CANDY

CARBON AND NITROGEN DYNAMICS
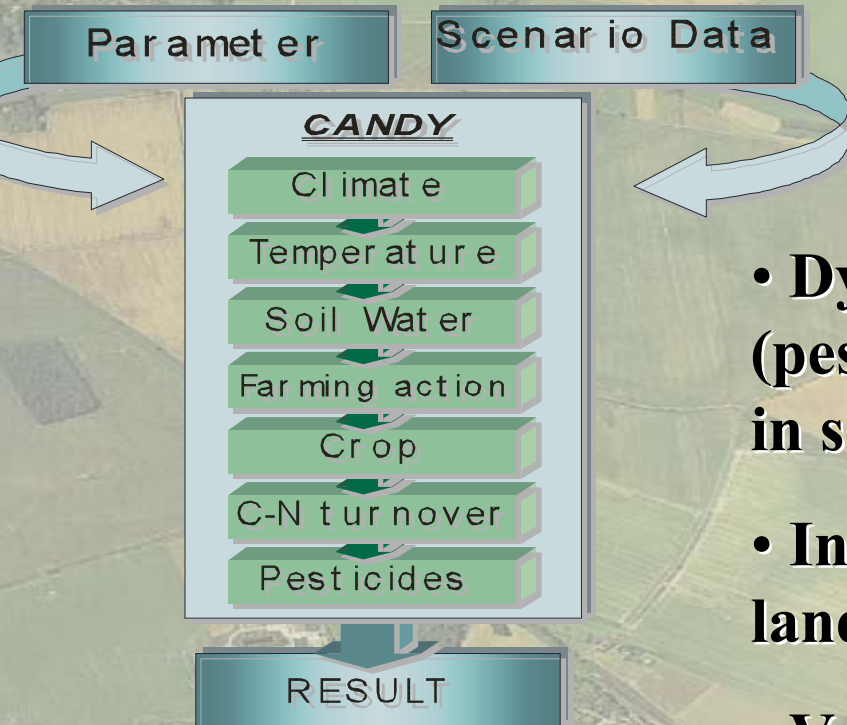

CENTRE FOR ENVIRONMENTAL RESEARCH LEIPZIG – HALLE

**Department of Soil Science,
Working Group Modelling and Regionalization**

www.bdf.ufz.de/CANDY

CANDY

Parameter

Scenario Data

CANDY
- Climate
- Temperature
- Soil Water
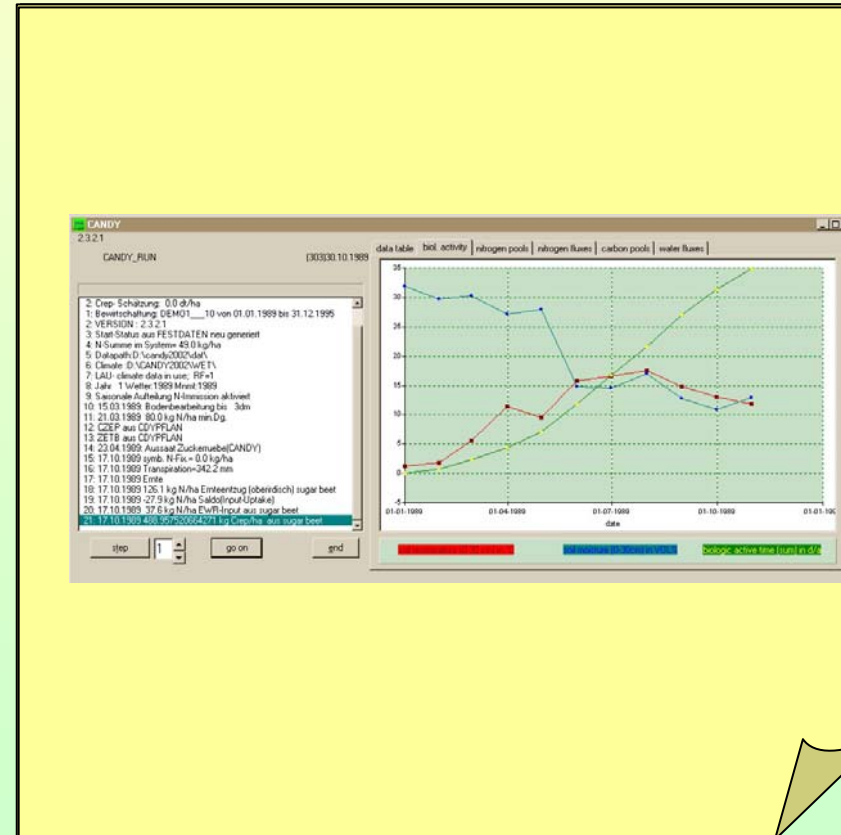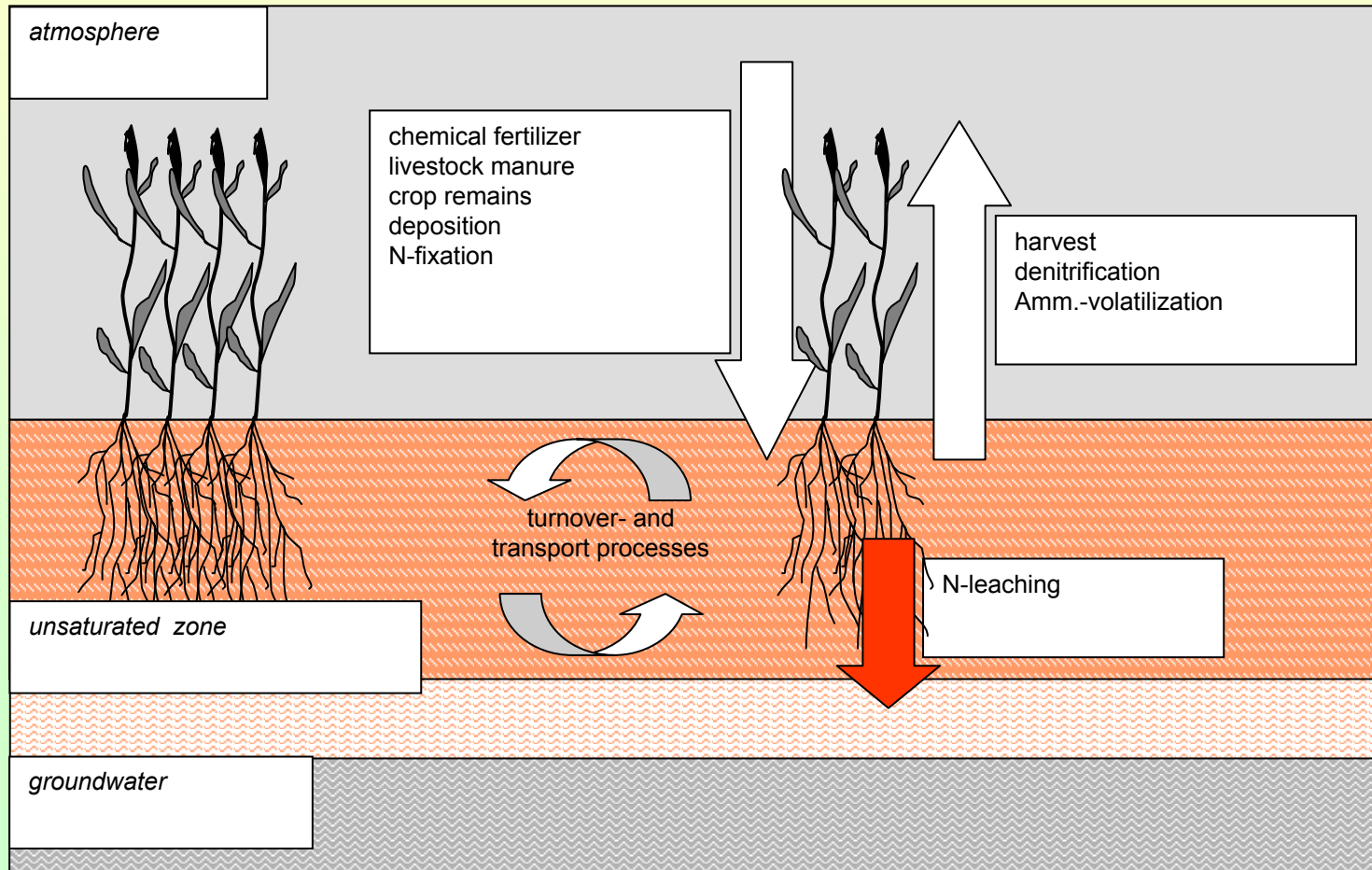- Farming action
- Crop
- C-N turnover
- Pesticides

