Change of precipitation and soil moisture on the Mongolian Plateau

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Outline

1. Background and Purposes
2. Water cycle change study on the Mongolian Plateau
   1) Methods
   2) Change of rainfall and soil moisture for 12 years
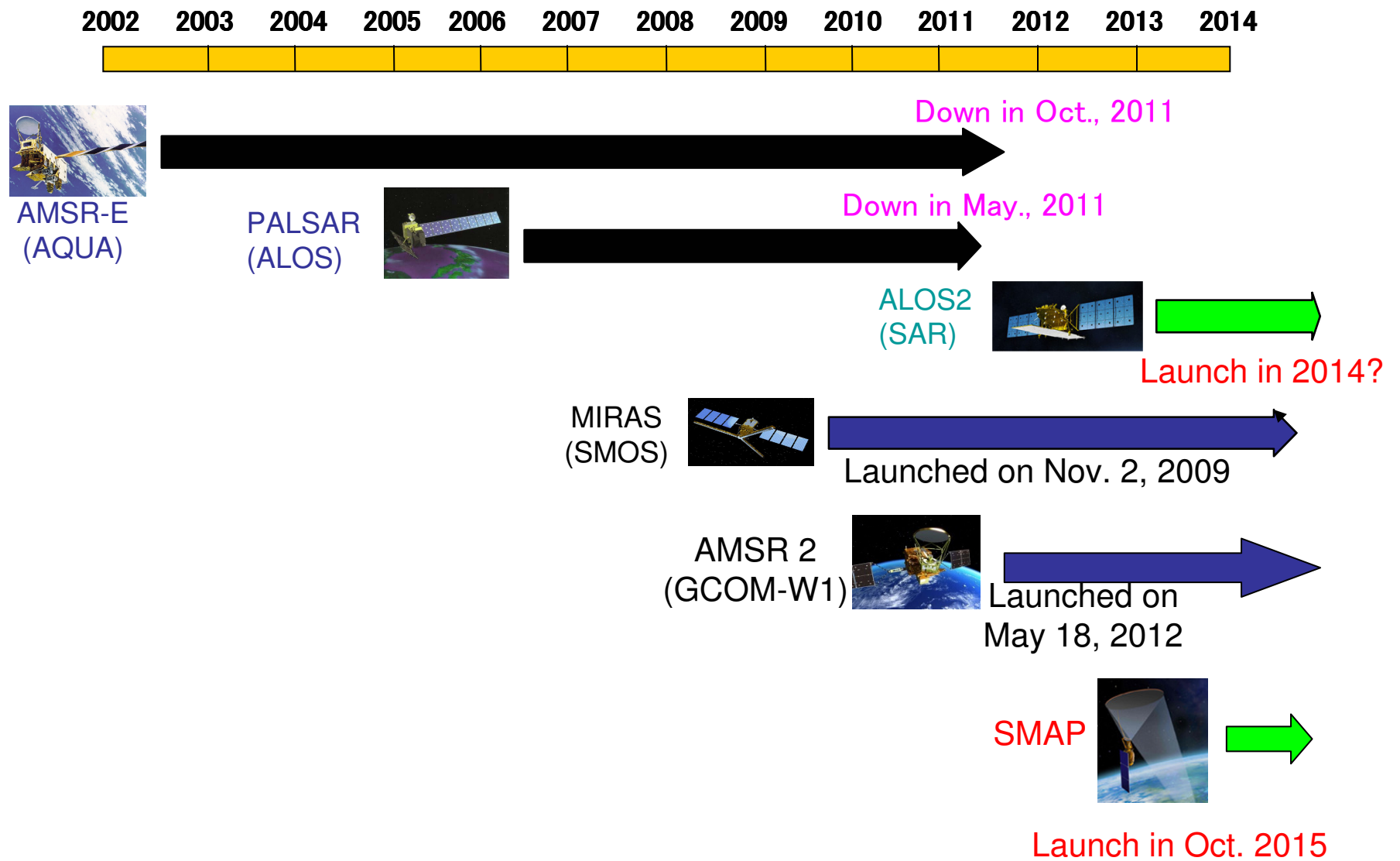   3) Influence of soil moisture change on vegetation
3. Summary

Background

◊ Studies of a role of soil moisture behaviors in water cycle, drought and vegetation change in Asia

