UN-GGCE International Workshop
JOINING LAND AND SEA
The Integration of Terrestrial, Maritime, Built, and Cadastral Domains

IHO International Hydrographic Organization

JCG JAPAN COAST GUARD

SEA LEVEL MODEL DEVELOPMENT
~ FOR HYDROGRAPHIC SURVEYS IN JAPAN ~

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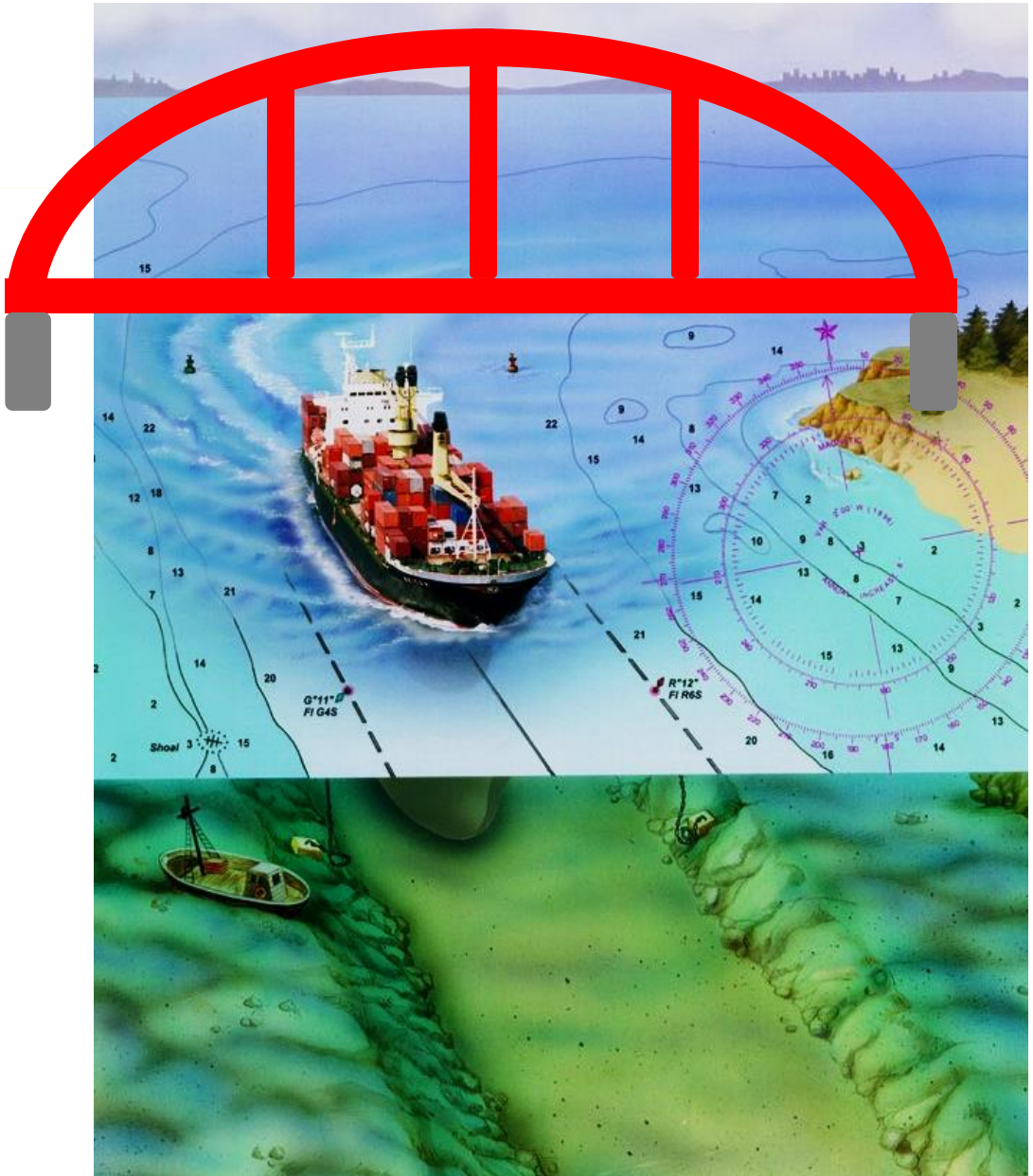
UN-GGCE WS "JOINING LAND AND SEA"
(ON 3RD DECEMBER 2024 IN BOGOR, INDONESIA)

VERTICAL DATUM IN HYDROGRAPHY

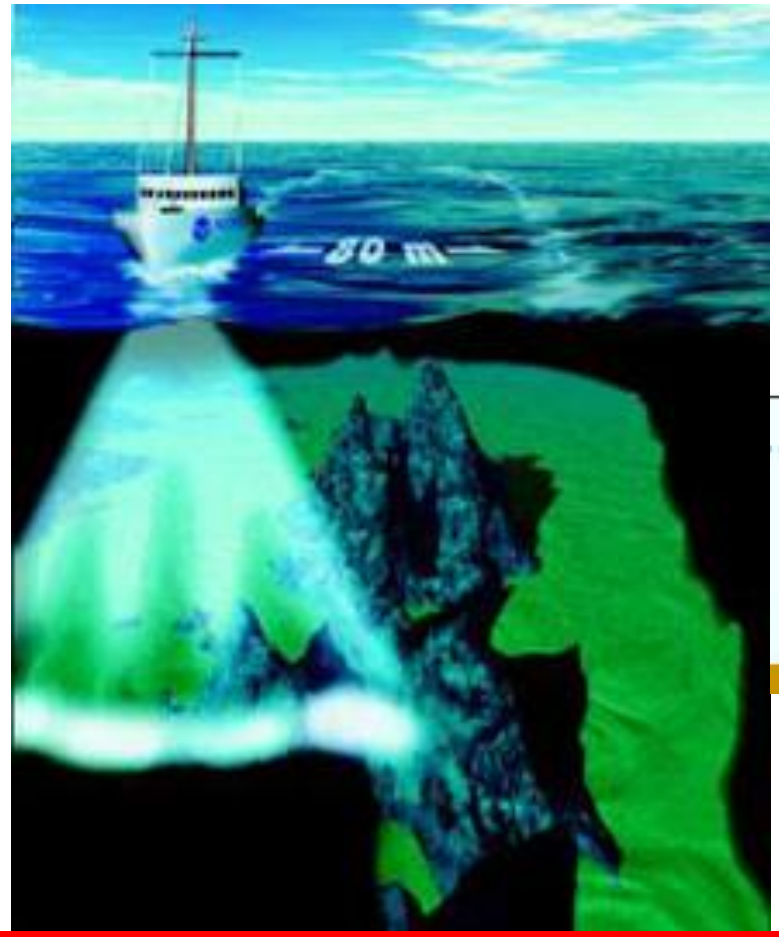


- Nautical chart
  - Subject map for navigation safety
- Vertical datum in nautical chart based on local water levels
  - Depth: LAT / MLLW / NLLW…
  - (Lighthouse height : MSL)
  - Bridge height : HAT / MHW / NHHW…
- Vertical datum in land: geoid

