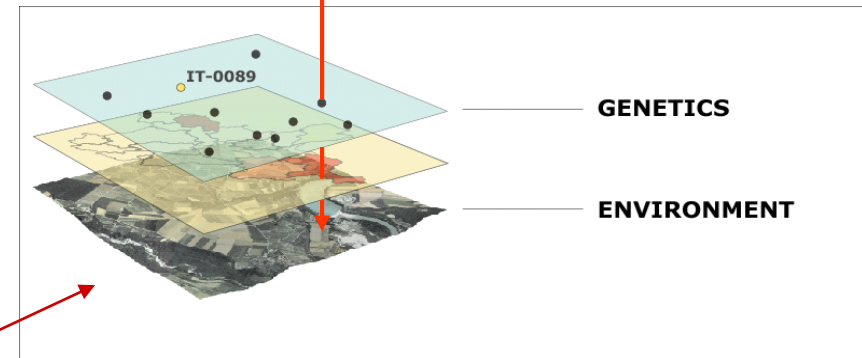
ECOLOGY

Time to Tap Africa's Livestock Genomes

Olivier Hanotte,¹ Tadelles Dessie,² Steve Kemp³

Fortunately, the fields of genetics and genomics (3–5) offer a new start for the sustainable improvement of African livestock productivity. Landscape genomics links genome-wide information to geo-environmental resource analysis to identify potentially valuable genetic material. Typically, researchers will perform a genome-wide scan on a number of animals from populations living in different habitats or across an ecological cline (from dry to wet areas, for instance).

Landscape genomics



- Correlative approaches and spatial statistics

Genome-wide information

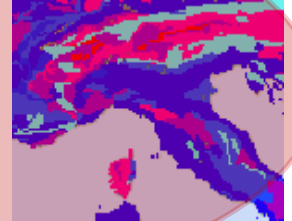
- Paradigm shift and transition phase

Data integration

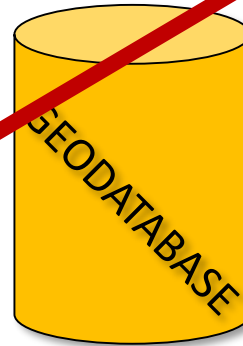


Administrative boundaries
Socio-Economic data
Socio-demographic data

Environmental data:
topography, climate,
soil, etc.

