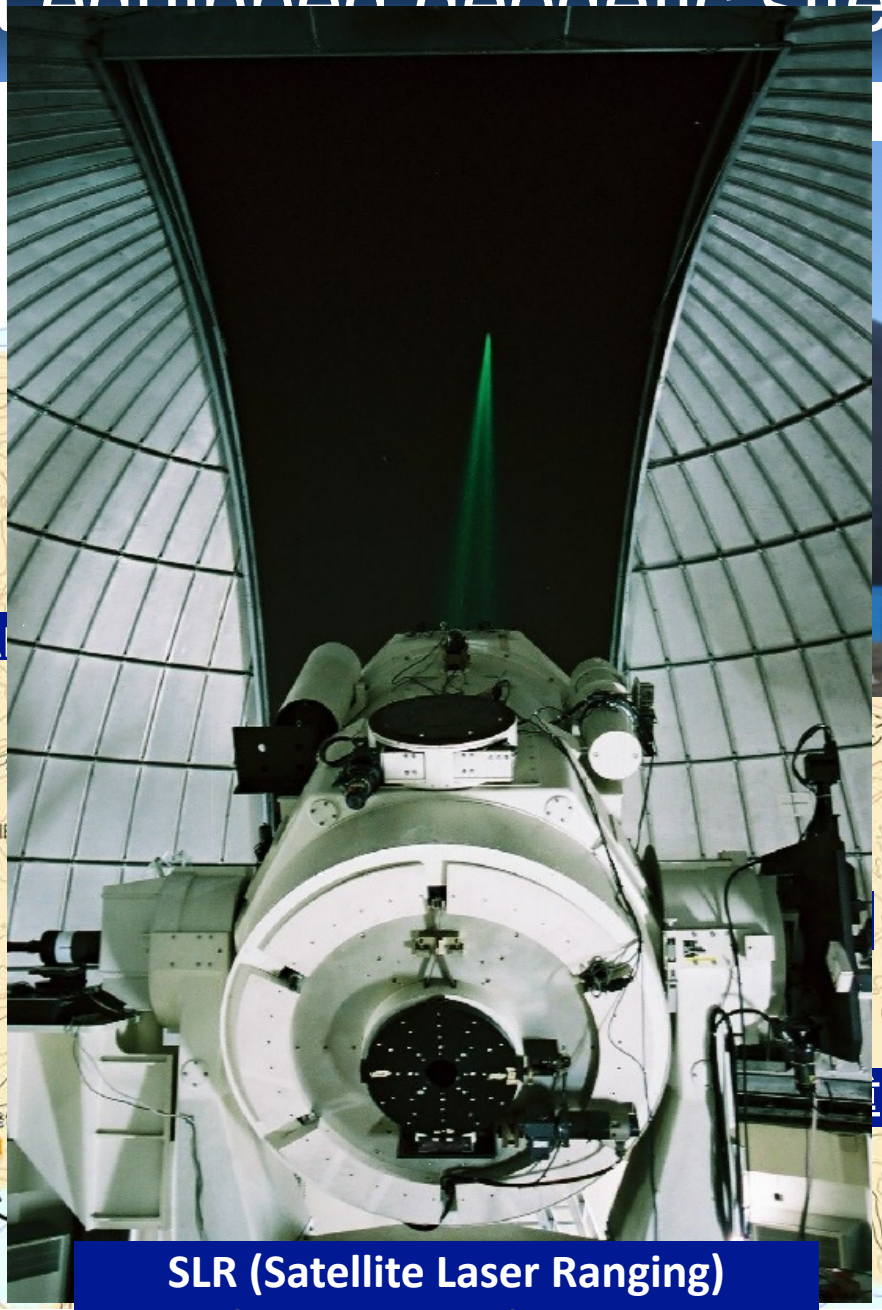
The Final Frontier for Satellite Laser Ranging: Antarctica

Toshimichi Otsubo[1*], Yuichi Aoyama[2], Akihisa Hattori[3], Koichiro Doi[2], Michael R Pearlman[4*] and Carey E Noll[5*]

[1] Hitotsubashi University, [2] NIPR, [3] Sokendai,
[4] Smithsonian Astrophysical Observatory,
[5] NASA/GSFC
* International Laser Ranging Service

Syowa: Best equipped geodetic site in Antarctica

DOR



SLR (Satellite Laser Ranging)

Future? Site Survey done in JARE59.

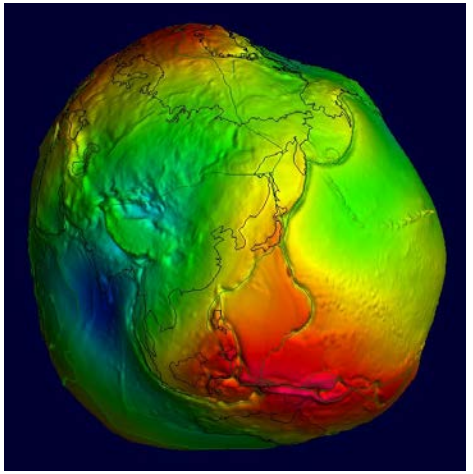
重力・SG

Geodesy is important.

Geodesy is exciting.

SLR x Antarctica is important.

SLR x Antarctica is exciting.



The First UN Resolution on Geodesy

The UN Committee of Experts on Global Geospatial Information Management (UN-GGIM) recognized since its inception the growing demand for more precise positioning services, the economic importance of a global geodetic reference frame and the need to improve the global cooperation within geodesy.

http://ggim.un.org

Photo: Kyoung-Soo Eom

General Assembly, 26 February 2015

GGOS: Global Geodetic Observing System

Vision: Advancing our understanding of the dynamic Earth system by quantifying our planet's changes in space and time.

New President (1 Nov 2019): B Miyahara (GSI)

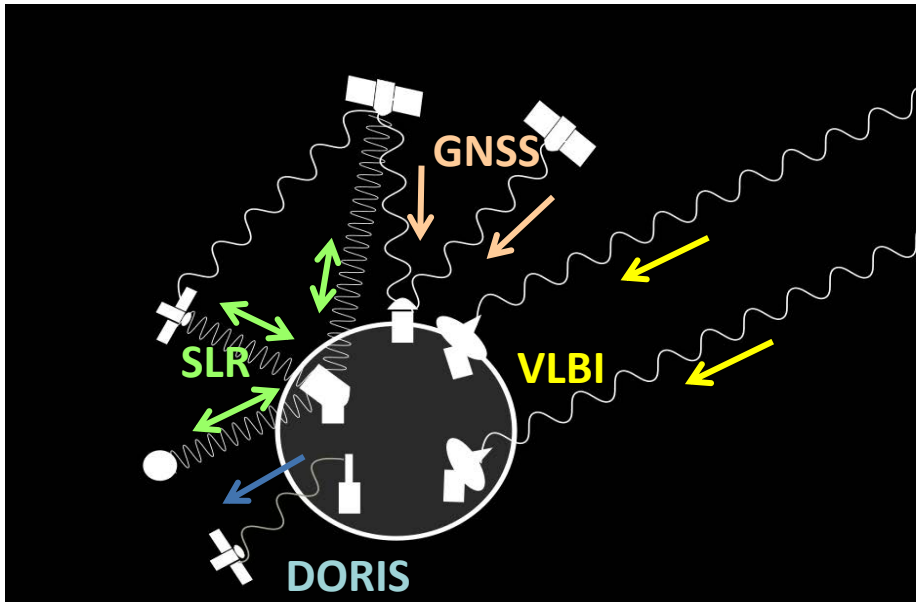
Integration of Geodetic techniques

GGOS Core Station:

equipped with VLBI,

SLR and GNSS

(and more).



Latest trends in/around geodesy

Geodesy for everyone?

Low-cost & high-precision-positioning GNSS receivers.

Strong demand for high-precision 3-D maps.

New countries. Worldwide collaboration.

New Sciences in/from Geodesy

New technologies and new satellite missions.

