

TROPICAL ANALYSIS

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2018 RA-IV WORKSHOP ON HURRICANE FORECASTING
AND WARNING

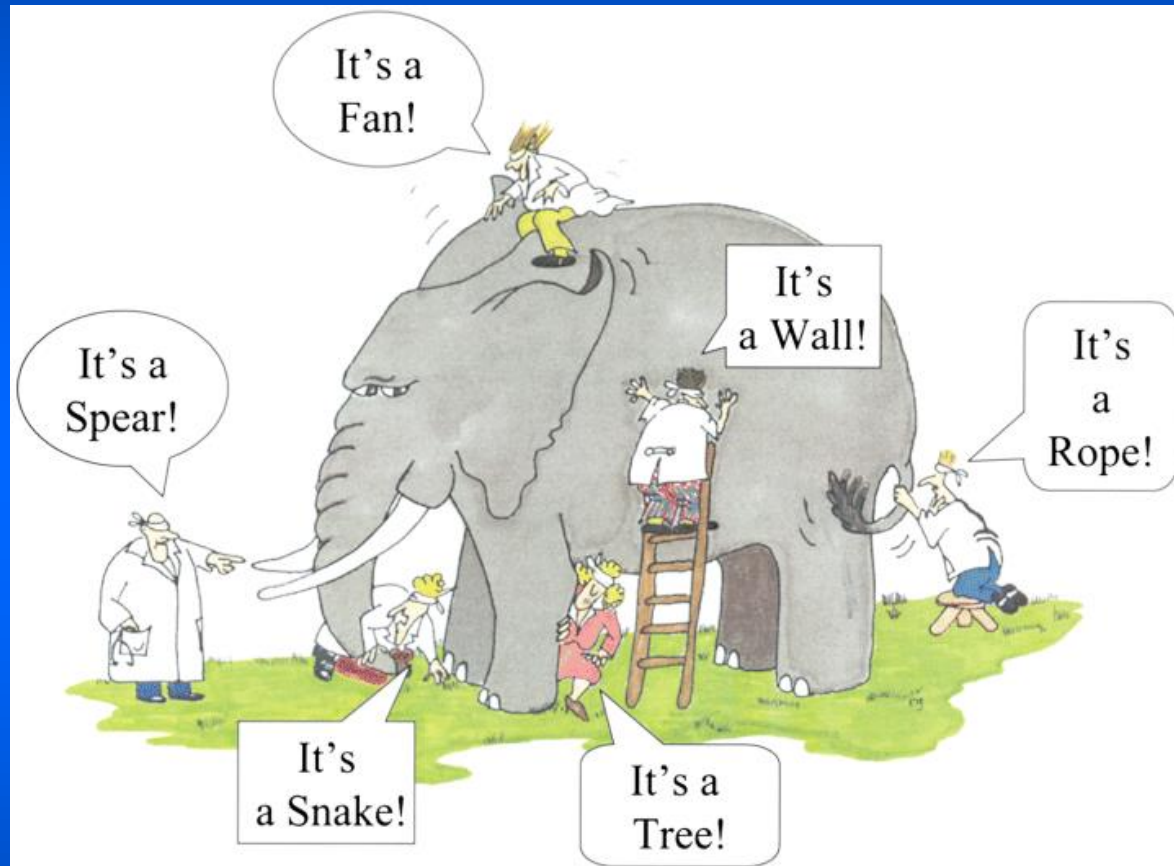
Miami, FL

March 5, 2018

Blind/blindfolded men and an elephant



Blind/blindfolded men and an elephant



When the data is very limited, and our knowledge about the subject is almost none, people sometimes come up with all kind of interpretation of the data they'd collected.

Why analyzing the tropics is more challenging?

- Poor data coverage
- Lack of understanding of tropical weather systems
- Many tropical weather systems have small amplitude
- Poor pressure/height - wind relationship
- Local effects
 - coastal, topographical, diurnal, semi-diurnal,...and they tend to be more noticeable
- Most textbooks teach mid-latitude systems

Analysis

To know the status of the atmosphere by interpreting the data you have

To make a good analysis one needs to:

- know the general circulation of the atmosphere
- have conceptual model of weather systems
- know the scales of different weather systems
- have the knowledge of how weather systems interact with each other
- know the history of the systems

In other words, know the Science (dynamics, thermodynamics, kinematics)

Why is a good analysis important

- Real-time analysis - May lead to better forecast
 - Case studies – Can help understand weather systems better
 - A good knowledge is the basis for a better real-time analysis and forecast
- (Don't believe everything you read. Do your own analysis if possible)

The Challenges for me

(This is the most difficult course to teach)

- Should I start with analysis methods
 - Apply to what? Analyzing what?
- Should I start with weather systems we normally deal with in the tropics
 - Sometime you can't see them without applying some analysis techniques
- Do both the same time using case studies

Some Useful Analysis Practices

- Check the data/analysis over a longer period of time — over a period that is comparable to the time scale of a synoptic system (and over a larger domain too)
- Time series analysis — use temporal coverage for the lack of spatial coverage
- Check vertical cross sections for structural coherence — Systems don't exist at just one level
- Space-time analysis — time series and structure
- Use wind analysis when possible — both streamlines and isotaches, but don't ignore surface pressure

Some Useful Analysis Practices

- Use all observations you have
- **Filtering** - separates different systems to allow better depictions of the system you want to identify
- **Spectral analysis** (1, 2, 3 dimensional)
- **If necessary, use continuity** — extrapolation
(Why are we allowed to do this? What you need to know first?)
- **If necessary, use short term forecast from previous model run**
- **When nothing else is available, use climatology** — just don't do it too often, why?

UNDERSTAND THE NATURE OF WEATHER SYSTEMS



If your job is to manage tropical fruits section

The weather you are analyzing may be influenced by

- Climatology
- Monsoon (the real monsoon)
- Easterly waves
- Equatorial waves
 - Rossby waves, Mixed Rossby-Graity waves, gravity waves, Kelvin waves, Madden-Julian Occillation,
- Tropical cyclones
- Local effects (topographical, coastal, etc.)
- Extra-tropical systems
- and

THE SCALES

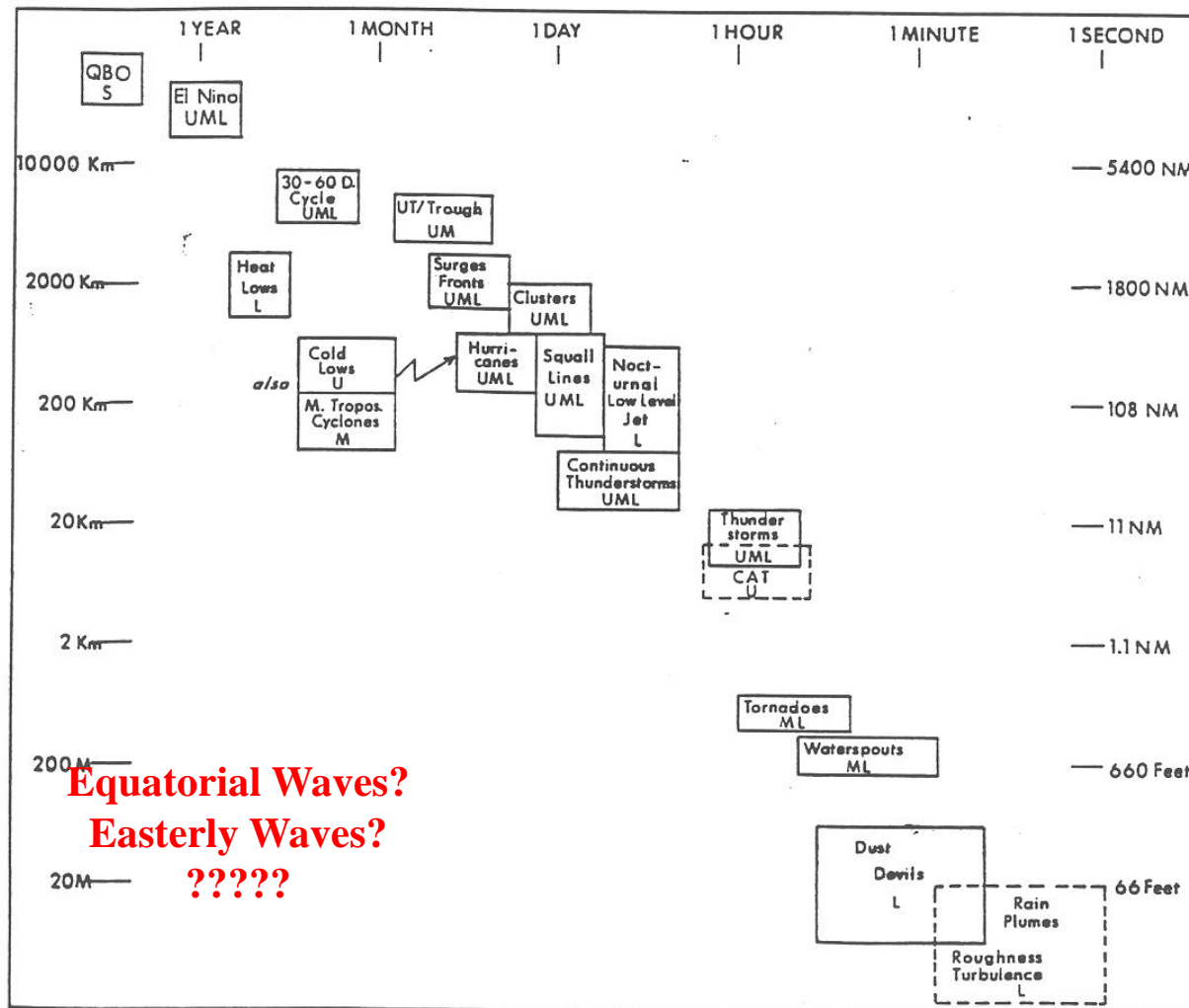
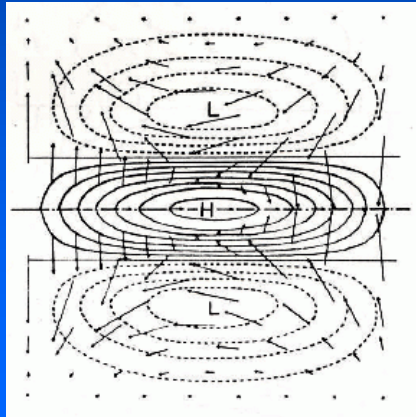


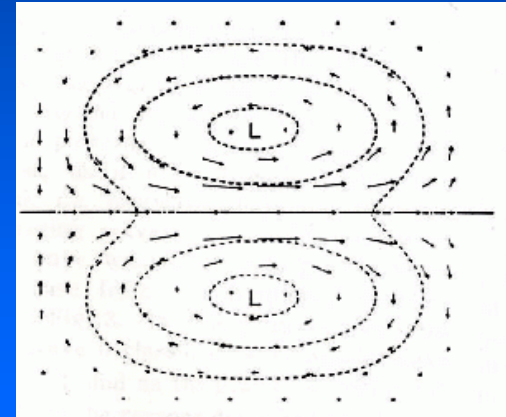
Figure 2-9. Approximate dimension and time scales of tropical systems (after Orlanski, 1975). Key: S - mainly stratosphere; U - mainly upper troposphere; M - mainly middle troposphere; and L - mainly lower troposphere.

PRESSURE AND WIND OF SOME OF THE LOWEST EQUATORIAL NORMAL MODES

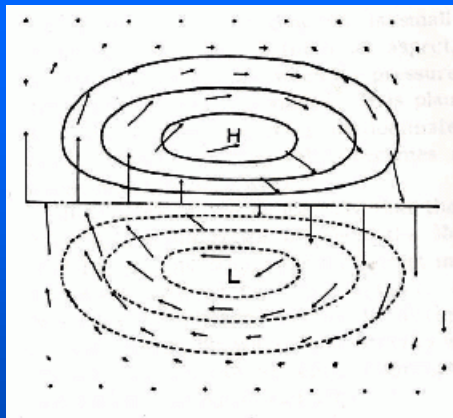


Eastward inertio-gravity wave

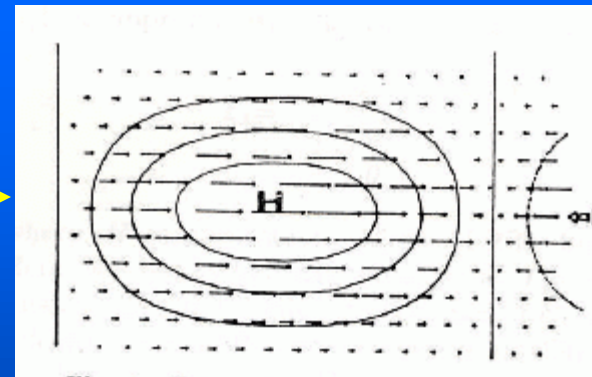
← EQ →



Rossby wave



← EQ →

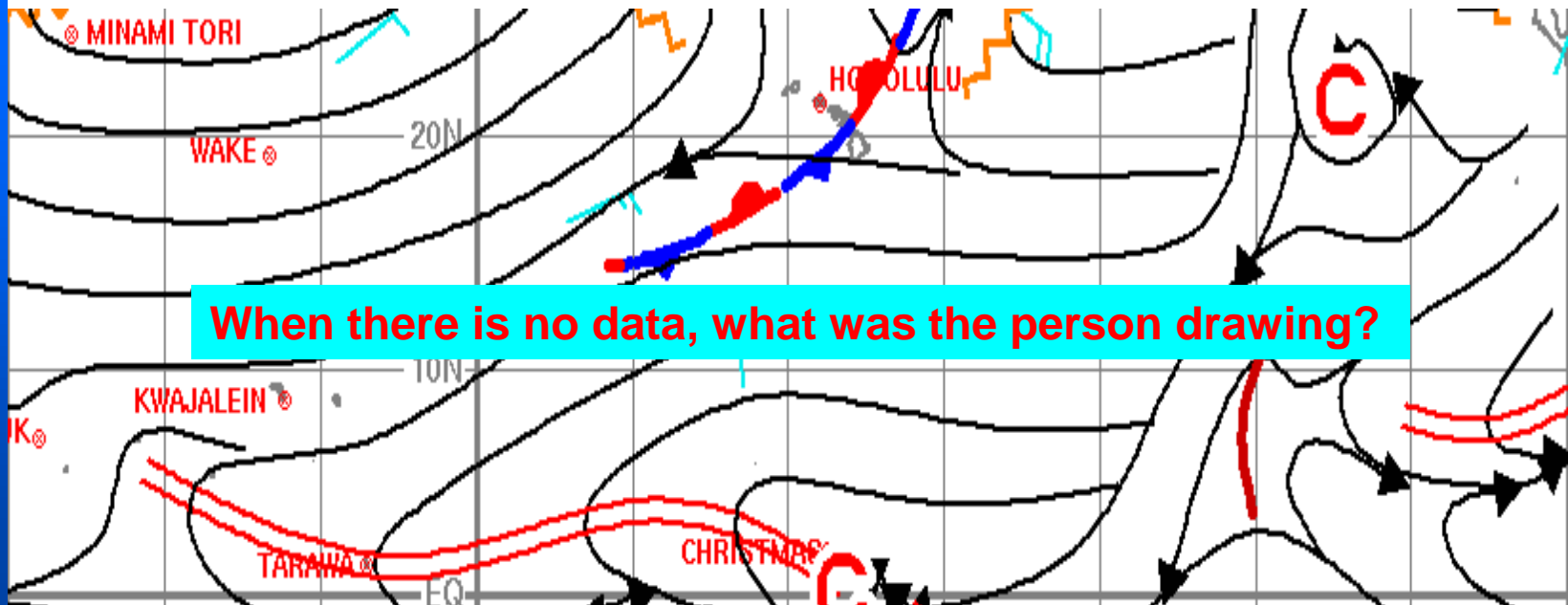
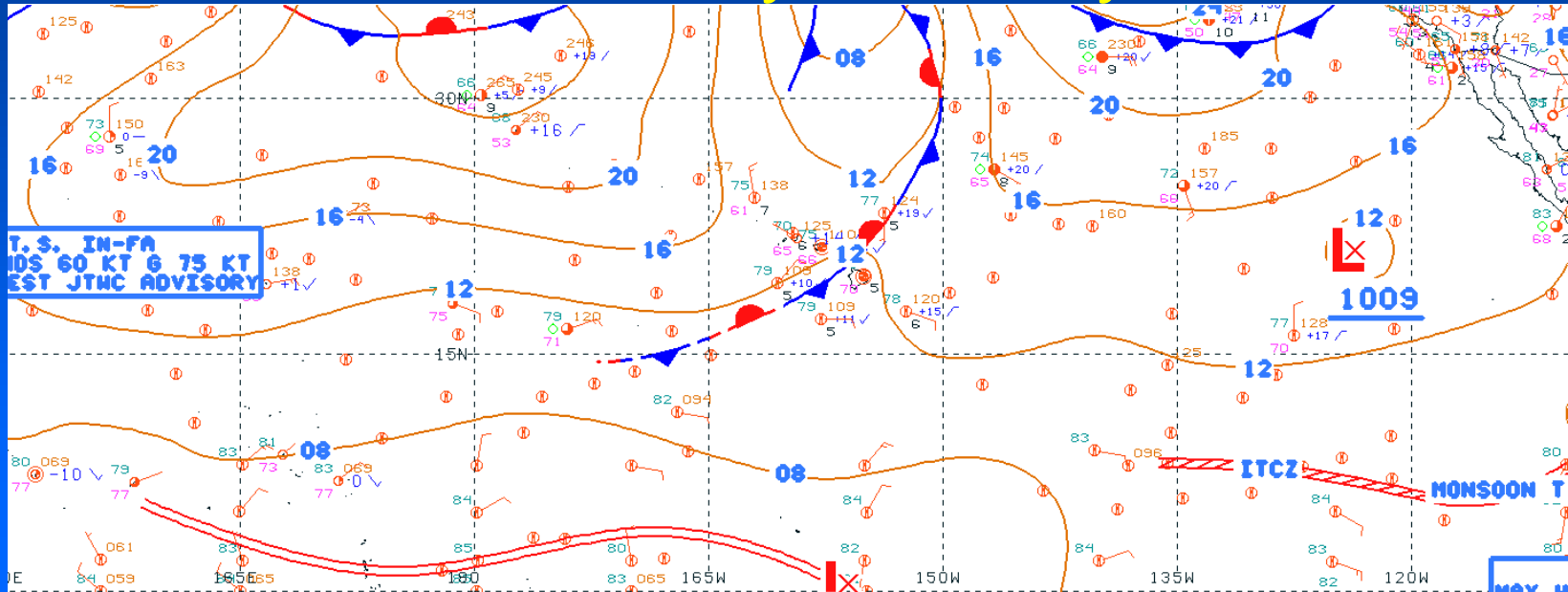


Kelvin wave

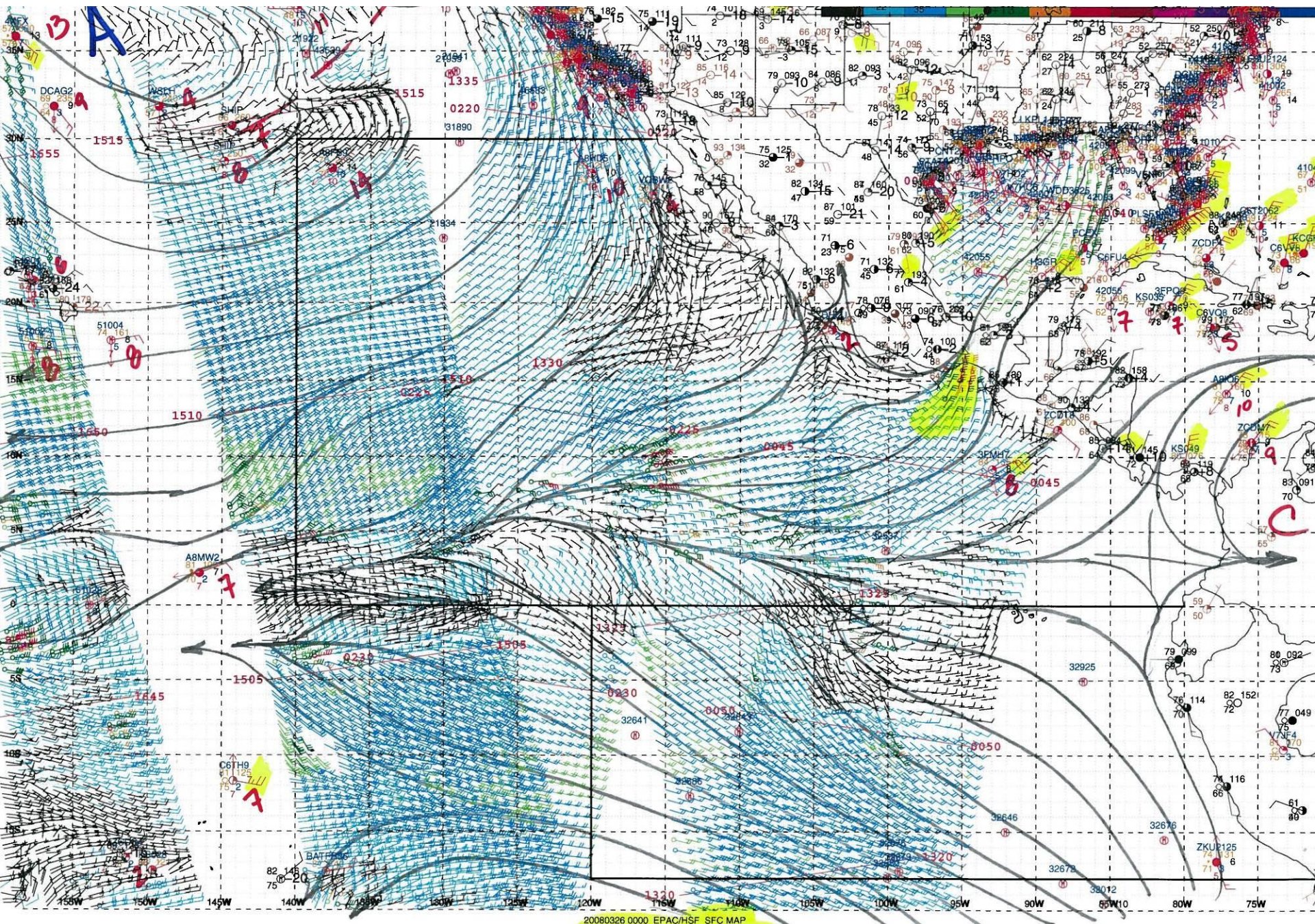
Westward mixed Rossby gravity wave

STREAMLINE ANALYSIS VS ISOBARIC ANALYSIS

Is Streamline Analysis Always Better?



Maybe With Satellite Derived Winds



Streamline analysis is better in the tropics but experts caution about the way it is used

Weather Analysis and Forecasting

Sverre Petterssen

// 2.2. Construction of Streamlines.

A mere freehand drawing of streamlines is rarely satisfactory, for on account of the relatively large distance between the observing stations there will be a tendency to carry the streamlines from one station to another and this may introduce systematic distortions." The most satisfactory method of constructing streamlines may be described as follows: (1) Plot the numerical values of the wind direction (in decade degrees) at each station. (2) Draw lines through the stations which have the same wind direction, or interpolate such lines between the stations. These lines are the isogons. It is usually satisfactory to draw isogons at intervals of 30° , except in regions of little variation, where intervals of 15° or 10° should be used. (3) Draw short line segments across each isogon such that the segments indicate the wind direction. (4) Connect the line segments by tangent curves. These curves are the streamlines.

Tropical Meteorology

Herbert Riehl

Streamline Analysis. Since the slopes of isobaric surfaces in the tropics are very small, it is never possible to make a reliable analysis from pressure-height data alone. The soundings are subject to the many errors listed above, and the spacing between two stations is often so great that a large disturbance can exist between them without affecting either. Contour analysis should never be attempted without close reference to the time sections, continuity, and the winds. This is no simple task because wind and contour directions can deviate appreciably. Further, upper contour charts must be prepared with aid of the differential analysis (thickness) technique in order to avoid gross errors in drawing contours in open networks; otherwise computations made from such charts are likely to fail. Several basic textbooks give a description of this method.

Streamline analysis is often more satisfactory. Its object is to represent the fields of wind direction and wind speed, and therefore the fields of vorticity and divergence, which are so important in all synoptic work.

The degree to which these objectives are attainable depends entirely on quantity and quality of the observations. "When stations are widely spaced and located mainly along a line, usually an air route, and when confidence in any existing pilot reports is low, many analysts extrapolate trough lines, shear lines, and centers from the time sections and past maps and then sketch streamlines that approximately outline the field of wind direction." It is the property of streamlines to parallel the wind direction everywhere. Figure 7.2 illustrates this type of analysis. Beyond depicting wind directions, very little is attempted. This is entirely proper considering the data situation. The author must warn against attempting too much with poor and sparse data. A reasonable balance should always exist between the observations that make up a chart and what the analyst tries to deduce from these observations. Otherwise, serious errors in the form of fantastic map constructions inevitably result.

Exercise #1

- Take a look at the following 2 surface plots for two minutes (focus on reports inside the box)

A map of the North Pacific Ocean region, showing the coastline of North America on the left and the coastline of Japan and the Philippines on the right. The map displays several sampling stations marked with circles and lines. Each station is labeled with a number (e.g., 136, 125, 121, 120, 109, 108, 100, 131, 12, 10, 96, 99, 84, 79, 73, 66, 5, 4, 3, 2, 1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808,

Exercise #1

- Turn the maps over
- Group 1 report your impression on the mean sea level pressure
- Group 2 report your impression on the winds
- The first thing you have to check is the date/time group (why I chose these two plots at 24 hours apart?)

What have you noticed?

What you may remember 24
hours later

Time-series analysis

- When there are not enough station reports to help you identify weather systems on a map

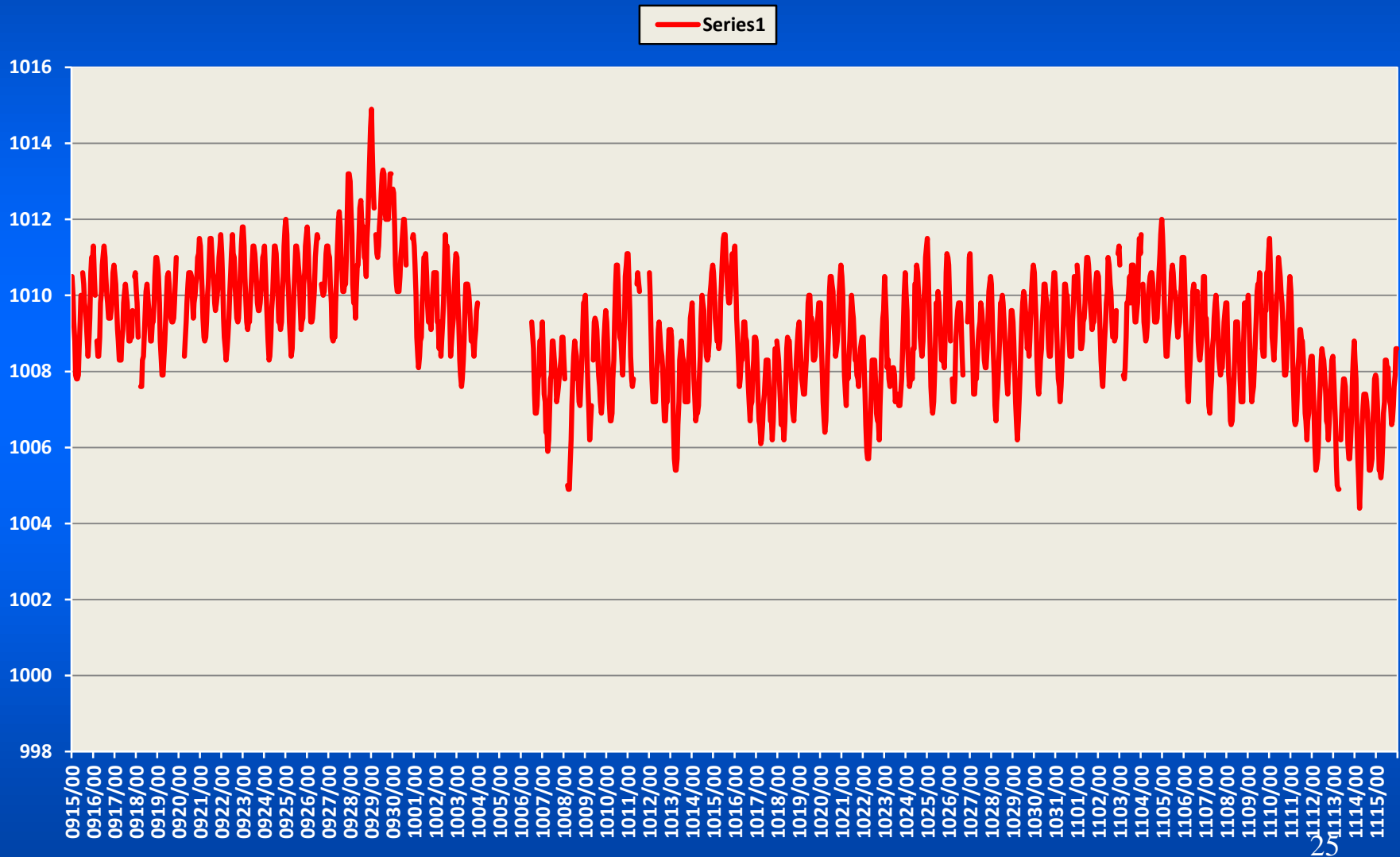
Time series of observations at fixed stations can be useful to identify weather systems that have passed those stations

Identifying Easterly Waves in the W Pacific

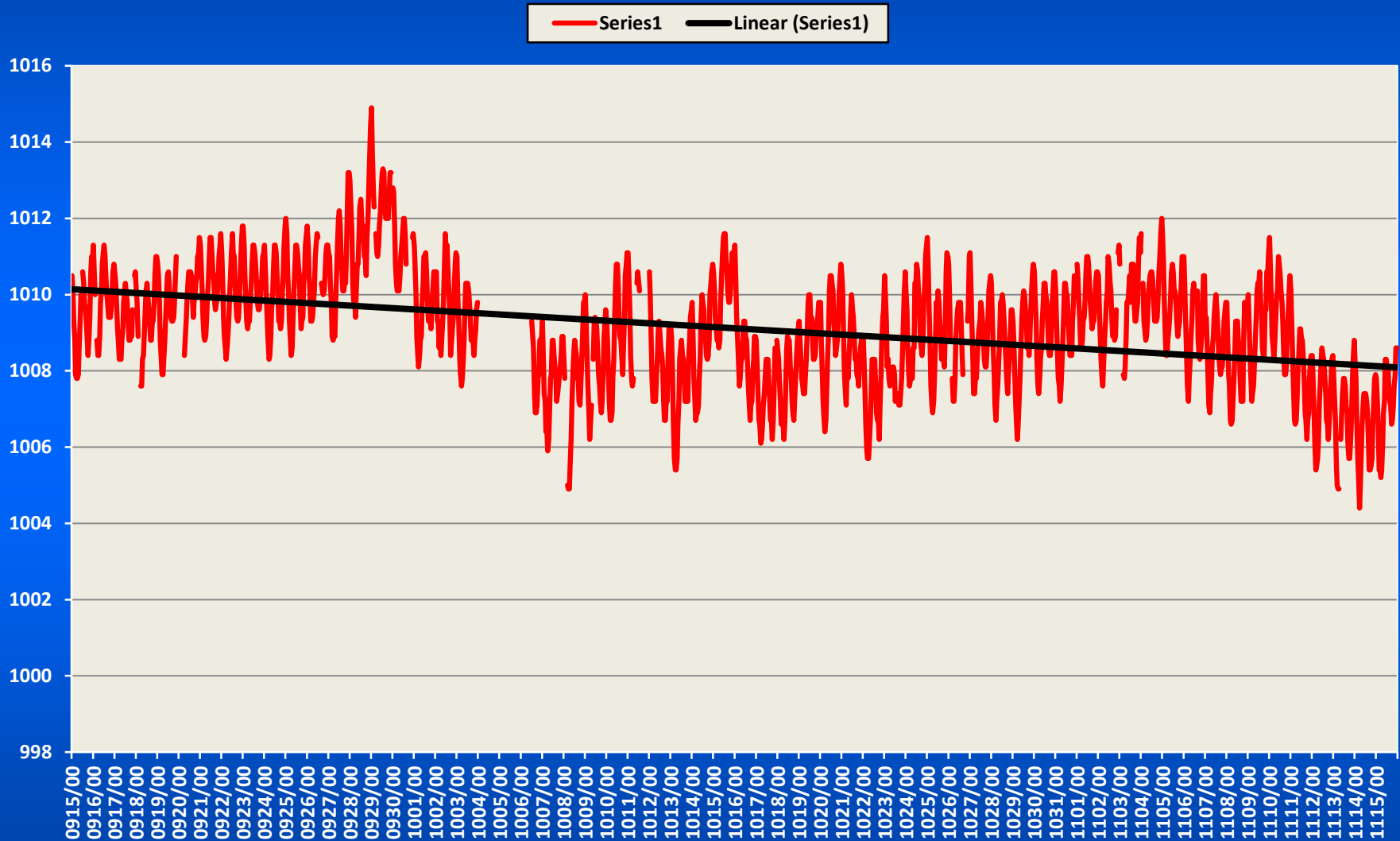
April 2015 Precipitation (Percent of Normal)



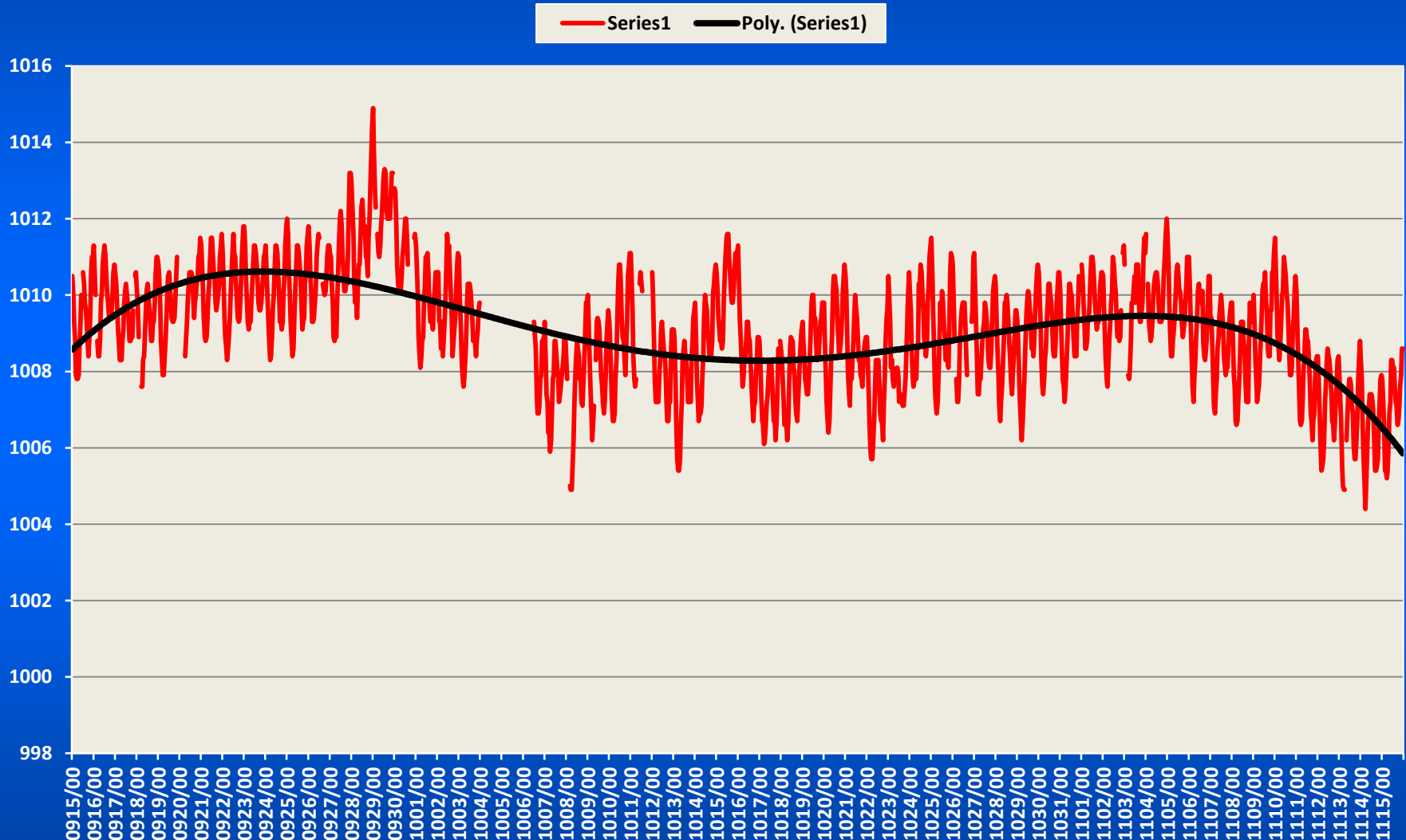
Time series of surface pressure at Truk(Truuk) from Sep. 15 – Nov. 15, 2000



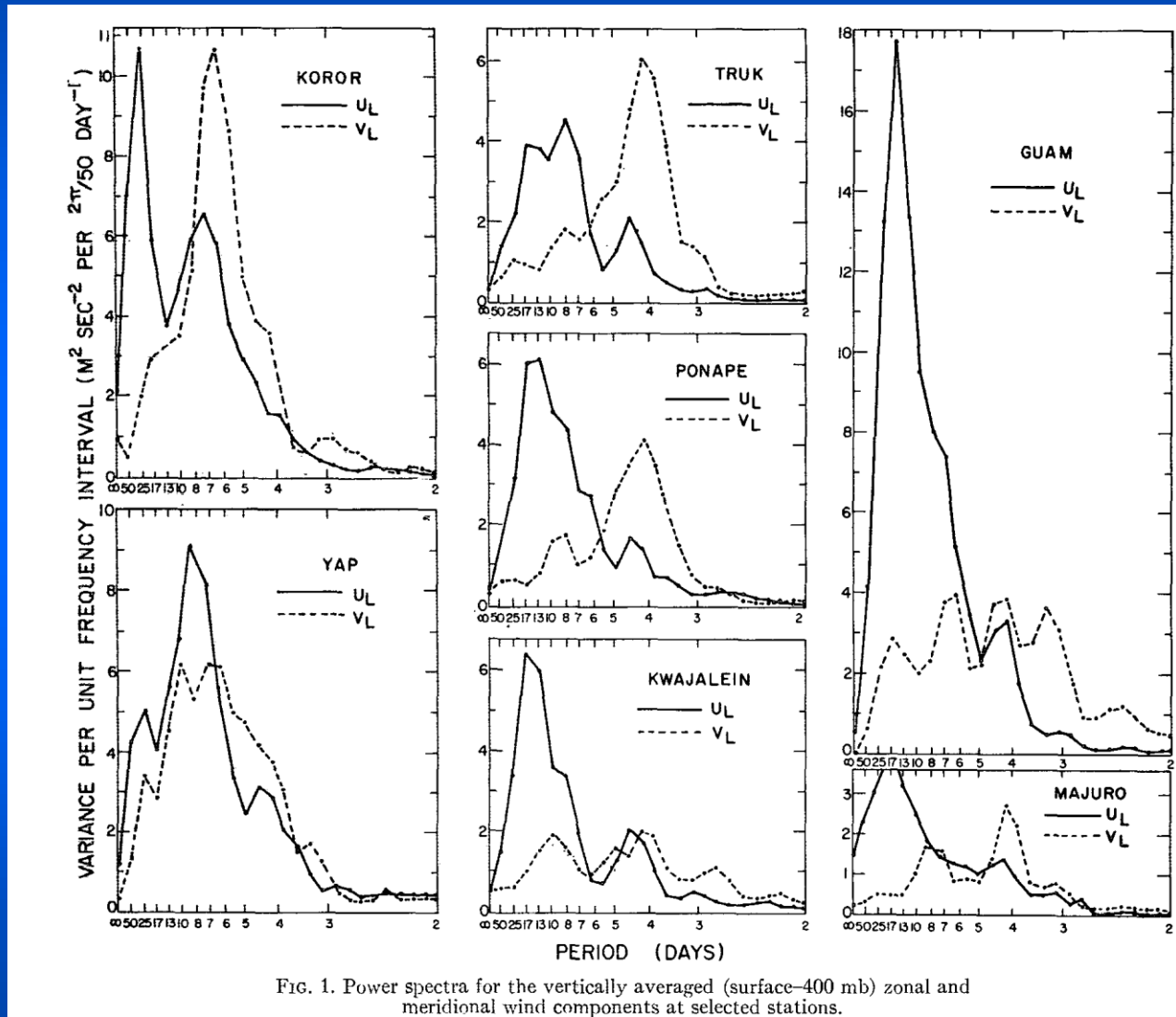
A linear trend during this period



Polynomial fit (period?)



