

MECHANISMS THAT FAVORED THE GENERATION OF THUNDERSTORMS IN IQUITOS, PERU DURING FEBRUARY 2015

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INTRODUCTION

Summer thunderstorms in the northern rainforests of Peru are frequent. This phenomena affects activities in Iquitos including flight delays. Forecasting thunderstorms in Iquitos is of great importance for the planification of flight schedules.

OBJECTIVE

Determine the mechanisms that favored the occurrence of thunderstorms in Iquitos during February 2015, with the ultimate goal os improving their forecasting.

GEOGRAPHIC LOCATION



Weather Station SPQT: “Coronel FAP Francisco Secada Vigneta”, Iquitos Airport.

Coordinates:
Latitude: 03°45' S
Longitude: 73° 15' W
Elevation: 125 m

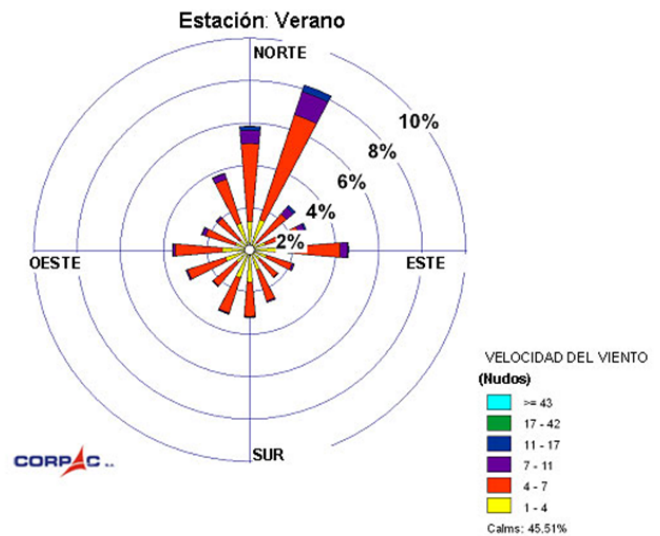
SPQT



Photo showing a thunderstorm and heavy rain in the SPQT airport.

FEBRUARY CLIMATOLOGY

- Highest frequency of thunderstorms during the summer.
- Temperatures: Max= 32° C Min=22° C
- Average wind: 2.5kt from the NNE
- Max winds: 15kt from the N
- Rainfall: 220 mm or ~9 in



The February (summer) climatology shows temperatures between 22 and 32°C, average winds from the north-northeast at 2.5kt, maximum winds from the N at 15kt and rainfall in the order of 220 mm or 9 inches. Note that the percentage of calm winds conditions reaches 45.51% of the time. The prevalence of northerly winds responds to the low-level pressure gradient. During February the North Atlantic High intensifies while lower pressures organize over central South America and along the Eastern foothills of the Andes.

MATERIALS

METAR reports from the Iquitos (SPQT) from February 2015

CPTEC satellite imagery

GFS 1° data

Software: WINGRIDDS

ANALYSIS

Three (3) cases of thunderstorms were selected using METAR data.
Dates: 13/14; 15/16 and 27/28 during February 2015.

Satellite imagery analysis ← Spatial and temporal distribution of convection

Upper level winds (250-200 hPa)
Upper divergence (250-200 hPa)
Low-level winds (850-925 hPa)
Low-level convergence (850-925 hPa) } Dynamic forcing/vertical motion enhancement

Mean flow (850-200 hPa) ← Cb movement

Relative humidity (850-200 hPa) ← Column saturation/clouds

Precipitable water ← Available moisture

Stability (GDI) ← Readiness for convective overturning

Three cases were selected when thunderstorms affected the SPQT airport. The cases were selected using METAR data only. The analysis was then complemented by the listed items .

RESULTADOS

Case 1 Feb 13-14 2015 (Trough in the trades)

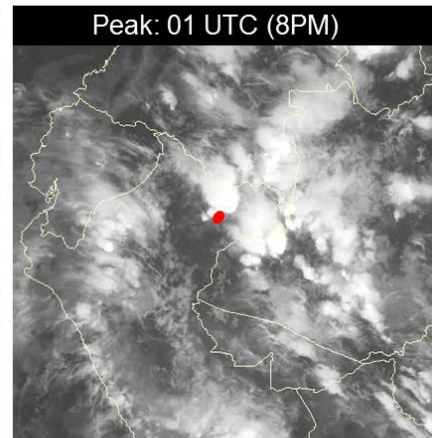
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TS

Storms occurred between 01 and 06 UTC, or during the evening/early night. The visibility was reduced to 2000m. [Las horas de ocurrencia de las tormentas se dan entre las 01 y 06 UTC del día 14 de Febrero y las 01UTC. La tormenta disminuyo la visibilidad horizontal a 2000 m]

Case 1 Feb 13-14 2015 (Trough in the trades)