RESULT

• **Dynamics of temperature, water, (pestizides) Carbon and Nitrogen in soil**

• **Inputs: parameters, soil data, land use and climate data**

• **Validation: Lysimeters, long term experiments, field experiments and farm fields**

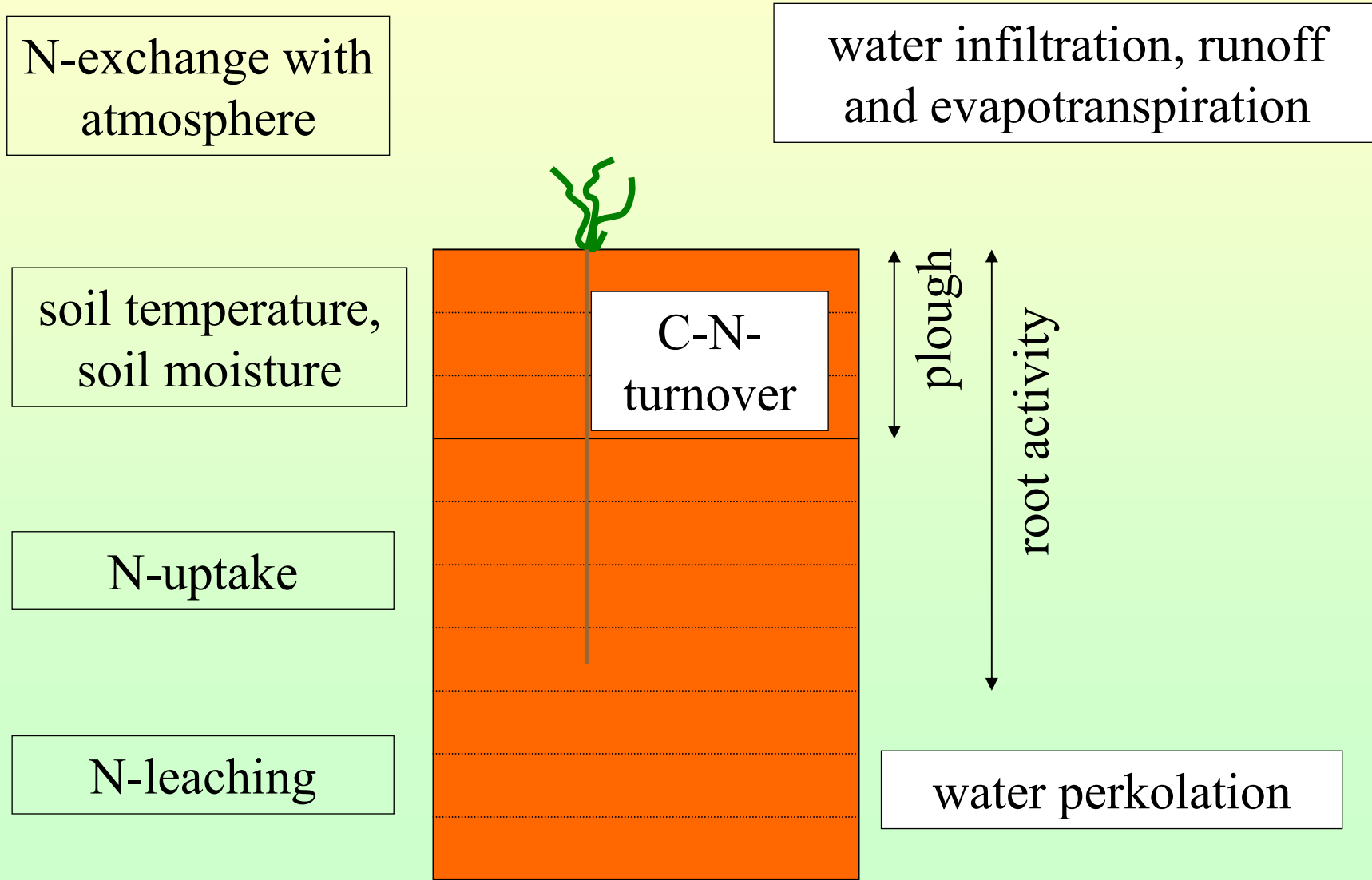# Development of the CANDY system

• 1988 model of C-N turnover with external temp. And water model

• 1989 integrated model (DOS)

• 1991 CANDY user interface

• 1998 GIS integration

• 2002 windows version (German lang.)

