

38 - YEARS OF GLOBAL AND REGIONAL REFORECAST AND SURFACE REANALYSIS AT ECCCC

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***Meteorological Service of Canada
Environment and Climate Change Canada (ECCC)***

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Motivation

- Increasing demands for:
 - long term reforecast and surface reanalysis datasets at higher resolution over North America.
 - Seamless and contiguous data over North America

Until recently:

- ✓ Dedicated products: not 'yet' available for North America
- ✓ Current long term reanalysis: too coarse space/time
- ✓ Resolution, limited available variables, ...
- ✓ Existing analysis: too short period of time, non-uniform in time/space (changes in the operational models)
- ✓ *But, models data and IT resources available to produce such a precipitation and surface reanalysis at an accessible cost*



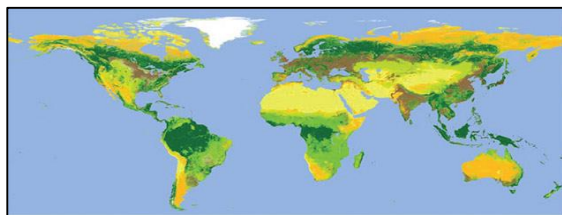
Motivation

- The reforecast/reanalysis will help to :
 - ✓ Gain an expertise for "home made" ECCC reforecast-reanalysis
 - ✓ Allows running the model back in time to 1980.
 - ✓ Better understand processes and model improvement
 - ✓ Support International efforts
 - ✓ Provide re -analysis for all Canada-USA transboundary watersheds
 - ✓ Useful for regional climatic studies, climate trend analyses, health studies, policy making and scientific agencies, research programmes, ecosystem studies, etc.
 - ✓ Estimate precipitation even in areas with limited gauge and radar coverage.



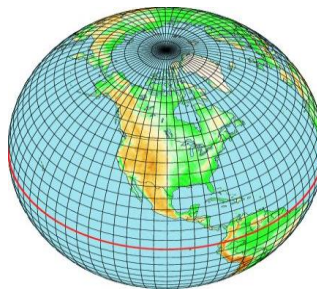
Methodology

ERA-Interim:
1979 to today
(~80km/6h)

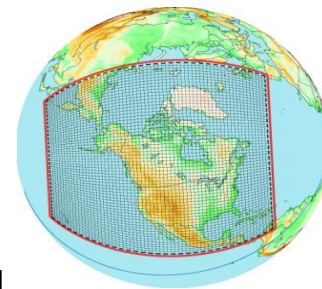


GEM-Surf (50 km)
surface model

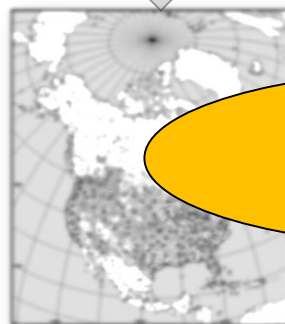
GEM GDRS (39 km)
atmospheric model



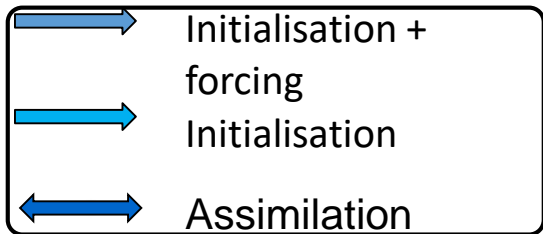
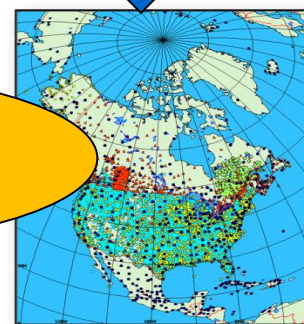
GEM RDRS (10 km)
atmospheric model



Precipitation and
surface data assimilation:
CaPA and CaLDAS



Surface
observations



CaPA-Canadian Precipitation Analysis System
CaLDAS-Canadian Land Data Assimilation System
G(R)DRS-Global (Regional) Deterministic Reforecast System
GEM - Global Environmental Multi-scale model



