APÊNDICE B

PROGRAMA KANTOR-DULANTO

```
;msg ñ implementado
;mapa foF2
;R<=M, M<=R, M<=M-R
; Estatística, histograma, std, média etc
; P41 maior do que +-1 ?
; procurar o File correspondente ao Plot que tenho do dia 120.

;#######################################
;# Prediccion01.pro                    #
;# Predição dos Coeficientes do GIM    #
;# Ivan J.Kantor - Miguel Dulanto      #
;# 01/05/02 - IDL 5.3   SJC INPE       #
;#######################################
;
; Programa lê 36 files de Coeficientes
; usa 30 para prever as próximas 6
; no. máximo = 36
; Lon = 73, Lat = 71 para mapa GIM
; etc
;

pro LeCoeficientes, Coef,Files,diretorio       ;--------------------------------------
;Subrotina para ler os coeficientes do Global Ionosphere Maps


; Armazenados da seguinte forma Coef[n,m]  n=grau m=ordem
;
;       |00 10 20 30 ..|        |0+0 1+1 2+2 3+3 ..|
; array |01 11 21 31 ..| = Coef |1-1 1+0 2+1 3+2 ..|
;       |02 12 22 32 ..|        |2-2 2-1 2+0 3+1 ..|
;       |03 13 23 33 ..|        |3-3 3-2 3-1 3+0 ..|
;       |...           |        |...               |
;
; array[i,j] = Coef[n,n-|m|]   m >= 0
;              Coef[n-|m|,n]   m <  0
;
; Coef[ n=i, m=i-j] = array[i,j]   i >= j
; Coef[ n=i-j, m=i]                i <  j
;          i = (m ge 0)? n:n+m
;          j = (m ge 0)? n-m:n
```

```
;vai armazenar 35 dias de 12 grupos de hora impar contendo 16x16 coeficientes
;Coef = dblarr(36,12,16,16)   ; 35x12x16x16 = 107.520 números

buffer = ''

Files = findfile(diretorio+'coe*.txt',count=NFile)
if NFile eq 0 then return        ; evitar file vazio
Files = Files(sort(Files))       ; ordena os files
;print,'Files,NFile', Files,NFile         ;
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
File = Files[0] ; le primeiro file de TEC, para obter número de coeficientes
openr,lun,File,/get_lun

comment='     ; recebe os dados de ordem e grau máximos do Polinômio de Legandre
while comment ne 'COMMENT / WA' do begin
        readf,lun,buffer
        comment = StrMid(buffer,0,12)
        if comment eq 'MAXIMUM DEGR' then reads,buffer,format="(49X,I4)",mMax
        ;está certo??
        if comment eq 'MAXIMUM ORDE' then reads,buffer,format="(49X,I4)",nMAx
        endwhile
close,lun & free_lun,lun

nm = (nMax+1)*(mMax+1)

;Le dados de TEC de cada File
for iFile=1,NFile do begin

        ;print, "processando file no. ",iFile    ; <<<<<<<<<<<<<<<<<<<<<<<<<
        File = Files[iFile-1]
        openr,lun,File,/get_lun

        comment='     ; posiciona a leitura

        for iHora=0,11 do begin
                comment='     ; posiciona a leitura
                while comment ne 'COEFFICIENTS' do begin
                        readf,lun,buffer
                        comment = StrMid(buffer,0,12)
                        ;help,comment          ;<<<<<<<<<<<<<<<<
                        endwhile
                readf,lun,buffer         ; pula titulo

                n=0 & m=0 & value=1.0d0 & rms=0.0d0
```

```
		for inm = 0,nm-1 do begin
			readf,lun,format='(I4,4X,I4,D18.8,D11.4)', n,m,value,rms
			;print, n,m,value,rms
			mm = abs(m)
			if (m ge 0) then Coef[iFile-1,iHora,n,n-mm]=value $
					else Coef[iFile-1,iHora,n-mm,n]=value
			endfor ; nm
		fim:

		;print,'Hora= ',iHora+1,' File= ',File
	endfor ; terminou leitura de um File de tec
	close,lun & free_lun,lun
		endfor
;print,'Terminou TODOS os Files'
;Leu todos os dados de TEC
;stop
end

pro LeFileGIM, TEC,File      ;--------------------------------------------------------------
; le primeiro file de TEC, para obter número de Lat e Lon

;NLon=73 & NLat=71

buffer = ''
A=0 & Mes=0 & D=0 & Hora=0 & M=0 & S=0.0
Lat=0.0 & Lon1=0.0 & Lon2=0.0 & DLon=0.0 & H=0.0
Lat1=0.0 & Lat2=0.0 & DLat=0.0

openr,lun1,File,/get_lun

comment=''     ; posiciona a leitura
while comment ne 'END OF HEADER' do begin
	readf,lun1,buffer
	comment = StrMid(buffer,60,13)
	if comment eq 'LAT1 / LAT2 /' then
reads,buffer,format="(2X,3F6.1)",Lat1,Lat2,DLat
	if comment eq 'LON1 / LON2 /' then
reads,buffer,format="(2X,3F6.1)",Lon1,Lon2,DLon
	endwhile

NLat=fix(abs((Lat2-Lat1)/DLat))+1 & NLon=fix(abs((Lon2-Lon1)/DLon))+1 ;&
Help,NLat,NLon
Lats = fltarr(NLat) & Lons=fltarr(NLon)
for i=1,NLat do Lats[i-1]=Lat1+DLat*(i-1)
for i=1,NLon do Lons[i-1]=Lon1+DLon*(i-1)
;print,'Lats=',Lats       ;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
```

```
T=fltarr(NLon) & TEC=fltarr(NLon,NLat,12)

close,lun1 & free_lun,lun1

openr,lun1,File,/get_lun

comment=''     ; posiciona a leitura
while comment ne 'END OF HEADER' do begin
	readf,lun1,buffer
	comment = StrMid(buffer,60,13)
	if comment eq 'LAT1 / LAT2 /' then
reads,buffer,format="(2X,3F6.1)",Lat1_,Lat2_,DLat_
	if comment eq 'LON1 / LON2 /' then
reads,buffer,format="(2X,3F6.1)",Lon1_,Lon2_,DLon_
	endwhile

if (Lat1_ ne Lat1)or(Lat2_ ne Lat2)or(DLat_ ne DLat) then stop,'latitudes diferentes'
if (Lon1_ ne Lon1)or(Lon2_ ne Lon2)or(DLon_ ne DLon) then stop,'longitudes
diferentes'

for iTempo=0,11 do begin
	readf,lun1,buffer	; pula header
