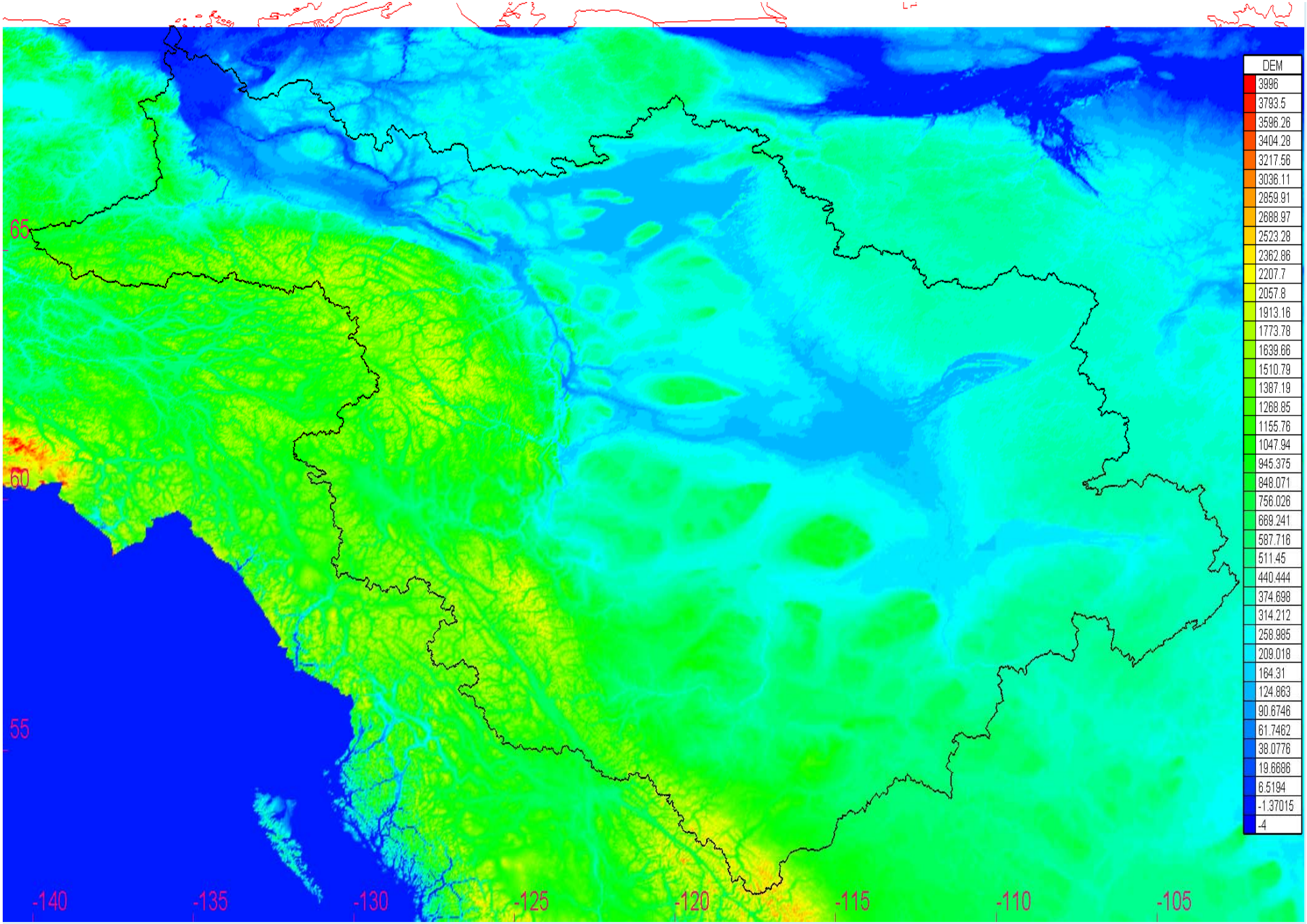
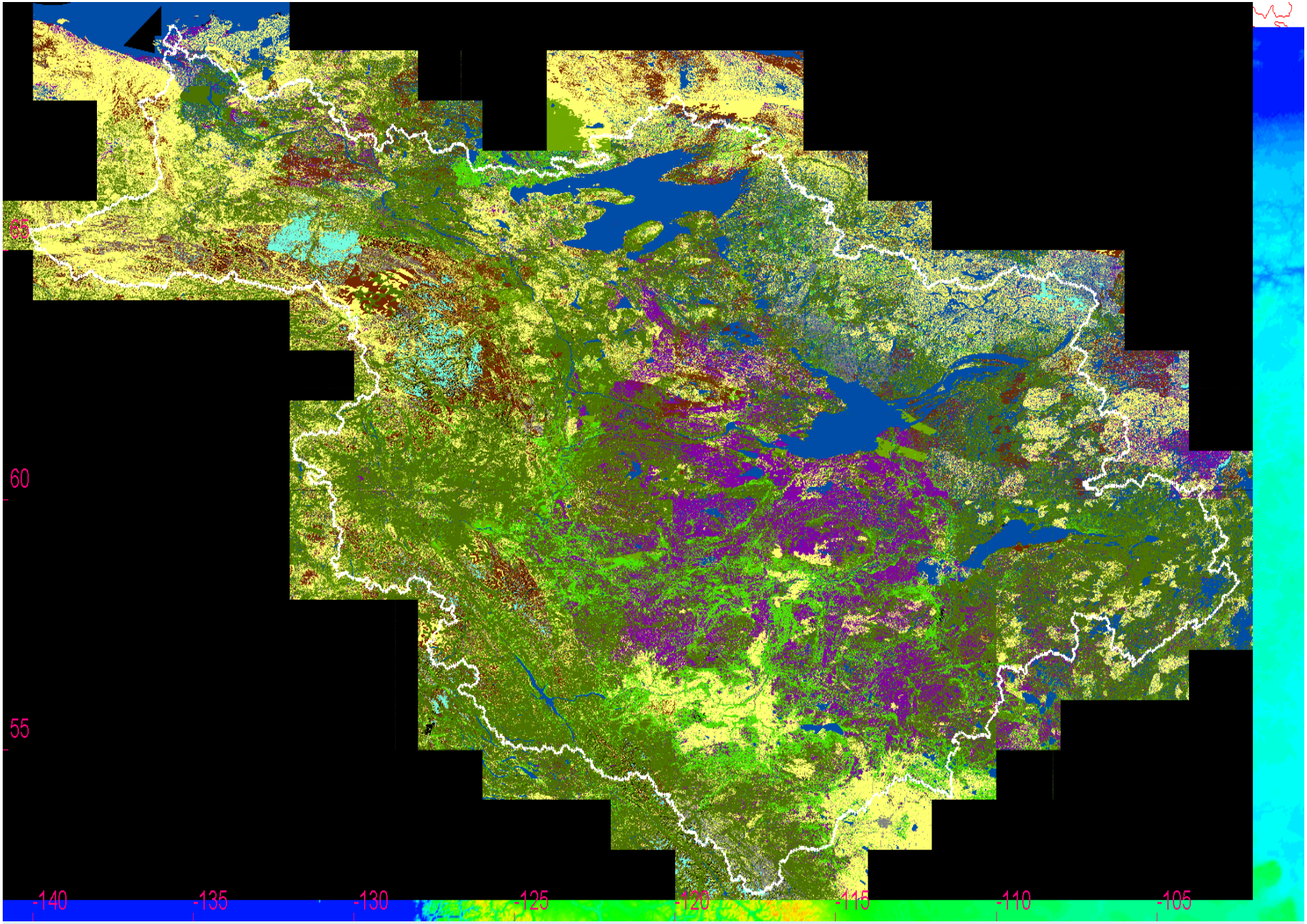
Setup WATFLOOD for the MRB watershed

- »DEM
- »Land cover map
- »Precip
- »Temperature
- »Streamflow
- »Snow course data
- »Diversions



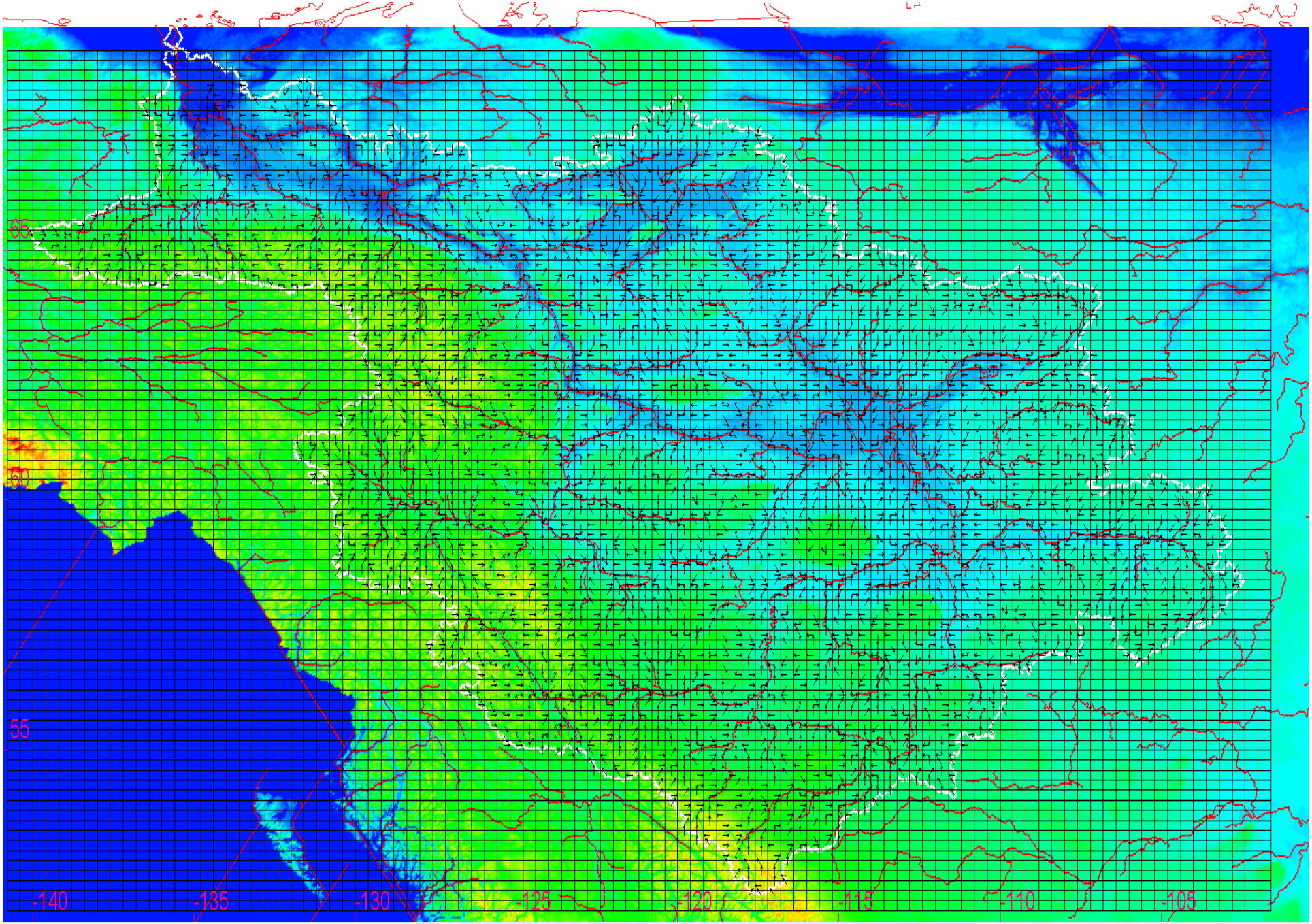
Start with a DEM



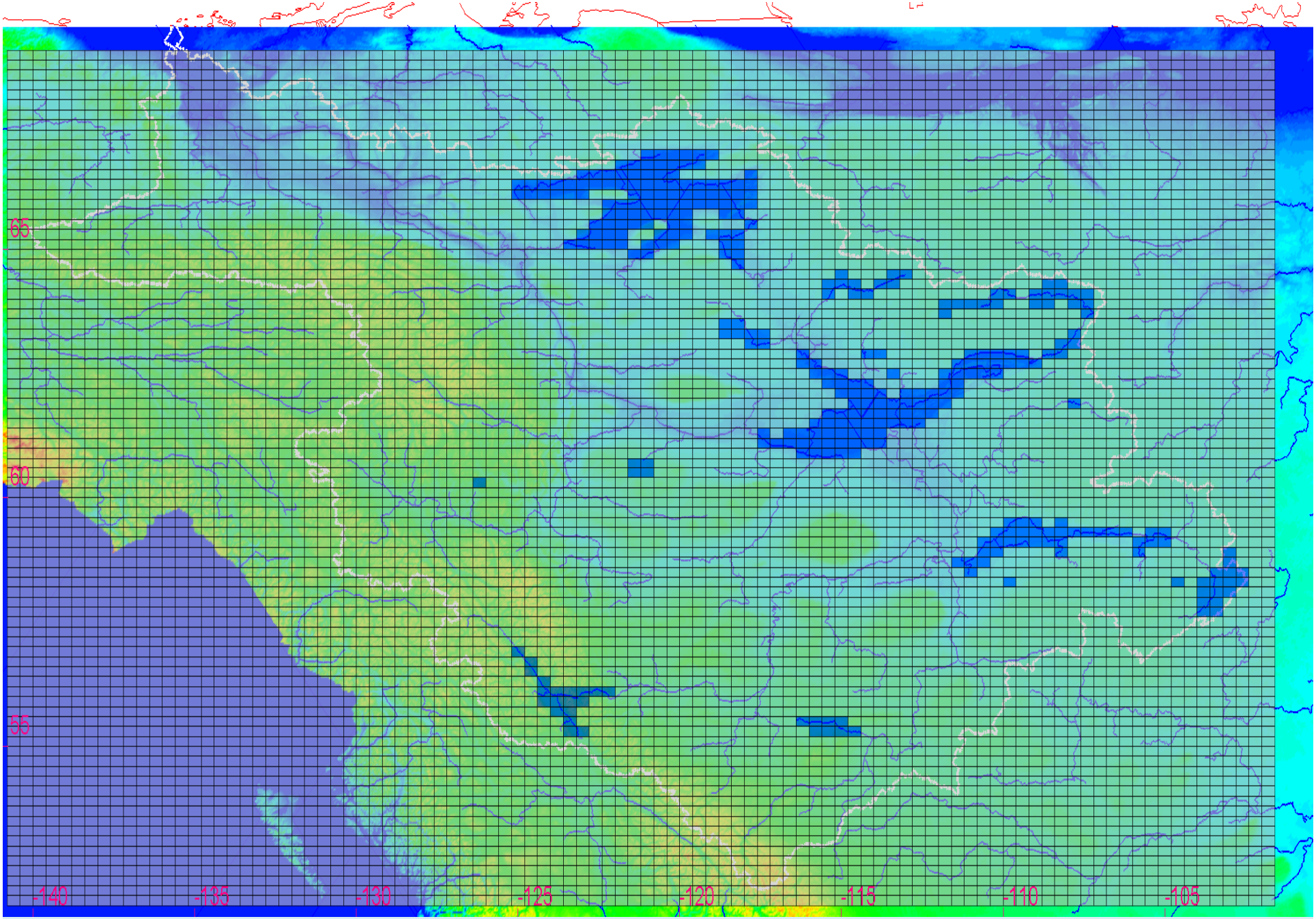
And a Land Cover map – note it is made up with “tiles”

