Processes above ground

Temperature and precipitation

HYPE has many possibilities to adjust the precipitation and temperature given in the Pobs.txt and Tobs.txt files. Adjustment is done because the supplied data can be of different reference height or (known to be) wrong in some areas, or because data vary over the subbasin but the input is given as one value, and or to compensate for non modelled processes.

Temperature adjustments

Subbasin air temperatures (T_i) in the input file are normally assumed to be for the subbasin's average elevation (*elev*). The same adjustments are made for maximum and minimum temperatures if available.

(1) If data with other reference height is used it is possible to adjust for that. The subbasin temperature can be adjusted depending on subbasin elevation with general parameter *tcelevadd* (° / *100m*). This adjustment assumes observations are located at sea level.

(2) Alternatively it can be adjusted based on the difference between subbasin elevation and temperature observation elevation by general parameter *tcobselev* (° / *100m*). The temperature observation elevation ($elev_{obs}$) then need to be supplied to the model.

(3) It can be adjusted based on month with the monthly dependent parameter *monthlapse* (° / *100m*)). These three subbasin elevation adjustments should not be used together. Subbasin temperature can be adjusted equally over all subbasins within a region with the parameter region dependent parameter *tempcorr*.

$$T_{gc} = T_i + tempcorr - \frac{tcelevadd \times elev}{100} - \frac{tcobselev \times \left(elev - elev_{obs} \right)}{100} - \frac{monthlapse \times elev}{100}$$

The temperature can also be adjusted for each class depending on their deviation from the subbasin average elevation (Δh). The class-dependent temperature (*T*) is calculated using the parameter *tcalt*. The temperature lapse rate often has a value of 0.6 (° / *100m*).

$$T = T_{gc} - \frac{tcalt \times \Delta h}{100}$$

Precipitation adjustments

Subbasin input precipitation (P_i) can be adjusted equally over all subbasins with the general parameter *pcaddg* or for some subbasins with the parameter region dependent parameter *preccorr*. Additionally it is possible to adjust precipitation for undercatch with different parameters (*pcurain,pcusnow*) depending on if the precipitation falls as snow or rain.

Subbasin precipitation (P_{gc}) is for subbasin average elevation (*elev*), but can be adjusted for elevation variations within the subbasin. The precipitation of a class (*P*) is adjusted for classes where the class average elevation is greater than a threshold (general model parameter *pcelevth*). The adjustment is determined by a general parameter (*pcelevadd*) that is the correction per 100m. The class elevation adjustment can alternatively be determined from the basin standard deviation of elevation ($elev_{std}$) and a parameter *pcelevstd*. The class height adjustment is limited by a general parameter *pcelevmax*. The precipitation of a class can additionally be adjusted with land-use dependent parameter *pcluse*, e.g. for interception evaporation.

$$P_{gc} = P_i \times \left(1 + pcaddg\right) \times \left(1 + preccorr\right) \times \left(1 + \left(pcurain \times \left(1 - snfrac\right) + pcusnow \times snfrac\right)\right)$$

$$pc_{height} = \begin{cases} 0 & elev + \Delta h < pcelevth \\ MIN\left(\dfrac{elev + \Delta h - pcelevth}{100} \times pcelevadd + \dfrac{elev_{std}}{100} \times pcelevstd , pcelevmax\right) & else \end{cases}$$

$$P = P_{gc} \times \left(1 + pc_{height}\right) \times \left(1 - pcluse\right)$$

Where Δh is a class's elevation deviation from the subbasin average elevation and *snfrac* is the average fraction of precipitation that falls as snow calculated from subbasin temperature (T_i) and temperature thresholds (see equation below), or from input.

