Stefan Metzger[1], Ankur R. Desai[2], David Durden[1], Jörg Hartmann[3], Jiahong Li[4], Hongyan Luo[1], Natchaya Pingintha-Durden[1], Torsten Sachs[5], Andrei Serafimovich[5], Cove Sturtevant[1], Ke Xu[2]

[1]: Battelle Ecology, National Ecological Observatory Network Project, Boulder, CO, USA

[2]: University of Wisconsin-Madison, Dept. of Atmospheric and Oceanic Sciences, Madison, WI, USA

[3]: Alfred Wegener Institute - Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

[4]: LI-COR Biosciences, Lincoln, NE, USA

[5]: GFZ German Research Centre for Geosciences, Potsdam, Germany

NEON: from scientific strategy to long-term operation

National Ecological Observatory Network

A project sponsored by the National Science Foundation and operated under cooperative agreement by Battelle.

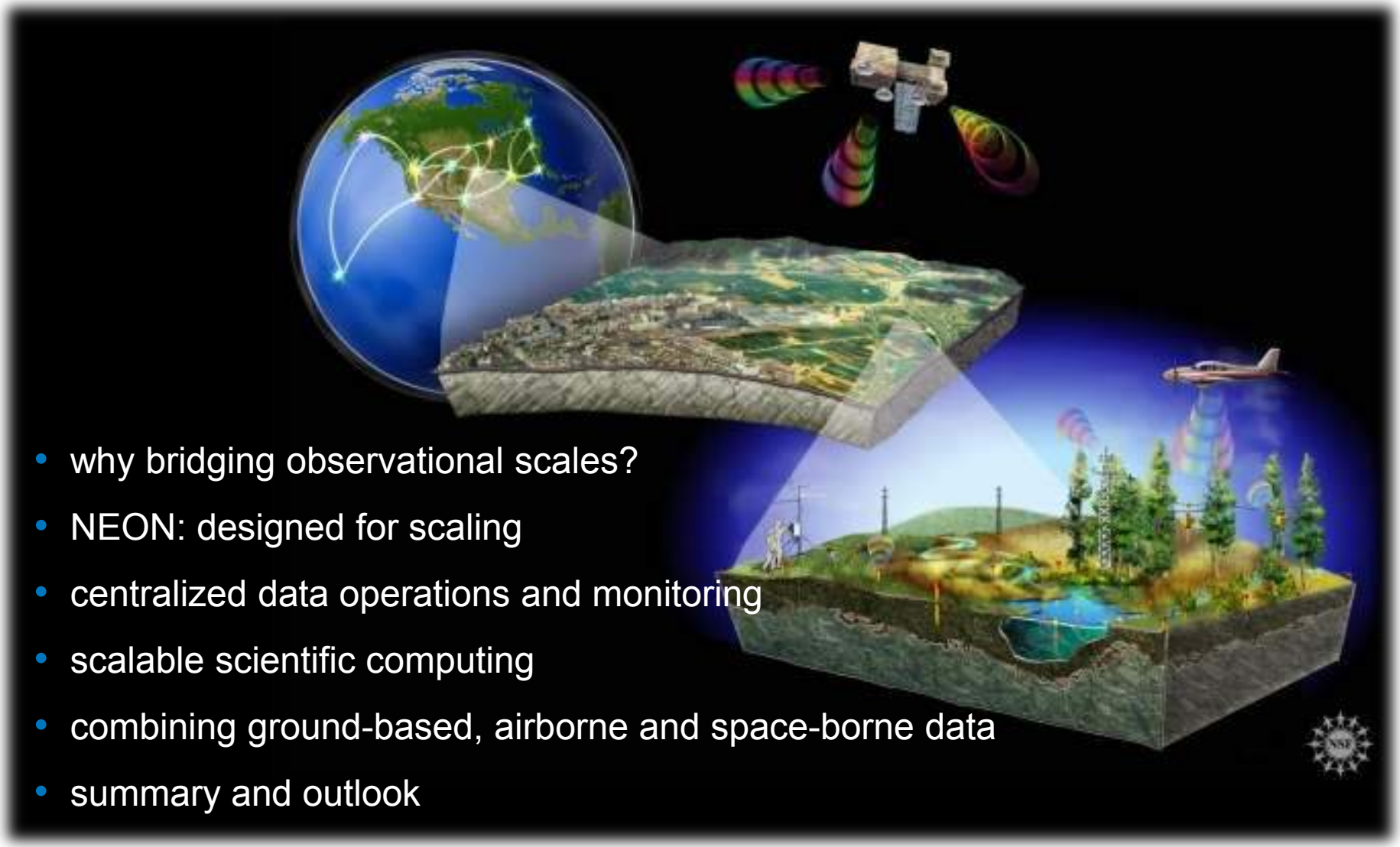
the spirit

- incorporate lessons-learned through collaborations with bottom-up networks like AmeriFlux, ICOS, LTER, TERN…

- NEON's centralized approach lends itself to explore novel systemic solutions

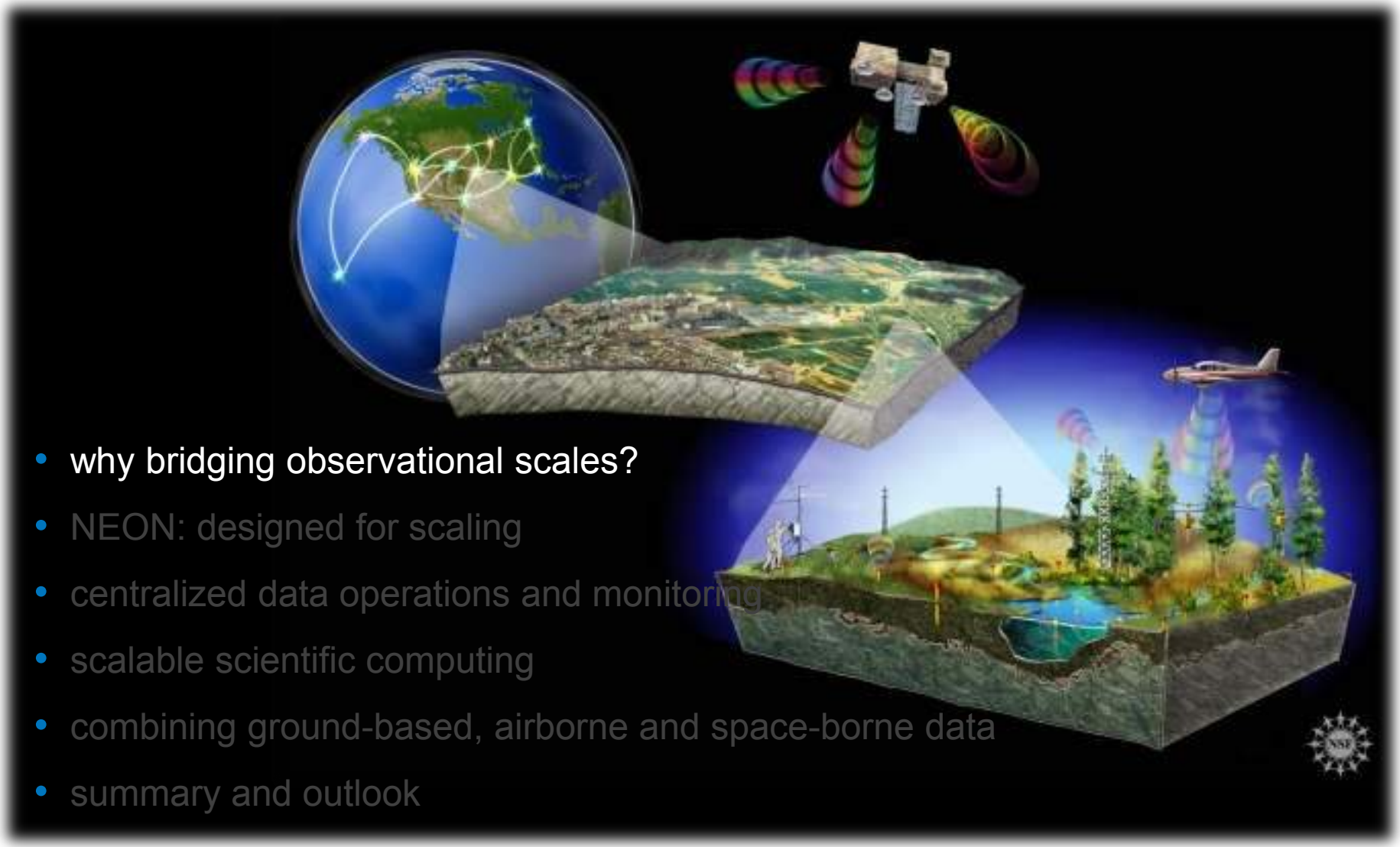
- starting to give back:
  - boots on the ground
  - software
  - data
  - educational resources

overview



- why bridging observational scales?
- NEON: designed for scaling
- centralized data operations and monitoring
- scalable scientific computing
- combining ground-based, airborne and space-borne data
- summary and outlook

overview



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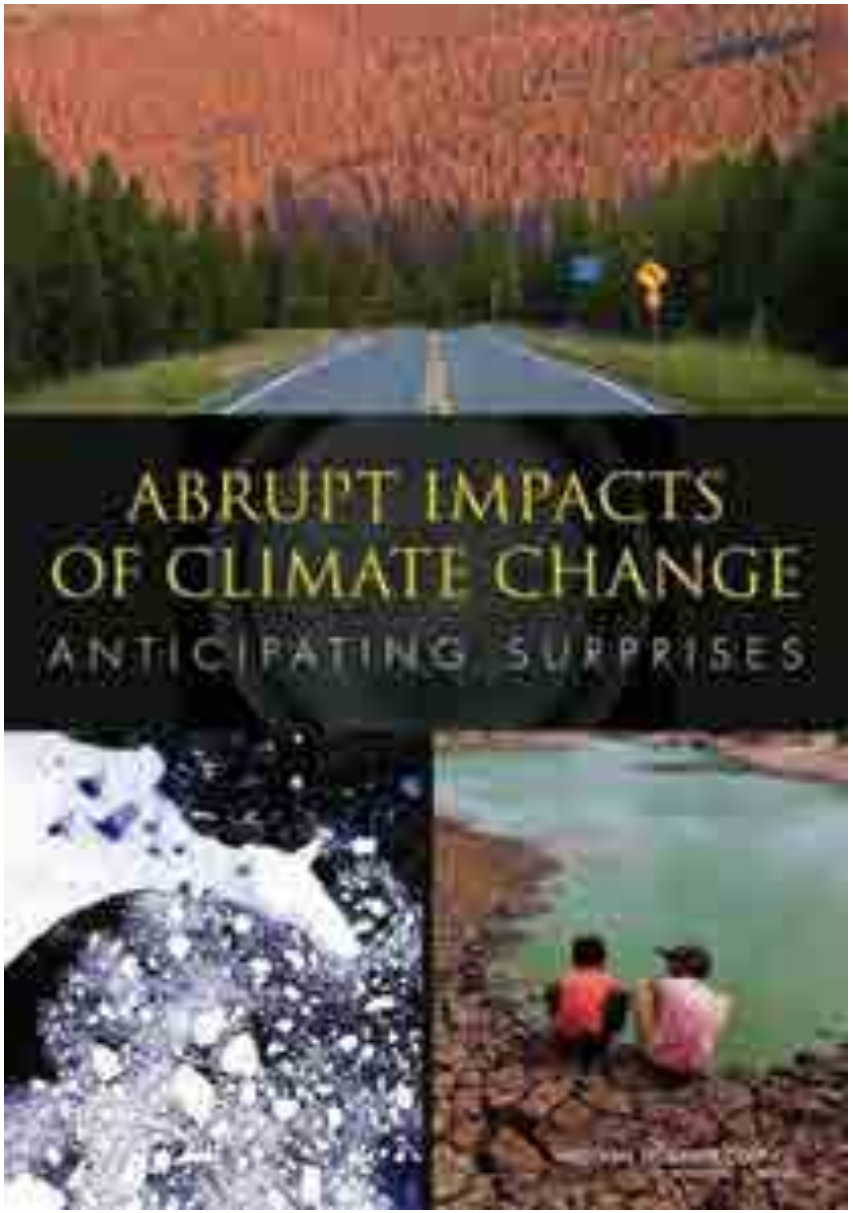
100 YEARS Journal of Ecology

FORUM

Identification of 100 fundamental ecological questions

William J. Sutherland[1], Robert P. Freckleton[2], H. Charles J. Godfray[3], Steven R. Beissinger[4], Tim Benton[5], Duncan D. Cameron[6], Yohay Carmel[7], David A. Coomes[8], Tim Coulson[9], Mark C. Emmerson[10], Rosemary S. Hails[11], Graeme C. Hays[12], Dave J. Hodgson[13], Michael J. Hutchings[14], David Johnson[15], Julia P. G. Jones[16], Matt J. Keeling[17], Hanna Kokko[18], William E. Kunin[19], Xavier Lambin[20], Owen T. Lewis[21], Yadvinder Malhi[22], Nova Mieszkowska[23], E. J. Milner-Gulland[24], Ken Norris[25], Albert B. Phillimore[26], Drew W. Purves[27], Jane M. Reid[28], Daniel C. Reuman[29,30], Ken Thompson[3], Justin M. J. Travis[14], Lindsay A. Turnbull[31], David A. Wardle[32] and Thorsten Wiegand[33]

- How does spatial structure influence ecosystem function and how do we integrate within and between spatial scales to assess function?



- "…data still remain too sparse spatially to test mechanisms of change using models…"

- "…provide the required data at high spatial and temporal resolution with the necessary continuity…"

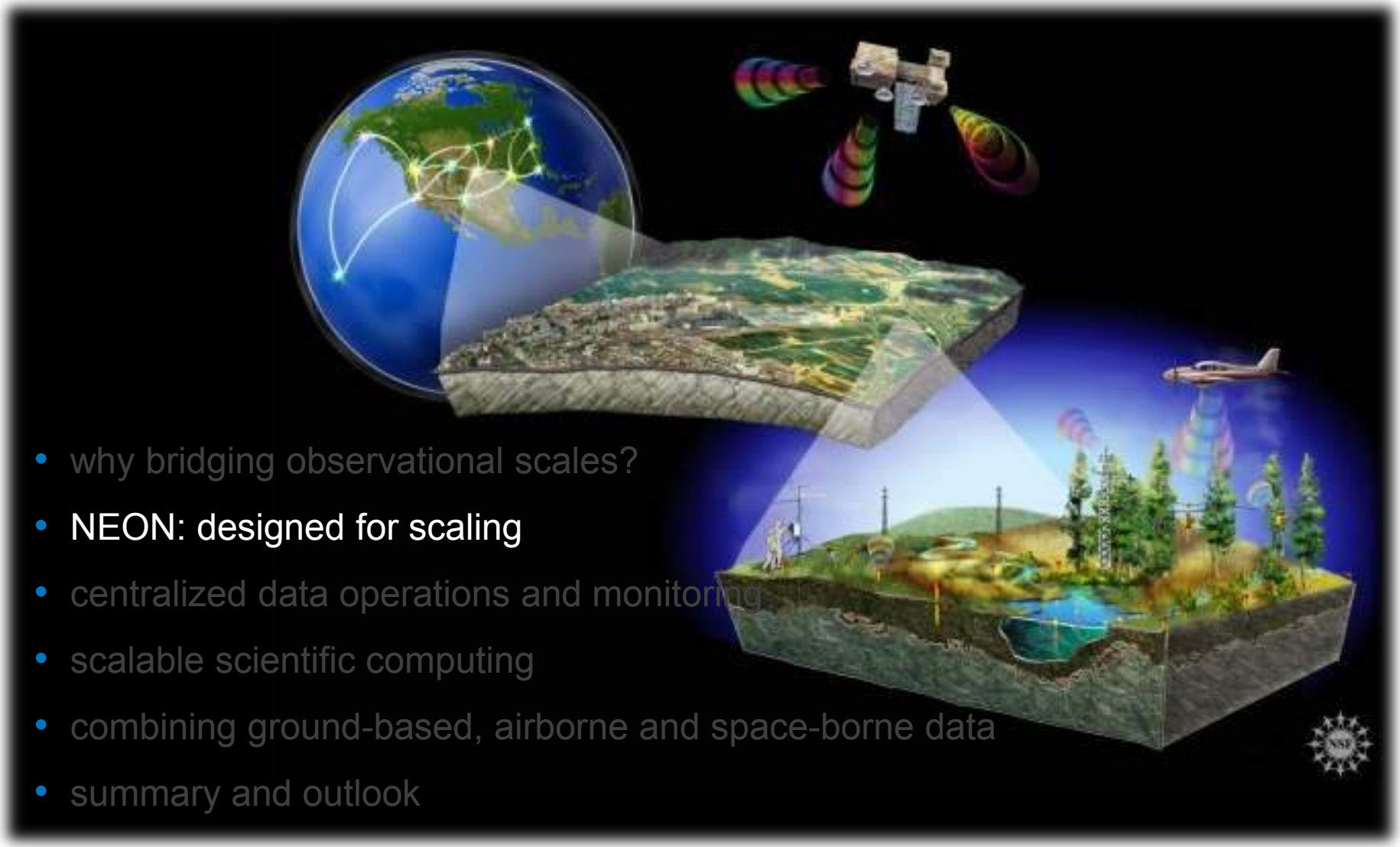
ECOSYSTEMS

COMMENTARY

Carbon Metabolism of the Terrestrial Biosphere: A Multitechnique Approach for Improved Understanding

