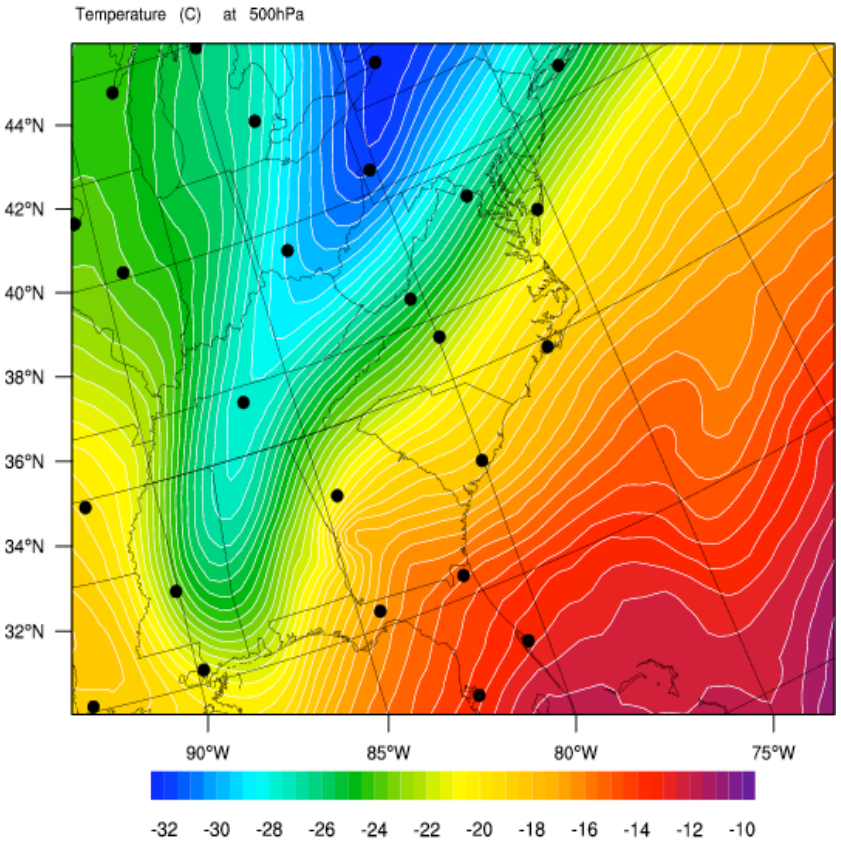
Objective Analysis (OBSGRID)

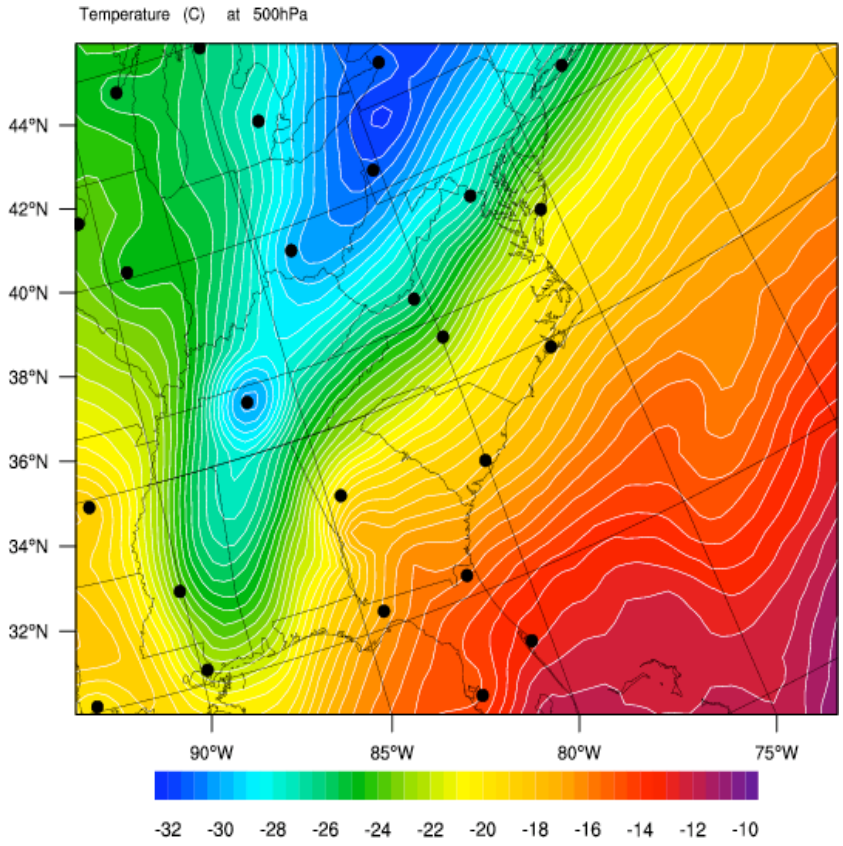
Cindy Bruyère

Objective Analysis

- **To improve a *first-guess* gridded analysis by incorporating additional observational information**
  - Traditionally, this first-guess analysis comes from low-resolution global analysis and forecast grids
  - These days, higher-resolution, regional scale analyses are more readily available
    - *These high-resolution analyses mean that in many cases, the objective analysis step is not essential when running WRF*

