Committee on Earth Observation Satellites

Working Group Calibration & Validation
Terrain Mapping Sub-Group (TMSG)

DEM Intercomparison eXercise DEMIX

Virtual progress meeting
17 July 2020 (updated 24 July)

Peter Strobl,
European Commission, Joint Research Centre (EC-JRC)

TMSG status

- Revival of the Terrain Mapping SubGroup (TMSG)
  - Proposed at WGCV45 in July 2019
  - Decided by SIT in September 2019
  - Invitation email sent to last available participant list in January 2020
  - as of July 17th 2020:
    - 47 subscriptions
    - 13 countries
    - ~50% with CEOS background
    - ~30% Geomorphometry.org
    - ~30 expressed interest in the intercomparison exercise DEMIX

Subscription page: https://ec.europa.eu/eusurvey/runner/WGCV-TMSG_membership

If not done already, please subscribe to TMSG and mark interest in DEMIX!

Digital Elevation Inter-Comparison (DEMIX)

Development:

- DEMIX call for participation issued 5 May 2020
- 28 participants registered (CAS, DLR, EC, ESA, JAXA, NASA, USGS) + domain experts & industry
- Kick-off meeting held with 26 participants on 26&30 June 2020
- 25 contributions to organisational survey by 17 July

Result:

- Three sub-groups are set-up (feel free to rename!):
  1) terminology and analytical basis (15)
  2) algorithms and software – open source tool box (14)
  3) platforms and processing (11)

Sub-group participation should help to **focus** on specific tasks, it should **not prevent** anyone from getting involved where they wish to do so. Within DEMIX all information should be available to anyone.

Overall scope

CEOS WGCV mandate for DEMIX:

- perform a state of the art comparison of the major global (free&open) DEMs
- provide recommendations on best available DEM options depending on domain and area to allow informed choices

Expected Outcomes

- Consistent and comprehensive DEM definitions and terminology (t)
- Base (t) and extended (g) set of benchmarking metrics and respective algorithms (t) and open source tools (g)
- Detailed comparison results on test areas (t) and aggregated wall to wall benchmarking results (g).
- Recommendation of a reference DEM and consistent orthoimage (g)
- Final report (t) and peer-reviewed publication (g)

Group 1

Group 1+2

Group 2

Group 2+3

Group 3

Group 1+3

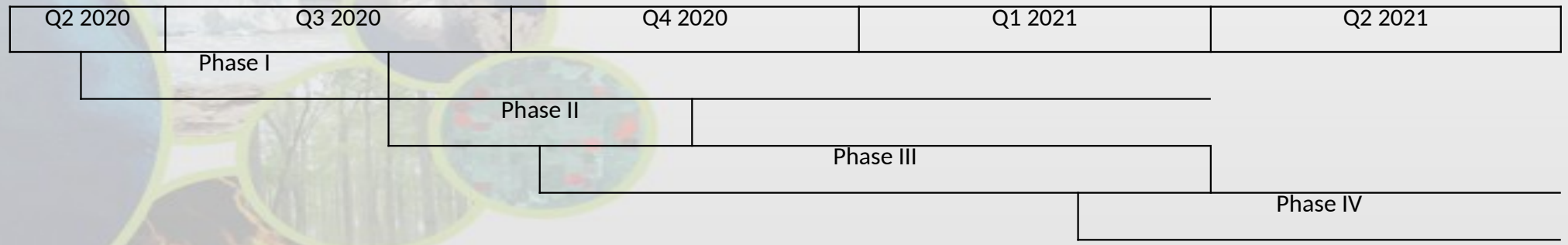
all Groups

Please see the project plan on Teams , feel free to ask questions or amend using the 'edit' function!

