

Severe Thunderstorms and Flash Floods over Southwestern Québec on May 29th 2012

Michael Elliott (and S. Mainville)

QSPC, MSC, EC, Montreal, QC, Canada



Environnement
Canada

Environnement
Canada

Summary of Events

- On May 29th, the combination of a warm and humid air mass, and a strong cold front resulted in severe thunderstorms over Southwestern Québec.
- Montreal was affected by torrential rain, St-Hubert and the Richelieu Valley by strong gusts and large hail.
- Elsewhere, Upper Gatineau, Lanaudiere and the Eastern Townships also have severe weather reports.
- Other than torrential rains, there was hail up to 4 cm observed in the regions of Howick, Ste-Clothide, St-Jean-sur-Richelieu and St-Hyacinthe.
- The airport at St-Hubert reported a wind gust of 100 km/hr, and a sugar bush near Duhamel in Upper Gatineau had 8000 trees uprooted by a micro-burst.

Torrential rain caused flash flooding in Montreal



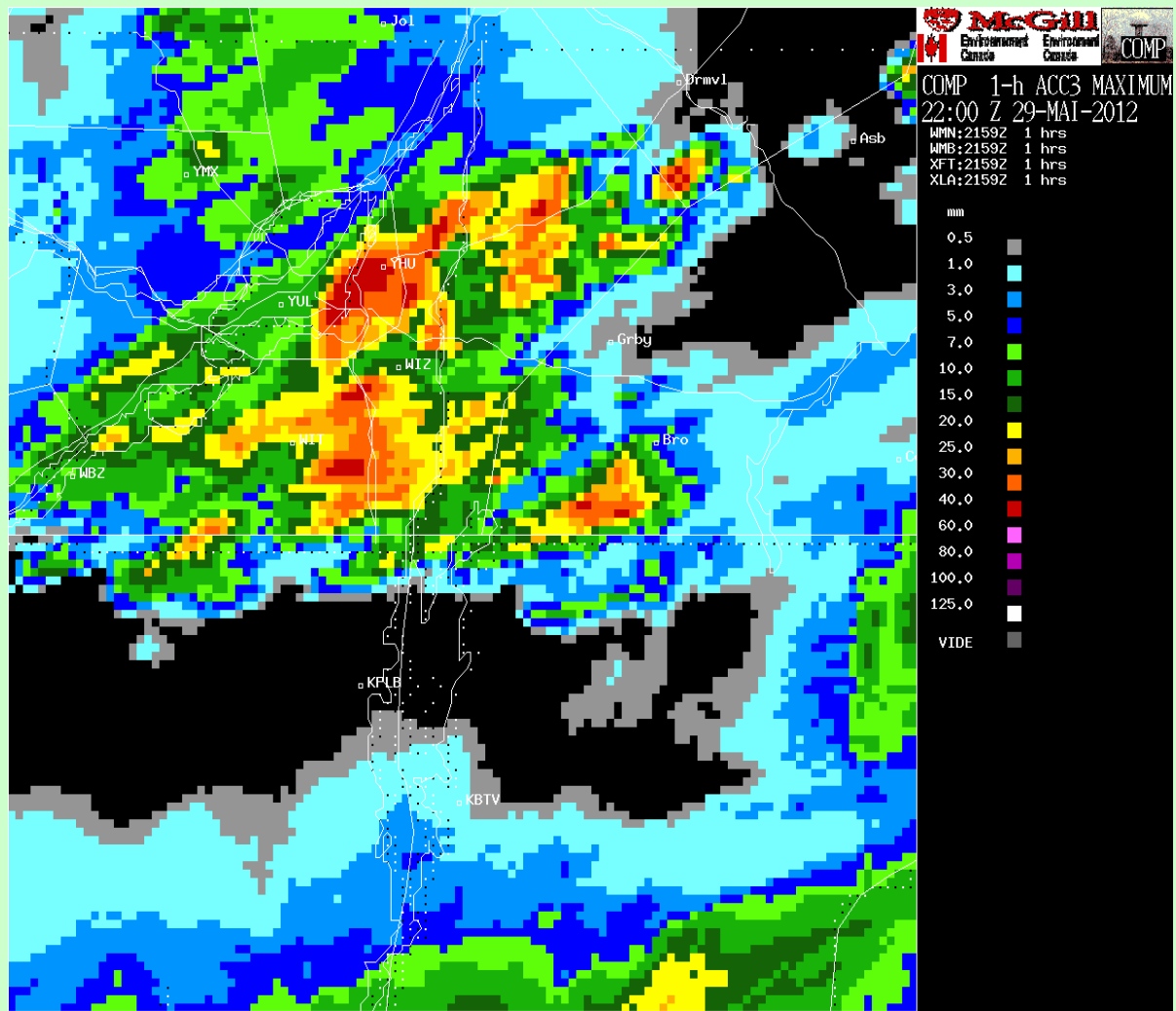
Journal Metro

CBC Montreal

Forecasting Torrential Rain – The Operational Guide Used at the QSPC

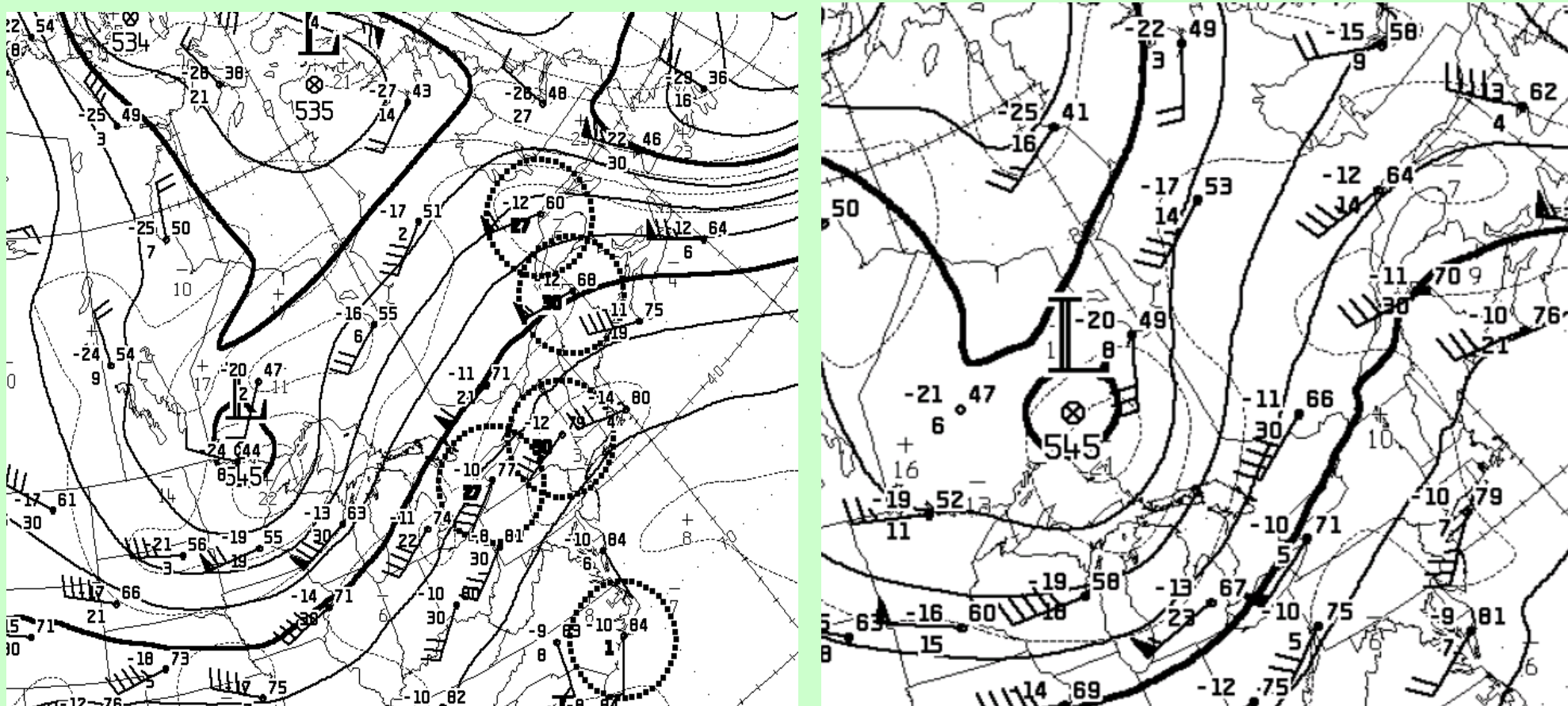
- In the Québec SPC we try to follow a forecast guide for torrential rain (TR) in the warm sector, defined as 50 mm or more in one hour. The daytime guide will be used.
- Conditions to look for:
 - A slow moving weather system
 - A moisture ridge with precipitable water greater than 35 mm. Location of TR usually on the left side of this ridge
 - CB generating an energy profile that is long and skinny
 - A K-index that is greater or equal to 34.
 - Weak to moderate wind shear.
 - A low level jet, it can be relatively weak, that is slow moving and cuts a trough or a thermal gradient.
 - Low level jet should be parallel or within 30 degrees of the upper level jet.
 - In the absence of a clear LLJ, look for low level convergence zones.

Total Rainfall Accumulation.