Objective Analysis



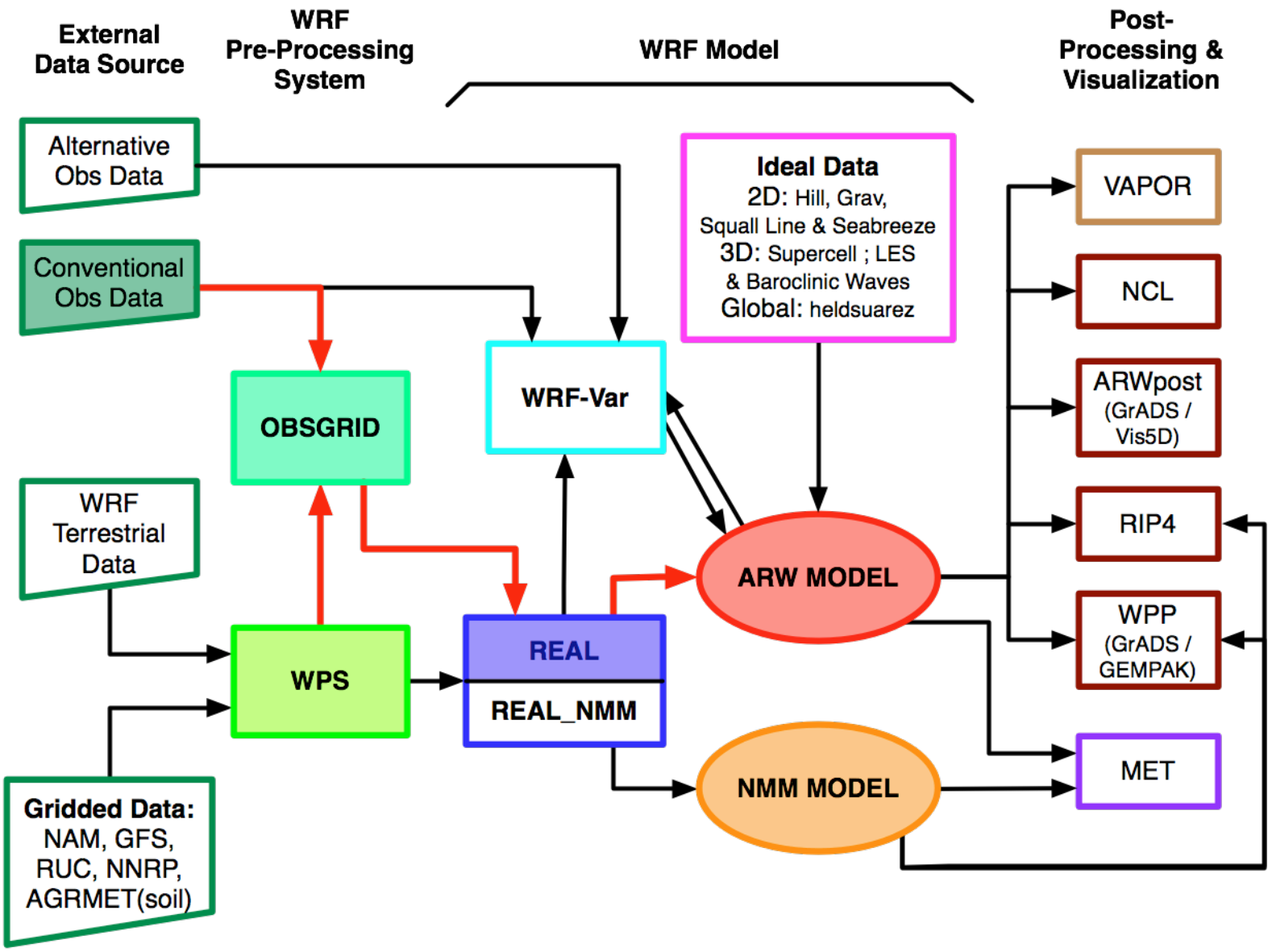


Objective Analysis in WRF

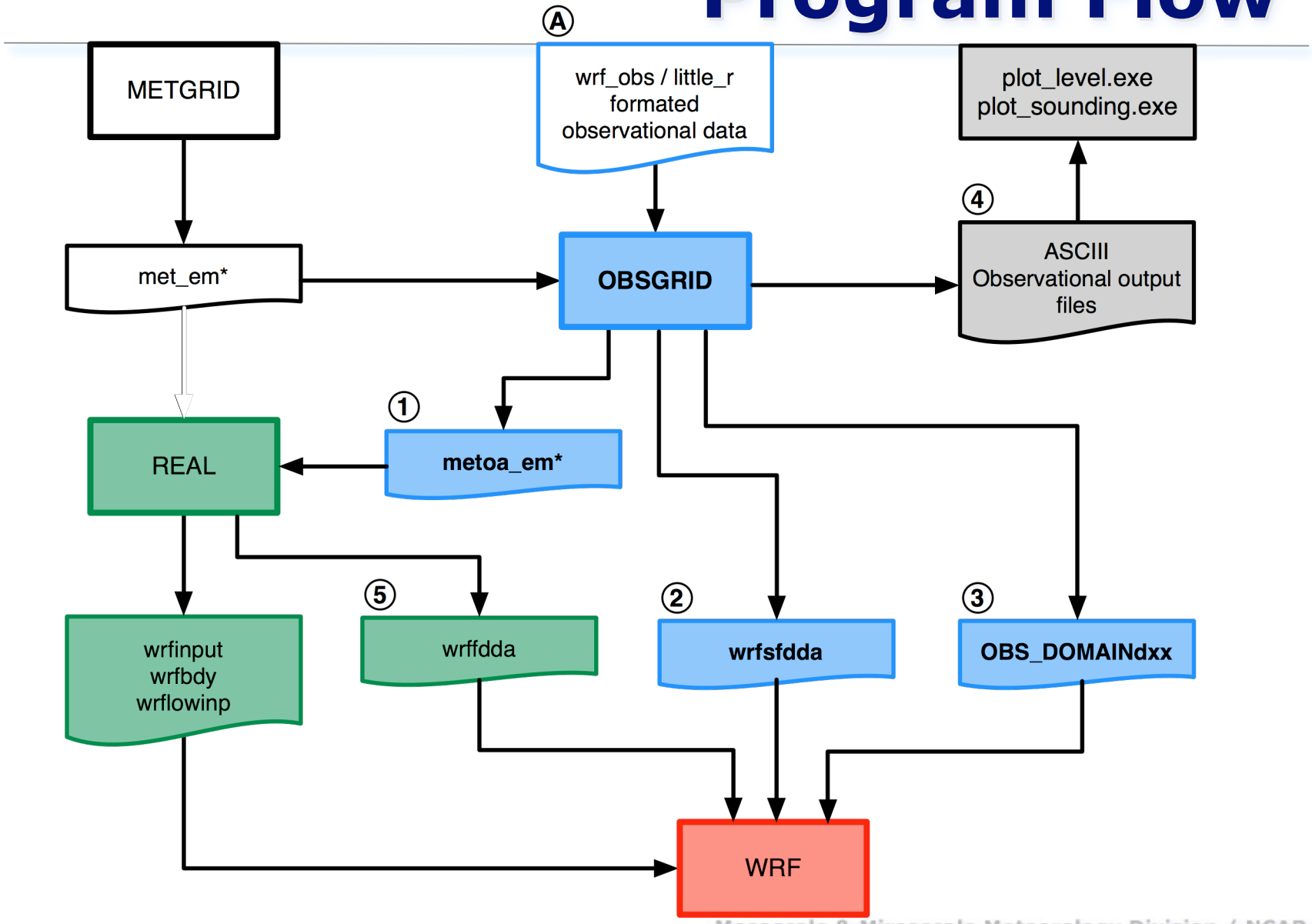
- **Traditional methods**
  - Direct observations of T, U, V, RH at surface and on pressure levels *(conventional observations)*

- **Variational Analysis**
  - Direct and indirect observations on model levels *(conventional + alternative observations)*

WRF Modeling System Flow Chart



Program Flow



Surface FDDA Option

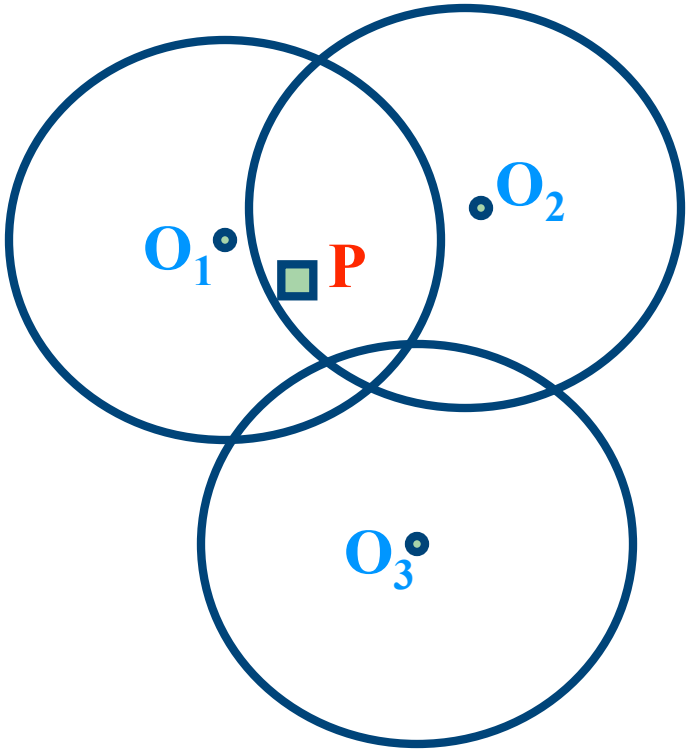
- **Creates a separate surface analysis file for later use by the WRF Surface FDDA Grid Nudging option**
- **Surface analyses usually created more frequently than upper-air analyses**
- ***WRF Surface FDDA available in WRF version 3.1 release***

