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Aristotle University, Research Dissemination Center (KEDEA)



VI-SEEM NAT-GR CL: National training event in Greece

WRF

Weather Research and Forecast Model

Meteorological applications on HPC ARIS

Hands-on

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Model Hangs-on

- This is not a WRF tutorial
- On-line tutorials are available with full description
- Objectives:
 - Get the model
 - Download all available static data
 - Build and compile WRF
 - **Edit and configure a model run**
 - **Submit a job**
 - Visualize input and output

Model Hangs-on: Get the model

- Visit http://www2.mmm.ucar.edu/wrf/users/download/get_source.html
 - If you are a new user fill-out the registration form by clicking on the link to '**New Users**'
 - If you have registered and wish to download the software again, please click on the link for '**Returning Users**'
 - Follow instructions
- Create a folder e.g. WRFV3.9.1
- Go to that folder and unpack the WRF and WPS codes
 - `tar -zxvf WRFV3.9.1.1.TAR.gz`
 - `tar -zxvf WPSV3.9.1.TAR.gz`
- These will create the WRFV3 and WPS folders

Model Hangs-on: Get the model

cd WRFV3/

Source code directories:

- **dyn_em/** Directory for ARW dynamics and numerics
- **dyn_nmm/** Directory for NMM dynamics and numerics, supported by DTC
- **dyn_exp/** Directory for a 'toy' dynamic core
- **external/** Directory containing external packages, such as those for IO, time keeping, and MPI
- **frame/** Directory containing modules for the WRF framework
- **inc/** Directory containing 'include' files
- **main/** Directory for main routines, such as wrf.F, and all executables after compilation
- **phys/** Directory for all physics modules
- **share/** Directory containing mostly modules for WRF mediation layer and WRF I/O
- **tools/** Directory containing tools for developers

Scripts:

- **clean** Script to clean created files and executables
- **compile** Script for compiling the WRF code
- **configure** Script to configure the *configure.wrf* file for compilation

Makefile Top-level makefile

- **Registry/** Directory for WRF Registry files
- **arch/** Directory where compile options are gathered
- **run/** Directory where one may run WRF
- **test/** Directory that contains several test case directories, may be used to run WRF

Model Hangs-on: Get the model

- cd WPS/

Source code directories:

- **geogrid/** Directory containing code to create the static data
- **metgrid/** Directory containing code to create input to WRFV3
- **ungrib/** Directory containing code to unpack GRIB data
- **util/** Directory containing some utilities
- **arch/** Directory where compile options are gathered

Scripts:

- **clean** Script to clean created files and executables
- **compile** Script for compiling WPS code
- **configure** Script to configure the 'configure.wps' file for compile
- **link_grib.csh** Script to link GRIB files

namelist.wps WPS namelist, basic options

namelist.wps-all_options WPS namelist, all available option

Model Hangs-on: Static data

- Visit http://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html
- 3 variations of the WPS geographical input data download sets
- Choose carefully what you need
- *Usually WPS program is running locally and all necessary met_em.d0* files can be transferred to ARIS (scp)*
- Although we need WPS folder for the sake of this presentation

Model Hangs-on: Build and Compile

- Set the environment correctly
 - export WRF_EM_CORE=1
 - export WRFIO_NCD_LARGE_FILE_SUPPORT=1
- In order to configure the code a number of modules must be loaded
- module avail...
- module load
 - intel/17.0.0
 - intelmpi/5.0.3
 - netcdf/4.1.3/intel
 - hdf5/1.8.12/intel
 - jasper/1.900.1
- libpng and zlib are already loaded to the system

Model Hangs-on: Build and Compile

```
[kartsios@login02 WRFV3]$ ./configure
checking for perl5... no
checking for perl... found /usr/bin/perl (perl)
Will use NETCDF in dir: /apps/libraries/netcdf/4.1.3/intel
PHDF5 not set in environment. Will configure WRF for use without.
Will use 'time' to report timing information

If you REALLY want Grib2 output from WRF, modify the arch/Config_new.pl script.
Right now you are not getting the Jasper lib, from the environment, compiled into WRF.

-----
Please select from among the following Linux x86_64 options:

 1. (serial)   2. (smpar)   3. (dmpar)   4. (dm+sm)   PGI (pgf90/gcc)
 5. (serial)   6. (smpar)   7. (dmpar)   8. (dm+sm)   PGI (pgf90/pgcc): SGI MPT
 9. (serial)  10. (smpar)  11. (dmpar)  12. (dm+sm)  PGI (pgf90/gcc): PGI accelerator
13. (serial)  14. (smpar)  15. (dmpar)  16. (dm+sm)  INTEL (ifort/icc)
                                     17. (dm+sm)  INTEL (ifort/icc): Xeon Phi (MIC architecture)
18. (serial)  19. (smpar)  20. (dmpar)  21. (dm+sm)  INTEL (ifort/icc): Xeon (SNB with AVX mods)
22. (serial)  23. (smpar)  24. (dmpar)  25. (dm+sm)  INTEL (ifort/icc): SGI MPT
26. (serial)  27. (smpar)  28. (dmpar)  29. (dm+sm)  INTEL (ifort/icc): IBM POE
30. (serial)                                     31. (dmpar)  PATHSCALE (pathf90/pathcc)
32. (serial)  33. (smpar)  34. (dmpar)  35. (dm+sm)  GNU (gfortran/gcc)
36. (serial)  37. (smpar)  38. (dmpar)  39. (dm+sm)  IBM (xlf90_r/cc_r)
40. (serial)  41. (smpar)  42. (dmpar)  43. (dm+sm)  PGI (ftn/gcc): Cray XC CLE
44. (serial)  45. (smpar)  46. (dmpar)  47. (dm+sm)  CRAY CCE (ftn/gcc): Cray XE and XC
48. (serial)  49. (smpar)  50. (dmpar)  51. (dm+sm)  INTEL (ftn/icc): Cray XC
52. (serial)  53. (smpar)  54. (dmpar)  55. (dm+sm)  PGI (pgf90/pgcc)
56. (serial)  57. (smpar)  58. (dmpar)  59. (dm+sm)  PGI (pgf90/gcc): -f90=pgf90
60. (serial)  61. (smpar)  62. (dmpar)  63. (dm+sm)  PGI (pgf90/pgcc): -f90=pgf90

Enter selection [1-63] : █
```

