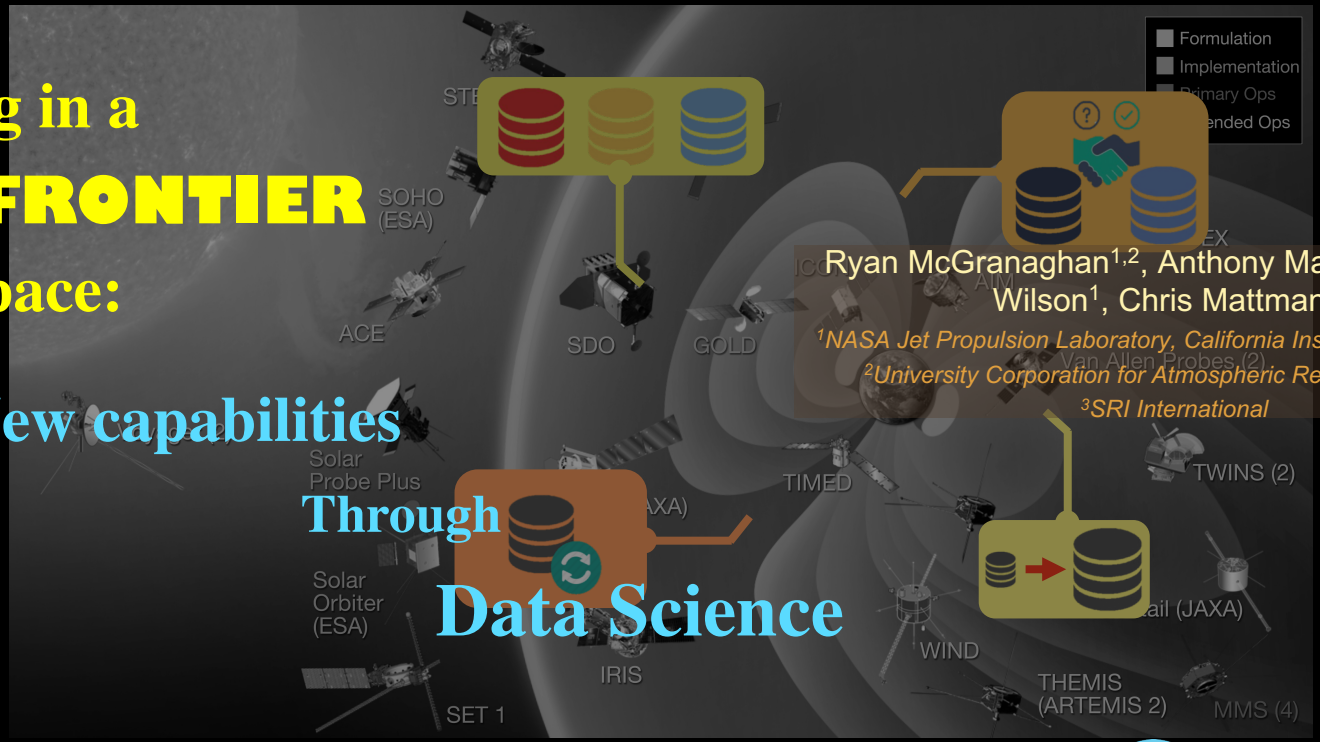
Ushering in a **NEW FRONTIER** in Geospace:

New capabilities Through Data Science



Ryan McGranaghan[1,2], Anthony Mannucci[1], Brian Wilson[1], Chris Mattmann[1]

[1]NASA Jet Propulsion Laboratory, California Institute of Technology

[2]University Corporation for Atmospheric Research (UCAR)