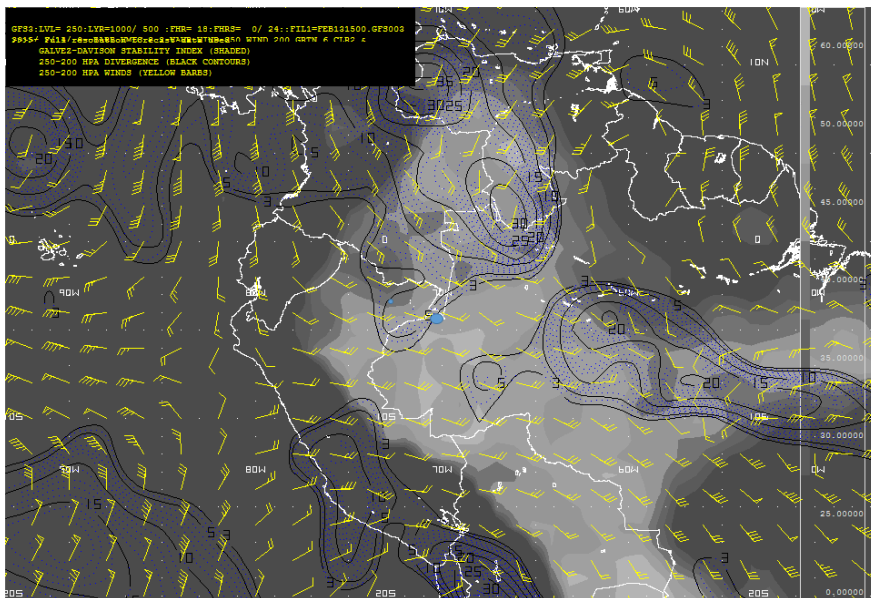
Iquitos
SPQT



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25/24 Q1012 NOSIG RMK PP240=

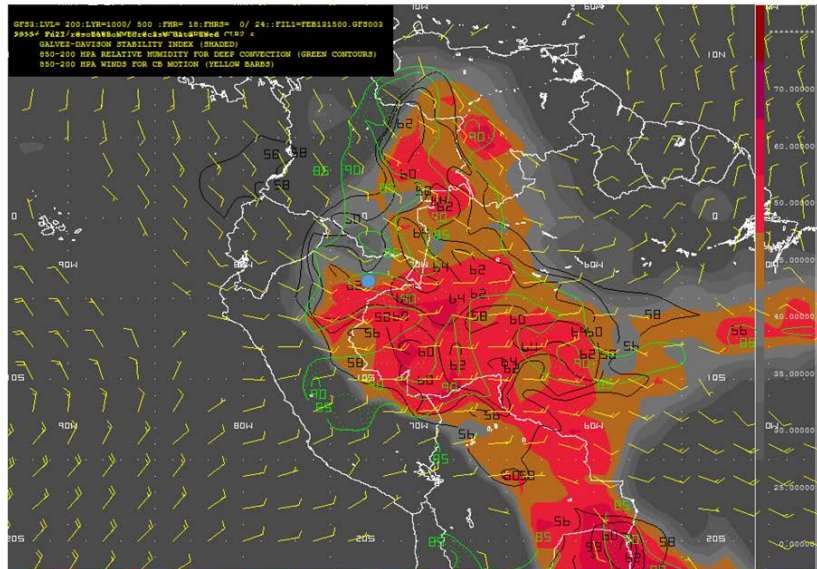
The satellite animation shows a wide region with convection affecting areas just to the east of Iquitos and moving into the region. The image to the right is a snapshot of the peak of the event. [Se muestran a continuación de la animación de las imágenes de satélite IR desde las 22 UTC del día 13 hasta las UTC del día 14 se muestra además la Imagen de las 01 UTC donde se registro la tormenta en SPQT]

Upper flow [kt] in yellow and upper divergence [$\times 10^{-6} \text{ s}^{-1}$] in black/blue



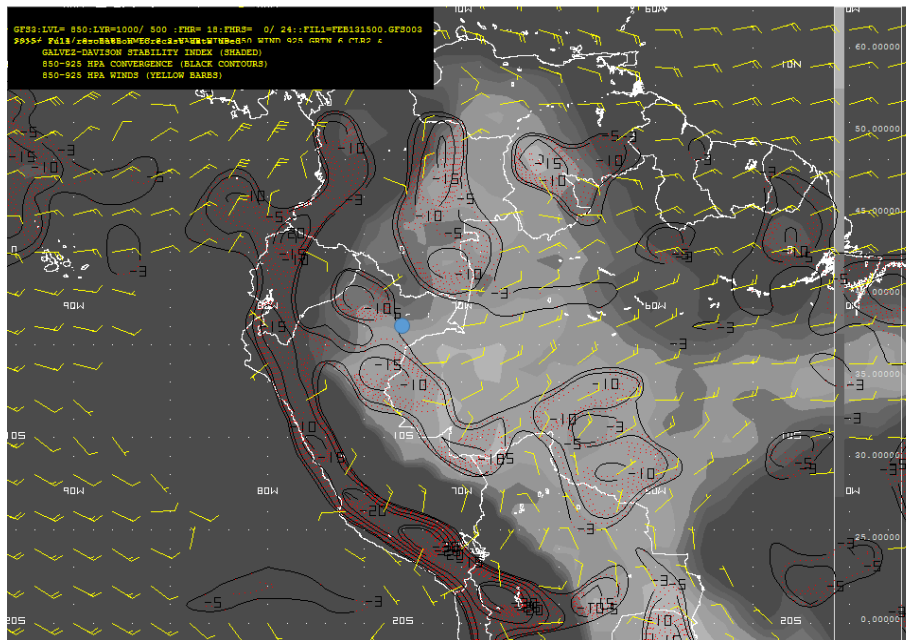
The upper tropospheric analysis shows east-southeasterlies with speeds of 20-30kt in the northern periphery of the subtropical high. This is associated with enhanced upper divergence with values of 3 to $8 \times 10^{-6} \text{ s}^{-1}$ and GDI values between 45 and 60, which suggests a high potential for deep convection. [Se presentan las animaciones del día 13 a las 18UT y del día 14 de 00UTC y 06 UTC en el cual se observan el flujo de nivel alto predomina del este con velocidades entre 20 y 30 nudos y la divergencia entre 3 a $8 \times 10^{-6} \text{ s}^{-1}$ y los valores del GDI entre 45 y 60 lo cual es un valor que nos indica alta convección y ocurrencia de tormentas]

