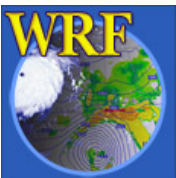




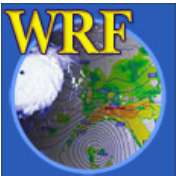
Objective Analysis (OBSGRID)

Cindy Bruyère

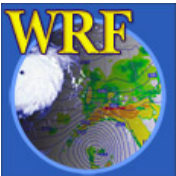
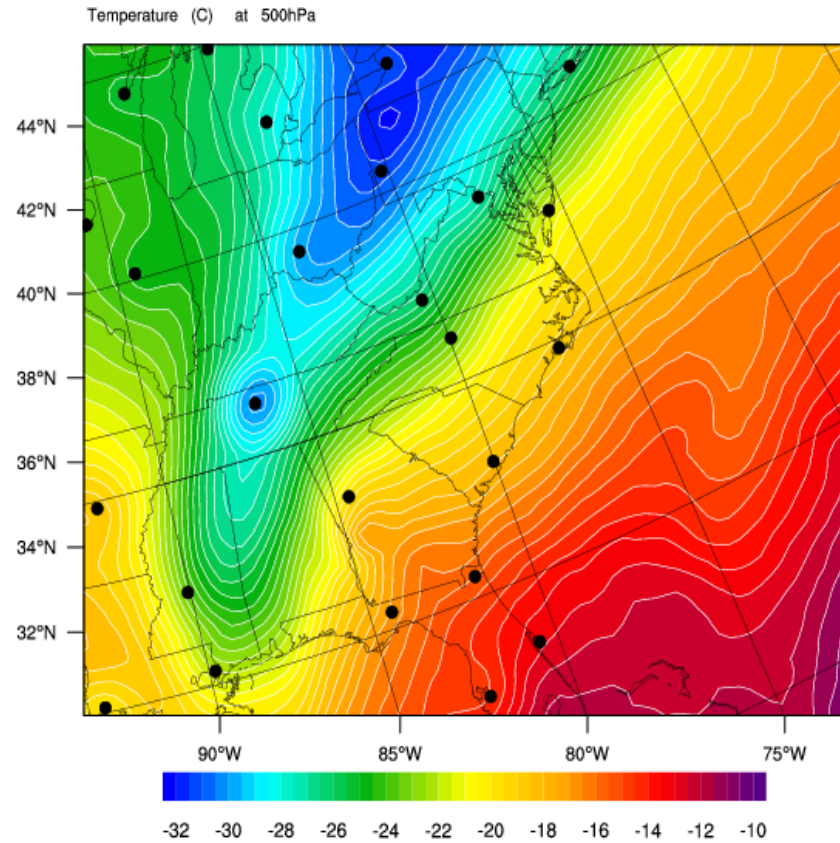
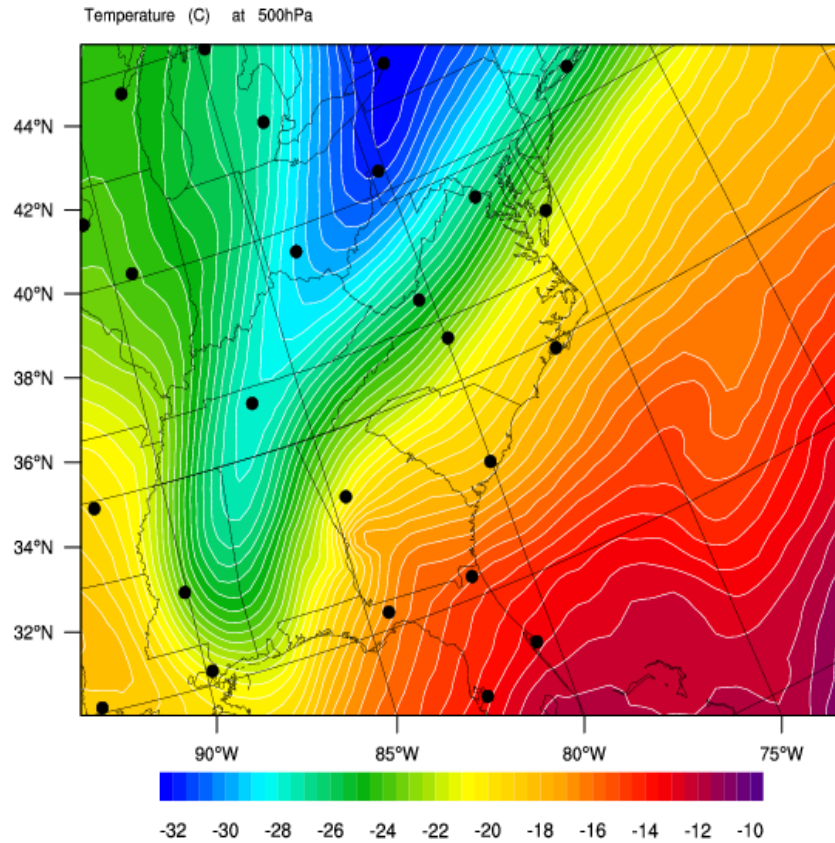


