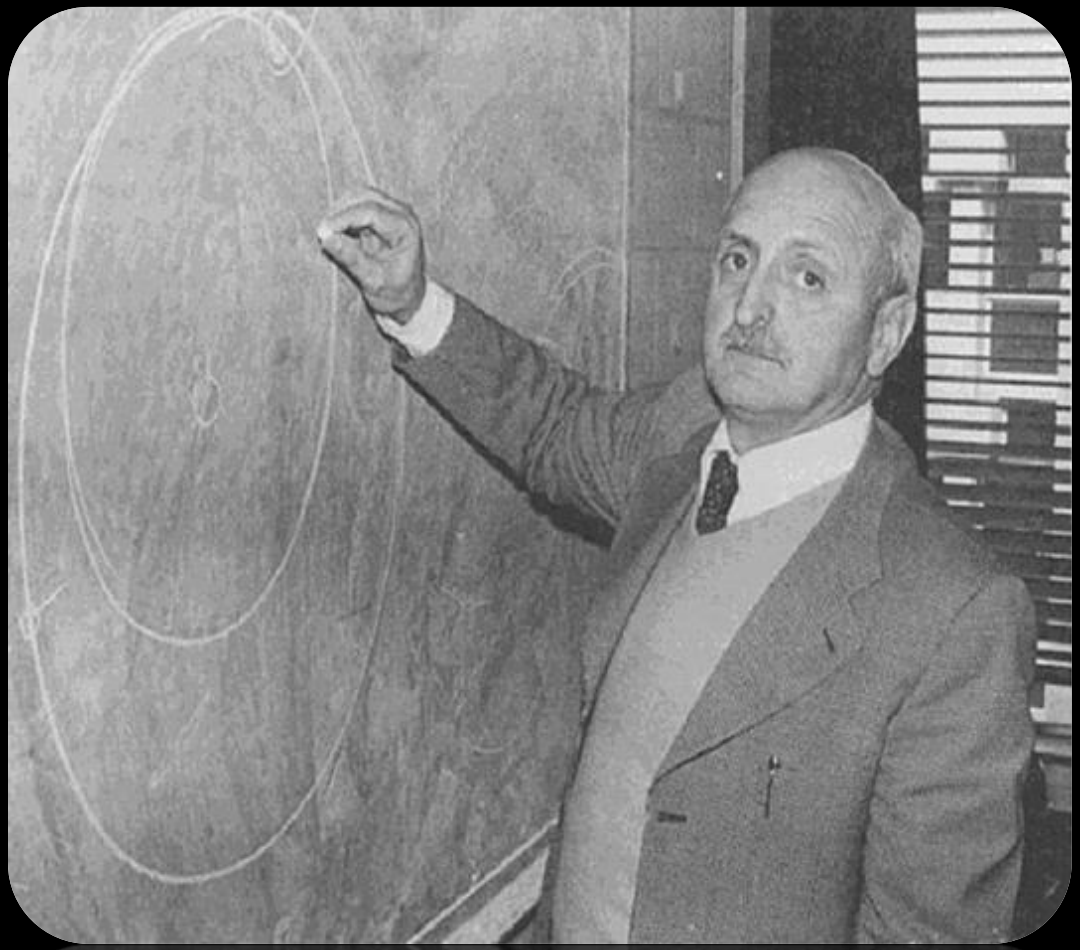
Agenzia Spaziale Italiana

The ASI Matera Centre for Space Geodesy «Giuseppe Colombo»

Giuseppe Bianco
ASI/CGS

Prof. Giuseppe *Bepi* Colombo

(Padua, October 2, 1920 – Padua, February 20, 1984)