	readf,lun1,format="(5I6,F6.0)", A,Mes,D,Hora,M,S
	for iLat=0,NLat-1 do begin
		readf,lun1,format="(2X,5F6.1)", Lat,Lon1,Lon2,DLon,H
		;print,"iLat=",iLat," Lat=",Lat," hora=",Hora," Tempo=",iTempo*2+1
	;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
		readf,lun1,format="(16I5)", T
		TEC[*,iLat,iTempo]=T
		;print,T		; TESTE
<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
		endfor
	readf,lun1,buffer	; pula header final
	endfor
close,lun1 & free_lun,lun1
end

Function PLgndr, n,m,x	;--------------------------------------
;Numerical Recipes

;x=findgen(101)/50-1 & plot,x,PLgndr(2,0,x)	;	teste
;if((m lt 0)or(m gt n)or(abs(x)gt 1.)) then stop,'bad arguments'
Pmm=0.0*x+1.d0	;truque para manter o array mesma dimensão de x
if m gt 0 then begin
```

```
        somx2 = sqrt((1.-x)*(1.+x))
        fact=1

        for i=1,m do begin
                ;Pmm = -Pmm*fact*somx2   ;MENOS???
                Pmm = Pmm*fact*somx2
                fact = fact + 2
                endfor
        endif
if n eq m then PLgndr = Pmm $
else begin
        PmmP1 =x*(2*m+1)*Pmm
        if n eq (m+1) then PLgndr = PmmP1 $
        else begin
                for nn=m+2,n do begin
                        Pnn = (x*(2*nn-1)*PmmP1-(nn+m-1)*Pmm)/(nn-m)
                        Pmm = PmmP1
                        PmmP1 = Pnn
                        endfor
                PLgndr = Pnn
                endelse
        endelse
return, PLgndr
end

Function PLgndrArfken, n,m,x,OK   ;---------------------------------------
sqrt1_x2 = sqrt(1.-x*x)
case 1 of       ;1=true
(n eq 1)and(m eq 1): P = sqrt1_x2                                       ;P11
(n eq 2)and(m eq 1): P = 3.*x*sqrt1_x2                                  ;P21
(n eq 2)and(m eq 2): P = 3.*(1-x*x)                                     ;P22
(n eq 3)and(m eq 1): P = (3./2.)*(5.*x*x-1.)*sqrt1_x2       ;P31
(n eq 3)and(m eq 2): P = 15.*x*(1.-x*x)             ;P32
(n eq 3)and(m eq 3): P = 15.*sqrt1_x2^3             ;P33
else: P=x
endcase
return, P
end

pro     GIM,E,Lon,Lat,info,Coef,modo       ;-------------------------------------
;Coef -> GIM
;modo=['calculate GIM','GIM grau fixo','GIM ordem fixa']

help,Coef
NLat=71 & Lat=findgen(NLat)*(-2.5)+87.5          ; talvez possa eliminar
<<<<<<<<<<<<<<<
```

```
NLon=73 & Lon=findgen(NLon)*5-180.
UT = info.iHora*2 + 01         ; Hora Universal (UT)
beta = double(Lat)*!DtoR
if info.SunEarth eq 1 then s=double(Lon+UT*15.-180.)*!DtoR $  ;earth-fixed
                                        else s=double(Lon)*!DtoR
        ;sun-fixed
E = dblarr(NLon,Nlat)          ; já vez zerada

for i=0,15 do begin
        for j=0,15 do begin
                help,i,j
                coef_nm = Coef[i,j]
                n = (i ge j)? i:j
                m = i-j
                ;help,n,m        ;<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<
                mm=abs(m)
                if modo ne 'calculate GIM' then begin
                        if (modo eq 'GIM grau fixo')and(n ne info.Grau) then goto,fim
                        if (modo eq 'GIM ordem fixa')and(mm ne info.Ordem) then
goto,fim
                        endif
                delta_0m = (0 eq m)?1:0        ; if(m=0)then 1 else 0
                lambda_nm=sqrt(factorial(n-mm)*(2*n+1)*(2-
delta_0m)/factorial(n+mm))

                ;goto, pula1
                ;aPLgndr = ((n eq 0)and(m eq
0))?(0.0*beta+1):lambda_nm*PLgndr(n,mm,sin(beta))
                aPLgndr = lambda_nm*PLgndr(n,mm,sin(beta))
                ;help, aPLgndr
                cossin_ms = (m ge 0)? cos(mm*s):sin(mm*s)
                Enm = aPLgndr*coef_nm##cossin_ms
                E = E + Enm
                ;help,E
                pula1:

                goto, pula2
                for iLat=0,70 do begin
                        aPLgndr = lambda_nm*PLgndr(n,mm,sin(beta[iLat]))
                        for iLon=0,72 do begin
                                cossin_ms = (m ge 0)? cos(mm*s[iLon]):sin(mm*s[iLon])
                                E[iLon,iLat] = E[iLOn,iLat] + aPLgndr*value*cossin_ms
                                endfor
                        endfor
                pula2:
```

```
                ;surface, E,Lon,Lat
                ;contour, E,Lon,Lat, NLevels=10,/fill,/overplot
                ;contour, E,Lon,Lat;, NLevels=10,/fill,/overplot      ; animação
                ;if ((n eq 15)and(m eq -15)) then goto,fim
                ;endwhile
                fim:
                endfor
        endfor
end

pro PlotGIM, E,Lon,Lat        ;--------------------------------------
;Plot GIM map

;loadct,33

MAP_SET,/mercator,/Grid,LONDEL=30,LATDEL=15;>>>>>>>>>mdc

contour, E,Lon,Lat, Levels=indgen(16)*10,/fill,/overplot
;contour, E,Lon,Lat, Levels=indgen(16)*10,/overplot                    ;coloca as
linhas
for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,10), 30*j+50,20 ; tabela de cores
;TEK_COLOR
;32 colors. Index 0=black,1=white,2=red,3=green,4=blue,5=cyan,6=magenta,8=orange
etc.