Rainfall and snowfall separation

The rain/snow fraction of precipitation is calculated based on temperature or given as an input time series. Different temperatures can be used in the equation, i.e. basin average or class temperature. When the air temperature (*T*) is around the threshold temperature for mixed precipitation (land-use dependent parameter *ttmp* plus general parameter *ttpd*) both rain and snow. The interval for mixed precipitation is given by the parameter *ttpi*. For temperature below threshold minus *ttpi*, the precipitation is assumed to be in solid form only and is added to the snowpack. If the air temperature is greater than the threshold temperature plus *ttpi*, the precipitation is assumed to be solely in liquid form. For intermediate temperatures, the precipitation is assumed to be a mixture of liquid and solid forms i.e. as both rain and snow. The proportion (a_{rain}) of precipitation that falls as rain depends linearly on the temperature.

$$a_{rain} = \begin{cases} 0 & T < ttmp + ttpd - ttpi \\ 1 & T > ttmp + ttpd + ttpi \\ \dfrac{\left(T - \left(ttmp + ttpd - ttpi\right)\right)}{\left(2 \times ttpi\right)} & else \end{cases}$$

Alternatively snowfall fraction (*sffrac*) may be read from input file and a_{rain} calculated as:

$$a_{rain} = 1 - sffrac$$

The amount of rainfall and snowfall is calculated from the corrected precipitation (*P*).

$$rainfall = P \times a_{rain} \quad snowfall = P \times \left(1 - a_{rain}\right)$$

Snowfall distribution

The optional snowfall distribution models redistribute the snowfall of a catchment among the classes within a subbasin or between subbasins depending on wind. The model uses Winstral coefficients. For each subbasin and class and wind direction a Winstral coefficient (*WSF*) is given as input data to the model. Wind direction is calculated from forcingdata of westerly (*U*) and southerly (*V*) wind. The wind direction is translated to the closest quadrant or octant, and the Winstral coefficient of that direction is used.

The Winstral coefficient is, with some scaling parameters, used to calculate the relative snowfall for each class this time step. There are two models; one that use a linear function (Gustafsson et al, 2015) and one that is log-linear (Clemenzi et al., 2023):

$$relative_{snowfall} = 1. + WSFscale \times WSFwind \times WSFluse \times \left(WSF + WSFbias\right)$$

$$relative_{snowfall} = 10^{\left(WSFscale \times WSFwind \times WSFluse \times \left(WSF + WSFbias\right)\right)}$$

WSFscale and *WSFbias* are general parameter, *WSFwind* is a scaling factor depending on wind speed (*wind*), *WSFluse* is a scaling parameter depending on land-use. The wind speed scaling factor reduced the snow fall redistribution for low wind speeds. It depends on one general parameter, *sndrwscale*, and the windspeed, and is calculated as:

$$WSFwind = 1 - \exp\left(-\left(sndrwscale \times wind\right)^2\right)$$

The relative snowfall is limited to the interval [1 - *sfdmax*, 1 + *sfdmax*] for the linear model and [0,*sfdmax*] for the log-linear. *sfdmax* is a general parameter. The relative snowfall is normalized within each subbasin so that the subbasin mean snowfall is preserved. The snowfall distribution is applied only if snow is falling for a fraction of the subbasin area that is larger than a limit (*limit*).

For the option of distributing snowfall also between subbasins, two versions are currently implemented. One option may distribute snowfall to the nearest downwind subbasin, while the other option distribute snowfall to all subbasins within a distance range. Both variants use the log-linear Winstral coefficients. They are used to calculate the relative snowfall for each class in all the subbasins separately. For the first version, the distribution of the snowfall of the upwind subbasin between the upwind and downwind subbasins is then calculated based on windspeed (*wind*) and distance (*d*). The two subbasins share the *sharefrac* of snowfall, and the rest goes to the upwind subbasin only. For the other version, the distribution of the snowfall is calculated for the subbasin within a range depending on windspeed, and with a reducing weight (*weight*) depending on distance (*d*).

$$share\,frac = \exp\left(-2 \times \left(\frac{d}{sndrscale \times wind}\right)^2\right)$$

$$weigth = \exp\left(-2 \times \left(\frac{d}{sndrscale \times wind}\right)^2\right)$$

The *sndrscale* parameter is a general length scale parameter (m per m/s). The distance is calculated for the subbasins X/Y coordinates. Subbasins with *weight* less than 0.1 is cut off.

