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INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE

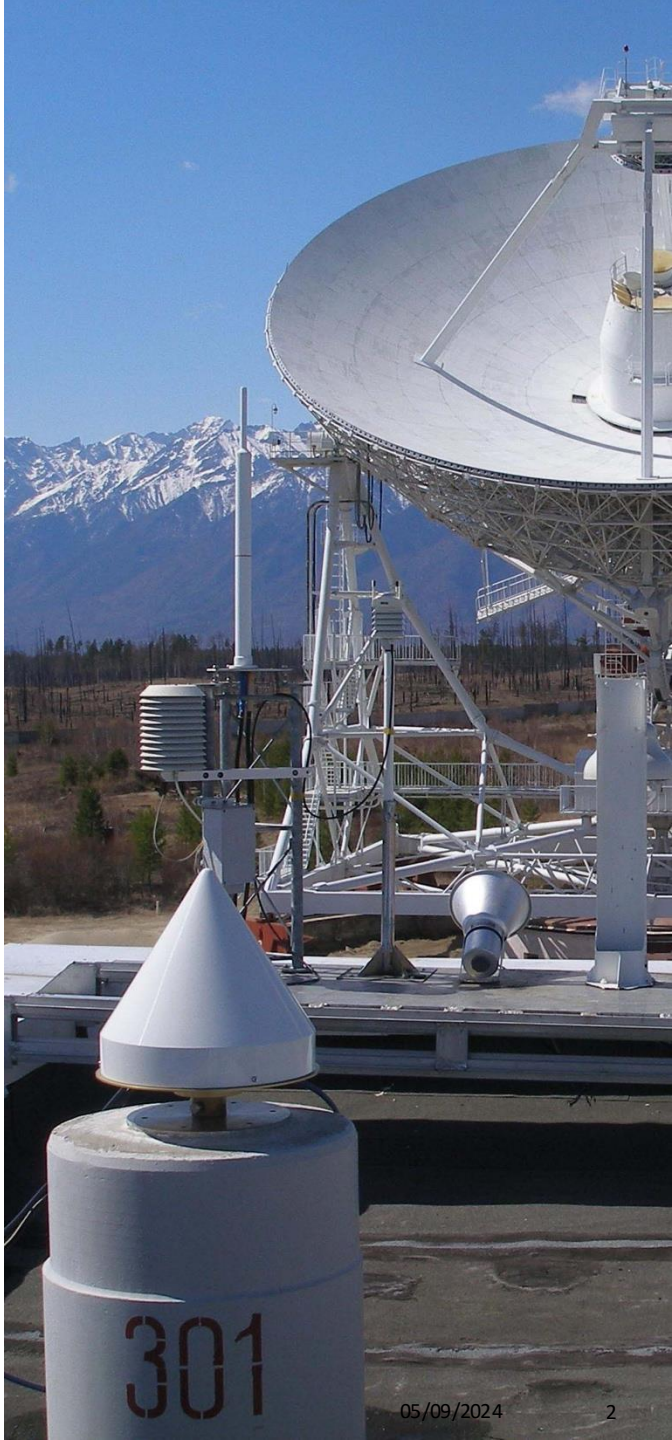
CHANGER D'ÉCHELLE

DORIS STATIONS CO-LOCATION

IDS WORKSHOP 2024, MONTPELLIER

J. SAUNIER (IGN), G. MOREAUX (CLS), V. GARCIA (CNES), D. PESCE (IGN)

OUTLINE



“WE SPEAK OF CO-LOCATION WHEN TWO OR MORE INSTRUMENTS FORMING PART OF THE GLOBAL OBSERVING SYSTEM’S CORE NETWORKS OPERATE ON THE SAME SITE .”

Requirements:

- **Stations part of IDS, IGS, ILRS, IVS, GLOSS, PSMSL networks**
- **Same geodetic site identifier (DOMES number)**
- **Spacing allowing high precision local tie surveys (< 1000 m)**

1. BENEFITS AND OBJECTIVES

CO-LOCATING DORIS HAS BEEN AN ONGOING OBJECTIVE THROUGHOUT THE NETWORK'S DEVELOPMENT

THE BENEFITS OF CO-LOCATION ARE MANIFOLD:

1. Knowledge of a site's physical properties
2. Contribution to the ITRF combination
3. Contribution to sea level monitoring
4. Local studies based on comparison of observations
5. Improving system performance

