

WPC Training Tropical Desk Presentation

“TUTT-Induced Hail Event in Suriname”

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TUTT – INDUCED HAIL EVENT IN SURINAME

- **Dwight Samuel, operational forecaster at the Met Service Suriname.**
 - We issue general (public), marine and aeronautical forecasts, and forecasts for individuals for specific times and/or events.
- **I am currently in training at the Tropical Desk.**
- **This (small) research will contribute to the forecasting of hail and/or heavy thunderstorms.**



Between 2° – 6°N and 54° – 58°W

Tropical Rainforest

Bi-modal rainfall regime – the position of the ITCZ generates 2 wet and 2 dry seasons.

Average rainfall: dry seasons between 100 – 150mm and wet seasons is twice as much; annually it could add up to 2200mm.

Suriname is located in the northeastern tier of Tropical South America. The national language is Dutch, but everybody speaks Surinamese. As said; we are a Caribbean country in South America. Positioned between 2° – 6°N and 54° – 57°W. Suriname has a small coastal plain, where almost the whole population lives, some savannah and the rest (south of 4°N) is tropical rainforest. This is where you'll find some mountain ranges, with the highest top at 1280m.

The rainfall regime in Suriname is bimodal. This means that it has two wet and dry seasons, which are modulated by the position of the ITCZ. This is well defined in the northern part of Suriname, while in the southern tier precipitation is organized for the most part in just two seasons: a dry and a wet one. Annual rainfall is often in the order of 2200mm/year.

HAIL

- Hail in Suriname is **very** uncommon. Until today we only have 3 events identified by the general public, but there is only reliable proof of one: January 16, 2014.
- There were no great impacts, other than that associated with the gusty winds.



Hail in Suriname is a very rare phenomenon. Until today there are only three identified cases. One occurred in the 1970's, one in September 2013 and another in January 2014. From these cases, only the latest one has sufficient reports to attain reliability. Confidence increased further more once the setup of the atmosphere was identified, as a large TUTT was present just to the north of the region with short wave vortices revolving in its southern periphery. The hail observed was smaller than dimes, so it did not really have a strong impact.

The only impacts were those associated with the gusty winds. Gusty winds are a feature we see with every thunderstorm the last few years, ranging from 20 – 35kts. But the strongest one dates from a few weeks back, peaking around 40kts.

THIS CASE STUDY.....

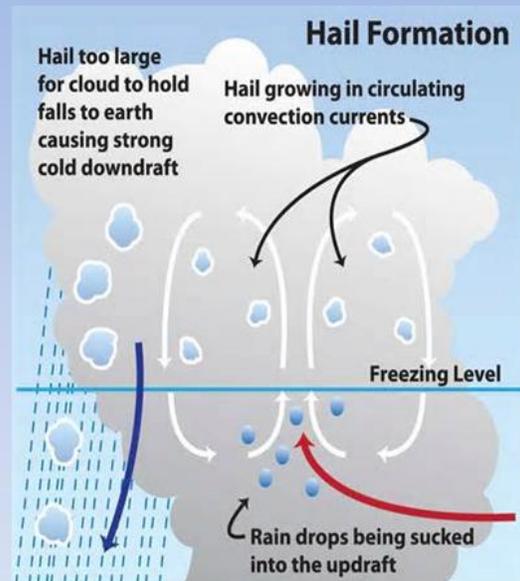
- **The focus will be on the event from January 16, 2014.**
- **Methods:**
 - **Analysis of different parameters relevant to the prediction of hail such as deep-layer instability (GDI, CAPE), vertical wind shear, freezing level height, dynamics favorable for strong updrafts;**
 - **Predictability assessment by looking how the GFS captured this event in different model runs (ensemble runs of different predictors);**
 - **Generation of Wingrids macros/scripts for the prediction of hail in Suriname .**
- **Tools used: GFS data using Wingrids, French-Guiana soundings, CPTec satellite images, Metar data.**

The case study focuses on the 16 January 2014 hail event that occurred at 23Z or right after sunset. The method of analysis considers different parameters relevant to the prediction of hail such as stability indices, vertical wind shear, freezing level height, 0°C wet bulb temperature near the 700 hPa level, and an evaluation of the dynamics favorable for strong updrafts.

The data and tools used consist of GFS model runs analyzed using Wingrids, French Guiana soundings, CPTec infrared-4 and water vapor satellite images and METAR observations.