Objective Analysis

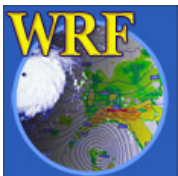
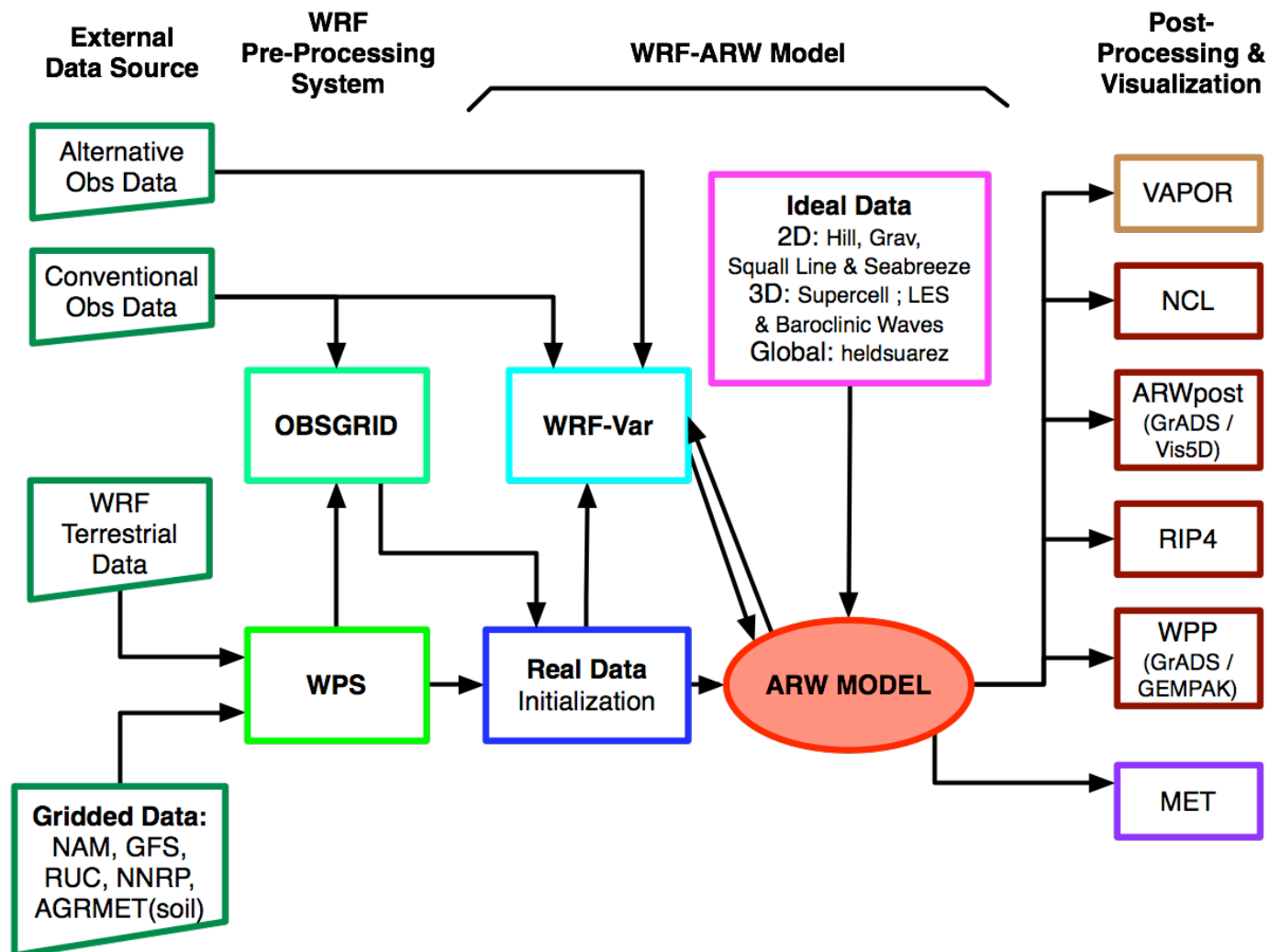
- To improve a *first-guess* gridded analysis by incorporating additional observational information
 - Traditionally, this first-guess analysis comes from low-resolution global analysis and forecast grids
 - These days, higher-resolution, regional scale analyses are more readily available
 - *These high-resolution 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



