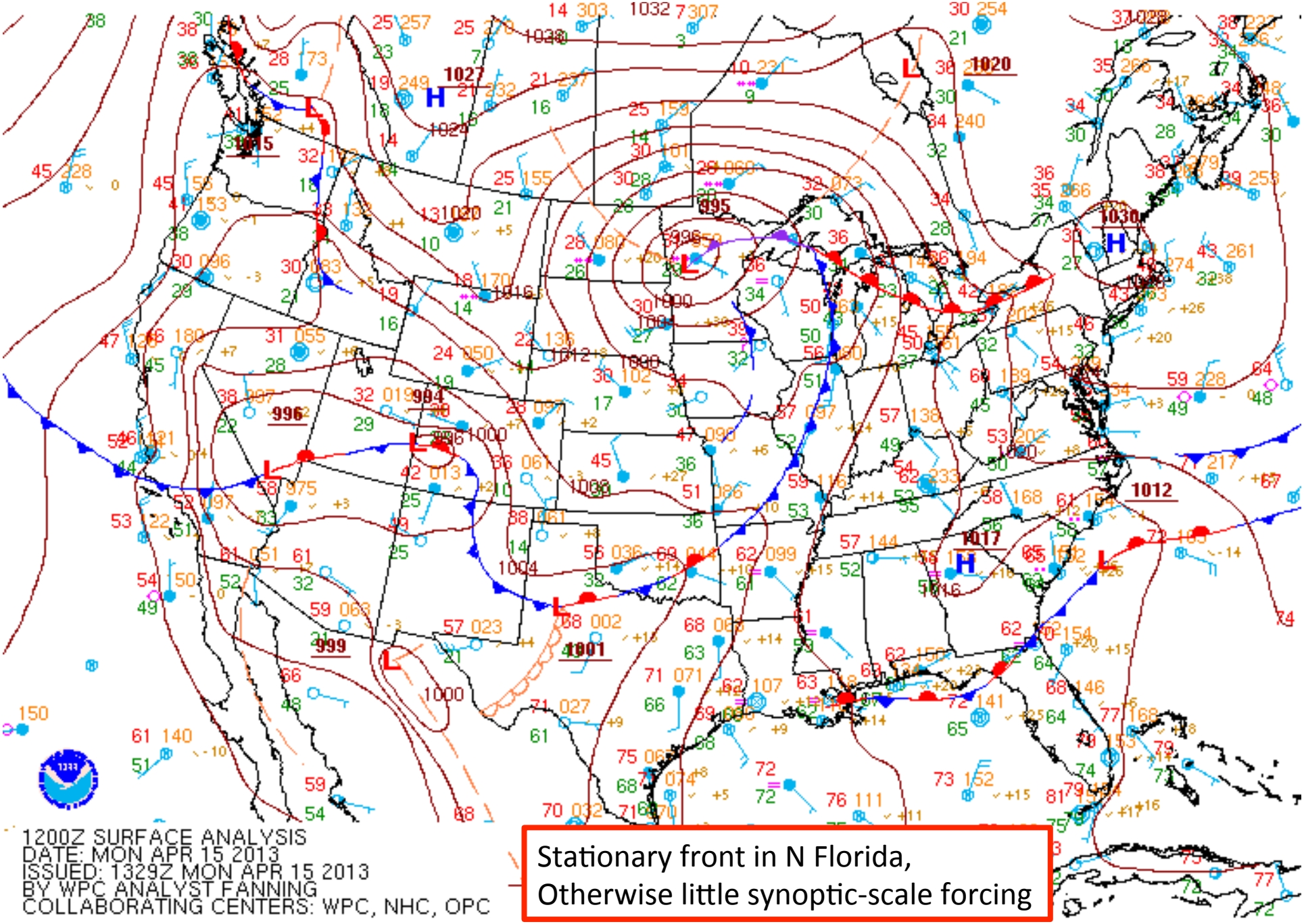
# Introduction to WRF and a sea-breeze case

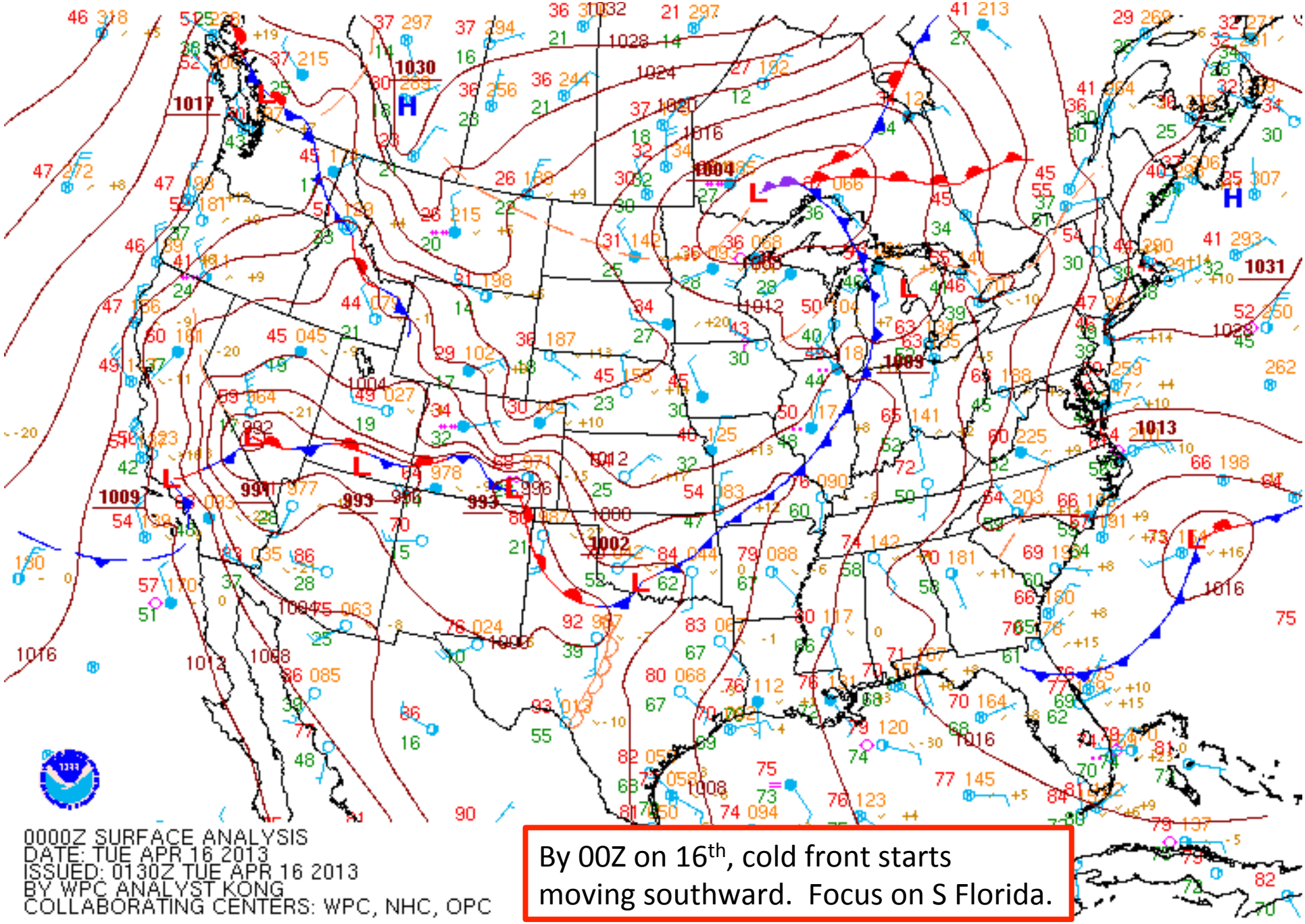
Part 1

# Copy some GrADS files and scripts

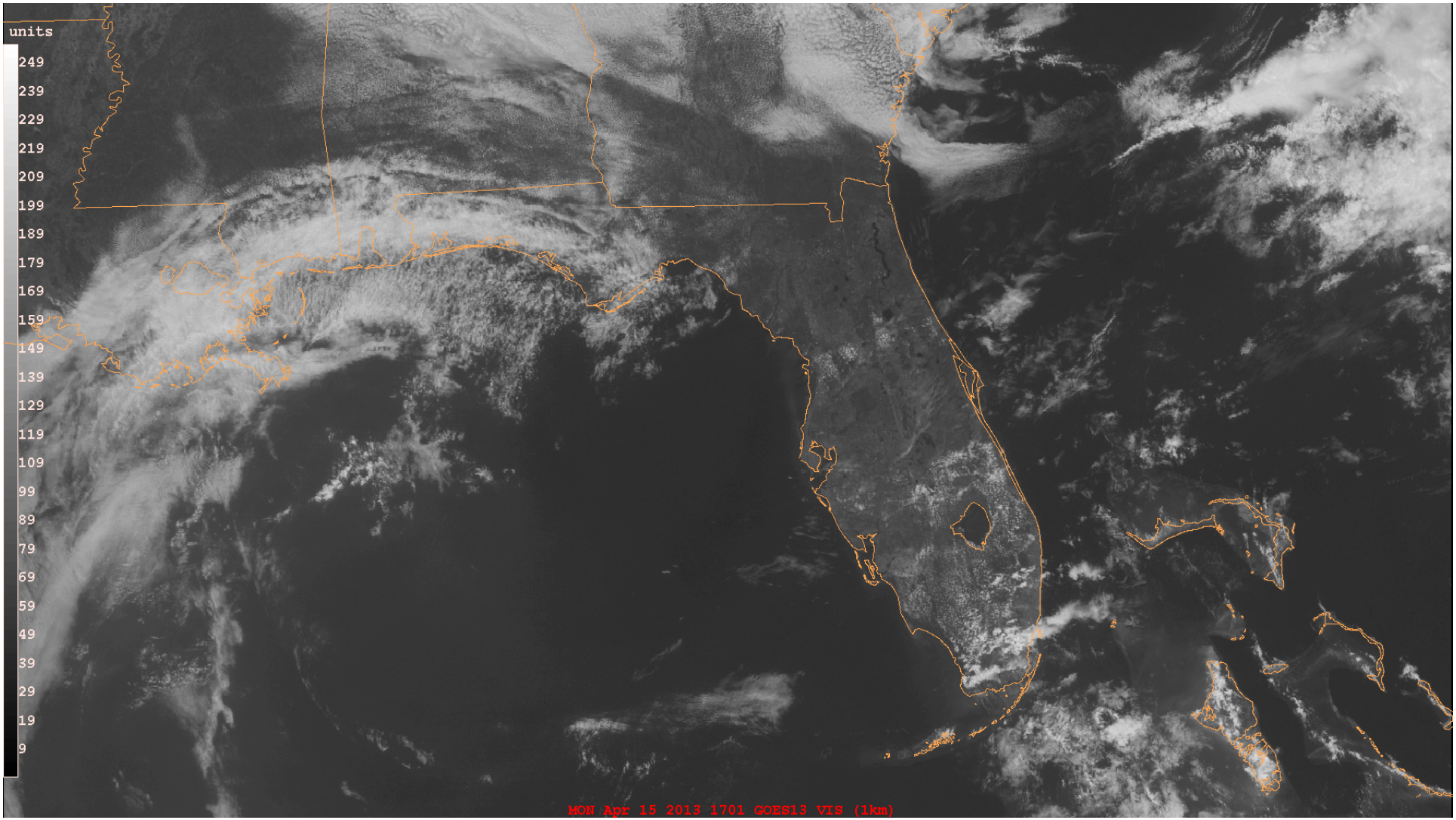
```
mkdir SEABREEZE
cd SEABREEZE
cp /home/c115-test/C115/SBexp* .
cp /home/c115-test/C115/*.gs .
```