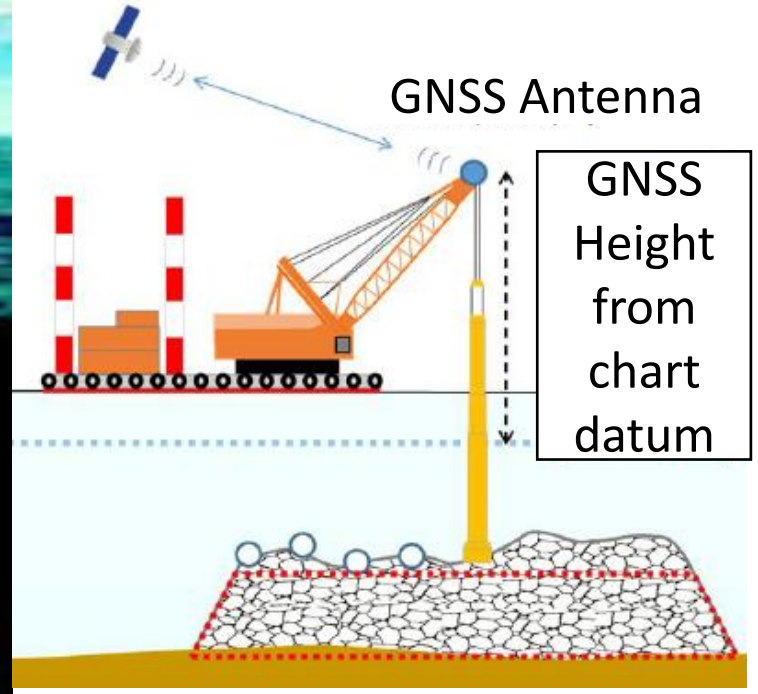
RECENT NEEDS FOR SEA LEVEL MODELS IN HYDROGRAPHY

DEPTH MEASUREMENT USING GNSS ELLIPSOID HEIGHTS AND VERTICAL CHART DATUM MODEL

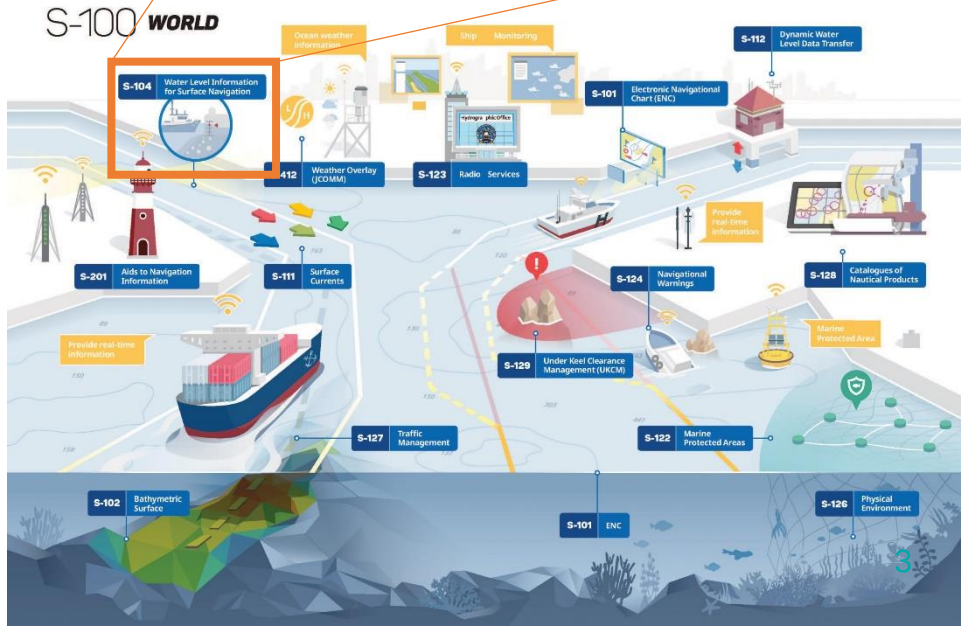
Fast & Efficient Hydrographic Survey (inc. Nav. Response)



