**Platforms, system and models for forecasting floods**

**European Flood Awareness System (EFAS[[1]](#footnote-1))**

This is an operational system monitoring and forecasting floods across Europe which provides flood early warning information up to 10 days in advance. EFAS regroup National and Regional Hydrological Services and the European Response and Coordination Centre (ERCC).

*It is carried out under Copernicus emergency management service framework.*

The EFAS bulletin from August – September 2017[[2]](#footnote-2) provides information about different flood events predicted in real-time that occurred during this period. Both continental scale (Europe) and national scale (France)

Information about EFAS flood modelling could be find in Alfieri, (2013)[[3]](#footnote-3). This modelling is based on GloFAS–*global ensemble streamflow forecasting and flood early warning*, which is composed of:

integrated hydro-meteorological forecasting chain + daily monitoring system



**DAS** (data assimilation system) based on operational forecasts of near-surface meteorological parameters. From DAS 🡺 daily forecasts.

**GMS** (Global circulation model) is a long-term dataset used to derive a climatological reference

**HTESSEL** is a land surface Hydrology that computes the land surface response to atmospheric forcing and estimate the water surface and energy fluxes, the temporal evolution of soil temperature, moisture content and snowpack conditions.

**ERA-Interim Land** is a global reanalysis of land-surface parameters. (*Reference climatology*)

**VarEPS** (Variable Resolution Ensemble Prediction System) is the operational ensemble forecasting products from ECMWF IFS (grid resolution:32 km for 10 days). This forecast is produced twice per day and turned in HTESSEL to generate runoff fields for the ensemble streamflow prediction. (*Daily forecasting*)

Fig. 1 GloFAS structure (Alfieri, 2013)

Hydrological modelling

LisFlood hydrological modelling is used to simulate river discharge for flow routing in the river network and groundwater mass balance. The global model is set up on global coverage to resolutions of 0.1° (~10 km) in space and daily time step for input/output data.

Two types of simulations are performed to estimate the discharge in the river network, which use the input runoff forcing (*voir VarEPS*) and an appropriate initial model state. Climatological streamflows are derived from *Era-Interim Land* and used to fit statistical distributions and to estimate corresponding discharge warning thresholds for selected return periods.

In the context of global flood modelling, the transformation from precipitation to surface and sub-surface runoff is done by the HTESSEL, which is not capable of simulating horizontal water fluxes along the river network. For this purpose, Lisflood is set up to simulate the groundwater and routing processes.

**Lisflood**[[4]](#footnote-4), is a GIS-based spatially distributed hydrological model, which includes a two-dimensional channel routing model. According to Alfieri, (2013), Lisflood is turned on 5 km spatial resolution by EFAS in whole European. Surface runoff is routed through each cell using finite-difference solution to solve the kinematic wave equations.

**Technical features of Lisflood**

This hydrological rainfall-runoff model was developed by Joint Research Centre (JCR) of the European Commission in 1997.

Applications: flood forecasting, assessing the effects of river regulation measures, assessing the effects of land –use change, assessing the effects of climate change.

Lisflood is grid-based, its applications have employed grid cell of 100 metres for medium-sized catchment, to 5 km for modelling the whole Europe and 0.1° (10 km) for modelling globally. Long-term water balance is simulated in daily time step and individual flood events in hourly time intervals, or even smaller.

The principal structure is composed by 2 layer soil water balance sub-model, sub-models for the simulation of groundwater and subsurface flows, a sub-model for routing of surface runoff to the nearest river channel, a sub-model for the routing of channel flow.

Meteorological forcing required: Precipitation (mm/d), ET0-potential evapotranspiration rate (mm/d), EW0-Potential evapotranspiration rate from open water surface (mm/d), ES0-Potential evapotranspiration rate from bare soil surface (mm/d), Average daily temperature (C°).

Main principles: Precipitation forcing by inverse distance interpolation, Snowmelt based on degree-day method, Evapotranspiration by Penman-Monteith using dynamic Lai based on satellite images, Infiltration is controlled by variable infiltration capacity (VIC), Soil water redistribution between 2 soil layer via Equilibrium method using van Genuchten hydraulic conductivity curves, Percolation to groundwater is based on (un)satured conductivity + Darcy equation.