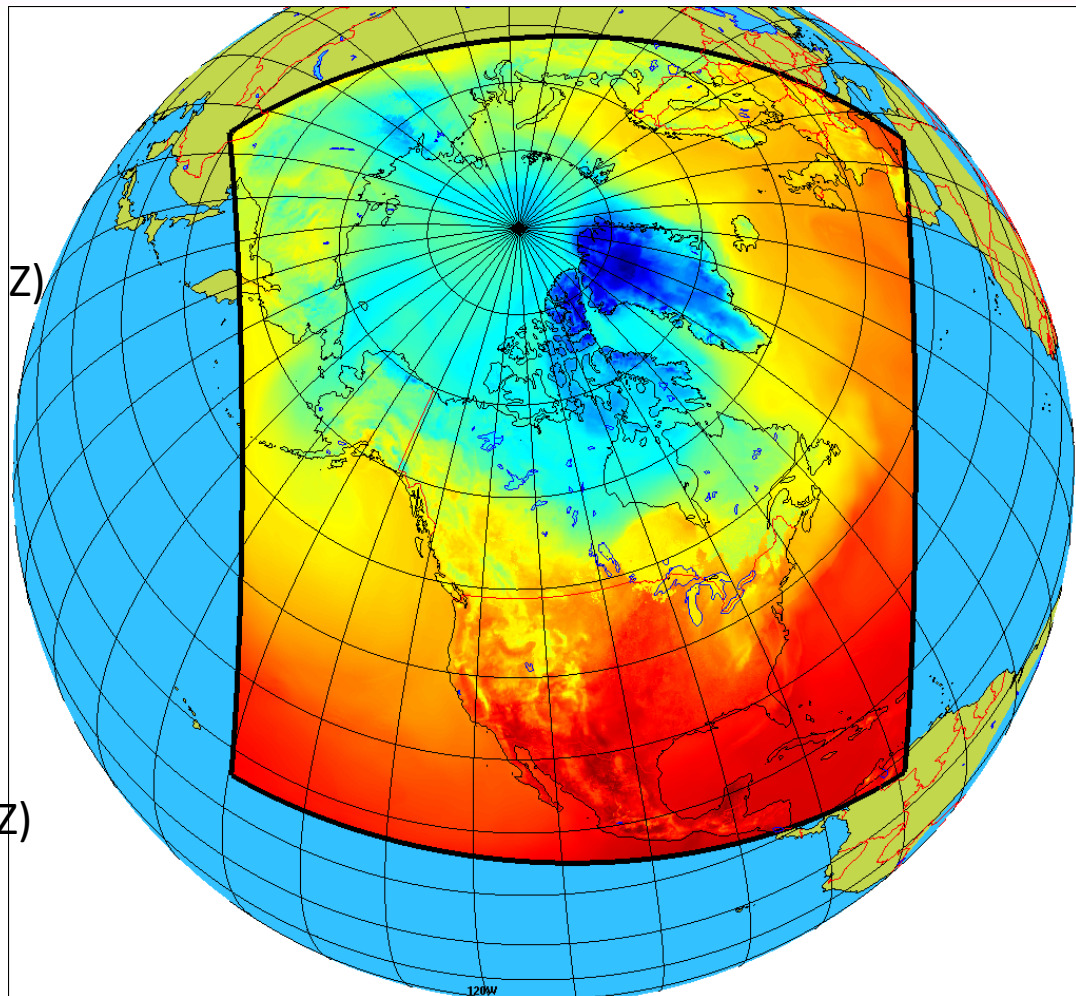
Reforecast Configuration

- **Global deterministic reforecast system (GDRS)**

- 39km resolution
- 12-h cycle/24-h reforecast (0Z and 12 Z)

- **Regional deterministic reforecast system (RDRS)**

- 10 km resolution
(cover Arctic Ocean)
- 12-h cycle/24-h reforecast(0Z and 12 Z)

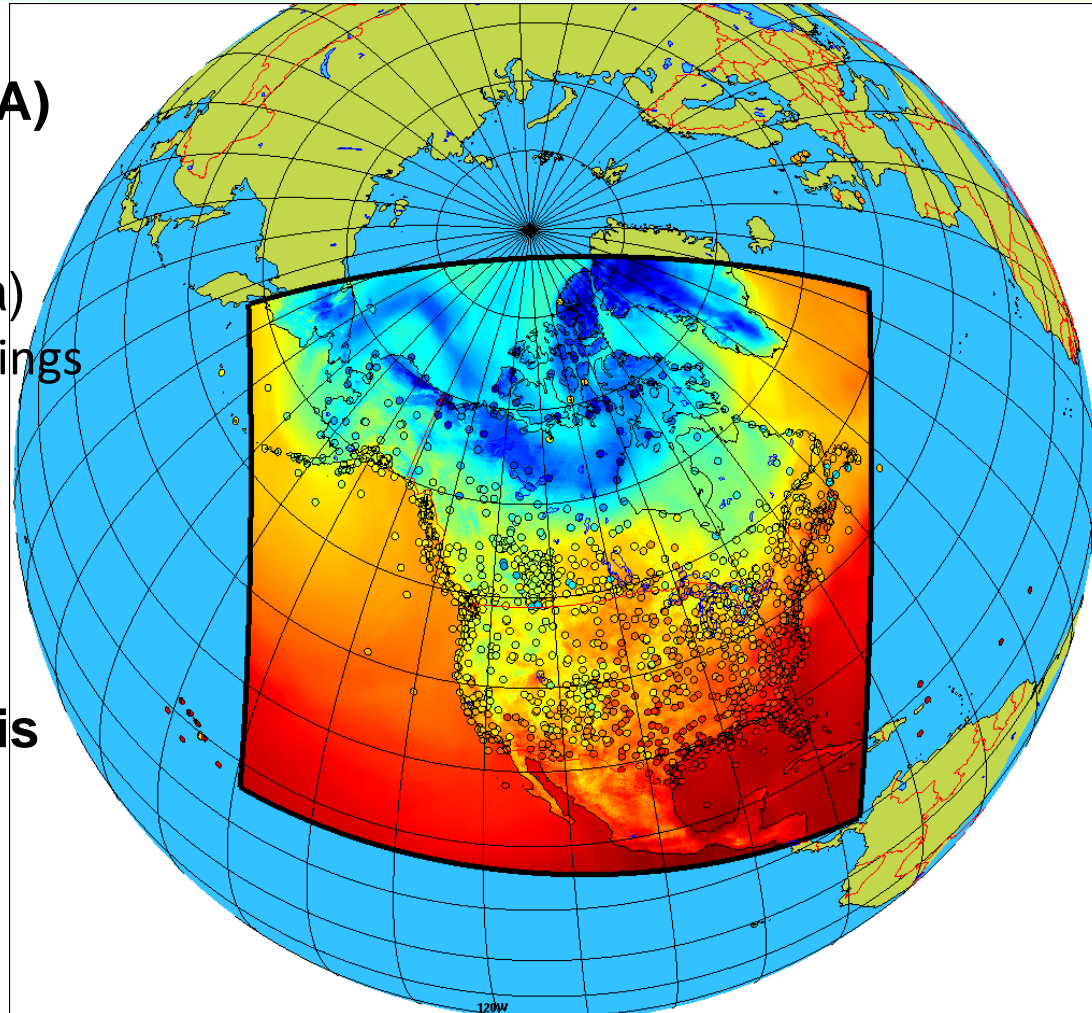


Reanalysis Configuration

- **Online precipitation and Surface analysis (CaLDAS/CaPA) (coupled with RDRS)**

- 10 km resolution (North-America)
- 12-h cycle (06Z and 18Z GEM forcings for CaLDAS/CaPA)
- Time step 3h

