Dynamic Water Balance at MDV

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19/07/2020

# 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\_Project\_Shared\\Modelling\\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

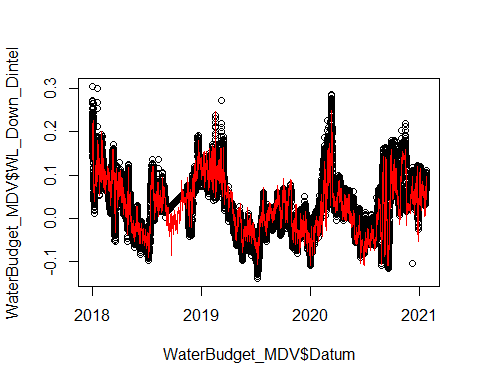
WaterBudget\_MDV$Qout\_Vliet <- approx(HF\_Qout\_Vliet$Datum%>%as.numeric,HF\_Qout\_Vliet$Qout\_Vliet,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

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

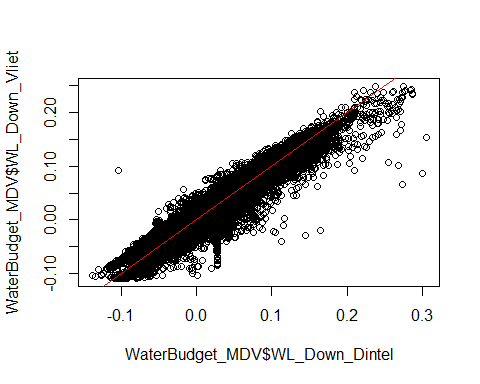
WaterBudget\_MDV$Qout\_Dintelsas <- approx(HF\_Qout\_Dintelsas$Datum%>%as.numeric,HF\_Qout\_Dintelsas$Qout\_Dintelsas,xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

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

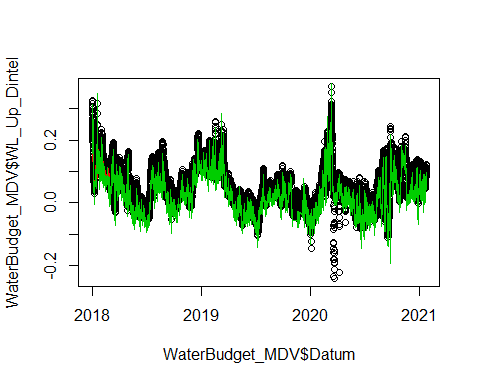
#### Compare the measurements at Dintel and Vliet downsteram as indicator of water depth dynamics at Volkerakmeer ####  
plot(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Down\_Dintel)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Down\_Vliet, col=2)



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



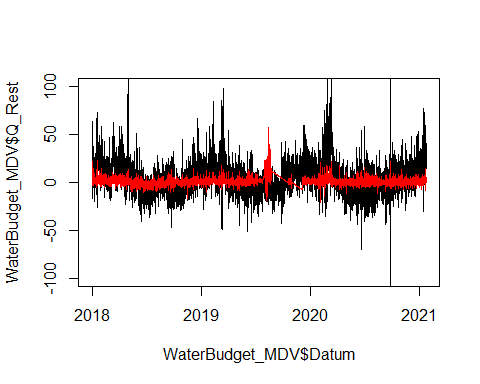
#### Compare depth measurements inside MDV system  
plot(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Up\_Dintel)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Up\_Vliet, col=2)  
lines(WaterBudget\_MDV$Datum, WaterBudget\_MDV$WL\_Gastel,col=3)



#### 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)

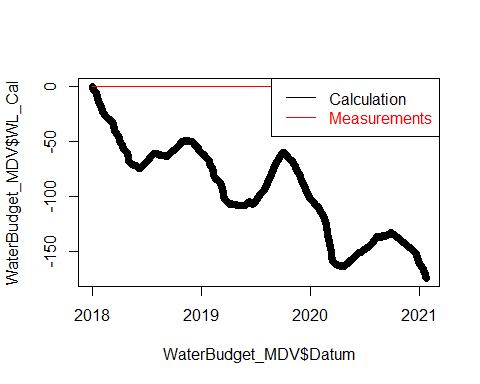
## [1] 1 3600

WaterBudget\_MDV <- WaterBudget\_MDV[which(WaterBudget\_MDV$dt!=0),]  
#WaterBudget\_MDV$dV <- c(0, diff(WaterBudget\_MDV$WL\_Up\_Dintel))\*Surface # m^3  
WaterBudget\_MDV$dV <- c(0, diff(WaterBudget\_MDV$WL\_Gastel))\*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$Q\_Rest <- WaterBudget\_MDV$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$Datum,WaterBudget\_MDV$Q\_Rest, 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)



