Investigate CME kinematics in WP3

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This is an R Markdown document outlining an initial exploration of the CME kinematics produced from the HELCATS WP3 catalogue.

```
# Read in the WP3 CSV file
wp3 <- read.csv("../WP3_catalogue/HCME_WP3_V02.csv")

# Print the number of rows and variables, and names of the variables
dim(wp3)
```

```
## [1] 1210   33
```

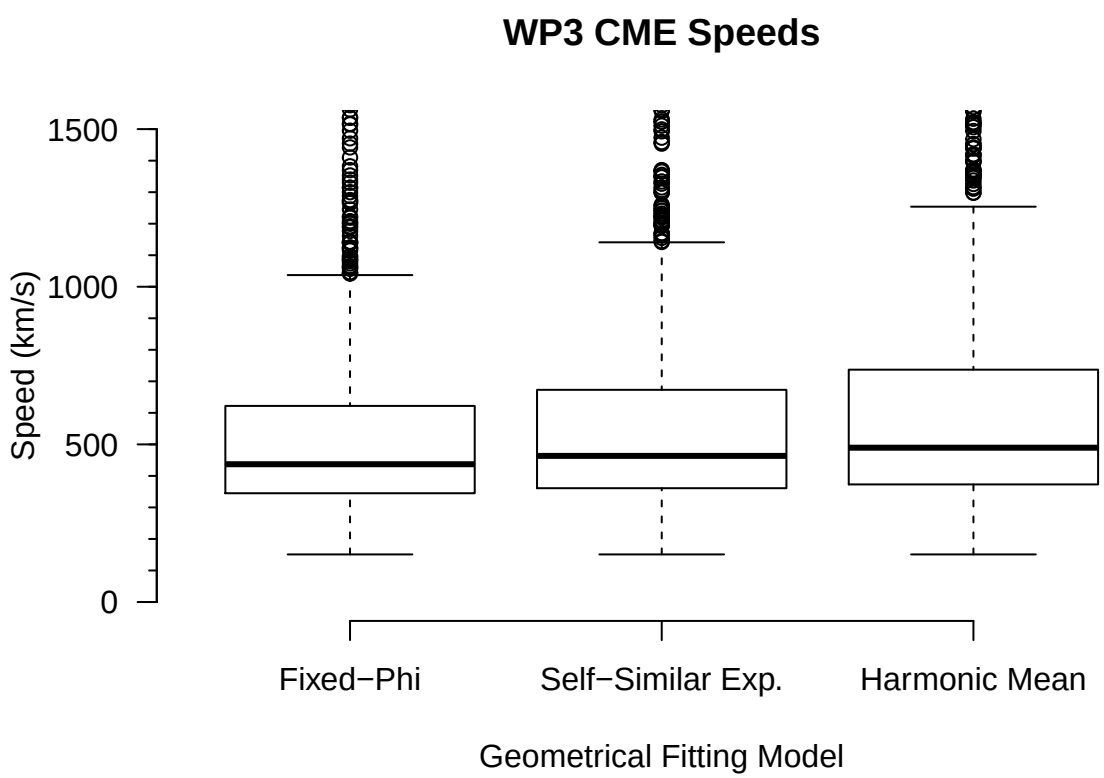
```
names(wp3)
```