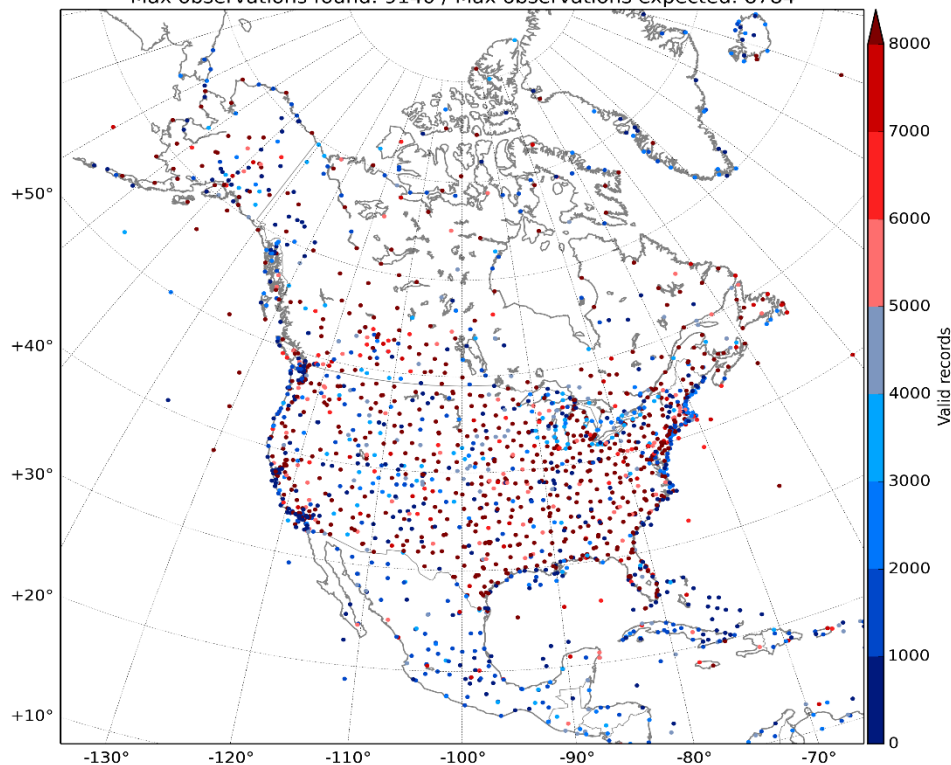
- **A posteriori 24-h pcp analysis will be produced for 1980-2000**



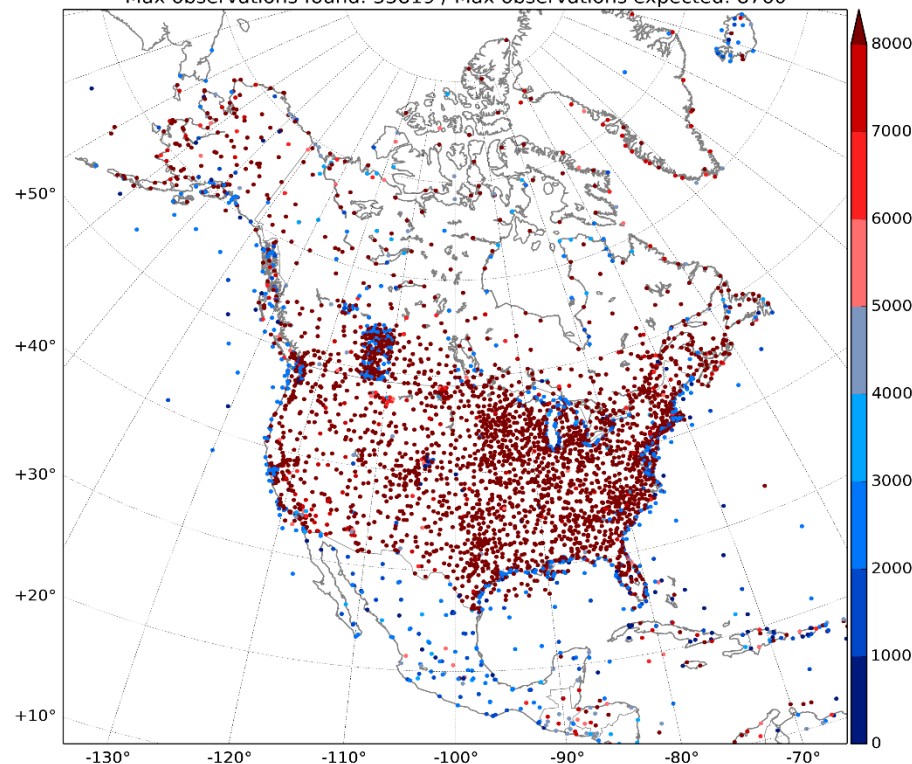
Surface Observations Datasets

- The growing availability of satellite data, and conventional observations (*weather balloons, stations, ships, buoys and aircraft*) provides a huge opportunity for improving reanalyses. *But ...it also presents some challenges.*

Temperature (12004)/1980 - ISD - Nr. of stations: 2004
Max observations found: 9140 / Max observations expected: 8784



