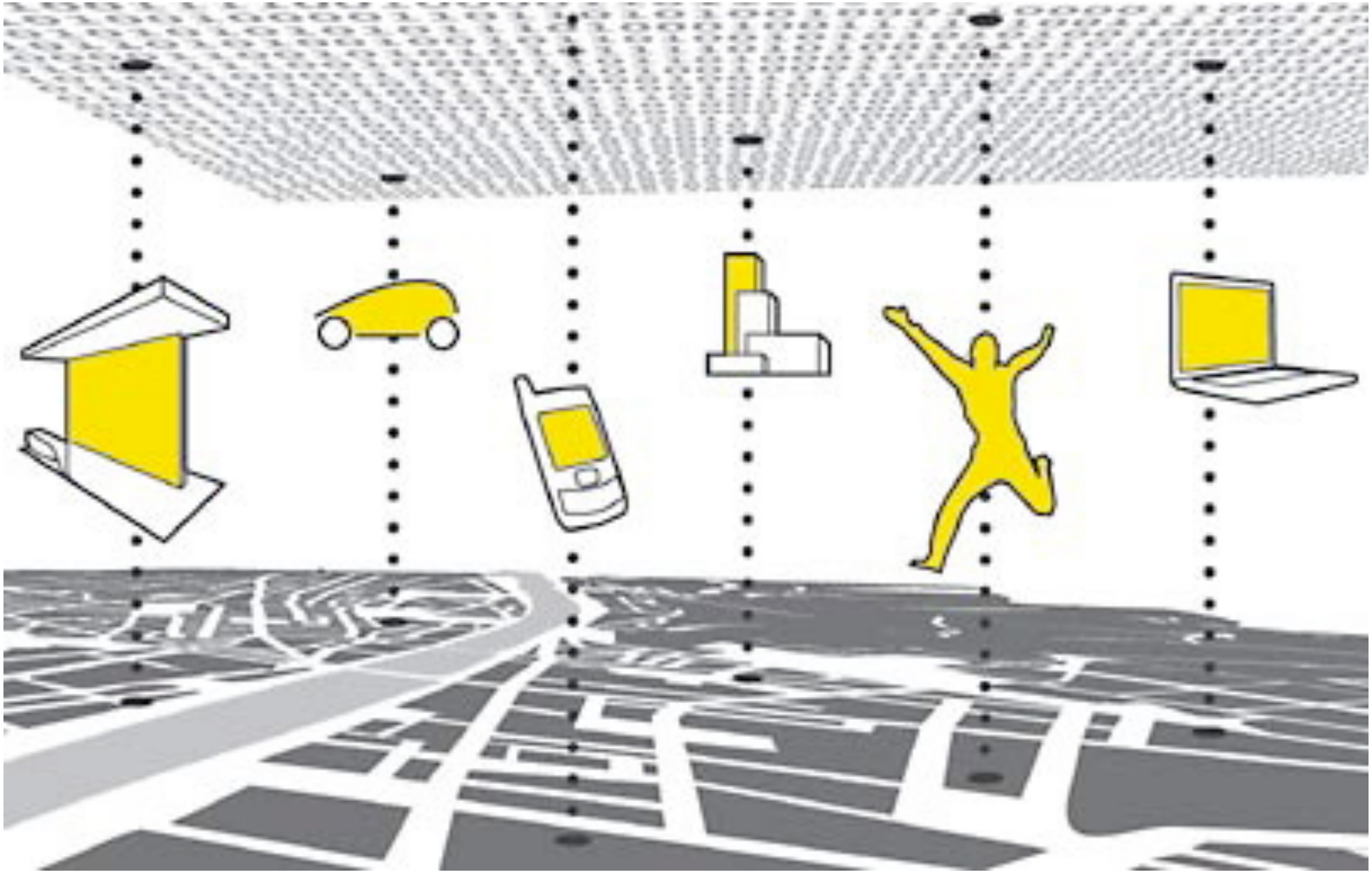


image: MIT Senseable City Lab

new technologies and statistics
partners for environmental monitoring and city sensing

g. borga, r. camporese, n. iandelli, a. ragnoli
iuav university of venice
new technologies and information on territory and environment research group

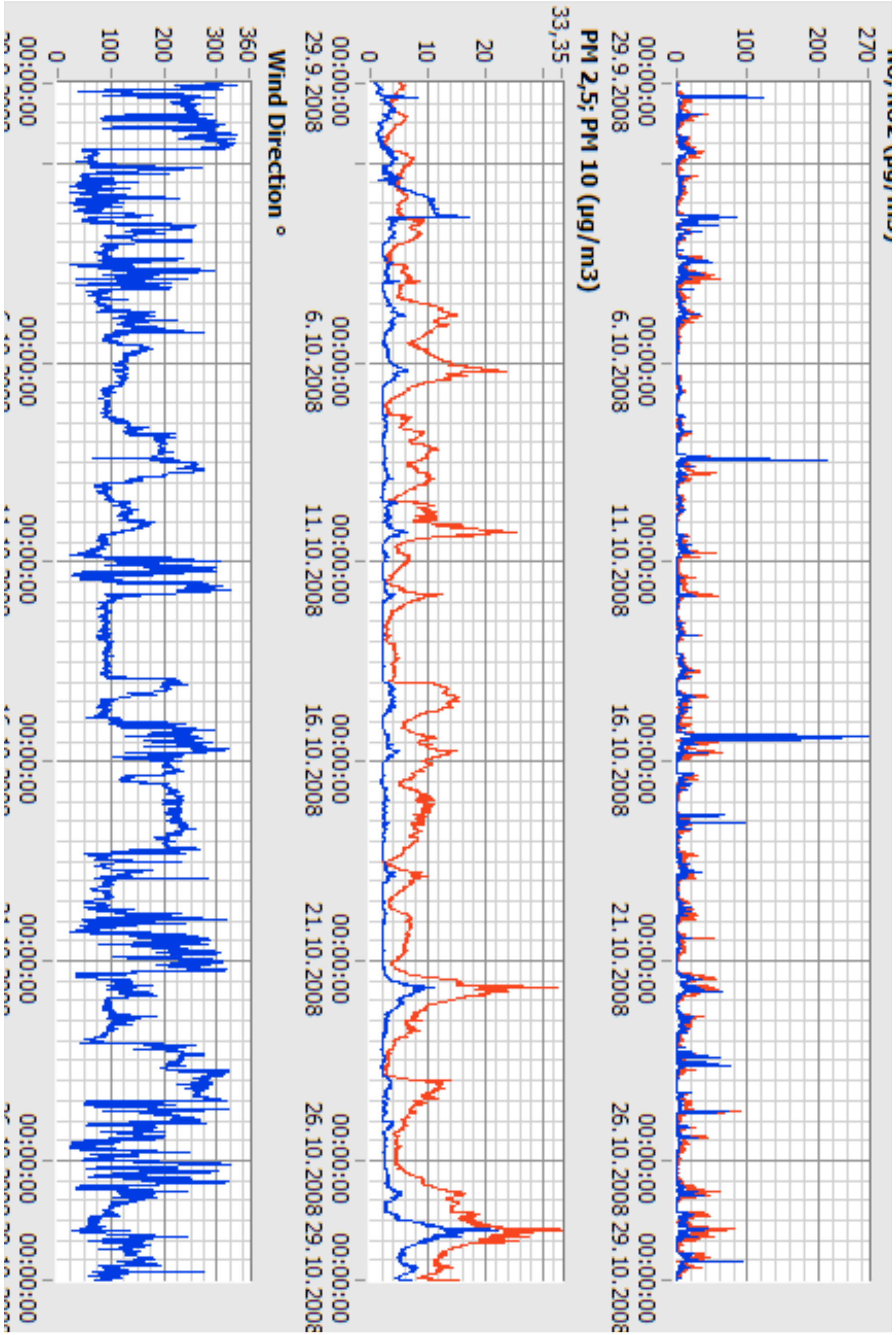
new environmental monitoring ?

