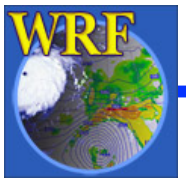
Objective Analysis (OBSGRID)

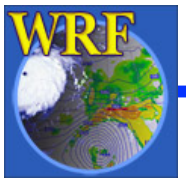
Cindy Bruyère



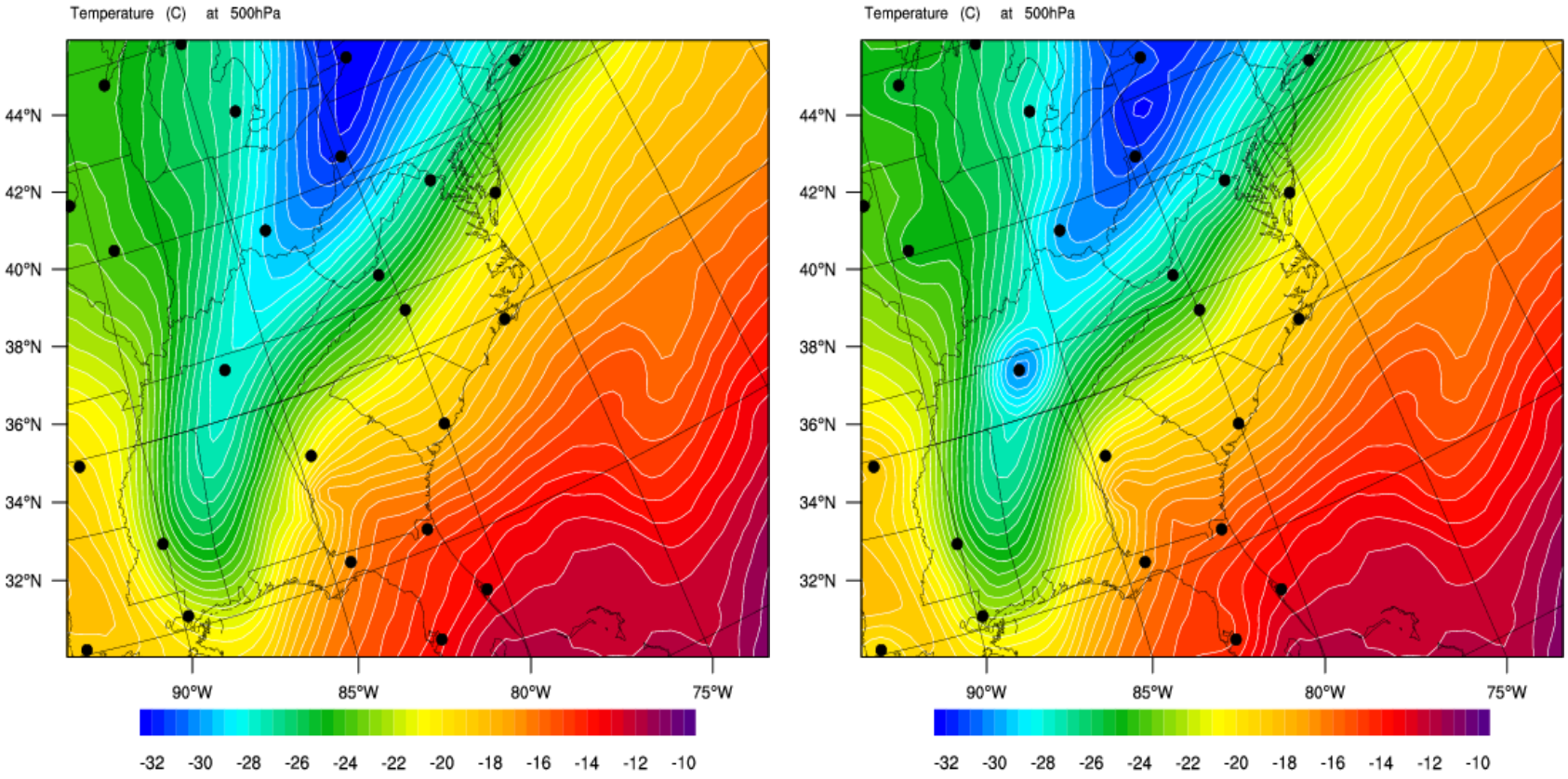
Objective Analysis

- **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*

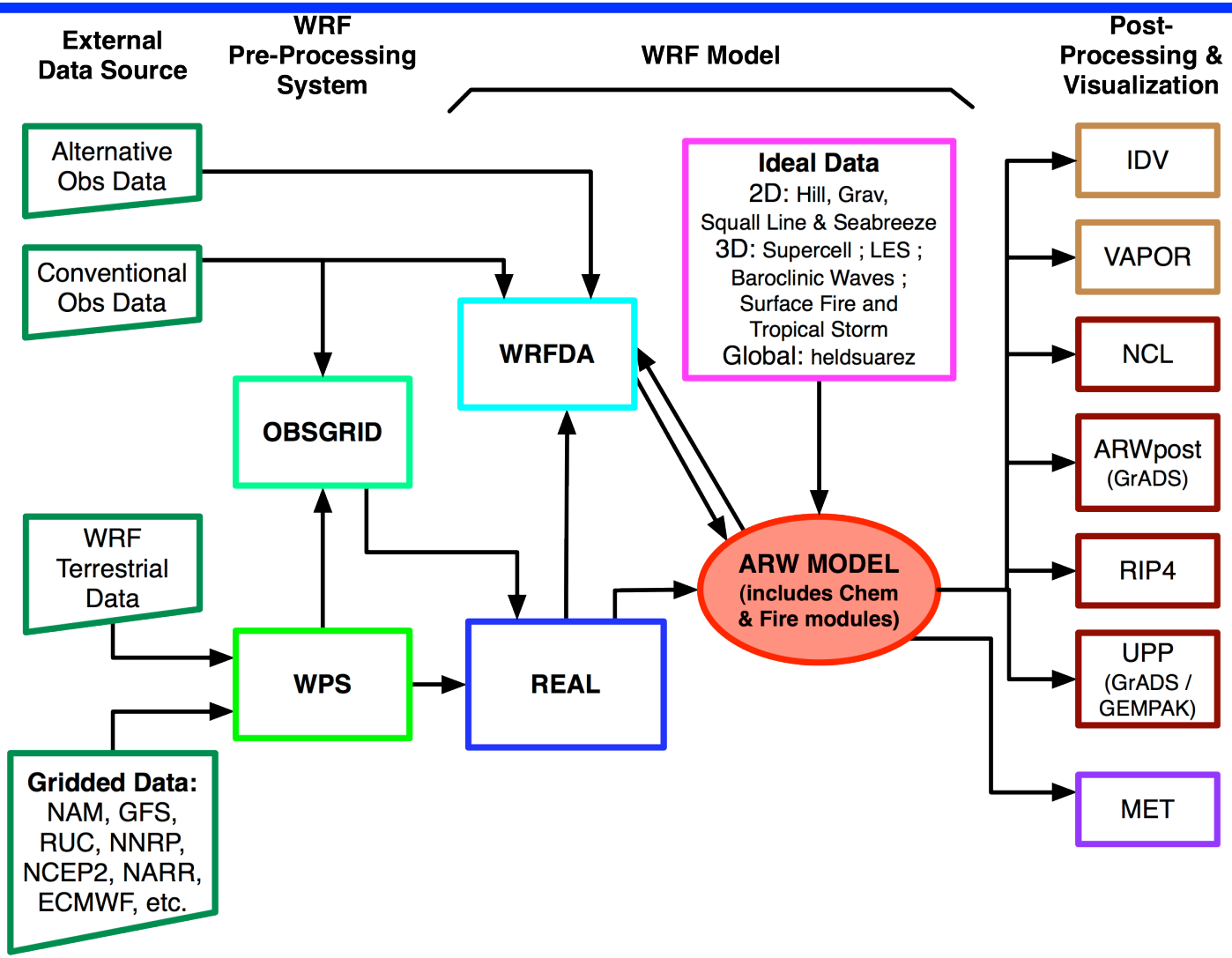
- **Methods**
  - **Traditional methods**
    - *Direct observations of T, U, V, RH at surface and on pressure levels (conventional observations)*
  - **Variational Analysis**
    - *Direct and indirect observations on model levels (conventional + alternative observations)*
    - *WRFDA*



