Environnement Canada Environment Canada

Canada

The First WMO Workshop on
Operational Climate Prediction
Pune, India, 9-11 November, 2015

Current Operational Practices for Producing Long-range Forecasts at Environment Canada

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(aka CMC)

Outline

- The Canadian context
- The forecast production timeline
- Climate bulletins
  - National Seasonal Outlook Briefing bulletin (internal)
  - Regional bulletins on climate impacts and outlook
- Summary

The Canadian Context

- Environment Canada (EC) is the primary source of weather and climate information in Canada.
- Canada is the second largest country in the world, but has a scattered population and for which climate conditions are various and sometimes extreme
- The number of weather/climate forecasters to cover the Canadian territory is relatively small

  => Given the immensity of his territory and the relatively scarce human resources, forecast processes have been automated to a large extent

Map representing country areas weighted by their population

The Canadian Context

- Operational Climate Prediction in Canada
  - Is performed by the Canadian Centre for Weather and Environmental Prediction (CCMEP /GPC Montreal) with R&D support from the Canadian Centre for Climate Modeling and Analysis (CCCma) in Victoria BC and the NWP R&D Sections in Montreal
  - Climate prediction has a long history, more than 20 years
  - Totally based on numerical weather/climate prediction models, no human intervention allowed from the first day we started to produce official public seasonal forecasts in the 90's

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  - Climate prediction has a long history, more than 20 years
  - Totally based on numerical weather/climate prediction models, no human intervention allowed from the first day we started to produce official public seasonal forecasts in the 90's
  - Since 2011, the predictions are based on a coupled system, the Canadian Seasonal to Interannual Prediction System (CanSIPS)
  - CanSIPS is a MME system (2 x 10 members)
  - Hindcasts based on 1981-2010 period
  - Forecast range & frequency= 12 months; monthly

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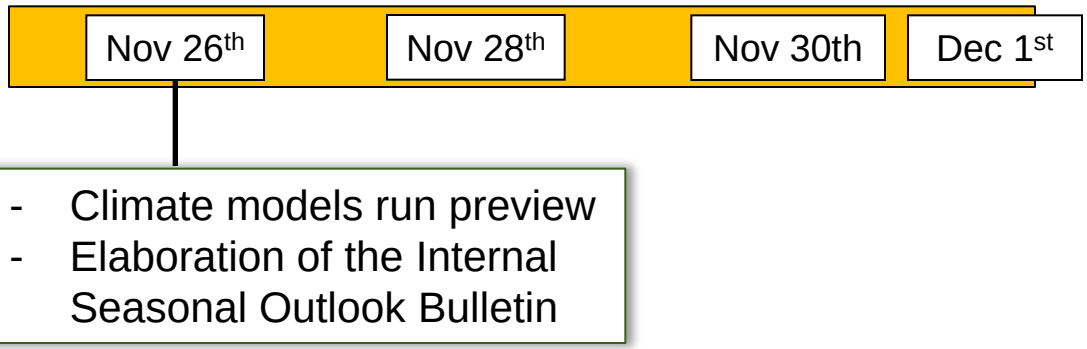
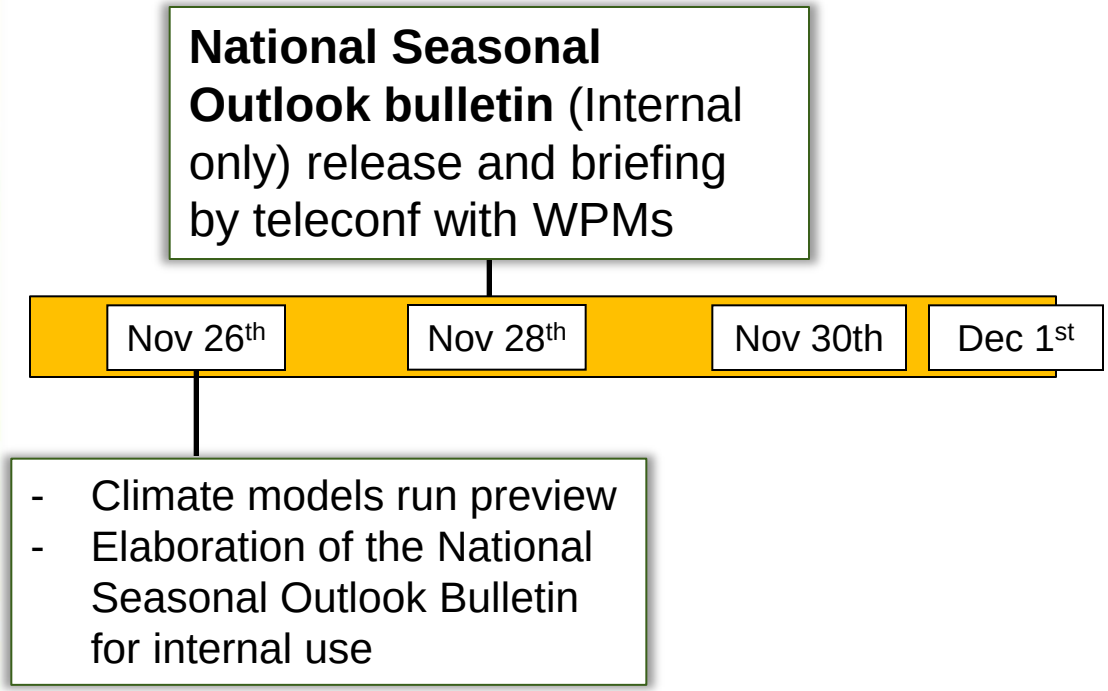
Forecast timeline for a main season

- Example for a winter forecast (Dec-Jan-Feb)



Forecast timeline for a main season

- Timeline: example for a winter forecast (Dec-Jan-Feb)



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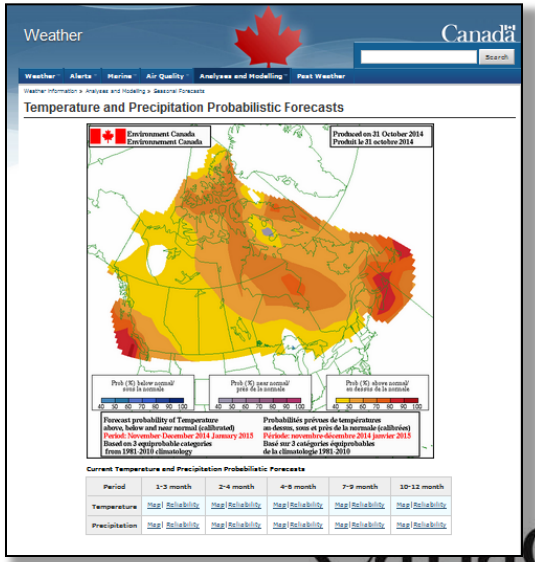
- Timeline: example for a winter forecast (Dec-Jan-Feb)

