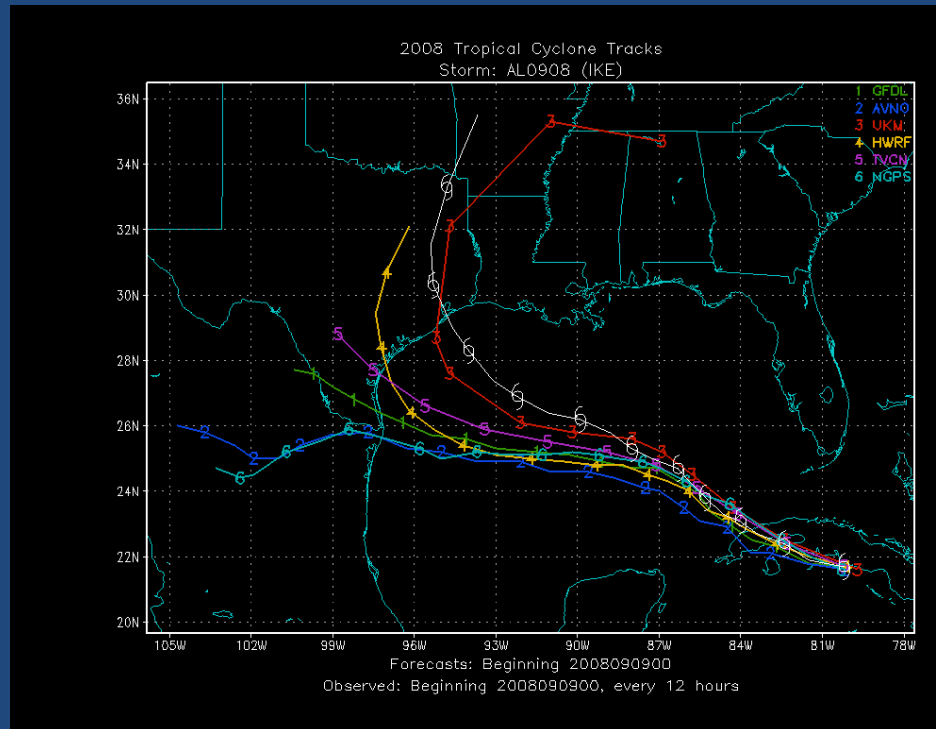


# Use of the GFDL Vortex Tracker



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WRF Tutorial for Hurricanes  
January 24, 2018

# Outline

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- History & description of the GFDL vortex tracker
- Inputs & Outputs
- Genesis tracking

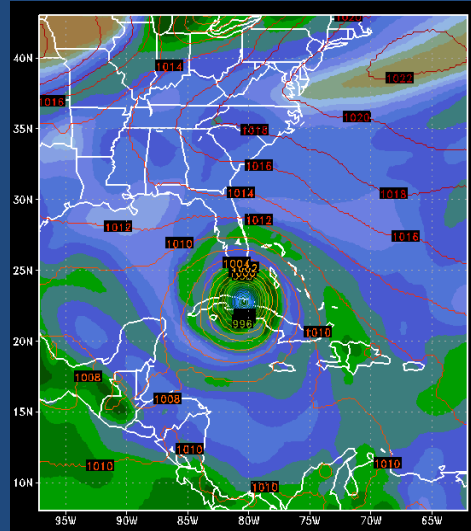
# GFDL Vortex Tracker: History

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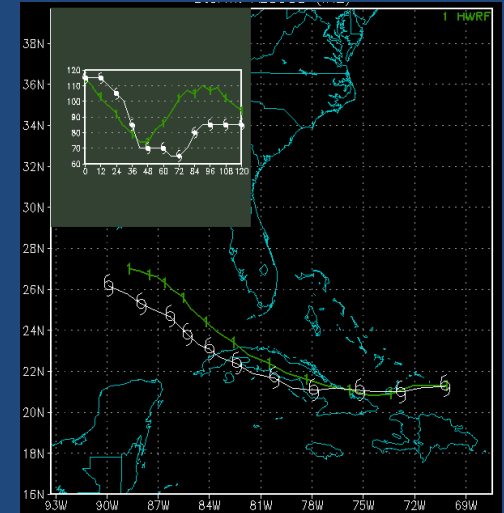
- Requirements:
  - A flexible tracking algorithm to work on a variety of models and resolutions.
  - Must run quickly
  - Must produce output in ATCF format
- Became operational at NCEP in 1998

# Purpose of a vortex tracker

```
11000100100100101010
00010010011110010010
11001110001101010001
00001010010011001011
10101110101100011001
10001110100100010100
```



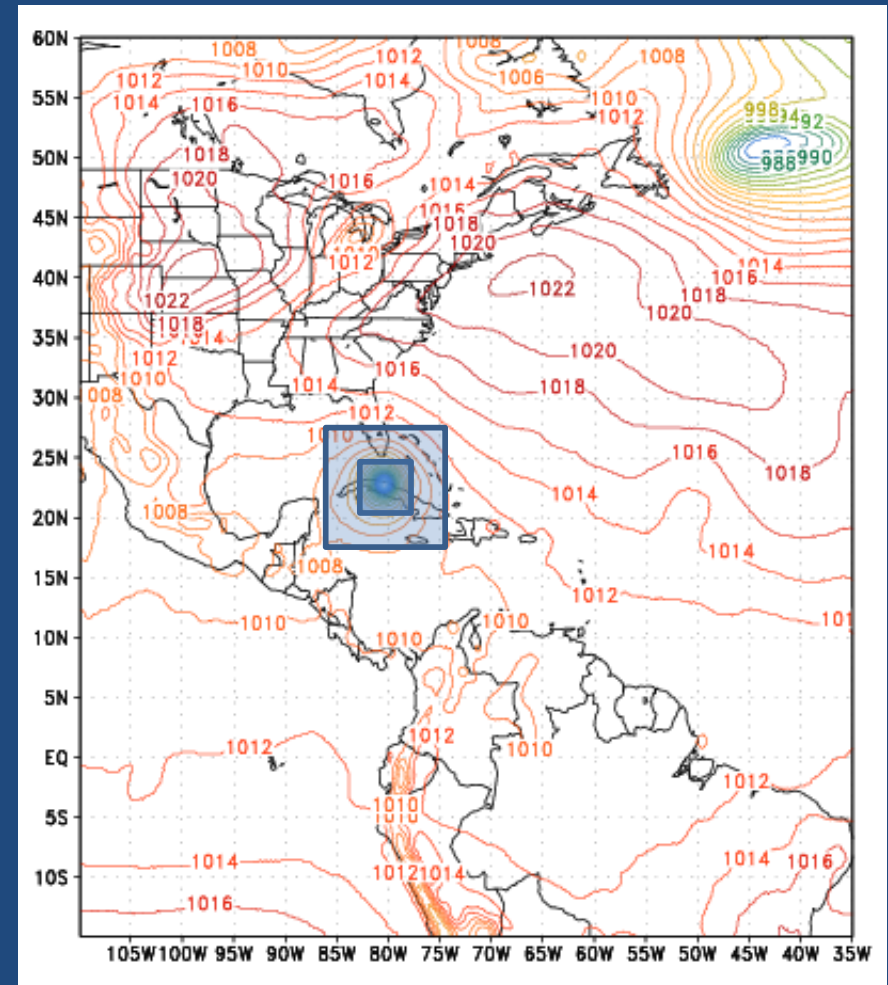
NOW  
→  
WHAT ?



- Operations: Quick reporting of track and intensity forecast data to NHC, JTWC, others.
- Research: Quick evaluation of the track & intensity skill of a forecast

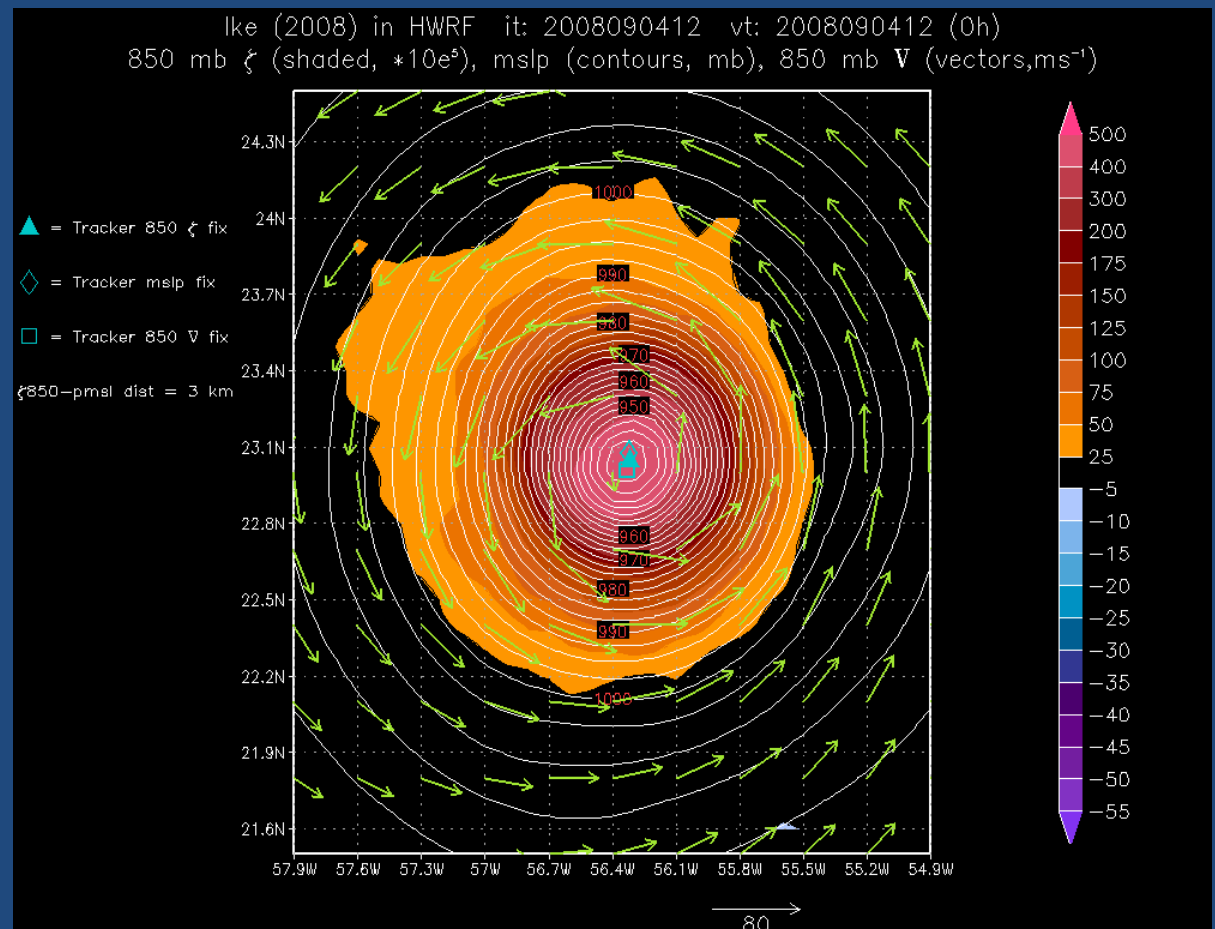
# Why the need for an external tracker?

- Valuable CPU time is not wasted during model execution.
- Tracking analysis can be re-done without re-running model.
- Uniform tracking criteria can be applied to multiple models.