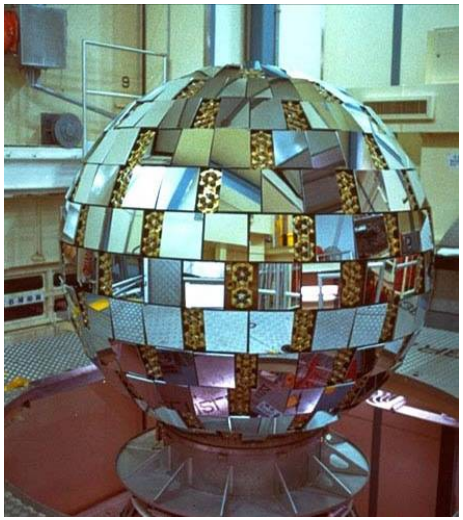
Wide application to Seismology, Volcanology, Oceanography, Hydrology, Atmosphere, Ionosphere, Cryosphere, Planetary Science, …

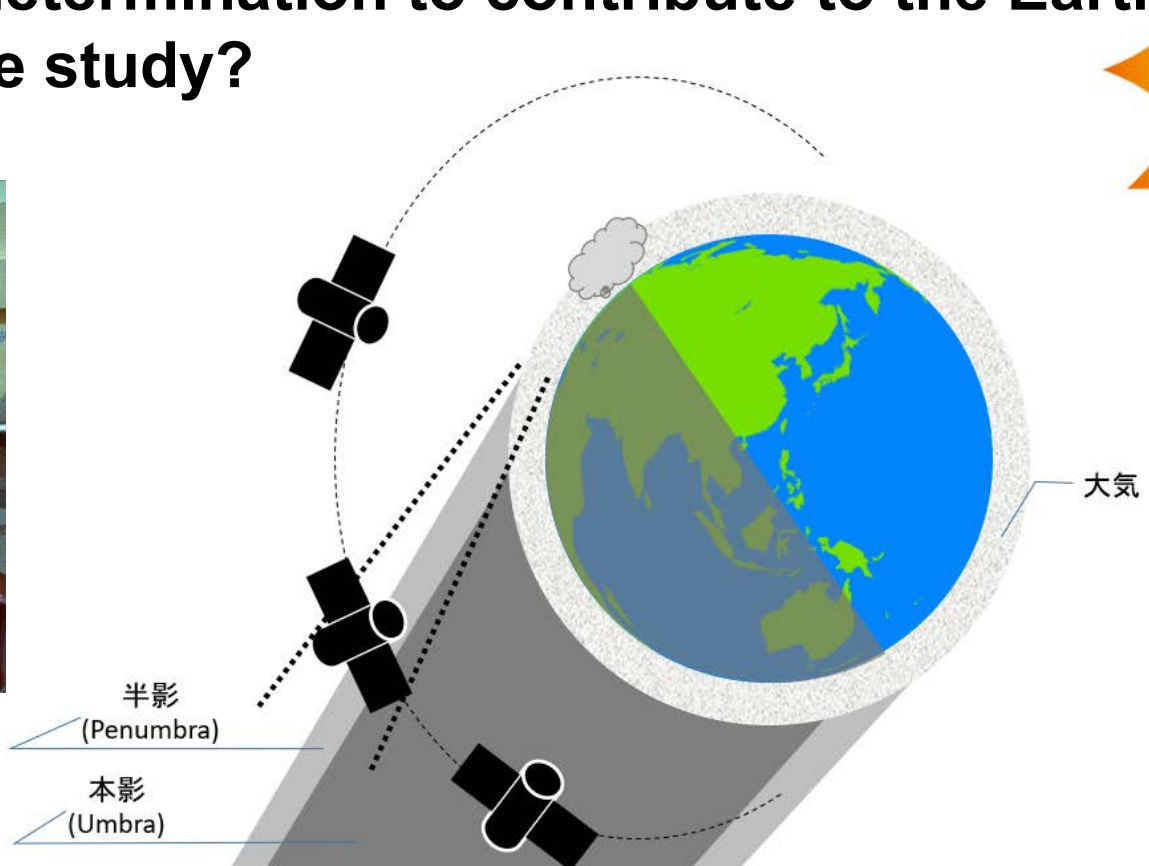
Solar Radiation Pressure → Total Solar Irradiance

Hattori & Otsubo (2019)

Supports TSI = 1361 W/m^2 from Ajisai Orbit analysis

Precise orbit determination to contribute to the Earth energy balance study?



