The High Resolution Deterministic Land Surface Prediction System (HRDLPS) Version 2.0.0 of the Meteorological Service of Canada (MSC)

Technical Specifications

The HRDLPS 2.0.0 was implemented at the Operations Division of the MSC's Canadian Centre for Meteorological and Environmental Prediction (CCMEP) on December 1, 2021.

- A technical note describing the High Resolution Deterministic Land Surface Prediction System (HRDLPS-2.0.0) is available here:

  http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/docs/tech_notes/technote_hrdlps-200_e.pdf

- The most recent changes to the CMC operational prediction systems are described here:

  https://eccc-msc.github.io/open-data/msc-data/changelog_nwp_en/

- **La version française de ce document est ici:**

  http://collaboration.cmc.ec.gc.ca/cmc/CMOI/product_guide/docs/tech_specifications/tech_specifications_HRDLPS_2.0.0_f.pdf

The HRDLPS is a forecast system that produces high-resolution medium-range forecasts of land surface and subsurface variables, and of near-surface atmospheric variables (1.5-m temperature and dewpoint, 10-m wind). The system runs the SPS (Surface Prediction System) model in two stages on a grid with a 2.5-km horizontal spacing covering Canada and part of the USA. The land surface component selected in SPS is SVS (Soil-Vegetation-Snow). HRDLPS is initialized with analysis and trial fields provided by the CaLDAS-NSRPS system and is driven by HRDPS forecasts during the first two days of integration (stage 1) and GDPS forecasts over the next four days (stage 2; Fig. 1). As a first application, HRDLPS provides the necessary driving fields to the forecast component of the Deterministic Hydrological Prediction System (DHPS).

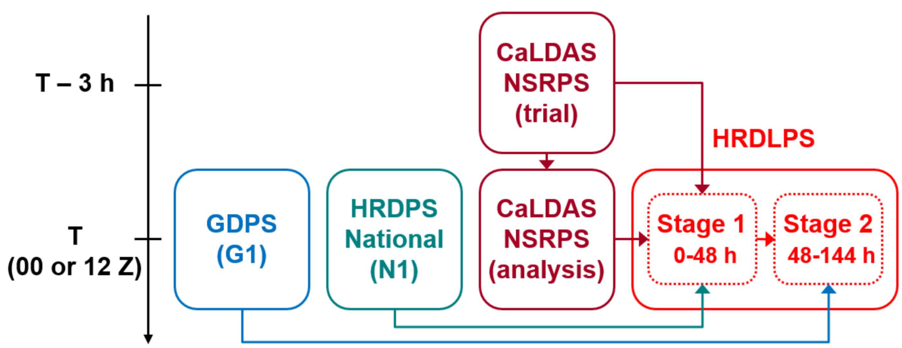

Figure 1. Schematic of the HRDLPS and its dependencies (CaLDAS-NSRPS, HRDPS and GDPS)

The run and processing times of the HRDLPS are given in Section 1. The configuration of the SPS model is described in section 2, the initial conditions in section 3 and the atmospheric forcing in section 4. Section 5 contains a short description of the changes made in this version of the system relative to the previous version. References and an appendix containing the configuration of the SPS are provided at the end of the document.

1. Daily Runs

Table 1.1 Summary of the daily runs of the HRDLPS

Frequency	Every 12 hours (00 and 12 Z)
Processing time	~95 minutes (~ 38 minutes for model runs on 80 CPUs on ppp3/4)
Disk space	~42 G per run

2. SPS Model Configuration

SPS (Surface Prediction System) is a stand-alone model consisting of the surface component of the GEM model and a driver. The model is configured to use the SVS land-surface scheme for the simulation of land surface processes in HRDLPS. An overview of the model configuration is given in Table 2.1. More details can be found in Appendix A.