This model is implemented in a raster GIS environment wrapped in a Python based interface. It can run in Windows and Linux environment.

For more information consult Revised LisFLOOD User Manual – JRC, 2013 [[5]](#footnote-5)

**SCHAPI – Service Central d'Hydrométéorologie et d'Appui à la Prévision des Inondations** *(Central hydrometeorology and flood forecasting support service)*

The operational flood forecast network in France can be visualized by the Vigicrues site, which informs about the flood threat of rivers in real time. It is updated twice a day in order to facilitate prevention or evacuation measures in case of floods. During flood the information can be updated at any time.

The national flood prevention network is integrated by several hydrometric units (28) that measure, adjust, record by telemetry and analyze water levels and flows and many flood forecasting service (19).

As for the meteorological forecasting these are provided by Meteo-France, rainfall products are derived from radar observations with corrections of terrestrial data.

The hydrological modeling is done using different models according to each watercourse, among the main models are: GRP – hydrological model, MASCARET 1D hydraulic model et MOISE and TELEMAC 2D hydraulic model.

*See ATHYS and SOPHIE platform*

In France the flash flood modeling in non-gauge basin is performed by AIGA

**AIGA – (Adaptation d’Information Géographique pour l’Alerte des crues)**

**Operational Method of the French national forecasting services**[[6]](#footnote-6)

This method is intended to better identify intense rainfall and to anticipate flash flood in basins that are not equipped with gauge station. AIGA[[7]](#footnote-7) is an operational method since 2017 which is based on hydrological modelling and radar weather information.

The principle of AIGA is to compare streamflows simulated from real-time rainfall with threshold values, in order to characterize a rain event. The radar rainfall information is provided over different duration (1h to 72h) by Météo-France.

Concerning the hydrological modelling, threes models are used which belongs to the family of GR (Génie Rural) conceptual models developed by Irstea, France.

SAJ is a continuous distributed daily model which represents the previous conditions of humidy. (grid model).

GR4J is a global model that allows to calculated a daily base flow for all predefined outlets.

GRSD is a semi-distributed hourly event model couple with both models mentioned above in order to initialize its production reservoir at the beginning of the event (SAJ) and its routing reservoir (GR4J).

**Technical features of models**

**GR4J** (in French Génie Rural à 4 paramètres Journalier) is a rainfall-runoff model developed by Irstea[[8]](#footnote-8). It is designed to reproduce the overall hydrological behavior of a basin and it is principally based on the link between the precipitation and the evapotranspiration on the basin and its flows at the outlet.

The structure of this empirical model is based on a set of interconnected reservoirs that empty and fill up over time translating rainfall into river flows. It operates on a daily time step and have 4 parameters, which have no direct physical meaning and are determinate by a calibration phase. (It requires a chronic flow observed ideally over 15 year)

The four parameters to optimize during calibration

***X*1**: the production store maximal capacity (mm),

***X*2**: the catchment water exchange coefficient (mm),

***X*3**: the one-day maximal capacity of the routing reservoir (mm),

***X*4**: the HU1 unit hydrograph time base (days).

Since 2012, the snow accounting model CemaNeige is integrated for improving discharge forecasts in snow-influenced catchments.[[9]](#footnote-9)

For more information <https://webgr.irstea.fr/wp-content/uploads/2012/09/Fiche-technique_GRP_2016.pdf>

**GRP**, is derived from GR4J

**Telemac**

**Flood Forecasting Centre (FFC) for England and Wales [[10]](#footnote-10)**

FFC is a specialized hydrometeorology service that forecast natural flooding like river, surface water, tidal/coastal and groundwater.

Flow data is derived from G2G…

**Technical features of models**

**G2G** (Grid-to-Grid) model is a physical-conceptual distributed hydrological model that represent the spatial variability in the catchment. It integrates rainfall forcing spatially distributed derived from networks of raingauges and/or radars.

The model is configured for FFC to run at a timestep of 15 min on a 1 km grid. Spatial datasets of terrain, soil/geology and land-cover are used to support its configuration and parametrization.

The principals inputs required for G2G are gridded values of rainfall and potential evaporation. It includes a water routing component based on a kinematic wave formulation.

