Towards estimating rainfall erosivity using weather satellites

Introduction

Geostationary weather satellites observe the earth from a fixed position in space at regular short time intervals. Fig.1 shows an image view of Western Europe, taken by Meteosat-9 or MSG-2, positioned at 0 North 0 East. The MSG-2 satellite is transmitting images in 12 spectral bands every 15 minutes to earth. This capability of observing space - time fields of weather systems over land and oceans offers new opportunities to analyze weather and climate impacts on soil environments.

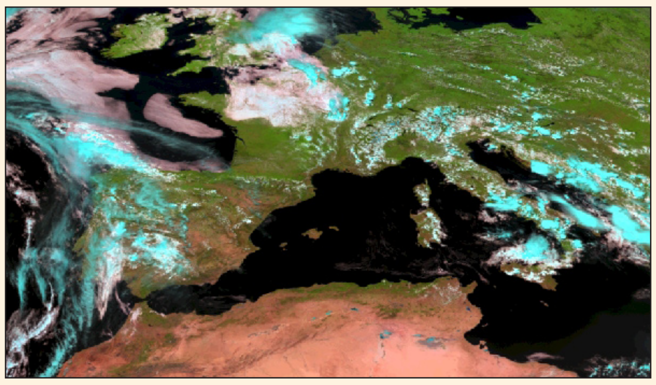

Fig.1: Meteosat-9 view over Western Europe (date 2007-06-08 12.00 GMT, @EUMETSAT)

Weather satellite data acquisition

Reception of weather satellite data today has become easier using digital satellite TV receiving systems like EUtelcast's Hotbird satellite constellation and EUMetcast. Data can also be received through fast internet from active archives (www.eumetsat.org). Fig.2 shows a low cost receiver facility at the ITC, NL.

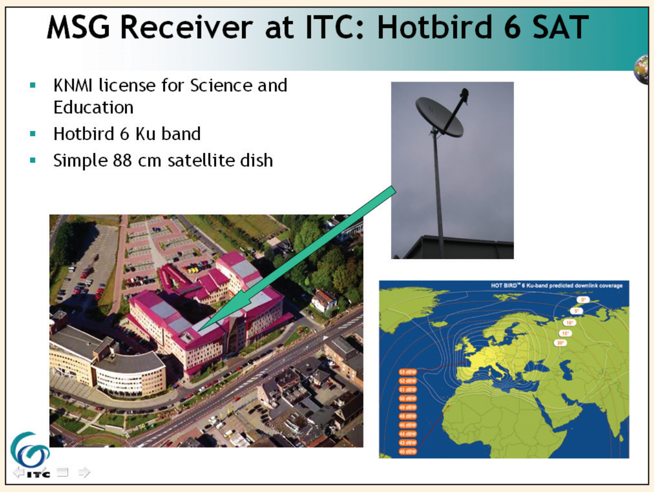

Fig.2 Low cost MSG receiver at ITC, NL.

Data at the ITC are stored in an active archive and can be retrieved using a MSG time series generator based on open source Geospatial data Abstraction Library routines(www.gdal.org).

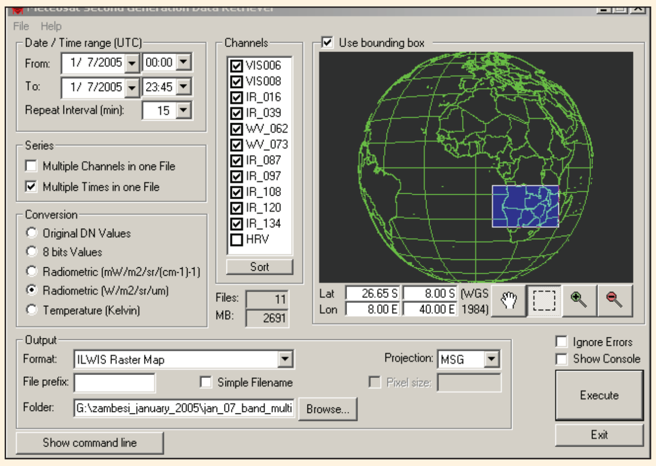

Fig.3: MSG data retriever and image analysis software (www.itc.nl/ilwis or www.52 North.org).

