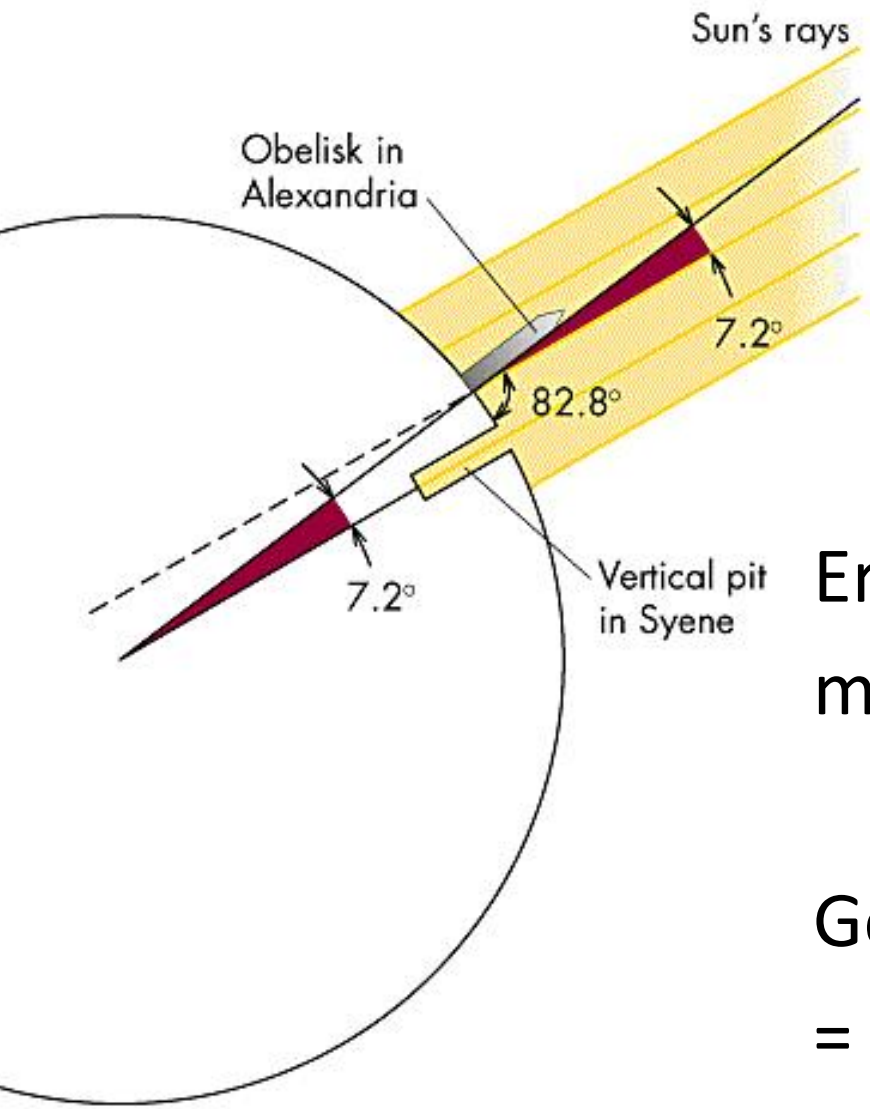
U02-20

International Cooperation within IAG's Geodetic Services ILRS and IVS, and the Japanese Contribution

Toshimichi Otsubo (Hitotsubashi Univ),
Shinobu Kurihara (GSI),
Carey E Noll and Dirk Behrend (NASA/GSFC)

Geodesy?



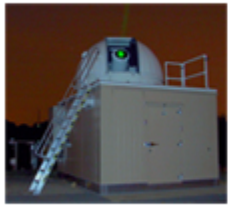
Eratosthenes (275BC-194BC) measured the size of the Earth.

Geodesy

= geometrical and gravitational measurement of the Earth

Space Geodesy

http://space-geodesy.nasa.gov/techniques/techOverview.html


SLR


VLBI


GNSS


DORIS

SLR/LLR (presented by Otsubo), **VLBI** (by Kurihara), GNSS, DORIS…

based upon ultra-accurate timing measurement.
by means of artificial satellites and natural objects.
→ unprecedented **high accuracy** & **global scale**.

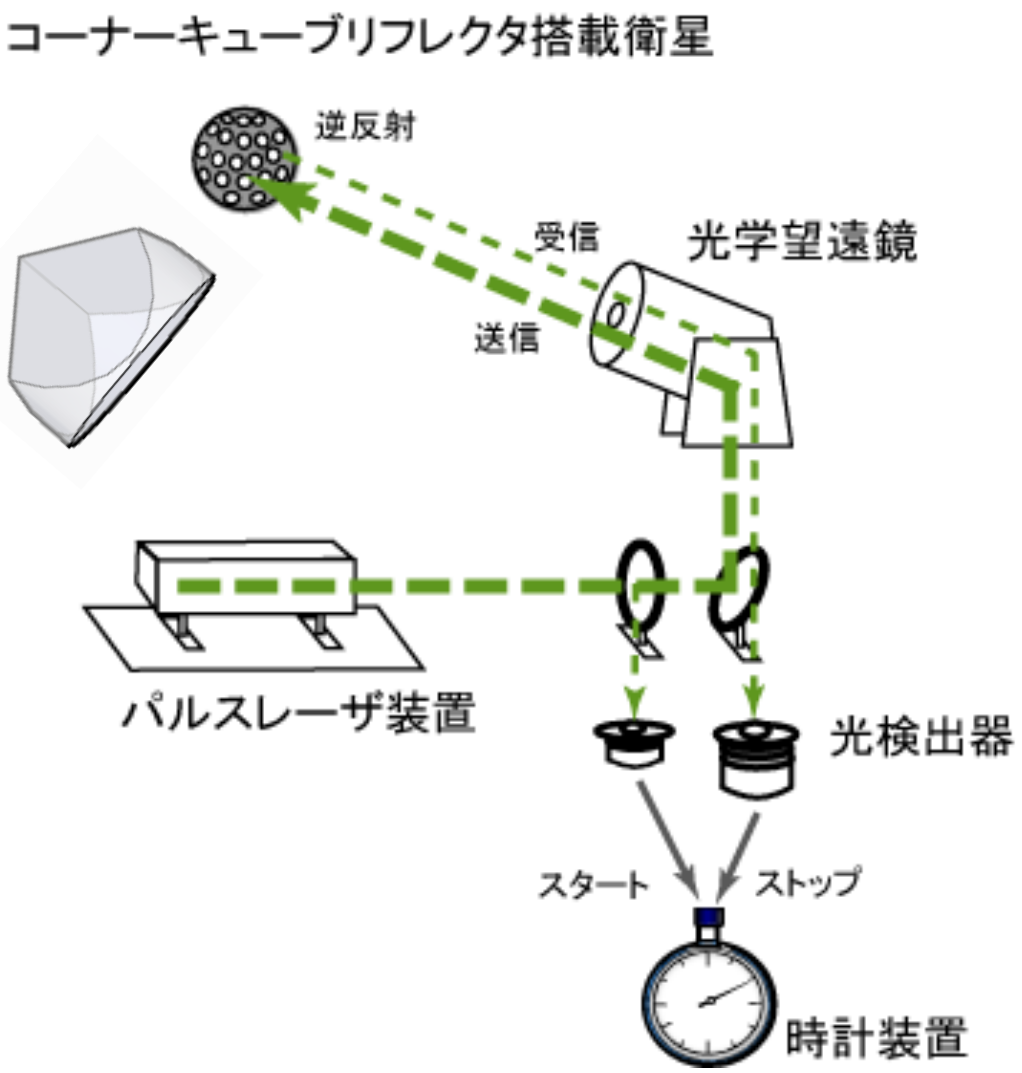
Current target:

1 mm (position) and 0.1 mm/y (velocity)

Applied to:

Crustal deformation studies
Reference frame, Mapping
Sea level rise
Earth gravity field
and more (→ Geodesy session on Thu)

What is SLR/LLR?