# 15-16 April 2013 Florida sea-breeze

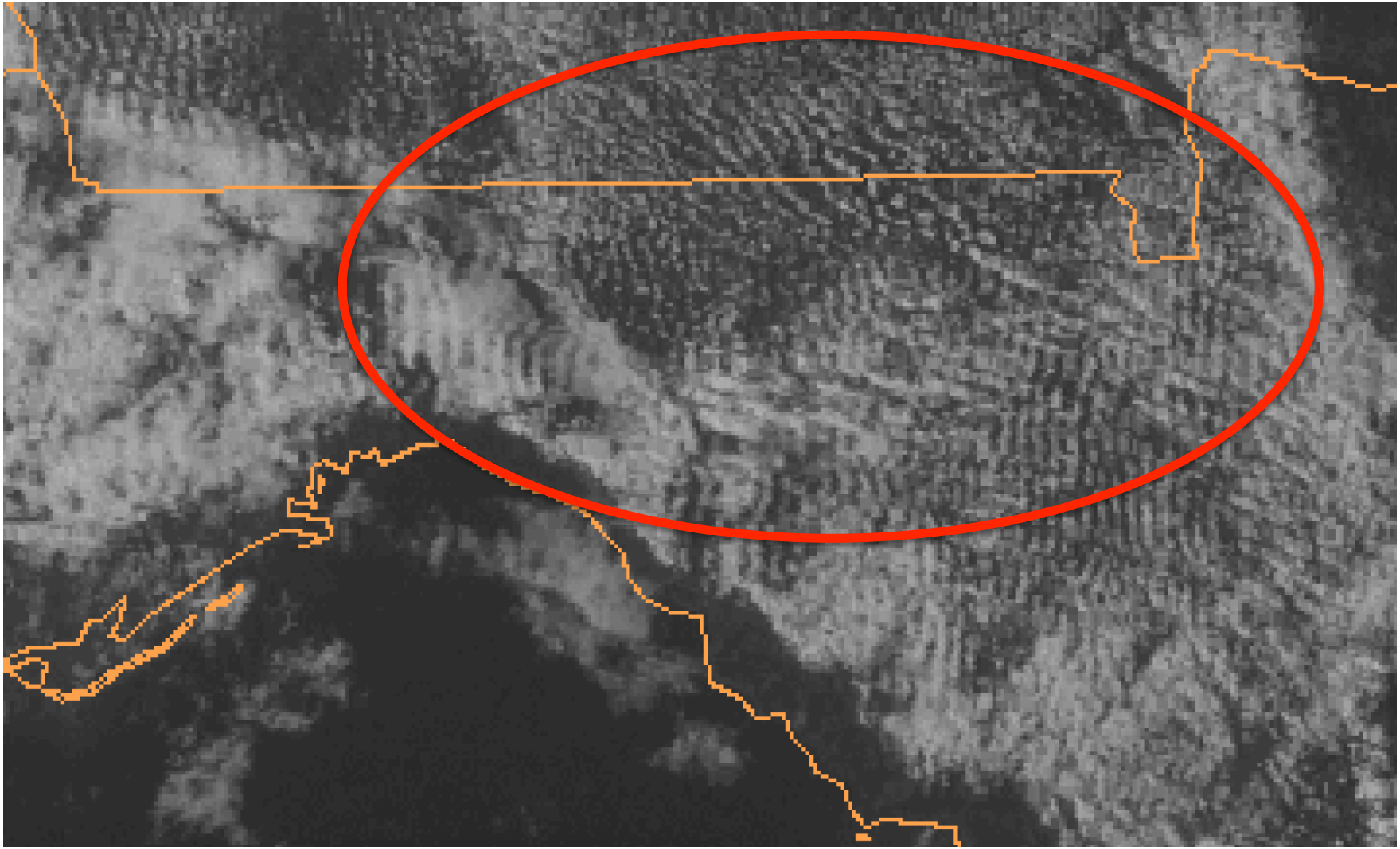

1200Z SURFACE ANALYSIS
DATE: MON APR 15 2013
ISSUED: 1329Z MON APR 15 2013
BY WPC ANALYST FANNING
COLLABORATING CENTERS: WPC, NHC, OPC
Stationary front in N Florida,
Otherwise little synoptic-scale forcing


0000Z SURFACE ANALYSIS
DATE: TUE APR 16 2013
ISSUED: 0130Z TUE APR 16 2013
BY WPC ANALYST KONG
COLLABORATING CENTERS: WPC, NHC, OPC
By 00Z on 16th, cold front starts moving southward. Focus on S Florida.

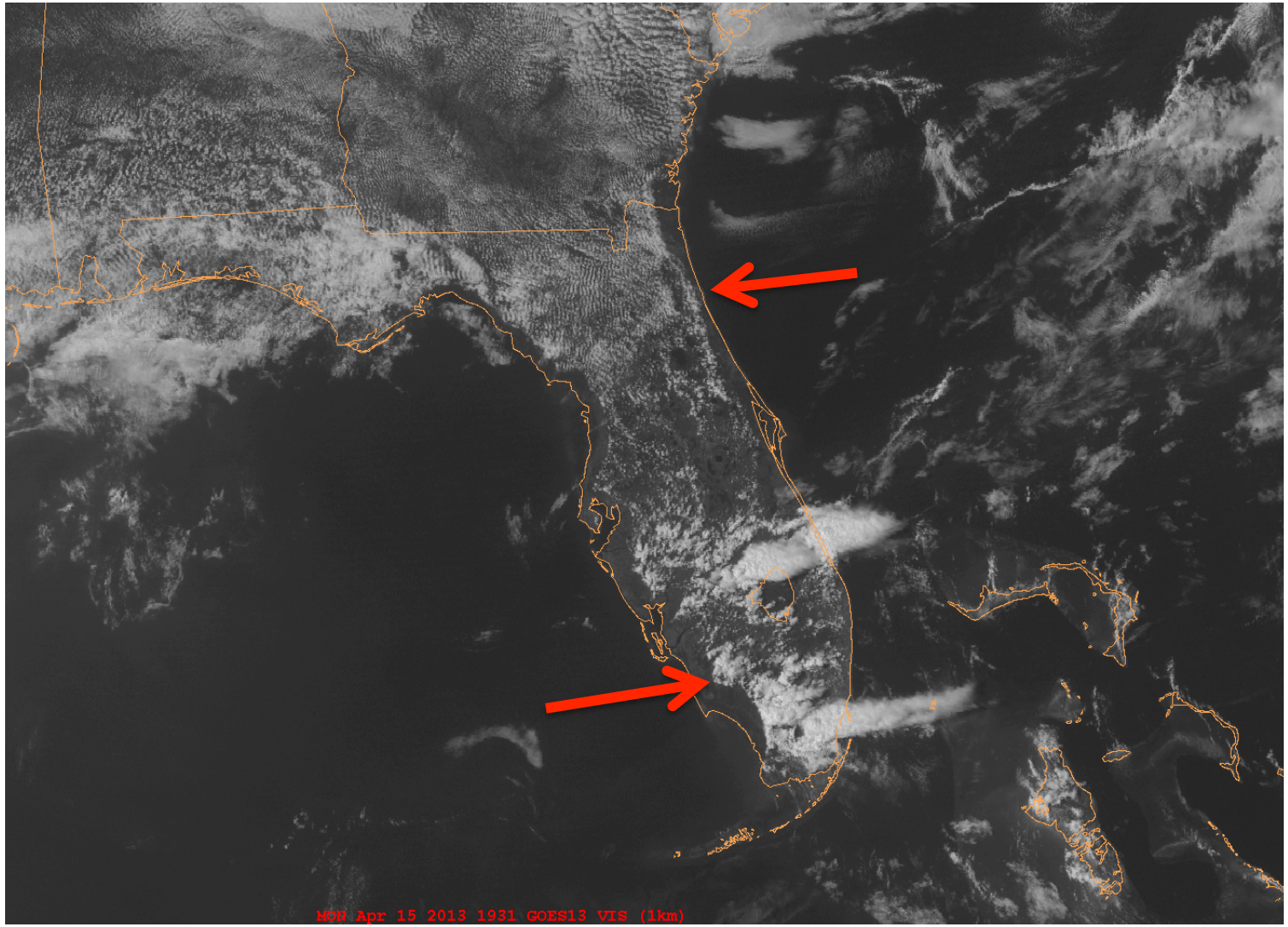
# Animation for 15 April 2013 case



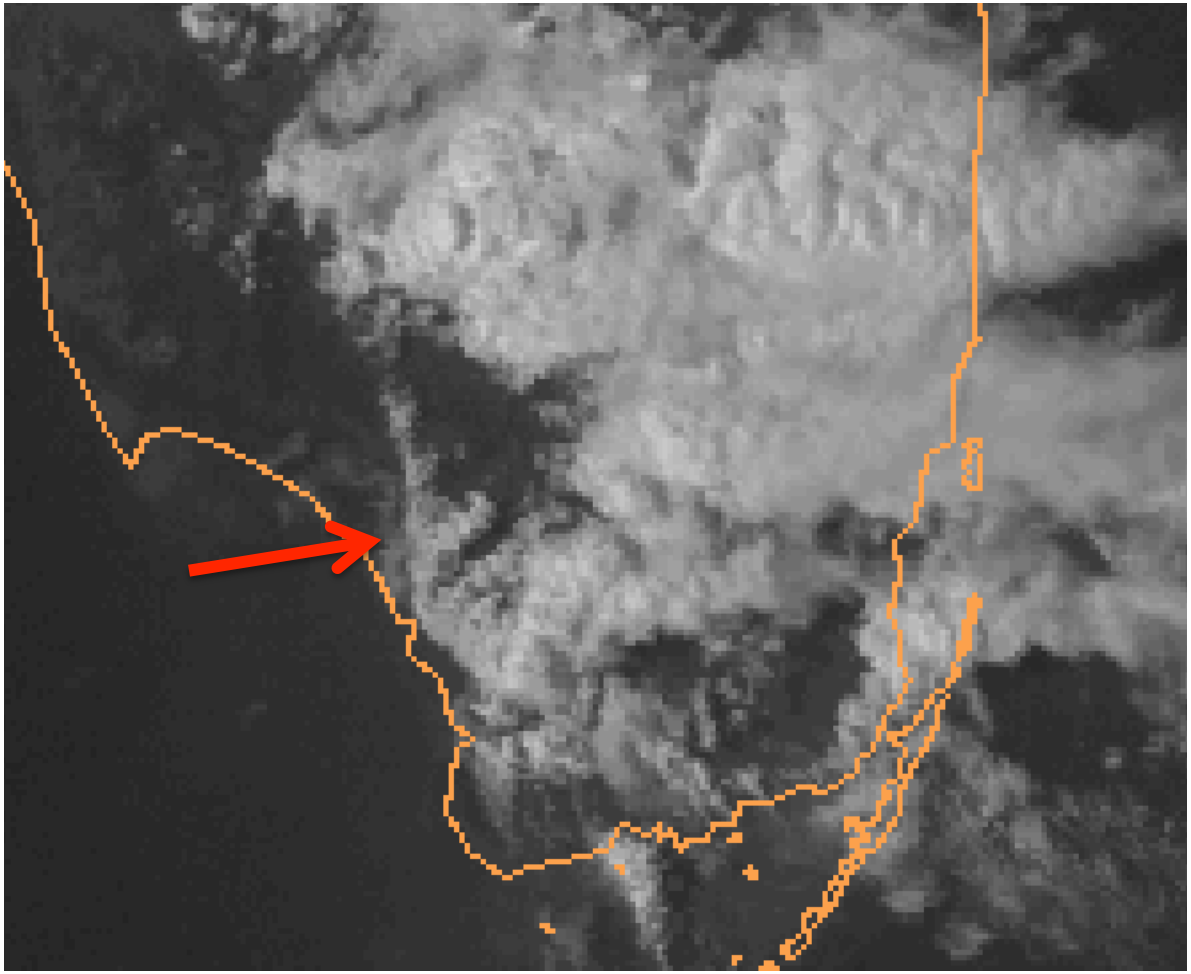
Horizontal convective rolls over land (fine-scale cloud bands)
Note their diurnal cycle… These will be **unresolvable** except for very high-resolution models.
Note change in orientation on either side of the front in N Florida.



Sea-breezes push inland on both coasts
Thunderstorms erupt in south Florida



Thunderstorm
outflow boundary



# Simulations using WRF

Weather Research and Forecasting model's Advanced Research WRF core (WRF-ARW)

# Simulation SBexp01 design

- 2 telescoping domains, 54 and 18 km horizontal resolution
- Initialized with NAM 40-km grids at 12Z on 15 April 2013, run 24 hours
- Model physics include WSM3 microphysics, RRTMG radiation, Noah land surface model, YSU planetary boundary layer scheme
- **No cumulus scheme used, and diabatic heating due to microphysics is neglected**
  - Water changes phase *without* releasing or absorbing heat
- GrADS files for inner domain are `SBexp01_D2.ctl` and `SBexp01_D2.dat`

# Important GrADS commands

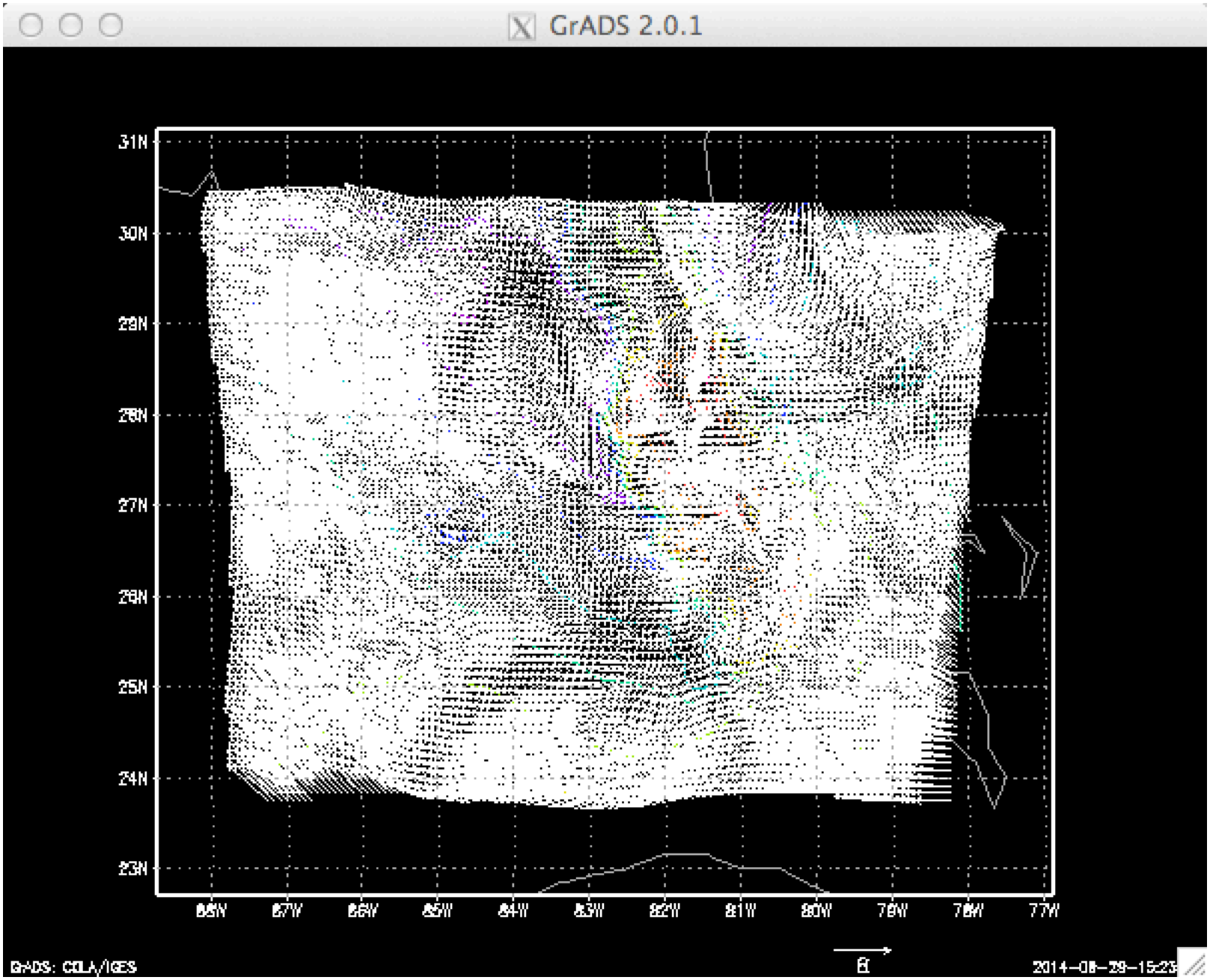
| | |
|---|---|
| `open [file]` | `open SBexp01_D2` |
| `q or query` | `q file, q dims` |
| `d or display` | `d theta, d qvapor` |
| `c or clear` | `c` |
| `set gxout` | `contour, shaded, print, scatter` |
| `d u;v` | `[plots vectors` |
| `set t 13` | `[sets to 13th time` |
| `set cint 1.5` | `[contour interval` |
| `set ccolor 4` | `[contour color blue` |
| `printim out.gif gif` | `[makes a GIF plot` |
| `set display color white` | `[makes white background**` |
| `quit` | `[quits GrADS` |