Precipitation analysis using MSG thermal and TRMM microwave data

Different methods for retrieval of precipitation from satellite data exist. A common method consists in combining cold cloud temperature data from geostationary orbits with active or passive microwave observations from LEO (low polar or equatorial orbits) like the TRMM Tropical Rainfall Measurement Mission satellite (Kummerow et al, 1998). Fig.4 shows an experimental correlation developed between the MSG 10.8 μm thermal channel brightness temperature and the rain rate from the TRMM Hydrometeor profile 2A12 dataset, at identical overpass time. We refer to Maathuis et al (2006) for more details.

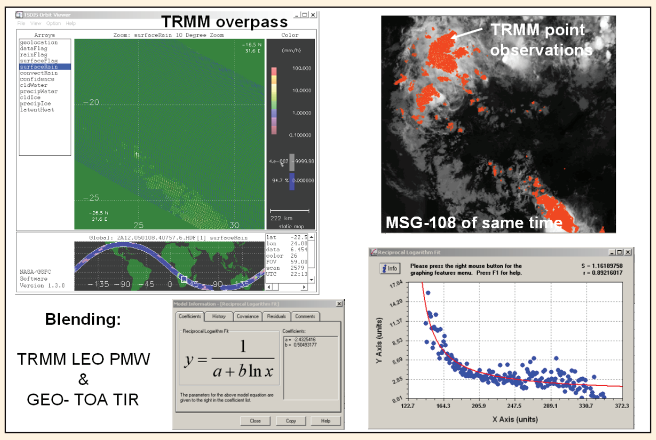

Fig.4: Relationship between MSG 10.8 μm brightness temperature and TRMM rain rates.

The (15-minute time resolution) thermal image data are converted to rain intensity images using this relationship. Figure 5 shows an image and a graph displaying a 6-hr temporal distribution of rainfall intensity at a certain pixel location in 24 time intervals. This spatial (3 X 3 km^2 pixel) and 15-min. rain rate distributions [mm/hr] form the satellite-based core dataset for further processing to rainfall erosivity.

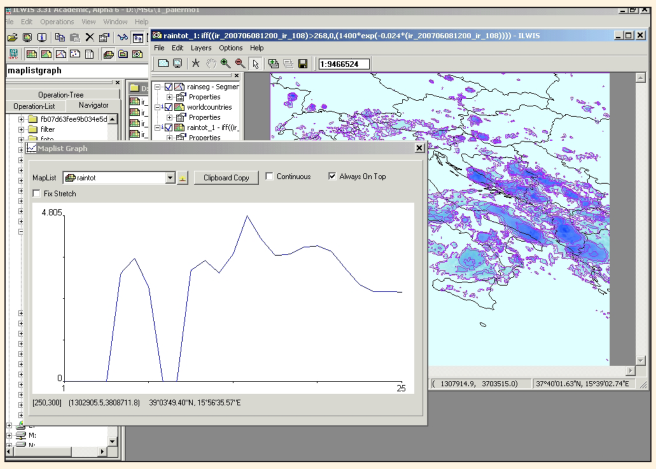

Fig.5: 6-hr rainfall hyetograph (15' time step) of 1 sample pixel from blended MSG and TRMM satellite data.

This rain retrieval procedure using TRMM and MSG can be used at lower latitudes between approx. 50 North - 50 South, and works for more convective precipitating cloud systems. At higher latitudes, other polar orbiting microwave sensors or alternative methods have to be used.

Rainfall erosivity processing

The kinetic energy of rainfall (in MJ/ha) was obtained by applying the Brown & Foster algorithm (1987) on the rain intensity images. The maximum 30-minute rainfall intensity was derived from the 15' rain intensity time series after aggregation. The rainfall erosivity is the product of kinetic energy times intensity and expressed in MJ/ha*mm/hr.

An instantaneous erosivity image is generated by multiplying a kinetic energy image with the rain intensity image at certain time observation point. The daily rainfall erosivity was obtained using 24-hr aggregated energy maps, multiplied with the maximum 30-min. rainfall intensity image.

