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Integrated Modeling Program for Canada IMPC

– Project A5: Model-intercomparison over Great Lakes –

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1 Forcing dataset

The forcing dataset is a subset from a preliminary sample of an atmospheric reforecast and precipitation/land-surface reanalysis dataset that is currently in development at ECCC-CMC (*Gasset et al.*, 2017, in prep.). To obtain such a dataset, as illustrated in Fig. 1, ERA-Interim reanalysis data ($\sim$ 80 km horizontal resolution) (*Dee et al.*, 2011) are used to initialize the so-called Global Deterministic Reforecast System (GDRS). The latter is based on the latest stable version of the Global Environmental Multiscale (GEM, v4.8-LTS) model (*Côté et al.*, 1998a,b; *Girard et al.*, 2013) and feature a global latitude-longitude uniform grid with about 50 km spatial resolution. Then, following a dynamical downscaling approach, the so-called Regional Deterministic Reforecast System (RDRS) is run. RDRS is also initialized by ERA-Interim but driven by the GDRS. The RDRS is based on the same version of GEM and feature a similar configuration, but the area is limited to a rotated latitude-longitude uniform grid with about 15 km horizontal resolution that covers whole North America and the Arctic Ocean. Both of these systems- the GDRS and RDRS- are closely related to the control member of the Global and Regional Ensemble Prediction System (GEPS/REPS) (*Charron et al.*, 2009; *Lavaysse et al.*, 2012; *Houtekamer et al.*, 2013; *Gagnon and Co-author*, 2015; *Lin et al.*, 2016) which are both operational at ECCC-CMC. Operational means that they have undergone a strict and thorough validation procedure. Both the GDRS and the RDRS are launched twice a day (every 12-h at 0 UTC and 12 UTC) and integrated for 24-h.

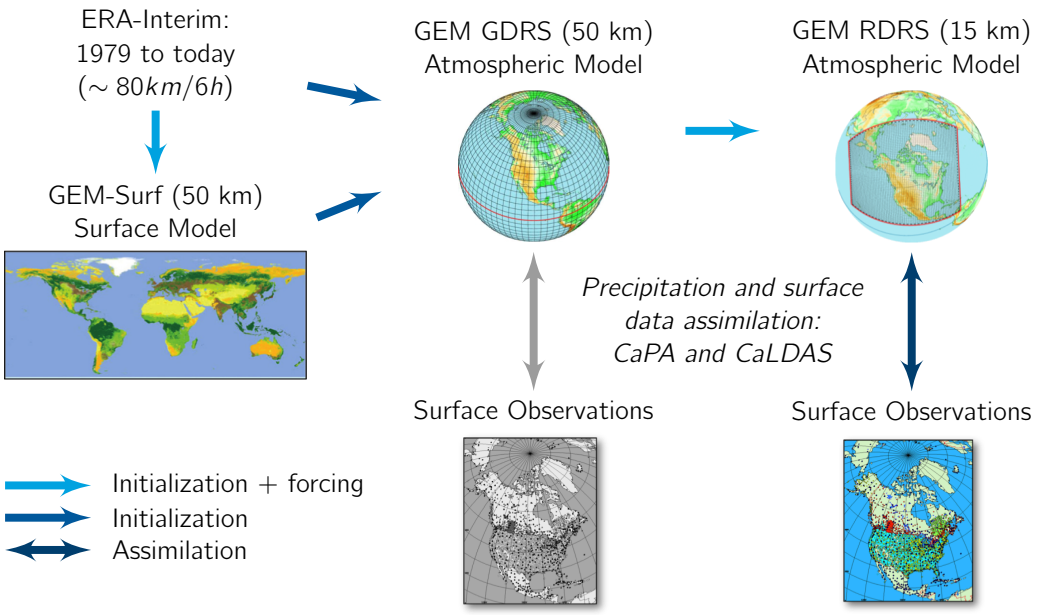

Figure 1: Illustration of the atmospheric reforecast and precipitation/land-surface reanalysis system that is currently in development at ECCC-CMC.