OA Techniques in OBSGRID

- **Cressman-based analysis**
  - Impact of observation within radius of influence only
  - Multiple scans
  - With ellipse and banana extensions

- **Multi-Quadric analysis**
  - Impact of observations are over the entire model domain
  - Scheme is sensitive to the data density distribution

Cressman Scheme

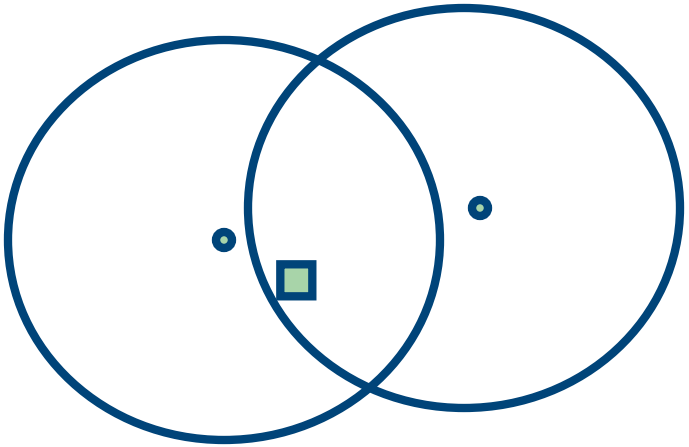


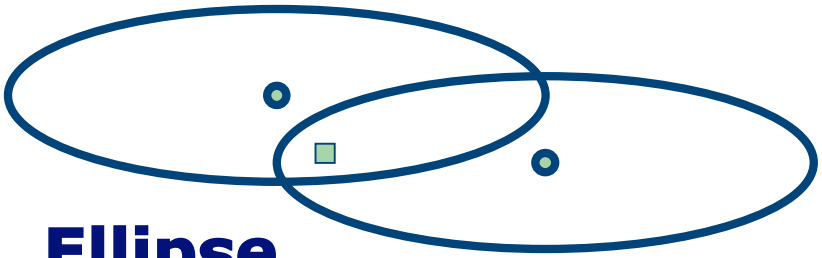
Observations

Grid Point

Observations O_1 and O_2 influences grid point P, O_3 does not

Cressman Scheme

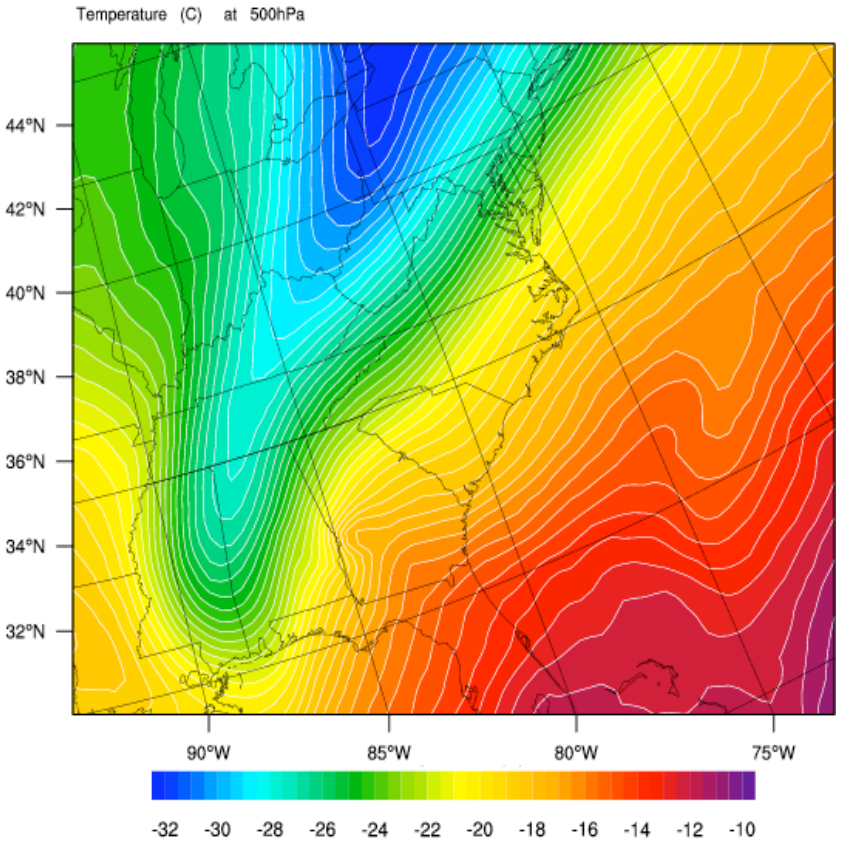


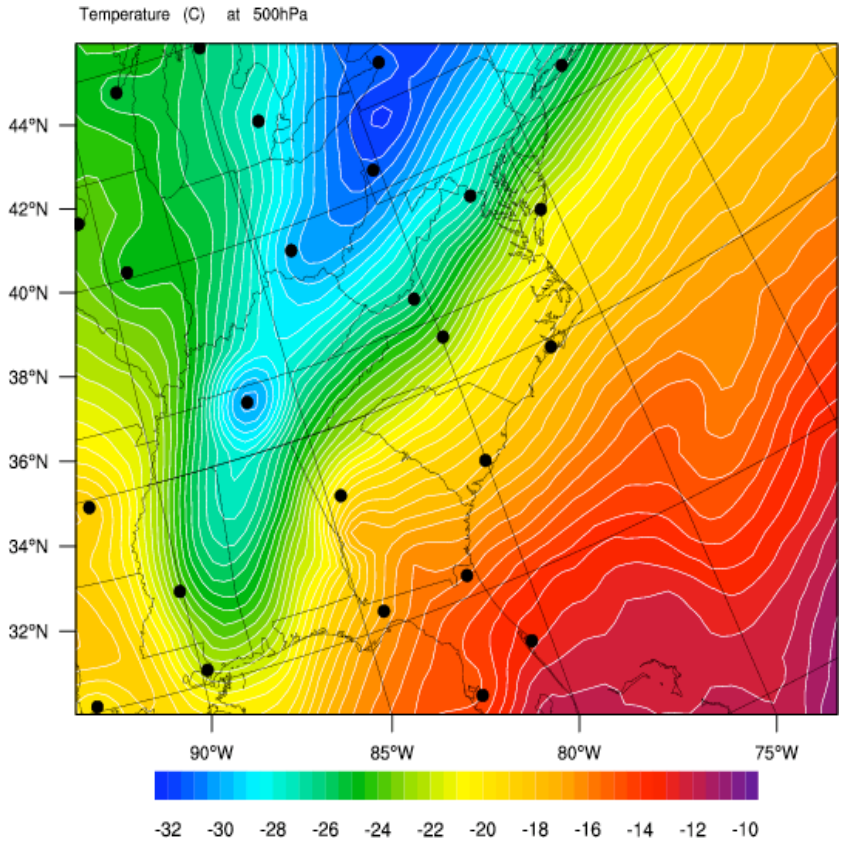


Ellipse

