New Set of Forecasting Tools developed by the WPC International Desks

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WPC International Desks Mission

To enhance weather analysis and forecasting practices in the region.

Aside from training, the mission extends to the development of forecasting tools:

- Specifically tailored to regional needs.
- Needs are identified by operational forecasting and communication with NWS partners in WMO RAIII and RAIV.

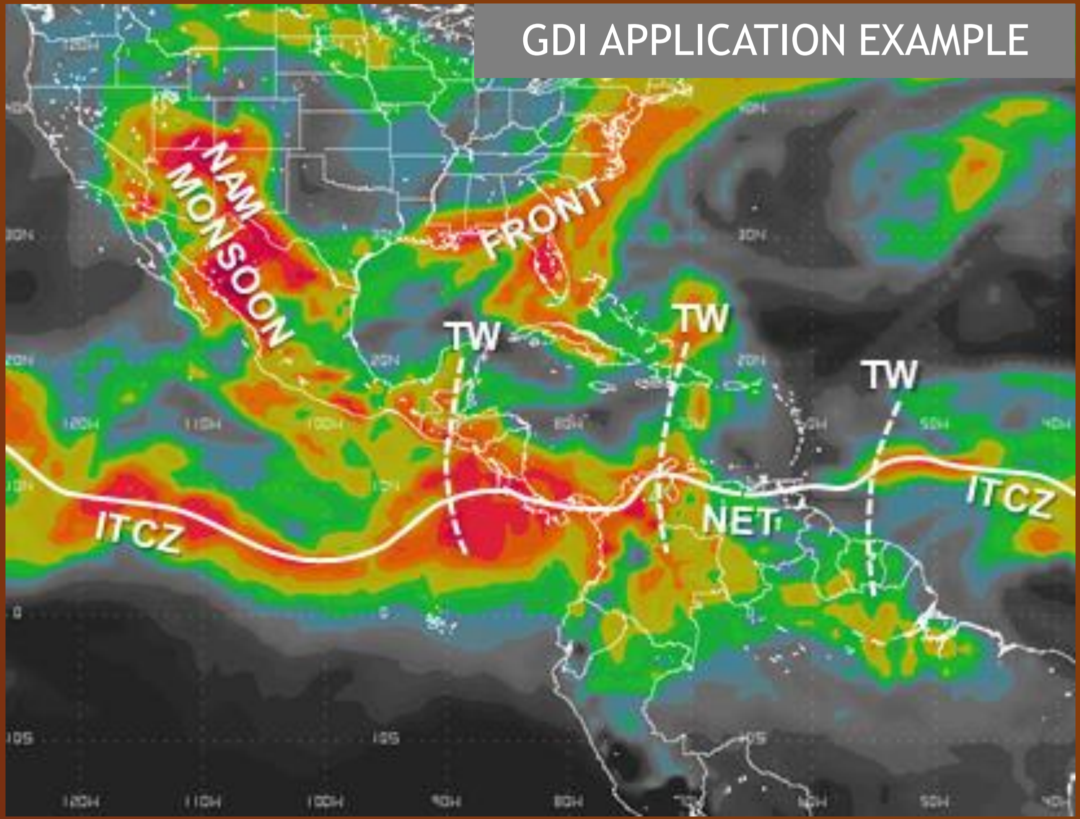


Fig. Example of a tool developed in 2014, now at use in different countries: The Gálvez-Davison Index (GDI).

The Galvez-Davison Index

Recalling the GDI:

Diagnoses environments favorable for different types of moist convection in the tropics and subtropics. Sum of 3 components:

-Column Buoyancy Index (CBI)

Positive factor. Deep-moist columns where θe is high in both 500 and 950 hPa. The higher the CBI, the higher GDI.

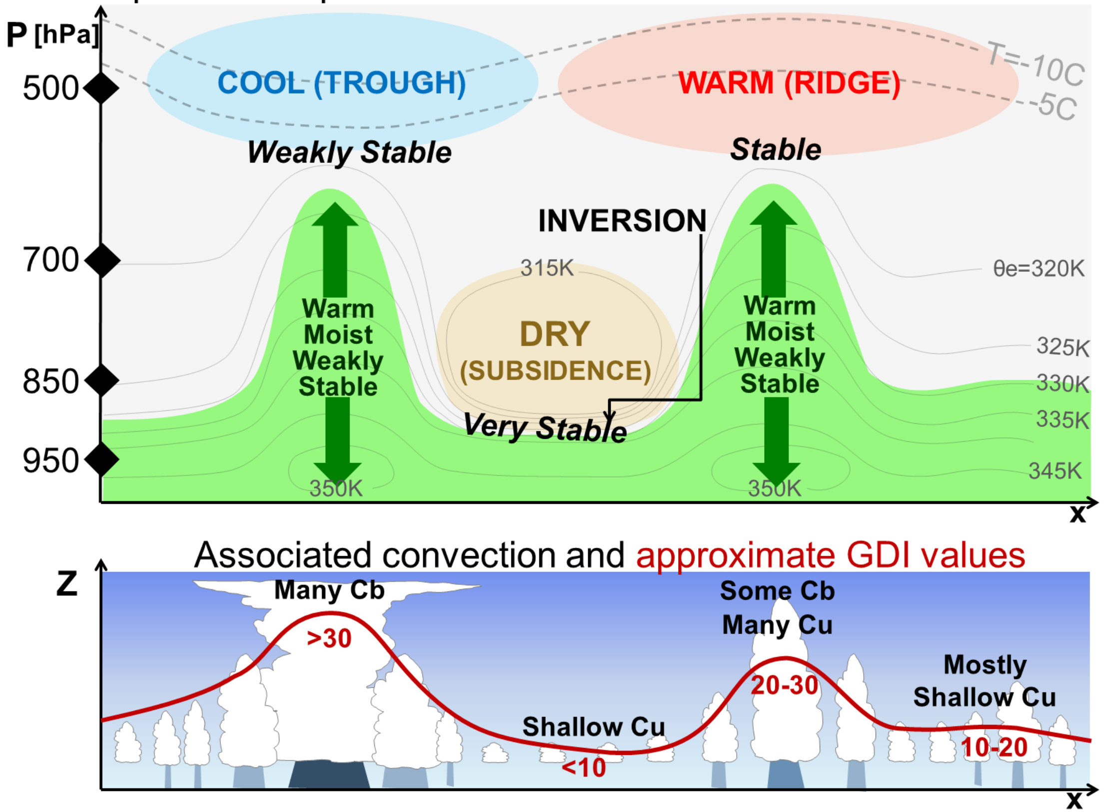
-Inversion Index (II)

Tampering factor (II ≤0). Strong inversion = very negative II. Represents dry entrainment into marine layer (sharp θe decrease with height), and/or stabilization (gentle 950-700 hPa lapse rates), No inversion means II=0, allowing GDI to remain high.

-Mid-Level Warming Index (MWI)

Tampering factor (II ≤0). Accounts for the stabilizing effects of warm mid-level ridges versus cool troughs. Becomes increasingly negative as 500 hPa temperatures increase from a threshold of –8°C, decreasing the GDI.

Tropical Atmosphere Processes considered for GDI calculations



The Galvez-Davison Index

GDI Resources

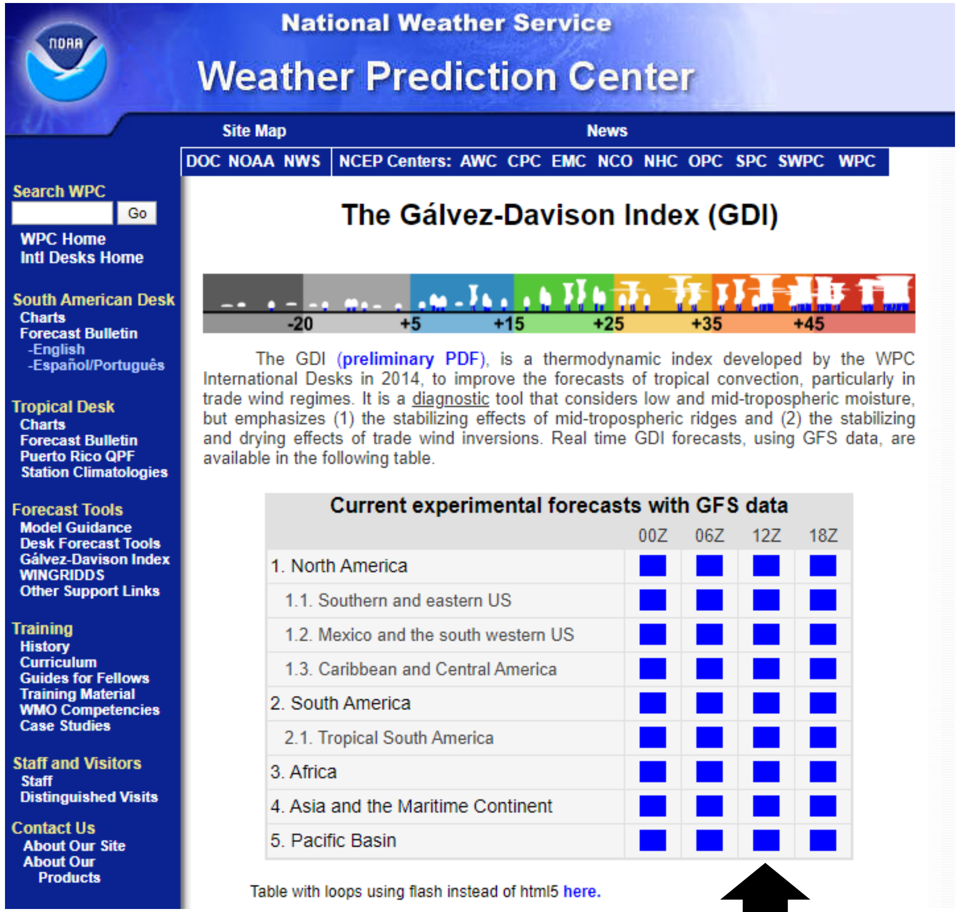
- Website
  https://www.wpc.ncep.noaa.gov/international/gdi/

- Manuscript (in web)
  Description and calculation algorithm.

- Experimental forecasts using GFS (in web)
  -Nine domains run operationally on 00, 06, 12 and 18Z GFS data.
  -Has been coded by different Weather Services in the world.

- Code for Wingridds

- ECMWF GDI
  The GDI has been computed on ECMWF data for internal use at NOAA, and is available in NAWIPS. The ECMWF-GDI tends to work better than the GFS-GDI in the deep tropics, especially in continental areas.



GDI Website: https://www.wpc.ncep.noaa.gov/international/gdi/

But we have developed more forecast tools!

- New Forecasting Tools since 2014:

  -Enhanced GDI (EGDI)
  -Trade Wind Inversion Diagnosis (TWIN)
  -Severe Weather Potential (GR02/GR02T)
  -Surface Front Identification (FRONT)
  -Central Andes Precipitation Accumulation (CAPI)

- Developed and programmed using WINGRIDDS Software

  -Open Source, developed by Jeff Krob
  (thank you Jeff for making this possible!)
  -Very versatile for analyzing gridded output.
  -For Windows users. It is easy to install and use.

Wingridds Website: http://winweather.org/

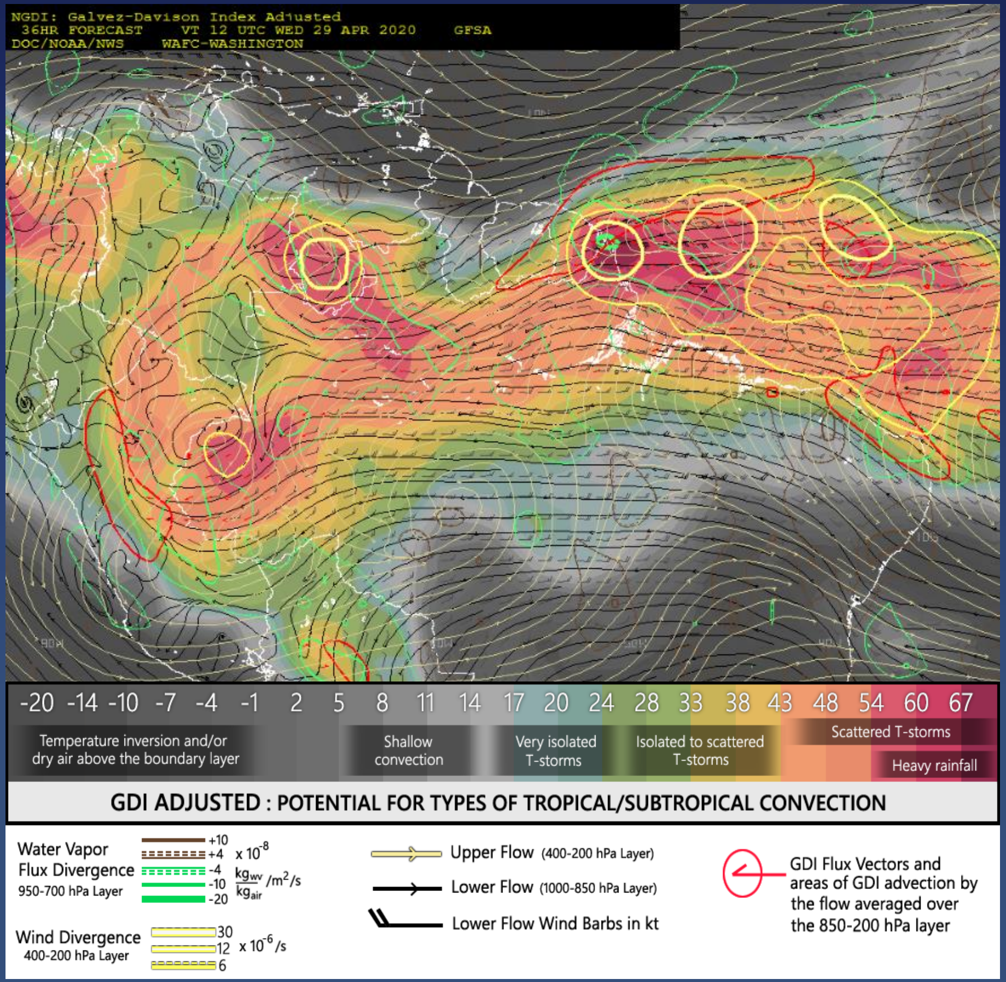


Fig. Example of the Enhanced GDI Tool (EGDI). Includes the Enhanced GDI and key aspects of the flow to diagnose regions prone to heavy rainfall.

How to access these new diagnostic tools?

https://www.wpc.ncep.noaa.gov/international/wng/

- Output using GFS data is available online routinely!
  - -Computed daily on 00 and 12 UTC 1° GFS data.
  - -Available for 12 domains in the Americas.
- Not all tools are coded for all domains.
  - -Implementation decision upon tool skill.
- The tools are still being validated.
  - -There is always room for improvement, so we welcome user feedback.
  - -Still learning the best ways to apply the tools based on changing weather scenarios.
  - -Work in progress: Building thorough documentation.

Example: Caribbean Domain Tools

This domain has four algorithms implemented:

- **Enhanced GDI** (EGDI)
  For quantitative precipitation forecasting (QPF) Purposes.
- **Trade Wind Inversion** (TWIN)
  Elevation and strength of the trade wind temperature inversion.
- **Hail and Severe Weather** (GR02T)
  Adaptation of GR02 (Hail algorithm for South America) to a wider range of severe convection regimes, applicable to the Caribbean.
- **Front Identification** (FRONT)
  Identification of fronts in Caribbean latitudes.

ALGORITHM	GFS 00Z	GFS 12Z
QPF: Enhanced GDI and flow - EGDI.CMD The Enhanced GDI (EGDI) is an enhanced version of the Galvez-Davison Index (GDI) that adds the detrimental effects of low relative humidity in the 300-400 hPa layer (also proxy for elevated inversions), the detrimental effects of upper convergence, the enhancing/detrimental effects of low-level moisture convergence/divergence, and a precipitable water enhancement factor. As the GDI, it helps to identify environments favorable for shallow convection, deep convection or deep convection with the potential for heavy rainfall. Loops include the low-level (1000-850hPa) and upper level (400-200hPa) flow to account for dynamic and orographic forcing, and movement of systems. It also plots 950-700 hPa convergence/divergence of the flux of mixing ratio, upper divergence (400-200hPa), and GDI advection and flux.	■	■
Trade Wind Inversion - TWIN.CMD Detects the height of the Trade wind inversion's base in shaded colors, and the strength of the inversion using boxes. Larger boxes indicate a stronger inversion.	■	■
Potential for severity and hail - GR02T.CMD GR02T highlights regions with the potential for severe convection in shades of colors. Light gray, green, red and fuscia generally relate to marginal, low, moderate and elevated risk for severe convection. If the shades match red/fuscia boxes encircled by red/fuscia contours, the risk for hail increases. GR02T is a modified version of the GR02 algorithm designed to detect the potential for hail in South America (Galvez and Santayana, 2019). **How does GR02T determine a potential for severity?** Environments suitable for deep moist convection are first defined by considering precipitable water, negative Lifted Index, and mid-level rising omegas, high relative humidity and cool air. Inside these 'deep moist convection' regions, the potential for severity is enhanced by 700-500 Lapse Rates > 16°C, 500 hPa temperatures<-8°C, Lifted <-3°C, enhanced 0-3km and 0-6km shear, enhanced 400-200 hPa divergence, enhanced 950-700 hPa moisture convergence and 500-300 hPa omegas.	■	■
Identification of fronts - FRONT.CMD Highlights surface fronts in the Caribbean basin based on horizontal gradients in a field constructed using thickness of 1000-850hPa and 1000-925 hPa; dewpoint at 1000 and 925 hPa; and precipitable water. Plots an average of 1000 and 925 hPa streamlines and wind barbs in kt (gray and black), 1000-850 hPa thickness in GPM (green contours), and the magnitude of the gradient in light blue, yellow and fuscia contour. The 18°C 2m dewpoint contours is included.	■	■

Tools to be introduced today

- **Enhanced GDI (EGDI)**
  -Plots an enhanced version of the GDI and key aspects of the flow.
  -For QPF Purposes.
- **Trade Wind Inversion Diagnosis (TWIN)** EMPHASIS
  -Plots the height and strength of the trade wind inversion.
  -For QPF, cloud cover and pollution (vertical mixing of aerosols such as Saharan dust).
- **Severe Weather Potential - specifically hail (GR02T)** EMPHASIS
  -Plots areas with environments favorable for severe weather.
  -For severe weather forecasting (**Hail**, gusty winds and large rainfall rates, primarily)
- **Surface Front Identification (FRONT)** EMPHASIS
  -Plots gradients of a field constructed with thickness and moisture in the low troposphere.
  -For the analysis of surface fronts.
- **Central Andes Precipitation Accumulation Index (CAPI)**
  -For QPF in the Central Andes (Ecuador, Peru, Bolivia and Northern Chile).

Key points to consider when using the tools:

- **They are <u>diagnostic</u> algorithms**
  -Thus, they depend on the quality of the gridded dataset.
  -If the GFS fails resolving an atmospheric structure, the tools will fail as well.

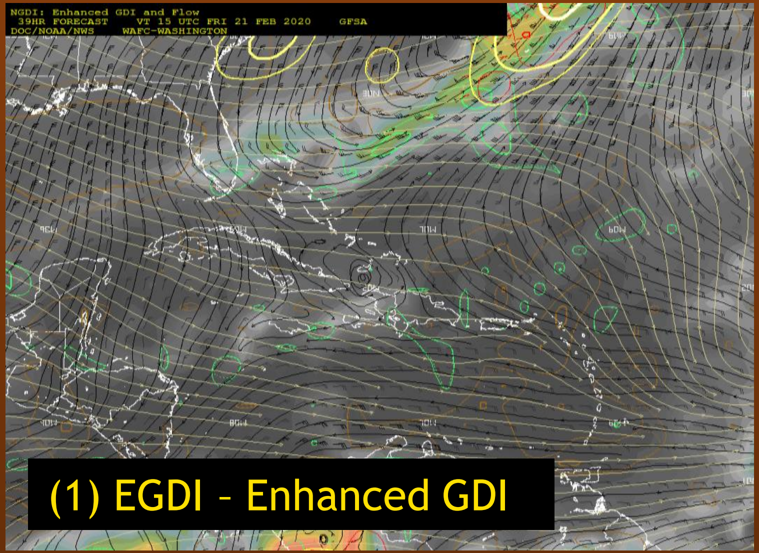
- **They are <u>designed to point the forecaster to potentially hazardous weather</u>, not to tell a detailed story of the factors producing the event**
  -If confidence is gained, the forecaster's role becomes conducting a more thorough analysis in regions and times of interest (cross sections, time sections, inter-comparison with other models and ensembles).

  -How to gain confidence? Cycle-to-cycle consistency and inter-comparison with other models. Knowing the climatology of the region, and relationship with the weather pattern.

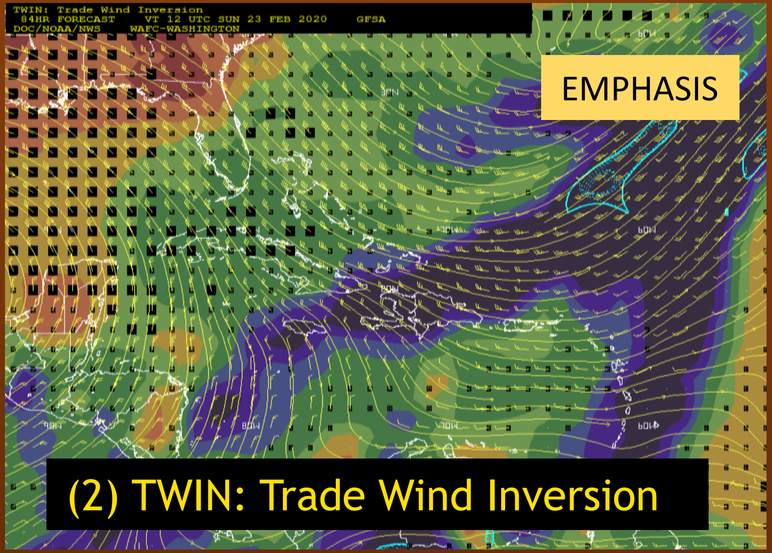
- **They are currently coded using GFS model data only**
  -GFS is a NOAA product, easily and fully available to us.

- **They are currently programmed only in Wingridds V5, available online**
  -Not available in NAWIPS or AWIPS at this time.
  -Target audience: Latin American Weather Services – most do not have NAWINS/AWIPS.