- "... scaling down from global and continental measurements and scaling up from stand-level measurements both are critical for an integrative program of C research."
- "Each approach has different spatial and temporal domains ..., and they have the potential to constrain the next level up or down"
- "One of the main barriers to rapid improvement of models is the lack of ground data for validation purposes."

overview



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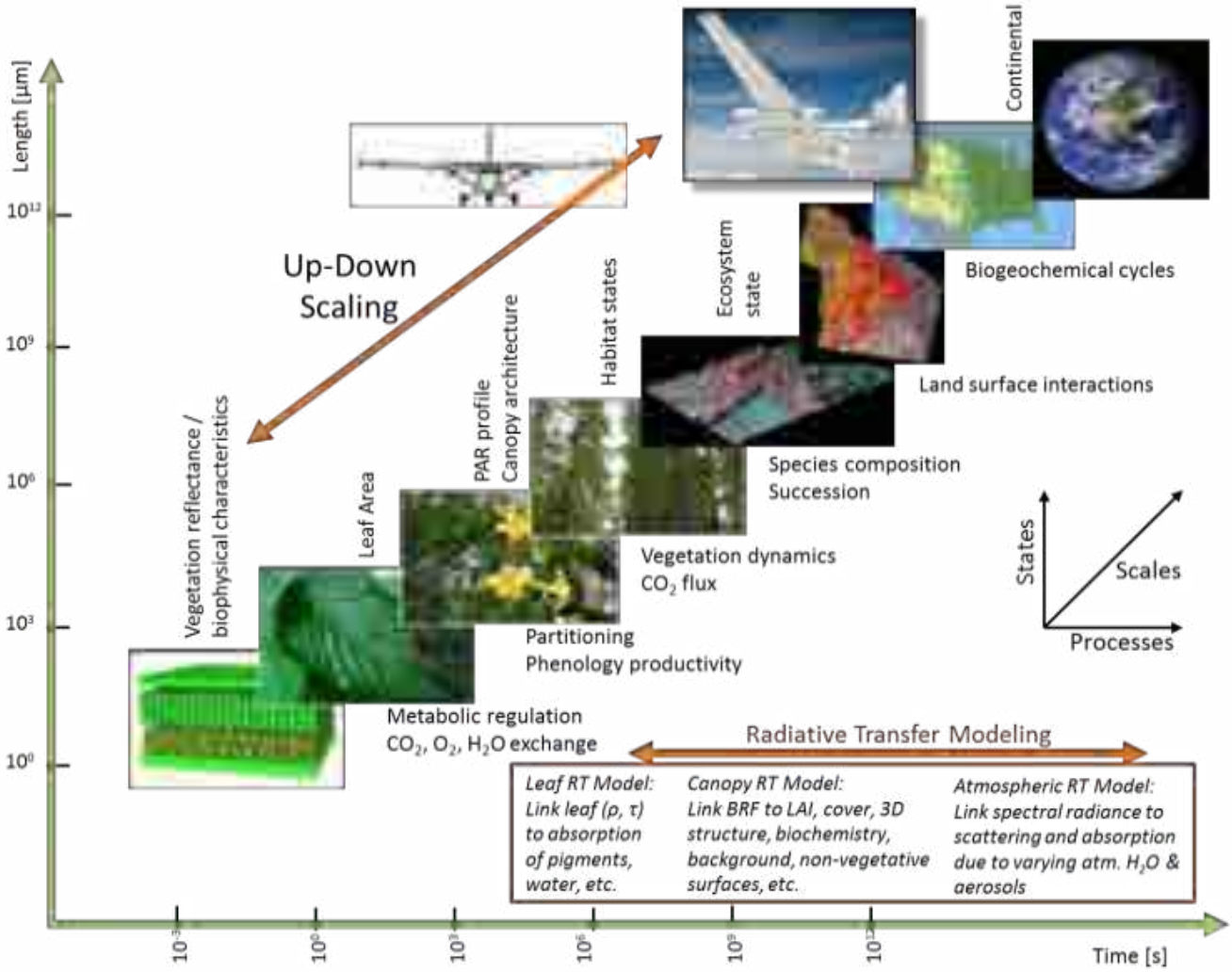
The National Ecological Observatory Network

NEON multi-scale observing system



state of the NEON “fairytale”

state of the NEON “fairytale”

instrumented sites

D01: HARVARD FOREST

instrumented sites

D02: Smithsonian Environmental Research Center - SERC

instrumented sites

D03: Ordway-Swisher Biological Station - OSBS

instrumented sites

D03: Ordway-Swisher Biological Station - Barco Lake - BARC

instrumented sites

D05: UNDERC - UNDE

instrumented sites

D07: Mountain Lake Biological Station - MLBS

instrumented sites

D07: Walker Branch - WALK

instrumented sites

D10: North Sterling, CO - STER

instrumented sites

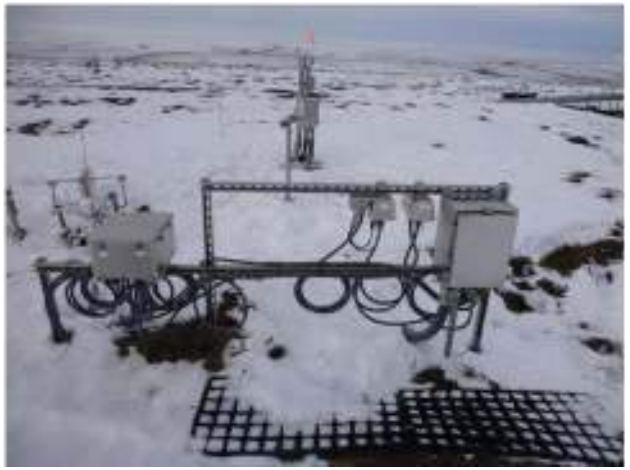
D10: Arikaree River - ARIK

instrumented sites

D14: Santa Rita Experimental Range - SRER

instrumented sites

D18: Toolik - TOOL



instrumented sites

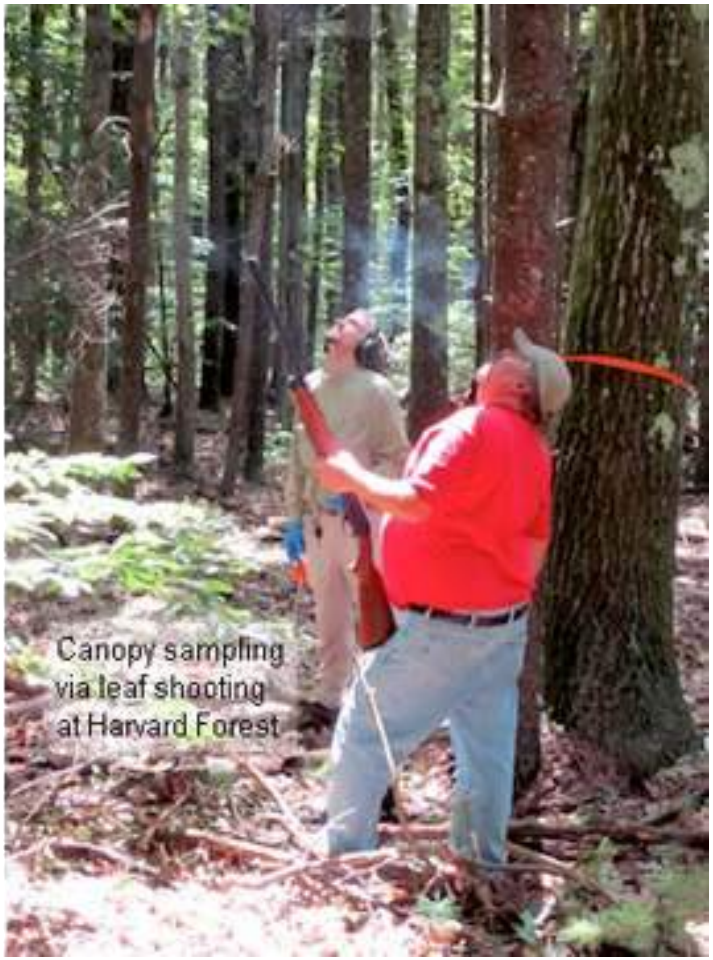
D18: Barrow Environmental Observatory - BARR

in-situ sampling, proximal and remote sensing

Field survey

in-situ sampling, proximal and remote sensing

Field sampling



in-situ sampling, proximal and remote sensing

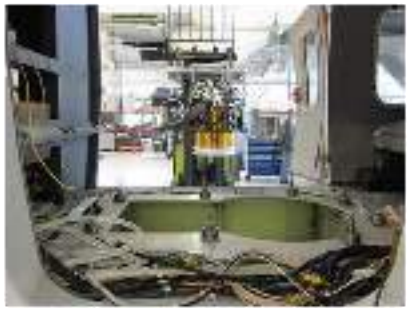
Field sampling

in-situ sampling, proximal and remote sensing

Field sampling

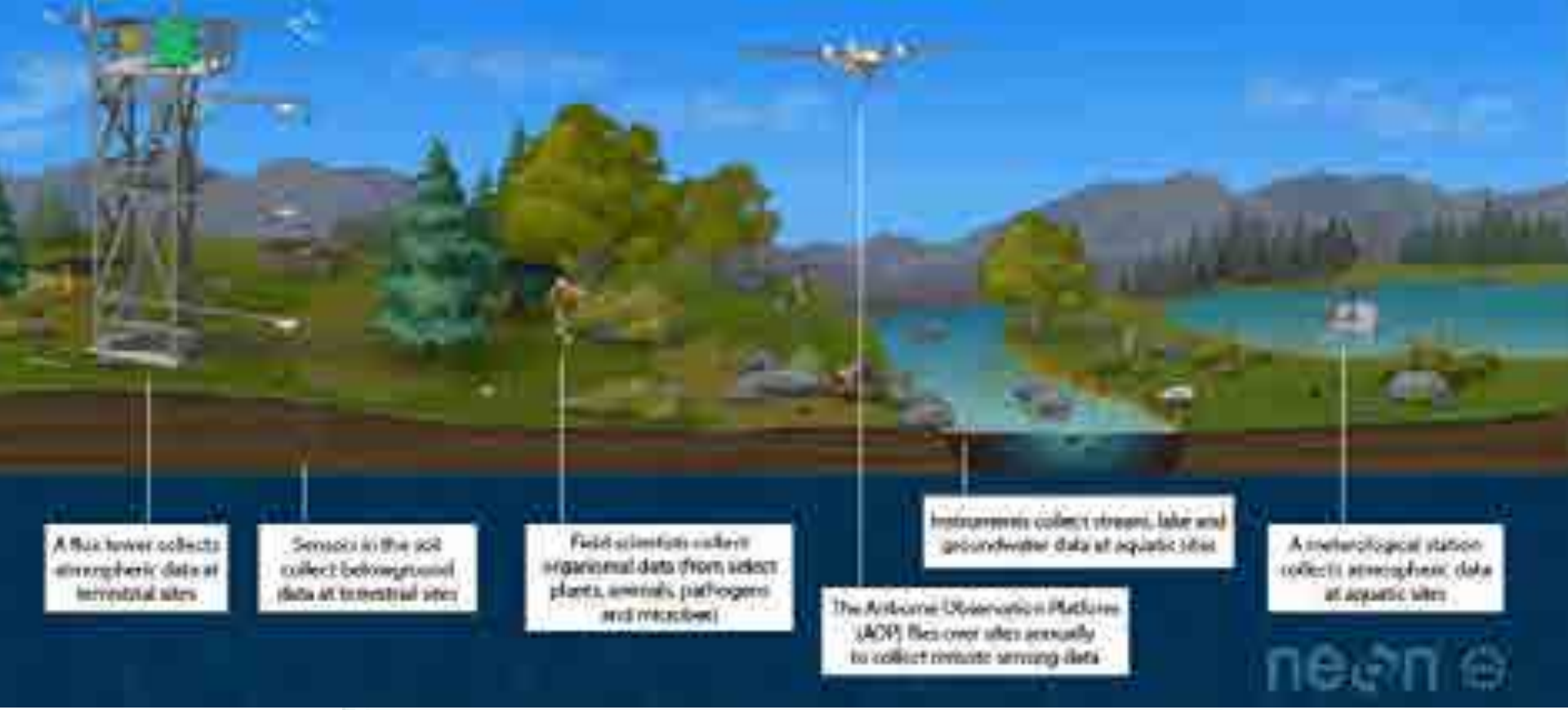
in-situ sampling, proximal and remote sensing

NEON AOP Flight Operations



in-situ sampling, proximal and remote sensing

Atmospheric Correction



Field Sites will be located in

24

STATES

(plus Puerto Rico)

The Observatory will include

81

FIELD SITES

(47 Terrestrial 34 Aquatic)

NEON will offer approximately

195

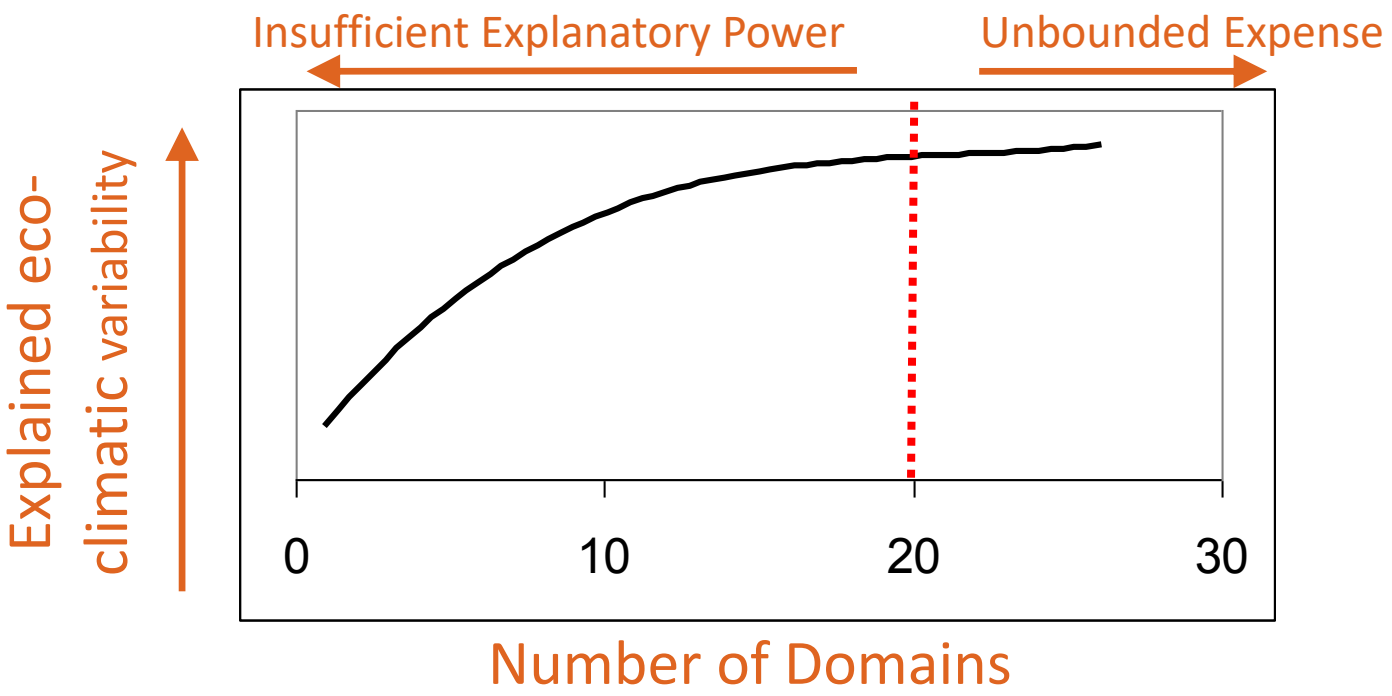
DATA PRODUCTS

(spanning decades and standardized across sites)

the National Ecological Observatory Network

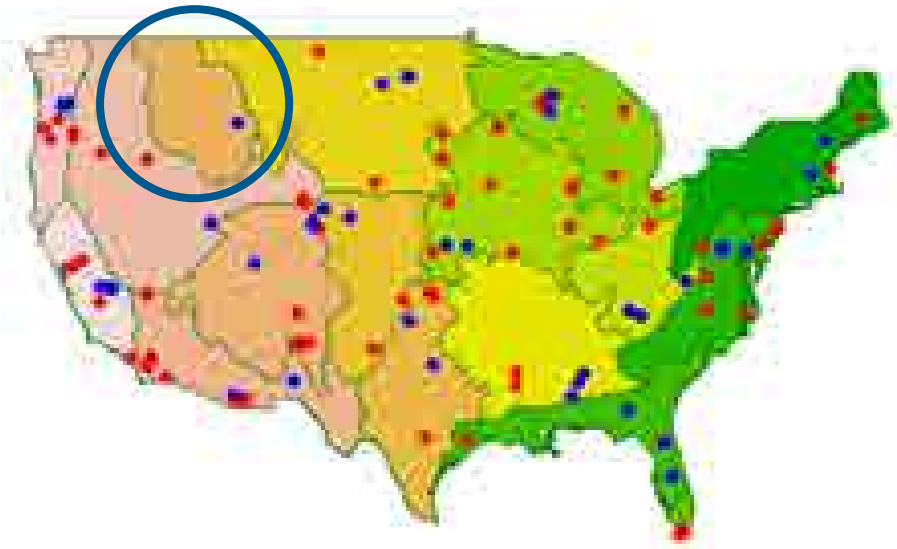
why 20 domains?