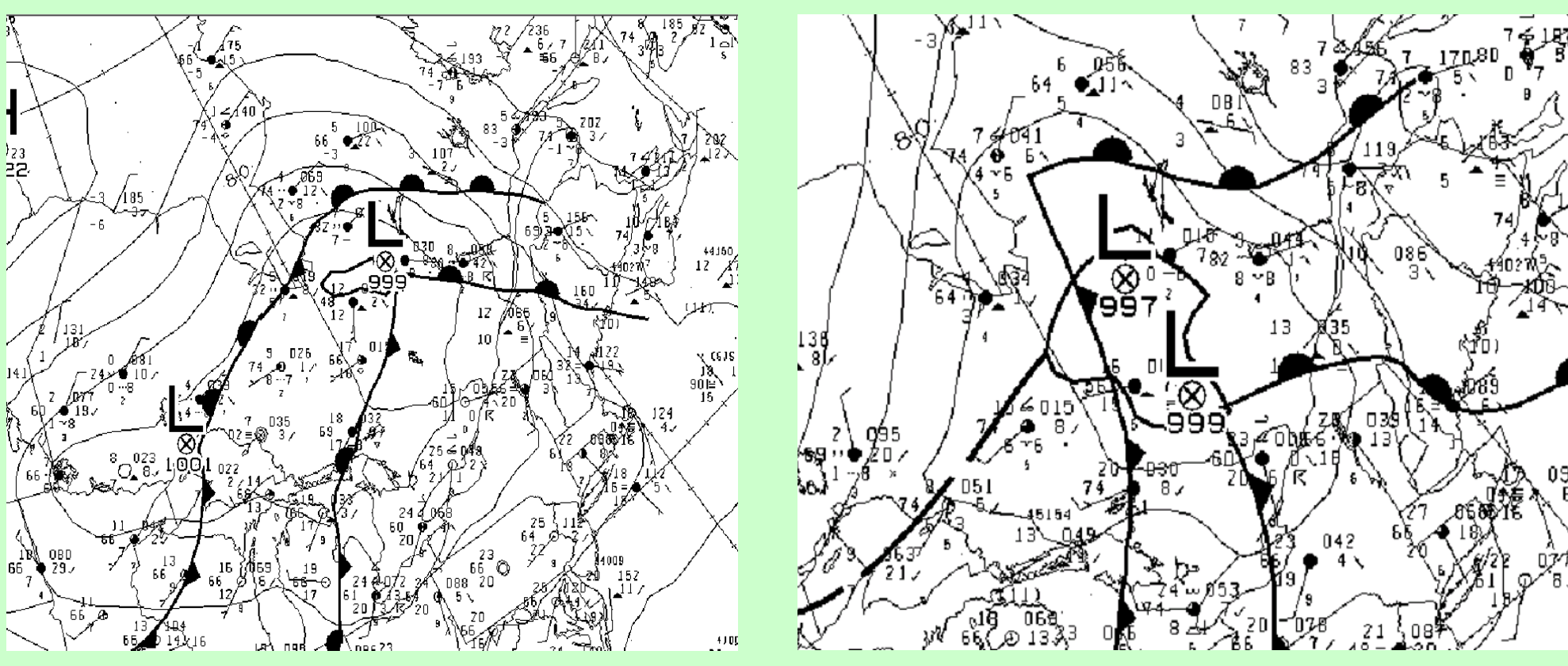


-Radar accumulation between 5 and 6 PM.
-40 to 70 mm of rain reported over downtown Montreal.
-46 mm measured at McTavish station (CWTA).

