# Monthly water balance model for climate change analysis in agriculture with R

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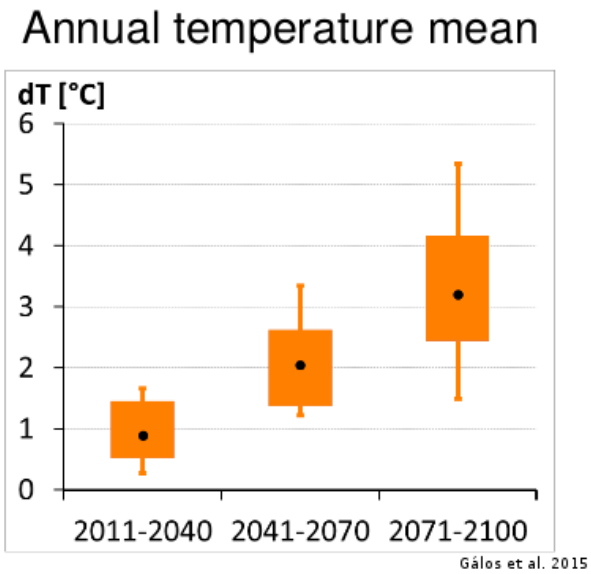
# Forecasts for agrarian sector

- RCMs projections suggest warmer climate for Hungary



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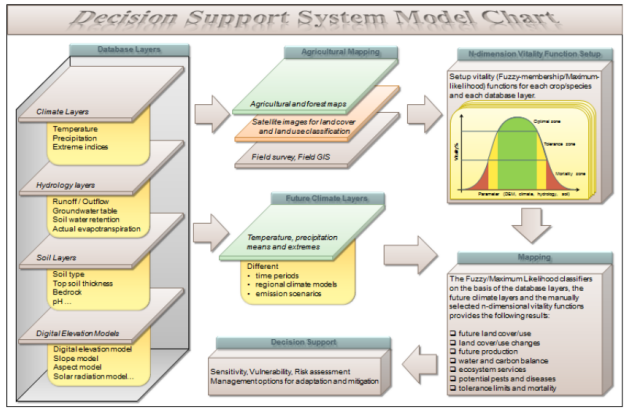
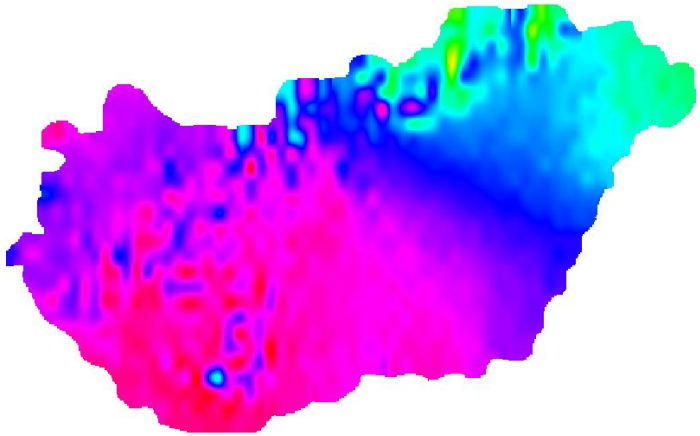


# Forecasts for agrarian sector

- RCMs projections suggest warmer climate for Hungary
- Traditional cropping technologies are no longer sustainable
- The situation more serious in forestry (more)
- GIS based decision support system (more)
- Water is one of the most important limiting factor in Hungary

# Hydrological model basics

- Thorntwaite-type monthly waterbalance model based on spatially interpolated temperature values

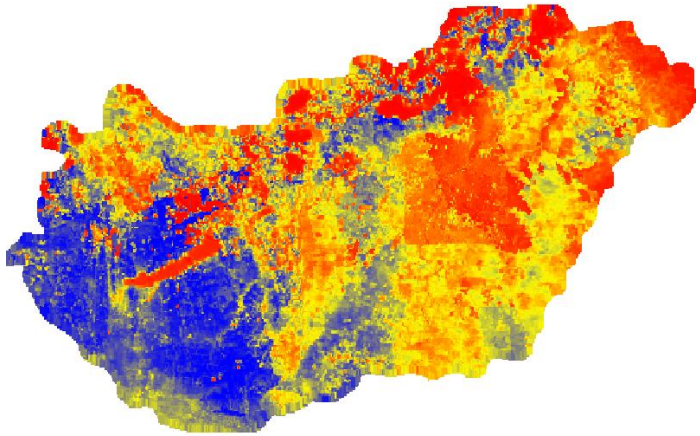


$$e_a^* = 0.6108 \cdot \mathrm{e}^{\frac{17.27 T_a}{T_a + 273.3}}$$

$$PETH = 29.8 \cdot D \cdot \frac{e_a^*}{T_a + 273.2}$$

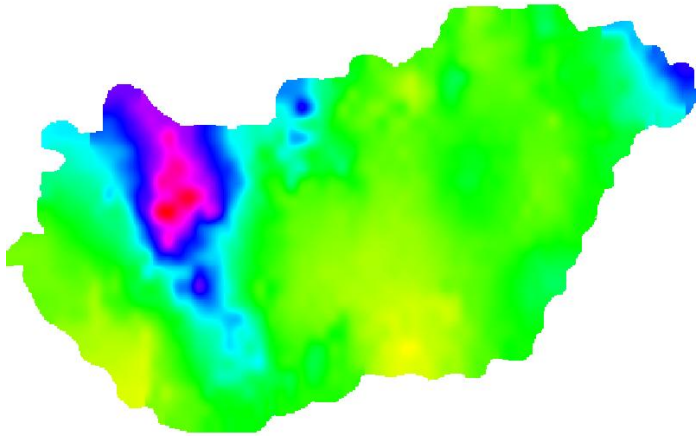
# Hydrological model basics

- Thorntwaite-type monthly waterbalance model based on spatially interpolated temperature values
- Stochastic calibration with $ET_{actual}$ (CREMAP)



