Dynamic Water Balance at MDV

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# dVol = Qin-Qout  
  
require(lubridate)

## Loading required package: lubridate

##   
## Attaching package: 'lubridate'

## The following object is masked from 'package:base':  
##   
## date

library(readr)  
require(dplyr)

## Loading required package: dplyr

##   
## Attaching package: 'dplyr'

## The following objects are masked from 'package:lubridate':  
##   
## intersect, setdiff, union

## The following objects are masked from 'package:stats':  
##   
## filter, lag

## The following objects are masked from 'package:base':  
##   
## intersect, setdiff, setequal, union

setwd("C:\\Users\\QingZ\\PhD-Qing\\GitProject\\Mark\_Dintel\_Vliet\\Modelling\\Advection-Diffusion-Production\\Waterbalance")# Set the working directory  
  
#### Data preparation ####  
# WL: Water depths  
# Up: Upstream of sluice  
# Down: Downstream of sluice  
  
WL\_Down\_Vliet <- read\_csv("WL\_Down\_Vliet.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 106734 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'WL\_Down\_Vliet.csv'  
## 2 -- 5 columns 4 columns 'WL\_Down\_Vliet.csv'  
## 3 -- 5 columns 4 columns 'WL\_Down\_Vliet.csv'  
## 4 -- 5 columns 4 columns 'WL\_Down\_Vliet.csv'  
## 5 -- 5 columns 4 columns 'WL\_Down\_Vliet.csv'  
## ... ... ......... ......... ...................  
## See problems(...) for more details.

WL\_Down\_Dintel <- read\_csv("WL\_Down\_Dintel.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 143850 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'WL\_Down\_Dintel.csv'  
## 2 -- 5 columns 4 columns 'WL\_Down\_Dintel.csv'  
## 3 -- 5 columns 4 columns 'WL\_Down\_Dintel.csv'  
## 4 -- 5 columns 4 columns 'WL\_Down\_Dintel.csv'  
## 5 -- 5 columns 4 columns 'WL\_Down\_Dintel.csv'  
## ... ... ......... ......... ....................  
## See problems(...) for more details.

names(WL\_Down\_Vliet) <- c("Datum", "WL\_Down\_Vliet")  
names(WL\_Down\_Dintel) <- c("Datum", "WL\_Down\_Dintel")  
# Water depth measurements at downstream of Dintel and Vliet as indicator of Water depth dynamics in Volkerakmeer  
  
WL\_Up\_Vliet <- read\_csv("WL\_Up\_Vliet.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 5561 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'WL\_Up\_Vliet.csv'  
## 2 -- 5 columns 4 columns 'WL\_Up\_Vliet.csv'  
## 3 -- 5 columns 4 columns 'WL\_Up\_Vliet.csv'  
## 4 -- 5 columns 4 columns 'WL\_Up\_Vliet.csv'  
## 5 -- 5 columns 4 columns 'WL\_Up\_Vliet.csv'  
## ... ... ......... ......... .................  
## See problems(...) for more details.

WL\_Up\_Dintel <- read\_csv("WL\_Up\_Dintel.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 107055 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'WL\_Up\_Dintel.csv'  
## 2 -- 5 columns 4 columns 'WL\_Up\_Dintel.csv'  
## 3 -- 5 columns 4 columns 'WL\_Up\_Dintel.csv'  
## 4 -- 5 columns 4 columns 'WL\_Up\_Dintel.csv'  
## 5 -- 5 columns 4 columns 'WL\_Up\_Dintel.csv'  
## ... ... ......... ......... ..................  
## See problems(...) for more details.

names(WL\_Up\_Vliet) <- c("Datum", "WL\_Up\_Vliet")  
names(WL\_Up\_Dintel) <- c("Datum", "WL\_Up\_Dintel")  
# Water depth measurements at upstream of Dintel and Vliet as indicator of Water depth dynamics in Mark-Dintel-Vliet system  
  
# Gastel (Molenbeak) water depth measurements  
WL\_Gastel <- read\_csv("WL\_Gastel.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 657340 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'WL\_Gastel.csv'  
## 2 -- 5 columns 4 columns 'WL\_Gastel.csv'  
## 3 -- 5 columns 4 columns 'WL\_Gastel.csv'  
## 4 -- 5 columns 4 columns 'WL\_Gastel.csv'  
## 5 -- 5 columns 4 columns 'WL\_Gastel.csv'  
## ... ... ......... ......... ...............  
## See problems(...) for more details.

