BMT

"Where will our knowledge take you?"

TUFLOW

TUFLOW 2017 and 2018 New Features

Phillip Ryan

Software Development Lead

2017 and 2018 Release

Since last UK TUFLOW workshop

2017-09

2017-09-AA released in 7th September 2017

2017-09-AB update 29th September 2017

2017-09-AC update 25th October 2017

2018-03

2018-03-AA released last week!

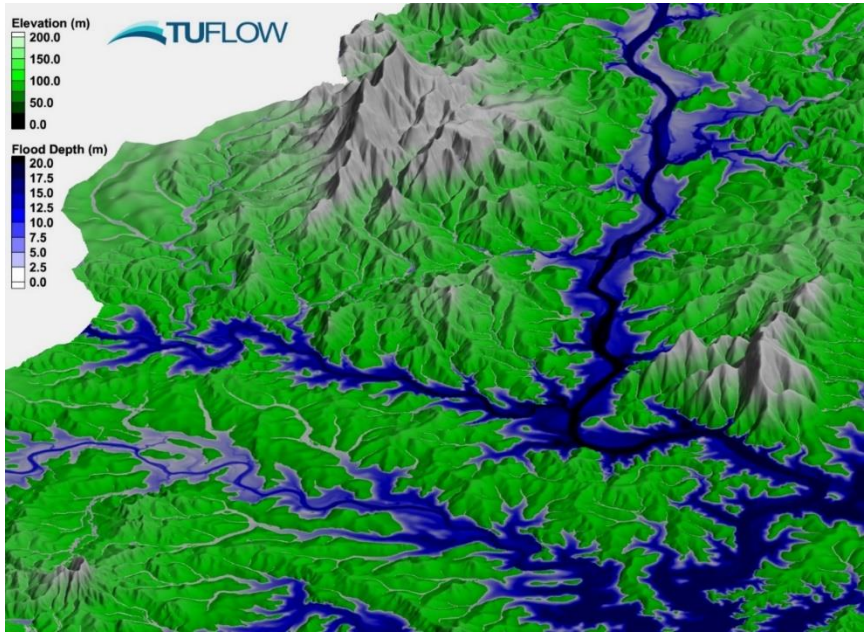
From 2017 onwards only 64bit versions of TUFLOW available

HPC Solver

One of the largest changes for the 2017 version of TUFLOW was the new HPC solver

Bill to cover this during the next session

In this session we'll look at other new and improved features for the 2017 and 2018 version of TUFLOW.



Intel Fortran 2017 – Results

For the 2017-09 Release of TUFLOW

Migrated to the latest Intel Fortran compiler version (17.0)

Change in compiler gives very slightly different results
(Don't ask why!!!)

Not possible to provide backward compatibility

The 2018-03 version uses the same Fortran version 17.0

2017-09 Default Settings

No major changes in default settings from 2016-03

New SX distribution method, based on depth in cells, for backward compatibility use:

SX Flow Distribution Cutoff Depth == 0.0

SX Head Distribution Cutoff Depth == 0.0

Checks on grid extent, skipped if outside model area

Process All Grids == ON

Use “Defaults == PRE 2017” to wind back to 2016-03 defaults

No change in defaults for 2018-03 compared to 2017-09

New Licencing Options

Software based licence available

Locked to computer rather than physical lock

Both local and network server options available

New option to control the licence search order

BMT, Jacobs, Aquaveo for both physical and software licences

New “TUFLOW_licence_settings.lcf” file

Default in the same folder as the TUFLOW.exe

If not found, looks in C:\BMT_WBM\

If not found, default settings applied (BMT dongles first)

`WIBU Firm Code Search Order ==`

Licence Free Test and Model Copy

Introduced for 2018-03-AA version

Requires -nlc (No Licence Check) input switch

```
TUFLOW_iSP_w64.exe -t -nlc runfile.tcf
TUFLOW_iSP_w64.exe -ca -nlc runfile.tcf
```

If running without a licence, no diagnostic output is generated

Successful test status is output to .tlf and .tsf

```
Simulation Start Test == SUCCESSFUL
```

Package Model Function

Introduced 2018-03-AA

New function to package inputs, for all events and scenario combinations

Does not check on model validity (e.g. check snapping of pits / pipes)

Therefore, much quicker than model copy

Does not require a TUFLOW licence

Use –pm (package model) input switch, e.g.

```
TUFLOW_iSP_w64.exe -pm runfile_~e1~hr_~e2~AEP_001.tcf
```

Package Model Function

Uses a “brute force” approach to handling events / scenarios

```
Processing source: USBC_EG05__event1__event2_.csv                    finition_005.tef...OK.
   Found event wildcard _event1_ in source USBC_EG05__event1__event2_.csv
   Found event wildcard _event2_ in source USBC_EG05__event1__event2_.csv
Attempting to copy 4 events associated with source: USBC_EG05__event1__event2_.csv
Found a total of 2 event sources

Event source 1 - wildcard - _event1_
2 possible event names:
Event name 1 - 2hr
Event name 2 - 4hr

Event source 2 - wildcard - _event2_
2 possible event names:
Event name 1 - 2hr
Event name 2 - 4hr

Found a maximum possible number of event combinations of 4
```

- USBC_EG05_100yr2hr.csv
- USBC_EG05_100yr4hr.csv
- USBC_EG05_PMFyr2hr.csv
- USBC_EG05_PMFyr4hr.csv

Package Model Function - Continued

Optional switches are:

“All” (-pmAll) copies all file extensions equivalent to –ca

“L” (-pmL) list the files to be copied, but do not copy. This also works with the model copy function

“ini” (-pmini) specify an ini file with user defined options

XF File Options

- -xf0 Do not copy xf files
- -xf1 Copy both raw inputs and xf files
- -xf2 Only copy xf files

Package Model Function - Continued

When packaging, all inputs relative to base folder.

