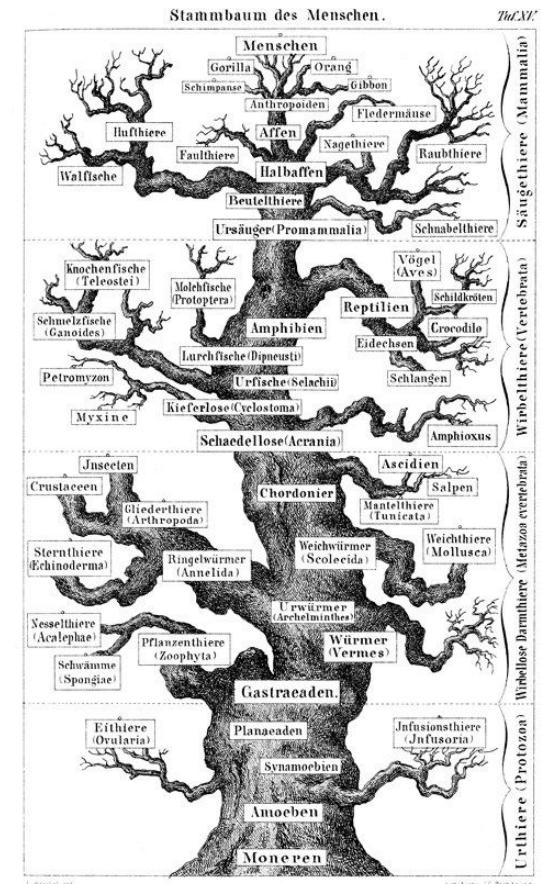
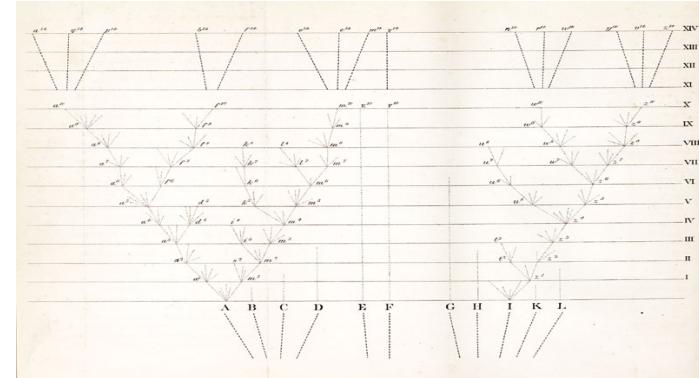
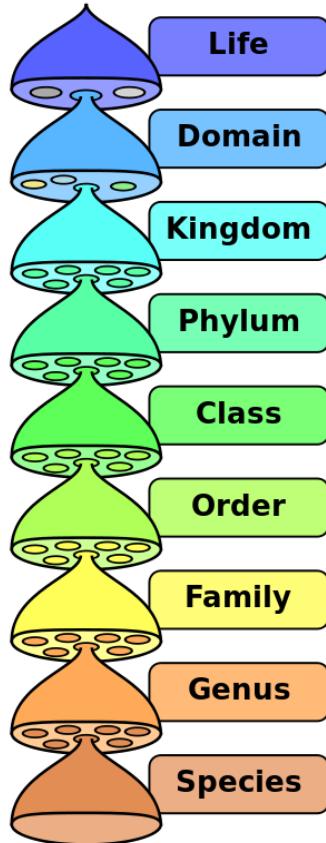


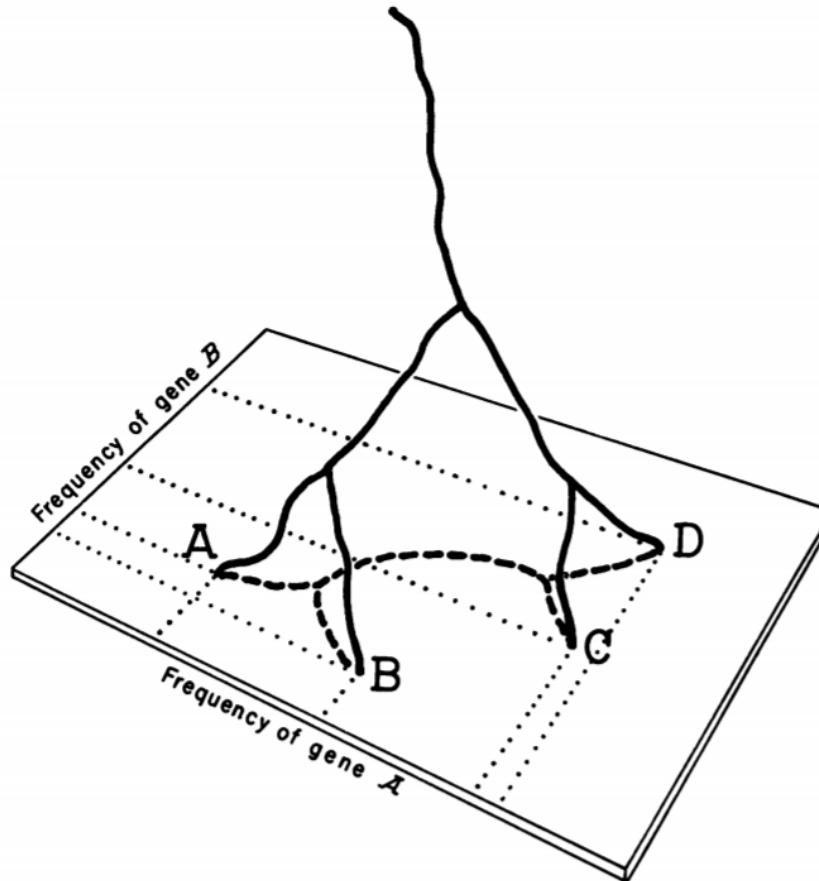
Trees, Admixture graphs and population structure

Using trees to describe (human) population structure

Trees are foundational to Systematics and Evolution



Where do trees come from?



Cavalli-Sforza & Edwards, 1967

But when does this model break?

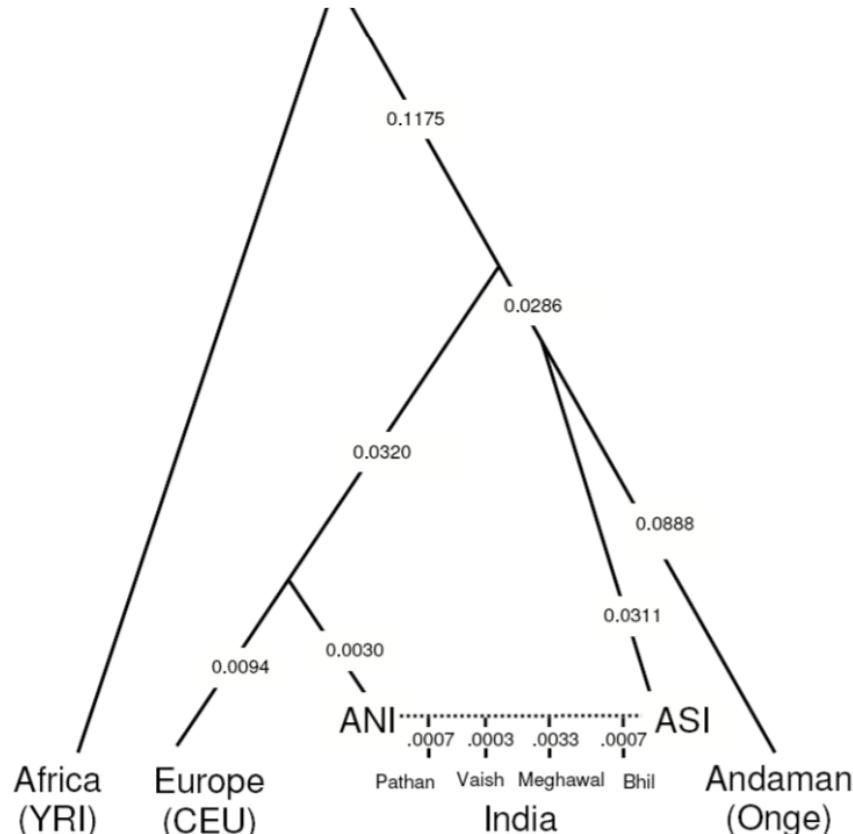
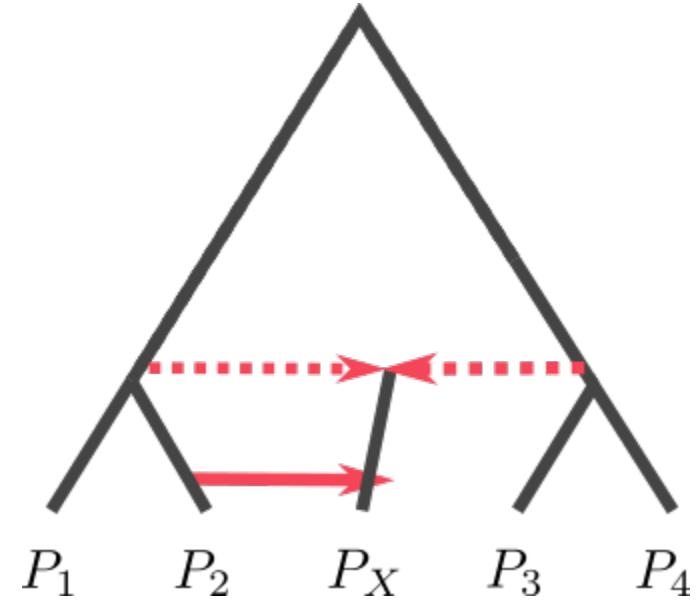
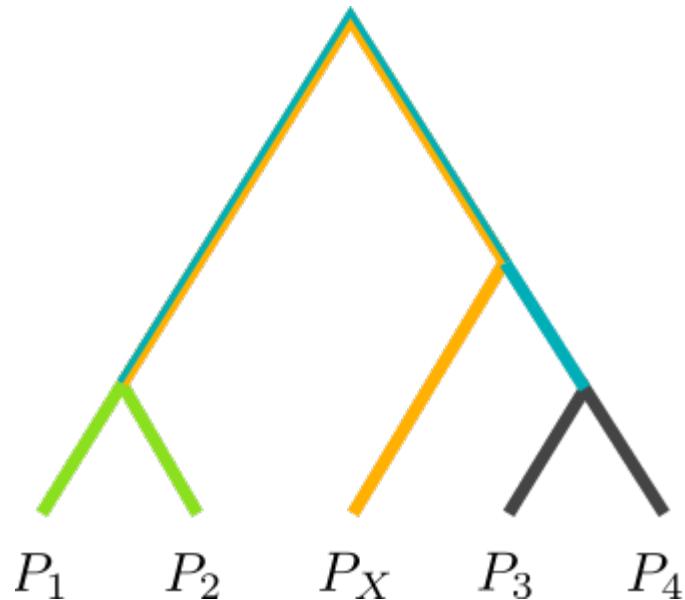


Figure 4.

A model relating the history of Indian and non-Indian groups. Modeling the Pathan, Vaish,

Trees and Admixture Graphs



Estimating Admixture Graphs

Admixtools / treemix



Admixture graphs

Robert Maier

OPEN  ACCESS Freely available online

 PLOS GENETICS

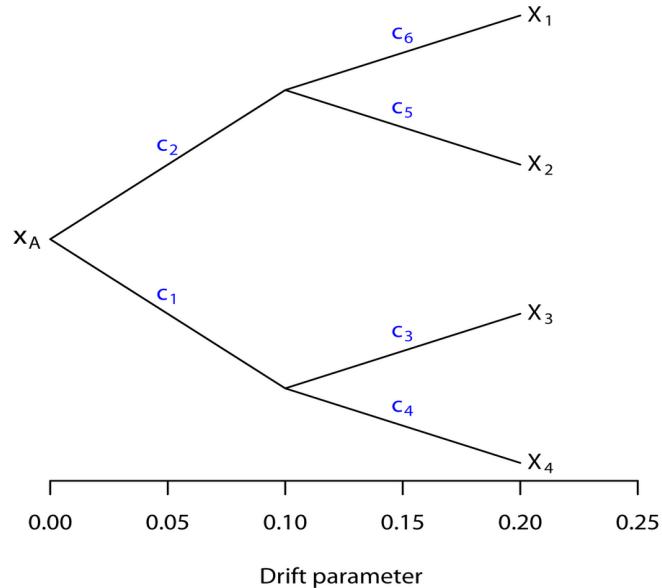
Inference of Population Splits and Mixtures from Genome-Wide Allele Frequency Data

Joseph K. Pickrell^{1,*}, Jonathan K. Pritchard^{1,2,*}

Inference of Population Splits and Mixtures from Genome-Wide Allele Frequency Data

Joseph K. Pickrell^{1,*}, Jonathan K. Pritchard^{1,2*}

A. Example tree

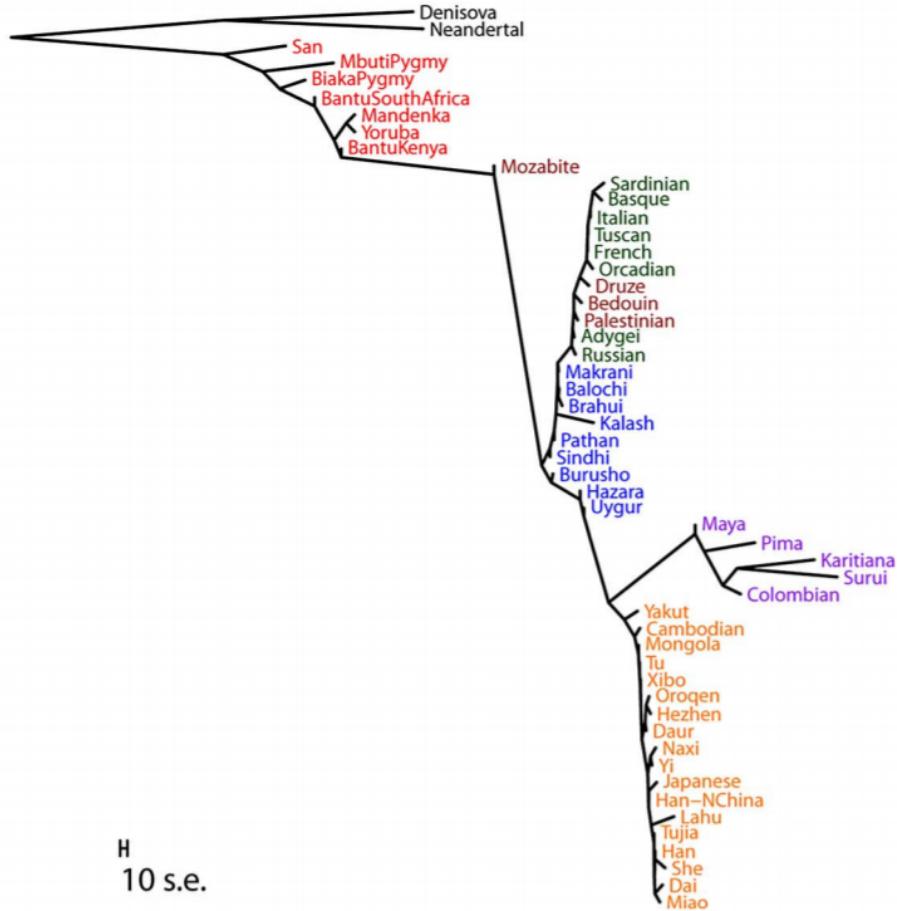


B. Covariance matrix for tree in A.

x_1	$c_2 + c_6$	c_2	0	0
x_2	c_2	$c_2 + c_5$	0	0
x_3	0	0	$c_1 + c_3$	c_1
x_4	0	0	c_1	$c_1 + c_4$
	x_1	x_2	x_3	x_4