850-200 Relative Humidity [%] in green, 850-200 mean flow, precipitable water [mm] in black, GDI shaded and



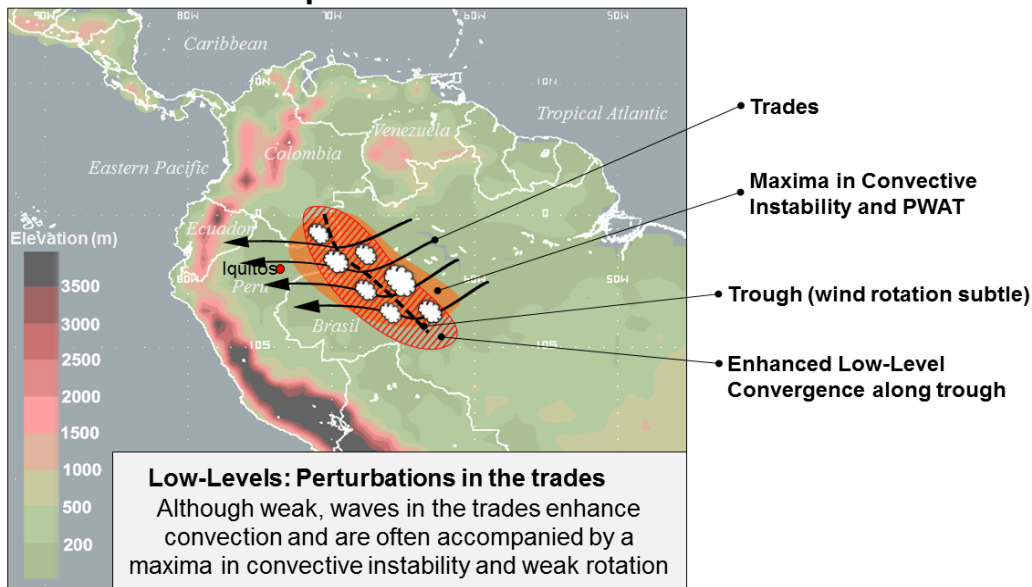
Relative humidity fluctuates between 85 and 90% showing a nearly-saturated layer. The averaged wind is from the east with speeds of 10-15kt which is related to the storm motion. Precipitable water fluctuates between 60 and 62mm and the GDI between 45 and 60. [Se presentan el comportamiento de la humedad relativa que fluctúa entre 85 y 90% y el viento promedio de dirección Este con velocidades de 10 a 15 nudos y el agua precipitable fluctúa entre 60 a 62 mm y el GDI entre 45 y 60]

Low-level convergence [$\times 10^{-6} s^{-1}$] black/red; Low-level flow (yellow); GDI (shaded)



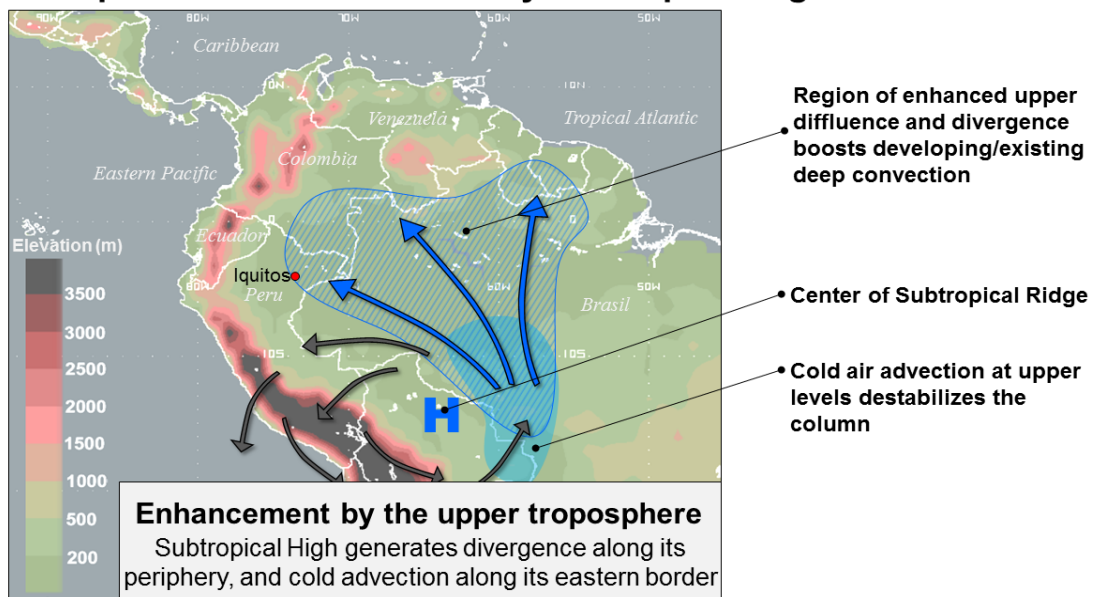
The low-level analysis shows winds at 850 hPa and the presence of a trough along Iquitos (light blue dot) and to the south into Acre/Madre de Dios; and enhanced low-level convergence near and ahead of the trough axis. [Se presenta la convergencia en nivel bajo y su valor entre 3 a $8 \times 10^{-6} s^{-1}$ y el viento de nivel bajo del NE con 10 nudos]