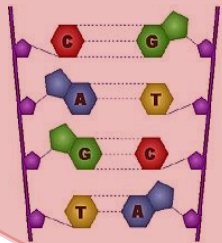


Geographic coordinates
X, Y



GIS

Sampling
Genetic data



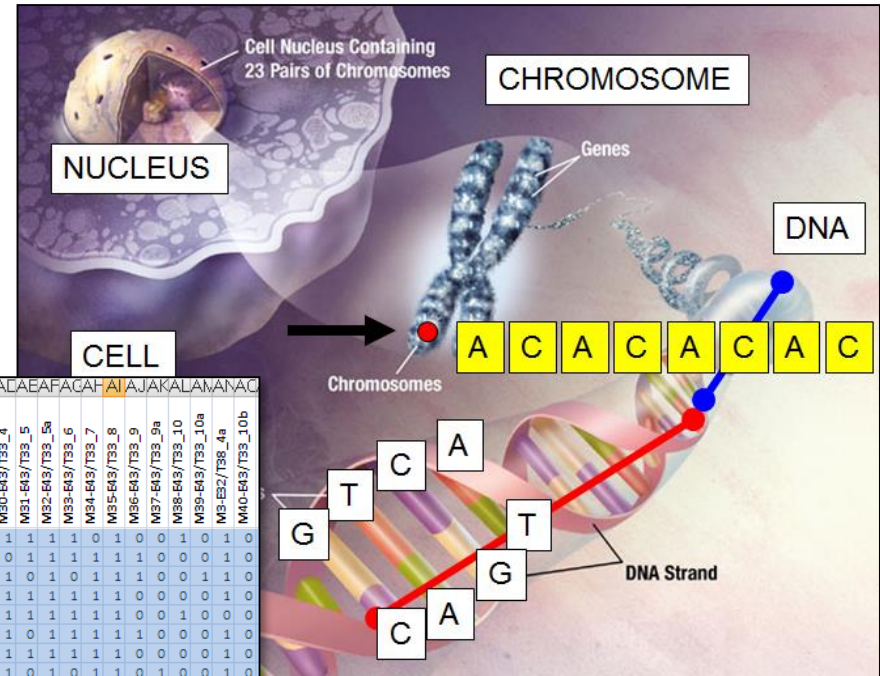
Questionnaires
Husbandry practices



Transfer of attributes

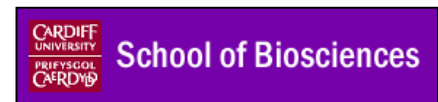
- Usually we start with a file containing the coordinates of the sampling locations
- Then we add molecular information
- The next step is to feed this geo-molecular matrix with environmental descriptors

Complete the genetic matrix...



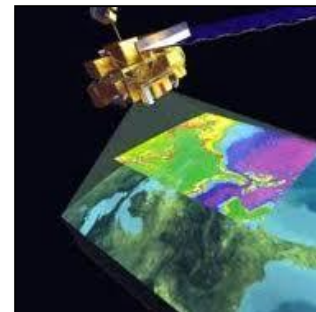
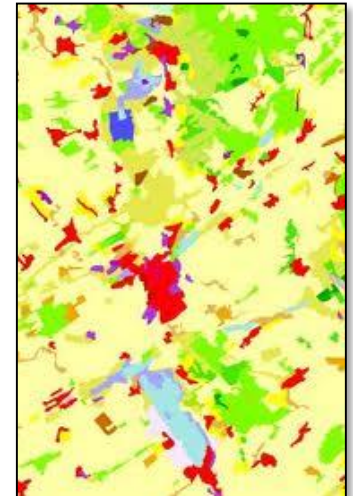
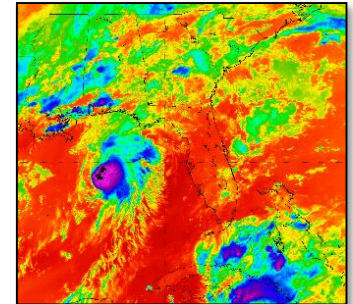
	A		D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AE	AC	AE	AF	AG	AI	AJ	AK	AL	AM	AN	AO				
					M100-E45/T32_37	M101-E45/T32_38	M102-E45/T32_39	M10-E32/T38_9	M11-E32/T38_10	M12-E32/T38_11	M13-E32/T38_11a	M14-E32/T38_11b	M15-E32/T38_12	M16-E32/T38_13	M17-E32/T38_14	M18-E32/T38_15	M19-E32/T38_17	M20-E32/T38_17a	M21-E32/T38_19	M22-E32/T38_20a	M25-E32/T38_21	M24-E32/T38_21b	M25-E32/T38_22	M26-E32/T38_22a	M27-E43/T33_1	M28-E43/T33_2	M29-E43/T33_3a	M2-E32/T38_4	M30-E43/T33_4	M31-E43/T33_5	M32-E43/T33_5a	M33-E43/T33_6	M34-E43/T33_7	M35-E43/T33_8	M36-E43/T33_9	M37-E43/T33_9a	M38-E43/T33_10	M39-E43/T33_10a	M3-E32/T38_4a	M40-E43/T33_10b		
1	farmid	longitude	latitude	ANIMALID																																						
2	PT-0015	-8.2676	41.6848	CHPOBRA3	1	1	1	0	1	1	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	PT-0022	-7.9273	41.5847	CHPOBRA26	1	1	1	0	1	1	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	PT-0023	-7.9273	41.5847	CHPOBRA28	1	1	0	0	1	1	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	PT-0023	-7.9273	41.5847	CHPOBRA29	1	1	1	1	1	1	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	PT-0021	-7.8426	41.395	CHPOBRA23	0	0	0	0	1	1	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	PT-0021	-7.8426	41.395	CHPOBRA25	1	1	1	1	1	1	0	0	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	PT-0017	-7.8269	41.4732	CHPOBRA10	1	1	1	1	1	1	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	