Project Matsu in Namibia

Race Clark
The National Weather Center
QPE – QUANTITATIVE PRECIPITATION ESTIMATES

• Merging satellite, rain gauges, and weather radars
• Expertise with PERSIANN, CMORPH, TRMM, MRMS
• Improvements to ground radar and satellite estimates

HYDROLOGIC MODELING

• EF5
• CREST
• HyPRO
• Data assimilation
• Coupling with snow models and landslide models
• Global, regional, and local modeling

FLASH (FLOODED LOCATIONS AND SIMULATED HYDROGRAPHS) PROJECT

• Suite of flash flood forecasting tools in United States
• Includes hydrologic models and other rainfall-driven tools
SERVIR is a joint venture between NASA and USAID (United States Agency for International Development)

- Satellite-based observation data
- Science applications
- Improve environmental decision making in developing nations

Centers throughout the world

- Marshall Space Flight Center in Huntsville, Alabama
- CATHALAC in Panama
- RCMRD in Kenya
- ICIMOD in Nepal

Floods, fires, droughts, frost
Global Hydrologic Modeling
Where Is Namibia?

Southwestern coast of Africa

German colony until WWI

South African protectorate until 1990 (called Southwest Africa)

Apartheid lifted and free elections begin
Namibia is famous for unspoiled wilderness and natural beauty.
Warthogs, a crocodile, and rhinos outside Windhoek, Namibia

...And abundant animal life!
NASA SERVIR started working in Namibia in 2009.

EO-1 satellite used to collect scenes of flooding.

OU develops the CREST hydrological model.

OU invited to use CREST to predict floods in Namibia and compare model results to EO-1.
Lack of computing resources and experience

- Old equipment
- Inconsistent maintenance

Communication difficulties

- Essentially no Internet access

Lack of hydrological and meteorological observations

Remote locations
Opportunities

Passion and drive for success in management

Strong personal relationships

E.U. and U.S. investment

Stable politics

Willingness to learn
Namibia Flood Dashboard

Hosted on OSDC

NASA GSFC responsible for design and maintenance, as well as satellite imagery

OU contributes model output

Namibian government contributes bulletins and observations

NGOs provide other interesting datasets

matsu.opencloudconsortium.org/namibiahflood
CREST: The Next Generation

**EF5 (Ensemble Framework for Flash Flood Forecasting)**

- C instead of FORTRAN
- Multiple model cores using same input data enables probabilistic forecasting
- Informative error handling
- Cross-platform
- Better flow routing and calibration schemes

Developed by OSDC PIRE fellow Zac Flamig
A New Training Course

Heavily focused on hands-on activities

Designed to encourage core competencies, starting with the basics

Logical progression of tasks leading up to final goal: obtain data, process data, run model, calibrate model, visualize output, and interpret output independently

Use of open-source software and free data

Developed by OSDC PIRE fellow Race Clark

EF5 Training Outline
30 Mar – 2 Apr 2015

Day 1 – Monday, 30 March 2015
1.1 WELCOME
   • Group photo; exchange contact information; training goals; system requirements; EF5 and CREST basics; training course contents and organization; OU, HyDROS, and NASA-SERVIR
   • Installing QGIS and TauDEM
1.2 INTRODUCTION TO HYDROLOGICAL MODELS
   • The water cycle; defining hydrological processes; modeling hydrological processes; types of hydrological models
   • Create hydrographs for Wang Chu River example
1.3 EF5 OVERVIEW
   • Features of EF5; model structure; control file options; warm-up and model states; model evaluation indices
   • Evaluate Wang Chu River example
1.4 DEM DERIVATIVES
   • Topographical information; sources of DEMs; creating your own
   • Create DEM and derivatives for Okavango River example

Day 2 – Tuesday, 31 March 2015
2.1 RAINFALL AND PET
   • Sources of rainfall and PET data; remote sensing vs. rain gauges; how satellite estimates of rainfall work
   • Download and visualize rainfall and PET data for Okavango River example
2.2 MANUAL CALIBRATION
   • Description of all EF5 parameters; function of parameters; manual calibration strategies; distributed and lumped parameters
   • Manually calibrate EF5 for Okavango River example
2.3 AUTOMATIC CALIBRATION
   • Discussion of automatic calibration algorithms; use of calibration and validation periods; connecting physical characteristics to model parameters
   • Use EF5 in calibration mode on Okavango River example
2.4 INTERPRETING AND USING MODEL OUTPUT
   • Using model data to make forecast decisions; confidence and uncertainty; how EF5 is used around the world for forecasting and monitoring; FLASH, EOS, RCMRD and other projects
Simulation Quality

Okavango River at Rundu, Namibia, for 2007

NSCE > 0.8 (very good)
Real-time Forecasts in Namibia

flash.ou.edu/namibia
Where do we go from here?
Provide real-time stream flow forecasts to the Dashboard

Obtain rating curves from Namibian government (or produce them with new 30-m DEM from NASA)

Convert flow to depth and then use EF5’s inundation model to forecast and plot flood extent

Cross-validate with EO-1 images on Dashboard
Current GIS Workflow

- DEM resampling (gdalwarp)
- DEM correction (Pit Remove)
- River vector filtering (Select by attribute)
- Convert rivers to raster (gdal_rasterize)
- Drainage basin outlining (Create vector layer)
- Burn river networks (Raster calculator)
- Create flow direction map (D8 Flow Directions)
- Create flow accumulation map (D8 Contributing Area)
- Check for accuracy
Can we automate it?

Yes! A script could call each GDAL process and ask the user for the subjective inputs

- Depth of burned rivers
- Edges of model domain in latitude and longitude
- Threshold for filtering out small rivers

Would save hours of work for new users, but only 10-15 minutes of work for power users

End goal: personalized hydrological modeling on demand anywhere in the world
What do we need?

Global satellite rainfall data (NASA TRMM or alternatives)

Global DEM from spaceborne radar (SRTM-2 project)

Global average potential evapotranspiration (USGS or FEWSNET)

Global a priori model parameters (soil type, texture, other data sets)
In-person training is great, but expensive, time-consuming, and not possible everywhere (security).

Working on securing funding/sponsorship to produce a MOOC at the University of Oklahoma.
Gauge station along typically dry river bed (has water usually less than 10 days per year)

Middle of Namib Desert but near coast

Source of groundwater for Walvis Bay

Namwater operates a station, tanks, and several boreholes

Inhabited by Topnaars – live in desert, speak click language, sell *nara* seeds
120 km SE of Walvis Bay
A river gauge station operated by Hydrology Dept (and another for Namwater)
Gauge installed in the 1970s; telemetry since 2012
Communicates via EUMETSAT
Water has not ever reached the gauge house but record gauge datum is over 3 meters
Tourism Dept/Desert Research Foundation has a research station nearby
Installed in the 1960s (160 km upstream of Gobabeb)
Not accessible by road; if stream has water they climb down the cliffs and hills (otherwise use 4x4 low and drive down the riverbed; 2 km or so from nearest bridge)
French had a station downstream in mid 2000s
When water in river, inject dye at the weir and then few hundred meters downstream monitor dye flow rates
We were lucky – water in river (but shallow enough to ford!)
– Rained in Windhoek on Tuesday – took until Friday or Saturday for water to reach Schlesienweir
CALIBRATION CERTIFICATE
Station number: 031
Float: Yellow
Cable length: 960 m
Distance from float to calibration mark: 253

CALIBRATION LEVEL

PEN POSITION LOWEST RECORDING LEVEL

Calibrated by: [Signature]
Date: 22-10-86