Interactive Visualization as a Visual Dialog for Data Investigation

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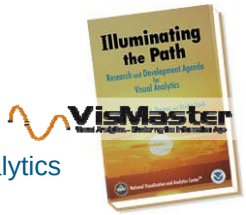
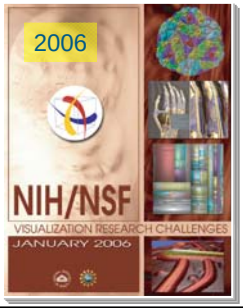
Visualization?

- Many different conceptions around...
- Here: **Data Visualization**
  - data from
    - measurements, e.g., medical imaging
    - computational simulation, e.g., industrial simulation
    - scientific modeling, e.g., dynamical systems
  - visualization for
    - exploration – detecting the unknown
    - analysis – confirming/rejecting hypotheses
    - presentation – dissemination
- Examples:
  - visualization for disseminating climate scenarios
  - medical visualization for intervention planning

Visualization History in Short

- The int'l scientific field of visualization: ~20ys. old
- Lot's of progress:
  - volume rendering
  - flow visualization
  - information visualization
  - etc.
- Milestones
  - IEEE VisWeek
  - EuroVis (2011: Bergen!)
  - etc.
- New challenges, e.g., visual analytics

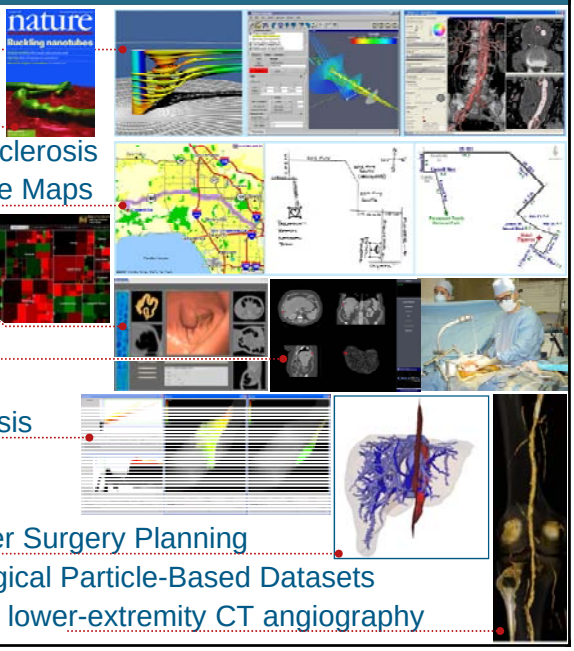




Visualization Success Stories

[according to Chris Johnson from SCI.Utah]