Table 2.1 Overview of the SPS configuration

Model version	6.1.0
Surface scheme	Tile approach with four surface types: land, glacier, water and lake/sea ice (Bélair et al. 2003a and 2003b). *The urban canopy model TEB and urban tile are not used in the current configuration. The urban areas are represented by a specific land cover class in SVS and thus belong to the land tile.*
Land surface scheme	SVS (Husain et al. 2016; Alavi et al. 2016)
Grid	• size: 2540x1290; projection: rotated latitude-longitude/pole • spacing: 0.0225º (~2.5 km along the rotated equator) • coverage: Canada, except for the northern part of the Canadian Arctic Archipelago, and Northern US • identical to the core grid of the HRDPS National (N1)
Soil layers (for hydrological processes only)	Depth (m) at the bottom of each of the 7 soil layers: 0.05, 0.1, 0.2, 0.4, 1, 2, 3. The lateral flow (ALAT) and drainage (O1) calculated for the river routing model of the client system DHPS are collected from the top 6 layers.
Geophysical fields	Surface elevation (unfiltered) and subgrid slope derived from the Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) with 7.5-arc-second spatial resolution (~145 m at 51° latitude). Vegetation fractions and land-lake-water mask generated from the CCI-LC 2015 land cover data at 300-m resolution and the inland water body data at 150-m resolution (ESA 2017). Soil texture fields (sand and clay percentages) generated from the GSDE data (Global Soil Dataset for use in Earth System Models (30-arc-second resolution; Shangguan et al. 2014).

	Momentum roughness length (z0) derived from tree height estimates based on LiDAR data and look-up table values; z0 does not include an orographic component.
Time step	600 s

3. Initial Conditions

Table 3.1 Initial fields for SPS in the two stages of the HRDLPS and their sources

Stage	Variables	Source
1	Bare soil and vegetation temperatures Amount of water retained on vegetation Soil volumetric water and ice contents *CaLDAS-NSRPS provides analyses of the soil volumetric water content in the top four layers (top 40 cm) and lets the same quantity evolve freely in the bottom three layers.* *The soil volumetric ice content is set to zero in the current version because soil freezing and thawing are not yet represented in SVS.* Snow variables representing the snowpacks overlying glaciers and lake/sea ice (trial fields from the analysis files) Snow albedo, temperature, depth, density and water equivalent for the two snowpacks simulated by SVS. *Note that only some of these fields are analysed. Check the documentation of CaLDAS-NSRPS v3.1.0 for details.*	CaLDAS-NSRPS v3.1.0: analysis files
	Temperature of lake/sea ice and surface and time-mean surface temperature of glaciers (all recycled in CaLDAS-NSRPS) Lake/sea water temperature and ice concentration. *The original sources of these fields are the CCMEP's global analyses of sea surface temperature and sea ice concentration.*	CaLDAS-NSRPS v3.1.0: 3-h trial files
	Sea ice thickness	CCMEP climatology
2	All of the necessary variables	48-h forecast file generated in stage 1

4. Atmospheric Forcing

The atmospheric forcing fields (listed in Table 4.1) are taken from the output of CCMEP's high-resolution and global deterministic weather forecast systems, HRDPS/N1 and GDPS/G1. The relative humidity (HR) is calculated in stage 1 from the air temperature, specific humidity and pressure because this quantity was not available in the HRDPS output used in the development of the current version of HRDLPS.

Table 4.1 Atmospheric forcing fields for SPS in the two HRDLPS stages and their sources

Stage	Variables	Forecast hours	Source
1	UU and VV at the lowest prognostic momentum level	0-48	HRDPS/N1

	TT and **HU** at the lowest prognostic thermodynamics level		v6.0.0
	FB, FI, P0, PR		
2	UU and VV at the lowest prognostic momentum level	48-144	GDPS/G1
	TT and **HR** at the lowest prognostic thermodynamics level		v8.0.0
	FB, FI, P0, PR		

Forcing adjustment is necessary to account for the difference between the surface elevations of the HRDPS and GDPS and that of the HRDLPS. The adjustment is performed in SPS by applying a height correction with a constant lapse rate of -0.006 K/m to the air temperature. This is followed by a corresponding correction of the surface pressure (Bernier et al, 2011). The relative humidity is kept unchanged. The phase of the precipitation is determined in SPS either by the original or by the adjusted air temperature (where forcing adjustment takes place).

