Chapter 7: INTERPF

Dave Gill
gill@ucar.edu

7.1 Purpose

- From p-level output to σ-level input
- Input: REGRID, RAWINS, little_r, INTERPB
- Widely ported, vanilla f90
- Linux support with RedHat and (PGI or Intel compilers)
- MAC OSX/xlf (must have UFS not HFS)

NCAR M^3

7.2 Procedure

- Input data
- Qv on p-levels for virtual temps
- Compute surface pressure
- Vertically interpolate variables to σ surfaces
  - u, v, RH: linear in p
  - θ: linear in *ln* p
  - Remove vertically-integrated mean divergence

NCAR M^3

7.2 Procedure

- Base state computations: p, ρ, T, Z
- Diagnose w from ω
- Re-interpolate u, v, T, Qv
- Balance – perturbation pressure

NCAR M^3

7.2 Procedure

- Accumulate output for LOWBDY file (SST, surface air temperature, snow, sea ice)
- Output outer rows/columns of data and tendencies for BDYOUT
- Output data for MMINPUT
- Output LOWBDY file

NCAR M^3

7.3 Surface Pressure

- All "x" symbols in this chapter's equations represent simple multiplication, not vector products
- Input on p-levels: T, Qv (from RH), Z, terrain elevation, and sea-level pressure
- Use estimated/extrapolated values of surface temp and sea-level temp to reduce diurnal variation (the "100-up" subscript)
- Diurnal average of surface temperature is an available option, suitable for use in areas of strong inversions

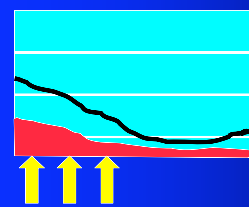
NCAR M^3

7.4 Vertical Interpolation

- First, p-level data to hydrostatic σ-level data
- σ-level data is bounded by p-levels, so no extrapolations
- $P_{ijk} = \sigma_k \, p^*_{ij} + P_{top}$
- All interpolations are linear, p or *ln* p
- Can have consecutive grid points with different trapping p-levels for bounds

NCAR M³

7.4 Vertical Interpolation



- Inconsistent levels with nearby points
- White: p-levels
- Black: s-level
- Red: terrain X-section
- Yellow arrows: consecutive grid points

NCAR M³

7.5 Mean Divergence

- Horizontal wind components on σ-levels
- Vertically-integrated mean divergence is the only initialization available
- Purpose: reduce spurious vertical motion introduced during objective analysis
- Effect: less “surprise” precip during first several time steps

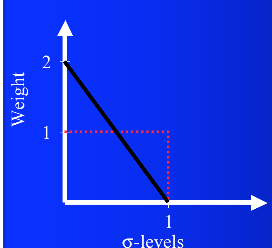
NCAR M³

7.5 Mean Divergence

- u and v coupled with p^*: PU_{ijk}, PV_{ijk}
- Vertically integrate: $U_{integ_{ij}}$, $V_{integ_{ij}}$
- Divergence of 2D wind field: DIV_{ij}
- Solve for velocity potential, Dirichlet BC, elliptic PDE using SOR
- Divergent component from partial of velocity potential: $U_{DIV_{ij}}$, $V_{DIV_{ij}}$
- Vertical weighting based on assumptions of observation data density
- Remove divergent component from total field

NCAR M³

7.5 Mean Divergence



- $w_k = 2 (1 - \sigma_k)$: Black line
- $w_k = 1$: red dashed line

NCAR M³

7.6 Base State

- Used to define the non-hydrostatic σ-levels
- Input: namelist constants + terrain elevation
- 2D Output: p^*
- 3D Output: p, T, Z, ρ
- REGRID regridder namelist: PTOP (Pa)
- INTERPF namelist: P0 (reference SLP, Pa), TLP (temp lapse rate, K), TS0 (reference sea-level temp, K), TISO (isothermal temperature in the stratosphere)

NCAR M³

7.6 Base State

- P0: 10^5 Pa
- TLP: 50 K
- TS0: not TOO sensitive, 270 K for winter-time at high latitudes, 290 K in the tropics
- TISO: optional, default is 0 K, profile gets no colder than TISO