α
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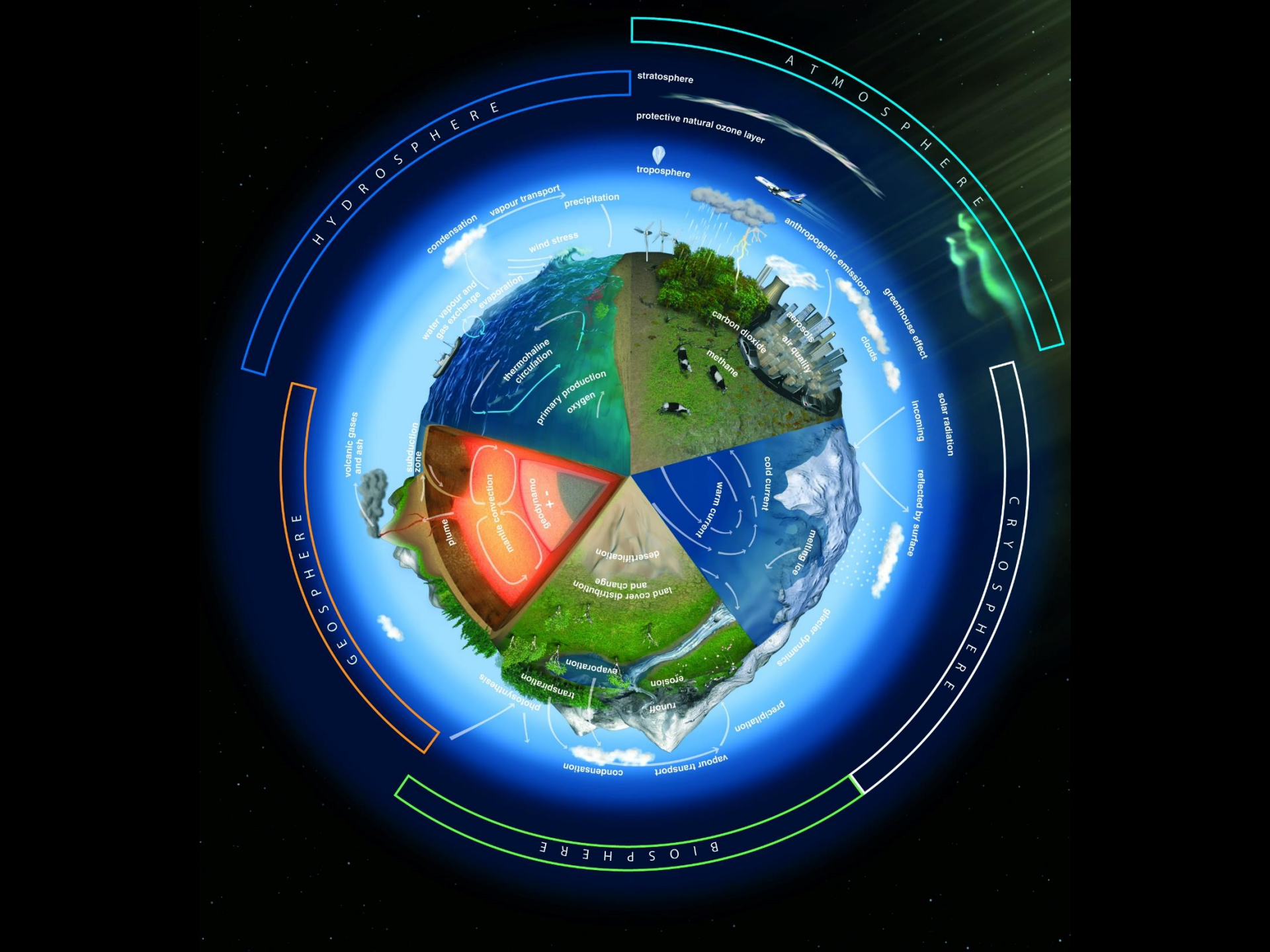
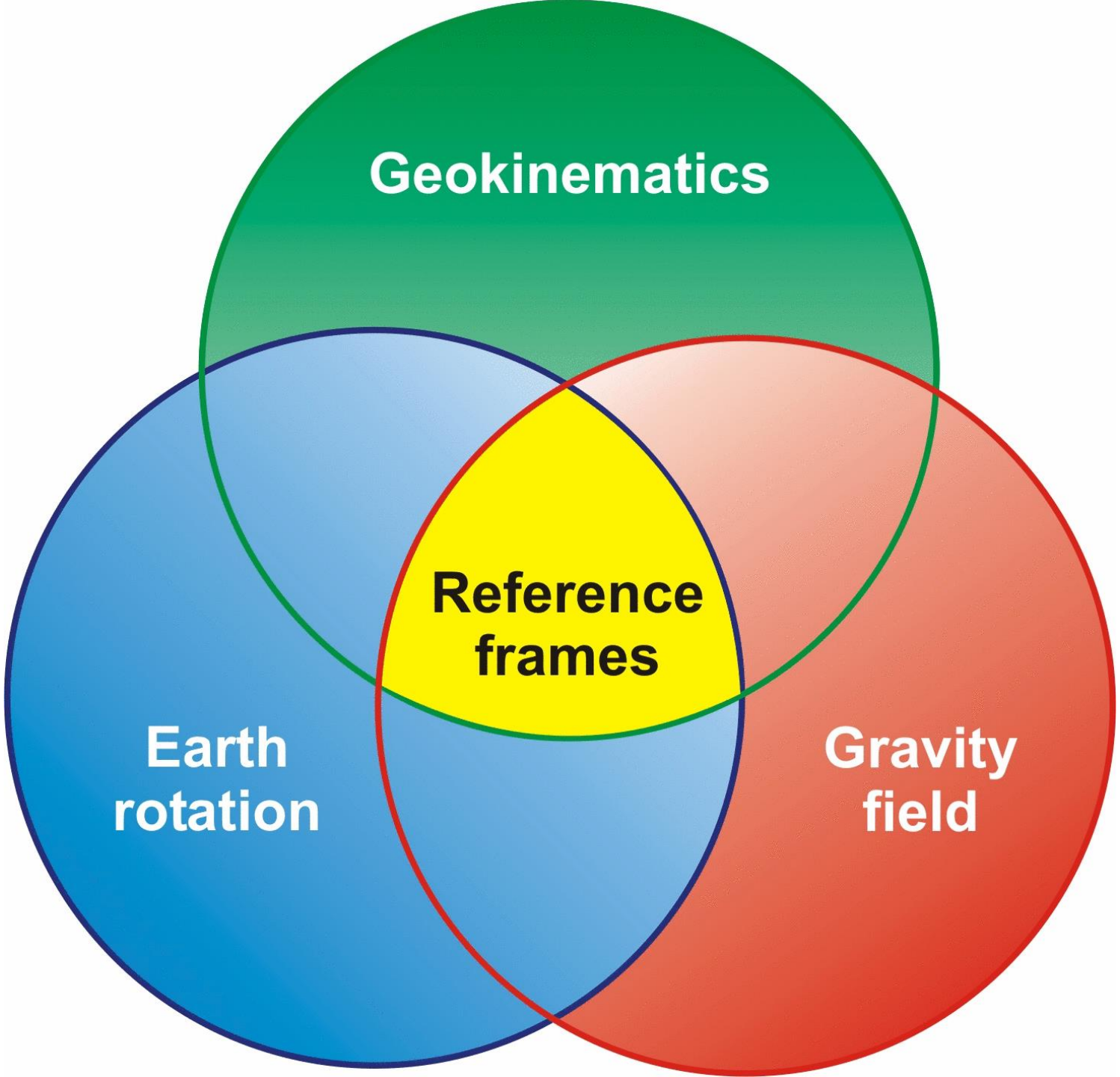
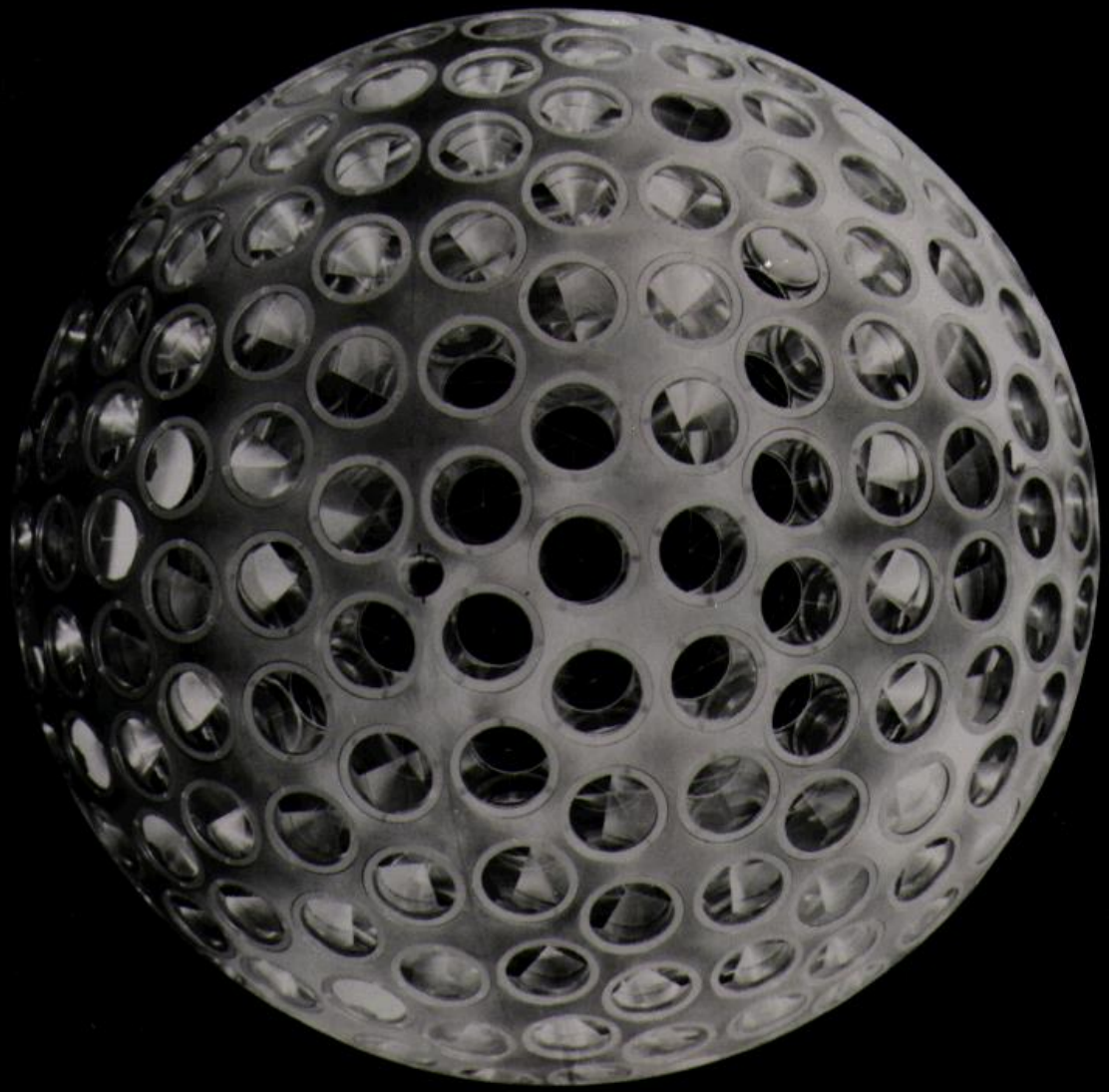
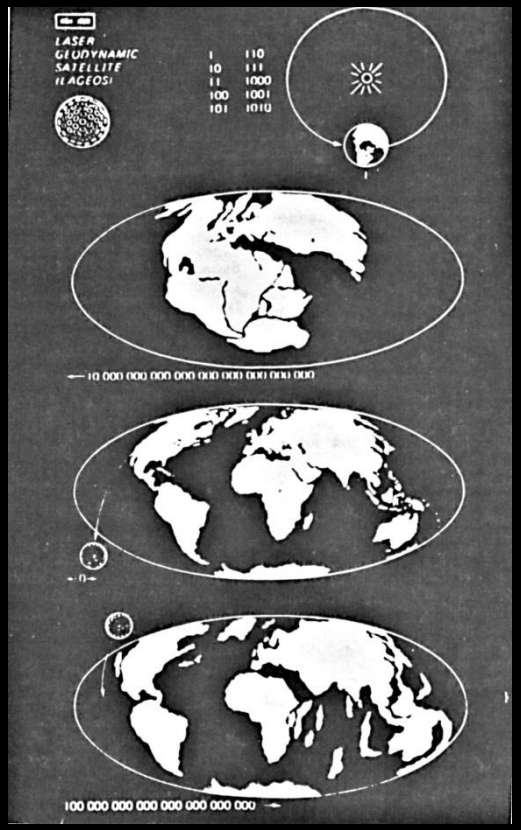
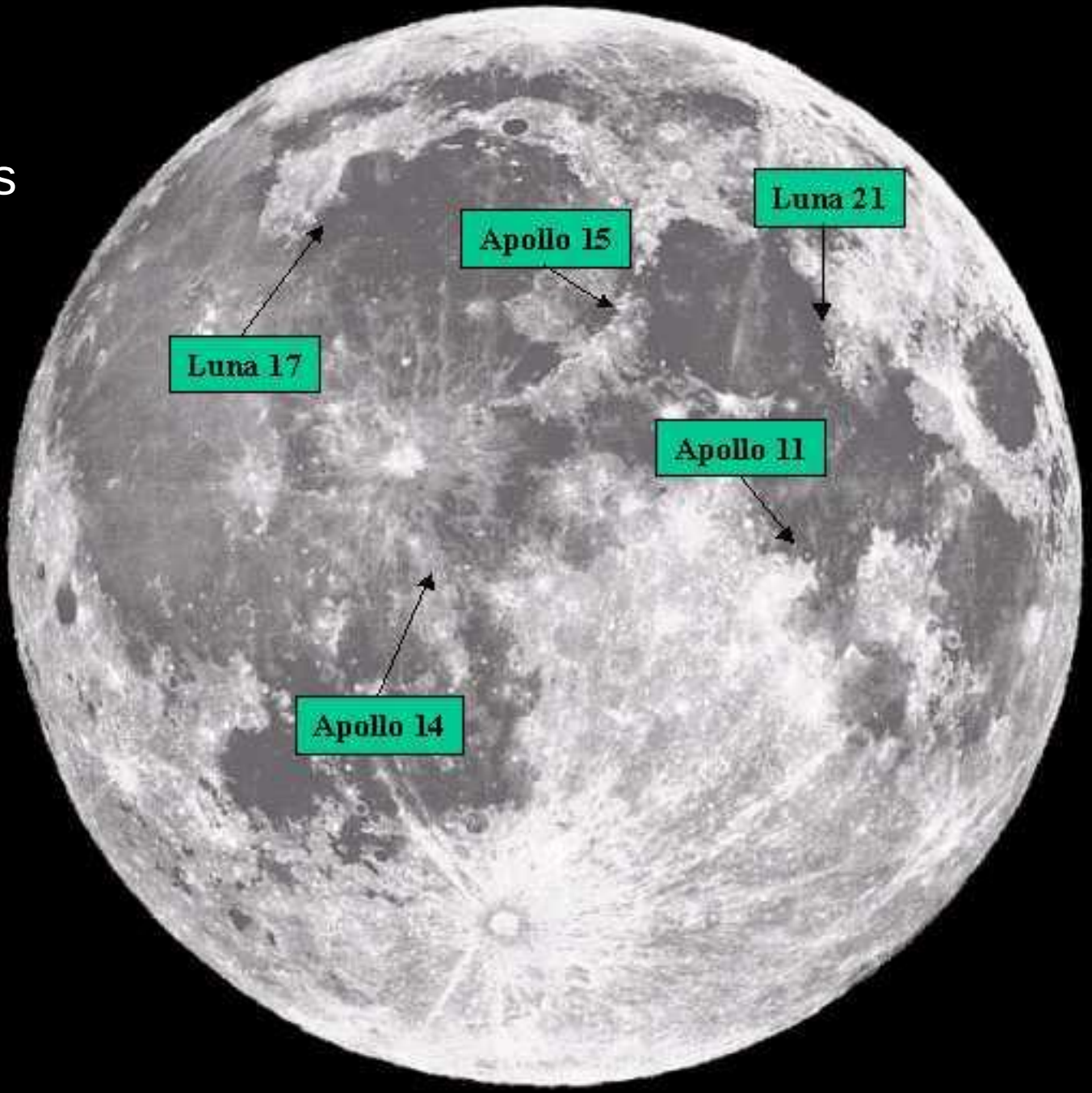