◊ Long term monitoring of soil moisture by satellites (AQUA, ALOS, SMOS, GCOM-W, SMAP··) and ground-based stations for International projects and flames (*e.g.*, CEOP) and validation of the soil moisture algorithms such satellites
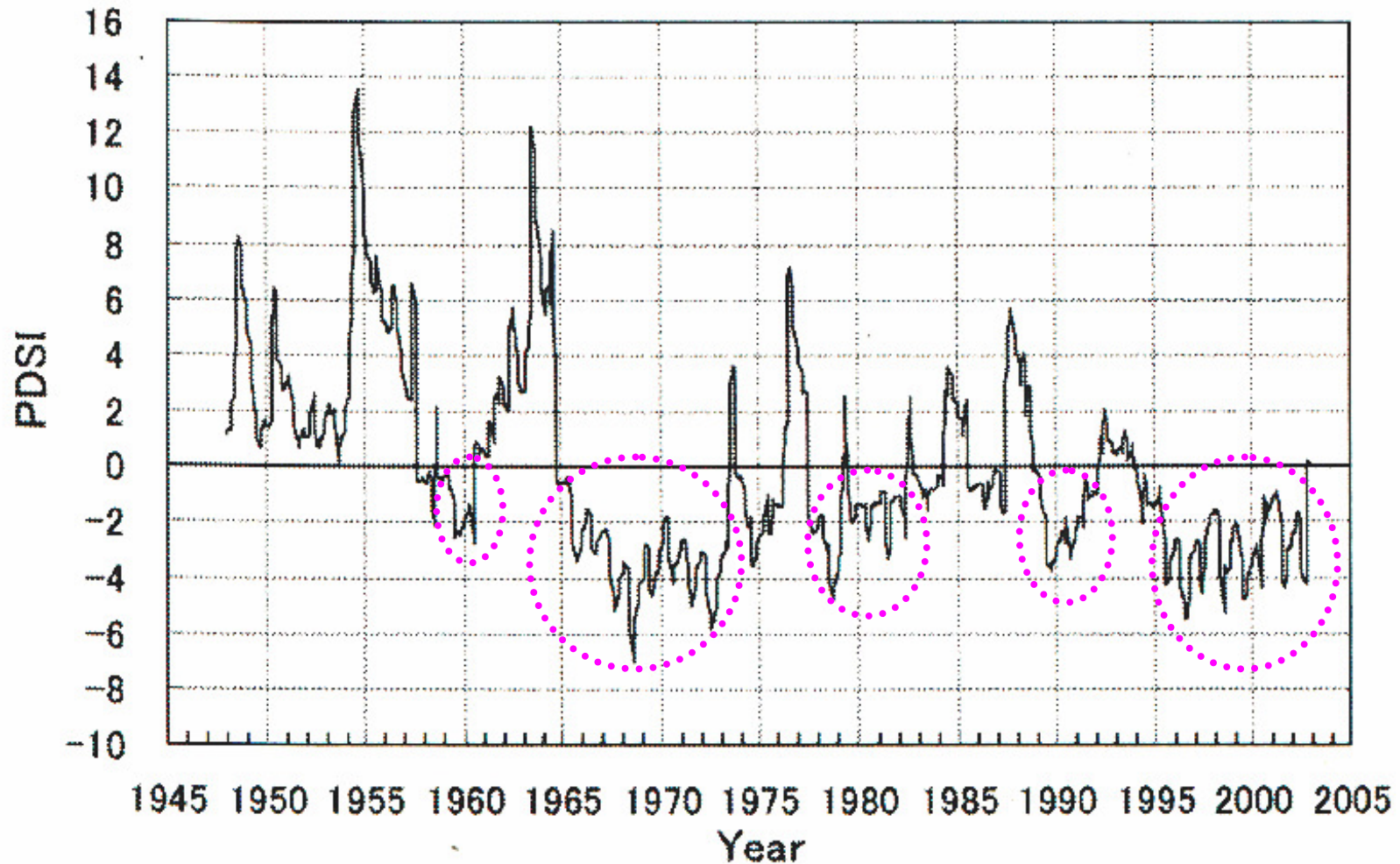
AQUA

ALOS

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014

Down in Oct., 2011

AMSR-E
(AQUA)

Down in May., 2011

PALSAR
(ALOS)

ALOS2
(SAR)

Launch in 2014?

