CRCM5

Katja Winger
Centre ESCER, Université du Québec à Montréal

UQÀM

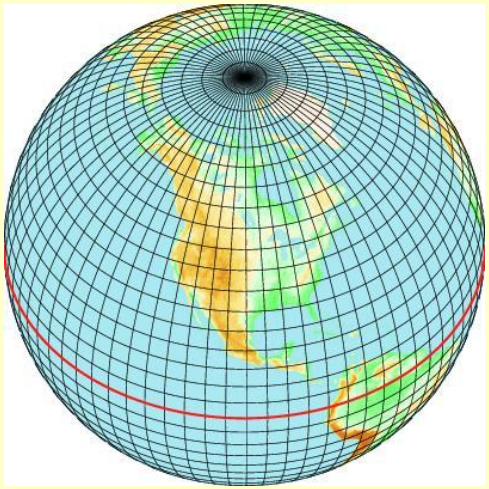
CENTRE ESCER
POUR L'ÉTUDE ET LA SIMULATION DU CLIMAT
À L'ÉCHELLE RÉGIONALE

Model: CRCM5 a.k.a. GEMCLIM

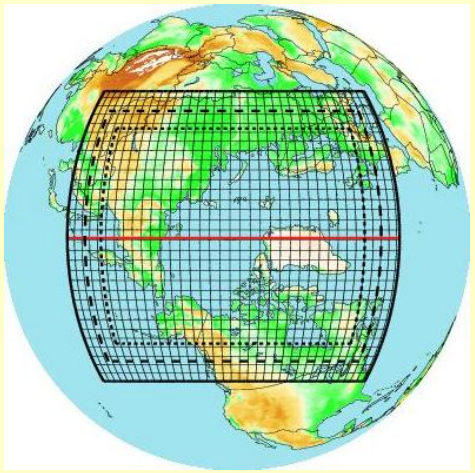
- 5th generation of the Canadian Regional Climate Model at UQAM
- based on **GEM** (**G**eneral **E**nvironmental **M**ultiscale), Environment Canada's numerical weather prediction model
- Dynamics GEM_3.3.3 & Physics_5.0.4 **+**
- Development at Centre ESCER primarily funded by CFCAS & Ouranos

- operates on massively parallelised computer architecture (such as CLUMEQ)
- supports a number of model configurations within a single system

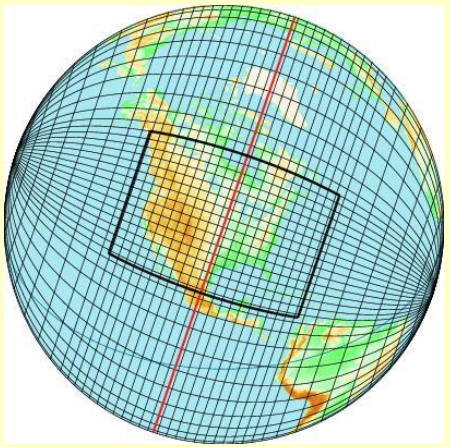
Global uniform



Limited area



Global variable

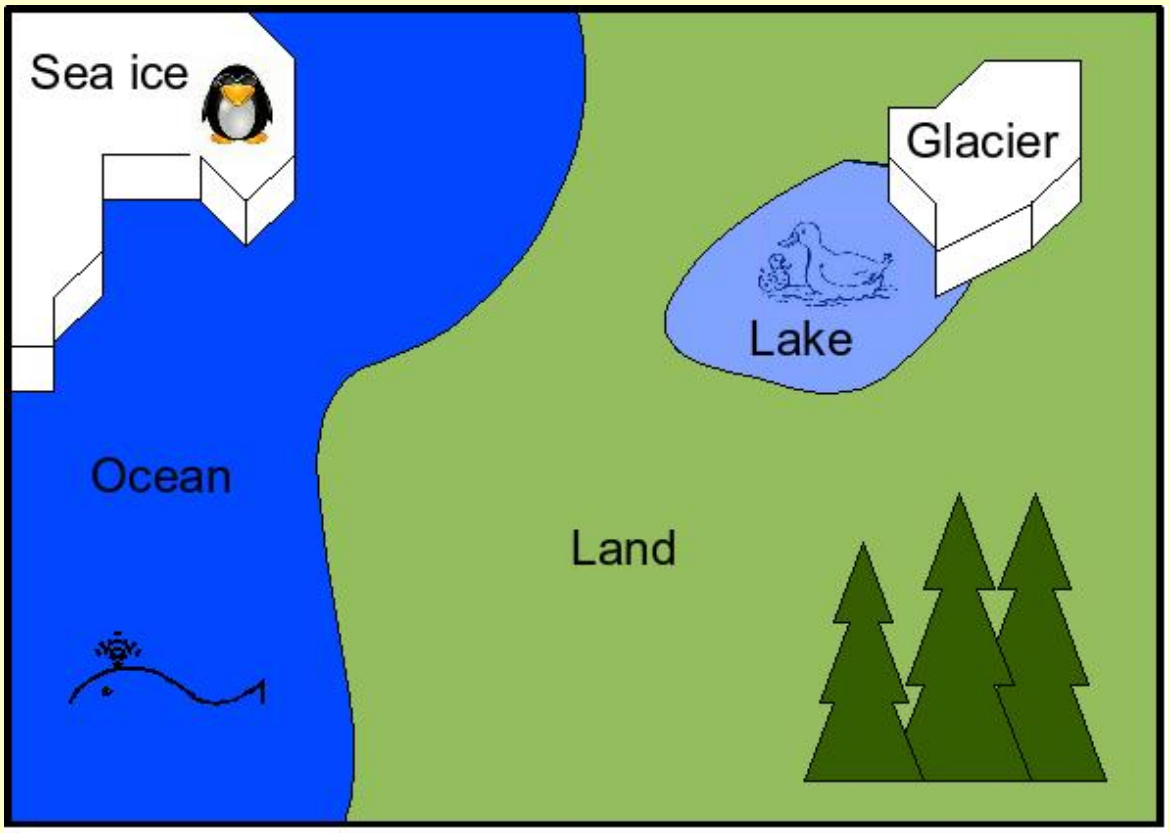


Outline

Rotated grids
Geophysical fields
Model grid “zones”
Model input / Driving data
Model output
Simulations

Aggregation

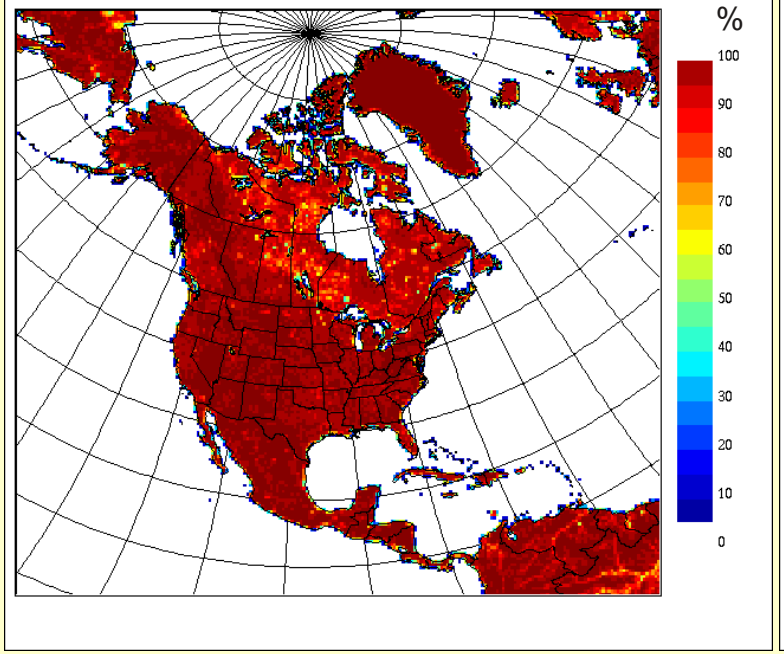
One grid cell => up to 5 different surface types:

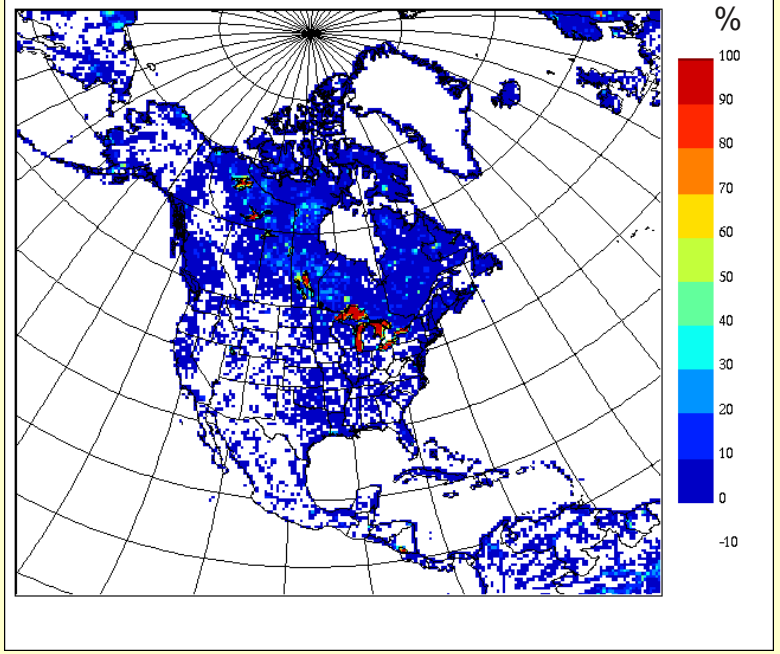


1: Soil / Land
2: Glaciers
3: Water / Ocean
4: Marine ice
5: Aggregated value
6: Lakes

