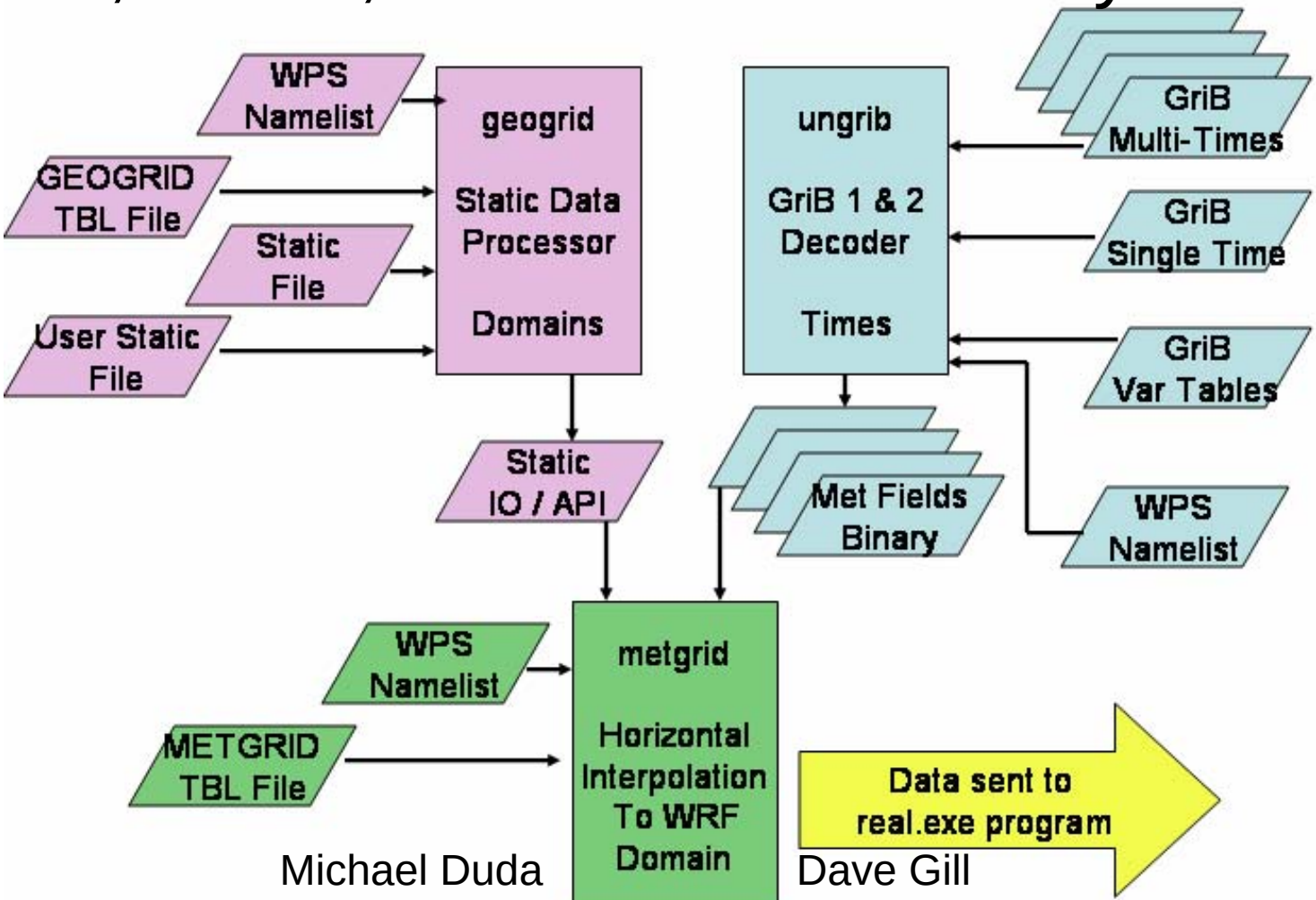
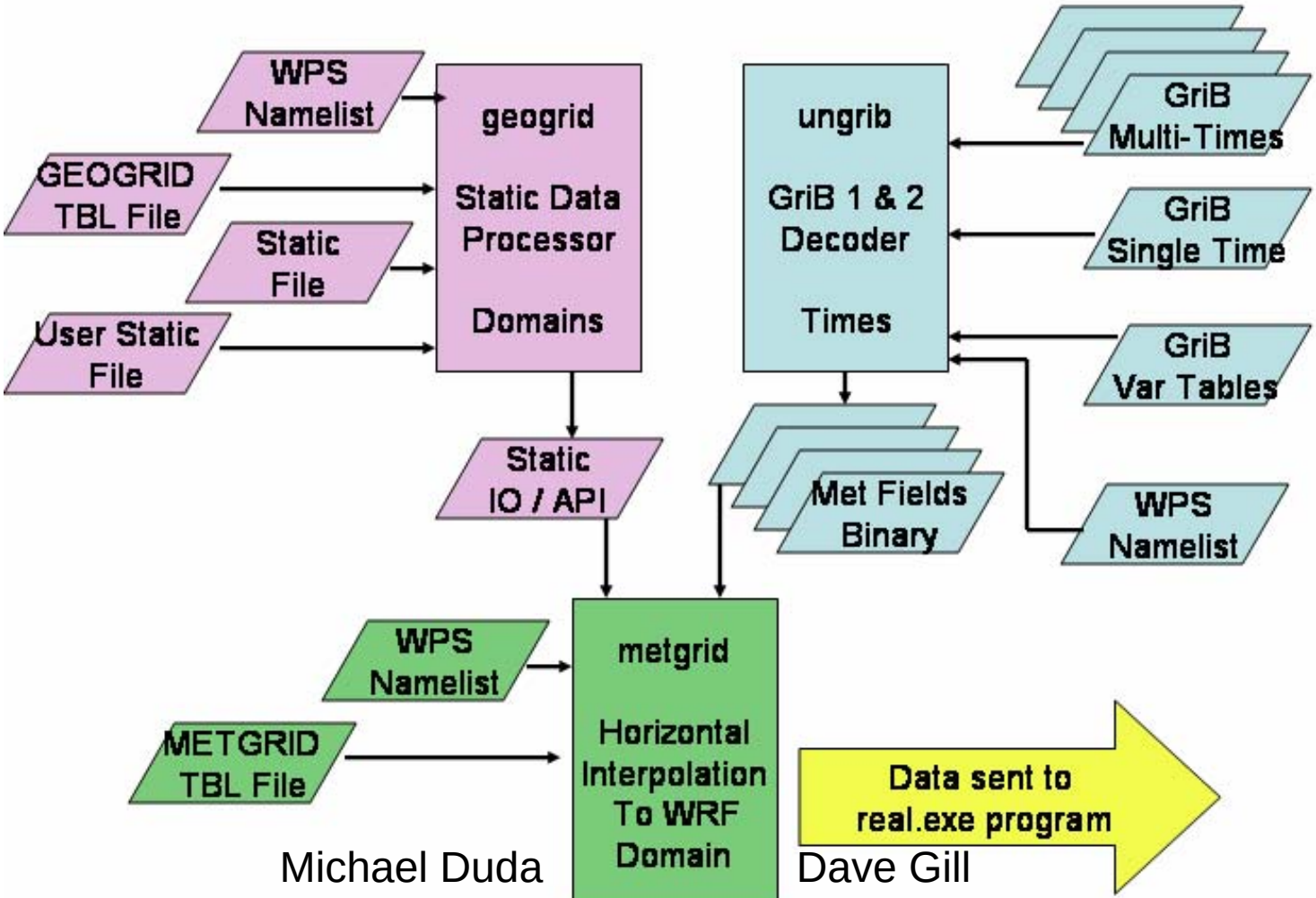
# A Package to Produce WRF Initial, Lower, and Lateral Boundary Conditions




Michael Duda
James Bresch

Dave Gill
Wei Wang
Kevin Manning
Jordan Powers
Jimy Dudhia

# WRF Preprocessing System
# WPS

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# WRF Preprocessing System Overview

- Motivation
- Design Requirements
- Specifics
  - Static Data - *geogrid*
  - GriB Decoder - *ungrib*
  - Horizontal Interpolator - *metgrid*
  - real.exe
- Examples
- Release Schedule

# WRF Preprocessing System Overview
# Motivation – Problems with SI

- User related
  - Concerns for ease of use
  - Medium domains hampered by timing performance and memory constraints, large domains not possible
- Developer related
  - Difficulty in expanding existing capabilities
  - Separate programs for ARW and NMM
  - Too many data formats, too many intermediate files

# WRF Preprocessing System Overview
# Motivation (*geogrid* timings)

| Grid Name | # Doms | Sizes | DX | SI | WPS |
|---|---|---|---|---|---|
| 44 | 2 | 300x237<br>253x253 | 15 km<br>5 km | 24 min | 30 sec |
| 92 | 1 | 354x222 | 15 km | 23 min | 22 sec |
| AMPS | 6 | Various | 60 km<br>→<br>2.22 km | 210 min | 2 min |

# WRF Preprocessing System Overview

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  - Horizontal Interpolator
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# WRF Preprocessing System Overview
# Design Requirements

Contributions provided by

- Keith Brewster (University of Oklahoma)
- Sue Chen (Naval Research Laboratory)
- Bill Gallus (University of Iowa)
- Paula McCaslin (ESRL/GSD, NOAA)
- Matt Pyle (National Centers for Environmental Prediction, NOAA)
- Brent Shaw (Weather Systems, Inc.)

# WRF Preprocessing System Overview
# Design Requirements

1) User impact
   a) Easy to install and use
   b) Documentation: user level, on-line tutorial
   c) Suitable for both research and operations
   d) Portable
   e) Flexible for user modifications

# WRF Preprocessing System Overview
# Design Requirements

2) Performance
   a) Efficient
   b) Scalable to large domains
   c) Minimal intermediate files

# WRF Preprocessing System Overview
# Design Requirements

3) Dynamical Cores
   a) Support rectangular and diamond staggers
   b) Nesting, moving nests
   c) Generic utilities
   d) Isolate core-specifics, developer responsible

# WRF Preprocessing System Overview Design Requirements

4) Projections
   a) ARW Real: Lambert, polar, Mercator
   b) NMM Real: Rotated lat/lon
   c) Input: cylindrical equidistant, Gaussian, recognized projections
   d) Global latitude/longitude and channel capabilities to be added this year

# WRF Preprocessing System Overview
# Design Requirements

5) Data Ingest
   a) User-supplied static files
   b) Increase GriB sources
   c) Tiled GriB
   d) Pressure-level and native vertical coordinate

# WRF Preprocessing System Overview
# Design Requirements

6) Needs from Larger WRF Community
   a) LSM (simplify adding new fields)
   b) Chemistry (ingest gridded data)
   c) Climate (process many time periods)
   d) Real-time (timing performance)
   e) TC bogus initialization (later this year)

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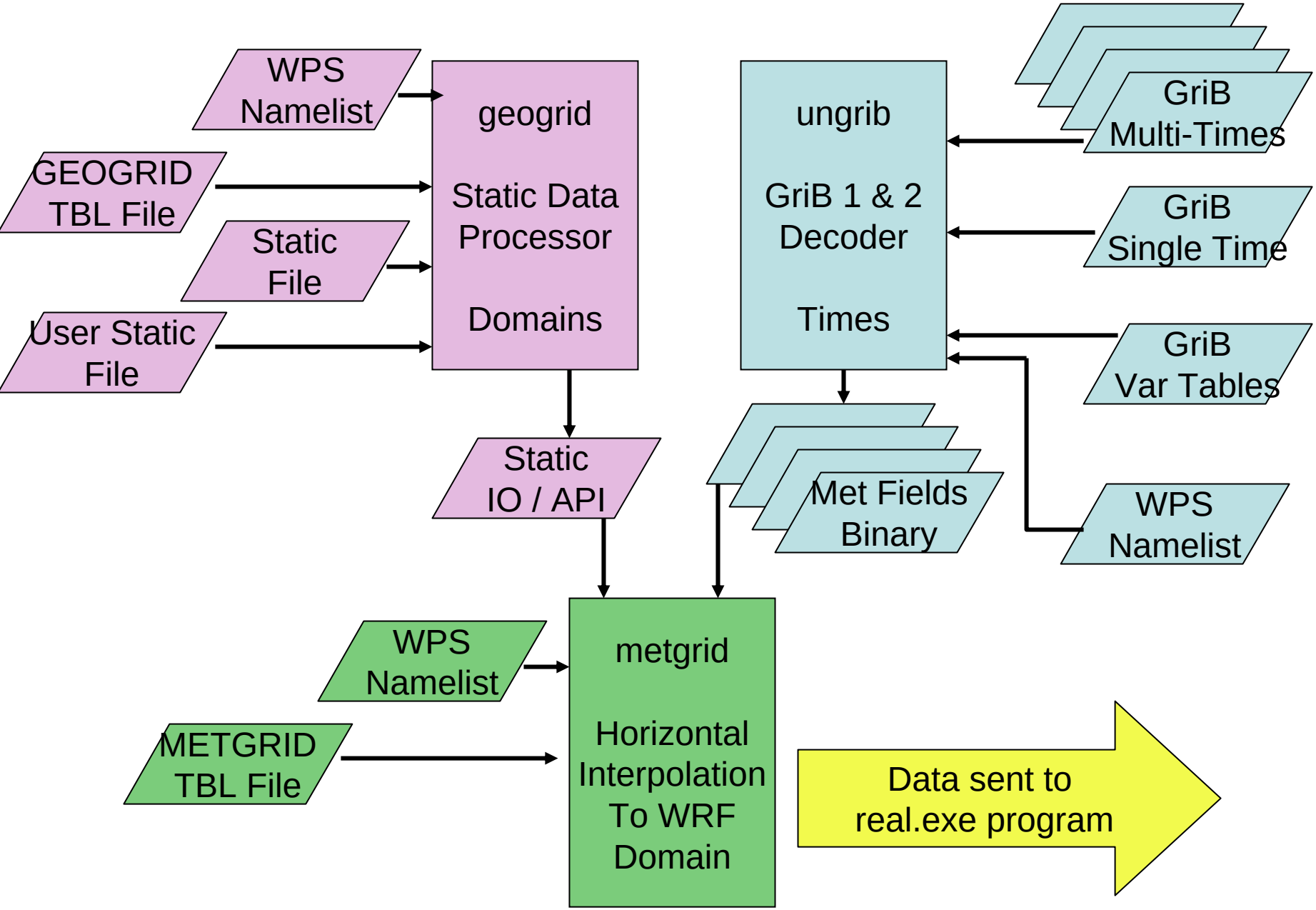
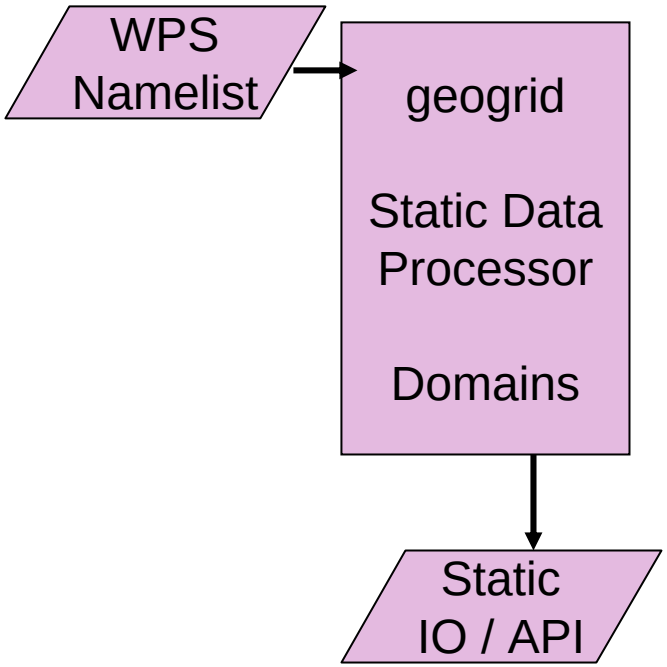
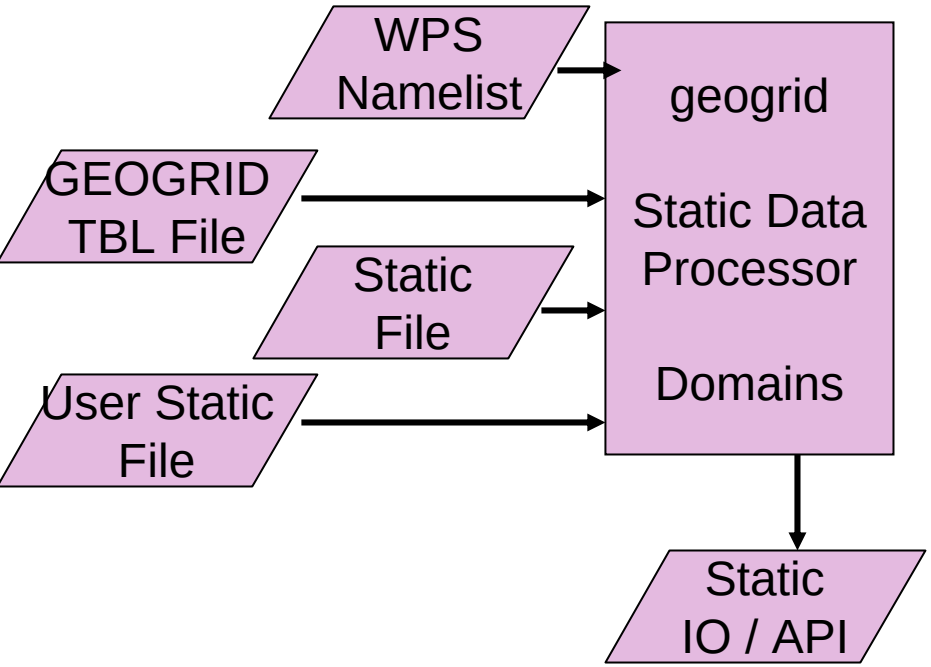
# WRF Preprocessing System Overview