1.1 SITE PHYSICAL PROPERTIES AND GEODETIC INFORMATION

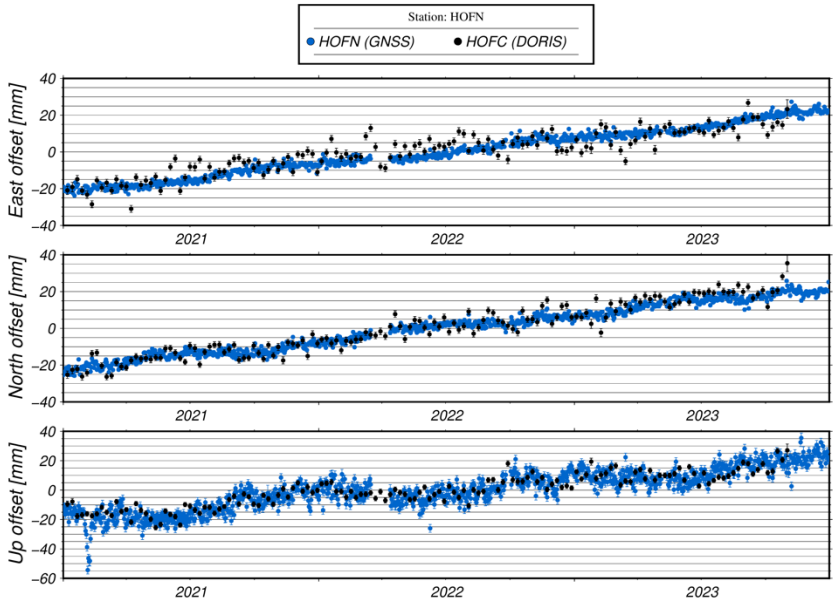
SITE STABILITY PRIOR TO INSTALLATION

Seeking to co-locate DORIS with other techniques provides geophysical and geodetic information prior to installation.

- Basement stability
- Plate velocities
- Site history and reliability

EXAMPLE: CHOOSING A NEW SITE IN ICELAND IN 2019

Locate DORIS outside the deformation zones where seismic events are thick



1.2 CONTRIBUTION TO ITRF

DORIS = 4TH SPACE GEODETIC TECHNIQUE CONTRIBUTING TO ITRF

Co-location with other geodetic techniques is essential for the ITRF combination to allow connecting the independent reference frames through tie vectors.

DORIS advantages for ITRF:

- Homogenous geographical distribution
- Long term and stability of the stations
- Numerous co-located stations (84%)

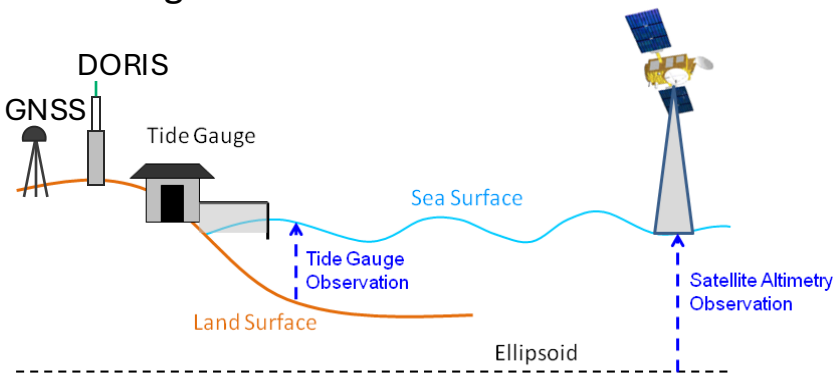
IDS CONTRIBUTION TO ITRF2020

- 1456 weekly combined solutions (4 AC)
- Up to 14 DORIS missions
- 28 years of data (1993.0-2021.0)
- 201 stations @ 88 sites
- Half of the DORIS sites have weekly position estimations for 15 years
- 26 site surveys between 2013 and 2020
- Positioning and EOPs: slightly better performances compared to ITRF2014
- Origin: similar performances
- Scale: differences due to new Alcatel PCV

1.3 CONTRIBUTION TO SEA LEVEL MONITORING

CONTRIBUTING TO OCEAN MONITORING IS A KEY OBJECTIVE FOR DORIS

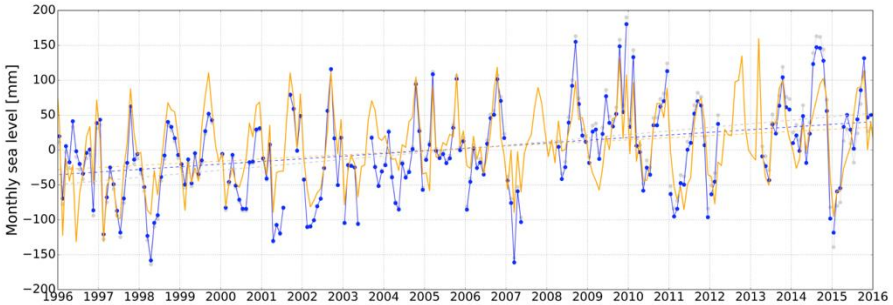
With many stations located on islands or in coastal areas for altimetry missions needs, the co-location with tide gauges contributes to the estimation of vertical land motion and monitoring of sea level.



