Data-driven unraveling Earth System Dynamics with the Earth System Data Cube

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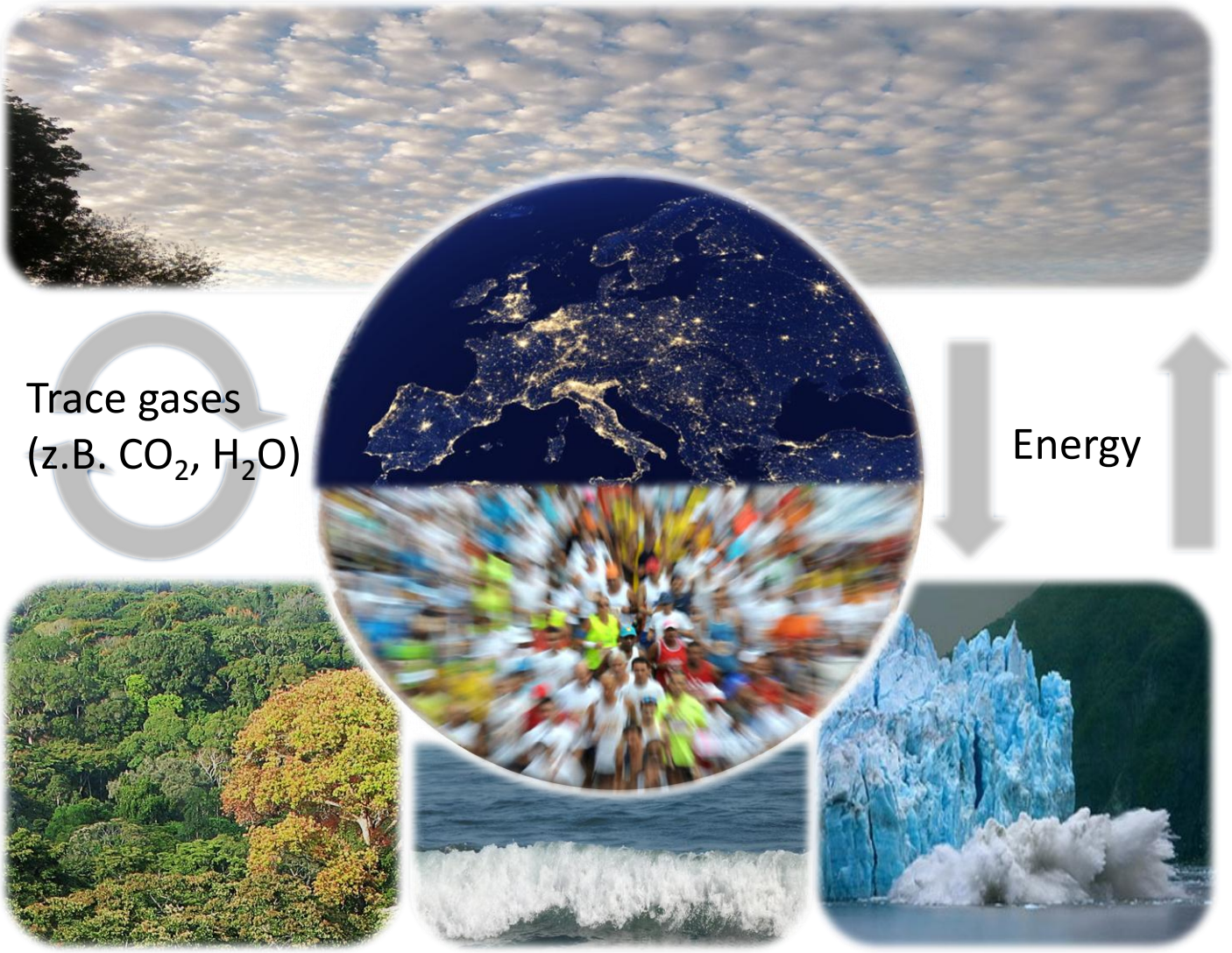
CAB-LAB

COUPLED ATMOSPHERE BIOSPHERE VIRTUAL LABORATORY

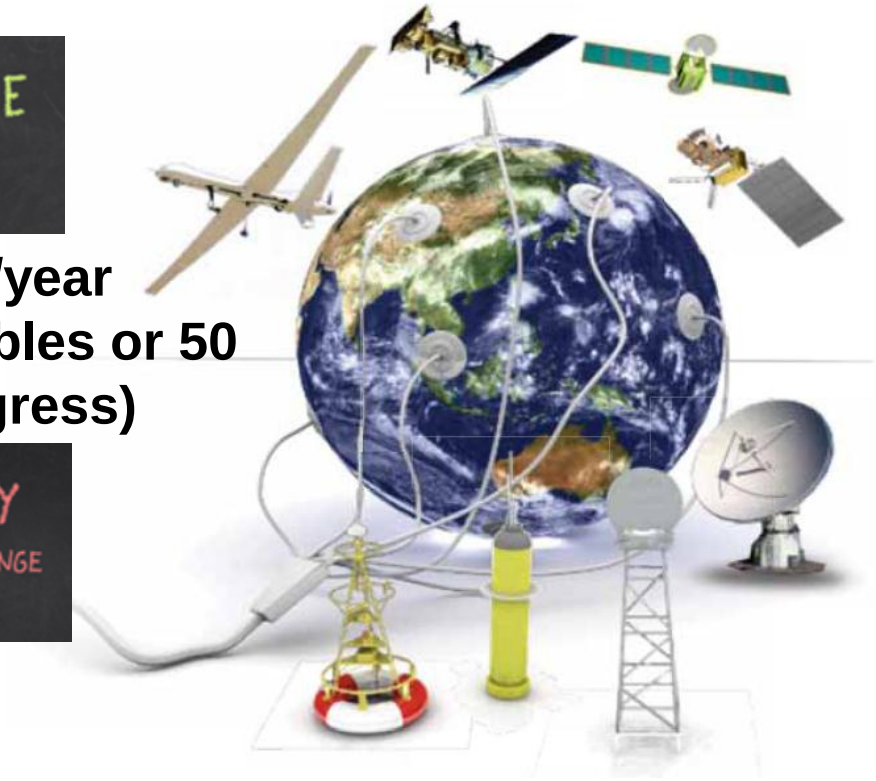
ESA STSE Coupled Atmosphere Biosphere Virtual Laboratory (CAB-LAB)

System Earth



Max-Planck Earth System Research Partnership

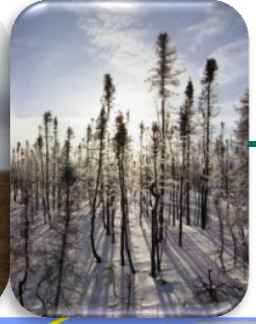
Data-driven Earth Science - Big data



>>1 Pbyte/year (~200 Billion bibles or 50 Lib of Congress)