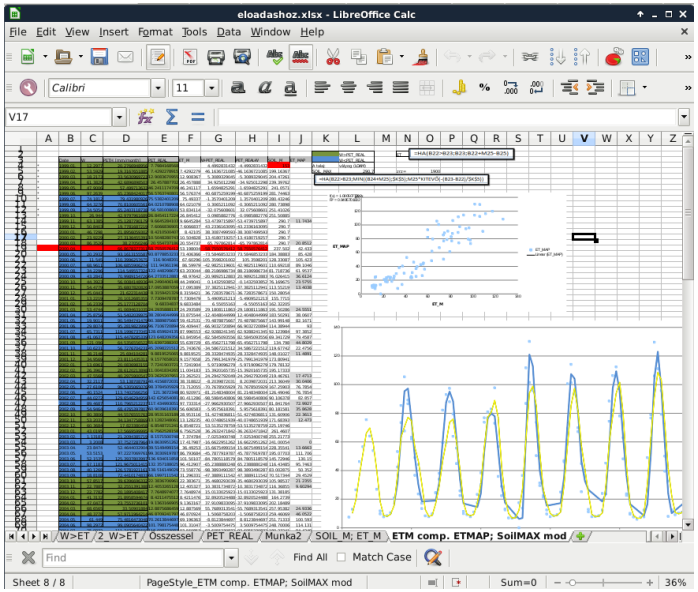
# Hydrological model basics

- Thorntwaite-type monthly waterbalance model based on spatially interpolated temperature values
- Stochastic calibration with $ET_{actual}$ (CREMAP)
- Soil parameter established by optimization of the simplified water balance (with precipitation input), which the basis of prediction



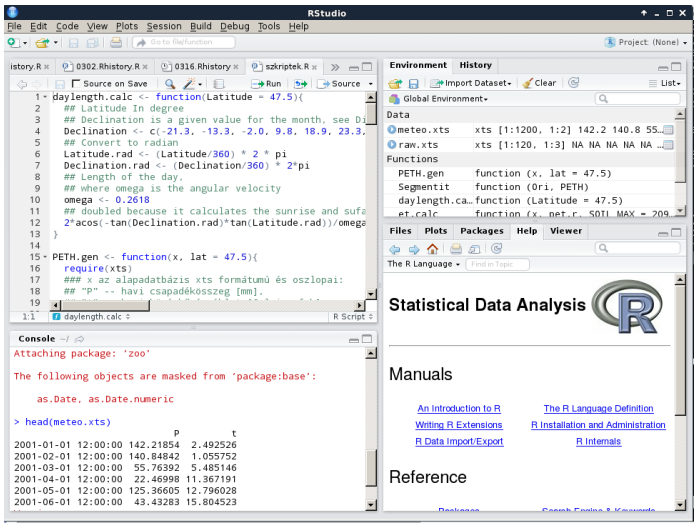
# Hydrological module development

- Early development in spreadsheet software and partial integration into GIS system



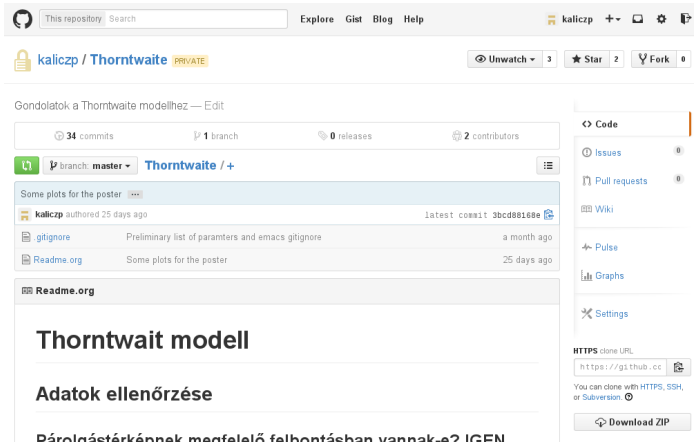
# Hydrological module development

- Early development in spreadsheet software and partial integration into GIS system
- Algorithm transfer into R (more)