Surface fraction

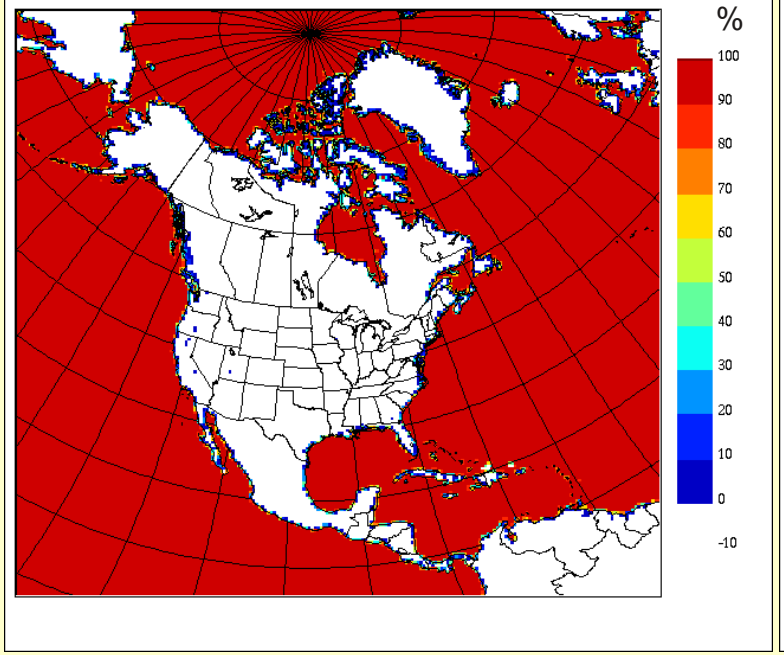
land-sea mask

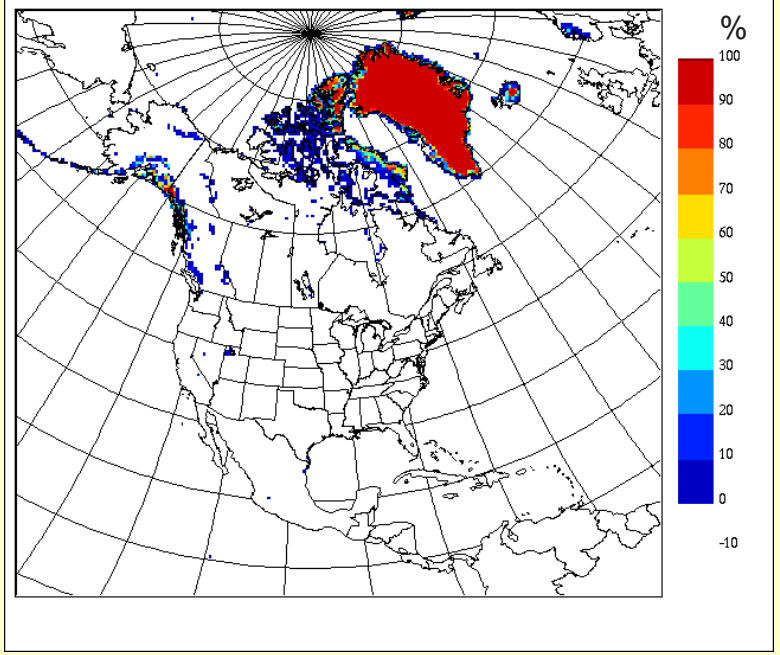




lakes

salt water

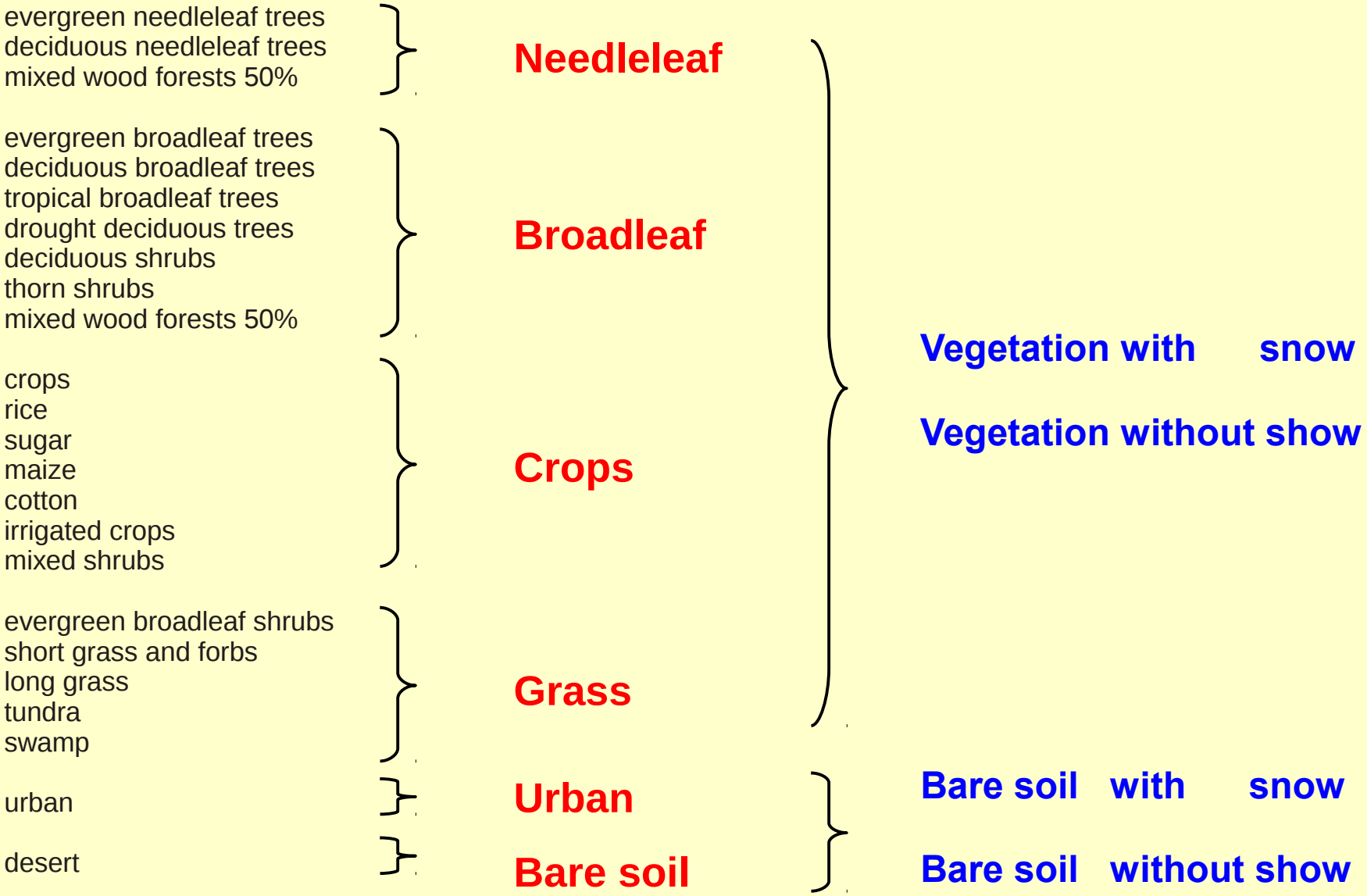




glaciers & ice sheets

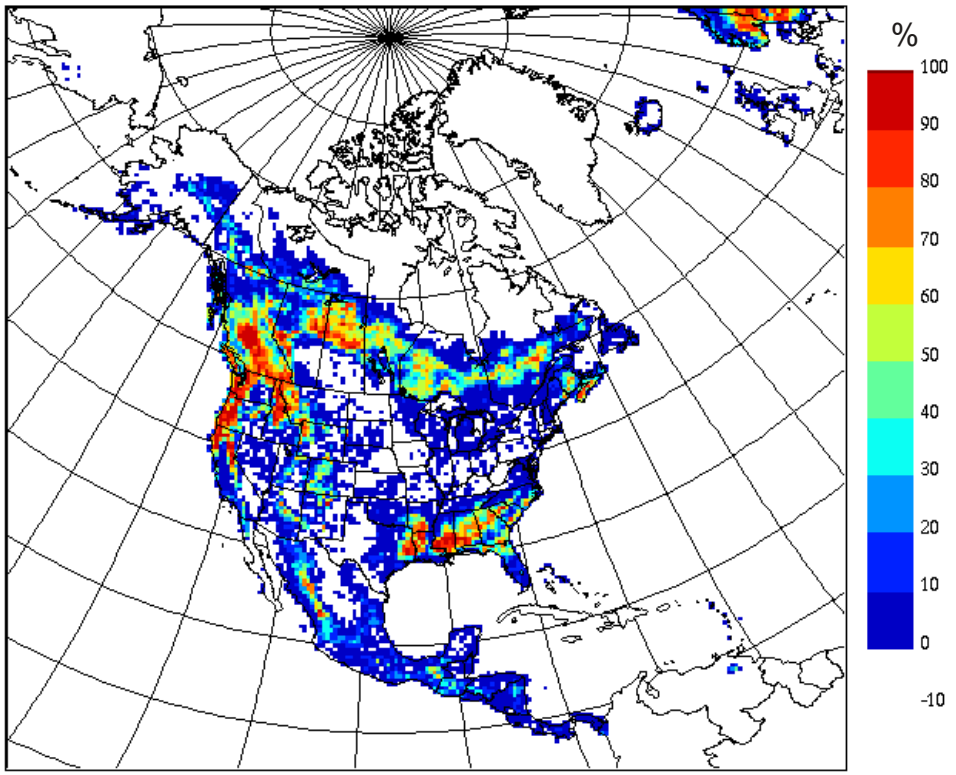
Vegetation fractions

The “Land” surface fraction gets constructed from 23 vegetation fractions