[3]SRI International

CPAESS

JPL

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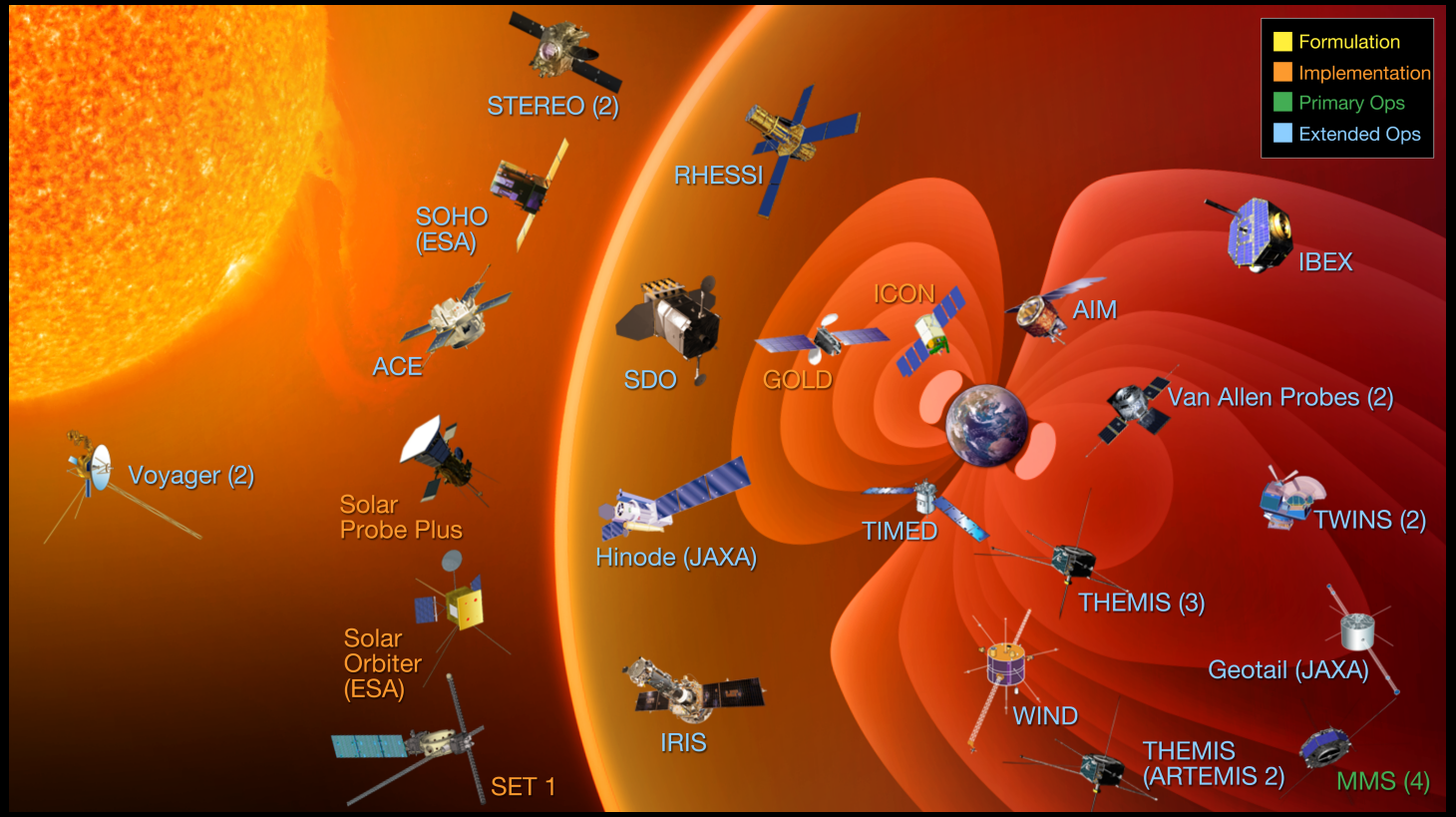
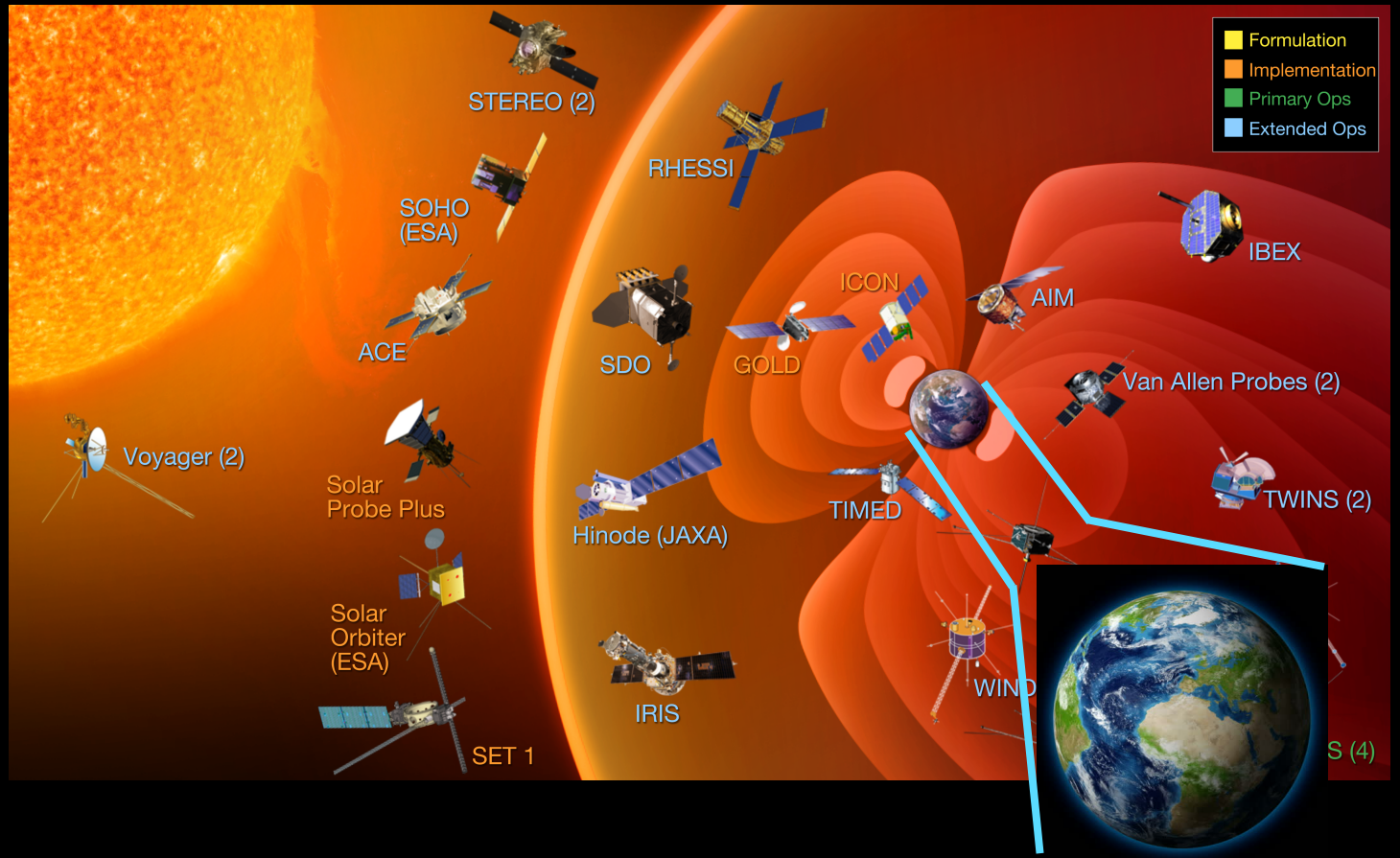

