

User Centered Procedure to Develop Sonification for Climate Scientists

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<http://sysson.kug.ac.at>

overview

- intro to sonification
- sonification techniques
- sonification of climate data
- user centered design approach

spontaneous sonification

stethoscope

geiger counter

sonar

why sound is used spontaneously?

- tradition of listening to the data (e.g. medicine, mechanics)
- technological reason:
 - no other measurement device is available
 - sound is a by-product of measurement
 - domain science and sound use the same technological aids
- monitoring processes

advantages of sonification?

- advantages of our auditory perception:
 - high temporal resolution
 - large frequency range
 - omnidirectional
 - parallel auditory streams, backgrounding
- eye-free conditions (e.g. sight-impaired)
- useful when visual information overload

limiting factors of sonification?

- sound parameters lack strict orthogonality
- individual differences and necessity of training (perceptual and cognitive abilities of the users)
- aesthetics: sound can easily get annoying
- longer history of visualization
- user's cultural bias

a taxonomy of intended sonification uses

- presentation: auditory demonstration of finished results
- exploration: interaction with the data; heuristic for generating hypotheses (because of high temporal resolution of auditory, pattern detection and anomalies)
- analysis: requires well-understood, reliable tools for detecting specific phenomena (e.g. trend identification, data structure or pattern recognition)
- monitoring: processes that benefit from continuous monitoring by observer (industrial production, hospitals), any sudden change is hearable
- pedagogy: learning and understanding structures and patterns in data for non visual students or visually impaired

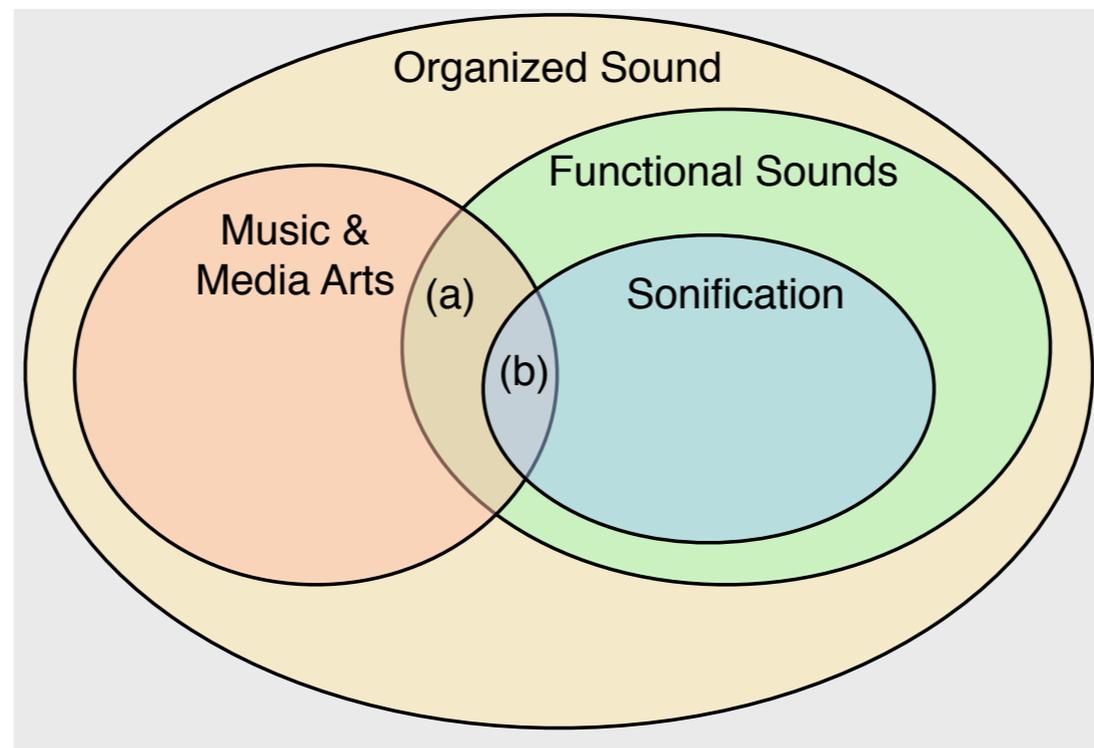
example: internet

<http://heavylistening.com/tweetscapes/>

definition

sonification is the use of non-speech audio to convey information [Kramer 99]

sonification is the data-dependent generation of sound, if the transformation is systematic, objective and reproducible, so that it can be used as scientific method. [Hermann 09]

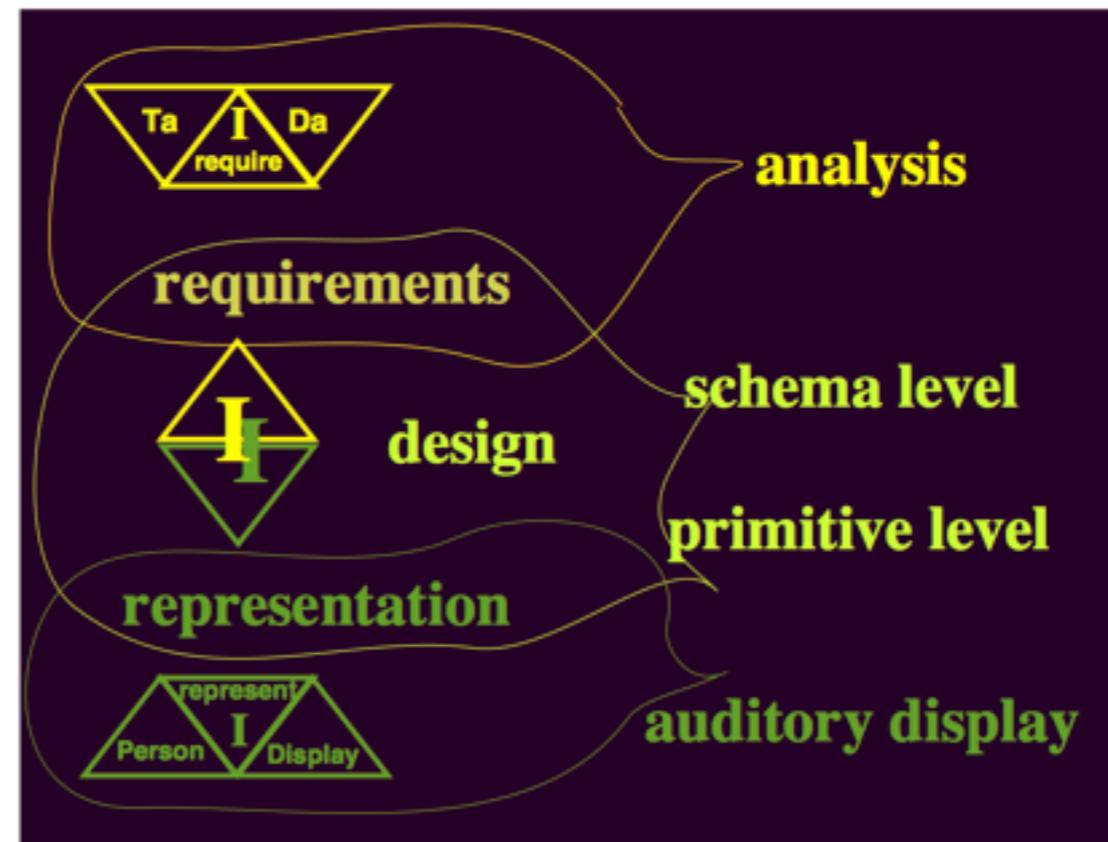
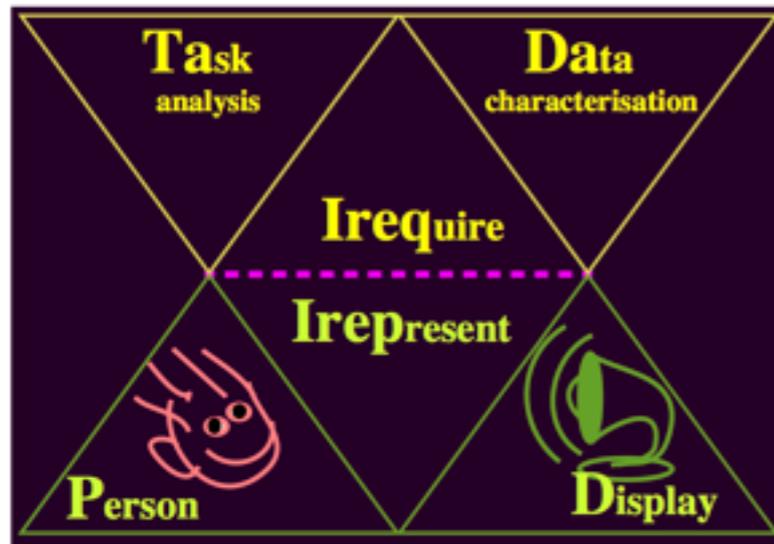


