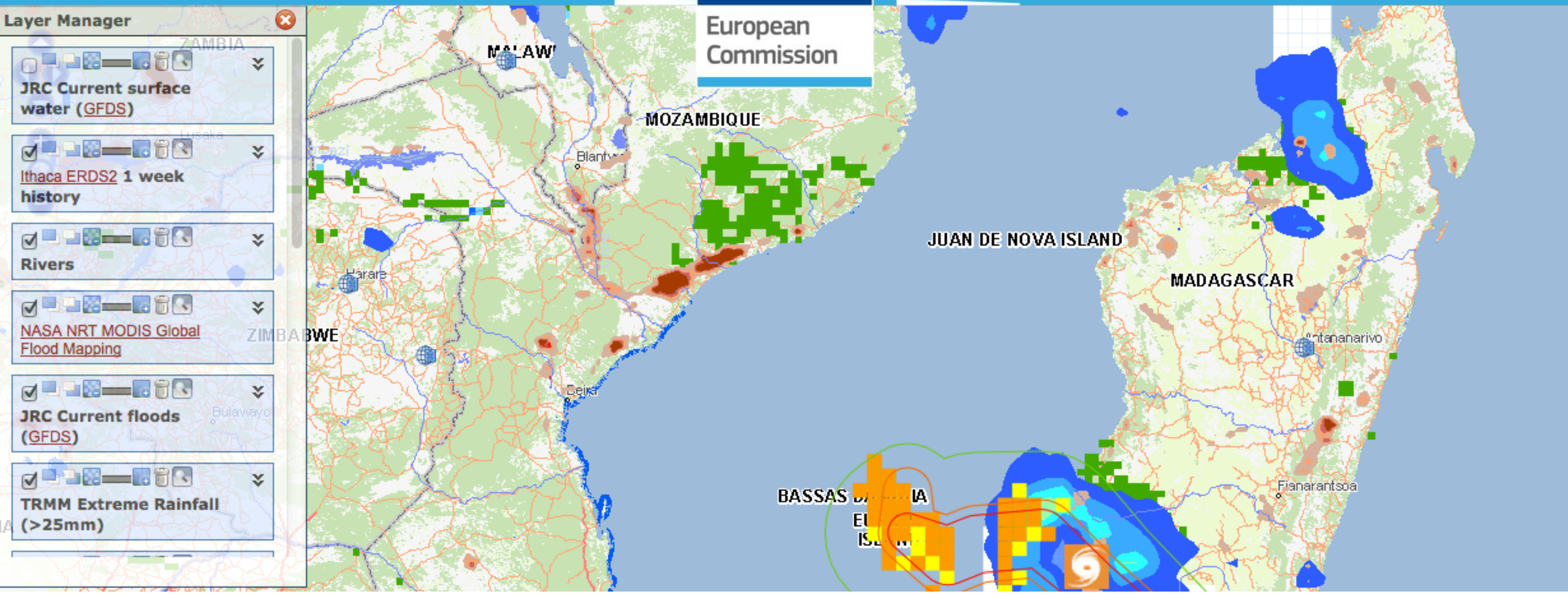

JRC TECHNICAL REPORTS

Global Integrated Flood Map

A collaborative product of the Global Flood Working Group

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2013

Report EUR 25892 EN

Joint Research Centre

European Commission
Joint Research Centre
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This publication is a Reference Report by the Joint Research Centre of the European Commission.

JRC80255

EUR 25892 EN

ISBN 978-92-79-29021-3 (pdf)

ISSN 1831-9424 (online)

doi: 10.2788/8655

Luxembourg: Publications Office of the European Union, 2013

Printed in Italy

Abstract

The Integrated Global Flood Map is a demonstration of the power of combining existing systems to create added value. With increasing observation and modelling capacity, scientists are now able to produce relevant information on flood disasters more rapidly and with sufficient accuracy and precision for a variety of humanitarian response tasks. A number of prototype or pre-operational systems were integrated, each with their own shortcoming and uncertainties, but also with their strengths and uniqueness. Together, they allow analysts to get a clear situational picture of major floods in the world.

Table of Contents

Introduction

With increasing observation and modelling capacity, scientists are now able to produce relevant information on flood disasters more rapidly and with sufficient accuracy and precision for a variety of humanitarian response tasks. Several research groups across the world have set-up pre-operational or operational monitoring systems as an outcome of their research. Since floods are complex phenomena that affect societies in many different ways, there is not one system that can completely meet all flood emergency and flood mitigation information needs. Some systems forecast flood arrival, but do not map the actual flood extent. Other systems produce detailed flood maps, but only when there is no cloud cover. Still other systems provide observations independent of cloud cover, but with low spatial resolution. And also mass media and social media provide information on floods, but not in a consistent and unbiased way. However, the combined information of all these systems can be used by analysts to create a detailed, comprehensive and rich situational picture before, during and after the floods. This provides not only better response capabilities, but increased ability to predict, plan for, and respond to future events.

This document describes a pilot project, the Global Integrated Flood Map, that integrates a number of existing pre-operational systems. The work was done in the context of the Global Flood Working Group, which initiated as a collaboration between the Joint Research Centre and the Dartmouth Flood Observatory. With annual international workshops, the group's objective is to advance the state of the art of near-real time global flood information. The initiative is supported by the Global Disaster Alert and Coordination System (GDACS), which is a cooperation framework between the United Nations, the European Commission and disaster managers and organizations worldwide to improve alerts, information exchange and coordination in the first phase after major sudden-onset disasters.

The Global Flood Working Group is an open group of academia, research institutes, practitioners, public and private organizations active in the field of flood risk and emergency management. The core group consists of organizations interested in bridging the gap between science and operations. This consists mainly of a dialogue between scientists and users whereby (1) scientists are dedicated to adapting scientific systems to the needs of emergency managers and (2) practitioners are willing to adapt and adjust existing emergency workflows to include new systems and data.

At this early stage, the Global Integrated Flood Map is not meant as an application ready for use by untrained practitioners. Instead, it is a proof of concept of how visual integration of information can enrich the situational picture for trained users. More work is needed to combine relevant information for specific user needs, be it risk assessments, early warning or post-disaster needs assessments. Use cases also vary for international organisations (such as the European Commission Office for Humanitarian Aid, the United Nations Office for the Coordination of Humanitarian Affairs, the World Bank Global Facility for Disaster Reduction and Recovery) or affected governments or businesses (insurance and reinsurance).

This document describes the steps taken to process information from contribution systems to integrate them visually. The basic approach is to (1) convert data and services into OGC compliant web map services and (2) co-visualize them using a web map client (OpenLayers in this case). Using a similar approach, other organisations can build their own integrated product dedicated to specific user needs.

Because of the voluntary and informal contribution of participating organisations, it must be noted that the pre-operational services used for this document may be discontinued or changed.

Integrated Global Flood Map
http://dma.jrc.it/map/?application=floods

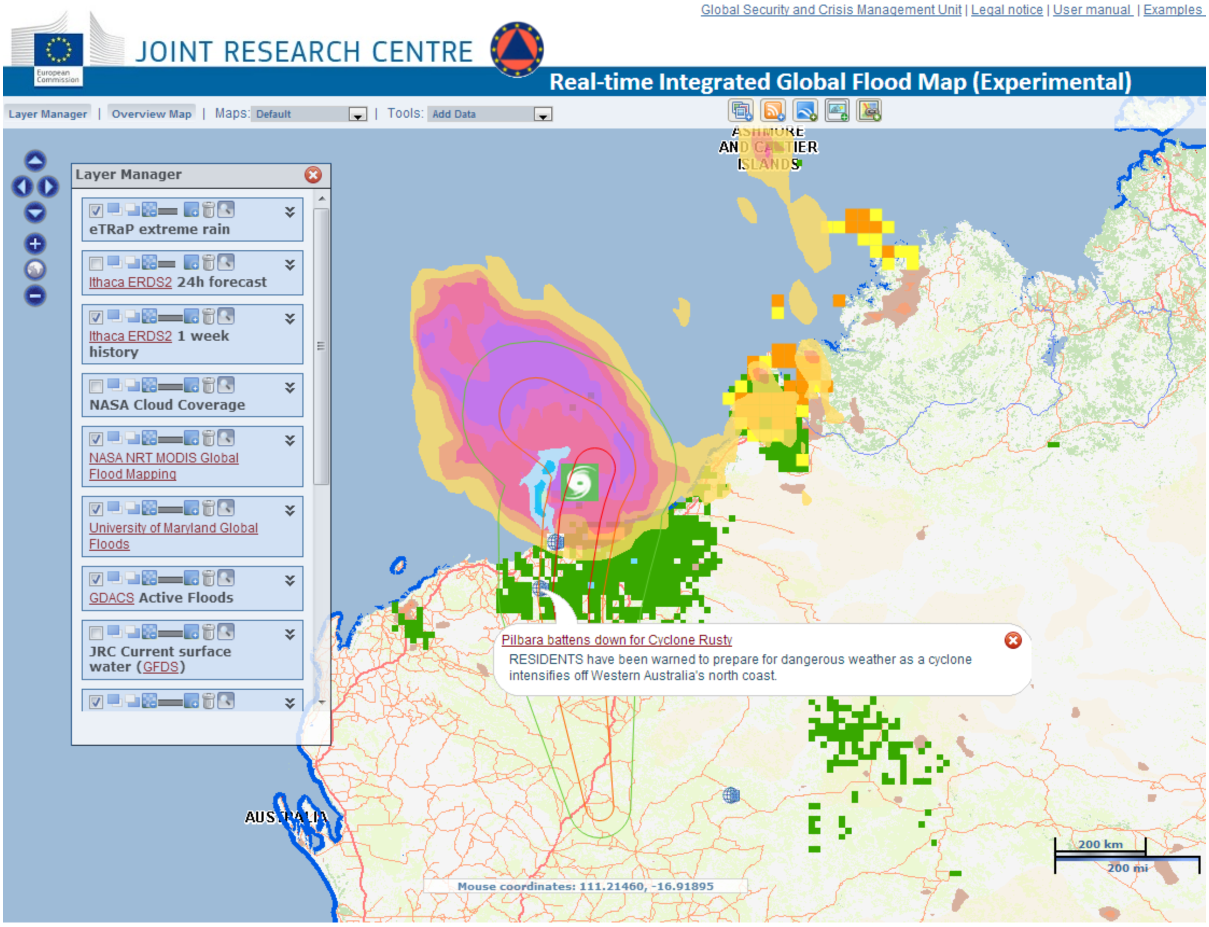

Figure 1. Snapshot of cyclone Rusty making landfall on 26 February 2013.