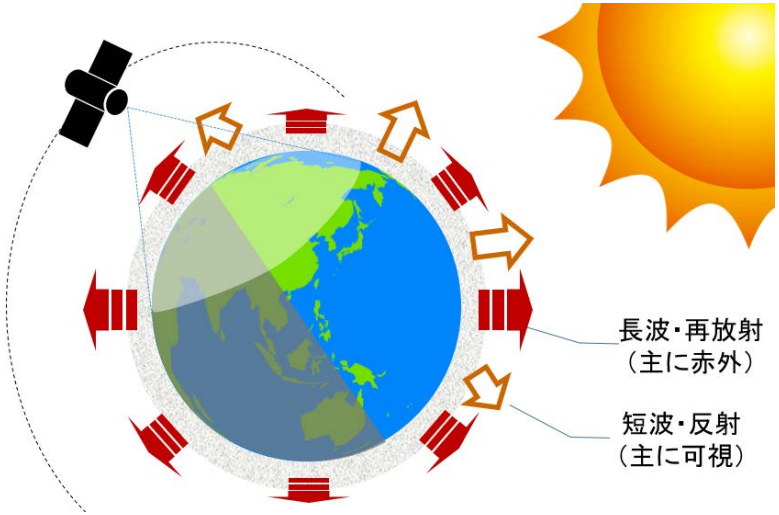


Earth Radiation Pressure
→ Optical properties of Earth surface

Earth radiation pressure

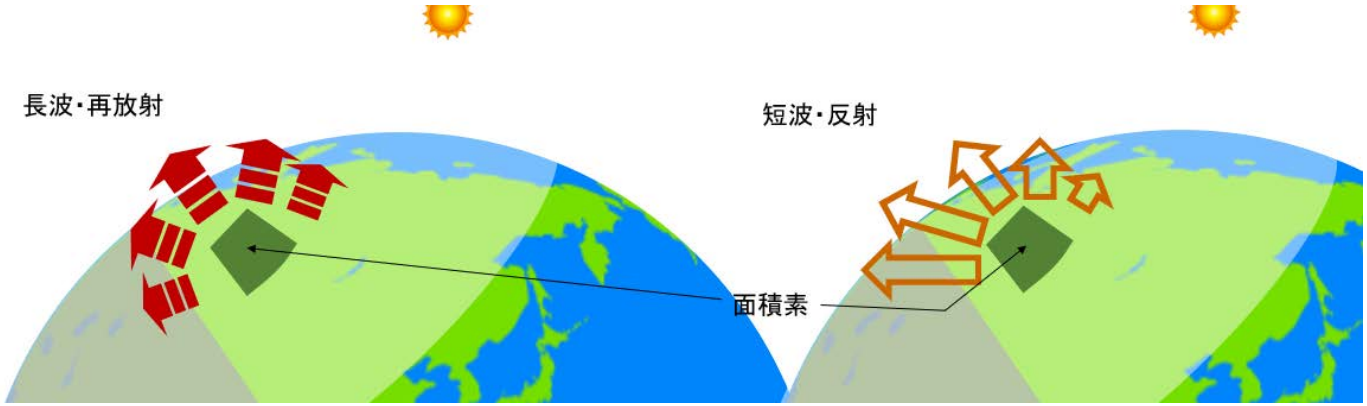
= IR + Albedo

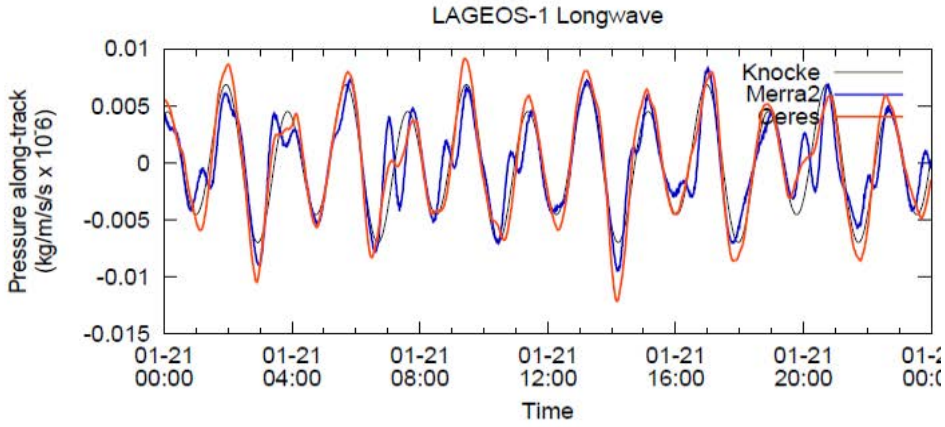
~ 10-30% of SRP

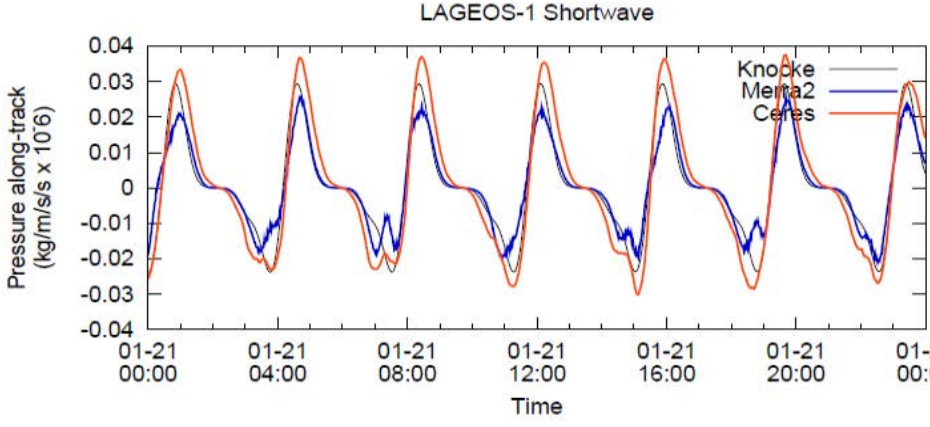


IR: Cloud coverage, temperature

Albedo: Surface & cloud coverage




LAGEOS-1 Longwave
Pressure along-track (kg/m/s/s x 10^6)
Time
Knocke
Merra2
Ceres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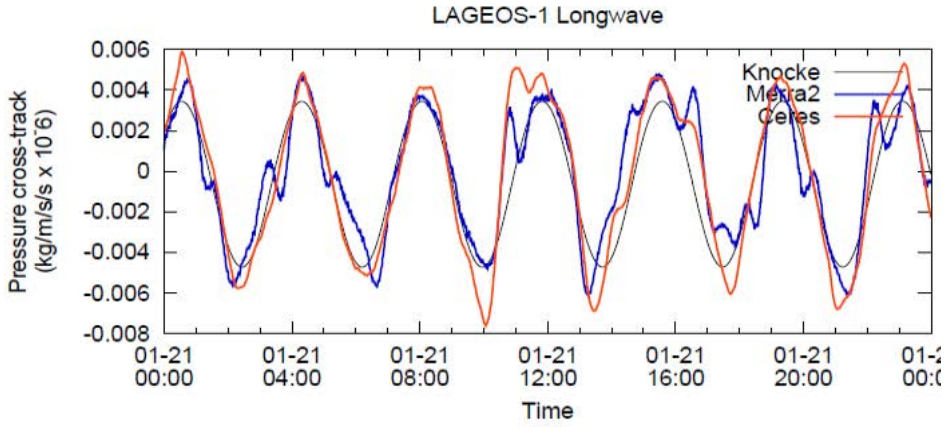
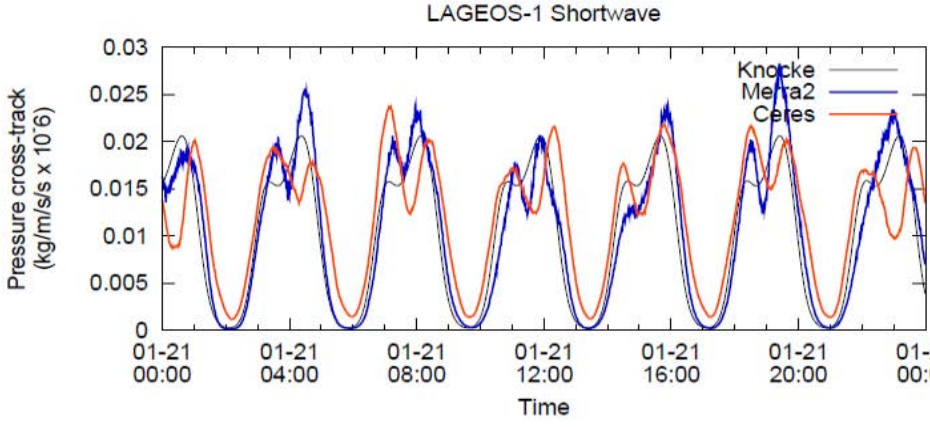

LAGEOS-1 Longwave
Pressure cross-track (kg/m/s/s x 10^6)
Time
Knocke
Merra2
Ceres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Pressure cross-track (kg/m/s/s x 10^6)
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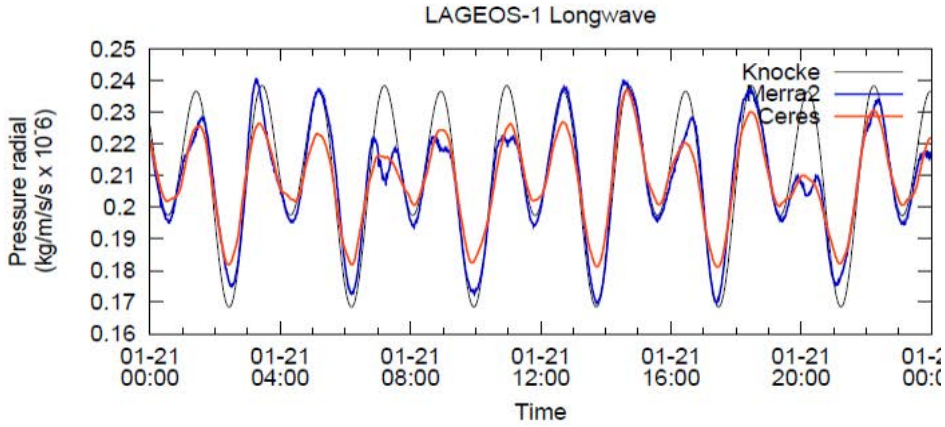
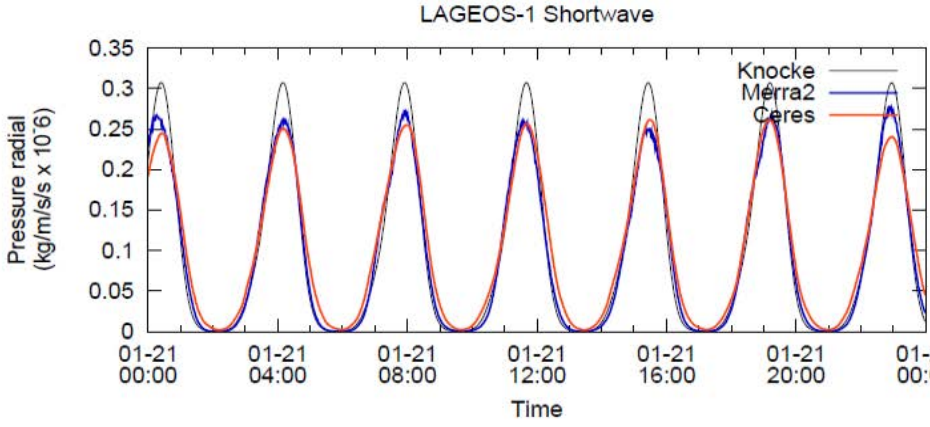

LAGEOS-1 Longwave
Pressure radial (kg/m/s/s x 10^6)
Time
Knocke
Merra2
Ceres


LAGEOS-1 Shortwave
Pressure radial (kg/m/s/s x 10^6)
Time
Knocke
Merra2
Ceres

Geodesy is important.

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SLR x Antarctica is important.