If configuration is successful:

Testing for NetCDF, C and Fortran compiler

This installation of NetCDF is 64-bit

C compiler is 64-bit

Fortran compiler is 64-bit

It will build in 64-bit

Model Hangs-on: Build and Compile

- Edit configure.wrf file
- Change the following lines:
 - DM_FC = mpif90 -f90=\$(SFC)
 - DM_CC = mpicc -cc=\$(SCC) -DMPI2_SUPPORT
 - LIB_EXTERNAL = \
 - -L\$(WRF_SRC_ROOT_DIR)/external/io_netcdf -lwrpio_nf -L/apps/libraries/netcdf/4.1.3/intel/lib -lnetcdff -lnetcdf
- to
 - DM_FC = mpiifort
 - DM_CC = mpiicc -DMPI2_SUPPORT
 - LIB_EXTERNAL = \
 - -L\$(WRF_SRC_ROOT_DIR)/external/io_netcdf -lwrpio_nf -L/apps/libraries/netcdf/4.1.3/intel/lib -lnetcdff -lnetcdf \
 - -L/apps/libraries/hdf5/1.8.12/intel/lib -lhdf5_fortran -lhdf5_hl -lhdf5 -lgpfs -lz
- Compile: `./compile em_real >& log.compile &`
- To monitor compilation process: `tail -f log.compile`

Model Hangs-on: Build and Compile

- If successful then at the end of log.compile file:

- =====

- build started: Thu Jul 20 14:12:48 EEST 2017
- build completed: Thu Jul 20 14:59:10 EEST 2017

- ---> Executables successfully built <---

- -rwxr-xr-x 1 kartsios kartsios 51482109 Jul 20 14:59 main/ndown.exe
- -rwxr-xr-x 1 kartsios kartsios 51469254 Jul 20 14:59 main/real.exe
- -rwxr-xr-x 1 kartsios kartsios 50788411 Jul 20 14:59 main/tc.exe
- -rwxr-xr-x 1 kartsios kartsios 57798630 Jul 20 14:57 main/wrf.exe

- =====

- Or just...

- **module load wrf/3.?.?/purempi**



Model Hangs-on: Build and Compile WPS

- WPS program can be built either in serial or parallel mode
 - Usually we need parallel mode if we are going for climate runs
- cd WPS
 - ./configure
 - ./compile >& log.compile &
- If your compilation is successful, you should see these executables created
 - geogrid.exe -> geogrid/src/geogrid.exe Generates static data
 - metgrid.exe -> metgrid/src/metgrid.exe Generates input data for WRFV3
 - ungrib.exe -> ungrib/src/ungrib.exe Unpacks GRIB data

Model Hangs-on: Domain setup

• cat ./WPS/namelist.wps

```
&share  
  wrf_core = 'ARW',  
  max_dom = 2,  
  start_date = '2006-08-16_12:00:00','2006-08-16_12:00:00',  
  end_date = '2006-08-16_18:00:00','2006-08-16_12:00:00',  
  interval_seconds = 21600  
  io_form_geogrid = 2,  
&END
```

```
&ungrib  
  out_format = 'WPS',  
  prefix = 'FILE',  
&END
```

```
&metgrid  
  !constants_name = 'SST_FIXED',  
  fg_name = 'FILE',  
  io_form_metgrid = 2,  
&END
```

```
&geogrid  
  parent_id = 1,1,2,  
  parent_grid_ratio = 1,3,3,  
  i_parent_start = 1,155,100,  
  j_parent_start = 1,50,110,  
  e_we = 368,436,640,  
  e_sn = 263,394,622,  
  geog_data_res = '30s','30s','30s',  
  dx = 15000,  
  dy = 15000,  
  map_proj = 'lambert',  
  ref_lat = 39.694,  
  ref_lon = 18.202,  
  truelat1 = 39.694,  
  truelat2 = 39.694,  
  stand_lon = 18.202,  
  geog_data_path = '/work/pr001/kartsios/geog_complete',  
  ref_x = 190.0,  
  ref_y = 124.0,  
&END
```