5. Changes relative to the previous version (v1.2.0)

5.1 Changes affecting system's performance

The GMED2010 dataset replaced the USGS dataset as the source of terrain elevation data used for the generation of the surface elevation and subgrid slope.

The initial conditions and atmospheric forcing fields are provided by upgraded versions of the CaLDAS-NSRPS, HRDPS and GDPS.

The hybrid initial conditions are no longer built and used.

The input relative humidity is calculated with respect to the water phase for subzero temperatures in stage 1.

SPS was upgraded to version 6.1.0.

A minimum Obukhov length (Lmin) is imposed for all surface types (as in GDPS).

Use of a time-varying Lmin over land given by sl_lmin_soil = 1 + frac * 19, with 'frac' varying so that sl_min_soil decreases from 20 m to 1 m in about 30 days (in June) and increases from 1 m to 20 m in about 30 days (in September). This minimum Obukhov length remains constant outside the two transition periods, namely 20 m in the cold season and 1 m in Jul-Aug.

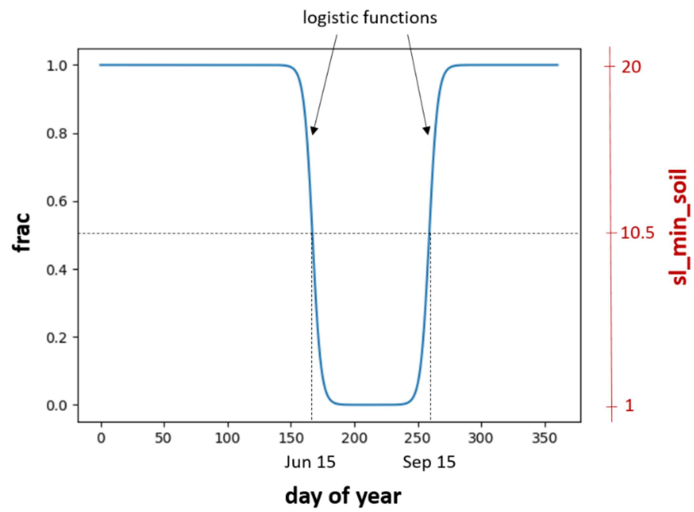

Figure 2. Dependence of the 'frac' coefficient used in calculation of sl_min_soil.

Delage's stability function for stable conditions in the atmospheric surface layer was replaced with Beljaars' function (as in GDPS).

Three parameters of the urban class have been modified in SVS. These are given in Table 5.1 along with their new and previous (default) values.

Table 5.1 Modified parameters of the urban class in SVS

Parameter	Default value	**New value**
bulk thermal coefficient of surface slab [$K\, m^2\, J^{-1}$] CVDAT(21)	2.e-5	**0.3e-5**
z0 [m] Z0MDAT(21)	5	**1**
bulk surface emissivity EMISDAT(21)	1	**0.95**

5.2 Other changes

Generation of netcdf files compliant with the Climate and Forecast Metadata Conventions for dissemination via Datamart.

References

Alavi, N., S. Bélair, V. Fortin, S. Zhang, S.Z. Husain, M.L. Carrera, and M. Abrahamowicz, 2016: Warm Season Evaluation of Soil Moisture Prediction in the Soil, Vegetation, and Snow (SVS) Scheme. *J. Hydrometeor*., 17, 2315–2332, https://doi.org/10.1175/JHM-D-15-0189.1

Bélair, S., L.-P. Crevier, J. Mailhot, B. Bilodeau and Y. Delage, 2003a: Operational implementation of the ISBA land surface scheme in the Canadian regional weather forecast model. Part I: Warm season results. *J. Hydrometeor.*, **4**, 352-370.

