Description of the ROVE database

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Preface

The datasets of the groundbased experiments (collected from 1975 to 1981) of the Dutch ROVE (Radar Observation on Vegetation) team are documented in this report.

The datasets are available for the research community at request to the current maintainer of the data:

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The data are currently stored in an ORACLE database format. They can easily be transformed to other formats.
All table and column names are in dutch. Their meaning is explained in the text.

Samenvatting

De werkgroep ROVE (Radar Onderzoek aan vegetaties) heeft vanaf 1975 metingen van de radarreflectie door gewassen uitgevoerd op proefboerderijen. De resultaten daarvan zijn geordend in een database. Dit rapport geeft een beschrijving van de meettechniek en van de inhoud van de database tabellen.
De LUW-vakgroep Hydrologie, Bodemnatuurkunde en Hydraulica is beheerder van de gegevens.

1 Introduction

The Dutch research team ROVE (Radar Observation on Vegetation), funded by the remote sensing organization NIWARS, started in 1974 to investigate the scattering of microwaves by crops and soils, in order to help interpretation of radar imagery.
The team members at that time where recruted from:

- The Microwave Department of the Delft University of Technology (TUD),	Delft
- The Physics and Electronics Laboratory (FEL-TNO),	The Hague
- The National Aerospace Laboratory (NLR),	Amsterdam
- The Centre for Agrobiological Research (CABO-DLO),	Wageningen
- The Department of Soils and Fertilizers of the Agricultural University (LUW),	Wageningen

During 1975 - 1981 radar data and accompanying grountruth were collected from experiments at agricultural trial farms.
The aim of the program was to investigate the microwave scattering of crops, to develop scatter models and to apply them in crop classification and biomass detection. The groundbased program was extented with SLAR flights and inventories over area's in Flevoland.
The instrumentation was build by TUD and calibration and data processing took place at FEL-TNO. The radar measurements were done by TUD.
The field layout and crop and soil sampling were done by CABO-DLO and LUW.
SLAR flights and image processing was organized by NLR.
This resulting dataset of the groundbased research is documented in this report.

Chapter 2 describes the kind of observations made, with an indication of their accuracy.

In Chapter 3 the experimental layout of the yearly programs is given.

The data are stored in an ORACLE relational database and Chapter 4 describes the contents and organization of the database.

Interpretation of the data and conclusions about the results are beyond the scope of this report, but a list of publications concerning the material is supplied in Chapter 5.

To get an overview of the contents of the database one can inspect the listings shown in the Appendices.

2 Measurement methodology

2.1 General

The groundbased ROVE experiments lasted from 1975 to 1981. To accommodate the variability in crop type, and for reasons of crop rotation and plot preparation, every year the trial location was changed.

The experiments were done at three different test farms in The Netherlands:

"Droevendaal" at Wageningen, with sandy soil	(1975-1977)
"De Bouwing" at Randwijk on alluvial clay	(1978-1979)
"De Schreef" near Dronten on marine clay	(1980-1981)

The radar backscattering was measured with a FM-CW scatterometer mounted on a trailer. This trailer could be moved over a rail system along the test plots, to measure them at different angles of incidence (from 10 to 80 degrees) and at 3 states of polarization (VV,HH,HV). See Figure below.

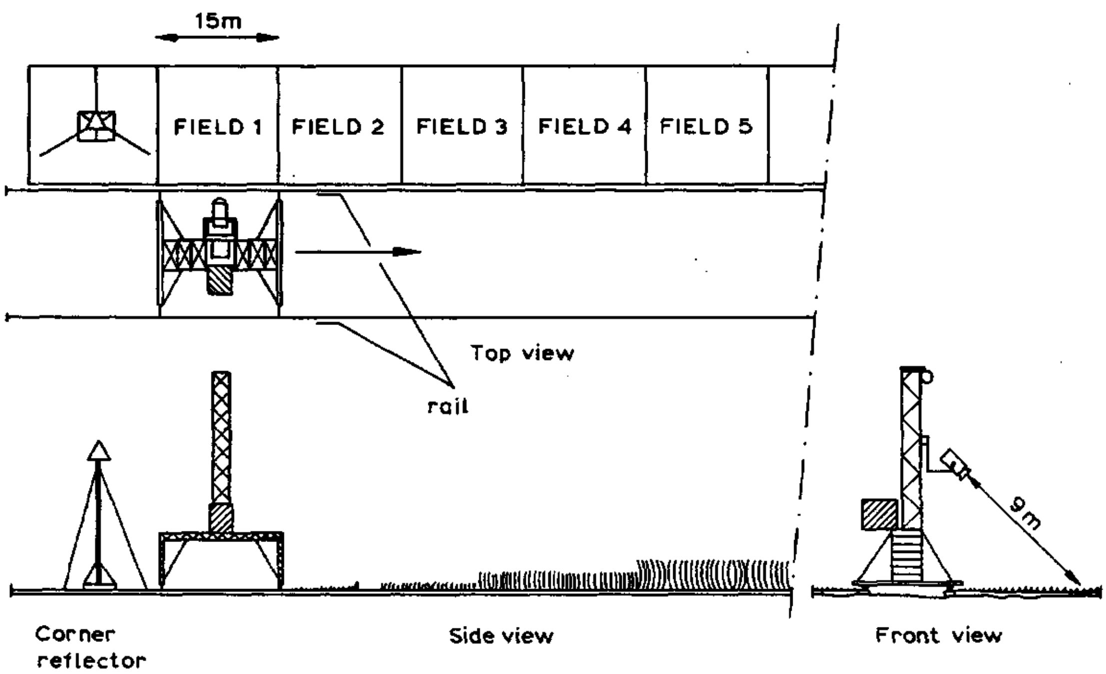

Figure 2.1 ROVE measurement set up (example 1977)

The radar measurements were repeated during the growing season with intervals of about 2 to 5 days (2 times a week). This resulted in 25 to 35 observation numbers (packet of all used wavelengths, polarization states, grazing angles and plots) per year.

The plots (mostly 10, see Appendix IV SCHEMA_ROVE) were sampled for biomass determination. Measurements or estimates of the soil moisture conditions, valid for all plots, were gathered. They are, together with the wind speed and direction around measurement time (estimated from field observation or from weather data of nearby meteo stations), stored in table TIJDEN_ROVE (see Appendix V).

2.2 Radar measurements

The scatterometer equipment was adjusted many times (de Loor et al.,1982), but the measurement configuration was not changed. The distance of the antennas to the target (soil surface !) remained constant at all angles of incidence (9 m along the axis of the beam).
The beam width (at the 50 % or 3 dB points of the antenna diagram) was 4 degrees. This configuration resulted in a cross section of nearby 0.6 m^2 at the place the microwaves are scattered by crop and soil (Figure 2.2).
From 1975 to 1979 an X-band scatterometer was used,with a central frequency of 9.5 GHz (wavelength of 3 cm) and a frequency sweep of 0.4 GHz.
The scatterometer used in 1980 and 1981 measured simultaneously X-band and Q-band (35 GHz, 8 mm).

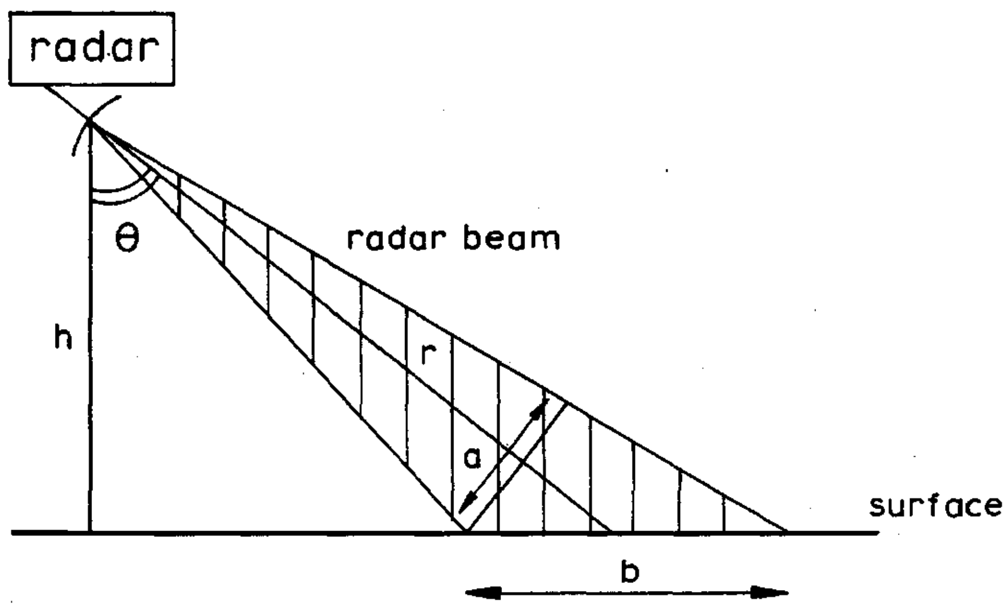

Figure 2.2. Schematic representation of the illumination geometry of the radar beam. The symbols in the figure have the following meaning: θ = angle of incidence; h = height of the radar; r = axis of the radar beam; a = projected area of the cross-section of the radar beam; b = area illuminated by the radar beam.

Three polarization states could be used (for both wavelengths):

VV , vertical polarized radiation transmitted and received.

HH , horizontal polarized radiation transmitted and received.

HV , horizontal transmitting and vertical receiving state.

The cross state (HV) was not used in 1979 and 1980.
For every used combination of polarization and grazing angle the plots were measured twice (going forward and backward on the rail looking sideways to the plots). With plots of at least 12 m long this resulted in sufficient independent samples per plot to calculate a mean radar return factor for the given time.

The radar backscattering was expressed as gamma:
the radar cross-section of the target per unit projected area of the cross-section of the radar beam (m^2/m^2).
The relationship between gamma (g) and the Normalised Radar Cross Section (NRCS or S0, defined as the radar cross-section per unit area illuminated by the antenna) is:

$$g = S0/\cos(\theta)$$

where θ is the angle of incidence:the angle between the radar beam and the vertical (Fig. 2.2).
In this report and in the database the grazing angle (90-θ) is used and gamma is always expressed in dB:

$$g\ (dB) = 10. * \log10\ (\ g\ (I)\ )$$

where I is the power received from the object target, relative to a reference.

2.2.1 Accuracy and calibration

A corner reflector, with radar cross section of 10 m^2, was used as reference. The radar was calibrated by directing the radar beam to this reflector,placed at 9 m from the antennas. The scatterometer was calibrated every time a new polarization (series of measurements at all plots for all angles) was started, by maximizing the power recieved from the corner reflector. More information on the calibration procedure is given by van Kasteren and Smit (1977) and by de Loor et al (1982).

The total measurement accuracy (as determined by the inaccuracies in the scatterometer, in the calibration procedure, in the data processing, and due to averaging over independent samples within a plot) was probably less then 0.5 dB (see Appendix II).
Caused by unknown effects of wind and wetness, a much larger spread is found between successive measurement days.
The difference between measurements of the same crop type in different years could be an instrumentation or calibration effect, but may also be explained by the effects of growth conditions on crop structure.

2.3 Groundtruth measurements

Together with the radar measurements, visual observations about the state of crops and soil were made and biomass sampling was done.
Soil cover was visually estimated and mean crop height was measured.
The crop morphology, phenological stage, and any anomalies were described and photographed. Some plants, of the area outside the reach of the radar, were harvested to determine biomass (gr) and size (cm) of whole plants and of components like stems, leaves and ears. Subsamples were dried at 70 degrees Celsius, to obtain the dry matter content of the components.

The sampling and analysis methods were adjusted to the crop type and growth phase. In some instances also characteristics like leaf size or ear- and stem length were estimated.

The moisture content of the top soil layer was determined from samples or visually estimated. From 1978 on almost every plot was sampled (with sample rings and/or by gathering crust material) on almost every measurement day. Nearby weather stations (Wageningen or Swifterbant) supplied data on rainfall, wind speed and wind direction.
The soil moisture observations and the rainfall data were combined to create soil wetness classes per measurement day, ranging from 1 for 'very dry' to 5 for 'very wet'. Also the wind data where grouped into classes: no wind or wind is blowing towards, across or from the direction of the radar beam.

