Cyclone tracking of geopotential height fields

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The *procedure* for tracking cyclones of geopotential height fields using the cyclone tracking software (CTS) is identical to that for mean sea level pressure (MSLP). However differences arise in some of the cyclone finding and one of the cyclone tracking namelist parameters. The former are largely associated with the different physical units (metres compared with hPa) and the latter relates to the change of the steering parameter (fsteer) with height.

Following on from earlier work by Keable et al. (2002), Lim and Simmonds (2007) investigated the variation of CTS parameters with different geopotential height fields. These investigations focussed primarily on a grid resolution of 2.5 degrees i.e. reanalysis data. In their research Lim and Simmonds created cyclone instruction template files, each containing the specific parameters for a given level e.g. 850 hPa.

As an aid to easily specifying these parameters a utility called calcparams has been written. For usage type: `calcparams`

```
Usage: calcparams [-n nmlfile] plevel
   plevel: Pressure level in hPa [100,1000]
   nmlfile: Namelist file (namelist: nmcalcp)
   See: calcparams.nml for defaults
 Examples:
   (1) calcparams 750.
   (2) calcparams -n params.nml 500.
```

The default settings of the parameter table should be suitable for resolutions in the range 1.5-2.5 degrees. They are based on the work of Lim and Simmonds. The example namelist file calcparams.nml is equivalent to the data statements in the program:

```
&nmcalcp
 nlev=10
 p= 1000., 925., 850., 700., 600., 500., 400., 300., 200., 100.
 a= 0.09, 0.147, 0.126, 0.078, 0.042, 0., 0., 0., 0., 0.
 z= 110.5, 768.75, 1457., 3012., 4206., 5574., 7185., 9163., 11774., 15796.
 rd= 5., 5., 5.5, 5.5, 6., 6., 6., 6., 6., 6.
 fs= 2., 2., 1.9, 1.5, 1.2, 1., 1., 1., 1., 1.
 c1= 1.66, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7
 c2= 1.66, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7, 1.7
 cw= 5.60, 5.95, 5.95, 5.95, 5.95, 5.95, 5.95, 5.95, 5.95, 5.95
 r= 1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.58, 0.46, 0.34, 0.22
&end
```

See the comments in the program (data section) or in calcparams.nml for a description of these variables.

Note: For resolutions appreciably different from 2.5 degrees the user would probably test the values of these parameters. The namelist file option (-n) can then be used to set up a table in calcparams that is appropriate for this resolution.

For example:

```
calcparams 750
```

gives the screen output:

```
p:   750. alpha: 0.094 :zsmax:  3493.7 :zscr:  2693.7 :rdpgrd: 5.5
rhoa: 0.93 :cmncw: 5.95 :cmnc1: 1.70 :cmnc2: 1.70 :fsteer: 1.6
```

The program is intended to be used in a C-shell script conjunction with a template file.

The following is an excerpt from a cyclone finding script. Note: # indicates a comment; variables are preceded by $ when used but not when set; @ is a numeric set; \ is a command continutation. The UNIX command sed is used for text substitution. The variables lev, l and L are used for level purposes e.g. for 750 hPa the variables lev = 750, l = z750, L=Z750 are set.

```
# Use calcparams to set cyclone finding parameters
# Also update incycloc.cur dastrt,dastop parameters
# For MSLP use a simpler template
 if ($lev == mslp) then
   cat incycloc.erain.mslp.template | sed -e "s/DASTRT/$dastrt/" | sed -e
"s/DASTOP/$dastop/" | \
     sed -e "s/LEV/$L/" >! incycloc.$l.cur
 else  # Geopotential height
   set params = `calcparams $lev`
   set ftopeq = $params[4]
   set zsmax =  $params[6]
   set zscr =   $params[8]
   set rdpgrd = $params[10]
   set rhoa = $params[12]
   set cmncw = $params[14]
   set cmnc1 = $params[16]
   set cmnc2 = $params[18]
# set fsteer = $params[20] # Used in tracking stage
   cat incycloc.erain.z.template | sed -e "s/DASTRT/$dastrt/" | sed -e
"s/DASTOP/$dastop/" | \
     sed -e "s/ZSMAX/$zsmax/g" | sed -e "s/ZSCR1/$zscr/" | sed -e
"s/FTOPEQ/$ftopeq/" | sed -e "s/RDPGRD/$rdpgrd/" |  \
     sed -e "s/RHOA/$rhoa/g" | sed -e "s/CMNCW/$cmncw/" | sed -e
"s/CMNC1/$cmnc1/" | sed -e "s/CMNC2/$cmnc2/" |  \
     sed -e "s/LEV/$L/" >! incycloc.$l.cur
 endif
# Print instruction file on screen
 cat incycloc.$l.cur

# Use instruction file to control cyclocx
# i.e. cyclocx … -i incycloc.$l.cur …
```

