```
%% LyX 2.1.1 created this file.  For more info, see http://www.lyx.org/.
\documentclass[12pt]{report}
\usepackage{mathptmx}
\usepackage[T1]{fontenc}
\usepackage[letterpaper]{geometry}
\geometry{verbose,tmargin=3.54cm,bmargin=2.54cm,lmargin=2.54cm,rmargin=2.54cm,headheight=1cm,headsep=2cm,footskip=0.5cm}
\usepackage{fancyhdr}
\pagestyle{fancy}
\setlength{\parskip}{\medskipamount}
\setlength{\parindent}{0pt}
\usepackage{color}
\usepackage[unicode=true]
 {hyperref}
\usepackage{breakurl}

\makeatletter

%%%%%%%%%%%%%%%%%%%%%%%%%%% LyX specific LaTeX commands.
%% Because html converters don't know tabularnewline
\providecommand{\tabularnewline}{\\}

%%%%%%%%%%%%%%%%%%%%%%%%%%% User specified LaTeX commands.
\input colordvi
\usepackage{color}
\fancyhead{}
\fancyfoot[CE,CO]{}
\newtoks{\addressee} \global\addressee={}
\newdimen\longindent \longindent=3.5truein
\fancyhead[L]{Memo to: \the\addressee \\ \datetoday \\ Page \thepage \hfill}
\renewcommand{\headrulewidth}{0.0pt}
\newenvironment{lyxlist}[1]
{\begin{list}{}
{\settowidth{\labelwidth}{#1}
\setlength{\leftmargin}{\labelwidth}
\addtolength{\leftmargin}{\labelsep}
\renewcommand{\makelabel}[1]{##1\hfil}}}
{\end{list}}
\newcommand{\datetoday}{\number\day\space
    \ifcase\month\or January\or February\or March\or April\or May\or
    June\or July\or August\or September\or October\or November\or
    December\fi
    \space\number\year}
\newcommand{\EOLmemo}{\null \vskip-1.5truein
{\raggedright \textsf{\textsc{\large \textcolor{blue}{Earth Observing Laboratory}}}}\par
{\raggedright \textsf{\textsl{\textcolor{blue}{Memorandum:}}}} \par \vskip6pt
{\color{blue}{\hrule}}\par
\vskip0.3truein \leftline{\hskip \longindent \datetoday} \vskip0.2truein
\thispagestyle{empty}}
\newcommand{\attachm}[1]{\begin{lyxlist}{Attachments:00}
\item [Attachments:] {#1}
\end{lyxlist}}
\newcommand{\cc}[1]{\begin{lyxlist}{Attachments:00}
\item [cc:] {#1}
\end{lyxlist}}
\newcommand{\attach}[1]{\begin{lyxlist}{Attachments:00}
\item [Attachment:] {#1}
\end{lyxlist}}
%usage: \encl{A\\B\\C} or \cc{ma,e1\\name2\\name3}

<<get-file-location, echo=FALSE, include=FALSE>>=

#script.loc <- dirname(sys.frame(1)$ofile)
# doesn't work. Keep looking; in the meantime, use
script.loc="/h/eol/cooperw/RStudio/Reprocessing/CONTRASTcalAOA.Rnw"

@


\makeatother

\begin{document}
\EOLmemo

\global\addressee={CONTRAST data-processing file}% change "File" to the "To:" name

\begin{tabular}{ll}
\textsf{\textsc{\textcolor{blue}{To:}}} & \the\addressee\tabularnewline
\textsf{\textsc{\textcolor{blue}{From:}}} & Al Cooper\tabularnewline
 \textsf{\textsc{\textcolor{blue}{Subject:}}} & example: AKRD coefficients, CONTRAST\tabularnewline
\end{tabular}
```

\bigskip

\section*{Equations underlying the calibration}

The first-order expression for the vertical wind w is

\begin{equation}
w=V\sin(\alpha-\phi)+w_{p}\label{eq:VWind}
\end{equation}

where V is the true airspeed, α the angle of attack, ϕ the pitch, and w_{p} the vertical motion or rate-of-climb of the aircraft. The solution for the angle-of-attack is

\begin{equation}
\alpha=\phi+\arcsin\frac{w-w_{p}}{V}\label{eq:SolvedForAOA}
\end{equation}

If it is reasonable to assume for some period of flight that w is zero, or that it averages to zero, then

\begin{equation}
\alpha^{*}=\phi-\arcsin\frac{w_{p}}{V}\label{eq:alphaWithwZero}
\end{equation}

can be used as a reference angle-of-attack to which to fit a parameterized formula. This fit reference depends on measurements of pitch, rate-of-climb, and true airspeed. Even in the presence of waves, fitting to this as functions of the radome measurements and other flight characteristics should average any real effects of vertical wind as long as the vertical wind over the flight segments used averages to zero.