NCAR M³

7.6 Base State

- Reference p* = f(elevation, constants)
- Reference 3D pressure
  $P_0 = p^*_0 \sigma_k + P_{top}$
- Reference 3D temperature
  $T_0 = T_{S0} + TLP \, ln \, (P_0 / P_{00})$
- Reference height, *fixed* at each (i,j,k)

NCAR M³

7.6 Base State - isothermal

- Reference temperature

$T_0 = MAX \, (T_0 , T_{ISO})$

- Reference pressure at isothermal base

$P_{ISO} = P_0 \exp \{ (T_{ISO} - T_{S0}) / T_{LP} \}$

- Reference height at isothermal base

Substitute P_{ISO} for P_0 in eqn 7.19

- Reference height in isothermal layer

$Z = Z_{ISO} - R/g \; T_{ISO} \; ln \, (P_0 / P_{ISO})$

NCAR M³

7.7 Initialization of Non-hydro

- p-levels to hydrostatic σ-levels
- Compute base state
- Interpolate linear in Z from the hydrostatic σ-levels to non-hydrostatic σ-levels
- $w = -\omega / (\rho \, g)$, where ω is from integrating the horizontal velocity divergence
- estimate p' at the lowest level, integrate Tv vertically to get p' at each level – this balance ensures no columnar vertical acceleration

NCAR M³

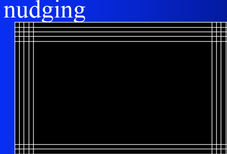
7.8 LOWBDY_DOMAIN*n*

- MMINPUT: contains 3D, 2D fields for initialization for MM5
- LOWBDY: either mean of SST and surface air temperature, or sequences of snapshot values for use in long-term simulations; has snow and sea ice info

NCAR M³

7.8 LOWBDY Cont'd

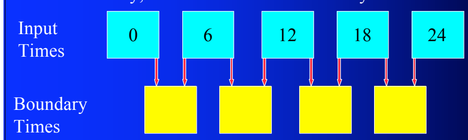
- BDYOUT_DOMAIN*n*: contains records of outer rows and columns of 3D fields used for lateral boundary conditions for large scale nudging



NCAR M³

7.8 LOWBDY Cont'd

- BDYOUT: contains *n*-1 time periods of boundary rows/columns of 3D fields nudged from large-scale analyses
- Composed of starting values and tendency terms, for each 3D array, for each of the four boundary side



NCAR M³

7.8 Substrate temperature

- mean T_{sfc} – either surface air temp from p-level analysis or the lowest σ-level data, used as the constant deep-soil temp when land-surface option is not selected
- SST – if the input field is the skin temperature, a daily mean is computed; otherwise a variable SST is available for a long-term simulation

NCAR M³

7.8 Substrate temperature

- Separate air and water temperatures aid in horizontal interpolation internal to the model ➔ reduces the fictitious coastal gradient
- Daily mean SSTs (if really skin temps) reduce the error from inland water bodies too small to be resolved in the temp field, but defined by the land use

NCAR M³

7.9 Cray, shell variables

- Similar to the other pre-processor job decks
- ExpName – MSS file location
- RetPd – how long (days) to keep these files
- Host – full rcp location of source, need to have both machines ~/.rhost files set-up
- ID – domain # of this data set (usually 1)
- OutIEEE – 32 bit, big endian IEEE output for compatibility with workstations and PCs

NCAR M³

7.9 Cray, shell variables

- InData – the analysis file name from REGRID, RAWINS, or little_r; on a Cray this is the MSS location
- UseMySource – *IF* you have a personal copy of the source code, and *IF* you know what you are doing, then good luck (in case of failure, no whining allowed)

NCAR M³

7.10 Parameter Statements

- There are no parameter statements that are used to dimension the horizontal or vertical extent of arrays. There are maximal values to dimension the array of pointers to arrays, but for model input, those should be large enough.