Power Spectra for the vertically averaged zonal and Meridional wind at selected west Pacific stations



Using statistical methods to construct the structure of a weather system

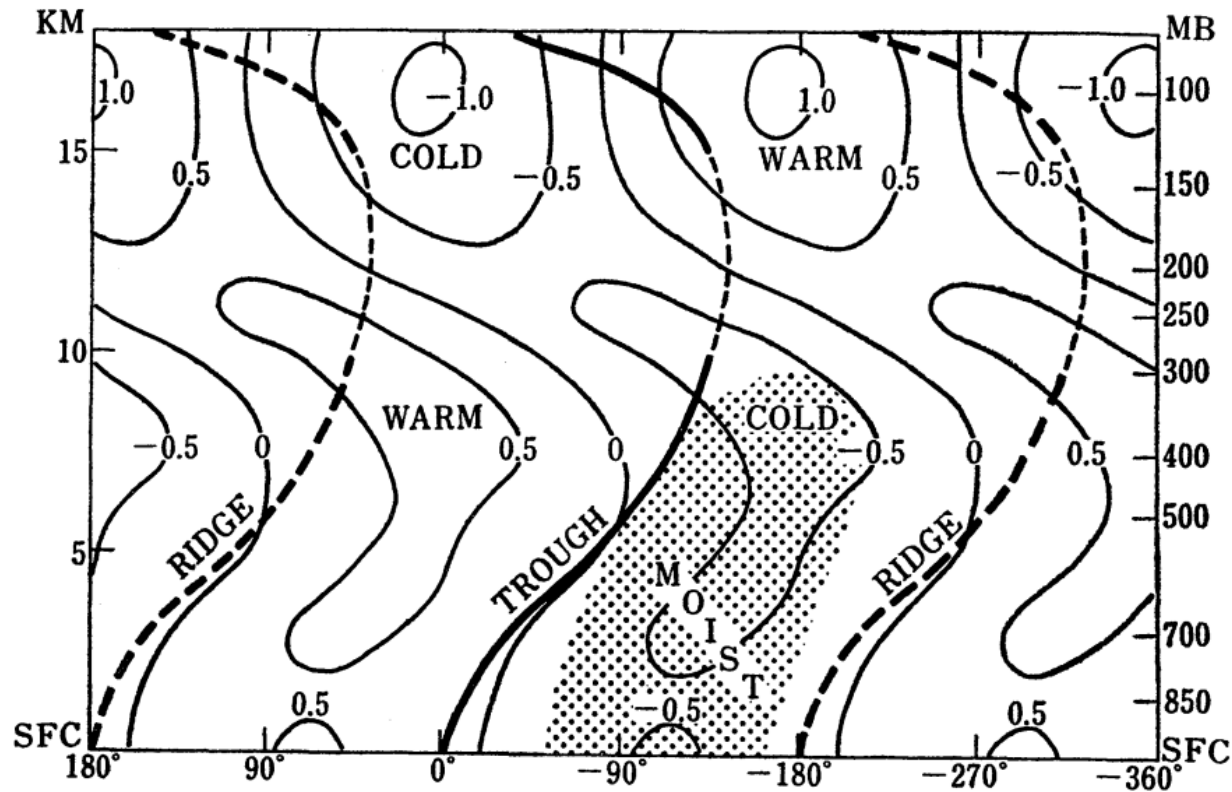
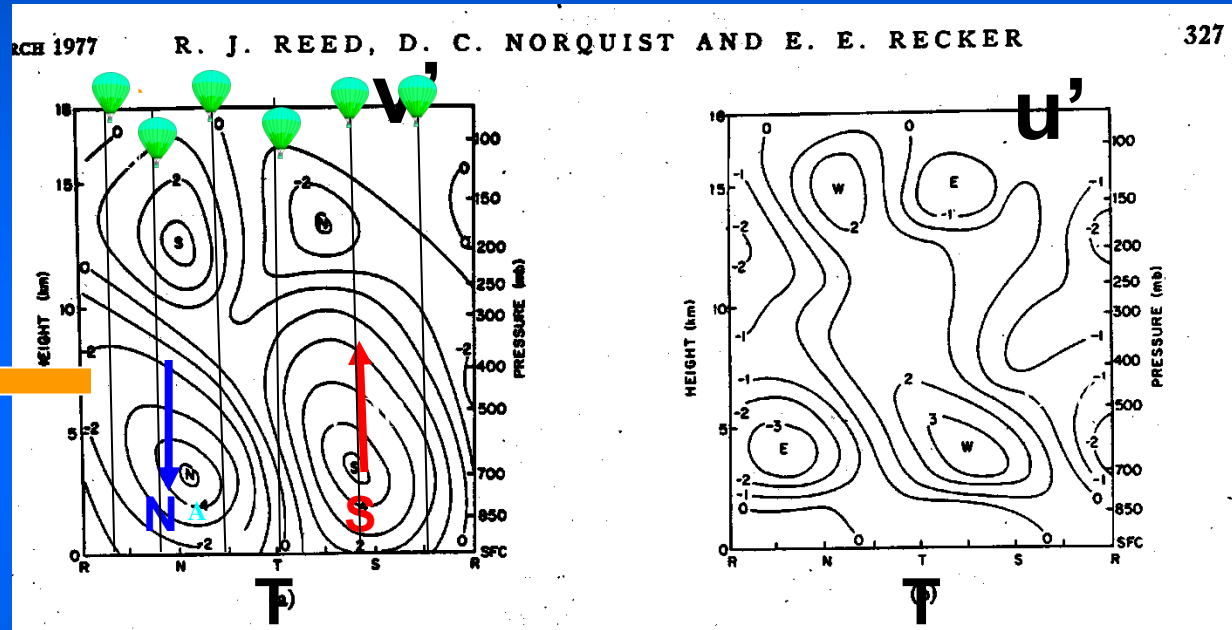


Fig. 14 Schematic structure of the disturbance in the western Pacific (see text).

Vertical Structure of Easterly Waves Along one Wavelength using composite analysis



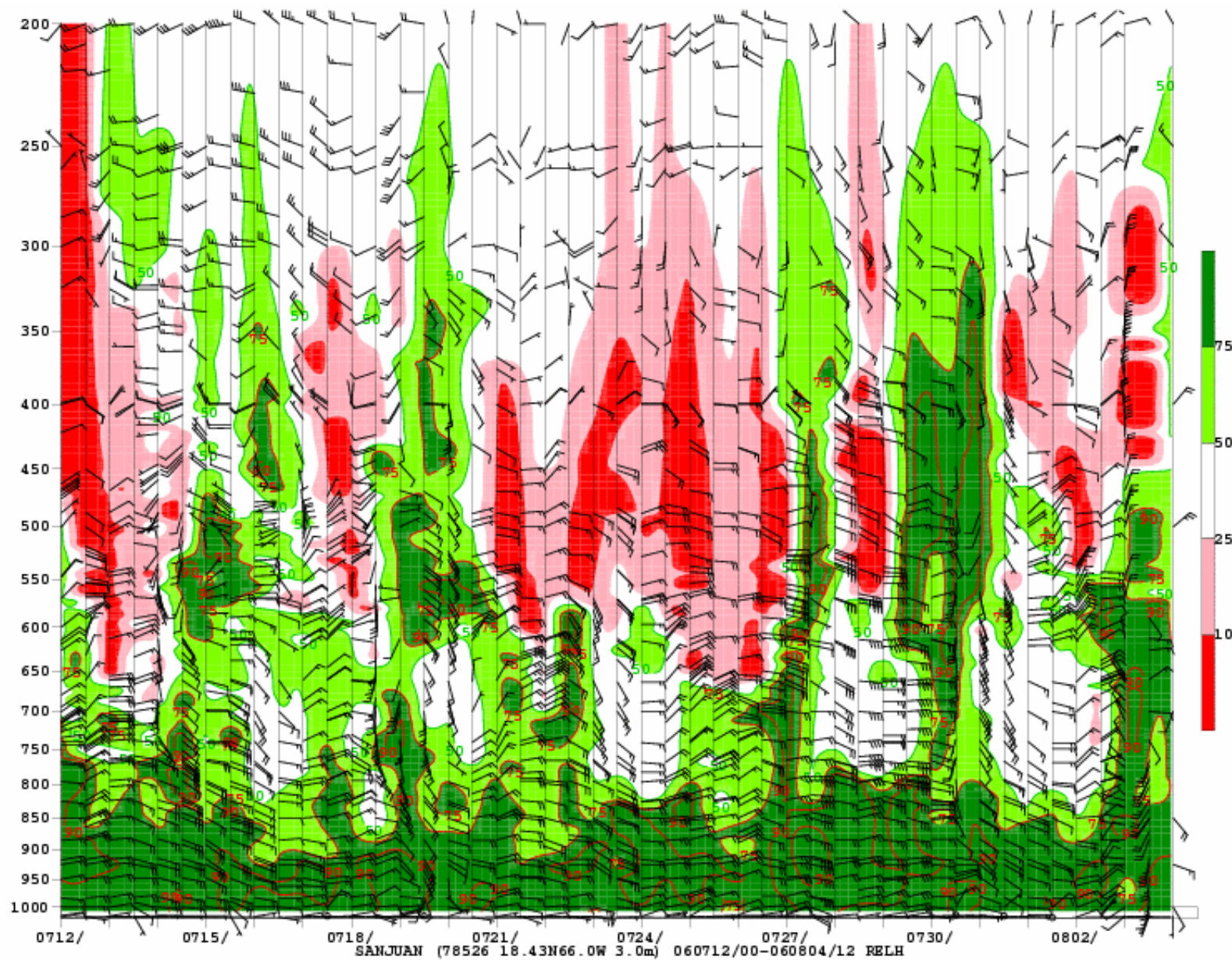
What will you see in the upper level winds when a wave passed your station from the east ?

Space-time composites

- Not just time series of observations at a given location at a given level
- Spatial coverage allows one to check for spatial coherence (structure)
- Time series for temporal structure

Time-Height Analysis

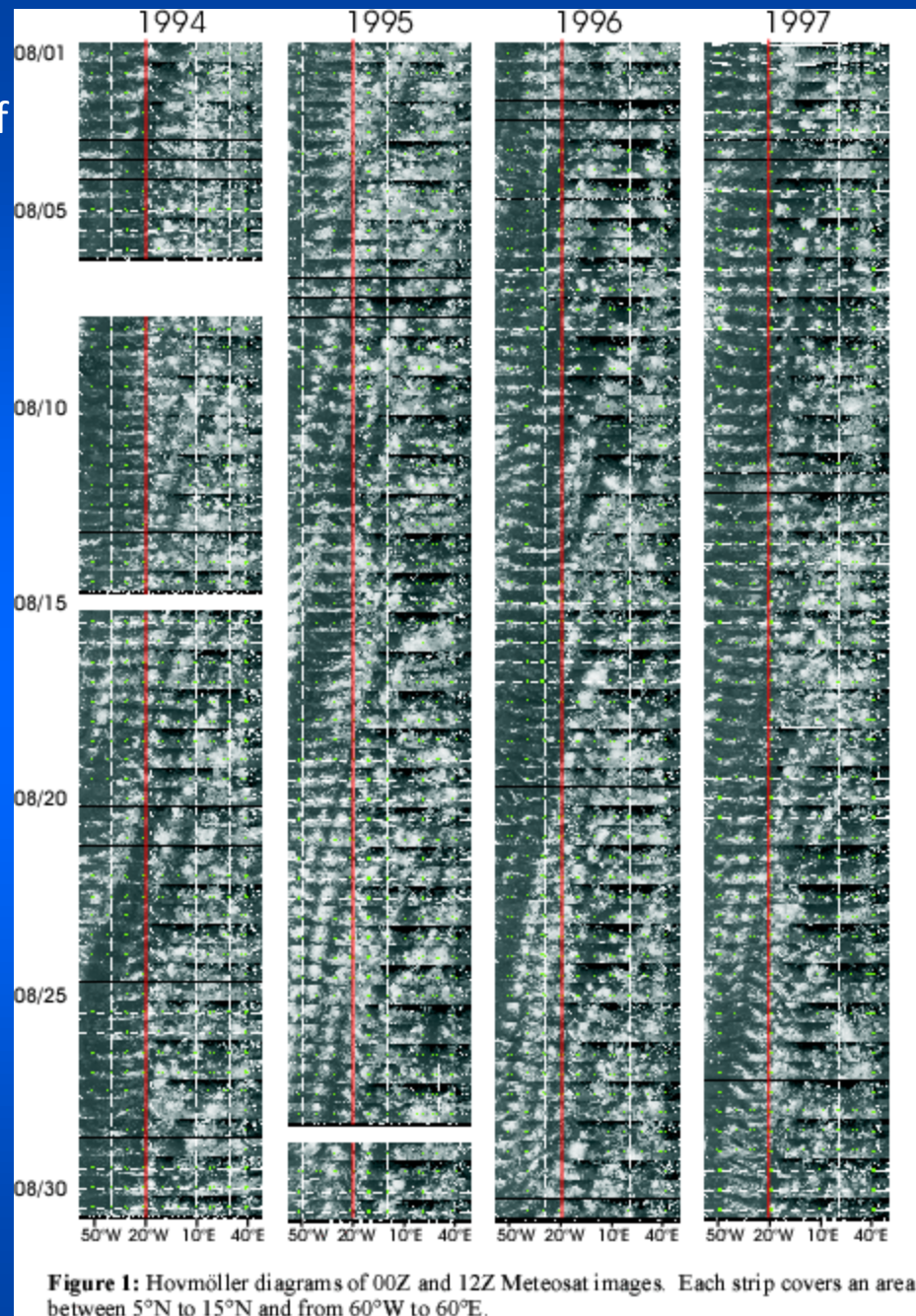
Relative humidity – San Juan July 12 – Aug 04, 2006



Hovmöller charts

Spatial (lat/lon) features and time series in one picture

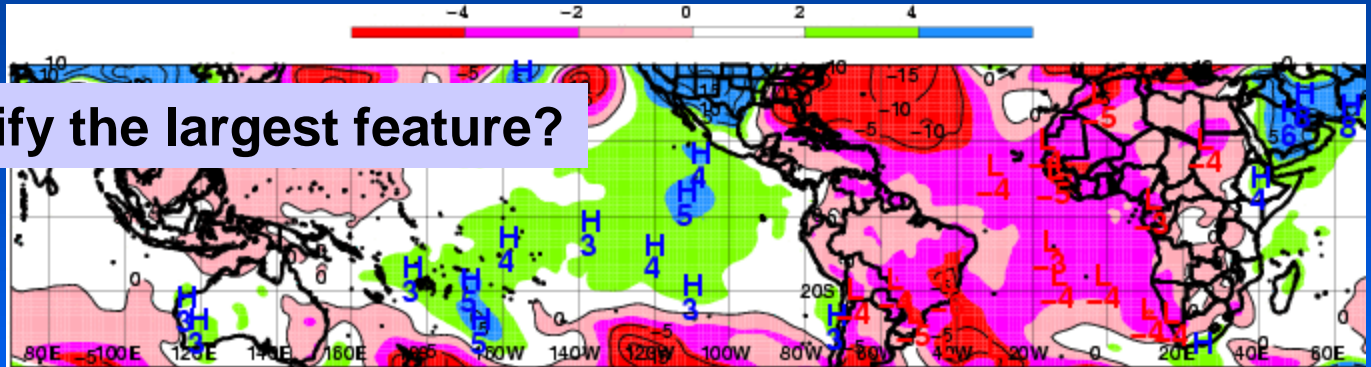
Interannual variability of
easterly wave activities



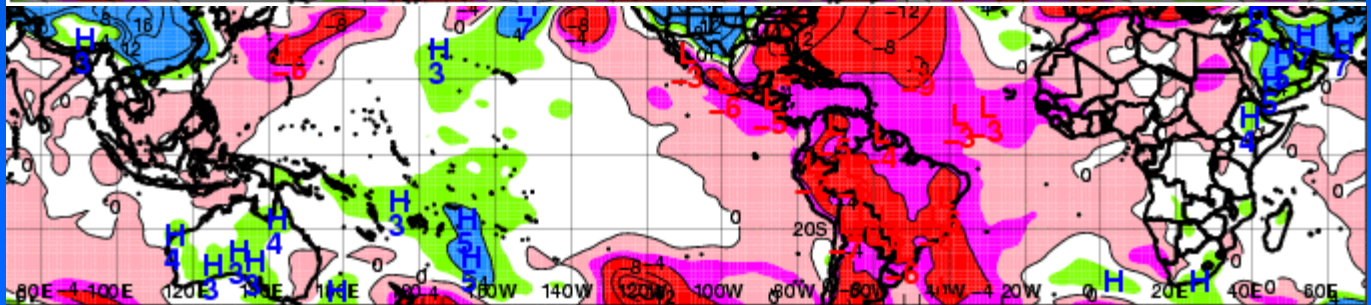
Constructing a Hovmuller Chart (MSLP anomalies)

Can you identify the largest feature?

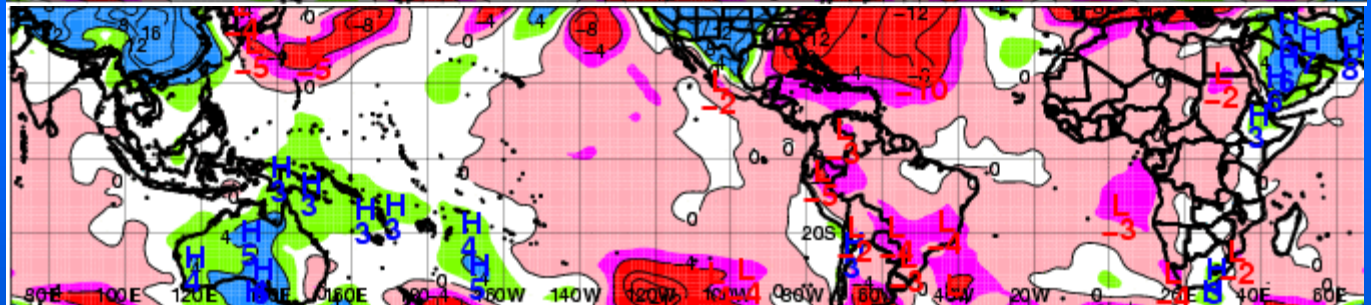
18Z Jan 5, 2006



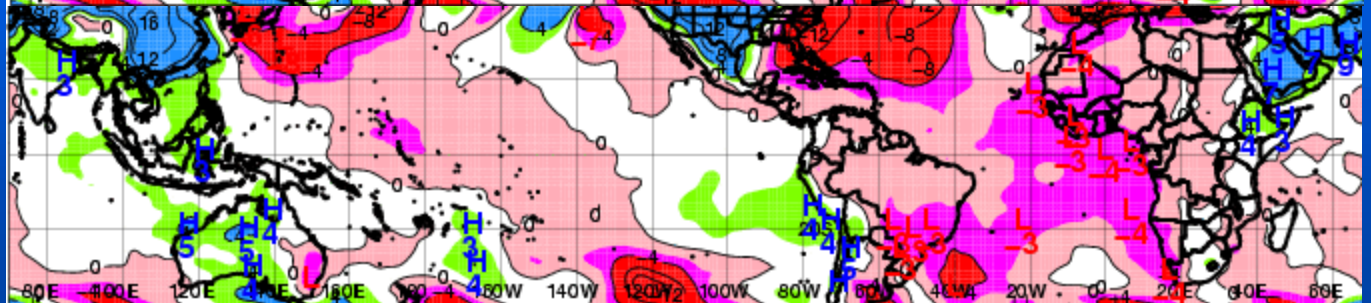
21Z Jan 5, 2006



00Z Jan 6, 2006



03Z Jan 6, 2006



January 2006 mean sea level pressure anomalies

PMSL Anomalies From Monthly Mean

Can you identify any pattern?

00Z 01/06/06

03Z 01/06/06

06Z 01/06/06

09Z 01/06/06

12Z 01/06/06

15Z 01/06/06

18Z 01/06/06

21Z 01/06/06

00Z 01/07/06

03Z 01/07/06

06Z 01/07/06

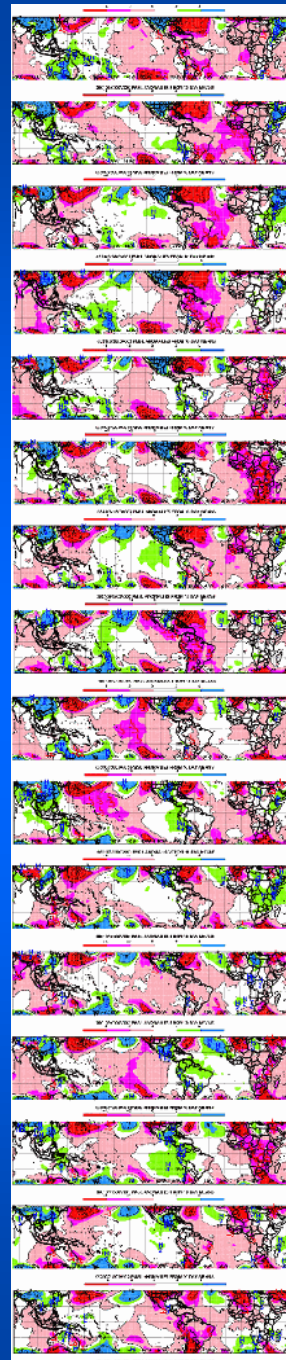
09Z 01/07/06

12Z 01/07/06

15Z 01/07/06

18Z 01/07/06

21Z 01/07/06



PMSL Anomalies From Monthly Mean

How many frames between any two lines?

How fast does the tide travel?

00Z 01/06/06

03Z 01/06/06

06Z 01/06/06

09Z 01/06/06

12Z 01/06/06

15Z 01/06/06

18Z 01/06/06

21Z 01/06/06

00Z 01/07/06

03Z 01/07/06

06Z 01/07/06

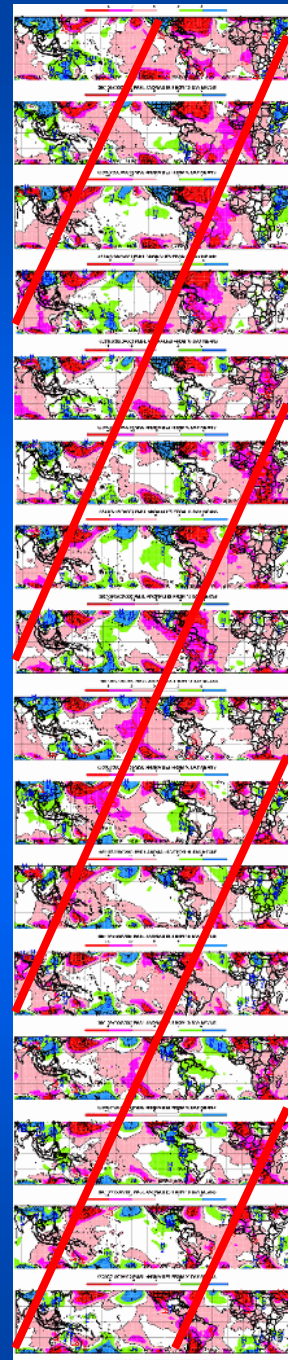
09Z 01/07/06

12Z 01/07/06

15Z 01/07/06

18Z 01/07/06

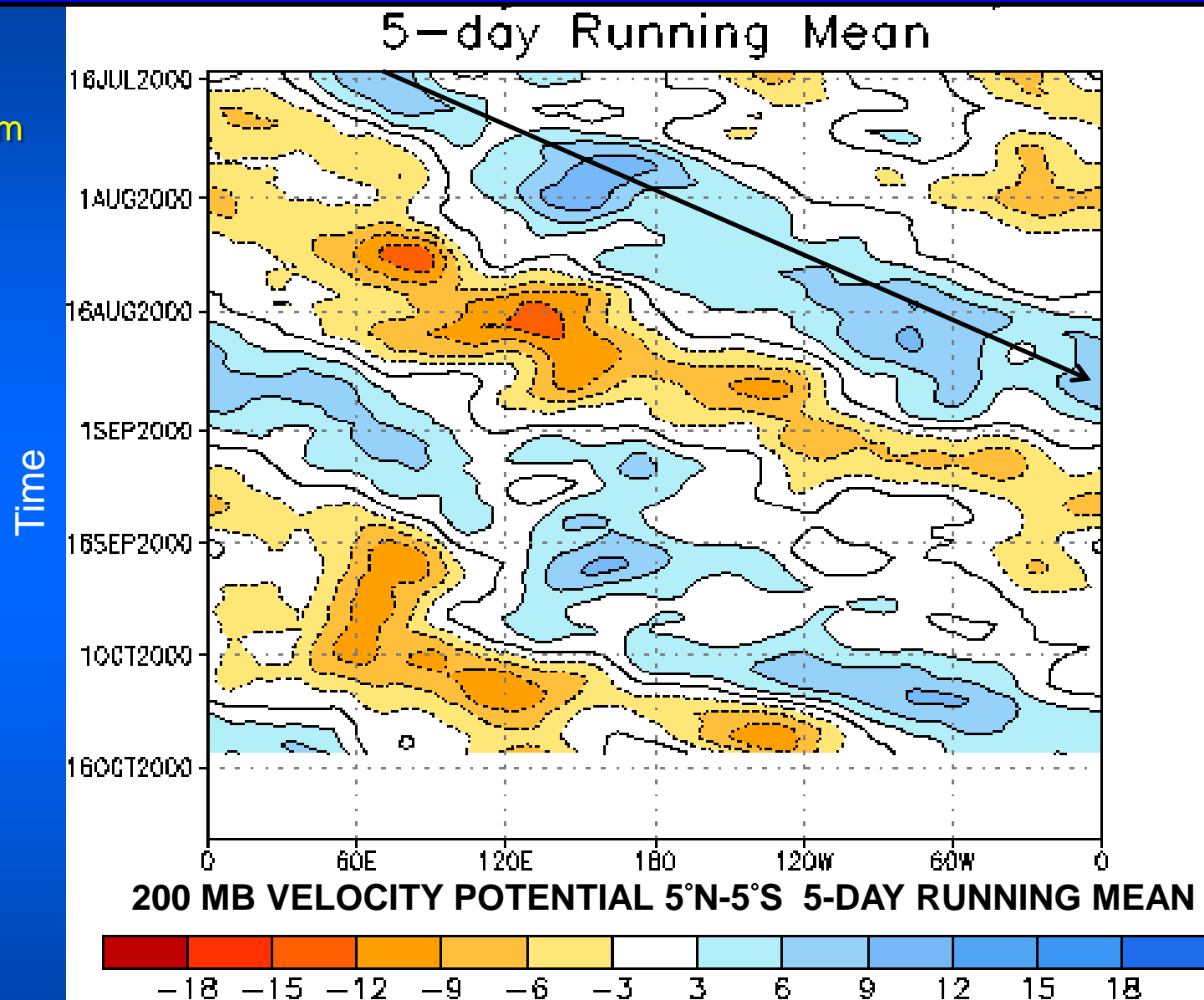
21Z 01/07/06



Using 200 mb velocity potential to track the MJO

What can we get from this picture?

- 1.
- 2.
- 3.
- 4.

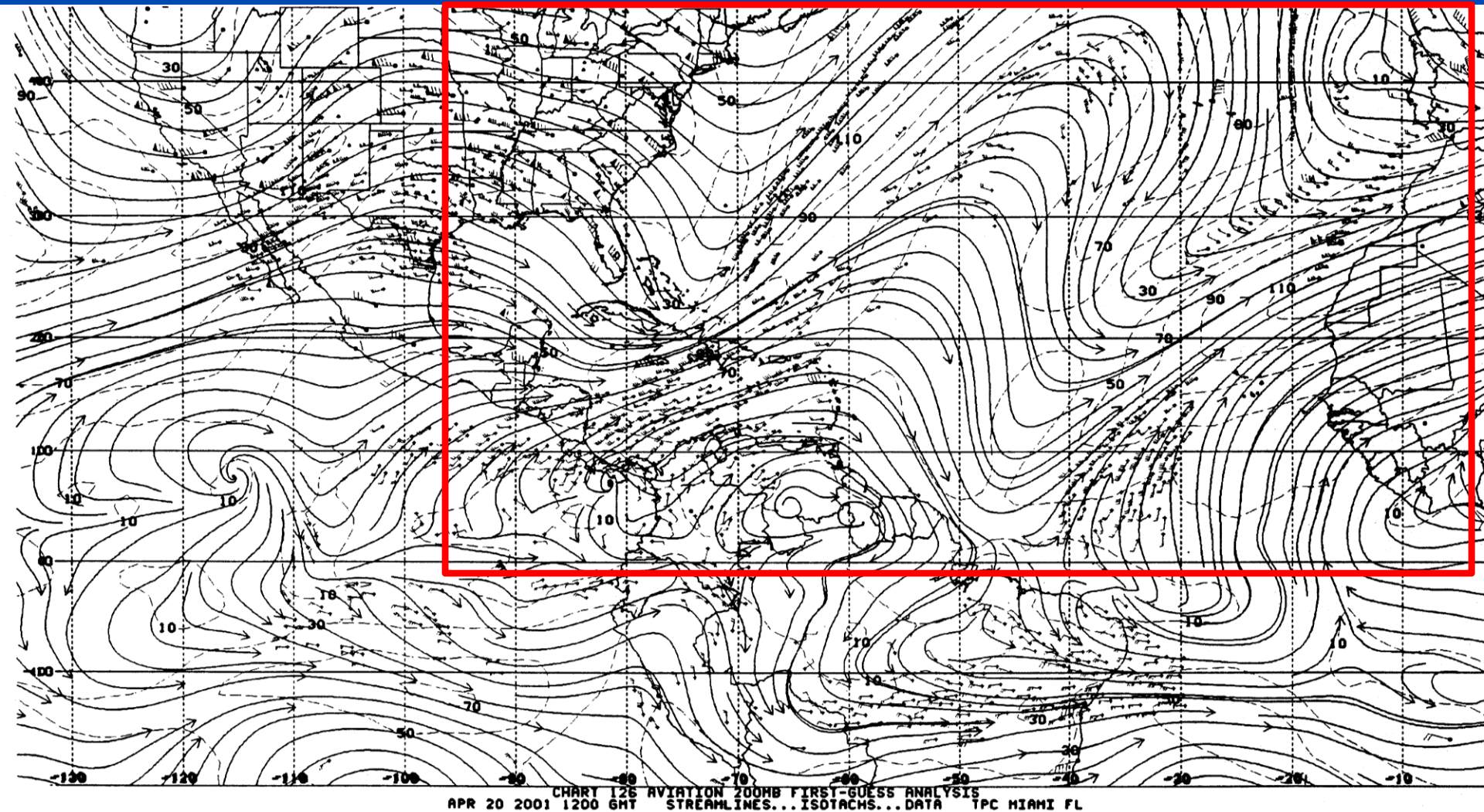


Exercise #2

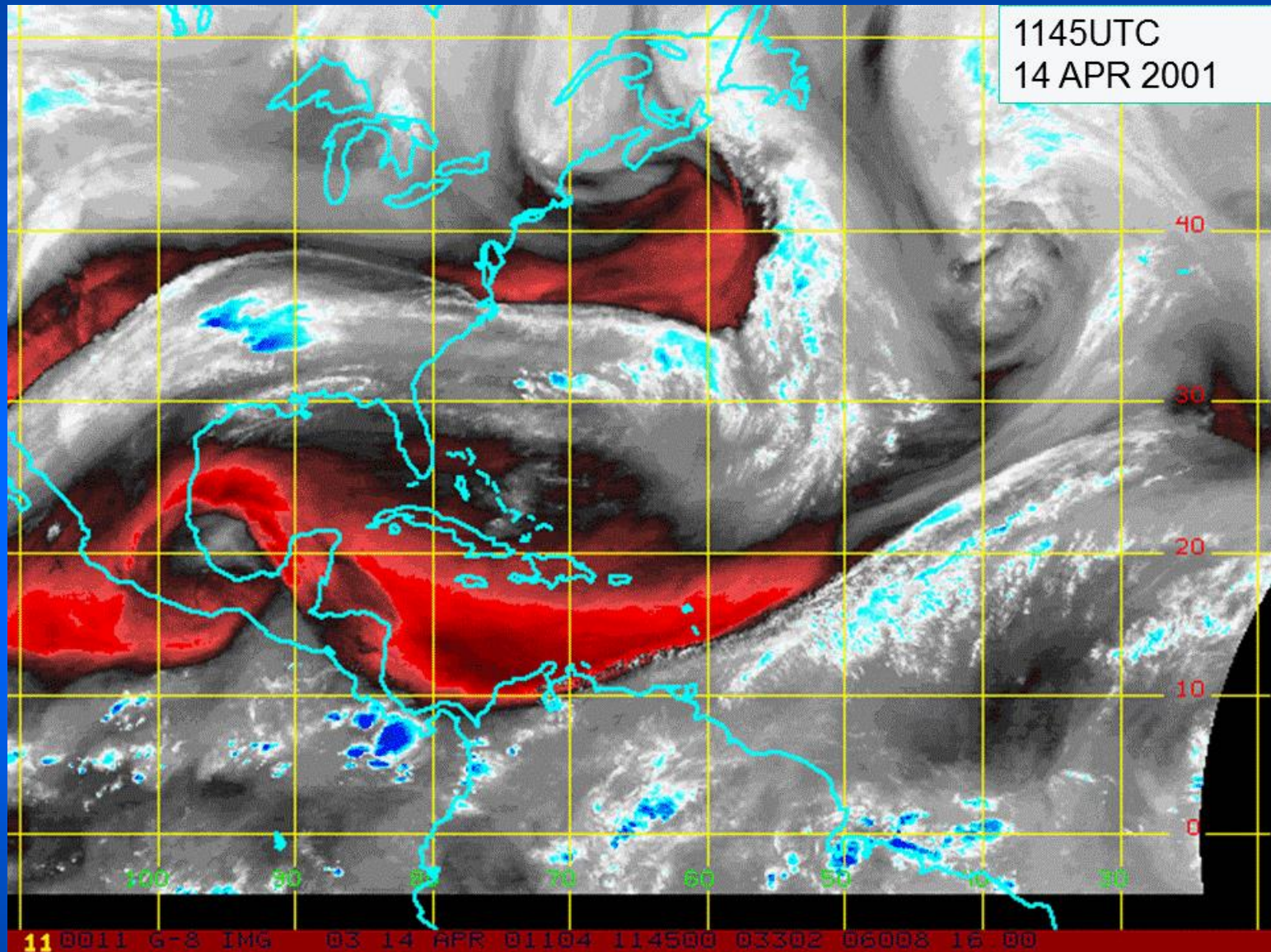
Explain what you see in the following
200 mb stramline chart

200 mb streamlines

How many large-scale features can you identify?

