Appendix_S2_Australia_Soil_Test

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Overview

This code runs simulations comparing the ability of the micro_ncep (NCEP weather grids) and micro_aust (AWAP weather grids) functions of NicheMapR to predict soil temperature and moisture as compared with the OzNet soil moisture data (Smith et al. 2012) http://www.oznet.org.au/.

Note that this script uses the opendap connection to the AWAP data in the micro_aust call which doesn't incorporate daily wind grids, but in the original analyses for the MS it used a database that included the McVicar daily wind speed grids to be comparable with Kearney and Maino (2018). Thus the results from this analysis will be slightly different to those reported in the MS.

It assumes the following files are in the working directory:

addTrans.R (transparent series in plots) plot_moist.R (plotting and analysing observed and predicted soil moisture) plot_temp.R (plotting and analysing observed and predicted soil temperature) compare.R (collating and comparing data across all sites) soilprops.txt (pre-extracted Soil and Landscape Grid of Australia soil properties for each site)

and that there is a subfolder 'oznet' with the collated OzNet soil data per site as well as a folder 'output' for the results to go in.

Loop through sites and compute

```r
library(NicheMapR)
library(microclima)
library(stringr)
library(raster)
library(zoo)
source("addTrans.R") # function to make transparent plots
source("plot_moist.R") # function to summarise and plot results and generate summary statistics
source("plot_temp.R") # function to summarise and plot results and generate summary statistics

sitedata<-read.csv("oznetsiteinfo2.csv", stringsAsFactors = FALSE)[,-1]
# delete sites with no soil moisture data
nomoist <- c("k14", "a2", "m3")
sitedata <- subset(sitedata, !name%in%nomoist)
allsitenames <- as.character(sitedata$name)
REFL <- 0.2
runaust <- 1
runncep <- 1
tzone <- paste("Etc/GMT+", 10, sep = "")

# pre-extracted SCAN soil properties
soilpro_all <- read.csv("soilprops.txt", header=FALSE)
colnames(soilpro_all) <- c('i', 'site', 'long', 'lat', 'desc', 'blkdens', 'clay', 'silt', 'sand')

for(isite in 1:nrow(sitedata)){ # start loop through all sites
```

```r
site <- sitedata[isite, ]
site2do <- site$name
OzNetsite <- site[3]
# set soil depths for prediction
SMDEP <- as.vector(site[, 9:18])  # 10 depths (cm) for moisture
TDEP  <- as.vector(site[, 19:28]) # 10 depths (cm) for temperature
eval(parse(text=paste('obs_depth_soil <- c(', site[7],')', sep='')))
eval(parse(text=paste('obs_depth_temp <- c(',site[8],')', sep='')))
oznetdatafreq <- site$min # frequency of measurement (usually 6min, 20min, or 30min)
longlat <- c(as.numeric(site[1]), as.numeric(site[2]))

ystart <- 2007
yfinish <- 2010
nyears <- yfinish - ystart + 1

# soil moisture simulation
DEP <- as.numeric(SMDEP)

#Set soil properties.

#pre-extracted soil properties
soilpro <- subset(soilpro_all, site == isite)
soilpro <- soilpro[, 5:9]
soilpro[, 1] <- c(2.5, 7.5, 22.5, 45, 80, 150)
colnames(soilpro)[1] <- 'depth'

# get hydraulic properties - uses Cosby et al. 1984 pedotransfer functions and splines soil compositi
soil.hydro<-pedotransfer(soilpro = as.data.frame(soilpro), DEP = DEP)
PE <- soil.hydro$PE
BB <- soil.hydro$BB
BD <- soil.hydro$BD
KS <- soil.hydro$KS
DD <- rep(2.6, 19)
# loam on top
PE[1:7] <- CampNormTbl9_1[4, 4]
BB[1:7] <- CampNormTbl9_1[4, 5]
KS[1:7] <- CampNormTbl9_1[4, 6]
BulkDensity <- BD[seq(1, 19, 2)] #soil bulk density, kg/m3

# search through observed textures and find the nearest match to Campbell and Norman's Table 9.1
stypes<-NULL
for(m in 1:nrow(soilpro)){
  ssq <- (CampNormTbl9_1[, 2] - soilpro[m, 4] / 100) ^ 2 + (CampNormTbl9_1[, 3] - soilpro[m, 3] / 100
  stypes[m] <- which(ssq == min(ssq))
}
# produce a table of the qualitative soil profile
soils <- as.character(CampNormTbl9_1[, 1])
profile <- as.data.frame(cbind(soilpro[, 1], soils[stypes]), stringsAsFactors=FALSE)
