Crafting a Minor to Produce T-Shaped Graduates

Roger H. French,
F. Alex Nason Professor
Faculty Director, Applied Data Science
Materials Science & Engineering, Case School of Engineering,
Case Western Reserve University

Debbie Hughes,
Senior Director of Higher Education and Workforce,
Business-Higher Education Forum

About the Business-Higher Education Forum

The Business-Higher Education Forum (BHEF) is a membership organization of Fortune 500 CEOs, college/university presidents, and other leaders who collaborate to promote innovation and enhance US global competitiveness through its National Higher Education and Workforce Initiative.

BHEF Mission

- BHEF members collaborate to increase baccalaureate attainment and improve alignment between higher education and the workforce by creating undergraduate pathways to produce a diverse, highly-skilled talent pool to meet demand in emerging fields.
- BHEF convenes business and academic leaders, promotes effective undergraduate program design and development to create workforce solutions, and offers guidance to increase the impact on baccalaureate outcomes.
- BHEF facilitates peer-to-peer engagement by its members and inspires peer leaders to act.

Shapes the National Agenda for Business & Higher Education Collaboration through Convenings

Influences Practice & Policy through Research & Thought Leadership

Addresses Workforce Needs through Programmatic Initiatives

BHEF's National Higher Education and Workforce Initiative (HEWI): *Strategy*

What are the supply challenges?

- Innovation and competition increasingly rely on new and emerging fields
- There is an increase in competition for talent
- Increased need to recruit and retain a diverse workforce

What is BHEF's strategy?

- Deploy a model of strategic business engagement with higher education to shift from transactional relationships to strategic partnerships to develop talent ecosystems
- Create undergraduate career pathways that satisfy employer demand for a high-skilled workforce, especially for women, minorities, and veterans

Why does this strategy work?

- BHEF has conducted extensive research to understand the interventions and strategies that work best to support the success of undergraduate students
- BHEF has successfully implemented this strategy, beginning with cybersecurity at the University of Maryland

Strategic Partnership Implementation Process

The process that BHEF follows when evaluating, designing, and launching new programs in collaboration with higher education and business

Elevating the Minor

For decades the minor has been a tool that allows students studying at post secondary institutions to pursue a secondary field of interest. Today, the minor can serve as a vehicle for preparing students for the workforce, integrating 21st century skills, and providing a credential that employers are demanding.

The WHY

- Minors are already embedded into the culture of most institutions
- Employers seek a recognized credential that they can hire to
- Colleges and Universities can add new minors with limited hurdles, such that the time to implementation can be quite rapid

The WHAT

- Minors can be used to 'round out' a students experience and intentionally develop T-shaped professional
- Allows students with deep expertise in a certain subject, particularly non-technical, to receive a credential that employers see as high-demand
- Crafted to integrate employer needs and experiential opportunities
- Often, few new courses need to be developed; just re-grouped and contextualized for the audience

Elements of the Ideal Minor

Regardless of the subject area, minors should be developed using a core set of design principles.

1. Pick subject areas that are high-demand and that employers feel a skills gap exists, such as data science or cybersecurity
2. Courses should be offered to cover:
   - An introduction to the field with hands-on learning
   - Technical content (required by all)
   - Interdisciplinary and applied content (students select based on interest)
   - A relevant semester-long applied learning experience
3. 21st century workplace skills should be intentionally embedded and evaluated; not taken as a siloed course
4. Embed real-world problem-sets, challenges, case studies, and interaction with employers throughout program
5. Link to student societies, competitions and professional associations to build sense of community amongst student peers

Data Science Provides a Remix Opportunity

Data Science is transforming education, business, society

- Through openness and remixing

Openness: Open Data, Open Standards, Open Source Codes,

- Open Source Development Processes, Reproducible Research,

Remix Culture: To allow and encourage derivative works

- By combining or editing existing materials to produce a new product

The Applied Data Science (ADS) Undergraduate Minor remixes

- Disciplines: Computer Science, Statistics, Math, Engineering, Science, Finance, Marketing, Genetics, Medicine, Physics, Sociology, Astronomy, etc.
- Students: Cross-disciplinary exposure to ADS and Domain Areas Expanding and diversifying students skill and tool sets
- Faculty, Departments, Schools: New connections outside of existing disciplinary structures
- Businesses: Traditional job categories, value chains and business lines, markets
- Society: Mobility of graduates, cross-generational interactions, societal solutions

Crafting the ADS Minor Requires Multiple Foci

Applied Data Science (ADS)

- Domain-based data science
  Applicable to multiple Domains
- Openness
- Collaboration
- Cyber security
- Ethics
- Reproducibility

Pedagogical Goals for ADS Courses

- Coding
- Inferential Statistics
- Exploratory Data Analysis
- ADS Data Science Research
- Modeling, Prediction & Statistical Learning

Open Data Science (ODS) Infrastructure.