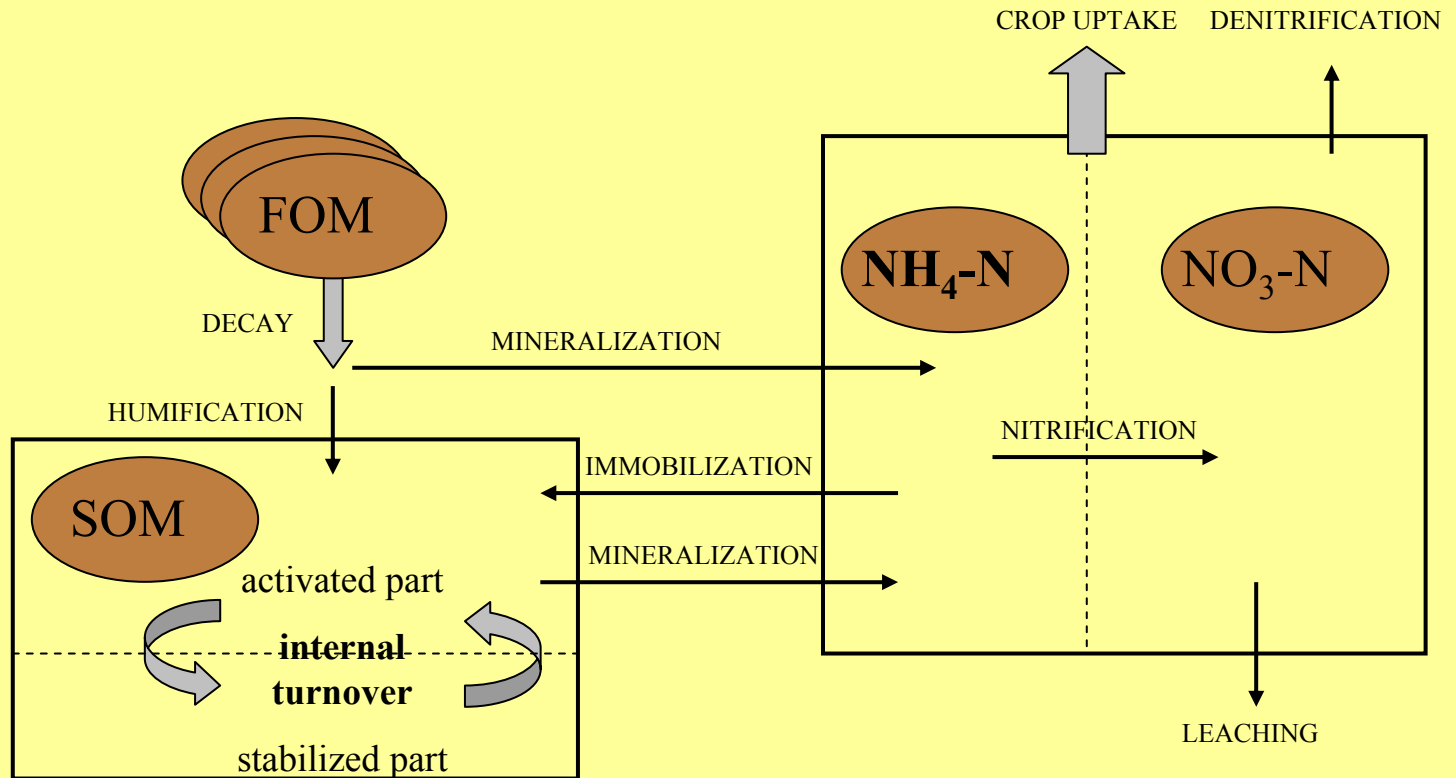• 2003 English version + manual

C-N-cycling

atmosphere

chemical fertilizer
livestock manure
crop remains
deposition
N-fixation

harvest
denitrification
Amm.-volatilization

turnover- and
transport processes

unsaturated zone

N-leaching

groundwater

Processes simulated by CANDY

N-exchange with atmosphere

water infiltration, runoff and evapotranspiration

soil temperature, soil moisture

C-N-turnover

plough

root activity

N-uptake

N-leaching

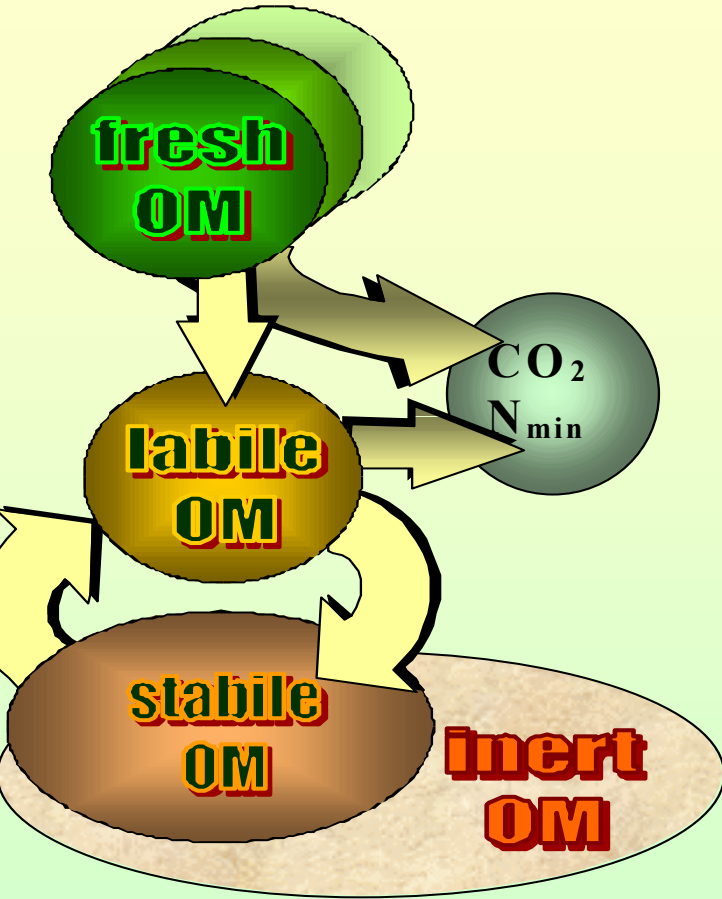water perkolation

C-N-Dynamics in CANDY

Modeling turnover of organic matter

$$\frac{d\,C_{REP}(t)}{d\,t} = \eta\;k_{FOM}\;C_{FOM}(t)$$

$$\frac{d\,C_{FOM}(t)}{d\,t} = -\,k_{FOM}\;C_{FOM}(t)$$

$$\frac{d\,C_A(t)}{d\,t} = \frac{d\,C_{REP}(t)}{d\,t} - (k_m + k_s)\,C_A(t) + k_a\,C_S(t)$$

$$\frac{d\,C_S(t)}{d\,t} = k_s\,C_A(t) - k_a\,C_S(t)$$

$$\frac{d\,N\min(t)}{d\,t} = \frac{k_m * \dot{C}_A(t)}{\gamma_A} + \frac{\gamma_A - \gamma_{FOM} * \eta}{\gamma_A * \gamma_{FOM}} * \dot{C}_{FOM}(t)$$

$$C_{FOM} = \sum \frac{P_0 + P_1 * YIELD}{\alpha} + \sum FYM$$

$$C_{DEC} = C_{DEC}^0 * \left(A_1 * \mathrm{e}^{\lambda_1 * t} + A_2 * \mathrm{e}^{\lambda_2 * t}\right) + \sum_{FOM} \frac{C_{FOM} * \eta_{FOM}}{BAT}\left(B_1 * \mathrm{e}^{\lambda_1 * t} + B_2 * \mathrm{e}^{\lambda_2 * t} + \frac{1+\xi}{k_m}\right)$$

steady state:
$$C_{DEC} = \frac{1+\xi}{k_m} * \frac{C_{REP}}{BAT}$$

where $\xi = 2.8$; $k_m = 0.00556$; $BAT = p0 + p1 * TEM + p2 * PRE$

Calculation of biological active time

temperature:

$$R_T(T) = Q^{(T-35)/10} \quad \text{if } T <= 35, \text{ else } 1$$

     T: soil temperature in °C,

water:

$$R_F(F) = 4 \, v \, (1-v) \quad \text{if } v \le 0,5; \text{ else } 1.$$

     $v = F/PV$,

     F: soil moisture (volumetric),

     PV: pore volume.

soil air / texture:

$$R_A(\varepsilon_L, h, FAT) = \exp\left(-h * \sqrt{\frac{\vartheta(FAT) * R_T(T) * R_F(F)}{\varepsilon_L * (\varepsilon_L - \varepsilon_P)}}\right)$$
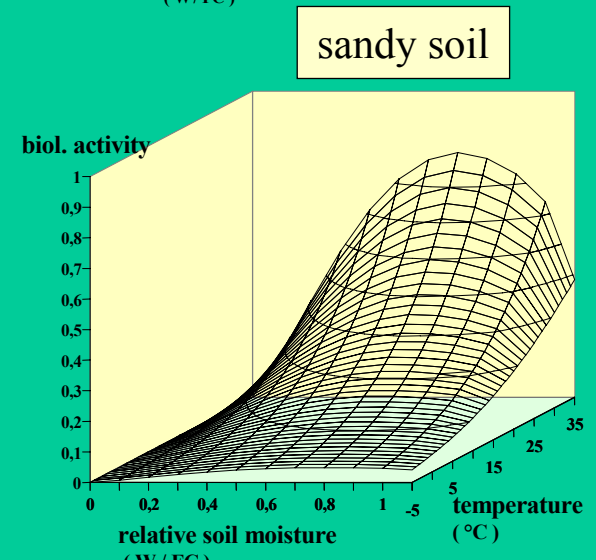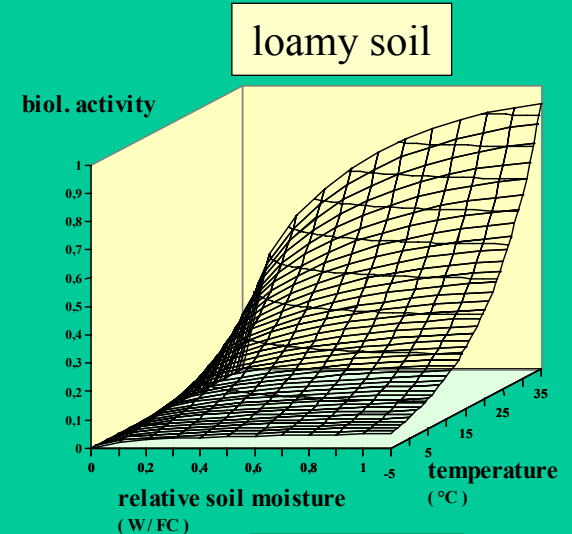
     h: depth (cm)

     FAT: texture indicator (particles≤6.3μm)

     ε_P: relative pocket volume (const.)

     ε_L: relative air volume

     $\vartheta(FAT)$:   soil texture function

loamy soil

biol. activity — relative soil moisture (W/FC) — temperature (°C)

sandy soil

biol. activity — relative soil moisture — temperature (°C)

CANDY input data

management data

Mineral N fertilization: - Date
            - Quantity (N-Input kg/ha)
            - type of fertiliser

Organic manure:
            - Date
            - Quantity (C –Input kg/ha)
            - type of manure

Cropping:
            - Date of sowing
            - Date of emergence
            - Date of harvest
            - Yield (t/ha)
            - N-Uptake (kg/ha)

Soil tillage (>1 dm)
            - Date
            - Depth

climate data

Daily global radiation (J / cm²)
or duration of sunshine (h/d)

Daily precipitation (mm)

Daily temperature (° C)

CANDY input data

Soil parameters (each soil horizon):