Potential of Multivariate Quantitative Methods for Delineation and Visualization of Ecoregions



data: science implications

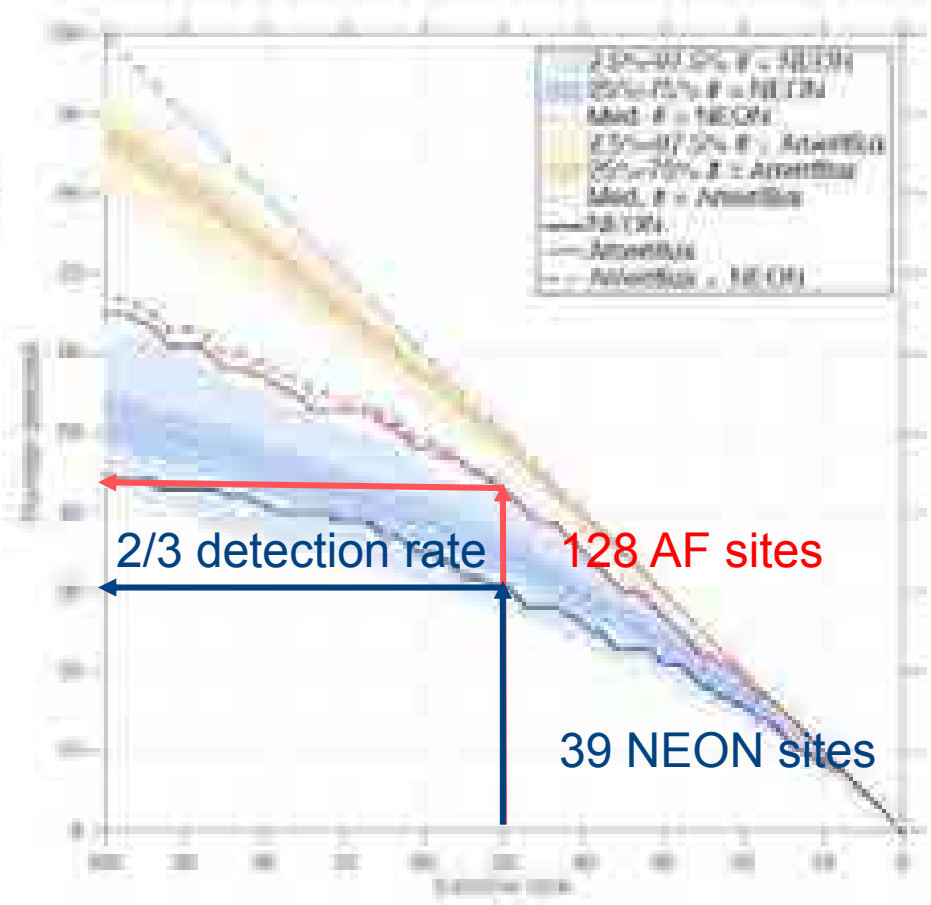
sites across eco-climatic regions



- AmeriFlux
- NEON

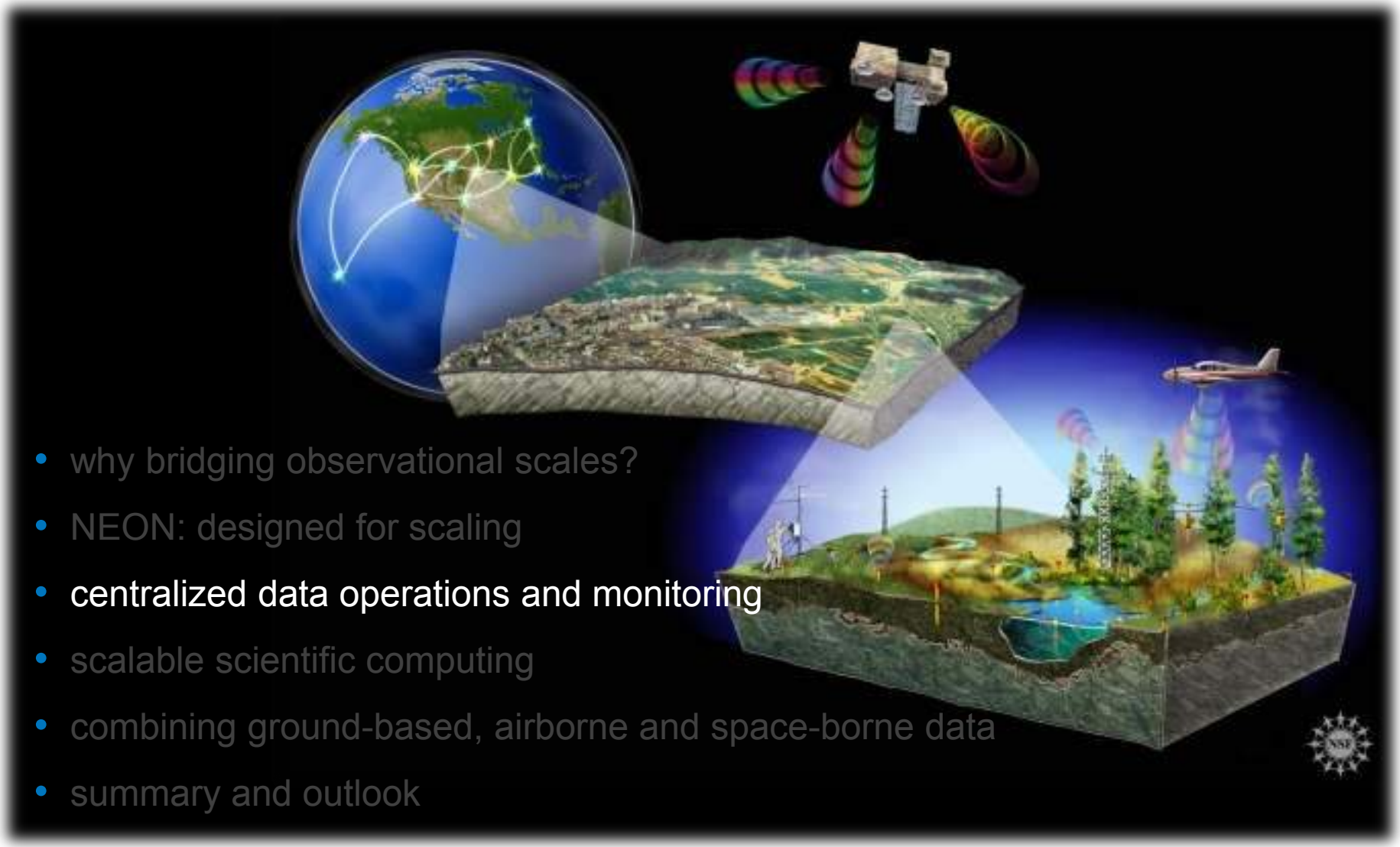
Hargrove and Hoffman, 1999 & 2004

detecting extreme events



Mahecha et al., 2017

overview



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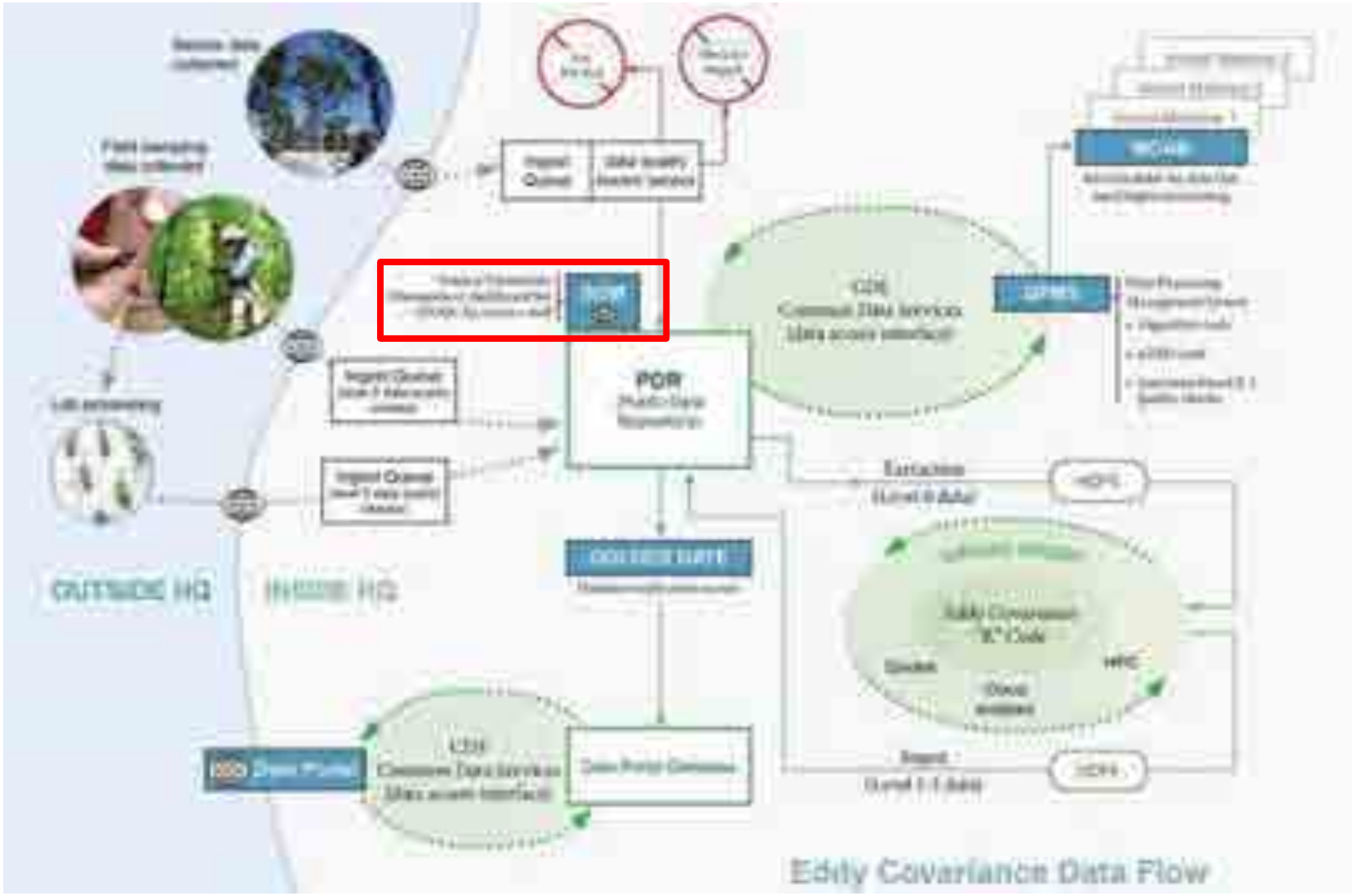
data operations architecture



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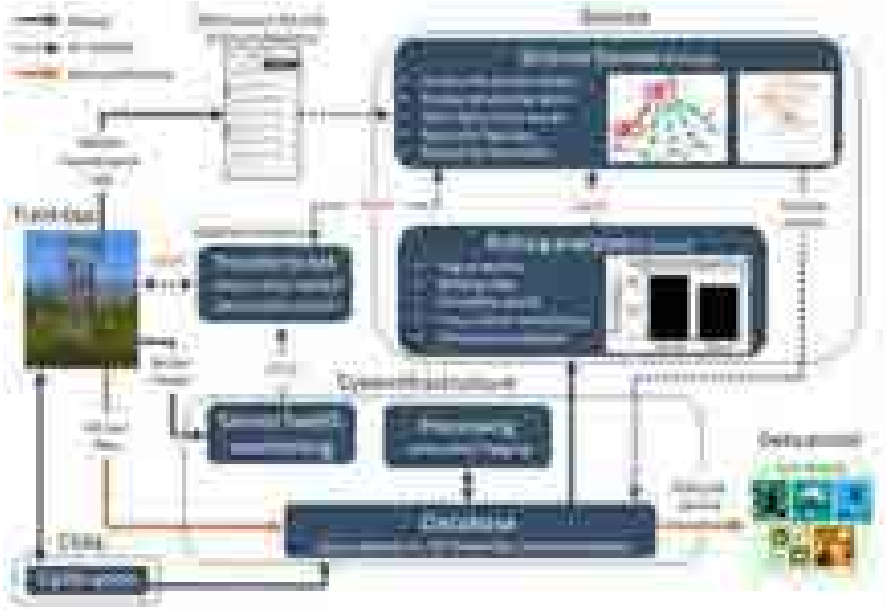
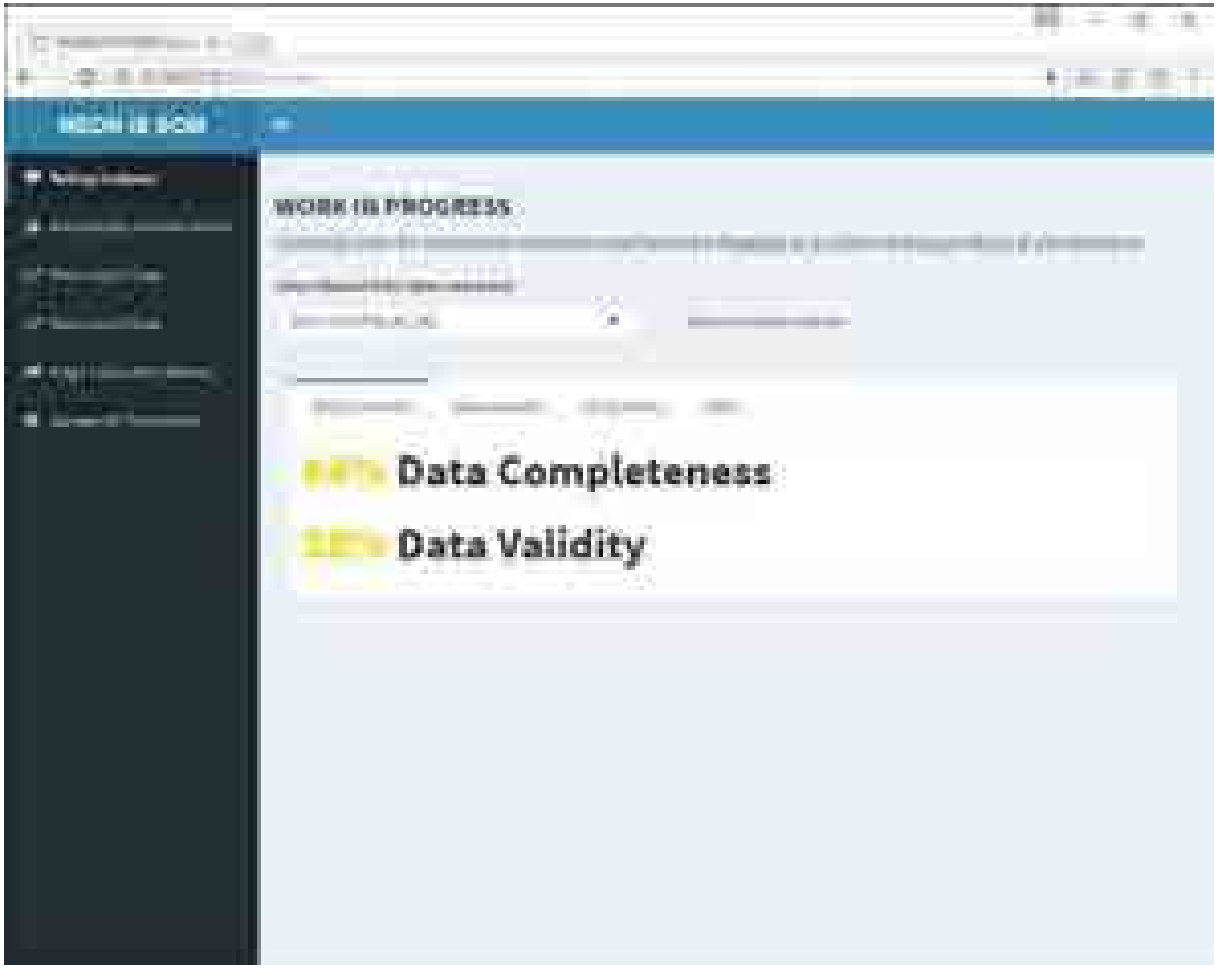
science operations management