Integrated Flood Map

Main data layers

The integrated flood map shows a collection of layers from different sources. When all layers are active, the picture is quite confusing. It mixes observations with forecasts, it has rainfall datasets and flood datasets, it has datasets at widely different scales.

Nevertheless, even a simple co-visualisation provides a powerful tool for analysts to get situational awareness just before, during and after major floods. When serious floods occur, all information sources typically have content, and they confirm or disprove each other. This provides a way for the analyst to gauge uncertainty and accuracy of information.

The main information layers are illustrated below, with their respective legends. Once the analyst is used to the legend, the interpretation of the map is easier. Layers can be turned on and off, and can be made transparent. Point layers (GeoRSS or KML) are clickable and provide additional information (such as time series graphs or news articles).

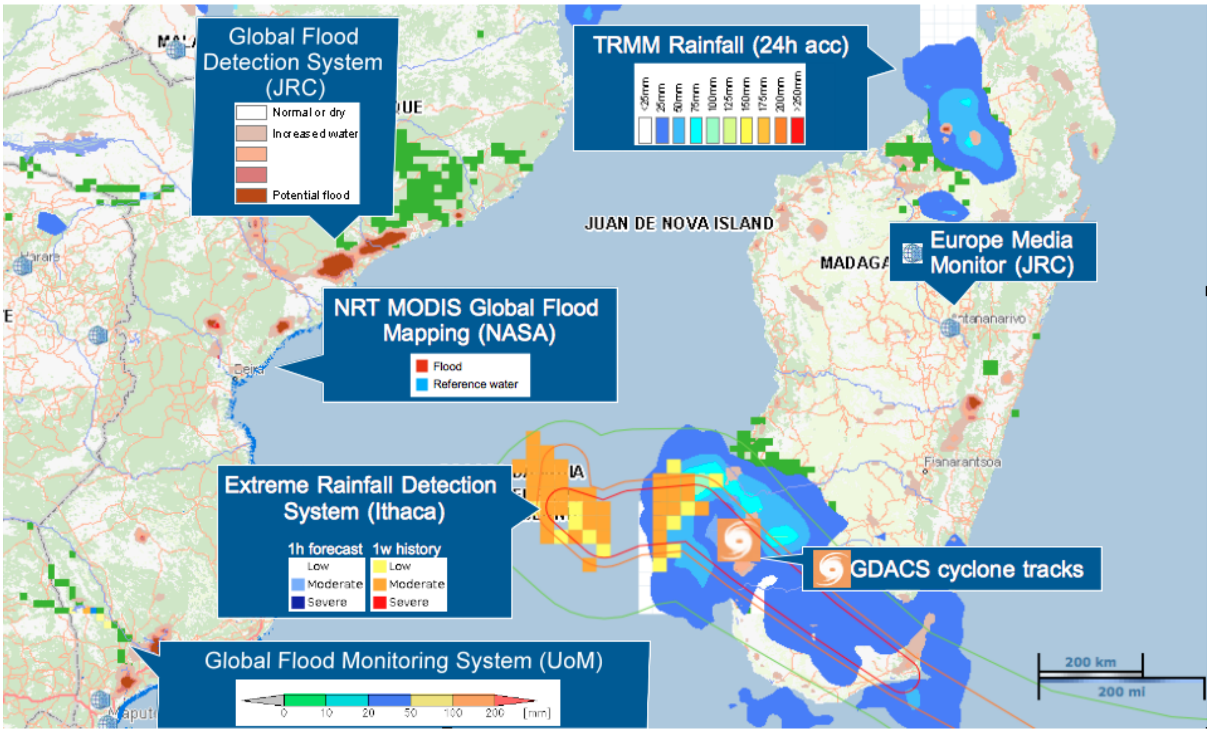

Figure 2. Main layers in the integrated flood map.

The map only shows the latest data, presumably near real-time, of each system. It can be considered as the most current knowledge of the flood situation and forecast. For historical or archived information, individual systems must be consulted.

For specific emergency management tasks, layers can be combined and integrated in more relevant ways, with symbology that is meaningful for the user and configurations that are tailored to an organisation’s need.

Reliability and validation

The Integrated Global Flood Map as well as most of the systems providing data are experimental or pre-operational. The accuracy and reliability of the individual data layers and the integrated view must be carefully considered. The participating systems were selected based on interest in participation (expressed during Global Flood Working Group workshops), availability of data and services and demonstrated added value in recent emergencies. The latter evaluation was performed by JRC by its operational disaster monitoring team.

However, by including a system in the Integrated Global Flood Map, JRC makes no statements on overall reliability and accuracy. This is the topic of coordinated further research and development.

Implementation framework

The chosen implementation framework is OpenLayers, OpenLayers is a JavaScript library for displaying map data in most modern web browsers, with no server-side dependencies. OpenLayers implements a JavaScript API for building rich web-based geographic applications, similar to the Google Maps APIs. More information is available at http://openlayers.org.

OpenLayers is built to read many geospatial formats, including:

- OGC Web Map Services
- GeoRSS and KML
- Tiling schemes

JRC has built a flexible mash-up environment built on OpenLayers. The JRC Crisis Map (http://dma.jrc.it/map) supports many mapping requirements of situation rooms operating in the context of global security. It provides tools for finding a place (gazetteer), finding the best available base map of a crisis area, displaying own data on a map, displaying third party data on a map (e.g. scientific data, media reports, social media), adding comments or data to a map, collaborative mapping and saving a mash-up as a map application. A user manual is available at http://dma.jrc.it/map/Critech_WebMapViewer.pdf.

Forecasting systems

When only forecasting layers are switched on, the forecasts can be confronted with each other. In the example below, tropical cyclone HARUNA just made landfall in Madagascar, and floods are to be expected. Ithaca's ERDS (yellow, orange pixels at ¼ degree = past week; white, blue at 1 degree = 24h forecast), UMD GFMS (green to red pixels at 1/8 degree), NASA TRMM rainfall (1/8 degree interpolated with cubic convolution) and NOAA's eTRaP products (ensemble tropical rainfall potential, processed by JRC) are shown.

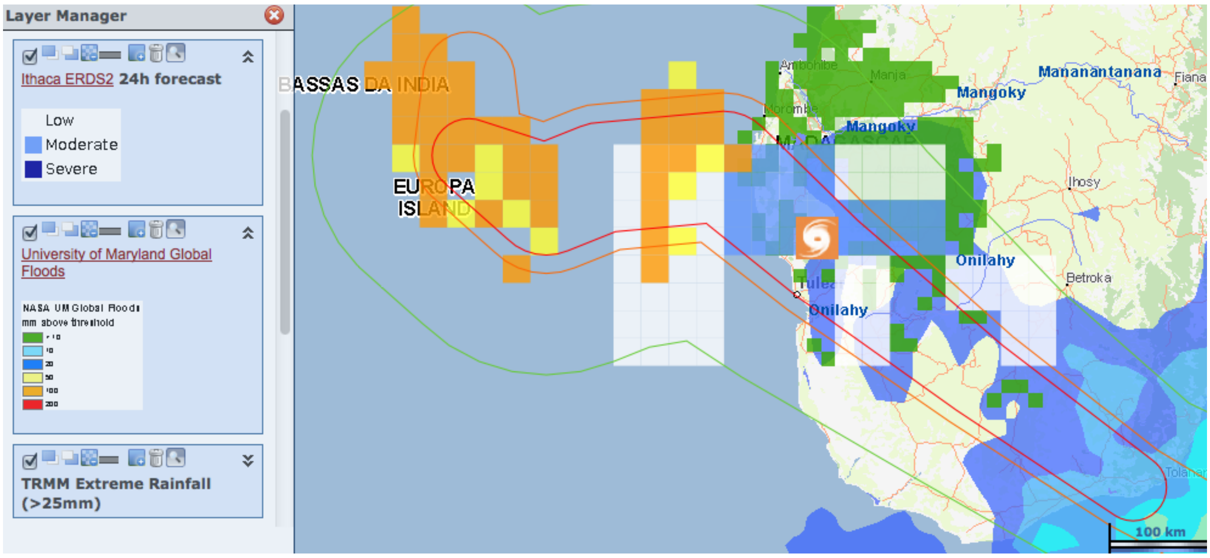

Figure 3. Ithaca's ERDS, UoM GFMS, NASA TRMM rainfall and GDACS cyclone tracks on 23 February 2013.

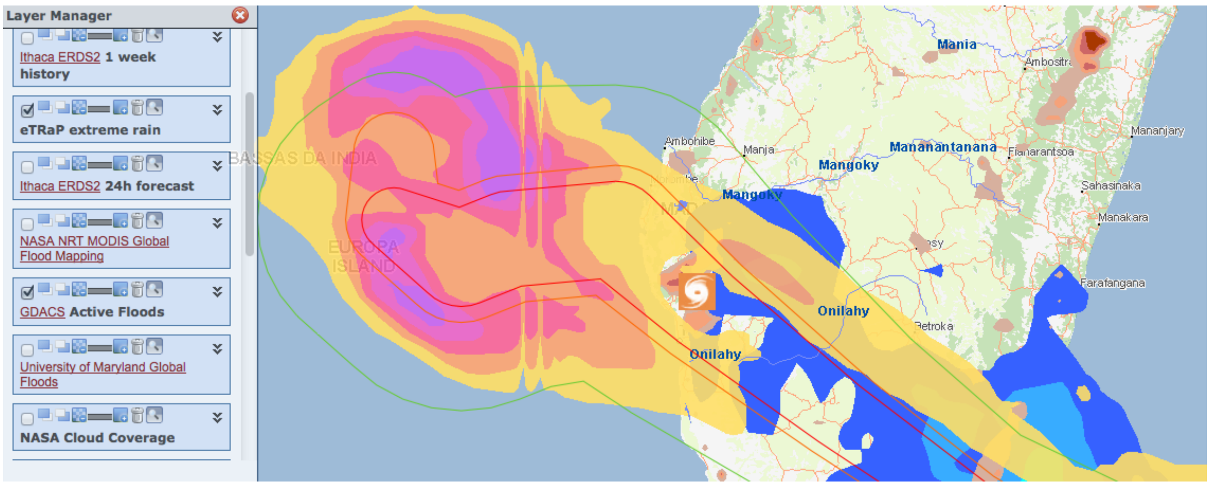

Figure 4. NOAA eTRaP and NASA TRMM rainfall and GDACS cyclone tracks on 23 February 2013.

