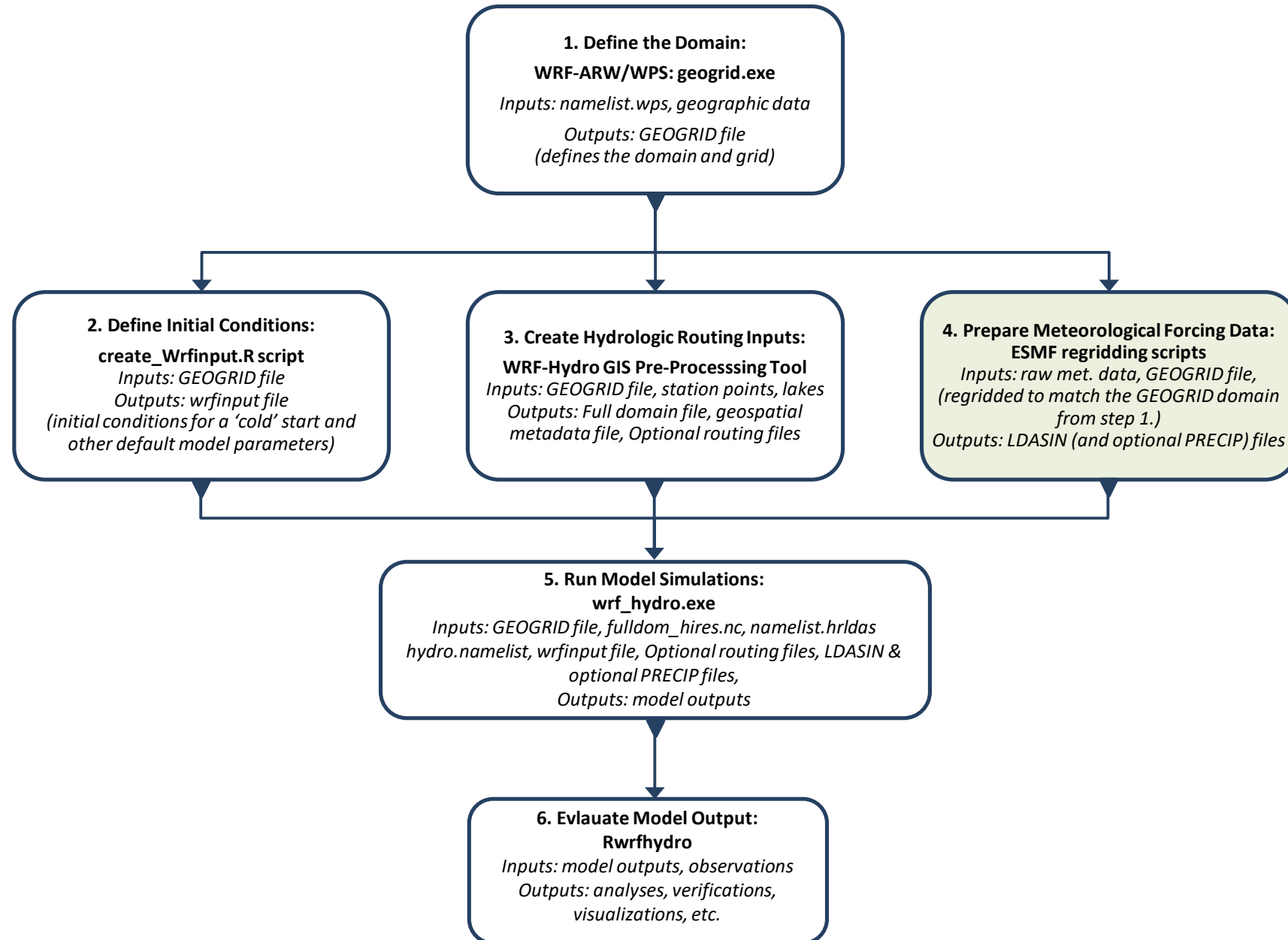# WRF-Hydro Forcing Engine Overview

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**National Center for Atmospheric Research**

# WRF-Hydro Workflow

**1. Define the Domain:**

**WRF-ARW/WPS: geogrid.exe**

*Inputs: namelist.wps, geographic data*

*Outputs: GEOGRID file
(defines the domain and grid)*

**2. Define Initial Conditions:**

**create_Wrfinput.R script**
*Inputs: GEOGRID file*
*Outputs: wrfinput file*
*(initial conditions for a 'cold' start and
other default model parameters)*

**3. Create Hydrologic Routing Inputs:**

**WRF-Hydro GIS Pre-Processsing Tool**
*Inputs: GEOGRID file, station points, lakes*
*Outputs: Full domain file, geospatial
metadata file, Optional routing files*