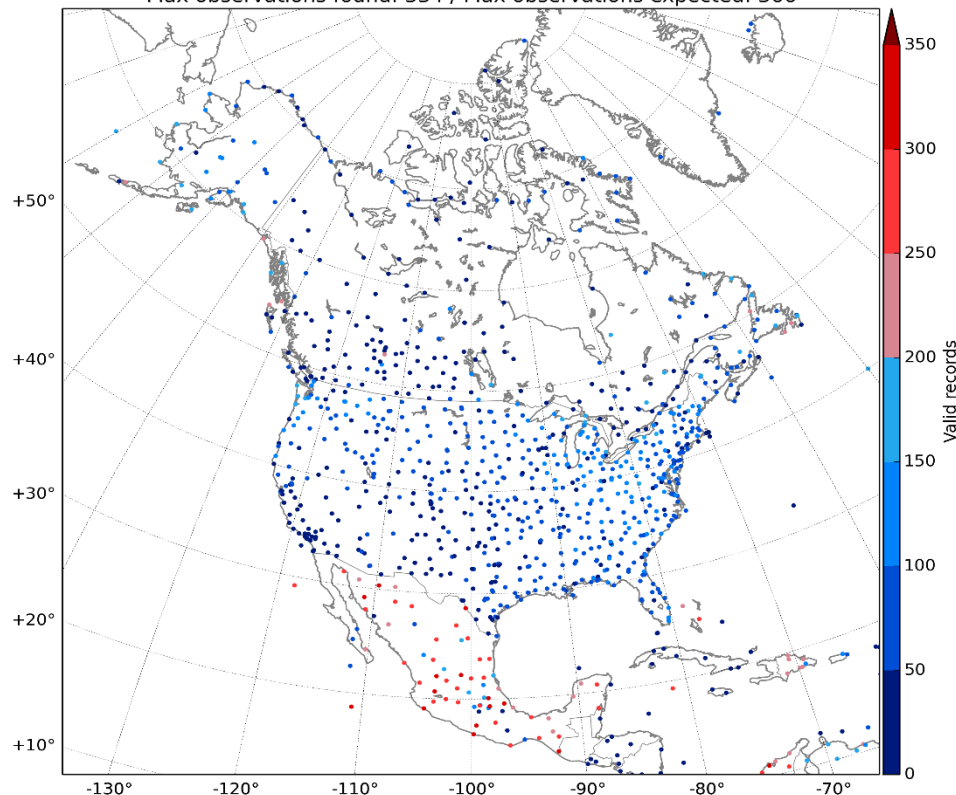
Temperature (12004)/2018 - ISD - Nr. of stations: 4238
Max observations found: 55819 / Max observations expected: 8760



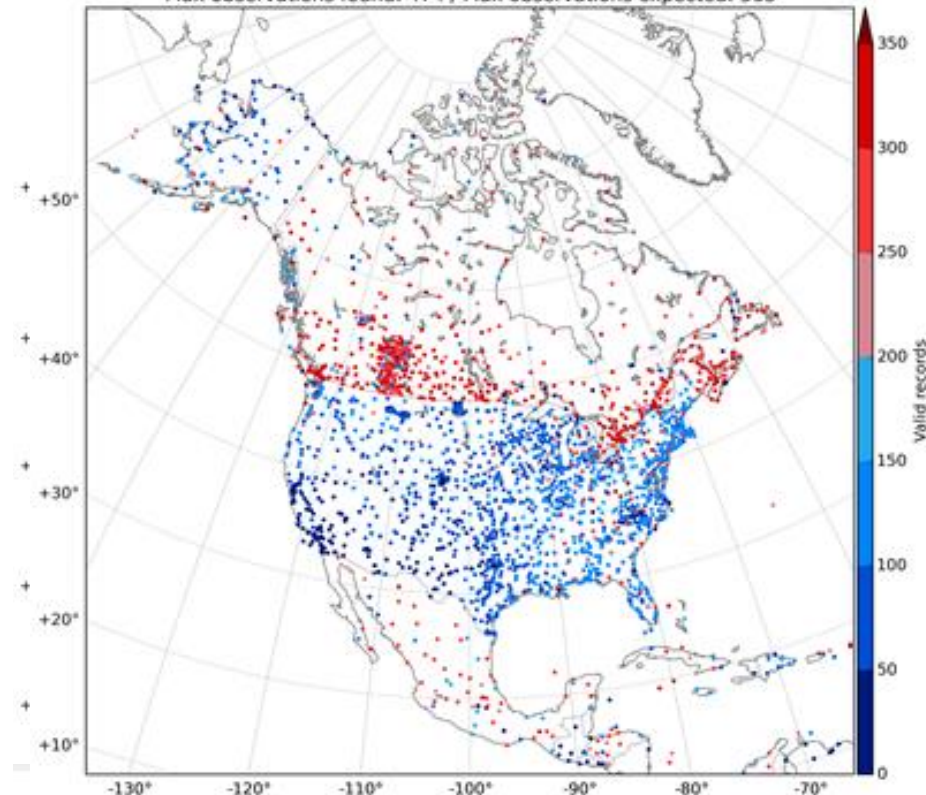
Surface Observations Datasets

- The growing availability of satellite data, and conventional observations (*weather balloons, stations, ships, buoys and aircraft*) provides a huge opportunity for improving reanalyses. *But ...it also presents some challenges.*

Total Precipitation 24h (13023)/1980 - ISD - Nr. of stations: 1031
Max observations found: 334 / Max observations expected: 366



Total Precipitation 24h (13023)/2018 - ISD - Nr. of stations: 2529
Max observations found: 474 / Max observations expected: 365



Surface Observations Datasets

- *Carefully selecting suitable observational datasets and ensuring the quality of the data is an important part of any reanalysis project*

ECCC Operational/Climat archive

Adjusted Daily Rain and Snow (AHCCD AdjDlyRS)

~ 3 500 stations Canada

24h precip. accum.

Extensive over Quebec from 1840 – today

MesoNet Québec

(inclus in CaPA/CaLDAS)

~ 1 200 stations Eastern Canada

3, 6, 24h precip. accum.



Environment and
Climate Change Canada

Environnement et
Changement climatique Canada

Integrate Surface Data (ISD) (NOAA)

- ~ 30 000 stations (Global dataset)
- Hourly observations from 1900 – today

TDL U.S. Canada Surface Hourly Obs. (inclus in IDS) (NOAA)

- ~ 5 500 stations - North American airports
- Hourly observations from 1978 – today

