Earth Surf. Dynam. Discuss.,
https://doi.org/10.5194/esurf-2018-12-RC2, 2018

Earth Surface Dynamics Discussions

Interactive comment on "How to explain variations in sea cliff erosion rates? Insights from a literature synthesis" *by* Mélody Prémaillonet al.

C. Moses (Referee)

c.moses@sussex.ac.uk

Received and published: 29 March 2018

Overview comments: The paper seeks to explain variations in sea cliff erosion rates, using a global database populated by cliff erosion rate data derived from scientific literature and national databases up to 2016. Marine and climate forcing factors are derived from models and data reanalysis in order to provide a uniformity of approach. Sea cliff lithological factors are characterised using the Hoek and Brown (1997) classification system, again in order to provide a uniform approach, and cliff height is been extracted from the 8" global DEM. The paper represents the most comprehensive collation and analyses of rock coast erosion data to date and is scientifically important in two key respects. First, it provides analyses and insights into key factors controlling rock coast erosion rates on a global scale. Second, it illustrates limitations of existing

studies/current gaps in knowledge in assessing the relative importance of lithological, subaerial and marine forcing factors. In so doing, it helps to set a new research agenda for the study of rock coast erosion dynamics and this could usefully be made clearer in the paper.

The conclusion is that rock resistance, rather than rock type per se, is a key influencing factor and that the number of frost days influence the erosion rates of only weak rock sea cliffs. Rainfall amount and marine forcing factors show no significant relationships with cliff erosion rates. This is interesting in that there is a keen debate on the importance of subaerial (weathering) versus marine forcing factors in the development of rock shore platforms, which are an integral component of the rock coast system. This debate extends also to cliffs. For example, it is known on the Chalk of SE England that most rockfalls occur during the winter (May, 1971; Hutchinson, 1972) associated with increased rainfall and lower temperatures. Lawrence et al. (2013) assess the contribution of sea water weakening to chalk cliff instability and Lageat et al. (2006) and Henaff et al. (2002) assess the influence of elevated groundwater and rock saturation associated with long periods of antecedent rainfall. Although this study assesses cliff erosion rates in relation to temperature variation, frost frequency and amount of rainfall, it would be interesting to give some consideration to duration of rainfall (as a proxy for degree of rock saturation) to see if this is important.

More specific comments: Page 1 Line 3: 'It turns into variable erosion rates' suggest amending this to 'Cliff erosion rates are highly variable over 4 orders . . . . . ' in order to improve clarity. Are these figures from the database? If so, it may be better to give the variation in rates after describing the database. Line 6: – it would be helpful to be clear about what is meant by erosion rate – rate of cliff-top retreat, volume of material removed? Is GlobR2C2 populated entirely with erosion rate data from publications? How is the Cerema national database incorporated? There is mention in the paper of the Eurosion database – is this also incorporated into GlobR2C2? The Eurosion database is being updated and extended by the Emodnet Geology project

and so there are new data, that the authors may wish to investigate, available at http://www.emodnet-geology.eu/data-products/ (coastal behaviour). I am wondering if the title is an accurate reflection of the database if it incorporates more than the scientific published literature. Line 12: space between numerical value and SI symbol (throughout). Line 13: Sentence beginning 'every other relations. . ..' Could be recast to improve clarity.

Line 18:. . . fundamental driver – suggest adding 'of cliff retreat'. Line 19: Remove " after limited. It would be helpful, in the introduction, to provide more context on the role of rock shore platforms in the dynamics of coastal rock cliff erosion dynamics. Although shore platforms are mentioned it would be helpful, for readers not familiar with the rock coast system, to set the context by outlining all of the key components. For example, Fig. 2 could usefully show the shore platform. Page 2 Line 12: Sentence beginning 'Climate through. . .' remove the s from precipitations; prepare for it? Fig. 2 is referred to on line 16 and Fig. 5 on line 29 – Figs. 3 and 4 are not mentioned – refer to Figs in order throughout. Par beginning line 19: 'they are inconclusive because. . .' it would be helpful to have more context on the focus of these papers as they did not necessarily set out to analyse the contribution of each factor etc., perhaps due to data limitations? Par beginning line 29: it would be helpful to have some more detail on the type of study – what they measure, degree of accuracy, limitations etc. (historical maps, air photos, TLS, Lidar, photogrammetry, use of drones). Page 3 Line 1: 'high time resolution of up to 20 minutes' – it would be helpful to say what this high temporal resolution data records – removal of individual small rock fragments from the cliff face? Line 5: 'study their relative efficiency'- not clear how this relates to linking erosion rates and external forcings – perhaps amend sentence to improve clarity. Line 8: 'reduces information to the largest common denominator' – yes, this may be a limitation but it is also an opportunity! It would be helpful if the paper can set out, on the basis of this study, a clear statement of the scale/resolution of study and also the important factors to record for future studies of rock coast erosion – in order to improve the resolution of the GlobR2C2 in the future.