National Seasonal Outlook bulletin (Internal only) release and briefing by teleconf with WPMs

Nov 26th | Nov 28th | Nov 30th | Dec 1st | **Winter**

- Climate models run preview
- Elaboration of the Internal Seasonal Outlook Bulletin

The official seasonal forecasts are released on weather.gc.ca as the climate models execute on the supercomputer. All forecasts are published by the evening.
No text, maps / spot forecasts only



Forecast timeline for a main season

- Timeline: example for a winter forecast (Dec-Jan-Feb)

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Integrated Seasonal Vigilance Bulletins: Regional forums with institutional partners to deliver message and discuss impacts

Nov 26th | Nov 28th | Nov 30th | Dec 1st | **Winter** | Dec 5th

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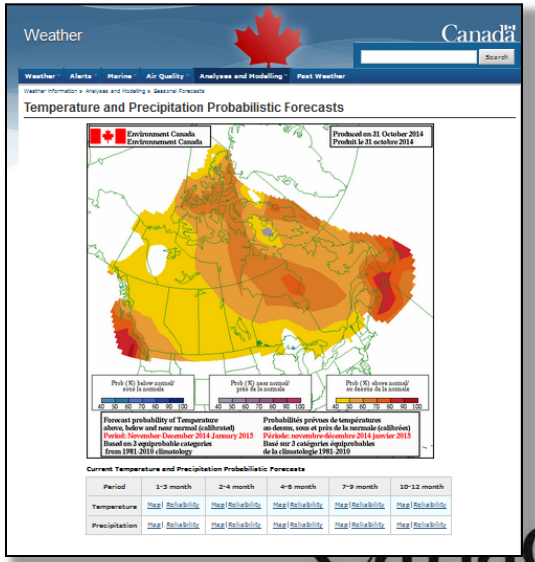
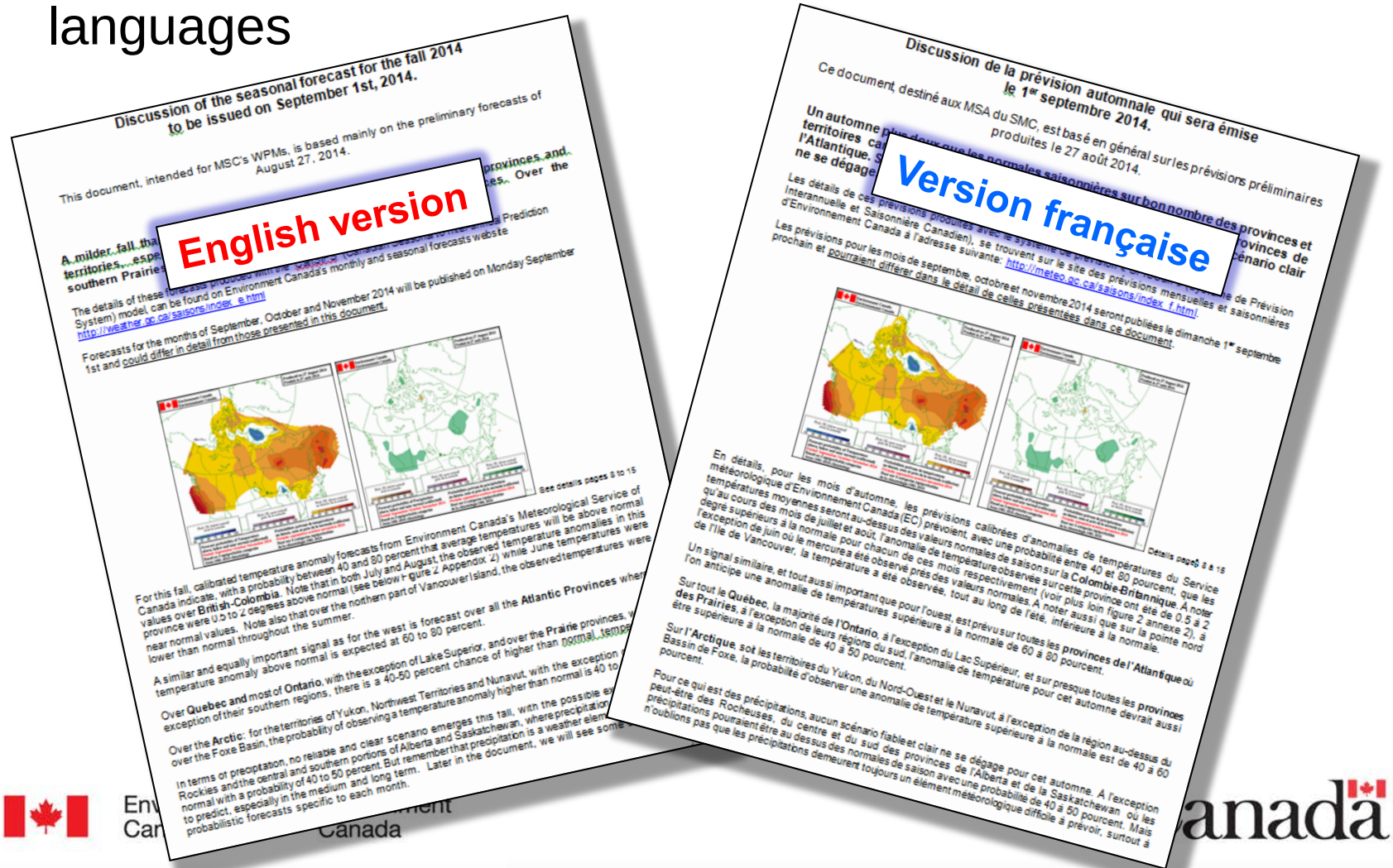


National Seasonal Outlook Briefing for Warning Preparedness Meteorologists (WPMs)

- Support for WPMs and climate service experts in their media and regional users interactions
- Four times a year (main seasons)
- Briefing is hold about two days before the official public forecast issuance:
  - Use a special ‘preview’ model run produced 4 days prior the official run
- Emphasis on probabilistic forecasts
- Manage expectancies about forecast skill
- Forecasts totally based on numerical models

National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- Briefing bulletin produced in the 2 official Canadian languages



National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- **First section:** current state of climate : ENSO, sea ice anomaly, etc…

Climatologically context in brief:

The return of an El Nino phenomenon is still expected.

