S-100WG

Paper for Consideration by S-100WG

Horizontal uncertainty and Geodetic datum of reduce resolution gridded data

Submitted by:	France (Shom)
Executive Summary:	Resolution gridded data coherent with horizontal uncertainty of source data and Geodetic datum.
Related Documents:	S-102 Bathymetric Surface Product Specification
Related Projects:	S-1XX project which used metric resolution gridded data

Introduction / Background

1. Bathymetric Surface Data Product gives us the ability to describe the seabed in high definition with metric resolution. With the specification of this gridded product come questions of grid node resolution and associated projection.

The key topics to be solved are:

- Assuring that horizontal uncertainties of the data source are saved in the S-102 product.
- Fixing a Geodetic datum in space and time for the use of all metric resolution gridded data.

Analysis/Discussion

2. In S-102 bathymetric surface product specification, one can find the following sentence about the S-102 coverage: "…*where each value is defined to be at an exactly specified geographic point (or grid node), hence negating the need for horizontal uncertainties."*

We acknowledge that grid nodes positions of the S-102 are unambiguously defined as a mathematical function (relative to coverage, grid spacing and projection). Comparatively, measured source data contain inherently both vertical and horizontal uncertainties. Grid nodes filling consist of the best estimation (binning or interpolation) of the bathymetry from the source data at the (fixed) grid node positions. Effects of horizontal uncertainty of the source data will have direct effect on the total propagated uncertainty (see underlying CUBE equation for example). We therefore think that for S-102 product it's essential to conserve as part of metadata the horizontal uncertainties of data sources. Due to different input surveys, the horizontal uncertainty will be different for each data sources and find only one horizontal uncertainty based on grid resolution is an excessive simplification.

Moreover, we believe that it is also crucial to conserve descriptive elements of the horizontal component of the uncertainty when considering soundings in exception (for the sake of safety of navigation) which are enumerated in the "tracking list".

3. The second part of this proposal is linked to the CRS. In S-102 PS, one can find "*For ENC S-102 the horizontal CRS must be EPSG: 4326 (WGS84). The full reference to EPSG: 4326 can be found at www.epsg-registry.org."*

If we look at the EPSG: 6326 anchor definition (Geodetic datum linked to the EPSG 4326) we read: "*Defined through a consistent set of station coordinates. These have changed with time: by 0.7m on 1994-06-29 (G730), a further 0.2m on 1997-01-29 (G873), 0.06m on 2002-01-20 (G1150), 0.2m on 2012-02-08 (G1674) and 0.02m on 2013-10-16 (G1762).*"

So basically depending of the epoch of the survey the definition of the WGS84 (Geodetic datum) is not the same. Between the beginning of WGS84 and today we will have a shift of 0.98 meters between the two WGS84 realizations G730 and G1762.

Epoch is an instant time, for example the reference epoch of WGS84 (G1762) is 2005.0 (first day of 2005 year). But if we used the WGS84(G1762) at the fisrt day of 2018 we will be at epoch 2018.0.

4. This question of dynamic versus static geodetic datum is tackled by the IOPG (international association of oil and gas producers) here: http://www.iogp.org/wp-content/uploads/2017/07/ID2017_Att05_IOGP_RogerLott.pdf.

5. According to National Geospatial-Intelligence Agency (NGA) which makes the definition of WGS84 Geodetic datum the WGS84(G1762)#(2005.0) is align with the ITRF2008#(2005.0) (see table 1).

Table 1: Comparison of previous WGS84 and ITRF2008@2005.0 to WGS84(G1762) (from NGA: department of defense world geodetic system 1984: its Definition and Relationships with Local Geodetic Systems)

Reference Frame (reference frame epoch)	Δx (mm) (sigma)	Δy (mm) (sigma)	Δz (mm) (sigma)	D (ppb) (sigma)	Rx (mas) (sigma)	Ry (mas) (sigma)	Rz (mas) (sigma)
WGS 84 (G1674)# (2005.0)	-4 (5.2)	3 (5.2)	4 (5.2)	-6.9 (0.82)	0.27 (0.215)	-0.27 (0.212)	0.38 (0.196)
WGS 84 (G1150)# (2001.0)	-6 (4.7)	5 (4.7)	20 (4.7)	-4.5 (0.74)	0 *	0 *	0 *
ITRF2008* (2005.0)	0 *	0 *	0 *	0 *	0 *	0 *	0 *

*Mean differences are 1-2 millimeters and significantly less than the error in the conversion, thus they are effectively zero.