Domain size

Center of the domain

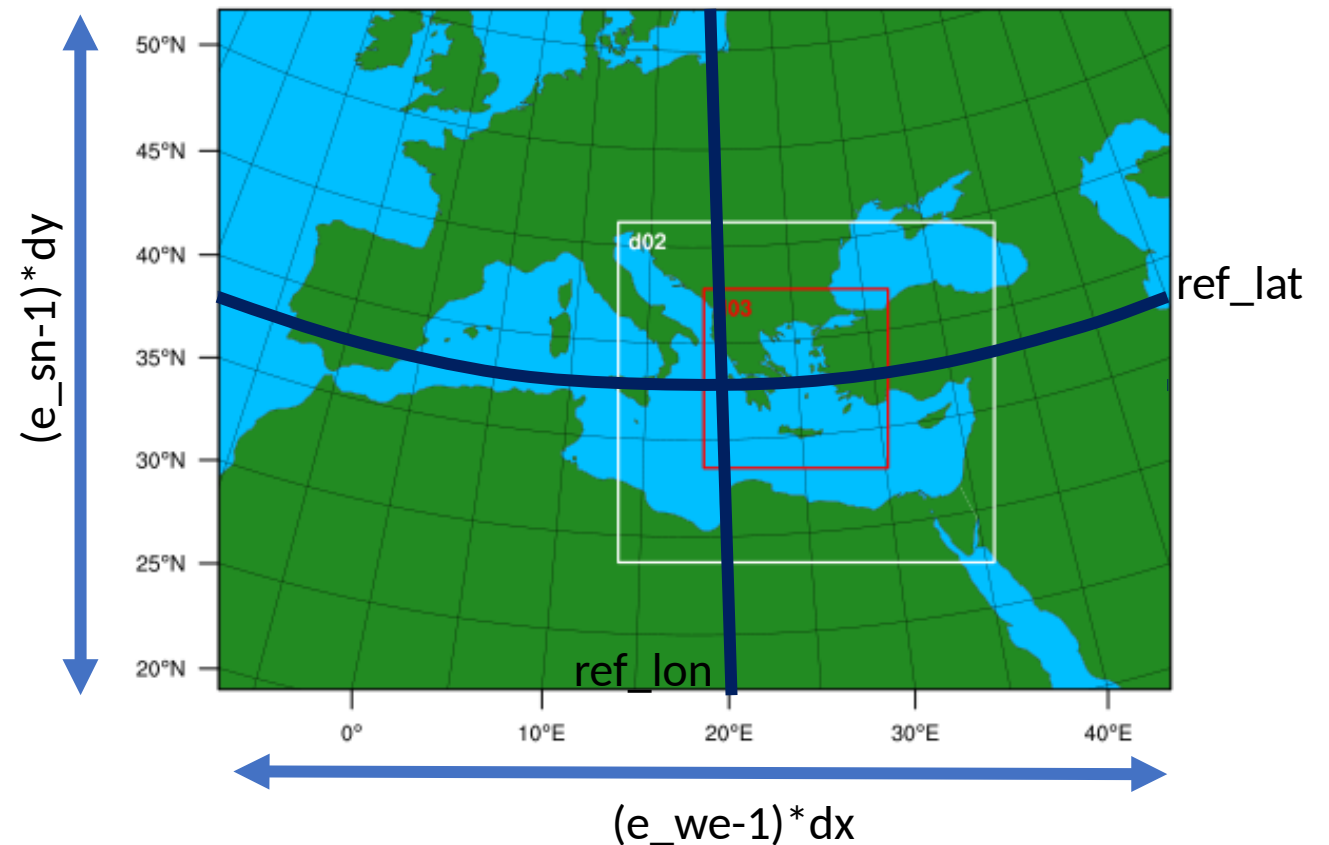
Parameters of the projection

Model Hangs-on: Domain setup

- Check your domains
 - ncl util/plotgrids_new.ncl
- ./geogrid.exe (serial)

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!  
! Successful completion of geogrid. !  
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```
- geo_em.d01.nc
 geo_em.d02.nc (nest)
 geo_em.d03.nc (nest)

