Setting Up & Running the WRF Standard Initialization

Paula McCaslin,

John Smart and Brent Shaw

NOAA / Forecast Systems Laboratory

June 25, 2005

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

SI Capabilities

- Provides 3 mandatory functions for WRF:

1. Define and localize a domain
2. Specify the ‘static’ surface characteristics of land, water and vegetation
3. Provide 3-D initial and lateral boundary condition files for “real” data cases
   - GRIB data pre-processing
   - Horizontal and vertical interpolation
   - Grid staggering

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Source Code

- Source code
  - Release v2.1, 18 July 2005
  - wrfsi_v2.1.tar.gz (22 MB)
  - Available at http:/wrfsi.noaa.gov/release
- Source code files
  - Static geographical and surface characteristics data (6 GB)
  - Available at http:/wrfsi.noaa.gov/release, or
  - Available at ftp://aftp.fsl.noaa.gov/divisions/frd-laps/WRFSI/Geog_Data

Source Code

- Source code files – Static geographical and surface characteristics data
  - Topo – c-stagger grid average elevation:
    - *topo_30s/topo_30s_[NW, NE, SW, SE].tar.gz*
  - Land use dominant categories (wetland, water, forest):
    - *landuse_30s/landuse_30s_[NW, NE, SW, SE].tar.gz*
  - Annual greenness fraction (min and max): *greenfrac.tar.gz*
  - Soil temperature, adjusted mean annual:
    - *soiltemp_1deg/T90S000E and T90S180W* (two 180 tiles)
  - Soil type – top layer dominant categories (silt, sand, clay, bedrock):
    - *soiltype_top_30s/soiltype_top_30s.[NW, NE, SW, SE].tar.gz*
  - Soil type – bottom layer dominant categories:
    - *soiltype_bot_30s/soiltype_bot_30s.[NW, NE, SW, SE].tar.gz*
  - Albedo: *albedo_ncep.tar.gz*
  - Max Snow Albedo: *maxsnowalb.tar.gz*
  - Terrain slope index: *islope.tar.gz*

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

System Requirements

- Unix or Linux operating system
  - Routinely built on IBM AIX, Intel-Linux, Alpha-Linux at FSL
  - Built on Alpha-True64 and SGI-IRIX at NCAR
- FORTRAN 90 Compiler
- C Compiler (gcc is preferred)
- netCDF Libaries
- Perl
- make Utility

System Requirements

- Disk Requirements
  - Recommended Minimum Total Space: 10 GB
  - Approx. 47 MB: 35 MB for source code and 12 MB executables
  - Approx. 6 GB for global static fields
  - 1-10 GB for each domain (in directory MOAD_DATAROOT)
    - Dependant on domain size, run length, etc.
    - E.g. NCAR 30km national domain requires approx. 1 GB to contain necessary files for a 48-hour forecast period with 3-hourly boundary conditions
  - 2-4 GB for *typical* initial and lateral boundary data (in directory EXT_DATAROOT)
    - E.g. 48 hours from GFS 1 deg and from ETA 40 km grids with hourly output

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Installing the Software

- Installation Overview

1. Choose directory locations and set environment variables
2. Check compiler options available on your system
3. Run the installation script
4. Check for successful installation

Installing the Software

1. Choose directories and set environment variables
   - Source root
     - Decide where the SI source code will be located (where to extract the file wrfsi.tar). Typically, as a subdirectory of WRF.
     - Set environment variable **SOURCE_ROOT** to this location by
       'setenv SOURCE_ROOT /directory'
   - Installation root
     - Decide where the executables will be installed
     - Can be same as $SOURCE_ROOT if desired
     - Set environment variable **INSTALLROOT**
   - Domain data root
     - Choose a top level directory where domain data will be written. Typically, not in SOURCE_ROOT(in order to keep previously created domains, esp. when upgrading new SI source code).
     - Set environment variable **MOAD_DATAROOT**
   - Locate your systems' Perl executable (e.g. /usr/bin/perl)
   - Locate netCDF path – Set environment variable **NETCDF**)

Installing the Software

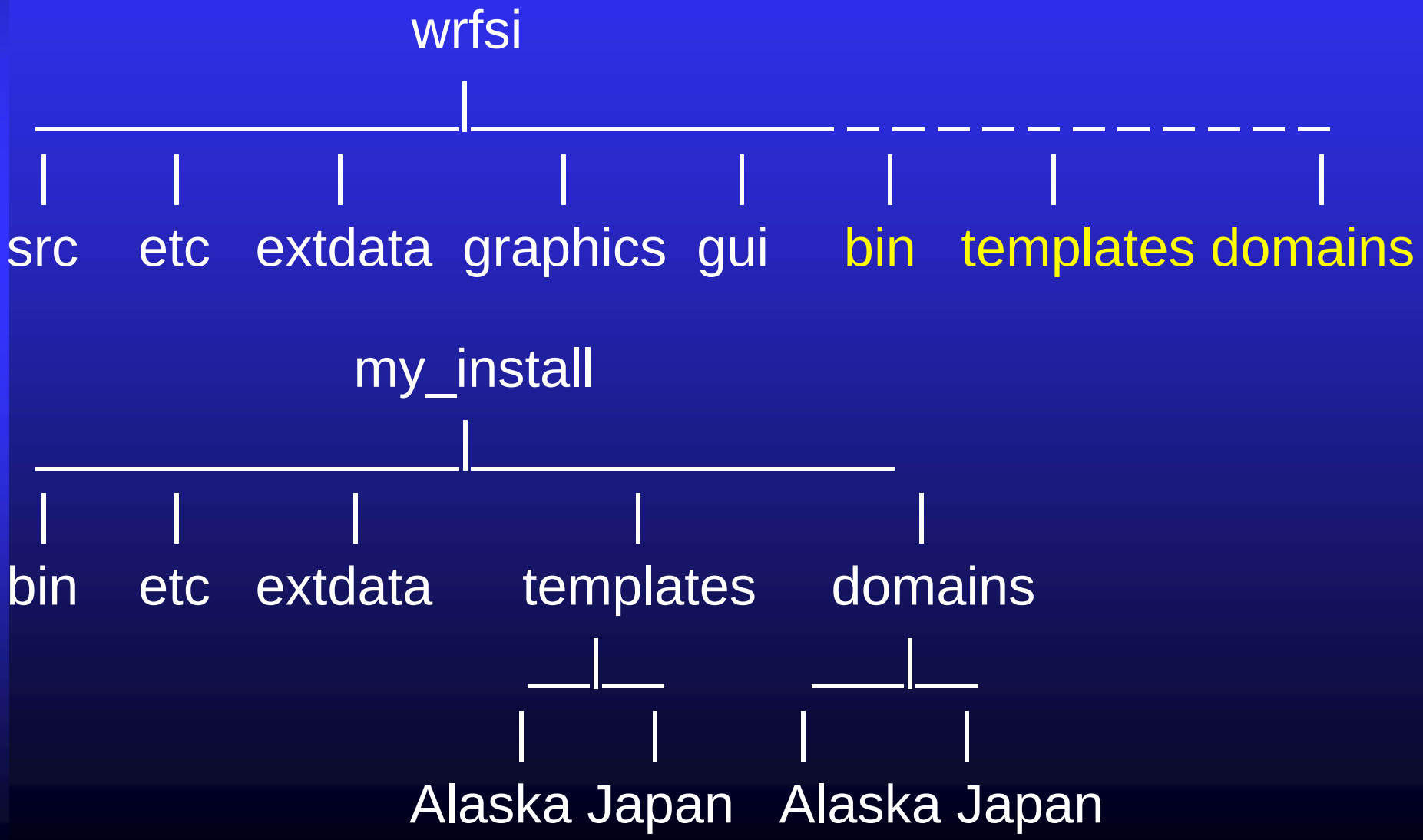
1. Choose directories and set environment variables (con't)
   - **SOURCE_ROOT** = "Directory path of (tar extracted) source code"
   - **INSTALLROOT** = "Directory path of installed (compiled) binary executables and scripts"
   - **TEMPLATES** = "Directory path containing template information for each domain"
   - **DATAROOT** = "Directory path where data from all domains will be located in order to write SI output data / WRF input data"
   - **MOAD_DATAROOT** = "Directory for domain DATAROOT/my-case"
   - **EXT_DATAROOT** = "Directory path containing output from grib_prep process (basically, a location for the decoded GRIB files)", this working dir supports multiple MOAD_DATAROOTs
   - **GEOG_DATAROOT** = "Directory path containing geography data subdirectories; topo_30s, landuse_30s, etc"
   - **PATH_TO_PERL** = "Directory path to perl"
   - **NETCDF** = "Directory path to netCDF"

