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| WORLD METEOROLOGICAL ORGANIZATIONCOMMISSION FOR BASIC SYSTEMSOPAG on DPFSMeeting of the Expert Team on Operational Prediction from Sub-seasonal to Longer-time ScalesBarcelona, Spain, 2-6 June 2018 |  | CBS-DPFS/ET-OPSLS /Doc. 4.1(12)(22.V.2016)\_\_\_\_\_\_\_Agenda item : 4.1ENGLISH ONLY |

**REVIEW OF THE WORK, FUNCTIONS AND SPECIFIC NEEDS OF THE GLOBAL PRODUCING CENTRES (GPCs)**

**STATUS / PROGRESS REPORT FOR *GPC-MONTREAL***

*(Submitted by Bertrand Denis et al. for GPC-Montreal)*

##### Summary and purpose of document

This document provides an update on the status of the GPC-Montreal and is provided for the information of the ET on the Extended and Long-range Forecasting.

##### Action Proposed

The meeting is invited to…

**STATUS / PROGRESS REPORT FOR *GPC Montreal***

**1. FORECASTING SYSTEM**

*Please note that items 1.1 and 1.2 should be repeated for different forecasting ranges: LRF, ELF and/or any other.*

**The Canadian sub-seasonal forecast system:**

1.1 Description of the forecasting system specification *[please also indicate where this information is published (web address / papers))*

This system is based on the Global Ensemble Prediction System (GEPS, see Houtekamer et al. 2014), by extending the lead time of the ensemble medium-range weather forecast out to 32 days once a week (see Gagnon et  al. 2013 and Gagnon et al. 2014a).  Subsequently, 32-day forecasts are assembled (by averaging the daily output) and presented as week-one (day 1 to day 7), week-two (day 8 to day 14) and week-three (day 15 to day 21) and week four (day 22 to day 28) probabilistic forecasts. A 4-week (day 1 to day 28) is also produced.

Although it is still a two-tier system, i.e., an uncoupled system with specified SST and sea ice conditions, it likely captures most of the major sources of predictability on the subseasonal time scale. Compared to CanSIPS, the GEPS based monthly forecast takes advantage of the increased model resolution and improved initialization, leading to improved forecast skill.

**System description**

The heart of the GEPS system is the Canadian Global Environmental Multi-scale model (GEM; Cote et al. 1998a, b). The current GEPS has a horizontal resolution of 0.45º×0.45º, and 40 vertical levels. GEPS is run twice daily out to 16 days with 20 perturbed members and one control member. The initial conditions are produced with the Ensemble Kalman Filter (EnKF; Houtekamer et al. 2009; Houtekamer et al. 2014), which receives observations that are background-checked and bias-corrected by the Global Deterministic Prediction System (GDPS; Buehner et al. 2015). Different members of GEPS have different model configuration perturbations (multi-parametrization physics). They also make use of stochastic perturbations of physics tendencies, and stochastic energy back-scattering. Land properties are initialized with the real-time CMC analysis. Once a week (Thursday 00Z), the forecast of GEPS is extended to 32 days, that makes the real time component of the monthly forecast. .

**Performance evaluation**

Our subs-seasonal forecasting system has been recently evaluated by Lin *et al.* (2016). Major sources of predictability on the sub seasonal time scale are reasonably well represented in our system through initialization and persistence of anomalies in SST and sea ice. The possibility of the system to correctly simulate the MJO influence contributed mostly to the forecast skill.

The skill was found to be better in winter than in summer. In extended winter, the North Pacific and eastern North America are among the only places where significant forecast skill is found beyond three pentads (five-day mean) for both geoponential height at 500hPa and near surface temperature. Over eastern North America, significant forecast skill is observed for all lead times up to pentad 6. These results indicate that a useful sub seasonal forecast is possible in this region.