NCAR M³

7.11 namelist.input File

- All of the run-time decisions for INTERPF are handled through a NAMELIST file, namelist.input.
- Must be named “namelist.input” and must reside in the working directory.
- Date information needs to be completed, everything else has a *reasonable* default

NCAR M^3

7.11 namelist.input record0

- input_file: character string with the name of the p-level input file
- Can include directory information
- Every record in the namelist.input file must end with a / character
- F90 namelist character strings are enclosed in single or double quotes

NCAR M^3

7.11 namelist.input record1

- start_year: 4-digit integer
- start_month: int, 2-digit month (01 to 12)
- start_day: int, 2-digit day (01 to 31)
- start_hour: int, 2-digit UTC hour (00 to 23)
- interval: integer time in seconds between analysis periods
- less_than_24h: logical T/F, force < 24 h in computing daily temp means

NCAR M^3

7.11 namelist.input record2

- sigma_f_bu: *f* is *full* levels, *bu* is *bottom-up*; an array of reals from 1.0 to 0.0 that are strictly monotonically decreasing; leave the 6 or so boundary layer values alone; there will always be one more value in this list than the value provided to MM5 as KMAX
- Output from all σ-level programs is *top-down*.
- Combining *top-down* and *bottom-up* is mooning in a convertible.

NCAR M^3

7.11 namelist.input record2

- ptop: real, the top pressure level (Pa) to be used in the analysis, and the same number used in computing the p^* arrays; this may be physically lower (greater) than the number provided in the regridder namelist.input file
- This permits multiple input data sets to generate a single forecast file, even if different large-scale forecast input sets had different top pressures

NCAR M^3

7.11 namelist.input record2

isfc: integer – basically how many σ-levels to modify with the lowest level p-level analsyis;

- isfc = 0: standard vertical interpolation
- isfc = 1: standard interpolation, but lowest σ -level gets the surface analysis
- isfc = *n*: lowest *n* σ-levels use the surface analsyis in the vertical interpolation

NCAR M^3

7.11 namelist.input record3

- Base state constants
- P0 – 10^5 Pa, reference sea-level pressure
- TLP – 50 K, temp difference between sea-level and 1/e of the depth of the model atmosphere (about 1000 to 300 mb)
- TS0 – reference sea-level temperature: 270 to 300 K, depending on location and season
- TISO – stratospheric isothermal temp, K

NCAR M³

7.11 namelist.input record4

- Seldom changed processing options
- removediv: T/F flag to remove the integrated mean divergence
- usesfc: T/F flag to use the input surface layer fields (T), or to vertically interpolate the isobaric fields to the surface (F); useful when the input surface analysis is questionable (regridder generates missing surface fields)
- wrth2o: T/F flag, saturation is computed wrt liquid (T) or ice (F)
- psfc_method: 0 ➔ 100 mb up; 1 ➔ surface temp

NCAR M³

7.11 namelist.input record5

- ifdatim, integer, number of time periods to have output in the MMINPUT file; unless analysis nudging is expected ifdatim=1 is adequate
- If all time periods are required in the output file, the magic flag then becomes: ifdatim=-1

NCAR M³

7.12 How to run INTERPF

Get the source from the NCAR anonymous ftp site maintained by MesoUser

ftp://ftp.ucar.edu/mesouser/MM5V3/INTERPF.TAR.gz

NCAR M³

7.12 How to run INTERPF

- Unzip and untar the file; an INTERPF directory will be created
- For a number of platforms, simply type "make" ("make intel" to get the ifort compiler) to build the executable; for unsupported machines, the Makefile will need to be modified to include compiler and loader options

NCAR M³

7.12 How to run INTERPF

- Edit the namelist.input file, particularly pay attention to the input file name and the processing dates
- Run the executable and re-direct the standard out to a file

```
interpf >&! foo
```

- The file naming convention foo is not required, but desirable and therefore highly recommended

NCAR M³

7.12 How to run INTERPF

- Upon successful completion of this most excellent program, the gentle user should find safely snuggled away in the working directory, three new files; these being:

MMINPUT_DOMAIN*n*

LOWBDY_DOMAIN*n*

BDYOUT_DOMAIN*n*

NCAR M³

7.13 What Went Wrong?

- I have no idea, so don't send me email!
- Most INTERPF errors that don't end with a seg fault have informative error messages – PLEASE USE THEM
- Check on STOP 99999, though this is necessary but not sufficient
- Relaxation did not converge: REMOVEDIV, modify relax.F (MM=20000), is this idealized

NCAR M³

7.13 What Went Wrong

- There are *n*-1 boundary time periods in an *n*-time analysis file
- THIS MEANS YOU NEED AT LEAST TWO (2), II (COUNT'EM), DEUX TIME PERIODS TO RUN INTERPF
- Out of order interpolation is usually indicative of poorly chosen σ-levels

NCAR M³

7. interpf

-33-

NCAR M³