Interactive Visual Analysis of Heterogeneous Scientific Data across an Interface

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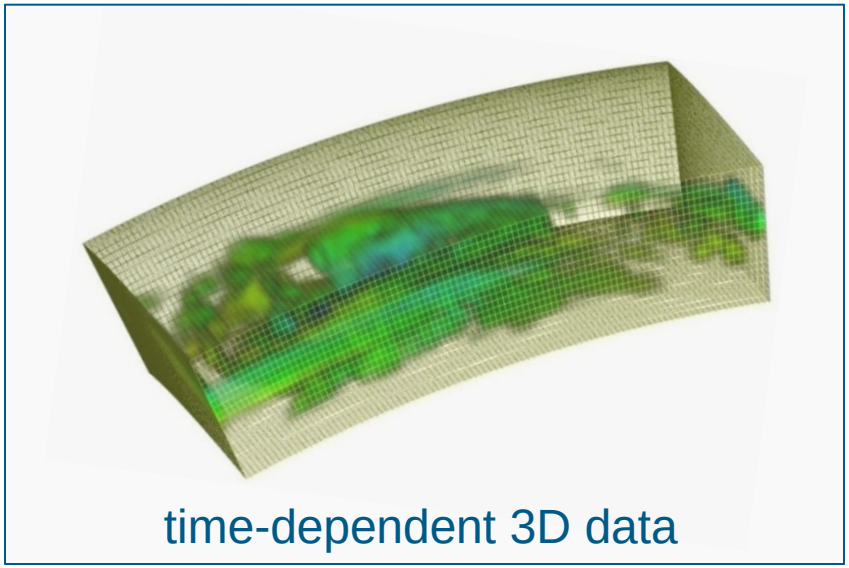
Heterogeneous Scientific Data

Single-part scenarios

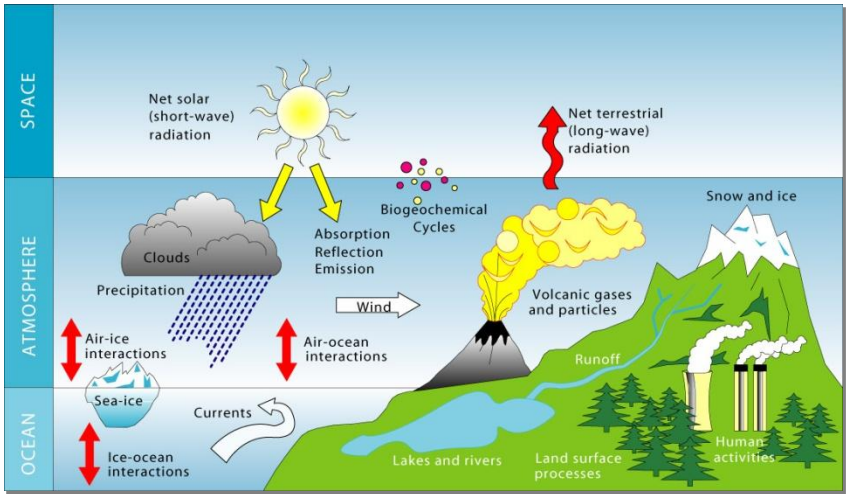
→ given in a coherent form
(spatio-temporal / multi-variate)



time-dependent 3D data

Multi-part scenarios

- 2 or more related data parts
- different simulation models
- different data sources
- various data grids
- different dimensionality
(2D/3D data)

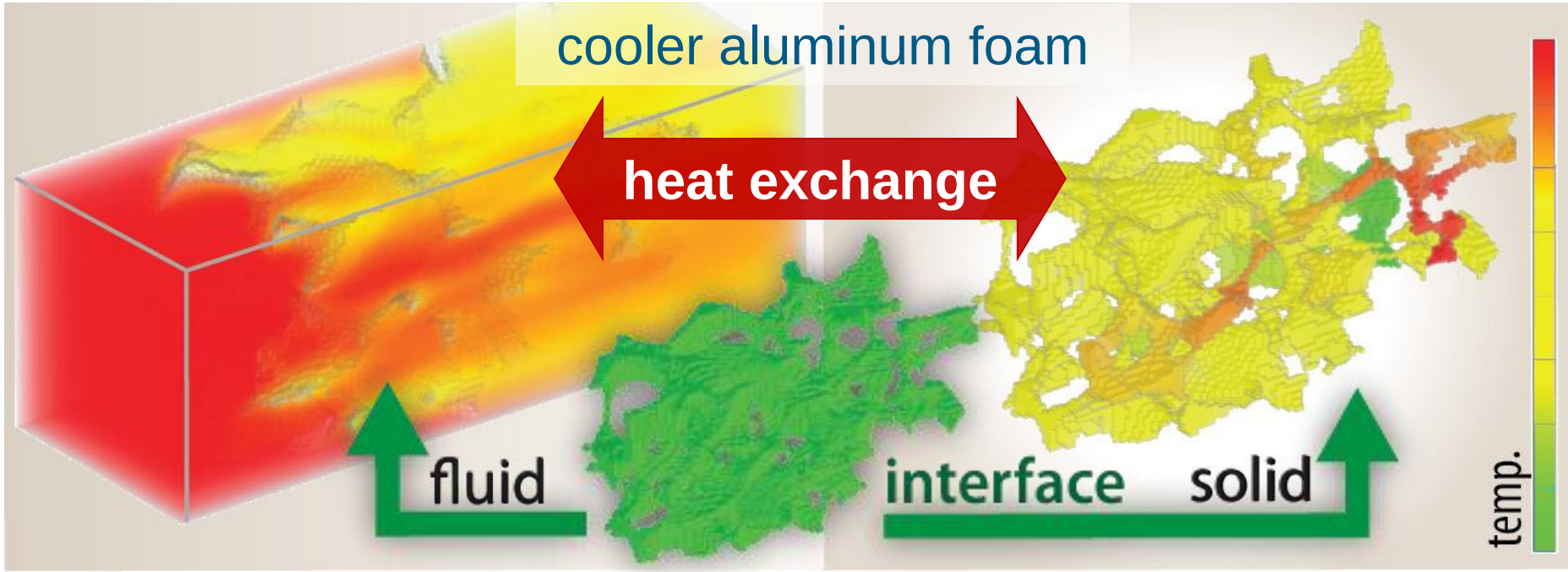


coupled climate model

Multi-physics Simulations

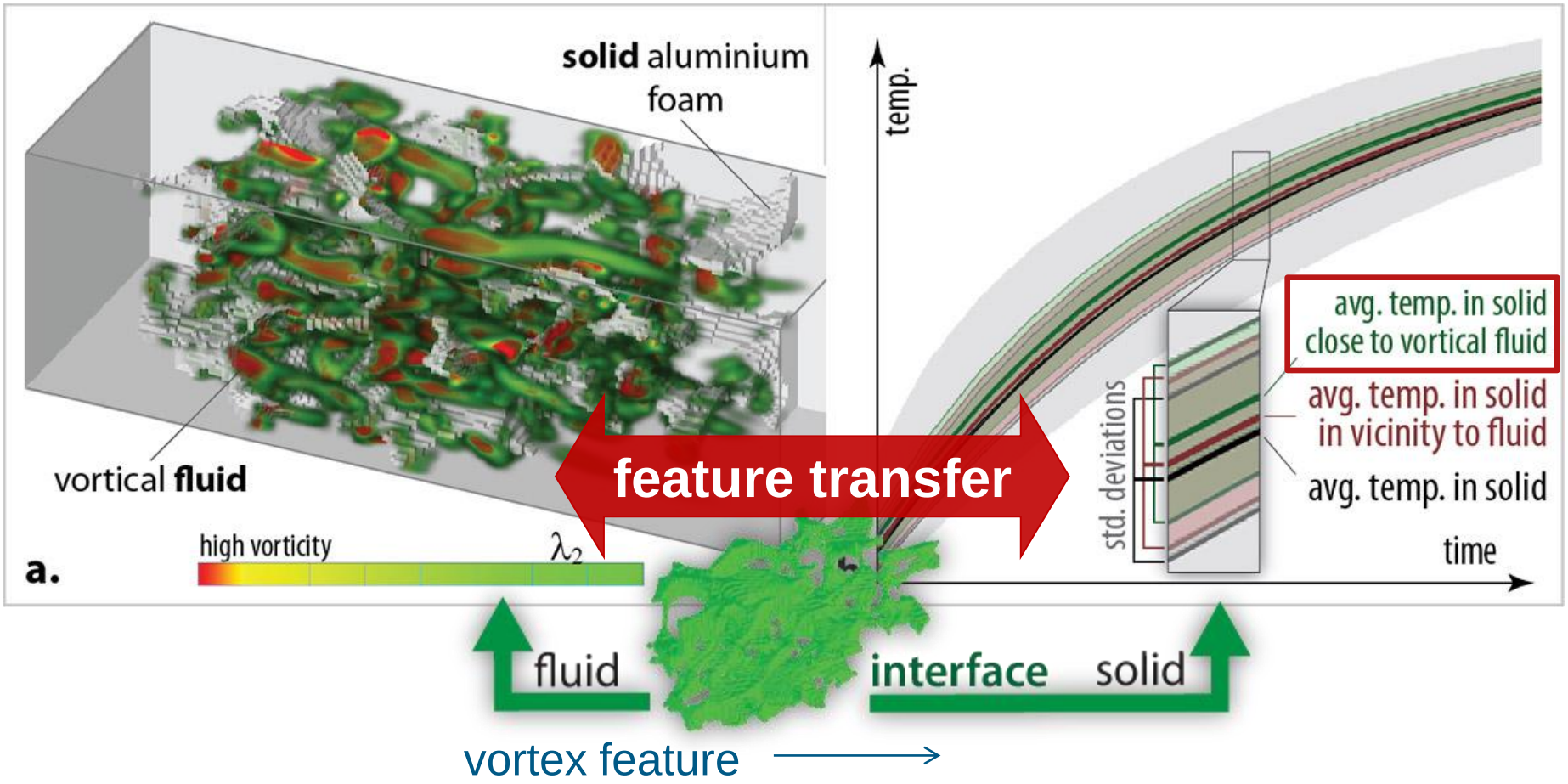
Example: fluid-structure interactions (FSIs)