```
##  [1] "ID"                   "Date.UTC."            "SC"
##  [4] "L.N"                  "PA.N.deg."            "L.S"
##  [7] "PA.S.deg."            "Quality"              "PA.fit"
## [10] "FP.speed.kms.1."      "FP.speed.Err.kms.1."  "FP.Phi.deg."
## [13] "FP.Phi.Err.deg."      "FP.HEEQ.Long.deg."    "FP.HEEQ.Lat.deg."
## [16] "FP.Carr.Long.deg."    "FP.Launch.UTC."       "SSE.speed.kms.1."
## [19] "SSE.speed.Err.kms.1." "SSE.Phi.deg."         "SSE.Phi.Err.deg."
## [22] "SSE.HEEQ.Long.deg."   "SSE.HEEQ.Lat.deg."    "SSE.Carr.Long.deg."
## [25] "SSE.Launch.UTC."      "HM.speed.kms.1."      "HM.speed.Err.kms.1."
## [28] "HM.Phi.deg."          "HM.Phi.Err.deg."      "HM.HEEQ.Long.deg."
## [31] "HM.HEEQ.Lat.deg."     "HM.Carr.Long.deg."    "HM.Launch.UTC."
```

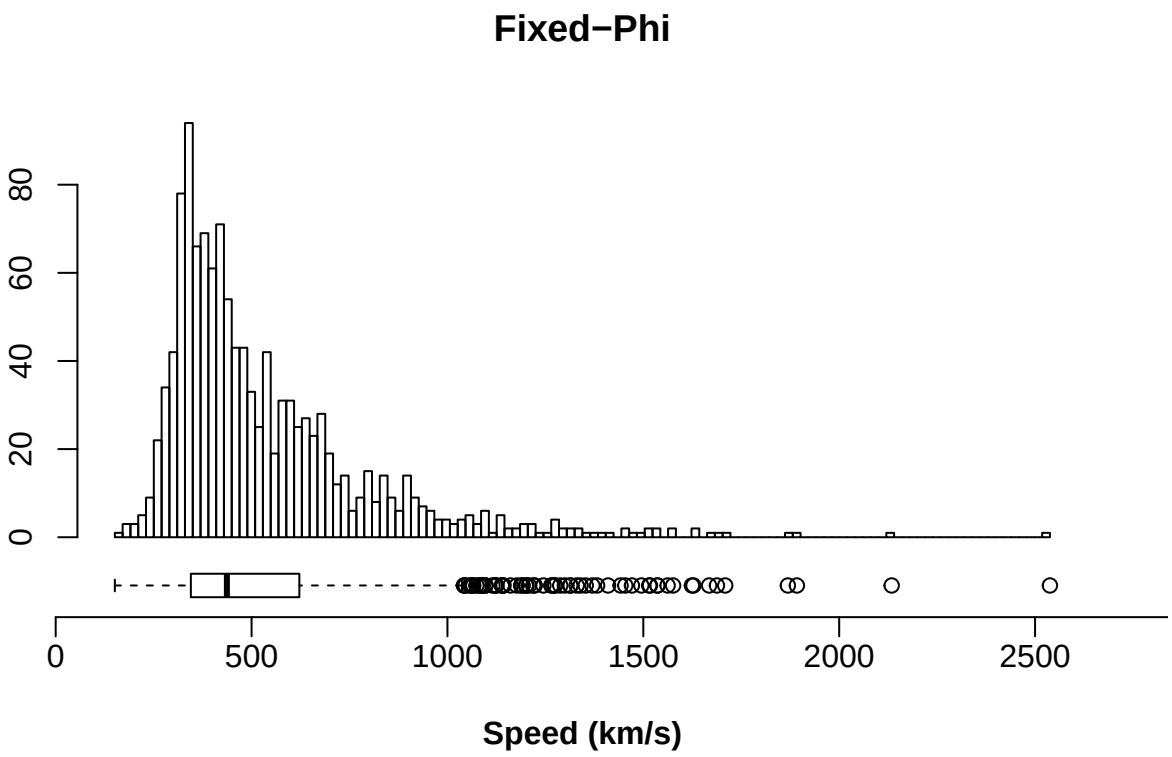
```
names(wp3) <- c("ID",
                "Date",
                "Spacecraft",
                "LN",
                "PA_N",
                "LS",
                "PA_S",
                "Quality",
                "PA_Fit",
                "FP_Speed",
                "FP_SpeedErr",
                "FP_Phi",
                "FP_PhiErr",
                "FP_HEEQLon",
                "FP_HEEQLat",
                "FP_CarrLon",
                "FP_LaunchUTC",
                "SSE_Speed",
                "SSE_Speed Err",
                "SSE_Phi",
```

```
                "SSE_PhiErr",
                "SSE_HEEQLon",
                "SSE_HEEQLat",
                "SSE_CarrLon",
                "SSE_LaunchUTC",
                "HM_Speed",
                "HM_Speed Err",
                "HM_Phi",
                "HM_PhiErr",
                "HM_HEEQLon",
