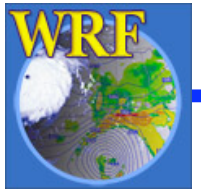
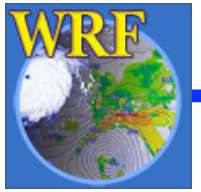
Objective Analysis (OBSGRID)

Cindy Bruyère

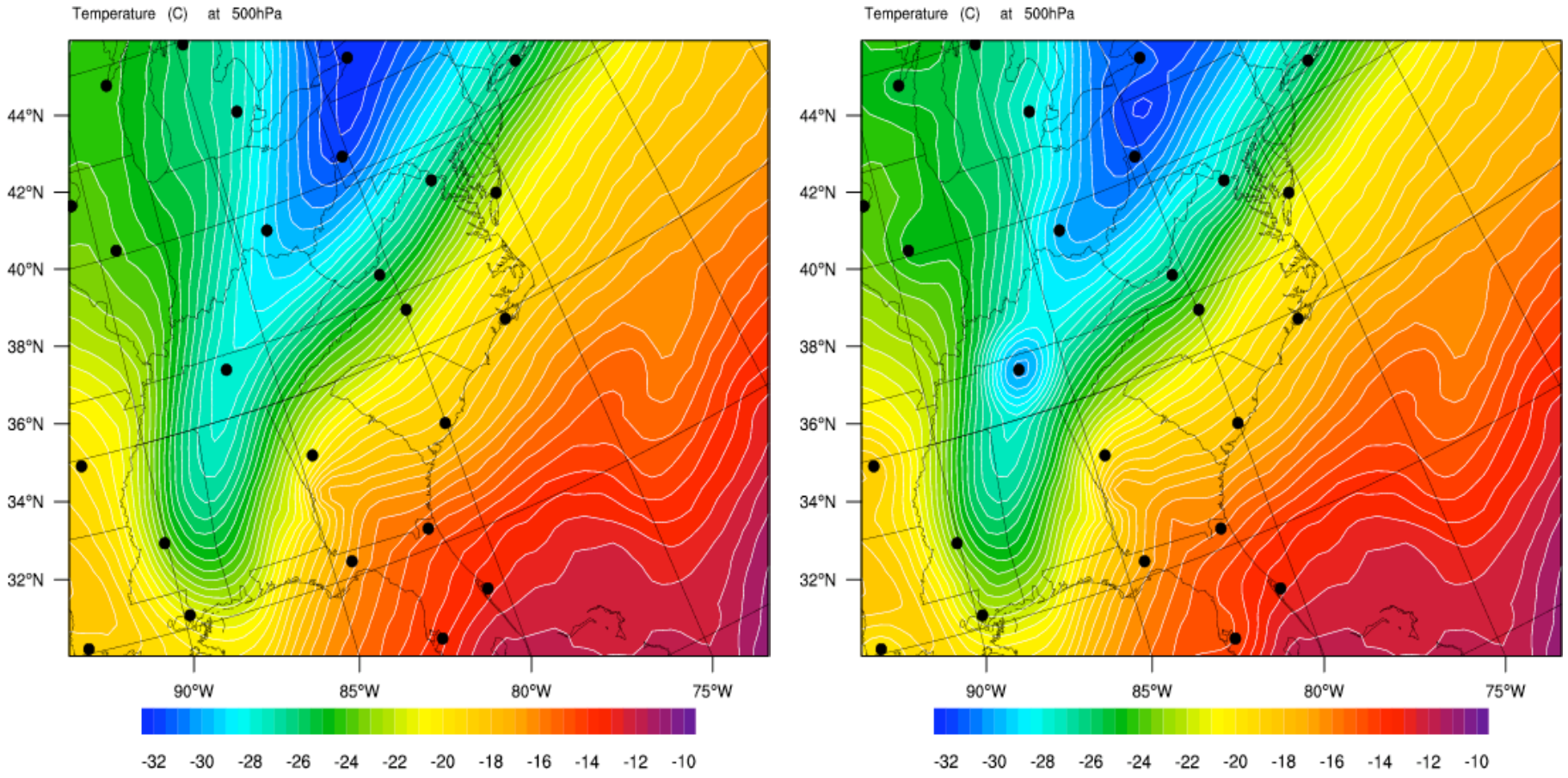


Objective Analysis

- **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



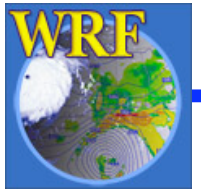