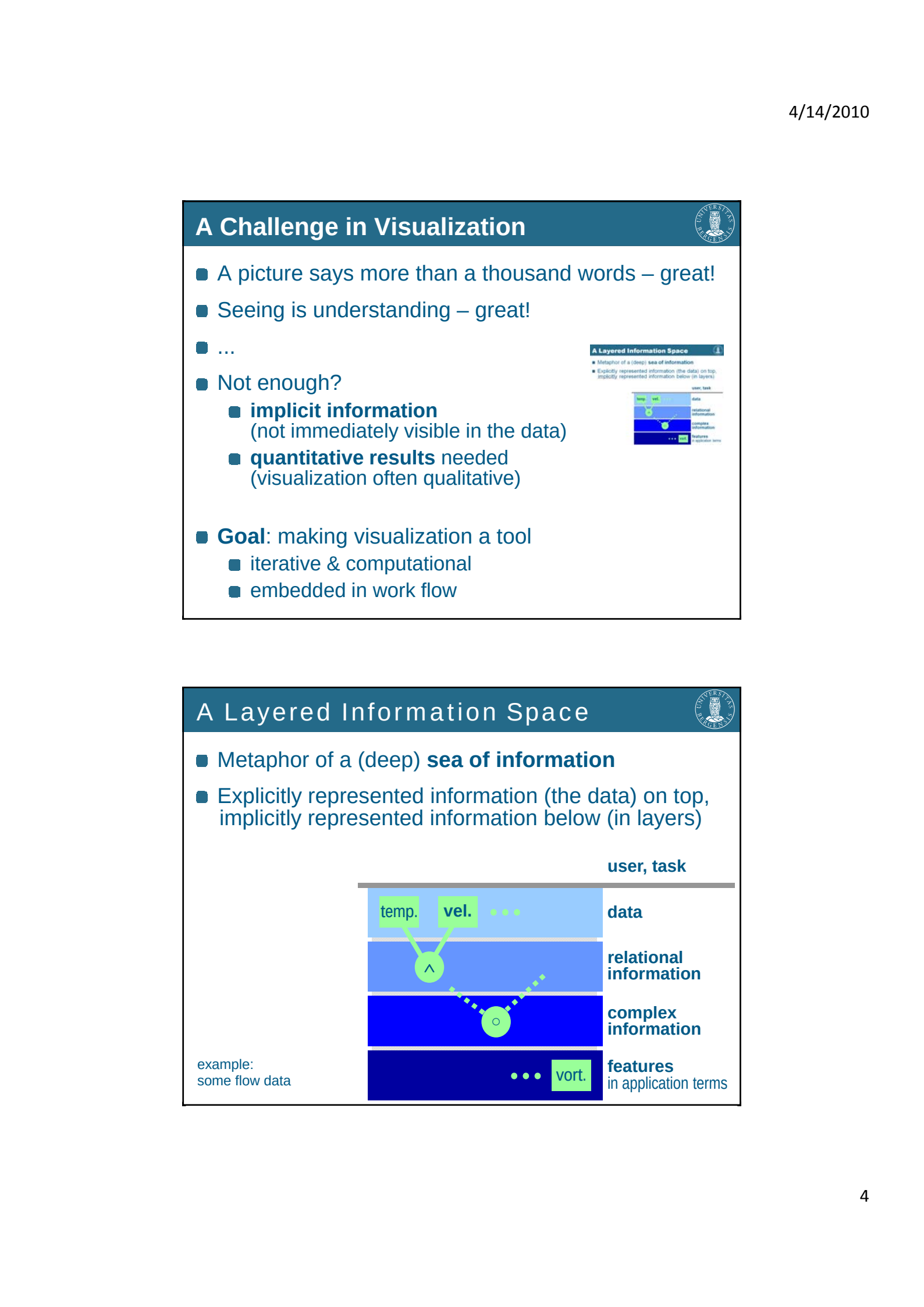
- The Visualization Toolkit
- Virus Structure
- Nanoscale Science
- Understanding Multiple Sclerosis
- Rendering Effective Route Maps
- Mapping the Market
- Virtual Colonoscopy
- Resource Allocation
- Image Guided Surgery
- Whale Tracks
- Visual Engineering Analysis
- Health Demographics
- Annotating Reality
- Visual Computing for Liver Surgery Planning
- Visualization of Cosmological Particle-Based Datasets
- AngioVis: Visualization of lower-extremity CT angiography



So how's visualization doing then?

- **Very well**!
  - it's a **booming research field**
    (more researchers, more publications, more funding, …)
  - it's paralleling the **increasingly visual world**
    ("everything" is getting graphical these days)
  - it's also **selling**
    (SpotFire, Tableau, MeVisLab, Amira, vtk, …)
- **Limitations**:
  - usually costly (esp. in terms of time, etc.)
  - often for experts only – and there aren't too many!
  - often somehow a "dead end street" – "just" showing the data

A Challenge in Visualization



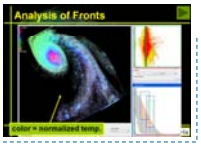
- A picture says more than a thousand words – great!
- Seeing is understanding – great!
- ...
- Not enough?
  - **implicit information**
    (not immediately visible in the data)
  - **quantitative results** needed
    (visualization often qualitative)
- **Goal**: making visualization a tool
  - iterative & computational
  - embedded in work flow