References

Gustafsson et al., 2015

Ilaria Clemenzi, David Gustafsson, Wolf-Dietrich Marchand, Björn Norell, Jie Zhang, Rickard Pettersson, Veijo Allan Pohjola, 2023. Impact of snow distribution modelling for runoff predictions. Hydrology Research 1 May 2023; 54 (5): 633–647. https://doi.org/10.2166/nh.2023.043

Links to file reference

Section	Symbol	Parameter/Data	File
Temperature adjustments	T_i		Tobs.txt
	elev	elev_mean	GeoData.txt
	Δh	dhslc_nn	
	$elev_{obs}$	tobselev	ForcKey.txt
		tcelevadd, tcobselev, monthlapse, tempcorr, tcalt	par.txt

Section	Symbol	Parameter/Data	File
Precipitation adjustments	P_i		Pobs.txt
		pcaddg, preccorr, pcurain, pcusnow, pcelevth, pcelevadd, pcelevstd, pcelevmax, pcluse	par.txt
	Δh	dhslc_nn	GeoData.txt
	$elev_{std}$	elev_std	
	snfrac	calculated based on T_i or from	SFobs.txt
Rainfall and snowfall calculations		ttmp, ttpd, ttpi	par.txt
	sffrac		SFobs.txt
Snowfall distribution	U, V		UWobs.txt, VWobs.txt
	wind	calculated from U, V	
	WSF	wsf_nn_d	GeoData.txt
	d	calculated from xcoord, ycoord	
		WSFscale,WSFluse,WSFbias,sfdmax	par.txt
	limit	sfdlim	
	sndrscale	sndrlscale	

Links to relevant procedures in the code

Modules (file)	Procedures
modelmodule (model_hype.f90)	model
soil_processes (soil_proc.f90)	calculate_snow
	infiltration
atmospheric_processes (atm_proc.f90)	calculate_class_atmospheric_forcing
	calculate_rain_snow_from_precipitation
	calculate_subbasin_temperature
	calculate_subbasin_precipitation
	set_atmospheric_parameters_corrections
	calculate_winddirspeed
	calculate_snowfall_distribution

Potential evaporation

Potential evaporation is calculated for each class based on land use and atmopheric variables. The potential evaporation is then used to calculate the current actual evapotranspiration from each land class (see Soil water - Evaporation. A river with an area (i.e. is a class), flooded floodplains and lakes are assumed to evaporate at the potential rate, when the air temperature is above the threshold temperature (ttmp). Evaporation is limited by the water body's volume.

Potential evaporation (epot in mm) is calculated based on the temperature if it is not read in from file (repo in Xobs.txt). Alternative PET models exist, and is described below. When the air temperature (T) is greater than the threshold temperature ttmp evaporation is assumed to occur. Snow melting, snow density and evaporation use the same threshold temperature. The basic potential evapotranspiration ($epot_{base}$) depends on the land use dependent rate parameter cevp.

$$cseason = 1 + cevpam \times \sin\left(\frac{2 \times \pi \times \left(dayno - cevpph\right)}{365}\right)$$

$$epot_{base} = \left(cevp \times cseason\right) \times \left(T - ttmp\right)$$

A seasonal factor *cseason* adjusts the potential evaporation rate (*cevp*) e.g. making it higher in the spring when the air is often dry, and lower in autumn when the air is often more humid than in spring. The factor is sinusoidal with two parameters *cevpam* and *cevpph*. It is not used if *cevpam* is zero. A *cevpph* around 45 days give a maximum correction in mid May (dayno=45+91=136). The minimum correction will then be a half year later in September (dayno=136+182). For an earlier maximum, reduce *cevpph*.

The basic potential evapotranspiration may be adjusted with a regional correction factor (*cevpcorr*) equally over the year depending on parameter region.

$$epot = epot_{base} \times \left(1 + cevpcorr\right)$$

Alternative potential evaporation models

HYPE give the option to exchange the default potential evaporation model for another model. Only the basic potential evaporation ($epot_{base}$) differs between models. Models 0-2 only use air temperature forcing. Models 3-5 want shortwave radiation and minimum and maximum daily air temperature, although if lacking approximations are made (see section Input to alternative potential evaporation models below). In addition, model 5 wants relative humidity and wind speed if available. Note, regardless of potential evaporation model, the actual evaporation is limited to temperatures above parameter *ttmp*.