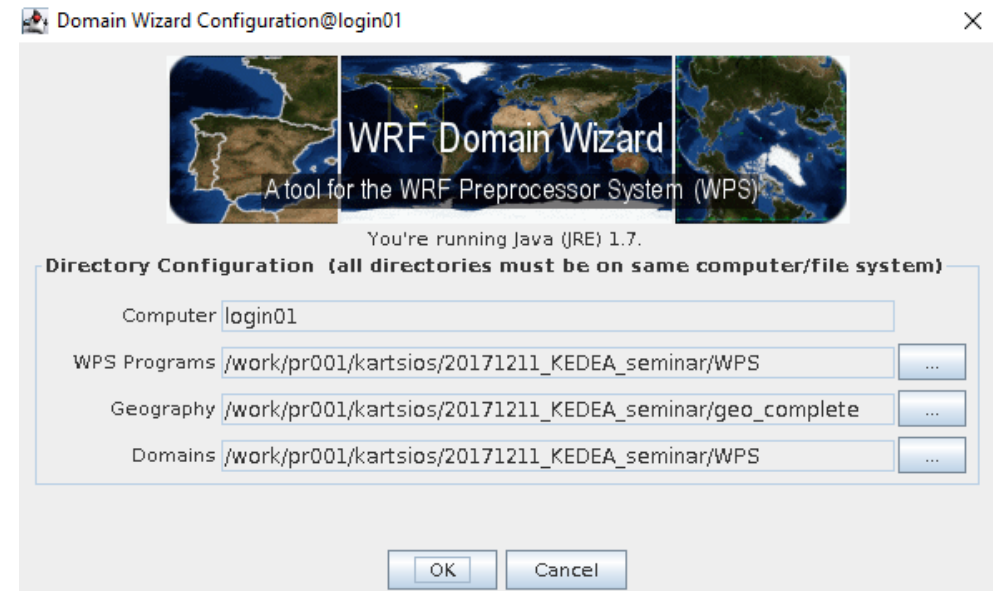
WPS Domain Configuration



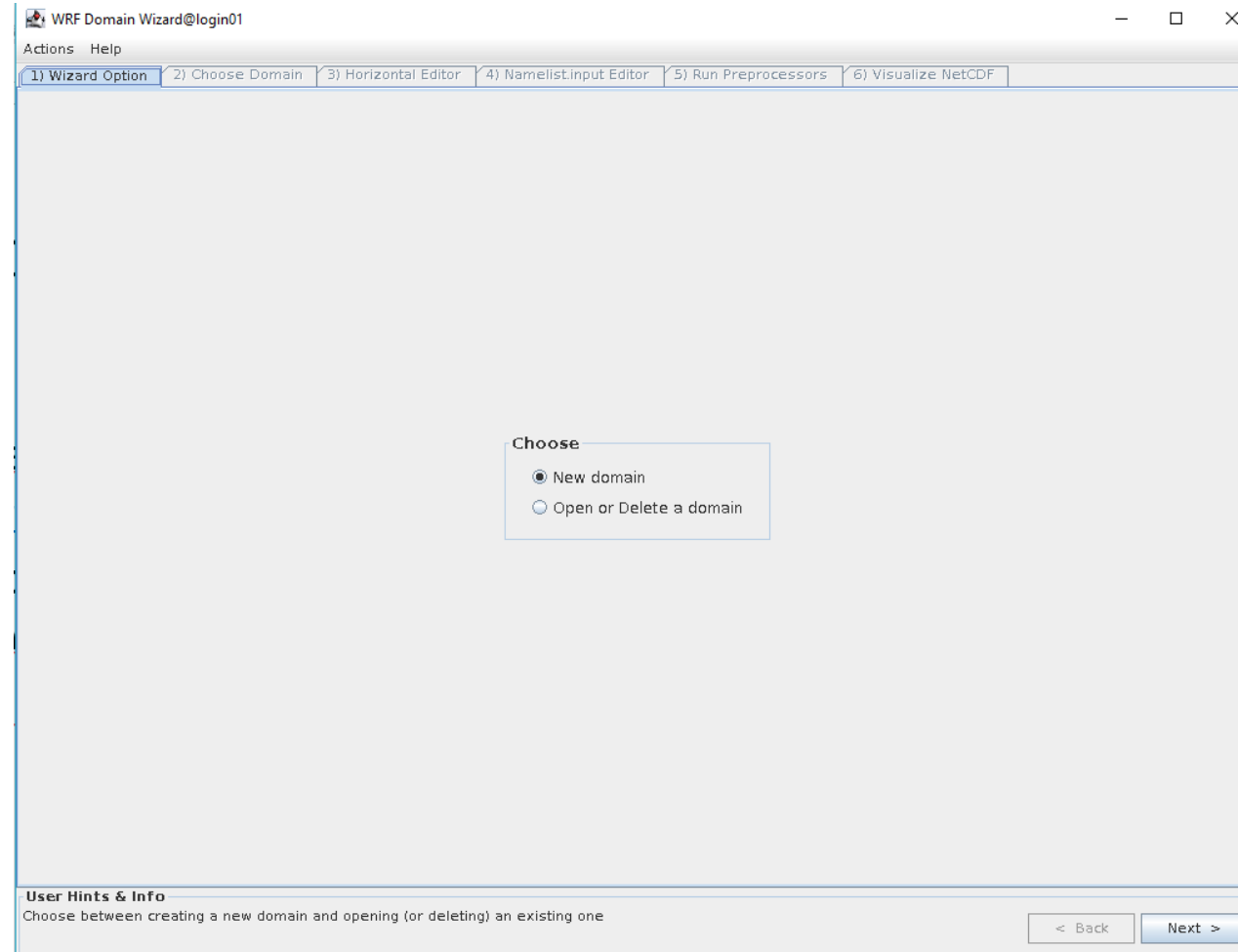
Model Hangs-on: Domain setup

- *WRF Domain Wizard*, a GUI for the WRF Preprocessor System (WPS) and namelist.input
 - <https://esrl.noaa.gov/gsd/wrfportal/DomainWizard.html>
- Unzip WRFDomainWizard.zip
 - `chmod +x run_DomainWizard`
- `./run_DomainWizard`