#### Correction of discharge at Gastel based on catchment area

HF\_Qin\_Roosendaal\_1 <- read\_csv("HF\_Qin\_Roosendaal\_1.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]

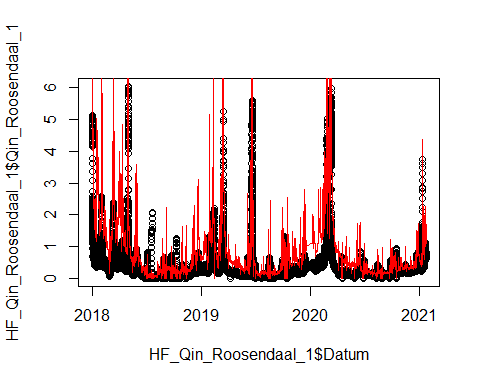
## Warning: 105134 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_1.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_1.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_1.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_1.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_1.csv'  
## ... ... ......... ......... .........................  
## See problems(...) for more details.

HF\_Qin\_Roosendaal\_2 <- read\_csv("HF\_Qin\_Roosendaal\_2.csv",  
 col\_types = cols(Datum = col\_datetime(format = "%d-%m-%Y %H:%M:%S"), Eenheid = col\_skip(),Serie = col\_skip(), X5 = col\_skip()))

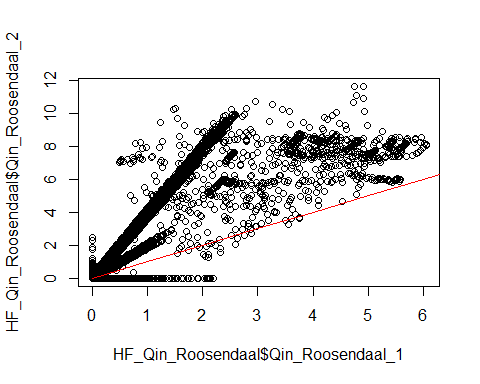
## Warning: Missing column names filled in: 'X5' [5]

## Warning: 105259 parsing failures.  
## row col expected actual file  
## 1 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_2.csv'  
## 2 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_2.csv'  
## 3 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_2.csv'  
## 4 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_2.csv'  
## 5 -- 5 columns 4 columns 'HF\_Qin\_Roosendaal\_2.csv'  
## ... ... ......... ......... .........................  
## See problems(...) for more details.

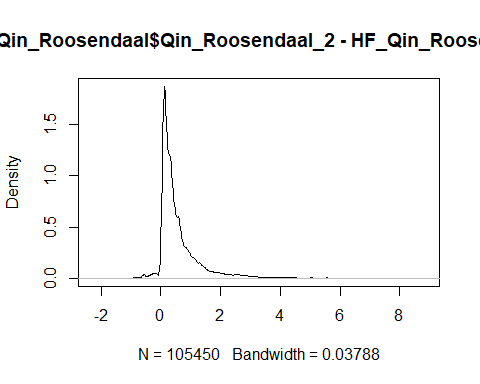
names(HF\_Qin\_Roosendaal\_1) <- c("Datum", "Qin\_Roosendaal\_1")  
names(HF\_Qin\_Roosendaal\_2) <- c("Datum", "Qin\_Roosendaal\_2")  
  
plot(HF\_Qin\_Roosendaal\_1$Datum, HF\_Qin\_Roosendaal\_1$Qin\_Roosendaal\_1)  
lines(HF\_Qin\_Roosendaal\_2$Datum, HF\_Qin\_Roosendaal\_2$Qin\_Roosendaal\_2, col=2)



HF\_Qin\_Roosendaal <- merge(HF\_Qin\_Roosendaal\_1, HF\_Qin\_Roosendaal\_2, by = "Datum")  
plot(HF\_Qin\_Roosendaal$Qin\_Roosendaal\_1, HF\_Qin\_Roosendaal$Qin\_Roosendaal\_2)  
lines(0:12,0:12, col="red")



plot(density(HF\_Qin\_Roosendaal$Qin\_Roosendaal\_2-HF\_Qin\_Roosendaal$Qin\_Roosendaal\_1))