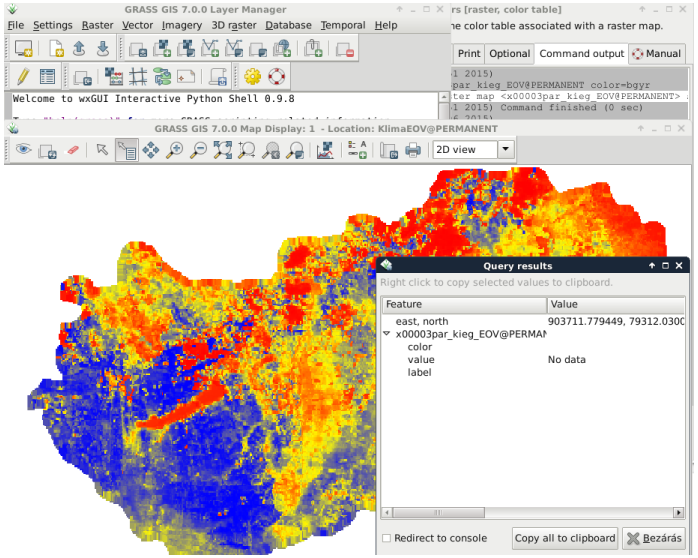
# Hydrological module development

- Early development in spreadsheet software and partial integration into GIS system
- Algorithm transfer into R (more)
- Code development under version control (more)



# Hydrological module development

- Early development in spreadsheet software and partial integration into GIS system
- Algorithm transfer into R (more)
- Code development under version control (more)
- Planned integration with GIS system



## See also

- Mon, 13 Apr, 17:30–19:00, Red 36 *Péter Csáki et al.* Development of a climate-runoff model for the catchment of Zala River (EGU2015-11107)
- Wed, 15 Apr, 17:30–19:00, Yellow 120 *Borbála Gálos et al.* Climate change information supporting adaptation in forestry and agriculture – results and challenges (EGU2015-11681)
- Thu, 16 Apr, 17:30–19:00, Red 69 *András Herceg et al.* A monthly water balance model for climate change analysis in Hungary (EGU2015-9419)

## Acknowledgement

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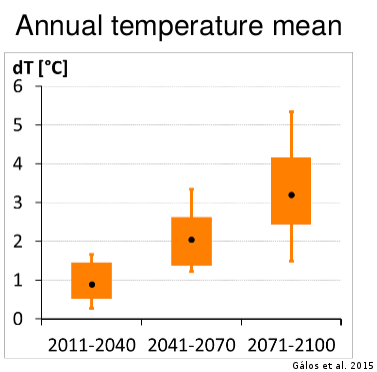
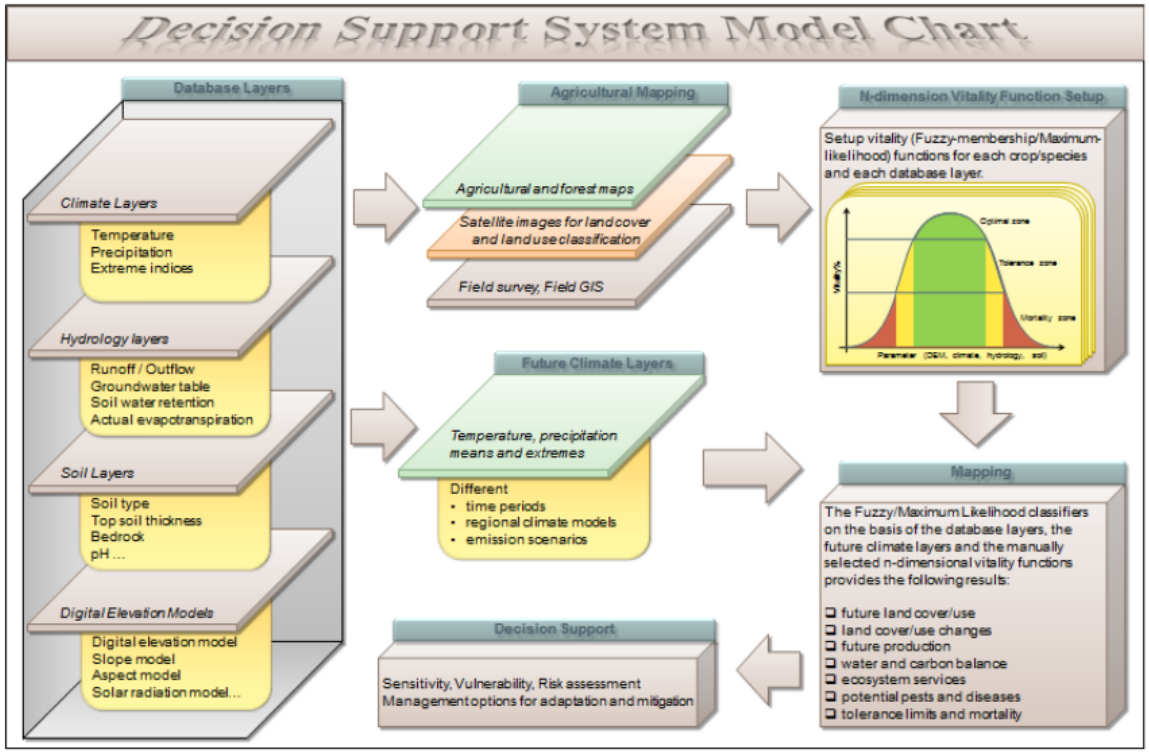
# Changing climate and agrarian sector

For Hungary regional climate models projections suggest a warmer climate and some changes in annual precipitation distribution. These changes force the whole agrarian sector to consider the traditional cropping technologies. This situation is more serious in forestry because some forest populations (eg. beech) are on their xeric distributional limits Gálos et al. 2014. Additionally, a decision has an impact sometimes longer than one hundred years.