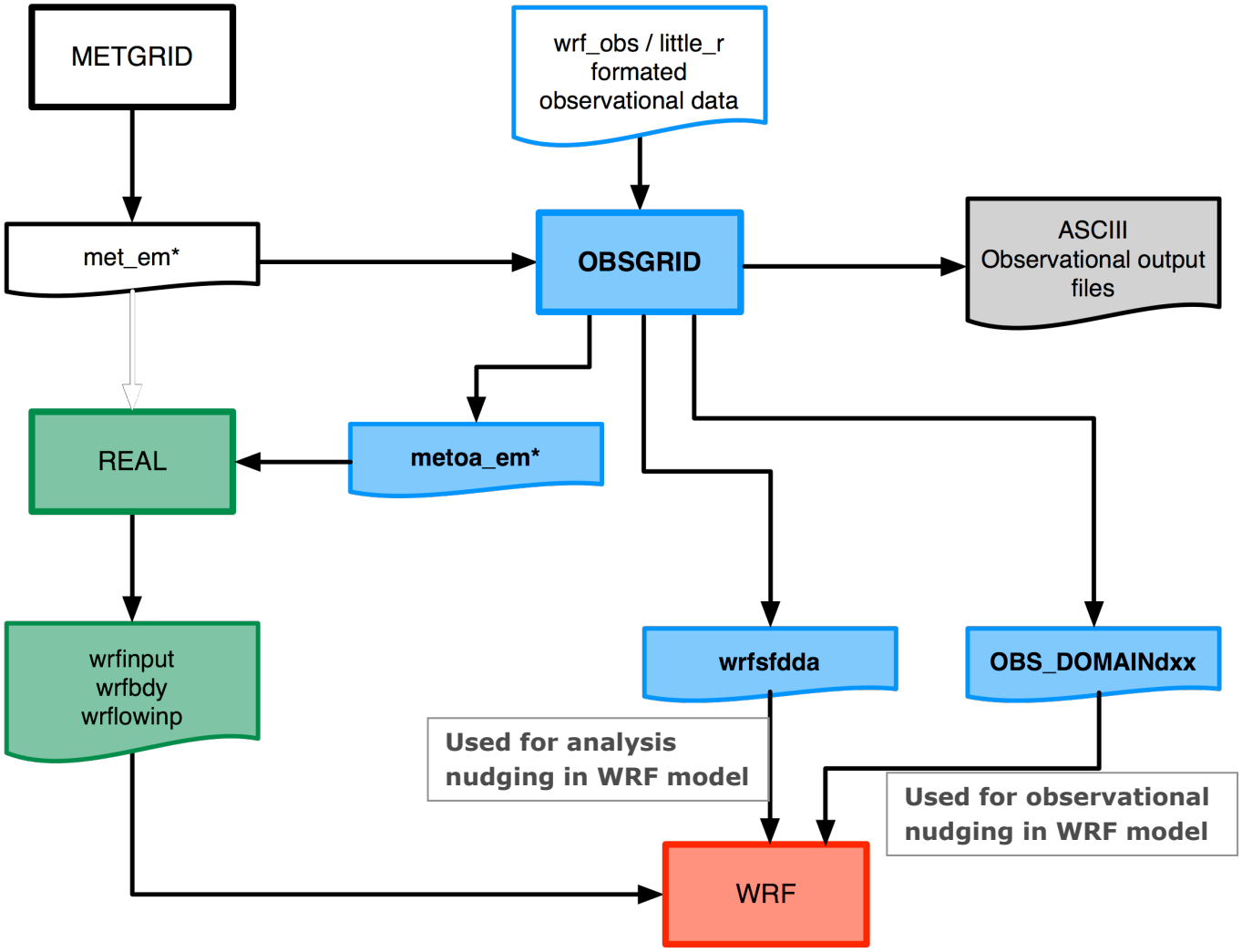
Objective Analysis



WRF Modeling System Flow Chart

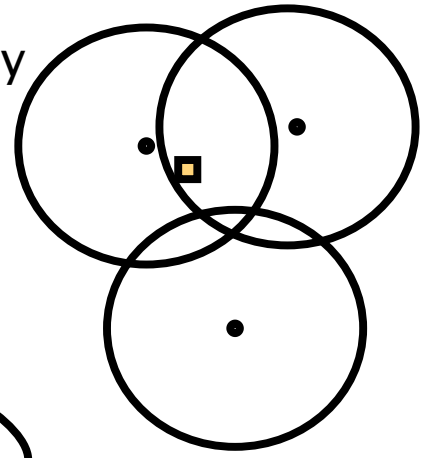


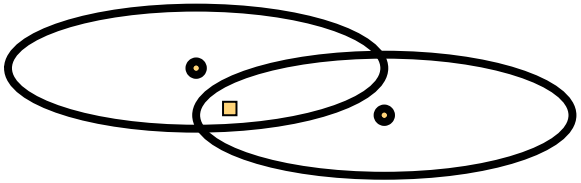
Program Flow

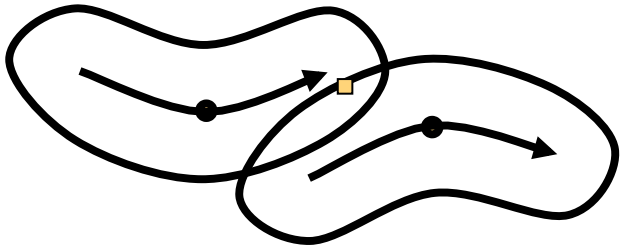


OA Techniques in OBSGRID

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