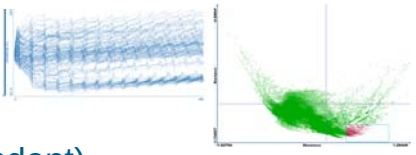
A Layered Information Space

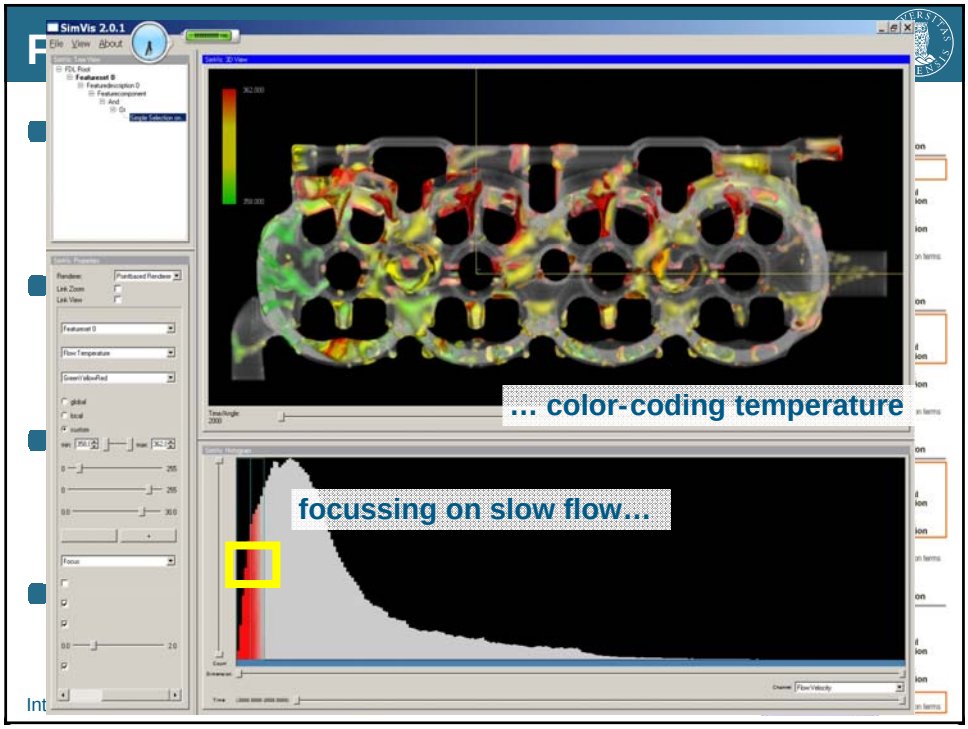
- Metaphor of a (deep) **sea of information**
- Explicitly represented information (the data) on top, implicitly represented information below (in layers)

Iterative Visual Analysis

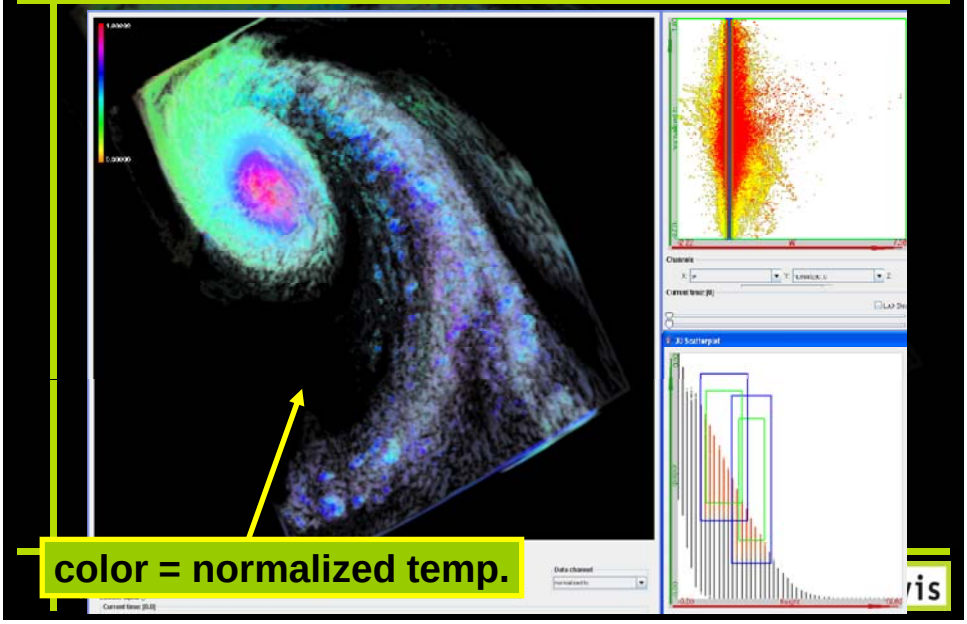
- **Interactive Visual Information Drill-Down** at levels of varying complexity:
  - show & brush
  - relational analysis
    - feature definition in DNF (disjunctive normal form)
  - complex analysis
    - attribute derivation *(today's focus)*
      - attribute transformations, e.g., normalization
      - derivatives, differences
      - local statistics
      - ...
    - advanced brushing
  - feature-based (appl.-dependent) analysis