Real-time construction in ports and harbors

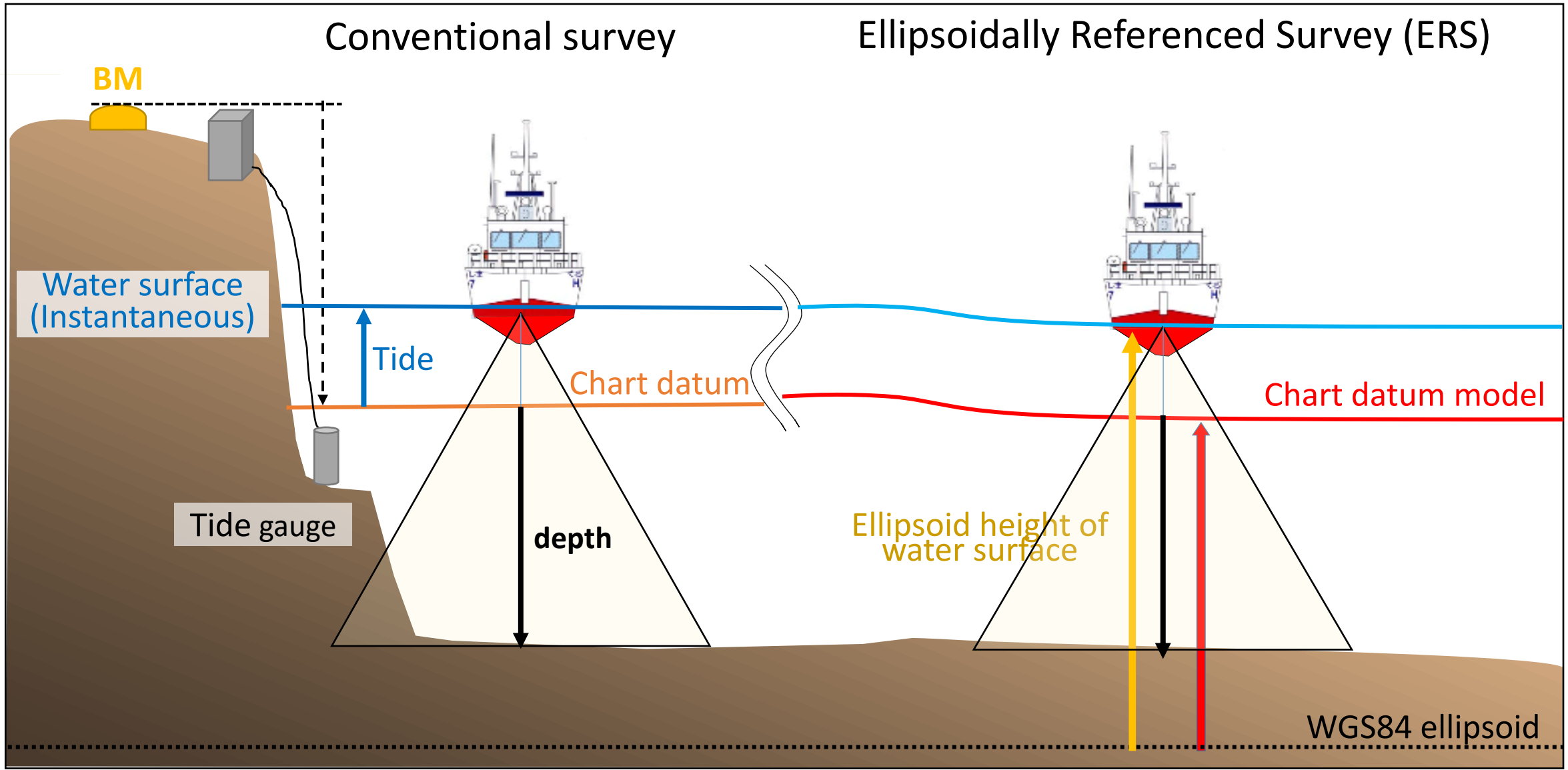


PRECISE NAVIGATION USING TIME-VARIABLE WATER LEVEL MODEL



ELLIPSOIDALLY REFERENCED HYDROGRAPHIC SURVEY

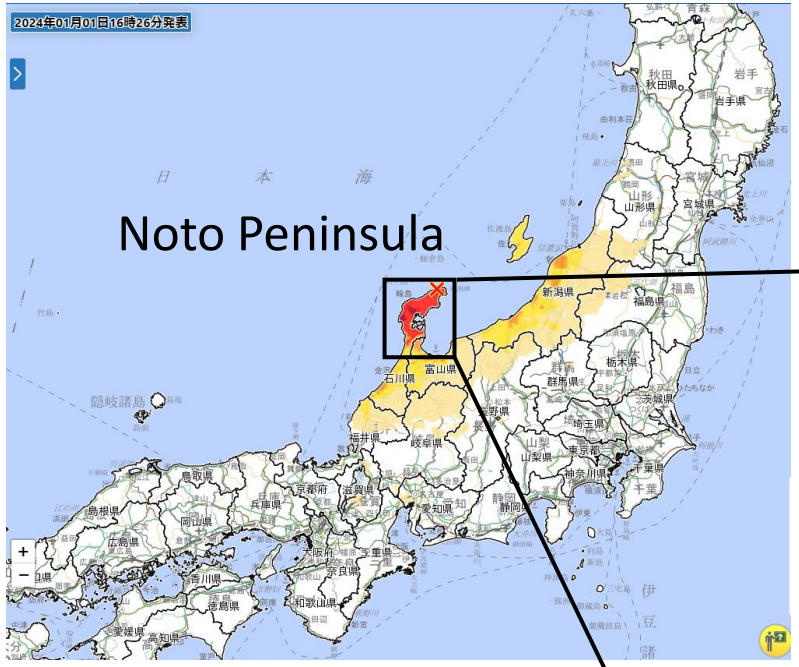
TECHNOLOGY BEING INTRODUCED IN DEVELOPED COUNTRIES AND BEING RESEARCHED IN JAPAN



THE 2024 NOTO PENINSULA EARTHQUAKE

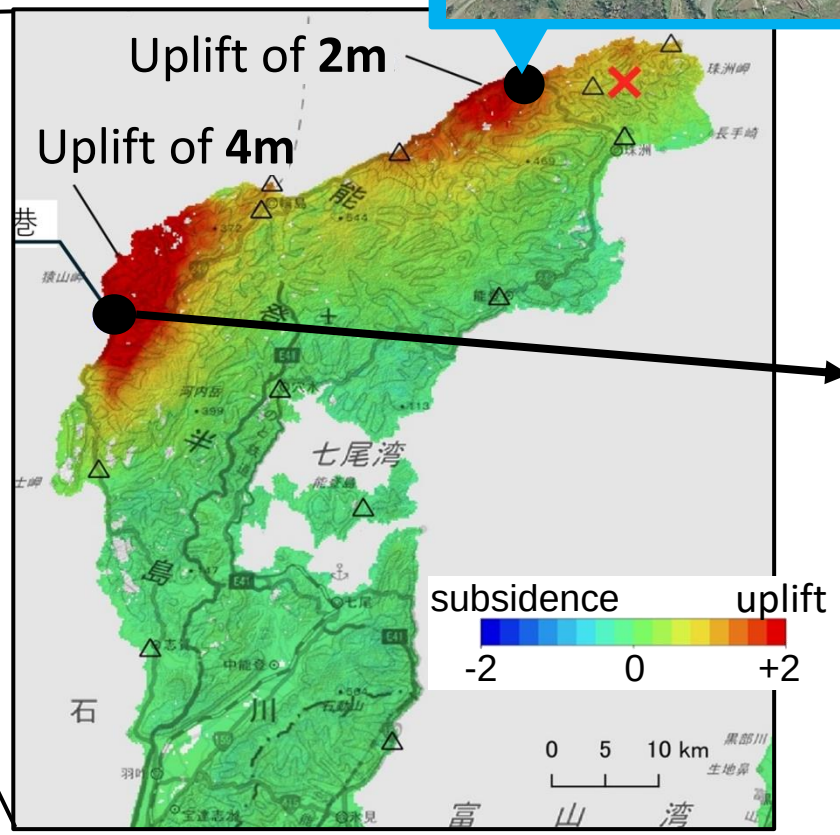
16:10 ON 1ST JANUARY 2024

MAGNITUDE (MJ) 7.6

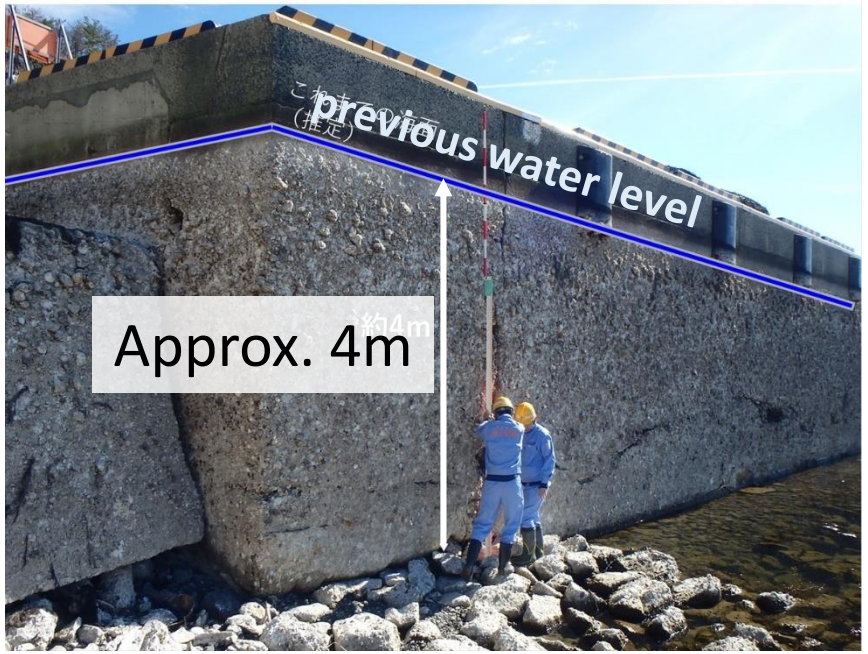


https://www.jma.go.jp/bosai/map.html#7/36.95/137.269/&contents=estimated_intensity_map&id=202401011610