Remember that during discussions about the summer forecast, the experts predicted the likely return of El Nino phenomenon during the summer. This prognosis was based of course on climate models. As summer ends and that event is not always observed (Figure 1), his return is still being considered, later than expected, but still on the radar of different climate models. It should appear within about the next 6 weeks; but it should be lower than anticipated before…

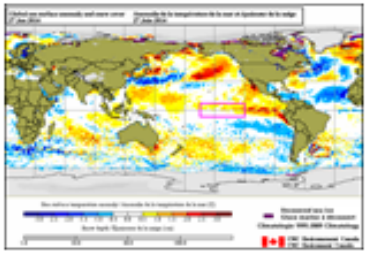
I invite you to watch this interesting video produced by the IRI (International Research Institute) of Columbia University, and presented by the Chief Meteorologist IRI, Dr Tony Barnston, worldwide expert in the El Nino at the following address:
http://iri.columbia.edu/news/august-climate-briefing-double-pinnochio-be/

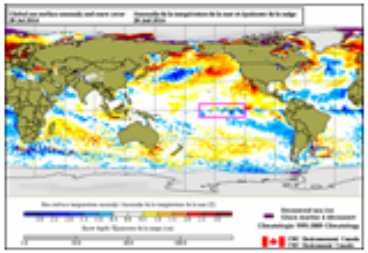
We recall that, according to several studies, this kind of phenomenon (El Niño or La Niña) influences the quality of the forecasts in North America, and from west to east, our level of confidence seasonal forecasts will be increased, especially in western Canada and Canadian Territories, and especially for the coming winter and spring seasons, if the El Nino begins and persists.

Climatologically context in details: Observations.

On the equatorial Pacific waters:

The following images (Figure 1), available on the official website of EC, show the sea surface temperature (SST) anomaly and snow depth observed during this summer on June 27, July 28 and August 27 2014.





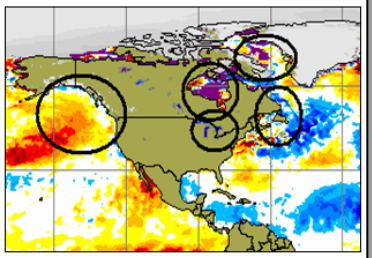
On the waters of the North Pacific Ocean and the North Atlantic Ocean:

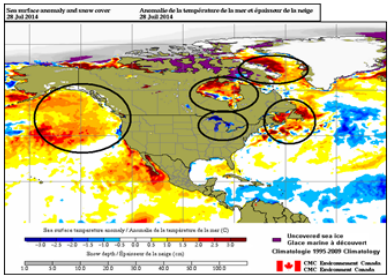
Unlike what was observed off the Peruvian waters, the variation of the sea surface temperature anomaly that has been observed in the waters that surround our countries and territories was greater.

Positive sea surface temperature anomaly which were observed during last winter and spring, remained during the summer of 2014 on the eastern **North Pacific.**

Closer to the coast, the anomaly appears to be positive as well, with the exception of the waters off Vancouver Island.

Also, amazing to note that, off the west coast of Alaska in August, the Arctic Sea up to the Bering Sea, positive SST anomalies observed exceeds 3 degrees Celsius.





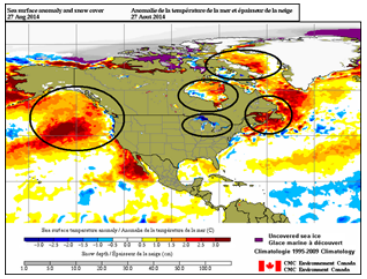


Figure 2: SST anomaly and snow depth, above right on 27 June, below bottom left on 28 July and bottom right on 27 August 2014.

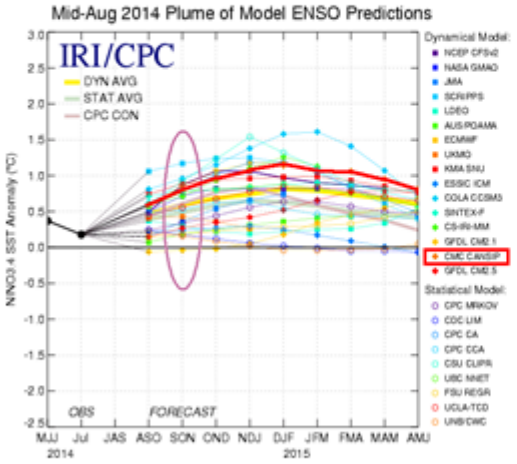
Canada

National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- **Second section:** Predicted evolution of SSTA: our coupled system (CanSIPS) and others

Climatologically context: forecasts "Plume diagrams"

As mentioned a bit earlier, the El Nino phenomenon we anticipated has not been observed; anomaly over +0.5 degree that was expected by the end of this summer has finally reached only a neutral value between 0.0 and +0.5 Celsius in July.



However you will notice in Figure 3 that all dynamic models predict a rise in sea surface temperature anomaly, offshore equatorial Pacific waters above 0.5 degrees Celsius.

The red line our CANSIPS model indicates this trend, even suggesting above average values (yellow) dynamic models but less than the maximum values of +1.5 degree Celsius expected by the COLA CCSM3 (IRI).

Also note that the forecast of our CANSIPS model follows closely the ECMWF (yellow square) one, at least until DJF 1415.

Figure 3: forecasts of ENSO by the IRI (International Research Institute), where CANSIP system forecast by CMC/CCCma is enhanced by the red line, issued on August the 15th 2014.

Other diagrams for ENSO forecasts:

The following ENSO forecasts also maintain the development of an El Nino, and quite rapidly in the coming weeks (right Figure 5). However, note that (Figure 6) official values to reach to observe the conditions of La Nina and El Nino of the Bureau of Meteorology Australian Government (where our model is displayed), are to -0.8 +0.8 degree Celsius.