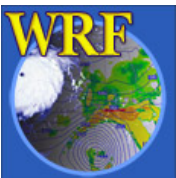
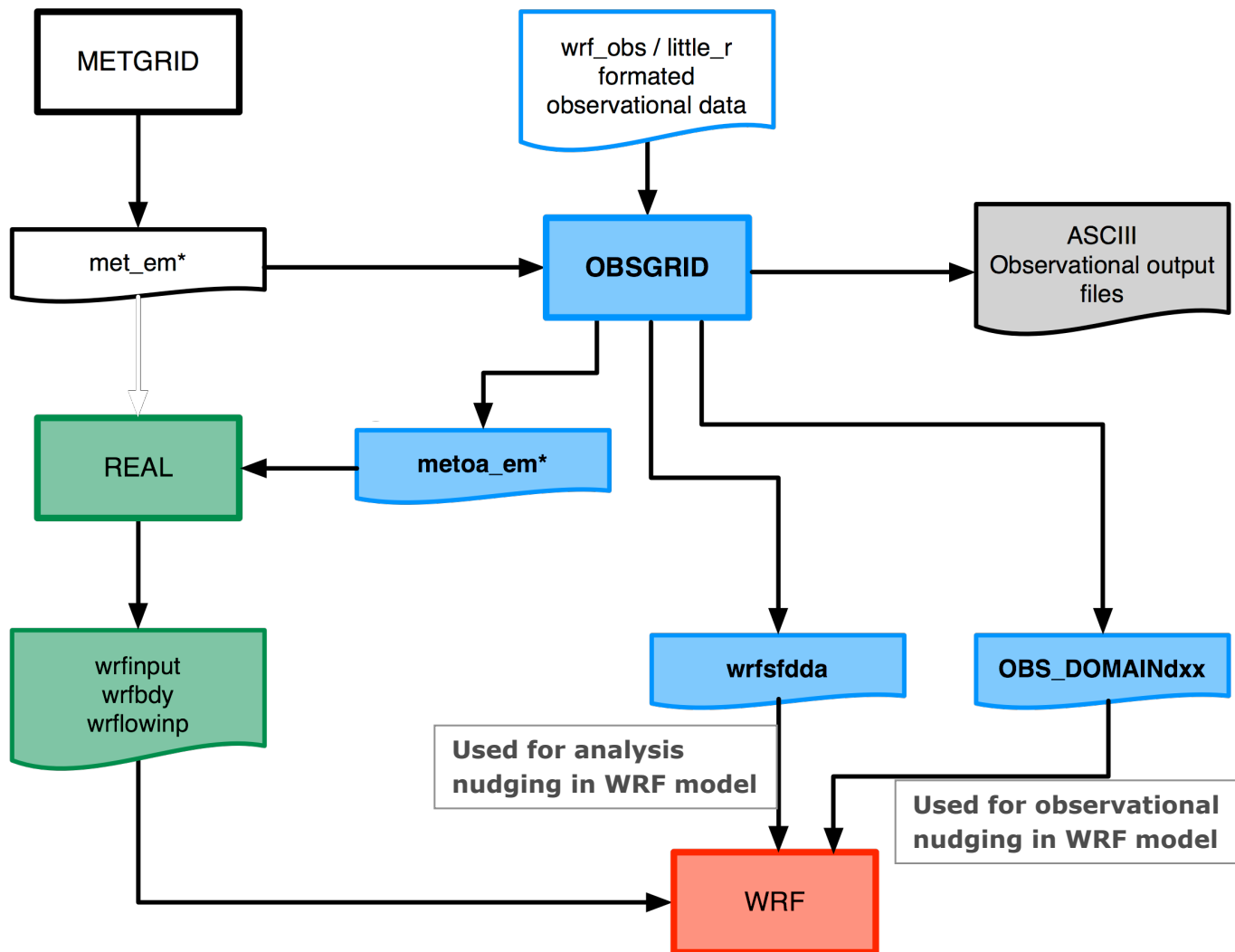
Objective Analysis



WRF-ARW Modeling System Flow Chart



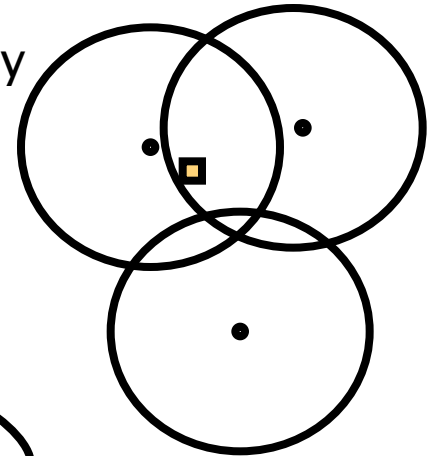
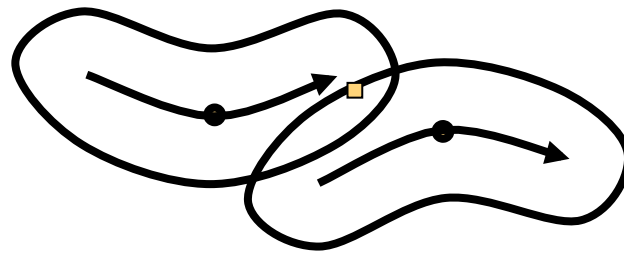
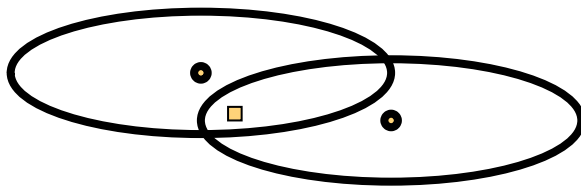
Program Flow



OA Techniques in OBSGRID

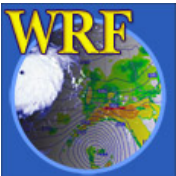
- Cressman-based analysis

- Impact of observation within radius of influence only
- Multiple scans
- With ellipse and banana extensions