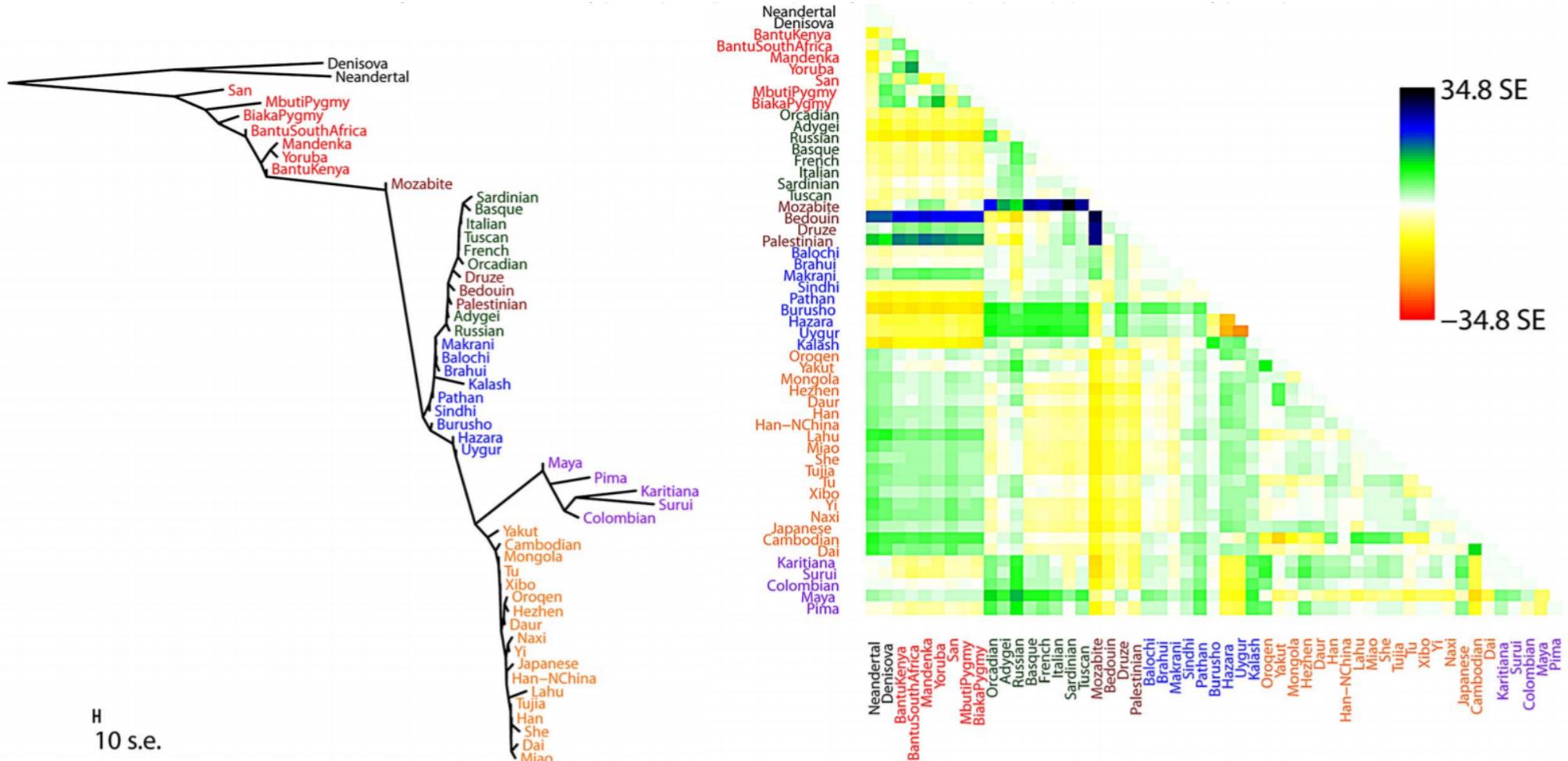
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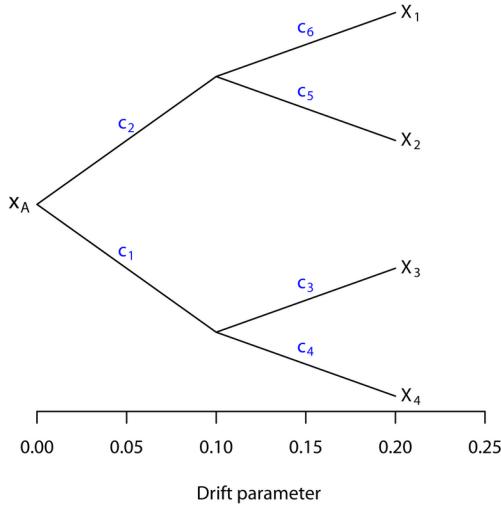


Inference of Population Splits and Mixtures from Genome-Wide Allele Frequency Data

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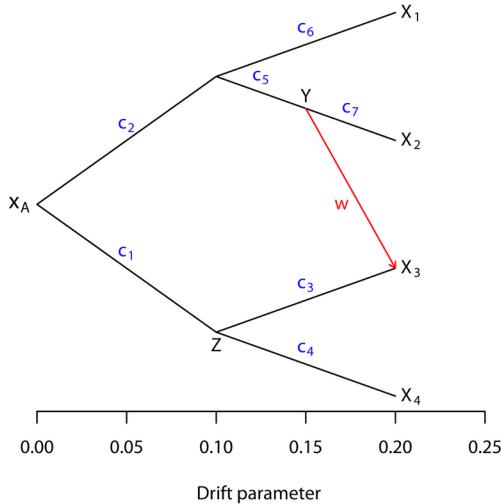
A. Example tree



B. Covariance matrix for tree in A.

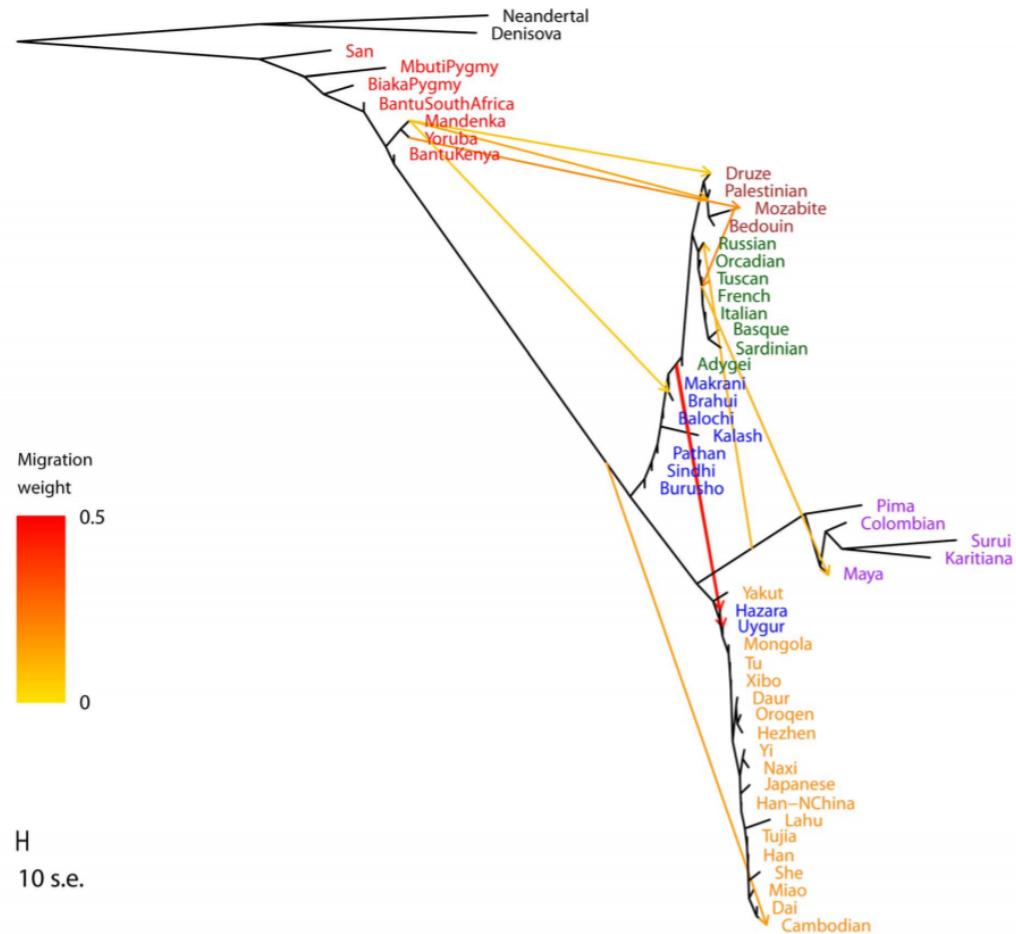
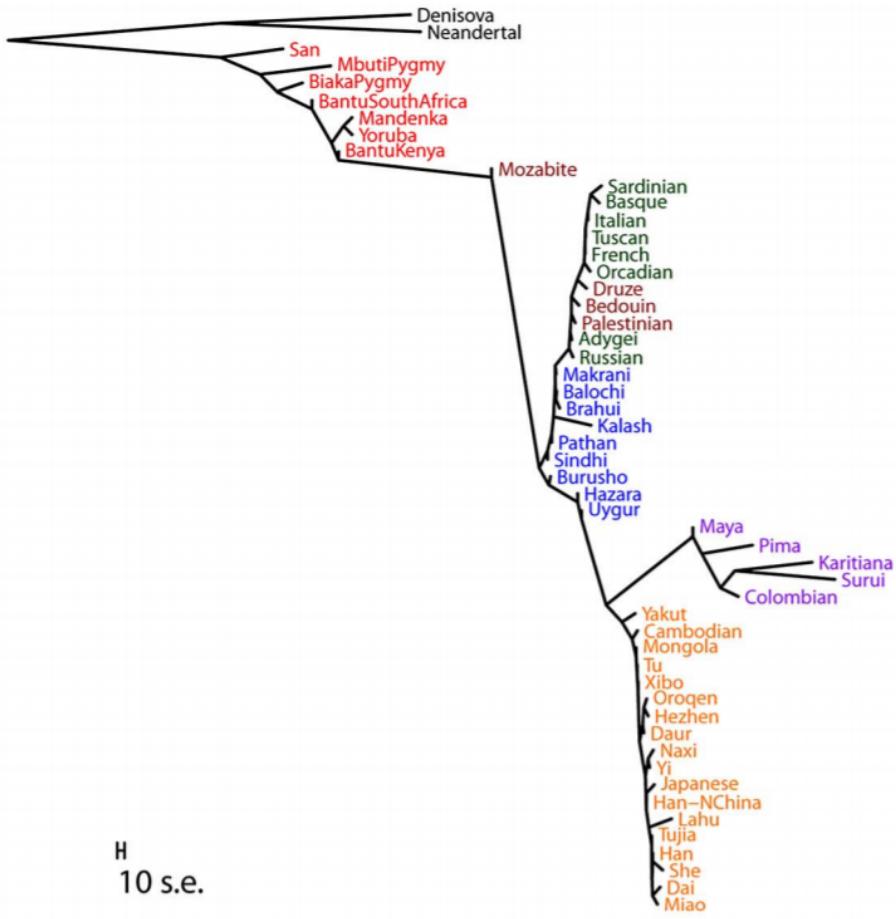
X_1	$c_2 + c_6$	c_2	0	0
X_2	c_2	$c_2 + c_5$	0	0
X_3	0	0	$c_1 + c_3$	c_1
X_4	0	0	c_1	$c_1 + c_4$
	X_1	X_2	X_3	X_4

