Pre-Processing: chgres_cube

UFS MRW App Training

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5 November 2020

MRW App Pre-Processing Summary

- The MRW App provides options to run with the following predefined global grids:
  - C96 (~100 km), C192 (~50 km), C384 (~25 km), and C768 (~13 km)
- Orography, landmask, and a number of other climo surface fields are pre-generated for each of the predefined global grids
  - These files are sourced by the CIME workflow in the MRW App for supported platforms, or downloaded automatically from the EMC FTP site for unsupported platforms
- Chgres_cube constitutes the only pre-processing component that the user needs to configure and run

Overview of chgres_cube

- For those familiar with WRF, chgres_cube can be thought of as a combination of the “ungrib”, “metgrid”, and “real” executables
- Built around Earth System Modeling Framework (ESMF) and based on an older NCEP spectral GFS pre-processor (“global_chgres”)
- Reads in global external model (atmospheric and surface) data from several GFS-based files
- Interpolates external model data variables to the target grid for initialization of the FV3
- Writes out NetCDF files separately for each tile for surface and atmospheric fields that are read in by the FV3 executable

The UFS_UTILS Code Repository

- The MRW App includes chgres_cube as part of the NCEPLIBS installation; however, for users interested in the source code:
- Chgres_cube can be downloaded as part of the UFS_UTILS repository:
  - https://github.com/NOAA-EMC/UFS_UTILS
  - The MRW App uses the ‘release/public-v1’ branch.
- Chgres_cube source code directory
  - sorc/chgres_cube.fd
- Code support exists on all NOAA HPC, Cheyenne, generic linux, and MacOS
- Additional information on the UFS_UTILS repository wiki page:
  - https://github.com/NOAA-EMC/UFS_UTILS/wiki

Static Inputs to chgres_cube

- Vertical coordinate definition file - *global_hyblev.levs.txt*
- Model grid mosaic file - *CRES_mosaic.nc*
- Model grid files - *CRES_grid.tile#.nc*
  - Grid point lat/lon; edge distance, area.
- Model orog files - *CRES_oro_data.tile#.nc*
  - Land-mask, orography, gravity wave drag fields.
- Surface climatological fields
  - *CRES_facsf.tile#.nc* (fractional coverage strong/weak zenith angle albedo)
  - *CRES_maximum_snow_albedo.tile#.nc* (maximum snow albedo)
  - *CRES_slope_type.tile#.nc* (slope type - category)
  - *CRES_snowfree_albedo.tile#.nc* (snow-free albedo)
  - *CRES_soil_type.tile#.nc* (soil type - category)
  - *CRES_substrate_temperature.tile#.nc* (soil substrate T)
  - *CRES_vegetation_greenness.tile#.nc* (plant greenness)
  - *CRES_vegetation_type.tile#.nc* (vegetation type - category)

External Model Input Data

- Supports several data types (only most recent 10 days of GFS GRIB2 and FV3GFS nemsio available online; others available only on NOAA HPSS):
  - Spectral GFS sigio/sfcio (v12, v13) *
  - Spectral GFS gaussian nemsio (v14) *
  - FV3GFS gaussian nemsio (v15 - current OPS)
  - FV3GFS gaussian NetCDF (v16 - to be implemented Feb. 2021)
  - FV3GFS tiled warm restart files (NetCDF) *
  - FV3GFS tiled history files (NetCDF) *
  - GFS GRIB2 PGB files (v14 and v15)
  - * HPSS only
- Can initialize with external model data starting from May 21, 2012 (using GFS v12 and v13 data)

Online External Model Input Data

- GFS GRIB2
  - 0.25-degree data; last 10 days available (Use the **gfs.tHHz.pgrb2.0p25.f000** files in subdirectory gfs.YYYYMMDD/HH):
    - https://nomads.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/
  - 0.5-degree data (Use the **gfs_4_YYYYMMDD_00HH_000.grb2** files, under **GFS Forecasts 004 (0.5-deg))**:
    - https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs
  - 1.0-degree data (Use the **gfs_3_YYYYMMDD_00HH_000.grb2 file**, under **GFS Forecasts 003 (1-deg)):**
    - https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs
- NEMSIO (GFS v15 - current OPS)
  - T1534 Gaussian; last 10 days available (Use the **gfs.tHHz.atmanl.nemsio** (atmospheric fields) and **gfs.tHHz.sfcanl.nemsio** (surface fields) files in subdirectory gfs.YYYYMMDD/HH):
    - https://nomads.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/
- NetCDF (GFS v16 - expected implementation date Feb. 3, 2021)
  - T1534 Gaussian - Use the **gfs.tHHz.atmanl.nc** (atmospheric fields) and **gfs.tHHz.sfcanl.nc** (surface fields) files in subdirectory gfs.YYYYMMDD/HH/atmos
    - https://nomads.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/
- Namelist setup for each input data, see this link:
  - https://ufs-utils.readthedocs.io/en/latest/chgres_cube.html#chgres-cube-namelist-options