DORIS/GNSS CORRECTED SEA LEVEL RECORDS FROM TIDE GAUGES

Example: Ponta Delgada

- Absolute sea-level trend:
- From DORIS corrected: 3.80 +/- 0.87 mm/yr
- From Altimetry: 3.04 +/- 0.51 mm/yr



1.4 OBSERVATIONS COMPARISON

CROSS-VALIDATION

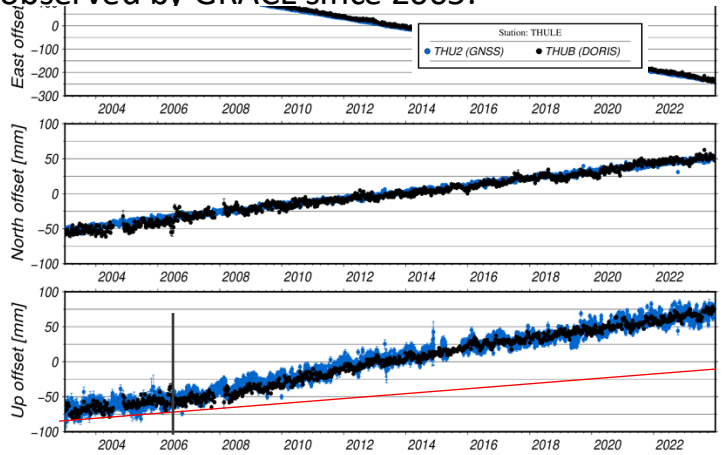
Co-location allows to confirm local events observed by data from several instruments:

- Land movement
- Crustal motion seasonal variations
- Building stability
- Time series discontinuity
- Enhanced understanding of geophysical phenomena
- Meteorology
- …

+ higher accuracy in data collection

ELASTIC REBOUND AT THULE (GREENLAND)

Comparison and agreement between time-series of the vertical component at DORIS and GNSS co-located stations enabled to confirm the vertical uplift at Thule and helped to the understanding of the mass loss observed by GRACE since 2005.



1.5 IMPROVING DORIS SYSTEM PERFORMANCE

BETTER UNDERSTANDING OF OSCILLATORS BEHAVIOR

Following its Retreat in 2018, IDS recommended to:

1. Connect DORIS beacons to atomic clocks where possible
2. Connect DORIS to GNSS on ground and on board

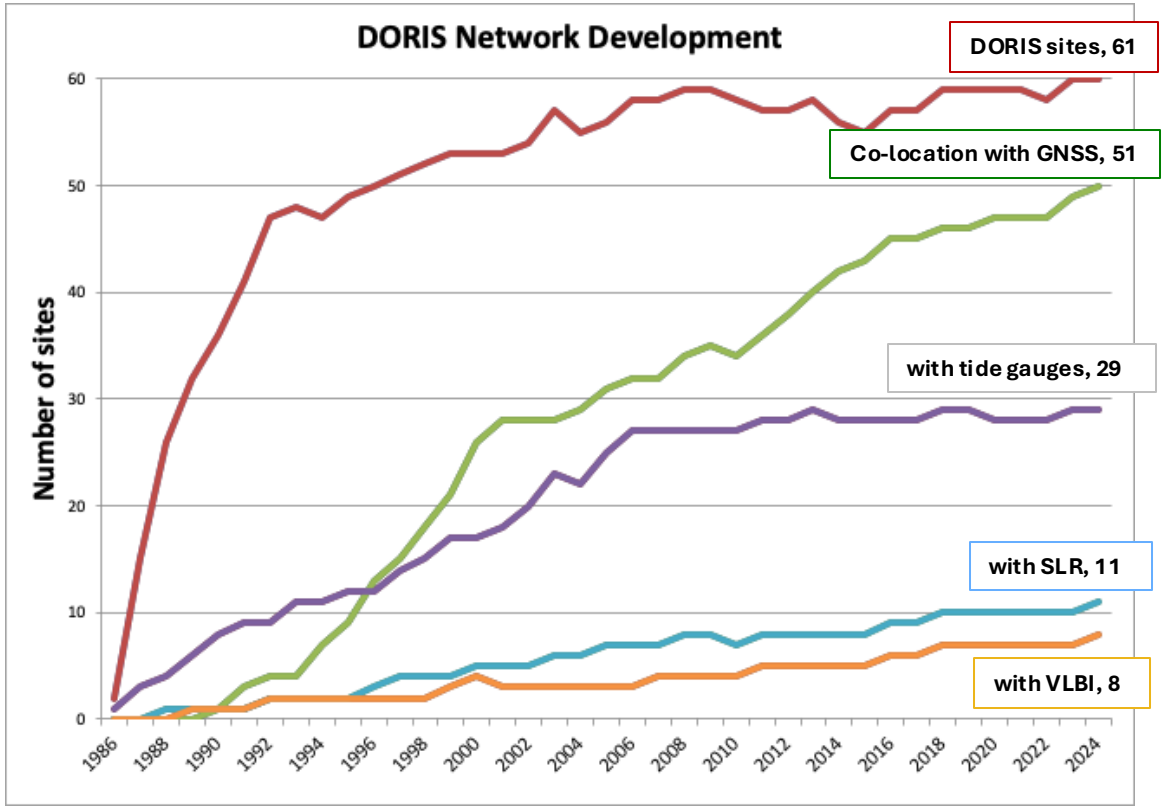
WORK IN PROGRESS

DORIS network has several stations located in geodetic observatories equipped with atomic clocks (14 sites) and many stations co-located with GNSS (51).

1. The connection with atomic clocks has been handled by the CNES network maintenance team since 2019
2. The coupling with GNSS will be carried out from this year onwards, when stations are installed or renovated.

