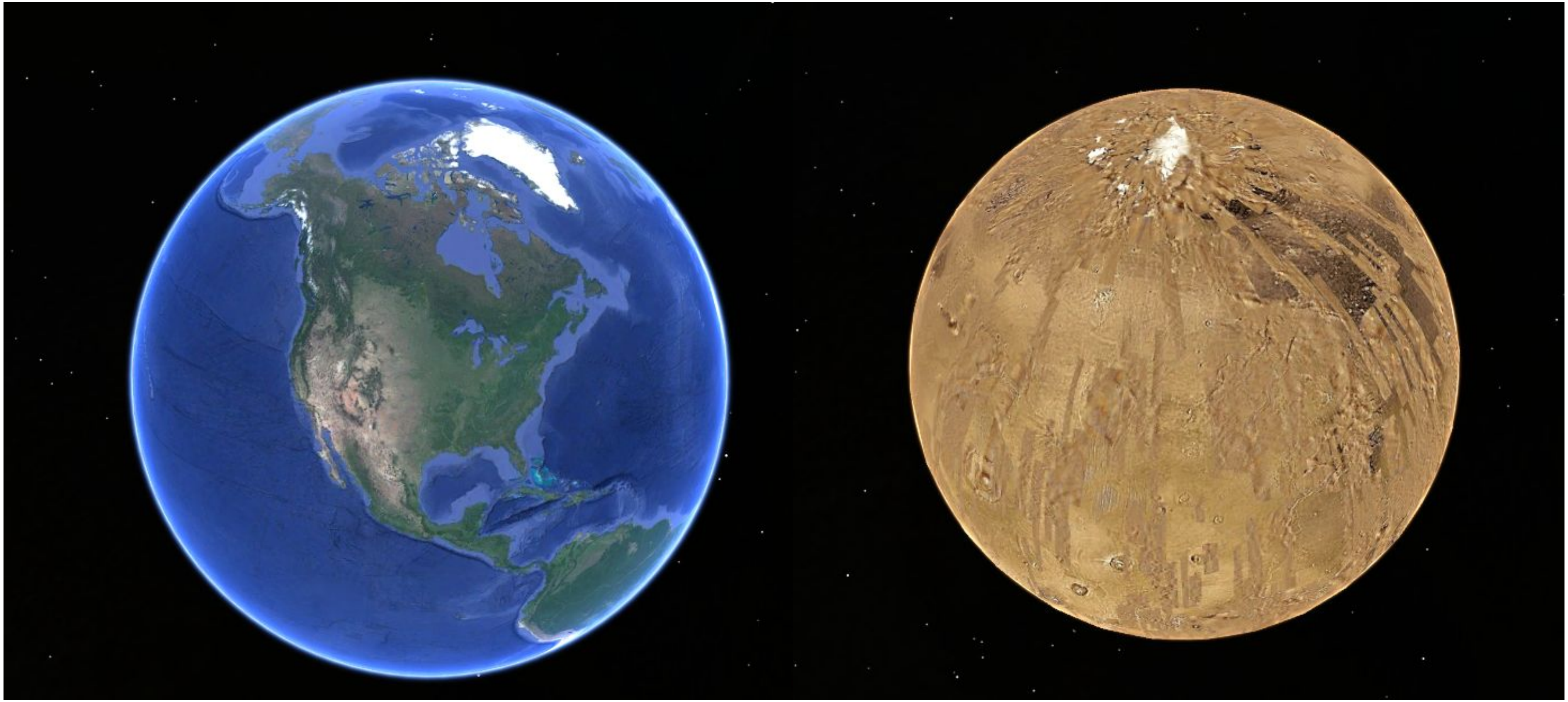
From the earth to the sky: How biofuels and other renewable energy sources may impact global climate change and alter the course of history

Stanton L Martin, PhD
PHM Conference 2019

A tale of two planets



How They Formed

RESEARCH LETTER

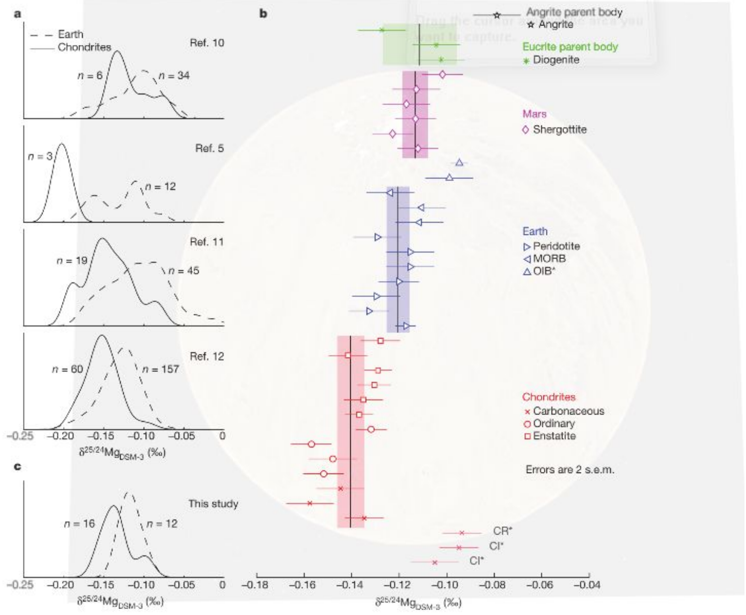


Figure 1 | Magnesium isotope compositions expressed as relative deviations from the standard DSM-3, $\delta^{25/24}Mg_{DSM\text{-}3}$. **a**, Probability density plots of magnesium isotope compositions from previous standard–sample bracketing work, highlighting the results of individual studies[5,10–12] that presented numerous analyses of both terrestrial and chondritic samples using the same methodology. These data show systematic, subtle differences (0.02‰–0.05‰) between the Earth and primitive meteorites. Typically authors refrained from interpreting such small differences. **b**, Samples from this study (measured by critical mixture double spiking) ordered according to sample type. Lines and shaded bars indicate means and 2 s.e.m. Samples displayed with pale symbols and marked with asterisks are excluded from means (see text). MORB, mid-ocean-ridge basalt; OIB, ocean island basalt. **c**, Earth and chondrite analyses from **b**, shown as a probability density plot to compare with **a**.

LETTER

doi:10.1038/nature23899

Magnesium isotope evidence that accretional vapour loss shapes planetary compositions

Remco C. Hin[1], Christopher D. Coath[1], Philip J. Carter[2]†, Francis Nimmo[3], Yi-Jen Lai[1]†, Philip A. E. Pogge von Strandmann[1,4], Matthias Willbold[1]†, Zoë M. Leinhardt[2], Michael J. Walter[1] & Tim Elliott[1]

It has long been recognized that Earth and other differentiated planetary bodies are chemically fractionated compared to primitive, chondritic meteorites and, by inference, the primordial disk from which they formed. However, it is not known whether the notable volatile depletions of planetary bodies are a consequence of accretion[1] or inherited from prior nebular fractionation[2]. The isotopic compositions of the main constituents of planetary bodies can contribute to this debate[3–6]. Here we develop an analytical approach that corrects a major cause of measurement inaccuracy inherent in conventional methods, and show that all differentiated bodies have isotopically heavier magnesium compositions than chondritic meteorites. We argue that possible magnesium isotope fractionation during condensation of the solar nebula, core formation and silicate differentiation cannot explain these observations. However, isotopic fractionation between liquid and vapour, followed by vapour escape during accretionary growth of planetesimals, generates appropriate residual compositions. Our modelling implies that the isotopic compositions of magnesium, silicon and iron, and the relative abundances of the major elements of Earth and other planetary bodies, are a natural consequence of substantial (about 40 per cent by mass) vapour loss from growing planetesimals by this mechanism.