Conceptual Model: Perturbation in the trades



This conceptual models shows the usual signature of a wave in the trades visible near 850 hPa. It is accompanied by a maxima in low-level convergence (red lines) and convective instability (orange). Diurnal convection is usually enhanced near the trough axis or where the maxima in convergence, precipitable water and instability intercept. *[Este modelo conceptual representa las condiciones para la ocurrencia de la tormenta del 13/14 de Febrero]*

Conceptual Model: Ventilation by Subtropical High at 200-250 hPa



This conceptual models of the upper levels show the importance of the subtropical ridge at upper levels in the ventilation of convection along its periphery. If upper divergence is present it will boost any deep convection that develops or already exists. *[Este modelo conceptual nos explica la importancia de la alta subtropical entre 250-200 hPa la cual garantiza la divergencia en altura, adveccion de aire frio].*

Case 2 Feb 15-16 2015 (Low-level jet from the north)

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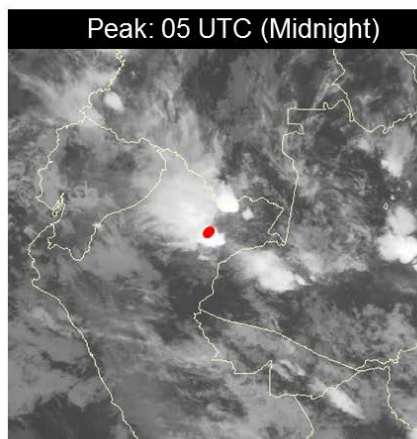
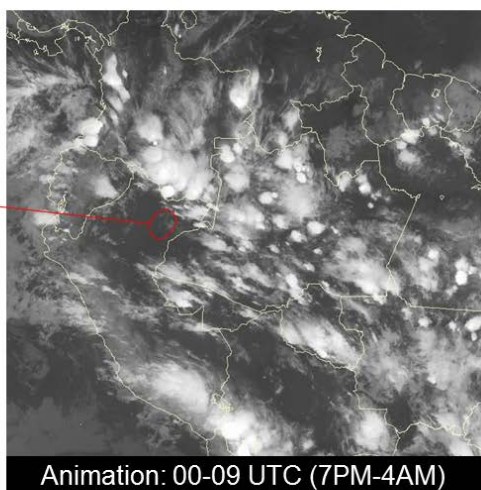
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TS

The second case study is that of February 15-16 2015. Thunderstorms started around 04Z or 11pm peaking at midnight. This case was associated with the generation of convection along a lee trough that forms to the southwest of the mountain range in Central Venezuela under northeasterly trades. A weak northerly low-level jet also intensified during the evening along the Colombian lowlands which enhanced low-level shear and convergence ahead of the storms in northern Peru. [Se presenta el segundo caso: Día 15/16 los reportes de tormenta es desde las 04 a 06 UTC del día 16 de Febrero del 2015 t al 0511].

Case 2 Feb 15-16 2015 (Low-level jet from the north)

Iquitos
SPQT

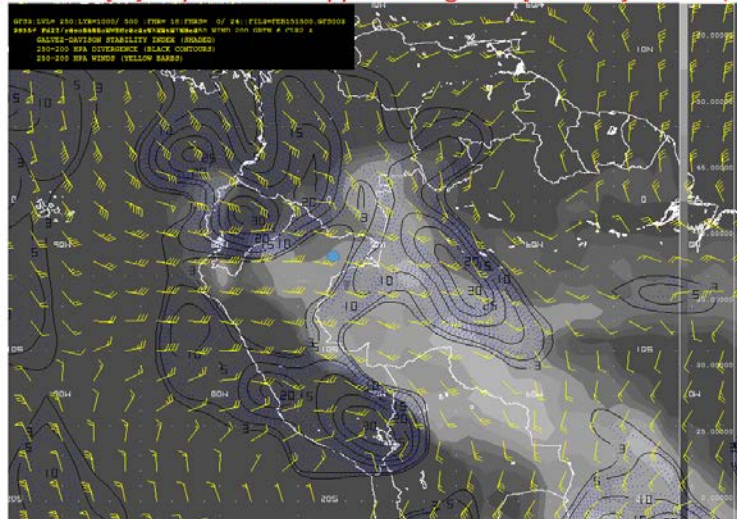


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201502160511 METAR SPQT
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25/23 Q1012=
    
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The IR4 satellite animation shows active convection moving into the región from the northeast. The area with convection is smaller than that of the previous case. [Se muestran a continuación de la animación de las imágenes de satélite IR desde las 00 UTC hasta las 09 UTC del día 14 se muestra además la Imagen de las 0511 UTC donde se registro la tormenta en SPQT].

