A Geoscience Facility from Space

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http://www.facebook.com/GEOScanEarthScience
What is GEOScan?

- **GEOScan** is a grass-roots scientific effort to place a suite of geoscience sensors on 66+ Iridium NEXT satellites.
- Proposing as a National Science Foundation orbital geoscience facility - Seeking Co-sponsorship
- March 2011 Workshop with over 120 attendees to define science and sensors
- Opportunities for PI proposed instruments as part of a hosted sensor program.

Why GEOScan?

- **Instantaneous Global View of the Earth - Fundamentally Changes our Understanding**
- **Urgent Global** science questions require global scientific measurement.
- **Real Time Iridium Data** Ideal for Both Discovery Science and Monitoring
- **Paradigm shift away from focused science mission to community facility**
Change the way we view the Earth
A time-lapse taken from the front of the International Space Station as it orbits our planet at night. This movie begins over the Pacific Ocean and continues over North America.
Most comprehensive mission to planet Earth - 66 Iridium NEXT satellites

Global coverage can tomographically image the geospace environment AND improve GRACE gravity science measurements from monthly to daily (global water flow)

Global coverage can resolve the climate change debate – measure absolute energy balance, and resolve the 30 year “missing carbon” problem
What is Earth’s current state of energy balance and climate change?

Earth’s albedo is inadequately determined from satellites (the top two rows) and poorly captured in climate models. De-seasonalized boxplots for global monthly mean Earth albedo from CERES (March 2000–December 2003), ERBE (1985–1989), and 20 climate models for February 1985–May 1989 (adapted from Bender et al., 2006) are shown.

The fact is that we can’t account for the lack of warming at the moment and it is a travesty that we can’t. –Kevin Trenberth, Climategate emails
Spatial coverage comparison between CERES on Terra and Aqua and ERIS/GEOScan for 1 hour. In 1 hour, the GEOScan system will make 3600 global TOR samples, providing a statistical noise reduction factor of 60.
Climate change is thought to result from a less than 1% imbalance between solar radiation coming and escaping out into space.

- ERIS will measure this absolute imbalance for the first time!
- ERIS will improve climate model performance
- Respected team of leading institutions and scientists including Nobel Laureates.
What is Earth’s current state of carbon balance, and will nature’s ability to sequester increasing CO₂ saturate?

Although we have learned a great deal about the carbon cycle, the scientific community is still limited in its ability to make confident predictions about the likely response of the carbon cycle to global environmental change.

Questions emerge about the likely roles of CO₂ fertilization vs. land-use change, about temperature vs. moisture changes, and about the potential wildcard effects of insects, plant disease, and wildfire.

These processes can be studied at their natural local scale, but aggregating their effects to the global scale is extremely difficult. —Schimel, 2007

Carbon source and sink strengths and their uncertainties for 2000–2006 in petagrams C per year (Canadell et. al, 2007). Fossil fuel emissions are increasing ~3% per year, with the oceans and terrestrial biosphere absorbing nearly half of this. Critically, we do not know whether the biosphere will saturate.
GRACE/GEOScan: One Month

- True and “observed” orbits were simulated, using positioning error spectrum derived from CHAMP mission data, equivalent to 2-3 cm 3D RMS uncertainty.
  - For more details, see
    - Ditmar et al., J. Geodesy, 2007
    - Gunter et al., J. Spacecraft & Rockets, 2011

- Accelerations derived using high-resolution, 6-hourly atmosphere, ocean, ice, hydrology, and solid-earth variations derived from a recent coupled Earth-system model.
  - See Gruber et al., ESSD, 2011

Gravity Variations from Iridium NEXT, B. Gunter
How does the large-scale transport of water and atmospheric mass affect, and respond to, changes in climate and water cycle on diurnal to annual timescales?

GRACE observations showing ground water losses in the sub-continent basin.

GEOScan extends GRACE monthly gravity measurements to daily.

GEOScan gravity is sensitive to changes equivalent to a 1000 km disc of water only 15 mm thick.
What is the global response of the geospace environment to changes in solar activity?

- Poorly understood, major geospace reconfigurations occur during storms - GEOScan images plasma in 3D and radiation belts in 2D
GEOScan’s System Sensor Suite

About the size of a shoebox, each System Sensor suite has been designed for easy accommodation within the hosted payload space of each of the Iridium NEXT satellites. GEOScan will consist of six sensors plus planned space for PI-Proposed Sensors (PIPS). Each sensor suite includes:

- A **Radiometer** to measure Earth’s total outgoing radiation
- A GPS **Compact Total Electron Content Sensor (CTECS)** to measure Earth’s plasma environment and gravity field.
- A **MicroCam Multi-spectral Imager** to image a uniform global view of Earth-land, oceans, vegetation and aurora.
- A **Compact Earth Observing Spectrometer (CEOS)** to measure aerosol-atmospheric composition and vegetation.
- A **Dosimeter** package to image the radiation belts.
- A **MEMS Accelerometer** package to measure non-gravitational forces and aid neutral density studies.
- **PIPS**- 1.4U NSF competed student/researcher experiments.
Meeting National Research Council Objectives at a Fraction of the Historical Cost

GEOScan meets 15-27% of NRC Earth Science decadal survey goals (conservative-optimistic)

GEOScan’s value far exceeds other NASA Earth Science Decadal Survey missions at a fraction of the cost. GEOScan (assuming ~$200M) is approximately 4-10 times more cost effective in terms of science per taxpayer dollar than any other Decadal mission.

From: Selva and Crawley, MIT, Rule-Based Optimization Framework
Synergistic Relationships: Industry and Public Sector

NATIONAL SPACE POLICY of the UNITED STATES of AMERICA

Strengthen U.S. Leadership In Space-Related Science, Technology, and Industrial Bases. Departments and agencies shall: conduct basic and applied research that increases capabilities and decreases costs, where this research is best supported by the government; encourage an innovative and entrepreneurial commercial space sector; and help ensure the availability of space-related industrial capabilities in support of critical government functions.

Improve space-based Earth and solar observation capabilities needed to conduct science, forecast terrestrial and near-Earth space weather, monitor climate and global change, manage natural resources, and support disaster response and recovery.
GEOScan on SmallSats

• Constellation of SmallSats is within economic reach
• GEOScan science can be achieved with as few as 40 satellites in a constellation
• To bring operations and production costs down: Government must partner with industry to leverage their expertise and infrastructure

Surrey SSTL-100

SNC built ORBCOMM OG2

APL MMN Cube-sat
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• www.facebook.com/GEOScanEarthScience
Hosted Payloads: Benefits?

• Solve known problems at dramatic cost savings
• Solve new problems not previously thought possible such as volcanic ash cloud imaging
• Eliminate the need for ground infrastructure
• Utilize modern and COTS, not yesterdays, technology
• A new and more flexible view of risk in scientific space missions
• Fundamentally change the paradigm of measurements from space, for the better!