scientific method

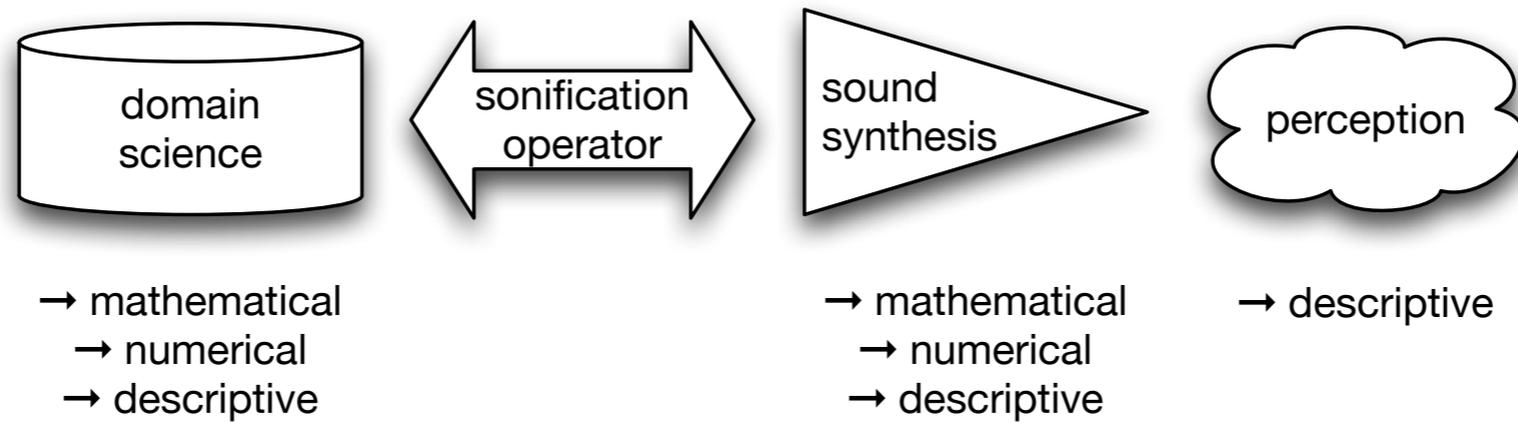
1. research question - hypothesis and prediction
2. data description (e.g. using TADA)
3. choosing a sonification method (e.g. using SDSM)
4. how could it sound like? (using metaphors)
5. describing the sonification designs:
6. sound synthesis, transfer function, sonification operator
7. discussion: what is hearable? how does it sound like?
8. gathering results, hypothesis
9. evaluations (using the sonification tool, how fast and how efficient can the user solve the problems? with how much training?) : clarity, efficiency, intuitivity, technical effort, ...

