

Mathematical understandings of Africa

Evans Harrell

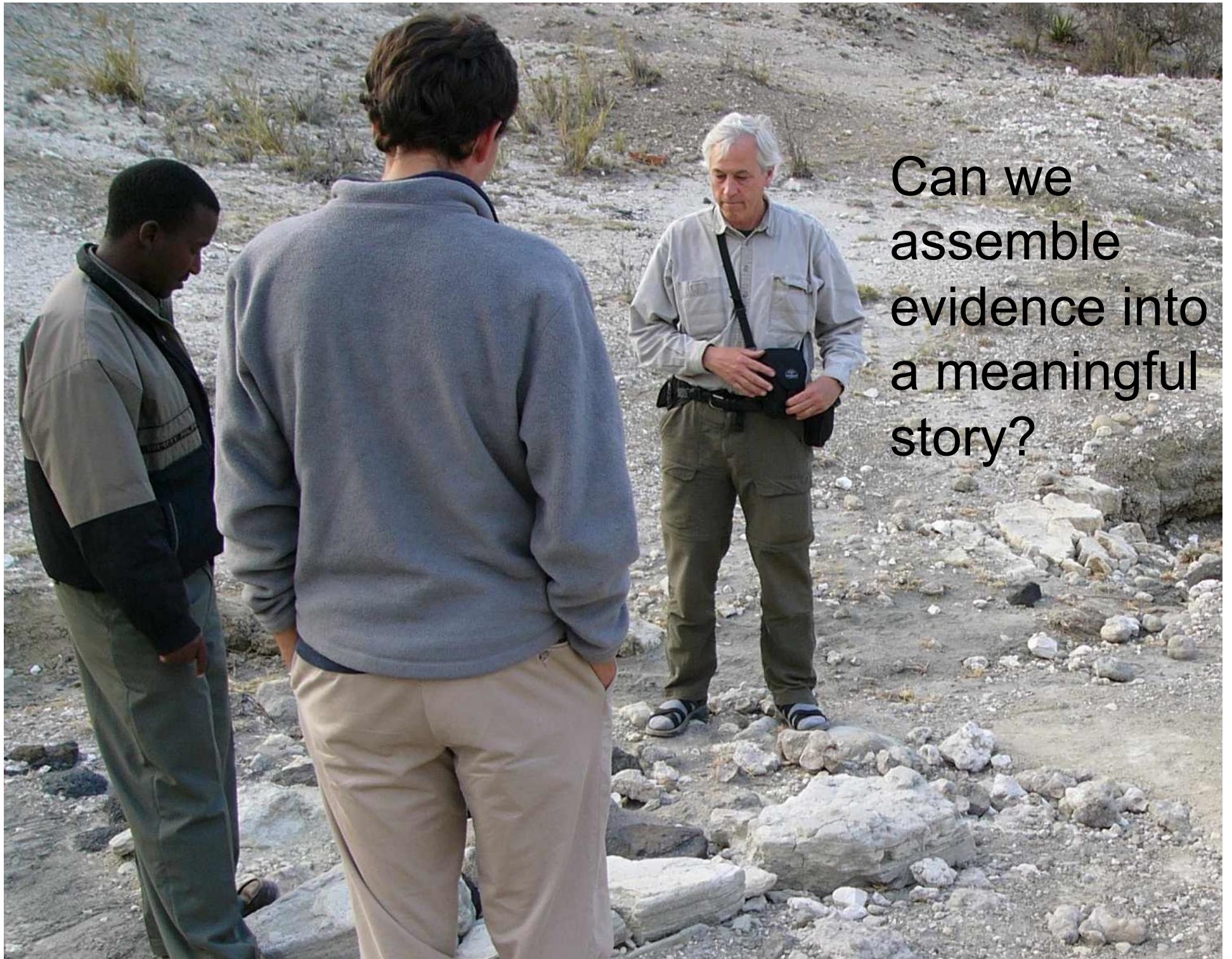
Georgia Tech

www.math.gatech.edu/~harrell

May, 2014

*Oldupai, mankind's oldest story,
in the scientific narrative.*



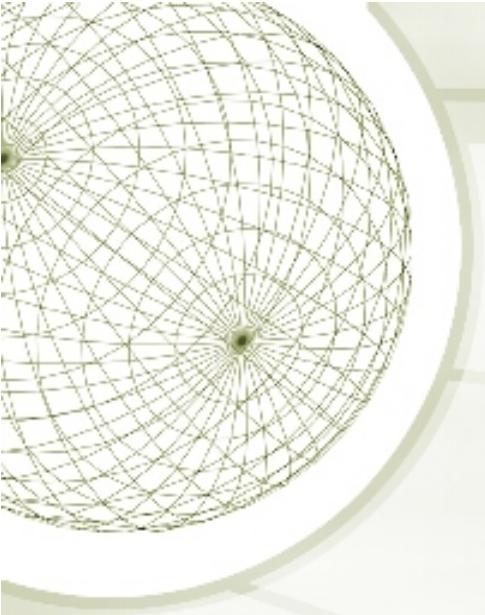


Can we
assemble
evidence into
a meaningful
story?