MIRAS
(SMOS)

Launched on Nov. 2, 2009

AMSR 2
(GCOM-W1)

Launched on
May 18, 2012

SMAP

Launch in Oct. 2015

Ongoing and future main satellites for water cycle monitoring

Drought analysis results using PDSI (Palmer Drought Severity Index) in the target area including the MAVEX study area (Suzuki and Yamanaka, 2004)

Purposes of this presentation
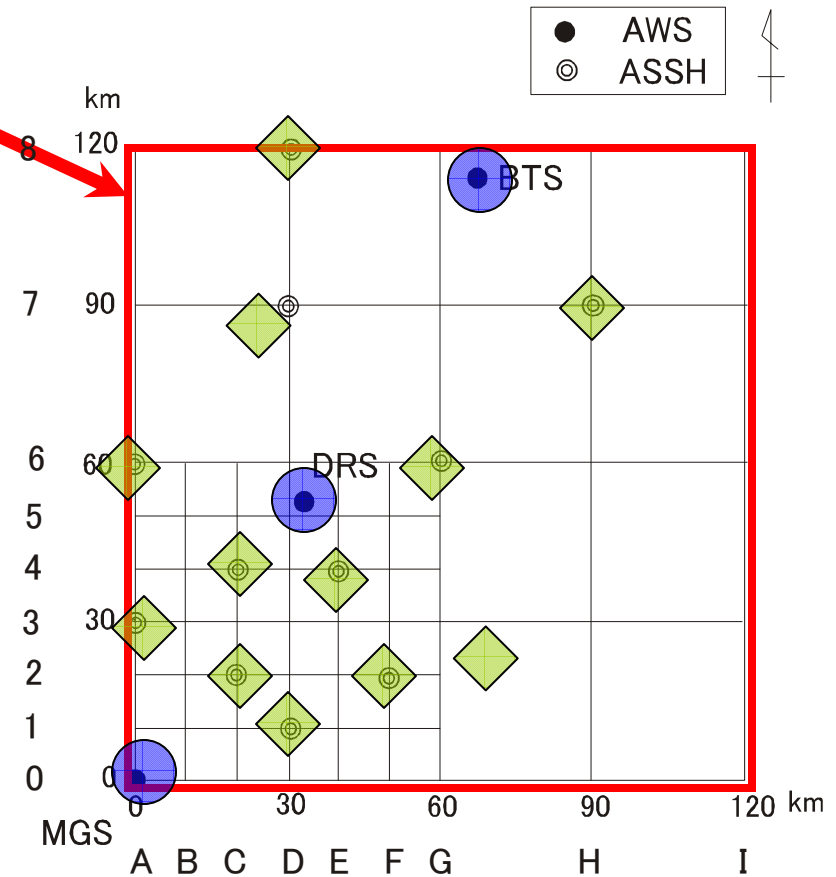
For understanding better drought