TADA: Task and Data Analysis

Stephen Barrass



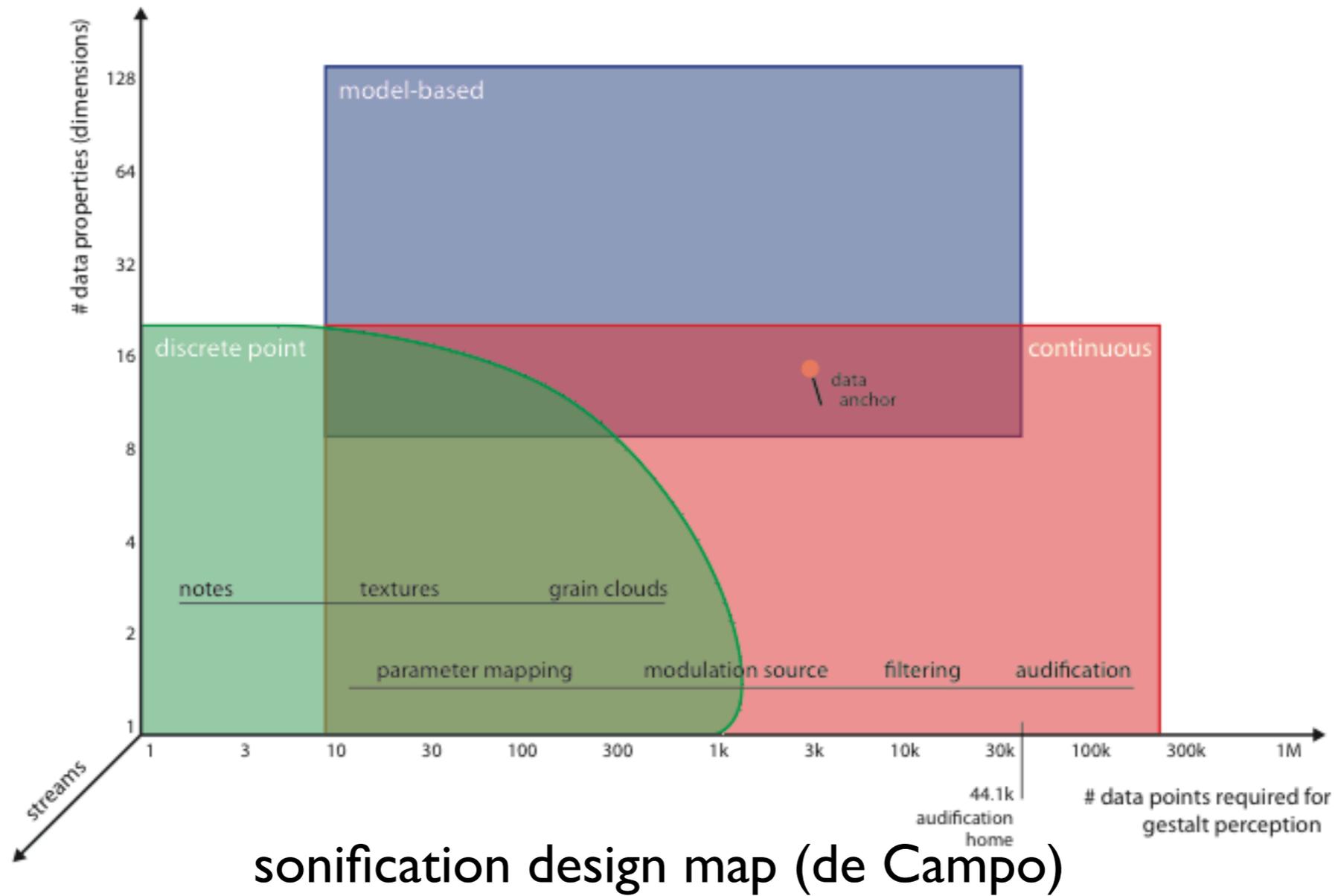
sonification design



$$\mathring{S} : \mathring{D} \rightarrow \mathring{Y}$$

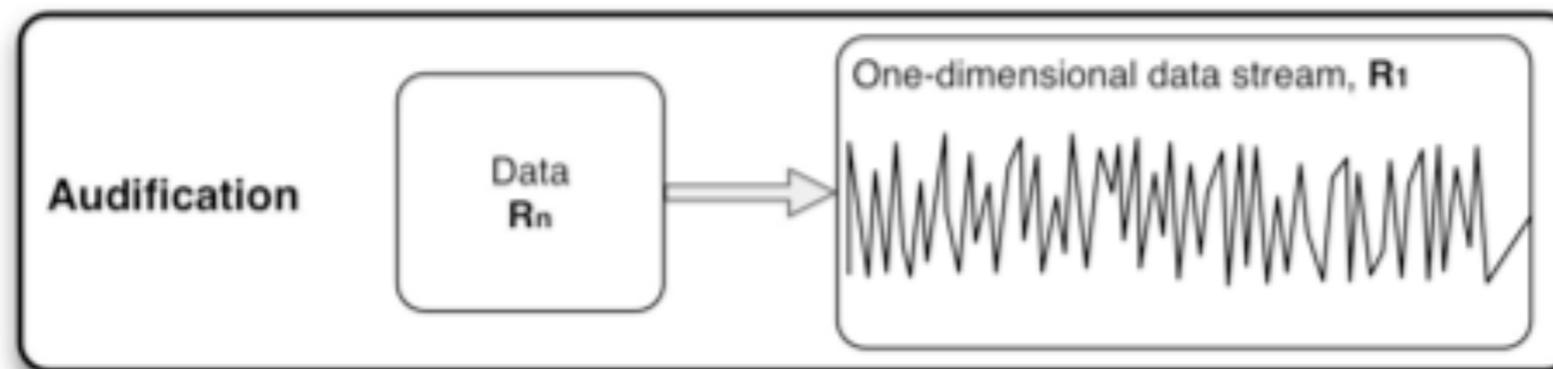
sonification operator is a function from the data space to the sound space

sonification techniques and approaches



sonification techniques and approaches

Audification is the most prototypical method of direct sonification, whereby waveforms of periodic data are directly translated into sound. [Kramer]