CONDITIONS THAT FAVOR HAIL

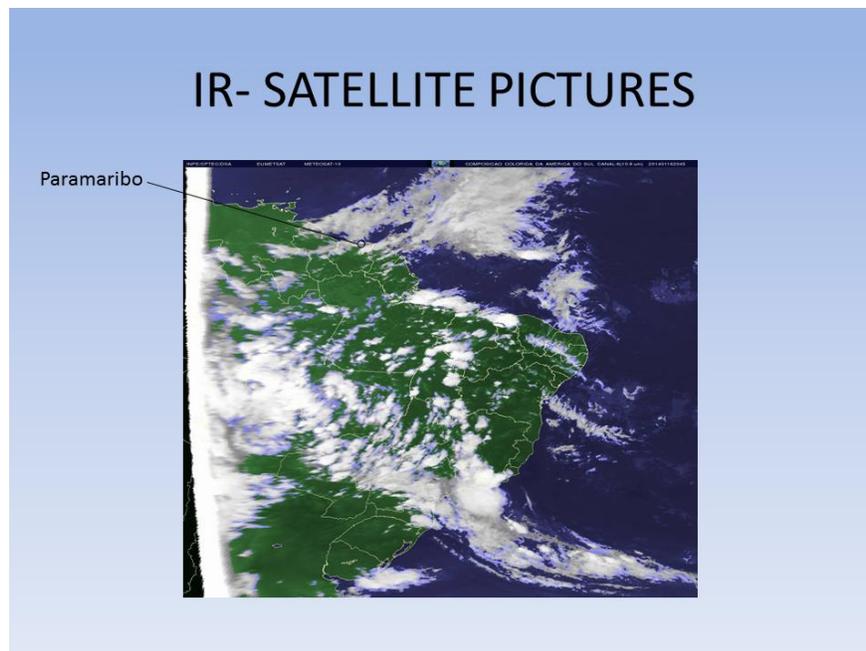
- **Cool mid troposphere**
 - Low Freezing Level
 - Large portion of the cloud $< 0^{\circ}\text{C}$
- **Strong updrafts**
 - Strong low/mid-level instability (e.g. steep 700-500hPa lapse rates, large CAPE)
 - Favorable large scale dynamics (e.g. upper divergence/low-level convergence)
 - Enhanced vertical wind shear
- **High moisture content**
 - Precipitable water
- **Dry air at mid levels** (enhanced evaporational cooling in hail-formation layer $\sim 0^{\circ}\text{C}$ to -10°C)
 - Wet bulb zero height
 - Low relative humidity at $\sim 500\text{hPa}$



The conditions that favor hail formation require the presence of a thunderstorm cool enough temperatures that favor accretion of supercooled water droplets into a growing ice particle, and with updrafts in the supercooled water layer sufficiently strong to increase the duration of the growing ice particle inside the supercooled water layer by counteracting the effects of gravity. The droplet grows bigger and once it becomes too heavy for the updraft to maintain it aloft it falls out of the cloud.

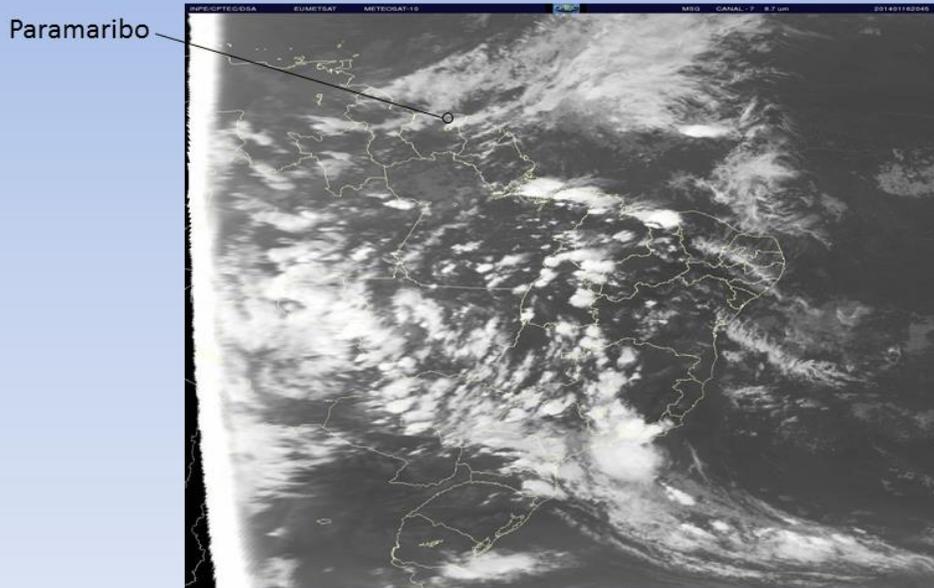
Cool mid-tropospheric temperatures can be assessed by identifying the height of the freezing level. A large part of the cloud below 0°C tends to favor the formation of hail. Strong updrafts are also very favorable. These can be evaluated by looking into mid-level instability. For example 700-500 hPa steep lapse rates favor strong updrafts at mid-levels. Large scale dynamics that favor deep-layer ascent are also favorable. For example, an upper divergent pattern ahead/in the periphery of a trough combined with a low-level convergent pattern such as a front, low-level trough, etc., can favor deep-layer ascent. Enhanced vertical shear also favors strong updrafts. High

moisture content, especially at low-levels, is also important. Precipitable water is an important variable to assess this. Finally, evaporational cooling in the hail-formation layer/near the freezing level favors hail formation as it enhances cooling. Evaporational cooling is enhanced when some dry air is present in the layer. Some parameters used are wet bulb zero height close to 700 hPa, and low-relative humidity at mid-levels.