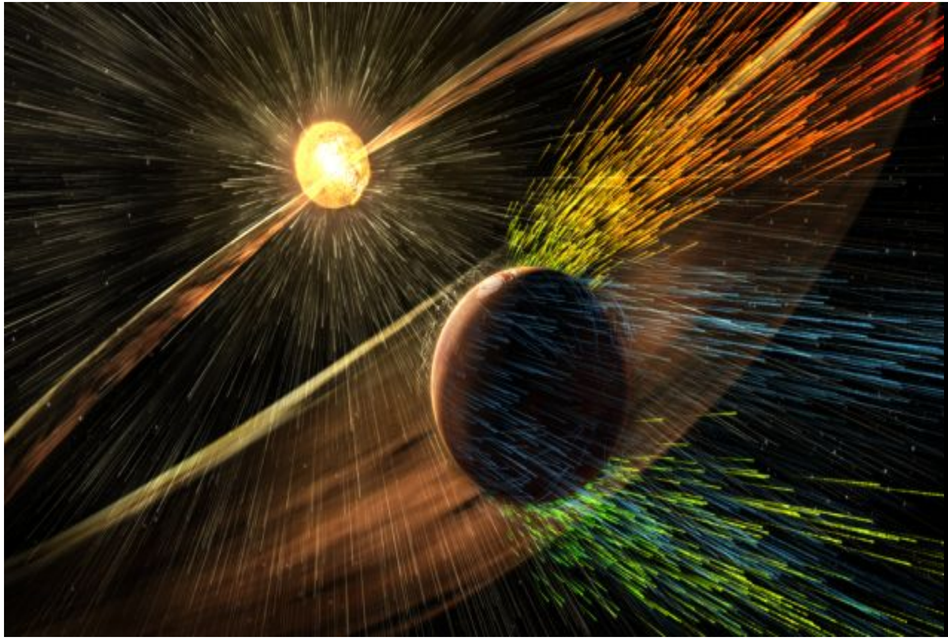
Magnesium is a fundamental building block of the terrestrial

In Fig. 1a we illustrate that several different studies report chondritic $^{25}Mg/^{24}Mg$ ratios that are around 0.03‰–0.05‰ lower than that of Earth[5,10–12], but in only one case is Earth argued to be non-chondritic[5]. Reliable resolution of such small isotopic differences requires tight control of analytical artefacts. Of particular concern is that samples and standards behave slightly differently during analysis, despite prior purification. Unlike the traditional sample–standard bracketing approach, the method of double spiking explicitly corrects such behaviour, but it is not standard for elements with only three stable isotopes, such as magnesium. We have therefore developed an approach called 'critical mixture double spiking' to overcome this problem[19] (see Methods for details). On the basis of propagation of conservative estimates of systematic error, this method has a limiting accuracy of less than 0.005‰ per AMU (ref. 19). Repeat measurements of solution standards and geological reference materials indicate that we can achieve reproducibilities of ±0.010‰ (2 s.e.m.) on means comprising eight replicate measurements.

We measured the magnesium isotope compositions of a range of terrestrial rocks and primitive and differentiated meteorites using critical mixture double spiking (Table 1). As shown in Fig. 1b and c, our data substantiate the finding that chondrites have $^{25}Mg/^{24}Mg$ ratios around 0.02‰ lower than the differentiated Earth, Mars, eucrite and angrite parent bodies.

Nature paper, September 28, 2017

How They Evolved



Artist's rendering of a solar storm hitting Mars and stripping ions, carbon dioxide, and oxygen from the planet's upper atmosphere.

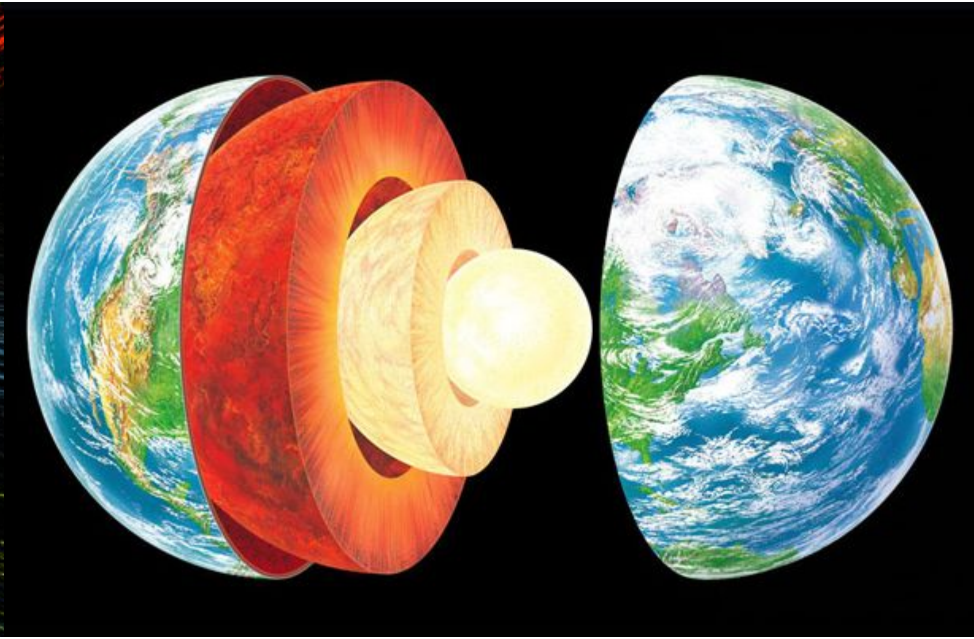
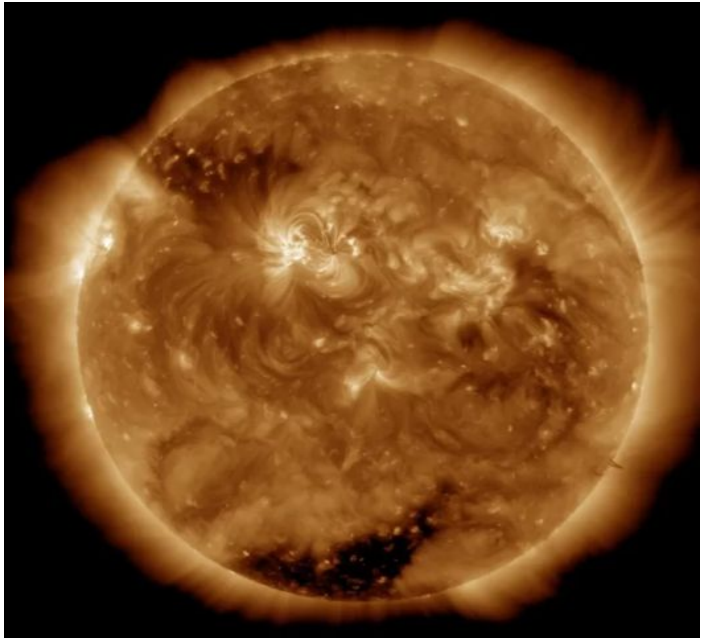
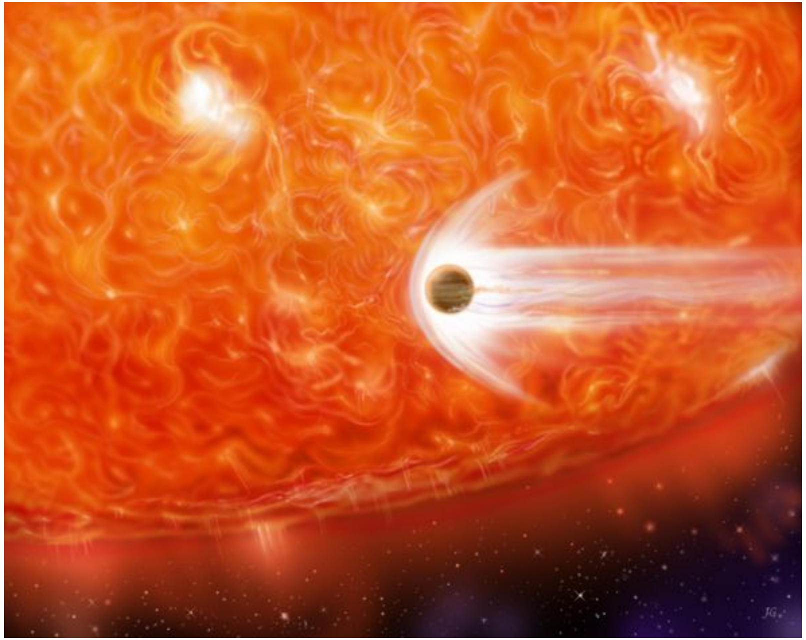


Illustration showing the Earth's internal structure.
The external layer shows the Earth's surface topography and atmosphere, including land, water and clouds. The mantle (red) is a viscous layer of rocks under high pressures and temperatures. The outer core (yellow) is a liquid layer of iron and nickel. The inner core (centre) is a liquid sphere of a iron-nickel alloy. Image: Illustrator Gary Hincks

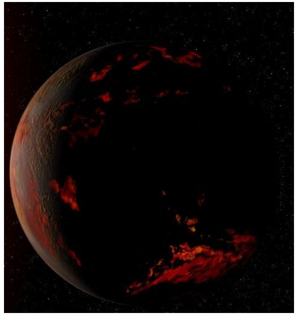
What will happen to them?