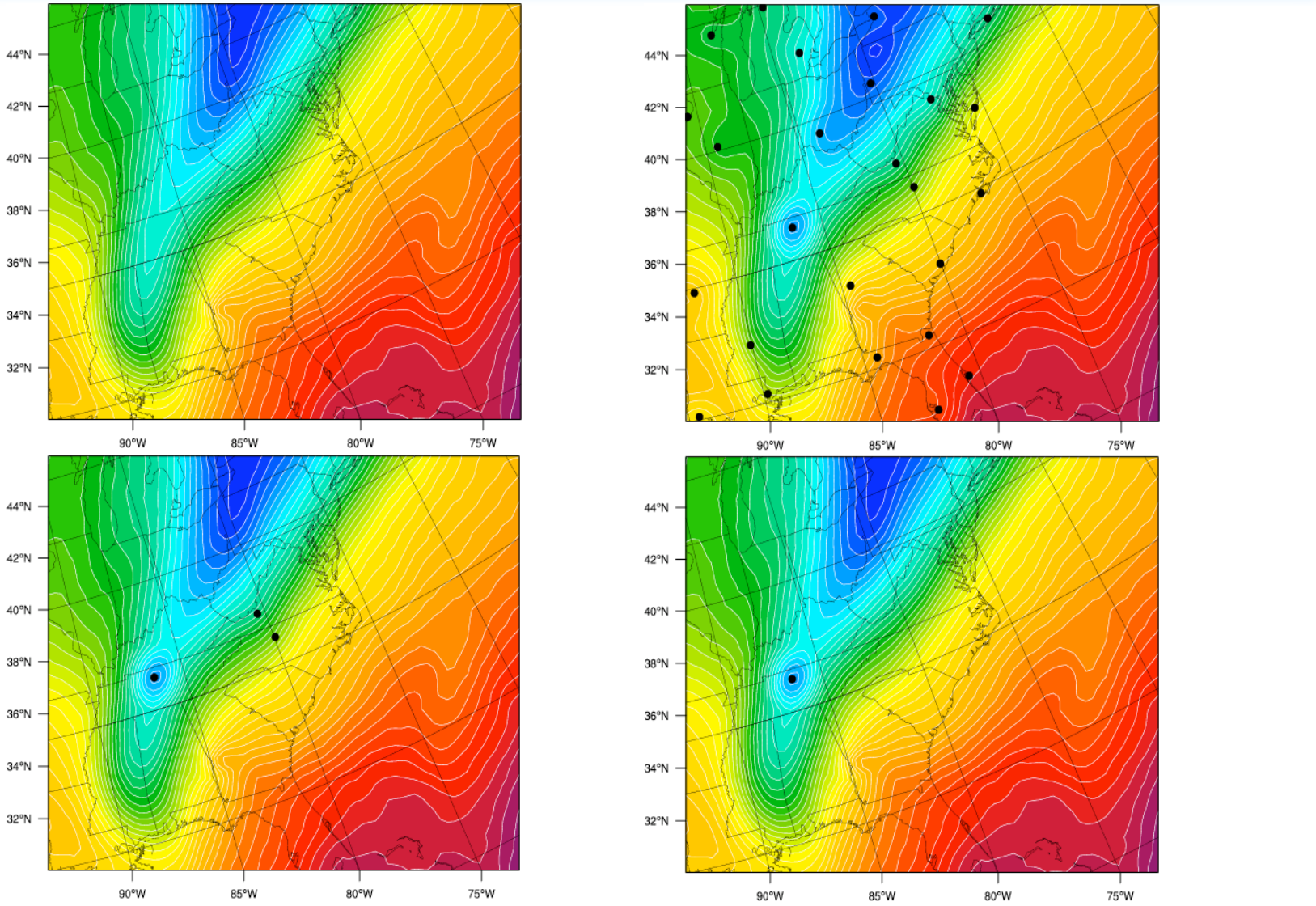
Banana

Cressman Scheme

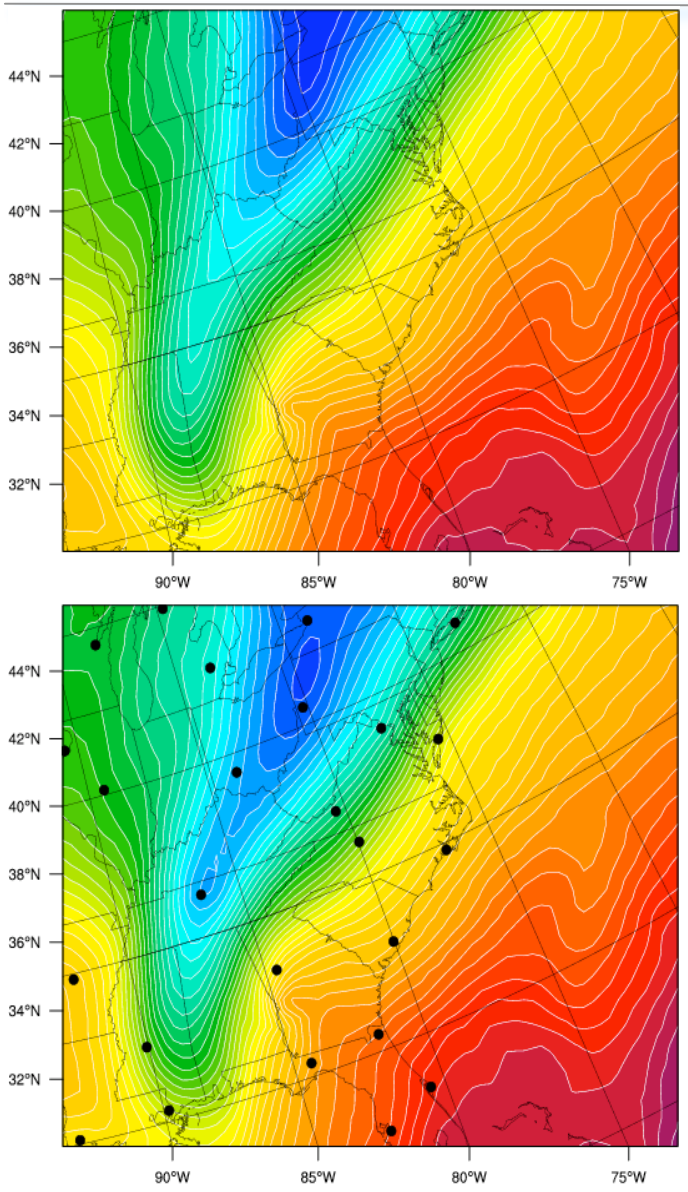




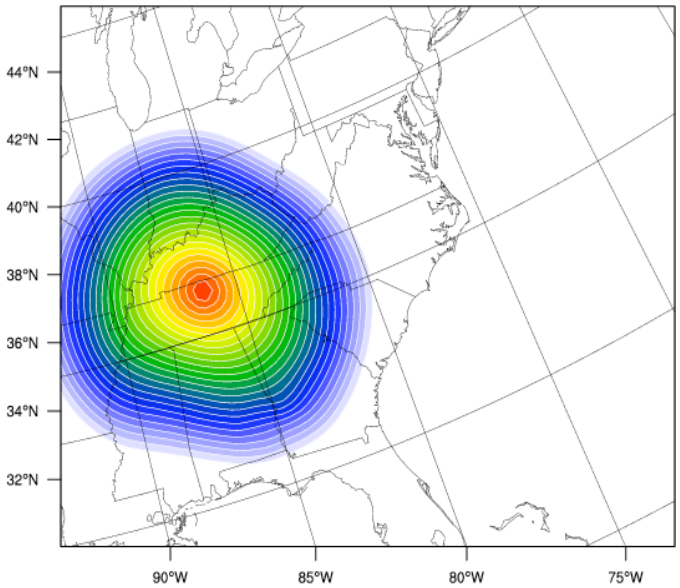
Cressman Scheme



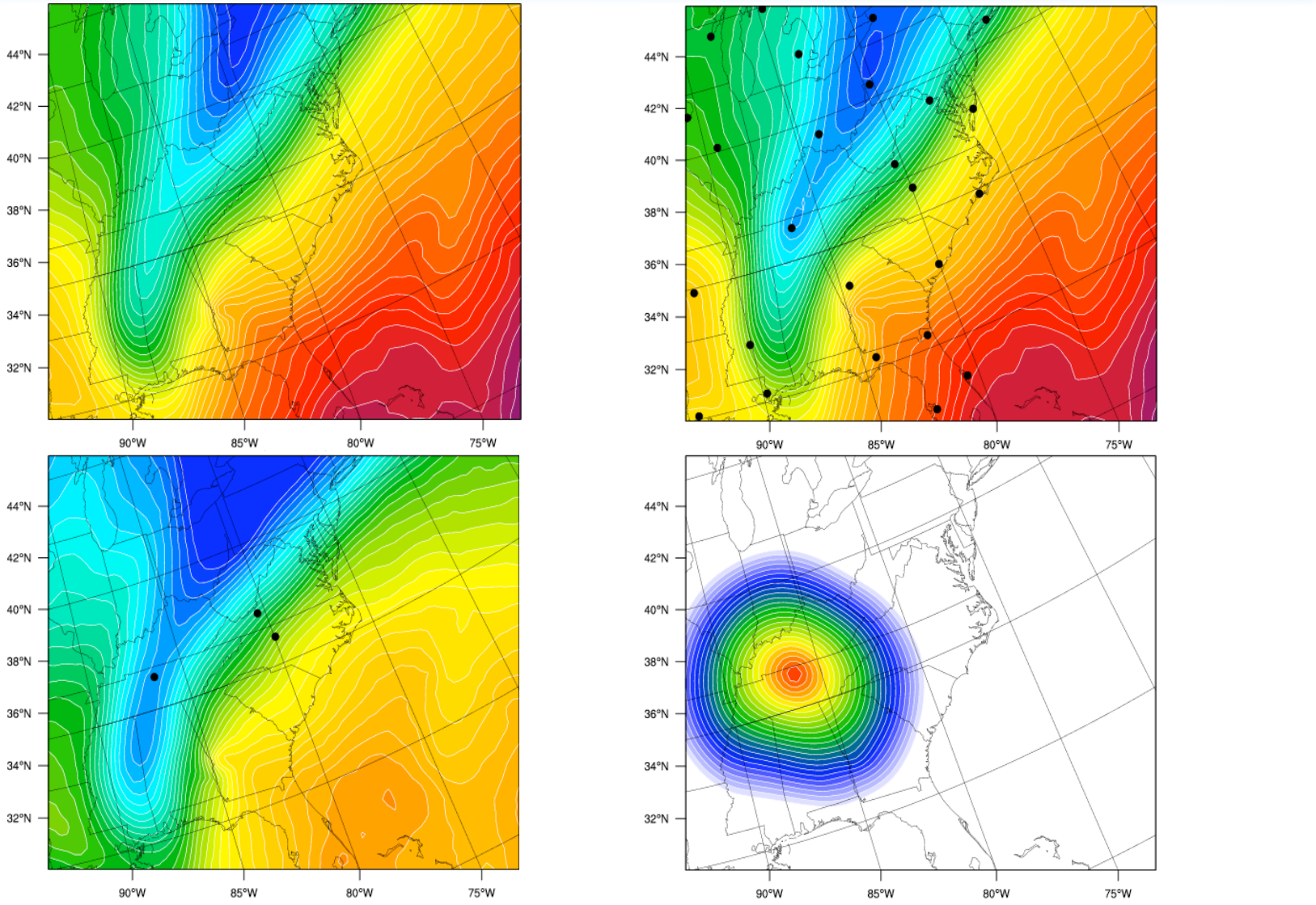
Multi-Quadric Scheme



Makes use of hyperboloid radial basis functions to interpolate observation corrections onto model grid