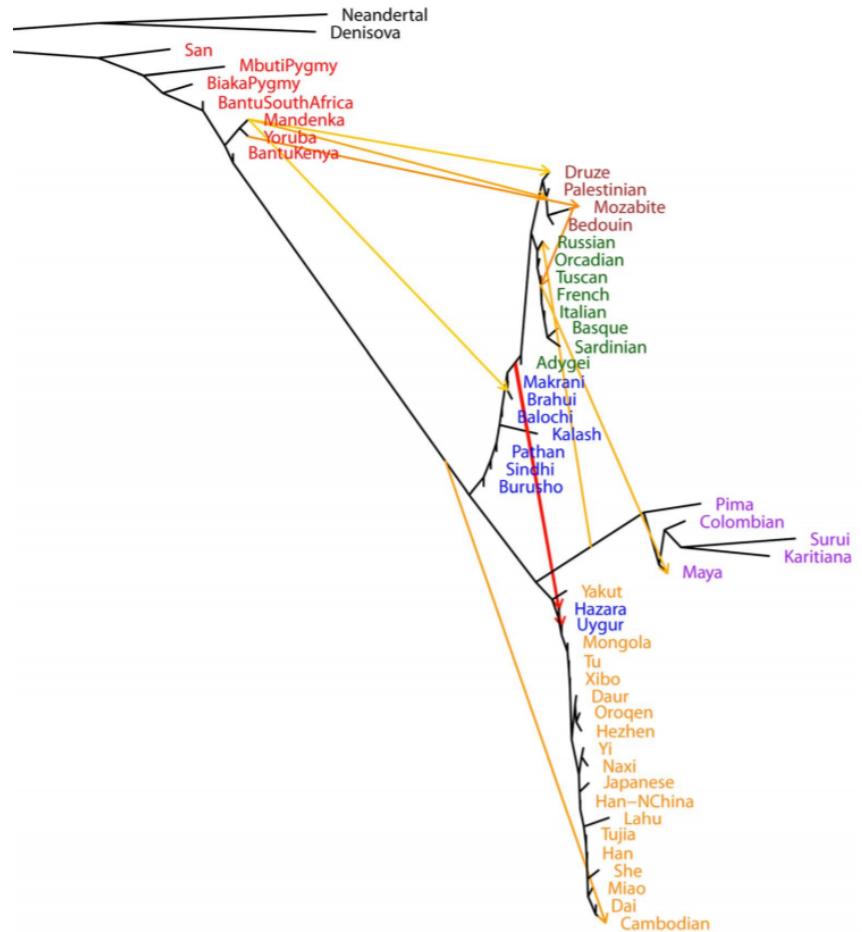
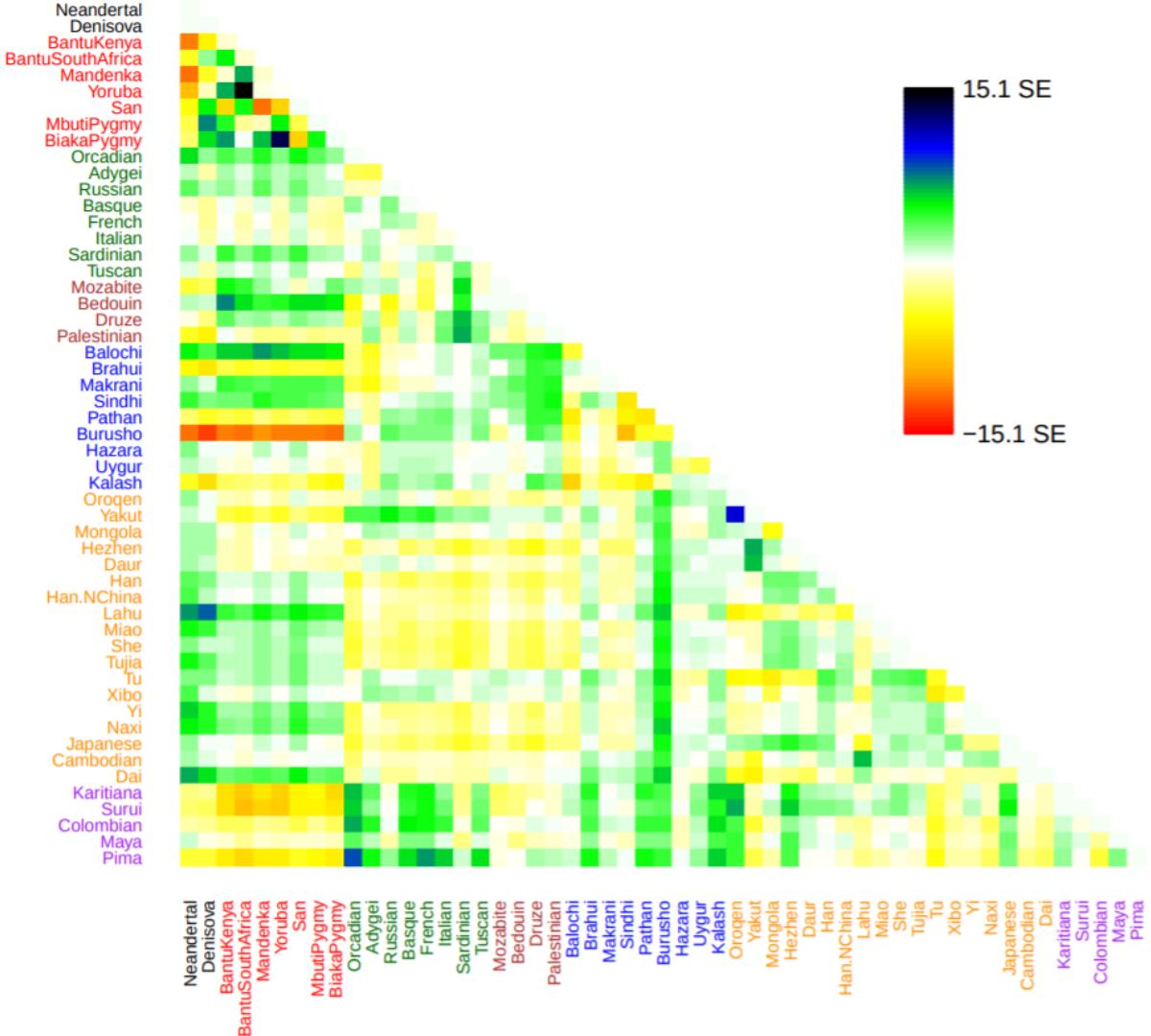
C. Example graph



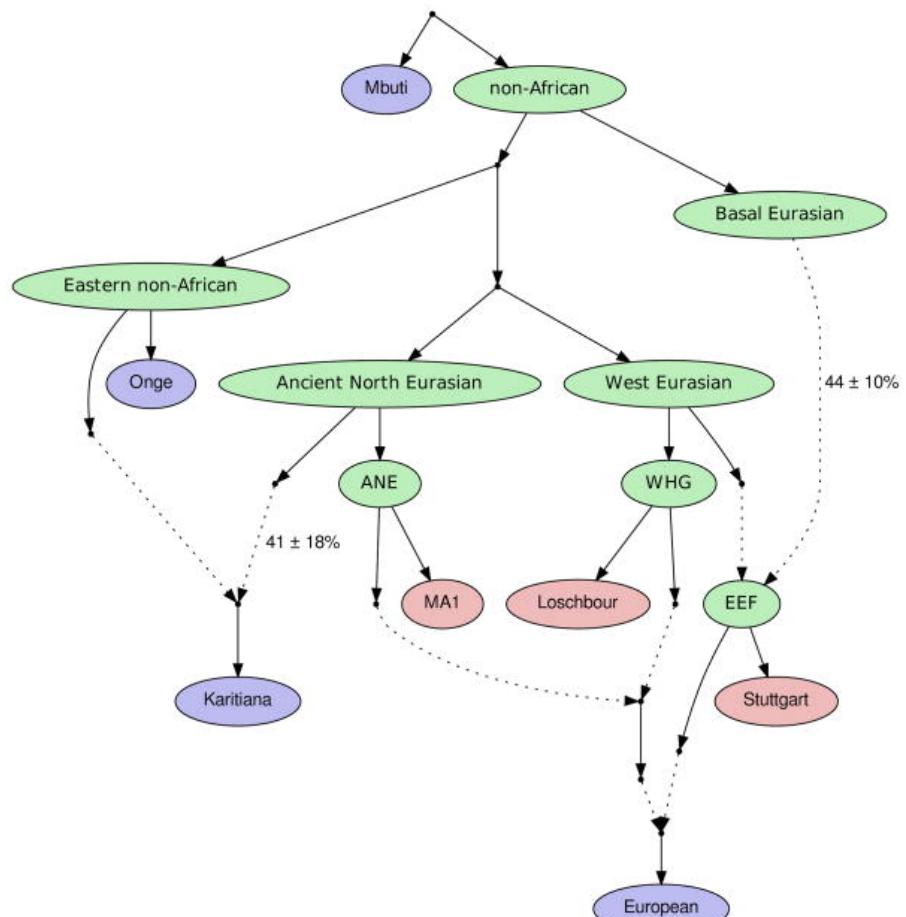
D. Covariance matrix for graph in C.

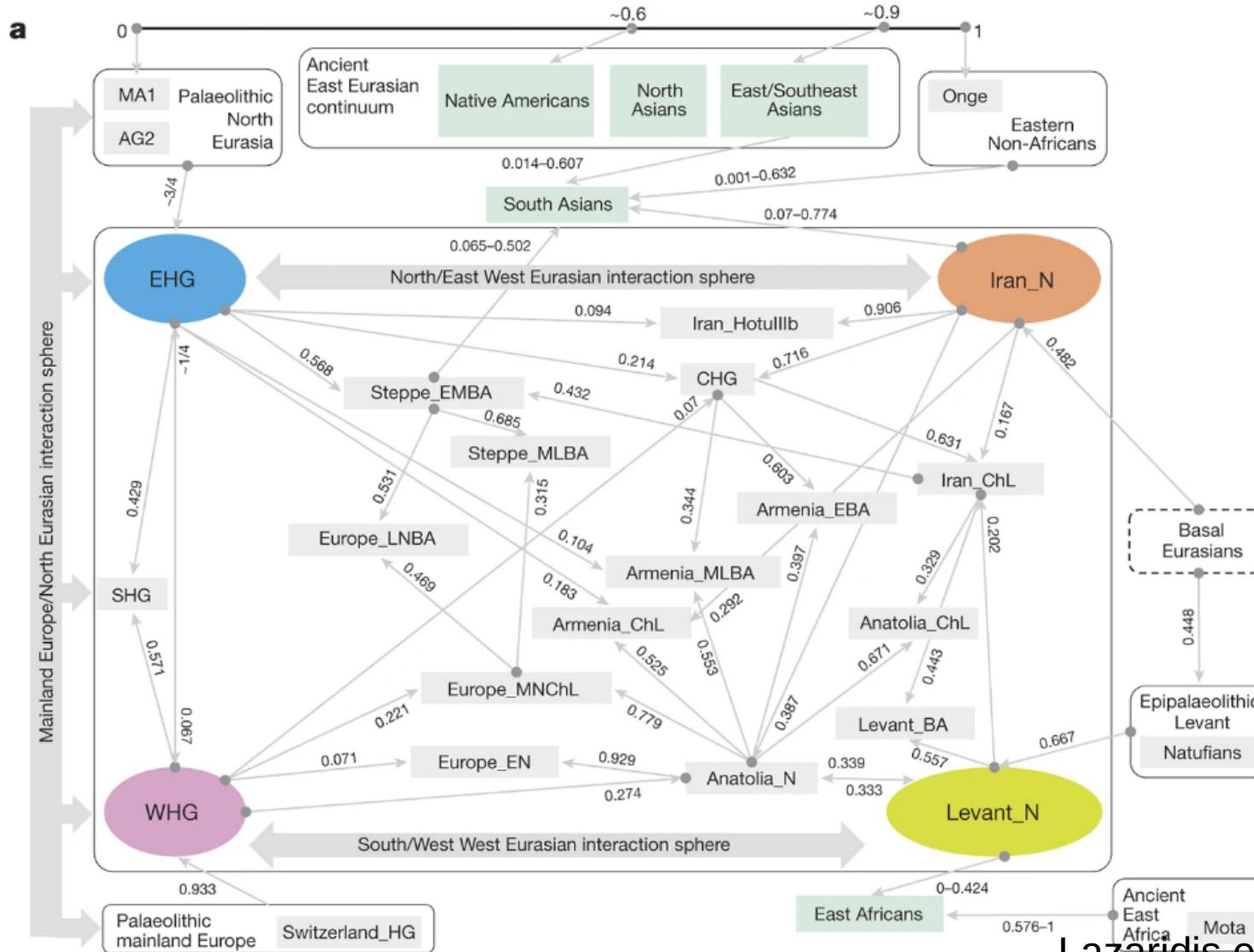
X_1	$c_2 + c_6$	c_2	$w c_2$	0
X_2	c_2	$c_2 + c_5 + c_7$	$w(c_2 + c_5)$	0
X_3	$w c_2$	$w(c_2 + c_5)$	$w^2(c_2 + c_5) + (1-w)^2(c_1 + c_3)$	$(1-w)c_1$
X_4	0	0	$(1-w)c_1$	$c_1 + c_4$
	X_1	X_2	X_3	X_4





Admixture graphs



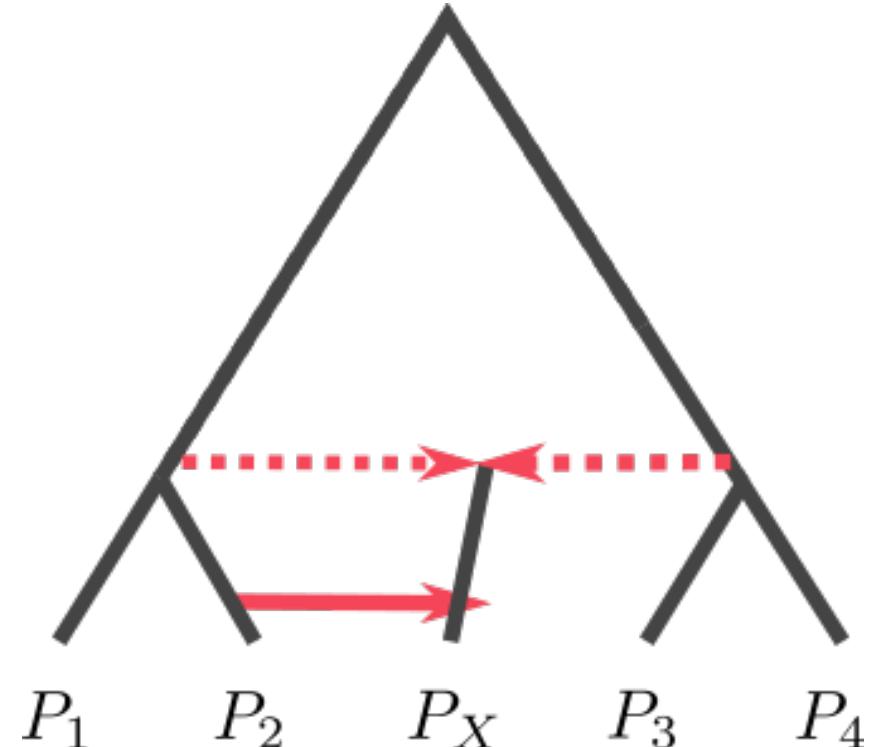


Practical Considerations: Which approach should I use?

- Admixture
- PCA
- Trees / Admixture Graph
- All of the above?