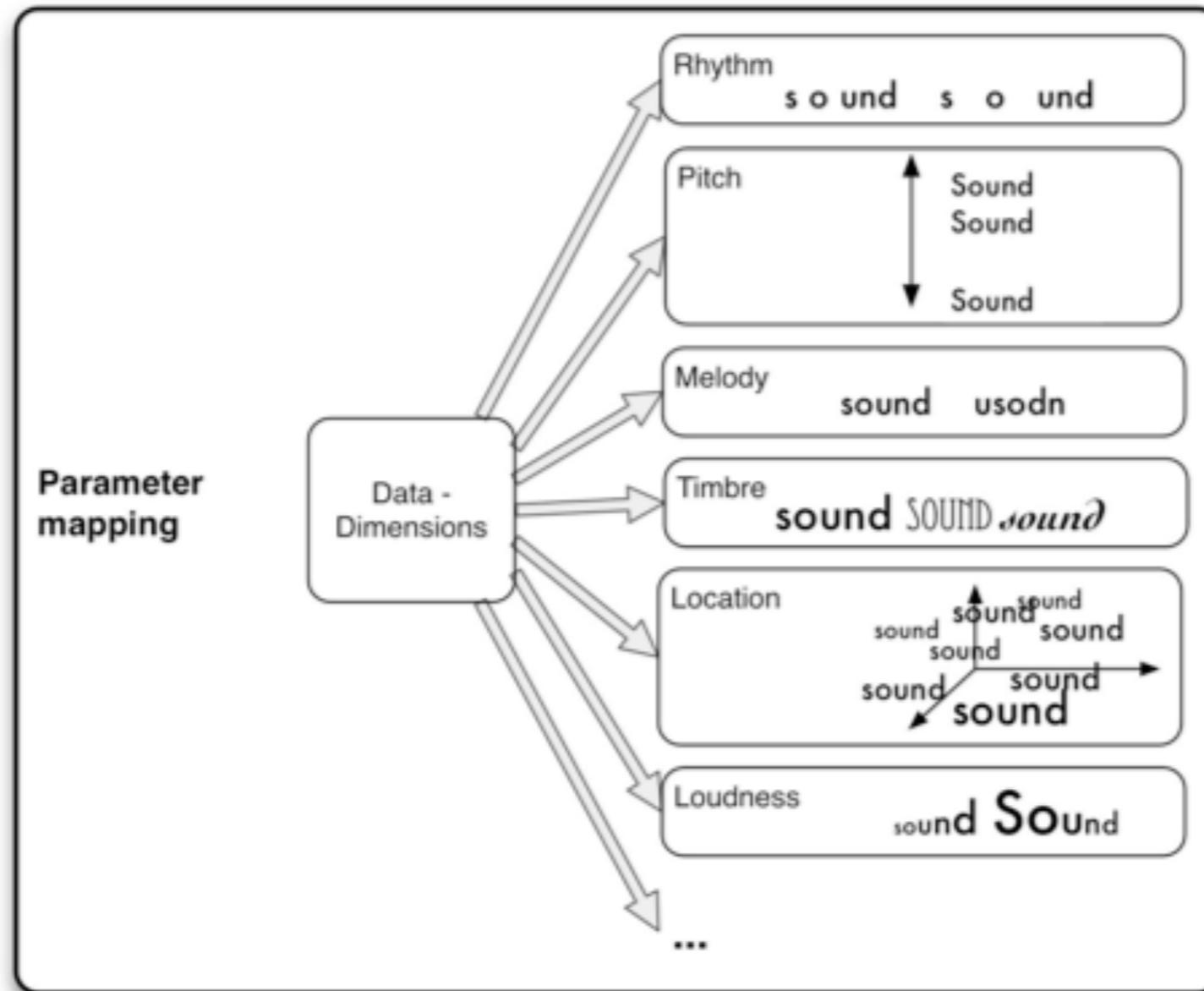
example: medicine

parkinson

essential

psychogenic

sonification techniques and approaches



example: sports, movement sonification

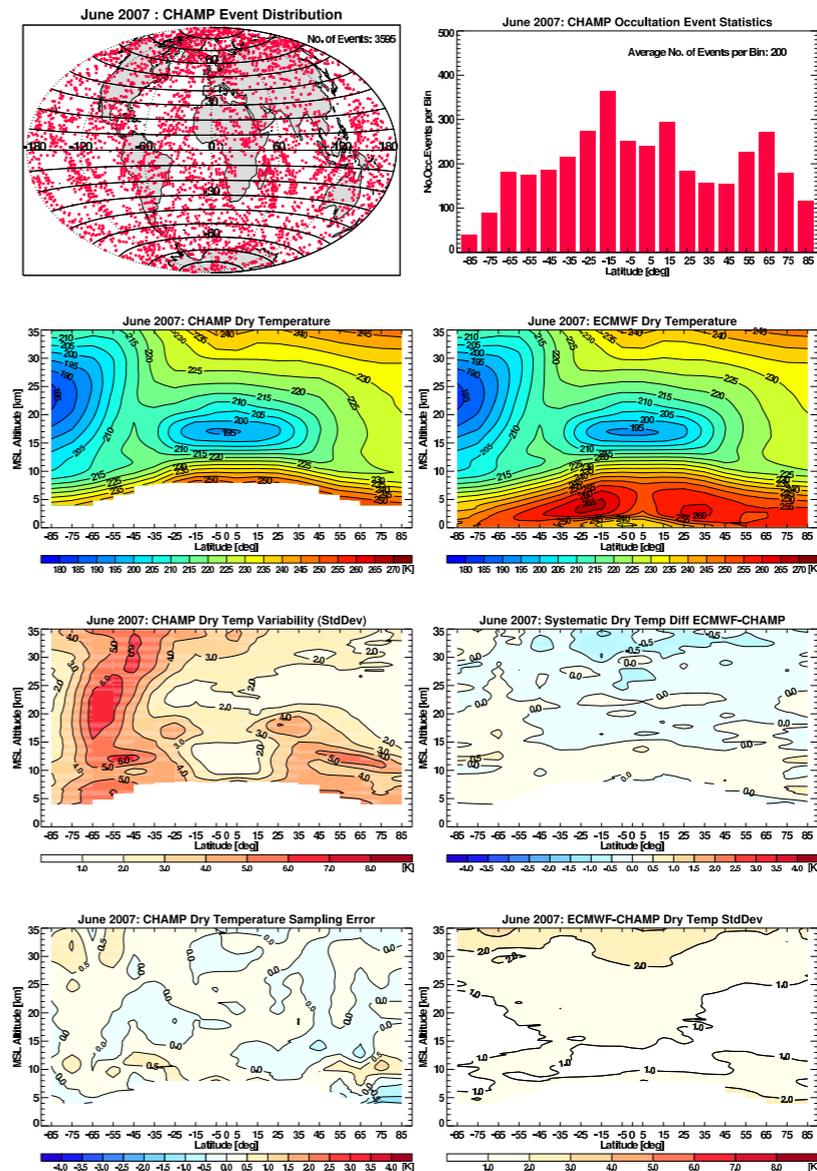


[http://tangibleauditoryinterfaces.de/
index.php/tai-applications/
jugglingsounds/](http://tangibleauditoryinterfaces.de/index.php/tai-applications/jugglingsounds/)

why sonification of climate science?

- huge amount of data
- multivariate data sets
- raise public awareness

June 2007: Dry Temperature



©Wegener Center 2008

research questions

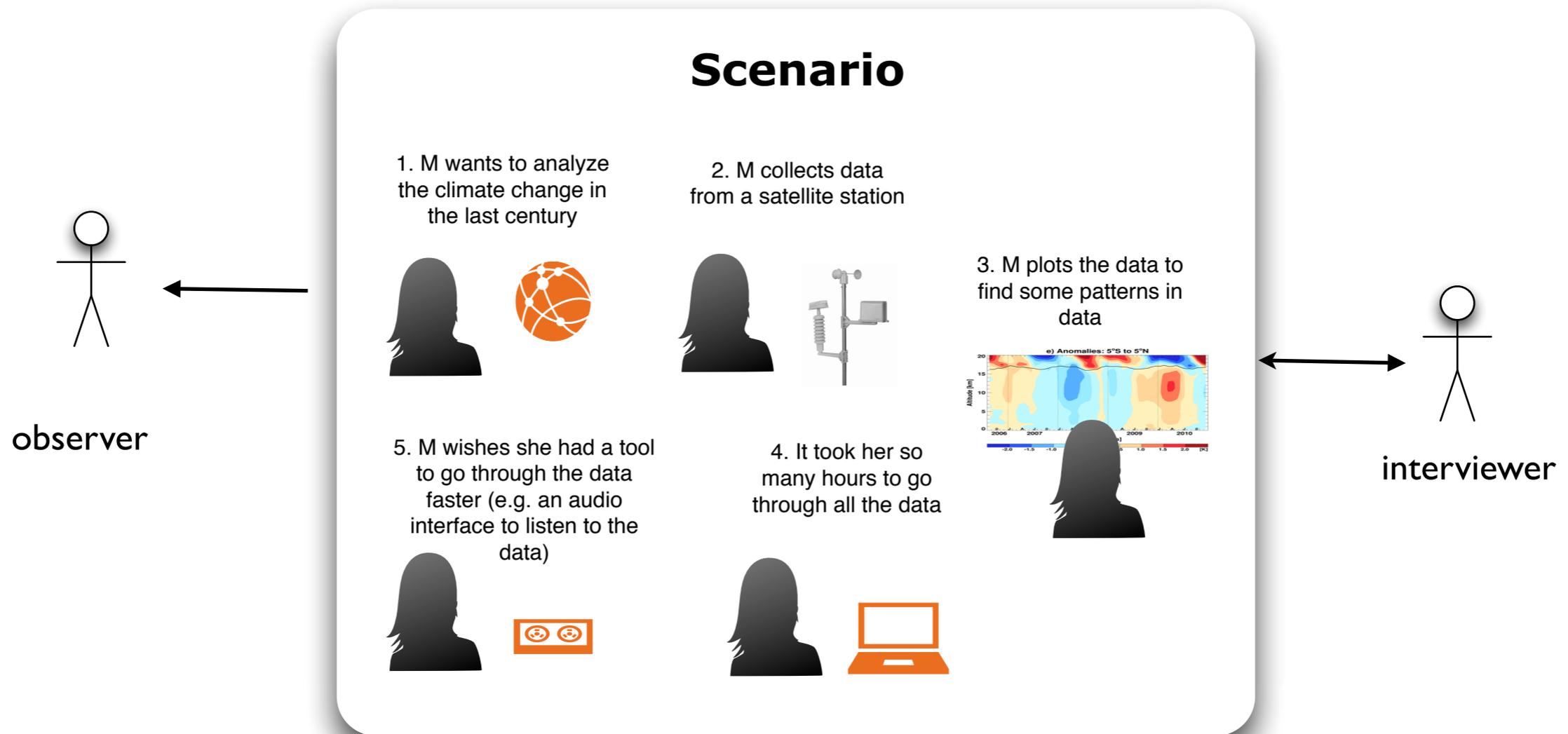
sonification of climate data

how do climate scientists
analyze data?

what are the main software
and visual tools they use?

how can an audio display be a
helpful addition to their
workflow?