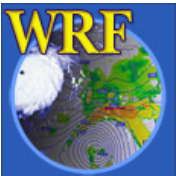
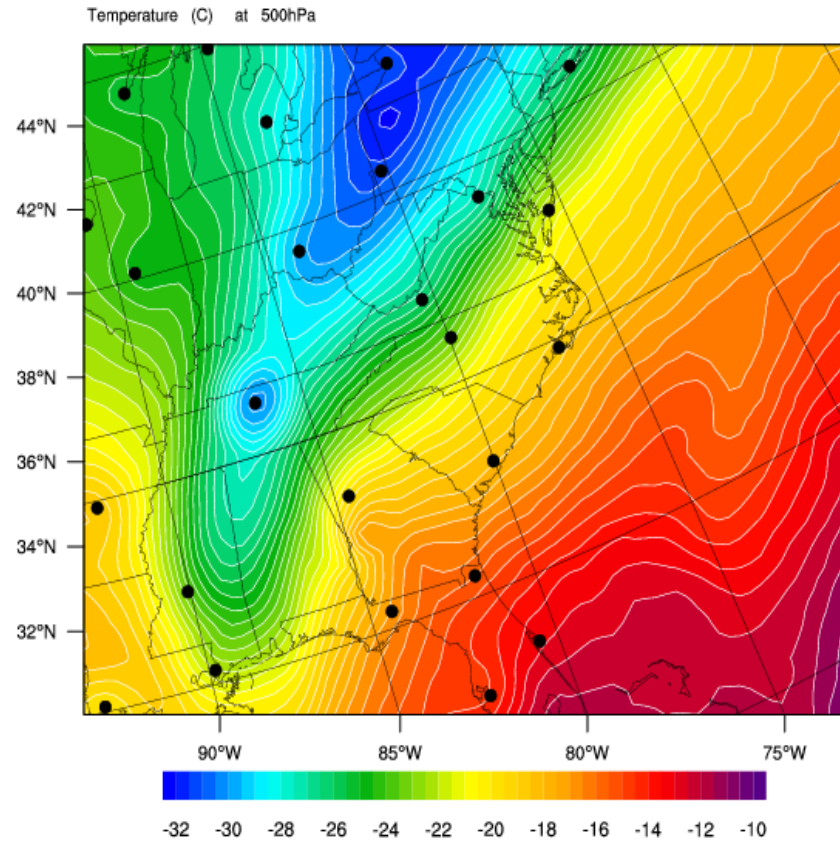
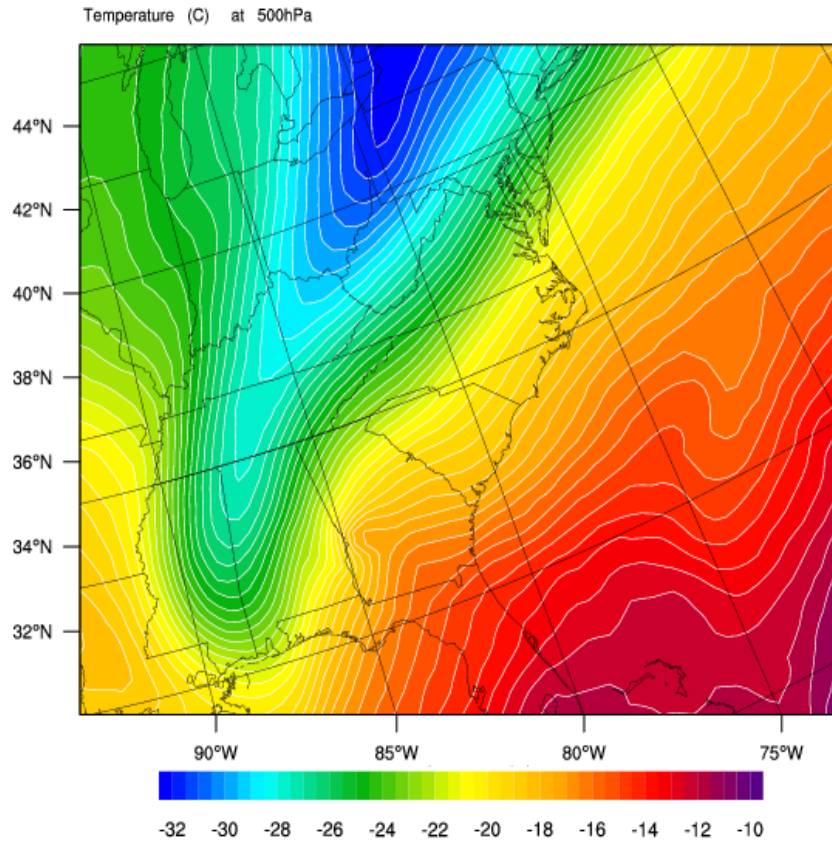


