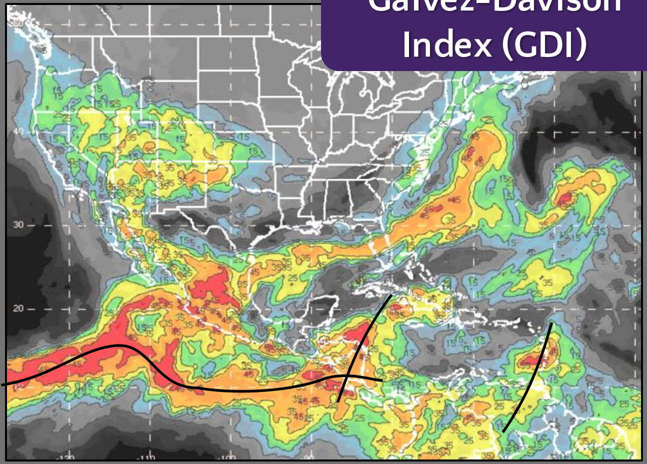
Forecasting Tools Developed at the WPC International Desks

By José Manuel Gálvez

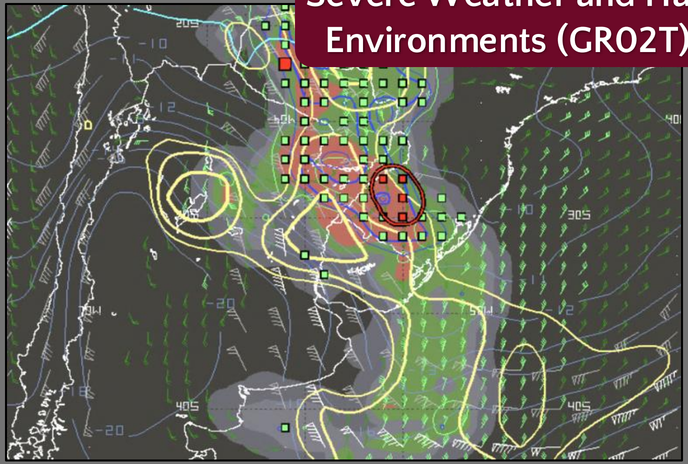
30 September 2025

Six Forecasting Tools have been developed since 2013

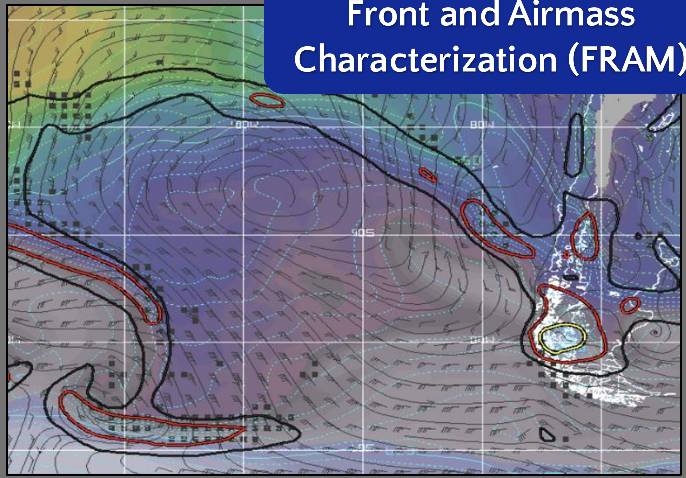
Gálvez-Davison Index (GDI)



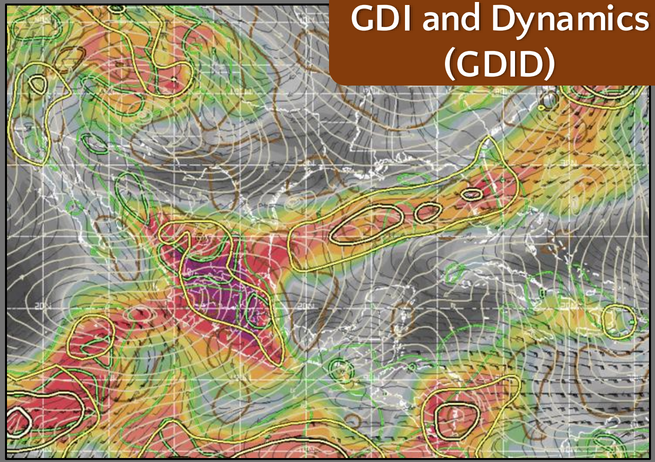
Severe Weather and Hail Environments (GR02T)



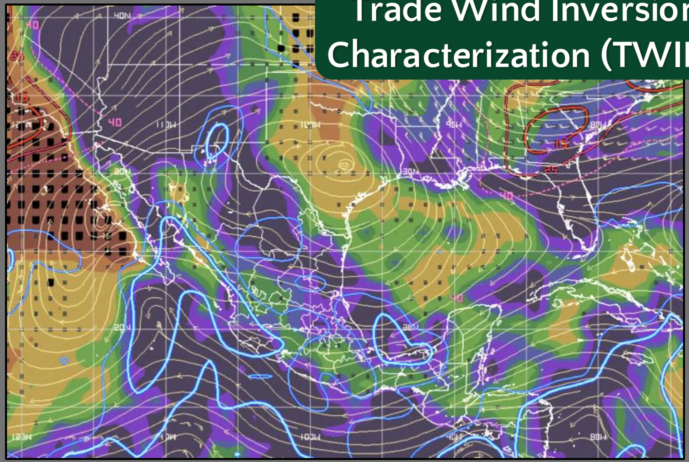
Front and Airmass Characterization (FRAM)



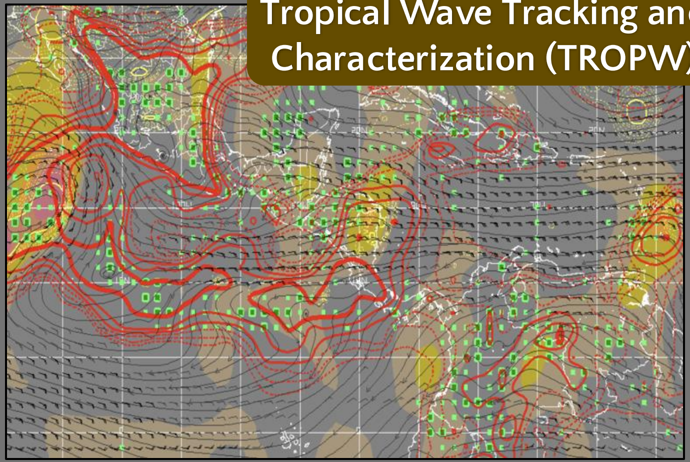
GDI and Dynamics (GDID)



Trade Wind Inversion Characterization (TWIN)



Tropical Wave Tracking and Characterization (TROPW)

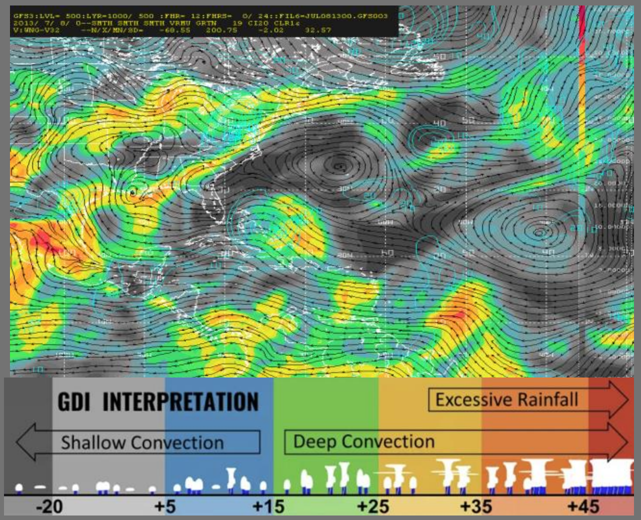


The first was the Gálvez-Davison Index (GDI)

Tool	Application Desired	Main Aspects Described	Authors and year
Gálvez-Davison Index (GDI)	Quantitative Precipitation Forecasting (QPF) in the tropics and subtropics	• Convective instability for tropical and subtropical convection	• José Gálvez (WPC) • Mike Davison (WPC) **2013**

GDI APPLICATIONS

- Excessive Rainfall Forecasting.
- Planning of Flight Routes in Aviation.
- Impactful Weather System Detection.
- Tropical Cyclone Structure Analysis.
- Tropical Wave tracking.
- Detection of environments for the formation of Mesoscale Convective Systems (MCS).

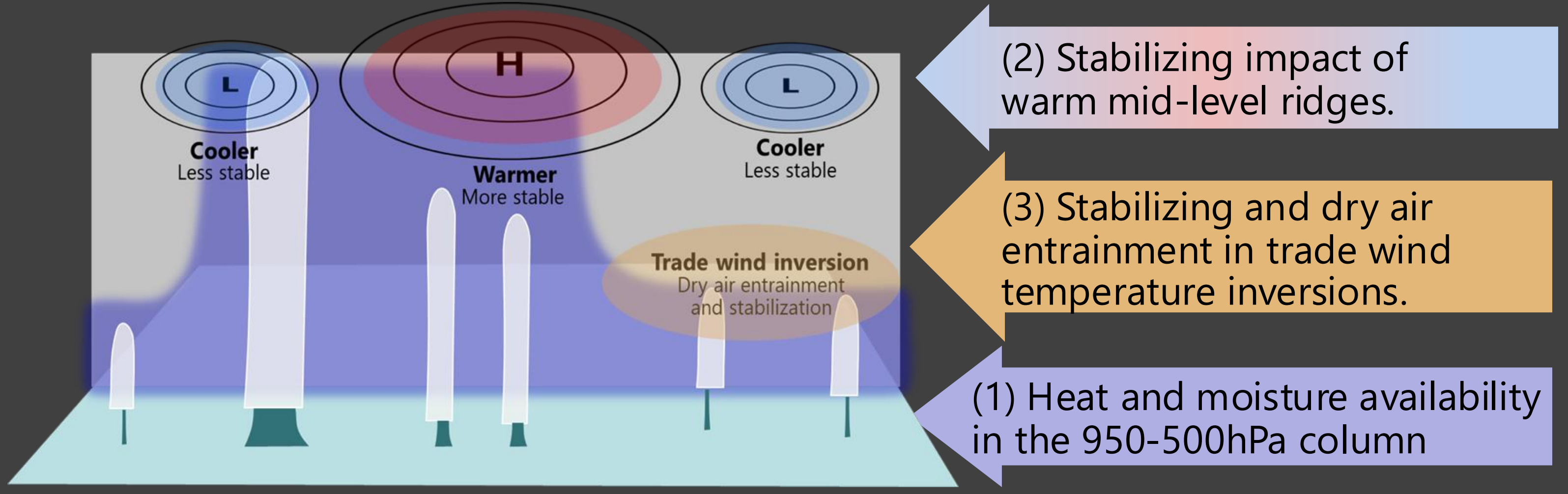


The GDI highlights:

(1) Heat and moisture availability at and below 500 hPa.

(2) Stabilizing impacts of mid-level ridges.

(3) Stabilizing and drying impacts of temperature inversions in trade wind regimes.



The GDI is available in many places!

US NWS

AWIPS

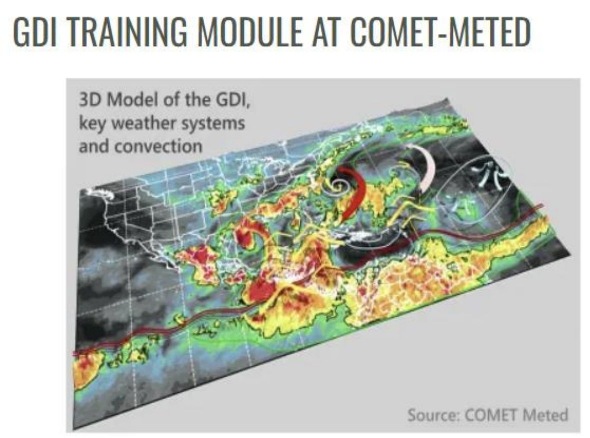
NAWIPS

Web

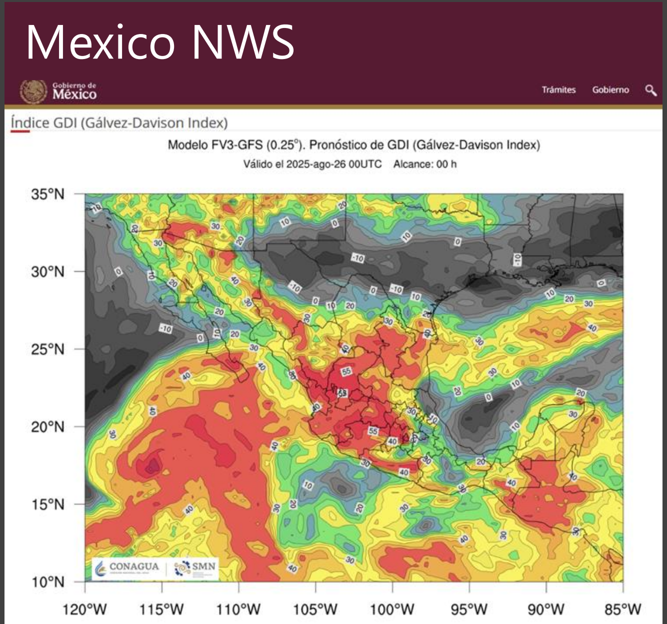
Used in WFOs

Used in the AWC

COMET Training Module



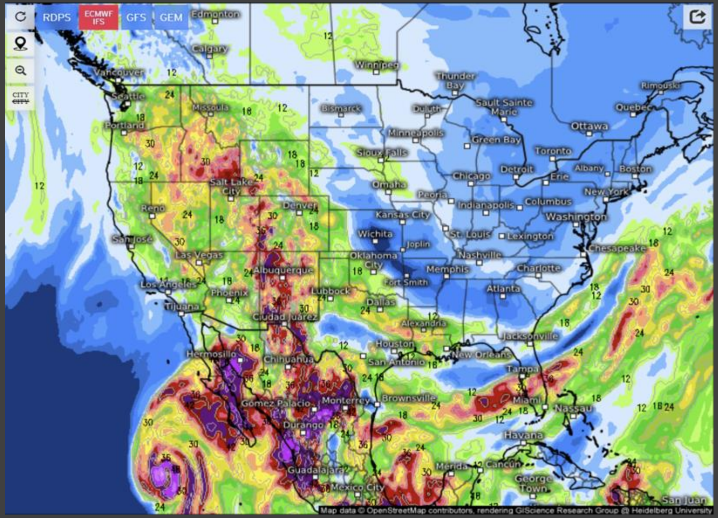
Coded by International Weather Services



Brazil NWS, internally

El Salvador NWS, internally

Coded by many private companies using different models, including ECMWF AIFS



Research:
17 published articles

Forecasting Tools Developed beyond the GDI: Five (5)