Ontario Power Generation

30 stn

Canada 

Verification vs operational model

rmse_PDRS01TEST / RDRPS		2014001 / 2014031	2014001 / 2014030	2014071 / 2014030	2014001 / 2014031
		All	All	All	All
Alaska plus Canadian Arctic	P0	2.86%	-0.25%	1.45%	3.59%
	TD	11.94%	7.39%	17.38%	11.42%
	TT	14.27%	-0.94%	3.46%	11.69%
	UV	0.00%	0.46%	0.14%	0.00%
Canada	P0	1.82%	0.15%	0.27%	0.47%
	TD	14.20%	8.34%	7.01%	8.42%
	TT	8.86%	-0.99%	1.08%	5.05%
Canada East	UV	-1.19%	0.14%	0.61%	-0.26%
	P0	6.22%	5.76%	7.17%	6.93%
	TD	9.70%	8.65%	3.90%	1.32%
Canada South	TT	10.36%	-4.36%	-2.22%	0.31%
	UV	-1.65%	0.09%	0.36%	0.11%
	P0	0.49%	0.04%	0.17%	0.03%
Canada West	TD	15.99%	9.16%	5.48%	8.73%
	TT	10.74%	0.64%	0.46%	4.86%
	UV	-1.07%	-0.03%	0.28%	-0.21%
Great Lakes Watersheds	P0	-0.24%	-0.14%	0.01%	-0.34%
	TD	19.81%	9.75%	5.67%	11.97%
	TT	10.87%	6.03%	2.28%	6.90%
Mexico	UV	-0.03%	0.53%	-0.23%	-0.59%
	P0	9.65%	12.37%	14.52%	10.46%
	TD	11.50%	7.30%	-4.34%	1.31%
North America	TT	7.22%	-4.35%	-8.44%	-1.43%
	UV	-0.75%	1.95%	1.63%	1.81%
	P0	10.79%	5.73%	6.90%	2.53%
North America East	TD	16.34%	16.70%	20.42%	16.95%
	TT	9.49%	5.32%	8.41%	9.22%
	UV	1.74%	0.05%	-0.08%	2.65%
North America West	P0	1.62%	0.38%	0.37%	0.44%
	TD	14.60%	8.26%	4.86%	6.13%
	TT	11.89%	2.57%	3.50%	7.71%
North America plus	UV	-0.52%	0.55%	0.75%	-0.09%
	P0	5.46%	5.58%	7.19%	5.95%
	TD	8.49%	6.90%	0.75%	-0.46%
United States of America	TT	9.60%	-2.77%	0.32%	1.69%
	UV	-1.30%	0.16%	0.61%	0.01%
	P0	1.10%	0.20%	0.20%	0.15%
United States of America East	TD	18.67%	9.32%	6.45%	11.06%
	TT	13.38%	7.55%	6.01%	10.43%
	UV	0.01%	0.95%	0.54%	-0.34%
United States of America West	P0	1.61%	0.30%	0.35%	0.48%
	TD	14.48%	8.00%	5.97%	8.77%
	TT	12.86%	2.16%	3.84%	9.00%
United States of America East	UV	-0.41%	0.54%	0.61%	-0.12%
	P0	3.01%	2.94%	2.57%	2.05%
	TD	12.10%	6.34%	3.94%	5.85%
United States of America West	TT	15.29%	7.51%	10.03%	13.92%
	UV	1.02%	1.30%	1.38%	0.38%
	P0	1.01%	4.20%	6.17%	0.12%
United States of America East	TD	6.15%	1.05%	-3.06%	-3.40%
	TT	9.03%	3.72%	6.95%	4.79%
	UV	0.05%	0.61%	1.52%	0.07%
United States of America West	P0	3.12%	2.86%	2.42%	2.13%
	TD	17.12%	8.51%	7.47%	11.47%
	TT	20.41%	9.17%	11.83%	20.11%
United States of America West	UV	1.80%	1.54%	1.67%	1.68%

Verification for 2014:

Legend:

Red – Reforecast system is better than the operational model

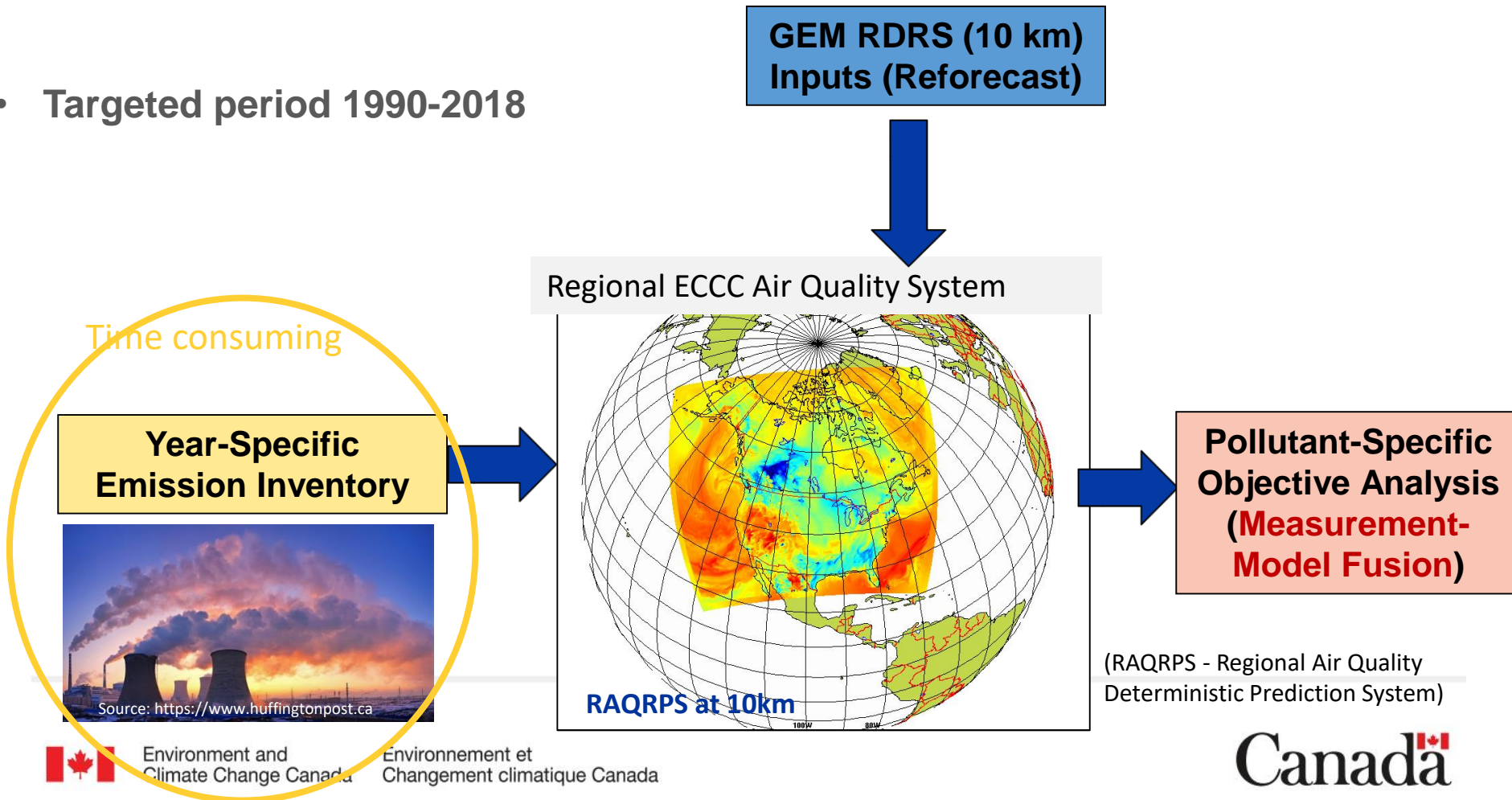
Blue - operational model is better than the reforecast system