Installing the Software

1. Choose directories and set environment variables (con't)
   - Example directory paths as env vars
     - setenv SOURCE_ROOT /home/wrf/wrfsi_v2.1
     - setenv INSTALLROOT /home/wrf/si_linux
     - setenv TEMPLATES /data/wrf/templates
     - If setenv DATAROOT /data/wrf/domains,
       then e.g. setenv MOAD_DATAROOT/data/wrf/domains/Alaska
   - Creating an EXT_DATAROOT
     - This is the location for grib_prep output
       - a location for the decoded (and time interpolated) GRIB files
       - allow at least 2 GB
     - Contains three related subdirectories that are created the first time install_wrfsi.pl is run:
       - extprd
       - log
       - work

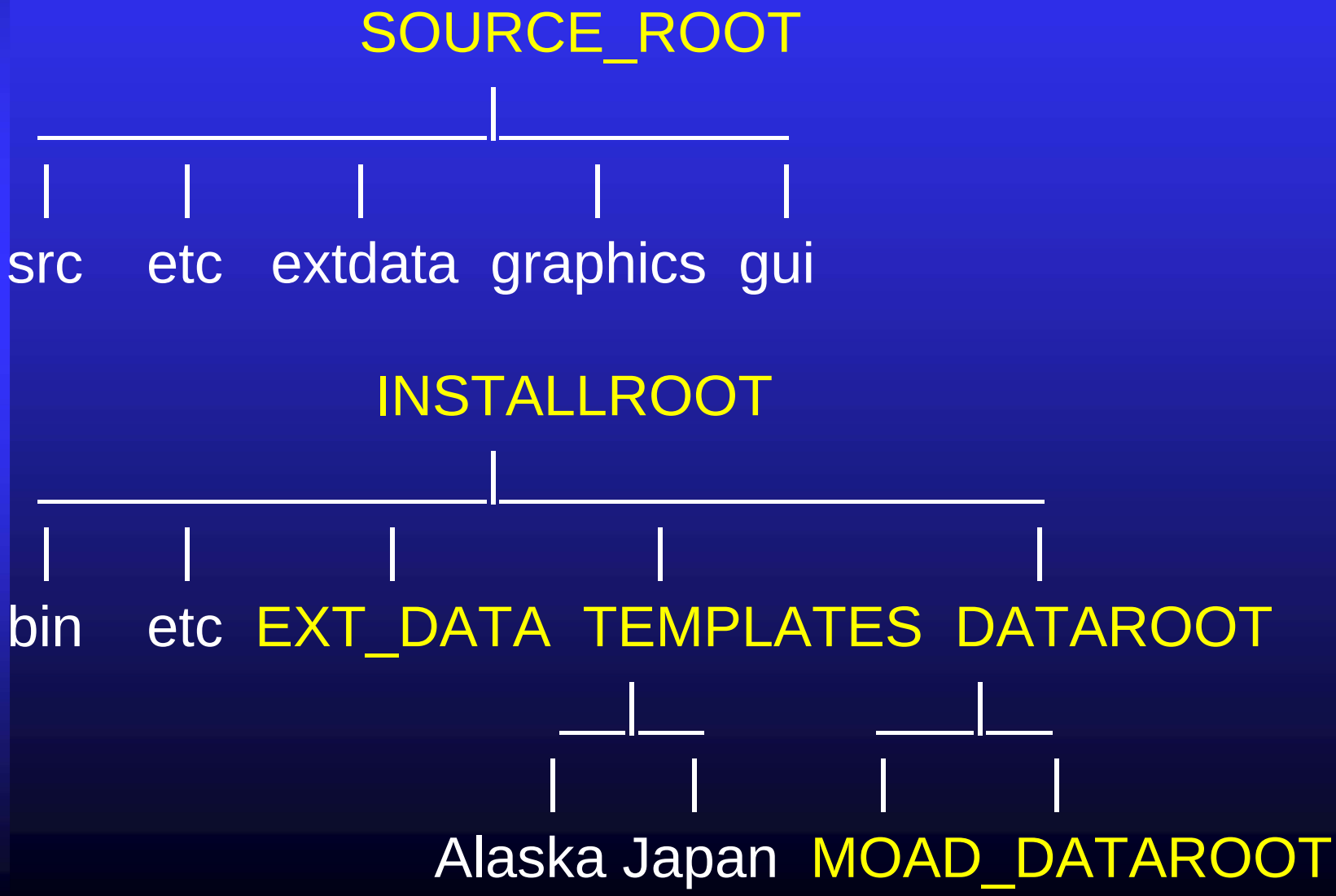
Installing the Software

1. Choose directories and set environment variables (con't)



Installing the Software

1. Choose directories and set environment variables (con't)



Installing the Software

2. Check Compiler Settings

- There are a several machine specific makefiles to building SI
  - E.g. makefile_ibm.inc.in
- Look in the directory, SOURCE_ROOT/src/include, for the existence of a file named "makefile_{MACH}.inc.in where MACH is the type of machine on which you are building
- If a makefile exists, check the various compiler options and flag settings in the file
- If a makefile does not exist, then copy one of the existing ones to a new name using your machine name and edit the compiler settings

Installing the Software

3. Run the installation script, install_wrfsi.pl
   - cd $SOURCE_ROOT then run install_wrfsi.pl in one of 3 ways:
   - A) Run install_wrfsi.pl, and have your SI environment variable directory paths configured prior to running this script. This is easiest approach and highly recommended for all users.
   - B) Or, run install_wrfsi.pl, and let the script try to configure all the directory paths.
   - C) Or, run install_wrfsi.pl with its command line options configure directory paths:

     perl install_wrfsi.pl --installroot=/home/wrf/si_aix
     --dataroot=/wrf/domains/Alaska
     --path_to_netcdf=/usr/local/netcdf
     --machine=ibm
     (where machine type corresponds to the makefile_{MACH}.inc.in file)

Installing the Software

3. Run the installation script, install_wrfsi.pl (con't)

- See INSTALLROOT/config_paths
  - It is written by successfully running install_wrfsi.pl
  - Contains all the environment variable paths
  - Can be used in a later session to reset your SI env paths

- When allowing script install_wrfsi.pl to define your environment (referred to previously as option B) this would the default directory path locations.
  - SOURCE_ROOT one dir level above install_wrfsi.pl
  - INSTALLROOT=SOURCE_ROOT
  - TEMPLATES=INSTALLROOT/templates
  - DATAROOT=INSTALLROOT/domains
  - EXT_DATAROOT=INSTALLROOT/extdata

Installing the Software

4. Check for a successful installation

- There will be status information written to log file SOURCE_ROOT/make_install.log (as well as text written to the screen) during the build.
- Check INSTALLROOT/bin for the executables:
  - gridgen_model.exe
  - grib_prep.exe
  - hinterp.exe
  - vinterp.exe
  - siscan, and
  - staticpost.exe
- Check INSTALLROOT/etc for scripts:
  - window_domain_rt.pl
  - grib_prep.pl
  - wrfprep.pl

Installing the Software

4. Check for a successful installation (con't)

- If an executable is missing from INSTALLROOT/bin
  - cd $SOURCE_ROOT/src
  - Look for the subdirectory used to build each executable
  - cd to the corresponding directory

    (e.g. cd grid for gridgen_model.exe)
  - Run 'make' to manually build the desired executable
  - On success, run 'make install' to move the exe to $INSTALLROOT/bin.
  - If compile errors are found try to debug the software for your system, or ask for help from wrfhelp@ucar.edu.
  - Also, please forward any problems and their solutions, if possible, to wrfhelp@ucar.edu