Tool	Application Desired	Main Aspects Described	Authors and year
Gálvez-Davison Index (GDI)	Quantitative Precipitation Forecasting (QPF) in the tropics and subtropics	• Convective instability for tropical and subtropical convection	• José Gálvez (WPC) • Mike Davison (WPC) 2013
Severe and Hail Environments (GR02T)	Severe weather forecasting in subtropical and mid-latitudes of South America, emphasis on hail	• General risk for severity • Specific risk for hail • Upper and low-level jet dynamics	• José Gálvez (WPC) • Néstor Santayana (INUMET, Uruguay NWS) 2015
GDI and Dynamics (GDID)	Quantitative Precipitation Forecasting (QPF) in the tropics and subtropics	• GDI instability • Dynamics that stimulate or limit the utilization of GDI to form convection	• José Gálvez (WPC) 2017
Trade Wind Inversion Characterization (TWIN)	Vertical development and structure of trade wind regime convection	• Height+strength of lowest stable layer • Dry air entrainment potential • Mid-level support	• José Gálvez (WPC) 2018
Front and Airmass Characterization (FRAM)	Surface boundary detection with emphasis on fronts	• Airmass thermal and moisture aspects • Airmass gradients • Position of surface fronts and shear lines	• José Gálvez (WPC) 2020
Tropical Wave Tracking and Characterization (TROPW)	Tropical wave detection, tracking and characterization	• Position and propagation of waves propagating in trade wind regimes • Convective aspects of waves • Dynamical aspects of waves	• José Gálvez (WPC) 2023 Contributions from Gabriela Chinchilla, Andrew Levine, Jay Alamo, Bonnie Castellanos and Shamal Clarke

Forecasting Tool work during my current WPC appointment

(1) Recoded each tool, to aid with their replication in other platforms.
- Created specific variables for each algorithm.
- Improved the documentation inside and outside the code.

(2) Improved four algorithms: calculations and visualization
- GDID: Reverted to the GDI, and optimized the graphics and thresholds plotted.
- TROPW: Optimized computation and visuals.
- TWIN: Optimized computation and visuals.
- FRAM: Modified calculations to better capture airmass gradients with improved mathematical robustness. Integrated low-level moisture flux for clearer boundary detection, upgraded visuals, and expanded domain coverage (e.g., Easter Island and fronts affecting Brazil and the United States).

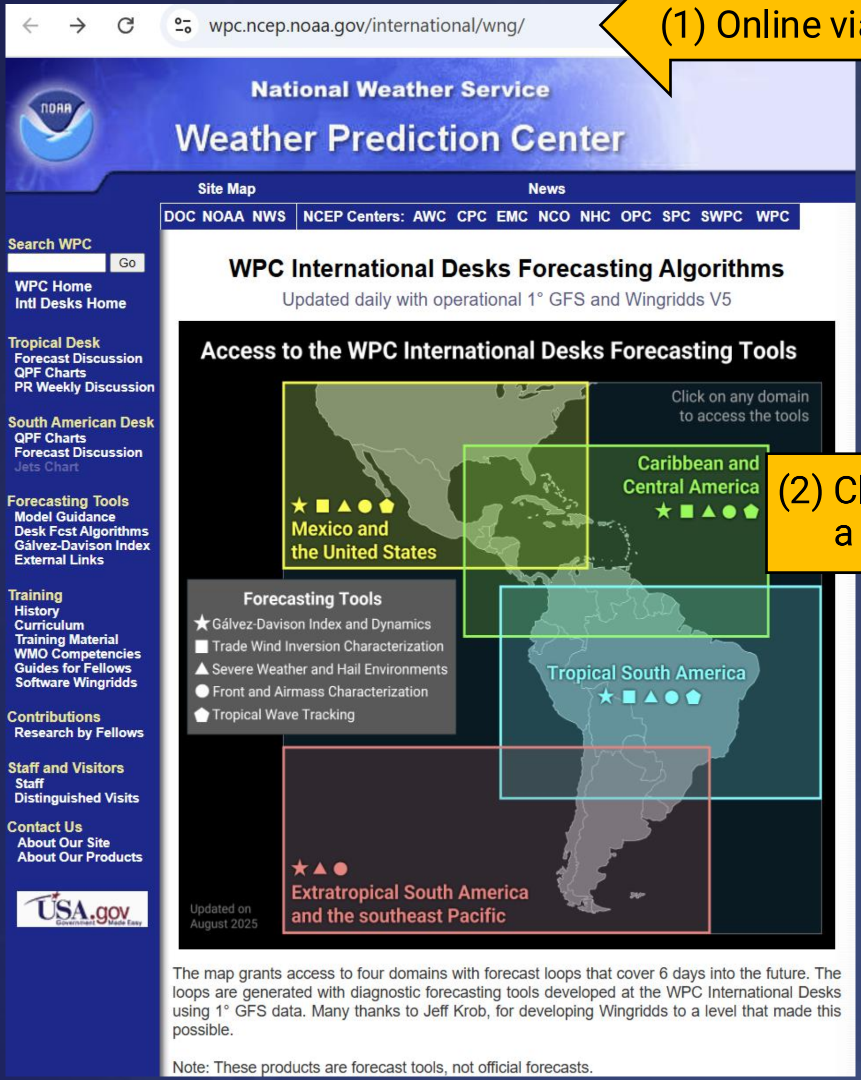
(3) Developed legends for all algorithms and implemented them online.

(4) Optimized the operational flow and implemented it.

(5) Improved the website and online information about applications of each tool.

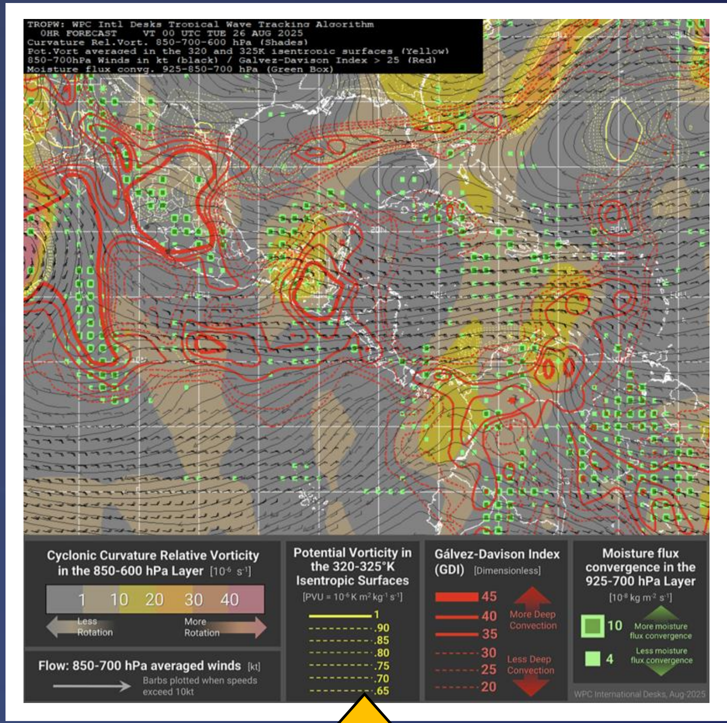
Current Access to the Forecasting Tools

(1) Online via https://www.wpc.ncep.noaa.gov/international/wng/



(2) Click on a domain

Forecasting Tool Currently Available	GFS 00Z	GFS 12Z
Galvez-Davison Index and Dynamics - GDID.CMD The Galvez-Davison Index describes convective instability favorable for tropical and subtropical convection. Yet, analyzing atmospheric dynamics is required to know whether the atmosphere might be capable of utilizing this instability to produce convection. The GDID tool plots the GDI in colors and overlays low-level flow, low-level moisture flux convergence and divergence, upper level flow and upper level divergence to better forecast regions where convection and precipitation might develop. **GDID Algorithm Legend** A quick guide is on the works.	Idle	Idle
Trade Wind Inversion Characterization - TWIN.CMD To understand convection types in trade wind regimes, understanding the racteristics of the trade wind inversion and overlying airmass are crucial. diagnoses the height of the lowest-lying stable layer with colors and its with boxes. 700-500 hPa low relative humidity contours signal the tial of dry air entrainment from the mid-troposphere into the marine layer. 0-400 hPa averaged flow describes mid-level ridges and troughs, which generally relate to enhanced subsidence and enhanced stability versus deep convection, respectively. High GDI contours signal regions with the potential of deep convection. More information in the **TWIN Algorithm Legend** . A quick guide is on the works.	Idle	Idle
Severe Weather and Hail Environments - GR02T.CMD GR02T highlights regions with a general the potential for severe weather with shades of color, and specifically detects a potential for hail where colored boxes appear inside colored contours over a color shaded area. Includes 925-850 hPa and 250-500 hPa winds to include impacts of low-level and upper jets on the analysis of the severe weather and hail potential. In addition, 500 hPa temperatures in contours show where mid-level short wave troughs might be present, and where temperatures are sufficiently cold to favor hail. In the Caribbean, these are often temperatures cooler than -8°C. More information in the **GR02T Algorithm Legend** . A quick guide is on the works.	Idle	Idle
Front and Airmass Characterization Algorithm - FRAM.CMD FRAM helps to identify surface fronts and airmasses of different characteristics. It uses horizontal gradients of thickness and dewpoint in the lower troposphere, and five variables to plot the magnitude of gradients between airmasses. 1000-925 hPa winds and 1000-925 hPa enhanced moisture flux convergence, included with boxes, aid with the placement surface boundaries. More information in the **FRAM Algorithm Legend** . A quick guide is on the works.	Idle	Idle
Tropical Wave Tracking and Characterization - TROPW.CMD TROPW was developed to help with the tracking and characterization of tropical waves propagating in the trades. It evaluates cyclonic curvature vorticity in the 850-600 hPa layer, potential vorticity in the 320-325°K isentropic surfaces and 870-700 hPa flow to evaluate features with rotation that propagate from east to west. Additionally, it includes Galvez-Davison Index contours to highlight axes of enhanced convecive instability associated with the waves; and 925-700 hPa enhanced moisture convergence with green boxes, which often cluster near tropical waves and signal regions where convection might be tiggered. More information in the **TROPW Algorithm Legend** . A quick guide is on the works.	Caribbean + Central America Idle Atlantic Idle	Not Available



(3) Click on a Forecasting Tool

Backup

https://www.drjosemanuelgalvez.com/tools/

www.drjosemanuelgalvez.com/tools/ 90%

Back to the main website

Forecasting Tools developed by José Manuel Gálvez and collaborators during his tenure at the WPC International Desks

This website hosts operational output of the forecasting tools developed by José Manuel Gálvez and collaborators during work at the WPC International Desks. Please click on any domain to access today's GFS Model forecasts.

I have created 18 operational domains that are baclups to the tools that are published operationally in NOAA's website. The tools I implemented use 00UTC 0.5-degree GFS Model Output. Note that there is room for occasional interruptions since the operational system has been implemented in my personal laptop.

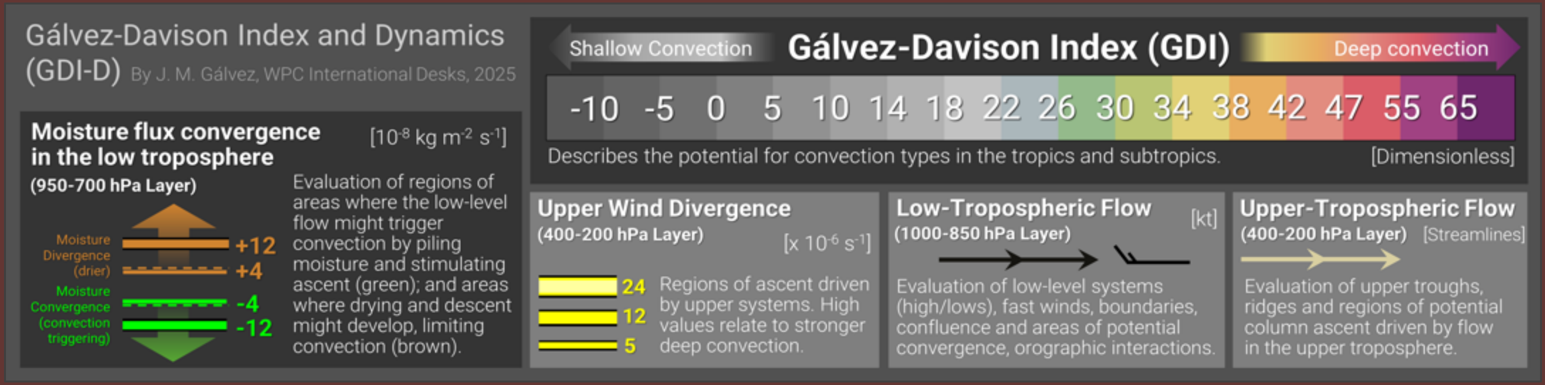
Let’s dive into the Forecasting Tools!