Model 0 (default)

As described above; evapotranspiration depends on the rate parameter *cevp* and air temperature (*T*) above a threshold *ttmp*. If the variable *repo* is given in Xobs.txt those values are used.

$$epot_{base} = \left(cevp \times cseason\right) \times \left(T - ttmp\right)$$

Model 1

Model 1 is the same as model 0, but it will not be using *repo* from input data, even if it is present.

Model 2 - Modified Jensen-Haise/McGuiness

The modified Jensen-Haise/McGuiness model follow Oudin et al. (2005). The potential evaporation

depends on extraterrestrial radiation (*radext*), latent heat of vaporization (λ) and temperature (*T*). Two general parameters (*jhtadd* and *jhtscale*) are used and one land use dependent (crop coefficient *kc2* or *kc*).

$$epot_{base} = \frac{kc}{jhtscale} \times MAX\left(0, \frac{radext}{\lambda} \times \left(T + jhtadd\right)\right)$$

Model 3 - Modified Hargreaves-Samani

The Hargreaves-Samani evaporation is modified to limit the "turbidity-factor". The potential evaporation depends on extraterrestrial radiation (*radext*), latent heat of vaporization (λ), temperature (*T*) and turbidity (*turbidity*). One general parameter (*krs*) is used and one land use dependent (crop coefficient *kc3* or *kc*).

$$epot_{base} = MAX\left(0, kc \times 0.0023 \times \frac{radext}{\lambda} \times \frac{turbidity}{krs} \times \left(T + 17.8\right)\right)$$

Model 4 - Priestly-Taylor

The Priestly-Taylor potential evaporation depends on net downward radiation (*netrad*), slope of saturated vapour pressure curve (*dsatvap*), latent heat of vaporization (λ) and a psychrometric constant (γ). One general parameter (*alfapt*) are used and one land use dependent (crop coefficient *kc4* or *kc*).

$$epot_{base} = MAX\left(0, kc \times alfapt \times \frac{dsatvap \times netrad}{\lambda \times \left(dsatvap + \gamma\right)}\right)$$

Model 5 - FAO Penman-Monteith

The FAO Penman-Monteith potential evaporation depends on net downward radiation (*netrad*), slope of saturated vapour pressure curve (*dsatvap*), saturated and actual vapour pressure (*satvap* and *actvap*), temperature (*T*), wind speed (*wind*) and a psychrometric constant (γ). One land use dependent parameter (crop coefficient *kc5* or *kc*) is used.

$$epot_{base} = MAX\left(0, \frac{kc \times 0.408 \times dsatvap \times netrad + \gamma \times \frac{900}{T+273} \times wind \times \left(satvap - actvap\right)}{dsatvap + \gamma \times \left(1 + 0.34 \times wind\right)}\right)$$

Input to alternative potential evaporation models

Summary of alternative input to PET models, and link to file reference.