***GrADS 2.1 and later ignores "color", so 'set display white' suffices*

# Starting a GrADS session

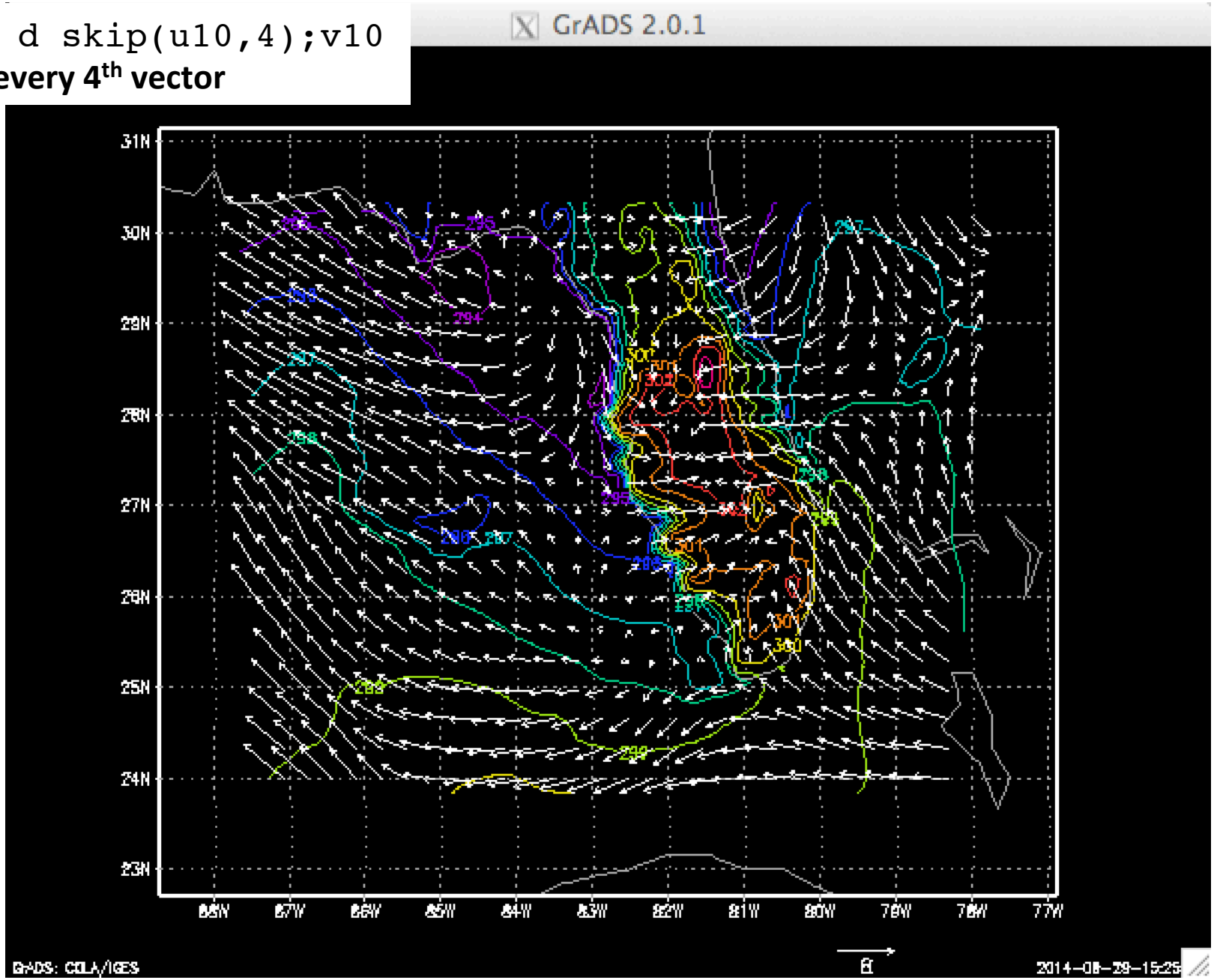
- Launching GrADS with `grads –l` puts you in the GrADS command line interface "`ga->`"

```
ga-> open SBexp01_D2
ga-> q file
ga-> set t 13
ga-> d t2
ga-> d u10;v10
```


GrADS 2.0.1
31N
30N
29N
28N
27N
26N
25N
24N
23N
88W
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
77W
GrADS: COLA/IGES
2014-08-29-15:23

```
ga-> d skip(u10,4);v10
```

**Plots every 4th vector**



# q file

```
ga-> q file
File 1 :
  Descriptor: SBexp01_D2.ctl
  Binary: SBexp01_D2.dat
  Type = Gridded
  Xsize = 147  Ysize = 105  Zsize = 90 Tsize =
25  Esize = 1
  Number of Variables = 33
     u  90  0  U Component of wind
     v  90  0  V Component of wind
     w  90  0  W Component of wind
     theta  90  0  Theta
[etc.]
```

**Some different variable names than DTDM**

# q dims

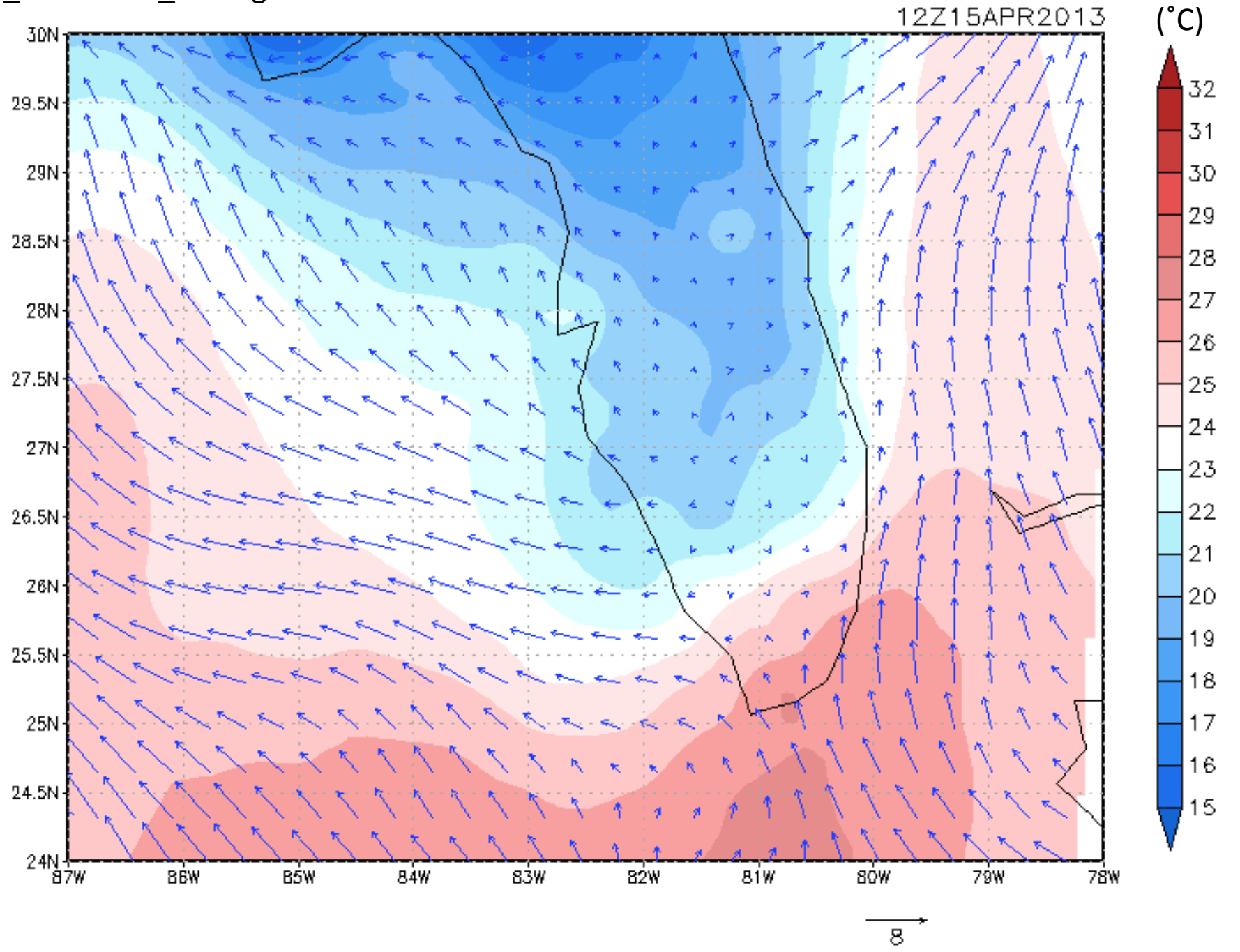
```
ga-> q dims
Default file number is: 1
X is varying   Lon = -88.7 to -76.8622  X = 1 to 147
Y is varying   Lat = 22.7 to 31.1324   Y = 1 to 105
Z is fixed     Lev = 0  Z = 1
T is fixed     Time = 00Z16APR2013  T = 13
E is fixed     Ens = 1  E = 1
```

**Longitudes and latitudes are “real”**

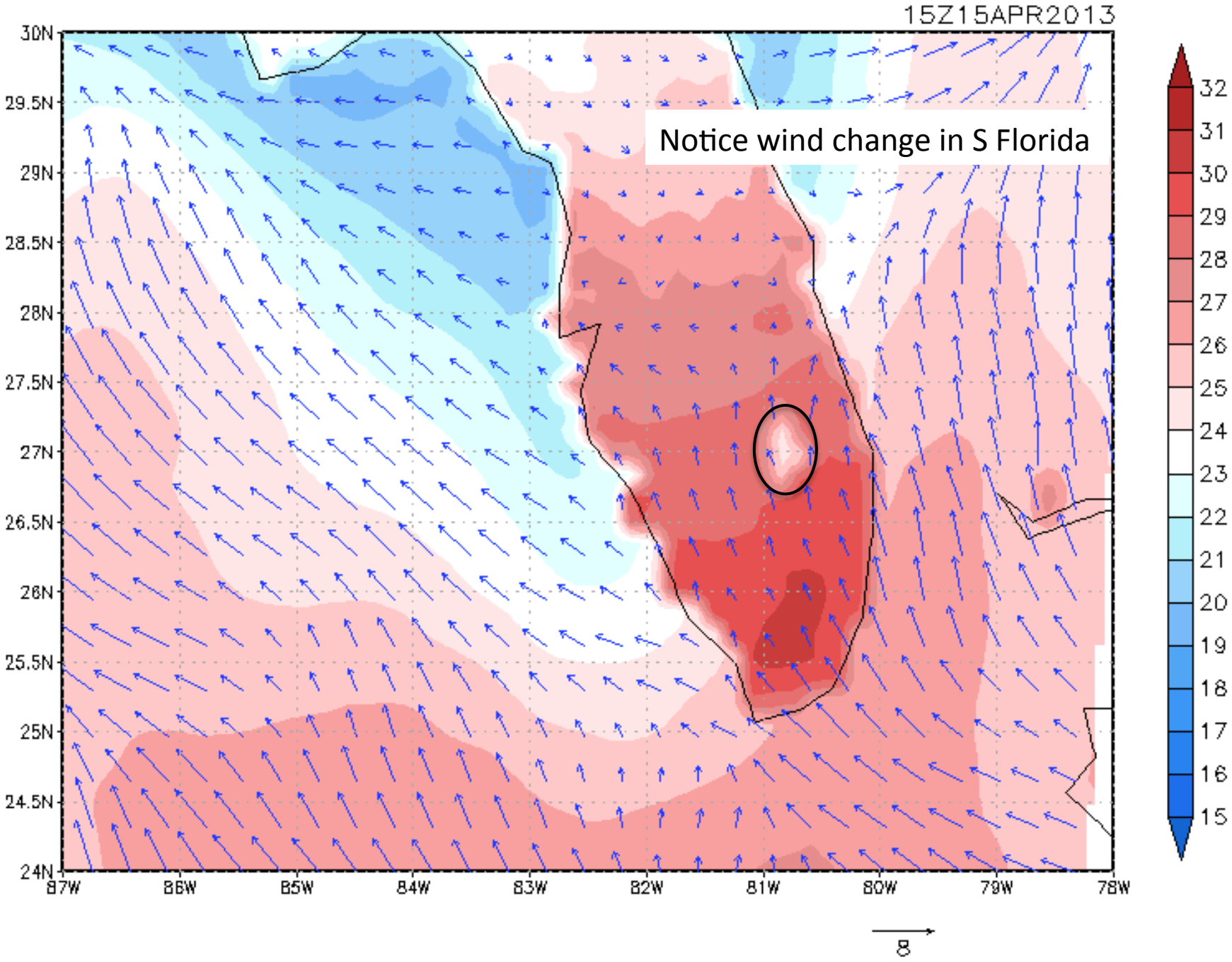
# GrADS scripts

- plot_seabreeze_horiz.gs
  - Plots 2-m temperature (colored) and 10-m wind vectors in Domain 2
  - Vectors scaled to 8 m/s length, only every 4$^{th}$ arrow plotted
- plot_seabreeze_vert.gs
  - Plots zonal (west-east) velocity (colored) and vertical velocity (contoured) below 5 km altitude at latitude 26.5˚N between 84˚ and 78˚W