**4. Prepare Meteorological Forcing Data:**
**ESMF regridding scripts**
*Inputs: raw met. data, GEOGRID file,
(regridded to match the GEOGRID domain
from step 1.)*
*Outputs: LDASIN (and optional PRECIP) files*

**5. Run Model Simulations:**
**wrf_hydro.exe**
*Inputs: GEOGRID file, fulldom_hires.nc, namelist.hrldas
hydro.namelist, wrfinput file, Optional routing files, LDASIN &
optional PRECIP files,*
*Outputs: model outputs*

**6. Evlauate Model Output:**
**Rwrfhydro**
*Inputs: model outputs, observations*
*Outputs: analyses, verifications,
visualizations, etc.*

# Input Forcing Data Requirements

| Variable name | Description | Units |
|---|---|---|
| SWDOWN | Incoming shortwave radiation | $W/m^2$ |
| LWDOWN | Incoming longwave radiation | $W/m^2$ |
| Q2D | Specific humidity | kg/kg |
| T2D | Air temperature | K |
| PSFC | Surface pressure | Pa |
| U2D | Near surface wind in the u-component | m/s |
| V2D | Near surface wind in the v-component | m/s |
| RAINRATE | Precipitation rate | mm/s or $kg/m^2/s$ |

**ALL FORCING DATA IS MAPPED TO SAME GRID  (based on the 'geogrid')**

**SPECIFIED PRECIPITATION MAY HAVE HIGHER TIME RESOLUTION (e.g. 5min)**

# Input Forcing Data Requirements

- Formats for forcing inputs:

  - Fully-coupled model
  - Existing wrf output files
  - Unified analysis (all met. variables together – Netcdf file, e.g. NLDAS-hourly)
  - Specified precipitation (Netcdf file , precipitation comes from alternate source, e.g. radar, satellite, gauge analysis)

**ALL FORCING DATA IS MAPPED TO SAME GRID  (based on WRF 'geogrid')**

**SPECIFIED PRECIPITATION MAY HAVE HIGHER TIME RESOLUTION (e.g. 5min)**

# Input Forcing Data Requirements

- Data Pre-processing Options:
  - Several utilities for formatting and creating 'forcing' data:
    - Using netcdf as the underlying data model…
    - One file per forcing input time…
    - Direct use or simple regrid of existing wrf output
    - ESMF/ncl scripts for conservative regridding of data between structured or unstructured grids, ASCII-netcdf formats, etc.
    - nco-based shell scripts to change variable names, threshold units, re-order grids, etc

* BEST PRACTICE: Use as high of time-resolution forcing data as possible! (particularly rainfall)