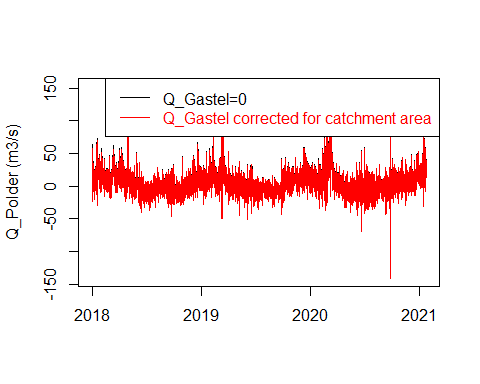
# From the visualization Roosendaal\_2 is on average larger than Roosendaal\_1, from previous results that calculates water level dynamics based on inflow and outflow measurements, we had a underestimation of total Qin. Therefore, I'm going to use the Roosendaal\_2 measurements rather than Roosendaal\_1.  
  
WaterBudget\_MDV$Qin\_Roosendaal <- approx(HF\_Qin\_Roosendaal$Datum%>%as.numeric, HF\_Qin\_Roosendaal$Qin\_Roosendaal\_2, xout = WaterBudget\_MDV$Datum%>%as.numeric)$y

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

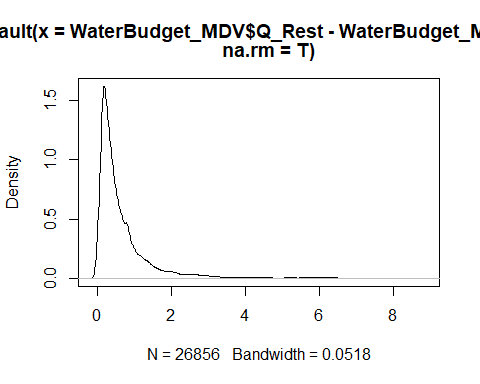
Roosendaal\_CatchmentArea <- 2277 # 1 ha = 10000 m2  
Molenbeek\_CatchmentArea <- 1709 # 1 ha = 10000 m2  
  
WaterBudget\_MDV$Qin\_Molenbeak\_CorrectedByCatchment <- WaterBudget\_MDV$Qin\_Roosendaal/Roosendaal\_CatchmentArea\*Molenbeek\_CatchmentArea

#### Calculation of Q\_Polder with catchment area corrected Q\_Gastel

WaterBudget\_MDV$Q\_Polder <- WaterBudget\_MDV$Q\_Rest-WaterBudget\_MDV$Qin\_Molenbeak\_CorrectedByCatchment  
  
plot(WaterBudget\_MDV$Datum,WaterBudget\_MDV$Q\_Rest, ylab = "Q\_Polder (m3/s)", xlab = "",t="l")  
lines(WaterBudget\_MDV$Datum,WaterBudget\_MDV$Q\_Polder,col=2)  
legend("topright",legend=c("Q\_Gastel=0","Q\_Gastel corrected for catchment area"),col=1:2,text.col = 1:2,lty=1)



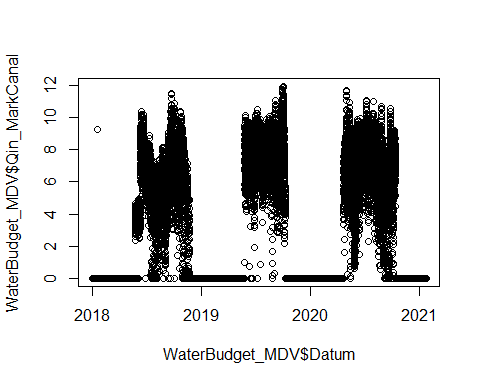
plot(density(WaterBudget\_MDV$Q\_Rest-WaterBudget\_MDV$Q\_Polder,na.rm = T))



mean(WaterBudget\_MDV$Q\_Polder,na.rm = T)

## [1] 4.842233

plot(WaterBudget\_MDV$Datum, WaterBudget\_MDV$Qin\_MarkCanal)