Objective Analysis



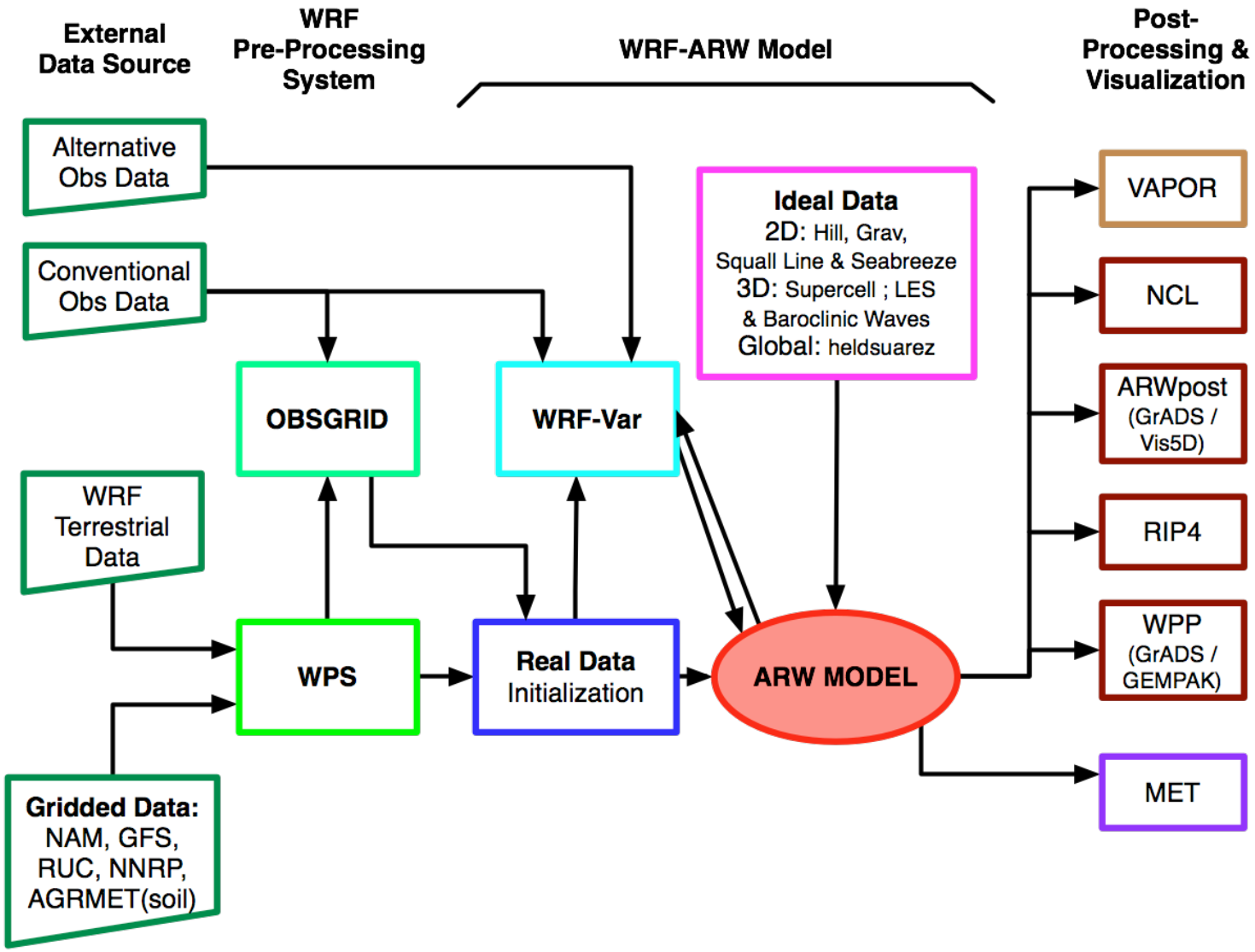
Objective Analysis in WRF

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

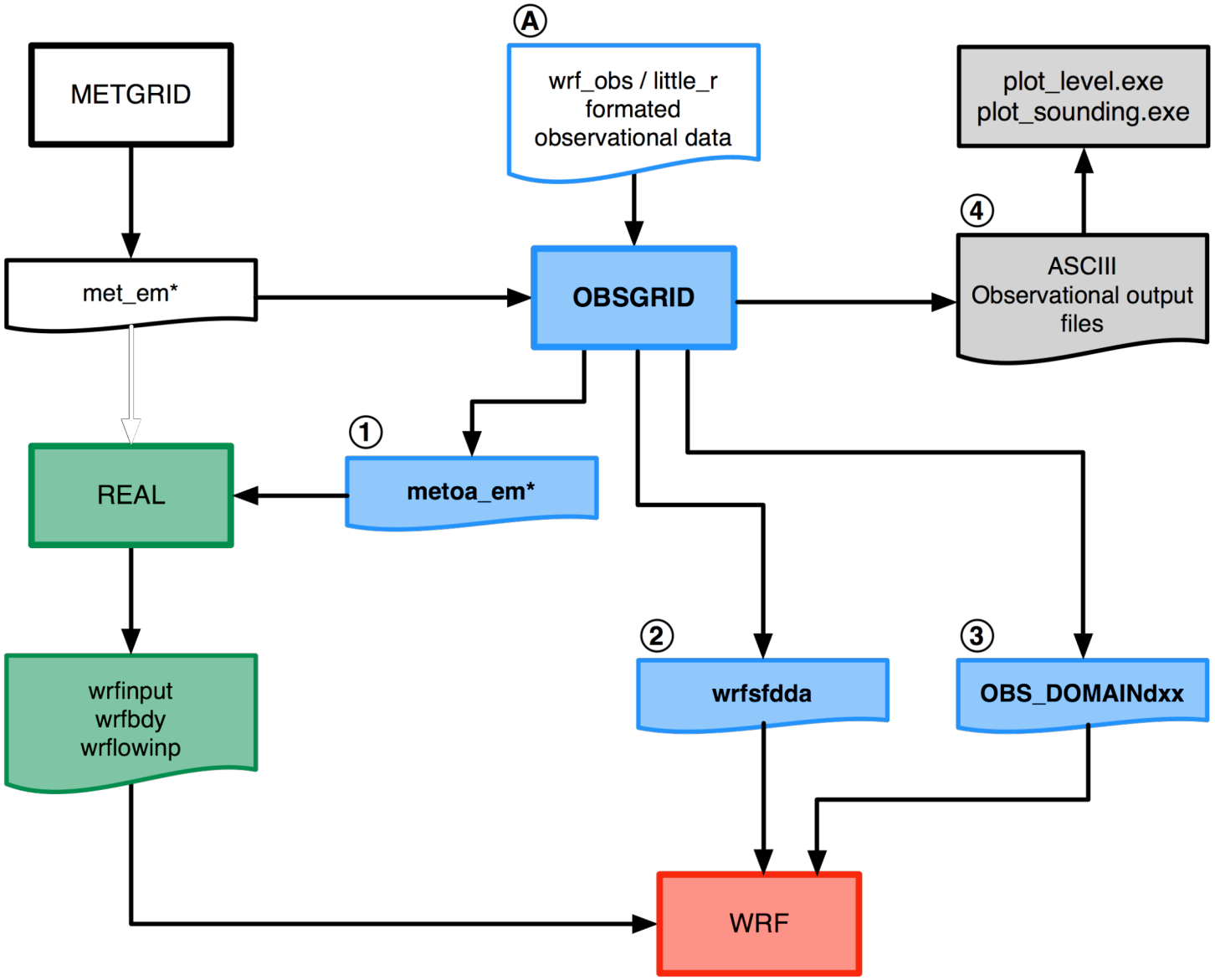
- **Variational Analysis**
  - Direct and indirect observations on model levels *(conventional + alternative observations)*



