Development of an Extreme Forecast Index (EFI): Preliminary Results

Hai Lin
RPN-A, Environment Canada

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Outlines

- Introduction of EFI
- Application of EFI in GEPS
- Case studies:
  - November 27, 2011 Alberta Chinook
  - January 2012 Prairie high temperature
  - Extreme warm March 2012
- Future work

Extreme Forecast Index (EFI)

- Early detection of abnormal weather conditions

  Lalaurette (Q.J.R.Meteorol.Soc. 2003)

EFI is an integral measure of the departure of an EPS forecast from the reference climate distribution.

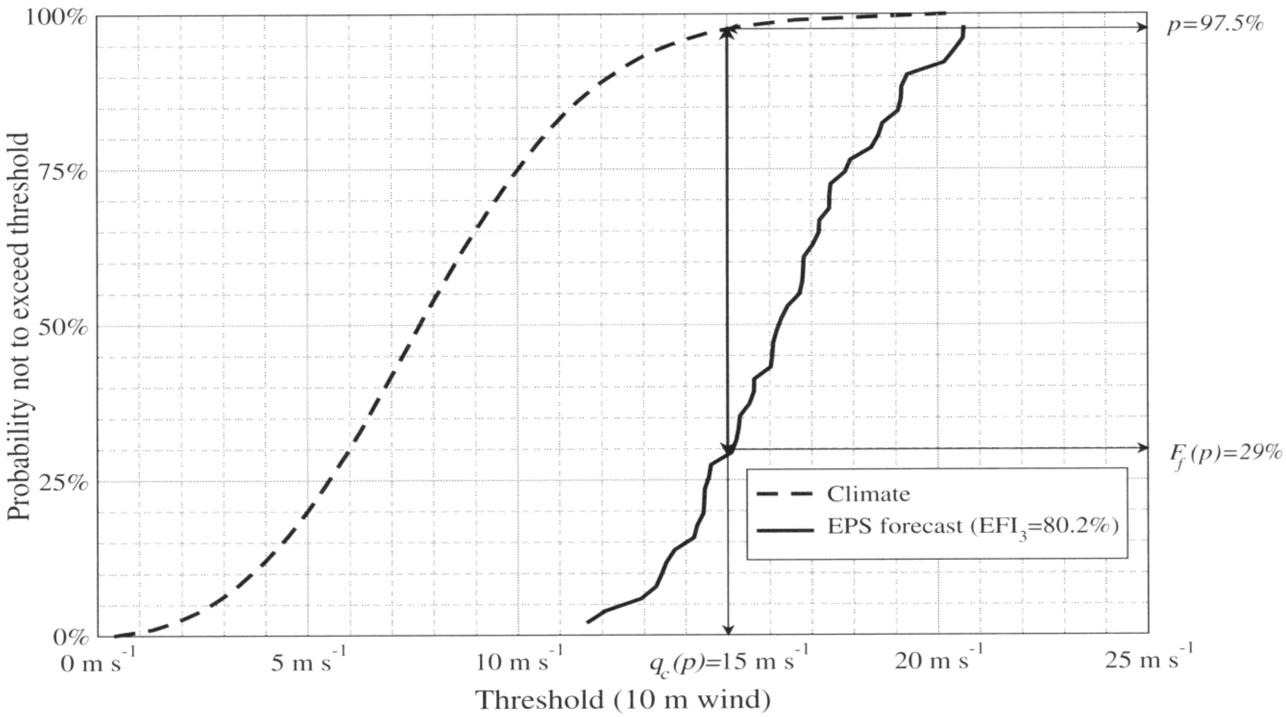
Extreme Forecast Index (EFI)

Reference climate distribution is determined by the history of the forecasting system (model climate)

Assume: extremes (rare cases) in model climate corresponds to extremes in reality

(systematic biases are automatically removed)

Extreme Forecast Index (Lalaurette, 2003)



The EFI is a measure of the difference between the model climatological forecast distribution and the current ensemble forecast distribution.

CDF: cumulative distribution function

$$EFI_{2m+1} = 2(m+1)\int_0^1 \{p - F_f(p)\}^{2m+1} dp$$

Extreme Forecast Index (EFI)

- EFI is considered a useful addition to EPS products. Directly related to severe weather (wind, temperature and rainfall)
- ECMWF has produced EFI information since January 2002.
- EFI ranges from -1 to +1.

>0 for above normal and <0 for below normal; 0 indicates a forecast equivalent to the model climate.

Revised formulation of EFI (Zsooter 2006): more sensitive to infrequent and unusual events located at the tails of the distribution

$$EFI_{AD} = \frac{2}{\pi}\int_0^1 \frac{p - F_f(p)}{\sqrt{p(1-p)}}dp$$

$F_f(p)$: the proportion of EPS members lying below the p percentile of the reference climate record.

GEPS system climate

- A crucial step for EFI calculation
- CMC GEPS has different physics for different members.
  It is not feasible to obtain a climatology for each configuration
- We will treat the whole package as a system → "system" climate (in contrast to model climate)

GEPS system climate

How to estimate the system climate?

Three possible approaches:

1) ECMWF early approach (tested)
2) Modified approach (tested)
3) Historical reforecasts (future…)

1) ECMWF early approach

Based on a relatively consistent EPS forecasts.

For each month, the EFI climate uses 3 months of EPS forecasts

- The current month of the previous year
- The following month of the previous year
- The previous month of the current year

The analysis and day-5 and day-10 forecasts are pooled for each 00 UTC EPS run

Size: 3months x 30days x (1+21members+21members)=3870

Shortcoming

1) A big window (3 months)
2) Too much weight on the previous year (two months)
3) Same climate for different lead times

2) Modified approach

Still based on a relatively consistent EPS forecasts.

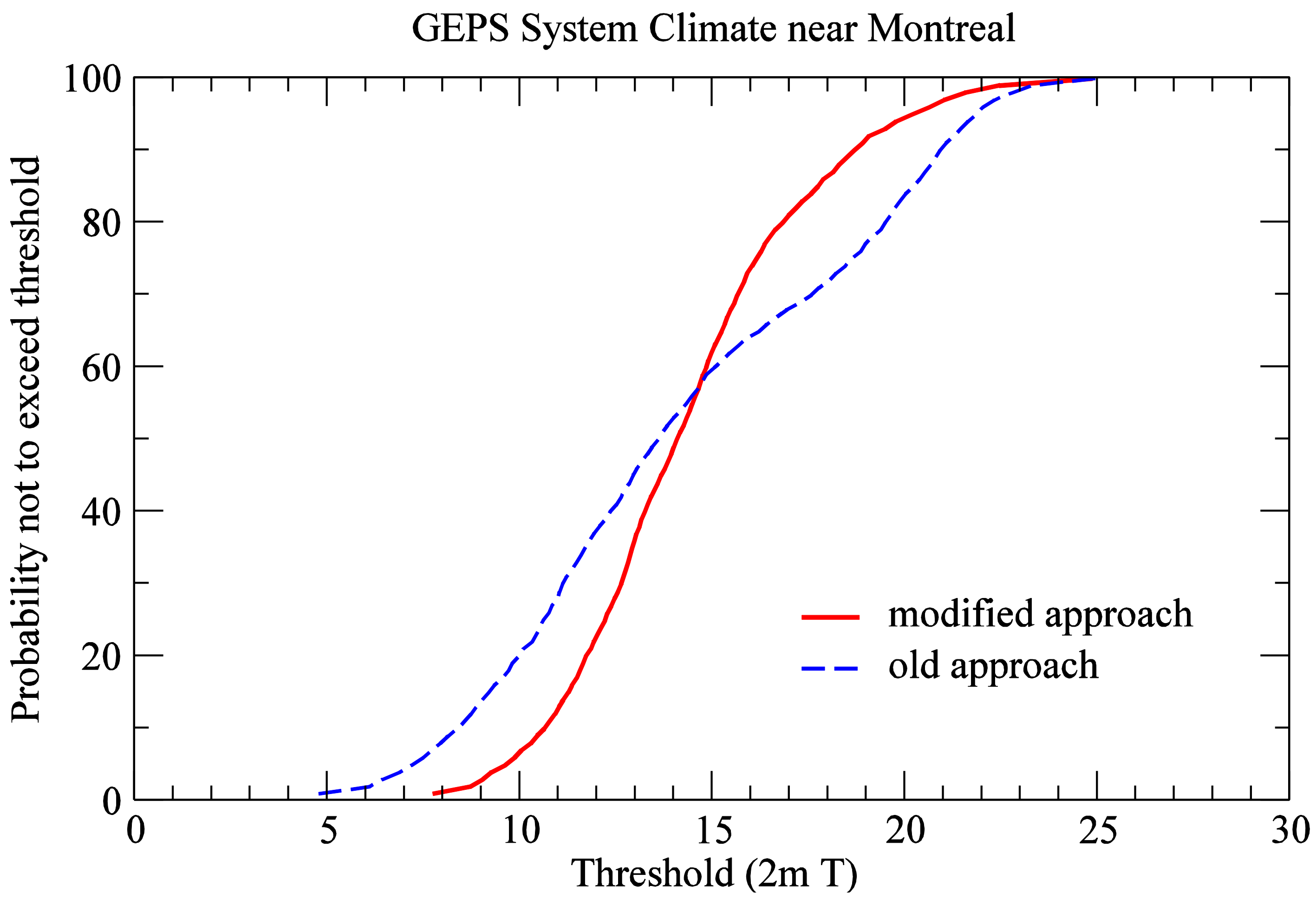
For each forecast day, the EFI climate uses EPS forecasts in the previous 3 years. Each year has 31 days centered at the same date of the forecast month