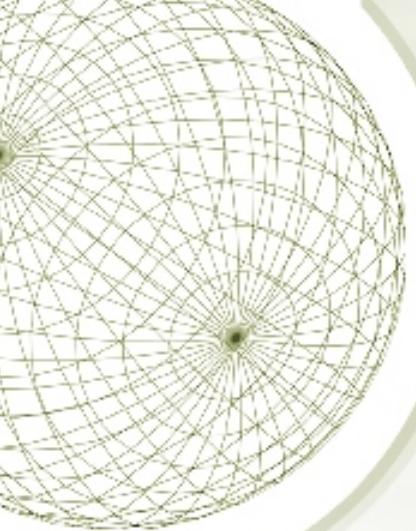
GT AFRICA PROJECTS, 2014

Faculty/Reser	Project Summ	GT School	GT College	Country of Project	Faculty/Reseracher's Name		
Ahamad, Must	Information M	CS	COC	Sudan	Hughes, Josep Water assessn CE	COE	Angola
Ahamad, Must	Information se	CS	COC	?	Hunter, Mike Monitoring Ele CS	CoC	Sudan
Amekudzi, Adj	Sustainable D	CE	COE	Ghana	Ippolito, Chrisl Representatior ML	IAC	Francophone Africa
Akyildiz, Ian F.	Telecom	ECE	COE	South Africa	Kakeu, Johnson ECON	IAC	Cameroon
Ammons, Jane	Uganda Milline	ISYE	COE	Uganda	Keskinocak, Pi Humanitarin L	ISYE	
Bartholdi, John	Supply chains	ISYE	COE	South Africa	Leon, Roberto Earthquake Eng	CEE	
Bauchspies, W	Sustainability,	HTS	IAC	West Africa	Lurie, Nicholas Marketing	Mgt.	Cameroon
Best, Michael	EHELD Bid	CC	COC	Liberia	McIntyre, Johr CIBER Center	Mgt.	??
Caravati, Kevii	Cameroon water Assessment			Cameroon	McKnight, Phil LBAT Program	Mod. LAN.	Egypt
Caravati, Kevii	Emory Center for Global Safe Water			Rwanda	Okereke, Raph ME	COE	Nigeria
Cherkaoui, Mo	Materials mod	MSE	COE	Morocco	Oyelere, Adegboyega, K.	Chemistry	
Chu, Meh	chu Former Presid	ECE	COE	Cameroon	Oyelere, Ruth School and HI	ECON	Nigeria
Cozzens, Susa	Nanotechnoloç Public Policy	IAC			Schatz, Michael Hands-on Res	Physics	Cameroon
Cozzens, Susa	Doctoral Progr Public Policy	IAC			Streelman, Jef Lake Malawai	Biology	Malawi
Ergum, Ozlem	Humanitarin L	ISYE	COE		Swann, Julie Humanitarin L	ISYE	
Esogbue, Aug	Advisor, GT Sc	ISYE	COE		Ragauskas, Ar Utilization of b	Chemistry	Kenya
Farooq, Nihad	Diaspora Stud	LCC	IAC		Taillefert, Mart Oceanography	EAS	
Fernandez, Fa	Drug quality	l Chemistry	COS	various locations	Thomas, Valer Renewable en	ISYE	South Africa
Foote, Andrew	Cameroon Water Project				Thomas, Valer Air pollution cc	ISYE	South Africa
Gangbo, Wilfré	Applied Mathe	Math	COS	Benin, Senegal, M	Uwaifo, Ruth C	Sustainability, ECON	West/Central Africa
Georgakakos,	Graduate Wat	CEE	COE	South Africa	Walker, Bruce STEM Educatic	Psyc.	Kenya
Georgakakos,	Nile Decision	SCCE	COE	Burundi, Congo, E.			
Georgakakos,	Environmental	CEE	COE	Democratic Repub			
Graham, Stuai	Community Er	Mgt.	COM	Tanzania			
Gleason, Rudo	HIV & Cardiov	ME	COE	Ethiopia, Cameroc			
Goodman, Sey	Difusion & Abs	INTA	IAC	Ghana, Togo			
Goodman, Sey	Information se	INTA/GTISC	IAC/COC	Tunisia, Rwanda			
Goodman, Sey	Cybercrime, Ir	INT, GTISC	IAC, COC	Cape Verde			
Goodman, Sey	Establish PhD	INTA	IAC	Ethiopia			
Goodman, Sey	Cyber Crime a	IAC	CoC	Mauritius			
Harrell, Evans	Applied Mathe	Math	COS	Senegal, Tunisia			
Harrell, Fox	The Living Lib	LCC	IAC	Liberia			
Hughes, Josep	Water assessn	CE	COE	Angola			

(List is known to contain inaccuracies.)



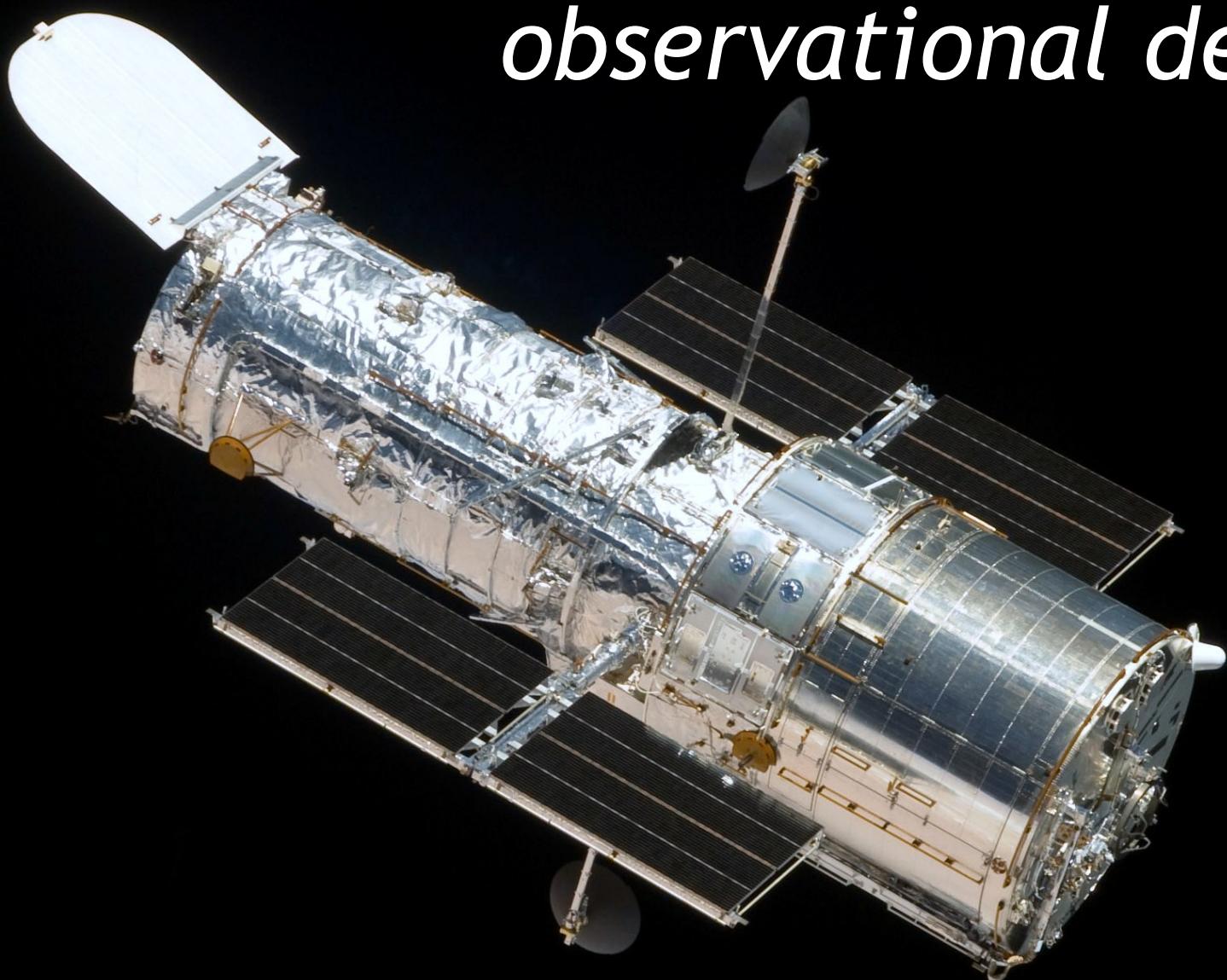
Mathematics - an observational device



Mathematics - an observational device

...just like a microscope, or a telescope,
or a mass spectrometer.