Collect data automatically with GreenKenue (yeah!):

- From the DEM
  - Channel Elevation
  - Size of each grid (frac)
  - Drainage direction out of each grid
  - River class – default = 1 & is edited later
  - Contour density in each grid – relates to overland slope
  - Channel density - affects routing efficiency
  - Reach number - default = 0 & is edited to insert lakes/reservoirs
- From the Land Cover Map
  - From the Land Cover map, collect the # of pixels of each land cover class and convert to a %



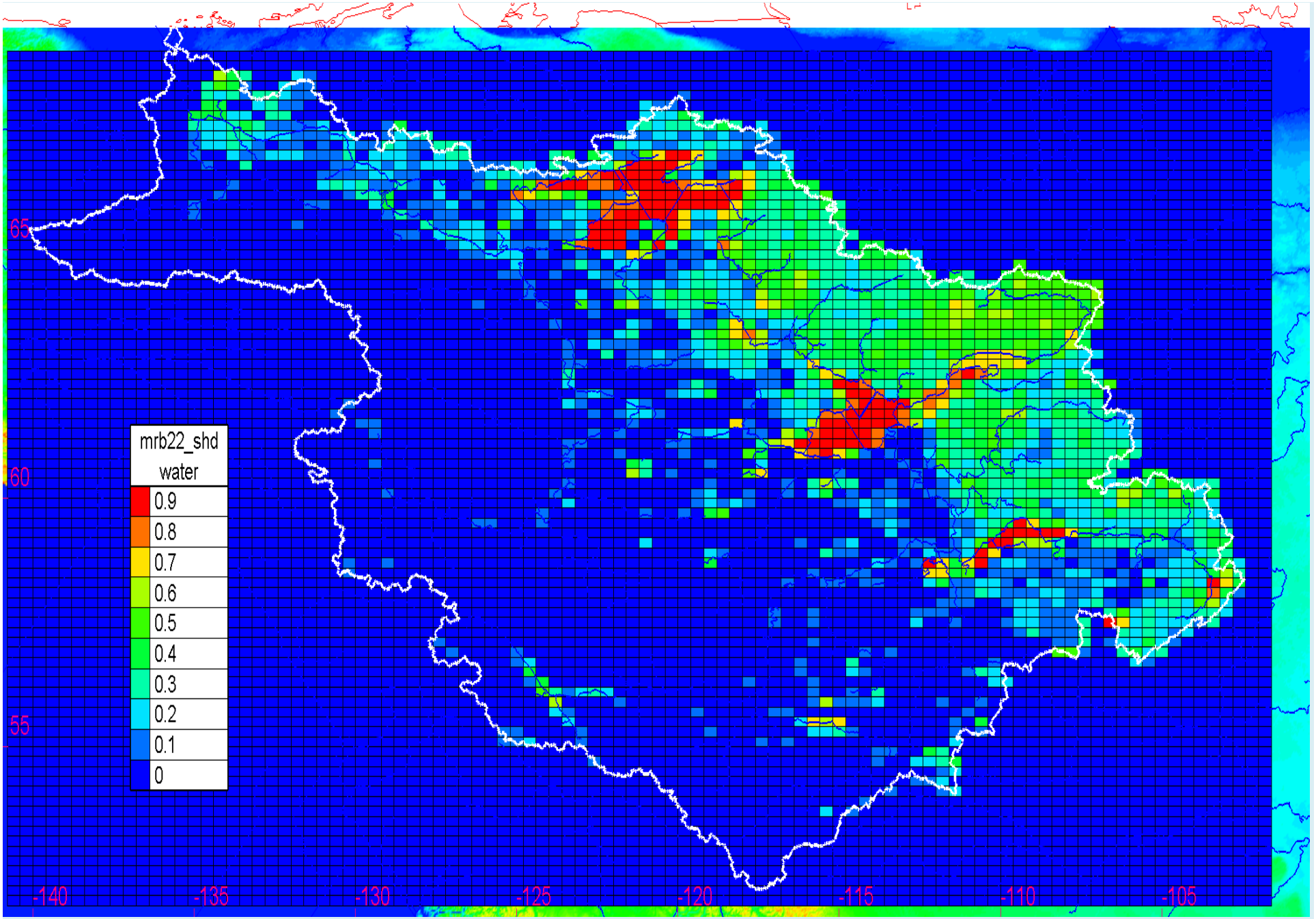
Create a watershed file, set up WATFLOOD grid and collect gridded drainage map



Code the lakes: mark & number grids as reaches/lakes

Next:

- Run BSN.exe to convert the raw data set into hydrologically usable data:
  - Determines grid rank: highest to lowest for computational order
  - Convert elevations and grid size into channel slope for routing
  - Convert contour density to overland slope
  - Bankfull channel x-section area
  - Combine classes that are similar to reduce # for computational efficiency



Collect land cover by % in each grid cell: 15 classes for the Mackenzie River watershed

MRB22_shd.r2c file:

```
########################################
:FileType r2c  ASCII  EnSim 1.0
#
# DataType               2D Rect Cell
#
:Application             WATFLOOD
:Version                 10
:WrittenBy          nk
:CreationDate       2014-04-02  17:03
#
#---------------------------------------
:SourceFileName     WSC_02HF_4.map
:NominalGridSize_AL     1000.000
:ContourInterval           1.000
:ImperviousArea            1.000
:ClassCount                   12
:NumRiverClasses               1
:ElevConversion            1.000
:TotalNumOfGrids            3488
:numGridsInBasin            3487
:DebugGridNo                1744
#
#effective nca %             0.00000
#
:Projection         CARTESIAN
:Ellipsoid          unknown
#
:xOrigin              1407000.00000
:yOrigin             11993000.00000
#
```

Shd file header in Green Kenue r2c format

```
:AttributeName 1 Rank
:AttributeName 2 Next
:AttributeName 3 DA
:AttributeName 4 Bankfull
:AttributeName 5 ChnlSlope
:AttributeName 6 Elev
:AttributeName 7 ChnlLength
:AttributeName 8 IAK
:AttributeName 9 IntSlope
:AttributeName 10 Chnl
:AttributeName 11 Reach
:AttributeName 12 GridArea
:AttributeName 13 FetchNE
:AttributeName 14 FetchE
:AttributeName 15 FetchSE
:AttributeName 16 FetchS
:AttributeName 17 FetchSW
:AttributeName 18 FetchW
:AttributeName 19 FetchNW
:AttributeName 20 FetchN
:AttributeName 21 grass
:AttributeName 22 crops
:AttributeName 23 conif
:AttributeName 24 decid
:AttributeName 25 mixed
:AttributeName 26 regen
:AttributeName 27 barren
:AttributeName 28 bog
:AttributeName 29 wetland
:AttributeName 30 wetland
:AttributeName 31 water
:AttributeName 32 impervious
```

Followed by 32 frames of gridded watershed data

Attribute list in the shd file

Data files in working directory – e.g. c:\watflood\mrb22:

```
Geographical           basin\mrb22.map
Geographical           basin\mrb22_shd.r2c
Point Precipitation    raing\yyyymmdd_rag.tb0
Gridded Precip         radcl\yyyymmdd_met.r2c
Point Temperature      tempg\yyyymmdd_tag.tb0
Gridded Temp           tempr\yyyymmdd_tem.r2c
Gridded TempvDiff      tempr\yyyymmdd_dif.r2c
Streamflow             strfw\yyyymmdd_str.tb0
Lake rules / releases  resrl\yyyymmdd_rel.tb0
Diversion flows        diver\yyyymmdd_div.tb0
Lake levels            level\yyyymmdd_lvl.tb0
Initial lake levels    level\yyyymmdd_ill.pt2
Snow Course Swe        snow1\yyyymmdd_crs.pt2
Gridded SWE            snow1\yyyymmdd_swe.r2c
Point Soil moisture    moist\yyyymmdd_psm.pt2
Gridded Soil Moisture  moist\yyyymmdd_gsm.r2c
```

Note:

tb0 files: station time series

pt2 files: static station point data

r2c files: both static & time series gridded data

Optional

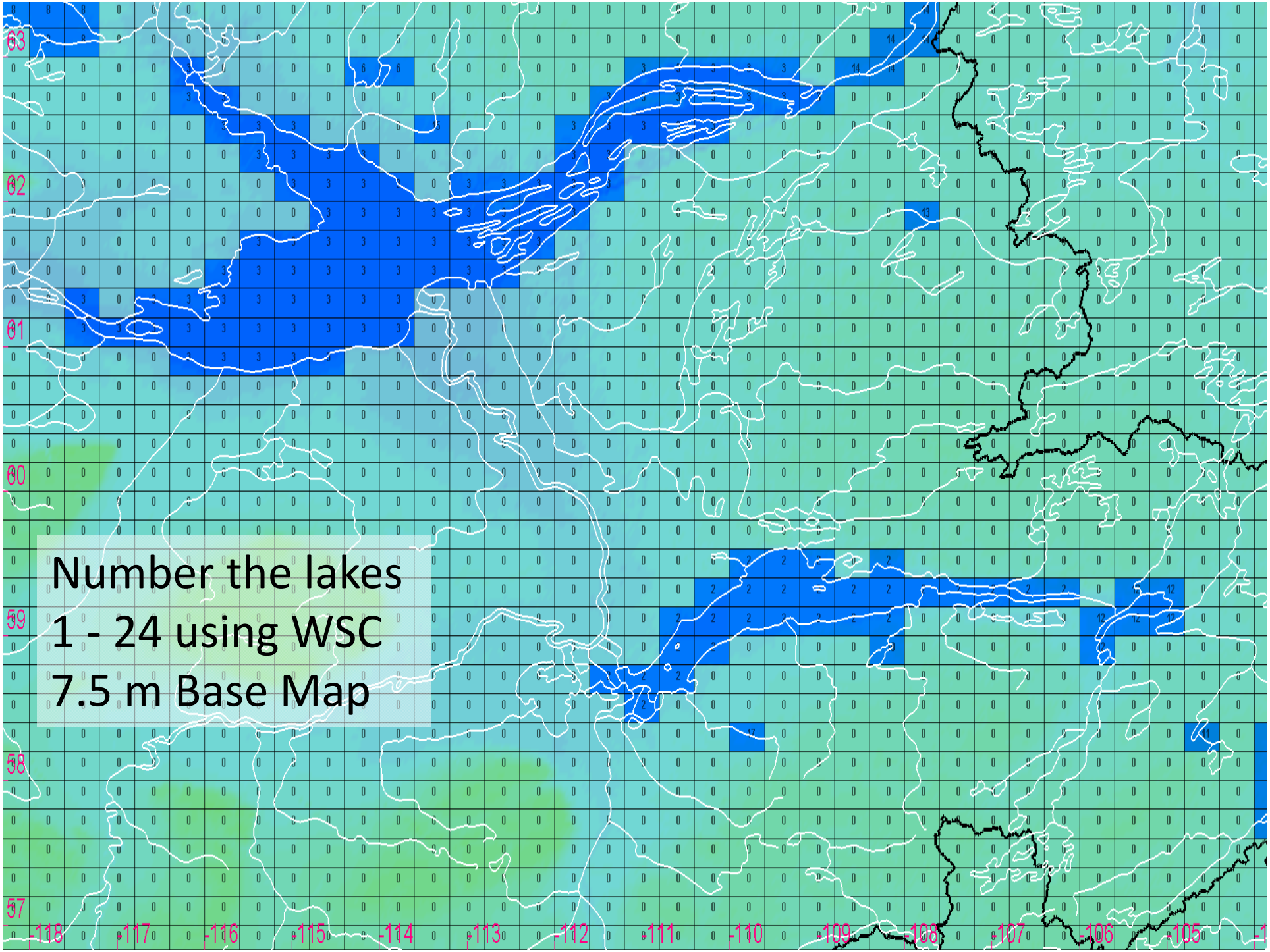
Modeling a watershed involves a gradual refinement of the model