;!P.Color=0
;!P.BackGround=1; linhas pretas em fundo branco
contour, E,Lon,Lat, Levels=indgen(16)*10,/overplot,color=1,XRANGE=[-
180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
,yGRIDSTYLE=1,yTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
map_continents, color=0,/Grid,LONDEL=30,LATDEL=15;>>>>>>>>>>mdc
plots,[50,30*15+50],[20,20],color=1,/device
plots,[50,30*15+50],[20+10,20+10],color=1,/device
for j=0,15 do plots,[30*j+50,30*j+50],[20,20+10],color=1,/device
for j=0,15 do xyouts, 30*j+5,8, j*10 ,color=1,/device
return
end


pro PlotGIM_BW, E,Lon,Lat          ;--------------------------------------
;Plot GIM map B&W

MAP_SET,/mercator,/Grid,LONDEL=30,LATDEL=15;>>>mdc


;contour, E,Lon,Lat, Levels=indgen(16)*10,/fill,/overplot
```

```
contour, E,Lon,Lat, Levels=indgen(16)*10,/overplot
;for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,10), 30*j+50,20 ; tabela de cores
;TEK_COLOR
;32 colors. Index 0=black,1=white,2=red,3=green,4=blue,5=cyan,6=magenta,8=orange
etc.
;!P.Color=0 & !P.BackGround=1; linhas pretas em fundo branco
contour, E,Lon,Lat, Levels=indgen(16)*10,/overplot
map_continents
return
end


pro calculate_plot_Default,info         ;--------------------------------
n=info.Grau
m=info.Sinal*info.Ordem
i = (m ge 0)? n:n+m
j = (m ge 0)? n-m:n
case info.plotDefault of
'Coef(dias)': begin
        plot,info.Coef[*,info.iHora,i,j],title='Coeficiente'+string(n)+string(m),xtitle='dia
s'
        end
'Coef(horas)': begin
        tempo = indgen(12)*2+1
        plot,tempo,info.Coef[info.iFile,*,i,j],title='Coeficiente'+string(n)+string(m),xtitle
='horas'
        end
'Coef(tempo)': begin
        x = info.Coef[0,*,i,j]
        for iFile=1,35 do x=[x,info.Coef[iFile,*,i,j]]
        plot,x,title='Coeficiente'+string(n)+string(m),xtitle='horas + dias'
        end
'correlação': begin
        x =info.Coef[*,info.iHora,i,j] & help,x         ; veja a dimensao
        lag = indgen(30)
        c = fltarr(30)
        for i=0,29 do c[i] = a_correlate(x,lag[i])
        plot,lag,c,title='Coeficiente'+string(n)+string(m)
        plots,[0,30],[0,0]
        end
'Espectro': begin
        espectro = abs(FFT(info.Coef[*,info.iHora,i,j]))
        plot,espectro[1:*],title='Coeficiente'+string(n)+string(m)
        end
'Plot Pnm(x)': begin
        x = (findgen(201)-100.)/100.
```

```
        plot,x,PLgndr(n,m,x),title='P'+string(n)+string(m),xtitle='x'
        oplot,x,PLgndrArfken(n,m,x,1),color=2,linestyle=2
        end
'Plot Pnm(senB)': begin
        B = findgen(181)-90.
        plot,B,PLgndr(n,m,sin(B*!DtoR)),title='P(senB)'+string(n)+string(m),xtitle='bet
a'
        end
else: print,'erro plot Default:',selecao
endcase
end

pro calculate_graphic_GIM,info,selecao      ;---------------------------------------
widget_control,/hourglass
GIM, E,Lon,Lat,info,reform(info.Coef[info.iFile,info.iHora,*,*]),selecao ;reform
elimina dimensão 1
info.GIM = E
contour, info.GIM,info.Lon,info.Lat, Levels=indgen(16)*10,/fill   ; default = contour
????????