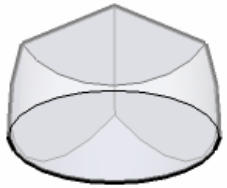
http://geo.science.hit-u.ac.jp/education/minilec-slr

Satellite/Lunar Laser Ranging

To measure:

- **round-trip time** (how far)
- **epoch** (when)
- auxiliary data

Satellites



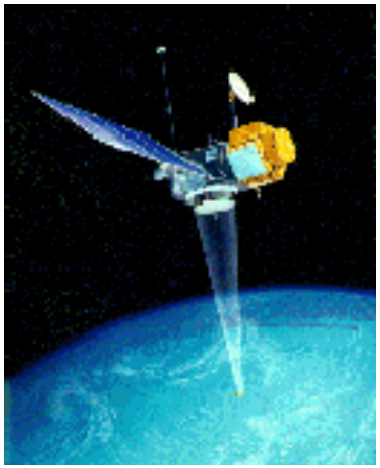
Geodesy

LAGEOS, ETALON, AJISAI, STARLETTE, STELLA, GFZ-1, BLITS, LARES

CHAMP, GRACE

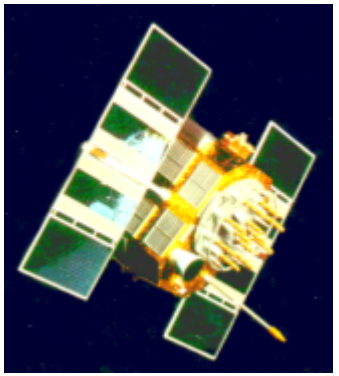
Remote sensing

ERS, TOPEX/POSEIDON, ADEOS, JASON, GFO, VCL, ICESAT, ALOS, ENVISAT, …



Navigation

GPS, GLONASS, GALILEO, COMPASS, ETS-8, QZS

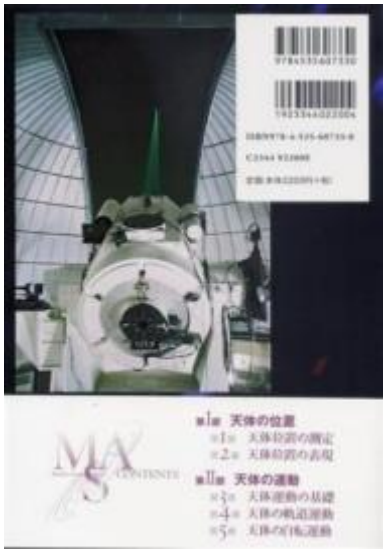


Stations

Photos: courtesy of each institute

Shimosato station (Japan Coast Guard) 1982-

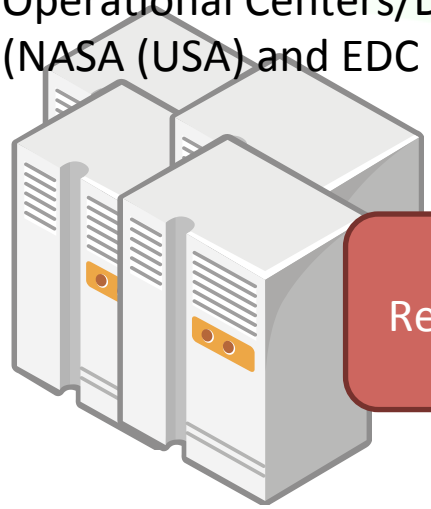
Tanegashima station (JAXA) 2004-



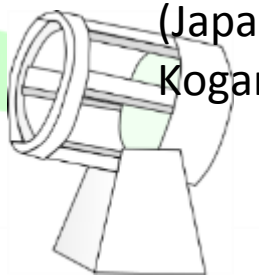
Koganei station (NICT) 1990-

Data Flow

Operational Centers/Data Centers
(NASA (USA) and EDC (Germany))



Laser Ranging Station
(Japan: Simosato,
Koganei &Tanegashima)



Observation Data
(within 1 hr)

Re-format

Observation Data

Geodetic Products

Quality check

Feedback

Prediction

Orbit analysis

Geodetic analysis

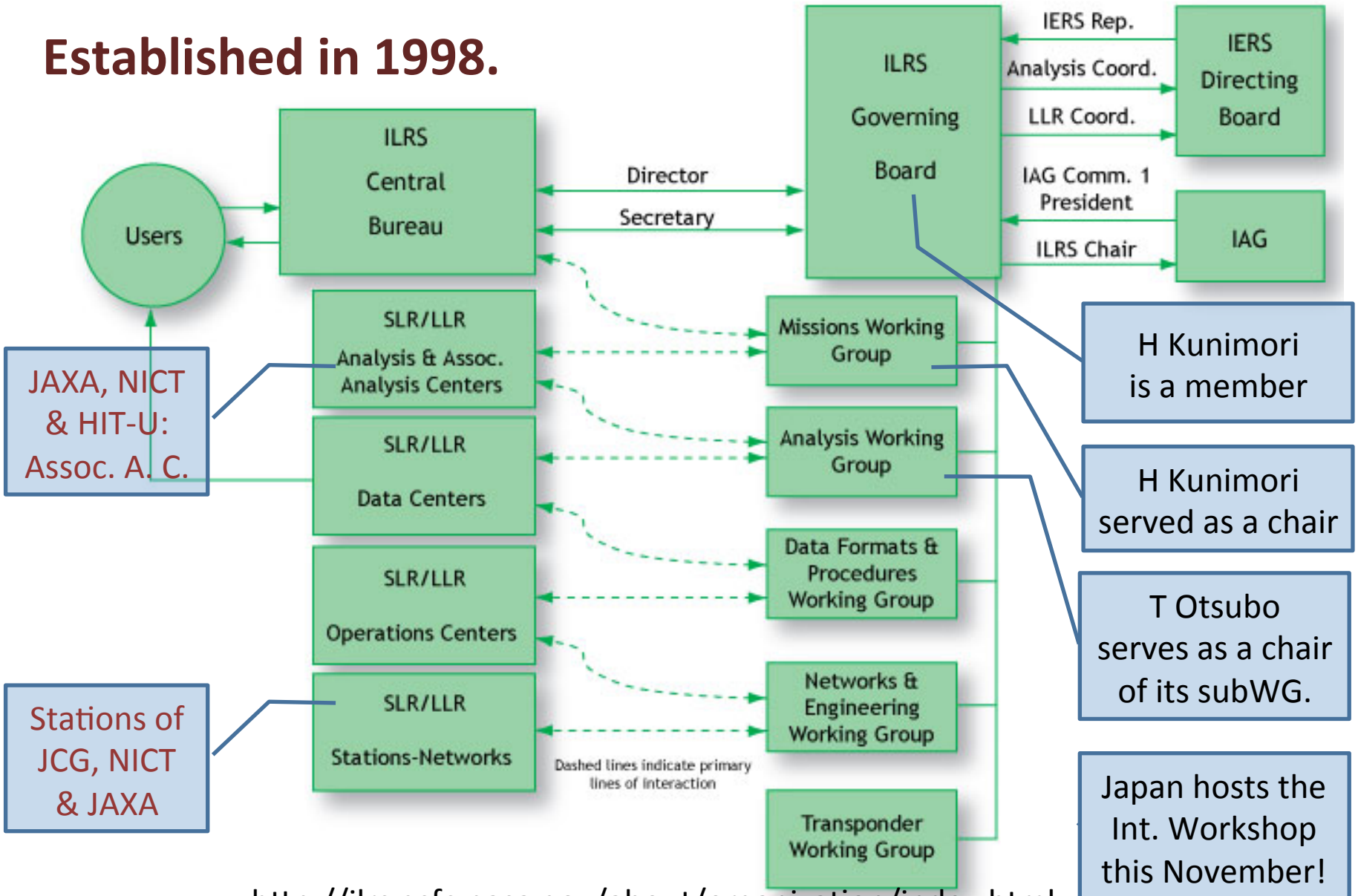
Paper

Scientific achievement

(Associate) Analysis Centers/Mission Centers
(Japan: NICT, JAXA & HIT-U)

International Laser Ranging Service

Established in 1998.



http://ilrs.gsfc.nasa.gov/about/organization/index.html

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Committees
Venue
Directions
Hotels

You are here: Home

18th International Workshop on Laser Ranging

- Pursuing Ultimate Accuracy & Creating New Synergies -

11-15 November 2013 Fujiyoshida, Japan

The 18th International Workshop on Laser Ranging is hosted by its Local Organising Committee closely working with International Laser Ranging Service (ILRS) after the unanimous decision made at the previous workshop held in Bad Kötzting.

This workshop is funded by the NICT International Exchange Program, and is supported by the Geodetic Society of Japan and also by the Japan Society for Aeronautical and Space Sciences.

The ILRS group meetings are also planned in and around the week. Email the Local Organising Committee (Z-LW18@jaxa.jp) for inquiries and information.

