What is the social engineering challenge of data science for Heliophysics and how do we solve it?

Transforming research through the *anti*disciplinary approach

Ryan McGranaghan

(with overwhelming collaboration across this room and many communities)

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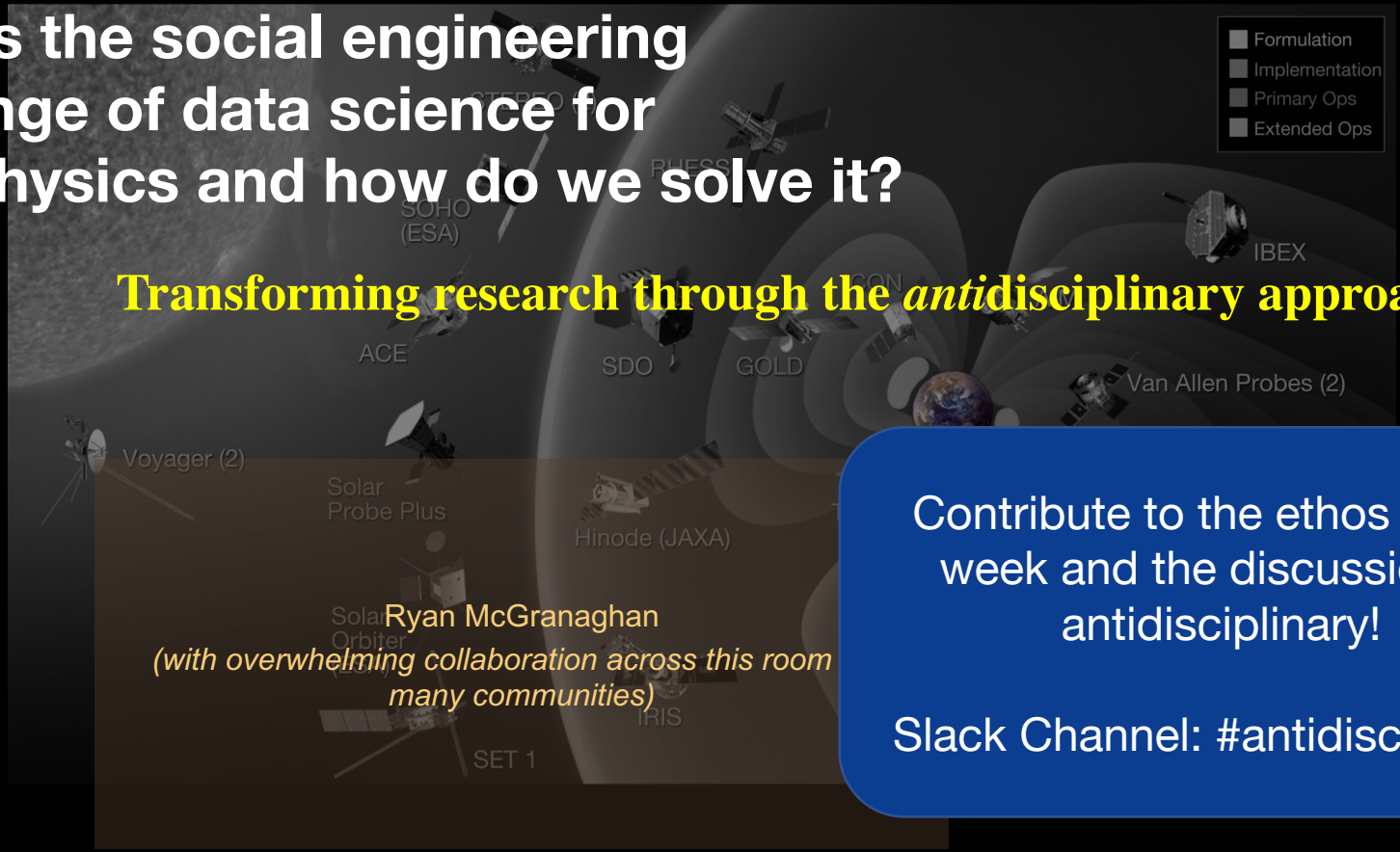


Transforming research through the *anti*disciplinary approach

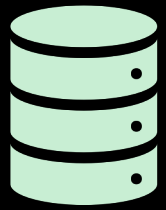
Ryan McGranaghan

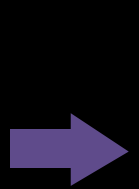
(with overwhelming collaboration across this room many communities)

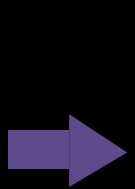
Contribute to the ethos of this week and the discussion of antidisciplinary!

Slack Channel: #antidisciplinary

Agenda





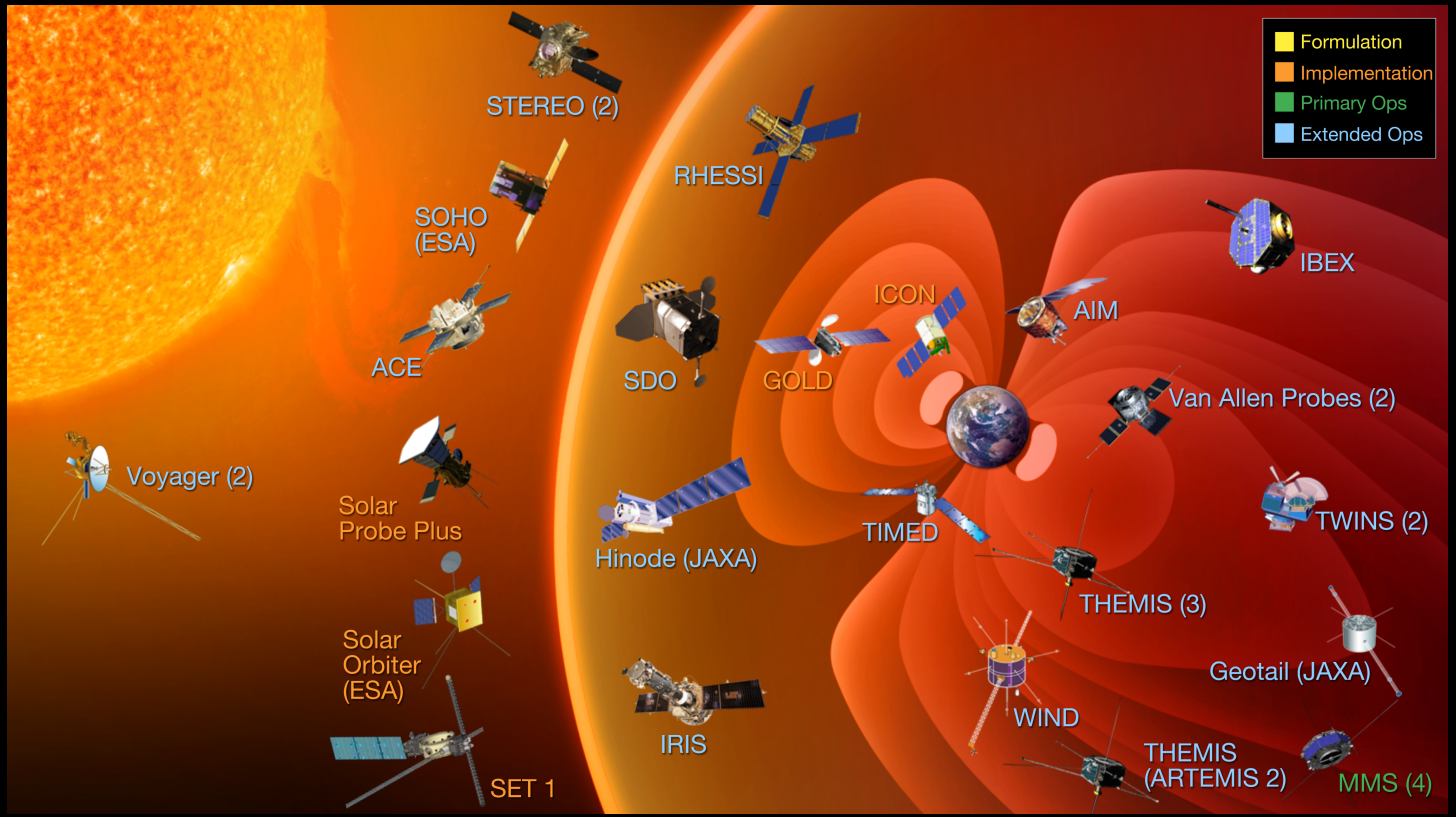


Why are we at a tipping point for data science (and ML) in Heliophysics?

What does it take to unify data science and Heliophysics?

What is the path forward?

Why are we at a tipping point for data science (and ML) in Heliophysics?


Formulation
Implementation
Primary Ops
Extended Ops
STEREO (2)
RHESSI
SOHO (ESA)
IBEX
ICON
AIM
ACE
SDO
GOLD
Van Allen Probes (2)
Voyager (2)
Solar Probe Plus
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Hinode (JAXA)
TIMED
THEMIS (3)
Solar Orbiter (ESA)
Geotail (JAXA)
WIND
IRIS
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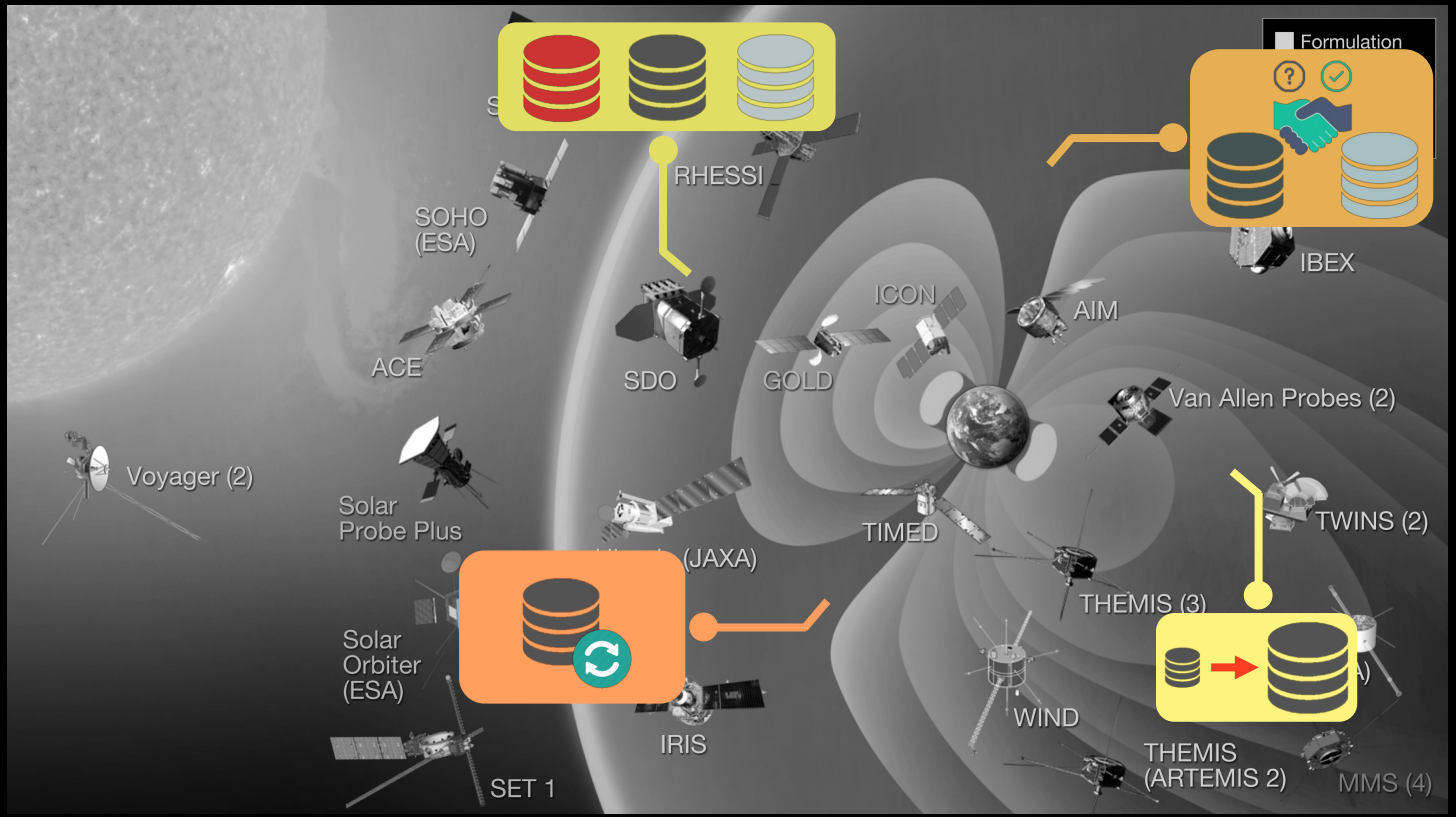
MMS (4)
SET 1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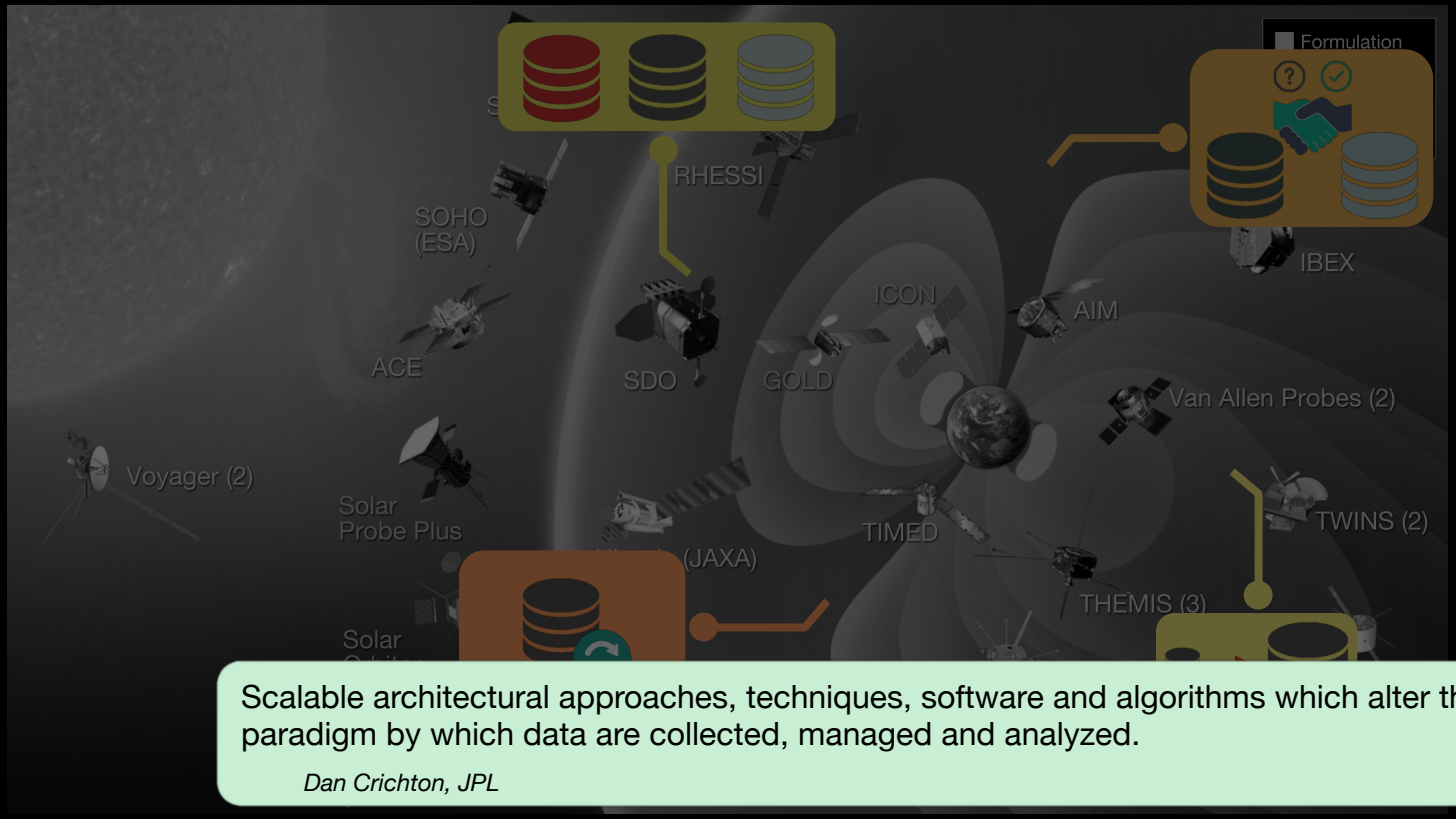