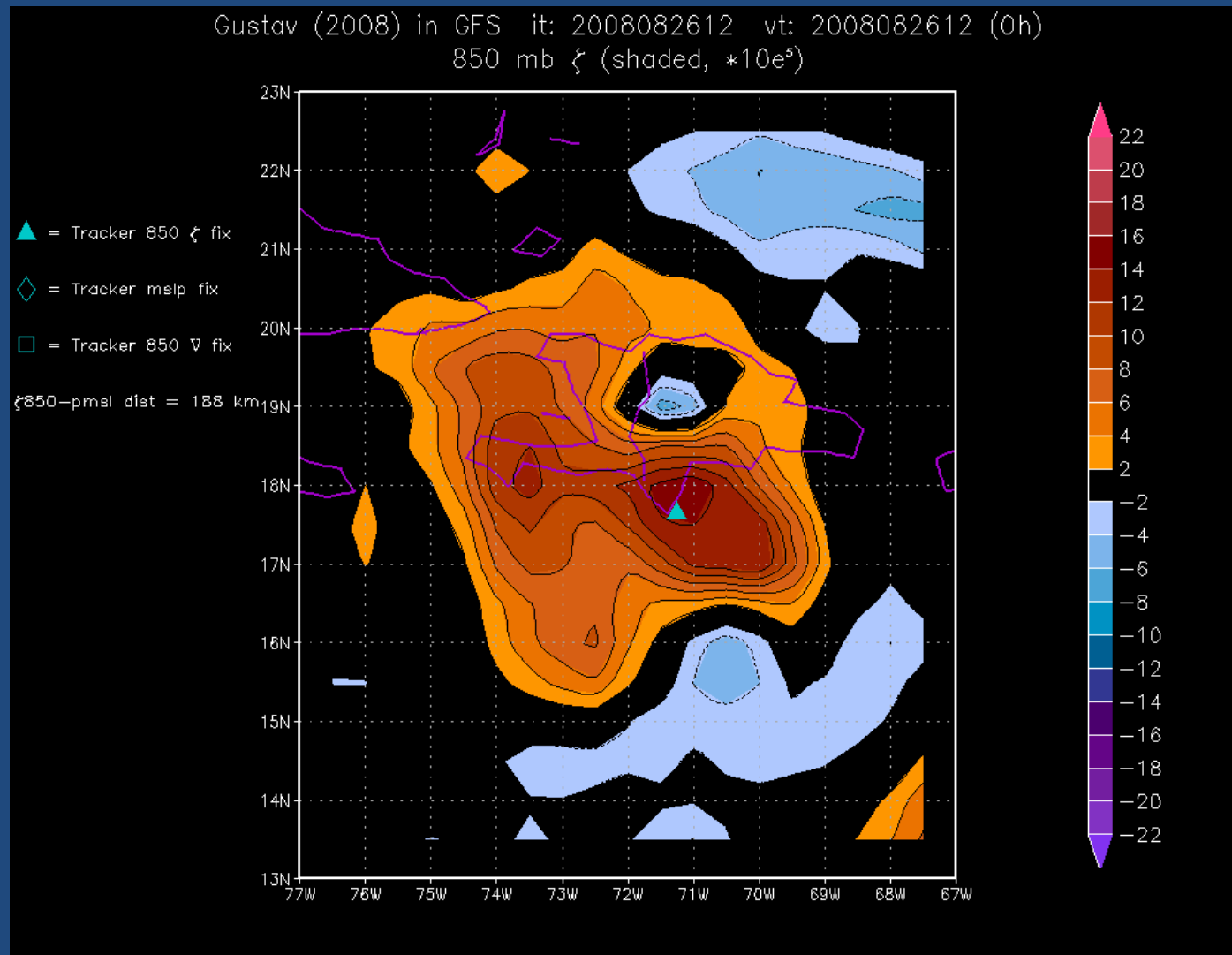


# Why the need for an external tracker?

- Hurricane Ike in HWRF: A well-defined storm with center locations collocated.
- So then... why the need for anything sophisticated?

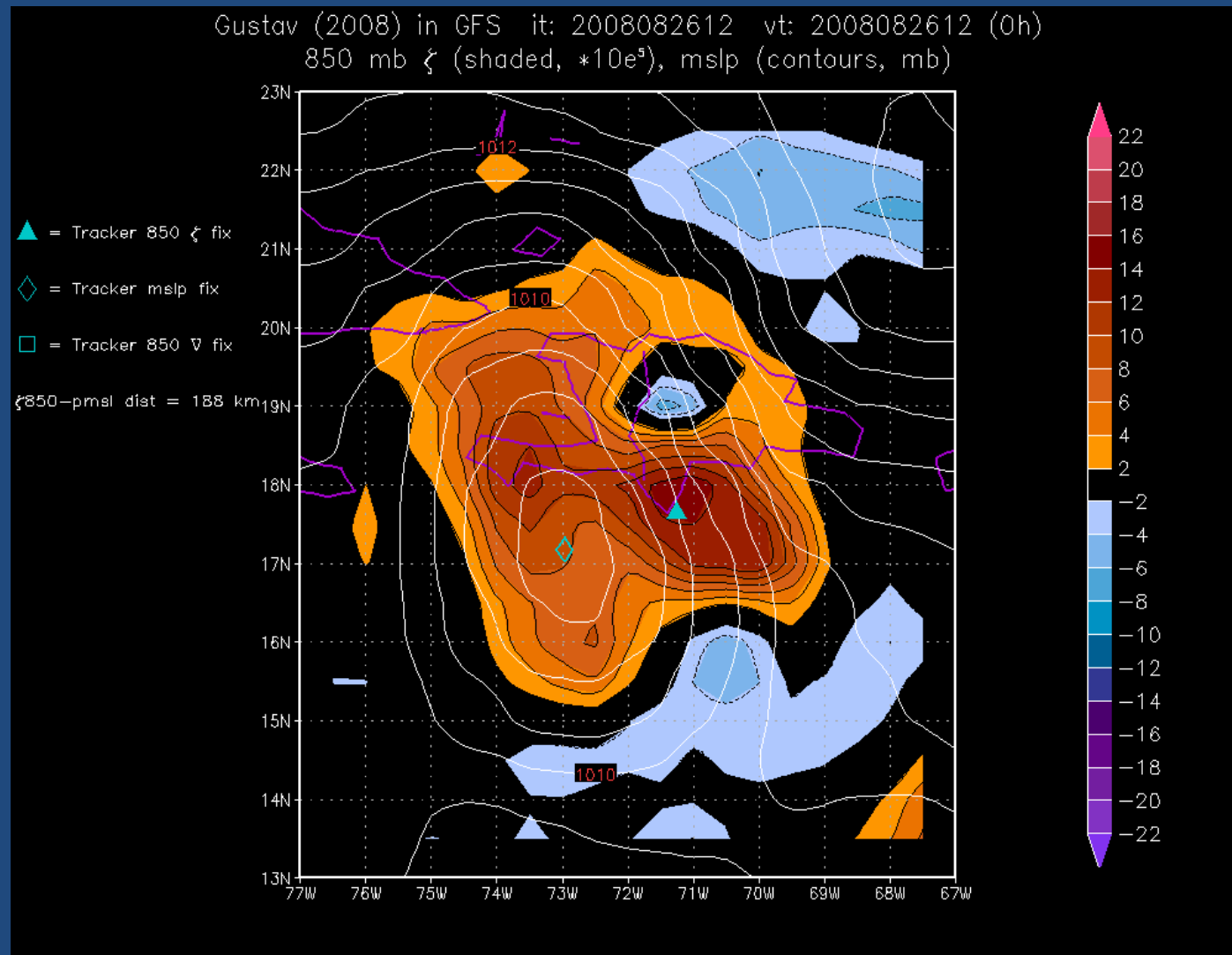


# Why the need for an external tracker?



- Gustav in GFS: For an observed 80-knot hurricane, the GFS was initialized with a poorly organized vorticity center.

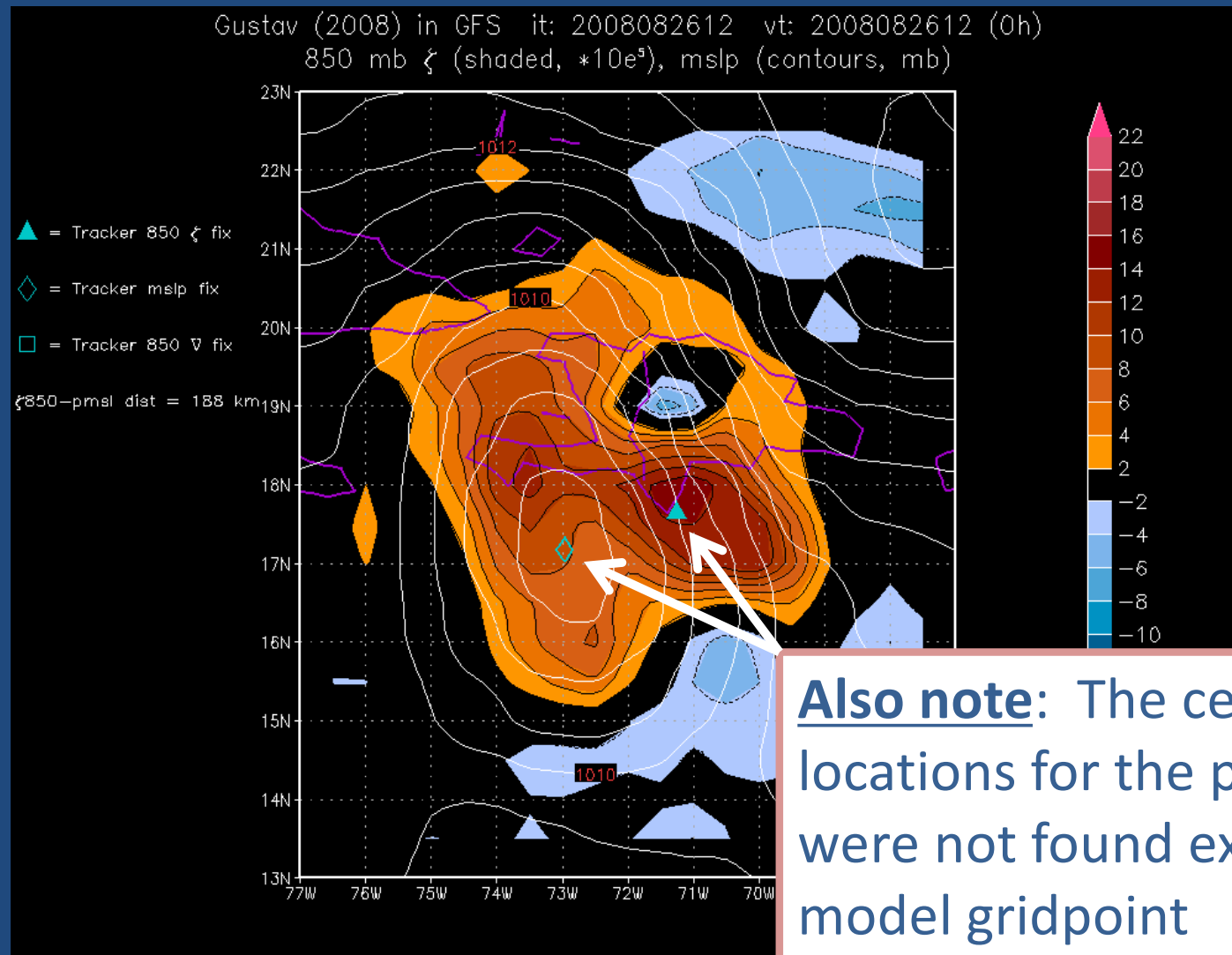
# Why the need for an external tracker?



- Gustav in GFS: The SLP center was found 188 km from the vorticity center. What is the storm's central position?



# Why the need for an external tracker?



- Gustav in GFS: The SLP center was found 188 km from the vorticity center.

# Tracker Design: Multiple Variables

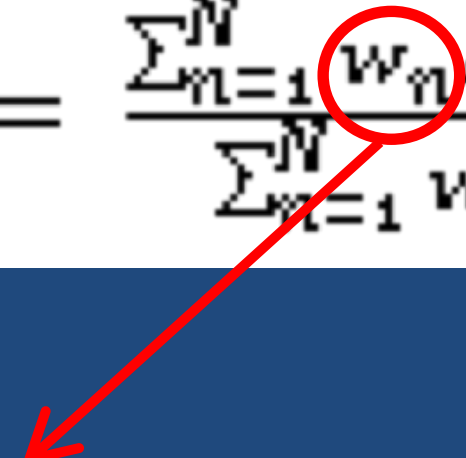
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- A weighted average of the positions of several variables (mainly lower-tropospheric) is used.
- Available tracking parameters:
  - 850 mb vorticity
  - 700 mb vorticity
  - Surface (10 m) vorticity
  - 850 mb wind circulation
  - 700 mb wind circulation
  - Surface (10m) wind circulation
  - 850 mb gp height
  - 700 mb gp height
  - Mean Sea-Level Pressure
  - 200-850 mb thickness
  - 500-850 mb thickness
- Selection of parameters to use for tracking is done via the input namelist.