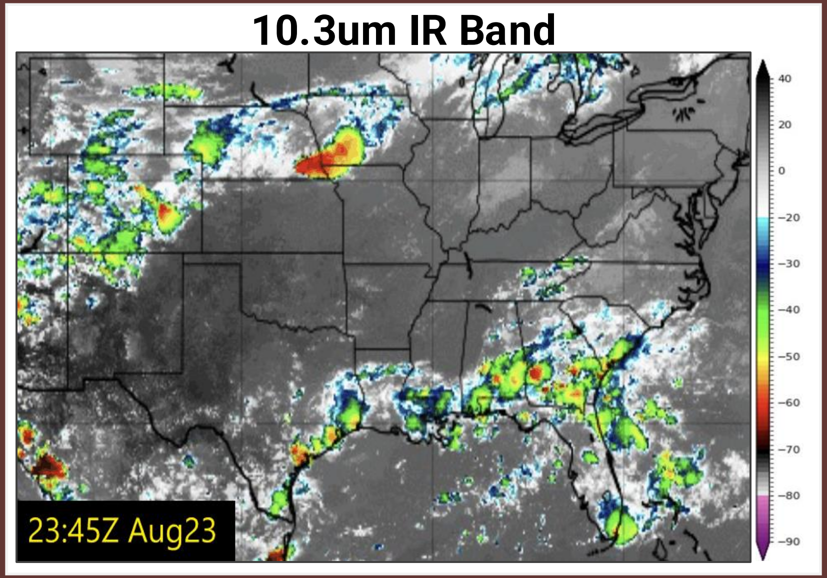
Gálvez-Davison Index and Dynamics (GDID)

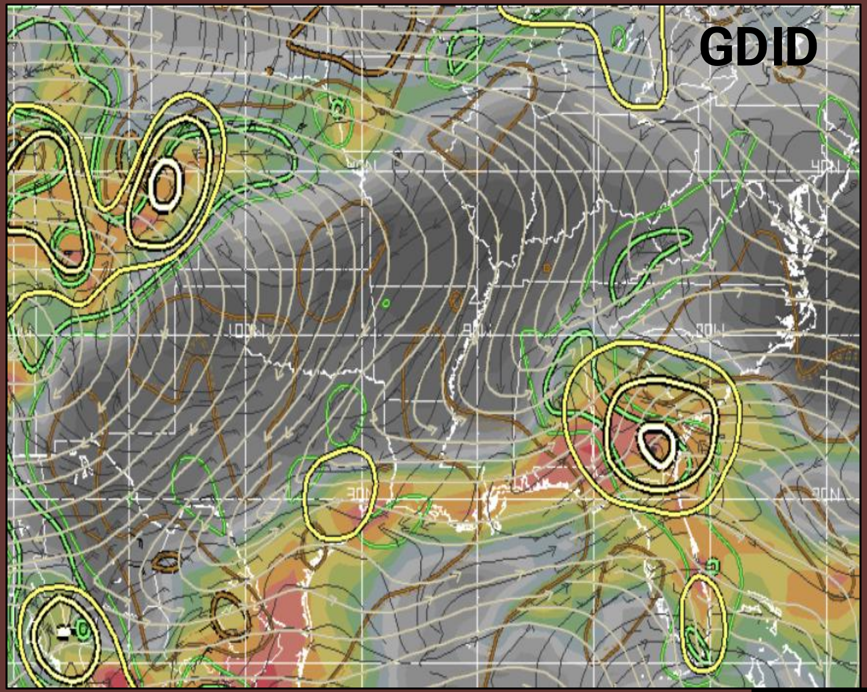
Thermodynamic indices describe the static environment, but need to be used in combination with dynamics to understand how the atmosphere might interact with such environments.

GDID was created to aid with the interpretation of atmospheric dynamics that might enhance of limit the ability of the atmosphere of benefiting from high GDI to produce convection.

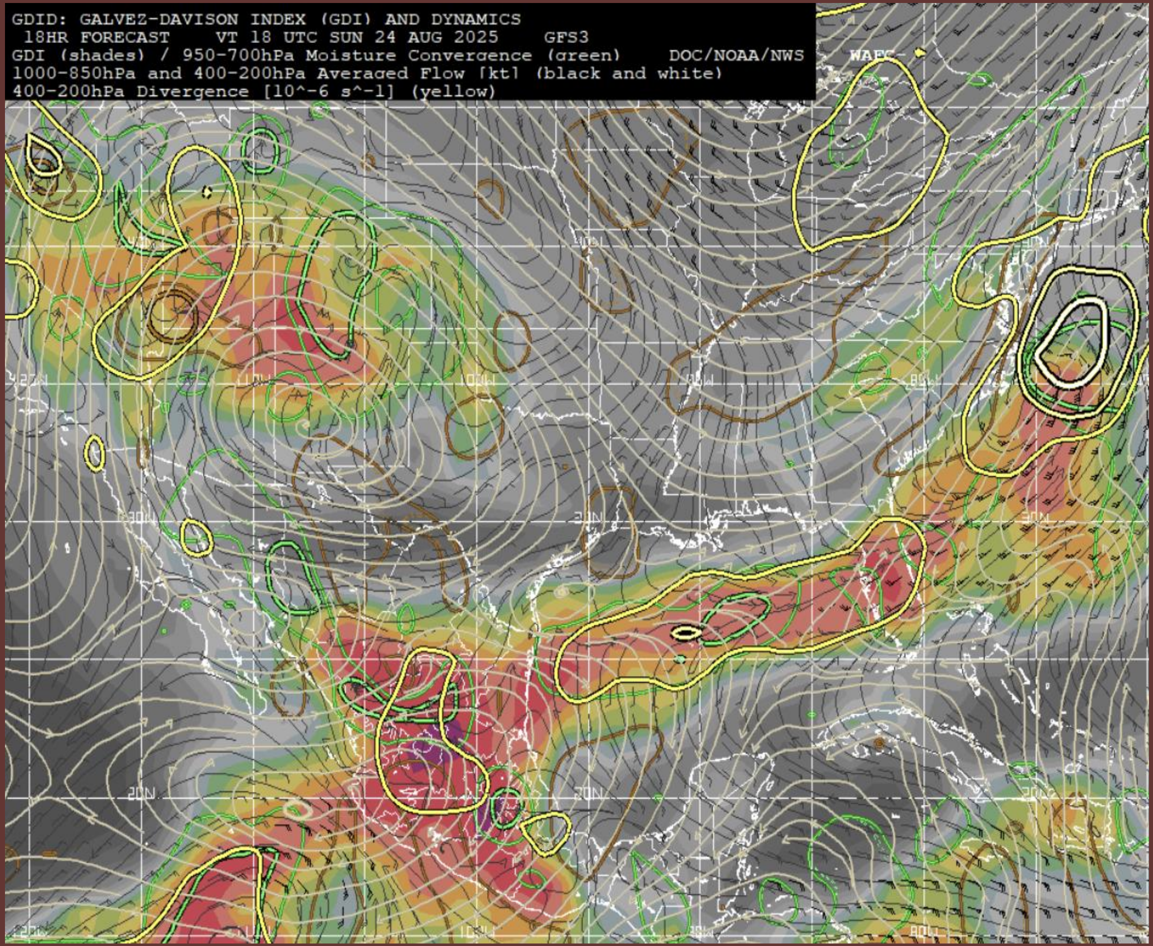
GDID is a simple overlay of a few dynamical fields over the GDI.

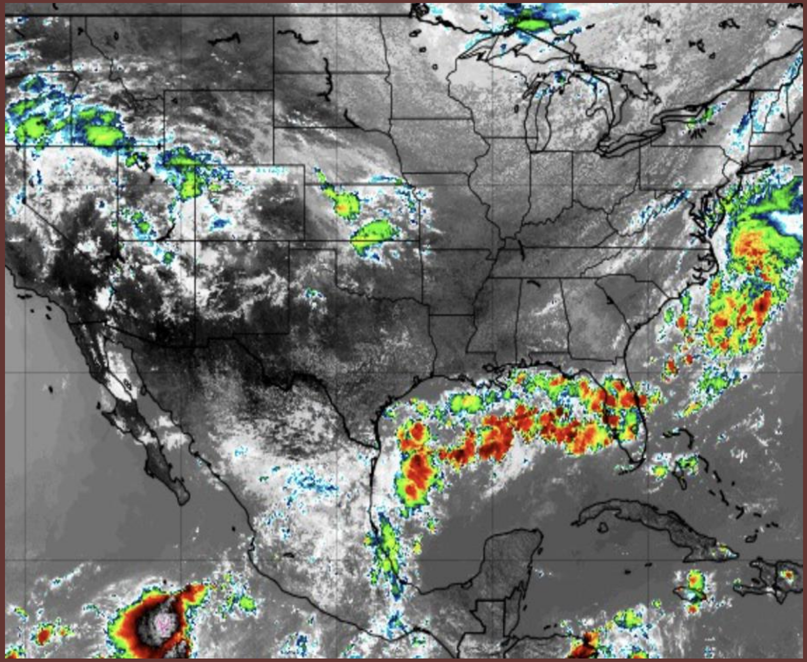


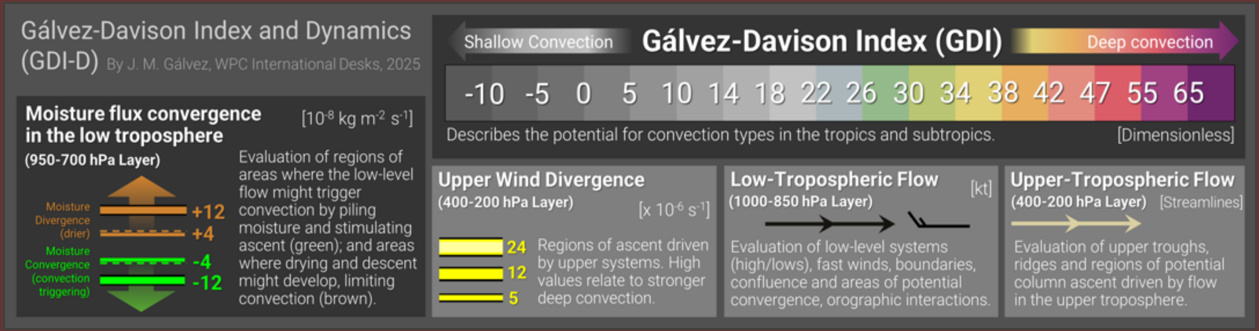




Gálvez-Davison Index and Dynamics (GDID)





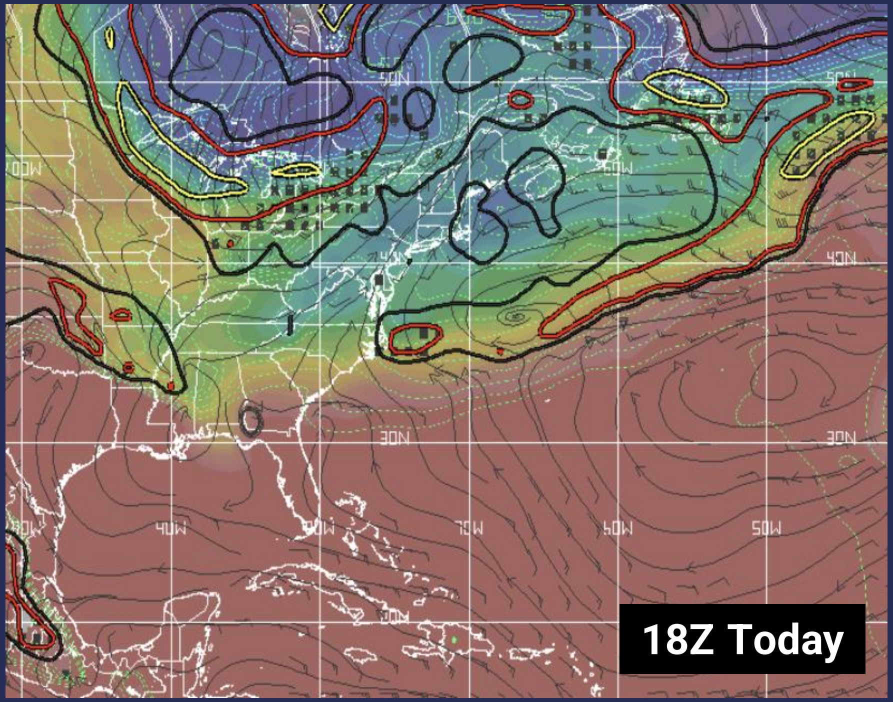


Front and Airmass Characterization (FRAM)

FRAM was developed to aid with the detection of surface boundaries in the Caribbean, where fronts and shear lines play an important role in cool season precipitation.