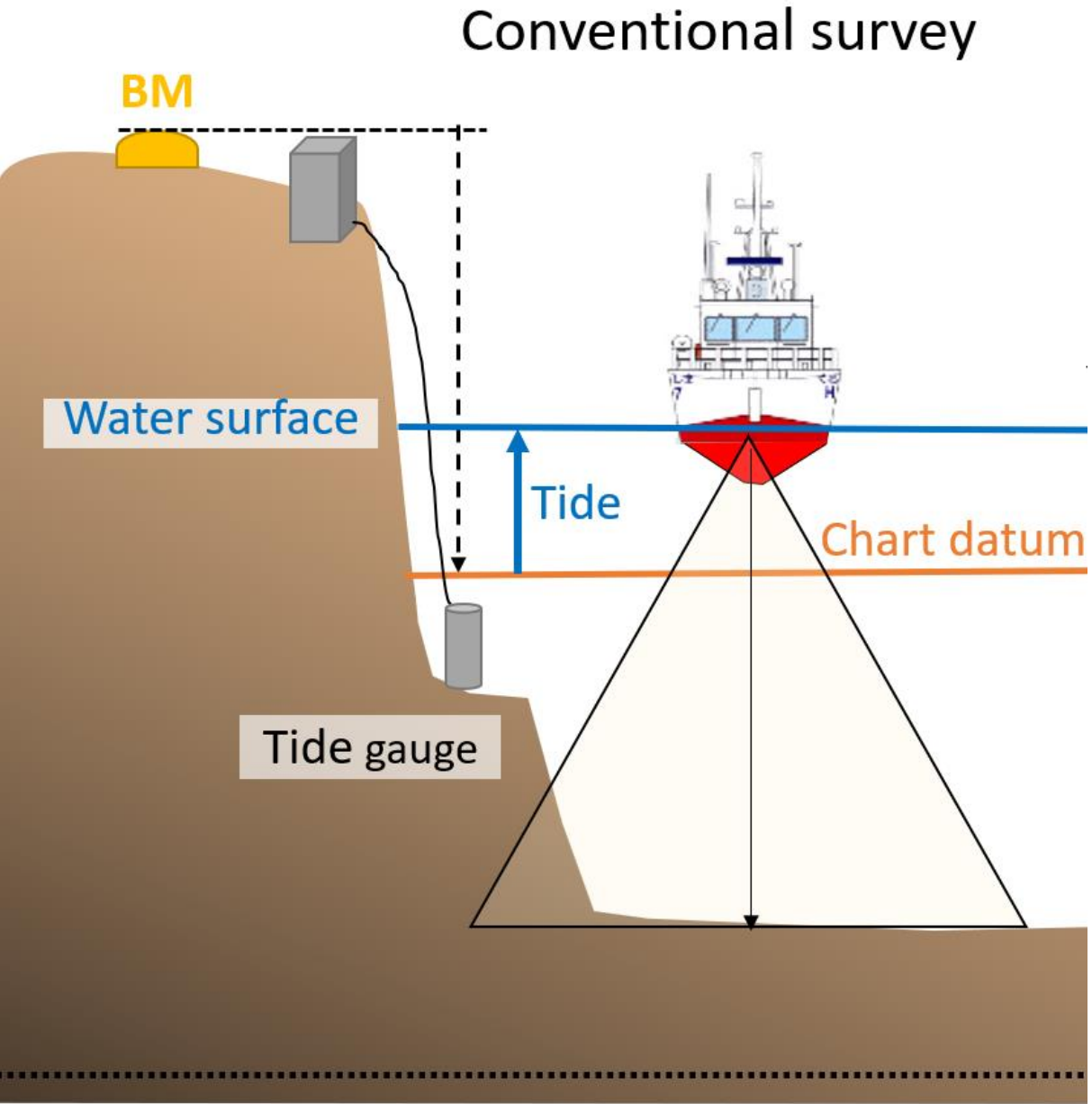
©GSI (https://www.gsi.go.jp/BOUSAI/20240101_noto_earthquake.html#5-1)



https://www.gsi.go.jp/BOUSAI/20240101_noto_earthquake.html#8

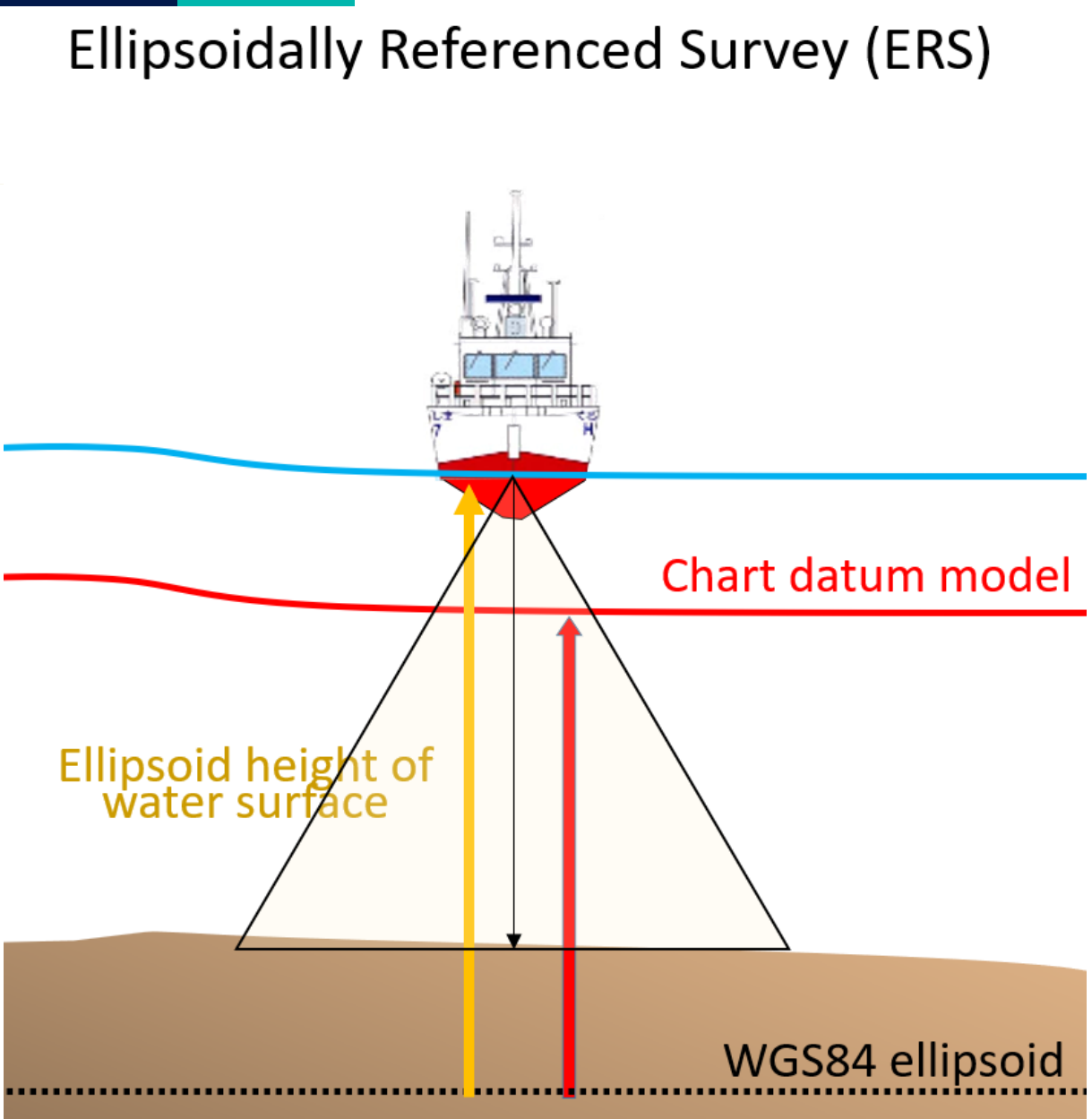


LOSS OF CHART DATUM DUE TO NOTO PENINSULA EARTHQUAKE



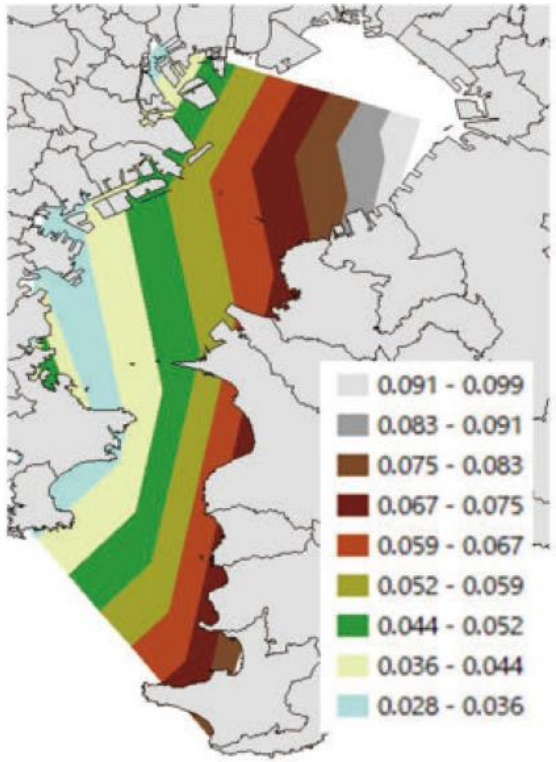
- The uplifts due to the earthquake moved more than 15 BMs tied to chart datums, making them unusable.
- Ellipsoid height measurements and tidal observations has been necessary to restore the chart datums.
  - Some of the BMs remains unrestored…
- Difficult to obtain sufficiently precise bathymetry quickly with conventional hydrographic survey method…