# Tracker Design: Center-fixing algorithm

- Instead of interpolation, a Barnes Analysis is performed on an array of points surrounding a guess storm location:

The Barnes function,  $B$ , provides a Gaussian-weighted average value for a variable,  $F(n)$ , at a given gridpoint,  $g$ .

$$B(g) = \frac{\sum_{n=1}^N w_n F(n)}{\sum_{n=1}^N w_n}$$


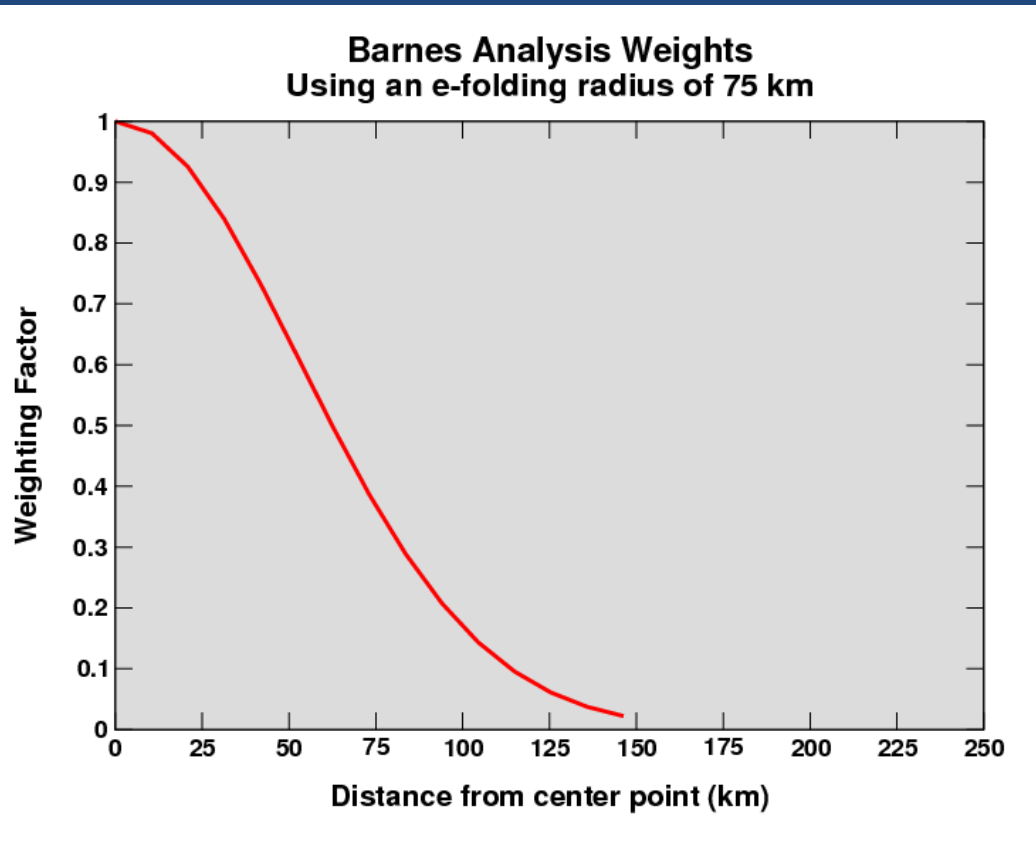
The weighting function,  $w$ , is dependent on the distance,  $d_n$ , of a point from the origin gridpoint,  $g$ , and the choice of the e-folding radius,  $r_e$ .

$$w = e^{-(d_n^2 / r_e^2)}$$

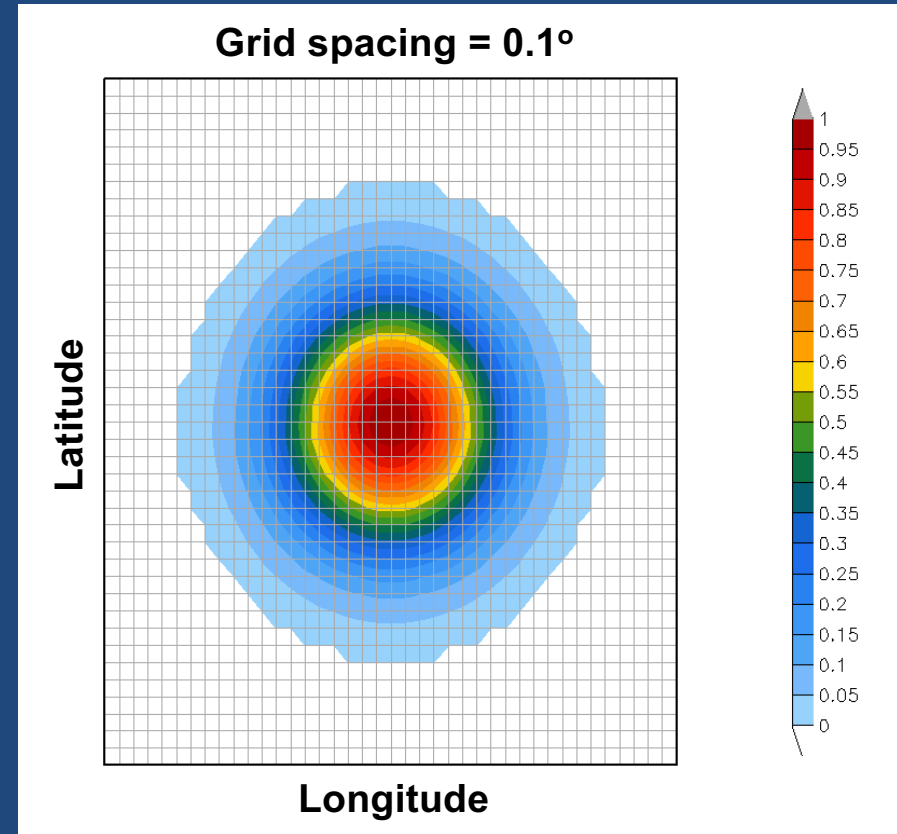
The center is found at the point where this Barnes function is maximized (e.g., NH vorticity) or minimized (e.g., MSLP).

# Barnes analysis weighting

## Linear Response



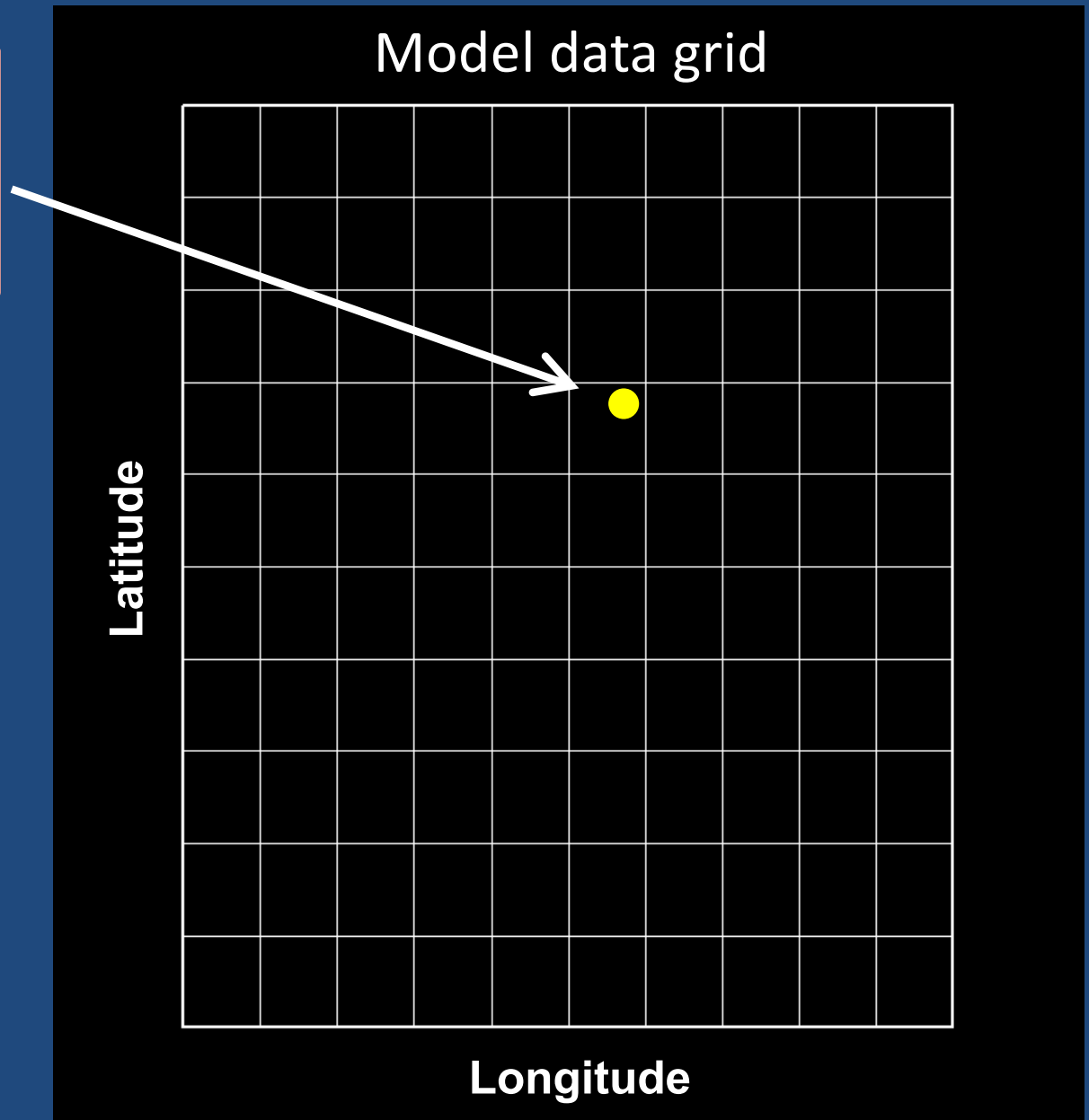
## Spatial Response



- Choosing  $r_e$ : A balance between including enough points to get a representative sample vs. too much smoothing.
- For most models, we use  $r_e = 75$  km. For  $dx < 0.1^\circ$ ,  $r_e = 60$  km.

# Barnes analysis: multiple search iterations

NHC observations  
indicate a storm  
initially located here

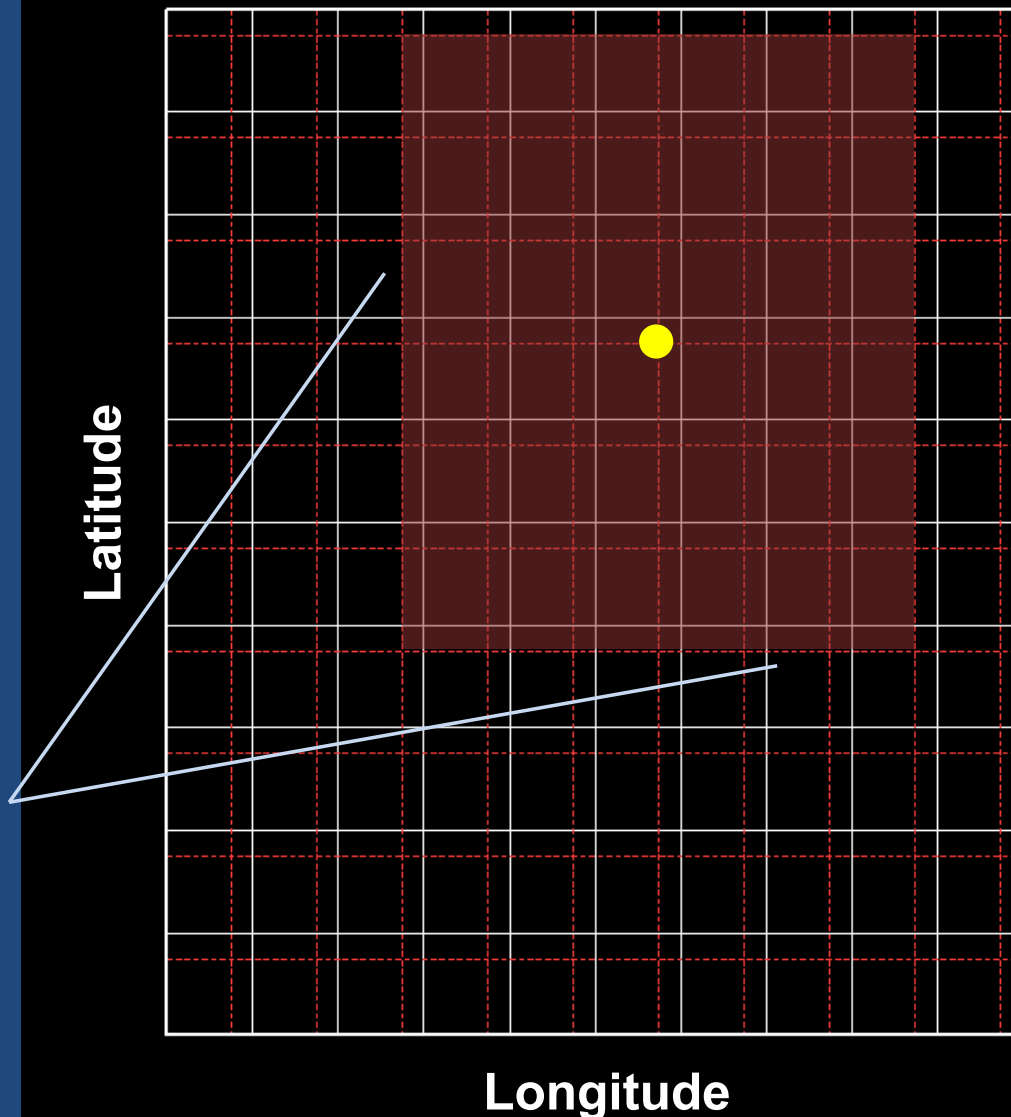


# Barnes analysis: multiple search iterations

A grid of analysis points is set up, relative to the NHC observed position.