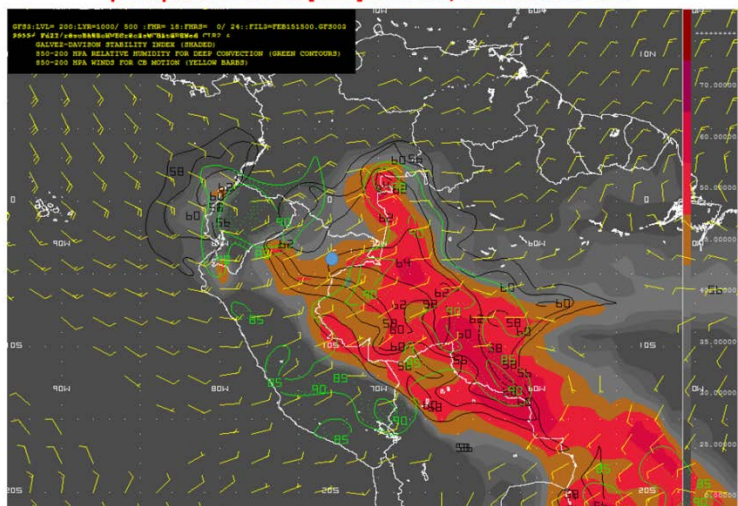
Upper flow [kt] in yellow and upper divergence [$\times 10^{-6} \text{ s}^{-1}$] in black/blue



This animation of the upper levels shows again an upper divergent pattern just to the east and northeast of Iquitos. This enhances the deep convection that developed in regions upstream of Iquitos. The convection often moves in from the east, thus the thunderstorms arrive to Iquitos already enhanced.

Se presentan las animaciones del día 15 a las 18UT y del día 16 de 00UTC y 06 UTC en el cual se observan el flujo de nivel alto predomina del Este con velocidades entre 25 y 35 nudos y una circulación anticiclónica al sur de Perú y Bolivia y la divergencia entre 5 a $15 \times 10^{-6} \text{ s}^{-1}$ que favorece a la convección en los niveles bajos de la zona de estudio y los valores del GDI entre 45 y 60 lo cual es un valor que nos indica alta convección y ocurrencia de tormentas

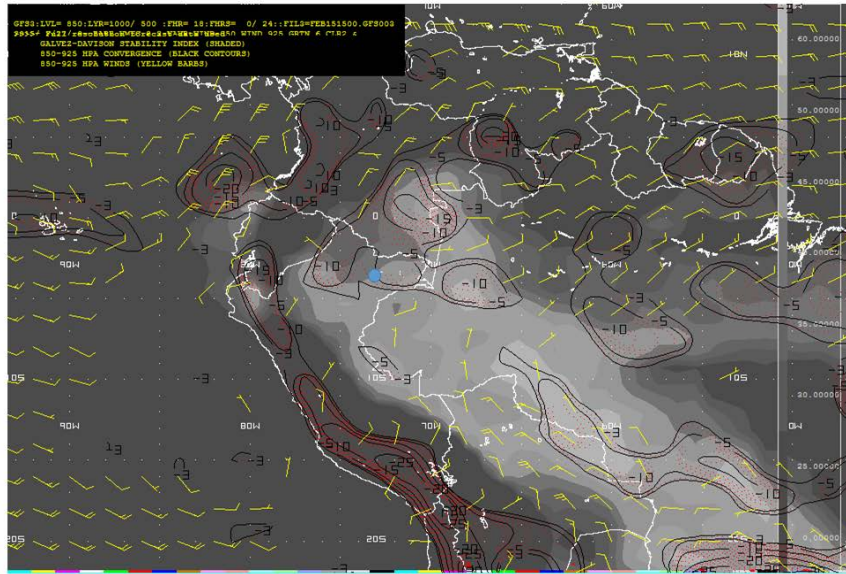
850-200 Relative Humidity [%] in green, 850-200 mean flow, precipitable water [mm] in black, GDI shaded and



This animation shows the mean flow from the east-northeast at 10-15kt, high convective instability with $\text{GDI} > 50$ and precipitable water over 60mm.

Se presentan el comportamiento de la humedad relativa que fluctúa entre 85 y 90% y el viento promedio de dirección Nor-este con velocidades de 10 a 15 nudos y el agua precipitable fluctúa entre 58 a 64 mm, lo cual garantiza la humedad disponible para la ocurrencia de las tormentas en la zona de estudio y el GDI entre 45 y 60 valores que indican la convección y la ocurrencia de tormentas

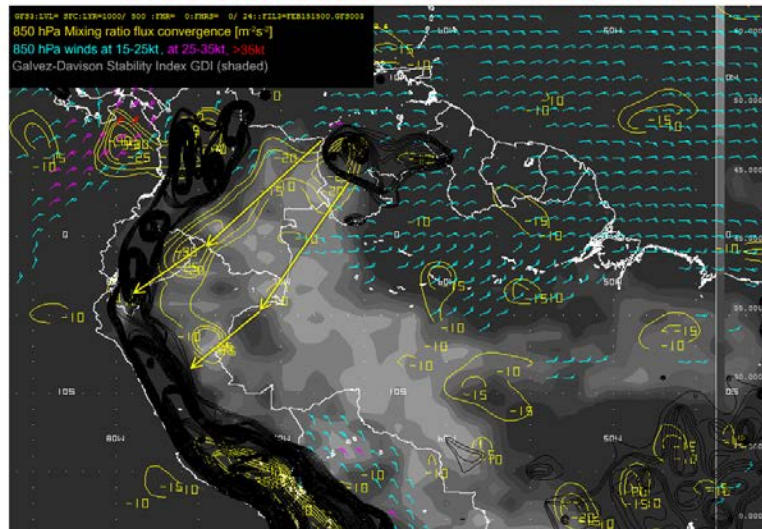
Low-level convergence [$\times 10^{-6} \text{ s}^{-1}$] black/red; Low-level flow (yellow); GDI (shaded)



The low-level analysis shows a región of enhanced low-level convergence between northern Peru and southern Venezuela, where the northeasterly Low-Level Jet in Colombia and the easterly trades over Brasil converge. Interactions between the flow and the southern Venezuela mountains produce perturbations that propagate southwestward into northern Peru when the trades are from the northeast. These perturbations propagate without weakening when the environment is favorable: enhanced convective instability and low-level convergence.\

Se presenta la convergencia en nivel bajo y su valor entre -5 a $-15 \times 10^{-6} \text{ s}^{-1}$ condiciones favorables para la ocurrencia de tormentas en la zona de estudio. El viento de nivel bajo del NE con 10 nudos y el GDI 45 a 60 valores que son favorables para la convección y la ocurrencia de tormentas.