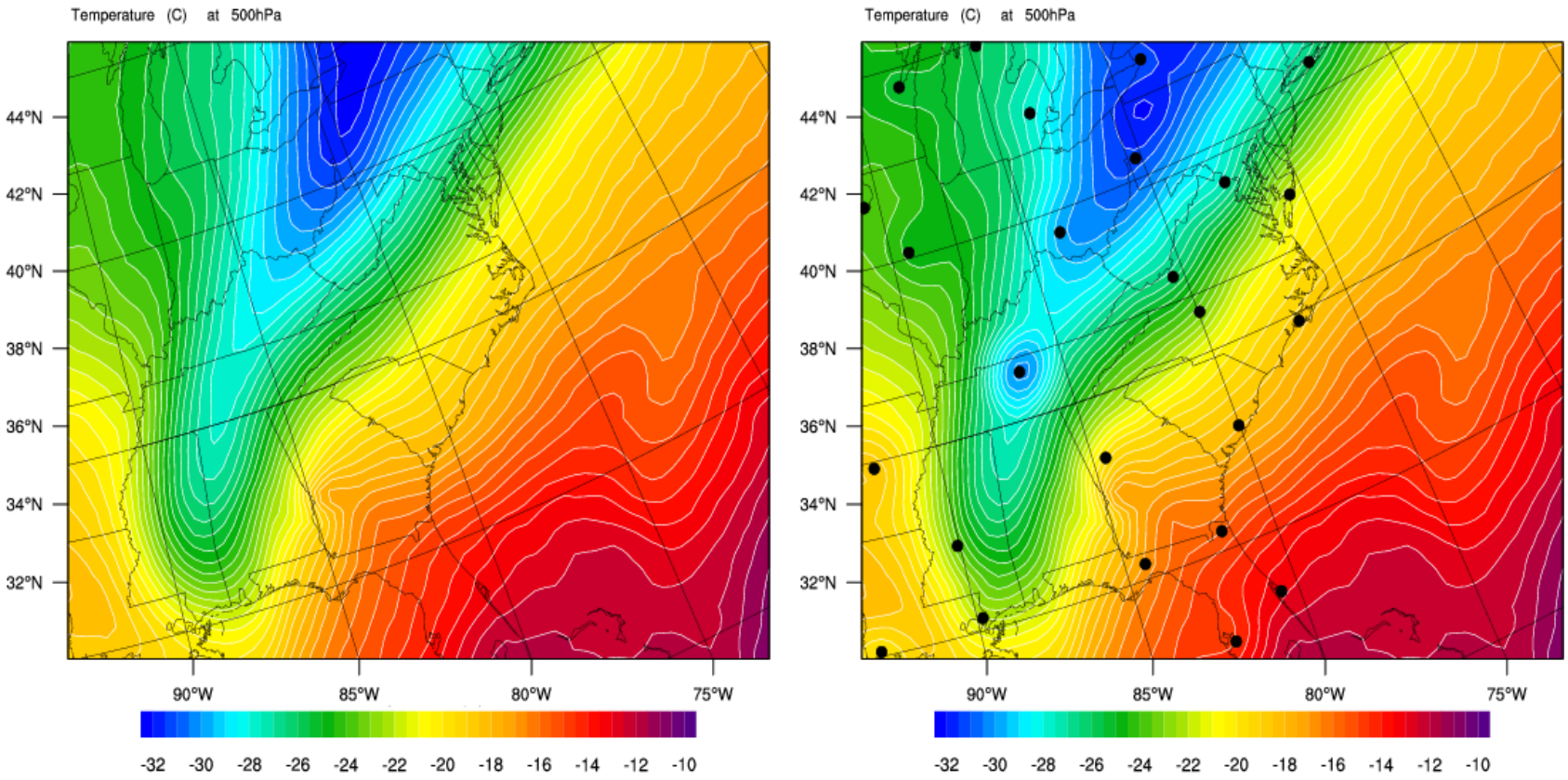




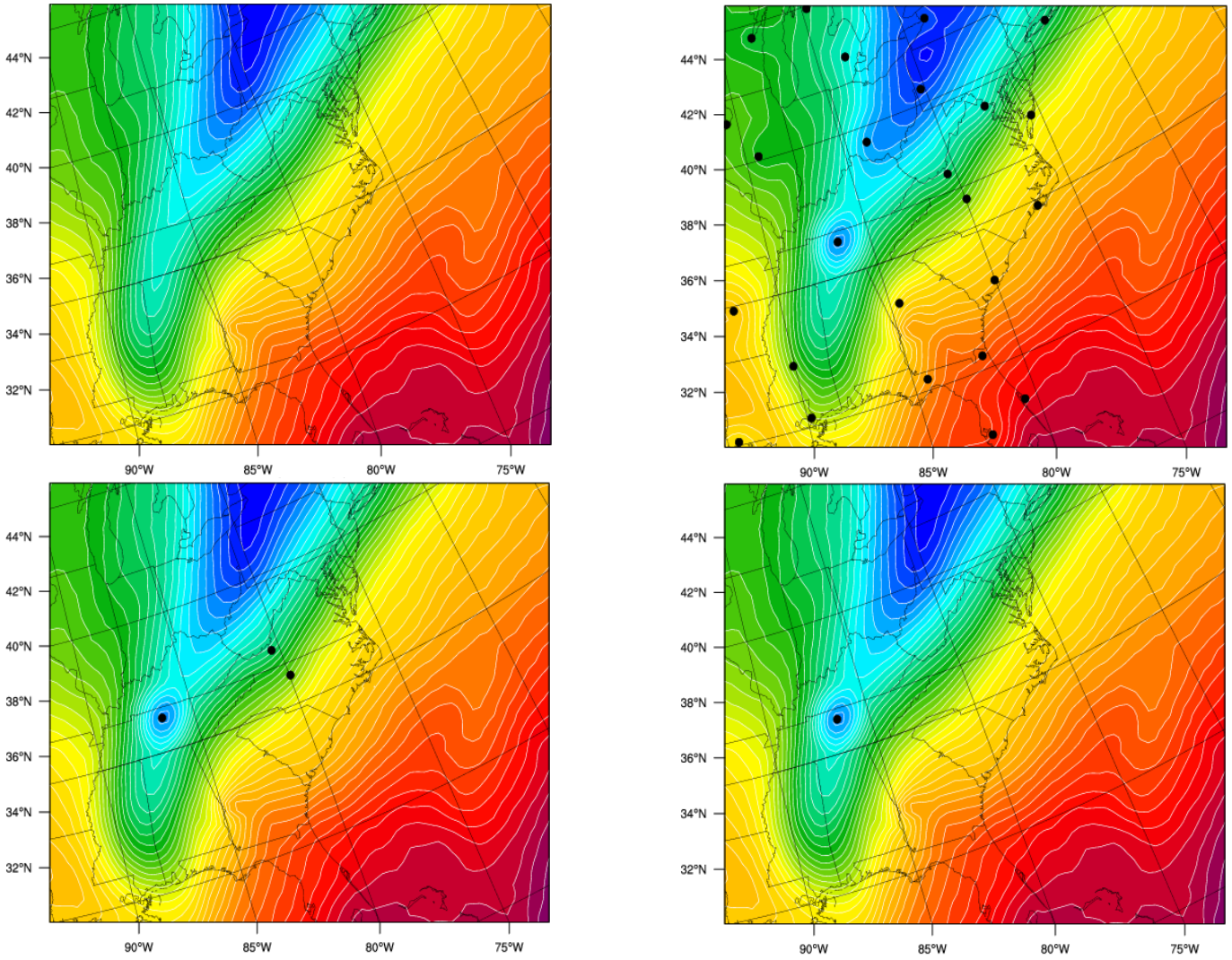


- **Multi-Quadric analysis**
  - Impact of observations are over the entire model domain
  - Scheme is sensitive to the data density distribution
  - Makes use of hyperboloid radial basis functions to interpolate observation corrections onto model grid