methodology: contextual inquiry



methodology: focus groups

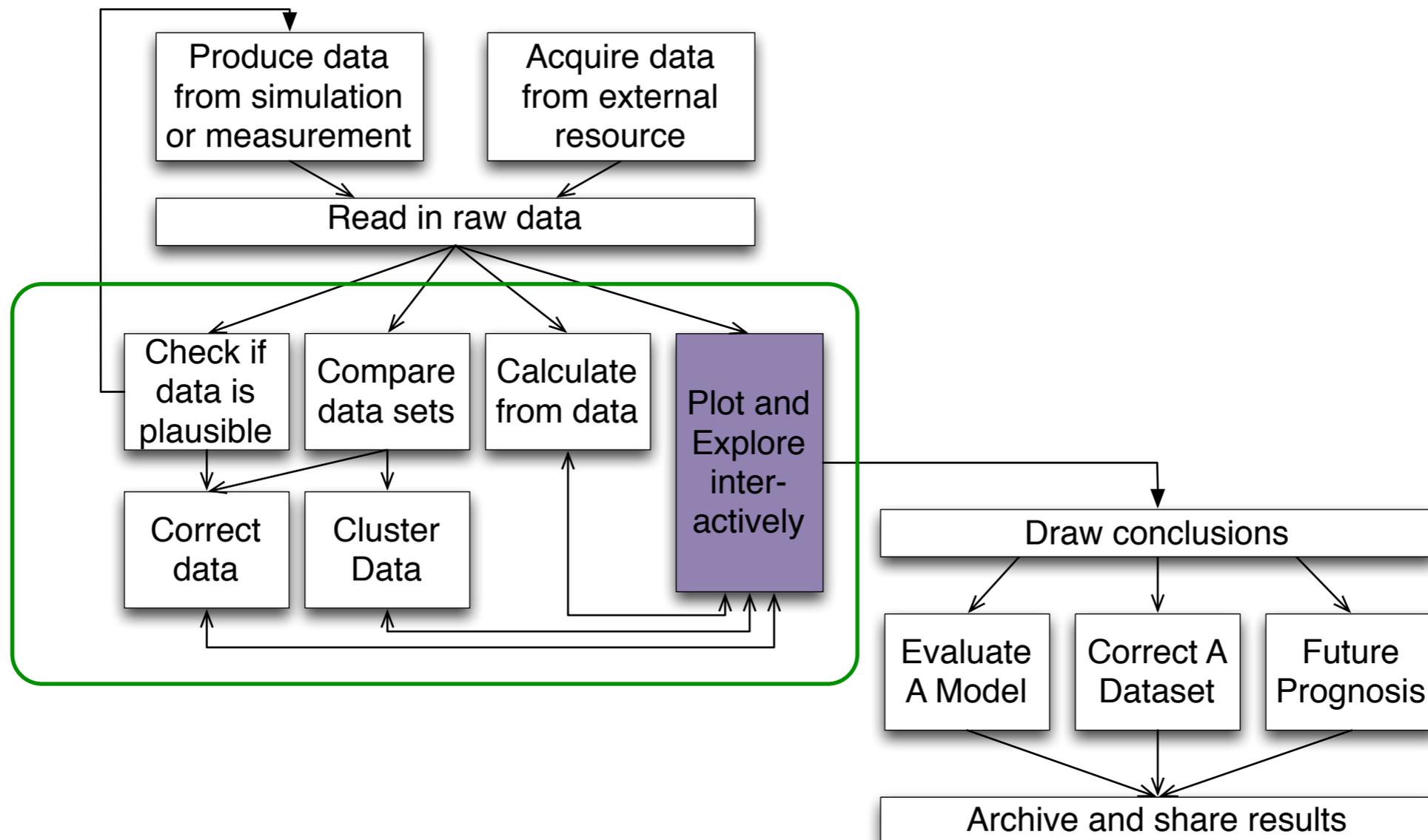
Research Group	
ArsCliSys	6
EconClim	5
ReLoClim	7
Gender	
F	8
M	10
Qualification	
MS Student	1
PhD Student	8
Post Doc	6
Professor	1
Staff	2
Years working in the field	
Average	6.3
Maximum	17
Minimum	0.5
Frequency of data analysis	
Once/day	57%
Once/Week	35%
Less often	7%
Field of studies	
Physics related	86%
Economics	14%

ArsCliSys - Atmospheric Remote Sensing and Climate System

ReLoClim - Regional and Local Climate Modeling and

EconClim - Economics of Climate and Environmental

a typical workflow of a data analysis task by the users



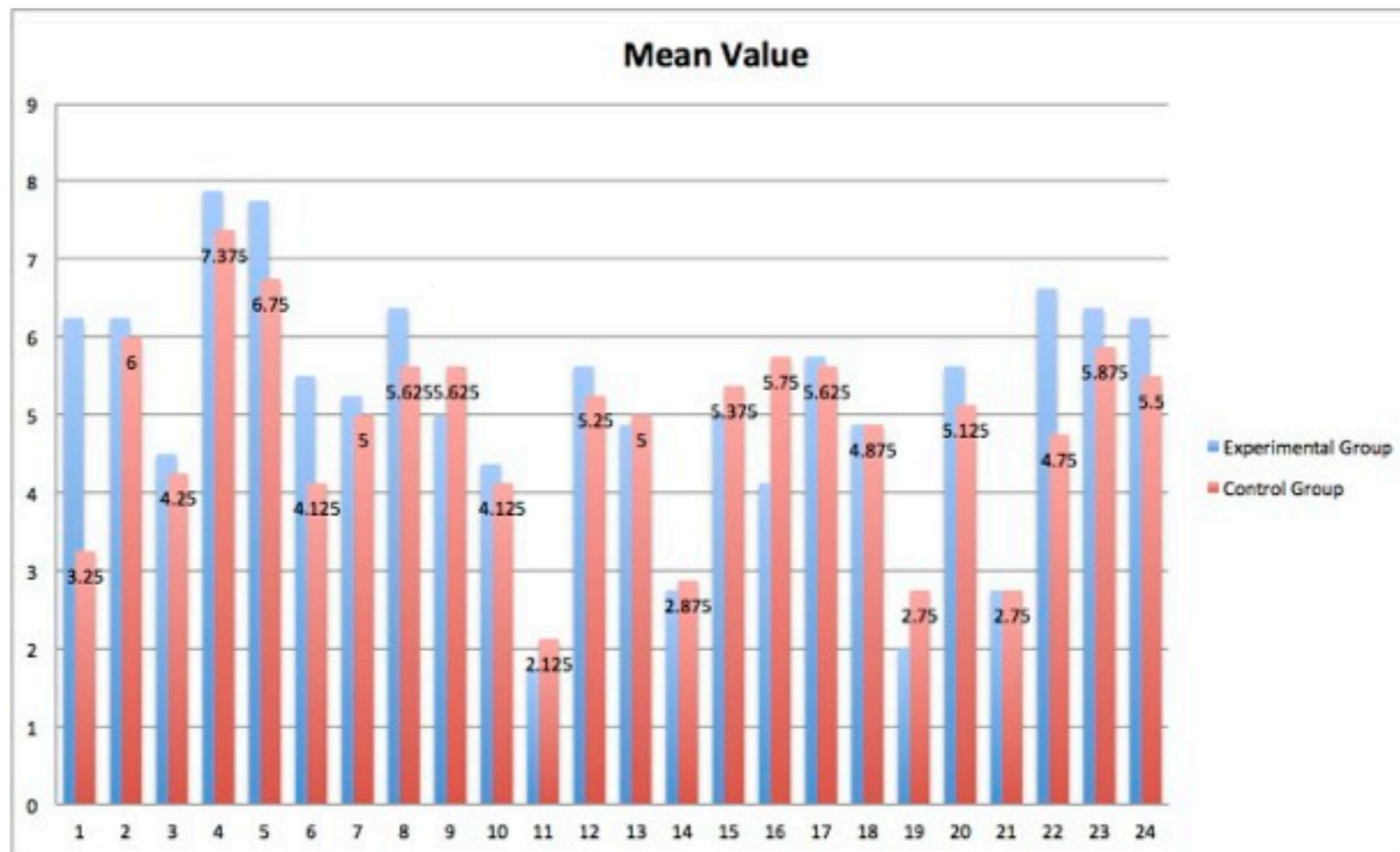
aesthetic preference and parameter mapping

experiment with:

- 8 climate parameter
- 24 sound samples 10 seconds each (3 for each climate parameter)
- 16 participants (8 EG, 8 CG)