Line 18-19: it woud be helpful to say here what databases are used. Line 27-30: sentence beginning 'It helps. . .' and the next sentence could be made clearer. For example, I am wondering if the conceptual exercise really minimises data capture? Should it be 'maximise data capture and minimise data redundancy'? Page 4 Line 8: three types of sources?; are the data from scientific papers really raw data? Not clear what is meant by gridded data and tidy covariates. Par beginning line 9: this could usefully be expanded to aid explanation. For example, is the method of measuring cliff erosion recorded and the time period over which it is measured? Figures will need to be re-numbered in order to ensure that they are referred to in the correct order. Section 2.3.2 Cliff lithology and description: it would be interesting to know how you have dealt with composite cliffs in the database – for example, a composite cliff may contain materials of different hardness/resistance at the toe and so marine forcing may be of reduced importance in such cases. Page 5 Line 2 – 4: meaning unclear and it would be helpful to recast these two sentences to improve clarity. Line 7: not clear what is meant by 'a primary key'. Line 10: etc. – please specify what is included in the etc.! Line 14: suggest amending to 'estimates. . . of volume loss to precise measurements using, for example, lidar. . ..' Line 15: suggest amending to '(iii) spatial extent along the coast. . ..' Line 23: not clear what is meant by 'the oldest method is rockfall inventory' Line 29: suggest amending to 'but with two caveats' Line 31: it would be helpful to say how data were 'specifically treated' beforehand in order to prevent bias. Page 6 Line 3: is it the case that faster eroding cliffs are more often sampled – are more densely populated cliffs not also more often sampled by regional/national authorities? Line 7: suggest amending to '. . .that quality of photographs limits. . ..' Line 11: not clear what is meant by 'and produce wetting drying cycles' – does this mean, influences the vertical extent of wetting drying cycles on the cliff face? How about any potential influence on groundwater levels in more porous rocks? Line 13-14: it would be helpful to add some explanation to the harmonics. Line 29: time steps Line 30: spelling – below. Page 7 Line 17: 'thus, 3D measures. . .' (rather than this?) Page 8 Line 12: Fig. 9 is referred to but the last Fig referred to was Fig 5 – Figs 6, 7 and 8?

Section 2.4.4: it would be helpful to have some more contextual detail on the Hoek and Brown rock resistance classification that is used in the study. Page 9. Line 6: Fig. 4 is out of synch. Line 8: suggest amend to '. . .1990s. . .for every type of method' Line 15: 6.4 km Line 26: provide the number of observations for each class rather than just one. Page 10 Line 17: '. . .amount of rainfall.' Line 27: '. . .design allows an assessment of the drivers of erosion'? Page 11 Section 4.2.1 See also Michoud et al. (2012) who estimated cliff retreat of the "Dieppe landslide": 'activated on 17–18 December 2012. . .. . . we measure a cliff retreat up to 40 m along two active scarps over 70 m wide' (p. 415). Page 12 Line 10: 'this finding reflects' (remove is) Line 29: amend TABLE Page 13 It would be helpful to have some discussion of the importance of weathering that can be drawn on for the conclusion. It would also be helpful to make some recommendations for future studies of rock coast erosion that would help to address the data gaps identified in the compilation of GlobR2C2. Figures Figure 1: suggest amend to: '. . .is similar to that. . .' Figure 2: diagram a could usefully show the shore platform; there is no mention of faulting in the cliff settings – if it is included then it would be helpful to mention it; not clear what is meant by 'aquiferous' in the continental forcing. Diagram b seems to use only half of the 58 studies that are used in the database (there are $\sim$ 23 dots on the graph). Also, it is not clear what is meant by the 'authors point of view'. It would be helpful to have some more explanation either in the caption or in the text. Figure 6: Hoek and Brown Figure 8: typo after temperature Figure 9: Woodroffe

Henaff, A., Lageat, Y., Costa, S., Plessis, E., 2002b. Modalités du recul des falaises du Pays de Caux. In: Delahaye, D., Levoy, F., Maqaire, O. (Eds.), Geomorphology: From Expert Opinion to Modelling. A Tribute to Professor Jea-Claude Flageollet, Strasbourg, pp. 225–233.Hutchinson, 1972 Lageat, Y., Hénaff, A., Costa, S., 2006. The retreat of the chalk cliffs of the Pays-de-Caux (France): erosion processes and patterns. Zeitschrift für Geomorphologie 144, 183–197. Lawrence, J.A., Mortimore, R.N., Stone, K.J. and Busby, J.P., 2013. Sea saltwater weakening of chalk and the impact on cliff instability. Geomorphology, 191, pp.14-22. May, V., 1971. The retreat of chalk

cliffs. The Geographical Journal 137, 203–206. Michoud, C., Carrea, D., Costa, S., Derron, M.H., Jaboyedoff, M., Delacourt, C., Maquaire, O., Letortu, P. and Davidson, R., 2015. Landslide detection and monitoring capability of boat-based mobile laser scanning along Dieppe coastal cliffs, Normandy. Landslides, 12(2), pp.403-418.

Interactive comment on Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2018-12, 2018.