All forecasts with the same lead time are pooled for each 00 UTC EPS run. Therefore the climate is dependent on lead time

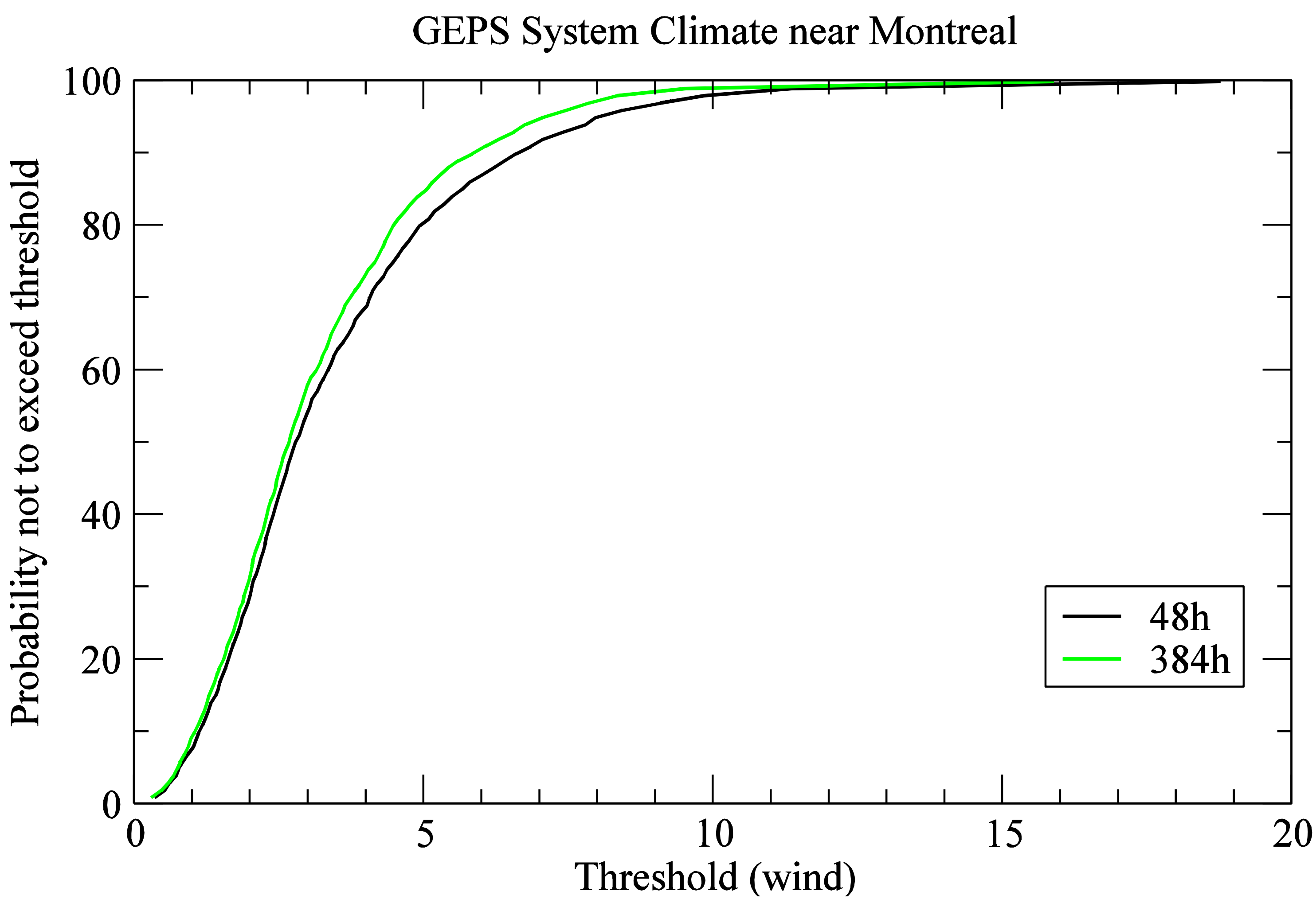
Size: 3years x 31days x 21members=1953

Shortcoming

1) No recent forecast data (could be improved if including the previous 15 days of the current day)
2) Still covers limited years (3 years)



For June 15, 2011. modified approach for 120-h forecast



10m wind speed. Dependence of lead time

EFI products

Lead time from 24 to 240 hours

- Daily 2m air temperature (at 00UTC)
- Daily 10m wind speed (at 00UTC)
- Total precipitation:

  -- 1-day accumulation daily

  -- 5-day accumulation

  -- 10-day accumulation

EFI products

EFI value

- 60% - 80%: unusual (warm, windy, rainy, etc)
- >80%: very unusual or extreme
- For temperature, negative values of equal interest

- In experimental mode since October 2011, daily products available

Case 1

Calgary Chinook

Nov. 27, 2011

Calgary Chinook (Nov. 27, 2011)