By default this is two folder levels above the .tcf

```
C:\Projects\Modelling\TUFLOW\runs\infile.tcf
C:\Projects\Modelling\
```

Within destination input folder structure is maintained. Base and Destination can be defined in .ini file. With the commands below:

```
Base Folder == C:\Projects\Modelling
Copy Dest == C:\tmp\pm\
```

Faster run times for 1D/2D linked models

Introduced for 2018-03-AA version

Sophisticated indexing system to improve run times for models with large numbers of SX and/or HX links

Improvement gain very dependent on model, may range from 5% to 4,000%!

Benefits both TUFLOW Classic and HPC solvers

ESTRY and external 1D engines (e.g. Flood Modeller, 12D)

May slightly change results for single precision simulations

New method can be turned off with .tcf command:

```
Index 1D/2D Links == OFF
```

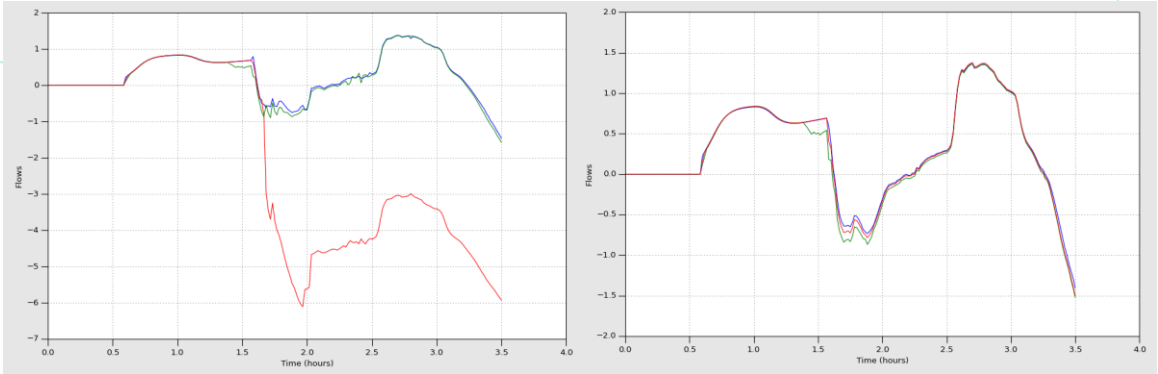
TUFLOW 1D Solver (ESTRY)

Now supports adaptive time stepping (to sync with HPC 2D solver)

Progressively parallelising ESTRY code

Work in progress

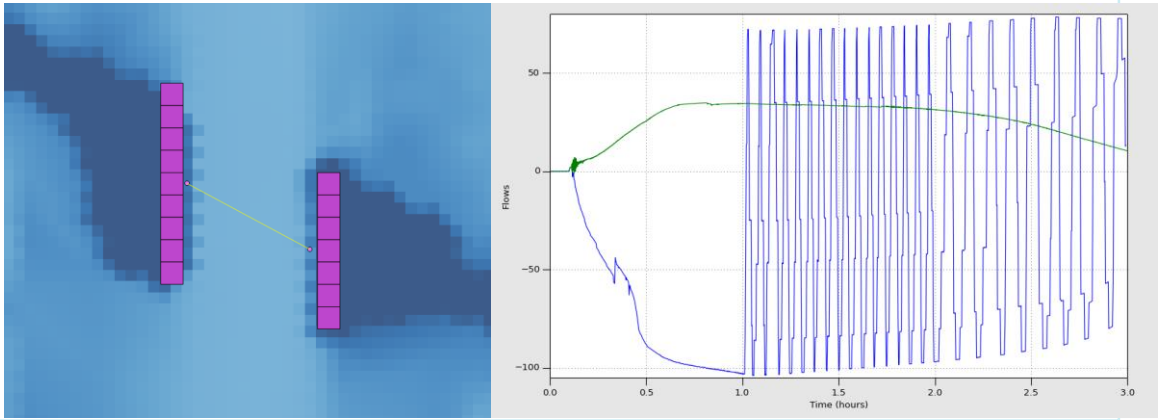
Primarily beneficial for very large 1D networks (e.g. large 1D pipe networks)



Culvert Enhancements

Improved stability when transitioning through reverse flow

Improved stability on difficult SX links



New SX Storage Feature (2017-09)

Assigns unused 1D storage to 2D SX cell(s)

1D node is a H boundary so storage not used
(H boundaries water level provided so mass balance equation not applied)

Average 1D surface area assigned to 2D SX cell(s)
(Varying 1D area over time creates/loses mass)