HYDROSPHERE
ATMOSPHERE
CRYOSPHERE
BIOSPHERE
GEOSPHERE
stratosphere
protective natural ozone layer
troposphere
condensation
vapour transport
precipitation
wind stress
water vapour and gas exchange
evaporation
thermohaline circulation
primary production
oxygen
anthropogenic emissions
greenhouse effect
carbon dioxide
methane
aerosols
air quality
clouds
solar radiation
incoming
reflected by surface
cold current
warm current
melting ice
glacier dynamics
precipitation
vapour transport
condensation
photosynthesis
transpiration
evaporation
erosion
runoff
desertification
land cover distribution and change
mantle convection
geodynamo
plume
subduction zone
volcanic gases and ash


Geokinematics
Reference frames
Earth rotation
Gravity field

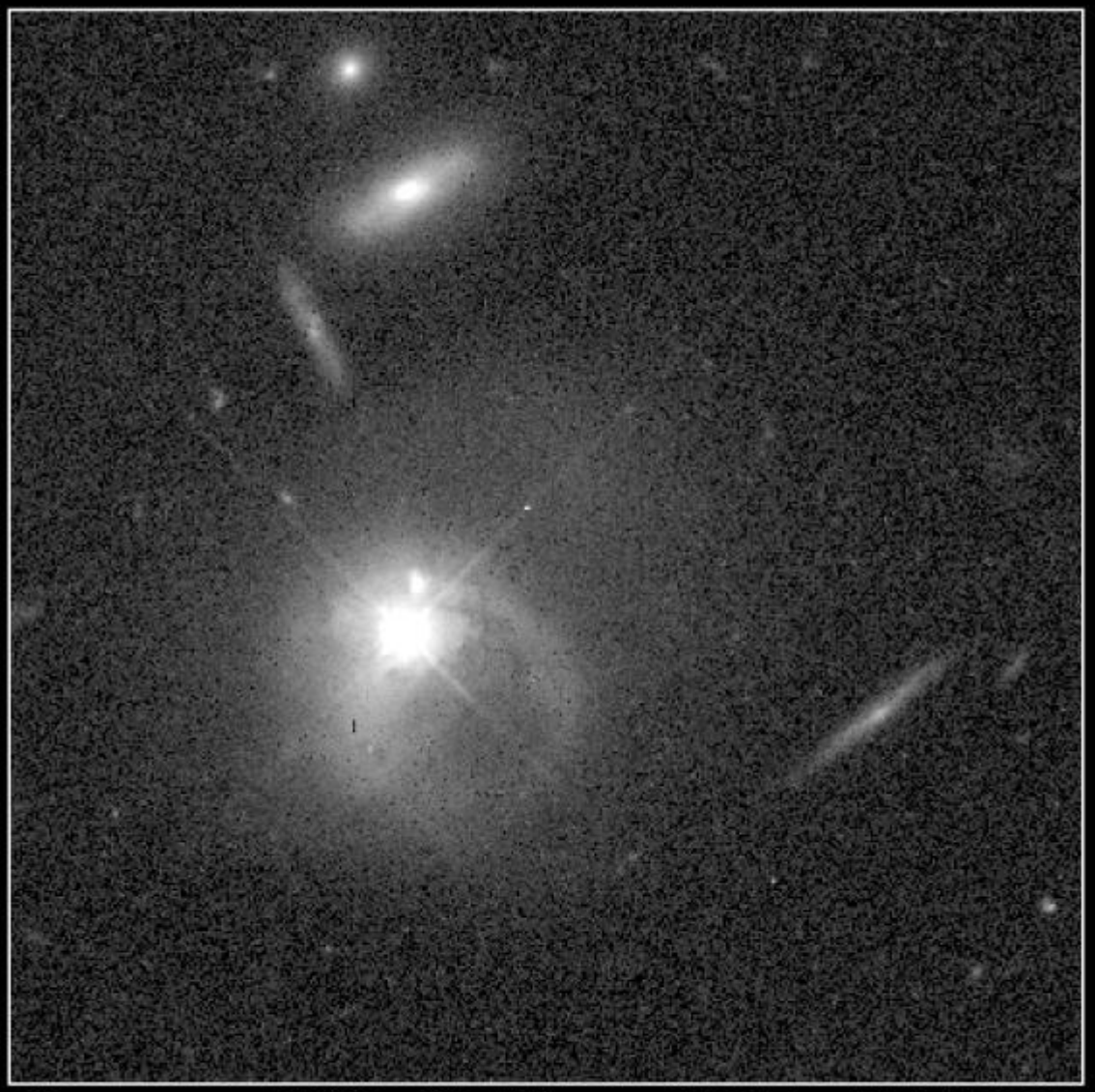



LASER
GEODYNAMIC
SATELLITE
II AGEOS)
1 110
10 111
11 1000
100 1001
101 1010
10 000 000 000 000 000 000 000 000 000 000
0
100 000 000 000 000 000 000 000 000 000