- problem tracking and resolution along the entire chain
  - training
  - sensor preventive maintenance
  - sensor calibration
  - sensor health status monitoring, incident tracking and resolution
  - data processing
  - continuous data quality monitoring
  - data revisioning



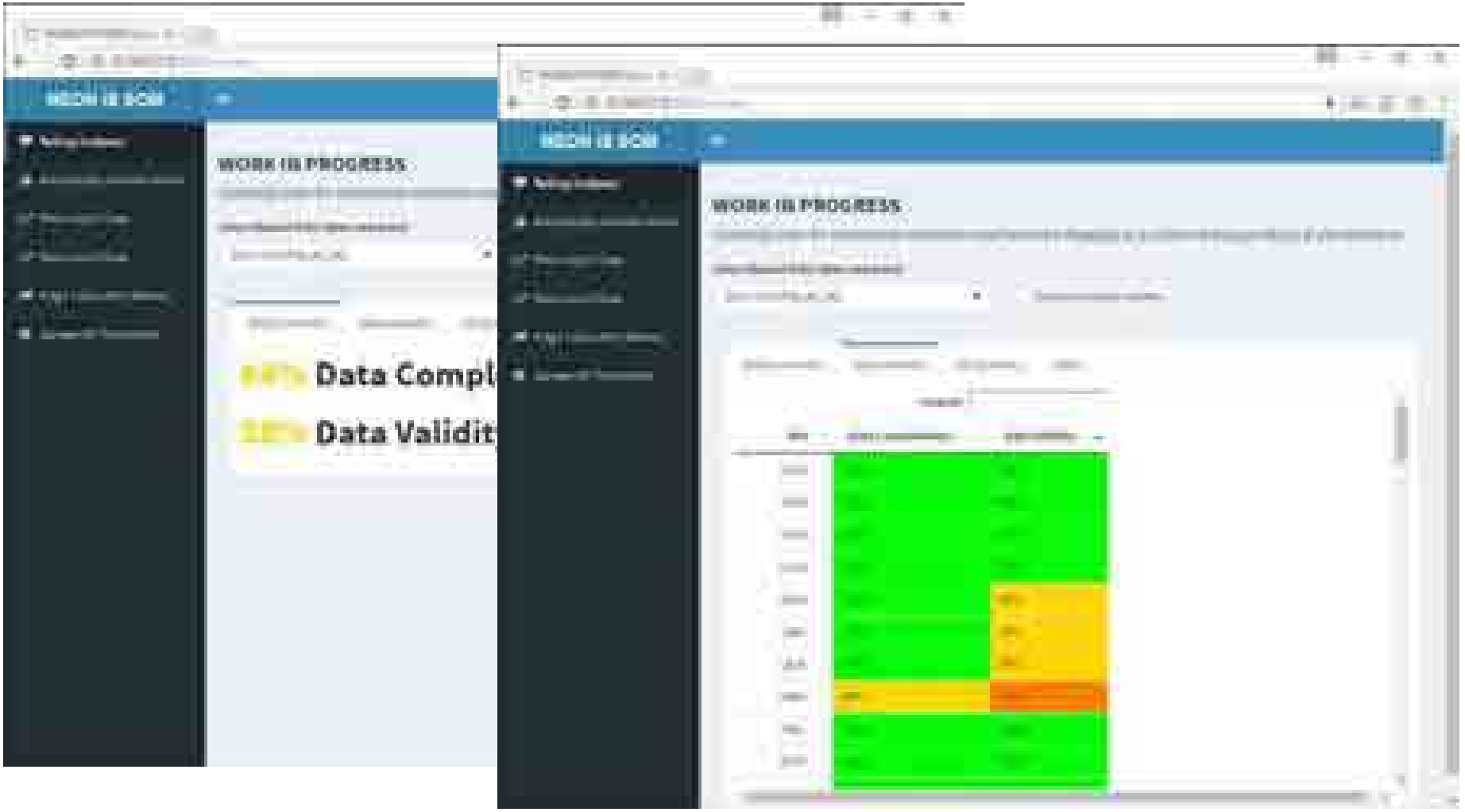
science operations management

- problem tracking and resolution along the entire chain



science operations management

- problem tracking and resolution along the entire chain

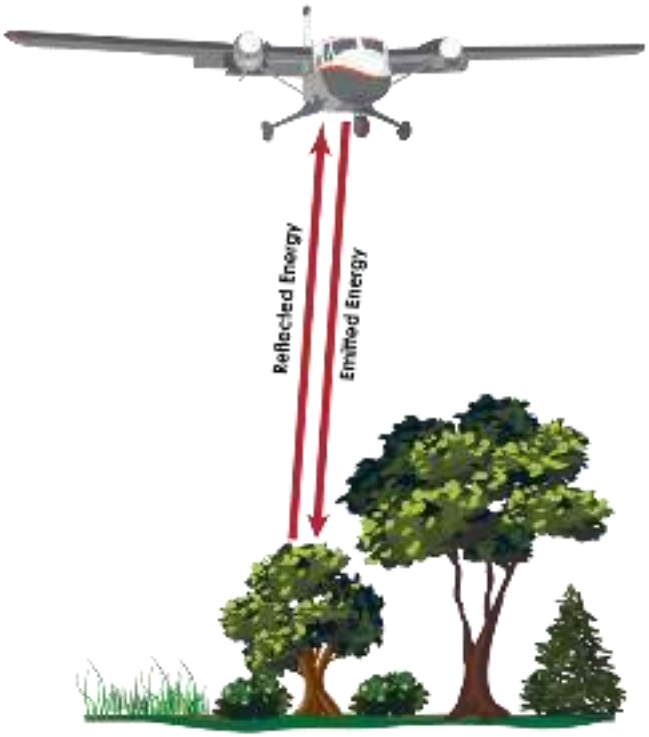


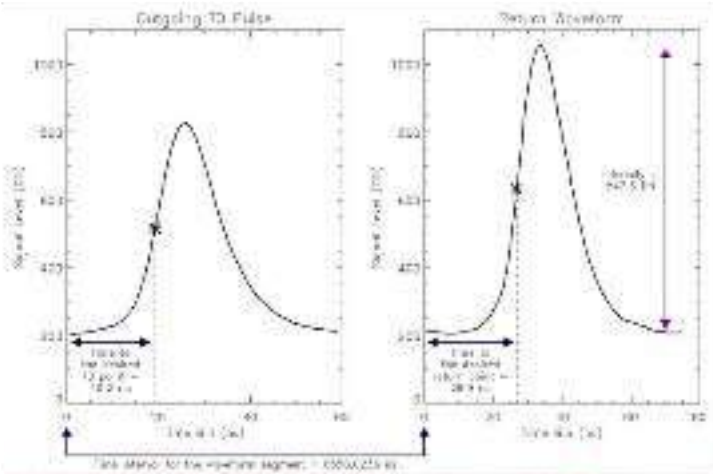
data products and access

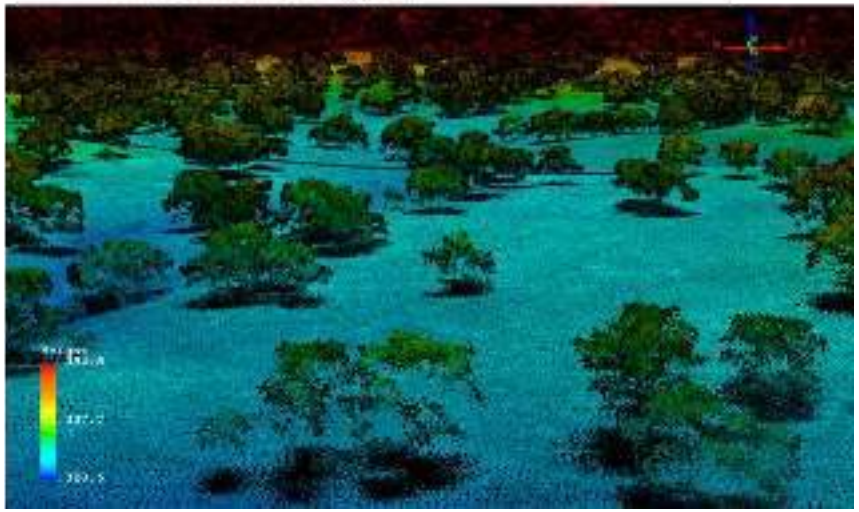
Digital Camera Imagery

data products and access

NEON discrete LiDAR Data – Point Cloud

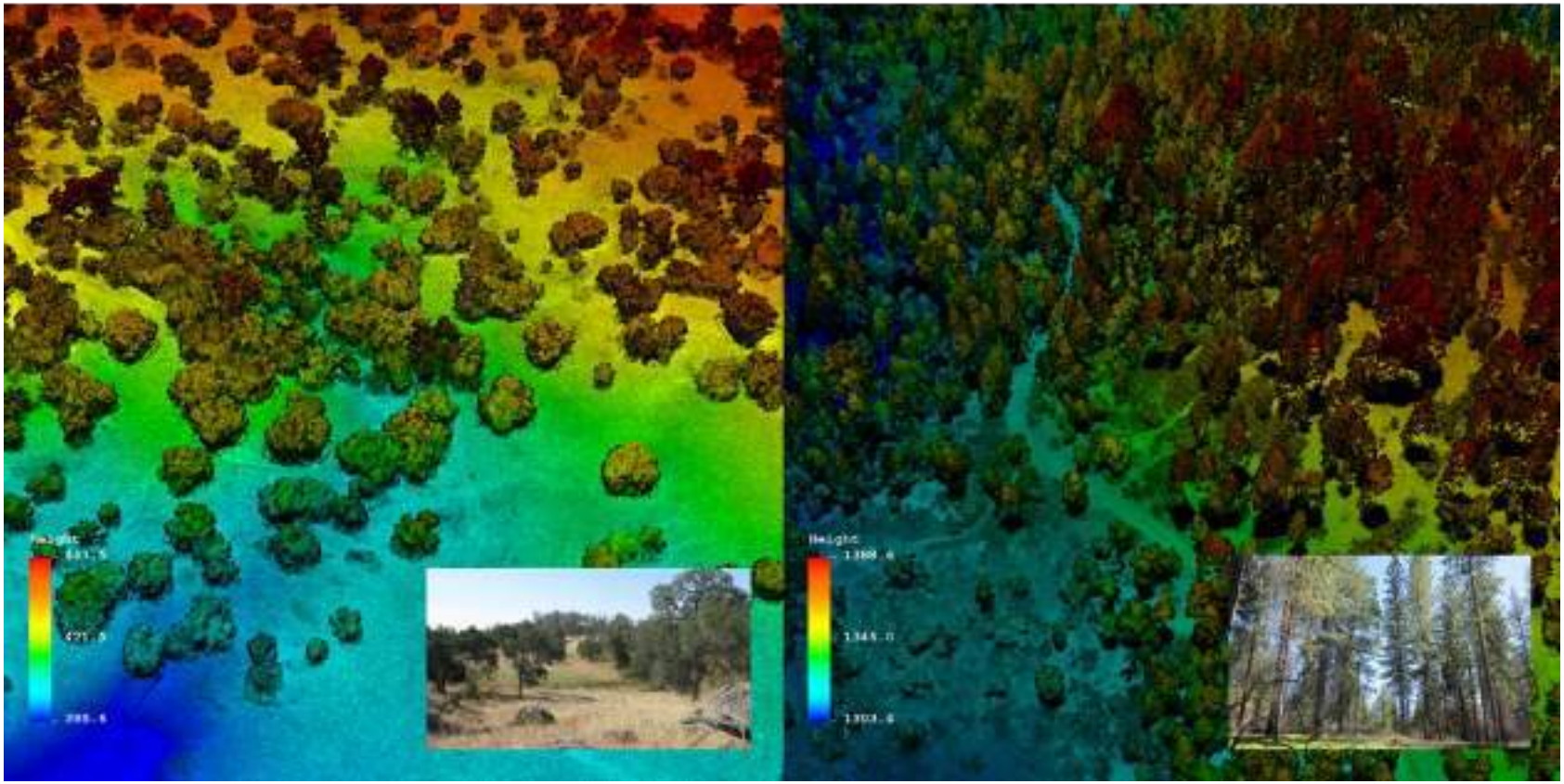






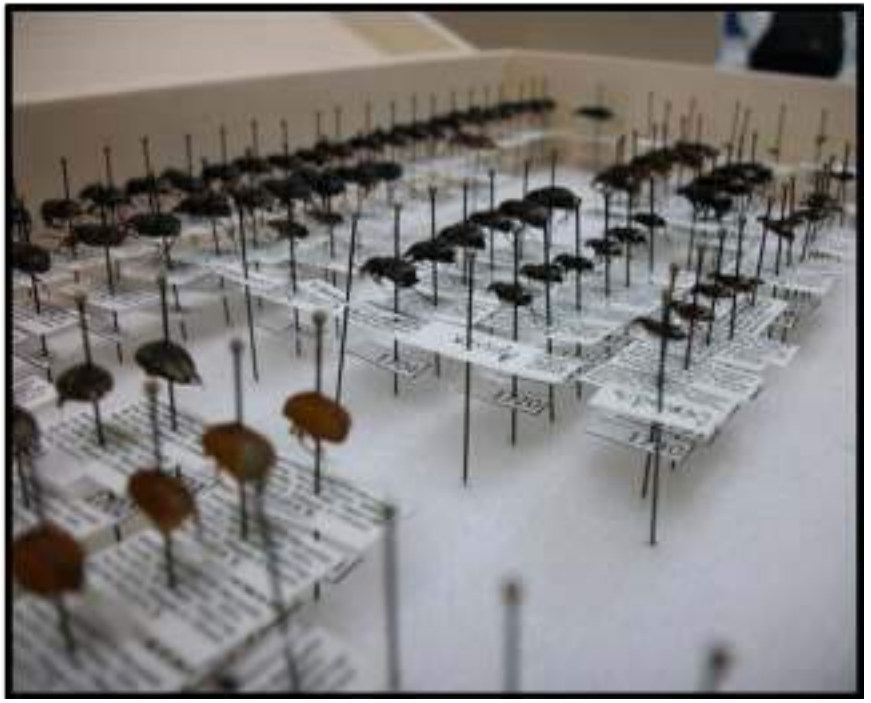
data products and access

Discrete and Waveform LiDAR



data products and access

Sample archiving



data products and access

data: interoperability

Pilot project: global interoperability

Globally interoperable eddy-covariance data products through affiliating NEON sites with AmeriFlux and FLUXNET

Authors: [illegible]

Affiliations: [illegible]