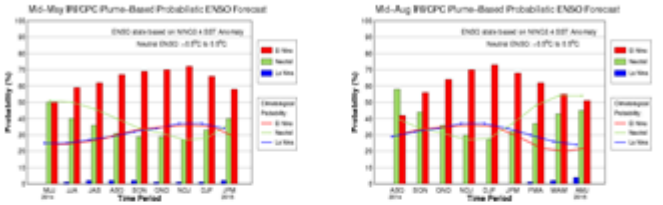


Figure 5: on left diagram of the probability of different ENSO conditions issued by IRI (International Research Institute) Columbia University on May the 15 2014 (last summary); on right same forecast but issued on August the 15;

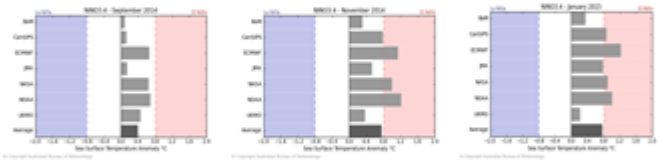


Figure 6: forecasts of ENSO conditions produced by different guidances, for the months of September and November 2014, January 2015 issued by Bureau of Meteorology, Australian Government

Forecasts for global SST:

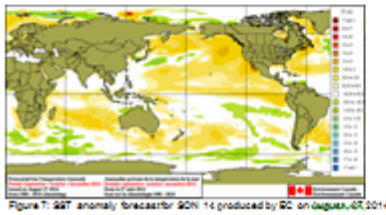


Figure 7: SST anomaly forecast for SON 14 produced by EC on August 07 2014.

Finally, Figure 7 shows the forecast of the sea surface temperature anomaly for next season (SON14) produced by EC. This new product is not yet available on our official website.

Figure 8 shows the same kind of forecast, but produced by other climate centers.

All models are similar in the equatorial Pacific waters.

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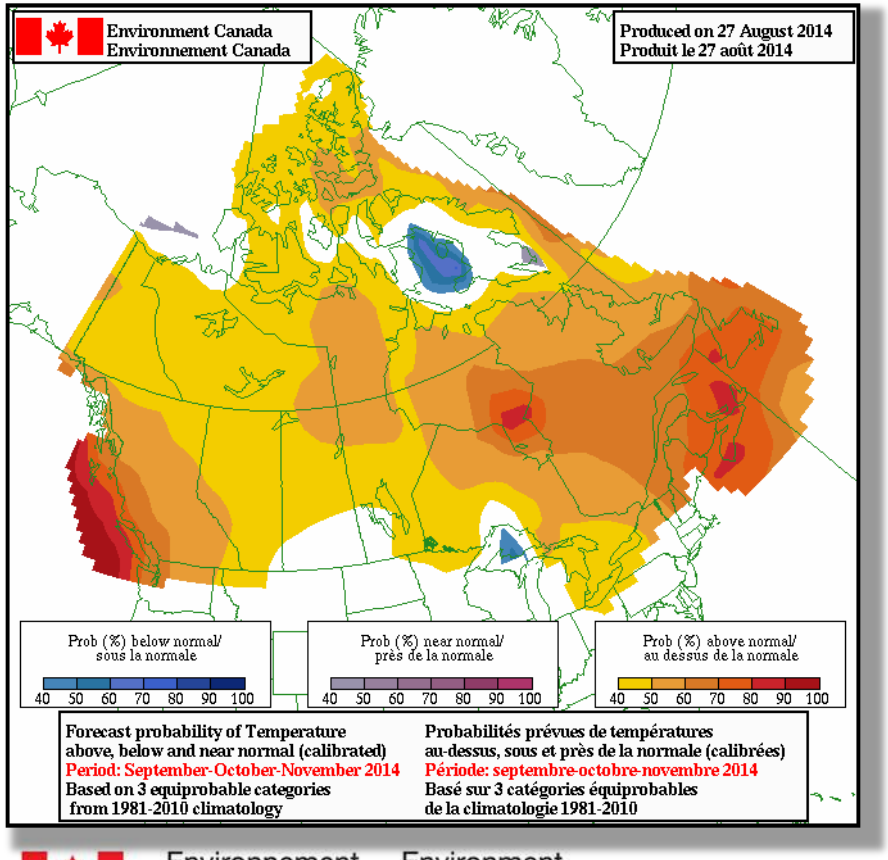
National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

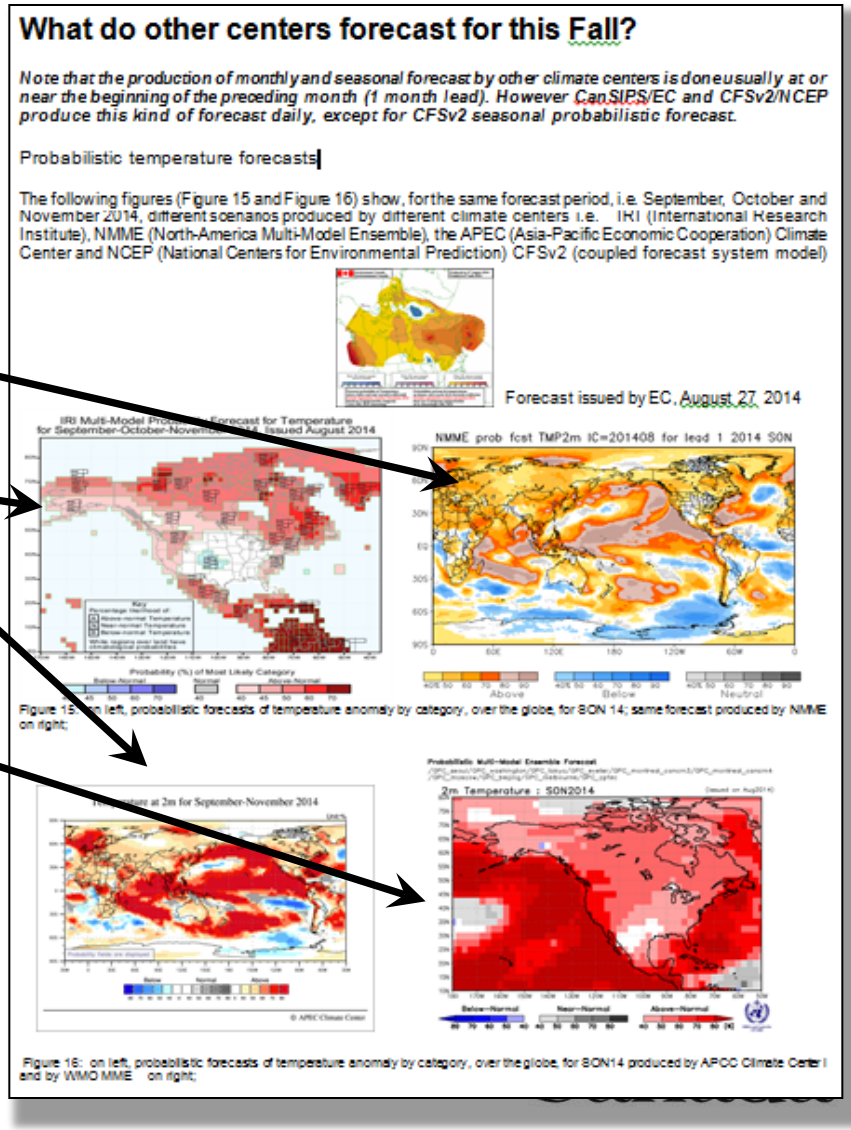
- **Third section**: the 'preview' temperature and precipitation forecasts for Canada