- ODS Tool Chain
- ODS data packages
- ODS Virtual Desktops (VDIs)
- Statistical & Machine Learning

Constituencies

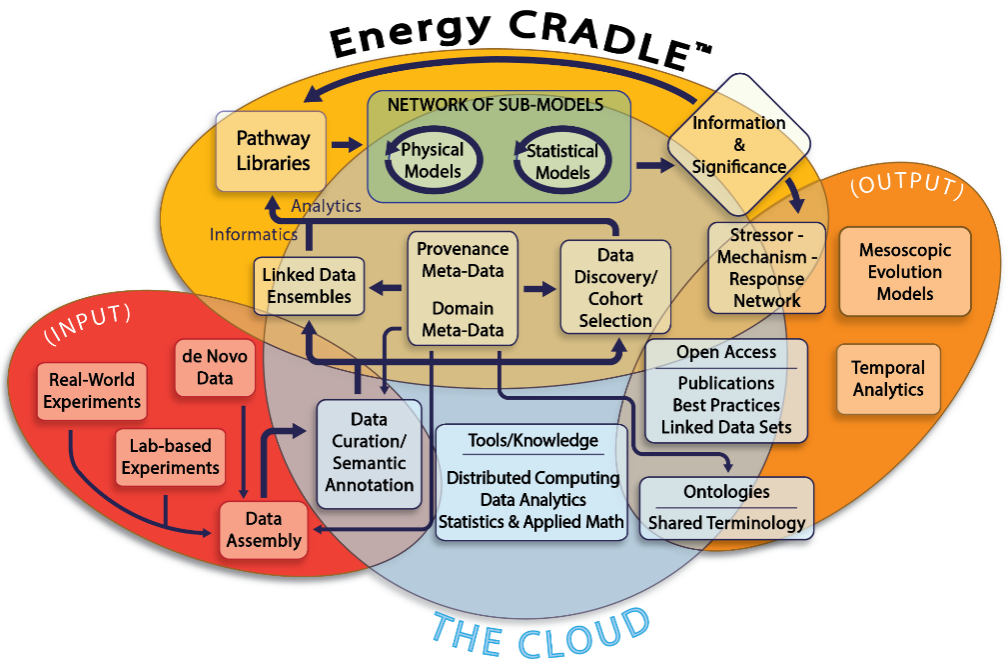
- Faculty, Departments, Schools
- ADS undergraduate students
- Graduate students
- Employers
- Society
- Change agent roles

Trajectories / Temporal Evolution Of

- ADS student
- University team research
- Collaborations,
- Remixing Departments, Schools
- Remixing of Undergraduate, Graduate Students,
- Change agents in Business and Society

A Minor in Applied Data Science (ADS)

Datascience.case.edu/minor



Available in all schools of CWRU

- Case School of Engineering
- College of Arts and Sciences
- School of Medicine
- School of Nursing
- Weatherhead School of Management

Student demand is strong

In Domain Areas of Expertise

- Applied Data Science Practitioners
- Who have the Major expertise in particular Domains

Based in the Case School of Engineering

Data Science Major also being established

- In approval process now

ADS Minor Graduates Know ADS's Essentials Elements

Steps of data analysis

1: Define the ADS questions

2: Identify, locate, and/or generate the data

- Including defining the ideal data set and variables
- Determining and obtaining accessible data
- Cleaning the data in preparation for analysis

3: Exploratory data analysis

- Start identifying the significant characteristics of the data and information it contains.

4: Statistical modeling and prediction

- Including interpretation of results,
- Challenging results, and
- Developing insights and actions

5: Synthesizing the results

- In domain context of domain
- Writing this up.

6: Creation of reproducible research

- Including code, datasets
- Documentation and reports

  Which are easily transferable and verifiable

ADS tools & application in domain area

1. Data Management:

- Datastores, sources, streams

2. Distributed Computing:

- Local & distributed computing
- Hadoop or other cloud computing

3. Informatics, Ontology, Query:

- Including search, data assembly, annotation

4. Statistical Analytics:

- Tools such as high level scripting languages
- e.g. R statistics, Python, Ruby

The Domain Areas being developed include

Engineering & Physical Sciences

- Energy
- Manufacturing
- Astronomy

Health

- Translational
- Clinical

Business

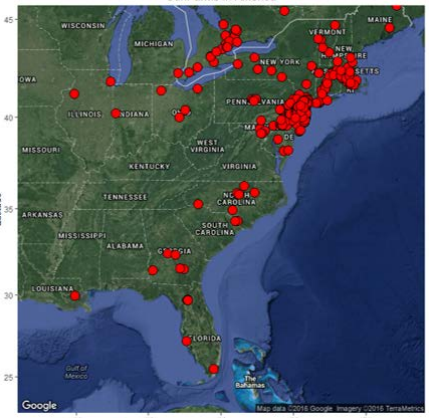
- Finance
- Marketing
- Economics

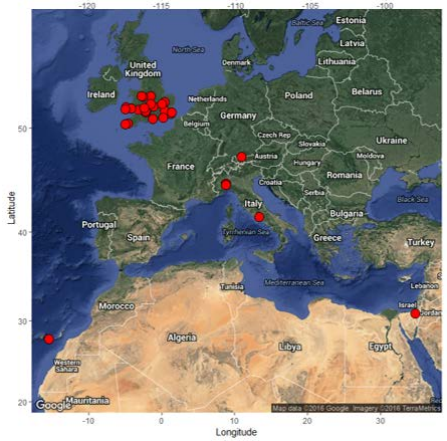
Domain areas added

- as we go forward

Synergy of Education

- With Industry, Research, Society





Faculty involved in Applied Data Science Minor Committee

ADS Minor Based In [The ADS Faculty]

Representing Faculty From

- Departments & Schools
- Supporting the ADS Minor

Developing DSA Curricula & Courses

- New Cross-cutting and Domain specific courses
- Updating Syllabi for existing courses

Are defining the ADS Minor for approvals

DSCI Course Code Established

- For cross listing ADS Minor classes
- Among departments and schools

Name	Dept./School	Domain
Roger French	EMSE/CSE	Energy/Man
Gurkan Bebek	Bioinformatics/SOM	Health
Jim McGuffin-Cawley	EMSE/CSE	Man
Alexis Abramson	EMAE/CSE	Energy
Mark Chance	SysBio/SOM	Health
Jagdip Singh	Design & Innovation/WSOM	Business
Robin Dubin	Economics/WSOM	Economics
William Mahnic	Finance/WSOM	Finance
Jennifer Carter	EMSE/CSE	Manufacturing
Chris Mihos	Astronomy/CAS	Energy & Phys. Sci.
Jenny Brynjarsdottir	Statistics/MAMS	CrossCutting

The ADS Minor Curriculum

Covers the spectrum of learning to achieve domain area ADS expertise

The curriculum is based on five, 3 credit, courses

- Progressing from Level 1 to Level 5,

The courses are chosen to be both

- Cross cutting In fundamental ADS concepts (Levels 1,2, and 4)
  such as scripting and statistics
- Domain area focused (Levels 3 and 5).