Scalable architectural approaches, techniques, software and algorithms which alter the paradigm by which data are collected, managed and analyzed.

Dan Crichton, JPL

What does it take to unify data science and Heliophysics?

STRETCHING GNSS SIGNALS FOR SPACE WEATHER DISCOVERY

Ryan McGranaghan, Anthony Mannucci

University Corporation for Atmospheric Research (UCAR)

NASA Jet Propulsion Laboratory, California Institute of Technology

Brian Wilson, Chris Mattmann, Sujen Shah, Huikyo Lee

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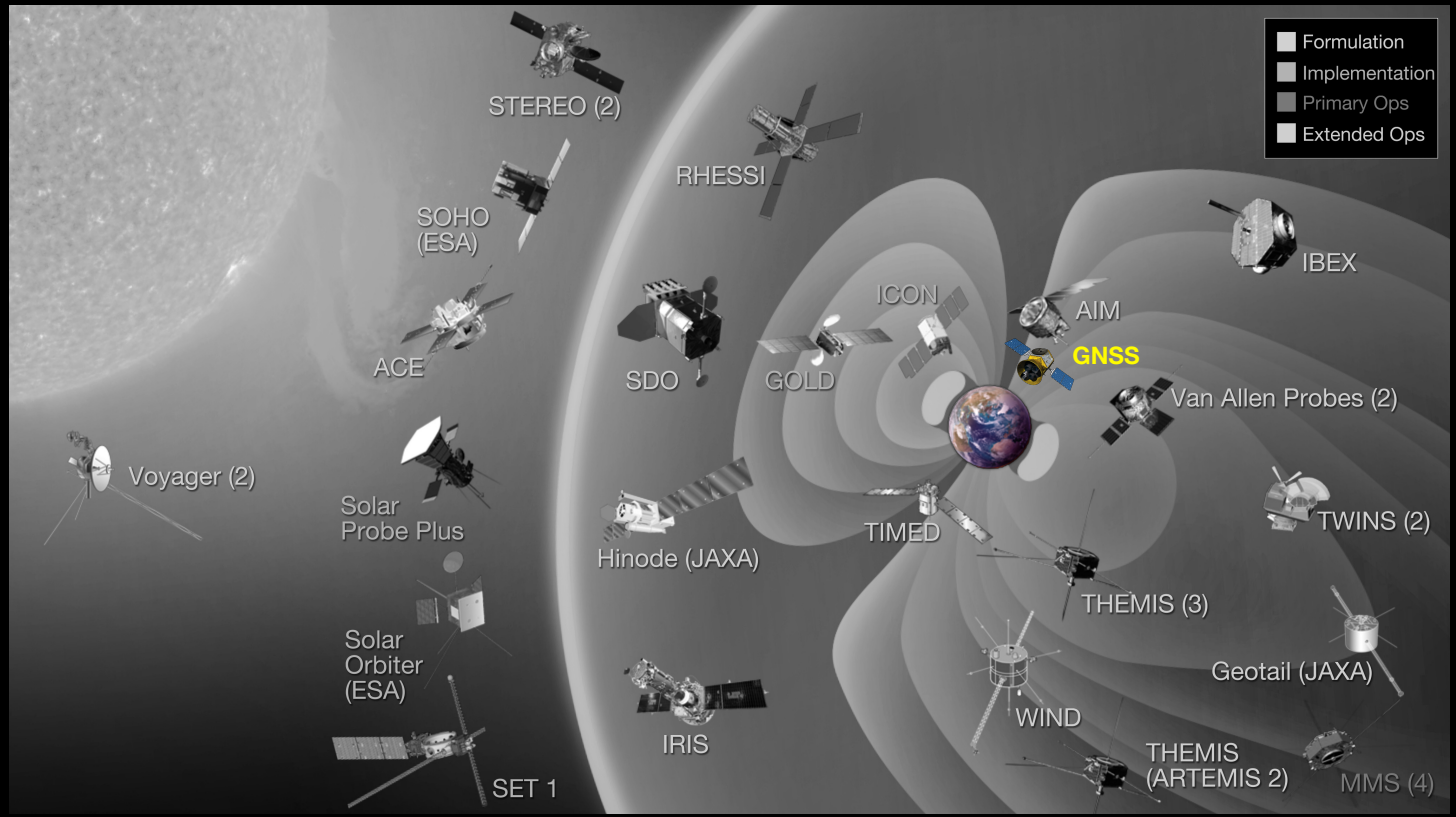
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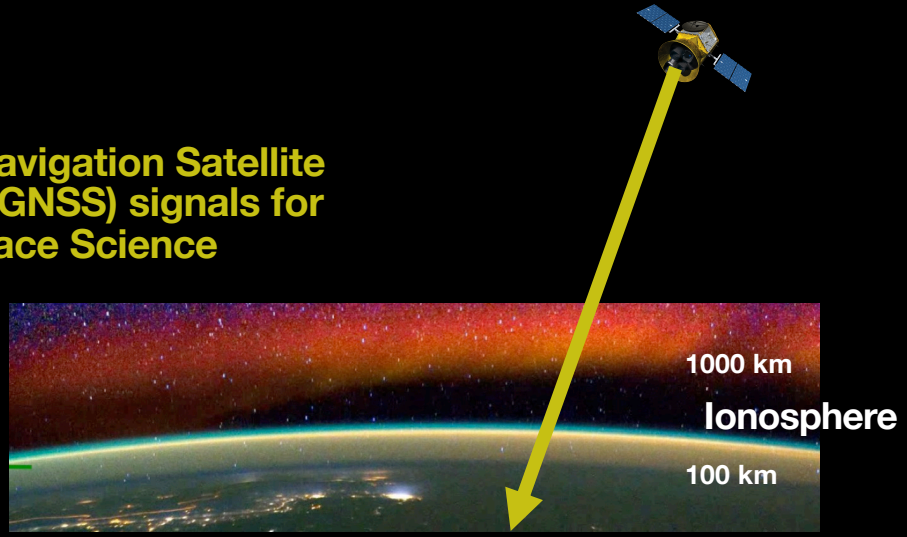
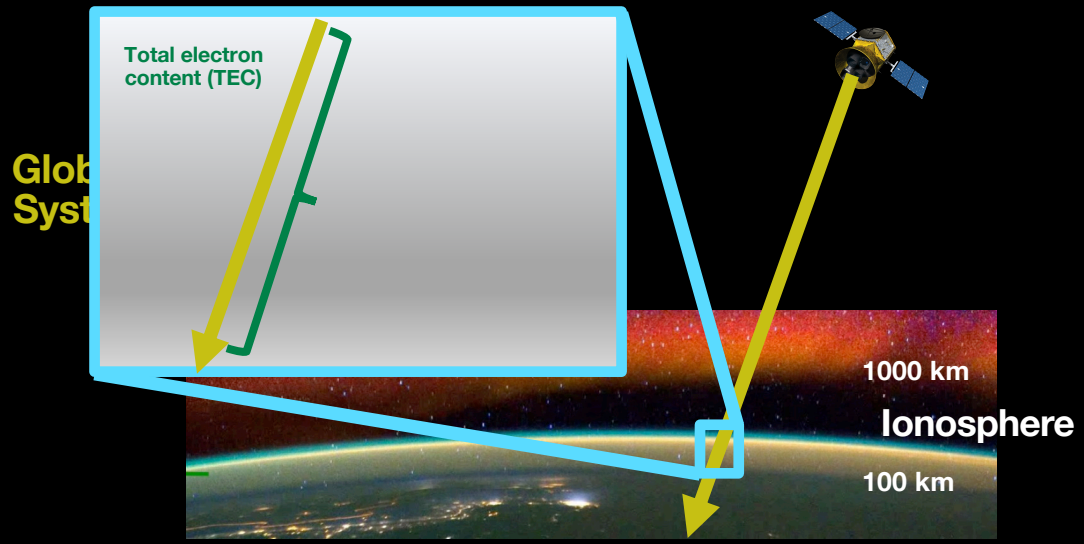
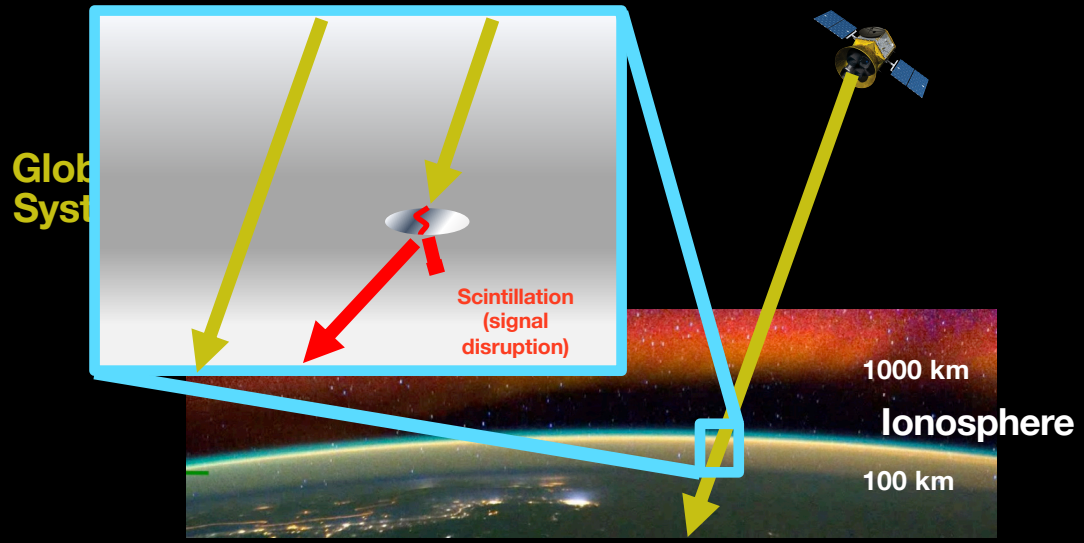
Global Navigation Satellite System (GNSS) signals for Space Science