1:00-5:00pm

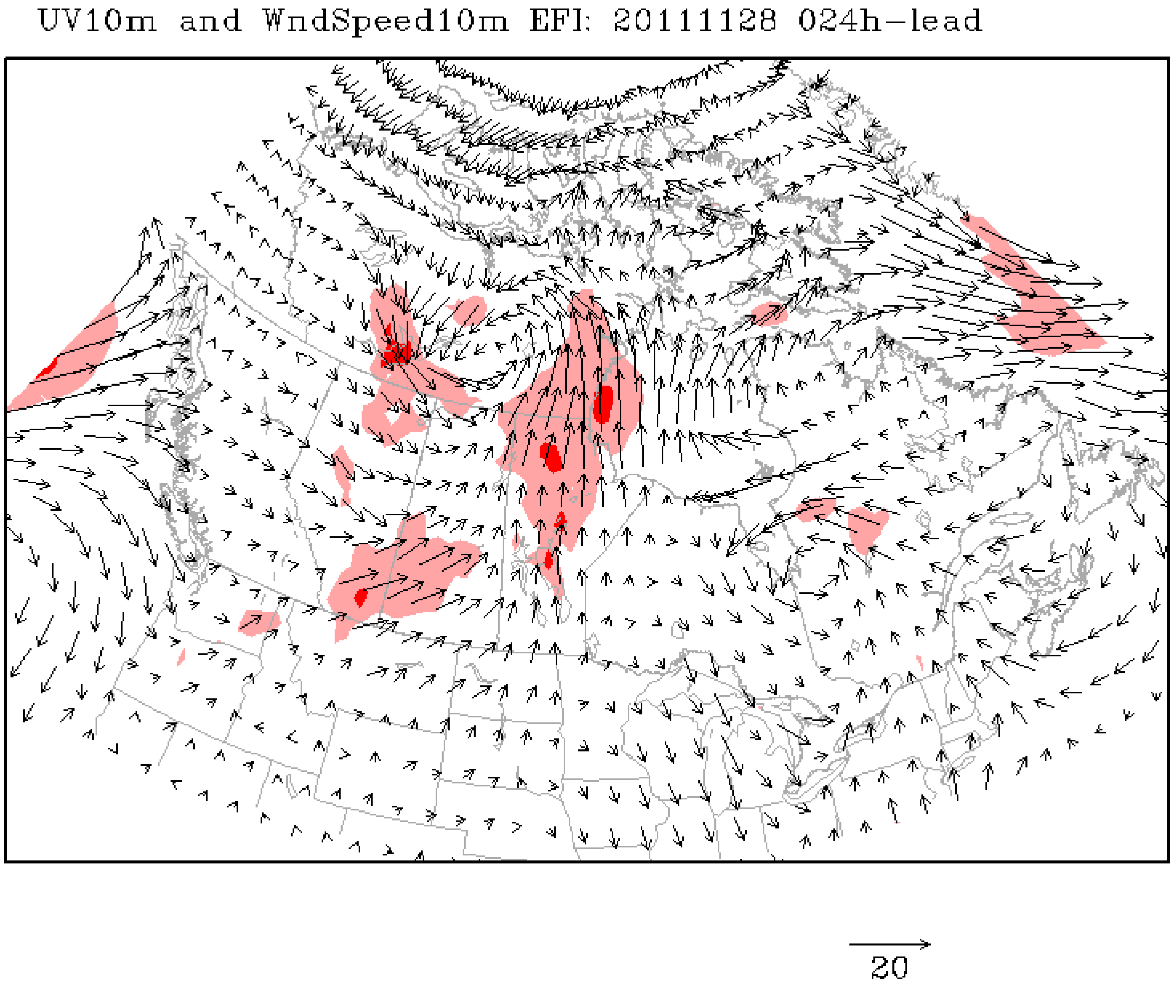
Calgary downtown wind: 149km/h

Category 1 hurricane force winds

temperature of 13C, well above the freezing-point average for this time of year

http://www.globaltvcalgary.com/explainer/6442530854/story.html

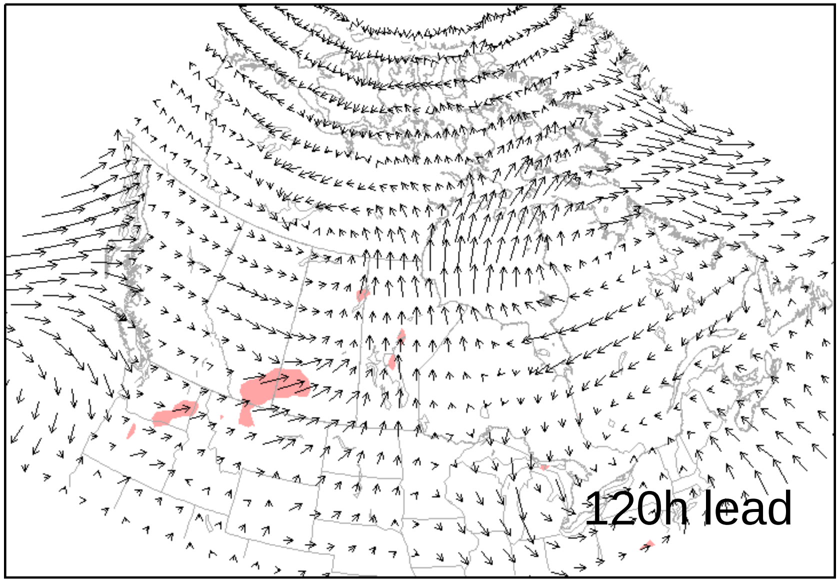
Verification time: Nov 27th 7:00pm EST



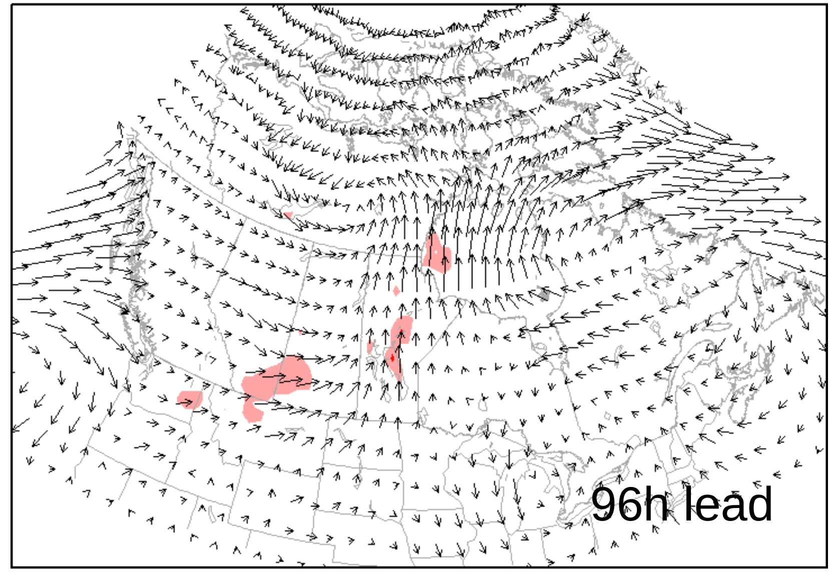
Vector: forecast 10m wind
Pink: Unusual windy, EFI from 0.6 to 0.8
Red: Extreme windy, EFI greater than 0.8

Verification time: Nov 27th 7:00pm

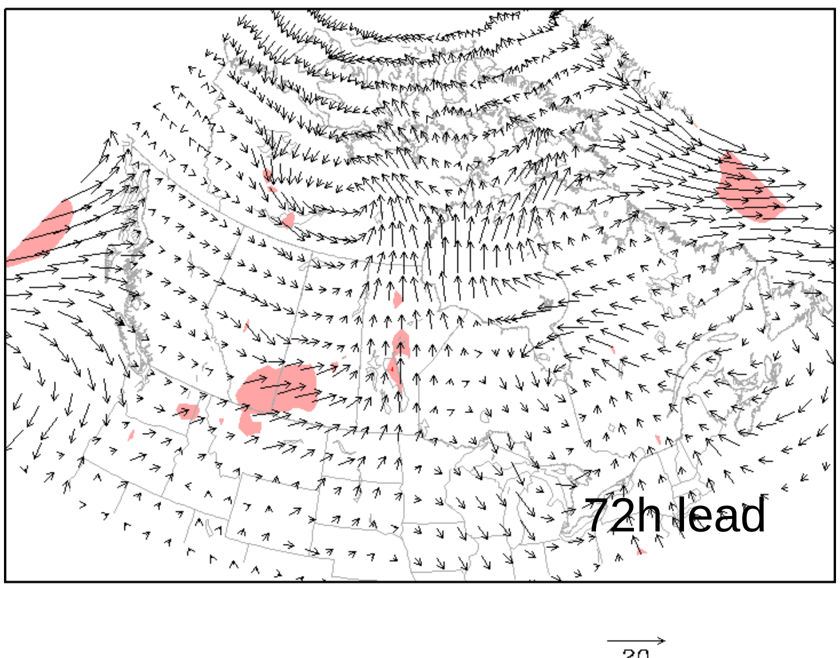
UV10m and WndSpeed10m EFI: 20111128 120h-lead



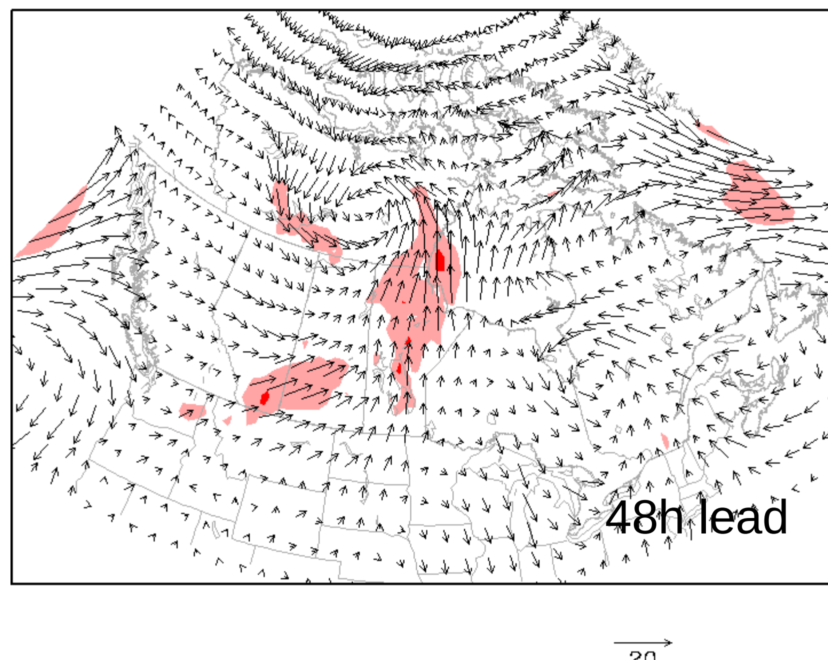
UV10m and WndSpeed10m EFI: 20111128 096h-lead