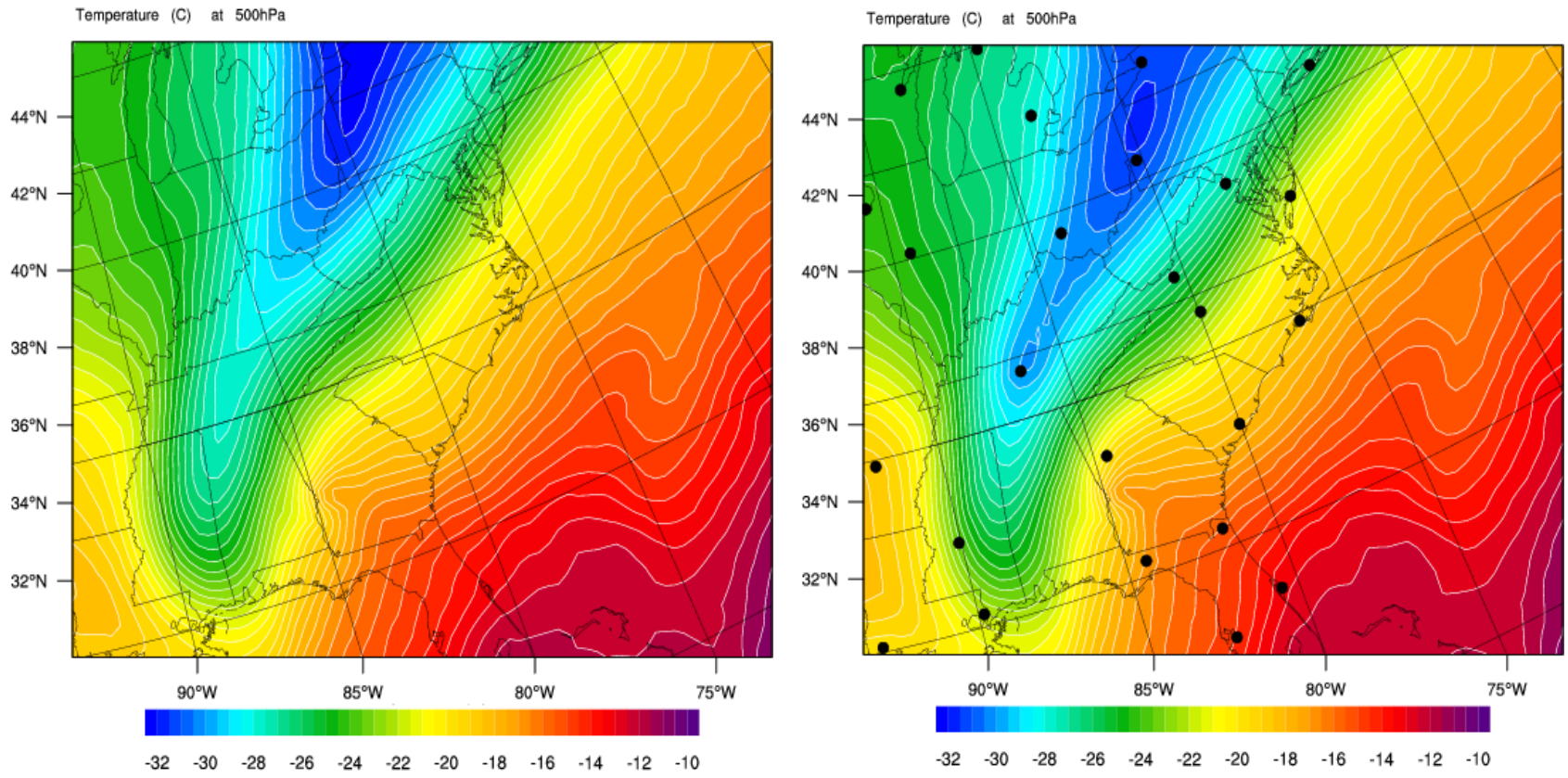
Cressman Scheme



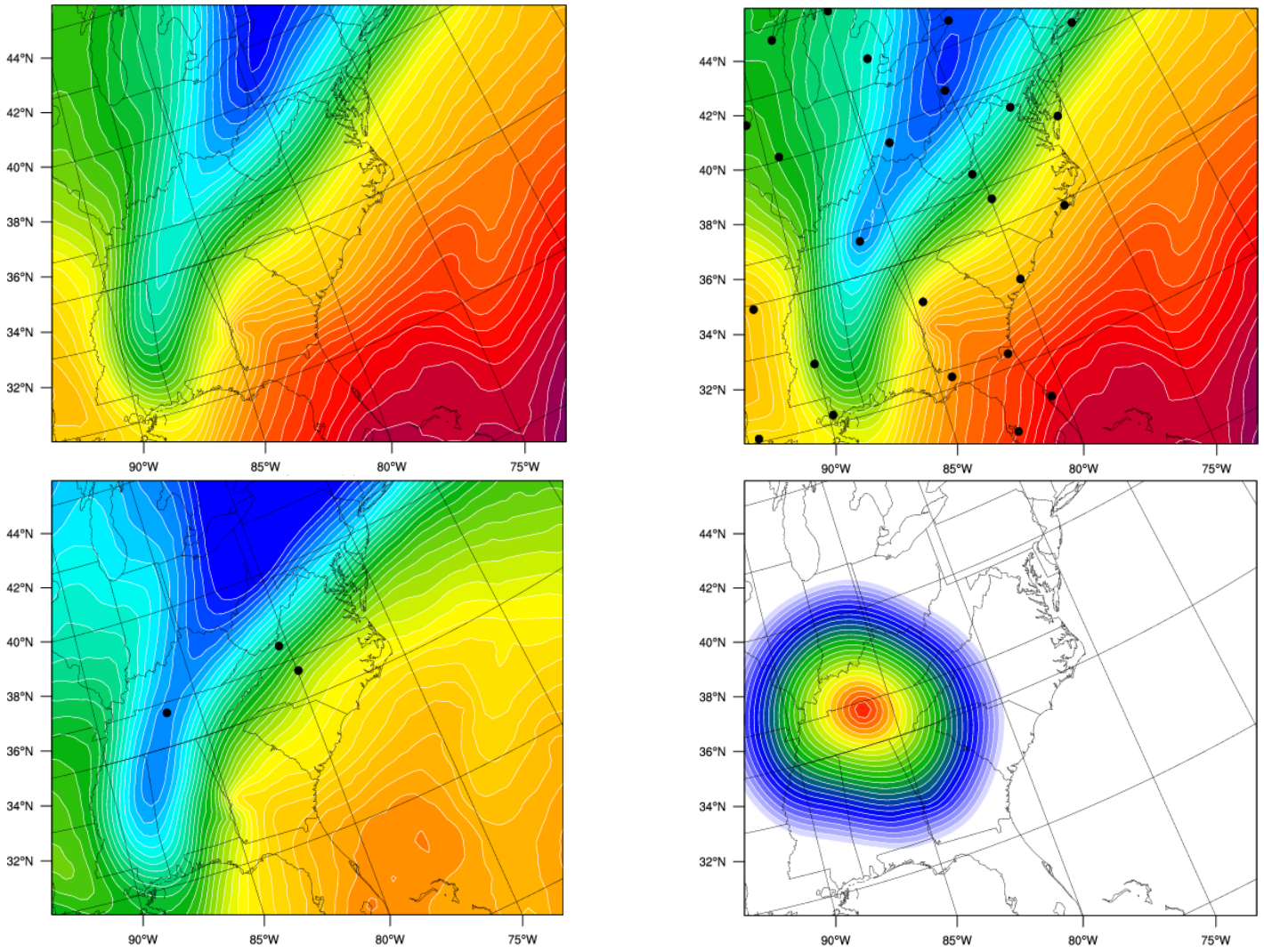
Cressman Scheme



Multi-Quadric Scheme



Multi-Quadric Scheme



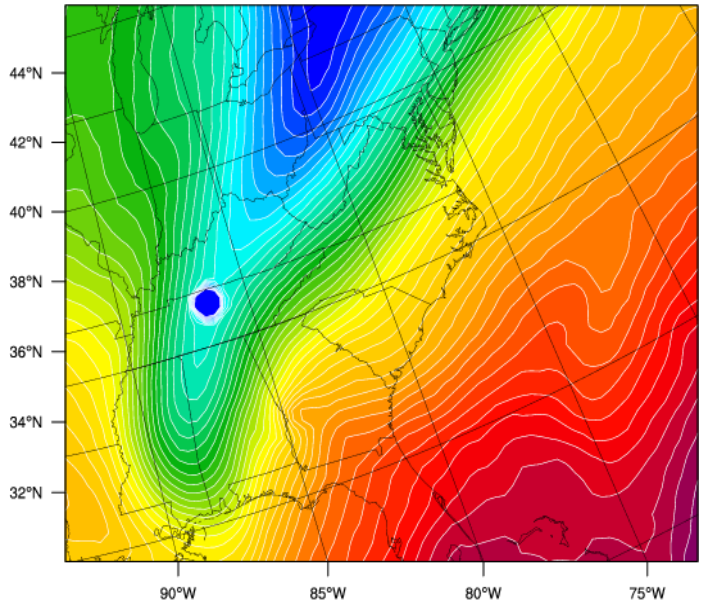
Quality Control for Observations

- **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**

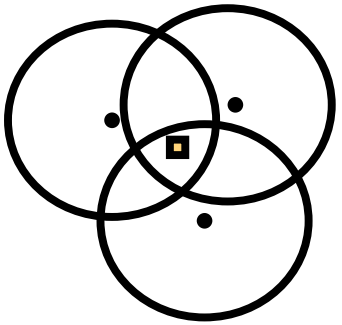


- **Tests performed in OBSGRID**
  - Tests on individual reports
    - *Only gross checks, no comparisons to other soundings or to first-guess field*
  - ERRMAX test
  - Buddy test

Tests performed in OBSGRID

- **ERRMAX test**
  - 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**