Laser Retroreflectors Arrays on the Moon

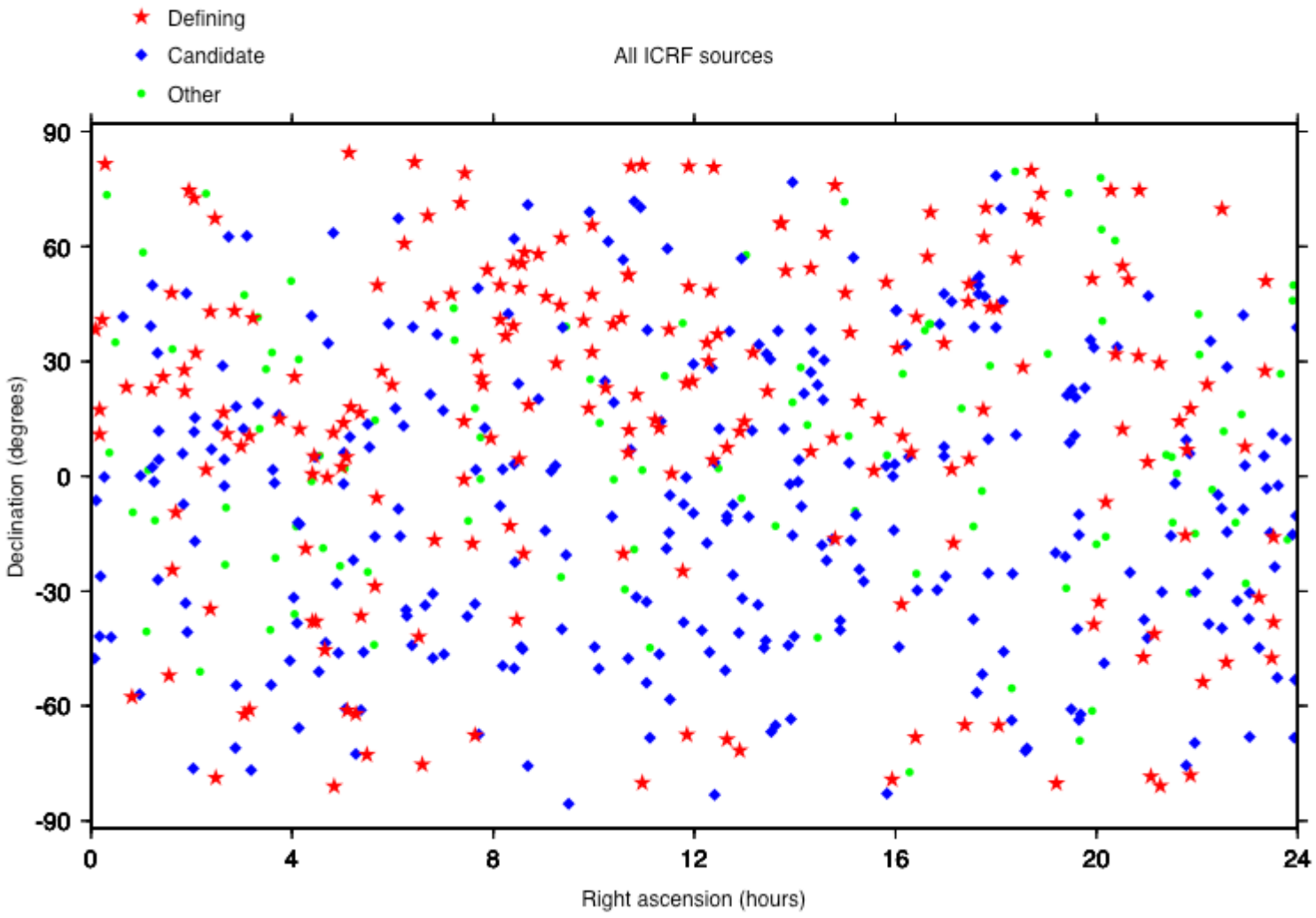


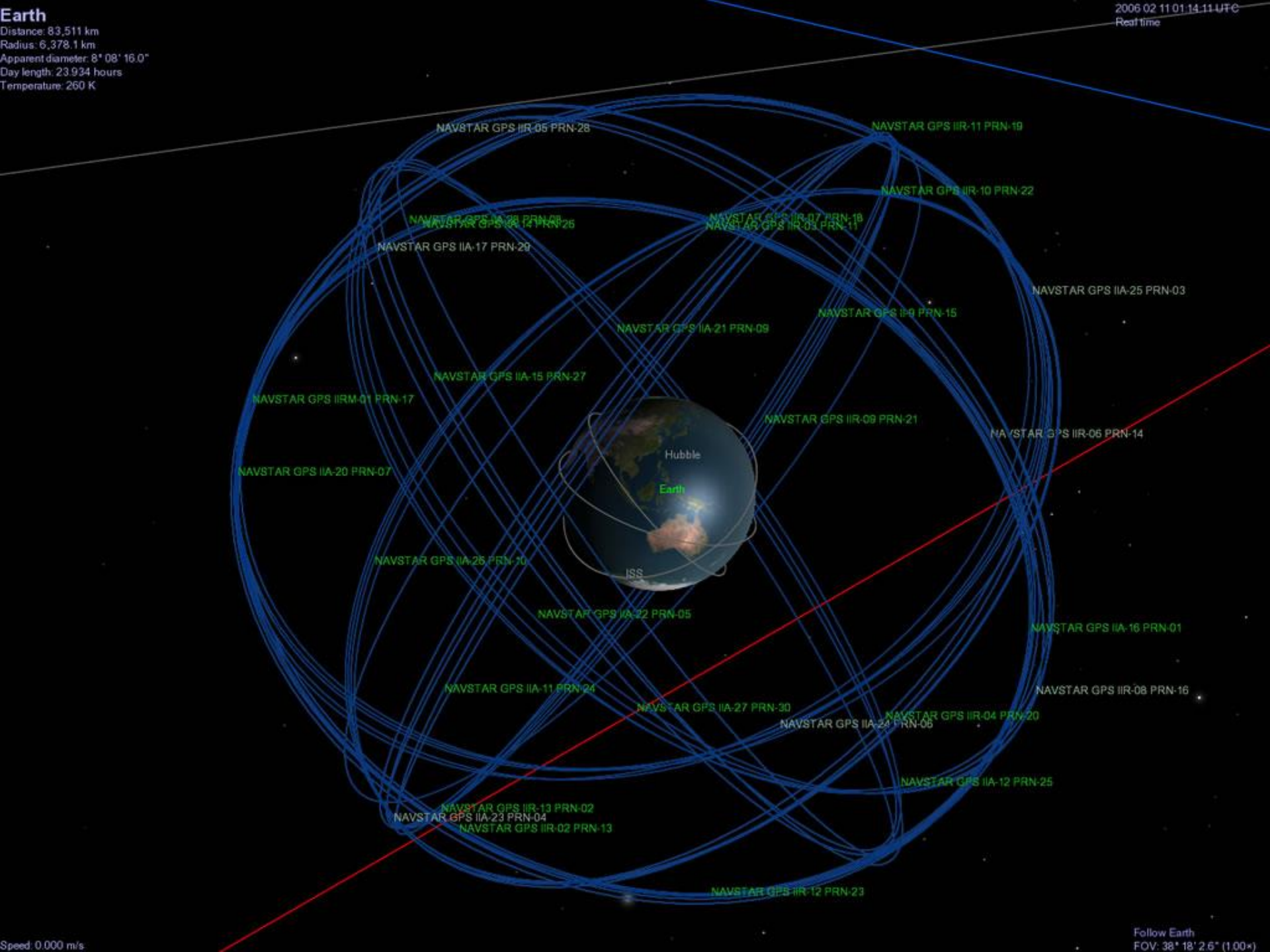
The ASI - Matera Laser Ranging Observatory is dedicated to Rocco Petrone (1926 – 2006)



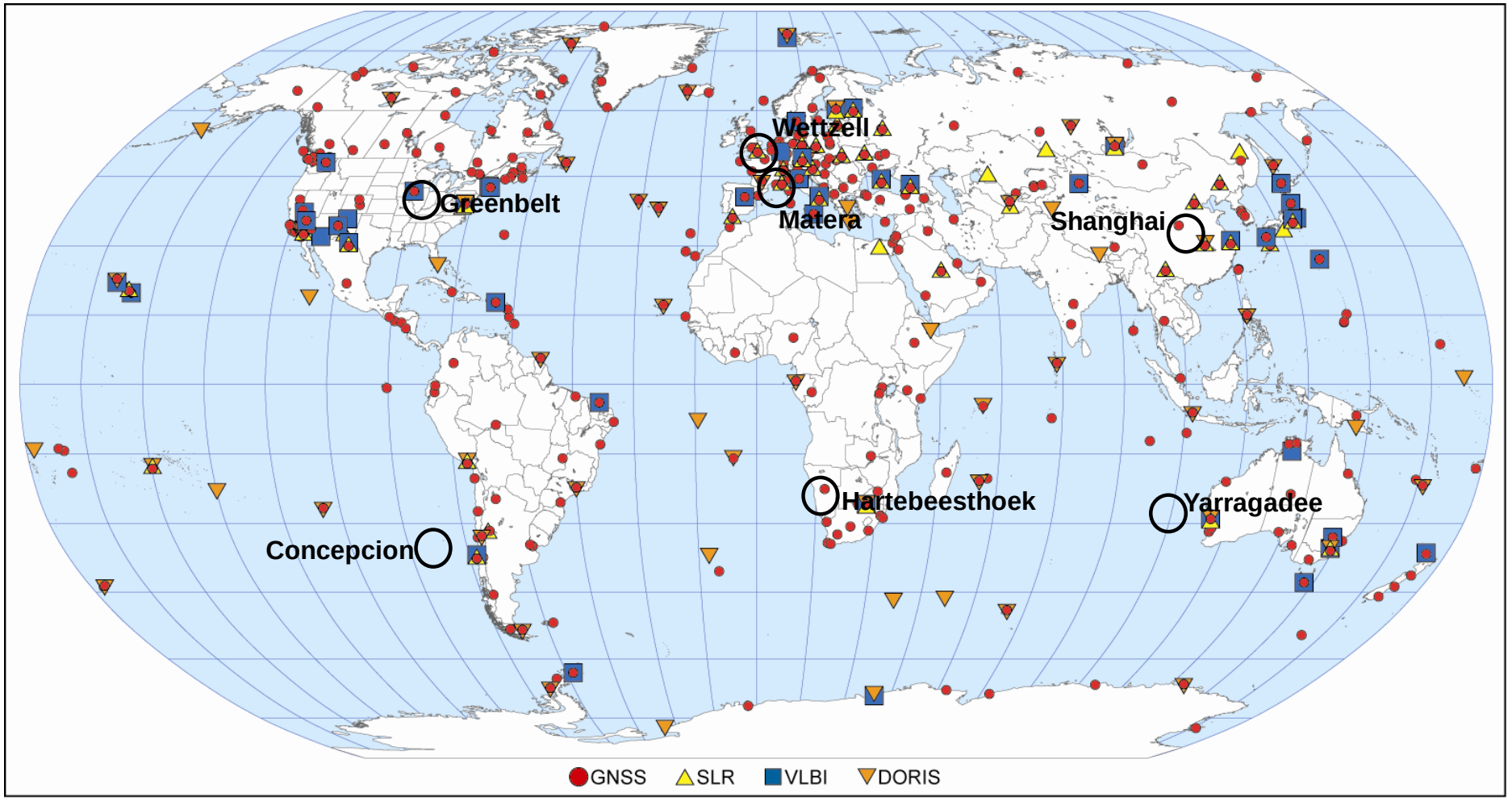
Quasar PKS 2349 HST • WFPC2

ST ScI OPO • January 1995 • J. Bahcall (Princeton), NASA


Defining
Candidate
Other
All ICRF sources
90
60
30
0
-30
-60
-90
Declination (degrees)
0
4
8
12
16
20
24
Right ascension (hours)