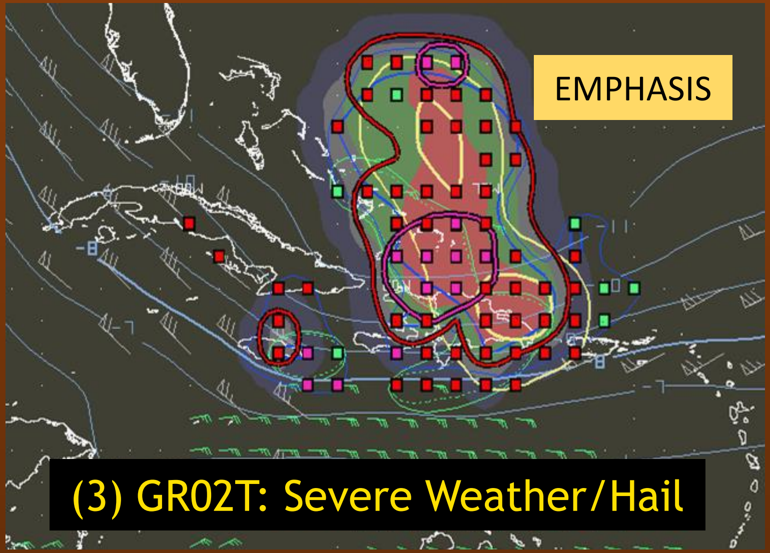
Graphical View of the Five Tools



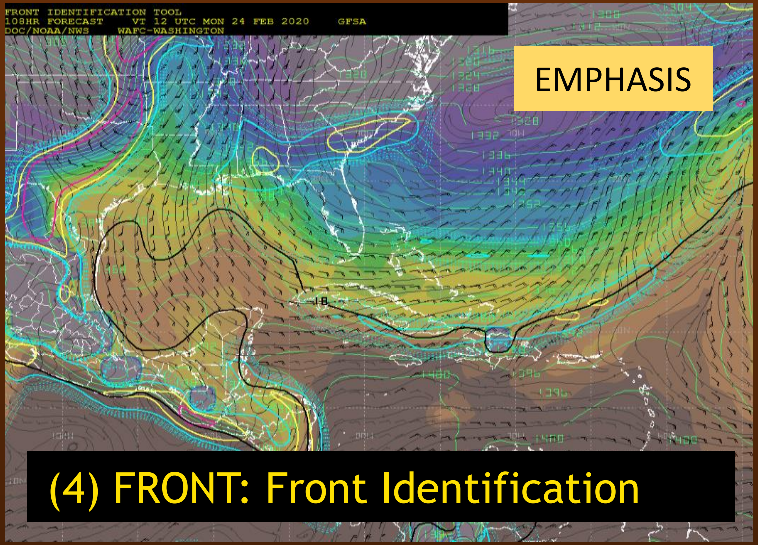
(1) EGDI – Enhanced GDI



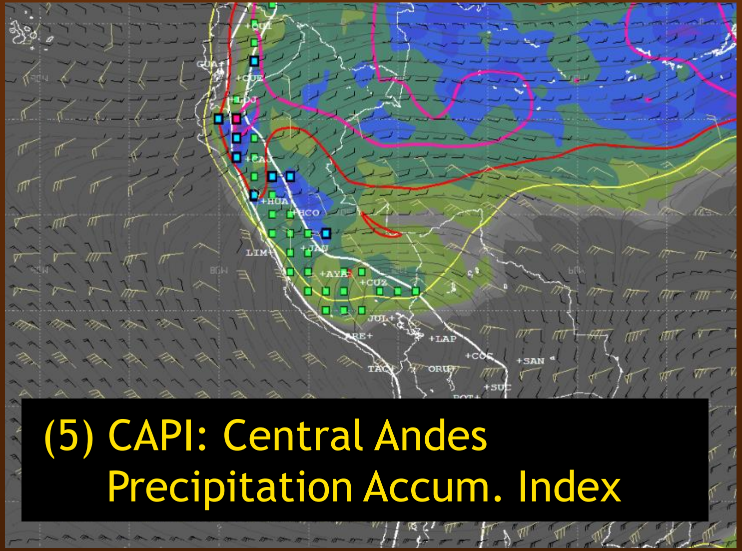
(2) TWIN: Trade Wind Inversion



(3) GR02T: Severe Weather/Hail



(4) FRONT: Front Identification


(5) CAPI: Central Andes
Precipitation Accum. Index

Special acknowledgements before starting:

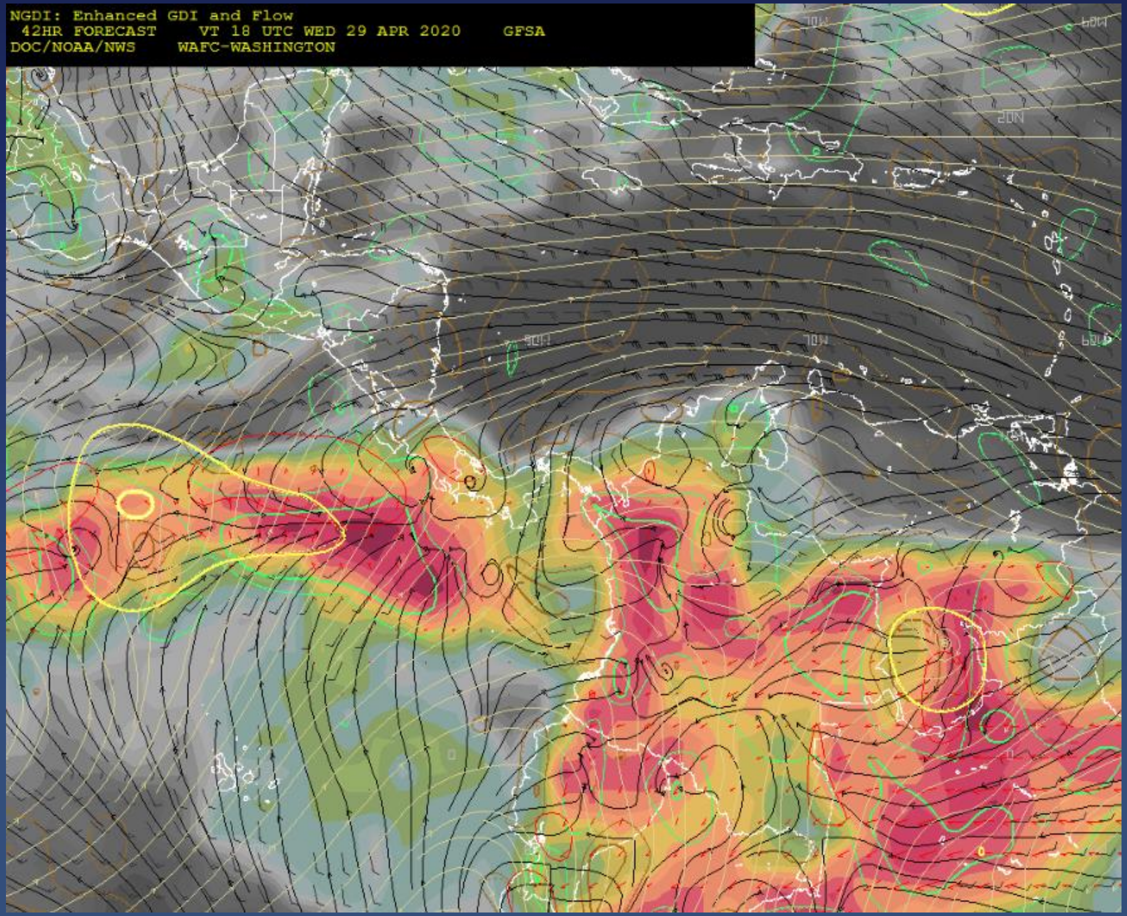
- **Néstor Santayana (INUMET, Uruguay)**
  - Forecasting Chief at the Uruguay Weather Service.
  - Key developer of the severe weather algorithm GR02
    - Néstor brought in ideas for hail forecasting based on hail observations in Uruguay.
    - Combining our efforts resulted in the development of GR01 ("Granizo Version 1 for Hail Version 1) in 2015, GR02 in 2019, and eventually GR02T, a more complex version of GR02, in 2020.

- **Jeff Krob (NOAA)**
  - Wingridds Developer
    - Jeff has been able to develop Wingridds to a level that allows complex calculations and automatization, adapting the software to changing data configurations.

- **All users**
  - For their support and feedback.
  - Special thanks to Manuela Sánchez (SMN Argentina), for the validation of GR02 and introducing it in routine forecasting practices at the Argentina Weather Service.

1. EGDI

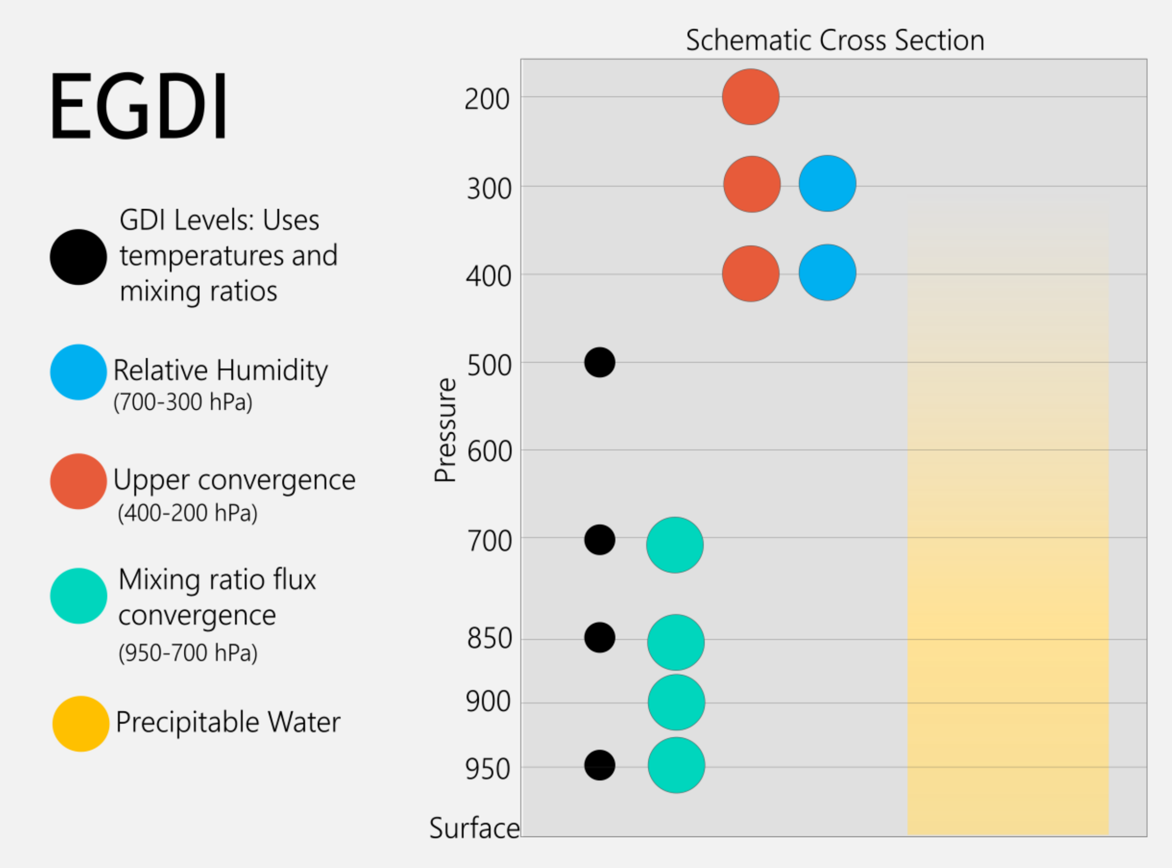
Enhanced Gálvez-Davison Index Tool



1. Enhanced Galvez-Davison Index (EGDI)

The EGDI (shades) is very similar to the GDI (Galvez and Davison, 2016), but enhanced with 4 additional parameters based on observations of convection in South America and the Caribbean:

- **Moisture convergence (950-700 hPa)**
  The convergence/divergence of the flux of mixing ratio in this layer has an important role in triggering new or stimulating pre-existing convection.
- **Upper Convergence (400-200 hPa)**
  Stimulates descent in the upper and mid-levels, elevated inversions that limit vertical development, and also associate with dry air aloft.
- **Relative Humidity (400-300 hPa)**
  Also associates with elevated inversions and/or the detrimental effects of dry air entrainment.
- **Precipitable water**
  Enhancement when values > 30mm, which often correlate with enhanced rainfall in the Caribbean.



1. Enhanced Galvez-Davison Index (EGDI)

Plot Components

Water Vapor Flux Divergence
950-700 hPa Layer
+10, +4, -4, -10, -20 $\times 10^{-8}$ $\frac{kg_{wv}}{kg_{air}}/m^2/s$

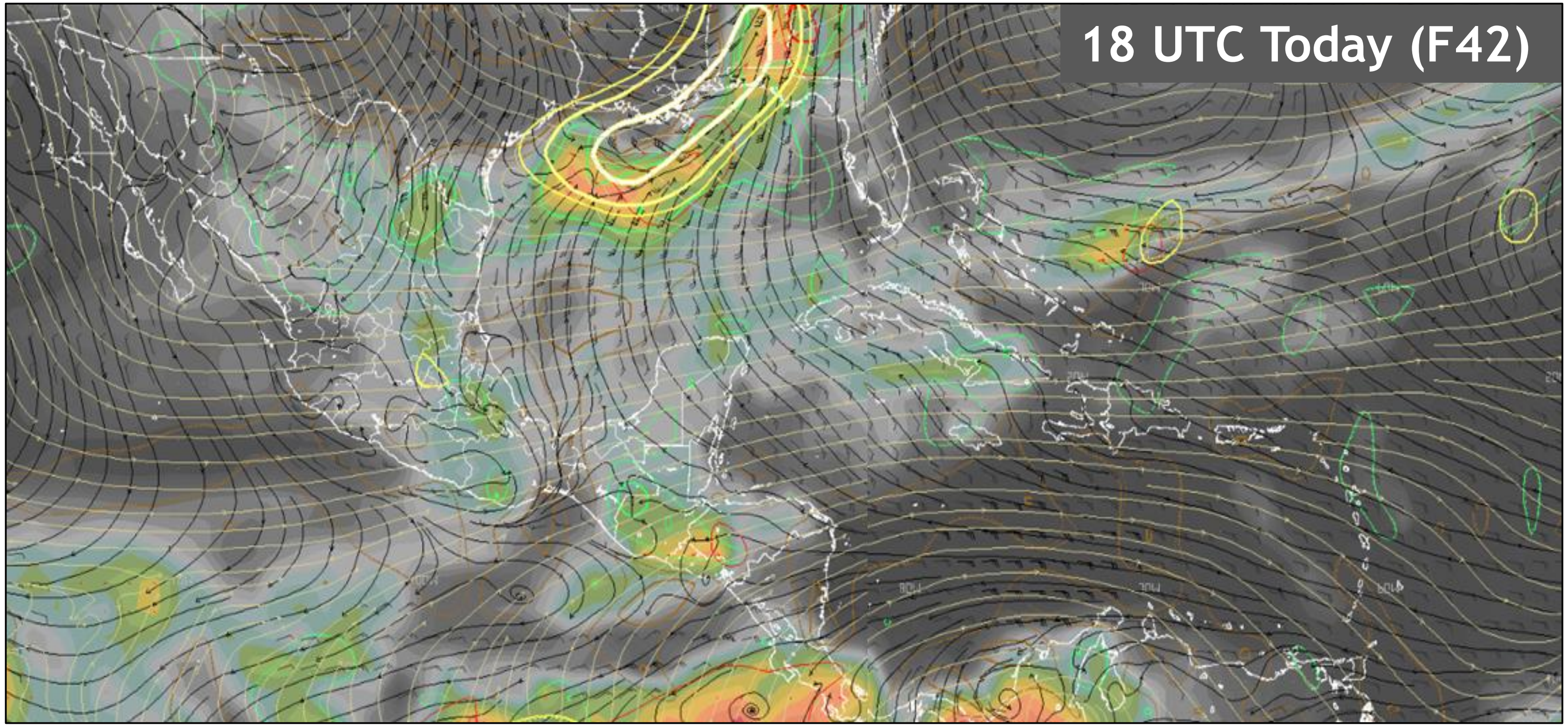
Wind Divergence
400-200 hPa Layer
30, 12, 6 $\times 10^{-6}/s$

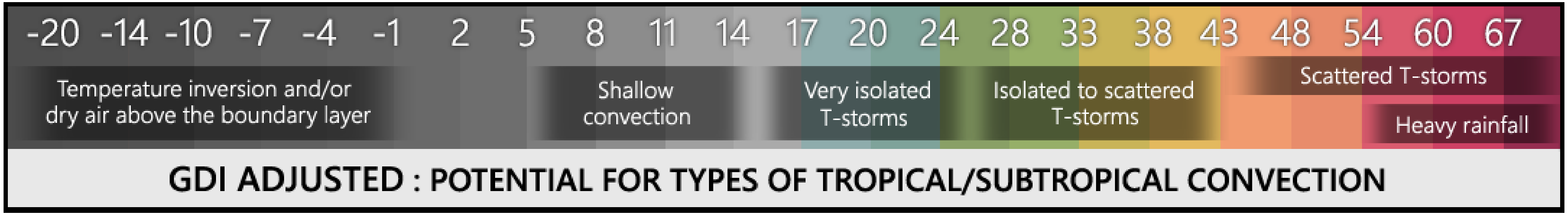
Upper Flow (400-200 hPa Layer)

Lower Flow (1000-850 hPa Layer)

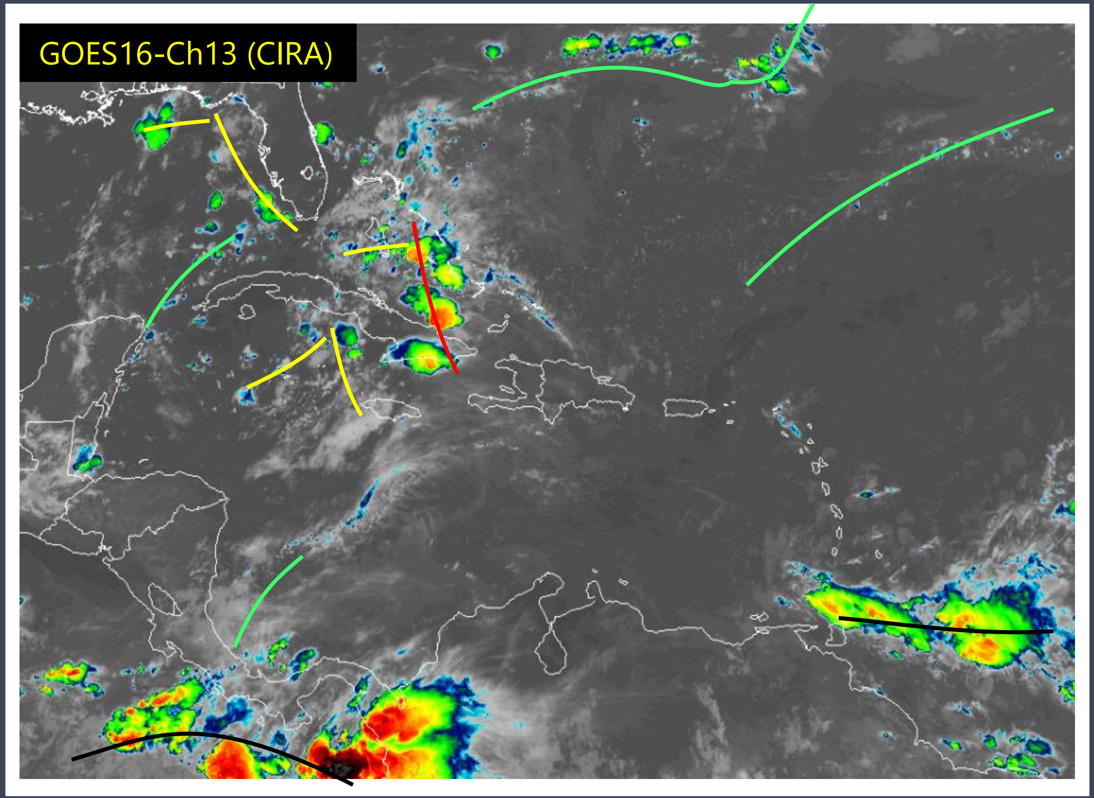
Lower Flow Wind Barbs in kt

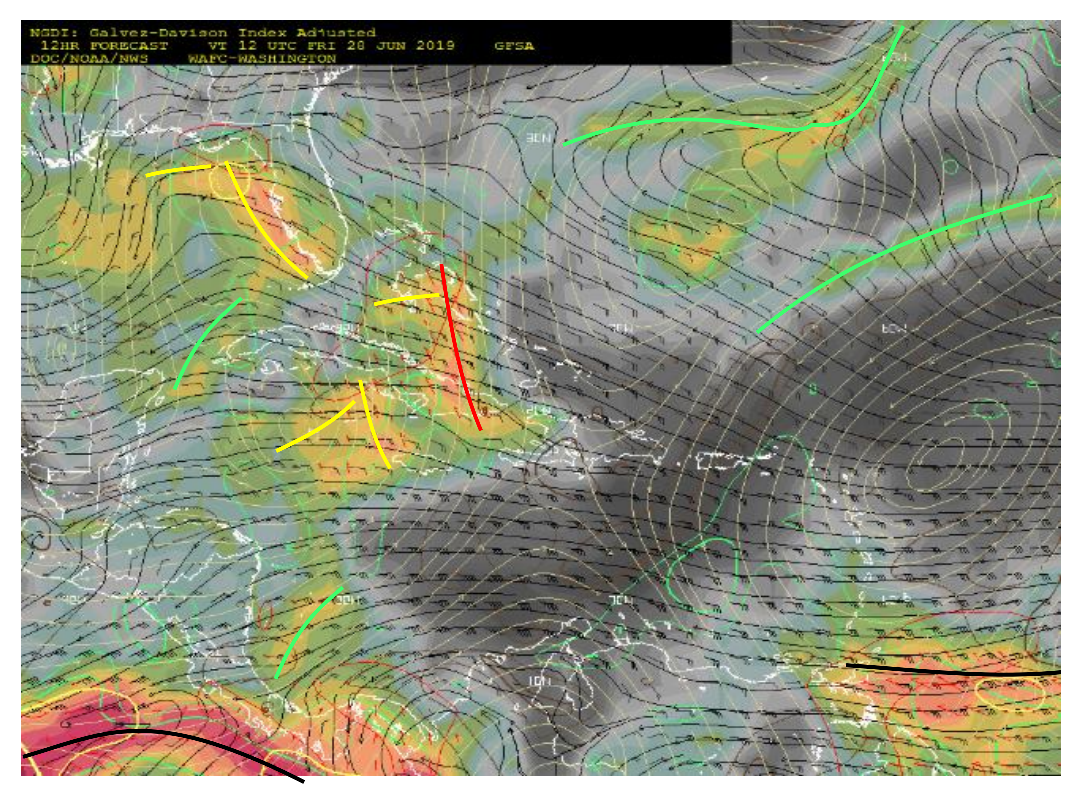
GDI Flux Vectors and areas of GDI advection by the flow averaged over the 850-200 hPa layer



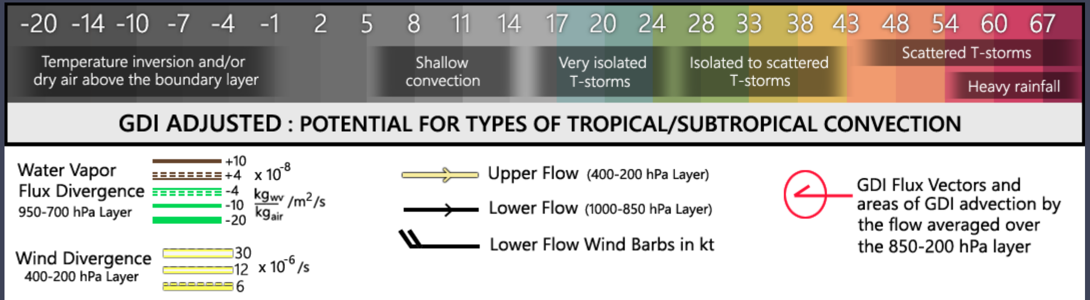


1. Enhanced Galvez-Davison Index (EGDI)



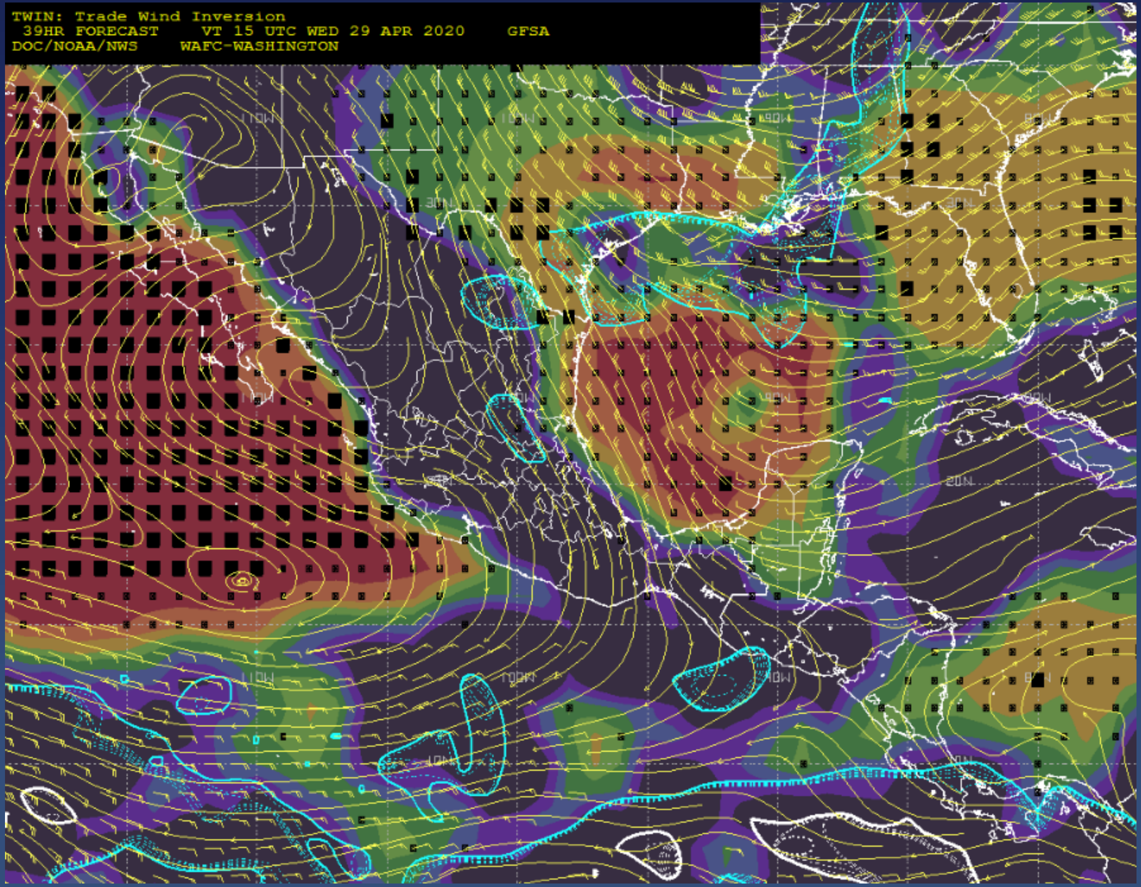


Convective features in the long wave IR (10.3um channel) align generally well with areas in the enhanced GDI product.