*Mathematics -an
observational device*



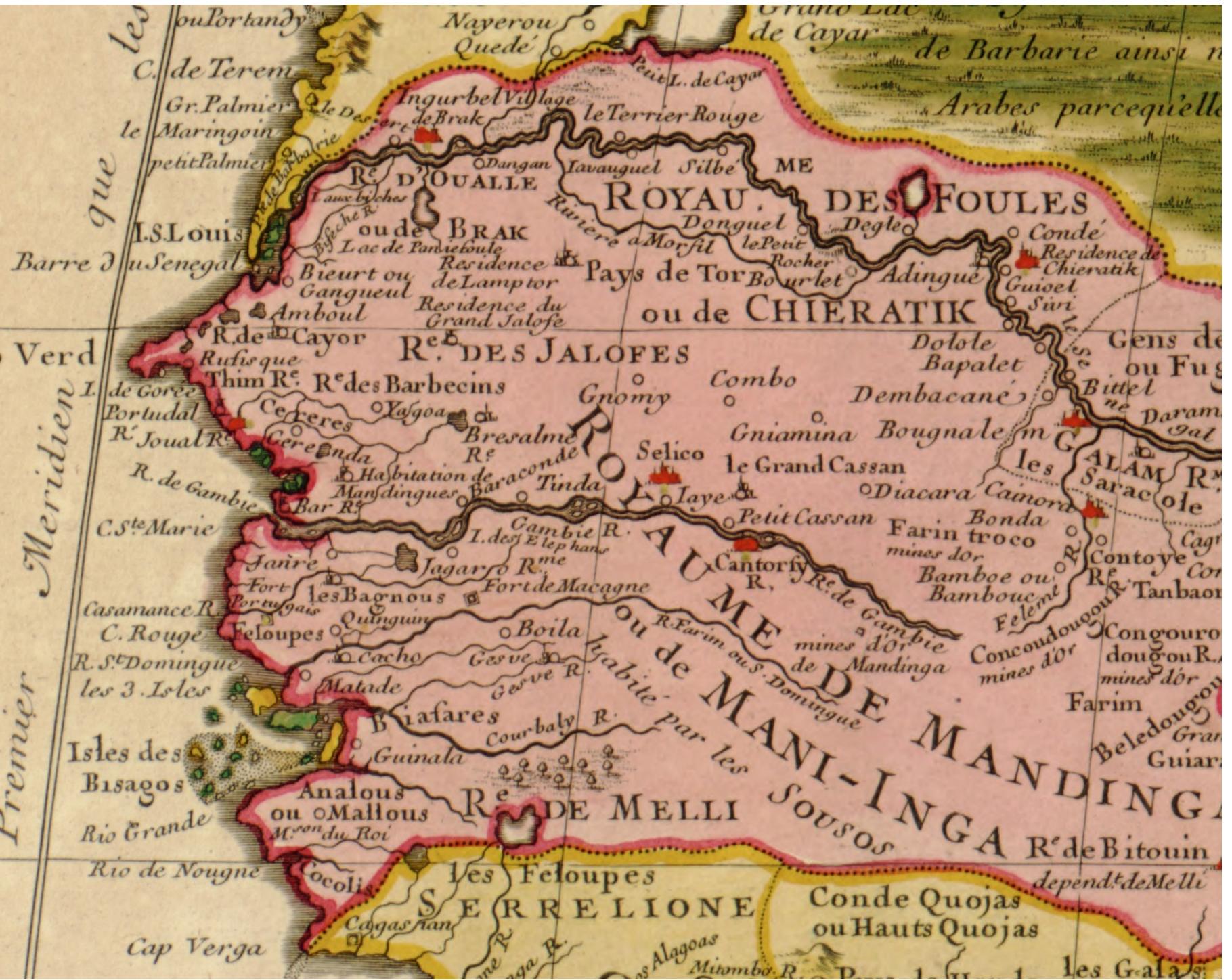


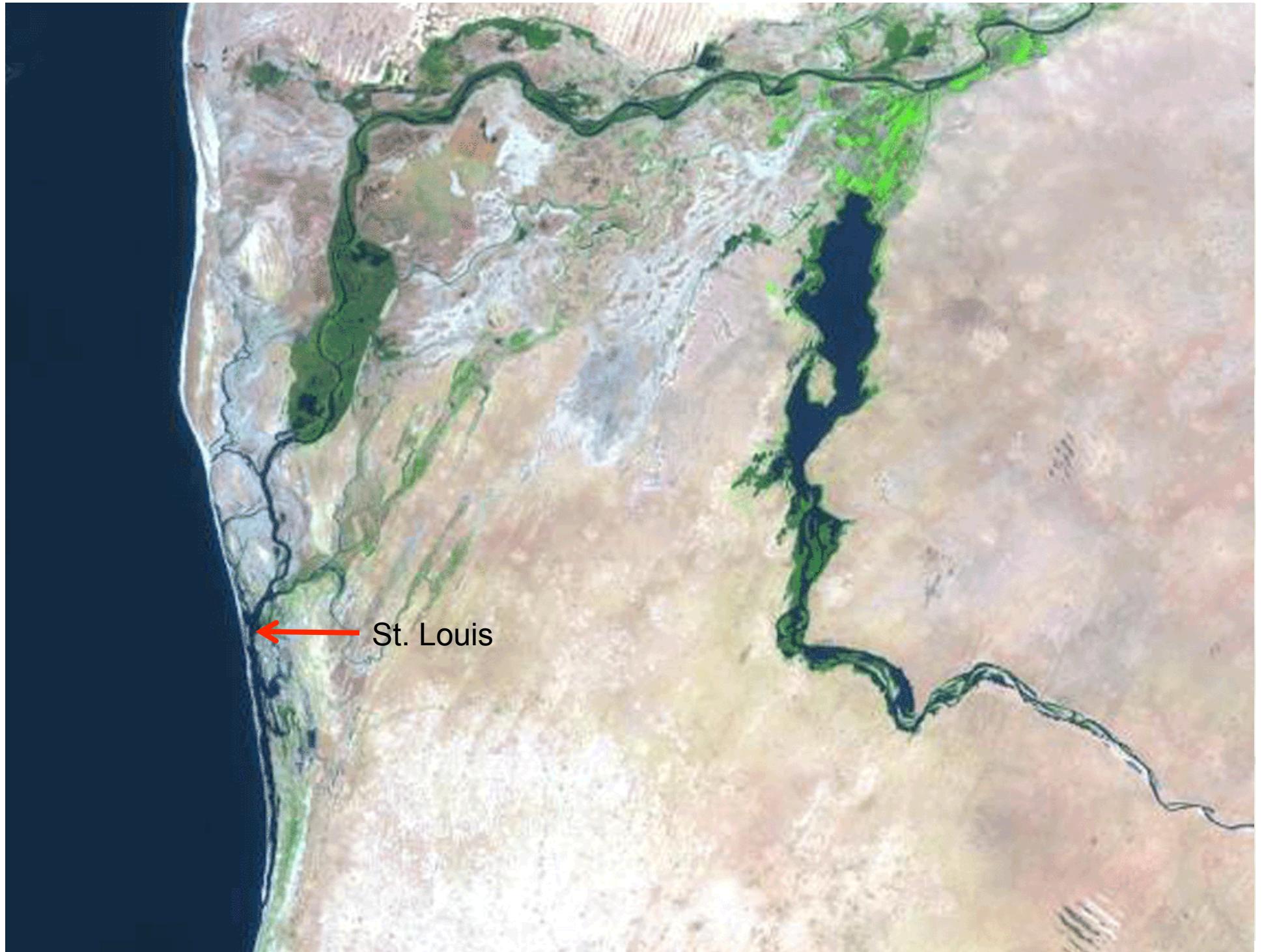
*Mathematics -an
observational device*

Langue de Barbarie, 2005



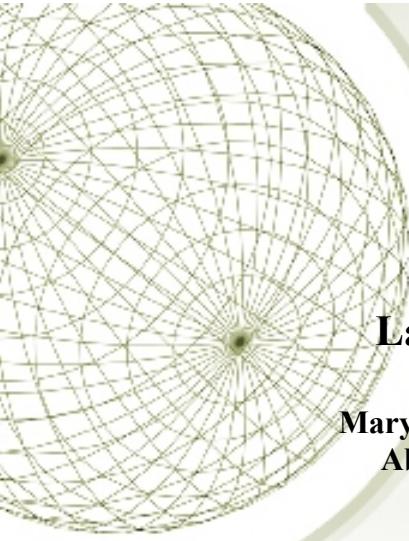
Premier Meridien





St. Louis





Langue de Barbarie : la brèche de l'espérance ?