PT-0017	-7.8269	41.4732	CHPOBRA11	1	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	PT-0017	-7.8269	41.4732	CHPOBRA12	1	0	0	Na	1	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	PT-0020	-7.8215	41.4235	CHPOBRA21	0	1	0	1	1	1	1	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	PT-0020	-7.8215	41.4235	CHPOBRA22	1	1	0	1	1	1	0	0	0	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	PT-0019	-7.7811	41.439	CHPOBRA18	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	PT-0019	-7.7811	41.439	CHPOBRA19	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	PT-0018	-7.78	41.4379	CHPOBRA13	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	PT-0018	-7.78	41.4379	CHPOBRA14	1	1	0	0	1	1	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	PT-0018	-7.78	41.4379	CHPOBRA15	1	1	0	1	1	1	0	0	0	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	PT-0016	-7.7291	41.4752	CHPOBRA5	1	1	1	0	1	1	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	PT-0016	-7.7291	41.4752	CHPOBRA6	1	0	0	1	1	1	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	PT-0016	-7.7291	41.4752	CHPOBRA8	1	0	0	1	1	1	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	ES-0060	-6.00263	37.7014	CHSPFLR35	1	0	0	0	1	1	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	ES-0060	-6.00263	37.7014	CHSPFLR37	1	0	0	0	1	1	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	ES-0060	-6.00263	37.7014	CHSPFLR38	1	1	0	0	1	1	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	ES-0060	-6.00263	37.7014	CHSPFLR39	1	1	1	0	0	1	1	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	ES-0060	-6.00263	37.7014	CHSPFLR40	1	1	0	1	1	1	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	ES-0059	-5.79995	37.9703	CHSPFLR27	1	1	0	0	1	1	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	ES-0059	-5.79995	37.9703	CHSPFLR28	1	1	0	1	1	1	1	0	0	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	ES-0059	-5.79995	37.9703	CHSPFLR29	1	1	1	1	1	1	Na	Na	1	1	0	1	Na	Na	0	1	0	0	0	Na	0	0	0	0	Na	1	1	1	0	1	0	0	0	Na	0	0	0	