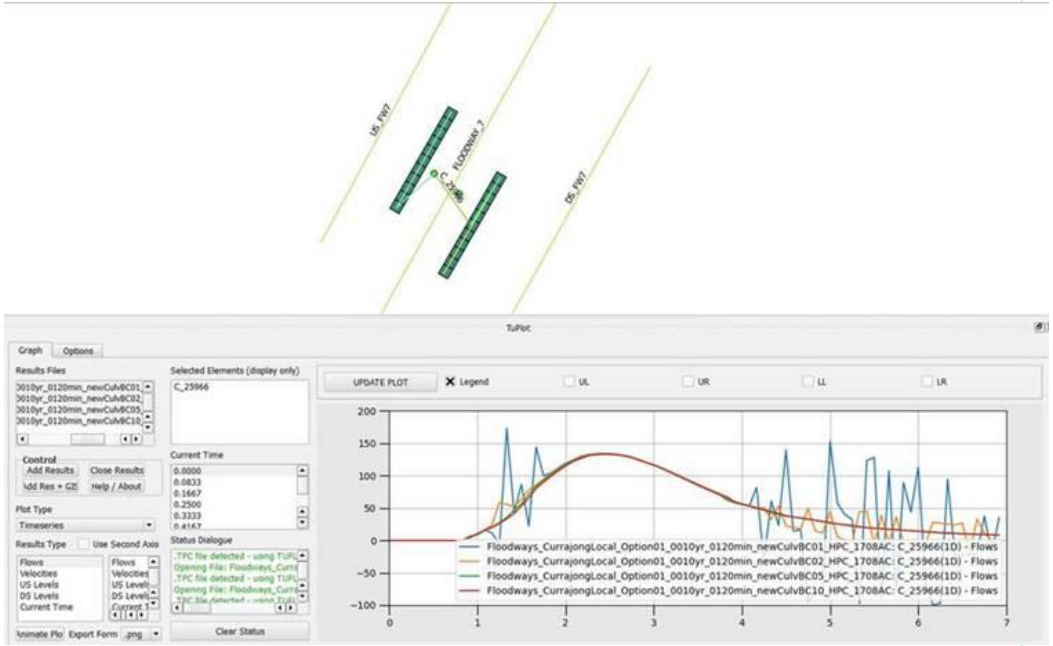
2d_bc "a" attribute can be used to add storage

Default is 1.0 (0.0 value treated as 1.0)

-1.0 does not apply (only 2D cell storage)

Increasing "a" has a stabilising effect on problematic SX links

Sensitivity test!



Blockage of Hydraulic Structures

Matrix Blockage

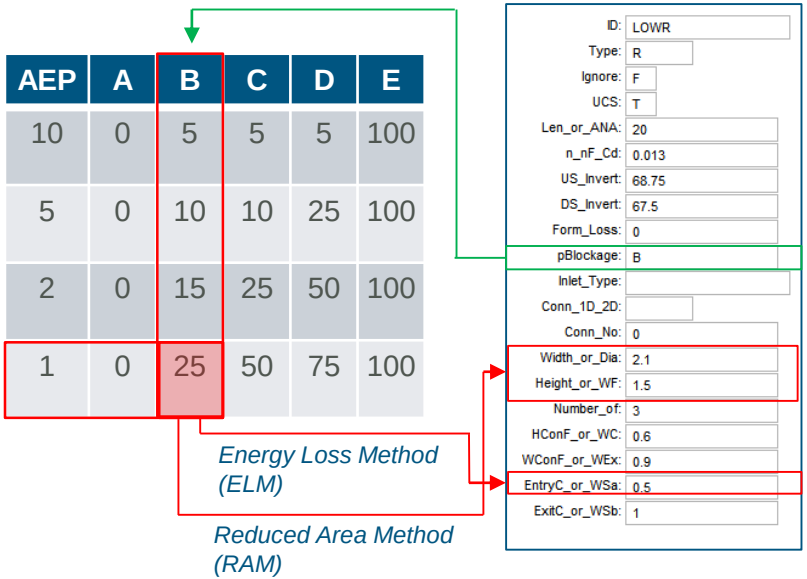
- Define the “Event” naming convention
- Create a blockage matrix
- Assign the blockage factor ID to the GIS entry

TUFLOW assigns a blockage value to the structure based on the simulation AEP

Two Methods Available

- Reduced Area Method
- Energy Loss Method (outlet control only)

$$C_{ELC\_modified} = \left(\frac{1+\sqrt{C_{ELC}}}{BR} - 1\right)^2$$



Blockage of Hydraulic Structures

- Modify pBlockage Field Data Type (or use 1d_nwkb)
- Add Matrix Blockage Commands to TCF
- Use Events File (.tef) for *Blockage ARI or AEP ==*
- Assign the blockage factor ID to the GIS entry

TUFLOW assigns a blockage value to the structure based on the simulation AEP

Blockage Risk Factor == 2

Blockage Override == A

Refer to latest TUFLOW Manual for model syntax information and http://wiki.tuflow.com for example models.

TCF Commands

```
Matrix Blockage == On                                    !
Matrix Blockage File == ..\model\Matrix_Blockages.csv
Blockage Method == RAM                                   !
Blockage Default == A                                    !
```

TEF Commands

```
!-----------------------------------------
Define Event == Q100
    BC Event Source == _event1_ | 100yr
    Timestep == 1
    Blockage ARI == 100
End Define
```

Blockage Matrix

```
ARI,A,B,C,D,E
1,0,10,10,10,100
20,0,10,10,20,100
50,0,10,20,50,100
100,0,20,50,70,100
2000,0,50,70,100,100
```

Pits – Changes for 2018-03

Classic now supports VPI (Virtual Pipe Inlet), previously only in GPU / HPC

Virtual Pipes and 1D can be included in the same model

Pits can be connected to virtual pipes and/or 1D networks in the

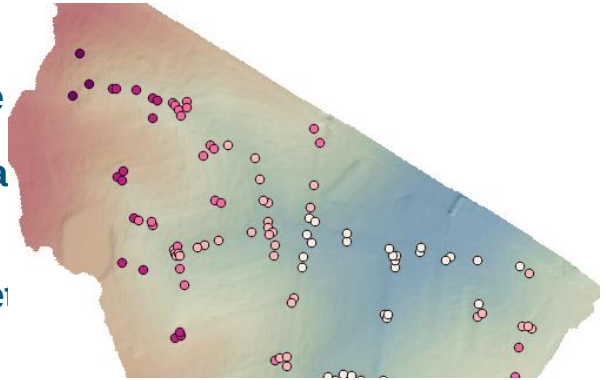
1d_pit layer can now be used for all pit types (previously this wa
TUFLOW GPU or HPC)