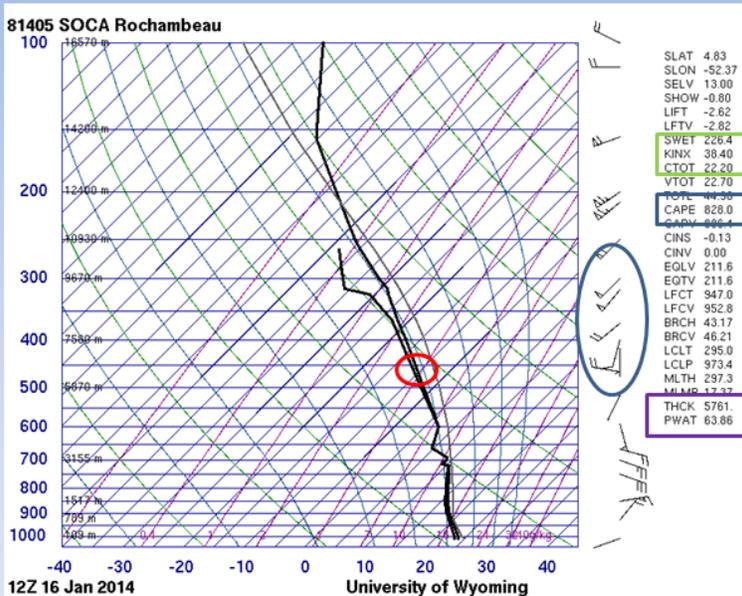


The satellite animation shows a band of convection positioned over northeastern Suriname. The band does not look very impressive but cold cloud tops were definitely present.