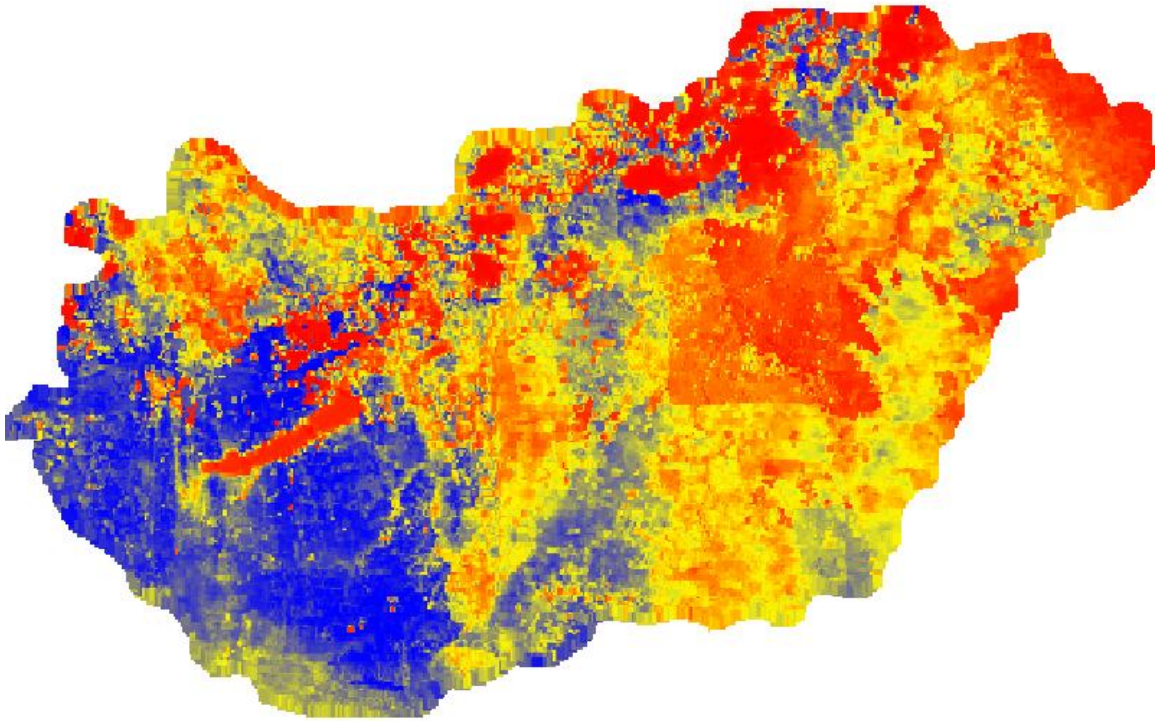

# Decision support system

To support the stakeholder there is a project which develops a GIS (Geographic Information System) based decision support system. Hydrology plays significant role in this system because water is often one of the most important limiting factor in Hungary. See Gálos et al. 2014.



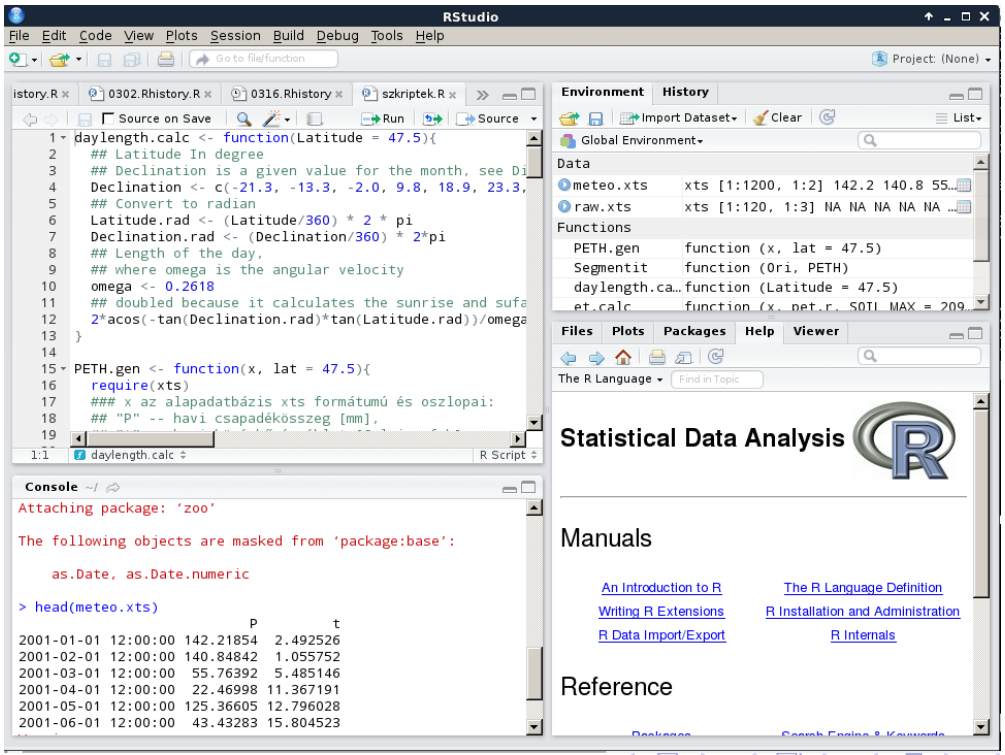
# Hydrological model calibration

The model is calibrated with the available data between 2000 and 2008. Beside other meteorological data we used mainly an estimated actual evapotranspiration ($ET_{actual}$) map in the calibration phase, which was derived with the Complementary-relationship-based evapotranspiration mapping (CREMAP) technique Szilágyi and Kovács 2011. $ET_{actual}$ is derived from the MODIS LST composits.