WRF-ARW Modeling System Flow Chart



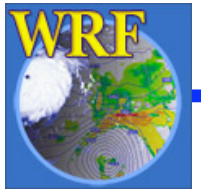
Program Flow



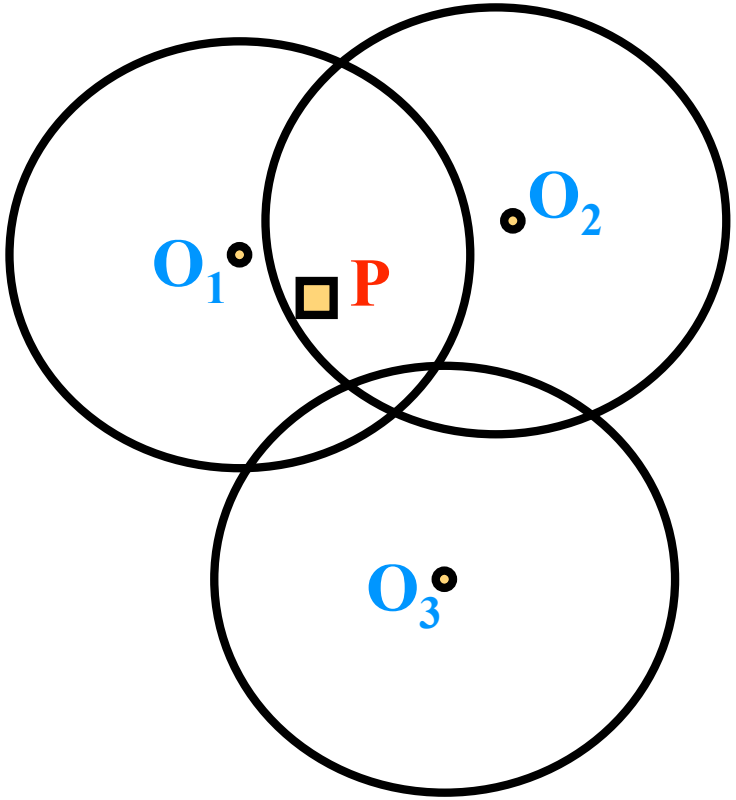
OA Techniques in OBSGRID

- **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

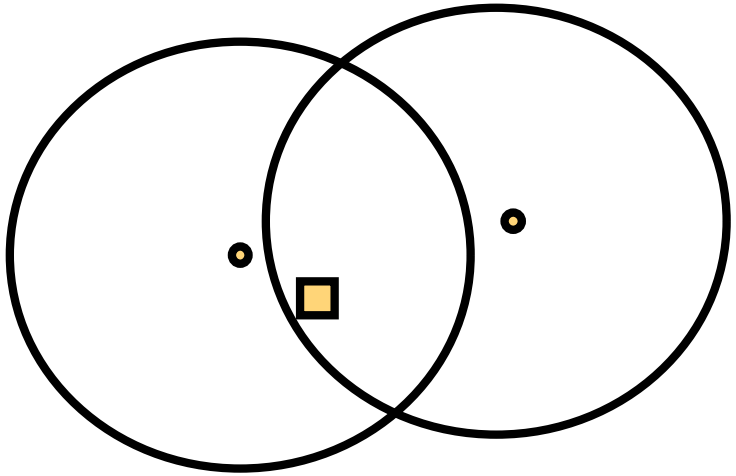


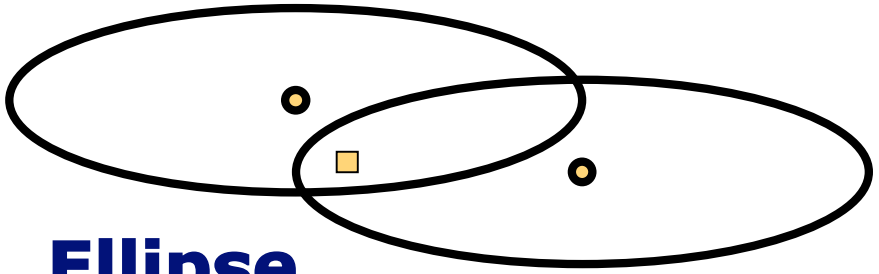
Observations

Grid Point

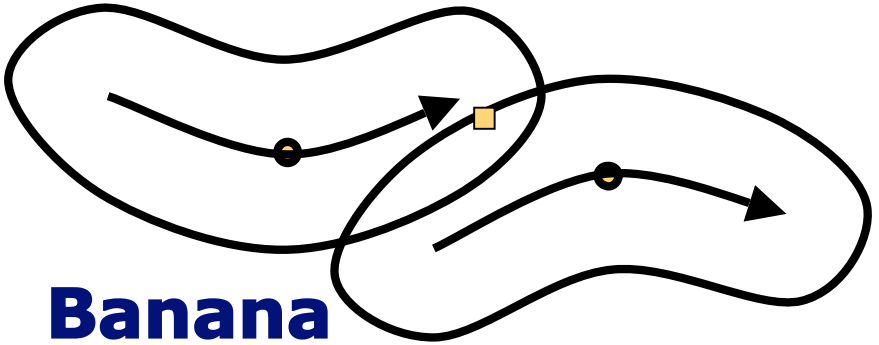
Observations O_1 and O_2 influences grid point P, O_3 does not