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Configuring Domains

- Configuring a Domain Overview

  To Define and localize a domain

1. Create a template and domain directory for your domain
2. Copy and edit the wrfsi Fortran namelist, wrfsi.nl, to your liking, including the domain specifications
3. Run localization perl script – window_domain_rt.pl
4. Check for a successful localization

Configuring Domains

1. Create a template and domain directory for your domain

   - Each domain you create needs new my-case subdirectory under TEMPLATES and DATAROOT
     - mkdir $TEMPLATES/”my-case”
     - mkdir $DATAROOT/”my-case”

   - Confirm the values in Fortran namelist, wrfsi.nl located in TEMPLATES/default/wrfsi.nl
     - Replace namelist section “sfcfiles” with the paths to your geographical data, if necessary. E.g.. replace

     Topo_30s = /data/lapb/geog/world_topo_30s with

     Topo_30s = /your/path/to/geog/data/geog/world_topo_30s

Configuring Domains

2. Copy and edit the wrfsi Fortran namelist, wrfsi.nl, to your liking, including the domain specifications
   - cp TEMPLATES/default/wrfsi.nl to TEMPLATES/"my-case"
   - chmod –R u+w my_case
   - cd TEMPLATES/"my-case"
   - Edit wrfsi.nl
     - &project_id section (simulation_name and user_desc)
     - &hgridspec section (sets up horizontal domain)
       - XDIM, YDIM = dimension in E-W and N-S direction, respectively
       - MAP_PROJ_NAME = 'lambert', 'mercator', or 'polar'
       - MOAD_KNOWN_LAT/LON = center latitude (+ N), longitude (+ E)
       - MOAD_STAND_LATS = true latitude1 (lambert and polar), true latitude for lambert (set to +/- 90 for polar)
       - MOAD_STAND_LONS = orientation longitude
       - MOAD_DELTA_X/Y = grid spacing in meters in x and y directions
   - We recommend removing all unedited namelist sections and variables that do not differ from the TEMPLATES/default/wrfsi.nl

Configuring Domains

3. Run localization perl script – window_domain_rt.pl

- Check that your SI environment variables are set configured
- Run INSTALLROOT/etc/window_domain_rt.pl
  - Required flag:
    - -t ‘Directory path to domain subdirectory; for example, TEMPLATES/”my-case”’
    - -w wrfsi (the software package you are localizing for vs. laps)
  - Optional flags:
    - -s, -i, and -d flags will override the environment variables if necessary
    - -c flag reconfigures the entire $MOAD_DATAROOT; ie. removes directories silog, siprd, static, and cdl. Without -c only the static and cdl directories are rewritten.
  - Example command line:

    perl window_domain_rt.pl -w wrfsi -t $TEMPLATES/”my-case”

Configuring Domains

4. Check for a successful localization

- Running ‘window_domain_rt.pl’ will result in one of the following messages.

  success:

  “window_domain_rt complete”

  failure:

  “Lines with error found in localize_domain.log”

  “→ localization incomplete ←”

  “window_domain_rt incomplete”

- Helpful print statements are written from window_domain_rt.pl to MOAD_DATAROOT/silog/localize_domain.log for more detailed information

Configuring Domains

4. Check for a successful localization (con't)

- Common Error conditions:
  - Geog path is not set properly
  - Not enough geog tiles to cover you domain (especially true if you get only one or two of the quarter sphere geog tar files)
  - Perhaps other values in wrfsi.nl are not set properly. Note that "window_domain_rt.pl" will save and copy the static subdirectory (called MOAD_DATAROOT/static_err) in the event of an error for you to check

- The existence of static file indicates success:
  - Check for MOAD_DATAROOT/static/static.wrfsi.d01
  - It is a netCDF file that can be viewed with ncdump or ncBrowse utility

Configuring Domains

4. Check for a successful localization (con't)

- To confirm domain localization generate graphical gmeta images
  - setenv NCARG_ROOT /usr/local/ncarg-4.3.0
  - setenv NCL_COMMAND $NCARG_ROOT/bin/ncl
    - Or, see wrfsi.noaa.gov/gui/faq_ncl

  - cd $INSTALLROOT/graphics/ncl
  - Run generate_images.pl -domain=/wrfsi/domains/Alaska
  - idt /wrfsi/domains/Alaska/static/meta.d01.ncgm

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Configuring Interpolation

- Configuring Interpolation Overview
  - Grib_prep Configuration
  - Wrfprep Set-up

Configuring Interpolation

- grib_prep configuration
  - GRIB Data
    - Acquire GRIB data for WRF's initial and lateral boundary conditions
  - GRIB Decoding
    - A Vtable (variable table) file contains information to extract model data from a GRIB file to initialize WRF
      - Contains a list of variables their levels based on standard GRIB codes; e.g. 11 is temp, 1 is surface level
      - Allows output name re-specification for each variable; e.g. name is skin temperature.
      - Vtable.GFS, Vtable.ETA, etc. are provided
    - Confirm that there is a Vtable for your selected GRIB data file available in EXT_DATAROOT/static/Vtable.{SOURCE} where SOURCE is, e.g. GFS

Configuring Interpolation

- grib_prep configuration (con't)
  - Edit EXT_DATAROOT/static/grib_prep.nl
    - &filetimespec
      - Set start and stop times
      - NOTE: This will be edited automatically if using the wrfsi.pl script to run the system.
    - &gpinput_defs
      - Set frequency of GFS and ETA grid receipt time and typical time delay, in hours, after cycle time, as well as Vtable name

```
SRCNAME = 'GFS', 'ETA'
SRCVTAB = 'GFS', 'ETA"
SRCPATH ='/public/data/grids/gfs/0p5deg/grib',
                  '/public/data/grids/40km_eta/grib'
SRCCYCLE = 3, 3
SRCDELAY = 1, 0
```

Configuring Interpolation

- wrfprep configuration
  - Edit $DATAROOT/my-case/wrfsi.nl (or, $TEMPLATES/my-case/wrfsi.nl if prior to running window_domain_rt.pl)
  - &interp_control
    - PTOP_PA: Top pressure level to consider from input data
    - HINTERP_METHOD
      - 0 = nearest neighbor (not recommended)
      - 1 = 4-point linear
      - 2 = 16-point quadratic
    - INIT_ROOT,
    - LBC_ROOT, and
    - LSM_ROOT: Model source prefixes (e.g. ETA:) of binary data files in EXT_DATAROOT/extprd to use for dynamic data

      (E.g. to run with ETA model and SST for LSM set
      - INIT_ROOT='ETA',
      - LBC_ROOT='ETA' and
      - LSM_ROOT='SST')

Configuring Interpolation

- wrfprep configuration (con't)
  - CONSTANTS_FULL_NAME: Full file names of data located in EXT_DATAROOT/extprd that contain values to be held constant for entire run
  - VERBOSE_LOG: Set to true for more extensive logging
  - LEVELS: List of “full” vertical levels from bottom to top of atmosphere starting at 0 for “ZETA” and starting at 1.0 for “ETAP”
  - OUTPUT_COORD: which vertical coordinate to use. Set to “ZETA” for height-based R-K WRF or “ETAP” for mass version.
  - Its recommend to leave all other settings as they are

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Running

- Running the SI Overview
  - Confirm set up
  - Run grib_prep.pl – for GRIB data pre-processing
  - Run wrfprep.pl – for horizontal, vertical interpolation, and grid staggering
  - Run wrfsi.pl – to run both grib_prep.pl and wrfprep.pl
  - What happens when scripts run
  - Did it run properly
  - Check the output

Running

- Confirm set up
  - Are INSTALLROOT and MOAD_DATAROOT path values set
  - Ensure wrfsi.nl has the correct EXT_DATAROOT path value
  - Ensure you have GFS or ETA GRIB data is available in the specified directory for the user requested time intervals
  - Note recognized GRIB file naming conventions are:
    - FSL: yyjjjhhmmffff
    - NCEP: ???.ThhZ.??????ff.????
    - NCEP: ???_yymmdd_hh_ff
    - And others
    - If your files do not conform to these naming conventions, the grib_prep script will assume every file is a possible match
  - Ensure domain configuration step has been successfully completed

Running

- Run grib_prep.pl
  - grib_prep.pl *manages* the time-series of data to process
  - grib_prep.pl *runs* the Fortran executable grib_prep.exe which loads the Fortran namelist EXT_DATAROOT/static/grib_prep.nl setting all the necessary filenames and values
  - grib_prep.pl to *decodes* and *extracts* GRIB model parameters
  - Output is written to EXT_DATAROOT/extprd
  - Log information is written to EXT_DATAROOT/log
  - While files are being created they are written to EXT_DATAROOT/work/GFS

  - Run e.g.