- movable or deformable structure ⇔ fluid
- flexible roofs, bridges, blood flow in arteries, etc.
  [Bungartz & Schäfer 2006]



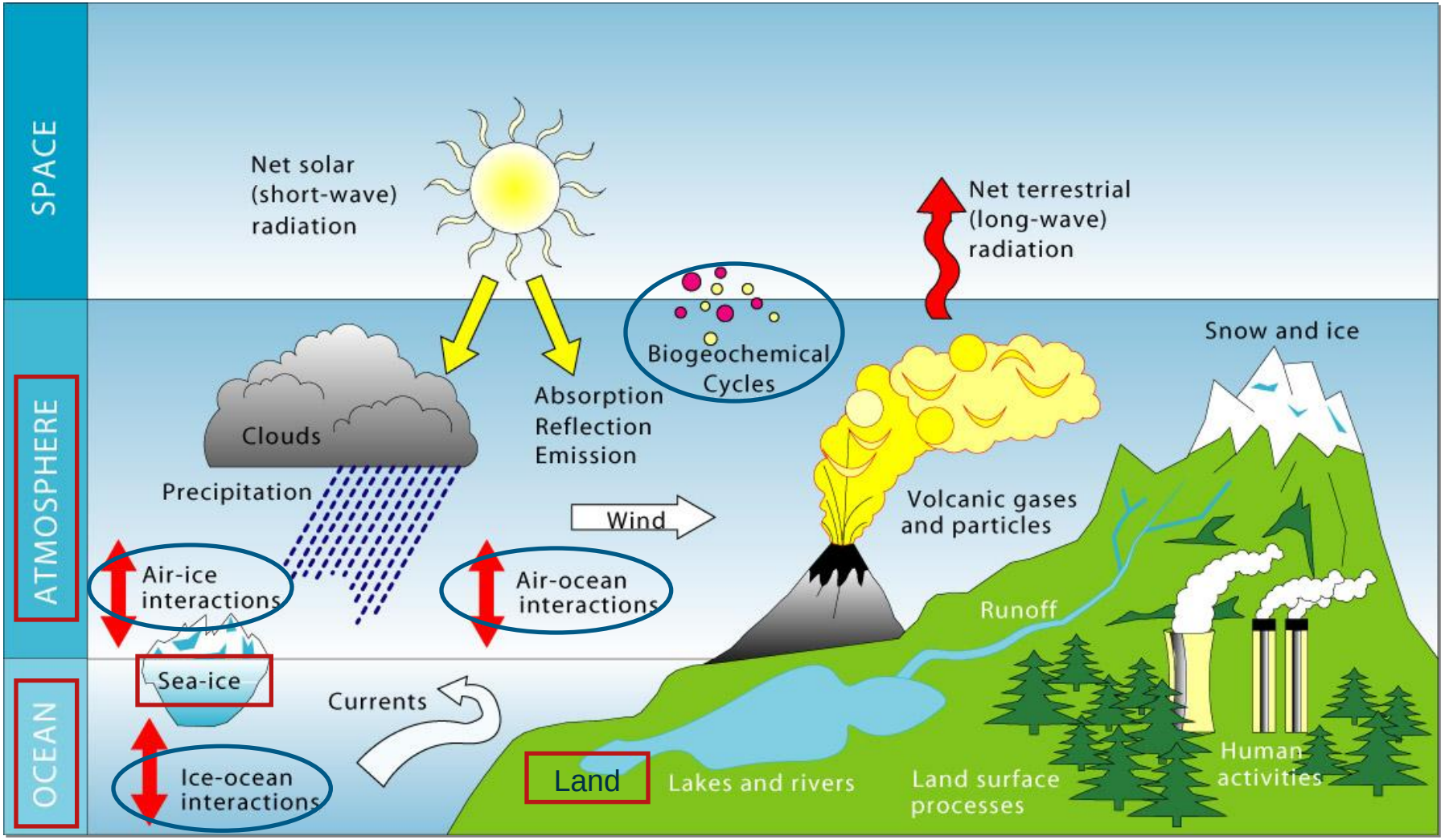
Sample Analysis of Heat Transfer

How is the heating (solid) influenced by surrounding vortical flow?



Multi-part Scenarios (cont.)

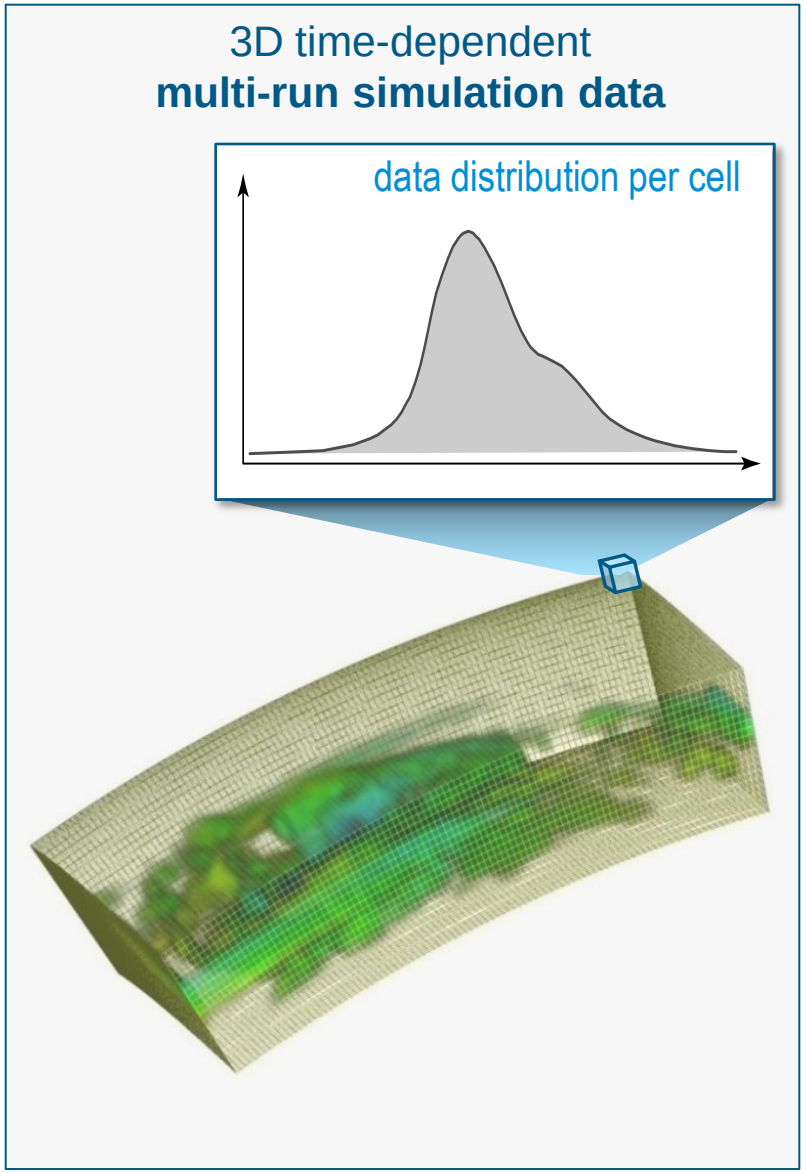
Coupled climate models



[Böttinger, ClimaVis08]

Multi-part Scenarios (cont.)