Formulation
Implementation
Primary Ops
Extended Ops
STEREO (2)
RHESSI
SOHO (ESA)
IBEX
ICON
AIM
ACE
SDO
GOLD
Van Allen Probes (2)
Voyager (2)
Solar Probe Plus
TWINS (2)
Hinode (JAXA)
TIMED
THEMIS (3)
Solar Orbiter (ESA)
Geotail (JAXA)
WIND
IRIS
THEMIS (ARTEMIS 2)
MMS (4)
SET 1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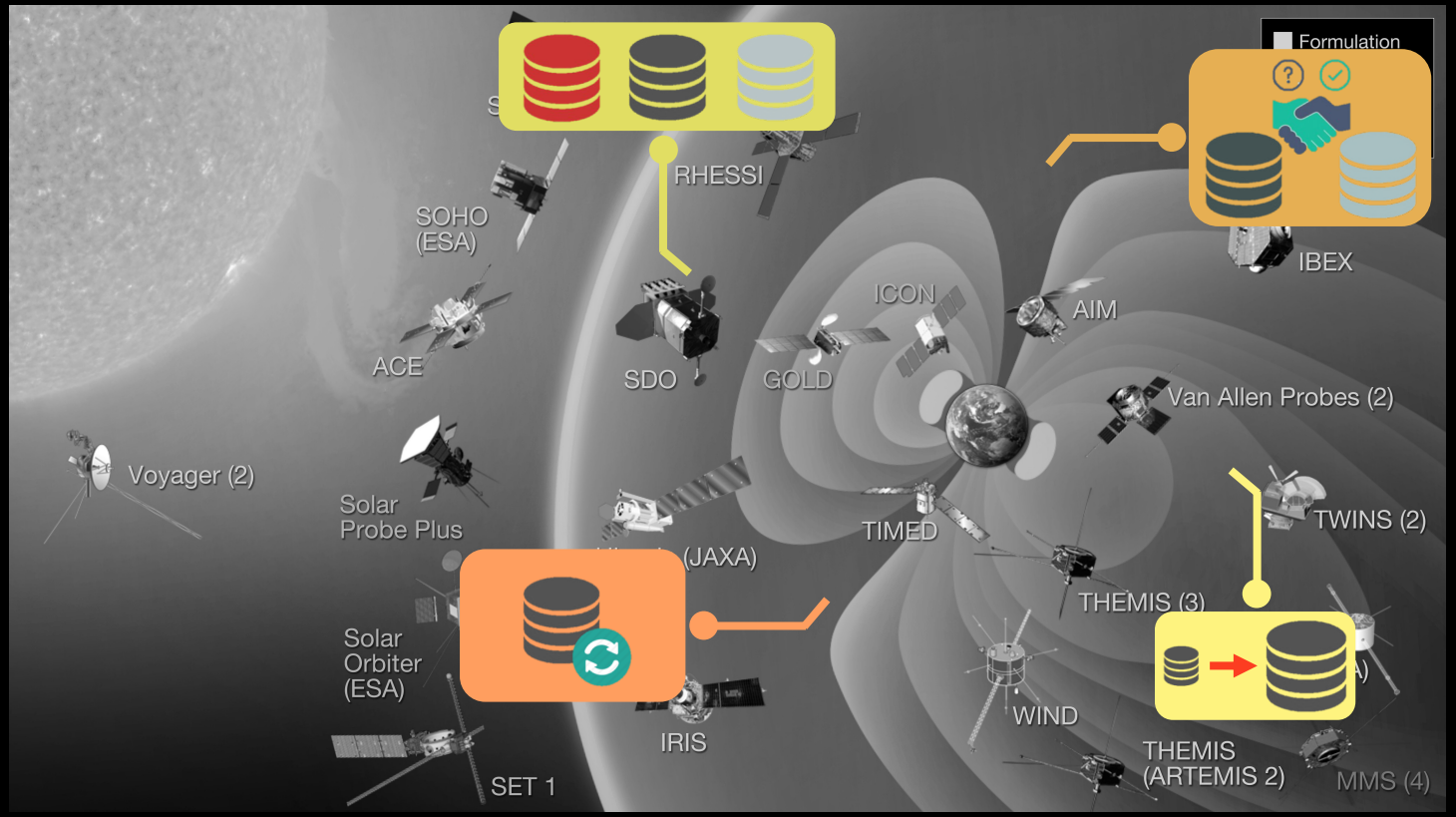
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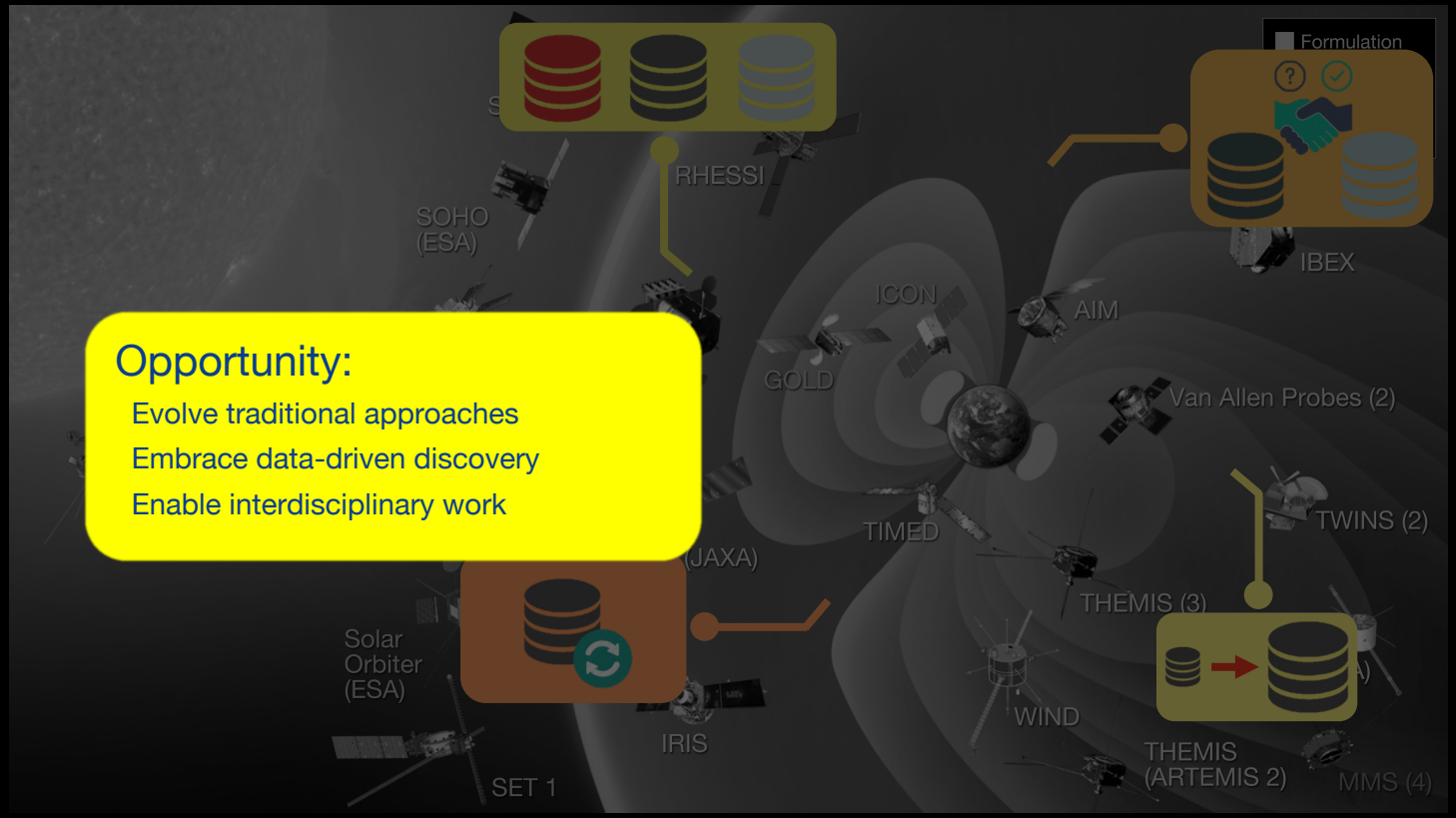
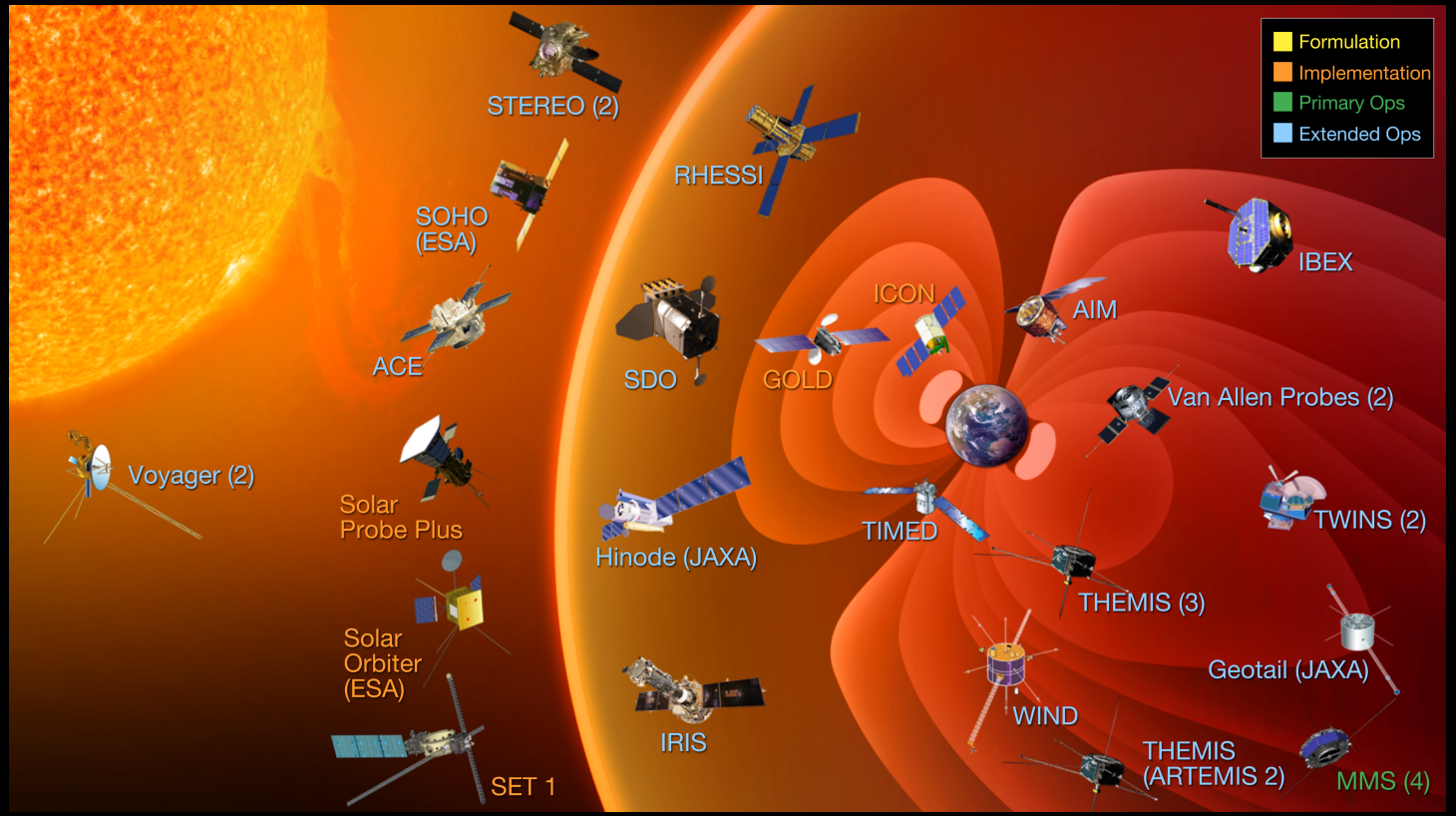