Air quality applications

Regional Air Quality Reforecasting

- When the production of our reforecast/reanalysis finish the air quality reforecasting will begin
- Targeted period 1990-2018

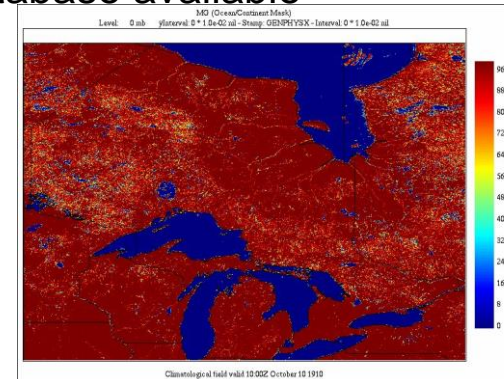
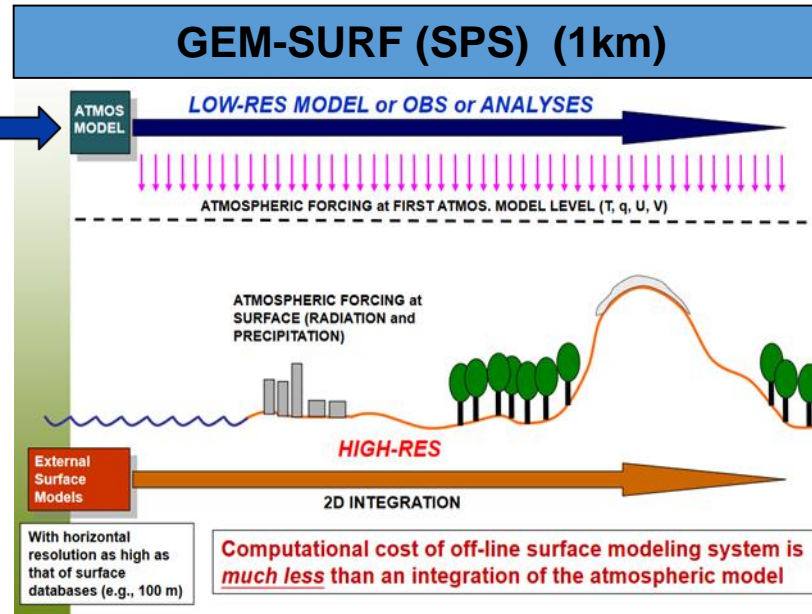
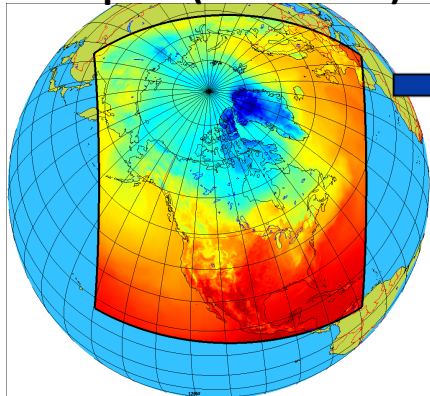


Air quality applications

Urban modelling

- Produce high resolution model outputs over Ontario province for health study purposes (Targeted period 2000-2018)
- drive directly the Surface Prediction System (SPS) with our reforecast fields
- SPS can run at resolution of most detailed surface characteristics database available

GEM RDRS (10 km)
Inputs (Reforecast)



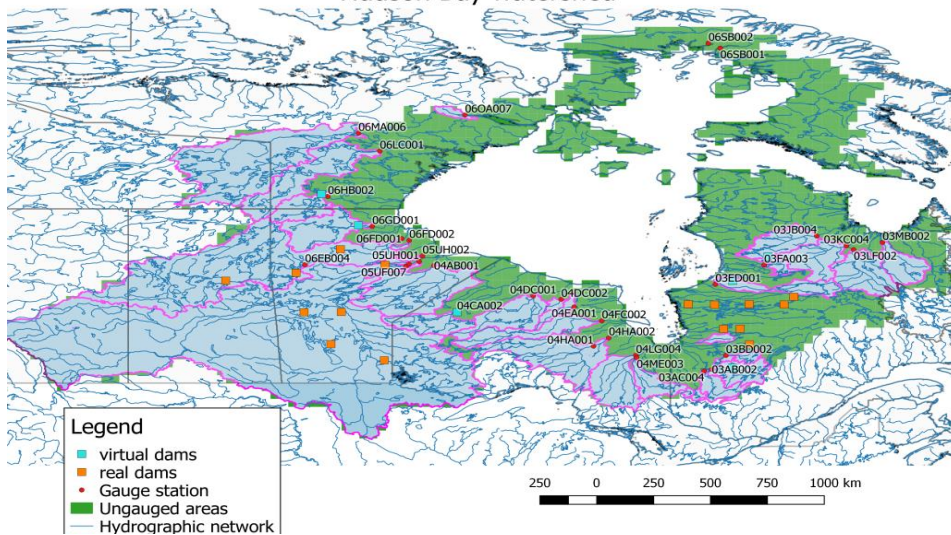
Producing high resolution (1km/hourly) model outputs over Ontario province for health study purposes