sensors and
computer networks
are rapidly developing

thousands of potential
data acquisition instruments
distributed and interconnected

providing potentially
near real time
data flows

traditional paradigm based on
few stand-alone monitoring stations
is displaced



city sensing

urban space
interconnected thanks to
a myriad of technological devices

pervasive low cost nodes
equipped with light sensors

data aggregated in a
geographic database

representing what is
happening around us

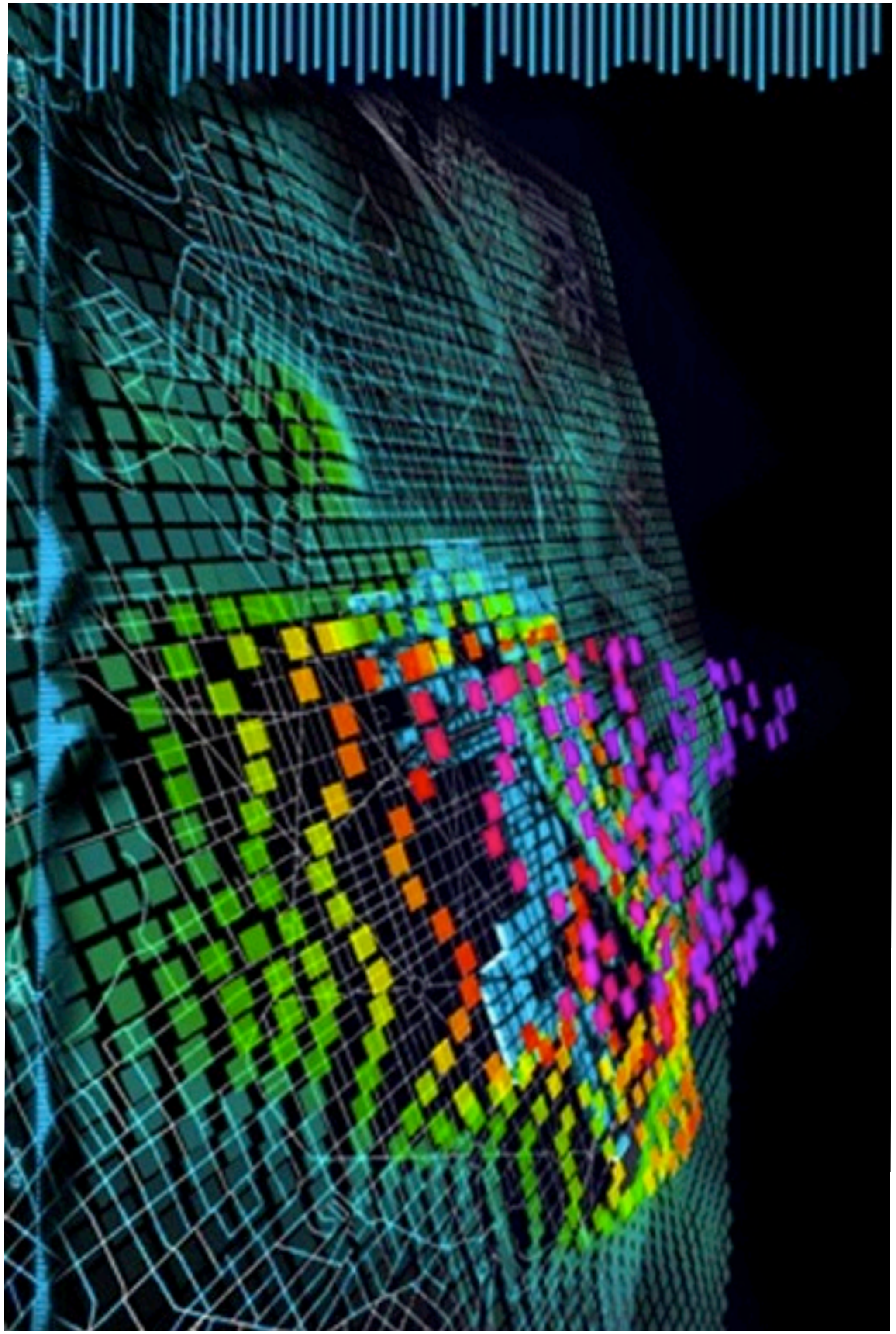
immersive sensing

sensor web

city sensing combined with
web 2.0 opportunities

performs
environmental monitoring
in the style of social networking

with a collaborative perspective



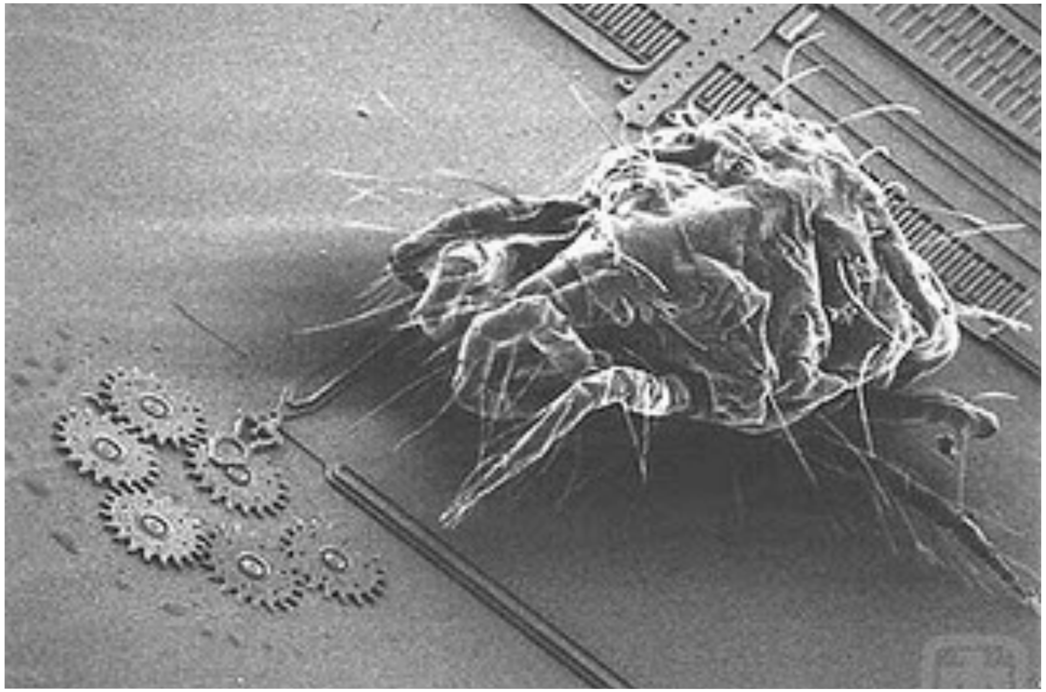
mems

new sensors are mainly based on micro-electro-mechanical-system

integrated in smart phones or wearable devices

translate variations of physical parameters into electrical impulses
e.g. temp, hum, magnetic fields, gas concentration, ...

each mobile phone could become an environmental station and a node of a larger monitoring network