profile[,1] <- as.numeric(profile[,1])
colnames(profile) <- c("depth", "soiltype")

ERR <- 3
```

```
#Run the microclimate model, retrieve output and append dates.
if(runaust == 1){
  #micro.aust <- micro_aust(opendap = 0, REFL = REFL, ERR = ERR, loc = longlat, ystart = ystart, yfin
  micro.aust <- micro_aust(opendap = 1, REFL = REFL, ERR = ERR, loc = longlat, ystart = ystart, yfinis
}
dstart <- paste0("01/01/", ystart)
dfinish <- paste0("31/12/", yfinish)
if(runncep == 1){
  dem <- microclima::get_dem(lat = longlat[2], long = longlat[1], resolution = 30) # mercator equal a
 #micro.ncep <- micro_ncep(runshade = 1, REFL = REFL, soilgrids = 0, dem = dem, dem2 = dem, spatial =
 micro.ncep <- micro_ncep(runshade = 1, REFL = REFL, soilgrids = 0, dem = dem, dem2 = dem, spatial = 
}

#Read in OzNet data.
XLdat <- read.table(paste("oznet/", OzNetsite, '_',oznetdatafreq, 'min_sm.txt', sep=""), header = FAL
rownames(XLdat) <- NULL
if(ncol(XLdat) == 9){
  colnames(XLdat)  <-c('DATE', 'TIME', 'Temp_2.5cm', 'Temp_15cm', 'SM_0_5cm', 'SM_0_30cm', 'SM_30_60cm
}else if(ncol(XLdat) == 15){colnames(XLdat) <- c('DATE', 'TIME', 'Temp_4cm', 'Temp_15cm','Temp_45cm',
}else{ warning("OzNet data has wrong number of columns!")
}
XLdat$DATE <- as.Date(XLdat$DATE, "%d/%m/%Y")

# take only hourly data (data in 20min intervals)
XLdat <- XLdat[seq(1, nrow(XLdat), 60 / oznetdatafreq), ]
XLdat0 <- subset(XLdat,  DATE > as.Date(paste('01/01/', ystart, sep = ""), "%d/%m/%Y"))
XLdat0 <- subset(XLdat0, DATE < as.Date(paste('01/01/', yfinish + 1, sep = ""), "%d/%m/%Y"))
years <- as.character(seq(ystart + 1, yfinish))

# subset observation data to years with observations
XLdat1 <- XLdat0
XLdat1[XLdat1[, ] == -99] <- NA
XLdat1$dates <- as.POSIXct(with(XLdat1,paste(DATE, TIME, sep = " ")),format="%Y-%m-%d %H:%M")
XLdat1 <- subset(XLdat1, format(XLdat1$dates, "%Y") %in% years)
XLdat1$dates <- as.POSIXct(with(XLdat1, paste(DATE, TIME, sep=" ")), format = "%Y-%m-%d %H:%M")
OTEMPDATES <- as.POSIXct(with(XLdat1, paste(DATE, TIME, sep=" ")), format = "%Y-%m-%d %H:%M")

# aggregate observations to daily
XLdat2 <- XLdat1
XLdat2$TIME <- as.POSIXct(XLdat1$TIME, format = "%H:%M") # to get rid of warnings, convert from char
XLdat1_day <- aggregate(XLdat2, by = list(format(XLdat1$DATE, "%d-%m-%Y")), FUN = mean, na.rm=TRUE, na
XLdat1_day$Group.1 <- as.POSIXct(XLdat1_day$Group.1, format="%d-%m-%Y", tz = tzone)
XLdat1_day <- XLdat1_day[order(XLdat1_day$Group.1), ]

XLrain <- aggregate(XLdat1$Rainfall, by = list(as.Date(XLdat1$dates, format='%d/%m/%Y')), sum)
colnames(XLrain) <- c('dates', 'Rainfall')
XLrain$dates <- as.POSIXct(XLrain$dates)

# plot output and generate summary statistics
plot_moist(ncep = 1)
plot_moist(ncep = 0)

# soil temperature simulation
```

```r
  DEP <- as.numeric(TDEP)

  #Set soil properties.

  # get hydraulic properties - uses Cosby et al. 1984 pedotransfer functions and splines soil compositi
  soil.hydro<-pedotransfer(soilpro = as.data.frame(soilpro), DEP = DEP)
  PE <- soil.hydro$PE
  BB <- soil.hydro$BB
  BD <- soil.hydro$BD
  KS <- soil.hydro$KS
  DD <- rep(2.6, 19)
  # loam on top
  PE[1:7] <- CampNormTbl9_1[4, 4]
  BB[1:7] <- CampNormTbl9_1[4, 5]
  KS[1:7] <- CampNormTbl9_1[4, 6]
  BulkDensity <- BD[seq(1, 19, 2)] #soil bulk density, kg/m3

  #Run the microclimate model, retrieve output and append dates.
  if(runaust == 1){
    #micro.aust <- micro_aust(microclima = 1, opendap = 0, runmoist = 1, soildata = 0, REFL = REFL, LAI
    micro.aust <- micro_aust(microclima = 1, opendap = 1, runmoist = 1, soildata = 0, REFL = REFL, LAI =
  }
  dstart <- paste0("01/01/",ystart)
  dfinish <- paste0("31/12/",yfinish)
  if(runncep == 1){
    #micro.ncep<-micro_ncep(runshade = 1, runmoist = 1, REFL = REFL, soilgrids = 0, dem = dem, dem2 = d
    micro.ncep <- micro_ncep(runshade = 1, runmoist = 1, REFL = REFL, soilgrids = 0, dem = dem, dem2 = d
  }

  # plot output and generate summary statistics
  plot_temp(ncep = 1)
  plot_temp(ncep = 0)

}
```