WPS
Namelist
geogrid
Static Data
Processor
Domains
Static
IO / API


WPS
Namelist
GEOGRID
TBL File
Static
File
User Static
File
geogrid
Static Data
Processor
Domains
Static
IO / API

# WRF Preprocessing System Overview
# Static Data - *geogrid*

- Single program for ARW and NMM
- Serial and DM parallel
- Run-time options: namelist and table file
- General programming, specifics in input files
- Optional user-supplied static-data input file(s)
- Multiple interpolator sequence, resolution tied to interpolator, masks, staggerings, input priorities
- WRF IO/API compatible

# WRF Preprocessing System Overview
# Static Data - *geogrid*

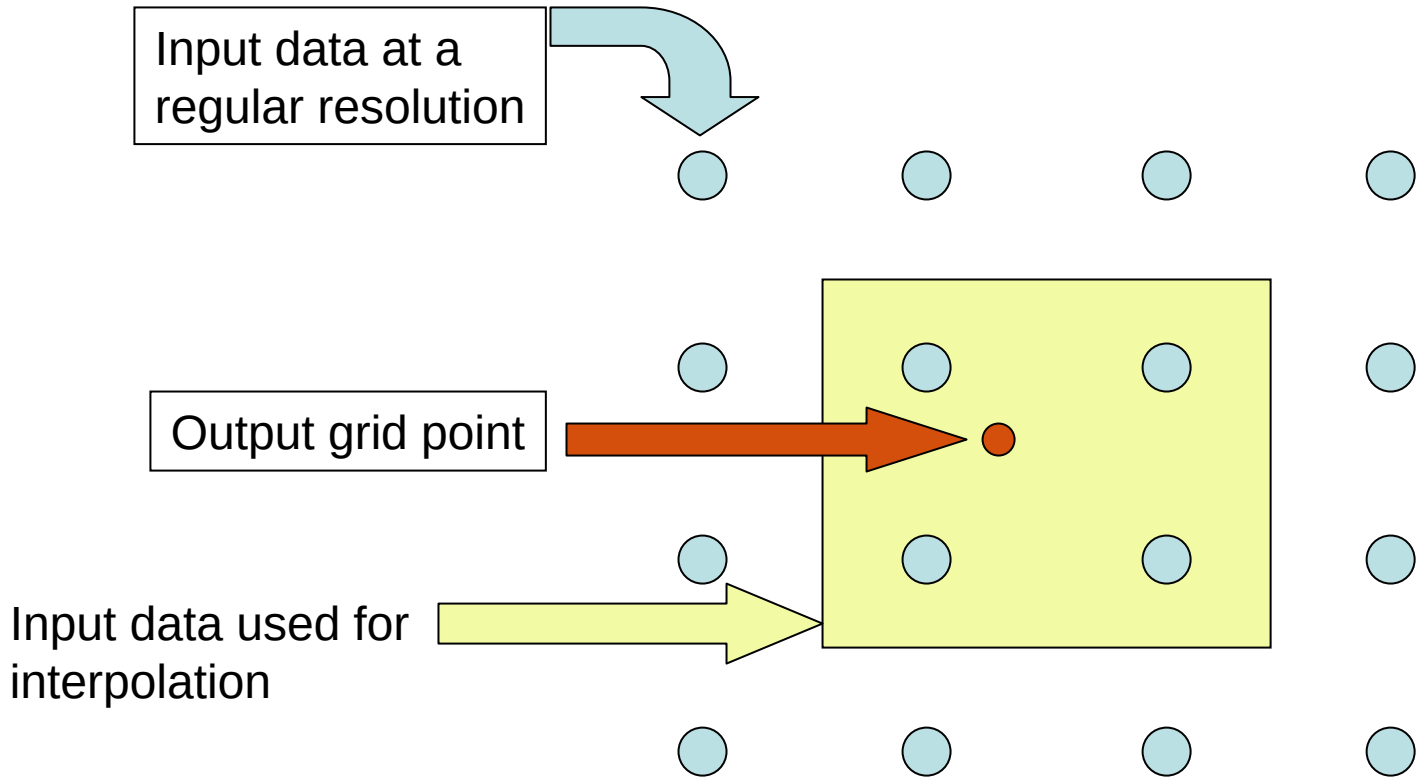
- Static data may either be projected or regular lat/lon
- Handles (i,j) ⇔ (lat,lon) for polar stereographic, Mercator, Lambert conformal, rotated lat/lon
- (lat,lon) ➔ (i,j) for Gaussian

# WRF Preprocessing System Overview
# Static Data - *geogrid*

- Interpolation from raw input data to target location at the correct stagger for the variable
- No intervening domains
- Interpolation schemes available for both static and meteorological fields
  - 4 point (16 point) interpolation
  - 4 point (16 point) average for masked fields
  - Nearest neighbor
  - Model grid cell average, can be masked
  - Search for closest of correct mask

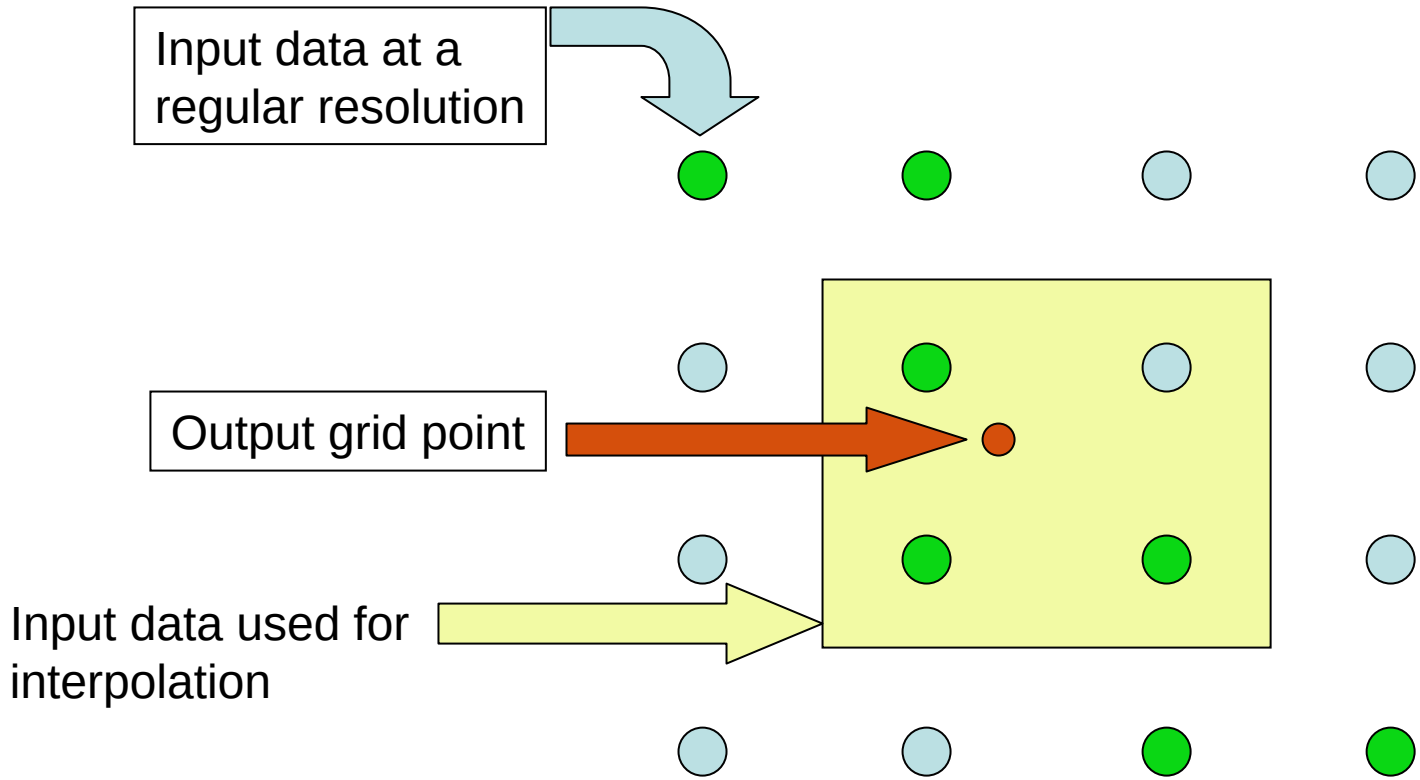
# Horizontal: Four Point (or 16 Point) Interpolation

Assumes that the input resolution is coarser than the output resolution
Useful for continuous fields
Requires all input values are the same mask as the target output
Bi-linear (or overlapping quadratic) interpolation



# Horizontal: Four Point (or 16 Point) Average

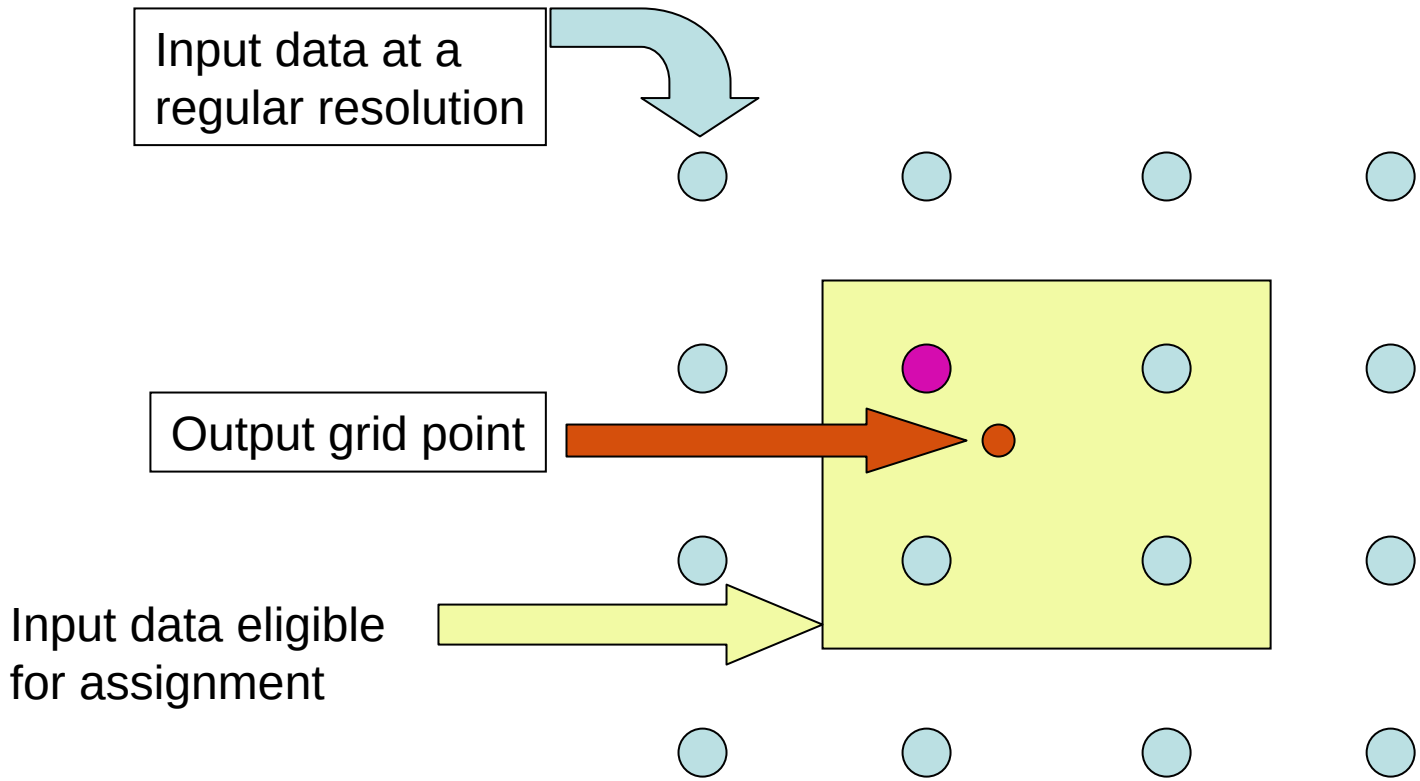
Assumes that the input resolution is coarser than the output resolution
Useful for continuous fields
Assumes target and input may have different masks
Average of correctly masked input points




If the output target point is masked similarly to the “green” input values, then the average of the three surrounding “green” points would be used.

# Horizontal: Nearest Neighbor

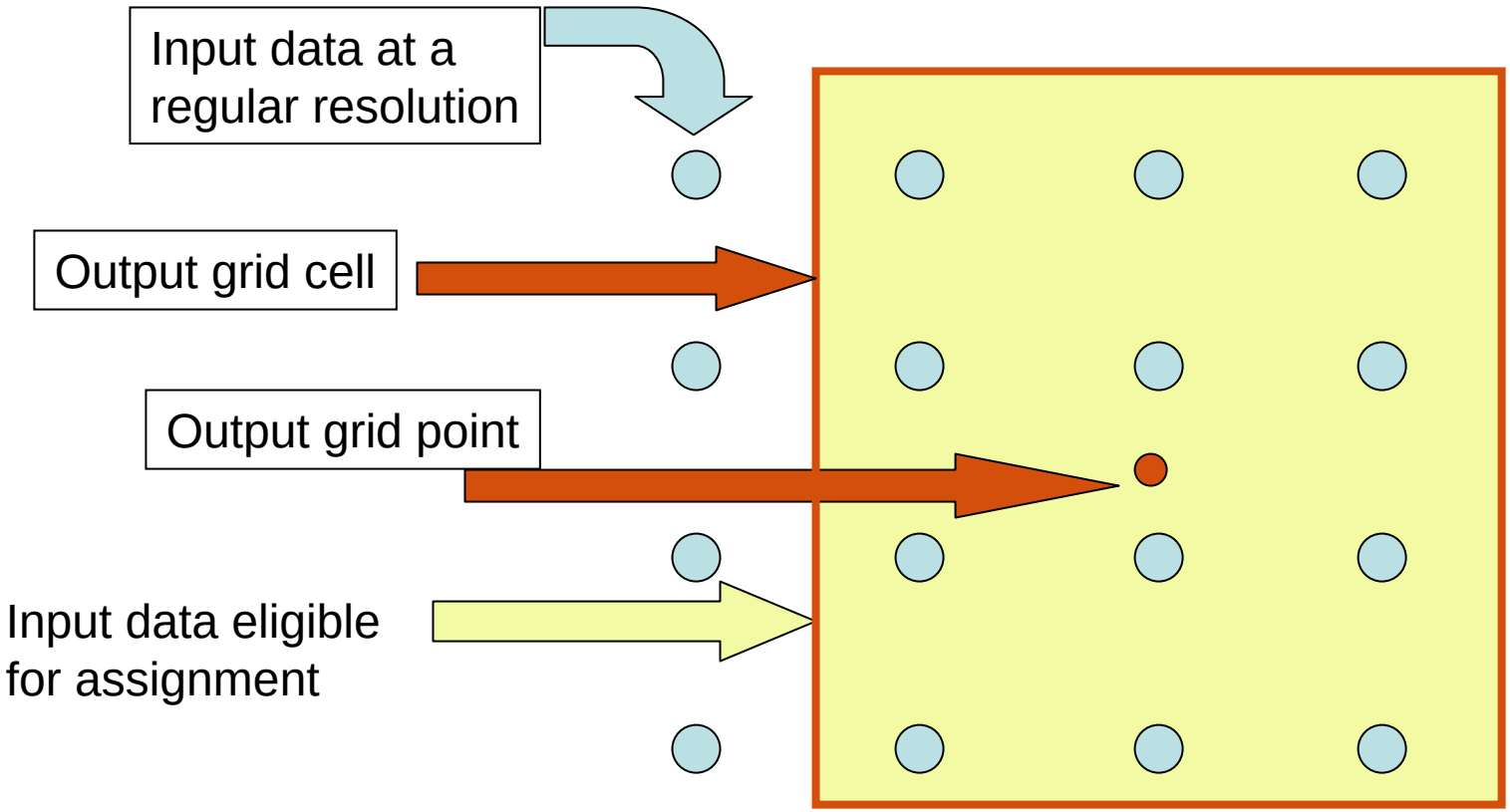
Assumes that the input resolution is coarser than the output resolution
Useful for discreet fields
Assumes target defines input mask
Selects closest of surrounding values




Since the output grid point is closest to the “purple” input grid point, the target value is assigned as that of the “purple” cell.