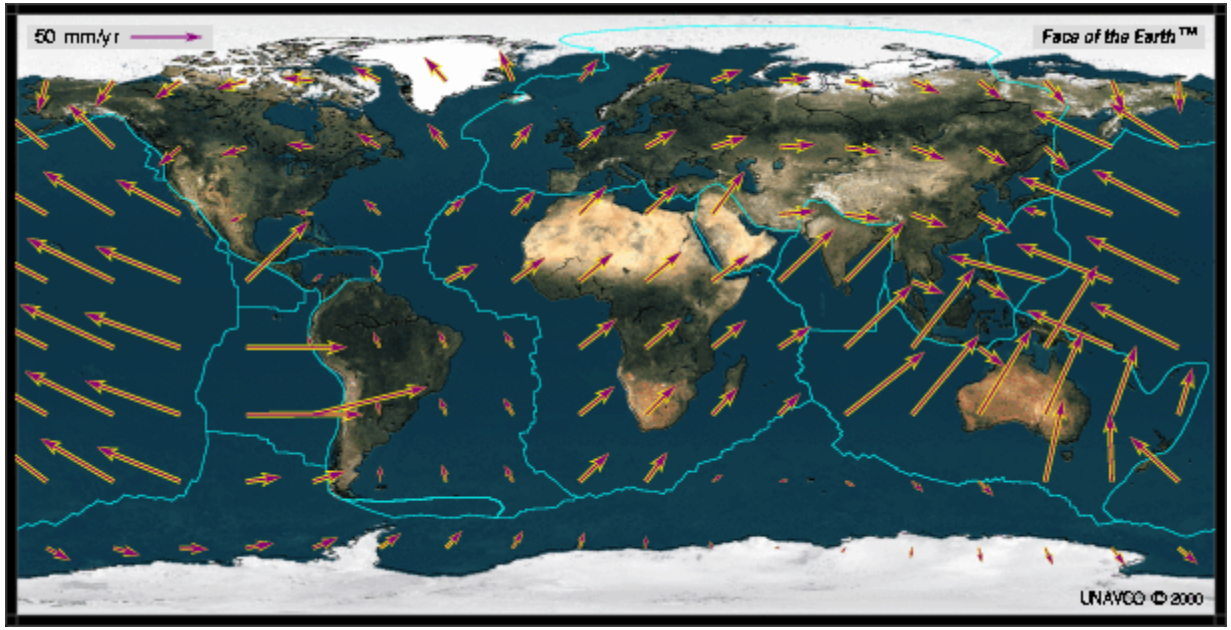

Earth
Distance: 83,511 km
Radius: 6,378.1 km
Apparent diameter: 8° 08' 16.0"
Day length: 23.934 hours
Temperature: 260 K
2006 02 11 01:14:11 UTC
Real time
NAVSTAR GPS IIR-05 PRN-28
NAVSTAR GPS IIR-11 PRN-19
NAVSTAR GPS IIR-10 PRN-22
NAVSTAR GPS IIA-17 PRN-29
NAVSTAR GPS IIA-25 PRN-03
NAVSTAR GPS IIA-21 PRN-09
NAVSTAR GPS IIA-15 PRN-27
NAVSTAR GPS IIRM-01 PRN-17
NAVSTAR GPS IIR-09 PRN-21
NAVSTAR GPS IIR-06 PRN-14
NAVSTAR GPS IIA-20 PRN-07
Hubble
Earth
ISS
NAVSTAR GPS IIA-22 PRN-05
NAVSTAR GPS IIA-16 PRN-01
NAVSTAR GPS IIA-11 PRN-24
NAVSTAR GPS IIR-08 PRN-16
NAVSTAR GPS IIA-27 PRN-30
NAVSTAR GPS IIR-04 PRN-20
NAVSTAR GPS IIA-12 PRN-25
NAVSTAR GPS IIR-13 PRN-02
NAVSTAR GPS IIA-23 PRN-04
NAVSTAR GPS IIR-02 PRN-13
NAVSTAR GPS IIR-12 PRN-23
Speed: 0.000 m/s
Follow Earth
FOV: 38° 18' 2.6" (1.00×)

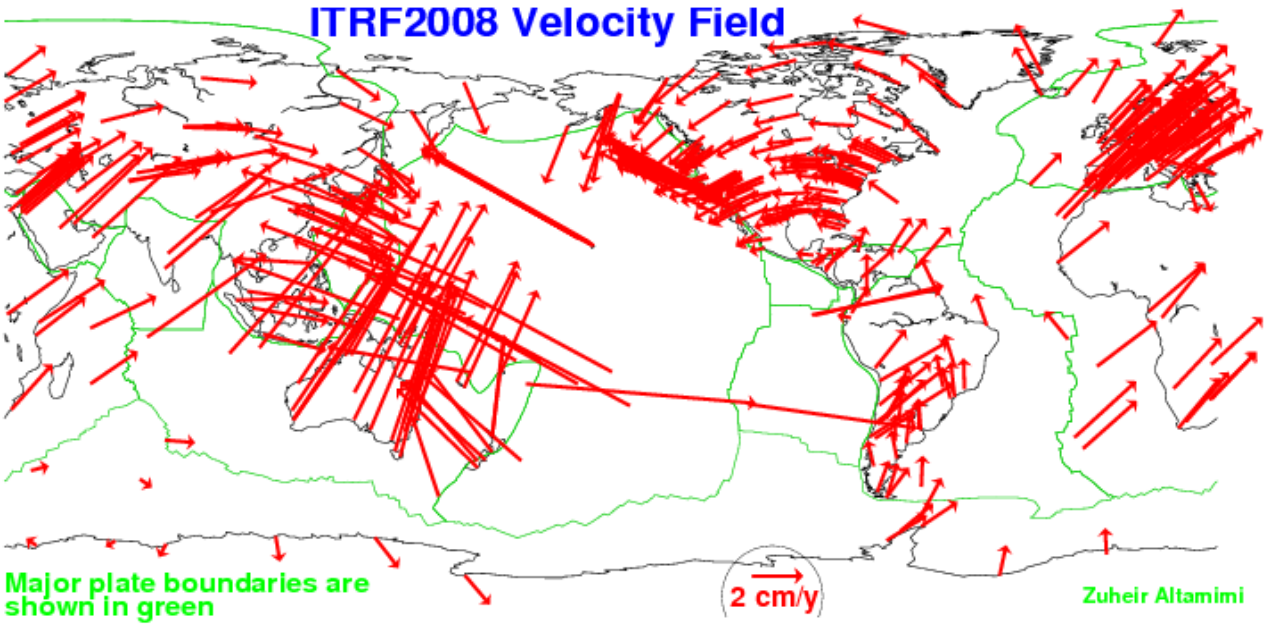
Current Networks of GNSS, SLR, VLBI, and DORIS Sites



○ Core sites

ASI/CGS aerial view (from GoogleEarth)


50 mm/yr
Face of the Earth™
UNAVCO © 2000


ITRF2008 Velocity Field
Major plate boundaries are shown in green
2 cm/y
Zuheir Altamimi

ILRSA 1993-2012 weekly geocenter vs ITRF2008 origin

Z (mm)