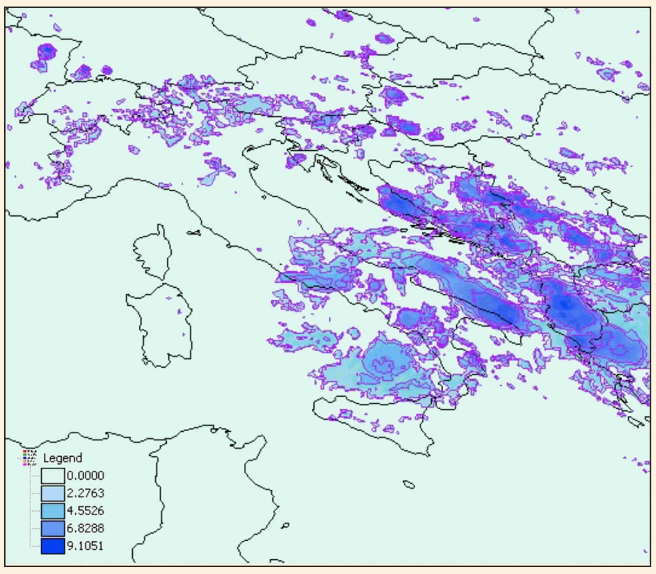

Fig.6: Rain rate (20070608 1200 GMT) of a precipitating cloud system above Southern Italy and Mediterranean (in mm/hr).

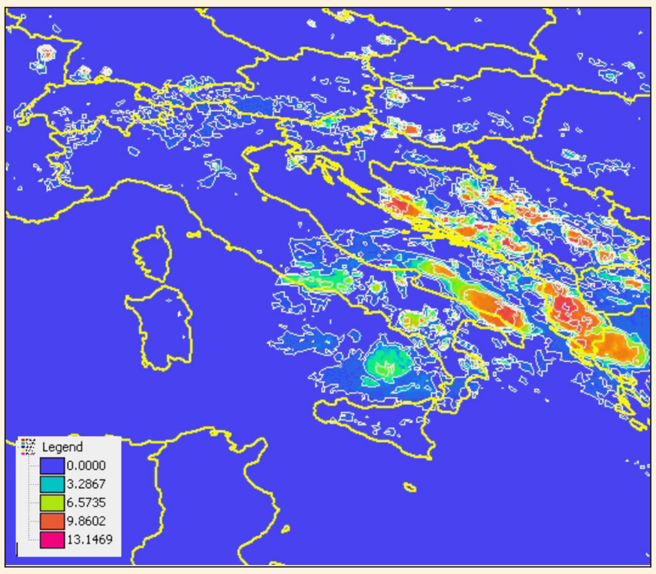

*Fig.7: Spatial rainfall erosivity field at 20070608 1200 GMT (in MJ/ha*mm/h).*

Calibration and validation issues

We are fully aware of the uncertainties associated with estimating rainfall from satellites. Research is ongoing and significant progress is currently being made using a new generation of geostationary platforms. The above shown method and figures are tentative and require further calibration and ground control. Rainfall erosivity estimation using ground-based rainfall gauge data is also prone to gauging, spatial and temporal interpolation errors, especially in areas with poor meteorological station density. Satellite data permit to monitor and quantify the rapid temporal and spatial dynamics of cloud and precipitation systems. Analysis may lead to new insights on spatial and temporal rainfall erosivity distributions over large areas.

This erosivity retrieval methodology is currently under development, calibration and validation using other algorithms, microwave sensors, ground radar and gauge data. Interested parties are welcomed to cooperate in the research.

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Kummerow, C., Barnes, W., Kozu, T., Shiue, J., Simpson,J. 1998. The tropical rainfall mission (TRMM) sensor package. J.Atmos.Oceanic technol., 15, pp.809-817.
Maathuis, B., Gieske, A., Retsios, V., v.Leeuwen, B., Mannaerts, C. and Hendrikse. J., 2006. Meteosat-8: from temperature to rainfall. ISPRS Tech. Commission VII, Mid Term Symposium, 8-11 May 2006.
http://www.eumetsat.org, http://www.itc.nl/ilwis, http://www.52N.org
http://www.gdal.org

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