# Horizontal: Cell Average (Special)

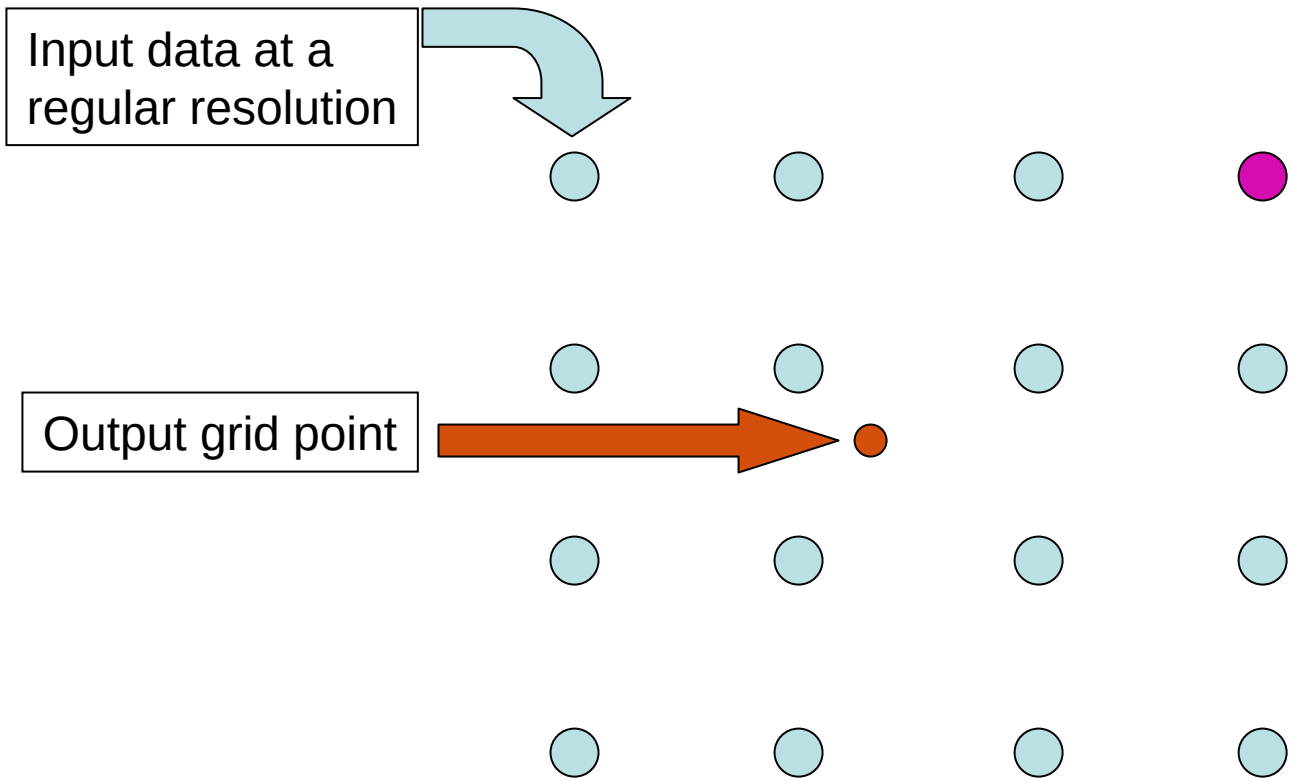
Assumes that the input resolution is finer than the output resolution
Useful for categorical or conserved fields
Assumes target defines input mask
Selects all values within single target cell




Either the average or the dominant value of the input points is assigned to the single coarser target grid point, all input within the target cell

# Horizontal: Search

Useful for masked fields
Assumes target defines input mask
Selects closest of suitable type, can be STREAKY

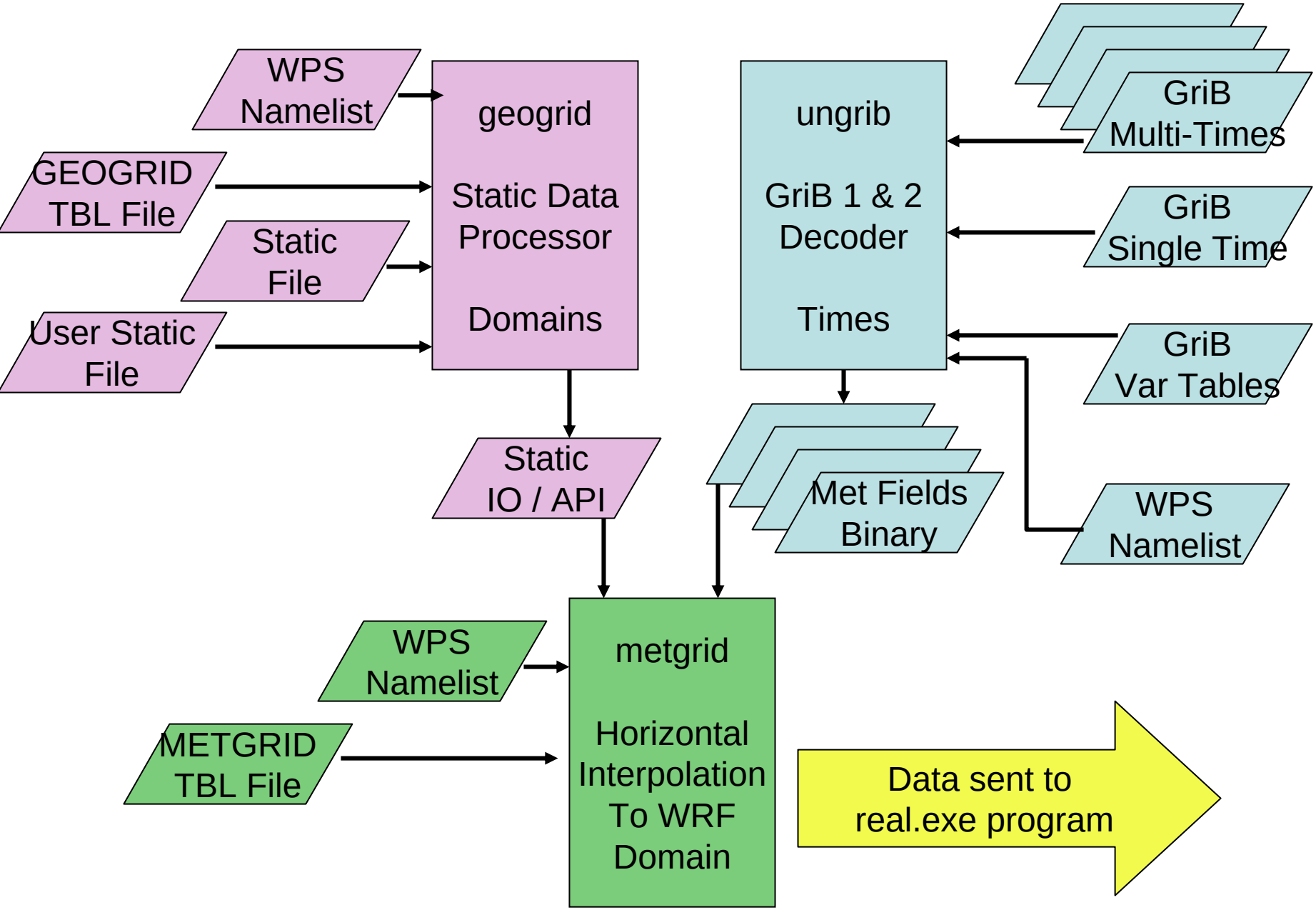


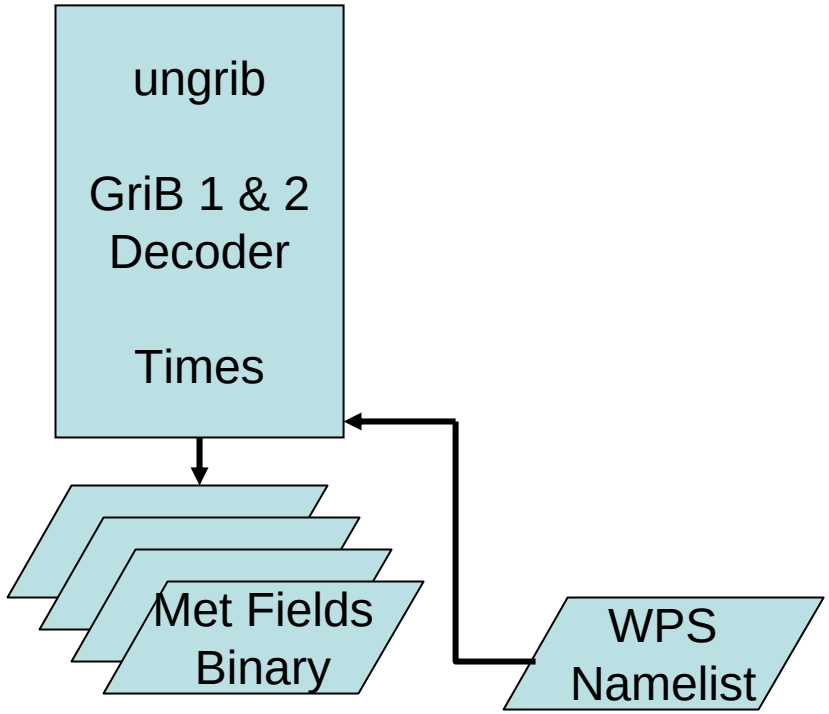

Since the output grid point is closest to the masked “purple” input grid point, the target value is assigned as that of the “purple” cell.

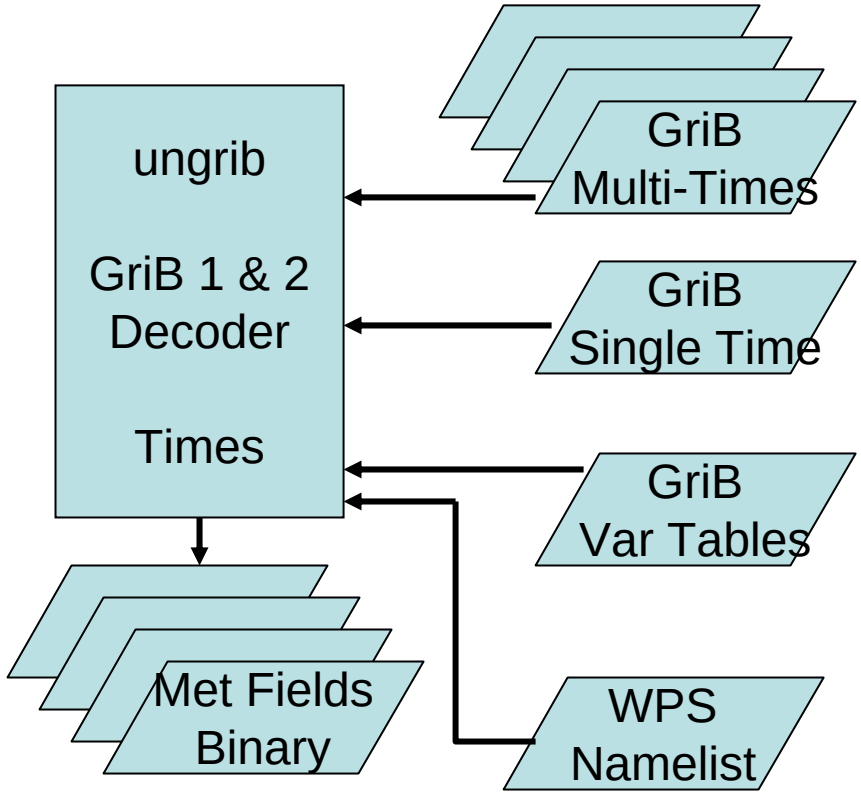
# WRF Preprocessing System Overview

- Motivation
- Design Requirements
- Specifics
  - Static Data
  - GriB Decoder - *ungrib*
  - Horizontal Interpolator
  - real.exe
- Examples
- Release Schedule

# WRF Preprocessing System Overview




ungrib
GriB 1 & 2
Decoder
Times
Met Fields
Binary
WPS
Namelist


ungrib
GriB 1 & 2 Decoder
Times
GriB Multi-Times
GriB Single Time
GriB Var Tables
WPS Namelist
Met Fields Binary

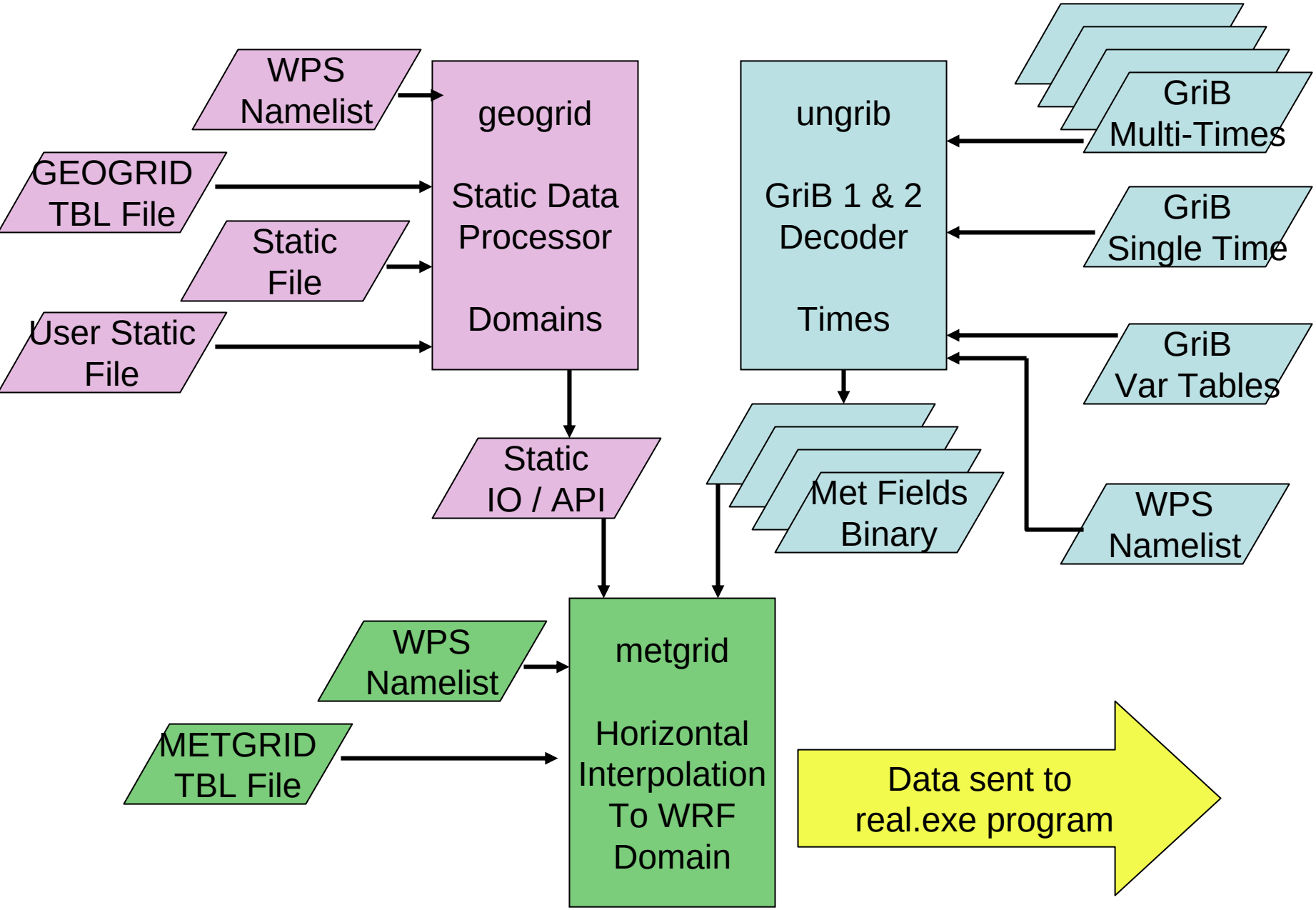
# WRF Preprocessing System Overview
# GriB Decoder - *ungrib*

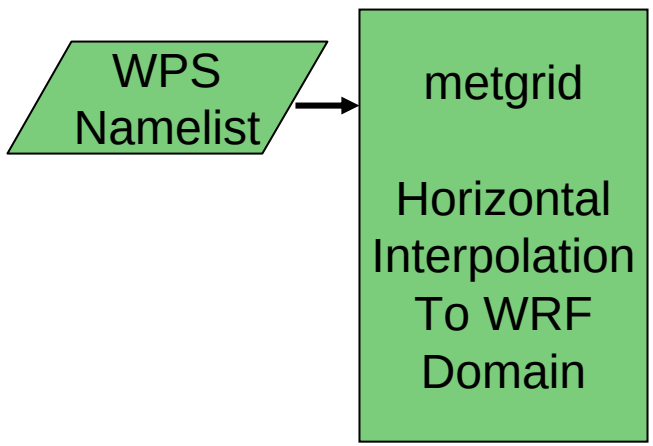
- GriB1 and GriB2
- Pressure and native vertical coordinate
- External jasper library (for compression) required for GriB2
- Run-time options through namelist and Vtables
- Backward compatible (also writes MM5 and SI decoded GriB)