ADVANTAGES OF ERS OVER EXISTING SURVEYING



- ERS uses chart datum model that is not affected by uplift, allowing for rapid bathymetry.
- Key is pre-building high-quality chart datum model.
- Precise GNSS measurements
  - Post-Processed Kinematic (PPK)
  - Real-Time Kinematic (RTK)
  - Virtual Reference Station (VRS)
  - Precise Point Positioning (PPP)

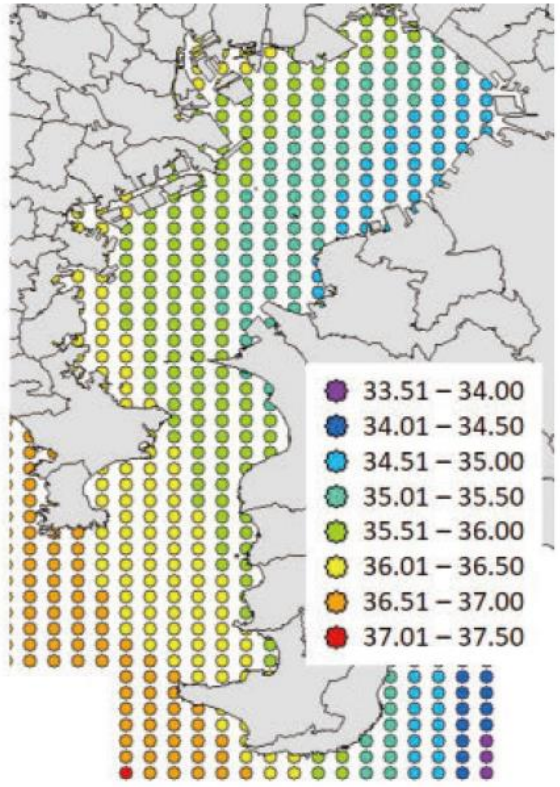
THE CONCEPT OF VERTICAL CHART DATUM MODEL



(1) MSL height [m]

Mean Sea Level height above geoid from permanent tide station

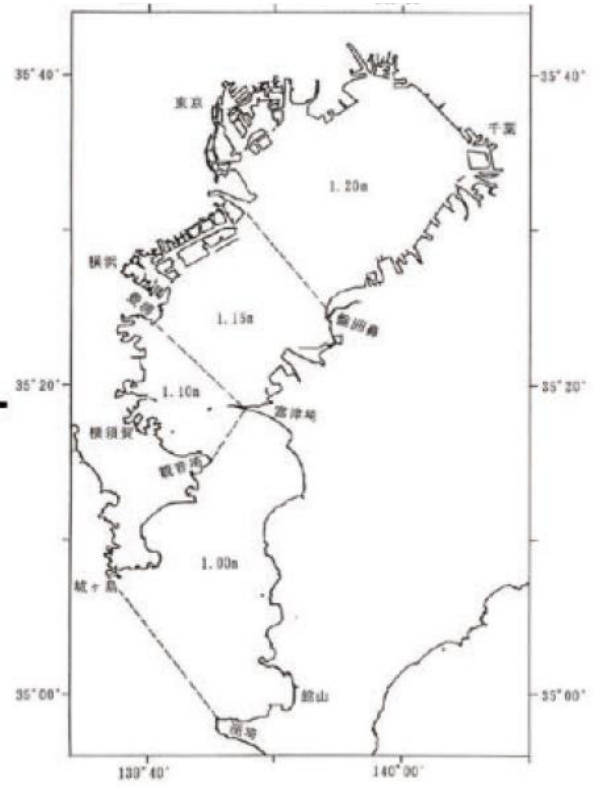
+



(2) Geoid model [m]

"JGEOID2011Ver2.x" by GSI

−



(3) Z_0 [m]

Z_0 (= MSL – CD) defined by "the list of datum levels" by JHOD

=

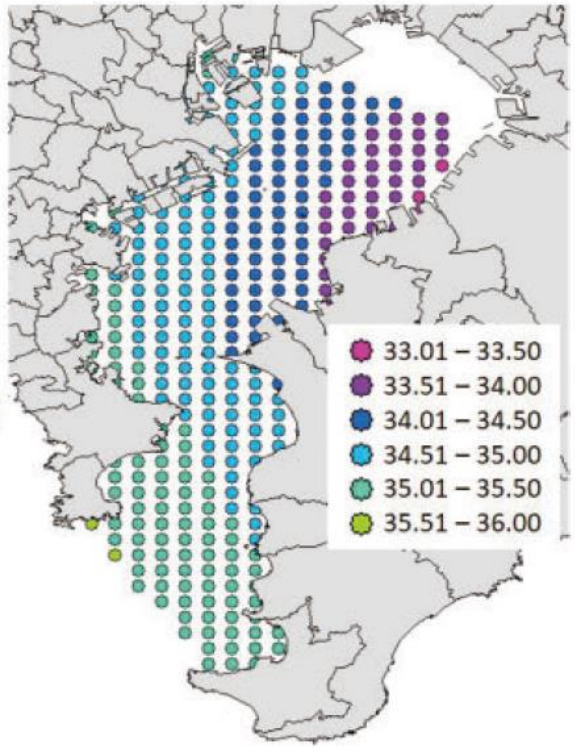
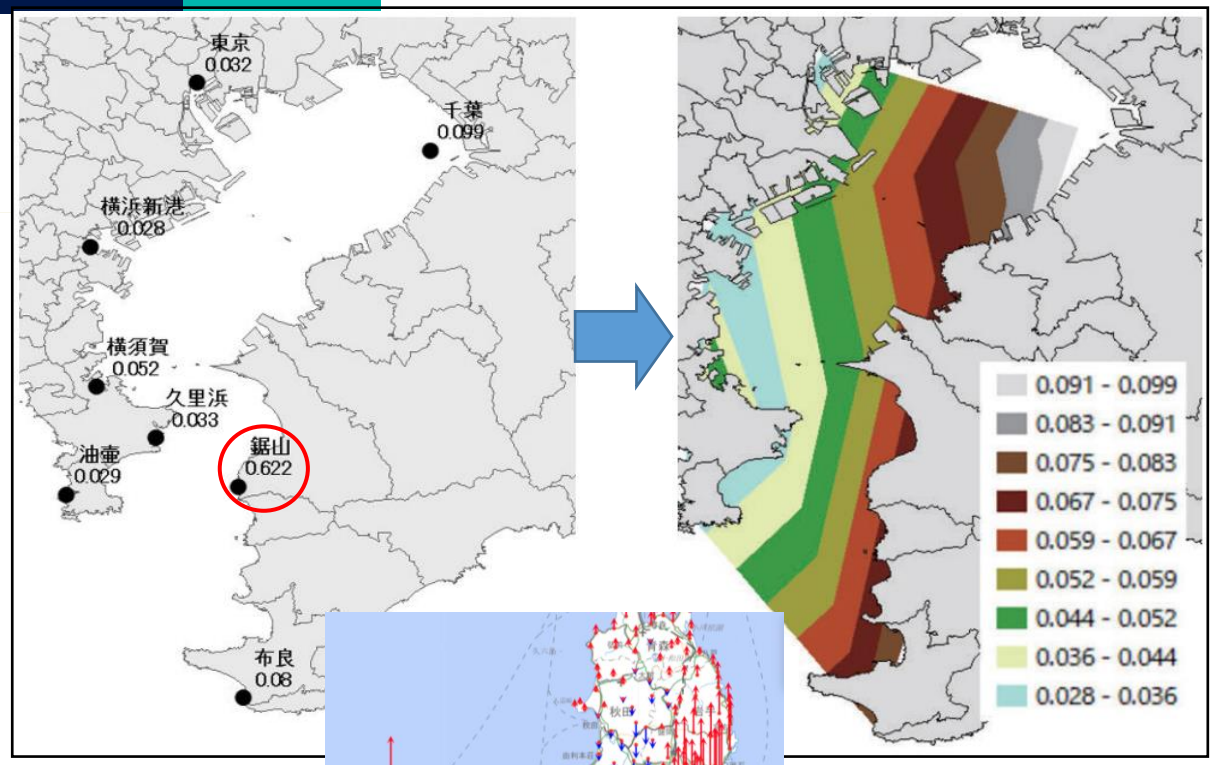