UV10m and WndSpeed10m EFI: 20111128 072h-lead



UV10m and WndSpeed10m EFI: 20111128 048h-lead



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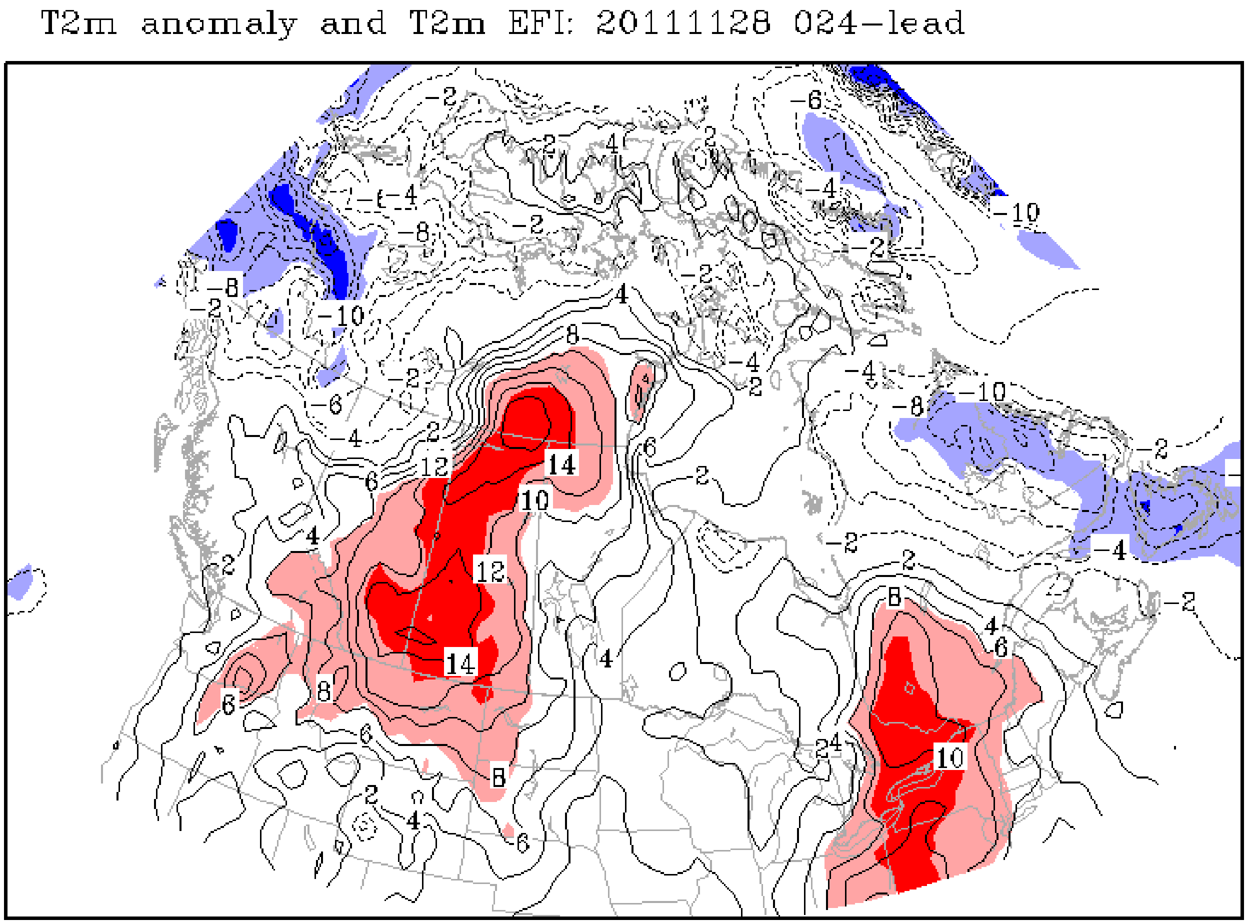
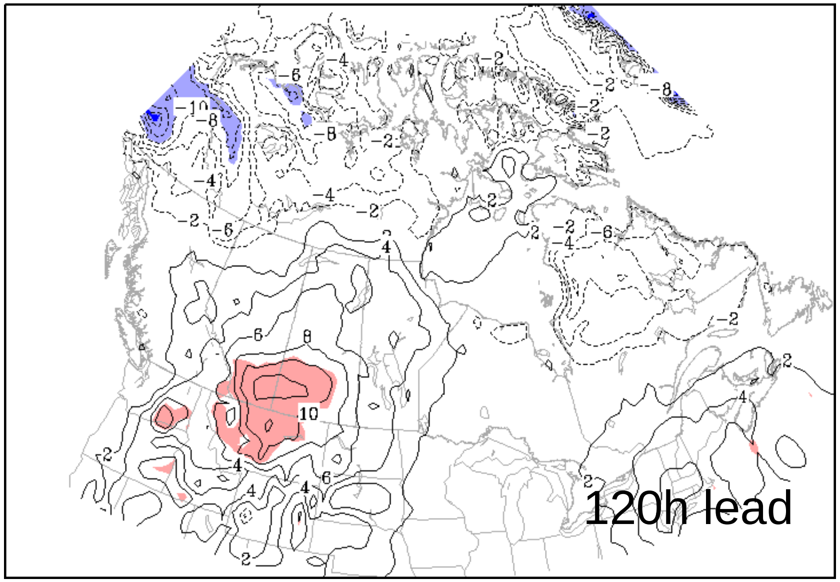
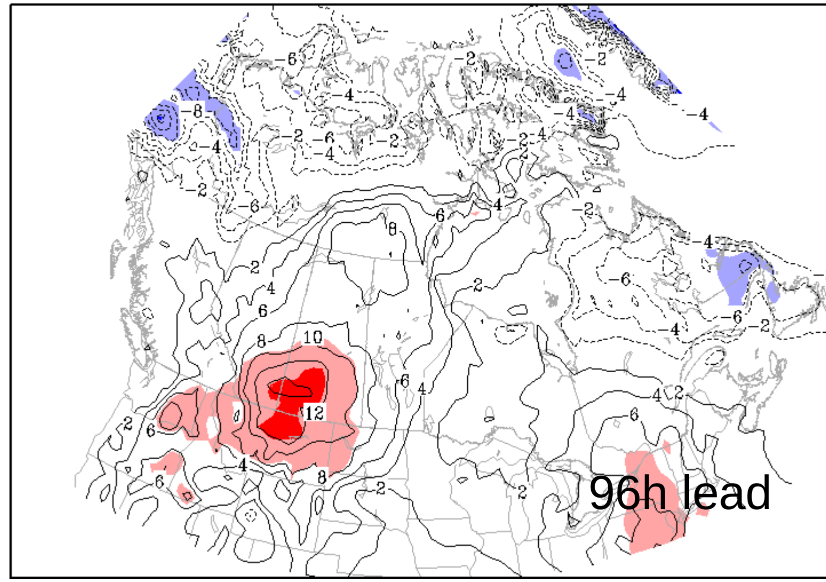


Verification time: Nov 27th 7:00pm

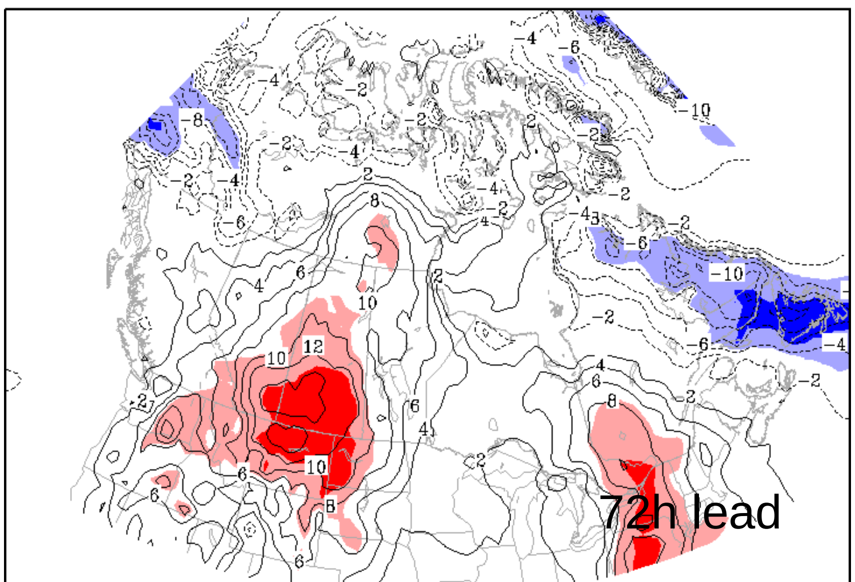
T2m anomaly and T2m EFI: 20111128 120h–lead



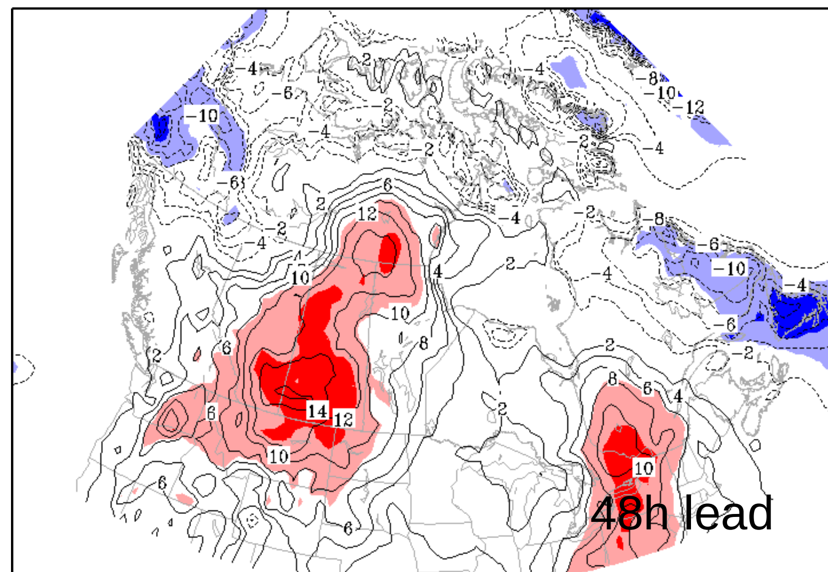
T2m anomaly and T2m EFI: 20111128 096h–lead