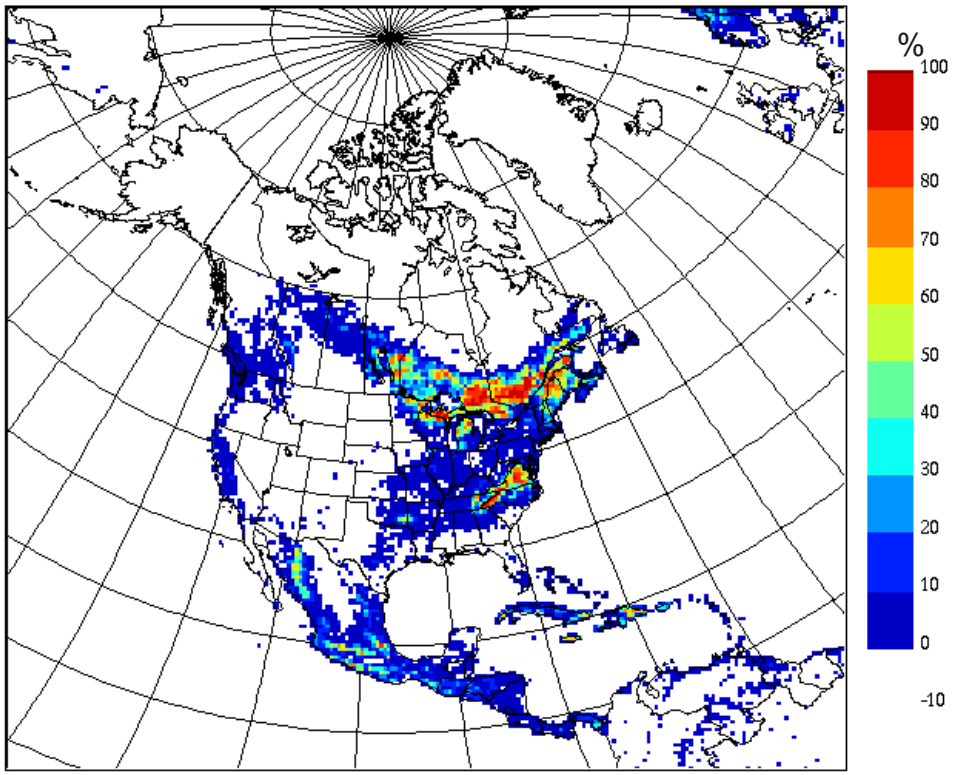


Needleleafs

evergreen needleleaf trees

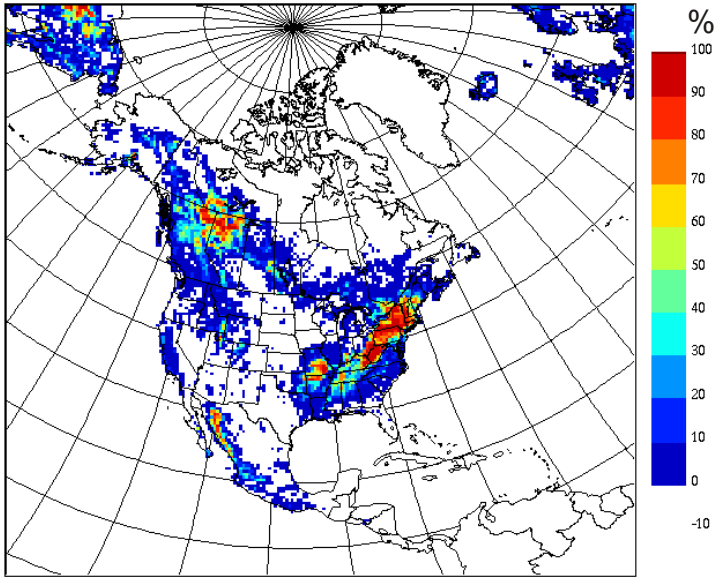


mixed wood forest 50%

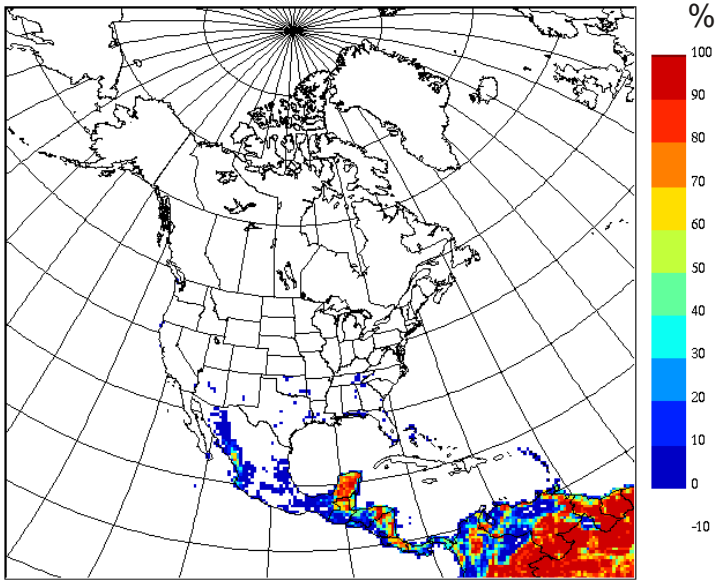


Broadleafs

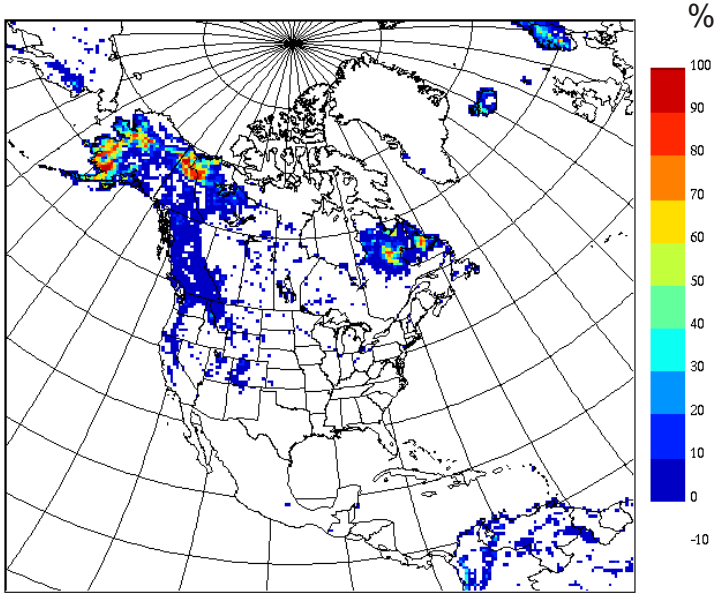
deciduous broadleaf



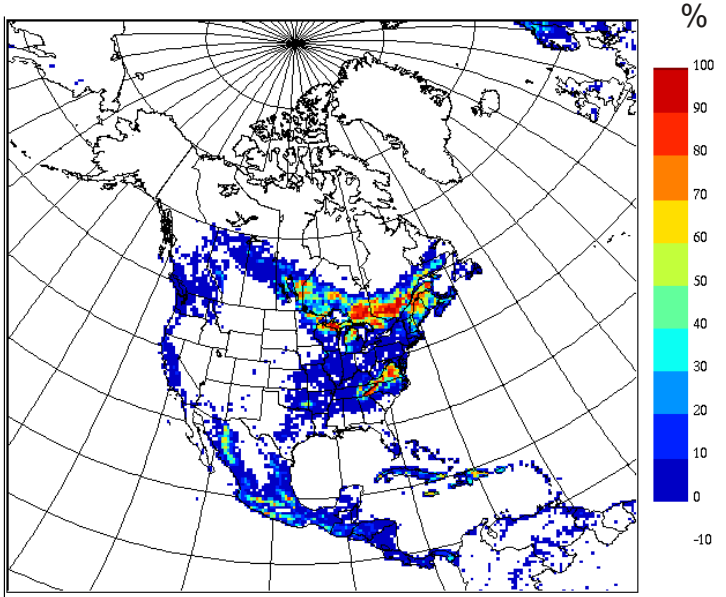
evergreen broadleaf trees



deciduous shrubs

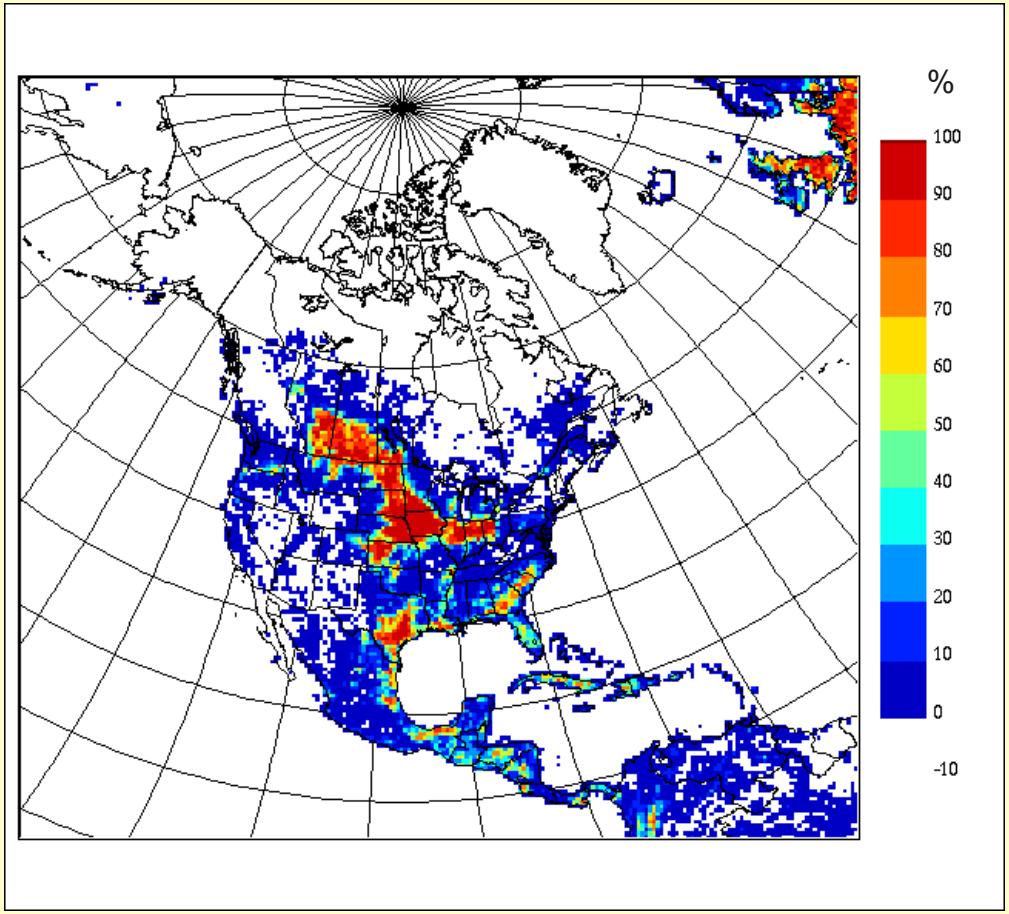