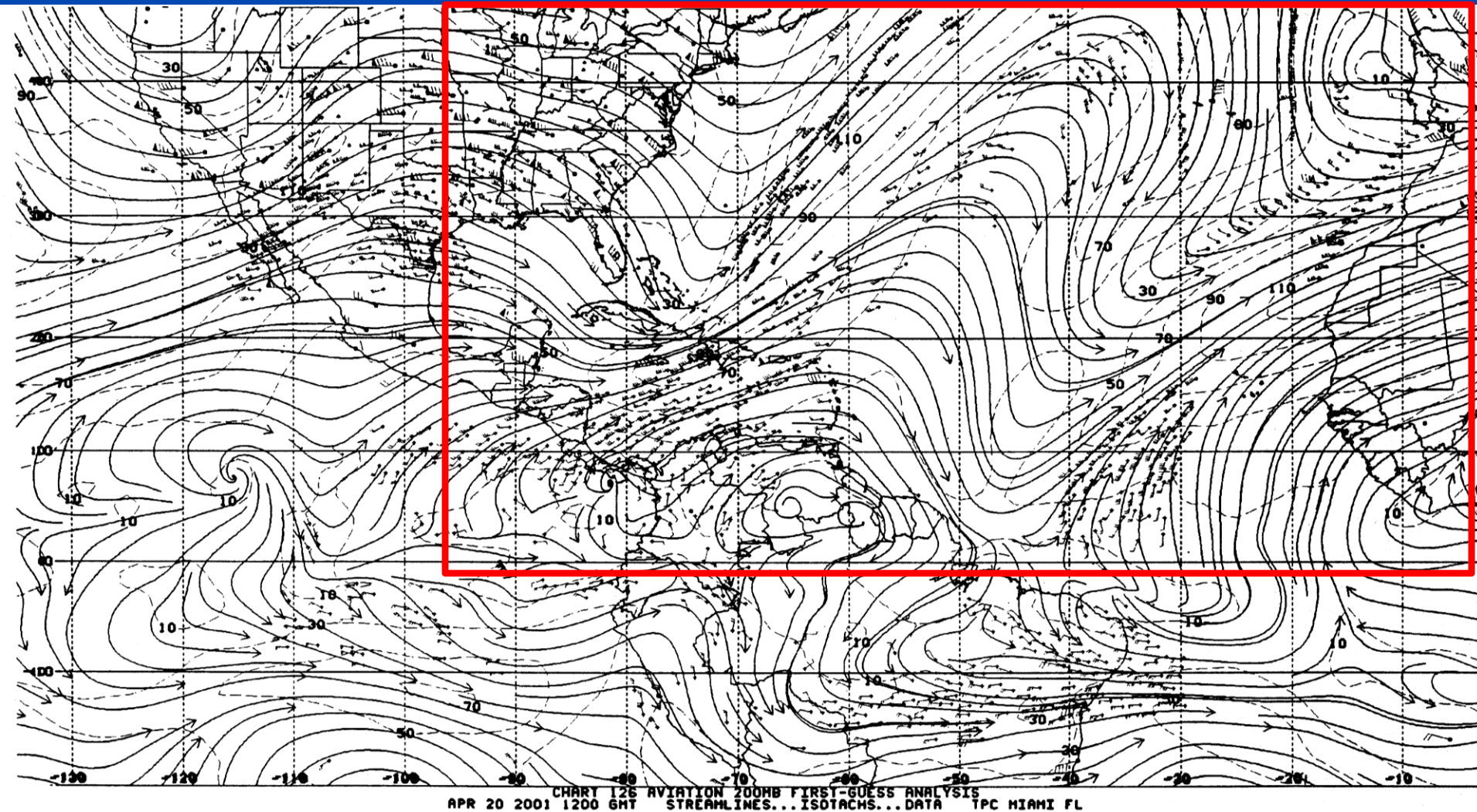


1200 UTC Apr. 20, 2001

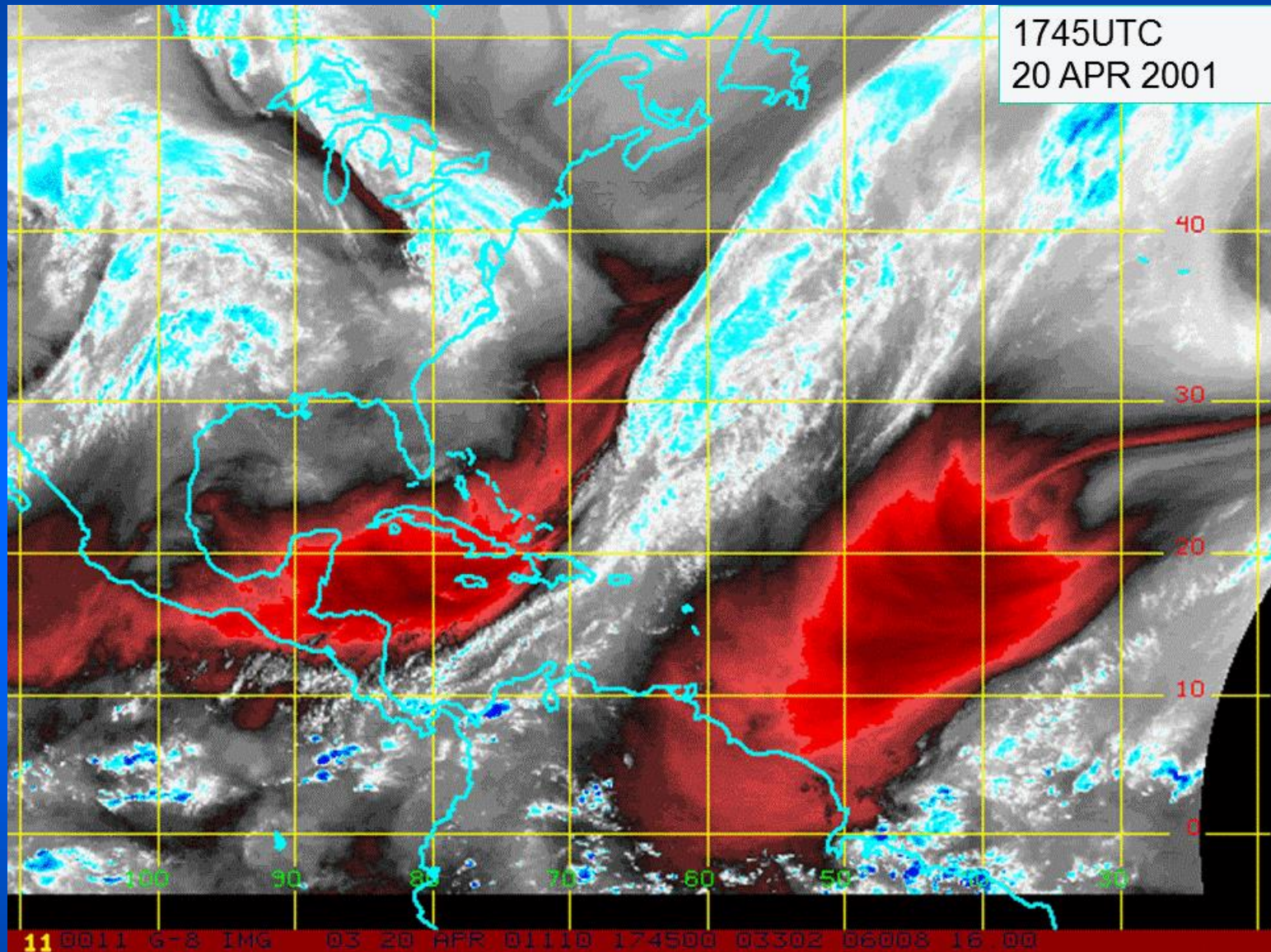


200 mb streamlines

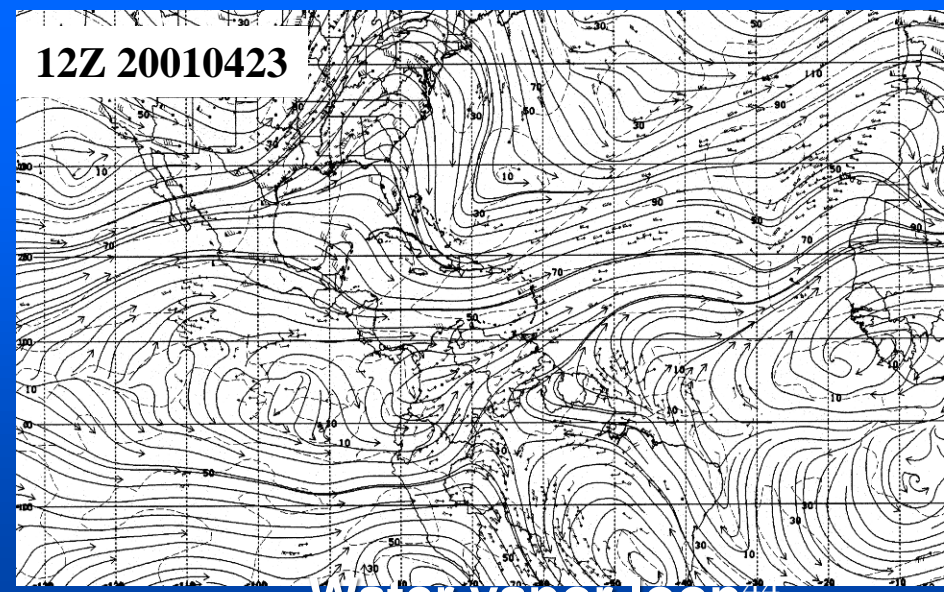
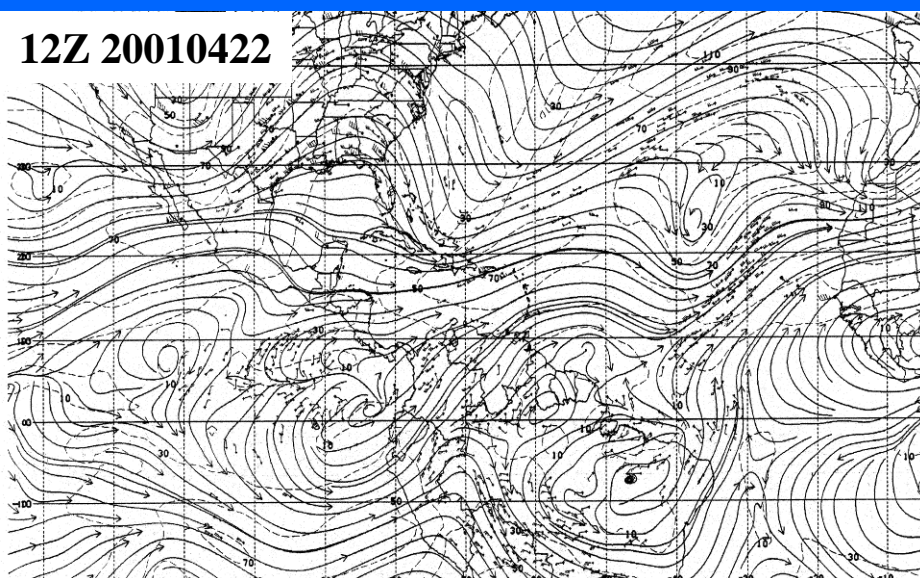
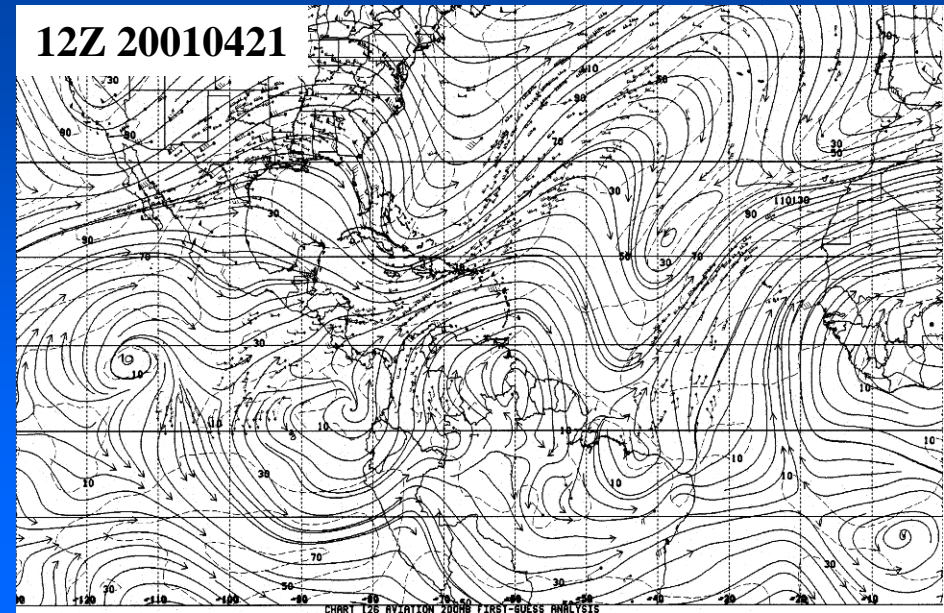
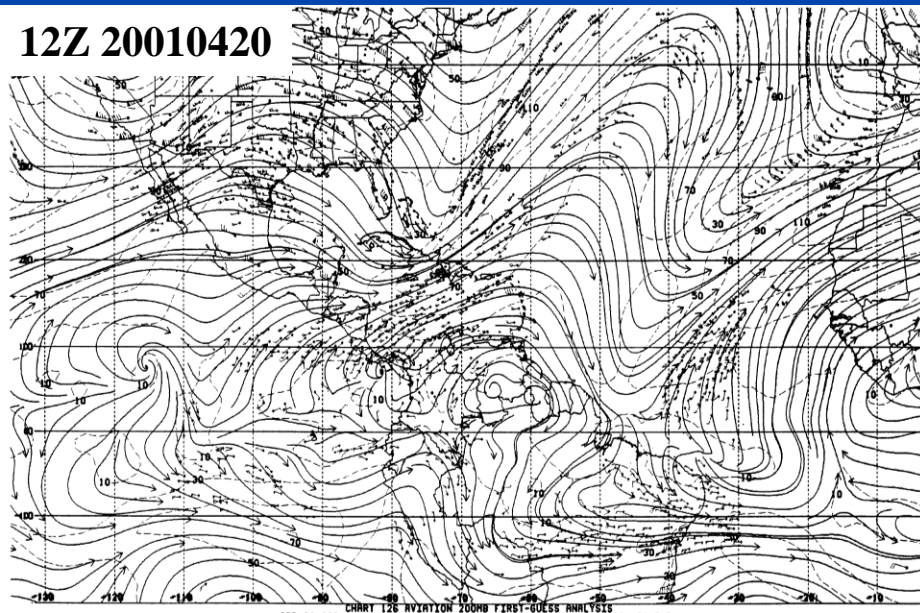
How many large-scale features can you identify?



1200 UTC Apr. 20, 2001



Days later



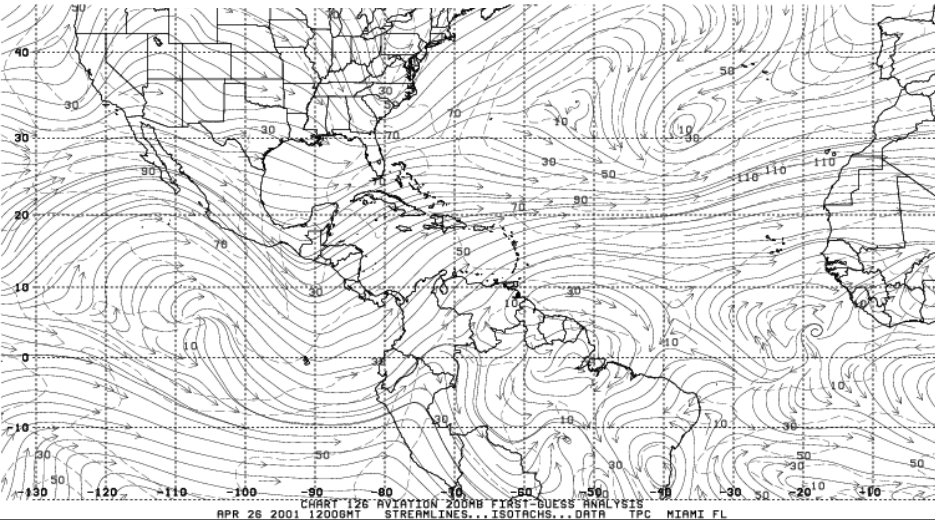
Water vapor loop⁴⁴



and later

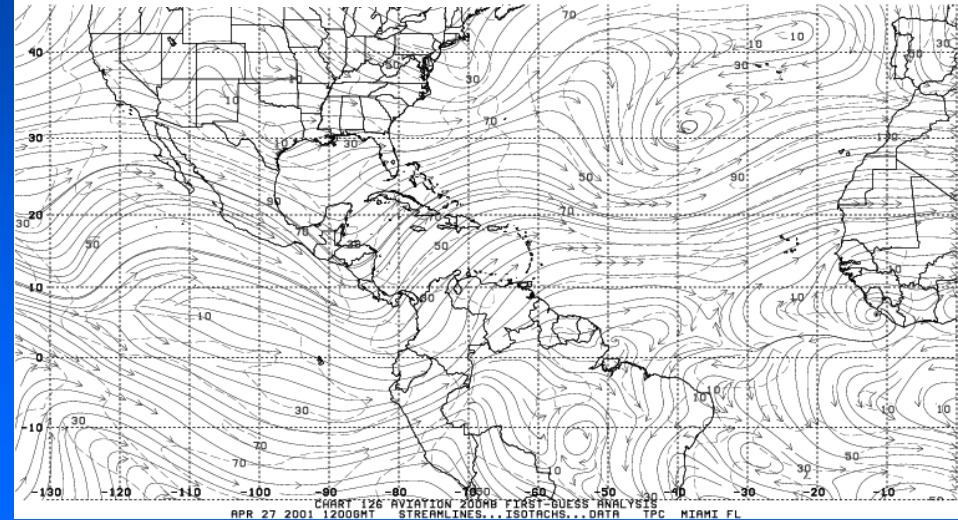
20010426/1200 UTC

WIND
△ PIREP



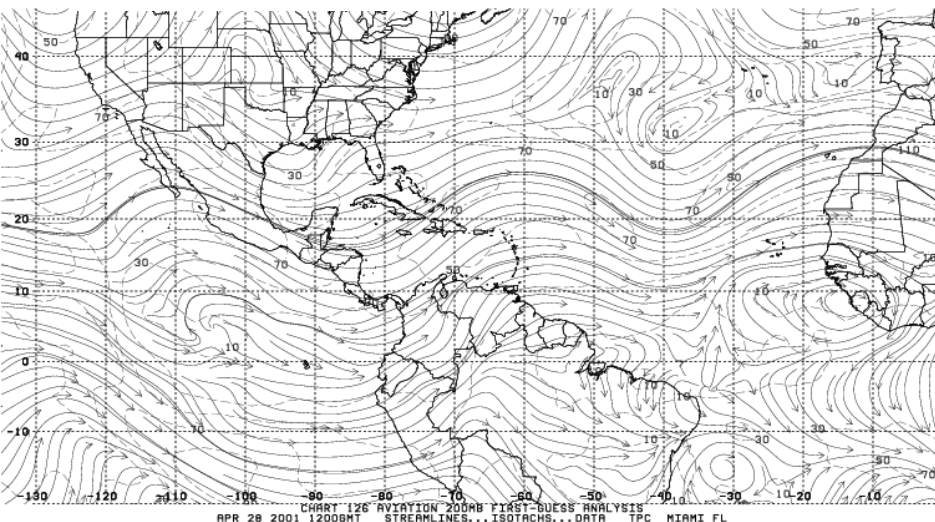
20010427/1200 UTC

ITWIND
△ PIREP



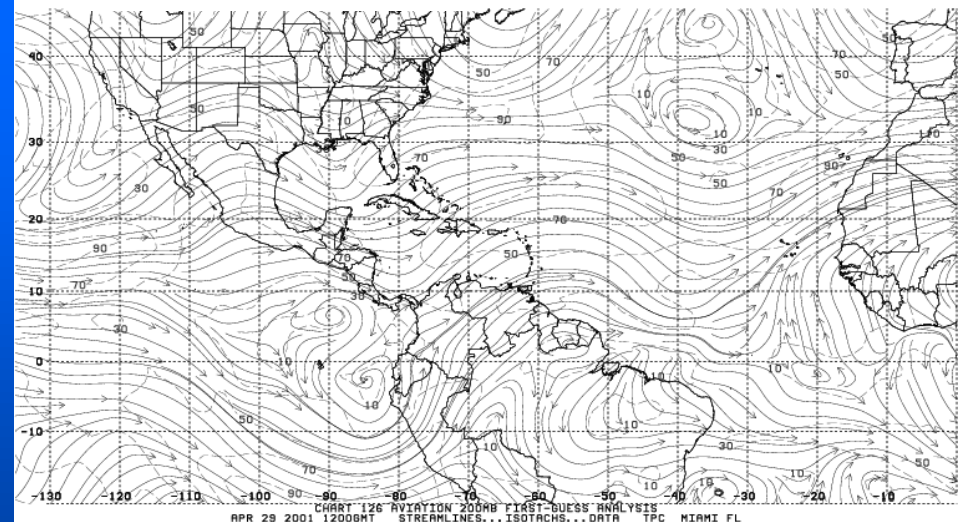
20010428/1200 UTC

ATWIND
△ PIREP



20010429/1200 UTC

SATWIND
△ PIREP



What we see on a chart maybe the combination of many different systems, sometimes from different latitudinal regimes

It is critical that a forecaster is able to identify and separate these different systems

Filtering

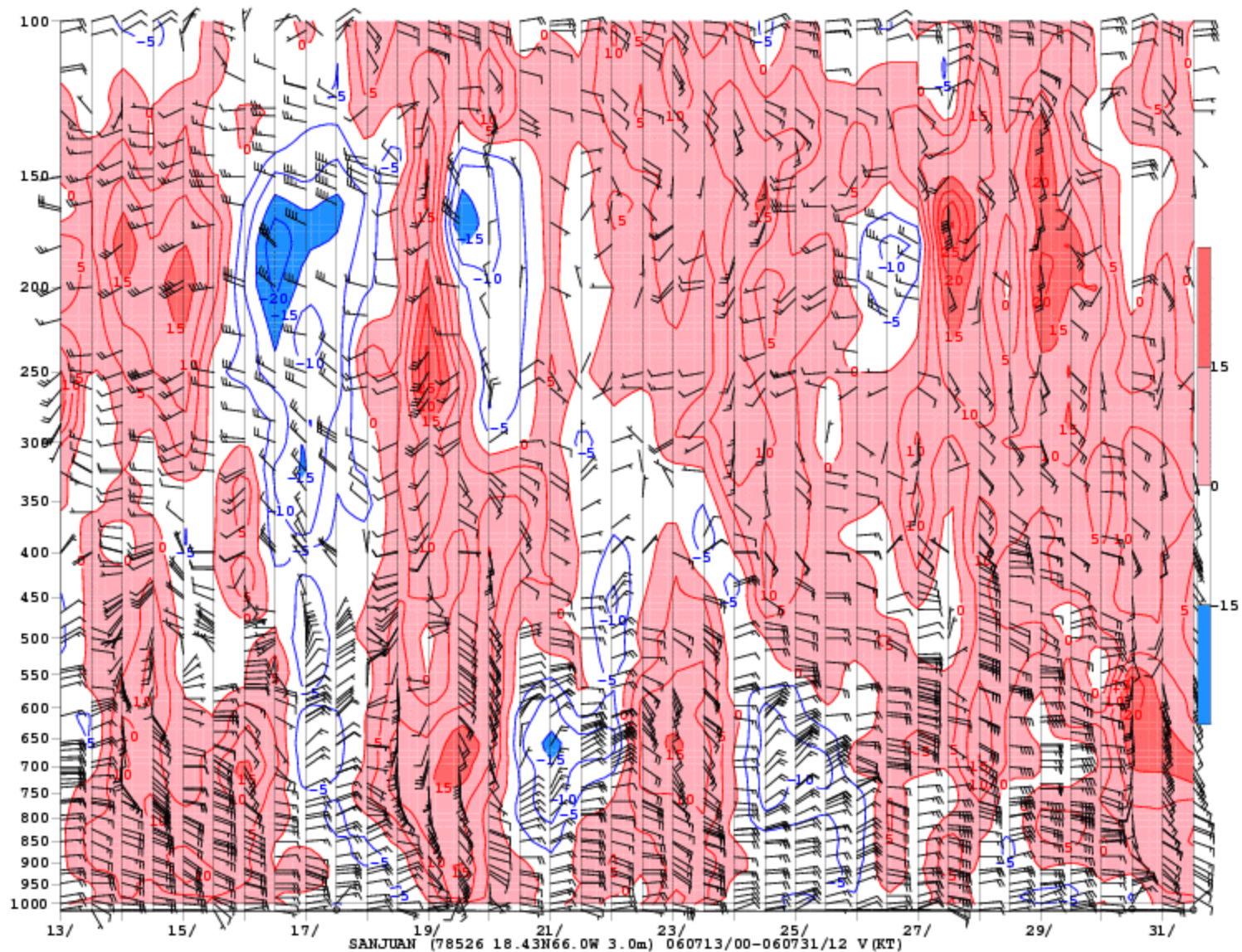
High pass, low pass, band pass, ...

Perturbation analysis (easiest one)

- Remove the area-mean or time-mean to show the anomalies
- It shows the presence of weather systems better
- Very useful in the tropics when the amplitude of many systems are small

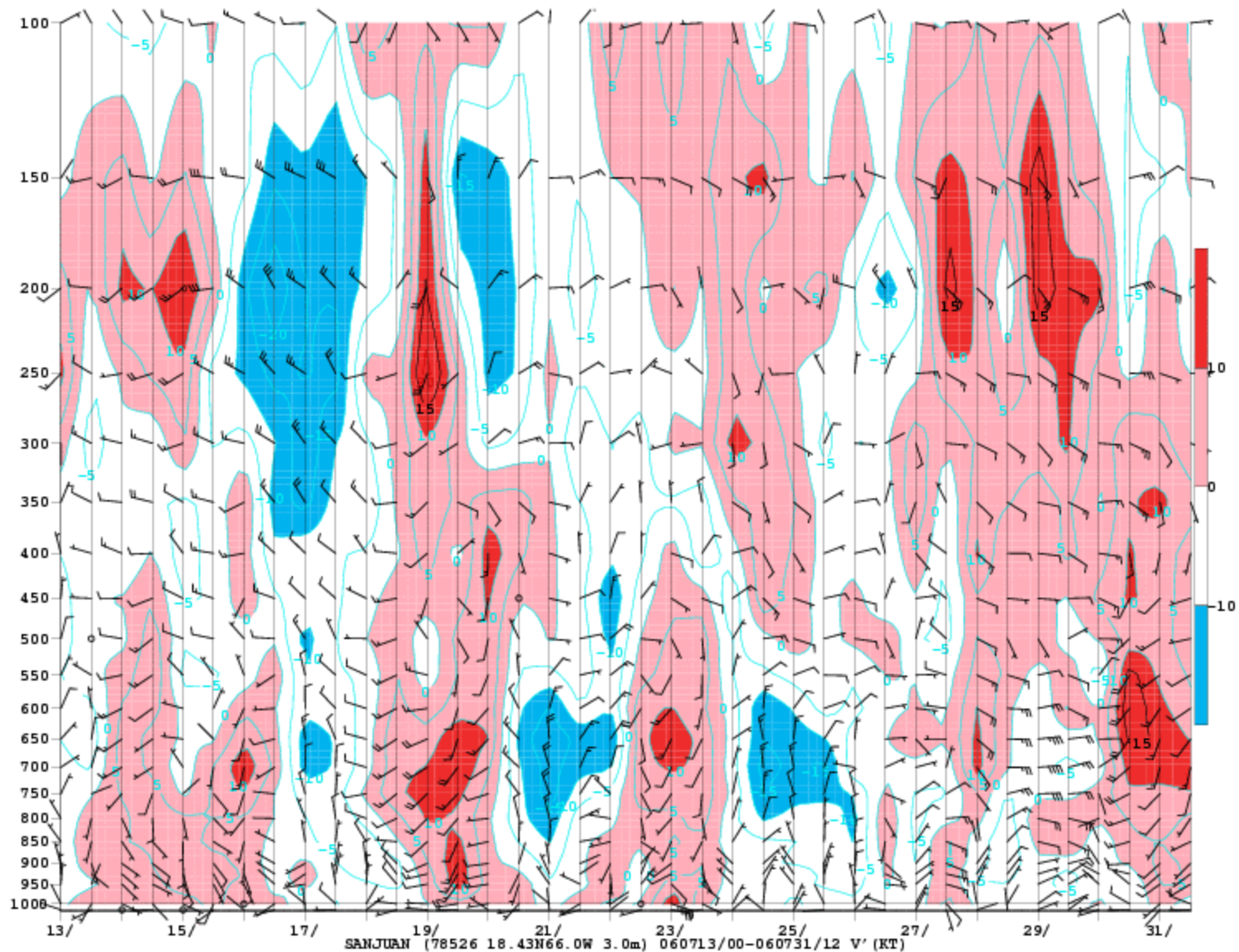
Meridional Wind – San Juan

July 13-July 31, 2006



Meridiornal Wind Anomalies – San Juan

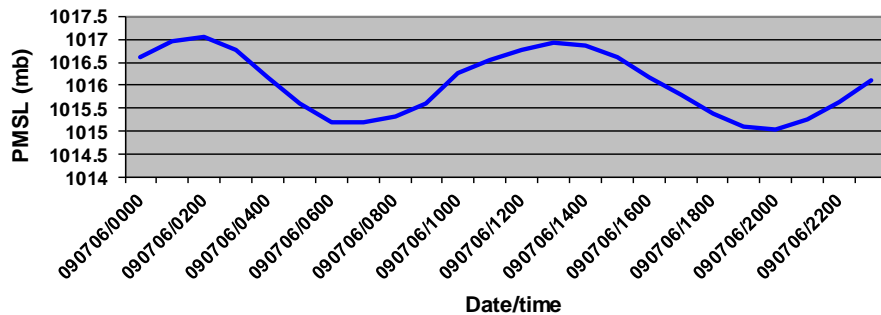
July 13-July 31, 2006 time-means at each level removed



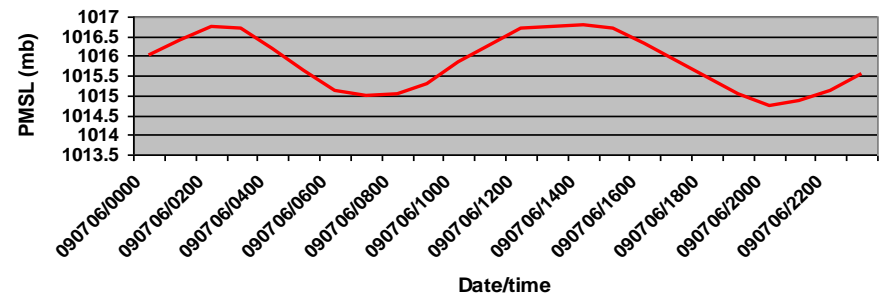
The hourly mean also hold information semidiurnal pressure tides

Guadeloupe PALT July 12-31, 2008

Hourly Mean PMSL at 41041



Hourly Mean PMSL at 41040



080712/0000 080713/0000 080714/0000 080715/0000 080716/0000 080717/0000 080718/0000 080719/0000 080720/0000 080721/0000 080722/0000 080723/0000 080724/0000 080725/0000 080726/0000 080727/0000 080728/0000 080729/0000 080730/0000 080731/0000

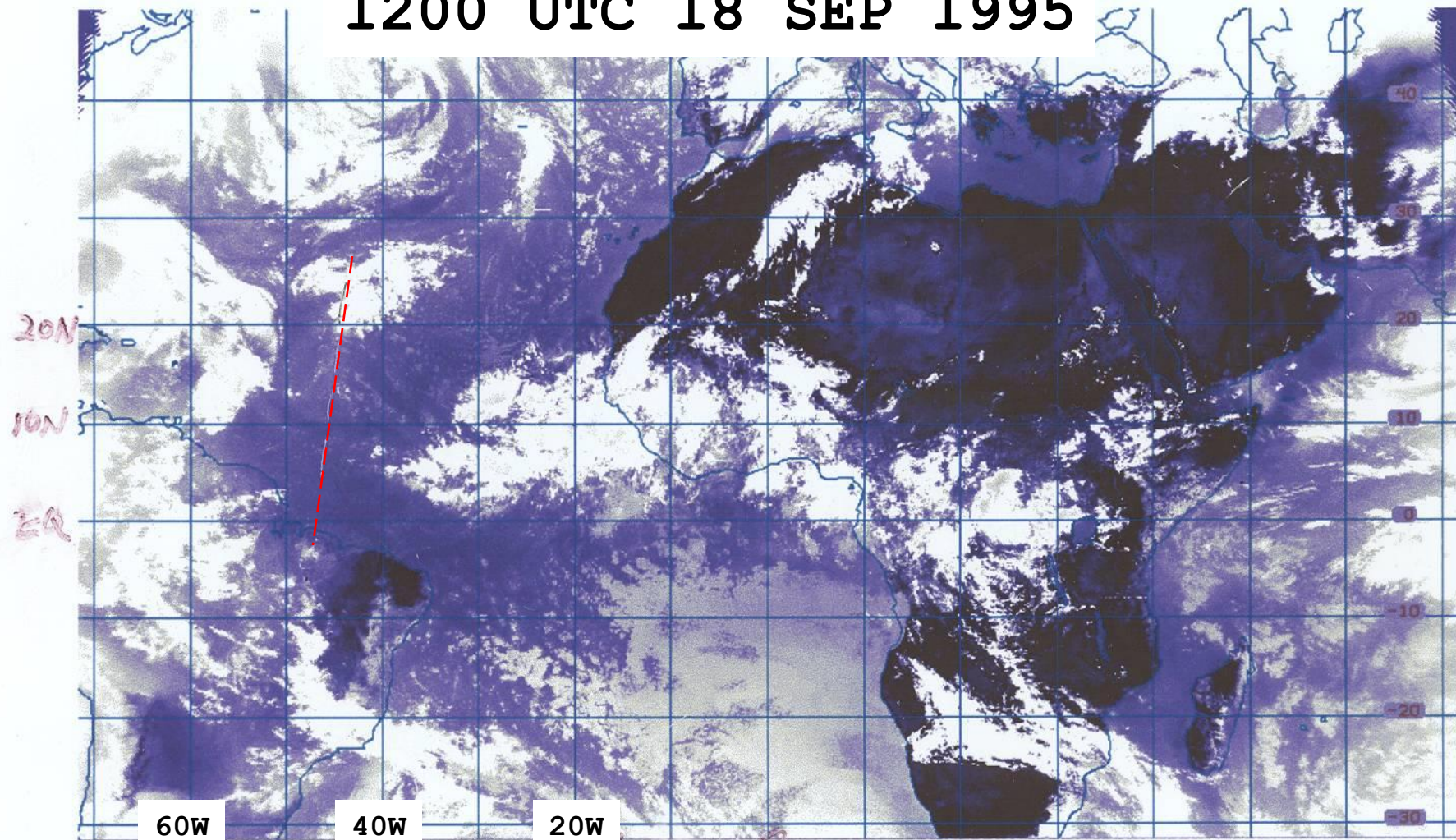
Date/time

- By averaging MSLP for each hour, 00Z, 01Z, 02Z, ... the resulting series show the Diurnal and semidiurnal surface pressure tide, and the long term mean (~1016 mb)
- By removing the long term man and the diurnal/semidiurnal tides from the observed data, we can see the effects of weather related surface pressure changes better.