advantages

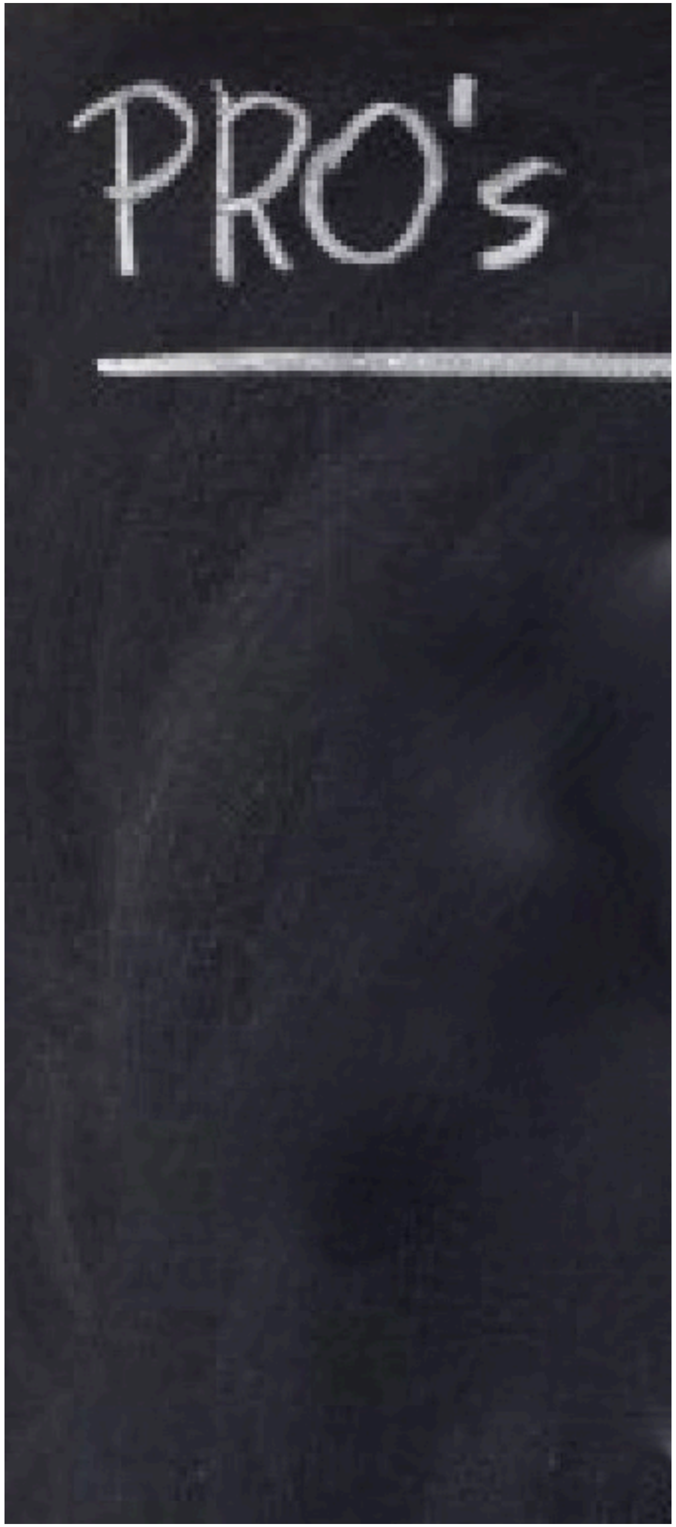
widespread and numerous measurements

lower unit cost

versus the traditional measures
precise
expensive
few in number

near real time communication

interaction with citizens



limits

low cost sensors
greater measurement error

huge amount of data
data overload

non homogeneous
instruments and procedures

pressure for real time can produce
hasty and unmeditated elaborations

role of statistics

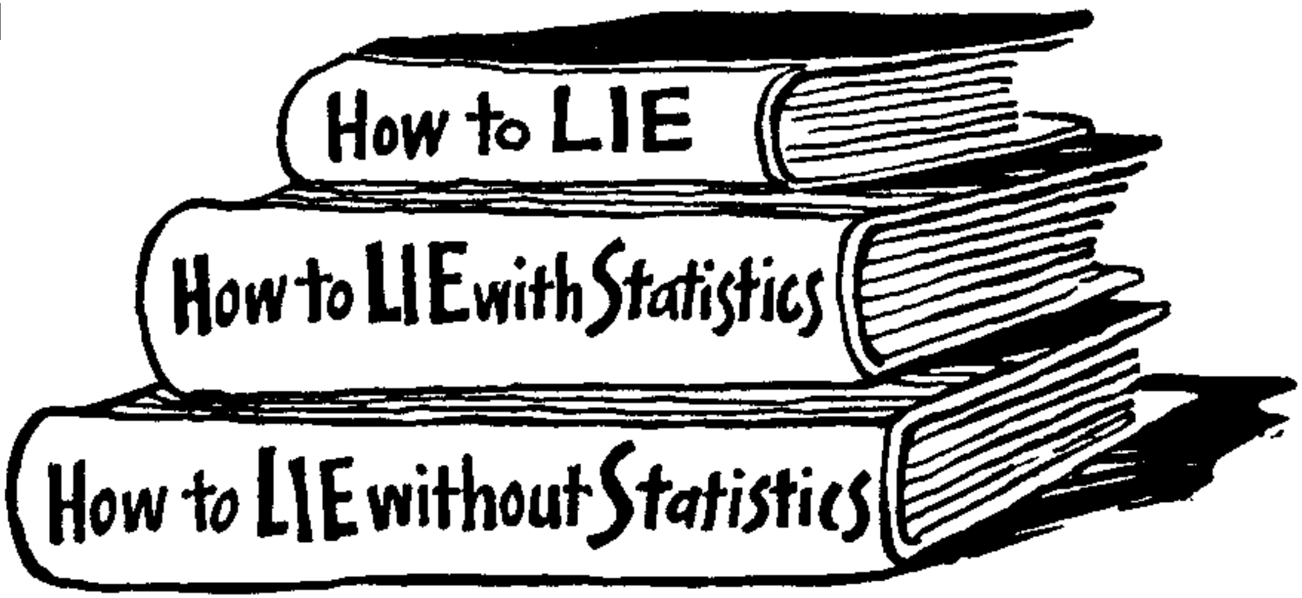
rationalise the
numerous and enthusiastic