- NEON gains participation in a globally harmonized network, improving scientific value and cross-network use
- AmeriFlux gains 40% additional active sites
- User community gains interoperable data products across networks with increased eco-climatic coverage

neon

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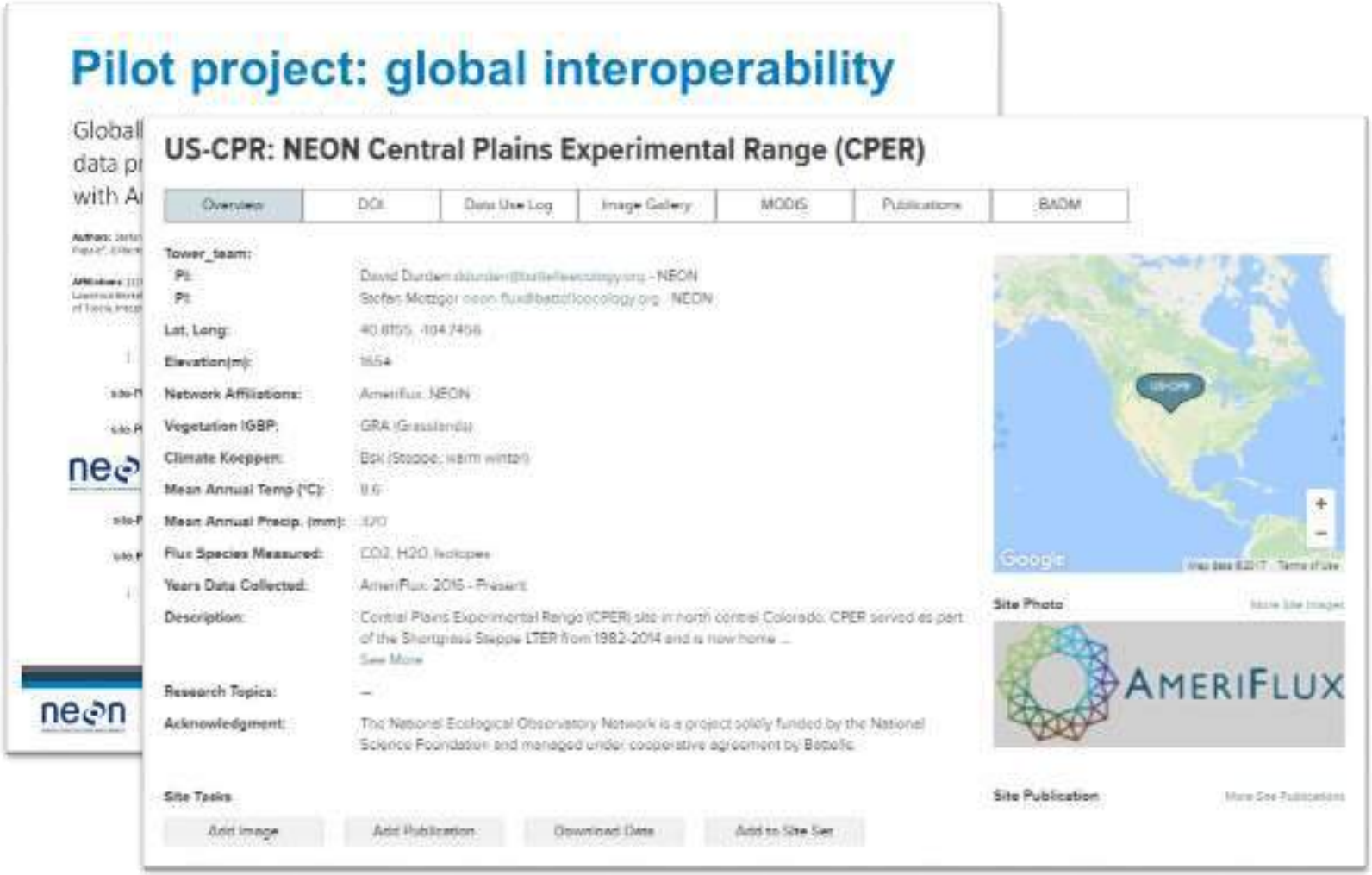
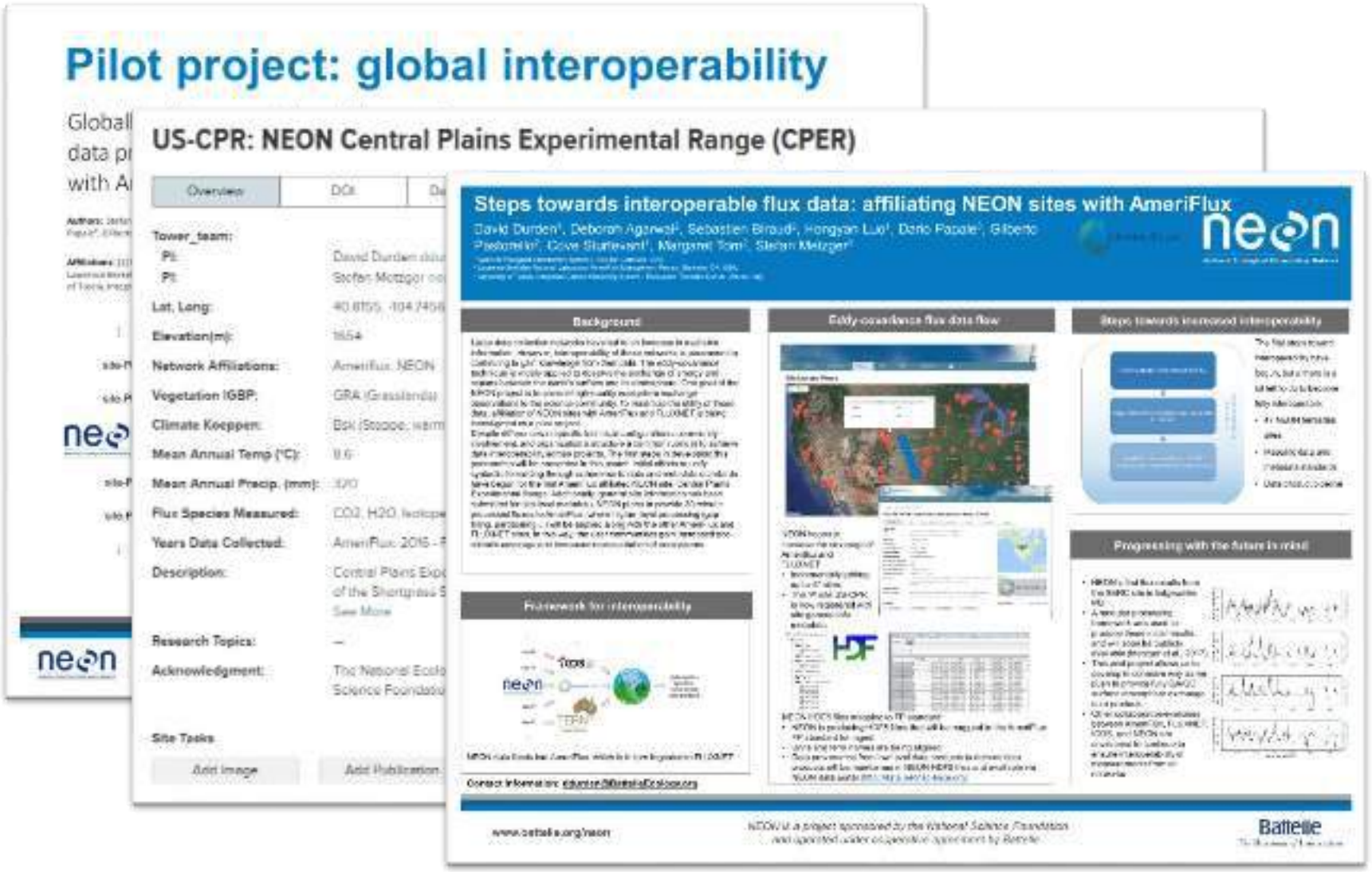
data: interoperability



data: interoperability



data: interoperability

Pilot project: global interoperability

US-CPR: NEON Central Plains Experimental Range (CPER)

Overview | DOI

Tower_team:
PI:
PI:

Lat, Long:
Elevation(m):
Network Affiliations:
Vegetation IGBP:
Climate Koeppen:
Mean Annual Temp (°C):
Mean Annual Precip. (mm):
Flux Species Measured:
Years Data Collected:
Description:
Research Topics:
Acknowledgment:
Site Tasks
Add Image | Add Publication

Steps towards interoperable flux data: affiliating NEON sites with AmeriFlux

David Durden, Deborah Agarwal, Sebastien Biraud, Hongyan Luo, Dario Papale, Gilberto Pastorello, Cove Sturtevant, Margaret Torn, Stefan Metzger

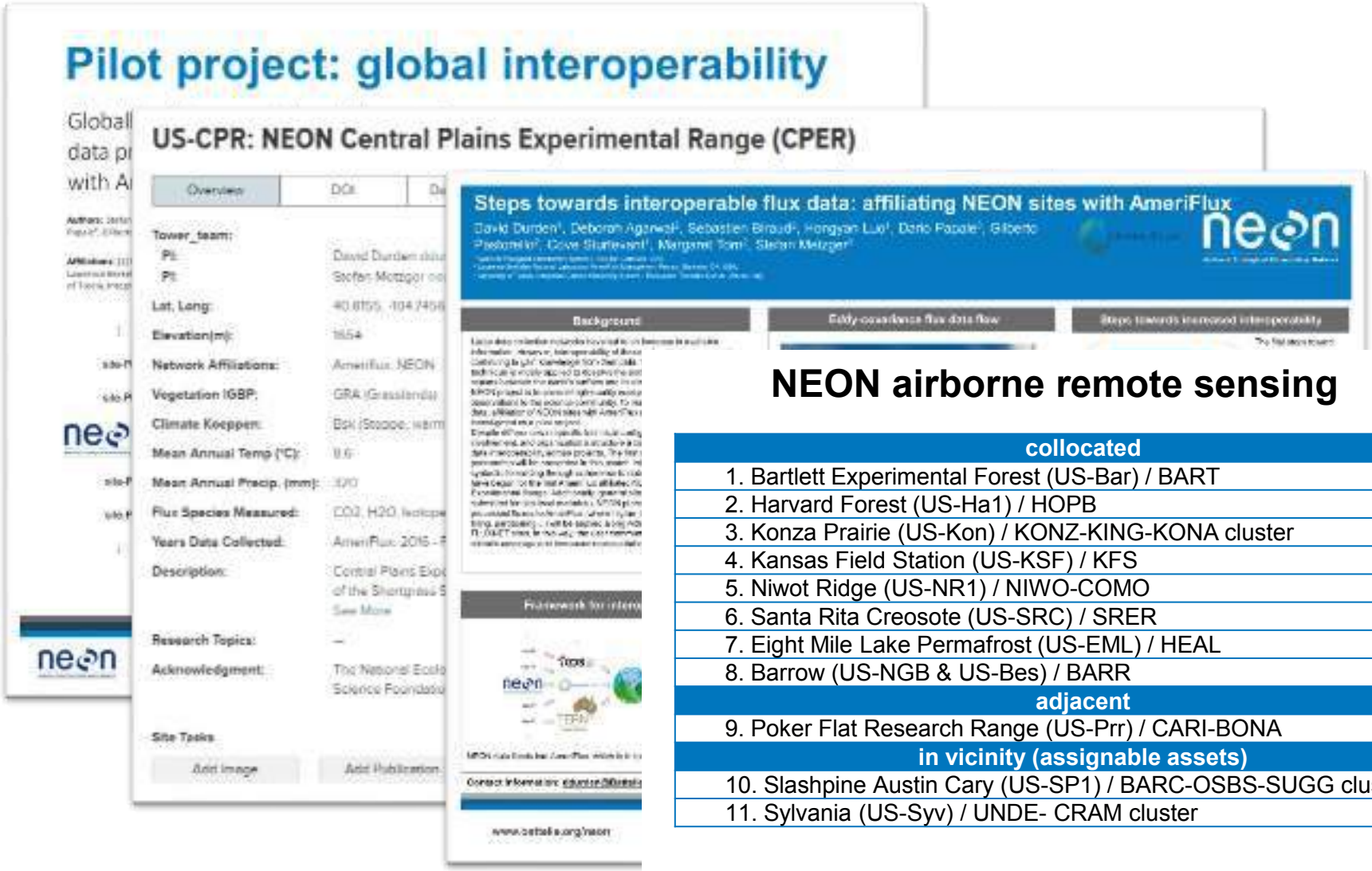
Background | Eddy-covariance flux data flow | Steps towards increased interoperability

Framework for interoperability

www.cattails.org/neon

NEON airborne remote sensing

data: interoperability

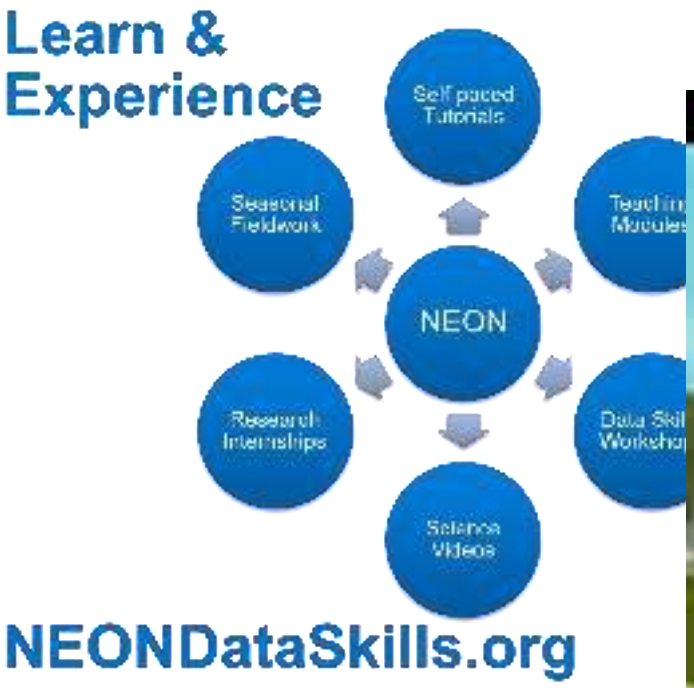


NEON airborne remote sensing

collocated
1. Bartlett Experimental Forest (US-Bar) / BART
2. Harvard Forest (US-Ha1) / HOPB
3. Konza Prairie (US-Kon) / KONZ-KING-KONA cluster
4. Kansas Field Station (US-KSF) / KFS
5. Niwot Ridge (US-NR1) / NIWO-COMO
6. Santa Rita Creosote (US-SRC) / SRER
7. Eight Mile Lake Permafrost (US-EML) / HEAL
8. Barrow (US-NGB & US-Bes) / BARR
adjacent
9. Poker Flat Research Range (US-Prr) / CARI-BONA
in vicinity (assignable assets)
10. Slashpine Austin Cary (US-SP1) / BARC-OSBS-SUGG cluster
11. Sylvania (US-Syv) / UNDE- CRAM cluster