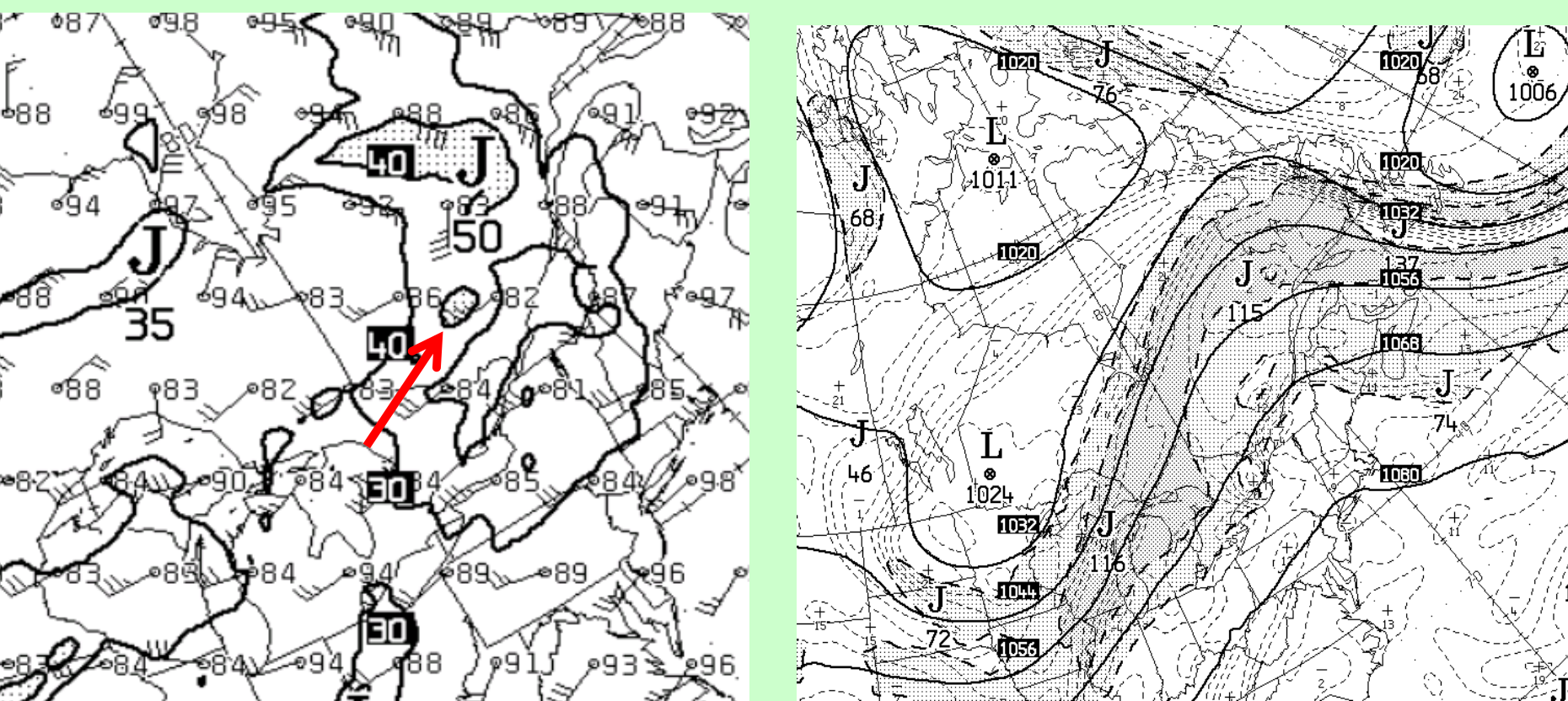
TR Guide – Synoptic Pattern



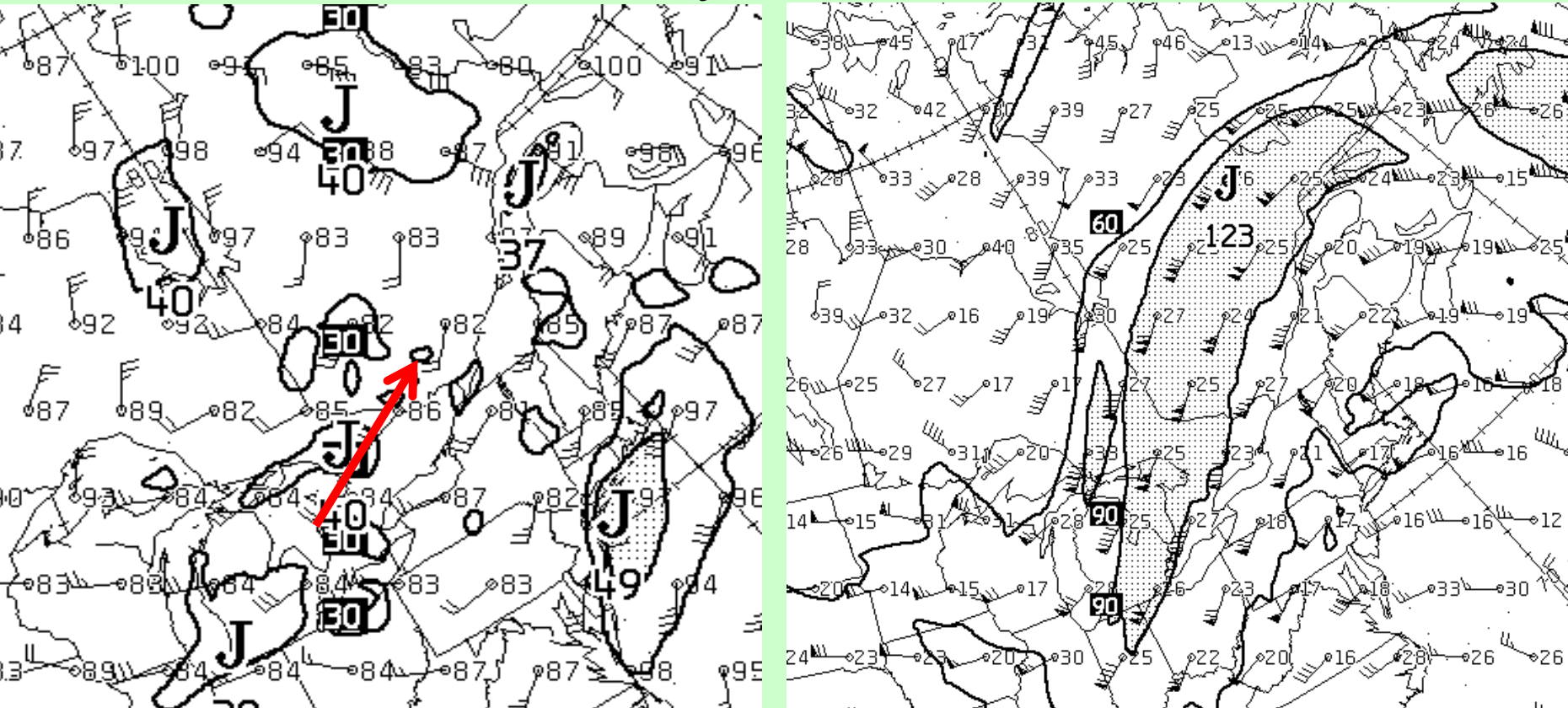
- The system at 500 mb between the morning (top left) and evening (top right) of May 29th. GEM-REG Analysis.
- CMC surface analysis on May 29th in the morning (bottom left) and evening (bottom right).
- Notice the strong cold front cutting through the warm sector