It aids with the detection of:

1) Airmass thermal and moisture aspects
2) Airmass gradients
3) Position of surface fronts and shear lines



Front and Airmass Characterization Tool (FRAM)

By J. M. Gálvez, WPC International Desks, 2025

Airmass Gradient Magnitude [Dimensionless]

- Weak gradients
- Moderate gradients
- Strong gradients

Note: The baroclinicity of some fronts is too weak to have gradient contours in the plots.

To evaluate gradients between airmasses. It is calculated using five parameters: (1) The gradient of the airmass characteristics field, (2) the gradient of equivalent potential temperature at 1000 hPa, (2) the thickness gradient of the 1000-925 hPa layer, (4) that of the 1000-850 hPa layer and (5) that of the 1000-700 hPa layer. Weights have been determined empirically based on improving visualization while capturing the most prominent fronts according to observations.

Airmass Characteristics Field [Dimensionless]

Cooler and Drier ← → Warmer and Moister

Constructed using thickness and dewpoints in the low troposphere.

1000-925 hPa Thickness [in GPM]

- 650 ← Relates to temperatures of 10-14°C at the surface
- 623 ← Relates to the occurrence of snowfall

To evaluate thermal aspects in the low troposphere, and the magnitude of thermal gradients.

Winds averaged in the 1000-925 hPa Layer [kt]

Shows changes in the low-level flow associated with surface boundaries.

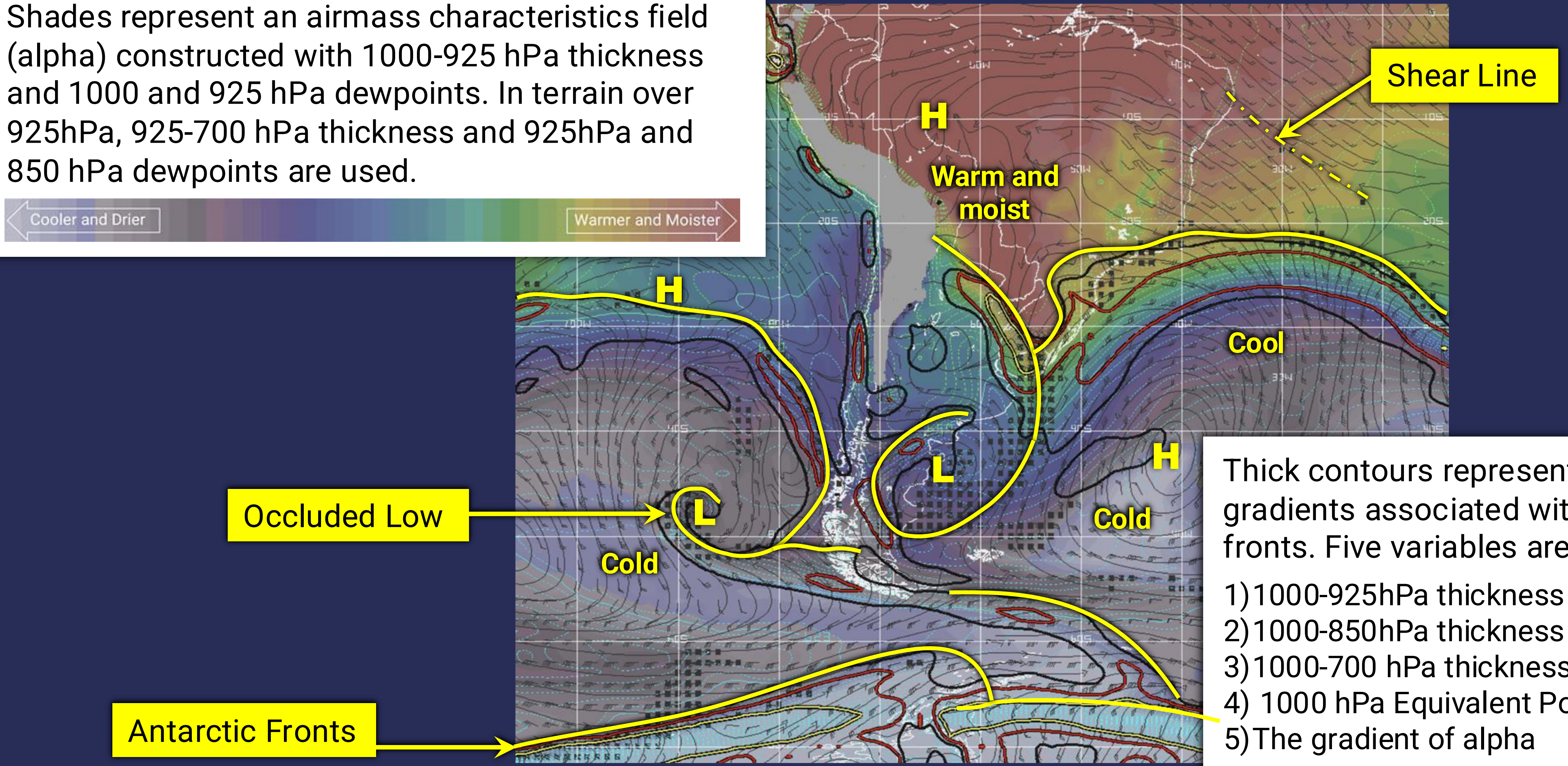
Moisture flux convergence in the 1000-925 hPa Layer

>1.4 [10^{-8} kg m^{-2} s^{-1}]

Aids with the detection of the placement of surface boundaries, including shear lines, which often exhibit little baroclinicity.

Front and Airmass Characterization (FRAM)

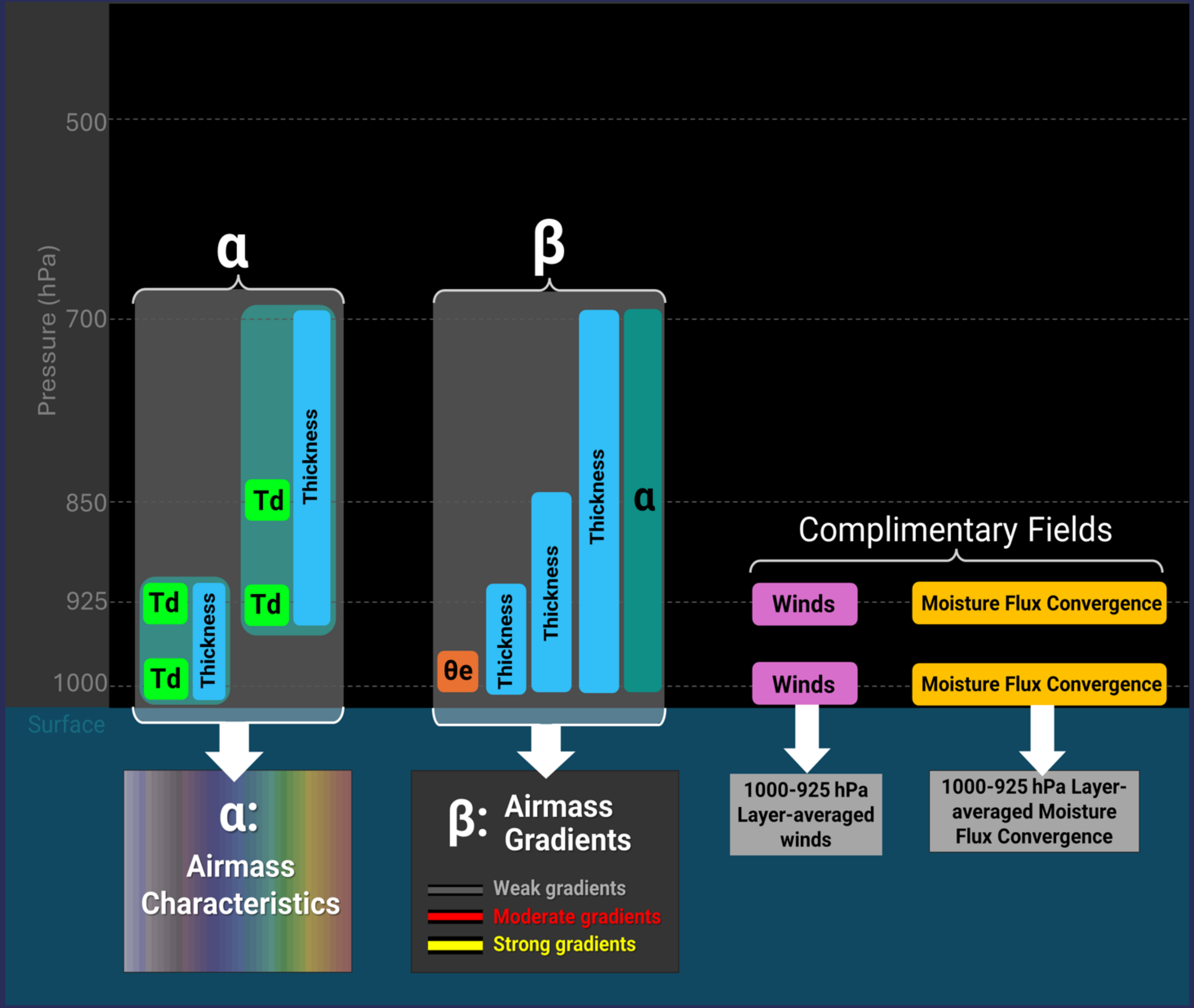
Shades represent an airmass characteristics field (alpha) constructed with 1000-925 hPa thickness and 1000 and 925 hPa dewpoints. In terrain over 925hPa, 925-700 hPa thickness and 925hPa and 850 hPa dewpoints are used.

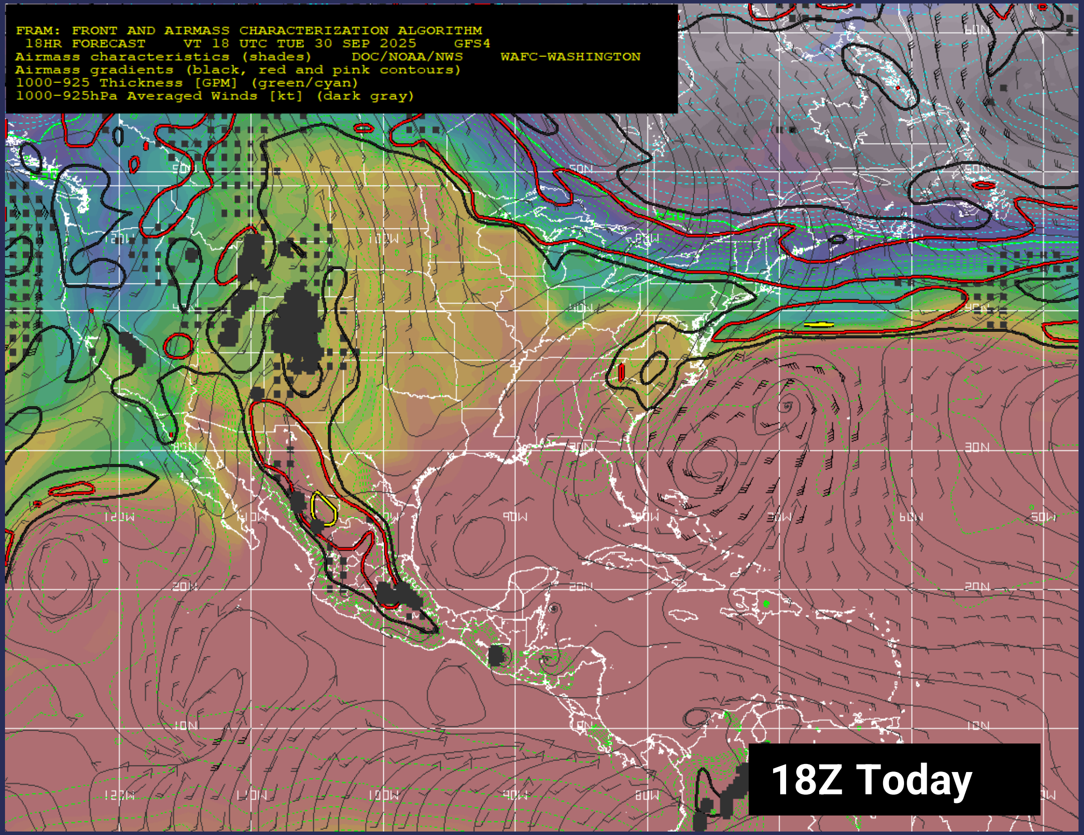


Thick contours represent airmass gradients associated with potential fronts. Five variables are used:

1) 1000-925hPa thickness
2) 1000-850hPa thickness
3) 1000-700 hPa thickness
4) 1000 hPa Equivalent Potential Temp.
5) The gradient of alpha

How does FRAM calculate the fields?