names(WL\_Gastel) <- c("Datum", "WL\_Gastel")  
  
# Inflow discharges:  
HF\_Qin\_MarkCanal <- read\_csv("HF\_Qin\_MarkCanal.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 105920 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qin\_MarkCanal.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qin\_MarkCanal.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qin\_MarkCanal.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qin\_MarkCanal.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qin\_MarkCanal.csv'  
## ... ... ......... ......... ......................  
## See problems(...) for more details.

names(HF\_Qin\_MarkCanal) <- c("Datum","Qin\_MarkCanal")  
  
HF\_Qin\_Oranjeboombrug <- read\_csv("HF\_Qin\_Oranjeboombrug.csv",col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 97692 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qin\_Oranjeboombrug.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qin\_Oranjeboombrug.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qin\_Oranjeboombrug.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qin\_Oranjeboombrug.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qin\_Oranjeboombrug.csv'  
## ... ... ......... ......... ...........................  
## See problems(...) for more details.

names(HF\_Qin\_Oranjeboombrug) <- c("Datum","Qin\_Oranjeboombrug")  
  
HF\_Qin\_BlauweKamer <- read\_csv("HF\_Qin\_BlauweKamer.csv",  
 col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 722945 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qin\_BlauweKamer.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qin\_BlauweKamer.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qin\_BlauweKamer.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qin\_BlauweKamer.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qin\_BlauweKamer.csv'  
## ... ... ......... ......... ........................  
## See problems(...) for more details.

names(HF\_Qin\_BlauweKamer) <- c("Datum","Qin\_BlauweKamer")  
  
HF\_Qin\_Molenbeak <- read\_csv("HF\_Qin\_Molenbeak.csv",  
 col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 588013 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qin\_Molenbeak.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qin\_Molenbeak.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qin\_Molenbeak.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qin\_Molenbeak.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qin\_Molenbeak.csv'  
## ... ... ......... ......... ......................  
## See problems(...) for more details.

names(HF\_Qin\_Molenbeak) <- c("Datum","Qin\_Molenbeak")  
  
# Outflow discharges:  
HF\_Qout\_Dintelsas <- read\_csv("HF\_Qout\_Dintelsas.csv",  
 col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 299449 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qout\_Dintelsas.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qout\_Dintelsas.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qout\_Dintelsas.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qout\_Dintelsas.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qout\_Dintelsas.csv'  
## ... ... ......... ......... .......................  
## See problems(...) for more details.

names(HF\_Qout\_Dintelsas) <- c("Datum", "Qout\_Dintelsas")  
  
HF\_Qout\_Vliet <- read\_csv("HF\_Qout\_Vliet.csv",  
 col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

## Warning: Missing column names filled in: 'X5' [5]

## Warning: 315749 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qout\_Vliet.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qout\_Vliet.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qout\_Vliet.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qout\_Vliet.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qout\_Vliet.csv'  
## ... ... ......... ......... ...................  
## See problems(...) for more details.

names(HF\_Qout\_Vliet) <- c("Datum", "Qout\_Vliet")  
  
# Integrating dataset #  
sTime\_numeric <- seq(HF\_Qin\_MarkCanal$Datum[1]%>%as.numeric,HF\_Qin\_MarkCanal$Datum[length(HF\_Qin\_MarkCanal$Datum)]%>%as.numeric, by=3600) #hourly interval  
  
WaterBudget\_MDV <- data.frame(Datum = ymd\_hms("1970-01-01 00:00:00")+sTime\_numeric,WL\_Down\_Dintel=NA,WL\_Down\_Vliet=NA,WL\_Up\_Dintel=NA,WL\_Up\_Vliet=NA,WL\_Gastel=NA,Qin\_MarkCanal=NA,Qin\_BlauweKamer=NA,Qin\_Molenbeak=NA,Qin\_Oranjeboombrug=NA,Qout\_Dintelsas=NA,Qout\_Vliet=NA)  
  
WaterBudget\_MDV$WL\_Down\_Dintel <- approx(WL\_Down\_Dintel$Datum%>%as.numeric,WL\_Down\_Dintel$WL\_Down\_Dintel,xout=WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