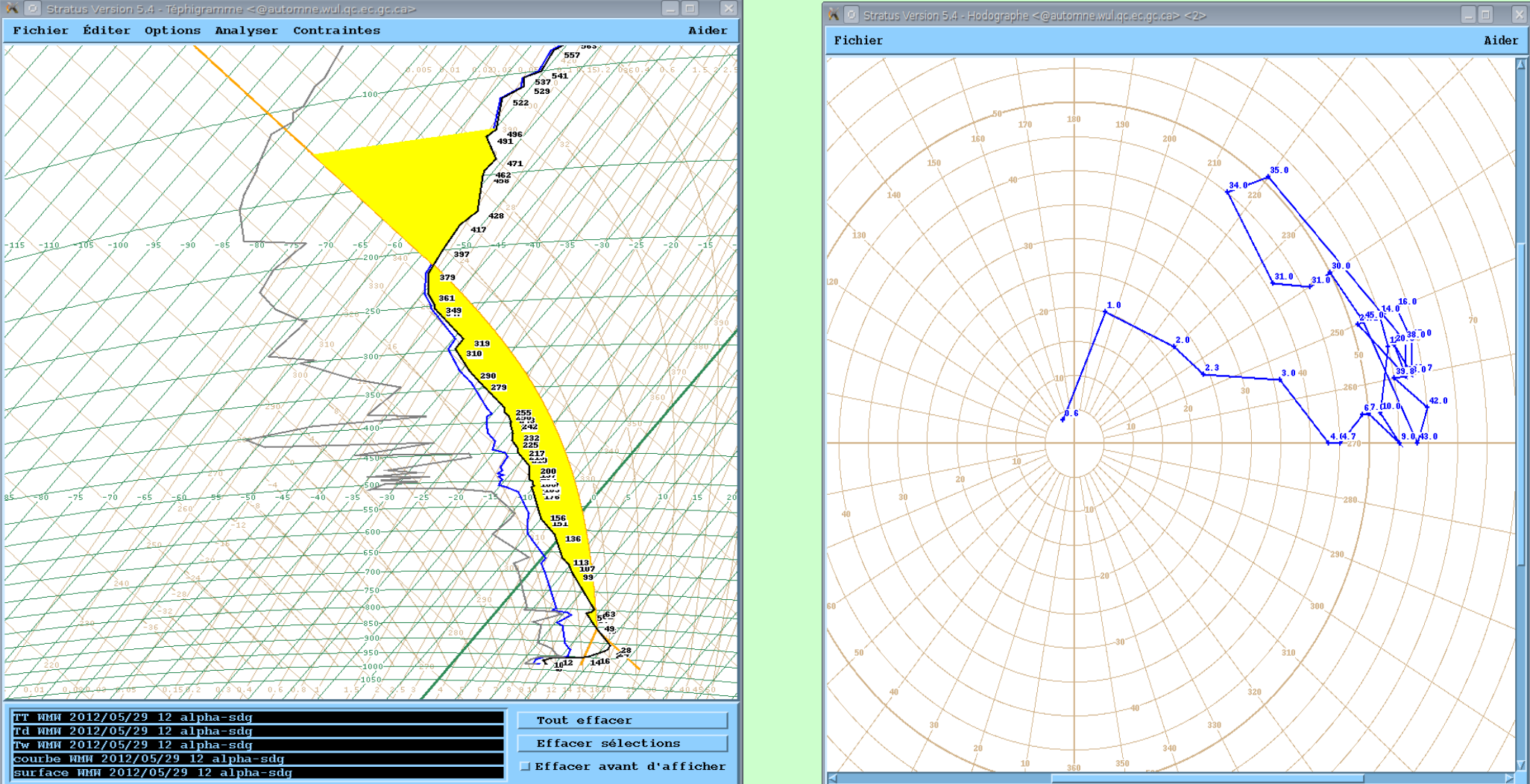
TR Guide – Low and Upper Level Jets



- In the morning of the 29th, we have a 40kt south-westerly LLJ (top left) in the Pontiac region, and it is fairly parallel to the ULJ at 250 mb (top right). GEM-REG 12Z 29 May 2012.
- In the evening of the 29th, the LLJ (bottom left) has migrated about 60 nautical miles to the east (in 12 hours), and remains parallel to the ULJ (bottom right). From GEM-REG 12Z May 29 2012.