$INSTALLROOT/etc/grib_prep.pl –s 200508241200 –l 12 –t 6 GFS

$INSTALLROOT/etc/grib_prep.pl –help (for list command options)

Running

- Run wrfprep.pl
  - wrfprep.pl runs the Fortran executables: hinters.exe and vinterp.exe
  - wrfprep.pl uses values set in the Fortran namelist wrfsi.nl section &interp_controls to locate and process the data
  - wrfprep.pl results in interpolating the previously extracted GRIB model parameters to fit the user defined domain.
  - These output files are written to MOAD_DATAROOT/siprd
  - Log files are written to MOAD_DATAROOT/silog for the hinterp and vinterp runs.

  - Run e.g.

$INSTALLROOT/etc/wrfprep.pl –s 200508241200 –f 12

$INSTALLROOT/etc/wrfprep.pl –help (for list of command options)

Running

- Run wrfsi.pl – to run both grib_prep.pl and wrfprep.pl
  - Run script with 4 arguments:
  - YYYYMMDDHH: Year, month, day, and hour UTC of model start time
  - FF: Length of forecast to be produce in hours
  - Source: GFS or ETA
  - Domain Name: A name for this run, my-case
  - Example:
    - $INSTALLROOT/etc/wrfsi.pl 2005082412 24 ETA myrun
  - You can optionally provide the dataroot and installroot using command line options -d and -i.
    - wrfsi.pl -d /my/dataroot -i /my/installroot 2005082412 24 ETA my-case

Running

- What happens when wrfsi.pl runs?
  - This script edits $MOAD_DATAROOT/static/wrfsi.nl for run time initialization and model source
  - This script calls grib_prep.pl which runs grib_prep.exe
  - This script calls wrfprep.pl which runs hinterp.exe and vinterp.exe
  - Output from script is written to MOAD_DATAROOT/siprd
  - A log file is written to EXT_DATAROOT/log for the grib_prep run
  - A log file is written to MOAD_DATAROOT/silog for the hinterp and vinterp runs.

Running

- Did it run properly?
  - Check for output in MOAD_DATAROOT/siprd
    - From previous run example, we should have:
      - wrf_input.global.metadata
      - wrf_input.d01.2005-08-24_12:00:00
      - wrf_input.d01.2005-08-24-15:00:00
      - wrf_input.d01.2005-08-24-18:00:00
      - ...
      - wrf_input.d01.2005-08-25-12:00:00
    - Frequency of output files is set in filetimespec portion of wrfsi.nl
  - If correct files are not present, check the log files for information to determine what is needed.
    - Consider rerunning wrfprep.pl with –o (offset time) –2 (previous 2 hrs, for example)

Running

- Checking the output
  - Use the IDL routines in the SOURCE_ROOT/util directory to read the hinterp/vinterp output files.
  - Use the INSTALLROOT/bin/siscan program to dump a summary of file contents
    - siscan {file}
- Other Notes
  - Each executable can be run directly without the use of any scripts by simply setting the $MOAD_DATAROOT environment variable and ensuring the namelist is correct
  - Consider using the WRFSI graphical user interface (GUI) to accomplish all of the SI processes.
  - See wrfsi.noaa.gov for additional instructions

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

Initializing the WRF Model

- Edit the WRF namelist.input file to make it consistent with the WRFSI domain configuration
  - ztop, dx, dy, io_form, etc.
- Run the WRF real.exe routine using the WRFSI output files (wrf_input.*) as input
- You can then run the model!
- See Dave Gill's presentation for more details.

Overview

- SI Capabilities
- Source Code
- System Requirements
- Installing the Software
- Configuring Domains
- Configuring Interpolation
- Running
- Initializing the WRF Model
- Summary

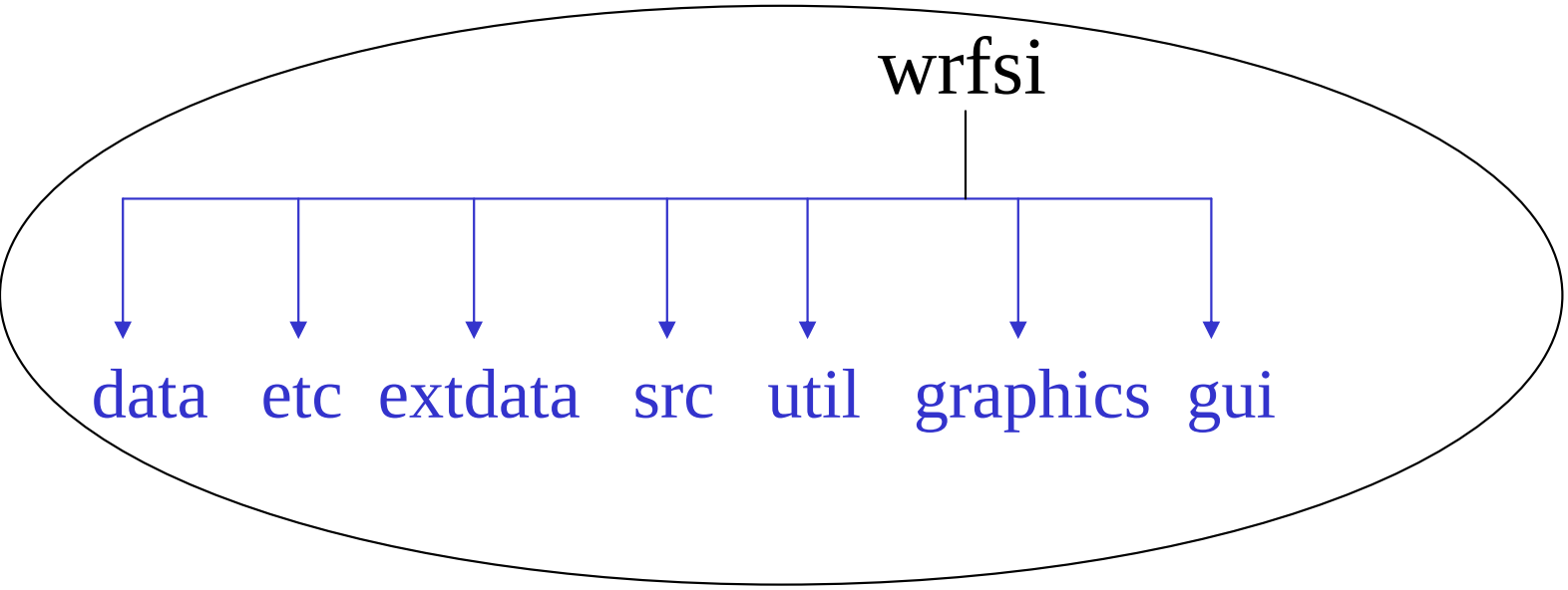
Summary

- Setting up and running the WRFSI is done by:
- 1) Building the software
- 2) Configuring your domain
  - Domain configuration is easy with the use of templates and localization scripts
- 3) Running the grib_prep.pl and wrfprep.pl scripts (or wrfsi.pl script)
  - The SI system is flexible enough to run each component separately