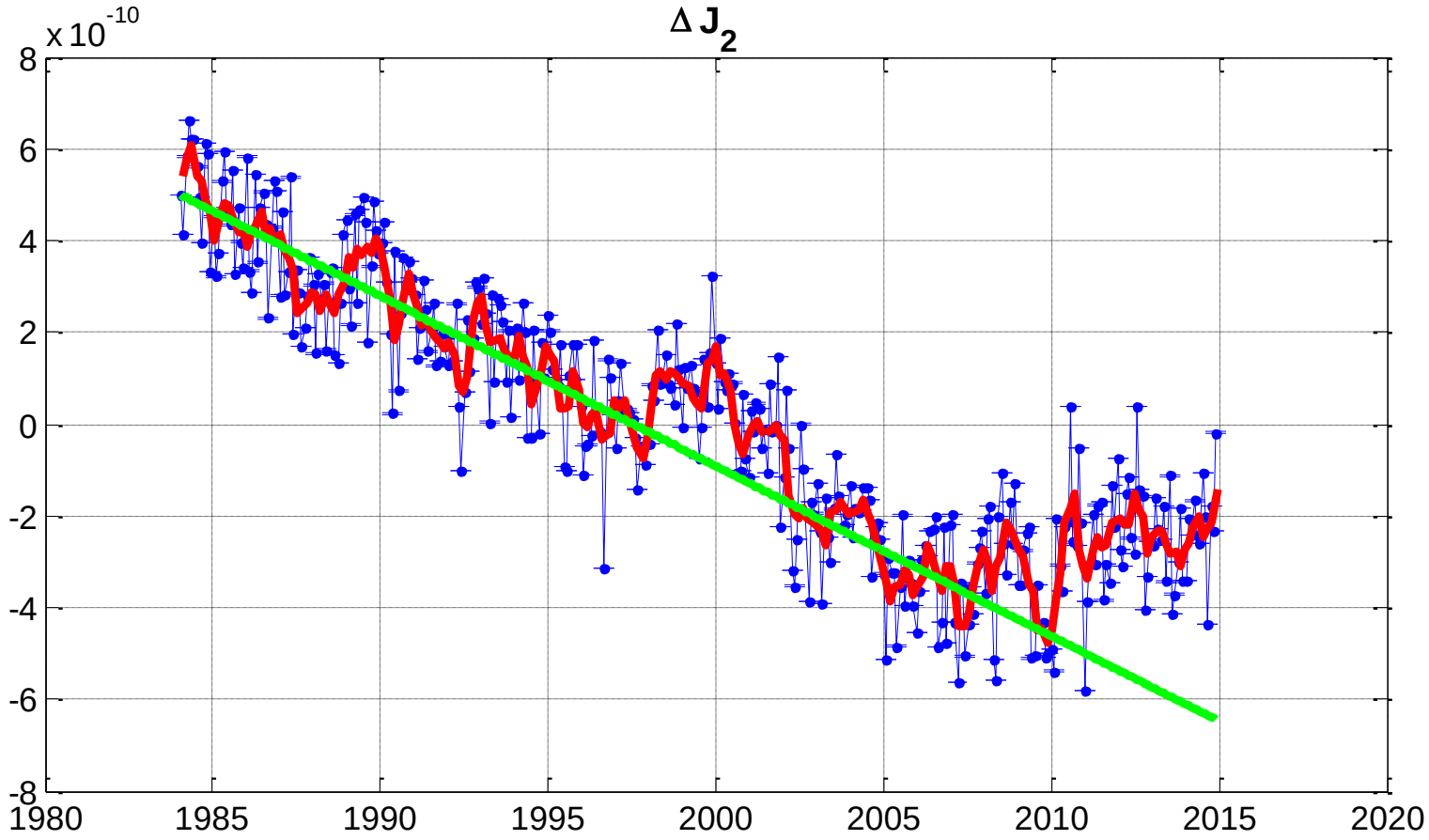
15
10
5
0
-5
-10
-15

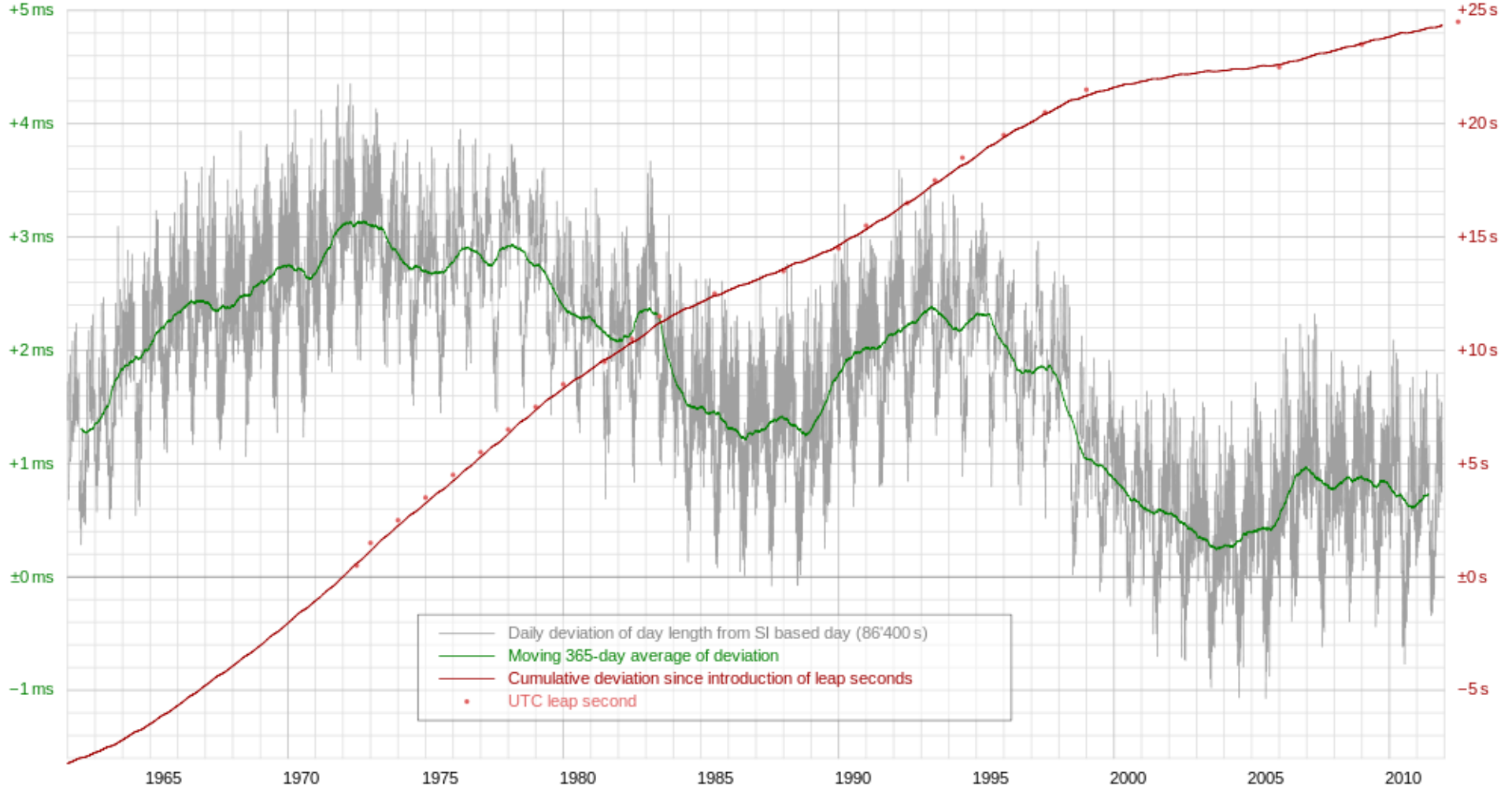
Y (mm)

15
10
5
0
-5
-10
-15

X (mm)

-15
-10
-5
0
5
10
15


Δ J2
x 10-10
8
6
4
2
0
-2
-4
-6
-8
1980
1985
1990
1995
2000
2005
2010
2015
2020

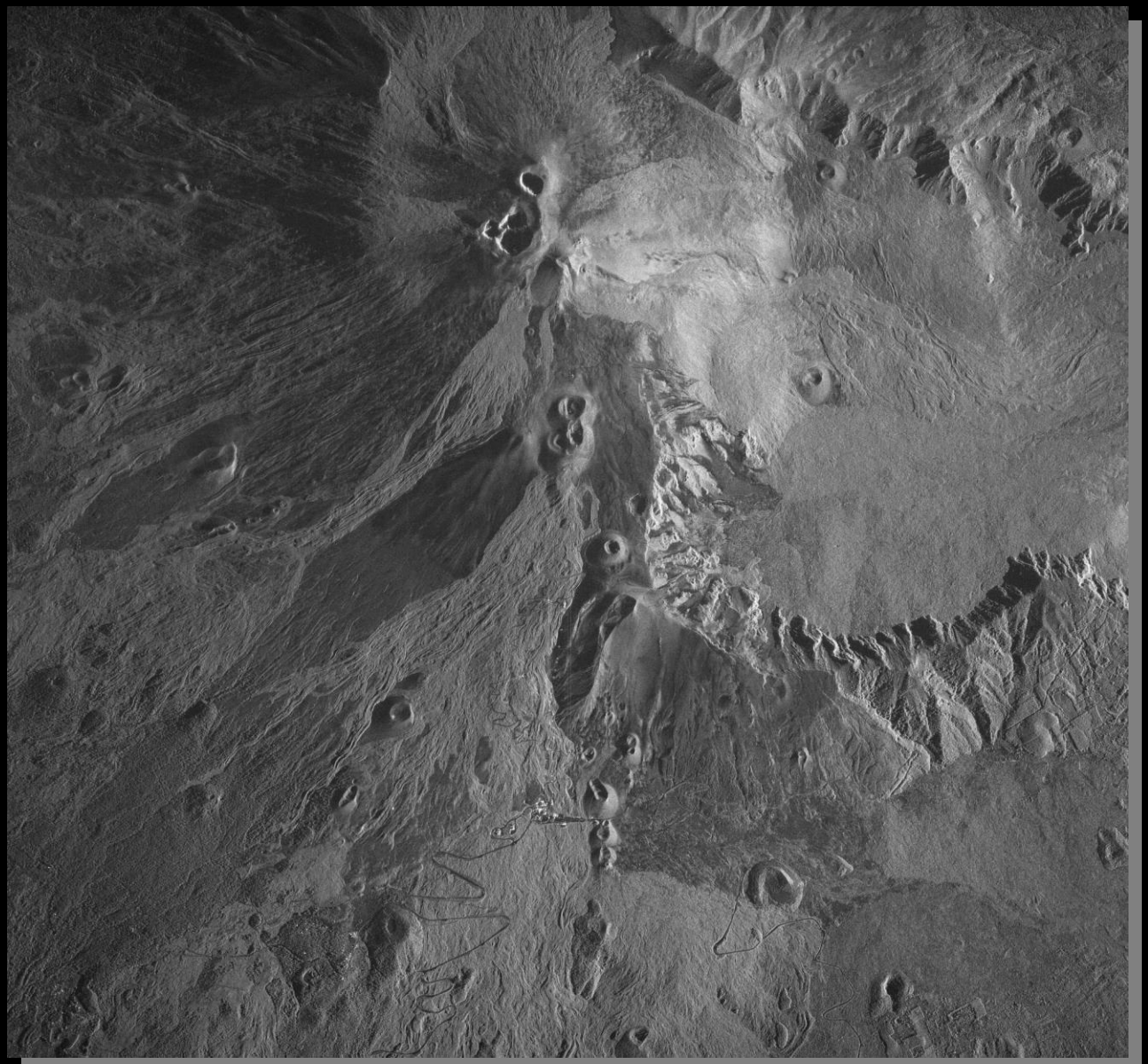

+5 ms
+4 ms
+3 ms
+2 ms
+1 ms
±0 ms
−1 ms
+25 s
+20 s
+15 s
+10 s
+5 s
±0 s
−5 s
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Daily deviation of day length from SI based day (86'400 s)
Moving 365-day average of deviation
Cumulative deviation since introduction of leap seconds
UTC leap second