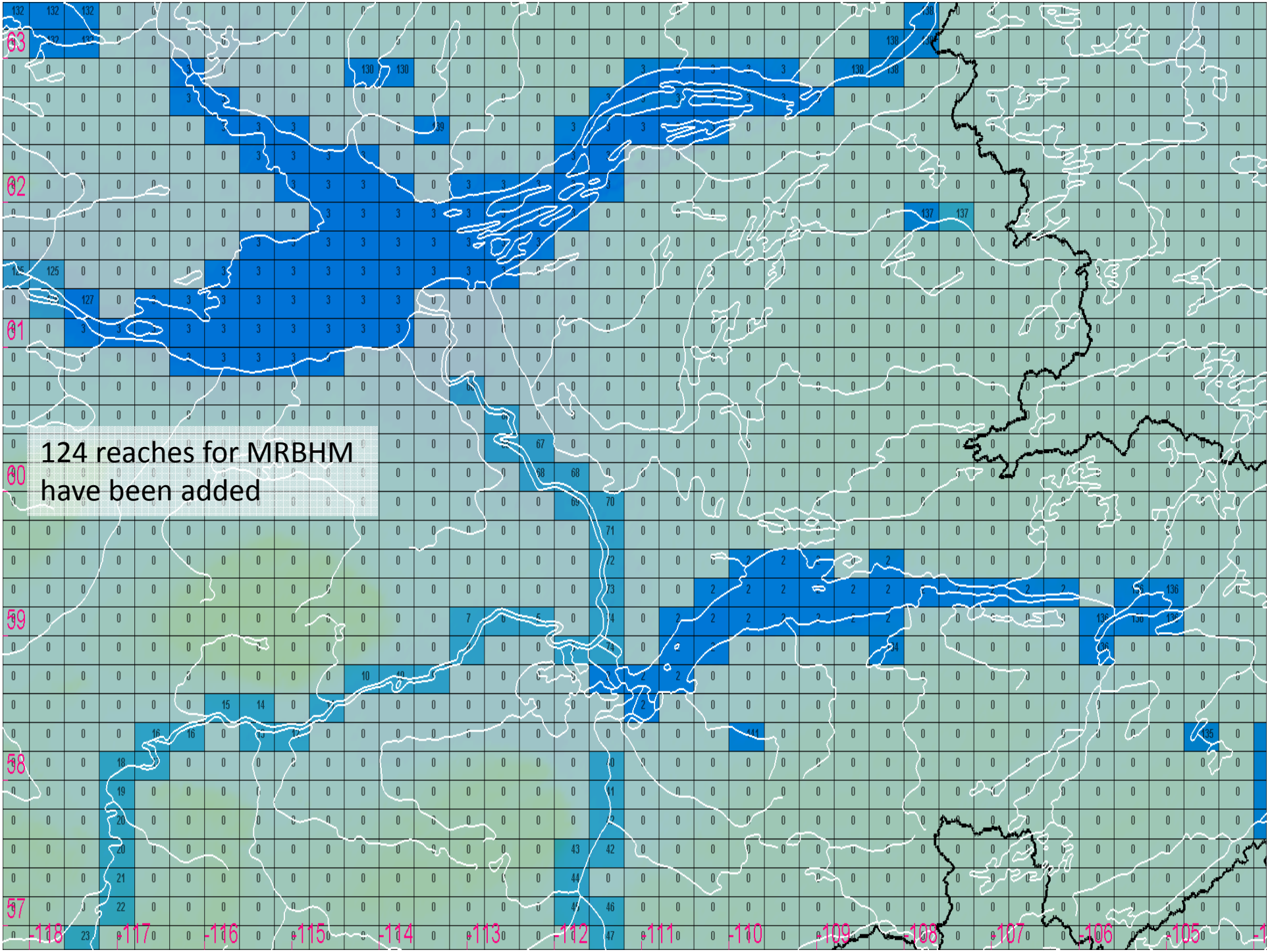
After DEM & landcover: mark lakes & reservoirs:

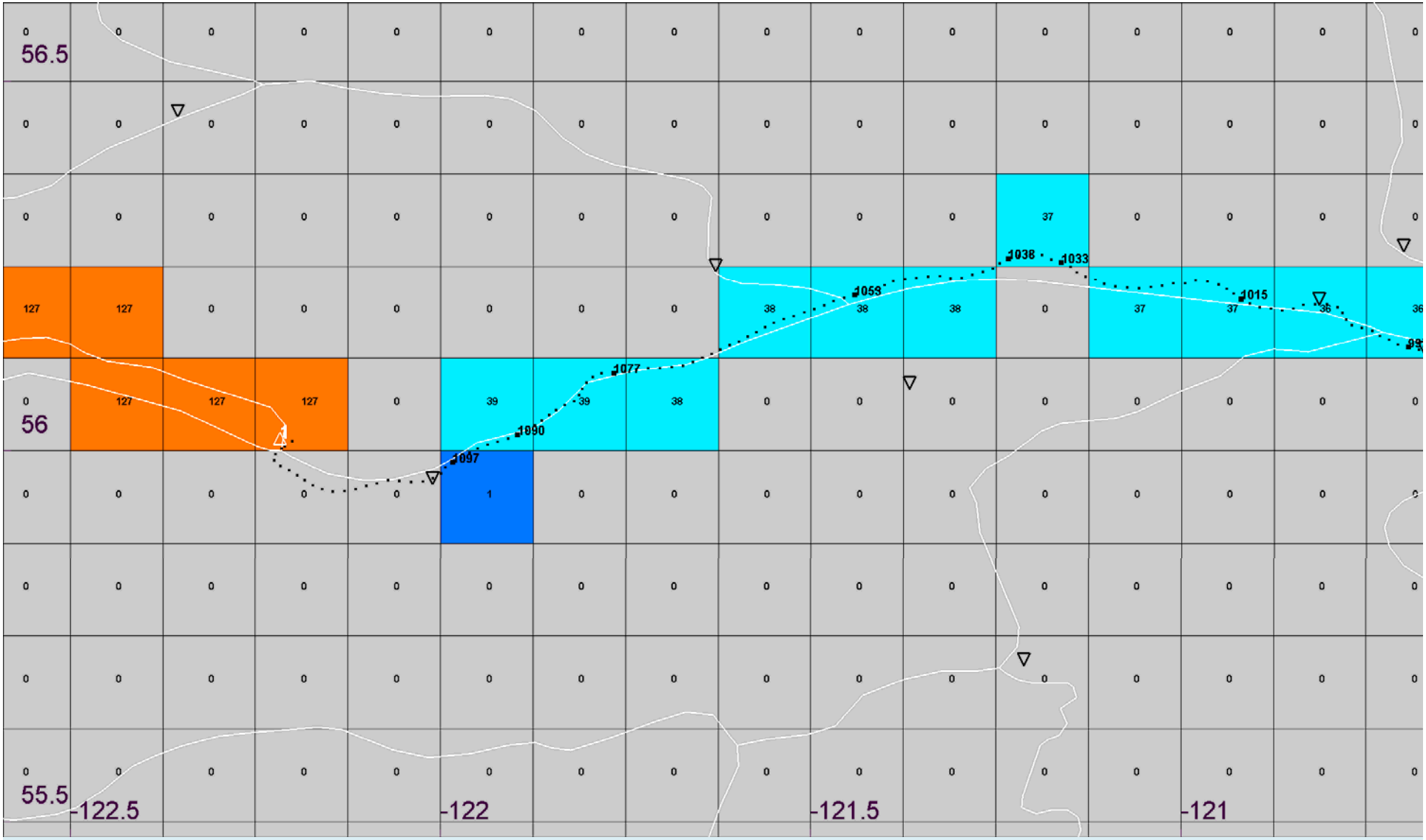
Each lake is assigned a number. All water entering a lake or land adjoining the lake is routed through a lake.

Initially, only large lakes are coded – then more added as needed

Lakes are called reaches (Numbering system was developed for a 1D model – NWS DWOPER. Flow1D / MRBHM has the same requirements – just a different file format)


Number the lakes
1 - 24 using WSC
7.5 m Base Map


124 reaches for MRBHM
have been added

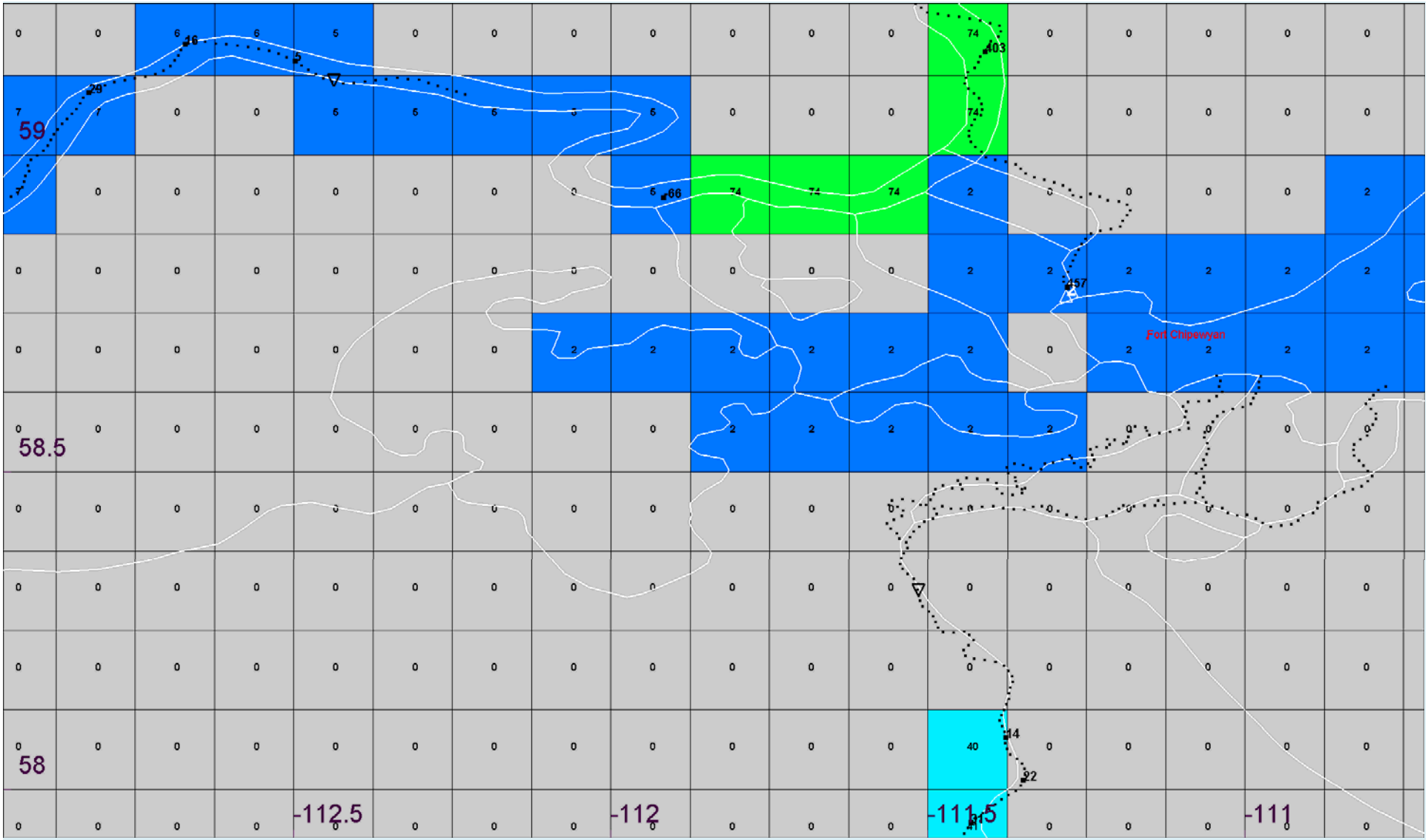


Black dots are MRBHM computational nodes **MRB_Rivers.i2s**

Numbered larger black dots are MRBHM Master Inflow Sites **MRB_MASTER_INFLOW_SITES_COL_SWITCH.pt2**

Numbered grids are WATFLOOD reach numbers **mrb22_MRBHM_reaches.map → mrb22_MRBHM_reaches_shd.r2c**

Δ Lake/reservoir outlets ∇ WSC flow stations



Reach numbering for the Lake Athabaska Delta

Reaches are coded in **lake_rules.csv**

MRBHM Nodes*

WATFLOOD Lakes

LongDecin	LatDecima	No	StationID	coef1	coef2	coef3	coef4	coef5	coef6	coef7	coef8
-121.984	55.98456	1	32_1097.5	0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.6	100	-1
-111.281	58.79104	2	21_457	0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.6	100	26
-117.381	61.20279	3	12_1385	0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.6	100	41
-116.055	54.201	4	42_913	0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.6	100	-1
-111.917	58.93322	5	31_-66.1	0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.6	100	-1
-112.498	59.14861	6	32_5	0.00E+00	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.6	100	-1
etc.											
etc.											
-123.474	65.144	128	Gr_Bear	1.60E-16	1.75E+00	0.00E+00	0.00E+00	0.00E+00	6.25	5.3	71.7
-117.758	65.598	129	Clut_L	1.00E-14	1.75E+00	0.00E+00	0.00E+00	0.00E+00	107	100	12
-114.217	62.8083	130	Prosperous_	1.50E-14	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.4	100	12
-114.756	55.305	131	Lssr_Slave_	4.00E-15	1.75E+00	0.00E+00	0.00E+00	0.00E+00	576.4	575.7	11.4
-117.27	63.1444	132	LacLaMatre	2.00E-15	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.2	100	12
-121.131	60.757	133	Trout_lake	2.00E-13	1.75E+00	0.00E+00	0.00E+00	0.00E+00	100.3	100	12
-108.175	58.967	134	Davy_Lake	1.00E-14	1.75E+00	0.00E+00	0.00E+00	0.00E+00	102	100	12
-104.608	58.386	135	Theriau_La	2.50E-14	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.7	100	12
-105.539	59.147	136	BlackLake	1.50E-14	1.75E+00	0.00E+00	0.00E+00	0.00E+00	101.8	100	12
etc.											
etc.		148	WollastonL								

* Williston Lake, Lake Athabasca & Great Slave Lake now have node numbers instead of names.