- Example
 - 36hrs hindcast for Europe (15km)
 - 12Z_27082005 - 00Z_29082005



Model Hangs-on: Domain setup



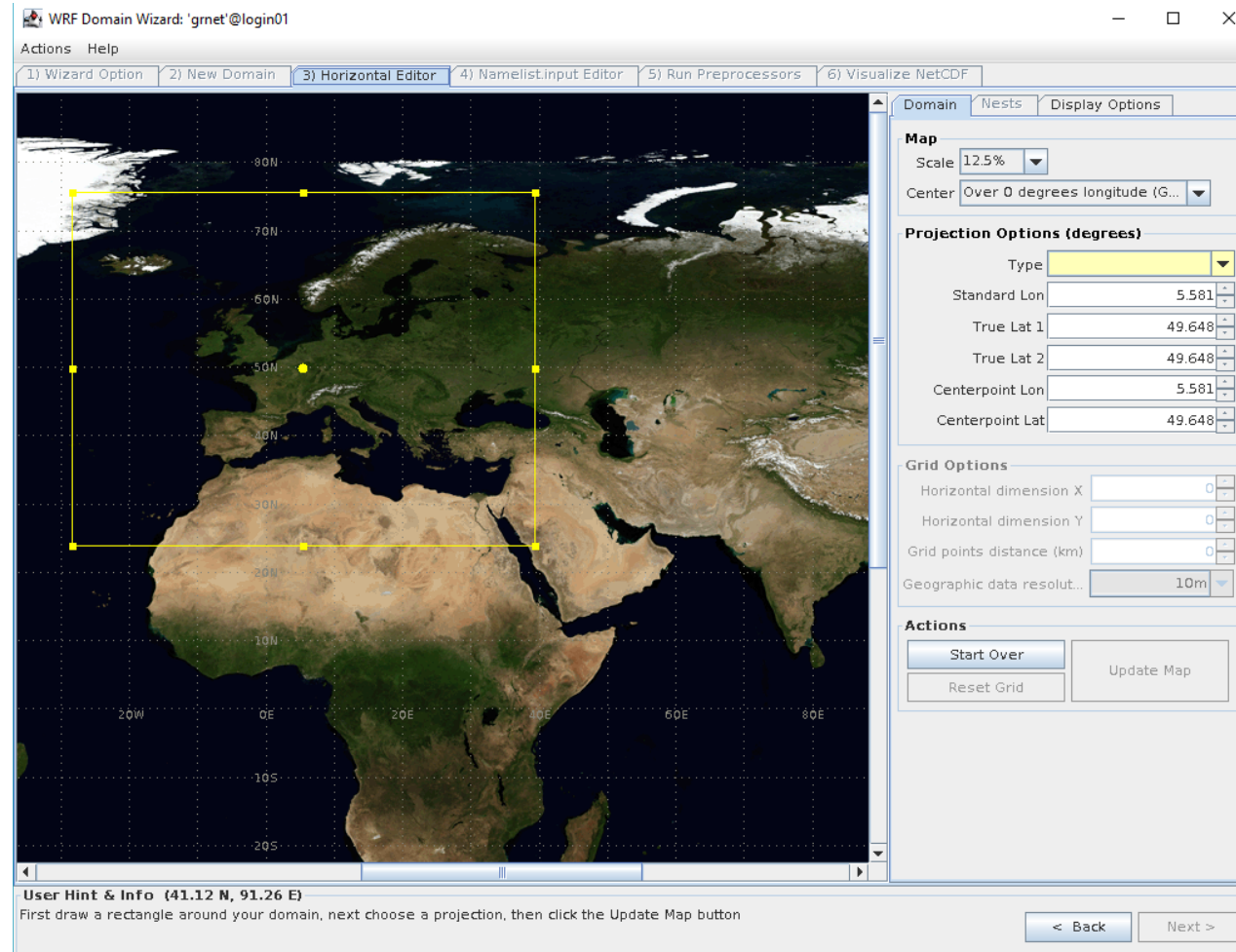
Model Hangs-on: Domain setup

The screenshot shows the 'WRF Domain Wizard' application window. The title bar reads 'WRF Domain Wizard: 'gnet'@login01'. The menu bar includes 'Actions' and 'Help'. The main window has a tabbed interface with six tabs: '1) Wizard Option', '2) New Domain' (which is the active tab), '3) Horizontal Editor', '4) Namelist.Input Editor', '5) Run Preprocessors', and '6) Visualize NetCDF'. The 'New Domain' tab contains a form with the following elements:

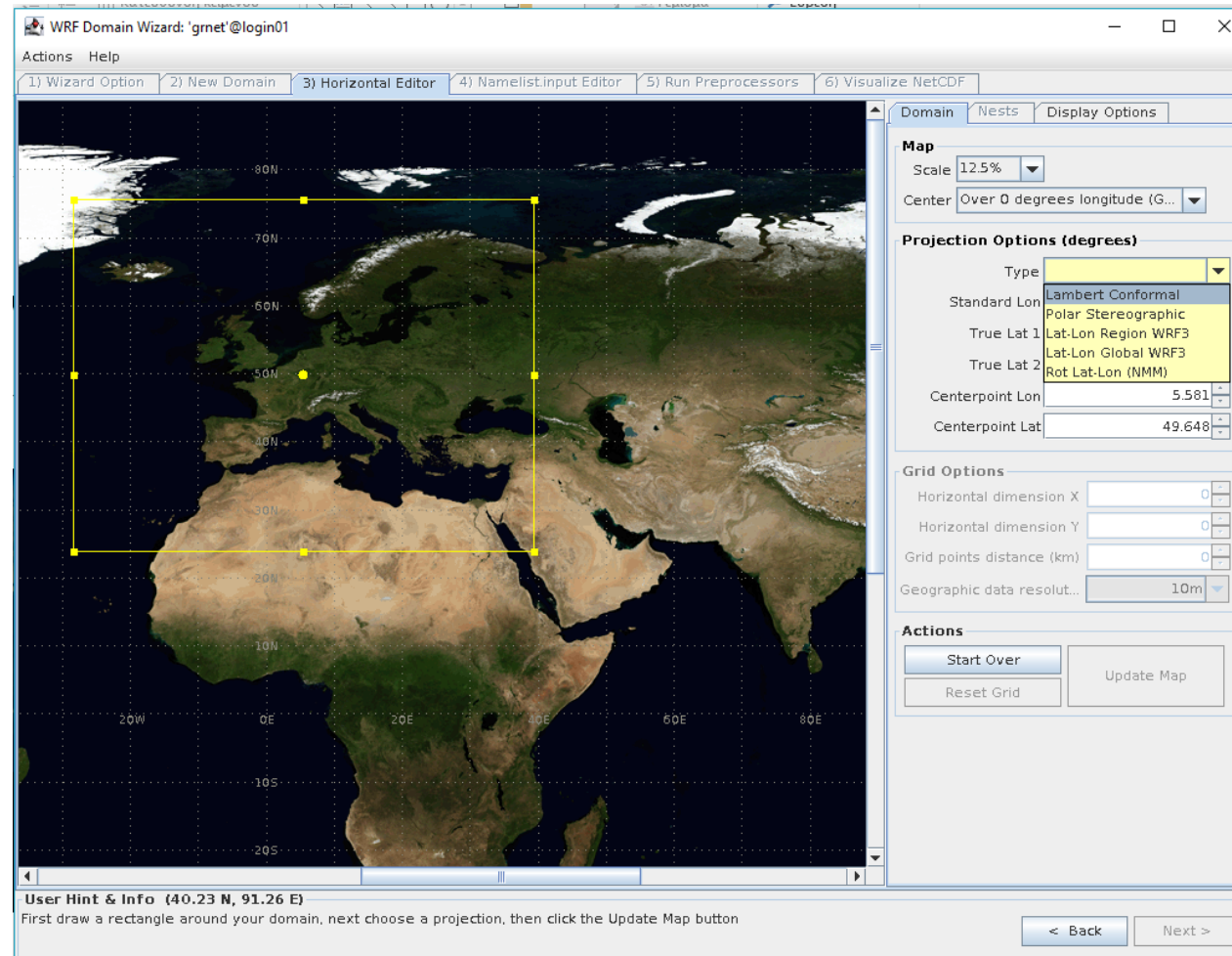
- A 'Name' text input field containing the text 'gnet'.
- A 'Description' text input field, which is currently empty.
- A 'Clear' button located to the right of the 'Description' field.
- A checkbox labeled 'Hurricane WRF (v3.5+) dom' which is currently unchecked.