Model	Parameters (**par.txt**)	Static data (**GeoData.txt**)	Forcing data (**files**)
0	cevp, ttmp		Xobs:repo, Tobs
1	cevp, ttmp		Tobs
2: modified Jensen-Haise/McGuiness	jhtadd, jhtscale, kc	latitude	Tobs
3: modified Hargreaves-Samani	kc, krs	elevation, latitude	SWobs, Tobs
3: modified Hargreaves-Samani	kc, krs	elevation, latitude, cloudiness	Tobs
3: modified Hargreaves-Samani	kc, krs	elevation, latitude	TMINobs, TMAXobs, Tobs
4: Priestly-Taylor	alb, alfapt, kc	elevation, latitude	RHobs, SWobs, TMINobs, TMAXobs, Tobs
4: Priestly-Taylor	alb, alfapt, kc, krs	elevation, latitude	SWobs, TMINobs, TMAXobs, Tobs
4: Priestly-Taylor	alb, alfapt, kc, krs	elevation, latitude	TMINobs, TMAXobs, Tobs
4: Priestly-Taylor	alb, alfapt, kc, krs	elevation, latitude, cloudiness	Tobs
5: FAO Penman-Monteith	alb, kc, roughness, zphd, zwind, zwish	elevation, latitude	RHobs, SWobs, TMINobs, TMAXobs, Tobs, Uobs
5: FAO Penman-Monteith	alb, kc, mwind	elevation, latitude	RHobs, SWobs, TMINobs, TMAXobs, Tobs
5: FAO Penman-Monteith	alb, kc, krs, roughness, zphd, zwind, zwish	elevation, latitude	SWobs, TMINobs, TMAXobs, Tobs, Uobs
5: FAO Penman-Monteith	alb, kc, krs, mwind	elevation, latitude	SWobs, TMINobs, TMAXobs, Tobs
5: FAO Penman-Monteith	alb, kc, krs, roughness, zphd, zwind, zwish	elevation, latitude	TMINobs, TMAXobs, Tobs, Uobs
5: FAO Penman-Monteith	alb, kc, krs, mwind	elevation, latitude	TMINobs, TMAXobs, Tobs
5: FAO Penman-Monteith	alb, kc, krs, mwind	elevation, latitude, cloudiness	Tobs

Actual vapour pressure

Actual vapour pressure (*actvap*) is calculated following FAO recommended procedure and function/data priority. Depending on availability of minimum, mean and maximum relative humidity (*rh*) and minimum, mean and maximum air temperature (T_{min}, T, T_{max}) equations with different combinations of saturated vapour pressure (calculated from temperature) times relative humidity is

used. For example:

$$actvap = \frac{satvap\left(T_{max}\right) \times rh_{min} + satvap\left(T_{min}\right) \times rh_{max}}{2}$$

$$actvap = satvap\left(T_{min}\right) \times rh_{max}$$

$$actvap = satvap\left(T\right) \times rh_{mean}$$

$$actvap = satvap\left(T_{min}\right) \times 1$$

In case not enough data is available, minimum temperature is calculated from turbidity and a general parameter (*krs*) and the last equation of those above is used.

$$T_{min} = T - 0.5 \times \left(\frac{turbidity}{krs}\right)^2$$

Eventually actual vapour pressure is limited by the calculated saturated vapour pressure.

Air pressure

Air pressure (*pa*) is calculated as a function of elevation for the class (*elev*).

$$pa = 101.3 \times \left(\frac{293 - 0.0065 \times elev}{293}\right)^{5.26}$$

Shortwave radiation

Shortwave radiation (*swrad*) is supplied as input forcing time series or otherwise calculated from extraterrestrial radiation.

$$swrad = radext \times turbidity$$

Extraterrestrial radiation

Extraterrestrial solar radiation (*radext*) is estimated from day of year and latitude. The equations used comes from FAO. The day of the year are used to estimate distance to the sun and declination. The sunset hour angle are calculated from latitude, but with special care for high latitudes (polar night and midnight sun). These variables together with latitude and the solar constant eventually give the

current extraterrestrial radiation for each subbasin.

Latent heat of vaporization

Latent heat of vaporization (λ) is a function of temperature (T).

$$\lambda = 2.501 - 0.002361 \times T$$

Net downward radiation

The net downward radiation (*netrad*) is used explicitly for PET model 4 and 5 (Priestly-Taylor and FAO Penman-Monteith). The net radiation is calculated following FAO recommended procedure. It is calculated as net shortwave radiation minus net longwave radiation. Net shortwave radiation (net_{short}) is calculated from the shortwave radiation (*swrad*) and the land use dependent albedo parameter (*alb*). Net longwave radiation (net_{long}) is calculated using temperature (T_{min}, T_{max}, T), actual vapour pressure (*actvap*) and relative shortwave radiation (*relsh*) if those are available, otherwise it is set to zero. The relative shortwave radiation is shortwave radiation in relation to clear sky shortwave radiation.