In the case of the radome, the relevant variables are ϕ=PITCH, w_{p}=GGVSPDB, and V=TASX.%
\footnote{There is an element of circularity that arises from TASX dependence on the pressure corrections but pressure corrections dependent on angle of attack. This is usually minor because the fractional change in TASX introduced by the pressure corrections is small, but it may be useful to iterate once, applying the new sensitivity coefficients in recalculation of TASX and then repeating the fit.%
} The radome measures the pressure difference (ADIFR) between top and bottom ports on the radome, and this pressure is usually normalized by some measure of dynamic pressure like QCF or QCXC or QCRC. The former is preferable because the use of corrected QCXC requires the application of static-defect corrections that themselves depend on α, leading to circularity in the calculation, and QCR and QCRC are sometimes affected by icing or freezing of accumulated water even when ADIFR continues to function.

```
<<initialization,echo=FALSE,include=FALSE>>=

require(Ranadu)
require(ggplot2)
require(grid)
library(knitr)
require(ggthemes)
require(vioplot)
require(plyr)
# the following do not work, so need to generate and save SessionInfo separately
#sink (file="./SessionInfo")
#print (sessionInfo (), locale=TRUE)
#sink()
Directory <- DataDirectory ()
Flight <- "rf08"
Project = "CONTRAST"
fname = sprintf("%s%s/%s%s.nc", Directory,Project,Project,Flight)
VarNames <- c("VYC","GGALT","LATC", "LONC", "PSXC", "QCXC",
"WDC", "WSC", "GGVEW", "GGVNS", "VEW", "VNS", "TASX",
"ADIFR", "AKRD", "SSLIP", "PITCH", "GGTRK", "PSF", "QCF",
"ROLL", "THDG", "BDIFR", "EWX", "WIC",
"VSPD", "ATX", "GGVSPDB")
Data <- getNetCDF (fname, VarNames)
r1 <- setRange (Data$Time, 82800,83700)
r2 <- setRange (Data$Time, 91700,92800)
r <- c(r1, r2)
DataSR <- Data[r,]
SaveRData <- "CONTRASTcalAOA.Rdata.gz"
```

```
# comment one of these
save(DataSR, file=SaveRData, compress="gzip")
load(file=SaveRData)
Valid <- (DataSR$TASX > 100.)
DataV <- DataSR[Valid,]

@

<<fit, echo=FALSE, include=FALSE>>=

attach(DataSR)
Cradeg <- pi / 180.
DataSR["Mach"] <- MachNumber (PSF, QCF)           # uses uncorrected measurements for q, p
#AOAREF <- PITCH - asin(VSPD/TASX) / Cradeg
DataSR["AOAREF"] <- PITCH - asin(GGVSPDB/TASX) / Cradeg
DataSR["AQR"] <- ADIFR/QCF                          # basic pressure ratio for AOA
DataSR["AQRM"] <- DataSR$AQR*DataSR$Mach
fit <- lm(AOAREF~AQR+AQRM, data=DataSR)        # linear model fit
cfit <- coefficients (fit)
detach(DataSR)

@


\section*{Determining the Sensitivity Coefficients}

The fit procedure is to determine the coefficients \{$c_{i}$\} in
the following equation that provide a best fit to $\alpha^{*}$ as
given by (\ref{eq:alphaWithwZero}):

\begin{equation}
\mathrm{AKRD}=c_{0}+\frac{\{\mathrm{ADIFR}\}}{\{\mathrm{QCXC}\}}\left(c_{1}+c_{2}\mathrm{\
{MACHX\}}\right)\label{eq:AKRDeq}
\end{equation}
The ``standard'' representation of angle of attack as described
in the document on processing algorithms (cf.~\href{https://drive.google.com/file/d/0B1kIUH45ca5ATFV5d3QyQ0JpSjA/view?
usp=sharing}{this link})
is this equation with coefficients \{$c_{0},\, c_{1},\, c_{2}$\}
= \{$4.604$\,,[^{\circ}]$, 18.67$\,,[^{\circ}]$, 6.49$\,,[^{\circ}]$\}.
However, this clearly did not provide a good fit to the CONTRAST measurements.
A good example of the need for revised coefficients comes from the
only speed runs I found in the CONTRAST flights, those from RF08 8:28:00--8:37:00
(about 19,000 ft altitude) and 9:17:00--9:26:00. A fit of (\ref{eq:AKRDeq}
to these measurements, summarized below and shown in Fig.~\ref{fig:SpeedRunPlot},
resulted in coefficients \{\Sexpr{cfit[1]}, \Sexpr{cfit[2]}, \Sexpr{cfit[3]}\},
a fit significantly different from the standard.

<<SpeedRunPlot,fig.cap="Data from the two speed runs from CONTRAST flight RF08, plotted as predicted vs.~fit angle-of-
attack for individual 1-s measurements. The dashed orange line shows the result expected for the fit to these
measurements.",fig.width=6, fig.height=5,echo=FALSE>>=

summary(fit)
DataSR["A1"] <- cfit[1]+cfit[2]*DataSR$AQR+cfit[2]*DataSR$AQRM
DataSR["A2"] <- 4.604+18.67*DataSR$AQR+6.49*DataSR$AQRM    # "standard"
#plot (DataSR$AOAREF, DataSR$A1, pch=16, cex=0.8, col='blue', xlab="Ref. AOA", ylab="fit AOA")
#lines (c(-3.,6.), c(-3.,6.), lty=2, lwd=3, col='darkorange')
clr <- c("Standard Fit","New Fit")
col <- c("darkgreen","darkorange")
g <- ggplot(data=DataSR,aes(x=AOAREF))
#g <- g + geom_point(aes(y=A2), colour="darkgreen", pch=19)
g <- g + geom_point(aes(y=A1), colour="blue", pch=19)
g <- g + xlab (expression(paste("Predicted AOA [", degree, "]")))
g <- g + ylab (expression(paste("AOA from fit [",degree,"]")))
g <- g + geom_line(aes(y=AOAREF), colour="darkorange", lwd=2, linetype=2)
g <- g + theme_WAC ()
g

@
\begin{center}
\textsf{\textcolor{blue}{-- End of Memo --}}
\par\end{center}
\vfill\eject


\section*{Instructions for re-use of the program that generated this memo}

In the first ``chunk'' labelled ``initialization'', change the
project and flight number and set the times of speed runs to include.
Alternately, it is possible to do this calculation on any period of
a flight, or the entire flight, or to merge additional flights into
```