Cressman Scheme



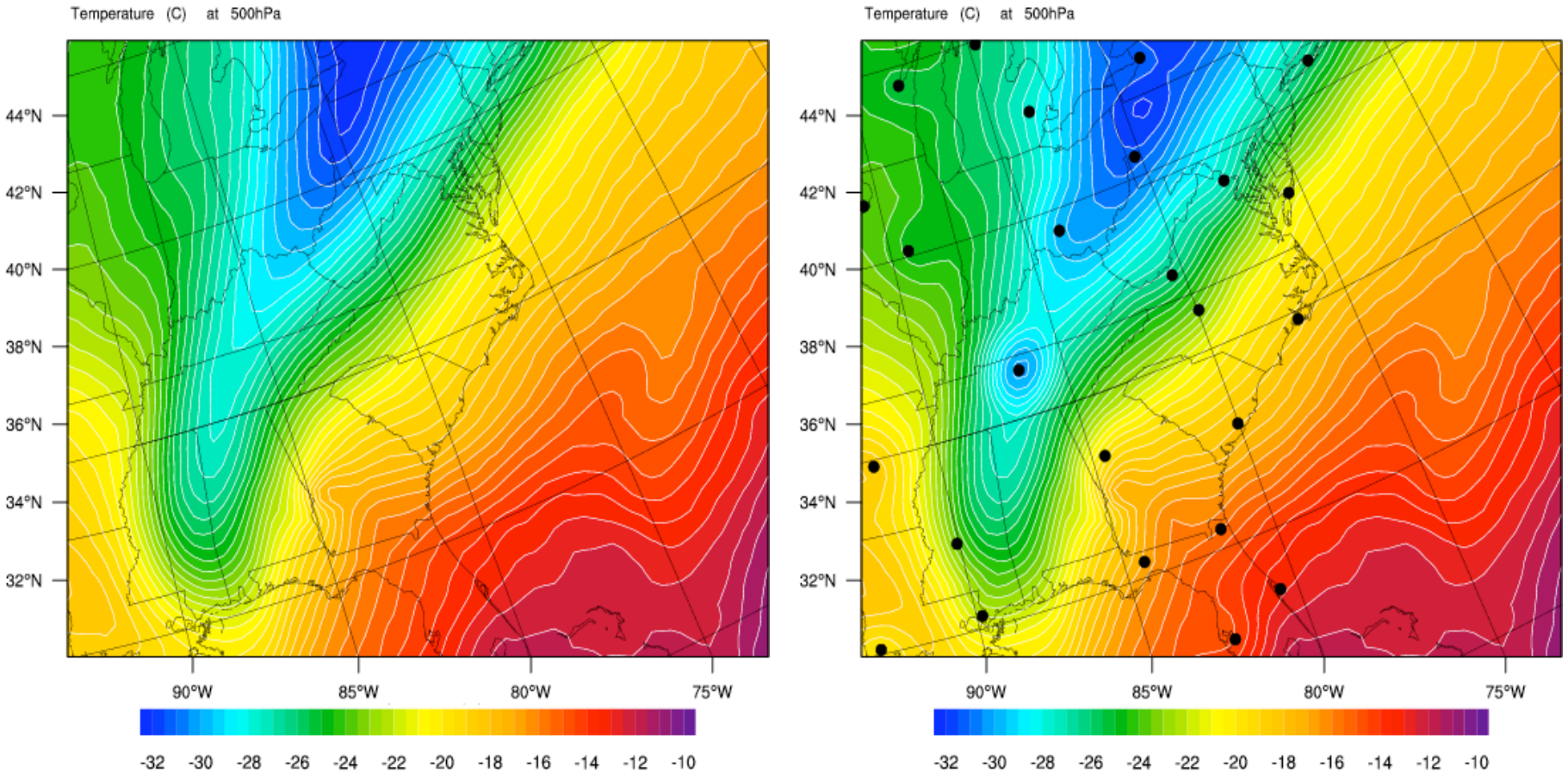


Ellipse

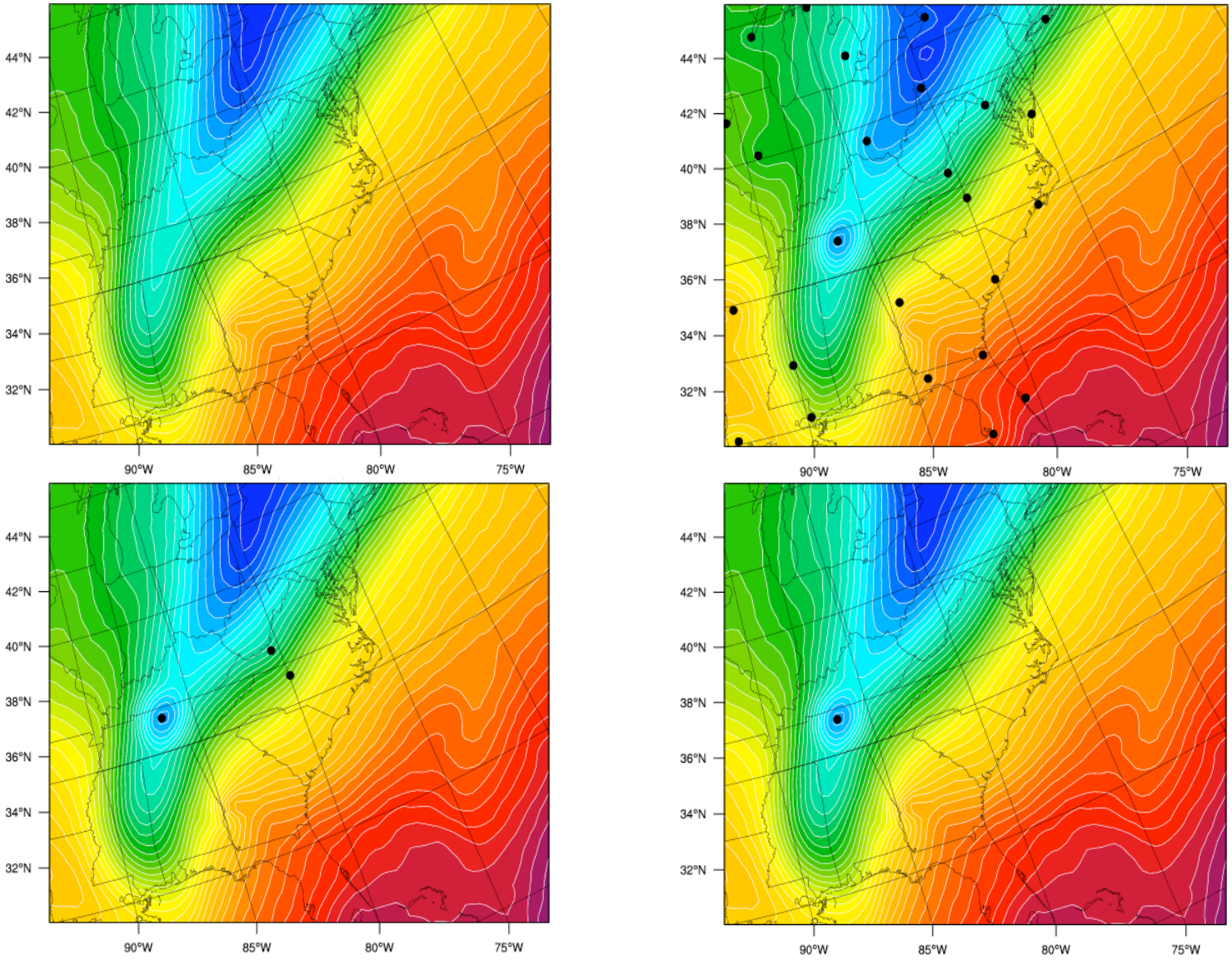


Banana

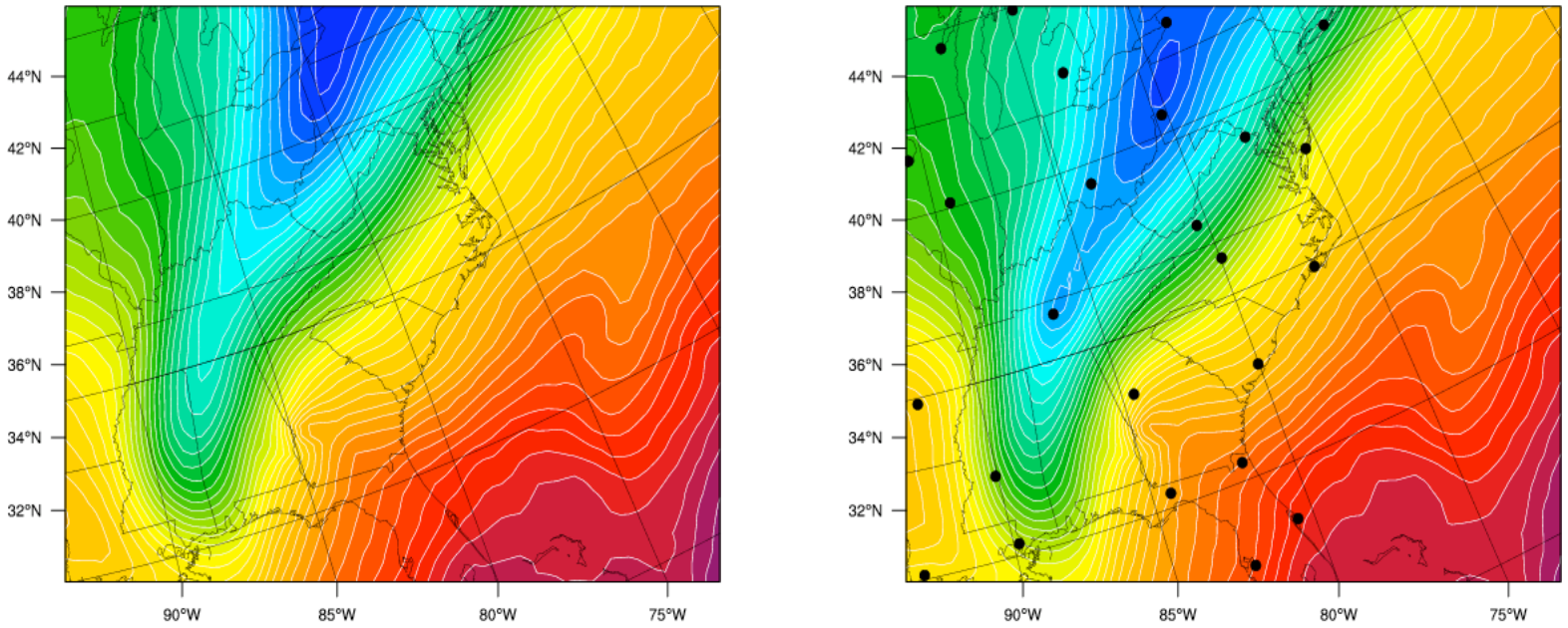
Cressman Scheme



Cressman Scheme

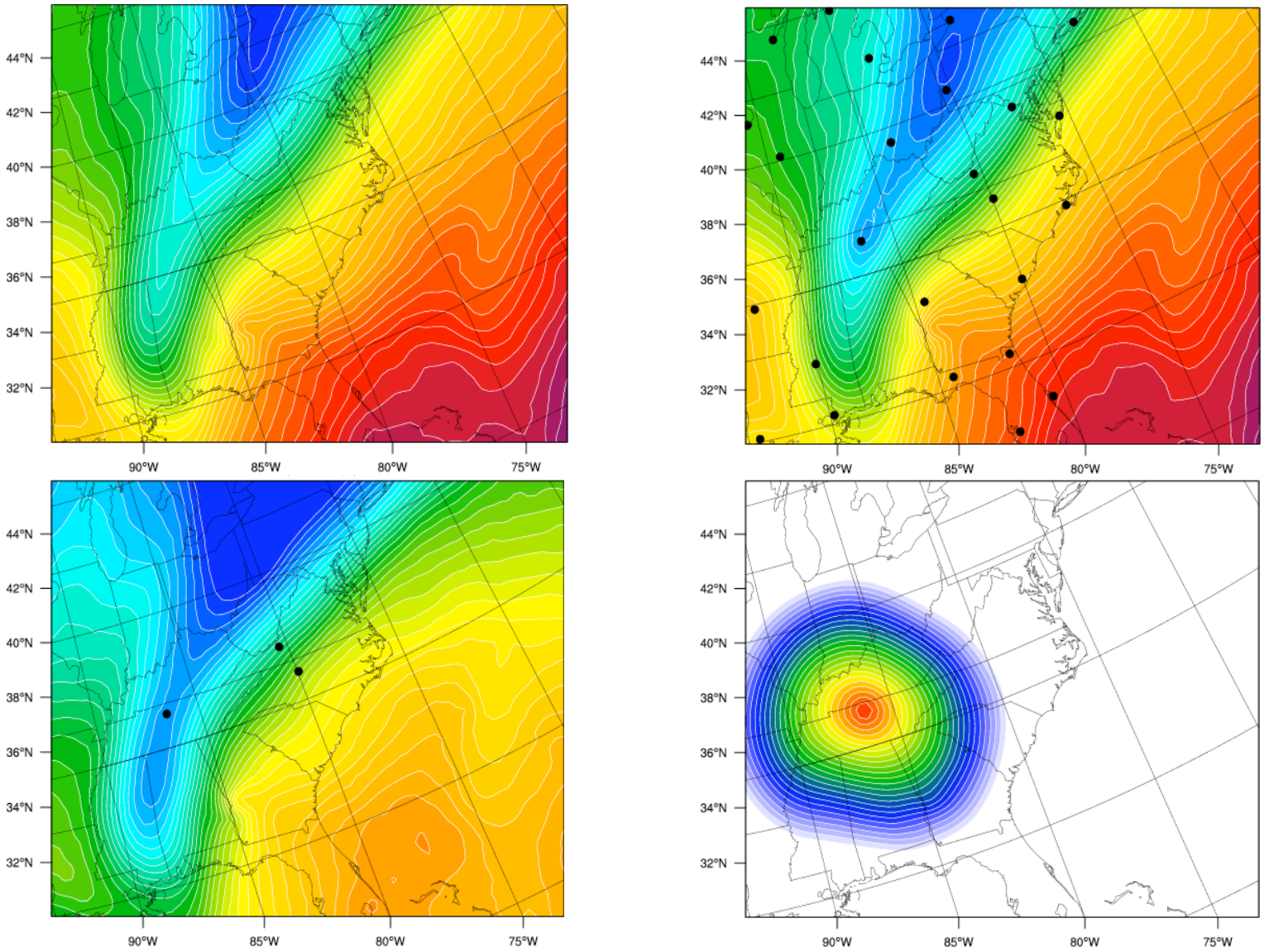


Multi-Quadric Scheme



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

Multi-Quadric Scheme



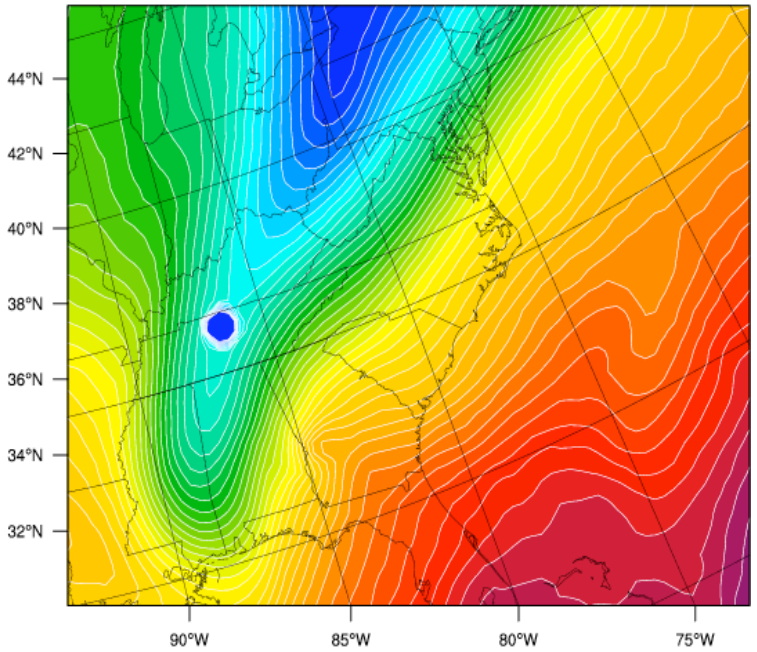
Quality Control for Observations

- **A critically important step**

  Bad observations = Bad objective analysis

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

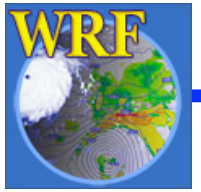
- **Default namelist settings should in most cases prevent this from happening**



- **Tests performed in OBSGRID**
  - Tests on individual reports
  - ERRMAX test
  - Buddy test