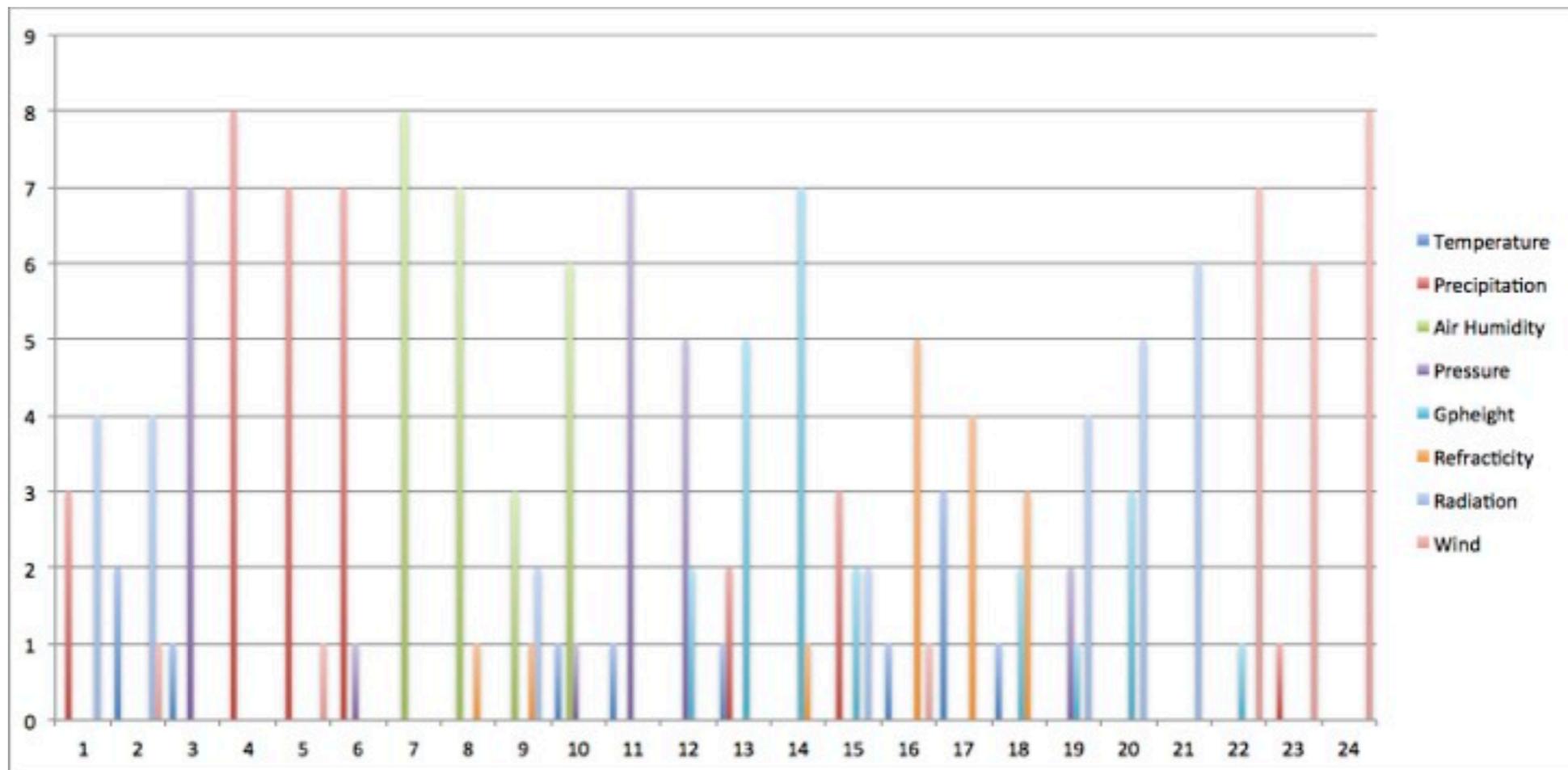
aesthetic preference and parameter mapping

I. aesthetic evaluation of sounds and why?



aesthetic preference and parameter mapping

2. mapping climate parameters to sound samples

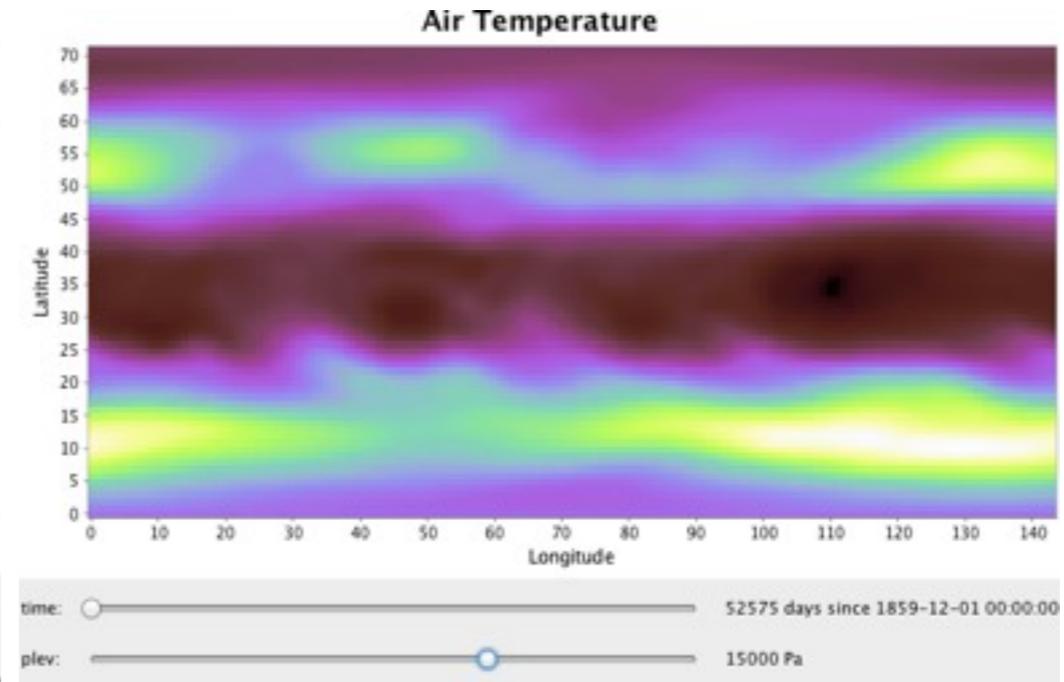
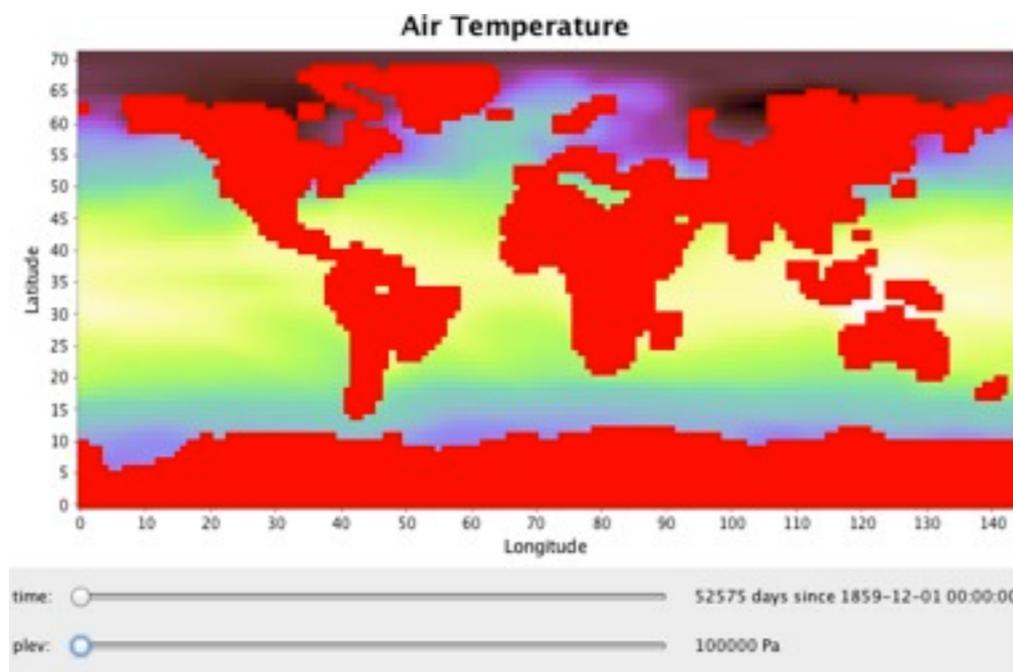


aesthetic preference and parameter mapping

Group	Hypothesis	Mostly Mapped by EG	Mostly Mapped by CG
1	Temperature	Precipitation	Radiation
2	Precipitation	Precipitation	Precipitation
3	Air Humidity	Refractivity	Air Humidity
4	Pressure	Pressure	Pressure
5	Geopotential Height	Precipitation	Precipitation
6	Refractivity	Refractivity	Refractivity
7	Radiation	Radiation	Radiation
8	Wind	Wind	Wind