**Availability of official products**

The main official products are posted on the Government of Canada web site for weather information: [http://weather.gc.ca/.](http://weather.gc.ca/.%20) A dedicated section for monthly (4 weeks) forecasting is found more precisely here: [https://weather.gc.ca/saisons/image\_e.html?img=mfe1t\_s](https://weather.gc.ca/saisons/image_e.html?img=mfe1t_s%20) and includes forecast for temperature only. However, beta-version of the forecasts for weeks 1 to 4 can be found here, and includes precipitation. The domain covered includes Canada as well as the entire globe. See [http://collaboration.cmc.ec.gc.ca/cmc/ensemble/monthly/prev\_mens\_geps.html](http://collaboration.cmc.ec.gc.ca/cmc/ensemble/monthly/prev_mens_geps.html%20)

1.2 Content of basic forecast outputs *[response options in brackets; change or delete as appropriate. For non-compliant elements, please indicate intended date of compliance]*

|  |  |
| --- | --- |
| Issue frequency: | Once a week |
| Temporal resolution: | Week-one, week-two, week-three, week-four |
| Spatial resolution: | 0.45º×0.45º, and 40 vertical levels |
| Spatial coverage: | *Global*  |
| Lead time: | 0 week, 1 weak, 2 week, 3 week  |
| Output types:  | *Beta-version of the graphical probabilistic products are available for temperature and precipitation through this link http://collaboration.cmc.ec.gc.ca/cmc/ensemble/monthly/prev\_mens\_geps.html. Probabilistic products are not calibrated yet. Public graphical products are not yet available, apart from the 4-week temperature forecast.* |
| Verification as per WMO SVSLRF | *Not available at this moment* |

**The Canadian Seasonal to Interannual Prediction System (CanSIPS):**

1.1 Description of the forecasting system specification *[please also indicate where this information is published (web address / papers))*

The Canadian Meteorological Centre (CMC) has been using since 2011 a global coupled seasonal prediction system for forecasting monthly to multi-seasonal climate conditions. The system named CanSIPS for Canadian Seasonal to Interannual Prediction System has replaced both the uncoupled (2-tier) prediction system previously used for producing seasonal forecasts with zero and one month lead times and the CCA statistical Prediction system previously used for forecasts of lead times longer than four months. With CanSIPS, Environment Canada is able to issue on monthly basis predictions of seasonal climate conditions covering a full year. This represents substantive progress with respect to the previous system. CanSIPS can also skillfully predict the ENSO phenomenon and its influence on the climate up to a year in advance.

The development and the implementation of this multi-seasonal forecast system is the result of a close collaboration between CMC and the Canadian Center for Climate Modeling and Analysis (CCCma).

**System description**

CanSIPS is a multi-model ensemble (MME) system based on two climate models developed by CCCma. It is a fully coupled atmosphere-ocean-ice-land prediction system, integrated into the CMC operational prediction suite and relying on the CMC data assimilation infrastructure for the atmospheric, sea surface temperature (SST) and sea ice initial states.

The two models used by CanSIPS are:

- CanCM3 which uses the atmospheric model CanAM3 (also known as AGCM3) with horizontal resolution of about 315 km (t63) and 31 vertical levels, together with the ocean model CanOM4 with horizontal resolution of about 100 km and 40 vertical levels and the CLASS land model. Sea ice dynamics and thermodynamics are explicitly modeled.

- CanCM4 which uses the atmospheric model CanAM4 (also known as AGCM4) also with an horizontal resolution of about 315 km (t63) but with 35 vertical levels. The CanOM4 ocean, CLASS land and sea ice components are essentially the same as in CanCM3.

Further information on these models is given on the CCCma web site at the following link:

<http://www.ec.gc.ca/ccmac-cccma/default.asp?lang=En&n=4A642EDE-1>

CanSIPS has two modes of operation:

- Assimilation mode: CanSIPS uses a continuous assimilation cycle for 3D atmospheric temperatures, winds and specific humidity as well as sea surface temperatures and sea ice. The assimilated data comes from the six hour CMC 4D-VAR global atmospheric final analyses and the daily CMC SST and sea-ice analyses. Additionally, just before launching the production of the forecasts, an 3D ocean analysis from the CMC Global Ice-Ocean Prediction System is assimilated into the CanSIPS ocean model background state. The initial conditions of 20 CanSIPS ensemble members are independent but statistically equivalent in the sense that their differences are of the same order as observational uncertainties. More details on the models and their initialization are given in Merryfield *et al.* (2013).