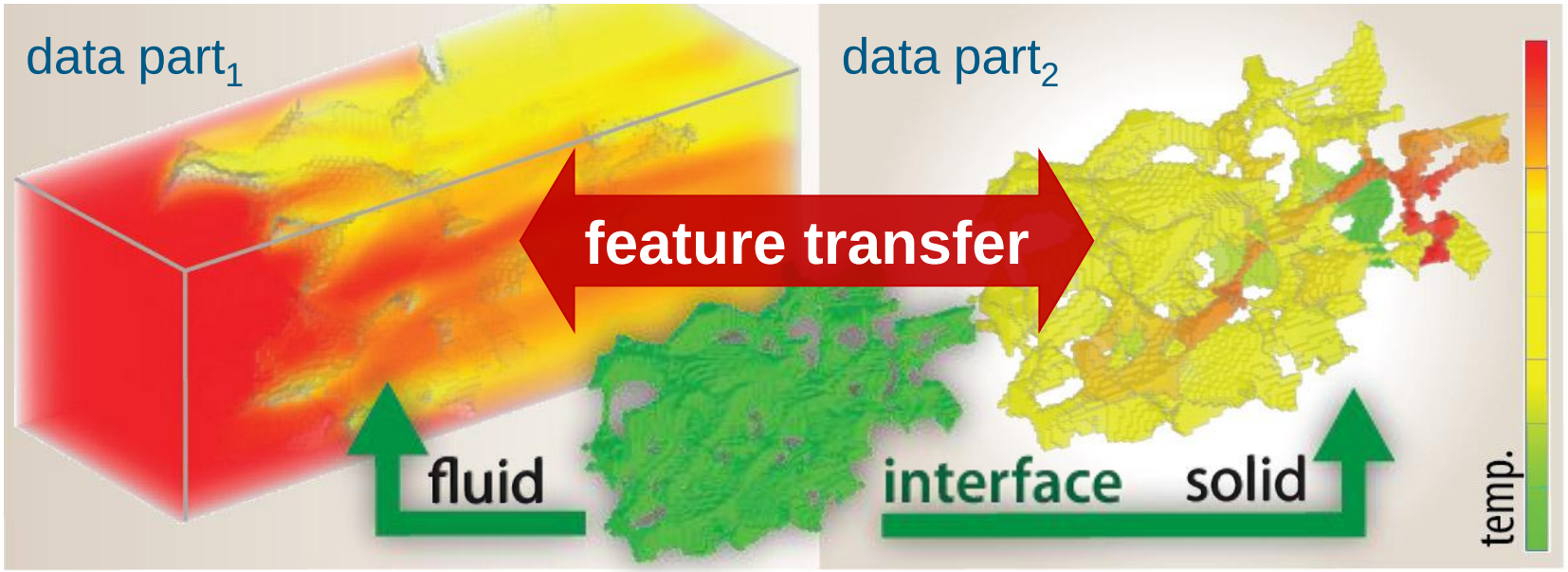
- Data in scientific visualization
  - **data values f(x)**
    (e.g., temperature, pressure values)
  - measured/simulated wrt. a **domain x** (e.g., 2D/3D space, time, simulation input parameters)
- **Dimensionality reduction**
  (e.g., computing statistics wrt. time / spatial axes)
- Reintegrate statistics into IVA through **attribute derivation**



Visual Analysis across an Interface

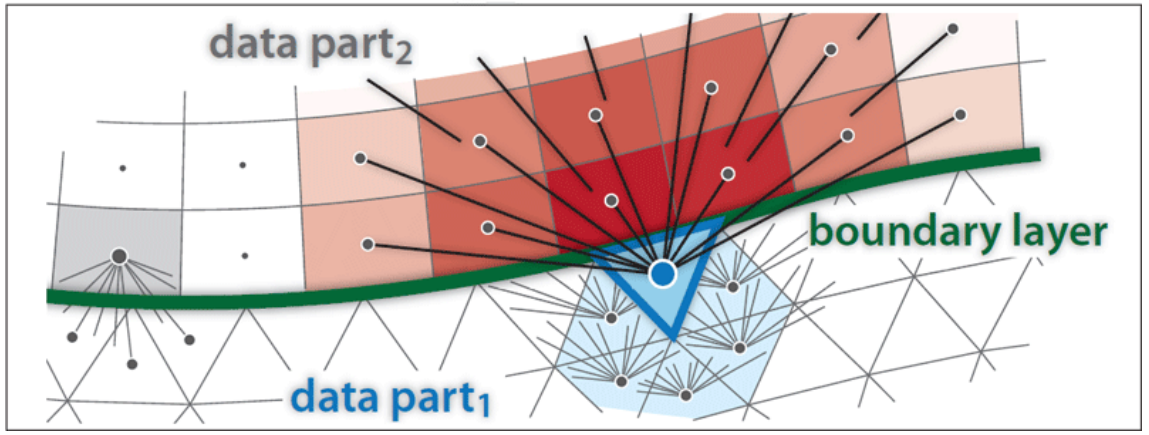
- Multiple linked views framework [Doleisch et al. '03]
- Integrate 2 related data parts
- Common level of data abstraction

  → degree-of-interest attribution ($DOI_i \in [0, 1]$)

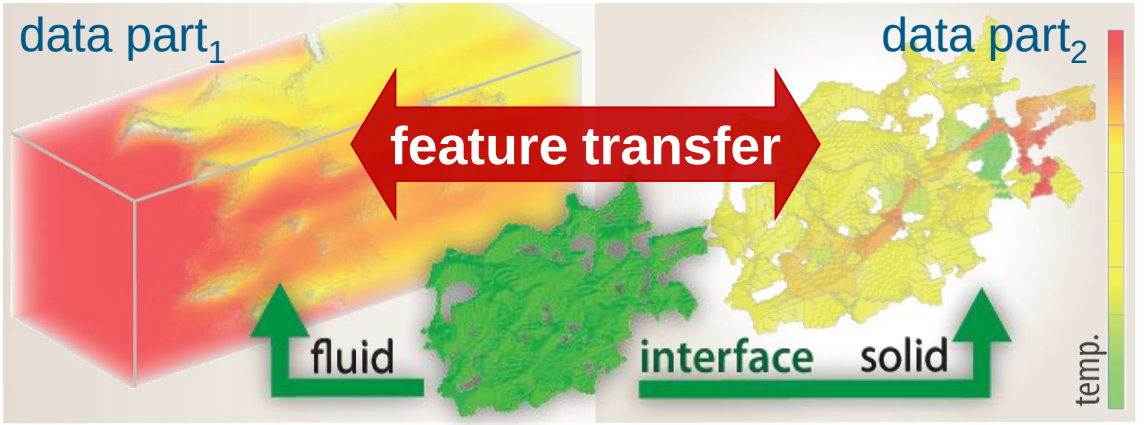


Interface

- **Relate** grid cells across data parts (no resampling necessary)



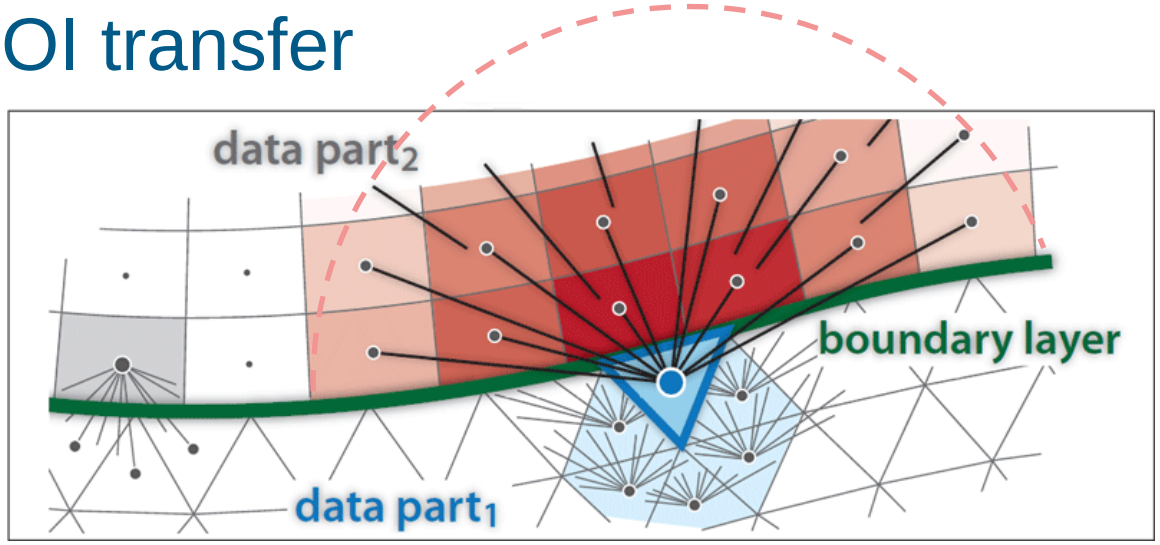
- **DOI transfer**
- **Automatic update** of feature spec.