Multi-Quadric Scheme

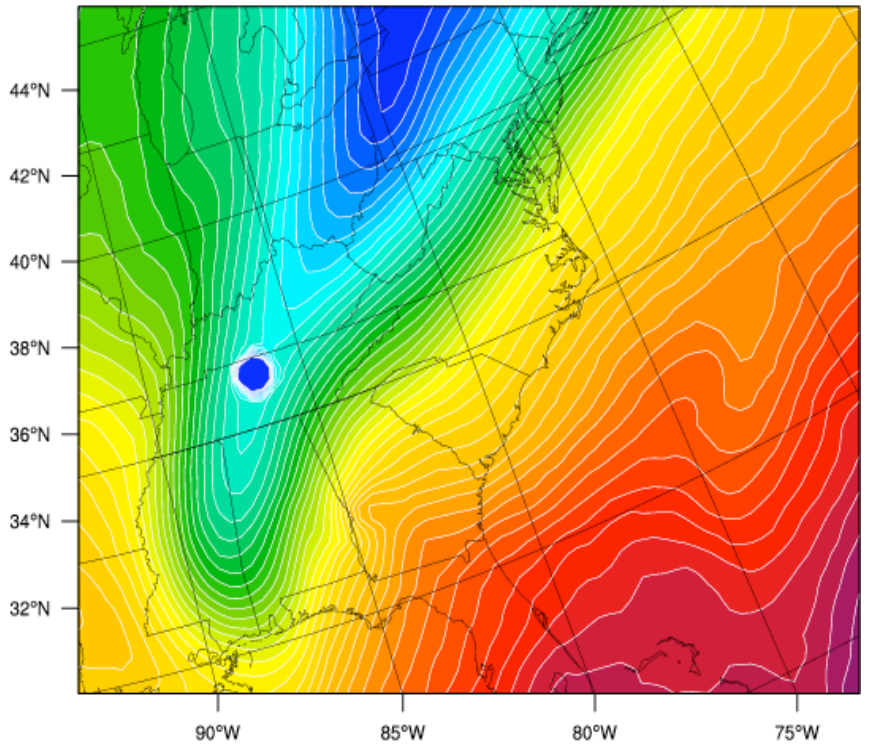


Quality Control for Observations

- **A critically important step**

  Bad observations = Bad objective analysis

- **Even a single bad observation can ruin initial conditions**



Quality Control for Observations

- Tests on individual reports
- ERRMAX test
- Buddy test

Tests on individual reports

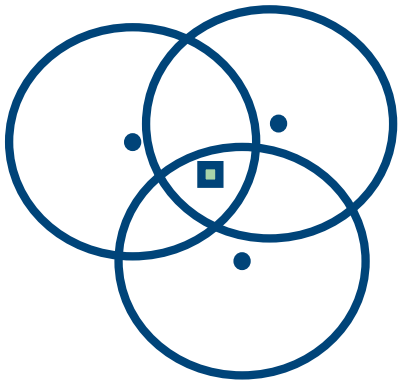
- **Gross error checks**
- **Remove spikes from temperature and wind profiles** *(optional, not recommended)*
- **Adjust temperature profiles to remove superadiabatic layers** *(optional, not recommended)*
- **No comparisons to other soundings or to first-guess field**

ERRMAX test

- Limited user control over data removal
- Observations are compared to first-guess field
- If the difference between the observation and the first-guess exceeds a threshold, the observation is discarded
- Threshold varies depending on field, level, time of day
- Works well with good first-guess field

Buddy test

- Limited user control over data removal
- Observations are compared to the first guess and to nearby observations
- If an observation deviates from the first guess in a manner inconsistent with the deviations of surrounding stations from the first guess, then that observation is discarded
- Works well in regions of good data density



How to run OBSGRID

- **Get the source code**
- **Compile *(./configure & ./compile)***
- **Prepare observations files**
  - Users need to generate this file *(some sample programs are available)*
- **Edit the namelist**
- **Run the program**
- **Check your output**

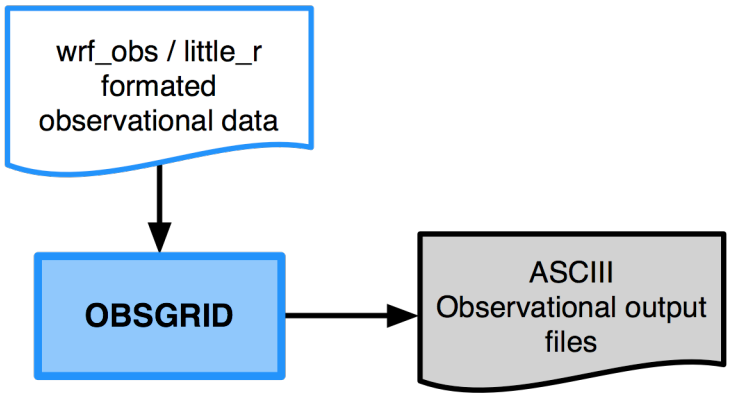
Observations

- **ASCII text files *(wrf_obs / little_r format)***
  - One entry per observation *(sfc or upper-air)*
    - Header ; Data ; End

UG: 7-13

- **Each time period is stored in a separate file**

- **OBSGRID combines reports, removes duplicates, interpolates to analysis levels**



Observations Format: *Header*

latitude	F20.5	Station latitude
longitude	F20.5	Station longitude
id	A40	Station ID
name	A40	Station name
platform	A40	Measurement device
source	A40	Source of observations
elevation	F20.5	Station elevation (m)
num_vld_fld	I10	Number of valid fields
num_error	I10	Number of errors in decoding
num_warning	I10	Number of warnings in decoding

Observations Format: *Header*

seq_num	I10	Sequence number of this report
num_dups	I10	Number of duplicates found for this report
is_sound	L10	Multiple or single levels
bogus	L10	Bogus or normal report
discard	L10	Duplicate and Discarded report
sut	I10	Time of report (s since 1970-01-01)
julian	I10	Day of the year of the report
date_char	A20	Report time (YYYYMMDDHHmmss)
slp, qc	F13.5, I7	SLP Value and QC flag
ref_pres, qc	F13.5, I7	Reference pressure and QC flag

Observations Format: *Header*

ground_t, qc	F13.5, I7	Ground T and QC flag
sst, qc	F13.5, I7	SST and QC flag
psfc, qc	F13.5, I7	Surface P and QC flag
precip, qc	F13.5, I7	Accumulated Precip and QC flag
t_max, qc	F13.5, I7	Daily maximum T and QC flag
t_min, qqc	F13.5, I7	Daily minimum T and QC flag
t_min_night, qc	F13.5, I7	Overnight min T and QC flag
p_tend03, qc	F13.5, I7	3-hr pressure tendency and QC
p_tend24, qc	F13.5, I7	24-r pressure tendency and QC
cloud_cvr, qc	F13.5, I7	Cloud cover (oktas) and QC flag
ceiling, qc	F13.5, I7	Height of cloud base and QC flag

Observations Format: *Data*

pressure, qc	F13.5, I7	Pressure
height, qc	F13.5, I7	Height
temperature, qc	F13.5, I7	Temperature
dew_point, qc	F13.5, I7	Dewpoint
speed, qc	F13.5, I7	Wind speed
direction, qc	F13.5, I7	Wind direction
u, qc	F13.5, I7	U-component of wind
v, qc	F13.5, I7	V-component of wind
rh, qc	F13.5, I7	Relative Humidity
thickness, qc	F13.5, I7	Thickness

Observations Format: *End*

num_vld_fld	I7	Number of valid fields
num_error	I7	Errors encountered in decoding
num_warning	I7	Warnings encountered in decoding

Quality-Control Flags

- **Binary flags indicating which warning and error conditions have been met**

Pressure interpolated from first-guess height	2**1	2
Temperature and dewpoint both 0	2**4	16
Wind speed and direction both 0	2**5	32
Wind speed negative	2**6	64
Wind direction < 0 or > 360	2**7	128
Level vertically interpolated	2**8	256
Value vertically extrapolated from a single level	2**9	512
Sign of temperature reversed	2**10	1012
Superadiabatic level detected	2**11	2048
Vertical spike in wind speed or direction	2**12	4096
Convective adjustment applied to temperature field	2**13	8192
No neighboring observations for buddy check	2**14	16384
Error maximum test failed	2**15	32768
Buddy test failed	2**16	65536
Observation outside domain	2**17	131072