- Forecast mode: CanSIPS forecasts are based on a 10-member ensemble forecasts produced with each CCCma climate model for a total ensemble size of 20. Monthly to multi-seasonal forecasts extending to 12 months are issued the first day of each month. Additionally, a one-month forecast is issued at mid-month (15th).

CanSIPS climatology is based on a hindcast period covering 1981-2010 and was produced during phase 2 of the Coupled Historical Forecast Project (CHFP2) research effort. The ensemble size (20) is the same for the forecast and the hindcasts. It should be noted that since June 2013, the probabilistic forecasts are all calibrated.

**Performance evaluation**

Objective verifications over the overlapping hindcast periods of the previous and new system have shown improvements in prediction skill at the global scale as well as over Canada. Improvement is clearly seen in seasonal surface temperature forecasts but far less for precipitation, which still remains a major challenge over extra-tropical countries for all seasonal prediction systems.

An overview of the design and the operational implementation of CanSIPS as well as an extensive performance evaluation are available in the technical note obtainable through this web address:

<http://collaboration.cmc.ec.gc.ca/cmc/CMOI/product_guide/docs/lib/op_systems/doc_opchanges/technote_cansips_20111124_e.pdf>

**Availability of official products**

The main official products are posted on the Government of Canada web site for weather information: <http://weather.gc.ca/>. A dedicated section for seasonal forecasting is found more precisely here: <http://weather.gc.ca/saisons/>. Other means of accessing the forecasts are detailed further down this document.

1.2 Content of basic forecast outputs *[response options in brackets; change or delete as appropriate. For non-compliant elements, please indicate intended date of compliance]*

|  |  |
| --- | --- |
| Issue frequency: | *The forecast system is run every day for a period covering the rest of the current month and the following month. Also, it is run for 12 months on the last day of each month. The basic model outputs are monthly averages.**Seasonal forecast products are issued every last day of each calendar month. They cover months 0-3, 1-4, 4-6, 7-9 and 10-12.*  |
| Temporal resolution: | 1 month and 3 months  |
| Spatial resolution: | *2.5 deg x 2.5 deg for the atmosphere and 1.41 deg x 0.94 for the ocean* |
| Spatial coverage: | *Global but public forecasts cover only Canada* |
| Lead time: | *Forecasts cover 12 months, with 0 to 9-month lead time. Seasonal forecasts for months 10-11-12 are issued with a 9-month lead time.* |
| Output types:  | *Monthly averages for each of the 20 members are available in numerical format (GRIB 2). Graphical deterministic and probabilistic products are available for both temperature and precipitation. Probabilistic products are calibrated. Public graphical products are available here:* [*http://www.weatheroffice.gc.ca/saisons/index\_e.html*](http://www.weatheroffice.gc.ca/saisons/index_e.html) |
| Verification as per WMO SVSLRF | *Expected skill derived from the 30 years hindcasts as well as real-time verification are available on the Environment Canada web site (*[*http://www.weatheroffice.gc.ca/saisons/index\_e.html*](http://www.weatheroffice.gc.ca/saisons/index_e.html)*). Due to HR pressure, the SVSLRF web site has not been update yet but will it be shortly. Meanwhile, the full list of verification scores are available for the CanSIPS Explorer web site (*[*http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal\_forecast/sf2*](http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2)*,user=cccmasf,pw=seasforum )**The ensemble size (20) is the same for the forecast and the hindcasts.* |

