Table 1: Products and water and energy variables for drought characterization and quantification

Data Type	Sample Variables	Time / Spatial Scale	Source
Surface observations / Surveys Census	Precipitation, winds, clouds (amount & type), temperature, humidity	Hourly / variable or gridded	AAFC / MSC / provincial water boards, provincial hydro utilities, network investigators
	Crop types, crop yields	monthly / variable	Stats Canada / AAFC/PFRA / CWB
	River flows, lake levels,	daily / variable	Water Survey of Canada / Provincial water authorities
	Wetland and water levels	monthly / variable	Canadian Wildlife Service / Ducks Unlimited
	Ground water levels	daily to monthly / variable	Manitoba Water Stewardship / Saskatchewan Research Council / Alberta Environment
	Snow water equivalent and snow covered area	daily to monthly	MSC, Alberta Environment, SWA, MWS
Upper air observations	Temperature, geopotential height, water vapor, winds	12 hours / variable	MSC
Model Analyses & re-analyses (e.g. CRCM, GEM, NCEP, ECMWF, Eta)	Numerous atmospheric and surface fields	6 hourly / gridded	MSC / NCEP / ECMWF
Model forecasts or simulations (GEM, MC2, CRCM, WATCLASS, CRHM, groundwater models)	Same as above for atmosphere but used for diagnosis of model performance	6 hourly / gridded	MSC / Network investigators & collaborators
	Streamflow, storage (at surface and deeper), ground water	daily / variable or gridded	Provincial water authorities / provincial hydro utilities / network investigators
Crop model output (spring wheat readily available)	Root-zone and top-zone soil moisture, ET, crop phenology, fractional leaf area, rooting depth	Daily / each station	MSC
Satellites/Airborne (see attached from RS)	Atmospheric fields Land cover type, Snow covered area, SWE, frozen ground extent, flood areas	30 min / variable variable / variable weekly / variable	MSC / NOAA / CEOP / AAFC / CFS / MCRS / Stats Canada / NSIDC
Canadian lightning detection network (CLDN)	Lightning location and polarity	seconds / variable	MSC
Radar	Precipitation, winds,	10 min / variable	MSC
Drought Indices	PDSI, Z-Index	Daily / variable or gridded	AAFC/PFRA
Forest Conditions	Forest fire hazard zones (forecast and historical)	weekly / variable	CFS / provincial forestry services
Flux and/or special meteorological towers	Soil moisture, latent and sensible heat fluxes	15 min / variable	BERMS / Fort Peck / research basins

List of Satellite Remote Sensing Products that Might Be Related to Drought Network:

Precipitation (Rainfall) Products:

• **SSM/I (Speical Sensor Microwave Imager)** on board DMSP (Defense Meteorological Satellite Program). Cover/Spatial Resolution: Global/15 km. Temporal Resolution: 12 hours. Data Availability: 1987-present.

• **AMSU (Advanced Microwave Sounding Unit)** on board NOAA KLM spacecraft. Cover/Spatial Resolution: Global/16 km. Temporal Resolution: 12 hours. Data Availability: 1998-present.

• **AMSR-E (Advanced Microwave Scanning Radiometer for EOS)** on board NASA EOS (Aqua) platform. Cover/Spatial Resolution: ±70 (lat) / 16 km. Temporal Resolution: 12 hours. Data Availability: 2002-present.

• **GOES (Geostationary Operational Environmental Satellites)** on board NOAA spacecraft. Cover/Spatial Resolution: Global / 5.4 km. Temporal Resolution: 30 minutes. Data Availability: 2002-present (historical data might need to process). GOES data might not be free (a few thousand dollars per year for either past few years products (over Southern Canada especially) or software to read out the data depending on the amount of data needed).

• Other products: Envisat-1 by ESA (Europe Space Agency). Data availability: May 2002 – present. RADARSAT by CSA (Canadian Space Agency). Data availability: Nov. 1995 – present (not free).