- Data Requirements:
  - Forcing Input: Forecast Example…
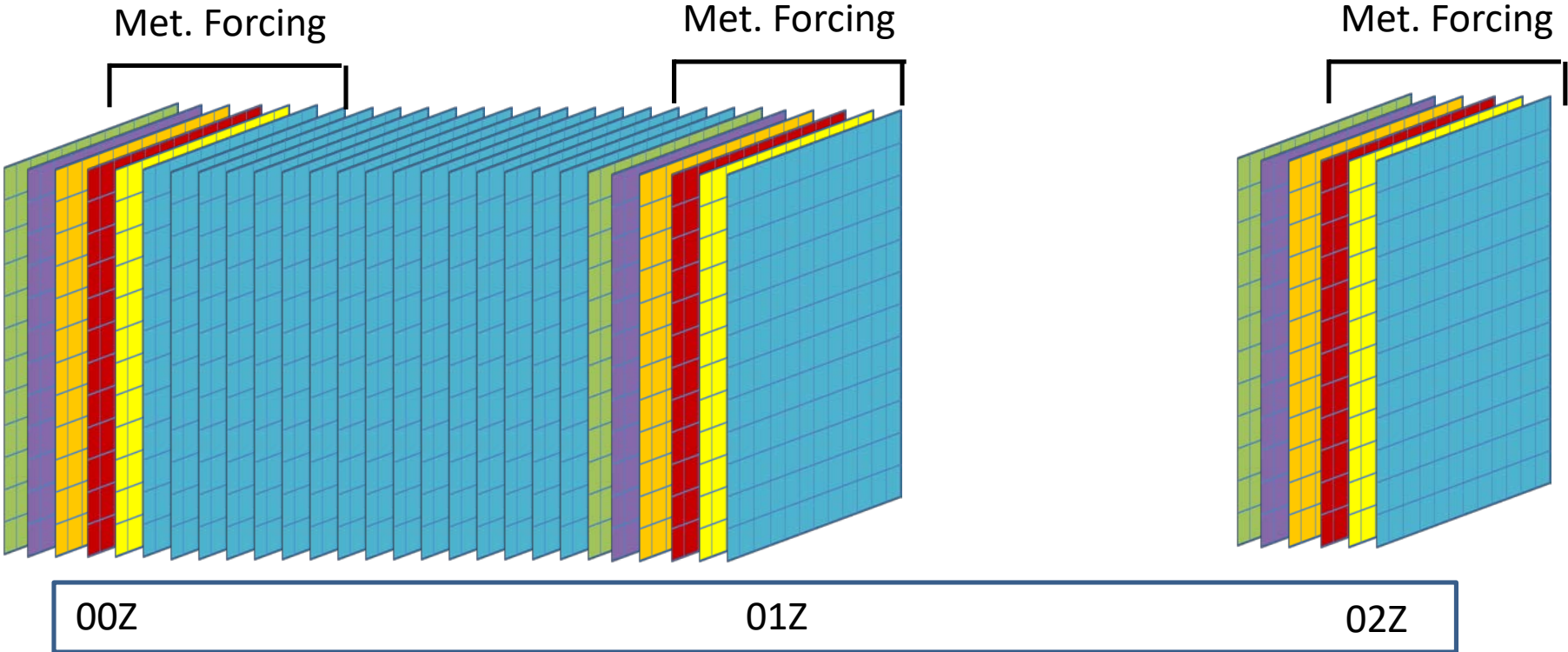