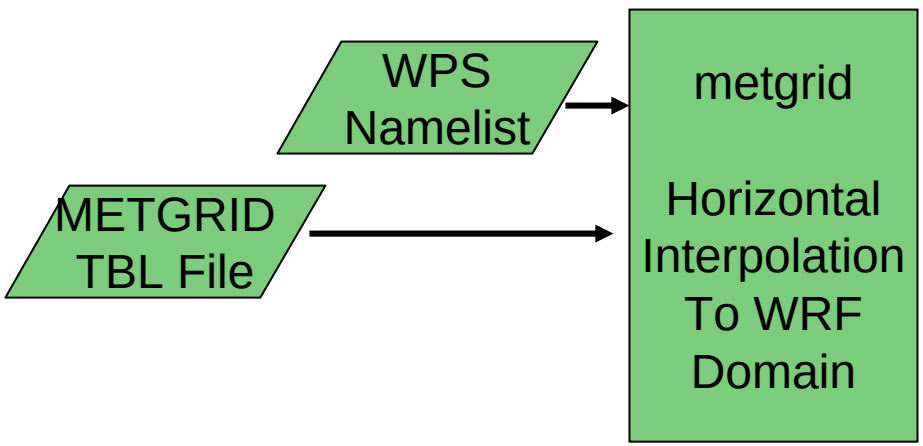
# WRF Preprocessing System Overview

- Motivation
- Design Requirements
- Specifics
  - Static Data
  - GriB Decoder
  - Meteo Fields - *metgrid*
  - real.exe
- Examples
- Release Schedule

# WRF Preprocessing System Overview




WPS
Namelist
metgrid
Horizontal
Interpolation
To WRF
Domain

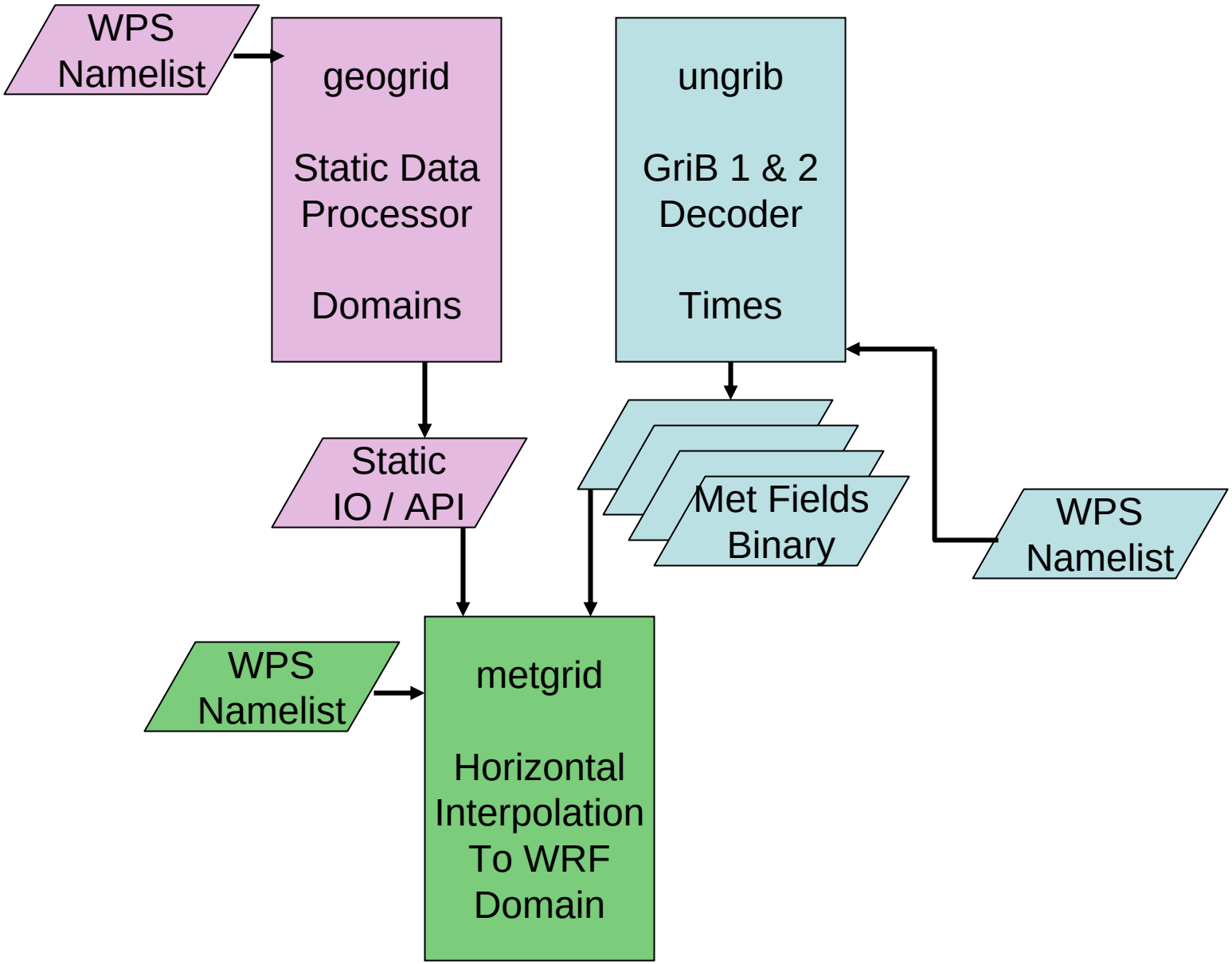

WPS
Namelist
METGRID
TBL File
metgrid
Horizontal
Interpolation
To WRF
Domain

# WRF Preprocessing System Overview
# Horizontal Interpolator - *metgrid*

- Single program for ARW and NMM
- Serial and DM parallel
- Run-time options: namelist and table file
- General programming, specifics in input files (exception: needs to know about U and V for map-projection wind rotation)

# WRF Preprocessing System Overview
# Horizontal Interpolator - *metgrid*

- Multiple interpolator sequence, masks, input priorities
- WRF IO/API compatible
- Small-memory roll-over to disk
- Backward compatible (also reads MM5 and SI decoded GriB)


WPS
Namelist
geogrid
Static Data
Processor
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ungrib
GriB 1 & 2
Decoder
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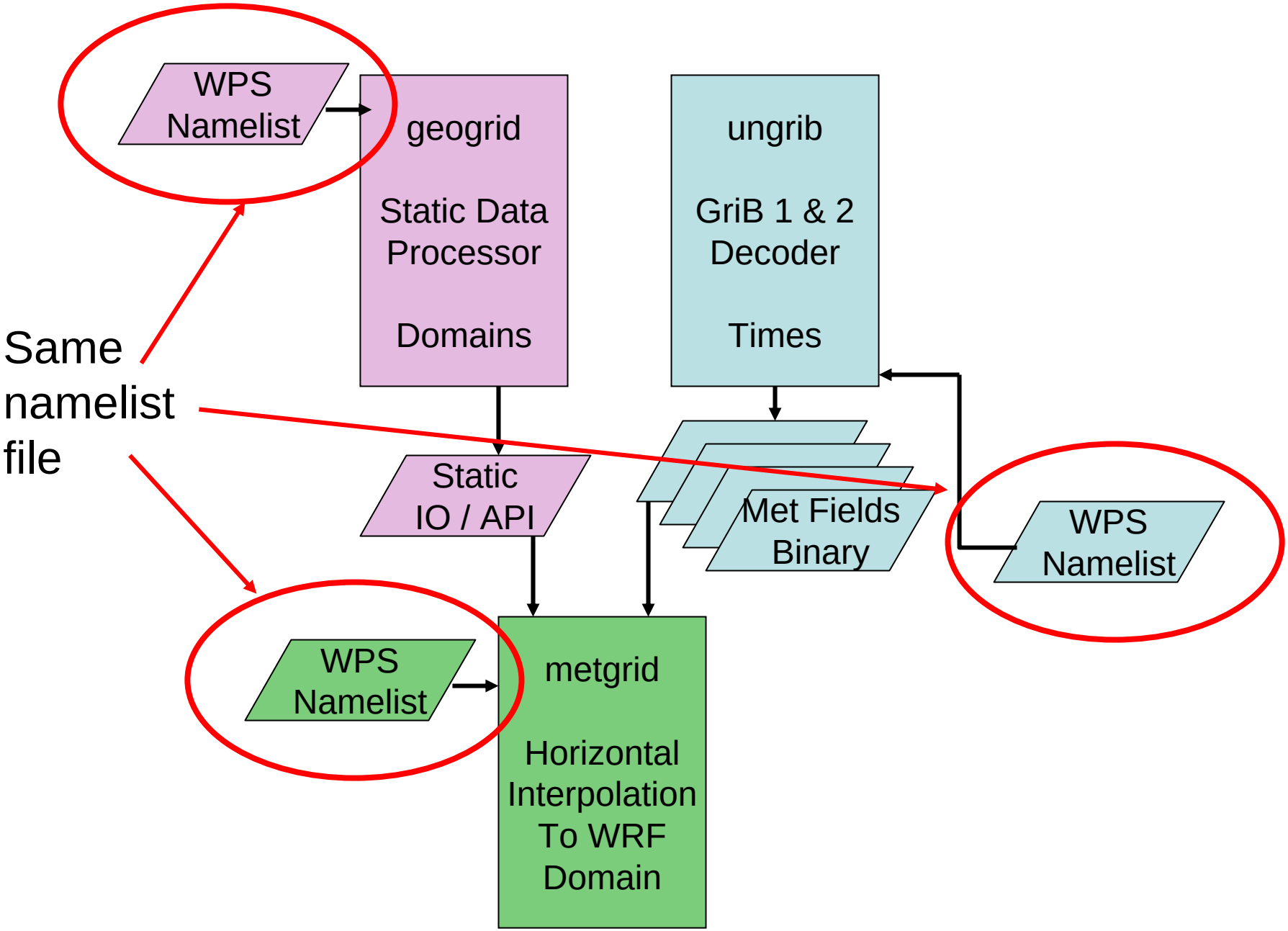
Static
IO / API
Met Fields
Binary
WPS
Namelist
WPS
Namelist
metgrid
Horizontal
Interpolation
To WRF
Domain


WPS
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namelist
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Interpolation
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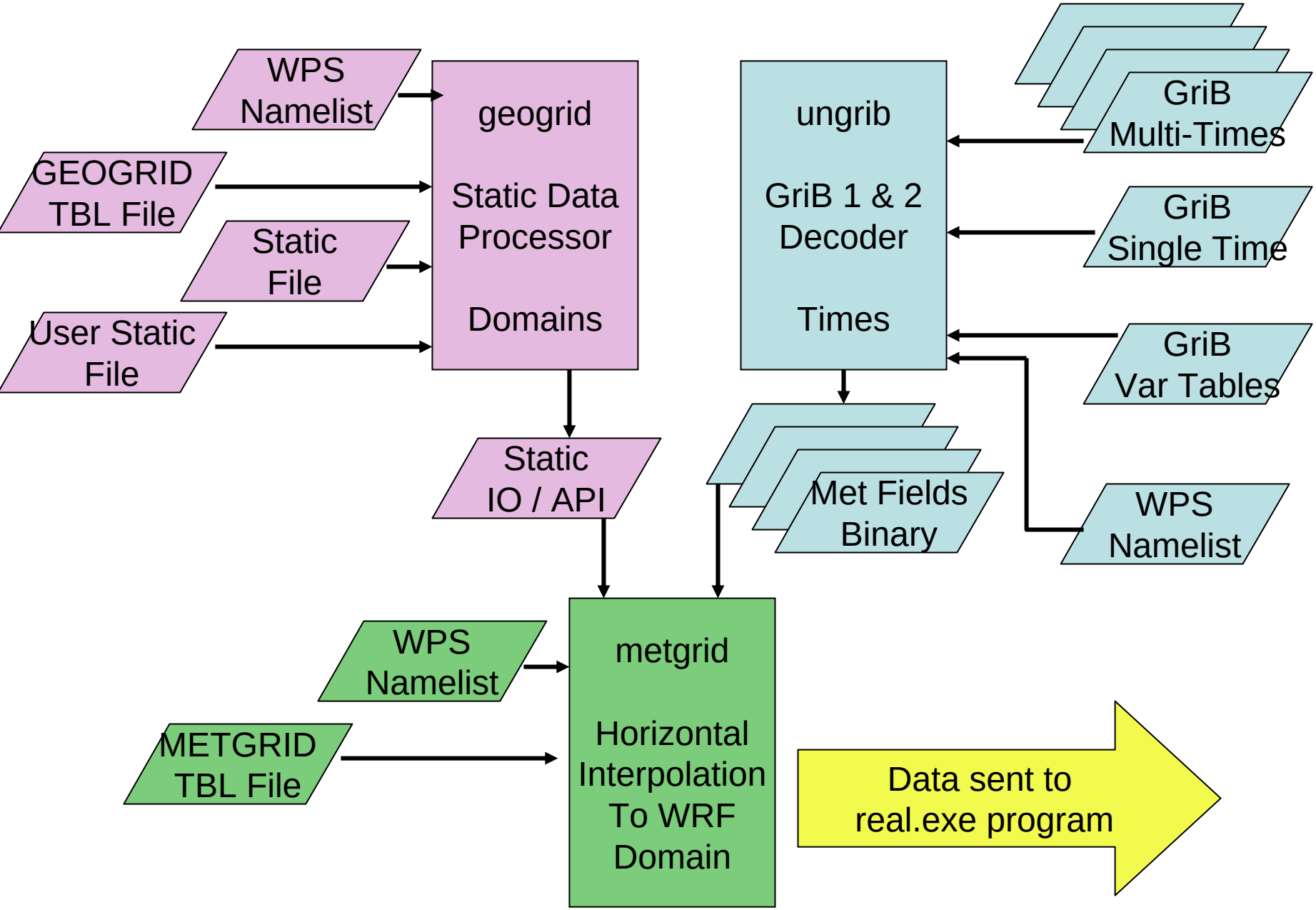
Domain

# WRF Preprocessing System Overview

- Motivation
- Design Requirements
- Specifics
  - Static Data
  - GriB Decoder
  - Horizontal Interpolator
  - real.exe
- Examples
- Release Schedule


WPS
Namelist
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TBL File
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User Static
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ungrib
GriB 1 & 2
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GriB
Var Tables
Met Fields
Binary
WPS
Namelist
WPS
Namelist
METGRID
TBL File
metgrid
Horizontal
Interpolation
To WRF
Domain
Data sent to
real.exe program

# WRF Preprocessing System Overview
# real.exe

- ARW only so far, working with NCEP for NMM core
- Vertical interpolation
  - Pressure
  - Native vertical coordinate
- Backward compatible (also reads input from SI)
- Two namelist changes:
  - Add # vert levels in namelist
  - Specify input file name

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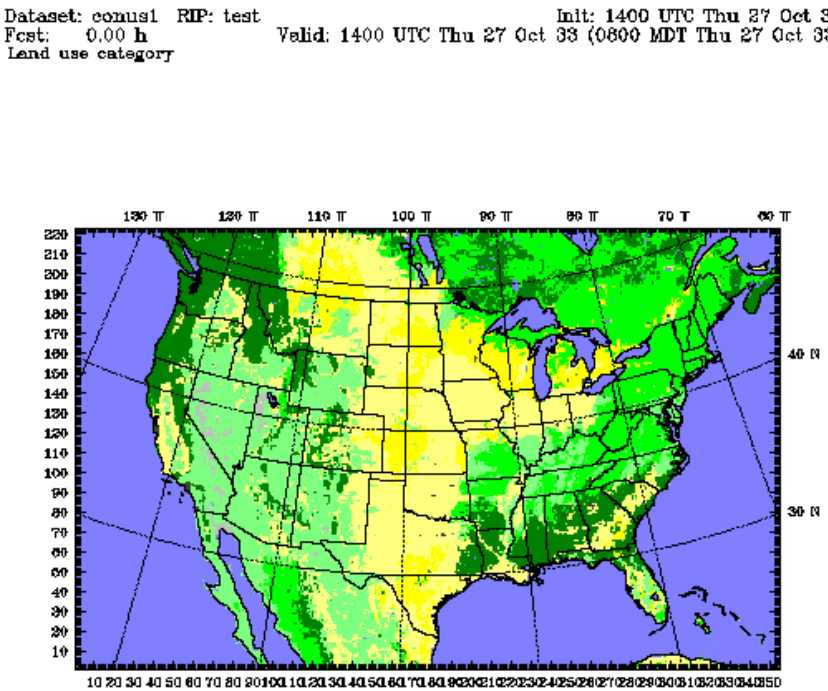
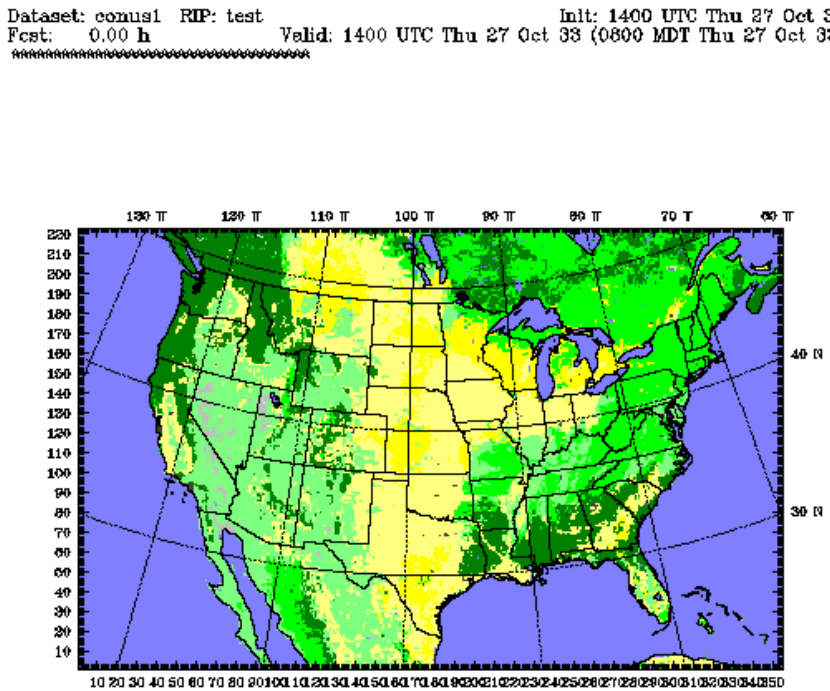
# WRF Preprocessing System Overview Examples