;PlotGIM, E,Lon,Lat
end

pro calculate_graphic_Default,info   ;--------------------------------
;---------------------------------
; Coef[00:35] = Coef. dos Files
; Coef[36:41] = Preditos       Coefp(6,12,16,16)
; Coef[42:47] = Pred. - Medidos
; Coef[48]    = Coef(Hora)     CoeFile(12,16,16)
; Coef[49]    = GIM(Hora)      TEC(73,71,12)
; Coef[50]    = memory                 M(73,71)
;---------------------------------
widget_control,/hourglass
;info.Lon = Lon         ;<<<<<<<<<<<<<<<<<<<VAI DAR
ERRADO<<<<<<<<<<<<<<<<<<<<
;info.Lat = Lat
case 1 of
35 ge info.iFile: begin
        GIM, E,Lon,Lat,info,reform(info.Coef[info.iFile,info.iHora,*,*]),'calculate GIM'
        ;reform elimina dimensão 1
        info.GIM = E
        end
41 ge info.iFile: begin          ; precisa mudar: como varia o dia e a hora ??
        iP = info.iFile - 36     ; indice do File predito
        GIM, E,Lon,Lat,info,reform(info.Coefp[iP,info.iHora,*,*]),'calculate GIM'
        ;reform elimina dimensão 1
        info.GIM = E
```

```
        end
47 ge info.iFile: begin ; diferenças
        iP = info.iFile - 42      ; indice do File predito - medido
        DCoef = reform(info.Coefp[iP,info.iHora,*,*]) -
reform(info.Coef[iP+30,info.iHora,*,*])
        GIM, E,Lon,Lat,info,DCoef,'calculate GIM';reform elimina dimensão 1
        info.GIM = E
        end
48 eq info.iFile: begin
        GIM, E,Lon,Lat,info,reform(info.CoeFile[info.iHora,*,*]),'calculate GIM'
        ;reform elimina dimensão 1
        info.GIM = E
        end
49 eq info.iFile: info.GIM = reform(info.TEC[*,*,info.iHora])
50 eq info.iFile: info.GIM = info.M[*,*]
else:
endcase
case info.graphicDefault of
'Plot GIM':      PlotGIM, info.GIM,info.Lon,info.Lat
'Plot Contour B&W':  PlotGIM_BW, info.GIM,info.Lon,info.Lat
'surface': SURFACE, info.GIM,info.Lon,info.Lat
'shade': shade_surf, info.GIM,info.Lon,info.Lat
'trigrid':begin
        end
'shade 3grid': begin
        end
'polar equador': begin
        plot,/polar, [info.GIM[*,35],info.GIM[0,35]], [info.Lon,info.Lon[0]]*!DtoR
        plots,0,0, PSym=1
        end
'polar Greenwich': begin
        plot,/polar, info.GIM[36,*], info.Lat*!DtoR
        plots,0,0, PSym=4
        end
'contour': begin
        SunEarth = ['sun-fixed','earth-fixed']
        GeogrGeomag = ['geographic','geomagnetic']
        contour, info.GIM,info.Lon,info.Lat, Levels=indgen(16)*10,/fill $
                ,title='MAPA UTEC  ' + info.Horas[info.iHora]+':00 UT'+'
'+info.FilesCoef[info.iFile] $
                +'  ('+SunEarth[info.SunEarth]+' /
'+GeogrGeomag[info.GeogrGeomag]+')',xtitle='W
UTEC      E' $
                ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
            ,yGRIDSTYLE=1,yTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
```

```
        for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
        plots,[70,680],[240,240],color=0,/device
        plots,[375,375],[40,440],color=0,/device
        plots,[150,30*15+150],[15,15],color=0,/device
        plots,[150,30*15+150],[15+8,15+8],color=0,/device
   for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
  for j=0,15 do xyouts,100+ 30*j+5,2, j*10 ,color=0,/device
return

        end
'estatistica': begin
        ;plot,histogram(info.GIM)
        data = info.GIM
        hist = HISTOGRAM(data)
        bins = FINDGEN(N_ELEMENTS(hist)) + MIN(data)
        ;PRINT, MIN(hist)
        ;PRINT, bins
        PLOT, bins, hist, YRANGE = [MIN(hist)-1, MAX(hist)+1], PSYM = 10, $
          XTITLE = 'TECU', YTITLE = 'Histograma'
        momento = moment(data,sdev=sdev,mdev=mdev)
        media = string(momento[0])
        varianca = string(momento[1])
        mdev = string(mdev)
        sdev = string(sdev)
        maxGim = string(max(data))
        minGIM = string(min(data))
        x=400 & y=400 & dy=-20
        xyouts,[x,x,x,x,x,x],[y,y+dy,y+2*dy,y+3*dy,y+4*dy,y+5*dy], $
                ['media'+media,'mean
abs.dev'+mdev,'variança'+varianca,'stdv'+sdev,'max'+maxGIM,'min'+minGIM],/device
        end
'subtrai GIM':
else: print,'erro plot Default:',selecao
endcase
end

pro MEM, G,mm,x,n,P         ;---------------------------------------
;Maximum Entropy Method
;Prediction Error Filter - Burg


G=fltarr(128) & EB=fltarr(128) & EF=fltarr(128) & GG=fltarr(128)
; n is limited to 128
;P=0.0 & for j=1,n do begin P=P+x[j]*x[j] & P=P/n
P=0.0 & for j=1,n do P=P+x[j-1]*x[j-1] & P=P/n & P0=P
print,format="(' M=  0',17X,' P=',E14.6)",P
```

```
;G[1]=1.0 & m=1 & EB[1]=x[1] & EF[n-1]=x[n]
G[1]=1.0 & m=1 & EB[1]=x[0] & EF[n-1]=x[n-1]
for j=2,n-1 do begin
;       EB[j] = x[j]
;       EF[j-1]=x[j]
        EB[j] = x[j-1]
        EF[j-1]=x[j-1]
        endfor
goto, IN

LOOP:
m = m + 1
G[m]=R & for j=1,m do GG[j]=G[j]
for j=1,n-m do begin
        EB[j] = EB[j]   + R*EF[j]
        EF[j] = EF[j+1] + R*EB[j+1]
        endfor

IN:
Nom=0.0 & Den=0.0
for j=1,n-m do begin
        Nom = Nom + EB[j]*EF[j]