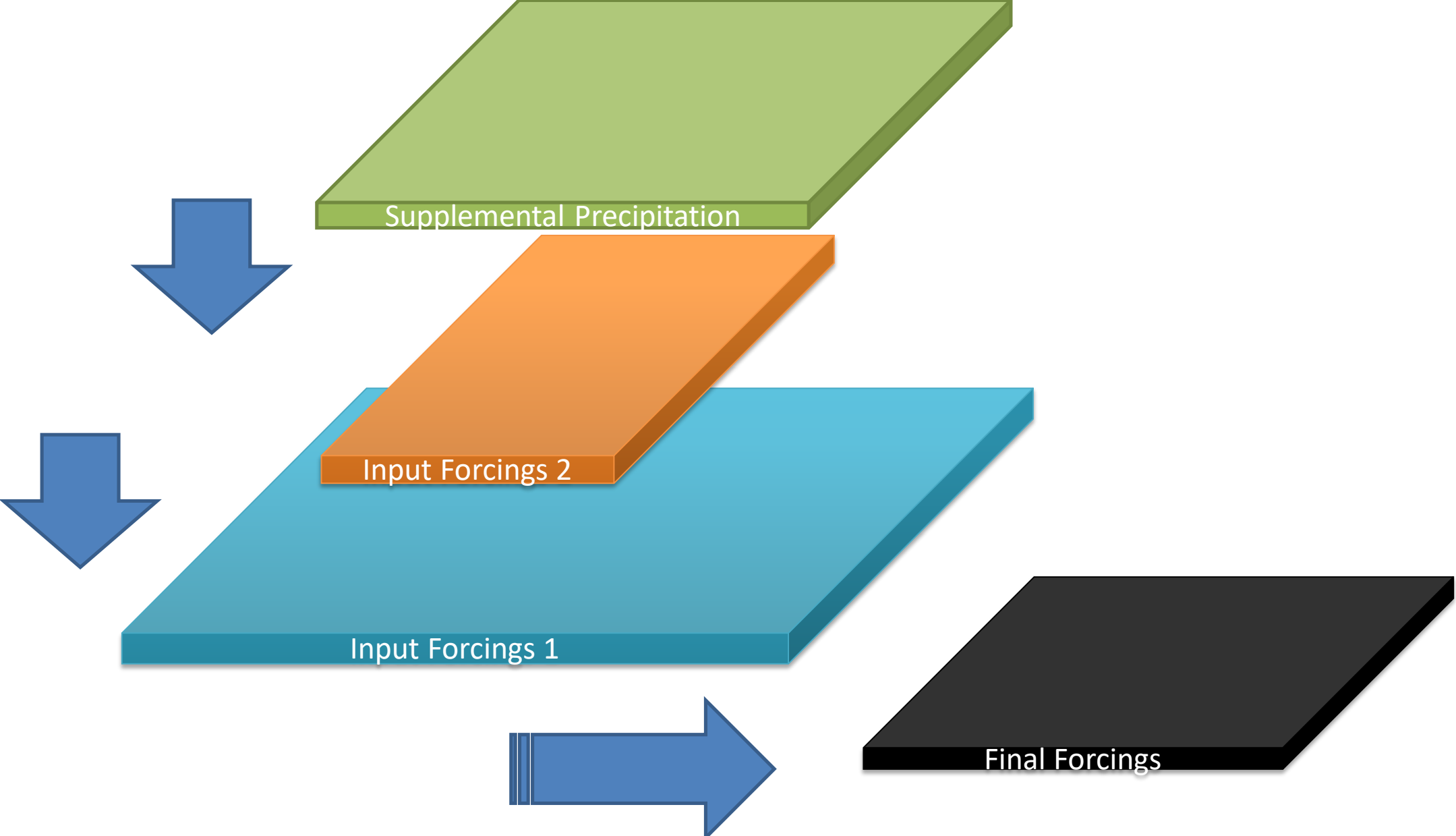
**Input NWP/Precip**
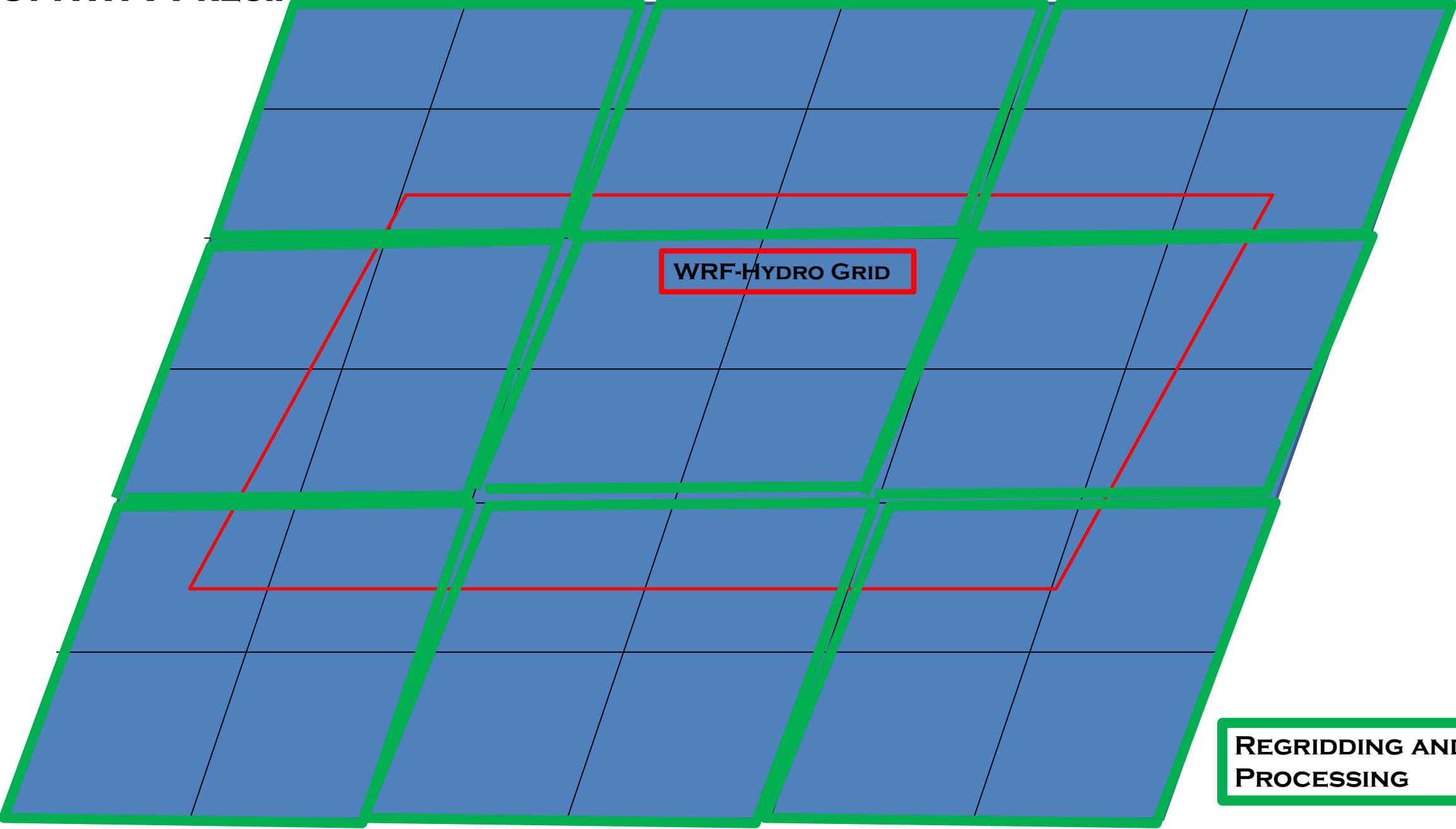
**WRF-Hydro Grid**