- CONUS, 360x230, 22 km resolution
  - Land use categories, nearest neighbor, categorical, 2 min static input
  - MM5 *Terrain vs* WPS *geogrid*
  - SI *grid_gen vs* WPS *geogrid*

# WRF Preprocessing System Overview Examples: CONUS, 360x230 22 km Land use categories, 2 min input

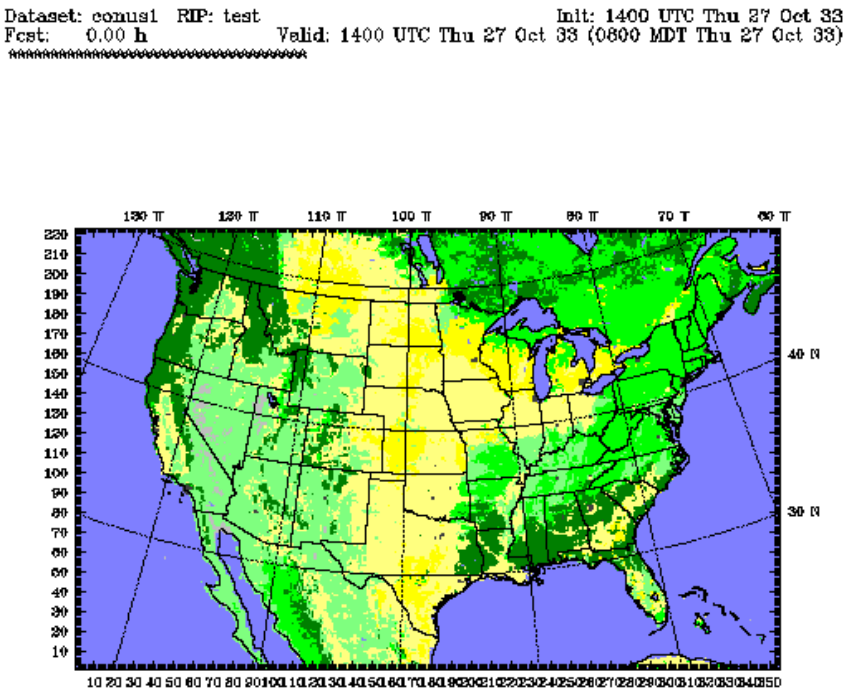



MM5 Land Use

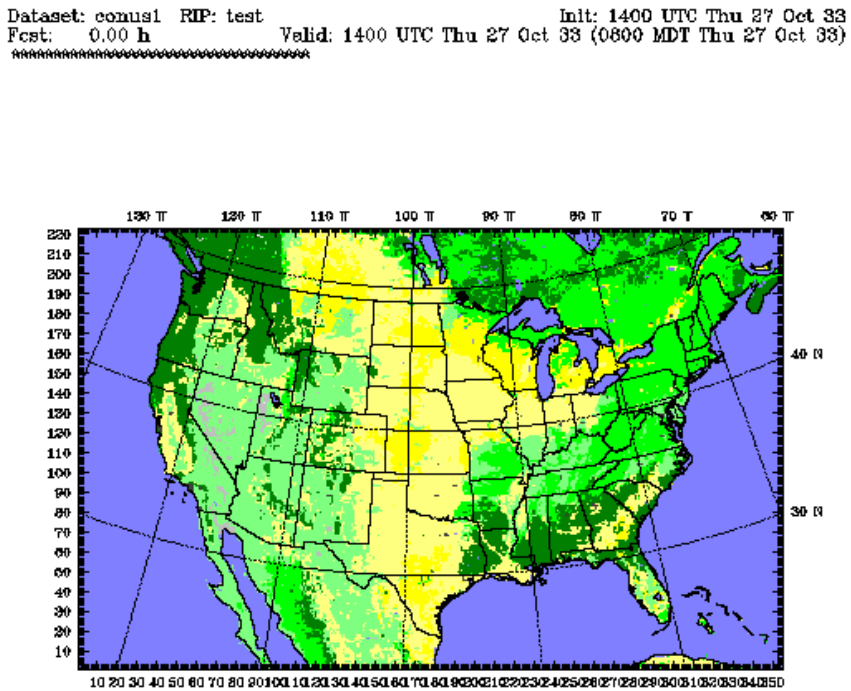



WPS *geogrid* Land Use

# WRF Preprocessing System Overview Examples: CONUS, 360x230 22 km Land use categories, 2 min input




SI Land Use

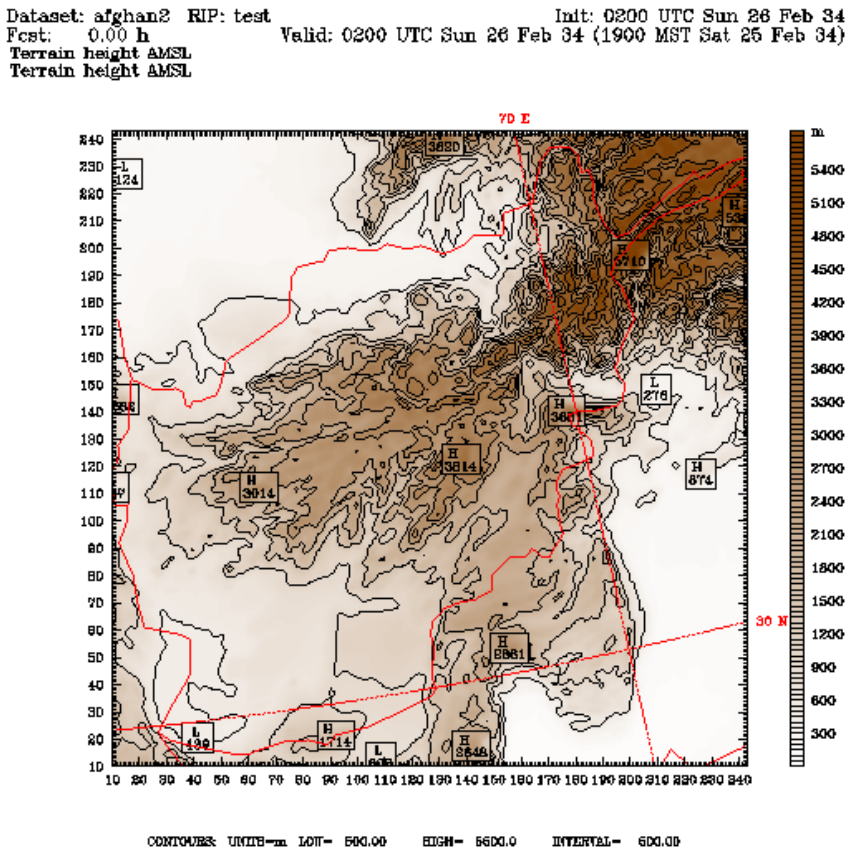


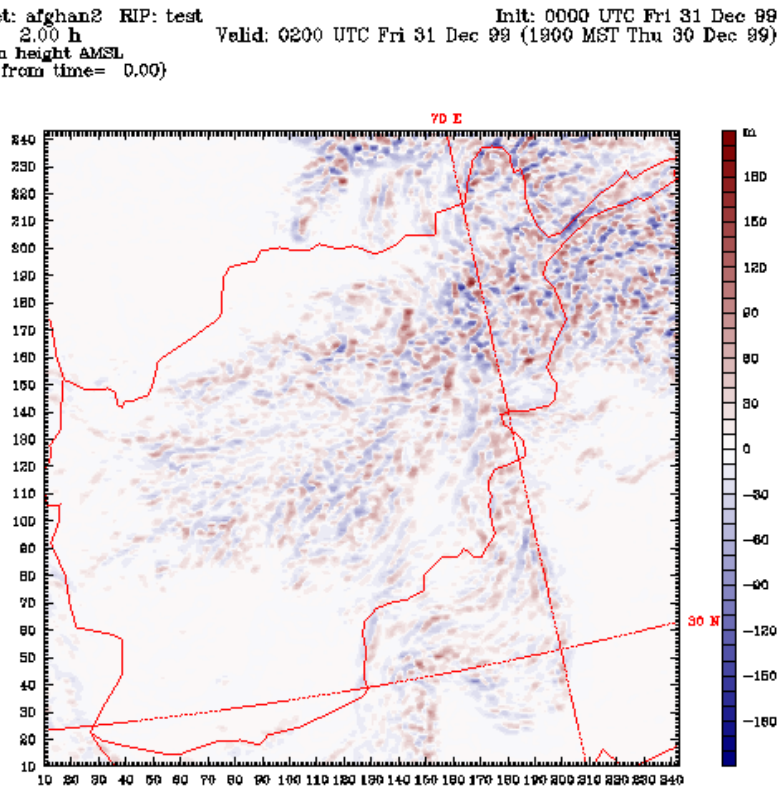

WPS *geogrid* Land Use

# WRF Preprocessing System Overview Examples

- Afghanistan, 241x241, 5 km resolution
  - Topography, 16-point interpolation, continuous, 30 second static input
  - WPS *geogrid*
  - Difference of WPS *geogrid* and SI grid_gen

# WRF Preprocessing System Overview
# Examples: Afghanistan, 241x241, 5 km
# Topography, 30 second input



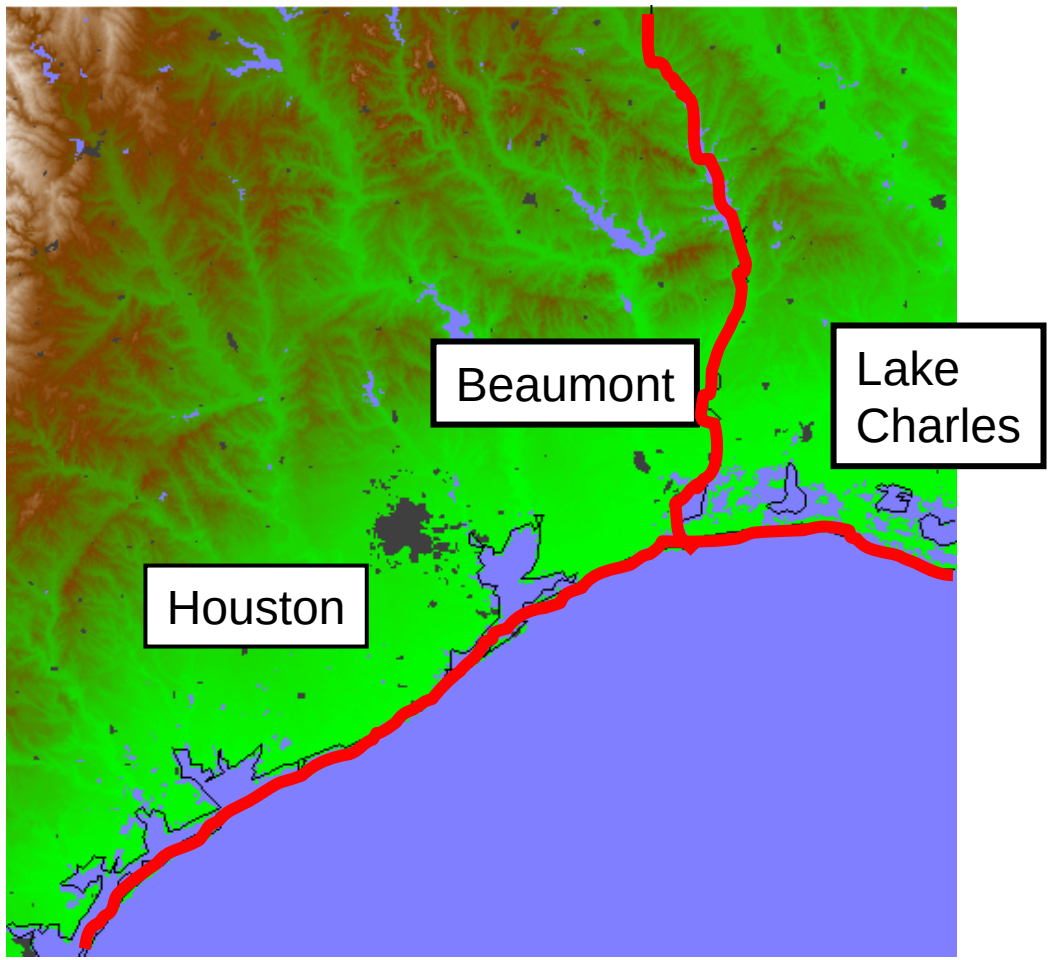




WPS *geogrid* vs WPS *geogrid* – SI *grid_gen*

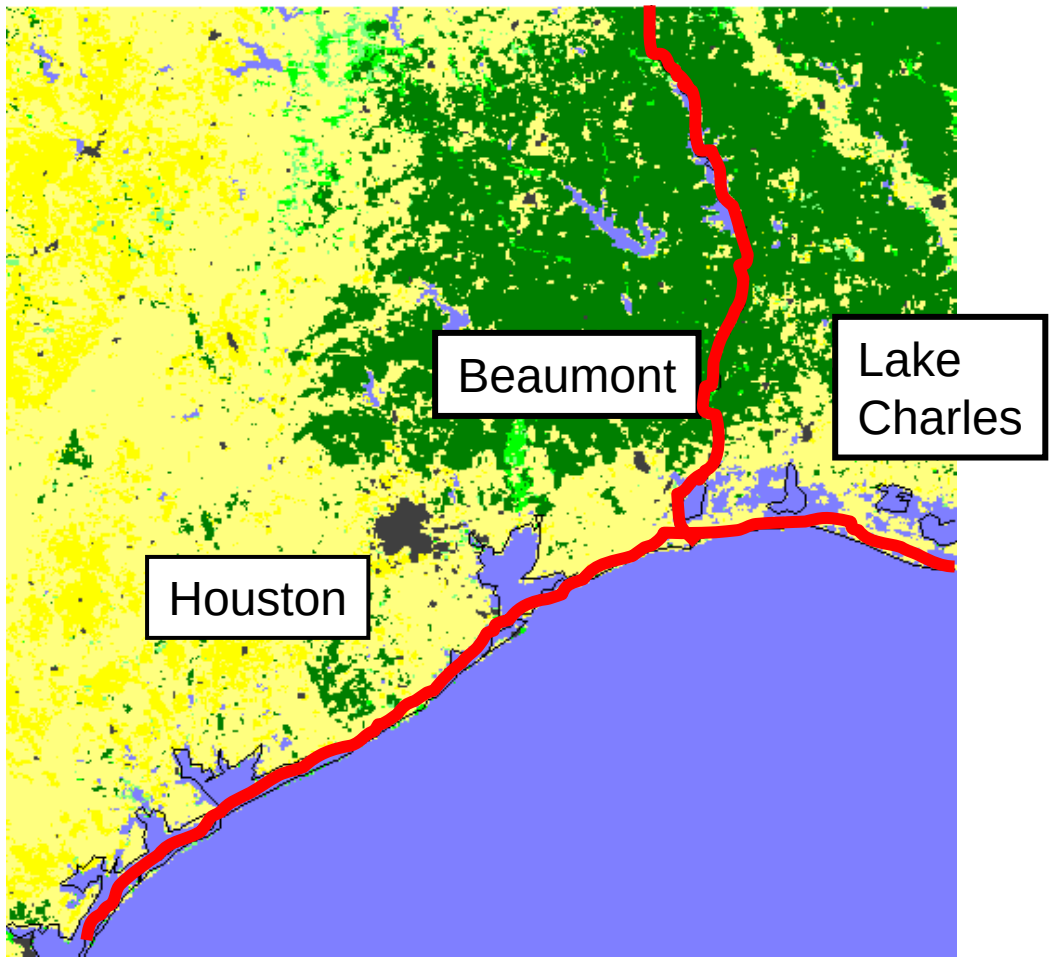
# WRF Preprocessing System Overview Examples

- Houston, 1000x1000, 500 m resolution
  - Topography, 16 point, continuous, 30 second static input
  - Land use categories, nearest neighbor, categorical, 30 second static input