WV- SATELLITE PICTURES

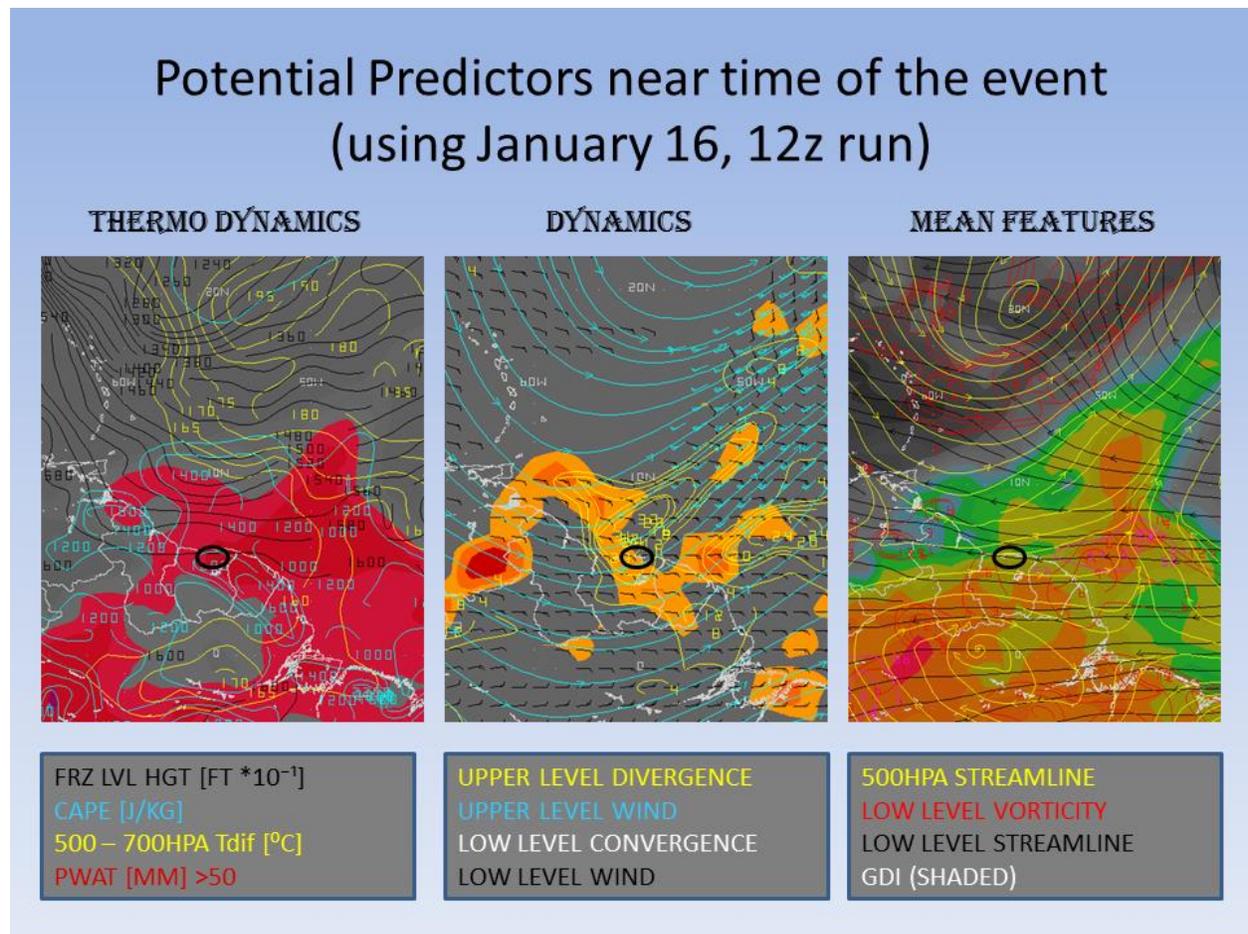


WINDSHEAR, FREEZING LEVEL HEIGHT AND STABILITY



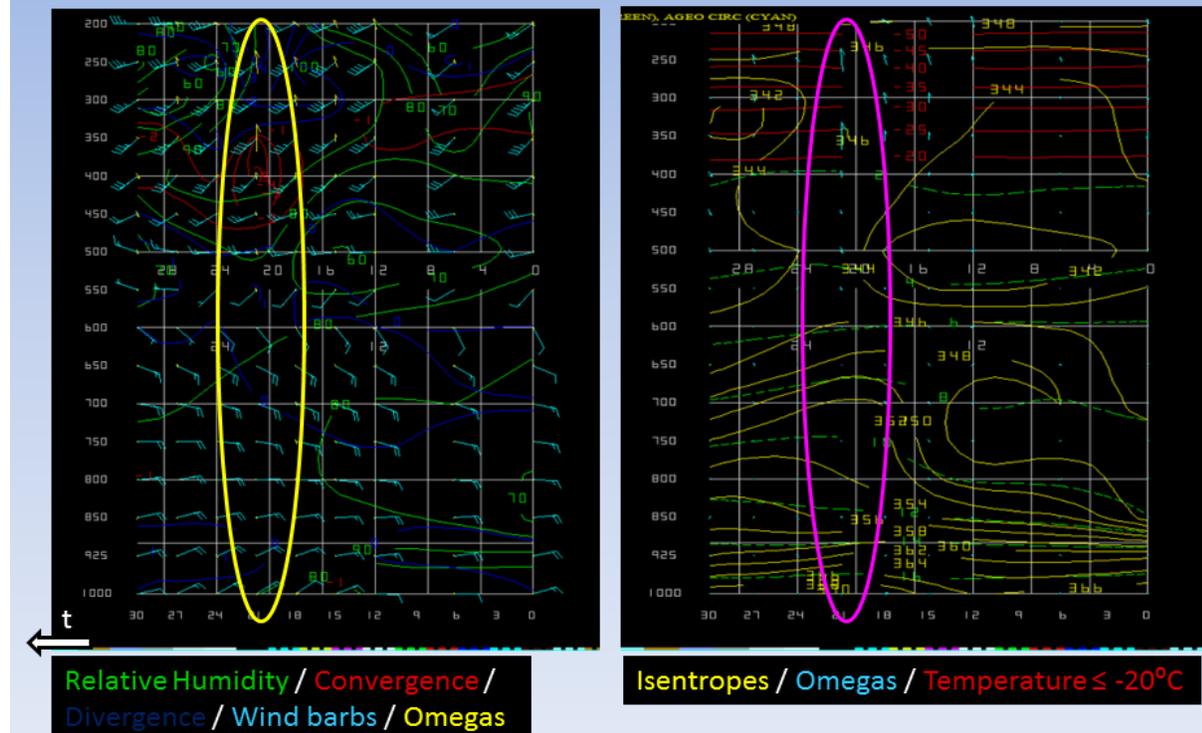
This is the sounding from French Guiana 12 hours before the event. The sounding station is in Rochambeau, French Guiana, approximately 320km east of Paramaribo. Considering the low-level flow, this is often upstream from Suriname. We were interested in confirming the height of the freezing level, looking for shear in the supercooled water layer and revising the values of stability indices. Note that when analyzing soundings one must be careful when nearly deep-layer moist adiabatic saturated profiles are present, as they can represent the radiosonde going through a cloud. Also one needs to keep in mind the location of the sounding with respect to the station of analysis, since in some levels it will fall upstream from the analysis location but in others it will fall downstream.