2. TWIN

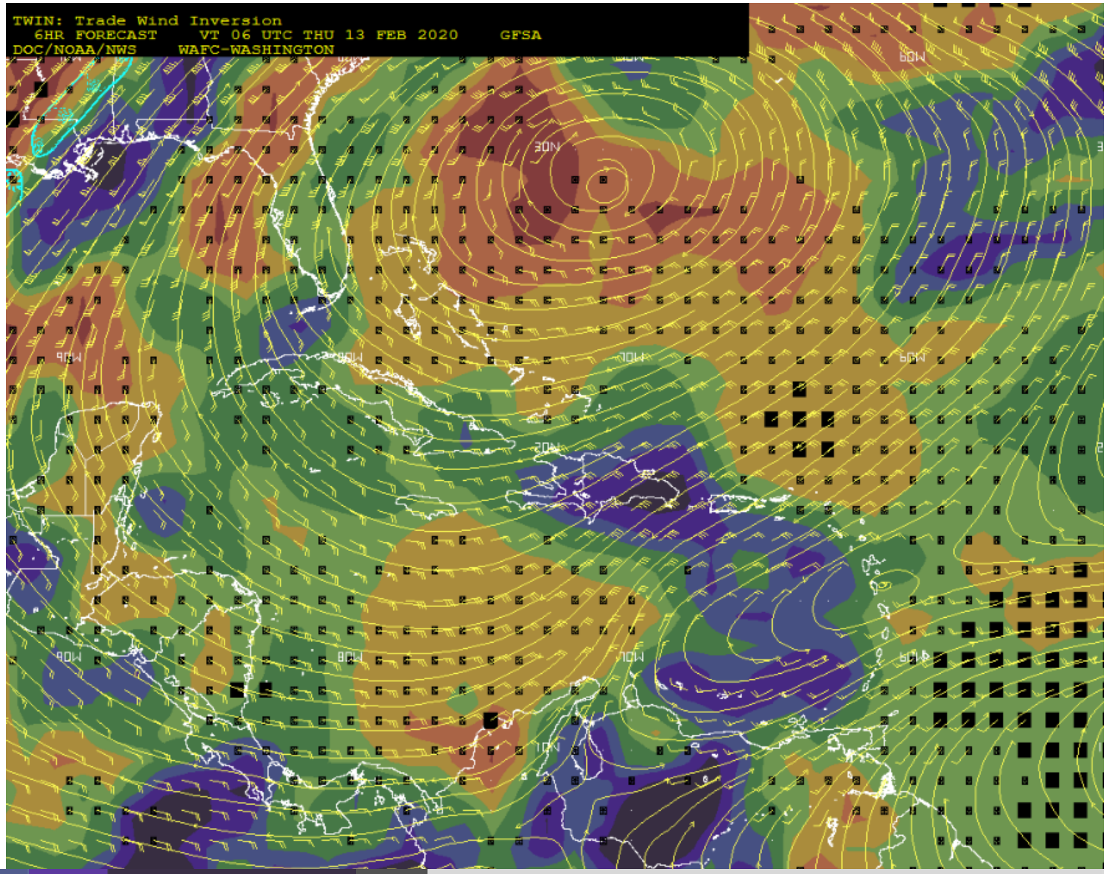
Trade Wind Inversion Diagnostic Tool

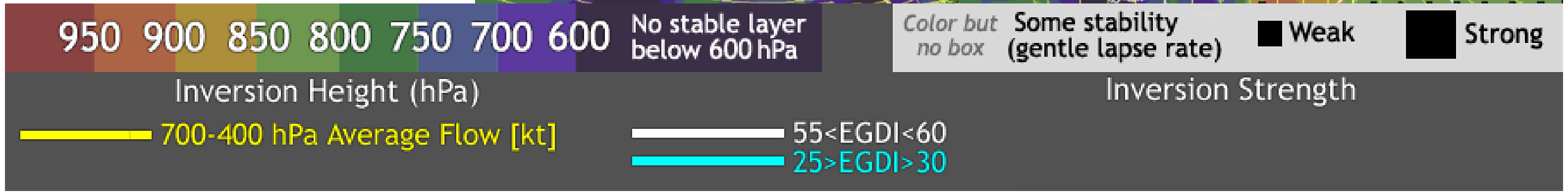


(2) Trade Wind Inversion Diagnostic Tool

What is plotted?

- The height and strength of the trade wind inversion (TWI) in color shades.
- Plots the mid-level flow to highlight mid-level troughs and ridges.
  - Mid-level ridges are generally linked to a stronger and longer-lasting TWI.
  - Troughs tend to relate with more convection and they can signal the effects of a TUTT or of easterly waves.

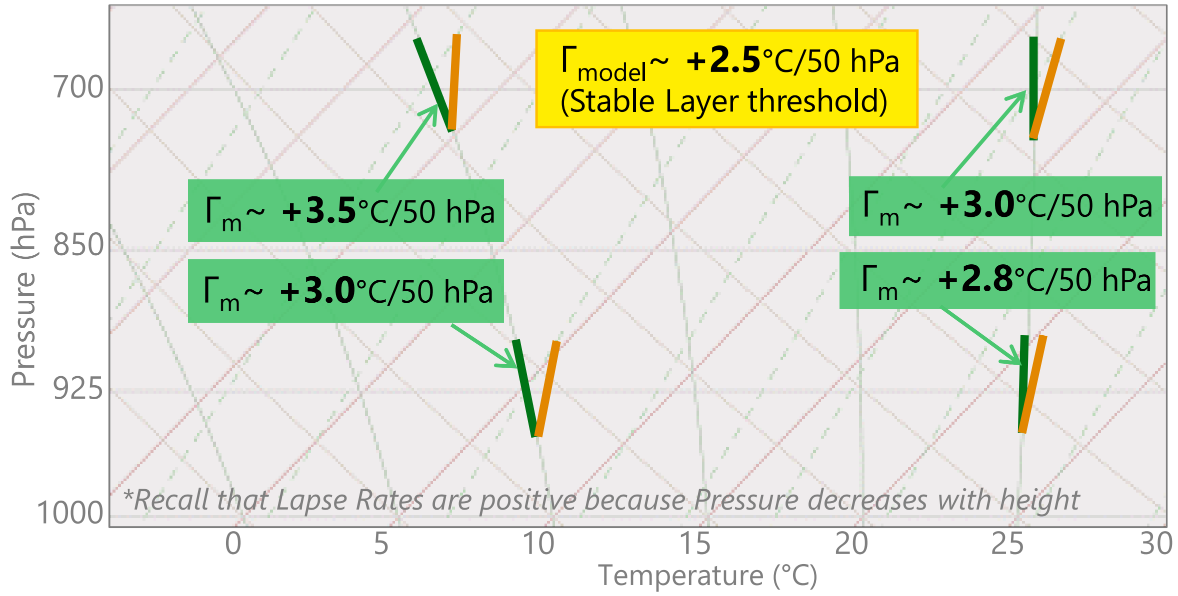




(2) Trade Wind Inversion Diagnostic Tool

How is the inversion detected?

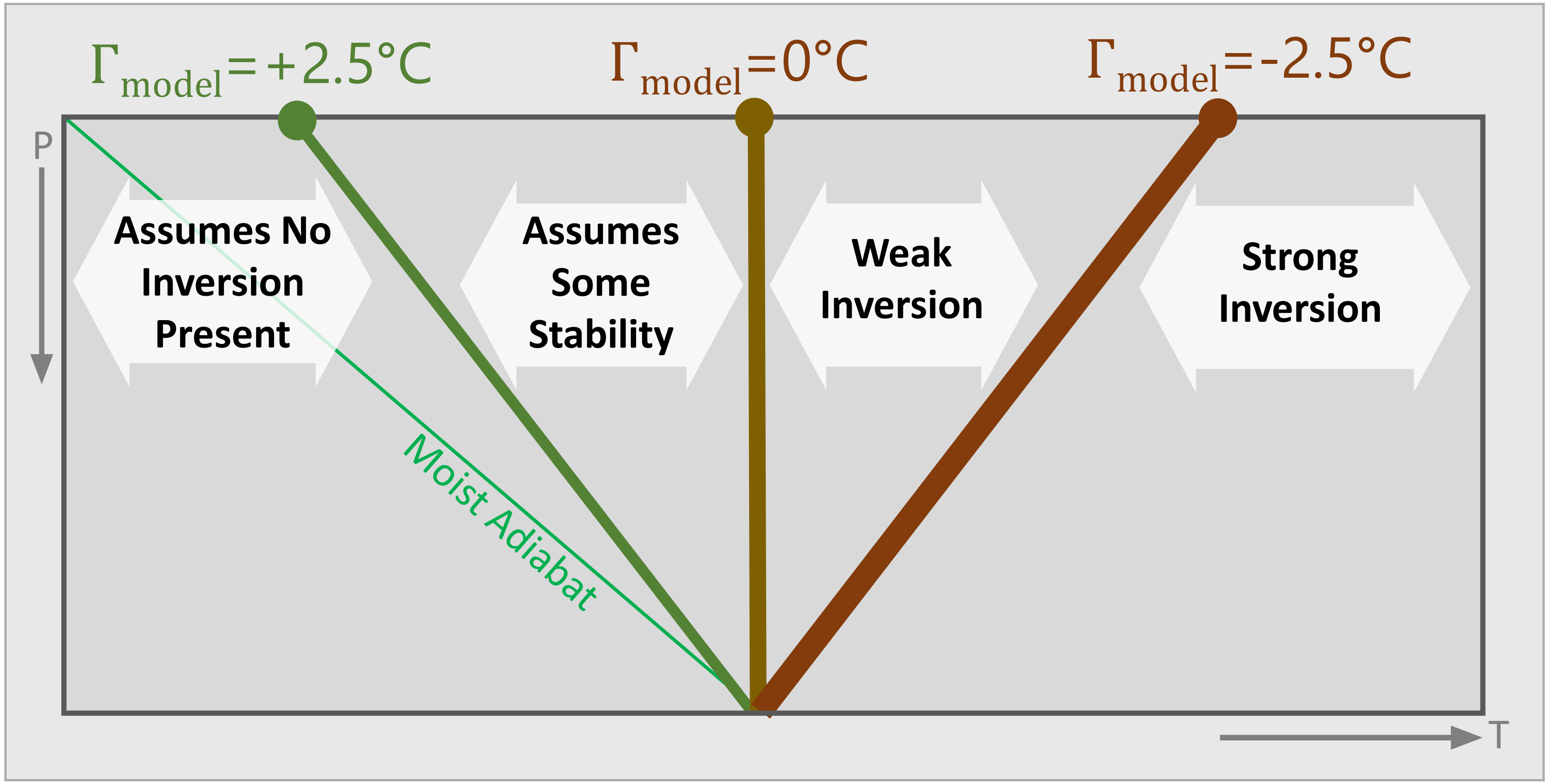
- By comparing the model lapse rate Γ_{model} with the moist adiabatic lapse rate Γ_m .
- Γ_m represents the rate of cooling of ascending saturated parcels.
- Typical values of Γ_m in the Caribbean mid-lower troposphere: +2.8 to +3.5°C /50hPa:
    - Stable Layer: If $\Gamma_{model} < \Gamma_m$
    - $\Gamma_{model} <$ +2.8°C/50hPa → some stability is present.



The presence of "some" stability is defined with a fixed threshold of **Γ_{model} < +2.5°C/50 hPa**. This can be improved, but this value is working for us so far.

(2) Trade Wind Inversion Diagnostic Tool

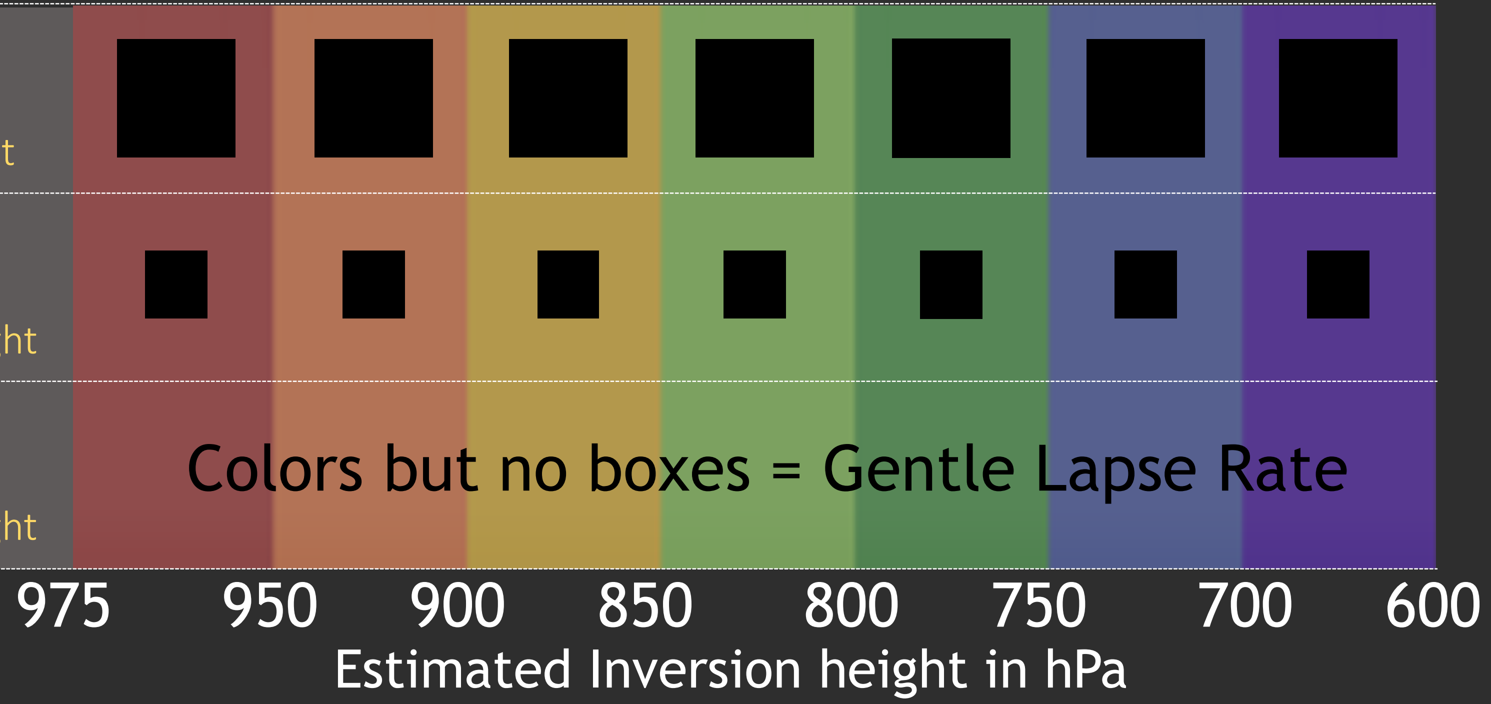
Thus, for a given 50 hPa layer:



(2) Trade Wind Inversion Diagnostic Tool

How is the inversion represented?

Strong Inversion	$\frac{\Delta T}{50hPa} < -2.5°C$ T increases >2.5°C with height	
Weak Inversion	$-2.5°C < \frac{\Delta T}{50hPa} < 0°C$ T increases 0 - 2.5°C with height	
Gentle Lapse Rate	$0°C < \frac{\Delta T}{50hPa} < +2.5°C$ T decreases <2.5°C with height	



Dark gray means that no stable layer was found under 600 hPa

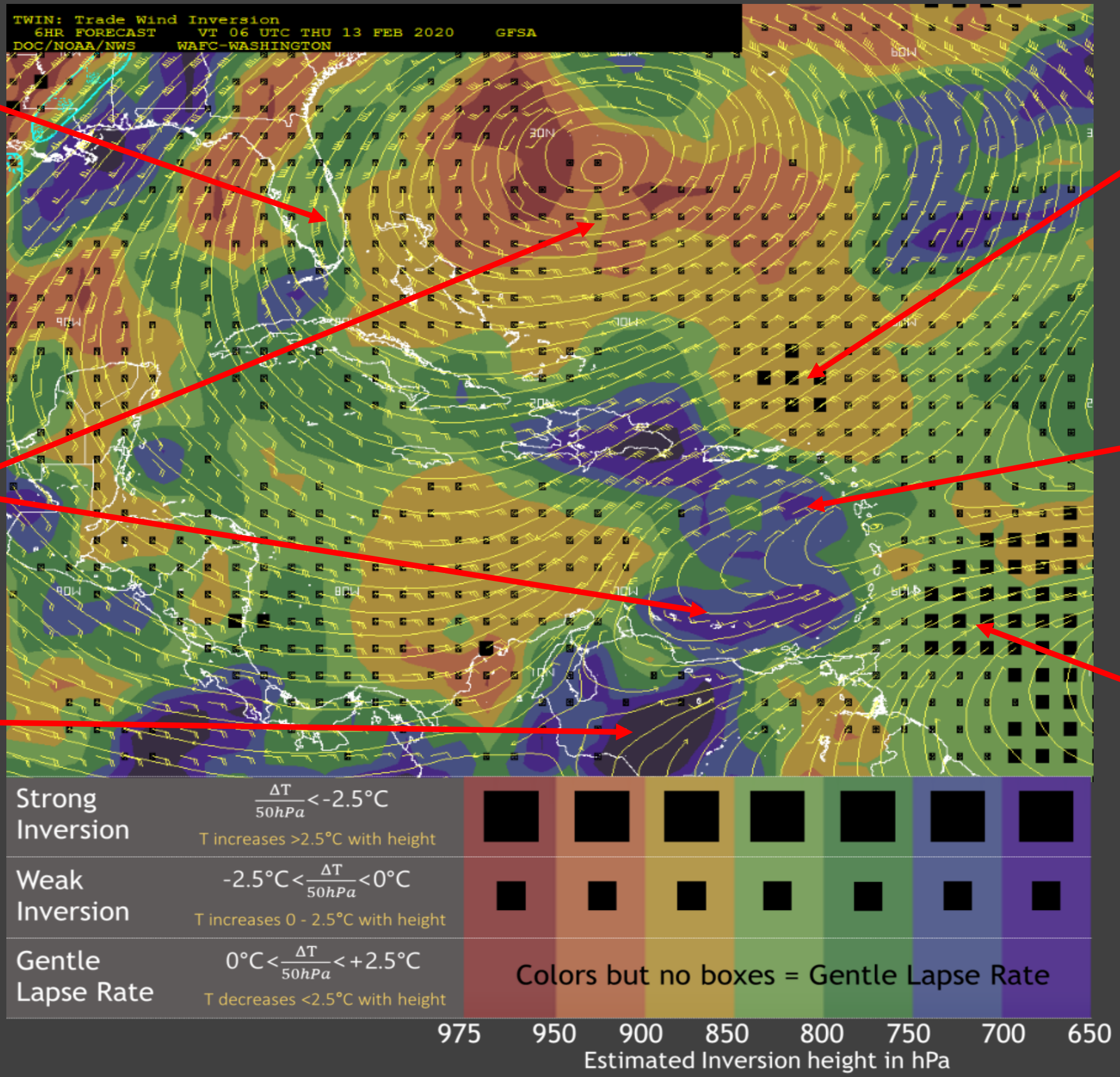
(2) Trade Wind Inversion Identification Tool

Interpretation Example

Weak inversion over Florida sitting between 800 and 750 hPa.

Note that the TWI is generally weaker and sits higher under mid-level troughs, and is lower and stronger under ridges.

No inversion found in Venezuela

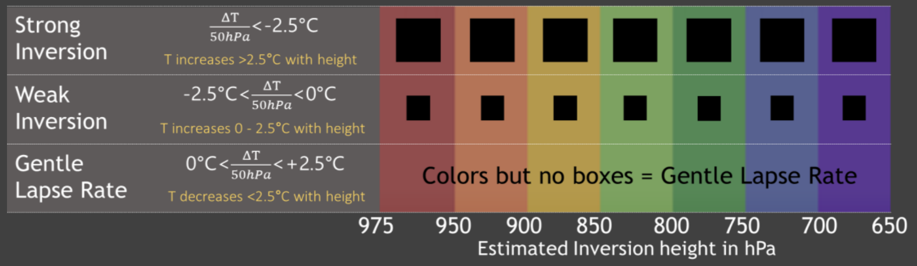


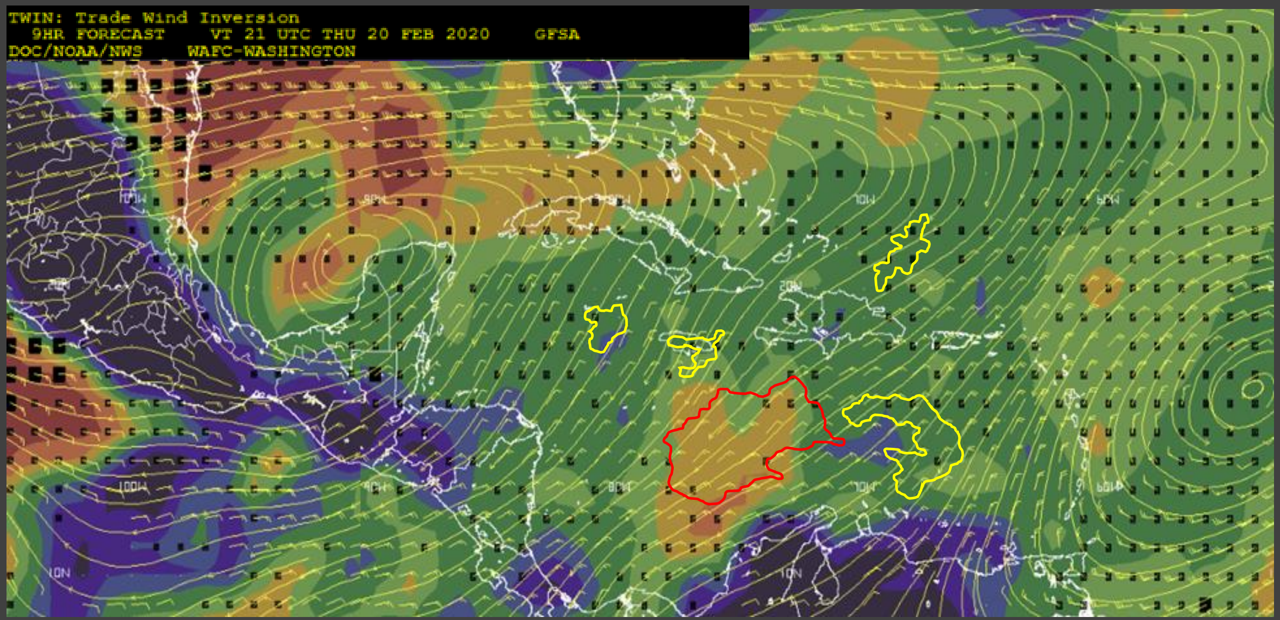
Strong inversion between 900 and 850 hPa. Shallow development and limited mixing with air mass aloft. Favors stratocumulus.

No inversion per se, but gentle lapse rate above 700 hPa. Sufficient for moderate showers, but if the air mass is too dry aloft, vertical mixing could reduce accumulation.

Strong inversion just under 800 hPa. Sufficiently strong to limit mixing with air mass aloft, and sufficiently elevated to allow trade wind showers.

(2) Trade Wind Inversion Identification Tool



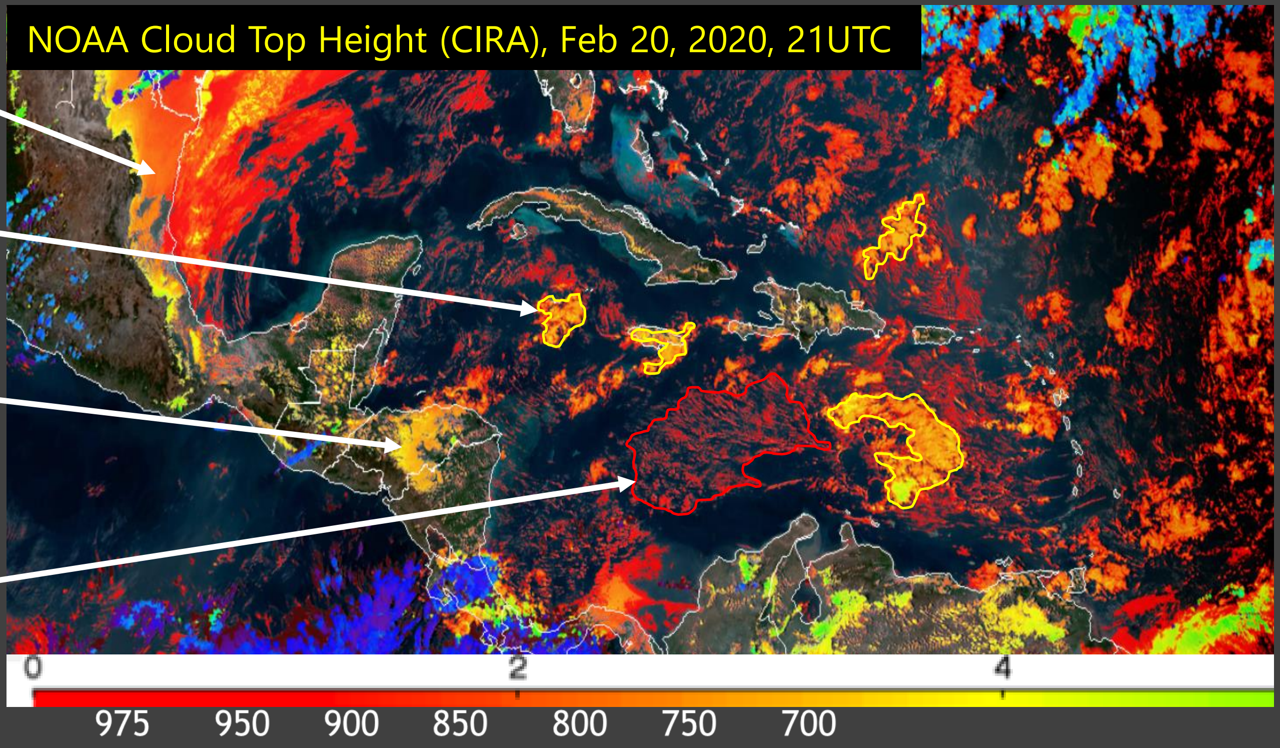


Sloping (color gradient) and strong (overcast) frontal inversion in NE Mexico, is consistent with the TWIN.