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Namelist

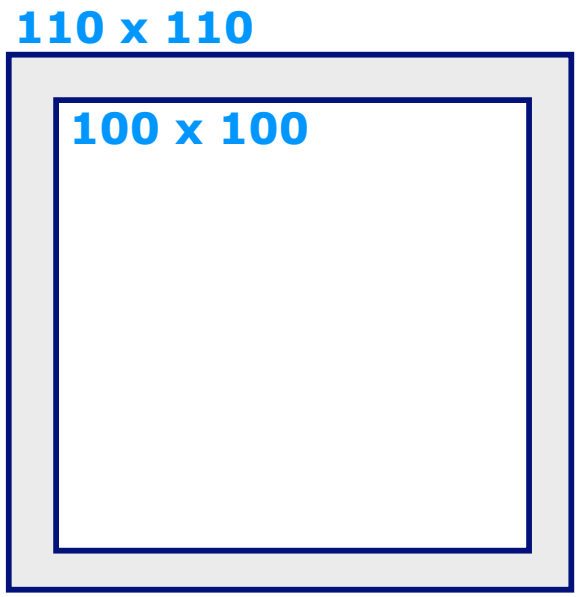
start_year	Four-digit starting year
start_month	Two-digit starting month (01-12)
start_day	Two-digit starting day (01-31)
start_hour	Two-digit starting hour (00-23)
end_year	Ending year
end_month	Ending month
end_day	Ending day
end_hour	Ending hour
interval	Time interval (s) to process

Namelist

domain_id	ID of domain to process
obs_filename	Root file name *(may include directory information)* of the observational files. All input files must have the format **obs_filename:<YYYY-MM-DD_HH>**. One file per time period. Also used when doing surface fdda *(**F4D=.TRUE.**)*
remove_data_ above_qc_flag	Data with qc flags higher than this will not be output to **OBS_DOMAIN*dxx***
remove_ unverified_data	Unverified data will not be output to **OBS_DOMAIN*dxx***

Namelist

trim_domain	Set to .TRUE. if this domain must be cut down on output
trim_value	Value by which the domain will be cut down in each direction



- **Why do this:**
This allows observations just outside the desired grid box of 100x100 grid points to be included in the OA

- ***geogrid* and *metgrid* run with a domain size of 110x110**

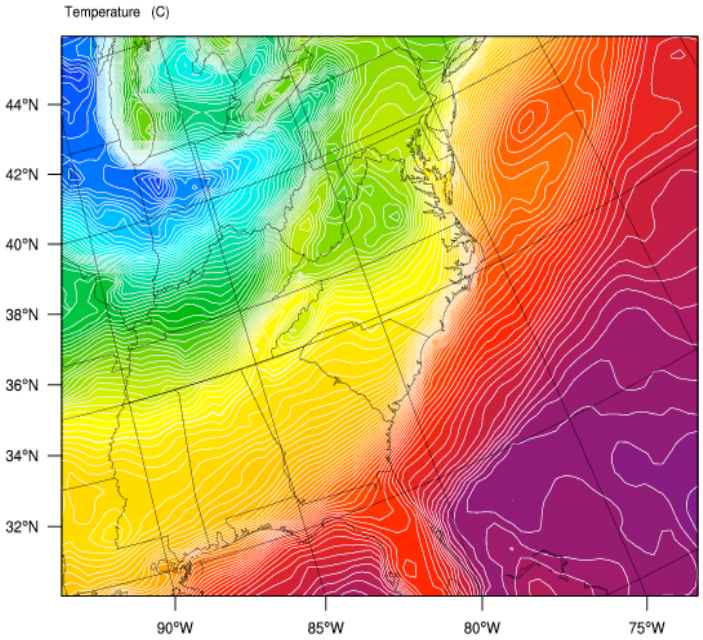
- **trim_domain = .TRUE.**
- **trim_value = 5**

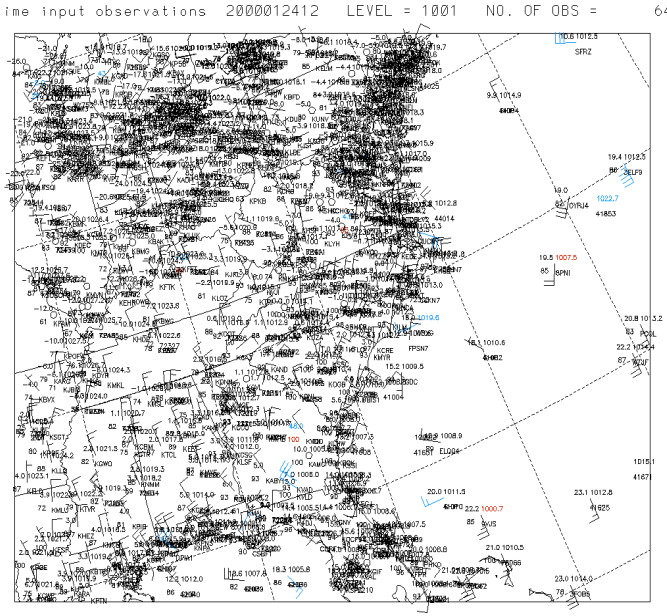
Namelist

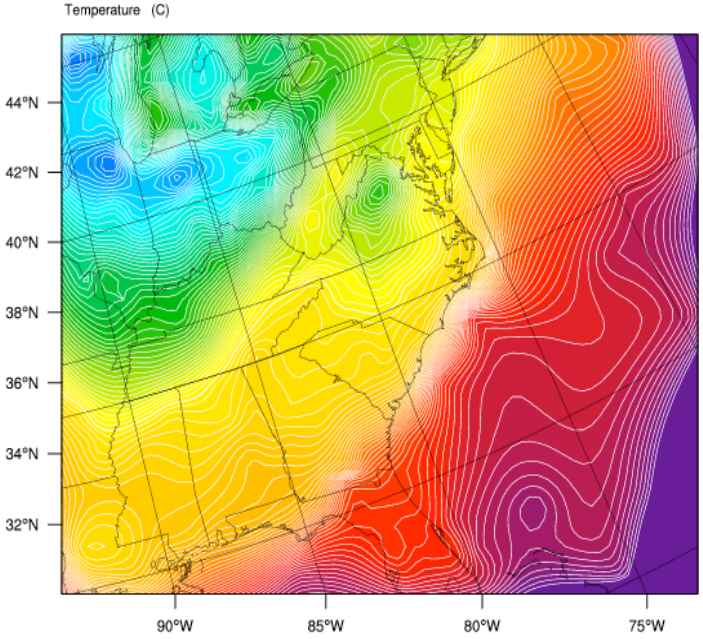
qc_test_error_max	Turn on error-max test (T/F)
qc_test_buddy	Turn on buddy test (T/F)
qc_test_vert_consistency	Turn on vertical tests (T/F)
qc_test_convective_adj	Remove superadiabatic (T/F)
max_error_t	Max T difference (K)
max_error_uv	Max u or v difference (m/s)
max_error_rh	Max RH difference (%)
max_error_p	Max SLP difference (Pa)
max_buddy_t	Threshold for T buddy check
max_buddy_uv	Threshold for u/v buddy check
max_buddy_rh	Threshold for RH buddy check
max_buddy_p	Threshold for SLP buddy check
buddy_weight	Scaling for buddy thresholds
max_p_extend_t	Pressure range (Pa) through which a single T report may be extended
max_p_extend_w	Pressure range (Pa) through which a single wind report may be extended