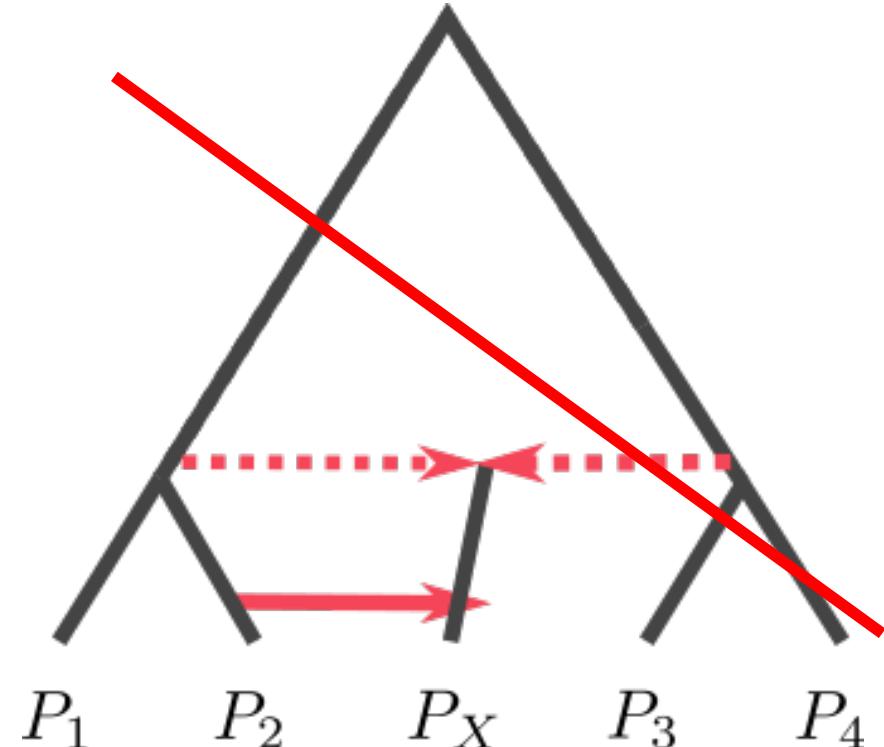
Practical Considerations: Which approach should I use?

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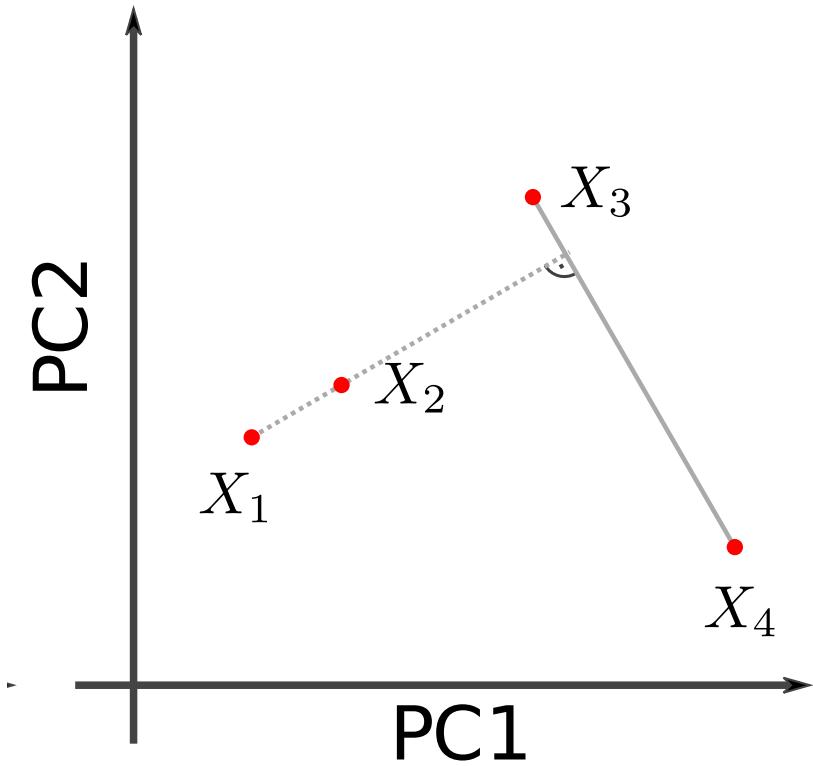
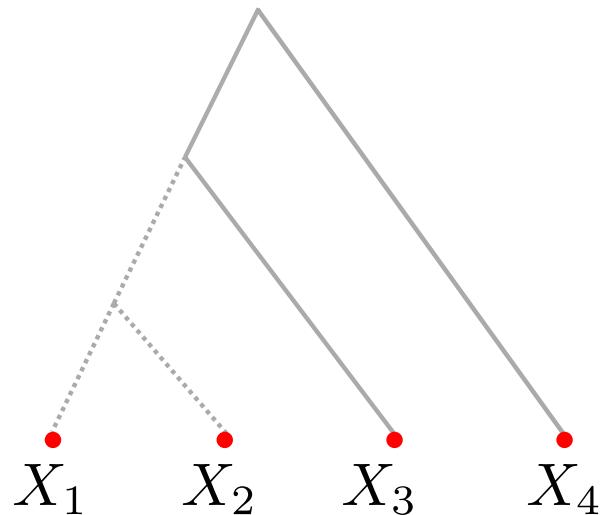
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- Admixture
- PCA
- Trees / Admixture Graph
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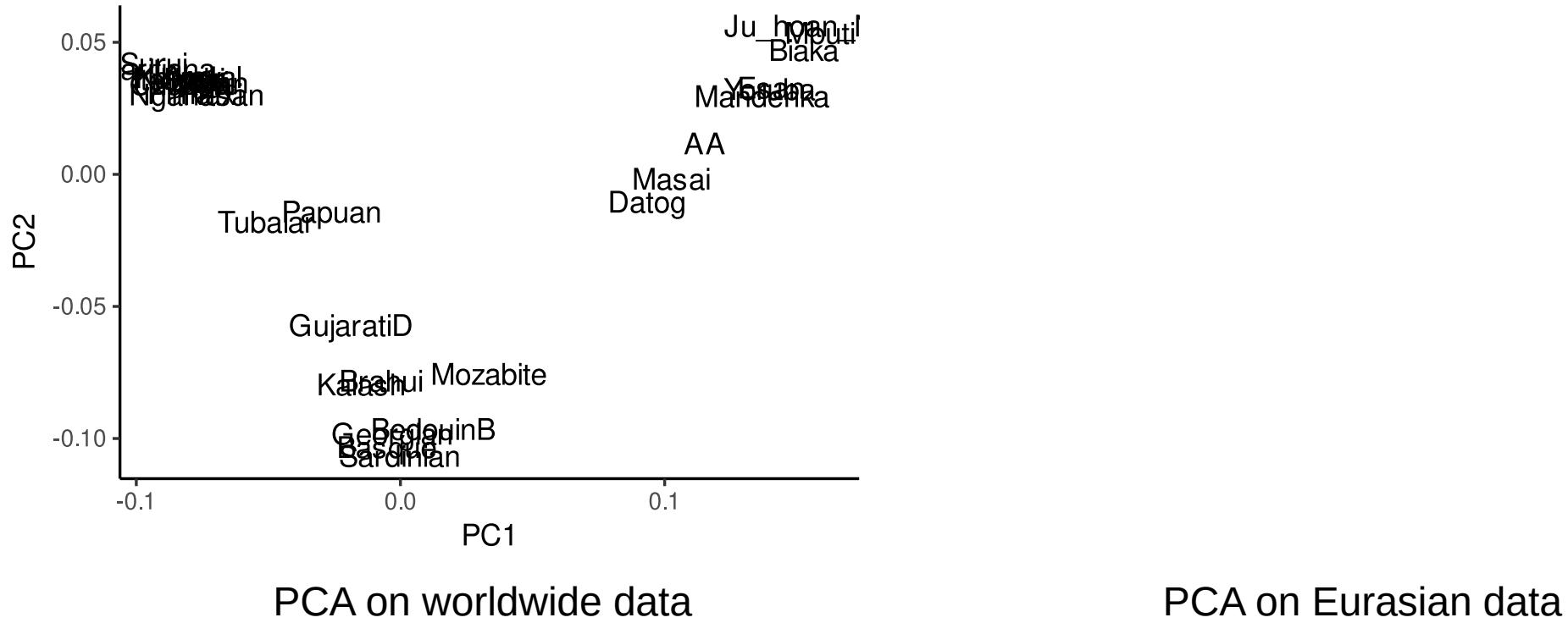


Trees vs PCA

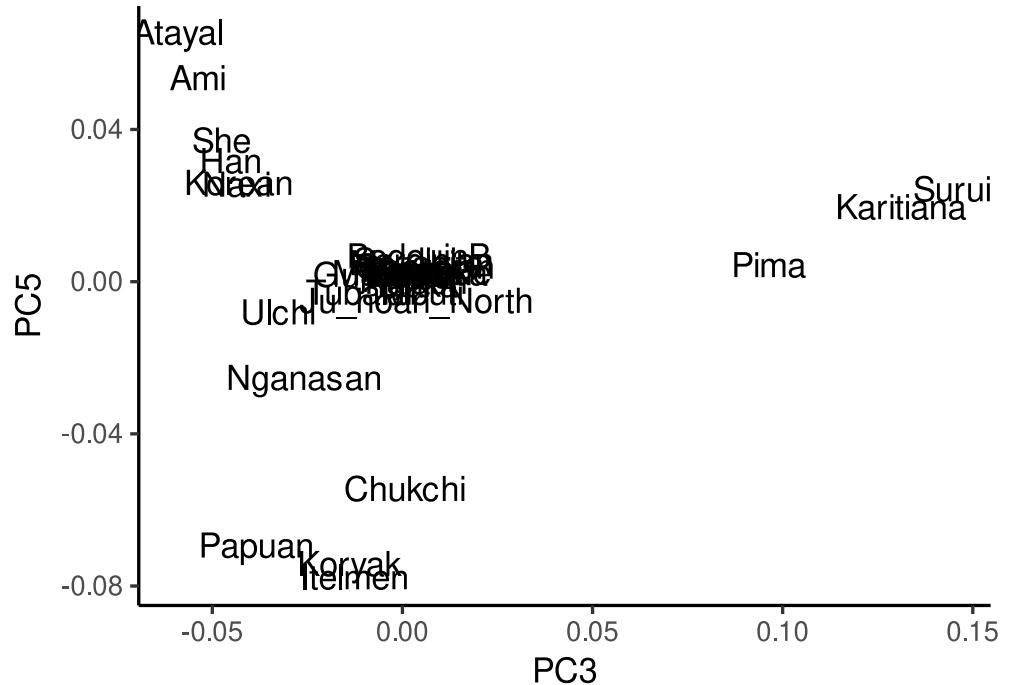
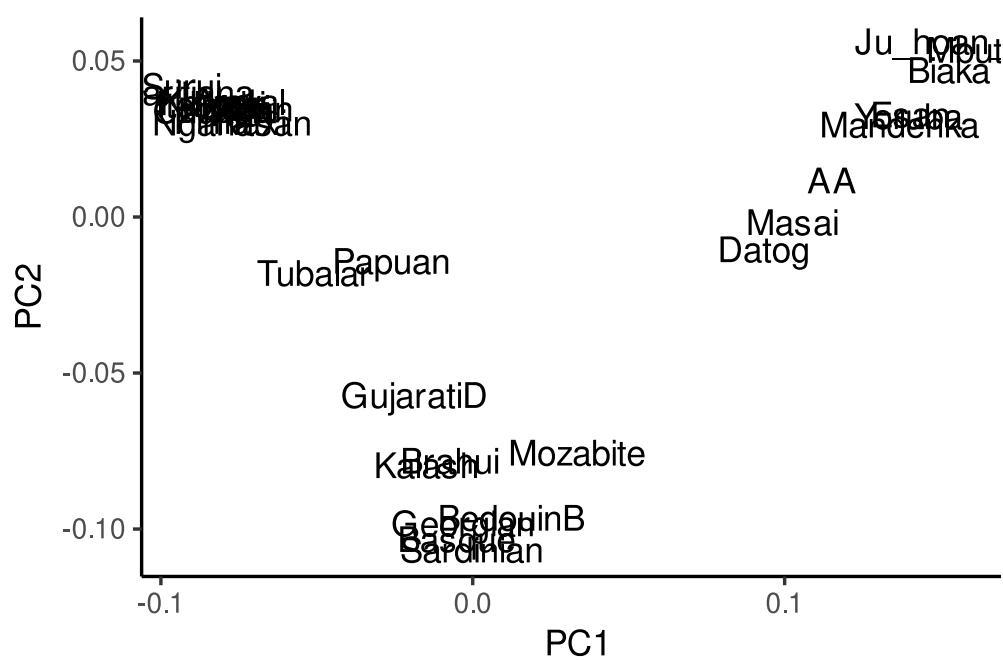
$$F_4(X_1, X_2; X_3, X_4)$$



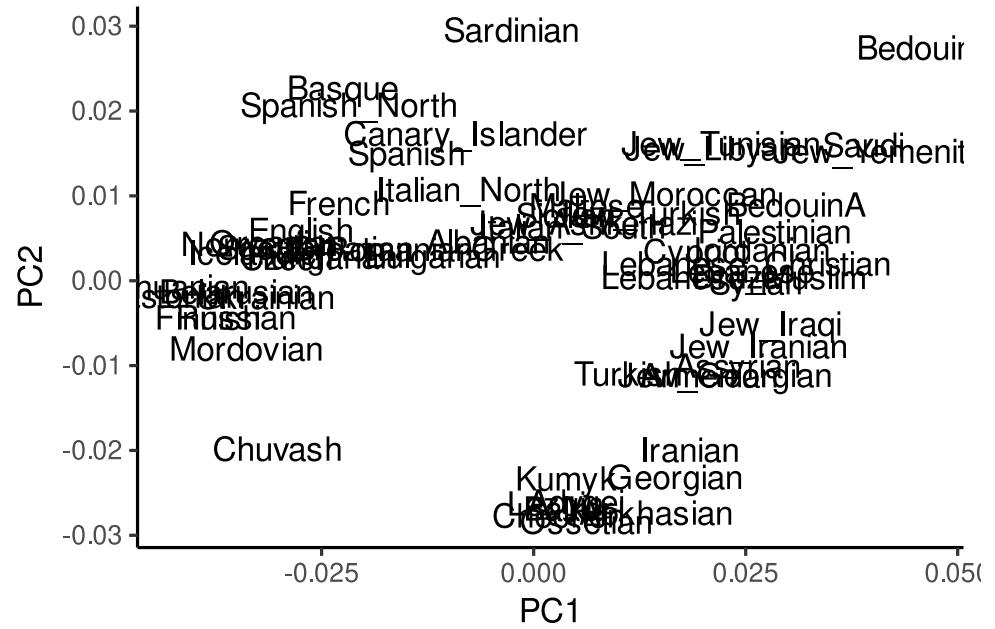
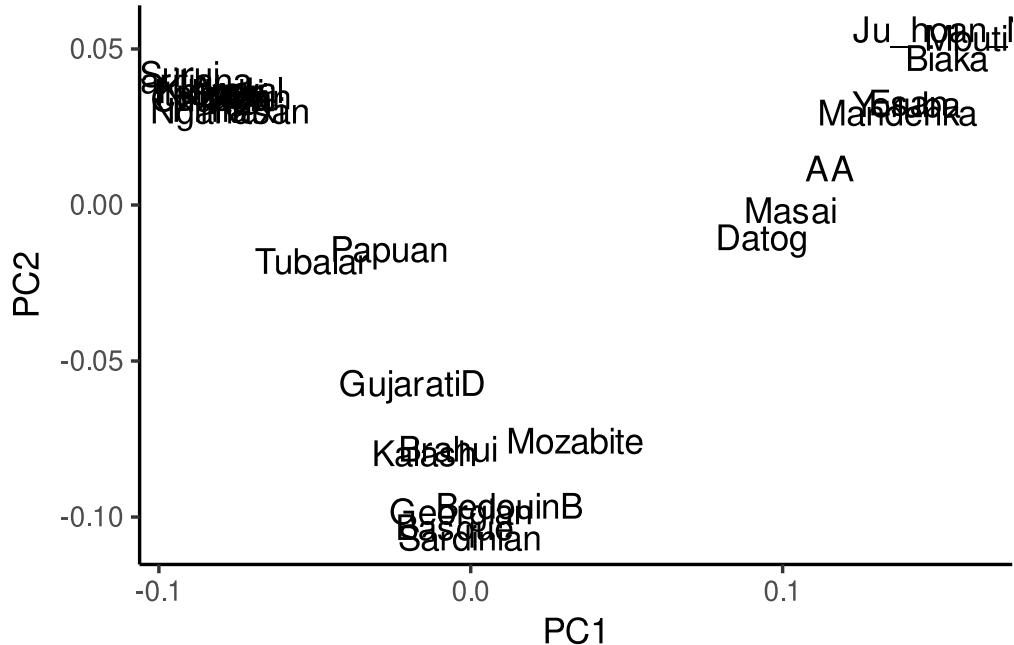
Trees vs PCA