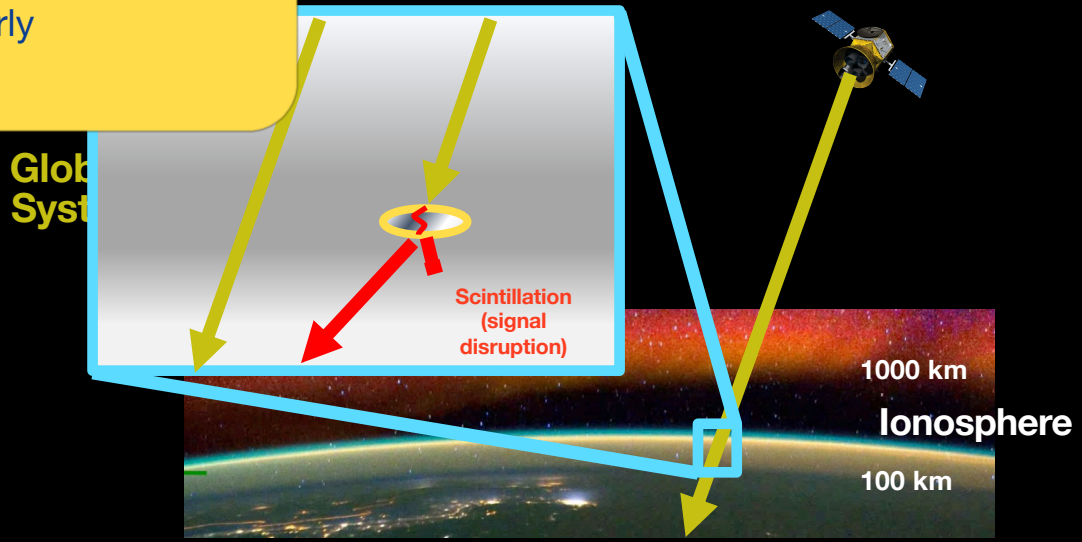



Glob
Syst
Total electron
content (TEC)
1000 km
Ionosphere
100 km


Glob
Syst
Scintillation
(signal
disruption)
1000 km
Ionosphere
100 km

Irregularities are random electron density fluctuations

- Complex
- Evolve nonlinearly



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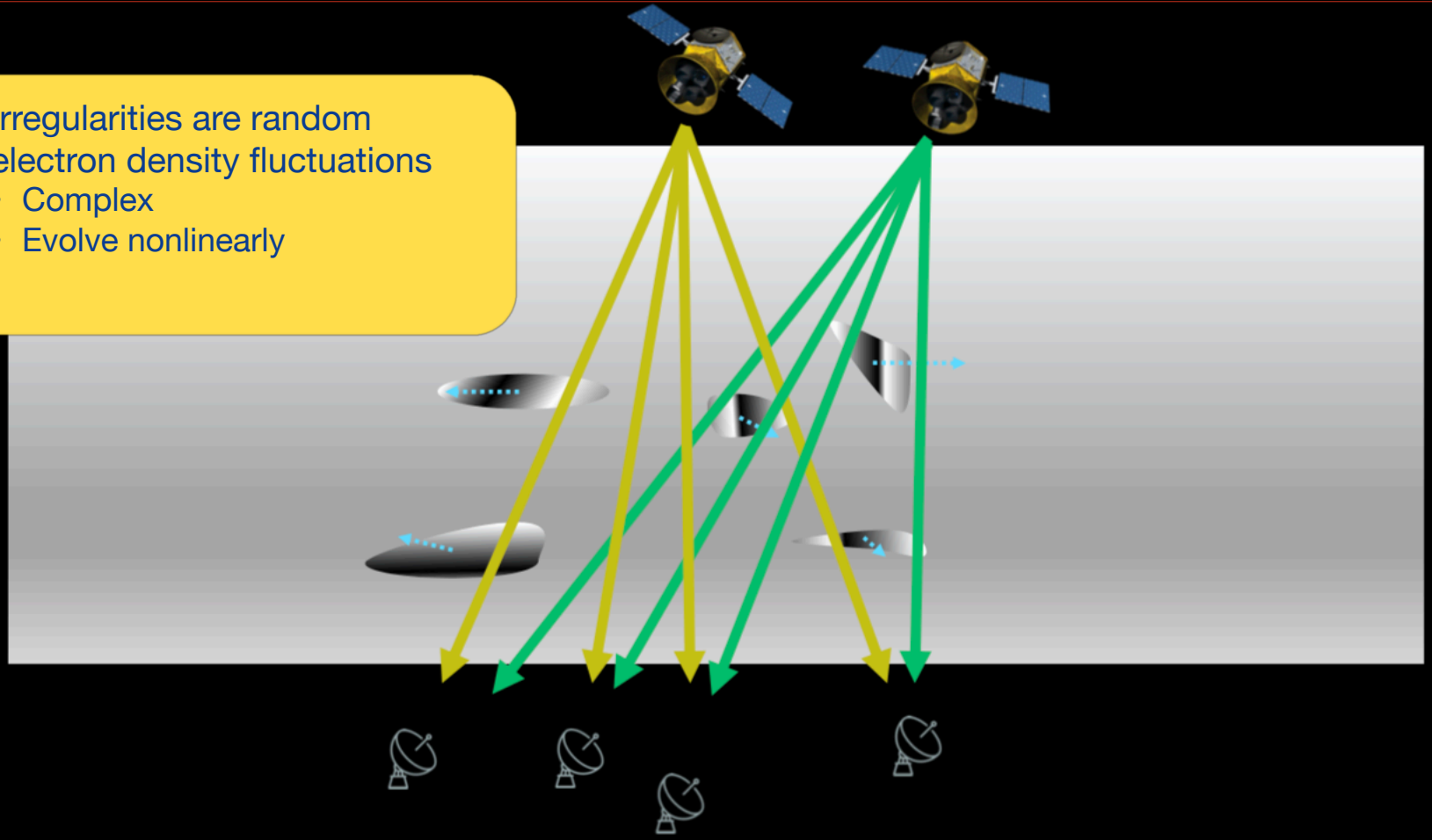

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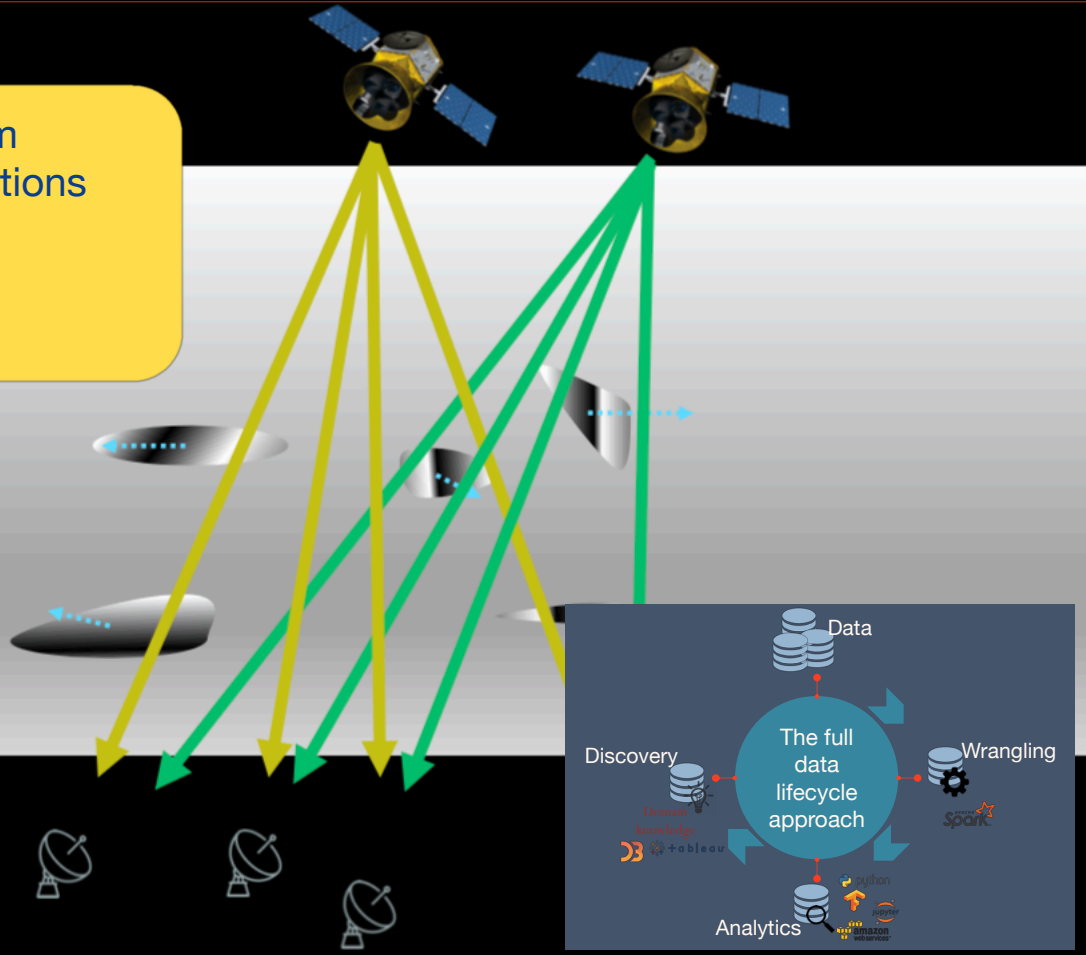

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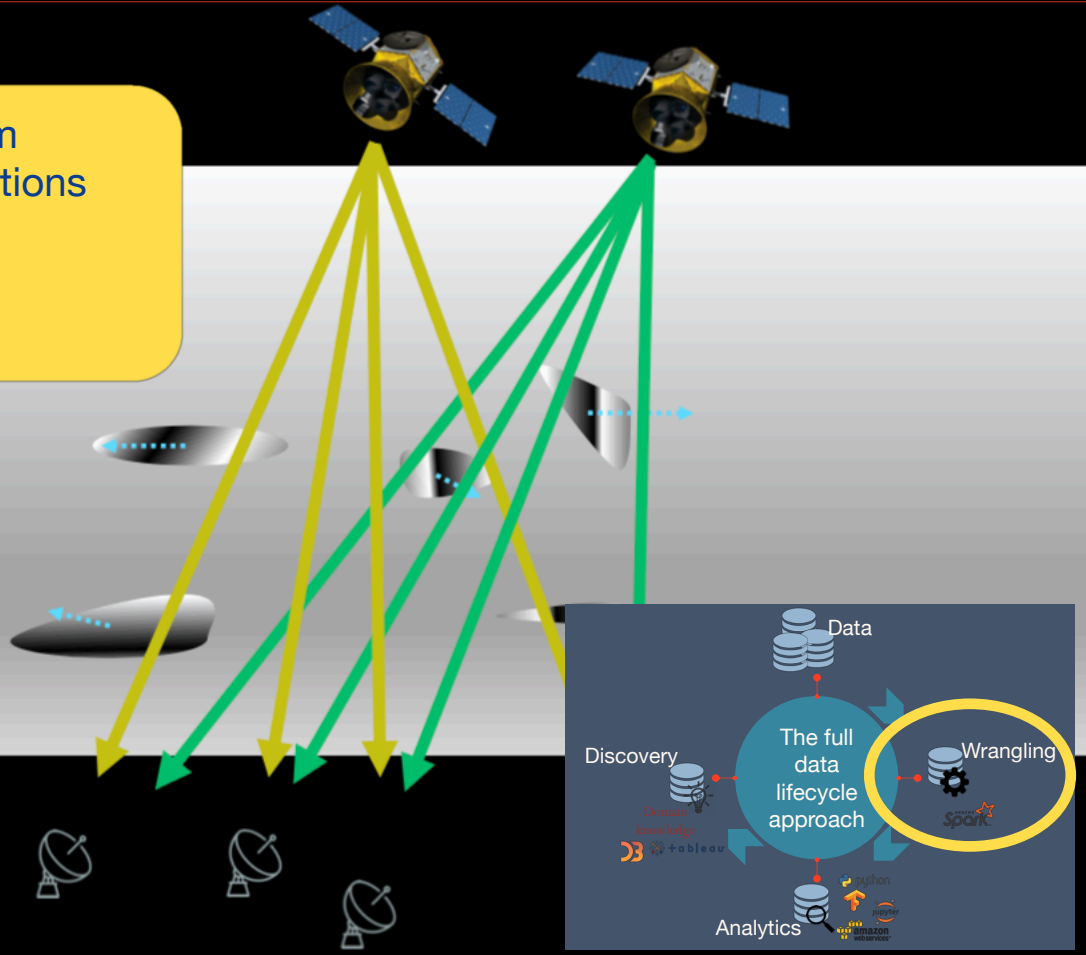