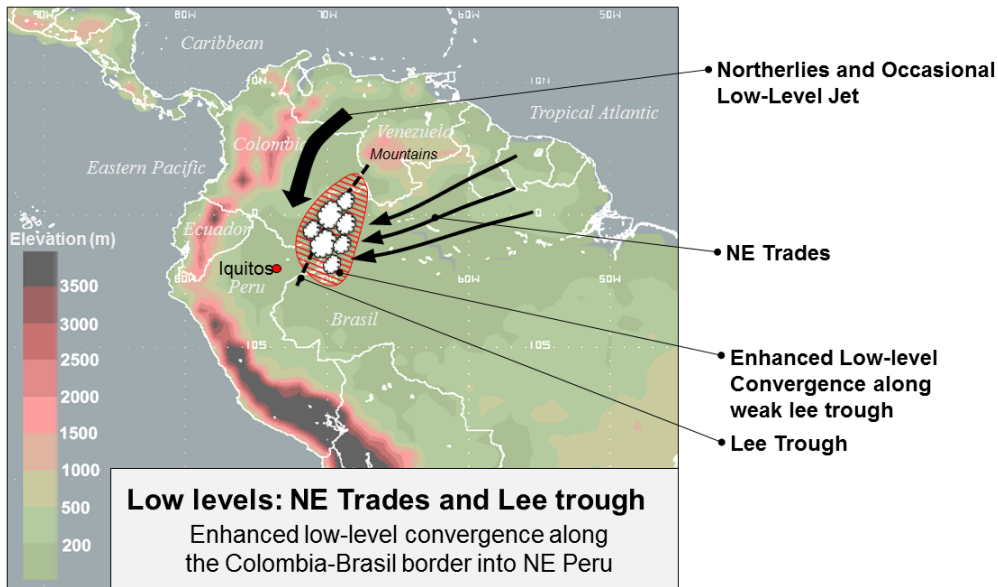
Lee Perturbations under NE trades



This animation shows the track that lee-side perturbations followed during this case. Note that convective is enhanced along the entire path, favoring storm maintenance.

Se presenta la animación de la convergencia a 850 hPa; Vientos entre 15 a 25 KT en nivel de 850 hPa y donde se observa la perturbación a sotavento de los alisios del Nor-Este , lo cual favorece la convección en la región de estudio.

Conceptual Model: Lee Perturbations under NE trades



This slide shows a conceptual model of the enhanced convergence and convection that form along the lee-side trough that forms southwest of southern Venezuela into extreme northeastern Peru.

Este modelo conceptual representa al Segundo caso de estudio. Los factores que dan lugar a esta tormenta son: Jet de bajo nivel; Alisios del NE,

Case 3 Feb 27-28 2015 (Trough/Weak Low-level Jet)

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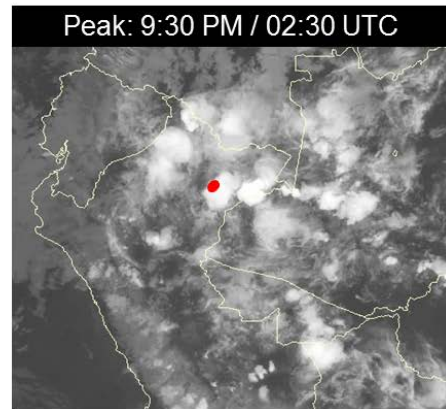
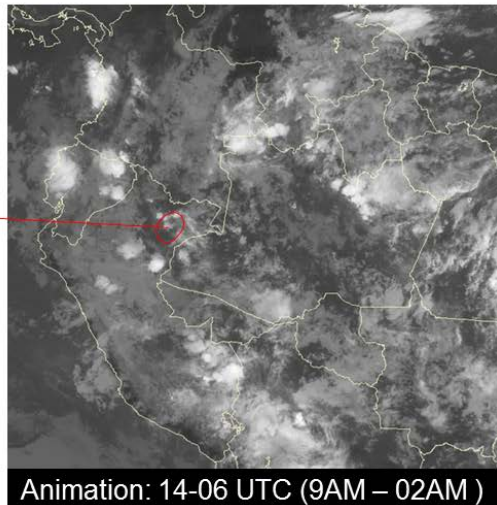
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TS

Case 3 is a hybrid case in which both the influence of a trough in the trades, and to a lesser extent, the low-level jet were present. Heavy rainfall was present at the station in this case with accumulations of 53mm in 2 hours associated with a line of convection that developed after 02 UTC (9pm local time).