Table 1. Mapping of Stimuli to Climate Parameters

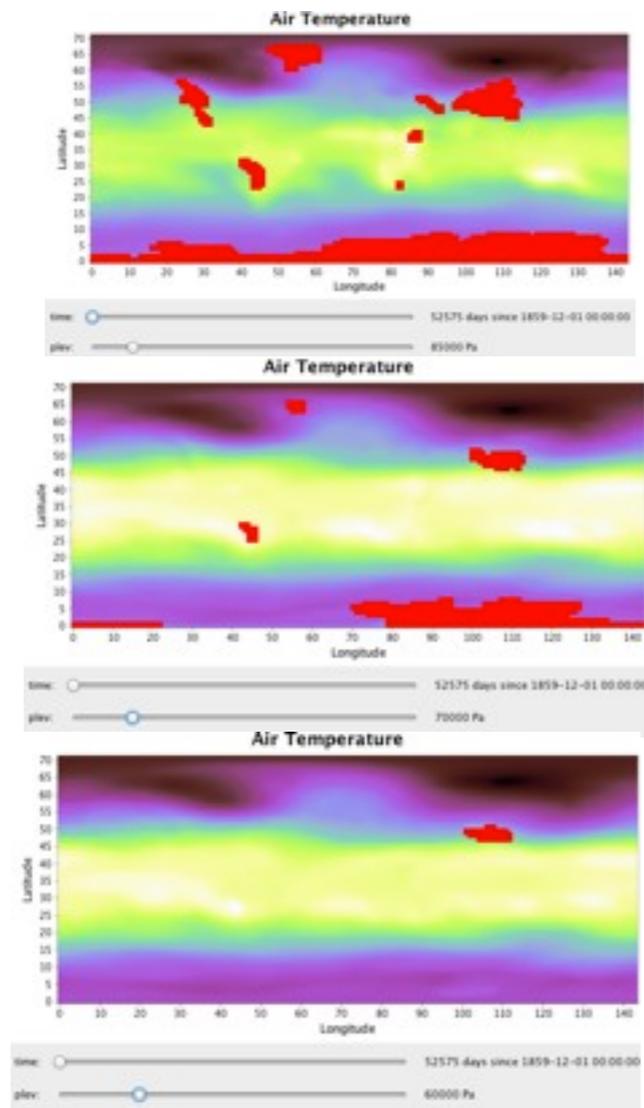
audio allows quick scanning of data



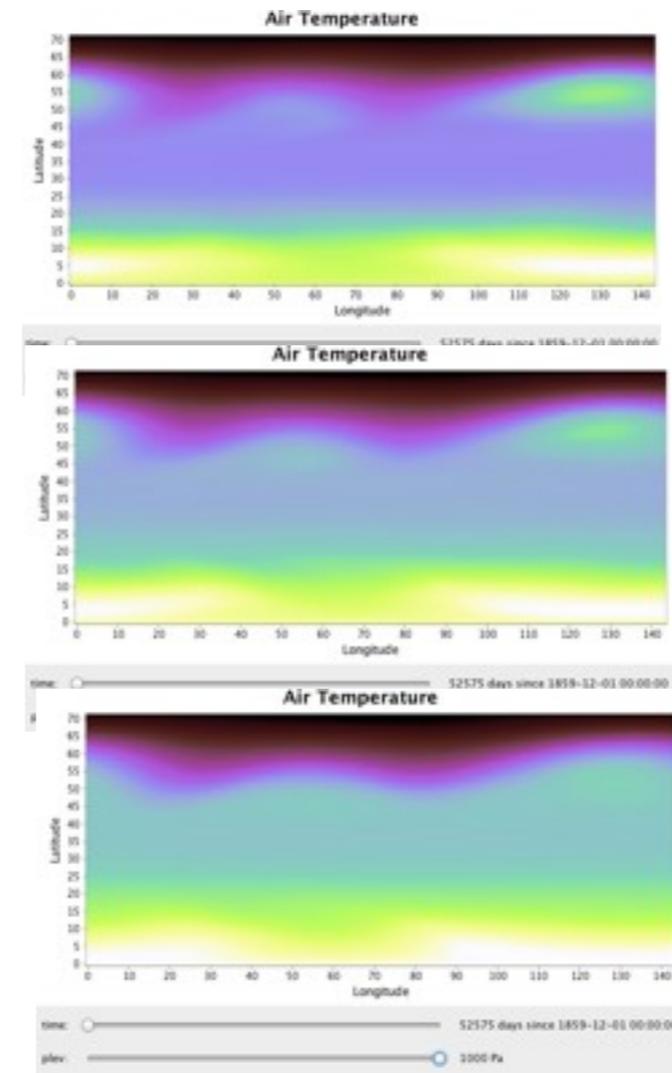
Air Temperature
Met Office Hadley Centre
CMIP5, experiment = RCP4.5