In 1980 and 1981 the optical reflectance of the plots was measured with a 3 filter spectrometer (green 550 nm, red 660 nm and infrared 870 nm; with a 50% bandwidth of about 10 nm). The output of the instrument is an average reflectance value (reflectance coefficient multiplied by a filter constant) of 5 to 10 sample spots per plot. The calibration constants were not accurately measured and therefore not applied.

After first interpretation of the ROVE data, it became clear that structure of the crop plays a dominant role in microwave scattering. So it was decided to define growth phases (column STAD of Appendix VI) based on morphology and biomass classes. The phase boundaries resulted from personal judgement by the author. These data may be used for grouping radar and groundtruth data in the time domain. The crop phases can be compared with classes formed by combination formulas of all other columns in the database.

The phase, soil cover,biomass,reflectance and soil moisture data are stored together with the radar data in the appropriate 'ROVE_year' table.

More information on sampling and analyses methods is found in the groundtruth reports (see Chapter 5).

2.3.1 Accuracy and smoothing

As the sampling must be done at plot sites outside the range reached by the radar beam, and given the difficult crop management system along fixed rails,the resulting data were not always as representative for the radar measured crop as wanted. Height and cover where determined every measurement day, but biomass sampling was done at irregural times. Because the groundtruth program had to fit the boundary condition for available labor and because there was a lack of knowledge about the 'suitability' of the various groundtruth elements, a fragmented set of data resulted. The data are rather inaccurate, relative to agricultural trial standards. Therefore a sometimes drastic hand smoothing of the groundtruth curves was applied (after judgement of drawing graphs). In 1980 the sampling results could be compared with optical reflectance to estimate more accurately the soil cover of the crop. The groundtruth data should only be used as indicative values and are not suitable for calibration purposes.

In 1978 (the bare soil year) water content by weight of the topsoil was determined by joining clods, gathered at 10 spots, to one sample per plot. Clods out of the top 0-4 cm layer and of the 4-8 cm layer were gathered separately. The layers boundaries ran parrallel to the "rough" surface.

3 Experiment description

In this chapter a description of the yearly programs is given first. Then, an overview of the trial designs and of special experiments is made. In 3.3 the used radar configuration is described.

3.1 Yearly programs

In this section a general description of the main goals and some remarks on the yearly programs are given. In general it was tried to grow crops according to standard practice with regard to fertilizer application, weed and disease control.

1975

In this first year of ROVE measurements, a selection of crops was sown on the sandy soil of trial farm Droevendaal. The main purpose was to find out the best time of the year for crop identification by SLAR flights. Although the radar data of 1975 fit in the 'general picture' of later measurements, the extreme variability cannot be explained by the groundtruth data.

1976

The crop selection was expanded to get a broader scope. Since 1976 was a very dry year,the crops suffered from drought which resulted in abnormal growth patterns. The radar data have a good accuracy but are not representative for 'normal' crops. At the end of the growing season of 1976 the crops were used to create some artificial canopy structures (see 3.2.1) .

1977

Only spring barley and spring wheat were sown, to facilitate the modelling work. Three row distances (12.5, 25, 37.5 cm) were used and the wheat block was repeated.

1978

To investigate slaking of bare soil, the radar equipment was transported to trial farm 'De Bouwing' with heavy alluvial clay soil. The trial design incorporated ploughing directions and seedbed preparations. Heavy rainfall was simulated by sprinkling. A lot of effort was made to measure roughness and moisture content of the surface layers (and find out the right method) .

1979

A broad selection of crops was sown or planted on De Bouwing. Changing environment from sand to river clay was expected to produce slightly different canopy structures.

1980

For reasons of homogenity of soil and to compare the groundbased measurements directly with airborne data, the experiments were moved to trial farm 'De Schreef' in East-Flevoland (newly reclaimed sea clay soil). The wet spring of 1980 caused delay in sowing dates. Especially the cereals showed therefore an unusual 'open' structure.

In 1980 (and 1981) the equipment was extended with a second wavelength: Q-band, simultaneously measured with X-band. Also reflectance measurement of visual and near infrared light was added to the program.

1981

In the last year, the design resembled a typical FLevoland area: Only sugarbeet, potatoe (with row directions parallel and perpendicular to the radar beam) and several varieties of winterwheat were involved. The soil and crop preparations were very similar to that of common farmers practice (best of all years). However,the program was already stopped by the beginning of July and the groundtruth data are very fragmental.

3.2 Trial design

The plots involved in the yearly programs are given in the table below.
The value in the table refer to the sequence number of the plots along the rail system (VNR) for that year (JR). For instance, in 1979 there were two bare soil plots, with VNR's 11 and 12.

		years						
CROP NAMES	GEW	'75	'76	'77	'78	'79	'80	'81
bare soil	KA*	8		10	1-6	11, 12	1,2	
grass	GR*	1, 2	1				3	
alfalfa	AL*		2					
potato	AA	3	3			8	7	3,4
sugar beet	BI	4	4			7	6	1,2
winter wheat	WT					1,2		5-10
spring wheat	ZT	5	6	1-3 7-9		3	8	
spring barley	ZG	7	7,8	4-6		4	10	
oats	HA	6				5	9	
maize	MA		9					
flax	VL		5					
sunflower	ZO		10					
pea	ER					9	4	
bean	BO*					13		
onion	UI					10	5	
poppy seed	BL					6		

* Sometimes extra plot identification numbers for the same area along the rail are created : Grasses and alfalfa are assigned new numbers after mowing. The beans were sown after destroying the bad onion plot of 1979.

After harvesting the main crop, some special bare soil plots were prepared.
The plots where grouped to TYPE's per year, with the same general growing pattern and geometrical structure (mainly cultivar and planting distance). A description of these crop types is given in Appendix III.

3.2.1 Special experiments

For a better understanding of the penetration, scattering and reflection mechanism of microwaves in crop canopies, some 'artificial crop structures' were created. These crop types got special plot numbers (VNR > 10) or special phase numbers (STAD > 10, see 3.3).
In 1976 the beet, maize and sunflower plots were thinned at the end of the season to get a more open structure. Also, increased density of biomass was created by mowing the flax plot '76 , leaving the stems spread over the soil. The ears of ripe wheat plot '76 were removed.

On 23 July 1981 (end of ROVE program) several experimental structures were created and fully measured (X and Q band, HH and VV, 8 angles):
- The number of plants of one sugar beet plot was decreased in 4 steps (repeated removal of half of the amount of present plants).
- The leaves of the potato plot with ridges perpendicular to the radar beam were killed by herbicide, 2 days before measurement.
- The ears of one Arminda wheat plot were clipped and left on the soil.
- Okapi winter wheat was mown and the 'liing' crop was measured.
- A totally slaked bare soil plot, covered with some weeds was measured before and after raking by hand.

NB: The July experiment is stored in the database with a deviating format.

A complete description of the plot designs is given in Paragraph 4.2 and in the Appendix IV.

3.3 Measurement numbers

The measured 'radar signature' changed from year to year. An overview of the used configuration per year is given in the next table.

farm and year	wave-lengths	polarizations	grazing angles									
Droevendaal'75	X	VV HH HV		15	20	30	40	50	60	70		
Droevendaal '76	X	VV HH HV			20	30	40	50	60	70		
Droevendaal '77	X	VV HH HV		(15)	20	30	40	50	60	70	80	
De Bouwing '78	X	VV HH HV	10	20	30	40	50	60	70	80		
De Bouwing '79	X	VV HH		15	20	30	40	50	60	70	75	80
De Schreef '80	X Q	VV HH		15	20	30	40	50	60	70	75	80
De Scheef '81	X Q	VV HH HV		15	20	30	40	50	60	70	75	80

After measuring all the plots of a year with the given combinations of wavelength, polarization and grazing angle, a new measurement number (MNR) was generated. These time sequence numbers (mostly 2 per week) are listed in Appendix V, together with the daily soil moisture and wind classes. The growing season of the crop plots was split up into phases (groups of measurement numbers) per crop (STAD).
The bare soil measurements of 1978 were grouped in slaking phases, according to rain and irrigation classes of 30 mm. The other bare soil plots were just grouped into monthly periods. For the definition of growing phases, see Appendix VI.

4 Database description

The ROVE dataset is currently stored in ORACLE tables. Version 5.1 of is this Data Base Management System was used to build the database and fill it with ROVE attributes.

Within a record of an ORACLE table, no special key columns are marked as such. So every column (record field) may be used as identifier of the others. However, their intended function will be denoted by special column separators describing a table according to the text conventions used in this report:

TABLENAME (ID1 < ID2 , ID3 =IDNR:IDENT I ATTR # A1,A2,A3)

,	Independent columns.
<	Values of first column are groups of second column values.
=	Combination of foregoing columns (mostly for joining).
:	The two column values have synonym meaning.
I	Separation between identifying keys and dependent attributes.
#	Next columns are repeated items, identified by their column name.

The data records in a table can virtually be extended with attributes from other tables (joining) by creating (extra) pointer column(s). They point to the set of records from the joined table(s), which have column values equal to the corresponding pointer value.

A table is defined by its column names and the type of data that are stored in the record fields. In this Chapter the following conventions are used to describe the table records.

Column type	Data type	Column number	Column name	Comments on the formal description
NN	d9	1	TIME	time of measurement in date format ---> WEATHER
NN	n2	2	VNR	identification number plot ---> SCHEMA (sowing)
				TIME,VNR ---> BIOMASS (growth phase and cover)
NN	c1	3	GOL	wavelength {X , Q}
	n3, 1	4	HV25	[dB] gamma for, cross polarization and angle 25
	c20	5	REMARK	comment on measurement conditions

Column type:

NN means a NOT NULL column: all elements of column TIME must have a value.
For column HV25 missing values allowed.

Data type:

n for NUMBER , c for CHARacter 'string' , d for DATE format.
The width of the field is given by digits after the type letter.
n without digits represents a real number of 40 decimal digits.
Truncated numerical data are indicated by n followed by width, a comma and the number of digits after the decimal point.

Column number:

Sequence number of column in the table description.

Column name:

identification of the column.

Used attributes in comments:

--->	column name points to possible join-tables
SCHEMA (sowing)	a table name, with indication of contents
[dB]	Physical dimension of the column values
{X, Q}	List of allowed values.

4.1 The main ROVE attributes

The most important keys and attributes of the ROVE DATABASE are grouped and described in this Paragraph. The given names are equal to the column names in the ORACLE tables.

crop domain:

GEW	Two or three letter code for the name of a crop.
RAS	Cultivar or abbreviation for genotype.
RIJRI	Row direction of planting with respect to incident radar beam. {null, D, M} D for perpendicular to beam (dwars op) M for parallel to beam (met radar mee)
TYPE	General appearance (fenotype,structure), defined for the combination of GEW, RAS, JR and treatment (mostly RIJRI).
STAD	Number indicating growth and development phase of crop.

place domain:

BOERD	Five letter code for the farm where the crops are grown.
VNR	Number code for a plot in a trial design. Sequence of the plots along the rails, for specific year.

time domain:

JR	Year without century number.
DATUM	Date in format 'DD-MON-YY'
TIJD	DATUM plus Time of day.
MNR	Measurement number. Time sequence of observations within a year.

instrument domain:

GOL	Wavelength {X, Q}
POL	Polarization {VV,HH,HV}
HOEK	Grazing angle in [degrees]

T (day)* P (farm) domain:

BOD	Wetness class of soil surface layer {1 very dry, 2, 3, 4, 5 very wet} valid for all plots of that day.
WIND	Characterization of wind { STIL, TOE, DW, AF }, according to WSN (windspeed in m/sec) and WRI (wind direction with respect to radar look direction {1, ... , 8 }).

T * P * C (crop) domain:

HO	[cm]	Crop height
BED	[%]	Percentage soil covered by plants
VERS	[kg/m^2]	Fresh above-ground total plant biomass
DS	[%]	Dry matter percentage of total plant
(B)VOCHT[%]		Water content (of matrix) of soil surface layer (crust)

When combining the attributes to tables of a database, architectural choices have to be made. In the current design the instrumentation columns are eliminated and replaced by gamma value columns, with names like QHH25 (Q for Q-band, HH for horizontal polarization and 25 for degrees grazing angle). The X for X-band is left out in gamma column names (default).

In the next Paragraphs, first the created join-tables and then tables with main data are described. A list of all tables is given in Appendix I.