Bélair, S., R. Brown, J. Mailhot, B. Bilodeau and L.-P. Crevier, 2003b: Operational implementation of the ISBA land surface scheme in the Canadian regional weather forecast model. Part II: Cold season results. *J. Hydrometeor.*, **4**, 371-386.

Bernier, N.B., S. Bélair, B. Bilodeau, and L. Tong, 2011: Near-Surface and Land Surface Forecast System of the Vancouver 2010 Winter Olympic and Paralympic Games. J. Hydrometeor., 12, 508–530, https://doi.org/10.1175/2011JHM1250.1

ESA, 2017: Land Cover CCI Product User Guide Version 2. Tech. Rep. Available at: http://maps.elie.ucl.ac.be/CCI/viewer/download/ESACCI-LC-Ph2-PUGv2_2.0.pdf

Husain, S.Z., N. Alavi, S. Bélair, M. Carrera, S. Zhang, V. Fortin, M. Abrahamowicz, and N. Gauthier, 2016: The Multibudget Soil, Vegetation, and Snow (SVS) Scheme for Land Surface Parameterization: Offline Warm Season Evaluation. *J. Hydrometeor.*, 17, 2293–2313, https://doi.org/10.1175/JHM-D-15-0228.1

Shangguan, W., Dai, Y., Duan, Q., Liu, B. and Yuan, H., 2014. A Global Soil Data Set for Earth System Modeling. Journal of Advances in Modeling Earth Systems, 6: 249-263.

Appendix A: SPS configuration files used in HRDLPS for a specific start date

Stage 1	Stage 2
@grid_cfgs	@grid_cfgs
Grd_typ_S = 'LU'	Grd_typ_S = 'LU'
Grd_ni = 2540	Grd_ni = 2540
Grd_nj = 1290	Grd_nj = 1290
Grd_dx = 0.0225	Grd_dx = 0.0225
Grd_dy = 0.0225	Grd_dy = 0.0225
Grd_iref = 1050	Grd_iref = 1050
Grd_jref = 670	Grd_jref = 670
Grd_lonr = 180.0	Grd_lonr = 180.0
Grd_latr = 2.75	Grd_latr = 2.75
Grd_xlon1 = -100.00	Grd_xlon1 = -100.00
Grd_xlat1 = 53.00	Grd_xlat1 = 53.00
Grd_xlon2 = -85.00	Grd_xlon2 = -85.00
Grd_xlat2 = 50.00	Grd_xlat2 = 50.00
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Step_runstrt_S = '20211117.000000'	**Step_runstrt_S = '20211119.000000'**
Step_dt = 600	Step_dt = 600
Step_gstat = 1	Step_gstat = 1
Step_bkup = -1	Step_bkup = -1
Step_total = 288	**Step_total = 576**
@levels_cfgs	@levels_cfgs
Lvl_typ_S = 'HS'	Lvl_typ_S = 'HS'
Lvl_ptop_8 = 1000.0	Lvl_ptop_8 = 1000.0
Lvl_list = 0.995000	**Lvl_list = 0.9975018**
@sps_cfgs	@sps_cfgs
ip1a = 95366840	**ip1a = 95369342**
ip1at = 95369337	**ip1at = 95370590**
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lapserate = 0.0060	lapserate = 0.0060
read_hu_L = .false.	read_hu_L = .false.
max_neg_pr0=-1.E-04	max_neg_pr0=-1.E-04
zta = -1.	zta = -1.
zua = -1.	zua = -1.
stat_list_s = 'TJ','TDK'	stat_list_s = 'TJ','TDK'
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Document History			
Version	**Date**	**Author/Modified by**	**Notes**
1.0.0	April 19, 2019	Daniel Deacu	First version
1.2.0	April 1, 2020	Daniel Deacu	Updated document for HRDLPS v1.2.0
2.0.0	Nov 18, 2021	Daniel Deacu	Updated document for HRDLPS v2.0.0 (IC3)