13 Permafrost

The permafrost sector in ISIMIP2a will not require any additional runs. The runs developed for the biomes sector and the water sector can also be assessed by the permafrost sector (see Section 7.2 for the scenario setup;). Finland (region 12) and the Lena catchment (region 11) are the two regions which are affected by permafrost. Therefore any runs over these regions can be assessed for permafrost. Permafrost will require additional output data. Models which do not include a carbon cycle should still submit the requested hydrological variables as these can be used to assess permafrost extent and thaw.

13.1 Sector-specific input

None

13.2 Output data

Table 37 below is very similar to **Table 21** in the Biomes sector, but with some hydrological variables added. **Soil temperature at each model level is the most important variable – if that is all you can deliver then please do so, it will be useful.**

Table 37 Variables to be reported for the permafrost sector

long name	units		output variable name	frequency	comment
Essential outputs					
Temperature of Soil	K	per gridcell	**tsl**	Day (mon)	Temperature of each soil layer. Reported as "missing" for grid cells occupied entirely by "sea". **THIS IS THE MOST IMPORTANT VARIABLE.** Also need depths in meters. Daily would be great, but otherwise monthly would work.

Pools (as Biomes output Table)					
Carbon Mass in Vegetation	kg m-2	per pft and gridcell total	**cveg_<pft>**	year	Gridcell total VegC is essential. Per PFT information is desirable.
Carbon Mass in Litter Pool	kg m-2	per gridcell	**clitter**	year	Total of all pools. Info for each individual pool is desirable.
Carbon Mass in Soil Pool	kg m-2	per gridcell	**csoil**	year	Total of all pools. Info for each individual pool is desirable.
Fluxes (as Biomes output Table)					
Carbon Mass Flux out of Atmosphere due to Gross Primary Production on Land	kg m-2 s-1	per gridcell	**gpp**	mon (day)	
Carbon Mass Flux into Atmosphere due to Autotrophic (Plant) Respiration on Land	kg m-2 s-1	per gridcell	**ra**	mon (day)	
Carbon Mass Flux out of Atmosphere due to Net Primary Production on Land	kg m-2 s-1	per gridcell	**npp**	mon (day)	
Carbon Mass Flux into Atmosphere due to Heterotrophic Respiration on Land	kg m-2 s-1	per gridcell	**rh**	mon (day)	
Carbon Mass Flux into Atmosphere due to CO2	kg m-2 s-	per gridcell	**fireint**	mon (day)	

Emission from Fire	1				
Fraction of cell burnt by fire	Fractional	Per gridcell	**firefrac**		Burnt area fraction: single value for each scenario corresponding to year 2100
Carbon Mass Flux out of Atmosphere due to Net Biospheric Production on Land	kg m-2 s-1	per gridcell	**ecoatmflux_c**	mon (day)	This is the net mass flux of carbon between land and atmosphere calculated as photosynthesis MINUS the sum of plant and soil respiration, carbonfluxes from fire, harvest, grazing and land use change. Positive flux is into the land.
Structure [as Biomes output Table]					
Fraction of absorbed photosynthetically active radiation	%	per pft and gridcell average	**fapar_<pft>**	mon (day)	
Leaf Area Index	1	per pft and gridcell average	**lai_<pft>**	mon (day)	
Plant Functional Type Grid Fraction	%	per gridcell	**pft_<pft>**	year (or once if static)	The categories may differ from model to model, depending on their PFT definitions. This may include natural PFTs, anthropogenic PFTs, bare soil, lakes, urban areas, etc. Sum of all should equal the fraction of the grid-cell that is land.
Soil moisture for each layer	kg m-2	per gridcell	**soilmoist**	mon	Please provide soil moisture for all depth levels and indicate depth in m. (As for Water sector)
Frozen soil moisture for each layer	kg m-2	per gridcell	**soilmoistfroz**	mon	Please provide soil moisture for all depth levels and indicate depth in m. **This is a new variable.**
Snow depth	m	per gridcell	**snd**	mon	Grid cell mean depth of snowpack. **This is a new variable.**

annual maximum thaw depth	m		**thawdepth**	year	calculated from daily thaw depths
Snow water equivalent	kg m-2	per gridcell	**swe**	mon	Total water mass of the snowpack (liquid or frozen) averaged over grid cell (As for Water sector)
Runoff	kg m-2 s-1	Per grid cell	**qtot**	mon (day)	Total runoff leaving the land portion of the grid cell (this is in both Biomes and Water Tables)
Optional outputs					
Carbon Mass in Leaves	kg m-2	per gridcell	**cleaf_<pool>**	year	
Carbon Mass in Wood	kg m-2	per gridcell	**cwood_<pool>**	year	including sapwood and hardwood
Carbon Mass in Roots	kg m-2	per gridcell	**croot_<pool>**	year	including fine and coarse roots
Carbon Mass in Litter Pools	kg m-2	per gridcell	**clitter_<pool>**	year	Non-cmip5, for each litterpool and gridcell
Carbon Mass Soil Pools	kg m-2	per gridcell	**csoil_<pool>**	year	Non-cmip5, for each soil pool and gridcell
Burnt Area Fraction	%	per gridcell	**burntarea**	mon (day)	fraction of entire grid cell that is covered by burnt vegetation

Note: If you cannot provide the data at the temporal or spatial resolution specified, please provide it the highest possible resolution of your model. Please contact the coordination team (Info@isimip.org) to for any further clarification, or to discuss the equivalent variable in your model.

13.3 Experiments

13.3.1ISIMIP2a - Historic runs and validation exercise

Table 38 Potential validation datasets for permafrost sector. These are additional data sets to those already highlighted in the Biomes and Water sectors.

Dataset	Source and further information	Variables included	Period	Scale	comment
Physical state of the permafrost					
Permafrost extent	http://nsidc.org/data/ggd318	What proportion of area is permafrost	Approximately representative of period 1960-1990	12.5km, 25km or 0.5 degree resolution	Gridded data
CALM	http://www.gwu.edu/~calm/	Active layer thickness	1991 – present day	Point sites	
Borehole permafrost temperature data	http://gtnpdatabase.org/	Permafrost temperature		Point sites	These data go fairly deep within the permafrost
Russian historical soil temperature data	http://nsidc.org/data/docs/fgdc/ggd251_soiltemp_fsu/	Soil temperatures and active layer thicknesses	1936-1990	Point sites	These were partly made on cleared sites so temperatures are not necessarily representative of a grid cell.
Land surface temperature	http://doi.pangaea.de/10.1594/PANGAEA.775962	Laud surface temperature	2000-2010	25 km pan arctic, 1km regionally.	Based on satellite data

GlobSnow SWE and SE	http://www.globsnow.info/	Snow water equivalent and snow extent	1979-present	25 km	Based on satellite data
CDR snow and snow cover extent		Snow water equivalent and snow extent			Based on satellite data
Soil moisture and freeze / thaw	http://doi.pangaea.de/10.1594/PANGAEA.775959, http://doi.pangaea.de/10.1594/PANGAEA.779658	Soil moisture of the land surface and freeze thaw	2007	25 km weekly data	Based on satellite data
Freeze thaw	http://doi.pangaea.de/10.1594/PANGAEA.779658	Freeze thaw of the land surface	1979-present	Daily	Based on satellite data
Carbon cycle					
Soil carbon	http://doi.pangaea.de/10.1594/PANGAEA.779658	Soil carbon	Approximately representative of present day	Resolutions from 0.012 degrees to 1 degree	