This particular sounding shows the freezing level at about 580 hPa, shows the presence of directional and speed shear in the supercooled water layer, and shows relatively unstable values for different indices. It also shows large precipitable water values, with numbers exceeding 63mm.



Different potential predictors, associated with the forecasting of hail, are plotted near the time of the event. The thermodynamic properties are presented on the left panel. Precipitable water was very high with values exceeding 55mm in association with the Inter-tropical Convergence Zone and a perturbation in the trades arriving from the east. CAPE was also plotted to evaluate instability, and shows values exceeding 1400 J/Kg. The freezing level height was plotted in black and was at approximately 16000ft, not necessarily low for the area. Finally 500-700 temperature differences were plotted to assess mid-level instability and largest values were present to the north in association with the TUTT. Other parameters such as wet bulb zero height (usually near 700 hPa during hail events) was also too high and was not plotted. The fact that the thermodynamic parameters showed marginal values for the generation of hail suggests that the dynamics were particularly important for this event.

TIME SECTIONS (5.8N 55.2W)

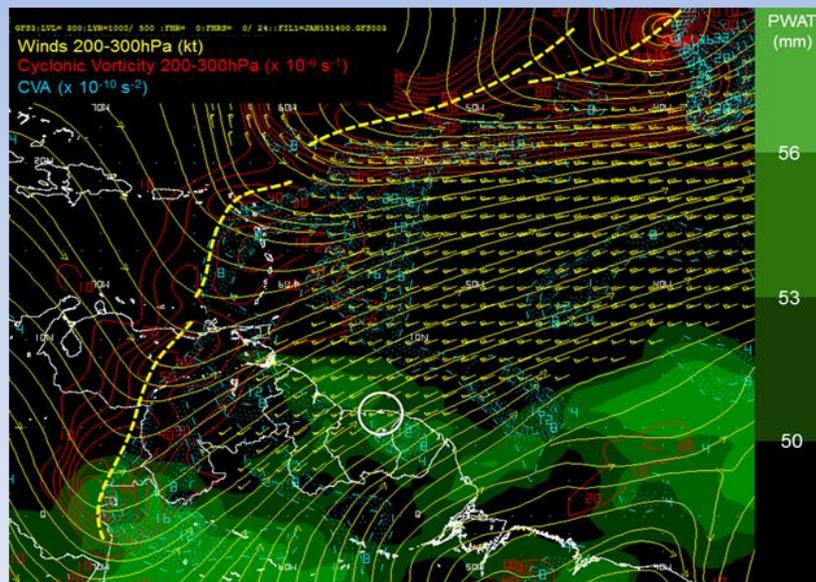


Time sections at a point in northern Suriname are presented. The period when hail occurred is indicated with ovals. The sections show the increase in instability below 600 hPa after 18Z as the perturbation in the trades arrived.

The perturbation shows as a change in the low-level winds from easterly/southeasterly at 15Z to northeasterly/ easterly by 21Z. Ascent was enhanced above 400 hPa in association with the upper trough.

GENERAL OVERVIEW OF UPPER DYNAMICS AND PWAT

Upper-level short wave vorticity entering in phase with the PWat max at lower level



The GFS model suggests that a short wave trough entered in phase with the arrival of the perturbation in the trades and precipitable water maxima.

GFS ENSEMBLE ANALYSIS

- Assessing predictability
- Determining predictors and values

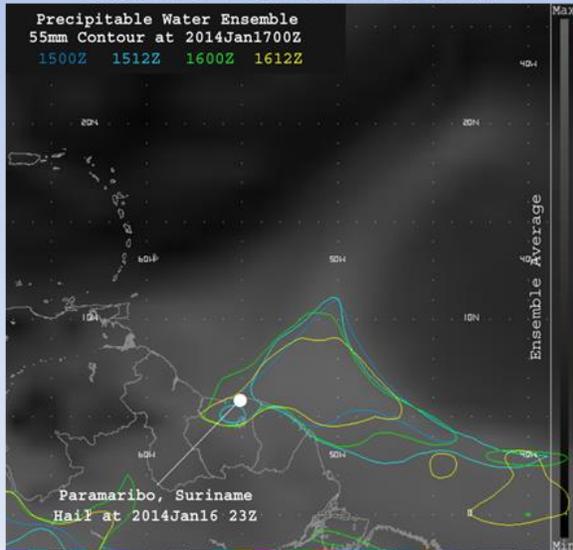
An EMSEMBLE analysis was made by comparing the contours of a few variable thresholds using different GFS simulations. This is a way to evaluate the confidence on the model solution.