<https://www.researchgate.net/publication/233754834_Operational_use_of_a_grid-based_model_for_flood_forecasting>

<https://www.witpress.com/Secure/elibrary/papers/UW16/UW16021FU1.pdf>

**Swedish Meteorological and Hydrological Institute**

This service employs operationally the Hype model to forecast flood the output are showed by a graphical user interface

**HYPE** (Hydrological prediction for the Environment)

<https://www.smhi.se/en/research/research-departments/hydrology/hype-in-sweden-s-hype-1.7891>

<https://www.smhi.se/en/research/research-departments/hydrology/hype-1.7994>

**DEWETRA**

Dewetra is an integrated operational system designed to forecast, monitor and prevention climate-related risks. It was created by CIMA foundation[[11]](#footnote-11) to be operated by the National Department for Italian Civil Protection (who have access to the platform).

This system or platform operates in real-time to collect different hydro-meteorological data that allow updating forecast models, analyze vulnerability areas and produce risk scenarios. Dewetra uses a software architecture that includes a Web-SIG interface to visualize the information such as real-time observations from automatic hydro-meteorological stations, weather radar and satellites. The streamflow forecasts also are added to the platform and the others models output to support decision-making concerning the issuing of warning messages.

According to CIMA this platform is currently used by at national level by forecasters and disaster managing authorities in different countries: Bolivia, Lebanon, Albania and the Caribbean at the regional level.

In terms of flood modelling this system uses the hydrological model FloodPROOFS (Probabilistic Flood Forecasting Operational System).

**FloodPROOFS**[[12]](#footnote-12) model provide an estimate of the probability of exceedance of critical levels in the key sections of the basins. It uses both the available meteorological observations and the quantitative forecast to compute the river discharge encompassing the snow melting and the effects of waterworks (dams, weirs,..)

This model integrate observed meteorological data (temperature, rainfall, solar radiation, wind speed and relative humidity) and satellite data (from: MODIS, Meteosat) to assess the extension of the snowpack and the soil saturation.

Besides the forecast of the river discharge, FloodPROOFS also offers a daily set of analysis of the current saturation level of the soil and of the main characteristics of the actual snow cover.

Check

The aim of the workshop was to show the potential of the DEWETRA platform and to assess the interest of those responsible for national early warning systems in the WMO affiliated countries. The workshop is part of Italy’s initiatives related to the offer of the DEWETRA platform as a national contribution to WMO programs on flood management and forecasting (FFI and APFM).The initiative was launched by the Italian delegation participating to the14th WMO Commission for Hydrology (CHy-14) in November 2012.

<http://www.cimafoundation.org/wp-content/uploads/doc/DEWETRA_english.pdf>

<http://www.cimafoundation.org/en/cima-foundation/seawetra/>

**DELFT-FEWS flow forecasting system**

Delft-FEWS is an operational platform developed for flood forecasting and warning system. It integrates real time data (rain, level, flow, temperature), numerical weather predictions, radar data and climatological data to generate flood forecasting…..

**This models are linked in this system**

HEC-HMS

HEC-RAS

[https://publicwiki.deltares.nl/display/FEWSDOC/Models+linked+to+Delft-Fews](https://publicwiki.deltares.nl/display/FEWSDOC/Models%2Blinked%2Bto%2BDelft-Fews)

<https://ac.els-cdn.com/S1364815212002083/1-s2.0-S1364815212002083-main.pdf?_tid=c5de3d94-c62f-11e7-a384-00000aacb362&acdnat=1510329594_77497a5c2bab8cf4acca75fd5162a9b5>

CHECKING…

GREEN KENUE (GK) is a tool composed by a graphical user interface for hydrologic modelers that allows to prepare, analyze and visualize data. It integrates an environmental databases and geo-spatial data. WATFLOOD and HBV-EC operate in GK environment.

**RAVEN Hydrological Framework** is constituted by a robust and extendible software architecture that is being used by a number of **Canadian organizations** for reservoir management and flood forecasting.