Ecrel.exe reads the lake rules and creates the **resrl\yyyymmdd_rel.tb0** file:

```
# DataType               Time Series
#
:Application             WATFLOOD
:Version                 2.1.23
:WrittenBy          ECrel.exe
:CreationDate       2016-04-25  18:17
#
#---------------------------------------
:SourceFile                   WSC flow_data
#
:Name               ReservoirReleases
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
:StartDate          1960/01/01
:StartTime          00:00:00.0
#
:DeltaT               24
#
:ColumnMetaData
   :ColumnUnits             m3/s        m3/s        m3/s        m3/s        m3/s     etc.
   :ColumnType             float       float       float       float       float
   :ColumnName          32_1097.5     21_457      12_1385     42_913     31_-66.1
   :ColumnLocationX     -121.9839   -111.2812   -117.3809   -116.0545   -111.9170
   :ColumnLocationY       55.9846     58.7910     61.2028     54.2010     58.9332
   :coeff1             0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   :coeff2             0.1750E+01  0.1750E+01  0.1750E+01  0.1750E+01  0.1750E+01
   :coeff3             0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   :coeff4             0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   :coeff5             0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
:EndColumnMetaData
:endHeader
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000
                          -1.000      -1.000      -1.000      -1.000      -1.000

                          etc.
```

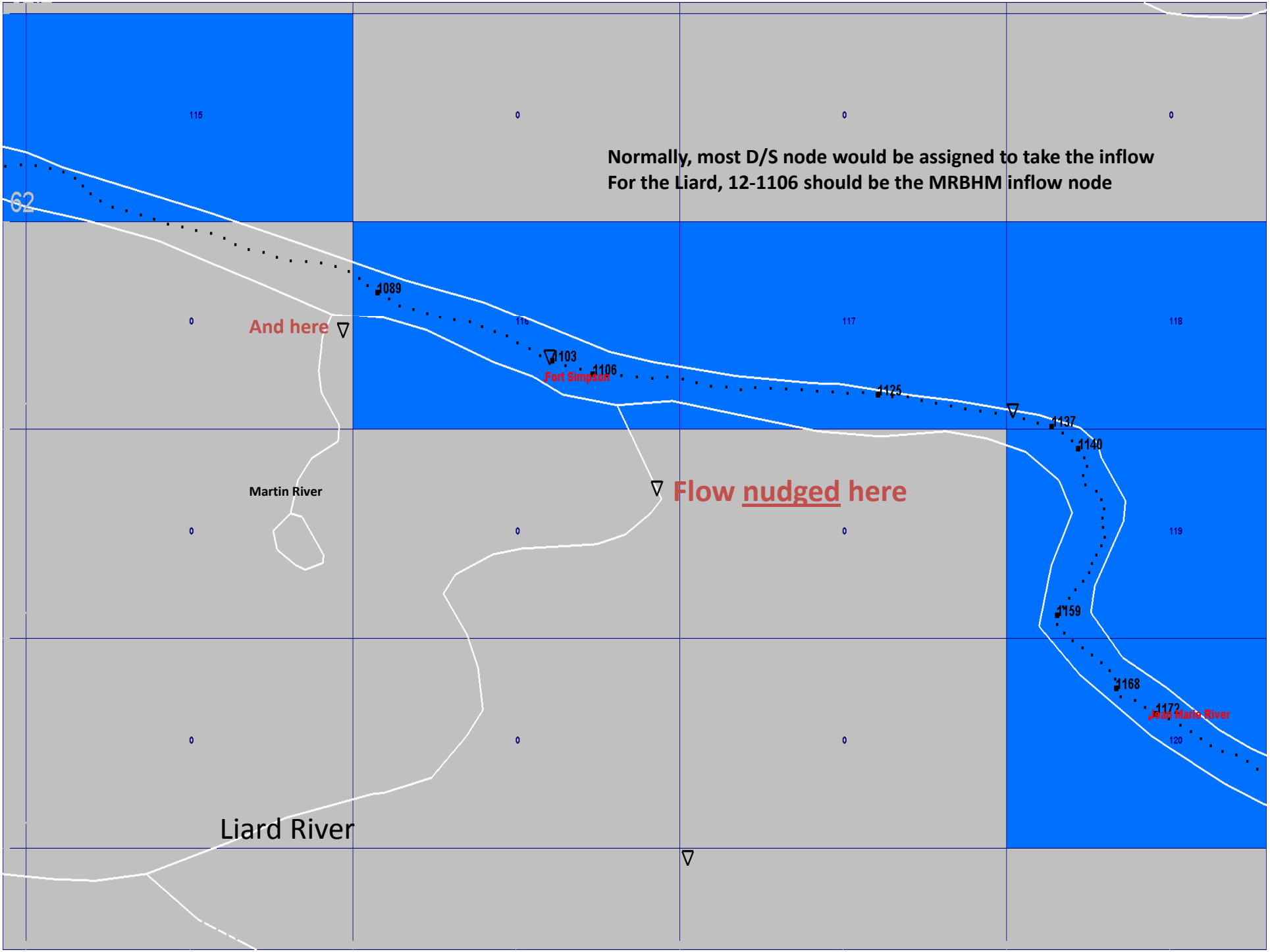
SPL.exe reads the rel files and creates the **MRBHM\MRB_MASTER_INFLOWS.tb0** file:

```
########################################
:FileType tb0  ASCII  EnSim 1.0
# DataType               Time Series
#
:Application             WATFLOOD
:Version                 2.1.23
:WrittenBy          WATROUTE
:CreationDate       2016-05-05  15:21
#
#---------------------------------------
#
#SourceFile                    last spl run
:Name                MRBB_MASTER_INFLOWS
#
:StartTime           2002/1/1     0:00:00
:DeltaT  24:00:00.000   //1 day
#
:ColumnMetaData
   :ColumnType        float       float       float       float       float      etc……
   :ColumnName     32_1097.5     21_457      12_1385     42_913      31_-66.1
:EndColumnMetaData
#
:endHeader
                1712.189     732.423     914.719      38.683     119.280
                1651.362     461.675     608.485      37.220     106.546
                1621.427     394.103     578.785      36.142      81.707
                1630.175     359.028     565.982      35.476      62.541
                1570.731     331.953     508.793      36.166      50.072
                1572.159     331.186     551.208      37.132      41.126
                1613.432     321.230     513.030      40.925      35.191
                etc.


              Hudson Hope   Slave R.    Mack. R.   Athabaska R.  Peace Pt.
```