4.2 Join tables

The join tables contain information about the individual values of an identification column(s) of the main data tables. Three such tables are described:

1) SCHEMA_ROVE for the plots (VNR) used in the ROVE trial designs
2) TIJDEN_ROVE for the measurement numbers (MNR)
3) ROVE_GEWSTAD for the description of crop growth phases (GEW, STAD)

Table 4.2.1 SCHEMA_ROVE

NN	c3		GEW	crop code name ---> COD_GEW
NN	n2		JR	year (and farm)
NN	n3		PRNR	trial (combination of GEW,JR) ---> PROEVEN_ROVE
----- general growth information				
	n3		ZAAI	julian daynumber
	d7	:	Z_DATUM	and date of sowing
	c10		RAS	cultivar name of crop
	n3		NGIFT	seasonal sum of nitrogen application
----- trial factors				
	c1		RIJRI	crop row direction {'D'=across , 'M'=along radar beam }
	n3,1		RIJAFST	[cm] distance between crop rows
	c8		FACTOR	trial treatment,combination of RIJRI,RIJAFST (and others)
-----				
	n1		BEH	sequence number for a treatment within a trial (PRNR)
NN	c5		TYPE	name for a combination of PRNR and BEH (general structure)
------				
	n1		HERH	duplication of a treatment
NN	n2		VNR	number code for plot (unique within a year)
	c8	:	VNAAM	readable name for the same plot
---- unique record identification				
NN	n5		PVNR	unique number for plot over years
NN	c8	:	VELDJE	unique name for a that plot
NN	n4	:	VSEQ	sequential number (= JR*100 + VNR)
----- attributes				
	d7		BEGIN	start date of gamma measurements
	n2		N_T	number of times the plot was measured
	d7		EIND	last measurement date

Every combination of crop and year (and farm) has been given a sequential 'trial number' (PRNR), mainly to fit in the architecture of databases from non-ROVE origin. Within the ROVE trial serie a plot can uniquely be identified by plot sequence number: VSEQ = JR*100+VNR.

In table SCHEMA_ROVE the bare soil experiment of 1978 (SCHEMA_KA78RKL) and the crop structure experiment (SCHEMA_JUL81) are included.

After cutting the grass (GR) and alfafa (AL) plots, these plots were given a new plot number (VNR). In some years new bare soil (KA) plots were created after harvesting one of the crops. They have separate VNR's too and are named (VNAAM) after the treatment they got. These bare plots are only measured a few times (N_T).
SCHEMA_ROVE can be used to calculate mean 'radar' growing curves for the given 'groups' of individual plots. The main group-attribute in this table is TYPE. Plant and leave size (crop or cultivar) as well as plant spacing are included in the coding of TYPE. An overview of the

the defined TYPE's is given in Appendix III and a complete listing of SCHEMA_ROVE is given in Appendix IV.

Table 4.2.2 TIJDEN_ROVE

NN	d7	1	DATUM	day and year of observation
NN	n2	2	JR	year
	n2	3	PER	a fortnight period
	n2	4	WE	week nr of the year (ORACLE date system)
	c6	5	DAT	day of month and month of year
	n3	6	DAG	julian day number
	c1	7	BO	soil wetness (D dry, V moderate, N wet)
	n1	8	BOD	soil wetness (1 very dry, ... , 5 very wet)
	n2	9	VOCHT	average water content of soil from all plots
	c4	10	WIND	wind class (STIL, AF, DW, TOE)
	n1	11	WRI	wind direction (1, ... , 8)
	n2	12	WSN	[m/sec] wind speed

NN	n4	13	MNR	measurement number <---- radar tables
NN	d7	14	TIJD	time including year ,day and hour
	c2	15	UUR	hour of day (0 ... 24)
	c2	16	MIN	minute (is always zero)
	n4	17	TSOM	[°C.day] accumulated temperature from 1 Jan. to DATUM
	n4	18	PSOM	[J/m2] accumulated global radiation " " "
	n4	19	RSOM	[mm] accumulated rain from 1 jan to DATUM
	n4	20	TSEQ	sequential time number = JR*100 + MNR

NB: The information in table TIJDEN_ROVE is averaged on a daily basis eliminating the TIJD column, resulting in table ROVE_DATUMS .

To get access to the weather conditions at a certain day, one has to join the radar data with table TIJDEN_ROVE, by means of the MNR columns.

A complete listing of the measurement numbers and an explaination of the accompanying weather data values is given in the Appendix V.

Table 4.2.3 ROVE_GEWSTAD

NN	nl		G1	group of crops
NN	c3	<	GEW	crop name code
NN	n2		STAD	crop growth phase
	c40		BESCHRIJVING	description of criteria for GEW,STAD definition

The growth phases are crop specific. So, when the radar data tables are joined with ROVE_GEWSTAD, the GEW as well as STAD columns have to be used. The contents of this table is described in Appendix VI.

4.3 Data tables

The radar data and the main groundtruth are stored in tables per year (ROVE_75, ..., ROVE_81). For the experiments on crop structure at 23-JUL-81, an extra table ROVE_JUL81 is made. Some crop-specific groundtruth, like weight of ears can be found in table ROVE_BIOM.

4.3.1 Radar year-tables

All main ROVE tables have the same columns for identification of the data. Some of these key attributes point to (--->) attributes in the join-tables. With exception of ROVE_78, all tables have the same column names for storing groundtruth too. The column names for the gamma measurements (radar backscatter coefficient in [dB]), differ per year. The used instrument configuration is incorporated in these column names:

Q stands for Q-band at 35 GHz (default is X-band at 9.5 GHz).

VV, HH, HV stand for vertical, horizontal and cross polarization.

10, 15 ... 80 represents the used grazing angle.

In 1980 and 1981 three columns for the optical reflectance measurements are included:

GR green 550 nm, RO red 665 nm, IR infrared 870 nm

Table 4.3.1

ROVE_75, ROVE_76, ROVE_77, ROVE_78, ROVE_79, ROVE_80, ROVE_81				
---- identification columns.				
NN	c2	1	GEW	Crop code ---> COD_GEW (crop name).
NN	n2	2	STAD	Growth phase classification, specific for ROVE 1,2 ---> ROVE_GEWSTAD (description).
NN	n2	3	VNR	Plotnr ---> SCHEMA_ROVE (treatments in trial design). Pilot number within the yearly trial.
NN	c5	:4	VNAAM	Synonym for VNR ; readible name for the plot.
NN	n1	5	GFASE	Growth phase like STAD numbers but the phase boundaries coincide now with week boundaries.
NN	d7	6	DATUM	date of measurement. ---> ROVE_DATUMS.
NN	n2	7	MNR	measurement nr ---> TIJDEN_ROVE (soil and weather condition). On a few dates, more then one radar serie was measured
	n1	8	BOD	Wetness scale for soil surface (1 dry ... 5 wet)
	n3,1	9	XFASE	Current content XFASE = (VV40+VV50+VV60 + HH40+HH50+HH60)/6 - (VV20+VV30 + HH20+HH30)/4
	n3	10	LEEFT	Age of the crop in days after sowing or planting
---- groundtruth columns		.		
	n3	11	HO	[cm] average height of the crop
	n2	12	BED	[%] estimated soil cover percentage
	n5	13	VERS	[g/m^2] above ground fresh weight (after smoothing in time)
	n3,1	14	DS	[%] dry matter content of the whole plant (dry/fresh)
	n3,1	15	BVOCHT	[%] measured soil moisture content (wet-dry)/dry

The column names for the gamma data of the year-tables are listed below. Also the number of records, present per year is given, divided in number of wavelengths (G), polarizations (P), angles (H), plots (V) and number of measurements dates (M).

table	ROVE_75		(G=1.	P=3	H=7	V=8.	M=27)	224	records
n3,1	16	VV15	VV20	VV30	VV40	VV50	VV60	VV70	
n3,1	23	HH15	HH20	HH30	HH40	HH50	HH60	HH70	
n3,1	30	HV15	HV20	HV30	HV40	HV50	HV60	HV70	

table	ROVE_76		(G=1	P=3	H=6	V=10	M=24		records
n3,1	16			VV20	VV30	VV40	VV50	VV60	VV70
n3,1	22			HH20	HH30	HH40	HH50	HH60	HH70
n3,1	28			HV20	HV30	HV40	HV50	HV60	HV70

table	ROVE_77		(G=1	P=3	H=8	V=10	M=32)	301	records
n3,1	16	VV15	VV20	VV30	VV40	VV50	VV60	VV70	VV80
n3,1	24	HH15	HH20	HH30	HH40	HH50	HH60	HH70	HH80
n3,1	32	HV15	HV20	HV30	HV40	HV50	HV60	HV70	HV80

table	ROVE_78		(G=1	P=3	H=8	V=6	M= 27)	162	records
n3,1	13	VV10	VV20	VV30	VV40	VV50	VV60	VV70	VV80
n3,1	21	HH10	HH20	HH30	HH40	HH50	HH60	HH70	HH80
N3,1	29	HV10	HV20	HV30	HV40	HV50	HV60	HV70	HV80

table	ROVE_79		(G=1	P=2	H=9	V=12	M= 36)	432	records	
n3,1	16	VV15	VV20	VV30	VV40	VV50	VV60	VV70	VV75	VV80
n3,1	25	HH15	HH20	HH30	HH40	HH50	HH60	HH70	HH75	HH80

table	ROVE_80		(G=2	P=2	H=9	V=10	M=39)	390	records	
n3,1	16	VV15	VV20	VV30	VV40	VV50	VV60	VV70	VV75	VV80
n3,1	25	HH15	HH20	HH30	HH40	HH50	HH60	HH70	HH75	HH80
n3,1	34	QVV15	QVV20	QVV30	QVV40	QVV50	QVV60	QVV70	QVV75	QVV80
n3,1	43	QHH15	QHH20	QHH30	QHH40	QHH50	QHH60	QHH70	QHH75	QHH80
n3	52	GR	RO	IR						

table	ROVE_81		(G=2	P=3	H=9	V=10	M=18)	180	records	
n3,1	16VV15		VV20	VV30	VV40	VV50	VV60	VV70	VV75	VV80
n3,1	25HH15		HH20	HH30	HH40	HH50	HH60	HH70	HH75	HH80
n3,1	34HV15		HV20	HV30	HV40	HV50	HV60	HV70	HV75	HV80
n3,1	43QVV15		QVV20	QVV30	QVV40	QVV50	QVV60	QVV70	QVV75	QVV80
n3,1	52QHH15		QHH20	QHH30	QHH40	QHH50	QHH60	QHH70	QHH75	QHH80
n3,1	61QHV15		QHV20	QHV30	QHV40	QHV50	QHV60	QHV70	QHV75	QHV80
n3	70GR		RO	IR						

The groundtruth columns of ROVE_78 differ from the other years, because only bare soil plots are involved. The columns 11-15 are replaced by two soil moisture content columns: WUP for the sampling of the upper layer (parallel to 'rough' surface) at 0 -4 cm depth, and WLOW for the lower soil layer at 4 -8 cm. The GFASE column of ROVE_78 is filled with rainsum data (zero at 1-JUN-78). This accumulated rain and irrigation [mm] is devided in steps of 30 mm, to represent slaking phases, which are stored in column STAD.

The results of the experiments at 23-JUL-81 are recorded in table ROVE_JUL81. The description of the used plots can be found in SCHEMA_ROVE or SCHEMA_JUL81.

Table 4.3.2

ROVE_JUL81				with 1140 records
— configuration				
NN	c2		POL	Polarization state (for both X- and Q-band instruments).
NN	n2		ANG	Rounded grazing angle.
NN	n3,1	<	HOEK	Grazing angle as measured.
— time sequence				
NN	n2		VS	1=forward or 2=backward movement of radar along plots.
NN	n2		MNR	{19,20,21,22}
NN	n1		S	Change in plot sequence after manipulations of some crop.mnr 19 and 20 is measured with XVV + QVV and XHH + QHH.during mnr 21 and 22 only VV polarization was used
NN	n2		UUR	Time of day (hour and minute)
NN	n2		UUR	per POL,HOEK combination (valid for all plots of S)
— plots				
NN	c5		TYPE	Name for plots with equal 'crop structure'
NN	n2	<	VNR	Plot number ---> SCHEMA_JUL81 with 20 plot descriptions.
# --- wavelength				
	n4,2		GAMX	X-band backscatter coefficient in [dB]
	n4,2		GAMQ	Q-band backscatter coefficient in [dB]

Because no other groundtruth data are collected, a description of the content of the VNR and TYPE columns of table SCHEMA_JUL81 is given below.