GENETICS



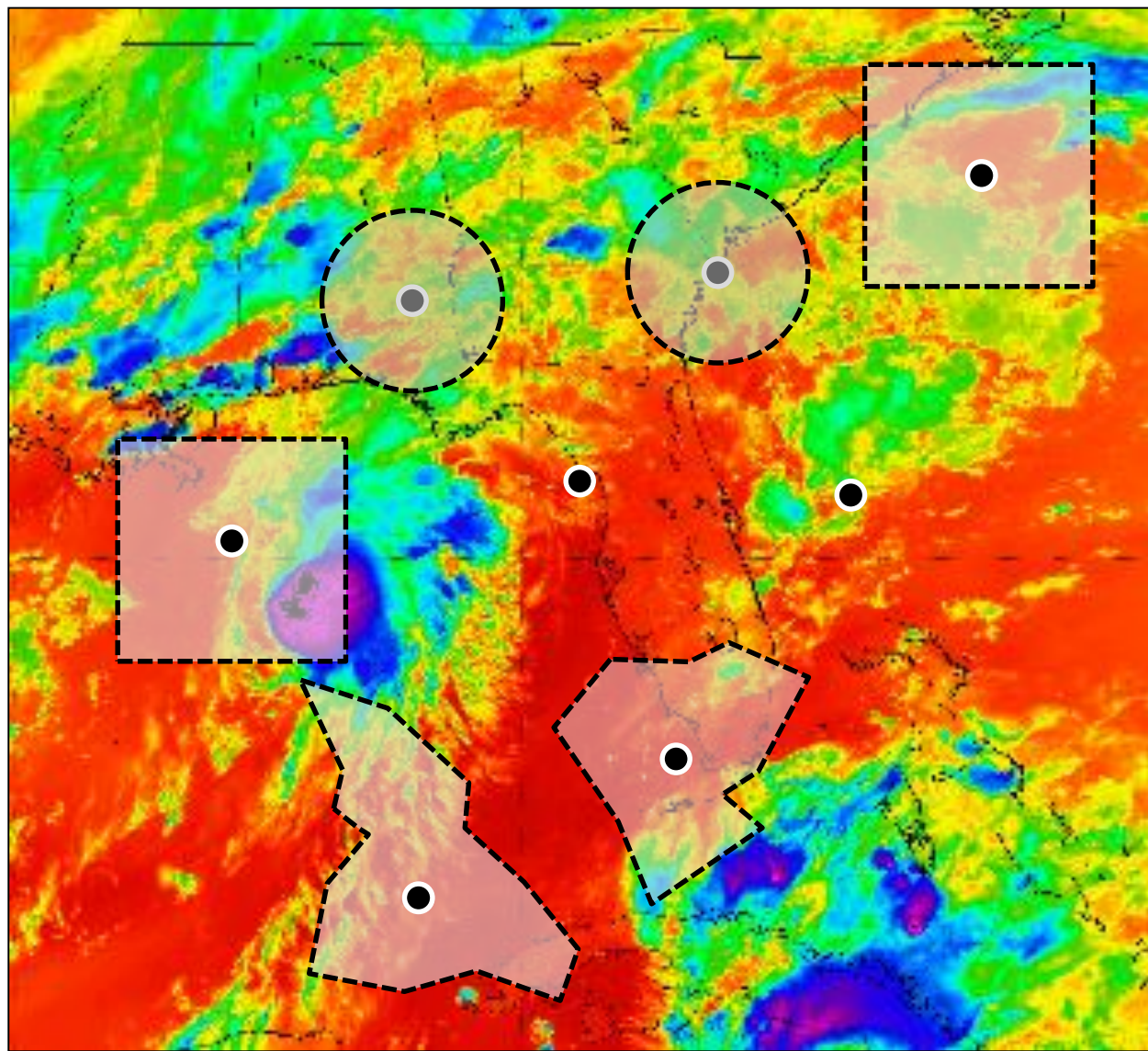
...with environmental variables characterizing sampling locations

GEO			GENETICS																ENVIRONMENT				
1	farmid	animalid	QARJMP29_allele2_137	QARJMP29_allele2_139	QARJMP29_allele2_141	QARJMP29_allele2_143	QARJMP29_allele2_145	QARJMP29_allele2_147	QARJMP29_allele2_149	QARJMP29_allele2_151	QARJMP29_allele2_153	QARJMP29_allele2_155	QARJMP29_allele2_157	QARJMP29_allele2_159	QARJMP29_allele2_161	QARJMP29_allele2_163	QARJMP29_allele2_165	QARJMP29_allele2_167	wndjan	altitude	wndfeb	wndmar	wndapr
1044	PL-4005	QAPLPOM25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.1	22	4.6	5	4.4
1045	PL-4005	QAPLPOM26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.1	22	4.6	5	4.4
1046	PL-4006	QAPLPOM01	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	5.3	153	4.8	4.9	4.3
1047	PL-4006	QAPLPOM15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3	153	4.8	4.9	4.3
1048	PL-4006	QAPLPOM24	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5.3	153	4.8	4.9	4.3
1049	PL-4007	QAPLPOM05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3	250	4.8	5	4.5
1050	PL-4007	QAPLPOM16	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5.3	250	4.8	5	4.5
1051	PL-4008	QAPLPOM09	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5.2	166	4.8	5	4.4
1052	PL-4008	QAPLPOM19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.2	166	4.8	5	4.4
1053	PL-4008	QAPLPOM20	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5.2	166	4.8	5	4.4
1054	PL-4009	QAPLPOM10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.5	87	5	5.2	4.6
1055	PL-4009	QAPLPOM21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.5	87	5	5.2	4.6
1056	PL-4010	QAPLPOM08	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5.4	208	4.9	5.1	4.5