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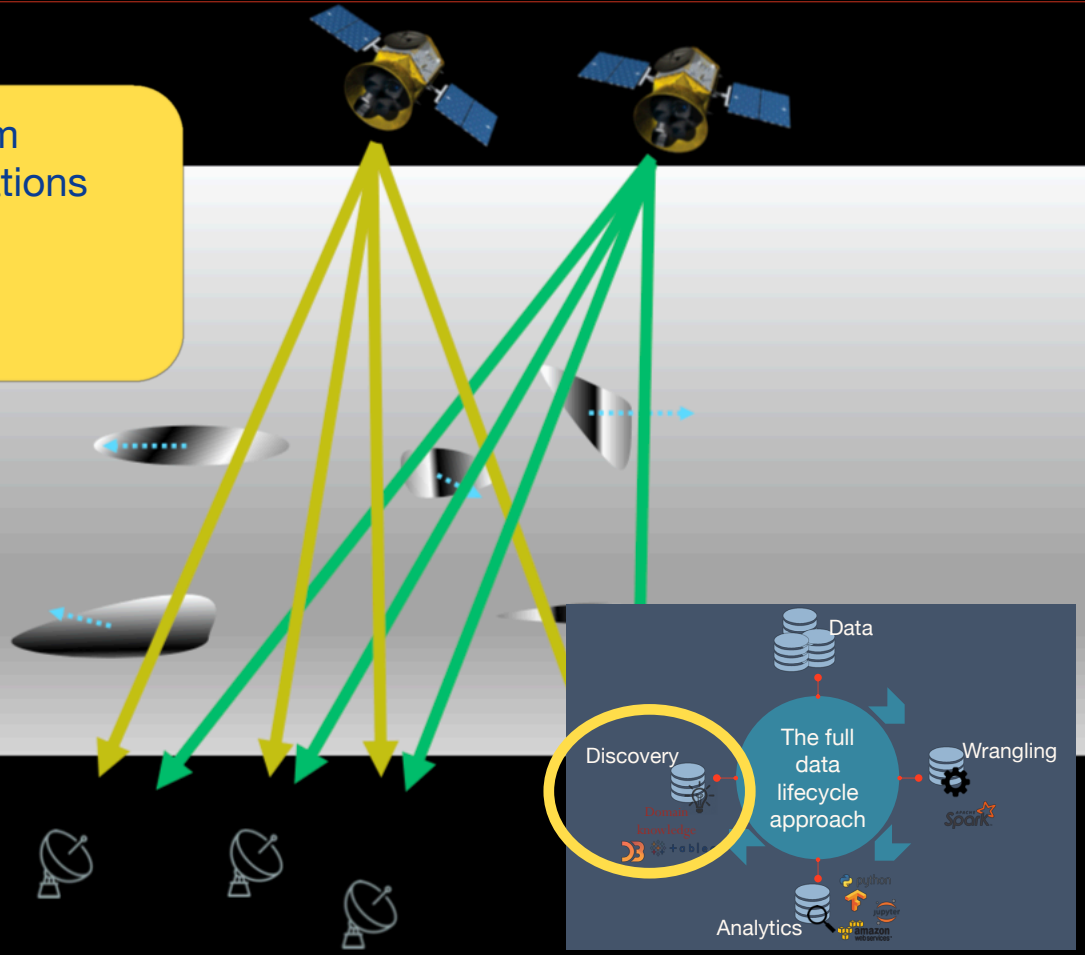
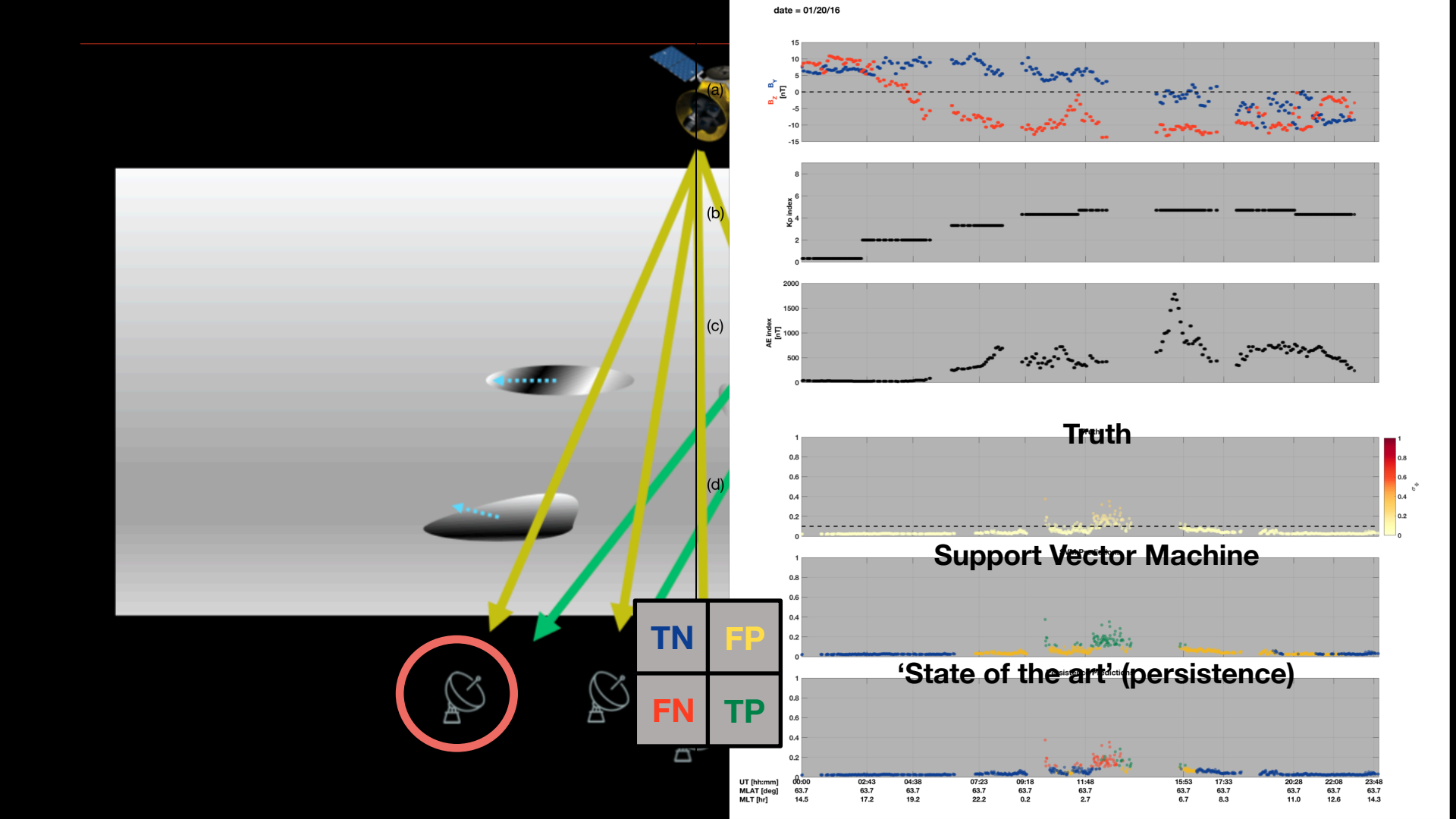
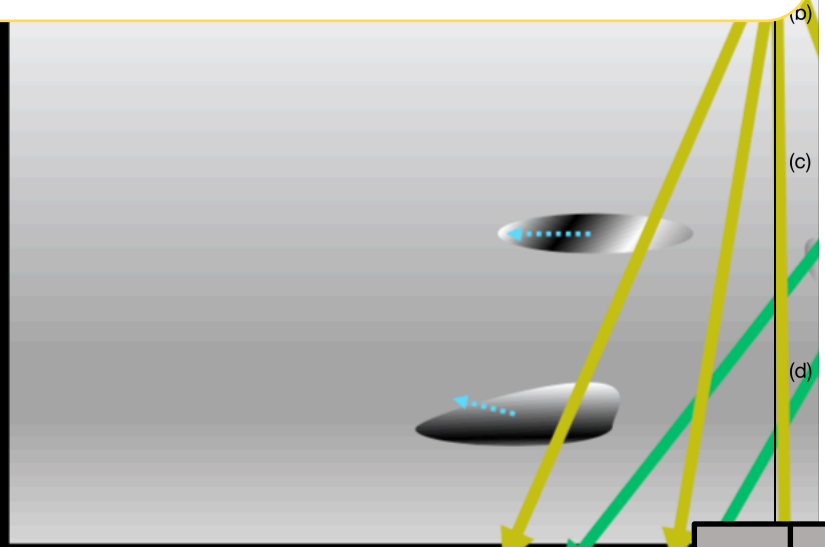



(a)
(b)
(c)
(d)
TN
FP
FN
TP
date = 01/20/16
Truth
Support Vector Machine
‘State of the art’ (persistence)
UT [hh:mm]
MLAT [deg]
MLT [hr]

Support Vector Machine (SVM) — Decision Trees — Random Forests — Neural Networks

Easily explainable → *Difficult to explain*

Create a narrative of new scientific understanding across spectrum of machine learning approaches



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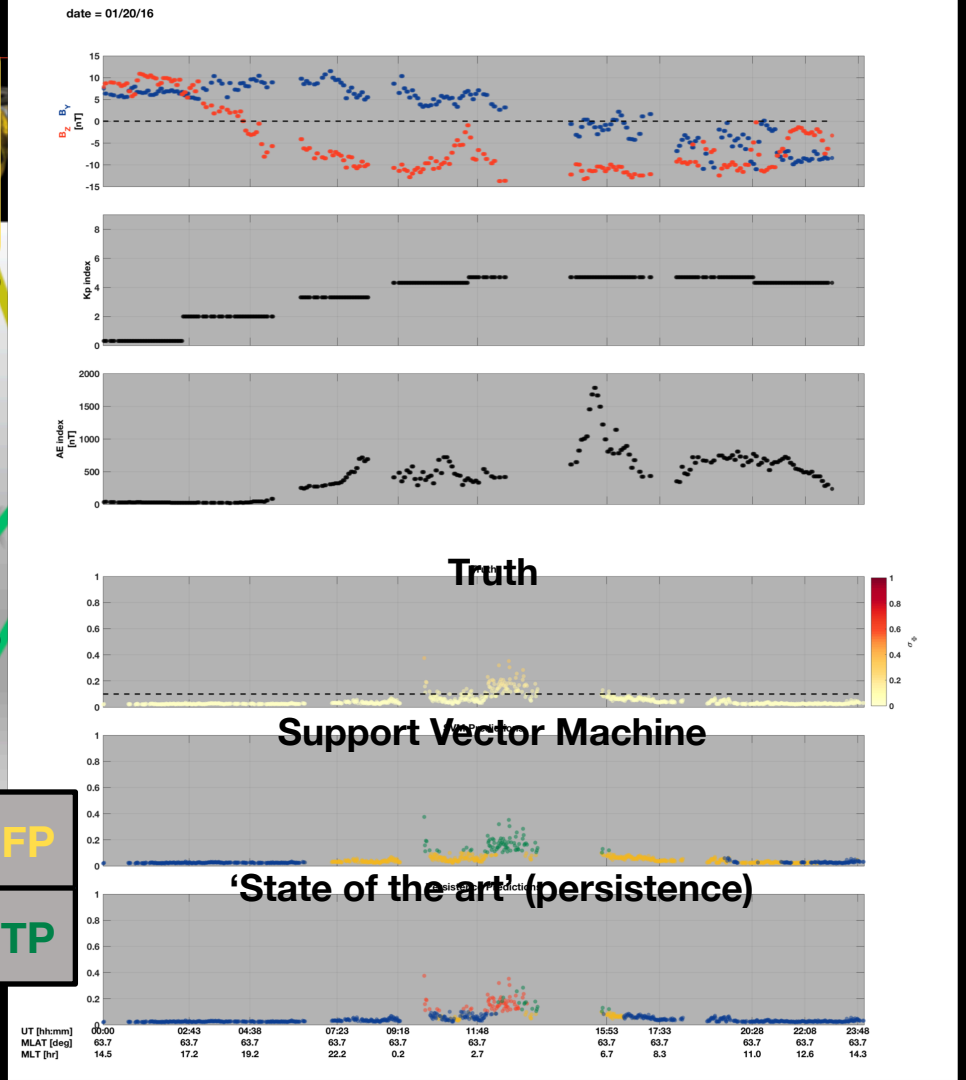