Table 4.3.3

VNR	TYPE	description
1	BI1	Undisturbed first beet plot of rove_81; used in all 6 series (100% soil cover and 50x20 cm2 plant spacing)
12	BI50	Second beet plot after thinning (S=1,2: 50%, 50 x 40)
13	BI25	Again alternating plants in row removed (S = 3,4: 25 %, 50 x 80)
14	BI12	Repeated proces of thinning in row (S = 3: 12.5 %, 50 x 160)
15	BI6	Alternated row completely harvested (S=4: 6.25 %, 100 x 160)
3	AA81	Potato plot with rows parallel to beam; undisturbed in all series
4	AA81D	Potatoes perpendicular to radar beam:undisturbed part of the plot
		Desiccation of the halms (sprayed with leaf killer) was done at the first 6 m of the plot (for steeper look angles).
41	AA81+	The boundary (ANG=50 and 60) became plot number 41 and
42	AA81+	the higher angles became number 42.
5	ARM81	Winter wheat cultivar ARMINDA (undisturbed), used in serie 1,2
51	ARM-	Plot 5 after cutting the ears, which fell on the soil (S=3,4,5,6)
6	ARM81	Replicates of ARMINDA plots with 'M' row direction.
10	ARM81	Undisturbed plots 6 and 10 were used in all series.
7	OKA81	Winter wheat OKAPI before mowing (S = 1, 2).
71	OKA?	OKAPI was mown, leaving the straw on the field, during serie 3 .
	OKA?	has therefore a undefined backscatter.
72	OKAm	OKAPI after cutting the halms. (S= 4, 5, 6)
8	DUR81	Undisturbed winter wheats: DURIN and ADAMANT
9	ADA81	DURIN was measured in serie 1, 2, 6 and ADAMANT in serie 3, 4, 5.
80	ONK81	Slaked bare soil, with some weeds,used in MNR 19
81	HAR81	After cleaning and raking a bare plot (MNR 20, 21, 22)

The mean gamma values (per POL and ANG) of the undisturbed plots (VNR 1 to 10) are stored in ROVE_81, under MNR=18.
The average backscatter per plot is also stored in the tables: JUL_XVV, JUL_XHH, JUL_QVV and JUL_QHH. The MIN and MAX values per plot are stored in table JUL#GP. See also Appendix II.

4.3.2 Groundtruth tables

The main groundtruth data are stored in 'year' tables. Biomass and crop moisture content are stored in the columns VERS and DS. When soil moisture samples are taken, the results can be found in column BVOCHT. An estimated soil wetness condition is always stored in TIJDEN_ROVE (BO,BOD).To store crop specific biomass data, table ROVE_BIOM is made.

Table 4.3.4

table		ROVE_BIOM				biomass data per plotnr and timenr					
----		identification									
NN	n2	1	JR	NN	c2	2	GEW	NN	c5	3	TYPE
NN	c5	15	BOERD	NN	n4	4	VNR				
NN	d7	6	DATUM	NN	n4	7	MNR	NN	n3	16	PRNR
----		general groundtruth									
NN	n2	5	STAD		n3	8	HO		n2	9	BED
	n5	10	VERS		n5	11	DROOG		n	12	DS
----		specific groundtruth									
	n5	13	VERS1		n4	14	DROOG1				

where:

JR=year,	GEW=crop,	TYPE=crop type
BOERD=farm,	VNR=plot nr	
DATUM=date,	MNR=measurement nr,	PRNR=trial nr
STAD=growth phase,	HO=height [cm],	BED=soil cover [%]
VERS=fresh [g/m2],	DROOG=dry [g/m2],	DS=dry matter [%]

The meaning of the columns VERS1 and DROOG1 differs per crop or year. For most plots these culumns are unused. For beet plots, leaf size is sometimes recorded in VERS1. For the cereals the VERS1 and DROOG1 columns are mostly filled with respectively fresh and dry weight of the ears.

The groundtruth data were averaged per crop,year and week. A listing of the contents of this table (ROVE_BIO) is made available in file GEWBESCHR.ROVE.
Remarks, in Dutch language, about the general condition of the crops are added to this file, together with a remark at growth phase switches.

Also the intensive soil surface water and roughness measurements at Bouwing 1978, are stored in special tables (ROVE_VOCHT_78 and ROVE_RUWH_78).

Table 4.3.5

			ROVE_VOCHT_78	
	n1	1	SL	slaking phases: steps of rain sum
	n4	2	REG	[mm] rain sum since plot preparation
NN	d7	3	DATUM	date of soil moisture sampling
	n2	4	DN	surface wetness classes {1=dry...5=wet}
	n1	5	L	sampled soil layer {1= 0-4 cm and 2= 4-8 cm}
#----moisture			content of layer L per plot-name	
	n4,1	6	PLDT	ploughed,furrow along rail, faced towards rail
	n4,1	7	PLM	ploughed with direction across rail
	n4,1	8	EG	fine seedbed, prepared with a rotary harrow (across)
	n4,1	9	CUL	rough seedbed, prepared with a cultivator (across)
	n4,1	10	WPD	ploughed before winter,along rail
	n4,1	11	PLDA	ploughed,furrow along rail, faced from rail away
	n2	12	VOCHT	mean water content per layer over all plots

Soil moisture content is calculated in weight percentages: 100* (wet - dry)/(dry)

Table 4.3.6

		ROVE_RUWH_78		
	n1	1	SLFASE	slaking phase
NN	d7	2	DATUM	at date
	n3	3	REGSOM	with rain sum
# ---- roughness in a column per plot name				
	n4,2	4	PLDT	ploughed, furrow along rail, faced towards rail
	n4,2	5	PLM	ploughed with direction across rail
	n4,2	6	EG	fine seedbed, prepared with a rotary harrow (across)
	n4,2	7	CUL	rough seedbed, prepared with a cultivator (across)
	n4,2	8	WPD	ploughed before winter, along rail
	n4,2	9	PLDA	ploughed, furrow along rail, faced from rail away

The 'needle board' roughness is defined as 100*log(RMS)

Publications

In this Chapter, references to the relevant reports written by ROVE team members are given.

Groundtruth data-reports

H.W.J. van Kasteren (CABO-DLO) and ir. M.K. Smit (TUD); Measurements on the backscatter of X-band radiation of seven crops, throughout the growing season of 1975. Comparison of the return parameter G with some properties of the crops and with the density on a SLAR-image. NIWARS rep.47.

H.W.J. van Kasteren (CABO-DLO); ROVE 1976 at the experimental farm "Droevendaal", vegetation data.

H.W.J. van Kasteren (CABO-DLO); ROVE 1977 op proefboerderij "Droevendaal", vegetatiegegevens.

A.R.P. Janse (LUW); Radar, bare soils 1978 data report.

D. Uenk, H.W.J. van Kasteren (CABO-DLO); ROVE 1979 op proefboerderij "De Bouwing", vegetatiegegevens.

D. Uenk (CABO-DLO); ROVE 1980 op proefboerderij "De Schreef", vegetatiegegevens.

D. Uenk (CABO-DLO); ROVE 1981 op proefboerderij "De Schreef", vegetatiegegevens.

G.P. de Loor (FEL-TNO), P. Hoogeboom (FEL-TNO) and E.P.W. Attema (TUD); The Dutch ROVE program. In: IEEE Transactions 1982; GE-20.1, 3-11

Analyses reports of the ROVE data (non-exhaustive list)

Attema E.P.W. (1974); Short range vegetation scatterometry. in Proc. URSI Specialist meeting: Microwave scattering and emission from the Earth, Bern (Switzerland), 177-184.

Kasteren H.W.J. van, (1981); Radar signatures of crops. The effect of weather conditions and the possibilities of crop discrimination. In: Proc. Coll. Spect. Sign. in R.S., Avignon 1981, 407-415.

Hoekman D.H., L. Krul & E.P.W. Attema (1982) (TUD); A multilayer model for radar backscattering from vegetation canopies. 2nd IEEE IGRS Munchen.

Loor G.P. de (1985); Variation of the radar backscattering of vegetation through the growing season. in Proc EARSeL Workshop Microwave remote sensing applied to vegetation ; Amsterdam Dec 1984, 63-67.

Loor G.P. de (1985); Moisture determination in and under vegetation canopies. part I:, FEL-TNO report 1985-52.

Loor G.P. de (1987); Moisture determination in and under vegetation canopies. part II: Results after parameterization of the CLOUD model. BCRS-87-03.

Bouman B.A.M.,(1987); Radar backscattering from three agricultural crops: beet, potatoes and peas. Report 71, CABO-DLO, Wageningen, .. pp.

Bouman B.A.M.,(1988); Microwave backscatter from beets, peas and potatoes throughout the growing season. in Proc. 4th International Colloquium on Spectral Signatures of Objects in R.S. (Aussois, France, ESA SP-287), 25-30.

Bouman B.A.M. and H.W.J.van Kasteren (1989); Ground-based X-band radar backscattering measurments of wheat,barley and oats 1975-1981. Report 119, CABO-DLO.

Bouman B.A.M. and J. Goudriaan (1989); Estimation of crop growth from optical and microwave soil cover. International Journal of Remote Sensing, 10(12): 1843-1855.

Bouman B.A.M. and H.W.J.van Kasteren (1990); Ground-based X-band (3 cm wave) radar backscattering of agricultural crops. I. Sugar beet and potato, backscattering and crop growth II. Wheat, barley and oats, the impact of canopy structure in Remote Sensing of Environment 32: 93-105 and 107-118.

Bouman Bas A.M. (1991); Linking X-bamd radar backscattering and optical reflectance with crop growth models. LUW thesis sep'91 (parts of the thesis are published in Journals on Remote Sensing).

Bouman B.A.M. (1991); Crop parameter estimation from groundbased X-band (3-cm waves) radar data. Remote Sensing of Environment.

Appendix I:
Directory of tables

```
================================================================================
COD_GEW       ( GROEP < G1 < GEW : GEWAS : CROP | N_STAD )

ROVE_GEWSTAD ( G1 < GEW , STAD | BESCHRIJVING )

COD_BOERD     ( BOERD : BOERDERIJ
              | BOERNR , PLNR , GEBNR , BOD < BODTYPE )

PROEVEN_ROVE ( GEW , B : BOERD , JR , WSTAT = PRNR
              | N_P , N_T )

SCHEMA_ROVE  ( SERIE , GEW , JR = PRNR
               Z_DATUM : ZAAI , RAS , NGIFT , RIJRI , RIJAFST = BEH
               RIJRI , RIJAFST = FACTOR
               BEH , HERH = VNR : VNAAM
               PRNR , BEH = TYPE
               PRNR , VNR = PVNR : VELDJE : VSEQ
             | BEGIN , EIND , N_T  )

TIJDEN_ROVE  ( PER , WE , DAG : DAT , JR = DATUM
               DATUM , UUR , MIN = TIJD : TSEQ
               JR < MNR = TSEQ : TIJD
             | BO < BOD : VOCHT
             , WIND < (WRI , WSN)
             , TSOM , PSOM , RSOM

year tables  ( GEW , VNR : VNAAM , DATUM , MNR
               BOD , STAD , GFASE , XFASE , LEEFT
             | HO , BED , VERS , DS , BVOCHT

ROVE_75          VV HH HV ,      15 20...70
ROVE_76          VV HH HV ,         20...70
ROVE_77          VV HH HV ,      15 20...70     80
ROVE_78          VV HH HV , 10      20...70     80    , WUP WLOW
ROVE_79          VV HH    ,      15 20...70  75 80
ROVE_80    X,Q   VV HH    ,      15 20...70  75 80    , GR RO IR
ROVE_81    X,Q   VV HH HV ,      15 20...70  75 80    , GR RO IR


experiment on 23 July 1981
-----------------------------------
ROVE_JUL81 ( MNR < S , UUR , MIN , POL , ANG , HOEK
             VS , TYPE < VNR  |# GAMX , GAMQ          )
```

```
JUL#GP     ( VNR , ANG , LIM
           | N # XVV , XHH , QVV , QHH )

JUL_XVV    ( VNR |# A10,A15,A20,A30,A40,A50,A60,A70,A75,A80 )
idem for   JUL_XHH    JUL_QVV    JUL_QHH
```

groundtruth

```
ROVE_BIOM  ( PRNR , GEW , JR , BOERD , TYPE , VNR , STAD , DATUM , MNR
           | HO , BED , VERS , DROOG , DS , VERS1 , DROOG1                )

ROVE_BIO   (       GEW , JR                        , FASE , PER , WE
           | HO , BED , VERS , DROOG        , VERS1 , DROOG1              )
with file GEWBESCHR.ROVE

ROVE_VOCHT_78 ( SL < REG , DATUM , L
              |# PLDT , PLM , EG , CUL , WPD , PLDA = DN < VOCHT )

ROVE_RUWH_78  ( SLFASE < REGSOM , DATUM
              |# PLDT , PLM , EG , CUL , WPD , PLDA  )
```

classification of TYPE's by X-band radar signature

```
ROVE_TYPE_DATUM ( GEW , XSTAD , XFASE , JR < WE
                  XTYPE   -----> ROVE_TYPES (TYPE | RAS,RIJRI ..)
                  XDATUM  -----> ROVE_DATUMS (DATUM | BOD,WIND ..)
                | HO , BED , VERS , DS
                  VV15 , VV25 , VV45 , VV65 , VV77
                  HH15 , HH25 , HH45 , HH65 , HH77
                  HV15 , HV25 , HV45 , HV65 , HV77
```