                "HM_HEEQLat",
                "HM_CarrLon",
                "HM_LaunchUTC")


# Simple plots


# Plot out stats on the speeds

speed_boxplots <- function(wp3){

    #pdf("CME_Speeds_boxplot.pdf",width=8,height=8)
    boxplot(wp3$FP_Speed, wp3$SSE_Speed, wp3$HM_Speed,
                main = "WP3 CME Speeds",
                xlab = "Geometrical Fitting Model",
                ylab = "Speed (km/s)",
                ylim = c(0,1500),
        axes = F
        )
        axis(1, at=1:3, labels=c("Fixed-Phi","Self-Similar Exp.","Harmonic Mean"))
    axis(2, at=seq(0,1500,by=500), las=1)
    axis(2, at=seq(0,1500,by=100), labels=F, tcl=-0.2)

    # Ignore the horizontal version of the boxplot
    if (FALSE) {
    boxplot(wp3$FP_Speed, wp3$SSE_Speed, wp3$HM_Speed,
                main = "WP3 CME Speeds",
                ylab = "Geometrical Fitting Model",
                xlab = "Speed (km/s)",
                ylim = c(0,1500),
                axes = F,
        horizontal = TRUE
                )
        axis(2, at=1:3, labels=c("Fixed-Phi","Self-Similar Exp.","Harmonic Mean"))
        axis(1, at=seq(0,1500,by=500), las=1)
        axis(1, at=seq(0,1500,by=100), labels=F, tcl=-0.2)
    }

    #dev.off()

}
```

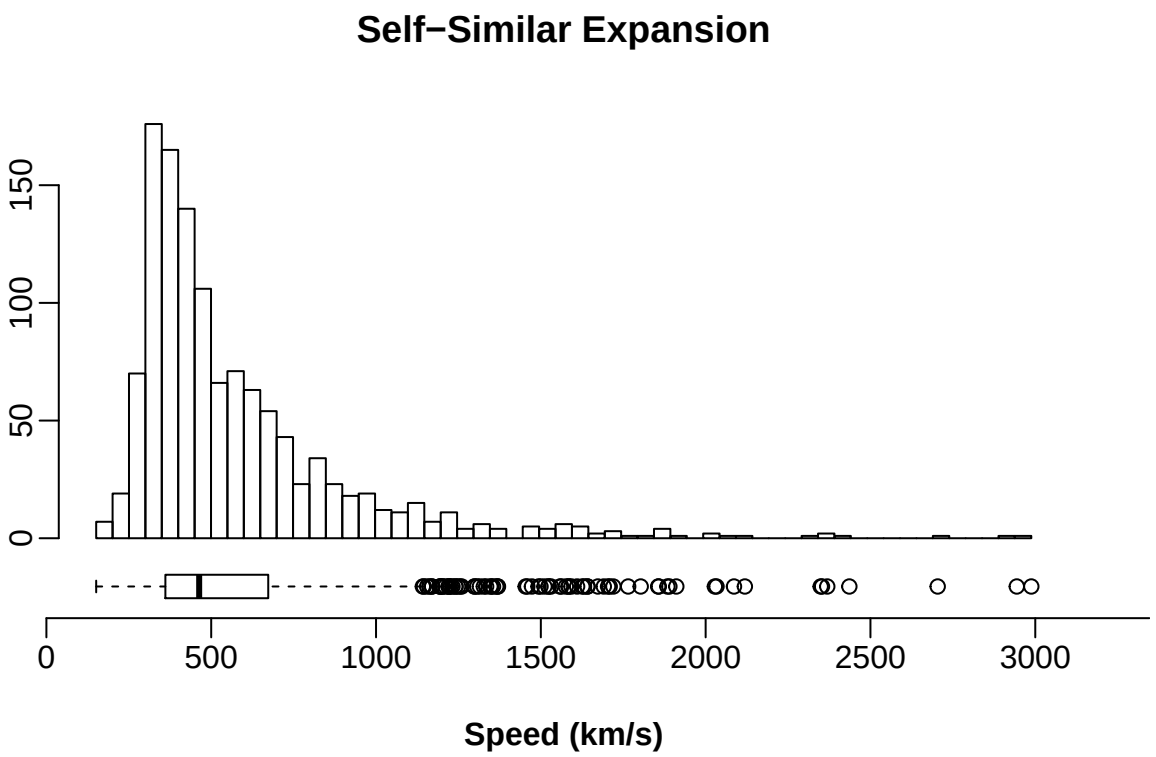
```
speed_boxplots(wp3)
```



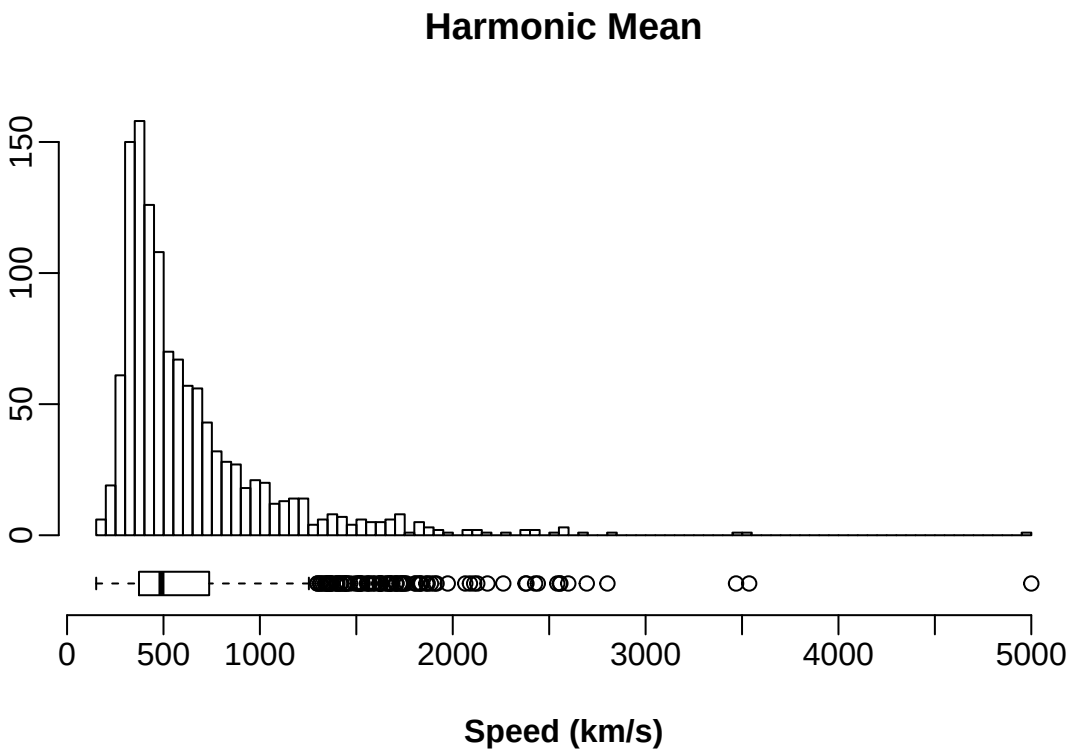

```
speed_hist <- function(speed,tit){

    #pdf(paste("CME_Speeds_hist",tit,".pdf"),width=8,height=8)

    layout(matrix(seq(2)),heights=c(0.7,0.3))
    par(mar=c(0,4.1,4.1,2.1))
    hist(speed,breaks=100,axes=F,main=tit,xlab="",ylab="")
    axis(2)
    par(mar=c(5.1,4.1,0,2.1),mgp=c(3,0.5,0.0))
    boxplot(speed,horizontal=TRUE,axes=FALSE)