And to remix students

- Across the university and domains
- Across undergraduate and graduate populations
- Between ADS Minor and the Data Science Major (being developed)

Domains =>	Engineering & Physical Sciences		Health		Business		
5. Modeling & Prognostics	Phys Sci ASTR 306	Energy & Mfg. DSCI 353	Trans. ADS SYBB 459	Clinical ADS SYBB 322	Finance BAFI 361	Marketing MKMR 308 MKMR 310	Econ ECON 327
4. UG ADS Research	DSCI 352: team taught SYBB387						
3. Exploratory ADS		DSCI 351	SYBB 311	SYBB 321		MKMR 201	
2. Inferential Statistics	OPRE 207, EPBI 431, SYBB 310 STAT 312R, STAT 201R						
1. Data Science Programming	DSCI 133 DSCI 134						

CWRU UG 2015 Choices Fair: 46 Students signed up

Applied Data Science

A New Undergraduate Minor

McKinsey Global Institute predicts **a nationwide shortage of 140,000 to 190,000 workers** with "deep analytical skills," and **a deficit of 1.5 million managers** capable of using big data analytics for actionable insights in their decision-making and predicts a **40 percent annual growth in global data** and **$300 billion in potential value-add** of data analytics to the nation's health care industry alone. Gartner Inc. indicates that by 2015, **4.4 million information technology jobs** globally will be created to support data science and analytics, generating **1.9 million IT jobs** in the U.S. The U.S. government anticipates a **shortage of about 50,000 qualified workers** in health IT between 2010 and 2015. Healthcare companies are increasingly borrowing technology specialists from other industries

Minor

Available to all CWRU undergraduate students-

Essential elements of ADS includes Data Management, Distributed Computing, Informatics, Ontology, query, Statistical Analytics.

Steps of Data Analysis:

1. Define ADS questions
2. Identify, locate, generate data
3. Exploratory data analysis
4. Statistical modeling and prediction
5. Synthesizing results
6. Creation of reproducible research

Curriculum

Level 1: Data Science Programming

Level 2: Inferential Statistics

Level 3: Exploratory Applied Data Science

Level 4: Undergraduate Applied Data Science Research

Level 5: Modeling & Prognostics

Domain Areas

Domain areas available for minor concentration are:

Engineering and Physical Sciences
- Energy
- Manufacturing
- Astronomy

Health
- Translational
- Clinical

Business
- Finance
- Marketing
- Economics

Faculty

ADS Minor Based In The Faculty

Representing Faculty From
- Departments & Schools
- Supporting the ADS Minor

Are defining the ADS Minor for approvals

Developing ADS Curricula & Courses
- New Cross-cutting and Domain specific courses
- Updating Syllabi for existing courses

DSCI Course Code Established
- For cross listing ADS Minor classes
- Among departments and schools

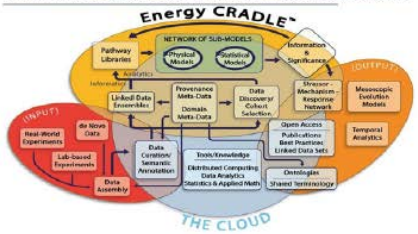
Name	Dept./School	Domain
Roger French	EMSE/CSE	Energy/Man
GQ Zhang	EECS/CSE	En/Man/Health
Jim McGuffin-Cawley	EMSE/CSE	Man
Alexis Abramson	EMAE/CSE	Energy
Mark Chance	SysBio/SOM	Health
Colin Drummond	BME/CSE	Health
Jagdip Singh	Design & Innovation/WSOM	Business
Robin Dubin	Economics/WSOM	Economics
William Mahnic	Finance/WSOM	Finance
Jennifer Carter	EMSE/CSE	Manufacturing
Chris Mihos	Astronomy/CAS	Energy & Phys.
Jenny Bryujarsdottir	Statistics/MAMS	CrossCutting
Gurkan Bebek	Nutrition/SOM	Health

CASE WESTERN RESERVE UNIVERSITY | GREAT LAKES ENERGY INSTITUTE

energy.case.edu | 216.368.0748
Olin Hall, 10900 Euclid Ave.
Cleveland, OH 44106

Data Sciences

Common Research Analytics and Data Lifecycle Environment



Energy-CRADLE: data source

Industry Engagement in CWRU ADS Minor

Energy/Manufacturing
- Eaton
- FirstEnergy
- GE
- Sherwin Williams
- Timken

Healthcare
- Accenture
- Cleveland Clinic
- Explorys
- GE
- KPMG LLP
- Medtronic
- Philips Healthcare
- Siemens
- University Hospitals
- IBM

Services
- Accenture
- GE
- Humana
- IBM
- Key Bank
- Medical Mutual of Ohio
- Teradata Corporation