At the bottom of the window, there is a 'User Hints & Info' section with the text: 'First draw a rectangle around your domain, next choose a projection, then click the Update Map button'. To the right of this text are two buttons: '< Back' and 'Next >'.

Model Hangs-on: Domain setup



Model Hangs-on: Domain setup



Model Hangs-on: Domain setup

The screenshot displays the WRF Domain Wizard interface. The main window shows a map of Europe with a yellow rectangular domain boundary. The map includes latitude and longitude grid lines. A yellow circle with the number '1' is placed on the map, indicating a specific location. The right-hand panel contains configuration options for the domain setup.

WRF Domain Wizard: 'gmet'@login01

Actions Help

1) Wizard Option 2) New Domain 3) Horizontal Editor 4) Namelist Input Editor 5) Run Preprocessors 6) Visualize NetCDF

Domain Nests Display Options

Map

Scale: 12.5%

Center: Over 0 degrees longitude (G...)

Projection Options (degrees)

Type: Lambert Conformal

Standard Lon: 5.581

True Lat 1: 49.648

True Lat 2: 49.648

Centerpoint Lon: 5.581

Centerpoint Lat: 49.648

Grid Options

Horizontal dimension X: 390

Horizontal dimension Y: 310

Grid points distance (km): 15

Geographic data resolut.: 30s

Actions

Start Over Update Map

Reset Grid

User Hint & Info (32.18 N, 16.91 E)
Resize your grid by dragging the points on the rectangle above or by typing in the grid values. Click on the 'Nests' tab on the upper right to edit nests.

< Back Next >

Model Hangs-on: Domain setup

WRF Domain Wizard: 'grnet'@login01

Actions Help

1) Wizard Option 2) New Domain 3) Horizontal Editor 4) Namelist.input Editor 5) Run Preprocessors 6) Visualize NetCDF

Add or Edit ETA Levels Reset For This Domain Validate Help /work/pr001/kartsios/20171211_KEDEA_seminar/WPS/grnet/namelist.input

GUI Editor Text Editor

Number of Domains (max_dom): 1

Parameter	Master Domain
start_month	01
start_day	24
start_hour	12
start_minute	00
start_second	00
end_year	2000
end_month	01
end_day	25
end_hour	12
end_minute	00
end_second	00
interval_seconds	21600
input_from_file	true.
history_interval	180
frames_per_outfile	1000
restart	false.
restart_interval	5000
io_form_history	2
io_form_restart	2
io_form_input	2
io_form_boundary	2
debug_level	0
&domains	
time_step	90
time_step_fract_num	0
time_step_fract_den	1
num_metgrid_soil_levels	4
num_metgrid_levels	27
eta_levels	1.0..0.0
force_sfc_in_vinterp	1

num_metgrid_soil_levels 4 number of vertical soil levels or layers input. from WPS metgrid program
num_metgrid_levels 27 number of vertical levels in the incoming data: type ncdump -h to find out (WPS data only)
eta_levels 1.0..0.0 model eta levels (WPS data only). If a user does not specify this, real will provide a set of levels
force_sfc_in_vinterp 1 use surface data as lower boundary when interpolating through this many eta

User Hint & Info (30.67 N, 46.29 E)
Edit this domain's namelist.input file. The following parameters have been defaulted for this domain: max_dom, s_we, e_we, s_sn, e_sn, dx, dy, l_parent_start, j_parent_start, time_step. Right click in the window to Copy, Paste, or Find.