News:

Wed, 1 May 2013	Mt Fuji to become a World Heritage site (japan times, bbc)
Tue, 23 Apr 2013	First Announcement released

Important Dates:

HOT NEWS

ILRS = ISCU-WDS Network Member

ICSU International Council for Science | International Laser Ranging Service | ICSU WORLD DATA SYSTEM

Consortium Agreement between the International Laser Ranging Service (ILRS) and the International Council for Science (ICSU)

The purpose of this Consortium Agreement is to define the conditions under which the International Laser Ranging Service (hereinafter ILRS) will contribute to the ICSU World Data System (ICSU-WDS) as a Network Member. This document is not legally binding.

1. Laser ranging activities are organized under ILRS, which provides global satellite and lunar laser ranging data and their derived products to support geodetic, geophysical, and fundamental research activities; as well as products important to the maintenance of an accurate International Terrestrial Reference Frame. ILRS is one of the space geodetic services of the International Association of Geodesy and one of the components comprising its Global Geodetic Observing System. ILRS provides free and open access to all its data and product holdings to the general public.

2. It is the intention of ILRS to contribute to ICSU-WDS, and to collaborate with its governing body, the WDS Scientific Committee (WDS-SC), in order to ensure the long-term stewardship and provision of quality-assessed data and/or data services to the international science community and other stakeholders.

3. By joining as a Network Member, ILRS will work towards achieving the following goals and objectives of ICSU-WDS. These are to:
   a. Enable universal and equitable access to quality assured scientific data, data services, products and information
   b. Ensure long-term data stewardship
   c. Foster compliance to agreed-upon data standards and conventions
   d. Provide mechanisms to facilitate and improve access to data

4. ILRS commits to fulfil the ICSU-WDS criteria for membership, including:
   a. Accepting the ICSU-WDS Constitution 2012 (Annex A).
   b. Complying with the ICSU-WDS Data Policy (Annex B), which includes a commitment to full and open exchange of data, metadata, and products deposited within ICSU-WDS.

5. There are currently no data activities of ILRS that fall outside of the scope of ICSU-WDS. If such data activities arise, this Consortium Agreement shall be amended.

ICSU International Council for Science | International Laser Ranging Service | ICSU WORLD DATA SYSTEM

6. If ILRS, for any reason, is unable to continue its long-term commitment, then it should endeavour to find a mechanism to secure its data activities by transferring them to another ICSU-WDS facility or other suitable host organization.

7. The resources required for the data activities of the ILRS are the responsibility of its constituent organizations. To ensure continuity, the constituent organizations will provide these resources on a long-term basis as their ability and funding allow.

8. ILRS, as a Network Member of ICSU-WDS, refrains from using the WDS logo and trademarks to make direct financial profit without explicit authorization from the WDS-SC.

9. This Consortium Agreement will enter into force upon signature by both parties. It is valid from the date of signature until one of the parties expresses its willingness to terminate it. This shall not occur prior to a five-year period from the date of signature.

10. This Consortium Agreement is to be signed between ICSU and ILRS by the respective heads of organizations or their authorized delegates.

SIGNED
(On behalf of ICSU)

Date: 04/03/2013
Name: Steven Wilson
Position: Executive Director

SIGNED
(On behalf of the ILRS)

Date: 15/2/2013
Name: Graham Appleby
Position: Chair, ILRS Governing Board

Data-related issues

- "Full-rate" vs "Normal-point"
  - 5 to 10 Hz → kHz laser
  - Satellite attitude →

Kucharski, ASR, 2013.

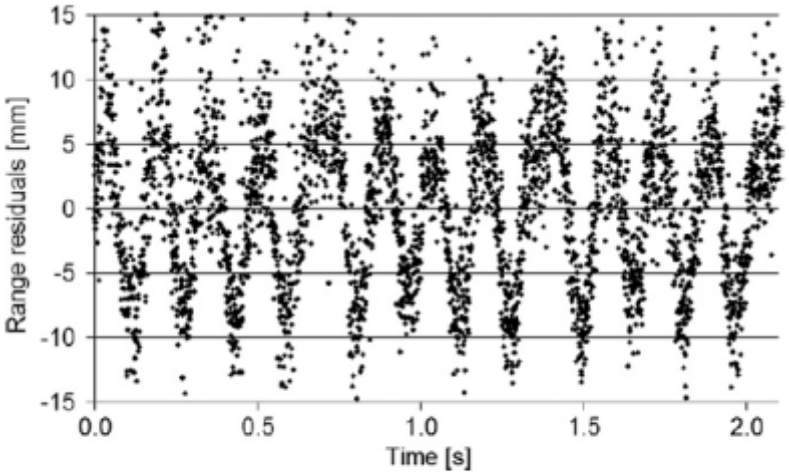


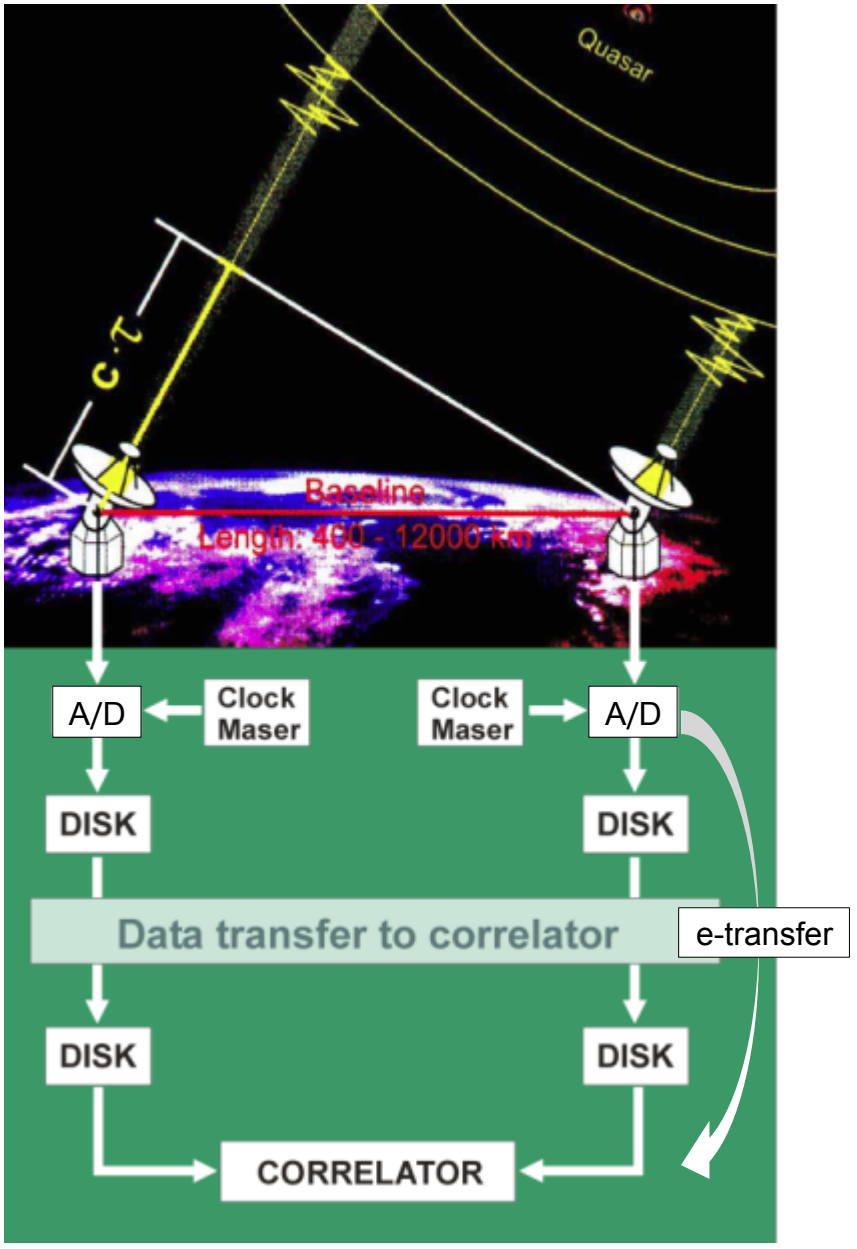
Fig. 3. Range residuals of Ajisai, calculated from Graz 2 kHz range measurements, during one rotation of the satellite (2.1s, September 9, 2008). 0 is the mean level.