With these "shrinked" dataset the effects of crop geometry (cultivar or row distance and direction) on radar backscatter are calculated.

crop tables

The ROVE data are also available in tables, organized per crop:

```
          AA  BI      BO  ER    BL  UI  VL  MA  ZO
          KA          GR  AL                WT  ZT  ZG  HA

GAM_&code  ( JR , VNR , STAD , WE , MNR  -----> ROVE_BIOM
             GOL , POL , HOEK   |  GAM  )
```

Appendix II:

Accuracy of July experiment

```
=========================================================================
        Only in the July experiment, data of repeated measurements on
the same object are available . The next SQL program gives an impression
of the accuracies involved in these data.

rem =====================  meetfout.sql  ===========================
rem  start meetfout  X or q
rem  enter for pol:  VV or HH
rem  enter for ang:  10 or 15 or 20 ..... 70 or 75 or 80

select s.GEW , s.TYPE
,avg(a.gam&1)  AVG  , count(a.gam&1)  N  , stddev(a.gam&1) STD
from schema_jul81 S , rove_jul81 A  where S.vnr = A.vnr
 and POL = upper('&pol')  and ANG = &ang
group by  gew , s.type  ;
rem ==============================================================
```

Some results are given below, for X-band with polarization VV and for (rounded) angles of 20,50,70 degrees. The mean value (AVG), the number of times a TYPE was measured (N) and the standard deviation (STD) are selected. For TYPE and VNR description see $ 4.3.1 or Appendix IV .

			X VV 20			X VV 50			X VV 70		
GEW	vnr's	TYPE	AVG	N	STD	AVG	N	STD	AVG	N	STD
AA	3	AA81	-6.17	12	.23	-1.83	8	.49	-1.38	10	.30
	4	AA81D	-6.29	12	.25						
	41,42	AA81+				-3.70	8	.39	-3.28	10	.71
BI	1	BI81	-2.31	11	.24	-2.32	8	.28	-1.60	9	.34
	12	BI50	-1.95	2	.05	-1.49	2	.25	-0.54	2	.06
	13	BI25	-2.37	2	.04	-3.19	2	.28	-2.03	4	.17
	14	BI12	-2.40	2	.13	-6.23	2	.06	-4.38	2	.06
	15	BI06	-2.36	6	.08	-7.83	2	.09	-5.29	1	**

WT	5,6,10	ARM81	-8.09	24	.19	-13.00	18	.39	-8.82	26	.69
	51	ARM-	-9.21	10	.15	-14.51	6	.10	-10.26	8	.23
	7	OKA81	-8.65	2	.18	-12.48	2	.27	-9.79	2	.11
	71	OKAm	-7.79	10	.11	-7.49	6	.11	-4.75	10	.14
	8	DUR81	-6.98	8	.14	-10.90	4	.70	-7.19	6	.14
	9	ADA81	-7.59	4	.19	-11.41	4	.21	-8.06	6	.30
KA	80	ONK81	-7.96	2	.07	-7.20	2	.07	-3.43	2	.01
	81	HAR81	-13.44	10	.13	-9.92	6	.15	-7.76	8	.12

Where N=2 , only forward and backwards along one plot was measured.
VV was repeated four times and HH only twice. Also a few angles have been measured twice.
Combining plots to TYPE's (as for ARMinda winter wheat) leads to large repeat counts. Even then the STD seldom rises above 0.50 dB .

Appendix III: Crop type definitions

The plots of ROVE are grouped to crop stucture types. Crop (GEW), year (JR) and treatment (BEH) are combined to a unique name for TYPE. In the table below '*n' indicates the number of replicates (HERH) of the same TYPE. Only types measured a whole growing season are included. When more types per crop and year are measured, the treatment effects are calculated (and stored in ROVE_EFF tables). The TYPE's with '*' are thereby used as reference object.

	Droevendaal			de Bouwing		de Schreef	
crop	'75	'76	'77	'78	'79	'80	'81
potatoes							
	AA75D	AA76			AA79	AA80	AA81*
							AA81D
sugarbeets							
	BI75	BI76			BI79	BI80	BI81 *2
winter wheat							
					ARM79*		ARM81* *3
					OKA79		OKA81
spring wheat							ADA81
	ZT75	ZT76	ZT77A		ZT79	ZT80	
			ZT77B*				
			ZT77C				
spring barley							
	ZG75	ZG76D	ZG77A *2		ZG79	ZG80	
		ZG76M	ZG77B* *2				
			ZG77C *2				
oats							
	HA75				HA79	HA80	

NB: D means :row direction perpendicular to radarbeam
M means : " parrallel "
A, B, C stands for rowdistance 12.5 , 25.0 , 37,5 respectively

miscellaneous

maize	MA76	onion	UI79	UI80	poppy seed	BL79
flax	VL76	peas	ER79	ER80		
sunflower	ZO76	beans(Phas.)	BO79			

meadows of grass or alfalfa at different cuttings

GR751 *2	GR761*	AL761	GR801
GR752 *2	GR762*	AL762	GR802
GR753 *2			
GR754 *2			

bare soil

KA75*	EG78*	PL78A	EG79*	EG80*
KA77	CUL78	PL78T	PL79	PL80
	WPL78	PL78M		

Appendix IV:
Description of the trial treatments

```
=====================================================================

table   SCHEMA_ROVE
---------------------------------------------------------------------
NN  c3  GEW     crop code name ----> COD_GEW
NN  n2  JR      year  (and farm)
NN  n3  PRNR    trial (combination of GEW,JR) ---> PROEVEN_ROVE
    c5  SERIE   trial series { 'ROVE' , 'JUL81' }
------ general growth information
    n3  ZAAI    julian daynumber
    d7 :Z_DATUM and date of sowing
    c10 RAS     cultivar name of crop
    n3  NGIFT   seasonal sum of nitrogen application
------ trial factors
    c1  RIJRI   crop row direction { 'D'=across , 'M'=along radar beam }
   n3,1 RIJAFST [cm] distance between crop rows
    c8  FACTOR  trial treatment,combination of RIJRI,RIJAFST (and others)
------
    n1  BEH     seq. nr for a treatment within a trial (PRNR)
NN  c5  TYPE    name for a combination of PRNR and BEH (general structure)
--------
    n1  HERH    repeat count for equal treatments (within BEH)
NN  n2  VNR     number code for a plot (unique within a year)
    c8 :VNAAM   readable name for the same plot
----- unique record identification
NN  n5  PVNR    unique number for a plot over years
NN  c8 :VELDJE  unique name for a that plot
NN  n4 :VSEQ    sequential number (= JR*100 + VNR)
------ attributes
    d7  BEGIN   start date of gamma measurements
    n2  N_T     number of times the plot was measured
    d7  EIND    last measurement date
---------------------------------------------------------------------
```

To show table SCHEMA_ROVE completely two listings of selected columns are made.

Remarks on column contents

SERIE The undisturbed plots of the July experiment have SERIE='ROVE' and the newly created plots have SERIE='JUL81'

ZAAI Julian day of sowing is negative for winter wheat plots.

RAS Where the cultivar was unknown the cropname is used instead. For bare soil plots (KA) suitable indicator values of roughness is filled in.

NGIFT Where value is NULL, nitrogen application is unknown

RIJRI Where value is NULL, there are no planting rows.

Listing 1

```
select prnr,serie,gew,jr
,zaai,z_datum,ras,ngift,rijri,rijafst,factor,beh
from SCHEMA_ROVE    order by prnr,vnr
```

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RIJ RI	RIJ AFST	FACTOR	BEH
1	ROVE	AA	75	126	06-MAY-75	AARDAPPEL		D	75	D 75	1
2	ROVE	AA	76	177	25-JUN-76	AARDAPPEL		M	67	M 67	2
3	ROVE	AA	79	109	19-APR-79	BINTJE	900	M	75	M 75	2
4	ROVE	AA	80	108	17-APR-80	BINTJE	770	M	75	M 75	2
5	ROVE	AA	81	106	16-APR-81	BINTJE	65	M	75	M 75	1
				106	16-APR-81	BINTJE	65	D	75	D 75	2
	JUL81	AA	81	106	16-APR-81	BINTJE	65	D	75	D A50	3
				106	16-APR-81	BINTJE	65	D	75	D A100	4

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
11	ROVE	BI	75	126	06-MAY-75	BIET		M	50	M 50	2
12	ROVE	BI	76	177	25-JUN-76	BIET		M	50	M 50	2
13	ROVE	BI	79	108	18-APR-79	MONOHIL	600	M	50	M 50	2
14	ROVE	BI	80	107	16-APR-80	MONOHIL	700	M	50	M 50	2
15	ROVE	BI	81	101	11-APR-81	MONOHIL	140	D	50	D100	1
				101	11-APR-81	MONOHIL	140	D	50	D100	1
	JUL81	BI	81	101	11-APR-81	MONOHIL	140	D	50	D50	2
				101	11-APR-81	MONOHIL	140	D	50	D25	3
				101	11-APR-81	MONOHIL	140	D	50	D12.5	4
				101	11-APR-81	MONOHIL	140	D	100	D6.25	5

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
20	ROVE	BL	79	108	18-APR-79	MARIANNE	500	M	25	M 25	2
21	ROVE	BO	79	183	02-JUL-79	BONEN STAM		M	25	M 25	2
22	ROVE	ER	79	110	20-APR-79	RONDO	0	M	25	M 25	2
23	ROVE	ER	80	102	11-APR-80	FINALE	0	M	25	M 25	2
57	ROVE	UI	79	110	20-APR-79	WABASTO	500	M	25	M 25	2
58	ROVE	UI	80	102	11-APR-80	WABASTO	385	M	25	M 25	2
45	ROVE	MA	76	177	25-JUN-76	MAIS		M	74	M 74	2
62	ROVE	VL	76	177	25-JUN-76	VLAS		M	8	M 8	2
88	ROVE	ZO	76	177	25-JUN-76	ZONNEBLOEM		M	50	M 50	2

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
====	=====	===	==	====	=========	=========	====	===	====	=======	===
26	ROVE	GR	75	126	06-MAY-75	FR				S1	1
				126	06-MAY-75	LP				S1	1
				155	04-JUN-75	FR				S2	2
				178	27-JUN-75	FR				S3	3
				210	29-JUL-75	FR				S4	4
				155	04-JUN-75	LP				S2	2
				178	27-JUN-75	LP				S3	3
				210	29-JUL-75	LP				S4	4
27	ROVE	GR	76	173	21-JUN-76	LP		M		S1	1
				227	14-AUG-76	LP				S2	2
10	ROVE	AL	76	173	21-JUN-76	ALFALFA		M	6	S1	1
				227	14-AUG-76	ALFALFA			6	S2	2
28	ROVE	GR	80	102	11-APR-80	LM TERLI	250	M	25	S1	1
				225	12-AUG-80	LM TERLI	0			S2	2