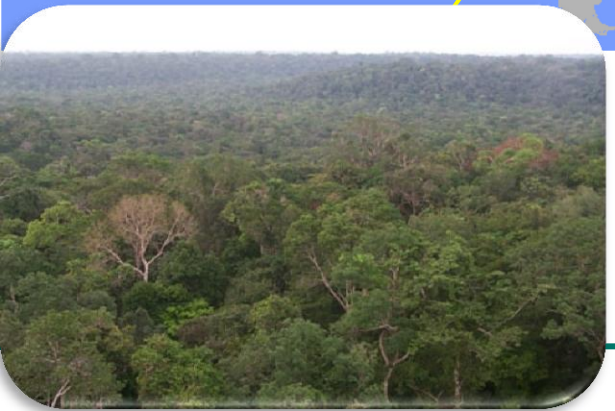
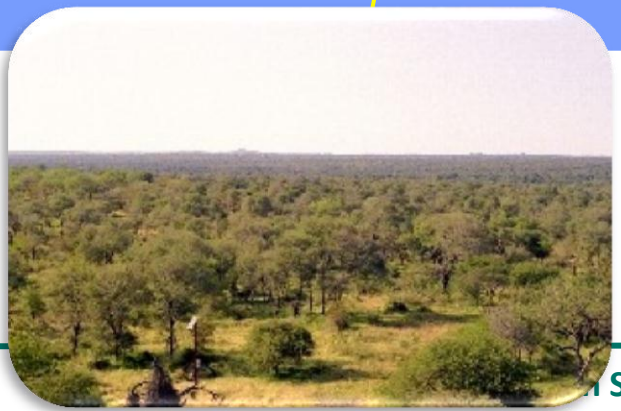
Heterogeneous data:

- **Organ to global**
- **Point, gridded, 1D-4D integrated**
- **Hourly to millenial time scale**
- **Uncertain and possibly inconsistent**

Max Planck Institute
for Biogeochemistry

FLUXNET
A Global Network

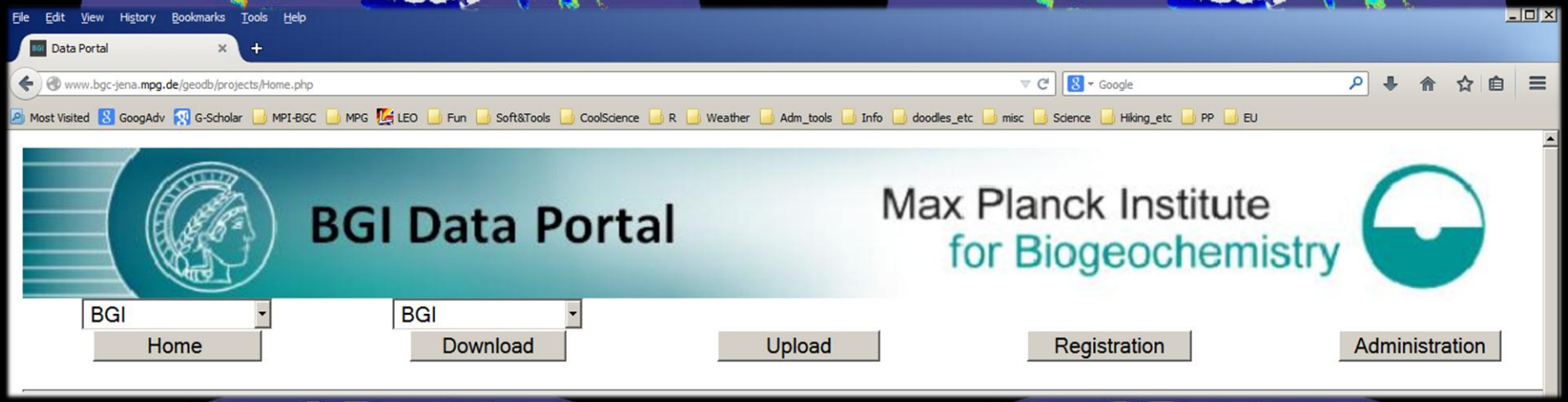




System

Data-driven view on dynamic Biosphere-Atmosphere Exchange

Primary production (GPP) [g m^{-2} day^{-1}]

Evapotranspiration [MJ m^{-2} day^{-1}]