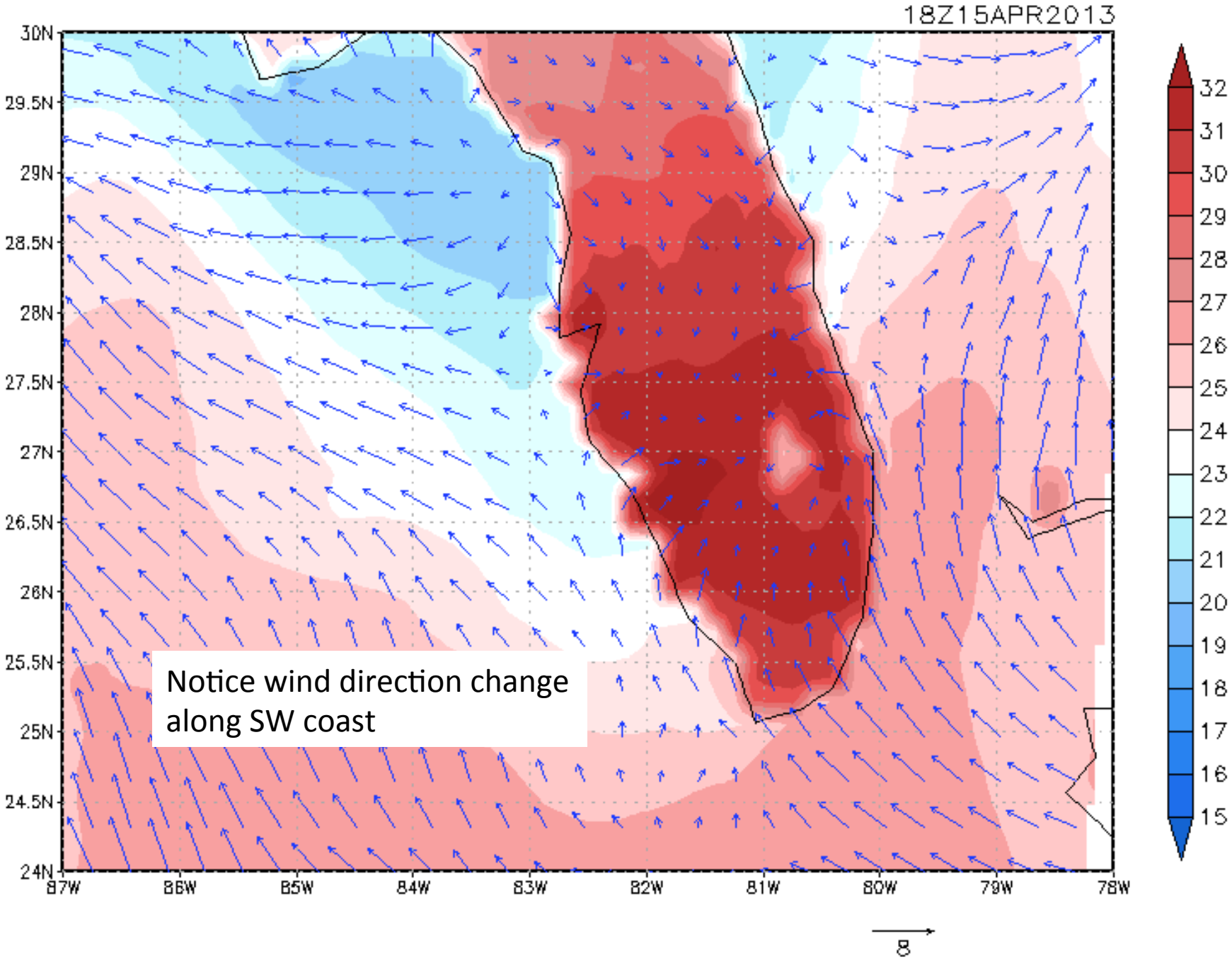
plot_seabreeze_horiz.gs **set t 1**

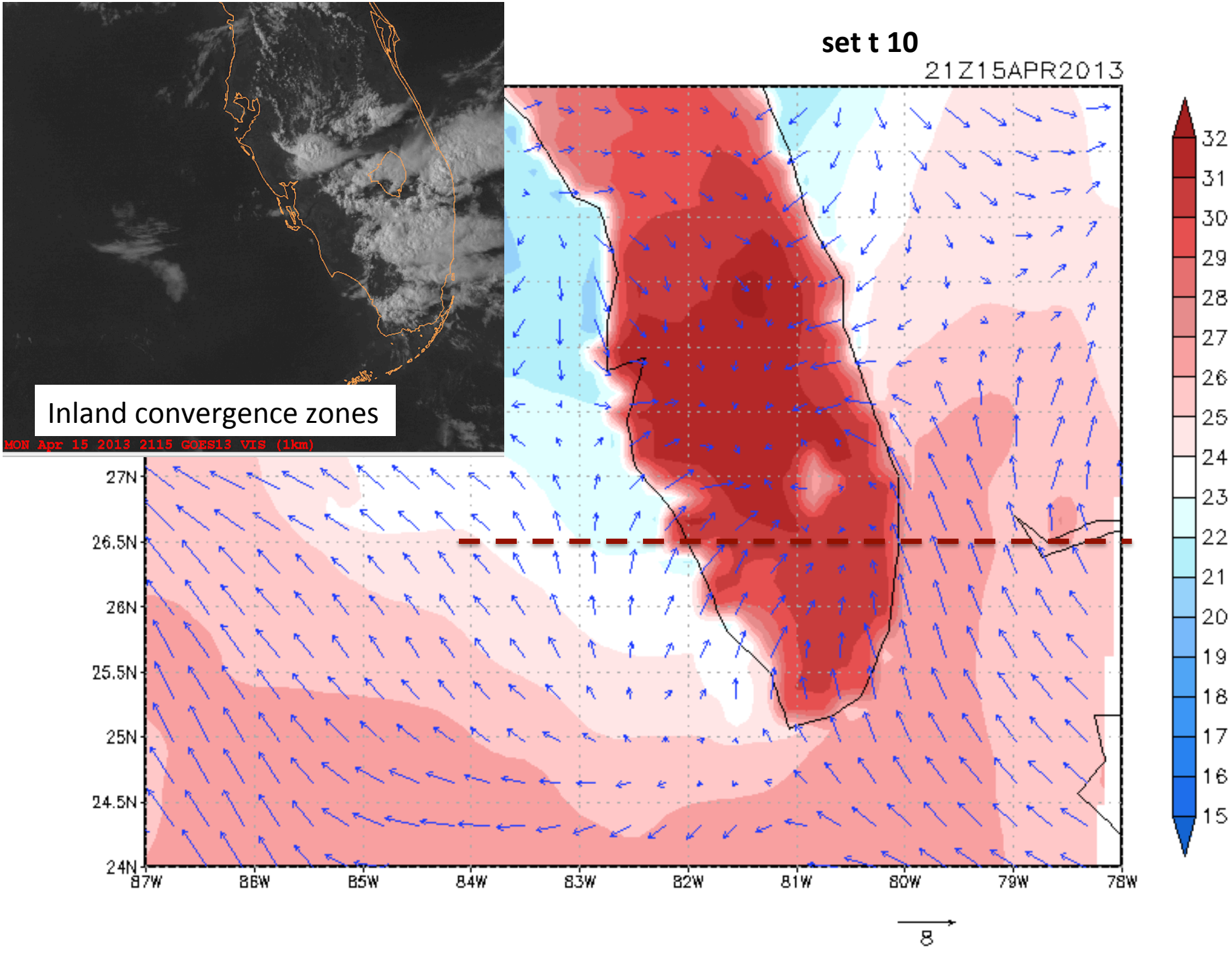


**set t 4**


15Z15APR2013
Notice wind change in S Florida
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
8

**set t 7**

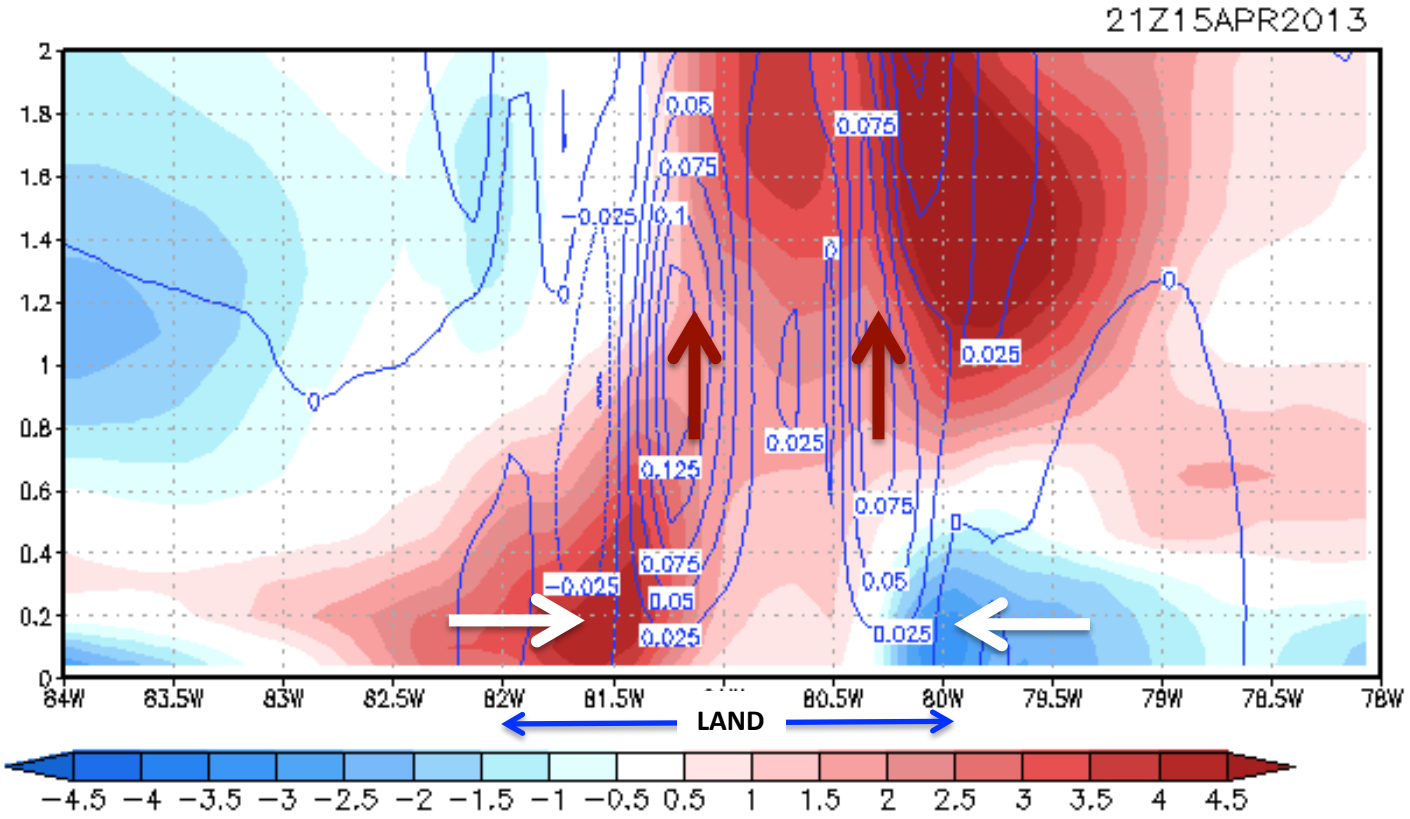

18Z15APR2013
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
8
Notice wind direction change along SW coast


set t 10
21Z15APR2013
Inland convergence zones
MON Apr 15 2013 2115 GOES13 VIS (1km)
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
8