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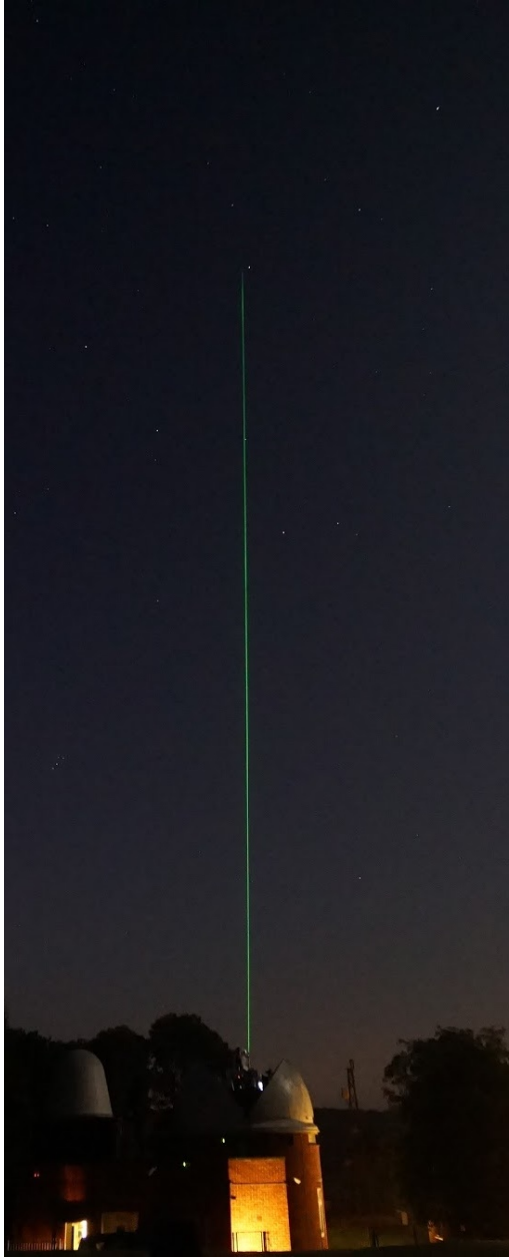
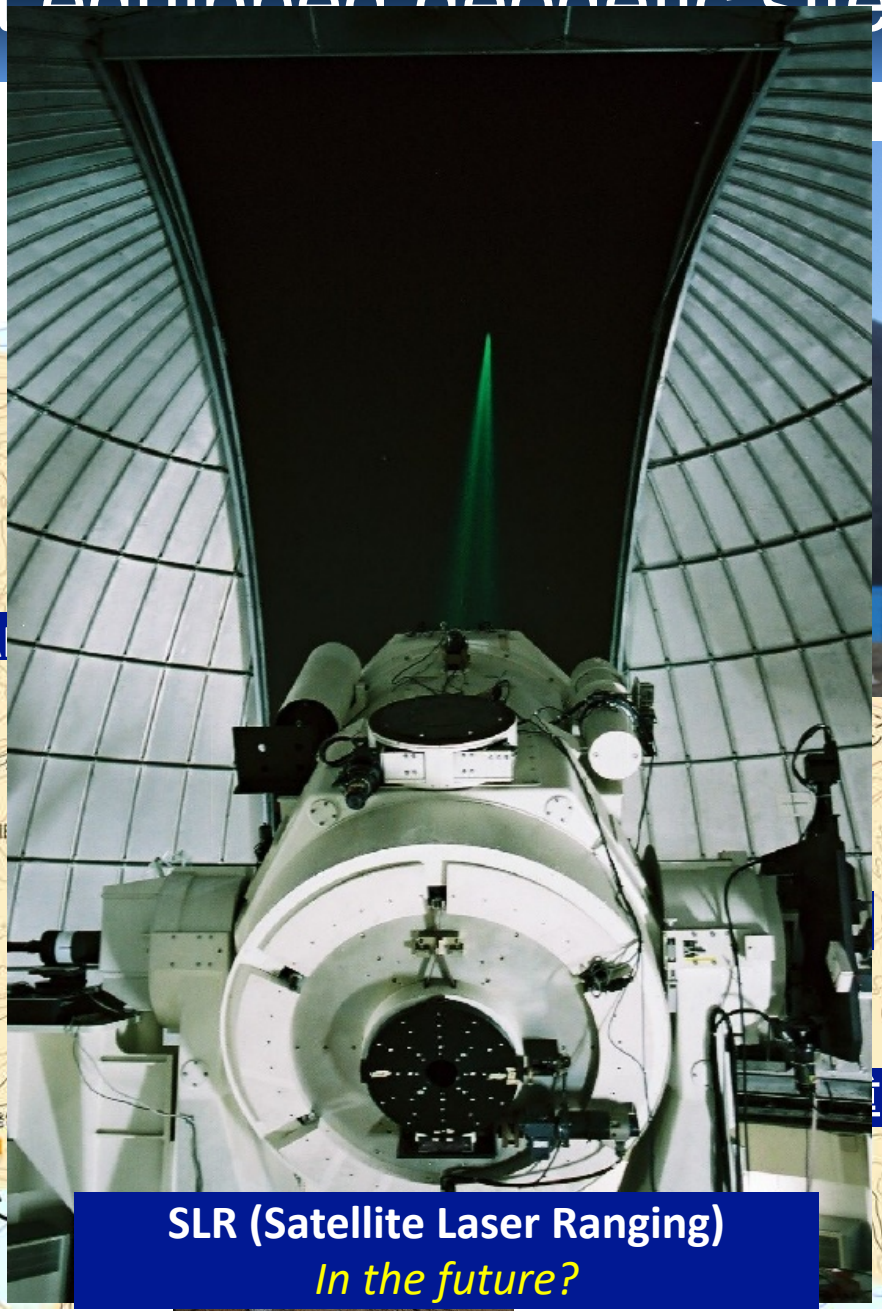


Herstmonceux UK
22 July 2016
TO

Syowa: Best equipped geodetic site in Antarctica

DOR



SLR (Satellite Laser Ranging)
In the future?