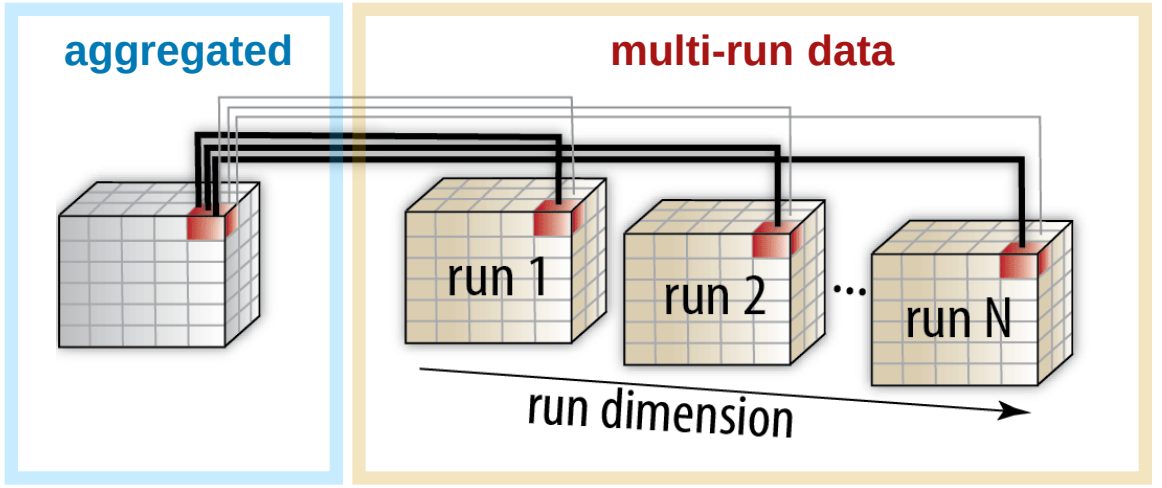


- **Analysis strategies** for 2-part scenarios

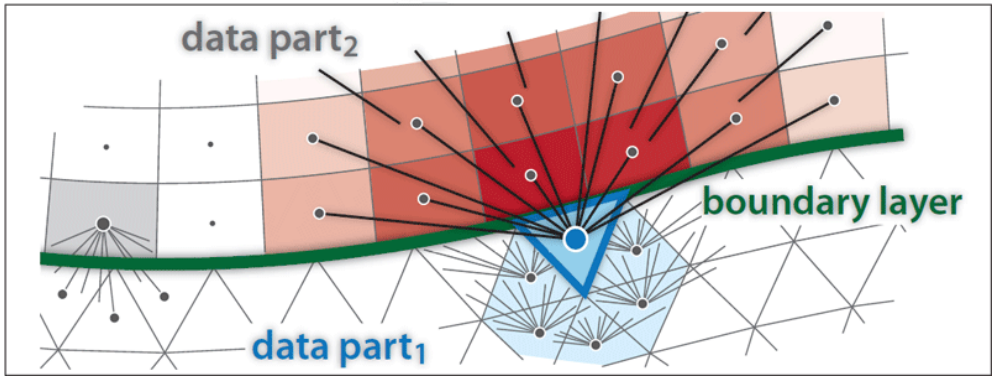
Interface (structural relation)

- relate grid cells
- weight values for DOI transfer
- many-to-many relation
- one-to-many relation





Degree-of-Interest (DOI) Transfer



- weighted sum

$$DOI'_i = \frac{1}{\sum_j w_j} \left(\sum_j w_j \cdot DOI_j \right)$$

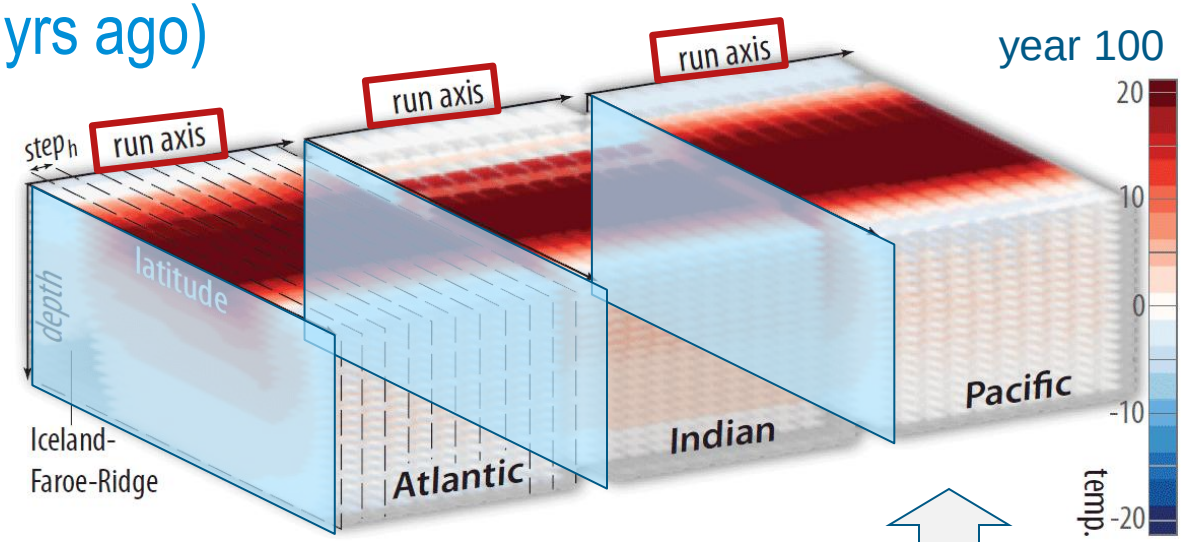
- maximum weighted DOI values

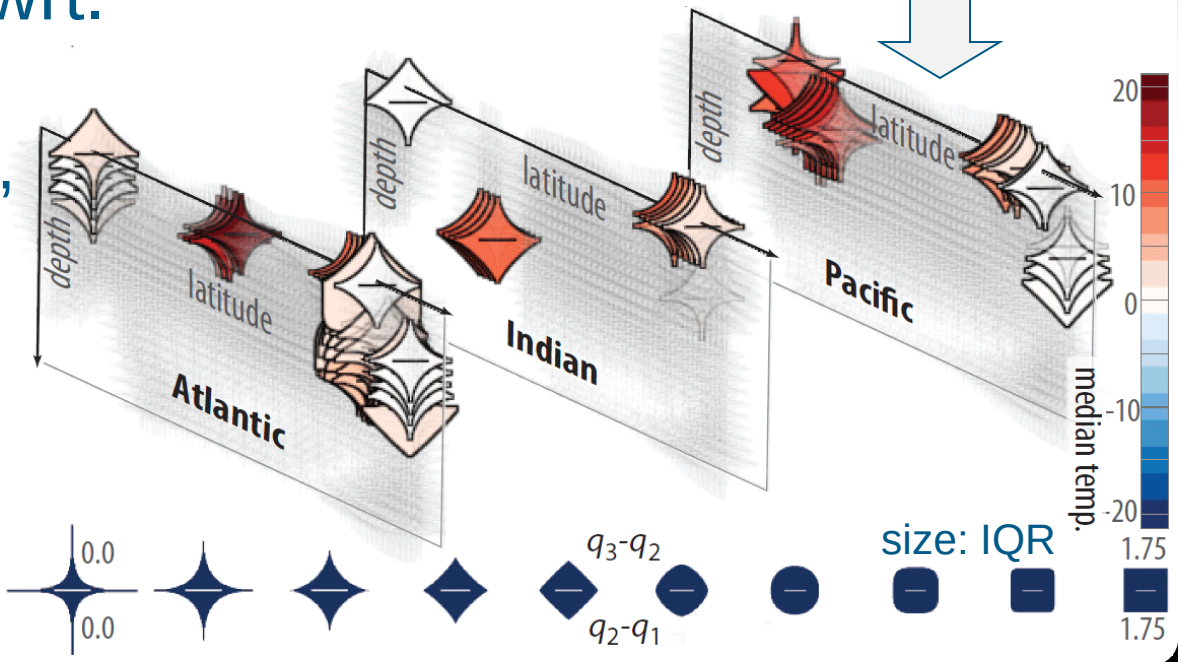
$$DOI'_i = \max_j (w_j \cdot DOI_j)$$

- maximum DOI value
- other model-based transfer

Case Study: Multi-run climate Data

- Cooling event (8200 yrs ago)
  - ocean simulation (2D sections)
  - 10 x 10 = 100 runs
  - time-dependent (250 time steps)
- Compute statistics wrt. the multiple runs
  - median, quartiles, etc.
  - billboard glyphs [Lie et al. 2009]