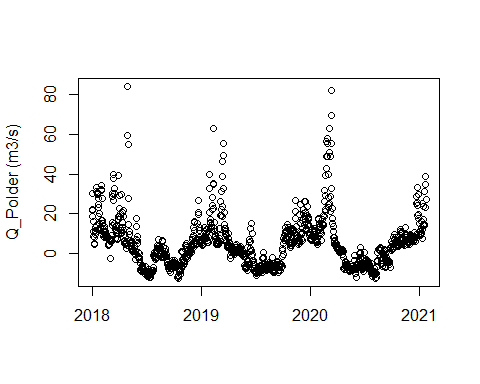


mean(WaterBudget\_MDV$Qin\_MarkCanal)

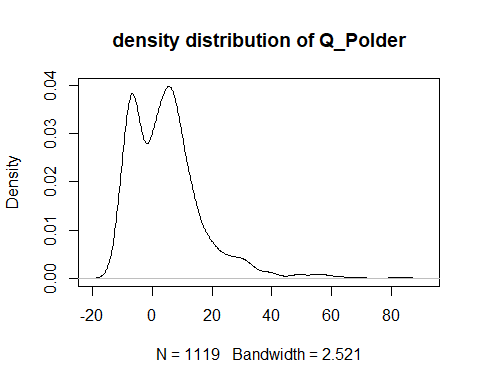
## [1] 2.794384

# Trunc date to daily

WaterBudget\_MDV$Daily <- trunc(WaterBudget\_MDV$Datum, "days")  
WB\_MDV\_Day <- aggregate(WaterBudget\_MDV[,2:21],by=list(as.character(WaterBudget\_MDV$Daily)),mean)  
names(WB\_MDV\_Day)[1] <- "Datum"  
WB\_MDV\_Day$Datum <- ymd(WB\_MDV\_Day$Datum)  
  
plot(WB\_MDV\_Day$Datum, WB\_MDV\_Day$Q\_Polder,ylab = "Q\_Polder (m3/s)", xlab = "")

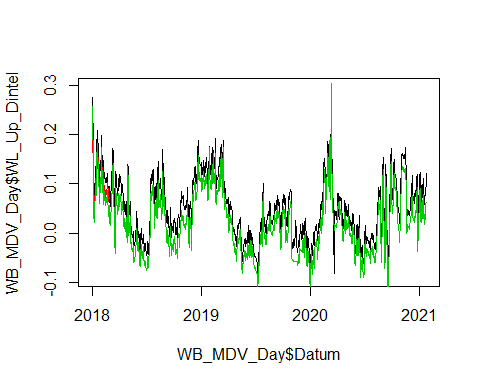


plot(density(WB\_MDV\_Day$Q\_Polder, na.rm = T),main = "density distribution of Q\_Polder")



#### Water level fluctuations

plot(WB\_MDV\_Day$Datum, WB\_MDV\_Day$WL\_Up\_Dintel, col=1, t="l")  
lines(WB\_MDV\_Day$Datum, WB\_MDV\_Day$WL\_Up\_Vliet, col=2)  
  
lines(WB\_MDV\_Day$Datum, WB\_MDV\_Day$WL\_Gastel, col=3)

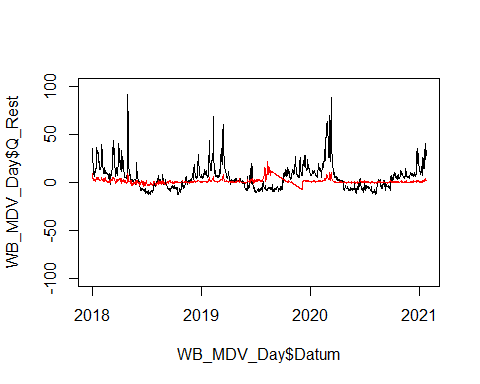


#### Water level fluctuations

#### 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  
WB\_MDV\_Day$dt <- c(1, diff(as.numeric(WB\_MDV\_Day$Datum))) # seconds  
range(WB\_MDV\_Day$dt)

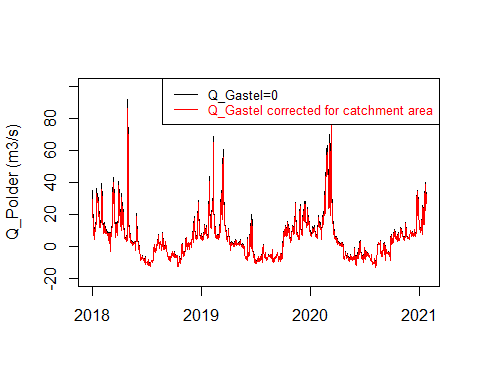
## [1] 1 1

WB\_MDV\_Day <- WB\_MDV\_Day[which(WB\_MDV\_Day$dt!=0),]  
#WB\_MDV\_Day$dV <- c(0, diff(WB\_MDV\_Day$WL\_Up\_Dintel))\*Surface # m^3  
WB\_MDV\_Day$dV <- c(0, diff(WB\_MDV\_Day$WL\_Gastel))\*Surface # m^3  
  