Applied Data Science

A New Undergraduate Minor

CASE WESTERN RESERVE UNIVERSITY | GREAT LAKES ENERGY INSTITUTE

Open-Data-Science

ODS Tool Chain

Open-source Programming Languages

- Interpreted: low barriers to entry
- Community-based support

R Project for Statistical Computing

Python

Git distributed version control

Shared Repositories

- For Codes
- For Projects
- For Classroom Materials

ODS Infrastructure

Common programming environment

- Across courses and students

Virtual Machines (VDIs or VMs)

- Default installs of ODS Tool Chain
- Simple Maintenance of VDI Software

Accessible from anywhere

- On any type of device

Reduces time lost to software problems

Expose all to new software packages

- Students & Faculty

Hosted on our ADS ODS Server

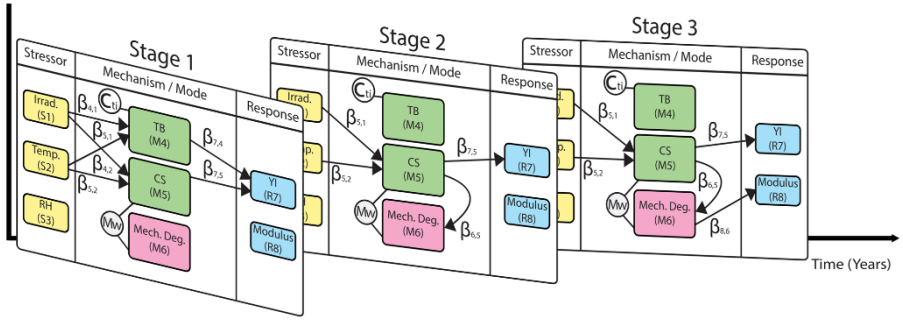
- Available to all ADS Students

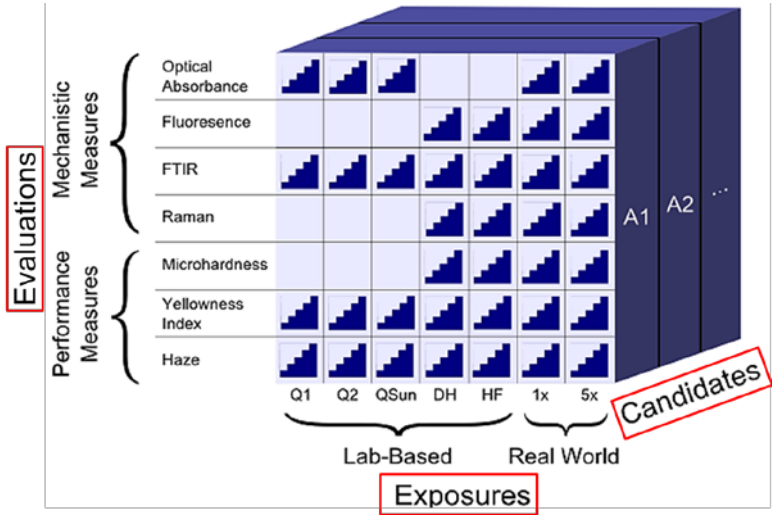
Open-Data-Science Packages

Real-World Datasets / Data Science Problems

Hardcoat Acrylic Film Degradation

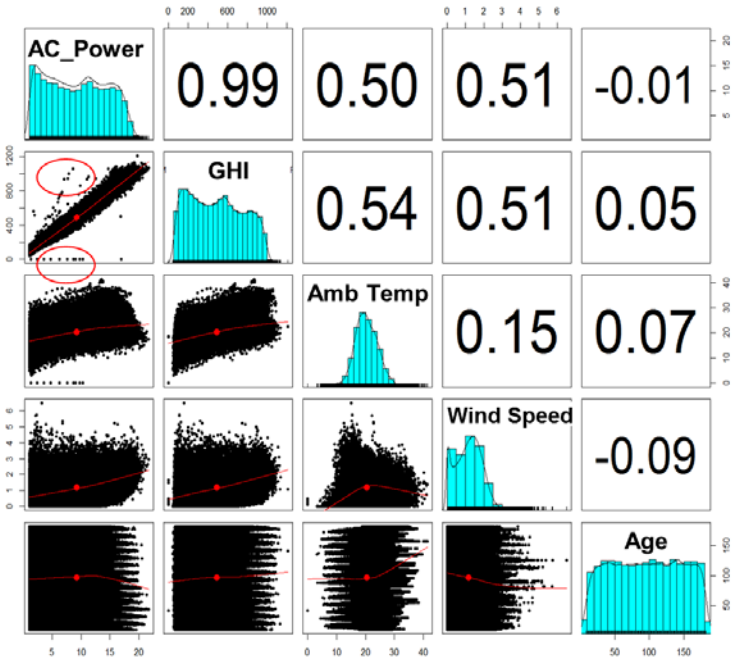
- You will work on degradation data from outdoor exposure of hard-coat acrylic films on polyester (PET) and urethane (TPU) substrates.