2. STATUS AND RESULTS

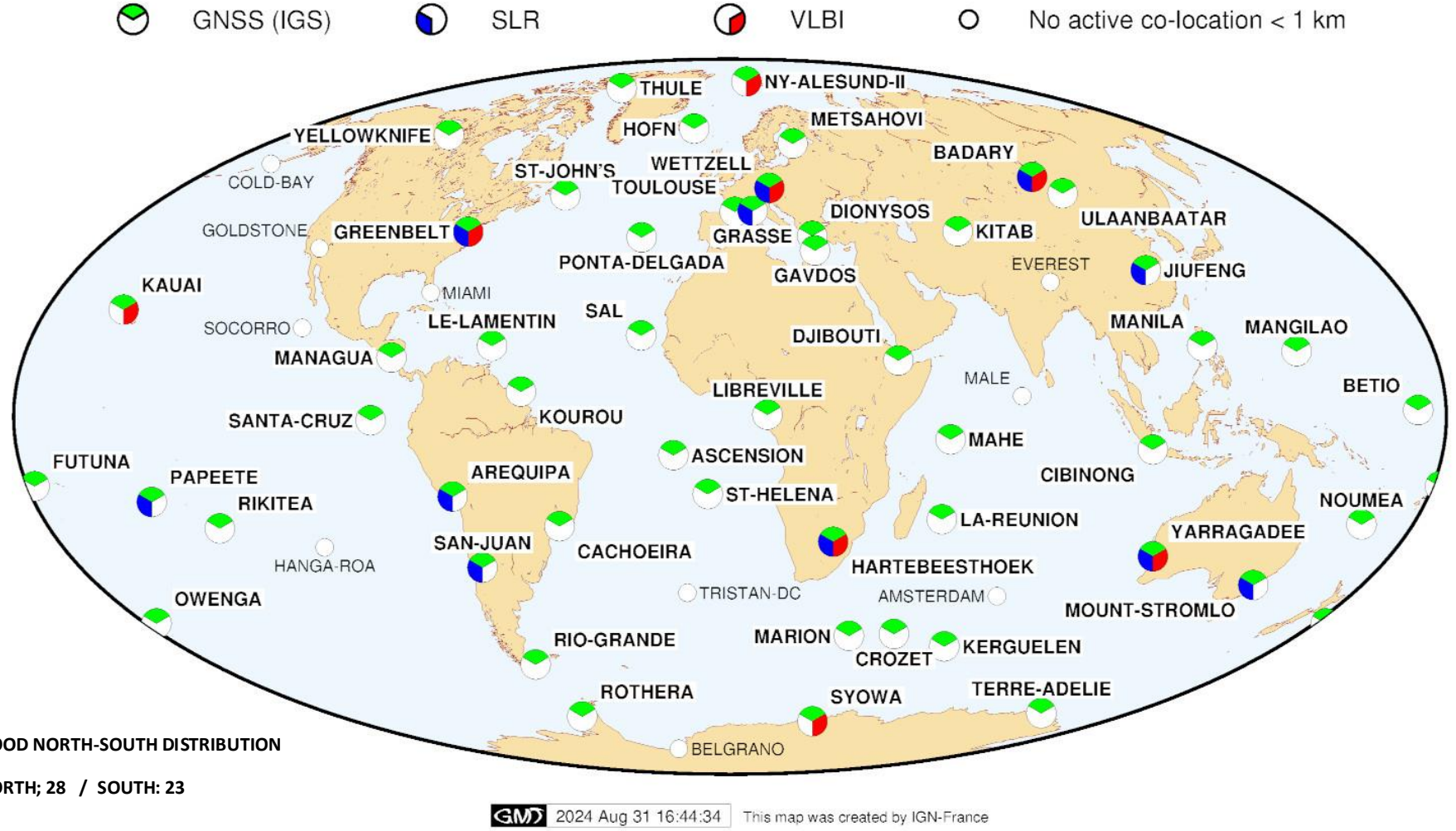
2.1 DORIS CO-LOCATION HISTORY



The number of co-located stations continuously increased over the network development. A constant effort to serve the needs of:

1. **Geodesy**
   - More that 80% of DORIS stations co-located with IERS techniques
2. **Satellite altimetry:**
   - Half of DORIS stations co-located with tide gauges