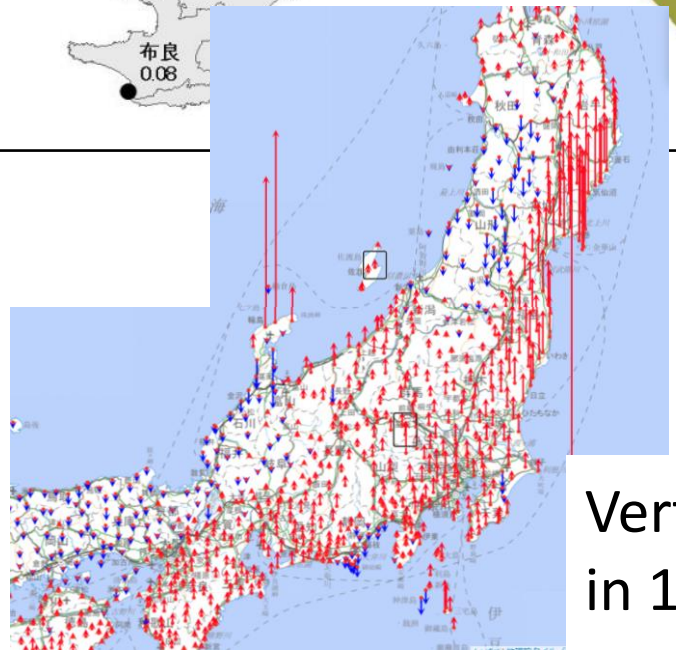
Chart Datum model [m]

Gridded ellipsoidal height of the chart datums

MSL HEIGHT CALCULATION GIVEN CRUSTAL DEFORMATION



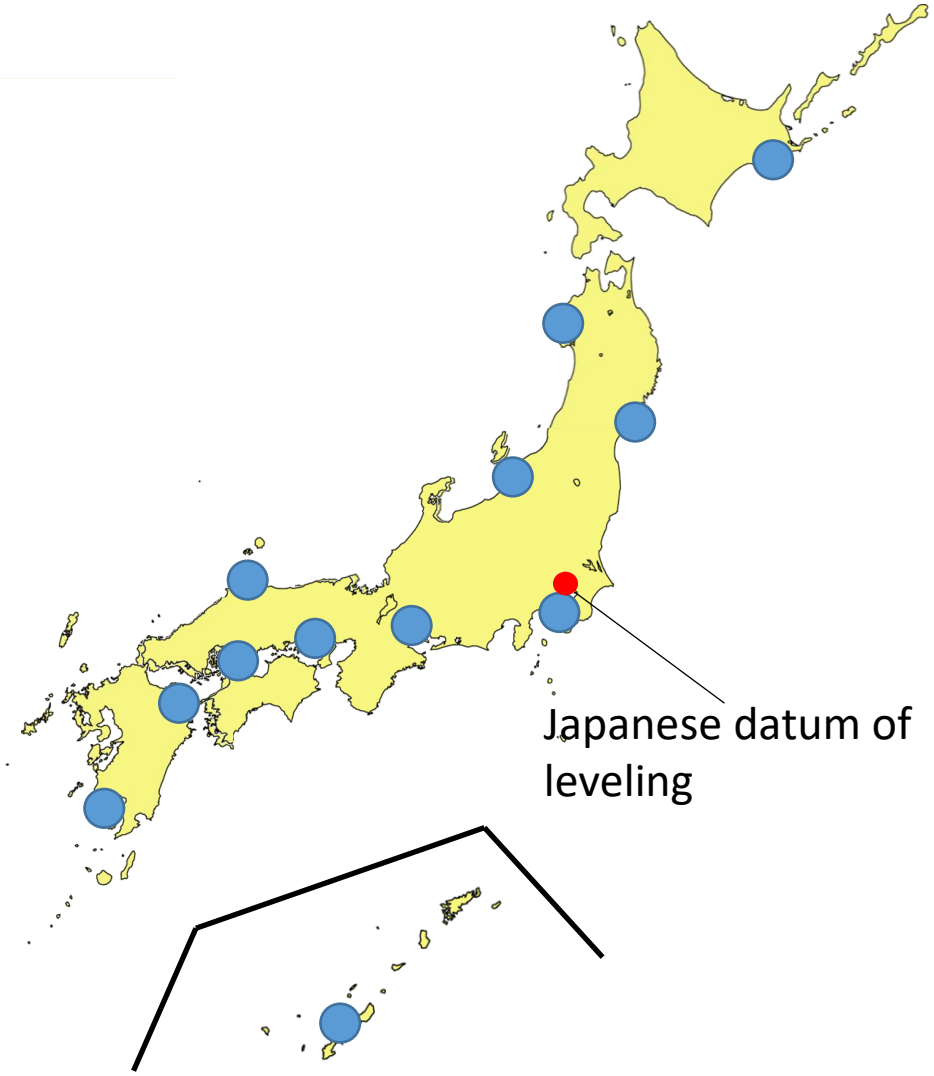
- MSL heights at the tide stations were calculated from
  - 5-year (2016-2020) MSLs by the permanent tide stations.
  - BM heights (zero levels at the tide gauge) by leveling to the Vertical Reference Point.
- In areas of high crustal deformation, BM heights were corrected by the vertical crustal deformation to match the MSL epochs.