- Multi-Quadric analysis

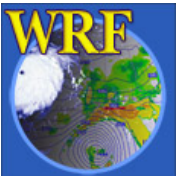
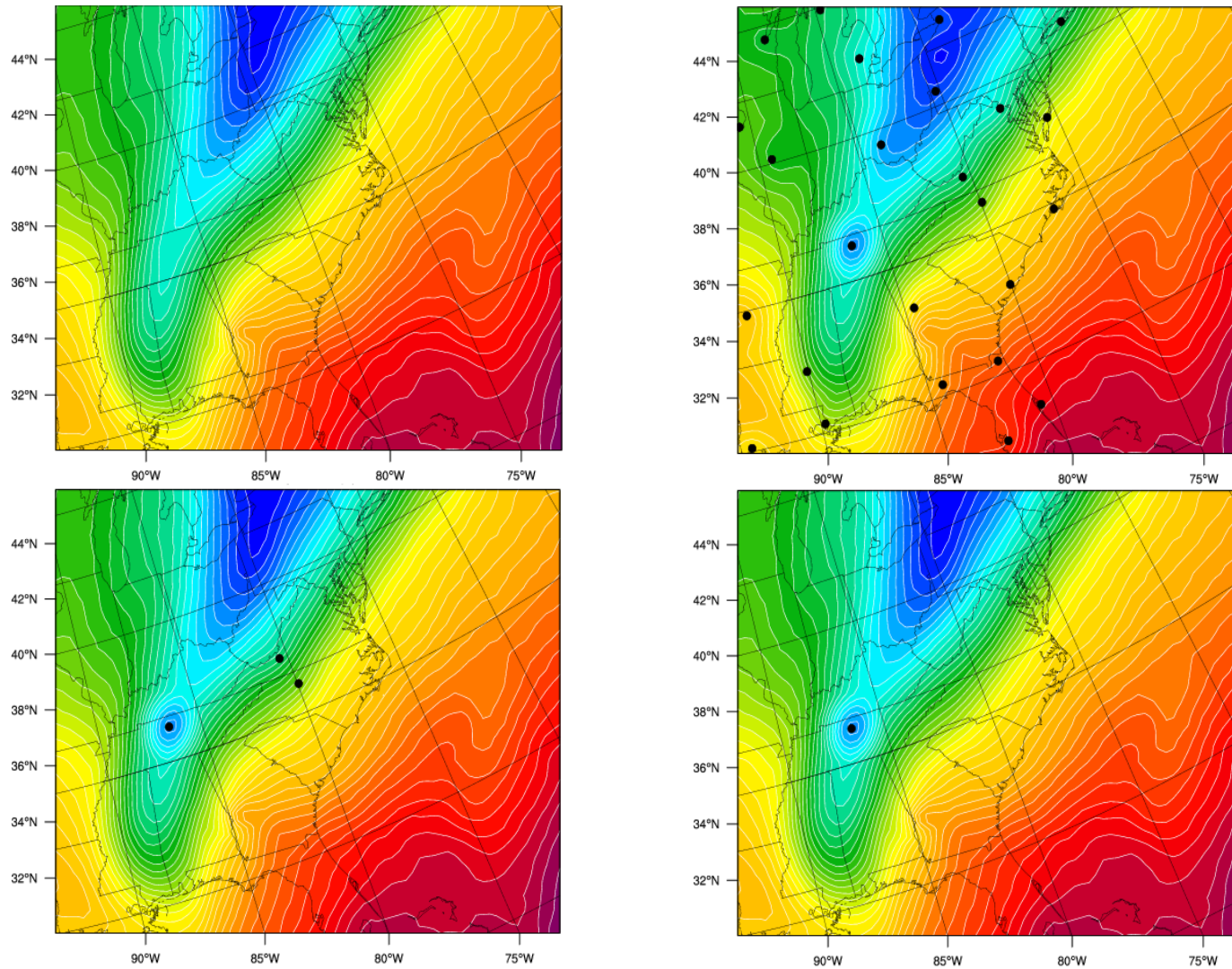
- Impact of observations are over the entire model domain
- Scheme is sensitive to the data density distribution
- Makes use of hyperboloid radial basis functions to interpolate observation corrections onto model grid



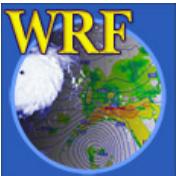
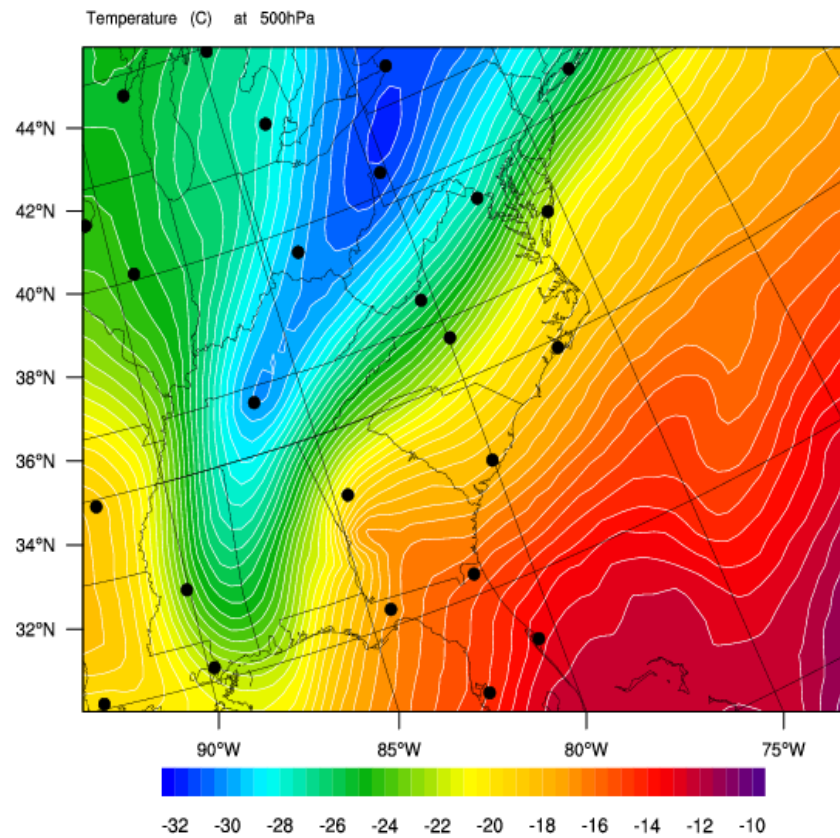
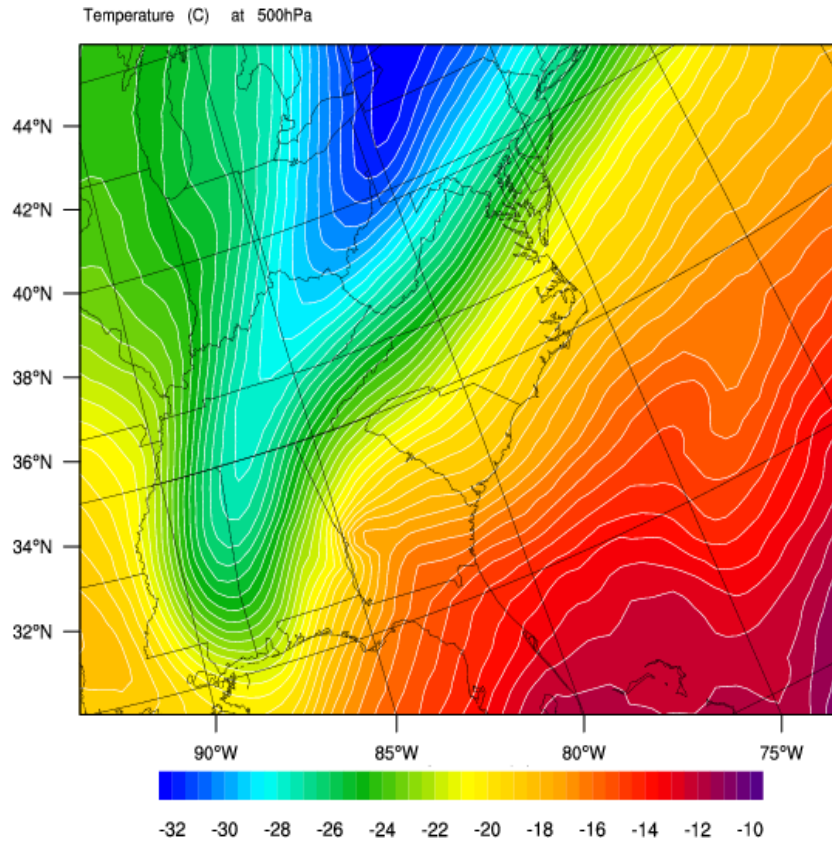
Cressman Scheme