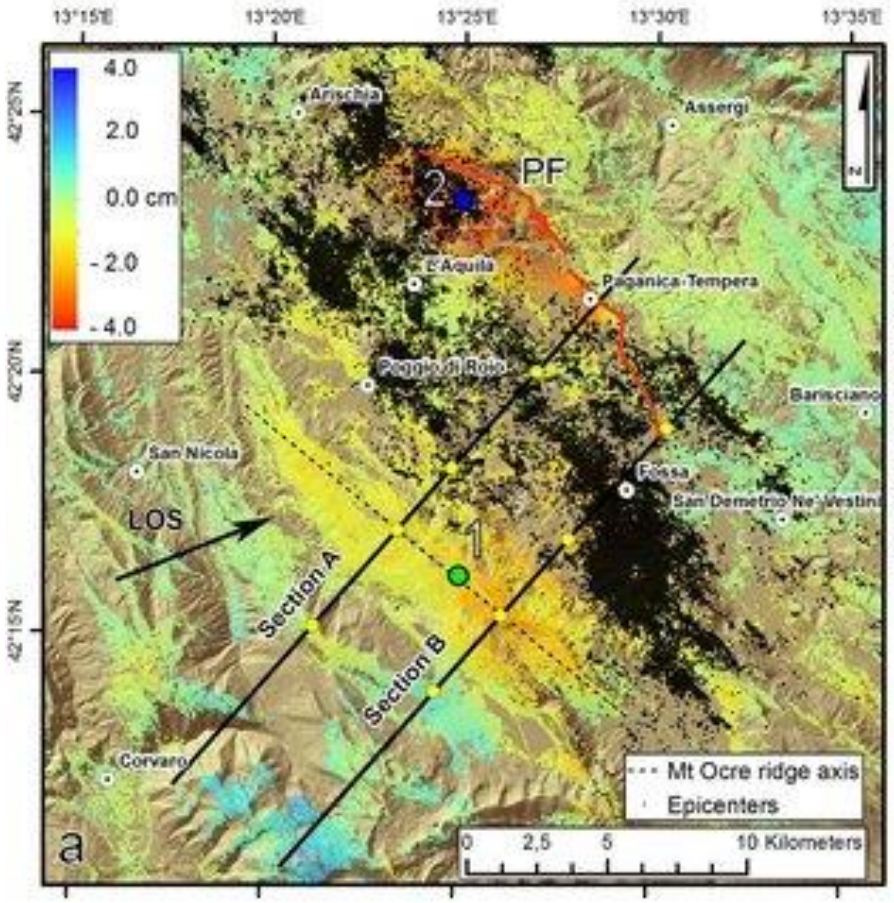
COSMO-SkyMed

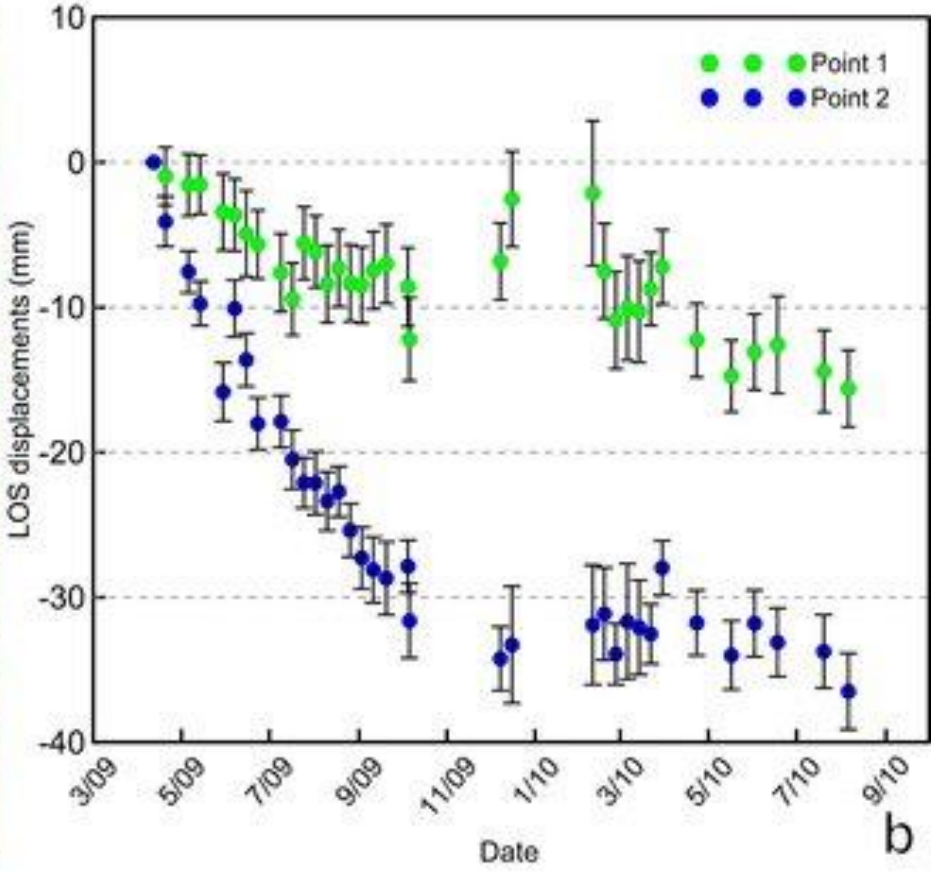
- 4 satellite, dual use constellation
- Italian Civilian User Ground Segment (I-CUGS) @ASI/CGS, Matera
- CSK-II generation to be lauched in 2019 and 2020

Tidal creek in Africa

Mt. Etna



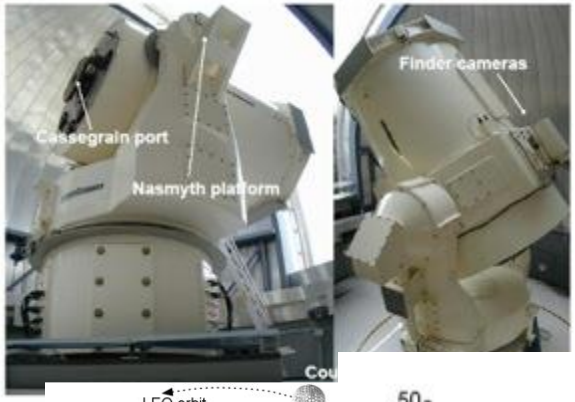

13°15'E
13°20'E
13°25'E
13°30'E
13°35'E
42°25'N
42°20'N
42°15'N
4.0
2.0
0.0 cm
- 2.0
- 4.0
Arischia
Assergi
PF
2
L'Aquila
Paganica-Tempera
Poggio di Roio
Barisciano
San Nicola
Fossa
San Demetrio Ne' Vestini
LOS
1
Section A
Section B
Corvaro
Mt Ocre ridge axis
Epicenters
0 2,5 5 10 Kilometers
N
a

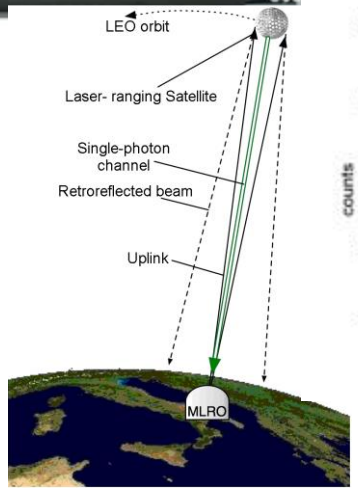

10
0
-10
-20
-30
-40
LOS displacements (mm)
Point 1
Point 2
3/09
5/09
7/09
9/09
11/09
1/10
3/10
5/10
7/10
9/10
Date
b

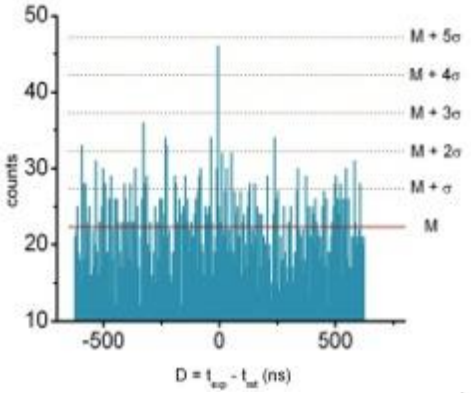
Italian Space Quantum Communications

Exchanging quantum states, or quantum communications, allows for the realization of Quantum Information protocols as Quantum Teleportation and Q Key Distributions.

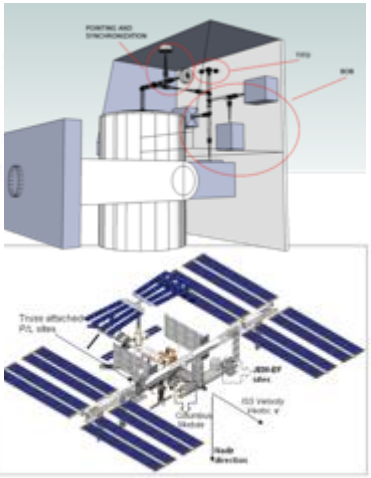
QuantumFuture Research Group of University of Padova, operated since **2003** at ASI **Matera Laser Ranging Observatory,** using its **1.5 m telescope with millimeter resolution in Satellite Laser Ranging.**

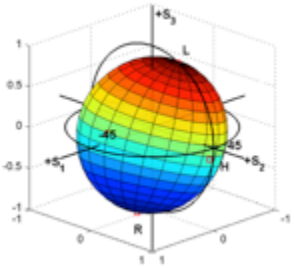


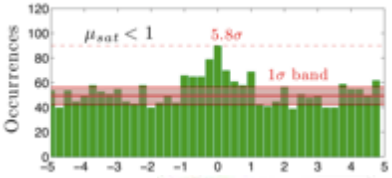




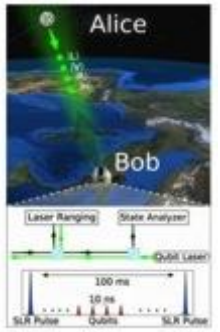
P. Villoresi et al. New J. Phys. 10 033038 (2008)







G. Vallone et al. Phys. Rev. Lett. vol 115 040502 (2015)



2003 – UniPD SpaceQ project

Optical front-end for single photon transceiver @ MLRO

2008 – first single-photon return from Ajisai

2009 Feasibility study Q payload for the ISS

2009-2011 Characterization of MLRO Mueller Matrix

2012 - Analysis of response for different satellites CCR

2013 state preparation and analysis, satellite synch

2014 – Q-Comm on satellites demonstrated

2015 Temporal modes demonstrated in satellite qubit

2016 – New limit in single photon exchange from MEO sat

2017-Testing wave-particle duality in Space

2018 20000km feasibility QComms

2019 sub-ns resolution - daylight free-space QKD

D. Dequal et al. Phys Rev. A Rapid Comm **93** 010301(2016)
F. Vedovato et al. - Science Adv. **3** e1701180 (2017)

Metrology: the Italian Link for Frequency & Time (LIFT)