Flood observation and mapping

For flood observation and extent mapping, optical high resolution data is most appropriate, and in particular MODIS data. MODIS based systems are available by NASA/DFO and DFO is developing a new 14-day composite product. The drawback is that optical systems don't have data with cloud cover, which is often the case at the early stages of flood events. The 14 day composite product solves cloud cover issues to a large extent for protracted floods. Higher resolution sensors don't have continuous data streams and must be tasked to have images. NASA GSFC has an experimental sensorweb system available, but it is as of now not integrated in the Integrated Flood Map. Also VHR images from UNOSAT, the Space Charted, GMES ERS, Sentinel and other space programmes could be useful.

Microwave remote sensing is less influenced by clouds and provides an alternative to optical flood monitoring. Active radar with high resolution is also not readily available: most systems need to be tasked and provide data on request in the space programmes previously mentioned. System based on passive microwave sensing, such as the Global Flood Detection System, provide continuous (if low resolution) flood maps.

The image below has all observation layers turned on. One can compare the flood waters in the upper Zambezi on 23 February 2013 between GFDS and MODIS. GFDS has two products: signal (proportional to percentage of pixel covered with water) and magnitude (anomaly of today's value with a 6 year average). The signal can be considered as a flood extent map, while the magnitude shows areas that are not usually flooded.

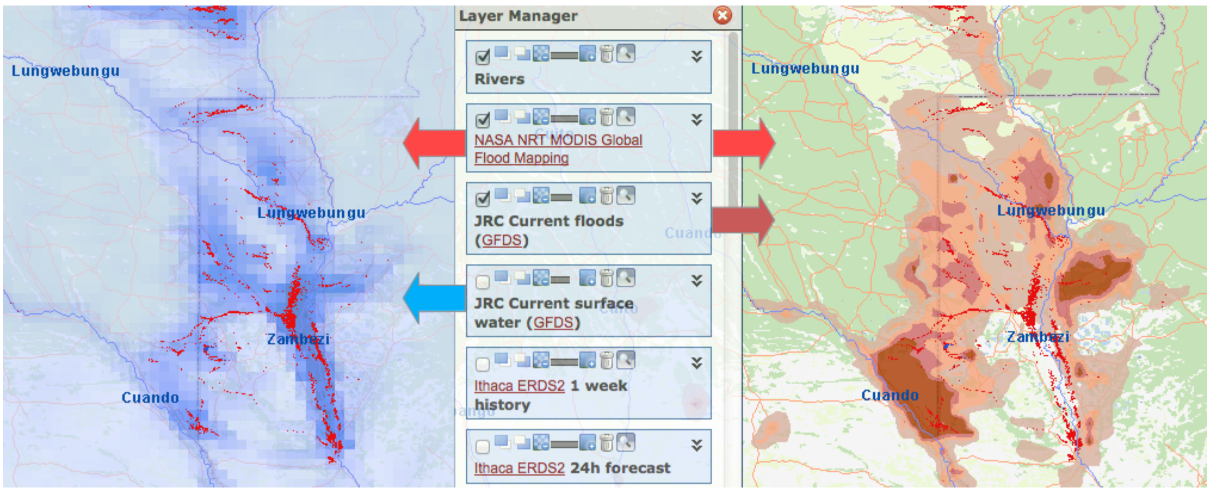

Figure 5. Integrated Map with observation layers shown, Upper Zambezi, 23 February 2013. Left: GFDS signal (surface water) and MODIS; left GFDS magnitude (anomalies, i.e. floods) and MODIS.

System description

Global Flood Detection System (JRC)

System description

The Global Flood Detection System monitors floods worldwide using near-real time satellite data. Surface water extent is observed using passive microwave remote sensing (AMSR-E and TRMM sensors). When surface water increases significantly (anomalies with probability of less than 99.5%), the system flags it as a flood. Time series are calculated in more than 10000 monitoring areas, along with small scale flood maps and animations.

Brightness temperature data at 36.5 or 37Ghz is downloaded at JRC, resampled (using a nearest neighbour approach) and mosaicked in daily grids with global coverage (see De Groeve and Riva, 2009 for a detailed description of the data processing steps). The result is global grid (4000 by 2000 pixels) of brightness temperature data, available by date. The data of the current day is recalculated whenever new swath data is available. Flood signals are calculated as soon as new data is available. Using the local 95 percentile in a window of 7x7 pixels as the calibration temperature, the signal (M/C value) is calculated for each pixel, resulting in a "signal image". In order to distinguish between areas with permanent water (e.g. lakes or wide rivers) and areas with flood waters, we look at change in flood signal over time. Based on a time series of 7 years (2002 to 2008), anomalies are automatically detected using a method described in De Groeve et al. (2006). Since lower M/C signals generally accounts for increased water coverage, extreme events, or major floods, should represent negative anomalies in the time series of a given site. In order to detect anomalies, they first determined the reference value for normal flow, which varies for each site based on the local emissivity properties and river geometry. This reference value was calculated as the average M/C value for the site since the launch of the satellite. They then set flood level thresholds based on the statistics of the time series. Flood magnitude was defined as the number of standard deviations (sd) from the mean (avg): M = (signal – avg) / sd. Floods appear typically for anomalies of 2 (small and regular flood) or 4 (large and unusual flood).

Figure 6. Brightness temperature (left) is transformed into GFDS water signal (proportional to percentage of surface water in each pixel; middle). Comparing this to a reference value, flood anomalies are calculated as the flood magnitude (right).

Contacts

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Collaborators: Robert G. Brakenridge (Robert.Brakenridge@Colorado.edu)

Data and services

Web site	http://www.gdacs.org/flooddetection/
Data access	http://old.gdacs.org/floods/data/ for geotiffs http://old.gdacs.org/flooddetection/data.aspx?type=html&alertlevel=red&datatype=4DAYS for data feeds • type: txt, html, kml or rss • alertlevel: red, orange, green • datatype: 4DAYS or DAILY (4 day averages reduce noise but increase latency) • from/to: period of interest (format YYYYMMDD) • areaid: only select data for an area, using the GFDS identifier • siteid: only select data for an area, using the DFO identifier (deprecated) http://old.gdacs.org/flooddetection/graph.aspx?AreaId=2346 for graphs of time series for one or multiple observation areas. Various formats available. • areaid: GFDS area id or gauging station id (up to 4 ids, separated by comma) • compare: true or false. If true, the system will look for an associated GFDS/gauging site and display both graphs for the same period • from, to: date range for data (YYYY-MM-DD) • years: YYYY, up to 4 years corresponding to the areaid values • colours: up to 4 colours corresponding to the areaid values • legends: up to 4 legend texts corresponding to the areaid values • output=png: will produce only an image and no HTML page (usefull for including a graph in another web page or KML feeds) • width, height: in pixels • parameter: M (magnitude), S (signal) or F (flooded area)
Data format	Geotiffs, GeoRSS, KML, CSV
Desktop software	JRC published a GFDS Client. This software has functions to synchronize data with a local MySQL database and to visualize and analyse geotiff images. It also has automation functions for inclusion of GFDS data in workflows.

Interpretation

GFDS has two products: the signal (proportional to percentage surface water in a pixel) and the magnitude (the anomaly of the current value expressed as standard deviations from the mean). Depending on the use, either the signal or the magnitude is used.

For detection floods, the magnitude is more appropriate, since it is a measure of anomaly, scaled by the local signal variability (the standard deviation) and offset by the reference value for normal flow (the average). For measuring flood surface, mapping flood extent or comparing with optical data, the flood signal is more appropriate, since it is proportional to the surface water area.

GFDS data has three main sources of noise.

- Variations in orbit geometry: because of the simple nearest neighbour approach for resampling into a fixed grid, orbit variability will introduce noise in pixels partially covering rivers or covering small rivers.
- Extreme rain: atmospheric water does influence the GFDS signal. It can be differentiated from floods by the duration: floods give a persistent signal over 3 to 4 days minimum.
- Snow: snow gives a similar signal as water and is not filtered out in the current version.

The first two influences are reduced by taking 4 day moving averages of the data, which is the main and most used product of GFDS. All images and data streams are available in two versions: 4DAYS and DAILY, respectively the 4 day average and the daily values.

In general, GFDS is suited for monitoring and measuring large floods and less so for small floods of short duration. In particular, GFDS provides unique information for dynamic aspects of floods and for quantitative measurement of flood impact.

Integration approach

Services are available as WMS, GeoRSS and KML. The WMS is used to show signal and magnitude maps, the KML to show sites in alert, including time series.