❏ To know the recent real conditions of rainfall change on the Mongolian Plateau

❏ To become aware of importance to measure soil moisture and rainfall for a long term
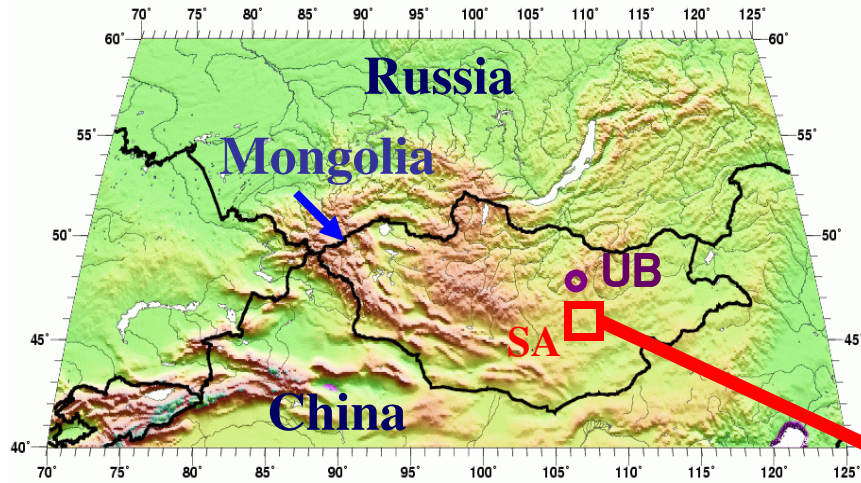
Study area for the AMSR-E/ AMSR2 validation in the Mongolian plateau (MAVEX site), AWCI and CEOP