50% of
mixed wood forest

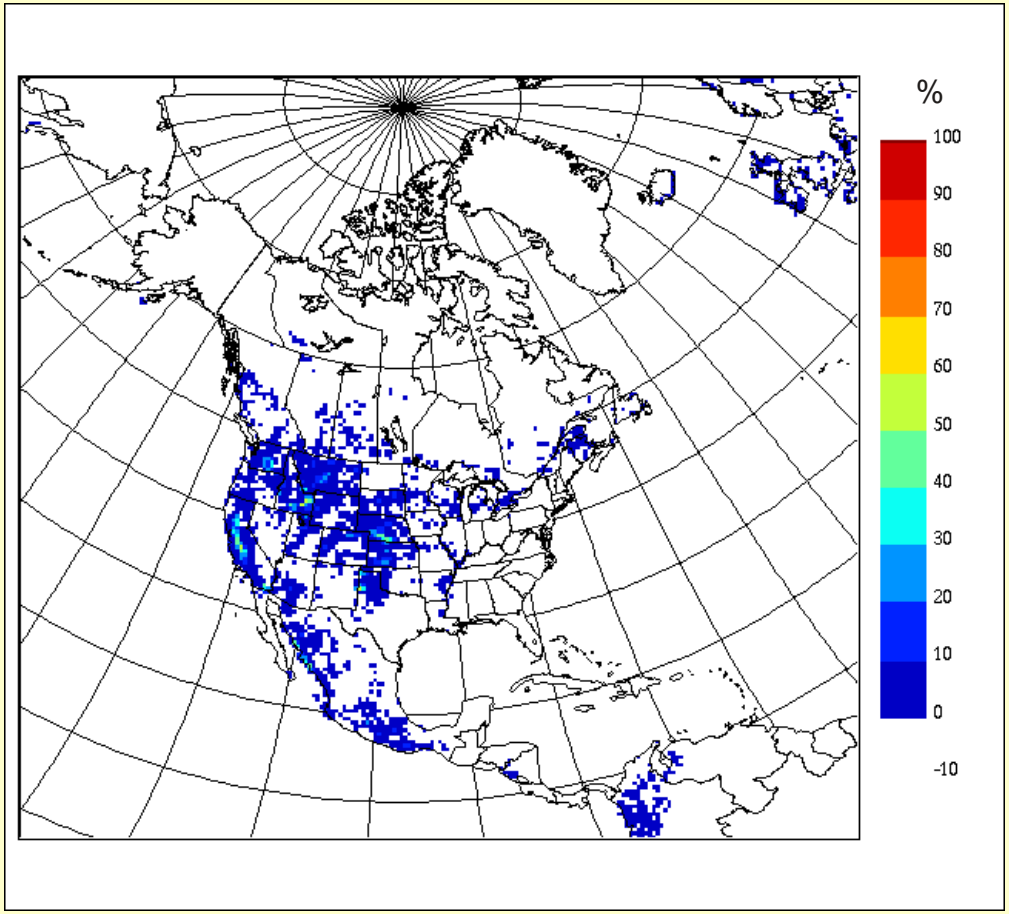


Crops

crops

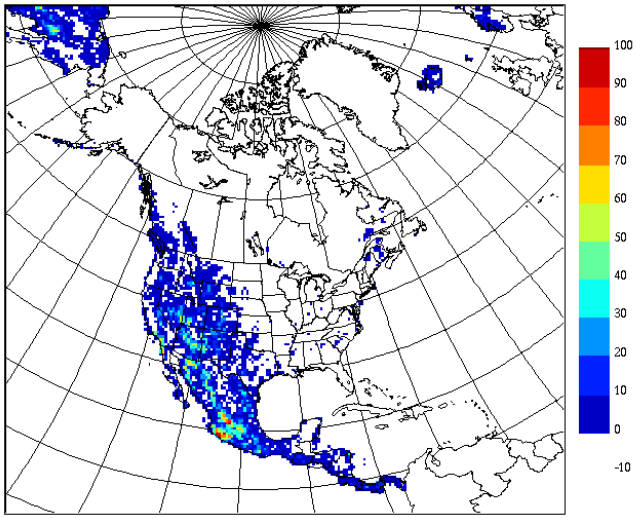


irrigated crops

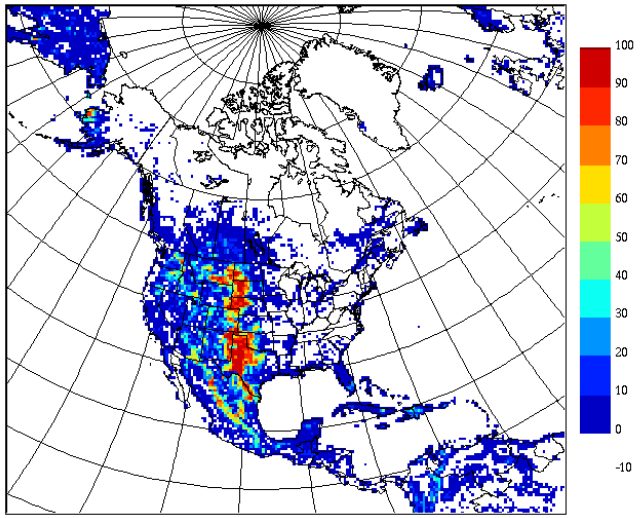


Crops

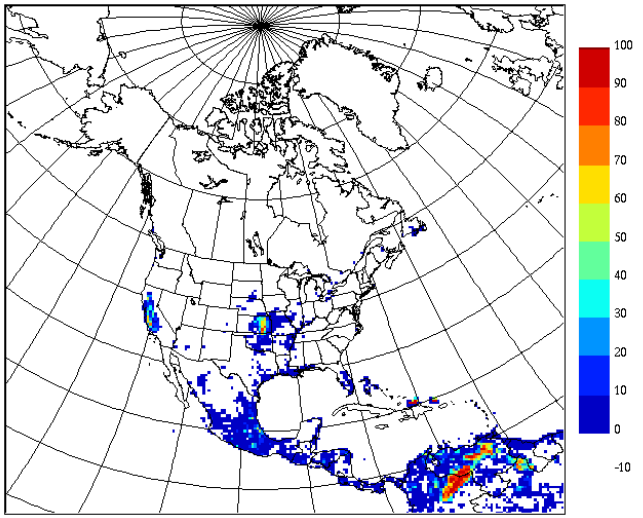
evergreen broadleaf shrub



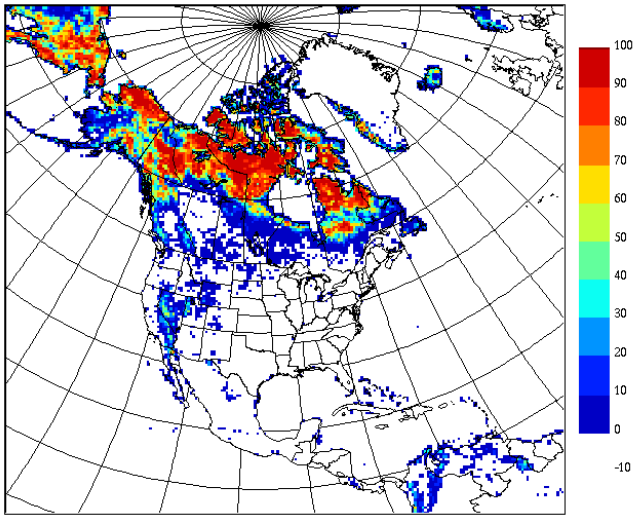
short grass and forbs