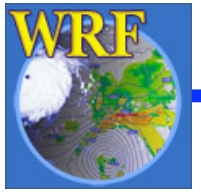
Tests on individual reports

- **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**



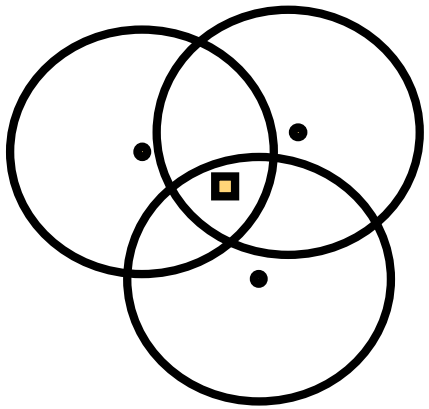
ERRMAX test

- **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**



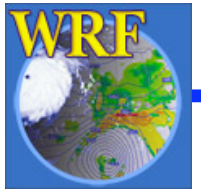
Buddy test

- **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**



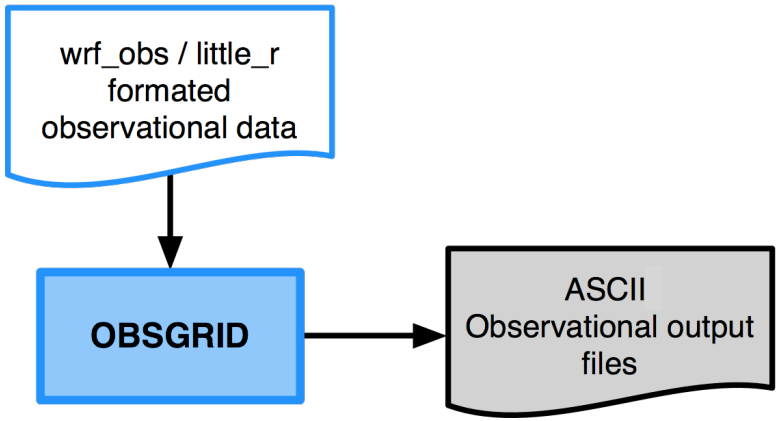
Observations

UG: 7-13

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

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

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



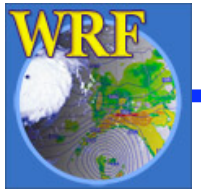
Observations Format

header

```
station_latitude, station_longitude, station_id,
station_name, type_of_observation, observation_source,
station_elevation, num_valid_fields, num_errors,
num_warnings, report_number, number_of_report_duplicates,
is_this_a_sounding, is_this_a_bogus_observation,
discard_the_report, time_of_report, julian_day,
report_time, slp, slp_qc, ref_pres, rpres_qc, ground_t,
t_qc, sst, sst_qc, psfc, psfc_qc, precip, precip_qc,
t_max, t_max_qc, t_min, t_min_qc, t_min_night,
t_min_night_qc, p_tend03, tend03_qc, p_tend24, tend24_qc,
cloud_cvr, cloud_qc, ceiling, ceiling_qc
```

end data

```
pressure, p_qc, height, z_qc, temperature, t_qc,
dew_point, td_qc, speed, spd_qc, direction, dir_qc, u,
u_qc, v, v_qc, rh, rh_qc, thickness, tn_qc
num_valid_fields, num_errors, num_warnings
```



Observations Format

```
 44.08000          -103.2100072662                                  RAPID CITY WFO, SD. / UNITED STATES OF AFM-35 TEMP                                  GTS (ATEC)
UEUS05 KWBC 190000                      1029.00000          20   -888888   -888888        446   -888888          T          F          F   -888888   -888888
20080119000000-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-
888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0
 100000.00000  0     249.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  92500.00000  0     852.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  90400.00000  0    1029.00000  0     260.65000  0     255.65000  0       6.18557  0     335.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  90300.00000  0-888888.00000  0     261.25000  0     252.25000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  89600.00000  0-888888.00000  0     261.05000  0     252.05000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  88900.00000  0-888888.00000  0     260.85000  0     247.85000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  85000.00000  0    1496.00000  0     257.65000  0     246.65000  0      15.46392  0     315.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  79500.00000  0-888888.00000  0     253.05000  0     244.05000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  78000.00000  0-888888.00000  0     252.45000  0     243.45000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  73100.00000  0-888888.00000  0     249.65000  0     245.05000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  72100.00000  0-888888.00000  0     250.65000  0     246.15000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  70000.00000  0    2931.00000  0     249.25000  0     244.25000  0      23.71134  0     330.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  69400.00000  0-888888.00000  0     249.05000  0     243.05000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  62300.00000  0-888888.00000  0     243.65000  0     233.65000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  55700.00000  0-888888.00000  0     237.85000  0     226.85000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
  50700.00000  0-888888.00000  0     232.05000  0     223.05000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
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  46100.00000  0-888888.00000  0     227.85000  0     217.85000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
   3100.00000  0-888888.00000  0     214.45000  0     213.65000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
-777777.00000  0-777777.00000  0      20.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
      20       0       0
```
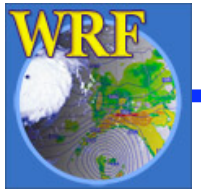
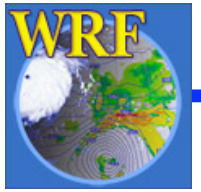

```
 51.48000          -0.4500003772                                  ICAO EGLL London / Heathrow Airport UnitFM-15 METAR                                 GTS (ATEC)
SAUK31 KWBC 190020 CCA                  24.00000          10   -888888   -888888        525   -888888          F          F          F   -888888   -888888
20080119002000-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0 101200.00000       0-888888.00000       0-888888.00000       0-
888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0-888888.00000       0
-888888.00000  0     24.00000  0     286.15000  0     284.15000  0       8.76289  0     230.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
-777777.00000  0-777777.00000  0       1.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0-888888.00000  0
      10       0       0
```



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



Namelist

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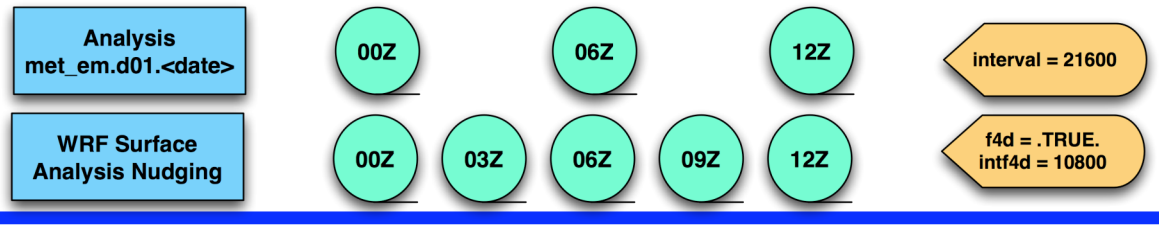
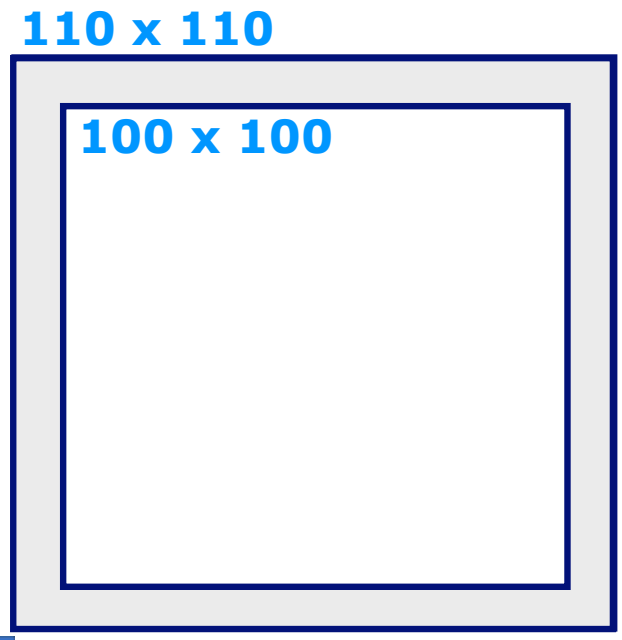
start & end _year _month _day _hour	Start and End dates
interval	Interval between analysis times (sec)
obs_filename	**Root file name *(may include directory information)* of the observational files. All input files must have the format** obs_filename:<YYYY-MM-DD_HH>. **One file per time period** **Also used when doing surface fdda *(F4D=.TRUE.)***
f4d	Turn on / off the creation of the surface analysis file *(wrfsfdda_d0x)*
intf4d	Time interval (*sec*) for surface analyses ***(typically smaller than interval between analysis)***