Two possibilities

- Characterize sampling points with the underlying value for a given environmental variable (typically the case for plants)
- Characterize sampling points with statistics of a given environmental variable for the underlying area (typically the case for animals → estimation of the movement range)



Environmental representativeness

- We just considered spatial representativeness of environmental variables
- Another issue is the temporal representativeness of environmental variables
- CRU data or Worldclim data are produced on the basis of observations collected during several years (e.g. 30 years for CRU, ~1960-1990)
- Can we compare genetic data which are the result of long evolutionary processes with environmental data characterizing only the very recent period ?
- Paleo-environmental datasets are available

Paleoenvironmental data

ECOGRAPHY

PATTERN AND
PROCESS IN ECOLOGY

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Software note

PaleoView: a tool for generating continuous climate projections spanning the last 21 000 years at regional and global scales

[Damien A. Fordham](#), [Frédéric Saltré](#), [Sean Haythorne](#), [Tom M. L. Wigley](#),
[Bette L. Otto-Bliesner](#), [Ka Ching Chan](#), [Barry W. Brook](#)

First published: 12 May 2017 [Full publication history](#)

DOI: 10.1111/ecog.03031 [View/save citation](#)

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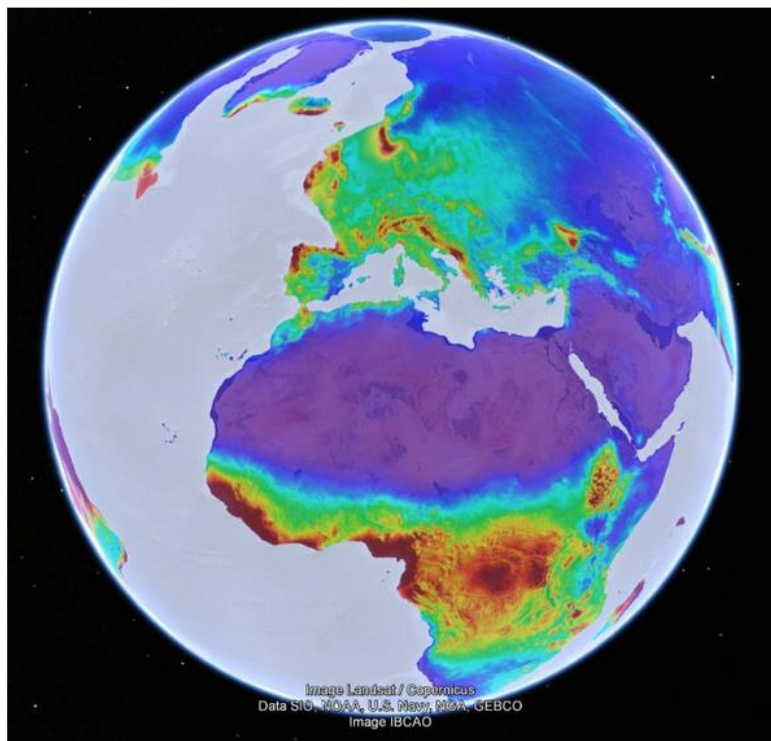
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Volume 40, Issue 11
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Pages 1348–1358



Climatologies at high resolution for the earth's land surface areas

Last glacial maximum climate

Downscaled global climatological data from the last glacial maximum (21.000 years ago). The CHELSA LGM data is based on a implementation of the CHELSA algorithm on PMIP3 data. For now we only implemented the CCSM4 global circulation model as a test dataset. It is available in via our [FILE SERVER](#).



Annual precipitation patterns during the last glacial maximum. Red areas indicate high precipitation, blue indicates low precipitation.

The data uses a paleoDEM at 30 arc second resolution and an interpolation of

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the performance of the timeseries



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26. Okt. 2017



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edaphic data and [#CHELSA](#) to model plant

Exercise

- Characterizing sampling points with environmental data