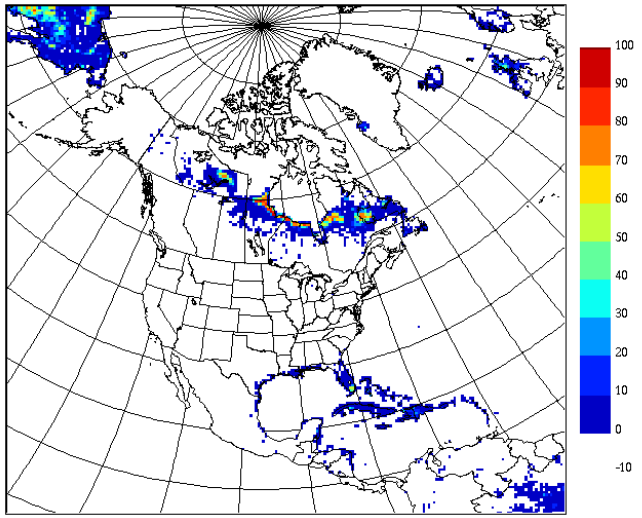
long grass



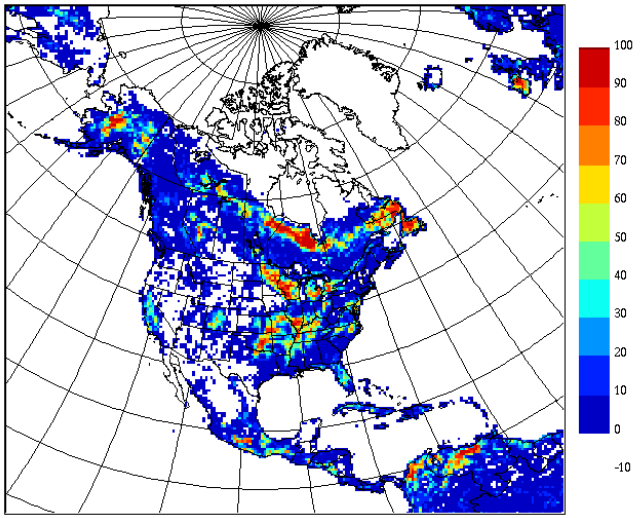
tundra



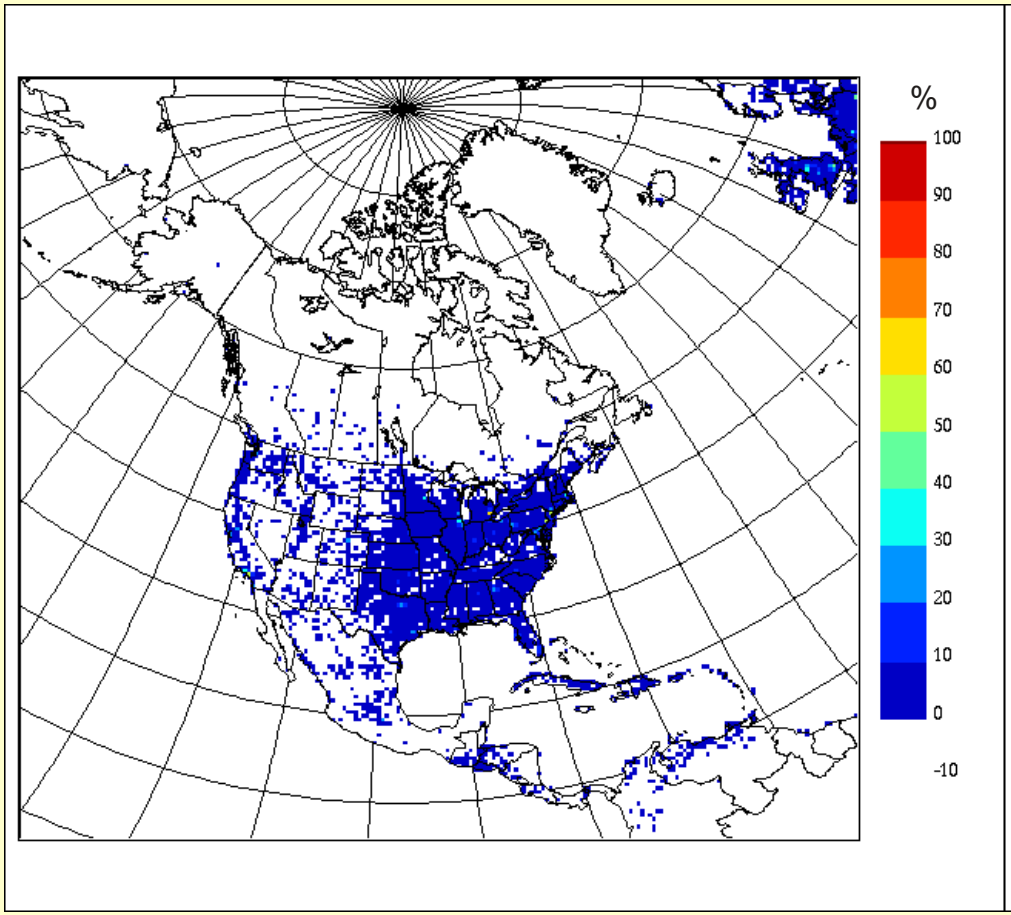
swamp



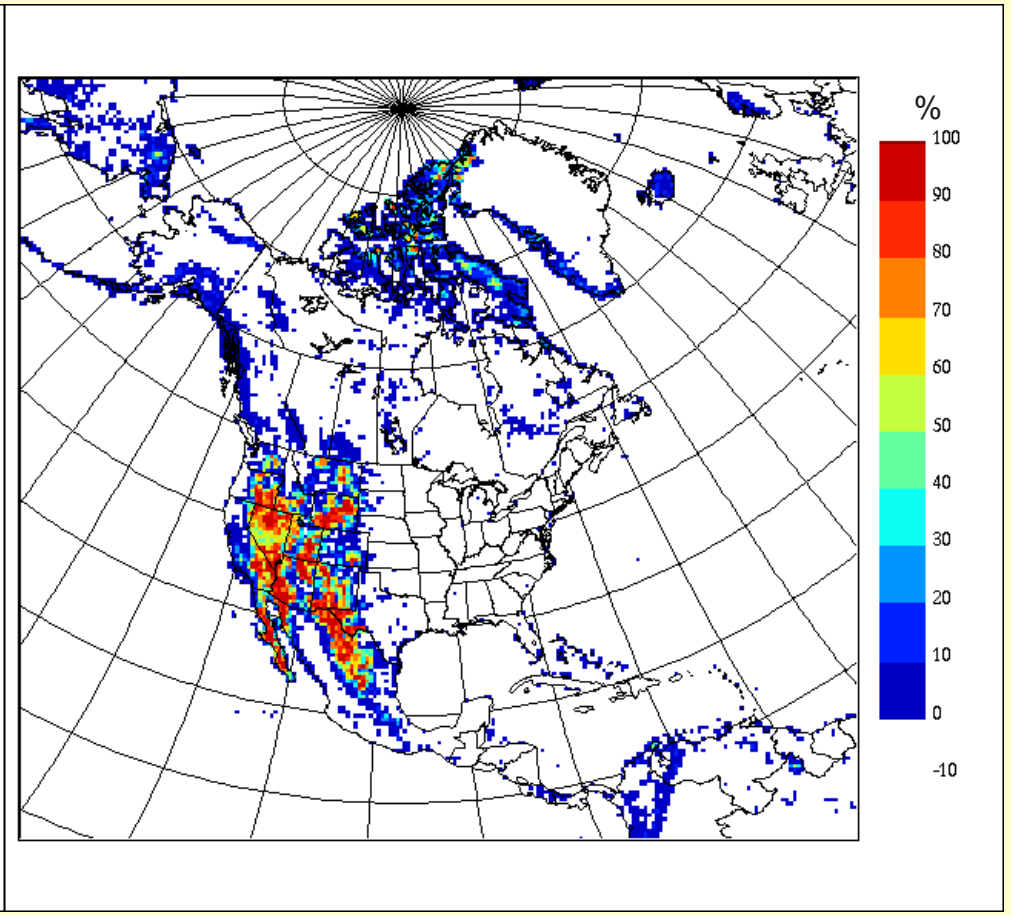
mixed shrubs



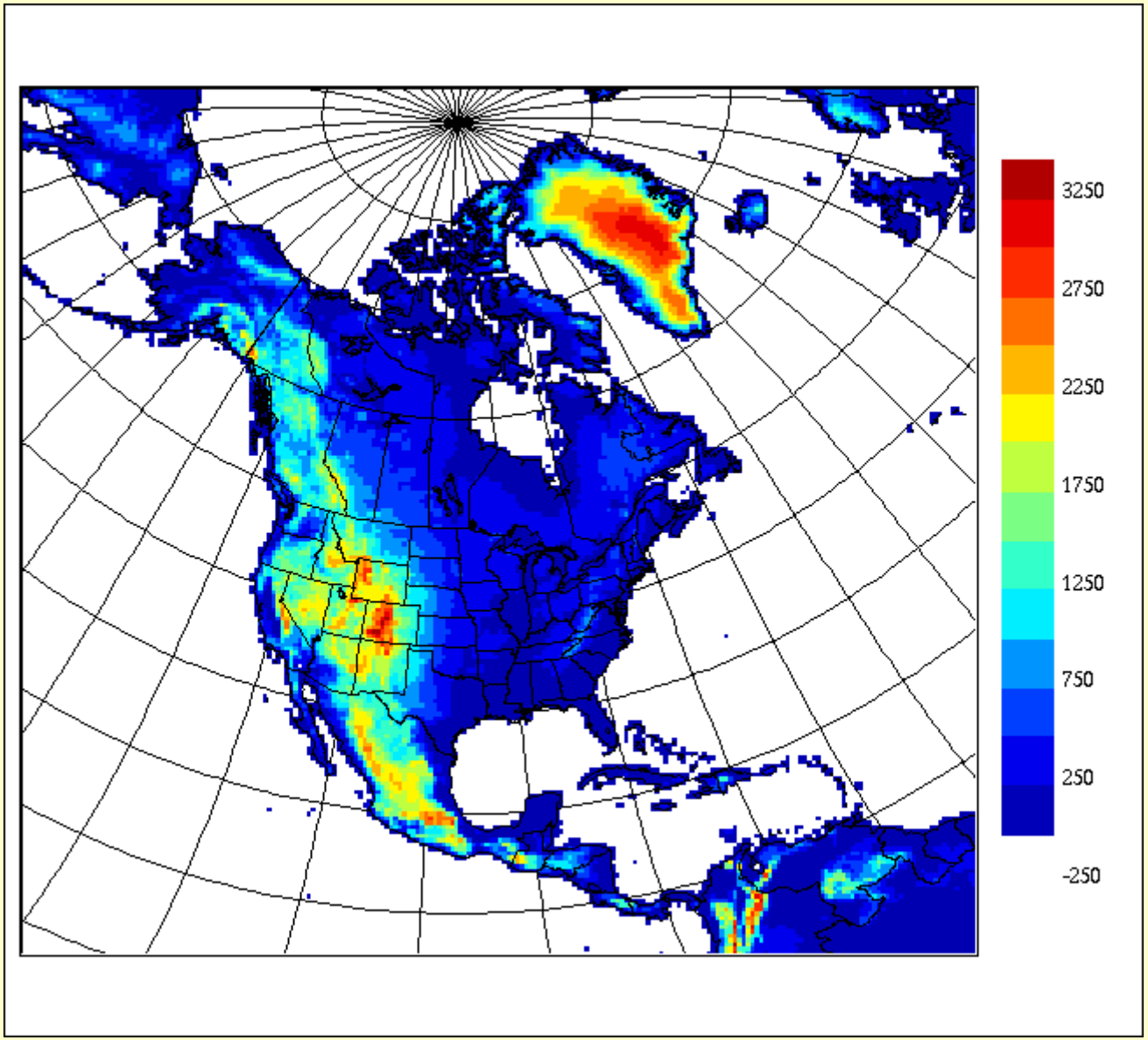
urban



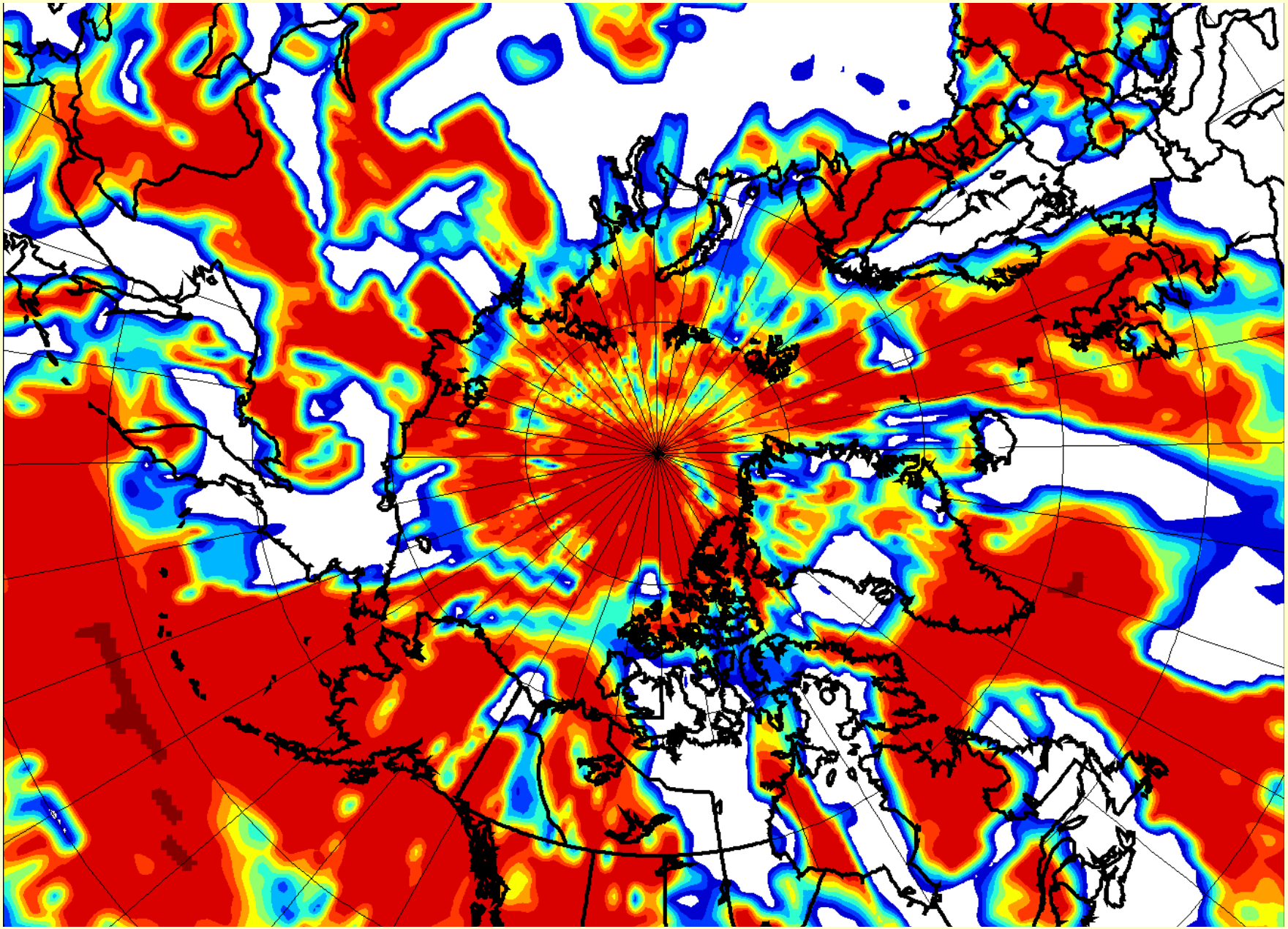
bare soil / desert



Mountain height

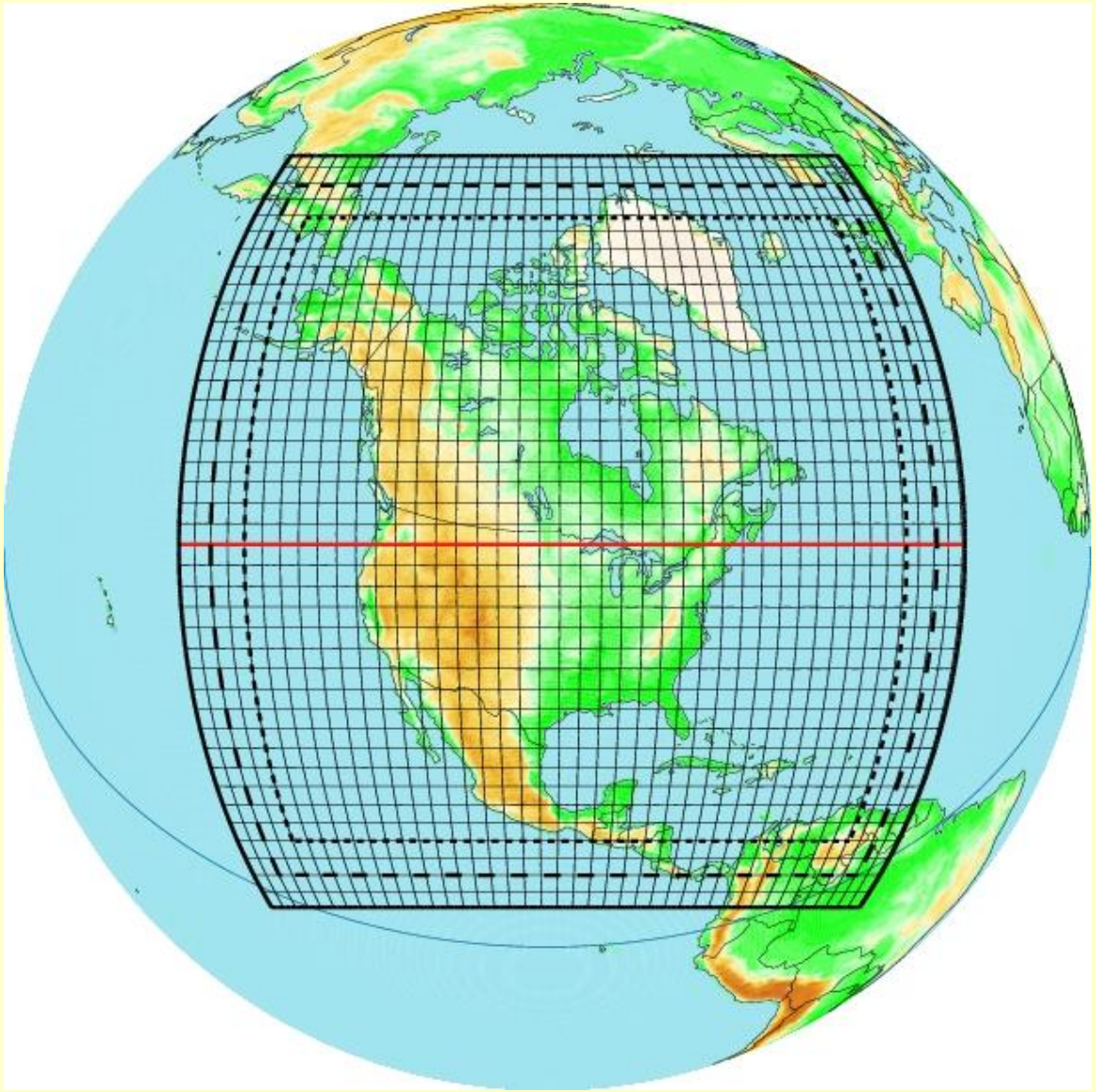