WaterBudget\_MDV$WL\_Down\_Vliet <- approx(WL\_Down\_Vliet$Datum%>%as.numeric,WL\_Down\_Vliet$WL\_Down\_Vliet,xout=WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

WaterBudget\_MDV$WL\_Up\_Dintel <- approx(WL\_Up\_Dintel$Datum%>%as.numeric,WL\_Up\_Dintel$WL\_Up\_Dintel,xout=WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

WaterBudget\_MDV$WL\_Up\_Vliet <- approx(WL\_Up\_Vliet$Datum%>%as.numeric,WL\_Up\_Vliet$WL\_Up\_Vliet,xout=WaterBudget\_MDV$Datum%>%as.numeric)$y  
WaterBudget\_MDV$WL\_Gastel <- approx(WL\_Gastel$Datum%>%as.numeric,WL\_Gastel$WL\_Gastel, xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

WaterBudget\_MDV$Qin\_MarkCanal <- approx(HF\_Qin\_MarkCanal$Datum%>%as.numeric,HF\_Qin\_MarkCanal$Qin\_MarkCanal,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

WaterBudget\_MDV$Qin\_BlauweKamer <- approx(HF\_Qin\_MarkCanal$Datum%>%as.numeric,HF\_Qin\_MarkCanal$Qin\_MarkCanal,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

WaterBudget\_MDV$Qin\_Molenbeak <- approx(HF\_Qin\_Molenbeak$Datum%>%as.numeric,HF\_Qin\_Molenbeak$Qin\_Molenbeak,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y  
WaterBudget\_MDV$Qin\_Oranjeboombrug <- approx(HF\_Qin\_Oranjeboombrug$Datum%>%as.numeric,HF\_Qin\_Oranjeboombrug$Qin\_Oranjeboombrug,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

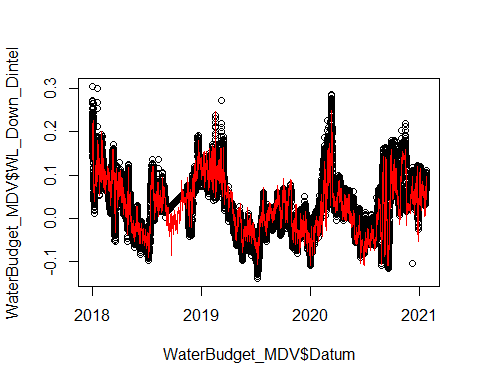
WaterBudget\_MDV$Qout\_Vliet <- approx(HF\_Qout\_Vliet$Datum%>%as.numeric,HF\_Qout\_Vliet$Qout\_Vliet,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

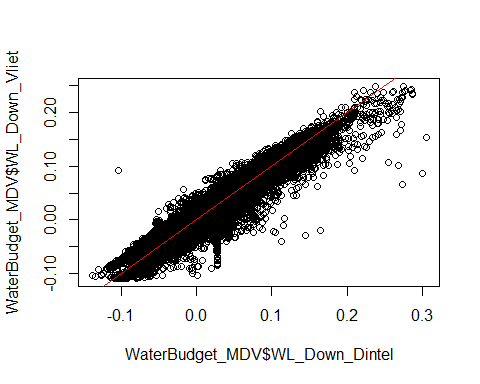
WaterBudget\_MDV$Qout\_Dintelsas <- approx(HF\_Qout\_Dintelsas$Datum%>%as.numeric,HF\_Qout\_Dintelsas$Qout\_Dintelsas,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

## Warning in regularize.values(x, y, ties, missing(ties)): collapsing to  
## unique 'x' values

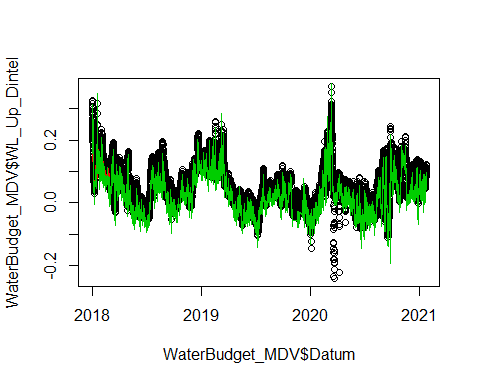
#### Compare the measurements at Dintel and Vliet downsteram as indicator of water depth dynamics at Volkerakmeer ####  
plot(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Down\_Dintel)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Down\_Vliet, col=2)



plot(WaterBudget\_MDV$WL\_Down\_Dintel, WaterBudget\_MDV$WL\_Down\_Vliet)  
lines(-2:2,-2:2,col=2) # 1:1 line