  - 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 observation is discarded
  - Works well in regions of good data density



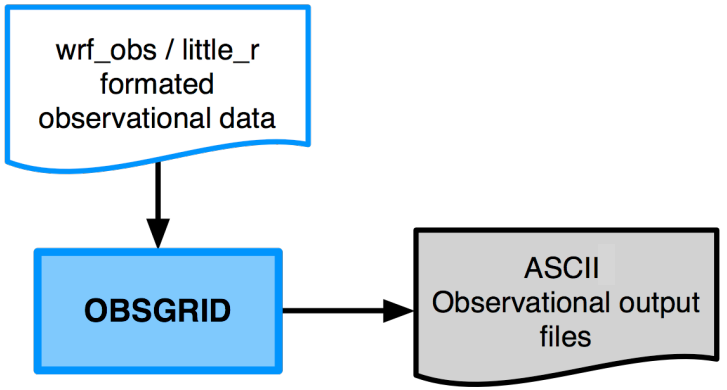
Observations

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
  - Naming convention: *obs_filename*:<YYYY-MM-DD_HH>

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



Observations Format

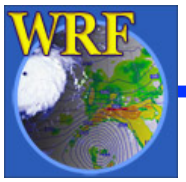
header

```
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
```

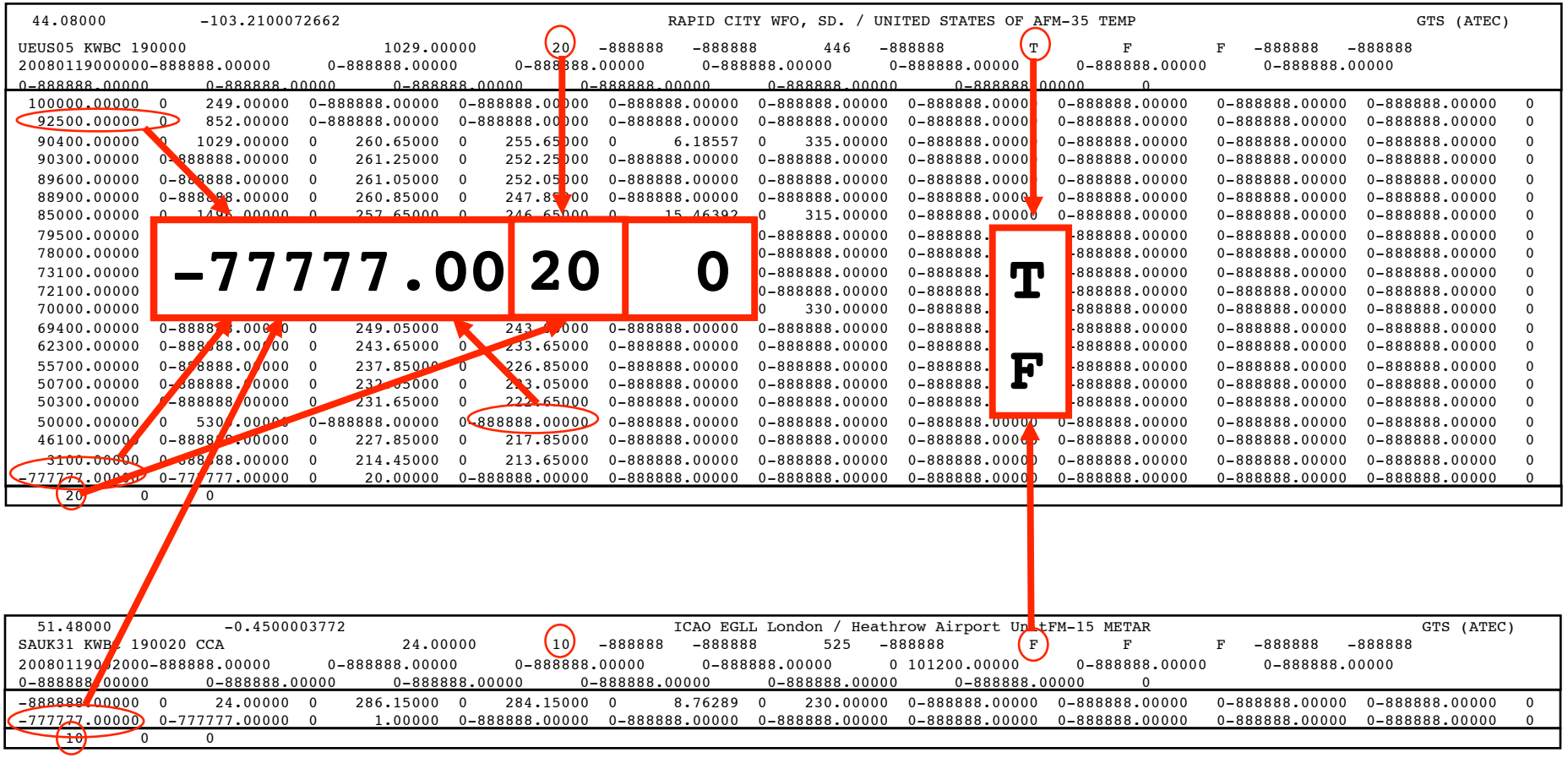
end data

```
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
```