The WMS service (and other services) is available at
http://dmarcgis.jrc.it/ArcGIS93/rest/services/GFDS/GFDS_activeDG/MapServer
http://dmarcgis.jrc.it/ArcGIS93/services/GFDS/GFDS_activeDG/MapServer/WMSServer?request=GetCapabilities&service=WMS

References

- De Groeve, T., Z. Kugler, G. R. Brakenridge, 2007. Near Real Time Flood Alerting for the Global Distaser Alert and Coordination System. Proceedings of the 4th International ISCRAM Conference (B. Van de Walle, P. Burghardt and C. Nieuwenhuis, eds.) Delft, the Netherlands, May 2007, pp.33-40. pdfDownload
- Brakenridge, G. R., Nghiem, S.V., Anderson, E., Mic, R. (2007) Orbital microwave measurement of river discharge and ice status, Water Resources Research, 43. pdfDownload.
- Kugler, Z. and T. De Groeve, 2007. The Global Flood Detection system. Office for Official Publications of the European Communities, EUR 23303 EN.pdf Download
- De Groeve, T., P. Riva, 2009. Early flood detection and mapping for humanitarian response. Proceedings of the 6th International ISCRAM Conference (J. Landgren, U. Nulden and B. Van de Walle, eds.) Gothernburg, Sweden, May 2009. pdf Download
- De Groeve, T., P. Riva, 2009. Global real-time detection of major floods using passive microwave remote sensing. Proceedings of the 33rd International Symposium on Remote Sensing of Environment Stresa, Italy, May 2009. pdf Download

Europe Media Monitor (JRC)

System description

The European Commission's Joint Research Centre (JRC) has developed a number of news aggregation and analysis systems to support EU institutions and Member State organisations. The EMM system is publicly accessible and attract up to 1,2 Million hits per day. The system was initially developed as an in-house application for the European Commission's Directorate General Communication (DG COMM) to enhance their manual media monitoring and press cutting services. Since then, EMM has become a crucial instrument in the daily work of almost all Commission services and many other public organisations.

EMM is the news gathering engine behind a number of applications, including the Global Disaster Alert and Coordination System (GDACS). EMM monitors the live web, i.e. the part of the web that has ever changing content, such as news sites, discussion sites and publications. All applications are developed, maintained and run by the JRC.

EMM automatically categorizes, clusters, translates and locates media information. EMM uses multiple news sources from around the world in 60 languages. Updated every ten minutes, the site groups related news, shows timelines and displays the biggest stories first.

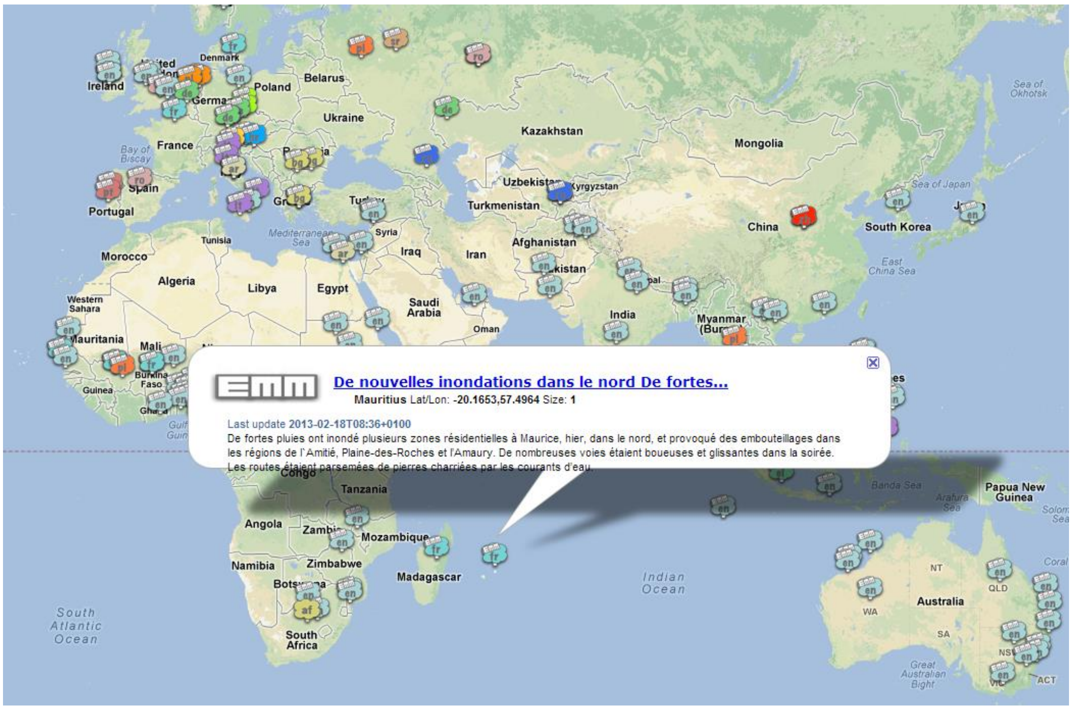

Figure 7. EMM news for flooding on 25 February 2013 showing articles by language (http://emm.newsbrief.eu/geo?format=html&type=rss&language=all&category=FloodingNew).

Contacts

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Data and services

Web site	http://emm.newsbrief.eu/NewsBrief/clusteredition/en/latest.html http://emm.newsbrief.eu/NewsBrief/alertedition/en/FloodingNew.html
Data access	http://emm.newsbrief.eu/rss?type=alert&id=FloodingNew&language=en Also available for other language and alert ids.
Data format	GeoRSS, KML

Interpretation

The most recent news articles categorized under the "flooding" category are shown. The categorization is not perfect, so there may be some irrelevant articles. However, when a flood event occurs, news is confirming satellite observations and model results, and provided additional information on impact.

Integration approach

The GeoRSS files are compatible with most map viewers. They were integrated in the OpenLayers platform.

References

- Best, Clive, et al. Europe media monitor. Technical Report EUR 22173 EN, European Commission, 2005.
- Steinberger, R., Bruno Pouliquen, and Erik Van der Goot. "An introduction to the europe media monitor family of applications." Proceedings of the Information Access in a Multilingual World-Proceedings of the SIGIR 2009 Workshop. 2009.
- Pouliquen, B., Steinberger, R., Ignat, C., & De Groeve, T. (2004, March). Geographical information recognition and visualization in texts written in various languages. In Symposium on Applied Computing: Proceedings of the 2004 ACM symposium on Applied computing (Vol. 14, No. 17, pp. 1051-1058).

DFO Surface Water Archive (DFO)

System Description

Satellite surveillance of the Earth's changing surface water

These map displays provide current surface water extent and the observed recent history of changes (2000 to present). Surface water expansions and contractions are both illustrated. The maps provide a comprehensive global record of surface water change in the late 20th and early 21rst centuries. The documented water expansions may be short-term, from inland flooding or storm surges. Or they may be long-term, from post-2000 reservoir construction and increases in rice agriculture or aquaculture. Mapped contractions may also be short-term, from temporary drought conditions. Alternatively, some contractions are progressive: for example, shrinking water bodies within drying wetlands.

In March 2013, automated daily updating is being implemented. Until updating is automated, this display will lag in time.

See also NRT Global MODIS Flood Mapping from NASA, and this link for technical information about the Survey, including hints for importing the maps into GIS. With citation of the source, this display can be further distributed and used under the Creative Commons Attribution 3.0 Unported License.

Contacts

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Collaborators: Kettner, A.J. (albert.kettner@colorado.edu)

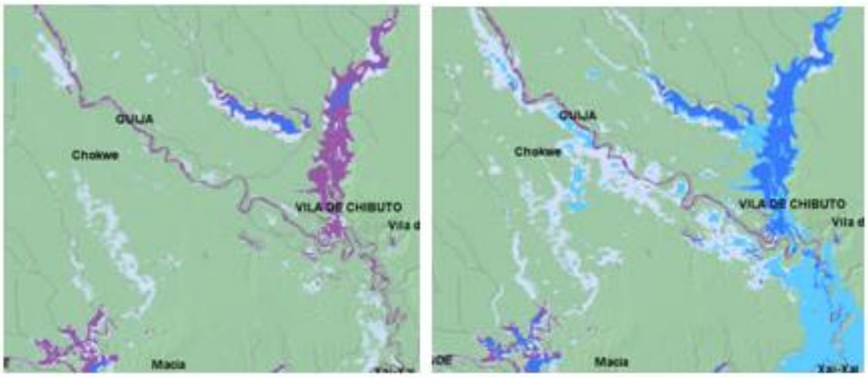
Data and services

Web site	http://floodobservatory.colorado.edu/, http://floodobservatory.colorado.edu/Version3/030E020Sv3.html
Data access	http://floodobservatory.colorado.edu/SurfaceWaterArchive/ (in development)
Naming convention	http://floodobservatory.colorado.edu/SurfaceWaterArchive/[TileNumber]/[TileNumber][YYYMMDD].tif TileNumber is 000E000N with E/W and N/S
Data format	JPG, geotiff

Interpretation

The most recent conditions are shown. Daily imaging is accumulated over 14 days to ensure removal of nearly all cloud obscuration. The areas of past flooding, also provided, allow the relative size of any ongoing flood events to be immediately assessed. These areas also indicate future flood hazard.

Symbology Key



Dry (left, January 22, 2013), and Wet (right, February 13, 2013), Mozambique.

1) Large areas of purple are dry land, formerly water in February, 2000, when the reference SWDB water body database was obtained.
2) Small areas of purple are water mapped by the SWDB, but not mappable as water by MODIS due to its coarser resolution.
3) Dark blue is water imaged by MODIS and by SWDB. Note temporary expansion of large wetland in map on the right.
4) Bright blue is flooding: expanded water areas mapped by MODIS.
5) Very light blue-gray is all previous (yr 2000-present) flooding imaged and mapped by MODIS (and now dry floodplain land).

Integration approach

No integration has been done so far. The process will be similar to the NASA NRT MODIS Global Flood Map.

References

- G. Robert Brakenridge and Albert J. Kettner, 2013. The Surface Water Survey, http://floodobservatory.colorado.edu/TheSurfaceWaterSurvey.html
- Citation: Brakenridge, G.R. and Kettner, A.J., map number, date of map, The Global Water Survey: University of Colorado, Boulder, CO, USA (http://floodobservatory.colorado.edu/TheSurfaceWaterSurvey.html).

NASA NRT MODIS Global Flood Map (NASA/GSFC)

System description

The twice daily near-global coverage of the MODIS instruments (on the Terra and Aqua satellites) at approximately 250 m resolution provides a unique resource for monitoring rapidly evolving events, such as large-scale flooding. Since late 2011, NASA Goddard's Office of Applied Science has operationalized daily, near real-time, global flood mapping using these data, building on the expertise and long-time efforts of the Dartmouth Flood Observatory (DFO) to map floodwater extent. The daily OAS products are now used as input for the more detailed DFO flood maps.