Mary Teuw Niane, Université Gaston Berger, Sénégal, niane@ugb.sn

Abdou Sène, Université Gaston Berger, Sénégal, asene@ugb.sn

Saint-Louis, le 01 janvier 2004

L'ouverture d'une brèche sur la Langue de Barbarie dans la nuit du vendredi 03 au samedi 04 octobre 2003 a sauvé une bonne partie de la ville de Saint-Louis et ses environs d'une inondation catastrophique certaine. D'ailleurs, depuis la mi-septembre certaines localités de Gandiole comme Pilot étaient sous les eaux et certaines zones de Pikine, Diameguène, Léona et Darou gardent encore les stigmates d'une saison des pluies certes tardive mais ayant donné de fortes averses et par conséquent des flaques très persistantes.

A la joie légitime et débordante des populations et des autorités de voir le niveau du fleuve baisser inexorablement a succédé l'étonnement voire l'inquiétude de constater qu'en plein mois de novembre les eaux du fleuve Sénégal s'étaient retirées de plusieurs arches et des enfants jouaient en toute innocence et gaieté sur une bonne partie du lit du fleuve. Ce spectacle presque

fantastique - du rarement vu selon les anciens- des piliers séculaires du Pont Faidherbe à découvert suscite aujourd’hui maintes supputations, inquiétudes et des conjectures allant d’un optimisme béat à un pessimisme apocalyptique. Une inquiétude est de plus en plus perceptible au niveau des populations, la peur que cette Profanation de la Nature ne conduise à une catastrophe. Cette inquiétude est permanente dans toutes les sociétés en particulier dans les sociétés africaines dans lesquelles - réminiscence du paganisme ancien - la Nature est presque sacrée.

**Sur la photo on
distingue bien les
deux écoulements,
l’ancien (flèche
droite) et le nouveau
(flèche courbée).**

**Photo : Claude
Lobry et Suzanne**



Langue de Barbarie, 2005



Equations [\[edit\]](#)

Conservative form [\[edit\]](#)

The shallow water equations are derived from the [equations of conservation of mass and conservation of momentum](#) (the [Navier–Stokes equations](#)), which hold even when the assumptions of shallow water break down, such as across a [hydraulic jump](#). In the case of no [Coriolis, frictional or viscous forces](#), the shallow-water equations are:

$$\frac{\partial \eta}{\partial t} + \frac{\partial(\eta u)}{\partial x} + \frac{\partial(\eta v)}{\partial y} = 0$$

$$\frac{\partial(\eta u)}{\partial t} + \frac{\partial}{\partial x} \left(\eta u^2 + \frac{1}{2} g \eta^2 \right) + \frac{\partial(\eta uv)}{\partial y} = -g \eta \frac{\partial H}{\partial x}$$

$$\frac{\partial(\eta v)}{\partial t} + \frac{\partial(\eta uv)}{\partial x} + \frac{\partial}{\partial y} \left(\eta v^2 + \frac{1}{2} g \eta^2 \right) = -g \eta \frac{\partial H}{\partial y}.$$

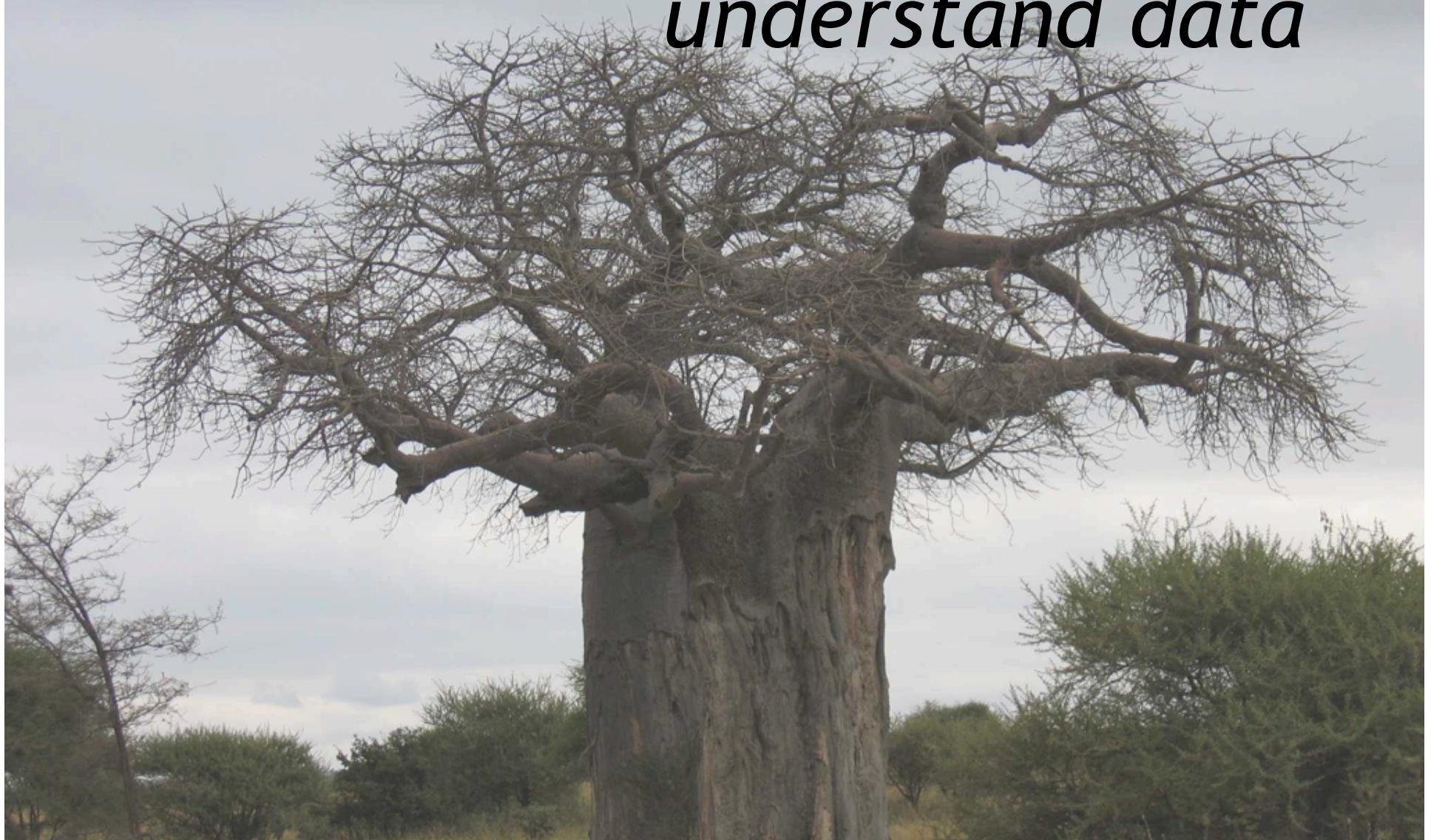
Here η is the total fluid column height, and "H" is the water depth if the surface is at rest. The 2D vector (u, v) is the fluid's horizontal velocity, averaged across the vertical column. g is acceleration due to gravity. The first equation is derived from mass conservation, the second two from momentum conservation.^[2]

Mathematics - an observational device

Those are (among the) equations applied mathematicians like the ones shown here use in order to see how water flows in a river network, how tidal the flow will be, how brackish the water will be at the dam.