重力・SG

The Global Geodetic Observing System

IUGG

IAG GGOS

Global Geodetic Observing System

Syowa Station

National Institute of Polar Research

is a member of the GGOS Space Geodesy Network




Richard Gross, Chair
Global Geodetic Observing System

Michael Pearlman, Director
GGOS Bureau of Networks and Observations

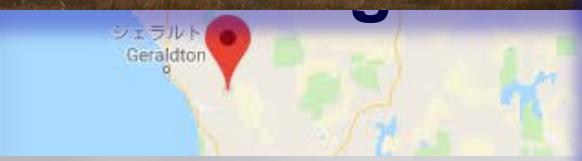
2 Nov 2018

DORIS

VLBI

SLR

GNSS

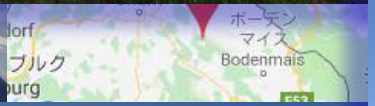


15 Dec 2016

VLBI
VLBI

GNSS

DORIS

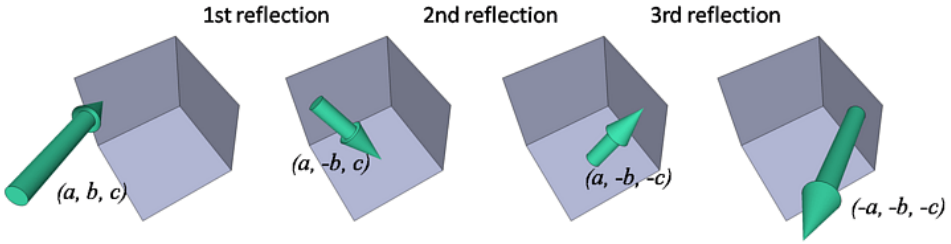


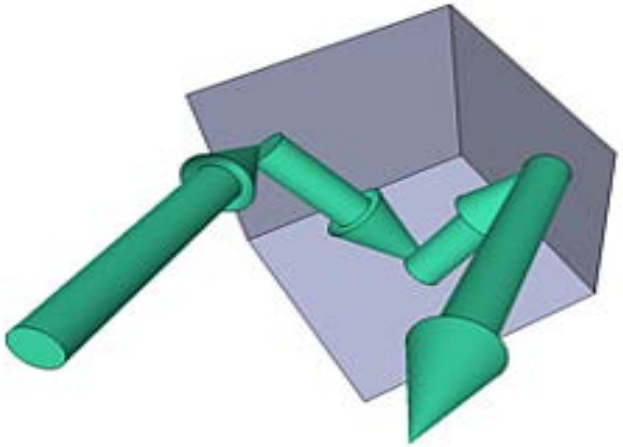
VLBI

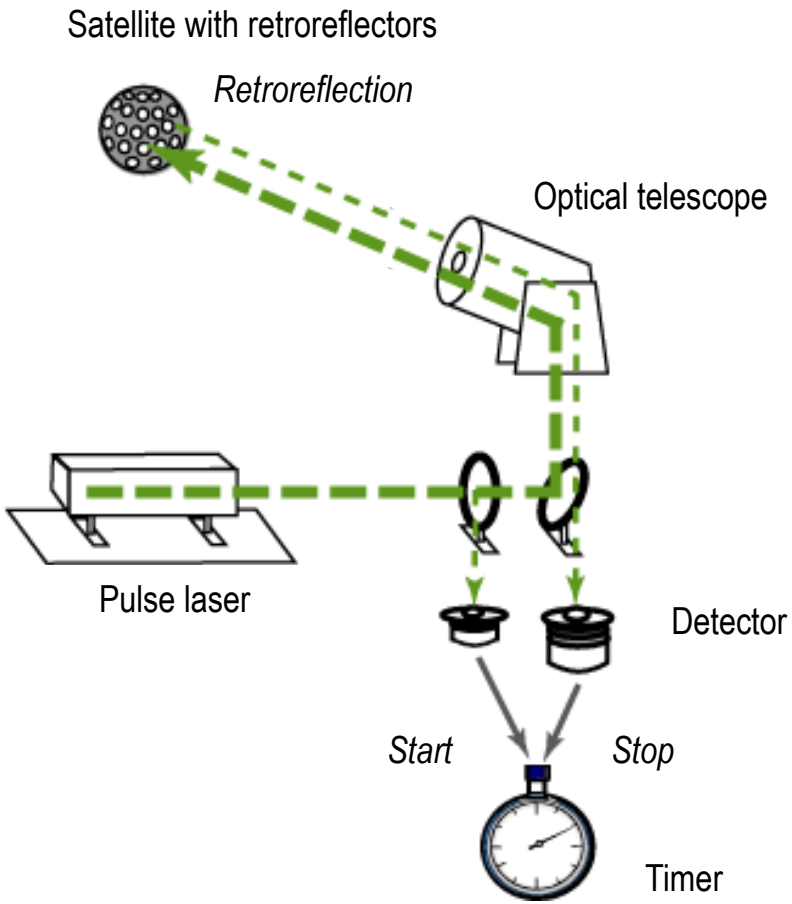
SLR

SLR

SLR: Satellite Laser Ranging







http://geo.science.hit-u.ac.jp/

International Laser Ranging Service
A service of the International Association of Geodesy

Search

IAG | GGOS

Welcome to ILRS

About ILRS | Network | Missions | Science | Data & Products | Technology

Overview

Satellite Laser Ranging (SLR) and Lunar Laser Ranging (LLR) use short-pulse lasers and state-of-the-art optical receivers and timing electronics to measure the two-way time of flight (and hence distance) from ground stations to retroreflector arrays on Earth orbiting satellites and the Moon. Scientific products derived using SLR and LLR data include precise geocentric positions and motions of ground stations, satellite orbits, components of Earth's gravity field and their temporal variations, Earth Orientation Parameters (EOP), precise lunar ephemerides and information about the internal structure of the Moon. Laser ranging systems are already measuring the one-way distance to remote optical receivers in space and can perform very accurate time transfer between sites far apart. Laser ranging activities are organized under the International Laser Ranging Service (ILRS) which provides global satellite and lunar laser ranging data and their derived data products to support research in geodesy, geophysics, Lunar science, and fundamental constants. This includes data products that are fundamental to the International Terrestrial Reference Frame (ITRF), which is established

Welcome

NGSLR Greenbelt, MD

Highlights

The 2019 ILRS Technical Workshop presentations and other information now available

Release Date: 11/06/2019

The 2019 ILRS Technical Workshop was held October 21-24, 2019 in Stuttgart, Germany. In addition, the first "SLR School" was held prior to the workshop on October 20. All abstracts, presentations, posters, and summary information from the workshop and the SLR School are available on the website:

Recent News

- **The 2019 ILRS Technical Workshop presentations and other information now available** - The 2019 ILRS Technical Workshop was held October 21-24, 2019 in Stuttgart, Germany. In addition, the first "SLR School" was held prior to the workshop on October 20. All abstracts, presentations, posters, and summary information from the workshop and the SLR School are available on the website:

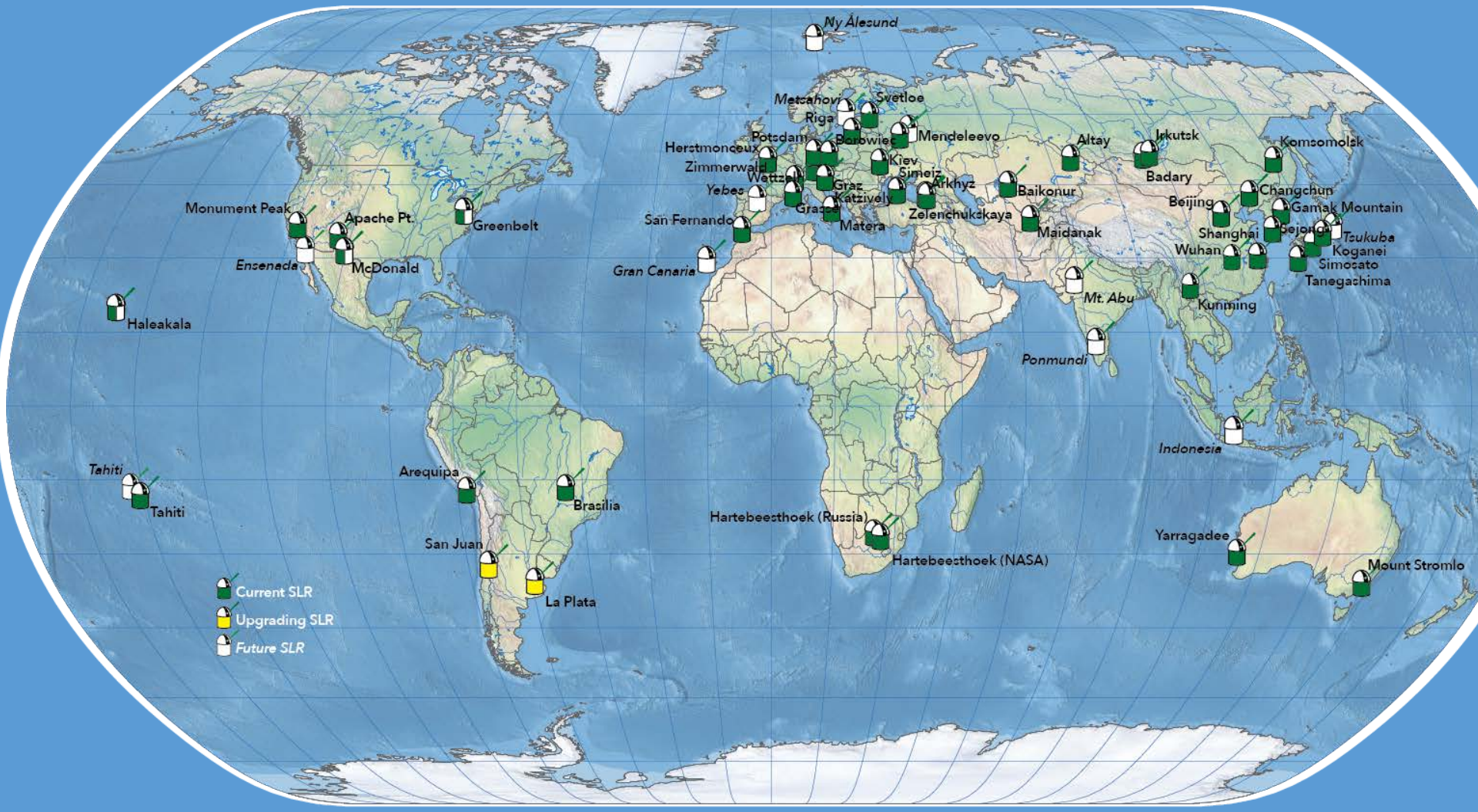
  https://cddis.nasa.gov/2019_Technical_Workshop

- **The Jason-2 mission has ended** - The Jason-2/Ocean Surface Topography Mission (OSTM), the third in a U.S.-European series of satellite missions designed to measure sea surface height, successfully ended its science mission on Oct. 1. NASA and its mission partners made the decision to end the mission after detecting deterioration in the spacecraft's power system.