Photovoltaic Power Plant Time-Series

- You will work on real-world power plant time series data sets. Directly accessed from Energy CRADLE



ADS Semester-long Research Projects

In DSCI Classes

- DSCI352: ADS UG Research
- DSCI353-453: Statistical Learning

Materials

- Degradation of Exterior Coatings
- PET Degradation
- **Rapid Alloy Qualification**
- Gloss Loss of PV Backsheets

Sustainability

- **Climate Change in Alaska**
- Fuel Cell Degradation

Energy

- PV Power Plant Time-series Analysis
- **Data-driven Building Energy Efficiency**

Image Analytics

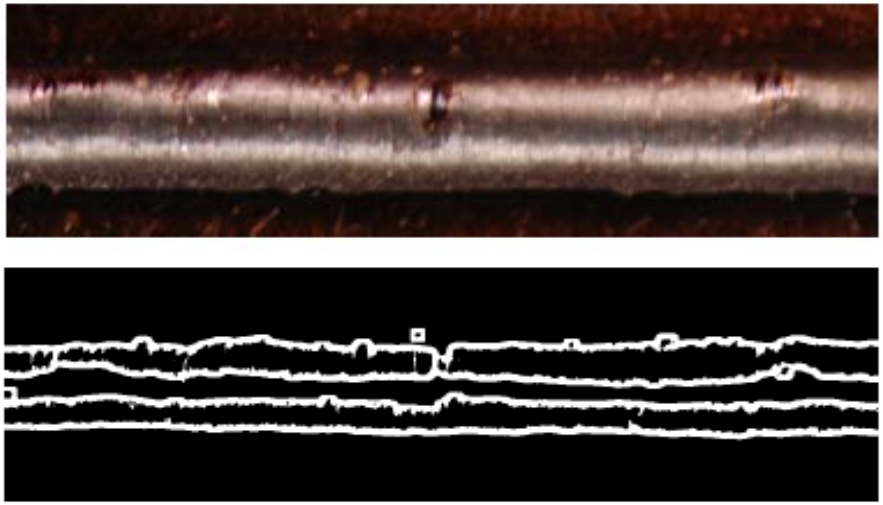
- **Automated SkyCamera Analytics of Clouds**
- **Facial Recognition for EVA Luminescence**
- Image Analytics of Fluorescence

Fashion Analysis

- Goal: Try to read the consumer's mind
- To predict changes in global trends,
- Using TwitteR and webscraping of

  Vogue Magazine's Twitter, Girl with Curves blog, and Retailers Forever 21, ASOS, Land's End.

Image Analytics of Weld Beads



Minors, Data Science, and the T-Shaped Graduate

Minors provide a recognized, tangible vehicle for developing T-shaped graduates. Data science, an interdisciplinary field that could benefit most students, provides an ideal example of this in action.

The New Minor

- Recognizable credential in emerging fields where there is demand
- Provides technical skills to non-technical students
- Provides cross disciplinary skills to all students

Data Science

- Being explored as a new method of inquiry in the liberal arts
- Begins to address value of education with relevant skills employers can recognize, need, and are hiring for

Scaling Across the Country

- Replicable process and core elements all institutions can follow
- Provides minimal disruption to institutional infrastructure
- Develop new programs in concert with business and employers

CASE SCHOOL
OF ENGINEERING

CASE WESTERN RESERVE
UNIVERSITY

CASE WESTERN RESERVE
UNIVERSITY EST. 1826
think beyond the possible

BHEF BUSINESS-HIGHER EDUCATION FORUM
Creating Solutions. Inspiring Action.

Abstract

The undergraduate Minor offers undergraduates pursuing their baccalaureate degree an opportunity to develop a secondary focus as part of their normal course of study. The process to develop and award Minors is already embedded within the structure of many post-secondary intuitions. Minors can be used by academic institutions to offer curriculum and learning in emerging fields, such as cybersecurity and data science.

New minors, particularly those which are created to address gaps in existing degree areas and directly meet industry's needs should be crafted as an intentional program of study, rather than a group of independent courses. These new minors should require experiential learning opportunities through an applied project, such as undergraduate research, internships, or a capstone project. Additionally, the required courses for the minor should be purposefully structured to embed 21st century workplace skills, such as critical thinking and communication. Graduates with this type of minor will be better prepared to enter the workforce and make an immediate contribution. Case Western Reserve University has developed this type of new Minor in Applied Data Science, which can serve as a national model.

The Applied Data Science Minor at Case Western Reserve University (CWRU) is available to all undergraduate students from any school across the campus. The program requires the students to advance through five levels: 1) Data Science Programming 2) Inferential Statistics 3) Exploratory Applied Data Science 4) Data Science Research 5) Statistical Learning; Modeling and Prediction. The ADS curriculum serves nicely as a generalized approach to many types of data science problems in today's society, where the challenge is to transform data to information. By having this tool in their arsenal, CWRU students will be able to capably differentiate themselves from other graduates in their domain and field. Furthermore, the ADS minor capabilities will open up doors across organizations that would otherwise be left undiscovered. The first students will graduate with the ADS minor in 2016.

SDLE Acknowledgements

Research Faculty & Associates

- Laura Bruckman, Tim Peshek, Mohamed Elsaeiti

Graduate Students

- Abdulkerim Gok, Yang Hu, Nick Wheeler,
- Mohammad Hossain, Yingfang Ma
- Devin Gordon, Pei Zhao

Undergraduates

- Matt Randall, Olga Eliseeva
- Cara Fagerholm, Ethan Pickering
- Taylor Nguyen, Jacob Schimelman
- Elizabeth Hodges, Kevin Laverty
- Justin Fada, Davis Zabiyaka
- Nikhil Goel, Raj Shekar
- Marc Sahlani, Noah Sweet