        Den = Den + EB[j]*EB[j] + EF[j]*EF[j]
        endfor
R=-2.*Nom/Den & P=P*(1.-R*R)
FPE = (n+m+1)*P*P/(n-(m+1))
print,format="(' M=',I3,' R=',E14.6,' P=',E14.6,' P%=',F8.3,'
FPE=',E14.6)",m,R,P,100.*P/P0,FPE
if (m eq 1) then goto, LOOP
for j=2,m do G[j]=GG[j]+R*GG[m-j+2]
if (m lt mm) then goto,LOOP
G[m+1] = R
return
end

pro Serie_Predita_MEM, xp,x          ;---------------------------------------------
n=36 & t=findgen(n)
nn=30 & m=nn/2
MEM, G,m,x[0:nn-1],nn,P     ; pega só os 30 pontos iniciais

;Print,' P=',P
;print,'G=',G

; Prediccion x=série; xp=x predito a partir de nn+1
ggg=-G[1:m+1] ;& print,ggg
xp=fltarr(n) & xp[0:nn-1]=x[0:nn-1]
```

```
for i=nn,n-1 do begin
        xp[i]=0.0
        for j=1,m do xp[i]=xp[i]+ggg[j]*x[i-j]
        endfor
;plot,t,x
;oplot,t[nn-1:n-1],xp[nn-1:n-1],color=2
xp = xp[nn:n-1]         ;toma só a parte predita
end

pro Prediccion01        ; ---------------------------------------------------------------------
; Lê os coeficientes do GIM, prepara a tela
set_plot,'WIN'
device,decompose=0
NOut=0          ; contador de Output Files
;TEK_color
;32 colors. Index 0=black,1=white,2=red,3=green,4=blue,5=cyan,6=magenta,8=orange
etc.
LoadCT,33
TVLCT,[0B,255B,255B,0B],[0B,255B,0B,0B],[0B,255B,0B,255B]        ;
[preto,branco,vermelho,azul]
!P.Color=0 & !P.BackGround=1      ; linhas pretas em fundo branco

;LEITURA DOS COEFICIENTES
Coef = dblarr(36,12,16,16)    ; 35x12x16x16 = 107.520 números
;File = 'D:/gps/Miguel/dadosTEC/Cod11475.ion'
;File = 'D:/gps/Miguel/dadosTEC/example.ion'
;diretorio='' & diretorio_D='c:\Miguel\CoefGIM\'
diretorio='' & diretorio_D='c:\Miguel\CoefGIM\'
File = findfile(diretorio_D+'Coeficientes.ini',count=NFile) & help,NFile & print,File
        ;<<<<<<<<<
if NFile eq 1 then begin        ; Já existe a Tabela de Coeficientes
        openr,lun,File[0],/get_lun
        readu,lun,Coef
        close,lun & free_lun,lun
        Files = findfile(diretorio_D+'coe*.txt',count=NFile)
        if NFile eq 0 then return       ; evitar file vazio
        Files = Files(sort(Files))      ; ordena os files
end else begin ; Não existe a Tabela dos Coeficientes, precisa lê-los
        read,PROMPT='Diretorio('+diretorio_D+'):',diretorio
                if(diretorio eq '') then diretorio=diretorio_D
        LeCoeficientes, Coef,Files,diretorio ;Le os coeficientes GIM nos files do
diretorio
        gravaCoef = dialog_message('Grava os Coeficientes ?',/question)
        if gravaCoef eq 'Yes' then begin
                openw,lun,diretorio+'Coeficientes.ini',/get_lun
                writeu,lun,Coef
```

```
                close,lun & free_lun,lun
                endif
endelse

FilesCoef = strarr(36+6+6+3)
FilesCoef[0:35]  = strmid(Files,10,/reverse)
FilesCoef[36:41] = 'Pred'+strmid(FilesCoef[30:35],3,4)
FilesCoef[42:47] = 'D-'+strmid(FilesCoef[30:35],3,4)
FilesCoef[48:50] = ['Coef(Hora)','GIM(Hora)','memory']
Horas = ['01','03','05','07','09','11','13','15','17','19','21','23']

descricao = [ $
        '1\Lê Files','0\File Coef','2\File GIM', $
        '1\Plot','0\Coef(dias)','0\Coef(horas)','0\Coef(tempo)','0\correlação','0\Espectro', $
        '4\Plot Pnm(x)','2\Plot Pnm(senB)', $
        '1\Calculate Coef','0\calculate GIM','0\GIM grau fixo','0\GIM ordem fixa','4\M
<= R','0\M = M - R','0\M = - M','4\sun-fixed','0\earth-fixed','4\geogr.','2\geomag.', $
        '1\GIM','0\Plot GIM','0\Plot Contour B&W','0\surface', $
                '0\shade','0\trigrid','0\shade 3grid','0\contour','4\polar equador','0\polar
Greenwich','0\estatistica','2\subtrai GIM', $
        '1\Predicao Coef','0\Kalman','0\MEM','2\MinQua', $
        '1\Predicao GIM','0\Kalman_GIM','0\MEM_GIM','2\MinQua_GIM', $
        '1\Animação','0\24 horas','2\36 dias', $
        '1\Frequência','0\Mapa F2crit','0\Pred. F2crit 1d','3\atraso','0\1 MHz ','0\10
MHz','0\100 MHz','0\1 GHz','2\10 GHz',$
        '1\Output','0\print
tela','0\annotate','0\coeficientes','0\Coef(File,H)','2\GIM(File,H)', $
        '1\Sair','0\teste','2\sair']
base0 = widget_base(/col,MBar=bar,title='GPS Predicción')
menu0 = cw_PDMenu(bar,descricao,/MBar,/return_name,uvalue='menu0')
base = widget_base(base0,/column)
;texto = widget_text(base,value='Stations.txt')
base1 = widget_base(base,/column)
        base10 = widget_base(base1,/row)
                iFile = widget_droplist(base10,value=FilesCoef,uvalue='file')
                        espaco = widget_label(base10,value='    ')
                hora = widget_droplist(base10,title='Hora',value=Horas,uvalue='hora')
                        espaco = widget_label(base10,value='      ')
                grau = widget_slider(base10,title='grau',max=15,value=0,uvalue='grau')
                        espaco = widget_label(base10,value='      ')
                maismenos =['+','-']
                sinal =
cw_bgroup(base10,maismenos,/row,/exclusive,/return_name,uvalue='sinal')
        ;label_top ??