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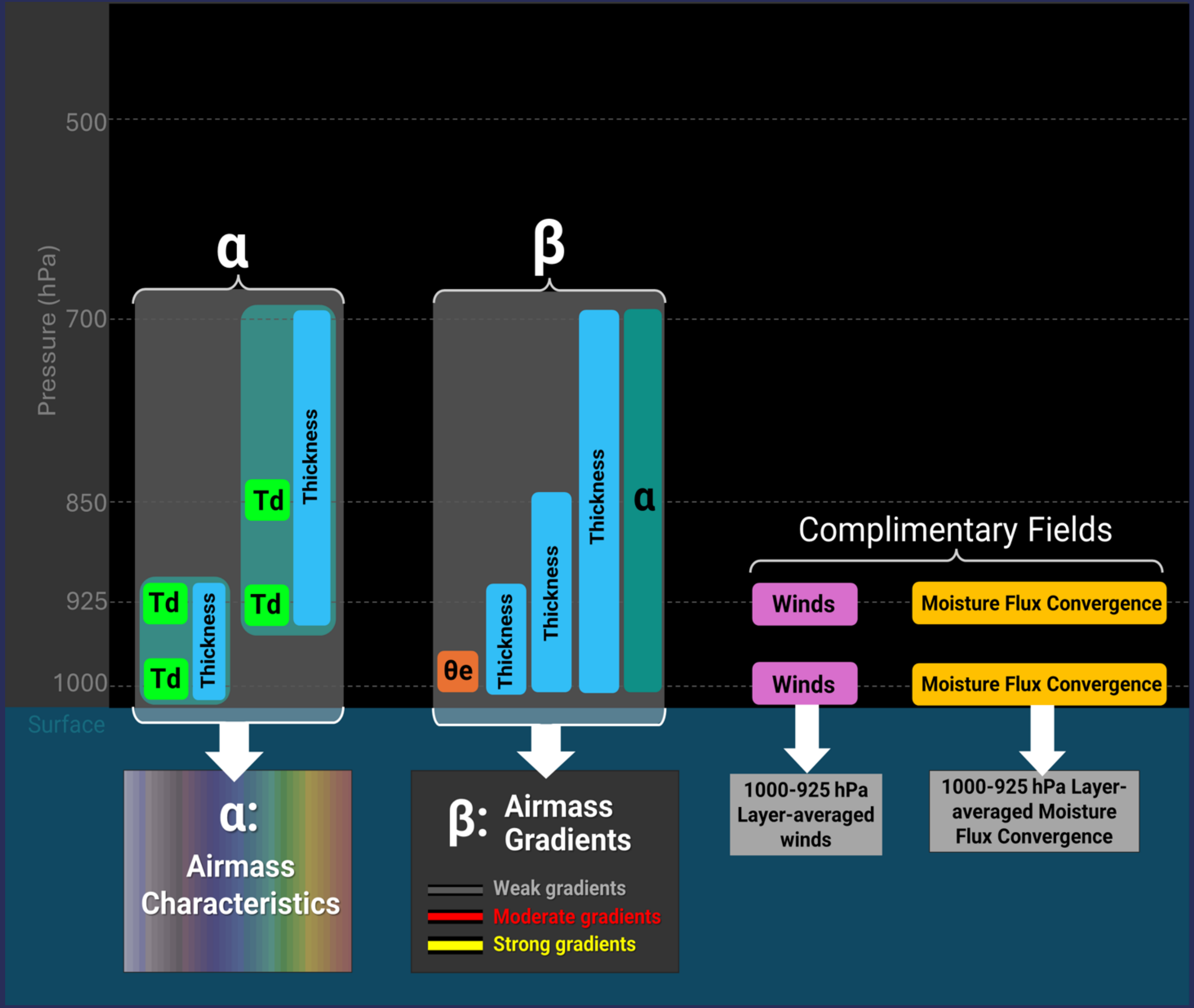

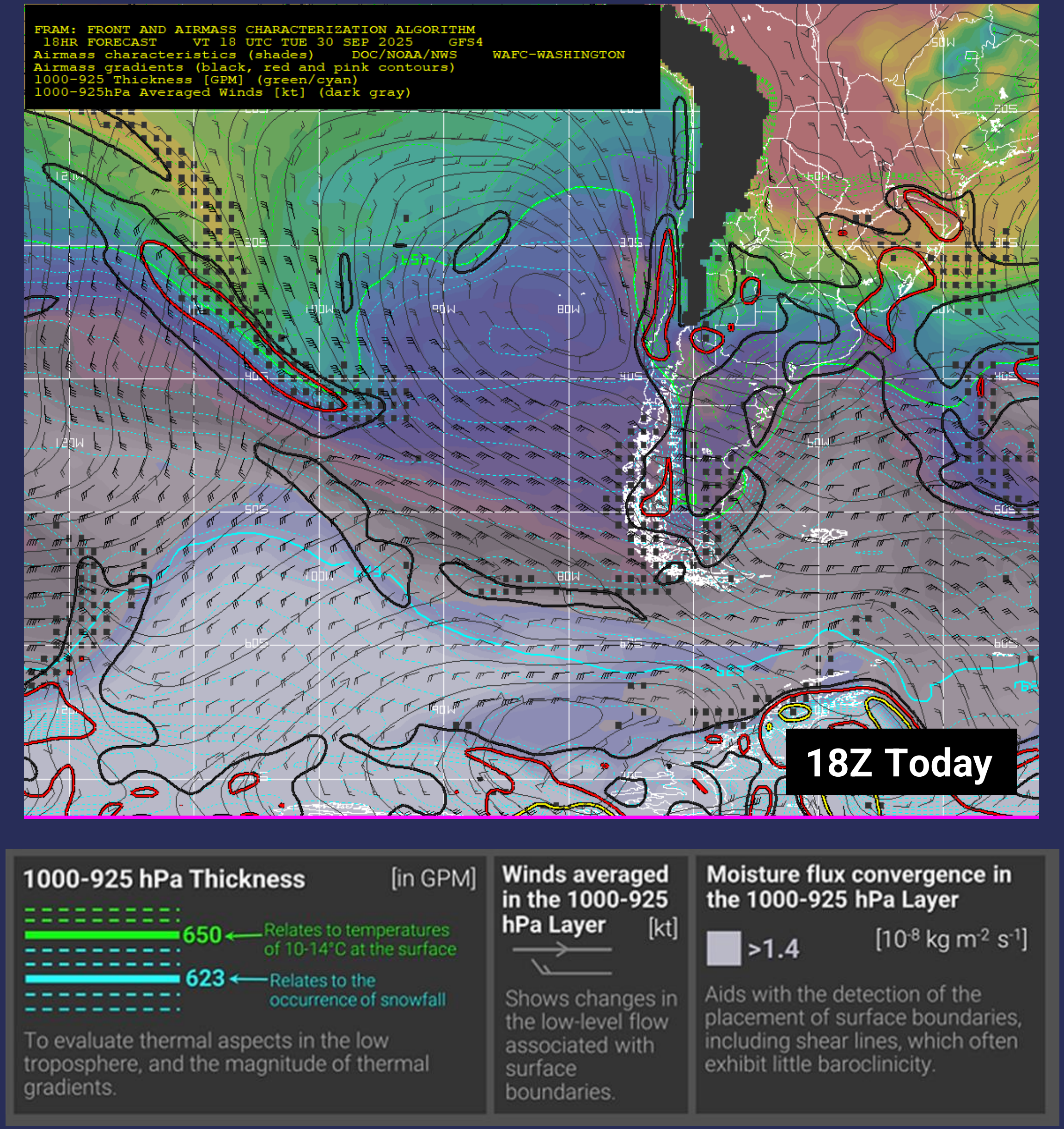

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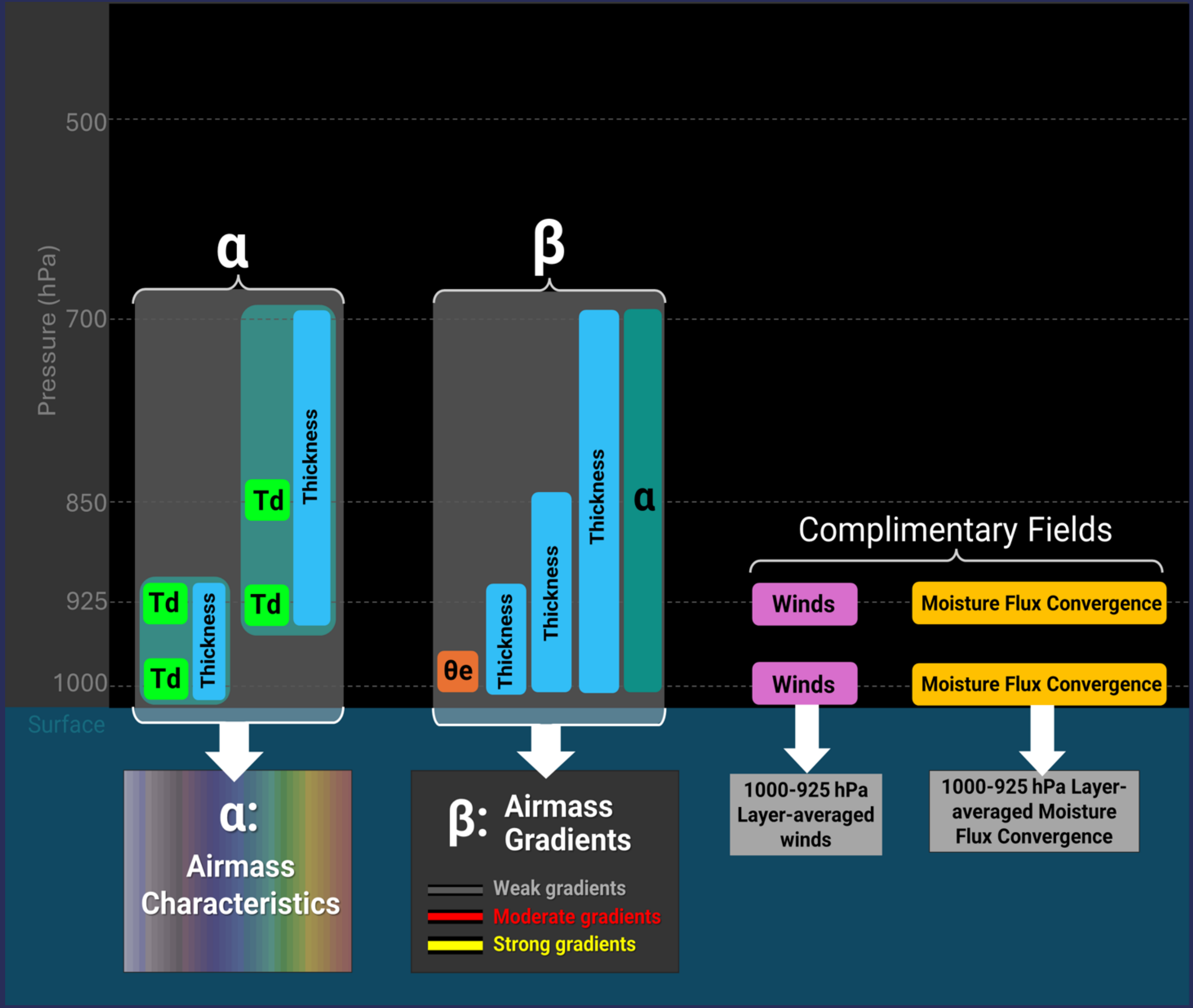
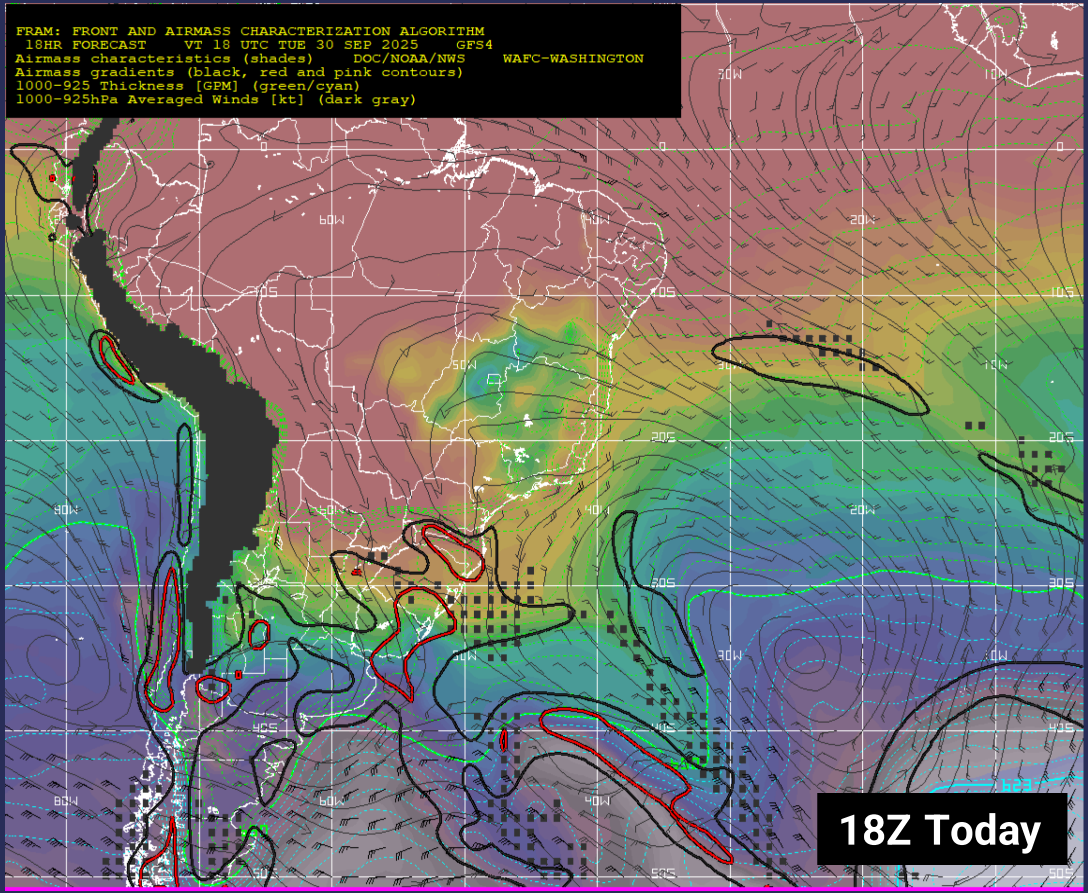




1000-925 hPa Thickness [in GPM]

650 ← Relates to temperatures of 10-14°C at the surface

623 ← Relates to the occurrence of snowfall

To evaluate thermal aspects in the low troposphere, and the magnitude of thermal gradients.