- Probabilistic forecasts
- 3 categories (below/near/above) normal
- Calibrated
- Fully automated - *no human intervention*
- Expected skill map provided

National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- Intercomparisons using Multi-Model Ensemble from:
  - North American MME
  - IRI MME
  - APEC Climate Center MME
  - WMO LRF MME



National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- Prediction for the individual months for:

Temperature and Precipitation

Following Figures 10 and 11 show, for each month individually, the calibrated probabilistic and deterministic temperature anomaly forecasts for this fall 2014. Furthermore, in the upper left on Figure 10, the probabilistic forecasts expected by the parallel guidance.

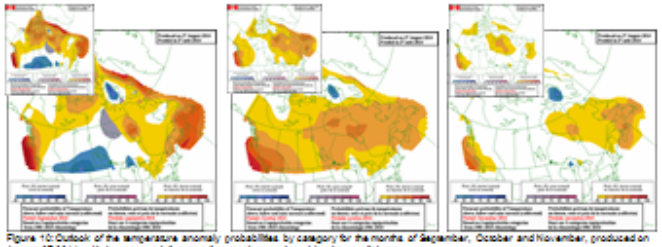


Figure 10: Outlook of the temperature anomaly probabilities by category for the months of September, October and November, produced on August 27 2014, with in upper on left, same forecastsbut produced by the parallel run;

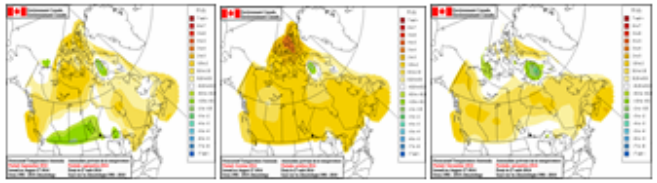


Figure 11: mean predicted temperature anomalies in degrees C for the months of June, July and August 2014, produced on May 27

Comparing the probabilistic seasonal forecast for SON14 (Figure 9) versus monthly forecasts shown individually (Figure 10), as well as the mean forecast temperature anomalies in Figure 11, we can draw the following conclusions:

- The clear signal of positive temperature anomaly over British Columbia should be observed every month of autumn;
- The positive temperature anomaly over Nunavut should be observed especially in the month of October. No real signal in November over its territories except Yukon where see surface temperature anomaly is expected to remain positive;
- We continue to see over Lake Superior, a negative temperature anomaly; probably related to temperature observed since last spring less than normal. The Canadian model CanSIPS still maintains this negative anomaly and decrease during the fall, probably too slow;
- Over the Foxe Basin in the Arctic, the anomaly expected throughout the fall is negative; keeping the cold bias was observed in the last month. However when we compare the official forecast versus forecast which issued by parallel run, the negative anomaly over the Foxe Basin dissipates over the months, such as the official forecast continues to forecast a negative anomaly.

Precipitation:

- EC's calibrated Probabilistic forecasts:

Once again, keep in mind that for seasonal forecasts, even if a high probability is expected for an above normal mean anomaly, there is still a chance, however small, that a below normal anomaly is observed, and vice versa.

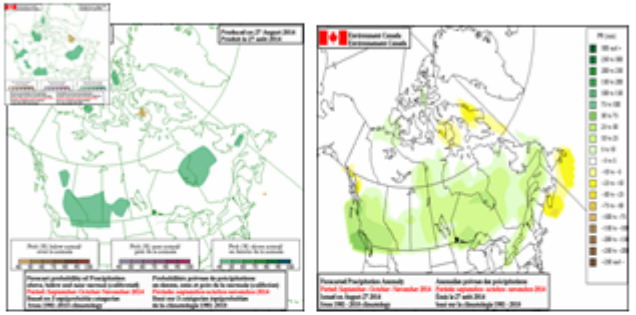


Figure 12: Calibrated forecastprobability of precipitation (by category) for the fall 2014, produced on August 27; in upper on left same forecastrun issued by parallel run; on right, forecast probability of precipitation (by interval) for each month individually for September, October and November 2014, produced on august 27 also;

Figure 12 shows the calibrated probabilistic forecasts for precipitation anomaly on left. In general, no signal merges this fall (white area). However exceptions regions are the Rockies, over southern and central regions of Alberta and Saskatchewan, the James Bay, and western part of southern Quebec province, where the probability to observe positive anomaly of precipitation could reach 40 to 50 percent.

According to Figure 13, showing the forecast probability of precipitation for each month, no real signal for October; much less for November 2014. However, if we look the precipitation anomaly forecast by intervals, it is much more "talkative" for each month of the fall.