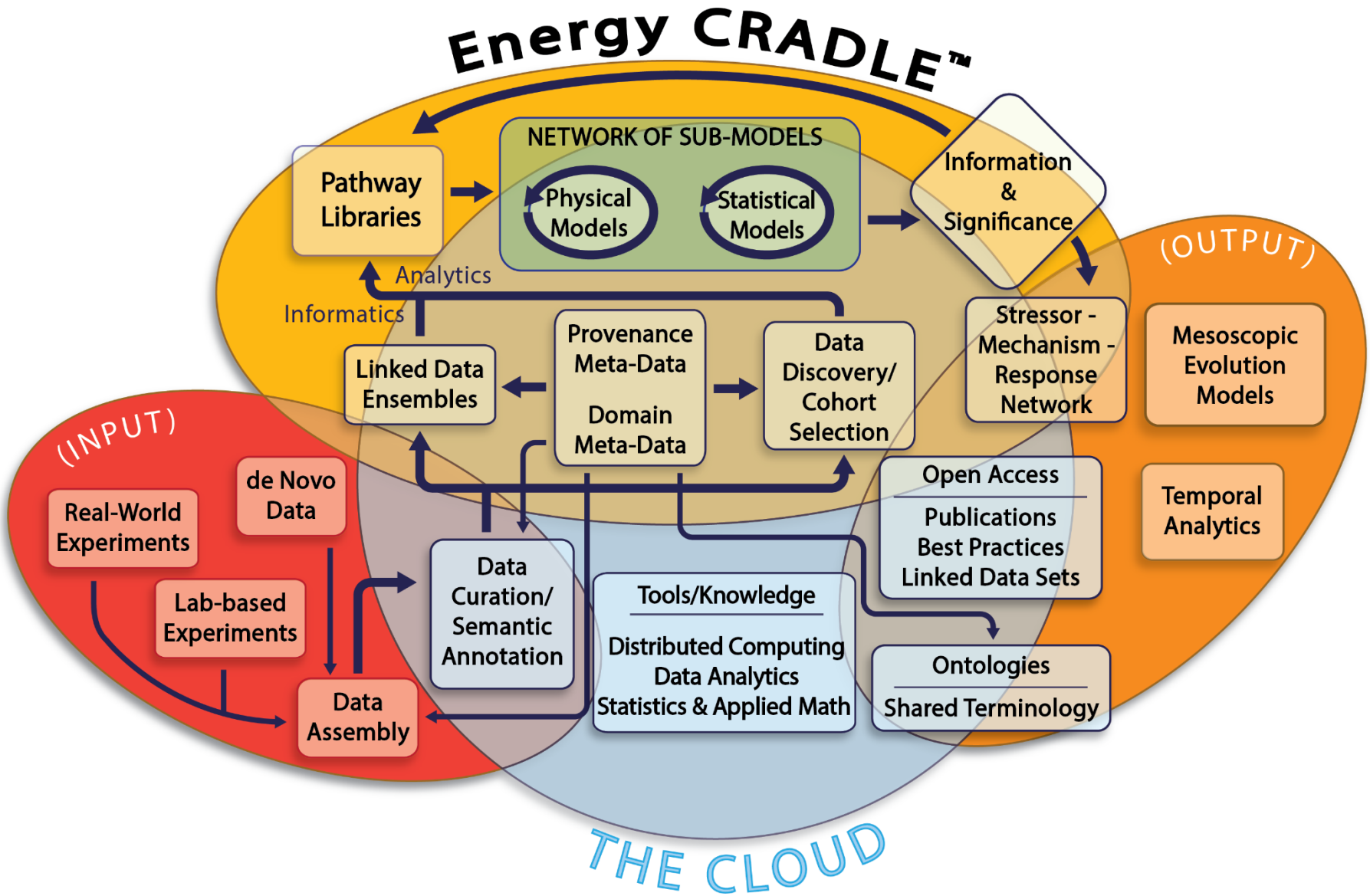
CWRU Faculty

- Jiayang Sun , GQ Zhang, Alexis Abramson, Jennifer Carter
- Nicole Steinmetz, Hongping Zhao, Joao Maia, Mike Hore