- Expanding applications
  - Time transfer
  - Deep space
  - One-way ranging

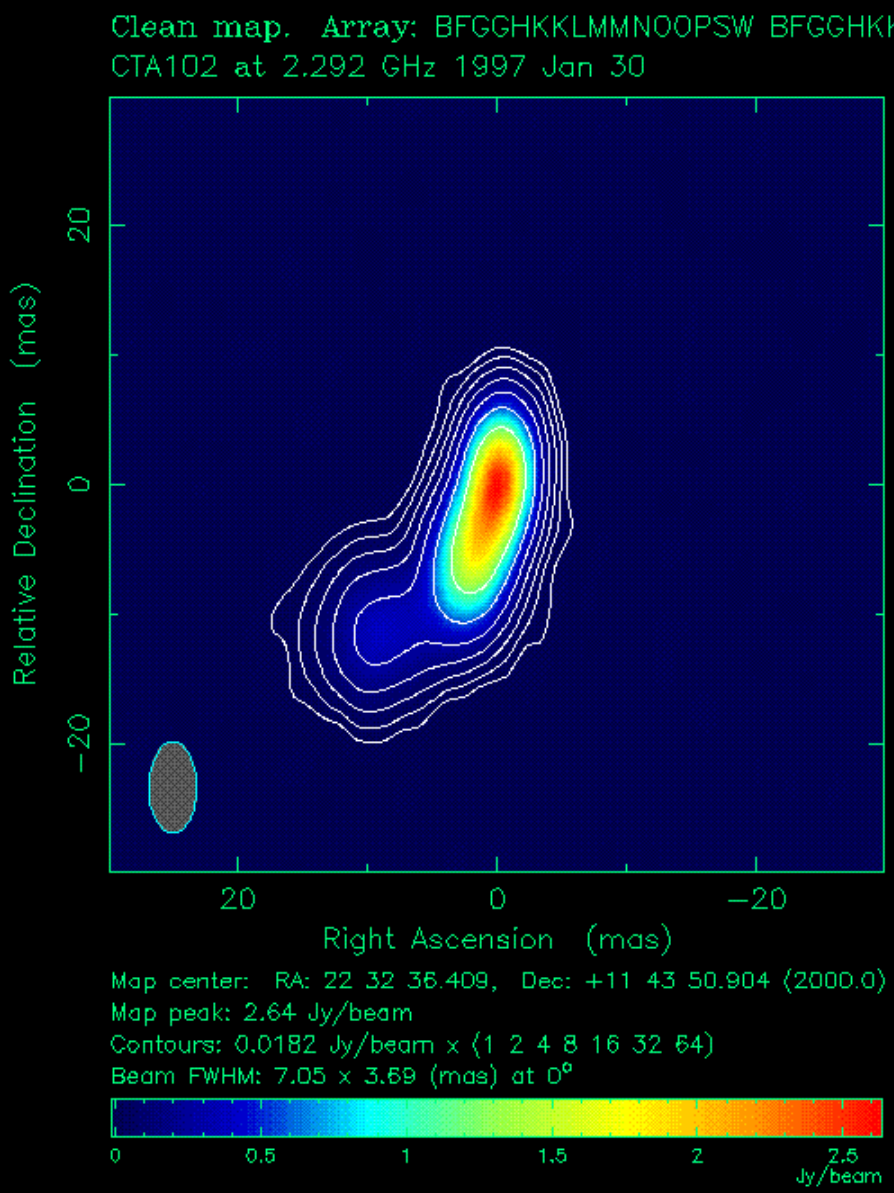
→New "CRD" format implemented in 2012.

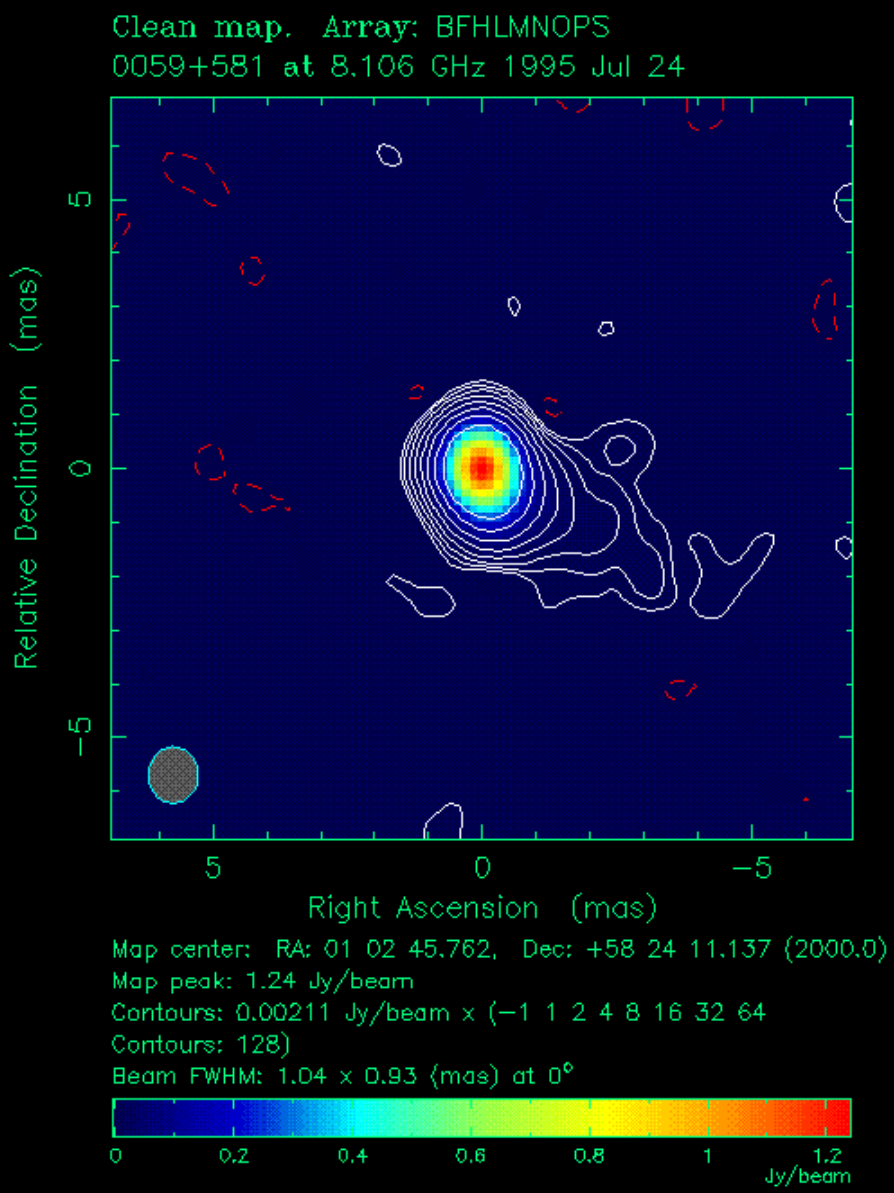
VLBI Observing System

- **Radio signals of quasars or radio galaxies**
  - 8 channels X-Band/8 GHz
  - 6 channels S-Band/2 GHz
  - Data 1 - 1.5 TByte/day·site
  - Time & Frequency
    - $\Delta F/F \sim 10e\text{-}15$ (Hydrogen Maser)
  - Data recording
    - HDD
    - e-transfer
- **Correlation (data processing)**
  - $\sigma_\tau \sim 10$ to 30 ps