Opportunity:

- Evolve traditional approaches
- Embrace data-driven discovery
- Enable interdisciplinary work

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

Dan Crichton, JPL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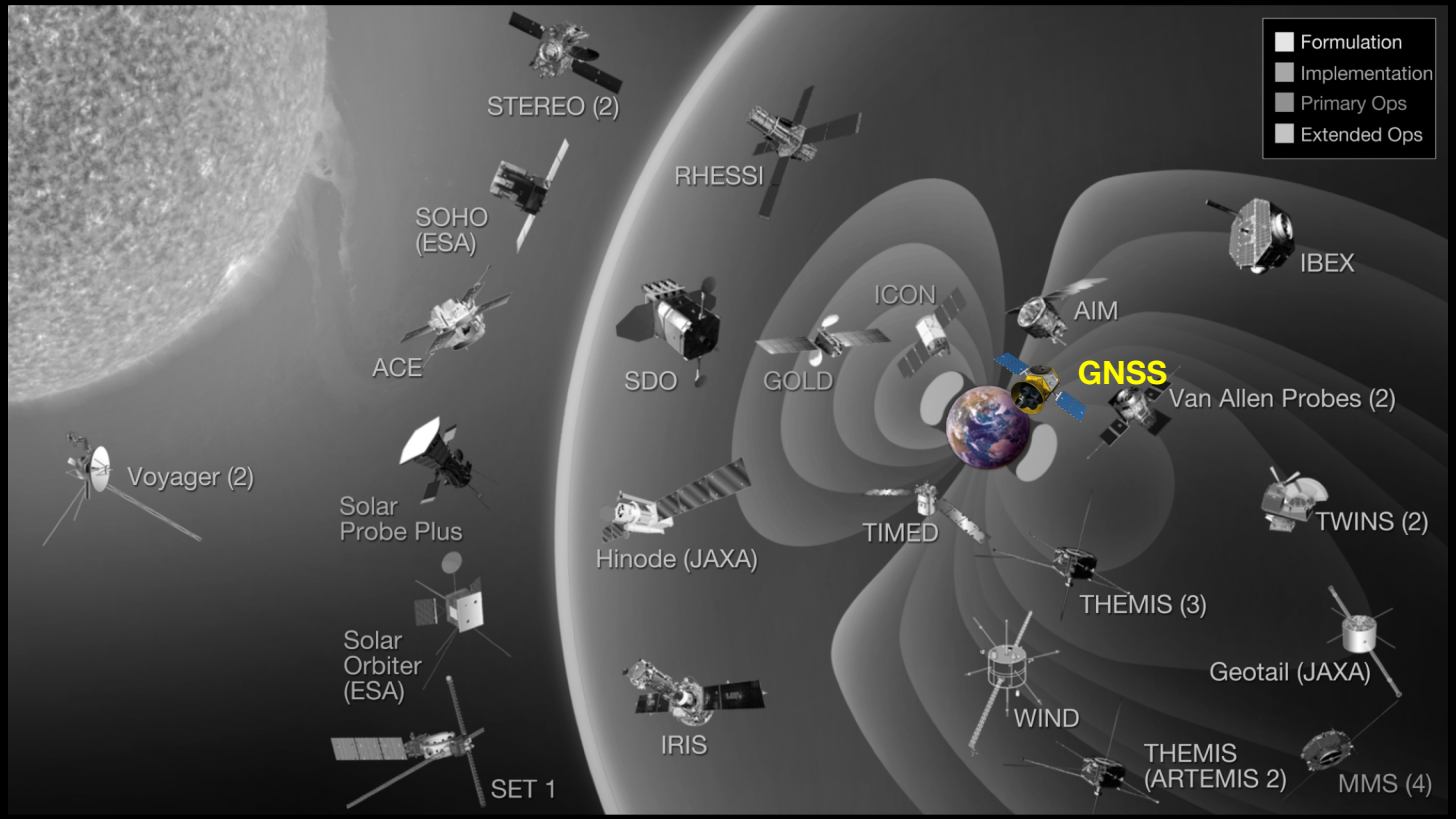
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STRETCHING GNSS SIGNALS FOR SPACE WEATHER DISCOVERY

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

NASA Jet Propulsion Laboratory, California Institute of Technology

Data-driven space weather:

Machine learning

Data-driven space weather:
Machine learning

Problems well-suited to machine learning

- Classification
- Event detection
- Segmentation
- Clustering
- Prediction
- Recommendation

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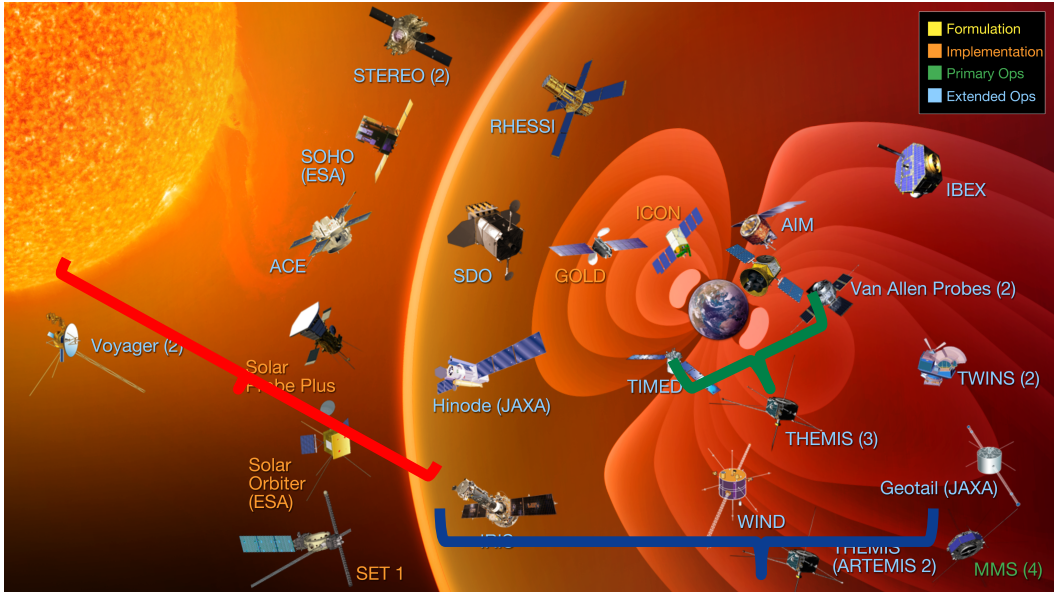
Support Vector Machine (SVM) — **Decision Trees** — **Random Forests** — **Neural Networks**