The template file incycloc.erain.z.template is:

```
&nmltrangp ni=161, nj=161, hemis='G', rproj=60., dmode='YMDHM',
            rdiff=2.0, rdifz=2.0
 &end

 &nmlcycloc ddhmmn=000600, ddhmmx=000600,
            dastrt=DASTRT, dastop=DASTOP, hrstrt=0000, hrstop=1800,
            latmnc=-90., latmxc=90., iopmxc=2, istmxc=11, nshell=4, sdrmx=10.,
            drmx1=0.7, drmx2=0.3, itmx1=20, itmx2=20, diflt1=2.,diflt2=2.,
            cmnh=0.0, cmnc0=0.0, cmnc1=CMNC1, cmnc2=CMNC2, dpmn=0.1, swvmn=0.00,
            fccmn=5, cvarad=2.0, itabc2=2, itabc3=4, itabc4=1,
            nrddir=18, rdincr=0.5, sphtrg=.false.,
            rdpgrd=RDPGRD, npgdir=12, alatgv=8., rhoa=RHOA, upfact=1.,
            zsmax=ZSMAX, zscr1=ZSCR1, zscr2=ZSMAX, ftopeq=FTOPEQ,
            cmncw=CMNCW, dpmnw=-999., swvmnw=0.00,
            icendp=2,
 &end

# Level: LEV
```

The command:

```
   set params = `calcparams $lev`
```

sets the variable params to the output of calcparams where lev might be 750. So:

```
   set ftopeq = $params[4]
```

takes the fourth field of params (which is 0.094) and assigns this to the variable ftopeq i.e. params is:

```
p:   750. alpha: 0.094

1     p:
2     750.
3     alpha:
4     0.094
etc.
```

Hence for 750 hPa (lev = 750, l = z750, L=Z750) the generated instruction file (incycloc.z750.cur) is:

```
&nmltrangp ni=161, nj=161, hemis='G', rproj=60., dmode='YMDHM',
            rdiff=2.0, rdifz=2.0
 &end

 &nmlcycloc ddhmmn=000600, ddhmmx=000600,
            dastrt=961115, dastop=980115, hrstrt=0000, hrstop=1800,
            latmnc=-90., latmxc=90., iopmxc=2, istmxc=11, nshell=4,
sdrmx=10.,
            drmx1=0.7, drmx2=0.3, itmx1=20, itmx2=20, diflt1=2.,diflt2=2.,
            cmnh=0.0, cmnc0=0.0, cmnc1=1.70, cmnc2=1.70, dpmn=0.1,
swvmn=0.00,
            fccmn=5, cvarad=2.0, itabc2=2, itabc3=4, itabc4=1,
            nrddir=18, rdincr=0.5, sphtrg=.false.,
            rdpgrd=5.5, npgdir=12, alatgv=8., rhoa=0.93, upfact=1.,
            zsmax=3493.7, zscr1=2693.7, zscr2=3493.7, ftopeq=0.094,
            cmncw=5.95, dpmnw=-999., swvmnw=0.00,
            icendp=2,
 &end

# Level: Z750
```

Note: For convenience a separate template file was used for MSLP.
A similar method is used for the cyclone tracking stage where FSTEER in a track template is substituted by the variable fsteer.

This approach is particularly useful for tracking at a set of levels for subsequent input to the vertical tracing software (VTS).

References

Keable, M., I. Simmonds and K. Keay, 2002: Distribution and temporal variability of 500 hPa cyclone characteristics in the Southern Hemisphere. *International Journal of Climatology*, **22**,131-150.

Lim, E.-P., and I. Simmonds, 2007: Southern Hemisphere winter extratropical cyclone characteristics and vertical organization observed with the ERA-40 reanalysis data in 1979-2001. *Journal of Climate,* **20,** 2675-2690.