Analysis of Fronts



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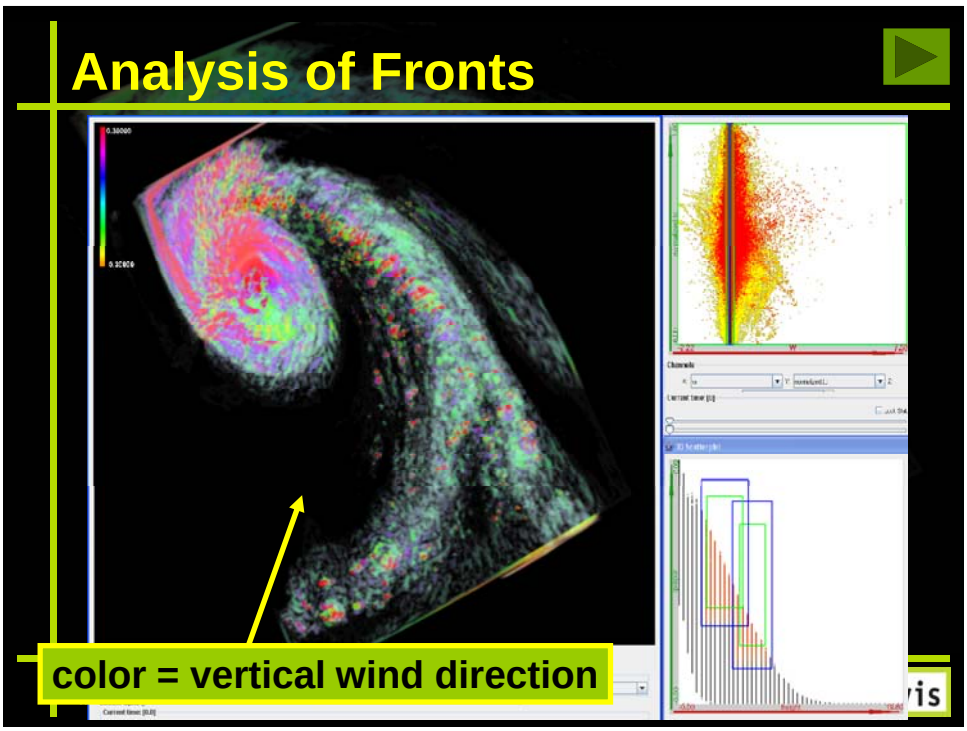
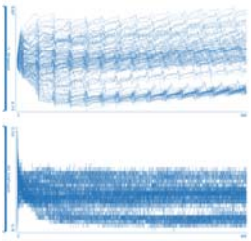


Analysis of a Climate Simulation Dataset

- Data: aggregated from large-scale climate simulation (simulation of CLIMBER model, by PIK.de)
  - >30 time series, e.g., Greenland temperature, ...
  - over 500 years each
  - for 10×10 simulation runs
- Challenges:
  - data characteristics (nature of the data/simulation)
    - mix of frequencies along time series
    - discrete values series
  - advanced analysis questions
    - which serties remain stable over time?
    - outliers?



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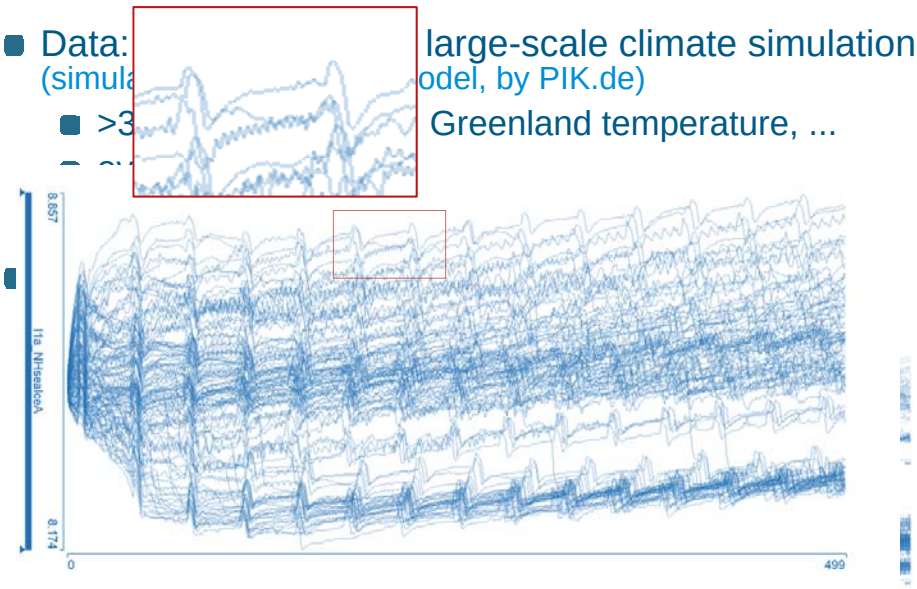
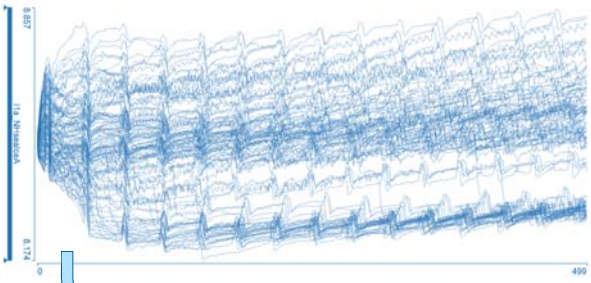