data collection processes

make them more
significant and representative

raise awareness of
measurement quality control

keep uncertainty
into consideration

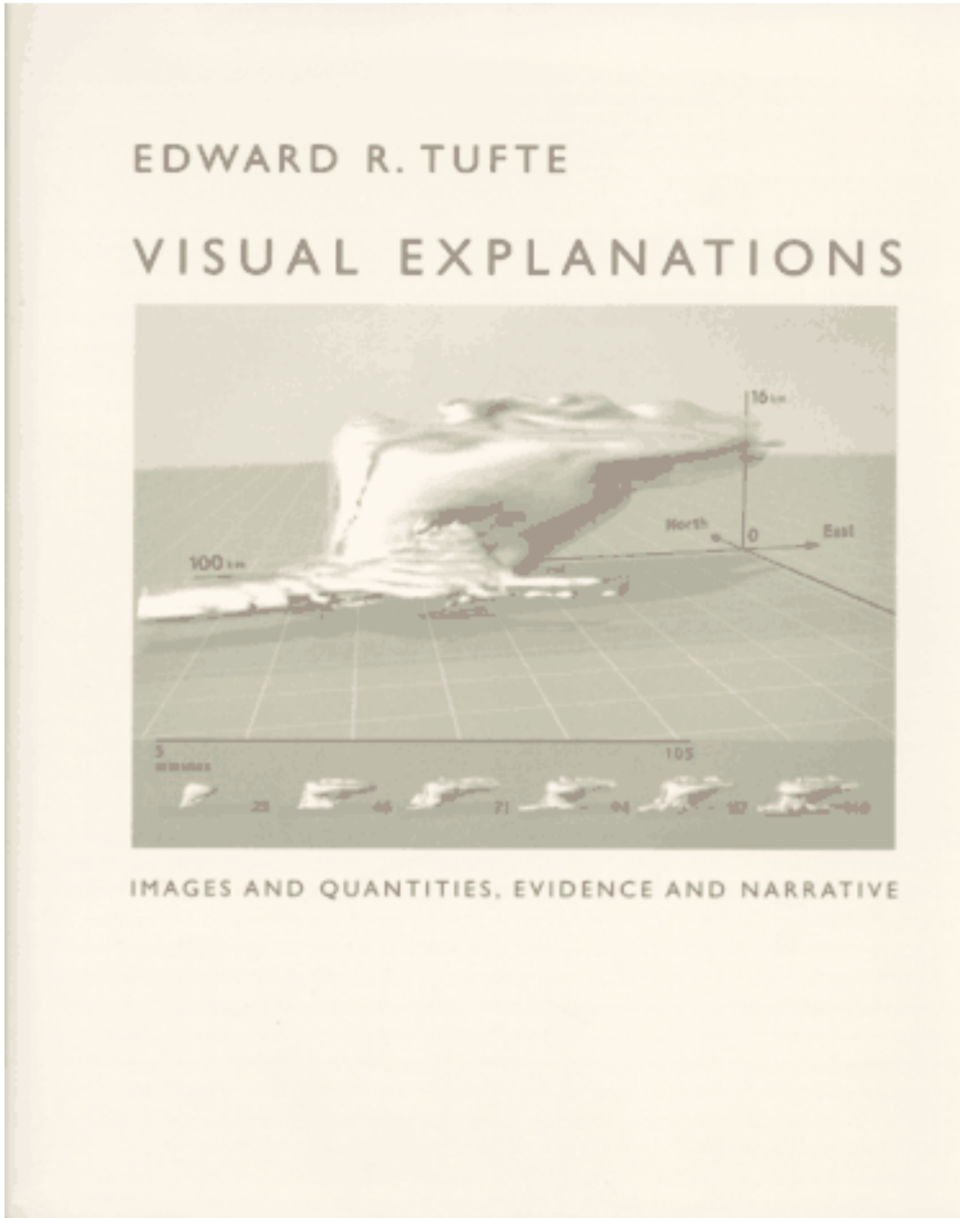
enhance the essential
role of metadata



in cooperation with information design

innovative solutions for
significant data synthesis
and representation

especially for
multidimensional data
by space and time



examples

how new technologies
can modify
the traditional approach to
environmental monitoring

air
&
noise

reference frame:

UN framework
for the development
of environment statistics

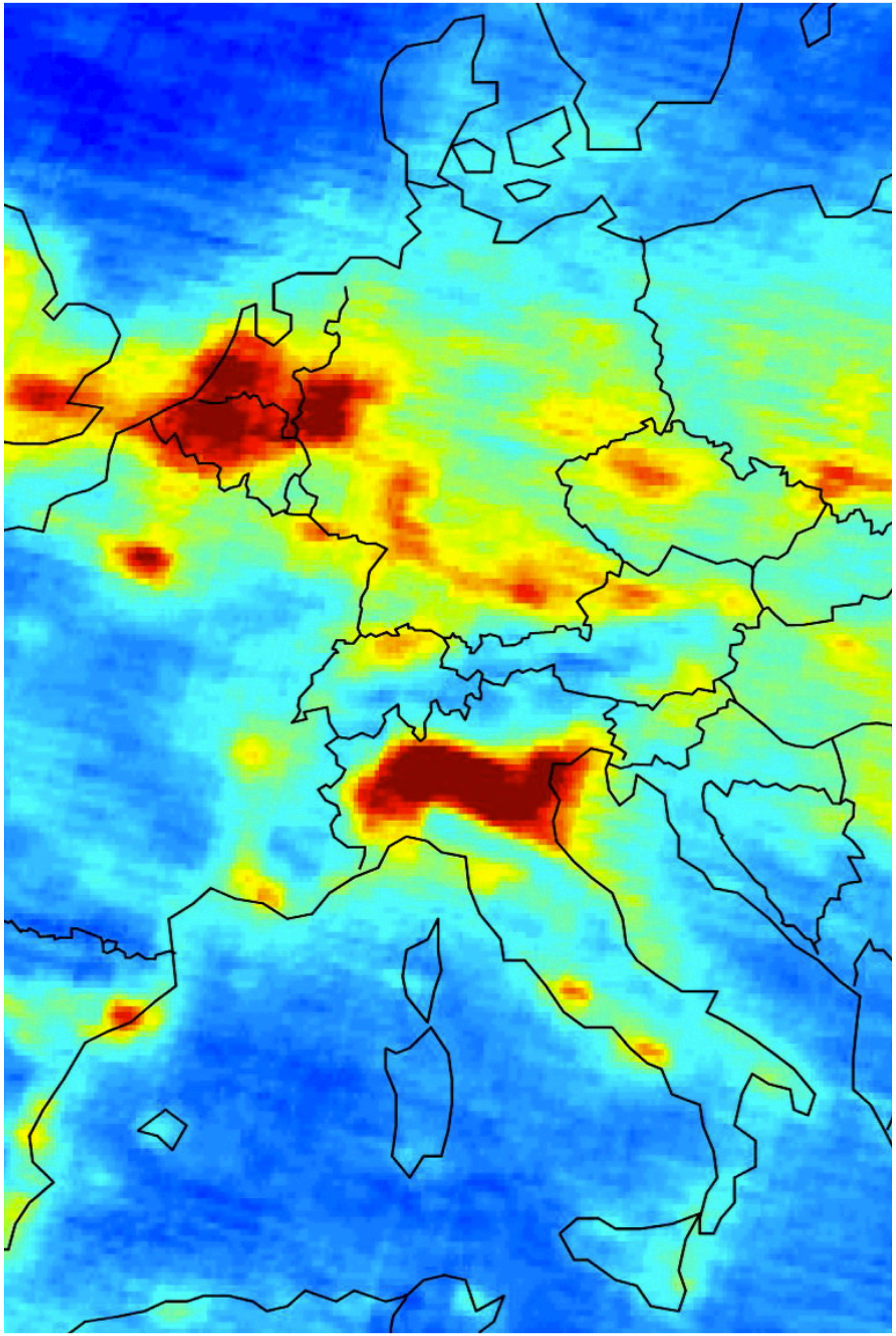
national statistics

air pollution

UNSD environmental indicators
regard mainly emissions
not concentration of pollutants

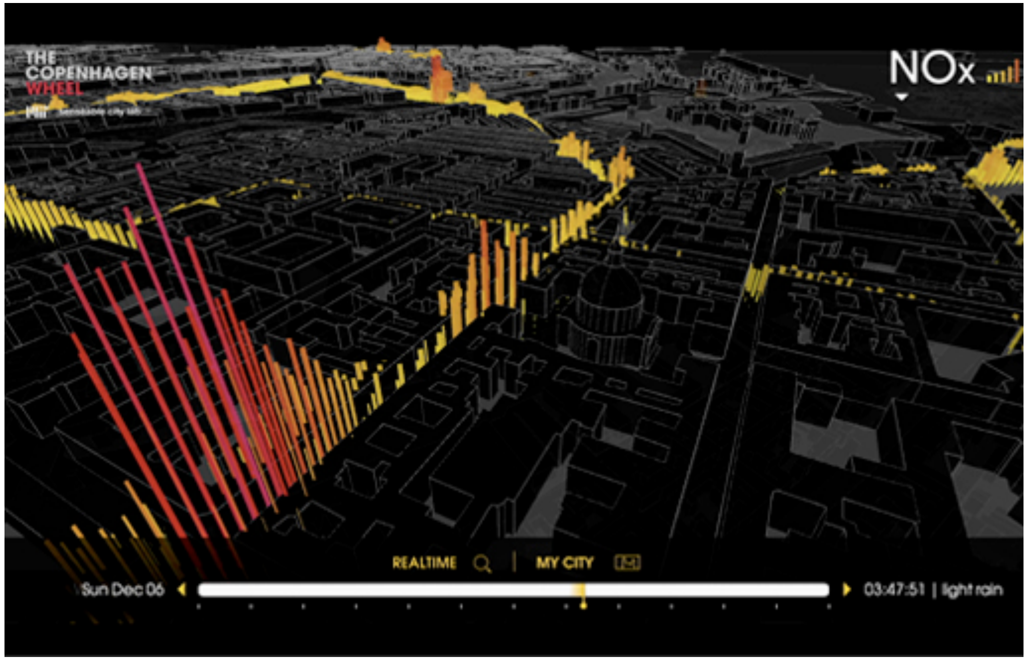
because their estimates often lack
quality, coverage, comparability

interestingly
national environmental statistics
monitor the monitoring network
instead of the phenomenon itself



why the past?