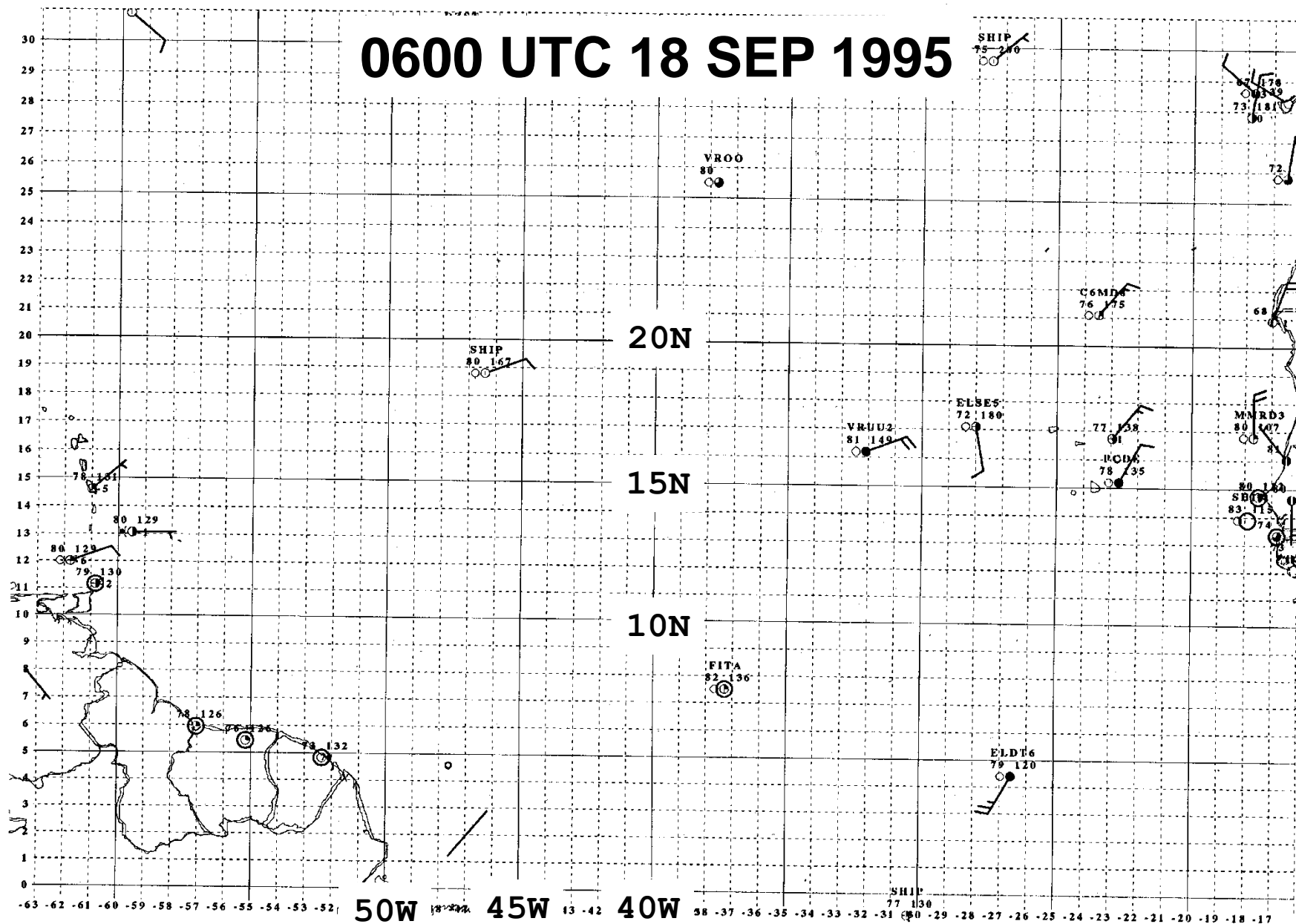
COMPOSITE ANALYSIS

Looking beyond just one reporting time

1200 UTC 18 SEP 1995

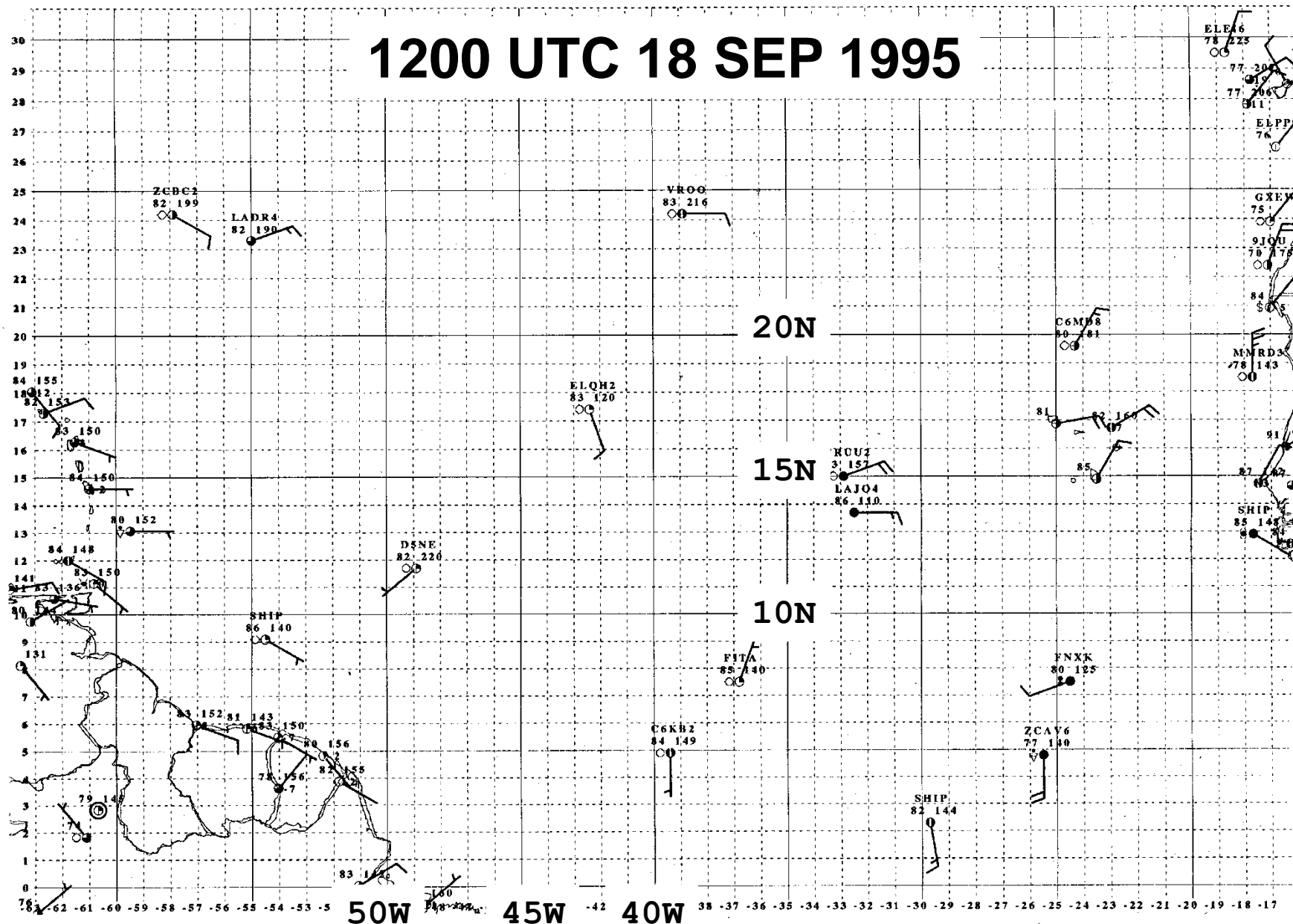


SHIP
75-240
100



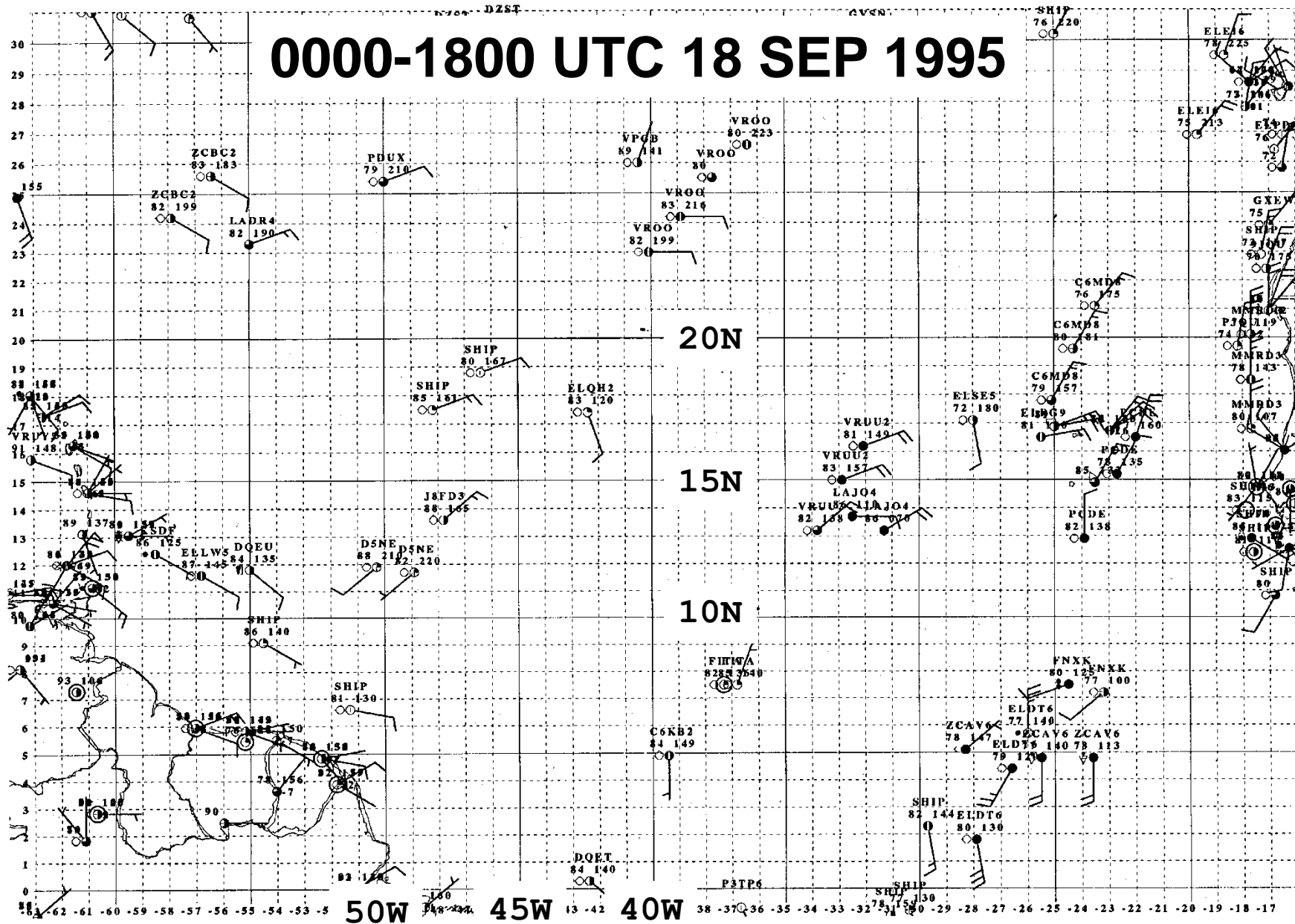
SHIP
77 130
31 50 -2

1200 UTC 18 SEP 1995



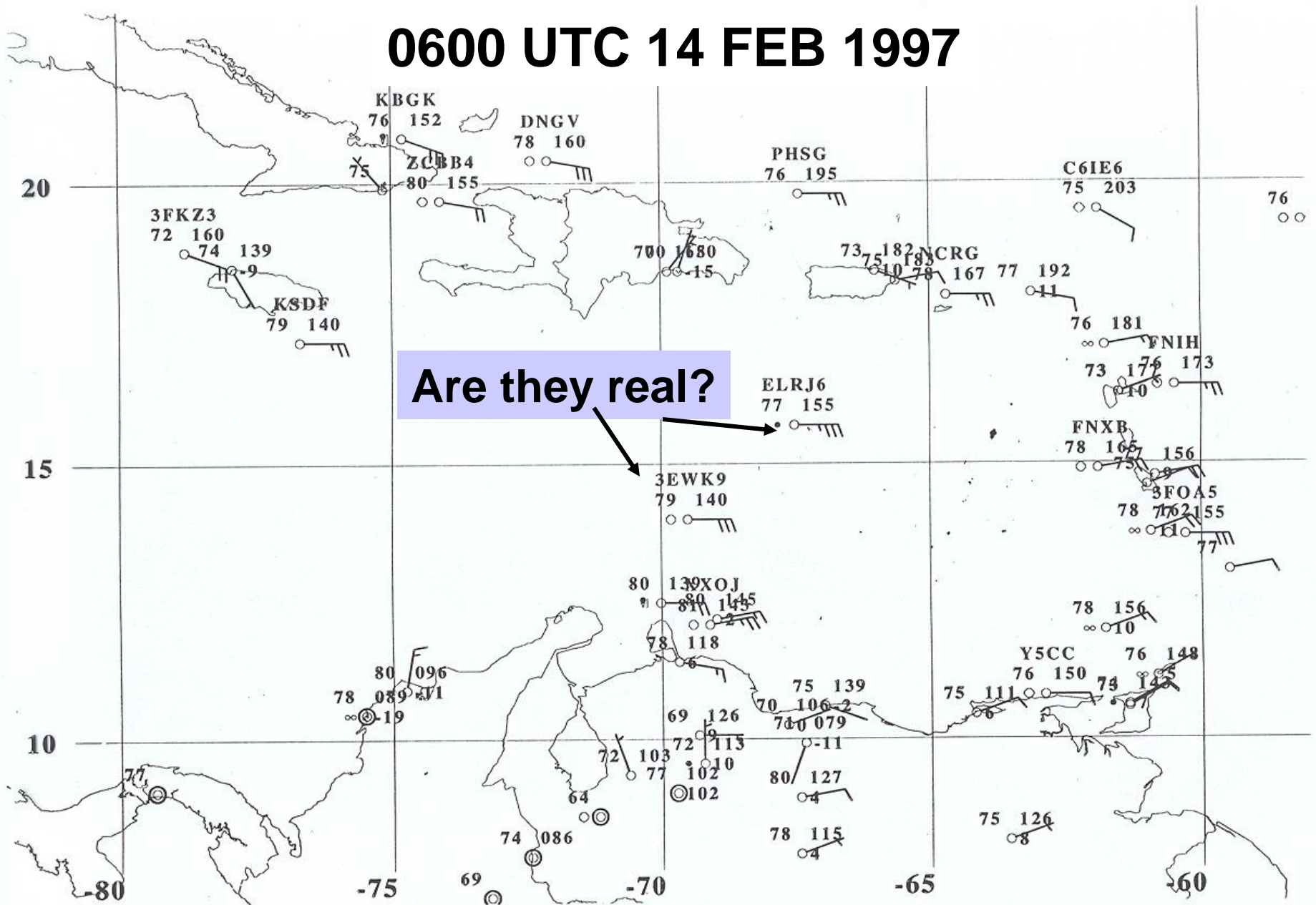
950918/12Z MEAN SEA LEVEL CHART

0000-1800 UTC 18 SEP 1995



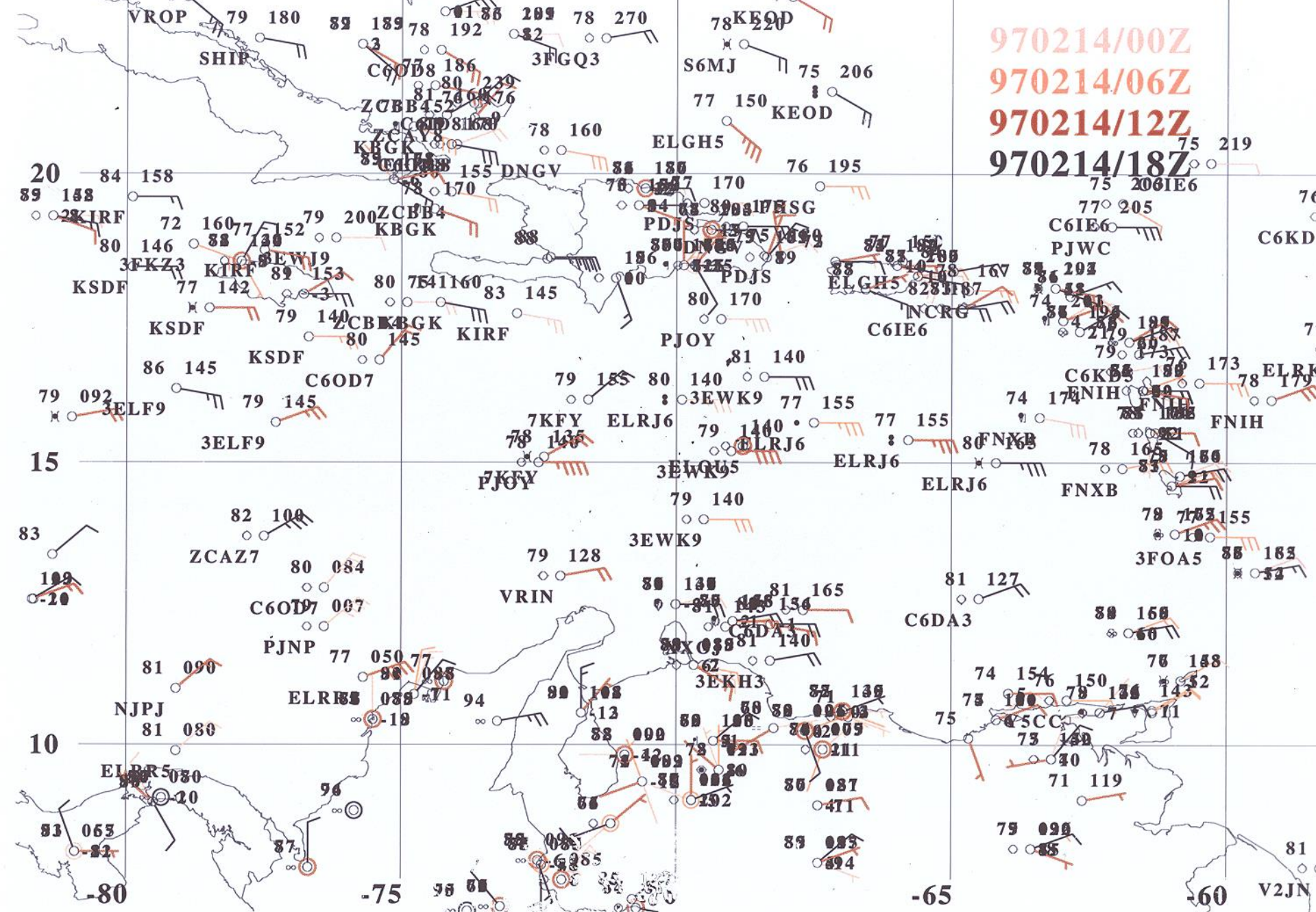
950918/00-18Z MEAN SEA LEVEL CHART

0600 UTC 14 FEB 1997



970214/06Z MEAN SEA LEVEL CHART

970214/18Z



970214/00Z-970214/18Z COMPOSITE MSL CHART

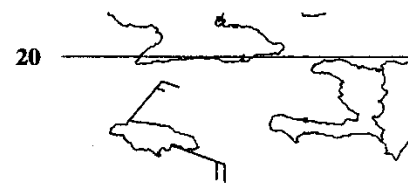
LOCAL EFFECTS

They can make synoptic analysis a very difficult task if not removed from the dataset
(either physically/mathematically or mentally)

Wind shift
between Kingston
and Montego Bay
at 18Z on those
days, suggesting
a trough over the
island



980701/18Z



980702/18Z



980703/18Z



980704/18Z

Heated island

But the wind shift
was mostly gone
by 00Z



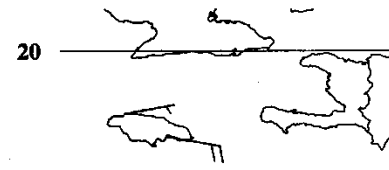
980701/00Z



980702/00Z



980703/00Z

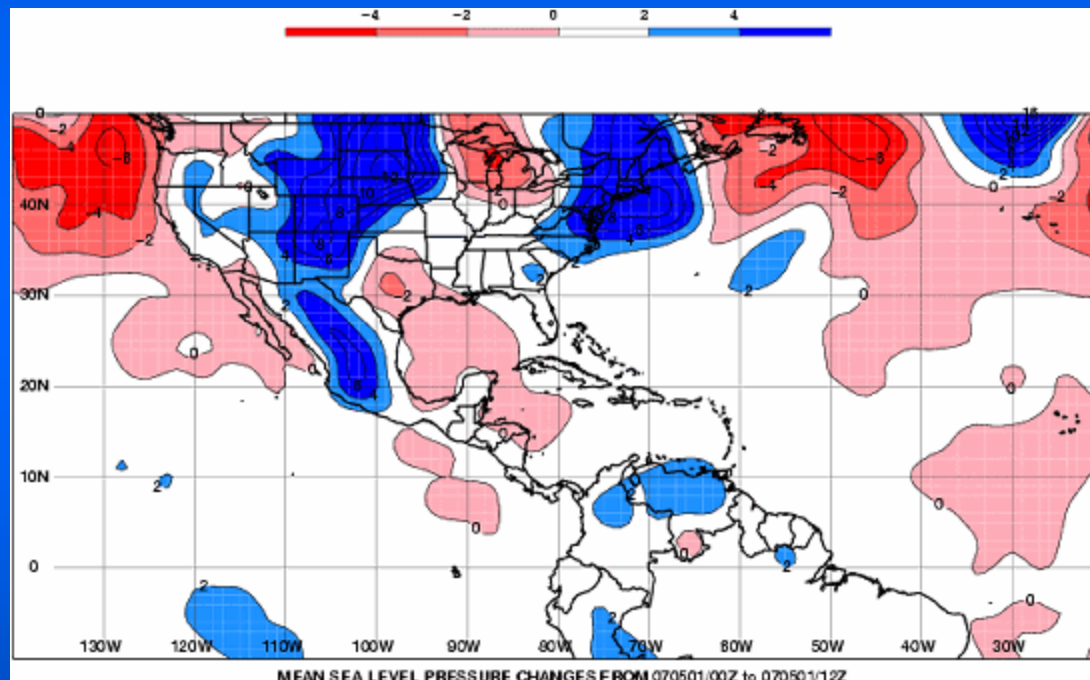


980704/00Z

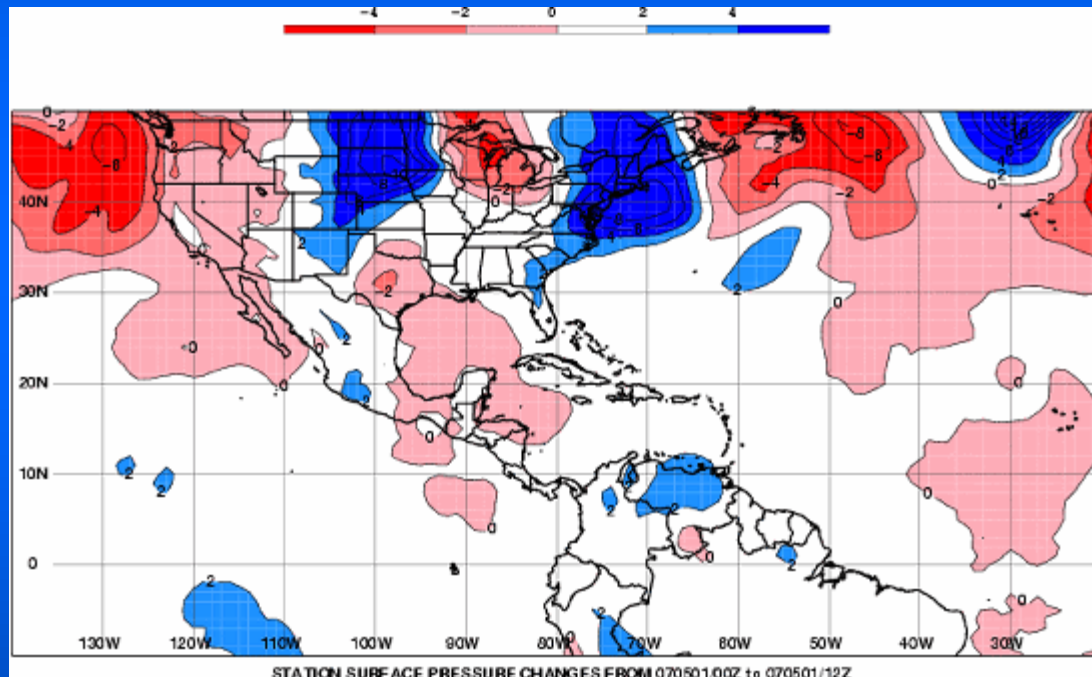
Topographical+Diurnal Effects Can Mislead You

Example: Mean Sea Level Pressure Changes (12Z – 00Z)

20070501-20070515

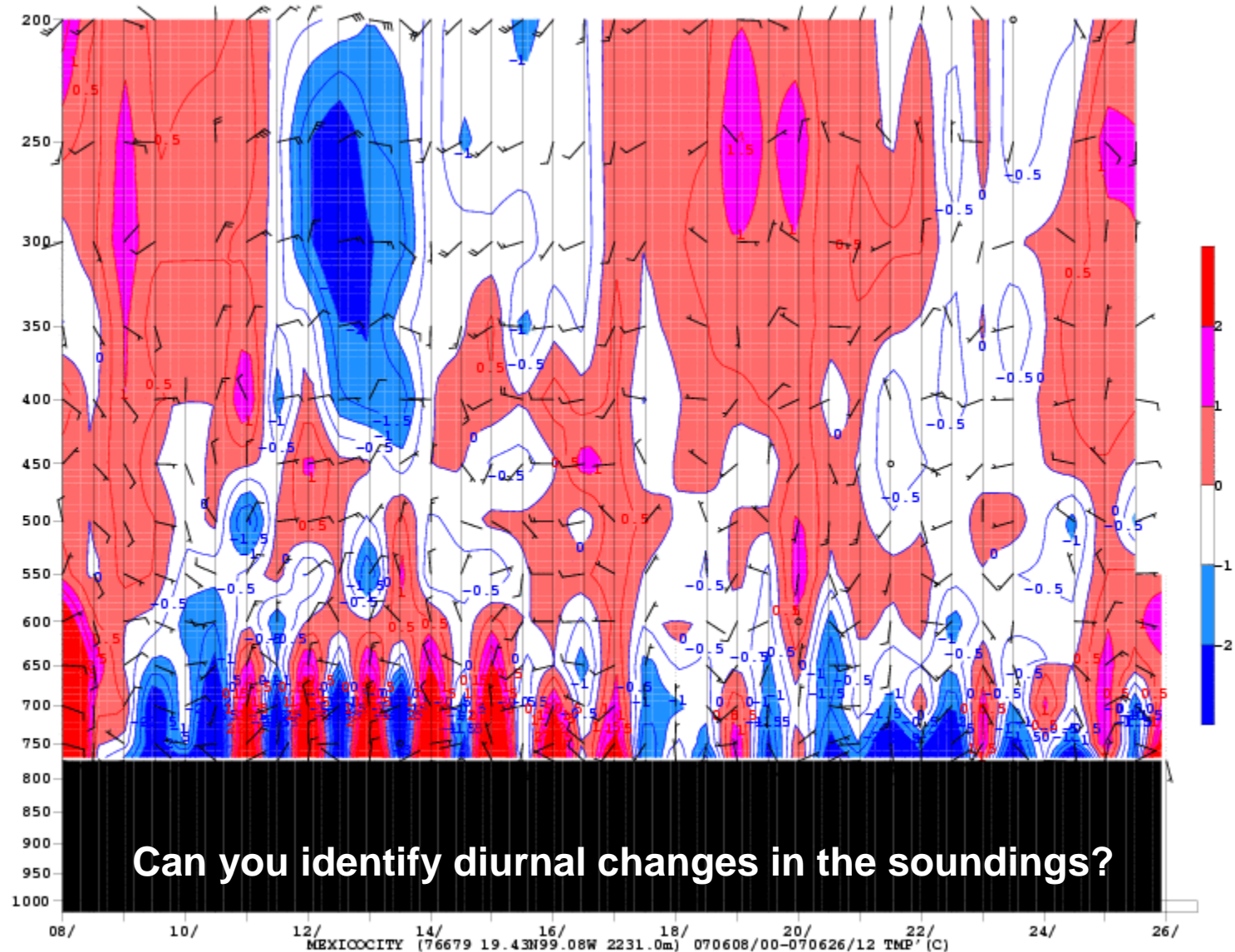


Surface Pressure Changes 12Z – 00Z



Morning high pressure persisted over Mexico in PMSL is not as strong
Low pressure can appear in the morning over the Rocky Mountains

Temperature (sounding) anomalies at Mexico City June 8 – June 26, 2007



Case Study

Example of a thorough analysis

- Identify the characteristics of African easterly waves (AEW) over the Atlantic ocean during this period
 - With the knowledge gained, you can do a better analysis tracking the waves
- Are AEW on the surface?

A good analysis can be useful in helping us understand the atmosphere

NHC analysis has been challenged:

Do tropical (easterly) waves really propagate from west Africa into the Caribbean Ocean?

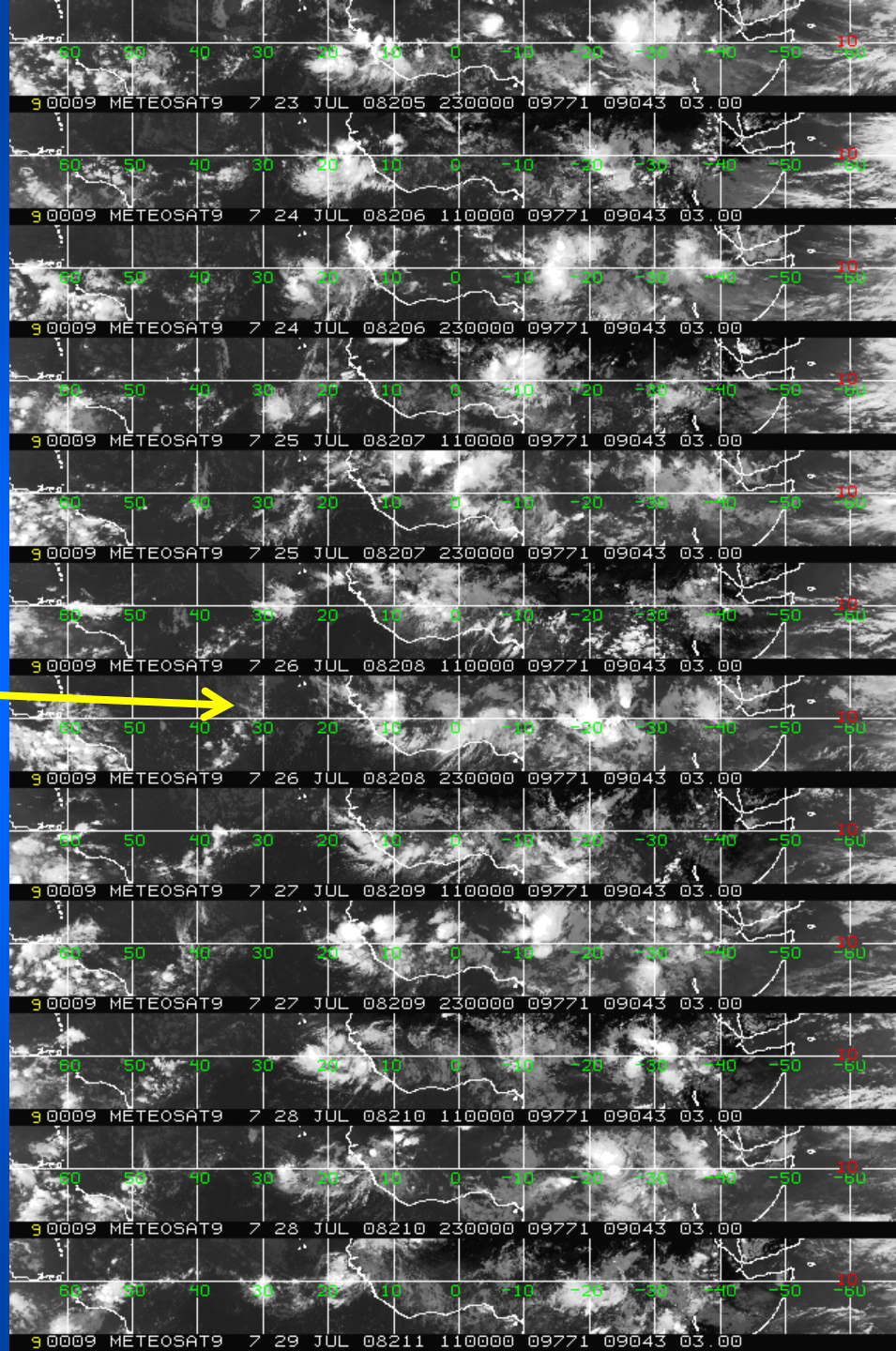
Are tropical (easterly) waves really on the surface?

The following case study uses several different techniques

Some Upper-Air Stations Referenced in This Presentation



This hovmöller chart
shows the foot print
of a weather system
propagating from
west Africa to eastern
Caribbean
Let's call it **wave X**



2300 UTC Jul 23, 2008

1100 UTC Jul 24, 2008

2300 UTC Jul 24, 2008

1100 UTC Jul 25, 2008

2300 UTC Jul 25, 2008

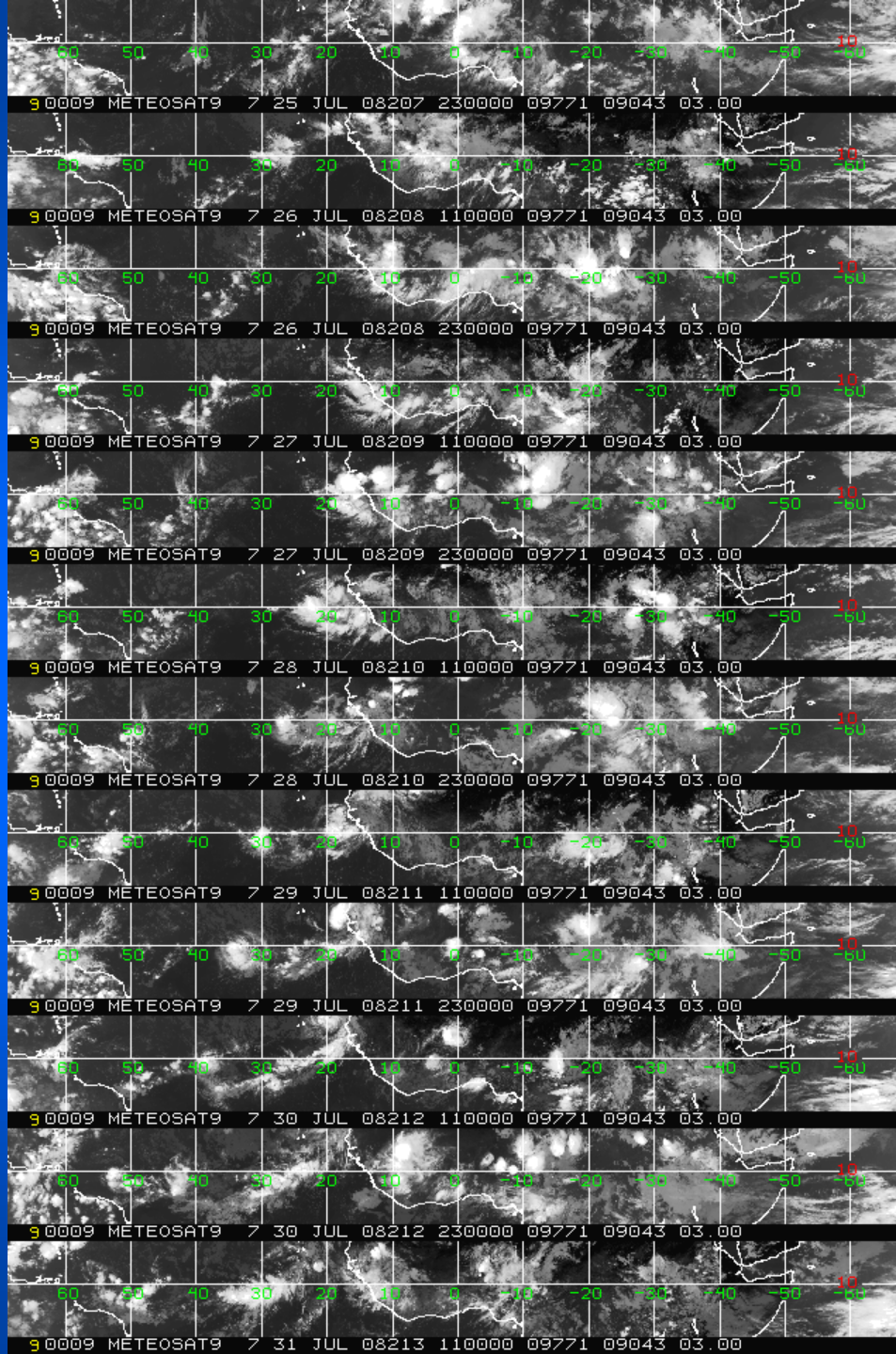
1100 UTC Jul 26, 2008

2300 UTC Jul 26, 2008

1100 UTC Jul 27, 2008

Q: When did this
wave pass Dakar?

**Q: When did
Wave X enter
eastern Caribbean**



2300 UTC July 25

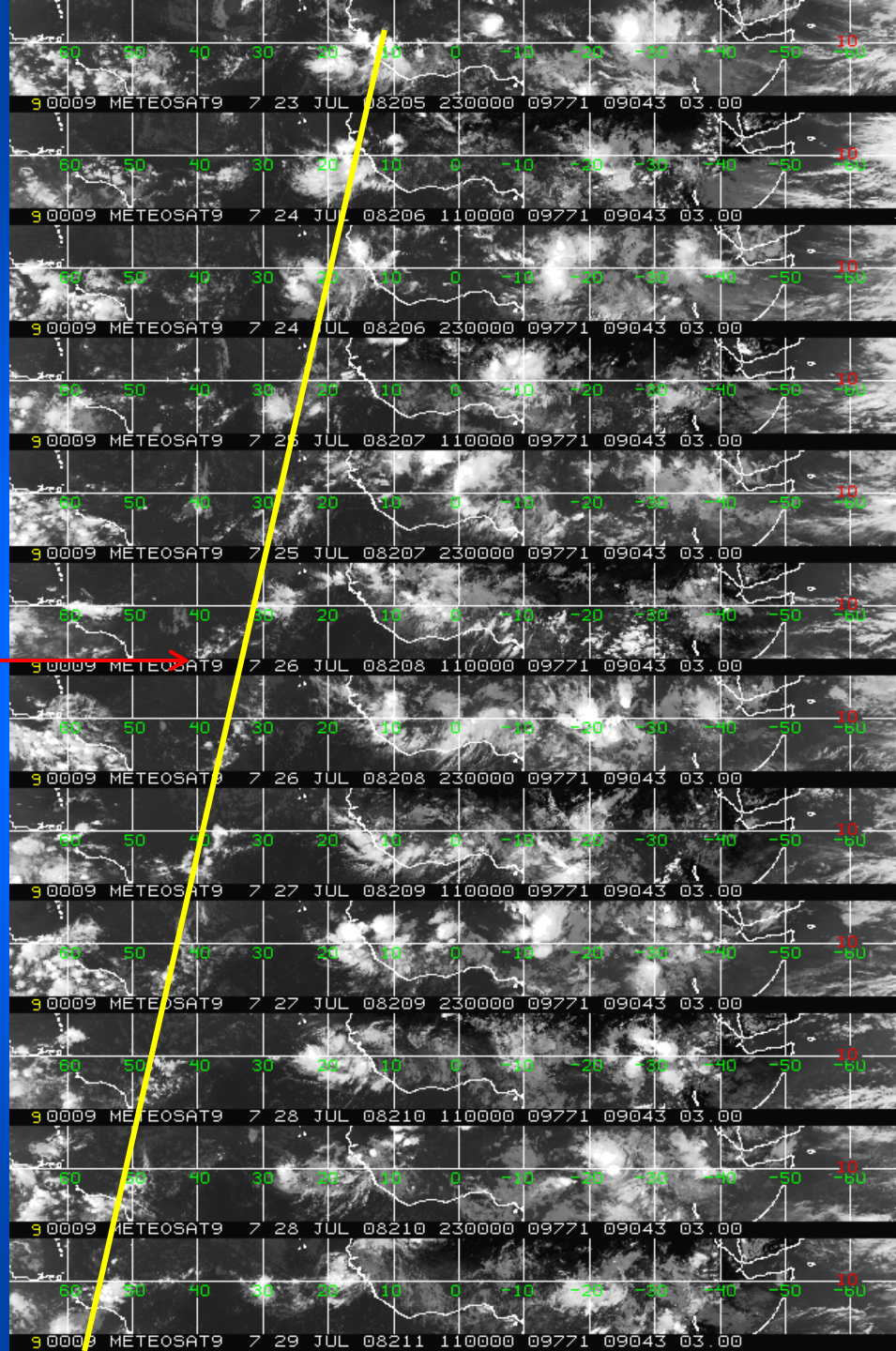
1100 UTC Jul 30

1100 UTC Jul 31

Questions

- How long did it take for wave X to propagate from the coast of west Africa to the eastern Caribbean?
- What is the approximate speed of propagation?
- Are these waves on surface?
 - Should you put them on a MSLP chart?

1. Identify the presence of a weather system based on the cloudiness pattern as it propagating from west Africa to eastern Caribbean
wave X

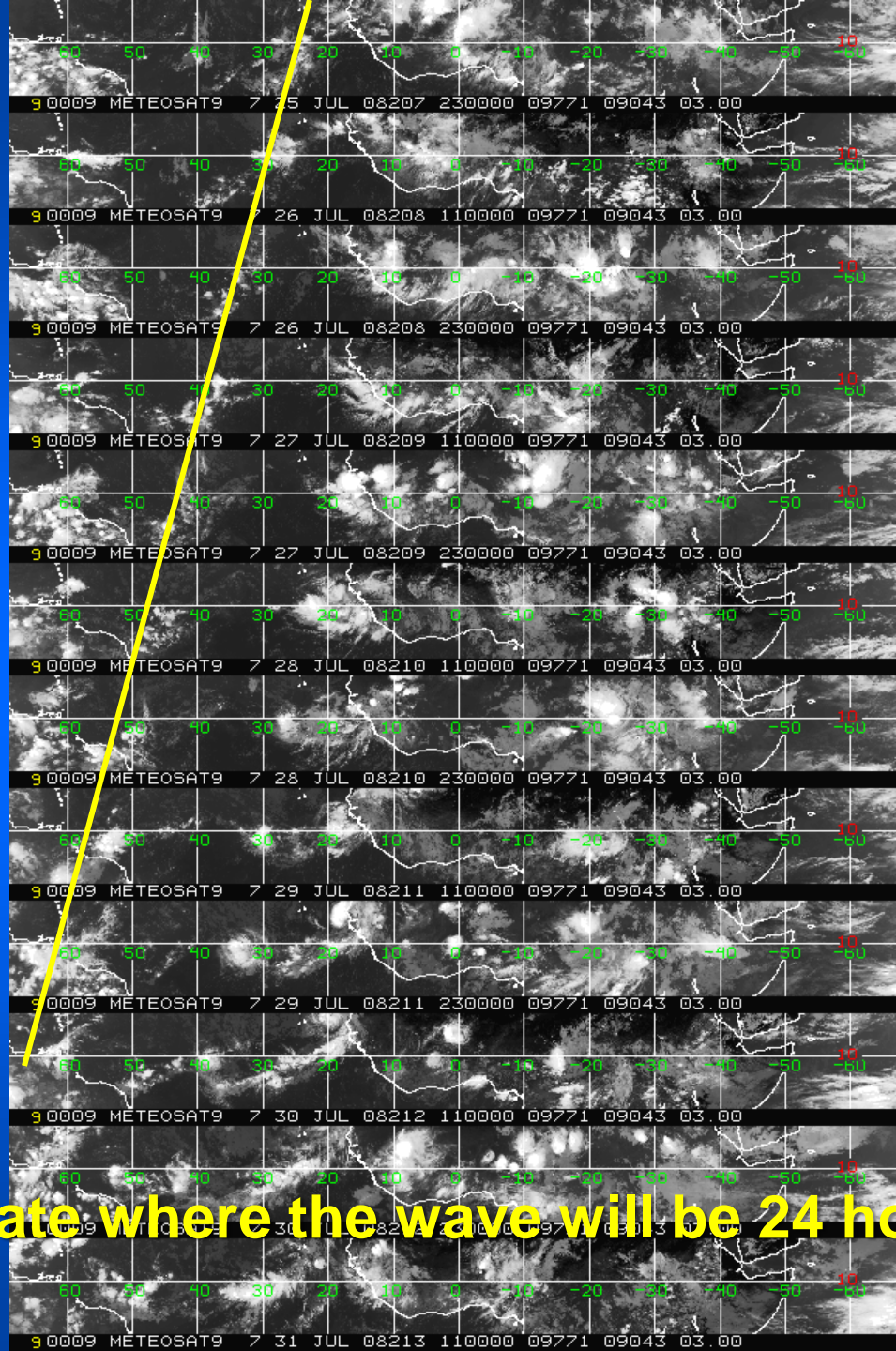


It passed west
Africa around
Jul 24, 2008
– an estimate

Wave X entered
eastern Caribbean
around, Jul 30,
2008 –
Almost 6 days later

Average speed of
Propagation:
~42 degrees of long.
over ~6 days

You can estimate where the wave will be 24 hours later. Why?