2.2 CO-LOCATION WITH OTHER IERS TECHNIQUES



GOOD NORTH-SOUTH DISTRIBUTION

NORTH; 28 / SOUTH: 23

51

Active DORIS co-locations with other IERS techniques

51

Co-locations with GNSS

11

Co-locations with SLR

8

Co-locations with VLBI

5

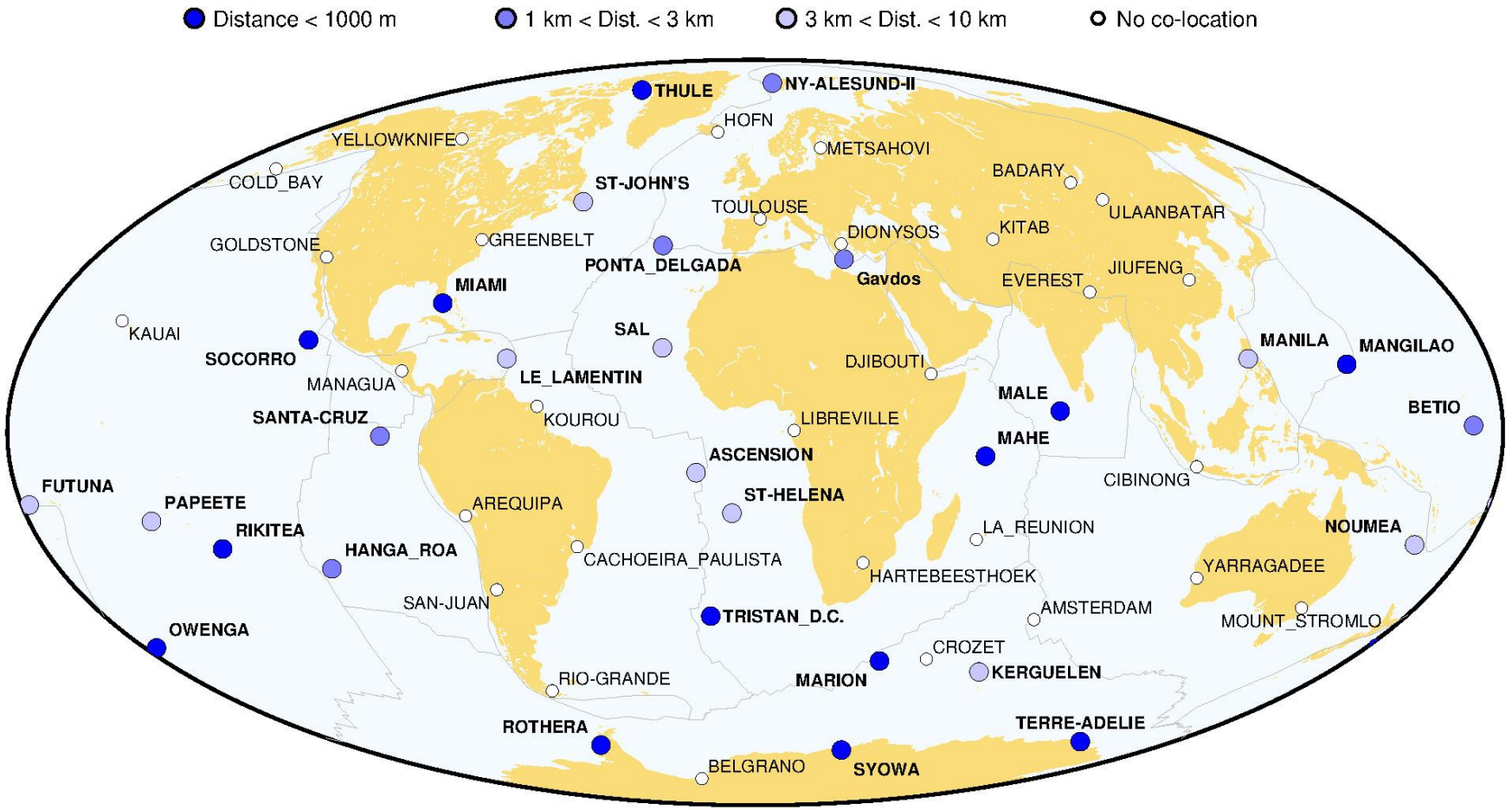
Sites with the 4 techniques

2.3 CO-LOCATION WITH TIDE GAUGES

Dist. < 1000m: **13**

1km < Dist. < 3km: **6**

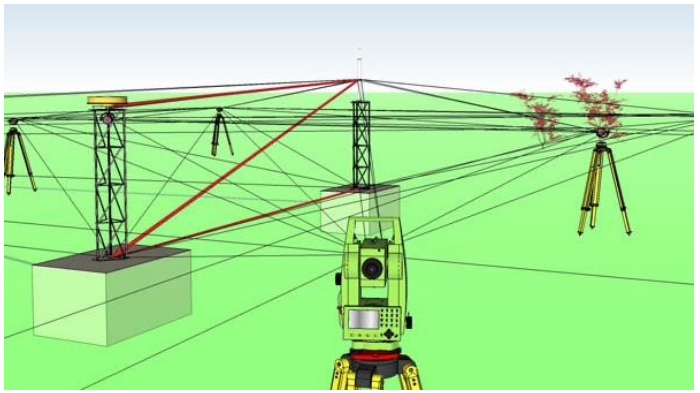
3km < Dist. < 10km: **10**



TOTAL TIDE GAUGE CO-LOCATIONS: 29

GMT 2024 Sep 04 07:28:30 This map was created by IGN-France

2.4 SITE SURVEYS AND TIE VECTORS



80% OF SITE SURVEYS PERFORMED BY IGN-F

High precision local tie surveys are carried out every time we install or renovate a DORIS site.

Conventional method: from terrestrial measurements of angles, distances and height diff.