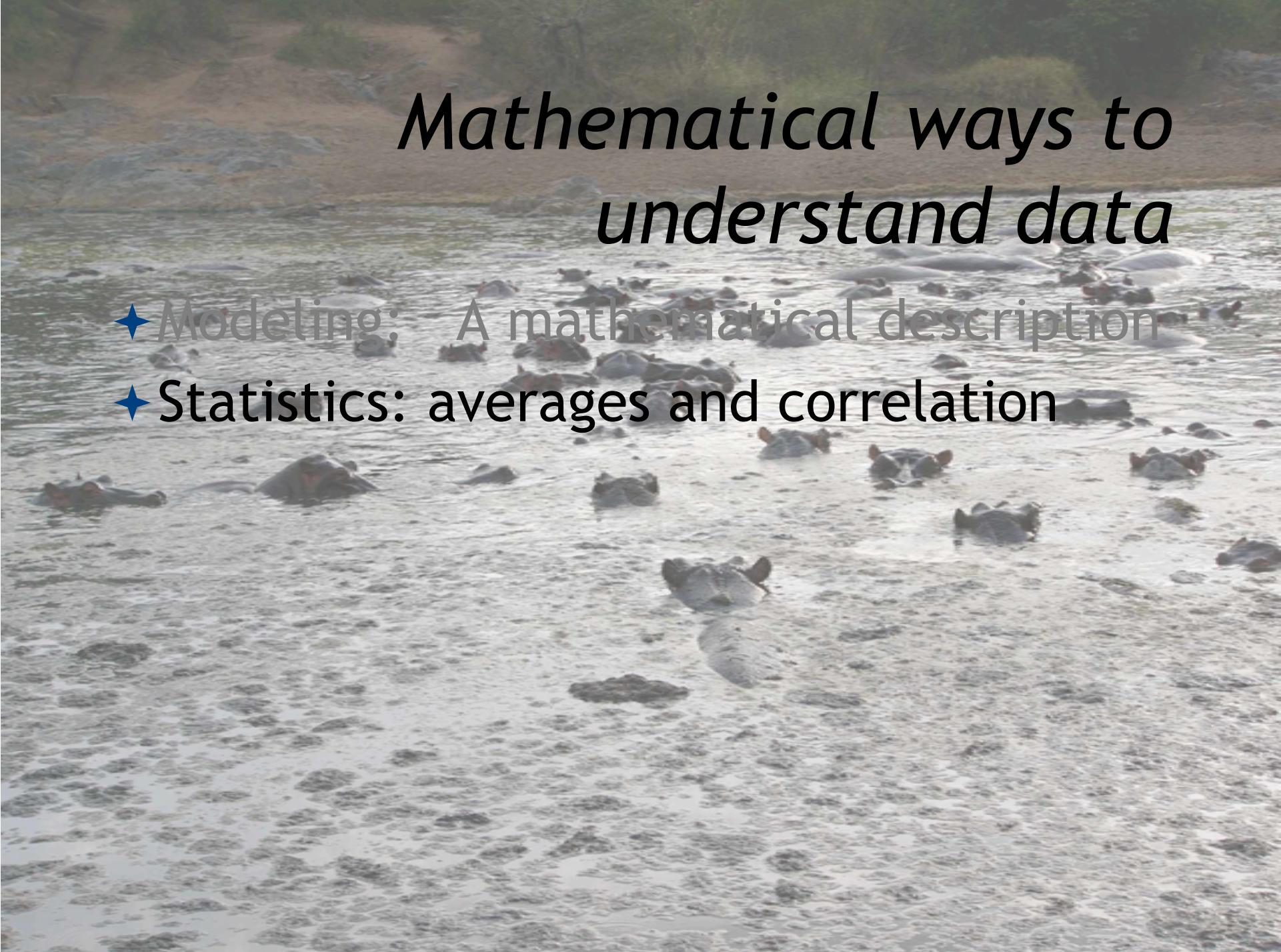


Mathematical ways to understand data



Mathematical ways to understand data

- ❖ Modeling: A mathematical description
= translating the story into our language

A photograph showing a large group of hippos swimming in a river. The water is shallow and rocky at the bottom. The hippos are mostly submerged, with their heads and backs visible above the water. They are scattered across the frame, some closer to the foreground and others further back. The background shows a grassy bank.

Mathematical ways to understand data

- ❖ Modeling: A mathematical description
- ❖ Statistics: averages and correlation

Mathematical ways to understand data

- ❖ Modeling: Describing in mathematical language
- ❖ Statistics: averages and correlations
- ❖ Geometry: shapes

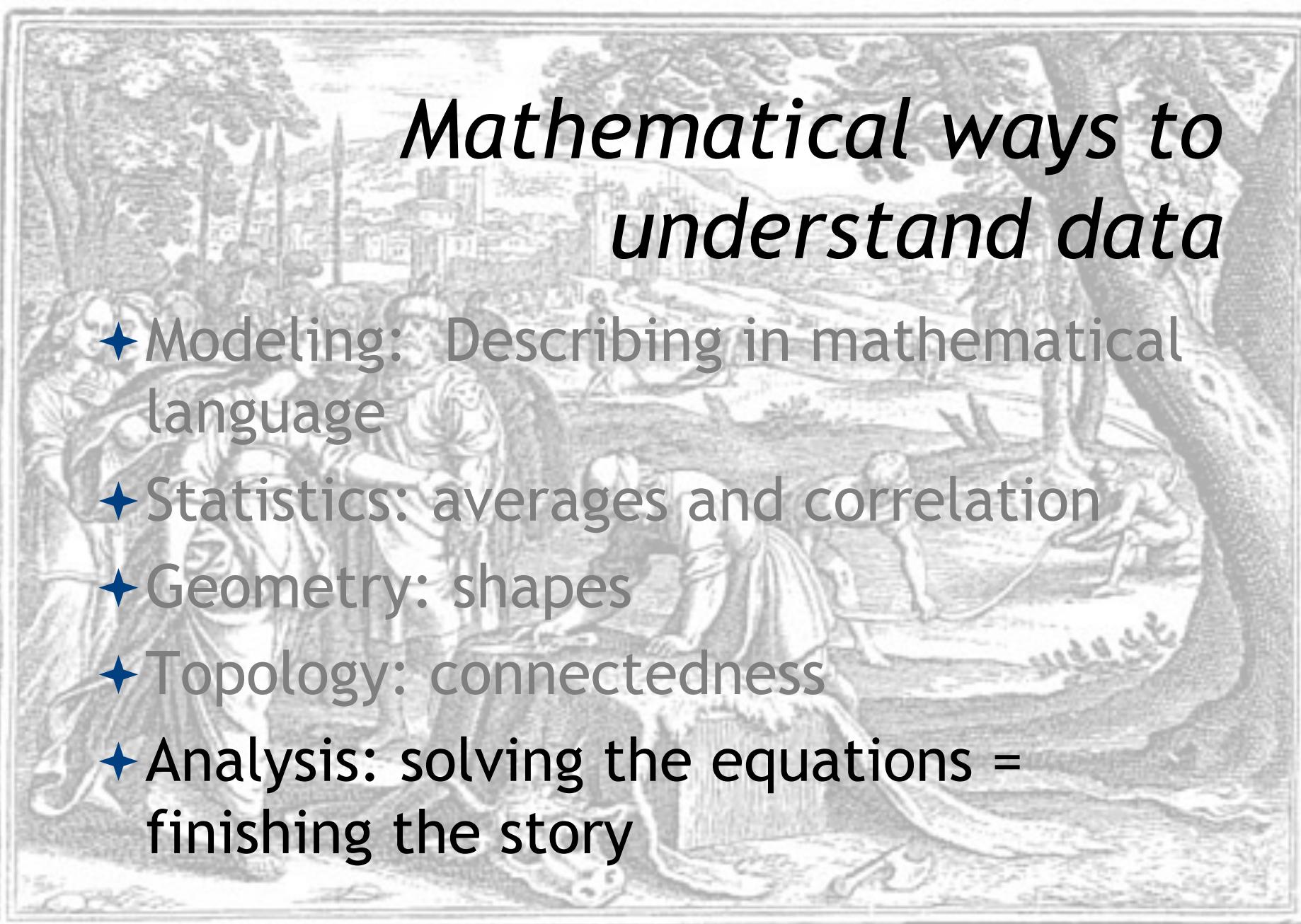


George
Lugwani

Mathematical ways to understand data

- ❖ Modeling: Describing in mathematical language
- ❖ Statistics: averages and correlation
- ❖ Geometry: shapes
- ❖ Topology: connectedness



A black and white engraving from Matthäus Merian's 'Historische Chronica'. It depicts Queen Dido of Carthage standing on a rocky shore, holding a long staff or scroll. She is facing a group of men who are cutting the hide of an ox into thin strips. In the background, a city with several domes and minarets is visible across a body of water. The scene illustrates the legend of how Dido used the oxhide to mark out a large area of land.