**2. PRODUCTS** *[response options in brackets; change or delete as appropriate. For non-compliant elements, please indicate intended date of compliance]*

|  |  |  |  |
| --- | --- | --- | --- |
| Variable: | Probabilities for tercile categories of 2m temperature | Probabilities for tercile categories of precipitation | Probabilities for tercile categories of SST (coupled models only) |
| Spatial resolution: | *2.5 deg x 2.5 deg* | *2.5 deg x 2.5 deg* | *2.5 deg x 2.5 deg* |
| Temporal Resolution: | *3 months (nonpublic: 1 month)* | *3 months (nonpublic: 1 month)* | *nonpublic: 1 and 3 months* |
| Coverage: | *Canada (nonpublic: global)* | *Canada (nonpublic: global)* | *nonpublic: global* |
| Issue frequency: | *Monthly* | *monthly* | *monthly* |
| Lead-time | L0 | *Y* | *Y* | Y |
| L1 | *Y* | *Y* | Y |
| L2 | *Y* | *Y* | Y |
| L3 | *Y* | *Y* | Y |
| L4 | *Y* | *Y* | Y |
| L4+ | *Y* | *Y* | Y |
| Location of rendered images: | <http://weather.gc.ca/saisons/image_e.html?img=mfe1t_s> (monthly forecasts only)<http://weather.gc.ca/saisons/index_e.html> (seasonal forecasts)*Password protected CanSIPS explorer: (*[*http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal\_forecast/sf2*](http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2) *user=cccmasf,pw=seasforum )* |
| Location of digital data (if available): | *Publicly available. More information on* [*http://weather.gc.ca/grib/grib2\_cansips\_e.html*](http://weather.gc.ca/grib/grib2_cansips_e.html) |

**3. VERIFICATION (Available for seasonal for the moment)***[response options in brackets; change or delete as appropriate. For non-compliant elements, please indicate intended date of compliance]*

3.1 SVSLRF Level 1 scores

The scores for all the variables for the 1-tier system (CanSIPS) could be made available on the LC-SVSLRF web site any time soon. Meanwhile all the scores for the are available on the CanSIPS Explorer web site: *site (*[*http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal\_forecast/sf2*](http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2) *user=cccmasf,pw=seasforum )*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable: | 2m temperature | Precipitation | SST (coupled models only) | Niño region indices |
| Seasons: | *All 12* | *All 12* | *All 12* | *All 12* |
| Leads: | *0-9 months* | *0-9 months* | *0-9 months* | *0-9 months* |
| ROC curves: | *yes* | *yes* | *yes* | *yes* |
| ROC area: | *yes* | *yes* | *yes* | *yes* |
| Reliability curve: | *yes* | *yes* | *yes* | *yes* |
| Frequency histograms (sharpness) | *yes* | *yes* | *yes* | *yes* |
| MSSS | *yes* | *yes* | *yes* | *yes* |
| Location of scores: | [*http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal\_forecast/sf2*](http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2) *(user=cccmasf,pw=seasforum )*and some for the public[*http://www.weatheroffice.gc.ca/saisons/index\_e.html*](http://www.weatheroffice.gc.ca/saisons/index_e.html) |
| Scores’ availability on the LC-SVSLRF web site | Currently, the LC-SVSLRF available scores are for the previous system and need to be updated for the current operational system. Meanwhile they are available from the web address above | *N/A* |
| *[For non-compliant elements, please indicate intended date of compliance]* | The scores on the LC-SVSLRF web site could be updated anytime soon. |

3.2 SVSLRF Level 2 scores

Most remarks are similar to for the Level 1 scores.

|  |  |  |  |
| --- | --- | --- | --- |
| Variable: | 2m temperature | Precipitation | SST (coupled models only) |
| Seasons: | *All 12* | *All 12* | *All 12* |
| Leads: | *0-9 months* | *0-9 months* | *0-9 months* |
| ROC maps: | *Yes* | *yes* | *yes* |
| MSSS maps: | *Yes* | *yes* | *yes* |
| MSSS 1 maps: | *Yes* | *yes* | *yes* |
| MSSS 2 maps: | *Yes* | *yes* | *yes* |
| MSSS 3 maps: | *Yes* | *yes* | *yes* |
| Location: | [*http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal\_forecast/sf2*](http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2) *(user=cccmasf,pw=seasforum )*and some for the public[*http://www.weatheroffice.gc.ca/saisons/index\_e.html*](http://www.weatheroffice.gc.ca/saisons/index_e.html) |
| *[For non-compliant elements, please indicate intended date of compliance]* | The scores on the LC-SVSLRF web site could be updated anytime soon. |

**4. DISSEMINATION**

Deterministic and probabilistic chart and table products of seasonal forecast are available on the Internet:

 Web access:

Public monthly and seasonal forecasts are available on the Environment Canada weather portal:

<http://weather.gc.ca/saisons/image_e.html?img=mfe1t_s> (monthly forecasts only)

<http://weather.gc.ca/saisons/index_e.html> (seasonal forecasts)

Note that the emphasis is on probabilistic forecasts (calibrated) but some forecasts are also available in a deterministic form.