Reports available on ITRF website: https://itrf.ign.fr/en/local-ties

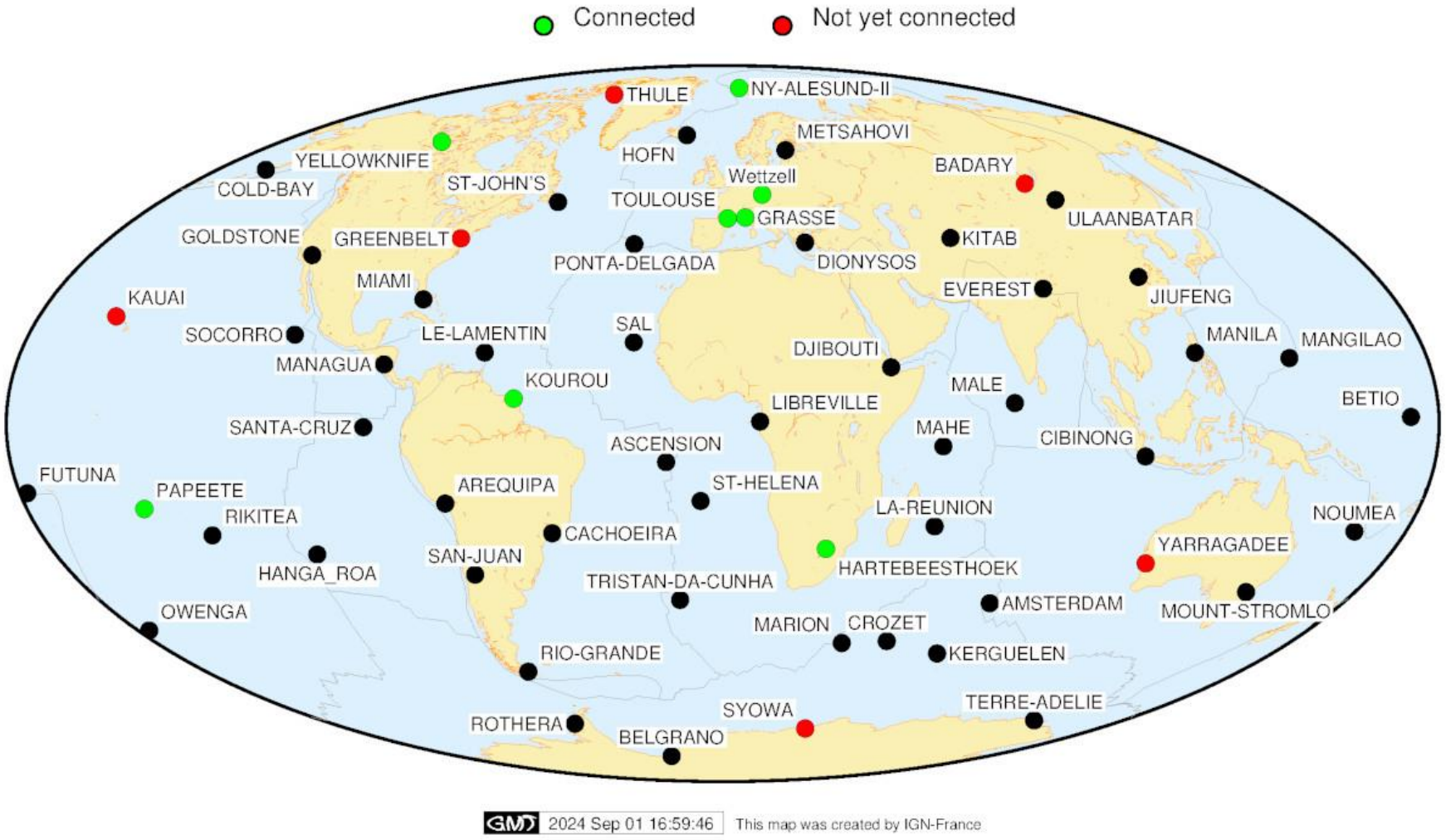
FULL LIST OF DORIS TIE VECTORS WITH OTHERS TECHNIQUES SINCE 1988

IGN maintains two files (updated 2 times a year):

1. Full list of all available DORIS tie vectors (210) at co-located sites: ftp.ids-doris.org/pub/ids/stations/**DORIS_ext_ties.txt**
2. All available tie vectors between successive DORIS antenna locations on the same site (135 tie vectors): ftp.ids-doris.org/pub/ids/stations/**DORIS_int_ties.txt**

2.5 CO-LOCATION WITH ATOMIC CLOCKS

8/14 beacons already connected to atomic clocks



3. CHALLENGES AND OUTLOOK

3.1 CHALLENGES

CO-LOCATION WITH IERS INSTRUMENTS

RF compatibility with VLBI:

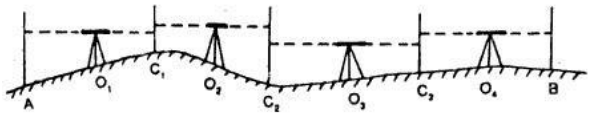
Following 3 successive RF compatibility campaigns (2014-2017), requirements were defined:

- Minimum distance: 300m
- No inter-visibility
- Having DORIS above VLBI
- Tests in real conditions

CO-LOCATION WITH TIDE GAUGES

Differential levelling is difficult to implement:

- Transporting 2m high levelling rods on aircraft
- Two people are needed to carry out the measurements