RAQRPS at 10km

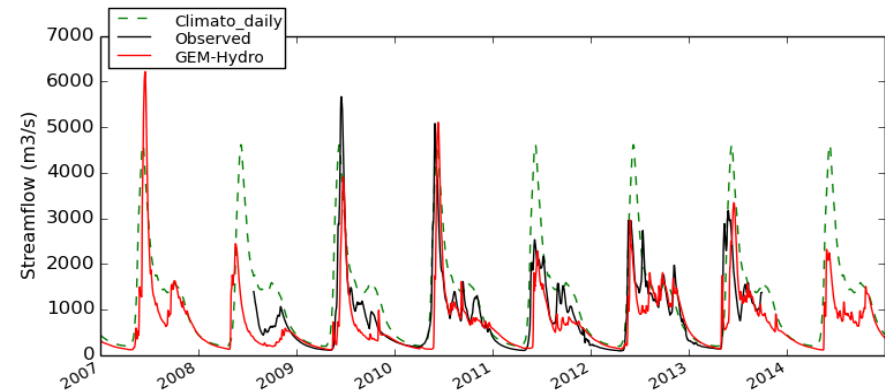


Hydrology applications: streamflows

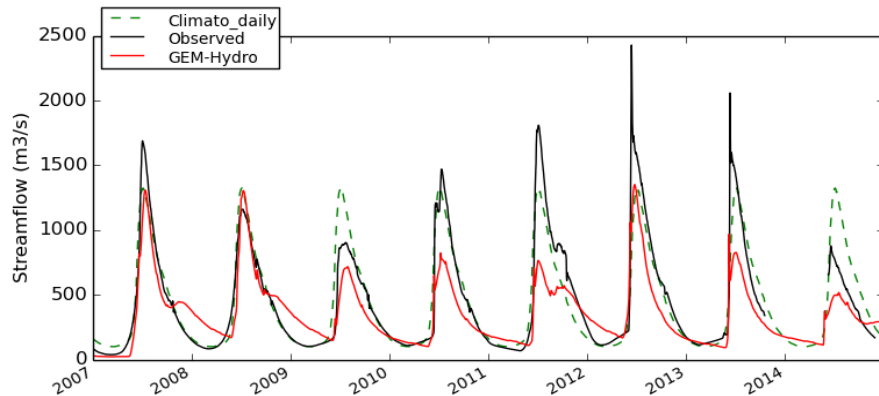
Hudson Bay watershed



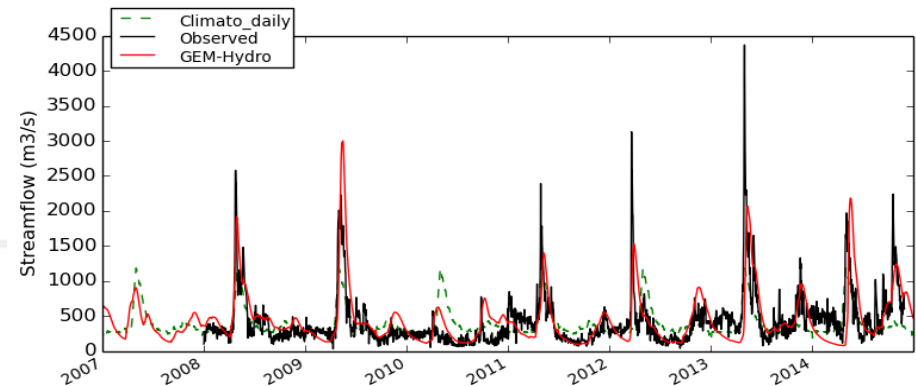
SVS1.0_agg5_decr_evap, gauge: 03LF002, river: Caniapiscau, DA error: -1.7%
 vs. E(obs): NSE : 0.54 SQRT_NSE : 0.62 LNSE: 0.66 PBIAS: 18.14
 vs. clim : NSE : 0.29 SQRT_NSE : 0.09 LNSE: -0.16
 minimum years for climato = 41 years



SVS1.0_agg5_decr_evap, gauge: 06LC001, river: Kazan, DA error: 1.4%
 vs. E(obs): NSE : 0.68 SQRT_NSE : 0.74 LNSE: 0.71 PBIAS: 18.76
 vs. clim : NSE : -0.91 SQRT_NSE : -1.15 LNSE: -1.49
 minimum years for climato = 44 years



SVS1.0_agg5_decr_evap, gauge: 04ME003, river: Abitibi, DA error: -4.4%
 vs. E(obs): NSE : 0.25 SQRT_NSE : 0.26 LNSE: 0.14 PBIAS: -6.40
 vs. clim : NSE : -0.10 SQRT_NSE : -0.01 LNSE: -0.00
 minimum years for climato = 45 years



Clients

Internal

- RPN-A/E/AD

Ocean/Glace

Surface

Hydrology

- Air Quality
- Climat

External :

- Agriculture Canada
- Pêche et Océan Canada
- Service des forêts Canadien
- Santé Canada
- Hydro-Quebec
- Ontario Power Generation
- RioTinto-Alcan

- *Ministère de l'Environnement et de la Lutte contre les*

 *changements climatiques*  *Environnement et
Changement climatique Canada*

- MesoNet-Quebec

• International:

- *National Oceanic and Atmospheric Administration (NOAA)*
- *United States Army Corps of Engineers (Office of Great Lakes Hydraulics and Hydrology)*
- *Environmental Protection Agency (EPA)*
- *European Centre for Medium-Range Weather Forecasts (ECMWF)*
- *MeteoFrance*

• International Joint Commission

- Ontario Climate Advisory Committee (OCAC)
- International Watershed Initiative (IWI)
- FloodNet
- Great Lakes Environmental Research Lab (GLERL)

• Universities



Public access to RF/RA

NOTE:

- ❖ *Direct ECCC data access is under development (GRIB, NETCDF...).*
- ❖ *Temporal solution is CaSPAr*




CaSPAr
Canadian Surface Prediction Archive



Juliane Mai, Kurt C. Kornelsen, Bryan Tolson, Paulin
Coulibaly, François Anctil, Vincent Fortin, Michael Leahy,
Brent Hall

<http://www.caspar-data.ca>

(limited for now to surface fields and precipitation)



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Thanks for your attention

Questions and/or comments?