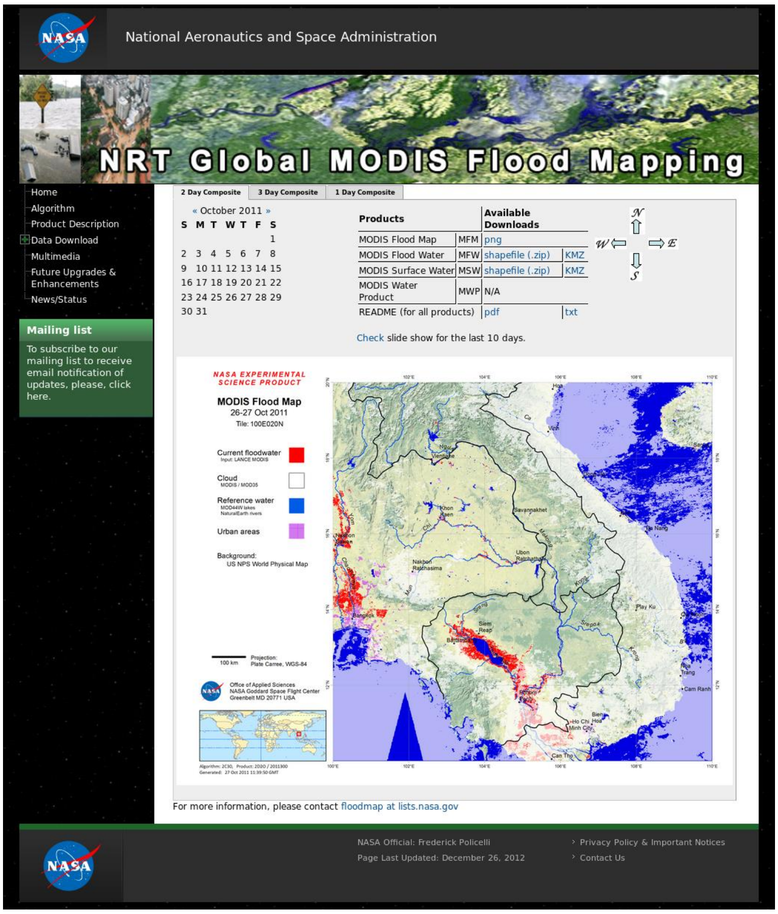
Water is detected via empirically-derived thresholds on MODIS bands 1, 2, and 7 (pan-sharpened to 250 m resolution). Due to the spectral similarity of water and cloud shadow in these bands, cloud shadows will often be initially flagged as water. To overcome this limitation, and to provide a product less affected by cloud cover, observations from each daily overpass are composited over 2 or 3 days. When water is detected in a pixel 2 (or 3) times over the 2 (or 3) day period, the pixel is flagged as water. Requiring these multiple water observations greatly limits false positives due to cloud shadow, which rarely recur in the same location over a short period of time. Compositing over several days also helps fill in cloudy areas. The cost is in the timeliness of the data. And despite these efforts, some regions are so consistently cloudy that no useful products may be available during or soon after flood events.

Flood is distinguished from expected surface water by comparison to the MOD44W MODIS Water Mask product: water exceeding that depicted in MOD44W is labelled as flood. However, the MOD44W water mask is temporally static and so does not provide an indication of normal seasonal water fluctuations; such areas may be labelled as flood in this product, but may not actually be considered flood locally.

A terrain shadow mask is also applied to remove water detected under predicted terrain shadows; along with cloud shadow, terrain shadows will also commonly be detected as water. The current correction is not completely effective, but reduces these false positives by 60-90%.

The current system is still in active development, with the following planned improvements:

- Incorporation of additional data sources, when available, such as radar and Landsat, to improve coverage in cloudy areas, and spatial resolution.
- Delivery of products via OGC services (WMS, WCS, etc).
- Masking of cloud shadows, potentially allowing use of single-day products without the current major risk of substantial false-positives from cloud shadow.
- Development of a custom, seasonal reference water mask, which will reduce the mislabelling of expected seasonal water variations as flood.
- Improved terrain shadow correction.
- More timely processing, delivering products 4-6 hours earlier than at present (currently products are typically delivered at approximately 8-10 pm local time).
- Test and incorporate NPP products. (NPP is the successor to MODIS).



Contacts

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Data and services

Web site	http://oas.gsfc.nasa.gov/floodmap
Feed	Real-time feed of processed tiles, with download links for individual products, is available at http://modis.geobliki.com/modis/geoactivities.atom
Data access	Current and archive products: http://oas.gsfc.nasa.gov/floodmap Individual products can be accessed by direct URL of the form: http://oas.gsfc.nasa.gov/Products/100W040N/MWP_2013050_100W040N_3D3OT.tif For details on product naming conventions, see http://oas.gsfc.nasa.gov/floodmap/README_MODISFloodMapProducts_27Jun12.pdf
Data format	2 or 3 day composites (2D2OT, and 3D3OT) provided daily for 10° x 10° tiles in several formats: MODIS Flood Map (MFM) graphic showing entire tile: png MODIS Flood Water (MFW) showing only flood: shapefile (.zip), KMZ MODIS Surface Water (MSW) showing all detected water: shapefile (.zip), KMZ

	MODIS Water Product (MWP) showing water, flood, and areas with insufficient data to determine: geotiff For details, see http://oas.gsfc.nasa.gov/floodmap/README_MODISFloodMapProducts_27Jun12.pdf

Interpretation

The product shows only areas that are not covered by clouds over the 2 (or 3) day compositing period. In the full product (MWP) pixels are classified as surface water (expected), flood water, dry, or insufficient data.

Users should be aware that terrain shadow and cloud shadow can result in false-positives. The product is useful to see the current water conditions, sacrificing completeness for timeliness.

Integration approach

At this resolution, the data volumes are quite large. Therefore, JRC chose to not synchronize the whole archive but only the latest available tiles. This is achieved through the real-time feed of processed tiles. A download script is generated periodically based on the content of the feed.

Files are saved without the data indication, only retaining the tile reference. Using ArcGIS, a raster catalog is generated, which effectively makes all tiles available as a single global layer. This layer is used as the sole layer in an OGC WMS service.

The following workflow was implemented:

1. Read feed and transform using XSLT into batch download script.
2. Synchronize local copy of latest tiles data
3. Refresh WMS service with latest data (automatically)

The WMS service (and other services) is available at
http://dmarcgis.jrc.it/ArcGIS93/rest/services/GFDS/MODIS_RealTime/MapServer
http://dmarcgis.jrc.it/ArcGIS93/services/GFDS/MODIS_RealTime/MapServer/WMSServer?request=GetCapabilities&service=WMS

The classification only retains two values of the original 4 in order not to mask other data layers with cloud coverage and no data values.

1	flood	
2	Reference water	
3	Clouds	X
4	No data	X

References

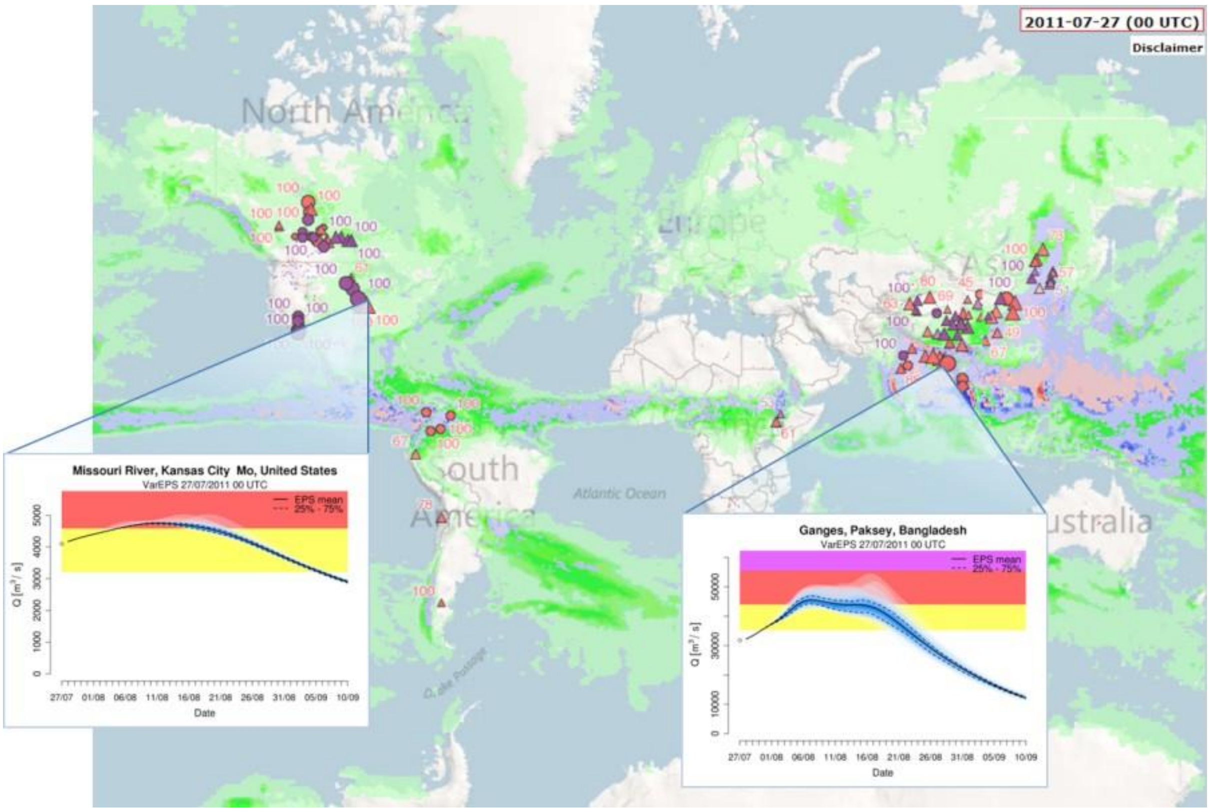
- G. Robert Brakenridge and Albert J. Kettner, 2013. The Surface Water Survey, http://floodobservatory.colorado.edu/TheSurfaceWaterSurvey.html

Global Flood Awareness System, GloFAS (JRC)

System description

Reacting to the increasing need for better preparedness to worldwide hydrological extremes, the Joint Research Centre has joined forces with the European Centre for Medium-Range Weather Forecast (ECMWF), to couple state-of-the art weather forecasts with a hydrological model on global scale. On a pre-operationally basis a fully hydro-meteorological flood forecasting model is running since July 2011 and producing daily probabilistic discharge forecast with worldwide coverage and forecast horizon of about 1 month. An important aspect of this global system is that it is set-up on continental scale and therefore independent of administrative and political boundaries – providing downstream countries with information on upstream river conditions as well as continental and global overviews.