Namelist

domain_id	ID of domain to process
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



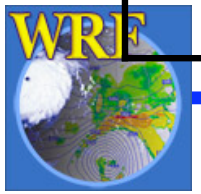
- **Why do this:**
  This allows observations just outside the desired grid box of 100x100 grid points to be included in the OA

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

- **When running *obsgrid* set**
  trim_domain = .TRUE.
  trim_value = 5

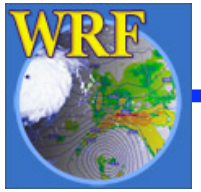
Namelist

qc_test_error_max	Turn on error-max test (T/F)
max_error _t _uv _rh _p	Max difference in T, uv, RH & SLP allowed for error-max test
qc_test_buddy	Turn on buddy test (T/F)
max_buddy _t _uv _rh _p	Threshold for T, uv, RH & SLP allowed for buddy test
buddy_weight	Scaling for buddy thresholds
qc_test_vert_consistency	Turn on vertical tests (T/F)
remove_data_above_qc_flag	Data with qc flags higher than this will not be output to **OBS_DOMAINdxx** *(32768)*
remove_unverified_data	Unverified data will not be output to **OBS_DOMAINdxx**



Namelist

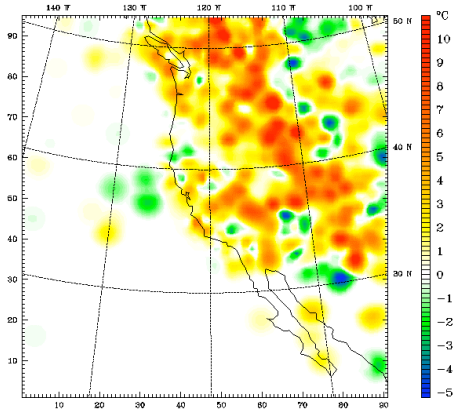
OA_type	"MQD" or "Cressman"
radius_influence	Radius of influence for Cressman **{0} ; {-5} ; {5,4,3,2}**
OA_min_switch (T/F) **MQD_minimum_num_obs**	Switch to Cressman if too few obs for MQD Minimum number of obs for MQD to switch
OA_max_switch (T/F) **MQD_maximum_num_obs**	Switch to Cressman if too many obs for MQD Maximum number of obs for MQD to switch
OA_3D_type	**"Cressman"**
OA_3D_option	**0 ; 1 ; 2**



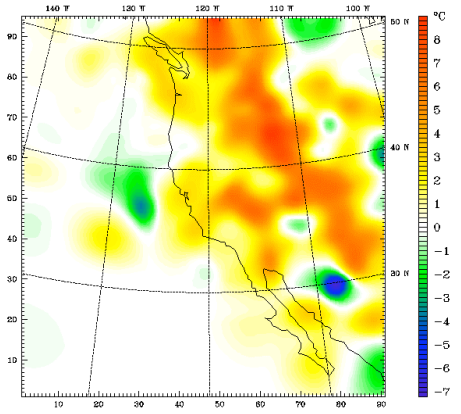
Namelist

- **OA_type = “Cressman”**
  - *All OA for surface and upper-air will be Cressman*
- **radius_influence**
  - ***0***
    Code will automatically calculate number of grids to use of OA
    Will use 4 scans
  - ***-5***
    Code will automatically calculate number of grids to use of OA
    Will use set number of scans (5 in the example)
  - ***5, 4, 3, 2***
    Use 4 scans with grid points as set

RIN=5,4,3,2

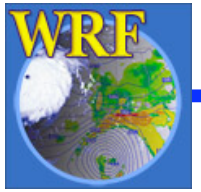


RIN=0



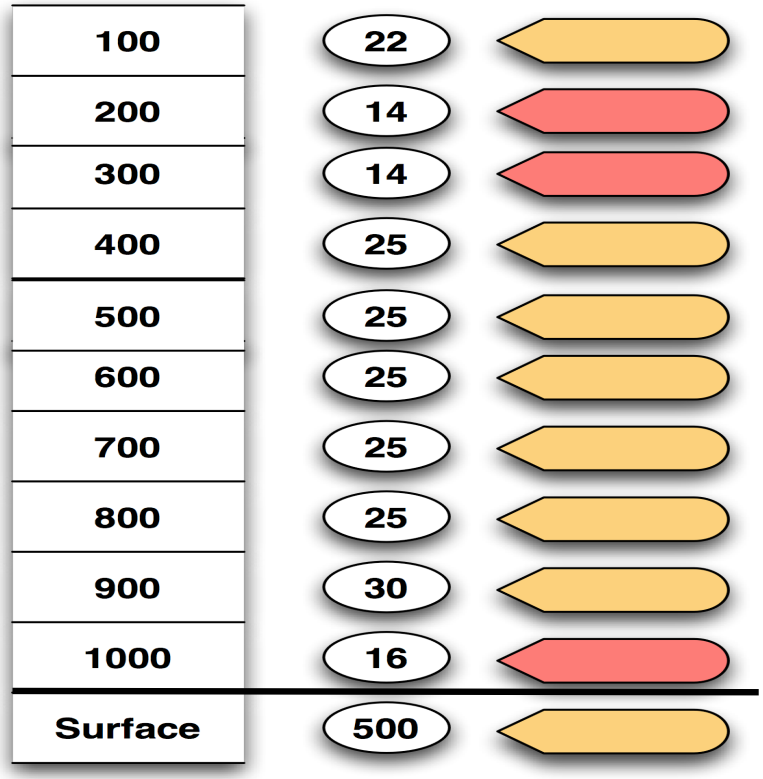
Namelist

- **OA_type = “MQD”**
  - *Will **attempt** to use MQD for all OA*
  - *Set radius_influence in case code has to switch to Cressman (recommend 0)*
- **OA_max_switch (T/F) ; MQD_maximum_num_obs**
  - ***T** ; Switch to Cressman if too many observations*
  - ***F** ; No OA if too many observations*
  - *Only needed if the code takes to long to execute due to large number of observations*
- **OA_min_switch (T/F) ; MQD_minimum_num_obs**
  - ***T** ; Switch to Cressman if too few observations*
  - ***F** ; No OA if too few observations*