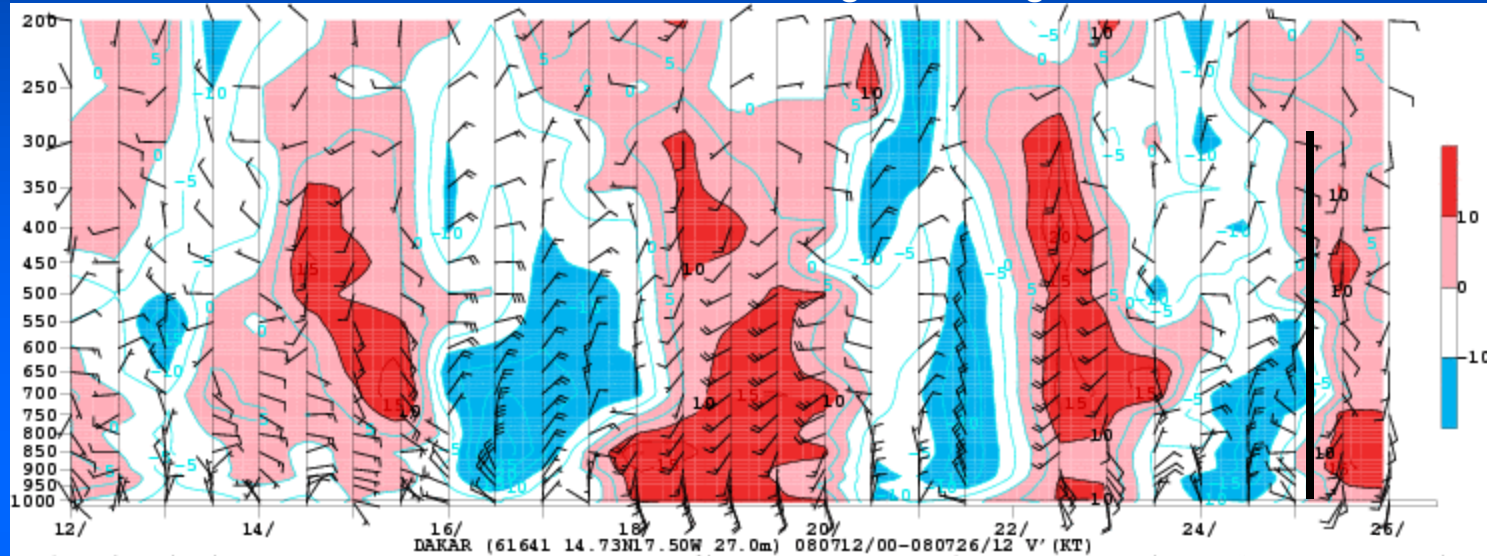
To prove these waves did travel across the Atlantic

Put timesections from Dakar and Guadeloupe together with a 6-day lag

We know from satellite image the approximate time of passage,
we then fine tune it using sounding data

Dakar

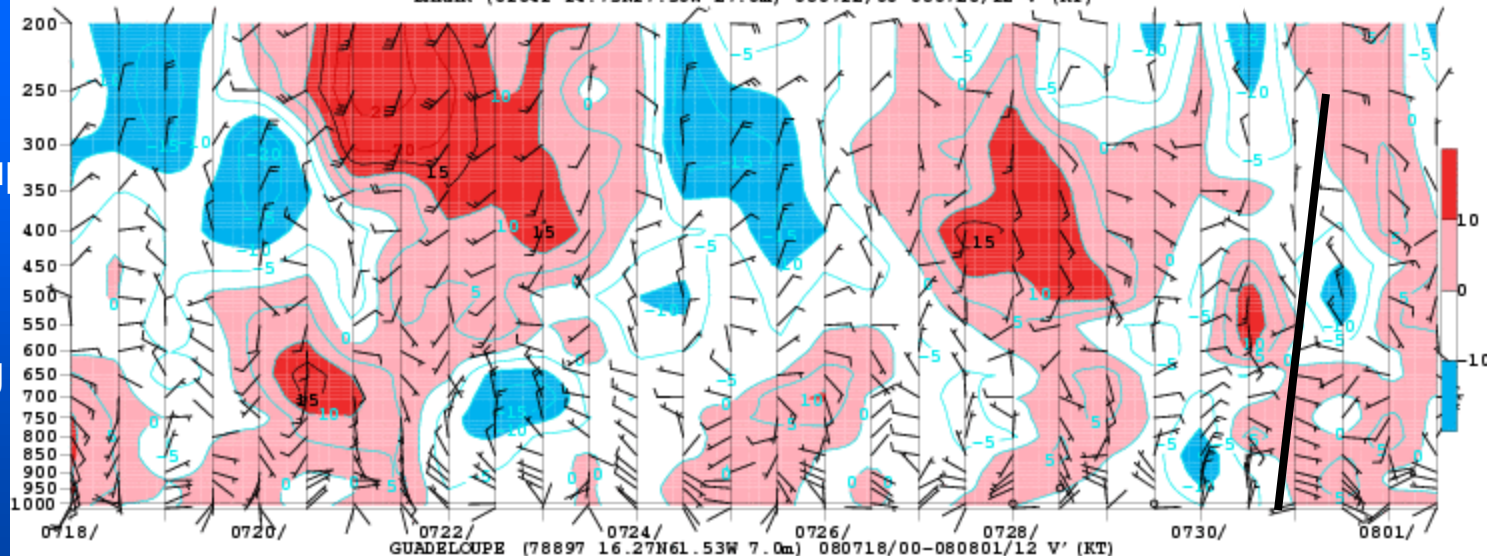
July 12



Guadeloupe

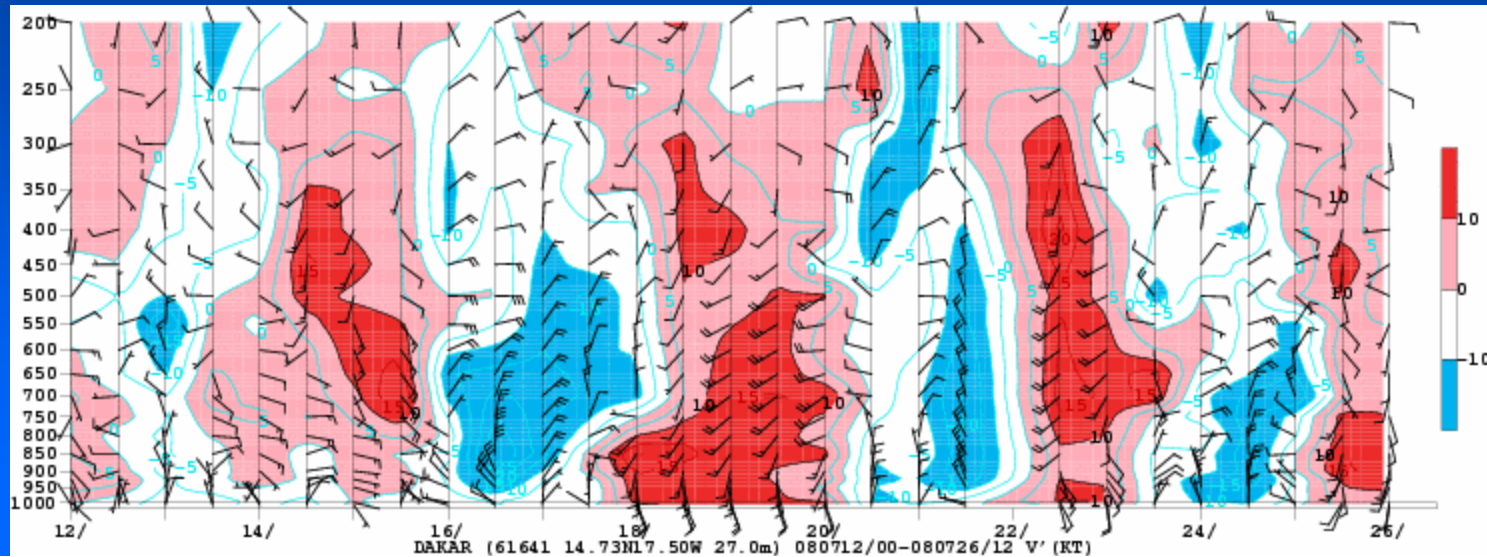
6 day lag

July 18



Sequence of Timesections of v' from Dakar

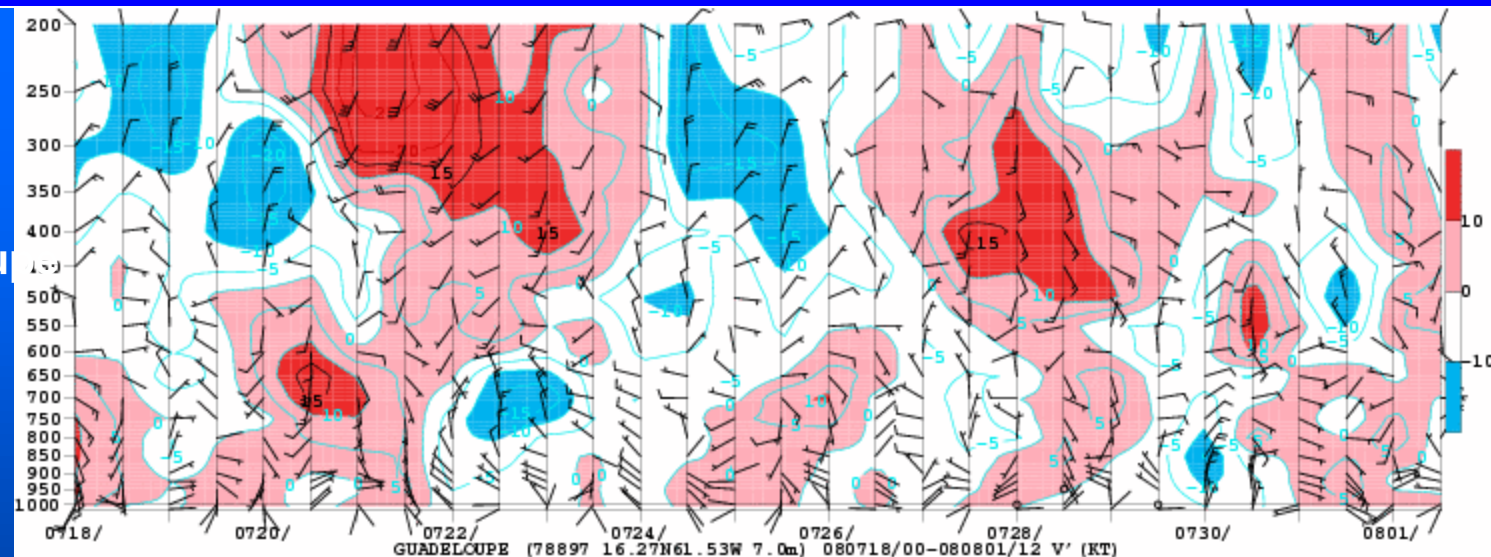
Dakar



We see waves passed through Dakar one after another

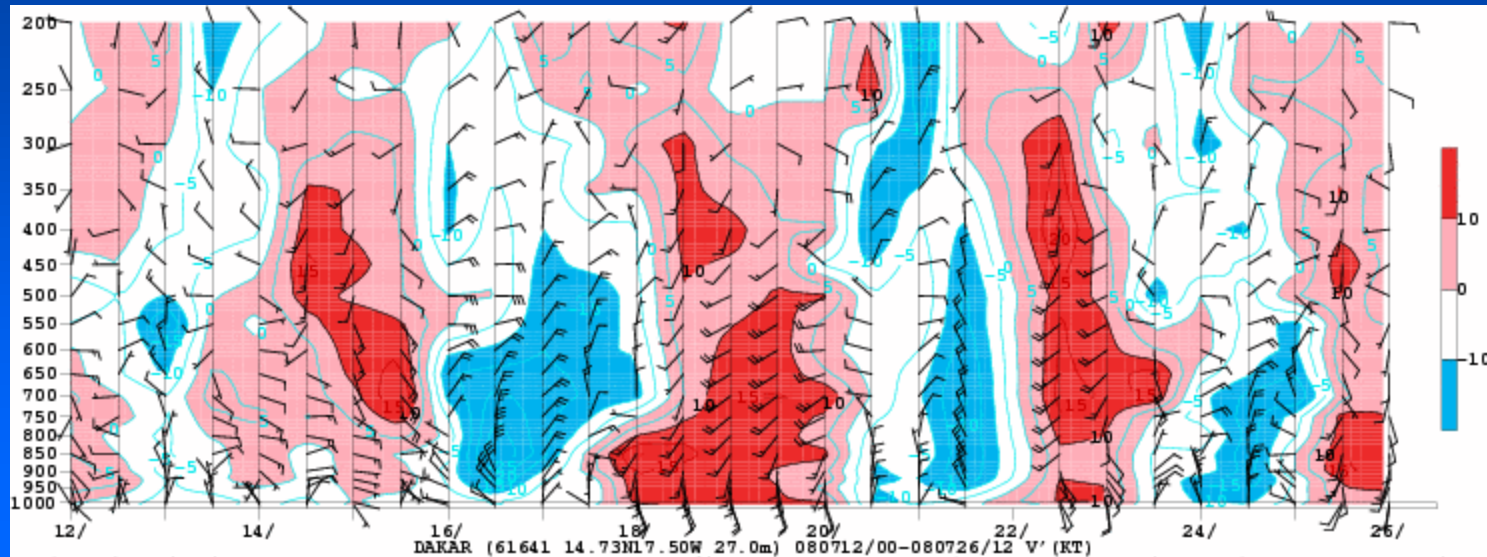
Sequence of Timesections of v' from Guadeloupe

We also see waves passed through Guadeloupe one after another

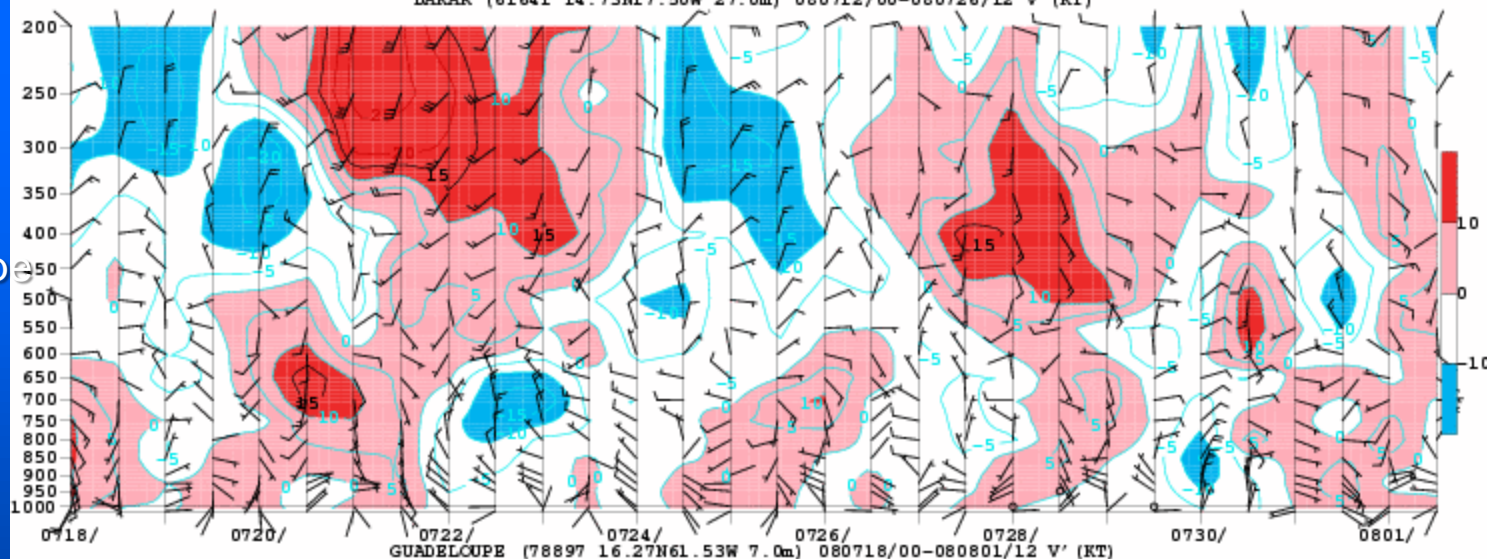


Sequence of Timesections of v' with 6-day lag

Dakar

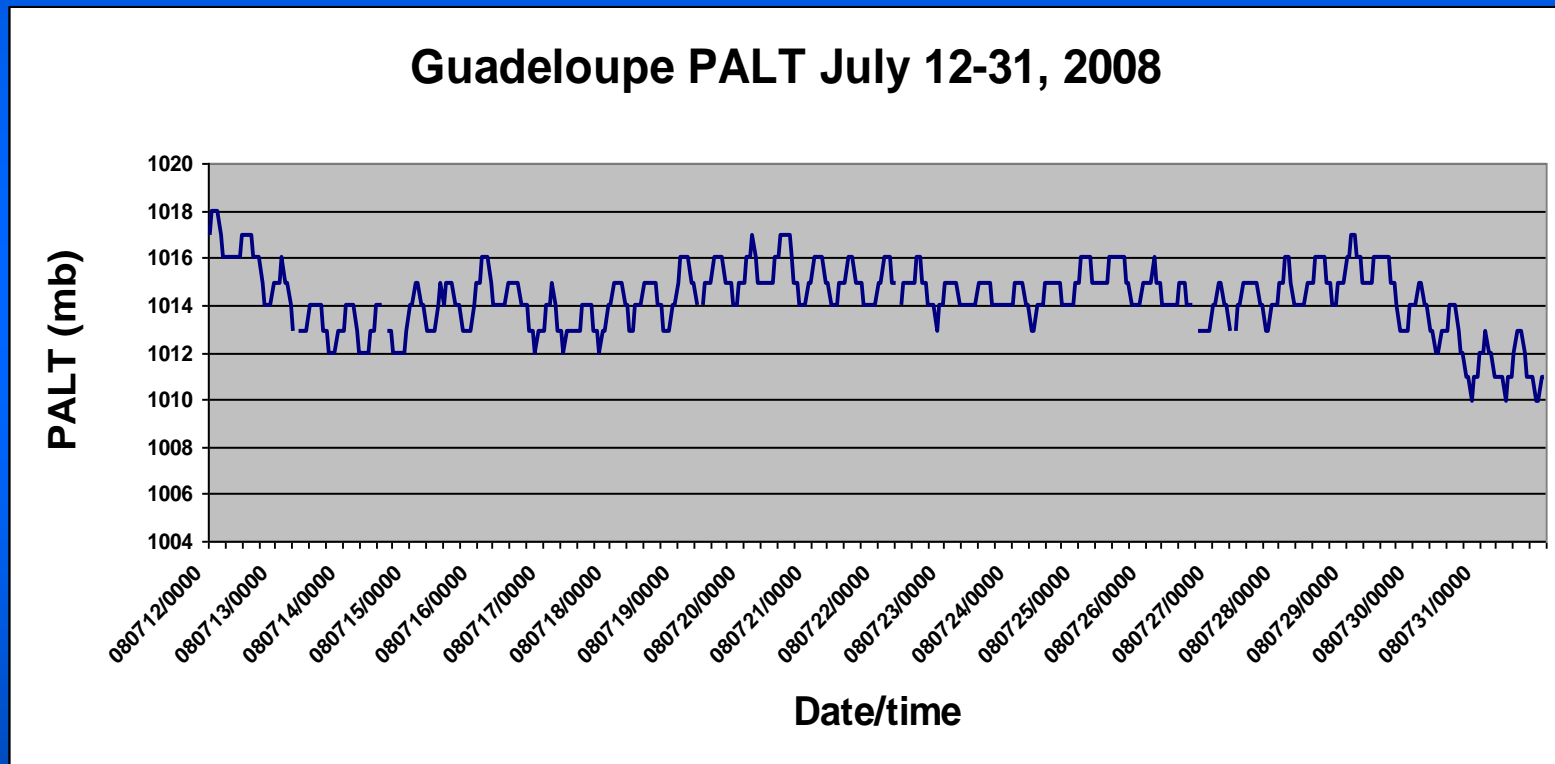


Guadeloupe
6-day lag



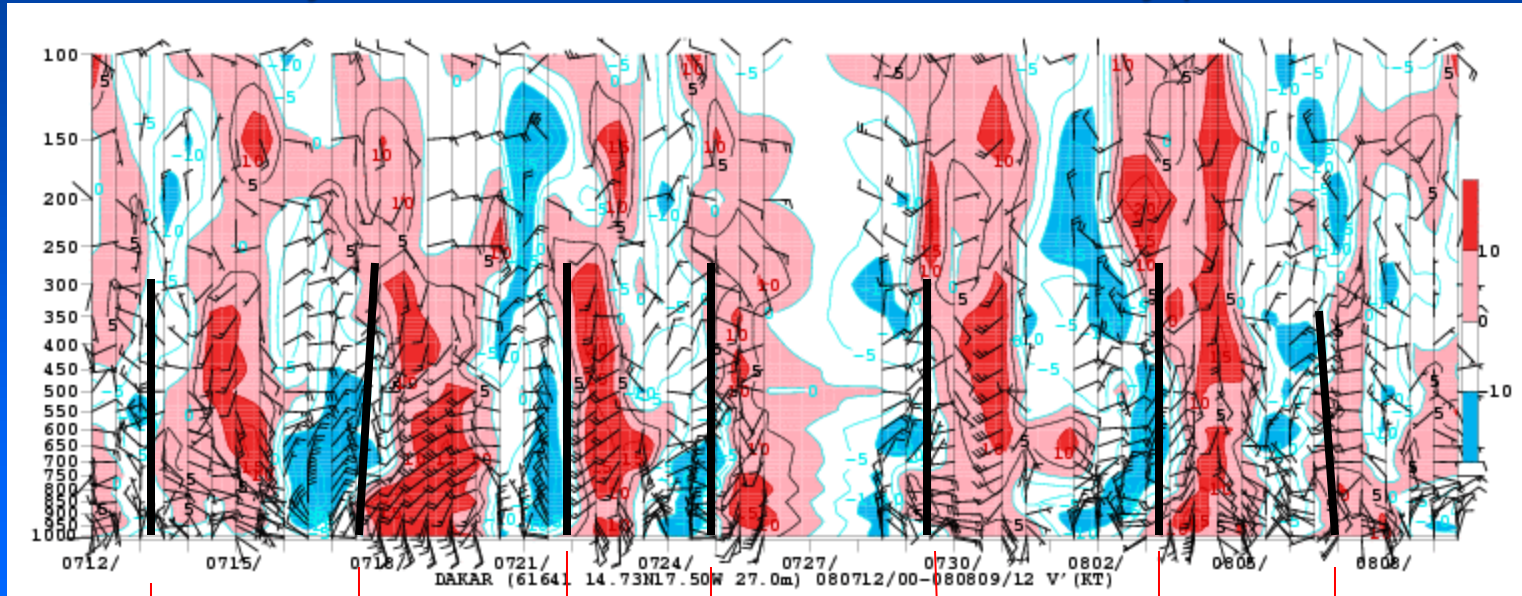
Every wave passed Dakar showed up at Guadeloupe 6-7 days later
What does it prove?

Surface pressure from Guadeloupe
did not strongly indicate passages of
waves – but...

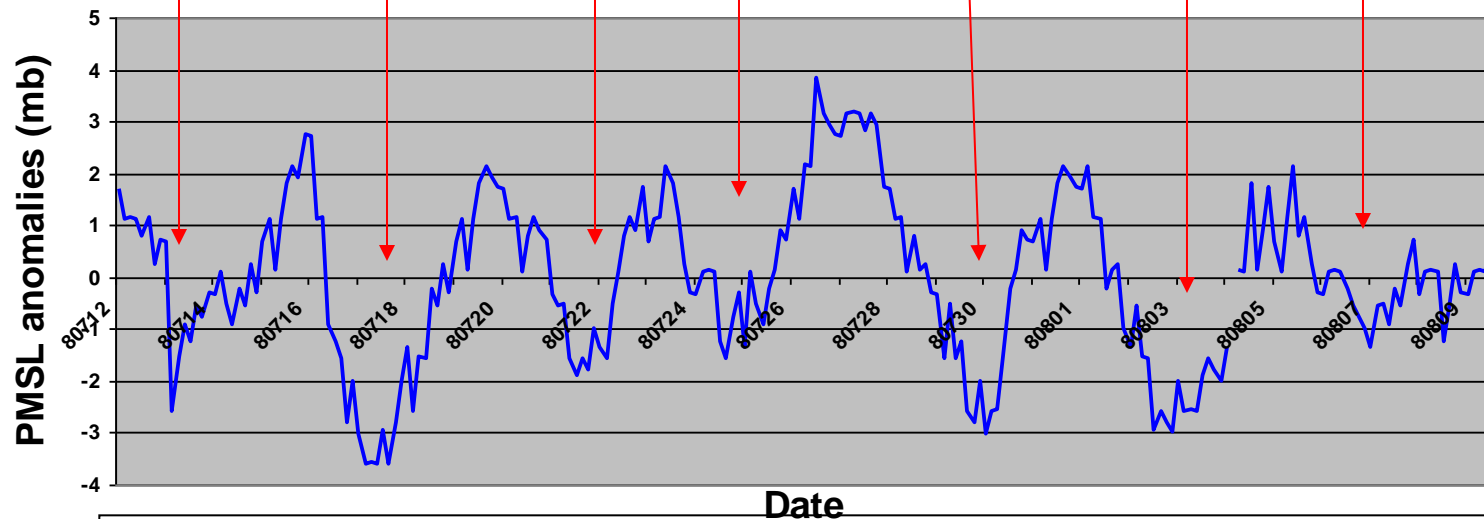


Most noticeable are semidiurnal tide. Some hint of longer period variations

Can we identify these waves at the surface as they passed Dakar?

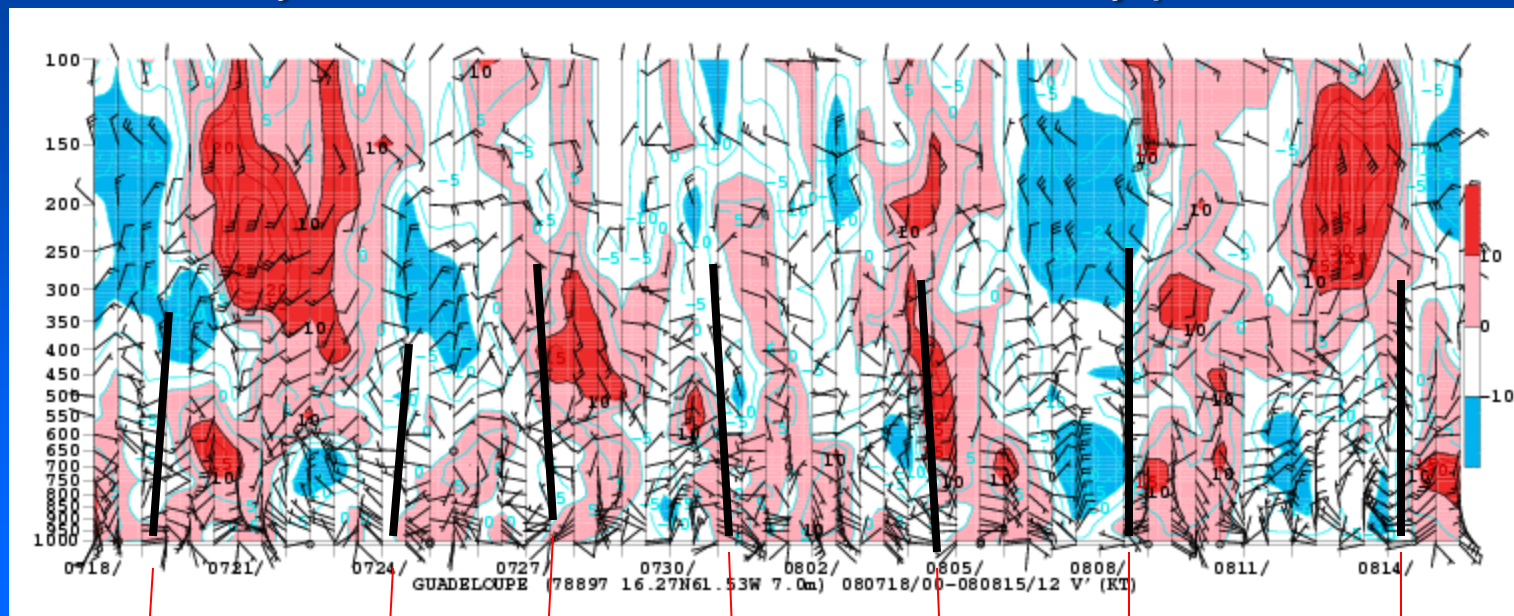


Dakar PALT anomalies July 12-August 09, 2008

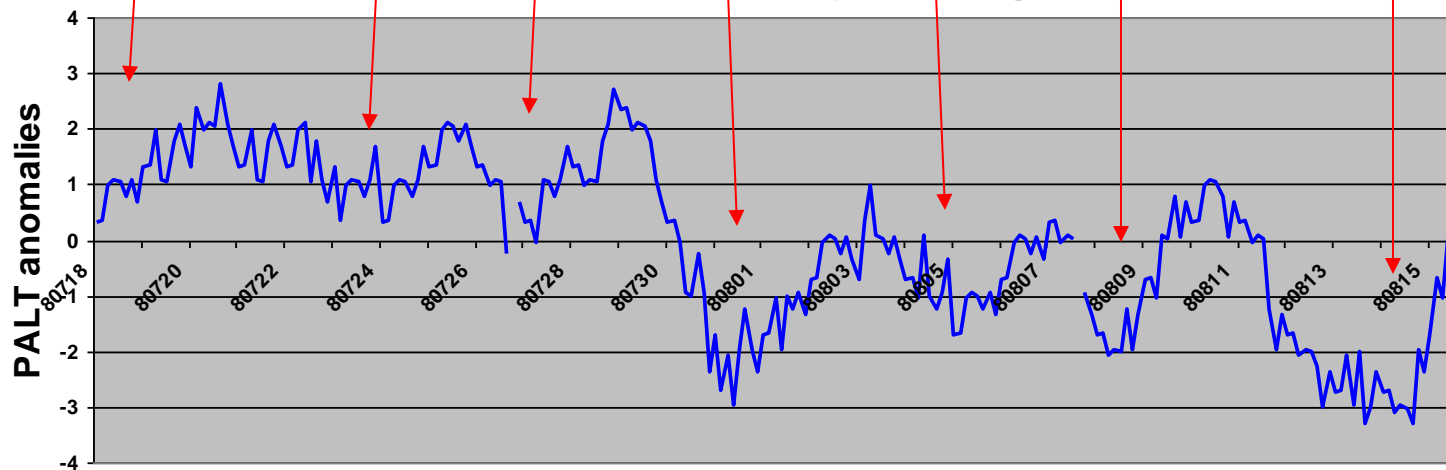


Surface pressure with mean and diurnal and semi-diurnal tide removed

Can we identify these waves at the surface as they passed Guadeloupe?



Guadeloupe PALT anomalies July 18 - August 15, 2008



Surface pressure with mean and diurnal and semi-diurnal tide removed

So AEW do exist and propagate from W. Africa into E Caribbean

- Are they on the surface?
- Whatever your answer is, how do you justify it?
- How do you define if something is on the surface or not?
- My answer is
 - If you can measure it (with any meteorological parameter), it is there.
 - If there is no observation at the surface, you need to use science, if not common sense.

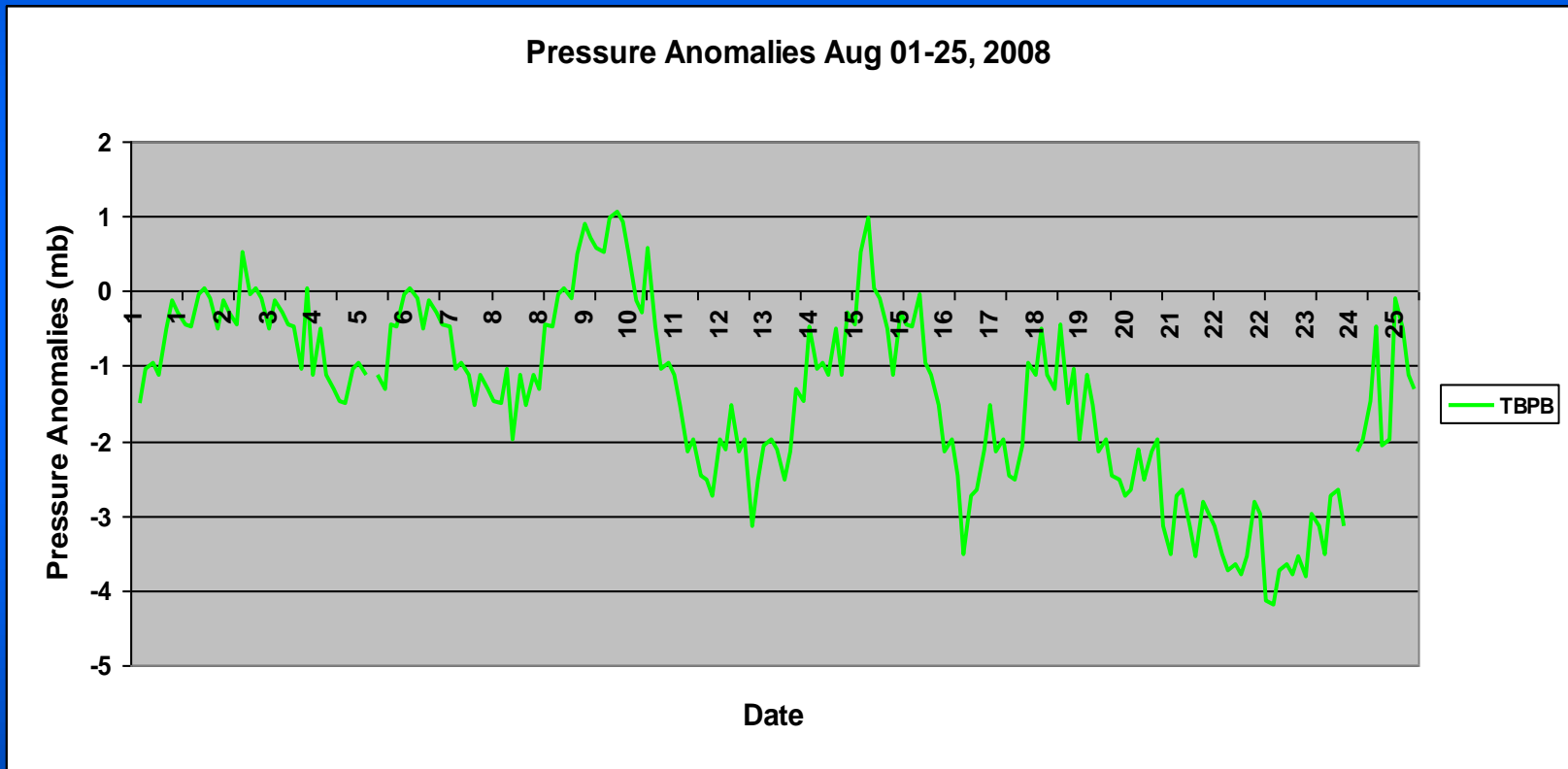
If those that passed Guadeloupe were easterly waves, they should also appear on the soundings and/or surface reports at other stations — Why?