< Back Next >

Model Hangs-on: Domain setup

Vertical Editor For ETA levels in /work/pr001/kartsios/20171211_KEDEA_seminar/WPS/gnet/namelist.input@login01

Level	Value
50	0.0000
49	0.0145
48	0.0287
47	0.0429
46	0.0571
45	0.0713
44	0.0855
43	0.0995
42	0.1134
41	0.1272
40	0.1407
39	0.1539
38	0.1667
37	0.1792
36	0.1915
35	0.2035
34	0.2165
33	0.2305
32	0.2465
31	0.2645
30	0.2845
29	0.3085

ETA Levels (eta_levels)

User Hints & Info
The Vertical Editor enables you to edit the vertical eta levels used by real.exe that are specified in a namelist.input file. Click on eta values in the right panel to edit them (or just highlight them in RED).

io_form_history 2
io_form_restart 2
io_form_input 2

run_hours 0 run time in hours
Note: if it is more than 1 day, one may use both run_days and run_hours or just run_hours. e.g. if the total run length is 36 hrs, you may set run_days = 1, and run_hours = 12, or run_days = 0, and run_hours 36
run_minutes 0 run time in minutes
run_seconds 0 run time in seconds

User Hint & Info (30.67 N, 46.29 E)
Edit this domain's namelist.input file. The following parameters have been defaulted for this domain: max_dom, s_we, e_we, s_sn, e_sn, dx, dy, i_parent_start, j_parent_start, time_step. Right click in the window to Copy, Paste, or Find.

module load ncview
ncview geo_em.d01.nc

```

/geogrind.exe
Parallel 25 entries in GEOGRID.TBL
Processing domain 1 of 1
Processing XLAT and XLONG
Processing MAPFAC
Processing F and E
Processing ROTANG
Processing LANDUSEF
Calculating landmask from LANDUSEF ( WATER = 17 21 )
Processing HGT_M
Processing SOILTEMP
Processing SOILCTOP
Processing SCT_DOM
Processing SOILCBOT
Processing SCB_DOM
Processing ALBEDO12M
Processing GREENFRAC
Processing LAI12M
Processing SNOALB
Processing SLOPECAT
Processing SLOPECAT
Processing CON
Processing VAR
Processing OA1
Processing OA2
Processing OA3
Processing OA4
Processing OL1
Processing OL2
Processing OL3
Processing OL4
Processing VAR_SSO
Processing LAKE_DEPTH
Processing URB_PARAM
Processing IMPERV
Processing CANFRA
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! Successful completion of geogrid. !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

```

Model Hangs-on: Running ungrib.exe

Supposing our forcing data (ERA-Interim) is available...

- Link the correct Vtable to the file name “Vtable” in the run directory
- Some Vtables are provided with WPS in the WPS/ungrib/Variable_Tables directory
- Ungrib always expects to find a file named Vtable in the run directory
- In -s ungrib/Variable_Tables/Vtable.ERA-interim.pl Vtable
- Link GRIB files to the correct file names in the run directory
- `./link_grib.csh /work/pr001/Kartsios/ERA/ERAInterim_*_{sfc,37pl}_4WRF*`
- `./ungrib.exe`
 - `ls GRIBFILE.*`

```
&ungrib
  out_format = 'WPS',
  prefix = 'FILE',
&END
```

Model Hangs-on: Running ungrib.exe

- *** Starting program ungrib.exe ***
- Start_date = 2005-08-27_12:00:00 , End_date = 2005-08-29_00:00:00
- output format is WPS
- Path to intermediate files is ./
- #####
- Inventory for date = 2003-11-01 00:00:00
- PRES GEOPT HGT TT UU VV RH DEWPT LANDSEA SOILGEO SOILHGT PSFC PMSL SKINTEMP SEAICE SST
SNOW_DEN SNOW_EC SNOW SNOWH ST000007 ST007028 ST028100 ST100289 SM000007 SM007028 SM028100 SM100289
- -----
- 1000.0 X X X X X
- 975.0 X X X X X
- 950.0 X X X X X
- 925.0 X X X X X
- 900.0 X X X X X
- 875.0 X X X X X

Model Hangs-on: Running metgrib.exe

- &share and &metgrid namelists need to be edited
- ./metgrid.exe

```
Processing domain 1 of 1
Processing 2005-08-27_12
FILE
Processing 2005-08-27_18
FILE
Processing 2005-08-28_00
FILE
Processing 2005-08-28_06
FILE
Processing 2005-08-28_12
FILE
Processing 2005-08-28_18
FILE
Processing 2005-08-29_00
FILE
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! Successful completion of metgrid. !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```


Submitting a Job

- In order to create a resource allocation and launch tasks you can submit a batch script.
- A batch script, submitted to the scheduling system must specify the job specifications:
 - resource queue , default is compute
 - number of nodes required
 - number of cores per node required
 - maximum wall time for the job , (please notice the jobs exceeding wall time will be killed)
- To submit a job, user can use the sbatch command
 - sbatch my_script

http://doc.aris.grnet.gr/run/job_submission/

Submitting a Job

```
#!/bin/bash
#####
# ARIS slurm script template      #
#                               #
# Submit script: sbatch filename #
#                               #
#####
#SBATCH --job-name=wrf_CPS        # Job name
#SBATCH --ntasks=240             # Number of processor cores (i.e. tasks)
#SBATCH --nodes=12               # Number of nodes requested
#SBATCH --ntasks-per-node=20     # Tasks per node
#SBATCH --cpus-per-task=1
#SBATCH --time=48:00:00          # walltime
#SBATCH --partition=compute      # Partition(s)
#SBATCH --mem=56G                # memory per node
#SBATCH --account=pr003005       # Accounting project
#SBATCH --output=mpijob.%j.out   # Stdout (%j expands to jobId)
#SBATCH --error=mpijob.%j.err    # Stderr (%j expands to jobId)
#####
#LOAD MODULES
module load intel/17.0.0 intelmpi netcdf/4.1.3/intel jasper/1.900.1 hdf5/1.8.12/intel ncarg/6.3.0
#
export WRF_EM_CORE=1
export WRFIO_NCD_LARGE_FILE_SUPPORT=1
export I_MPI_FABRICS=shm:dapl
```

Submitting a Job