Open access data & open source code

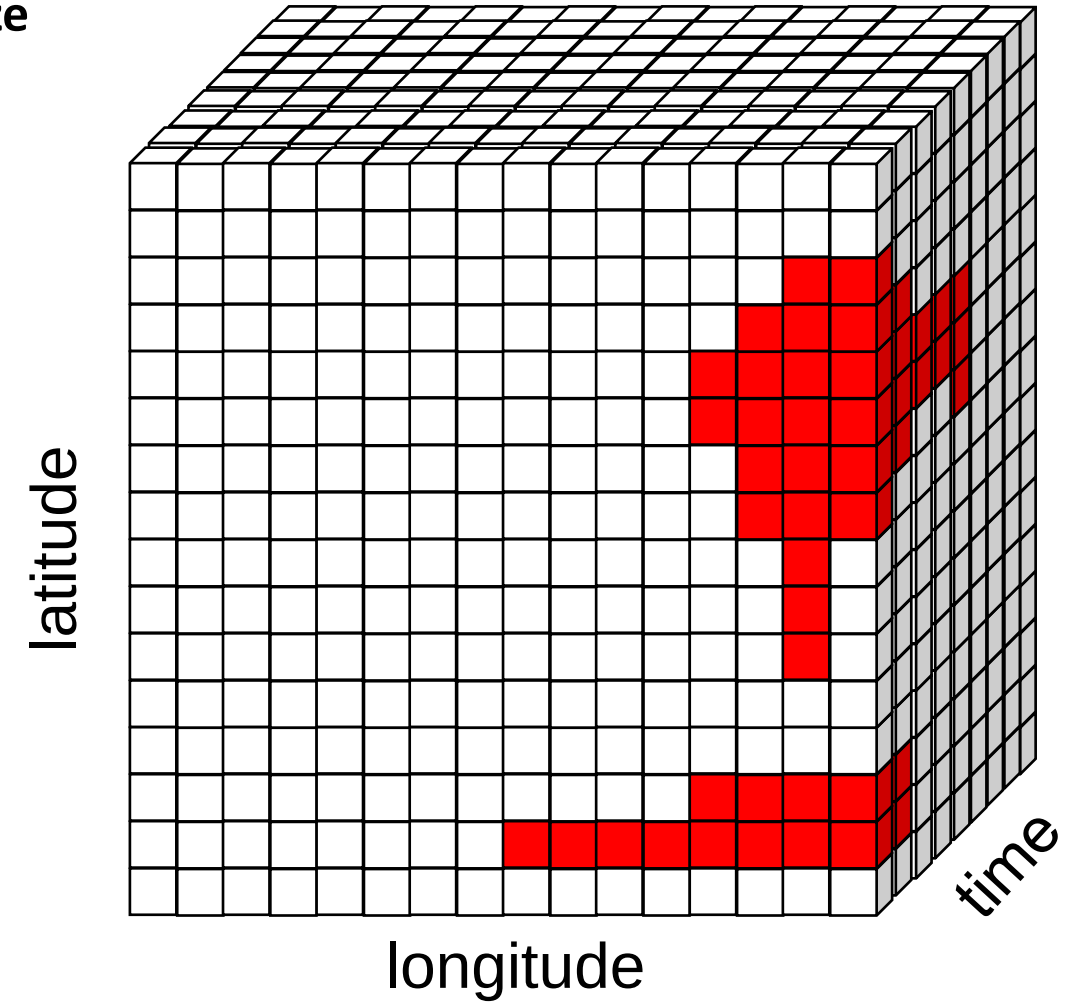
0 2.5 5 7.5 10

0 40 80 120 160

Data: Jung et al. (2011). Animations: F. Gans, MPI-BGC

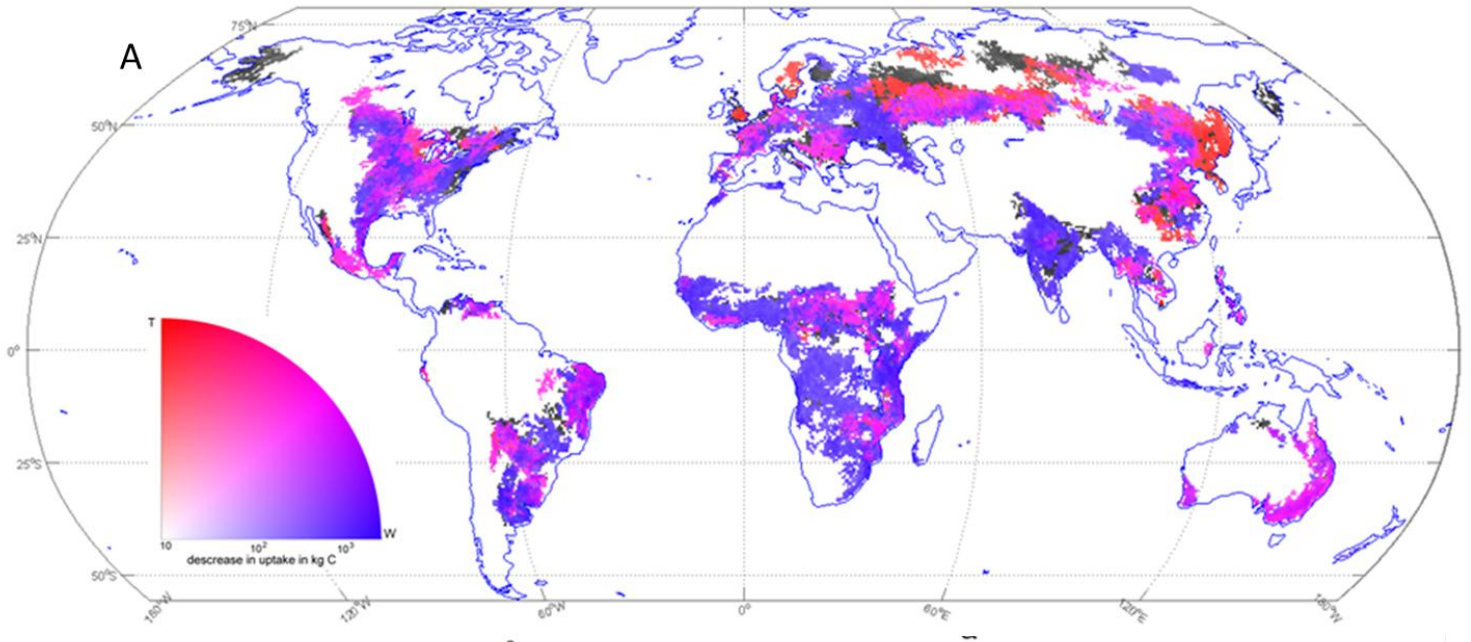
Extraction of events from data cubes

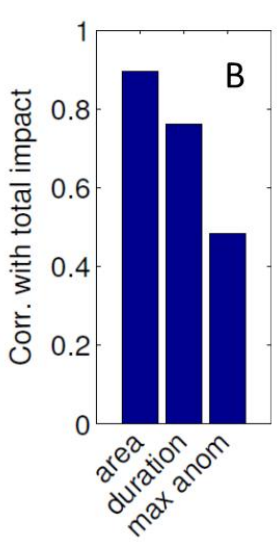
1. **Detrend and deseasonalize** pixel by pixel
2. **Tag voxels** (lat, lon, time) with extreme anomaly
   - ➢ *Based on 1%, 5% or 10% percentile*
3. Find **spatio-temporally connected voxels**
   - ➢ *"Extreme events"*
4. **Characterize** them
   - ➢ *Magnitude*
   - ➢ *Spatial extent*
   - ➢ *Duration*
   - ➢ *Total integral*
   - ➢ *…*

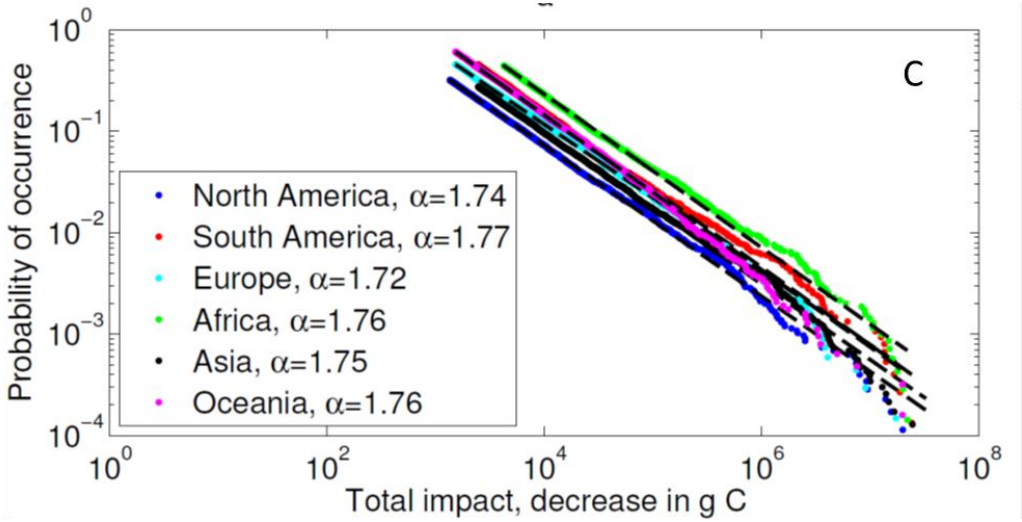


Based on this: Zscheischler et al. 2013, Ecol. Inf, Zscheischler et al. 2014, 2015