Get a better idea on how far out (N/S) the waves extend

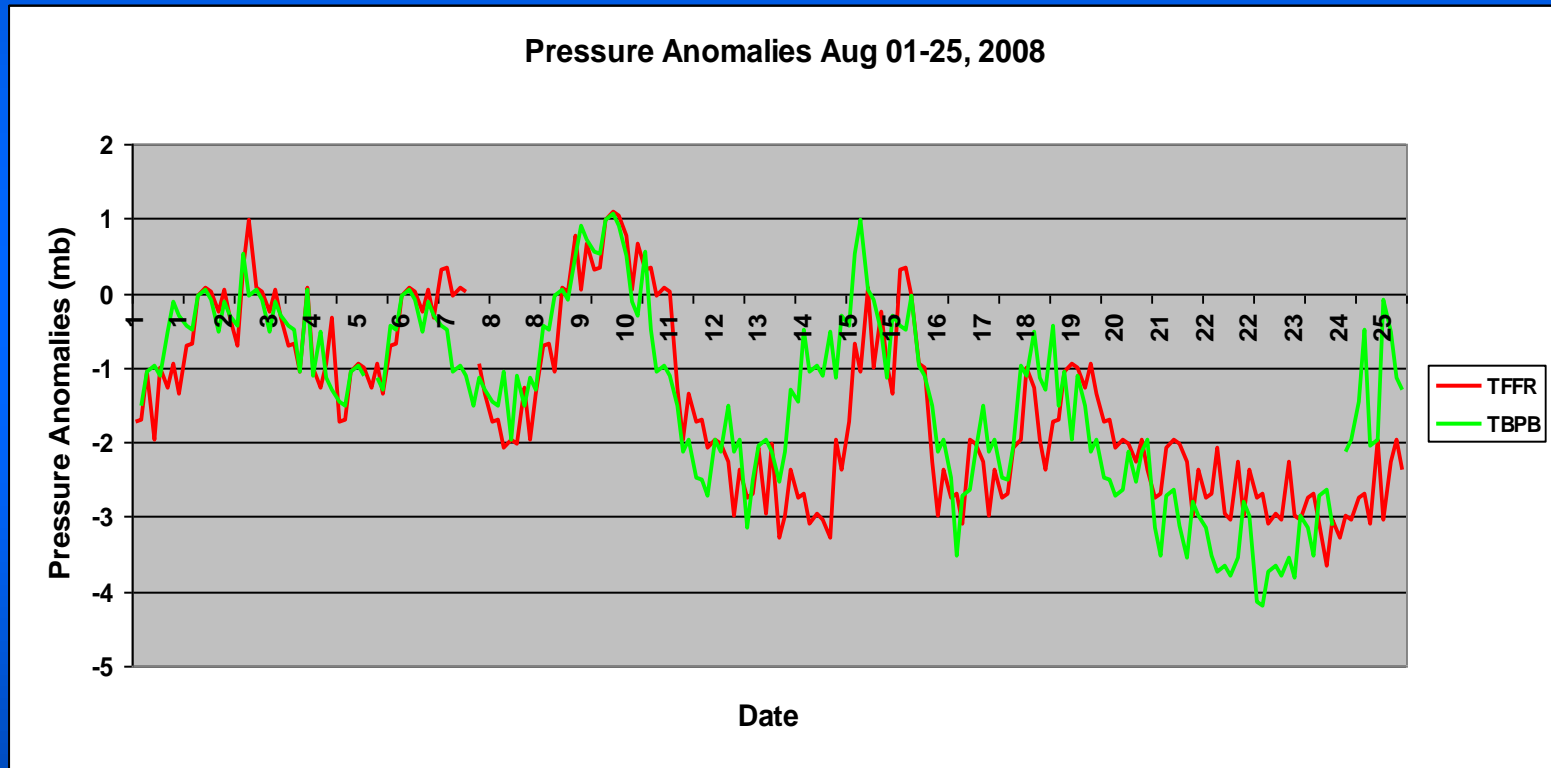
Again, we are trying to build a better knowledge of these waves so we can do a better analysis - building a conceptual model

Let's check surface pressure anomalies from four eastern Caribbean RAOB stations

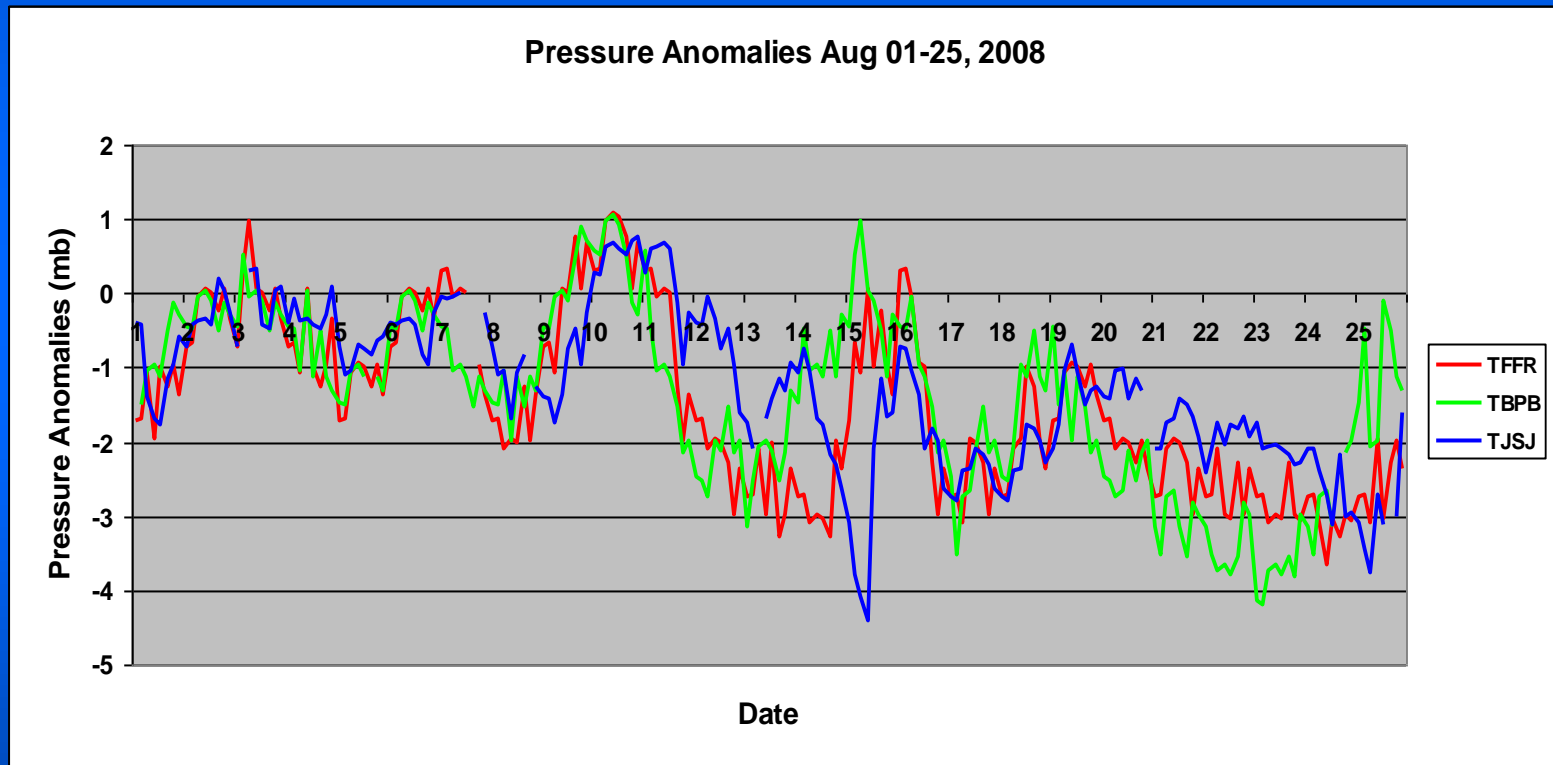
Barbados



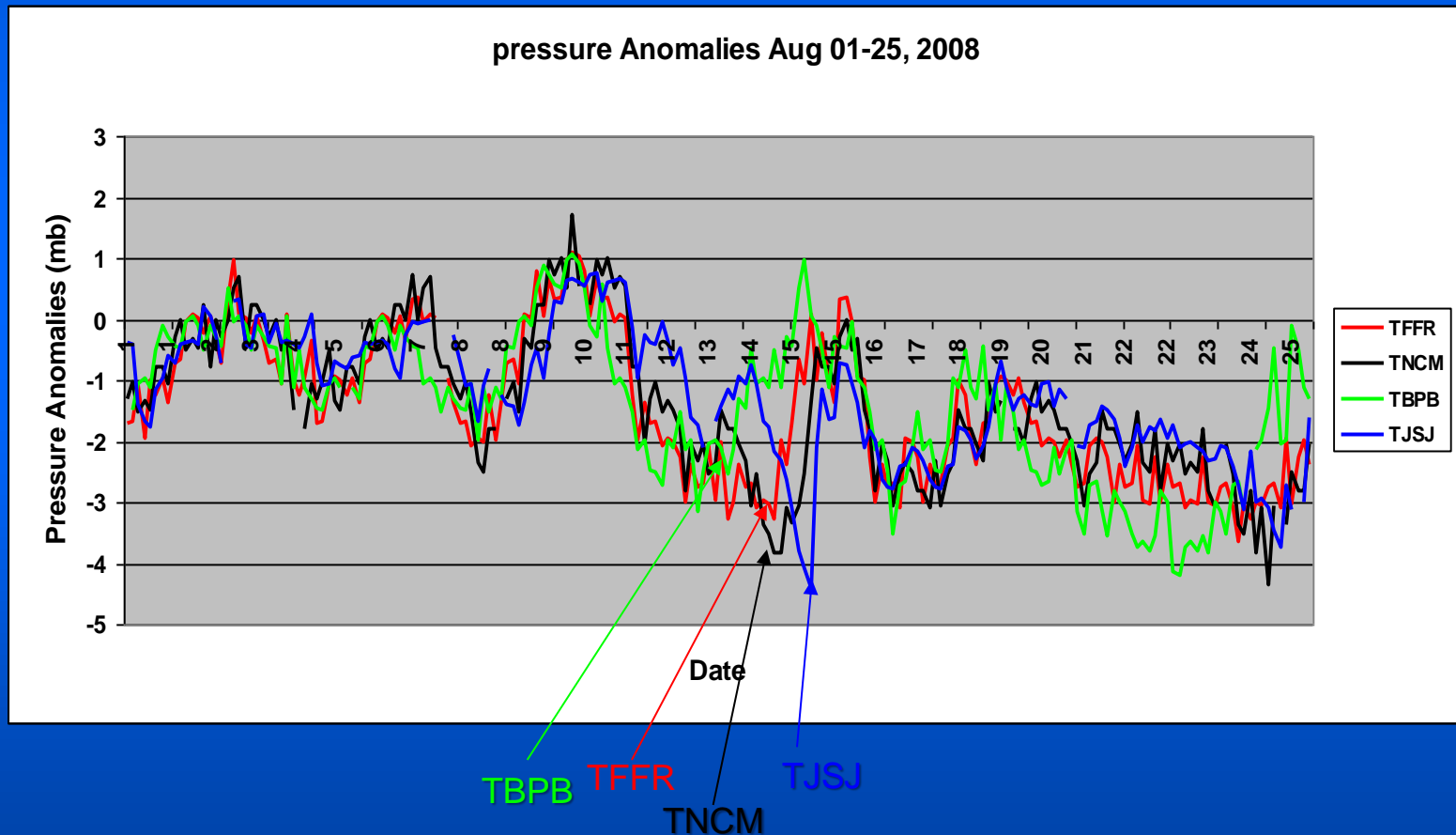
Surface pressure anomalies from Barbados and Guadelope



Surface pressure anomalies from Barbados, Guadeloupe, and San Juan



Surface pressure anomalies from Barbados, Guadeloupe, St. Marteen, and San Juan



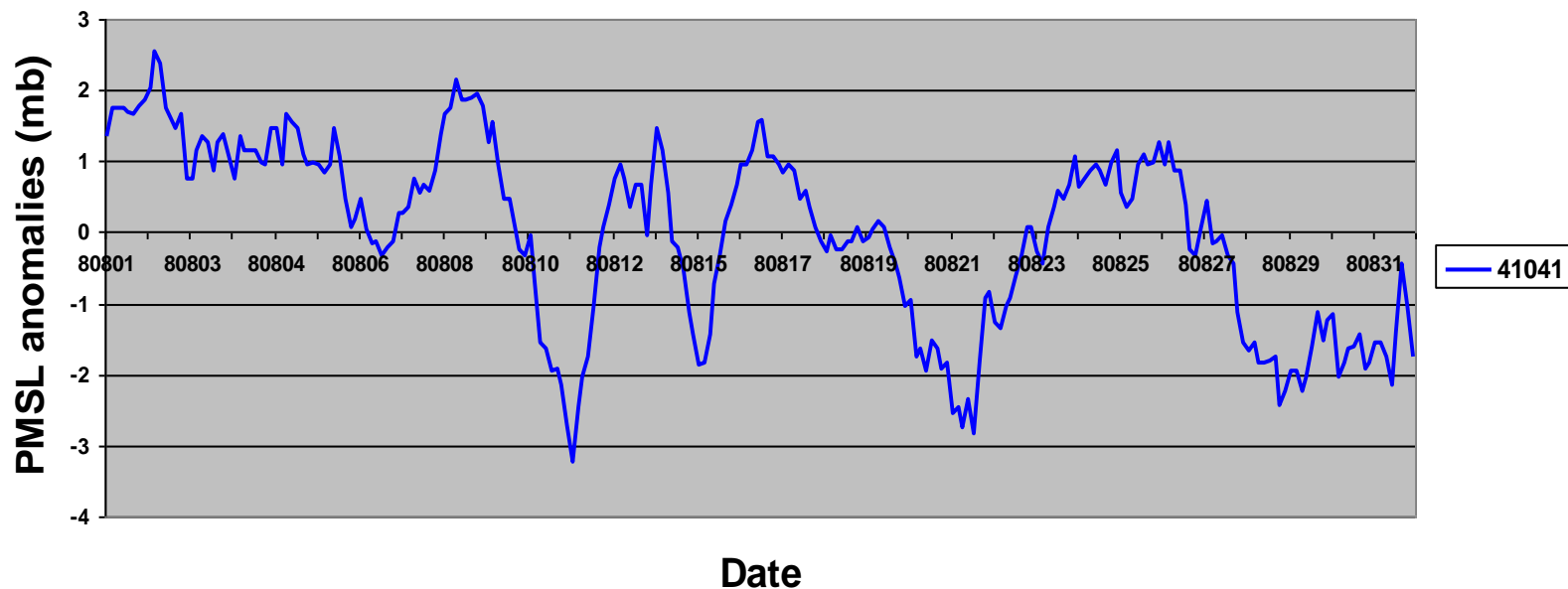
Most of the August the pressure anomalies were below 0

Can we find these waves over the water – at the surface?

- Why not? What's there to prevent the wave amplitude from reaching the surface?
- Let's look at some buoy data.

Buoy 41041

PMSL anomalies, August 2008

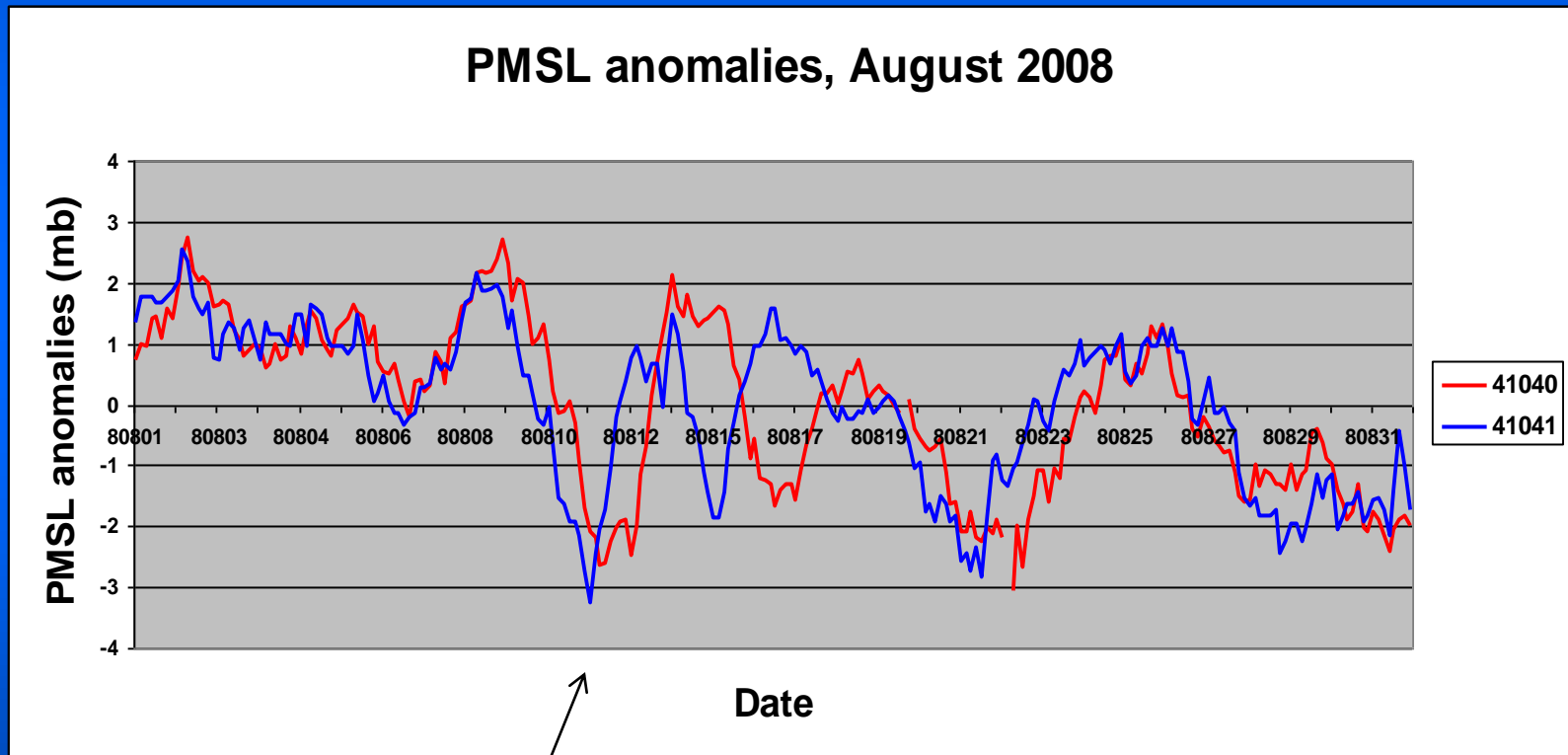


Again, time mean, diurnal and semi-diurnal tides were removed

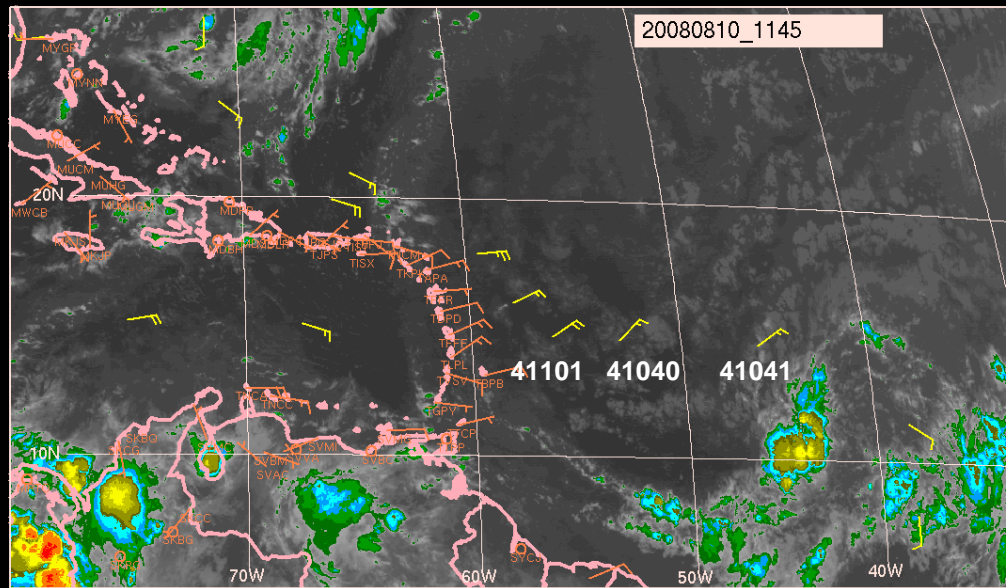
Buoys 41041 and 41040

Noticed the coherent pattern between these two buoys?

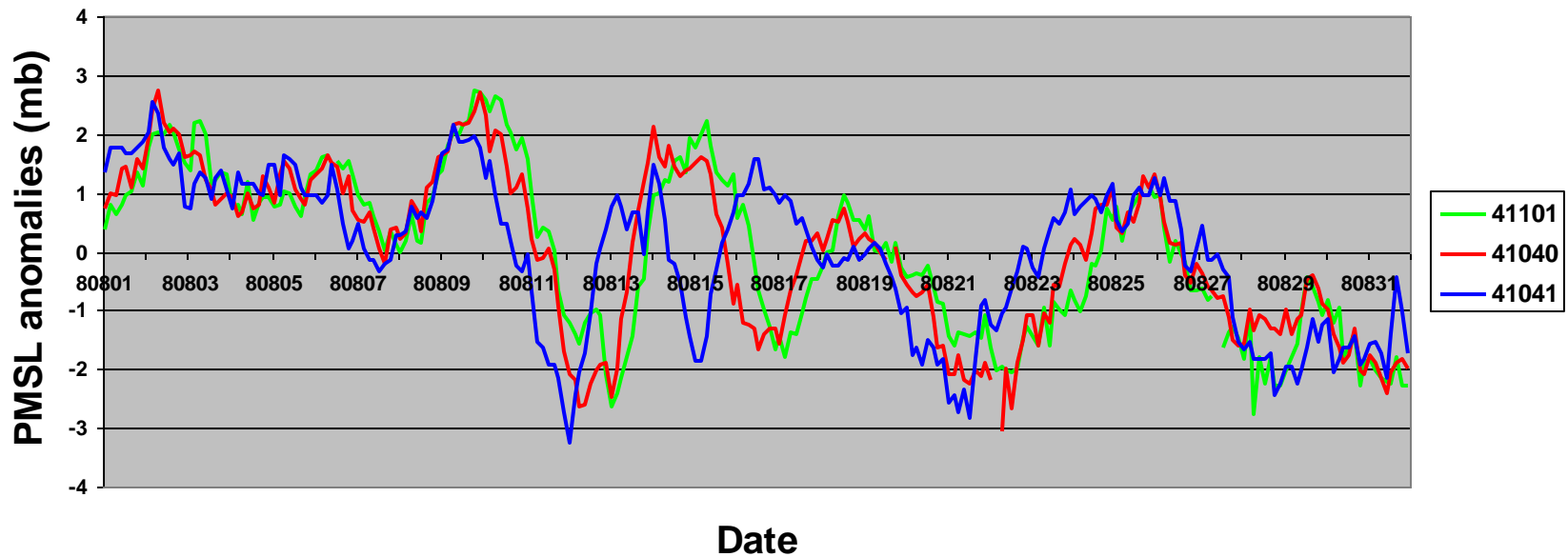
Can you tell which buoy is located to the east?

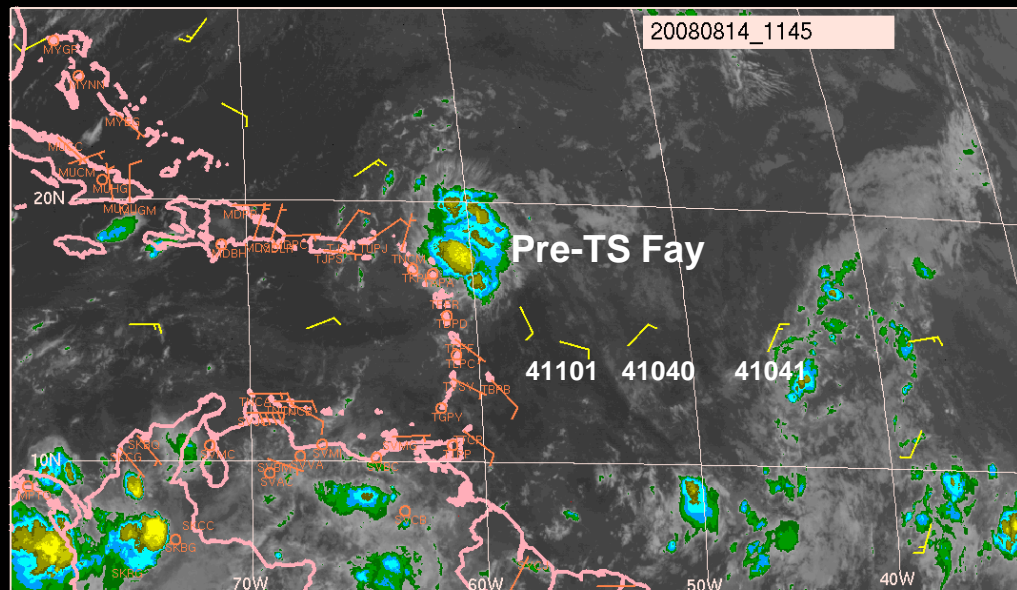


1. The gap between the two lines is wider during this period. What does it mean?
2. The speed of propagation of easterly waves does change from time to time, place to place.

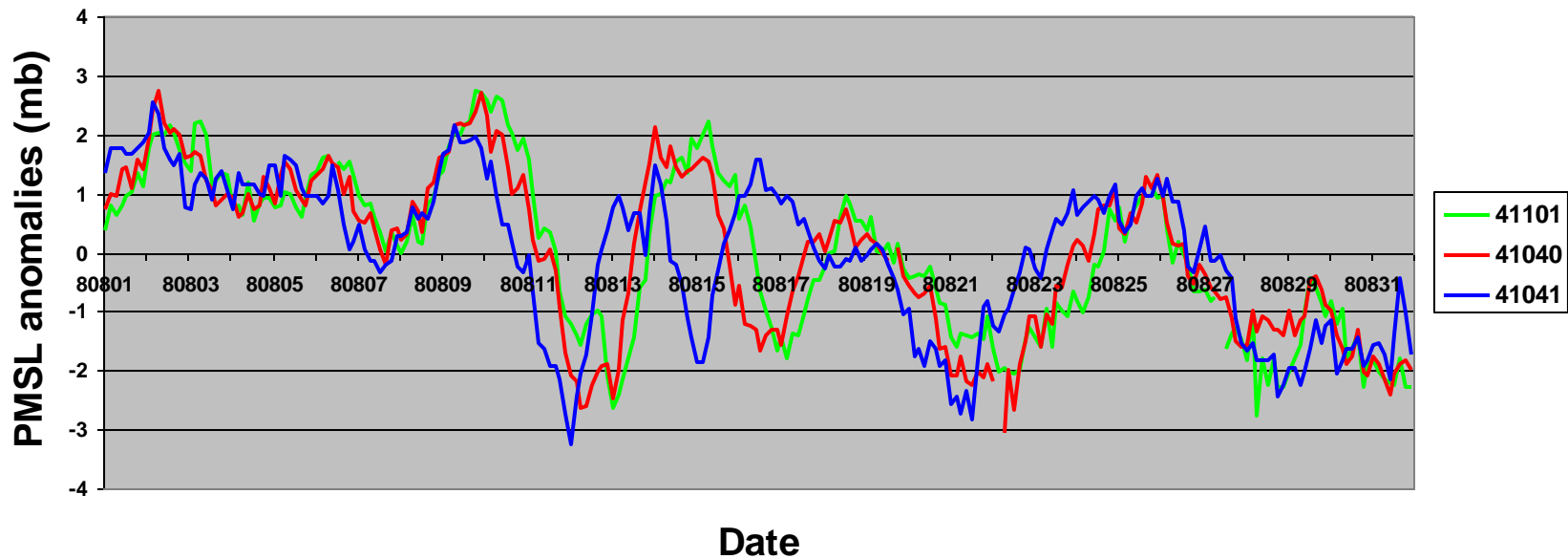


PMSL anomalies, August 2008





PMSL anomalies, August 2008



Identifying and tracking easterly waves

- Identify them over west Africa using satellite imagery – looking for rotations in low/mid clouds
- Verify their passage over western Africa rawindsonde stations – check for wind shifts using timesections
- Follow the rotating low/mid level clouds across the Atlantic
- Recognize the characteristics of the waves during that period – wavelength, period, speed of propagation
- With the above, use continuity – extrapolation
- Verify and adjust the locations using timesections from eastern Caribbean rawindsonde stations
- Use continuity/extrapolation again if you don't have timesections from east pacific

Identifying and tracking easterly waves

Cloudiness tend to be associated with waves
but they do not define the waves

The N-S extension of a wave **IS** not defined by the
area of convection

Convection is a meso-scale phenomena, while
easterly waves are synoptic-scale

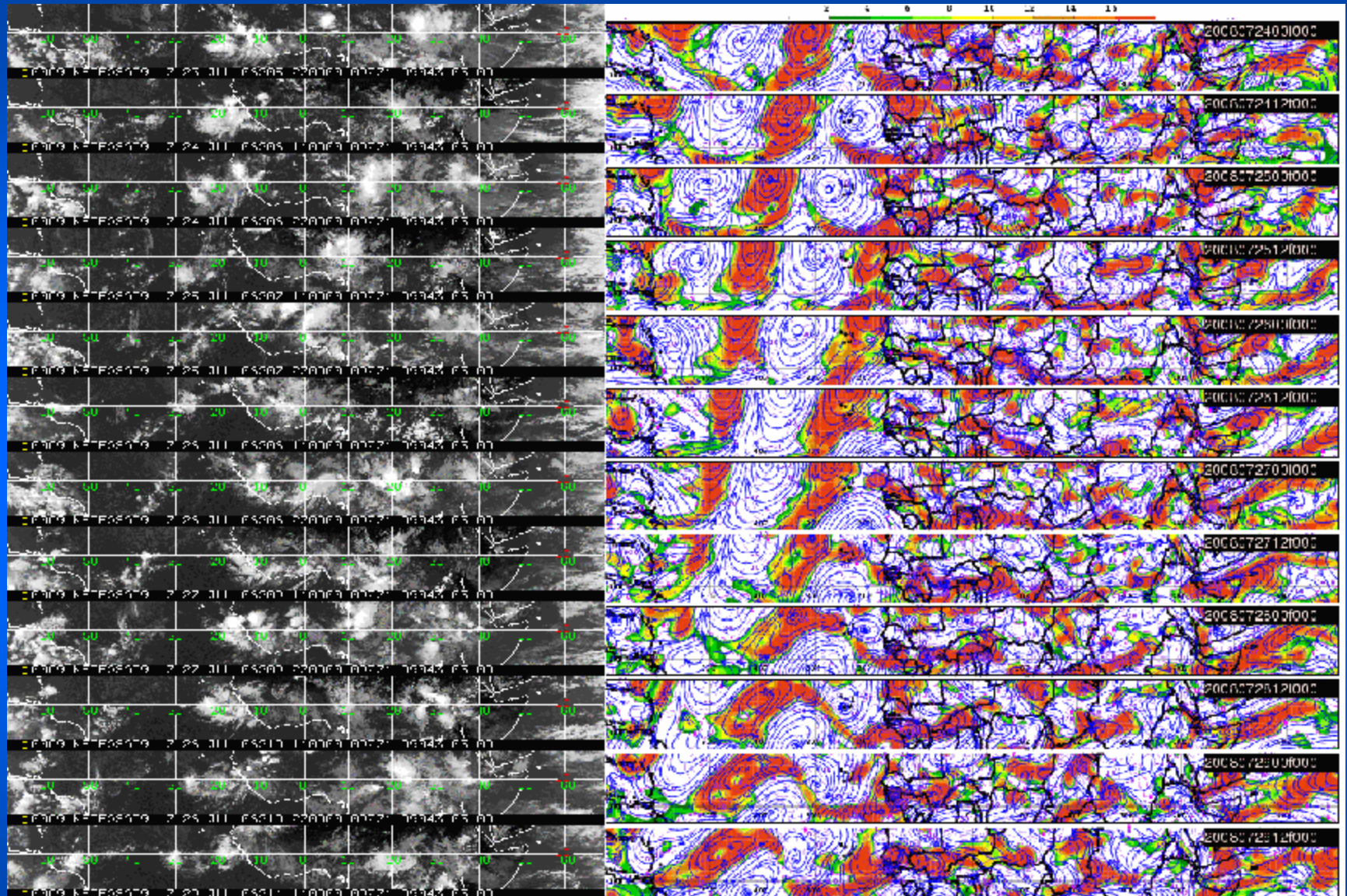
- With the knowledge and proper analysis methods, we can identify systems that are otherwise difficult to be identified
- We also learn more about those systems which will help us perform better analysis
- Don't just take what I said, or what Simon said, unless you strongly agree with my analysis.

Can we find easterly waves in numerical models?

- Global models are known to be able to carry AEW
- Global models may also carry signals from other sources, some computational (no physical meanings)
- Same as analyzing observed data, filtering of model data makes the weather systems much better defined

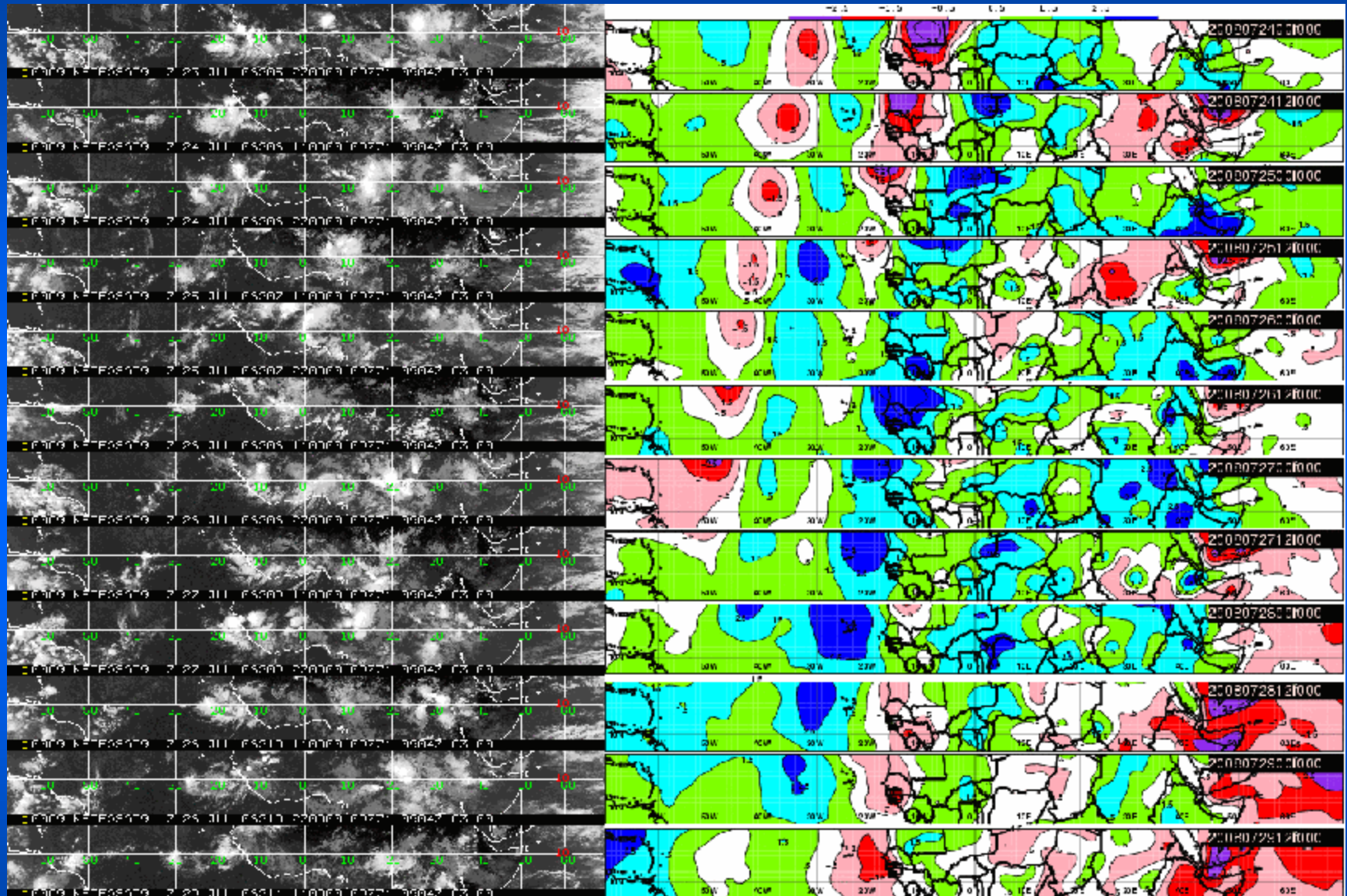
Satellite Hovmöller Charts

700 mb Rel Vort Anomalies



Satellite Hovmöller Charts

PMSL Anomalies



July 24-August 07, 2008

Identifying Easterly Waves in the W Pacific

April 2015 Precipitation (Percent of Normal)