1d_pit layer has less attributes than 1d_nwk layer. Attributes de

A % blockage can be specified on the 1d_nwk or 1d_pit layer

HPC Solver supports 1D "Pit D
pipe inlets (VPI)

New 1d _pit_A_check layer



C13_q1000_CLA+2018-03-AA_pit_A_check :: Features total: 159, filtered: 159, selected: 0

	ID	Type	VP_Network_ID	Inlet_Type	VP_Sur_Index	VP_QMax	Width	Conn_2D	Conn_No	pBlockage	Number_of	Invert	Q_factor	i_1d_layer
1	13S0001	Q	0	EC	0	0	1		0	0	1	42.793	1	2
2	13S0002	Q	0	EC	0	0	1		0	0	1	41.554	1	2
3	13S0005	Q	0	OM	0	0	1		0	0	1	39.558	1	2
4	13S0008	Q	0	EC	0	0	1		0	0	1	37.221	1	2

Show All Features

Tiled Grid Processing

Extents of input grid are now compared to model extent

Grids outside of model extent are skipped (e.g. red tiles)

```
Process All Grids == ON
```

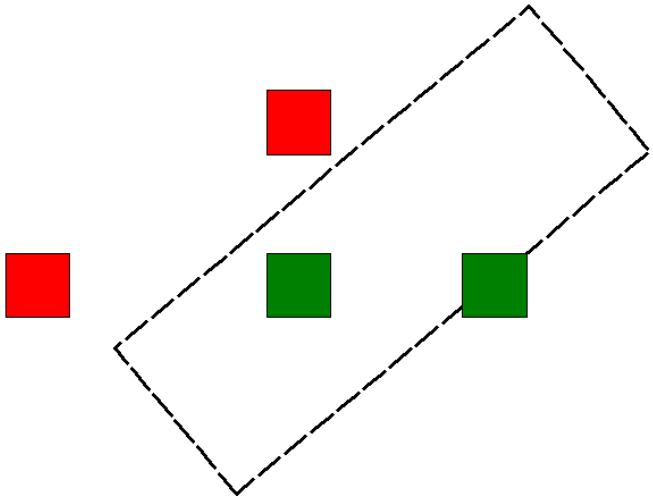
Faster simulation start-up

Potentially reduced memory usage

Memory allocated to read entire DEM

178GB DEM (entire UK), split into tiles

Single read file containing all read grids



Start-up Time Summary File

New output file in log folder

<simulation_name>_start_stats.txt

Summary of the time various model start-up phases

Allows us to help prioritise tasks

We may ask you to email support!

```
Reading Boundary File Domain_001                ,    1216.60,       0.00
Finished Reading Boundary File Domain_001       ,    1223.24,       6.65
Initialising 2D Data (Stage 1) Domain_001       ,    1223.24,       0.00
Finished Initialising 2D Data (Stage 1) Domain_001,  1225.66,       2.42
Initialising 2D Data (Stage 2) Domain_001       ,    1225.66,       0.00
Finished Initialising 2D Data (Stage 2) Domain_001,  1226.51,       0.85
Start Writing _grd_check                        ,    1230.89,       4.38
End Writing _grd_check                          ,    1242.13,      11.24
Start Writing _zpt_check                        ,    1242.13,       0.00
End Writing _zpt_check                          ,    1260.88,      18.75
Start Writing _uvpt_check                       ,    1260.88,       0.00
End Writing _uvpt_check                         ,    1274.54,      13.66
Start Writing check DEMs                        ,    1284.36,       9.82
Start Calculating grid interpolation factors    ,    1284.36,       0.00
End Calculating grid interpolation factors      ,    1287.53,       3.17
End Writing check DEMs                          ,    1288.83,       1.30
Starting Simulation                             ,    1288.85,       0.02
Summary File Close                              ,    1288.85,       0.00
```

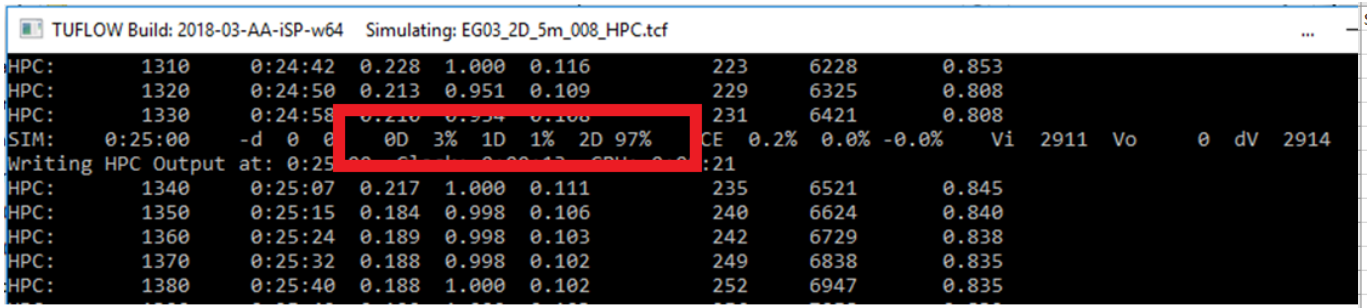
Relative Computational Efforts

A new output file in the log folder

"<simulation_id>_run_stats.txt"

Contains that percentage of time that TUFLOW spends in the 1D, 2D and other sections of the calculations

This data is also output to the console window as the simulation progresses.