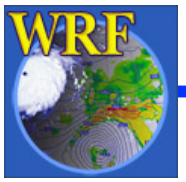
Observations Format



Quality-Control Flags

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

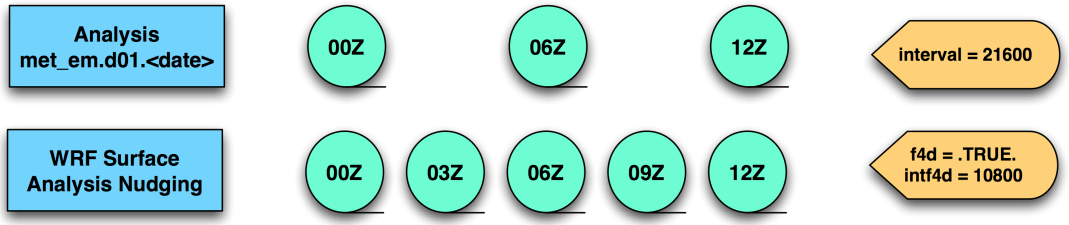
Pressure interpolated from first-guess height	2**1	2
Temperature and dewpoint both 0	2**4	16
Wind speed and direction both 0	2**5	32
Wind speed negative	2**6	64
Wind direction < 0 or > 360	2**7	128
Level vertically interpolated	2**8	256
Value vertically extrapolated from a single level	2**9	512
Sign 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

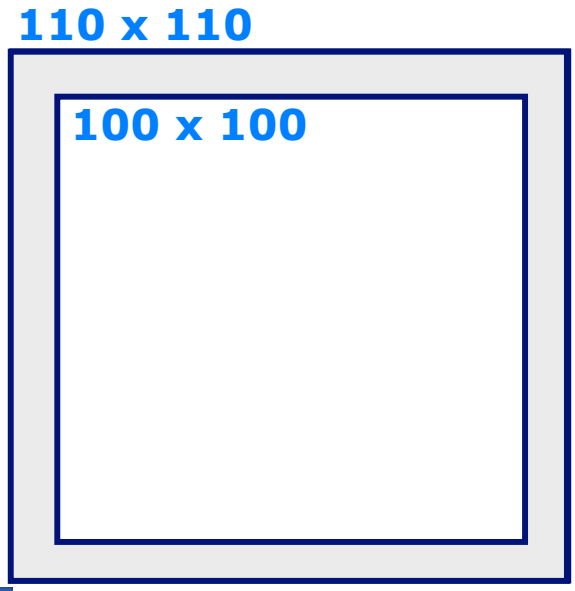
UG: 7-15

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.)*
interval	Interval between analysis times (*sec*) *i.e., interval between met_em.d0x.<date> files*
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



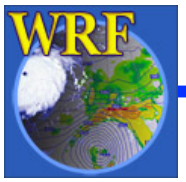
- **Why do this:**
  This allows observations just outside the desired grid box of 100x100 grid points to be included in the OA

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

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

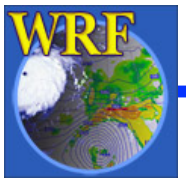
Namelist

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

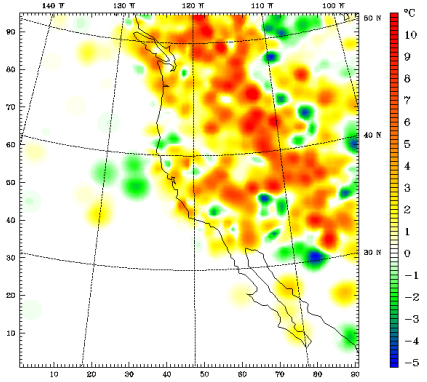
OA_type	"MQD" or "Cressman"
radius_influence	Radius of influence for Cressman {0} ; {-5} ; {5,4,3,2}
OA_min_switch (T/F) **MQD_minimum_num_obs**	Switch to Cressman if too few obs for MQD Minimum number of obs for MQD to switch
OA_max_switch (T/F) **MQD_maximum_num_obs**	Switch to Cressman if too many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