Easily explainable → *Difficult to explain*

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

Data-driven space weather:

Machine learning



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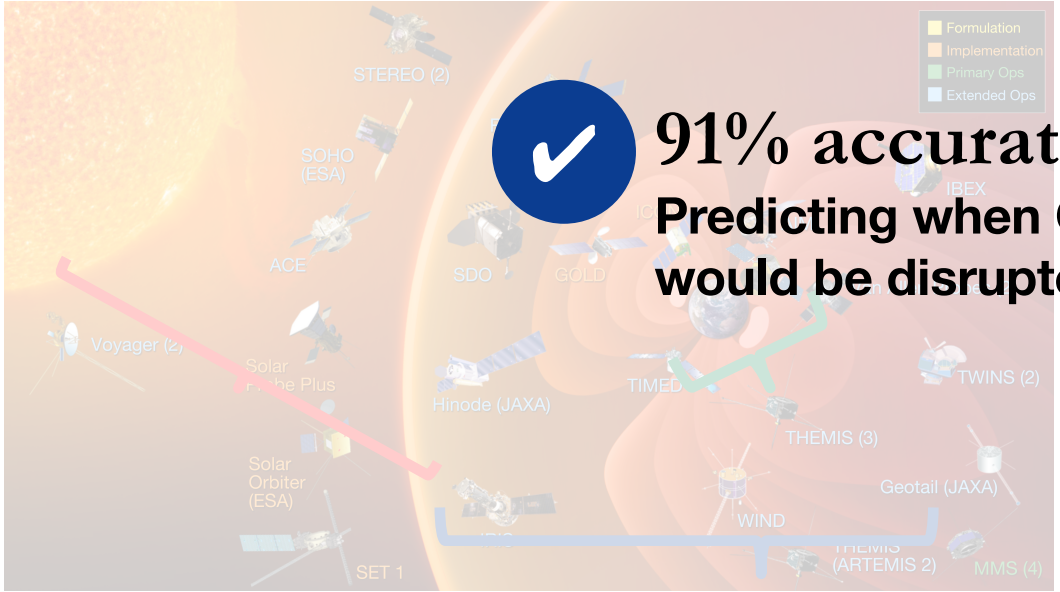

91% accurate

Predicting when GNSS signal would be disrupted

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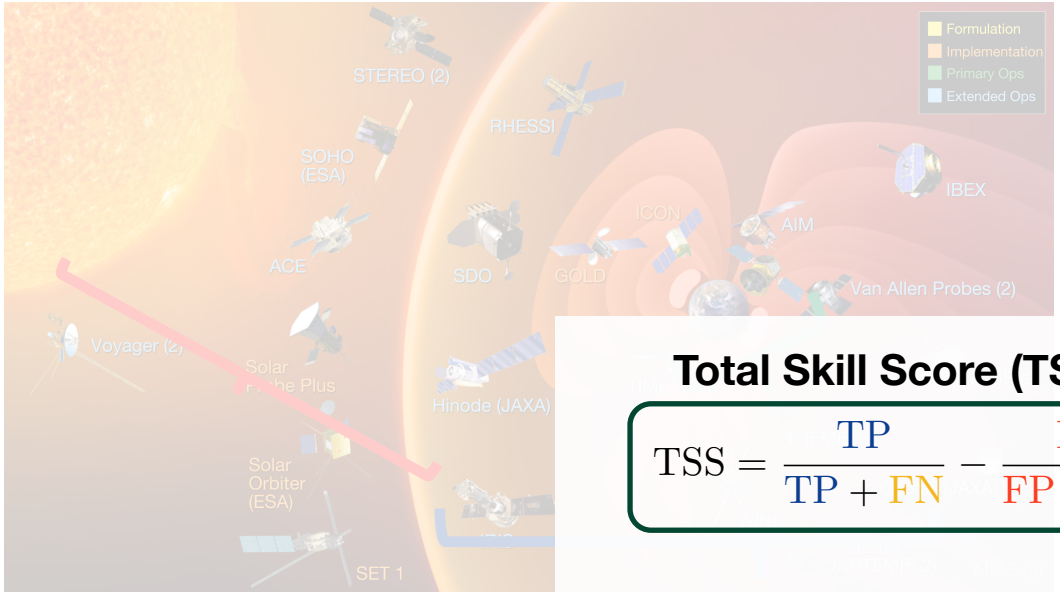

Total Skill Score (TSS)

$$\mathrm{TSS} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}} - \frac{\mathrm{FP}}{\mathrm{FP} + \mathrm{TN}}$$

TSS

-1
Worst

+1
Perfect

Support Vector Machine (SVM)