The prototype of a Global Flood Alert System consists of HTESSEL land surface scheme coupled with LISFLOOD hydrodynamic model for the flow routing in the river network. Both hydrological models are set up on global coverage with horizontal grid resolution of 0.1° and daily time step for input and output data.



To estimate corresponding discharge warning thresholds for selected return periods, the coupled HTESSEL-LISFLOOD hydrological model is driven with ERA-Interim input meteorological data for a 21 year period from 1989 onward. For daily forecasts the ensemble stream flow predictions are run by feeding Variable Resolution Ensemble Prediction System (VarEPS) weather forecasts into the coupled model. VarEPS consist of 51-member ensemble global forecasts for 15 days. The hydrological simulations are computed for a 45-day time horizon, to account the routing of flood waves through large river basins with time of concentration of the order of one month.

Both results, the discharge thresholds from the long term run and the multiple hydrographs of the daily ensemble stream flow prediction are joined together to produce probabilistic information of critical threshold exceedance. Probabilistic discharge forecasts are compared with three warning threshold maps. Results are displayed through a password protected web-portal where the members can browse in an easy and intuitive way different aspects of the most recent or past forecasts as spatially distributed information. Critical points in the river channels showing an increased probability of flooding over various forecasts are linked to time series of flood threshold exceedances in order to provide more detailed information.

Having demonstrated its potential in recent catastrophic floods, e.g. the Pakistan 2010 floods, now further research and development, rigorous testing and adaptations are ongoing.

Contacts

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Collaborators: Jutta Thielen (jutta.thielen@jrc.ec.europa.eu) and Lorenzo Alfieri lorenzo.alfieri@ecmwf.int)

Data and services

GloFAS is currently not publicly accessible.

Integration approach

The system has not been integrated at the moment, mainly due to a security layer in GloFAS which would require the implementation of an equivalent security layer for the integrated flood map.

References

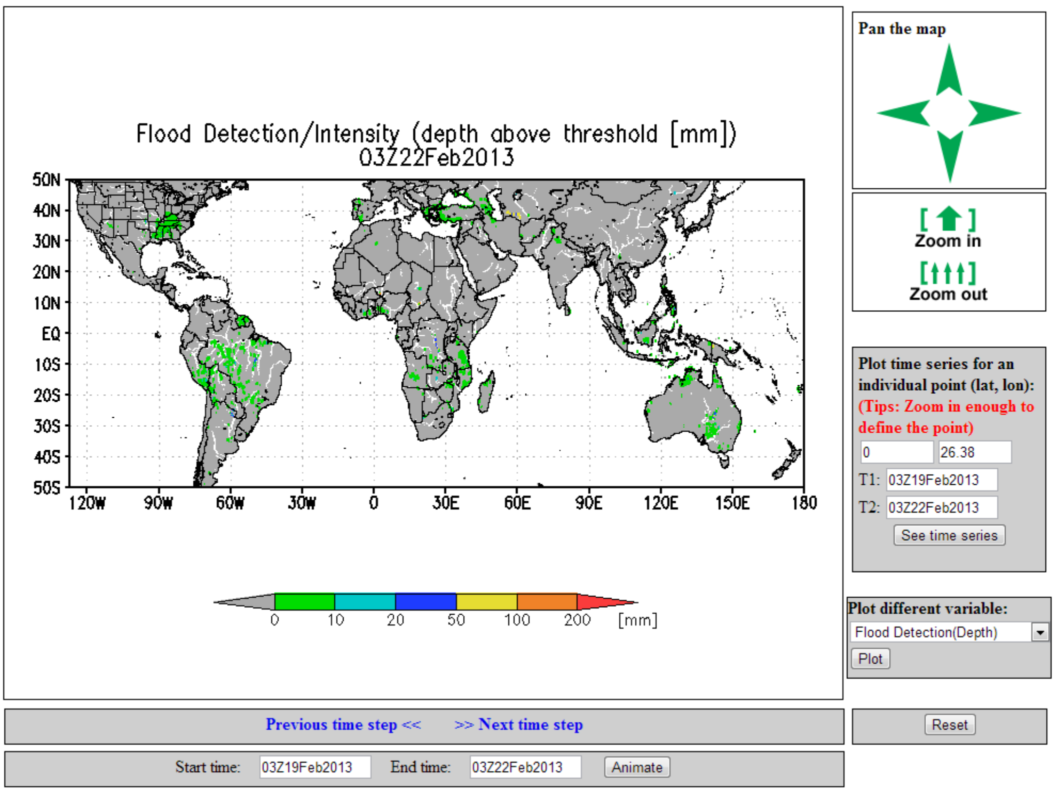
- Alfieri, L., P. Salamon, F. Pappenberger, P. Burek, B. Krzeminski, D. Muraro, J. Thielen, and A. de Roo. "TOWARDS A SEAMLESS FLOOD EARLY WARNING SYSTEM: FROM FLASH FLOODS TO GLOBAL FORECASTING." FLOODS IN 3D: PROCESSES, PATTERNS, PREDICTIONS (2011): 73.
- Burek, P., Alfieri, L., Thielen-del Pozo, J., Muraro, D., Pappenberger, F., & Krzeminsk, B. (2012, April). Looking at the big scale-Global Flood Forecasting. In EGU General Assembly Conference Abstracts (Vol. 14, p. 3993).

University of Maryland Global Flood Monitoring System (UMD)

System description

The GFMS is a NASA-funded experimental system using real-time TRMM Multi-satellite Precipitation Analysis (TMPA) precipitation information as input to a quasi-global (50°N - 50°S) hydrological runoff and routing model running on a 1/8th degree latitude/longitude grid. Flood detection/intensity estimates are based on 13 years of retrospective model runs with TMPA input, with flood thresholds derived for each grid location using routed runoff statistics (95th percentile plus parameters related to basin hydrologic characteristics). The intensity value is the calculated water depth above the flood threshold. Calculations of streamflow are also shown as well as streamflow values above a flood threshold determined from retrospective model runs. In addition, the latest maps of instantaneous precipitation and totals from the last day, three days and seven days are displayed. All the calculations are updated every three hours. Users can "zoom in" to regional areas, time sequence the maps over the last few days or months and plot time sequences of data at a point.

The flood model is based on the University of Washington Variable Infiltration Capacity (VIC) land surface model (Liang et al., 1994) coupled with the University of Maryland Dominant River Tracing Routing (DRTR) model (Wu et al., paper in preparation). The flood detection algorithm is described in Wu et al. (2012). The real-time TMPA precipitation data product (Huffman et al., 2010) is obtained from the NASA Goddard TRMM/GPM Precipitation Processing System (PPS). An initial evaluation of the new GFMS based on 15-yr (1998~2012) retrospective simulation against gauge streamflow observations and reported flood event archives has been performed and presented recently in 2013 American Meteorological Society(AMS) Annual Meeting.



Contacts

Organisation: University of Maryland, Earth System Science Interdisciplinary Center
Project lead: Robert Adler (radler@umd.edu)
Collaborators: Huan Wu (huanwu@umd.edu), Martina Ricko (mricko@umd.edu)

Data and services

Web site	http://flood.umd.edu
Data access	http://flood.umd.edu/download Only Flood Detection/Intensity for now
Naming convention	http://flood.umd.edu/download/[YYYY]/[YYYYMM]/Flood_byStor_[YYYYMMDDHH].bin
Data format	Binary files in a 800*2485 grid in 4-byte float type. The first row of the data is for the northern row. The geo-reference parameters are: • ncols: 2458, nrows: 800, • xllcorner: -127.25, yllcorner: -50, • cellsize: 0.125, NODATA_value: -9999

Integration approach

JRC wrote a conversion program to convert the binary files to geotiff files. This is used in the following workflow:

4. Synchronize local copy of data
5. Convert binary to geotiff files
6. Copy latest available file to map server
7. Refresh WMS service with latest data (automatically)

The WMS service (and other services) is available at
http://dmarcgis.jrc.it/ArcGIS93/rest/services/GFDS/OASGlobalFloods/MapServer
http://dmarcgis.jrc.it/ArcGIS93/services/GFDS/OASGlobalFloods/MapServer/WMSServer?request=GetCapabilities&service=WMS

It has two layers: (0) the latest data, i.e. changing every three hours, (1) yesterday's data of 23:00 UTC. The classification is identical as the original website.

References

- Liang, X., D. P. Lettenmaier, E. F. Wood, and S. J. Burges, 1994: A Simple hydrologically Based Model of Land Surface Water and Energy Fluxes for GSMs, J. Geophys. Res., 99(D7), 14,415-14,428.
- Wu H., R. F. Adler, Y. Hong, Y. Tian, and F. Policelli (2012), Evaluation of Global Flood Detection Using Satellite-Based Rainfall and a Hydrologic Model. J. Hydrometeor, 13, 1268.1284.
- Huffman, G.J., R.F. Adler, D.T. Bolvin, E.J. Nelkin, 2010: The TRMM Multi-satellite Precipitation Analysis (TMPA). Chapter 1 in Satellite Applications for Surface Hydrology, F. Hossain and M. Gebremichael, Eds. Springer Verlag, ISBN: 978-90-481-2914-0, 3-22.

Ithaca Extreme Rainfall Detection System

System description

The Extreme Rainfall Detection System (ERDS), developed and implemented by ITHACA, is a service for the monitoring and forecasting of exceptional rainfall events, with a nearly global geographic coverage.