The sun, as it appeared on April 13, 2016. Though it's been burning for some 4.5 billion years, the sun is only about halfway through its life. Credit: NASA/SDO



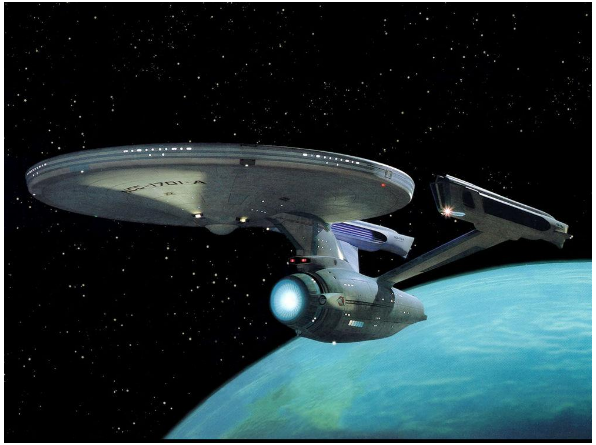
Expanding red giant stars will swallow too-close planets. In the solar system, the sun will engulf Mercury and Venus, and may devour Earth, as well.(Image: © James Gitlin/STScI AVL)



Scorched Earth

Source:Digital Commons

What will happen to us?



Star Trek: USS Enterprise
Gene Roddenberry

Dead Poet Society
Robin Williams

The Blessed Hope
Nathan Anderson

The end is Nigh.. ish

QUARTZ

THE END IS NIGH-ISH

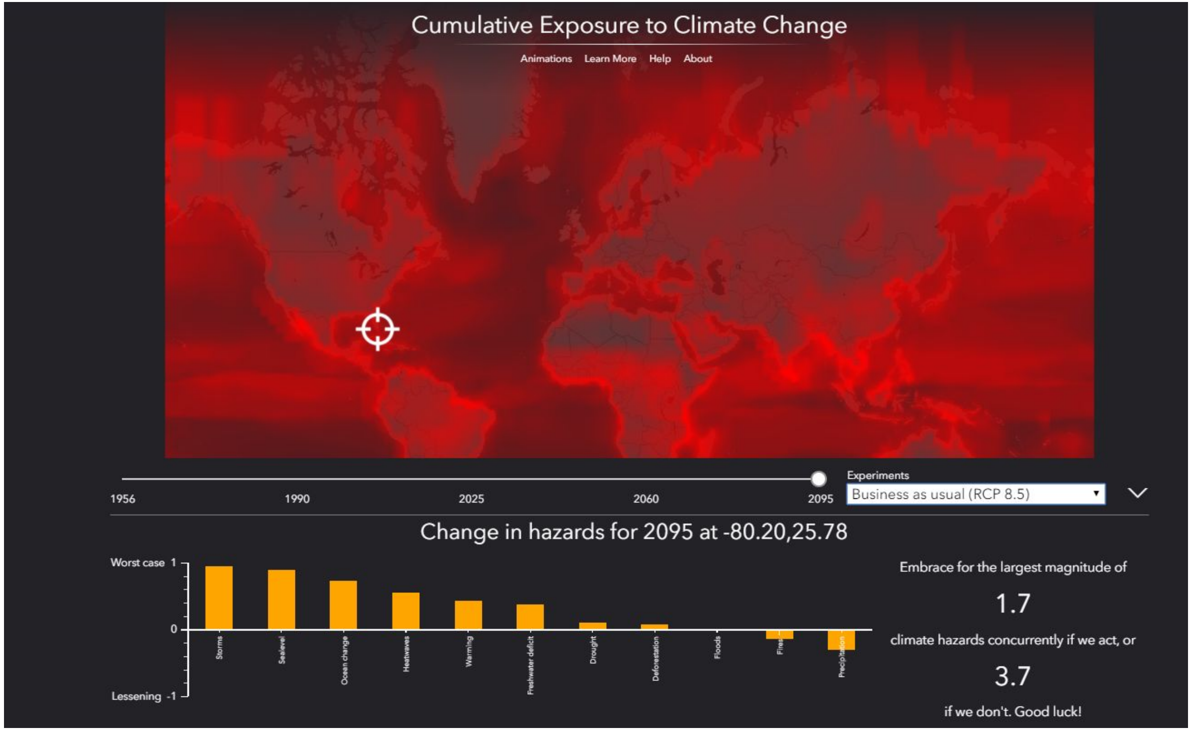
The human race could live forever—if we can make it through the next 100 years

By Georgia Frances King • January 30, 2019

It's the most dangerous time in human history to be alive—but if we get through it, we could survive forever.

nature climate change
LETTERS
PUBLISHED ONLINE: 19 JUNE 2017 | DOI: 10.1038/NCLIMATE3322

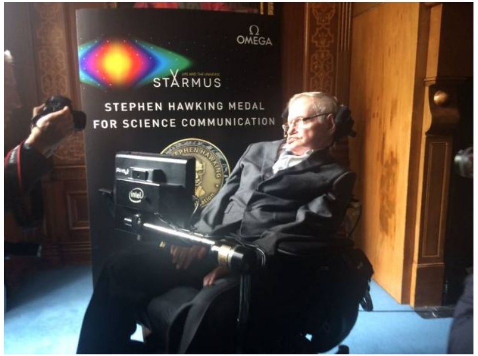
Global risk of deadly heat



Camilo Mora[1]*, Bénédicte Dousset[2], Iain R. Caldwell[3], Farrah E. Powell[1], Rollan C. Geronimo[1], Coral R. Bielecki[4], Chelsie W. W. Counsell[3], Bonnie S. Dietrich[5], Emily T. Johnston[4], Leo V. Louis[4], Matthew P. Lucas[6], Marie M. McKenzie[1], Alessandra G. Shea[1], Han Tseng[1], Thomas W. Giambelluca[1], Lisa R. Leon[7], Ed Hawkins[8] and Clay Trauernicht[6]

How to survive for the next 100 years?

And how to leave earth?