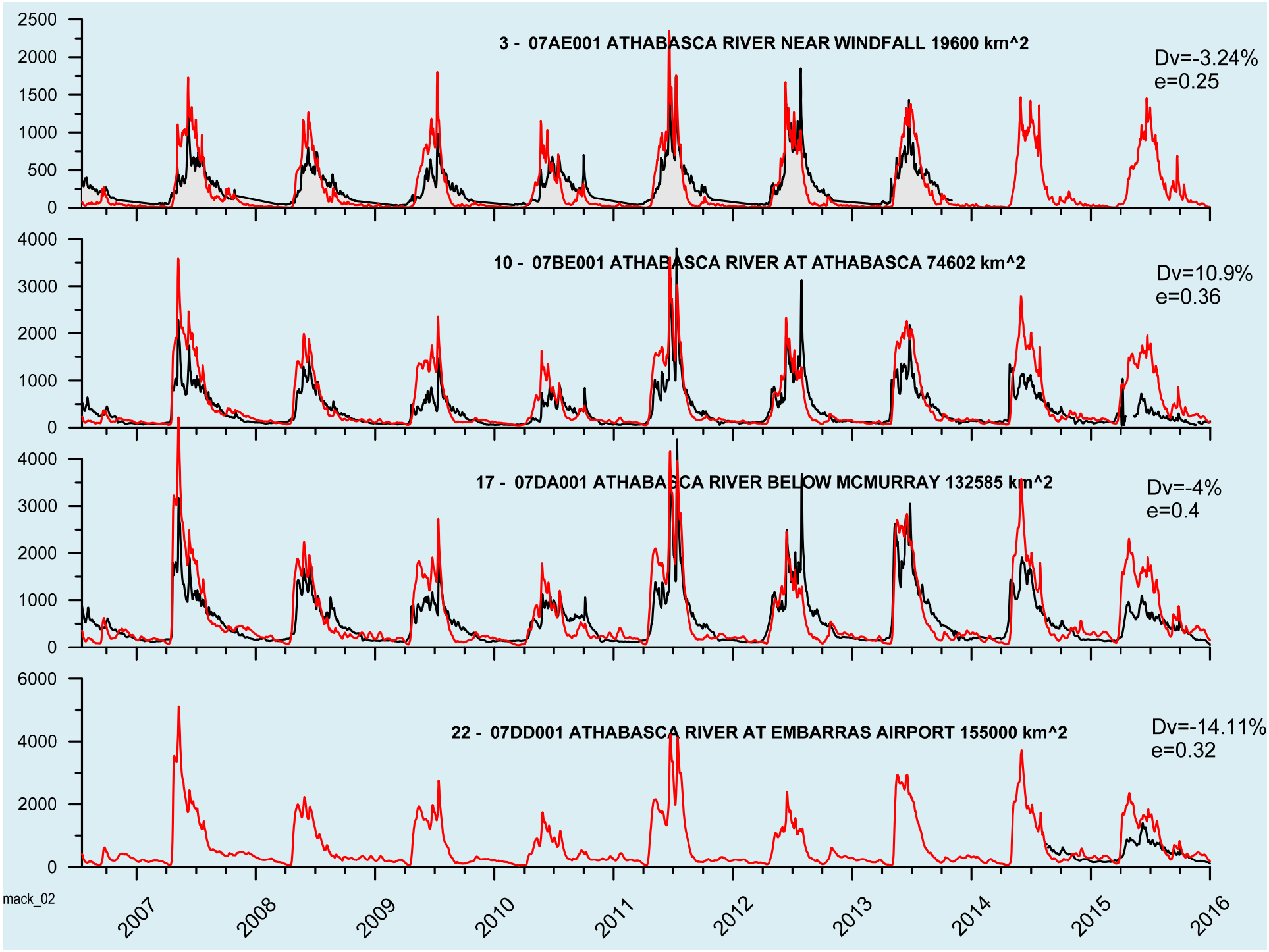
Modelling Results

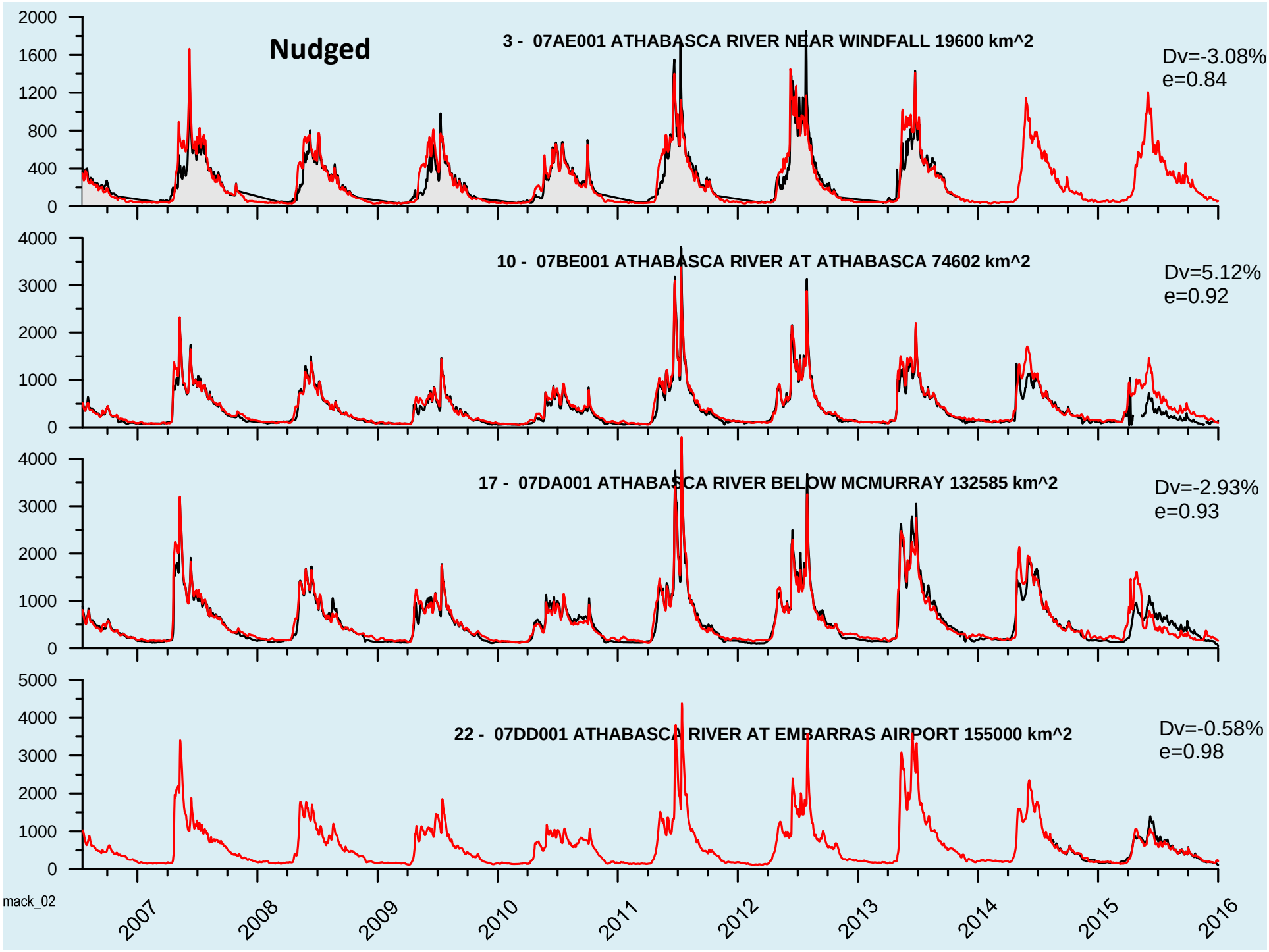
1. not – nudged
2. nudged

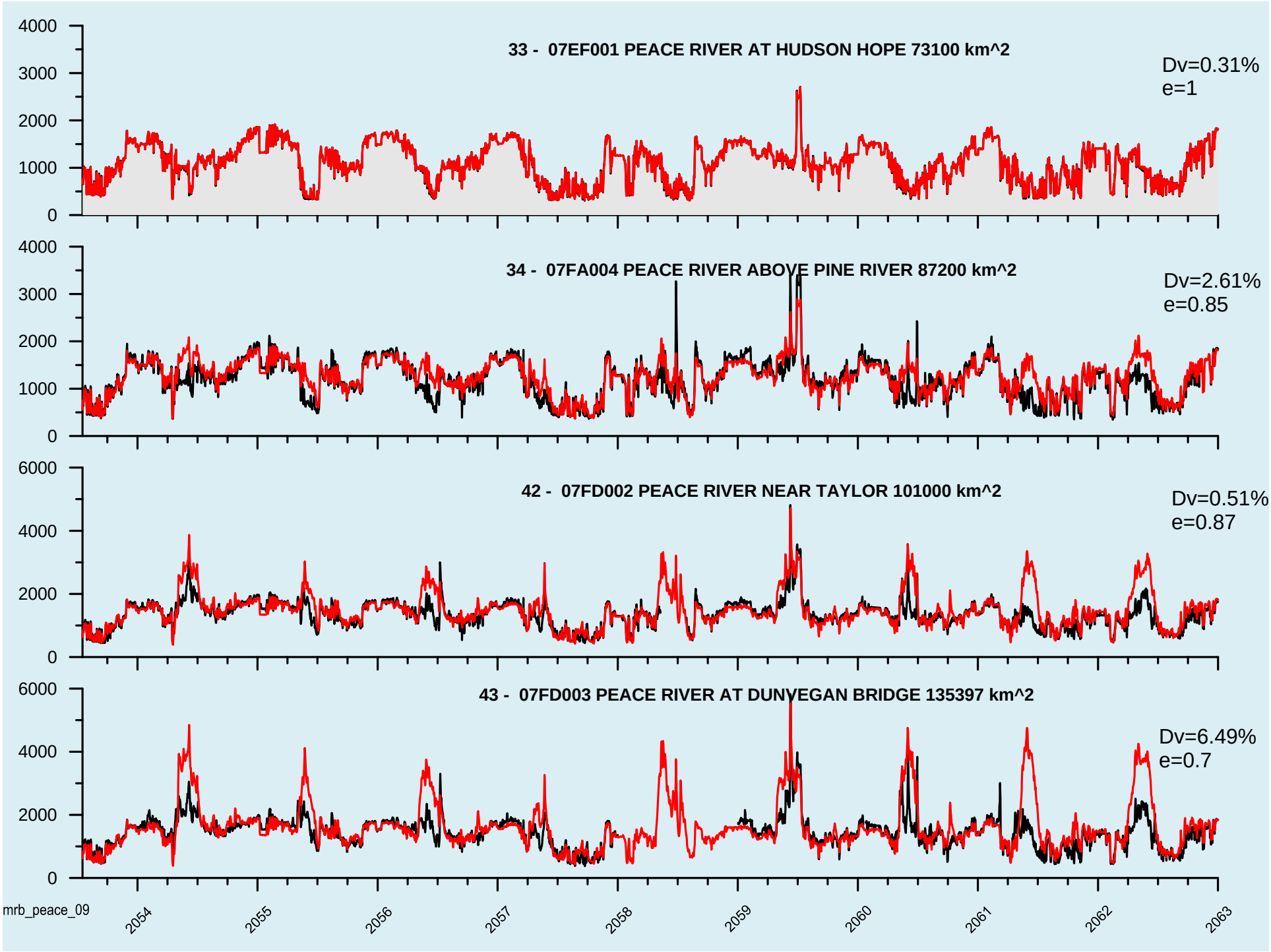

Normally, most D/S node would be assigned to take the inflow
For the Liard, 12-1106 should be the MRBHM inflow node
62
1089
And here
1103
1106
Fort Simpson
1125
1137
1140
Martin River
Flow nudged here
1159
1168
1172
Liard River

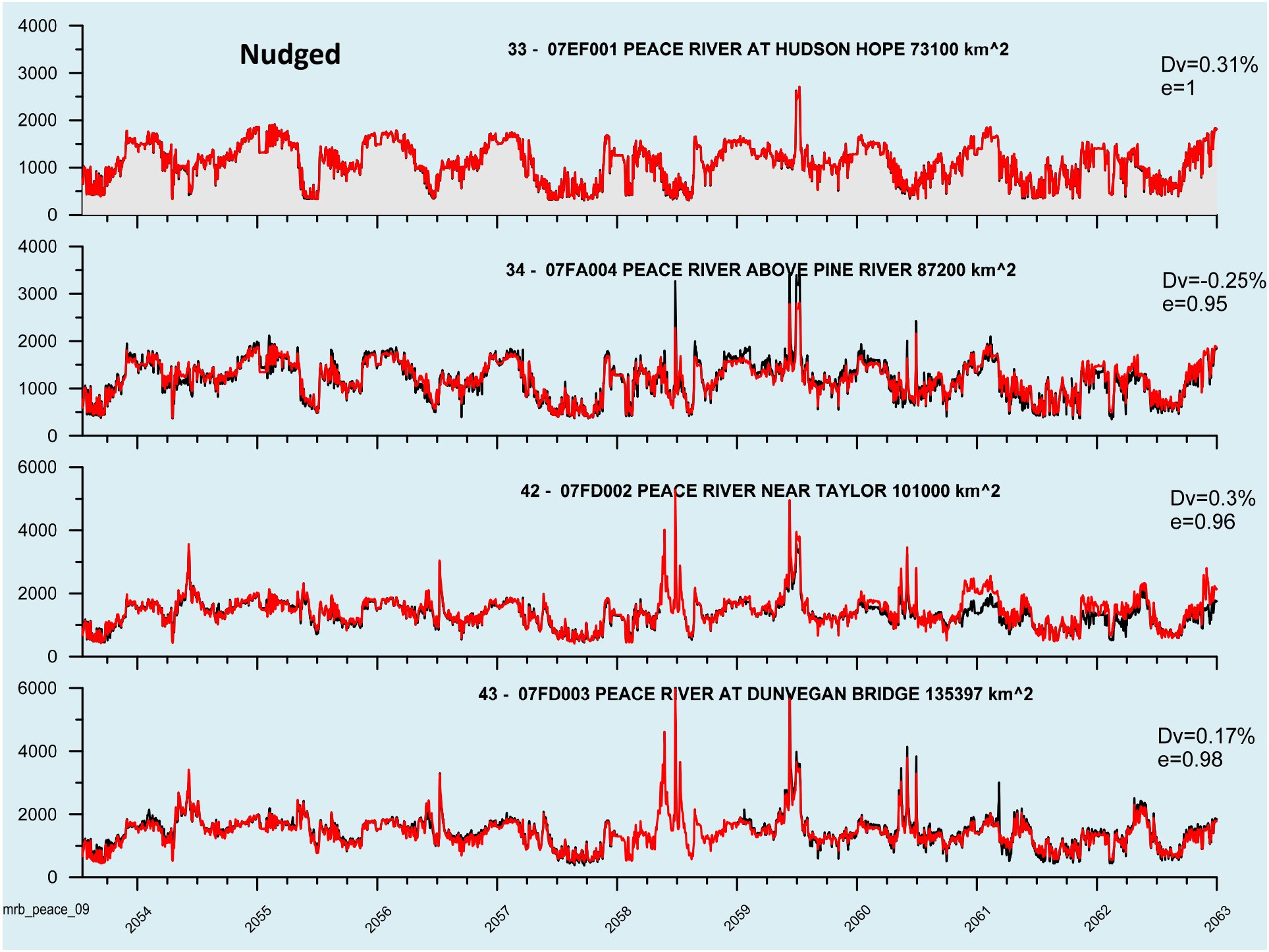
Comparison of WATFLOOD model flows with nudged flows

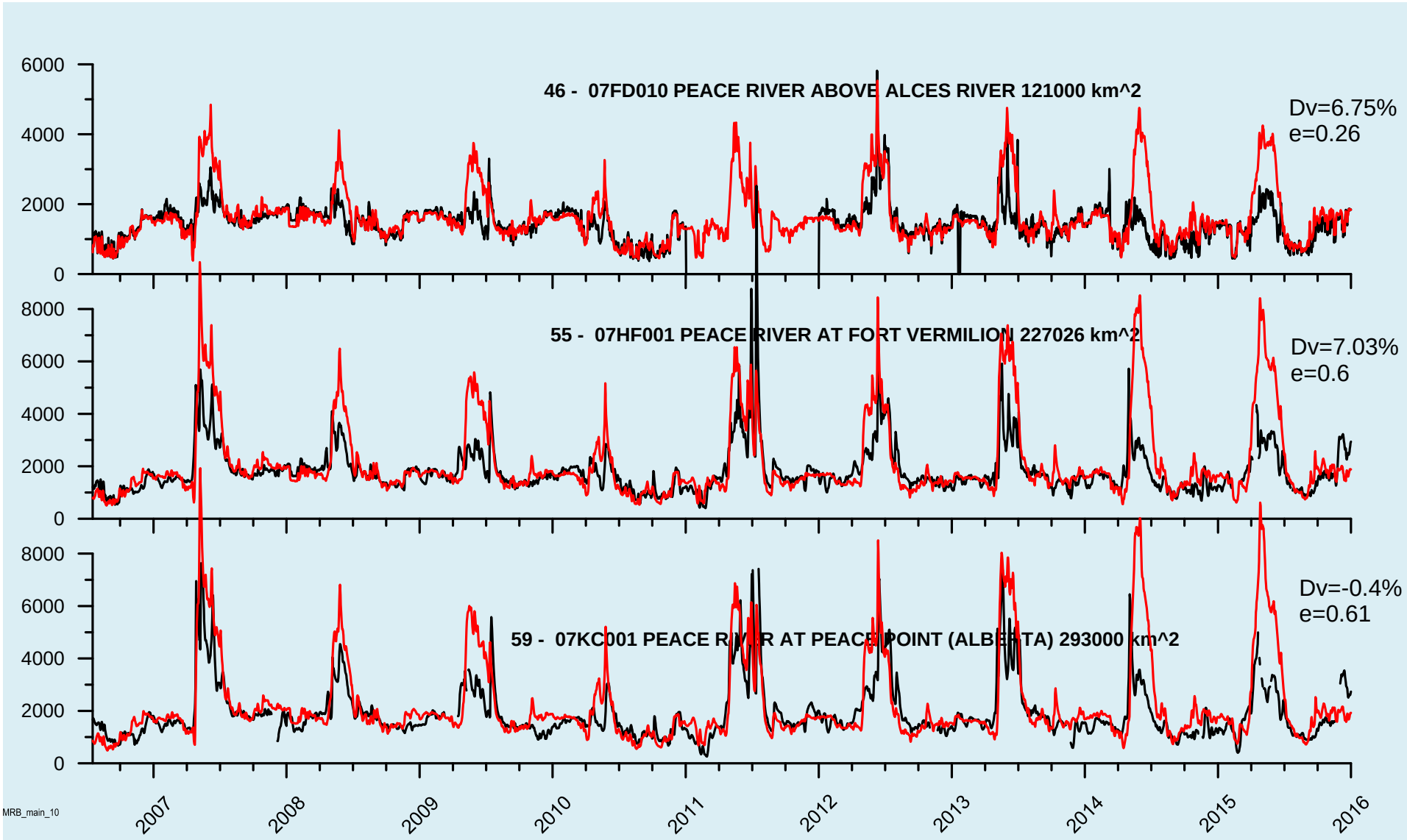
- Pairs of hydrographs

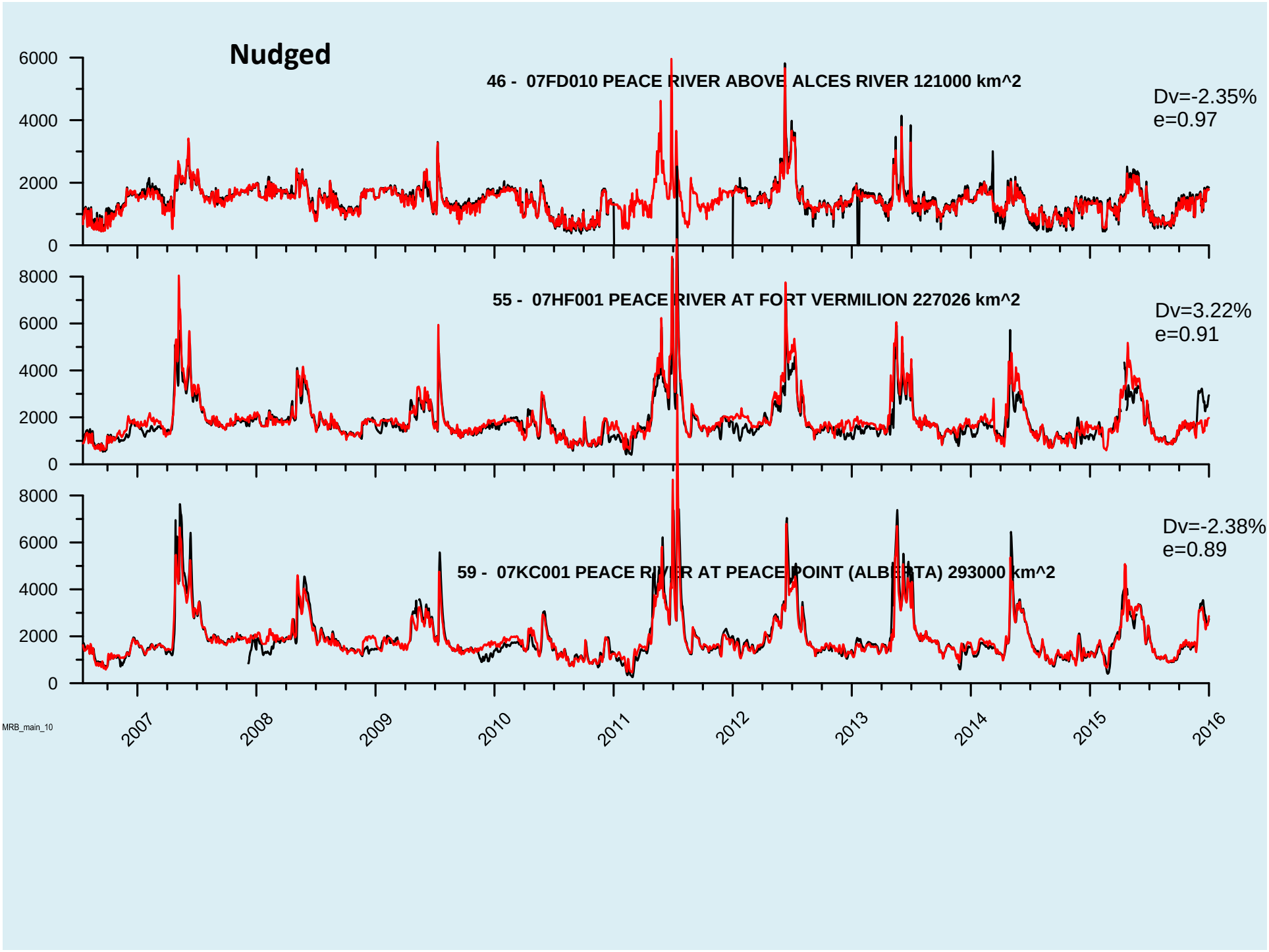

3 - 07AE001 ATHABASCA RIVER NEAR WINDFALL 19600 km^2
Dv=-3.24%
e=0.25
10 - 07BE001 ATHABASCA RIVER AT ATHABASCA 74602 km^2
Dv=10.9%
e=0.36
17 - 07DA001 ATHABASCA RIVER BELOW MCMURRAY 132585 km^2
Dv=-4%
e=0.4
22 - 07DD001 ATHABASCA RIVER AT EMBARRAS AIRPORT 155000 km^2
Dv=-14.11%
e=0.32
2500
2000
1500
1000
500
0
4000
3000
2000
1000
0
4000
3000
2000
1000
0
6000
4000
2000
0
mack_02
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