Satellite Hovmoller chart for 1 July-14 August 1967 5N-10N, 150E-100W

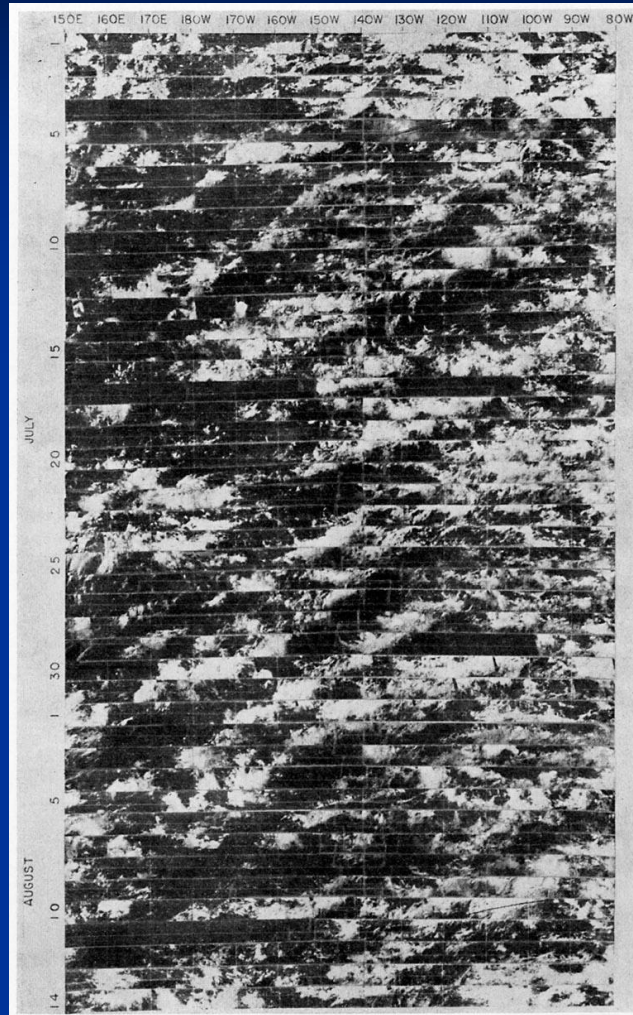
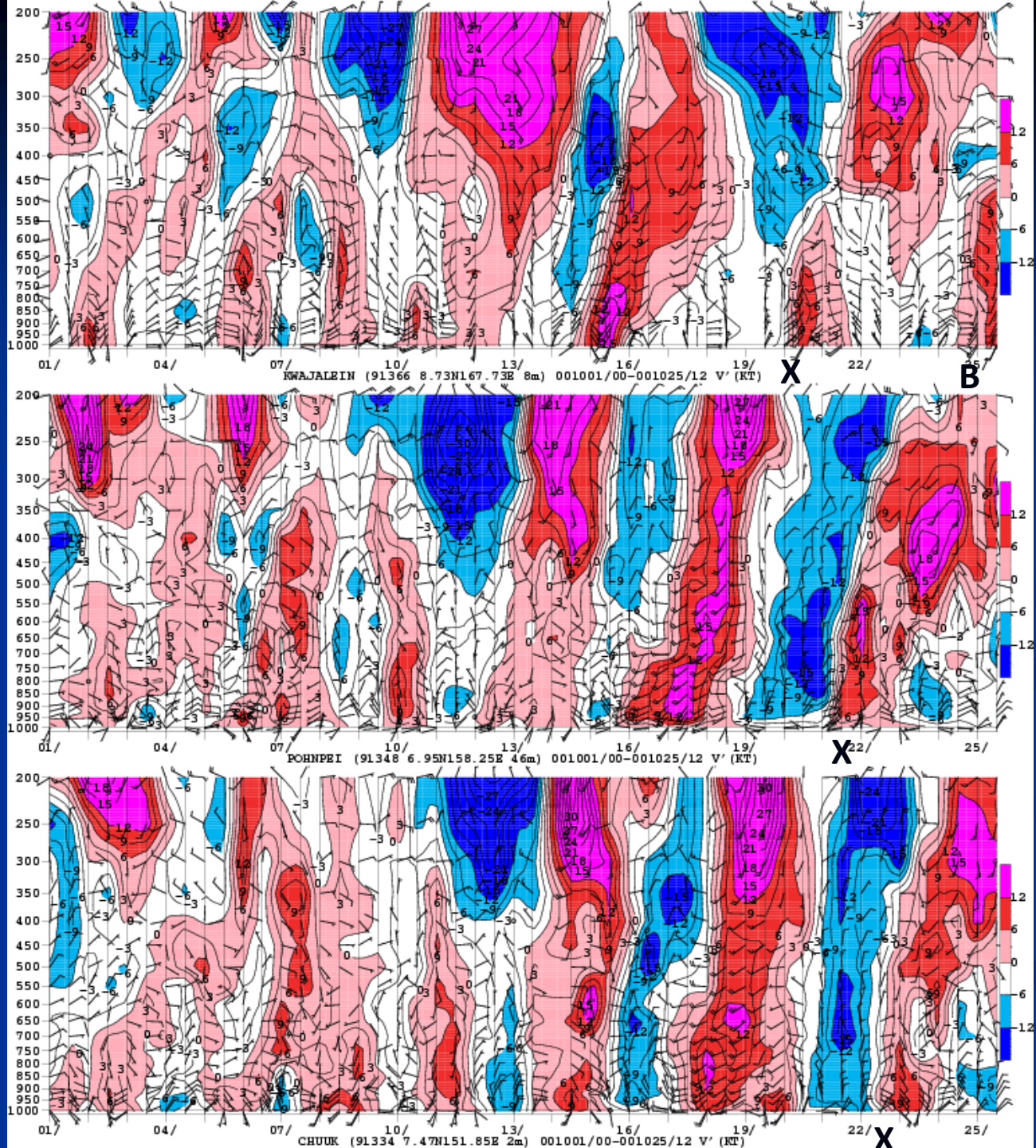
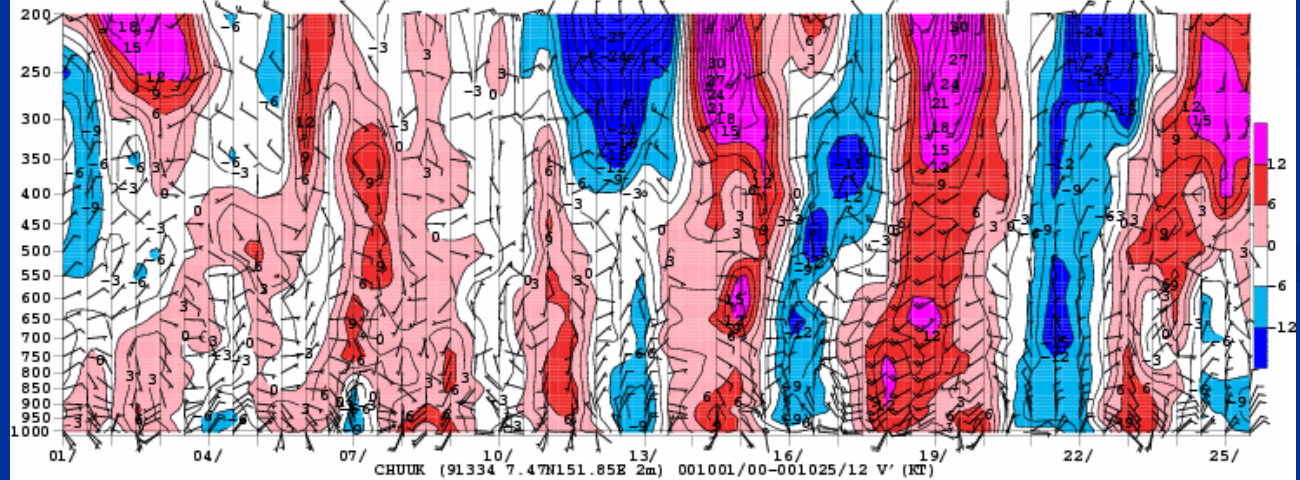
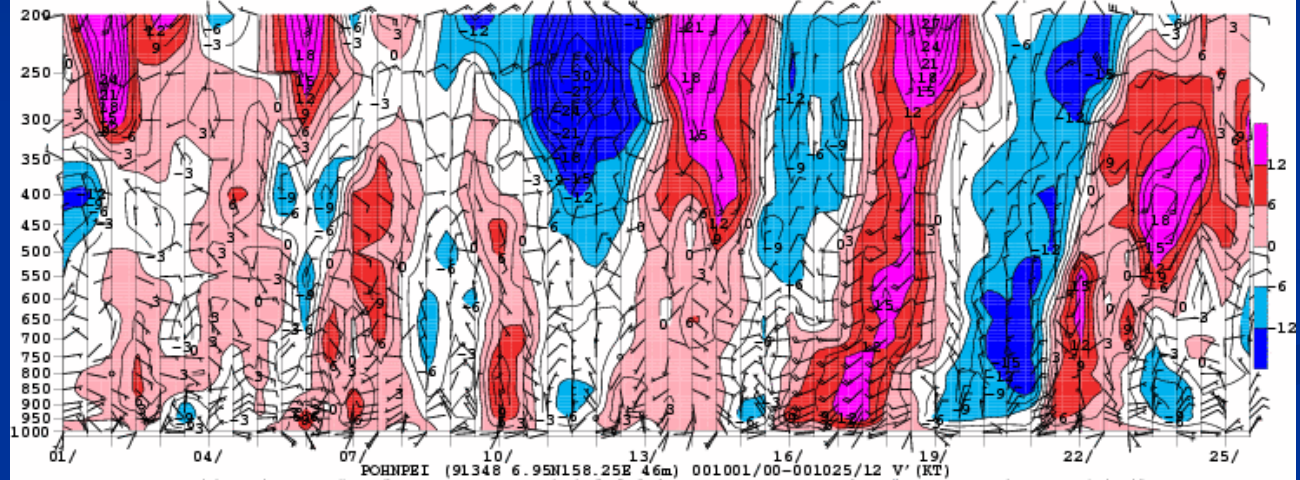
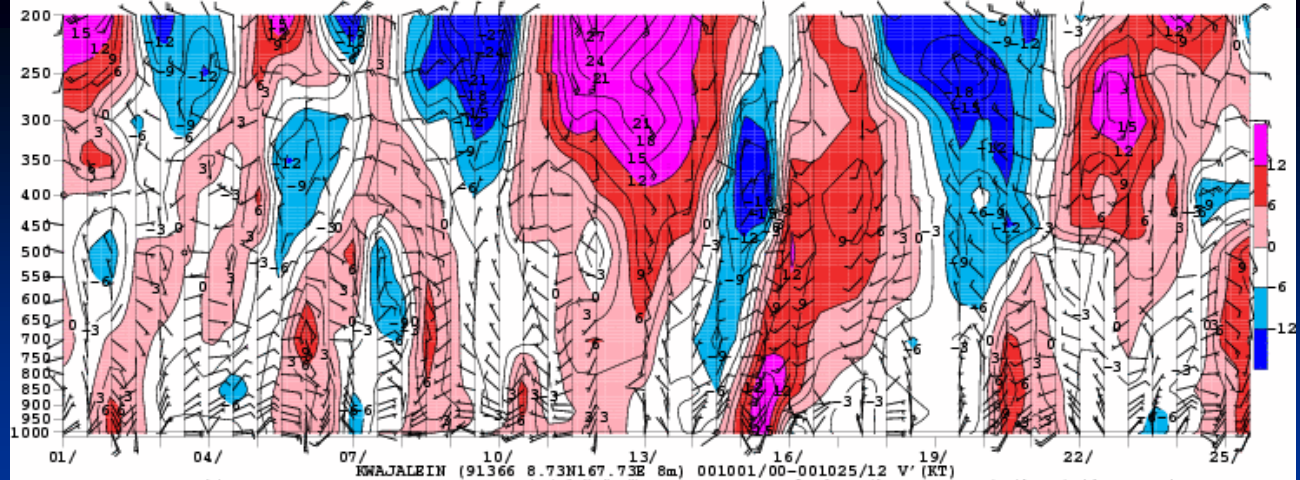


FIG. 1. Time-longitude section of satellite photographs of the period 1 July-14 August 1967 for the 5-10N latitude band in the Pacific. The following data are missing: 4 July (150E-155W), 17 July (150E-150W, 130W-100W), 29 July (130W-100W), 11 August (150E-150W).

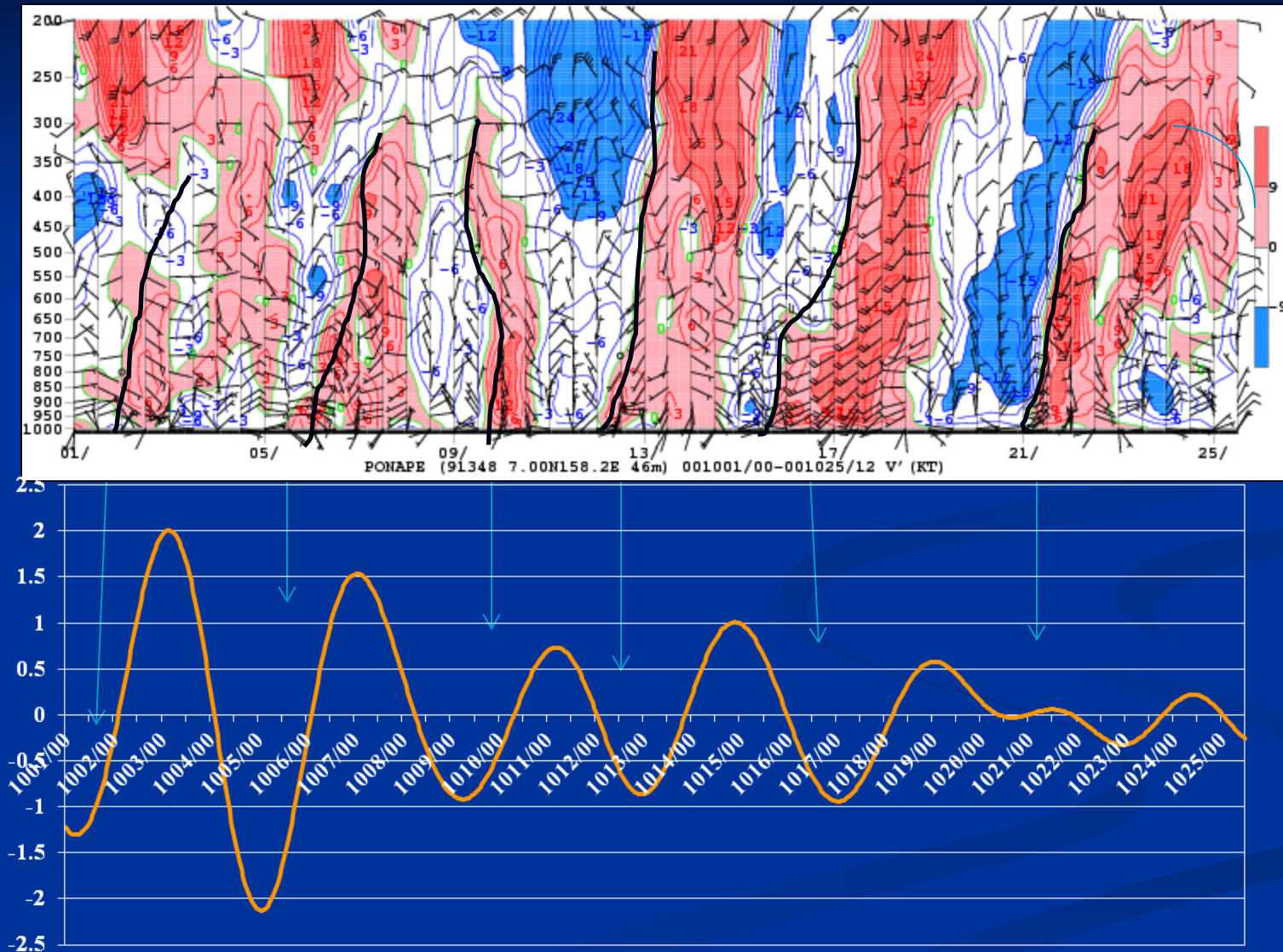
Easterly waves
over western north
Pacific

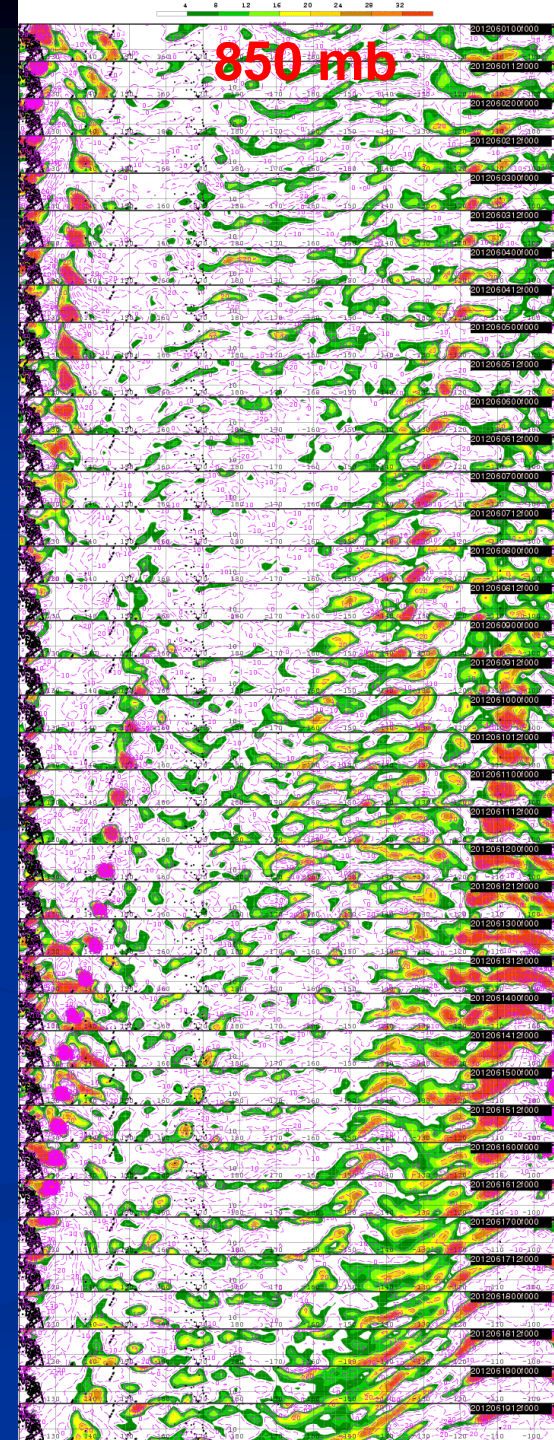
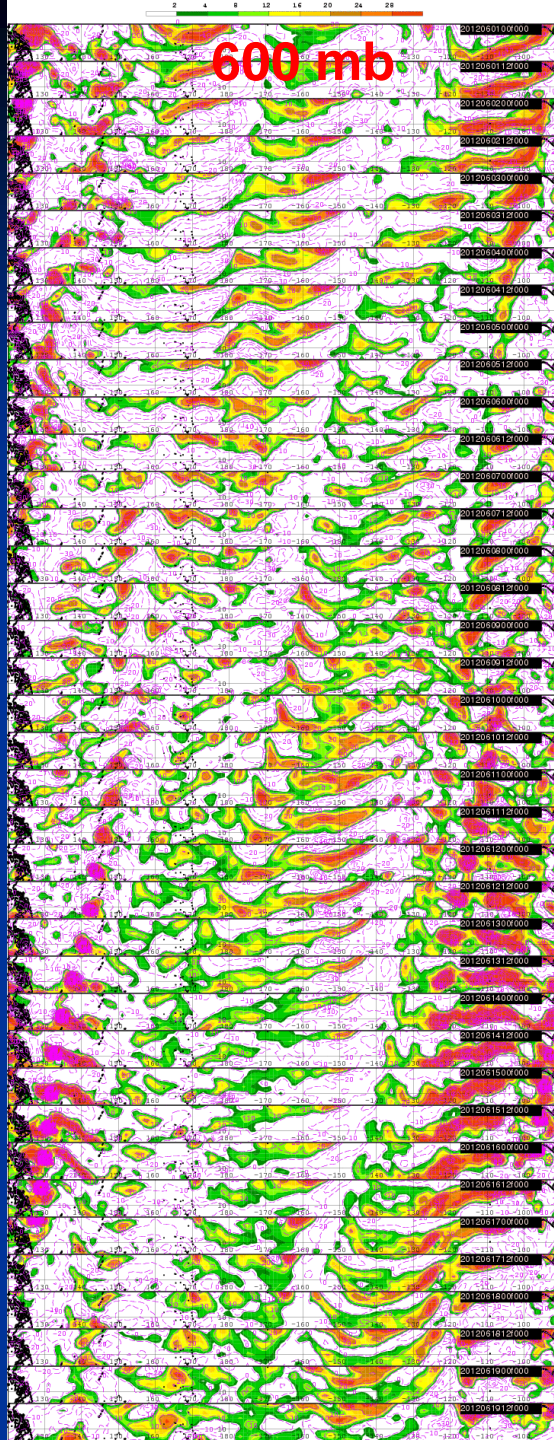




Time series of upper air data and surface pressure

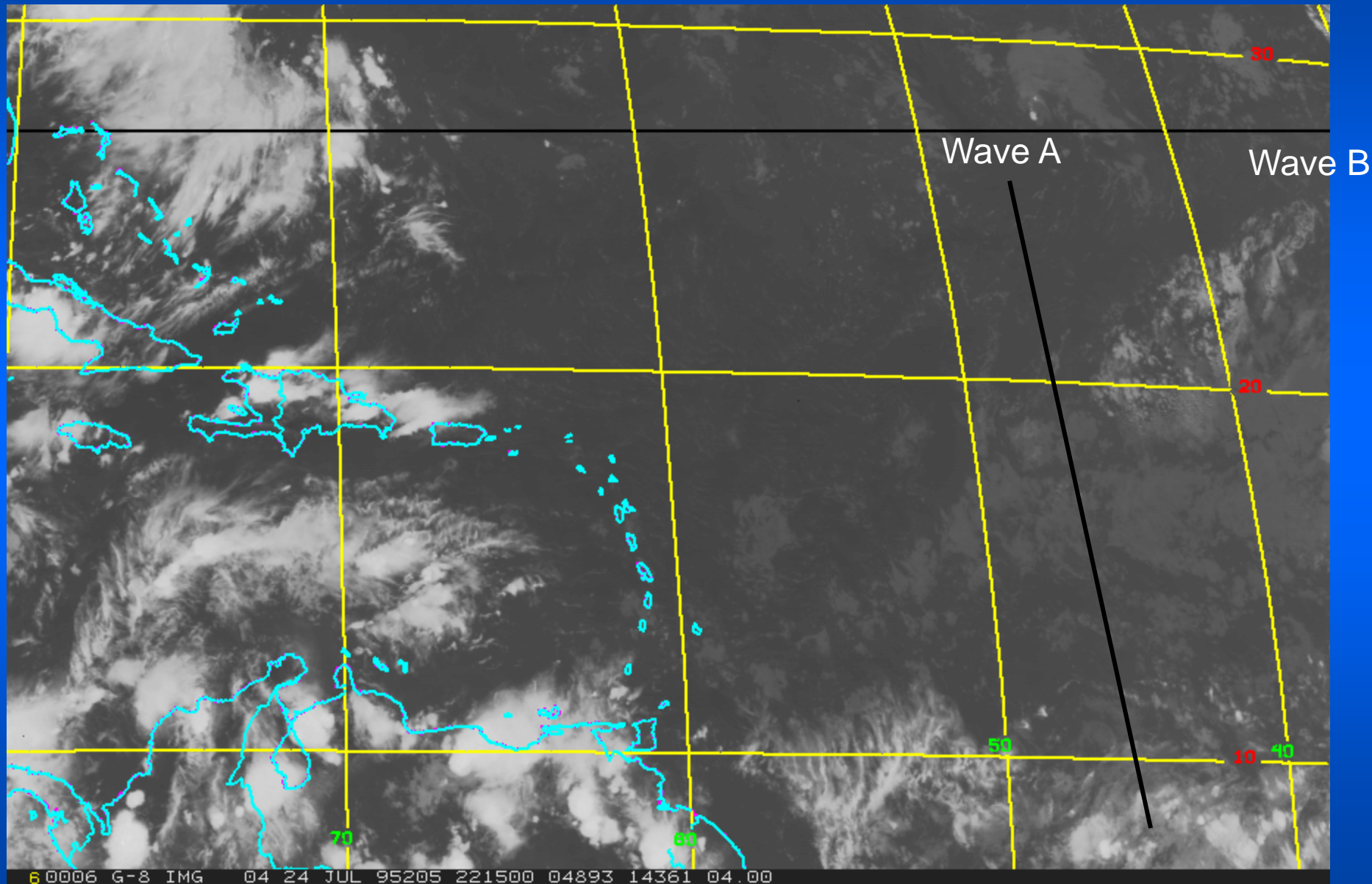
Pohnpei 20000901-20000925



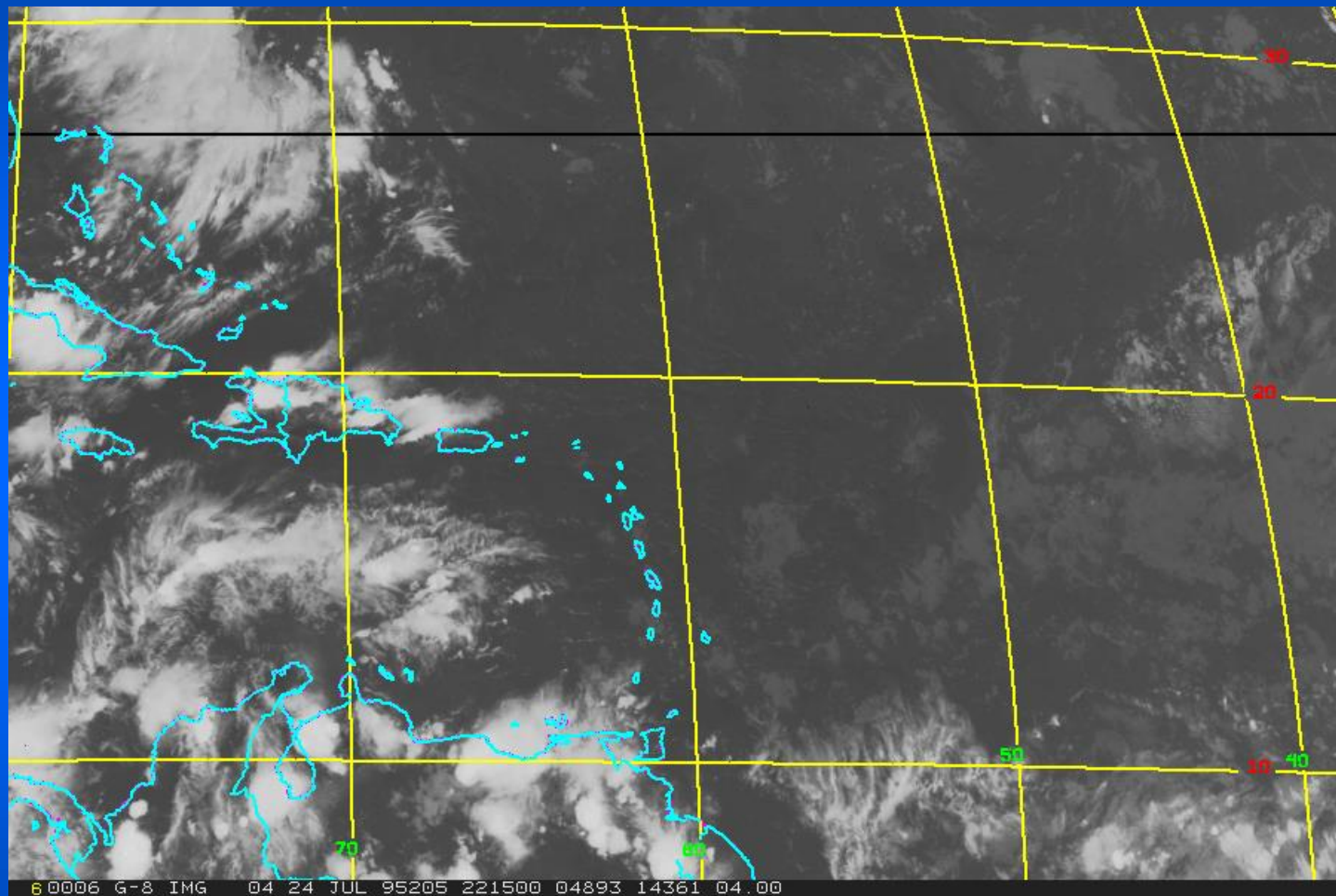


Interactions between different
systems of different scales –
very often causes for heavy rainfall

Example of systems interacting with each other



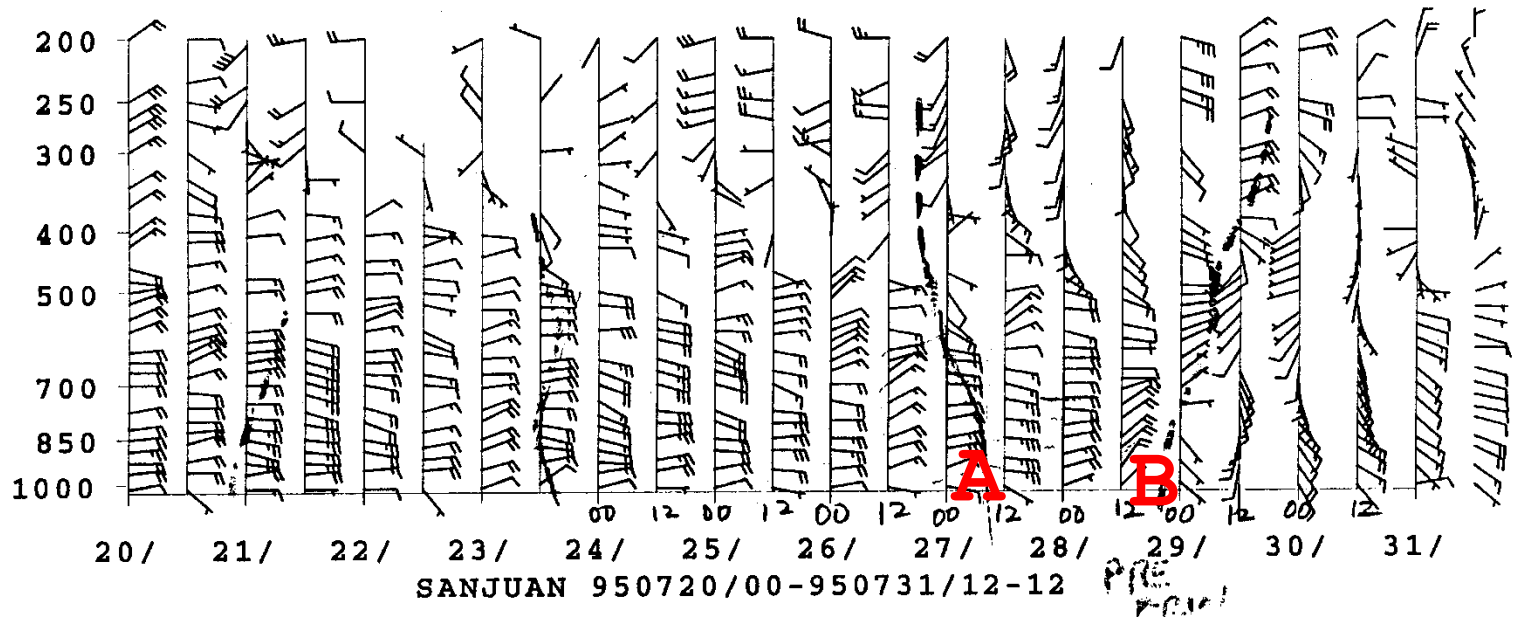
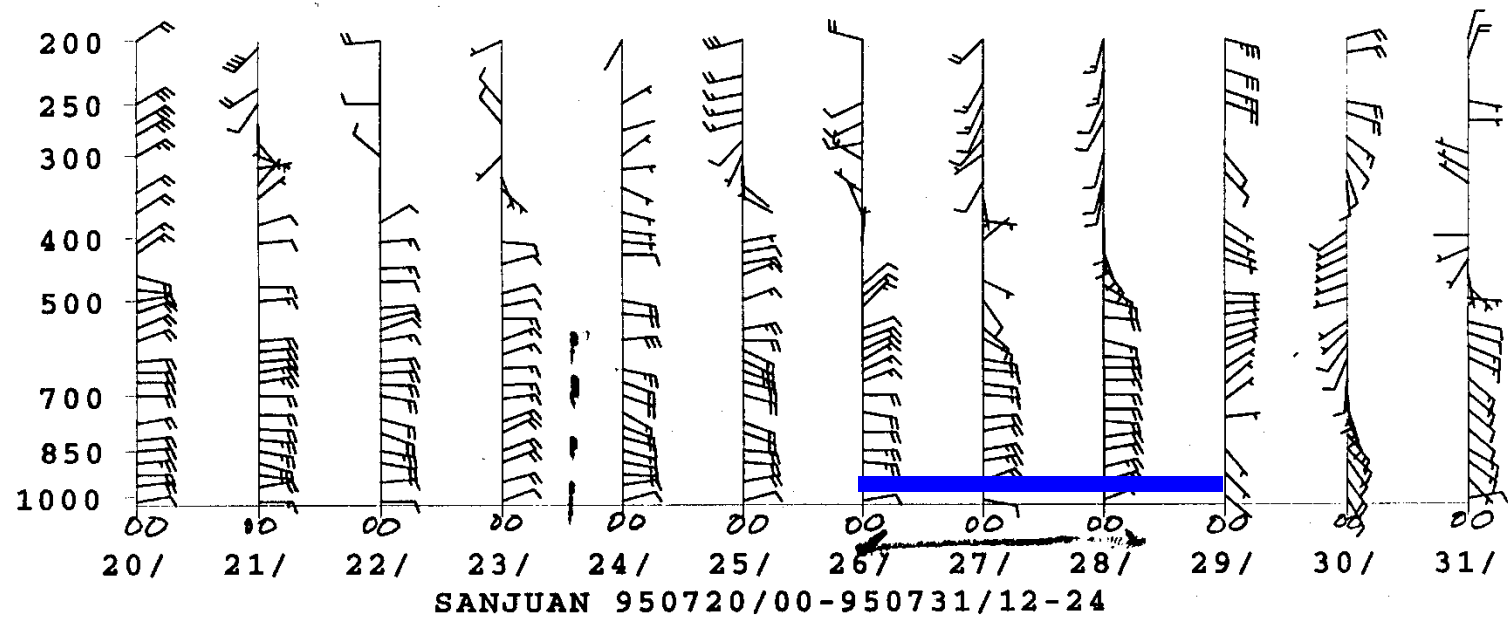
July 24 – 27, 1995



IS ONCE-A-DAY RAWINSONDE ENOUGH?

The wave in the above example passed TJSJ
between 00Z and 12Z of 27 July 1995

Can you locate the wave Between 00-12Z 27 July?



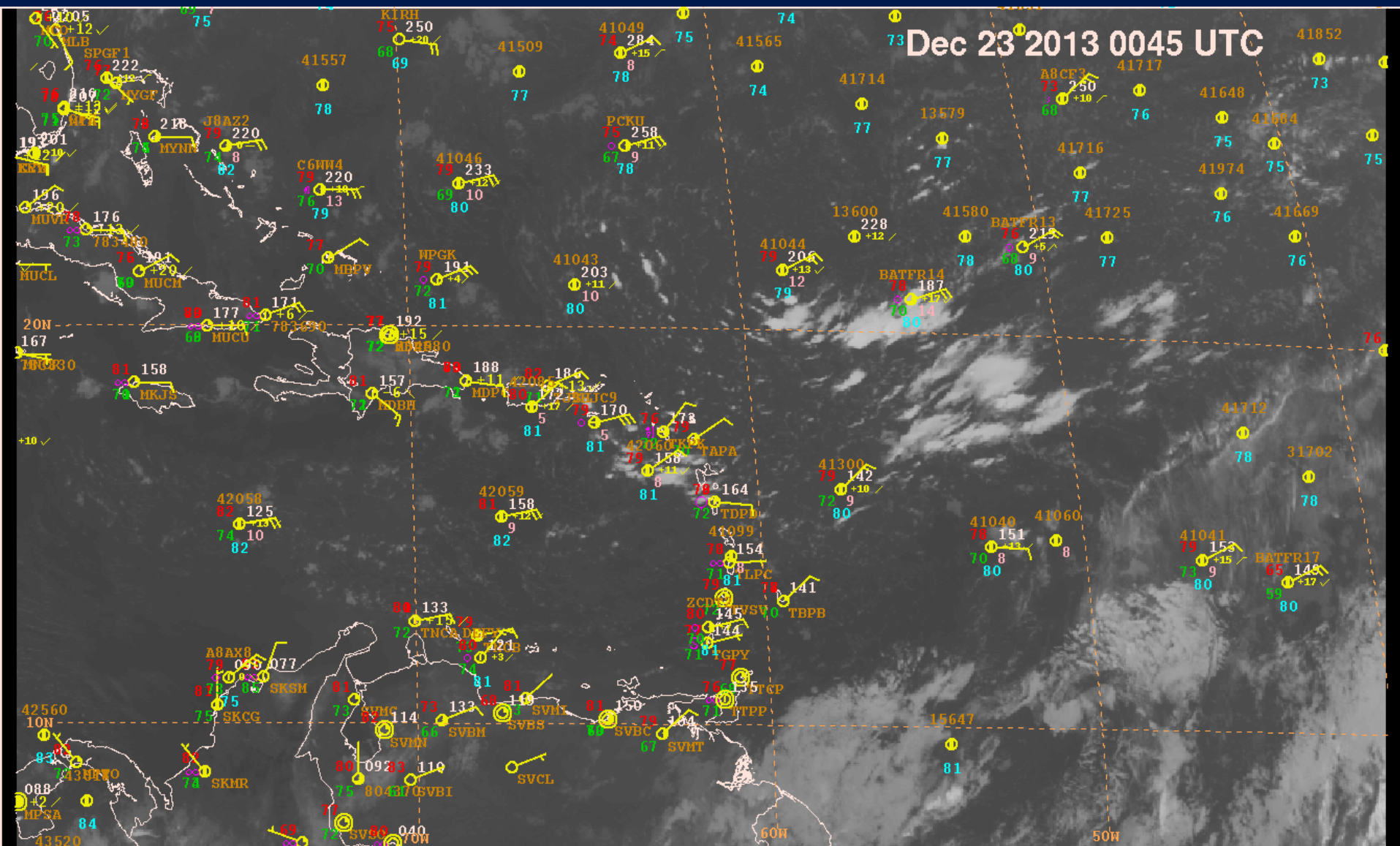
Heavy rainfall over the eastern Caribbean Islands December 24-26, 2013

A quick look

Eastern Caribbean: Floods and Landslides - Dec 2013

- Severe rains and high winds due to a low level trough system caused floods and landslides in St. Vincent and the Grenadines, Saint Lucia and Dominica from 23-25 Dec 2013 – *reliefweb.int*
- Torrential rains on Christmas Eve, with **15 in falling in 24** hours, led to dramatic floods and landslides that washed through St Vincent and the Grenadines, St Lucia and Dominica –*theguardian.com*
- From 6 to 10 inches of rain has fallen on part of the Leeward and Windward islands during the early and middle part of this past week - *AccuWeather.com*
- This is the third wettest December on record for St. Thomas and at least the fifth wettest on record for St. Croix, according to the National Weather Service in Puerto Rico

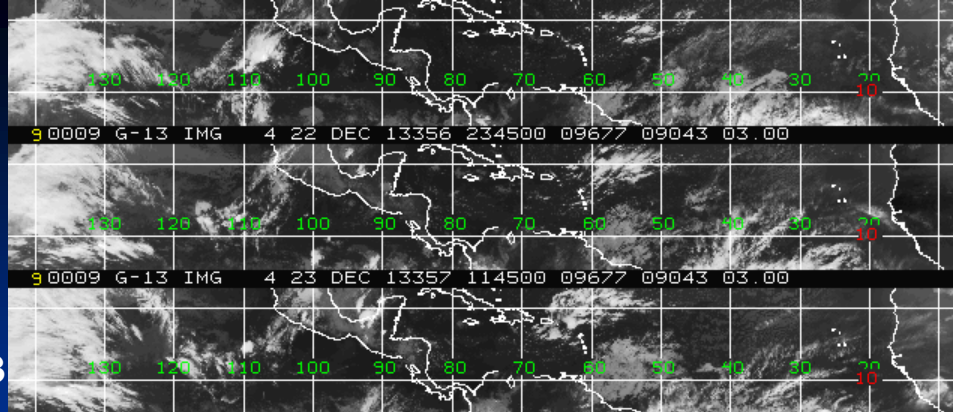
A quick view using GOES-E imagery



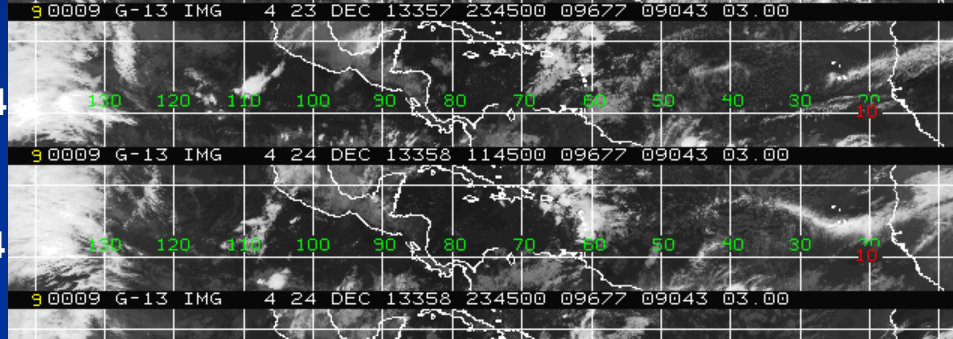
Dec 23 2013 0045 UTC GOES-E IR and Surface Obs