Professor Stephen Hawking speaking ahead of the Starmus IV Festival 2017

Credit WIRED UK

Stephen Hawking at
Starmus IV
2-17

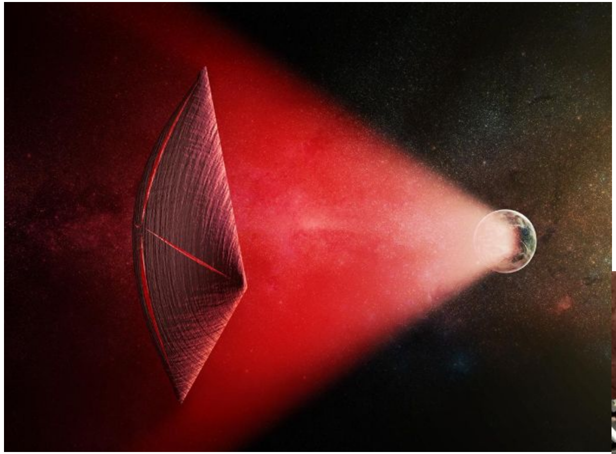
Humanity has only 100 years left to leave Earth or perish, Stephen Hawking believed

Best get Elon Musk and pals working on Mars rockets

A mere century of human existence is left on Earth, Stephen Hawking predicted

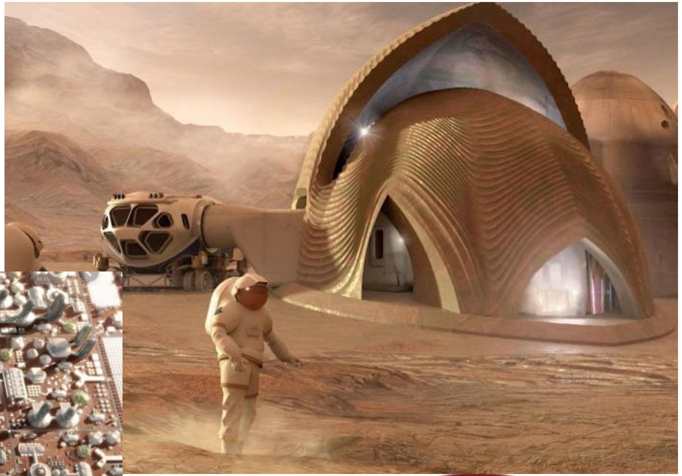
Earth will be a “ball of fire” within 600 years
- Stephen Hawking

Survival Initiatives

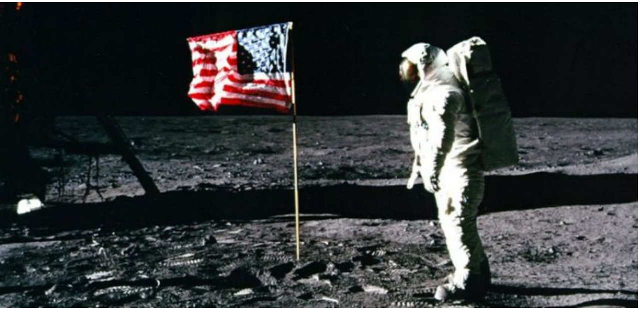


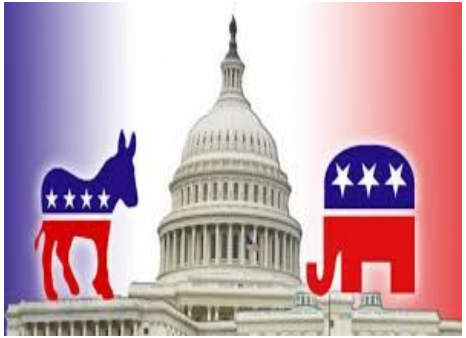
Breakthrough StarShot

SpaceX Has a Bold Timeline for Getting to Mars and Starting a Colony



Oh, and one other minor player...

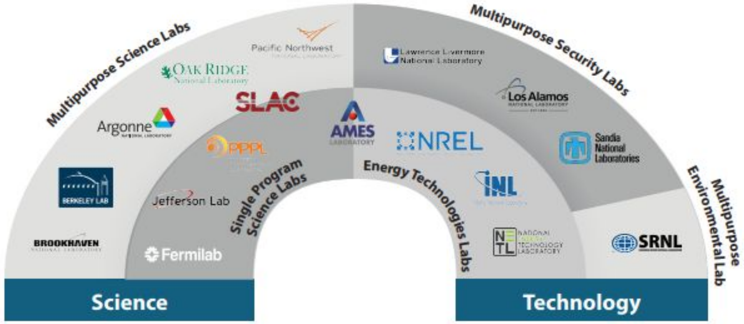




DOE Laboratories

Ames Laboratory (Ames)
Argonne National Laboratory (ANL)
Brookhaven National Laboratory (BNL)
Fermi National Accelerator Laboratory (FNAL)
Idaho National Laboratory (INL)
Lawrence Berkeley National Laboratory (LBNL)
Lawrence Livermore National Laboratory (LLNL)
Los Alamos National Laboratory (LANL)
National Energy Technology Laboratory (NETL)
National Renewable Energy Laboratory (NREL)
Oak Ridge National Laboratory (ORNL)
Pacific Northwest National Laboratory (PNNL)
Princeton Plasma Physics Laboratory (PPPL)
Sandia National Laboratories (SNL)
Savannah River National Laboratory (SRNL)
SLAC National Accelerator Laboratory (SLAC)
Thomas Jefferson National Accelerator Facility (TJNAF)

- Uncle SAM has 17 National Laboratories
- GOCO entities
- Average annual funding: $13 billion/ year
- Multipurpose Science, technology and security labs



NASA Facilities

- Uncle SAM has 18 NASA research centers on earth
- And one in space
- Annual budget of $21.5 billion

About ORNL

DOE’s national missions:

- Scientific Discovery
- Clean Energy
- Security

Major areas of science and technology:

- Neutrons
- Computing
- Materials
- Nuclear

About Biosciences

Understanding Biological Systems:

- Biological and Environmental Research Information Systems
- Biological and Nanoscale systems.
- Metabolomics and Bioconversion
- Systems Genetics
- Molecular Biophysics

Biosciences

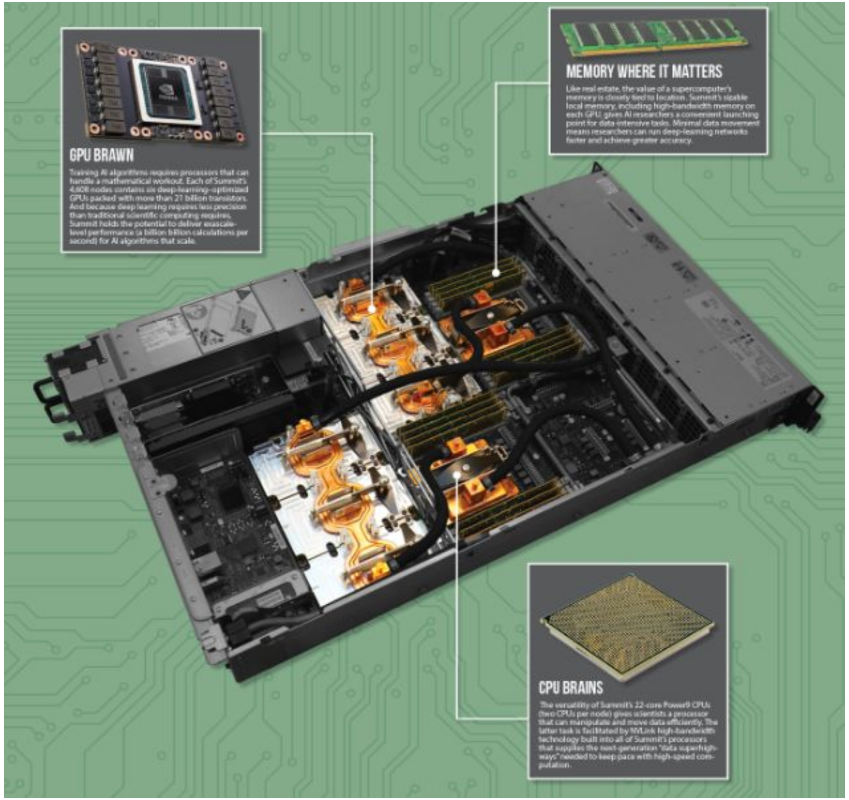
The Biosciences Division at Oak Ridge National Laboratory (ORNL) is focused on advancing science and technology to better understand complex biological systems and their relationship with the environment. The division has expertise and special facilities in genomics, computational biology, microbiology, microbial ecology, biophysics and structural biology, and plant sciences. This collective expertise includes collaborations within and outside ORNL and focuses on scientific challenges in biology for Department of Energy (DOE) missions in energy and the environment