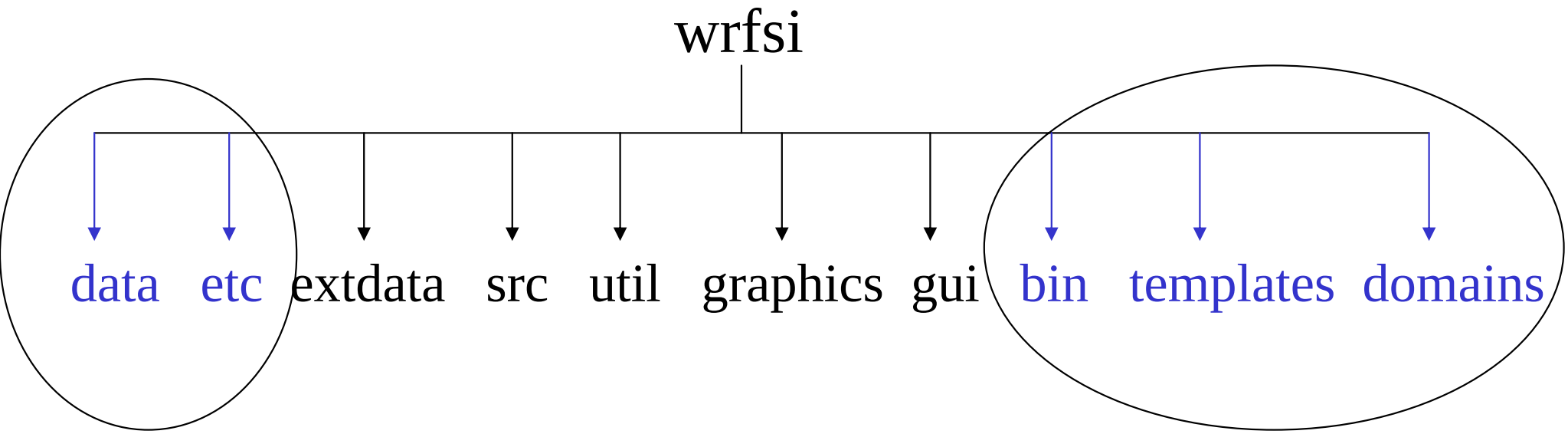
- The WRFSI development at FSL is complete and operational.
  - NCAR/MMM is rewriting gridgen_model and hinterp to be optimized and parallelized.
  - Bug fixes and minor enhancements will be done as resources permit
  - We welcome feedback, bug reports, etc.

wrfsi – Directory Structure

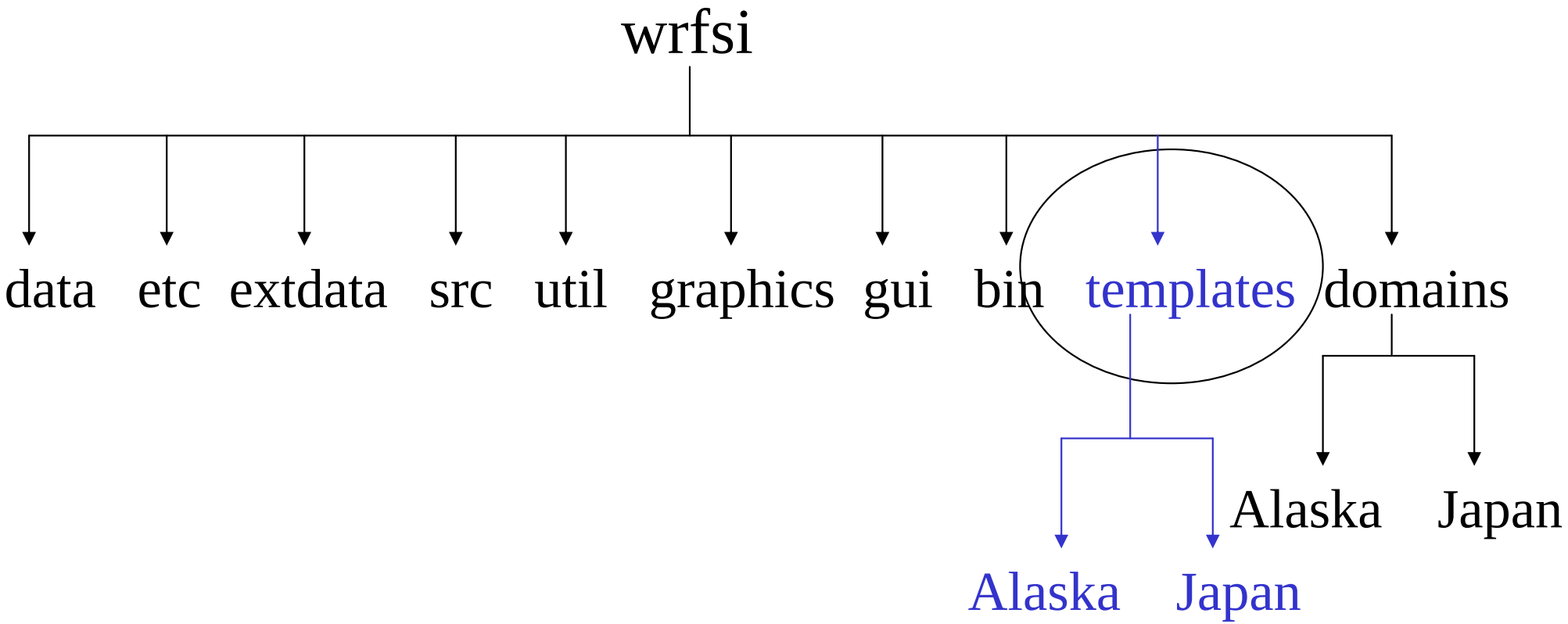
Environment variables, indicated with circles, can be part of SOURCE_ROOT, or located *anywhere* on your system.