**Regridding and Processing**

# Forcing Engine Workflow
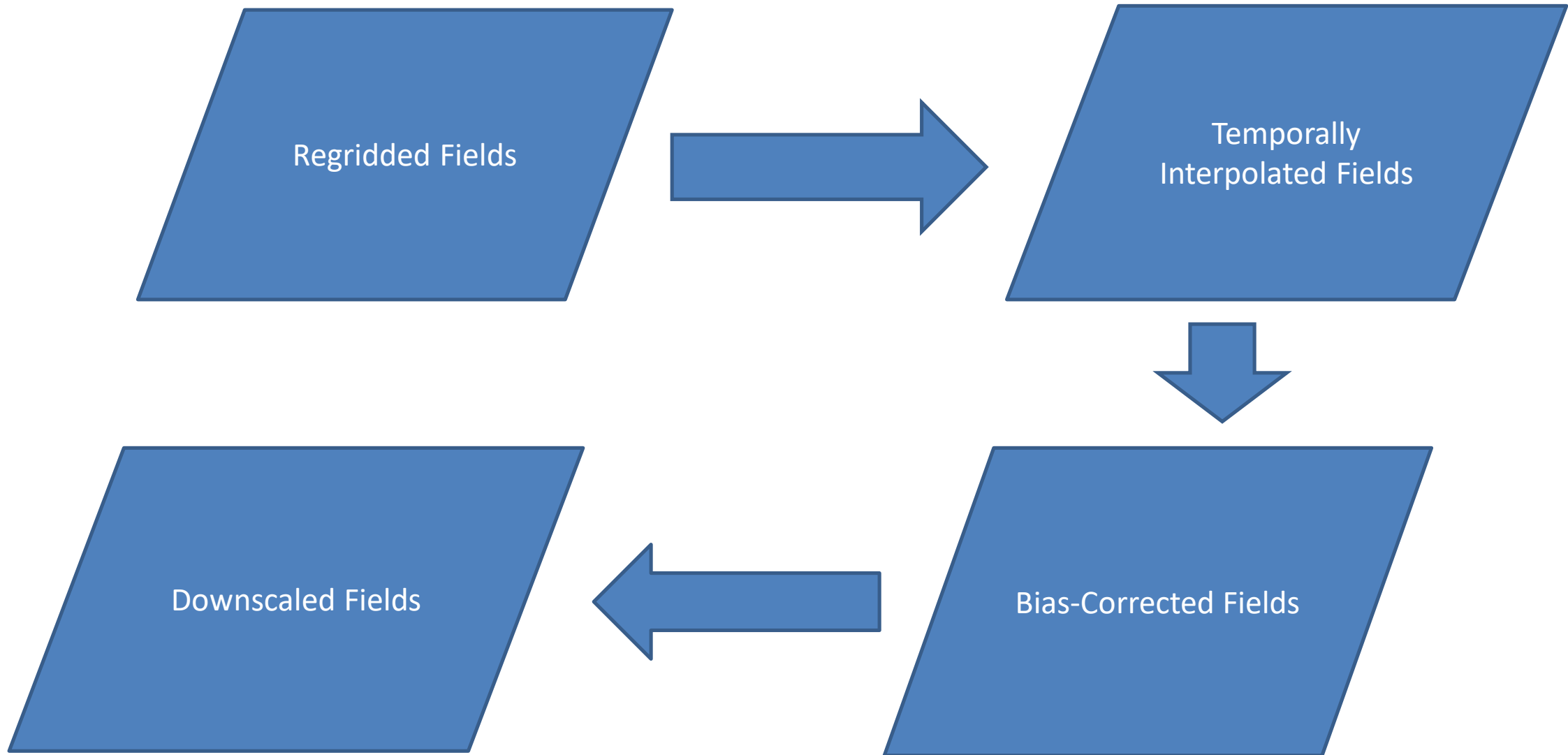
# Forcing Engine Workflow

# Input Forcing Data Requirements

- netcdf forcing input file header

A11. Forcing data netcdf file header

```
netcdf \201111040900 {
dimensions:
        Time = UNLIMITED ; // (1 currently)
        south_north = 475 ;
        west_east = 475 ;
variables:
        float Q2D(Time, south_north, west_east) ;
                Q2D:FieldType = 104 ;
                Q2D:MemoryOrder = "XY " ;
                Q2D:description = "QV at 2 M" ;
                Q2D:units = "kg kg-1" ;
                Q2D:stagger = "" ;
                Q2D:coordinates = "XLONG XLAT" ;
        float T2D(Time, south_north, west_east) ;