    axis(1,at=seq(0,5000,by=500),xpd=TRUE)
    mtext("Speed (km/s)",side=1,line=2.5,font=2)

    #dev.off()

}

speed_hist(wp3$FP_Speed,"Fixed-Phi")
```




```
speed_hist(wp3$SSE_Speed,"Self-Similar Expansion")
```




```
speed_hist(wp3$HM_Speed,"Harmonic Mean")
```




```
compare_speeds <- function(wp3){

    #dev.copy("CME_speeds.png",width=8,height=8,unit="in",res=300)
    #pdf("Compare_CME_Speeds.pdf",width=8,height=3)
    par(mfrow=c(1,3),pty="s")
    plot(wp3$FP_Speed, wp3$SSE_Speed,
        xlab="FP Speed (km/s)", ylab="SSE Speed (km/s)",#main="WP3 CME Speeds",
        xlim=c(0,3000), ylim=c(0,3000),
        pch=3)
    abline(0,1,col="black",lty=5)
    reg <- lm(wp3$SSE_Speed~wp3$FP_Speed)
    abline(reg,col="red")
    legend("bottomright",c(paste("y =",signif(reg$coefficients[[2]],digits=2),"x +",round(reg$coefficie

    plot(wp3$FP_Speed, wp3$HM_Speed,
            xlab="FP Speed (km/s)", ylab="HM Speed (km/s)",#main="WP3 CME Speeds",
            xlim=c(0,5000), ylim=c(0,5000),
            pch=3)
    abline(0,1,col="black",lty=5)
    reg <- lm(wp3$HM_Speed~wp3$FP_Speed)
    abline(reg,col="red")
    legend("bottomright",c(paste("y =",signif(reg$coefficients[[2]],digits=2),"x +",round(reg$coefficie

    plot(wp3$HM_Speed, wp3$SSE_Speed,
            xlab="HM Speed (km/s)", ylab="SSE Speed (km/s)",#main="WP3 CME Speeds",
            xlim=c(0,5000), ylim=c(0,5000),
            pch=3)
    abline(0,1,col="black",lty=5)
    reg <- lm(wp3$SSE_Speed~wp3$HM_Speed)
    abline(reg,col="red")
```

```
    legend("bottomright",c(paste("y =",signif(reg$coefficients[[2]],digits=2),"x +",round(reg$coefficie
    #dev.off()
}

compare_speeds(wp3)
```