Quasars Observed by VLBI

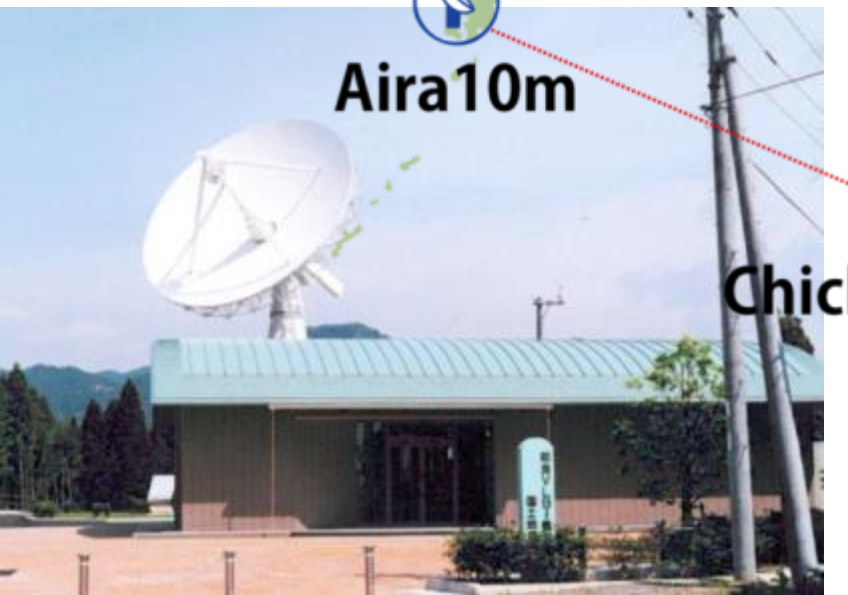




U.S. Naval Observatory

Geodetic VLBI Stations in Japan

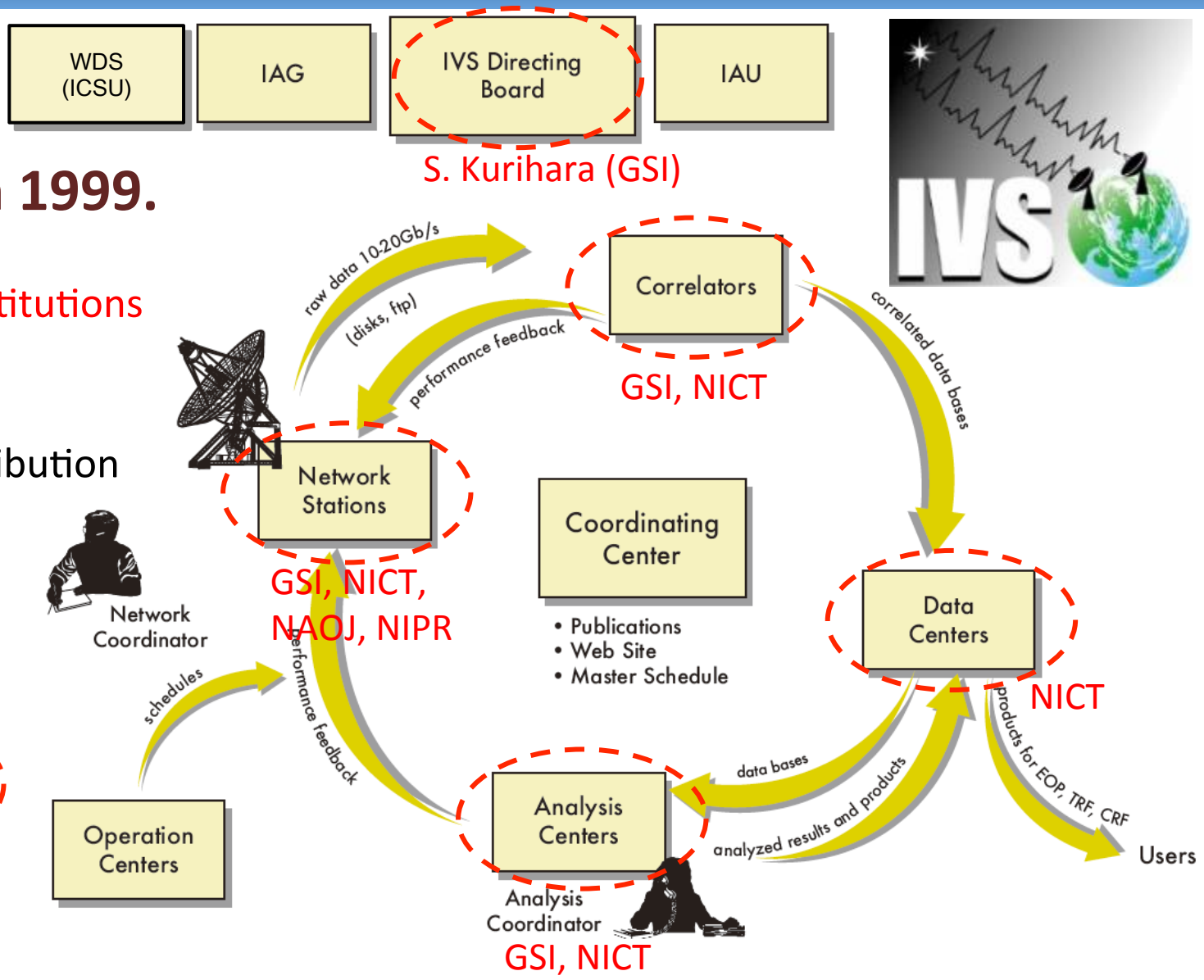
Geospatial Information Authority of Japan



IVS Network Stations

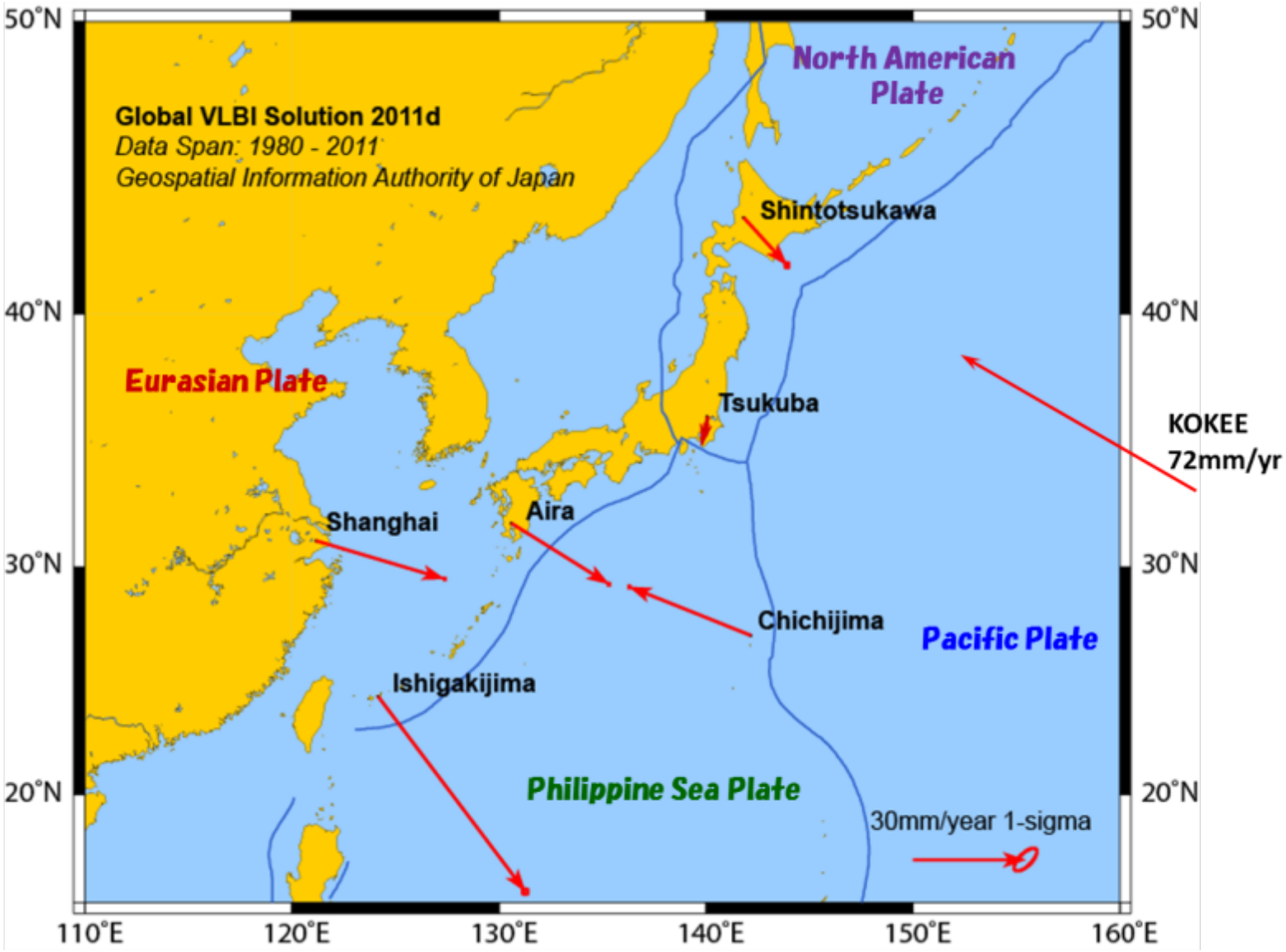
52 stations, 16 countries observed in 2012.