Northern hemi-sphere ice area, mix of different periods

Sample Analysis of Sea Ice Changes

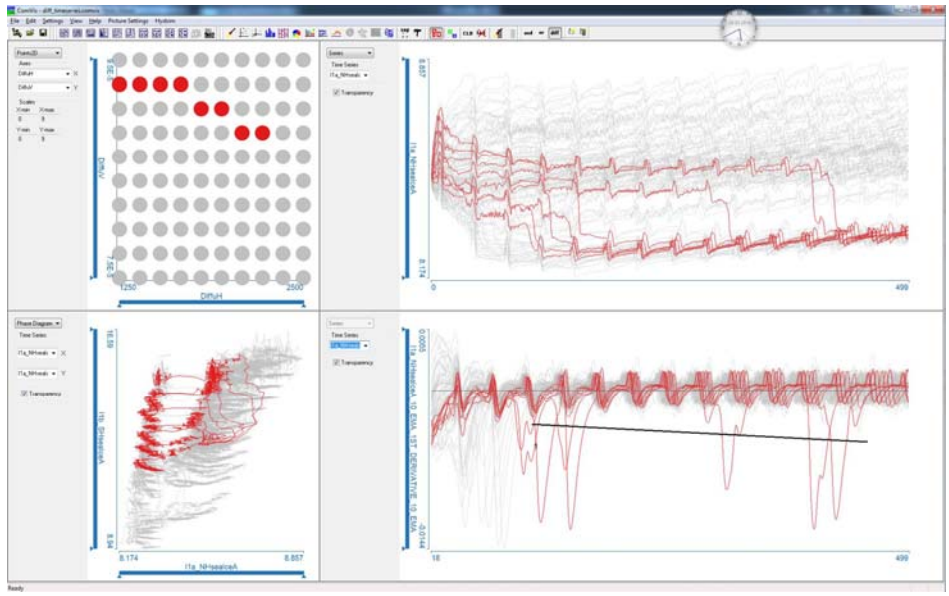
- Starting from the multi-frequency times series



Q: any large-scale changes?

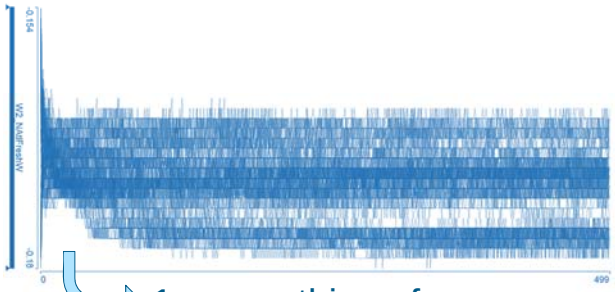
1. smoothing of curves
2. 1st order derivation
3. smoothing of derivatives