Cloud cluster south of the Cayman Islands reaches 750 hPa, consistent with the TWIN.

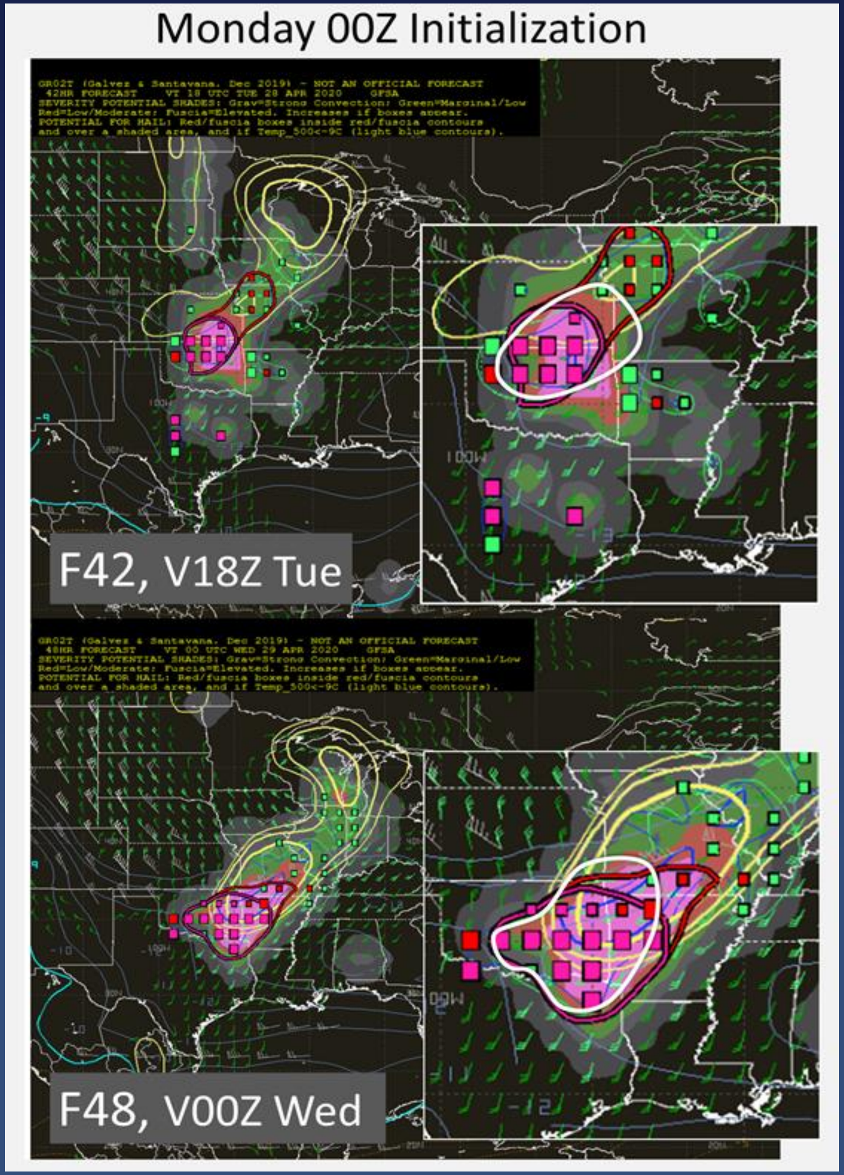
Convection in Honduras surpasses 700 hPa, suggested by the TWIN.

Low-lying gentle lapse rate in the TWIN is consistent with shallow convection and dry air entrainment, generating fair weather Cu fields in the Central Caribbean.



3. GR02T

Potential for Severe Weather and Specifically Hail



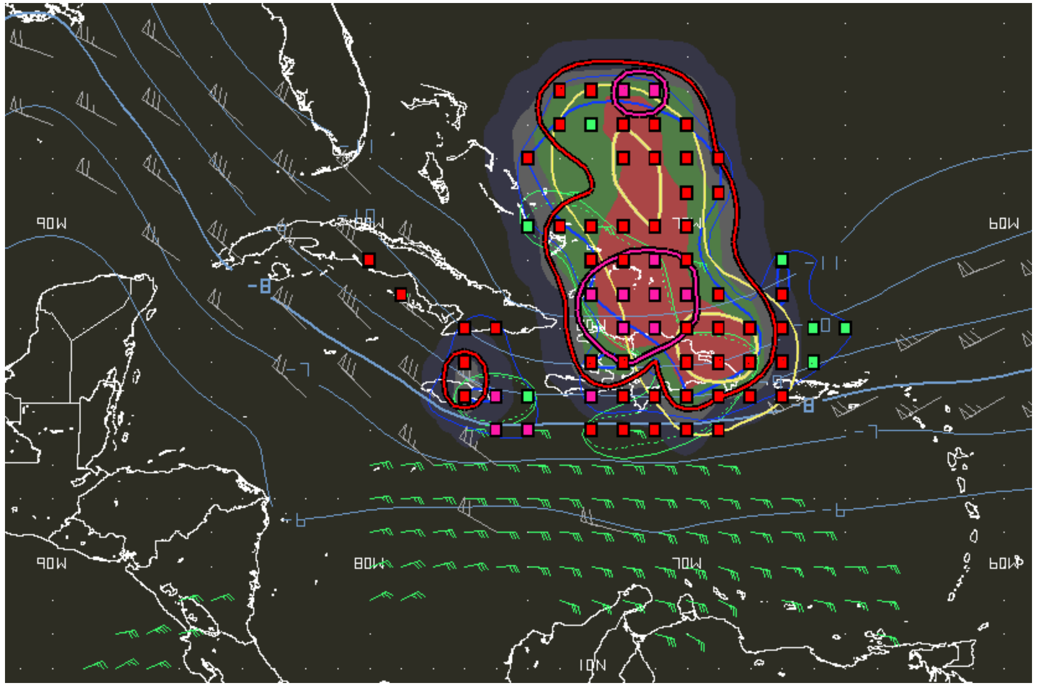
(3) GR02T: Potential for Severe Weather and specifically Hail

- Based on hail potential algorithms developed for South America GR01 (Galvez and Santayana, 2015) and GR02 (Galvez and Santayana, 2019).

- Adapted for a wider range of severe weather.

- In the Caribbean, color shades (risk for severity) generally implies squally weather.

- If mid-level temperatures are too cold (<-9°C) and/or the terrain is elevated, the risk for hail increases:

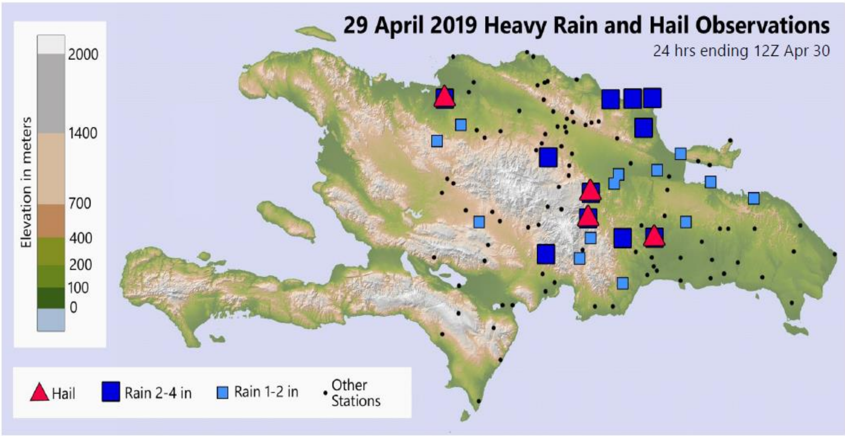


  - Conditions favorable for hail are indicated by red/fuscia squares encircled by a red/fuscia contour. Higher chance if T500<-8°C (light blue contours) and if they fall in a color-shaded region.

(3) GR02T: Potential for Severe Weather and specifically Hail

Example of a hail event in higher elevations/foothills in Hispaniola (Apr 29, 2019).

Day 2 (Apr 29): Local Flooding and hail in Hispaniola

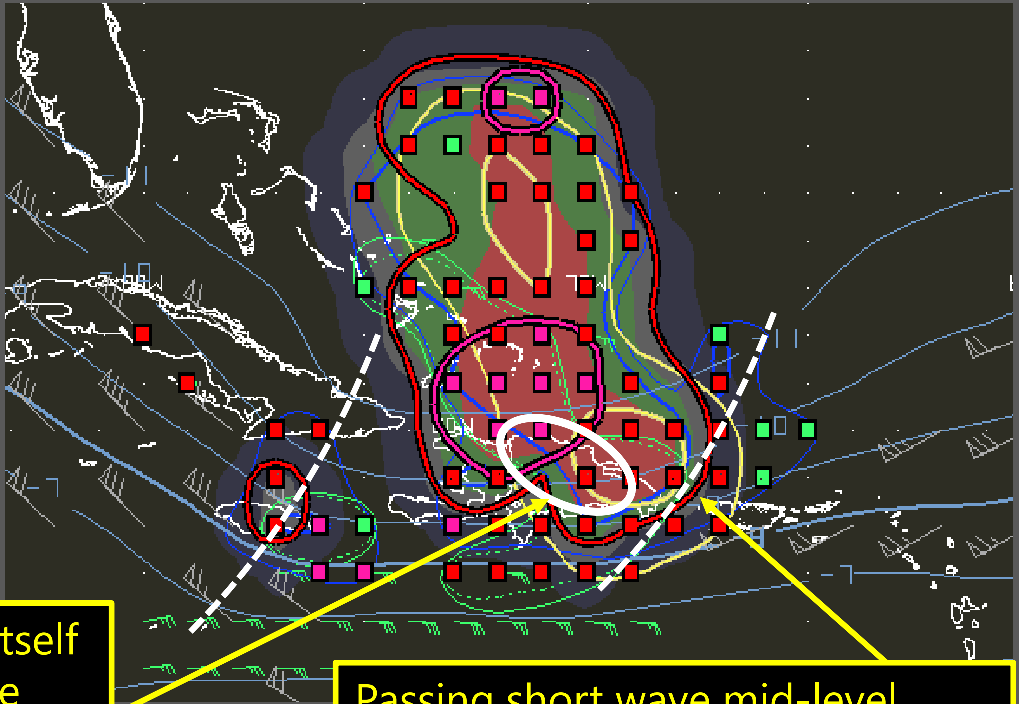


HAIL
5% of stations

Heavy rain (>2in)
11% of stations

Heavy rain (1-2in)
13% of stations

Note: Hail reported in lower elevations



Although the environment for hail and squally weather was large, hail itself only occurred at higher elevations and foothills in Hispaniola, where the column was cold enough and the orographic forcing strong enough.

Hail occurred where the following intercepted: (1) Boxes inside contours, (2) red shaded area, (3) orographic effects, (4) mid-level perturbations, (5) enhanced upper divergence.

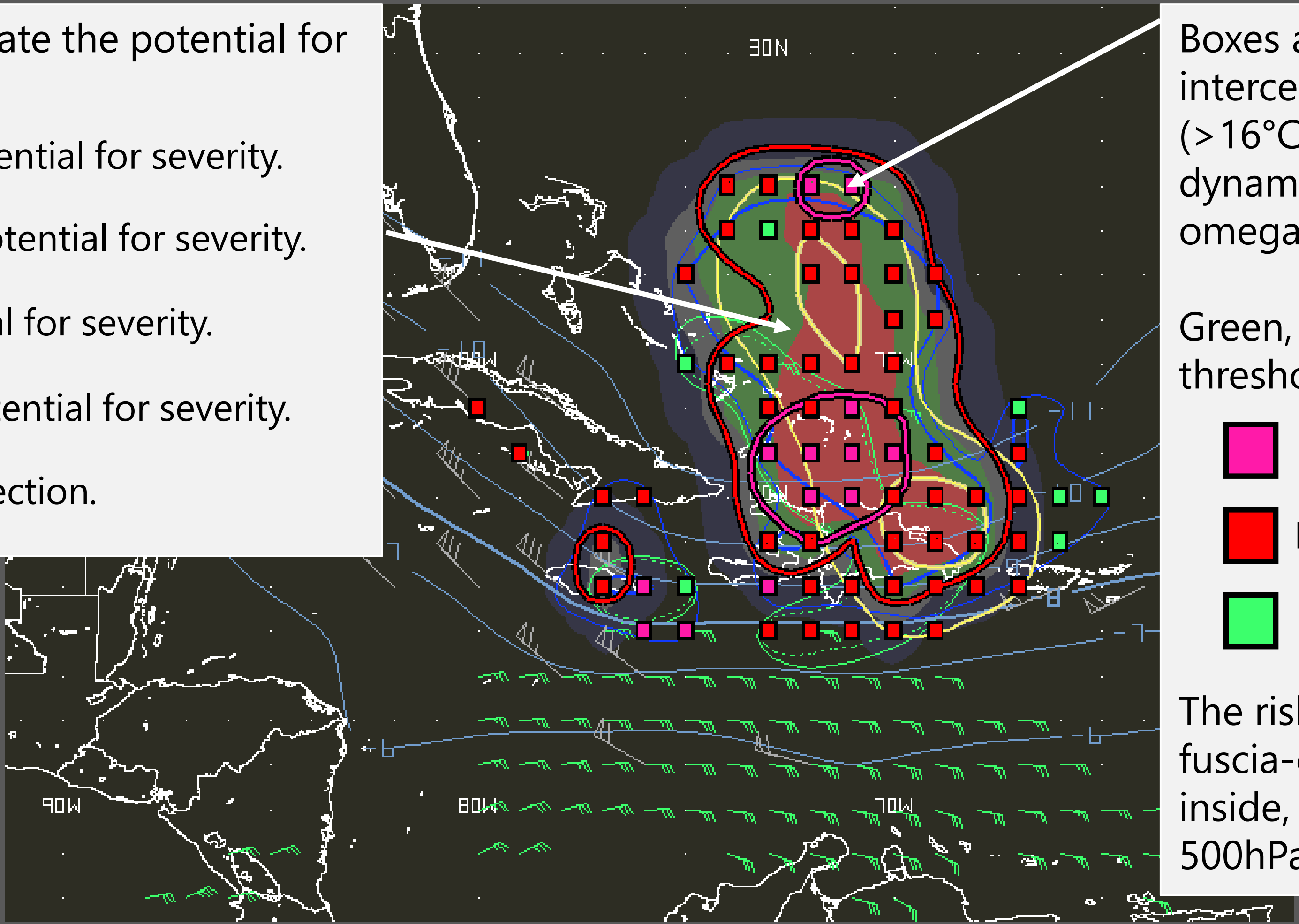
Passing short wave mid-level troughs, evident in the 500 hPa temperature field (not drawn by the algorithm), played a role.

(3) GR02T: Potential for Severe Weather and specifically Hail

Interpretation

Color shades indicate the potential for severity:

- Elevated potential for severity.
- Moderate potential for severity.
- Low potential for severity.
- Marginal potential for severity.
- Strong convection.



Boxes are drawn when the following intercept: steep 700-500 hPa lapse rates (>16°C) and unstable Lifted Index; and dynamically-induced ascent or negative omegas in the 600-300 hPa layer.

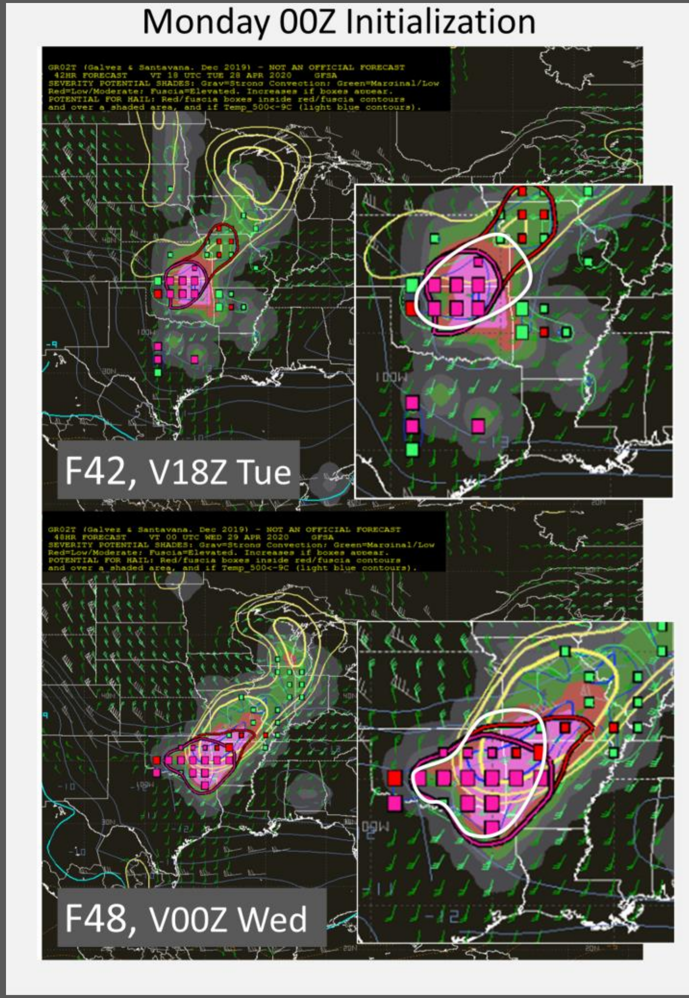
Green, red and fuscia indicate different thresholds of these variables:

- LI<-6°C OMGA<-2x10^{-2} Pa s^{-1}
- LI<-3°C OMGA<-2x10^{-2} Pa s^{-1}
- LI<-1°C

The risk for severity increases if red- and fuscia-colored contours with boxes inside, intercept color shaded areas and 500hPa temperatures < -8°C.

(3) GR02T: Potential for Severe Weather and specifically Hail

Interpretation

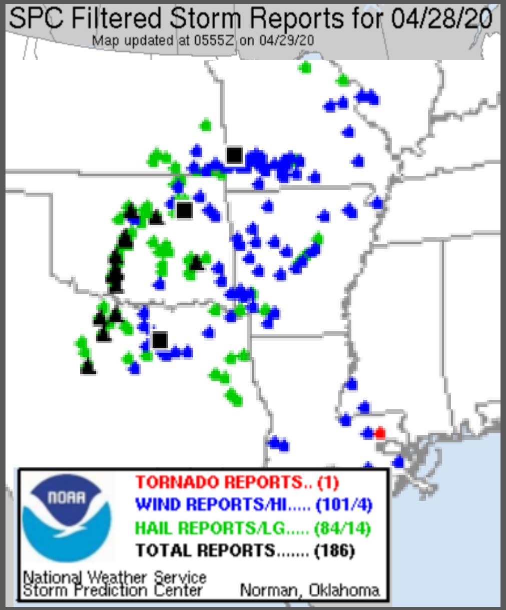


GR02T: Risk for Severity

Risk increases if boxes appear overlaid to color shaded areas

Strong Convection	Marginal to Slight Risk	Slight to Moderate Risk	Elevated Risk

- 925-850 hPa Winds [kt]
- 250-200 hPa Winds [kt]
- 300-200 hPa Divergence
- 500 hPa Temperatures [°C]
- Mixing ratio$_{500}$ >2 g/kg
- Enhanced mixing ratio flux convergence in the 950-700 hPa layer.



Specific Risk for Hail

- **Elevated** (boxes inside fuscia contours)
- **Slight to Moderate** (boxes inside red contours)
- **Marginal**, only if forcing is strong. Isolated occurrence.

Confidence increases if boxes inside contours occur over color shaded areas, if 500 hPa temperatures<-9°C, and if forcing is strong. Large boxes mean extreme 700-500 hPa lapse rates.

(3) GR02T: Potential for Severe Weather and specifically Hail

How are the shaded areas constructed?

(1) Detection of areas with the potential for strong deep moist convection. Generation of "Strong deep moist convection SDMC mask"

a) Binary masks are created:

-They contain 1 where a favorable variable is identified, zeros otherwise.

-The following variables are used:

1) PWAT > 20mm – *Assumes sufficient deep-layer moisture available for deep convection*
2) LI<0°C – *Deep-layer instability, potential for thunderstorms*
3) T_{600} < +2°C – *Mid-level instability (strong updrafts) and cold air (hail stone closer to the ground)*
4) $RH_{700\text{-}500}$ > 80% – *Saturation in hail-formation layer (favorable for hail growth)*
5) $OMEGA_{600\text{-}300} < -10^{-4}$ Pa s^{-1} – *Dynamically-induced ascent*

b) They are multiplied:

-Thus '1' will be present ONLY when these 5 factors are ALL present

(3) GR02T: Potential for Severe Weather and specifically Hail

How are the shaded areas constructed?