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TRENDS

- New team structure (*radically interdisciplinary*)
- Data made *usable*
- Open by default

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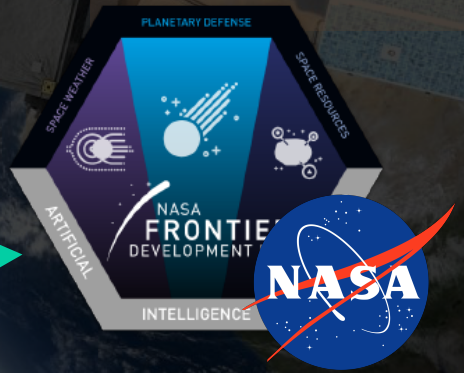
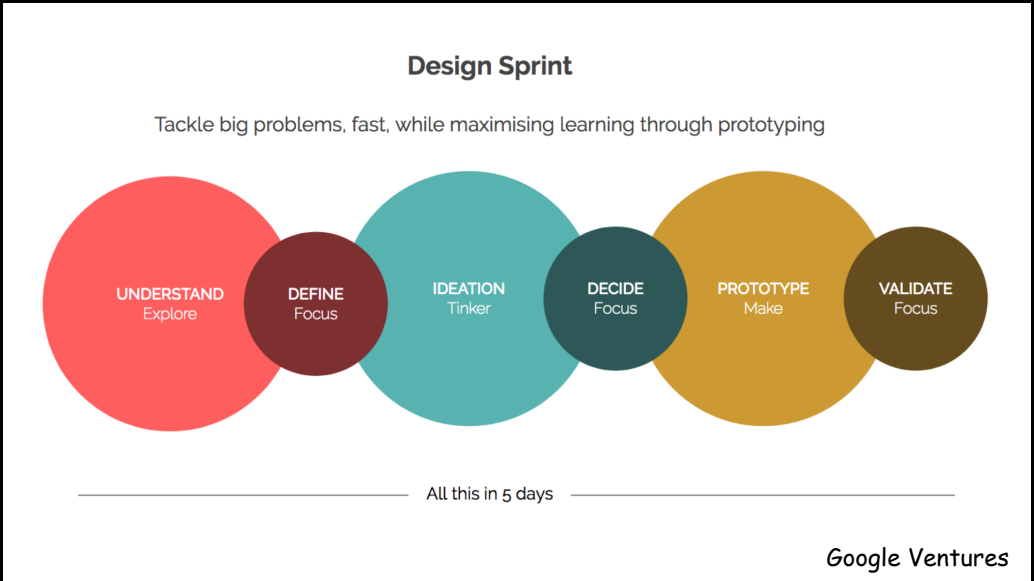
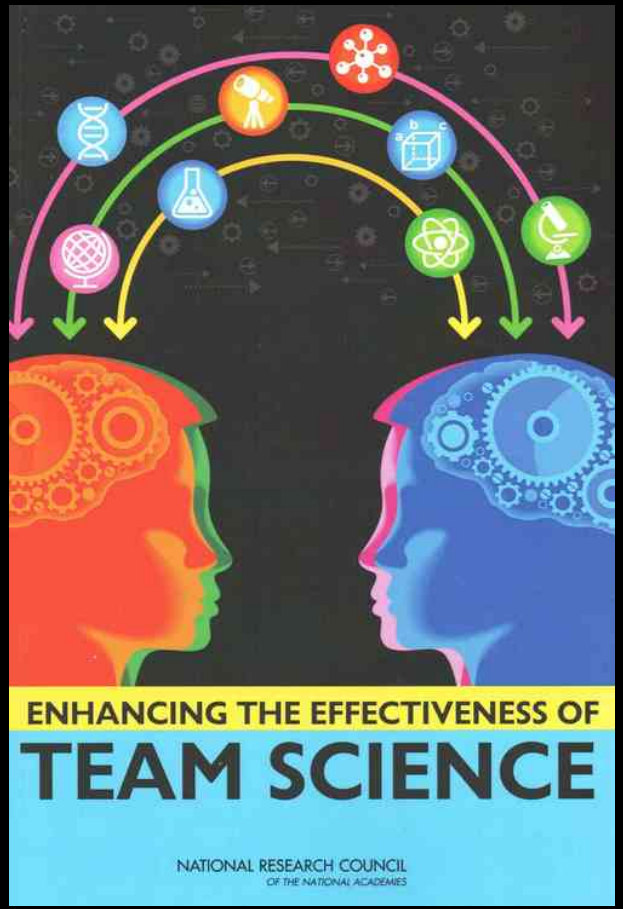
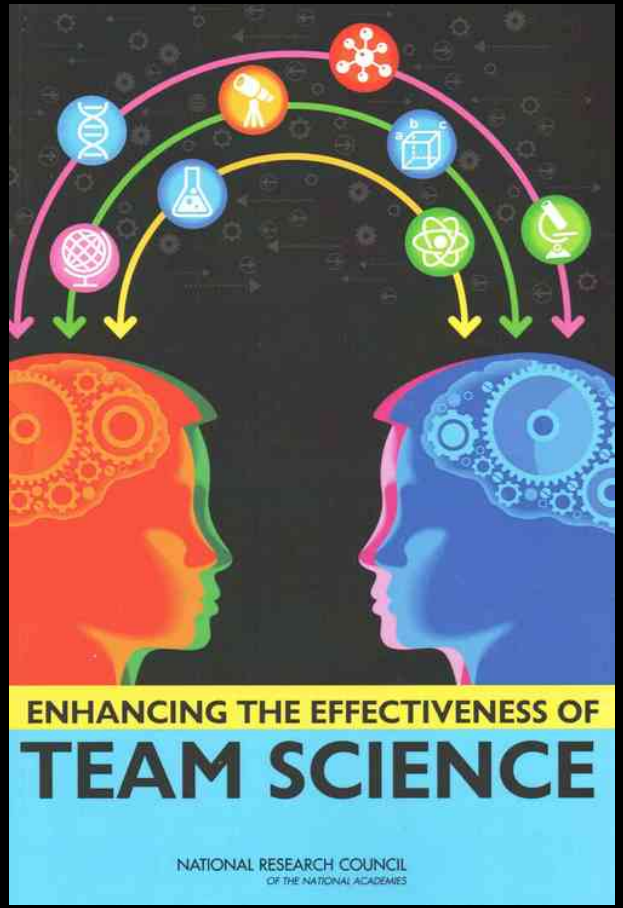



NOVEL APPROACHES
to MULTISCALE GEOSPACE
PARTICLE TRANSFER
Improved understanding and
prediction through uncertainty
quantification and machine learning

How do we run it?
A design sprint




ENHANCING THE EFFECTIVENESS OF
TEAM SCIENCE
NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES



Community of Practice

Short term: Members
Cross-disciplinary knowledge

Work on meaningful problems

Short term: Organization
Knowledge integration

Methodology transfer

Long term: Members
Personal development

Widespread collaboration

Long term: Organization
Innovation

Strategically build on open foundation

**Adapted from Serrat [2016]*

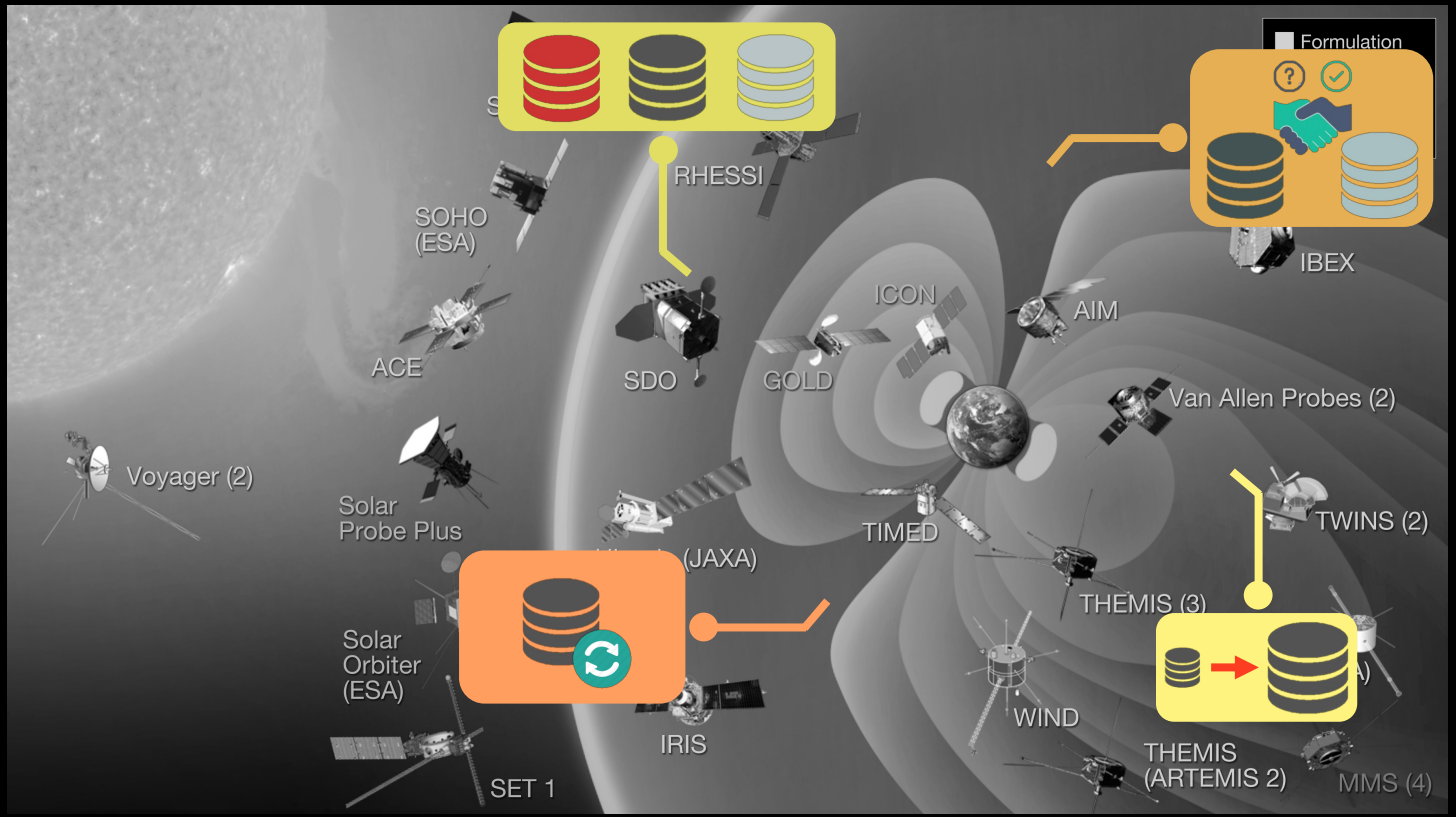
NOVEL APPROACHES
to MULTISCALE GEOSPACE PARTICLE TRANSFER

Improved understanding and prediction through uncertainty quantification and machine learning

TRENDS

- Embrace and transfer novel methodologies
- Change the pace of science
- Create Communities of Practice to deeply integrate knowledge