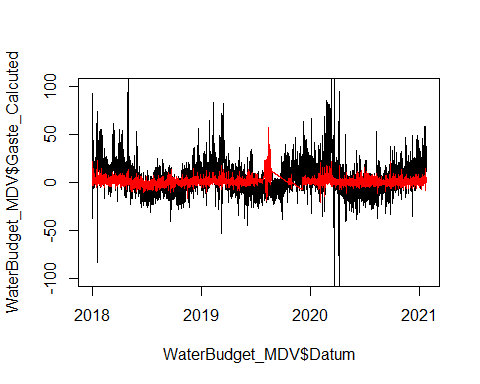
#### Compare depth measurements inside MDV system  
plot(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Up\_Dintel)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Up\_Vliet, col=2)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Gastel,col=3)



#### Closing the water balance by adjusting the inflows at Gastel (Molenbeak)  
Surface <- 50\*(114-0)\*40+50\*(640-114)\*50+50\*(666-640)\*100+50\*(743-666)\*40+50\*(760-743)\*26+50\*(1117-760)\*30 # m^2  
WaterBudget\_MDV$dt <- c(1, diff(as.numeric(WaterBudget\_MDV$Datum))) # seconds  
range(WaterBudget\_MDV$dt)

## [1] 1 3600

WaterBudget\_MDV <- WaterBudget\_MDV[which(WaterBudget\_MDV$dt!=0),]  
WaterBudget\_MDV$dV <- c(0, diff(WaterBudget\_MDV$WL\_Up\_Dintel))\*Surface # m^3  
  
#### Calculting the rest discharge to close the water budget ####  
WaterBudget\_MDV$Q\_diff <- WaterBudget\_MDV$dV/WaterBudget\_MDV$dt # m3/s  
  
#### Calculation of discharge at Gastel  
WaterBudget\_MDV$Gaste\_Calcuted <- WaterBudget\_MDV$Q\_diff-(WaterBudget\_MDV$Qin\_MarkCanal+WaterBudget\_MDV$Qin\_BlauweKamer+WaterBudget\_MDV$Qin\_Oranjeboombrug-WaterBudget\_MDV$Qout\_Dintelsas-WaterBudget\_MDV$Qout\_Vliet)  
  
#### Compare it with Measurements at Molenbeak ####  
plot(WaterBudget\_MDV$Datum,WaterBudget\_MDV$Gaste\_Calcuted, type = "l",ylim = c(-100,100))   
lines(WaterBudget\_MDV$Datum,WaterBudget\_MDV$Qin\_Molenbeak, col=2)



#### Calculating the water level in Vliet based on Inflowsa and Outflows we have

WaterBudget\_MDV$dV\_Cal = (WaterBudget\_MDV$Qin\_MarkCanal+WaterBudget\_MDV$Qin\_BlauweKamer+WaterBudget\_MDV$Qin\_Molenbeak+WaterBudget\_MDV$Qin\_Oranjeboombrug-WaterBudget\_MDV$Qout\_Dintelsas-WaterBudget\_MDV$Qout\_Vliet)\*WaterBudget\_MDV$dt  
  
WaterBudget\_MDV$WL\_Cal = NA  
WaterBudget\_MDV$WL\_Cal[1]=WaterBudget\_MDV$WL\_Up\_Dintel[1]  
for (t in 2:nrow(WaterBudget\_MDV)) {  
 WaterBudget\_MDV$WL\_Cal[t] = WaterBudget\_MDV$WL\_Cal[t-1]+WaterBudget\_MDV$dV\_Cal[t-1]/Surface  
}   
  
plot(WaterBudget\_MDV$Datum,WaterBudget\_MDV$WL\_Cal)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Up\_Dintel, col=2)  
  
legend("topright",legend = c("Calculation","Measurements"),col=1:2,text.col = 1:2,lty=1)