Surface initial conditions such as sea surface temperature, sea ice concentration/thickness, soil moisture, soil temperature and snowpack conditions that are consistent with the driving data and

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the surface scheme of GEM are additionally required as input of the GDRS and RDRS. For the GDRS, they are obtained from an a priori 30 years off-line (open-loop) simulation of GEM land-surface model GEM-Surf (*Carrera et al.*, 2010; *Bernier and Bélair*, 2012) on the same grid as the GDRS and directly forced by the near-surface fields of ERA-Interim reanalysis as well as the 3-hour precipitation amounts (*Gagnon and Co-author*, 2015). This off-line system includes a land-surface scheme, i.e., ISBA (*Noilhan and Planton*, 1989; *Noilhan and Mahfouf*, 1996), as well as a sea ice and a glacier scheme which are part of the GEM model itself. For the RDRS, the surface initial fields are obtain though a coupling with the Canadian Land Data Assimilation System (CaLDAS) (*Balsamo et al.*, 2007; *Carrera et al.*, 2015) which include the Canadian Precipitation Analysis (CaPA) system (*Mahfouf et al.*, 2007; *Lespinas et al.*, 2015) to feed the Ensemble Kalman Filter (EnKF) members with 6-h precipitation analysis. Such an approach have been shown to notably improve surface results compared to the ECCC-CMC operational deterministic approaches for the years 2010-2014 (*Gasset et al.*, in prep.). It allows to produce more representative reforecast and precipitation/ land-surface retrospective analysis consistent in time and space at a higher resolution than current reanalysis dataset.
In addition to the above described approach, CaPA is also run in an a posteriori manner to produce 24-h precipitation analysis at 12 UTC relying on the GDRS and RDRS precipitation accumulation as background field. This allows including additional observation datasets, such as data in the Standard Hydrological Exchange Format (SHEF) (*Bissell et al.*, 1984), that only report 24-h accumulation. It also enables the assimilation of the so-called Adjusted Daily Rain and Snow (AdjDlyRS) observations dataset (*Wang et al.*, 2017) which is part of the Adjusted and Homogenized Canadian Climate Data (AHCCD). This newly released dataset covering only Canada features one of the most advanced quality control and bias correction procedures allowing, e.g., mitigating under-catchments of solid precipitation in the winter (*Wang et al.*, 2017). The inclusion of such a dataset has also been proven to improve notably results where stations are present (*Gasset et al.*, in prep.).
Five years of data (2010-01-01 12:00:00 UTC to 2015-01-01 12:00:00 UTC) have been provided at an hourly timestep covering North America and parts of Central America (see Figure 2 for spatial coverage). Variables provided include all major forcings needed to run hydrologic and land-surface models (Table 1). Except for precipitation, all variables are outputs from 6-h to 18-h reforecast leadtime (not CaLDAS analysis) from the RDRS. For its part, precipitation is based on the after-the-fact 24-h accumulation CaPA analysis that has been disaggregated on an hourly basis relying on the spatio-temporal evolution of precipitation from the RDRS 6-h to 18-h reforecast leadtime as well as on 6-h accumulation CaPA analysis achieved online.
The 5-years dataset provided by ECCC-CMC is in FST format and was converted to NetCDF. Each day of the dataset was provided as a separate file following the name pattern `YYYYMMDD12.nc` specifying the issue date. Each file contains 25 time steps (YYYY-MM-DD 12:00, YYYY-MM-DD 13:00, YYYY-MM-DD 14:00, ..., YYYY-MM-DD+1 11:00, YYYY-MM-DD+1 12:00). For all variables except precipitation the first timestep of one file is the same as the last time step of the previous issue date. Precipitation is zero at the first timestep (YYYY-MM-DD 12:00). When files are merged, it is hence important to discard the first time step and keep the last timestep of each file. Also, as a side note, the sum of the 24 hourly accumulation of precipitation fields contained in a file produce exactly the original 24-h CaPA analysis.

The shape of Lake Erie was downloaded from `https://www.sciencebase.gov/catalog/item/530f8a0ee4b0e7e46bd300dd` (see Figure 3c) and used to crop the domain of Lake Erie (see Figure 3d). All files of the RDRS dataset were merged to one single file which contains the domain of Lake Erie and all hourly timesteps of the 5 years, i.e. 2010-01-01 12:00 to 2015-01-01 12:00.