                        widget_control,sinal,set_value=0
```

```
                w_ordem =
widget_slider(base10,title='ordem',max=15,value=0,uvalue='ordem')
                        espaco = widget_label(base10,value='        ')
                base11 = widget_base(base10,/column)
                        aviso1 = widget_label(base11,value='geogr./earth-fixed
')
                        aviso2 = widget_label(base11,value='output: predicaoNN.txt ou
gif        ')
        draw = widget_draw(base1,xsize=700,ysize=460)
NLat=71 & Lat=findgen(NLat)*(-2.5)+87.5
NLon=73 & Lon=findgen(NLon)*5-180.
widget_control,base0,set_uvalue = $
        {                               $
        ;texto:texto,    $
        FilesCoef:FilesCoef,  $
        iFile:0,          $
        Horas:Horas,  $
        iHora:0,                $
        Grau:0,                 $
        Ordem:0,                $
        w_ordem:w_ordem,   $
        Sinal:+1,               $       ; Sinal = +1 ou -1  [default=+1]
        Coef:Coef,              $       ; Coef = dblarr(36,12,16,16)  ; 35x12x16x16 =
107.520 números
        Coefp:dblarr(6,12,16,16),     $ Coef.preditos
        GIM:dblarr(73,71),    $       ; register
        M:dblarr(73,71),        $       ; memory
        Lon:Lon,                $
        Lat:Lat,                $
        TEC:fltarr(73,71,12),           $       ;TEC lido de file GIM
        CoeFile:dblarr(12,16,16),     $       ;Coef lido de file Coef
        SunEarth:1,             $       ; sun-fixed(0), earth-fixed(1=default)
        GeogrGeomag:0,        $       ; geographic(0=default. geomagnetic(1)
        plotDefault:'Coef(tempo)',    $       ; default para o plot
        graphicDefault:'contour',     $       ; default para o graphic
        DadosPredicao:'dados',                  $       ; default dados p/ graphic
        aviso1:aviso1, $
        aviso2:aviso2, $
        NOut:NOut}
widget_control,base0,/realize
erase,1
xmanager,'Prediccion01',base0,/no_block
end

pro Prediccion01_event, event         ; ----------------------------------------------------
widget_control,event.id,get_uvalue=selecao
```

```
if selecao eq 'menu0' then selecao=event.value
widget_control,event.top,get_uvalue=info
case selecao of
'File Coef': begin
        diretorio='c:\Miguel\CoefGIM\'
        ;diretorio='c:\gps\Miguel\DadosTEC\CoefDissertacao\'
        FileCoef = dialog_pickfile(path=diretorio,filter='*.txt',title='Diretório de
file.Coef:',/read)
        ;LeCoeficientes, Coef,Files,diretorio;Le os coeficientes GIM nos files do
diretorio
        ; AINDA NAO LE <<<<<<<<<<<<<<<<<<<
        end
'File GIM': begin
        diretorio = 'c:\Miguel\Jpl\'
        ;diretorio = 'd:\gps\Miguel\DadosTEC\'
        FileGIM = dialog_pickfile(path=diretorio,filter='*.txt',title='Diretório de
file.GIM:',/read)
        LeFileGIM, TEC,FileGIM
        help,TEC        ; Float [73,71,11]
        info.TEC = TEC/10.