A Barnes analysis is performed for all points within a specified distance from the NHC position.

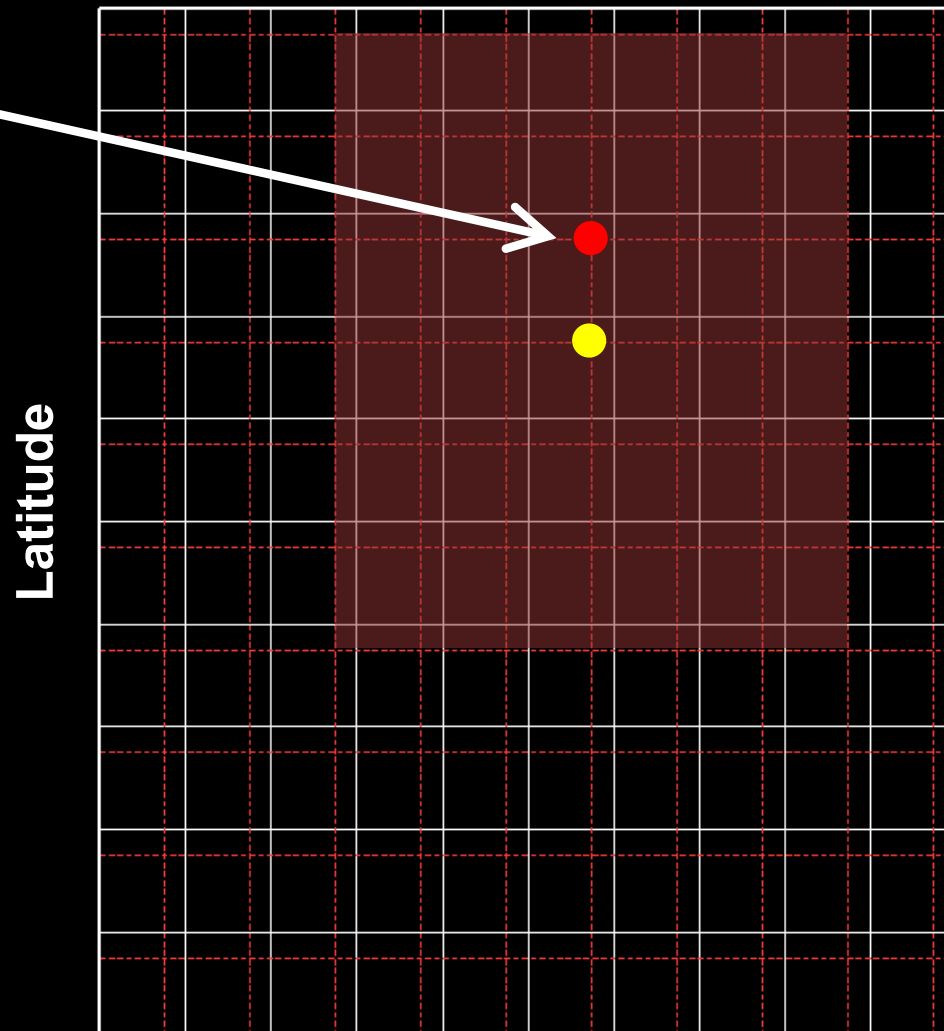
Model data grid + Barnes analysis grid



# Barnes analysis: multiple search iterations

After the first iteration through all the points, suppose the Barnes analysis identifies the center as being here.

Model data grid + Barnes analysis grid

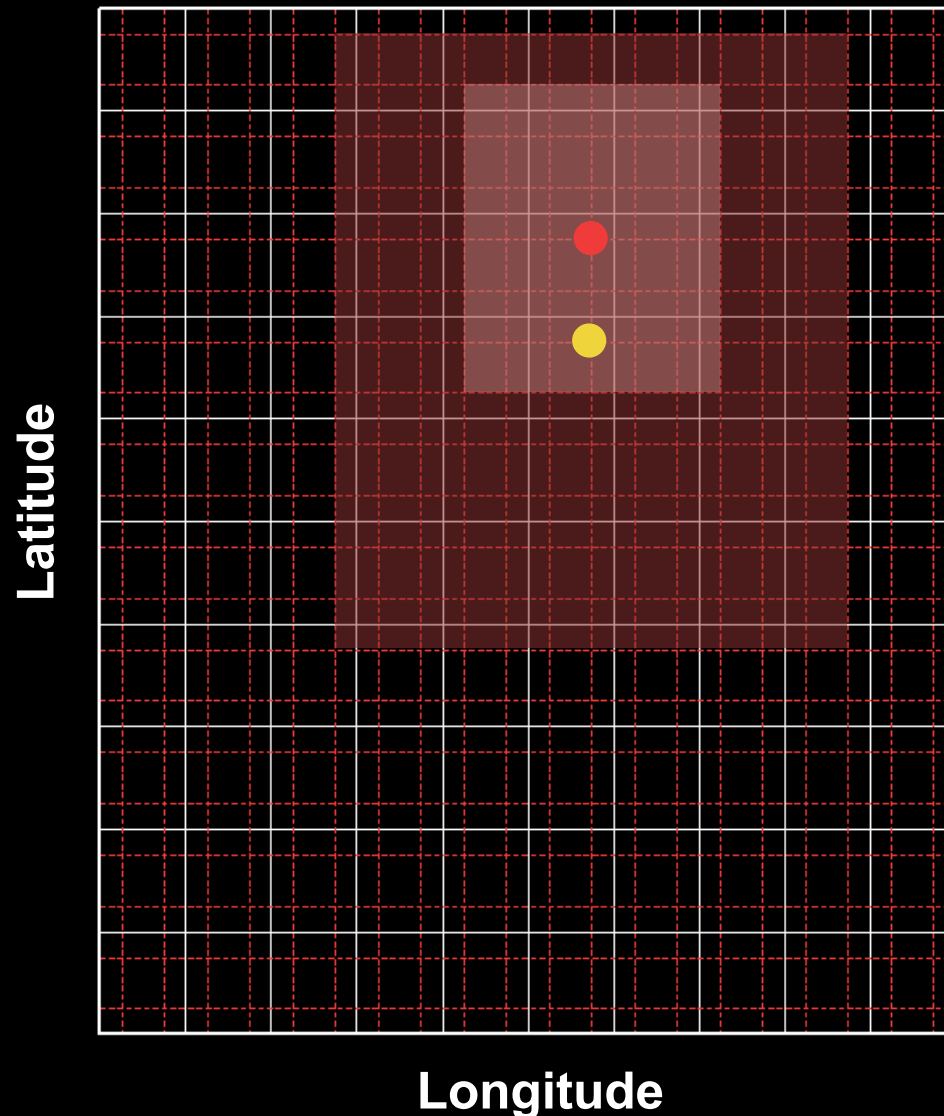


Longitude

# Barnes analysis: multiple search iterations

A second iteration through the Barnes analysis is performed after further limiting the domain and halving the grid spacing.