                T2D:FieldType = 104 ;
                T2D:MemoryOrder = "XY " ;
                T2D:description = "TEMP at 2 M" ;
                T2D:units = "K" ;
                T2D:stagger = "" ;
                T2D:coordinates = "XLONG XLAT" ;
        float SWDOWN(Time, south_north, west_east) ;
                SWDOWN:FieldType = 104 ;
                SWDOWN:MemoryOrder = "XY " ;
                SWDOWN:description = "DOWNWARD SHORT WAVE FLUX AT
GROUND SURFACE" ;
                SWDOWN:units = "W m-2" ;
                SWDOWN:stagger = "" ;
                SWDOWN:coordinates = "XLONG XLAT" ;
        float LWDOWN(Time, south_north, west_east) ;
```
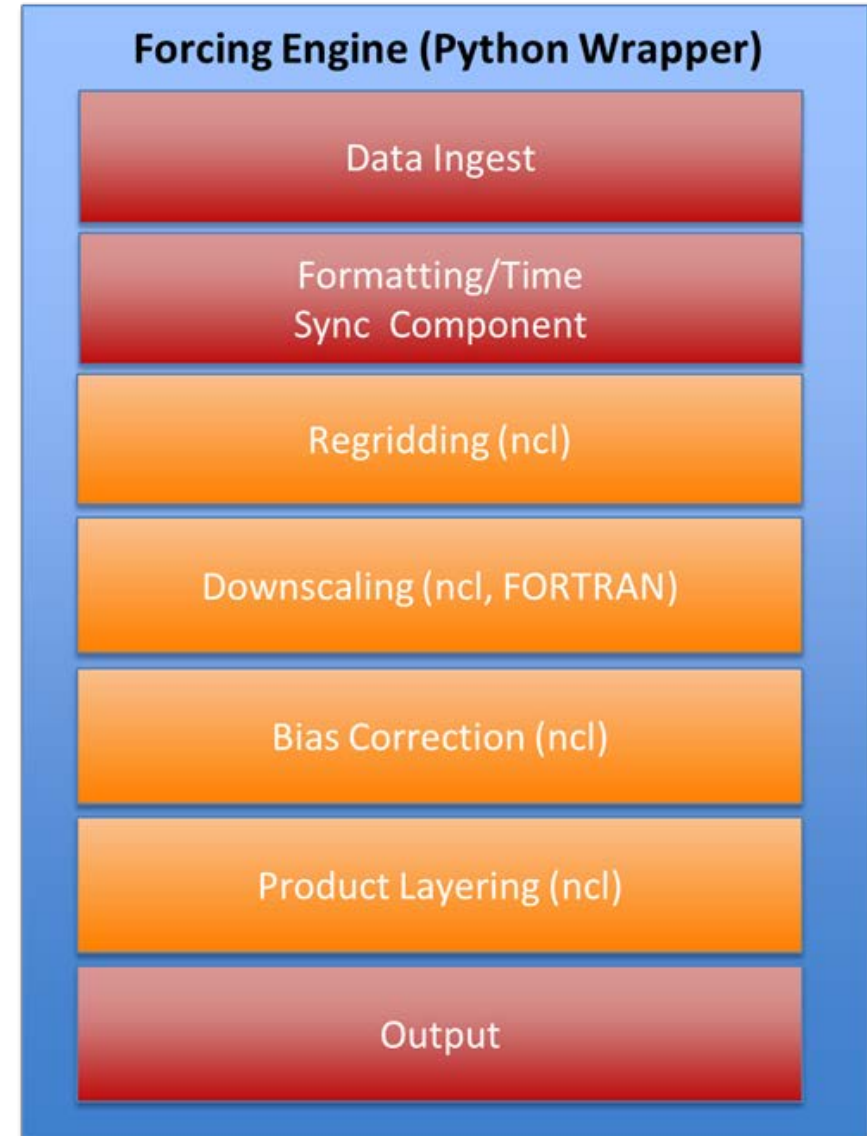
# Broader WRF-Hydro Forcing Data Engine Construction