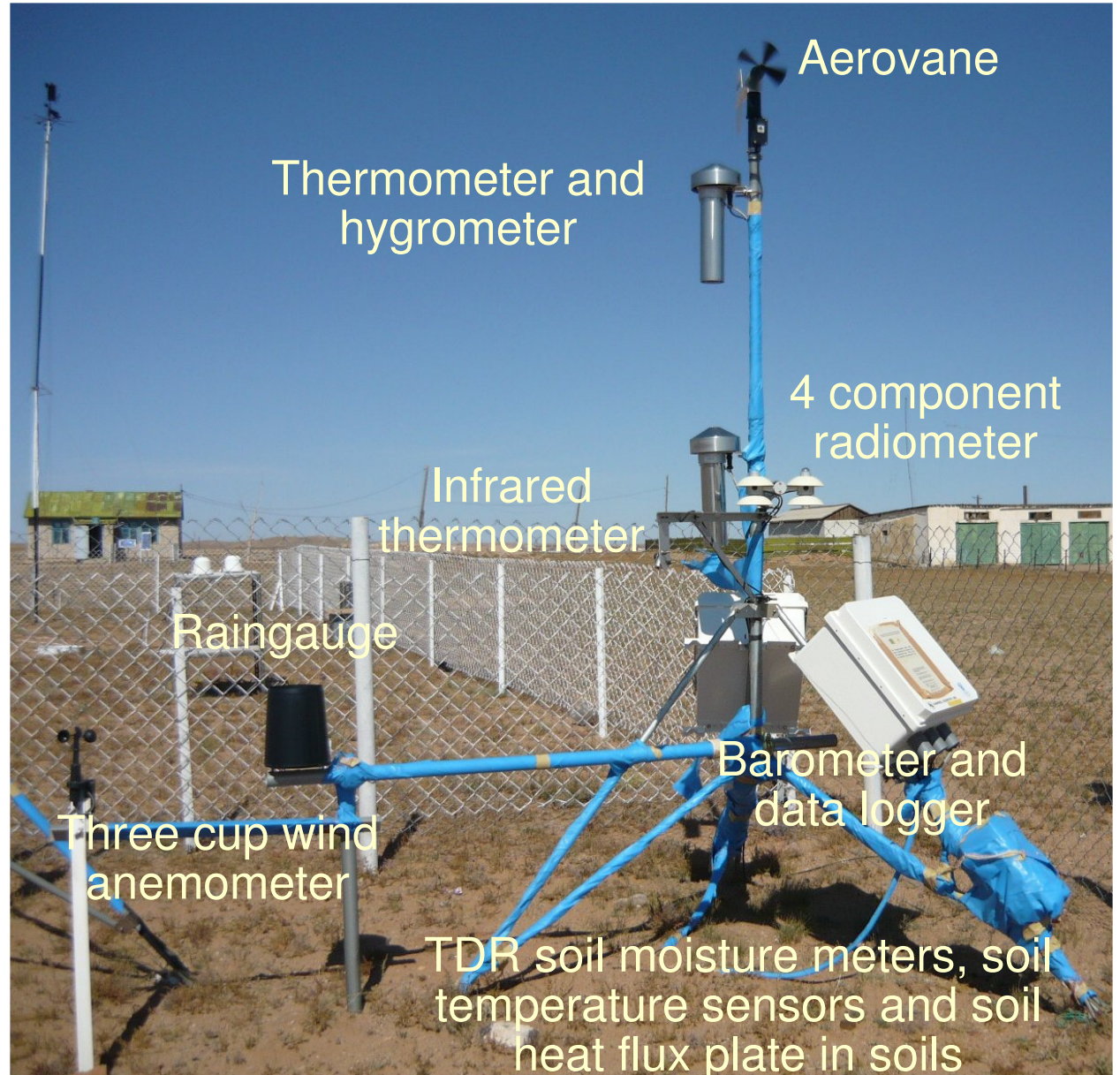
Working stations in the MAVEX (Mongol AMSR/AMSR-E/ALOS Validation Experiment) study area as of Sep., 2011 (:AWS (Automatic Weather Station), : ASSH (Automatic Station for Soil Hydrology), SA : Study area of AMPEX/MAVEX, UB: Ulaanbaatar)
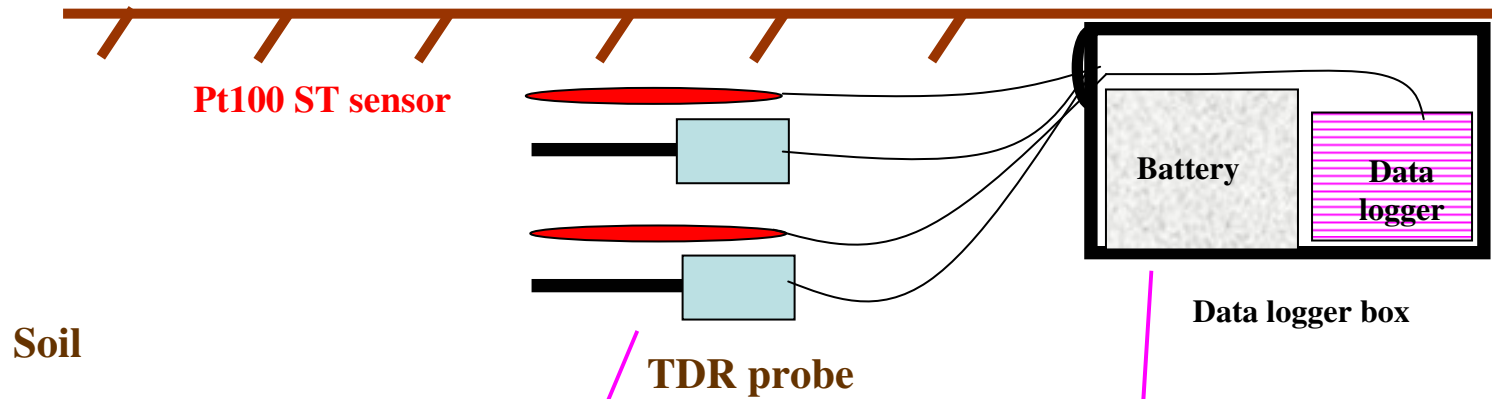
Flux AWS