# Choose R

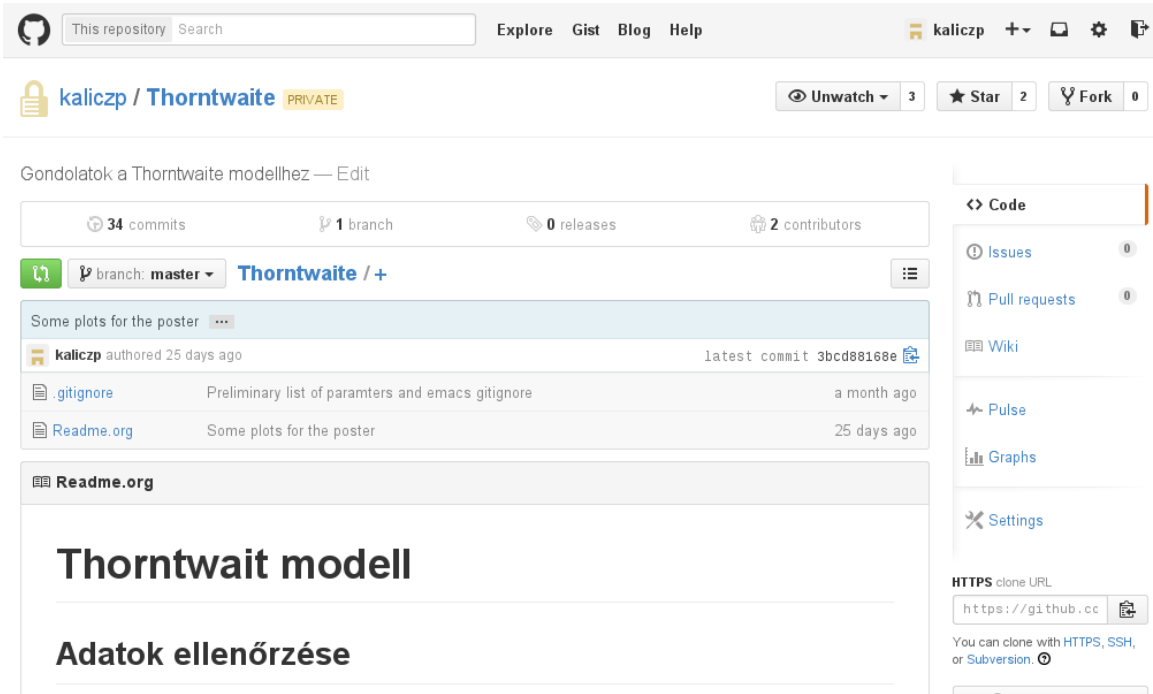
The calibration process is pixel based and it has several stochastic steps.
We try to find a flexible solution for the model implementation which easy to automatize and can be integrate in GIS systems. The open source R programming language was selected which well satisfied these demands.



# Communication solution

Communication among researchers is solved by `git` an open-source distributed version control software.

- It helps to collaborate researchers.
- Accessible everywhere.
- Solve backup tasks through github.
- Secure solution
- History of changes