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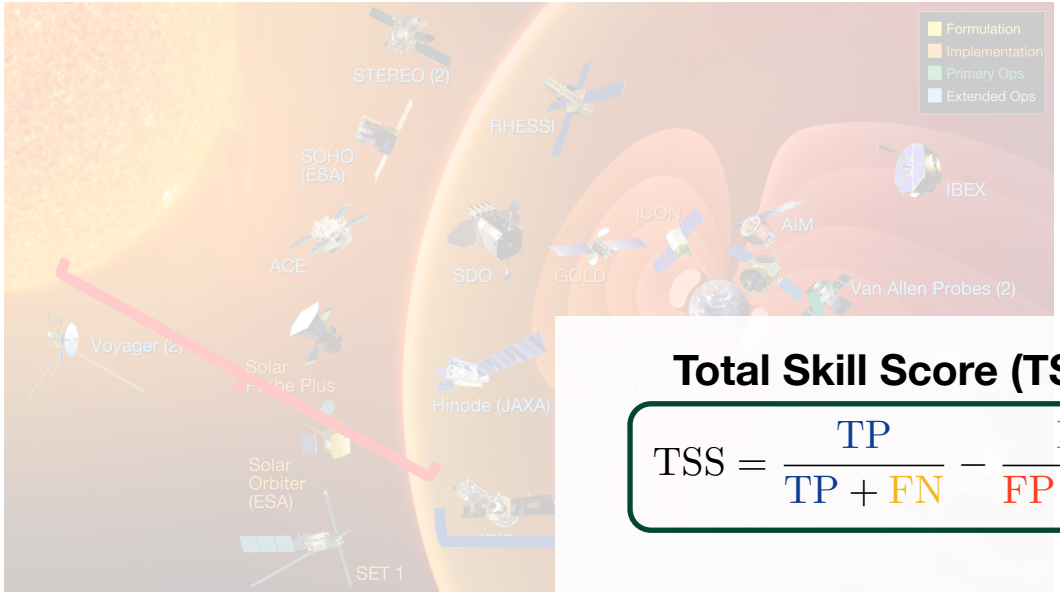

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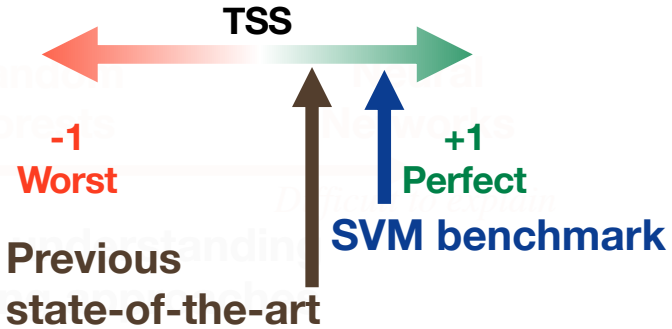

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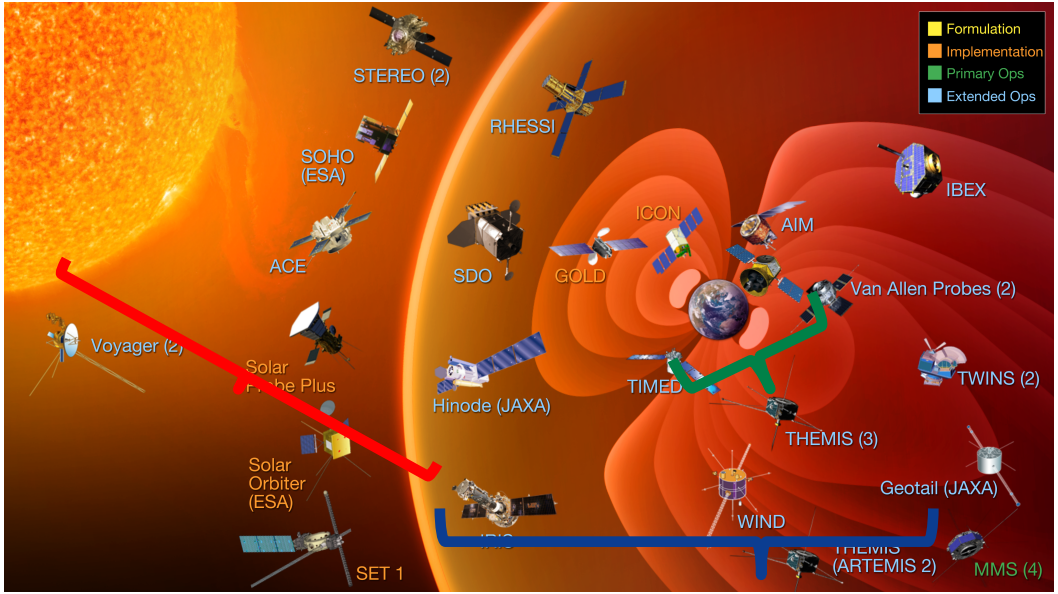

Support Vector Machine (SVM) → **Decision Trees** → **Random Forests** → **Neural Networks**

Easily explainable → *Difficult to explain*

Machine Learning as a Service (MLaaS)

What's next?

- Be radically interdisciplinary (i.e., *convergence*)
- Understand the models
- Be open by default

@AeroSciengineer
ryan.mcgranaghan@jpl.nasa.gov

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

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Siloed AI and science research → **Fused AI-Science**

Capability demonstration → **Technology infusion**

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