T2m anomaly and T2m EFI: 20111128 072–lead



T2m anomaly and T2m EFI: 20111128 048–lead



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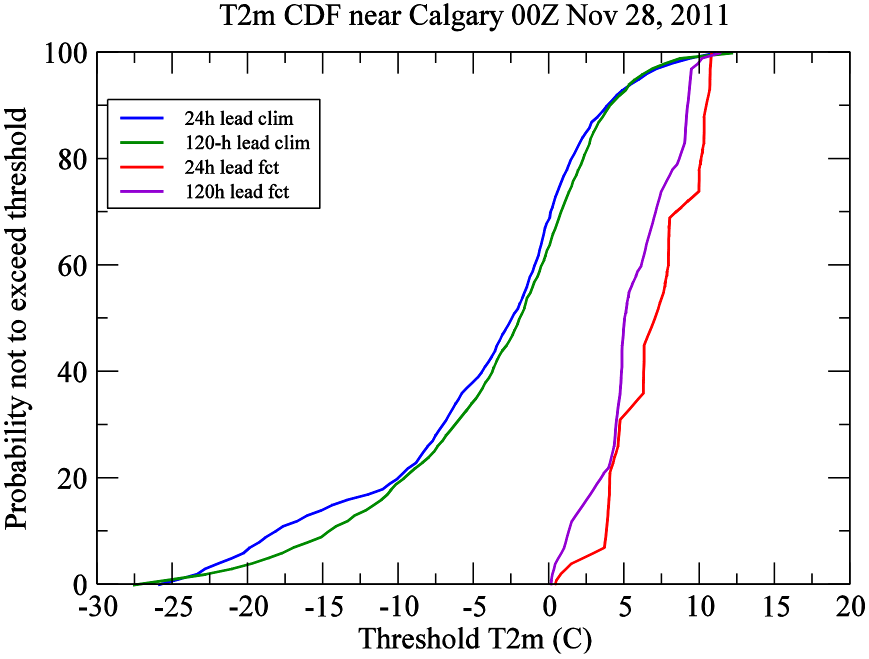
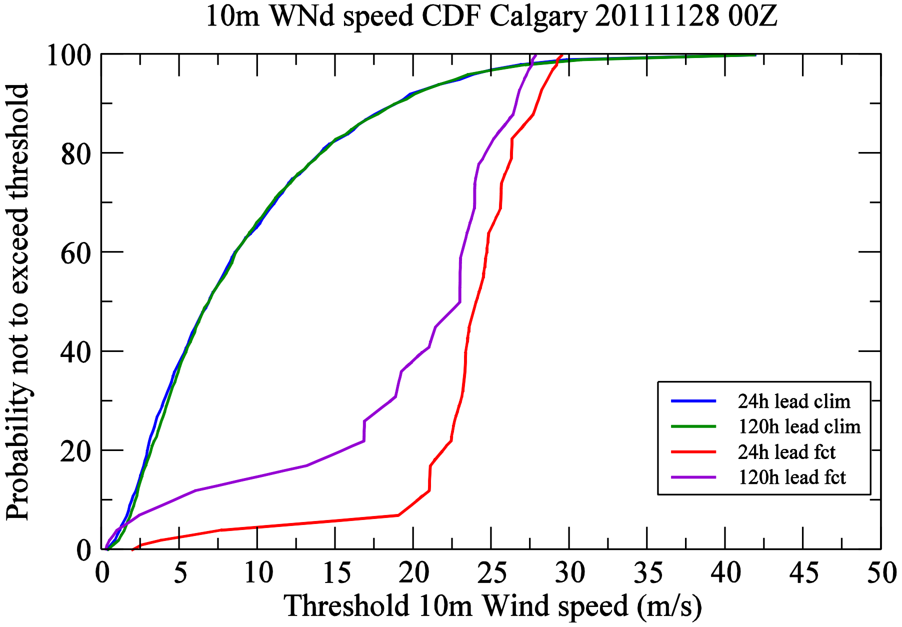




Case 2

Prairies high temperature

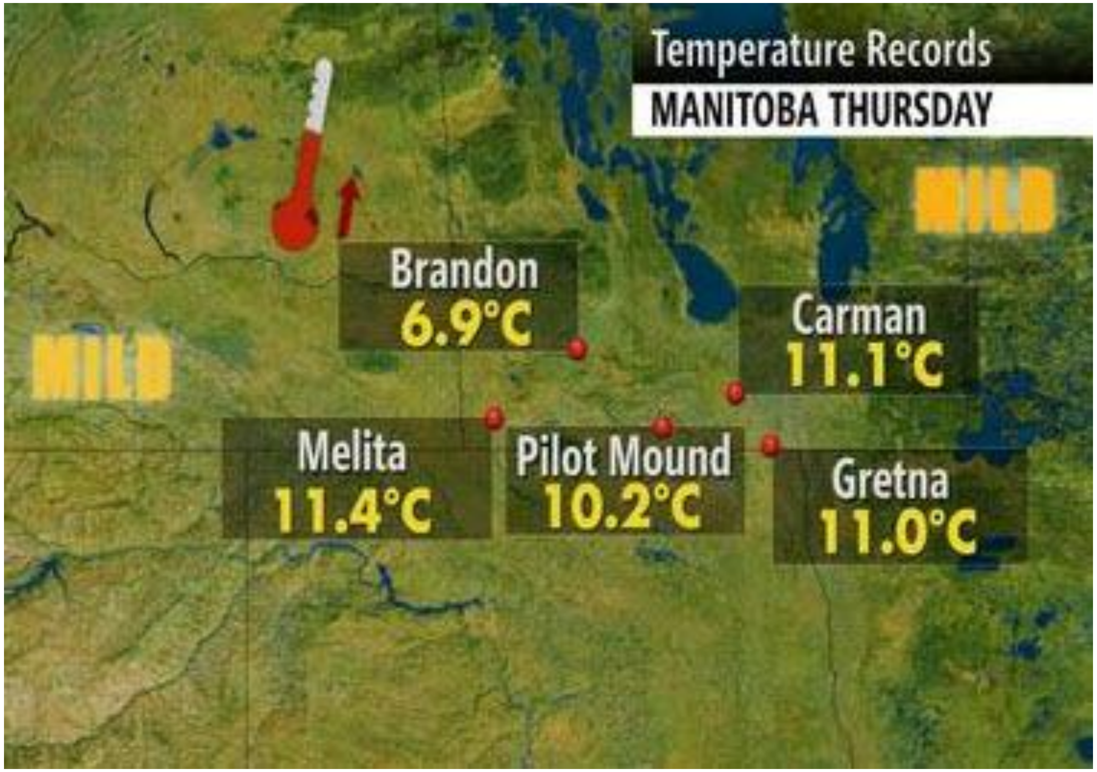
Jan. 5, 2012

Prairies high temperature ,Jan. 5, 2012

- **Record temperatures in western Canada**
- **Warm, dry and windy weather also contributed to grass fires**

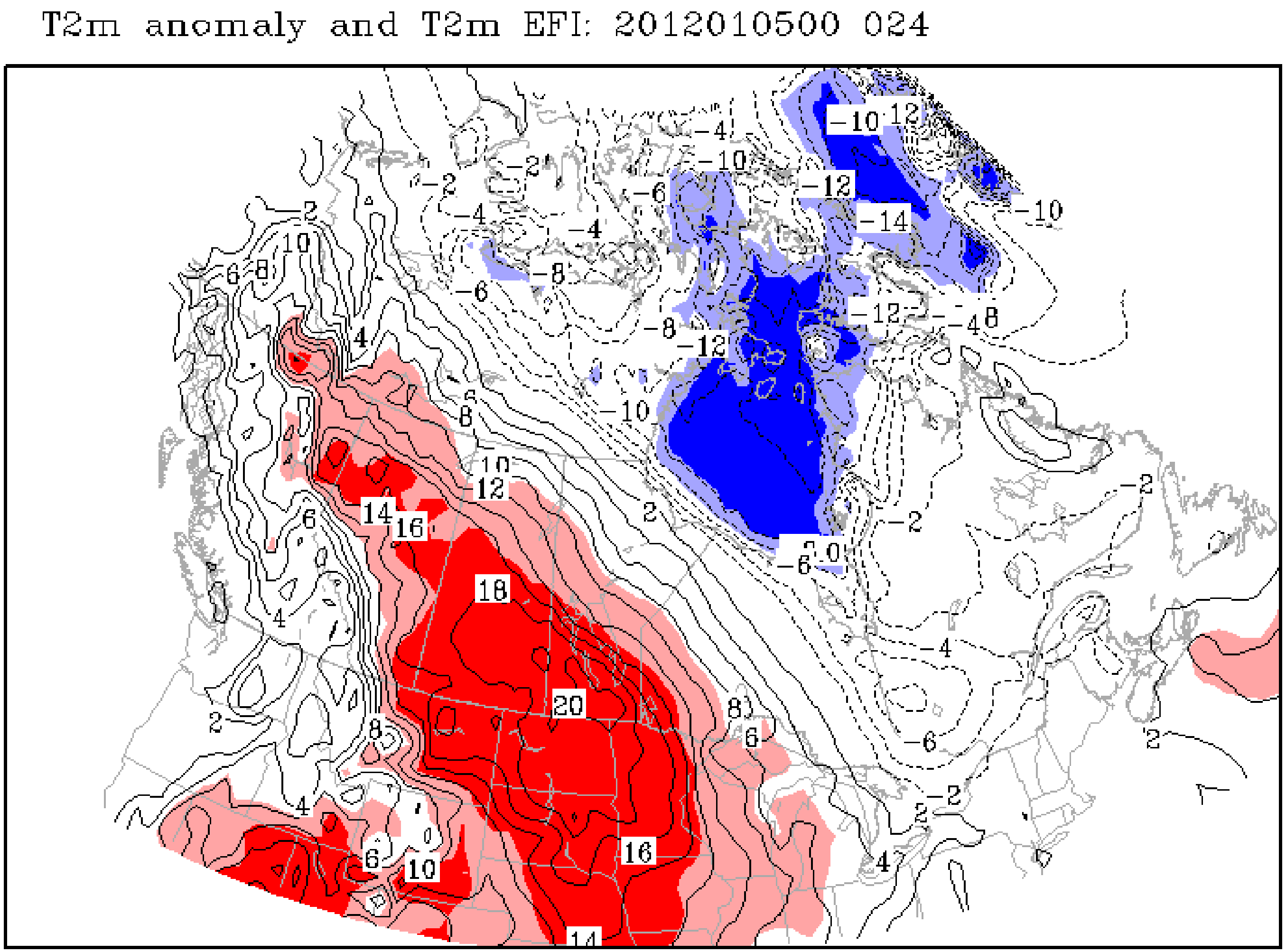
- **Calgary soared to 15.3°C, breaking a record set 98 years ago.**