UN, 1991
the cost of environmental monitoring has inhibited the development of statistically valid space/time sampling frame



The Copenhagen Wheel

a possible future?

low cost sensor networks open a new scenario

challenges

instruments calibration

proper space and time dependent sample strategies

statistical validity

significant data reduction of massive datasets

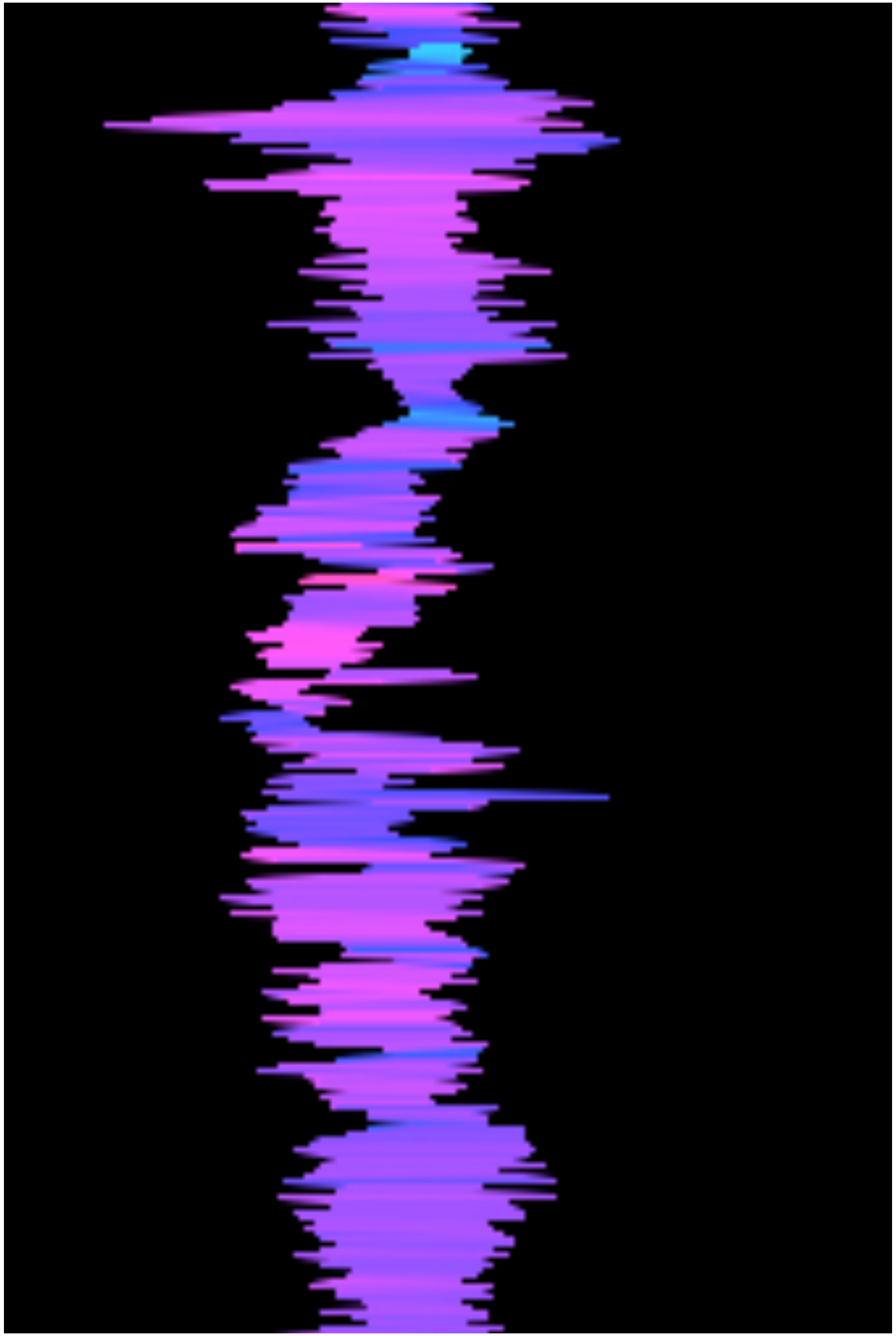
rapidly changing data

noise

UN 1998
suitable indicator:
population exposed
to excessive noise
i.e. noise levels exceeding national standards

EU Directive 2002 requires
harmonized strategic noise maps

actual national statistics
responses to noise pollution
i.e. actions and policies adopted
to reduce noise pollution



noise sensors

widespread
even smart phones mics

lower cost and
better measurement quality

as compared to performances of
gas concentration sensors
which are more controversial

idea

noise exposure maps
along the roads
in urban environment

EU indicators
.day-evening-night level in decibels
.night-time noise
A-weighted long-term average sound levels
over all the day periods of a year

sample strategy ?

stratification

space

.road segments

by techno-functional characteristics

i.e. speed limit, traffic flow

source: road register

.urban environment

by urban fabric density

i.e. continuous, dense, medium, low, sparse

by functional characteristics

residential, industrial, ...