plot_seabreeze_vert.gs

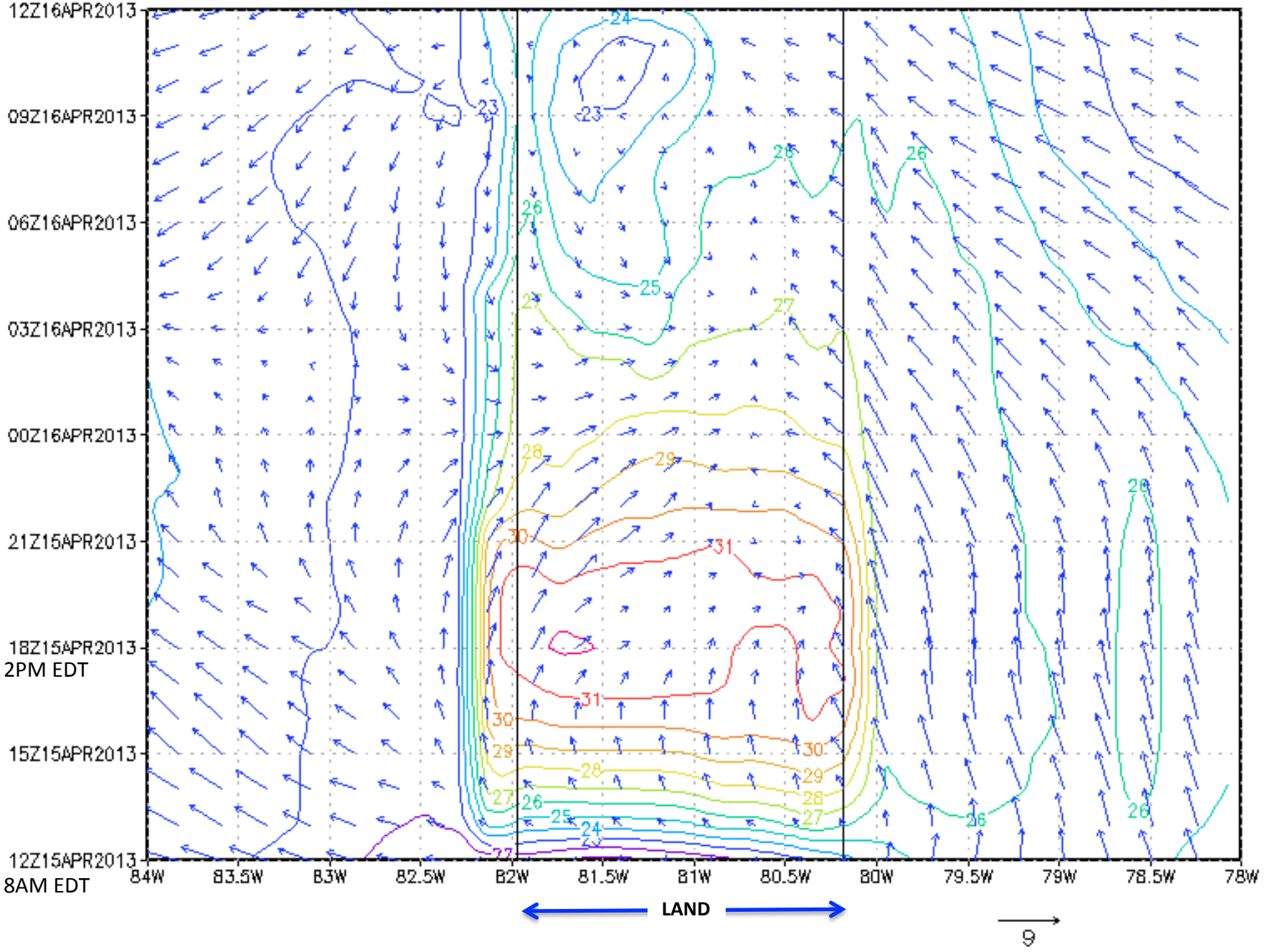
# Vertical cross-section

Colored: zonal wind
Contoured: vertical velocity

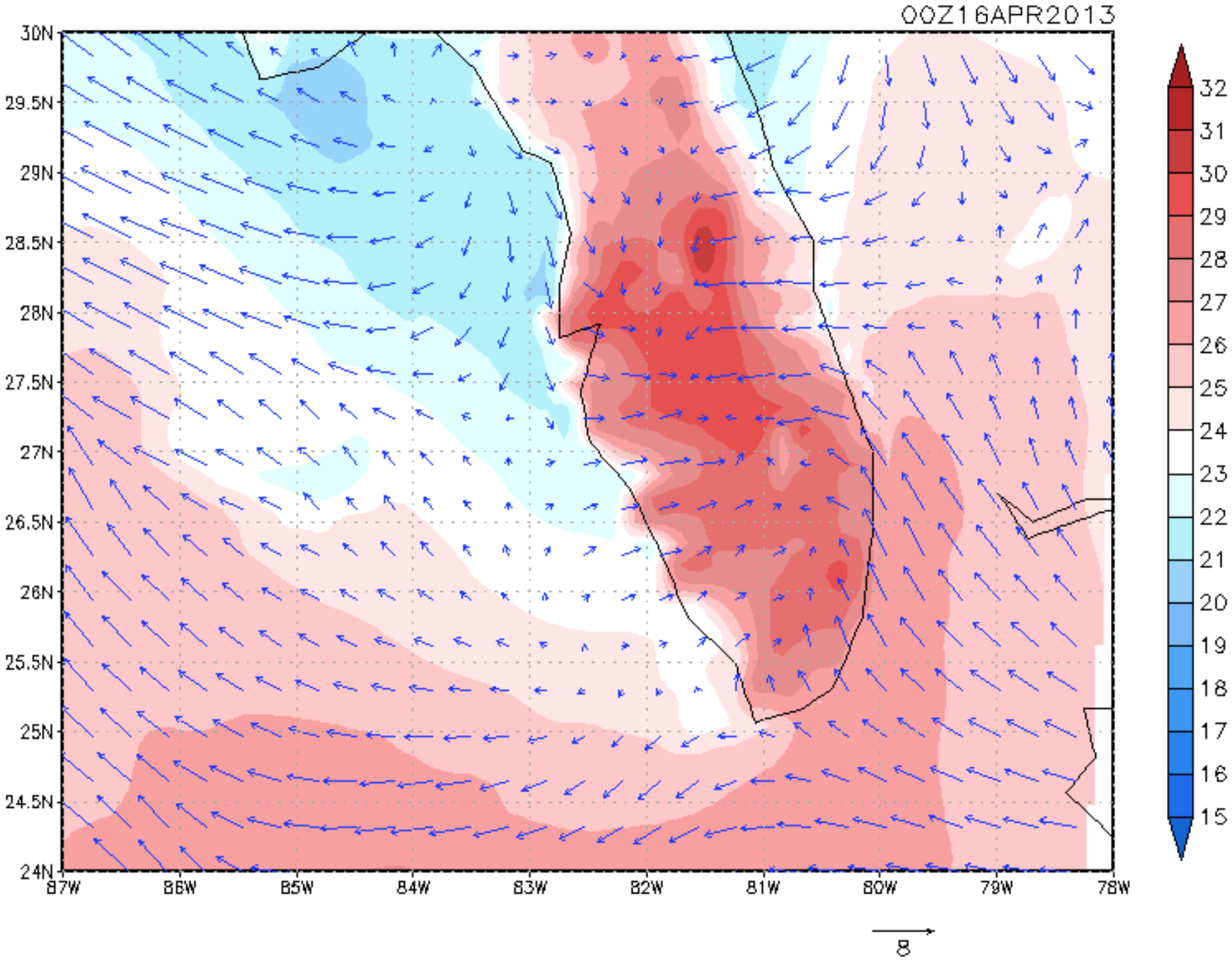


# Hovmoller diagram

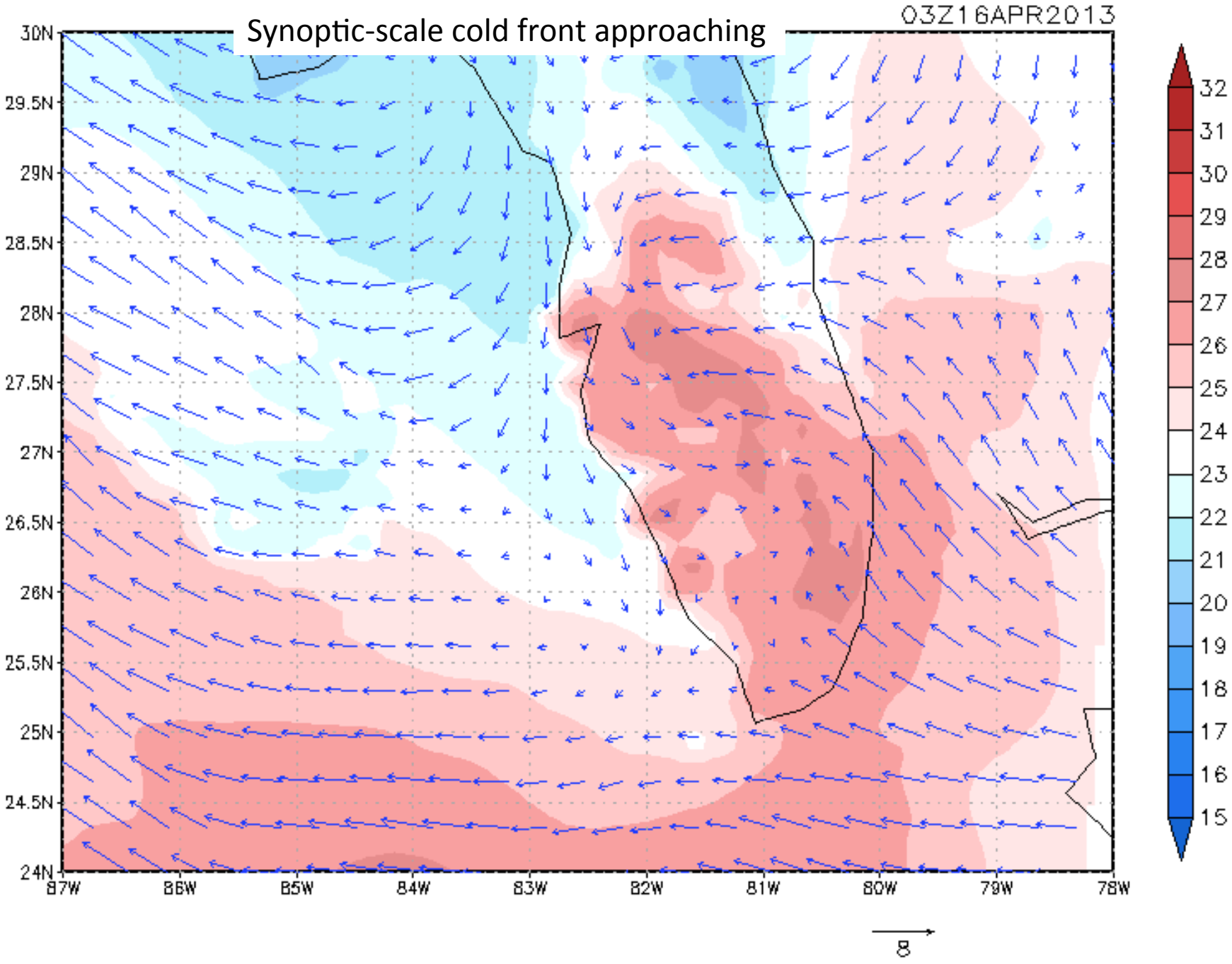
```
set t 1 25
set lat 26.5
set lon -84 -78     [note negative!]
d t2-273
set ccolor 1
set cint 1
d xland             [landmask]
set ccolor 4
d skip(u10,3,1);v10
```

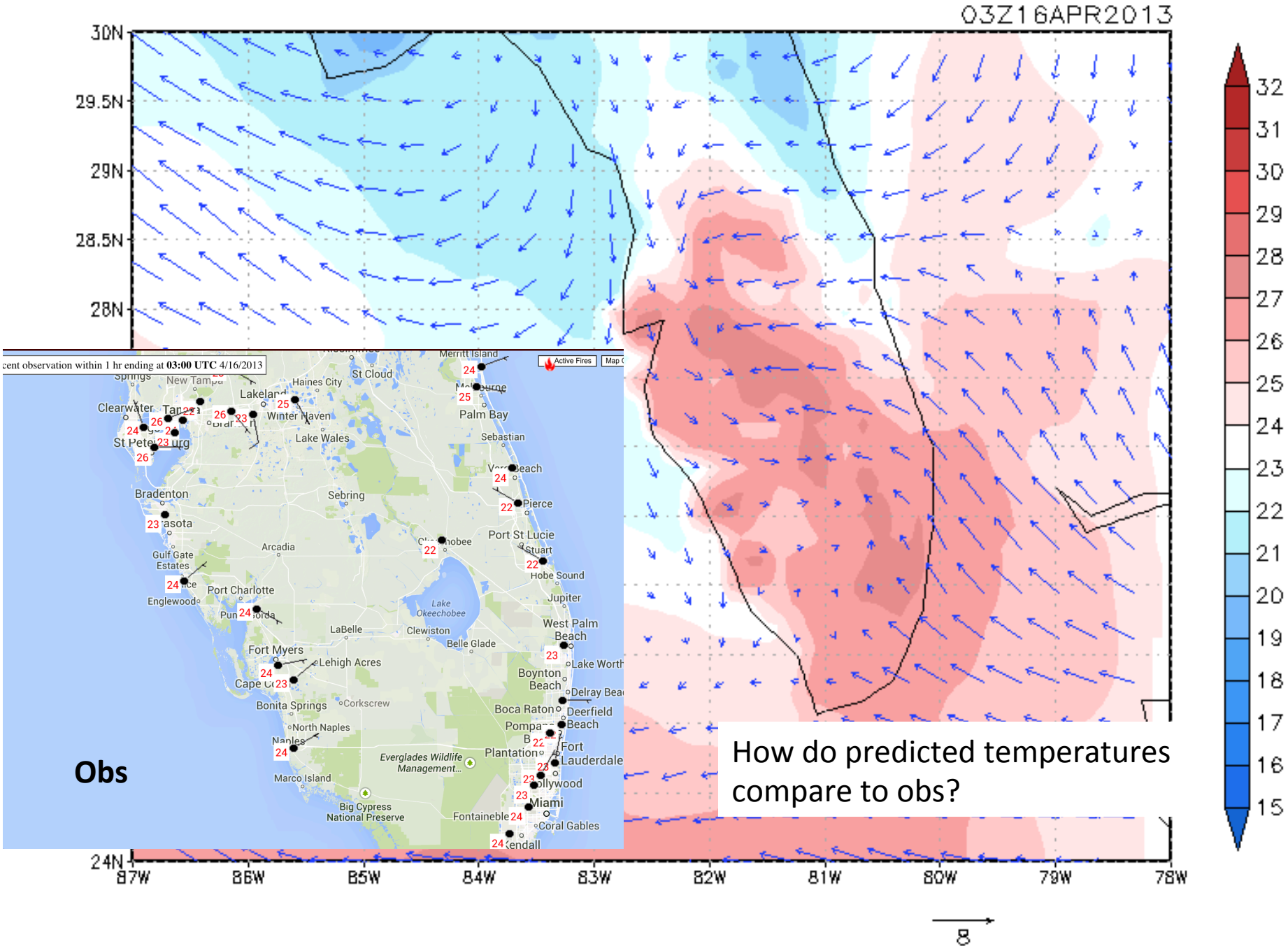

12Z16APR2013
09Z16APR2013
06Z16APR2013
03Z16APR2013
00Z16APR2013
21Z15APR2013
18Z15APR2013
2PM EDT
15Z15APR2013
12Z15APR2013
8AM EDT
84W
83.5W
83W
82.5W
82W
81.5W
81W
80.5W
80W
79.5W
79W
78.5W
78W
LAND
9
GrADS: COLA/IGES
2014-10-30-20:33