the data set before fitting. The program runs under RStudio on tikal,
accessible via \href{http://tikal.eol.ucar.edu}{this link}. Copy
the file referenced in the header of this memo to your work space
and, once loaded into RStudio, run via the ``Compile PDF'' button.

Reproducibility:

\begin{tabular}{ll}
\textsf{\textsc{\textcolor{blue}{Project:}}} &
CONTRAST cal AOA\tabularnewline
\textsf{\textsc{\textcolor{blue}{Archive package:}}} &
CONTRASTcalAOA.zip\tabularnewline
\textsf{\textsc{\textcolor{blue}{Contains:}}} &
attachment list below\tabularnewline
\textsf{\textsc{\textcolor{blue}{Program:}}} &
/h/eol/cooperw/RStudio/Reprocessing/CONTRASTcalAOA.Rnw\tabularnewline
\textsf{\textsc{\textcolor{blue}{Original Data:}}} &
/scr/raf_data/CONTRAST/CONTRASTrf08.nc \tabularnewline
\textsf{\textsc{\textcolor{blue}{Archive:}}} &
git://github.com:WilliamCooper/RSessions.git
\tabularnewline
\end{tabular}

%\attach{attachment}

\attachm{ProgramFile listed above\\CONTRASTcalAOA.pdf\\\Sexpr{SaveRData}\\SessionInfo}

%\cc{first attachment\\second\\3rd att}

%\attach{attachment}

%\attachm{first\\second}
%\cc{first attachment\\second\\3rd att}

<<save-system-info, echo=FALSE>>=

cat (toLatex(sessionInfo()), file="SessionInfo")

@
<<make-zip-archive, echo=TRUE, INCLUDE=TRUE>>=

system ("zip CONTRASTcalAOA.zip CONTRASTcalAOA.Rnw CONTRASTcalAOA.pdf SessionInfo CONTRASTcalAOA.Rdata.gz")

@

\end{document}