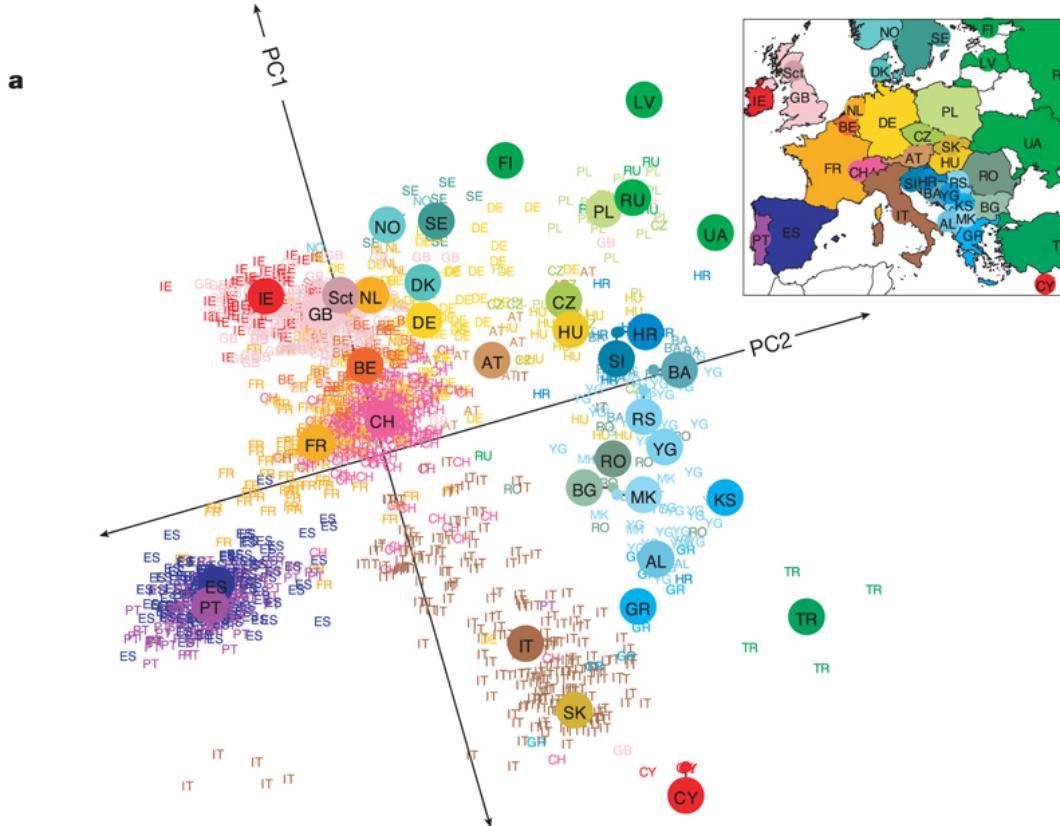
Trees vs PCA



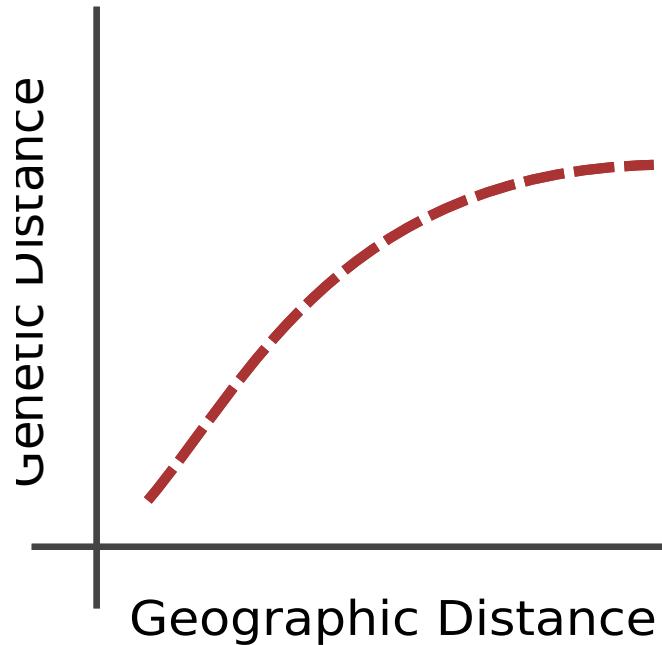
Trees vs PCA



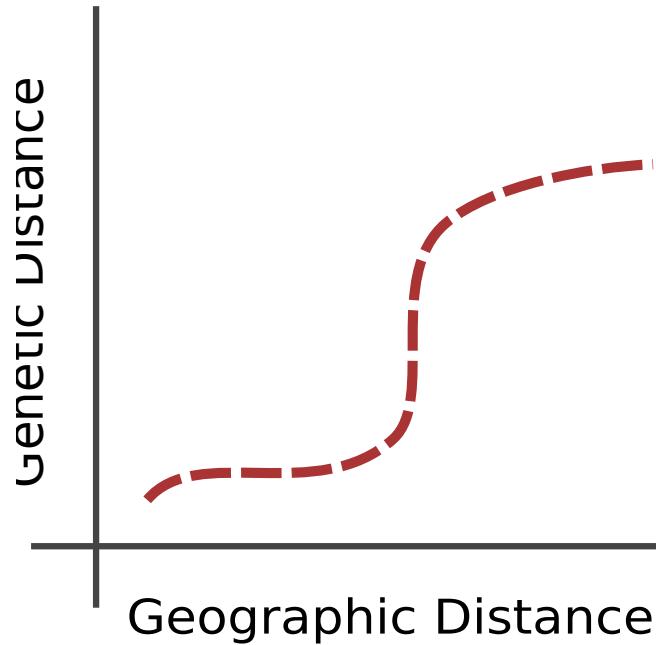
Many other possibilities



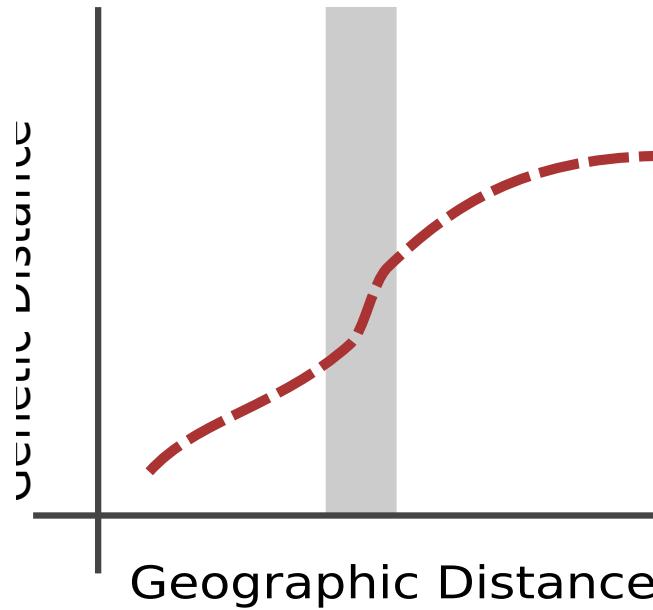
Spatial structure



Discrete structure



Inferring discontinuities

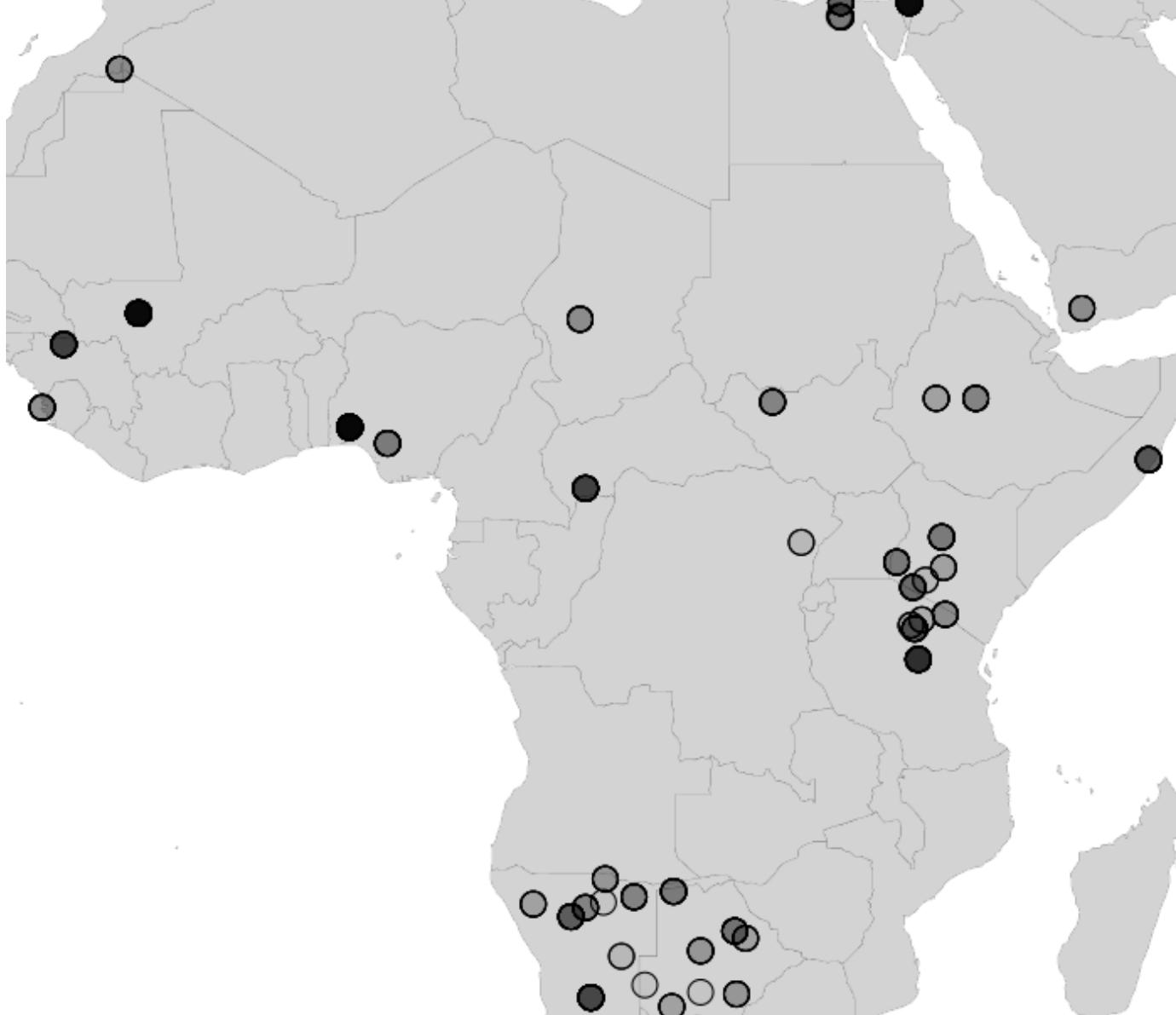


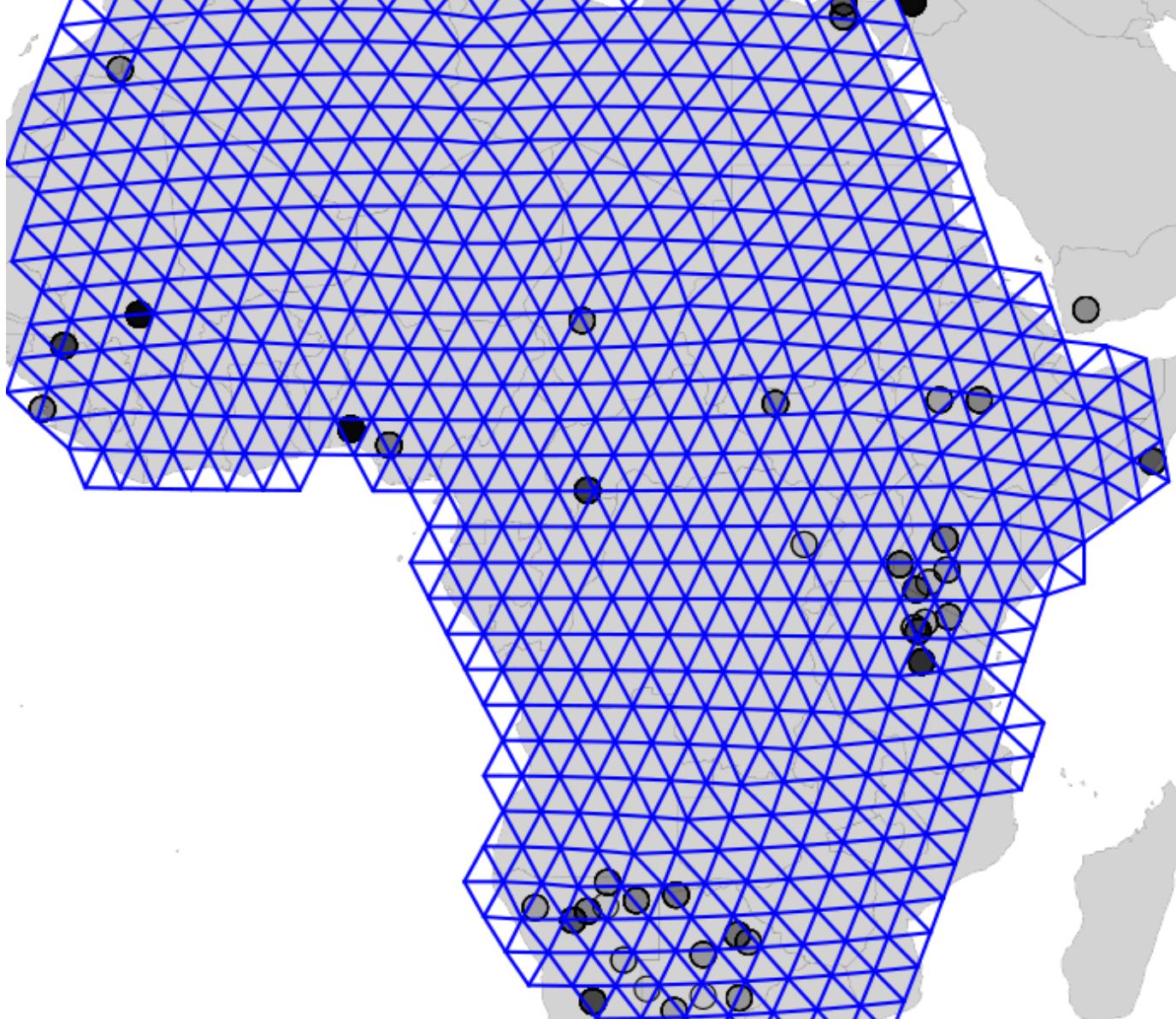
EEMS: Estimating Effective Migration Surfaces

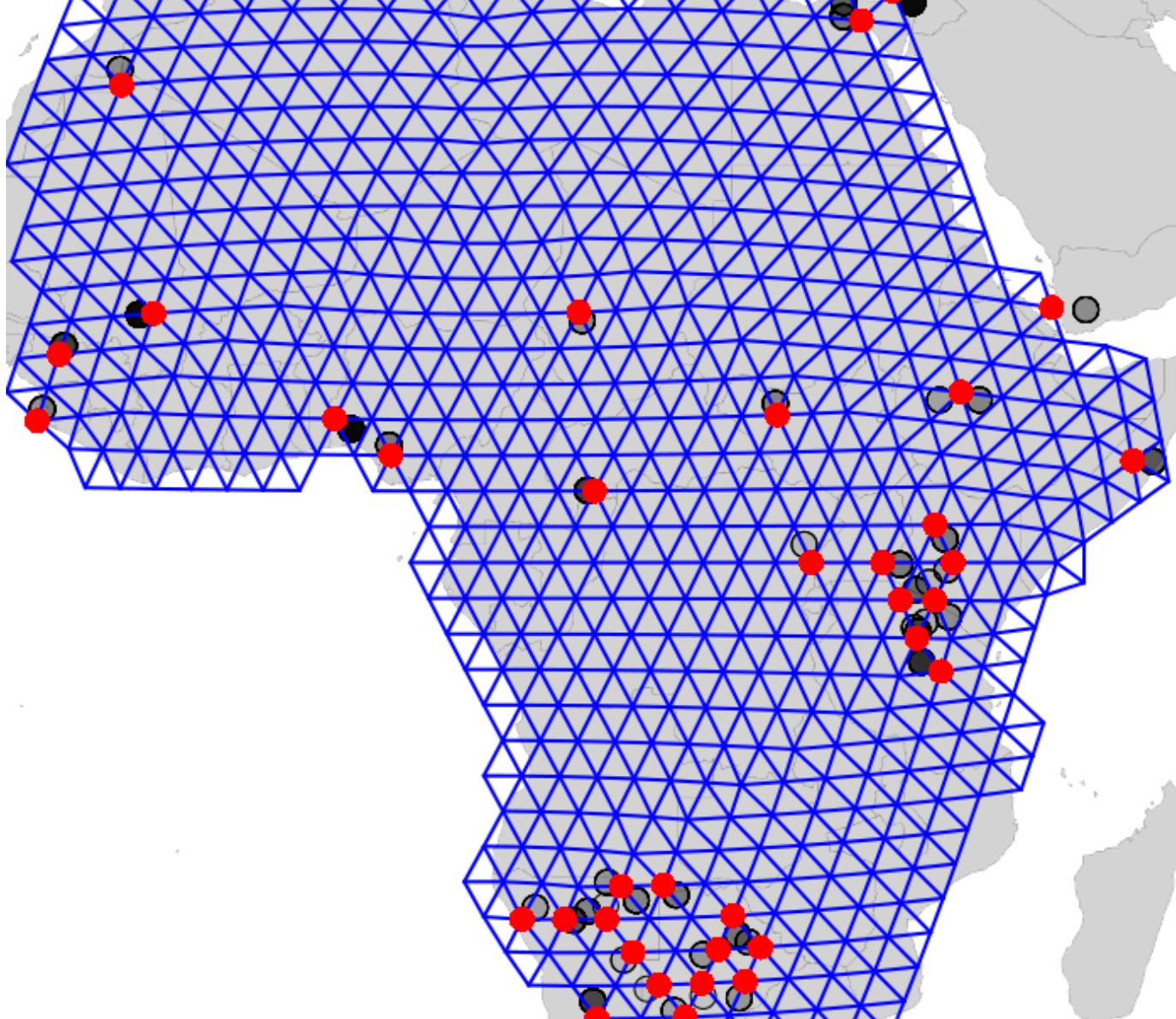
- Petkova, Novembre & Stephens (2016)