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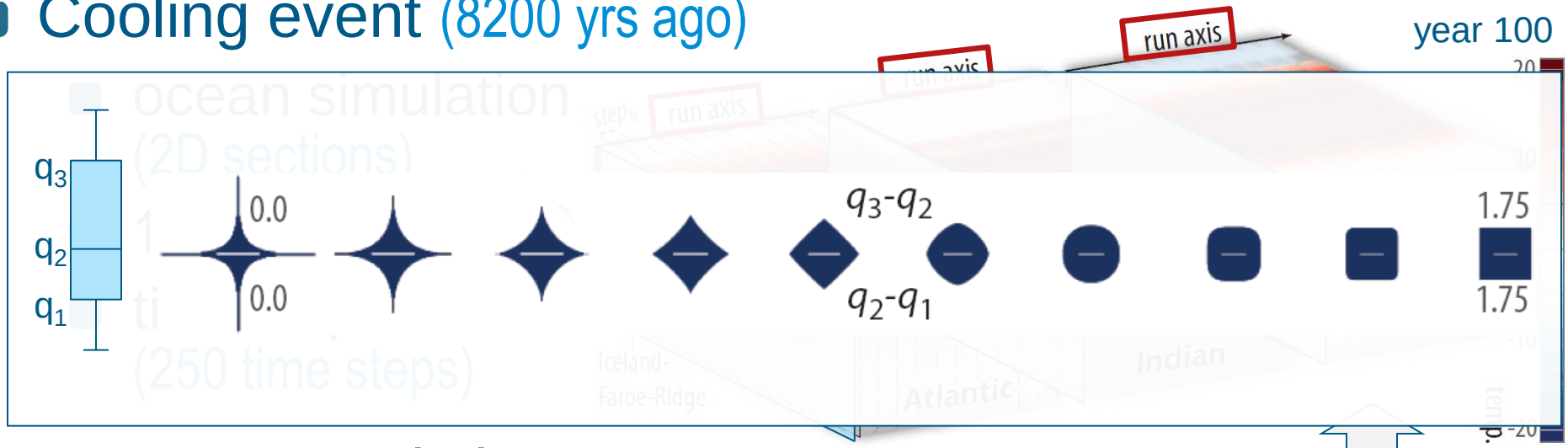

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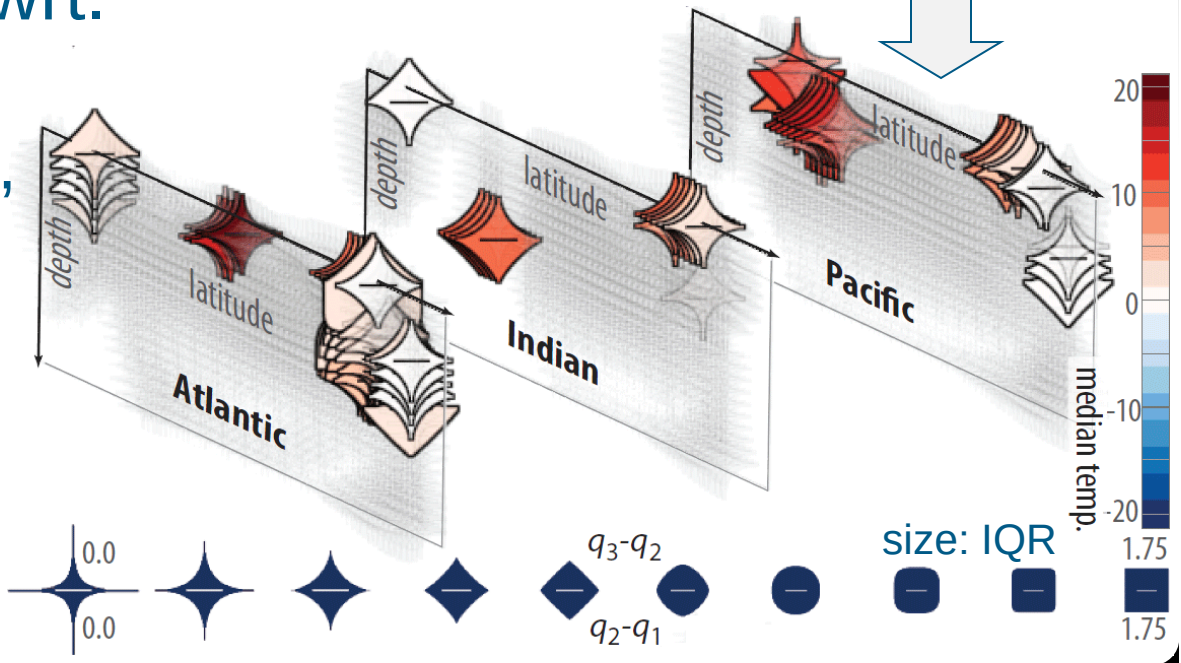
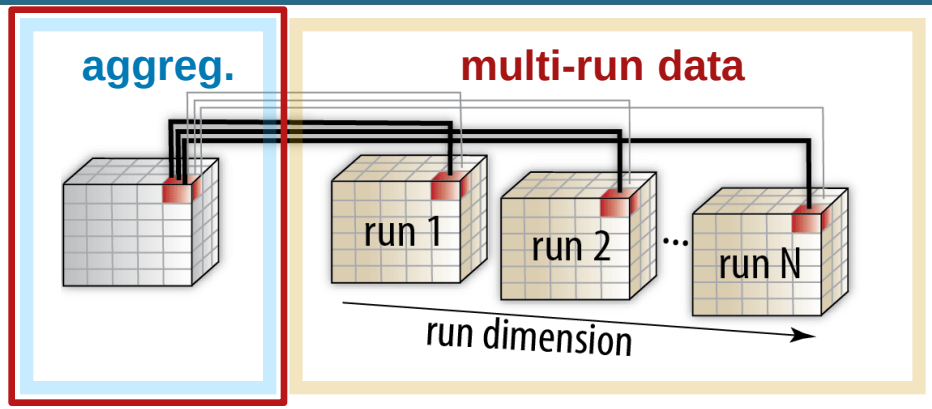
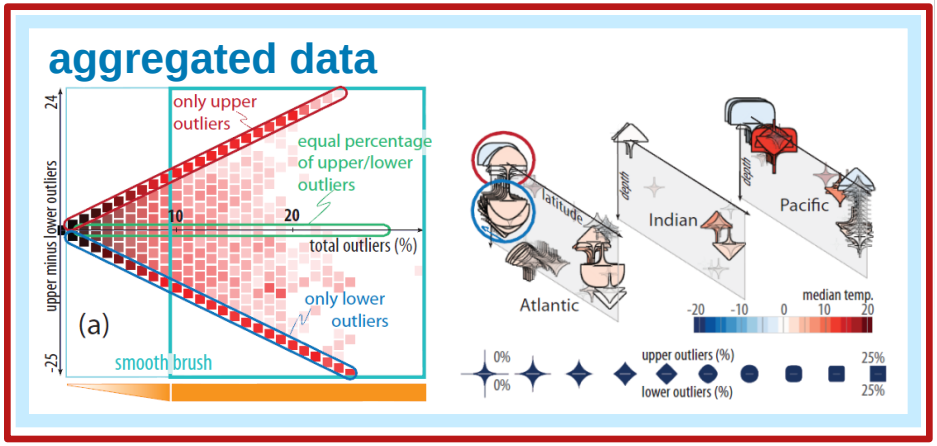
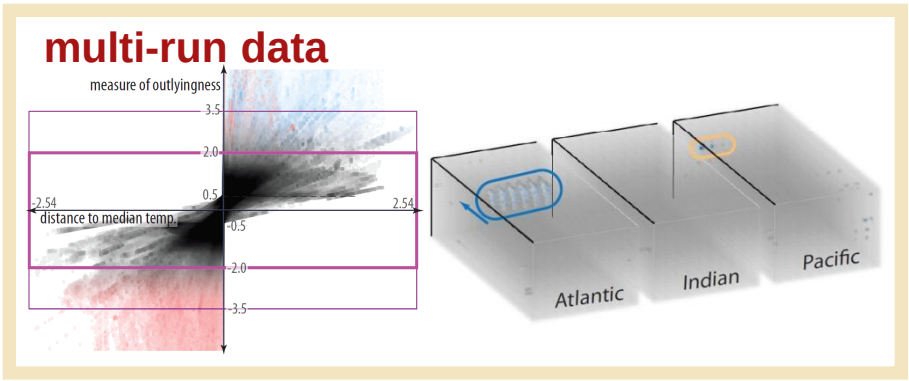


Visual Analysis of Multi-run Data



- Starts at aggregated level (summary statistics)
  - specify features via brushing
  - derive new attributes
- Refine features at multi-run level (details)
- Investigate further





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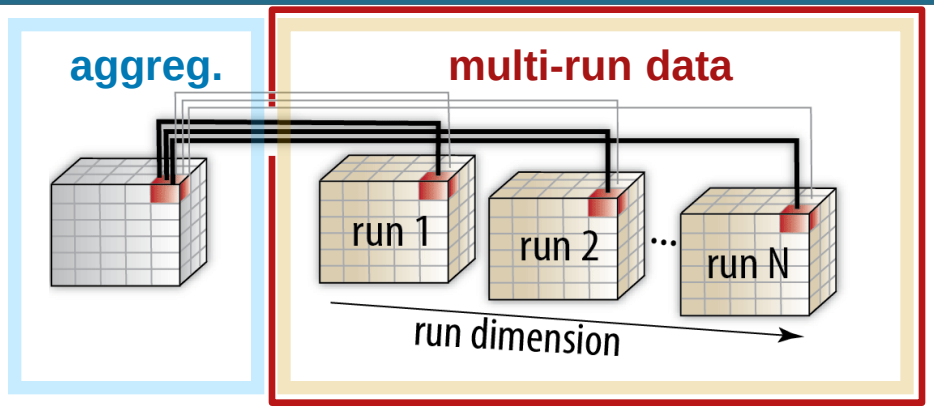