January 5th, 2012, Manitoba



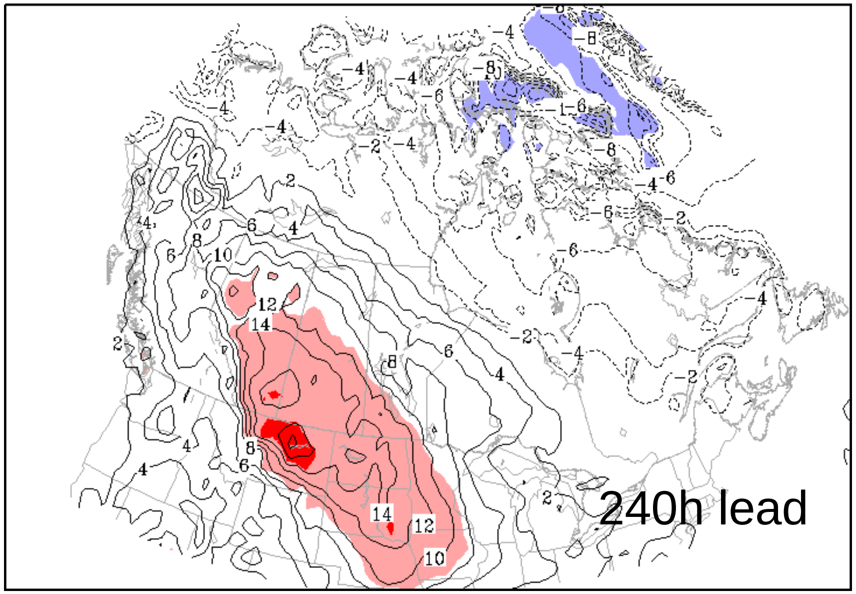
From: http://www.theweathernetwork.com

Verification time: Jan 5th 7:00pm

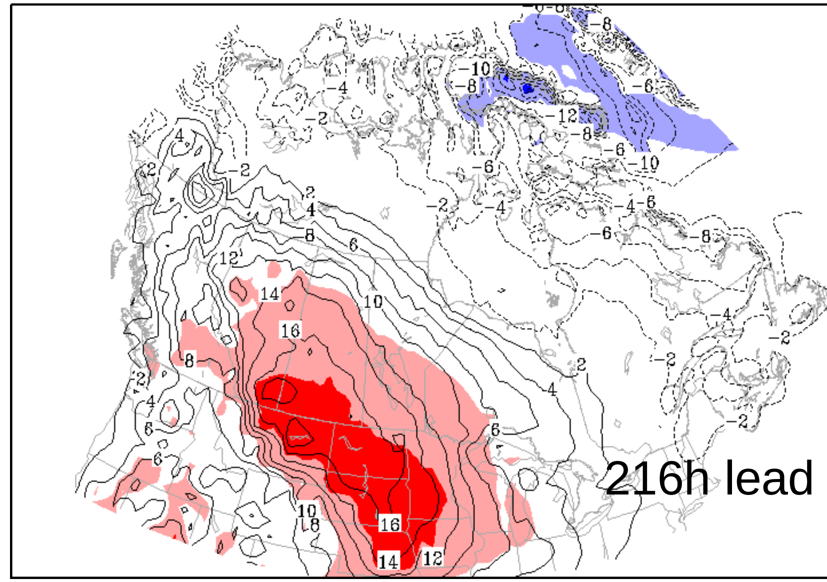


Verification time: January 5th 7:00pm

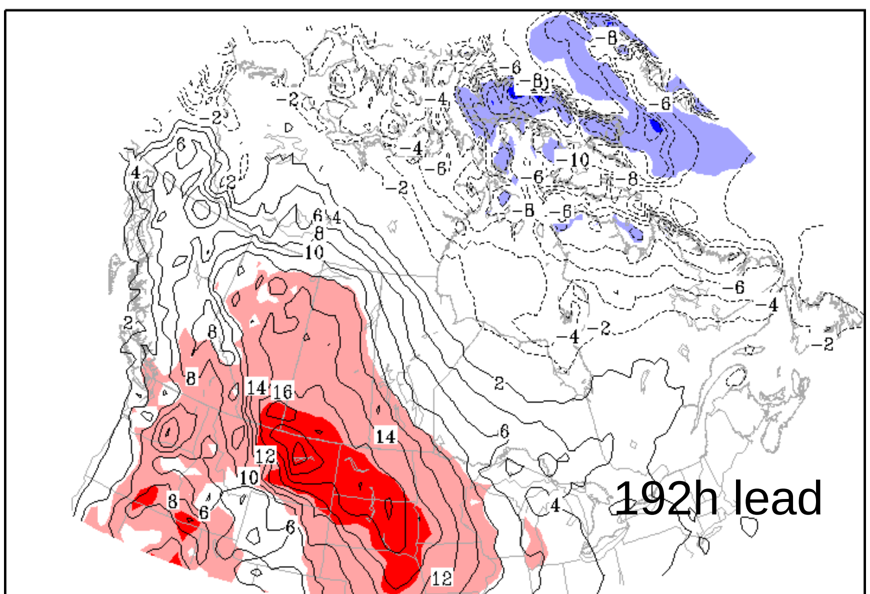
T2m anomaly and T2m EFI: 2011122700 240



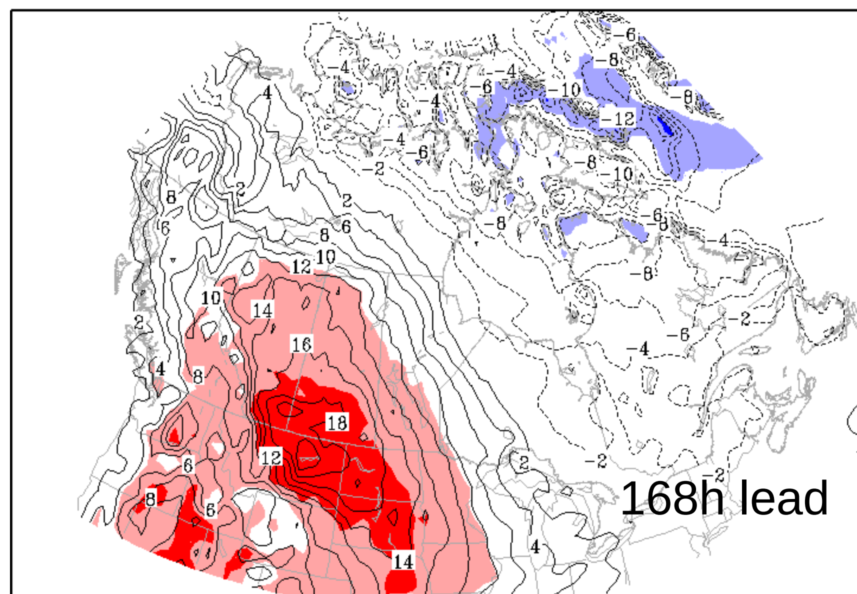
T2m anomaly and T2m EFI: 2011122800 216



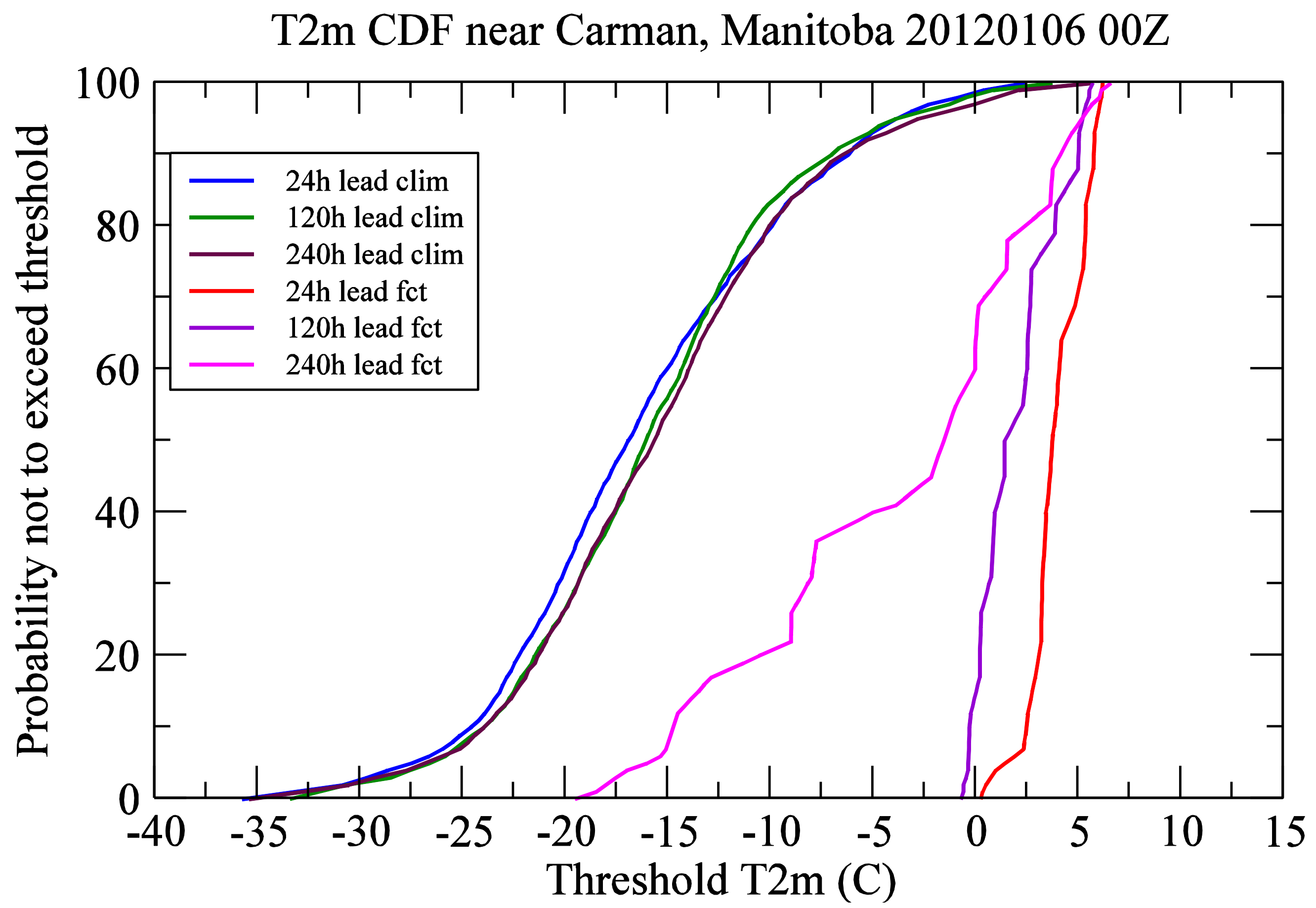
T2m anomaly and T2m EFI: 2011122900 192



T2m anomaly and T2m EFI: 2011123000 168



Verification time: Jan 5th 7:00pm



Case 3

Extreme warm March

March 13-22, 2012

Extreme warm March, 2012

- Multiple Canadian cites break all-time April records for warmth in March

On March 21, 2012:

St. John, New Brunswick 25.4C (previous March record 17.5C, April 22.8C)
Halifax, Nova Scotia 25.8C (All time March record 25.6C, April 26.3C)
Ottawa (27.4C), Montreal (25.8C), Windsor (27.8C), Hamilton (25.6C), London (26.4C), and Fredericton (27.1C)

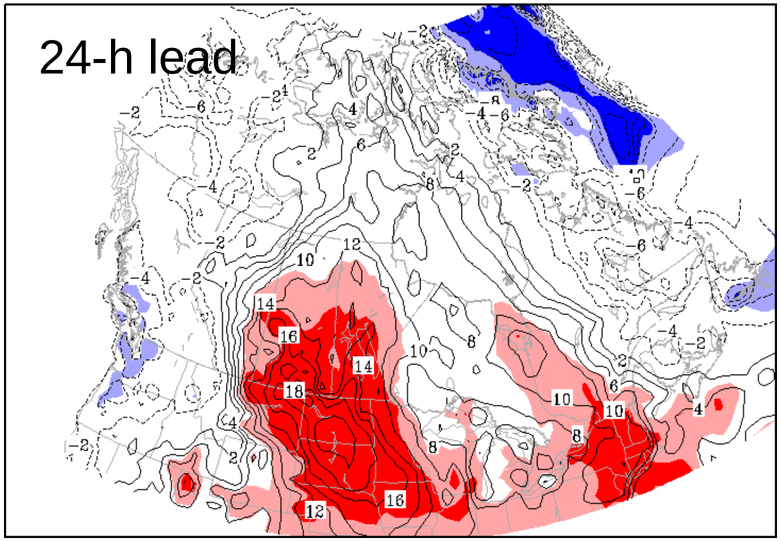
- For much of March, record temperatures hit as high as 35 degrees above normal and averaged about 18 degrees warmer than usual