Digital Elevation Inter-Comparison (DEMIX)

- DEMIX to be performed in 4 phases
  I. General agreement among main contributors (data owners) on approach & scope; Call for expression of interest to further partners (commercial tbd); circulation of JRC Workshop report (in preparation) & selection of base (△x, △y, △z) & extended (slope, aspect, morphology) testing methods and algorithms; Identification of suitable test areas (at least 1 per continent);
  II. Cross-comparison of all participating data sets on test areas and, if feasible, identification of a reference dataset (at DGED L1). If available and where applicable cross-comparison to suitable orthorectified (reference?) imagery (Sentinel-2?); Workshop to exchange experiences from the test areas and agree on details of an eventual global roll-out;
  III. Feasibility testing & potential global roll out of at least base tests & determination of suitable aggregation scale for reporting;
  IV. Calculation of agreed comparison metrics for all candidates and publication of results.

- Timeline



DEM use typologies

Applicability and usefulness of DEM quality metrics depend on application area and user needs!

→ Wanted: a ‘universal’ typology of DEM use cases!

- Not a priority within DEMIX (maybe to be proposed to TMSG)
- Within DEMIX for now we should concentrate on:
  - orthorectification
  - atmospheric and terrain slope correction

  of remotely sensed Earth Observation data

Others can be served as resources allow!

What is a ‘good’ DEM?

Once we agreed on the metrics to describe a DEM we can set threshold and target values, which however will depend on the application!

- For orthorectification:
  - Most important is maximum observation angle and then GSD
  - DEM must share same Reference Geometry as imagery

- For terrain correction:
  - Slope and Aspect must be realistic, to better 10º
  - DEM and imagery must be co-registered at (sub-?)pixel level

Group1: terminology and analytical basis

Participants(15)*: J. Bamber, C. Carabajal, B. Csatho, J. Danielson, D. Gesch, C. Grohmann, L. Hawker, M. Huber, Z. Li, C. Lopez, J-P. Muller , S. Riazanoff, A. van Niekerk

CoLead: P. Guth, I. Florinsky

Main tasks:

- Review existing terminology chapter, compare against other resources e.g. ASPRS DEM Users Manual (DeliveryDate: 2020/09/15)
- Review analytics chapter and check for consistency wrt terminology (DD: 2020/09/15)
- Contribute to the algorithm development and check consistency of algorithms wrt to analytics (DD: 2020/10/15)

*for colour codes of names see slide 4

Group2: algorithms and software

Participants(14)*: G. Amatulli, B. Bookhagen, J. Bamber, B. Csatho, P. Guth, L. Hawker, Z. Li, C. Lopez, S. Muehlbauer, E. Nicolas, C. Qin , S. Riazanoff