Variable Mapping (varmap) Table for GRIB2 Data

- The chgres_cube namelist contains an entry (“varmap_file”) to define the varmap table
- Controls how chgres_cube handles variables that may be missing from external model GRIB2 files
- Each varmap file contains three columns
  - Column 1: Variable names the code searches for in the GRIB2 files
  - Column 2: Variable names written to the chgres_cube output NetCDF files
  - Column 3: Behavior to follow (“skip”, “set_to_fill”, or “stop”) when the code can’t find the variables in column 1
  - Column 4: If column 3 = “set_to_fill”, then this value is used to fill in all points in the input field (note that certain variables may be overwritten by climatology, particularly the vegetation type, soil type, vegetation fraction, max/min vegetation fraction, and leaf area index surface fields)
  - Column 5: Variable type descriptor (“T” - 3D tracer, “D” - 3D non-tracer, “S” - 2D surface array)

GFS GRIB2 Data Considerations

- Does not contain fields needed for the Near Sea Surface Temperature (NSST) scheme
  - Run model with NSST off; or use spin-up cycle - see this link
- Data is relatively coarse compared to the other supported GFS data, therefore the initialization of FV3 may suffer
- Sea/lake ice thickness and column temperatures are unavailable - fill values from varmap file used.
- Soil moisture is created using bilinear interpolation, therefore may be a mix of values from different soil types
- Ozone is not available at all isobaric levels - fill value from varmap file used.
- Only GFS v14 and v15 GRIB2 data has been tested, older data (prior to 12Z July 19, 2017) may not work

Output Files

- Separate surface and atmosphere NetCDF files for each tile
- Atmospheric files
  - Surface pressure, temperature, winds, tracers, etc.
- Surface files
  - Fifty surface and Near Sea Surface Temperature (NSST) fields

External Model Data Processing in chgres_cube

- Processing of the atmospheric, surface, and NSST fields are independent of each other
- Namelist options allow the user to determine whether to process all fields together or one at a time
- “convert_atm”, “convert_sfc”, and “convert_nsst” namelist settings can be defined as “true” or “false”
- Useful for code development
- Useful for future LAM capability when creating atmospheric lateral boundary conditions.

External Model Atmospheric Data Processing

- Similar to the old spectral GFS program (‘global_chgres’)
- Horizontally interpolates from external model data input to FV3 model grids
  - For winds, ‘x’, ‘y’, and ‘z’ components are processed
- Adjusts surface pressure for terrain differences
- Reads the vertical coordinate definition file
- Computes 3D pressure
- Vertically interpolates to model hybrid levels.
- MP schemes supported: GFDL and Zhao-Carr

External Model Surface Data Processing

- Assumes Noah LSM
- Reads static surface climatology fields
- Interpolates fields from external model data input to FV3 model grids
  - Account for masks - land to land; non-land to non-land; land ice to land ice.
- Adjusts soil temperature for terrain differences
- Computes frozen portion of total soil moisture
- Sets roughness for land and ice points (from vegetation type table)
- Rescales soil moisture for soil type differences
  - Attempts to preserve latent/sensible heat fluxes

Code Structure

- chgres_cube is built around Fortran modules
  - chgres.F90 - main driver routine
  - program_setup.F90 - reads namelist, computes soil parameters, sets up program execution
  - model_grid.F90 - sets ESMF grid objects for external model data input and FV3 model grids
  - static_data.F90 - reads FV3 model grid surface climatology data, interpolates in time
  - write_data.F90 - writes FV3 model grid NetCDF files
  - input_data.F90 - reads external model atmospheric and surface fields
  - utils.f90 - general utility routines
  - grib2_util.F90 - utility routines for GRIB2 data
  - surface.F90 - processes surface/NSST fields

Code Contributions

- Developers are welcome to tinker with the code, but *only under their own fork* of the repository.
- Code management must follow GitFlow protocols
  - Create a ‘feature’ branch off ‘develop’.
  - Ensure ‘develop’ under their fork stays up-to-date with the authoritative repository.
- Bug fixes and changes that support current or future NCEP operations will be given priority for inclusion into the authoritative repository
- Prior to code merges, a series of regression tests must be run on all NOAA officially supported machines - WCOSS, Orion, Jet and Hera.
- For more details, see the UFS_UTILS wiki page:
  - https://github.com/NOAA-EMC/UFS_UTILS/wiki

Documentation

- Additional information on chgres_cube exists online in relation to the MRW App release:
  - https://ufs-utils.readthedocs.io/en/latest/

QUESTIONS?