Contact: nedka.pentcheva@canada.ca



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Canada 

The Canadian Land Data Assimilation System (CaLDAS)

IN

Ancillary land surface data

Orography, vegetation, soils, water fraction, ...

Atmospheric forcing

T, q, U, V, Pr, SW, LW

Observations

Screen-level (T, Td)

Surface stations snow depth

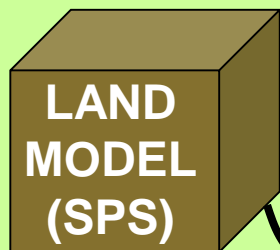
L-band passive (SMOS, SMAP)

MW passive (AMSR-E)

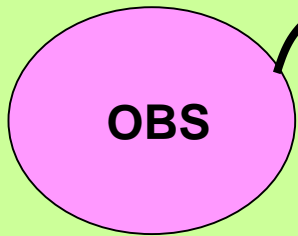
**Optical / IR (MODIS, VIIRS)*

Combined products (GlobSnow)

CaLDAS



x^b



y

EnKF

$$x^a = x^b + K \{ y - H(x^b) \}$$

with

$$K = BH^T (HBH^T + R)^{-1}$$

OUT

Analyses of...

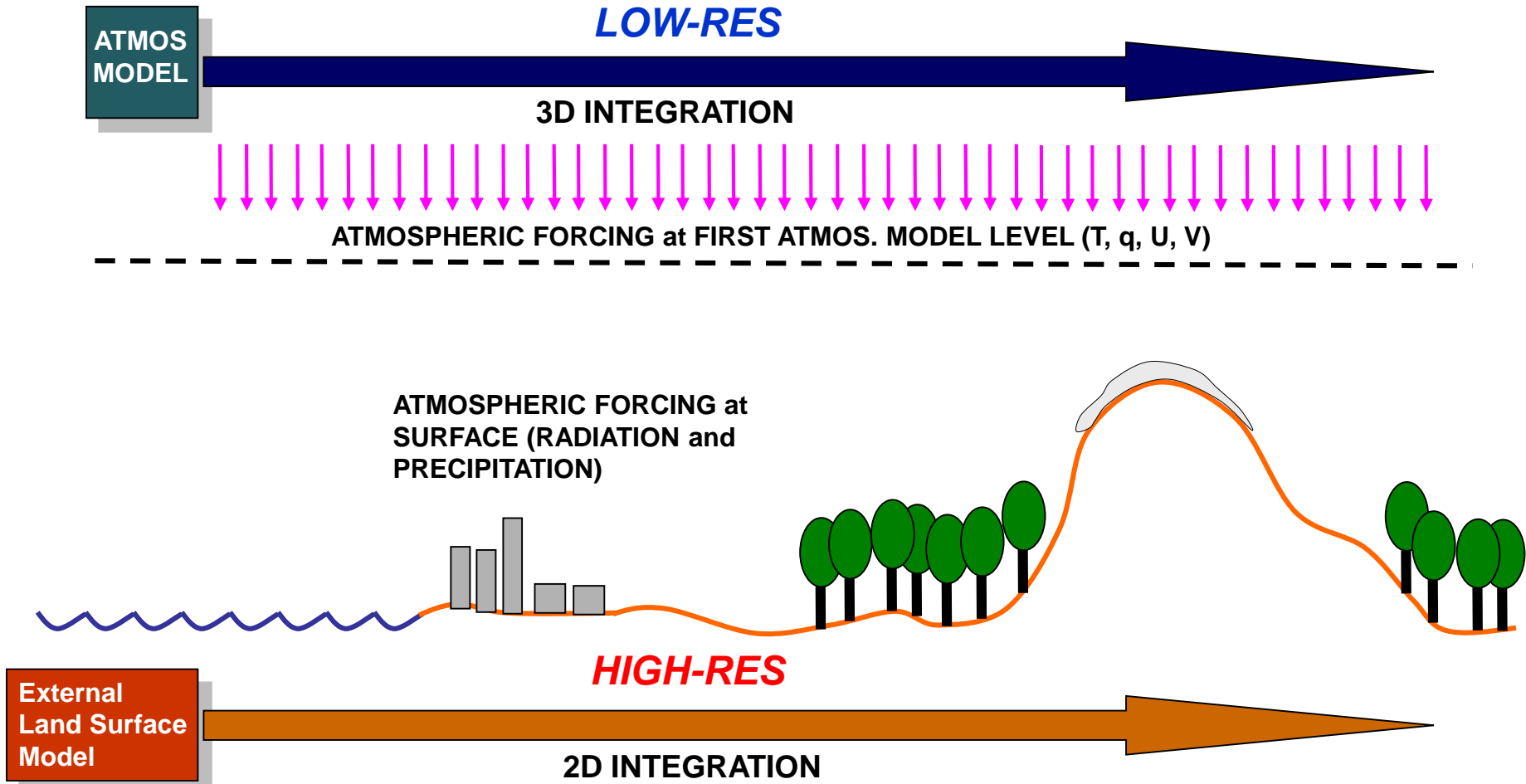
Surface Temperature

Soil moisture

Snow depth or SWE

Vegetation*

Land surface prediction system (SPS)



With horizontal resolution as high as that of surface databases (e.g., 100 m)

Computational cost of off-line surface modeling system is ***much less*** than an integration of the atmospheric model