Mathematical ways to understand data

- ❖ Modeling: Describing in mathematical language
- ❖ Statistics: averages and correlation
- ❖ Geometry: shapes
- ❖ Topology: connectedness
- ❖ Analysis: solving the equations = finishing the story

Dido Purchases Land for the Foundation of Carthage. Engraving by Matthäus Merian the Elder, in *Historische Chronica*, Frankfurt a.M., 1630. Dido's people cut the hide of an ox into thin strips and try to enclose a maximal domain.

The Next Einstein Project



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A PART OF THE AIMS NEXT-EINSTEIN INITIATIVE, AIMS-SENEGAL IS A BRAND NEW CENTER OF A PAN-AFRICAN NETWORK THAT IS PLANNED TO GROW UNTIL REACHING ABOUT FIFTEEN SUCH INSTITUTES. >

Building Science in A

Quick Links

- > Apply and 2013- 2014 Program
- > AIMS-Journal-Club
- > Essay Proposal
- > Recruitment
- > Webmail
- > AIMS Courses 2012/2013
- > Next Einstein Initiative
- > Events
- > worth knowing

News

Workshop on "Mathematical tools for understanding and managing fisheries : Synthesizing and refining data and models" du 07 au 09 Mai 2014, see more details!!!!

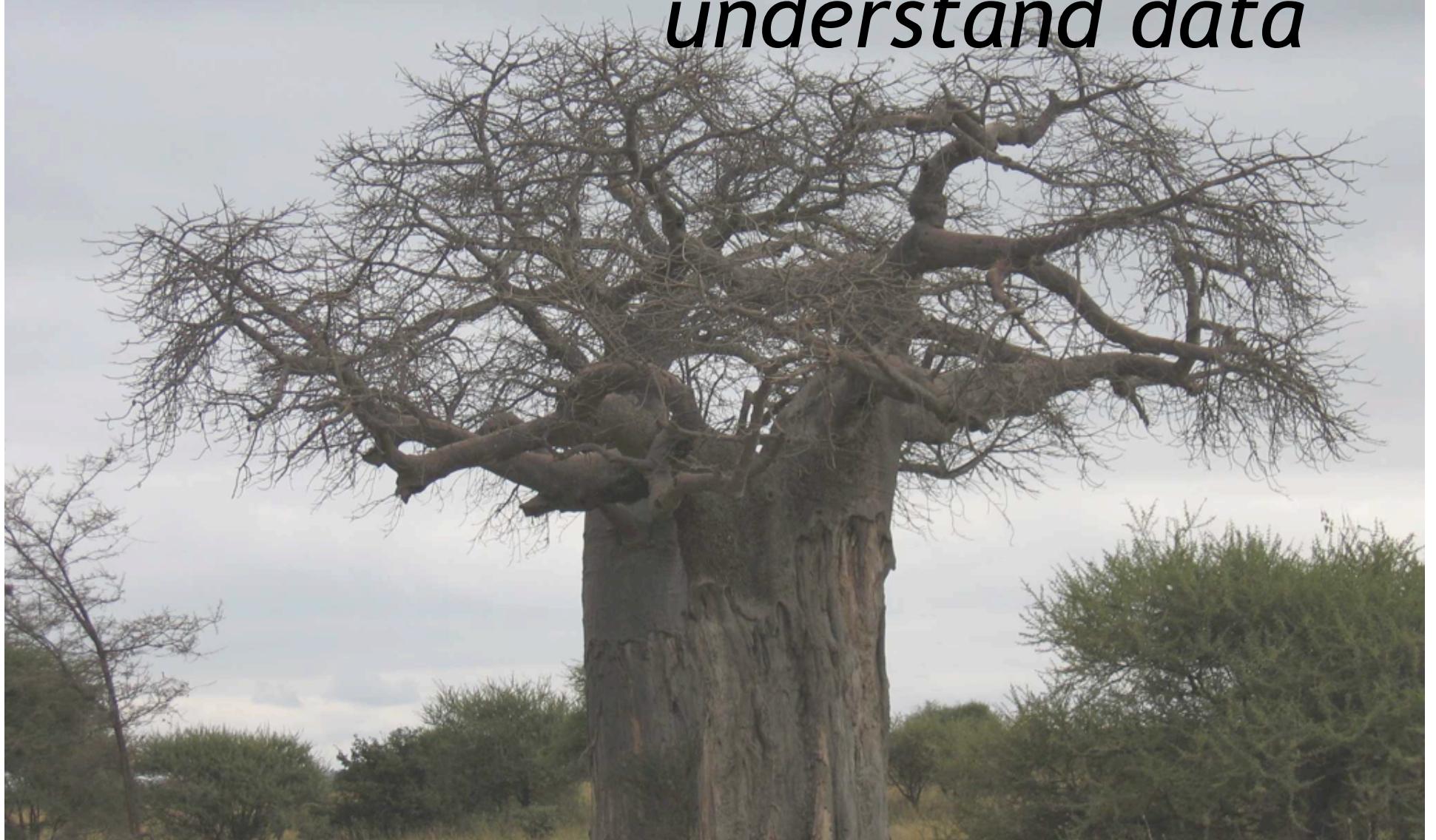
Mr. Mary Teuw Niane (Minister for Higher Education and Research in Senegal), Professor Mamadou Sangharé (President of the African Institute for Mathematical Sciences) and Dr. Long Do Cao (Tutor at AIMS SENEGAL) will wonder around the following question: "The next Einstein will he African?" on RFI see more....