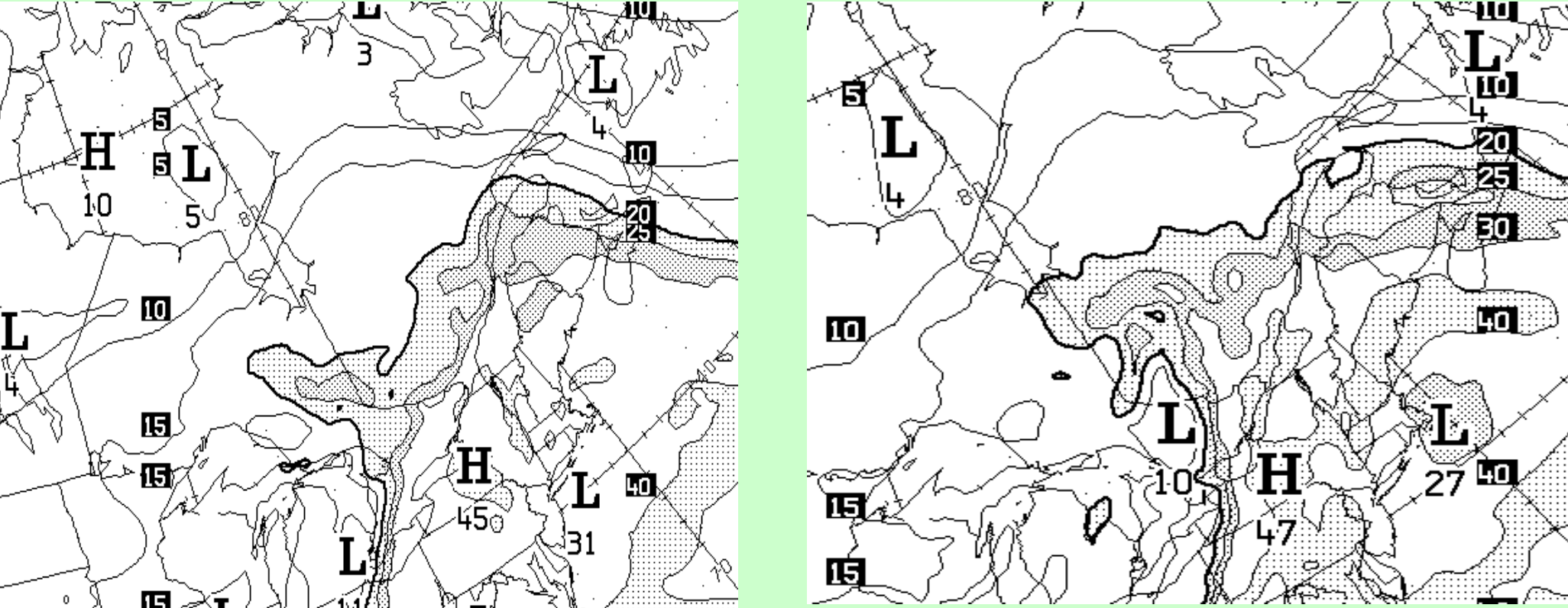


Energy Profile and Wind Shear



- The Maniwaki tephigram (top left) at 12Z modified for a forecast T=28°C and Td = 19°C. Gives possible CBs up to 48000 feet.
- The hodograph (top right) shows curvature to 4000 feet.
- CAPE=2000 J/Kg, Storm Severity Index (SSI) = 120.
- 0 to 6 km shear = 57, supercells probable.
- EHI = 4, strong possibility for tornadoes.
- Delta-theta E = 25 K, possible damaging wind gusts.
- The K index is 27 at Maniwaki and 39 at Albany (not shown).

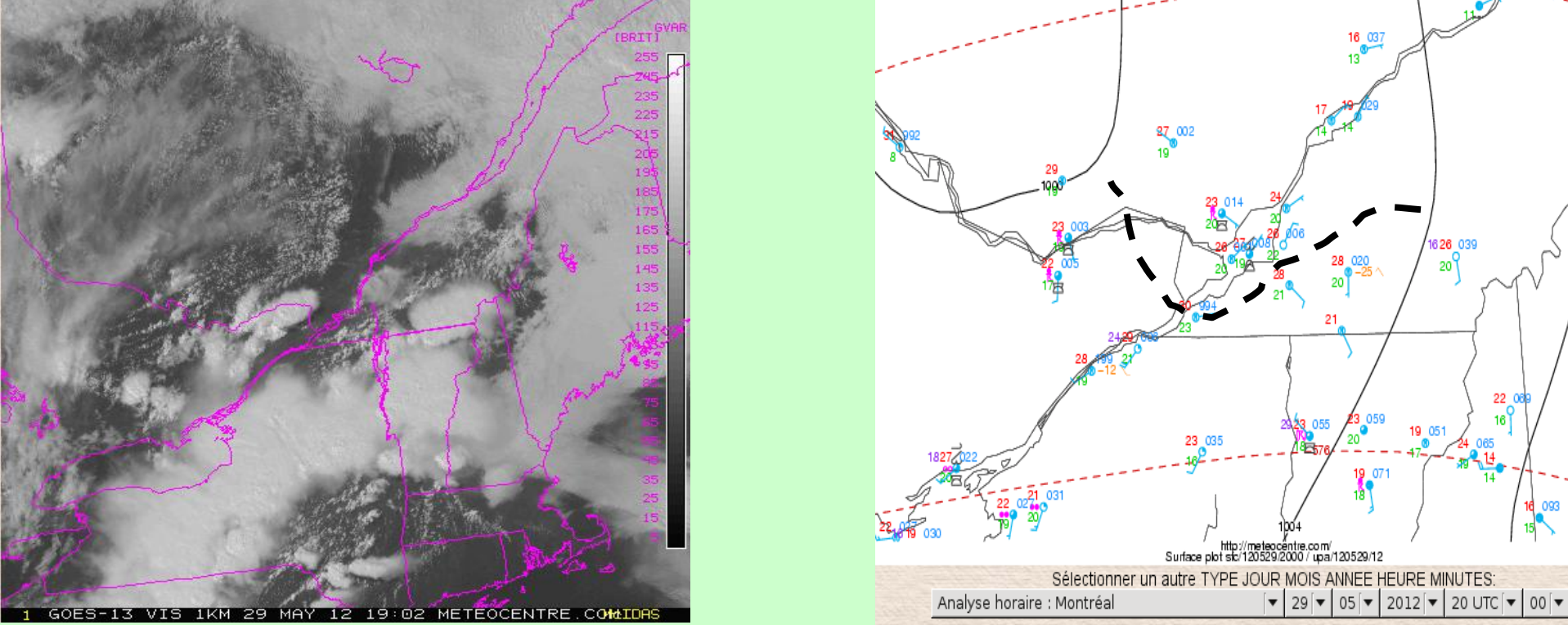
TR Guide – Precipitable Water



- Precipitable water for 18Z on the 29th (top left) and 00Z on the 30th (top right). GEM-REG 12Z May 29th 2012.
- Well placed moisture ridge with PWAT values around 45 mm over southwestern portions of the province.

TR Guide – Thermal Gradient and Convergence

- Visible satellite imagery at 19Z (left) shows clear sunny skies ahead of thunderstorm formation with clouds to the east.
- Surface observations at 20Z (right) show convergence between northeast winds along the Saint-Lawrence valley and southerly winds surrounding the region (also seen with CU formation).