Winds averaged in the 1000-925 hPa Layer [kt]

Shows changes in the low-level flow associated with surface boundaries.

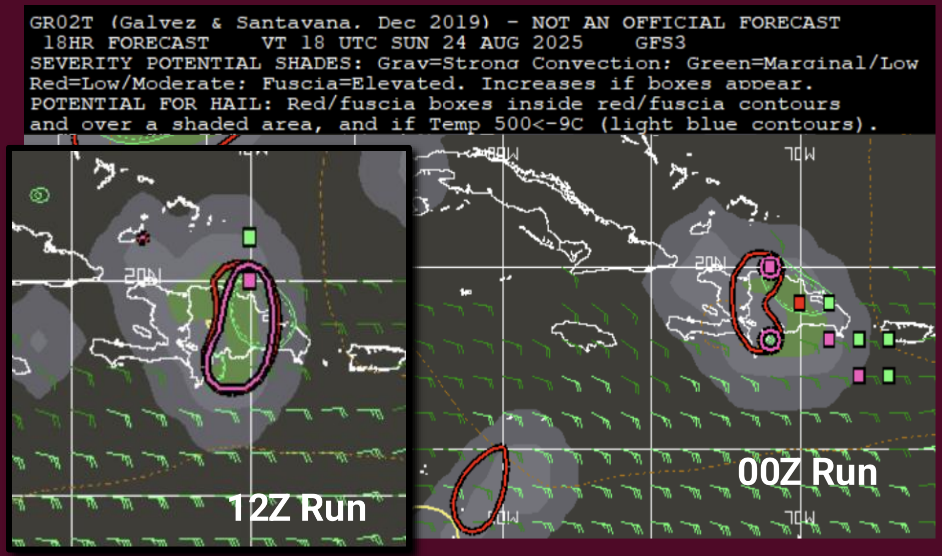
Moisture flux convergence in the 1000-925 hPa Layer

>1.4 [10^{-8} kg m^{-2} s^{-1}]

Aids with the detection of the placement of surface boundaries, including shear lines, which often exhibit little baroclinicity.

Severe Weather and Hail environments (GR02T)

(1) Tool Output

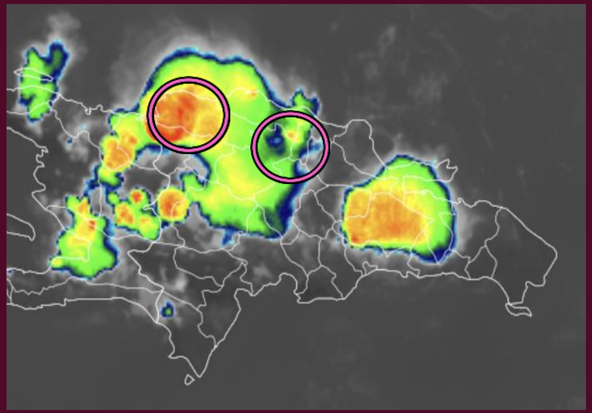


(2) Forecast

- The tool suggests a potential for hail in the Dominican Republic.
- Forecasters know that, of the Greater Antilles, this is the most sensitive island to an algorithm signal due to complex terrain and previous verification.
- A **Risk for Severity** note on the forecast should be evaluated.

(3) Verification

- Hail and severe winds are reported in two locations.



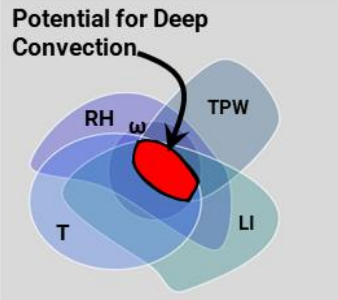
How does GR02T calculate the fields?

Parameters are calibrated with Severe Weather events in South America

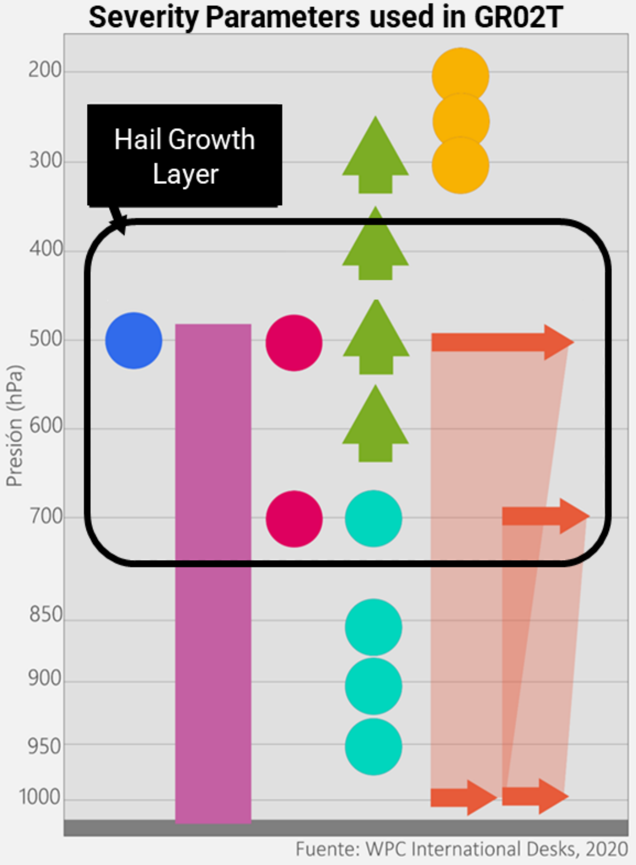
PART I. Detection of areas with the potential for deep convection

1) Evaluates 5 parameters that relate to deep convection
   - Column Moisture (TPW>20m)
   - Instability (LI<+1°C)
   - Condensation potential ($RH_{700-500}$>50%)
   - Ascent ($\omega_{600-300}$<-10^{-4} Pa s^{-1})
   - Cool mid-levels/instability (T_{600}<+2°C)

2) If **ALL** of them exceed established thresholds in a grid point, it is marked as prone to deep convection.



PART II. Addition of Severity Parameter values in grid points where deep convection is possible.



1. **Cold aloft (T_{500}<-8°C).** Instability and higher chance of hail stones reaching the ground.
2. **Enhanced deep instability (Li < 0):** Favors strong and deep updrafts than can favor hail growth.
3. **700-500 hPa lapse rates (>16°C):** Violent vertical motions in the hail-growing layer, stimulating hail growth.
4. **Dynamic ascent in 600-300 hPa layer** (ω<0 Pa s^{-1}) stimulates updrafts and can trigger convection.
5. **Convergence of the flux of mixing ratio in the 950-700 hPa layer > 0.5 10^{-8} kg m^{-2} s^{-1}** stimulates moist ascent into updraft, stimulating moisture available for hail growth.
6. **0-3km and 0-6km averaged bulk shear (>20 m s^{-1})** enhances internal storm motions, potentially rotation.
7. **Upper Divergence om the 300-200 hPa Layer (> 13 10^{-6} s^{-1})** stimulates ascent and can reflect the role of upper jets.

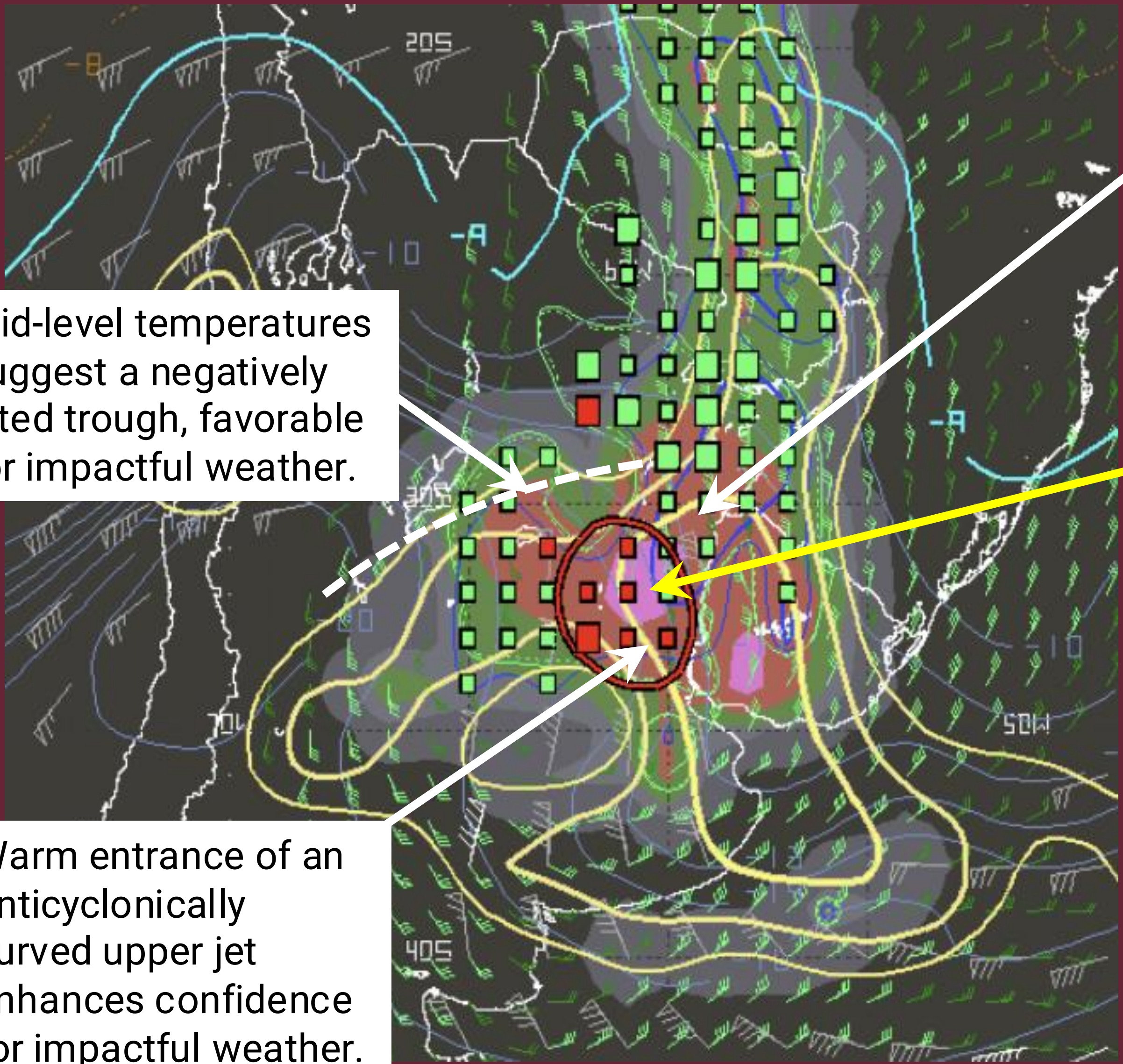
PART III. Risk for Hail

Inside areas with the potential for deep convection (part 1), evaluates:

- LI
- 600-300 hPa Omegas
- 500-700 hPa lapse rates

When thresholds are exceeded the risk for hail is marked with different ranges of severity.

GR02T Output interpretation



Mid-level temperatures suggest a negatively tilted trough, favorable for impactful weather.

Low-level jet moisture convergence on its cyclonic exit also enhances confidence of impactful weather.

Highest risk for hail, as red boxes appear inside a red contour and in a region with a slight to moderate risk for severity

Warm entrance of an anticyclonically curved upper jet enhances confidence for impactful weather.

General Risk for Severity

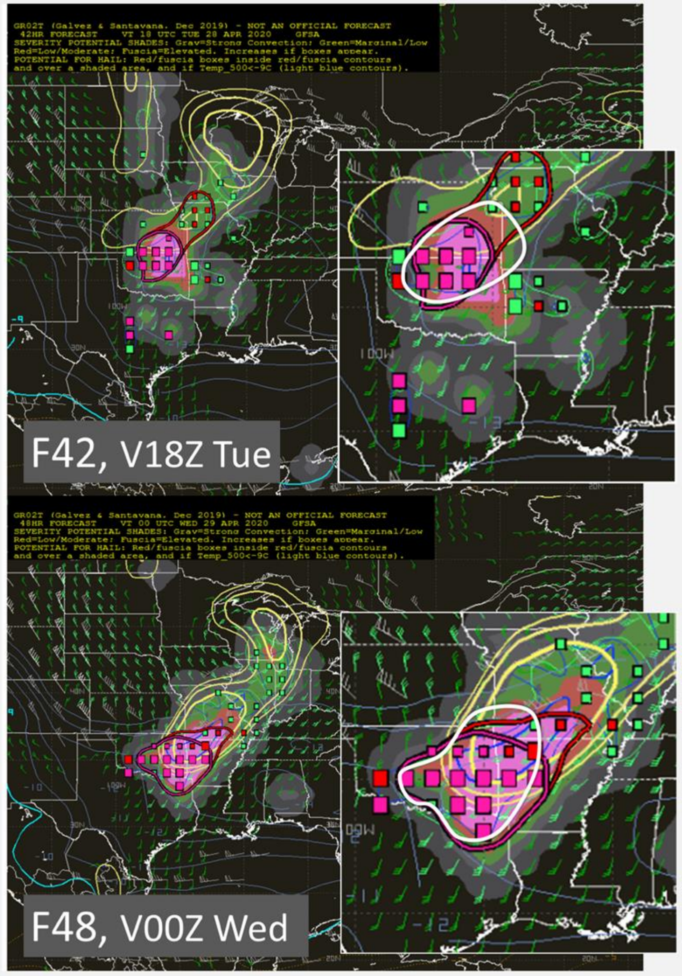
Strong Convection	Marginal to Slight Risk	Slight to Moderate Risk	Elevated Risk

Risk for Hail

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

Severe Weather and Hail environments (GR02T)

Monday 00Z Initialization

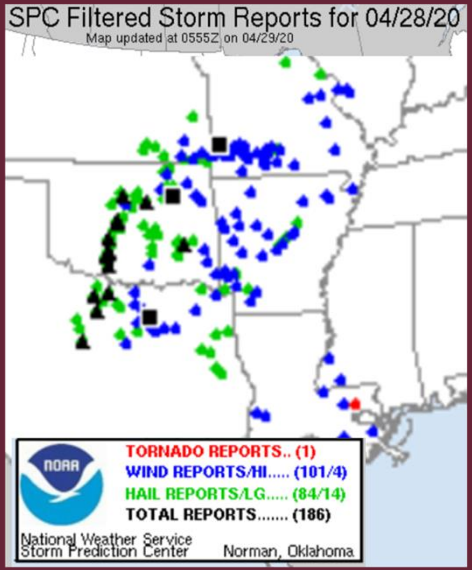


GR02T: Risk for Severity

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.