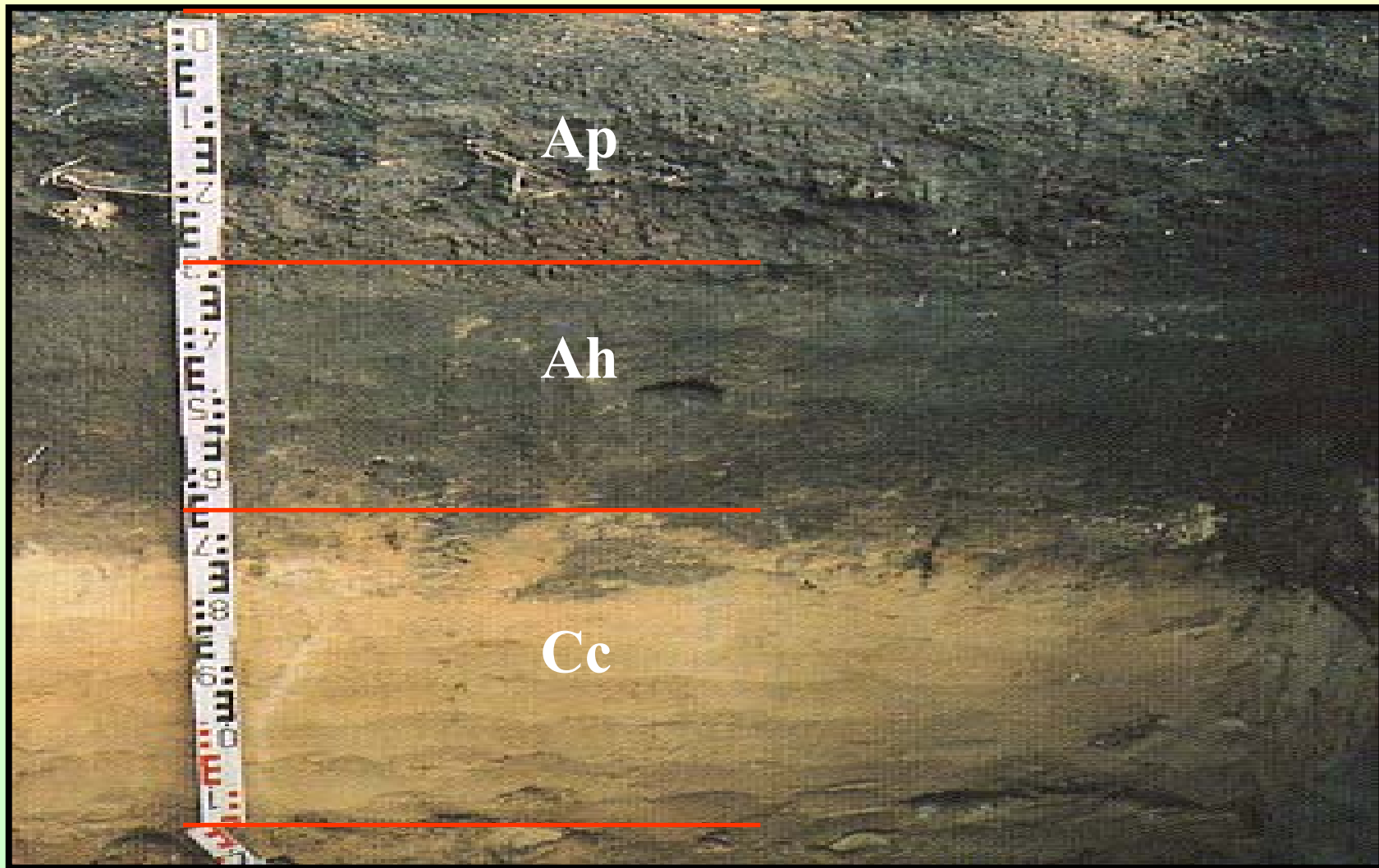- depth of soil horizon (dm)
- substrate density (g/cm^3)
- bulk density (g/cm^3)
- permanent wilting point (VOL%)
- field capacity (VOL%)
- clay content < 2μm (M %)
- fine silt content 2-6,3 μm (M %)