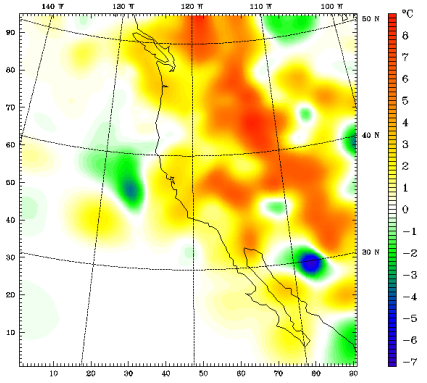
Namelist

- 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

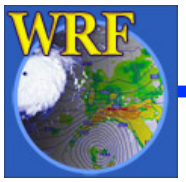


RIN=0



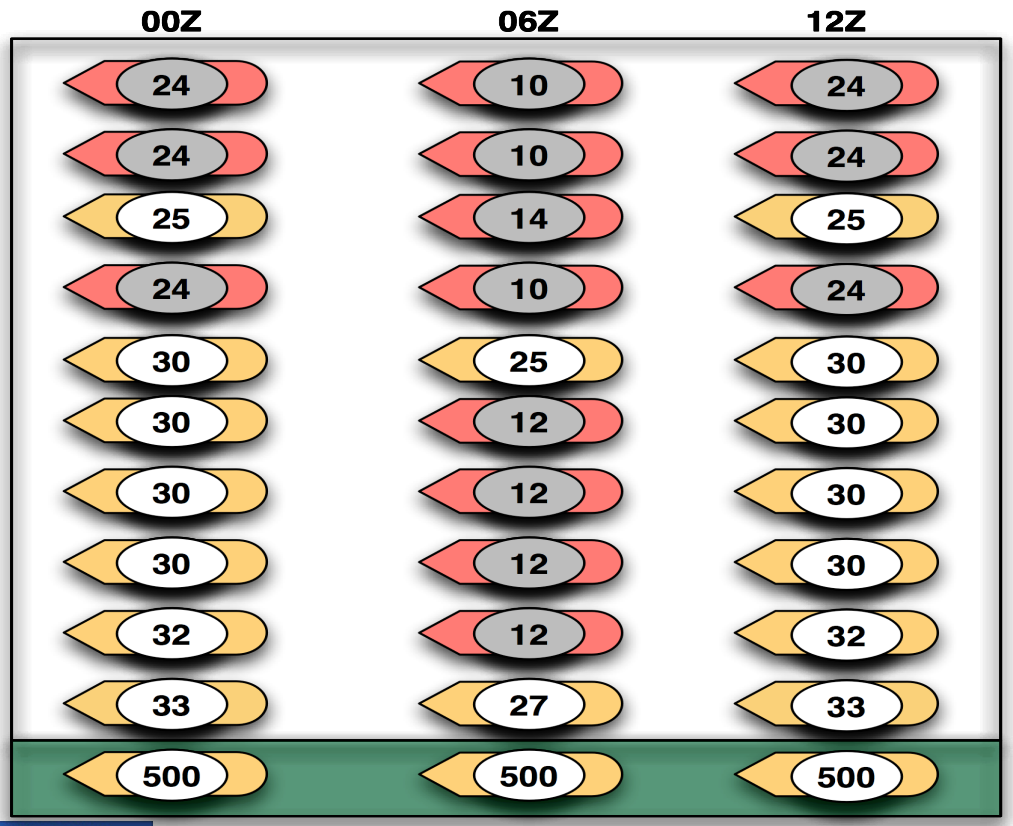
Namelist

- 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 = 25



MQD ; Cressman

Different schemes used in surface and upper-air is fine

Switch in upper-air between MQD and Cressman is undesired

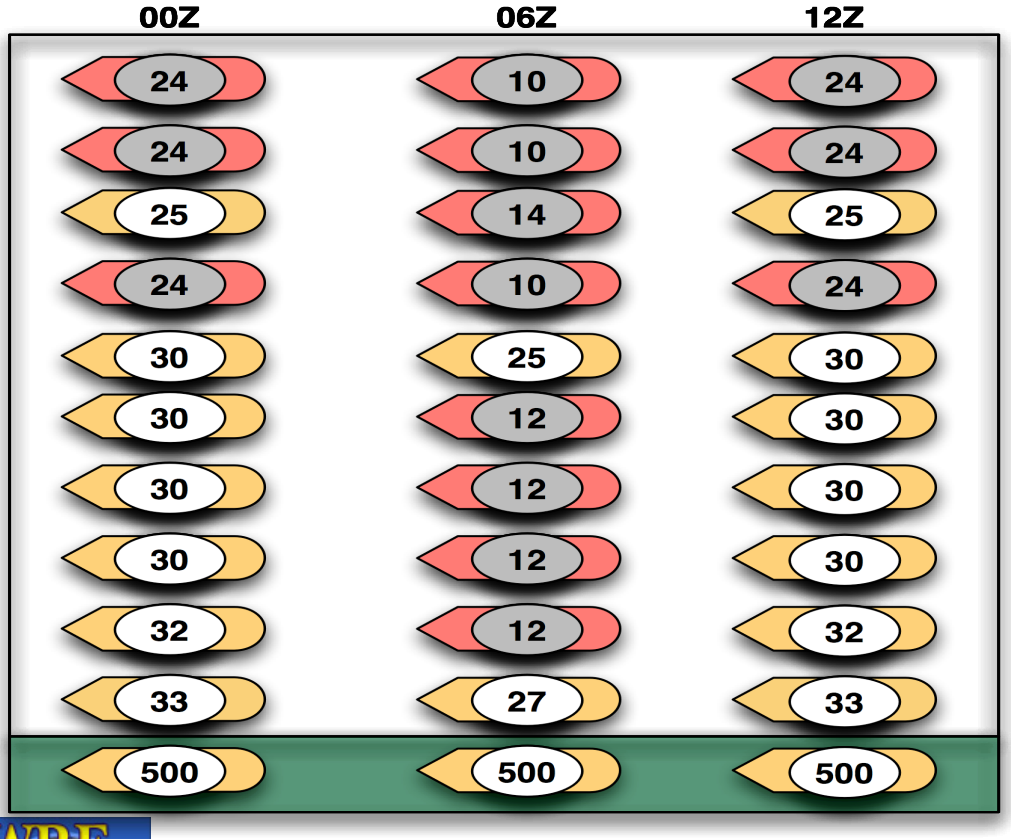
Code will STOP
{OA_3D_option = 0}

Can force this behavior
{OA_3D_option = 2}

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

Namelist

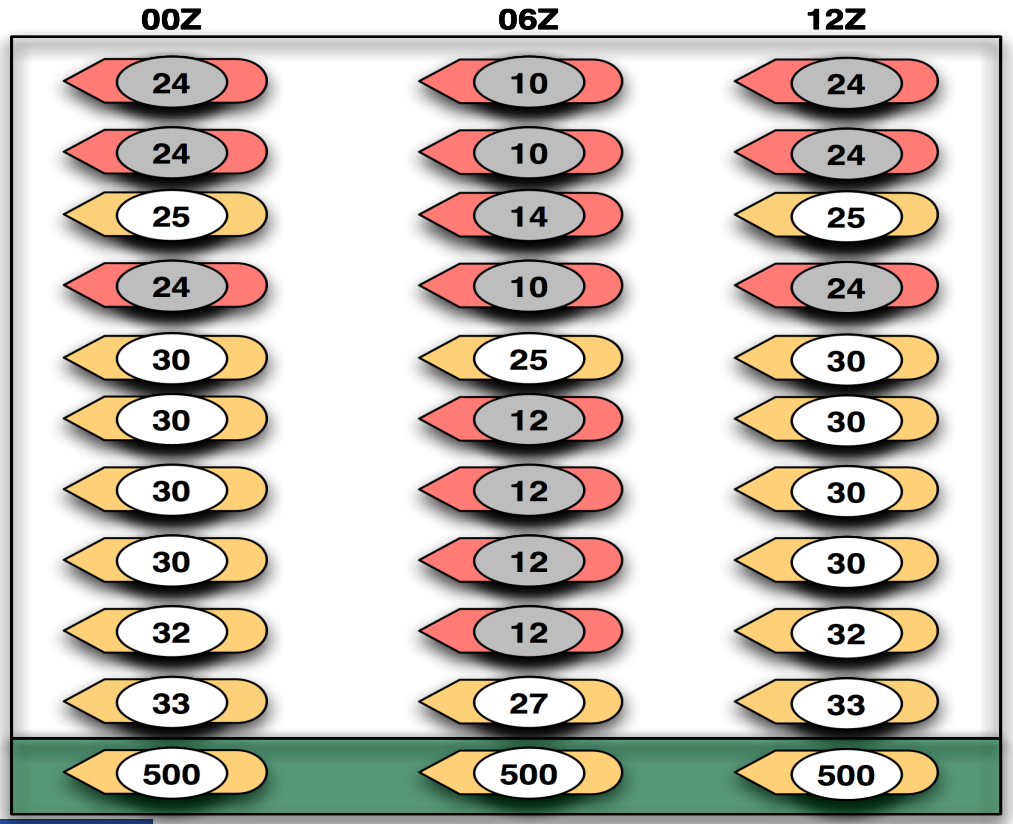
- OA_type = "MQD" ;
  OA_min_switch = T ; MQD_minimum_num_obs = 25



MQD ; Cressman

Namelist

- OA_type = "MQD" ;
  OA_min_switch = T ; MQD_minimum_num_obs = 25



MQD ; Cressman

Different schemes used in surface and upper-air is fine

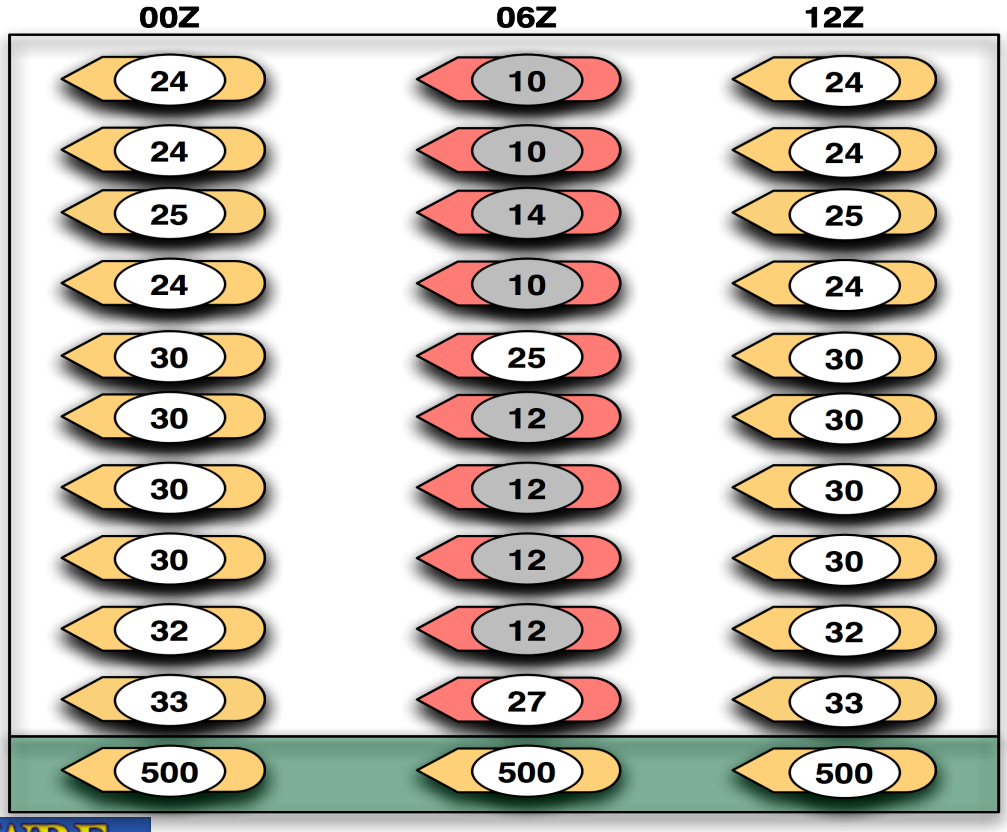
Switch in upper-air between MQD and Cressman is undesired