IVS: International VLBI Service for Geodesy and Astrometry



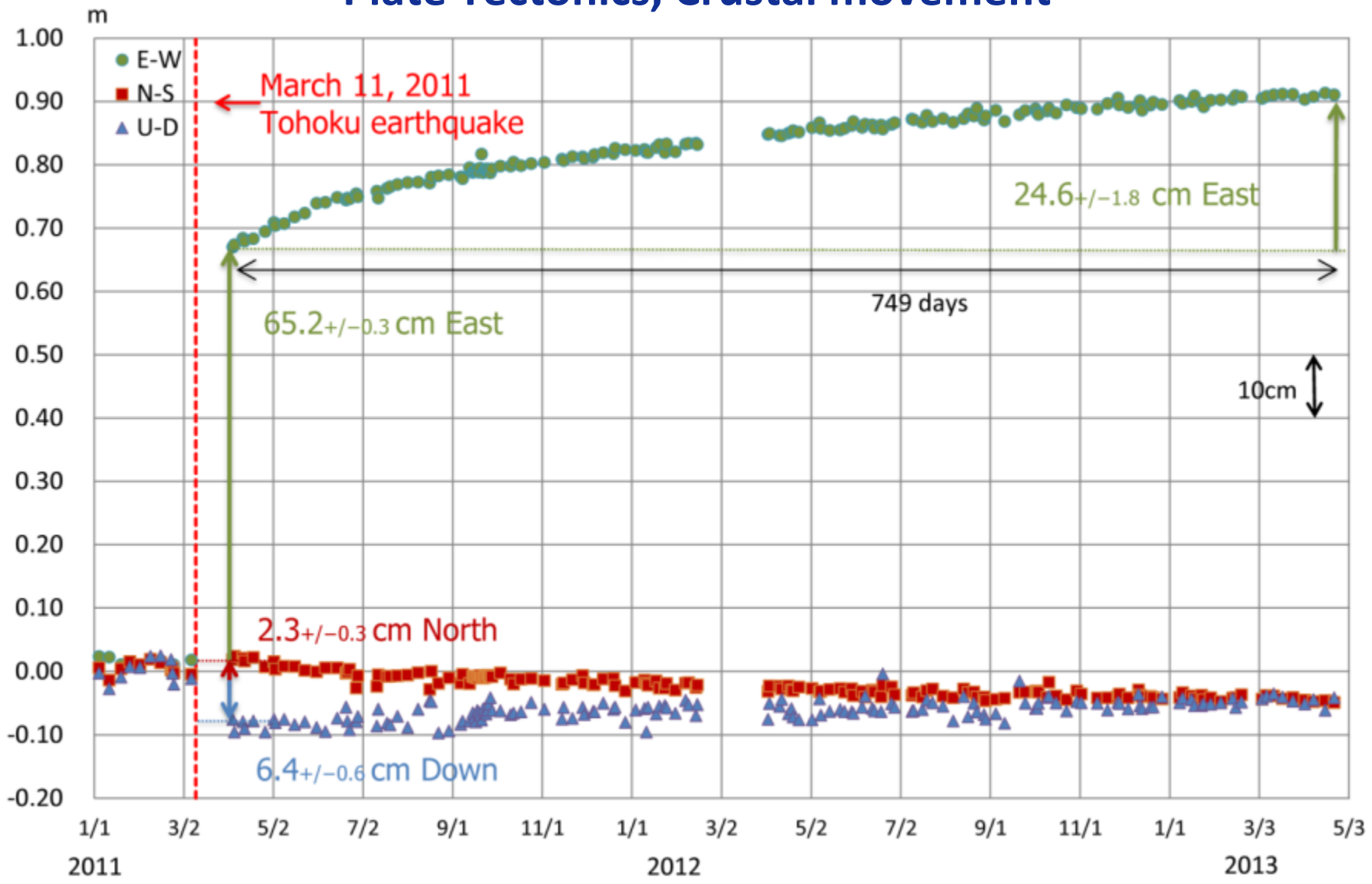
Typical results of VLBI (1)

Plate Tectonics, Crustal movement



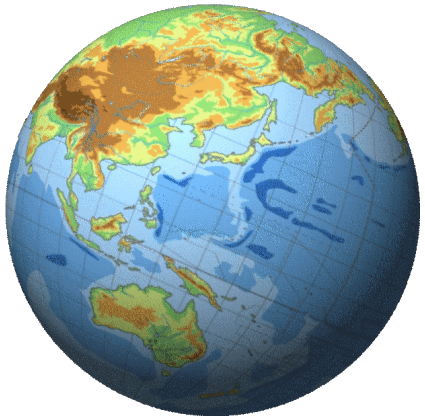
Typical results of VLBI (1)

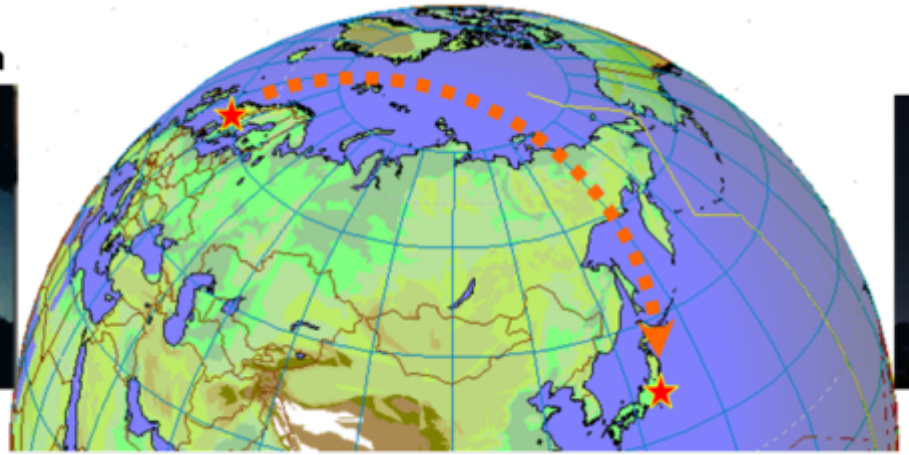
Plate Tectonics, Crustal movement



Typical results of VLBI (2)

Earth Orientation Parameter (EOP)

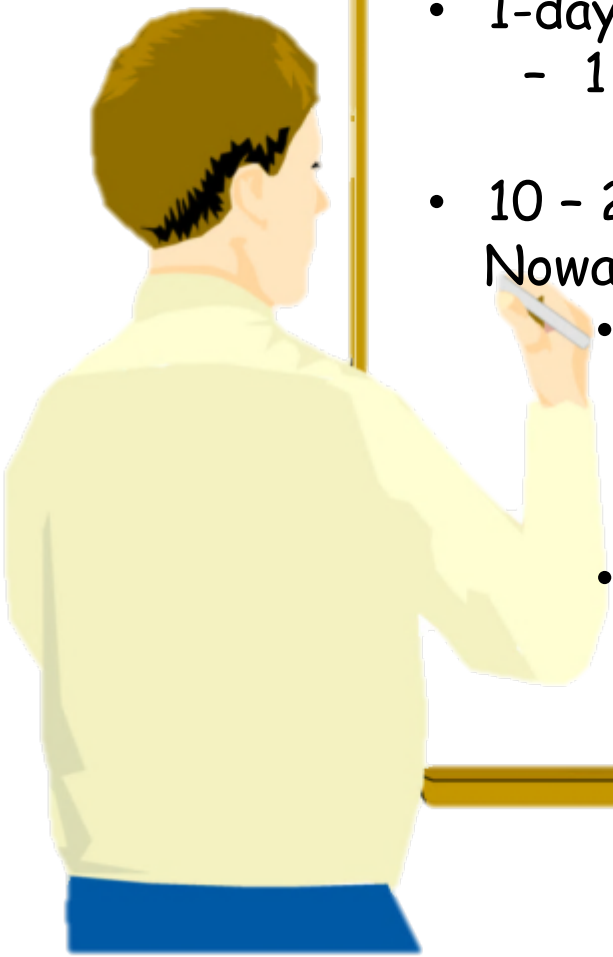




- The EOP varies from moment to moment, difficult to predict.
- Actual observation is needed. Essential parameter for satellite, and space prove, time keeping as well.
- VLBI is the unique technique to measure the full-set of EOP.
- Latency from observation to deriving a result (rapid-turnaround) is significant. A few minutes is available!
- Real-time data transfer with Tsunami UDP protocol (~600 Mbps).

Big data in VLBI

How big amount of row data do we deal with in VLBI?



- Row data from quasar A/D-sampled with 256 MHz.
- 1-day observation:
  - 1 – 1.5 (TB) x 8-10 (sites) **~ 15 (TB/day)**
- 10 – 20 HDDs are needed if 2TB/HDD.
  Nowadays, **e-transfer** is a state-of-the-art way.
  - 15 (TB) x 8 (bit) / 500 (Mbps)
    ~ 7(hours/site)

1-day data transfer rate

- 170 days in a year
  ~ 2.5 (Pbyte) total amount of data
  ~ 50 (days) required time to transfer

ICSU-WDS Network Member

Agreement between the IVS and the ICSU relating to the Service's contribution to the WDS.