Calendar

<< < May 2014 > >>

S	M	T	W	T	F	S
					1	2
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

Mathematical ways to understand data



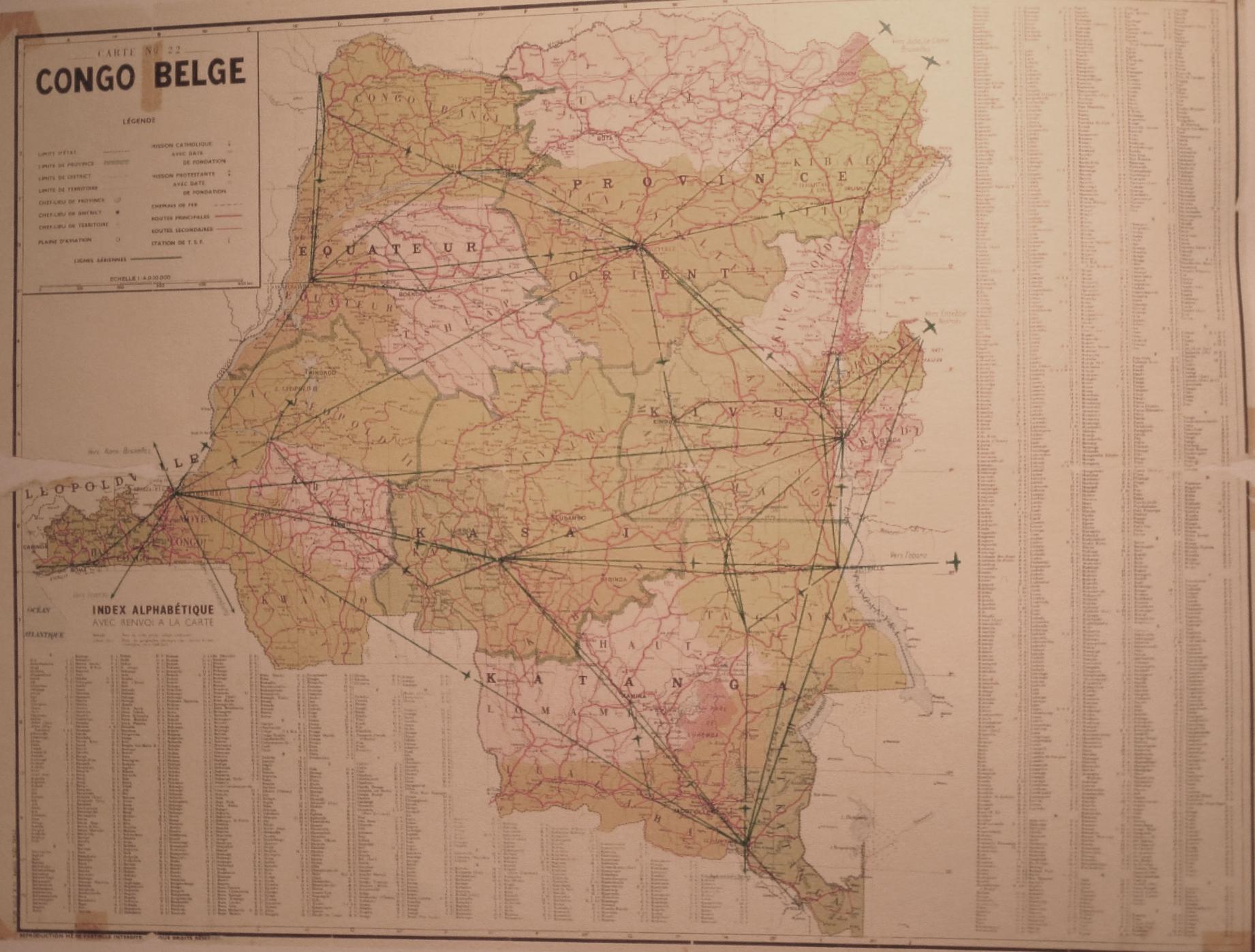
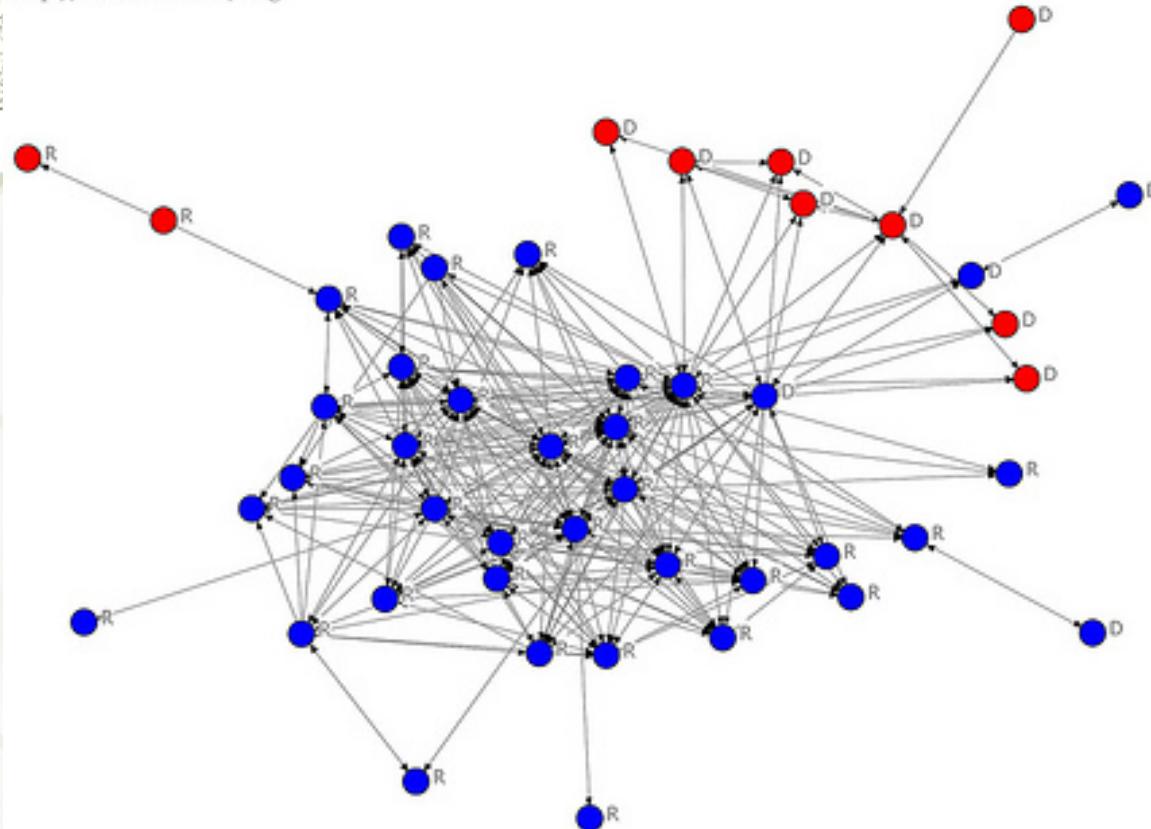


Figure 19: Carte No. 22: Congo Belge (Air route map ca. 1958) Georgia Tech is pleased to recognize the loan of the map from the collection of Mr. Herbert Weiss.

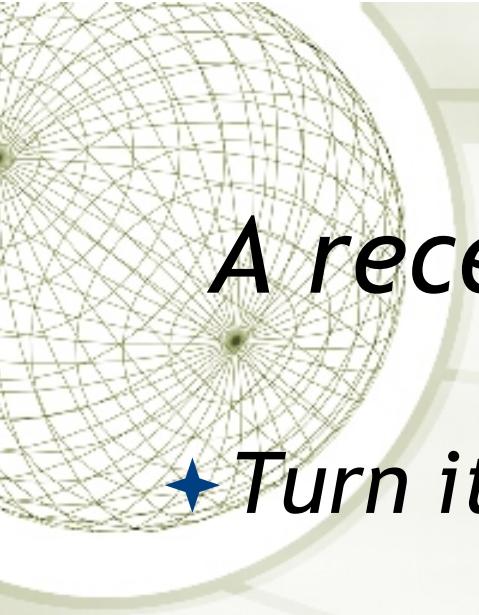
Mathematical understandings of social data

Map of US Congress Twitter People
coloured by calculated party affiliation
February 3, 2009
<http://mediaczar.com/blog>



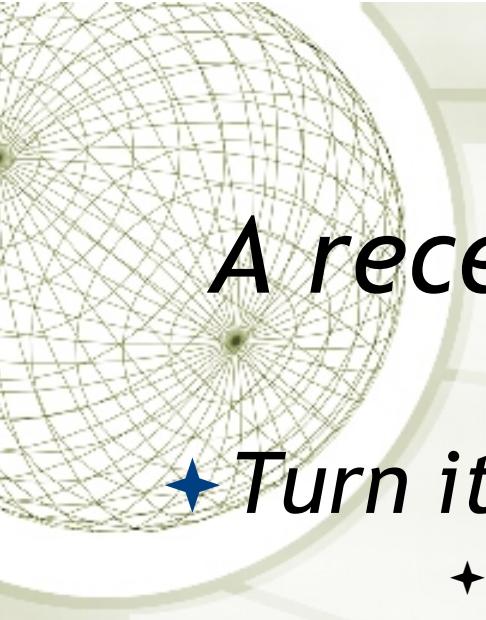


A recent trend in “data mining”