Extreme carbon cycle events triggered by water



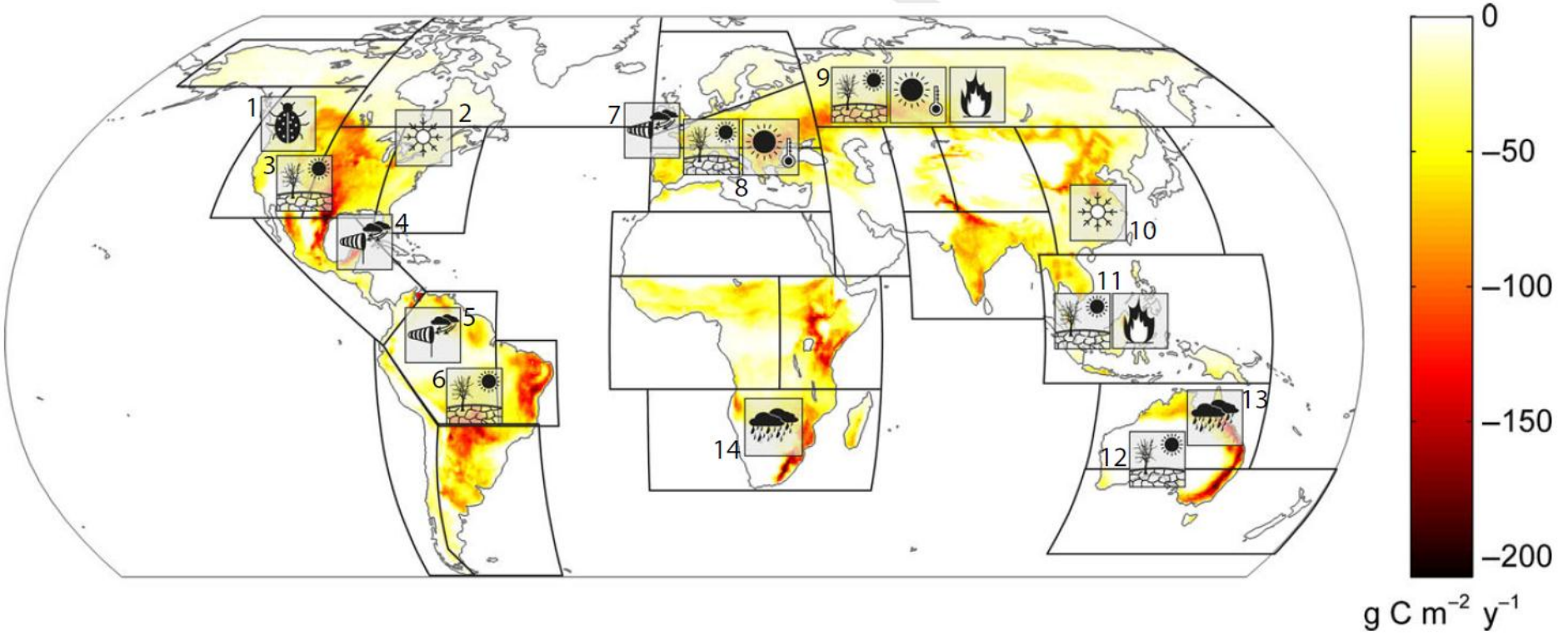




Total impact: >2 PgC yr^{-1}

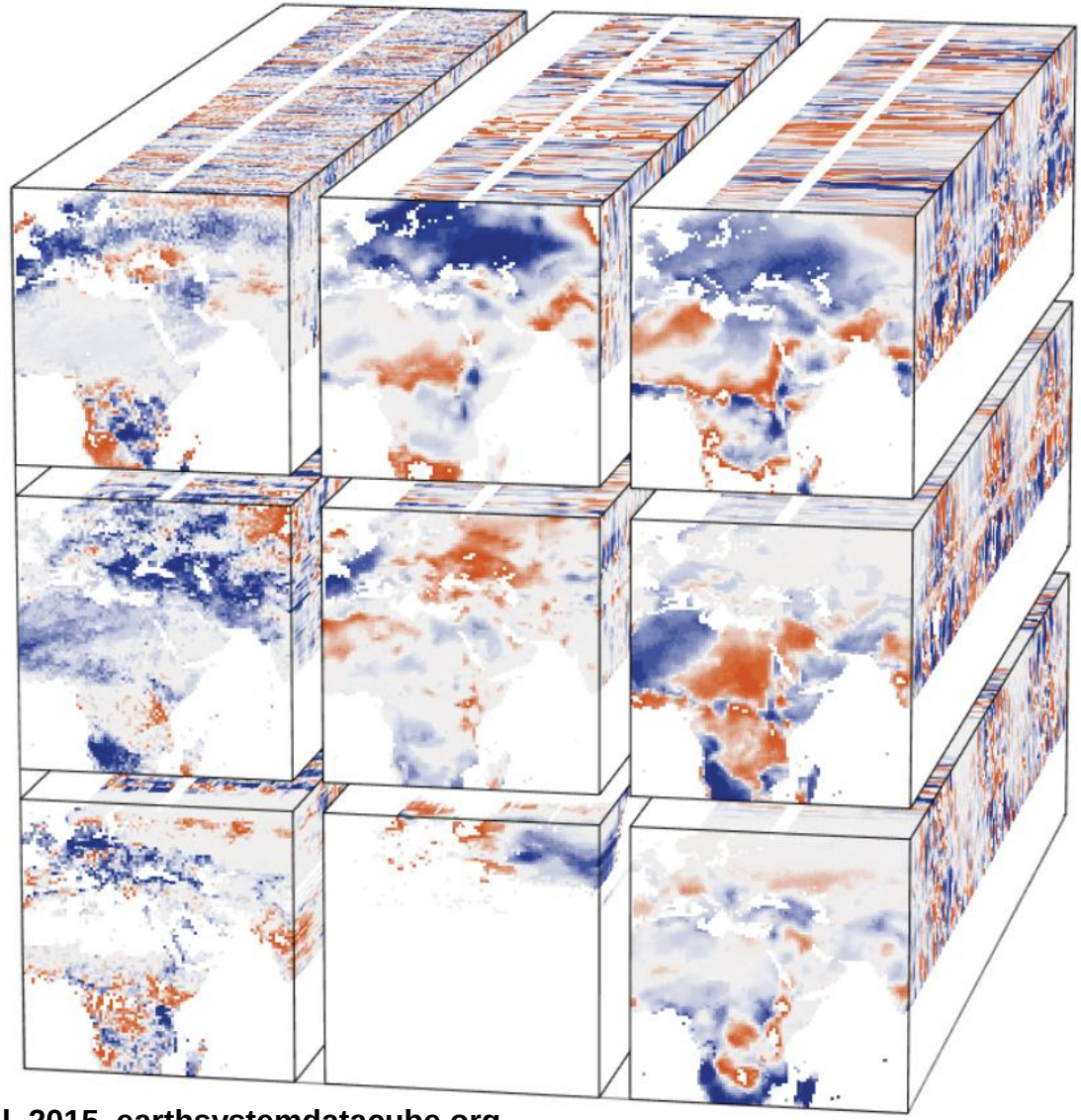
Reichstein et al. 2013, Nature

Many extreme events not “recorded” without Earth Observation