Sample Analysis of Sea Ice Changes



Sample Analysis N-Atlantic Fresh Water

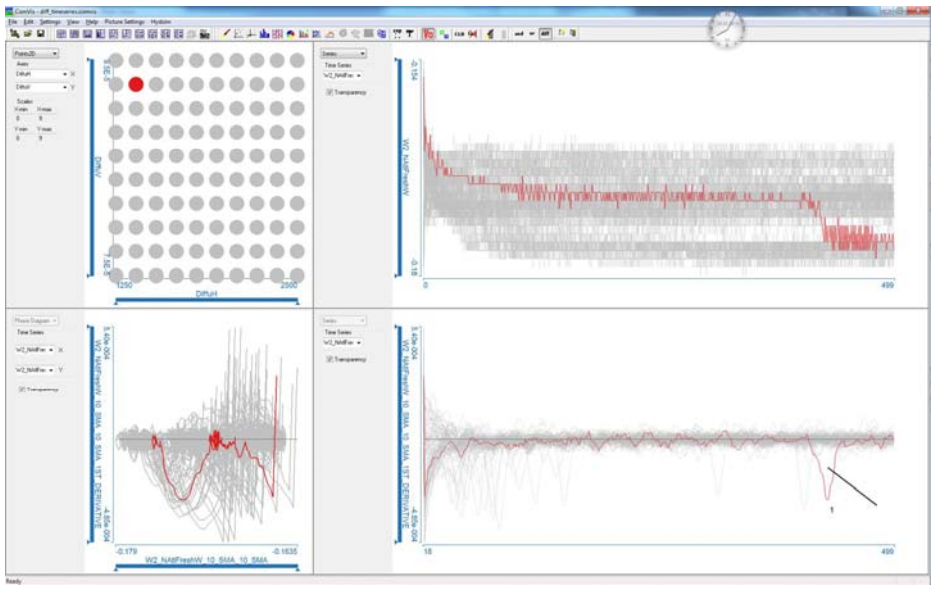
- Starting from the discrete value series



Q: any atypical curves?

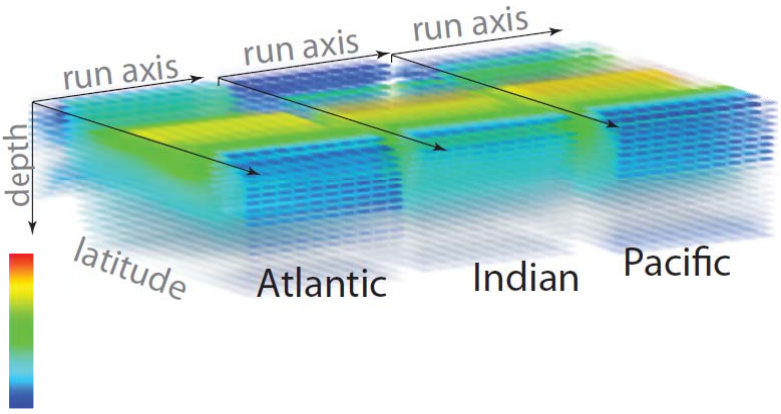
1. smoothing of curves
2. another smoothing iteration
3. 1st order derivation

Sample Analysis N-Atlantic Fresh Water



Making Visualization Quantitative

- Measuring in visualization
  - what can we see? (⇒ perceptual psychology)
  - important: show scales, legends, values!
  - interpolation or discretization?



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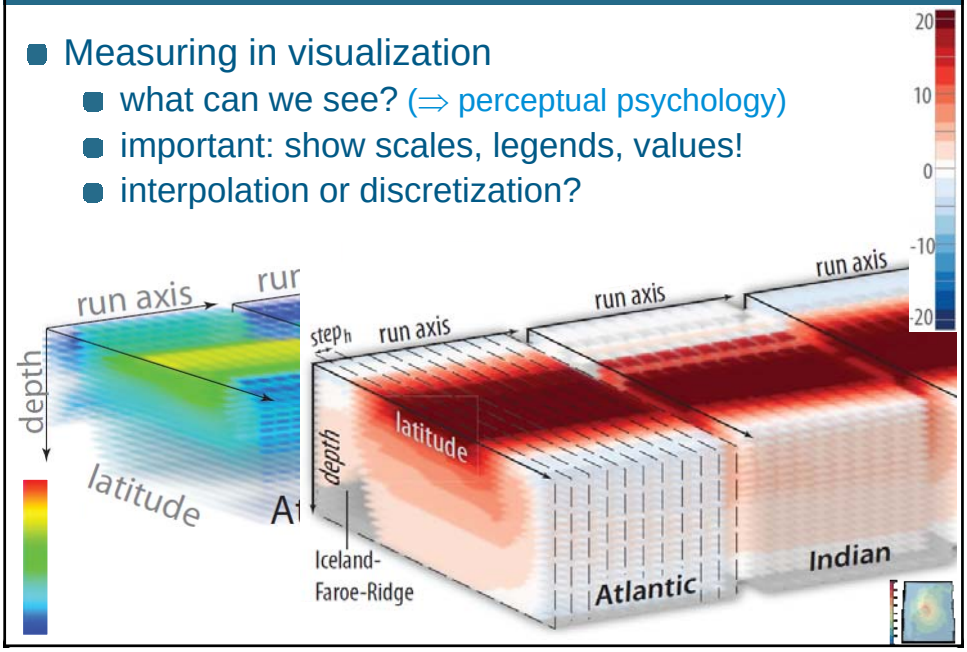
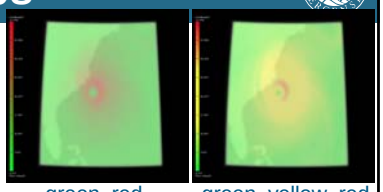
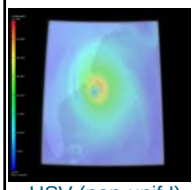