        print,info.TEC;>>>>>>>>>>>>
        end
'file': begin
        info.iFile = event.index
        calculate_graphic_Default,info
        end
'hora': begin
        info.iHora = event.index
        calculate_graphic_Default,info
        end
'grau': begin
        info.Grau = event.value
        widget_control,info.w_ordem,set_slider_max=info.Grau
        if info.Ordem gt info.Grau then info.Ordem=info.Grau      ;caso |m|>n
        calculate_plot_Default,info
        end
'ordem': begin
        info.Ordem = event.value
        calculate_plot_Default,info
        end
'sinal': begin
        info.Sinal = (event.value eq '+')? +1:-1
        calculate_plot_Default,info
        end
'Coef(dias)':    begin & info.plotDefault=selecao & calculate_plot_Default,info & end
'Coef(horas)':  begin & info.plotDefault=selecao & calculate_plot_Default,info & end
```

```
'Coef(tempo)':          begin & info.plotDefault=selecao & calculate_plot_Default,info
& end
'correlação':   begin & info.plotDefault=selecao & calculate_plot_Default,info & end
'Espectro':     begin & info.plotDefault=selecao & calculate_plot_Default,info & end
'Plot Pnm(x)': begin & info.plotDefault=selecao & calculate_plot_Default,info & end
'Plot Pnm(senB)':begin & info.plotDefault=selecao & calculate_plot_Default,info & end
'calculate GIM': calculate_graphic_GIM,info,selecao
'GIM grau fixo': calculate_graphic_GIM,info,selecao
'GIM ordem fixa': calculate_graphic_GIM,info,selecao
'M <= R': info.M = info.GIM                     ; coloca o GIM na Memory
'M = M - R':info.M = info.M - info.GIM     ; subtrai o Registro da Memory
'M = - M': info.M = - info.M                    ; inverte o sinal da Memory
'sun-fixed': info.SunEarth = 0
'earth-fixed': info.SunEarth = 1
'geogr.': info.GeogrGeomag = 0
'geomag.': info.GeogrGeomag = 1
'Plot GIM':             begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'Plot Contour B&W':  begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'surface':                      begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'shade':                        begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'trigrid':                      begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'shade 3grid':          begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'polar equador':        begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'polar Greenwich':      begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'estatistica':          begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'contour':                      begin & info.graphicDefault = selecao &
calculate_graphic_Default,info & end
'24 horas': begin
        widget_control,/hourglass
        for iHora=0,11 do begin
                infoL = info
                infoL.iHora = iHora+1
                GIM, E,Lon,Lat,infoL,reform(info.Coef[info.iFile,iHora,*,*]),selecao
        ;reform elimina dimensão 1
                PlotGIM, E,Lon,Lat
                endfor
        end
```

```
'36 dias': begin
        widget_control,/hourglass
        for iFile=0,11 do begin
                GIM, E,Lon,Lat,info,reform(info.Coef[iFile,info.iHora,*,*]),selecao
        ;reform elimina dimensão 1
                PlotGIM, E,Lon,Lat
                endfor
        end
'subtrai GIM': begin
        GIM, E,Lon,Lat,info,reform(info.Coef[info.iFile,info.iHora,*,*]),selecao
        ;reform elimina dimensão 1
        E = info.GIM - E
        PlotGIM, E,Lon,Lat
        info.GIM = E
        end
'Kalman':
'MEM': begin
        n=info.Grau
        m=info.Sinal*info.Ordem
        i = (m ge 0)? n:n+m
        j = (m ge 0)? n-m:n
        help,i,j

        ;plot,info.Coef[*,info.iHora,i,j],title='Coeficiente'+string(n)+string(m)
        n=36 & t=findgen(n)
        x = info.Coef[*,info.iHora,i,j]

        ;print,'x',x & plot,t,x
        nn=30 & m=nn/2
        MEM, G,m,x[0:nn-1],nn,P     ; pega só os 30 pontos iniciais

        ;Print,' P=',P
        ;print,'G=',G

        ;plot,P/abs(complex(FFT(G)))^2
        ;y=fltarr(33) & y[0:15]=x & print,y & oplot,abs(FFT(y))
        ; Prediccion x=série; xp=x predito a partir de nn+1
        ggg=-G[1:m+1] & print,ggg
        xp=fltarr(n) & xp[0:nn-1]=x[0:nn-1]
        for i=nn,n-1 do begin
                xp[i]=0.0
                for j=1,m do xp[i]=xp[i]+ggg[j]*x[i-j]
                endfor
        plot,t,x,xtitle= 'Dias',xrange=[0,35],/xstyle,ytitle=
'UTEC',/ystyle,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=15 $
```

```
        ,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=35;mmmmmmmmm
mmm
        oplot,t[nn-1:n-1],xp[nn-1:n-1],color=2,psym=2
        end
'MinQua':
'Kalman_GIM':
'MEM_GIM': begin
        widget_control,/hourglass
        for iHora=0,11 do begin
                for i=0,15 do begin
                        for j=0,15 do begin
                                widget_control,info.aviso2,set_value='Hora
='+string(iHora*2+1)
                                x = info.Coef[*,iHora,i,j]
                                Serie_Predita_MEM, xp,x
                                info.Coefp[*,iHora,i,j] = xp
                                endfor; j
                        endfor; i
                endfor; iHora
        end
'Mapa F2crit':begin
  NT=info.GIM
  C=270;Verão=270,Outono=Primavera=240,Inverno=210
  R12=103.05;R12=SSN
  T=C*(1+0.005*R12);dado em Km
  NF=NT/1.125;NT(UT)=NF(UT)=aNF(max), a=0.1 USA,a=0.15, Usado a=0.125, NT
em UTEC=10^16e/m2
  NmF2=NF/T
  FoF2= sqrt(80.6*NmF2*10)
  Lon=info.Lon
  Lat=info.Lat
  contour,FoF2,Lon,Lat,Levels=indgen(16)*1,/fill,title='Frequencia critica F2 em MHz
' $
  + info.Horas[info.iHora] +':00 UT'+'  '+info.FilesCoef[info.iFile] $
  ,xtitle='W                                                    MHz       E' $
 ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
  ,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
        for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
        plots,[150,30*15+150],[15,15],color=0,/device
        plots,[150,30*15+150],[15+8,15+8],color=0,/device
   for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
 for j=0,15 do xyouts,100+ 30*j+5,2, j*1 ,color=0,/device