Frank et al. 2015, Glob Ch Biol

Earth System Data Cube

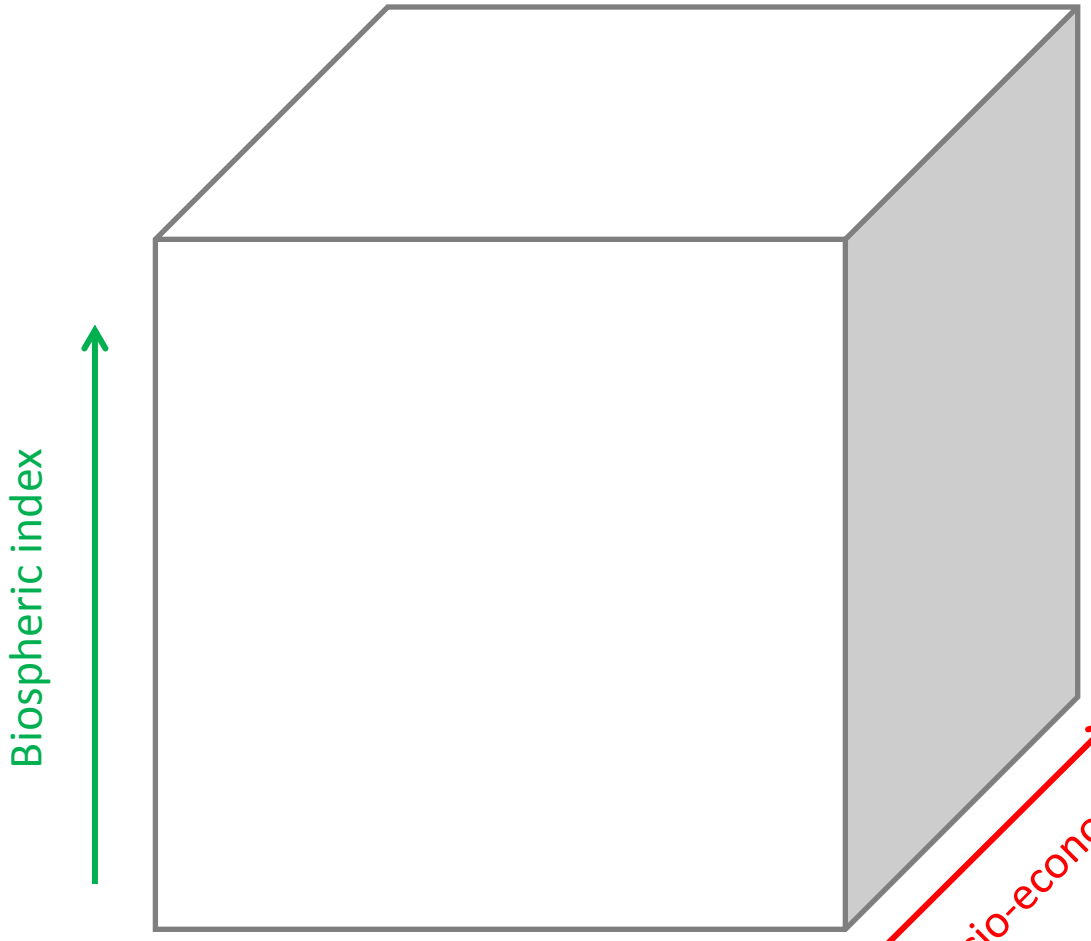


- High dimensional
- Same resolution in
  - space
  - time
- Compatible units

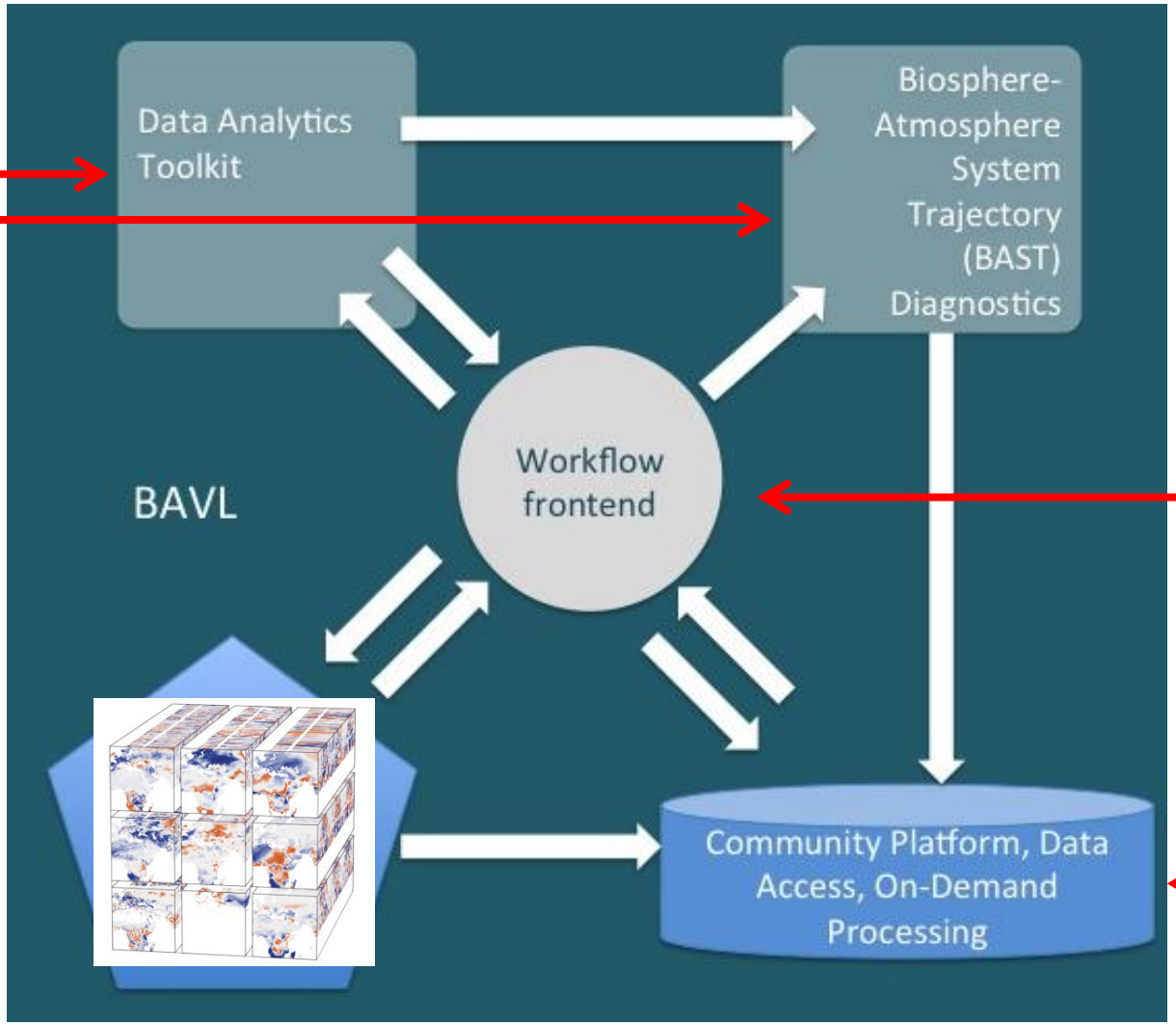
Nice, but analytical challenges
➔ Dimensionality reduction