MOISTURE PREDICTORS EXAMPLE

Consistent Solutions

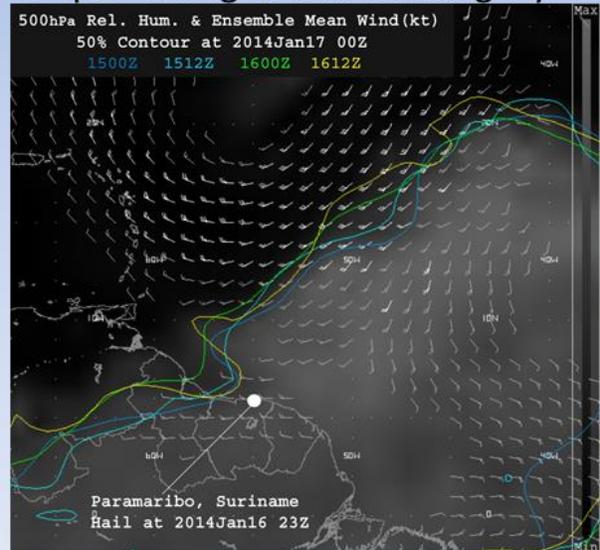
PWAT=55mm

Column Available Moisture



RH₅₀₀=50%

Evap. Cooling in hail-forming layer

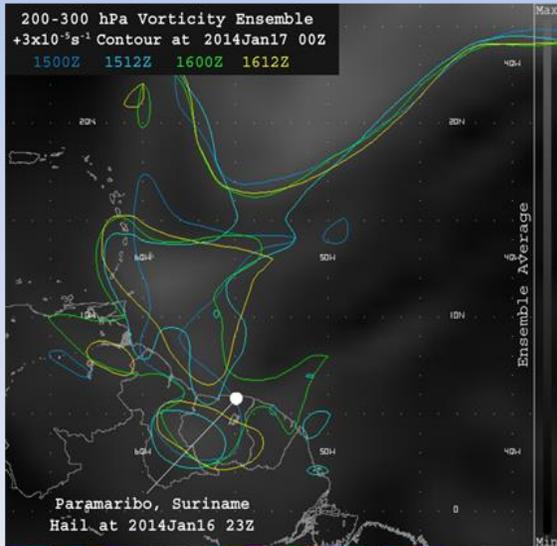


Two moisture parameters are compared using the ENSEMBLE technique. The contour of precipitable water=55mm (left) and the relative humidity₅₀₀=50%. Blue indicates older simulations and yellow the most recent ones. The background shading represents the ensemble average. The model was consistent with the different solutions for both quantities analyzed.

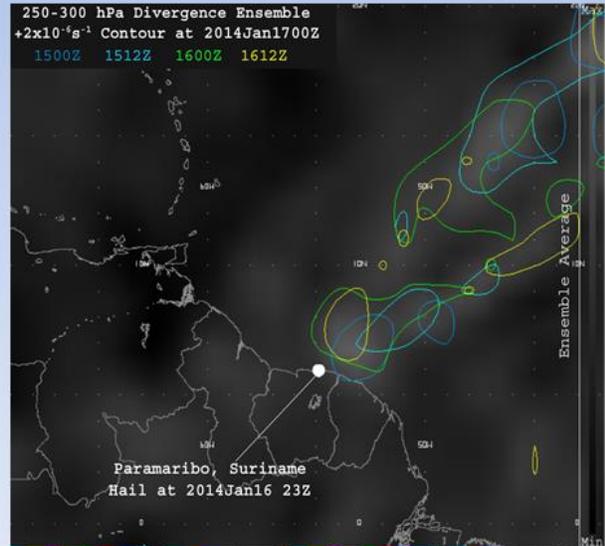
DYNAMIC PREDICTORS EXAMPLE

Solutions still consistent but more variability

Cyc. Vorticity 200-300hPa
Short wave troughs



250-300hPa Divergence
Ventilation



Cyclonic vorticity and upper divergence are compared using a similar ensemble technique near the peak of the event. These figure evidence more variability on the solution of these dynamic variables with respect to the moisture parameters.

CONCLUSIONS

1. Predictability:

- ❖ The models did capture the event looking at the predictors. The predictors were all there around the time of the actual event, but, as we've seen, they did not all meet the theoretical threshold values.
- ❖ Model ensemble showed minor changes, with largest uncertainty regarding the short wave (upper level).