$$net_{short} = swrad \times \left(1 - alb \right)$$

$$net_{long} = 4.903 \times 10^{9} \times \frac{\left(T_{max} + 273.15 \right)^{4} + \left(T_{min} + 273.15 \right)^{4}}{2} \times \left(0.34 - 0.14 \times actvap^{0.5} \right) \times \left(1.35 \times relsh - 0.35 \right)$$

$$relsh = \frac{turbidity}{clearturb}$$

Psychrometric constant

The psychrometric constant (γ) is a function of air pressure (*pa*) and latent heat of vaporization (λ) following FAO.

$$\gamma = \frac{0.001013 \times pa}{0.622 \times \lambda}$$

Saturated vapour pressure

Saturated vapour pressure (*satvap*, kPa) is calculated from temperature (*temp*) following FAO. If daily minimum and maximum air temperature is available *satvap* is set to the average of the saturated vapour pressure calculated for each of those two temperatures, otherwise it is calculated from daily average air temperature.

$$satvap = 0.6108 \times EXP\left(\frac{17.27 \times temp}{temp + 237.3}\right)$$

Slope of saturated vapour pressure curve

The slope of saturated vapour pressure temperature function (*dsatvap*) is used explicitly for PET model 4 and 5 (Priestly-Taylor and FAO Penman-Monteith). The slope is calculated from daily mean air temperature (*T*).

$$dsatvap = 4098 \times 0.6108 \times EXP\left(\frac{17.27 \times T}{T + 237.3}\right) \times \frac{1}{\left(T + 237.3\right)^2}$$

Turbidity

The turbidity factor is used explicitly for the PET model 3 - modified Hargreaves-Samani. If shortwave radiation (*swrad*) has been given as forcing data time serie, the turbidity factor is calculated as

$$turbidity = \frac{swrad}{radext}$$

but limited by a minimum turbidity value (0.25) and an estimated clearsky turbidity. The clearsky turbidity (*clearturb*) is estimated by the Ångström formula (FAO):

$$clearturb = 0.75 + elev \times 0.00002$$

where *elev* is subbasin elevation in meter above sea level. If no shortwave radiaton time series are given, but montly cloudiness climatology is provided (*cloudiness*), the turbidity is calculated as

$$turbidity = \left(clearturb - 0.25\right) \times \left(1 - cloudiness\right) + 0.25$$

If no cloudiness are given either, but time series of daily minimum and maximum temperature are, the turbidity is calculated as in the "ordinary" Hargreaves-Samani turbidity function:

$$turbidity = krs \times SQRT\left(T_{max} - T_{min}\right)$$

but still limited by the minimum turbidity value and the calculated clearsky turbidity.

Wind speed

Wind speed is used in PET model 5 - FAO Penman-Monteith. Wind speed (*wind*) may be given as a constant general parameter (*mwind*) or as a forcing data time series. The time serie wind is given for each subbasin (U_i). It is possible to adjust the time serie wind speed to different height than observations. If the general parameters *zwind*, *zwish*, *roughness*, and *zpdh* is set, wind speed is adjusted with the transformation factor *windtrans*.

$$wind = U_i \times windtrans$$

$$windtrans = \frac{\ln\left(zwind - zpdh\right) - \ln\left(roughness\right)}{\ln\left(zwish - zpdh\right) - \ln\left(roughness\right)}$$

Links to file reference

Section	Symbol	Parameter/Data	File
Evaporation		cevp, ttmp, cevpam, cevpph, cevpcorr, epotdist, lp, ttrig, tredA, tredB	par.txt
	wp	calculated from wcwp, wcwp1, wcwp2, wcwp3 and soillayerdepth	
	fc	calculated from wcfc, wcfc1, wcfc2, wcfc3 and soillayerdepth	
	soillayerdepth		GeoClass.txt
Alternative potential evaporation models	epot		Xobs.txt
		jhtadd, jhtscale, kc, kc2, kc3, kc4, kc5, krs, alfapt	par.txt
Input to alternative potential evaporation models		alb, mwind, zwind, zwish, roughness, zpdh	par.txt
	U_i		Uobs.txt
	swrad	calculated or from	SWobs.txt
	elev	elev_mean	GeoData.txt
		latitude, cloudiness	