(2) Population of SMDC mask with enhancers of severity.

a) The following enhancers are considered:

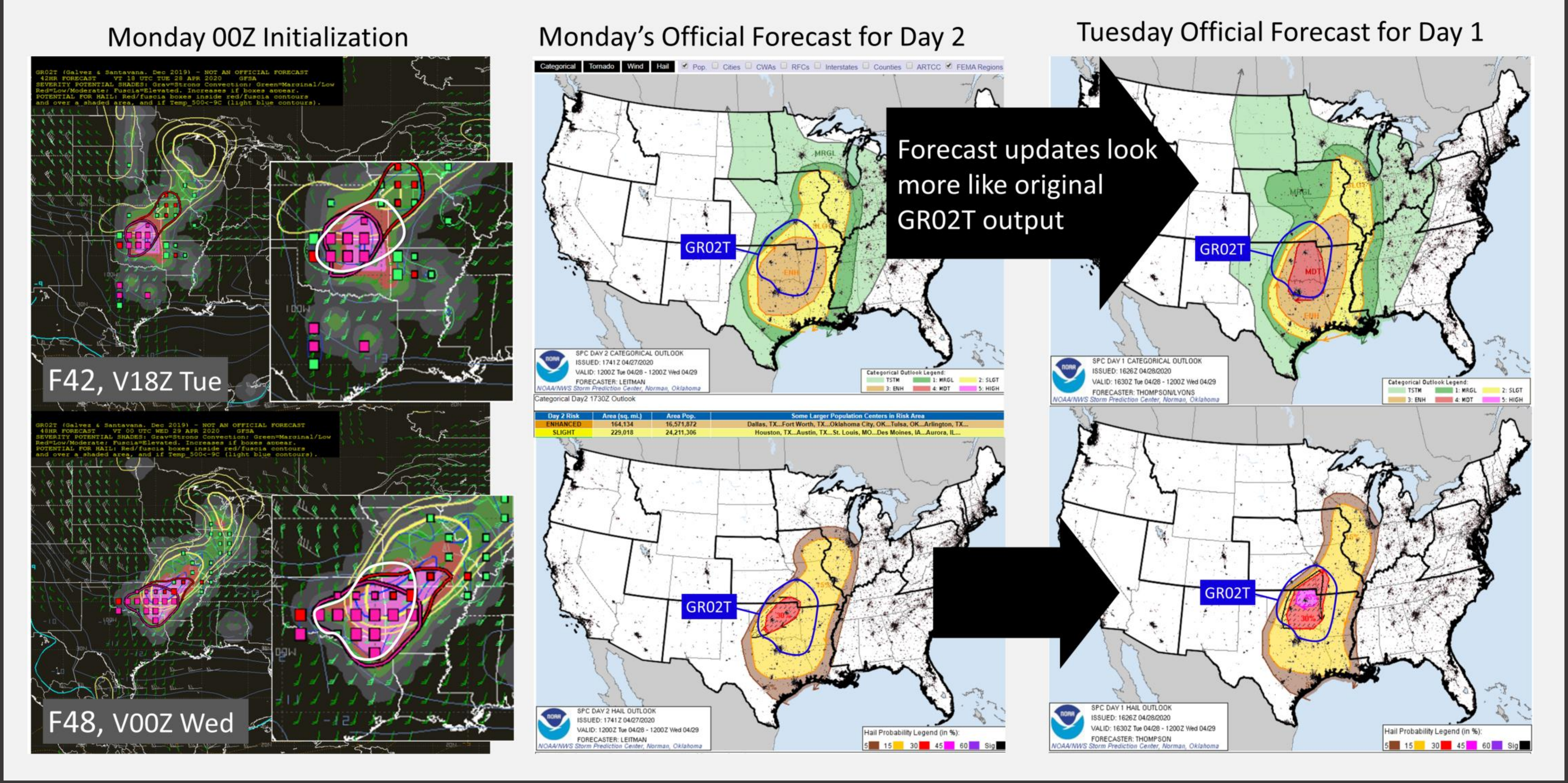
1) LI < 0°C *– Deep-layer instability (sfc to 500 hPa)*
2) $LR_{700\text{-}500}$ > 16°C *– Mid-level instability (strong updrafts in hail growing layer)*
3) T_{500} < -8°C *– Mid-level instability and cold air (preserves hail stone closer to the surface)*
4) $OMEGA_{600\text{-}300}$ < 0 Pa s^{-1} *– Dynamically-induced ascent*
5) $Shear_{0\text{-}3km}$ $Shear_{0\text{-}6km}$ > 20 m s^{-1} *– Updraft preservation/strong updrafts, strong descending currents, rotation.*
6) Low-level Moisture $Converg._{950\text{-}700}$ < -0.5 10^{-8} kg kg^{-1} m^{-2} *– Moist ascent from low-levels/trigger.*
7) Upper $Divergence_{400\text{-}200}$ > 1.3 10^{-5} s^{-1} *– Dynamically-induced ascent*

b) Weights are added to each enhancer
-Weights based on calibration for South America

Room for improvement

Evaluation of GR02T

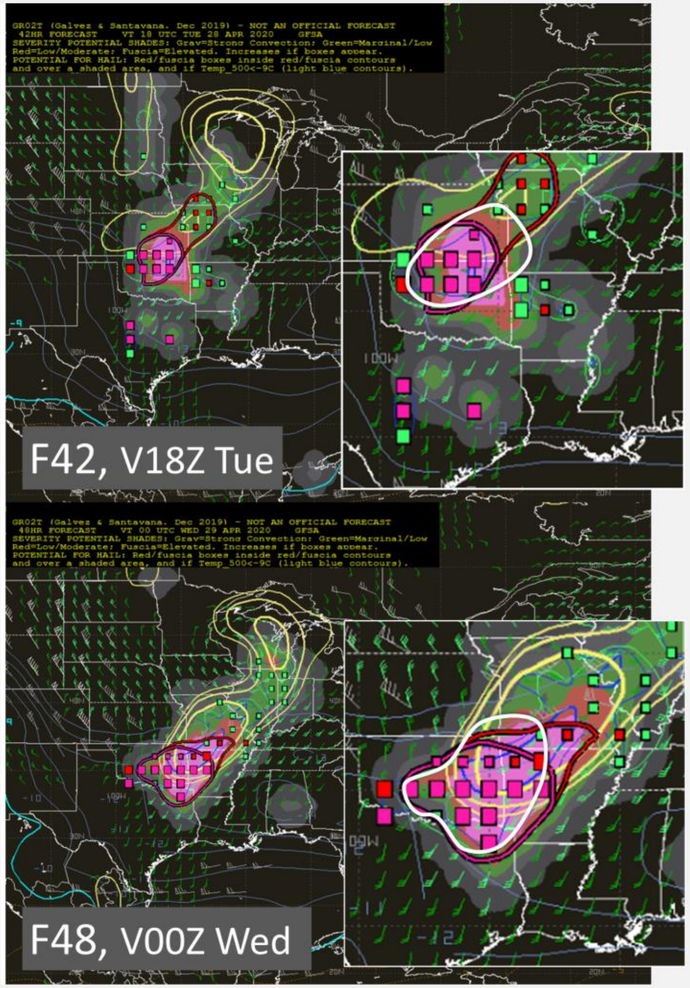
Yesterday's Severe Weather in the Southern Plains

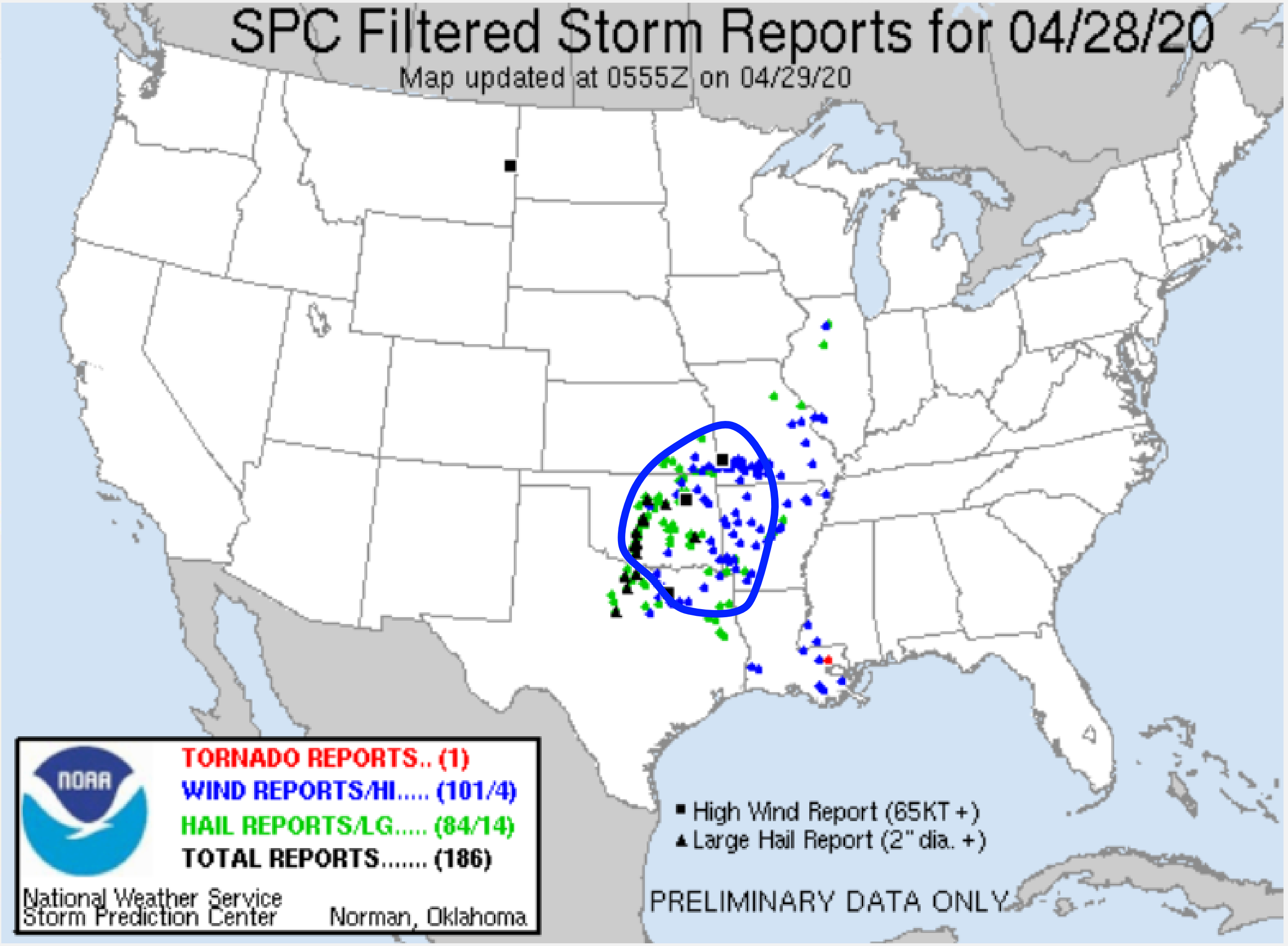


Evaluation of GR02T

Yesterday's Severe Weather in the Southern Plains

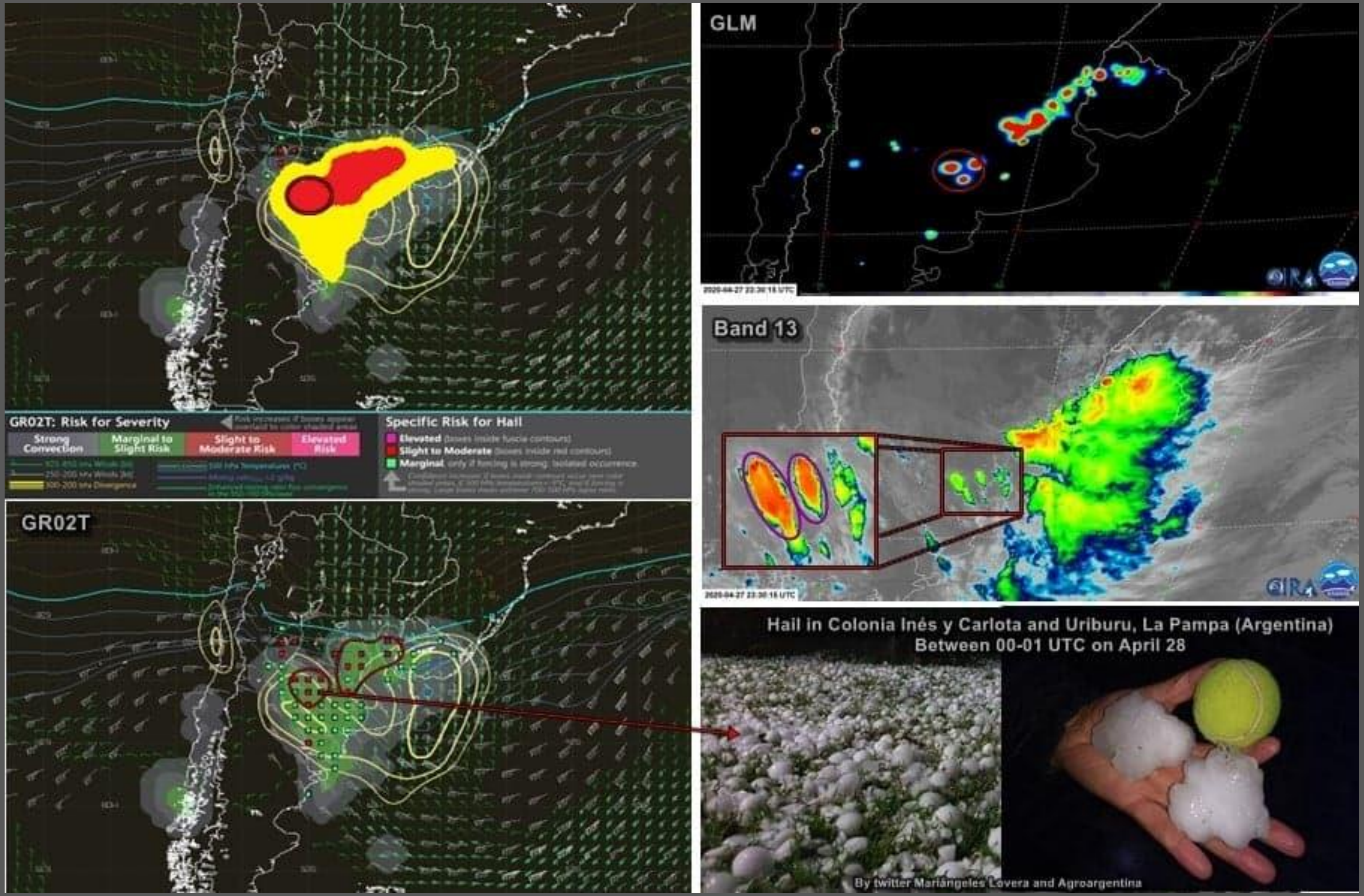
Monday 00Z Initialization





(3) GR02T: Potential for Severe Weather and specifically Hail

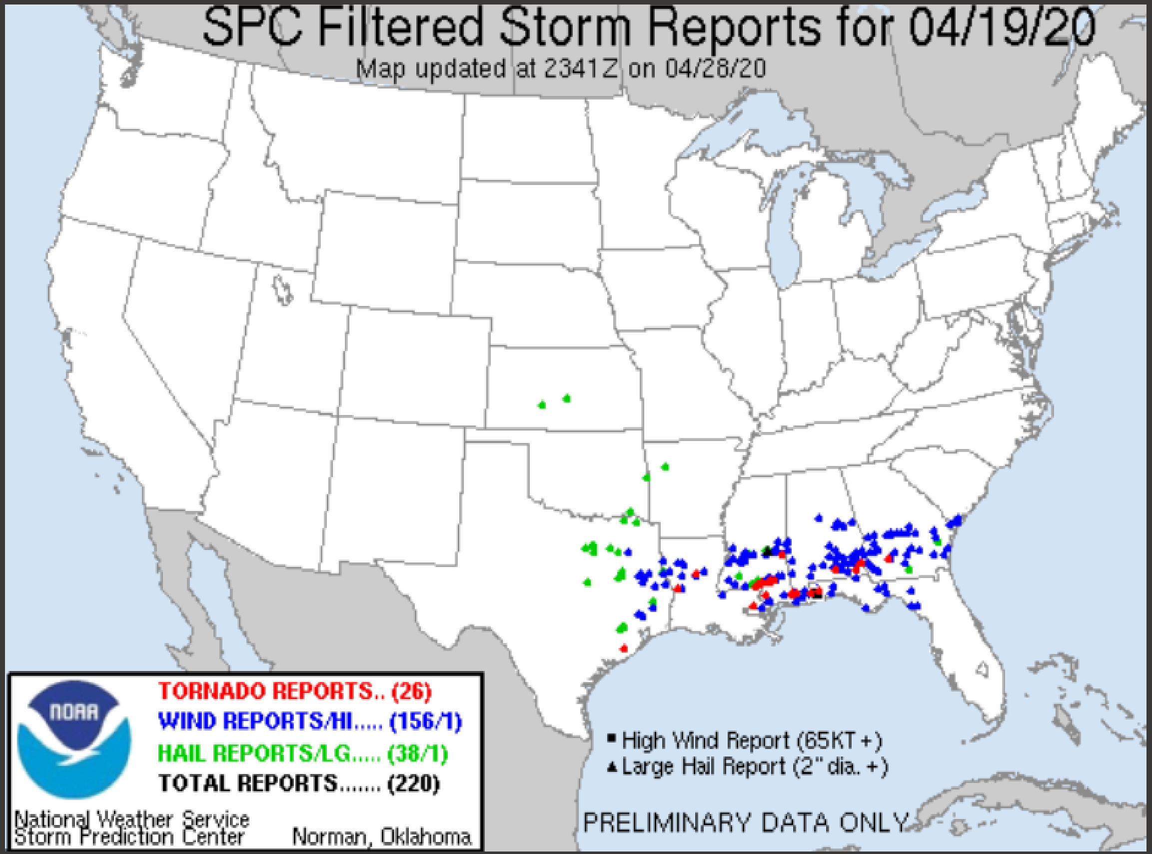
Event in South America on April 28

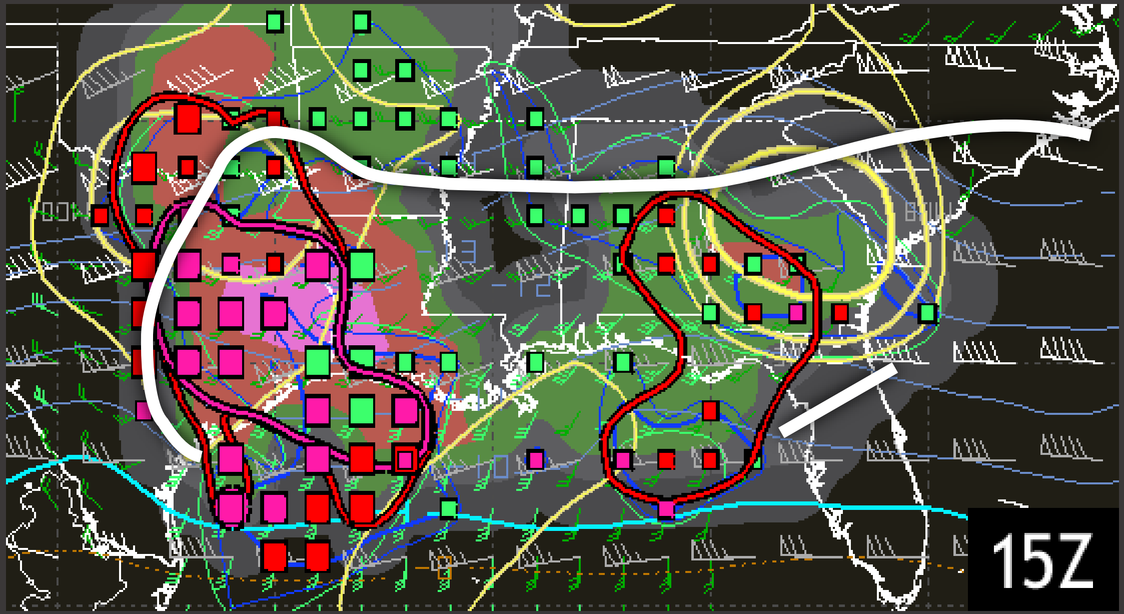


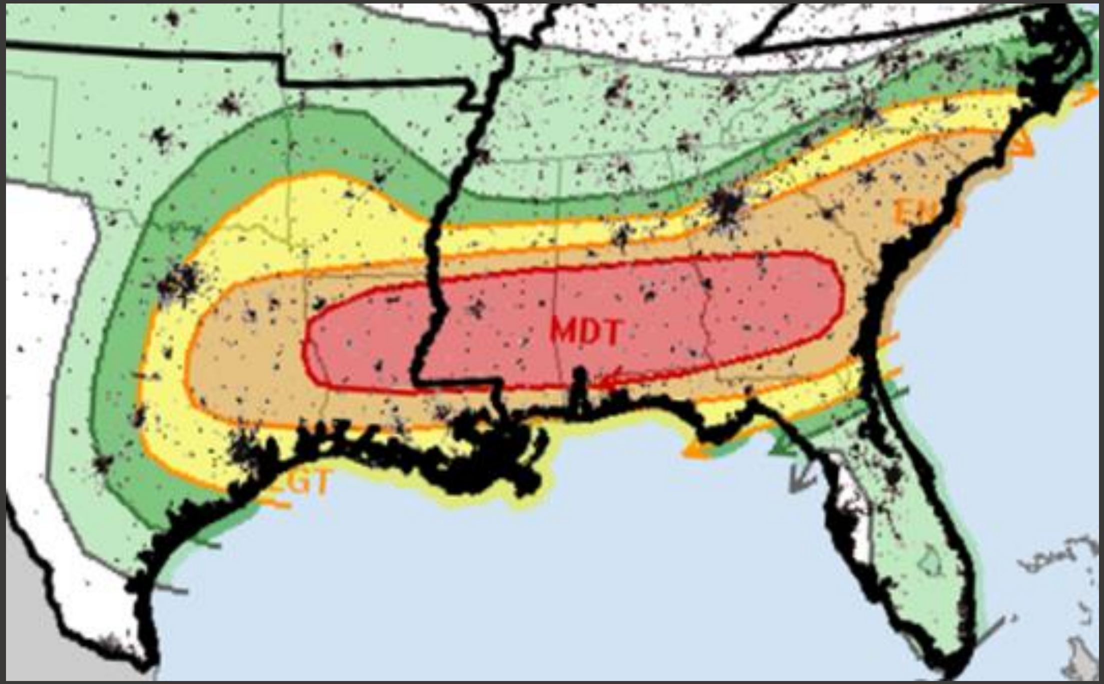
Evaluation of GR02T

Severe Weather Event

April 19, 2020



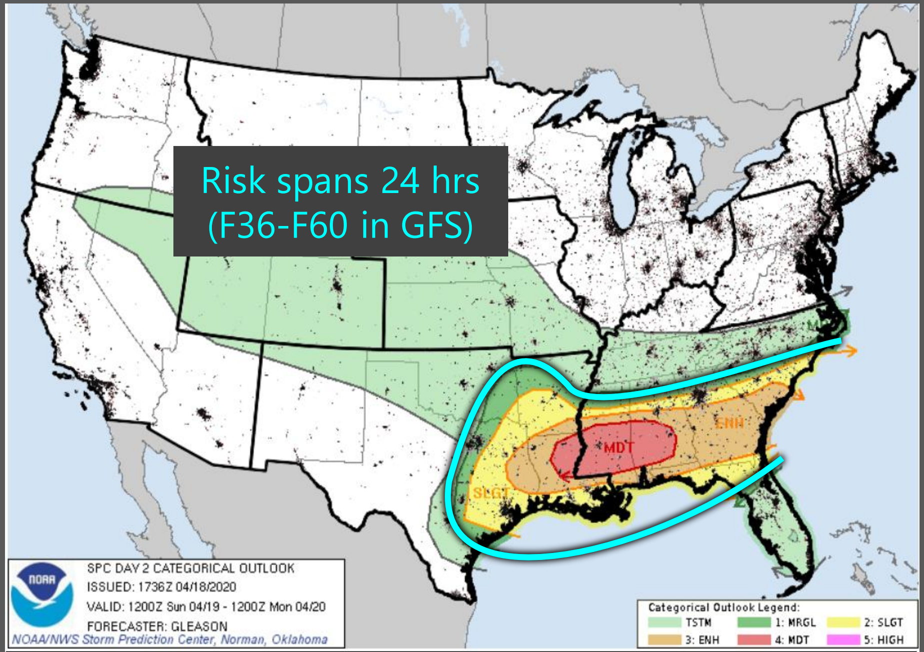




Evaluation of GR02T

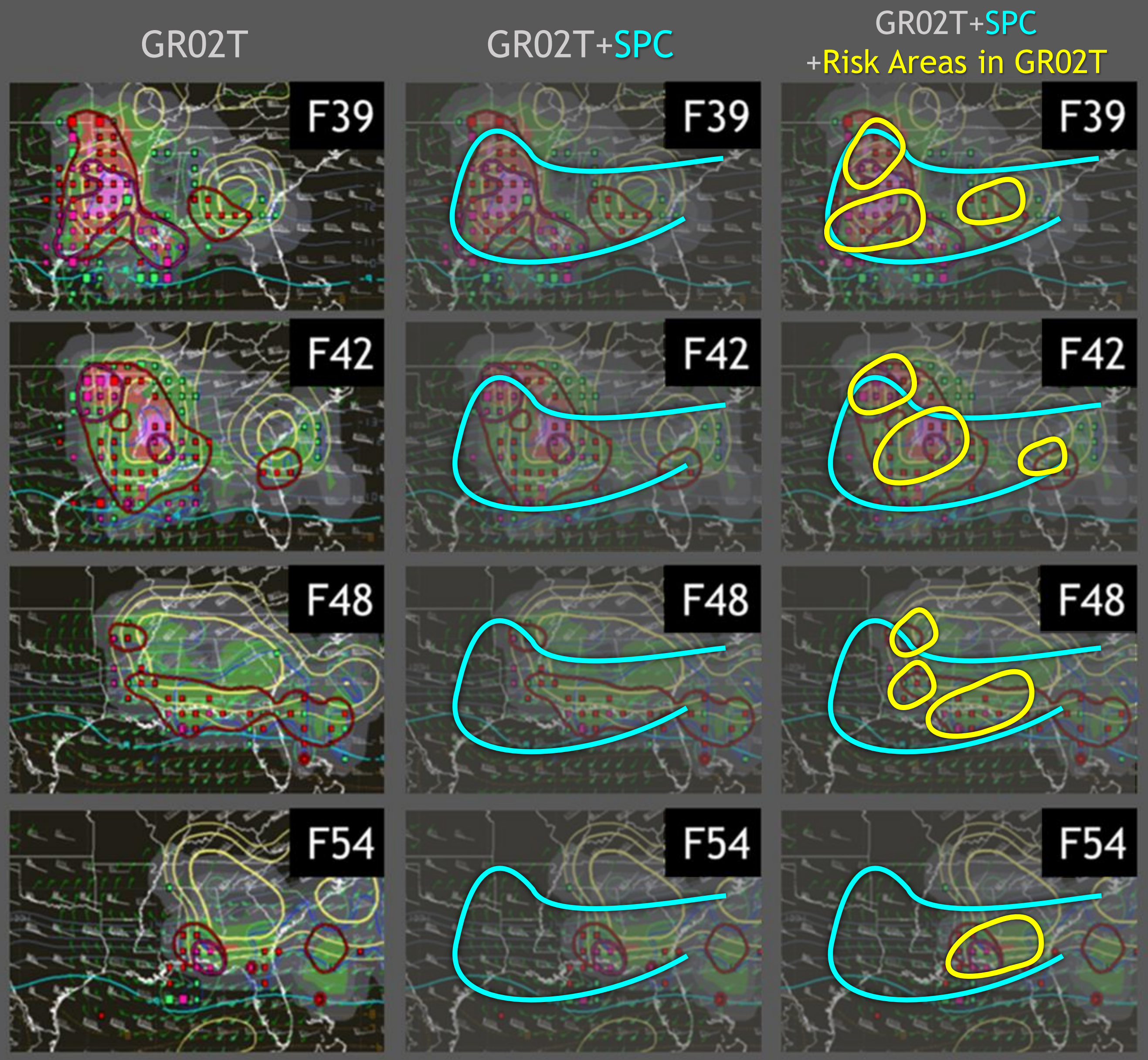
How did GR02T perform against SPC's Official Perspective?