2. Forecasting hail for Suriname:

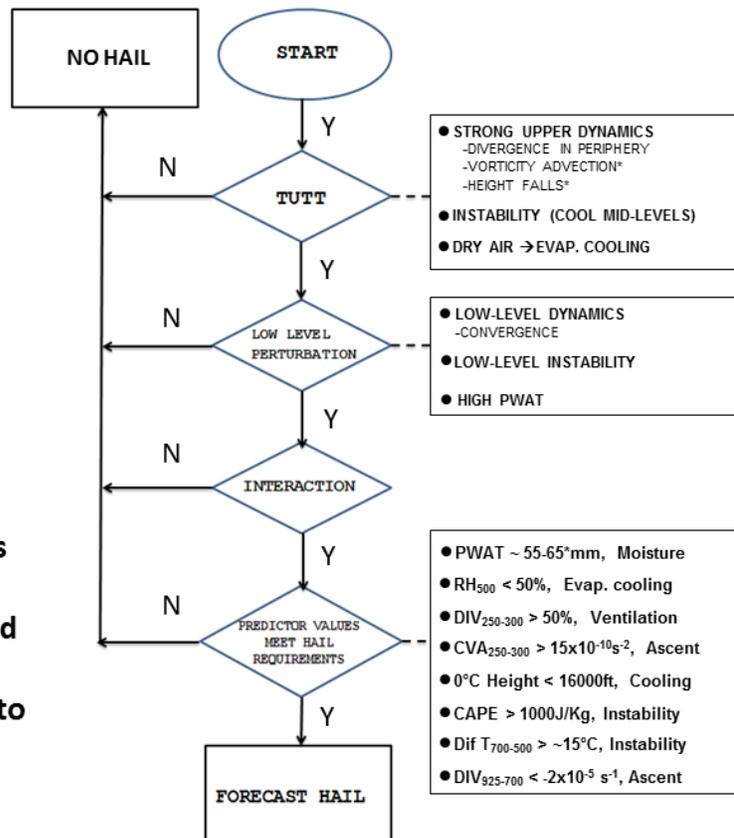
We saw that although not all the theoretical threshold values were met, it was still enough for the development of hail. We do need all the predictors, that we focused on, to be in place on the same time (clash of the titans).

In conclusion: GFS data can be used to forecast hail in Suriname.

⚠ Note that this case was based on only one event in a particular season. Further research may find different conclusions using this information looking at the different seasons.

Proposed Flux Diagram for forecasting hail in Suriname

To establish threshold values there is still more research required. This case was based on just one event. Similar events (in the Tropics) need to be explored to refine the forecasting method for Suriname.



Appendix

Three macros/scripts were developed for the software Wingrids. These are SU01.CMD, SU02.CMD, and SU03.CMD. These should be placed in the folder C:/WINGRIDDS/MACROS/. Two color tables were also generated. These are CFC6.DAT and CFC7.DAT. The color tables should be placed in the folder C:/WINGRIDDS/USER/. Winds and divergence for the lower troposphere (925-700hPa) and the upper troposphere (200-400hPa) were calculated on the ALIAS.USR file. This file is also in the C:/WINGRIDDS/USER/ folder. All files must be in their respective places for the macros/scripts to work.

The following text needs to be included in the ALIAS.USR file.

```
@@@@@@@@@@@@@@@@
@@@WINDS AND DIVERGENCE IN THE 925-700 HPA LAYER - START
@@@@@@@@@@@@@@@@
LLC1=SMTH SMLC 1+6 DVRG WIND 700
LLC2=SMTH SMLC 1+6 DVRG WIND 925
LLC3=SMTH SMLC 1+6 DVRG WIND 850
LLC0=SDVC 3 SSUM LLC1 SSUM LLC2 LLC3
LLW0=VDVC 3 VSUM BKNT 700 VSUM BKNT 925 BKNT 850
@@@@@@@@@@@@@@@@
@@@WINDS AND DIVERGENCE IN THE 925-700 HPA LAYER - END
@@@@@@@@@@@@@@@@
```

```
@@@@@@@@@@@@@@@@
@@@WINDS AND DIVERGENCE IN THE 300-200 HPA LAYER - START
@@@@@@@@@@@@@@@@
ULD1=SMTH SMLC 1+6 DVRG WIND 300
ULD2=SMTH SMLC 1+6 DVRG WIND 250
ULD3=SMTH SMLC 1+6 DVRG WIND 200
ULD0=SDVC 3 SSUM ULD1 SSUM ULD2 ULD3
ULW0=VDVC 3 VSUM BKNT 300 VSUM BKNT 250 BKNT 200
@@@@@@@@@@@@@@@@
@@@WINDS AND DIVERGENCE IN THE 300-200 HPA LAYER - END
@@@@@@@@@@@@@@@@
```

The macros/scripts created follow.