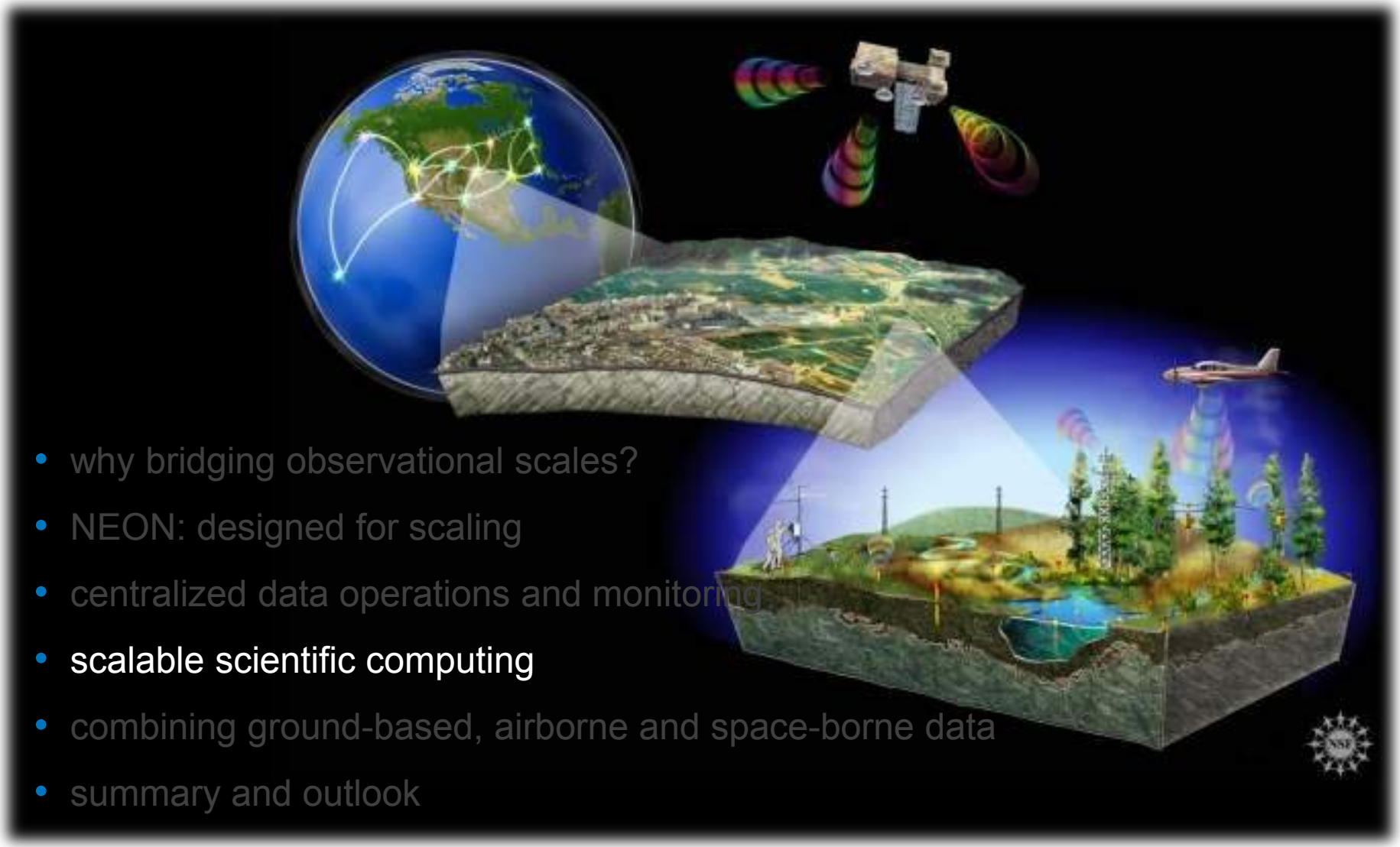
educational resources

educational resources



educational resources

overview



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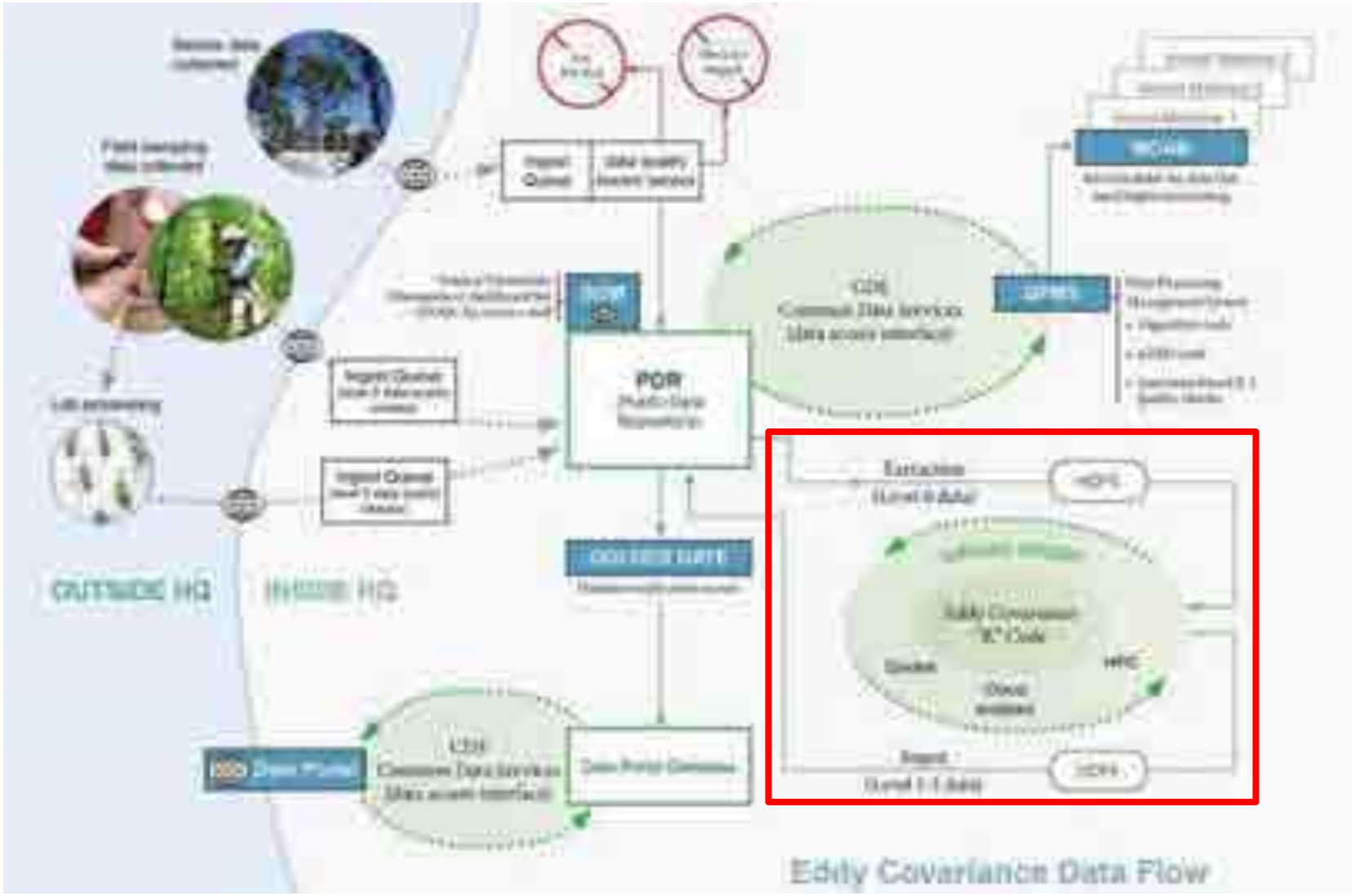
data operations architecture



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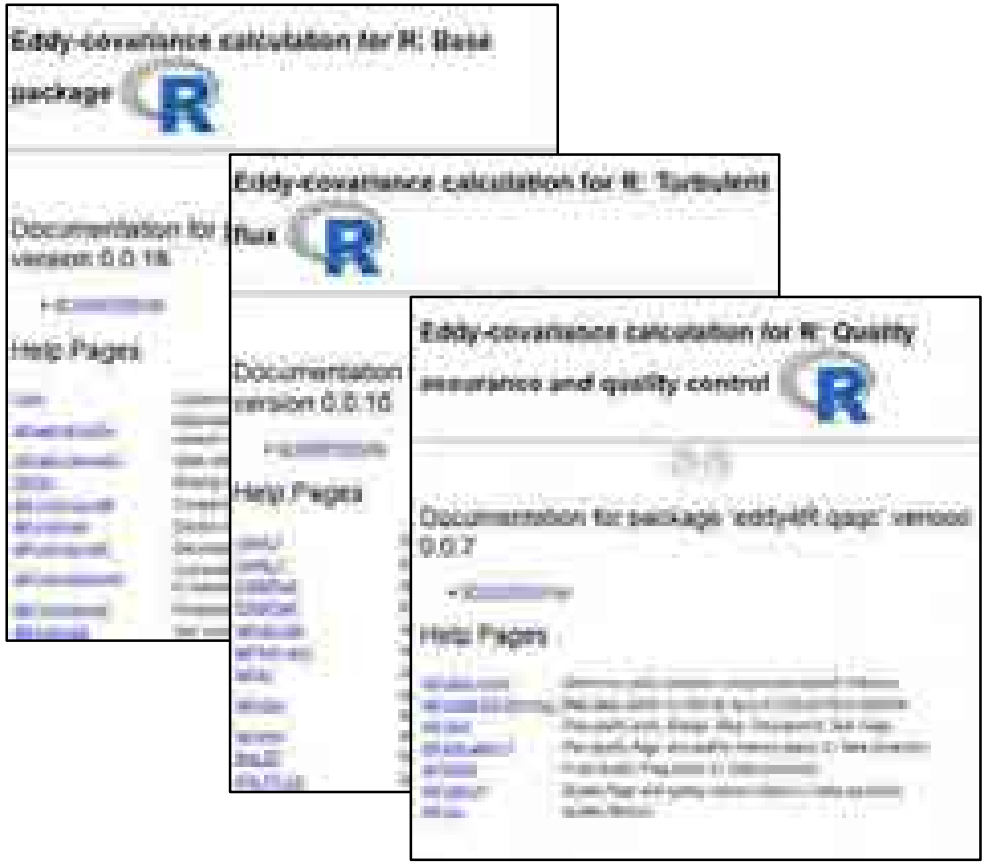
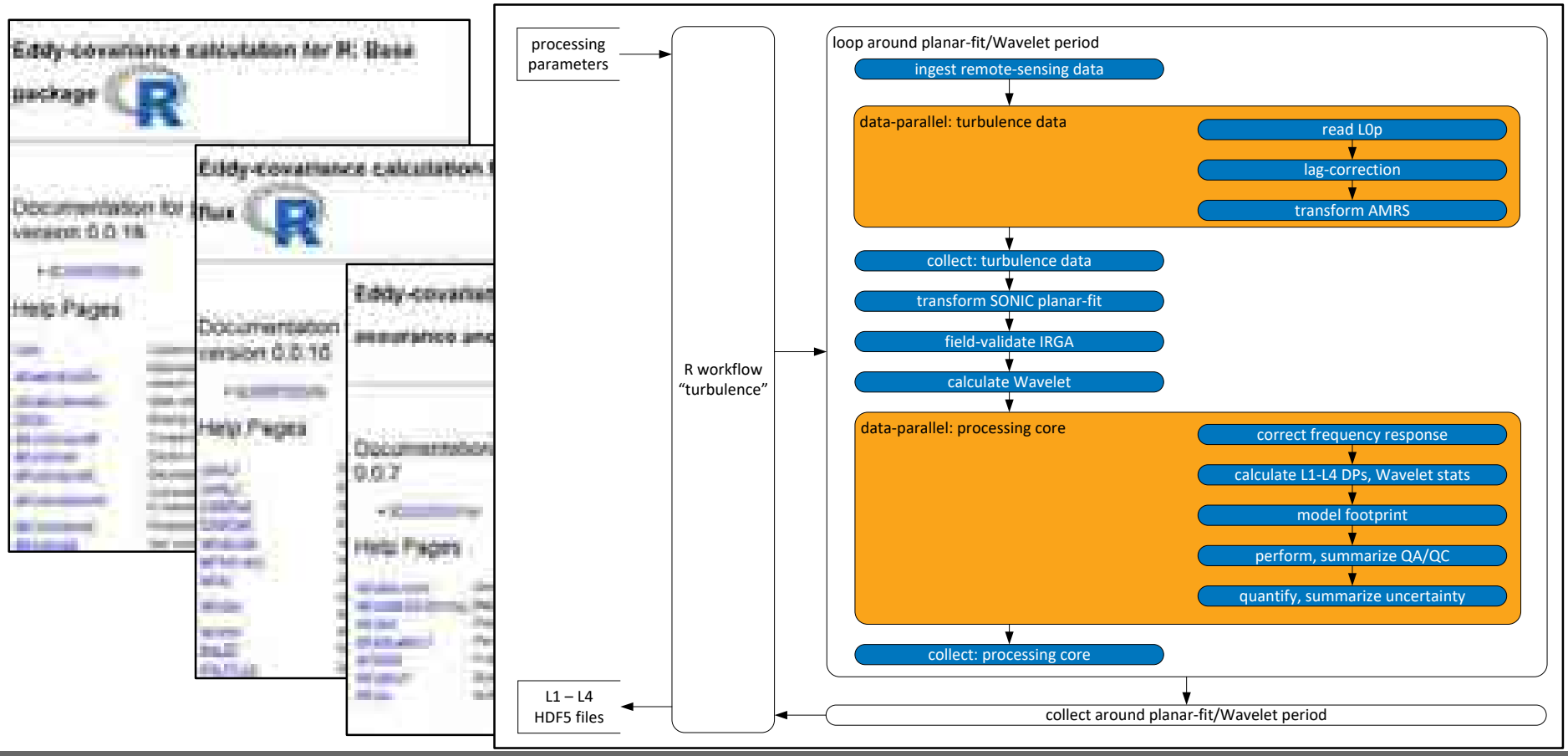
software: eddy4R eddy-covariance R-packages

- eddy4R family of R-packages (raw data → 30 min)



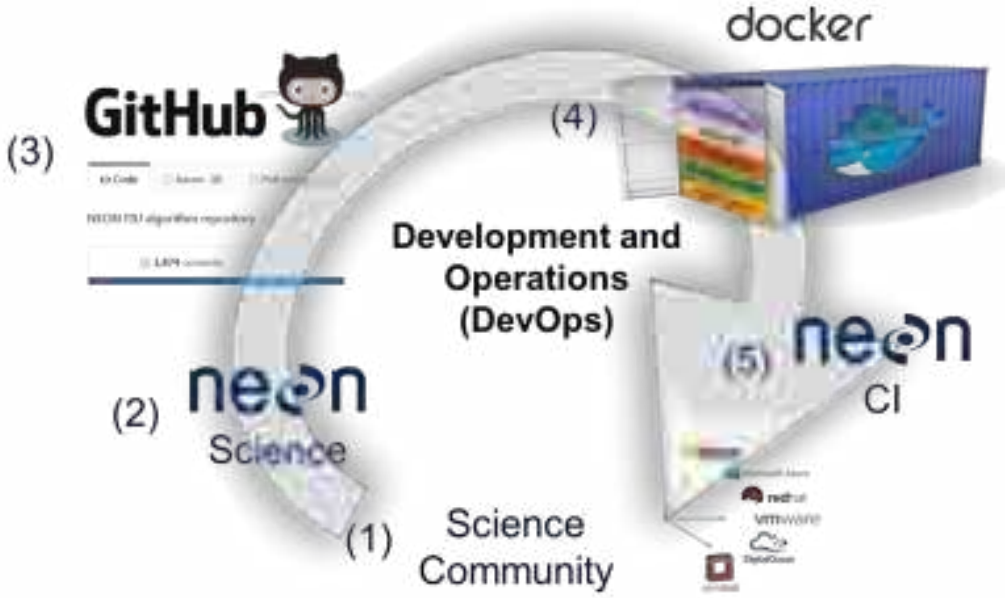
software: eddy4R eddy-covariance R-packages

- eddy4R family of R-packages (raw data → 30 min)
- NEON's eddy4R, nneo, metscanner + MPI's REddyProc R-packages: end-to-end, modularly adjustable and extensible workflows in single R-environment

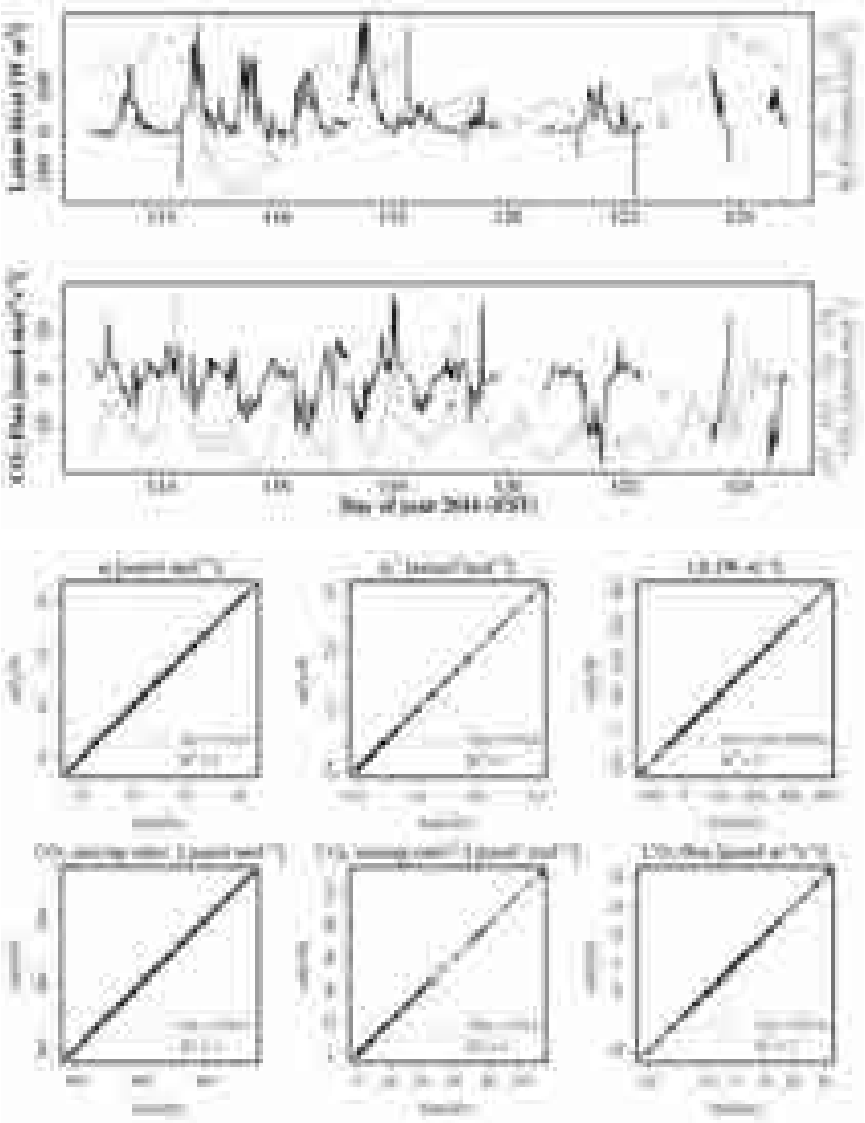


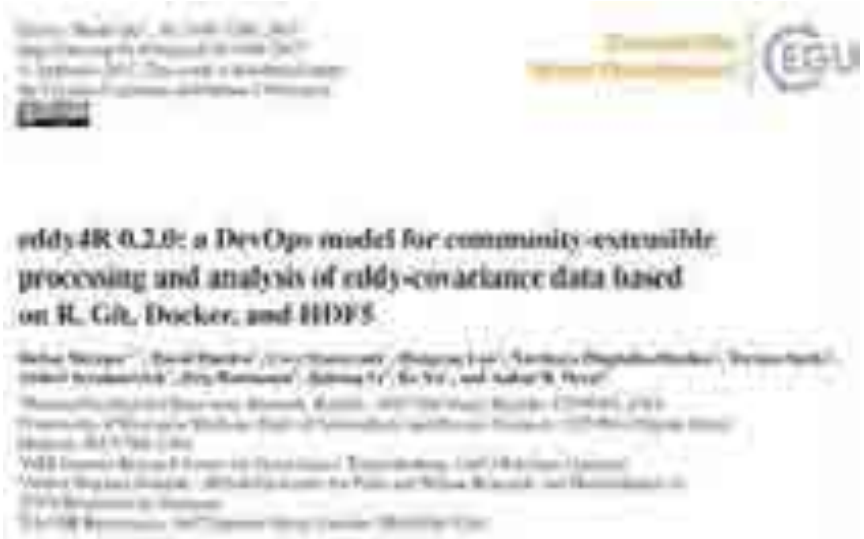
software: community access and extensibility