What is the path forward?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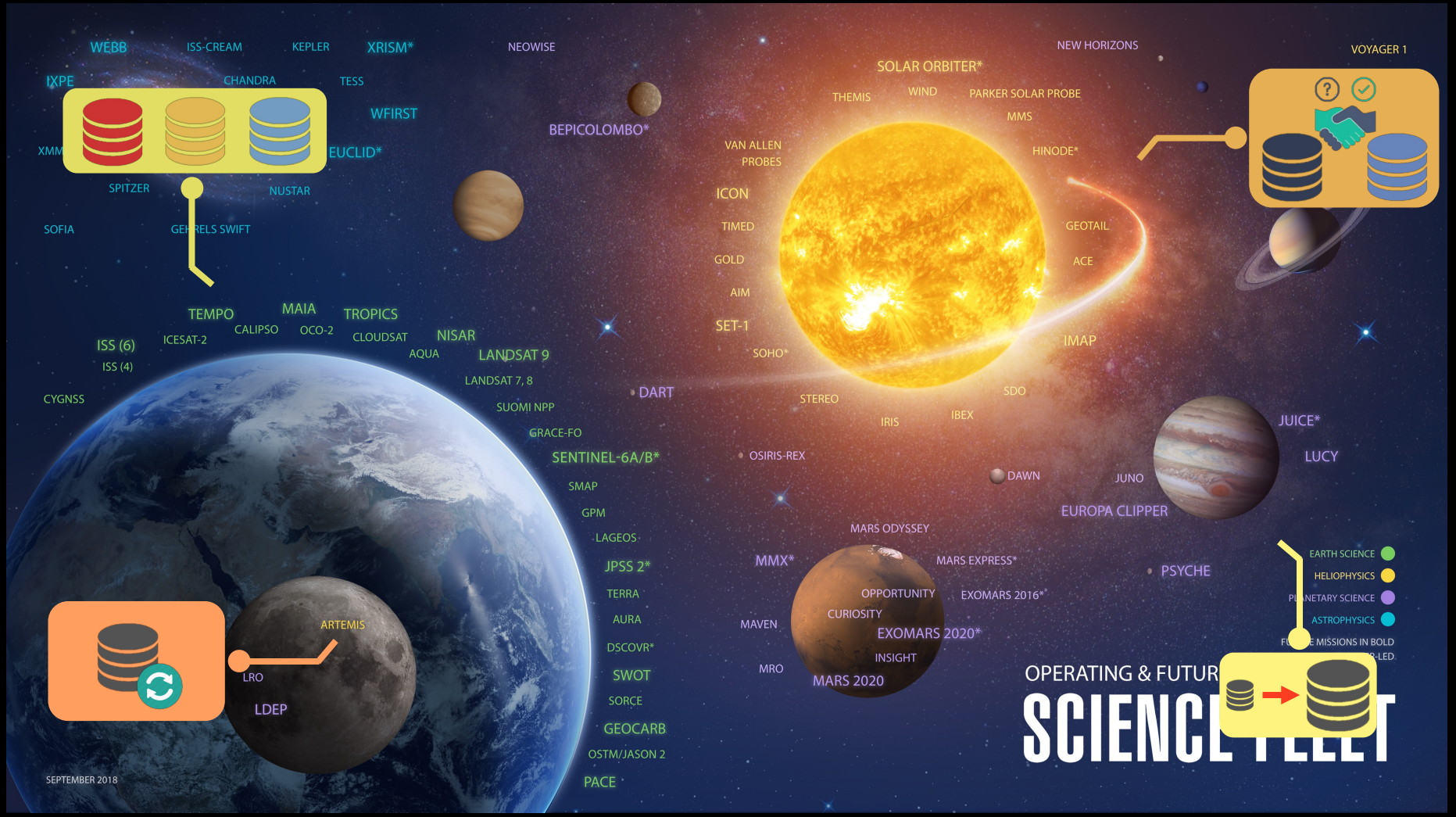
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OPERATING & FUTUR
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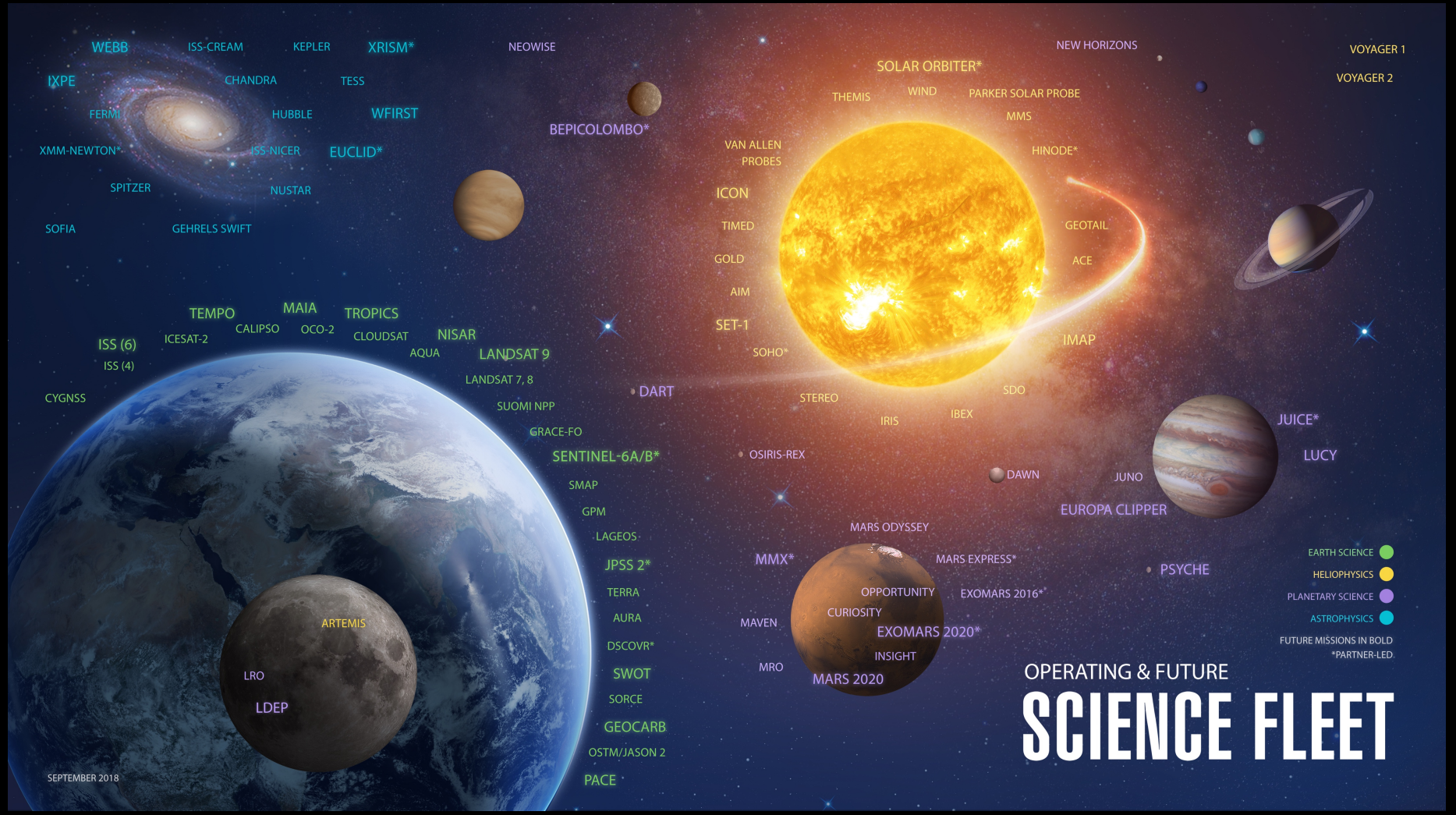
SEPTEMBER 2018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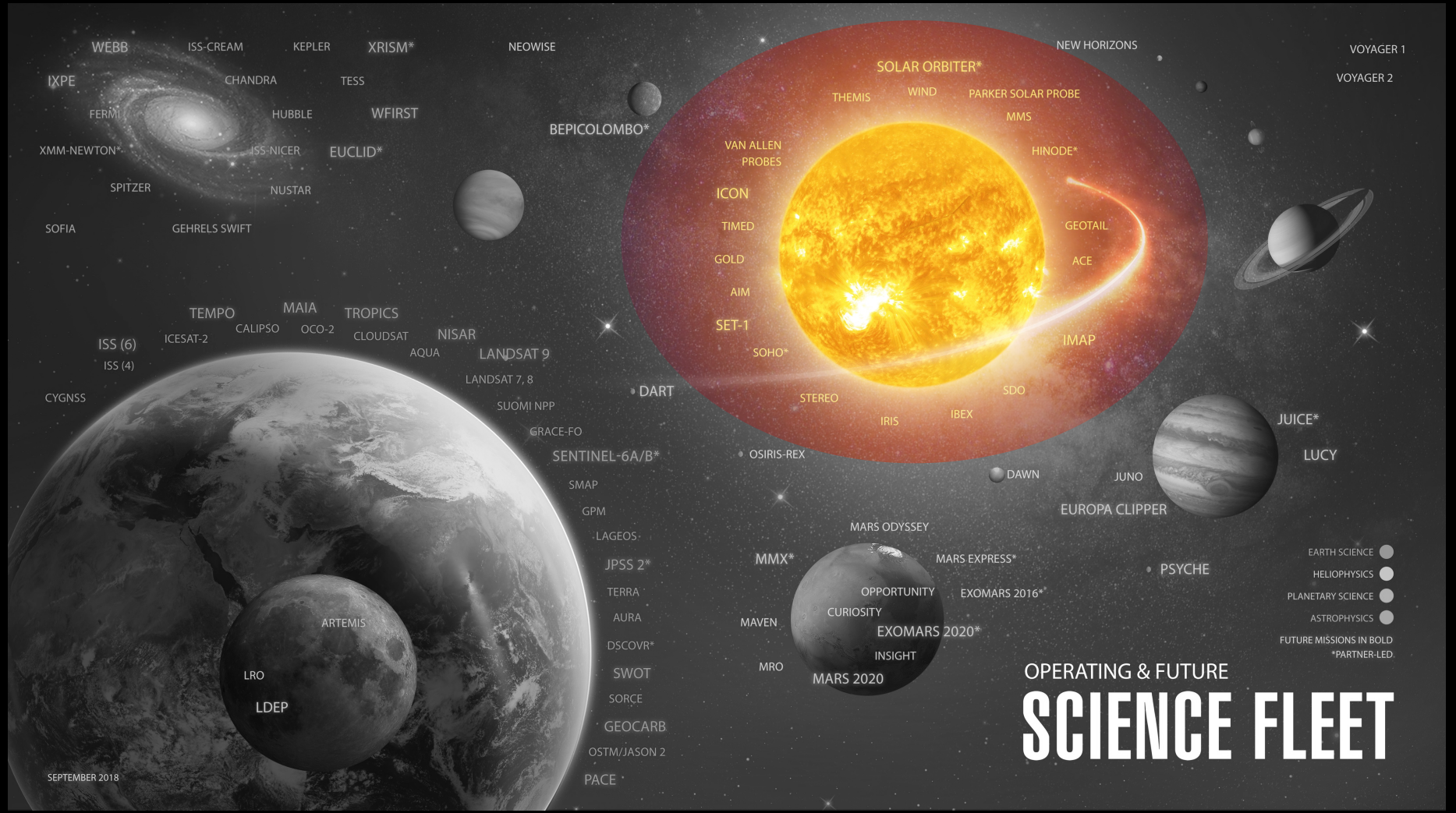
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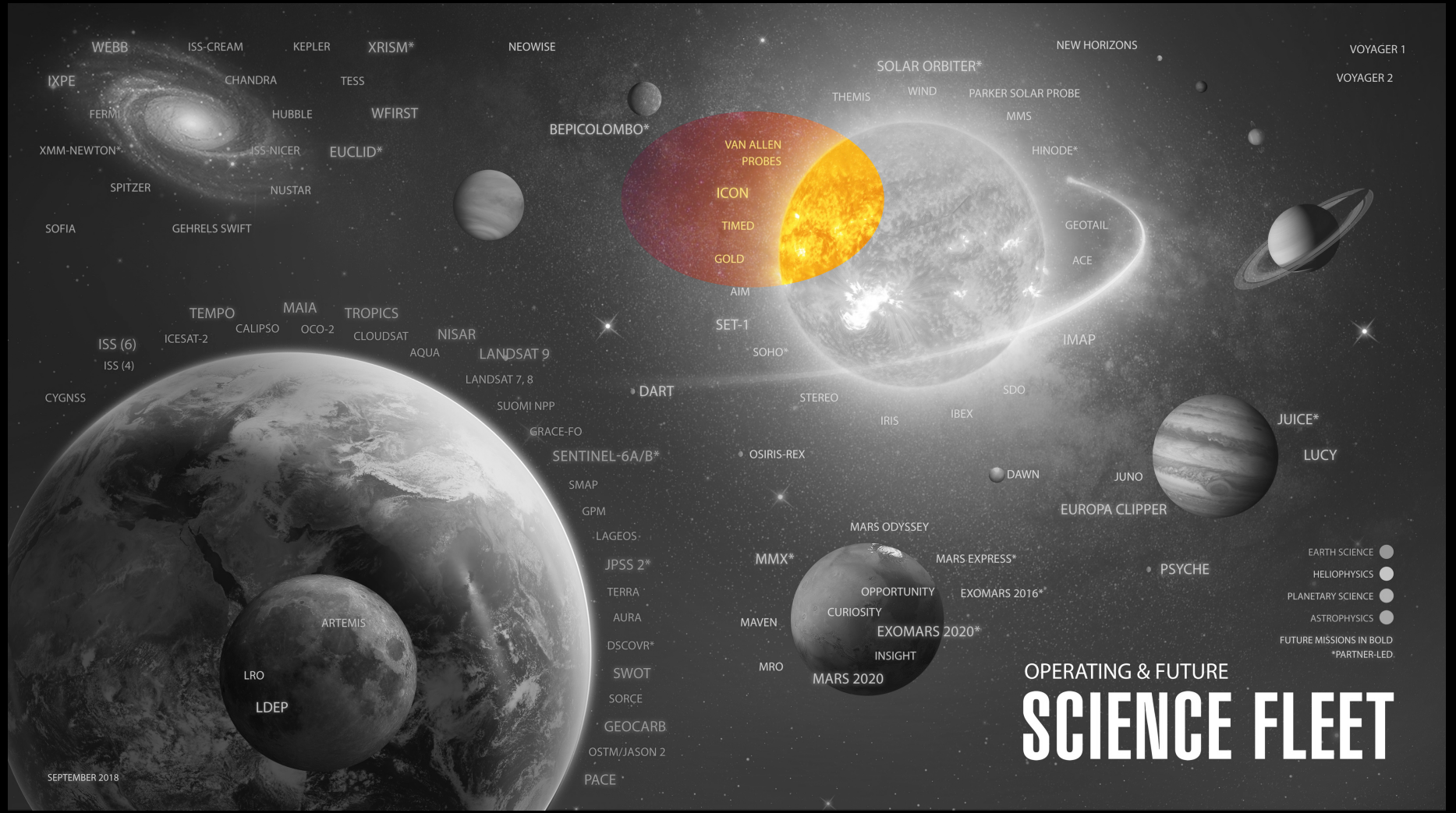