**set t 13**


00Z16APR2013
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
8

**set t 16**


Synoptic-scale cold front approaching
03Z16APR2013
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
8


03Z16APR2013
30N
29.5N
29N
28.5N
28N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
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26
25
24
23
22
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19
18
17
16
15
8
cent observation within 1 hr ending at 03:00 UTC 4/16/2013
Active Fires
Map
Merritt Island
St Cloud
Haines City
Lakeland
Winter Haven
Clearwater
Tampa
St Petersburg
Lake Wales
Palm Bay
Melbourne
Sebastian
Vero Beach
Pierce
Bradenton
Sarasota
Sebring
Arcadia
Okeechobee
Port St Lucie
Stuart
Hobe Sound
Gulf Gate Estates
Englewood
Port Charlotte
Punta Gorda
Lake Okeechobee
Jupiter
LaBelle
Clewiston
Belle Glade
West Palm Beach
Fort Myers
Lehigh Acres
Lake Worth
Cape Coral
Boynton Beach
Delray Beach
Bonita Springs
Corkscrew
Boca Raton
Deerfield Beach
North Naples
Naples
Pompano Beach
Fort Lauderdale
Everglades Wildlife Management...
Plantation
Marco Island
Hollywood
Miami
Big Cypress National Preserve
Fontainebleau
Coral Gables
Kendall
Obs
How do predicted temperatures compare to obs?

mesowest.utah.edu/index.html

C115 SEC FIOS Apple *Runs* News MyUCLA Registrar Registrar/AS UCLAmail AOSMail Stuff Radar links Siga

**Station Search** Help

Address

**LINKS**

What's New

Current Status

Help

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Department of Atmospheric Sciences

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MESOWEST

THE UNIVERSITY OF UTAH

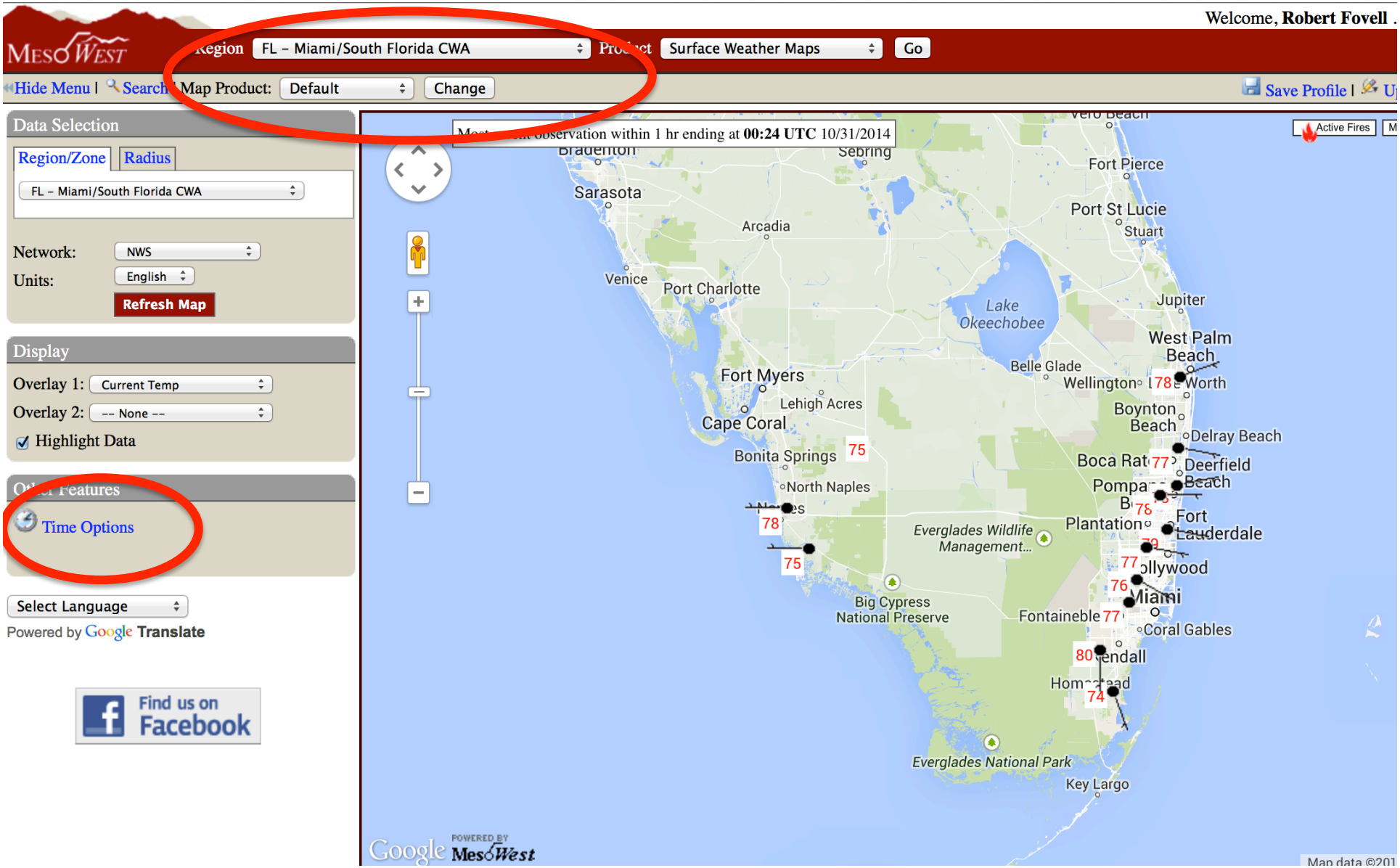
# States

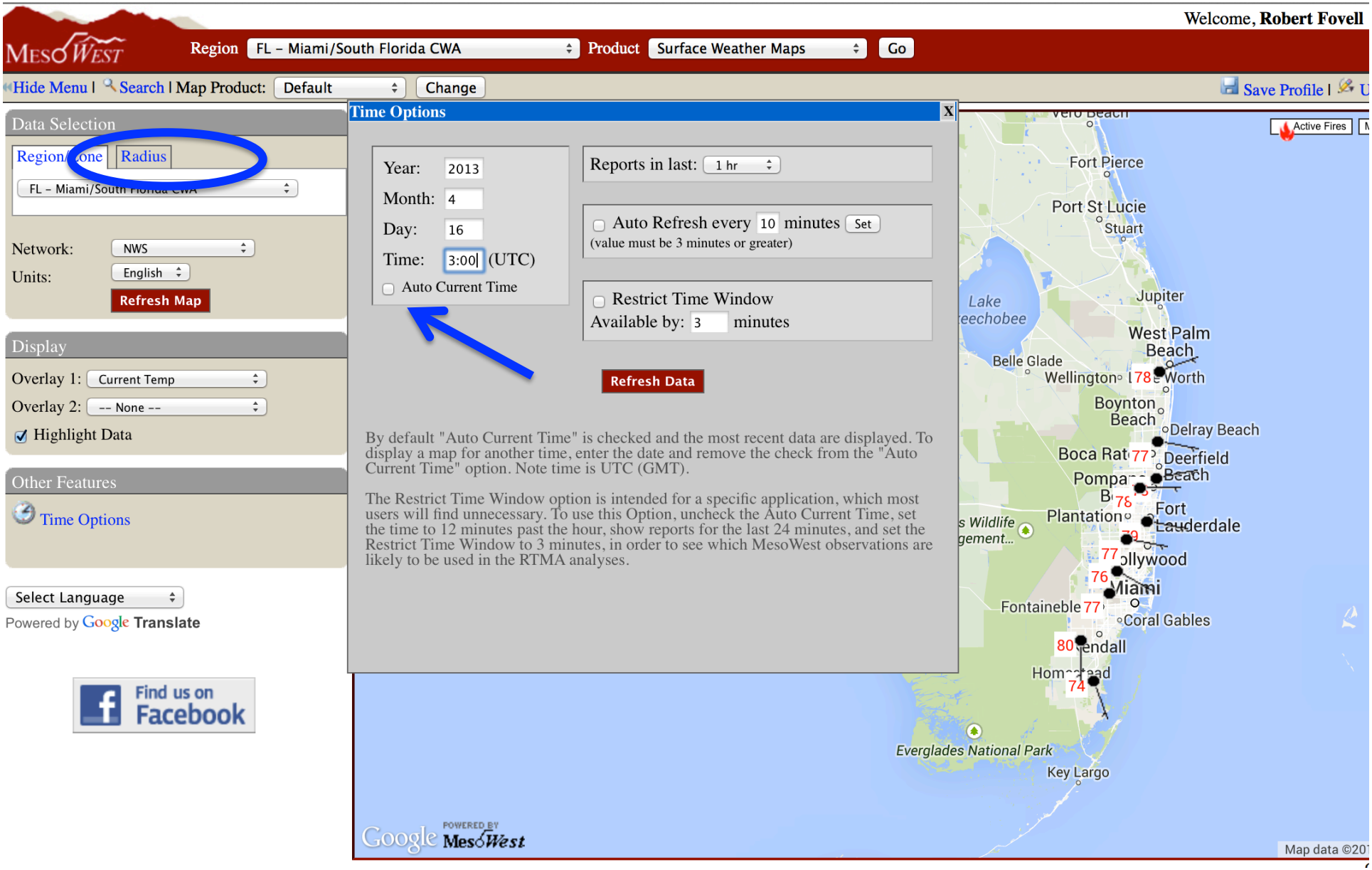
*Click on a State to access weather observations*

**Create a free account (optional)**

States CWAs Text Only

## Observations and Summaries


Welcome, Robert Fovell .
MesoWest
Region
FL – Miami/South Florida CWA
Product
Surface Weather Maps
Go
Hide Menu | Search | Map Product:
Default
Change
Save Profile |
Data Selection
Region/Zone
Radius
FL – Miami/South Florida CWA
Network:
NWS
Units:
English
Refresh Map
Display
Overlay 1:
Current Temp
Overlay 2:
-- None --
Highlight Data
Time Options
Select Language
Powered by Google Translate
Find us on Facebook
observation within 1 hr ending at 00:24 UTC 10/31/2014
Active Fires
Sarasota
Arcadia
Venice
Port Charlotte
Fort Myers
Lehigh Acres
Cape Coral
Bonita Springs
North Naples
Lake Okeechobee
Everglades Wildlife Management...
Big Cypress National Preserve
Everglades National Park
Key Largo
Fort Pierce
Port St Lucie
Stuart
Jupiter
West Palm Beach
Belle Glade
Boynton Beach
Delray Beach
Deerfield Beach
Fort Lauderdale
Plantation
Miami
Coral Gables
Fontainebleau
Google
POWERED BY MesoWest


Welcome, Robert Fovell
MesoWest
Region
FL - Miami/South Florida CWA
Product
Surface Weather Maps
Go
Hide Menu | Search | Map Product:
Default
Change
Save Profile |
Data Selection
Region/Zone
Radius
FL - Miami/South Florida CWA
Network:
NWS
Units:
English
Refresh Map
Display
Overlay 1:
Current Temp
Overlay 2:
-- None --
Highlight Data
Other Features
Time Options
Select Language
Powered by Google Translate
Find us on Facebook
Time Options
X
Year:
2013
Month:
4
Day:
16
Time:
3:00
(UTC)
Auto Current Time
Reports in last:
1 hr
Auto Refresh every
10
minutes
Set
(value must be 3 minutes or greater)
Restrict Time Window
Available by:
3
minutes
Refresh Data
By default "Auto Current Time" is checked and the most recent data are displayed. To display a map for another time, enter the date and remove the check from the "Auto Current Time" option. Note time is UTC (GMT).
The Restrict Time Window option is intended for a specific application, which most users will find unnecessary. To use this Option, uncheck the Auto Current Time, set the time to 12 minutes past the hour, show reports for the last 24 minutes, and set the Restrict Time Window to 3 minutes, in order to see which MesoWest observations are likely to be used in the RTMA analyses.
Active Fires
Fort Pierce
Port St Lucie
Stuart
Jupiter
West Palm Beach
Belle Glade
Wellington
Boynton Beach
Delray Beach
Deerfield Beach
Plantation
Fort Lauderdale
Miami
Fontainebleau
Coral Gables
Everglades National Park
Key Largo
Google
POWERED BY MesoWest
Map data ©201