(1) SU01.CMD plots the convergence of 925-700 hPa winds and the divergence of 200-300 hPa winds plus the winds. The code follows:

```
LOOP
CTFC CFC7 LLC0
LLW0 CLRG GRTN 10/
ULD0 GRTN 1 CIN4 CLR2/
STRM ULW0 CLR1 GRTN 40/
ULW0 CLR1 GRTN 50/
TXT2 **LOW LEVEL CONVERGENCE (SHADED) AND UPPER DIVERGENCE*****
TXT3 **REQUIRES COLOR TABLE CFC7 AND CALCULATION OF LLW0 and ULW0**
TXT4 **IN THE ALIAS.USR FILE**
ENDL
```

(2) SU02.CMD plots the GDI, precipitable water, 925-700 hPa winds, 500 hPa winds and 850-700 hPa vorticity, often the level of better defined vorticity in trade wind waves. The code follows:

```
LOOP
CTFC CFCB GDIF
STRM LLW0 CLRG/
SMC 1+6 SAVR RVRT WIND 850 RVRT WIND 700 GRTN 0.1 CIN3 CLR6/
SMC 10 PWAT GRTN 55 CIN1 CLR3/
STRM WIND 500 CLR2/
TXT2 **GDI, PWAT, 925-700 WINDS(LLW0), 500 WINDS *****
TXT3 **850-700 POSITIVE RELATIVE VORTICITY **
TXT4 **REQUIRES ALIAS.USR FOR THE CALCULATION OF LLW0 **
ENDL
```

(3) SU03.CMD plots some parameters used in the prediction of hail:

```
LOOP
CTFC CFC6 SMLC 10 PWAT
SMTH SMLC 10 SDIF TEMP 700 TEMP 500 grtn 155 cin5 CLR2/
SDVC 10 SMTH M2F= HGHT 0DEG lstrn 1600 CI20 CLRG/
SMTH CAPE GRTN 1000 C200 CLR1/
TXT3 ***THERMODYNAMIC PREDICTORS FOR HAIL
TXT4 ***PWAT in mm (Water vapor)
TXT5 ***700-500 Temperature Difference (C)
TXT6 ***Freezing level height (ft)
TXT7 ***CAPE
ENDL
```

The color tables generated follow.

COLOR TABLE CFCB.DAT

```
!  
!Configuration file for Contour Line-Fill/Color  
!  
!Color Mode - 1=MAX/MIN COLOR, 2=MULTI INTERPOLATION, 3=INDIVIDUAL  
COLORS  
!  
3  
!  
!Number of Data Entries (ONLY 2 ALLOWED IN COLOR MODE 1)  
!  
21  
!  
!Number of Color Entries (ONLY 2 ALLOWED IN COLOR MODE 1)  
!  
21  
!  
!Min to Max Values  
!  
-26  
-22  
-18  
-14  
-10  
-06  
  
-03  
00  
03  
07  
  
11  
15  
  
20  
25  
  
30  
35
```

40
45

50
60
70

!
!R-G-B Values (Top-min, Bottom-max)

!
035 035 035
040 040 040
045 045 045
060 060 060
065 065 065
070 070 070

090 090 090
095 095 095
100 100 100
105 105 105

090 120 125
070 125 140

025 150 050
035 160 040

150 150 015
150 140 010

190 100 006
190 085 009

205 020 055
195 010 032
150 000 080

***** END-OF-DATA *****

COLOR TABLE CFC6.DAT

```
!  
!Configuration file for Contour Line-Fill/Color  
!  
!Color Mode - 1=MAX/MIN COLOR, 2=MULTI INTERPOLATION, 3=INDIVIDUAL  
COLORS  
!  
3  
!  
!Number of Data Entries (ONLY 2 ALLOWED IN COLOR MODE 1)  
!  
6  
!  
!Number of Color Entries (ONLY 2 ALLOWED IN COLOR MODE 1)  
!  
6  
!  
!Min to Max Values  
!  
42  
46  
50  
54  
58  
62  
!  
!R-G-B Values (Top-min, Bottom-max)  
!  
095 095 095  
100 100 100  
105 105 105  
205 020 055  
195 010 032  
150 000 080  
*****  
*****  
***** END-OF-DATA *****  
*****  
*****
```

COLOR TABLE CFC7.DAT

!
!Configuration file for Contour Line-Fill/Color
!
!Color Mode - 1=MAX/MIN COLOR, 2=MULTI INTERPOLATION, 3=INDIVIDUAL
COLORS
!
3
!
!Number of Data Entries (ONLY 2 ALLOWED IN COLOR MODE 1)
!
6
!
!Number of Color Entries (ONLY 2 ALLOWED IN COLOR MODE 1)
!
6
!
!Min to Max Values
!
-20
-15
-10
-5
-2
-1
!
!R-G-B Values (Top-min, Bottom-max)
!
100 000 000
150 000 000
200 000 000
250 100 000
250 150 000
100 100 100

***** END-OF-DATA *****