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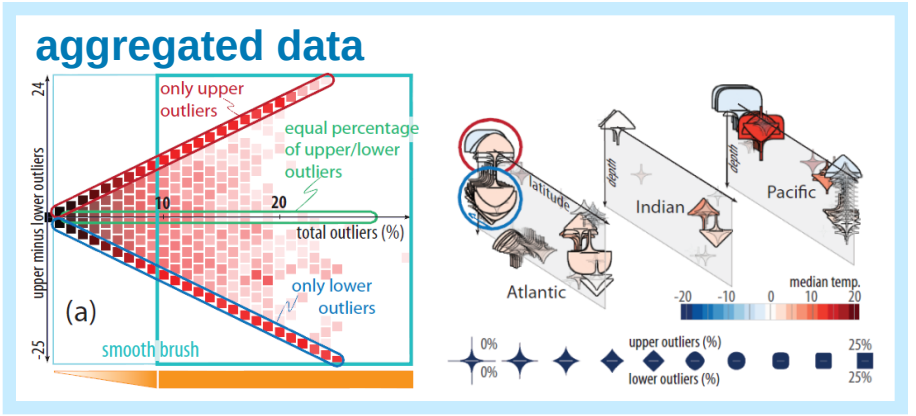
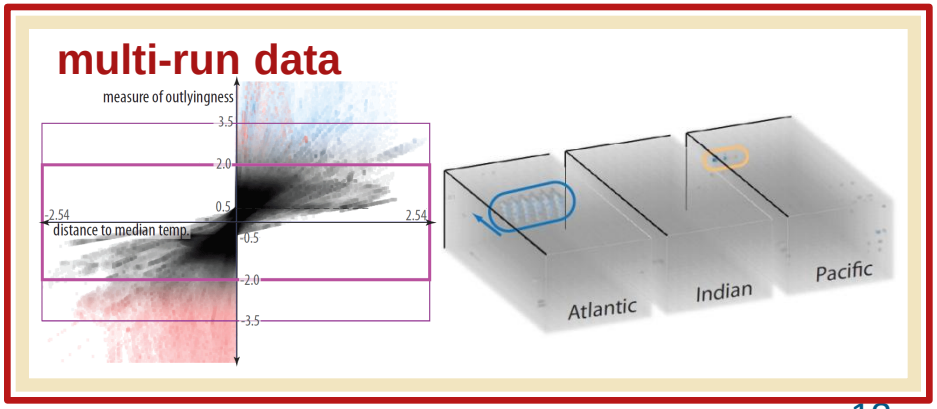
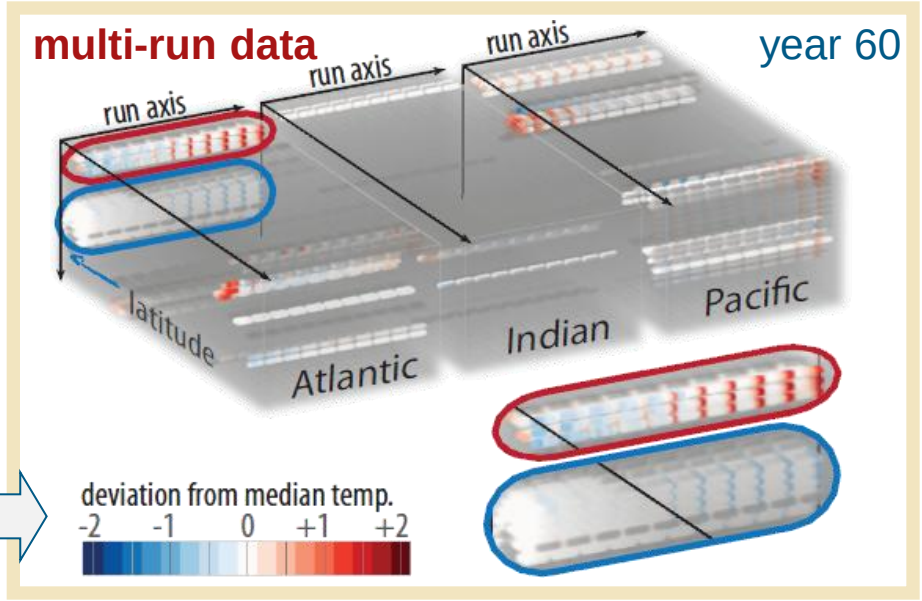
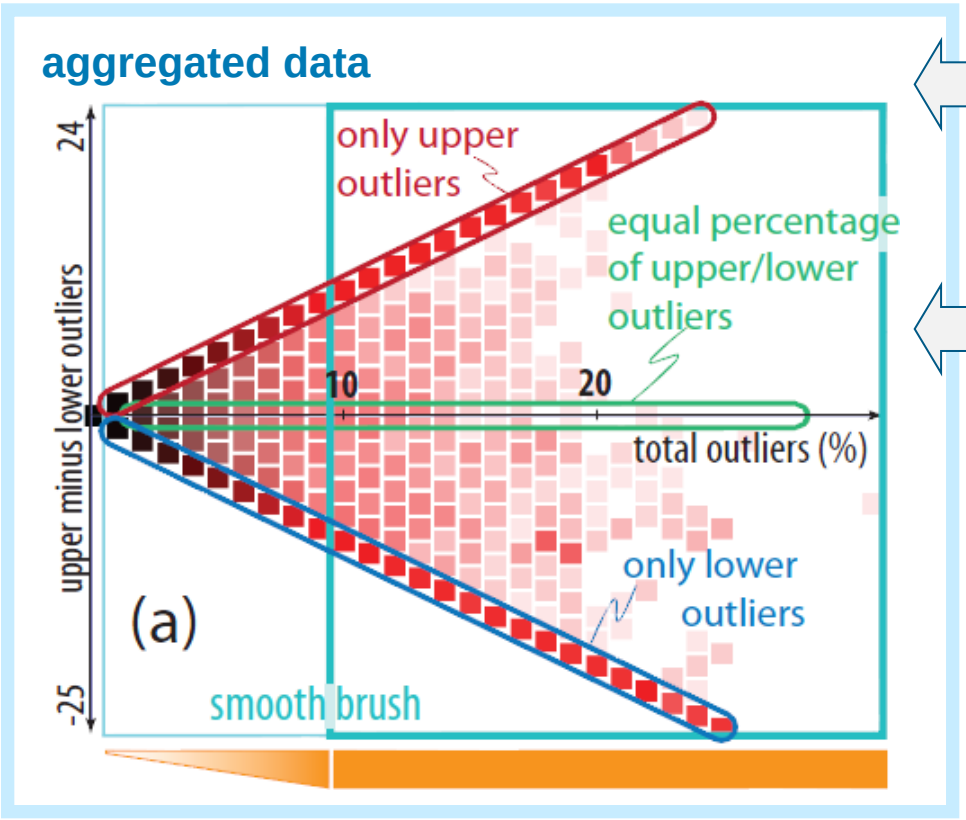


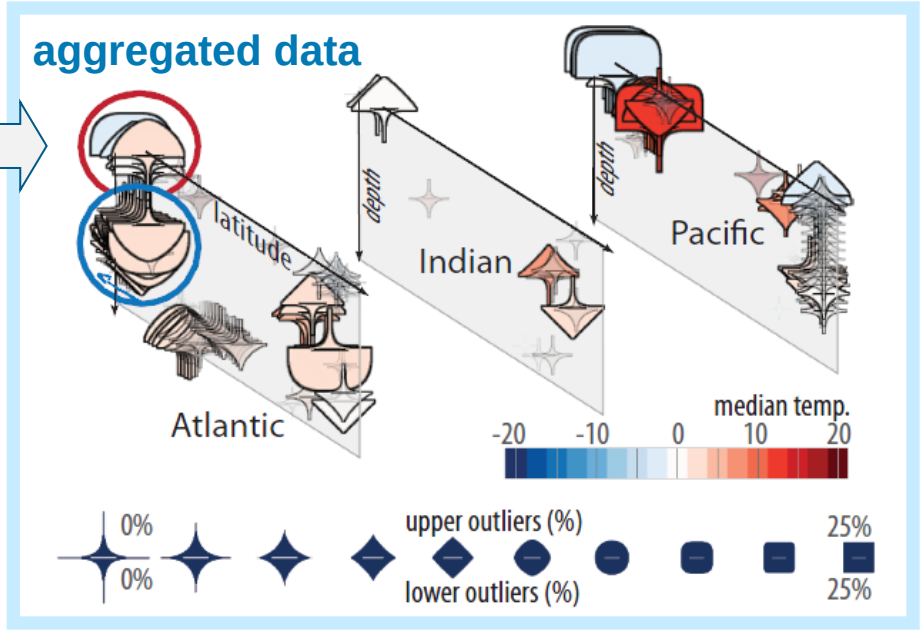


Outlier Analysis: Aggregated Data

- Derive total number of outlier
- Where are outlier located?
  (% outlier > 3rd quartile + 1.5 IQR) –
  (% outlier < 1st quartile – 1.5 IQR)