  Read more about the Jason-2 mission...

https://ilrs.cddis.eosdis.nasa.gov/

ILRS network

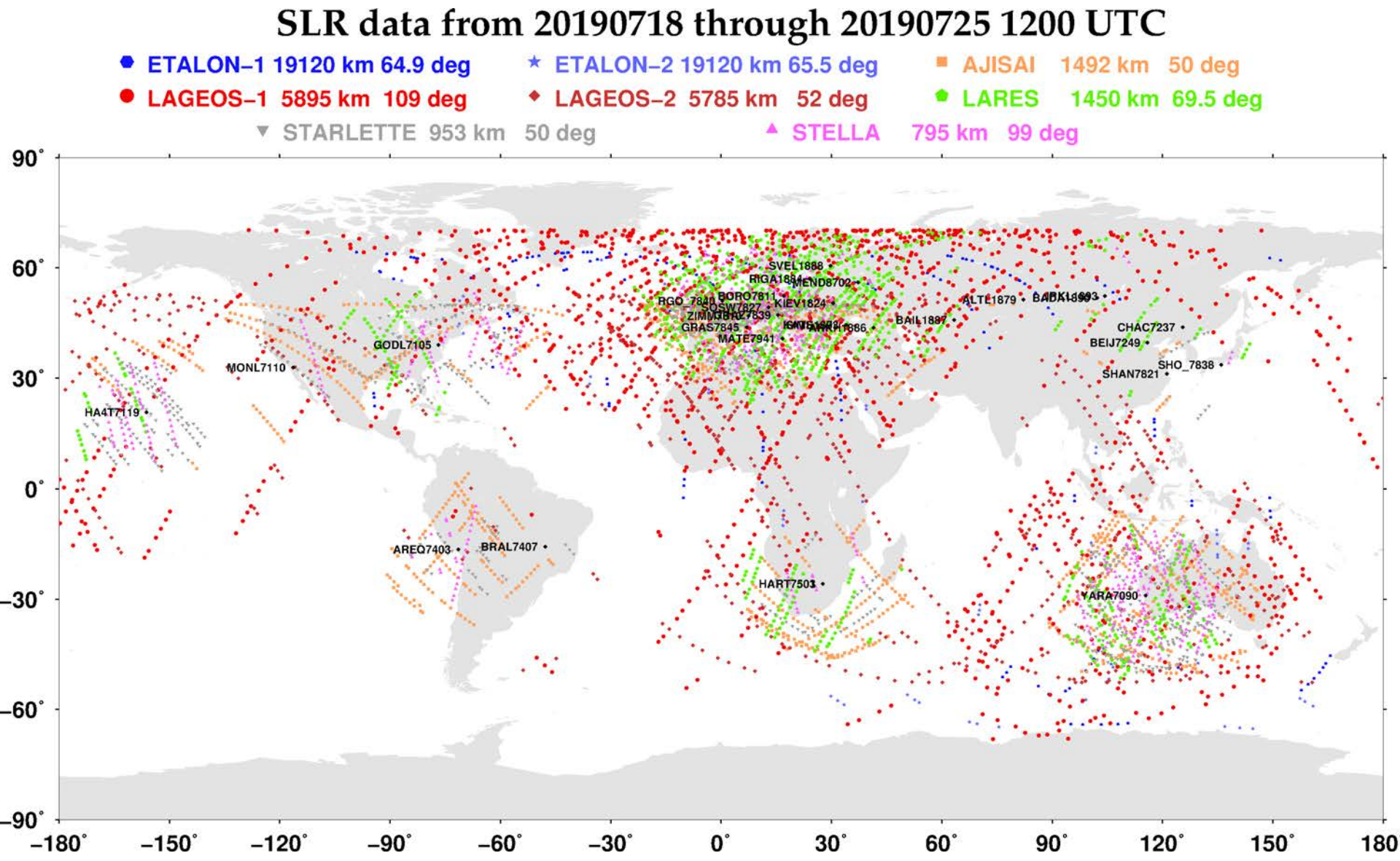


What is good about SLR

- **Optical wavelength**
  → No delay in ionosphere. Better delay model for troposphere.
- **2-way range**
  → Robust over clock error/fluctuation.
- **Long-time continuity**
  → Suitable for earth monitoring.
- **Wide applications**
  → (shown later)

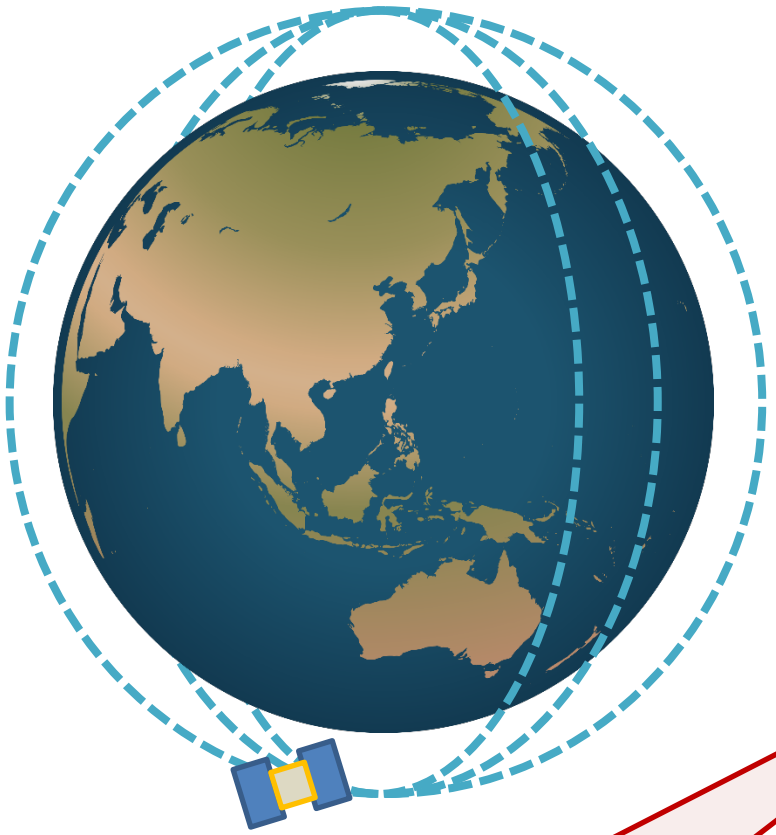
What is good about installing SLR in Antarctica

- **Filling the largest gap**
  No SLR station exists below 37S.
- **Better geodetic products**
  Geocentre, TRF Scale, Earth gravity, EOP.
- **Better satellite orbits**
  SLR to cover the whole revolution.
- **No one did it in Antarctica.**



https://ilrs.cddis.eosdis.nasa.gov/network/system_performance/recent_groundtrack.html