Case 3 Feb 27-28 2015 (Trough/Weak Low-level Jet)

Iquitos
SPQT

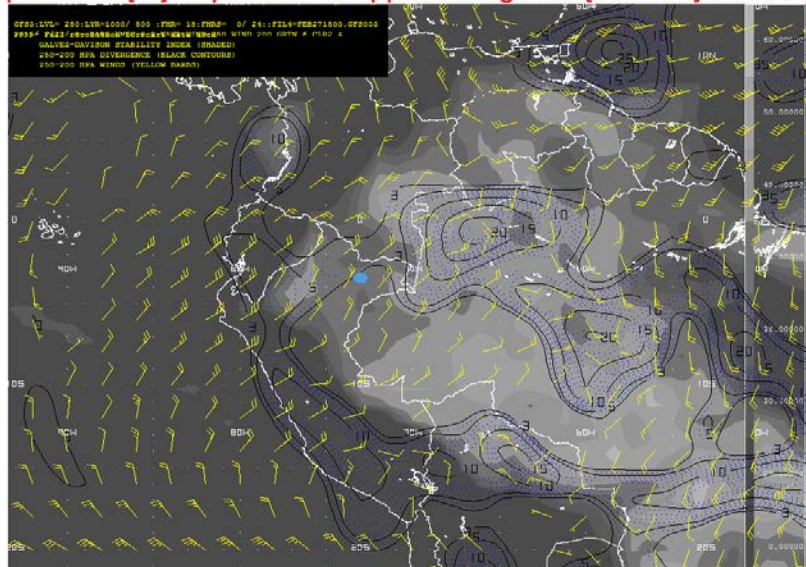


201502280228 METAR SPQT
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BKN100 24/22 Q1012=

Case three consists of another trough in the trades in this case interacting with a weak nocturnal low-level jet that developed across Central Colombia. Areas of convection were more widespread than during previous cases and accumulations reached approached 60mm/day.

Se muestran a continuación de la animación de las imágenes de satélite IR desde las 14 UTC del día 27 hasta las 06UTC del día 28, en el cual se observa el desplazamiento de la convección hacia la zona de estudio SPQT. Se muestra además la Imagen de las 0230 UTC imagen cuando se presentó la tormenta en SPQT

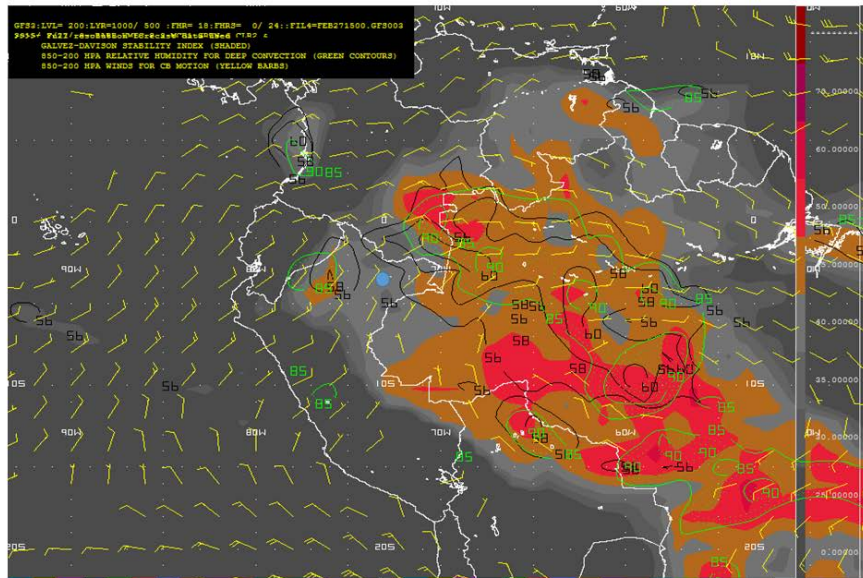
Upper flow [kt] in yellow and upper divergence [$\times 10^{-6} \text{ s}^{-1}$] in black/blue



In this case the subtropical ridge was located over Rondonia in Brasil with areas of enhanced upper diffuence over northern Amazonas-Brasil into Southern Colombia, upstream from Iquitos.

Se presentan las animaciones del día 27 a las 18UT y del día 28 de 00 UTC y 06 UTC en el cual se observan el flujo de nivel alto predomina del Este con velocidades entre 15 y 20 nudos; se observa una circulación anticiclónica de altura en Perú y Bolivia y la divergencia entre se varia entre 3 a $12 \times 10^{-6} \text{ s}^{-1}$ y los valores del GDI entre 45 y 60 lo cual es un valor que nos indica alta convección y ocurrencia de tormentas

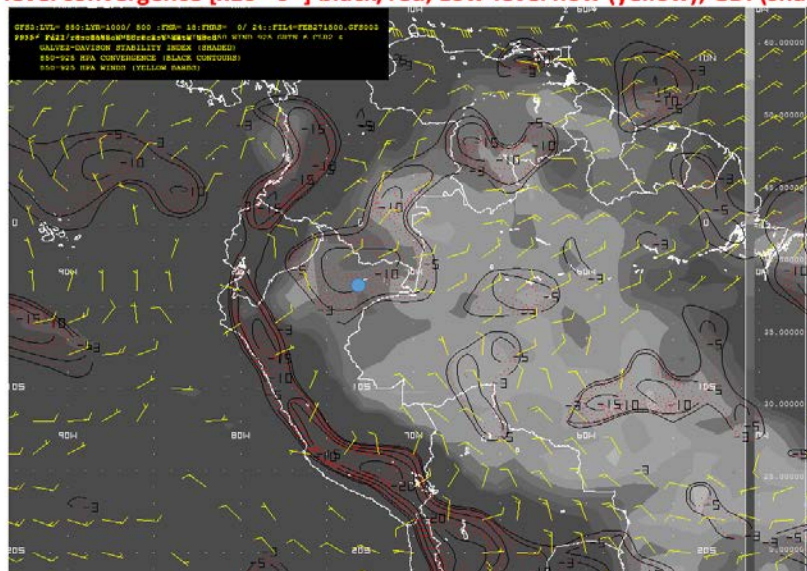
850-200 Relative Humidity [%] in green, 850-200 mean flow, precipitable water [mm] in black, GDI shaded and



