

Interactive comment on “Use of ENVISAT ASAR Global Monitoring Mode to complement optical data in the mapping of rapid broad-scale flooding in Pakistan” by D. O’Grady et al.

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Received and published: 5 August 2011

1. We would like to thank the reviewer for his constructive and useful comments and advice. We address the comments in the order that they appear, as follows:
2. *from what I read, the topic is not entirely new and the authors are in fact just using a type of change detection method, which is pretty common in most software packages nowadays (or I have not understood correctly, please explain better then).*

Two problems are addressed with two variations in method, the combination of
C3245

which we have not come across in other work, though we are open to advice to the contrary:

- In those situations where floodwaters coincide with dry desert areas, the low backscatter response due to absorption in dry sand can be confused with the low backscatter response due to specular reflection on the surface of open water. This issue is mitigated by deducting a temporally close image taken from the same orbit track, to offset those regions of consistent value, whilst at the same time mitigating the effects of incidence angle on the values across the swath, the latter being an advantageous "side-effect" of secondary consideration.
 - The probability density function of backscatter values for flooded and non-flooded areas overlap somewhat at the boundary between the two classes, causing relatively high ambiguity and therefore inaccuracy at those transitions. It is for this reason that the region-growing algorithm was used to determine the boundary between the classes.
3. *Furthermore, the authors speak of systematic and emergency response, while also indicating there are many region dependent factors that should be taken into account (as far as the ASAR signal is concerned). The article would be more unique if a window towards systematic global use would be made. When trying to do things more systematically, one should try to minimize these region dependent factors. This would be good extra topic for the discussion.*

This comment is indeed valid and very topical for us, as the problem does form the subject of an upcoming submission. The painful truth is that there are indeed many region-dependent factors affecting the precise method one may use to discriminate flood extents using radar data. We would like for nothing more than to be able to draw a high temporal frequency global flood map from the data

systematically. This can only be made possible by taking into account vegetation growth, dihedral and multihedral interactions between semi-submerged trees etc. and, perhaps above all, surface "wetness", whether it be on the ground or even, with C-band, at the canopy level. Another factor, the high response on open water due to Bragg Resonance under certain wind conditions, perhaps places a permanent limitation on the use of radar as a definitive systematic identifier of flood waters.

4. *Also, while in the theory explaining there is a minimal difference for environmental conditions, in the case study there could be differences because of vegetation (p5779).*

Differences in backscatter due to variation in vegetation will be experienced, this is true. However, such differences result mainly in the rise and fall of values within a range which is still of a relatively high backscatter value, perhaps between absolute values of -4 and -10 dB, which are therefore unlikely to be mistakenly classified as water. As mentioned, it is those very dry regions, devoid of much vegetation, which are being eliminated by this method.

5. *[minor] Explain term Digital Number: ASAR products are provided as radar brightness and pixel values correspond to amplitude information. Therefore, for detected products: $DN_{i,j}$ = pixel value at line and sample "i,j"...*

We propose that we add the following to the front of line 18 on page 5775 to address this comment:

Digital Numbers (DN) in ASAR detected products correspond to brightness amplitude.

6. *[minor] p.5774: "The incidence angles and the DEM were then used to calculate local incidence angles () for each pixel. Both the orthorec-*
C3247

tified Digital Number (DN) and surfaces were then transformed to geographic coordinates by third order polynomial transformation."Could the authors explain if the calculation from incidence angle to local incidence angle would change whether one is using ascending or descending data and thus if it is possible to done systematically?

The local incidence angle takes into account terrain orientation at the target and therefore will, of course, change with ascending and descending orbits. All such calculations become systematic to some extent, in that we have written scripts to draw the required data (slant range times, incidence angles, tie points) from the headers, and the calculations can therefore be done on a multi-node high performance computing network. Individual processing is very necessary, especially in light of the gradual change in orbit alignment now taking place with the Envisat satellite.

7. *starting on page 5775, the authors say: "Given a reasonably close temporal separation of images, and in the absence of flooding, the environmental conditions, and therefore the nature of F , are similar for a given pixel in the target image to the corresponding pixel in the dry baseline offset. Converting to decibels and deducting the base backscatter values formulae (3) and (4)... This assumes that the difference in between the two images is negligible." This of course is true for a short difference in time, but the function F is heavily changing with the type of land cover. Where there is e.g. agricultural use, the time between two passings can be up to a week, in which a crop can grow and change the function F heavily, also causing the backscatter of the C-band signal to change. I would be very interested in the difference between the different seasons or months of this function and the deviations occurring from it.*

This is very true, but remember that we are really only trying to eliminate two

effects, and to this end I would refer you to our response to Item 2 above. We are not trying to detect change in vegetation, but rather to reduce ambiguity in the signal. In a flooded matrix, our only interest in the vegetation itself is whether it is totally submerged by the flood waters or is emergent. In non-flooded areas, if there are in fact changes in vegetation, then such differences will manifest as they would when observing a single image, but at least we ensure that areas of homogeneity in terms of backscatter response across the swath actually appear homogeneous in the image.

8. *Also, the procedure in 3.4.2 (and thus the end of 3.4.1) is not entirely clear. Please explain. Have the authors taken the exact same image (e.g. the 35 day revisit image) or another image with a different angle of incidence? Both are possible, but both have different implications on the backscatter and relation to the angle-environment-backscatter relation.*

We have indeed taken the very same frame from the previous 35-day orbit cycle (i.e. the same orbit track) where possible. This ensures that corresponding pixels from the two dates have almost the same incidence angle. The orbit cycles and tracks are explicitly listed in Tables 2 and 3, pp.5793.

9. *Paragraph 5.4 Overall, the paragraph now reads like a piece of extra information that might just as well be left out. Do the authors want to say that there is a possible combination between the flood data and the soil moisture datasets to be used in hydrological? If yes, how, what should be the way to go?*

We apologize if this paragraph may seem disjointed somewhat from the main theme. It was merely our intention to point out that GM data has perhaps proven more useful than may have originally been envisaged, in light of the fact that it was foreseen predominantly as a tool to monitor sea ice. In our experience, those

C3249

who are used to the beautifully fine resolutions offered by other modes of ASAR or other radar sensors are inclined to scoff at the coarse spatial resolution of GM mode data, and we are moved to point out that some benefits may be derived from its temporal resolution, as demonstrated not only by our work, but by the work of others. We do see your point, however, and therefore propose either to remove the offending paragraph, or to explain it more in terms of what we are saying here.

10. *Furthermore, this paragraph looks a bit incomplete. For example, at p5786, "...also offer a unique opportunity to retrieve soil moisture at a global scale with a spatial resolution on the order of 1 km (Pathe et al., 2009)." Why don't the authors mention the work of the SHARE initiative, a.o. Doubkova, Bartsch, Wagner, as well as some Australian CSIRO scientists Ticehurst and van Dijk?*

We see your point. Our reference to Pathe's paper was one example of several great papers produced by him and his colleagues under Professor Wagner. We refer to our response to the previous comment. Should it be decided that it would be better to remove this paragraph, then this last comment is superseded. Otherwise, we propose to include those very worthy references as suggested.