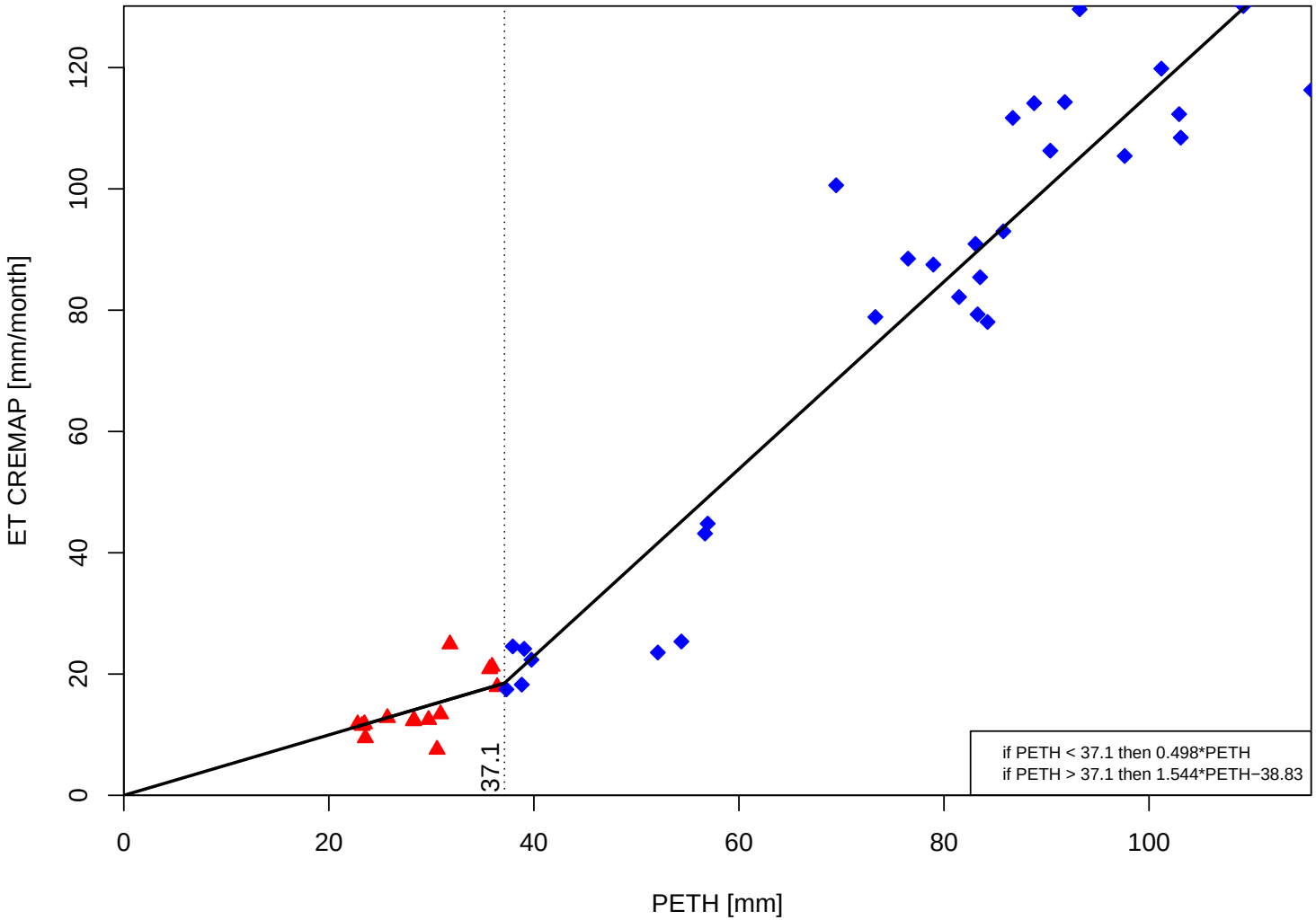


# R functions

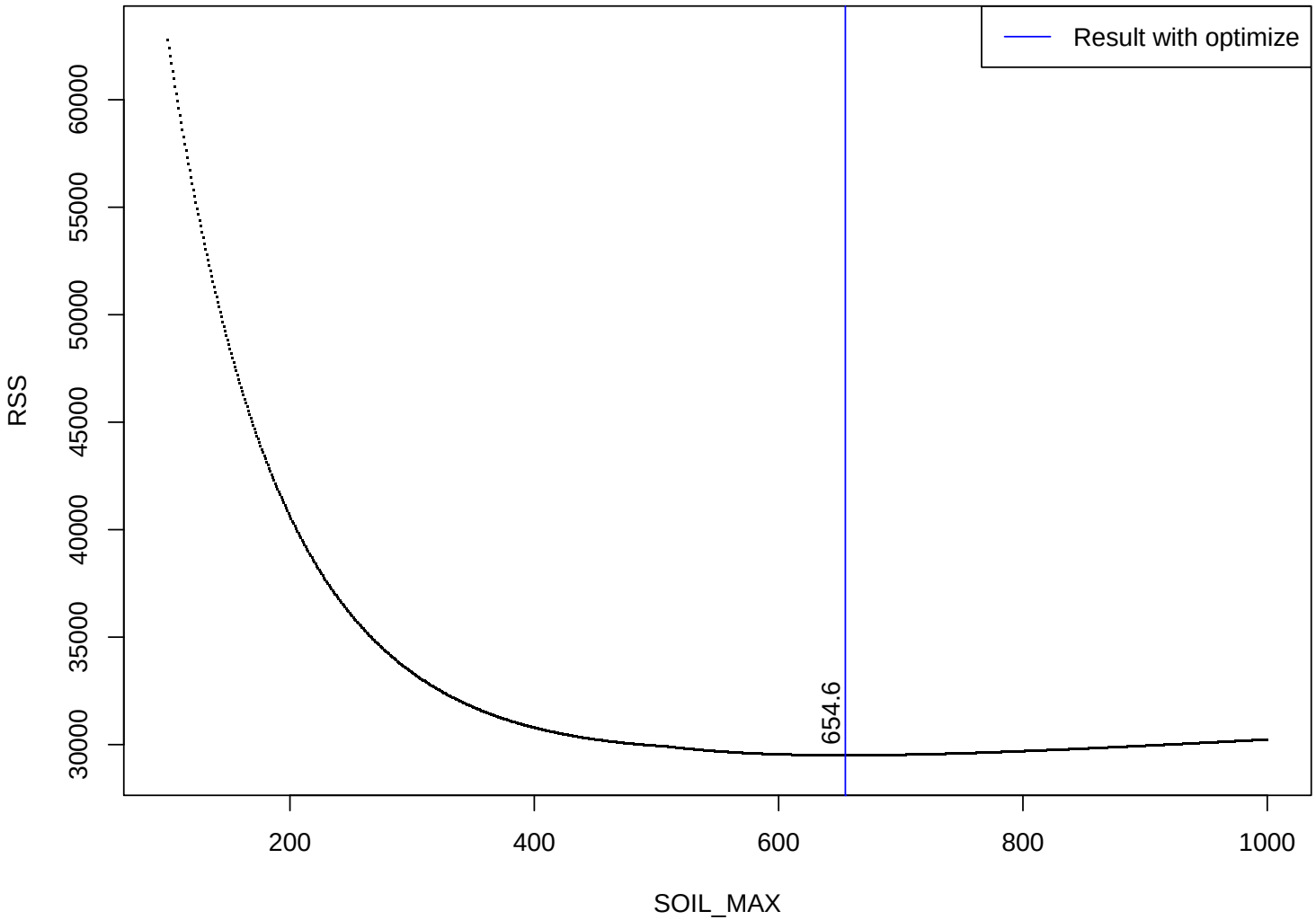
The result of this development is summarized as R functions.

```
daylength.calc <- function(Latitude = 47.5){
  ## Latitude In degree
  ## Declination is a given value for the month
  Declination <- c(-21.3, -13.3, -2.0, 9.8, 18.9, 23.3,
   21.3, 13.7, 3.0, -9.0, -18.6, -23.3)
  ## Convert to radian
  Latitude.rad <- (Latitude/360) * 2 * pi
  Declination.rad <- (Declination/360) * 2*pi
  ## Length of the day,
  ## where omega is the angular velocity
  omega <- 0.2618
  ## doubled because it calculates the sunrise
  ## and sufall befor and after noon
  2*acos(-tan(Declination.rad)*tan(Latitude.rad))/omega
}
```