SDLE Staff: Chris Littman, Rich Tomazin

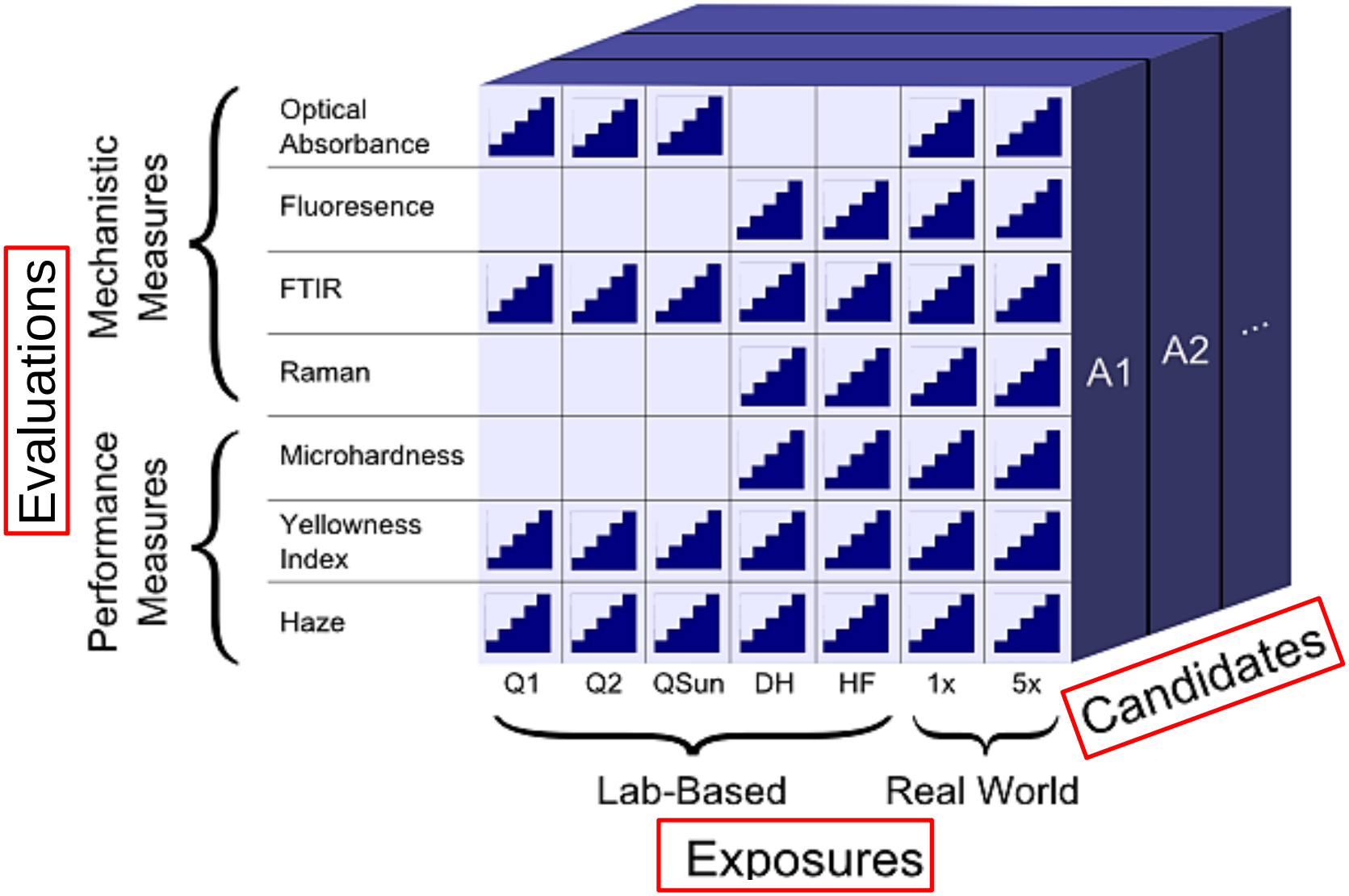
Funding

Common Research Analytics and Data Lifecycle Environment



Degradation Science "Data Block" For Statistical Analytics

Using a Stress | Mechanism | Response Framework



2 SDLE Power Plants: 15 years of Time-series datastreams

SDLE PV Data Covers ~3.4 GW

Encompass 1.92% of Global PV Plants

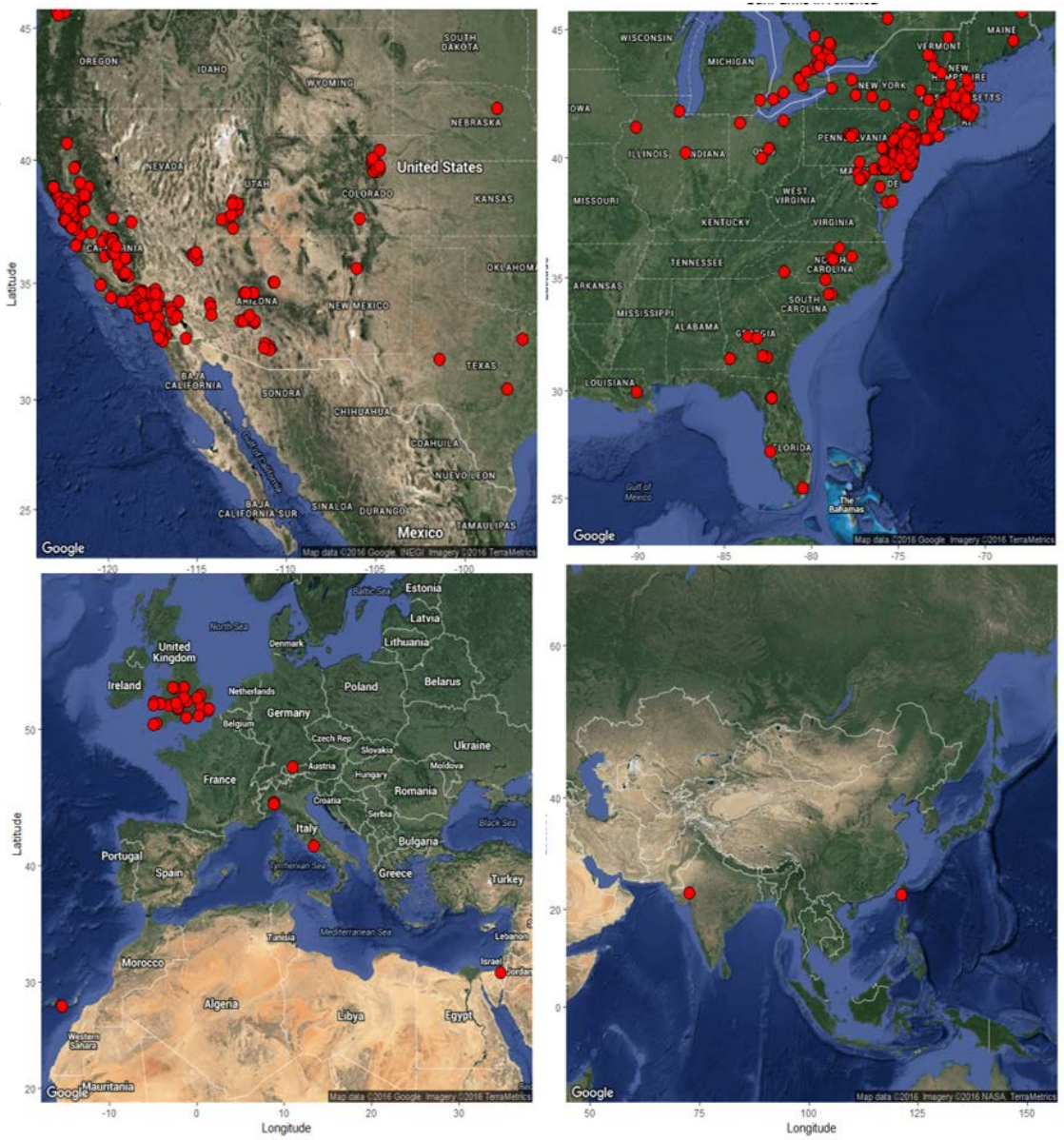
- **787 PV Plant Sites**
- **5638 PV Plants** (Inv. & Modules)
- **60 PV Module Brands/Models**
- **38 PV Inverter Brands/Models**
- Single Modules to 265 MW plants
- Going Back Up To 15 years