Source: thinkprogress.org, USAToday, huliq.com

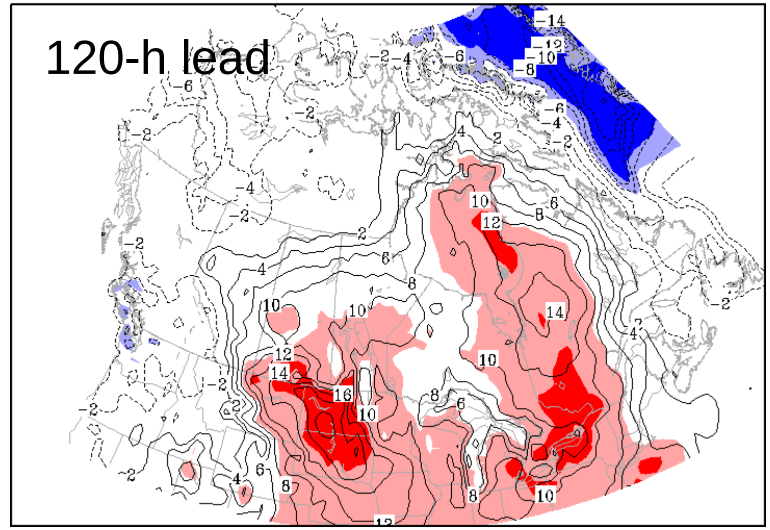
March 13 7:00pm

Event Start

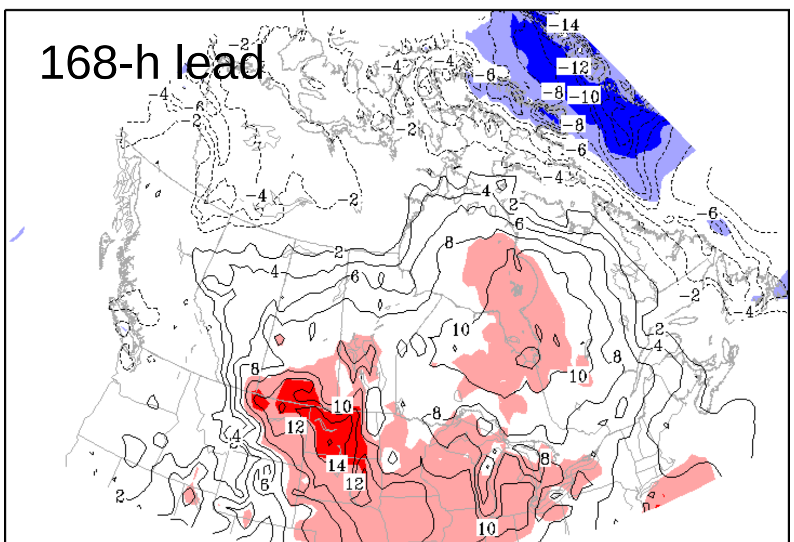
T2m anomaly and T2m EFI: 2012031300 024



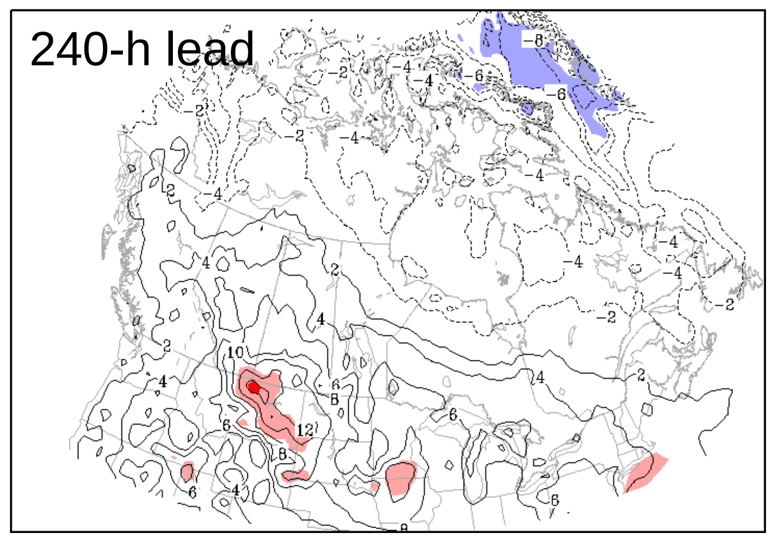
T2m anomaly and T2m EFI: 2012030900 120



T2m anomaly and T2m EFI: 2012030700 168



T2m anomaly and T2m EFI: 2012030400 240

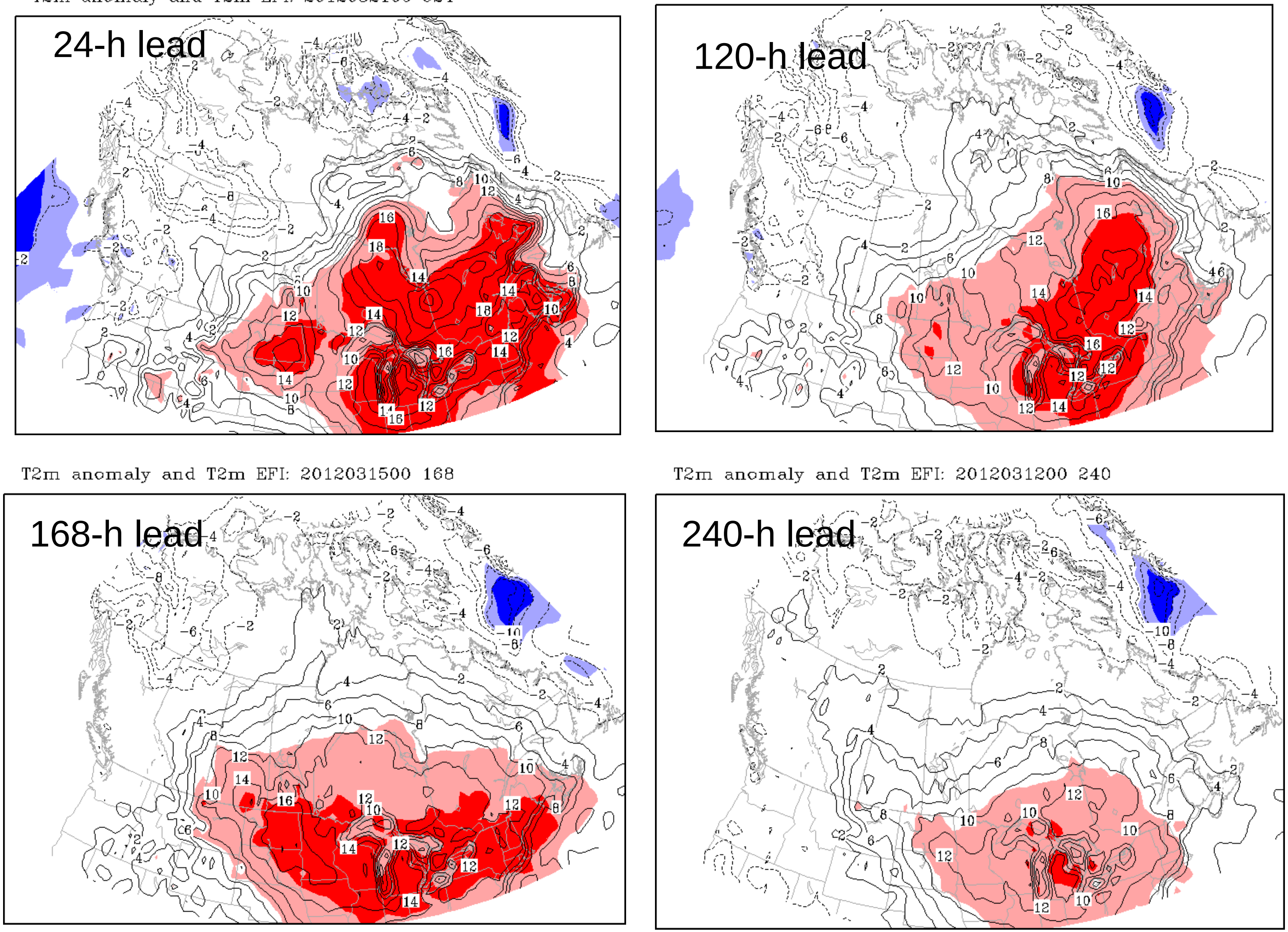


March 21 7:00pm

Event Peak

T2m anomaly and T2m EFI: 2012032100 024

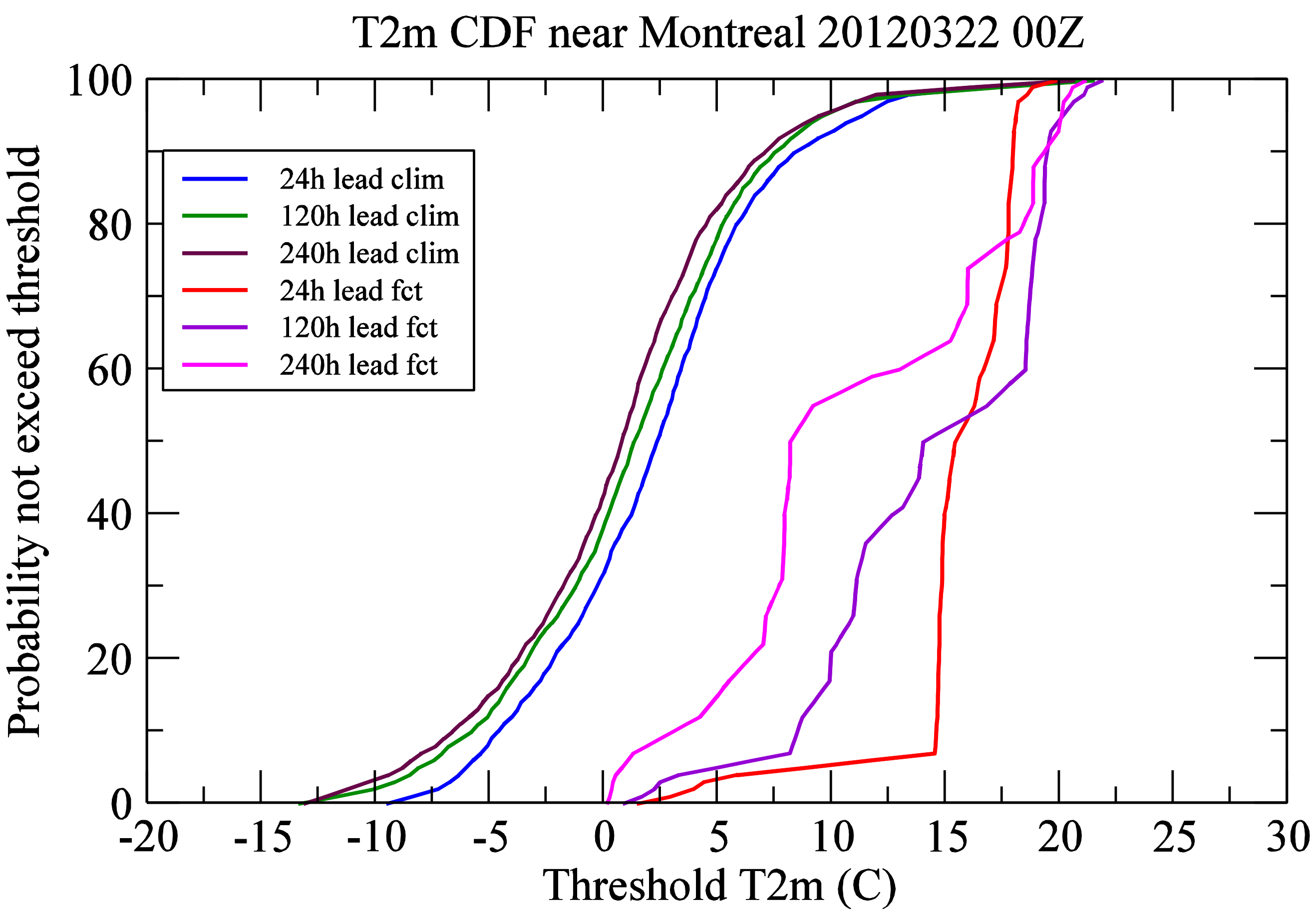
T2m anomaly and T2m EFI: 2012031700 120



T2m anomaly and T2m EFI: 2012031500 168

T2m anomaly and T2m EFI: 2012031200 240

Verification time: March 21 7:00pm



Summary

- A framework for EFI calculation has been set up for CMC GEPS
- Two approaches of estimating system climate have been tested
- Using the past three years of 31-day windows gives a superior climate estimation
- Dependence on lead time should be considered in climate estimation
- Usefulness of EFI is demonstrated for Canadian extreme events in the past half year

Future work

- Implementation in early summer of 2012
- Create task in Maestro that produces the maps (then into VIZAWEB)
- It is planned to improve climate distribution using historical weekly reforecasts (past 20 years, 4 members, 5 weeks)
- Verification system against analysis?

Thank you!