6. To illustrate this need of a fixed epoch we made computation of a Tahiti point to demonstrate the horizontal shift thought the years (the Pacific tectonic plate being the fastest one on the planet ~10cm/y). Here we make the assumption that WGS84 will stay **strictly** aligned to the ITRF2008 (that's not true as NGA defines their WGS84 terrestrial reference frame in 2016 presentation: ftp://ftp.nga.mil/pub2/gps/sat_out/SteveM/NGA_ICG11_2Nov.pdf).

The coordinate shows below are in Mercator projection (to compare in a metric way).

Table 2 : coordinate difference due to epoch change

epoch	ITRF2008@2005.0 (WGS84@2005.0)	ITRF2008@2018.0 (WGS84@2018.0)	ITRF2008@2038.0 (WGS84@2038.0)
North coordinate	-1975206.227	-1975205.760	-1975205.040
East coordinate	-16654114.037	-16654114.929	-16654116.301
Up coordinate	98.021	98.013	98.000
North difference (2005-other)	0	**-0.467**	**-1.187**
East difference (2005-other)	0	**0.892**	**2.264**
Horizontal biais	0	1.007	2.556

The table 2 illustrates the fact that, due to the tectonic plate move, the coordinates of a point change through epoch.

7. If we want to use metrics resolution for our products we cannot allowed this kind of horizontal shift in our Geodetic datum. So we need to save in metadata the Geodetic datum and epoch (mandatory) and we can define an epoch for all our gridded product (to discuss). This is a NGA recommendation, in

"the department of defense world geodetic system 1984: its Definition and Relationships with Local Geodetic Systems (2014-07-08 version 1.0.0)" we can read: *"**The WGS 84 Reference Frame and Coordinate System are delivered via the GPS**. The most accurate approach for obtaining WGS 84 coordinates is to acquire satellite tracking data at the site of interest and position it directly in WGS 84 using GPS positioning techniques. For precise surveying applications, it is recommended that coordinates be maintained with an **epoch assigned to each coordinate determination** along with an indication of the fixed station GPS coordinate set used for the realization, such as WGS 84 (G1762)."*

8. Moreover NGA always tries to keep WGS84 aligned to the best ITRF available. In addition, ITRF (based on a more densified network and not only built throught GNSS techniques, but also SLR, VLBI etc.) are more consistent than WGS84. So it could be interesting to use an ITRF with a fixed epoch as our reference Geodetic datum.

9. If we take the example of NOAA GNSS reference stations, most of the coordinates of these stations are given in IGS08#(2005.0) (that can be assimilated to ITRF2008#(2005.0) at the precision level needed for our use). And basically when we post process navigation data with IGS analyse center productsthey are referenced into an ITRF. So to limit the coordinate transformation for data producer, it would be easier and more accurate to choose an ITRF as Geodetic datum.

Conclusions

Example given above shows us the importance to save and fix a relevant Geodetic datum for our entire S-1XX product with metric resolution.

Recommendations

- In order to control the pertinence or resolution choice, it is recommended to keep in metadata the source data horizontal uncertainties.
- Save in metadata the Geodetic datum (**space** and **time**) of the S-102 product.
- Fixe an appropriate international Geodetic datum (**space** and **time**) for all gridded data in S-1XX product.
- Take into account the conclusions inside the document.

Justification and Impacts

These recommendations will procure the serenity of working with metric resolution gridded data without depend on future Geodetic datum change. It will give us the opportunity to always compare our entire mesh product. It is essential to clarify this information to avoid any horizontal shift in gridded data.

Action Required of S-102WG

The S-100WG is invited to:

a. **Note** this paper;

b. **Discuss** the recommendations;

c. **Propose** improvements of S-102 PS.