Episode IV: A New Hope

WiC's second "Introduce Your Daughter to AI" workshop was the largest event it's hosted thus far. Image Credit: Carlos Jones, ORNL

SUMMIT

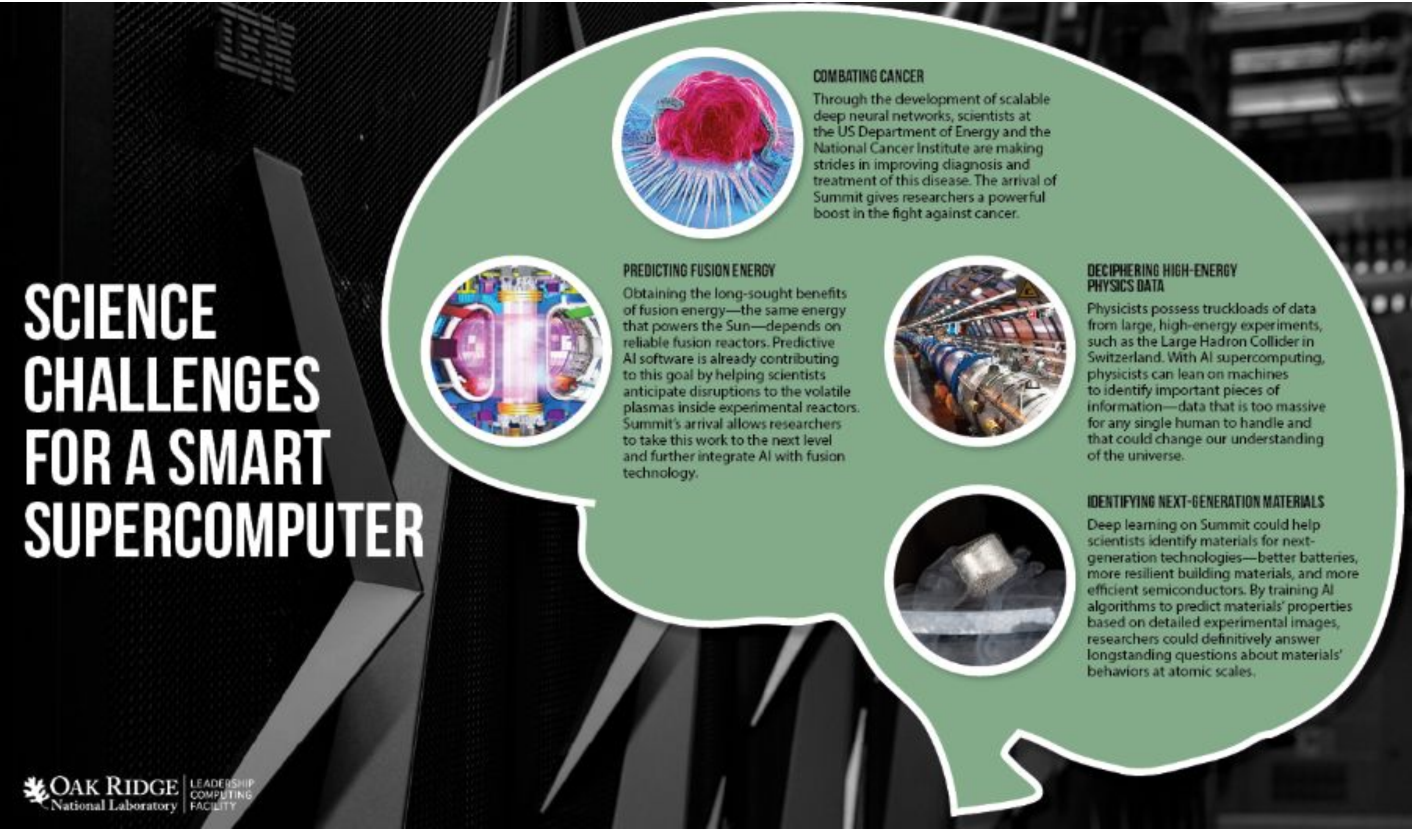
- A **200-petaflop** machine, Summit can perform 200 quadrillion (peta-) floating point operations per second (flops).
- For AI, we can use less precise calculations, so we can **quadruple** Summit’s performance to **exascale levels**.
- Summit’s file system can store **250 petabytes** of data



GPU Brawn: Summit links more than 27,000 deep-learning optimized NVIDIA GPUs with the potential to deliver exascale-level performance (a billion billion calculations per second) for AI applications.

High-speed Data Movement: NVLink high-bandwidth technology built into all of Summit's processors supplies the next-generation "information superhighways" needed to train deep learning algorithms for challenging science problems quickly.

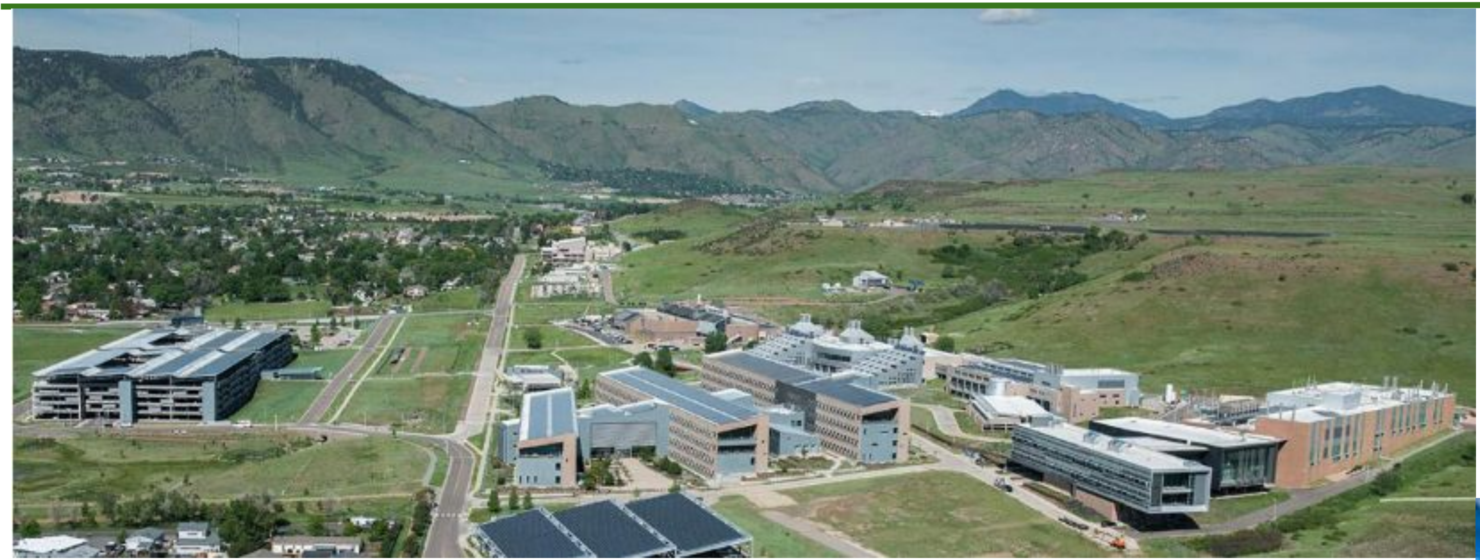
Memory Where It Matters: Summit's sizable local memory allows for data-intensive tasks, which enables faster AI training and greater algorithmic accuracy.