- Docker shipping container system for code
- eddy4R-Docker: turn-key, reproducible, extensible and portable data processing + analysis environment
- DevOps community development framework



data: eddy-covariance



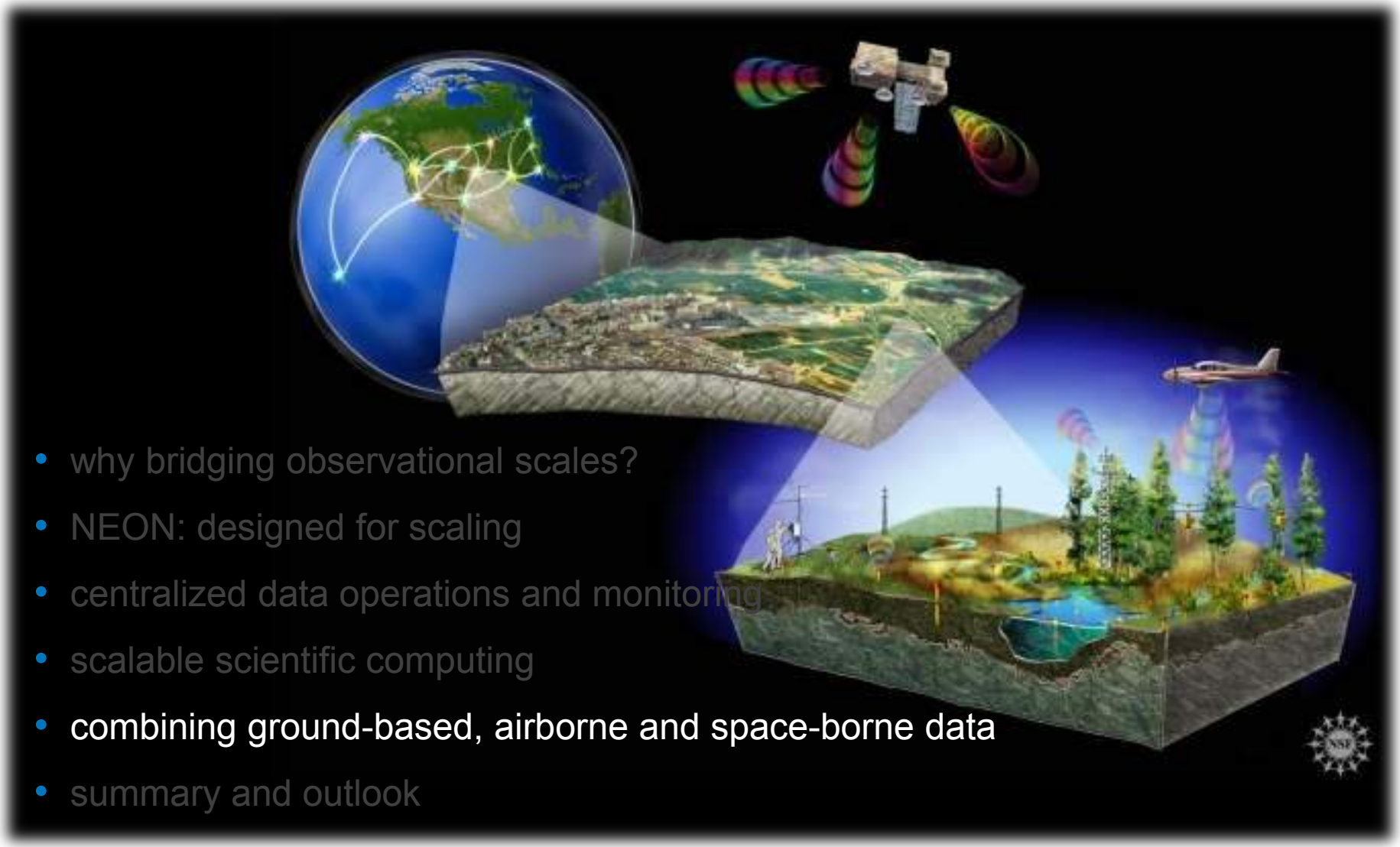


eddy4R 0.2.0: a DevOps model for community-extensible processing and analysis of eddy-covariance data based on R, Git, Docker, and HDF5

processing pipeline characteristics

- near-real-time (1 week → 1 month)
- extensible: e.g. operational data fusion

overview



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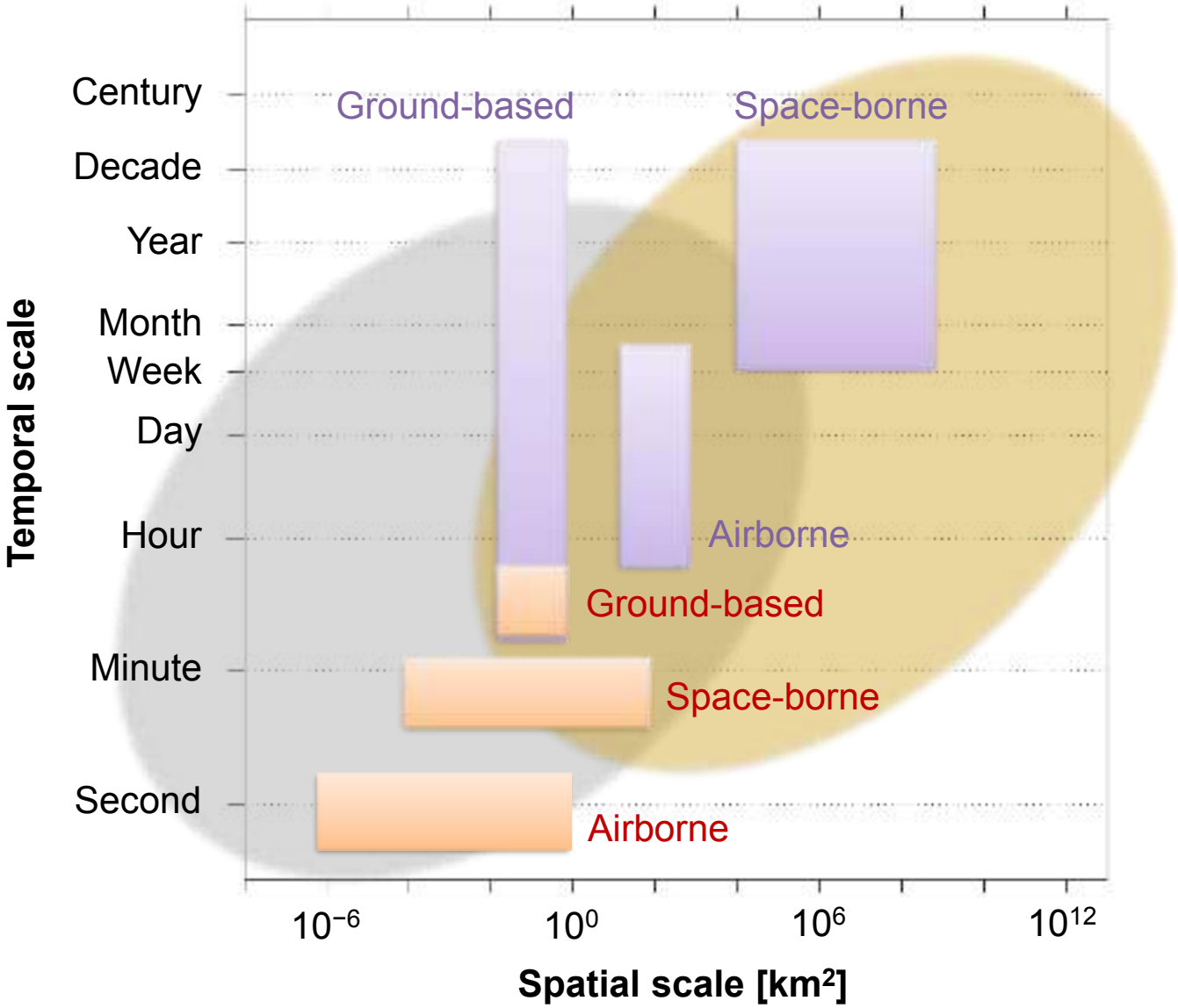
scope of the task



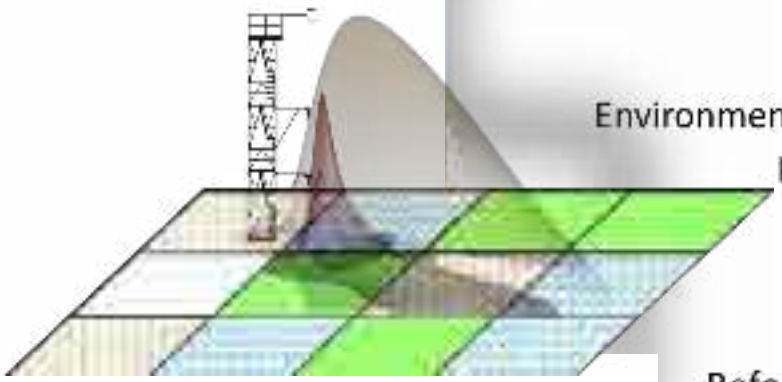
Coverage

Resolution

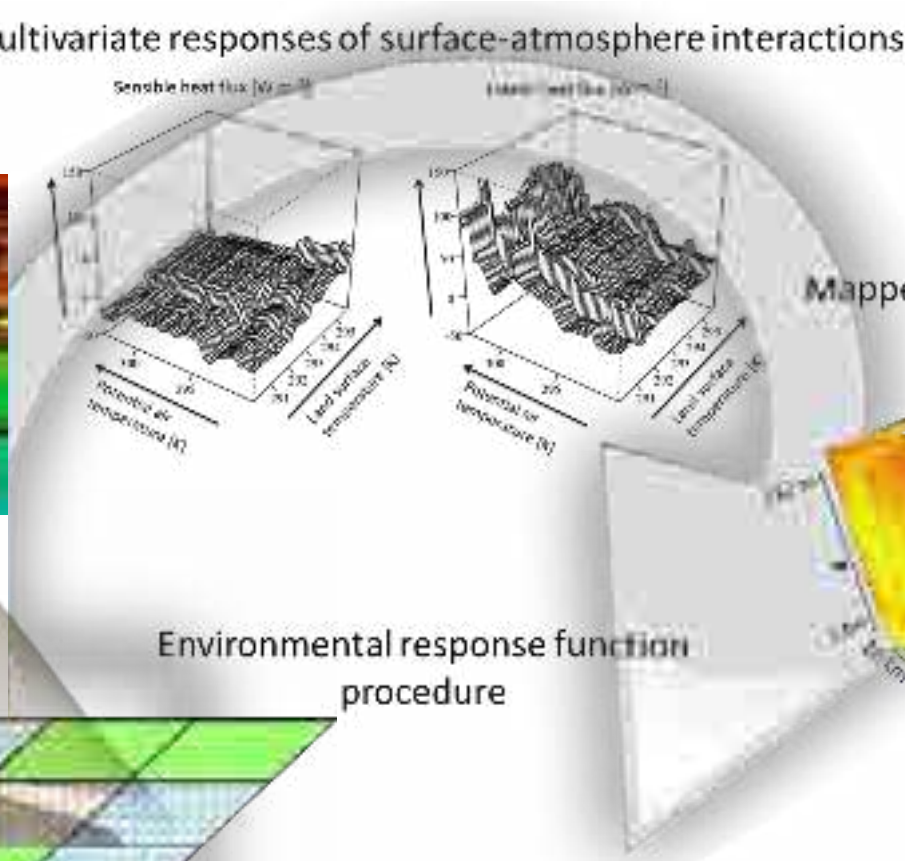
Earth system model

Model-data fusion

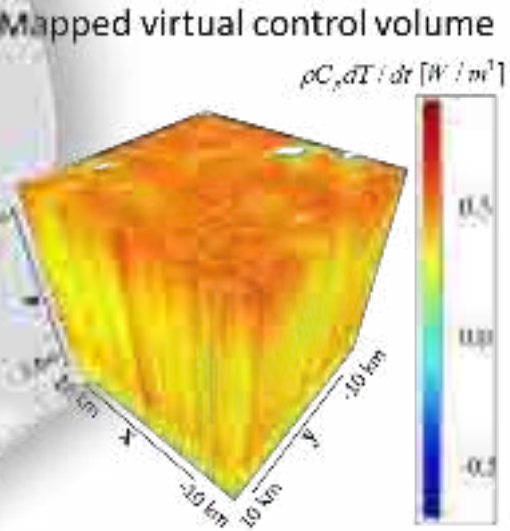
environmental response function virtual control volume



Footprint modeling over coordinated observations of drivers and responses

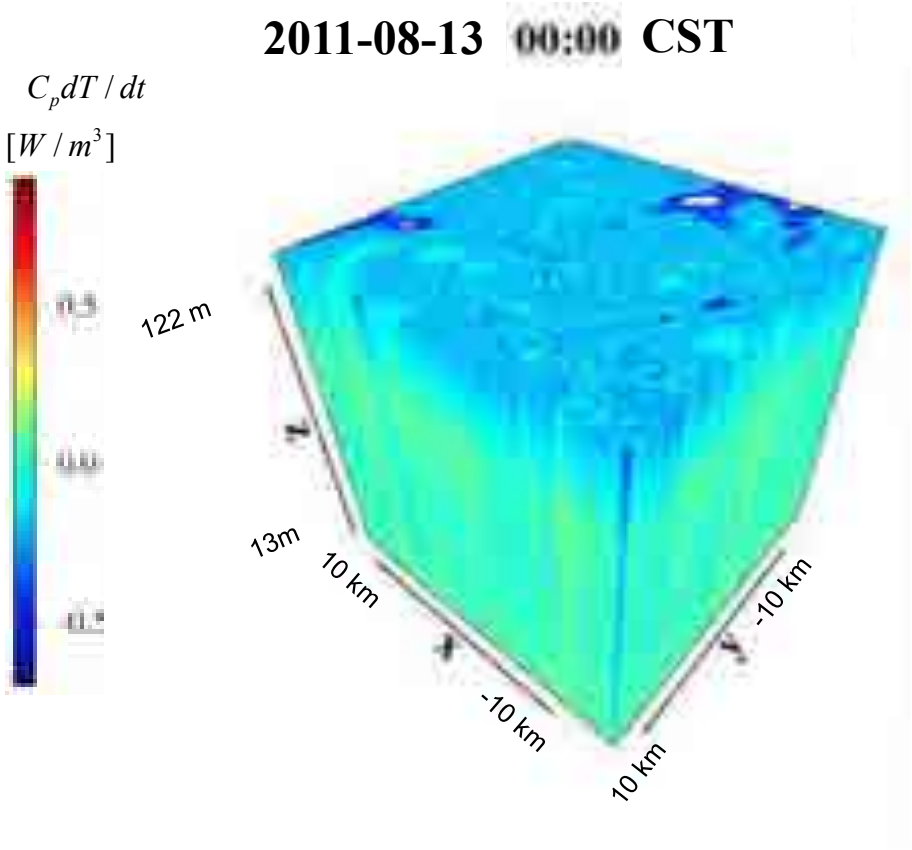


Metzger (2017)