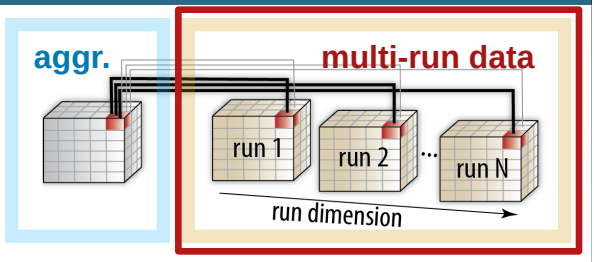


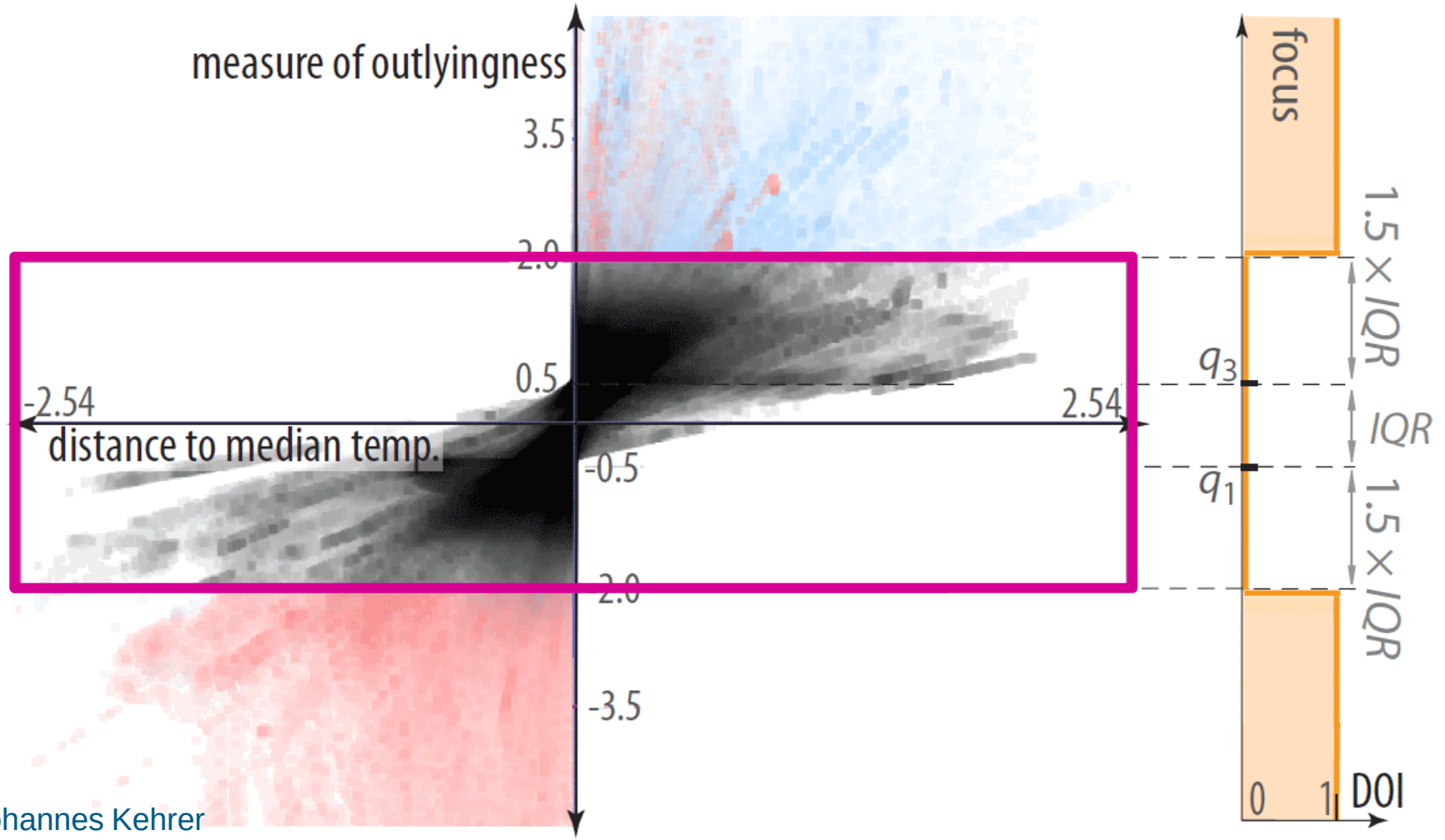


Feature Refinement: Multi-run Data

Derive measure of *outlyingness*

[Kehrer et al. 2010]





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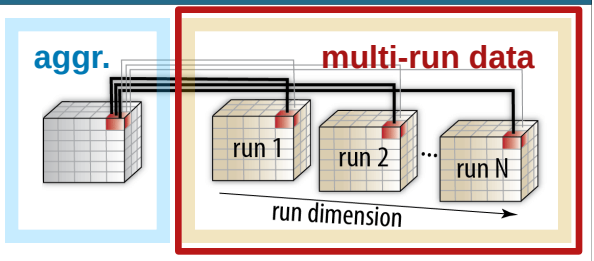
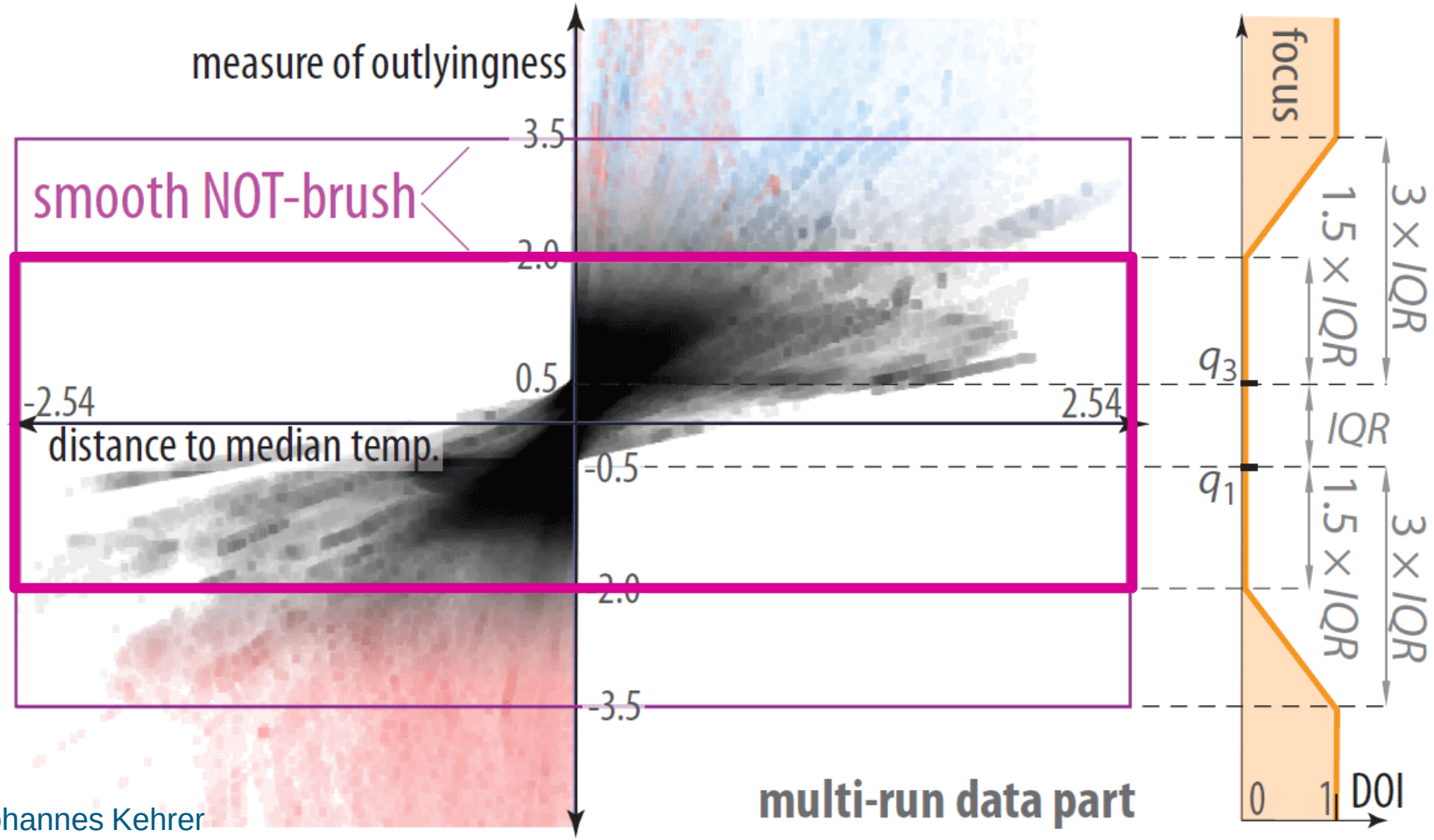
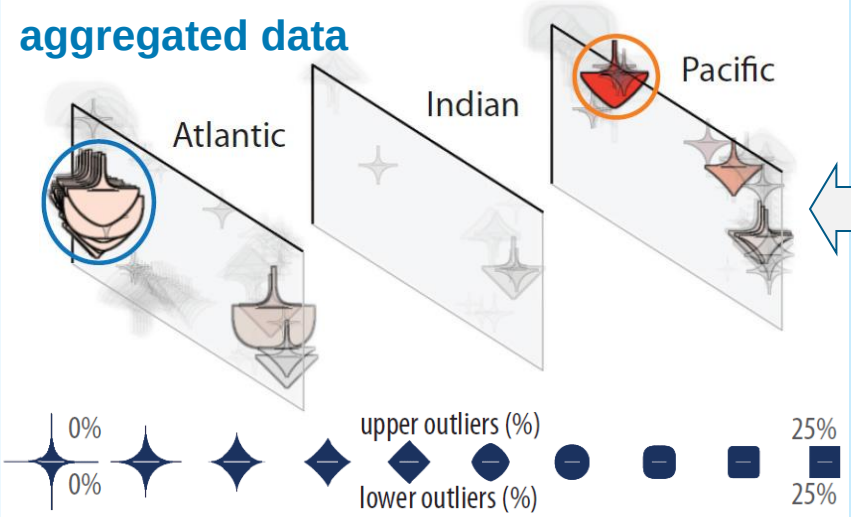