Namelist

- **OA_type = "MQD" ;**
  OA_min_switch = T ; MQD_minimum_num_obs = 20



MQD ; Cressman

Different schemes used in surface and upper-air is fine

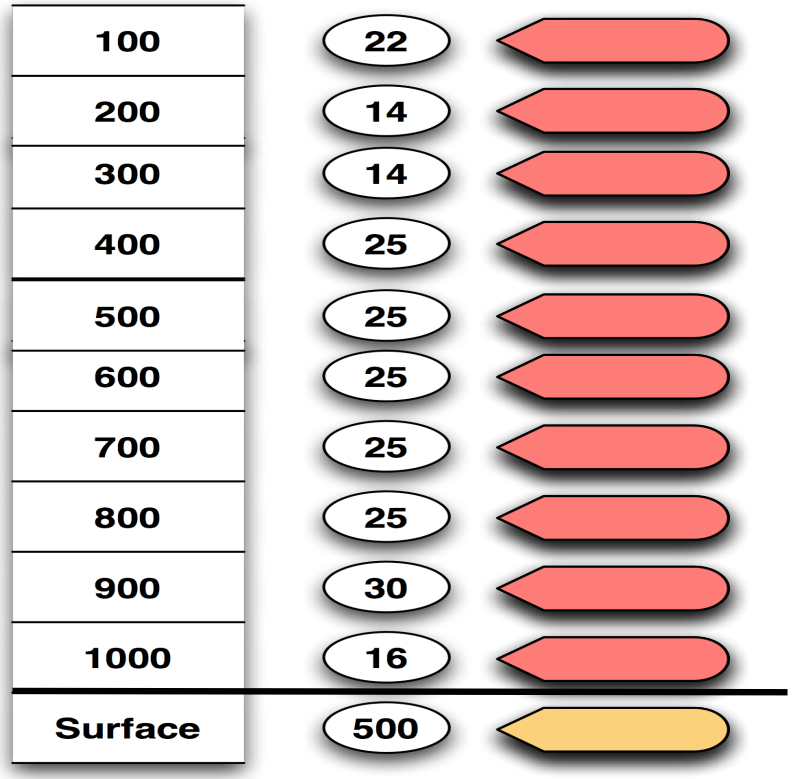
Switch in upper-air between MQD and Cressman is undesired

Code will STOP
{OA_3D_option = 0}

Can force this behavior
{OA_3D_option = 2}

Namelist

- **OA_type = "MQD" ;**
  OA_min_switch = T ; MQD_minimum_num_obs = 20



MQD ; Cressman

MQD_minimum_num_obs = 14

Do not make this to low in order to force MQD

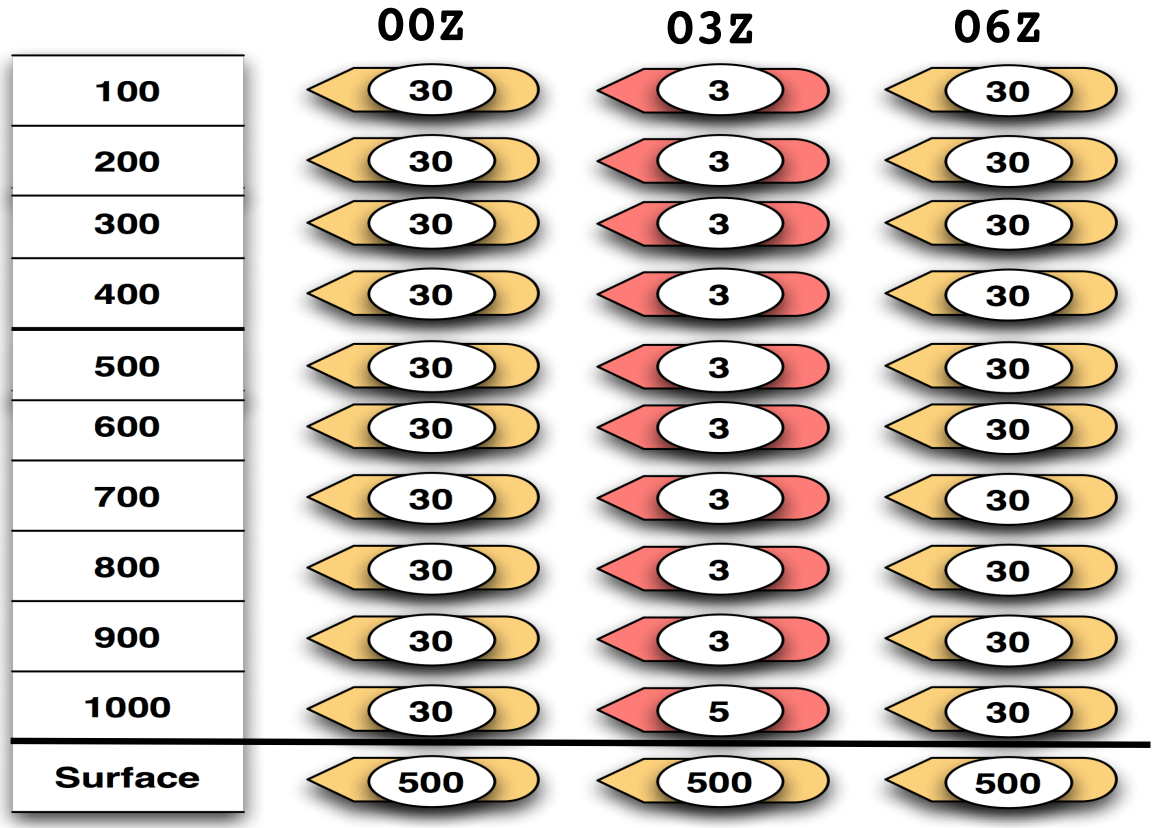
MQD_minimum_num_obs = 20

OA_3D_type = "Cressman"
All upper-air, all times Cressman

OA_3D_option = 1
All upper-air, at a given time
Especially good for f4d runs

Namelist

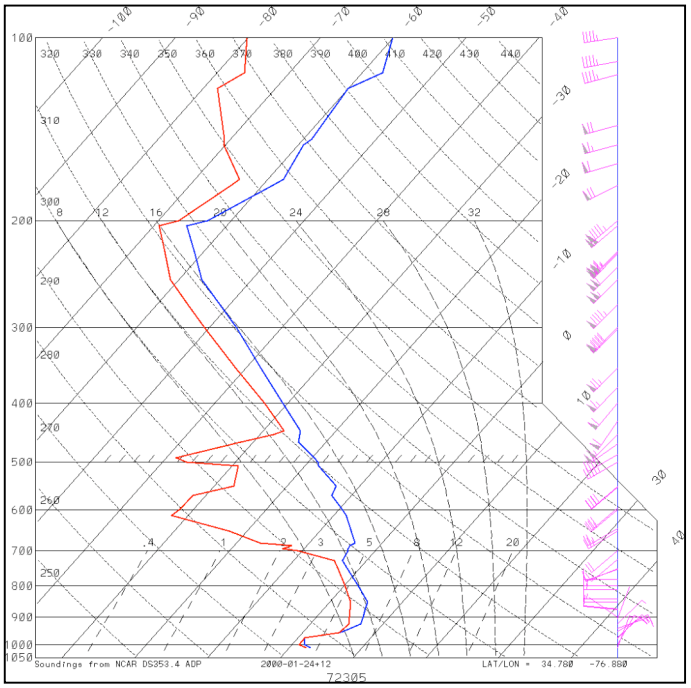
- **OA_type = "MQD" ;**
  OA_min_switch = T ; MQD_minimum_num_obs = 20 ;
  OA_3D_option = 1



MQD ; Cressman

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**