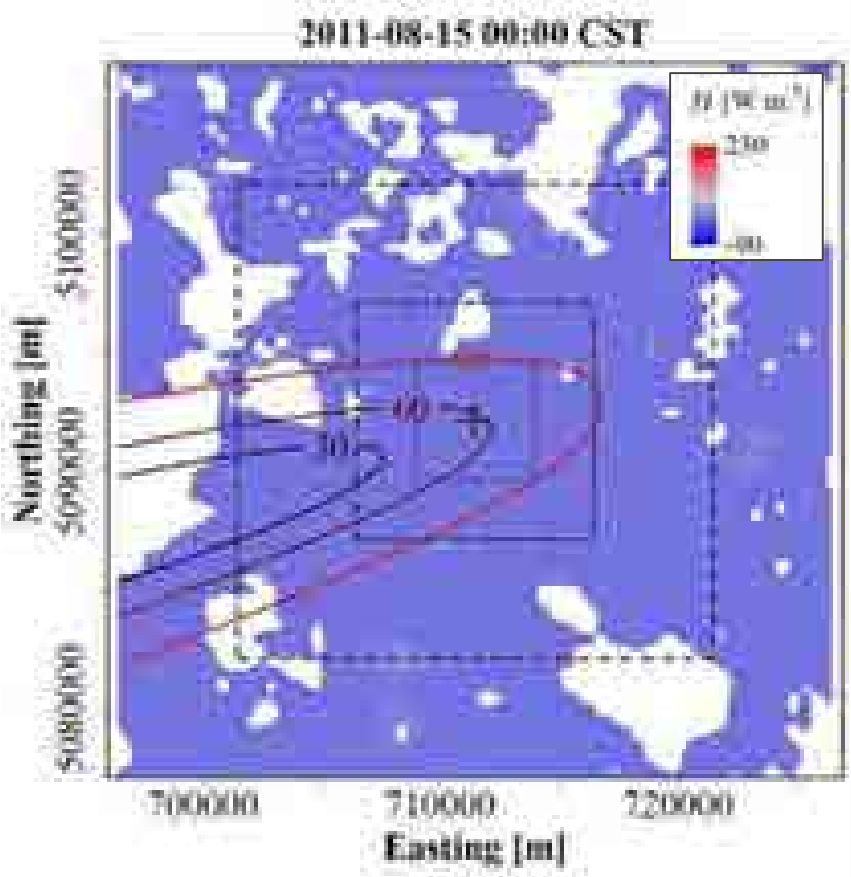


environmental response function virtual control volume

volume-projected heat storage change



grid-projected turbulent heat flux



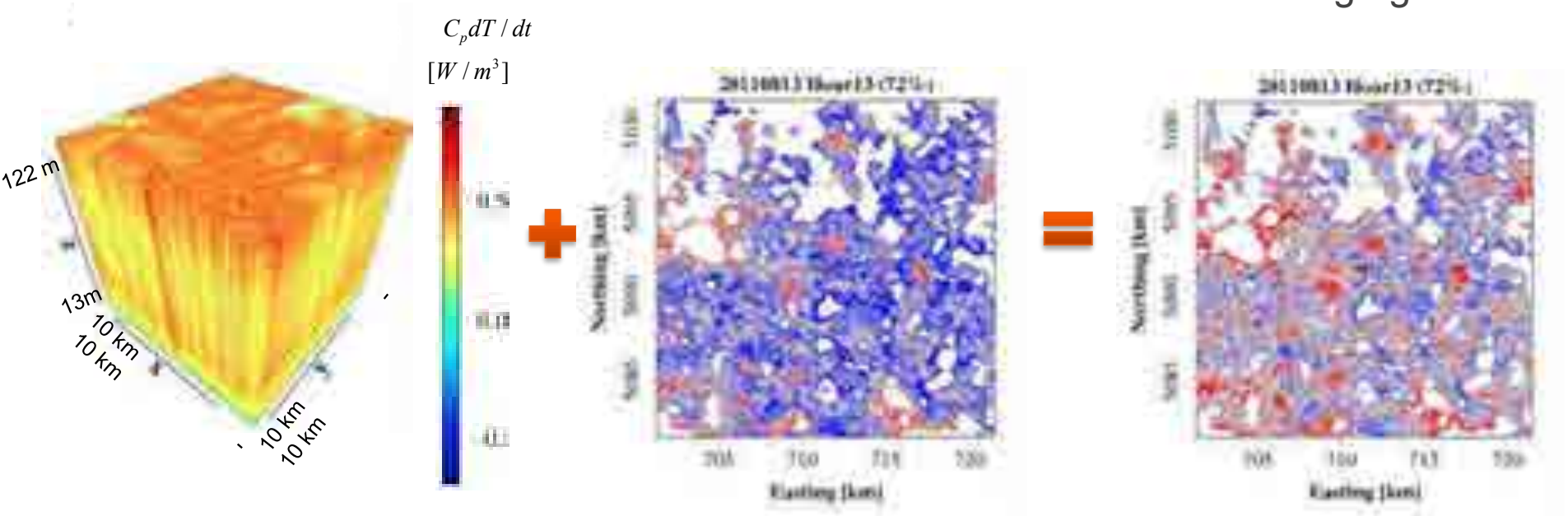
Xu et al. (2017)

environmental response function virtual control volume

storage flux

turbulent flux grids

surface-atmosphere exchange grids



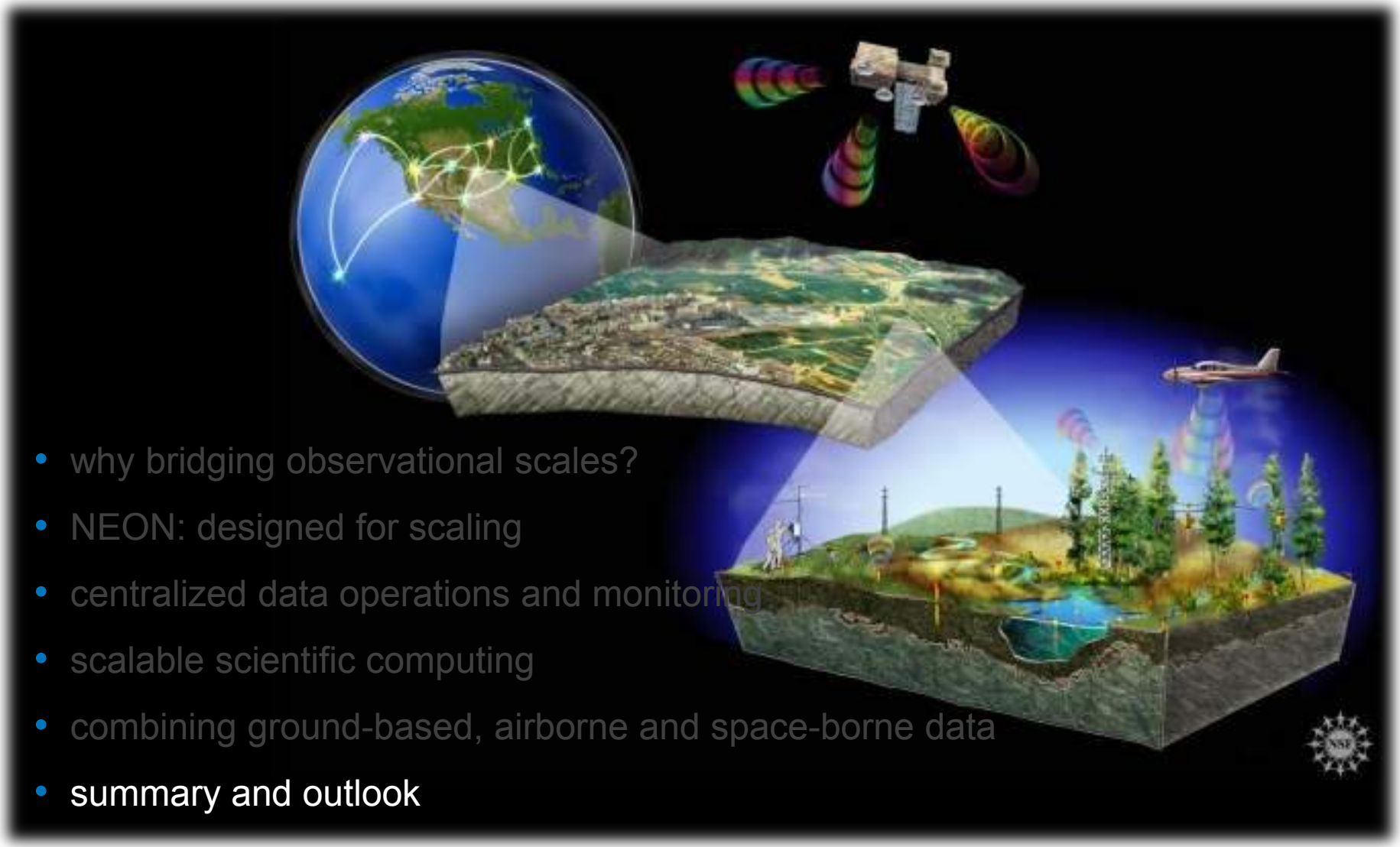
application examples

- near-real-time capability (1 week → 1 month, e.g. AmeriFlux)
- operational data fusion (e.g., NASA ECOSTRESS)

$[W/m^2]$

Xu et al. (2017)

overview

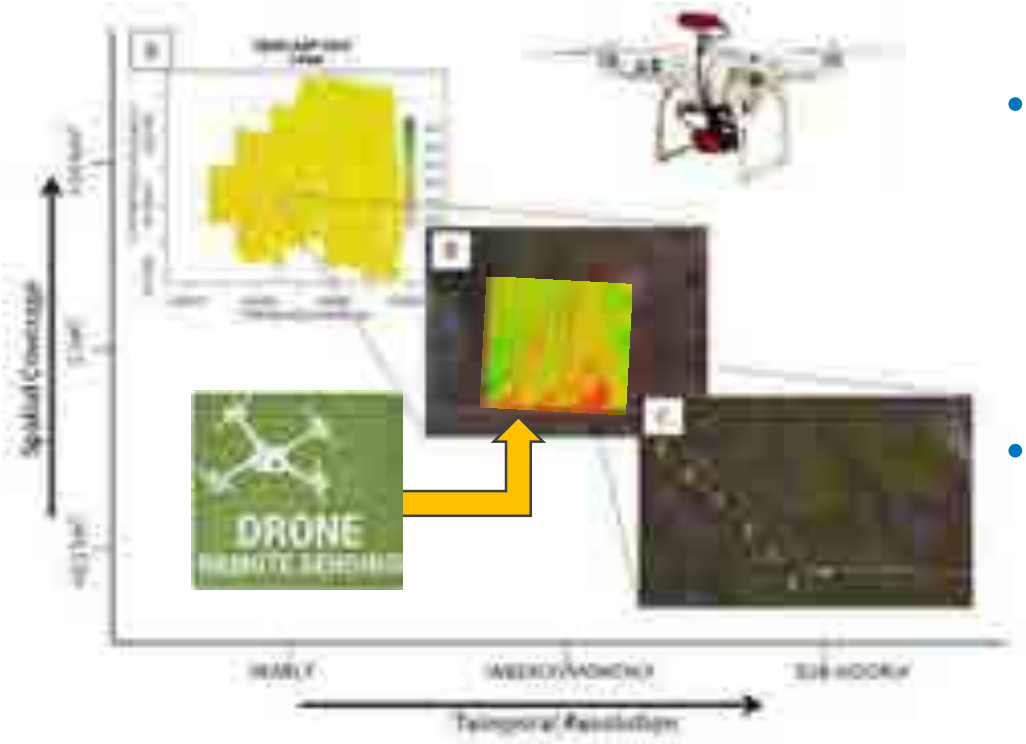


- why bridging observational scales?
- NEON: designed for scaling
- centralized data operations and monitoring
- scalable scientific computing
- combining ground-based, airborne and space-borne data
- summary and outlook

conclusions and outlook

- bridging scales one of the fundamental challenges in ecology
- NEON's observation hierarchy is designed for scaling (continuity)
- centralized data operations efficiently manage data quality and standardization
- coordinated, interoperable NEON flux, in-situ, proximal and remote sensing data
- public NEON "eddy4R" + GitHub + Docker flux software and usability tools
- combining data across scales with environmental response functions
- joint proposal writing for operational data fusion

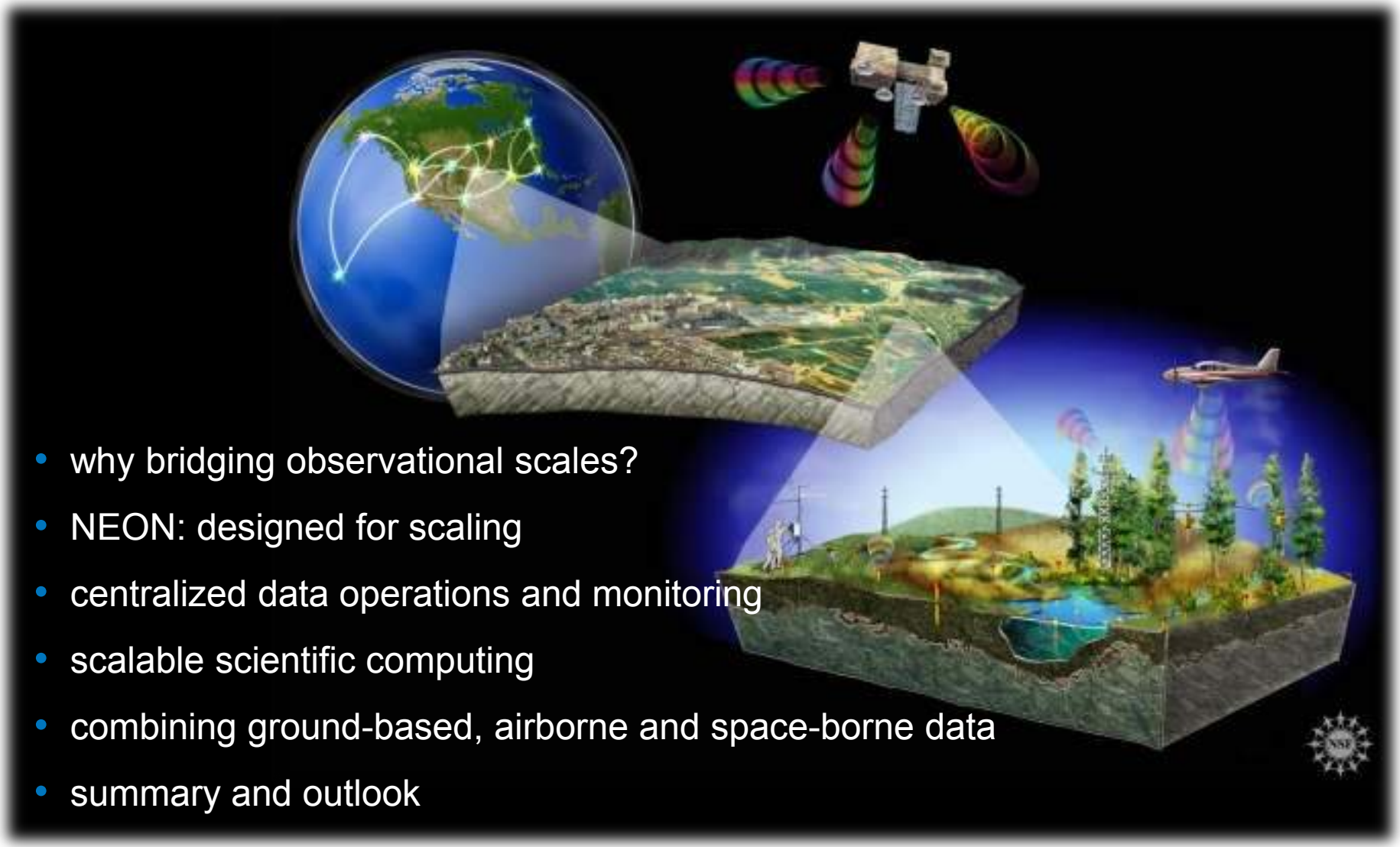
airborne remote-sensing observation node (ARGON)



- NEON data products span large spatio-temporal scales, e.g. airborne remote sensing and automated tower measurements
- we aim to bridge these spatio-temporal gaps in NEON data products using a unmanned aerial vehicle remote-sensing platform

- objectives
  - develop less expensive and more agile remotely sensed data products.
  - enabling target-of-opportunity measurement campaigns for extreme ecological events

overview



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