Storm Prediction Center Forecast



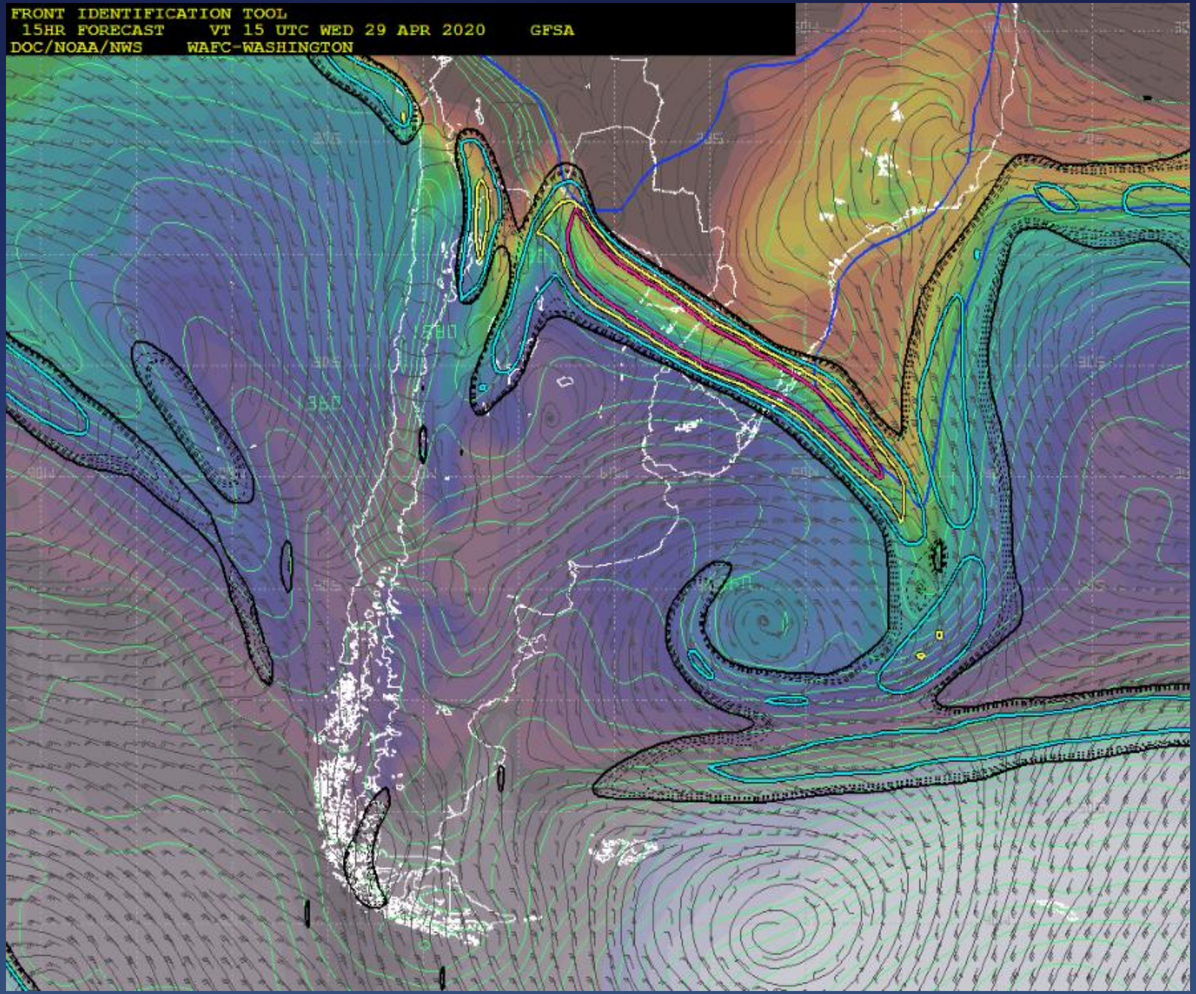
Categorical Day2 1730Z Outlook

Day 2 Risk	Area (sq. mi.)	Area Pop.	Some Larger Population Centers in Risk Area
MODERATE	50,735	2,534,795	Montgomery, AL...Jackson, MS...Monroe, LA...Hattiesburg, MS...Alexandria, LA...
ENHANCED	114,892	8,768,527	Birmingham, AL...Shreveport, LA...Mobile, AL...Columbus, GA...Savannah, GA...
SLIGHT	142,505	21,867,077	Houston, TX...Jacksonville, FL...New Orleans, LA...Atlanta, GA...Baton Rouge, LA...
MARGINAL	83,671	12,780,215	Dallas, TX...Austin, TX...Arlington, TX...Plano, TX...Garland, TX...



4. FRONT

Surface Front Identification Tool



(4) Surface Front Identification Tool

Caribbean fronts have different characteristics than mid-latitude fronts. Especially the further south they reach:

- **Low baroclinicity:**
  Weak thermal gradients. Interactions with warm SST can decrease the thermal signature close to the surface. Sometimes better defined at 950 or 925 hPa.

- **Shallower:**
  Sometimes invisible at 850 hPa. We need to look low in the troposphere.

- **Moisture fields matter a lot:**
  Signature in moisture fields can overwhelm the thermal signature. Extra weight on moisture gradients for proper identification of the boundary.

- **Ageostrophic peculiarities:**
  Unique regional topographical features cause peculiarities. Examples: “Nortes” or northerly surges in the western Gulf of Mexico; Tehuantepecer low-level jet; etc.

(4) Surface Front Identification Tool

Is there a way to enhance frontal signatures in the GFS?

Thermal aspects: they show up in thickness

- 1000-850 hPa ... Good
- 1000-925 hPa ... Also good, sometimes better
- ~~1000-500 hPa~~ ...not as good (they are shallow)

Moisture aspects: important in the tropics

- 1000 and 2m dewpoints ...good ← Td_{2m} <18°C
- 925 hPa dewpoints ... Great signal at lower latitudes, less "pollution" by sfc moisture.
- Precipitable water ... Extra useful tool, even when boundary is best defined near the sfc.

Forecasting experience in the WPC International Desks has identified that surface station and 2m-model dewpoints ≤18°C very rarely occur in pre-frontal environments. The 18°C isodrosotherm generally relates well to the southernmost front.

(4) Surface Front Identification Tool

What is plotted?

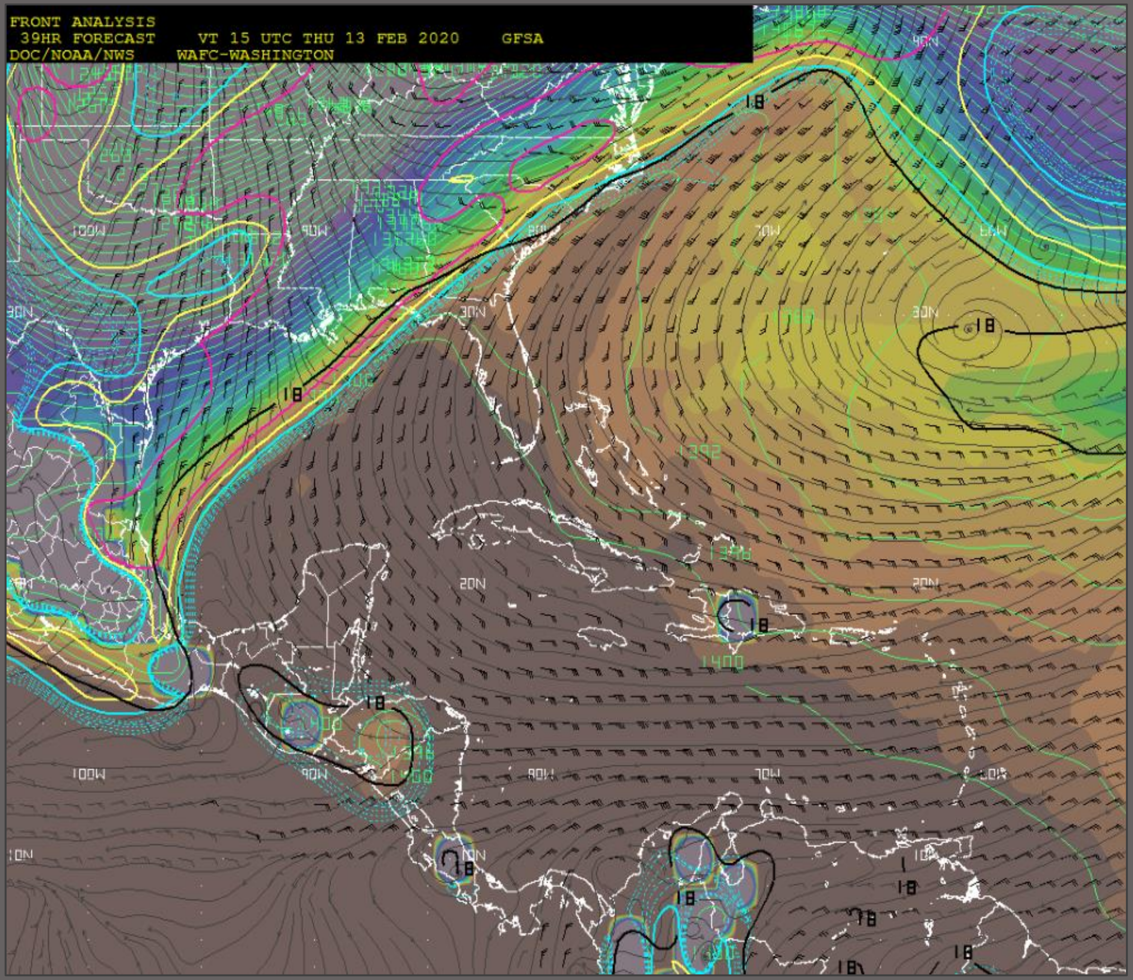
(1) Shaded: “air mass characteristics” field, hereafter, α.

(2) Contours (light blue, yellow, fuscia):
-Magnitude of the gradient of α, enhanced by the gradients of PWAT and $\theta_{e\_1000\ hPa}$

(3) Complementary fields:

- 1000-850 hPa thickness (GPM)
- 18°C 2m dew point (C)
- 1000-925 hPa averaged winds (kt)

925 hPa wind field is “cleaner” due to reduced surface roughness “pollution”



(4) Surface Front Identification Tool

Algorithm summary

(1) Constructs an "air mass type" field (α) using:

- 1000-850 hPa thickness (GPM)
- 1000-925 hPa thickness (GPM)

} **Thermal Aspects**

- 1000 hPa Dewpoint (K)
- 925 hPa Dewpoint (K)

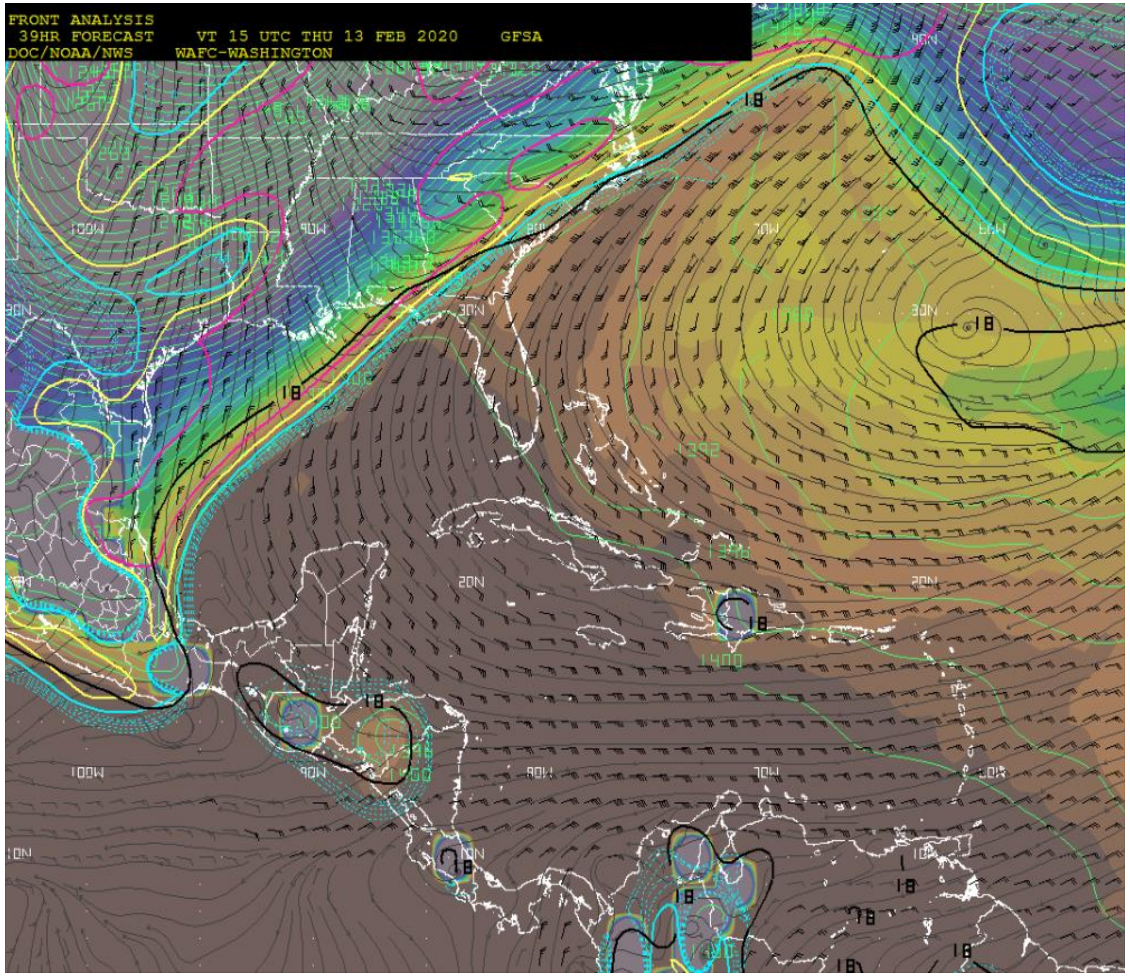
} **Moisture Aspect**

Quantities are <u>multiplied</u> versus added, to highlight horizontal changes.

(2) Calculates the <u>magnitude of the gradient</u> of a field constructed with α, PWAT and $\theta_{e\_1000\ hPa}$

(3) Plots the complementary fields:

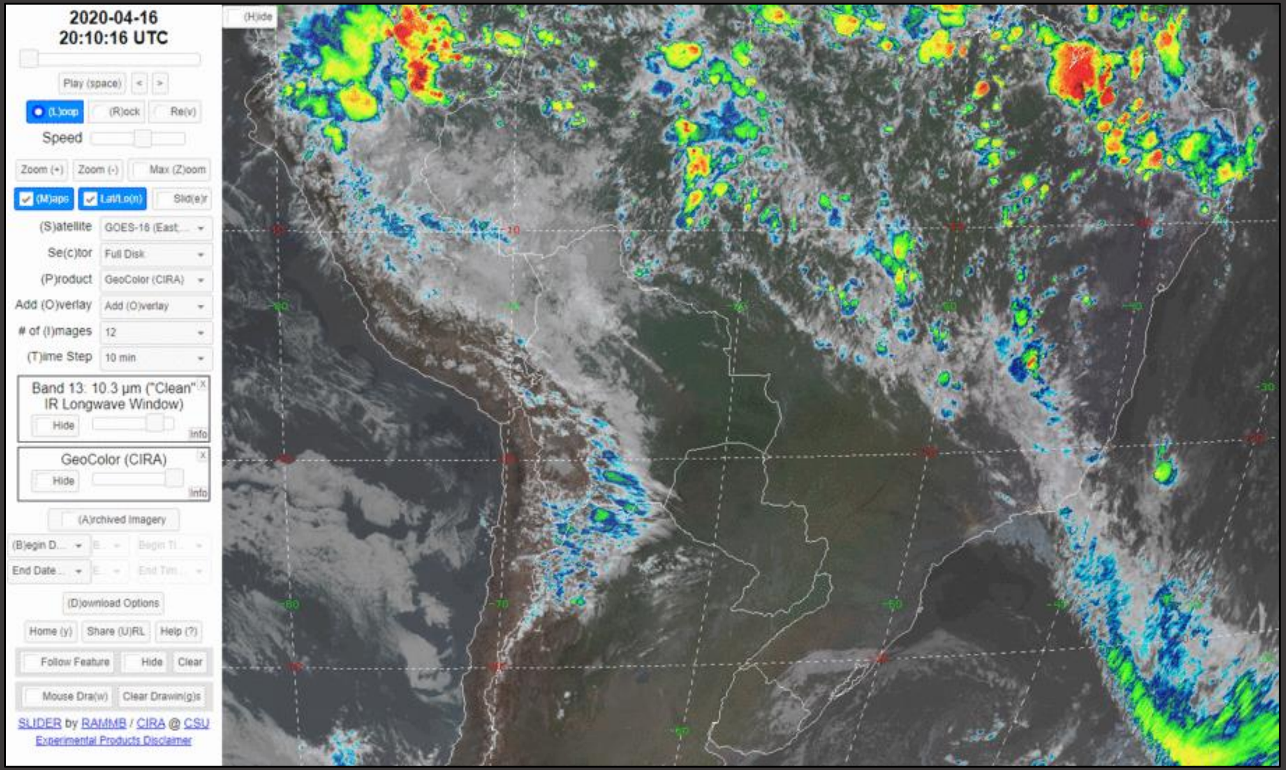
- 1000-850 hPa thickness (GPM)
- 1000-925 hPa averaged winds (kt)
- 18°C 2m dew point (C)



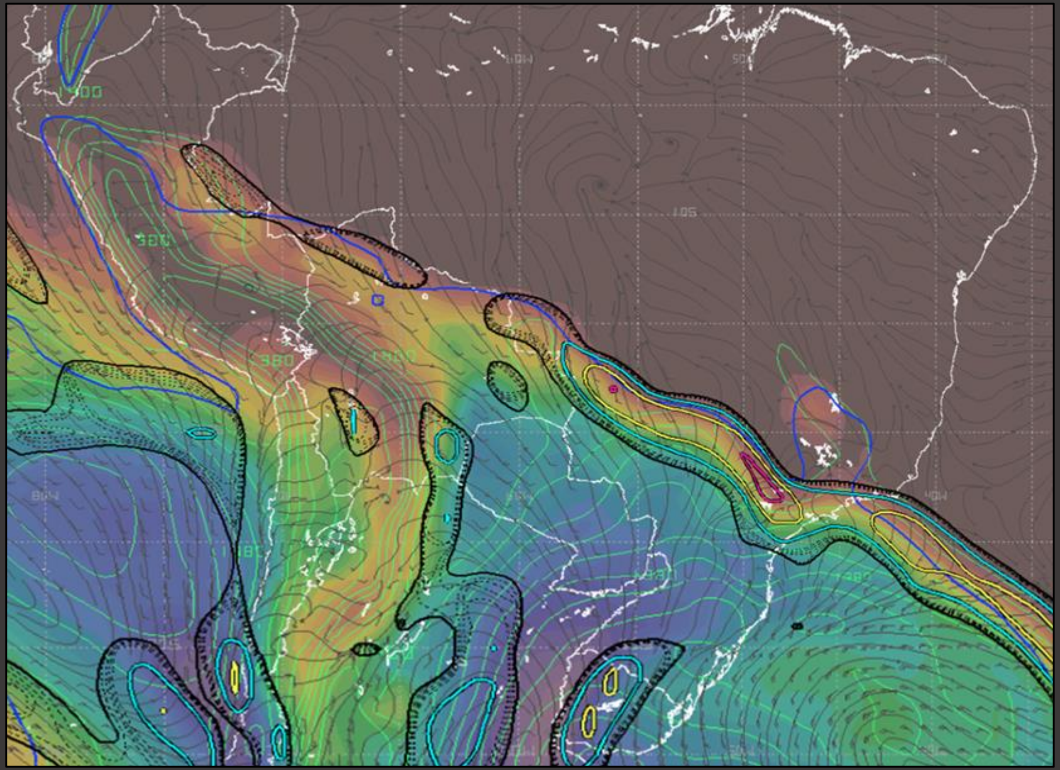
Front in South America

Where would you place the front and associated components?

(Shear line and prefrontal trough)



Combination of the CIRA Geocolor product and Channel 13 of the GOES-16 during April 16, 2020, near 21 UTC.

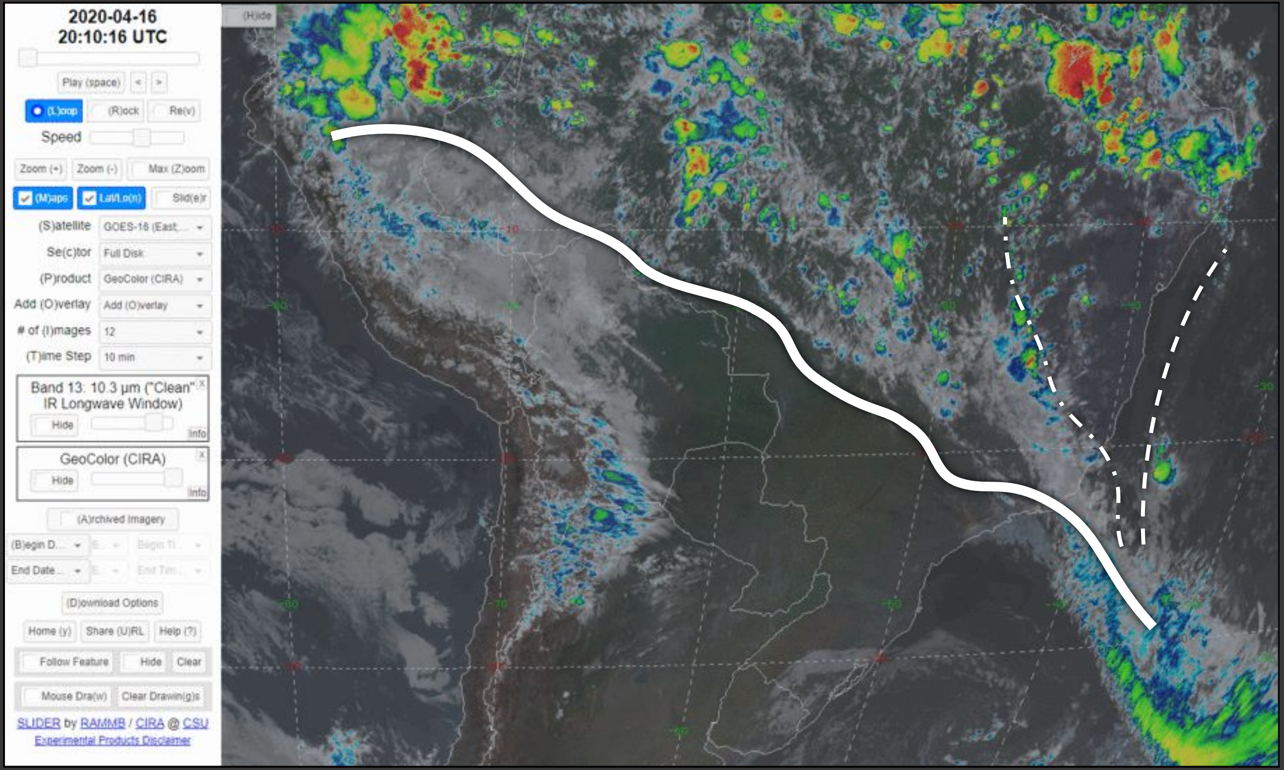


Front Algorithm on the GFS Model Forecast (F21) for 21 UTC April 16, 2020.