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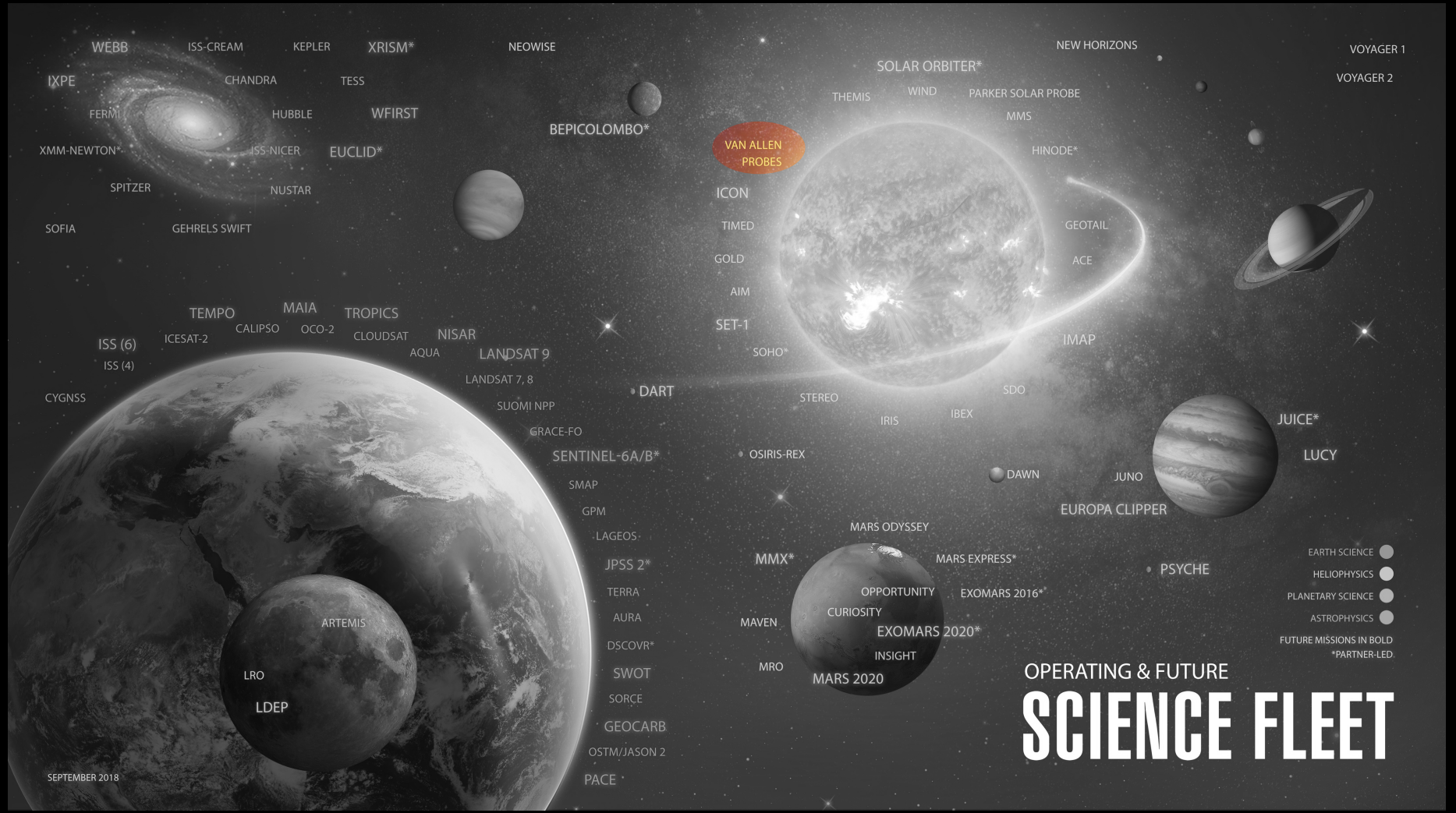
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FUTURE MISSIONS IN BOLD
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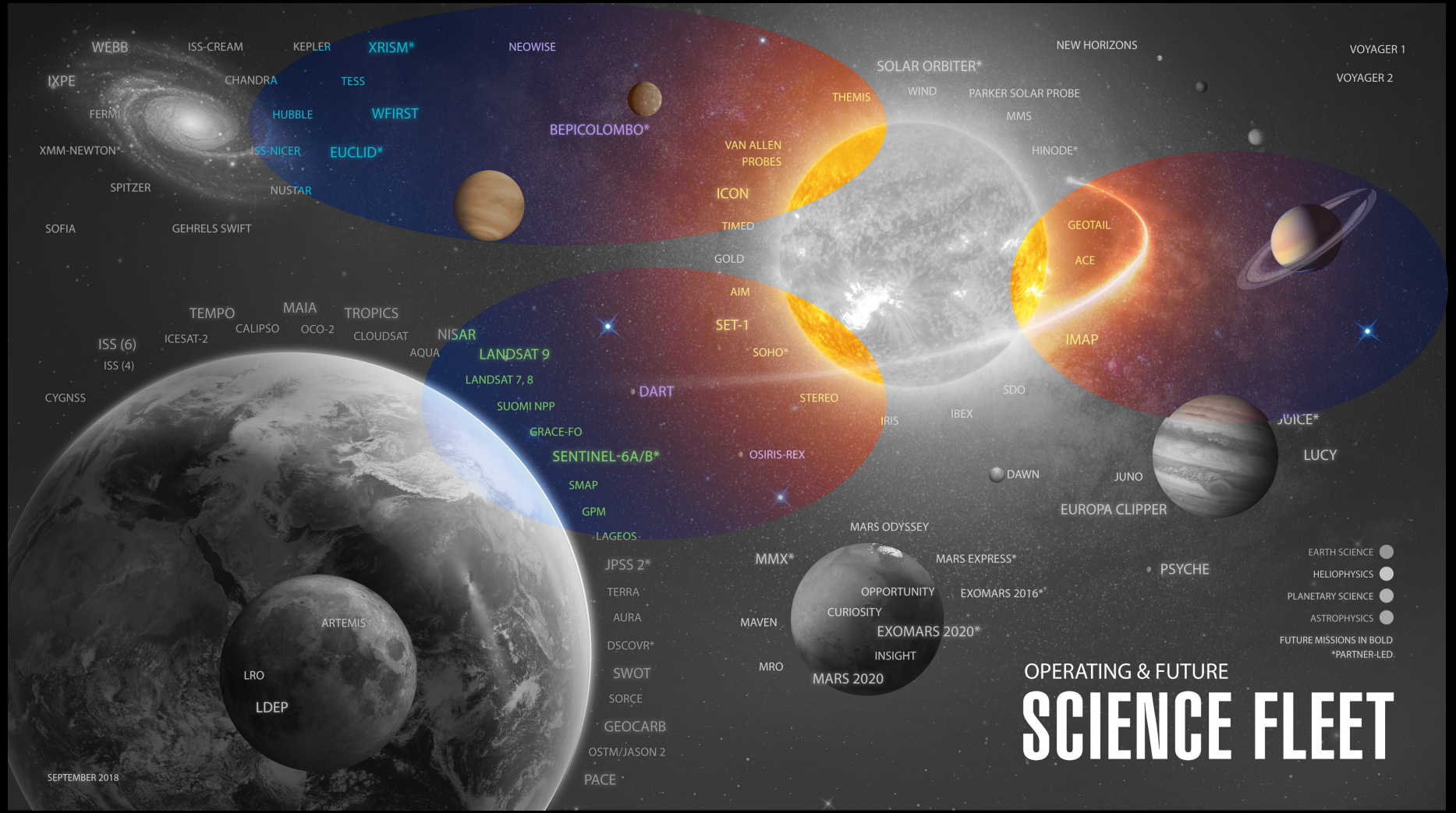
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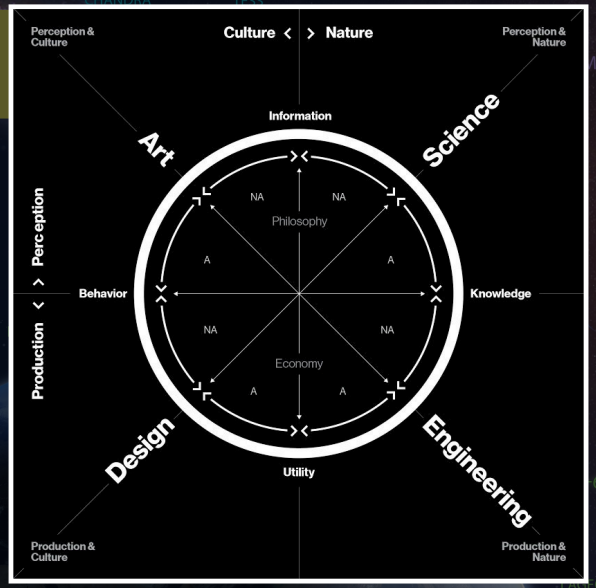
Someone or something that doesn't fit within traditional academic discipline-a field of study with its own particular words, frameworks, and methods