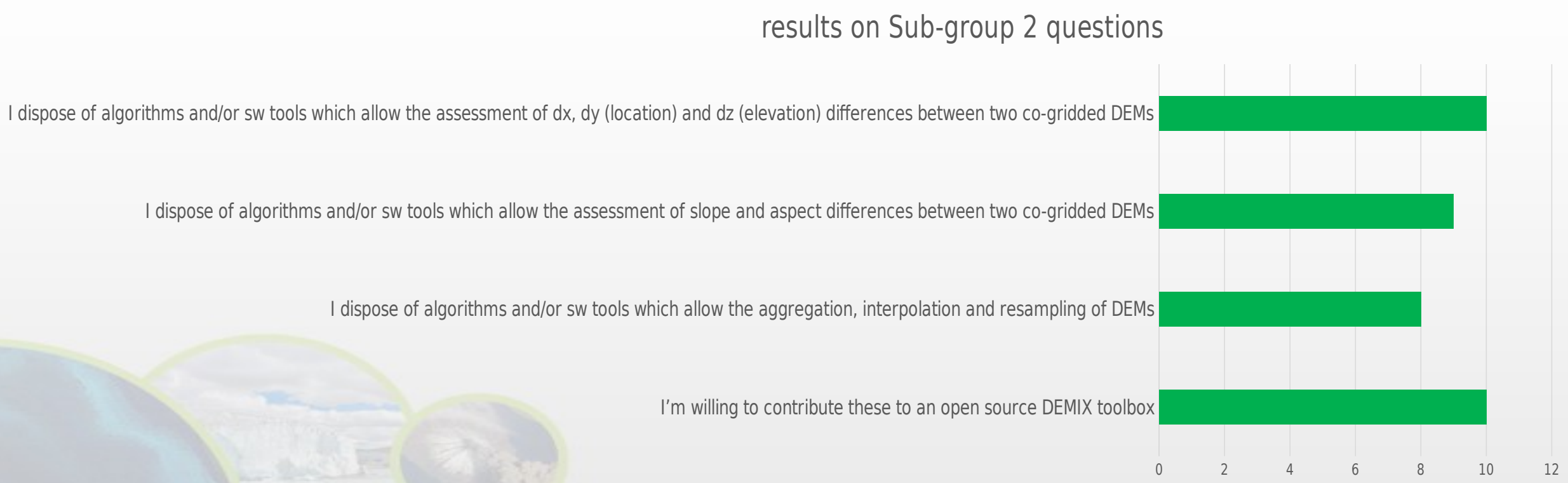
CoLead: C. Bielski, C. Grohmann

Main tasks:

- review existing metrics chapter, complement where necessary (DD: 2020/09/15)
- prepare an inventory of available sw tools (functionality, restrictions, language, etc.)(DD: 2020/09/15)
- propose aggregation methods of metrics for reporting (DD: 2020/10/15)
- check compatibility of algorithms and sw with terminology and analytical basis (DD: 2020/10/15)
- assess feasibility of a common open-source toolbox and propose way forward (DD: 2020/11/15)

*for colour codes of names see slide 4

Group2: algorithms and software



Group 3: platforms and processing

Participants(11)*: C. Albinet, G. Amatulli, B. Bookhagen, C. Bielski, C. Carabajal, D. Gesch, F. Gascon, M. Hofton, M. Huber, J-P. Muller

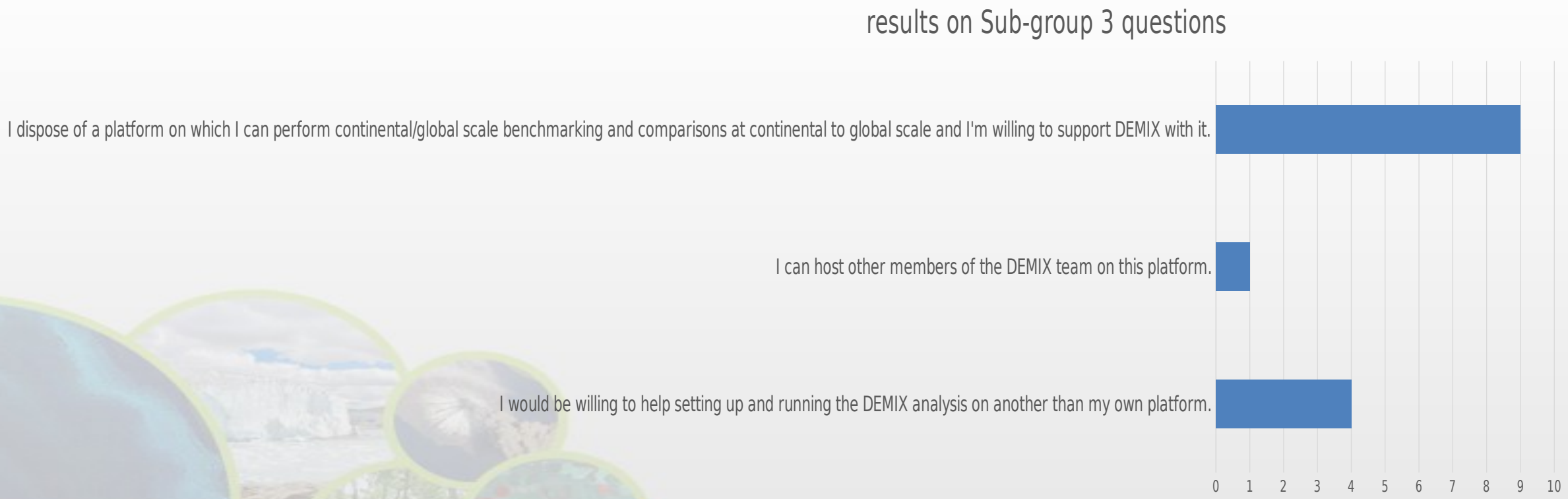
CoLead: Z. Li, S. Riazanoff

Main tasks:

- lay out a viable workshare as a mix of products and geographical zones (DD: 2020/09/15)
- check compatibility of existing tools with methods set out by group 2 (DD: 2020/09/15)
- make available the applicable (f&o) DEM and validation data (DD: 2020/09/15)
- support the implementation of compatible tools where not already available (DD: 2020/10/15)
- perform test rounds with pilot areas and compare results (DD: 2020/11/15)
- run benchmarking (DGEG Level1) (DD: 2020/12/15)

*for colour codes of names see slide 4

Group 3: platforms and processing



Digital Elevation Inter-Comparison (DEMIX)

- Scope and Products to be included: All datasets which have an at least continental coverage and are available under a free & open data policy, including latest versions of
  - NASADEM (NASA, JPL, most recent decent of the SRTM product line, eventually also NGA'sTFRMv4)
  - AW3D30 (JAXA, f&o version of the Japanese ALOS based global DEM)
  - ASTER-GDEM, (METI, NASA)
  - TanDEM-X90, (DLR, free version for scientific of the TanDEM-X mission)
  - Copernicus DEM90 (EC/ESA, f&o version of WorldDEM™, the commercial version of TanDEM-X procured by Airbus)

What is a DEM? … and what not?

Unambiguous and shared terminology is a prerequisite of any joint endeavor (since Babylonian times)

- Definition: DEM (digital *elevation** model): general term for a *georectified grid*-based digital representation for a *topographic surface*, composed of *elevations* on the Earth.

  Consequently, DEMs are commonly referred to as having 2.5 dimensions (2.5D) and not three dimensions (3D). Alternative structures for digital topography, like triangulated irregular networks (TINs), contours, and point clouds **are not DEMs** because they are not grids. Digital bathymetry is a DEM, as the collection method with sonar is not fundamentally different from the lidar, optical, or radar collections on land, which themselves have different characteristics, and the gridded representations are similar and must increasingly be integrated for coastal models.

*these *terms* have their own definitions!

What are the most important features of a DEM?

Before talking about quality we must fix the metrics which characterize our subject. Three main groups were identified:

1. Linear differences (or error) statistics such as RMSE, LE90, CE90, Median and normalized median absolute difference (NMAD), separately for horizontal and vertical directions, by e.g. slope, land cover, and not generalized over more than 10^6-10^7 values.
2. Morphological descriptors, e.g. differences in slope, aspect, roughness and in their distribution. Complex morphological metrics like number of peaks and pits, length of ridges and troughs, number of outliers (spikes), consistency of stream networks.
3. Other: Autocorrelation length, SNR,
4. Non quantitative: Completeness and reliability of Metadata

What is **consistency** or **coherence**?

So far **consistency** and **coherence** are rather qualitative terms which are however frequently and interchangeably used as quality criteria.

- Need for a (better) definition!
- and if possible quantification!

Which is the better DEM?

Assessment of DEMs requires either to establish their absolute accuracy or to compare them with each other (relative)

- Validation requires a reference which is considerably higher in accuracy than the validated data set
- Benchmarking can be performed between any compatible data set
- If multiple data sets are to be benchmarked against each other it might however be desirable to use one as reference


Thanks!
SRTM = 1687.0 m.
ALOS = 1631.0 m.
Difference = 56.0
Ritzingen
Blitzingen
Niederwald
Fieschertal
Ernen

DEMIX participants, suggested acronyms and email

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