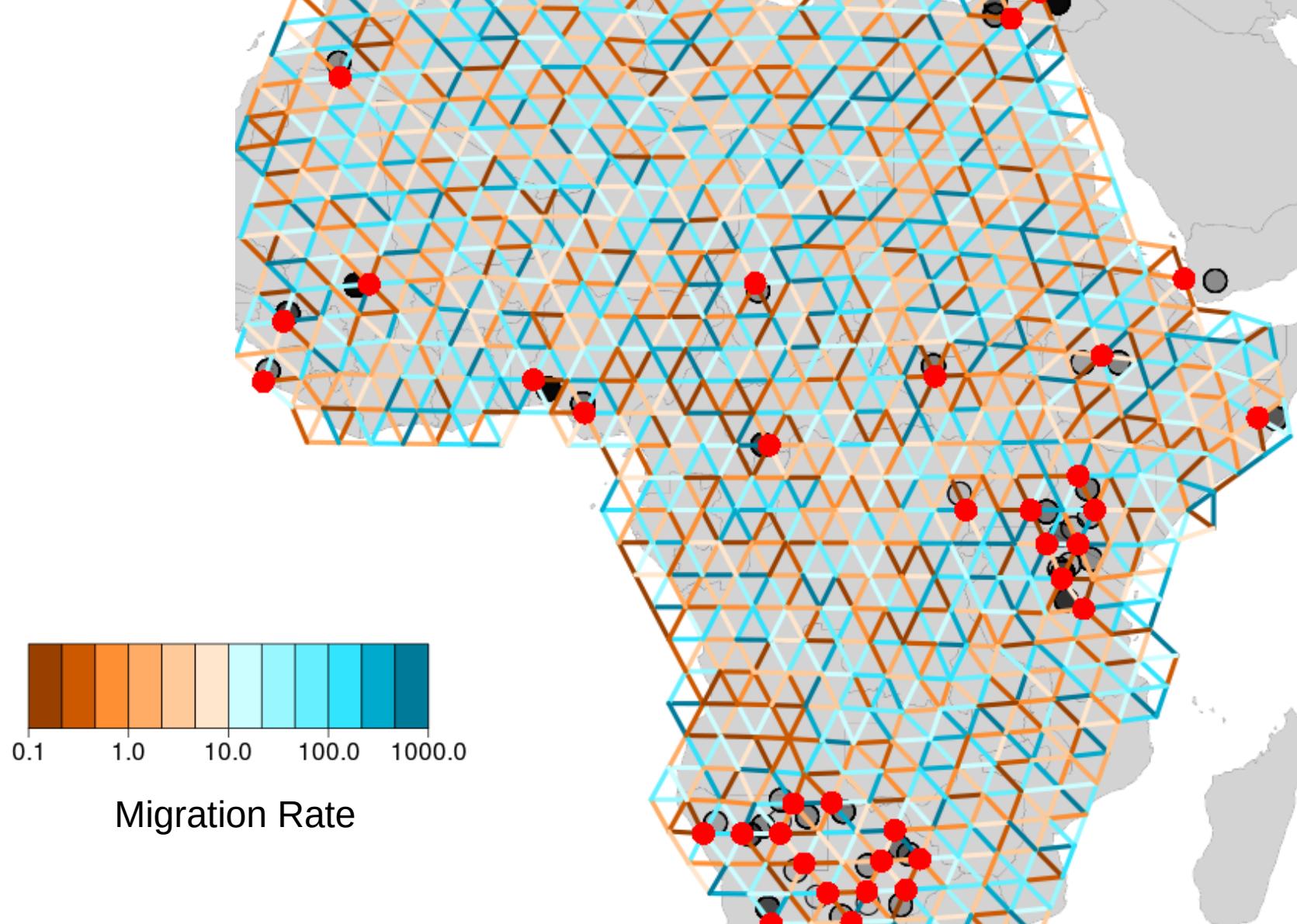


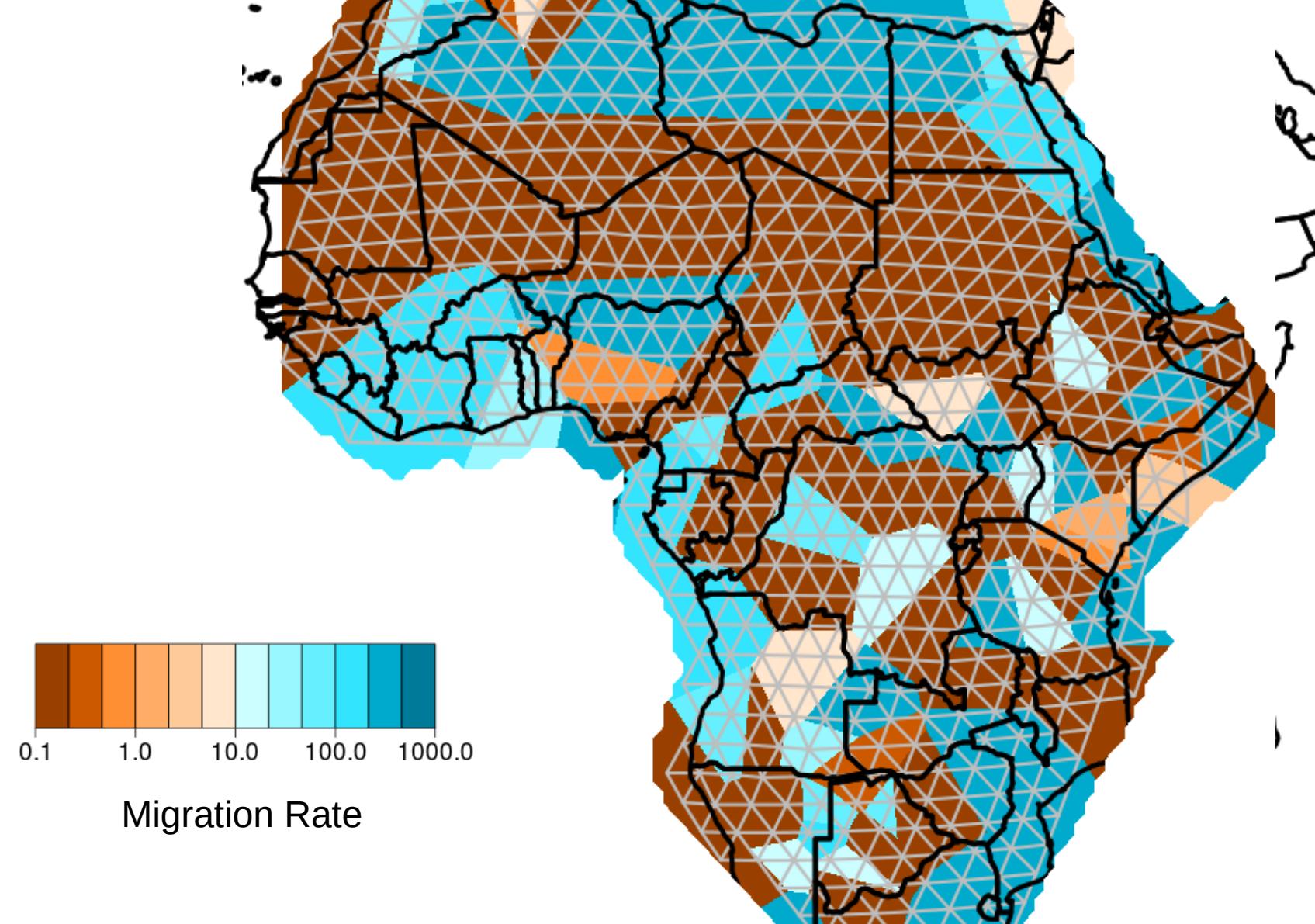


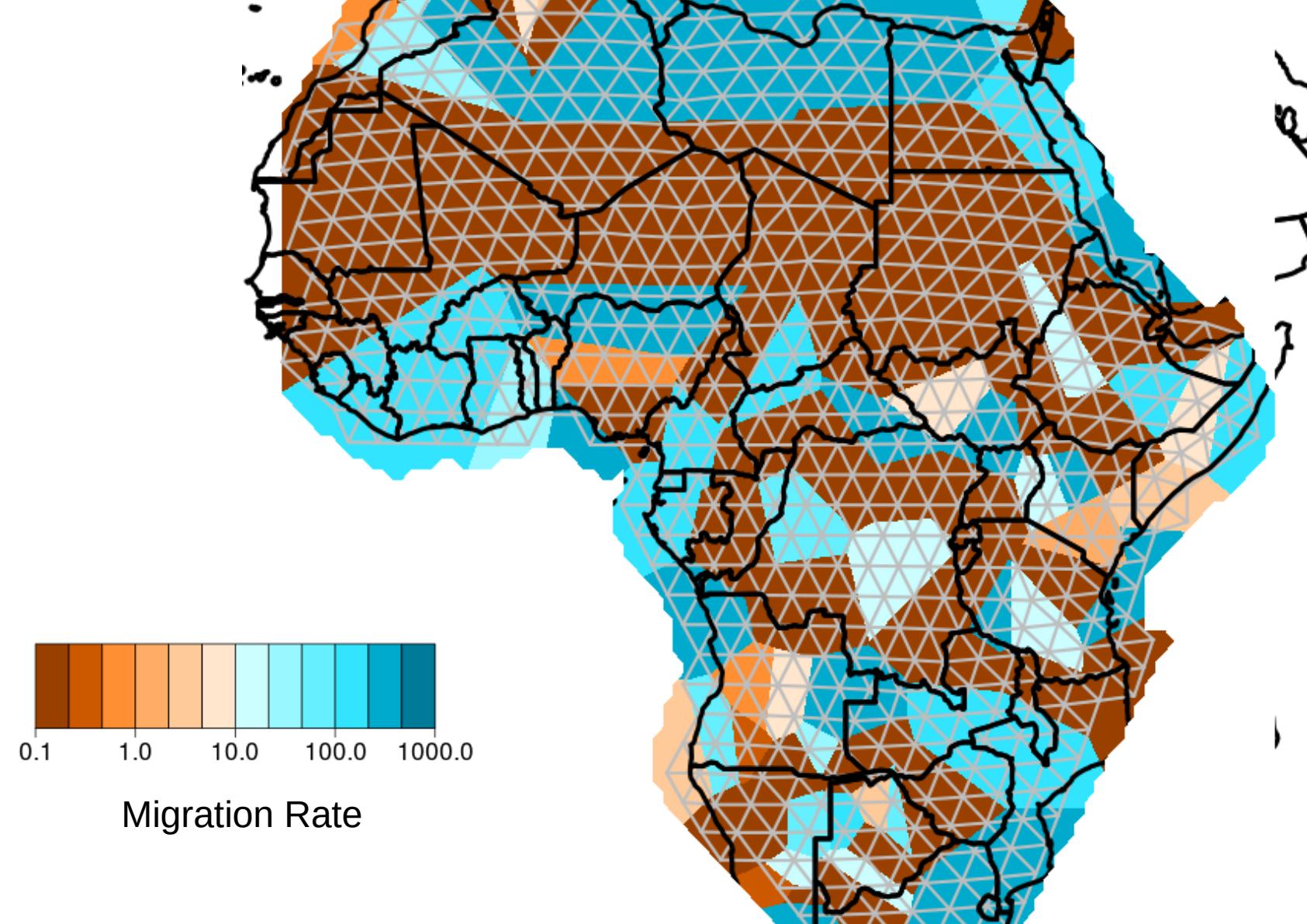


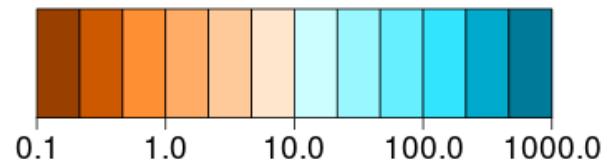