Torrential Rain Evaluation

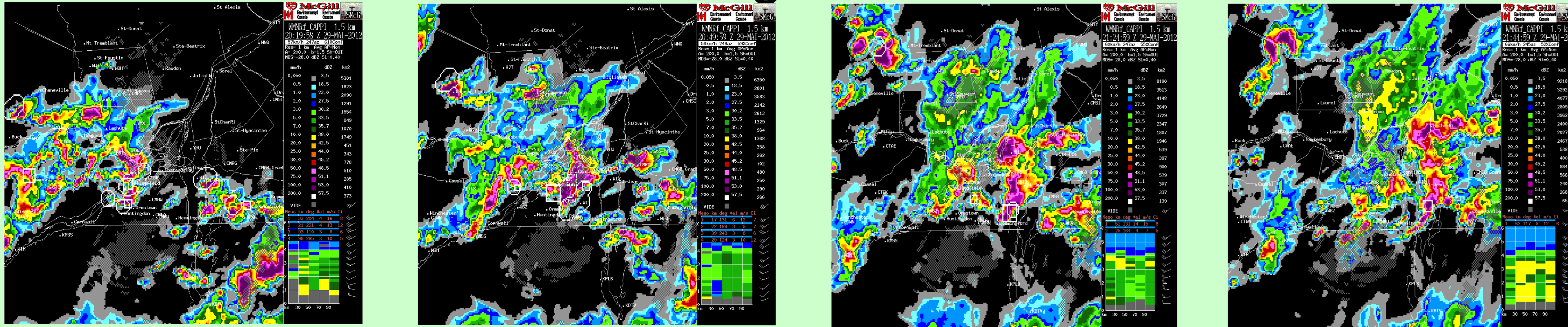
- The guide points to torrential rain in this case, the only ingredient missing is a skinny tephri profile. An updated addition to the guide narrows the extent and amount of rain:

QSPC Torrential Rain Guide for Diurnal Cases					
1. LLJ Slow moving	+ LLJ ≥ 35 kt	+ PWAT ridge ≥ 35mm	=	Small TR extent	
2. LLJ Slow moving	+ LLJ ≤ 30 kt	+ PWAT ridge ≥ 35mm	=	Small TR extent	
		+ PWAT ridge ≥ 45mm	=	TR Risk > 75mm over a small/large extent	
3. LLJ Average moving	+ LLJ ≤ 30 kt	+ PWAT ridge ≥ 35mm	=	Small/large TR extent	

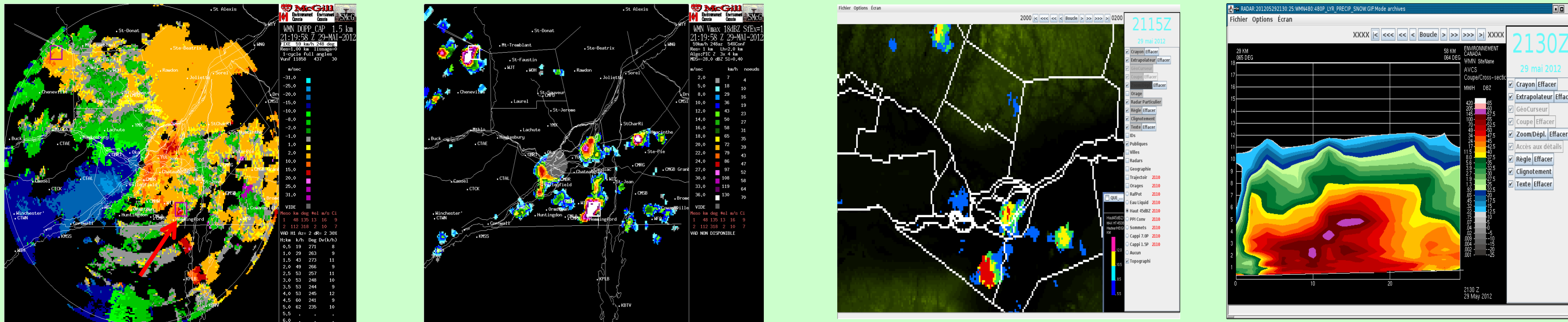
Note: Localised Torrential Rain (TR) can still occur if one or a few of these ingredients are missing.
Note: Slow moving Low Level Jet (LLJ): if ≤ 60 nautical miles in 6 hours / Average moving LLJ: if 60-120 nautical miles in 6 hours
Note: "Small TR extent" < 1000 km² / "Large TR extent" > 1000 km² (1000 km² = approximately 2X Island of Montreal). "Extent" corresponds to the area that covers related TR reports.

- According to the previous table, this case would be somewhere between number 1 and 2 (part 2): Slow moving LLJ + LLJ > 35 knots + PWAT ridge > 45 mm, giving small extent of TR, but risk of > 75mm.

Radar Images of the Event



Cappi at 4:20 PM, 4:50 PM, 5:25 PM and 5:45 PM (above). Note the strong cells moving over the Upper Gatineau, Montreal, Huntingdon and the Richelieu. McGill radar echoes are hidden as the cells pass directly over the radar dome only to "reappear" over downtown Montreal as they move away from the McGill radar.



Cappi Doppler at 5:20 PM (left). Rotation detected near Ormstown, but no tornado was reported. Downdraft potential at 5:20 PM (middle left). Hail likely interferes with data on the South Shore. Height of the 45 dBZ at 5:15 PM (middle right) and the vertical cross-section of the storm after it hit Montreal at 5:30 PM (right).