Simulation Time	1D (%)	2D (%)	Other (%)
0.0000	0	23	77
0.0167	1	87	12
0.0333	2	89	9
0.0500	2	90	8
0.0667	2	91	7
0.0833	2	91	7
0.1000	2	91	7
0.1167	2	92	6
0.1333	2	92	6
0.1500	2	92	5
0.1667	2	92	5
0.1833	3	92	6
0.2000	3	92	6
0.2167	3	91	6

New XF Files (2017-09)

Additional Binary Files to speed up model initialisation

Database .csv files (boundary database and pit inlet database) and .ts1 files

For .csv file converts all columns, assumes data starts in the 1st row

.ts1 files now support time units other than minutes, search for the following in 1st column

Sec

Min

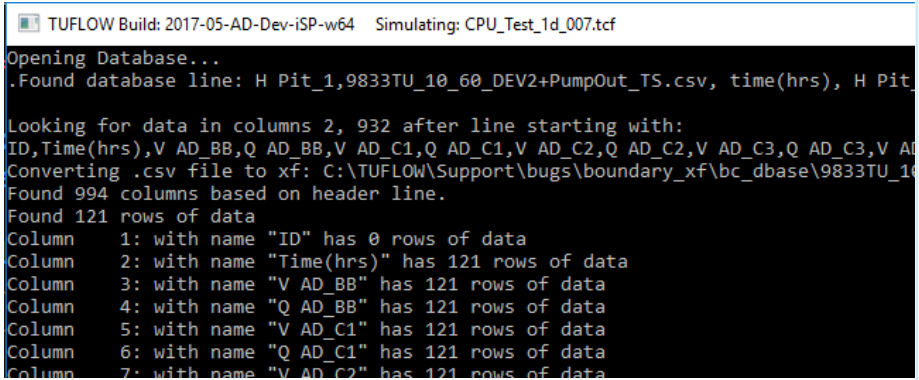
Hour or hr

Day

If none of above, assumes time is in minutes (pre 2017)

New check for incomplete (zero size) .xf files

2018-03-AA supports more than 50,000 rows for .csv



New Auto Terminate Feature

New option for stopping simulation after peaks have been reached

Assessed at each map output interval

Both classic and HPC

User specify cells to be monitored

```
Set Auto Terminate == 0
Read GIS Auto Terminate == ..\model\gis\2d_AT_001_R.shp
```

Specified tolerance on wet cells and velocity-depth product

```
Auto Terminate Wet Cell Tolerance == 0
Auto Terminate dv Cell Tolerance == 0
Auto Terminate dv Value Tolerance
```

Minimum simulation time can be set

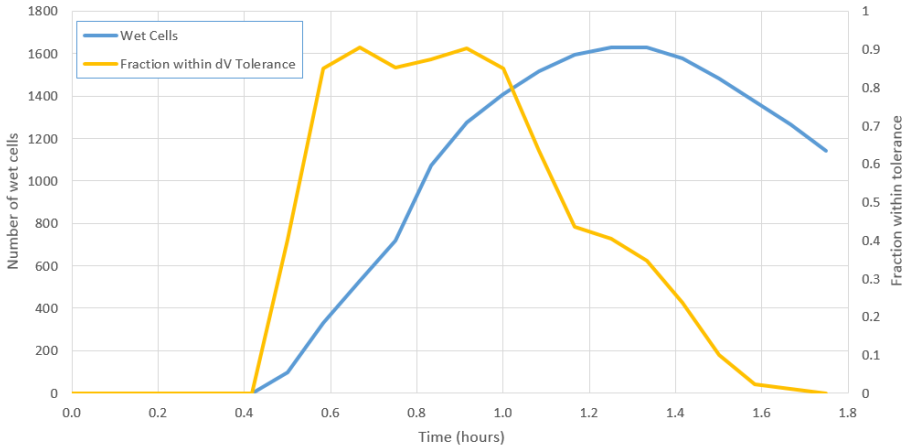
```
Auto Terminate Start Time == 2.5 !time in hours
```

Auto Terminate (continued)

Output to console

Additional .csv file output

written as simulation progresses




```
Assessing Auto Terminate.
Current number of monitored cells that are wet: 1375
Percentage of cells that have now become wet: 0.%
Percentage of cells that have current dV within tolerance of maximum: 2.327%
Wet:        4948  Vol:            104109.6
HPC:       8800     1:35:51  0.422  0.997  0.220         4848    101894       0.725
HPC:       8900     1:37:03  0.425  0.997  0.218         4765     99197       0.727
HPC:       9000     1:38:16  0.426  0.994  0.219         4684     96458       0.727
HPC:      iStep        time  maxNu  maxNc  maxNd         nWet       vol          dt
HPC:       9100     1:39:29  0.425  0.990  0.219         4625     93674       0.727
Writing HPC Output at: 1:40:00  Clock Time: 0:24:29  CPU Time: 0:00:34
Pulling maximum H from HPC
Pulling maximum Z0 from HPC
Assessing Auto Terminate.
Current number of monitored cells that are wet: 1268
Percentage of cells that have now become wet: 0.%
Percentage of cells that have current dV within tolerance of maximum: 1.025%
Wet:        4615  Vol:             92793.9
HPC:       9200     1:40:42  0.433  0.998  0.224         4551     90830       0.735
HPC:       9300     1:41:56  0.442  0.997  0.229         4482     87891       0.738
HPC:       9400     1:43:10  0.454  0.997  0.233         4401     84885       0.741
HPC:       9500     1:44:24  0.464  0.992  0.236         4334     81822       0.741
Writing HPC Output at: 1:45:00  Clock Time: 0:24:31  CPU Time: 0:00:35
Pulling maximum H from HPC
Pulling maximum Z0 from HPC
Assessing Auto Terminate.
Current number of monitored cells that are wet: 1142
Percentage of cells that have now become wet: 0.%
Percentage of cells that have current dV within tolerance of maximum: 0.%
Wet:        4317  Vol:             80600.1

Auto Terminate conditions have been met, stopping simulation.
```