Mahecha et al. 2015, earthsystemdatacube.org
Matthieu et al. submitted to IGARSS

Atmosphere, biosphere & anthroposphere properties as three dimensions



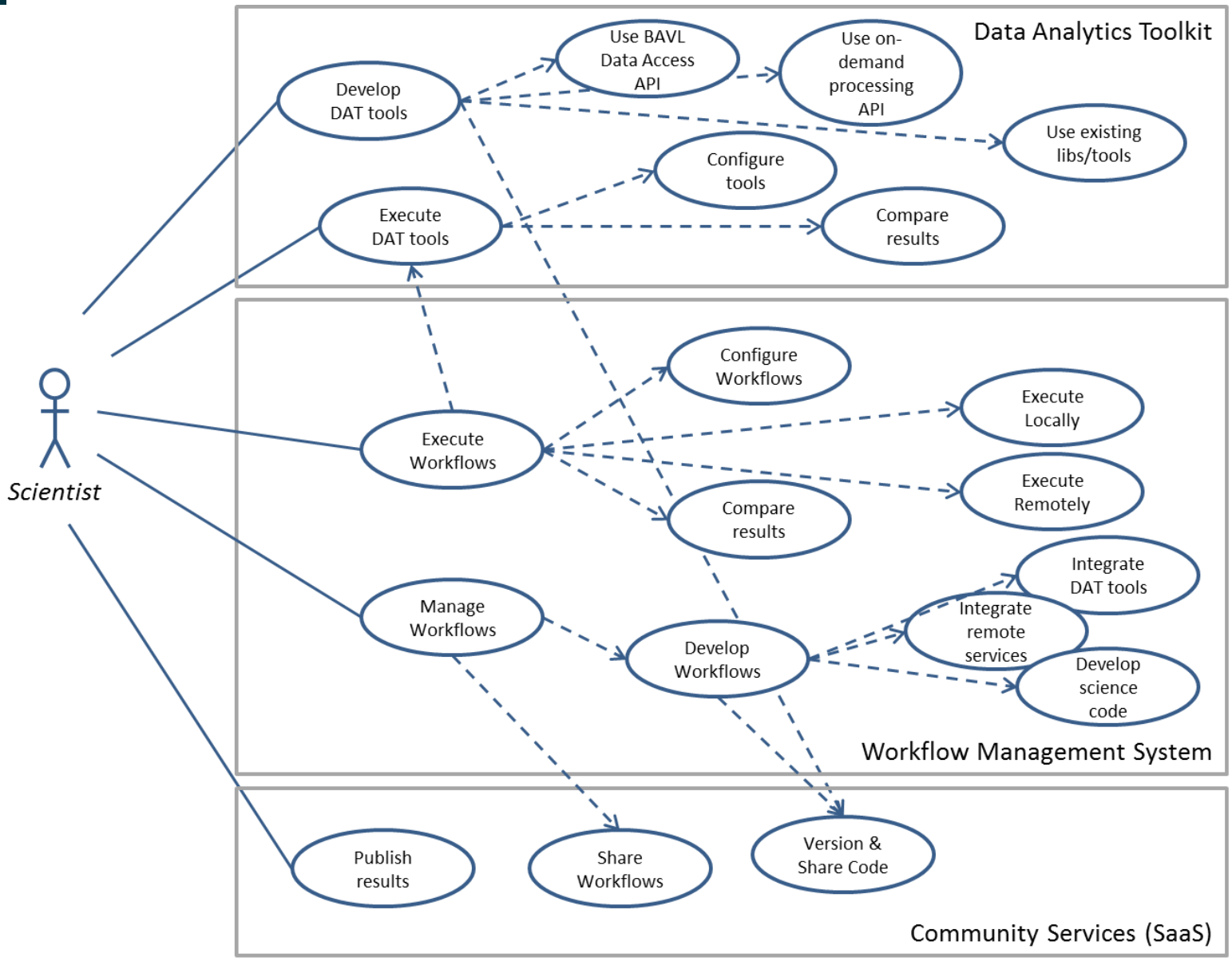
Biosphere-atmosphere virtual lab (BAVL)



Brockmann et al. 2015, CAB-LAB proposal (modified)

Not download, but subscribe (tools to the data), seamless updates by "living data cube"

CAB-LAB BAVL use-cases



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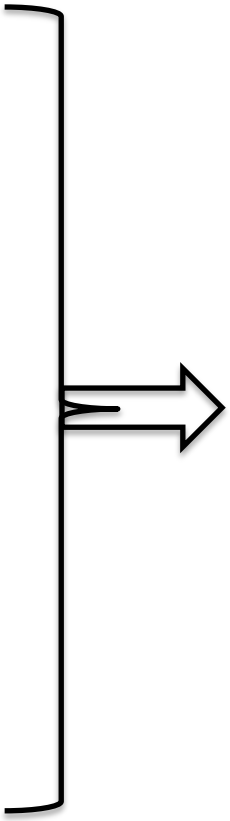
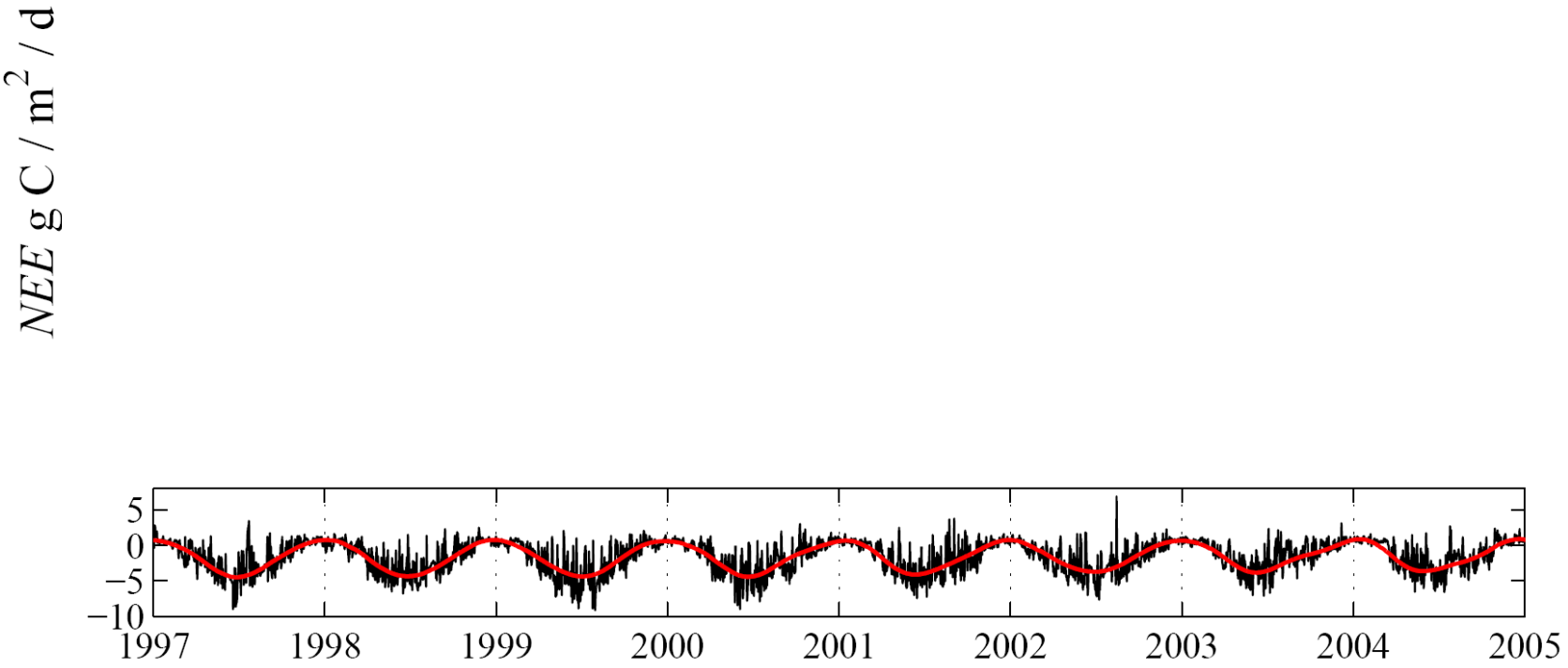
1st BAST runs on preliminary ESDC