Soil Moisture Products:

• **AMSR-E (Advanced Microwave Scanning Radiometer for EOS)** on board NASA EOS (Aqua) platform. Cover/Spatial Resolution: ±70 (lat) / 16 km. Temporal Resolution: 12 hours. Data Availability: 2002-present.

• Other products: ADEOS-II, Japan, 2002 – present. Soil Moisture Ocean Salinity (SMOS), Europe Space Agency, start 2006.

Cloud Products

• **CERES (Clouds and the Earth s Radiant Energy System)** on board NASA Terra (March, 2000 – present) and Aqua (June, 2002 – present) platforms (Cloud Base and Top Pressure, Cloud Layer Area, Cloud Infrared Emissivity, Ice and Liquid Water Paths, Cloud Particle Phase and Size, Visible Optical Depth)

• **MODIS (Moderate Resolution Imaging Spectroradiometer)** on board NASA Terra (March, 2000 – present) and Aqua (June, 2002 – present) platforms

(cloud top properties (cloud top temperature and emissivity), and cloud phase, optical thickness, effective radius, cloud fraction (cloud amount), cloud mask, particle radius, and thermodynamics)

• **AVHRR (Advanced Very High Resolution Radiometers)** on board NOAA platforms (1979-2005) (cloud top properties (cloud top temperature and emissivity), and cloud amount, cloud mask , cloud optical thickness and particle sizes)

• **GOES (Geostationary Operational Environmental Satellite)** on board NOAA platforms (1994-present) (cloud top properties (cloud top temperature and emissivity), and cloud amount, cloud mask, cloud optical thickness and particle sizes)

Aerosol Products:

• MODIS on board NASA Terra (March, 2000 – present) and Aqua (June, 2002 – present) platforms (optical thickness, effective radius,

• **MISR (Multi-angle Imaging Spectrometer)** on board NASA Terra (March, 2000 – present) and Aqua (June, 2002 – present) platforms

• **TOMS (Total Ozone Mapping Spectrometer)** aerosol products, especially sensitive to absorbing aerosol from sandstorm and wildfire.

Radiative Flux Products:

• **CERES (Clouds and the Earth s Radiant Energy System)** on board NASA Terra (March, 2000 – present) and Aqua (June, 2002 – present) platforms. Broadboard SW (shortwave) and LW (longwave) radiative fluxes at TOA.

• AVHRR, MODIS, GOES – narrowboard SW & LW radiative fluxes at TOA (narrowband to broadband conversion algorithm developed by Feng and Leighton is needed)

• Surface absorbed solar radiation can be derived using Li and Leighton algorithm.

NDVI (Normalized Difference Vegetation Index) & LAI (Leaf Aera Index) Products:

• AVHRR, MODIS, Landsat TM (Thematic Mapper) and ETM+ (Enhanced Thematic Mapper Plus), and SPOT-VEGETATION) have vegetation retrieval products (NDVI and LAI). MODIS products are best (global coverage, near real time (3-5 days delay), spatial resolution: 1km and data availability: 2000 – present.

Snow Cover and SWE (Snow Water Equivilent) Products:

- The current snow coverage products include low spatial resolution products from NOAA AMSU (Advanced Microwave Sounding Unit) (48km/12 hours), DMSP (Defense Meteorological Satellite Program) SSM/I (Special Sensor Microwave Imager) (25km/daily), and NASA AMSR-E (Advanced Microwave Scanning Radiometer – EOS) (25km/daily) as well as high spatial and low temporal resolution products from Landsat ETM+ (30m/16 days).

- Since early 2004, NOAA NESDIS Satellite Analysis Branch (SAB) began to produce daily Interactive Multisensor Snow and Ice Mapping System (IMS) maps for northern hemisphere with ~4km spatial resolution. The IMS incorporates multiple satellite imagery (AVHRR, GOES, SSMI, etc.) as well as derived mapped products (USAF Snow/Ice Analysis, AMSU, etc.) and surface observations to produce the daily northern hemisphere snow and ice cover.

- MODIS daily and 8 days globe (500m x 500 m grid) snow cover and fractional snow cover products are available at NSIDC DAAC. Data availability: 2000-present.