Consortium Agreement between the International VLBI Service for Geodesy and Astrometry (IVS) and the International Council for Science (ICSU)

The purpose of this Consortium Agreement is to define the conditions under which the International VLBI Service for Geodesy and Astrometry (hereinafter IVS) will contribute to the ICSU World Data System (ICSU-WDS) as a Network Member. This document is not legally binding.

1. IVS is an international collaboration of organizations that operate or support Very Long Baseline Interferometry (VLBI) components. IVS provides a service that supports geodetic and astrometric work on reference systems, Earth science research, and operational activities. IVS is a Service of the International Association of Geodesy and the International Astronomical Union.

2. It is the intention of IVS to contribute to ICSU-WDS, and to collaborate with its governing body, the WDS Scientific Committee (WDS-SC), in order to ensure the long-term stewardship and provision of quality-assessed data and/or data services to the international science community and other stakeholders.

3. By joining as a Network member, IVS will work towards achieving the following goals and objectives of ICSU-WDS. These are to:
   a. Enable universal and equitable access to quality assured scientific data, data services, products and information
   b. Ensure long-term data stewardship
   c. Foster compliance to agreed-upon data standards and conventions
   d. Provide mechanisms to facilitate and improve access to data

4. IVS commits to fulfil the ICSU-WDS criteria for membership, including:
   a. Accepting the ICSU-WDS Constitution 2012 (Annex A).
   b. Complying with the ICSU-WDS Data Policy (Annex B), which includes a commitment to full and open exchange of data, metadata, and products deposited within ICSU-WDS.

5. There are currently no data activities of the IVS that fall outside of the scope of ICSU-WDS. If such data activities arise, this Consortium Agreement shall be amended

6. If IVS, for any reason, is unable to continue its long-term commitment, then it should endeavour to find a mechanism to secure its data activities by transferring them to another ICSU-WDS facility or other suitable host organization.

7. The resources required for the data activities of IVS are the responsibility of its constituent organizations. To ensure continuity, the constituent organizations will provide these resources on a long-term basis.

8. IVS, as a Network Member of ICSU-WDS, refrains from using the WDS logo and trademarks to make direct financial profit without explicit authorization from the WDS-SC.

9. This Consortium Agreement will enter into force upon signature by both parties. It is valid from the date of signature until one of the parties expresses its willingness to terminate it. This shall not occur prior to a five-year period from the date of signature.

10. This Consortium Agreement is to be signed between ICSU and IVS by the respective heads of organizations or their authorised delegates.

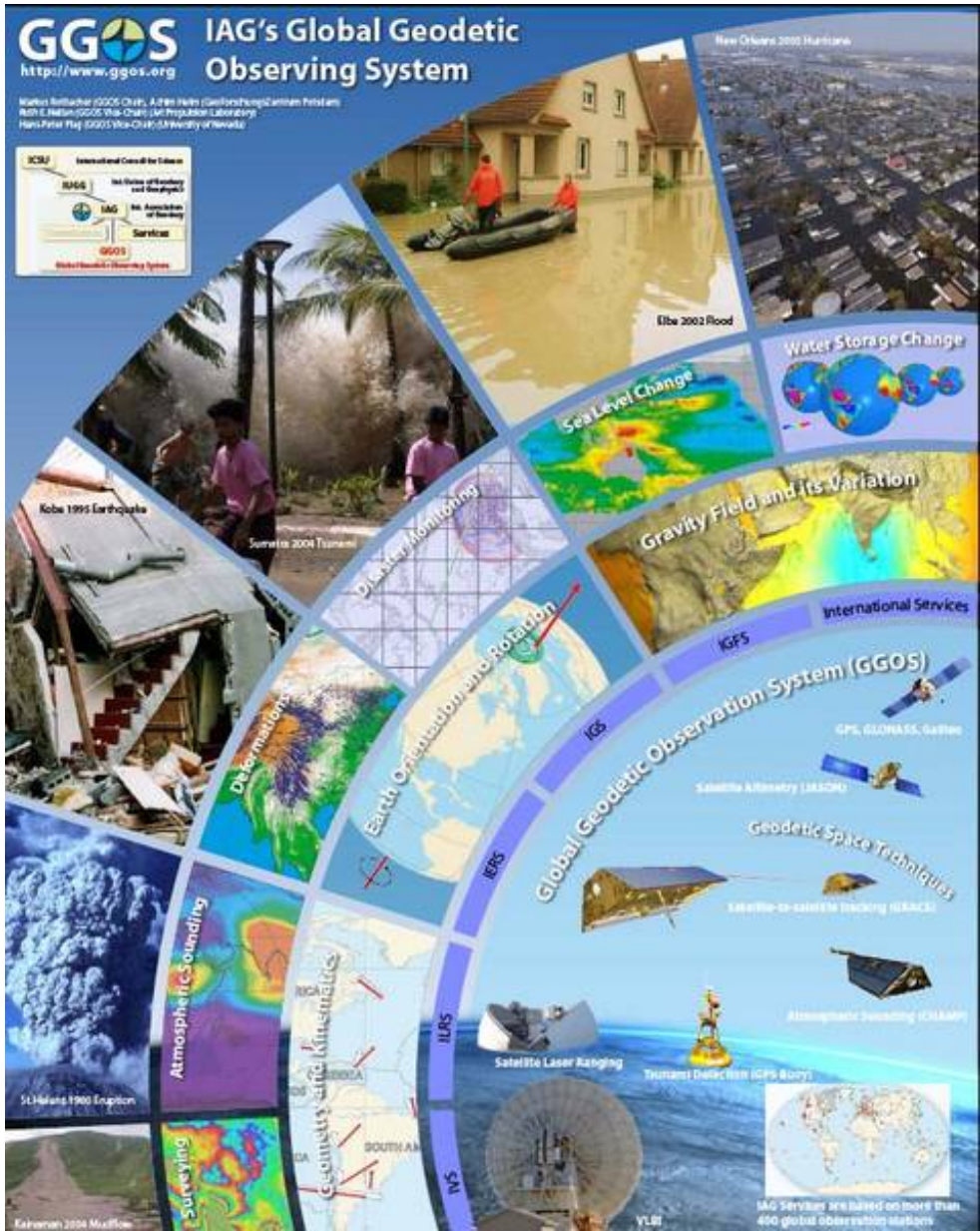
SIGNED	SIGNED
(On behalf of ICSU)	(On behalf of IVS)
Date: 4/3/13	Date: 15.02.2013
Name: Steven Wilson	Name: Harald Schuh
Position: Executive Director	Position: Chair, IVS Directing Board

GGOS: Global Geodetic Observing System

Contributes to several environmental problems; sea level rise, climate change, and natural hazards; megaquake, typhoon.

Permanent service of the International Association of Geodesy (IAG).

Contributes to GEOSS and GEO.



GGOS: Global Geodetic Observing System

The Reference Frame and the sustainable observations are necessary for considering these environmental problems.

Accuracy:

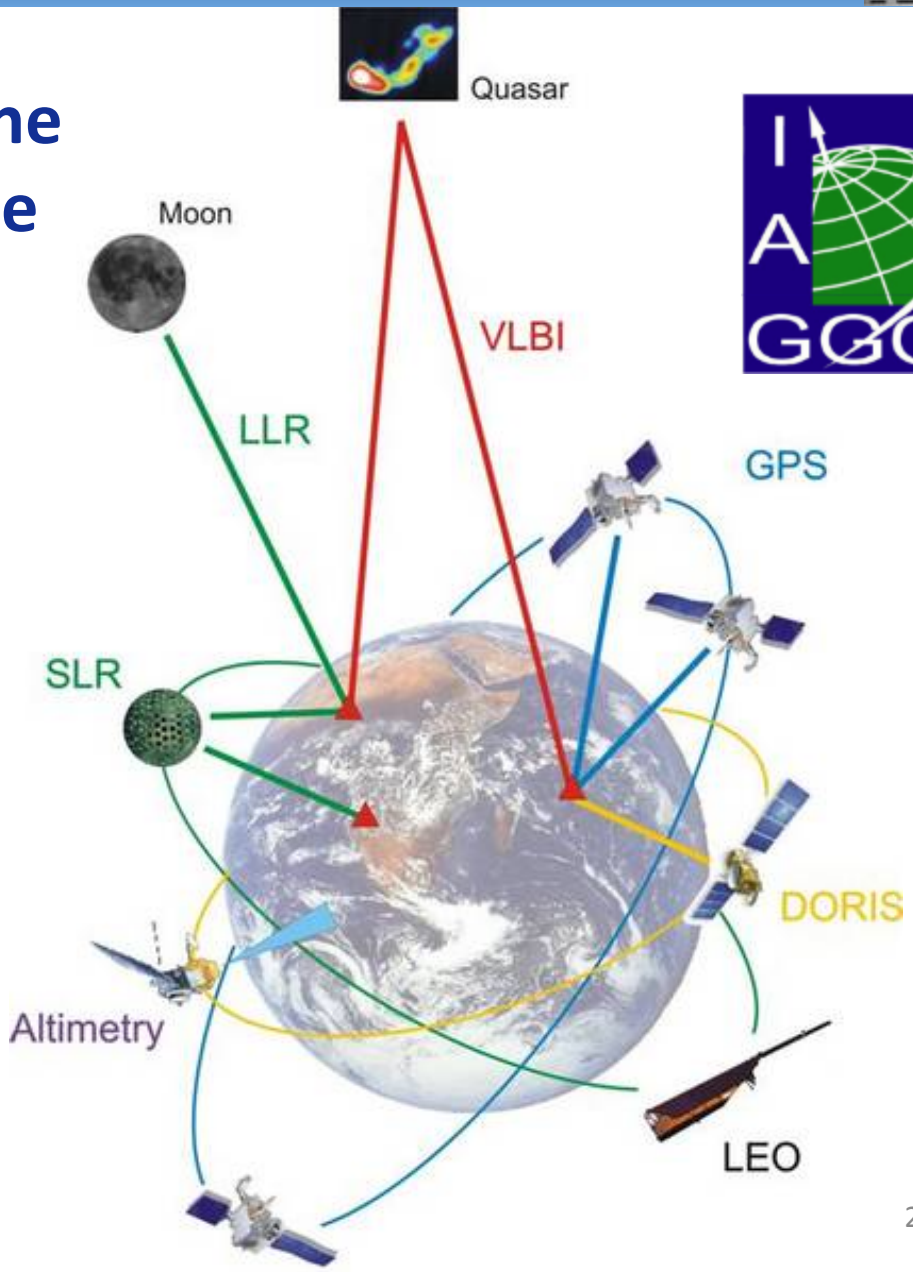
- **< 1 mm (site positions)**
- **< 0.1 mm/yr (velocities)**

Continuous observation:

- **24-hour, 365-day**

↓

- **Data size definitely increases!**

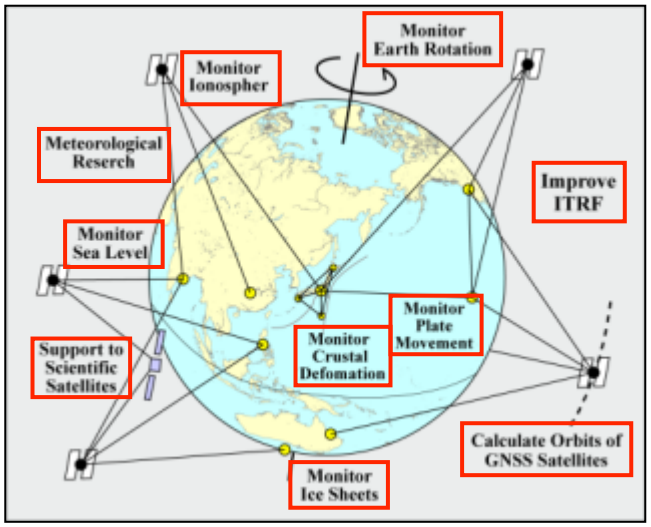


Summary

- Two IAG's services **ILRS** and **IVS**
  - deal with massive amount of data,
  - recently **signed the agreement with ICSU** relating to the service's contribution to the **WDS**.
- SLR:
  - Data flow coordination and growing application area.
- VLBI:
  - Real-time data transfer and rapid turnaround of EOP.
- **GGOS**: Geodetic Observation in Future
  - Contribution to environmental problems and natural hazards.
  - Sustainable and long-term observation is needed.
  - The amount of data should **increase definitely**.

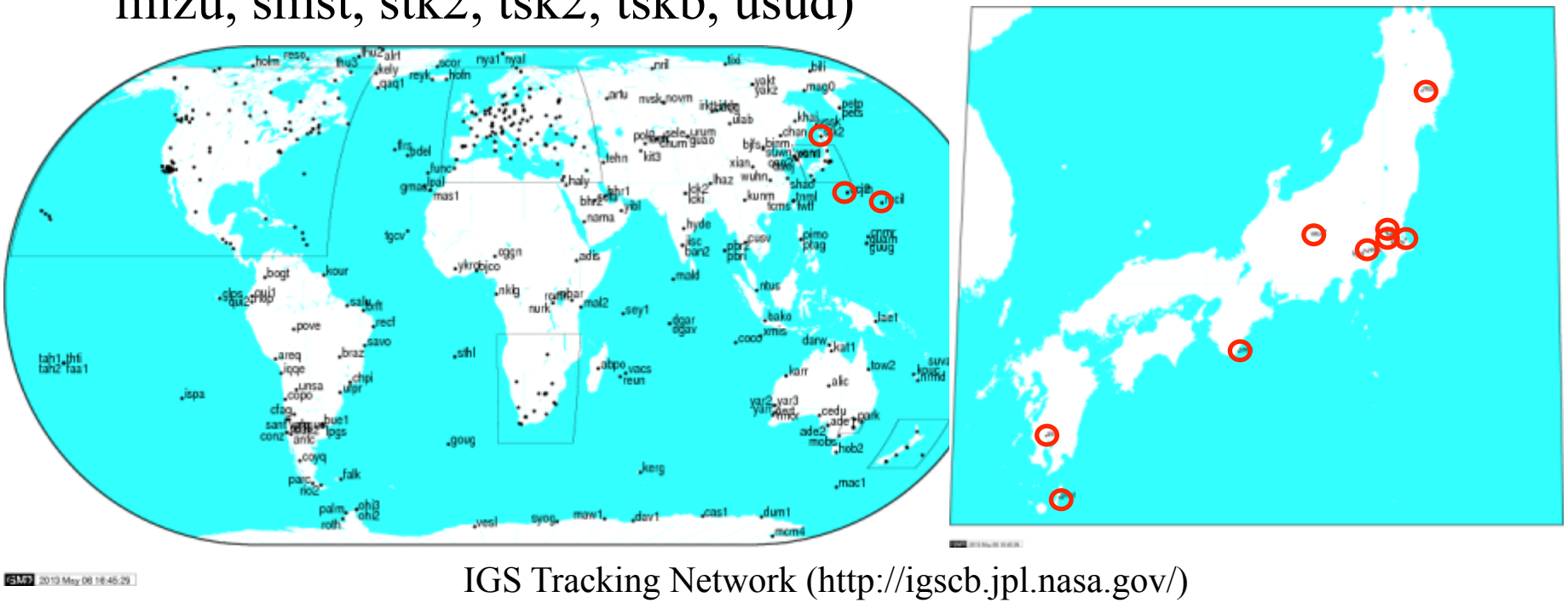
IGS : International GNSS Service

- Established in 1994 under the International Association of Geodesy
- Voluntary Federation
  - More than 200 worldwide agencies participate (Japan: GSI, JAXA, NICT, NAOJ, JCG, ENRI)
  - Pool resources and GNSS data to generate precise products
- Purposes
  - Support the earth science research
  - Develop the Standard format of GNSS products
  - Provide high quality data and products of GNSS（e.g. Precise ephemeris and Clock info of Satellites, Observation data and Coordinate of IGS stations）



IGS Scientific Objectives

- IGS Tracking Network
  - 427 stations and 360 stations are active（6th/May./2013）
  - 12 stations are in Japan (aira, ccj2, gmsd, kgni, ksmv, mcil, mizu, smst, stk2, tsk2, tskb, usud)



IGS Tracking Network (http://igscb.jpl.nasa.gov/)

- IGS Activities for WDS
  - IGS is WDS regular member
  - IGS benefits: ICSU level accredited, Visibility and recognition as a model of international community cooperation as a scientific service, Partnerships with global data services, Emphasis on data sharing principles

(Ruth E. Neilan (2012), The IGS as a Member of ICSU World Data System, *IGS 2012 Workshop*)