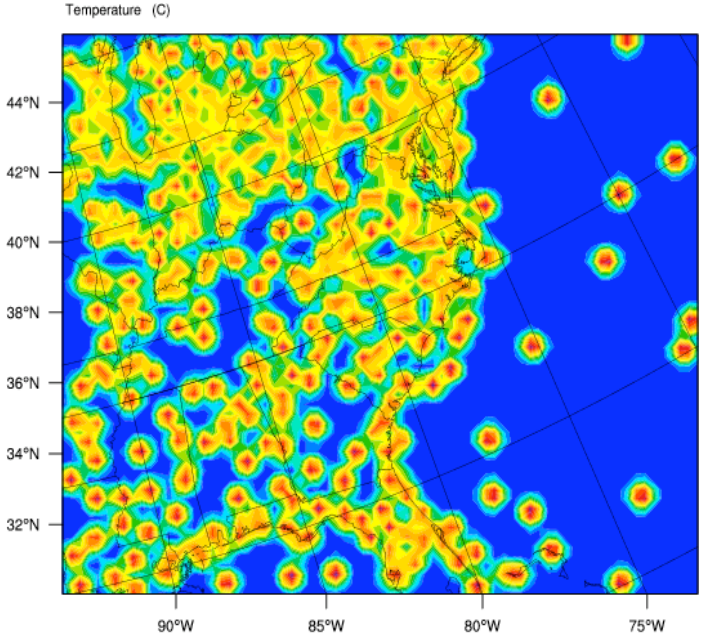
Namelist

use_first_guess	.TRUE.
f4d	Turn on (.TRUE.) or off (.FALSE.) the creation of surface analysis files *(wrfsfdda_d0x)*
intf4d	Time interval (*sesonds*) for surface analyses
lagtem	Use a lag-time (.TRUE.) or temporal interpolation (.FALSE.) for surface analysis first guess.









Mesoscale & Mircoscale Meteorology Division / NCAR

Namelist

OA_type	"MQD" or "Cressman"
MQD_minimum_num_obs	Minimum number of obs for MQD
MQD_maximum_num_obs	Maximum number of obs for MQD
radius_influence	Radius of influence for Cressman
OA_min_switch (T/F)	Switch to Cressman if too few obs for MQD
OA_max_switch (T/F)	Switch to Cressman if too many obs for MQD

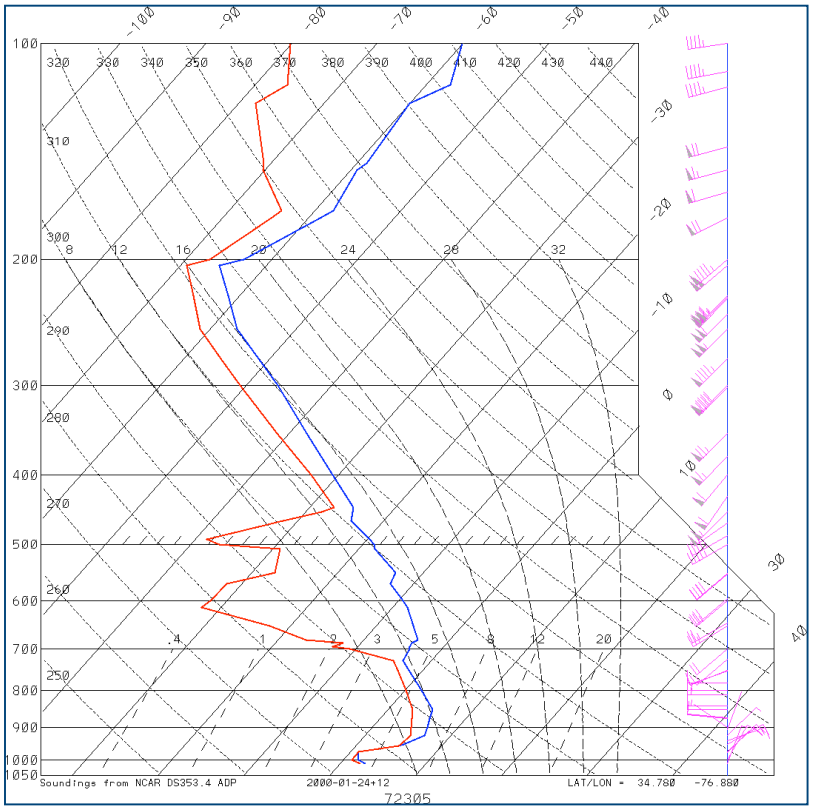
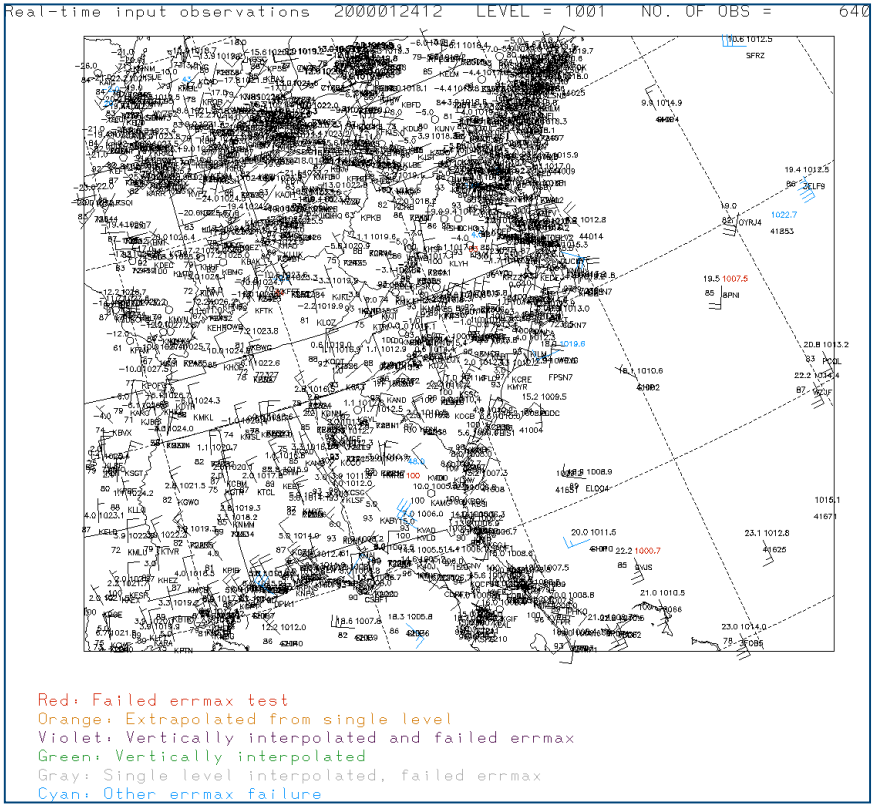
Utilities

- **plot_sound**
  - Plot sounding from the 'raw' or 'used' wrf_obs / little_r output files
  - Namelist control: **&record1, &record2, &plot_sounding**

- **plot_level**
  - Plot data used on all levels
  - Namelist control: **&record1, &record2**

Utilities

plot_sounding



plot_level