Links to relevant procedures in the code

Modules (file)	Procedures
soil_processes (soil_proc.f90)	initiate_soil_water
	calculate_potential_evaporation
	calculate_actual_soil_evapotranspiration
surfacewater_processes (sw_proc.f90)	calculate_river_evaporation
	calculate_actual_lake_evaporation

References

Richard G. Allen, Luis S. Pereira, Dirk Raes & Martin Smith, 1998. Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements. FAO Irrigation and drainage paper 56. Rome, Italy: Food and Agriculture Organization of the United Nations. ISBN 92-5-104219-5

Oudin, L., F. Hervieu, C. Michel, C. Perrin, V. Andreassian, F. Anctil and C. Loumagne 2005. Which potential evapotranspiration input for a lumped rainfall–runoff model?: Part 2—Towards a simple and efficient potential evapotranspiration model for rainfall–runoff modelling, Journal of Hydrology 303(1-4):290-306.

Atmospheric deposition

Atmospheric deposition can be added to the model as load or as concentration of precipitation.

Wet deposition

Atmospheric deposition in the form of wet deposition of IN and SP is added as a concentration of rainfall. You can specify a time series of the concentration in precipitation in Xobs.txt (implemented for IN, SP, and T1). Otherwise wet deposition (as a concentration) is specified in AtmdepData.txt for each subbasin.

If parameter (*aloadconst*) is set, the wet deposition load in considered constant and not dependent on precipitation corrections. Thus the concentration of precipitation is changed to keep the load constant, when precipitation correction is applied.

Atmospheric deposition to the soil

Dry deposition is specified in AtmdepData.txt for each subbasin. It can be specified for different vegetation types or land uses.

Dry deposition of nitrogen and phosphorus is added to the snow or, if there is no snow, directly to the ground. Phosphorus deposition is added to PartP-pool in the upper soil layer and nitrogen deposits to the IN dissolved in soil water if the parameter *ponatm* is not set. A new concentration of IN in the soil water is then calculated. The parameter *ponatm* indicates that some of the nitrogen deposition will be added to organic nitrogen pool (*fastN*) instead of to the IN pool.

For both nitrogen and phosphorus wet deposition is added through the concentration of precipitation (as described above). Precipitation may fall as snow and be added to the snow pack or if it is rain added to the potential infiltration. Depending on the fate of the infiltration, the wet atmospheric deposition will mix with the recieving water (e.g. surface runoff, soil layer water, macropore flow).

Atmospheric deposition to rivers and lakes

Deposition is specified in AtmdepData.txt for each subbasin, as load and/or as concentration for wet deposition. It can be specified for different vegetation types or land uses, and thus water surfaces may have a different deposition than land surfaces. In addition monthly deposition can be specified.

For both nitrogen and phosphorus wet deposition is added through the concentration of precipitation (as described above), while for dry deposition an amount of the nutrient is added to the river (if it has a class-area) or lake water.

Links to file reference

Section	Parameter/Data	File
Wet deposition	*cpT1, cpIN, cpSP*	Xobs.txt
	XX_WD, XX_WD_Ln, XX_WD_Vn (*XX* is substance, *n* is index of landuse or vegetation type)	AtmdepData.txt
	aloadconst	par.txt
Atmospheric deposition to the soil	*XX_DD, XX_DD_Ln, XX_DD_Vn, XX_DD_Mn_Vn* (*XX* is substance, *n* is index of landuse, vegetation type, or month)	AtmdepData.txt
	ponatm	par.txt
Atmospheric deposition to rivers and lakes	*XX_DD, XX_DD_Ln, XX_DD_Vn, XX_DD_Mn_Vn* (*XX* is substance, *n* is index of landuse, vegetation type, or month)	AtmdepData.txt

Links to relevant procedures in the code

Modules (file)	Procedures
npc_soil_processes (npc_soil_proc.f90)	add_dry_deposition_to_landclass
	atmdep_in_loss
atmospheric_processes (atm_proc.f90)	set_class_precipitation_concentration_and_load
	set_T2_concentration_in_precipitation_on_water
npc_surfacewater_processes (npc_sw_proc.f90)	add_deposition_to_river_as_load
	add_deposition_to_lake_as_load