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
====	=====	===	==	====	=========	=========	====	===	====	=======	===
34	ROVE	KA	75	126	06-MAY-75	KAAL					0
				274	01-OCT-75	PLAT					0
				274	01-OCT-75	HARK					1
				274	01-OCT-75	RUW					2
				274	01-OCT-75	ZRUW					3
35	ROVE	KA	77	161	10-JUN-77	KAAL					1
184	ROVE	KA	78	138	18-MAY-78	PLOEGEN		D	50	D TOE	3
				138	18-MAY-78	PLOEGEN		M	50	M DW	5
				131	11-MAY-78	EGGEN		M		M	1
				138	18-MAY-78	CULTIVATOR		M	25	M	2
				-37	24-NOV-77	PLOEGEN		D	50	D AF	0
				138	18-MAY-78	PLOEGEN		D	50	D AF	4
36	ROVE	KA	79	130	10-MAY-79	EGGEN					1
				-82	10-OCT-78	PLOEGEN		M	50	M 50	2
				235	23-AUG-79	STOPPEL PL		M	50	M 50	3
				235	23-AUG-79	CULTIVATOR		M	25	M 25	4
				233	21-AUG-79	HARKEN					5
37	ROVE	KA	80	-60	01-NOV-79	PLOEGEN		M	50	M 50	2
				102	11-APR-80	EGGEN					0
				253	09-SEP-80	PLO na GR		M	50	M 50	3
				253	09-SEP-80	EGD na GR					1
187	JUL81	KA	81	101	11-APR-81	SLEMP				ONKR	1
				204	23-JUL-81	GEHARKT				HARK	2

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
====	=====	===	==	====	=========	=========	====	===	====	=======	===
64	ROVE	WT	79	-73	19-OCT-78	ARMINDA	400	M	25	M 25	1
				-73	19-OCT-78	OKAPI	400	M	25	M 25	2
66	ROVE	WT	81	-75	16-OCT-80	ARMINDA	110	D	18.8	D	0
				-75	16-OCT-80	ARMINDA	110	M	18.8	M	1
				-75	16-OCT-80	OKAPI	110	M	18.8	M	2
				-75	16-OCT-80	DURIN	110	M	18.8	M	4
				-75	16-OCT-80	ADAMANT	110	M	18.8	M	3
				-75	16-OCT-80	ARMINDA	110	M	18.8	M	1
	JUL81	WT	81	-75	16-OCT-80	ARMINDA	110	D	18.8	-AAR	5
				-75	16-OCT-81	OKAPI	110			BEZIG	6
				-75	16-OCT-81	OKAPI	110			MAAIEN	7

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
====	=====	===	==	====	=========	=========	====	===	====	=======	===
75	ROVE	ZG	75	126	06-MAY-75	ZGERST		M	25	M 25	2
76	ROVE	ZG	76	177	25-JUN-76	ZGERST		M	20	M 20	2
				177	25-JUN-76	ZGERST		D	25	D 20	1
77	ROVE	ZG	77	69	10-MAR-77	ARAMIR		M	12.5	M A	1
				69	10-MAR-77	ARAMIR		M	25	M B	2
				69	10-MAR-77	ARAMIR		M	37.5	M C	3
78	ROVE	ZG	79	101	11-APR-79	ARAMIR	250	M	25	M 25	2
79	ROVE	ZG	80	102	11-APR-80	HAVILA	150	M	25	M 25	2

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
====	=====	===	==	====	=========	=========	====	===	====	=======	===
89	ROVE	ZT	75	126	06-MAY-75	ZTARWE		M	25	M 25	2
90	ROVE	ZT	76	177	25-JUN-76	ZTARWE		M	20	M 20	2
91	ROVE	ZT	77	69	10-MAR-77	MELCHIOR		M	12.5	M A	1
				69	10-MAR-77	MELCHIOR		M	25	M B	2
				69	10-MAR-77	MELCHIOR		M	37.5	M C	3
				69	10-MAR-77	MELCHIOR		M	12.5	M A	1
				69	10-MAR-77	MELCHIOR		M	25	M B	2
				69	10-MAR-77	MELCHIOR		M	37.5	M C	3
92	ROVE	ZT	79	101	11-APR-79	ADONIS	350	M	25	M 25	2
93	ROVE	ZT	80	102	11-APR-80	BASTION	150	M	25	M 25	2

PRNR	SERIE	GEW	JR	ZAAI	Z_DATUM	RAS	NGIFT	RI	AFST	FACTOR	BEH
29	ROVE	HA	75	126	06-MAY-75	HAVER		M	25	M 25	2
30	ROVE	HA	79	101	11-APR-79	LEANDA	150	M	25	M 25	2
31	ROVE	HA	80	102	11-APR-80	DULA	150	M	25	M 25	2

96 trial plot records selected from SCHEMA_ROVE.

listing 2

```
select prnr,type,herh,vnr,vnaam,pvnr,veldje,vseq,begin,n_t,eind
from SCHEMA_ROVE   order by prnr,vnr
```

PRNR	TYPE	HERH H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
1	AA75D		3	AAD	7503	AA75ZA	7503	06-MAY-75	26	01-OCT-75
2	AA76		3	AA	7603	AA76ZA	7603	25-JUN-76	22	29-SEP-76
3	AA79		8	AA	7908	AA79RK	7908	09-MAY-79	36	31-AUG-79
4	AA80		7	AA	8007	AA80ZK	8007	29-APR-80	39	09-SEP-79
5	AA81		3	AAM	503	AA81ZK M	8103	18-MAY-81	21	23-JUL-81
	AA81D		4	AAD	504	AA81ZK D	8104	18-MAY-81	21	23-JUL-81
	AA81+		41	AAD+	541	AA81 D+	8141	23-JUL-81	4	23-JUL-81
	AA81+		42	AAD++	542	AA81 D++	8142	23-JUL-81	4	23-JUL-81
11	BI75		4	BI	7504	BI75ZA	7504	06-MAY-75	26	01-OCT-75
12	BI76		4	BI	7604	BI76ZA	7604	25-JUN-76	22	08-OCT-76
13	BI79		7	BI	7907	BI79RK	7907	09-MAY-79	36	31-AUG-79
14	BI80		6	BI	8006	BI80ZK	8006	29-APR-80	39	09-SEP-79
15	BI81	1	1	BI1	1501	BI81ZK 1	8101	18-MAY-81	21	23-JUL-81
	BI81	2	2	BI2	1502	BI81ZK 2	8102	18-MAY-81	17	03-JUL-81
	BI50		12	BI50	1512	BI81 50%	8112	23-JUL-81	1	23-JUL-81
	BI25		13	BI25	1513	BI81 25%	8113	23-JUL-81	1	23-JUL-81
	BI12		14	BI12	1514	BI81 12.5%	8114	23-JUL-81	1	23-JUL-81
	BI06		15	BI6	1515	BI81 6.25%	8115	23-JUL-81	1	23-JUL-81

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
20	BL79		6	BL	7906	BL79RK	7906	09-MAY-79	36	31-AUG-79
21	BO79		13	BO	7913	BO79RK	7913	04-JUL-79	19	31-AUG-79
22	ER79		9	ER	7909	ER79RK	7909	09-MAY-79	32	17-AUG-79
23	ER80		4	ER	8004	ER80ZK	8004	29-APR-80	38	29-AUG-80
57	UI79		10	UI	7910	UI79RK	7910	09-MAY-79	17	29-JUN-79
58	UI80		5	UI	8005	UI80ZK	8005	29-APR-80	39	09-SEP-80
45	MA76		9	MA	7609	MA76ZA ROVE	7609	25-JUN-76	22	08-OCT-76
62	VL76		5	VL	7605	VL76ZA	7605	25-JUN-76	22	14-SEP-76
88	ZO76		10	ZO	7610	ZO76ZA	7610	25-JUN-76	22	08-OCT-76

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
26	GR751	1	1	FR1	7501	GR75ZA FR1	7501	06-MAY-75	14	29-MAY-79
	GR751	2	2	LP1	7502	GR75ZA LP1	7502	06-MAY-75	14	29-MAY-75
	GR752	1	11	FR2	7511	GR75ZA FR2	7511	04-JUN-75	3	19-JUN-75
	GR753	1	12	FR3	7512	GR75ZA FR3	7512	27-JUN-75	4	17-JUL-75
	GR754	1	13	FR4	7513	GR75ZA FR4	7513	29-JUL-75	14	01-OCT-75
	GR752	2	21	LP2	7521	GR75ZA LP2	7521	04-JUN-75	3	19-JUN-75
	GR753	2	22	LP3	7522	GR75ZA LP3	7522	27-JUN-75	4	17-JUL-75
	GR754	2	23	LP4	7523	GR75ZA LP4	7523	29-JUL-75	14	01-OCT-75
27	GR761		1	LP1	7601	GR76ZA LP1	7601	25-JUN-76	16	08-OCT-76
	GR762		11	LP2	7611	GR76ZA LP2	7611	18-AUG-76	9	08-OCT-76
10	AL761		2	AL1	7602	AL76ZA 1	7602	25-JUN-76	16	08-OCT-76
	AL762		21	AL2	7621	AL76ZA 2	7621	18-AUG-76	9	08-OCT-76
28	GR801		3	LM1	8003	GR80ZK LM1	8003	29-APR-80	32	08-AUG-80
	GR802		31	LM2	8031	GR80ZK LM2	8031	12-AUG-80	6	29-AUG-80

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
34	KA75		8	KA	7508	KA75ZA	7508	06-MAY-75	25	15-SEP-75
	PLAT		60	PLAT	7560	KA75ZA PLAT	7560	01-OCT-75	1	01-OCT-75
	HARK		61	HARK	7561	KA75ZA HAR	7561	01-OCT-75	1	01-OCT-75
	RUW		62	RUW	7562	KA75ZA RUW	7562	01-OCT-75	1	01-OCT-75
	ZRUW		63	ZRUW	7563	KA75ZA ZRUW	7563	01-OCT-75	1	01-OCT-75
35	KA77		10	KA	7710	KA77ZA	7710	10-JUN-77	22	30-AUG-77
184	PL78T		1	PLTOE	7801	KA78RK PLTOE	7801	09-JUN-78	27	01-SEP-78
	PL78M		2	PLMET	7802	KA78RK PL M	7802	09-JUN-78	27	01-SEP-78
	EG78		3	EG	7803	KA78RK EG	7803	09-JUN-78	27	01-SEP-78
	CUL78		4	CUL	7804	KA78RK CUL	7804	09-JUN-78	27	01-SEP-78
	WPL78		5	PLWV	7805	KA78RK PL WV	7805	09-JUN-78	27	01-SEP-78
	PL78A		6	PLDAF	7806	KA78RK PL AF	7806	09-JUN-78	27	01-SEP-78
36	EG79		11	EG	7911	KA79RK EG	7911	09-MAY-79	36	31-AUG-79
	PL79		12	PL	7912	KA79RK PL WV	7912	09-MAY-79	36	31-AUG-79
	ST PL		31	STPL	7931	KA79RK PL ST	7931	24-AUG-79	3	31-AUG-79
	CULTI		41	CUL	7941	KA79RK CUL	7941	24-AUG-79	3	31-AUG-79
	GLAD		51	HARK	7951	KA79RK HAR	7951	21-AUG-79	4	31-AUG-79
37	PL80		1	PL	8001	KA80ZK PL	8001	29-APR-80	39	09-SEP-80
	EG80		2	EG	8002	KA80ZK EG	8002	29-APR-80	39	09-SEP-80
	GEPL		11	PL2	8011	KA80ZK PL2	8011	09-SEP-80	1	09-SEP-80
	GEEGD		21	EG2	8021	KA80ZK EG2	8021	09-SEP-80	1	09-SEP-80
187	KA81		80	KA1	18780	KA81ZK ONKR	8180	23-JUL-81	1	23-JUL-81
	KA81		81	KA2	18781	KA81ZK HARK	8181	23-JUL-81	3	23-JUL-81