Password protected access to the CanSIPS ‘Explorer’ :

<http://www.cccma.ec.gc.ca/cgi-bin/data/seasonal_forecast/sf2>

User: cccmasf

PW: seasforum

Public digital data (forecasts and hindcasts)

[*http://weather.gc.ca/grib/grib2\_cansips\_e.html*](http://weather.gc.ca/grib/grib2_cansips_e.html) *(numerical data in GRIB2 format)*

Note that since CanSIPS contributes to MMEs, its forecasts can be also viewed on these web sites:

APCC: <http://www.apn-gcr.org/> (password required)

NMME: <http://www.cpc.ncep.noaa.gov/products/NMME/> (**no** password required)

WMO LRF: <https://www.wmolc.org> (password required)

**5. LRF MULTI-MODEL ENSEMBLE**

For CanSIPS is already a MME system made of two CCCma AGCM/OGCM versions, each having 10 members.

CanSIPS members are contributing to:

* WMO LRF MME
* APCC MME
* NMME (North American MME)
* IRI MME and Nino 3.4 forecast
* Seasonal forecasts for the Indian Summer monsoon for the SASCOF region
* Seasonal forecast, including sea ice, for the Pan Arctic Regional Climate Outlook Forum
* Contribution to the Sea Ice Prediction Network Sea Ice Outlook (https://www.arcus.org/sipn)

Also not officially run by CMC, a version of CanSIPS run by CCCma at CMC is also contributing to the Met Office multi-seasonal to decadal experiment.

On the subseasonal prediction, the subseasonal prediction system based on GEPS is currently in a data transmission testing mode with ECMWF for contributing to the WCRP/WWRP S2S project.

**6. ADDITIONAL INFORMATION PROVIDED BY THE GPC**

Experimental products are generated internally. These are related to sea-ice, soil moisture, snow water equivalent and climate indices. The experimental products are available on the CanSIPS Explorer web site for evaluation. National seasonal forecast bulletin produced for each of the four main seasons is also available.

**7. CAPACITY BUILDING AND TRAINING**

Four times per year, shortly before we issue our seasonal forecasts for the official seasons (i.e. DJF, MAM, JJA, SON), we hold a national conference call. These conference calls are used to explain and train the National Weather Preparedness Meterologists on how to interpret the forecasts. GPC Montreal has contributed to the capacity building on verification for 2015-2016 winter forecast session held by the CARICOF last Fall.

**8. SPECIFIC NEEDS**

Very tight resources make challenging to fulfillment of our duties as a GPC *and* as Lead Centre for Standard Verification System for Long Range Forecasts (SVS-LRF).

Our current Canadian governmental web site (<http://weatheroffice.ec.gc.ca>) is not flexible enough to support more specialized products. Also, we have been restrained to post global maps on that public web site. Our GPC global map products are only available through a password protected web portal.

**9. FUTURE DEVELOPMENTS**

Within the next year:

* Add GEM + NEMO coupled model to CanSIPS
* Improved sea ice thickness initialization
* Calibration of sea ice prediction
* Use of web services such as WMS, WFS and WCS for distributing forecast images and data

Also considered for the for upgrades:

* Post-processing CanSIPS outputs for drought forecasting applications
* Horizontal resolution of CanCMx T63 → T127?
* Assimilate land surface analysis
* Use of a RCM for downscaling

**10. USERS OF THE LRF**

National users: Meterological Service of Canada and other Canadian specialized users (Forestry, Energy Sector, Agriculture, etc..)

International users: APCC, WMO LRF MME, North American MME and IRI.

External users that access the GRIB II data from the EC depot: <http://dd.weatheroffice.ec.gc.ca/>.

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