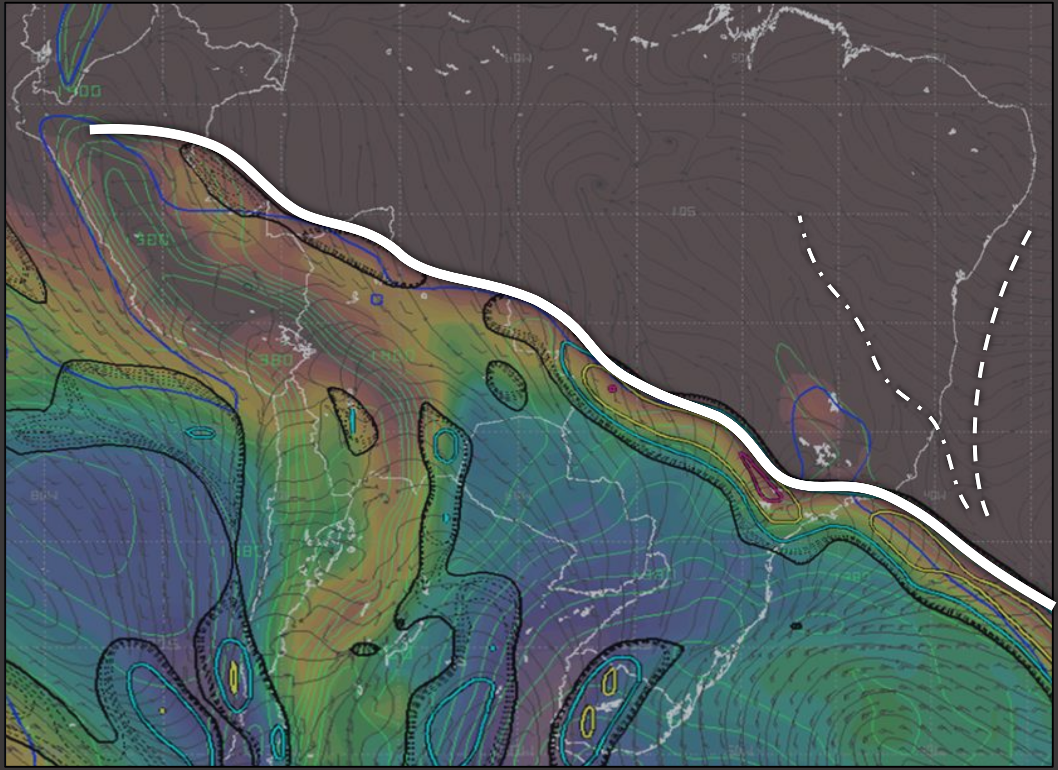
Front in South America

Where would you place the front and associated components?

(Shear line and prefrontal trough)



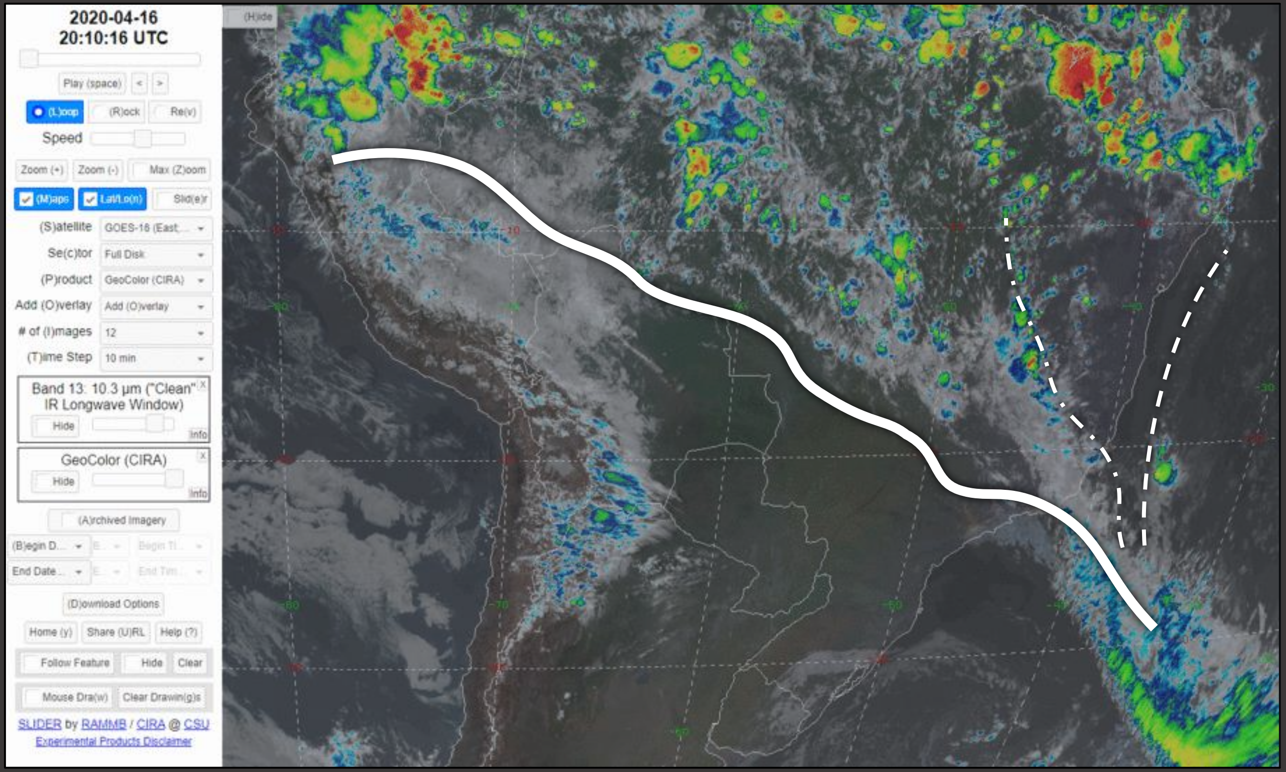
Combination of the CIRA Geocolor product and Channel 13 of the GOES-16 during April 16, 2020, near 21 UTC.



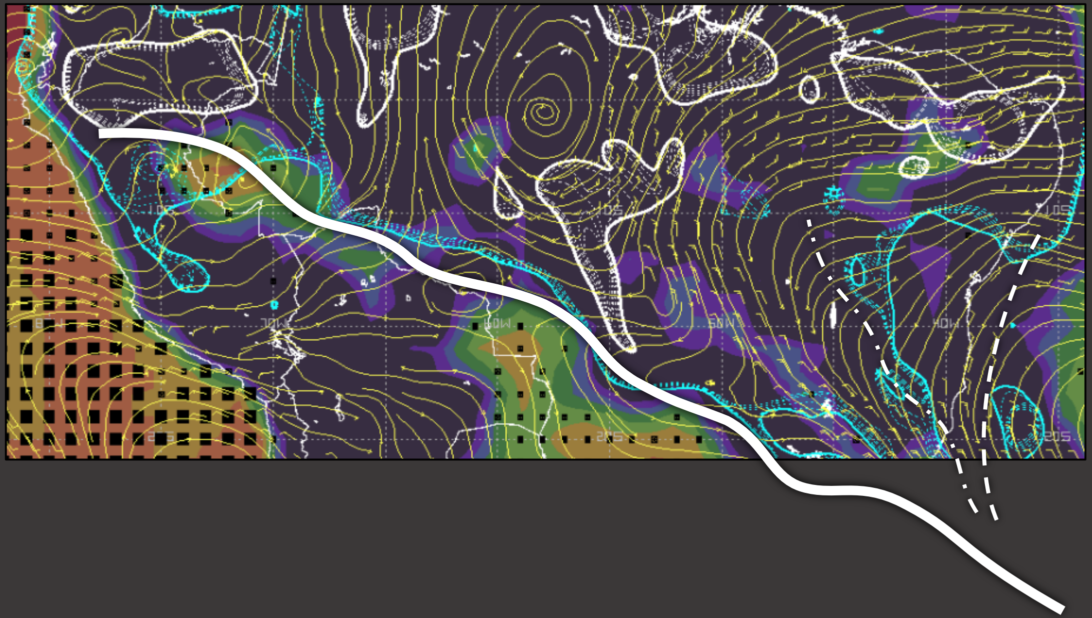
Front Algorithm on the GFS Model Forecast (F21) for 21 UTC April 16, 2020.

Front in South America

Signature on the macro TWIN



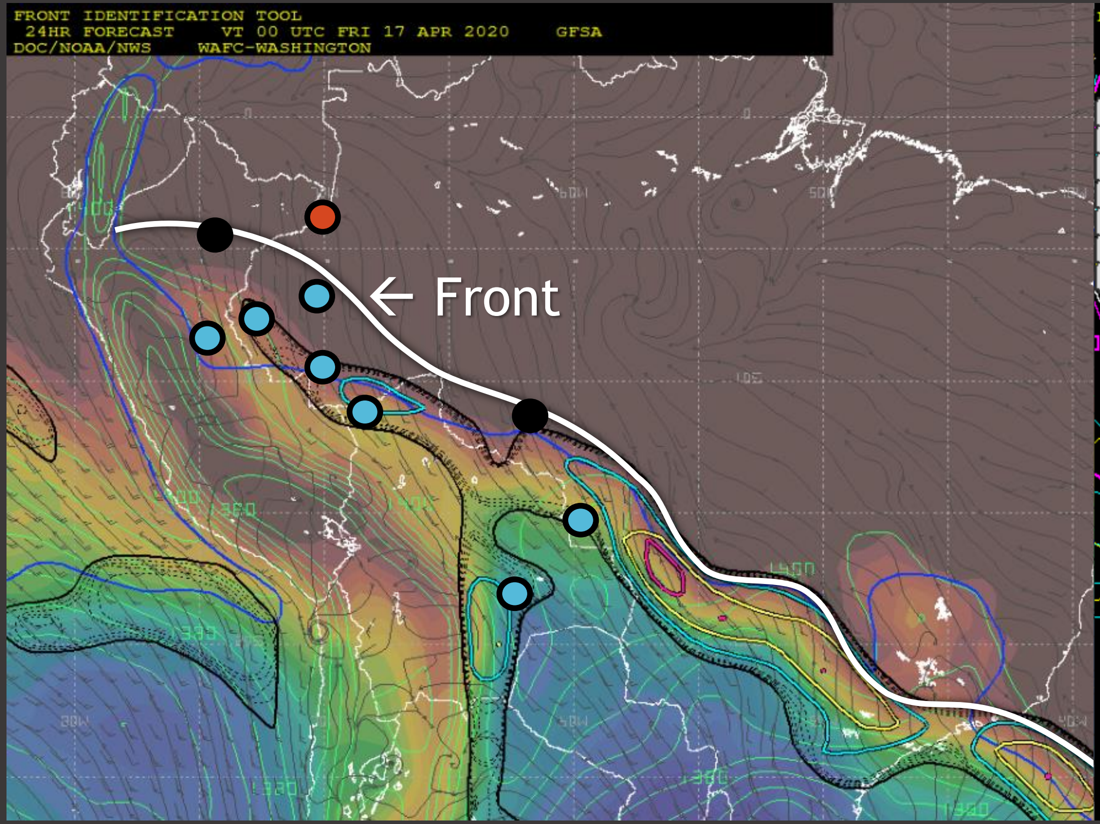
Combination of the CIRA Geocolor product and Channel 13 of the GOES-16 during April 16, 2020, near 21 UTC.



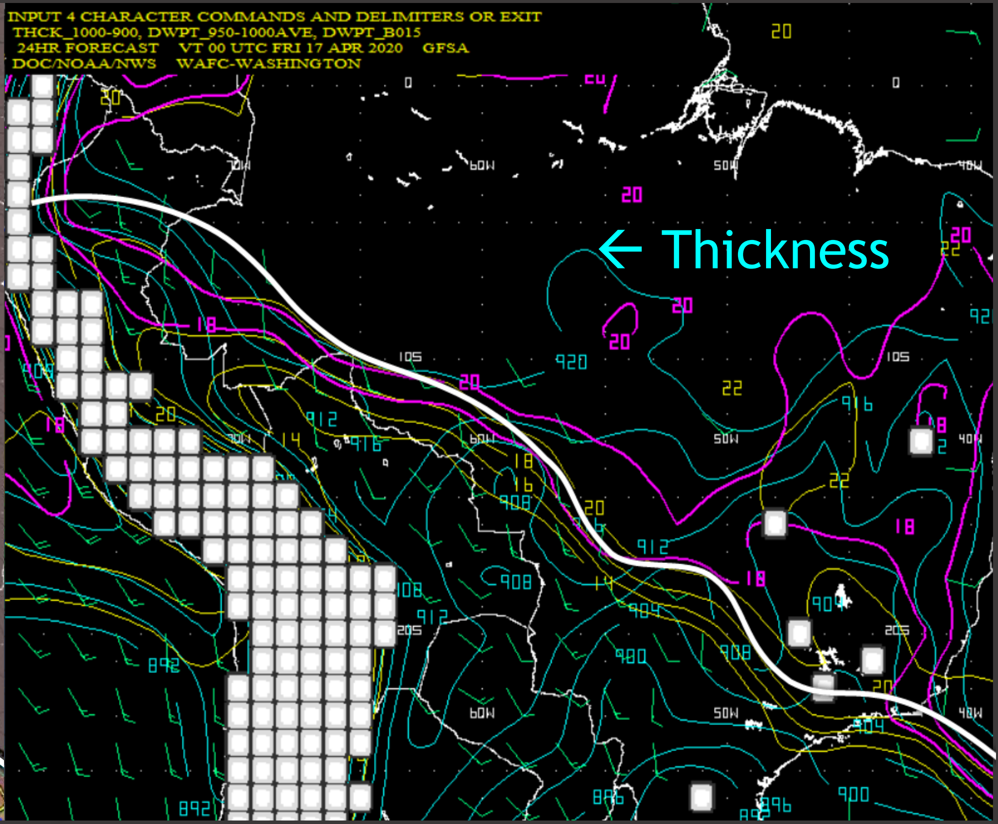
Should we give more weight to thermal gradients?

Room for improvement

- In the tropics, fronts can be downstream from the suggested gradient.
- 1000-925 hPa thickness and wind speed across the front seem to matter.

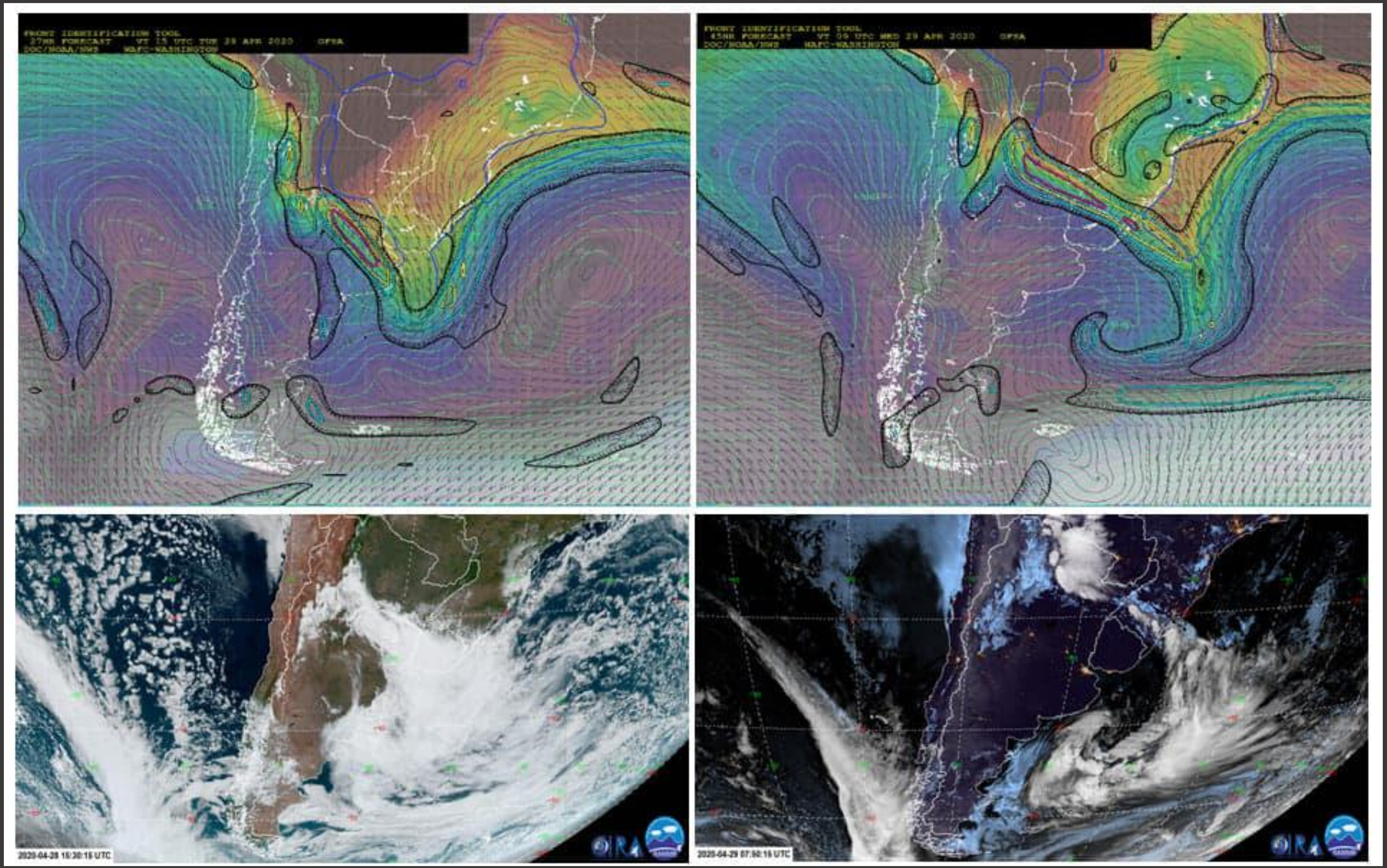


Blue dot stations were post frontal, black were frontal and red pre-frontal.



In this case, 1000-950 hPa thickness captured the frontal position best.