Earth System Data Cube (ESDC)

Index of Biosphere-Atmosphere System Trajectory (iBAST)

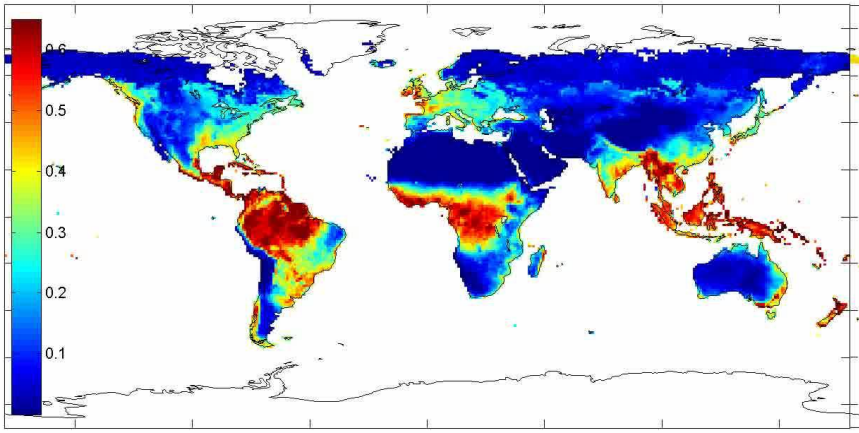
Data analytics toolkit (primitives)



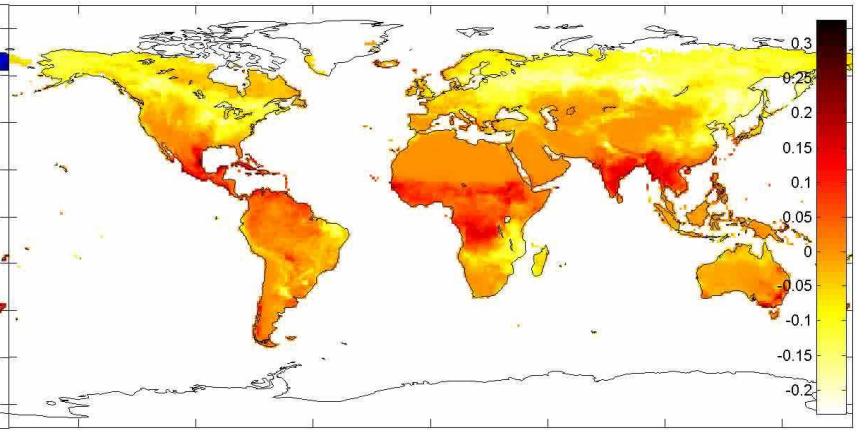
Time series decomposition by Singular Spectrum Analysis (SSA)

Decomposed & mapped fPAR times series

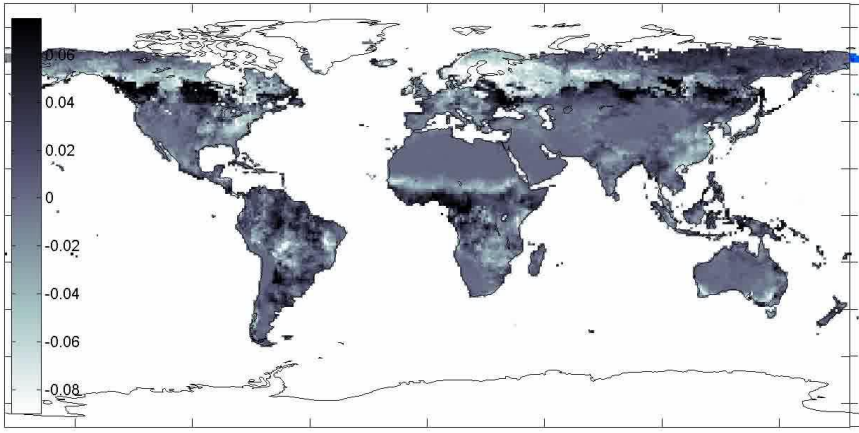
FPAR original data



Seasonal signal

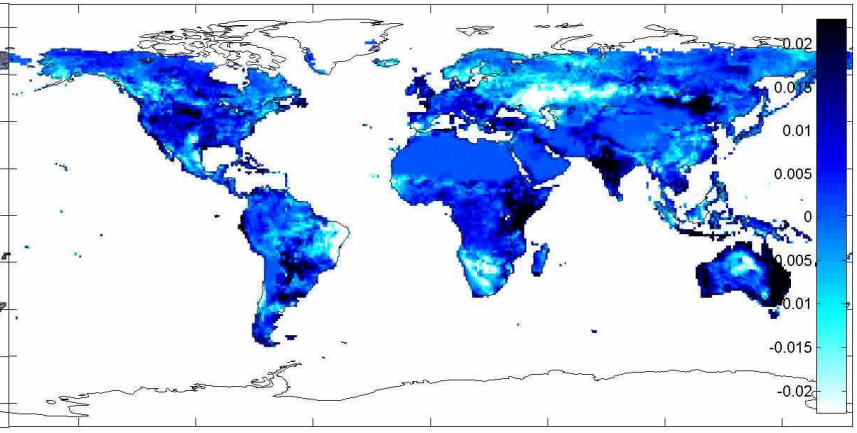


Fluctuations (high freq)



FAPAR: high frequency var.