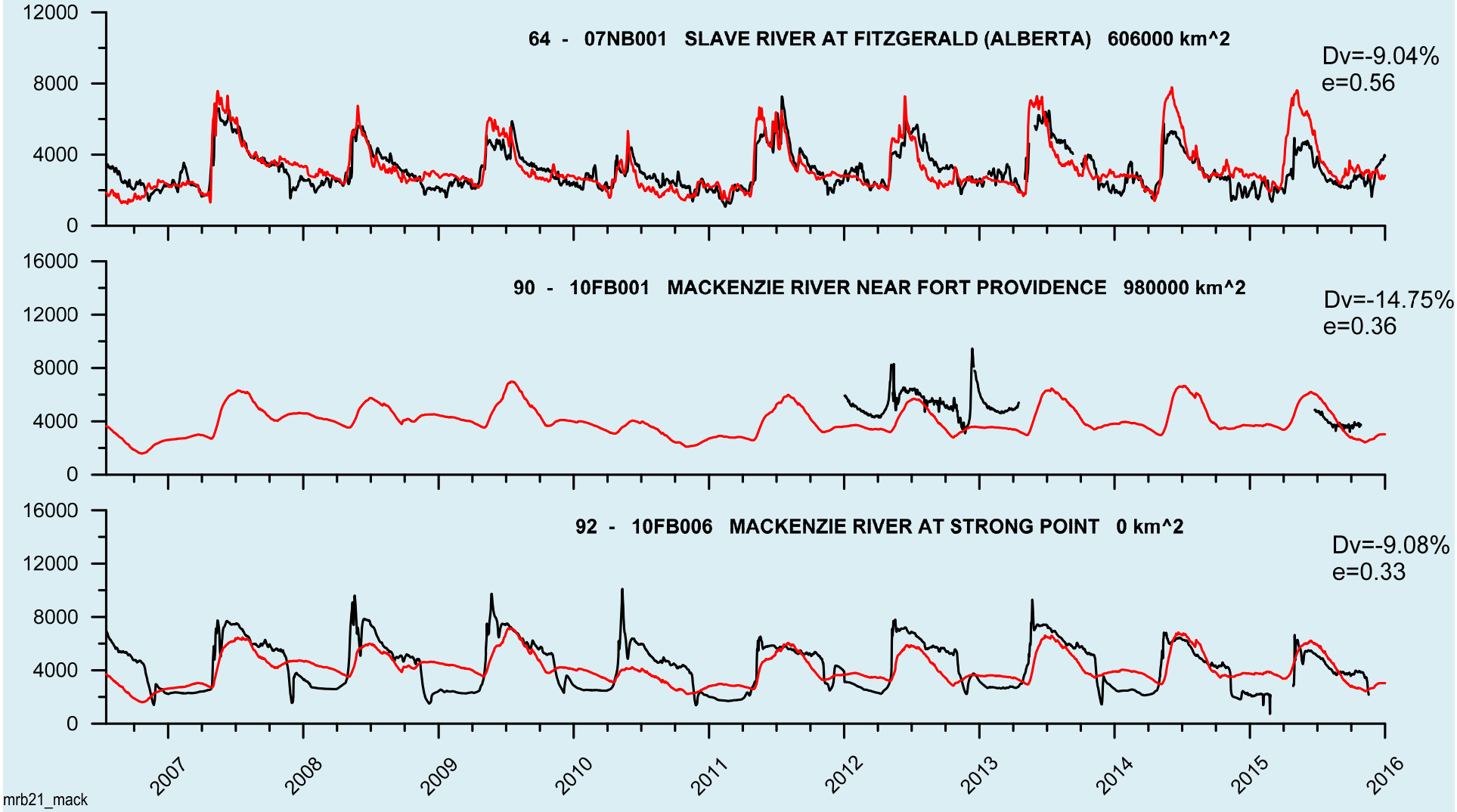

Nudged
3 - 07AE001 ATHABASCA RIVER NEAR WINDFALL 19600 km^2
Dv=-3.08%
e=0.84
10 - 07BE001 ATHABASCA RIVER AT ATHABASCA 74602 km^2
Dv=5.12%
e=0.92
17 - 07DA001 ATHABASCA RIVER BELOW MCMURRAY 132585 km^2
Dv=-2.93%
e=0.93
22 - 07DD001 ATHABASCA RIVER AT EMBARRAS AIRPORT 155000 km^2
Dv=-0.58%
e=0.98
mack_02
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

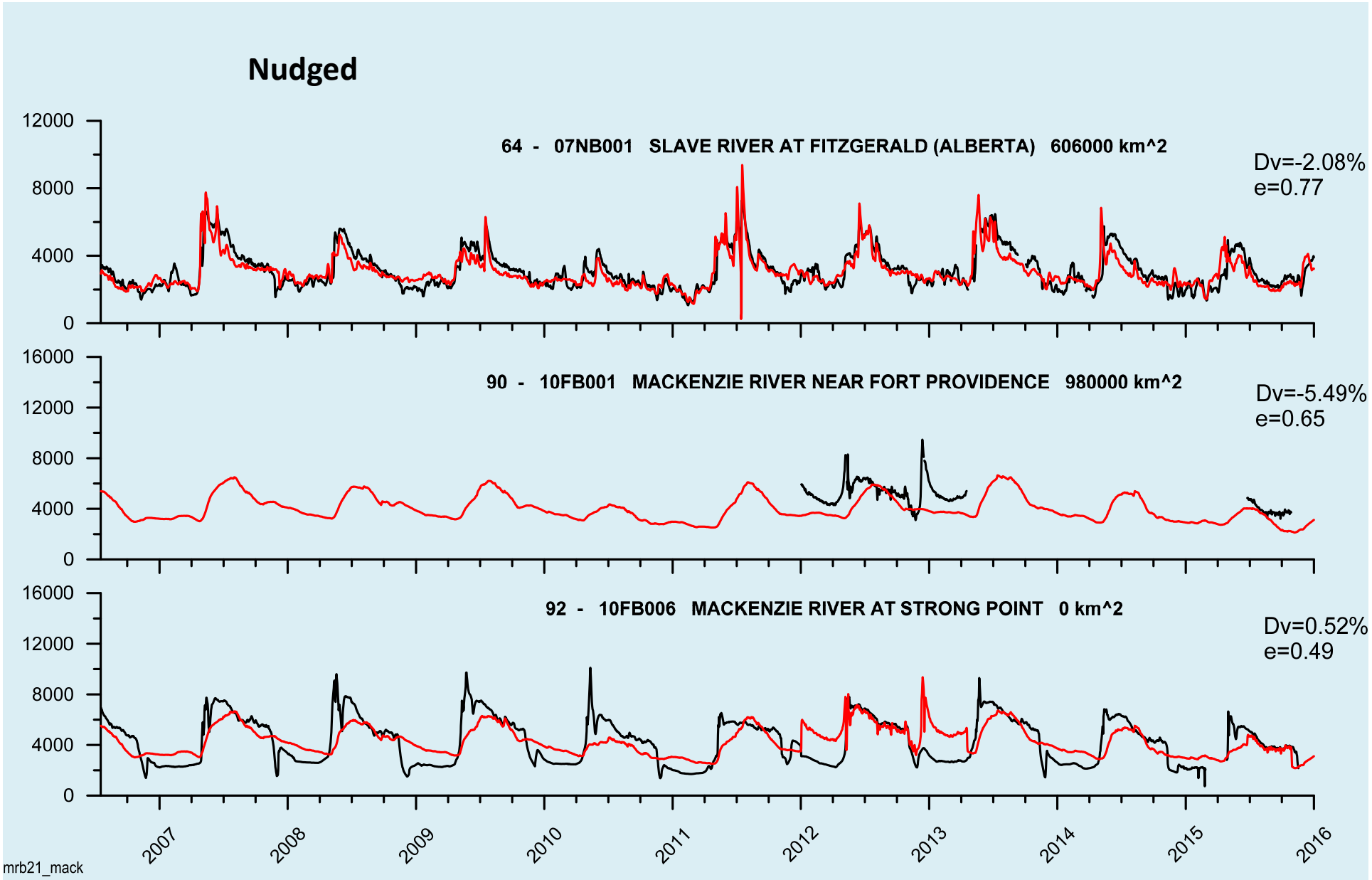

33 - 07EF001 PEACE RIVER AT HUDSON HOPE 73100 km^2
Dv=0.31%
e=1
34 - 07FA004 PEACE RIVER ABOVE PINE RIVER 87200 km^2
Dv=2.61%
e=0.85
42 - 07FD002 PEACE RIVER NEAR TAYLOR 101000 km^2
Dv=0.51%
e=0.87
43 - 07FD003 PEACE RIVER AT DUNVEGAN BRIDGE 135397 km^2
Dv=6.49%
e=0.7
0
1000
2000
3000
4000
6000
mrb_peace_09
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063

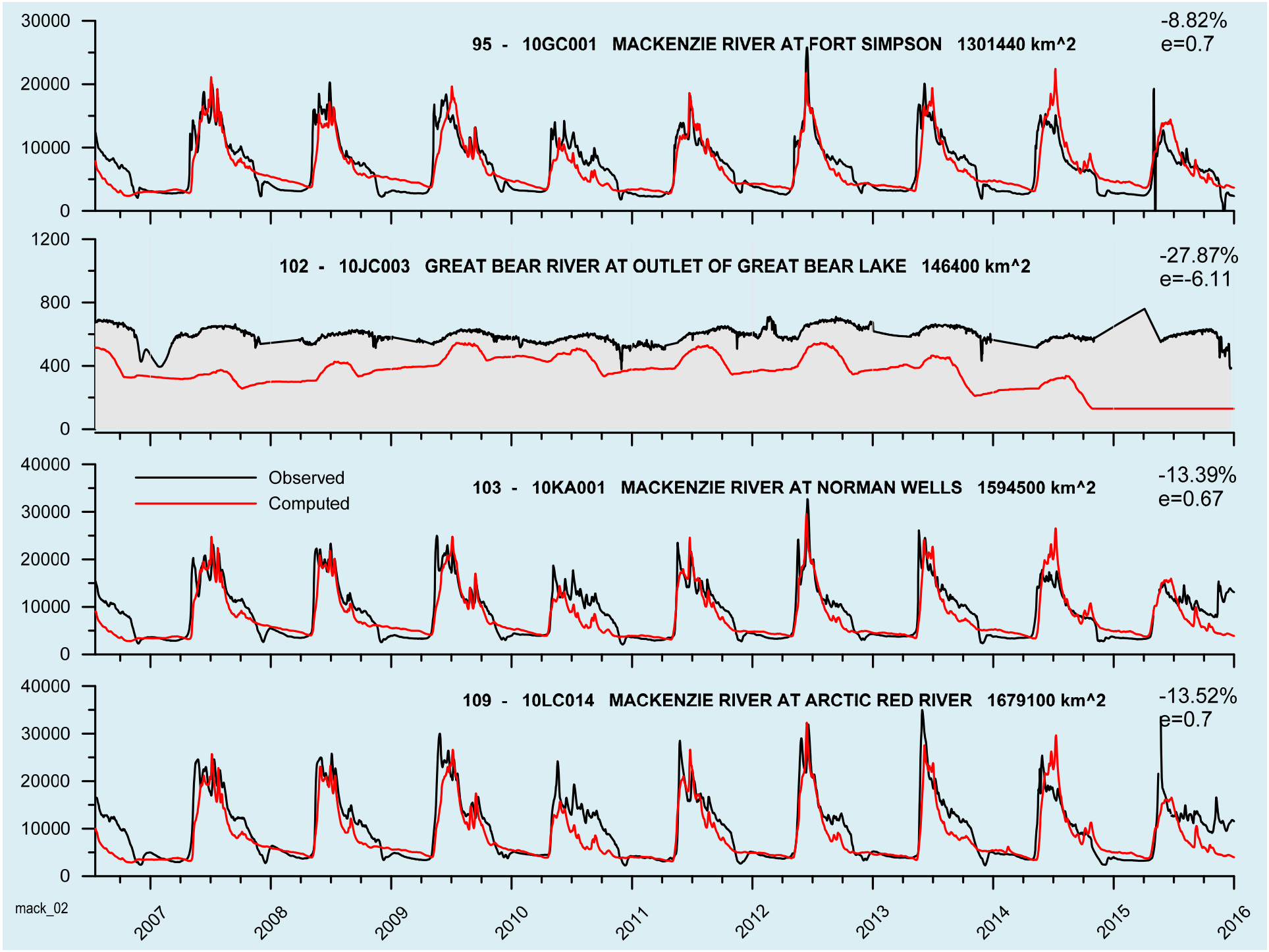

Nudged
33 - 07EF001 PEACE RIVER AT HUDSON HOPE 73100 km^2
Dv=0.31%
e=1
34 - 07FA004 PEACE RIVER ABOVE PINE RIVER 87200 km^2
Dv=-0.25%
e=0.95
42 - 07FD002 PEACE RIVER NEAR TAYLOR 101000 km^2
Dv=0.3%
e=0.96
43 - 07FD003 PEACE RIVER AT DUNVEGAN BRIDGE 135397 km^2
Dv=0.17%
e=0.98
4000
3000
2000
1000
0
6000
4000
2000
0
mrb_peace_09
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063