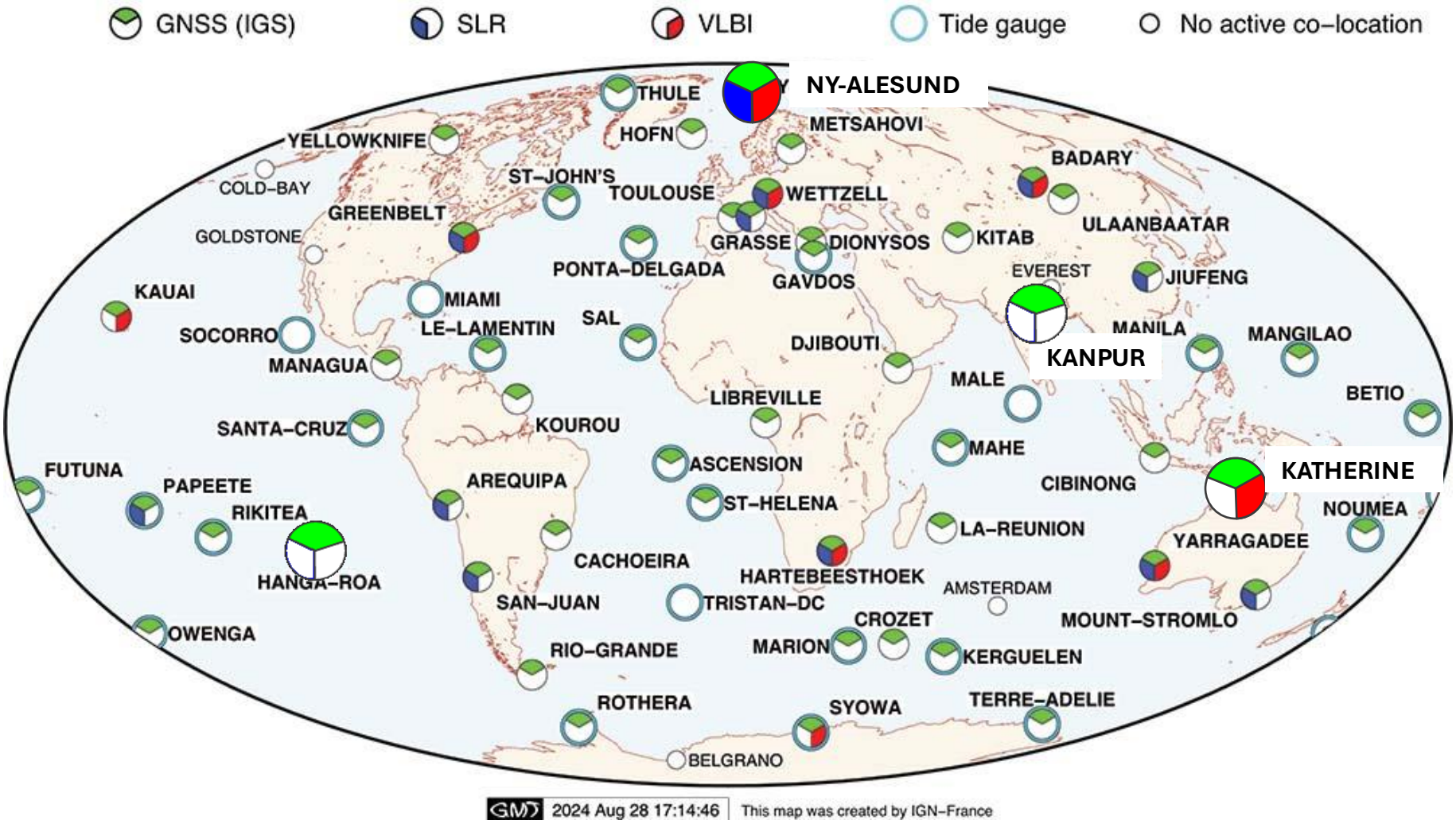
CO-LOCATION WITH CLOCKS

Coupling DORIS beacon with GNSS receivers is not always possible:

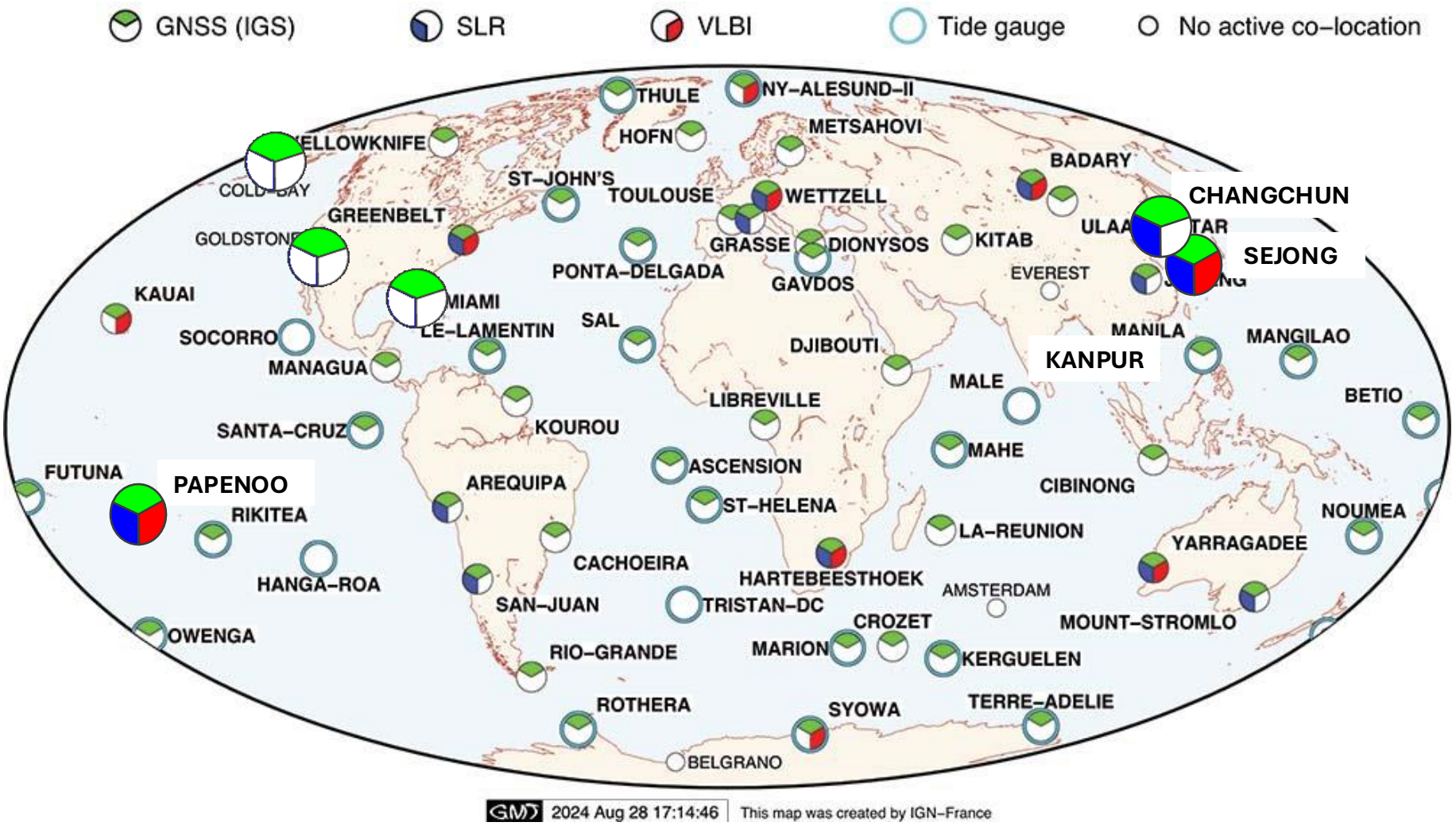
- Not all receiver models in the REGINA network are equipped with a PPS* output

*Pulse-Per-Second

3.2 FUTURE CO-LOCATIONS in 2025



3.2 FUTURE CO-LOCATIONS in the coming years…



3.3 CONNECTION WITH CLOCKS

IDS WORKING GROUP "INTEGRATED CLOCK CORRECTIONS FOR DORIS"

CNES and IGN DORIS Network maintenance teams will undertake the connection with GNSS receivers at co-located sites everywhere possible on the occasion of station installations or renovations, and keep the WG informed of progress.

REGINA Network (CNES + IGN management) has 33 stations co-located with DORIS.

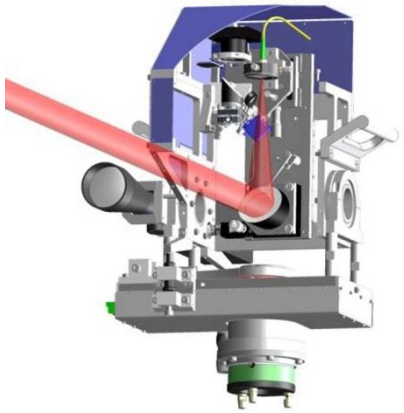
PREPARING DORIS TO ESA GENESIS MISSION

Objective = contribute to improve ITRF accuracy and stability by providing co-location in space and on ground

Run all instruments (DORIS, GNSS, VLBI) on the same clock

Need coordination between CNES/IGN DORIS teams and GENESIS DORIS WG

3.4 SURVEYING METHODS AND ACCURACY



EUROPEAN GeoMetre PROJECT

Developing enhanced large-scale dimensional metrology for geodesy:

- Novel distance meters with a range of up to 5km
- Novel strategy for GNSS-based distance determination
- Novel approaches for reference point determination of space-geodetic telescopes

SURVEYING METHODS CHANGE?

Using the novel long-distance instrumentation* could change surveying methods:

- Multilateration measurements instead of angles measurements
- Longer distances (> 1km) between geodetic instruments are possible
- Better tie vectors accuracy

* such as a two-colour instrument which intrinsically compensates the refractive index changes due to temperature or pressure

FACTORS CONDUCIVE TO INCREASED CO-LOCATED SITES

- IAG objectives: GGOS core sites with the 4 techniques in progress; IERS WG “Metrology of space geodetic infrastructure”

- UN-GGCE (Global Geodetic Centre of Excellence): supporting the development of a permanent, worldwide governmentally coordinated geodetic infrastructure

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