# WRF Preprocessing System Overview Examples: Houston, 1000x1000 500 m Topography, 30” input



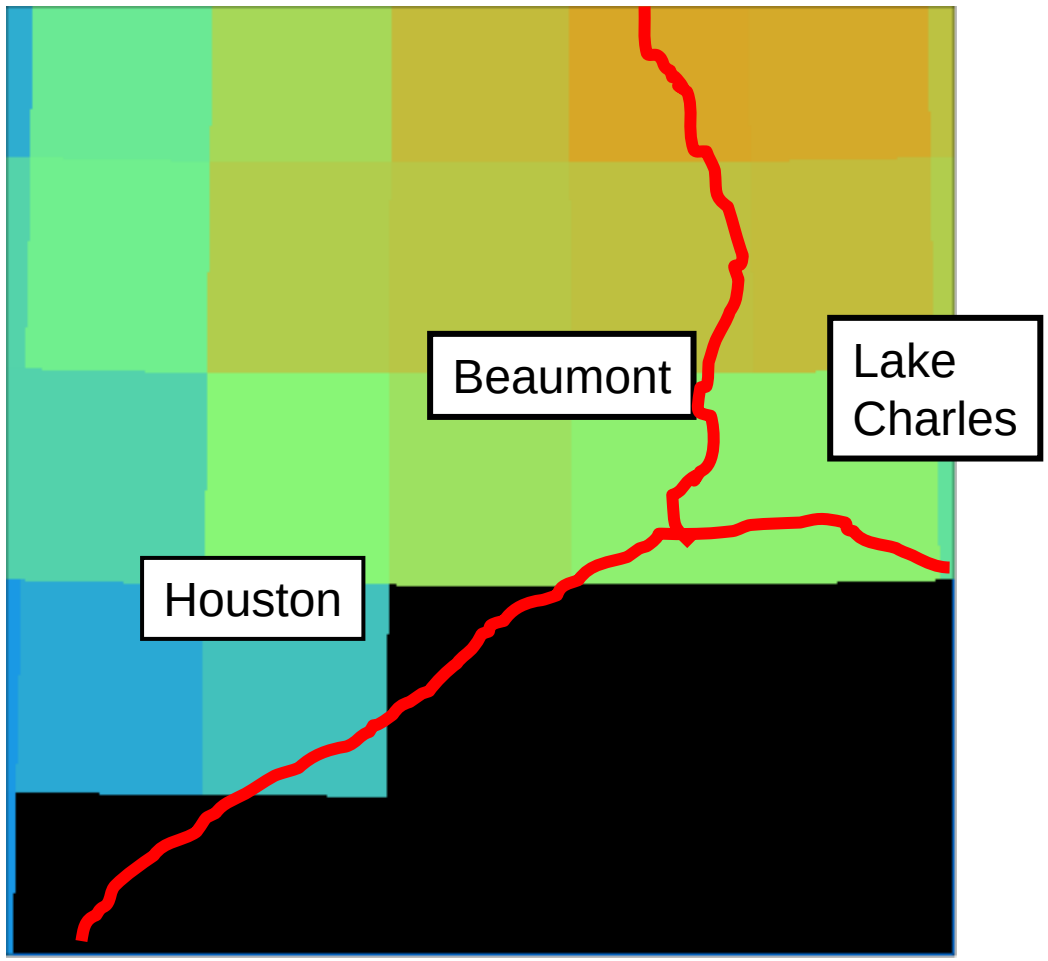
# WRF Preprocessing System Overview Examples: Houston, 1000x1000 500 m Land use categories, 30” input



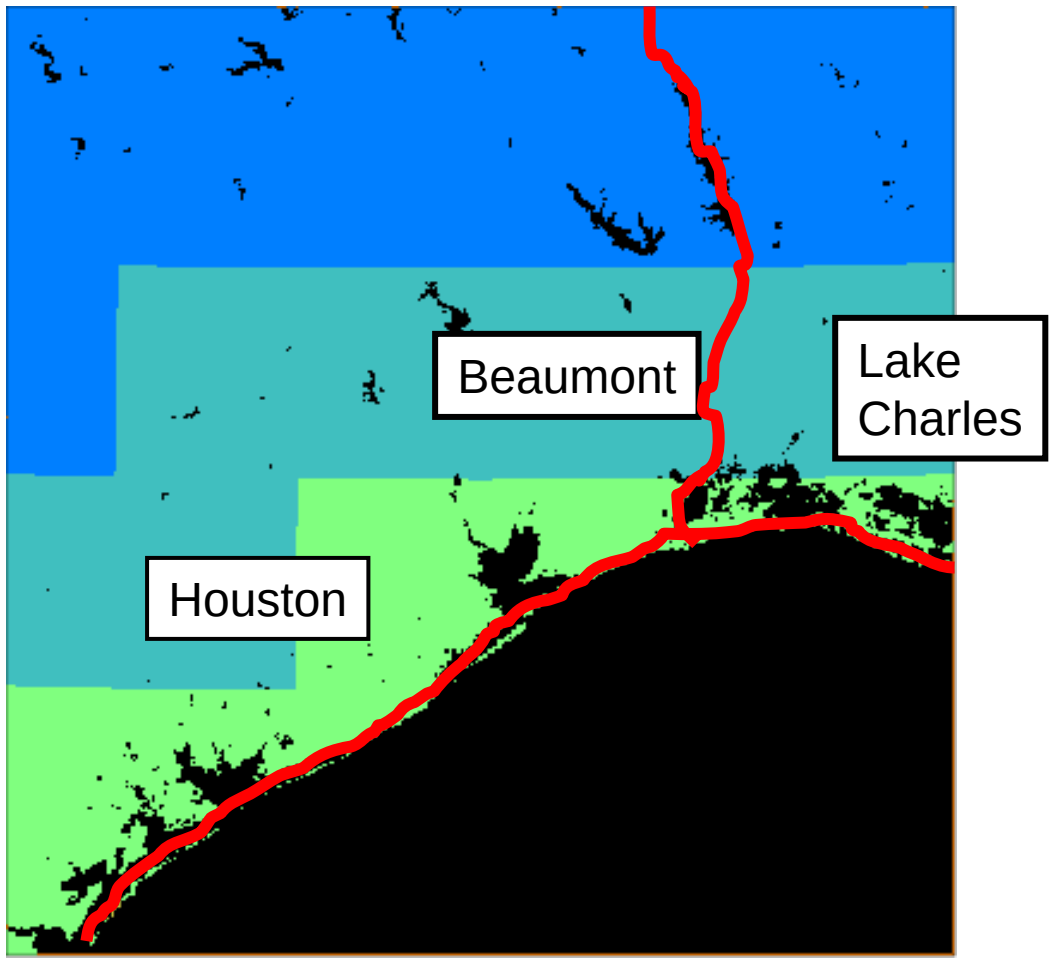
# WRF Preprocessing System Overview Examples

- Houston, 1000x1000, 500 m resolution
  - Raw GFS 1 degree: soil moisture
  - GFS 1 degree: interpolating method
  - GFS 1 degree: interpolated soil moisture
  - NAM 12-km: interpolated soil moisture

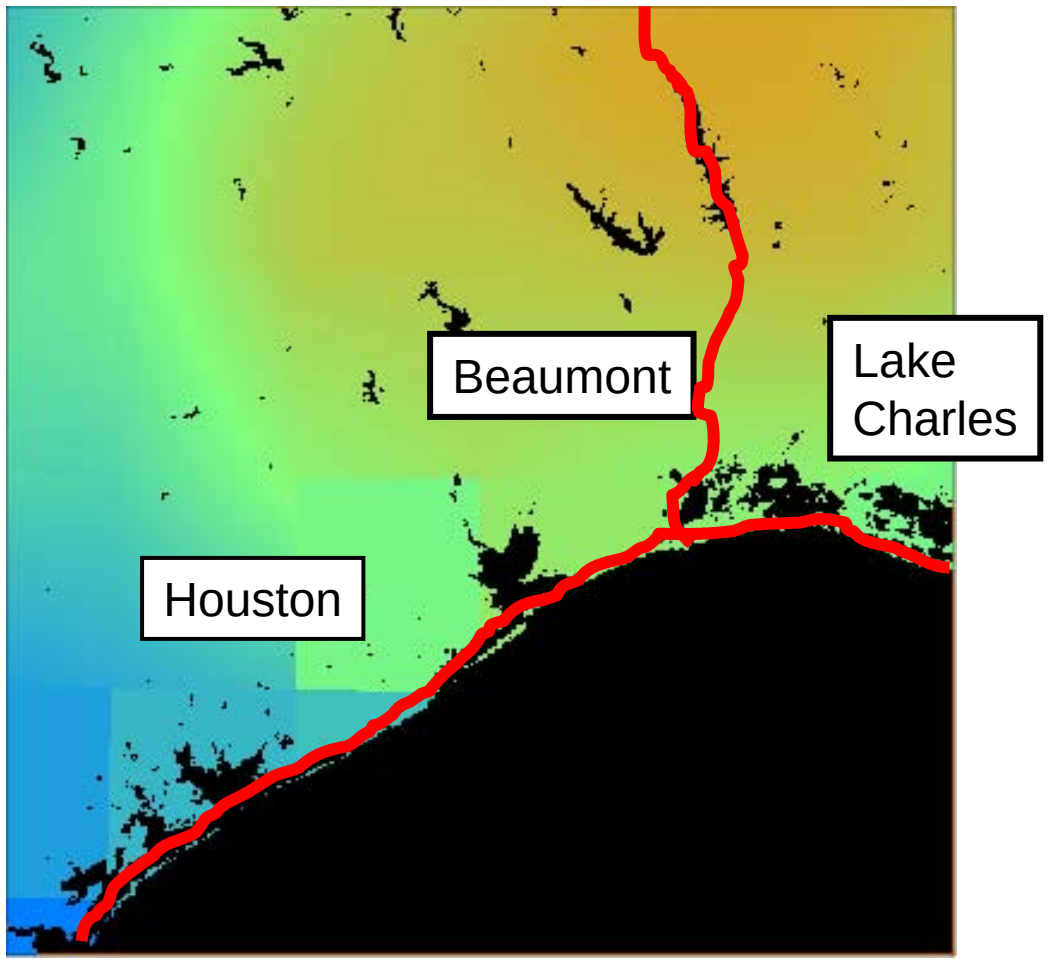
# WRF Preprocessing System Overview
# Examples: Houston, 1000x1000 500 m
# Soil moisture, Raw 1 degree GFS input



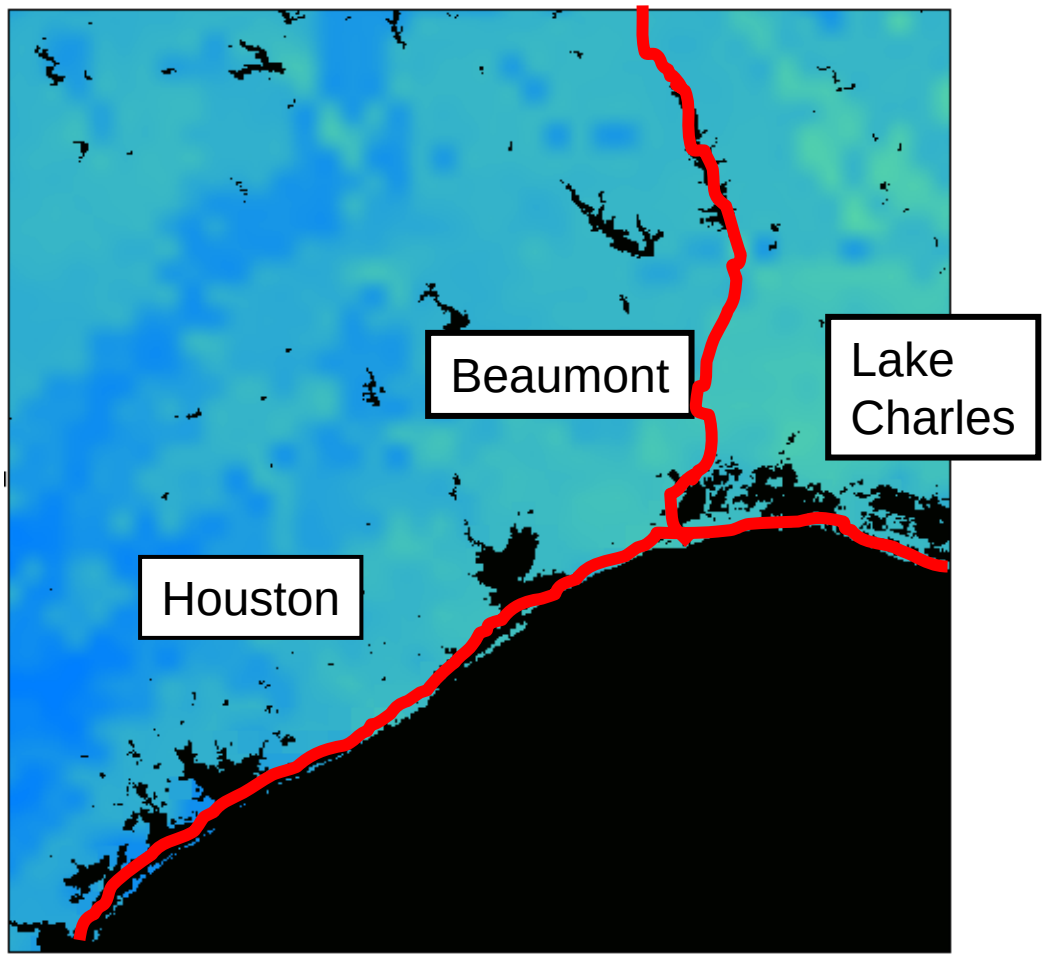
# WRF Preprocessing System Overview
# Examples: Houston, 1000x1000 500 m
# Interpolating Methods, 1 degree GFS input



# WRF Preprocessing System Overview Examples: Houston, 1000x1000 500 m Soil Moisture, 1 degree GFS input



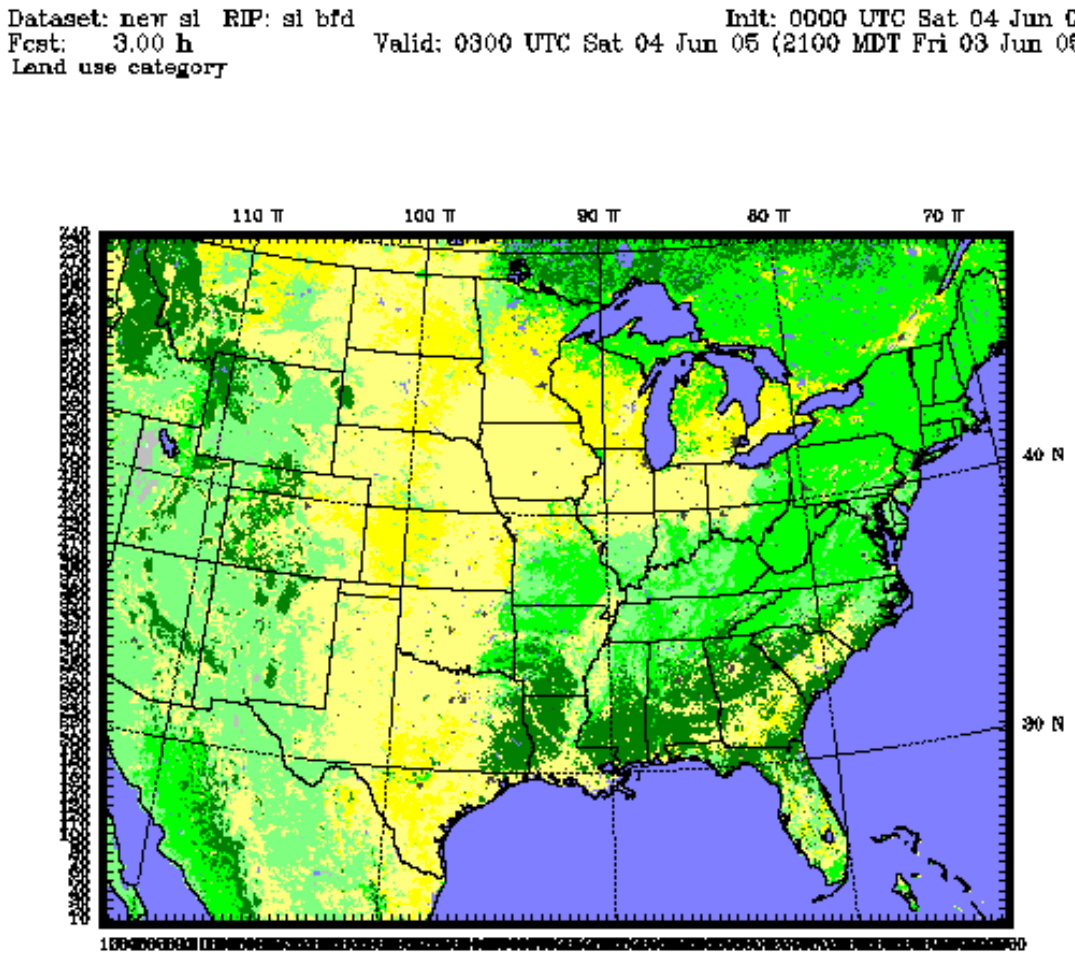
# WRF Preprocessing System Overview Examples: Houston, 1000x1000 500 m Soil Moisture, 12-km NAM input