Current Use Cases:

- Cancer
- Fusion Energy
- Materials Science
- High Energy Physics

About NREL



National Centers:

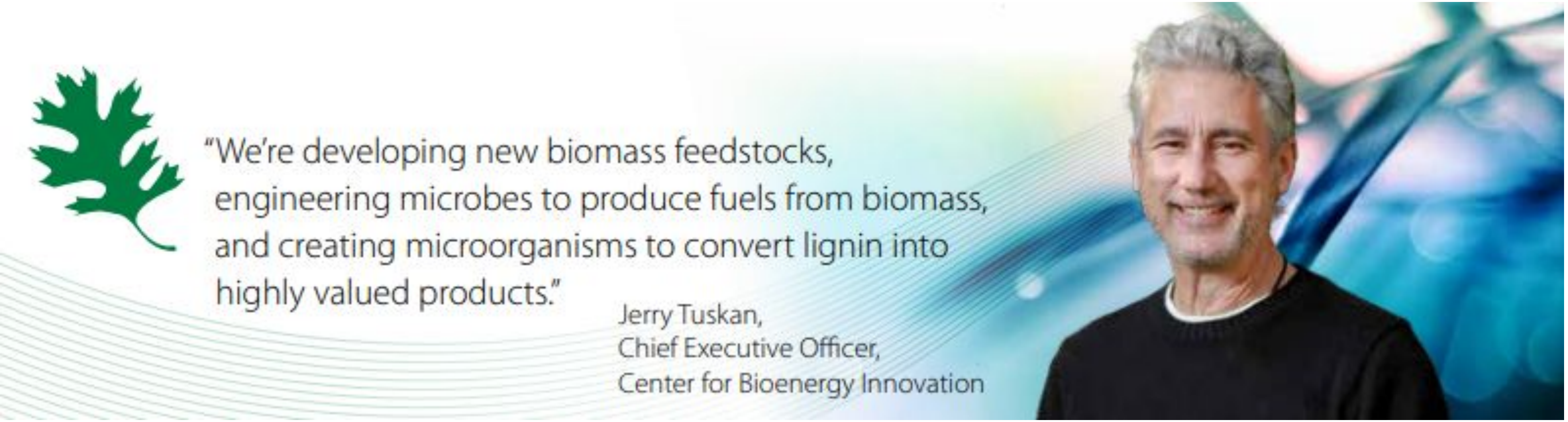
- National Bioenergy Center
- National Center for Photovoltaics
- National Wind Technology Center

Leading Research And Development in:

- Advanced Manufacturing
- Bioenergy
- Buildings
- Chemistry and Nanoscience

Energy Systems Integration Facility
Golden, Colorado

About CBI



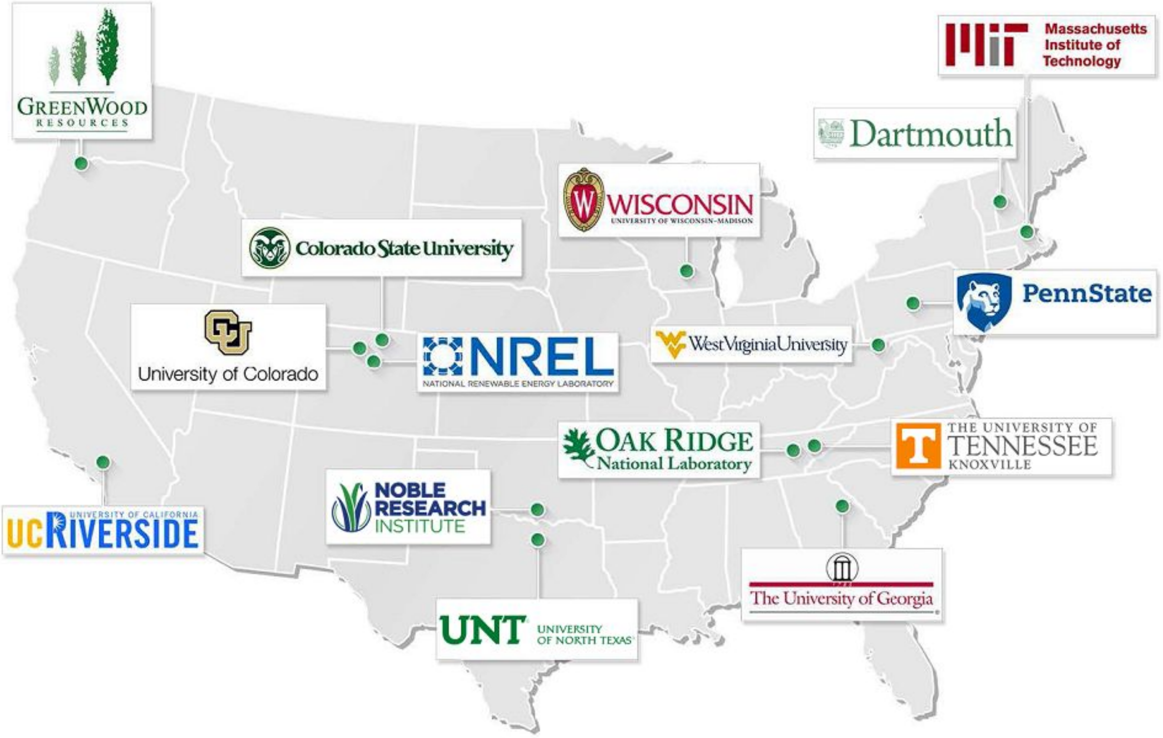
Moving Toward Bioproducts from Biomass:

- Developing sustainable biomass feedstock crops using plant genomics and bioengineering.
- Improving processes to simultaneously break down and convert plants into advanced biofuels.
- Creating valuable products from the lignin residue remaining after bioprocessing.

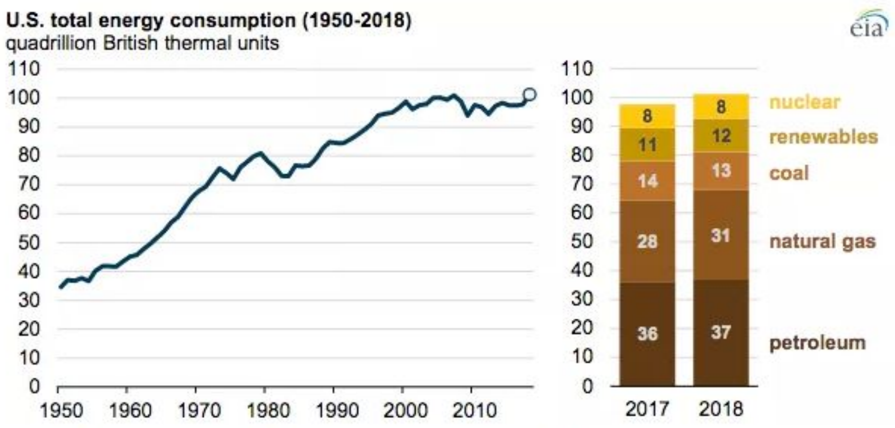
Research And Development Focus Areas:

- Sustainability
- Feedstock Development
- Deconstruction and Separation
- Conversion to Specialty Biofuelds and Bioproducts

Our Partners



What we need to do



US energy consumption hit a record high in 2018. | US Energy Information Administration

In 2018 80% of US total energy consumption came from fossil fuels

Ten-Year Agreement between National Renewable Energy Laboratory, National Energy Technology Laboratory, and ExxonMobil Will Bring Lower-Emissions Tech

New partnerships wanted!

What do we need to do in the next 10 years to survive to 100 years?

1. Stop Fighting

War planning leads to war...