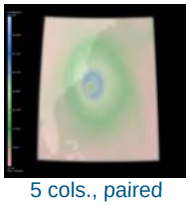
A Large Space of Color Maps

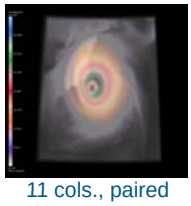
- Continuous vs. discrete maps
- Diverging vs. sequential maps
- Continuous vs. paired maps

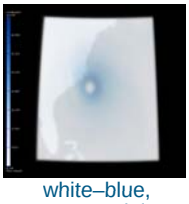

green–red, diverging

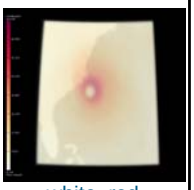
green–yellow–red

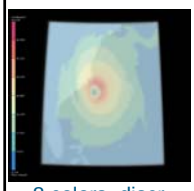

HSV (non-unif.!)

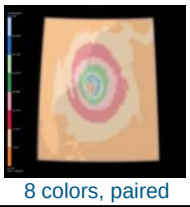

5 cols., paired

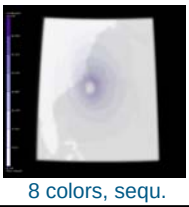

11 cols., paired


white–blue, sequential


white–red, sequential


8 colors, discr.


8 colors, paired


8 colors, sequ.

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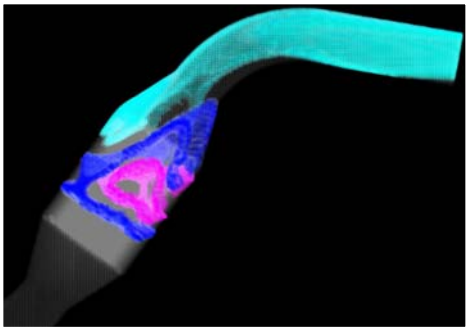
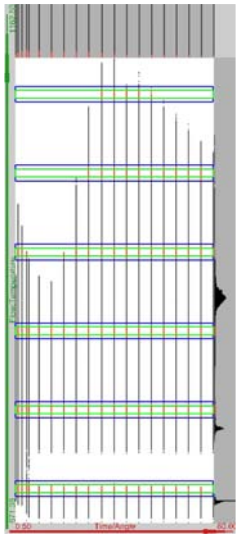
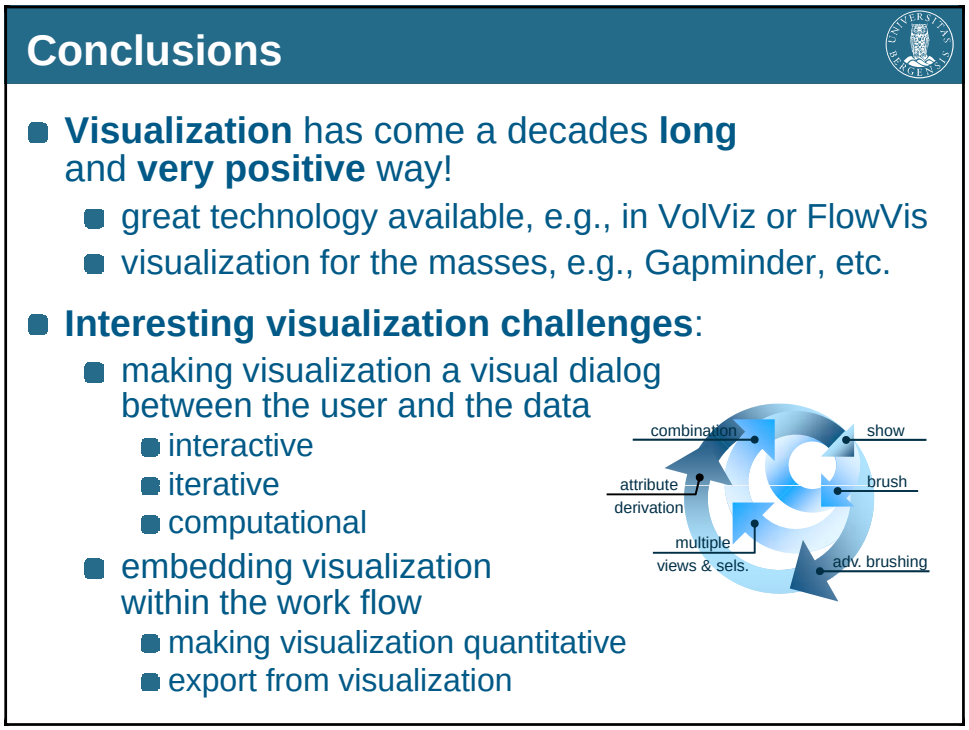
  - important: show scales, legends, value
  - interpolation or discretization?
  - transformation into quantitative scales plus value-accurate interaction