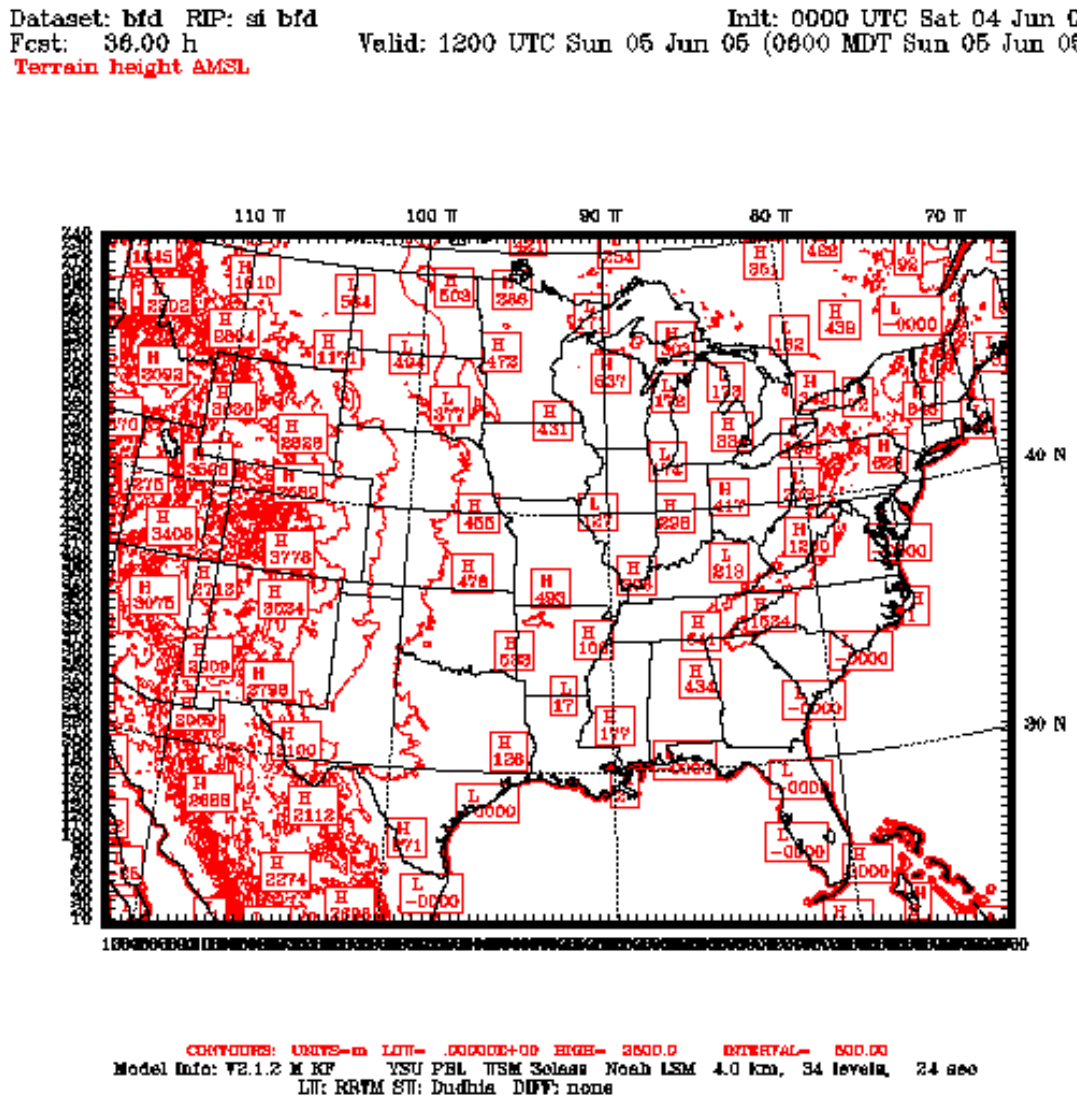
# WRF Preprocessing System Overview Examples

- CONUS, 971x741 domain size, 4-km resolution, 36-h forecast
  - Land use categories
  - Topography
  - SLP, T sfc, sfc wind
  - 500 mb T, height, winds
  - Reflectivity

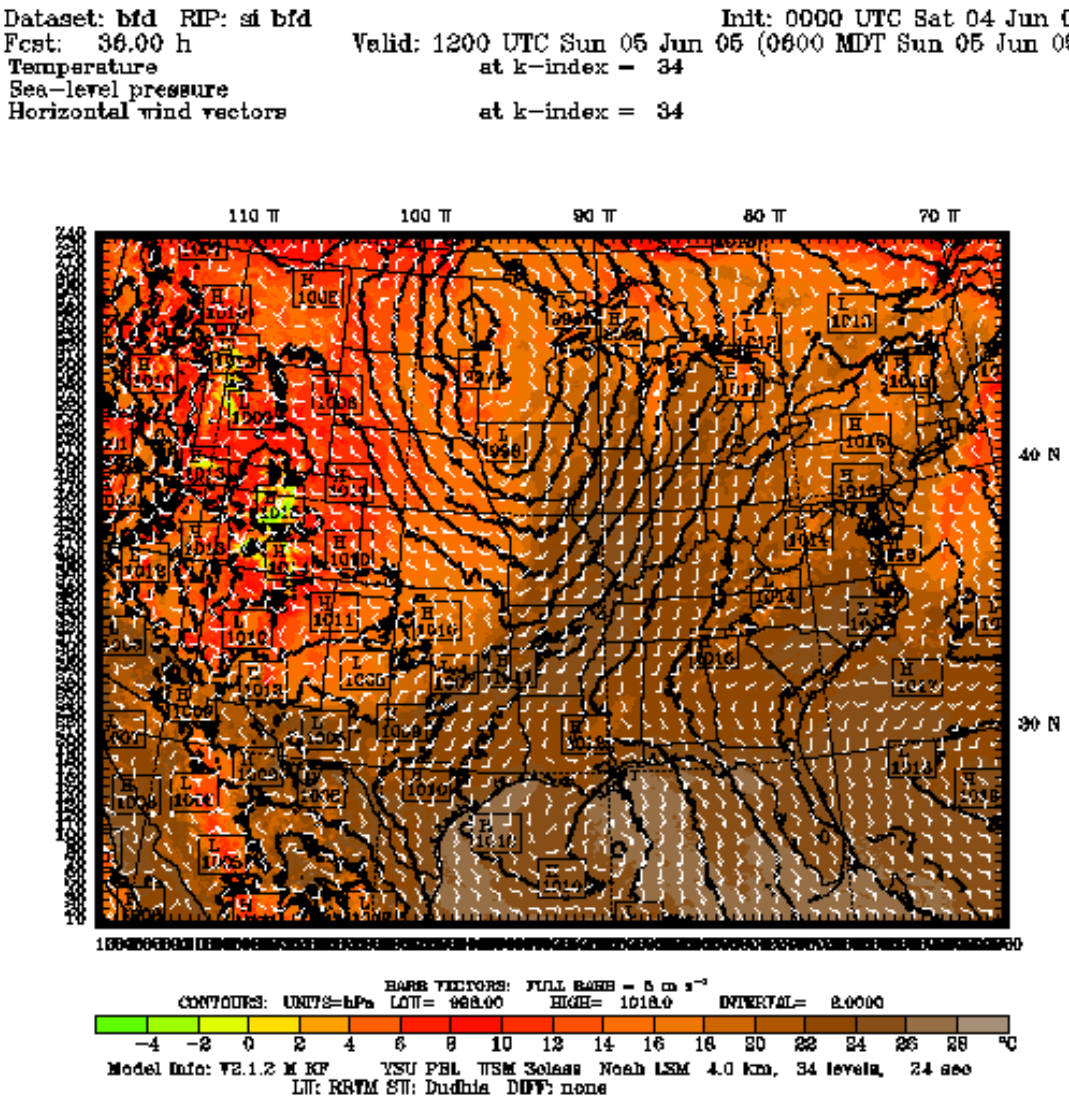
# WRF Preprocessing System Overview
# Examples: CONUS, 971x741 4km
# Land use categories



# WRF Preprocessing System Overview Examples: CONUS, 971x741 4km Topography



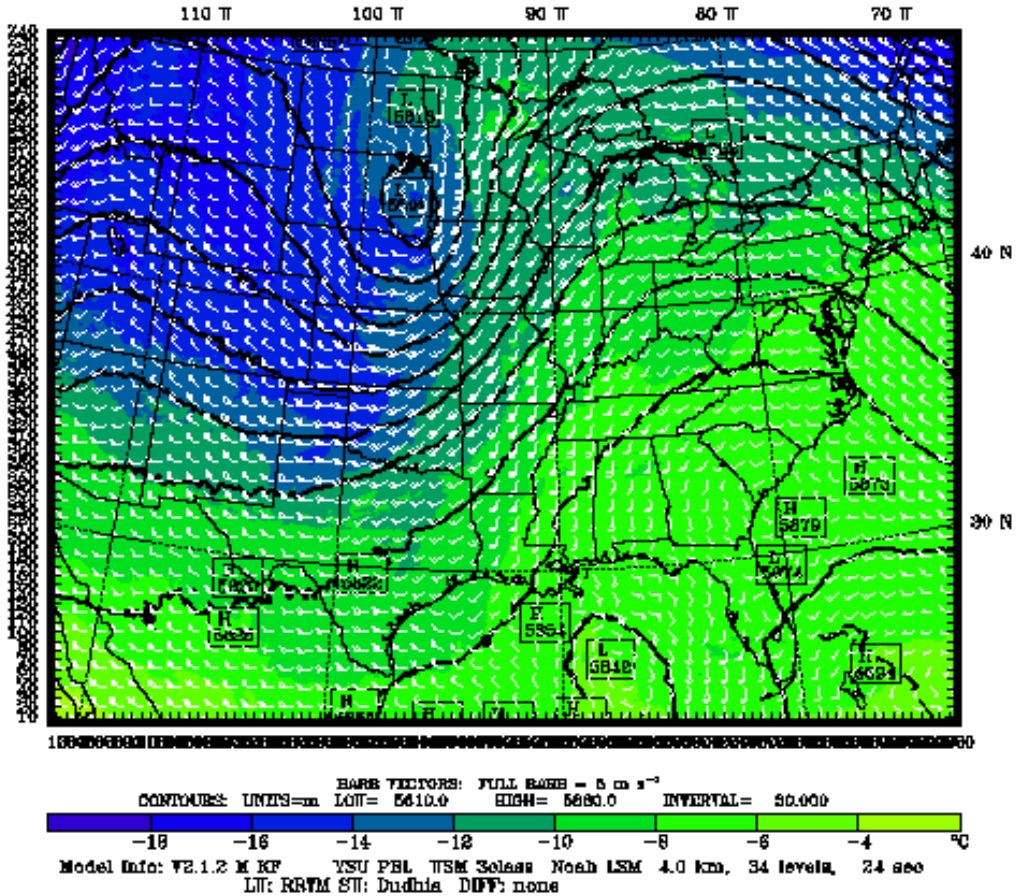
# WRF Preprocessing System Overview Examples: CONUS, 971x741 4km SLP, surface T and winds



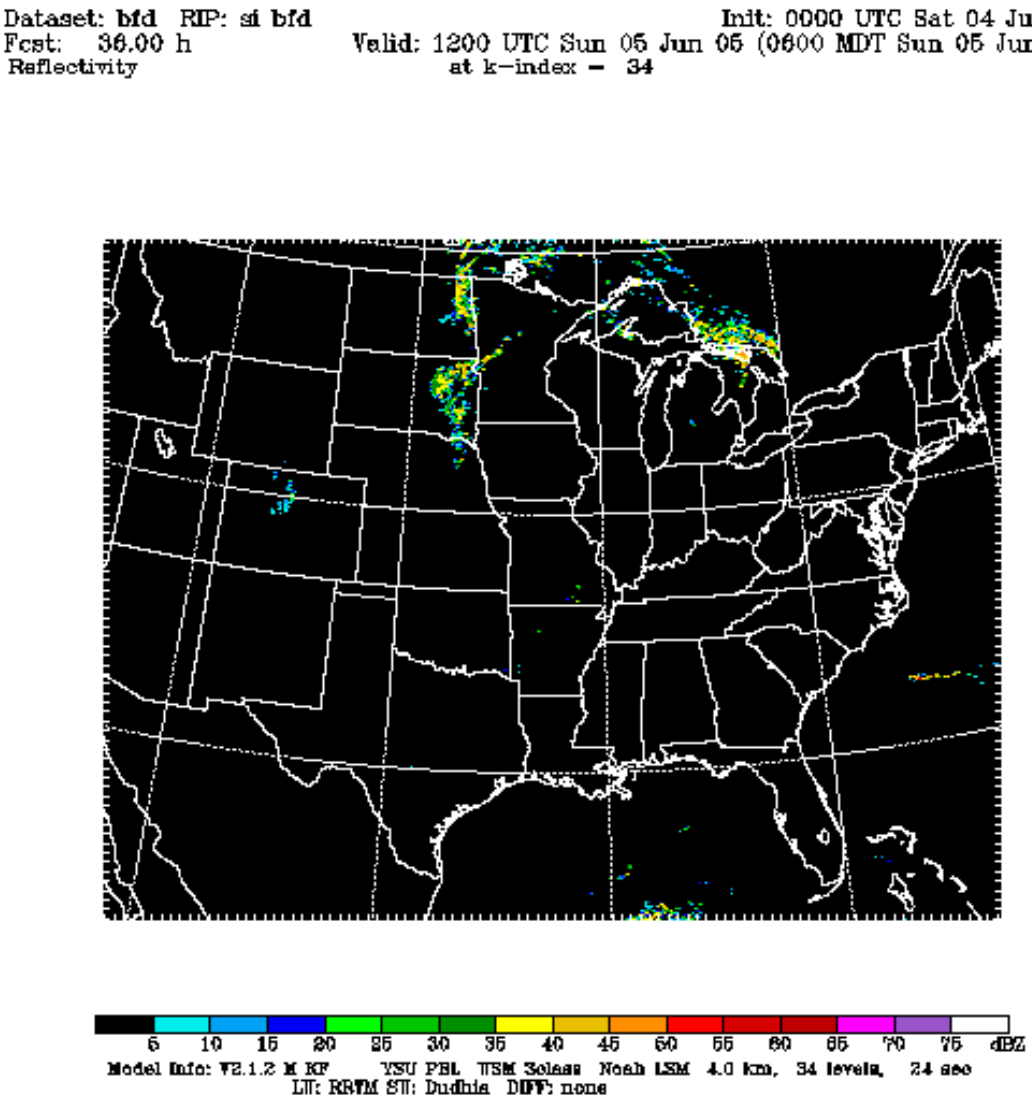
# WRF Preprocessing System Overview Examples: CONUS, 971x741 4km 500 mb T, height, winds

Dataset: bfd RIP: si bfd
Fcst: 36.00 h
Temperature
Geopotential height
Horizontal wind vectors

Init: 0000 UTC Sat 04 Jun 05
Valid: 1200 UTC Sun 05 Jun 05 (0600 MDT Sun 05 Jun 05)
at pressure = 500 hPa
at pressure = 500 hPa
at pressure = 500 hPa



# WRF Preprocessing System Overview Examples: CONUS, 971x741 4km Reflectivity



# WRF Preprocessing System Overview

- Motivation
- Design Requirements
- Specifics
  - Static Data
  - GriB Decoder
  - Horizontal Interpolator
  - real.exe
- Examples
- Release Schedule

# WRF Preprocessing System Overview Release Schedule

- World-wide premiere 1-hr tutorial Thursday (Michael Duda)
- Taught at July 2006 WRF ARW Tutorial
- Friendly user release early August 2006
- Supported release end of September 2006
  - RIP
  - MM5 converter (*metgrid* emulator output)
  - Domain Wizard

# WRF Preprocessing System Overview Release Schedule – Domain Wizard

- Standalone Java GUI deployed via Java webstart
- Just click on a web page and it will pop up and run
- Looks similar to the existing WRFSI GUI
- Supports Polar Stereographic, Lambert Conformal, and Mercator projections

# WRF Preprocessing System Overview Release Schedule – Domain Wizard

- Supports ARW and NMM, and nested domains
- Can either be run standalone, or can be run as a part of the WRF Portal software (the GUI for WRF)
- Localizes your domain (creating the namelists) and also runs *geogrid* for you

- There is a flash demo of the Domain Wizard:
  http://www.wrfportal.org/flash/domainwiz_demo.html

# WRF Preprocessing System Overview
# Release Schedule

- Future Work
  - Embarrassingly parallel over time periods
  - Remove computations from unused middle
  - TC bogus scheme
  - Use of tiled GriB files from ungrib
  - New projections: channel and global
  - Idealized initial data

# Domain Wizard
## Next Generation of WRFSI GUI

Jeff Smith
Paula McCaslin
www.wrfportal.org

Standalone Java GUI deployed via Java webstart
Just click on a web page and it will pop up and run
Looks similar to the existing WRFSI GUI
Supports Polar Stereographic, Lambert Conformal, and Mercator projections
Supports ARW and NMM and nested domains
Can either be run standalone, or can be run as a part of the WRF Portal software (the GUI for WRF)
Localizes your domain (creating the namelists) and also runs *geogrid* for you

There is a flash demo of Domain Wizard here:
http://www.wrfportal.org/flash/domainwiz_demo.html

Domain Wizard: 'United States'

Actions

1) Wizard Option | 2) Open Domain | 3) Horizontal Editor | 4) Run Localization | 5) Visualize