- saturated conductivity (mm/d)
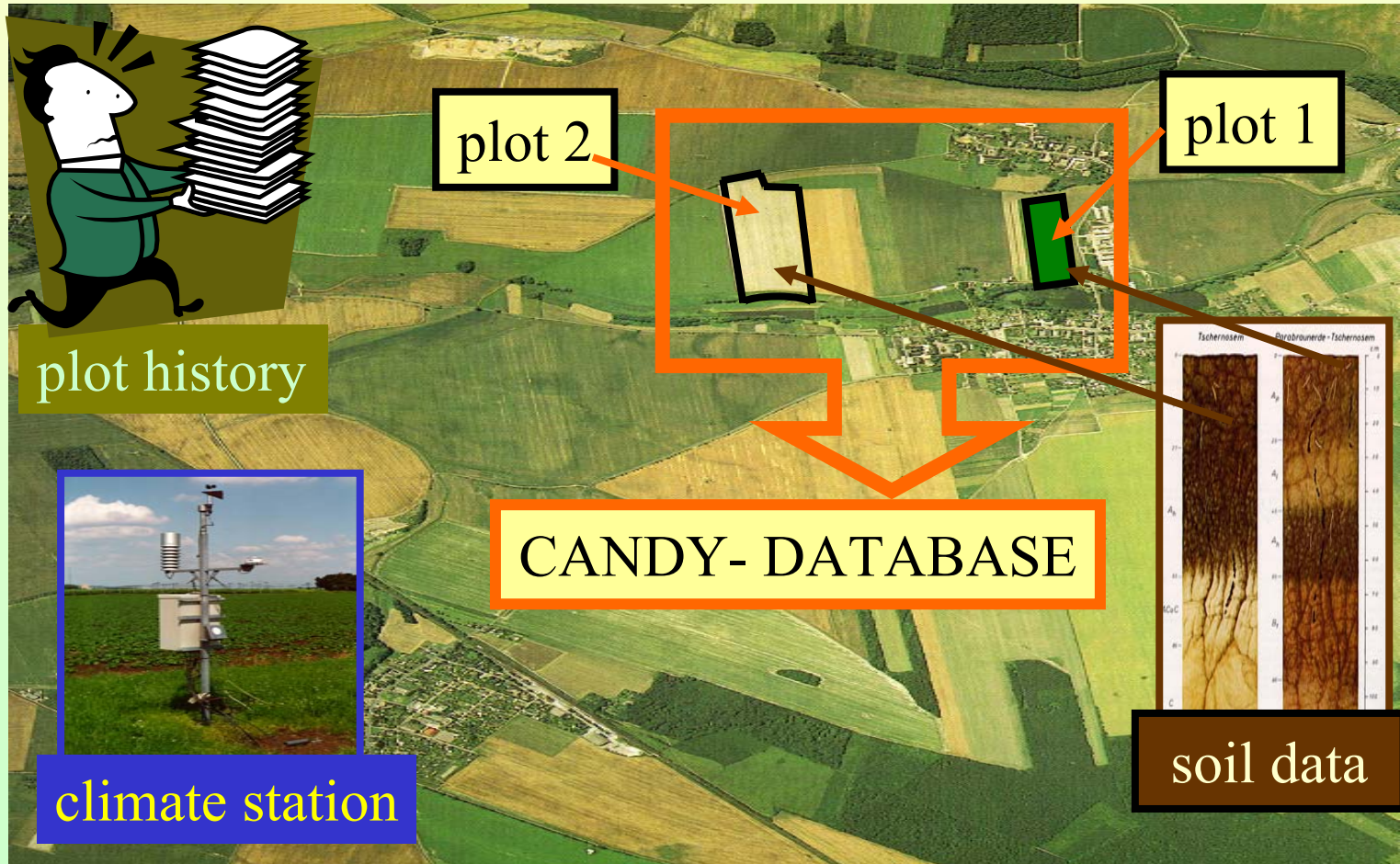
not necessary but appreciated :
- Soil water measurements (VOL%)
- observations of C and N dynamics in soil
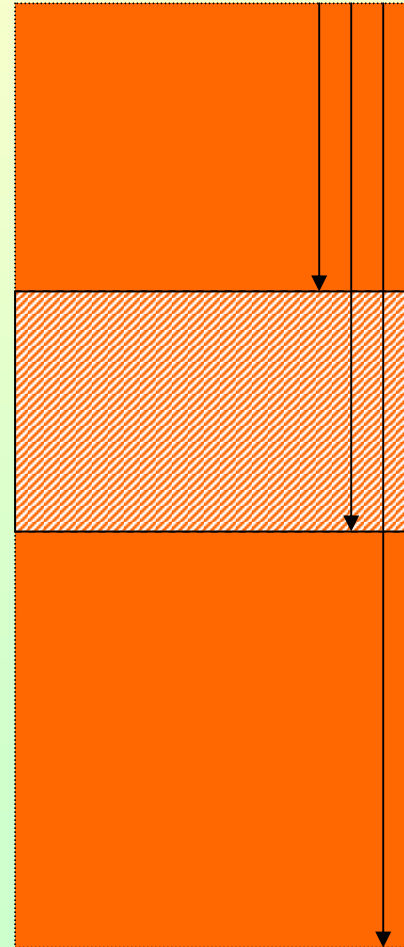
Soil profile