Multi-annual signal

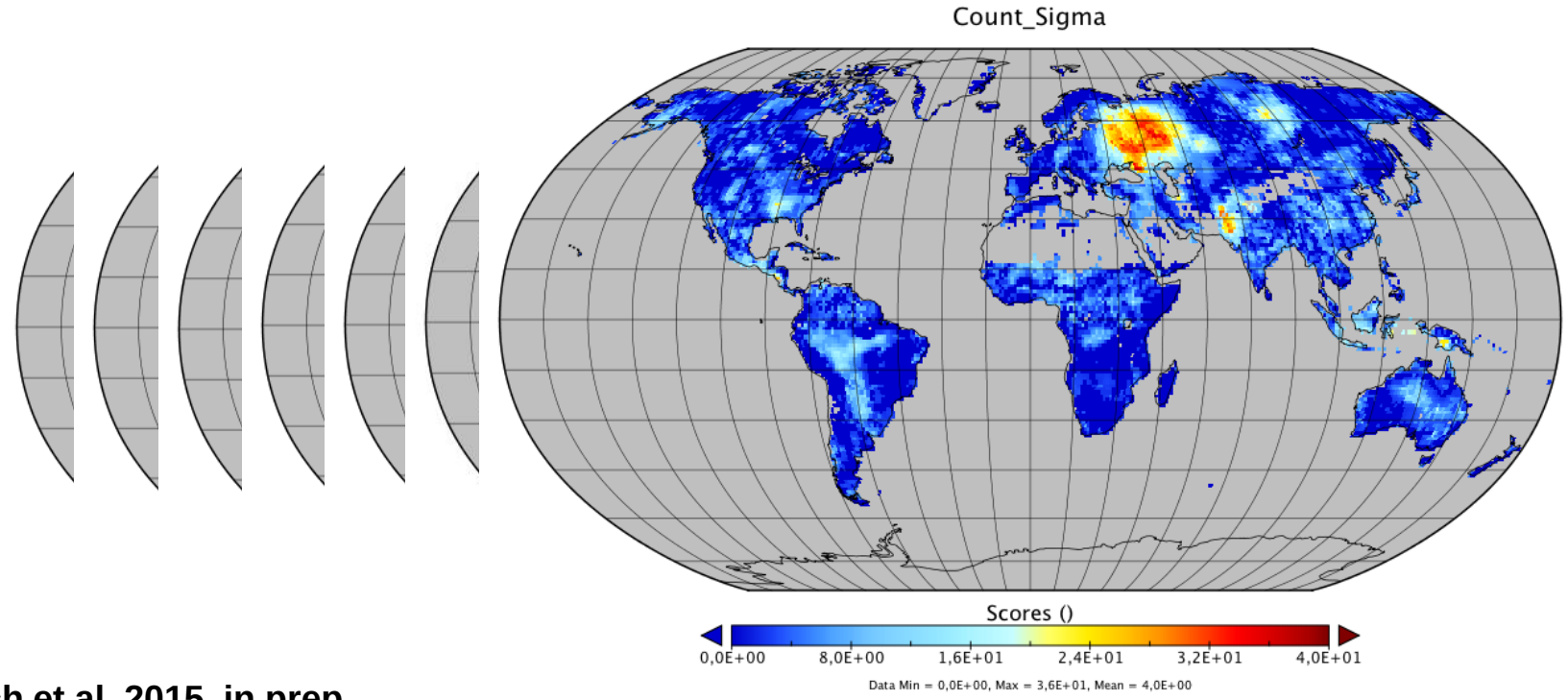


FAPAR: low frequencies var.

cf. Mahecha et al. (2010), Pat Recog Lett.

1st BAST runs on preliminary ESDC

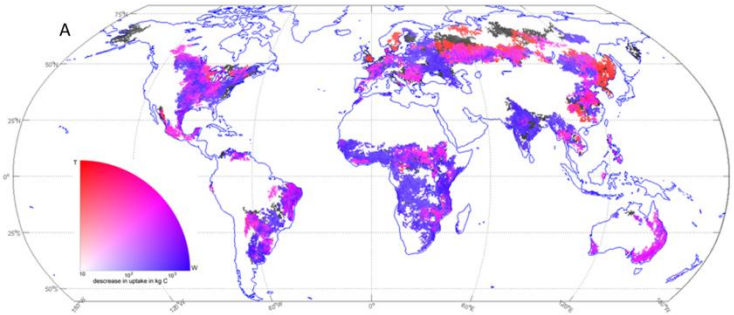
- Multi-method approach: extracting robust features; here: novelty detection

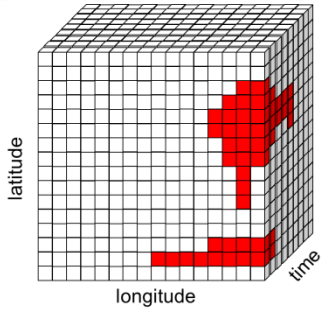


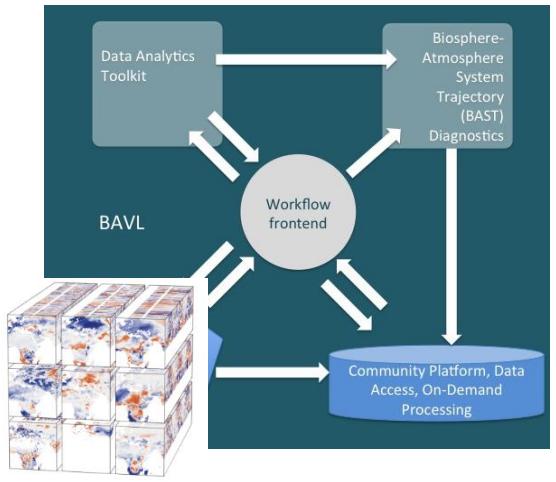
Flach et al. 2015, in prep.

Summary

- Earth System Data Cube highly relevant for Earth System Science
- Detecting localized events efficiently done
  - C cycle extremes globally important, related to water cycle
- Biosphere-Atmosphere-Virtual Lab being established for use by the community for free DA
  - Now: Prototyping with existing data
  - Future: Sentinels







Thanks to collaborators and funders!

CAB-LAB

COUPLED ATMOSPHERE BIOSPHERE VIRTUAL LABORATORY

ESA STSE Coupled Atmosphere Biosphere Virtual Laboratory (CAB-LAB)

esa

Brockmann Consult GmbH

Max Planck Institute for Biogeochemistry

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship

Stockholm University

CARBO Extreme

BACI

SEVENTH FRAMEWORK PROGRAMME

erc
European Research Council
Established by the European Commission

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