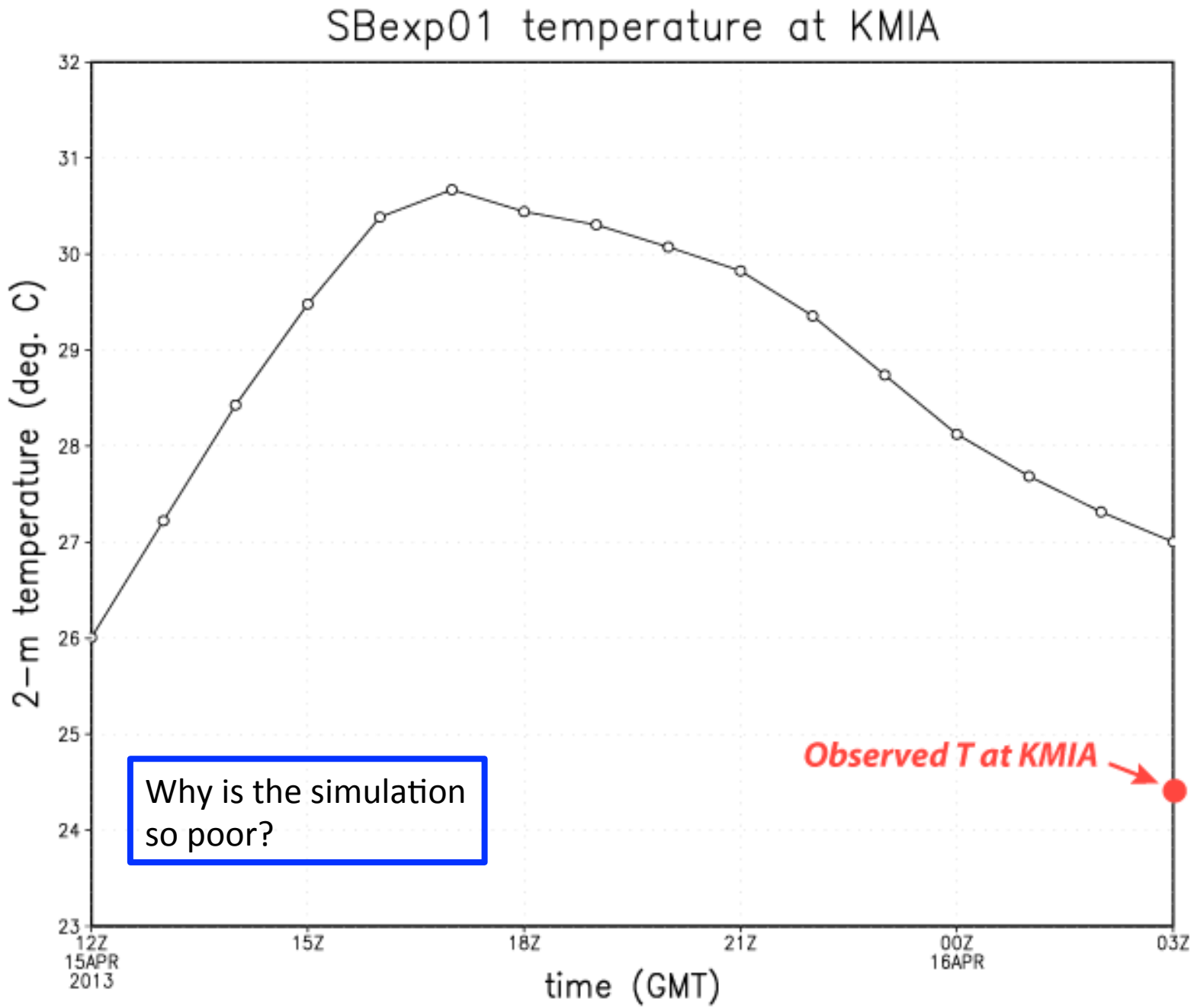
# Plotting a time series at a single point
## (example: at KMIA Miami Airport)

```
ga-> set lat 25.79056
ga-> set lon -80.3486
ga-> set t 1 16
ga-> set vrange 23 32
ga-> d t2-273                [2-m T, in Celsius]

ga-> draw xlab time (GMT)
ga-> draw ylab 2-m temperature (deg. C)
ga-> draw title SBexp01 temperature at KMIA

ga-> enable print image_sbexp01_timeseries_t2_KMIA.m
ga-> print
ga-> disable print

ga-> !gxps –c –i image_sbexp01_timeseries_t2_KMIA.m –o
image_sbexp01_timeseries_t2_KMIA.ps
```

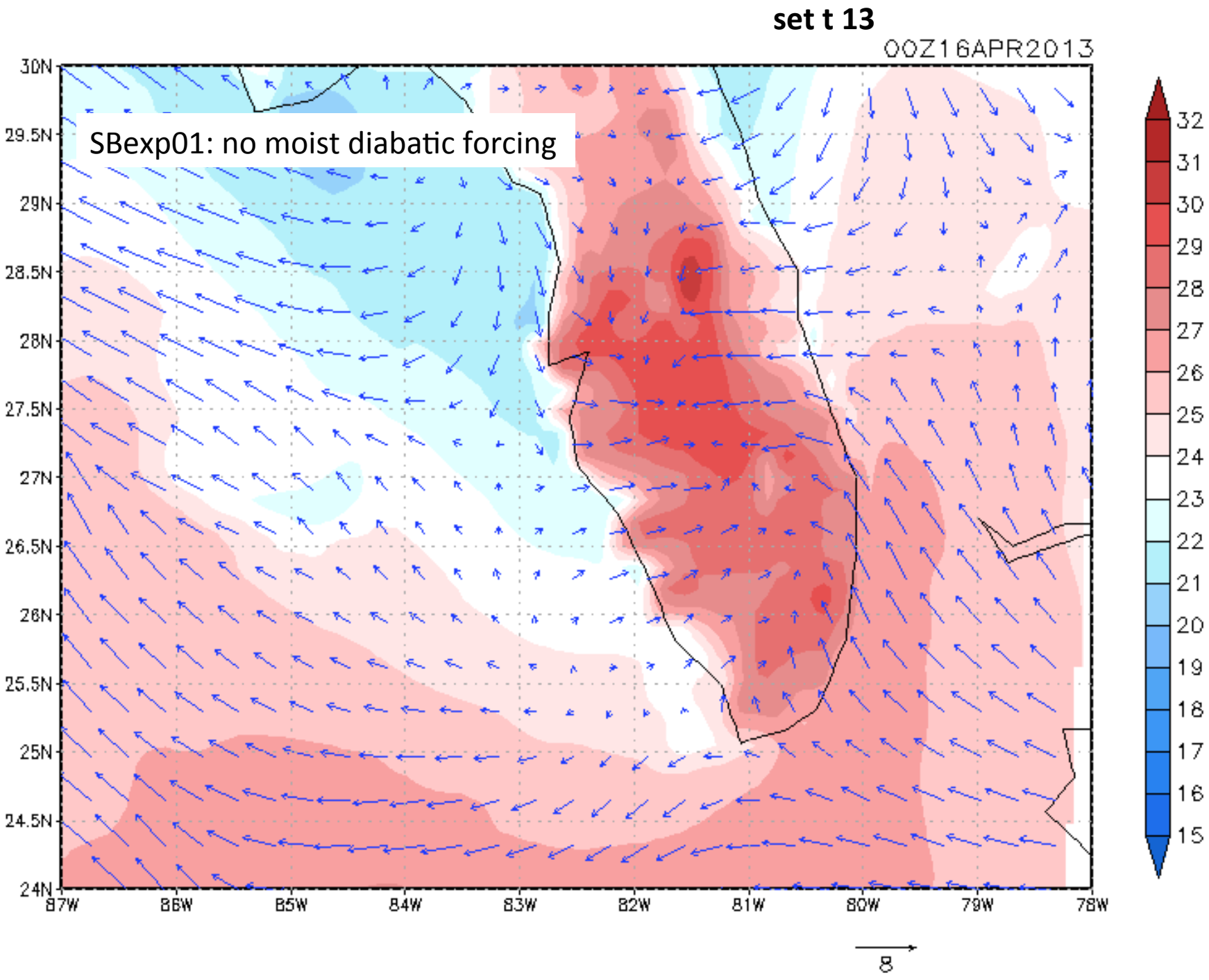

SBexp01 temperature at KMIA
2-m temperature (deg. C)
32
31
30
29
28
27
26
25
24
23
12Z
15APR
2013
15Z
18Z
21Z
00Z
16APR
03Z
time (GMT)
Observed T at KMIA
Why is the simulation so poor?

# Simulation SBexp02 design

- As SBexp01, but **permit diabatic heating and cooling** due to water substance phase changes
- Also, permit **subgrid scale clouds** (see next slide) to exist and affect environment

# Two complementary mechanisms for handling saturation and convection

- *Cloud microphysics schemes* (e.g., WSM3, WSM6, Thompson…)
  - We can resolve the clouds themselves but cannot follow every condensed water particle
  - We divide condensate into species (e.g., cloud droplets, raindrops, cloud ice, snow, graupel, hail) and predict total mass of each species type
  - Microphysics uses mass to determine fall speeds, conversion rates, evaporation and sublimation, etc..
- *Cumulus convection schemes* (e.g., Kain-Fritsch, Grell, Arakawa-Schubert)
  - We cannot even resolve the clouds themselves
  - These "subgrid" clouds vertically transport mass, moisture, momentum, alter atmospheric stability, etc.. Cumulus scheme tries to account for these.
- **Precipitation reaching the ground = RAINNC+RAINC**
  - RAINNC is produced by the cloud microphysics parameterization
  - RAINC is produced by the cumulus convection scheme