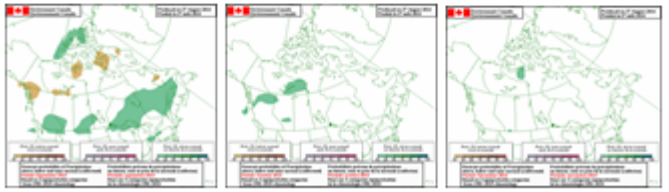
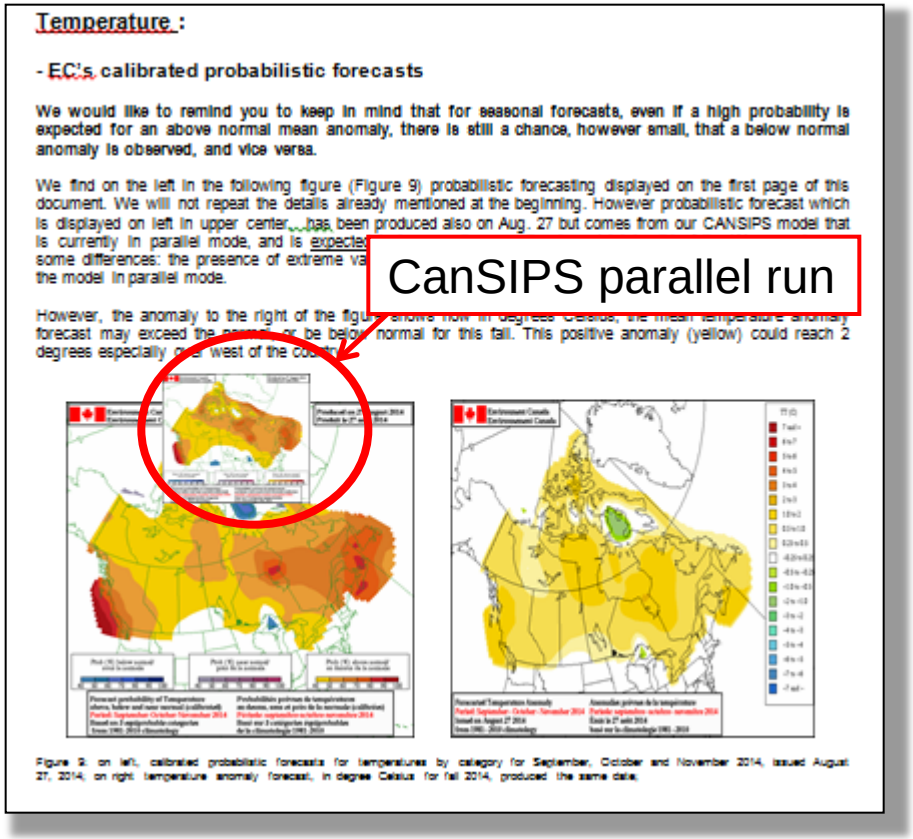


Figure 13: Forecast probability of precipitation (by category) for each month individually September, October and November 2014, produced on August 27

National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- Give access view to our experimental prediction systems



Temperature :

- EC's calibrated probabilistic forecasts

We would like to remind you to keep in mind that for seasonal forecasts, even if a high probability is expected for an above normal mean anomaly, there is still a chance, however small, that a below normal anomaly is observed, and vice versa.

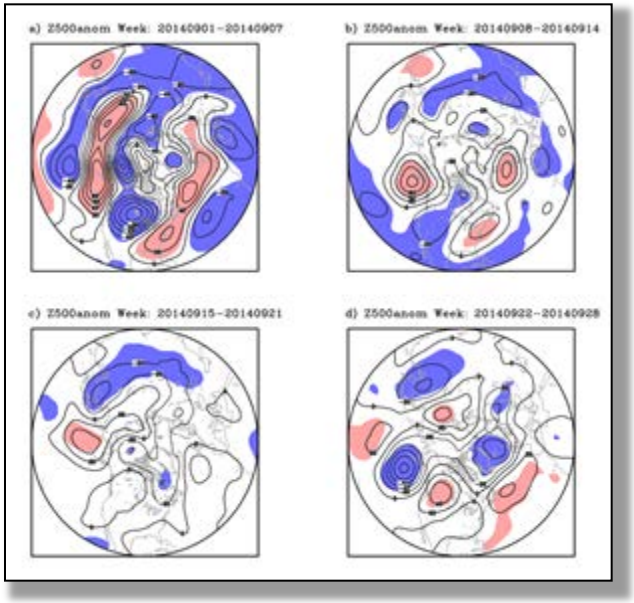
We find on the left in the following figure (Figure 9) probabilistic forecasting displayed on the first page of this document. We will not repeat the details already mentioned at the beginning. However probabilistic forecast which is displayed on left in upper center, has been produced also on Aug. 27 but comes from our CANSIPS model that is currently in parallel mode, and is expected some differences: the presence of extreme va the model in parallel mode.

However, the anomaly to the right of the figu forecast may exceed the [illegible] be below normal for this fall. This positive anomaly (yellow) could reach 2 degrees especially over west of the coun

CanSIPS parallel run

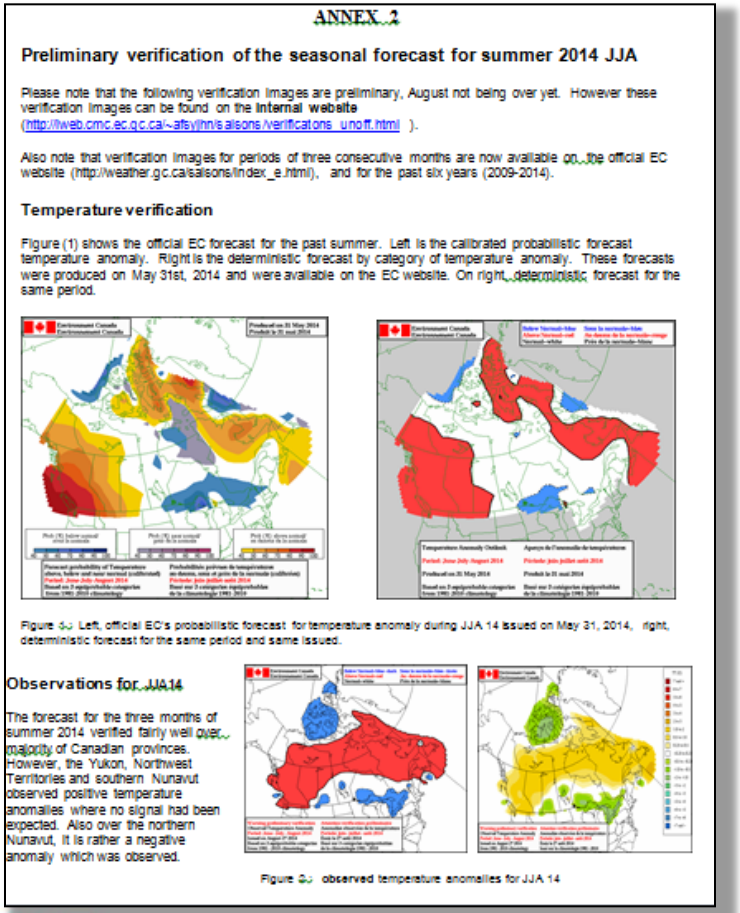
Figure 9: on left, calibrated probabilistic forecasts for temperatures by category for September, October and November 2014, issued August 27, 2014; on right temperature anomaly forecast, in degree Celsius for fall 2014, produced the same date.