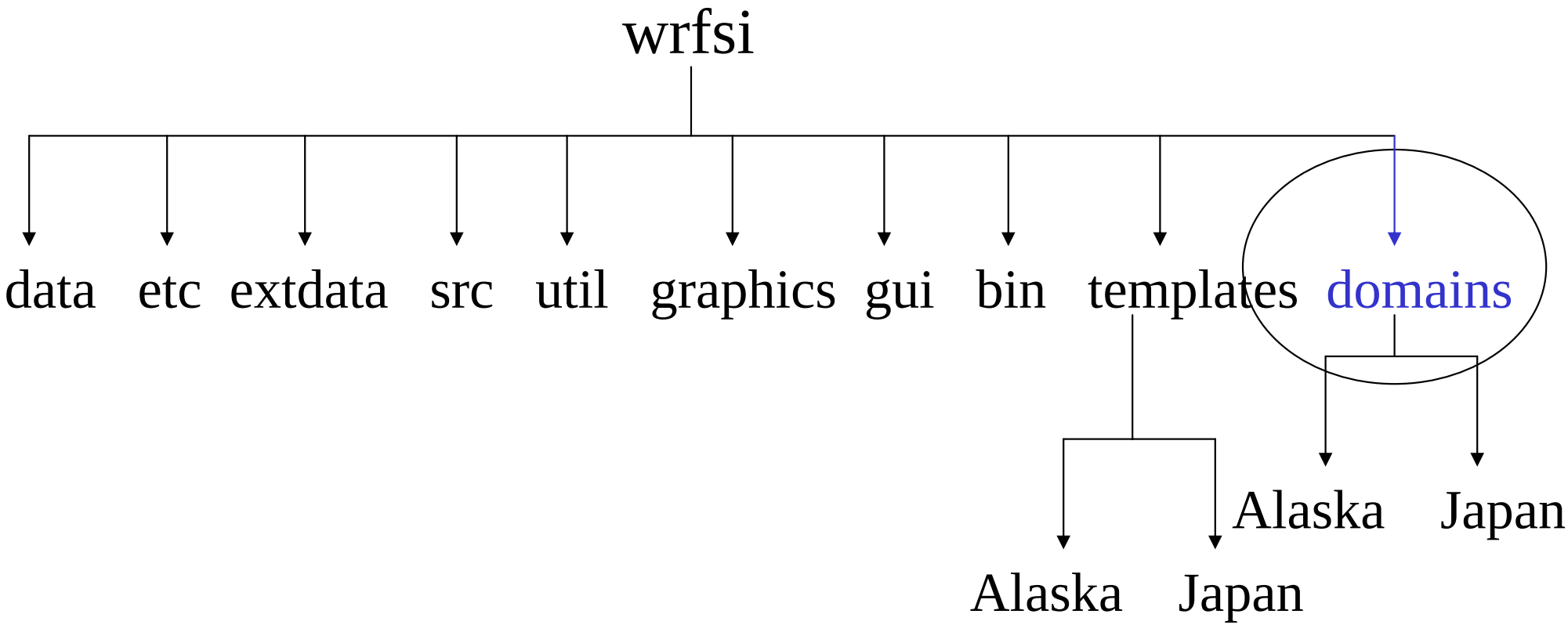
SOURCE_ROOT



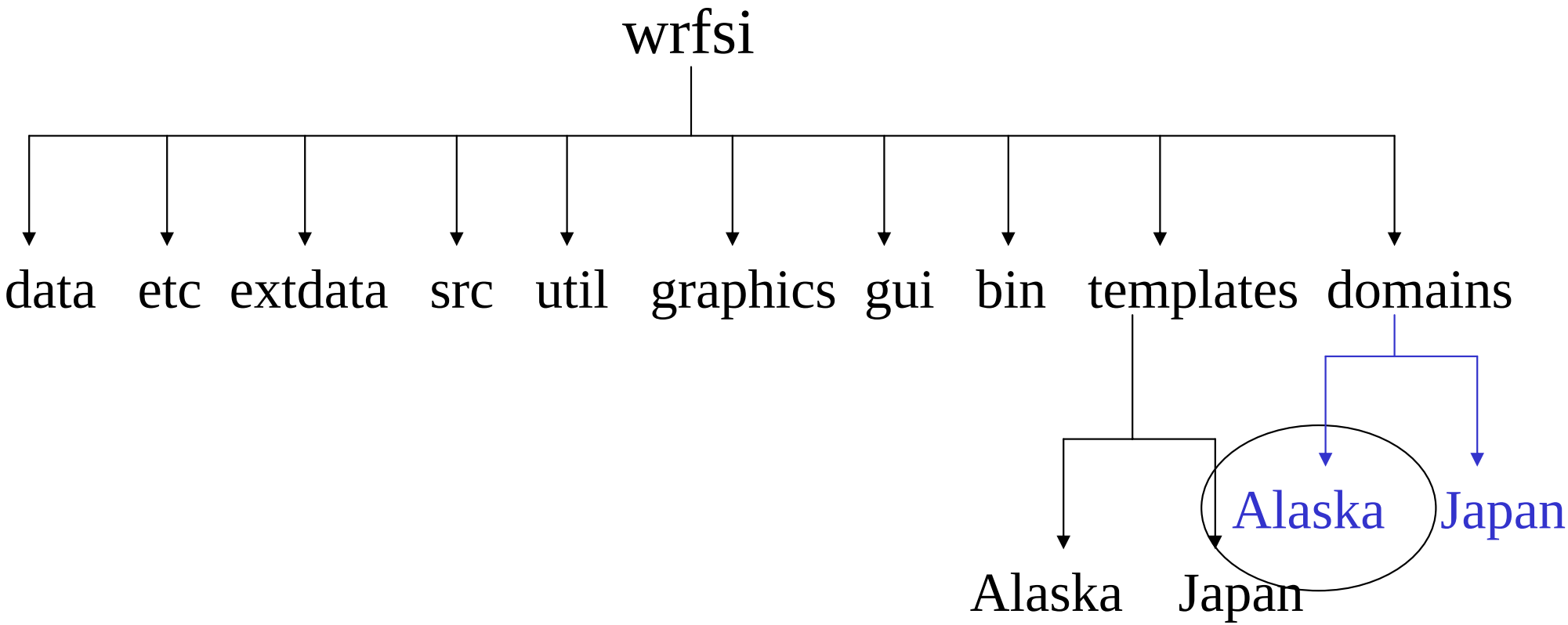
INSTALLROOT


wrfsi
data
etc
extdata
src
util
graphics
gui
bin
templates
domains
Alaska
Japan
Alaska
Japan

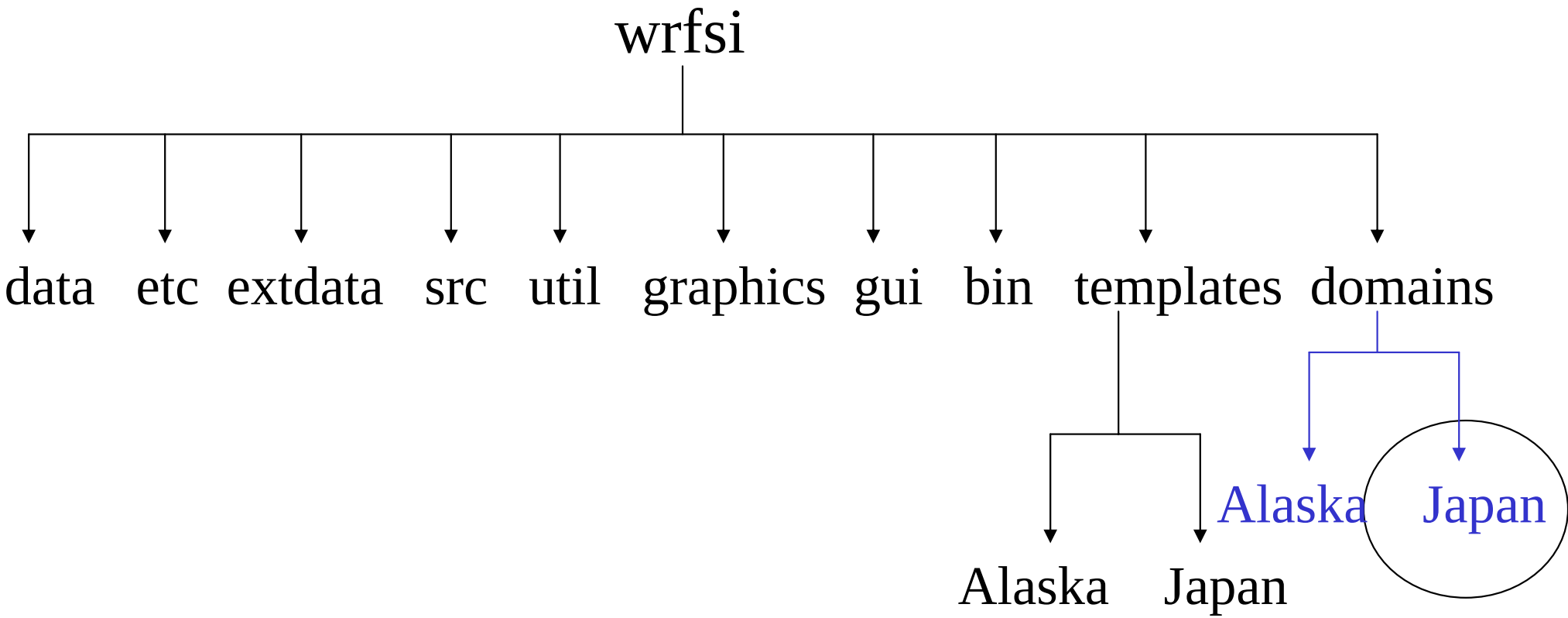
TEMPLATES


wrfsi
data
etc
extdata
src
util
graphics
gui
bin
templates
domains
Alaska
Japan
Alaska
Japan