New Cell Centred Result Output

Uses NetCDF File format to output cell centred results

Allows raw rotated grid to be saved

Efficient (storage) compared to default raster output

Compressible using "NetCDF Output Compression ==”

Ideal for scripting (Matlab, python) for customised processing:

Determining rate of rise

Processing result windows
(e.g. 5 year simulation, extract duration of inundation for certain years)

Currently no 1D WLL or multiple 2D domain support

```
import numpy
from netCDF4 import Dataset

nc_f = r'..\Results\2d\Sim_001.nc'
threshold = 0.01 #depth of 1cm

nc_fid = Dataset(nc_f, 'r')
variables = nc_fid.variables
time = nc_fid.variables['time'][:]
dep_var = nc_fid.variables['depth']
```

Time of maximums

Time of maximums now extended to tracked maximums

Previously was limited to:

Water level (classic and GPU)

Velocity (CPU)

Classic and HPC now include

Velocity supported in HPC

All hazard outputs

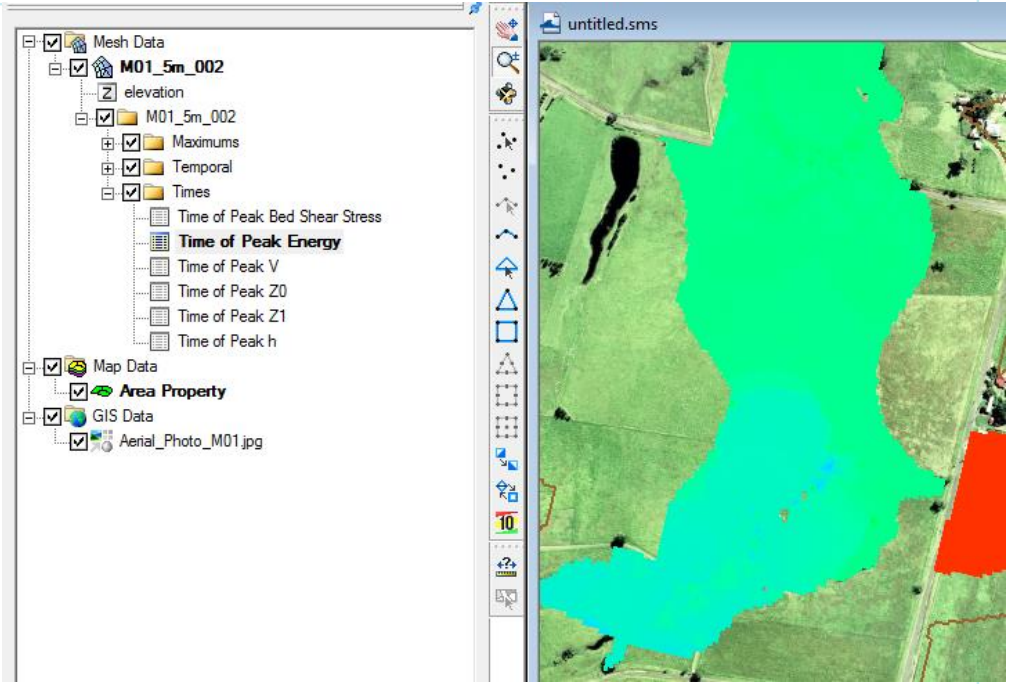
Energy

Bed Shear Stress

Stream Power

Default is off (except for h and v), can be changed with:

```
Maximums Track Time == ON | {OFF}
```



Other Output Changes

TUFLOW now track cell centre v

Improved output extents for these outp
maximum flood extent

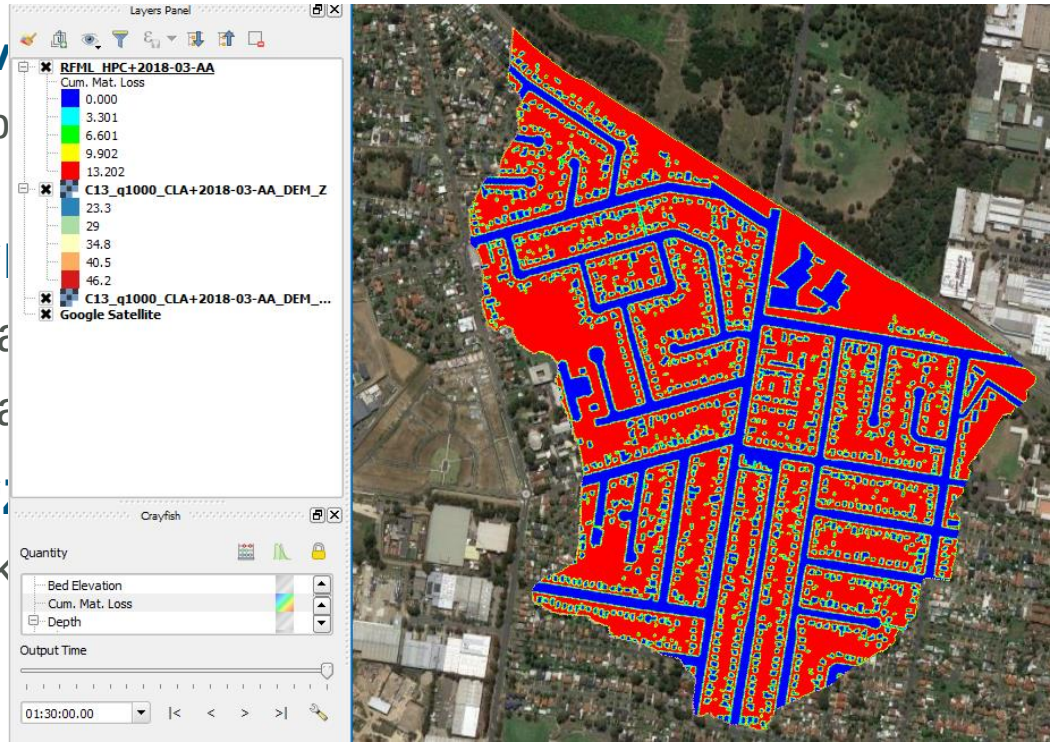
New Map Output Data Type == "