#### Calculting the rest discharge to close the water budget ####  
WB\_MDV\_Day$Q\_diff <- WB\_MDV\_Day$dV/(WB\_MDV\_Day$dt\*86400) # m3/s  
  
#### Calculation of discharge at Gastel  
WB\_MDV\_Day$Q\_Rest <- WB\_MDV\_Day$Q\_diff-(WB\_MDV\_Day$Qin\_MarkCanal+WB\_MDV\_Day$Qin\_BlauweKamer+WB\_MDV\_Day$Qin\_Oranjeboombrug-WB\_MDV\_Day$Qout\_Dintelsas-WB\_MDV\_Day$Qout\_Vliet)  
  
#### Compare it with Measurements at Molenbeak ####  
plot(WB\_MDV\_Day$Datum,WB\_MDV\_Day$Q\_Rest, type = "l",ylim = c(-100,100))   
lines(WB\_MDV\_Day$Datum,WB\_MDV\_Day$Qin\_Molenbeak, col=2)

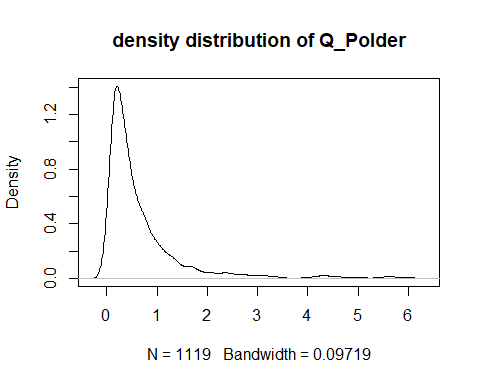


#### Q\_Polder daily data

WB\_MDV\_Day$Q\_Polder <- WB\_MDV\_Day$Q\_Rest-WB\_MDV\_Day$Qin\_Molenbeak\_CorrectedByCatchment  
  
plot(WB\_MDV\_Day$Datum,WB\_MDV\_Day$Q\_Rest, ylab = "Q\_Polder (m3/s)", xlab = "",t="l", ylim = c(-20, 100))  
lines(WB\_MDV\_Day$Datum,WB\_MDV\_Day$Q\_Polder,col=2)  
legend("topright",legend=c("Q\_Gastel=0","Q\_Gastel corrected for catchment area"),col=1:2,text.col = 1:2,lty=1,cex=0.8)



plot(density(WB\_MDV\_Day$Q\_Rest-WB\_MDV\_Day$Q\_Polder,na.rm = T),main = "density distribution of Q\_Polder")



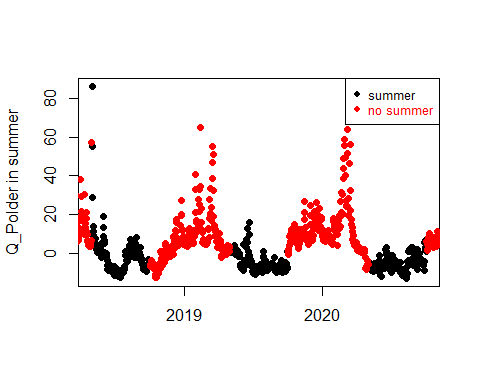
mean(WB\_MDV\_Day$Q\_Polder,na.rm = T)

## [1] 4.841757

# for polder discharge in summer  
plot(WB\_MDV\_Day$Datum[which(month(WB\_MDV\_Day$Datum)%in%c(5:9))],WB\_MDV\_Day$Q\_Polder[which(month(WB\_MDV\_Day$Datum)%in%c(5:9))], xlab = "",ylab = "Q\_Polder in summer",t="p",col=1,pch=19)  
mean(WB\_MDV\_Day$Q\_Polder[which(month(WB\_MDV\_Day$Datum)%in%c(5:9))])