Pole problem

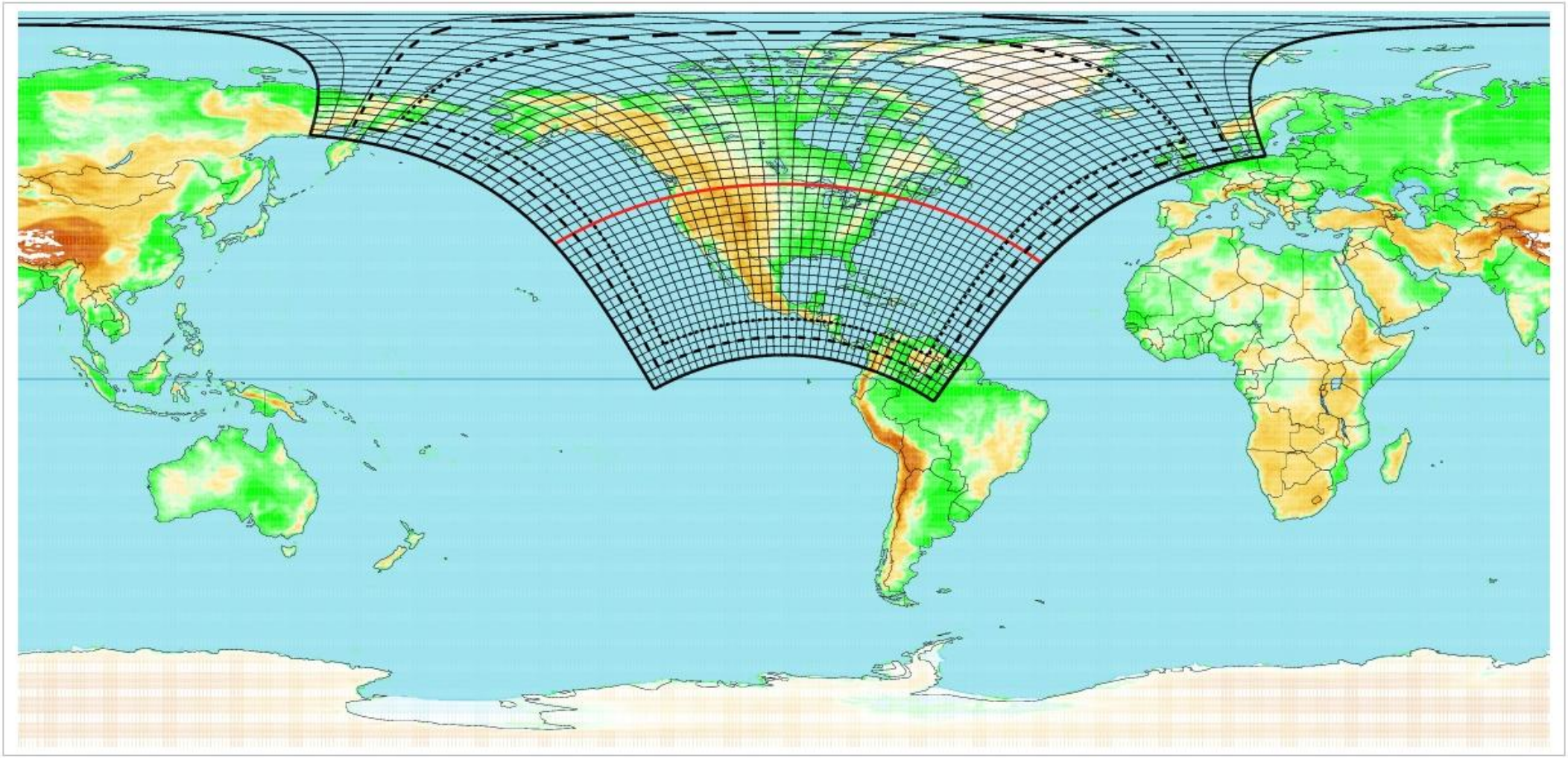


2-D cloud fraction

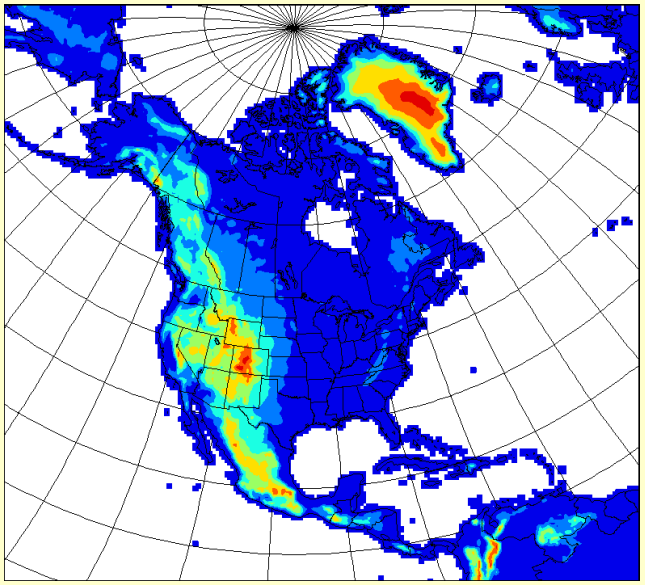
Rotated grid

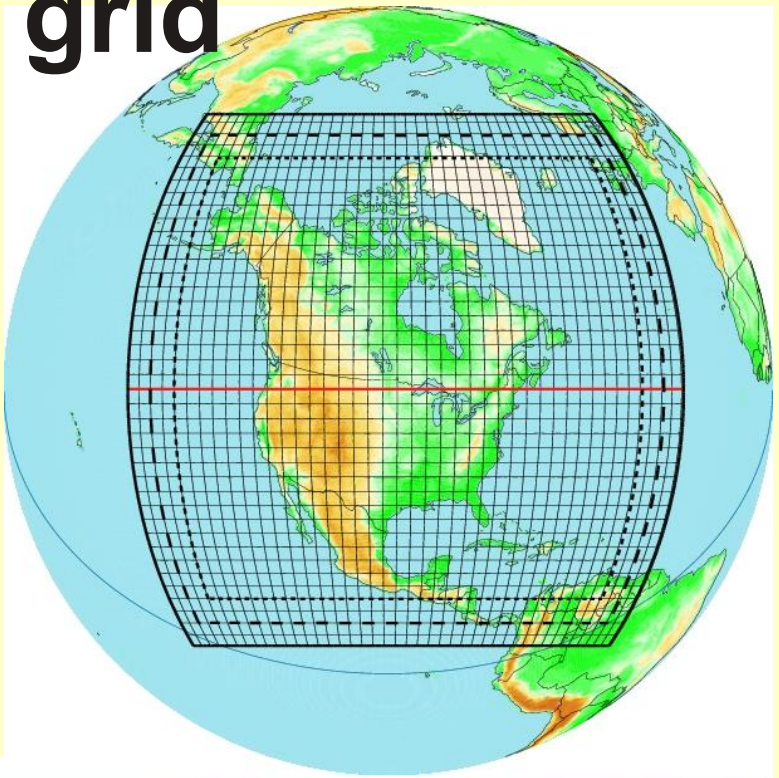


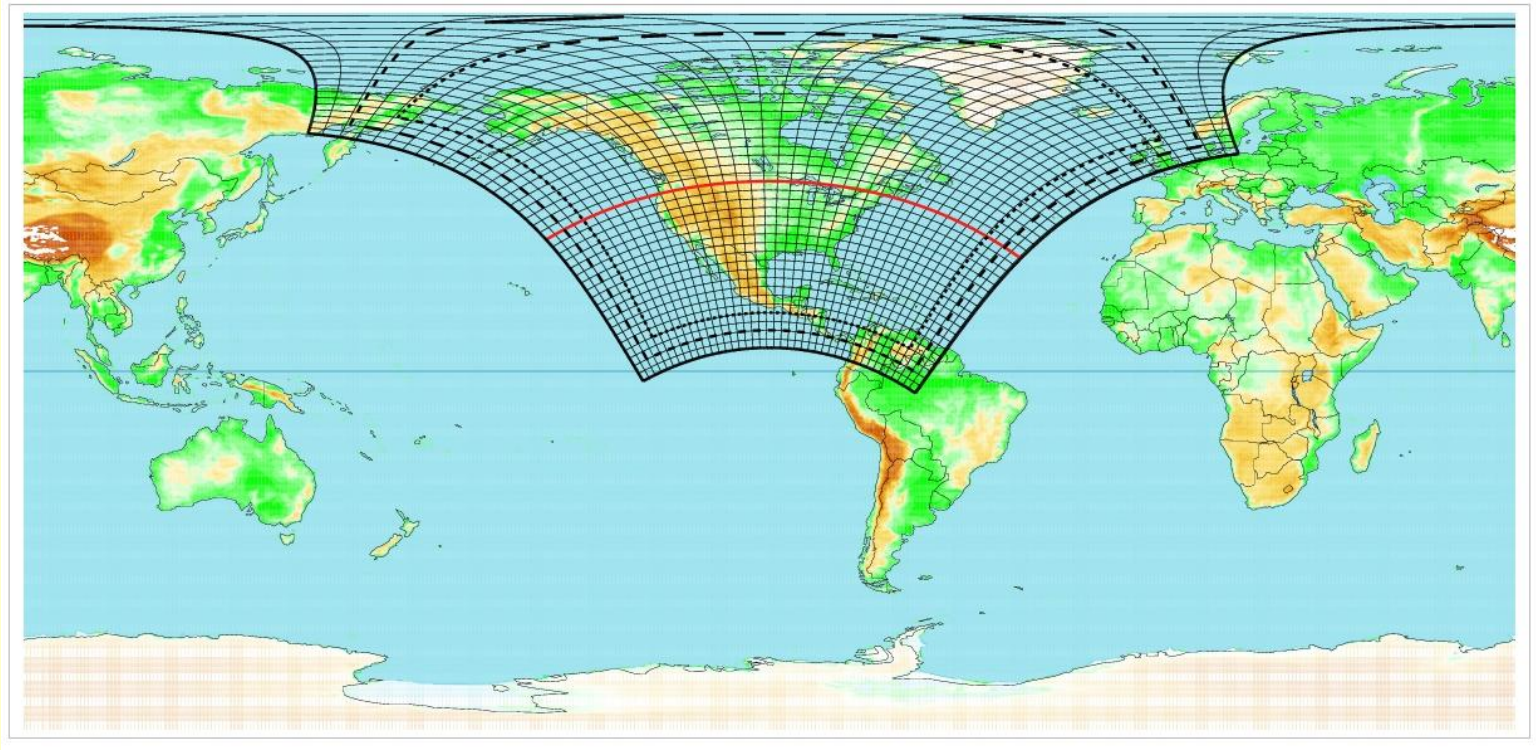
Rotated grid



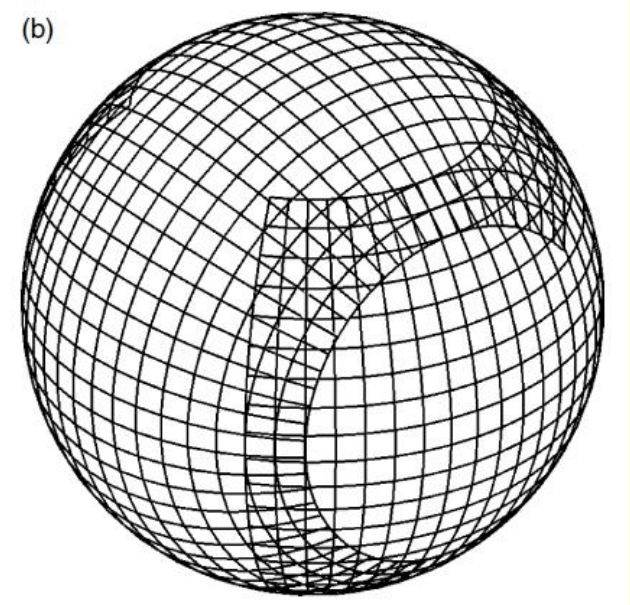
Rotated grid



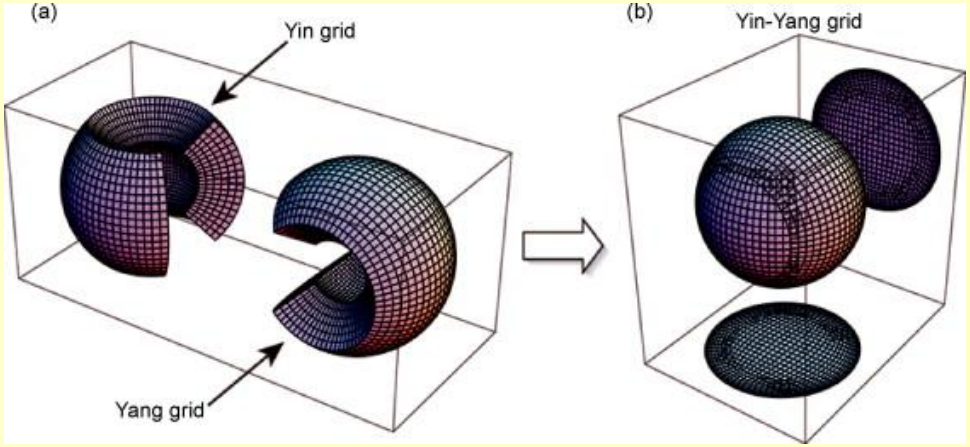




Yin-Yang grid (GEM 4)