Contains the total rainfall losses ba

Sum of initial and cumulative rainfa

New Map Output Data Type == "

Based on FD2320 (ZUK0 and ZUK



Volume / Flux on a Model Sub-Area

Ability to output volume within a sub-region of the model over time

2d_po region object

Output options are:

Havg – Average Water Level (of wet cells)

Hmax – Maximum water level

Qin – Flow into the region

Qout – Flow out of the region

SS – Sink / Source flows applied within the region (rainfall, infiltration, SA flows, SX flows)

Vol – Total volume of water within region

Output to standard .csv files as per other PO

Can view in TuPlot

No Console runtime option

New runtime option –nc

Disables console window when TUFLOW running

Console output can be captured, e.g.:

```
TUFLOW_iSP_w64.exe -nc runfile.tcf > runfile_output.txt
```

Primarily for

Linux platforms using windows emulator

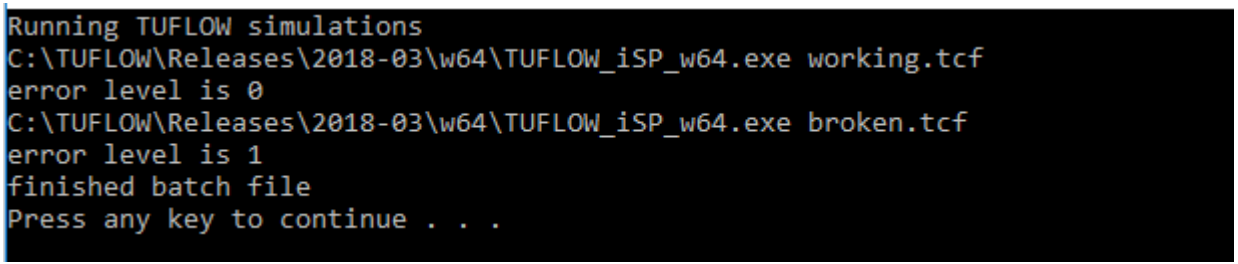
Running “blind” on specialised hardware grid

Error level reporting to OS

If TUFLOW exits unsuccessfully, e.g. an error during initialisation or due to an instability a return code is passed back to operating system or the calling process.

This can be checked using batch file or other scripts.

```
start “TUFLOW” /wait TUFLOW_iSP_w64.exe runfile.tcf
echo error level is %errorlevel%
```



Rainfall Boundary Multiplier

Rainfall Boundary Factor == [<value> | {1.0}]

Applies to all rainfall boundaries including:

Global Rainfall

Read GIS RF

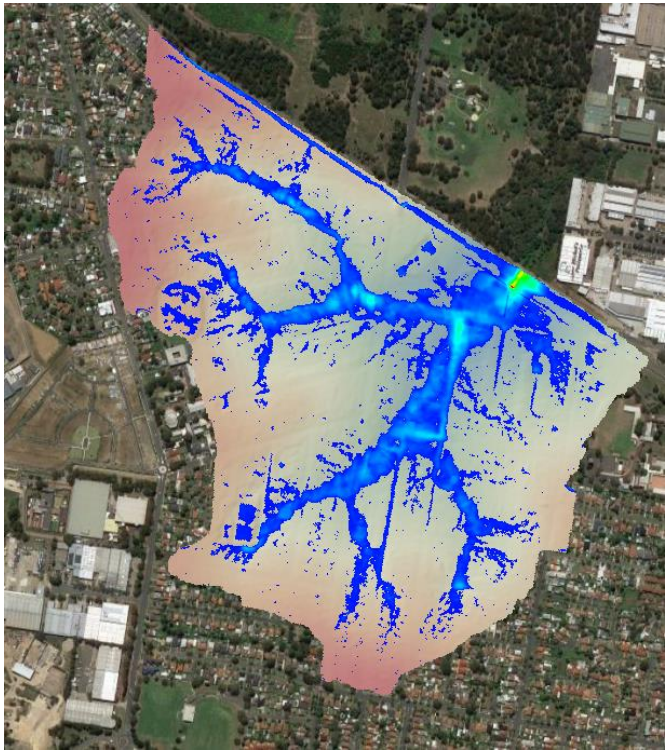
Read GIS SA RF

Gridded rainfalls

TUFLOW rainfall control file (.trfcf)

Applies prior to rainfall losses

Useful to test, for example, 10% increase in rainfall



New external stress file

Spatially and temporally varying wind stresses can be applied

```
External Stress File == <filename.tesf>
```

Three types of wind/stress boundary:

1. Global Wind (temporally, not spatially varying)
2. Grid interpolation based on point boundaries
3. User specified time varying gridded stresses

Note can’t be used with “WT” boundary in 2d_bc layer

External stress - continued

Similar options to .trfcf (rainfall control file) for gridding:

1. **Based on IDW interpolation**
2. **Based on Polygons**

Stress calculations based on

Wu (1980)

$$\tau = C_{10} \times \rho_{air} \times U_{10}$$

Where:

τ is the shear stress in N/m^2

ρ_{air} is the density of air in kg/m^3.