1. Create national 1km gridded fields of:
   - Temperature, mixing ratio, surface pressure, u-, v-windspeed, longwave and shortwave radiation, precipitation rate
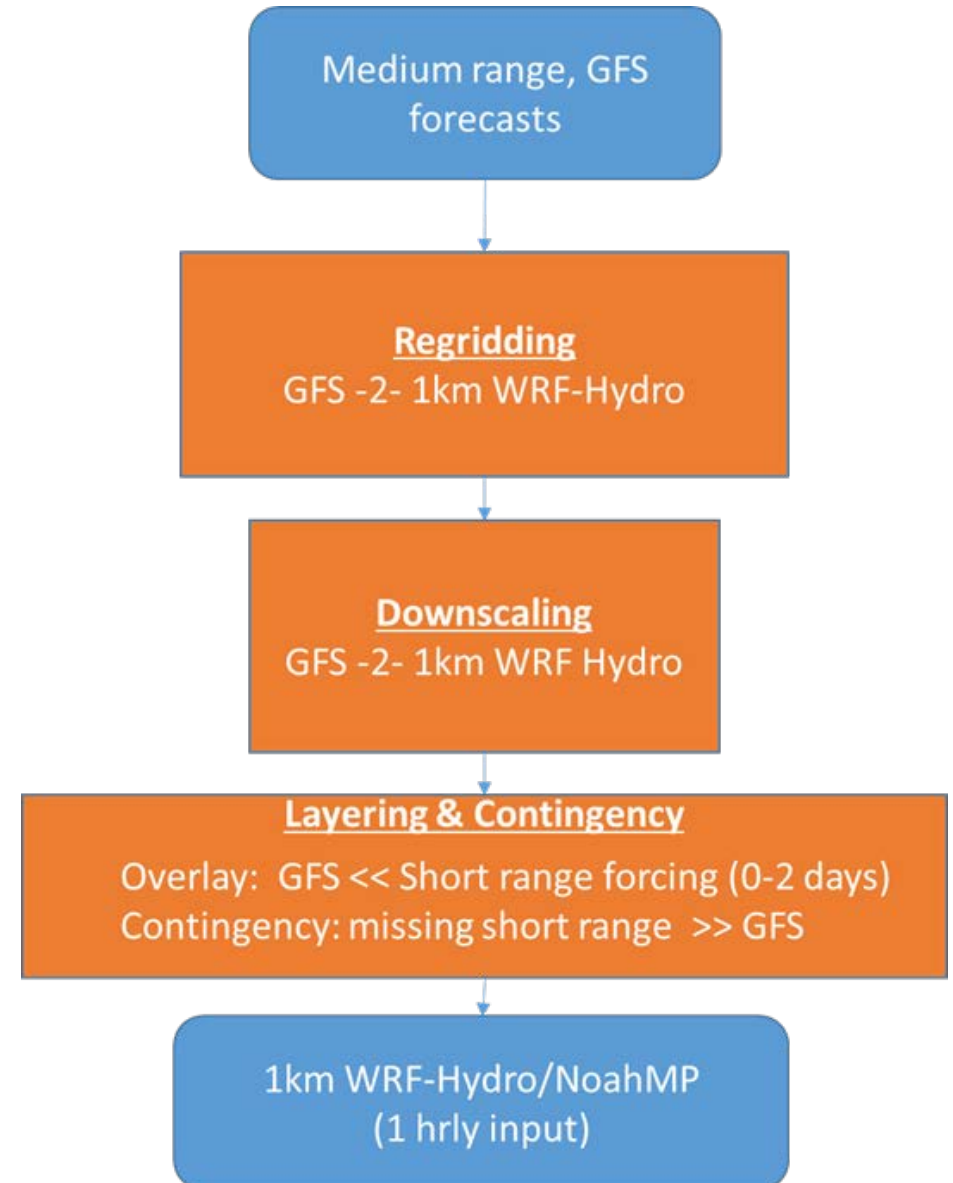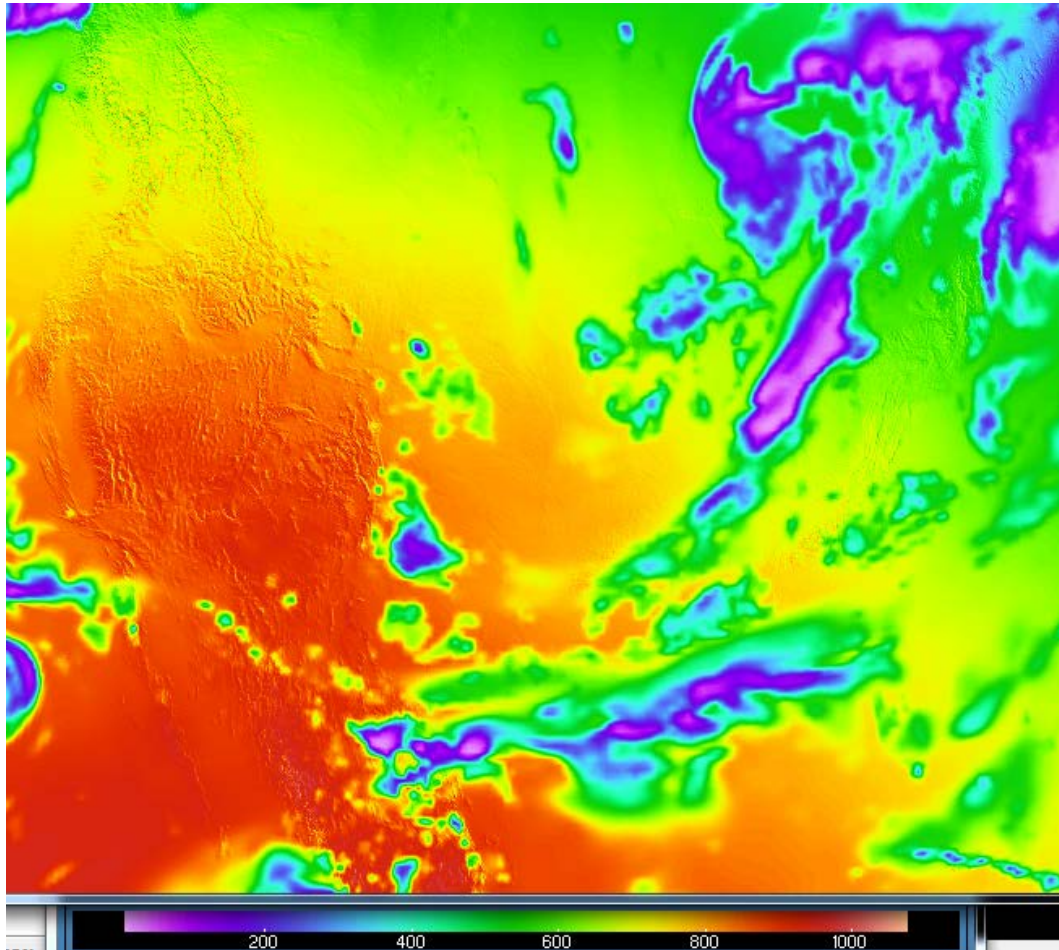
2. Downscaling of:
   - Temperature (NARR distributed climatological lapse rate)
   - Mixing ratio (conserve RH)
   - Surface pressure
   - Incoming shortwave radiation (terrain slope and aspect)