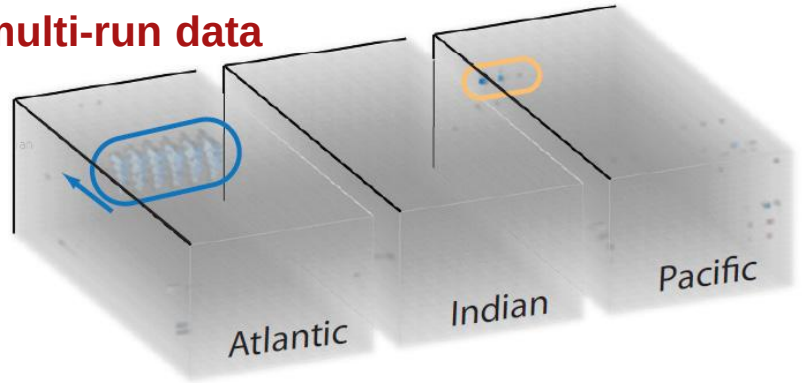


Sensitivity Analysis

aggregated data



multi-run data



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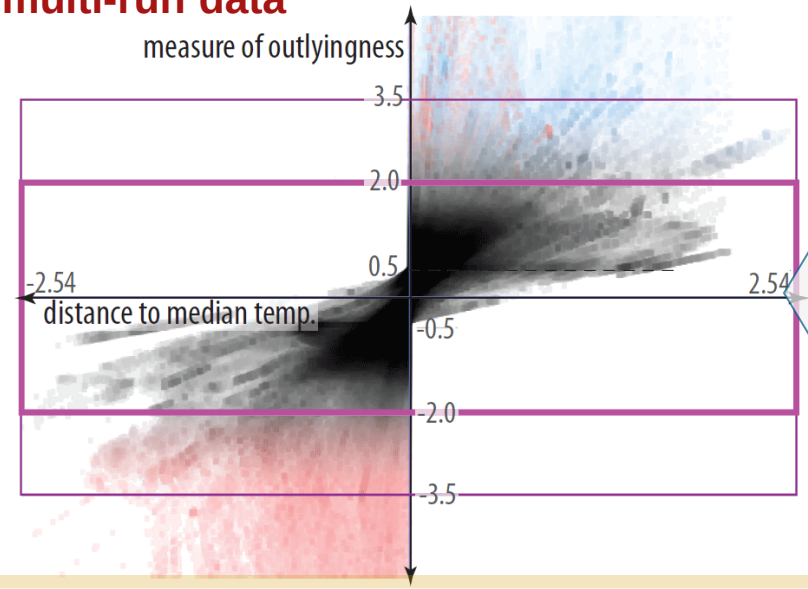
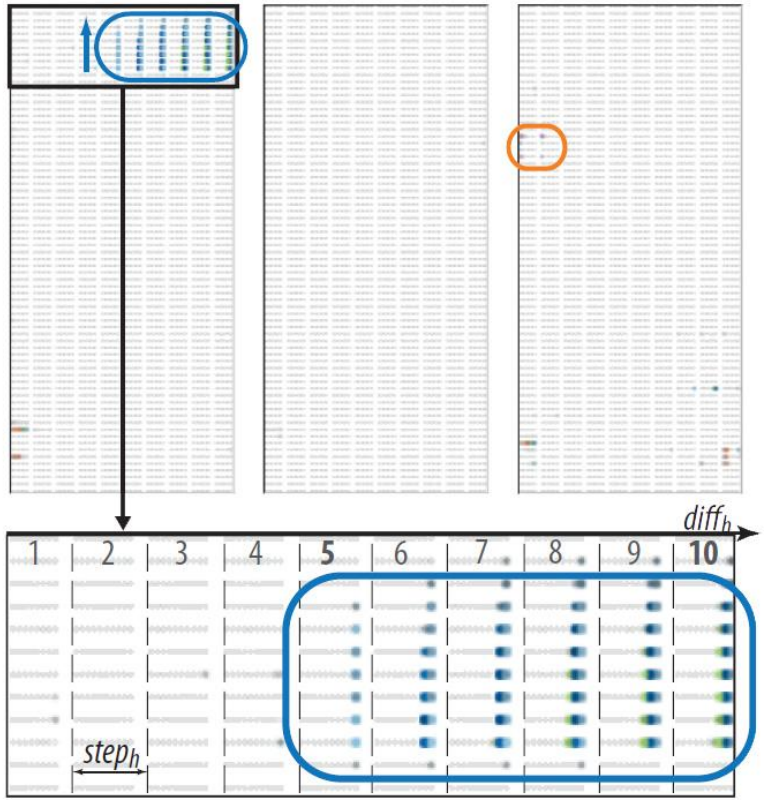




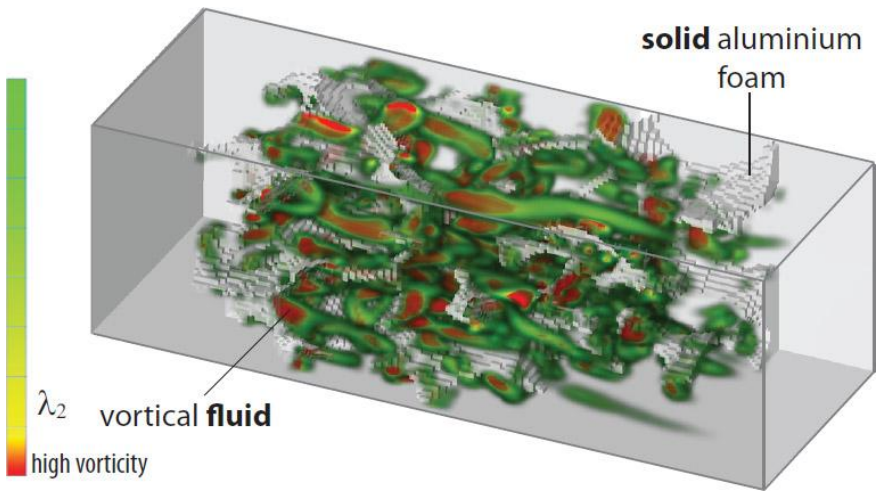
Conclusions

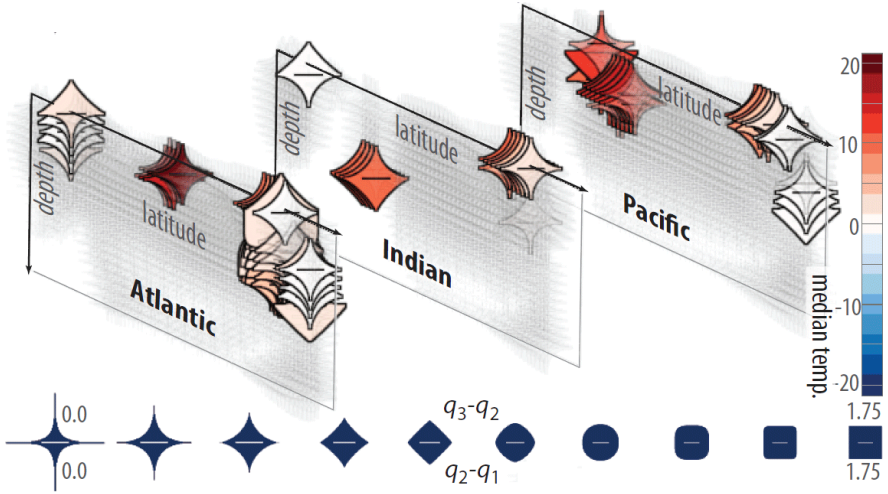
- Joint visual analysis across **two data parts**
- Bidirectional **feature transfer** via interface
- **Workflow** for analyzing 2 data parts simultaneously

  multi-run data ⇔ aggregated statistics

  fluid ⇔ structure

- Aggregated statistics and measures of outlyingness





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