A Web Based Interface for Distributed Short-Term Pollution Potential Forecast: Coupling SWAT with the Global Forecast System Model

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Hydrologic Flowpaths
Overview

Introduction – Why short-term?

Methods – forecast framework development

Results - Hindcasting and distributed forecasts

Application – Web Based Decision Support System

Future Work – Further development
Intro

Studies exist incorporating long-term future climate projections into hydrologic models

These studies cannot accurately predict daily hydrology in the short-term

Why short-term?
Intro

Variable Source Area (VSA) hydrology plays a major role in runoff and pollutant transport.

Saturation-Excess driven runoff on agricultural land.

“Pollutant Sources”

Ditch - Stream

Runoff Flow Path
Motivation

Identify short-term high risk areas to better inform management practices
Intro

When and where should we spread manure, fertilizers, etc?

Objective: Provide sub-field scale short-term distributed hydrology forecast to inform landscape management decisions
Study Area: SF Shenandoah

Identified by the EPA as a Critical Nitrogen and Phosphorus Source to the Chesapeake Bay

Landuse Profile

Area - 2600 km$^2$
Forest - 50%
Agriculture - 38%
Urban - 11%
SWAT-VSA Model Initialization

TopoSWAT used for SWAT-VSA initialization

No HRU thresholds for full hru definition

Spatial Inputs:
- 3 m DEM
- FAO Soils
- NLCD 2011

We want detailed distributed hydrology
SWAT-STF: Short Term Forecast

Inputs → Model → Outputs

Topographic Data
- Elevation Model
- Land Cover
- Soil Distribution

Meteorological Data
- Past CFSR
- Chached GFS Forecasts
- USGS Precipitation Gage

Hydrologic Data
- Past USGS Flow Gage

Daily Live Forecasts
- Hydrographic Flow Forecasts
- Distributed Pollution Risk Forecasts

Calibration / Validation
- Hydrographic Flow Estimations

Hindcast Validation
- Hydrographic Flow Hindcasts

SWAT-VSA

Sommerlot et al., 2015
Calibration

2004 – 2011
NSE = 0.61

SF Shenandoah Outlet Flow Calibration

NSE = 0.61
Pbias = -4.2
RSR = 0.62
Validation

SF Shenandoah Outlet Flow Validation

NSE = 0.85

2012 – 2014

F-SWAT
USGS Gage
NSE  0.63
Pbias -9.5
RSR  0.6

Jan-2012  Sep-2012  May-2013  Jan-2014  Aug-2014

m³/s
Hindcast Data Set

~ 6 TB of Raw Forecast outputs in GRIB format

Thousands of Files – each a sub-daily worldwide grid

We Need to: Download and Parse the data into SWAT input files
Hindcast Preprocessing

Hindcast Data
NOAA Server

Download to temp cache

Bias Correct and format

Interpolate to subbasin centroids

Impute missing values

Repeat for each forecast day

format to daily times series

8 time series sets of SWAT weather file inputs:

.tmp
.pcp
.hmd
.slr
.wnd

X8
Hindcast Validation

SF Shenandoah Outlet Flow: 24 h Forecast

SF Shenandoah Outlet Flow: 48 h Forecast

SF Shenandoah Outlet Flow: 72 h Forecast

SF Shenandoah Outlet Flow: 96 h Forecast

- SWAT-STF
- USGS Gage

NSE: 0.85
Pbias: -18
RSR: 0.39

NSE: 0.89
Pbias: -6.8
RSR: 0.34

NSE: 0.71
Pbias: -10
RSR: 0.54

NSE: 0.89
Pbias: -11.1
RSR: 0.34
Hindcast Validation

Major Message: Short term forecasting with SWAT-STF is possible up through 4 days

Sommerlot et al., 2015
Distributed Hydrology Forecast

24 h Forecast

48 h Forecast

72 h Forecast

96 h Forecast

0 mm Precipitation

17 mm Precipitation

28 mm Precipitation

15 mm Precipitation

Runoff Index

0 - 0.2

0.2 - 0.4

0.4 - 0.6

0.6 - 0.8

0.8 - 1
Distributed Hydrology Forecast
Web-Based Decision Support System

What It Takes:

1. Automation Update multiple times daily
2. Parallel Processing
3. Modular Code (R, python, shell script)
4. 1,000s of Georeferenced Map Tiles
5. Hosting
6. User Interface (python flask app, javascript, html, css)
Forecast Framework

Remote Data Servers → Data Processing → 3rd Party Processing → Hosting

- NCEP (National Centers for Environmental Prediction)
- GFS (Global Forecast System)
- SWAT (Soil & Water Assessment Tool)
- USGS
- USDA
- Weather Data
- Runoff
- Phosphorus
- Nitrogen
- Sediment
- Land Cover
- Soil Types
- Crop Rotations
- Elevation
- Web Map Tiles
- Google API V3
- Web Based Forecasting
- HTML5

Watershed Science and Engineering Group
Sommerlot et al., 2015
Screen Shots
Screen Shots
Screen Shots
Screen Shots
Conclusion

1. SWAT-STF can provide satisfactory hydrographic forecasts up to 4 days in advance and distributed forecasts

2. SWAT-STF can provide the backend hydrologic modeling in a real-time for a web-based DSS

Future Work

1. Validation of Distributed Forecasts
2. Improvement of Weather Forecast inputs
3. Feed back and improvement of DSS