Model data grid + Barnes analysis grid

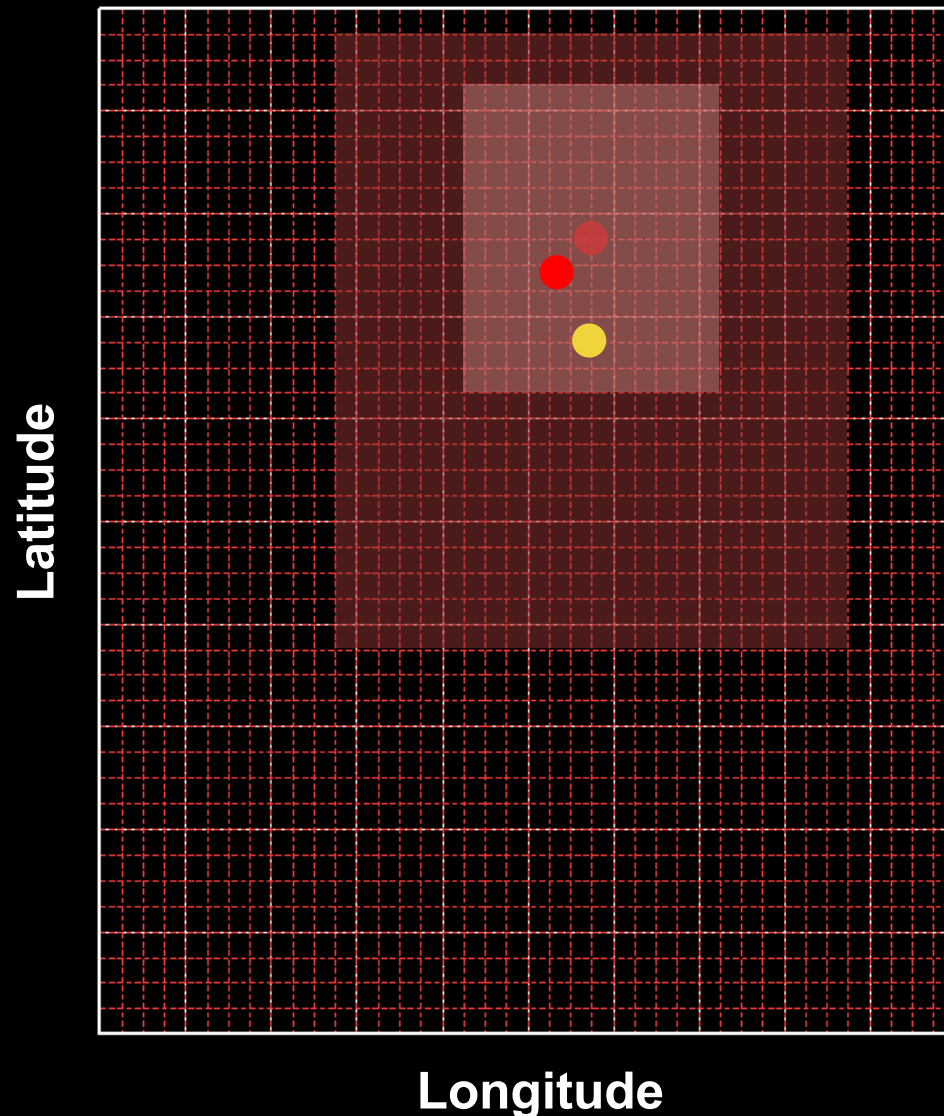




# Barnes analysis: multiple search iterations

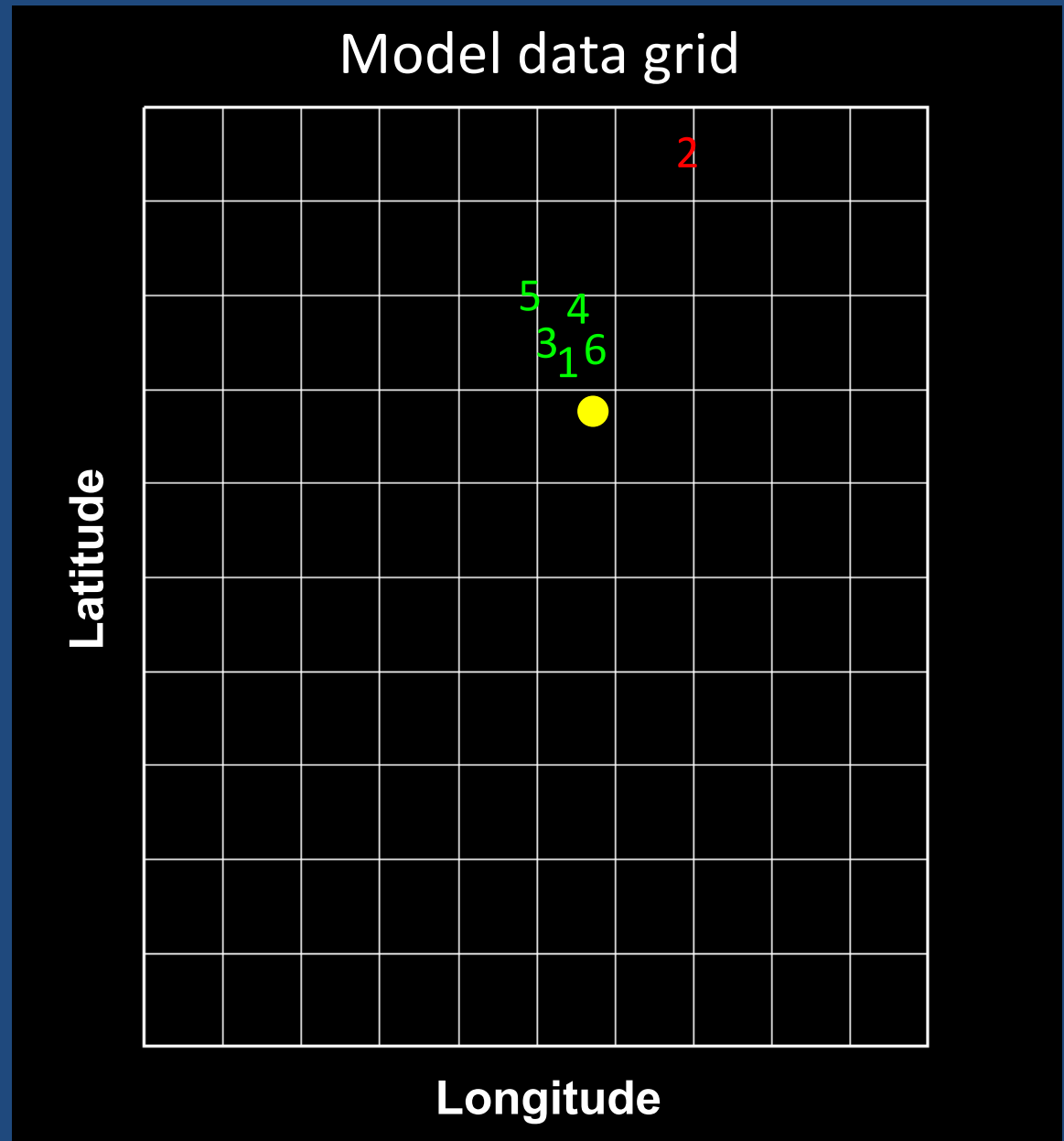
This process is repeated multiple times (up to 5), halving the grid spacing for the Barnes analysis each time, until a center position is fixed using a Barnes analysis grid spacing  $< 0.1^\circ$ .

Model data grid + Barnes analysis grid



The Barnes analysis is repeated for all parameters to produce fix positions for each.

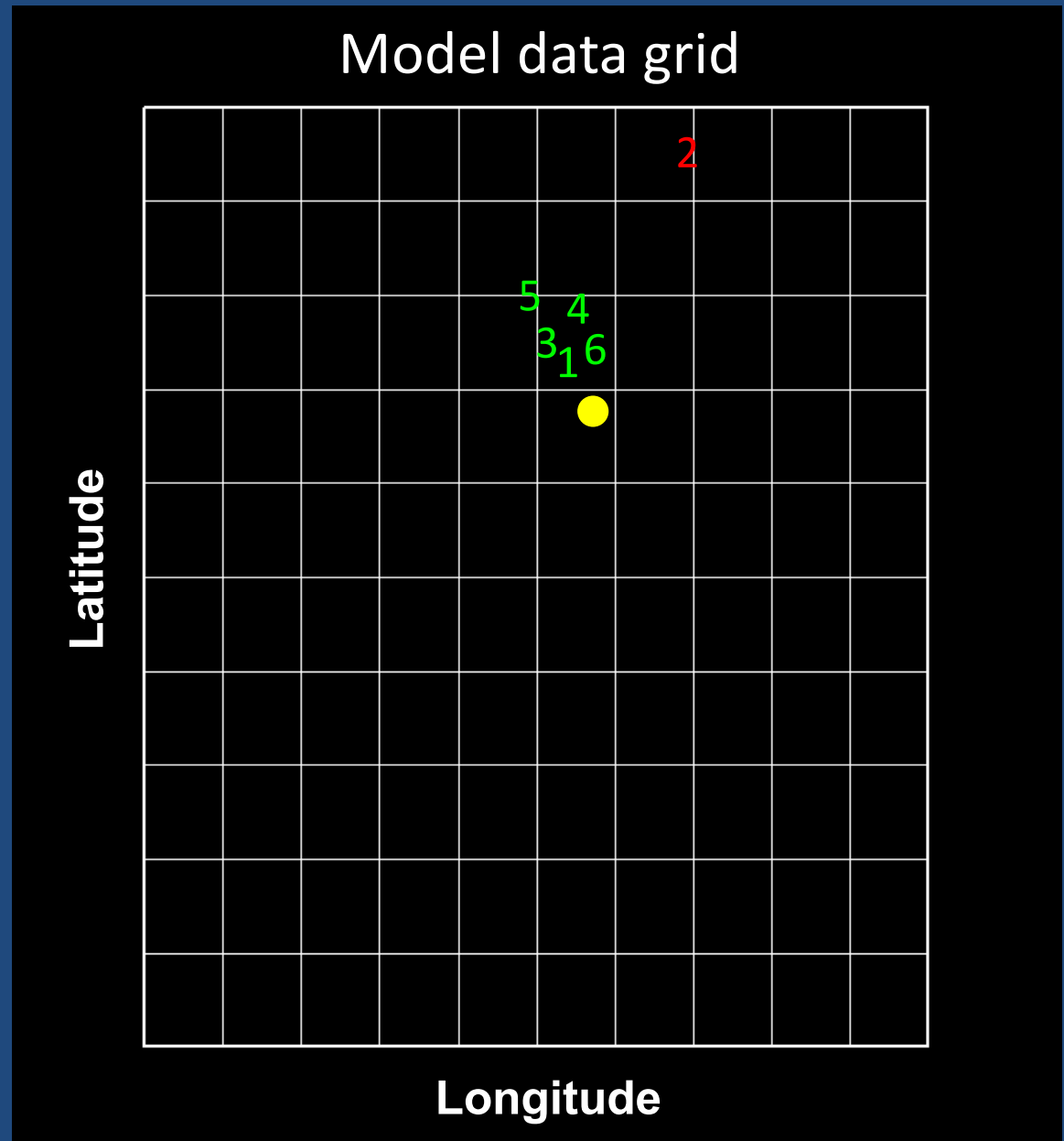
Parameters fixes that are within a specified error distance threshold of the current guess position are used to create a mean fix position.



# Computing the center position, Part II

Parameters fixes that are beyond a specified error distance threshold of the current guess position are **discarded**.

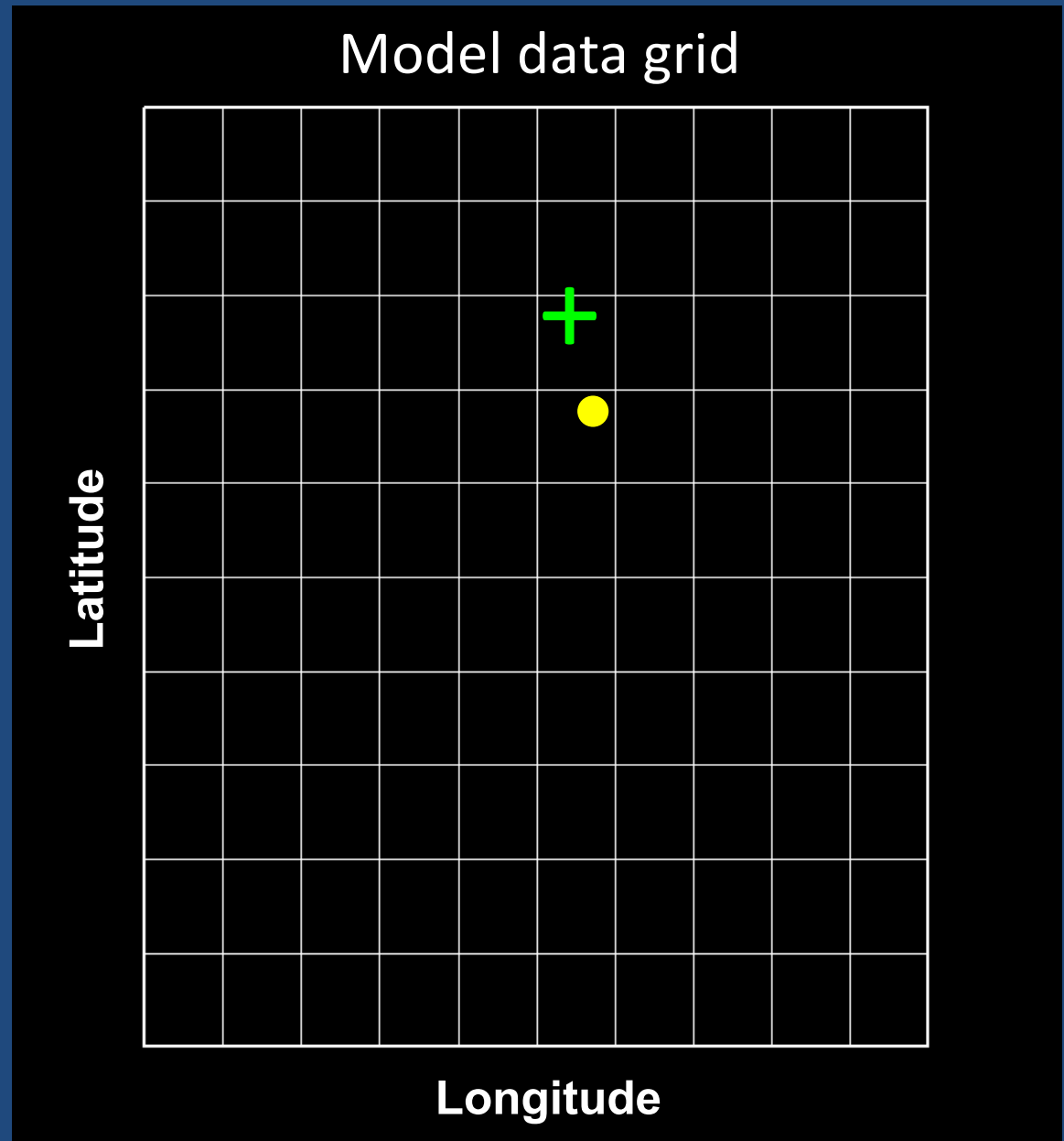
- Error distance thresholds:
  - Initially 275 km
  - At later times, can be a function of spread in previous position fixes



# Computing the center position, Part III

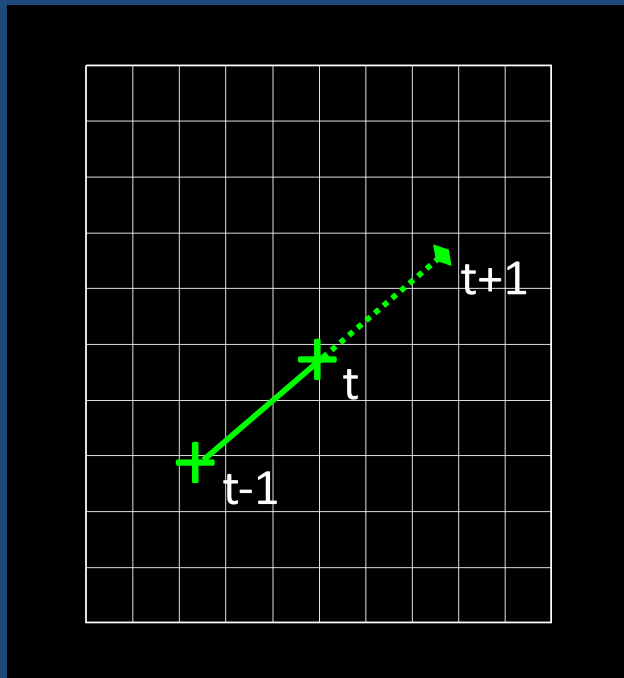
The remaining parameter fixes are averaged to produce the mean position fix for each forecast hour.