**Forcing Engine (Python Wrapper)**

- Data Ingest
- Formatting/Time Sync Component
- Regridding (ncl)
- Downscaling (ncl, FORTRAN)
- Bias Correction (ncl)
- Product Layering (ncl)
- Output

# NWM Forcing Data Engine Construction

- ## Medium Range Configuration
  - Downscaled GFS (incoming shortwave radiation Sept. 11, 2015 21Z)





Medium range, GFS forecasts

**Regridding**
GFS -2- 1km WRF-Hydro

**Downscaling**
GFS -2- 1km WRF Hydro

**Layering & Contingency**
Overlay:  GFS << Short range forcing (0-2 days)
Contingency: missing short range  >> GFS

1km WRF-Hydro/NoahMP
(1 hrly input)

# NWM Meteorological Forcing Engine (MFE)

1. Create national 1km gridded fields of:
   - Temperature, mixing ratio, surface pressure, u-, v-windspeed, longwave and shortwave radiation, precipitation rate

2. Terrain Downscaling of:
   - Temperature (NARR distributed climatological lapse rate)
   - Mixing ratio (conserve RH)
   - Surface pressure
   - Incoming shortwave radiation (terrain slope and aspect)
   - Rain-snow portioning (in development)
   - Wind (in development)

3. Statistical Bias Correction

4. Open source python workflow utilizing ESMF regridding tools

5. Multi-thread job, scales almost linearly because there is no memory sharing across processors (1-d calculations)
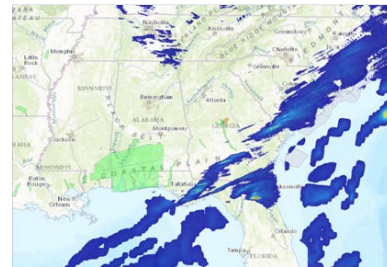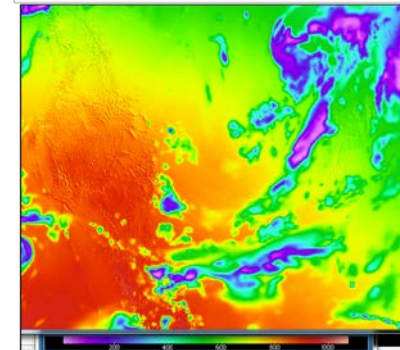
**Seasonally-varying MRMS RQI**
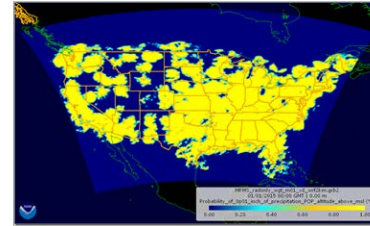
**HRRR-RAP 2m Air Temperature**
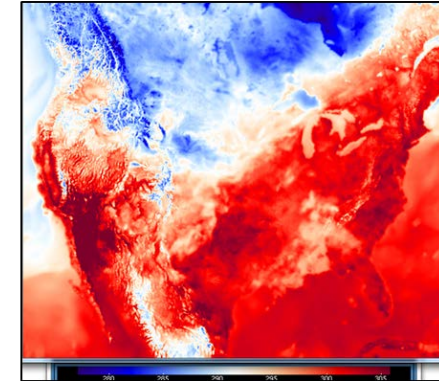
**Blended MRMS-HRRR Precipitation**

**GFS – derived incoming shortwave radiation**

Developed by Logan Karsten, Yongxin Zhang and Joe Grimm

# Questions?