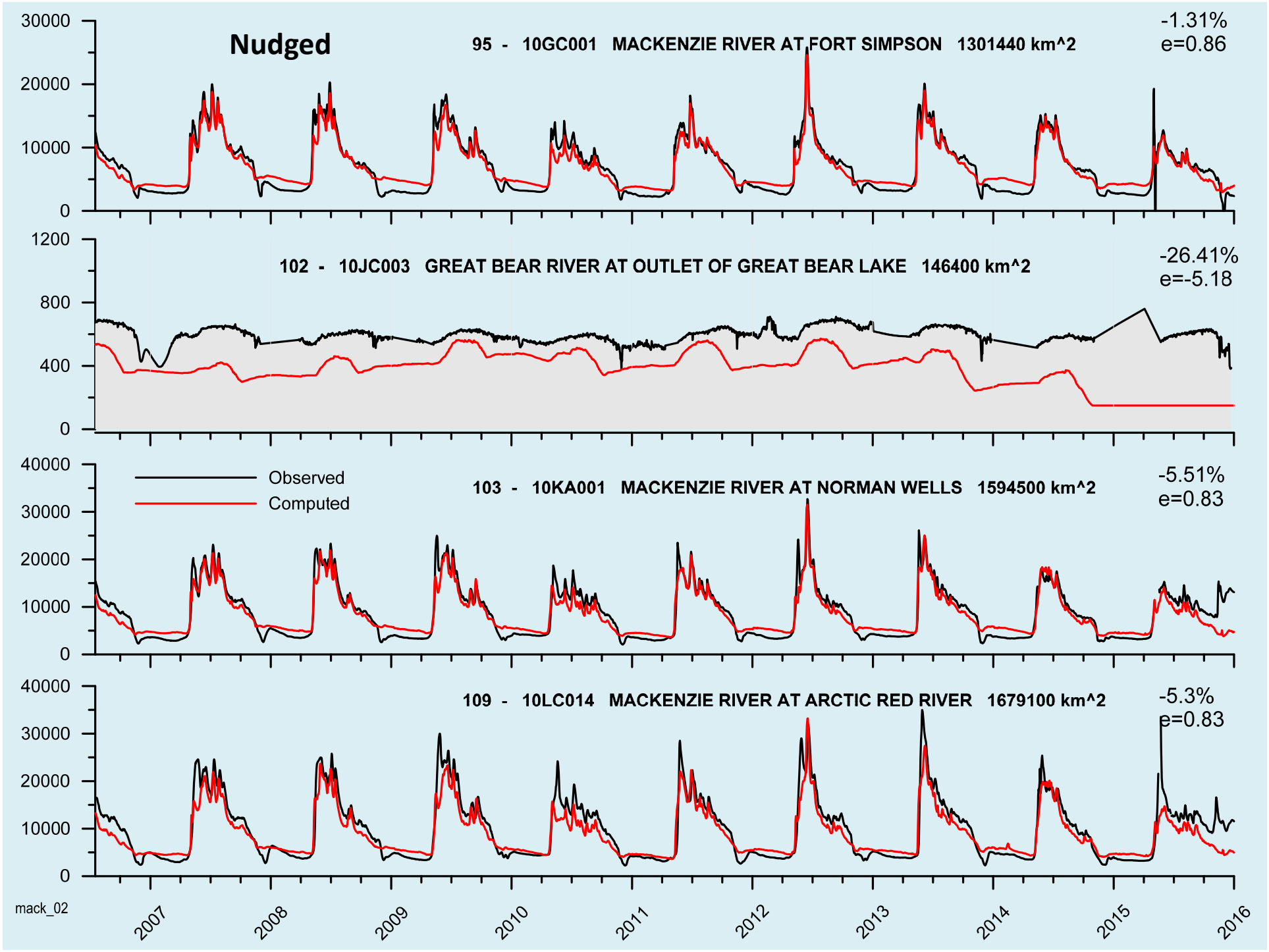

46 - 07FD010 PEACE RIVER ABOVE ALCES RIVER 121000 km^2
Dv=6.75%
e=0.26
55 - 07HF001 PEACE RIVER AT FORT VERMILION 227026 km^2
Dv=7.03%
e=0.6
59 - 07KC001 PEACE RIVER AT PEACE POINT (ALBERTA) 293000 km^2
Dv=-0.4%
e=0.61
6000
4000
2000
0
8000
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
MRB_main_10

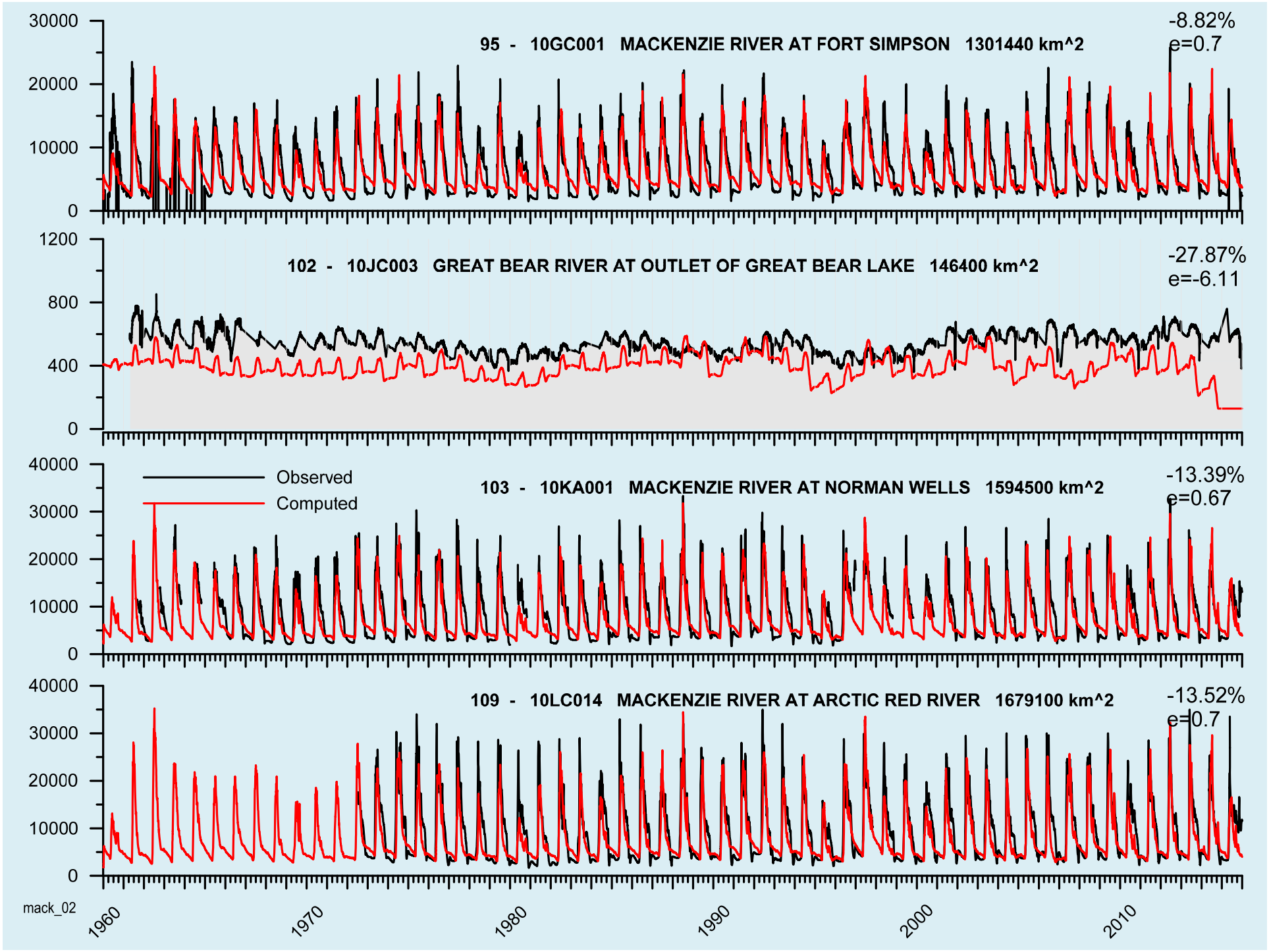

Nudged
46 - 07FD010 PEACE RIVER ABOVE ALCES RIVER 121000 km^2
Dv=-2.35%
e=0.97
55 - 07HF001 PEACE RIVER AT FORT VERMILION 227026 km^2
Dv=3.22%
e=0.91
59 - 07KC001 PEACE RIVER AT PEACE POINT (ALBERTA) 293000 km^2
Dv=-2.38%
e=0.89
6000
4000
2000
0
8000
6000
4000
2000
0
8000
6000
4000
2000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
MRB_main_10


64 - 07NB001 SLAVE RIVER AT FITZGERALD (ALBERTA) 606000 km^2
Dv=-9.04%
e=0.56
90 - 10FB001 MACKENZIE RIVER NEAR FORT PROVIDENCE 980000 km^2
Dv=-14.75%
e=0.36
92 - 10FB006 MACKENZIE RIVER AT STRONG POINT 0 km^2
Dv=-9.08%
e=0.33
12000
8000
4000
0
16000
12000
8000
4000
0
16000
12000
8000
4000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
mrb21_mack


Nudged
64 - 07NB001 SLAVE RIVER AT FITZGERALD (ALBERTA) 606000 km^2
Dv=-2.08%
e=0.77
90 - 10FB001 MACKENZIE RIVER NEAR FORT PROVIDENCE 980000 km^2
Dv=-5.49%
e=0.65
92 - 10FB006 MACKENZIE RIVER AT STRONG POINT 0 km^2
Dv=0.52%
e=0.49
12000
8000
4000
0
16000
12000
8000
4000
0
16000
12000
8000
4000
0
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
mrb21_mack


95 - 10GC001 MACKENZIE RIVER AT FORT SIMPSON 1301440 km^2
-8.82%
e=0.7
102 - 10JC003 GREAT BEAR RIVER AT OUTLET OF GREAT BEAR LAKE 146400 km^2
-27.87%
e=-6.11
Observed
Computed
103 - 10KA001 MACKENZIE RIVER AT NORMAN WELLS 1594500 km^2
-13.39%
e=0.67
109 - 10LC014 MACKENZIE RIVER AT ARCTIC RED RIVER 1679100 km^2
-13.52%
e=0.7
30000
20000
10000
0
1200
800
400
40000
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
mack_02


Nudged
95 - 10GC001 MACKENZIE RIVER AT FORT SIMPSON 1301440 km^2
-1.31%
e=0.86
102 - 10JC003 GREAT BEAR RIVER AT OUTLET OF GREAT BEAR LAKE 146400 km^2
-26.41%
e=-5.18
Observed
Computed
103 - 10KA001 MACKENZIE RIVER AT NORMAN WELLS 1594500 km^2
-5.51%
e=0.83
109 - 10LC014 MACKENZIE RIVER AT ARCTIC RED RIVER 1679100 km^2
-5.3%
e=0.83
30000
20000
10000
0
1200
800
400
40000
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
mack_02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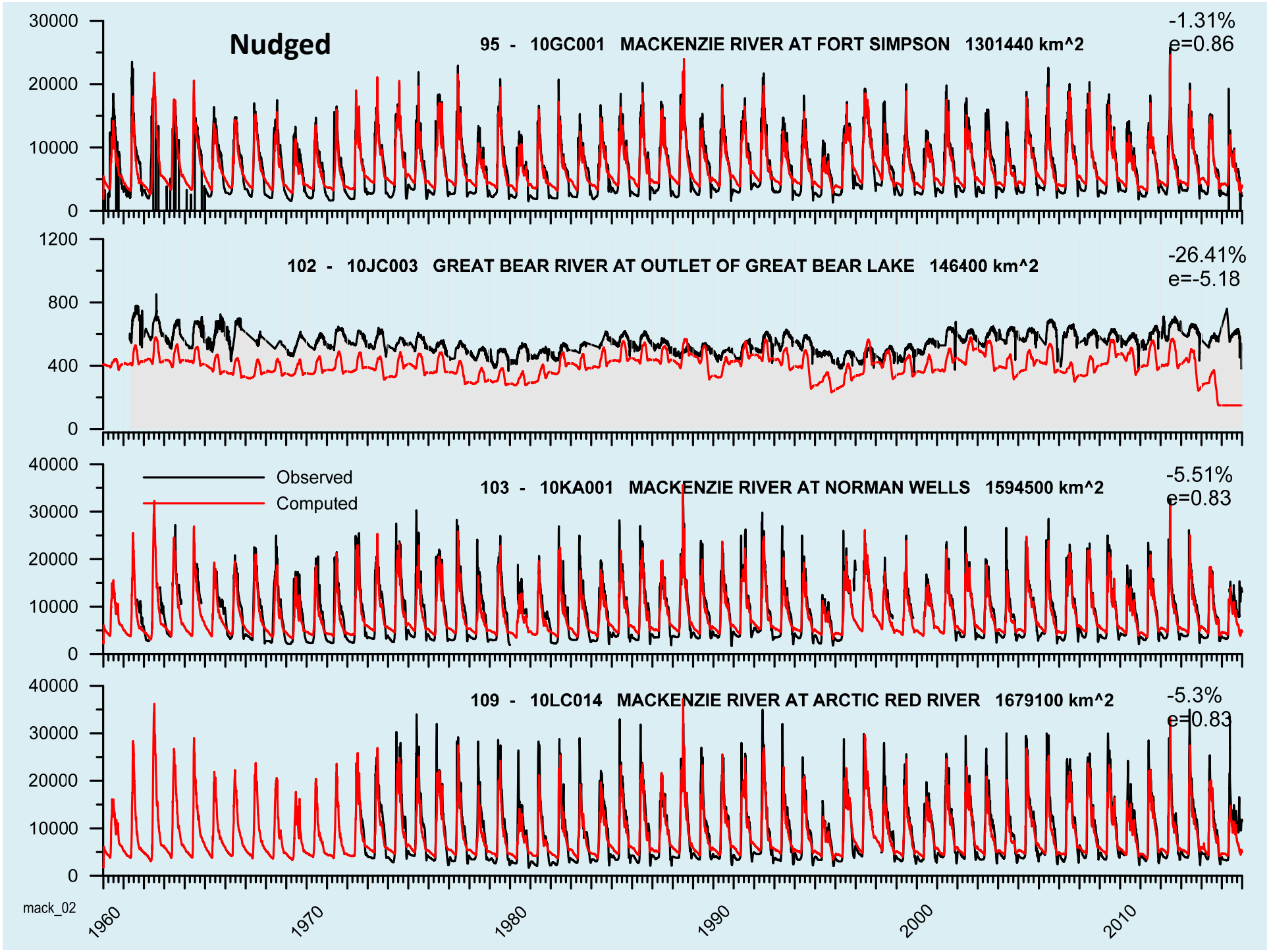
109 - 10LC014 MACKENZIE RIVER AT ARCTIC RED RIVER 1679100 km^2
-13.52%
e=0.7
30000
20000
10000
0
1200
800
400
40000
1960
1970
1980
1990
2000
2010
mack_02