source: GSE Land European Urban Atlas
European Earth Observation Programme

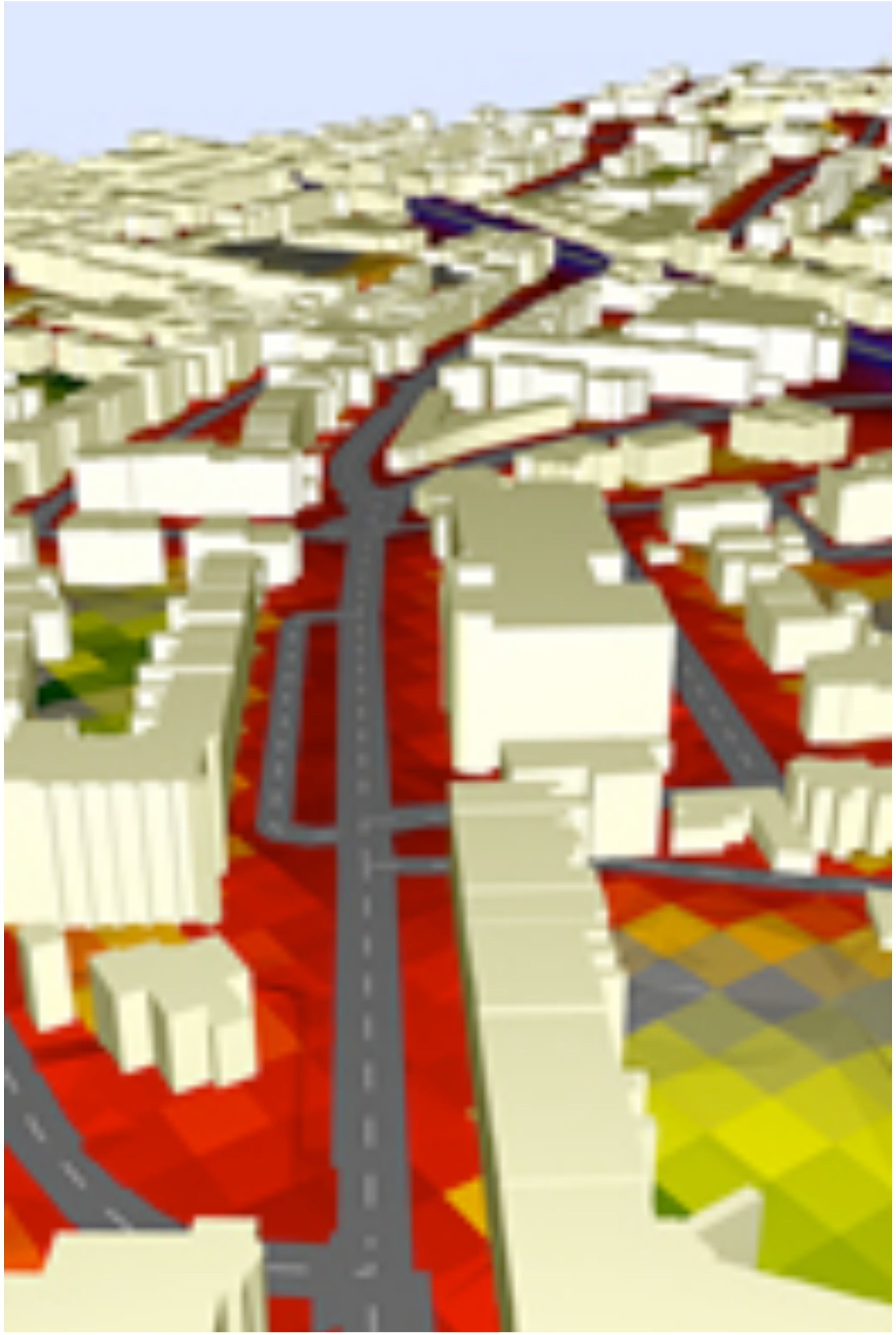
time

12 months - 24 hrs - 7 days

by month and type of the day (mon-fry, sat, sun)

harmonized european time use survey

portable noise meters
would easily adapt to such a sample



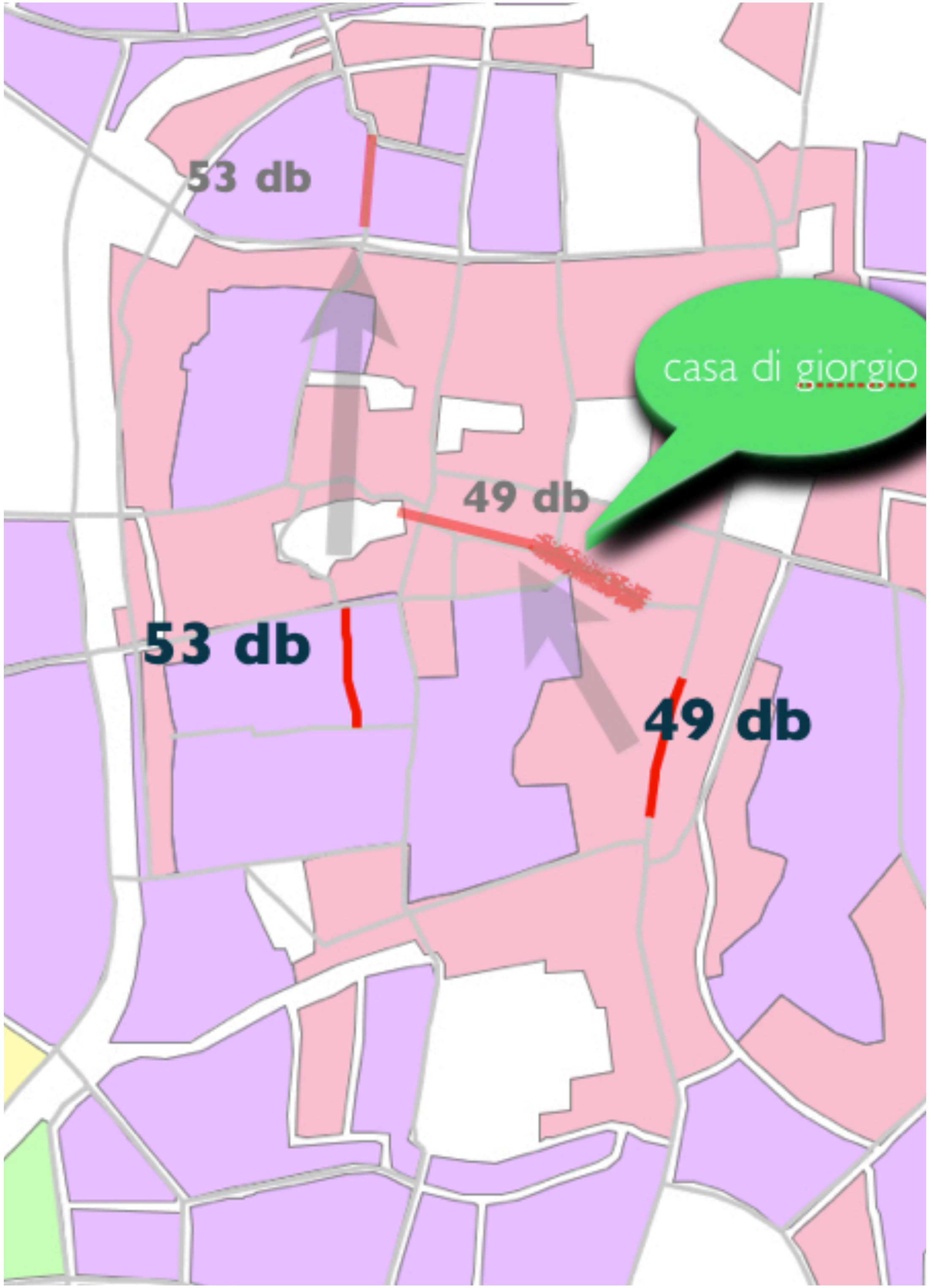
risky proposal

if the output is a noise map where
estimates from sample locations
generate expected values
for non surveyed road segments

why not contaminate this traditional
approach with a **wiki** component?

integrating traditional measurements
with spontaneous contributions
from smart phones apps
for non-sampled areas and times

final estimates:
ex-post weight calibration and
proper weighted averages



citizen science

OpenStreetMap.org
collaborative mapping

GalaxyZoo.org
a million galaxies images
available on the web
morphological classification
carried out by a network
of registered web users
after a brief on-line tutorial phase