Experimental new monthly prediction system based on our medium-range EPS (weeks 1,2,3,4)



National Seasonal Outlook Briefing for MSC Warning Preparedness Meteorologists (WPMs)

- Verification of the previous seasonal forecast provided



ANNEX 2

Preliminary verification of the seasonal forecast for summer 2014 JJA

Please note that the following verification images are preliminary, August not being over yet. However these verification images can be found on the **internal website** (http://iweb.cmc.ec.gc.ca/~afsyjhn/saisons/verifications_unoff.html).

Also note that verification images for periods of three consecutive months are now available on the official EC website (http://weather.gc.ca/saisons/index_e.html), and for the past six years (2009-2014).

Temperature verification

Figure (1) shows the official EC forecast for the past summer. Left is the calibrated probabilistic forecast temperature anomaly. Right is the deterministic forecast by category of temperature anomaly. These forecasts were produced on May 31st, 2014 and were available on the EC website. On right, deterministic forecast for the same period.

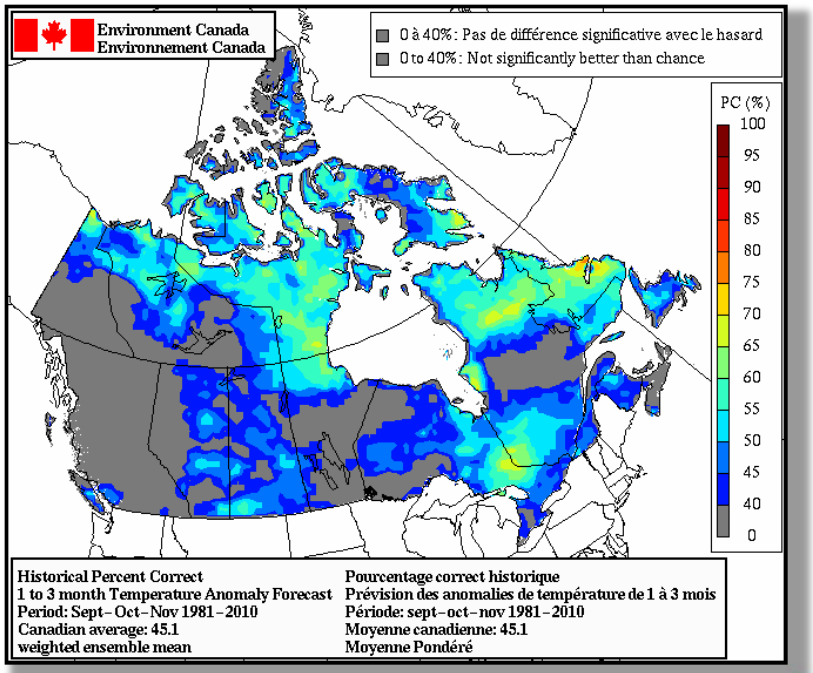
Figure 1: Left, official EC's probabilistic forecast for temperature anomaly during JJA 14 issued on May 31, 2014, right, deterministic forecast for the same period and same issued.

Observations for JJA14

The forecast for the three months of summer 2014 verified fairly well over majority of Canadian provinces. However, the Yukon, Northwest Territories and southern Nunavut observed positive temperature anomalies where no signal had been expected. Also over the northern Nunavut, it is rather a negative anomaly which was observed.

Figure 2: observed temperature anomalies for JJA 14

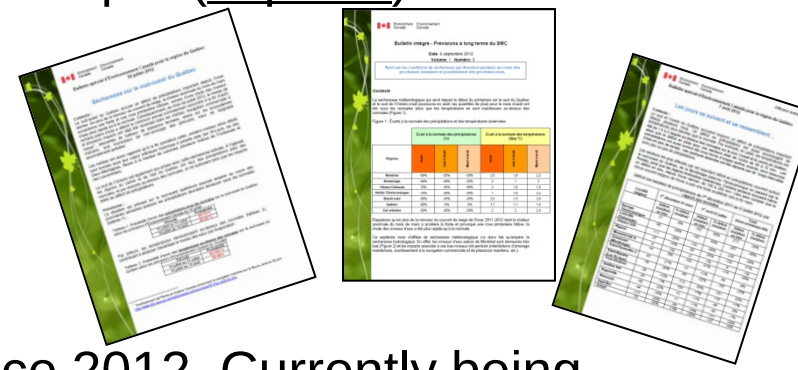
- Expected skill maps computed from hindcast provided



Regional Integrated Seasonal Vigilance Bulletins

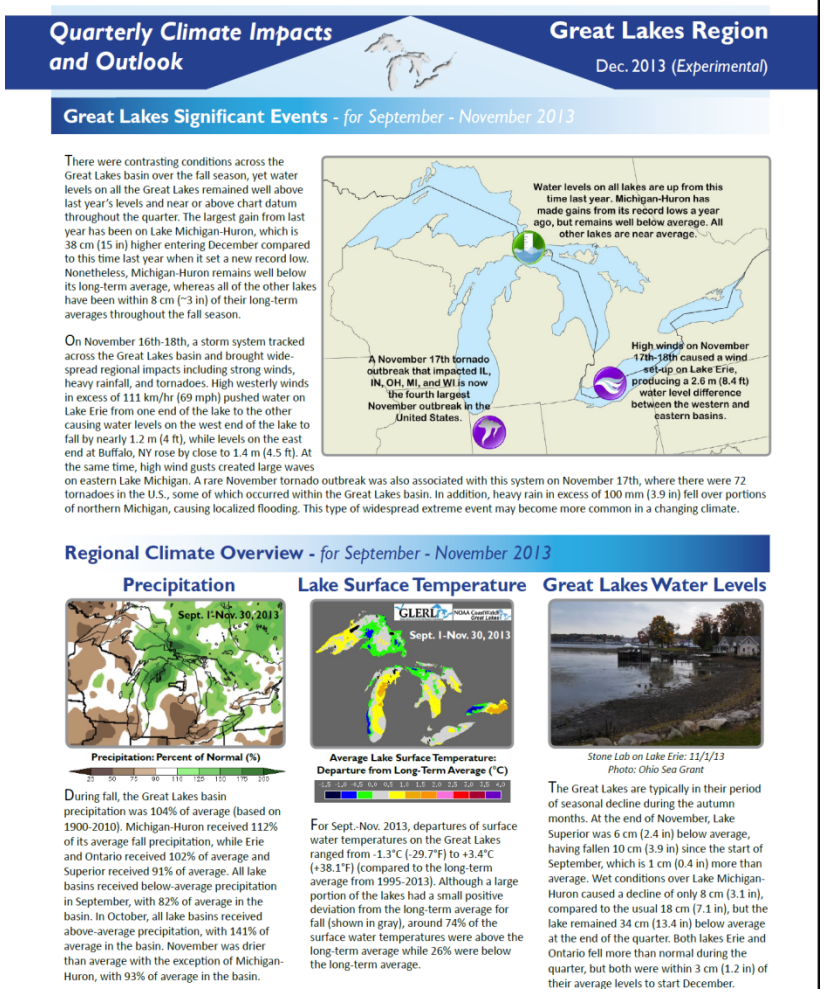
- Regional bulletins and conference calls happen about one week after the issuance of the main season forecasts