```
#SET SOME ALLIAS
RUNDIR=/work/pr001/kartsios/20171211_KEDEA_seminar/WRFV3/run
#
echo "Start at `date`"
echo "Running on hosts: $SLURM_NODELIST"
echo "Running on $SLURM_NNODES nodes."
echo "Running $SLURM_NTASKS_PER_NODE tasks per node"
echo "Job id is $SLURM_JOBID"
#####
# RUN THE PROGRAM
t0=$(date +%s)
cd $RUNDIR
#
ulimit unlimited
ulimit -c unlimited
ulimit -s unlimited
srun real.exe
wait
srun wrf.exe
t1=$(date +%s)
echo "WRF execution: $(( $t1 - $t0 )) sec"
#####
date
echo "End at `date`"
#####
exit
```

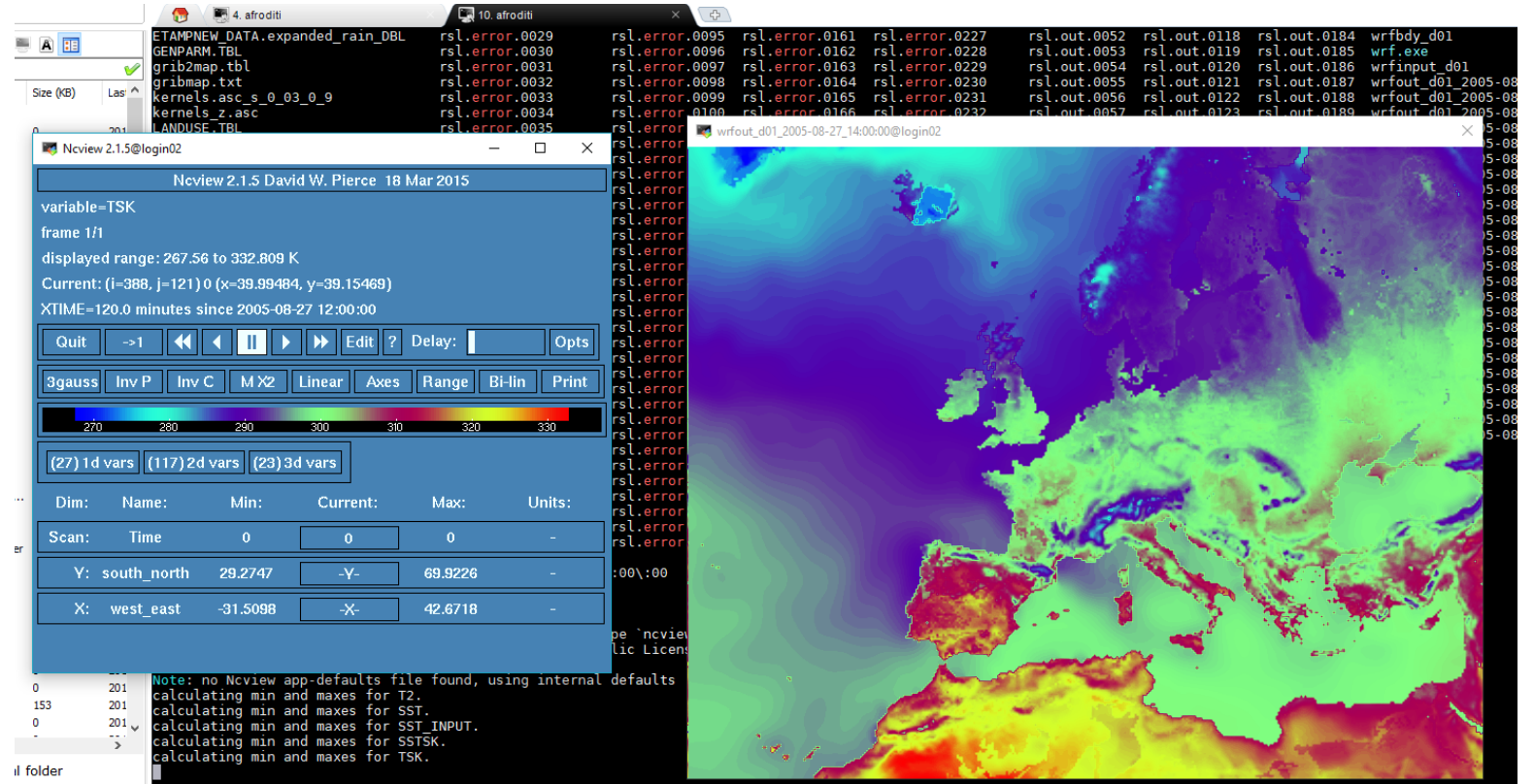
Submitting a Job

Before submit our job...

- cd to running directory
- Am I seeing my met_em.d01.* files? Move them here, or link them.
- Edit namelist.input accordingly
- Things to consider:
 - Is everything consistent regarding domain configuration between namelist.input and namelist.wps?
 - Physics involved?
 - Choose physics options carefully
 - Microphysical double moment schemes are more computational costly than single moment schemes
 - For the 15 km grid we need convection parameterization
 - More advanced surface models are more expensive e.g. CLM costs about 25% in compare to NOAH

Submitting a Job

- Check your input data
 - ncbview met_em.d01.2005-08-27_12:00:00.nc
 - ncbview wrfinput_d01
- Check your output data
 - ncbview wrfout_d01_2005-08-27_14:00:00





Thank you for your attention!

Questions?



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grnet - ViSEEM

Tuesday, December 12, 2017