Vertical Crustal Deformation
in 10 years（2014-2024）

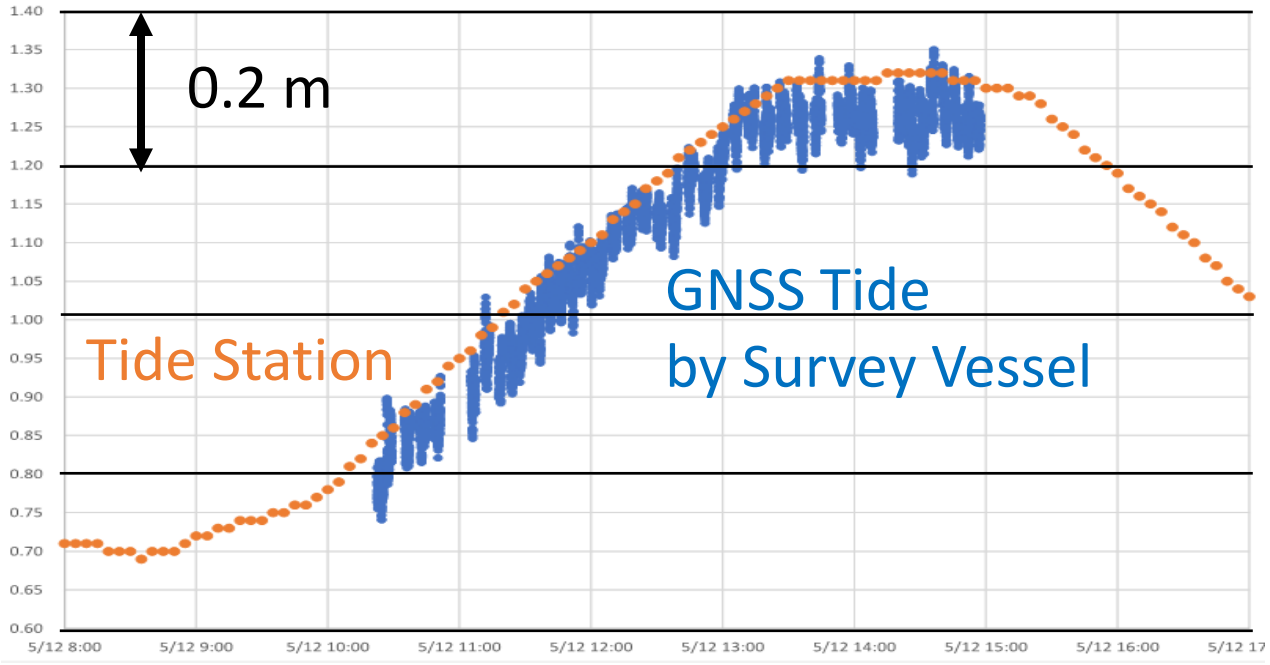
VERIFICATION TESTS OF CHART DATUM MODEL

GENERALLY REASONABLE CD MODELS CREATED IN 12 PORT AREAS THROUGHOUT JAPAN.

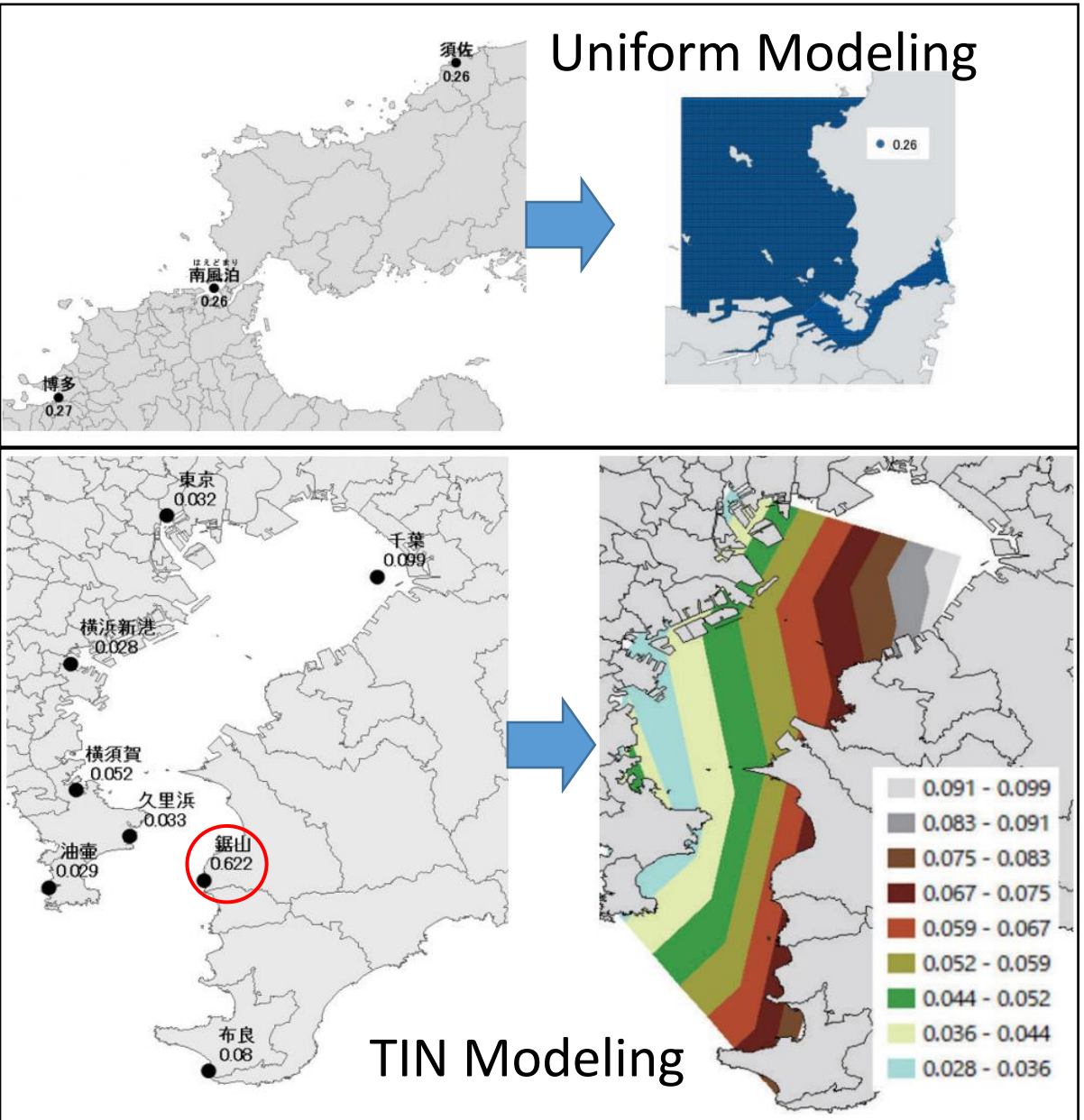


- The depth differences obtained by the ERS and conventional survey methods were within the range of S-44 Special Order.
  - $TVU = \sqrt{0.25^2 + (0.0075 \times depth)^2}$ = 0.29 m @ 20 m depth

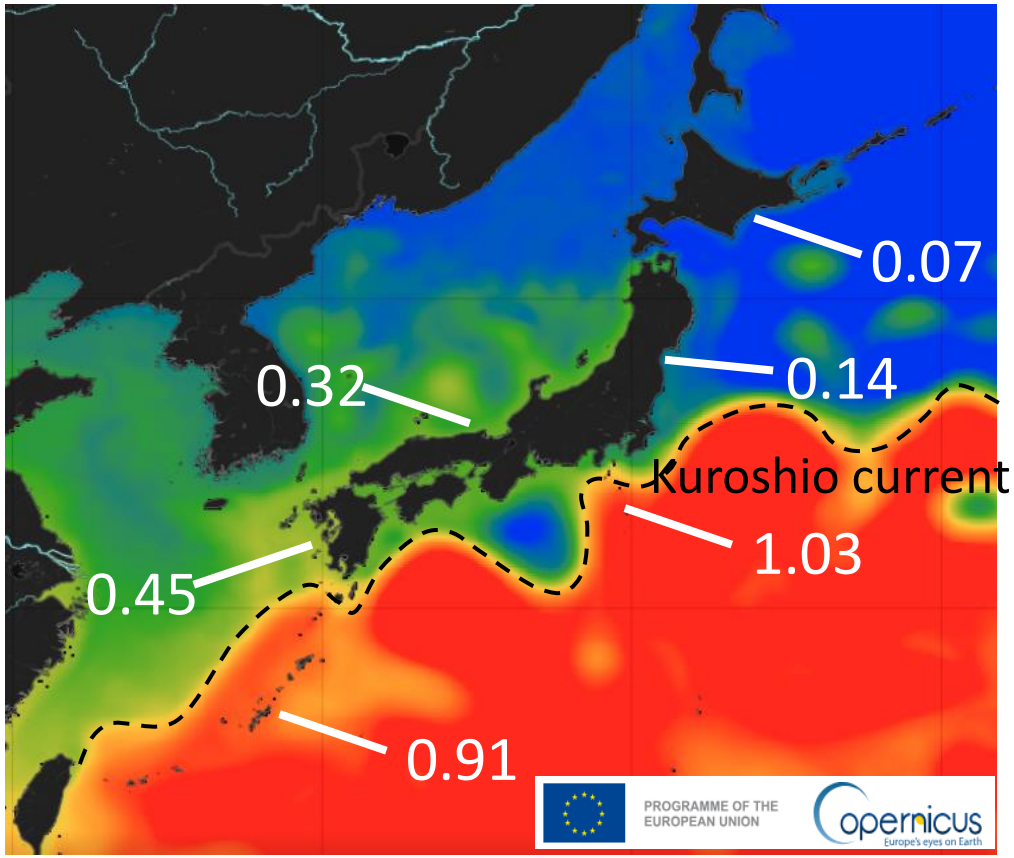
- The GNSS tide and tide station levels matched.