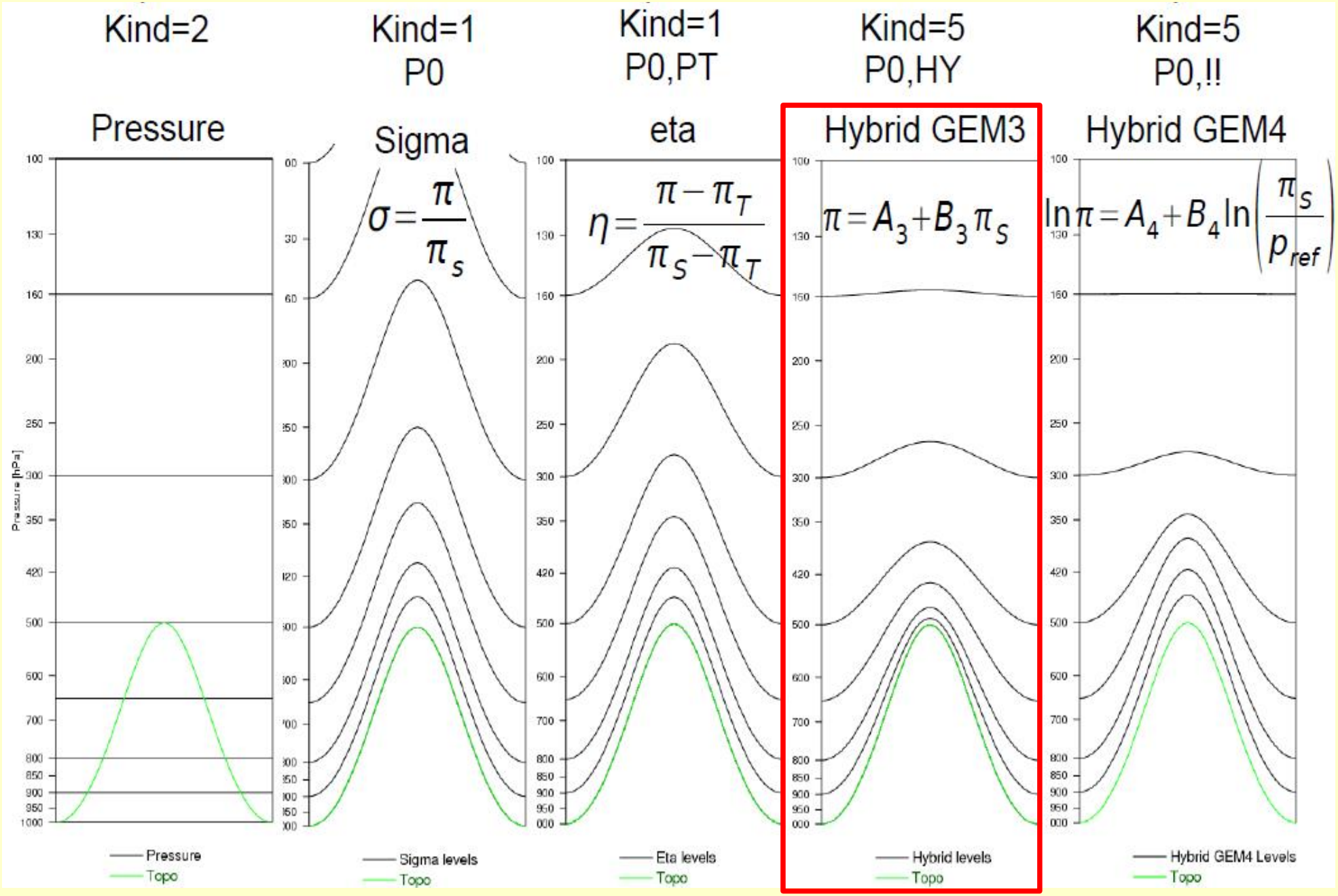


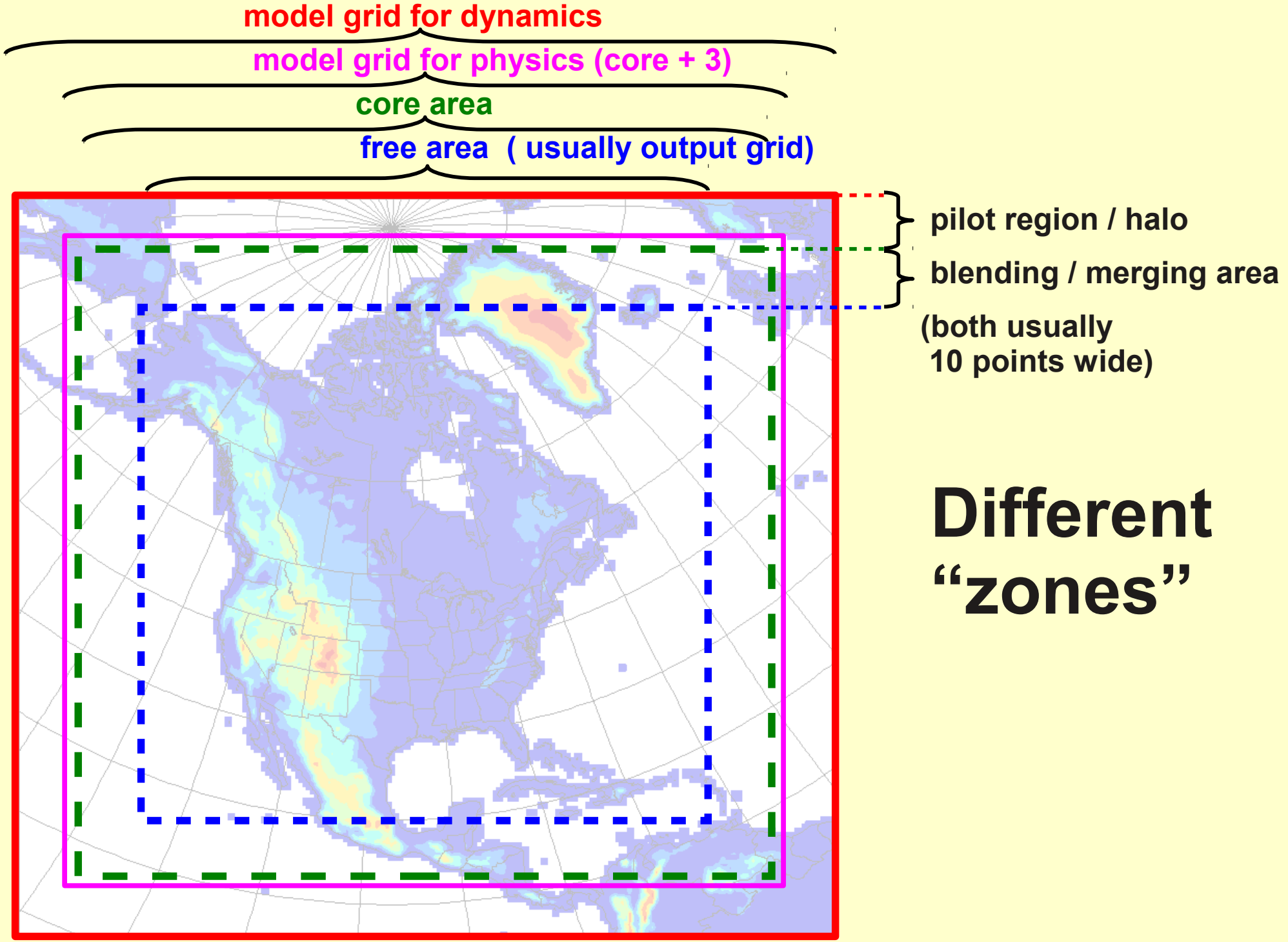
Qaddouri, A., and V.Lee, 2011



M. Kameyama et al. 2008

Model level types




model grid for dynamics
model grid for physics (core + 3)
core area
free area (usually output grid)
pilot region / halo
blending / merging area
(both usually
10 points wide)
Different
“zones”

Parallelization

of CRCM5,

a grid point model

(there are also global “spectral” models)

MPI

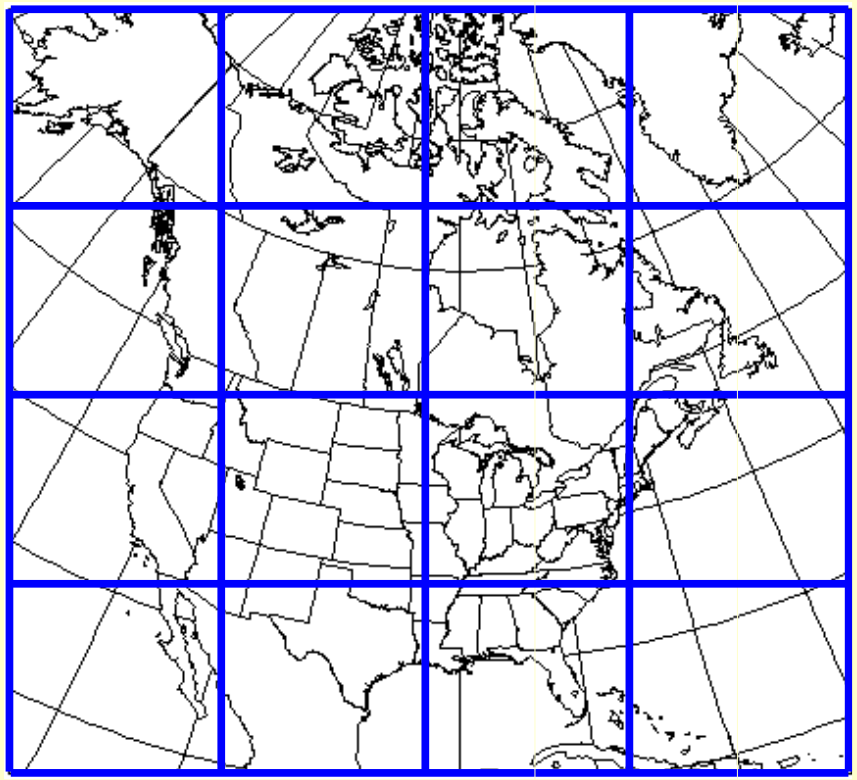
"**M**essage **P**assing **I**nterface"

distributed memory

Partitioning of the domain into tiles

Each cpu will execute the model on one tile.