This system is conceived to be a strategic tool, providing complete, immediate and intuitive information about potential flood events, to be used during the preparedness and response phases of the emergency cycle. Information are accessible through a WebGIS application, developed in a complete Open Source environment, that processes and disseminates warnings in an understandable way also for non-specialized users. Available capabilities include the analysis of near real-time rainfall amount and of forecasted rainfall for different lead times, with the aim to deliver extreme rainfall alerts. The combination of such information with reference data allows the system to generate value-added and event-specific information, such as the list of the affected countries and an estimation of the affected population. Currently the system is one of the tools used by UN World Food Programme (WFP) Emergency Preparedness Unit.

The data used for the near-real time detection of extreme events are mainly based on the Tropical Rainfall Measuring Mission (TRMM) Multisatellite Precipitation Analysis (TMPA) data, updated on a 3-hour basis. Spatial resolution of TRMM data is 0.25x0.25 lat/lon degrees, between 50° latitude N and 50° latitude S.

This system is also able to provide a longer lead-time alerts (up to 6 days) for heavy rain and floods, using forecast rainfall data, coming from NOAA-GFS (Global Forecast System) deterministic weather prediction models, with 1.0x1.0 lat/lon degrees resolution and worldwide coverage, updated on a 6-hour basis.

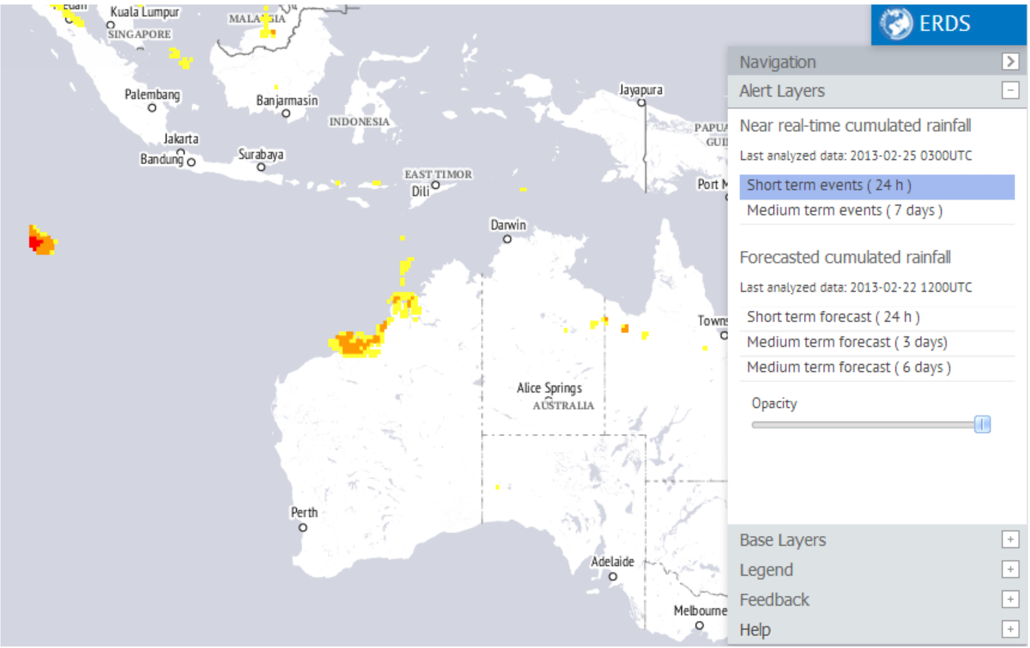


Figure 8. Example of ERDS2 output for 25 February 2013.

Contacts

Organisation: Information Technology for Humanitarian Assistance, Cooperation and Action (Ithaca), http://www.ithacaweb.org
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Data and services

Web site	http://erds2.ithacaweb.org/
Data access	WMS service: http://erds2.ithacaweb.org/geoserver/gwc/service/wms Layers: erds:forecast_alert_grid_h24_gdacs, erds:trmm_alert_geom_h168

Interpretation

Three different alert levels can be visualized (low, moderate and severe), based on specific rainfall intensity threshold, defined as the amount of precipitation for a given duration over a specific climatological area. Concerning real-time rainfall data, two kinds of events are considered: short term events, up to 24 hours cumulated rainfall, and medium terms events, up to 1 week cumulated rainfall. In case of forecasted rainfall data, three kinds of events are considered: short term events (24 hours), and medium term events both on 72 hours basis and 6 days basis.

Integration approach

The WMS layers are visualized directly in OpenLayers.

References

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- Albanese A., Boccardo P., F. Giorgi, N. P. Premachandra, O. Terzo, Vigna R. (2010). Application of an Early Warning System for floods. In: Advances in Earth Observation of Global Change, Emilio Chuvieco, Jonathan Li and Xiaojun Yang (Eds.), Springer, pp. 217 – 237. ISBN 978-90-481-9084-3, e-ISBN 978-90-481-9085-0, DOI10.1007/978-90-481-9085-0 (ithaca_extreme_flood_event.pdf)
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- O. Terzo, L. Mossucca, A. Albanese, P. Boccardo, R. Vigna and N. P. Premachandra (2012). Engineering of an Extreme Rainfall Detection System using Grid Computing. Journal on Systemics, Cybernetics and Informatics (JSCI), IIIS, Vol. 10, N. 5, ISSN: 1690-4524, pp. 45-49.

Ensemble Tropical Rainfall Potential, eTRaP (NOAA)

System description

Single-orbit TRaP forecasts are produced by advecting rainfall rates derived from instruments on low-Earth orbiting satellites (currently AMSU, TRMM and SSMIS) forward in time 24 hours (in 6-hour segments) along the predicted track of a tropical system. All of the single-orbit 6-h TRaP segments covering the same time period (which may use different microwave sensors, observation times, and track forecasts) are then combined in a simple ensemble to produce eTRaP forecasts. These forecasts include both deterministic rainfall accumulation forecasts and the probability of exceeding various rainfall accumulation thresholds. The eTRaP forecasts are centered on the synoptic hours (i.e., 00Z, 06Z, 12Z, 18Z), from single-orbit TRaP segments with start times up to 3 hours after the synoptic hour.

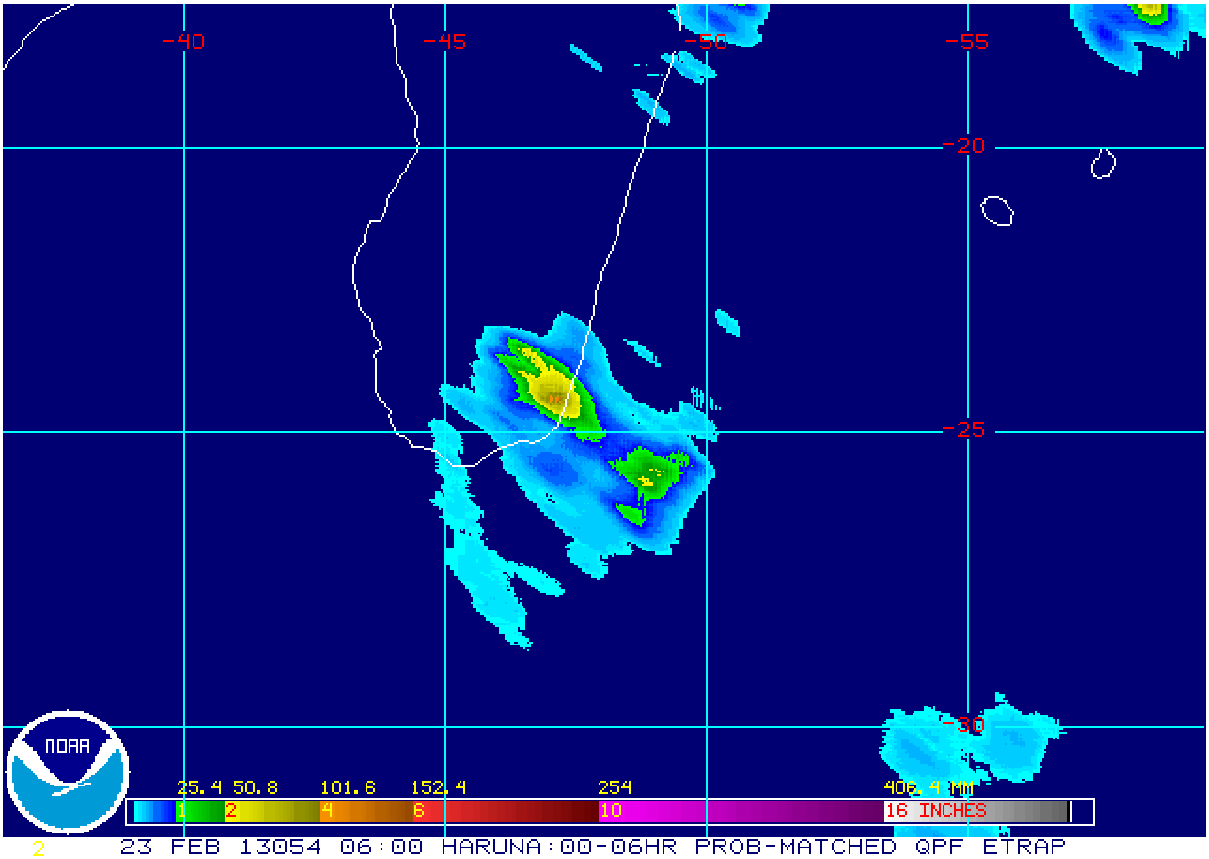

Figure 9. Example of eTRaP product.