Effective for polar orbiters

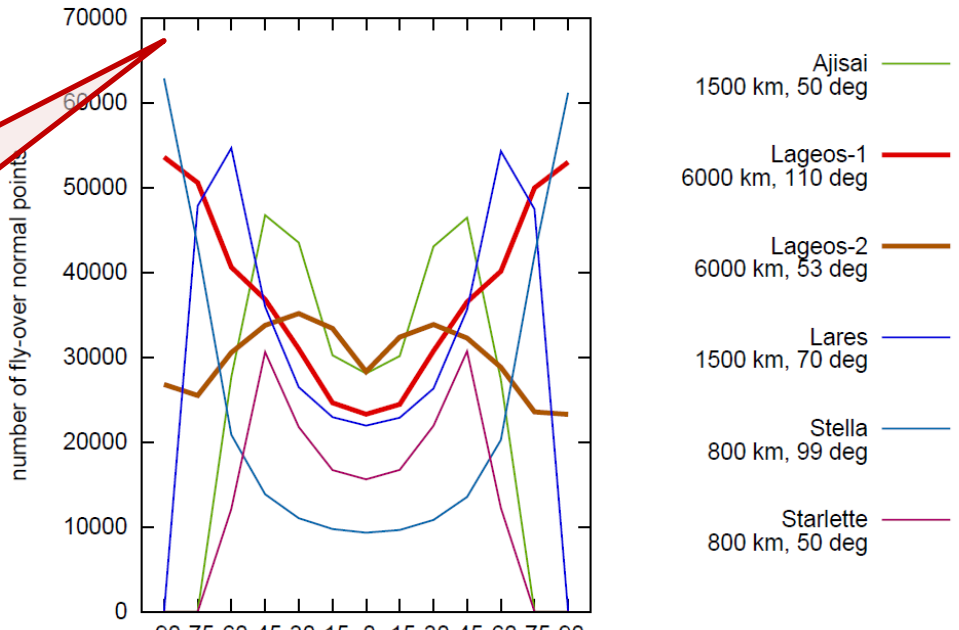


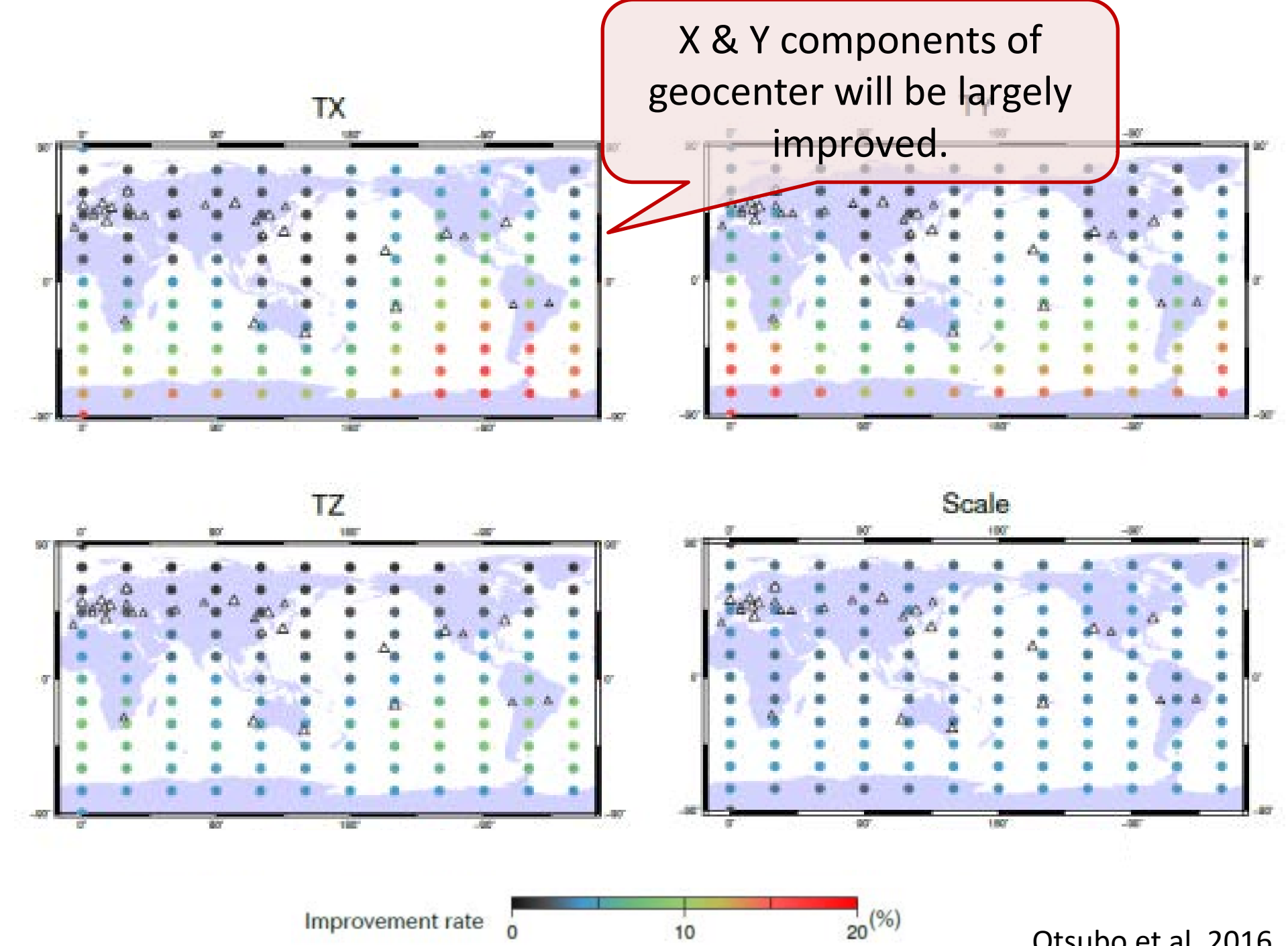
Polar orbit: ~ 90-deg inclination

- Earth observations satellites incl GRACE, ICESAT, Cryosat, …
- Possible application to satellite communications.

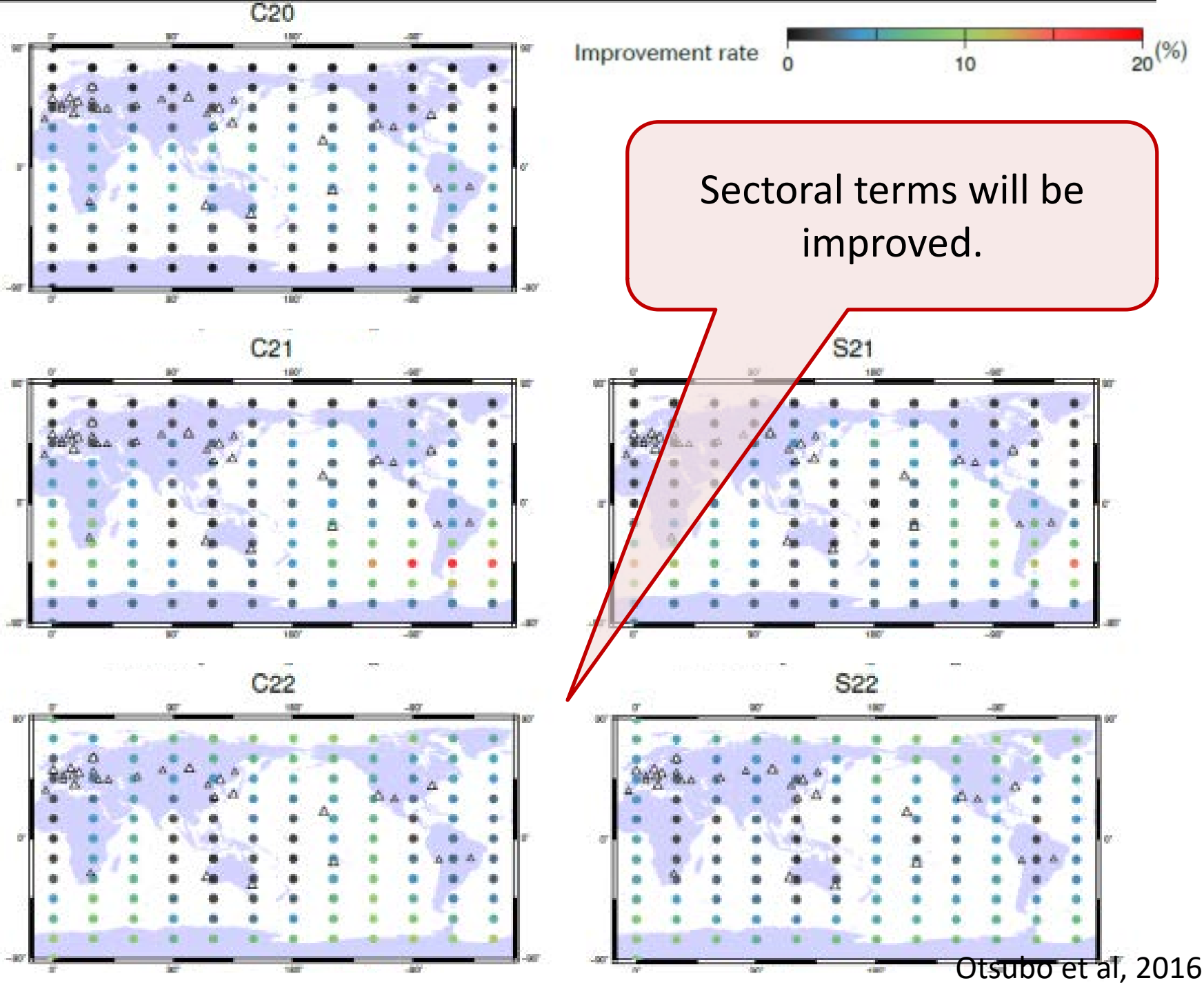
→ **Collaboration with space agencies/projects?**

Polar orbiters fly over Antarctica every rev.