organising the user data: basic information
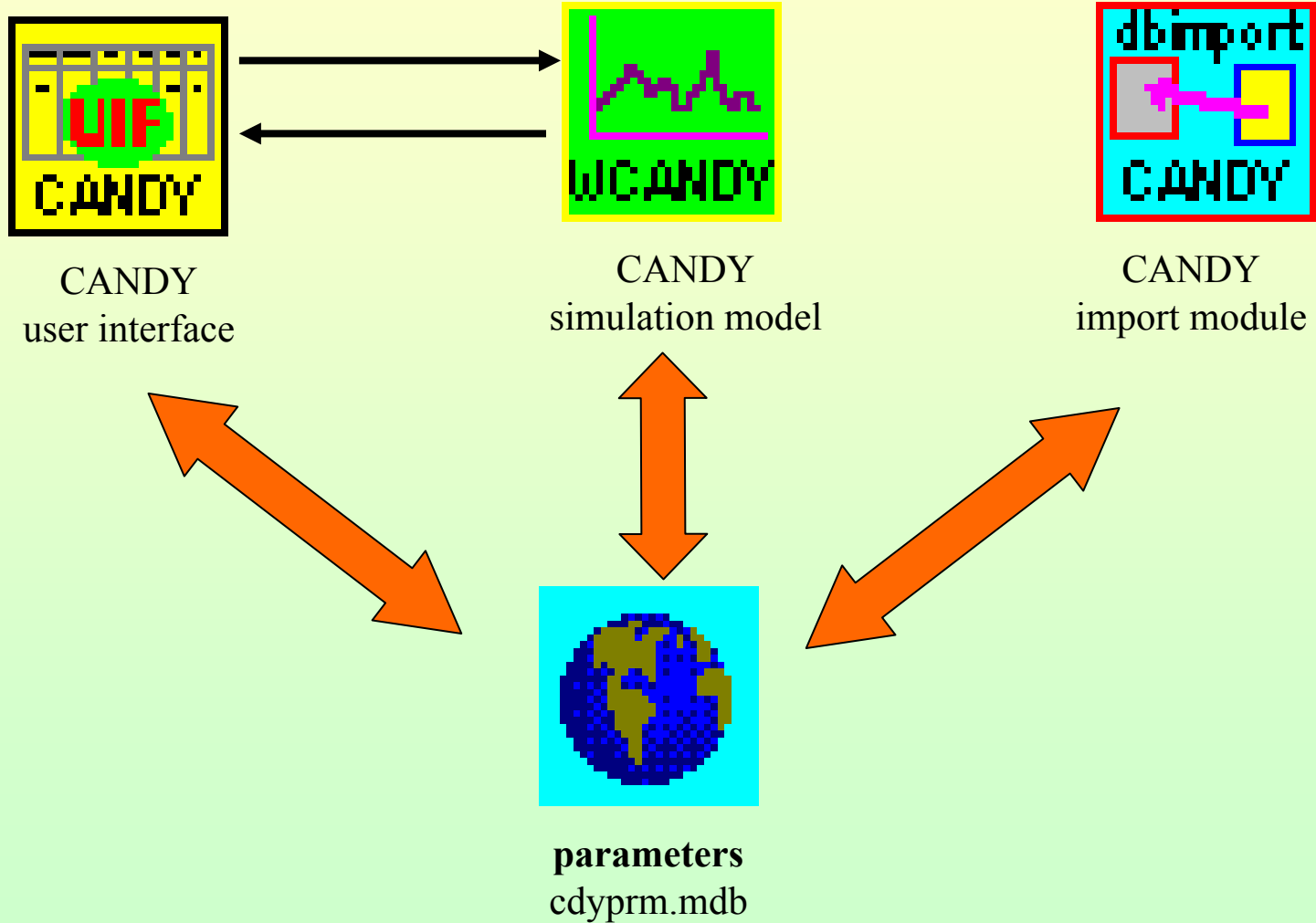
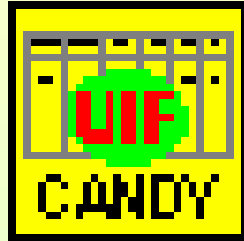# simulation objects