***(Review.. the text below is copied and pasted from***

<http://www.civil.uwaterloo.ca/jrcraig/Raven/About.html> )

Emulation Capabilities
Raven is uniquely **capable of emulating other hydrological modelling codes** by building the model structure piecemeal. Level 1 (near-exact) emulation has been implemented for the hydrological simulators HBV-EC (Environment Canada's version of the HBV code), GR4J, and the UBC Watershed Model developed by Dr. Michael Quick of the University of British Columbia. Level 2 (conceptual) emulation is available for various algorithms comparable to those used within Brook90, SWAT, VIC, PRMS, WATFLOOD, and/or described within various hydrological texts, such as Dingman's 2002 'Physical Hydrology'. A complete description of available algorithms is included in the manual.

WATFLOOD is a distributed flood forecast model for catchment

<http://www.tandfonline.com/doi/abs/10.4296/cwrj1301062>

HBV-EC

The HBV-EC model uses Hydrological Response Units (HRUs) to simulate the hydrology efficiently in a semi-distributed manner. Land cover, elevation, slope and aspect divide the watershed in various HRUs. Additionally, in the HBV-EC model written in a C-language climate zones account for climate gradients which can occur in large basins. This novelty – in comparison with the HBV model – has not been transferred into the IDL version. Inputs for the HBV-EC model are the daily values for mean Temperature (T [oC]), total rainfall (RF [mm]) and total snowfall (SF [mm]). Additionally, in the C-language version the mean monthly potential evaporation (EP [mm]) is necessary

To calculate rainfall and snowfall from the precipitation time series of the climate stations, there is a threshold temperature TT [oC] and a parameter TTI [oC], which is used to create an interval TT ± TTI. In this interval it is supposed that there is a mixture of rain and snow falling. Above the interval there is only rain and below the interval there is only snow. The rainfall and snowfall records are corrected by the rainfall correction factor RFCF [-] and the snowfall correction factor SFCF [-] respectively. That way systematic measurement errors and the representativity of the climate station for the basin are taken into account. Additionally, the snow fall correction factor adjusts for the missing evaporation and sublimation from the snow pack (SEIBERT, 1997). To calculate values for each elevation band the following equations are used

<http://www.hydrology.uni-freiburg.de/abschluss/Spiegelhalter_K_2009_DA.pdf>

<https://www.hydrol-earth-syst-sci.net/16/849/2012/hess-16-849-2012.pdf>

Check how NOAA uses hec-ras in theirs modelling

HEC-RAS for coastal forecasting

<https://acwi.gov/sos/pubs/2ndJFIC/Contents/7F_Charley_02_19_10.pdf>

<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.527.2780&rep=rep1&type=pdf>

<http://ieeexplore.ieee.org/document/7984347/?reload=true>

<http://oss.deltares.nl/web/delft-fews/>

1. https://www.efas.eu/ [↑](#footnote-ref-1)
2. https://www.efas.eu/download/efasBulletins/2017/bulletin\_aug-sep\_17.pdf [↑](#footnote-ref-2)
3. https://www.hydrol-earth-syst-sci.net/17/1161/2013/hess-17-1161-2013.pdf [↑](#footnote-ref-3)
4. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC78917/lisflood\_2013\_online.pdf [↑](#footnote-ref-4)
5. http://publications.jrc.ec.europa.eu/repository/bitstream/JRC78917/lisflood\_2013\_online.pdf [↑](#footnote-ref-5)
6. http://www.set-revue.fr/mises-en-oeuvre-operationnelles-de-la-methode-aiga-pour-anticiper-les-crues-sur-les-cours-deau-non [↑](#footnote-ref-6)
7. http://www.set-revue.fr/sites/default/files/articles/pdf/set-revue-risque-inondation-anticiper-methode.pdf [↑](#footnote-ref-7)
8. https://webgr.irstea.fr/en/modeles/journalier-gr4j-2/fonctionnement\_gr4j/ [↑](#footnote-ref-8)
9. https://webgr.irstea.fr/en/modeles/modele-de-prevision-grp/ [↑](#footnote-ref-9)
10. <http://www.ffc-environment-agency.metoffice.gov.uk/> [↑](#footnote-ref-10)
11. http://www.cimafoundation.org/en/cima-foundation/dewetra/ [↑](#footnote-ref-11)
12. http://wikiwmo.cimafoundation.org/index.php/FloodPROOFs\_Marche\_-\_Output\_Maps [↑](#footnote-ref-12)