Mean flow was from the northeast, once again transporting thunderstorms from the región with enhanced upper divergence into Iquitos. GDI values were also high between 45 and 55.

Se presentan el comportamiento de la humedad relativa que fluctúa entre 85 y 90% y el viento promedio de dirección Nor-Este con Velocidades de 10 nudos y el agua precipitable fluctúa entre 56 a 60 mm y el GDI entre 45 y 60 lo cual indica convección y tormentas en la región de estudio. El flujo del nor-este nos indica el movimiento de las tormentas

Low-level convergence [$\times 10^{-6} \text{ s}^{-1}$] black/red; Low-level flow (yellow); GDI (shaded)



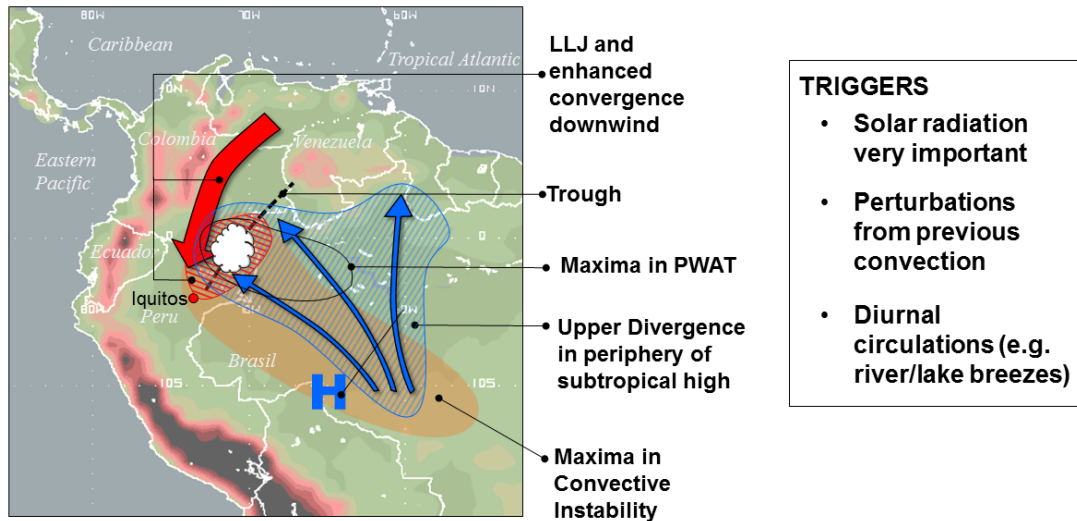
The figure shows low-level convergence in the order of -5 a $-15 \times 10^{-6} \text{ s}^{-1}$ under flow from the northeast exceeding 10kt. This together with GDI values of 45-60 are favorable for the development of thunderstorms in the region.

Se presenta la convergencia en nivel bajo y su valor entre -5 a $-15 \times 10^{-6} \text{ s}^{-1}$ condición favorable para la ocurrencia de la tormenta y el viento de nivel bajo del NE con 10 nudos y el GDI 45 a 60 el cual nos indica condición favorable para la ocurrencia de la tormenta

Conclusions

1 Where might storms form?

Convective Initiation: Region most favorable is where factors interact



2 How will storms move/propagate?

- Mostly controlled by the mean flow (e.g. average of 850-200 hPa winds)

3 Will storms persist/regenerate?

More likely if the environment is favorable:

- LLJ exit: enhances low-level convergence and provides shear.
- Trough in the trades enhances low-level convergence as well as coverage and magnitude of the perturbations/triggers.
- Enhanced convective instability ahead of storm ($GDI > 45$).
 - Clear skies during daytime, maximum heating;
 - Deep moisture, usually from remnants of convection in the region.
- Enhanced precipitable water (55mm+) ahead of the storm.

CONCLUSIONS

PREDICTOR VALUES FOR EACH CASE

VARIABLES	CASE1: FEB 13/14	CASE2: FEB 15/16	CASE3: FEB 27/28
GDI	45 - 60	45 - 60	55 - 60
250-200 DIVERGENCE x $10^{-6} s^{-1}$	3 - 10	5 - 15	3 - 12
250-200 WIND kt	NE y 15 -30	NE Y 25 - 35	NE y 15 - 20
RELATIVE HUMIDITY%	85 - 90	85 - 90	85 - 90
PRECIPITABLE WATER mm	60 - 62	58 - 64	56 - 60
RAINFALL mm (SPQT)	37.6	6.0	52.6
850 -200 kt WINDS	E y 10 - 15	NE - E y 10	NE y 15
850-925 CONVERGENCE x $10^{-6}s^{-1}$	-3 - -10	-5 - -15	-5 - -15
850-925 WINDS kt	NE y 5 - 10	NE - E y 10	NE y 10