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

Turin

Florence

LENS European Laboratory for Non-Linear Spectroscopy

INO-CNR ISTITUTO NAZIONALE DI OTTICA

- ✓ Total Fiber Haul 3000 km
- ✓ Two Commercial Dark Fibers available /DWDM and CWDM channels/bidirectional Erbium Doped Fiber Amplifier
- ✓ Fiber provided by Consortium GARR and Consortium TOP-IX

Bologna

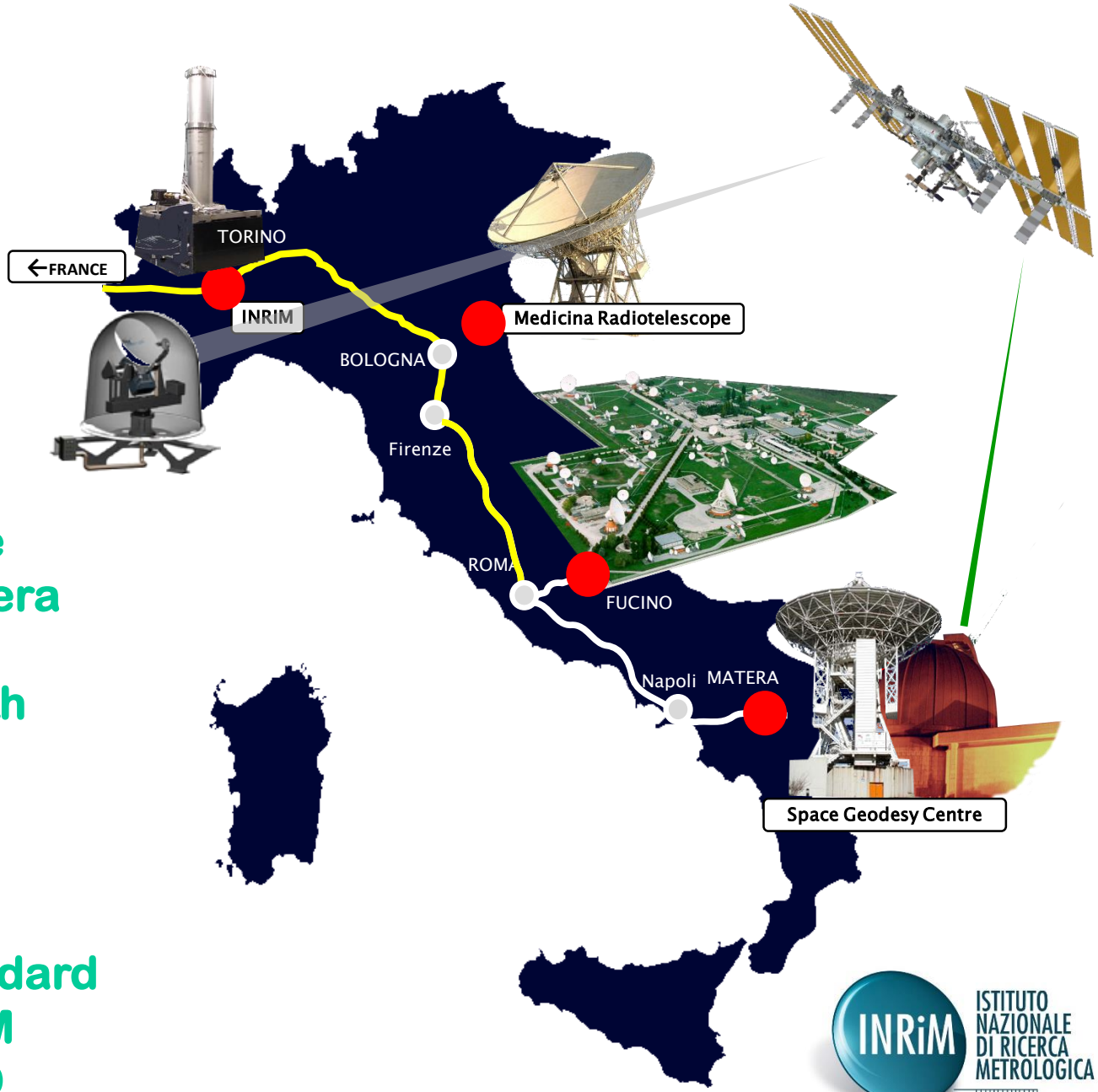
32-m dish for Very Long Baseline Interferometry (VLBI) Part of the European VLBI Network

INAF ISTITUTO NAZIONALE DI ASTROFISICA NATIONAL INSTITUTE FOR ASTROPHYSICS

Matera

asi agenzia spaziale italiana

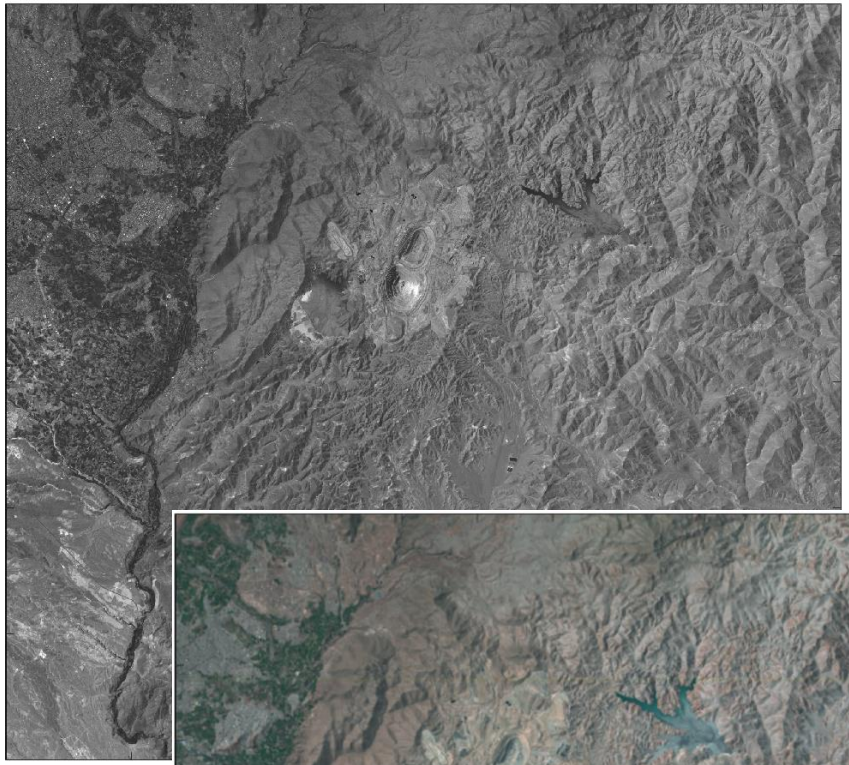
agenzia spaziale italiana



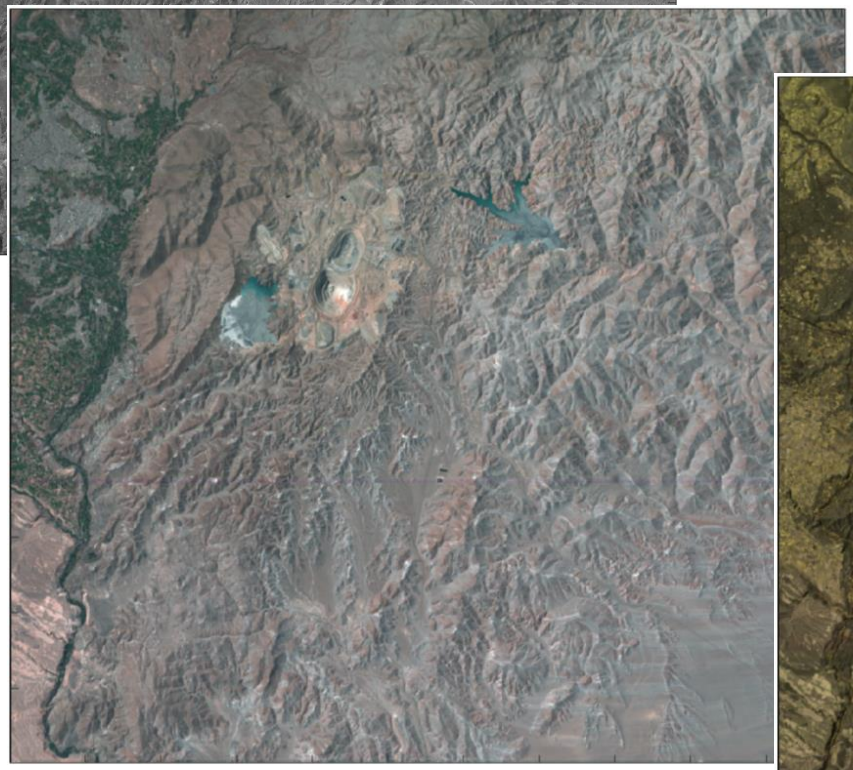
- **H-Maser Absolute calibration in Matera**
- **Geodesy VLBI with common clock Medicina/Matera**
- **Italian Primary Metrological Standard provided by INRIM available at MLRO**

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

SST (Space Surveillance and Tracking)



PAN



VNIR

SWIR

ASI/INFN Joint Lab

- ASI/CGS Matera and INFN/LNF Frascati
  - Characterization of Corner Cubes Retroreflectors
  - LARES2 calibration
  - Development of CCR arrays for interplanetary exploration
  - Development of CCR’s for Lunar Laser Ranging

Legacy and new directions

- Space Geodesy (GGOS core station)
- Remote Sensing (SAR, hyperspectral) operations and applications development
- Free Space Quantum telecom
- Active and passive Space Debris tracking
- Time and frequency metrology
- Outreach