plevs = 100000, 15000 Pa

human hearing is used to resolve rhythmic patterns

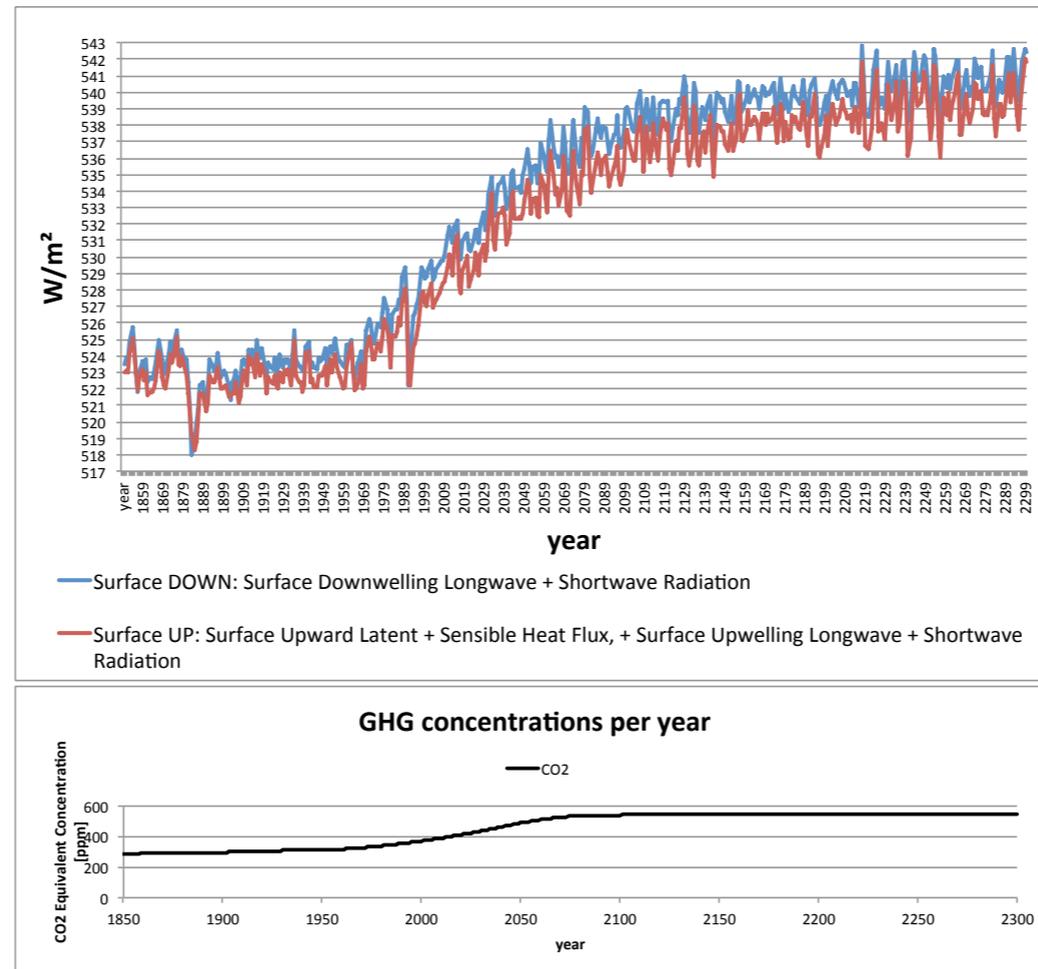


longitude = -28.75, -26.25, -23.75 degrees east
 latitudes = -13.75, -11.25, -8.75 degrees north
 plevs ("2bis4") = 85000, 70000, 60000 Pa
 time : 2005 ... 2100 (monthly mean)



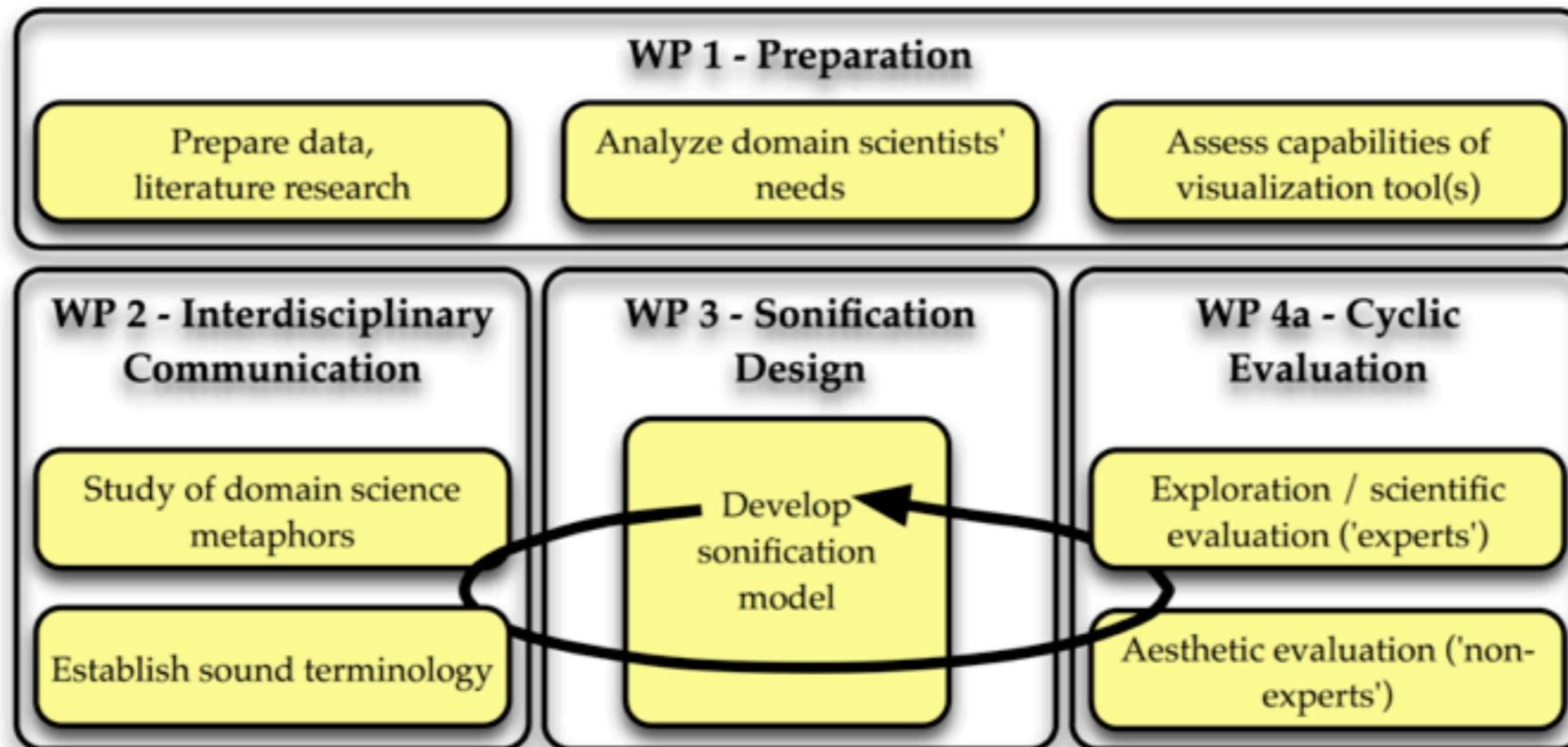
longitude = -28.75, -26.25, -23.75 degrees east
 latitudes = -13.75, -11.25, -8.75 degrees north
 plevs ("14bis16") = 3000, 2000, 1000 Pa
 time : 2005 ... 2100 (monthly mean)

audio display gives different insights



Radiation Balance, GHG concentrations, Solar activity
 1850- 2300 (historical run and prediction), Amon:
 Atmospheric monthly means
 Max Planck Institute
 CMIP5, experiment = RCP4.5

milestones and future work



software for sonification

special software for sonification

- xSonify (NASA, java-based, only special data formats readable)
- Sonification Sandbox (cross-platform, parameter mapping, midi output, data format: CSV)
- Sonifyer (standalone for osx, audifocation and fm based parameter mapping)
- Image Sonification (osx, black and white images as input data)
- PD-toolkit for sonification
- SoniPy (python, open source)

software for sonification

music and sound programming languages

- Offline synthesis: Csound
- Graphical patching: MAX/MSP, PureData
- Real-time text-based environments: SuperCollider, Chuck

references

The Sonification Handbook. Edited by Thomas Hermann, Andy Hunt, John G. Neuhoff Logos Publishing House, Berlin 2011, 586 pages, 1. edition (11/2011). ISBN 978-3-8325-2819-5

ONLINE!: <http://sonification.de/handbook/>

International Conference on Auditory Display – Papers: <http://icad.org/biblio>

Kramer, Gregory, ed. (1994). Auditory Display: Sonification, Audification, and Auditory Interfaces. Santa Fe Institute Studies in the Sciences of Complexity. Proceedings Volume XVIII. Reading, MA: Addison-Wesley. ISBN 0-201-62603-9.

Das geschulte Ohr . Eine Kulturgeschichte der Sonifikation Hrsg. v. Andi Schoon u. Axel Volmar. Verlag transcript. 2012. ISBN 978-3-8376-2049-8

[TADA] Barrass, St., Auditory Information Design, PhD thesis, The Australian National University, 1997.

[SDSM] De Campo, A., Science by Ear. An interdisciplinary Approach to Sonifying Scientific Data. Dissertation. Institute of Electronic Music and Acoustics, University of Music and Dramatic Arts, Graz, 2009.

[Sonification Operator] Vogt, K., Höldrich, R., Translating Sonifications, J. Audio Eng. Soc., Vol. 60, No. 11, pp. 926-935, November 2012.



THANK YOU!