- In support to decision-makers with their input (impacts):
  - FED: Fisheries, Defence, Environ.
  - PROV: Health, Env., Flood forecasters, Public Security, Forest, Energy



- Available for the Quebec province since 2012. Currently being replicated as pilot projects in other Canadian regions:
  - New-Brunskwick held their first forum in December 2013; pilot until Fall 2014
  - Ontario and BC started last Spring (March-April)
  - Prairies and Northern Regions / Arctic : Great interest to embark

Binational Climate Impacts & Outlook bulletins



Quarterly Climate Impacts and Outlook

Great Lakes Region

Dec. 2013 (*Experimental*)

Great Lakes Significant Events - *for September - November 2013*

There were contrasting conditions across the Great Lakes basin over the fall season, yet water levels on all the Great Lakes remained well above last year's levels and near or above chart datum throughout the quarter. The largest gain from last year has been on Lake Michigan-Huron, which is 38 cm (15 in) higher entering December compared to this time last year when it set a new record low. Nonetheless, Michigan-Huron remains well below its long-term average, whereas all of the other lakes have been within 8 cm (~3 in) of their long-term averages throughout the fall season.

On November 16th-18th, a storm system tracked across the Great Lakes basin and brought widespread regional impacts including strong winds, heavy rainfall, and tornadoes. High westerly winds in excess of 111 km/hr (69 mph) pushed water on Lake Erie from one end of the lake to the other causing water levels on the west end of the lake to fall by nearly 1.2 m (4 ft), while levels on the east end at Buffalo, NY rose by close to 1.4 m (4.5 ft). At the same time, high wind gusts created large waves on eastern Lake Michigan. A rare November tornado outbreak was also associated with this system on November 17th, where there were 72 tornadoes in the U.S., some of which occurred within the Great Lakes basin. In addition, heavy rain in excess of 100 mm (3.9 in) fell over portions of northern Michigan, causing localized flooding. This type of widespread extreme event may become more common in a changing climate.

Water levels on all lakes are up from this time last year. Michigan-Huron has made gains from its record lows a year ago, but remains well below average. All other lakes are near average.

A November 17th tornado outbreak that impacted IL, IN, OH, MI, and WI is now the fourth largest November outbreak in the United States.

High winds on November 17th-18th caused a wind set-up on Lake Erie, producing a 2.6 m (8.4 ft) water level difference between the western and eastern basins.

Regional Climate Overview - *for September - November 2013*

Precipitation

Sept. 1-Nov. 30, 2013

Precipitation: Percent of Normal (%)

25 50 75 90 110 125 150 175 200

During fall, the Great Lakes basin precipitation was 104% of average (based on 1900-2010). Michigan-Huron received 112% of its average fall precipitation, while Erie and Ontario received 102% of average and Superior received 91% of average. All lake basins received below-average precipitation in September, with 82% of average in the basin. In October, all lake basins received above-average precipitation, with 141% of average in the basin. November was drier than average with the exception of Michigan-Huron, with 93% of average in the basin.

Lake Surface Temperature

GLERL NOAA CoastWatch Great Lakes

Sept. 1-Nov. 30, 2013

Average Lake Surface Temperature: Departure from Long-Term Average (°C)

-5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

For Sept.-Nov. 2013, departures of surface water temperatures on the Great Lakes ranged from -1.3°C (-29.7°F) to +3.4°C (+38.1°F) (compared to the long-term average from 1995-2013). Although a large portion of the lakes had a small positive deviation from the long-term average for fall (shown in gray), around 74% of the surface water temperatures were above the long-term average while 26% were below the long-term average.

Great Lakes Water Levels

Stone Lab on Lake Erie: 11/1/13
Photo: Ohio Sea Grant

The Great Lakes are typically in their period of seasonal decline during the autumn months. At the end of November, Lake Superior was 6 cm (2.4 in) below average, having fallen 10 cm (3.9 in) since the start of September, which is 1 cm (0.4 in) more than average. Wet conditions over Lake Michigan-Huron caused a decline of only 8 cm (3.1 in), compared to the usual 18 cm (7.1 in), but the lake remained 34 cm (13.4 in) below average at the end of the quarter. Both lakes Erie and Ontario fell more than normal during the quarter, but both were within 3 cm (1.2 in) of their average levels to start December.

- USA-Can initiatives
- **Great Lakes:** Produced under North American Climate Services Partnership –and EC/NOAA MOU;
  - Bulletins issued quarterly; next one: ~ Nov 20th 2015
- Experimental version for the **Gulf of Maine**
- Exploration of a future bulletin for the **Arctic** with NOAA/Alaska

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Summary

- The Canadian context has forced us to automate the public forecast process
  - No human intervention to the forecast maps
  - Forecast maps and values at stations are quickly produced and issued on the web, the same day the models run
  - Although forecast maps are not altered by a human, internal bulletins & conference calls are needed to explain the climatological context and the model forecasts to our Warning Preparedness Meteorologists and other partners
  - At this moment, no text is provided with the forecast maps on the web, this may change in the future
- Hindcast verifications (expected skill) and real-time verifications are essential aspects of our climate prediction system
- Quality Management System (ISO -9001) is in place for all the R2O processes as well as for the operational forecast production itself

Thank you

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