Collate and tabulate results

```r
source('compare.R')
library(knitr)

badtemp<-c("a14","a445","k123","k133","k14","k175","k24","k54","k73","m64","a475","k375")

ncep_raw <- read.csv('output/micro_ncep_temp.csv')
ncep_raw$soil <- 'ncep'

awap <- read.csv('output/micro_aust_temp.csv')
awap$soil <- 'awap'

analysis <- compare(awap, ncep_raw, 'awap', 'ncep', badtemp)
kable(analysis$stats, digits = 2, caption = "Summary statistics for Cosby vs Campbell and Norman, soil m
```

Table 1: Summary statistics for Cosby vs Campbell and Norman, soil moisture

depth	scenario	r mean	r stdev	RMSE mean	RMSE stdev
4	awap	0.85	0.03	5.29	0.78
15	awap	0.95	0.06	2.79	0.84
45	awap	0.98	0.01	2.70	0.83
75	awap	0.98	0.02	2.58	1.25
4	ncep	0.94	0.01	3.64	0.63
15	ncep	0.95	0.04	2.77	1.00
45	ncep	0.98	0.02	2.40	1.51
75	ncep	0.97	0.02	1.96	0.58
overall	awap	0.93	0.07	3.55	1.47
overall	ncep	0.96	0.03	2.90	1.12

```
kable(analysis$ttests, digits = 4, caption = "Paired t-tests for Cosby vs Campbell and Norman, soil mois
```

Table 2: Paired t-tests for Cosby vs Campbell and Norman, soil moisture

depth	r Pval	r Diff	RMSE Pval	RMSE Diff
4	0.0000	-0.0941	0.0000	1.6453
15	0.6167	0.0025	0.8928	0.0247
45	0.0353	0.0073	0.3725	0.2961
75	0.5488	0.0021	0.1590	0.6242

```
badmoist<-c("k1275","k1245","a445","y34")

awap <- read.csv('output/micro_aust_moist.csv')
awap$soil <- 'awap'

ncep <- read.csv('output/micro_ncep_moist.csv')
ncep$soil <- 'ncep'

analysis <- compare(awap, ncep, 'awap', 'ncep', badmoist)
kable(analysis$stats, digits = 2, caption = "Summary statistics for Cosby vs Campbell and Norman, soil m
```

Table 3: Summary statistics for Cosby vs Campbell and Norman, soil moisture

depth	scenario	r mean	r stdev	RMSE mean	RMSE stdev
4	awap	0.79	0.07	8.42	3.14
15	awap	0.76	0.09	6.84	2.11
45	awap	0.52	0.40	7.37	4.05
75	awap	0.53	0.29	7.07	4.14
4	ncep	0.60	0.12	8.04	2.01
15	ncep	0.56	0.13	6.88	2.08
45	ncep	0.40	0.28	7.75	3.76
75	ncep	0.43	0.24	7.73	4.30
overall	awap	0.65	0.28	7.42	3.46

depth	scenario	r mean	r stdev	RMSE mean	RMSE stdev
overall	ncep	0.50	0.22	7.59	3.19

```
kable(analysis$ttests, digits = 4, caption = "Paired t-tests for Cosby vs Campbell and Norman, soil moi
```

Table 4: Paired t-tests for Cosby vs Campbell and Norman, soil moisture

depth	r Pval	r Diff	RMSE Pval	RMSE Diff
4	0.0000	0.1922	0.3040	0.3845
15	0.0000	0.1932	0.8692	-0.0345
45	0.0144	0.1206	0.2132	-0.3830
75	0.0385	0.0962	0.0305	-0.6624

References

Kearney, M. R., & Maino, J. L. (2018). Can next-generation soil data products improve soil moisture modelling at the continental scale? An assessment using a new microclimate package for the R programming environment. Journal of Hydrology, 561, 662–673. doi:10.1016/j.jhydrol.2018.04.040

Smith, A. B., Walker, J. P., Western, A. W., Young, R. I., Ellett, K. M., Pipunic, R. C., … Richter, H. (2012). The Murrumbidgee soil moisture monitoring network data set. Water Resources Research, 48(7), n/a-n/a. doi:10.1029/2012WR011976