U_{10} is the wind velocity as 10 m above the mean water surface in m/s.

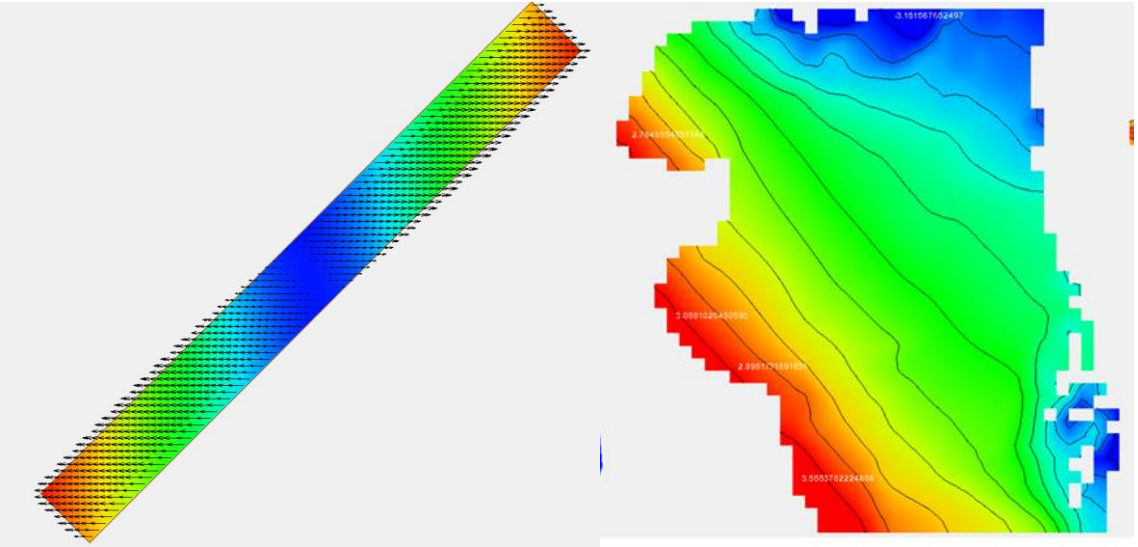
$$C_{10} = (0.8 + 0.065\, U_{10}) \times 10^{-3}$$

For user specified grids, input grids are stress in the x and y direction with units of N/m^2 or lbf/ft^2. So could be used for other stresses (e.g. wave radiation stresses)

External stress - continued

New output data type “tau”

Vector output of shear stress in N/m^2 (or lbf/ft^2)



Other Changes

Start and End Time can now be specified via a command line argument

-st<time in hours>

-et<end time in hours>

Highest priority (overwrites all control file .tcf, .tef)

For Variable Z Shape, start of breach now reported

.tlf and messages layer for Classic

.hpc.tlf for HPC solver

Boundary files now supported in the DELFT FEWS .xml or .csv file formats.

Specify, LocationID, ParameterID and optionally EnsembleID

Name	Source	Column 1	Column 2
FC01	FEWS | Input.csv		Location1 | Q.sim.hist
FC02	FEWS | Ensemble_Input.csv		Location2 | Q.sim.hist | 1

Other Changes

User specified null for dry in PO

Time Series Null Value == <value> | {Cell Elevation}

The default is the same as previous versions, the cell ZC elevation was output when the cell is dry

For 2018-03-AA HPC now supports “Write PO Online == ON”

Plot output files written at each map output interval (as per TUFLOW Classic)

Rainfall timeseries read into .trfcf can have a user defined null value (IDW only)

`Rainfall Null Value == <null value> | {-99999}`

If a null value is detected with IDW interpolation is revised to ignore null locations.

Evacuation routes GIS Output (_RCP) now supports Shapefile format

Check Files

Structure Group Check files

_Str_Grp_All.csv

_Str_Grp_Multi.csv

Now specifies if channel is reversed

	A	B	C	D	E	F	G
	Name	Primary Channel	Below	Channels Below	Above	Channels Above	
	281	281	4	279 (reversed) |280|281|282	1	mc00970W	

Bug Fix Summary

Bug fixes include

Blue Kenue outputs working for Double Precision

Structure group check file with reversed channels

Linked TUFLOW-Flood Modeller fails during writing of check files

Read Grid Location if x or y origin < -99,999

Close off advection-dispersion .dat files at end of simulation

Fixed issue with automatically assigned WLLp elevations from cross-sections

Fixed issue with SP and BSS outputs for cell centred outputs

Fix issue with maximum outputs being blank if no temporal output was created during simulation

Mass balance reporting issue with 1D nodes with a HT / HQ boundary and a 2D HX link.

Manual / release note for full list

Updated Manual, New Wiki Pages and Handy Resources

Manual available for 2017-09-AC (2018-03 under progress)

Wiki Changes

Rework hardware benchmarking page as "what hardware", "how fast is my scheme", "which GPU"

QGIS Training documents

Hardware selection

Memory usage

Classic vs HPC

1st or 2nd Order

New Features 2017 / 2018