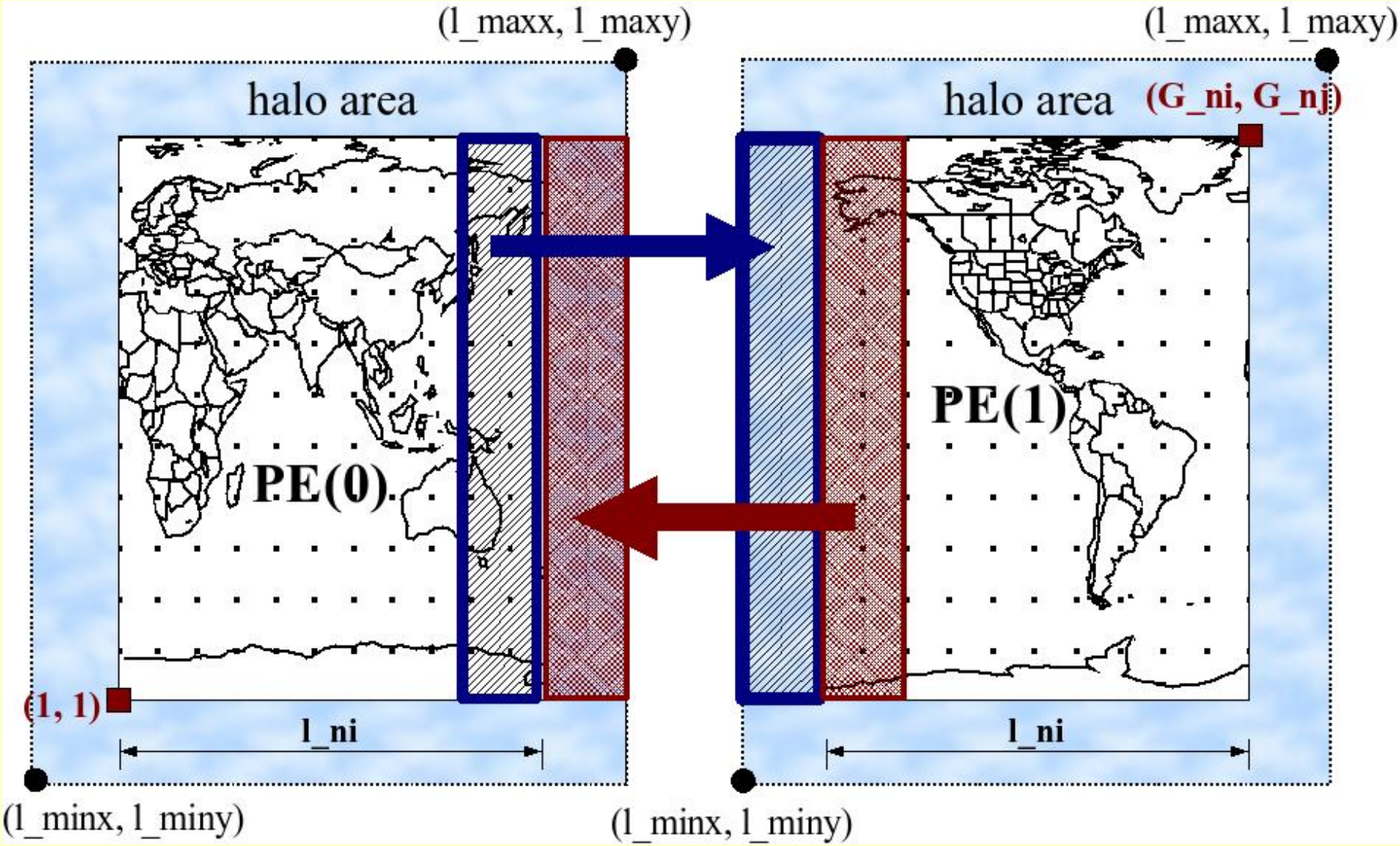
LAM grid partitioned into 4x4 tiles:



MPI

"**M**essage **P**assing **I**nterface"

distributed memory

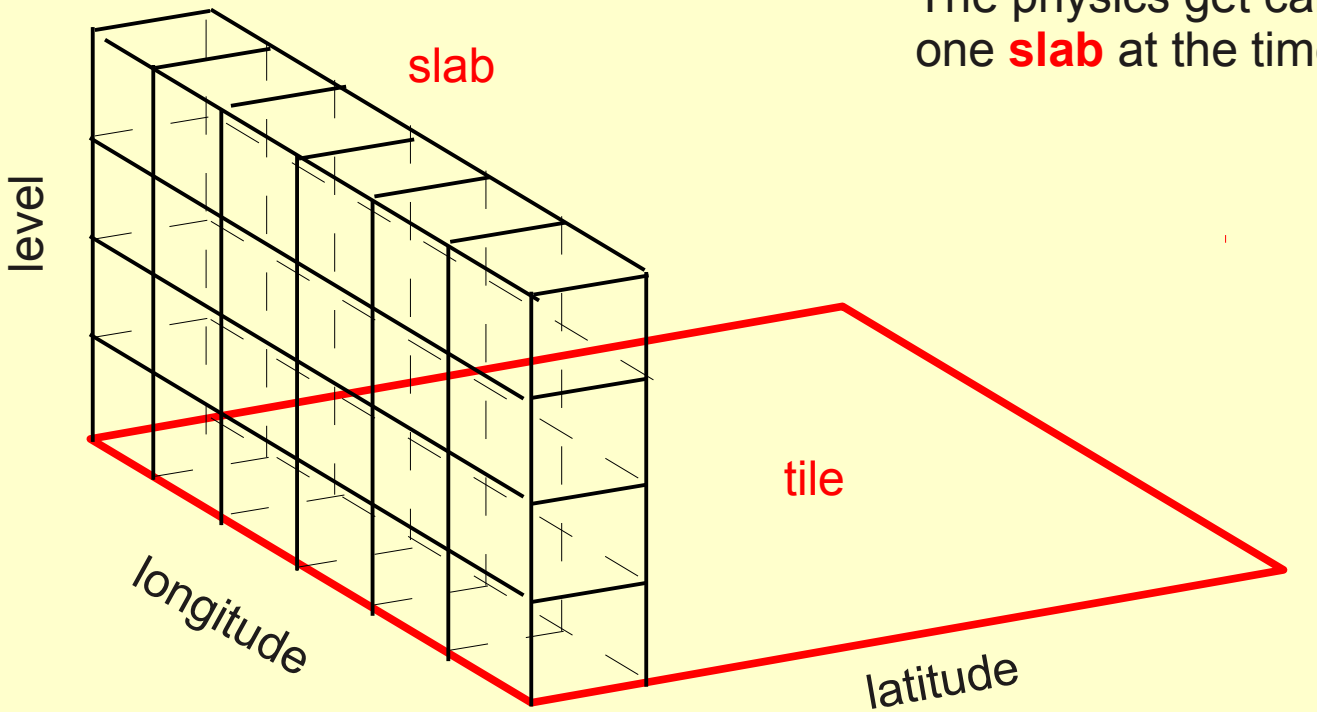


Courtesy of Vivian Lee

OpenMP

using shared memory

OpenMP in the physics:



The physics get called one **slab** at the time

Model input

- 3 **config files** (simulation, input and output configurations)
- **Geophysical fields**
  (land/sea mask, orography, vegetation type and fraction soil types, etc.)
- **Analysis or initial condition file**
  Fields needed to initialize soil and atmospheric variables
- **Lateral BC's** / Driving data / Pilot files (**LAM** mode only!!!)
  temperature,
  u-wind,
  v-wind,
  humidity (relative, specific or dew point temperature),
  geopotential (if data are on pressure levels),
  clouds (if available)
- **Lower BC's** (SST & sea ice)
- Atmospheric **ozone** (AMIP2, 2-D climatology: 61 latitudes and 59 levels)
- **Deep soil temperature**
- Global average yearly **greenhouse gas concentrations** (i.e. RCP_4.5, RCP_8.5)

Driving data

- Analysis
  - GEM,
  - ECMWF

- Reanalysis
  - ERA40 / ERA-Interim (ECMWF),
  - JRA25 (Japan),
  - NCAR (USA),
  - ...

- Model output (GCM / LAM)
  - CRCM5,
  - CanESM2 (CCCma, Canada),
  - MPI-ESM-LR/MR (MPI, Germany),
  - HadGEM2-ES (Hadley Centre, UK),
  - ...

CRCM5 is divided into two parts:

Dynamics

- grid setup
- parallelism (MPI and OpenMP)
- memory allocations
- advection
- horizontal diffusion
- lateral boundary conditions (LAM)
-
-

Physics

- radiation
- convection
- condensation
- land surface schemes (CLASS, ISBA, ...), ocean, lakes, glaciers, sea ice
- boundary layer vertical diffusion
- specified surface forcings (when no ocean model)
-

Model output

- usually we output on the “free” grid

- Output files are divided into files with
  dynamics resp. **physics** fields (first character) on
  model resp. **pressure** levels (second character)

  Example:

  dm... : **d**ynamics on **m**odel levels
  dp... : **d**ynamics on **p**ressure levels
  pm... : **p**hysics on **m**odel levels
  pp... : **p**hysics on **p**ressure levels

Archiving

In the **archive directory of each simulation**
you find some (or all) of the following subdirectories:

Samples: Original 2-/3-D model output;
one subdirectory per month containing
dm-, dp-, pm-, pp-files with
1 or more time steps per file (usually 1 file per month)

Diagnostics: Monthly means and variances
one subdirectory per month containing
dm-, dp-, pm-, pp-files for
mean (moyenne) and variance

Timeseries: Station time series

Pilots: Monthly pilot files

Analysis: Analysis initial condition files step (usually 1 per month)

Restarts: Restart files

Listings: Listings from all machines

Jobs: At runtime created jobs/scripts

Listings: Listings from all machines

Dynamic fields...

3-hourly output

... at the surface (dm-files)

TT : 2m temperature [°C]
UU : 10m u-wind component (east-west direction) [knots]
VV : 10m v-wind component (north-south direction) [knots]
UV : 10m wind modulus [knots]
HU : 2m specific humidity [kg/kg]
HR : 2m relative humidity [0-1]
P0 : surface pressure [hPa]
PN : sea level pressure [hPa]

... on pressure levels (dp-files)

TT : air temperature [°C]
UU : u-wind component (east-west direction) [knots]
VV : v-wind component (north-south direction) [knots]
WW: vertical momentum [Pa/s]
HU : specific humidity [kg/kg]
GZ : geopotential [dam]

Physic fields

3-hourly output

- precipitation (total; liquid/solid; convective/large scale) (hourly total precipitation)
- runoff (total; surface; drainage)
- radiation (long/short wave; model top/surface; up/down/net)
- clouds (2-D; liquid/ice water path; int. water vapour)
- snow (depth; density; albedo; temperature; SWE; water in snow pack)
- albedo; glacier temperature (constant glacier fraction)
- skin temperature & humidity
- soil (temperature; liquid & ice water content)
- SST (BC); sea ice (fraction (BC); temperature; thickness)
- lake fields

- daily 2m minimum & maximum temperature
- 10m maximum wind

Variable dictionaries

http://people.sca.uqam.ca/~winger/GEM/Version_3.3.2/GEMCLIM_output.html#Variable_dictionaries

Available simulations

http://cnrcwp.uqam.ca/documents/simulations

Observation
Analysis
Reanalysys
datasets

http://crystal.sca.uqam.ca/wiki/index.php/Obs_ReAnalysis