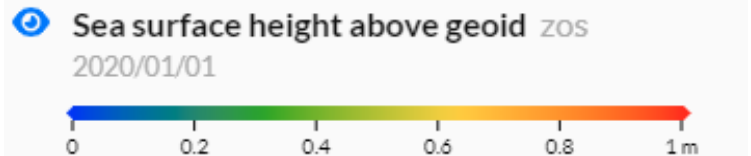


FUTURE CHALLENGING: MSL HEIGHT MODELING



- Appropriate modeling of very complex MSL heights around Japan, considering the influence of Kuroshio current channels.

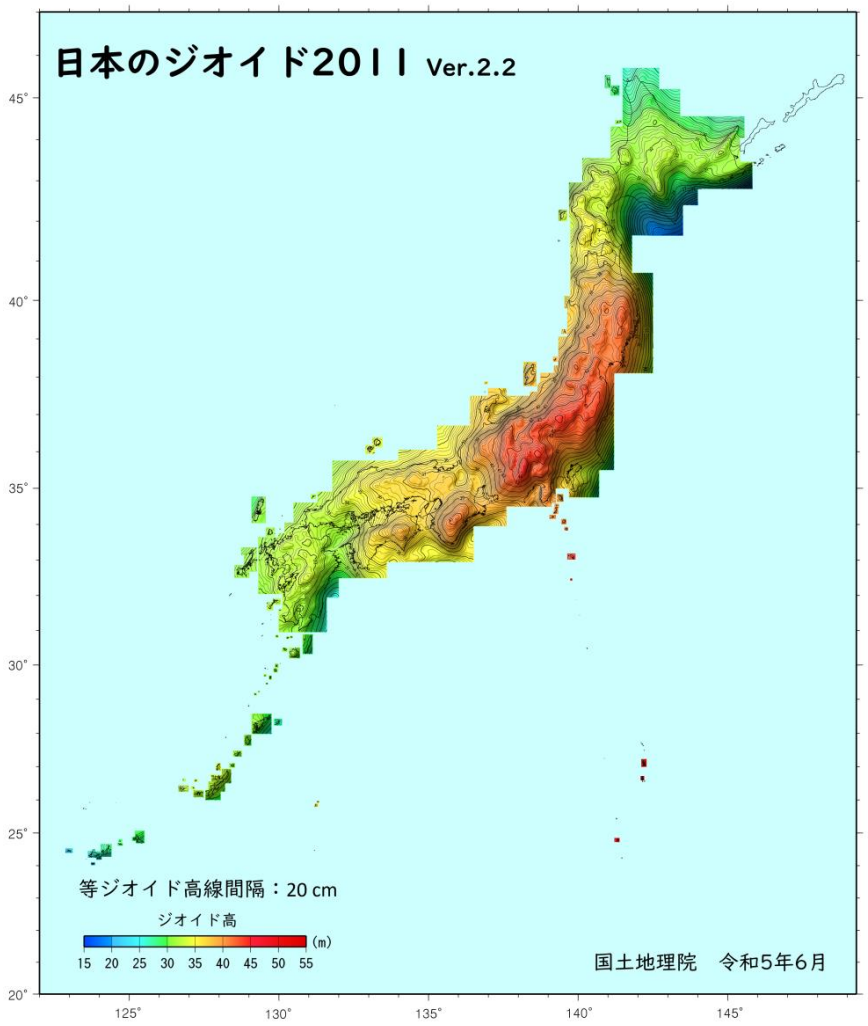




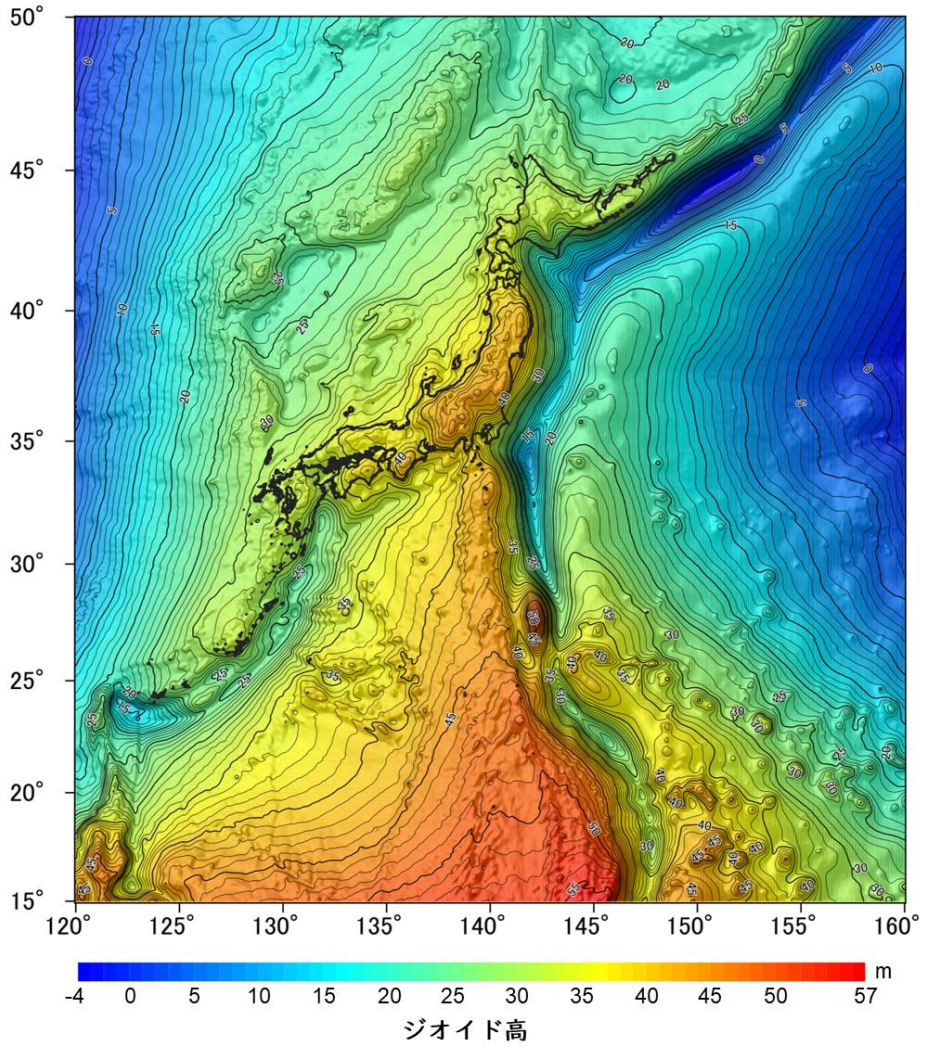
MORE PRECISE GEOID MODEL BY GSI: JGEOID2024

HIGHER ACCURACY IN CHART DATUM MODEL WITH THE USE OF THE JGEOID2024.

JGEOID2011 Ver. 2.x



JGEOID2024 (in prep.)



SUMMARY

- Sea level model for ellipsoidally referenced hydrography survey is researching & developing in some countries including Japan.

- In Japan, chat datum models at each port on a trial basis are being tested for the introduction of ERS and are being verified through comparison with conventional survey results.

- To create higher quality chart datum model, it is necessary to consider regional characteristics such as crustal deformation and oceanic effects, as well as to use high-precision geoid model.

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THANK YOU SO MUCH FOR YOUR ATTENTIONS!

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