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 = 24



MQD_minimum_num_obs = 24

Do not make this to low in order to force MQD ***(i.e., 9 in this case)***

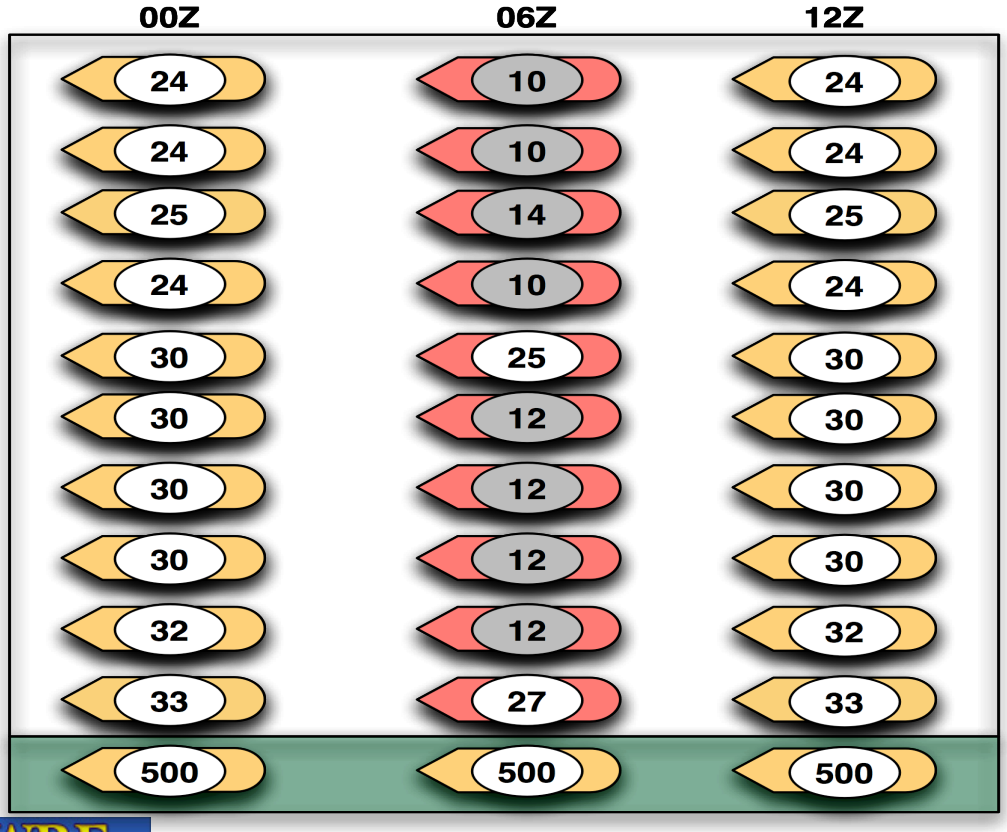
OA_3D_option = 1

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

MQD ; Cressman

Namelist

- OA_type = "MQD" ;
  OA_min_switch = T ; MQD_minimum_num_obs = 24



MQD_minimum_num_obs = 24

Do not make this to low in order to force MQD ***(i.e., 9 in this case)***

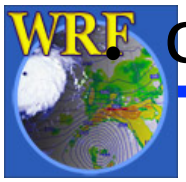
OA_3D_option = 1

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

MQD ; Cressman

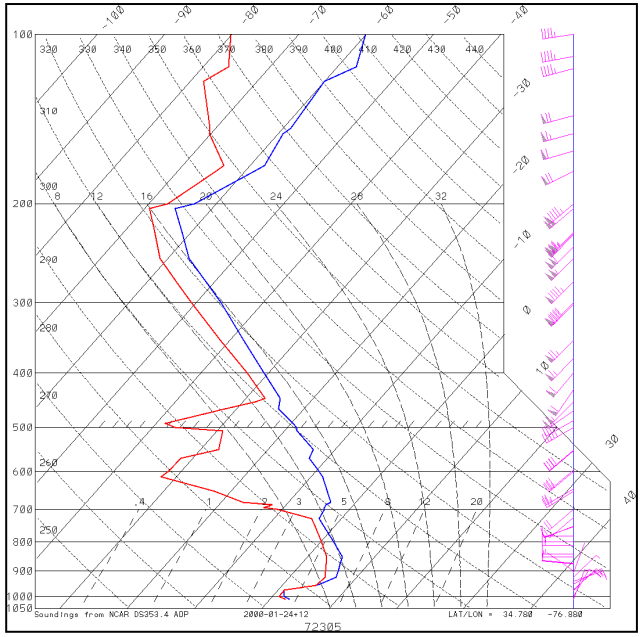
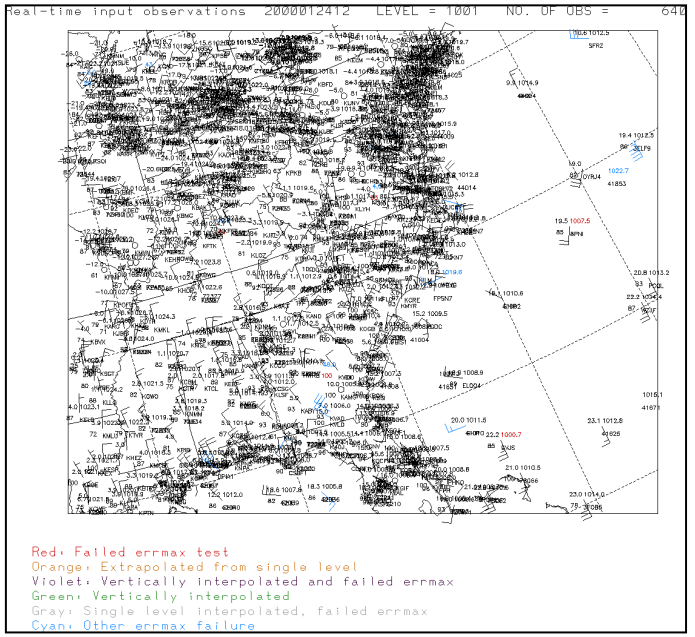
How to run OBSGRID

- 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



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**