- These additional parameters are computed once the center fix is made:
  - Max surface wind
  - $R_{\max}$
  - Minimum MSLP
  - 34-, 50- and 64-kt wind radii



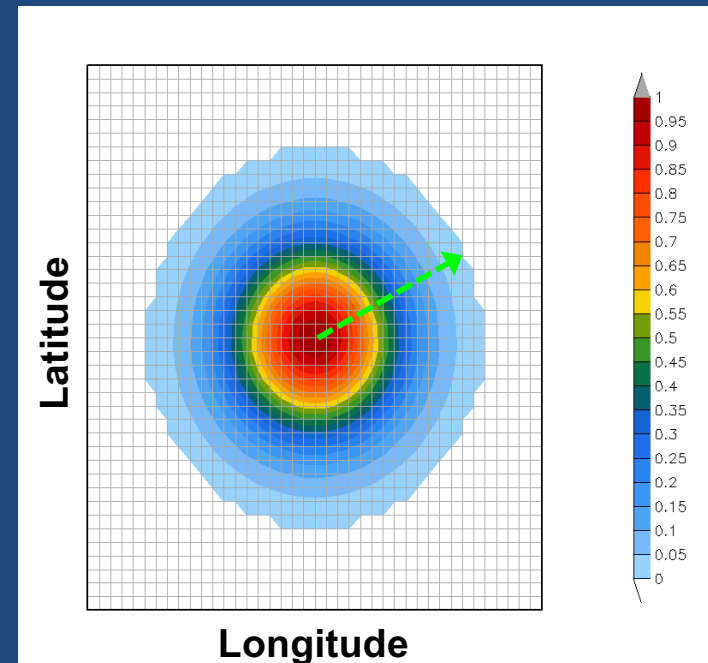
# Tracking from one lead time to the next

## Linear extrapolation



The guess positions from these 2 methods are averaged to compute a final guess position for the search at the next lead time.

## Barnes analysis & advection



A Barnes analysis with a large  $r_e$  at 850, 700 & 500 mb is used to compute mean steering winds. A parcel is advected to a guess position at the next lead time.

# “Quality Control”

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A series of checks is applied to ensure that the tracker is following a storm that is the system of interest

**MSLP Gradient**: Gross check to ensure minimum gradient ( $\sim 0.5$  mb / 300 km) exists within 300 km of center. Set in script: “mslpthresh” variable

**$V_T$  (850 mb)**: Mean  $V_T$  within 225 km must be cyclonic and exceed threshold. Default ( $1.5 \text{ ms}^{-1}$ ) is set in script: “v850thresh” variable

**$DIST_{(MSLP-Zeta850)}$** : This distance between the MSLP and  $Zeta_{850}$  parameter fixes must not exceed a distance defined in source by “max\_mslp\_850” (usually set to 400 km).

**Translational speed**: Speed of storm movement must not exceed threshold, set by “maxspeed\_tc” variable (usually set to 60 knots).

# Outline

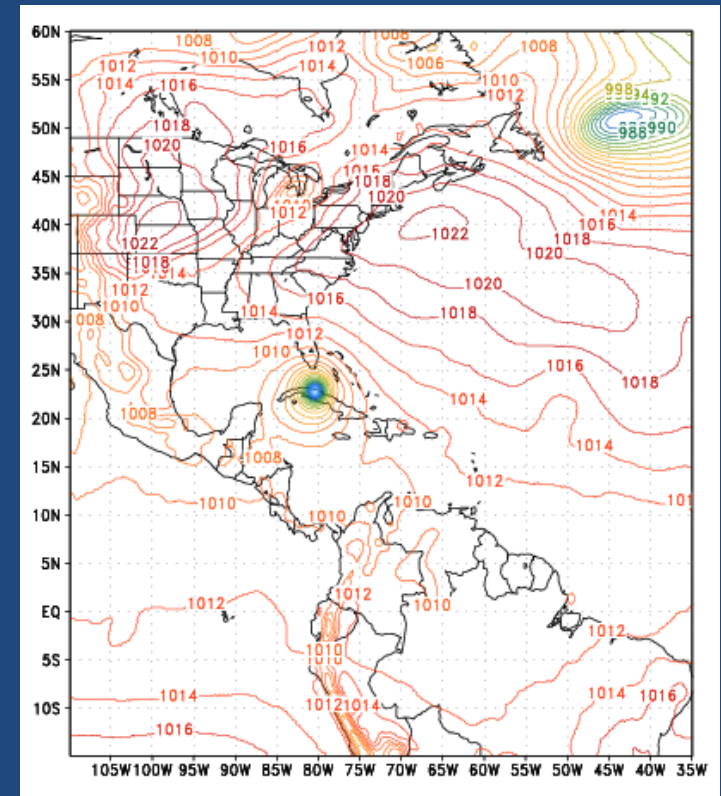
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- History & description of the GFDL vortex tracker
- Inputs & Outputs
- Genesis tracking

# Tracker inputs: Synoptic data

- Data must be in NetCDF or in Gridded Binary (GRIB) format (Both GRIB1 and GRIB2 are okay).
- Data points must increment from northwest (1,1) to southeast (imax, jmax).
- Data must be on a lat/lon grid.
- dx does not need to equal dy, but both must remain uniform over the domain.
- Data lead time intervals do not need to be evenly spaced

(1,1)



(imax,jmax)



# Tracker inputs: GRIB files & names

- GRIB files can either contain individual files for each tau or can contain records for all taus in one big file.
- If using one big file, the file is linked from the script and the file name format is flexible.
- If using separate files for each tau, the files are opened internally, and a specific file name format must be followed. Example:

“gmodname”:  
model name

“atcfdescr” (Optional): Can contain  
ATCF name or other descriptive info

hwrf.10th\_deg.ike09l.2008091012.f03960

“rundescr”:  
run description

Initial YMDH  
of forecast

Lead time in minutes  
(must be 5 digits)

# Tracker inputs: Observed TC data

- Tracker searches for a vortex initially at a location specified by NHC or JTWC on a “TC Vitals record”:

NHC 12L KATRINA 20050829 0000 272N 0891W 335 046 0904 1006 0649 72 037  
0371 0334 0278 0334 D 0204 0185 0139 0185 72 410N 815W 0167 0167 0093

ATCF ID (12L = 12<sup>th</sup> storm in the Atlantic).

E = Eastern Pacific

C = Central Pacific

W = Western Pacific

Report date  
and time

Observed storm  
latitude & longitude

Observed direction of  
storm motion in  
degrees from north  
(335 = ~NNW), and  
storm translation  
speed (046 = 4.6 ms<sup>-1</sup>)

# Tracker inputs: Namelist options

```
&datein inp%bcc=20,inp%byy=17,inp%bmm=10,  
inp%bdd=10,inp%bhh=00,inp%model=41,  
inp%modtyp='global',  
inp%lt_units='hours',  
inp%file_seq='onebig',  
inp%nesttyp='fixed'/  
&atcfinfo atcfnum=15,atcfname='FV3',  
atcfymdh=2017101000,atcffreq=600/  
&trackerinfo trkrinfo%westbd=105.0,  
trkrinfo%eastbd=180.0,  
trkrinfo%northbd=50.0,  
trkrinfo%southbd=1.0,  
trkrinfo%type='tracker',  
trkrinfo%mslpthresh=0.0015,  
trkrinfo%use_backup_mslp_grad_check='y',  
trkrinfo%v850thresh=1.5000,  
trkrinfo%use_backup_850_vt_check='y',  
trkrinfo%gridtype='global',  
trkrinfo%enable_timing=1,  
trkrinfo%contint=1.0,  
trkrinfo%want_oci=.TRUE.,  
trkrinfo%out_vit='n',
```

Starting date & time

Model type: 'global' or 'regional'

Indicator for GRIB data lead time units

"multi" = 1 file for each tau; "onebig" = 1 file for all taus

Grid type: "fixed" or "moveable"

Frequency to write out ATCF data (hours \* 100)

Starting yyymmddhh for output ATCF record

For genesis tracking only, to limit area of search.

'tracker', or genesis options: 'midlat', 'tcgen'.

Thresholds for mslp gradient and  $V_{t_{850}}$  checks

Best to leave these checks as 'y'...

Model grid type: 'regional' or 'global'

Set to 1 to print out timing diagnostics

MSLP contour interval for genesis detection & tracking

Diagnose ROCI and include it in atcfunix output

For genesis runs. Print out "gen\_vitals" for 00h storms.

# Tracker inputs: Namelist options (cont'd)

For genesis runs, checks land-sea mask

Data type: 'grib' or 'netcdf'

For GRIB data, 1 = GRIB1, 2 = GRIB2

For GRIB2 data, 0 = analysis or fcst; 1 = ensemble fcst

GRIB2 MSLP ID: 192 = membrane, 1 = standard

GRIB1 MSLP ID: 130 = membrane, 102 = standard

GRIB1 near-sfc winds: Most models = 105 & 10 combo

Thermal diagnostics. phasescheme = 'vtt', 'cps' or 'both'

Beta feature, not supported. Structure diagnostics.

File name info, if "multi" option chosen for inp%file\_seq

For use by the operational HWRF job

```
trkrinfo%use_land_mask='y',  
trkrinfo%inp_data_type='netcdf',  
trkrinfo%gribver=2,  
trkrinfo%g2_jpdtm=0,  
trkrinfo%g2_mslp_parm_id=192,  
trkrinfo%g1_mslp_parm_id=130,  
trkrinfo%g1_sfcwind_lev_typ=105,  
trkrinfo%g1_sfcwind_lev_val=10/  
&phaseinfo phaseflag='n',  
  phasescheme='vtt',  
  wcore_depth=1.0/  
&structinfo structflag='n',  
  ikeflag='n'/  
&fnameinfo gmodname='fv3',  
  rundescr='xxxx',  
  atcfdescr='xxxx'/  
&waitinfo use_waitfor='n',  
  wait_min_age=10,  
  wait_min_size=100,  
  wait_max_wait=1800,  
  wait_sleeptime=5,  
  per_fcst_command="/
```

# Tracker inputs: Namelist options (cont'd)

```
&netcdflist netcdfinfo%num_netcdf_vars=999,  
  netcdfinfo%netcdf_filename='/work1/fv3/atmos.nc',  
  netcdfinfo%rv850name='X',  
  netcdfinfo%rv700name='X',  
  netcdfinfo%u850name='u850',  
  netcdfinfo%v850name='v850',  
  netcdfinfo%u700name='u700',  
  netcdfinfo%v700name='v700',  
  netcdfinfo%z850name='h850',  
  netcdfinfo%z700name='h700',  
  netcdfinfo%mslpname='slp',  
  netcdfinfo%usfcname='UGRD10m',  
  netcdfinfo%vsfcname='VGRD10m',  
  netcdfinfo%u500name='u500',  
  netcdfinfo%v500name='v500',  
  netcdfinfo%tmean_300_500_name='tm',  
  netcdfinfo%z500name='h500',  
  netcdfinfo%z200name='h200',  
  netcdfinfo%lmaskname='X',  
  netcdfinfo%z900name='X',  
  netcdfinfo%z850name='h850',  
  netcdfinfo%z800name='X',
```

Leave this as 999

Full pathname of the input NetCDF file

Names of the NetCDF variables inside your file. By specifying the name with just 'X', you are letting the program know that this variable does not exist in your file.