## [1] -3.770813

points(WB\_MDV\_Day$Datum[which(month(WB\_MDV\_Day$Datum)%in%c(10,11,12,1,2,3,4))],WB\_MDV\_Day$Q\_Polder[which(month(WB\_MDV\_Day$Datum)%in%c(10,11,12,1,2,3,4))],col=2,pch=19)  
legend("topright",legend=c("summer","no summer"),col=1:2,text.col = 1:2,pch=19,cex=0.8)

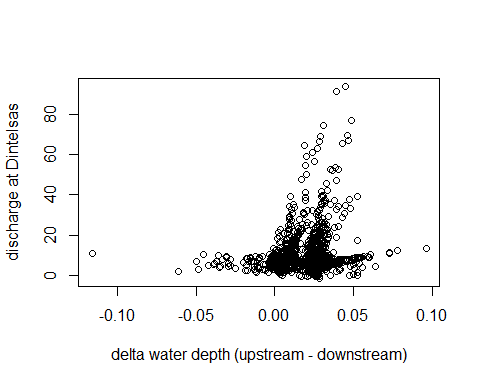


mean(WB\_MDV\_Day$Q\_Polder[which(month(WB\_MDV\_Day$Datum)%in%c(10,11,12,1,2,3,4))],na.rm = T)

## [1] 10.83141

#### Q vs delta Water depth

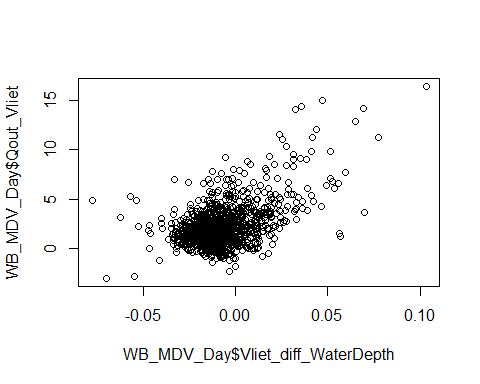
WB\_MDV\_Day$Dintel\_diff\_WaterDepth <- WB\_MDV\_Day$WL\_Up\_Dintel-WB\_MDV\_Day$WL\_Down\_Dintel  
WB\_MDV\_Day$Vliet\_diff\_WaterDepth <- WB\_MDV\_Day$WL\_Gastel-WB\_MDV\_Day$WL\_Down\_Vliet  
  
plot(WB\_MDV\_Day$Dintel\_diff\_WaterDepth, WB\_MDV\_Day$Qout\_Dintelsas,ylab = "discharge at Dintelsas", xlab = "delta water depth (upstream - downstream)")



summary(lm(WB\_MDV\_Day$Qout\_Dintelsas~WB\_MDV\_Day$Dintel\_diff\_WaterDepth))

##   
## Call:  
## lm(formula = WB\_MDV\_Day$Qout\_Dintelsas ~ WB\_MDV\_Day$Dintel\_diff\_WaterDepth)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -14.403 -5.807 -3.033 2.205 80.650   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 8.4618 0.4881 17.338 < 2e-16 \*\*\*  
## WB\_MDV\_Day$Dintel\_diff\_WaterDepth 108.6184 18.8752 5.755 1.12e-08 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 10.59 on 1118 degrees of freedom  
## Multiple R-squared: 0.02877, Adjusted R-squared: 0.0279   
## F-statistic: 33.11 on 1 and 1118 DF, p-value: 1.121e-08

plot(WB\_MDV\_Day$Vliet\_diff\_WaterDepth,WB\_MDV\_Day$Qout\_Vliet)



summary(lm(WB\_MDV\_Day$Qout\_Vliet~WB\_MDV\_Day$Vliet\_diff\_WaterDepth))

##   
## Call:  
## lm(formula = WB\_MDV\_Day$Qout\_Vliet ~ WB\_MDV\_Day$Vliet\_diff\_WaterDepth)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -5.2406 -1.1327 -0.1653 0.8119 9.4190   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.71182 0.06087 44.55 <2e-16 \*\*\*  
## WB\_MDV\_Day$Vliet\_diff\_WaterDepth 64.53140 3.25426 19.83 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 1.861 on 1117 degrees of freedom  
## (1 observation deleted due to missingness)  
## Multiple R-squared: 0.2604, Adjusted R-squared: 0.2597   
## F-statistic: 393.2 on 1 and 1117 DF, p-value: < 2.2e-16