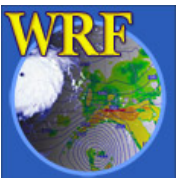
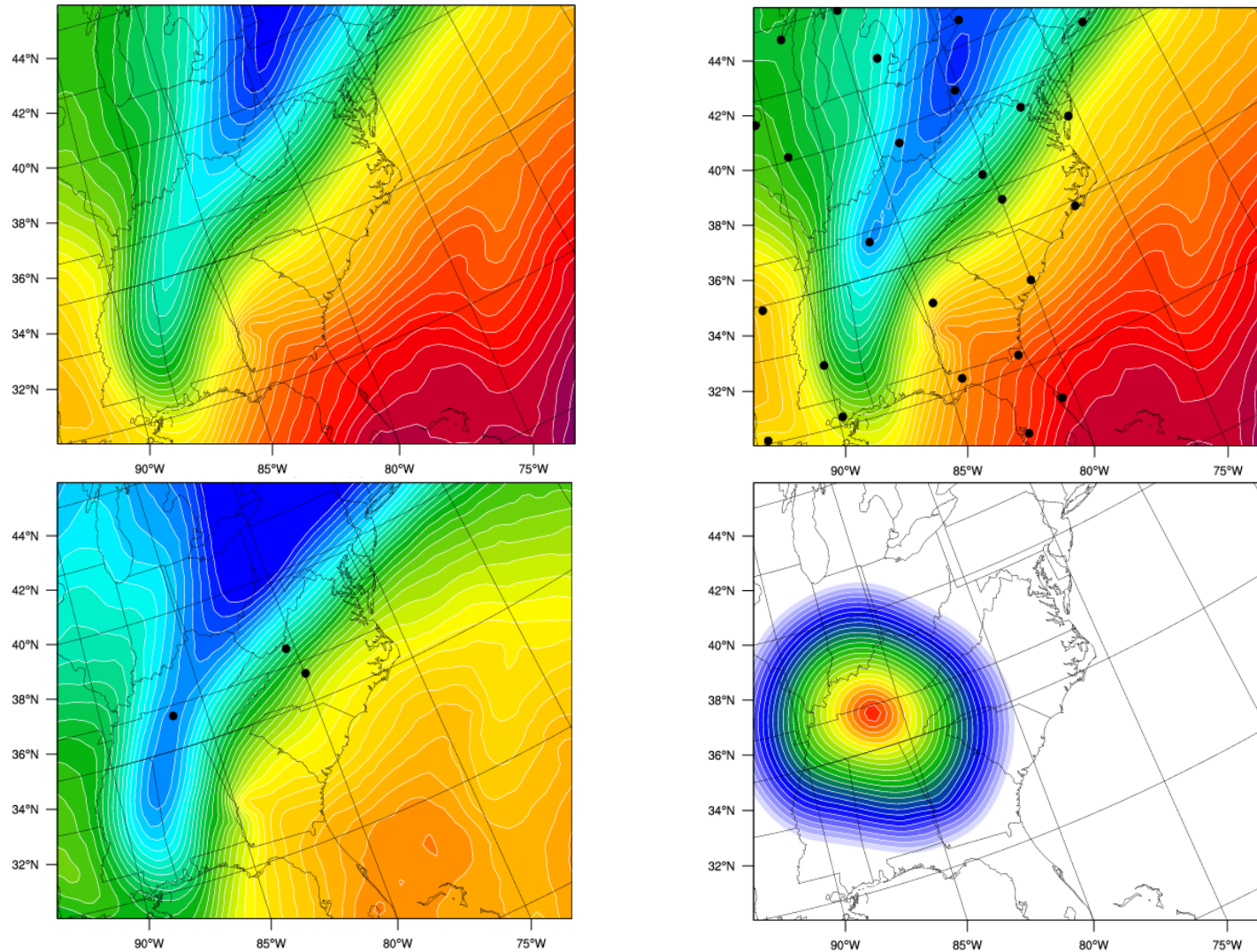
Cressman Scheme