Nudged
95 - 10GC001 MACKENZIE RIVER AT FORT SIMPSON 1301440 km^2
-1.31%
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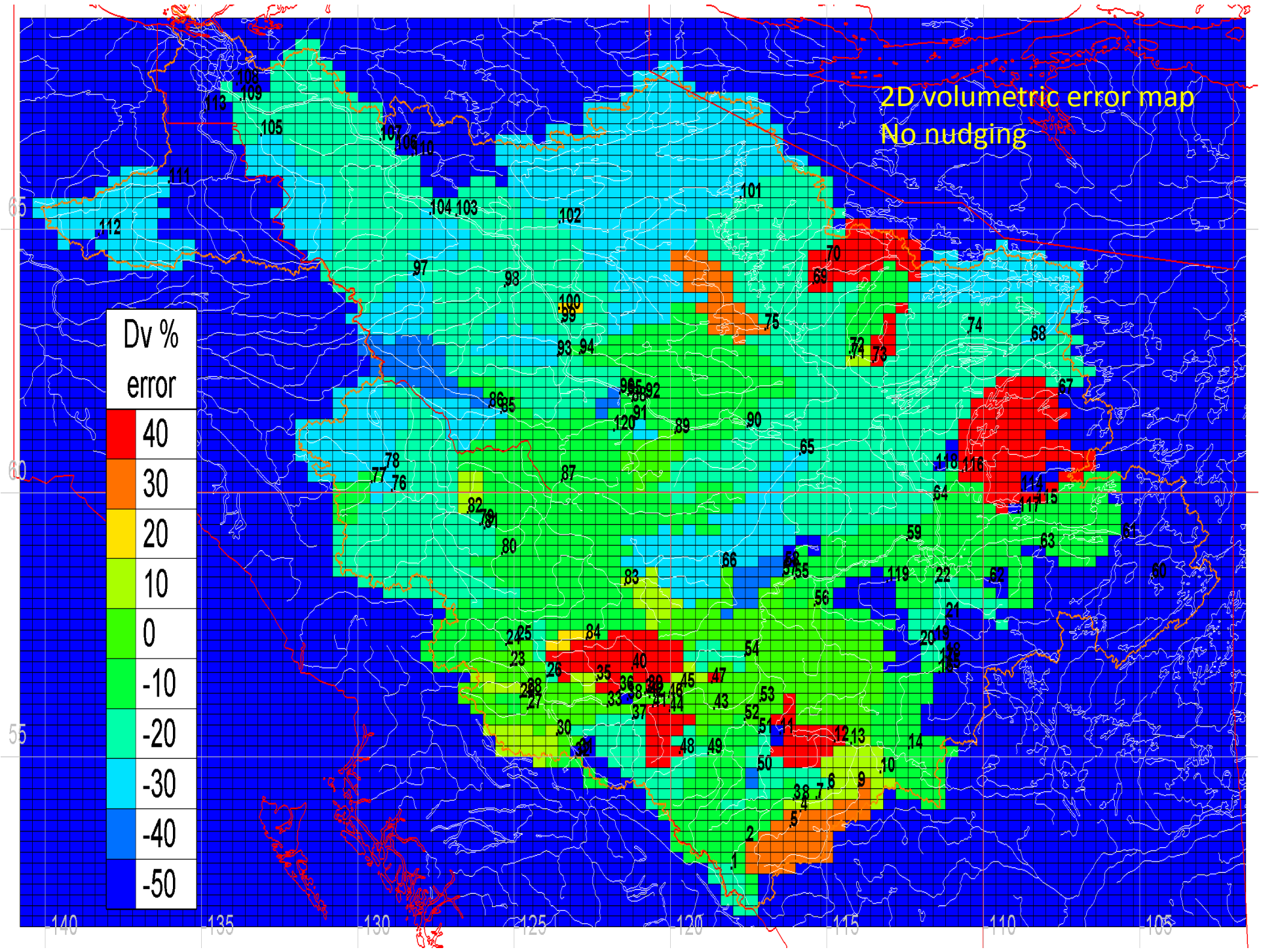
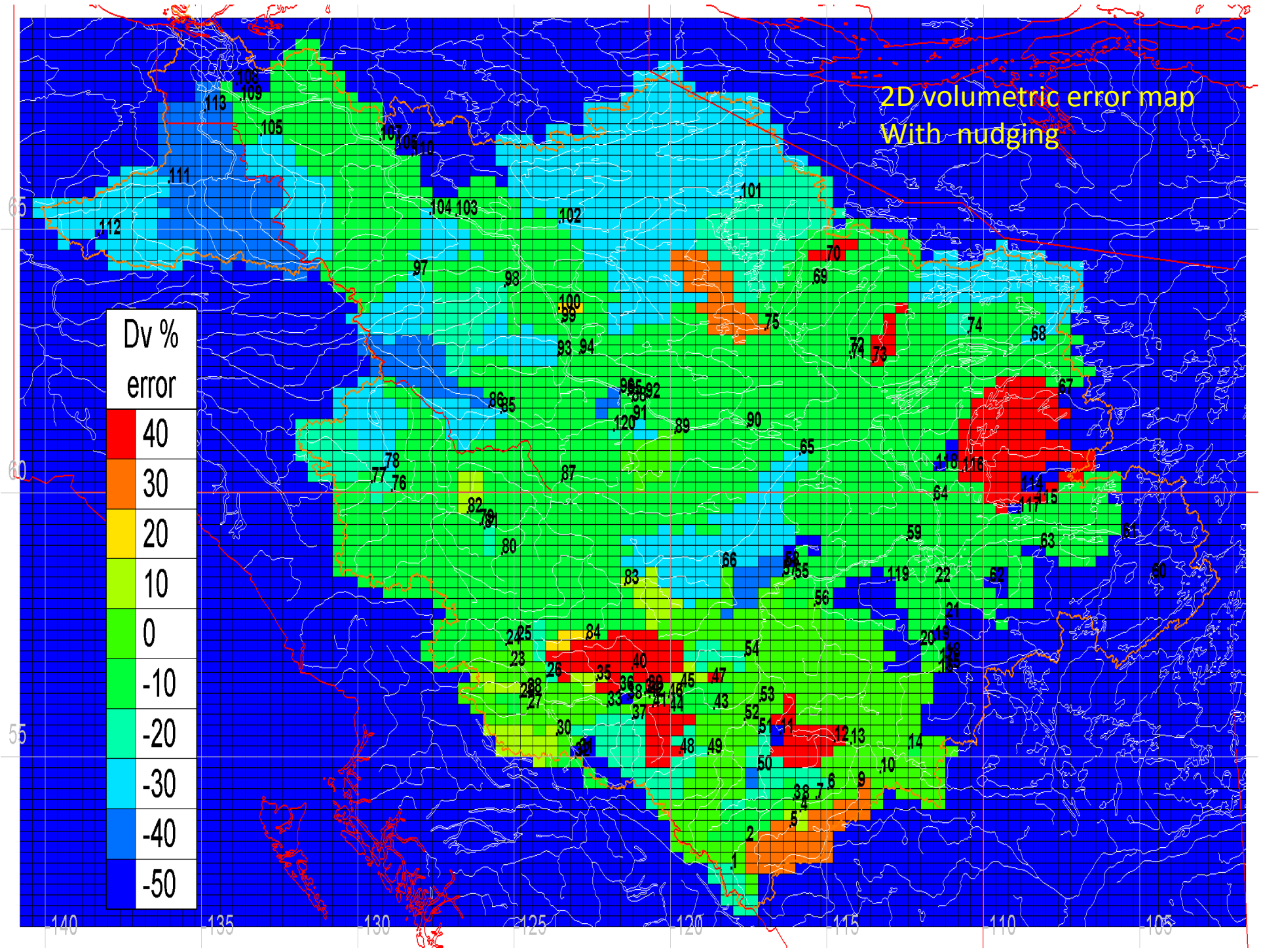
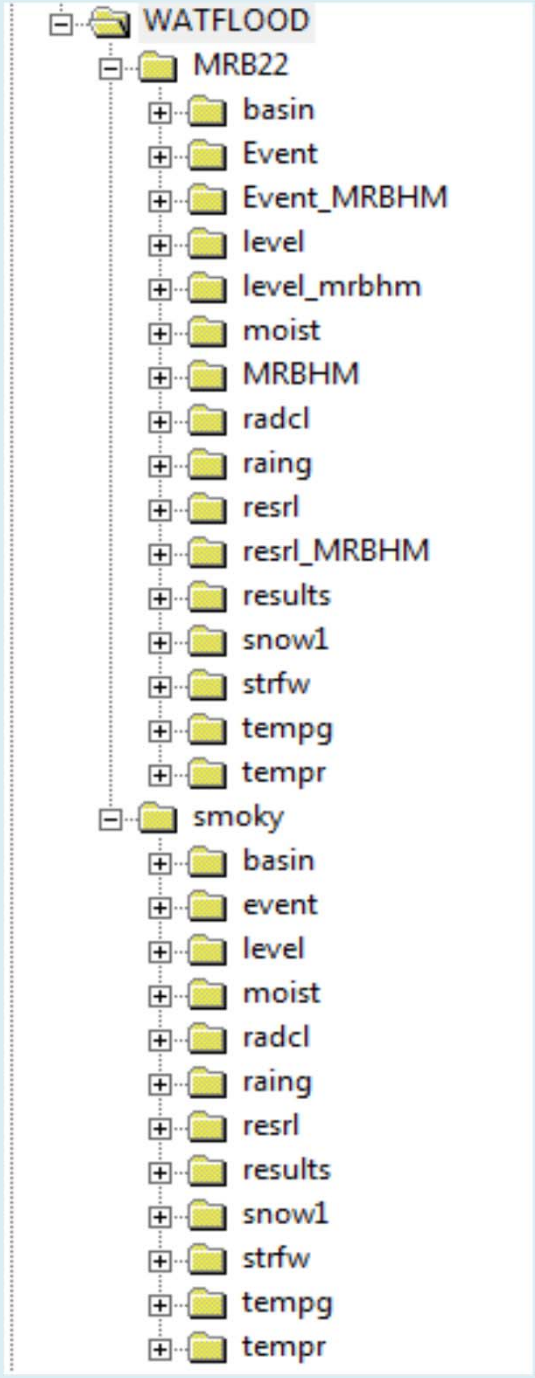
-5.3%
e=0.83
mack_02
1960
1970
1980
1990
2000
2010


2D volumetric error map
No nudging
Dv %
error
40
30
20
10
0
-10
-20
-30
-40
-50
65
60
55
140
135
130
125
120
115
110
105


2D volumetric error map
With nudging
Dv %
error
40
30
20
10
0
-10
-20
-30
-40
-50
65
60
55
140
135
130
125
120
115
110
105

Model Setup

The DVD has data for 2 watersheds:
the whole MRB and the Smoky river



- The file structure is explained in Section 1.1.3 of the WATFLOOD manual. Each type of data file is in a separate directory.
- It is recommended that the WATFLOOD directory be in the root directory on the C: drive and that it be in the computer's path so all executables can be put there.
- Each watershed model has its own directory under WATFLOOD
- Names are meant to be self-expalnitory:
  - basin for watershed files
  - event is for config files
  - level is for water level data
  - moist is for initial moisture
  - MRBHM for the master inflow file
  - radcl for gridded precip.
  - raing for point precip
  - resrl for reservoir/lake rules & releases
  - results for model output
  - snow1 for SWE data
  - strfw for flow data
  - tempg for point temperatures
  - tempr for gridded temperature
- For the MRBHM there are 3 extra directories as in addition to the lakes(=reaches) that are normally incorporated in the watershed file, there are additional reaches needed to create inflows at the inflow nodes of the MRBHM. This requires separate files for the level and reservoir data for each reach
- The 2 sets of event files point to the respective sets of files
- the MRBHM directory receives the MRB_master_inflow.tb0 file

1. Create a directory called WATFLOOD – preferably in the root of C:
2. Copy the MRB22.zip & Smoky.zip files into the C:\WATFLOOD directory
3. Extract these files “HERE” (or maybe the DVD will have un-zipped files in which case no need to unzip) (Not decided at time of writing)

Lunch maybe?