Which has huge environmental impacts

and impoverishes the participants

Stop war at the ballet box
And through travel for business, for fun, and for service

2. Switch to renewables

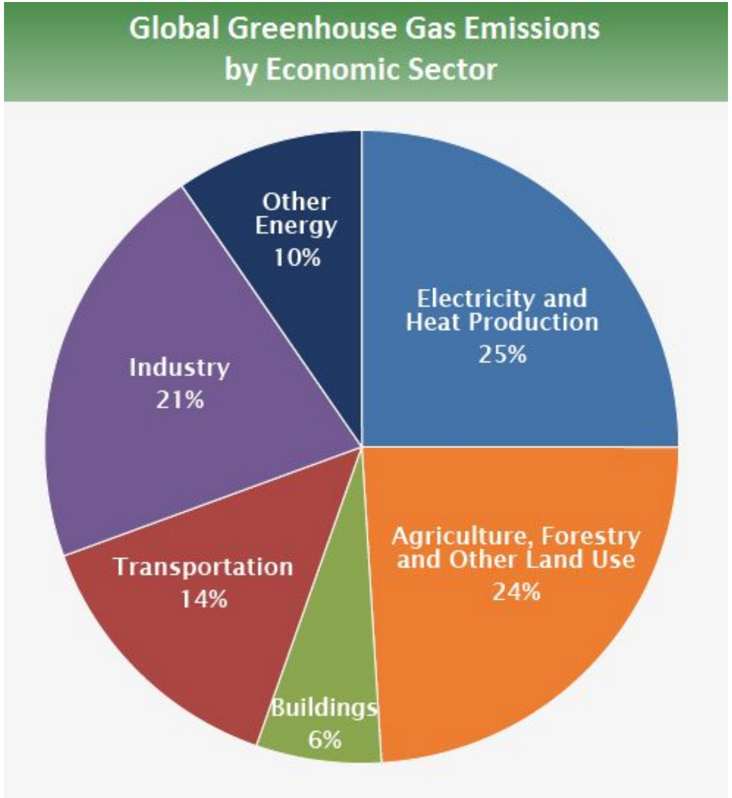
The most effective clean energy policy gets the least love

In defense of renewable energy mandates.

By David Roberts | @drvox | david@vox.com | Updated Oct 21, 2017, 9:31am EDT

SHARE

(Shutterstock)



Renewables at home

Activism: Must change laws

GENERAL

Homeowners could see easier access to solar energy under new bill

Homeowners could see easier access to solar energy under new bill

N.C. law is murky on HOA regulation of solar power

Michael Hunter

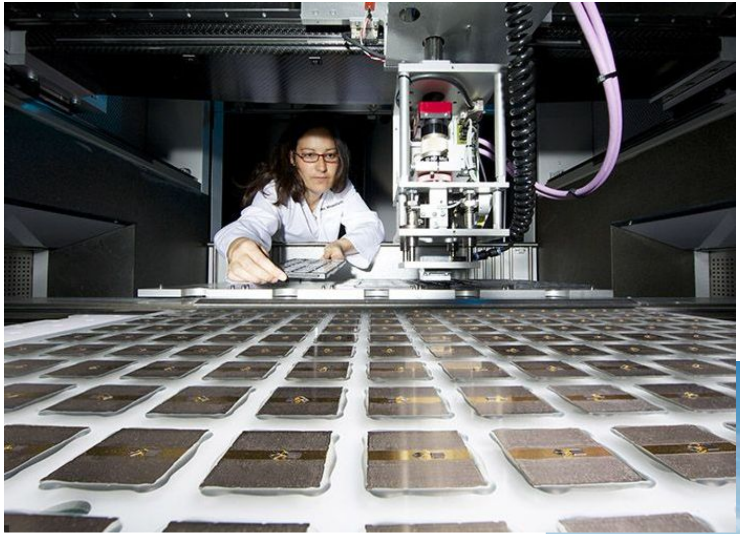
CORRESPONDENT

OCTOBER 14, 2015 02:11 PM, UPDATED OCTOBER 15, 2015 07:09 PM

North Carolina law on the HOA regulation of solar panels is murky. PATRICK T. FALLON *BLOOMBERG*

NC House Bill 750
may change this

Renewables at work

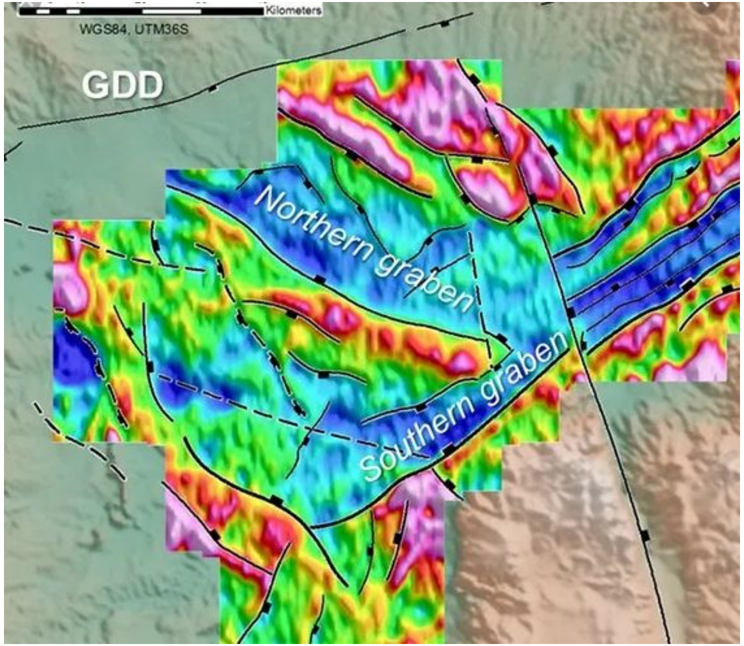


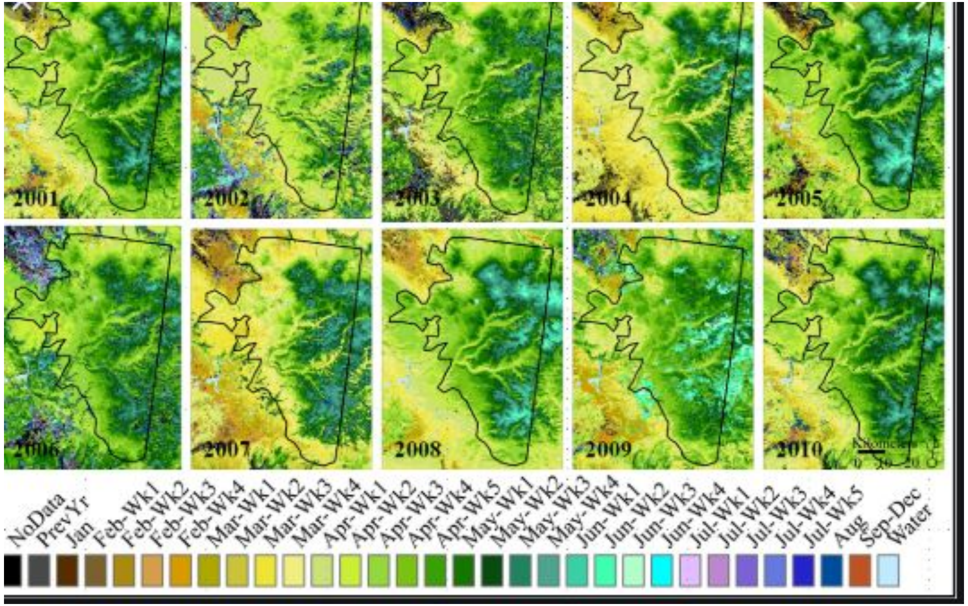
Precision on the farm
And in the forest

What to plant, when to plant, how to manage

Surveillance, seeding, spraying
Current capability: 300 pods, 2.4 acres, 18 minutes