Multi-Quadric Scheme

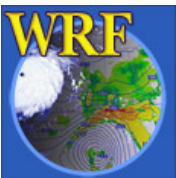
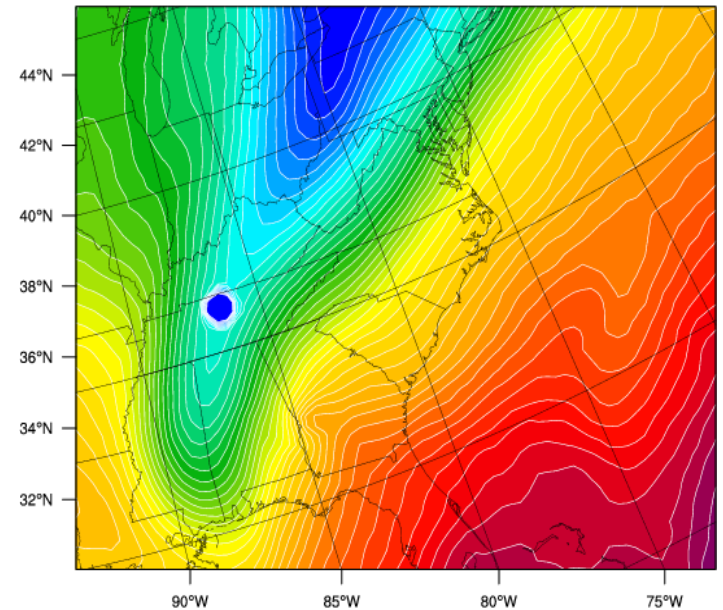


Multi-Quadric Scheme



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



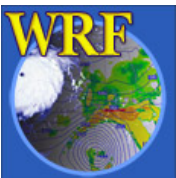
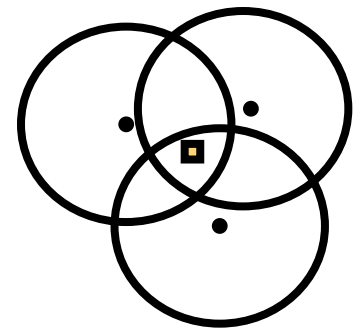
Tests performed in OBSGRID

- **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**

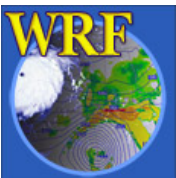
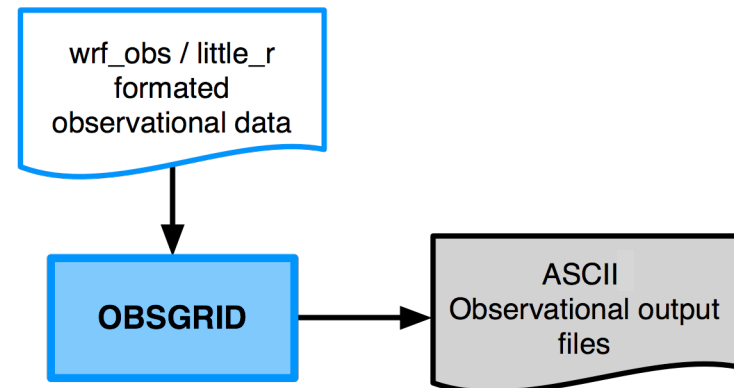
- Observations are compared to the first guess and to nearby observations
- If an observation deviates from the first guess in a manner inconsistent with the deviations of surrounding stations observation is discarded
- Works well in regions of good data density



Observations

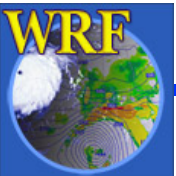
UG: 7-13

- 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

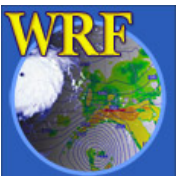
header	{	station_latitude, station_longitude, station_id,		
		station_name, type_of_observation, observation_source,		
		station_elevation, num_valid_fields, num_errors,		
		num_warnings, report_number, number_of_report_duplicates,		
		is_this_a_sounding, is_this_a_bogus_observation,		
		discard_the_report, 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

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	0-888888.00000	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
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	0-888888.00000
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	0-888888.00000
90400.00000	0	1029.00000	0	260.65000	0	255.65000	0	6.18557	0	335.00000	0-888888.00000
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
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
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
85000.00000	0	1496.00000	0	257.65000	0	246.65000	0	15.46392	0	315.00000	0-888888.00000
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
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
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
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
70000.00000	0	2931.00000	0	249.25000	0	244.25000	0	23.71134	0	330.00000	0-888888.00000
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
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
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
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
50300.00000	0-888888.00000	0	231.65000	0	222.65000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000
50000.00000	0	5300.00000	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
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
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
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	0-888888.00000
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	0-888888.00000	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	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000	0-888888.00000
-888888.00000	0	24.00000	0	286.15000	0	284.15000	0	8.76289	0	230.00000	0-888888.00000
-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	0-888888.00000
10	0	0									