return

end
```

```
'Pred. F2crit':

'1 MHz ':begin
  Val=info.GIM
  A=Val*1.343
  Lon=info.Lon
  Lat=info.Lat
  contour,A,Lon,Lat,Levels=indgen(16)*13,/fill,title='Atraso em milisegundos de 1
MHz  ' $
  + info.Horas[info.iHora] +':00 UT'+'  '+info.FilesCoef[info.iFile] $
  ,xtitle='W                                                    miliseg      E' $
 ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
  ,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
        for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
        plots,[150,30*15+150],[15,15],color=0,/device
        plots,[150,30*15+150],[15+8,15+8],color=0,/device
   for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
 for j=0,15 do xyouts,100+ 30*j+5,2, j*13 ,color=0,/device
return

end
'10 MHz':begin
  Val=info.GIM
  A=Val*13.43
  Lon=info.Lon
  Lat=info.Lat
  contour,A,Lon,Lat,Levels=indgen(16)*100,/fill,title='Atraso em microsegundos de 10
MHz  ' $
  + info.Horas[info.iHora] +':00 UT'+'  '+info.FilesCoef[info.iFile] $
  ,xtitle='W                                                    microseg  E' $
 ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
  ,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
        for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
        plots,[150,30*15+150],[15,15],color=0,/device
        plots,[150,30*15+150],[15+8,15+8],color=0,/device
   for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
 for j=0,15 do xyouts,100+ 31*j+5,2, j*100 ,color=0,/device
return

end
'100 MHz':begin
  Val=info.GIM
```

```
   A=Val*0.1343
   Lon=info.Lon
   Lat=info.Lat
   contour,A,Lon,Lat,Levels=indgen(16)*1,/fill,title='Atraso em microsegundos de 100
MHz  ' $
   + info.Horas[info.iHora] +':00 UT'+'  '+info.FilesCoef[info.iFile] $
   ,xtitle='W                                                    microseg    E' $
  ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
   ,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
          for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
          plots,[150,30*15+150],[15,15],color=0,/device
          plots,[150,30*15+150],[15+8,15+8],color=0,/device
    for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
  for j=0,15 do xyouts,100+ 30*j+5,2, j*1 ,color=0,/device
return

end

'1 GHz':begin
   Val=info.GIM
   A=Val*1.343
   Lon=info.Lon
   Lat=info.Lat
   contour,A,Lon,Lat,Levels=indgen(16)*13,/fill,title='Atraso em nanosegundos de 1
GHz  ' $
   + info.Horas[info.iHora] +':00 UT'+'  '+info.FilesCoef[info.iFile] $
   ,xtitle='W                                                    nanoseg    E' $
  ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
   ,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
          for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
          plots,[150,30*15+150],[15,15],color=0,/device
          plots,[150,30*15+150],[15+8,15+8],color=0,/device
    for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
  for j=0,15 do xyouts,100+ 30*j+5,2, j*13 ,color=0,/device
return

end

'10 GHz':begin
   Val=info.GIM
   A=Val*13.43
   Lon=info.Lon
   Lat=info.Lat
```

```
  contour,A,Lon,Lat,Levels=indgen(16)*100,/fill,title='Atraso em picosegundos de 10
GHz  ' $
  + info.Horas[info.iHora] +':00 UT'+'  '+info.FilesCoef[info.iFile] $
  ,xtitle='W                                                    picoseg    E' $
 ,ytitle='LATITUDE',XRANGE=[-180,180],/XSTYLE,YRANGE=[-
90,90],/YSTYLE,XGRIDSTYLE=1,XTHICK=1.2,XTICKLEN=1,XTICKS=18 $
  ,YGRIDSTYLE=1,YTHICK=1.2,YTICKLEN=1,YTICKS=12;>>>mdc
        for j=0,14 do TV, replicate((!D.Table_Size/15)*j,30,8), 30*j+150,15
        plots,[150,30*15+150],[15,15],color=0,/device
        plots,[150,30*15+150],[15+8,15+8],color=0,/device
   for j=0,15 do plots,[30*j+150,30*j+150],[15,15+8],color=0,/device
 for j=0,15 do xyouts,100+ 30*j+5,2, j*100 ,color=0,/device
return

end


'print tela': begin
        info.NOut = info.NOut + 1
        OutFile = strcompress('predicao'+string(info.NOut)+'.gif')
        write_gif,OutFile,color_quan(TVRD(true=1),1,R,G,B,colors=32),R,G,B
        widget_control,info.aviso2,set_value='OUTPUT = '+OutFile
        end
'annotate': annotate
'coeficientes':  ; todos
'Coef(File,H)': begin
        if (info.iFile le 35)then begin
                info.NOut = info.NOut + 1
                OutFile = strcompress('predicao'+string(info.NOut)+'.txt')
                openw,lun,OutFile,/get_lun
                printf,lun,'File =',info.iFile,' Hora = ',info.Horas[info.iHora]
                for n=0,15 do begin             ;Grau
                        for mm=0,n do begin ;Ordem
                                m = +mm
                                        i = (m ge 0)? n:n+m
                                        j = (m ge 0)? n-m:n
                                        printf,lun,'n,m =
',n,m,info.Coef[info.iFile,info.iHora,i,j]
                                m = -mm
                                        i = (m ge 0)? n:n+m
                                        j = (m ge 0)? n-m:n
                                        printf,lun,'n,m =
',n,m,info.Coef[info.iFile,info.iHora,i,j]
                                        endfor & endfor
                close,lun & free_lun,lun
                widget_control,info.aviso2,set_value='OUTPUT = '+OutFile
```

```
                endif
        end
'GIM(File,H)': begin  ;         ; imprime tabela de GIM*10 números inteiros
        info.NOut = info.NOut + 1
        OutFile = strcompress('predicao'+string(info.NOut)+'.txt')
        openw,lun,OutFile,/get_lun
        printf,lun,'File =',info.iFile,' Hora = ',info.Horas[info.iHora]
        printf,lun,fix(info.GIM*10)
        close,lun & free_lun,lun
        widget_control,info.aviso2,set_value='OUTPUT = '+OutFile
        end
'teste': stop,'teste'
'sair':   widget_control,event.top,/destroy
endcase
if selecao ne 'sair'then begin
        F51='(F5.1)'
        SunEarth = ['sun-fixed','earth-fixed']
        GeogrGeomag = ['geographic','geomagnetic']
        widget_control,info.aviso1,set_value=SunEarth[info.SunEarth]+' /
'+GeogrGeomag[info.GeogrGeomag]
        widget_control,event.top,set_uvalue=info
        endif
end
```