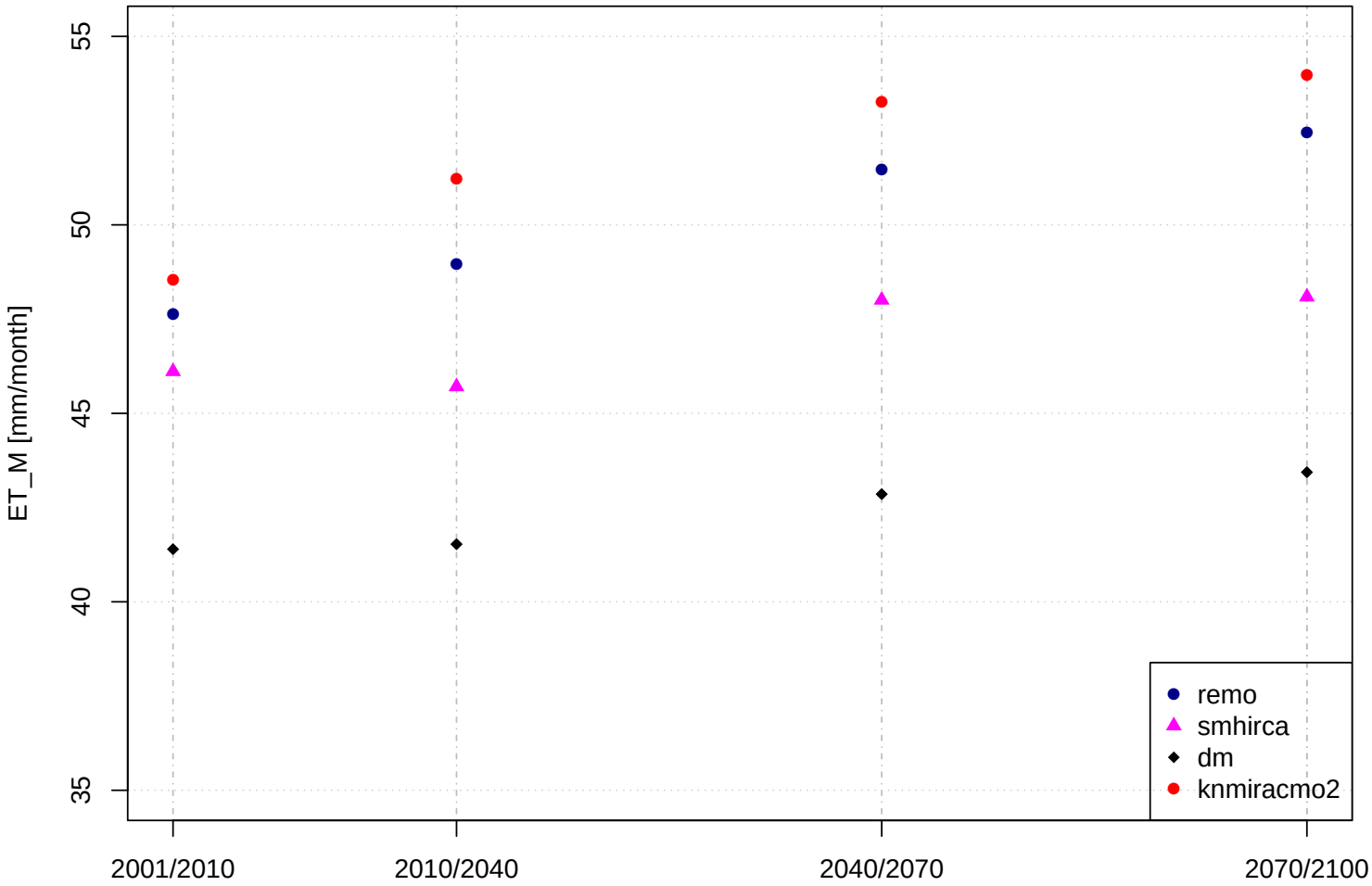
# $ET_{actual}$ vs. PETH



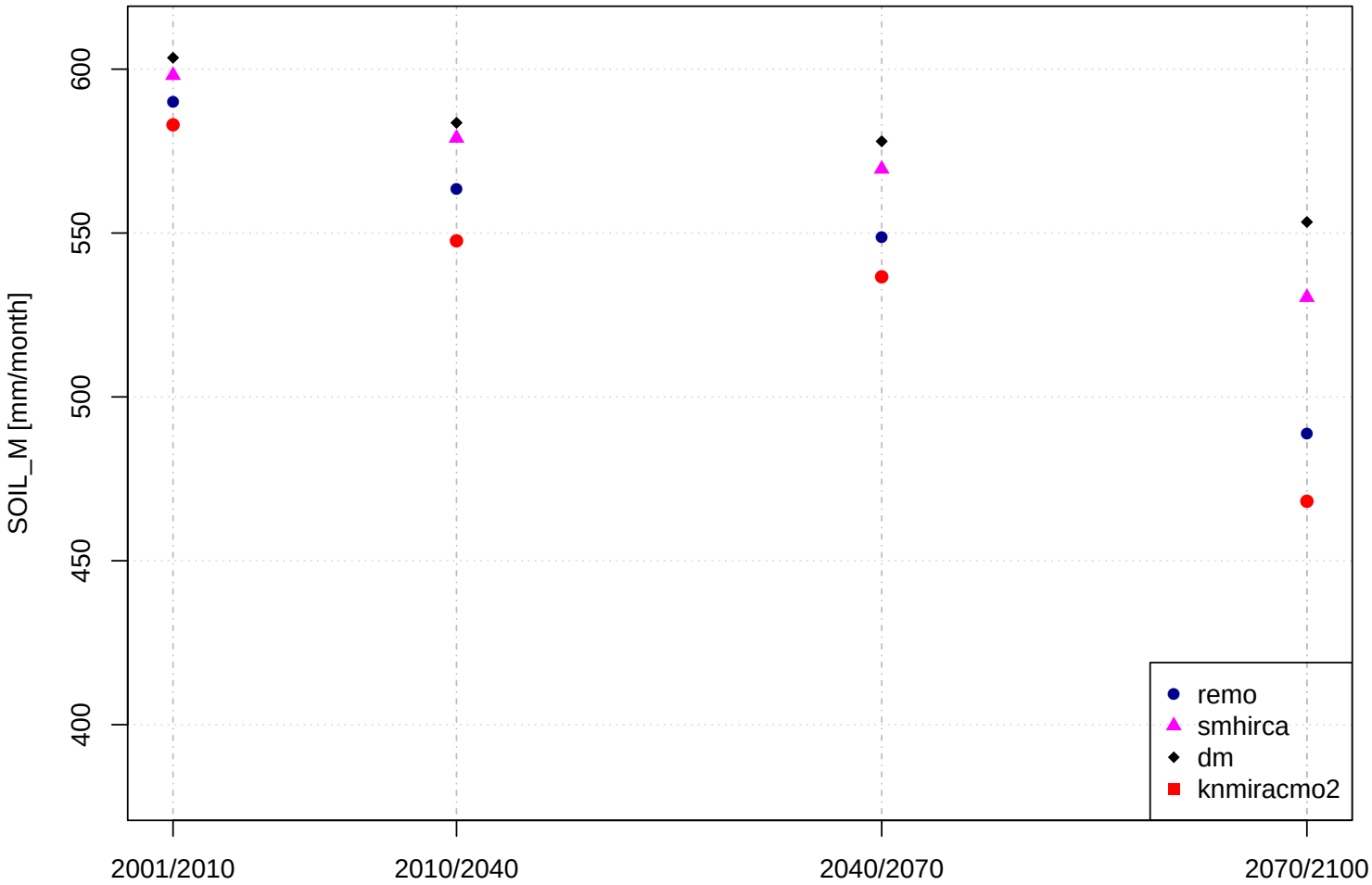
# $SOIL_{MAX}$ parameter optimisation



# Modelled ET


ET_M [mm/month]
55
50
45
40
35
2001/2010
2010/2040
2040/2070
2070/2100
remo
smhirca
dm
knmiracmo2

# Modelled $SOIL_M$



# Acknowledgement

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# References


Gálos, Borbála et al. (2014). "Forest ecosystems, sewage works and droughts – possibilities for climate change adaptation". In: *Natural Hazards and Climate Change/Riesgos Naturales y Cambio Climático*. Ed. by Santamarta J.C., Hernandez-Gutiérrez L.E., and Arraiza M.P. Madrid: Colegio de Ingenieros de Montes, pp. 91–104.

Szilágyi, József and Ákos Kovács (2011). "A calibration-free evapotranspiration mapping technique for spatially-distributed regional-scale hydrologic modeling". In: *J. Hydrol. Hydromech.* 59.2, pp. 118–130. URL: http://dlib.lib.cas.cz/6678/1/2011_59_2_szilagyi_118.pdf.