Quality-Control Flags

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

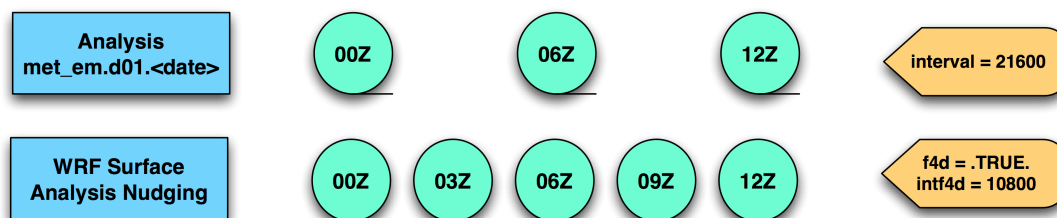
Pressure interpolated from first-guess height	2**1	2
Temperature and dewpoint both 0	2**4	16
Wind speed and direction both 0	2**5	32
Wind speed negative	2**6	64
Wind direction < 0 or > 360	2**7	128
Level vertically interpolated	2**8	256
Value vertically extrapolated from a single level	2**9	512
Sign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

UG: 7-15

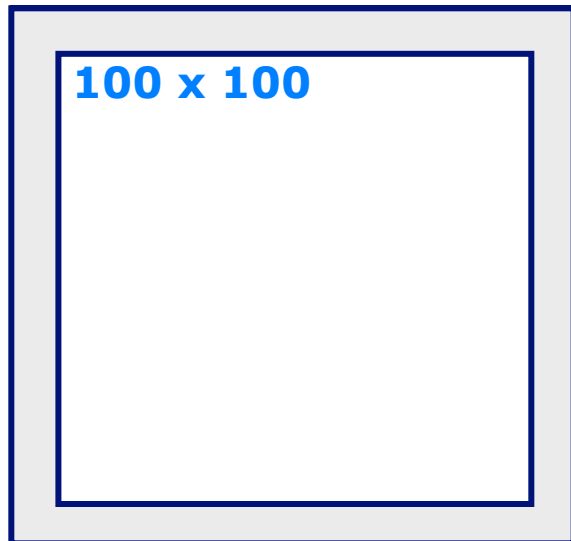
obs_filename	Root file name (<i>may include directory information</i>) of the observational files. All input files must have the format obs_filename:<YYYY-MM-DD_HH>. One file per time period Also used when doing surface fdda (<i>F4D=.TRUE.</i>)
interval	Interval between analysis times (sec) <i>i.e., interval between met_em.d0x.<date> files</i>
f4d	Turn on / off the creation of the surface analysis file (<i>wrfsfdda_d0x</i>)
intf4d	Time interval (sec) for surface analyses (<i>typically smaller than interval between analysis</i>)



Namelist

<code>domain_id</code>	ID of domain to process
<code>trim_domain</code>	Set to <code>.TRUE.</code> if this domain must be cut down on output
<code>trim_value</code>	Value by which the domain will be cut down in each direction

110 x 110

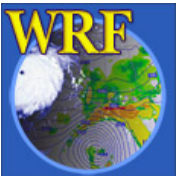


- **Why do this:**

This allows observations just outside the desired grid box of 100x100 grid points to be included in the OA

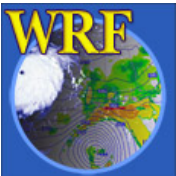
- ***geogrid* and *metgrid* run with a domain size of 110x110**

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



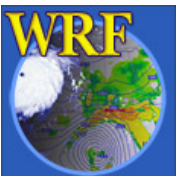
Namelist

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



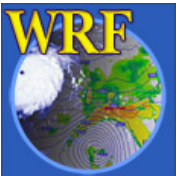
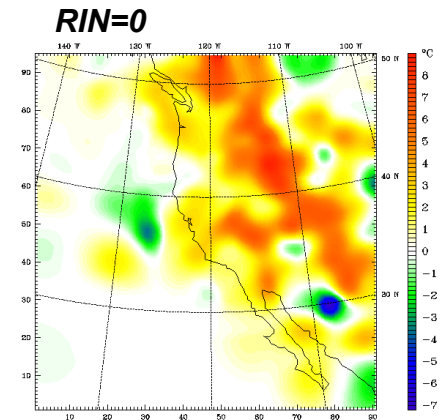
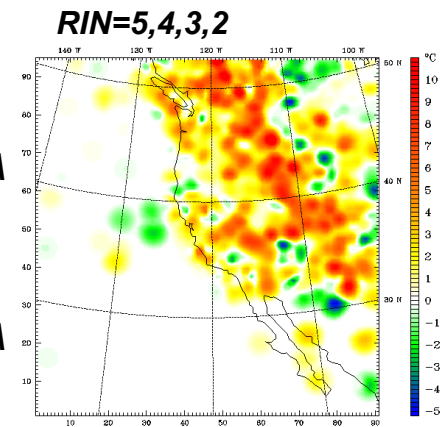
Namelist

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



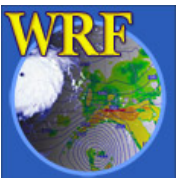
Namelist

- 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



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 too 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 = 24

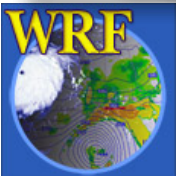
00Z	06Z	12Z
24	10	24
24	10	24
25	14	25
24	10	24
30	25	30
30	12	30
30	12	30
30	12	30
32	12	32
33	27	33
500	500	500

MQD_minimum_num_obs = 24

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

OA_3D_option = 1

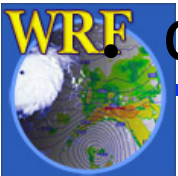
*All upper-air, at a given time
Especially good for f4d runs*



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