# Tracker inputs: Namelist options (cont'd)

```
netcdfinfo%z750name='X',  
netcdfinfo%z700name='h700',  
netcdfinfo%z650name='X',  
netcdfinfo%z600name='X',  
netcdfinfo%z550name='X',  
netcdfinfo%z500name='h500',  
netcdfinfo%z450name='X',  
netcdfinfo%z400name='X',  
netcdfinfo%z350name='X',  
netcdfinfo%z300name='X',  
netcdfinfo%time_name='time',  
netcdfinfo%lon_name='grid_xt',  
netcdfinfo%lat_name='grid_yt',  
netcdfinfo%time_units='hours/'  
&parmpreflist user_wants_to_track_zeta850='y',  
user_wants_to_track_zeta700='y',  
user_wants_to_track_wcirc850='y',  
user_wants_to_track_wcirc700='y',  
user_wants_to_track_gph850='y',  
user_wants_to_track_gph700='y',  
user_wants_to_track_mslp='y',  
user_wants_to_track_wcircsfc='y',  
user_wants_to_track_zetasfc='y',  
user_wants_to_track_thick500850='n',  
user_wants_to_track_thick200500='n',  
user_wants_to_track_thick200850='n'/  
&verbose verb=3,verb_g2=0/
```

...More names of NetCDF variables inside your file. By specifying the name with just 'X', you are letting the program know that this variable does not exist in your file.

Time units used for NetCDF file. Can be either 'hours' or 'days' (which is fractions of days)

Flags that dictate which variables will be used as tracking parameters.

Flags for verbose output. verb=3 prints almost all std out. verb\_g2=0 suppresses GRIB2 I/O messages.



# Tracker inputs: List of forecast hours

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- The tracker can handle lead times that are stored in the GRIB file header either in units of minutes or hours.
- Explicitly detailing the forecast hours allows for irregularly spaced intervals.
- Regardless of whether your GRIB data lead time units are in minutes or hours, you must supply a text file as input that has the lead times listed in minutes (code will convert to hours).

|    |      |
|----|------|
| 1  | 0    |
| 2  | 360  |
| 3  | 720  |
| 4  | 1080 |
| 5  | 1440 |
| 6  | 1800 |
| 7  | 2160 |
| 8  | 2520 |
| 9  | 2880 |
| 10 | 3240 |
| 11 | 3600 |
| 12 | 3960 |
| 13 | 4320 |
| 14 | 4680 |
| 15 | 5040 |
| 16 | 5400 |
| 17 | 5760 |
| 18 | 6120 |
| 19 | 6480 |
| 20 | 6840 |
| 21 | 7200 |
| 22 | 7560 |

# Tracker output: Standard ATCF file

- Text format. Minimum of 1 record per lead time (↓), maximum of 3.
  - 1<sup>st</sup> record contains track & intensity info, plus radii for 34-knot winds
  - 2<sup>nd</sup> record: Same track & intensity info, plus radii for 50-knot winds, if present.
  - 3<sup>rd</sup> record: Same track & intensity info, plus radii for 64-knot winds, if present.

|    |    |            |    |     |     |      |      |    |     |    |    |     |      |      |      |      |   |   |     |
|----|----|------------|----|-----|-----|------|------|----|-----|----|----|-----|------|------|------|------|---|---|-----|
| AL | 09 | 2008091012 | 03 | HWR | 000 | 239N | 855W | 68 | 969 | XX | 34 | NEQ | 0163 | 0146 | 0086 | 0124 | 0 | 0 | 064 |
| AL | 09 | 2008091012 | 03 | HWR | 000 | 239N | 855W | 68 | 969 | XX | 50 | NEQ | 0090 | 0088 | 0063 | 0070 | 0 | 0 | 064 |
| AL | 09 | 2008091012 | 03 | HWR | 000 | 239N | 855W | 68 | 969 | XX | 64 | NEQ | 0067 | 0000 | 0000 | 0048 | 0 | 0 | 064 |
| AL | 09 | 2008091012 | 03 | HWR | 006 | 240N | 861W | 95 | 960 | XX | 34 | NEQ | 0262 | 0285 | 0168 | 0214 | 0 | 0 | 052 |
| AL | 09 | 2008091012 | 03 | HWR | 006 | 240N | 861W | 95 | 960 | XX | 50 | NEQ | 0114 | 0122 | 0092 | 0095 | 0 | 0 | 052 |
| AL | 09 | 2008091012 | 03 | HWR | 006 | 240N | 861W | 95 | 960 | XX | 64 | NEQ | 0084 | 0087 | 0049 | 0073 | 0 | 0 | 052 |
| AL | 09 | 2008091012 | 03 | HWR | 012 | 244N | 866W | 97 | 958 | XX | 34 | NEQ | 0255 | 0239 | 0136 | 0159 | 0 | 0 | 046 |
| AL | 09 | 2008091012 | 03 | HWR | 012 | 244N | 866W | 97 | 958 | XX | 50 | NEQ | 0160 | 0122 | 0090 | 0091 | 0 | 0 | 046 |
| AL | 09 | 2008091012 | 03 | HWR | 012 | 244N | 866W | 97 | 958 | XX | 64 | NEQ | 0072 | 0098 | 0055 | 0071 | 0 | 0 | 046 |
| AL | 09 | 2008091012 | 03 | HWR | 018 | 249N | 872W | 99 | 954 | XX | 34 | NEQ | 0263 | 0245 | 0182 | 0241 | 0 | 0 | 035 |
| AL | 09 | 2008091012 | 03 | HWR | 018 | 249N | 872W | 99 | 954 | XX | 50 | NEQ | 0142 | 0158 | 0103 | 0098 | 0 | 0 | 035 |
| AL | 09 | 2008091012 | 03 | HWR | 018 | 249N | 872W | 99 | 954 | XX | 64 | NEQ | 0094 | 0095 | 0049 | 0078 | 0 | 0 | 035 |

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# Tracker output: Standard ATCF file

|    |    |            |    |      |     |      |      |    |     |    |    |     |      |      |      |      |   |   |     |
|----|----|------------|----|------|-----|------|------|----|-----|----|----|-----|------|------|------|------|---|---|-----|
| AL | 09 | 2008091012 | 03 | HWRF | 000 | 239N | 855W | 68 | 969 | XX | 34 | NEQ | 0163 | 0146 | 0086 | 0124 | 0 | 0 | 064 |
| AL | 09 | 2008091012 | 03 | HWRF | 000 | 239N | 855W | 68 | 969 | XX | 50 | NEQ | 0090 | 0088 | 0063 | 0070 | 0 | 0 | 064 |
| AL | 09 | 2008091012 | 03 | HWRF | 000 | 239N | 855W | 68 | 969 | XX | 64 | NEQ | 0067 | 0000 | 0000 | 0048 | 0 | 0 | 064 |
| AL | 09 | 2008091012 | 03 | HWRF | 006 | 240N | 861W | 95 | 960 | XX | 34 | NEQ | 0262 | 0285 | 0168 | 0214 | 0 | 0 | 052 |
| AL | 09 | 2008091012 | 03 | HWRF | 006 | 240N | 861W | 95 | 960 | XX | 50 | NEQ | 0114 | 0122 | 0092 | 0095 | 0 | 0 | 052 |
| AL | 09 | 2008091012 | 03 | HWRF | 006 | 240N | 861W | 95 | 960 | XX | 64 | NEQ | 0084 | 0087 | 0049 | 0073 | 0 | 0 | 052 |
| AL | 09 | 2008091012 | 03 | HWRF | 012 | 244N | 866W | 97 | 958 | XX | 34 | NEQ | 0255 | 0239 | 0136 | 0159 | 0 | 0 | 046 |
| AL | 09 | 2008091012 | 03 | HWRF | 012 | 244N | 866W | 97 | 958 | XX | 50 | NEQ | 0160 | 0122 | 0090 | 0091 | 0 | 0 | 046 |
| AL | 09 | 2008091012 | 03 | HWRF | 012 | 244N | 866W | 97 | 958 | XX | 64 | NEQ | 0072 | 0098 | 0055 | 0071 | 0 | 0 | 046 |
| AL | 09 | 2008091012 | 03 | HWRF | 018 | 249N | 872W | 99 | 954 | XX | 34 | NEQ | 0263 | 0245 | 0182 | 0241 | 0 | 0 | 035 |
| AL | 09 | 2008091012 | 03 | HWRF | 018 | 249N | 872W | 99 | 954 | XX | 50 | NEQ | 0142 | 0158 | 0103 | 0098 | 0 | 0 | 035 |
| AL | 09 | 2008091012 | 03 | HWRF | 018 | 249N | 872W | 99 | 954 | XX | 64 | NEQ | 0094 | 0095 | 0049 | 0078 | 0 | 0 | 035 |

Basin (AL, EP, WP, etc)

Storm number in basin

Forecast initial DTG

Max sfc wind (knots)

Minimum MSLP (mb)

2-char storm class

NE Quad radii (n mi)

SE Quad radii (n mi)

SW Quad radii (n mi)

NW Quad radii (n mi)

Model ID (3 or 4 char)

Lead time

Forecast latitude \* 10

Forecast longitude \* 10

Wind radii threshold (kts)

Begin radii in NE Quad

$R_{max}$  (n mi)

# Tracker output: Modified ATCF file

- Nearly same format as standard ATCF file, except the lead time (↓) has 2 extra places for fraction of an hour, allowing for ATCF-style output at non-hourly times.
  - Example: “04825” would be 48.25 hours, or 48 hours, 15 minutes.



```
AL, 09, 2008091012, 03, HWRF, 00000, 239N, 855W, 68, 969, XX, 34, NEQ, 0163, 0146, 0086, 0124, 0, 0, 64
AL, 09, 2008091012, 03, HWRF, 00000, 239N, 855W, 68, 969, XX, 50, NEQ, 0090, 0088, 0063, 0070, 0, 0, 64
AL, 09, 2008091012, 03, HWRF, 00000, 239N, 855W, 68, 969, XX, 64, NEQ, 0067, 0000, 0000, 0048, 0, 0, 64
AL, 09, 2008091012, 03, HWRF, 00600, 240N, 861W, 95, 960, XX, 34, NEQ, 0262, 0285, 0168, 0214, 0, 0, 52
AL, 09, 2008091012, 03, HWRF, 00600, 240N, 861W, 95, 960, XX, 50, NEQ, 0114, 0122, 0092, 0095, 0, 0, 52
AL, 09, 2008091012, 03, HWRF, 00600, 240N, 861W, 95, 960, XX, 64, NEQ, 0084, 0087, 0049, 0073, 0, 0, 52
AL, 09, 2008091012, 03, HWRF, 01200, 244N, 866W, 97, 958, XX, 34, NEQ, 0255, 0239, 0136, 0159, 0, 0, 46
AL, 09, 2008091012, 03, HWRF, 01200, 244N, 866W, 97, 958, XX, 50, NEQ, 0160, 0122, 0090, 0091, 0, 0, 46
AL, 09, 2008091012, 03, HWRF, 01200, 244N, 866W, 97, 958, XX, 64, NEQ, 0072, 0098, 0055, 0071, 0, 0, 46
AL, 09, 2008091012, 03, HWRF, 01800, 249N, 872W, 99, 954, XX, 34, NEQ, 0263, 0245, 0182, 0241, 0, 0, 35
AL, 09, 2008091012, 03, HWRF, 01800, 249N, 872W, 99, 954, XX, 50, NEQ, 0142, 0158, 0103, 0098, 0, 0, 35
AL, 09, 2008091012, 03, HWRF, 01800, 249N, 872W, 99, 954, XX, 64, NEQ, 0094, 0095, 0049, 0078, 0, 0, 35
.
```

# Tracker output: Standard out

- A table is printed out that lists the tracker-derived fixes for each parameter and distance from the guess.