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
64	ARM79		1	ARM	7901	WT79RK ARM	7901	09-MAY-79	36	31-AUG-79
	OKA79		2	OKA	7902	WT79RK OKA	7902	09-MAY-79	36	31-AUG-79
66	ARM81		5	ARM1	6605	WT81ZK ARM1	8105	18-MAY-81	18	23-JUL-81
	ARM81	1	6	ARM2	6606	WT81ZK ARM2	8106	18-MAY-81	21	23-JUL-81
	OKA81		7	OKA	6607	WT81ZK OKA	8107	18-MAY-81	18	23-JUL-81
	DUR81		8	DUR	6608	WT81ZK DUR	8108	18-MAY-81	19	23-JUL-81
	ADA81		9	ADA	6609	WT81ZK ADA	8109	18-MAY-81	19	23-JUL-81
	ARM81	2	10	ARM3	6610	WT81ZK ARM3	8110	18-MAY-81	21	23-JUL-81
	ARM-		51	ARM-	6651	ARM-aar	8151	23-JUL-81	3	23-JUL-81
	OKA?		71	OKA?	6671	OKA?bezig	8171	23-JUL-81	1	23-JUL-81
	OKAm		72	OKAm	6672	OKAmaaien	8172	23-JUL-81	3	23-JUL-81

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
75	ZG75		7	ZG	7507	ZG75ZA	7507	06-MAY-75	25	29-AUG-75
76	ZG76M		7	ZGM	7607	ZG76ZA M	7607	25-JUN-76	22	14-SEP-76
	ZG76D		8	ZGD	7608	ZG76ZA D	7608	25-JUN-76	22	14-SEP-76
77	ZG77A		4	ZGA	7704	ZG77ZA A	7704	03-MAY-77	31	30-AUG-77
	ZG77B		5	ZGB	7705	ZG77ZA B	7705	03-MAY-77	31	30-AUG-77
	ZG77C		6	ZGC	7706	ZG77ZA C	7706	03-MAY-77	31	30-AUG-77
78	ZG79		4	ZG	7904	ZG79RK	7904	09-MAY-79	33	21-AUG-79
79	ZG80		10	ZG	8010	ZG80ZK	8010	29-APR-80	39	09-SEP-80

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
89	ZT75		5	ZT	7505	ZT75ZA	7505	06-MAY-75	25	29-AUG-75
90	ZT76		6	ZT	7606	ZT76ZA	7606	25-JUN-76	22	01-SEP-76
91	ZT77A	1	1	ZTA1	7701	ZT77ZA A1	7701	03-MAY-77	31	30-AUG-77
	ZT77B	1	2	ZTB1	7702	ZT77ZA B1	7702	03-MAY-77	31	30-AUG-77
	ZT77C	1	3	ZTC1	7703	ZT77ZA C1	7703	03-MAY-77	31	30-AUG-77
	ZT77A	2	7	ZTA2	7707	ZT77ZA A2	7707	03-MAY-77	31	30-AUG-77
	ZT77B	2	8	ZTB2	7708	ZT77ZA B2	7708	03-MAY-77	31	30-AUG-77
	ZT77C	2	9	ZTC2	7709	ZT77ZA C2	7709	03-MAY-77	31	30-AUG-77
92	ZT79		3	ZT	7903	ZT79RK	7903	09-MAY-79	33	21-AUG-79
93	ZT80		8	ZT	8008	ZT80ZK	8008	29-APR-80	39	09-SEP-80

PRNR	TYPE	H	VNR	VNAAM	PVNR	VELDJE	VSEQ	BEGIN	N_T	EIND
29	HA75		6	HA	7506	HA75ZA	7506	06-MAY-75	25	29-AUG-75
30	HA79		5	HA	7905	HA79RK	7905	09-MAY-79	36	31-AUG-79
31	HA80		9	HA	8009	HA80ZK	8009	29-APR-80	39	09-SEP-80

96 "trial plot" records selected from SCHEMA_ROVE.

Appendix V:
Soil and weather conditions

In this Appendix a description of table TIJDEN_ROVE is given.

column name	comment and range of values
BO < BOD < VOCHT	Estimates of soil moisture content of crust layer.
VOCHT moisture [%]	Determined from samples of a variable number of plots, subjectively averaged.
BOD wetness number	Classes made by visual observation. { 1= very dry ; 2= dry ; 3 drying ; 4= wet ; 5 = very wet (dark) }
BO wetness char	{ D for BOD=1,2 ; V for BOD= 3 ; N for BOD=4,5 ? for unknown }
WIND < WSN , WRI	Estimates of wind speed and direction.
WSN wind speed	[m/sec] Derived from applicable weather station.
WRI wind direction	relative to look angle plane of radar { 0 ... 8 }. { 0 = wind blows towards antenne (or rails) 4 = wind blows parallel to rails 8 = wind and look direction coincide }
WIND type	{ STIL no wind : if WSN < 2.5 m/sec TOE towards : not STIL and WRI=0,1,2 DW sidewind: not STIL and WRI=3,4,5 AF away from radar : not STIL and WRI=6,7,8 ? for unknown }
WE week	week number, derived from ORACLE date format function
TIJD time	Time of radar measurement set (all polar. and angles) TIJD includes date, hour (and second)
MNR measurement number	Sequential in time and unique witin year.

TSOM,PSOM,RSOM — Accumulated dayly mean Temperatuur, PAR radiation (0.5 * global rad. in MJoule), rainfall [mm] Derived from meteo station Wageningen or Swifterbant The sums start with zero at 1-jan of the year.

The moisture condition of the top soil layer (estimated from rainfall data) and the wind situation during the radar measurement series are presented in table listings per year.

measurement numbers and weather of ROVE year : 1975 DROEV

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
18	D	AF	2		6	5	06-may:12	1	129	434	241
19	?	?					09-may:12	2	147	457	246
20	N	STIL	4	19	2	2	14-may:12	3	170	497	256
	D	STIL	2	12		1	20-may:12	4	209	544	263
21	D	STIL	2		2	2	23-may:12	5	218	578	263
22	D	STIL	1	10	5	2	29-may:12	6	250	634	263
23	V	TOE	3	18	2	3	04-jun:12	7	260	684	274
24	D	AF	1		7	3	11-jun:12	8	317	765	280
25	V	STIL	3	18	2	1	19-jun:12	9	394	840	303
26	D	STIL	2		5	2	27-jun:12	10	480	920	345
27	V	DW	3	18	5	3	04-jul:12	11	535	982	346
28	V	STIL	3			1	11-jul:12	12	621	1053	369
29	D	STIL	2			1	17-jul:12	13	699	1101	380
30	D	STIL	1			1	29-jul:12	14	822	1187	434
(31)											
32	D	STIL	1	6	7	2	06-aug:12	15	939	1281	440
----- 24 hours experiment ---------											
33	D	STIL	1		7	3	14-aug:09	16	1076	1359	449
	D	STIL	1		7		14-aug:12	17	1076	1359	449
	D	STIL	1		7		14-aug:15	18	1076	1359	449
	D	STIL	1		7		14-aug:18	19	1076	1359	449
	D	STIL	1		7		14-aug:21	20	1076	1359	449
	D	STIL	1		7	3	15-aug:00	21	1093	1369	449
	D	STIL	1		7		15-aug:03	22	1093	1369	449
	D	STIL	1		7		15-aug:06	23	1093	1369	449
	D	STIL	1		7		15-aug:09	24	1093	1369	449
(34)											
35	D	STIL	2			2	29-aug:12	25	1238	1470	484
(36)											
37	N	STIL	4		2	1	15-sep:12	26	1406	1574	519
(38,39)											
40	V	DW	3	12	4	3	01-oct:12	27	1551	1663	552

measurement numbers and weather of ROVE year : 1976 DROEV

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
26	D	STIL	1		7	1	25-jun:12	1	532	983	206
	D	AF	1		7	3	29-jun:12	2	604	1032	206
27	D	STIL	1		5	2	02-jul:12	3	651	1074	206
	D	DW	2		5	3	06-jul:12	4	723	1126	206
28	D	STIL	1		6	1	09-jul:12	5	770	1166	206
	D	STIL	1		4	2	14-jul:12	6	833	1212	208
29	D	STIL	1		2	2	19-jul:12	7	906	1249	220
30	D	STIL	2		7	2	22-jul:12	8	939	1267	222
								(9,10)			
	D	STIL	1		8	1	27-jul:12	11	985	1313	231
31	D	DW	2		4	3	02-aug:12	12	1034	1357	235
32	D	STIL	1		8	1	06-aug:12	13	1068	1384	240
33	D	STIL	1		7	1	12-aug:12	14	1135	1438	240
	D	STIL	1		7	2	13-aug:12	15	1147	1447	240
	D	STIL	1		8	1	18-aug:12	16	1205	1499	240
	D	STIL	2		8	1	18-aug:16	17	1205	1499	240
(34)											
35	D	STIL	1		8	2	26-aug:12	18	1305	1578	243
	D	STIL	1		4	2	01-sep:12	19	1372	1618	249
	D	STIL	1		4	2	01-sep:16	20	1372	1618	249
36	D	STIL	1		3	1	07-sep:12	21	1413	1653	269
37	D	TOE	2		0	3	14-sep:12	22	1459	1687	276
(38)											
39	V	STIL	3		1	1	29-sep:12	23	1584	1756	284
(40)											
41	V	STIL	3		1	2	08-oct:12	24	1662	1789	300

measurement numbers and weather of ROVE year : 1977 DROEV

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
18	V	STIL	3	12		2	03-may:12	1	124	433	215
	V	STIL		12			06-may:12	2	139	444	221
19	N	TOE	4	17	1	3	13-may:12	3	166	495	238
20	D	AF	2	5	7	4	17-may:12	4	178	524	250
	N	AF	4	16	7	4	20-may:12	5	201	560	250
21	D	AF	1	2	7	3	24-may:12	6	222	595	256
	D	AF	1	1	7	5	27-may:12	7	251	634	256
22	D	STIL	1	1	6	2	31-may:12	8	278	681	256
	V	DW	3	5	4	3	03-jun:12	9	291	710	256
23	V	DW	3	14	4	3	10-jun:12	10	339	759	267
								(11)			
24	V	STIL	3	7	2	2	14-jun:12	12	385	800	292
	V	STIL	3	13	4	2	17-jun:12	13	417	814	305
25	V	STIL	3	10	3	1	21-jun:12	14	448	828	305
	D	STIL	2	5	3	1	24-jun:12	15	472	854	305
26	D	STIL	2	5	1	2	28-jun:12	16	506	884	307
	V	TOE	3	10	0	4	01-jul:12	17	533	905	315
27	D	STIL	1	2	7	2	05-jul:12	18	580	938	315
	D	STIL	1	1	6	2	08-jul:12	19	621	970	316
28	D	STIL	1	1	4	1	12-jul:12	20	668	1015	316
	D	STIL	1	2	4	2	15-jul:12	21	696	1045	316
29	N	TOE	4	14	0	4	19-jul:12	22	729	1072	325
	V	STIL	3	8	2	2	22-jul:12	23	756	1088	340
30	N	STIL	5	21	1	2	27-jul:12	24	805	1115	352
	N	AF	4	17	6	3	29-jul:12	25	823	1125	377
31	D	TOE	1	2	2	3	05-aug:12	26	891	1175	379
32	N	STIL	4	15	1	2	09-aug:12	27	939	1207	380
33	N	AF	4	14	8	3	16-aug:12	28	1011	1244	409
	N	STIL	5	19	4	2	19-aug:12	29	1042	1255	434
34	N	STIL	5	21	6	2	23-aug:12	30	1080	1275	466
35	N	STIL	4	15		1	30-aug:12	31	1143	1325	508
	V	STIL	3	15		1	30-aug:16	32	1143	1325	508

measurement numbers and weather of ROVE year : 1978 KA_BOUW

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
23	D	?	1	9		4	09-jun:12	1	397	740	253
24	D	?	2	10		3	13-jun:12	2	423	775	253
	V	?	3			2	16-jun:12	3	442	799	254
25	D	?	1	4		2	20-jun:12	4	478	846	257
	N	?	5	21		4	23-jun:12	5	503	875	258
26	N	?	4	20		4	27-jun:12	6	527	900	287
27	V	?	3	17		6	04-jul:12	7	579	935	309
	N	?	5	21		4	07-jul:12	8	599	953	325
28	V	?	2	13		1	11-jul:12	9	624	972	339
	D	?	1	6		3	14-jul:12	10	651	1000	339
29	D	?	1			2	19-jul:12	11	682	1040	339
	V	?	2	14		2	21-jul:12	12	700	1056	347
30	D	?	2			2	25-jul:12	13	734	1092	347
	D	?	1			1	28-jul:12	14	765	1117	348
31	V	?	3	10		2	01-aug:12	15	828	1157	348
	D	?	2	10		4	04-aug:12	16	863	1174	349
32	N	?	5	27		4	08-aug:12	17	900	1191	353
	N	?	5	24		4	09-aug:12	18	907	1199	353
	N	?	4	21		2	11-aug:12	19	923	1212	354
	N	?	4	24		2	12-aug:12	20	930	1217	354
33	V	?	3	12		3	15-aug:12	21	955	1236	355
	N	?	5	26		1	18-aug:12	22	988	1262	356
	N	?	5	25		2	19-aug:12	23	996	1272	356
34	V	?	3	16		2	21-aug:12	24	1019	1293	356
	D	?	2	9		2	24-aug:12	25	1050	1321	356
35	D	?	2	11		3	28-aug:12	26	1078	1345	356
	N	?	4	21		3	01-sep:12	27	1103	1366	374