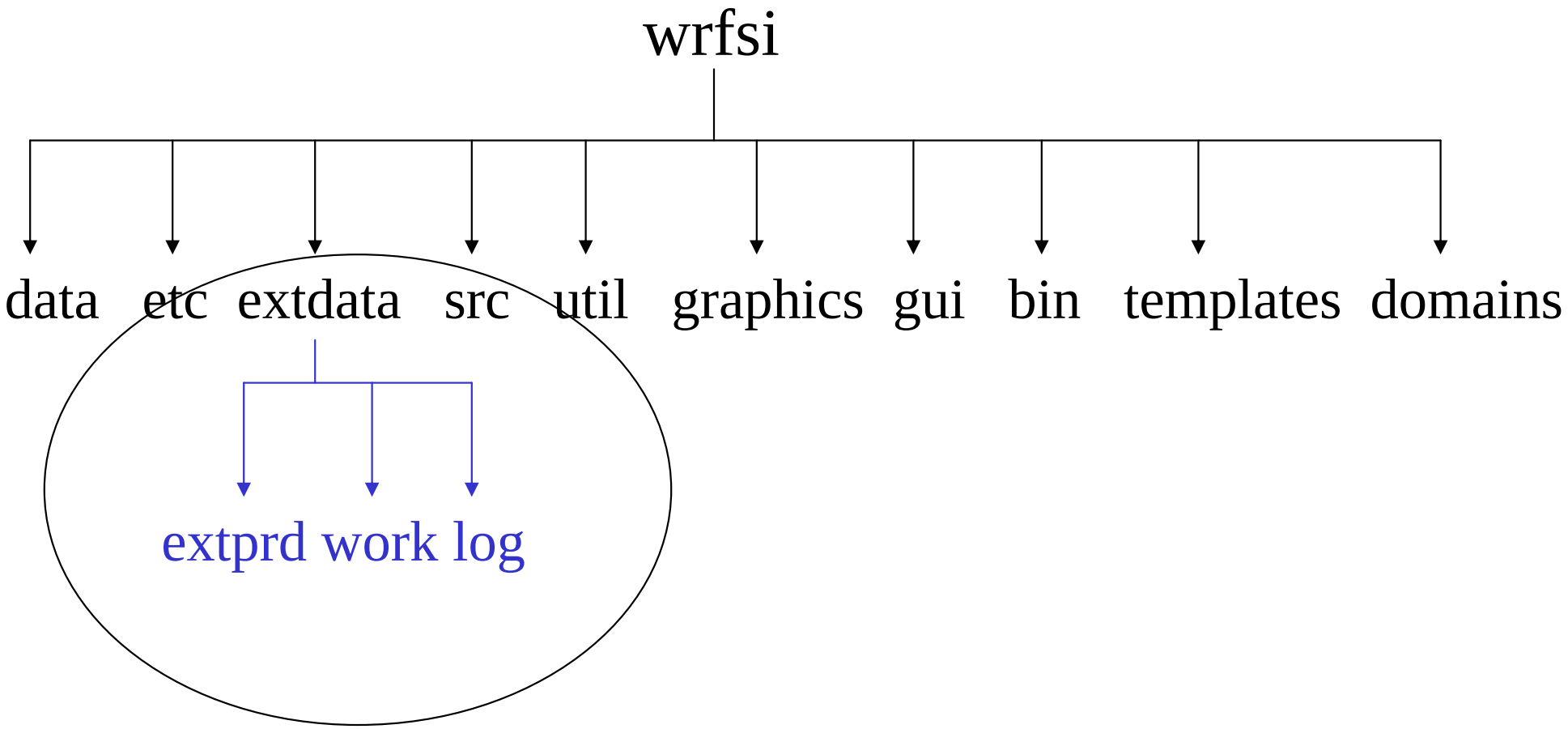
DATAROOT



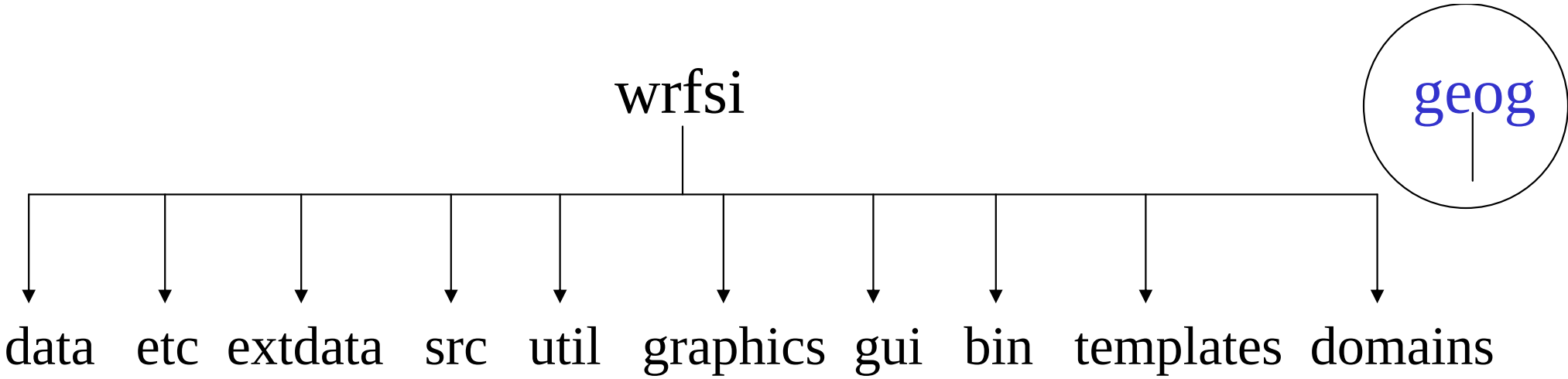
MOAD_DATAROOT



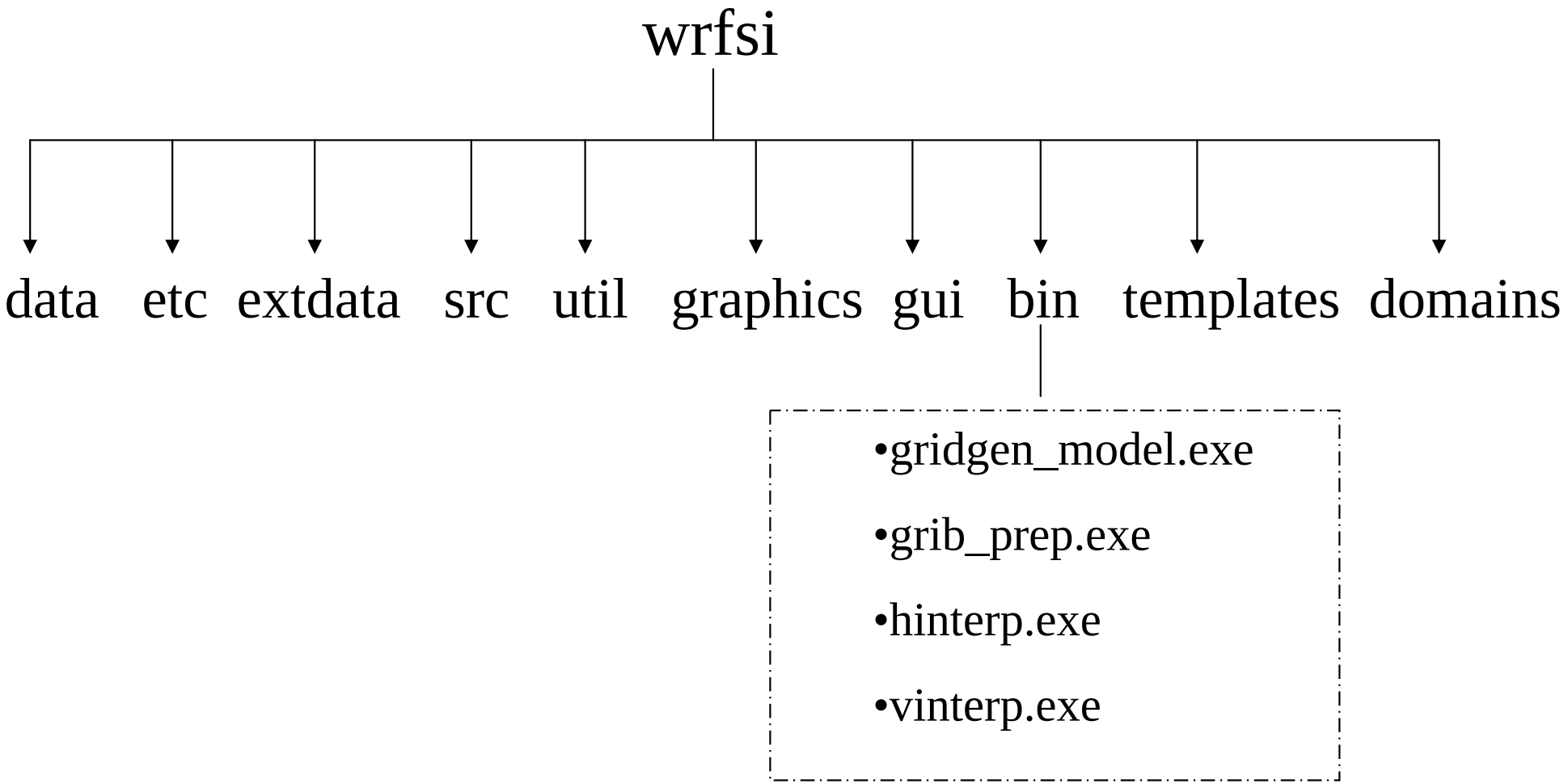
MOAD_DATAROOT