Maximum allowable distance that a parameter fix can be from the guess location in order to be included

```
At beg of fixcenter, stderr(ist,ifh-1) = 16.64 xavg_stderr= 11.70
At beg of fixcenter, errpgro = 1.2500000000000000
At beg of fixcenter, errinit = 275.0000000000000000
At beg of fixcenter, errpmax = 485.0000000000000000
At beg of fixcenter, ifh= 17 errmax= 275.0000000000000000
```

Storm & lead time info

Guess location for this lead time

```
-----
Individual fixes follow..., fhr= 96:00 09L IKE
Gen ID (if available): 2008091012_F000_238N_0853W_09L
Model name = GFDT
Values of -99.99 indicate that a fix was unable to be
made for that parameter. Parameters 4 & 6 are not used.
Vorticity data values are scaled by 1e5. errdist is the
distance that the position estimate is from the guess
position for this time. MSLP value here may differ from
that in the atcfunix file since the one here is that
derived from the area-averaged barnes analysis, while
that in the atcfunix file is from a specific gridpoint.
Guess location for this time: 266.46E ( 93.54W) 37.48
```

Max or min barnes-averaged value found by tracker

Distance of parameter fix from guess location

| parm# | parm     | Max/Min  | Lon_fix(E) | Lon_fix(W) | Lat_fix | Max/Min_value | calcparm | errdist(km) |
|-------|----------|----------|------------|------------|---------|---------------|----------|-------------|
| 1     | zeta 850 | Max      | 267.73     | 92.27      | 37.94   | 59.92         | T        | 122.74      |
| 2     | zeta 700 | Max      | 267.99     | 92.01      | 38.05   | 43.82         | T        | 148.76      |
| 3     | vmag 850 | Min      | 267.40     | 92.60      | 38.15   | 12.30         | T        | 110.81      |
| 4     | NOT USED | NOT USED | .00        | .00        | .00     | .00           | F        | .00         |
| 5     | vmag 700 | Min      | 267.40     | 92.60      | 38.65   | 8.79          | T        | 153.44      |
| 6     | NOT USED | NOT USED | .00        | .00        | .00     | .00           | F        | .00         |
| 7     | gph 850  | Min      | 267.75     | 92.25      | 37.60   | 1253.22       | T        | 114.48      |
| 8     | gph 700  | Min      | 267.78     | 92.22      | 37.67   | 2917.31       | T        | 118.31      |
| 9     | MSLP     | Min      | 267.72     | 92.28      | 37.53   | 98165.14      | T        | 111.22      |
| 10    | vmag sfc | Min      | 267.40     | 92.60      | 37.65   | 6.58          | T        | 84.76       |
| 11    | zeta sfc | Max      | 267.34     | 92.66      | 37.65   | 19.72         | T        | 80.13       |

Flag to indicate if parameter fix is within errmax distance and will be included in fix average for this lead time

# Outline

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- History & description of the GFDL vortex tracker
- Inputs & Outputs
- Genesis tracking

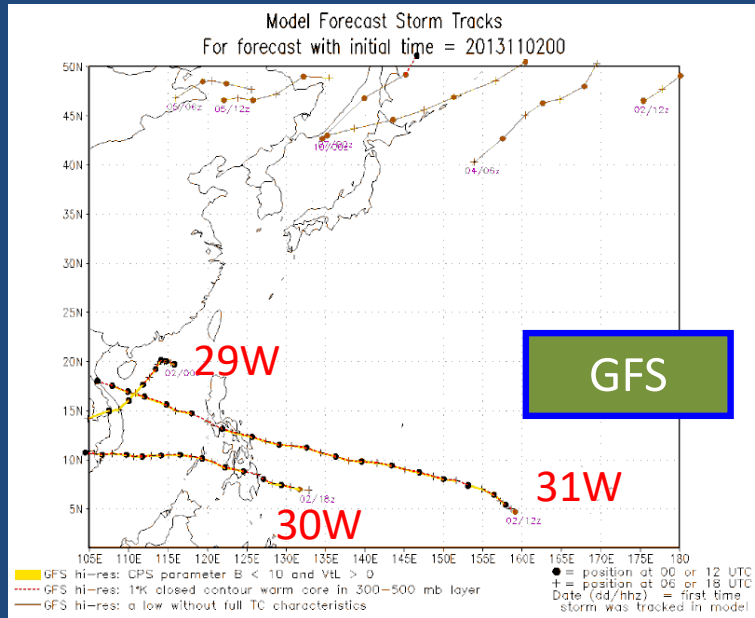
# Genesis Tracking

---

- When run in genesis mode (trkrinfo%type set to either 'tcgen' or 'midlat' in input namelist), the tracker detects new storms that the model develops during a forecast and tracks them.
- Candidate lows are identified by a simple grid point analysis of lowest MSLP, and then the Barnes tracking scheme is applied to all candidate lows to more accurately fix the center.
- "tcgen" mode: All parameters used for regular TC tracking are used here.
- "midlat" mode: Only MSLP is used to track storms.

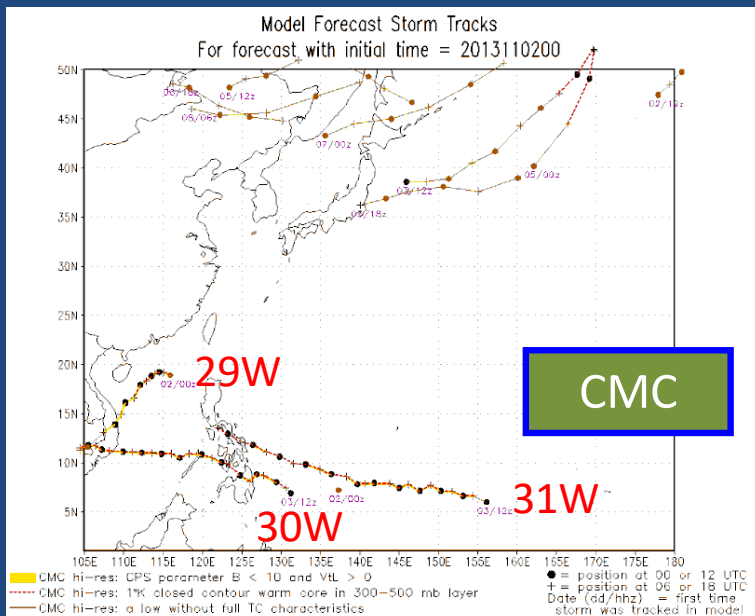


# Genesis Tracking Example: 2013110200



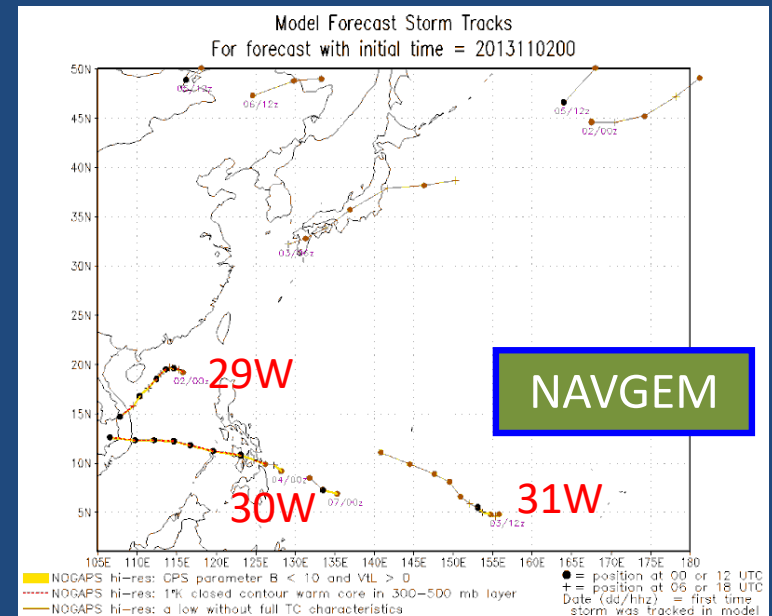
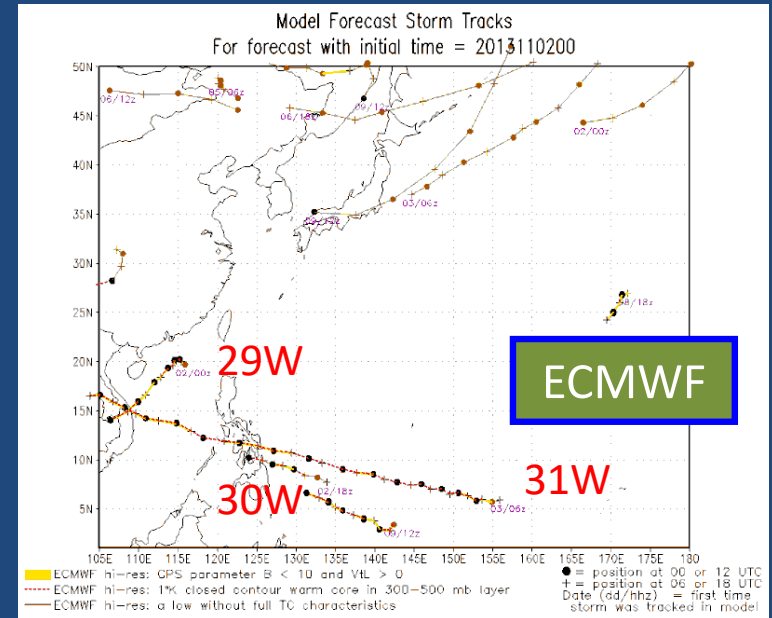
- Haiyan (31W) genesis and track well forecast by GFS, ECMWF & CMC. NAVGEM struggled to develop Haiyan.

- TD 30 (30W) genesis well forecast by all 4 models.



- Genesis runs also track existing cyclones -- TY Krosa (29W)

- Numerous mid-latitude cyclones also detected.



# Genesis Tracking: New & Modified Criteria

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- Criteria for detection and continuity of tracking are based on cyclone structure in general, not necessarily tropical cyclone structure.
- Closed contour in the MSLP field – Must be met in at least 50% of lead times in a 24-h period.
- 850 mb mean wind circulation – Must meet threshold in at least 75% of lead times in a 24-h period.
- Thermal structure diagnostics are computed and provided as extra data, but do not feed back into the tracking algorithm and will not cut off tracking.

# Genesis Tracking: Thermal Structure Diagnostics

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- Simple 300-500 mb warm core check, based on Vitart(1997): Warm anomaly must have closed contour (value of contour defined in namelist).
- Cyclone Phase Space (Hart, 2003):
  - “Parameter B”: Storm-motion-relative 900-600 mb thickness asymmetry.
  - $V_T^L$  : Lower-tropospheric (900-600 mb) thermal wind
  - $V_T^U$  : Upper-tropospheric (900-600 mb) thermal wind
  - $V_T^L$  and  $V_T^U$  are both evaluated via hypsometric relationship using GP Height fields.



# Genesis Tracking: Modified ATCF file

A critical element is the naming of new model storms with a unique ID composed of strings with the date, lead time, and lat & lon where the storm was first identified.

TG, 0005, 2013110200\_F012\_047N\_1591E\_FOF, 2013110200, 03, GFS0, 012, 47N, 1591E, 15, 1008, XX,  
 TG, 0005, 2013110200\_F012\_047N\_1591E\_FOF, 2013110200, 03, GFS0, 018, 50N, 1586E, 20, 1006, XX,  
 TG, 0005, 2013110200\_F012\_047N\_1591E\_FOF, 2013110200, 03, GFS0, 024, 54N, 1579E, 23, 1007, XX,  
 TG, 0005, 2013110200\_F012\_047N\_1591E\_FOF, 2013110200, 03, GFS0, 030, 58N, 1572E, 23, 1005, XX,

- cont'd -

34, NEQ, 0000, 0000, 0000, 0000, 1009, 188, 139, -999, -9999, -9999, N, 272, 35, 92, 101, 149, 210  
 34, NEQ, 0000, 0000, 0000, 0000, 1007, 182, 155, 6, -202, 140, Y, 288, 31, 93, 110, 146, 207  
 34, NEQ, 0000, 0000, 0000, 0000, 1008, 114, 159, 12, -134, 137, Y, 294, 44, 109, 124, 153, 201  
 34, NEQ, 0000, 0000, 0000, 0000, 1006, 113, 160, -12, 75, 132, Y, 297, 39, 117, 133, 135, 175

Parameter B (x10)

$V_T^L$  (x10)

$V_T^U$  (x10)

Warm core (Vitart) flag

Storm motion direction

Storm speed (m/s \* 10)

Mean and grid point values of 850 and 700 mb Zeta

# Questions?



Delaware River flooding River Road in Washington Crossing, Pennsylvania, after Hurricane Ivan. September, 2004.