Precision requires accurate sensors and data processing





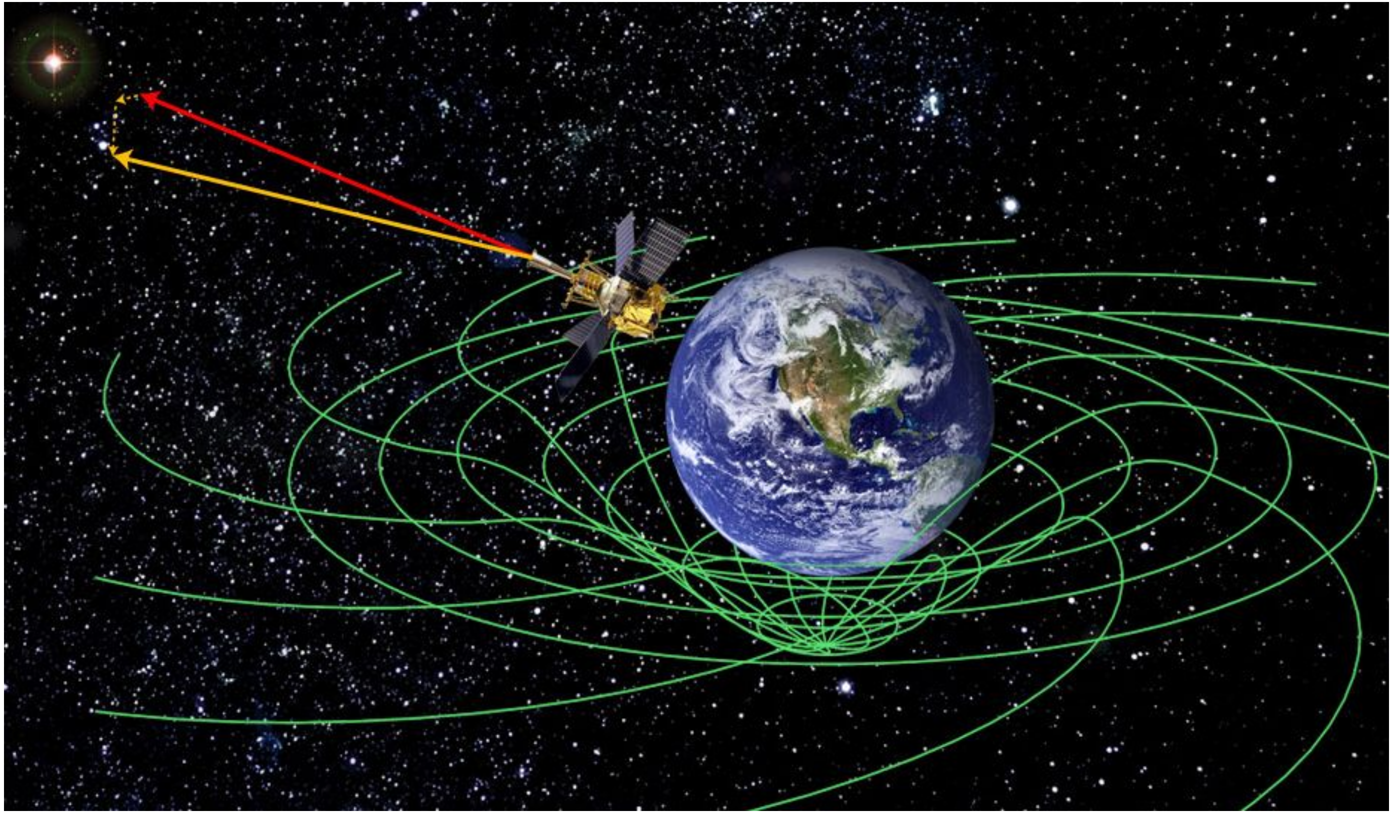
The most powerful sensor of all

1. Accelerometer
2. Gyroscope
3. Magnetometer
4. GNSS (GPS)
5. Proximity Sensor
6. Ambient Light Sensor

And many more…

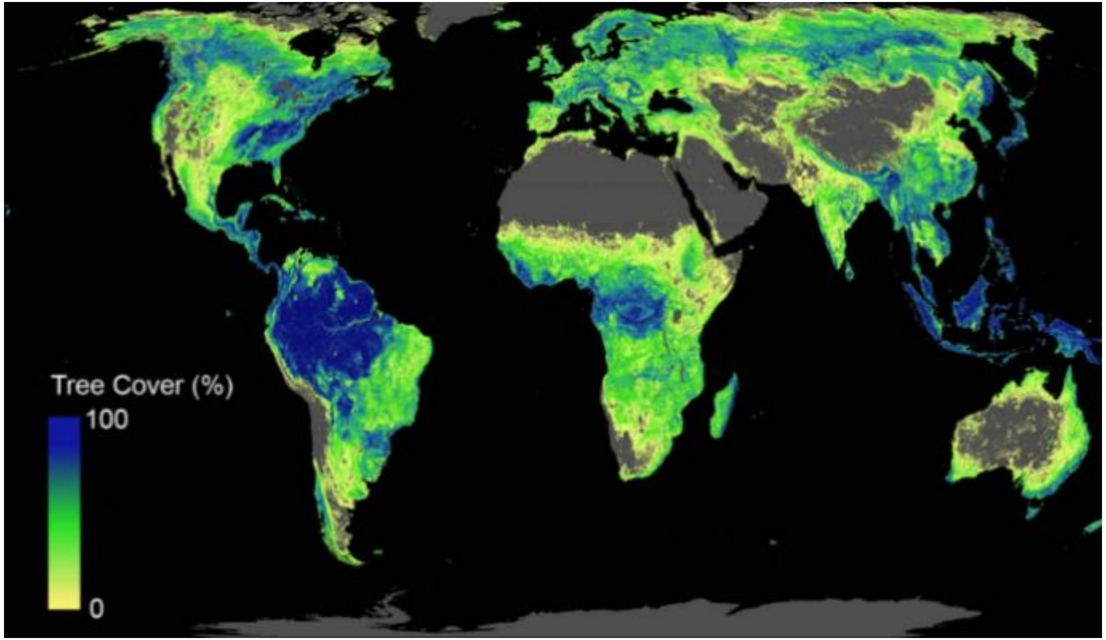
Sensor Demo:

Observing the space time continuum



How this is useful

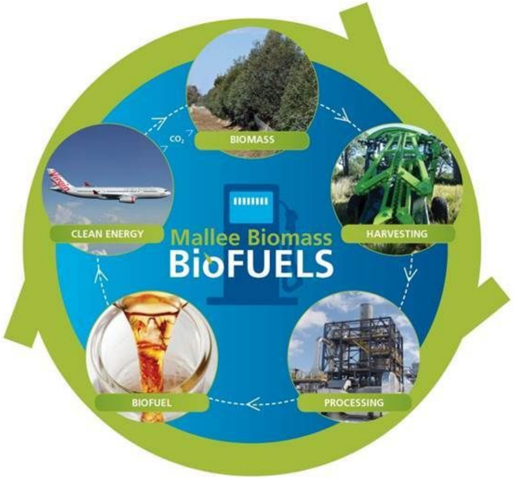
3. Plant Trees



The global tree restoration potential

Bastin, et. al. Science, 05 July 2019

- Earth could support 4.4 billion hectares of canopy cover
- Which could store 205 gigatonnes of carbon
- Which could reverse the climate change trajectory



Thank you

OAK RIDGE National Laboratory

About Us User Facilities Science and Discovery News Our People Careers

Stanton Martin

Data Management Lead

Contact Information

martins@ornl.gov

Related Organizations

Energy and Environmental Sciences Directorate

- Biosciences Division
- Center for Bioenergy Innovation

Bio

Welcome to the data management group for the BioSciences Division at Oak Ridge National Laboratory. We focus on utilizing cutting edge sensor and data management technologies to standardize and streamline the acquisition, management, and curation of data on scales ranging from individual genomes to entire ecosystems. Our strategy is to leverage the ongoing work of colleagues who are developing existing bioinformatics tools and pipelines and expand on these to accommodate larger and more diverse data types. We have a strong interest in developing packages to manage data streams from sensors mounted on both proximal and remote sensing platforms. These data streams can then be merged and curated to create holistic and FAIR data repositories that lend themselves to rapid and automated extraction of information for analysis, research, publications, and public dissemination. We utilize both specialized equipment (such as hyperspectral imagers mounted on UAV's) and commodity equipment (cell phone GPS and cameras) to rapidly acquire field and greenhouse image data that can be translated into phenology measurements of interest to researchers.

One significant focus for our group is managing the data streams coming from experiments associated with the Center for Bioenergy Innovation (CBI). These data streams derive from individual genotypes of Poplar and Switchgrass that have been sequenced and cultivated in common gardens and green house facilities across the United States. Data types from these experiments can include tissue assays, soil assays, microbial assays, and environmental assays. We collaborate with researchers to develop new methods and new tools to help with standardizing and homogenizing the data streams coming from the experiments. Data is curated, manipulated, and FAIRified on our internal data platforms before being released as production data sets.