Otsubo et al, 2016



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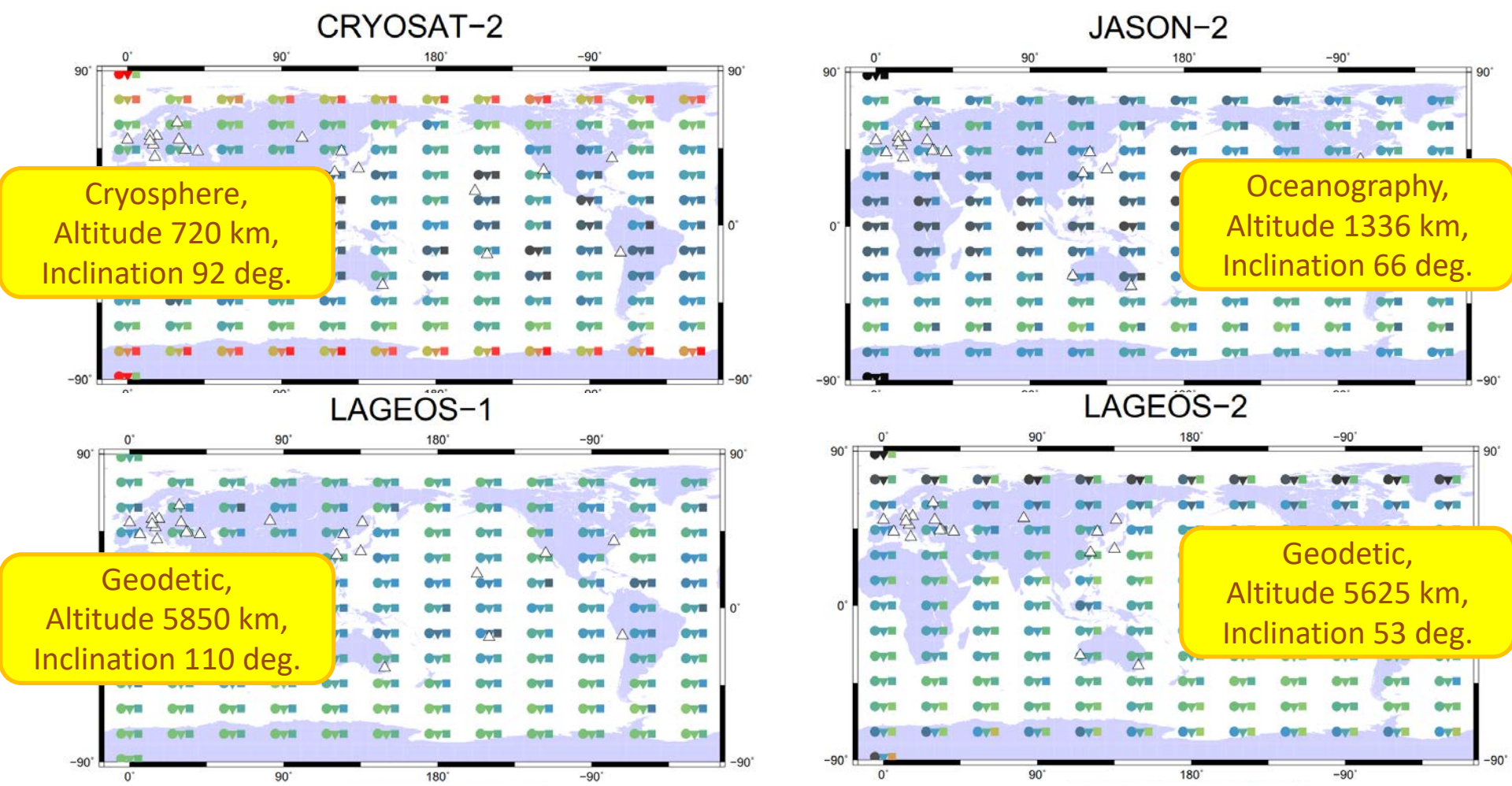

CRYOSAT−2
JASON−2
LAGEOS−1
LAGEOS−2
Cryosphere,
Altitude 720 km,
Inclination 92 deg.
Oceanography,
Altitude 1336 km,
Inclination 66 deg.
Geodetic,
Altitude 5850 km,
Inclination 110 deg.
Geodetic,
Altitude 5625 km,
Inclination 53 deg.
Improvement ratio (%)
0
10
20
Existing stations
active for the satellite in Feb 2016
Virtual station's contributions
for along-track, radial and cross-track
orbital components

Laser ranging: To improve ***economy,***
performance, *and* ***adoption for new applications***

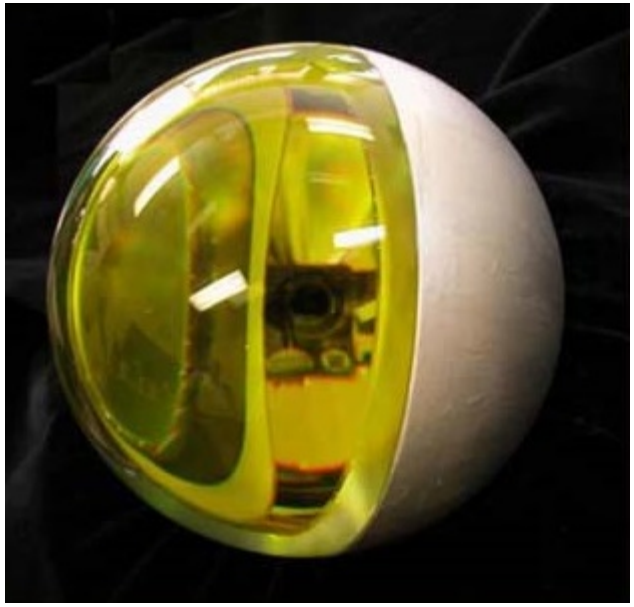
SLR: Latest trends and new applications

New Technologies

High-rate laser ranging using kHz ~ 100 kHz laser.

Infrared laser ranging with higher efficiency.

Innovative “zero-signature” satellite (e.g. BLITS-M).



New Applications

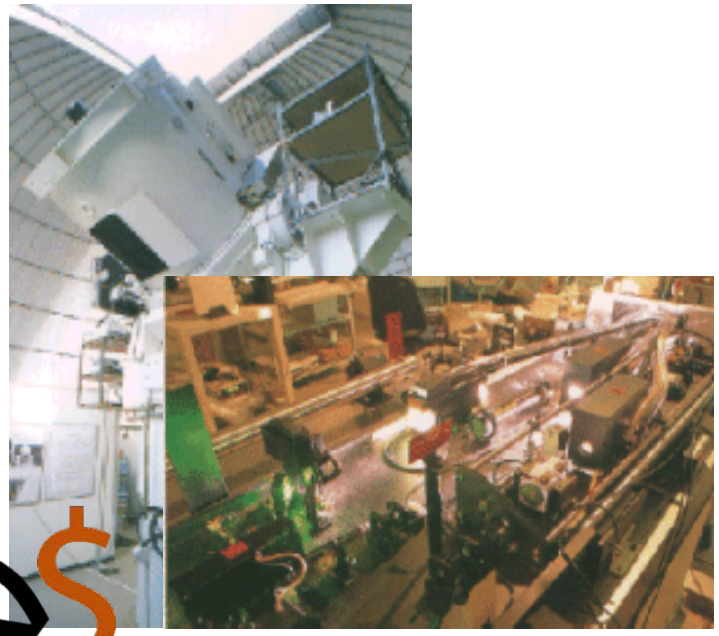
Lunar & Deep-space projects.

Space communications.

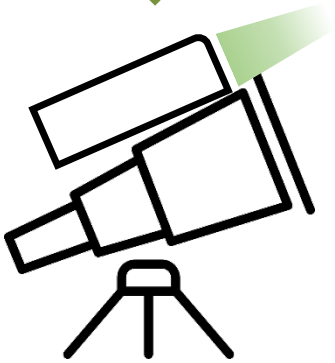
Space debris tracking.

Time transfer/comparison.

Low Cost? More Stations!



What will happen?



- SLR: Multi-million EUR/USD

  → 40 stations worldwide

- GNSS: 1% of SLR cost

  → 18,000 stations worldwide

Final remarks

Syowa to become a GGOS Core Station?

Budget hunting → Design & prototype testing