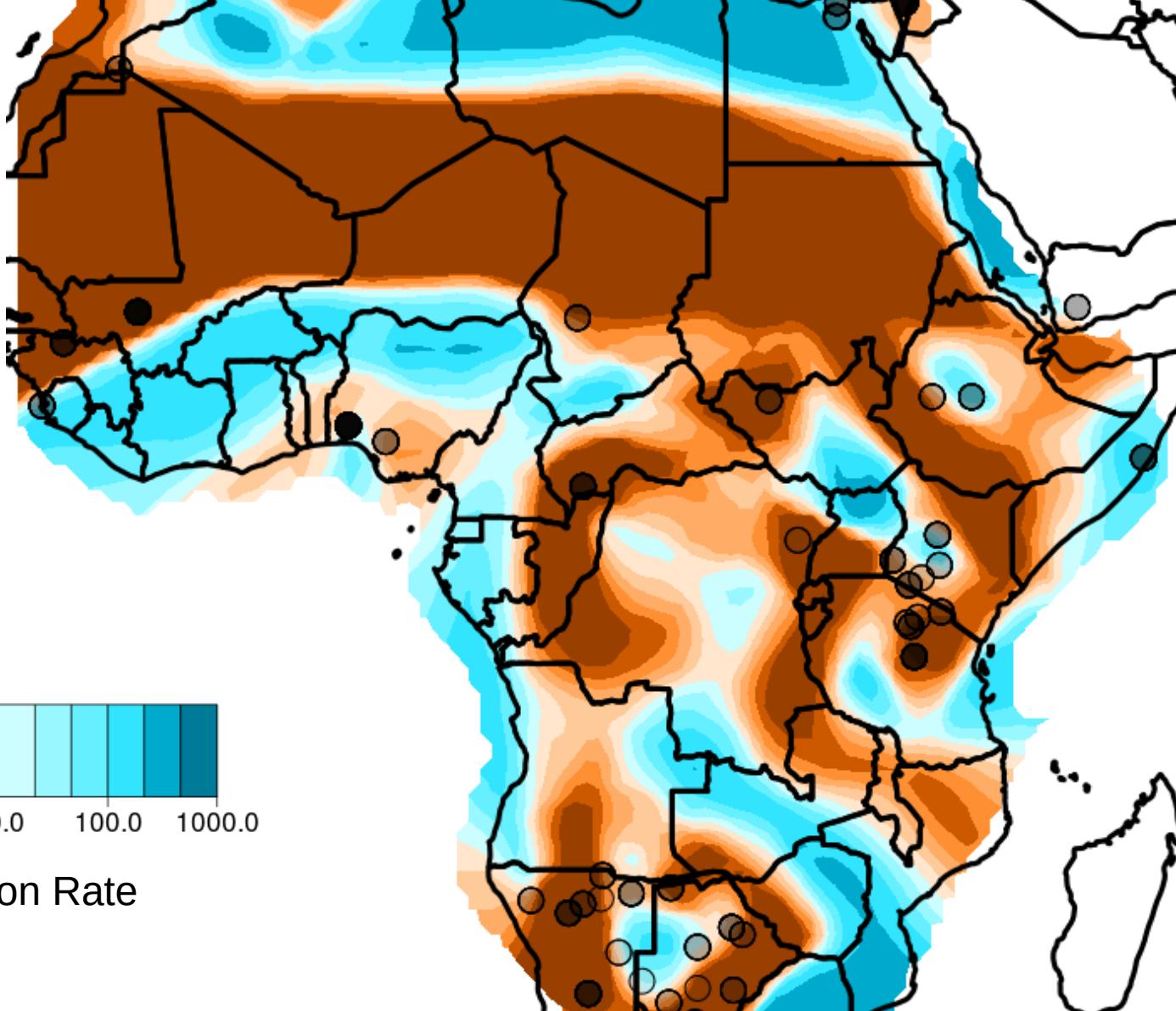




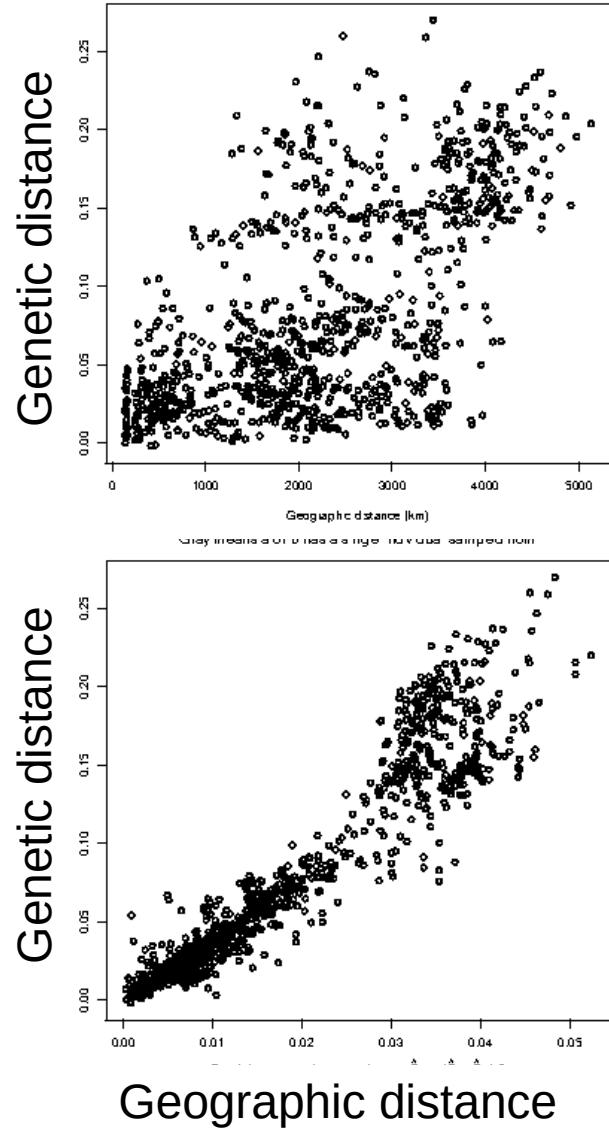
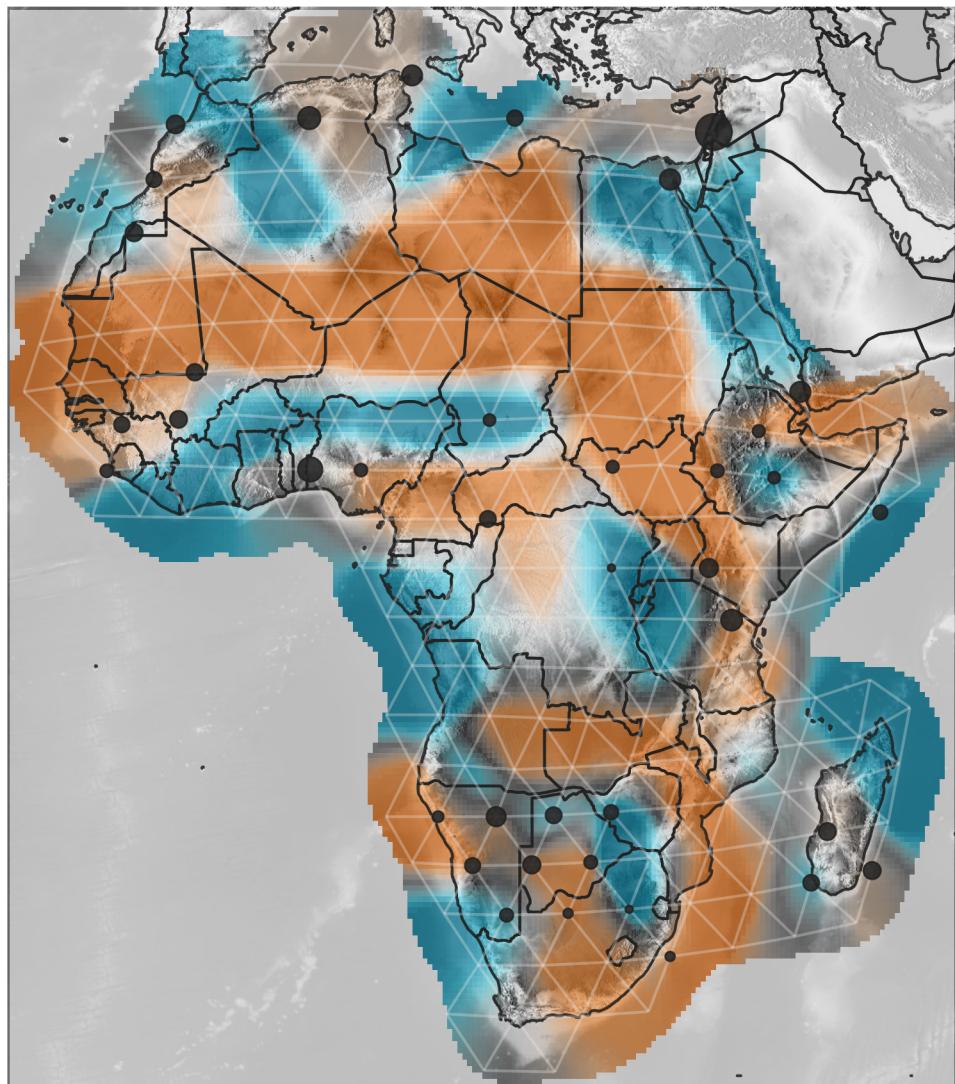