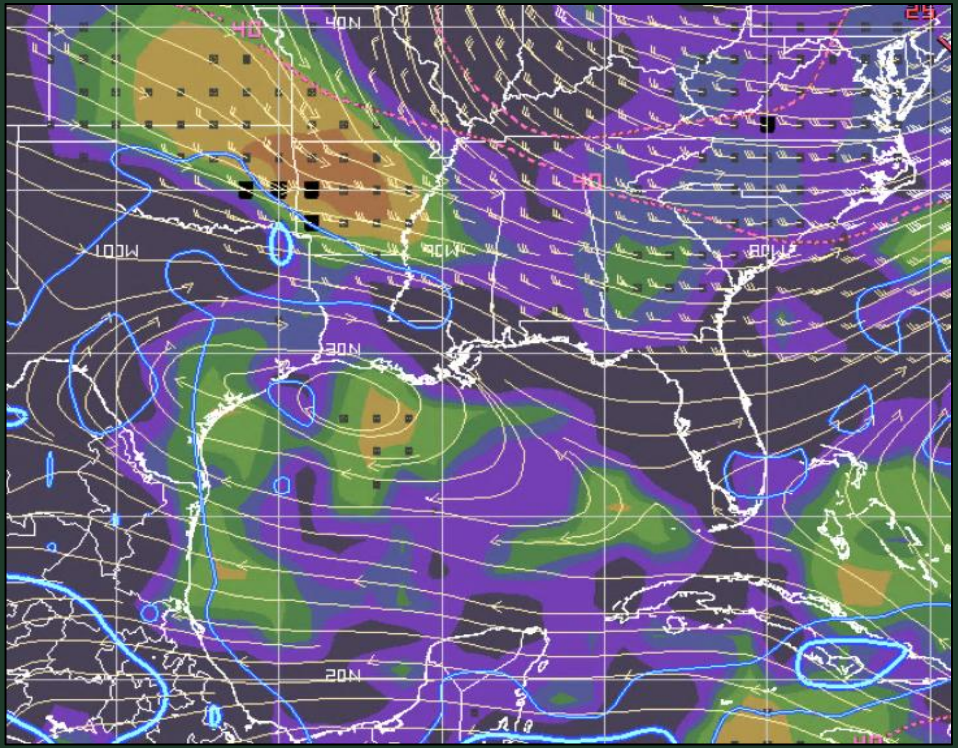
Confidence increases if boxes inside contours occur over color shaded areas, if 500 hPa temperatures<-9°C, and if forcing is strong. Large boxes mean extreme 700-500 hPa lapse rates.

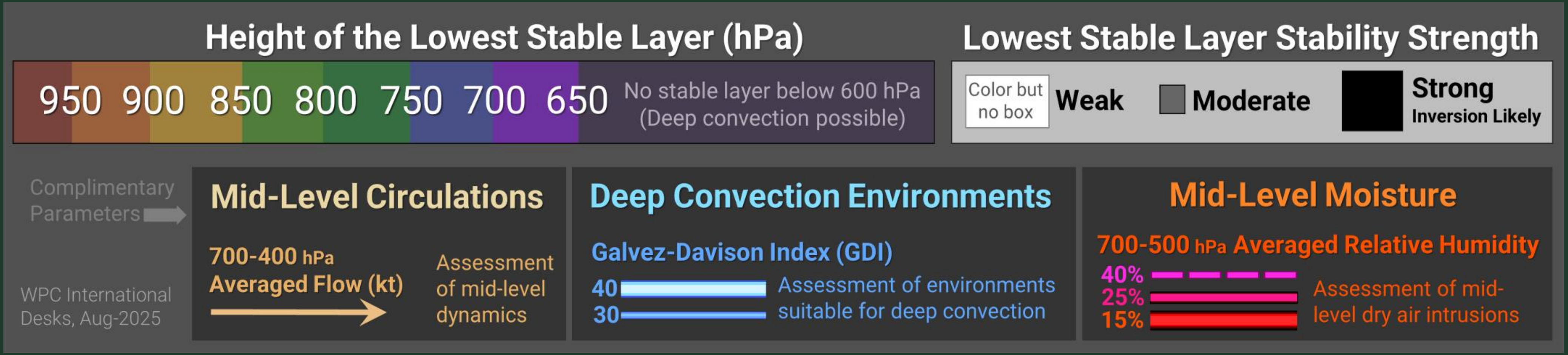
Captures SPC warning areas and Svr Wx reports

Trade Wind Inversion Characterization

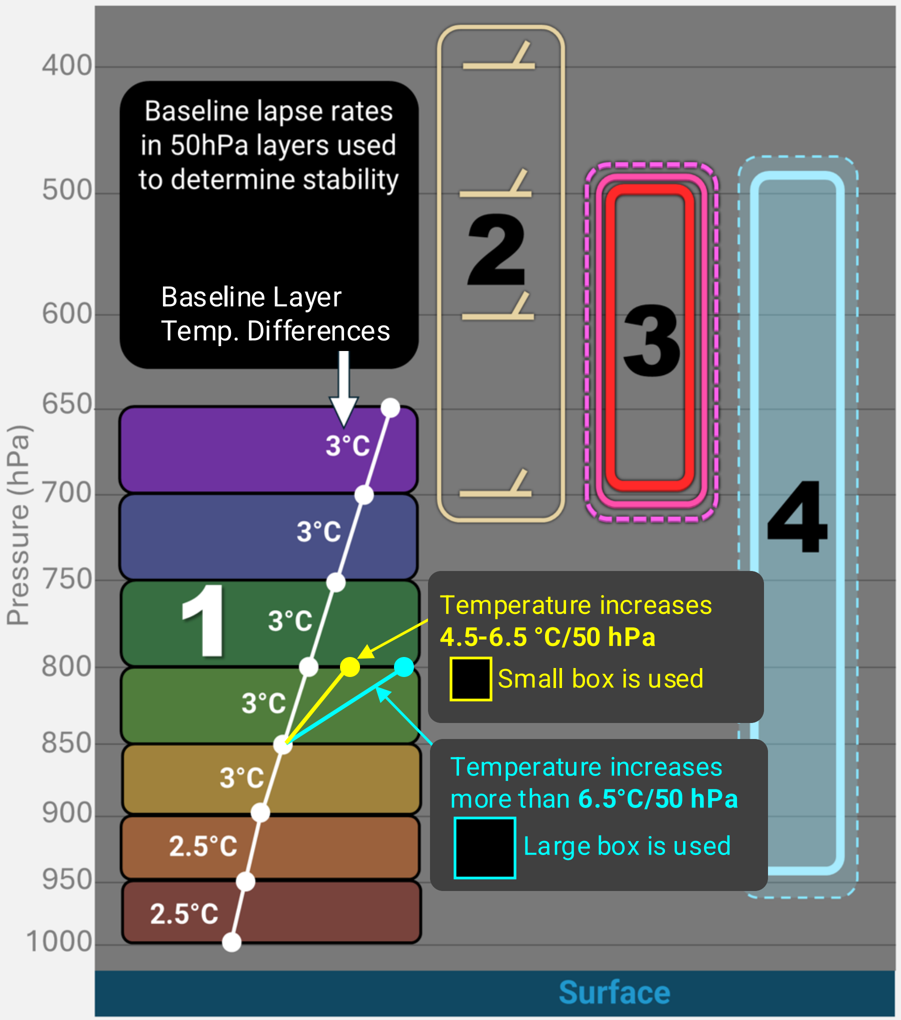
TWIN aids with the diagnosis of the vertical development and structure of trade wind regime convection by providing information about:

- Height+strength of lowest stable layer
- Dry air entrainment potential
- Mid-level support





How does TWIN calculate the fields?



1 **Height of the lowest stable layer,** evaluated by comparing atmospheric lapse rates to baseline lapse rates. Stability strength is determined based on lapse rate differences and depicted with boxes:

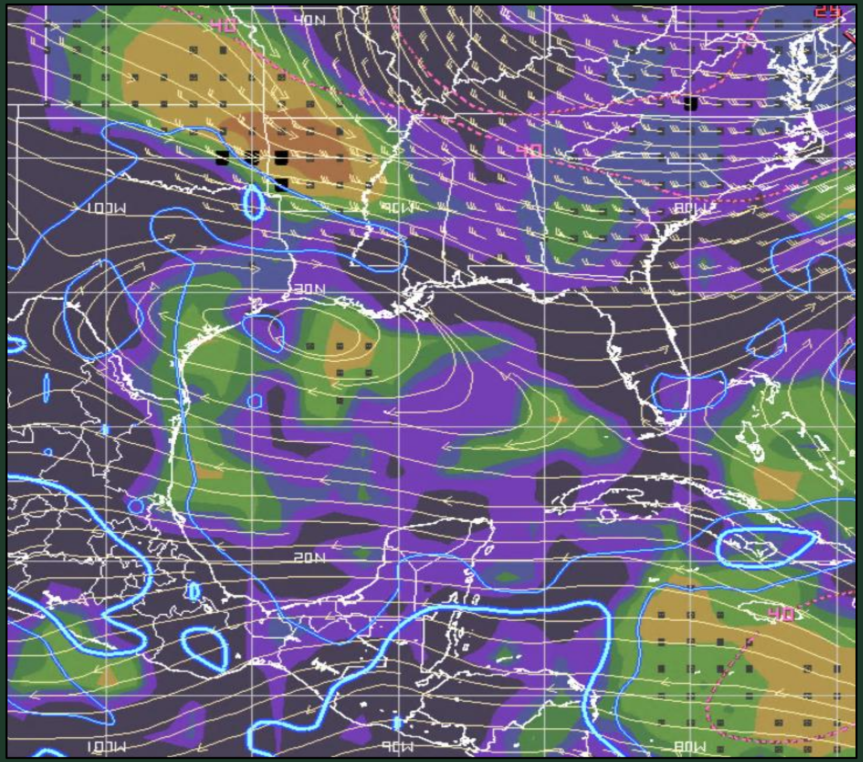
> 1.5 = Small box = Moderate stab.

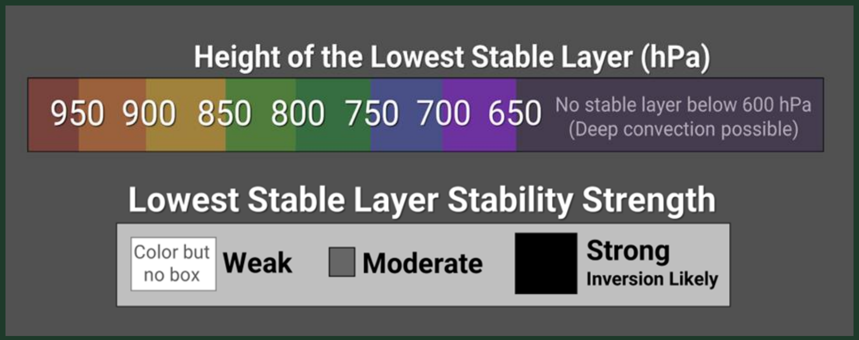
> 3.5 = Small box = Strong stability

2 **Winds** averaged in the 700-400 hPa layer, to evaluate mid-level troughs and ridges, which often relate to a stronger inversion or ascent that favors convection, respectively.