Epidemiological PV Populations

- Of Time-series datastreams
- Real World Exposure Conditions
- Real World Systems
- Operating Over Real Time-scales
- Not Just Accelerated Lab Exposures

Population-based Studies Identify

- Statistically Significant Factors
- Controlling Lifetime Performance
- Real-world Degradation & Failure



Pair-wise Plot and Monthly Predictive Model: m4jmg2n

Scatter plots of variable pairs

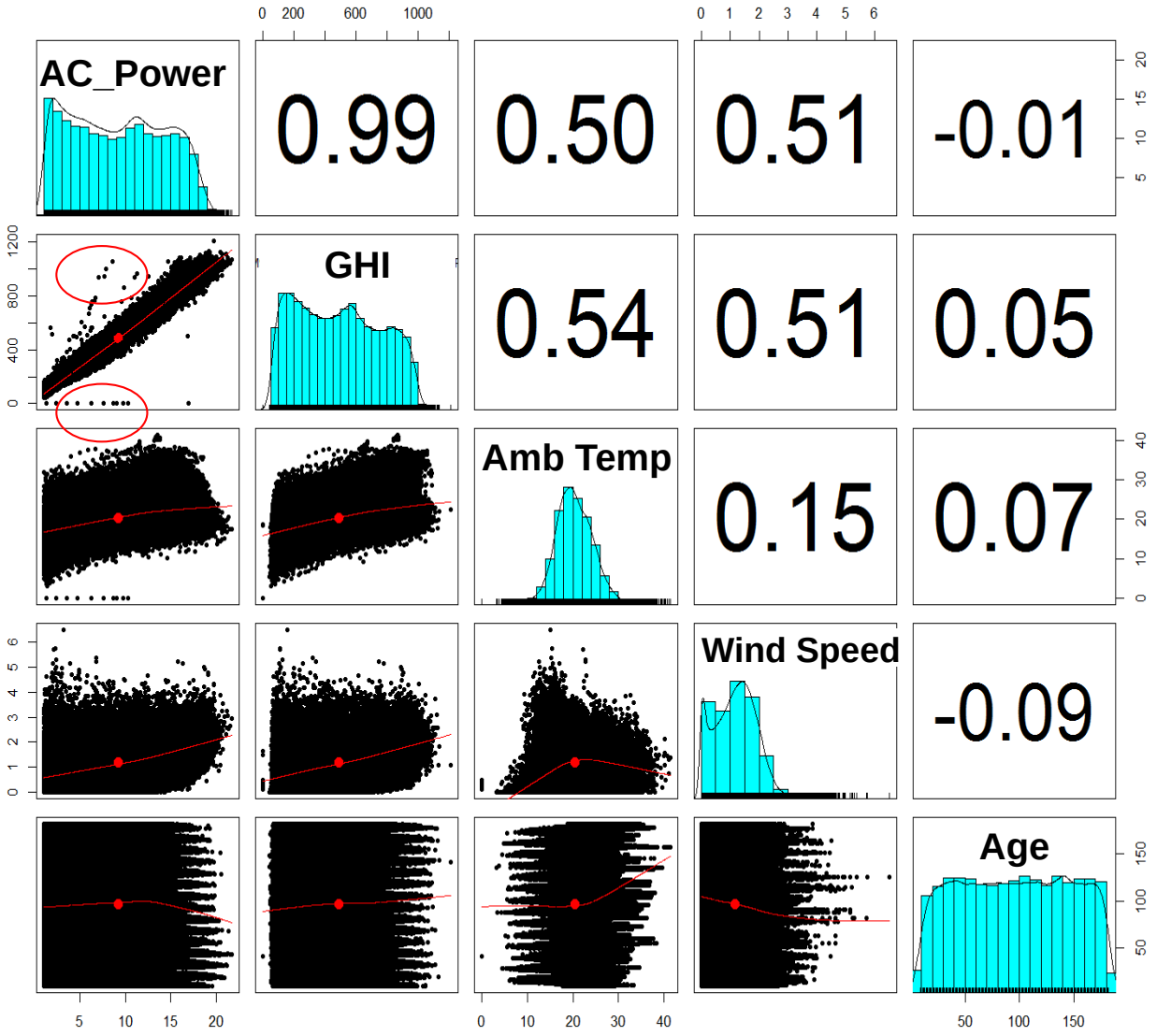
- bottom left corner:

Histogram of each variable

- diagonal:

Correlation coeff of each pair

- upper right corner:



Same PV Module Brand

Power Plant No. : m4jmg2n

Climate Zone :

BSk Arid-Steppe-Cold

Date of operation 1999-10-27

PowerPlant No. : fy9jhn6

Climate Zone :

BSh Arid-Steppe-Hot

Date of operation 1999-10-27