GOES-E

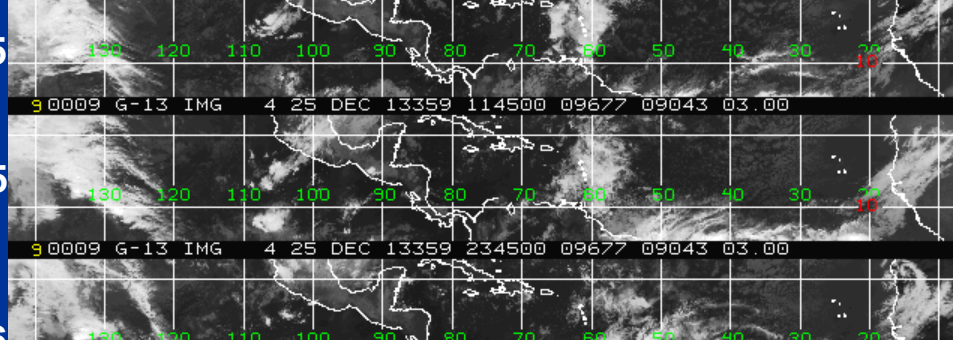
2345 UTC Dec 23



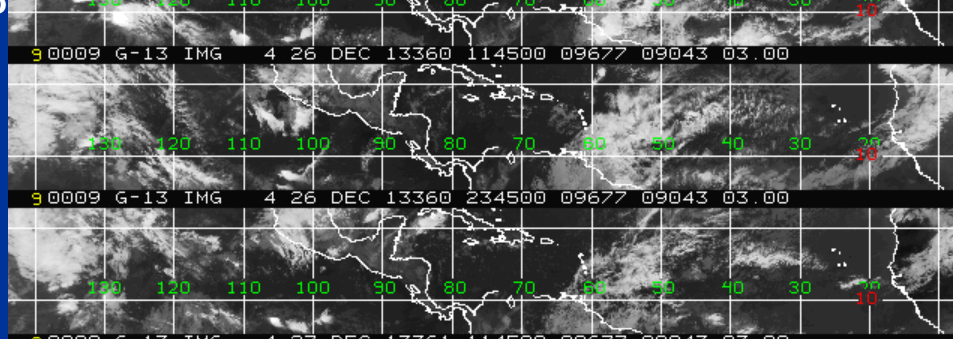
1145 UTC Dec 24



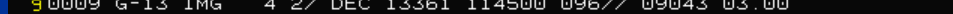
2345 UTC Dec 24



1145 UTC Dec 25



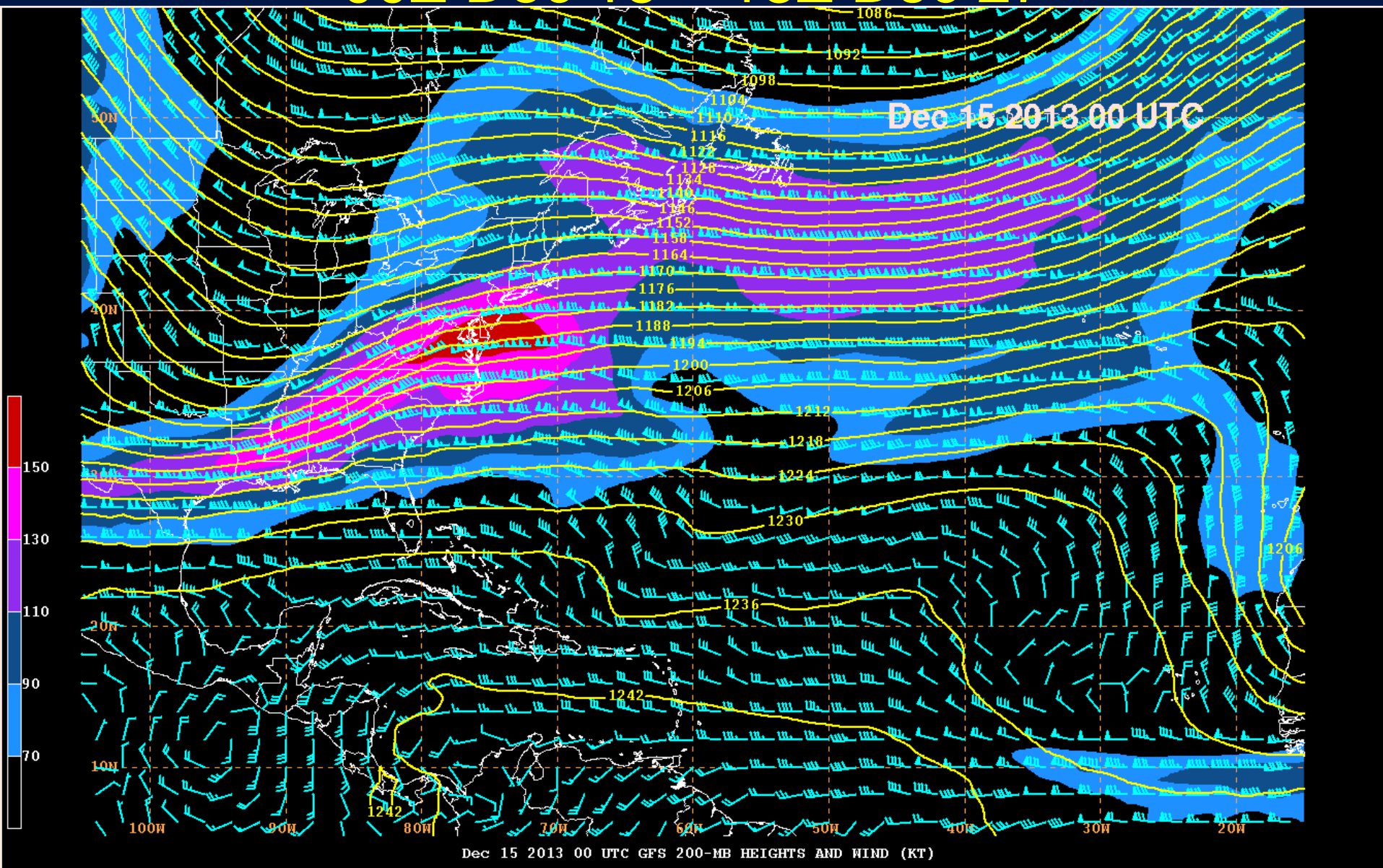
2345 UTC Dec 25



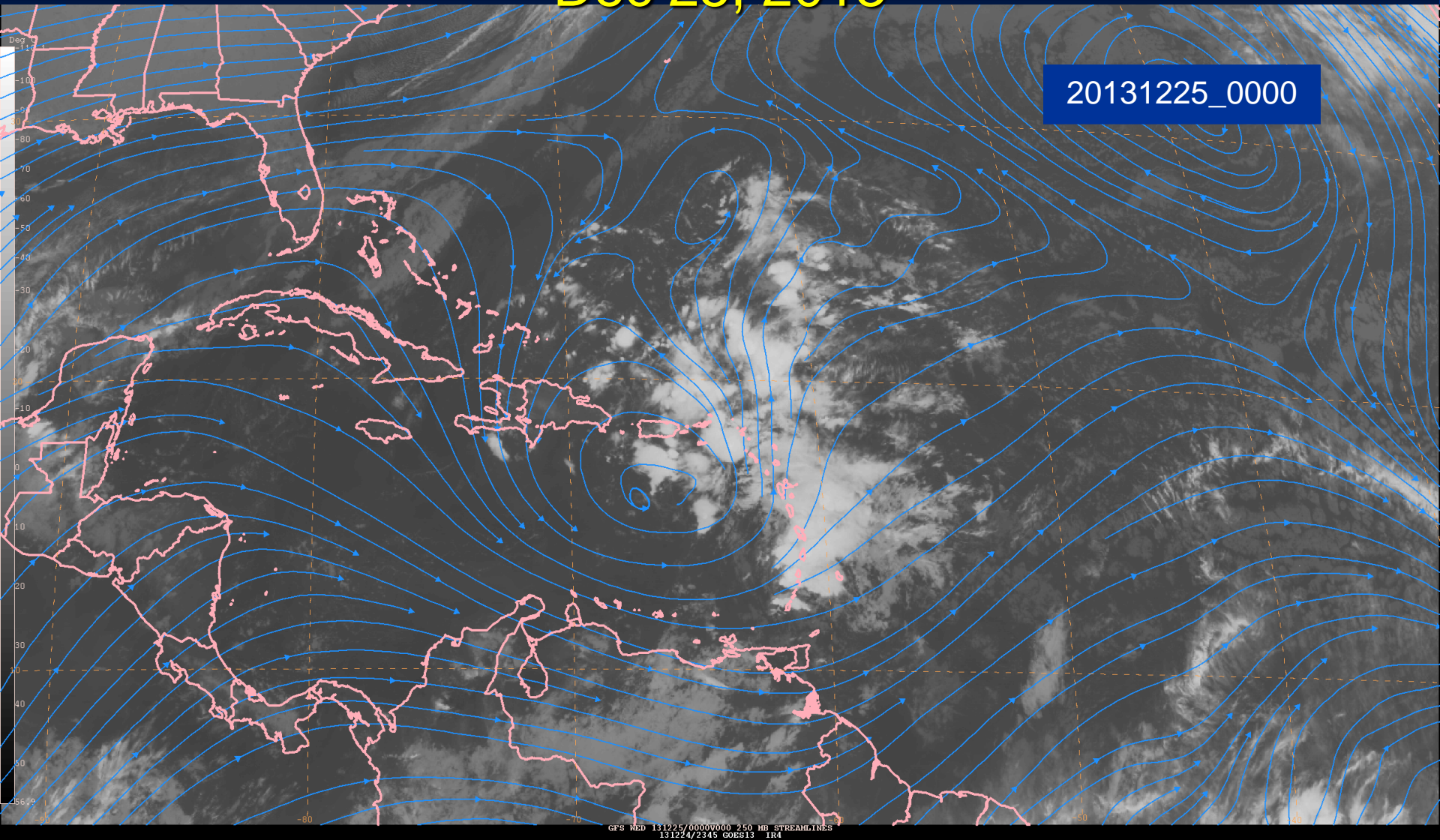
1145 UTC Dec 26

200 mb heights and wind

00Z Dec 15 – 18Z Dec 27

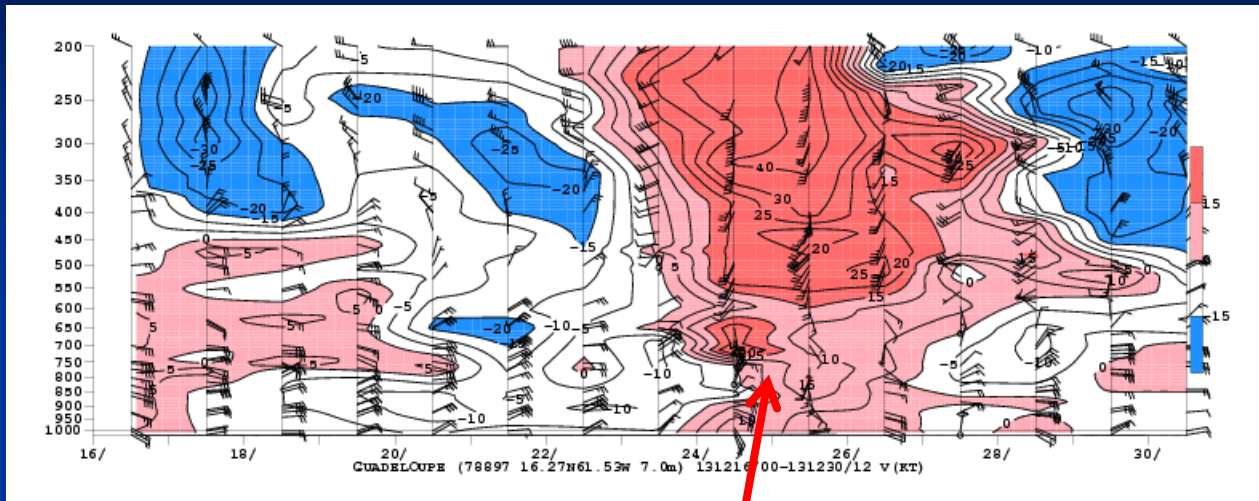


IR image and 250 mb streamlines at 0000 UTC Dec 25, 2013

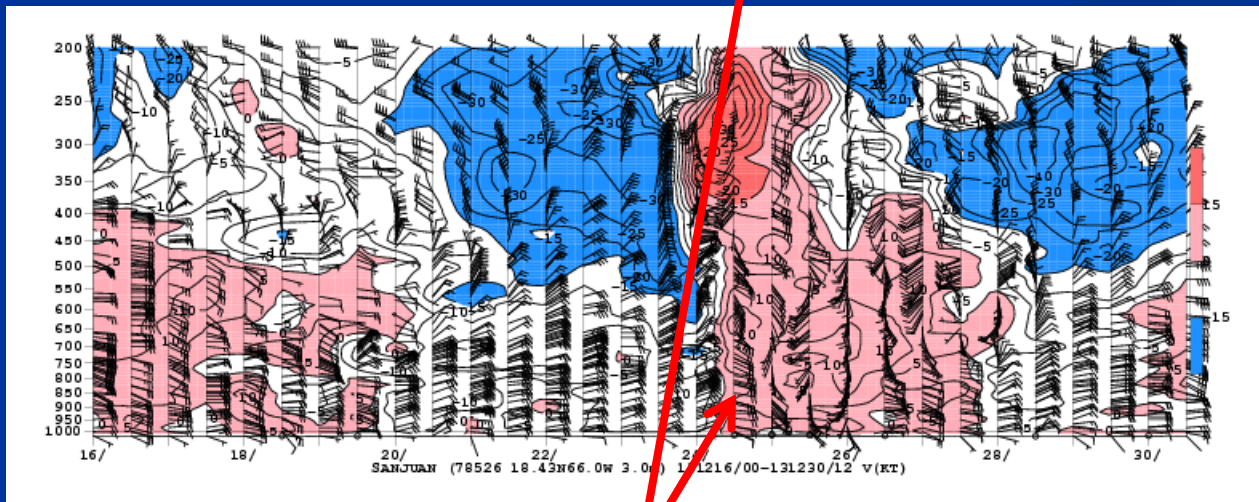


Sounding winds Dec 16 – Dec 30

Guadeloupe



San Juan

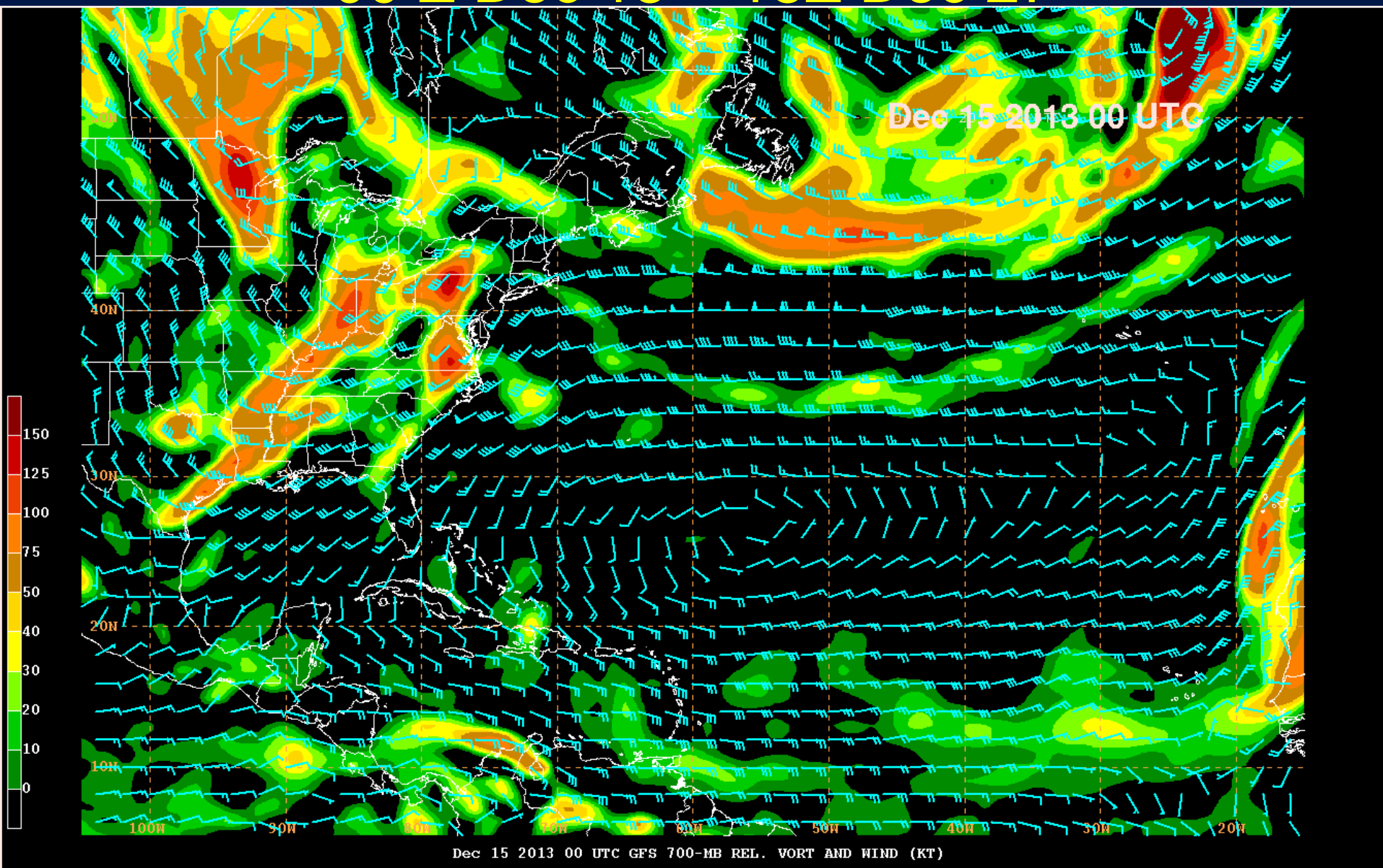


Was the low level southerly winds related to the upper level low only?

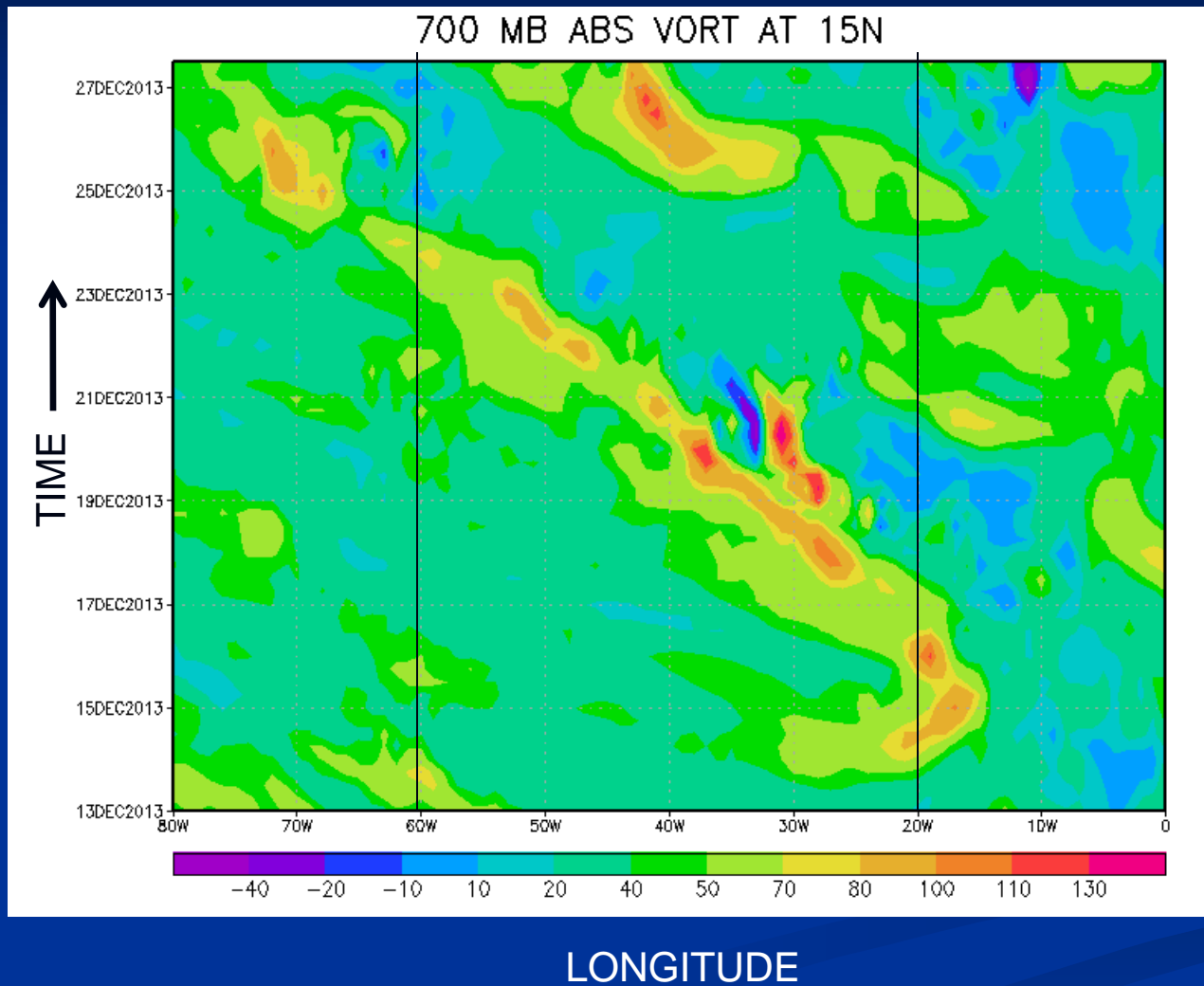
Was the heavy rainfall over the Windward Islands caused by the upper level low and a shortwave, or by the low level trough, or both?

700 mb relative vorticity and wind

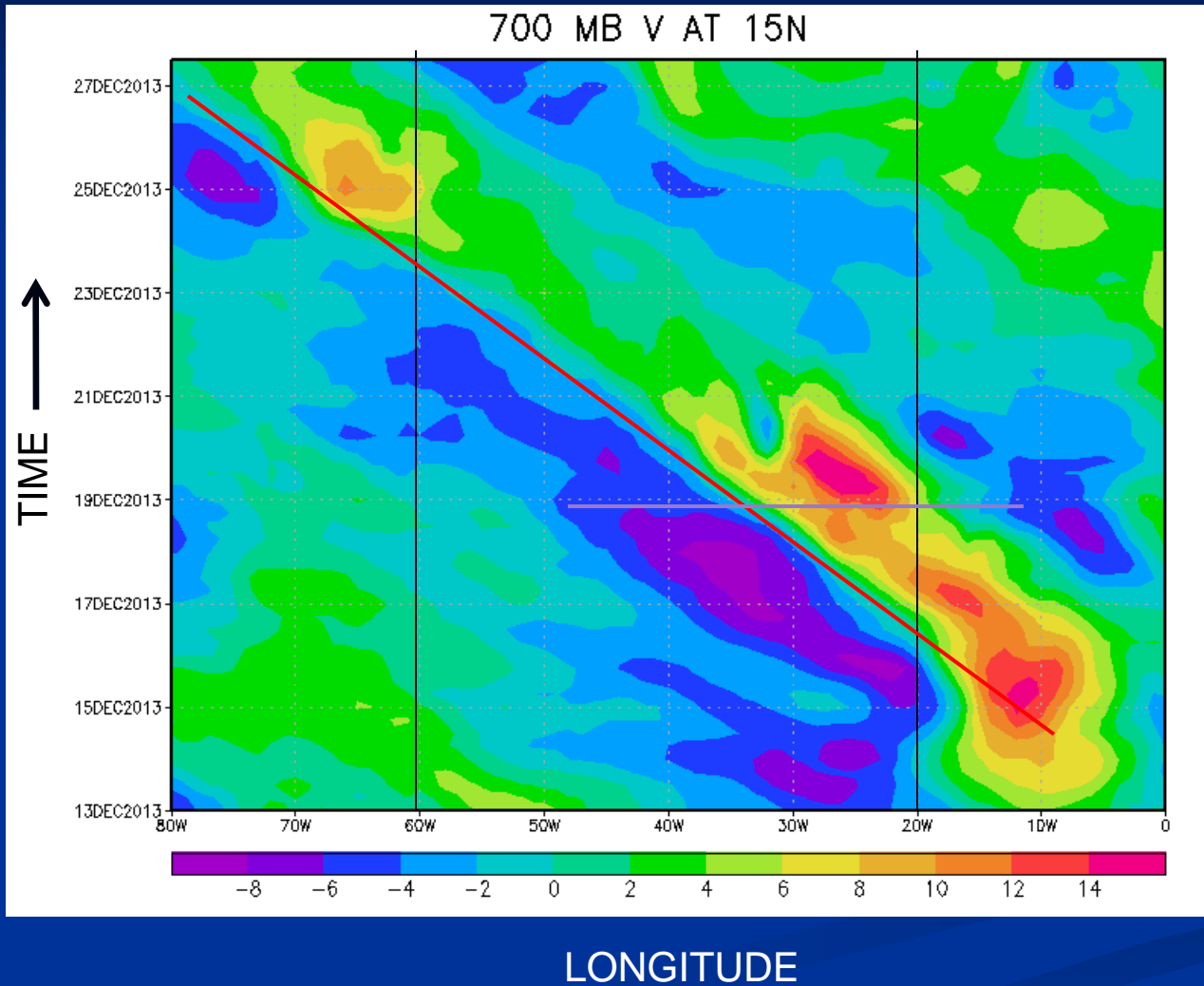
00 Z Dec 15 – 18Z Dec 27



GFS analysis



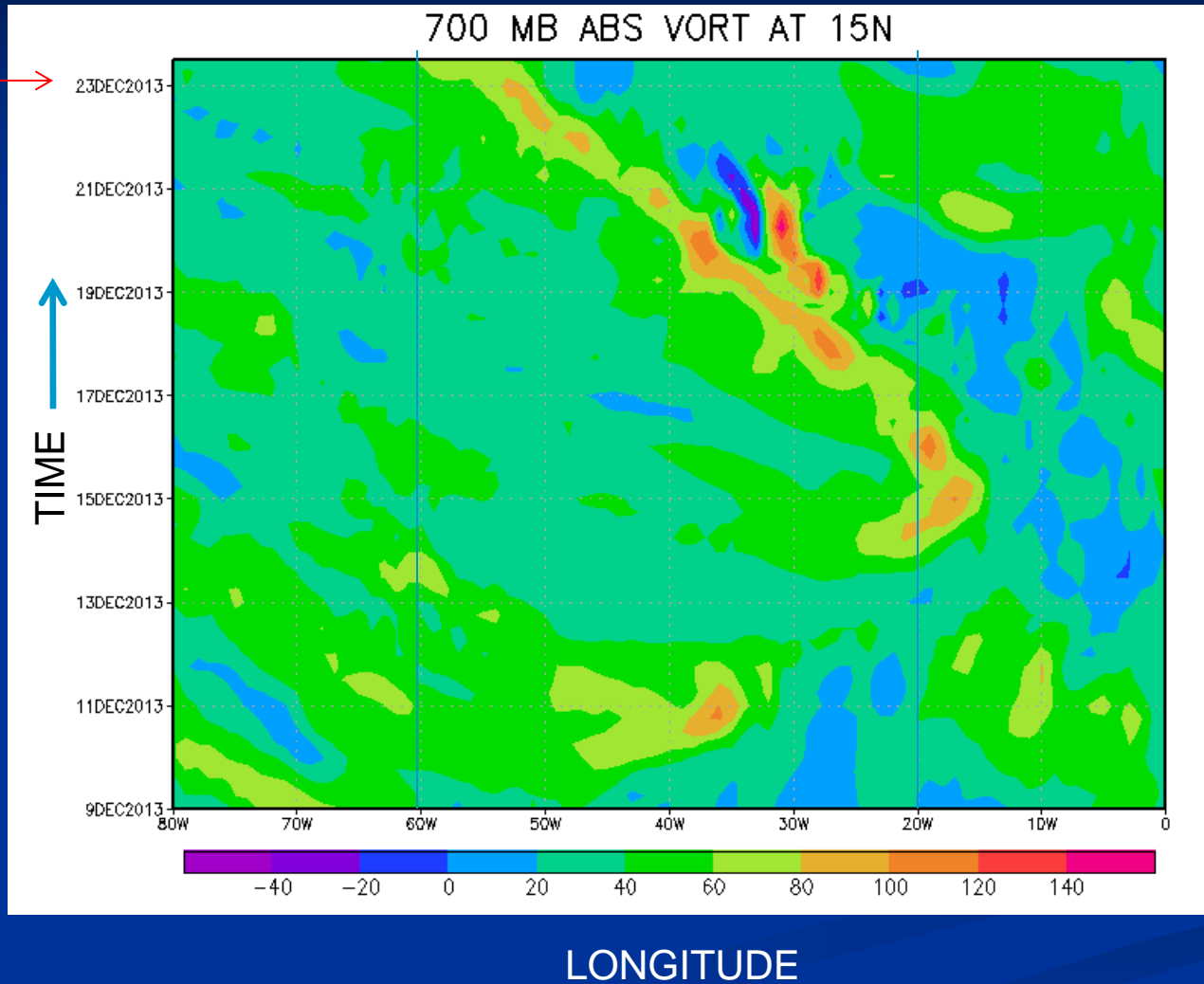
GFS analysis



In real time

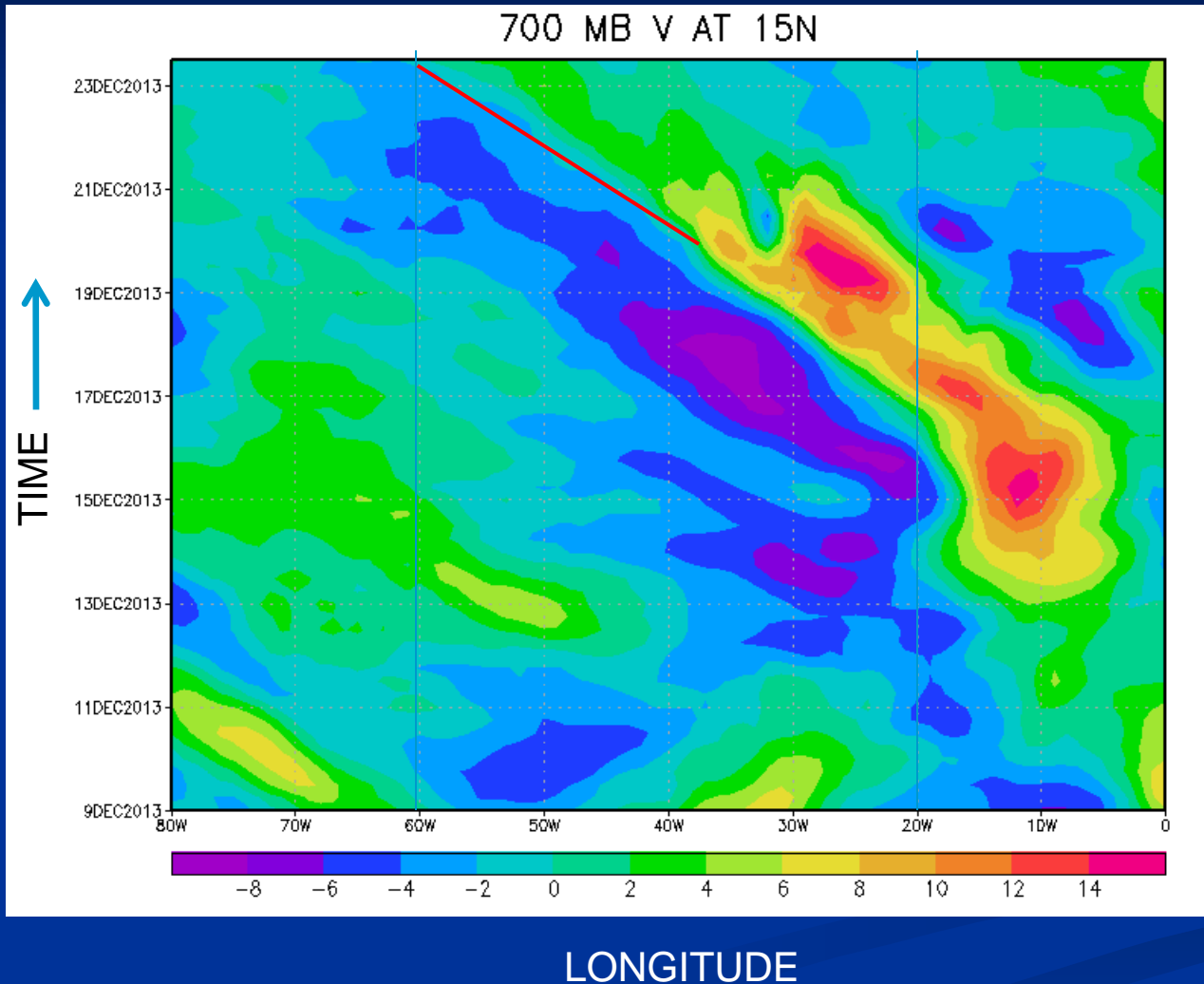
GFS analysis

You are on duty,
1200 UTC Dec. 23,
2013



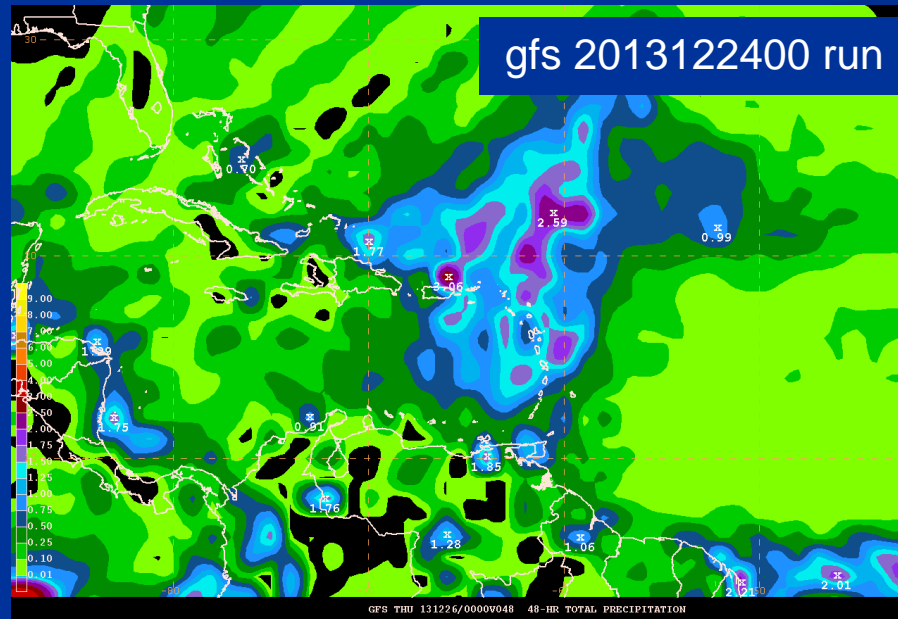
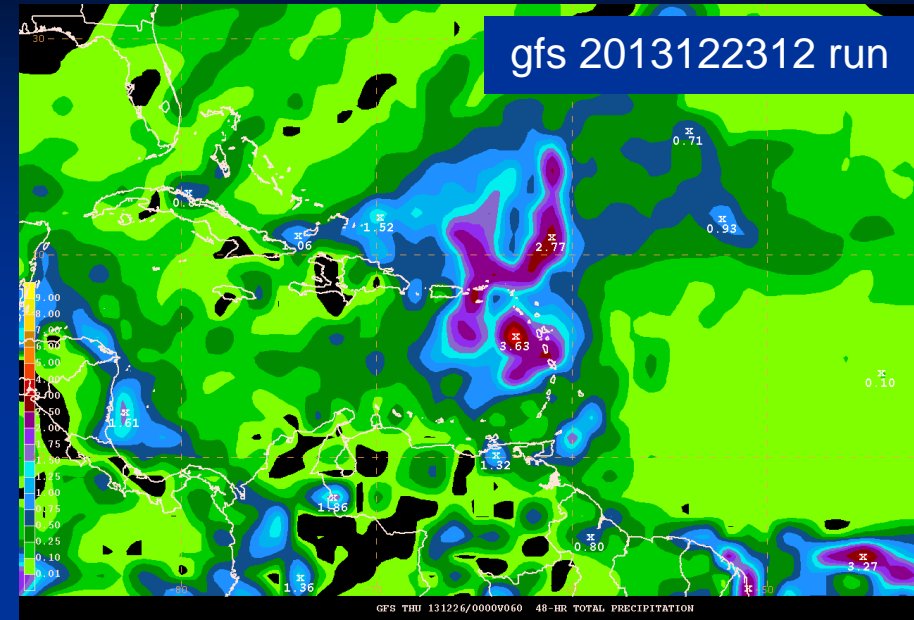
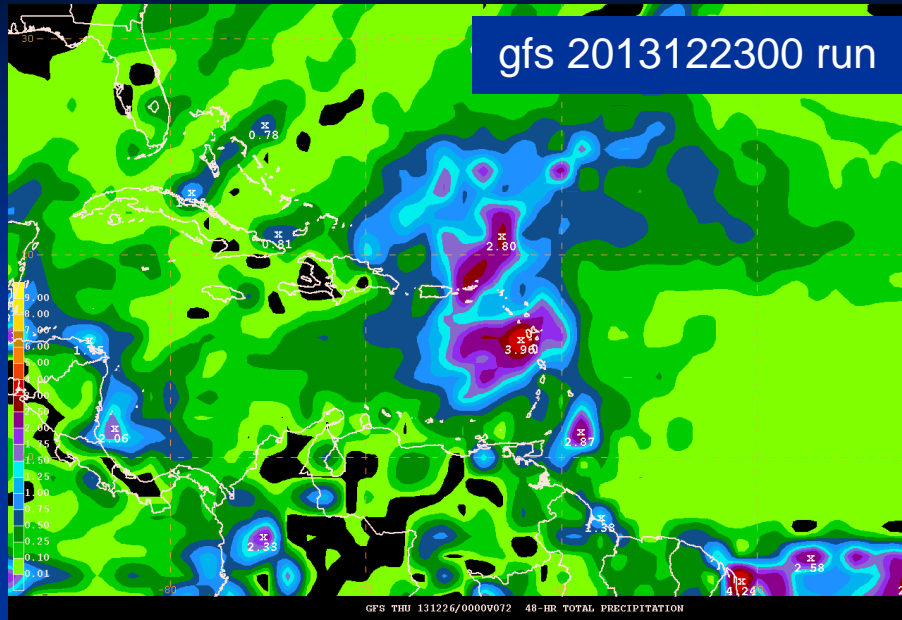
A well defined low/mid-level system is approaching 60W by 12 UTC December 23, 2013

GFS analysis



A well tracked, westward moving, low/mid-level trough is about to move pass 60W at 12 UTC December 23, 2013

GFS 48 hr total precipitation forecast for the period 00Z 24 - 00Z 26



What do you think?

This case is very similar to the earlier example of July 24-27, 1995

- Unusual/unexpected heavy rainfalls in the tropics tend to be the results of interaction of various systems in favorable environments
- Good analysis, close monitoring/tracking of all systems, upper-level and low-level, gives forecasters confidence in making rainfall forecasts
- Frequent update of rainfall amount and forecast is helpful

Now someone says there is an elephant outside and you have been asked to make a good analysis

What's the best approach?

- Do some quick research on elephants
- Step back and see the whole thing
- Then approach it and take a detailed look
- . . .
-

(Don't do cross section analysis)

Some Advises on Performing Analysis

- On satellite animations (loops)
 - Always start your day by watching a long loop that covers 2-3 days of images and over a large domain. One frame per hour is more than enough.
 - Identify large-scale features, their motions, and intensity changes, if any.
 - Then watch a shorter loop on systems you are interested in (with higher imagery frequency).
 - Apply this approach even if you are doing Dvorak classification.

Some Advises on Performing Analysis

- On Analyzing maps, surface analysis or upper level charts
 - Step back and look at the large picture (whole domain).
 - Take a look at previous maps and gain some ideas of the features there and the history of them.
 - Then look at the current map and check the area where these systems should be.
 - Cloudiness may suggest locations of synoptic features, but synoptic features do not always have convection accompany them.


Some Advises on Performing Analysis

- If your office do not use paper charts, and all the lines are drawn by computer automatically
 - If you have doubt, print a page and analyze that section by hand.
 - Ask supporting staff to program the computers to generate some of the analysis tools you've seen earlier like timesections, timeseries, Hovmöller charts (of satellite image or model fields).

Analysis tools on NHC web site

www.nhc.noaa.gov/analysis_tools.php

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Below are tools and data made available for the web.

	<i>Atlantic</i>	<i>East Pacific</i>
Hovmöller Diagram (5 day Satellite)	Tropical Atlantic and Caribbean (GOES-E) Gulf of Mexico and subtropical Atlantic Eastern Atlantic and Africa (METEOSAT-10) Southern CONUS and subtropical Atlantic (GOES-E)	East Pacific (GOES-W)
Upper-Air Time Sections	Selected Observing Stations	
GFS Pressure Change Analysis	See image	See image
ASCAT Ocean Wind Data	See recent data	
Streamlines	NCEP Model Analyses & Guidance	
Sea Surface Temperature	Analysis and Anomalies	
Tropical Rainfall	Experimental Text & Graphics	

Anything else that can help?

Spectral analysis-on demand???

Thank you

20140822/0600Z

Take a look at the report from this buoy