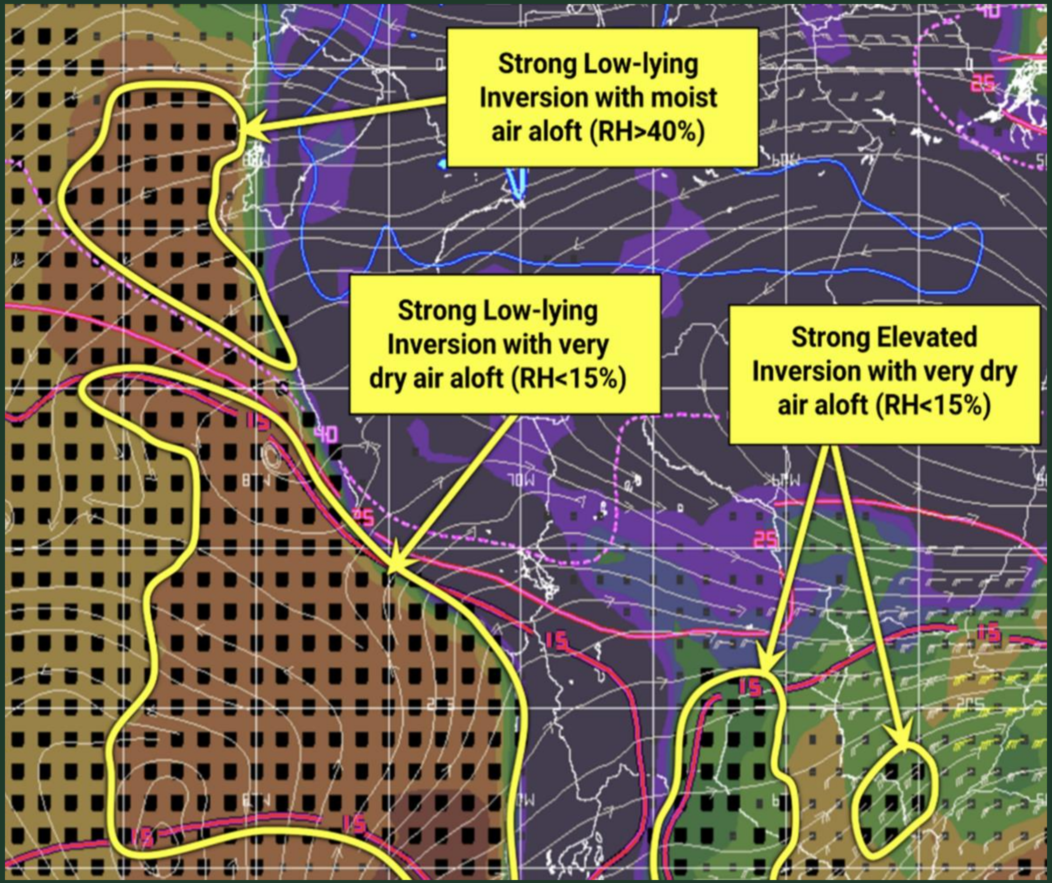
3 **Low relative humidity** averaged in the 700-500 hPa layer, to evaluate the potential for dry air intrusions into the marine layer, if convection breaks the inversion.

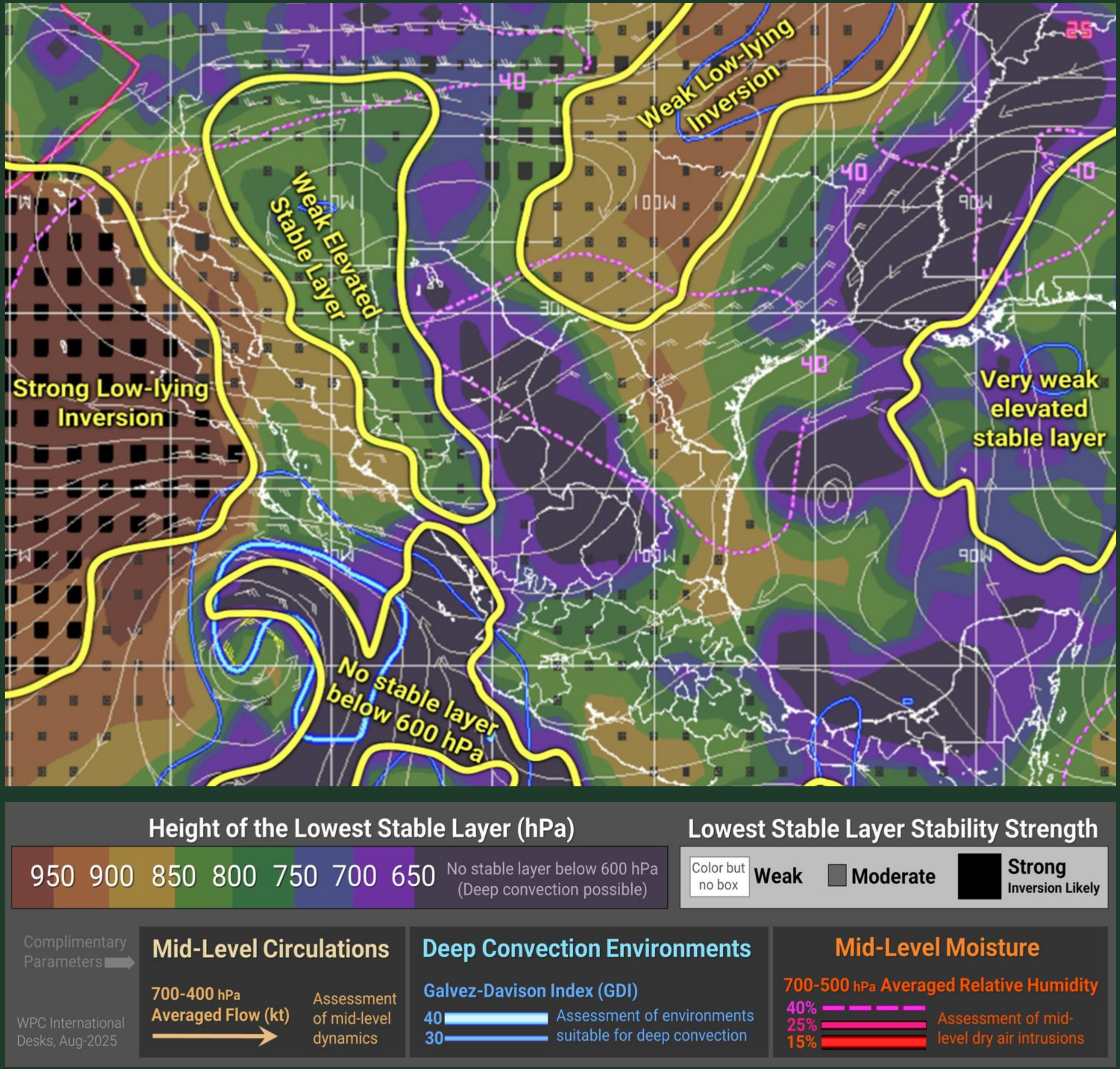
4 **Gálvez-Davison Index** to evaluate potential convection and available column moisture





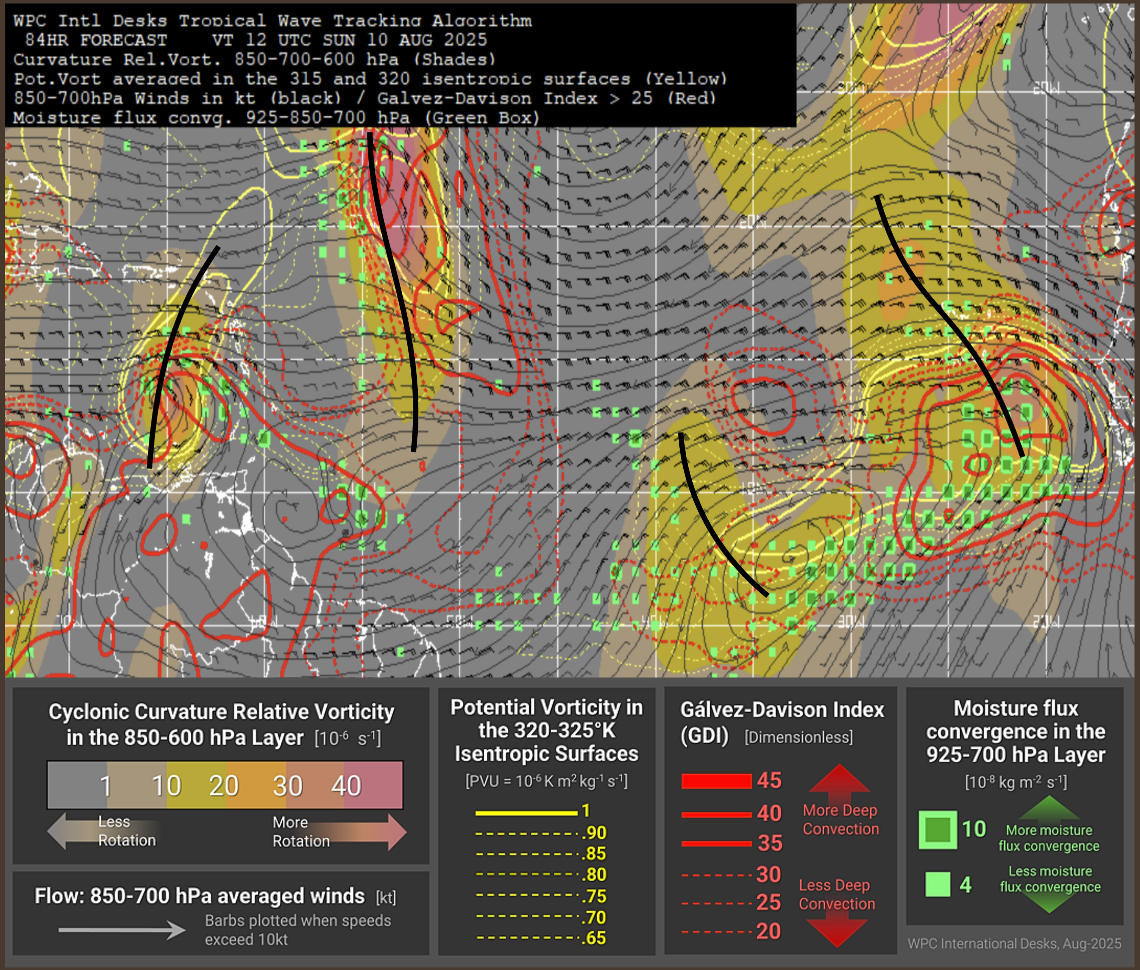
TWIN Interpretation Examples

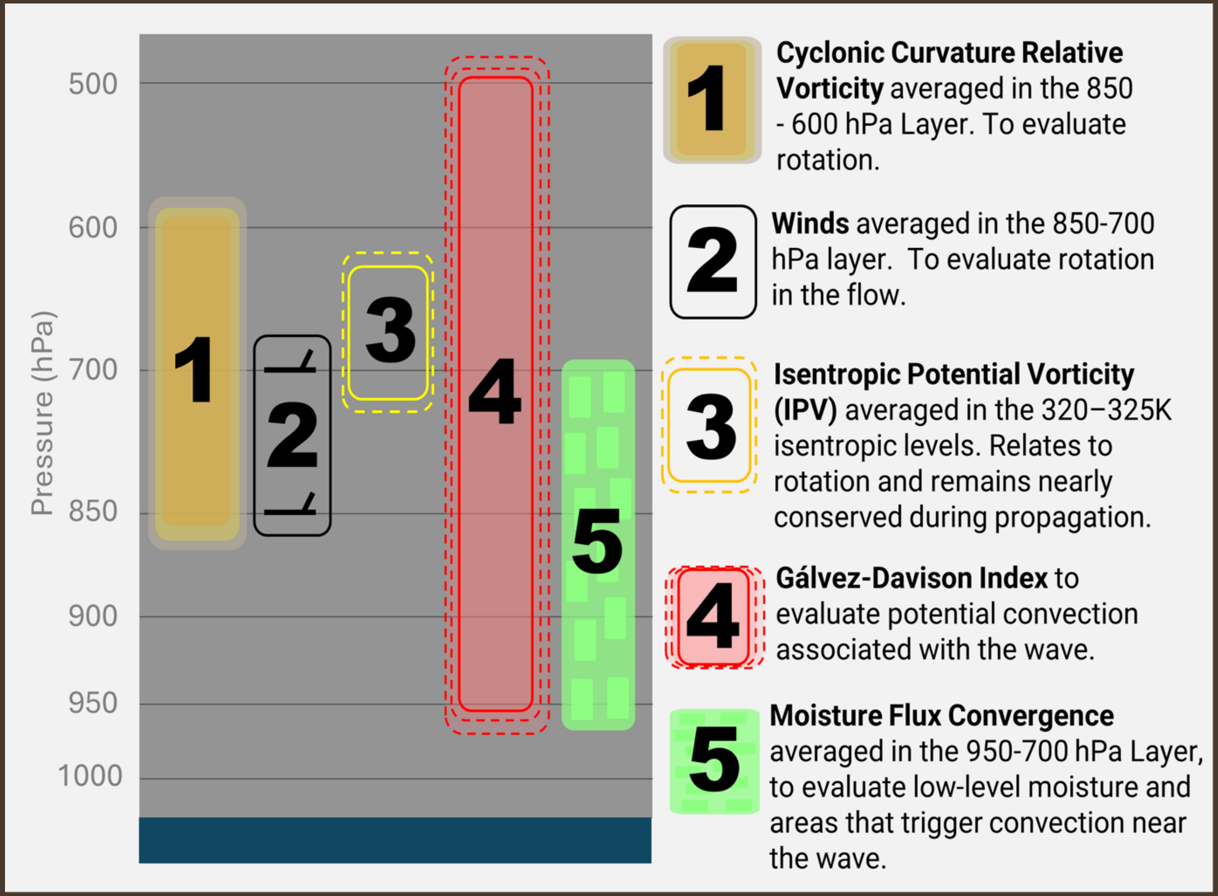




Tropical Wave Tracking (TROPW)

- Simple overlay of 5 parameters that associate with Tropical Waves.
- Their different distributions in each wave allow to characterize them.





Tool documentation and code

It is still under development.

What do we have available in final form?

- Wingridds Code. For each tool you need three components:

  1. Code for the ALIAS.USR file, where the variables are programmed.
  2. Code for each of the 5 macros/scripts.
  3. A color table for each of the 5 macros/scripts.

Thank you!

Questions?