NoiseTube.net
participative approach
to noise pollution monitoring

work in progress

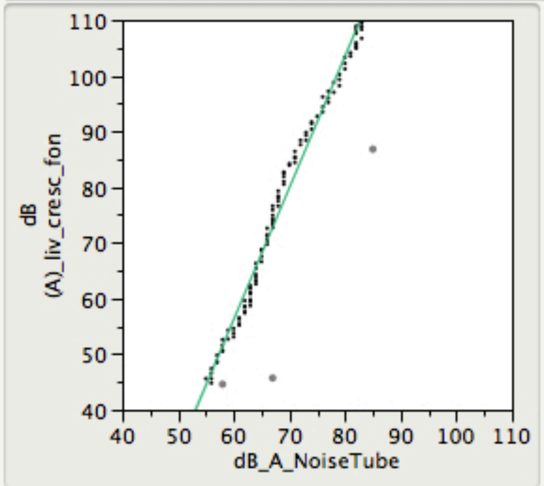
in collaboration with arpa and
department of technical physics
at the university of padova

measurement quality control
comparing smart phones and
sound level meters performances

calibration sessions
in reverberation room
and open field
right after this session

...

Bivariate Fit of dB (A)_liv_cresc_fon By dB_A_NoiseTube modello=nokia E71, battery_level=medium



Linear Fit

Linear Fit

dB (A)_liv_cresc_fon = -85,8344 + 2,3669125*dB_A_NoiseTube

Summary of Fit

RSquare	0,98793
RSquare Adj	0,987833
Root Mean Square Error	2,250047
Mean of Response	78,60079
Observations (or Sum Wgts)	127

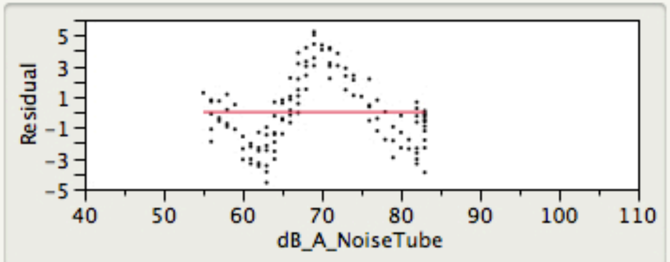
Lack Of Fit

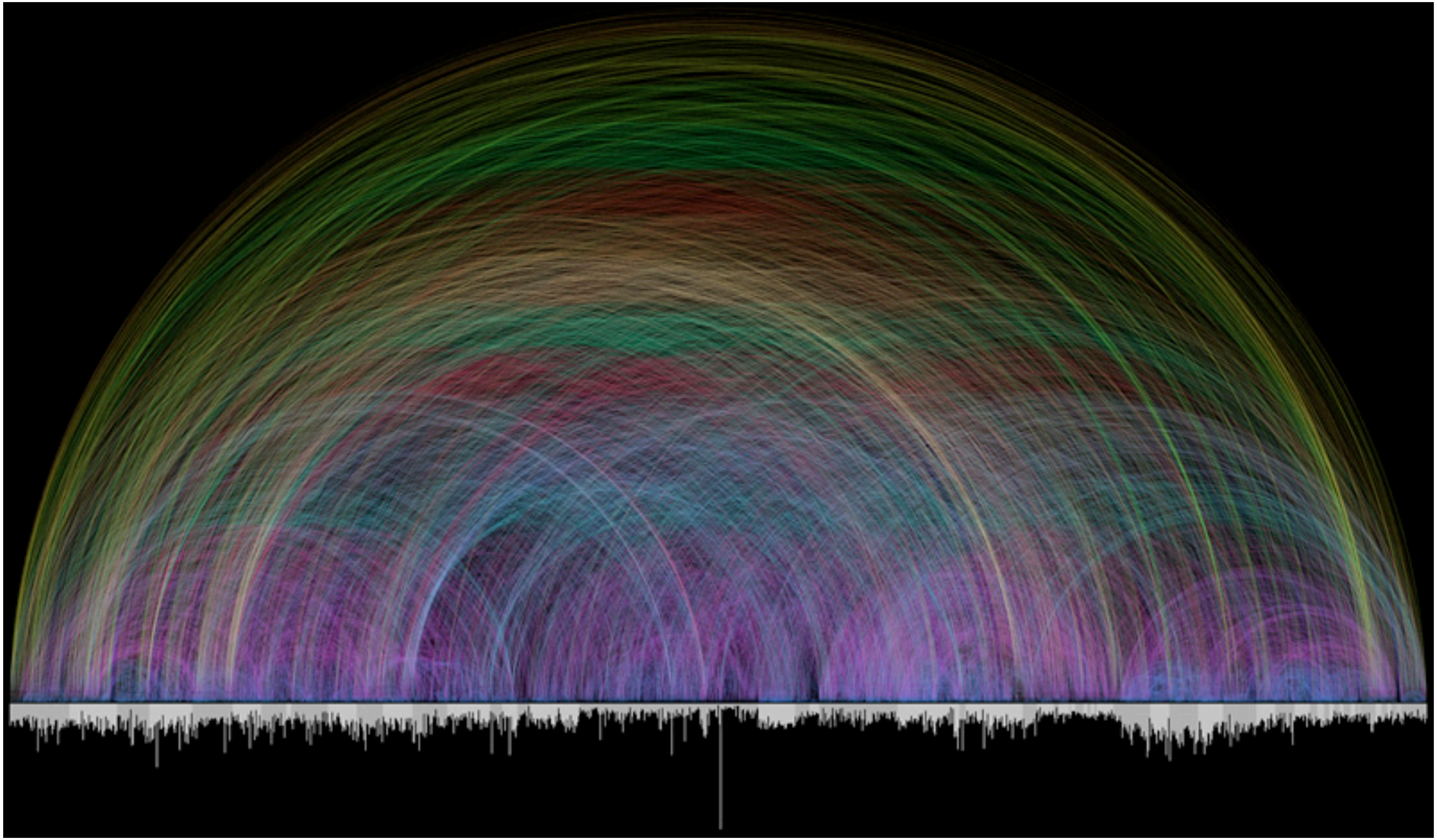
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	51796,691	51796,7	10231,01
Error	125	632,839	5,1	Prob > F
C. Total	126	52429,530		<,0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-85,8344	1,637896	-52,41	<,0001*
dB_A_NoiseTube	2,3669125	0,0234	101,15	<,0001*





complex | but intriguing