Computer: local

Cases (domains) dir: C:\domains

Select

Domain Name

Europe-Africa

United States

Delete Domain

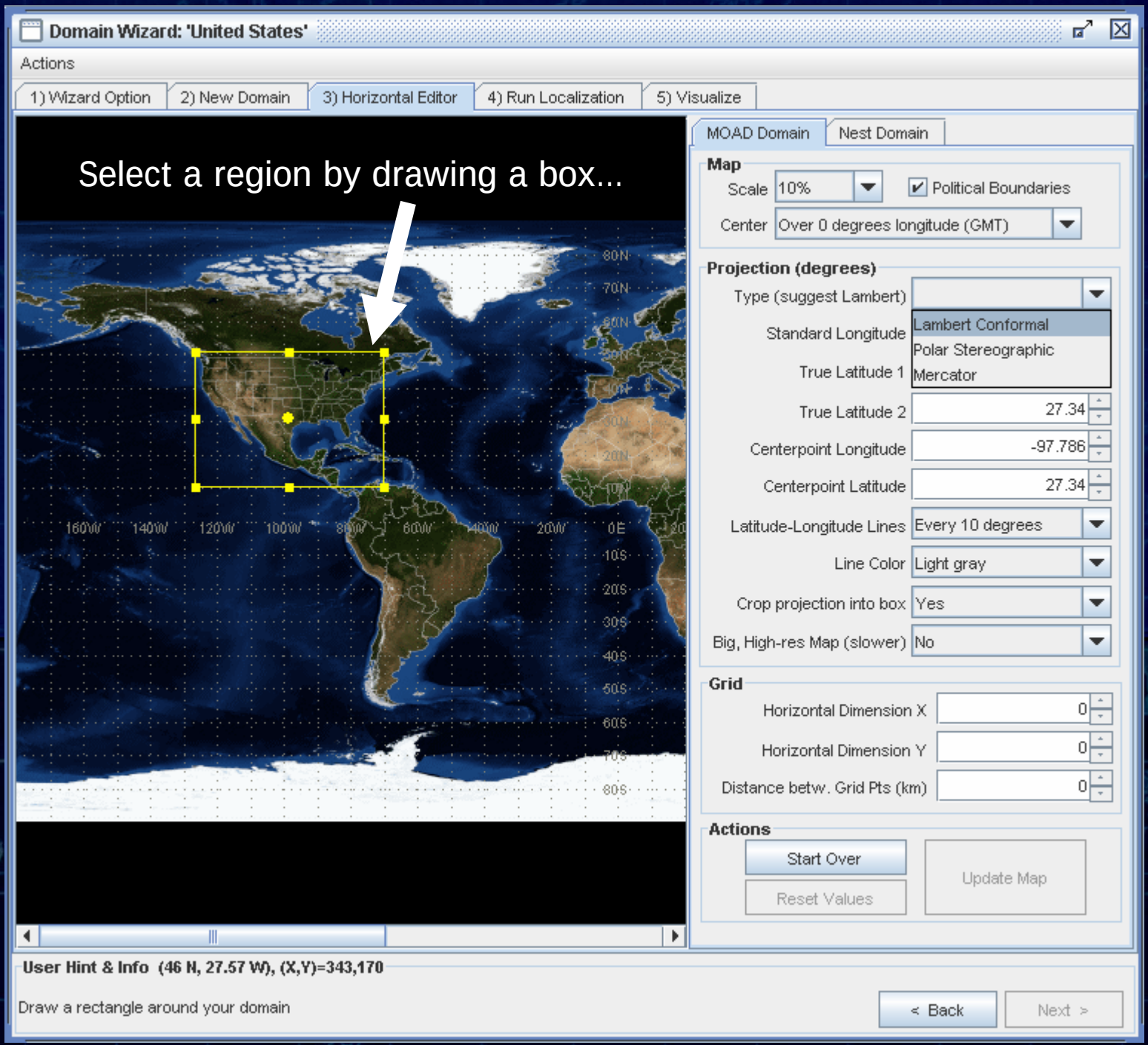
Preview

Open an existing domain by choosing one from the list on the left.

**User Hint & Info**

Open or delete a domain

< Back | Next >

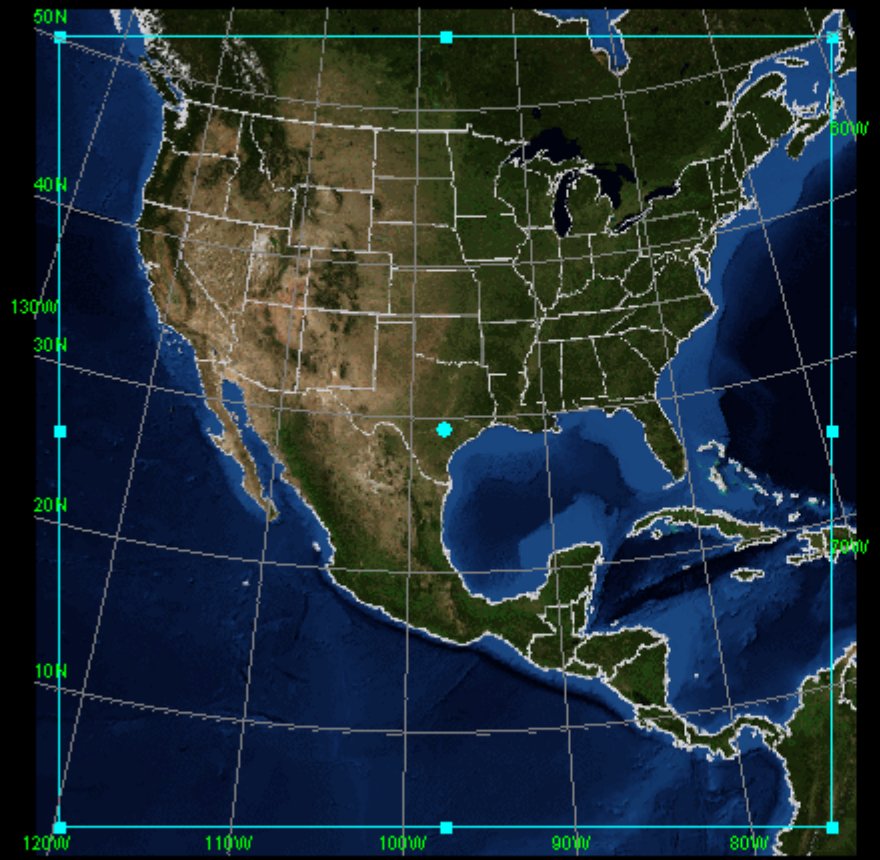

Domain Wizard: 'United States'
Actions
1) Wizard Option
2) New Domain
3) Horizontal Editor
4) Run Localization
5) Visualize
Select a region by drawing a box...
80N
70N
60N
50N
40N
30N
20N
10N
160W
140W
120W
100W
80W
60W
40W
20W
0E
10S
20S
30S
40S
50S
60S
70S
80S
MOAD Domain
Nest Domain
Map
Scale
10%
Political Boundaries
Center
Over 0 degrees longitude (GMT)
Projection (degrees)
Type (suggest Lambert)
Lambert Conformal
Polar Stereographic
Mercator
Standard Longitude
True Latitude 1
True Latitude 2
27.34
Centerpoint Longitude
-97.786
Centerpoint Latitude
27.34
Latitude-Longitude Lines
Every 10 degrees
Line Color
Light gray
Crop projection into box
Yes
Big, High-res Map (slower)
No
Grid
Horizontal Dimension X
0
Horizontal Dimension Y
0
Distance betw. Grid Pts (km)
0
Actions
Start Over
Reset Values
Update Map
User Hint & Info (46 N, 27.57 W), (X,Y)=343,170
Draw a rectangle around your domain
< Back
Next >

Domain Wizard: 'United States'

Actions

1) Wizard Option | 2) New Domain | 3) Horizontal Editor | 4) Run Localization | 5) Visualize

Click “Update Map” to project your region (in this case as Lambert Conformal)




MOAD Domain | Nest Domain

**Map**

Scale: 10% | Political Boundaries

Center: Over 0 degrees longitude (GMT)

**Projection (degrees)**

| | |
|---|---|
| Type (suggest Lambert) | Lambert Conformal |
| Standard Longitude | -98.23 |
| True Latitude 1 | 34.006 |
| True Latitude 2 | 34.006 |
| Centerpoint Longitude | -98.23 |
| Centerpoint Latitude | 34.006 |
| Latitude-Longitude Lines | Every 10 degrees |
| Line Color | Light gray |
| Crop projection into box | Yes |
| Big, High-res Map (slower) | No |

**Grid**

| | |
|---|---|
| Horizontal Dimension X | 95 |
| Horizontal Dimension Y | 97 |
| Distance betw. Grid Pts (km) | 69.317 |

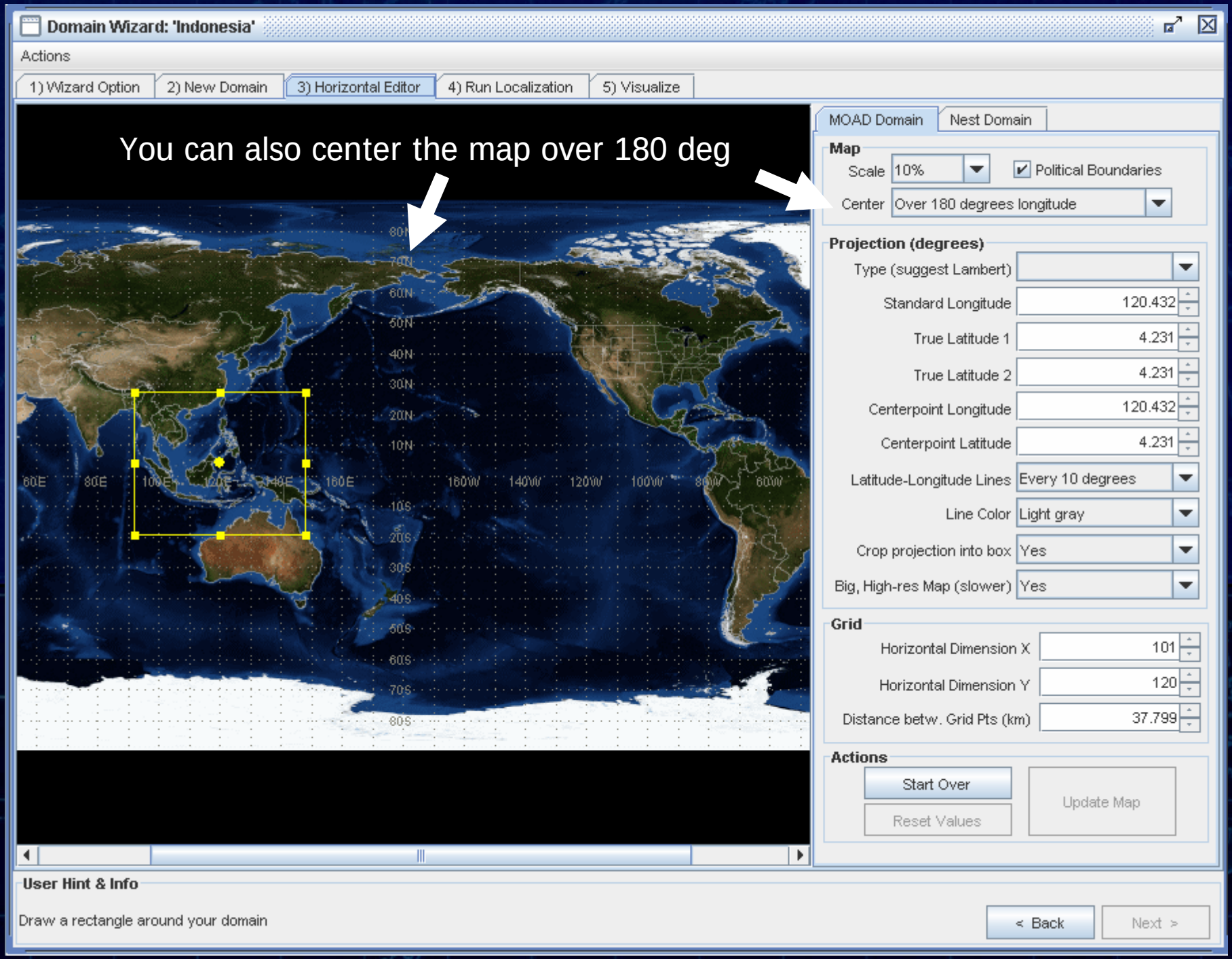
**Actions**

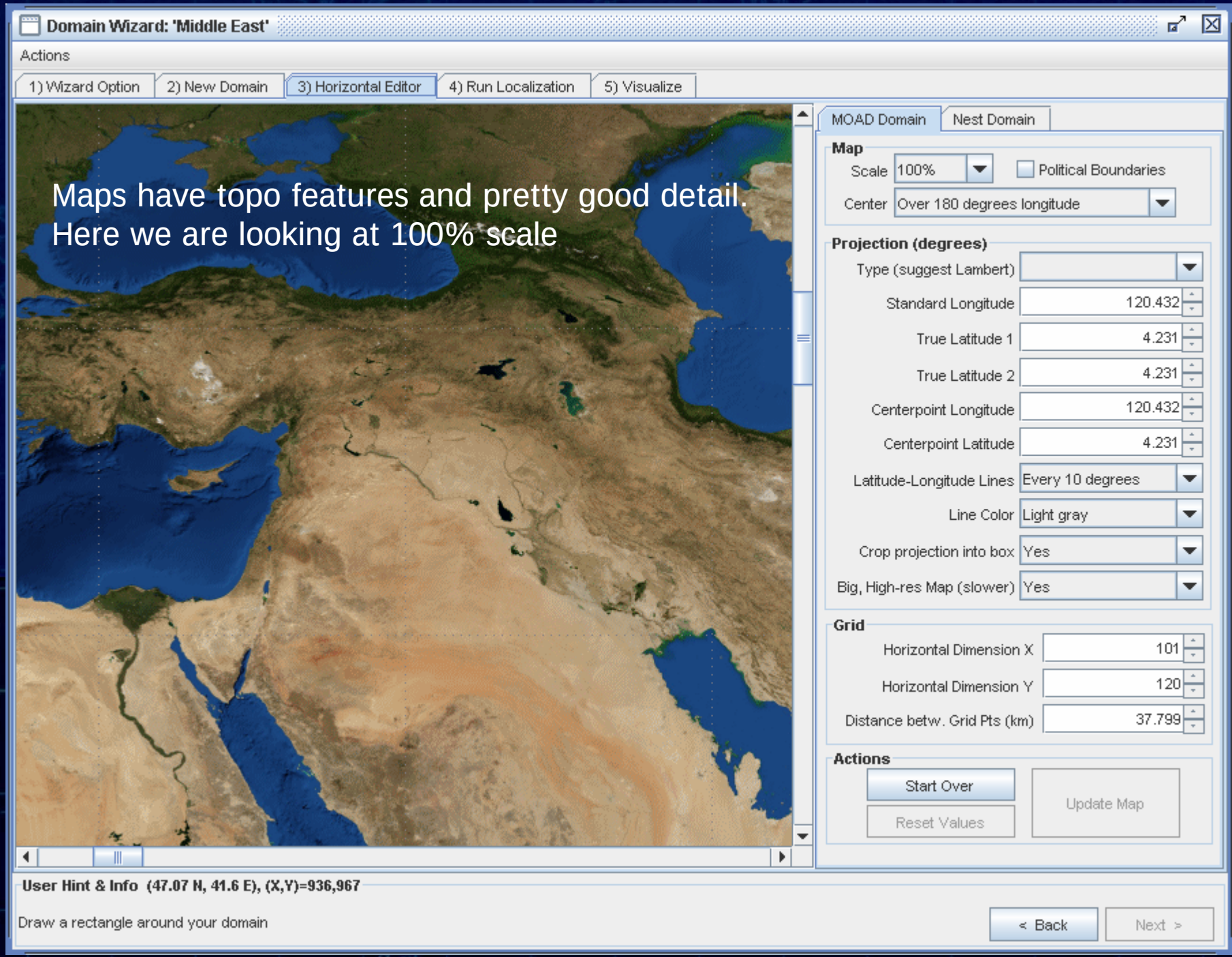
Start Over | Reset Values | Update Map

**User Hint & Info**

Draw a rectangle around your domain

< Back | Next >


Domain Wizard: 'Indonesia'
Actions
1) Wizard Option
2) New Domain
3) Horizontal Editor
4) Run Localization
5) Visualize
You can also center the map over 180 deg
MOAD Domain
Nest Domain
Map
Scale 10%
Political Boundaries
Center Over 180 degrees longitude
Projection (degrees)
Type (suggest Lambert)
Standard Longitude 120.432
True Latitude 1 4.231
True Latitude 2 4.231
Centerpoint Longitude 120.432
Centerpoint Latitude 4.231
Latitude-Longitude Lines Every 10 degrees
Line Color Light gray
Crop projection into box Yes
Big, High-res Map (slower) Yes
Grid
Horizontal Dimension X 101
Horizontal Dimension Y 120
Distance betw. Grid Pts (km) 37.799
Actions
Start Over
Reset Values
Update Map
User Hint & Info
Draw a rectangle around your domain
< Back
Next >


Domain Wizard: 'Middle East'
Actions
1) Wizard Option
2) New Domain
3) Horizontal Editor
4) Run Localization
5) Visualize
Maps have topo features and pretty good detail.
Here we are looking at 100% scale
MOAD Domain
Nest Domain
Map
Scale
100%
Political Boundaries
Center
Over 180 degrees longitude
Projection (degrees)
Type (suggest Lambert)
Standard Longitude
120.432
True Latitude 1
4.231
True Latitude 2
4.231
Centerpoint Longitude
120.432
Centerpoint Latitude
4.231
Latitude-Longitude Lines
Every 10 degrees
Line Color
Light gray
Crop projection into box
Yes
Big, High-res Map (slower)
Yes
Grid
Horizontal Dimension X
101
Horizontal Dimension Y
120
Distance betw. Grid Pts (km)
37.799
Actions
Start Over
Reset Values
Update Map
User Hint & Info (47.07 N, 41.6 E), (X,Y)=936,967
Draw a rectangle around your domain
< Back
Next >