---- dates without radar measurements ----

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
22	?	?		5			01-jun:12	28	292	664	239
23	?	?		6			06-jun:12	29	363	718	245
24	?	?		17			15-jun:12	30	435	789	254
29	?	?		8			18-jul:12	31	674	1029	339
30	?	?		7			29-jul:12	32	778	1128	348

measurement numbers and weather of ROVE year : 1979 BOUW

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
19	D	TOE	1		1	3	09-may:12	1	83	456	216
	D	STIL	1		2	2	10-may:12	2	87	468	216
(20)											
21	V	STIL	3	10	4	2	23-may:12	3	183	580	227
	V	TOE	3		2	4	25-may:12	4	194	590	233
22	?	?		16			31-may:12	5	246	641	261
	N	STIL	5	27	4	2	01-jun:12	6	261	653	263
23	N	STIL	5	25	1	2	05-jun:12	7	316	685	362
	V	TOE	3	14	1	5	08-jun:12	8	342	710	365
24	N	DW	4	23	4	3	11-jun:12	9	366	741	365
	N	DW	5	27	4	3	13-jun:12	10	383	749	371
	N	TOE	5	26	2	3	15-jun:12	11	397	756	399
25	D	DW	2	14	3	3	18-jun:12	12	413	782	401
	D	STIL	1	13	8	1	20-jun:12	13	429	805	401
	V	TOE	3	21	0	3	22-jun:12	14	452	830	401
26	V	TOE	3	16	2	4	25-jun:12	15	477	852	407
	D	STIL	2	14	0	2	27-jun:12	16	493	864	407
	D	TOE	2	13	1	3	29-jun:12	17	511	886	407
27	D	STIL	1	9	0	1	02-jul:12	18	532	905	407
	D	STIL	1	10	3	2	04-jul:12	19	547	922	407
	D	STIL	1	5	1	2	06-jul:12	20	564	937	407
28	D	STIL	2	10	2	2	10-jul:12	21	604	973	411
	D	STIL	1	9	6	2	13-jul:12	22	636	1004	411
29	V	STIL	3	11	0	2	17-jul:12	23	667	1026	411
	N	STIL	4	21	0	2	20-jul:12	24	697	1038	423
30	V	TOE	3	18	0	3	24-jul:12	25	729	1062	430
	D	STIL	1	5	3	1	27-jul:12	26	763	1091	430
31	D	TOE	2	13	2	4	31-jul:12	27	814	1124	435
	D	TOE	2	13	2	4	03-aug:12	28	847	1144	439
32	D	STIL	1	12	2	2	07-aug:12	29	889	1182	453
	N	TOE	5	26	0	3	10-aug:12	30	918	1196	473
33	N	STIL	4	21	0	1	16-aug:12	31	976	1235	474
	N	TOE	4		2	3	17-aug:12	32	986	1240	475
34	N	TOE	4	21	2	3	21-aug:12	33	1022	1260	478
	V	TOE	3	12	2	3	24-aug:12	34	1043	1279	484
35	N	TOE	4	22	0	3	28-aug:12	35	1069	1302	515
	D	STIL	2	10	1	2	31-aug:12	36	1094	1326	515

measurement numbers and weather of ROVE year : 1980 SCHR

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
17	?	?		4			24-apr:12	1	46	338	133
18	D	TOE	2	7	1	3	29-apr:12	2	52	365	136
	D	AF	1	3	6	8	02-may:12	3	63	392	136
19	D	AF	1	3	6	6	06-may:12	4	69	434	136
	N	TOE	5	27	1	3	07-may:12	5	73	443	136
	D	DW	1	3	5	4	09-may:12	6	77	454	138
20	D	AF	1	2	6	8	13-may:12	7	93	503	138
	D	AF	1	1	6	5	16-may:12	8	113	542	138
21	D	AF	1	2	7	4	20-may:12	9	142	586	138
	D	TOE	1	4	0	3	23-may:12	10	162	622	138
22	D	STIL	1	2	6	2	27-may:12	11	181	646	139
	D	TOE	2	13	0	5	30-may:12	12	203	668	153
23	D	TOE	2	7	0	3	03-jun:12	13	222	710	155
	D	STIL	1	3			06-jun:12	14	249	734	155
24	D	STIL	1	3	4	2	13-jun:12	15	318	792	185
	D	DW	2	8	4	5	16-jun:12	16	358	818	187
25	D	TOE	2	14	1	4	18-jun:12	17	375	829	191
	N	TOE	5	28	2	5	20-jun:12	18	390	843	191
	N	DW	5	30	4	3	23-jun:12	19	410	862	220
26	N	TOE	5	29	0	4	25-jun:12	20	422	874	235
	N	TOE	4	26	0	4	27-jun:12	21	432	889	240
27	N	STIL	5	32	5	2	01-jul:12	22	458	915	254
	V	DW	3	18	4	3	04-jul:12	23	483	934	274
28	N	TOE	5	29	0	3	11-jul:12	24	540	972	319
29	N	TOE	4	28	0	4	15-jul:12	25	570	997	352
	V	TOE	3	23	2	4	18-jul:12	26	595	1019	353
30	V	STIL	3	20	4	2	22-jul:12	27	628	1034	370
	D	AF	2	16	6	4	25-jul:12	28	655	1070	370
31	D	DW	2	12	5	5	29-jul:12	29	707	1107	370
	V	AF	3	25	8	4	01-aug:12	30	741	1128	392
32	D	TOE	2	8	2	6	05-aug:12	31	794	1162	392
	D	AF	1	7	8	3	08-aug:12	32	832	1181	392
33	N	TOE	5	33	1	5	12-aug:12	33	869	1209	406
	V	AF	3	21	8	5	15-aug:12	34	901	1228	417
34	D	TOE	2	12	0	3	19-aug:12	35	953	1258	417
	D	TOE	2	9	0	6	21-aug:12	36	976	1270	417
35	D	AF	2	12	6	4	26-aug:12	37	1014	1304	433
	D	DW	2	10	5	4	29-aug:12	38	1040	1325	433
(36)											
37	D	TOE	2	6	1	6	09-sep:12	39	1143	1393	442

measurement numbers and weather of ROVE year : 1981 SCHR

WE	BO	WIND	BOD	VOCHT	WRI	WSN	TIJD	MNR	TSOM	PSOM	RSOM
20	D	DW	2		4	3	18-may:12	1	252	486	208
21	D	DW	2	13	5	3	21-may:12	2	282	515	212
	V	DW	3	21	4	4	26-may:12	3	320	553	230
22	D	STIL	2		7	2	29-may:12	4	337	577	233
	V	STIL	3	19		3	02-jun:12	5	381	618	241
23	D	AF	1		6	6	05-jun:12	6	416	650	241
	V	DW	3	23	5	6	09-jun:12	7	452	681	251
24	N	AF	4	28	6	4	12-jun:12	8	475	702	267
	D	AF	2	18	8	5	15-jun:12	9	494	725	267
	D	AF	1		7	5	16-jun:12	10	504	730	267
	N	AF	4	26	7	5	17-jun:12	11	511	737	271
25	V	AF	3	25	6	4	18-jun:12	12	517	744	274
	D	STIL	2	4	4	1	19-jun:12	13	522	748	274
26	N	DW	4		5	5	01-jul:12	14	602	819	314
27	D	STIL	2		5	2	02-jul:12	15	610	826	314
	V	AF	3		6	4	03-jul:12	16	619	831	327
	V	AF	3		6	5	03-jul:16	17	619	831	327
(28,29)											
30	D	STIL	1			2	23-jul:09	18	819	992	359

JUL81 experiment	23-jul:11.02	19
	23-jul:15.22	20
	23-jul:18.12	21
	23-jul:18.59	22

209 "weather" records selected from TIJDEN_ROVE

Appendix VI:
Crop growth phase definitions

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For table ROVE_GEWSTAD (G1 < GEW , STAD ! BESCHRIJVING), the crops (GEW) are grouped in genetic classes (G1) with the following meaning:

0	bare (KA) soils like ploughed (PL) , cultivatored (CUL) or harrowed (EG)
1	meadow crops like grasses (GR) and alfalfa (AL)
2	beets (BI) 3 potato (AA)
4	leguminous crops like beans (BO) and peas (ER)
5	cereals sown before winter (WT)
6	cereals sown in spring : wheat (ZT) , barley (ZG)
7	oats (HA) is a seperate class because of their panicle in top
8	poppy seed (BL)
9	onions (UI)
10	maize (MA)
11	flax (VL)
12	sunflower (ZO)

It was tried to find a phase definition set applicable to all crop classes, combining morphological properties and biomass criteria. But in practice at least two sets of criteria had to be made : One for tall, flowering crops (cereals and BL,MA,VL,ZO) and one for shorter or only vegetative growing crops (AA,BI,ER,BO,UI and GR,AL) .

The following sets of criteria were used to fill the STAD column in the ROVE_year tables:

Bare soils

In 1978 rain sum classes of 30 mm were used to define phases.
In other years the bare soil field changes during the year are just grouped in month classes.

Cereals and alike

STAD	used criteria
0	Seed bed and emergence phase.
1	Cover < 20% and dry crop weight < 50 g/m2.
2	Cover between 20% and 50%, dry weight < 100 g/m2.
3	cover > 50% and height < 50 cm.
4	Stem elongation while unfolding the 2 top leaves (start around dry weight is 250 g/m2).

5 Start of heading (ears or flowers) , top layer of the crop still consists mainly of leaves (Feekes scale F10).
6 Ears are lifted above the leaf layer, by the stem top.
7 Grain filling (fruit making) while the lower leaves are yellowing.
8 Process of yellowing and loosing leaves reaches the top layer.
9 Ripening, dry matter percentage of ears > 40 % .
10 Dying: brown top leaves, dry matter of ears > 50 % and dry matter of stems > 35 %.
11 Harvestable , ears bending downwards (dry matter of ear and straw > 80 %).

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meadows and other vegetatave crops

STAD	meadows	others
0	(pre)emergence	(pre)emergence and seedling
1	dry 10 - 50	cover 2 - 10
2	dry 50 - 100	cover 10 - 20
3	dry 100 - 150	cover 20 - 50
4	dry 150 - 200	cover < 80 or dry < 200
5	dry 200 - 500	dry weight 225 - 500
6	dry weight > 500	dry weight > 500 g/m2

NB: For meadow crops only dry weight [g/m2] is used and for other row crops, soil cover [%] is the main phase selector.

When above ground dry weight reaches 100 g/m2 normally phase 3 begins.

When applicable for the crop (or situation) also the phases of the senescence proces are used :

7 Start of yellowing.
8 Severe yellowing.
9 or 10 Without any functioning leaves.
11 Harvestable in normal practice.

Some phase numbers are reserved for special situations :

21 Lodging of the crop in an early (or green) phase.
22 Lodging in later (or ripening) phases.
30 Stubbels remainin`g after harvest.
31,32 The first regrowth phases of grass after mowing.
35 Regrowth of germinating cereal kernels after harvest.

91 In 1979 and 1981 the potato leavage was killed (like in seed potato practice).

99 Special cases.
Deliberately created situations (like clipping ears).

The actual phase classification per plot, together with the corresponding mean groundtruth data and remarks about the condition of the crop, is available in file GEWBESCHR.ROVE (in dutch language).