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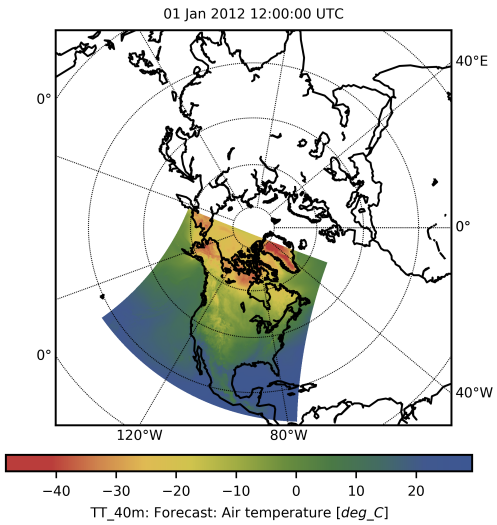

Figure 2: The Regional Deterministic Reforecast System (RDRS) dataset provided by ECCC-CMC (*Gasset et al.*, 2017, in prep.) covers North America and parts of Central America. The plot shows as an example variable (temperature `TT_40m`) at a randomly selected time step (2012-01-01 12:00 UTC noon). The spatial resolution of each RDRS variable is about 14.3 km. The temporal resolution is hourly spanning the period from Jan 1, 2010 12:00 UTC to Jan 1, 2015 12:00 UTC.

Table 1: Variables in the reforecast dataset provided by ECCC-CMC (*Gasset et al.*, 2017, in prep.). The forcings are either available at surface or 40 m height. The average spatial resolution is 14.3 km while the temporal resolution is 1 h.

Variable	Var. name	Long name	Unit	Level
Precipitation Rate	PR0	Quantity of precip.	[m]	SFC
Air Temperature	TT	Air temperature	[°C]	40m
Inc. Shortwave Rad.	FB	Downward solar flux	[W/m^2]	SFC
Inc. Longwave Rad.	FI	Surf. inc. infrared flux	[W/m^2]	SFC
Atmospheric Pressure	P0	Surface pressure	[mb]	SFC
Specific Humidity	HU	Specific humidity	[kg/kg]	40m
Wind Components	UU, VV	U/V-comp. of wind (along grid X/Y)	[kts]	40m
Corr. Wind Components	UUC, VVC	U/V-comp. of wind (along W-E/S-N direct.)	[kts]	40m
Wind Speed	UVC	Wind modulus	[kts]	40m
Wind Direction	WDC	Meteorol. wind direction	[degree]	40m

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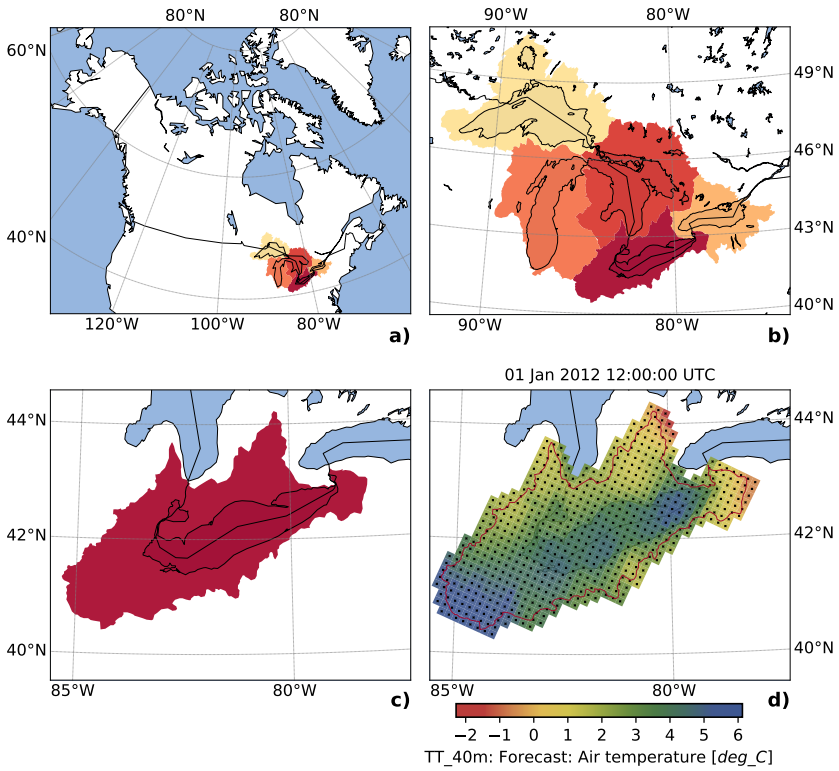

Figure 3: The location of the five color-coded Great Lakes (red: Lake Erie, dark-orange: Lake Huron, orange: Lake Michigan, light-orange: Lake Ontario, yellow: Lake Superior) as (a) an overview and (b) a close-up. (c) This study focuses on the domain of Lake Erie. (d) The domain of Lake Erie is cropped from the reforecast dataset provided by ECCC-CMC (*Gasset et al.*, 2017, in prep.). The last panel shows the temperature (`TT_40m`) of a randomly selected time step (2012-01-01 12:00 UTC noon).

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