climate

soil

management

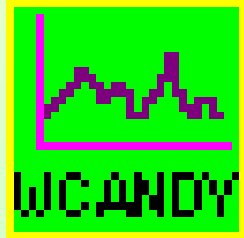starting info

Components of the CANDY system

CANDY
user interface

CANDY
simulation model

CANDY
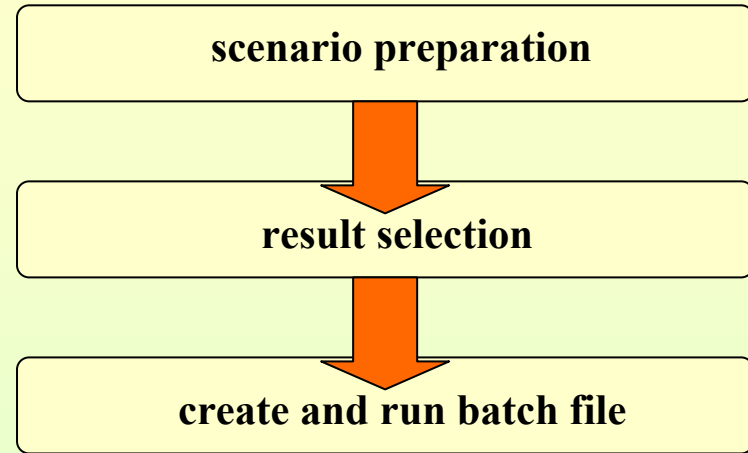import module
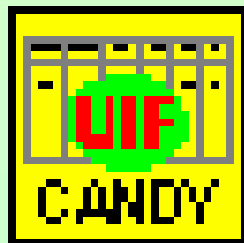
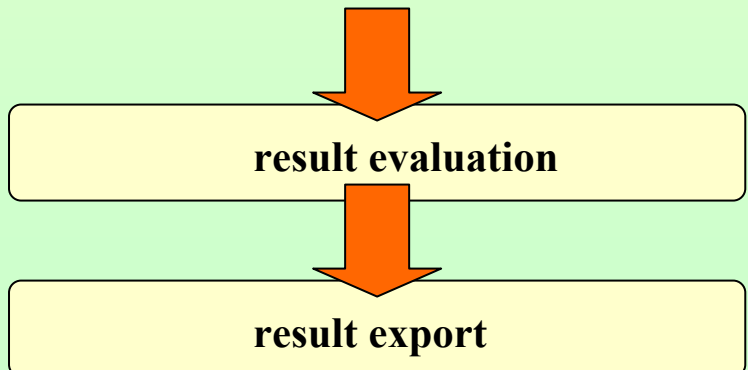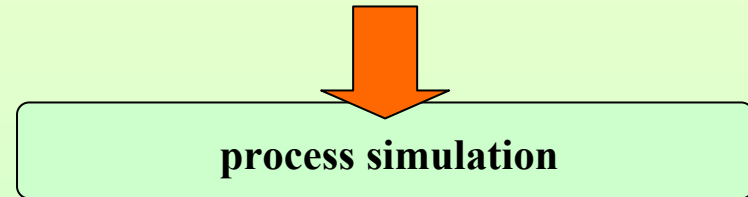**parameters**
cdyprm.mdb

technology of CANDY simulations

CANDY
user interface

CANDY
simulation model

CANDY
user interface

scenario preparation

result selection

create and run batch file

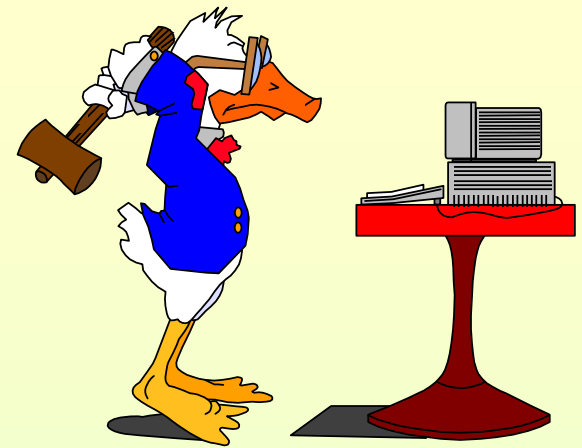| process simulation |
| --- |

result evaluation

result export

some technical aspects

- software developed with DELPHI

- database access through Borland Database Engine (BDE)

- database formats: *ACCESS97* (parameters) DBF (user data)

- access to GIS data through mapobjects (ESRI software)

- data export (results) to EXCEL spreadsheets

CANDY structures on your hard disk

(CANDY) program directory

> Windows applications
>
> ACCESS database cdyparm.mdb

data directory (user database)

> Basic (fixed) data   FDA*.dbf
>
> management data   MAS*.dbf
>
> measurement data   MWE*.dbf
>
> GIS-data (dbf/shp/shx) MAP*.???
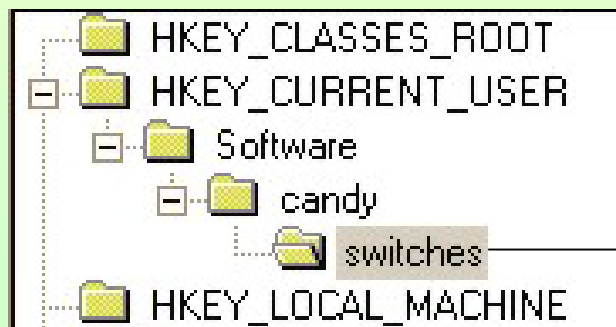>
> ...

climate data directory

> WETsssyyyy.dbf

result data directory

CANDY on your registry

HKEY_CLASSES_ROOT
HKEY_CURRENT_USER
  Software
    candy
      switches
HKEY_LOCAL_MACHINE

ab	dpath	\<INSTALLDIR\>\candy_da
ab	wpath	\<INSTALLDIR\>\candy_we
ab	modus	win
ab	rpath	\<INSTALLDIR\>\candy_da
ab	database	\<INSTALLDIR\>\cdyprm.mdb
ab	ppath	\<INSTALLDIR\>

HKEY_CLASSES_ROOT
HKEY_CURRENT_USER
  Software
    candy
      switches
HKEY_LOCAL_MACHINE

ab	cdy_db	""
	cdypfl	0x00000001 (1)
	dynsp	0x00000000 (0)
	gism	0x00000000 (0)
	k_prec	0x00000001 (1)
	lysm	0x00000000 (0)
	outfm	0x00000001 (1)
	outfr	0x00000003 (3)
	prsm	0x00000000 (0)
	sgen	0x00000000 (0)
	stst	0x00000000 (0)
	wait	0x00000001 (1)
	wgen	0x00000000 (0)