set t 13
00Z16APR2013
SBexp01: no moist diabatic forcing
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
8
32
31
30
29
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25
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22
21
20
19
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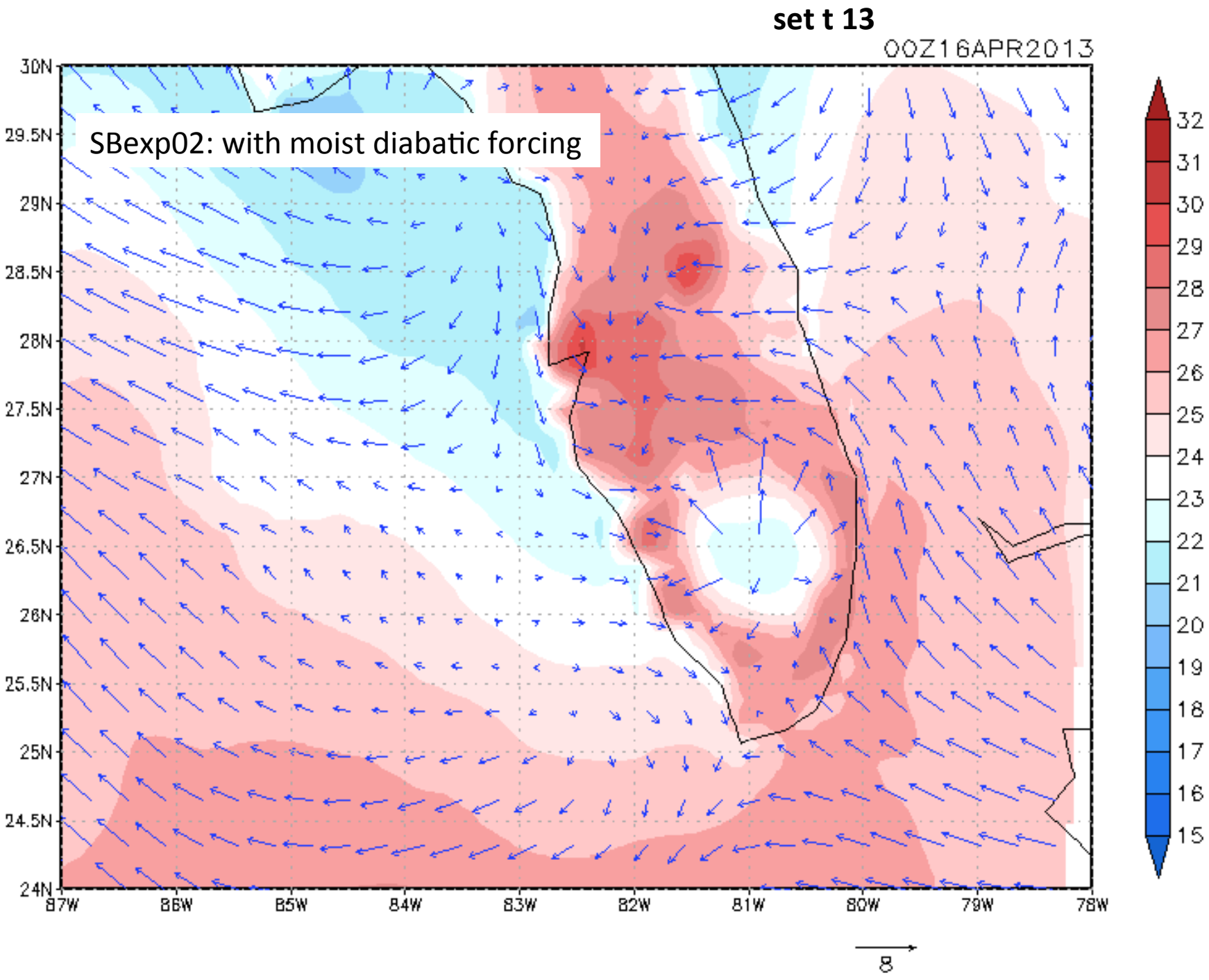
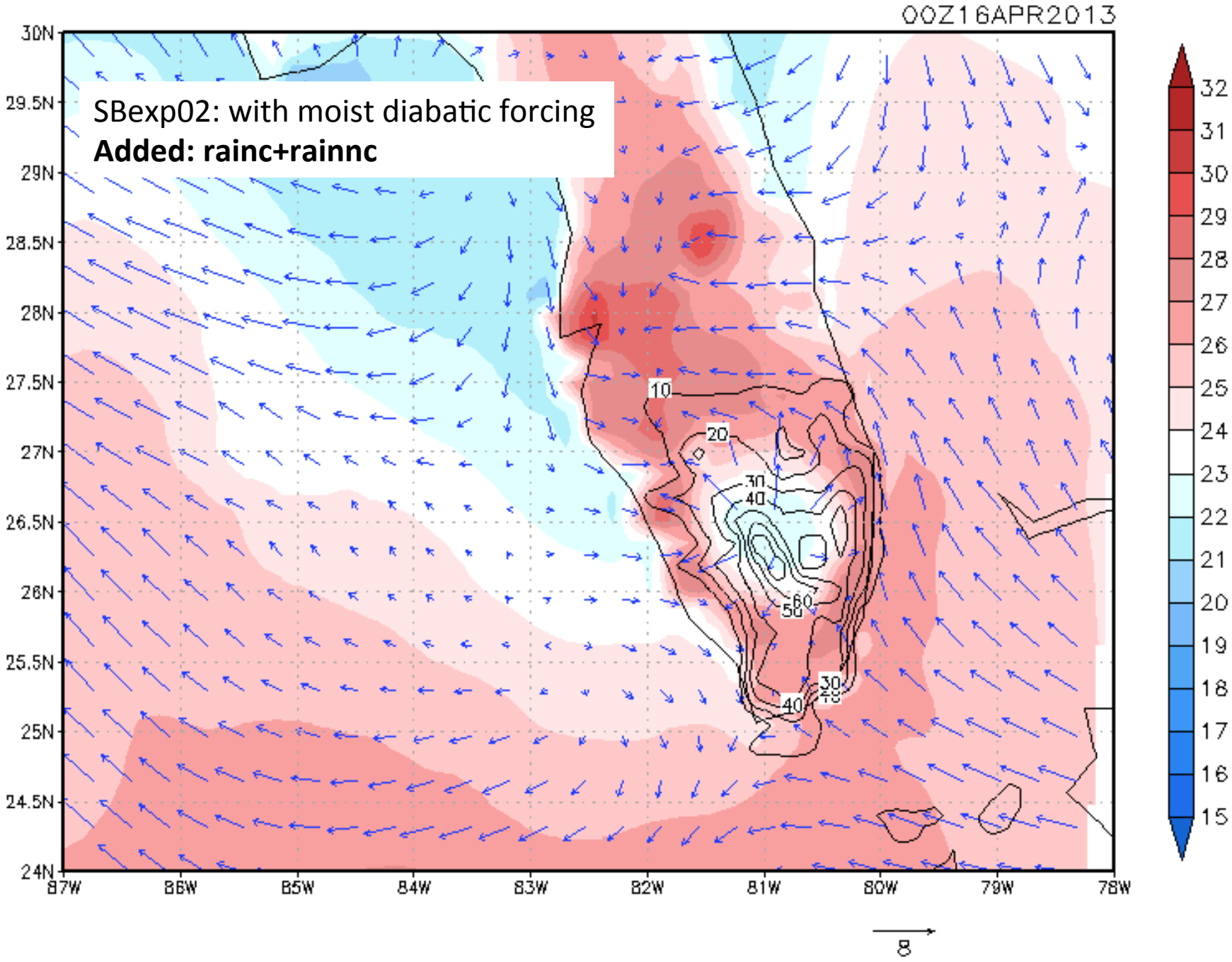
17
16
15


set t 13
00Z16APR2013
SBexp02: with moist diabatic forcing
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
8
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15

**set t 13**


00Z16APR2013
SBexp02: with moist diabatic forcing
**Added: rainc+rainnc**
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
10
20
30
40
60
50
30
40
8
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15

# Previous slide's plot

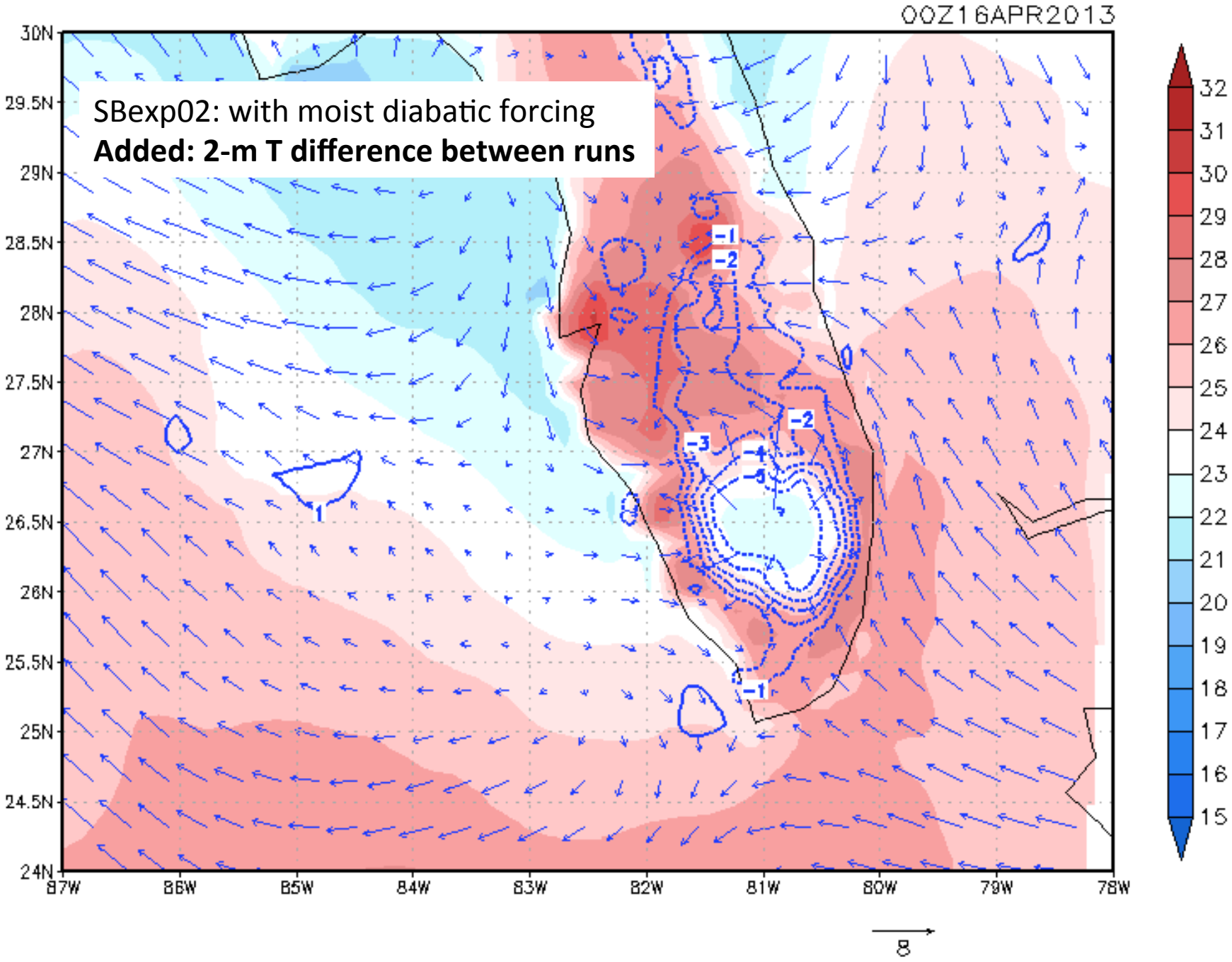
```
ga-> set t 13
ga-> plot_seabreeze_horiz.gs
ga-> set ccolor 1
ga-> set black 0 0
ga-> d rainc+rainnc
```

*Tries to suppress zero contour*

# GrADS on multiple files

```
ga-> open SBexp02_D2
ga-> open SBexp01_D2
ga-> set t 13
ga-> plot_seabreeze_horiz.gs
ga-> set ccolor 4
ga-> set black 0 0
ga-> set cthick 8
ga-> d t2.1-t2.2
```

**set t 13**


00Z16APR2013
SBexp02: with moist diabatic forcing
**Added: 2-m T difference between runs**
30N
29.5N
29N
28.5N
28N
27.5N
27N
26.5N
26N
25.5N
25N
24.5N
24N
87W
86W
85W
84W
83W
82W
81W
80W
79W
78W
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
8

# Some future questions

- Is SBexp02 any better at predicting KMIA temperature than SBexp01?
  - If yes, why? If no, why not?
- WRF has an large number of physics options, resulting in an enormous number of possible model configurations (although not all of them work properly).
  - Would a different land surface or PBL scheme do better?
  - Would different microphysics or cumulus schemes do better?
- WRF can be initialized from a sizable number of sources, including NCEP's GFS and NAM models, reanalyses (NARR, NNRP, ERA-Interim, CFSR).
  - Would any of these make a difference?

# Printing data values to the screen

```
ga-> set lat 25.79056
ga-> set lon -80.3486
ga-> set t 1 16
ga-> set gxout print
ga-> set prnopts %10.3e 1 1
ga-> d t2-273
Notice:  Automatic Grid Interpolation Taking Place
Printing Grid -- 16 Values -- Undef = -9.99e+08
 2.601e+01
 2.723e+01
 2.840e+01
 2.945e+01
 2.972e+01
 2.997e+01
 3.022e+01
 3.020e+01
 2.989e+01
[etc.]
```

When done, `set gxout contour` again

# More important commands

`ga-> reset`

- resets GrADS environment to starting conditions… Time dimension set to 1st time, gxout to contour, etc.. Does not close open files.

`ga-> reinit`

- resets AND closes all open files. "All but quit."

# Inside a GrADS script

# plot_seabreeze_horiz.gs

```
'set display color white'
'c'
'set vpage off'
'run rgbset.gs'
'set grads off'

'set lat 24 30'
'set lon -87 -78'
'set z 1'
```

*Most script commands reside between single quote marks*

*Use full plotting page*

*Defines many new colors*

# plot_seabreeze_horiz.gs (continued)

'set ccols 49 48 47 46  45 44 43 42 41 0 61 62 63 64 65 66 67 68 69'

*Defines colors… refers to rgbset.gs*

'set clevs 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32'

*Defines contour level for those ccols*

'set gxout shaded’

'd t2-273'

'run cbarn'

*A color legend*

'set gxout contour'

'set ccolor 4'

'set arrscl 0.5 8'

*Control vector magnitude/length*

'd skip(u10,4);v10'

# Some variables in the GrADS output

(in addition to the obvious ones)

- h_diabatic – diabatic heating from microphysics
- rthratlw – diabatic heating from LW radiation
- rthratsw – diabatic heating from SW radiation
- slvl – sea-level pressure
- psfc – surface pressure
- q2 – vapor mixing ratio at 2 m above ground
- hgt – terrain height
- xland – landmask (“1 if by land, 2 if by sea”)
- xlat (latitude) and xlong (longitude)

# Some ready WRF outputs

- Control configuration: YSU PBL, Noah LSM, RRTMG LW and SW, WSM3 microphysics, KF cumulus
- No heating runs (no_mp_heating = 1, cu_physics=0,0)
  - SBexp01_D2 - control
  - SBexp01A_D2 - MYJ PBL/surface
  - SBexp01B_D2 - PX LSM, ACM2 PBL/surface
  - SBexp01C_D2 - TD LSM
  - SBexp01D_D2 – MYNN2 PBL (surface=1)

# Some ready WRF outputs, continued

- With microphysics and cumulus heating on
  - SBexp02_D2 - control
  - SBexp02A_D2 - MYJ PBL/surface
  - SBexp02B_D2 - PX LSM, ACM2 PBL/surface
  - SBexp02C_D2 - TD LSM
  - SBexp02D_D2 - MYNN2 PBL (surface=1)
- With YSU PBL and Noah LSM, vary microphysics
  - SBexp03A_D2 - Kessler mp=1
  - SBexp03B_D2 - LFO mp=2
  - SBexp03C_D2 - Ferrier mp=5

# HW3 (due next Wednesday)

- Come to class with a short PPT describing something of interest you see in these experiments.
  - Might focus on differences (but see next slide) between 2 simulations, or among many simulations
  - One possible approach:
    - I focused on <this>
    - I examined <these> fields in <those> simulations
    - This is my interesting difference
    - This is how it came about, and why it is relevant

"A difference is a difference only if it makes a difference."

– Darrell Huff, *How to Lie With Statistics*

If you see a difference:

Why is it there? What does it impact? What is its importance?

# Websites

- WRF model users site
  - http://www2.mmm.ucar.edu/wrf/users/
- GrADS home page
  - http://grads.iges.org/grads/grads.html
- GrADS default colors
  - http://grads.iges.org/grads/gadoc/gadocindex.html
- Observations obtained from MesoWest
  - http://mesowest.utah.edu