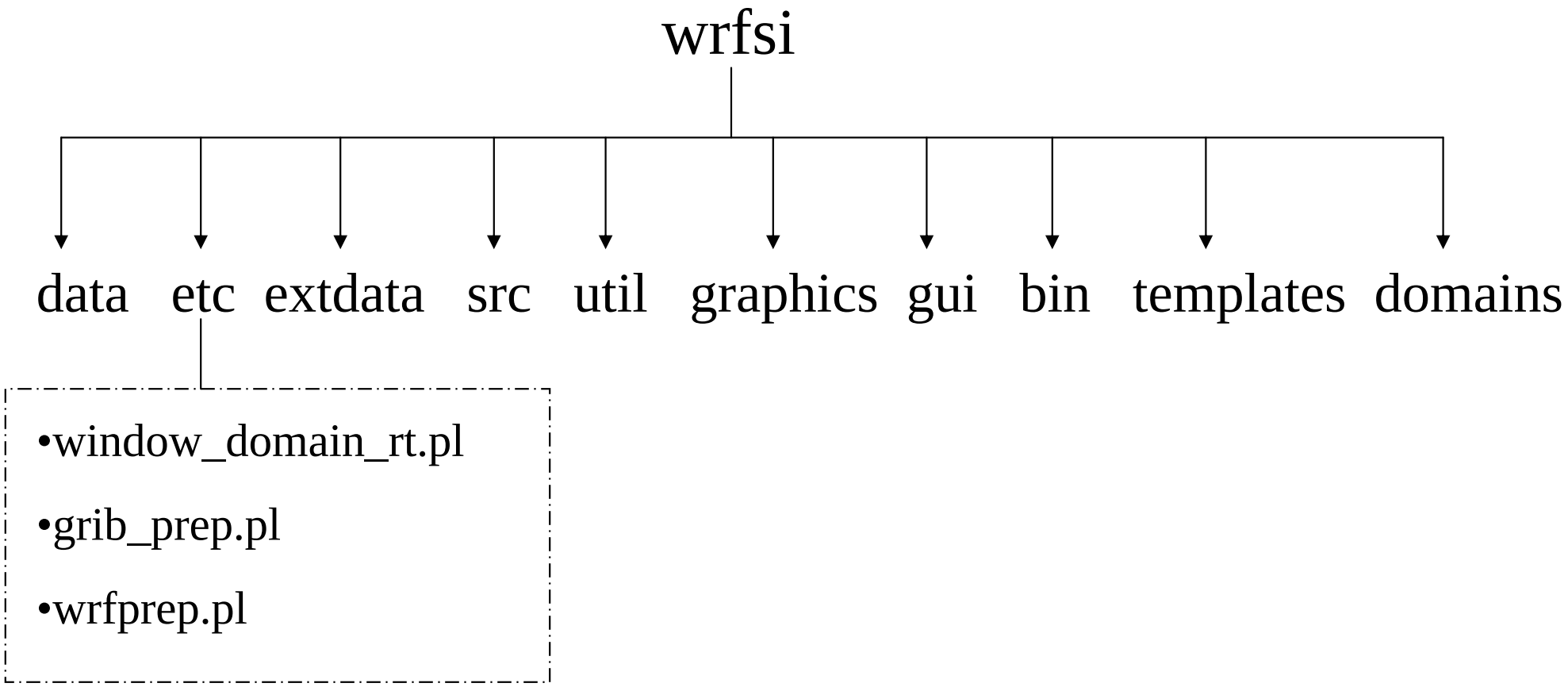
EXT_DATAROOT



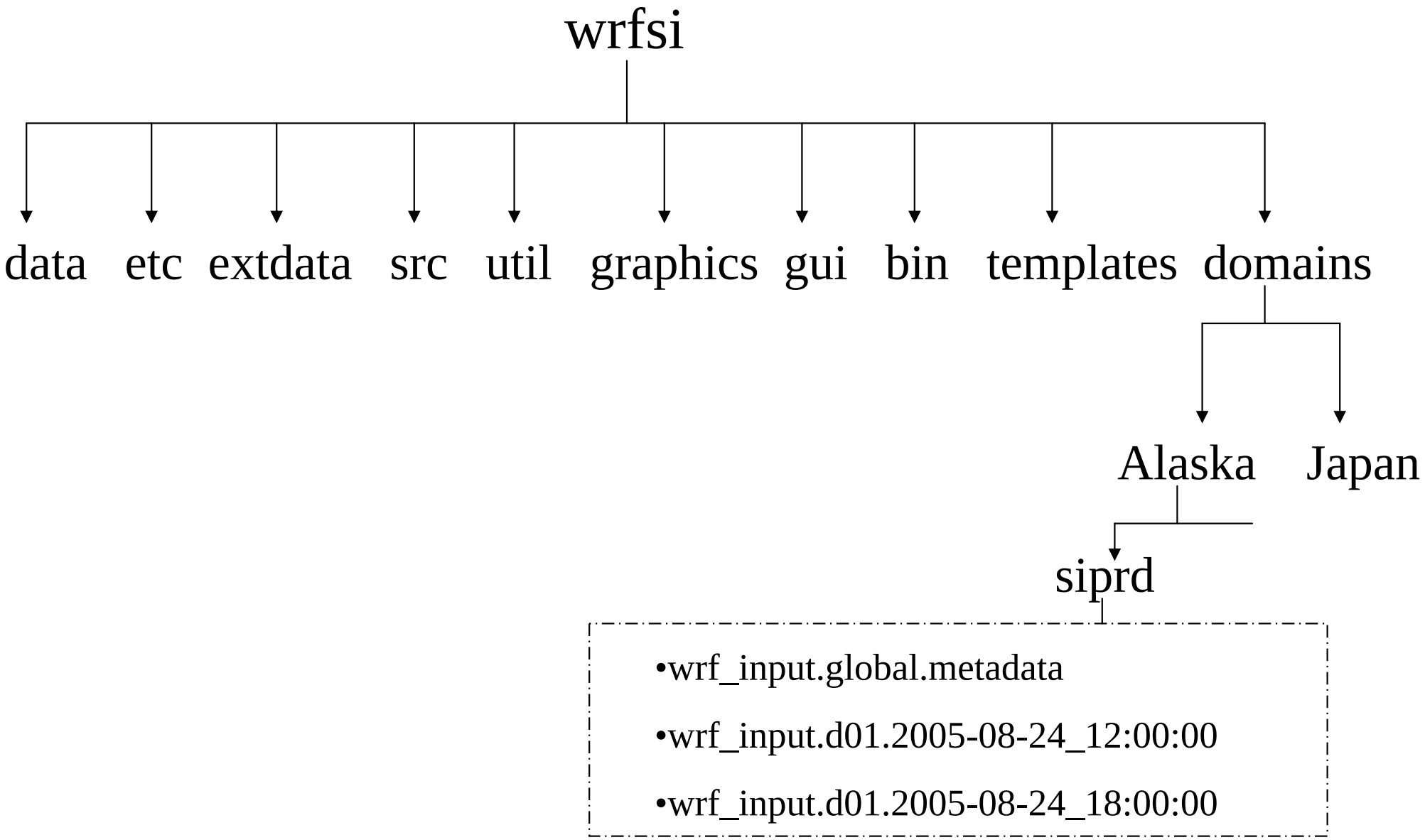
GEOG_DATAROOT



Look for Fortran executables



Look for Perl scripts



Look for input to WRF model