Contacts

Organisation: NOAA NESDIS
Project lead: Mike Turk (michael.turk@noaa.gov)
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Data and services

Web site	http://www.ssd.noaa.gov/PS/TROP/etrap.html
Data access	ftp://satepsanone.nesdis.noaa.gov/TRAP/ETRAP/ Last 5 days of data only

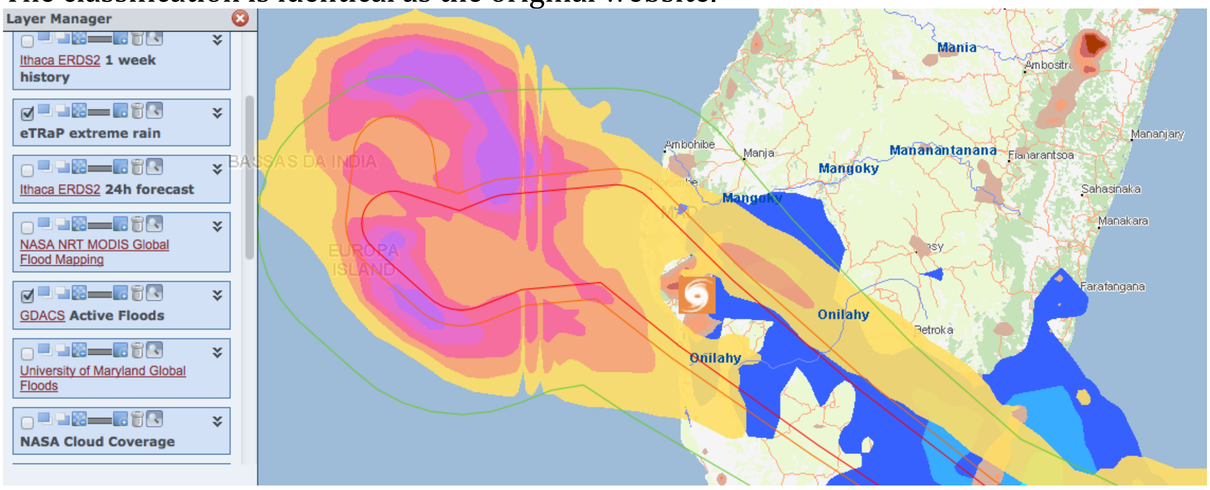
Data format	McIDAS area file, text file and gif file Sample text files, McIDAS area files and gif files can be accessed through the following site: ftp://satepsanone.nesdis.noaa.gov/TRAP/ETRAP/example/ Explanations on the format are available from http://www.ssd.noaa.gov/PS/TROP/etrap-expl.html

Integration approach

JRC wrote a conversion program to convert the text files to geotiff files. All 6h products are summed up for the duration of the cyclone, effectively providing a new product of total precipitation accumulation for the cyclone. Both the individual files and the accumulated product are then vectorized for a set of thresholds and imported in a Spatial Data Infrastructure. These datasets are used for visualization using WMS services.

The WMS service (and other services) is available at
http://dmarcgis.jrc.it/ArcGIS93/rest/services/GDACS/gdacsTCRainactiveBG/MapServer
http://dmarcgis.jrc.it/ArcGIS93/services/GDACS/gdacsTCRainactiveBG/MapServer/WMSServer?request=GetCapabilities&service=WMS

The classification is identical as the original website.



References

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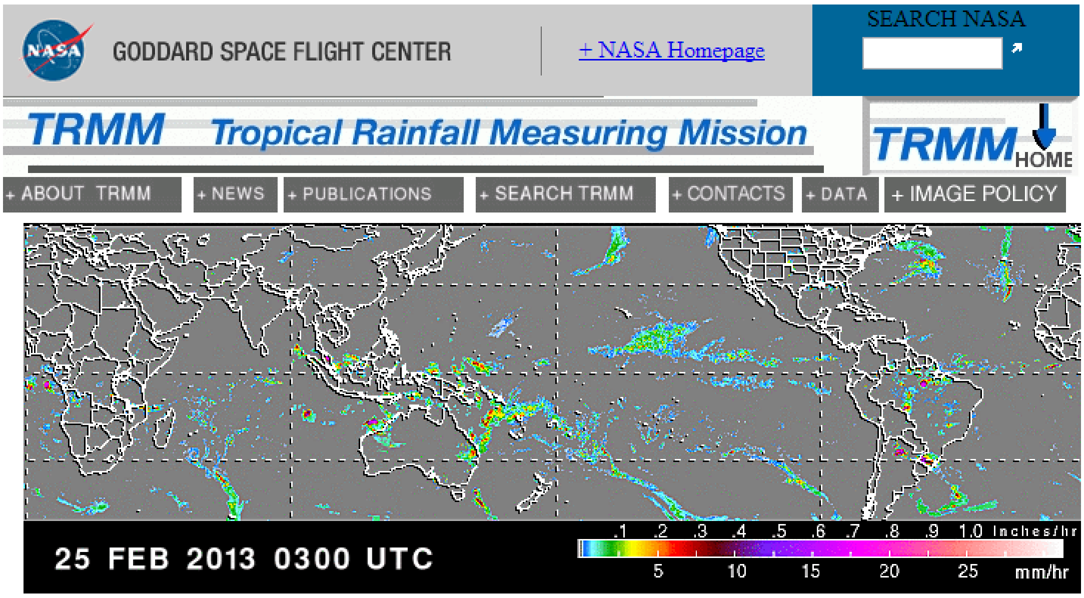
- Ebert, E. E., Salemi, A. E., Turk, M., Spampata, M., & Kusselson, S. (2009, January). Validation of the ensemble tropical rainfall Potential (e-TRaP) for landfalling tropical cyclones. Preprints, 16 th Conference on Satellite Meteorology and Oceanography, AMS 89th Annual Meeting, Phoenix, AZ (pp. 12-15).

NASA TRMM-based precipitation estimates

System description

A series of quasi-global, near-real-time, TRMM-based precipitation estimates is available to the research community via anonymous ftp. The estimates are provided on a global 0.25 ° x0.25 ° grid over the latitude band 50 ° N-S within about seven hours of observation time. Three products are being provided: A TRMM-calibrated merger of all available TMI, AMSR-E, SSM/I, and AMSU-B precipitation estimates (three-hourly accumulations); a geosynchronous infrared estimate which is calibrated by the merged-microwave data (hourly estimates); and a combination of the first two fields (three-hourly accumulations).



Data and services

Web site	http://trmm.gsfc.nasa.gov/
Data access	http://trmm.gsfc.nasa.gov/affinity/affinity_3hrly_rain.html ftp://trmmopen.gsfc.nasa.gov/pub/gis ftp://trmmopen.gsfc.nasa.gov/pub/merged
Naming convention	ftp://trmmopen.gsfc.nasa.gov/pub/gis/3B42RT.[YYYYMM]*00.7.1day.tif
Data format	Geotiff Users are urged to download the README first for additional details: ftp://trmmopen.gsfc.nasa.gov/pub/merged/V7Documents/3B4XRT_README.pdf

Integration approach

The 24h accumulation files (1day.tif) are downloaded every 3 hours at JRC. The latest available file is copied to TRMM_now.tif, and served in a WMS service.

The WMS service (and other services) is available at
http://dmarcgis.jrc.it/ArcGIS93/rest/services/GFDS/TRMMRain/MapServer
http://dmarcgis.jrc.it/ArcGIS93/services/GFDS/TRMMRain/MapServer/WMSServer?request=GetCapabilities&service=WMS

Discussion

The Integrated Global Flood Map has been progressively developed over the past three years in collaboration with research teams across the world. Prototype systems and pre-operational systems were modified to be compatible with OGC standards for geographic information sharing. A mash up based on OpenLayers technology was built to combine these services.

This project is a technical demonstration of how such integration can be done. However, the participating research groups and systems can change. No service level agreements are in place to guarantee a service. Data licensing issues have not been addressed, since most data is available without formal licenses.

Co-visualization of information is only a first step towards integrating information. More is needed to support flood analysts in their tasks to detect new floods, measure the size of on-going floods and assess the impact of large flood disasters. There are three areas for further development:

- First, the map symbology can be designed as an integrated product rather than a collection of stand-alone maps. For instance, in the current implementation, red is used by most systems to depict the highest level of floods size, flood risk or rainfall, which can be confusing. Colour schemes can be designed to make the information easier to understand. In addition, information can be hidden at certain scales where it is not relevant, or where other systems provide more relevant information.

- Second, the integrated flood map should allow seeing the information for a particular date in the past, and not only the most recent information. This would allow comparison with past cases, or to go back to the situation at the start of the floods. It requires contributing systems to support querying information by time.

- Third, visualization of quantitative information must be supported. Many systems provide not only maps, but also data that can be graphed in time series. Comparison of trends, flood peaks, arrival times and anomaly sizes are important to understand a situation. This requires access to time series, and tools for transforming and integrating them in a single graph.

These developments cannot be done by a single organisation but needs a coordinated approach to align research and development for a common goal and with a clear output. It is a way to bridge the gap between scientific research and operational information that can be used to mitigate and respond to disastrous floods.

Conclusion

The Integrated Global Flood Map is a demonstration of the power of combining existing systems to create added value. A number of prototype or pre-operational systems were integrated, each with their own shortcoming and uncertainties, but also with their strengths and uniqueness. Together, they allow analysts to get a clear situational picture of major floods in the world.

The Integrated Global Flood Map is the result of small, but coordinated efforts between a number of research groups. It is a concrete outcome of the Global Flood Working Group, and is a useful tool for scientists to compare their systems with other similar ones, or with reference data. For practitioners, it offers a way to have a lot of information at a glance.

European Commission
EUR 25892 – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: **Global Integrated Flood Map: A collaborative product of the Global Flood Working Group**

Authors: Tom De Groeve, Luca Vernaccini, Robert G. Brakenridge, Robert Adler, Martina Ricko, Huan Wu, Frederick S. Policelli, Daniel Slayback, Adriana Albanesi, Elena Cristofori, Robert Kuligowski, Sheldon Kusselson

Luxembourg: Publications Office of the European Union

2013 –29x pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online)

ISBN 978-92-79-29021-3 (pdf)

doi: 10.2788/8655

Abstract

The Integrated Global Flood Map is a demonstration of the power of combining existing systems to create added value. With increasing observation and modelling capacity, scientists are now able to produce relevant information on flood disasters more rapidly and with sufficient accuracy and precision for a variety of humanitarian response tasks. A number of prototype or pre-operational systems were integrated, each with their own shortcoming and uncertainties, but also with their strengths and uniqueness. Together, they allow analysts to get a clear situational picture of major floods in the world.

LB-NA-25892-EN-N

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Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

Publications Office

ISBN 978-92-79-29021-3