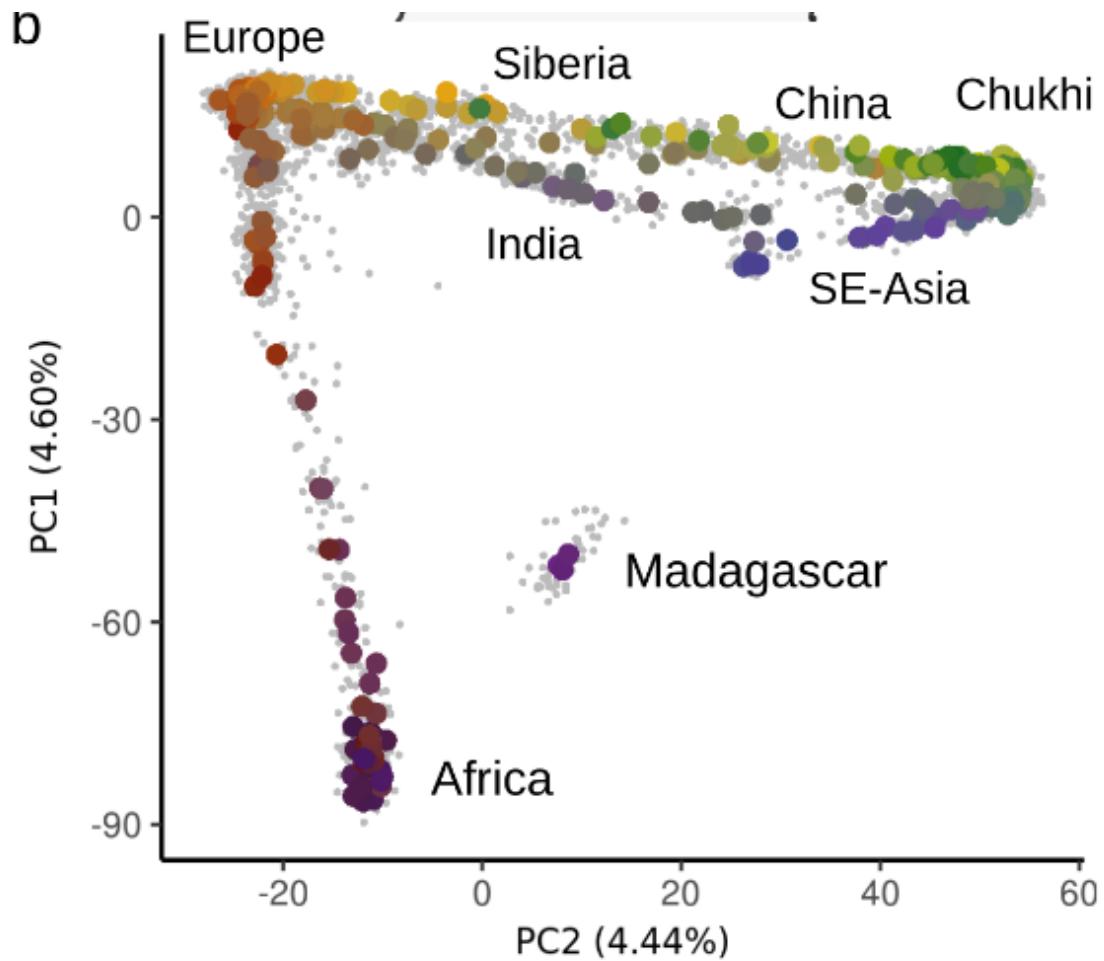
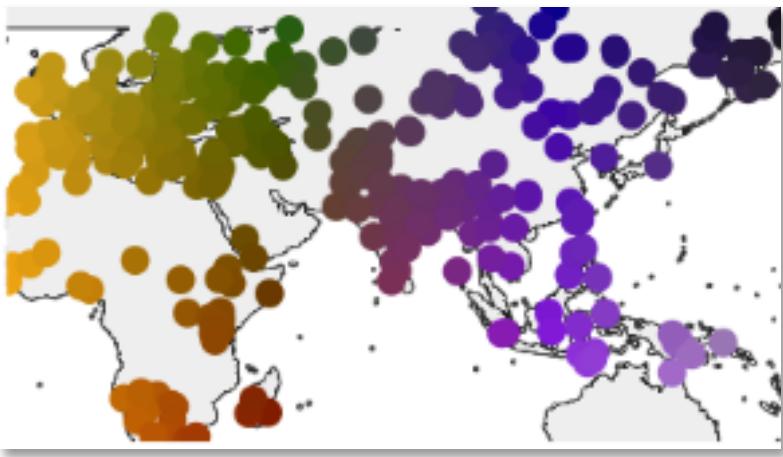


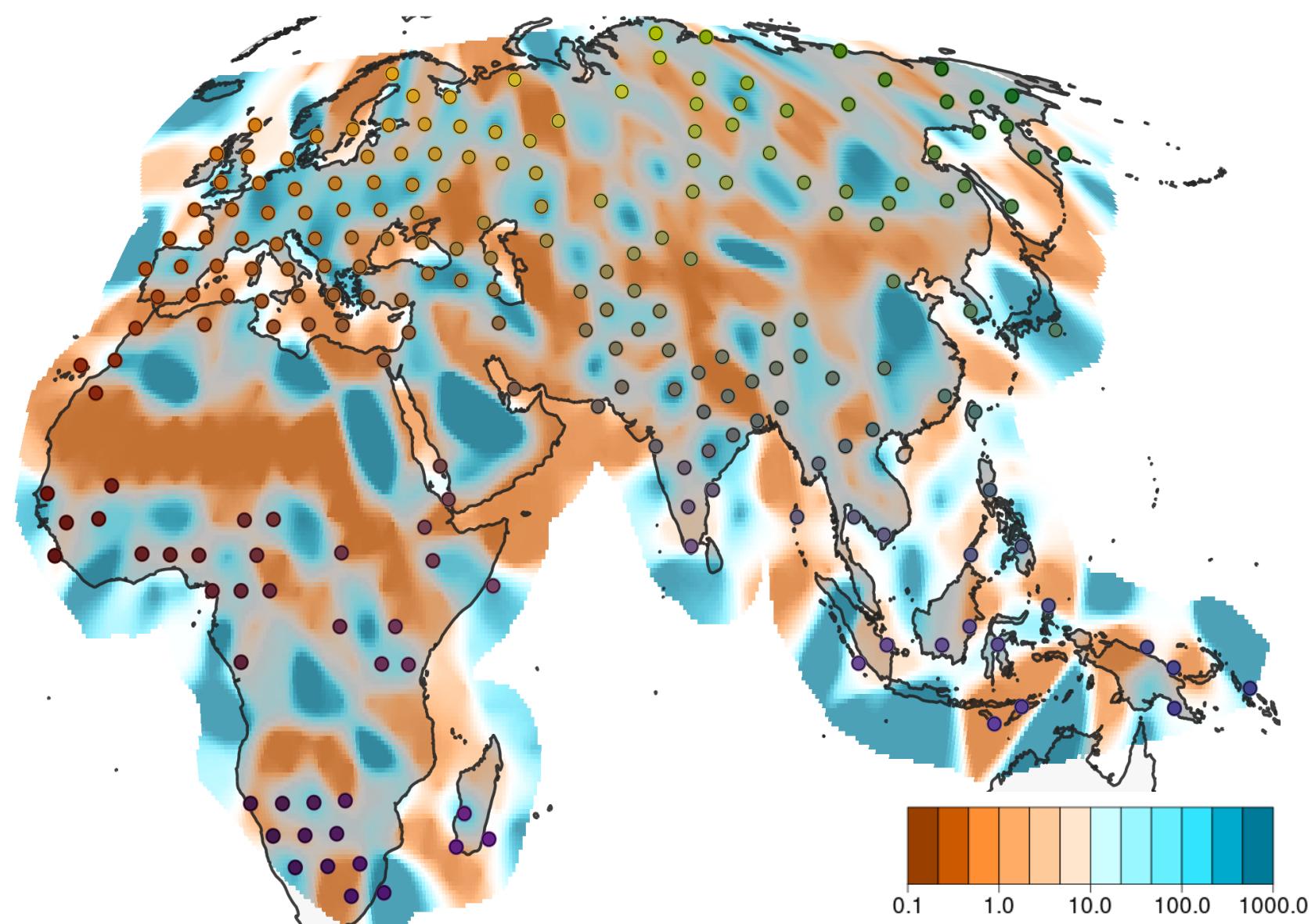


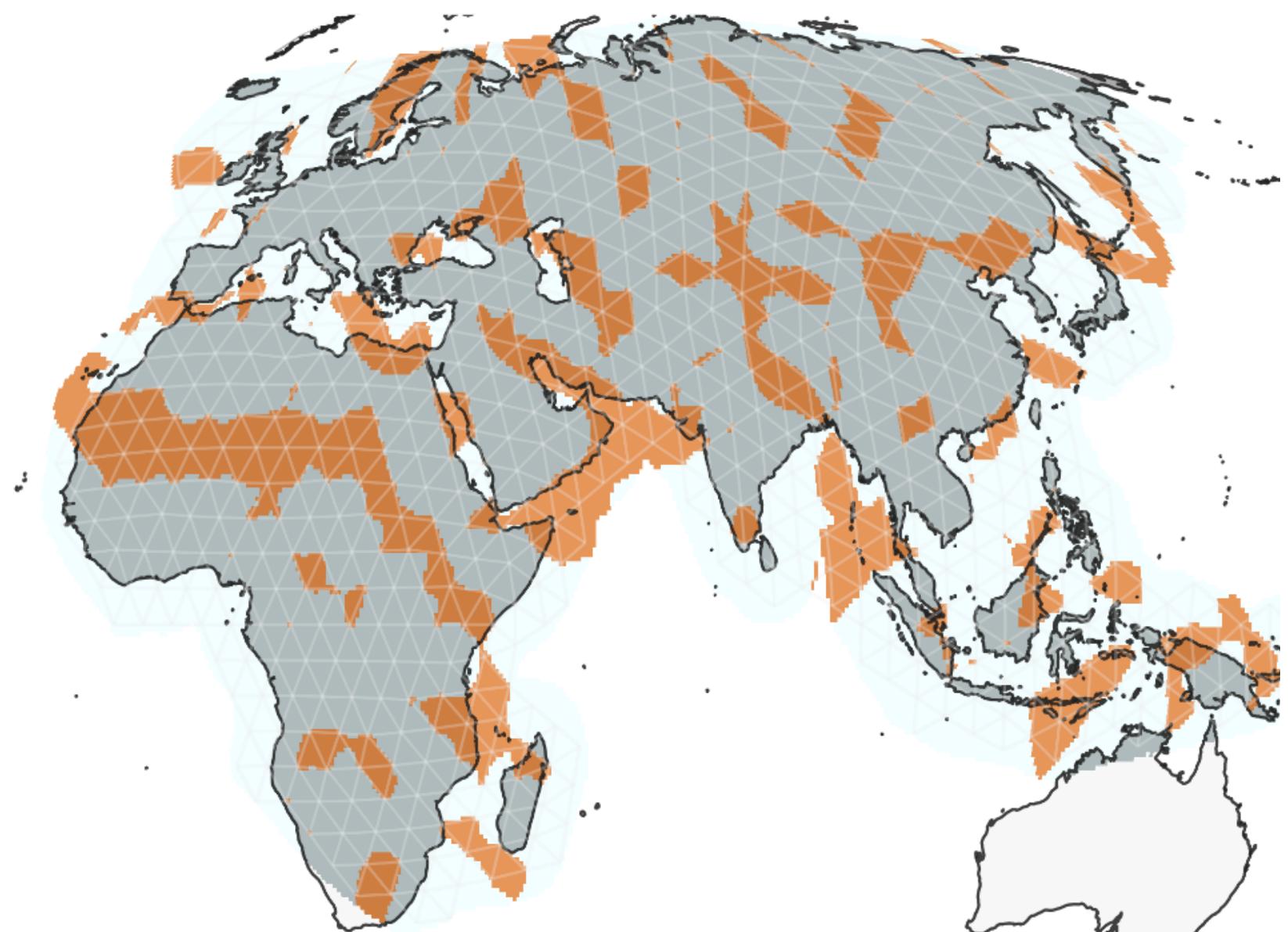
Migration Rate

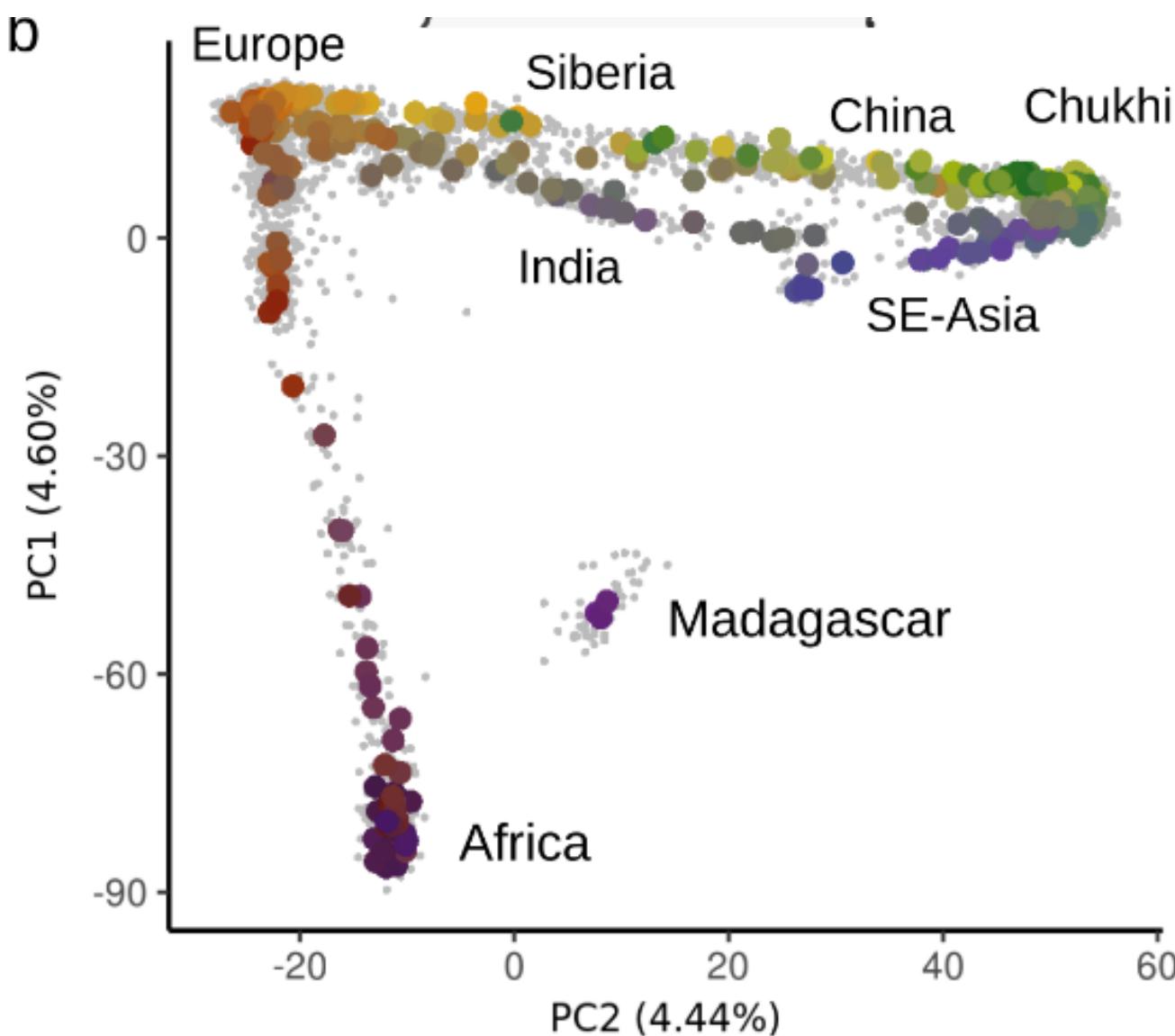


Example









When should we use trees/admixture graphs?

Trees / Admixture graph

- Sparse structure / sampling
- Hierarchical structure
- Large time scales

Spatial/continuous models

- High-density sampling
- Small time scales
- Continuous structure