Joi Ito, MIT Media Lab, “Antidisciplinary”



Someone or something that doesn't fit within traditional academic discipline-a field of study with its own particular words, frameworks, and methods

Joi Ito, MIT Media Lab, "Antidisciplinary"

Take action!

- Contribute to white paper (*overleaf doc to write this week*; Slack channel #antidisciplinary)
- Help build resources to clarify misconceptions, provide training, and reveal *home runs*
- Be pioneers of antidisciplinary

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McGranaghan, R. M., A.J. Mannucci, B.D Wilson, C.A. Mattmann, and R. Chadwick. (2018), New capabilities for prediction of high-latitude ionospheric scintillation: A novel approach with machine learning, Space Weather, 16. https://doi.org/10.1029/2018SW002018

AGU 100 ADVANCING EARTH AND SPACE SCIENCE

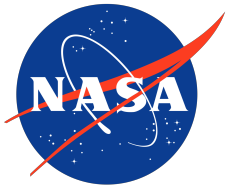
FALL MEETING

San Francisco, CA | 9–13 December 2019

Town Hall!

Antidisciplinary: Science and engineering in the digital age

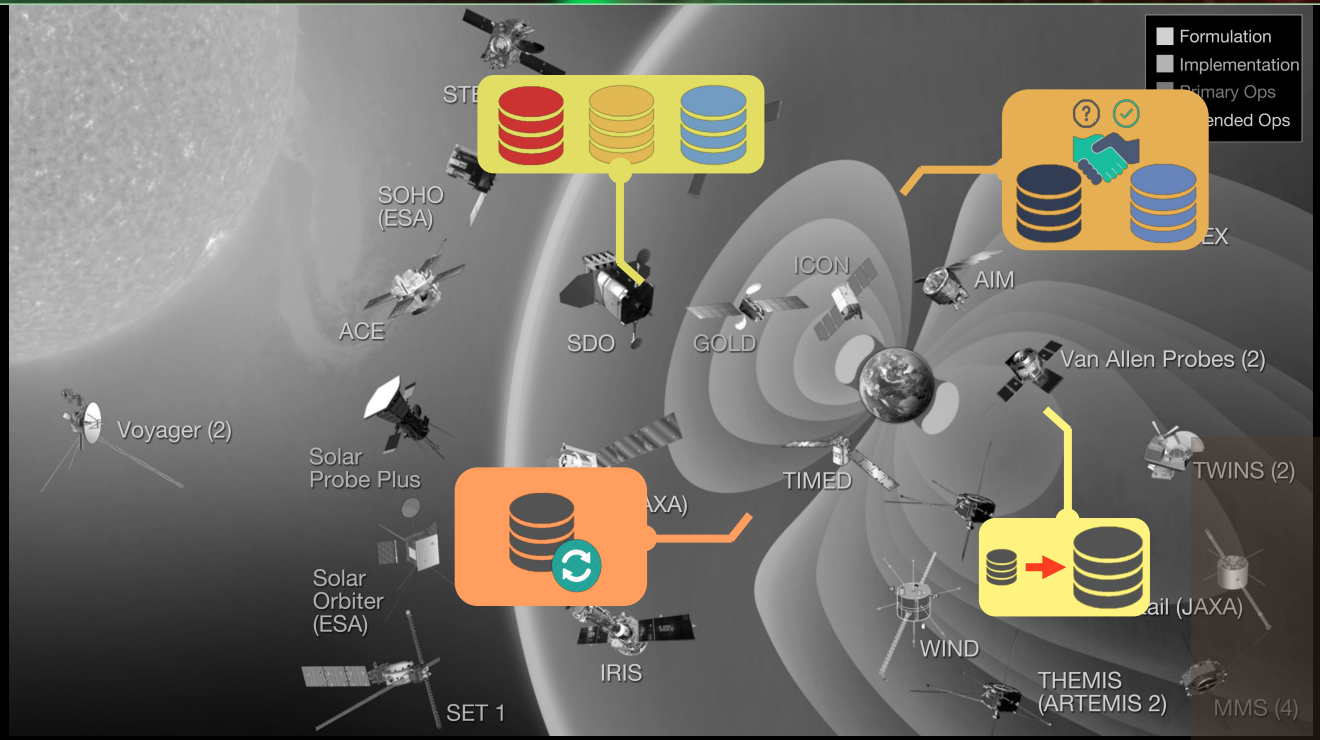
Join a *radically* interdisciplinary group to shape the New Frontier



McGranaghan, R. M., Bhatt, A., Matsuo, T., Mannucci, A. J., Semeter, J. L., & Datta-Barua, S. (2017). Ushering in a new frontier in geospace through data science. Journal of Geophysical Research: Space Physics, 122, 12,586– 12,590. https://doi.org/10.1002/2017JA024835

SWSC Journal of Space Weather and Space Climate

Space Weather in the Digital Age and across the full data lifecycle



For a full description of the topical issue, relevant information, and manuscript submission link please visit https://bit.ly/2CerJWZ.

Topical Editors:
Ryan M. McGranaghan
Anastasios Anastasiadis
Enrico Camporeale
Manolis Georgoulis

Submission Deadline: September 30, 2019

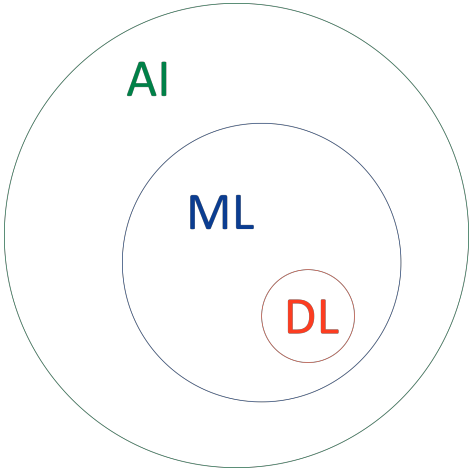
Backup

Link to online materials

https://drive.google.com/open?id=1XhPgdx7-RNJDfug3KdpyrFF388Kaqe0I

What's going on now? How can you contribute?

- New communication
  - NASA Scientific Visualization Studio
  - Origins
- White paper that will be developed *this week (before we conclude on Friday)* - overleaf
- Eos article on Google Design Sprint for the sciences forthcoming
- Be a part of the conversation
  - JSWSC topical issue
  - AGU Town Hall: "Antidisciplinary: Tackling the technical and social challenges to data science-driven discovery"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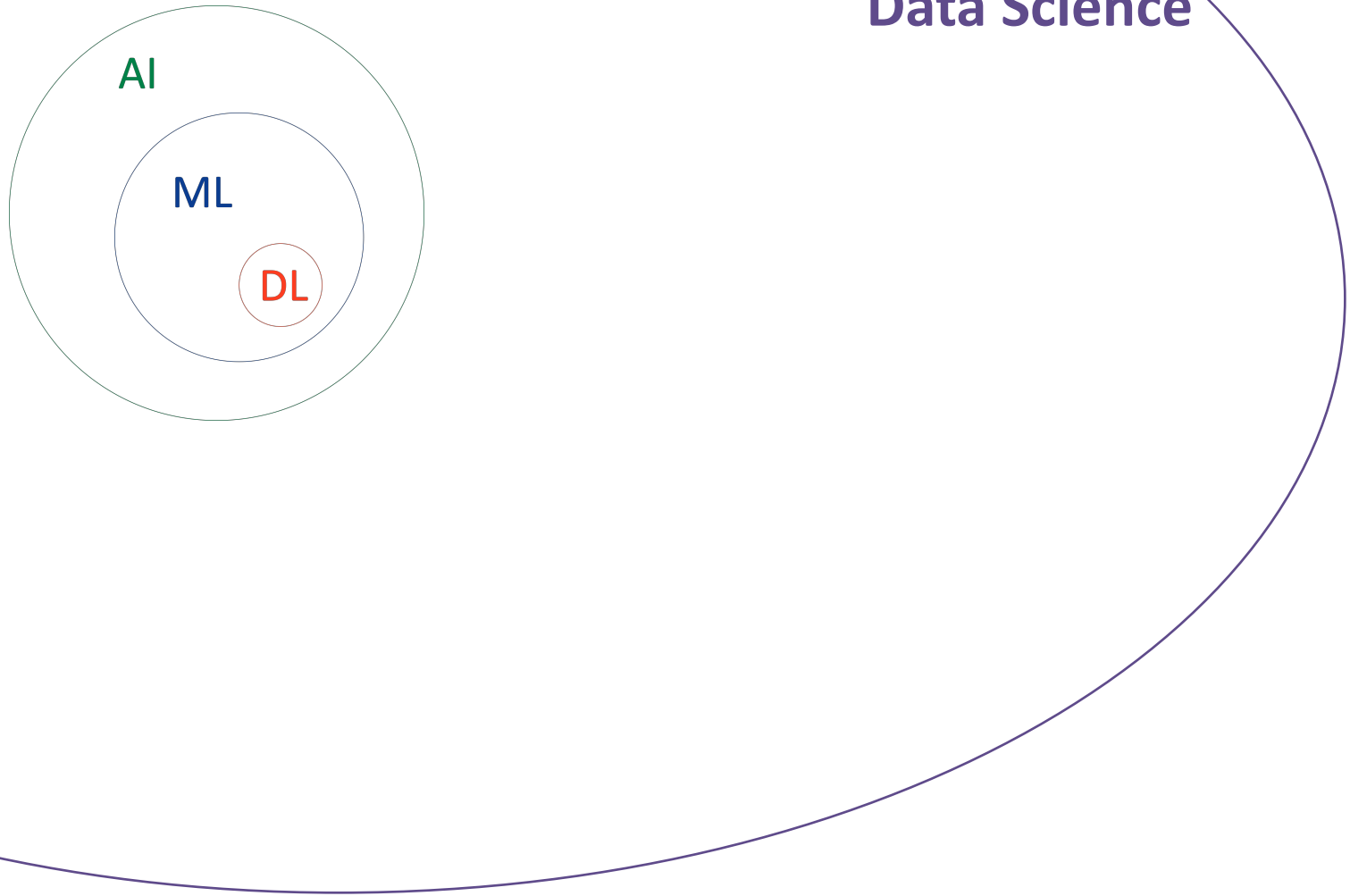
Data Science
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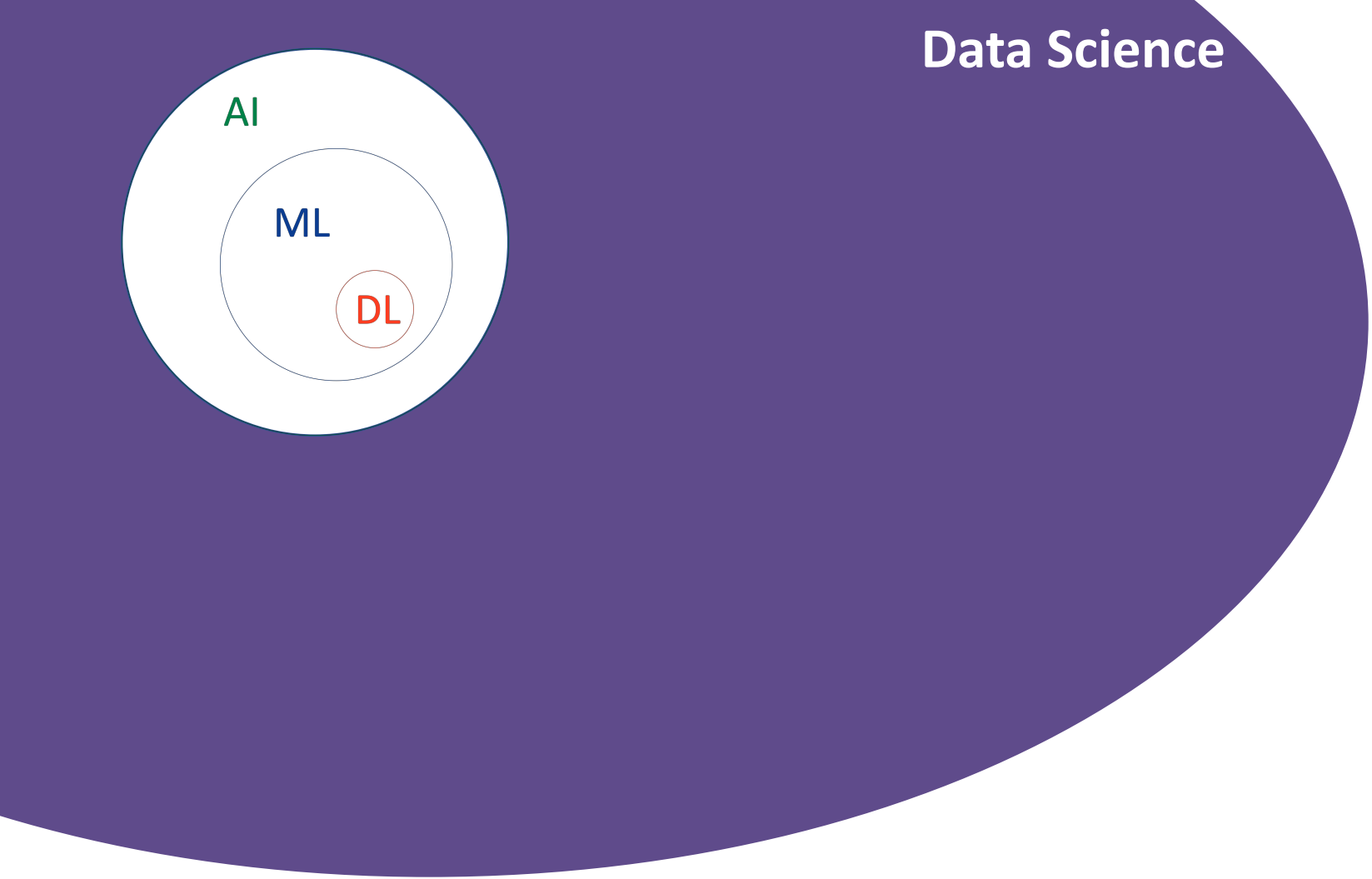
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