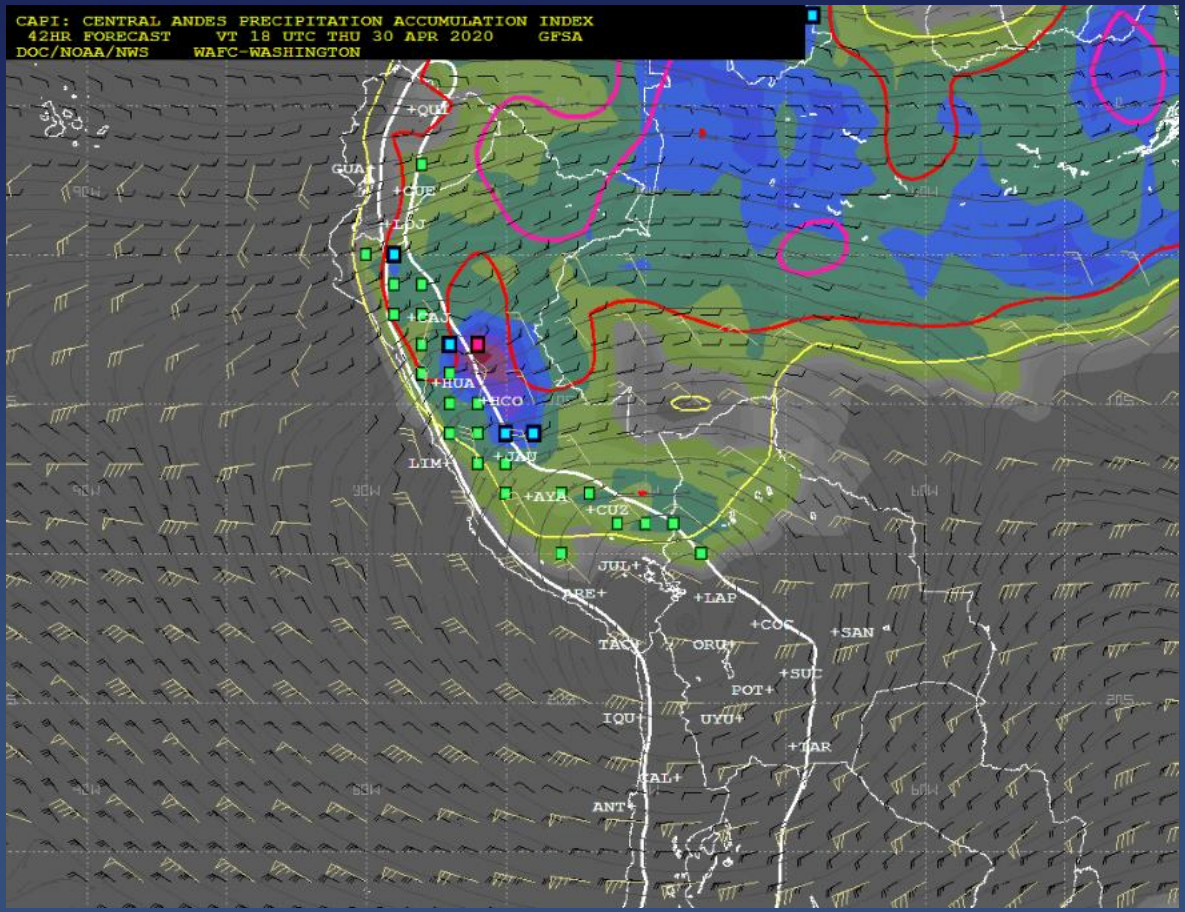
Another Example for South America



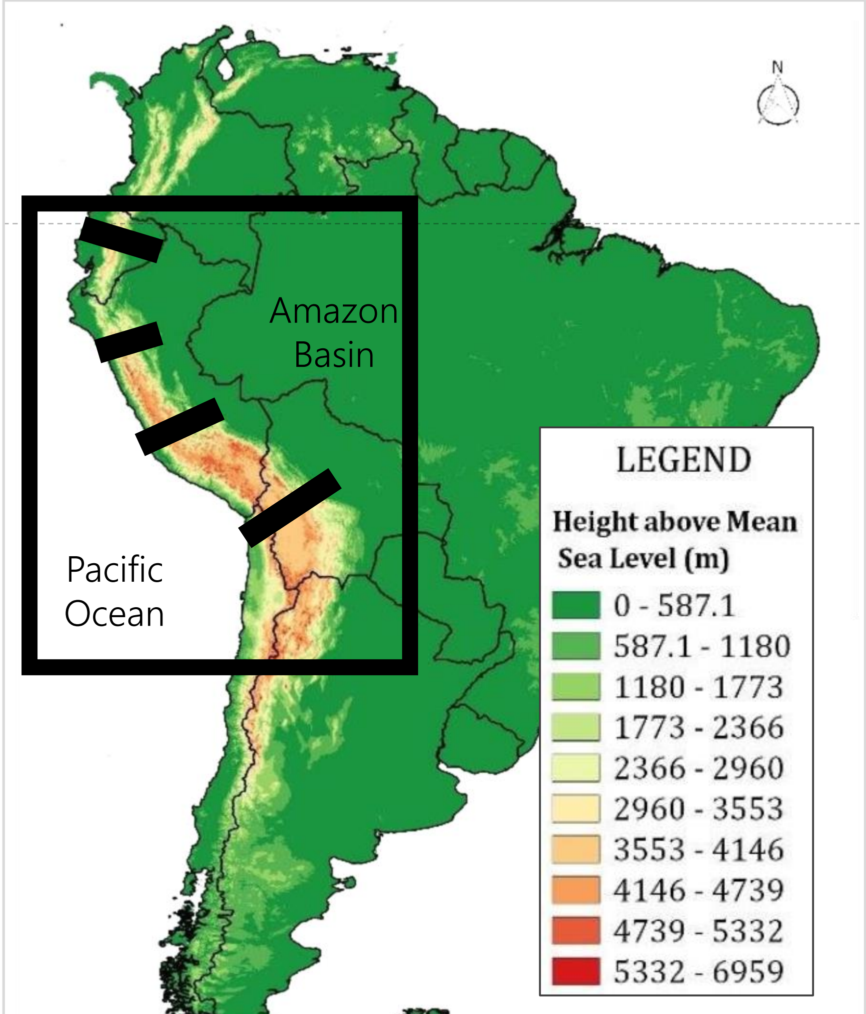
Courtesy: Nestor Santayana

5. CAPI

Central Andes Precipitation Accumulation Index

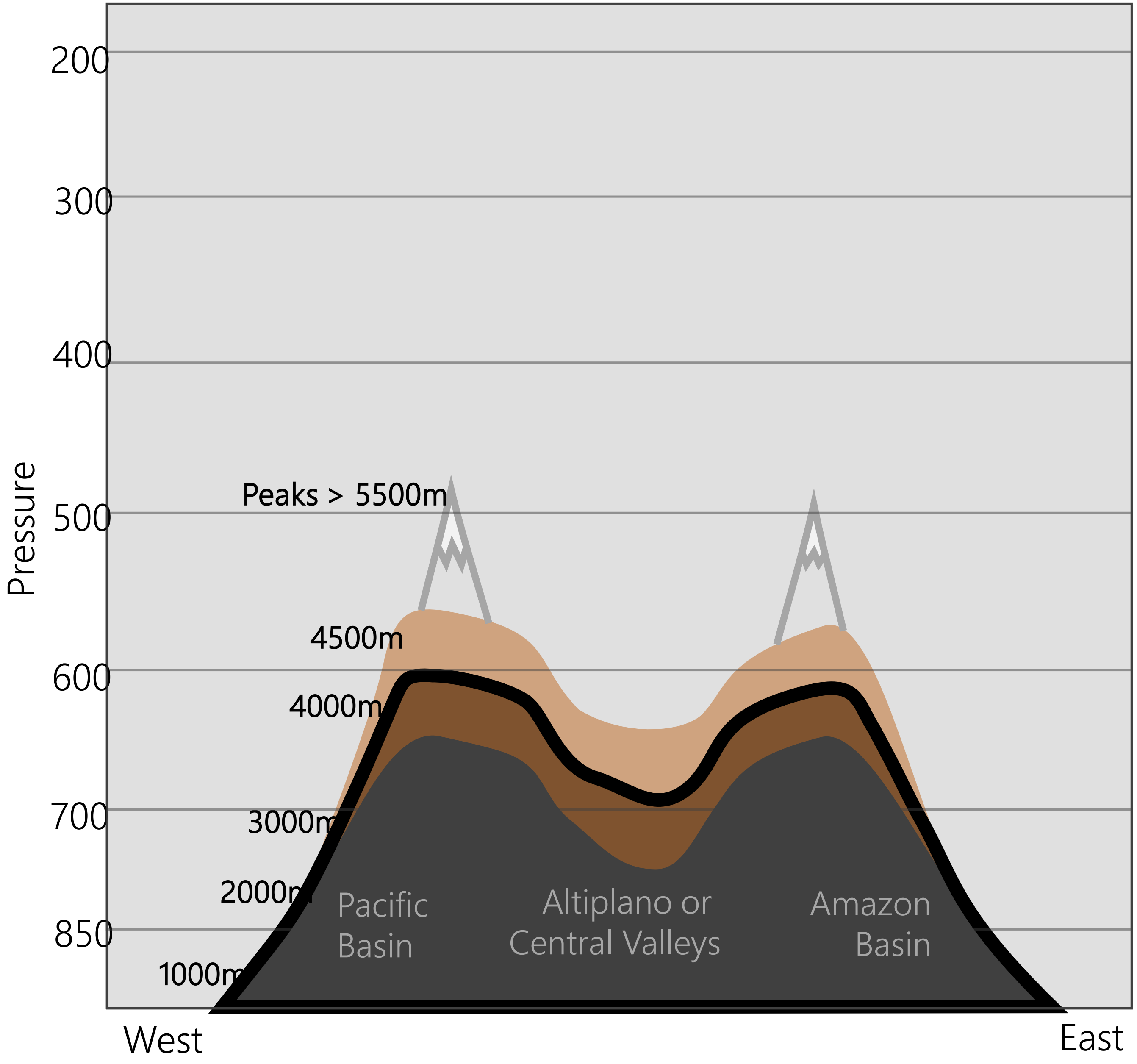


Representative cross section of the Central Andes

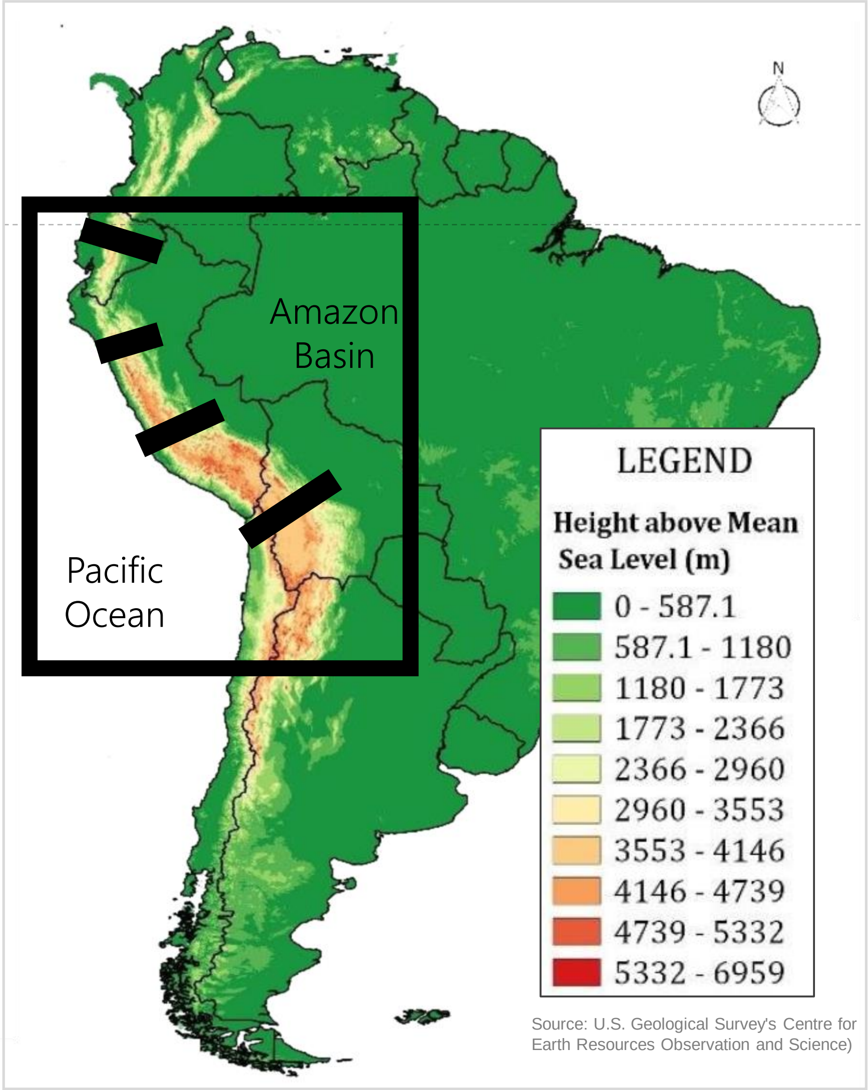


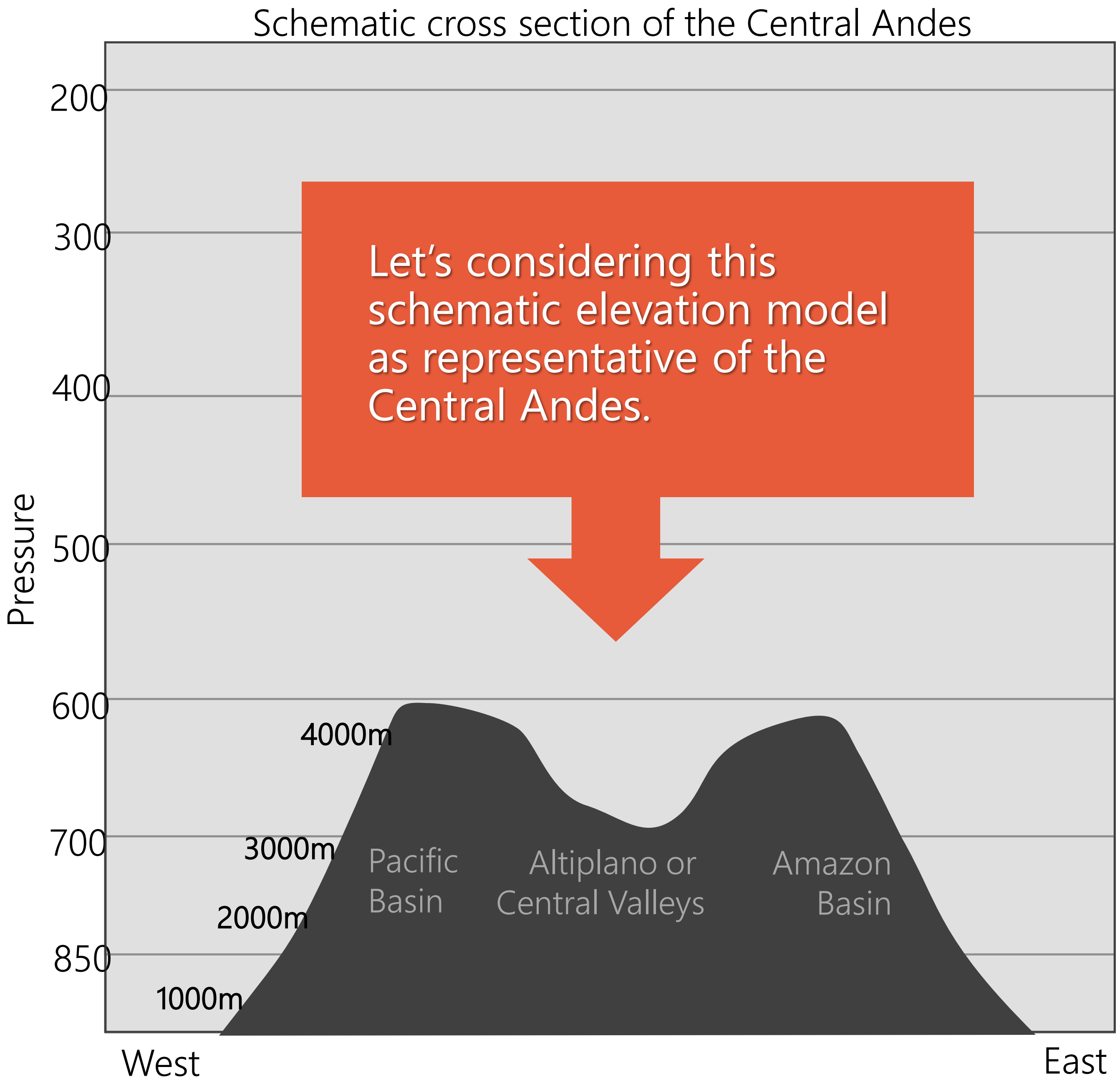
Source: U.S. Geological Survey's Centre for Earth Resources Observation and Science)

Schematic cross section of the Central Andes



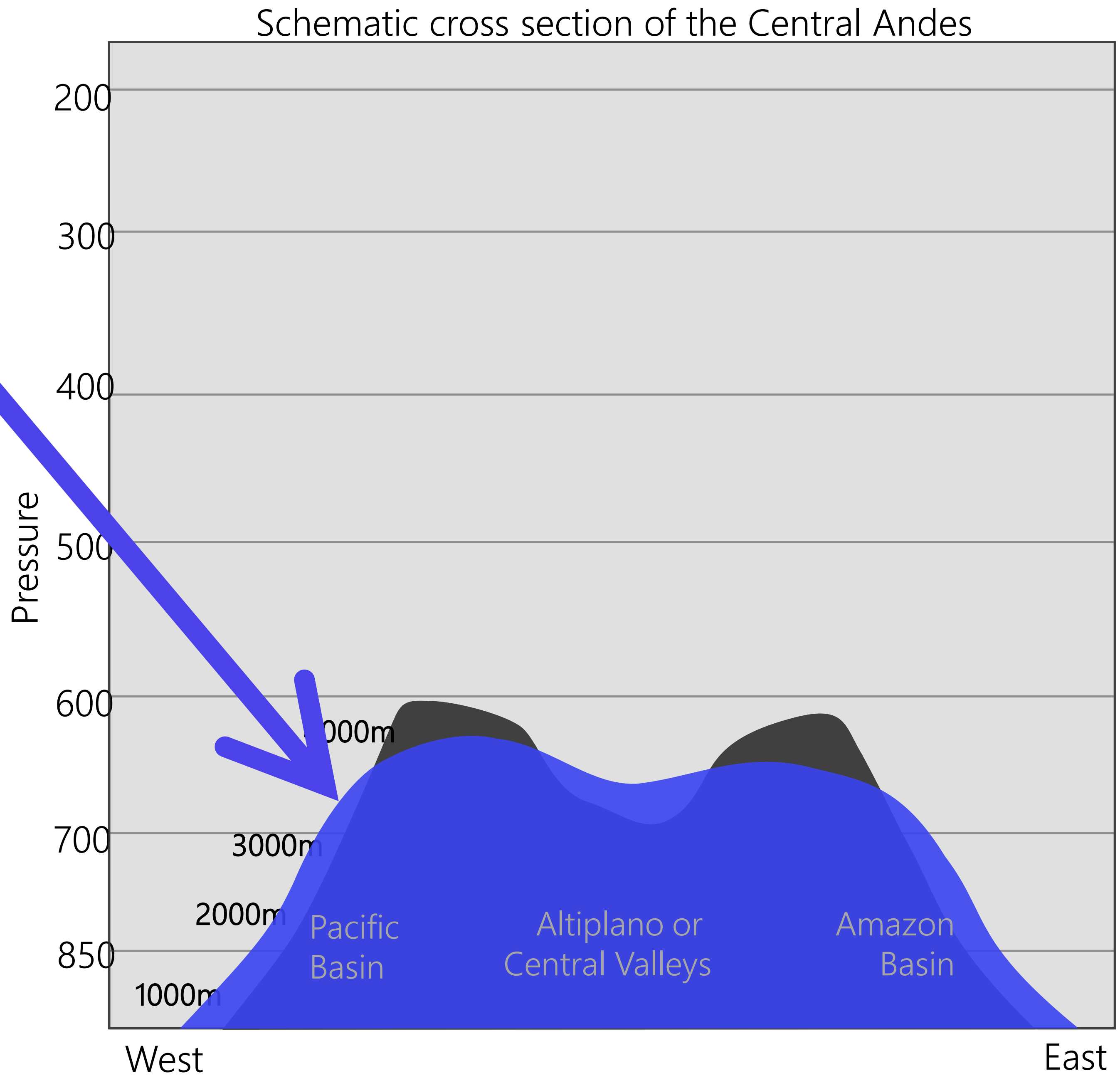
Representative cross section of the Central Andes





But wait: n the 1° GFS the Andes look more…

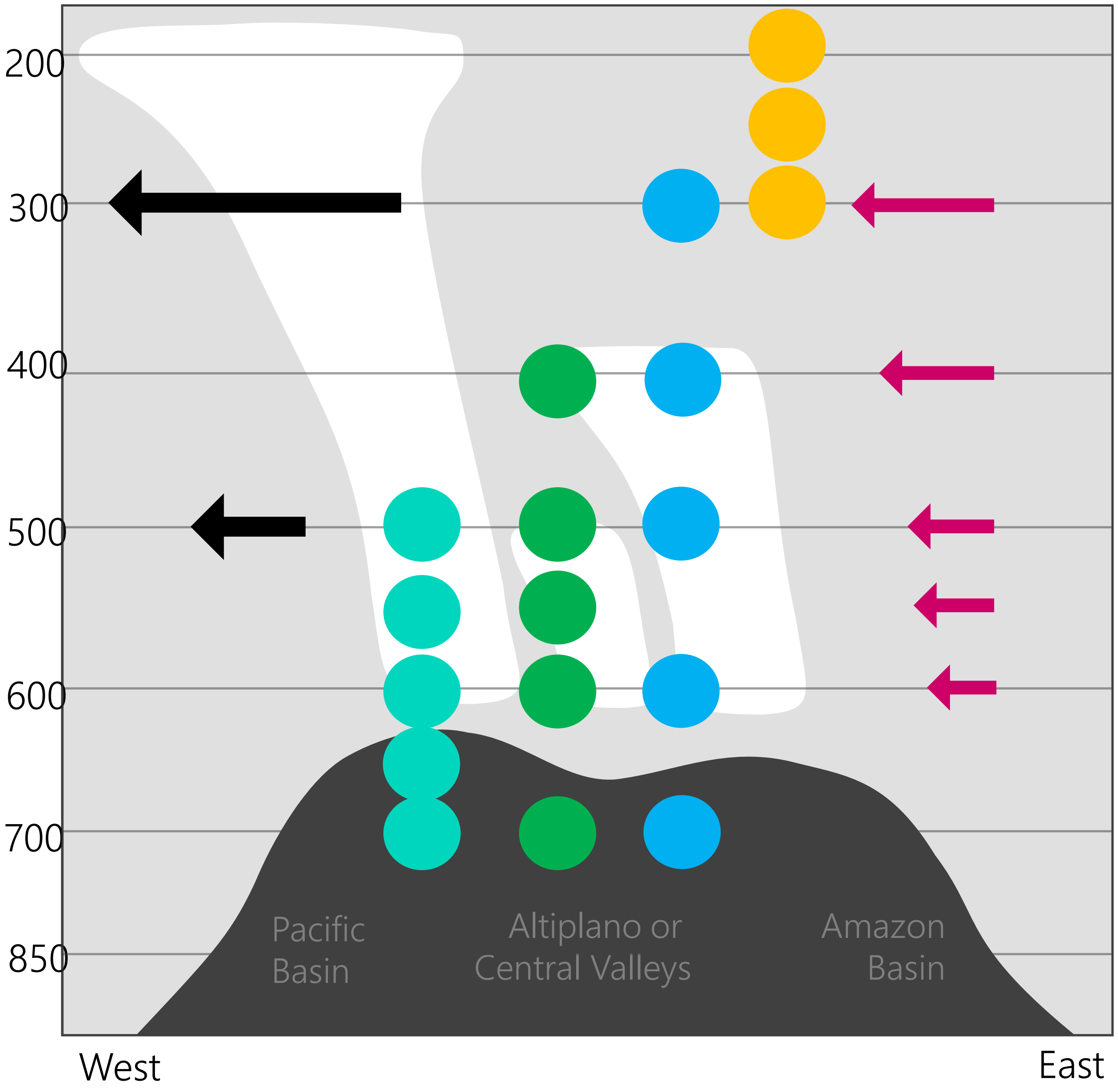
…like this



Accordingly, we will evaluate GFS variables with this elevation model in mind.

CAPI

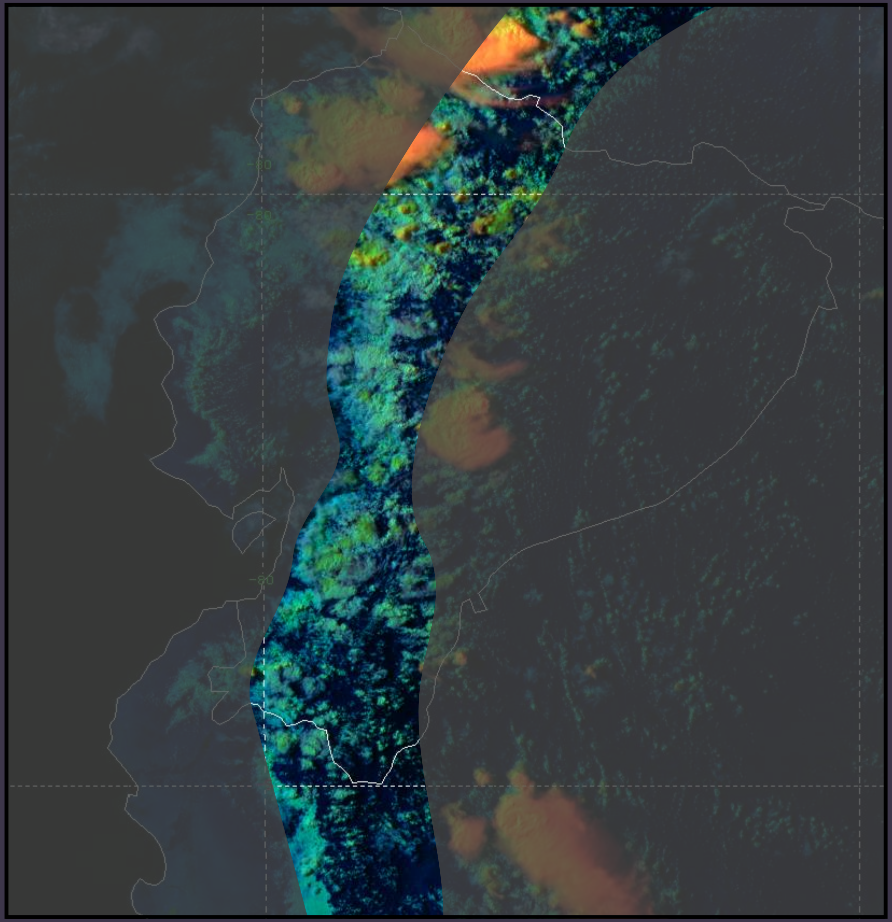
- Wind divergence (200-300 hPa)
- Wind shear (500-300 hPa)
- Steering flow (600-300 hPa)
- Relative Humidity (700-300 hPa)
- Mixing Ratio (700-400 hPa)
- Mixing ratio flux convergence (700-500 hPa)



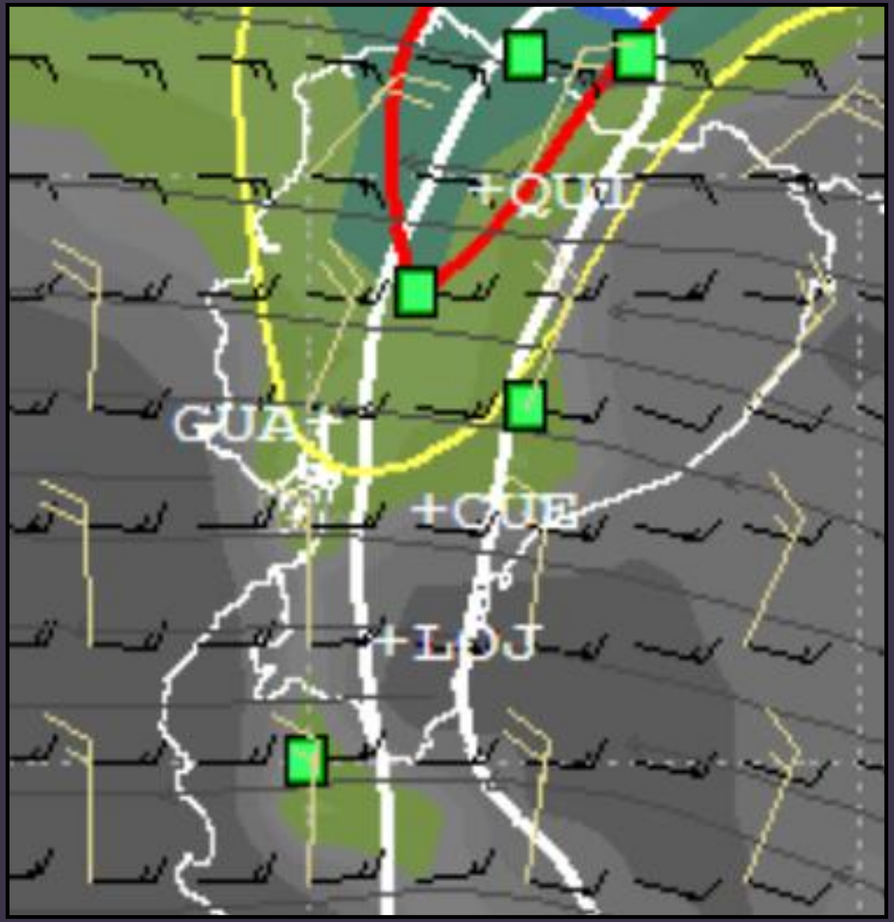
April 22

Too much shear. Mostly shallow convection: capped and sheared out.

Cloud Phase Distinction 20:30 UTC



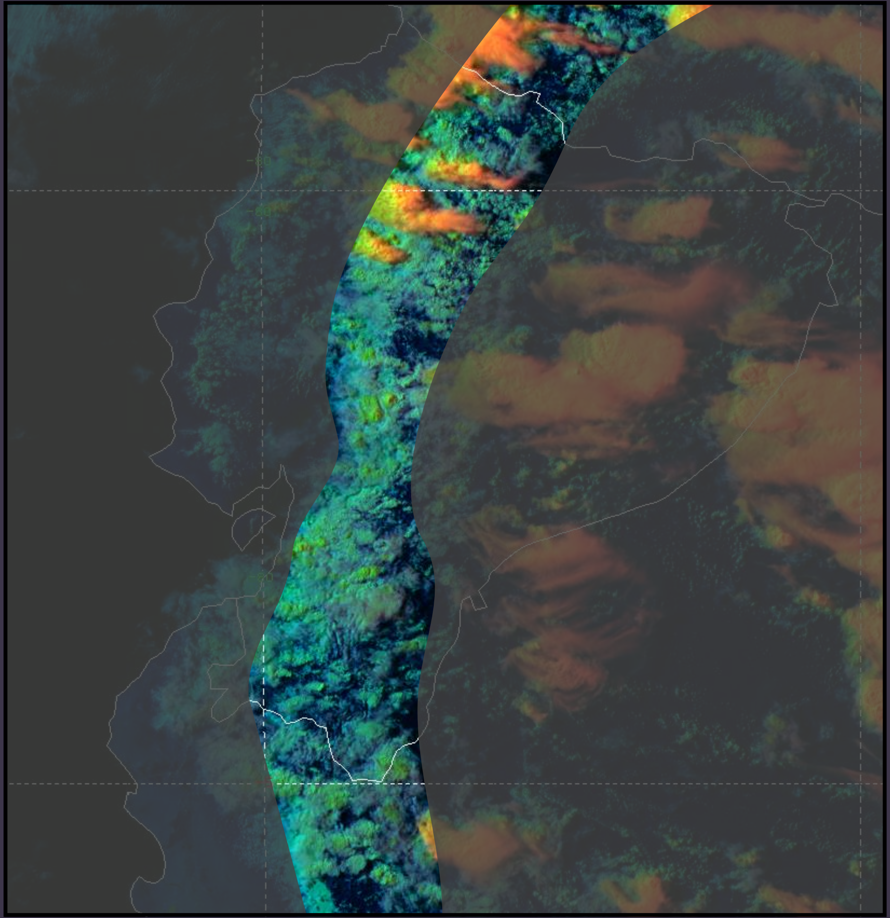
CAPI 21 UTC (F21)



April 23

Increased coverage and vertical development of convection. Less shear.

Cloud Phase Distinction 20:30 UTC



CAPI 21 UTC (F21)