Hail Evaluation

- The guide below is used to determine the if hail can be anticipated and what hailstone size according to the tephigram profile:

Freezing level from T* profile of interest CB	< 10 000'	Between 10 000' et 14 000' inclusively	> 14 000'	> 14 000'
Sounding freezing level	n/a	n/a	≤ 13 000'	> 14 000'
Profile type between CB T* and environment T* for a layer from -5 to -25 °C approximately	n/a	Skinny profile	Medium or fat profile	Fat profile
Hailstone size	Small hail (< 2cm)	Small hail (< 2cm)	Large hail (≥ 2cm but generally 2-4cm) OR Very large hail (> 4cm)	Large hail (≥ 2cm) OR No hail reported

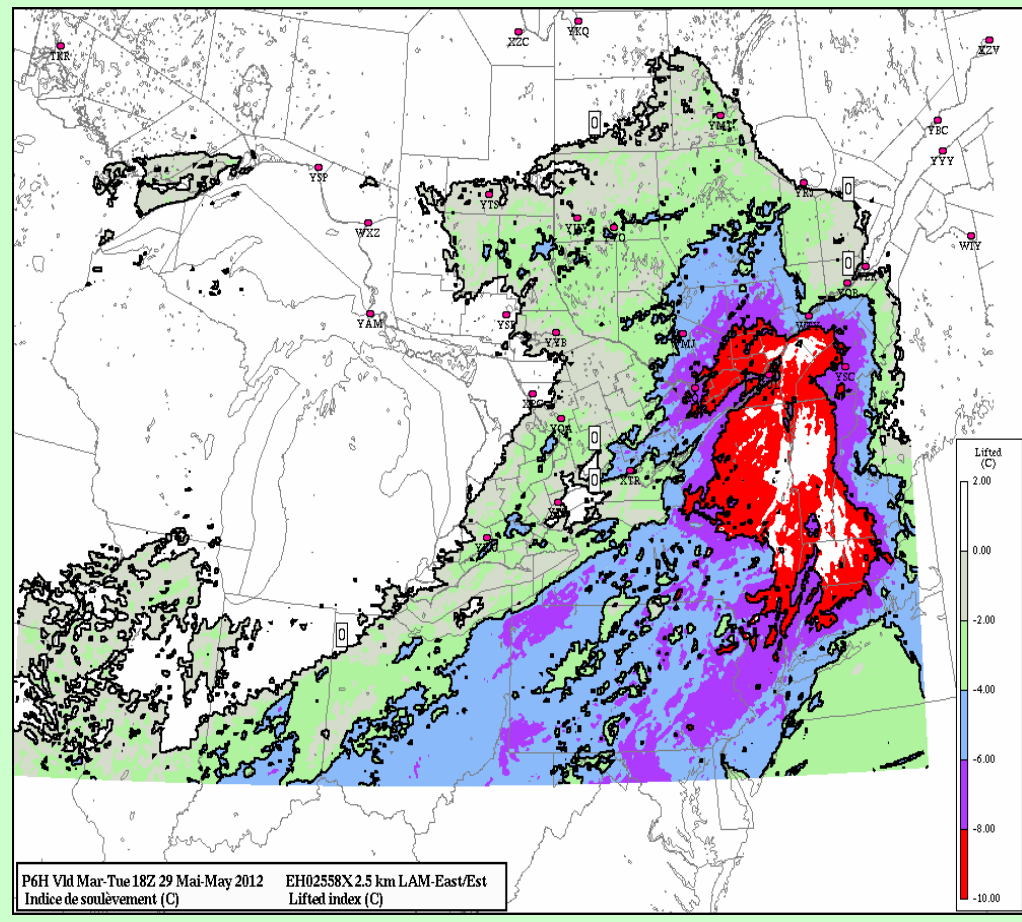
DEFINITIONS :
skinny profile : ≤ 4 °C medium profile : 5-7 °C fat profile : ≥ 8 °C

- According to the table, and the information from the tephigram analysis above, large hail is possible given the freezing level at 13000 ft, an inferred CB freezing level at 16000 ft and a medium profile.
- 4 cm diameter hail was reported south of Montreal.

Microburst Evaluation

Listed below are a few favourable ingredients for microbursts in a humid air mass that were present in this case:

- Unstable air mass: CAPE = 2000 J/Kg and Lifted Index of nearly -10 according to GEM-LAM at 18Z on the 29th (right).
- The Delta Theta-E from the teph analysis was 25 K.
- Cloud base at about 850 mb.
- LLJ at about 40 kts.
- 100 km/hr winds gusts were reported.



Large hail at St-Jean-sur-Richelieu (left) and uprooted trees at Duhamel in the Upper Gatineau (right).

Conclusion

- A number of lines of severe thunderstorms formed along and in front of an important cold front.
- Upper Gatineau, Montreal and the South Shore were hard hit by strong gusts, torrential rain and large hail.
- Most ingredients pointed to the possibility of torrential rain as seen in the forecast guide.
- Hail evaluation using the Hail Anticipation guide correctly estimated the size of some reported hailstones.
- The microburst evaluation correctly pointed to the potential for damaging wind gusts.

References

Mainville, S. 2004. **Heavy convective rain events over Québec: a forecasting tool.** preprint AMS 22nd Conference on Severe Local Storms, P8.7.