A recent trend in “data mining”

- ★ *Turn it into music and listen.*



A recent trend in “data mining”

- ★ *Turn it into music and listen.*

- ★ *First Life - Translating Scientific Data Into Music, a collaboration of Steve Everett, Professor of Music at Emory and Martha Grover, Chemical & Biomolecular Engineering at Georgia Tech. (Sept. 2013, at the Atlanta Botanical Garden.)*
- ★ *Molecular music. (March, 2014, Atlanta Science Festival.)*
- ★ *European Science Café Atlanta, last week.*

A recent trend in “data mining”

The poster features a stylized, abstract graphic on the left side composed of intersecting blue and red lines forming a complex geometric pattern.

**Center for Chemical
EVOLUTION** | Emory Chamber Music
Society of Atlanta | **Georgia Tech**

First Life

imagining the chemical origins of life

by *Steve Everett*

a multimedia performance
for string quartet and narration

featuring

Vega String Quartet
Martha Grover and David Lynn, narration



A recent trend in “data mining”

- ★ Fourier transform. *Same data, but viewed in a different way*
 - ★ *like looking at the shape of the sound wave vs listening to the sound.*

Artistic understandings of social data



A Luba lukasa memory board:
A sort of map including history
and personal and political
relationships.



Roberts and Roberts
Memory

Luba Art and the Making of History.
Museum of African Art, 1996

MAPPING PLACE: AFRICA BEYOND PAPER



FEBRUARY 28, 2014 - JUNE 6, 2014

The understanding of a lukasa board has been (mostly) lost.
Can we use math to bring
some of it back?



MAPPING PLACE: AFRICA BEYOND PAPER



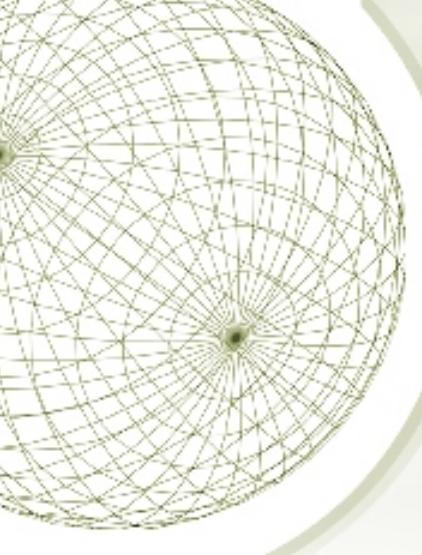
FEBRUARY 28, 2014 - JUNE 6, 2014

Mathematics - an observational device

Out[53]=



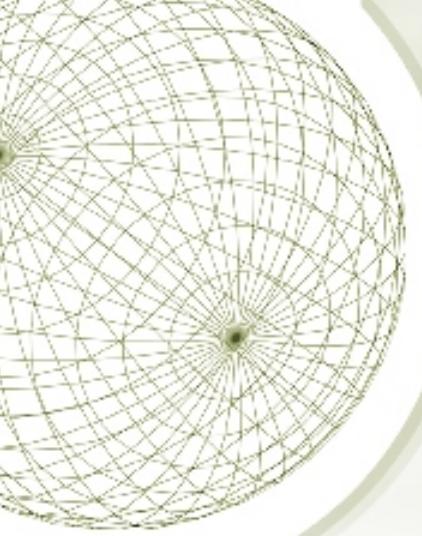
This is a randomly generated “graph” showing 520 connections among 100 items. How many independent kinds of information (“dimensions”) are there?



Mathematics - an observational device

$$\sum_{j=1}^{k-1} \lambda_j \leq \frac{\pi^2 |\mathcal{E}|}{3} \left(\frac{k}{|\mathcal{V}|} \right)^{1+\frac{2}{\nu}}$$

Harrell-Stubbe, to appear in *Linear Algebra and Applications*



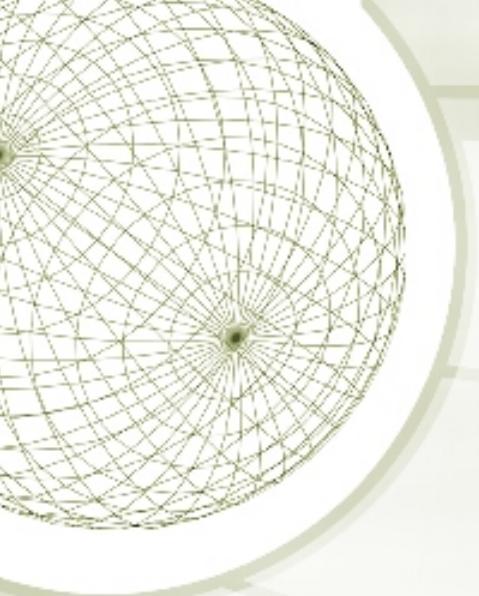
Mathematics - an observational device

$$\sum_{j=1}^{k-1} \lambda_j \leq \frac{\pi^2 |\mathcal{E}|}{3} \left(\frac{k}{|\mathcal{V}|} \right)^{1+\frac{2}{\nu}}$$

Do not fear! Think:

Harrell-Stubbe, to appear in *Linear Algebra and Applications*

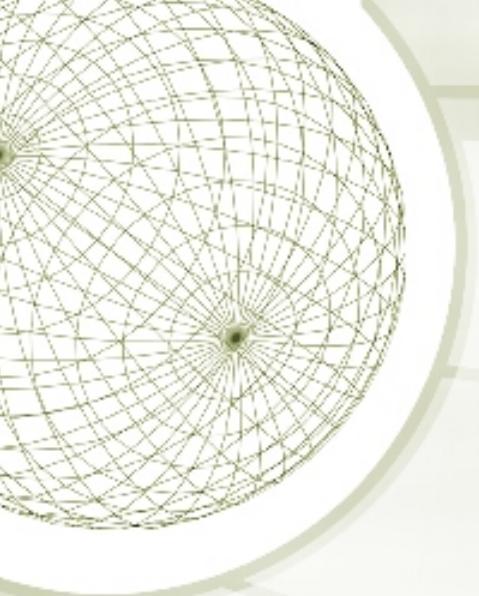




Mathematics - an observational device

$$\sum_{j=1}^{k-1} \lambda_j \leq \frac{\pi^2 |\mathcal{E}|}{3} \left(\frac{k}{|\mathcal{V}|} \right)^{1+\frac{2}{\nu}}$$

These “eigenvalues” are in essence the musical tones you would generate by making the graph produce sound. These and the other numbers in the formula, *other than the exponent*, are just things you can measure.



Mathematics - an observational device

$$\sum_{j=1}^{k-1} \lambda_j \leq \frac{\pi^2 |\mathcal{E}|}{3} \left(\frac{k}{|\mathcal{V}|} \right)^{1+\frac{2}{\nu}}$$

This “dimension” indicates the complexity of data about relationships.

Mathematics - an observational device



This is a randomly generated “graph” showing 520 connections among 100 items. How many independent kinds of information (“dimensions”) are there?

According to our theorem: *It is only three-dimensional!*
The story of this graph can be understood in terms of three questions.

THE END