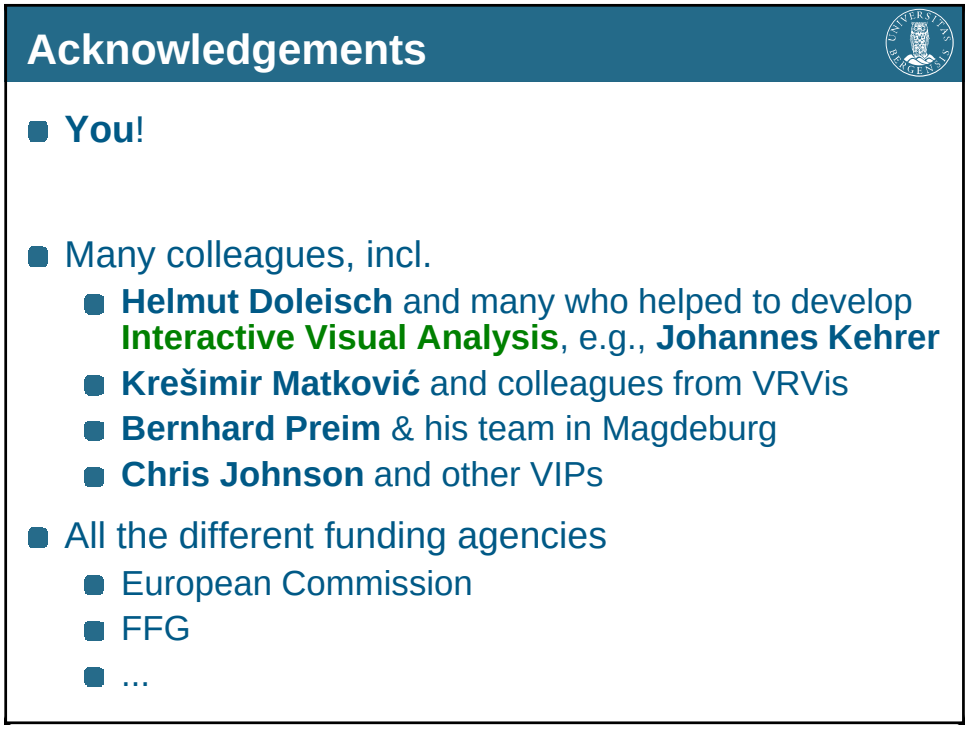


Conclusions



- **Visualization** has come a decades **long** and **very positive** way!
  - great technology available, e.g., in VolViz or FlowVis
  - visualization for the masses, e.g., Gapminder, etc.
- **Interesting visualization challenges**:
  - making visualization a visual dialog between the user and the data
    - interactive
    - iterative
    - computational
  - embedding visualization within the work flow
    - making visualization quantitative
    - export from visualization

Acknowledgements



- **You**!
- Many colleagues, incl.
  - **Helmut Doleisch** and many who helped to develop **Interactive Visual Analysis**, e.g., **Johannes Kehrer**
  - **Krešimir Matković** and colleagues from VRVis
  - **Bernhard Preim** & his team in Magdeburg
  - **Chris Johnson** and other VIPs
- All the different funding agencies
  - European Commission
  - FFG
  - ...