AWS

3d. ultrasonic wave sensor

Thermometer and Hygrometer

Aerovane

Thermometer and hygrometer

4 component radiometer

Infrared thermometer

Raingauge

Barometer and data logger

Three cup wind anemometer

TDR soil moisture meters, soil temperature sensors and soil heat flux plate in soils

In situ observation at MGS
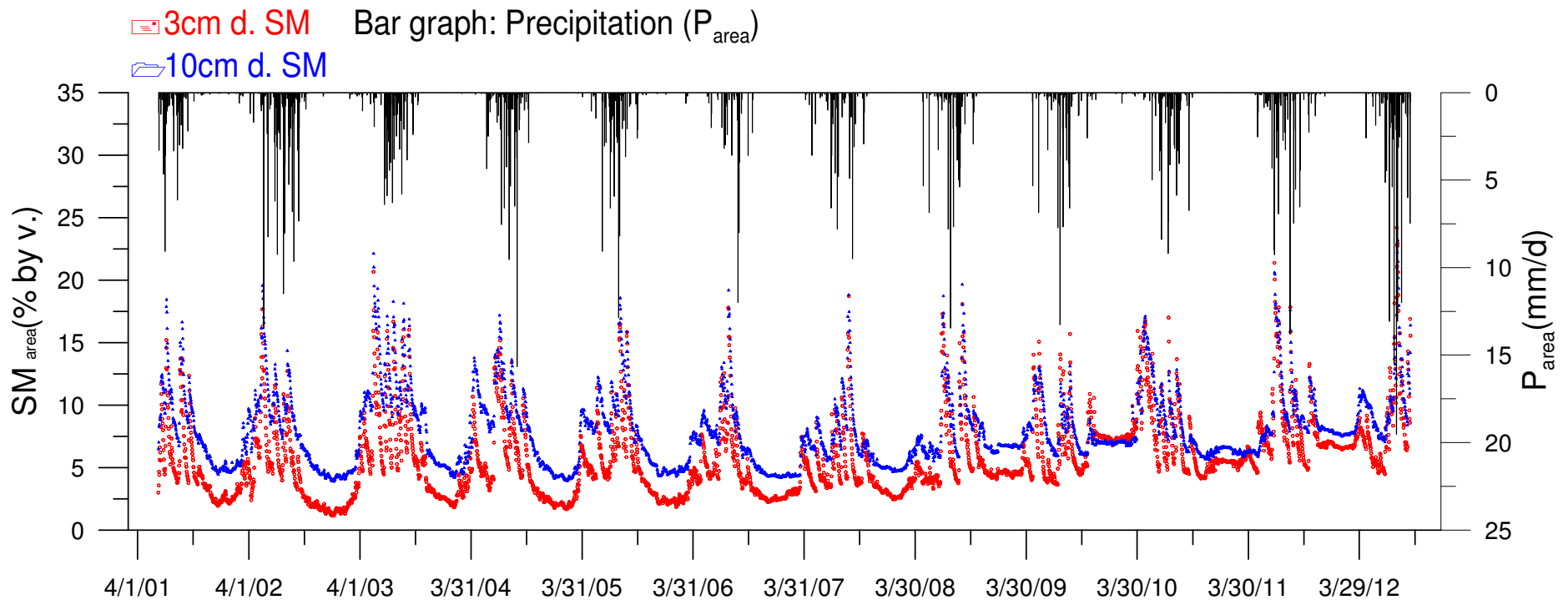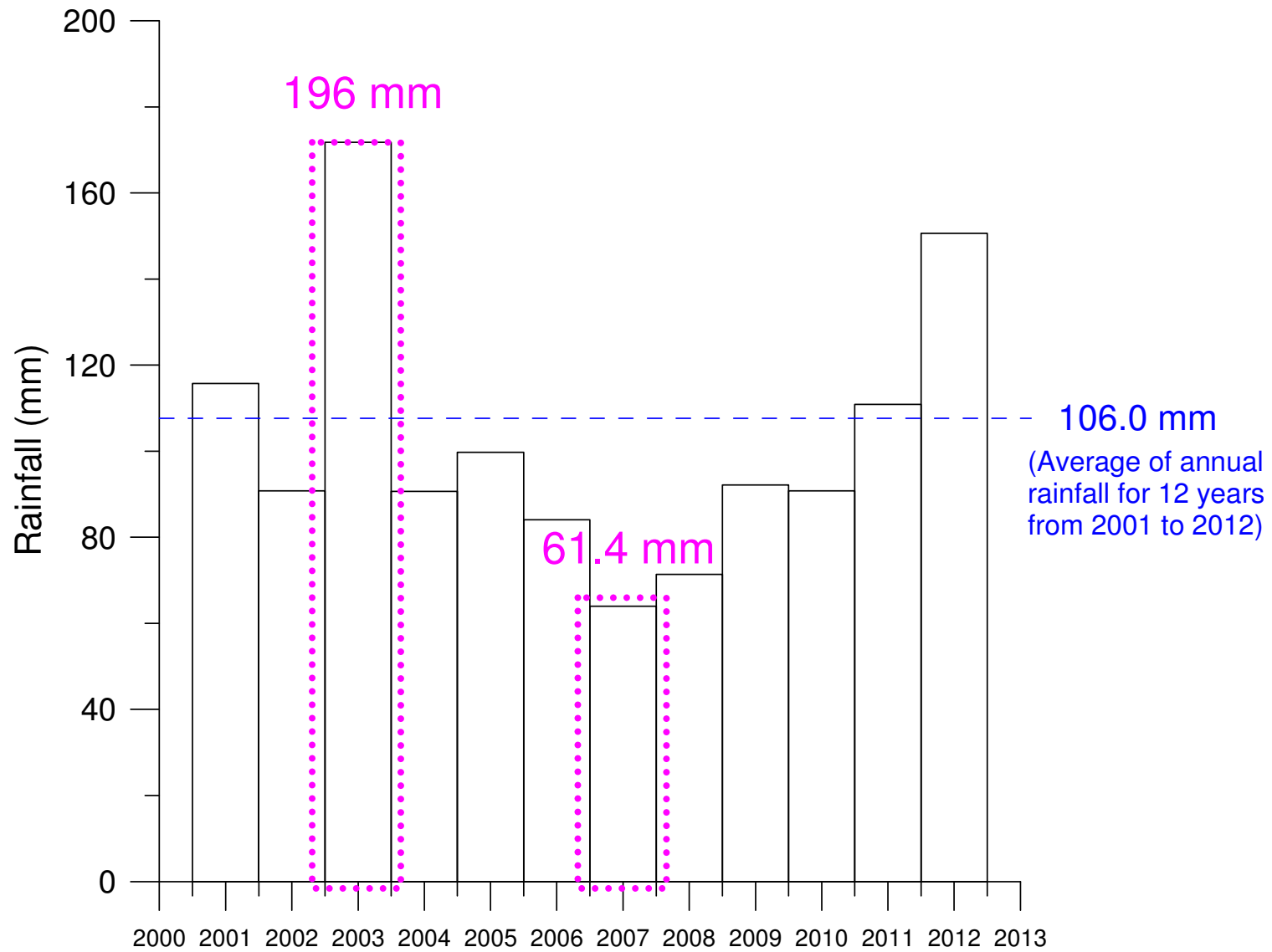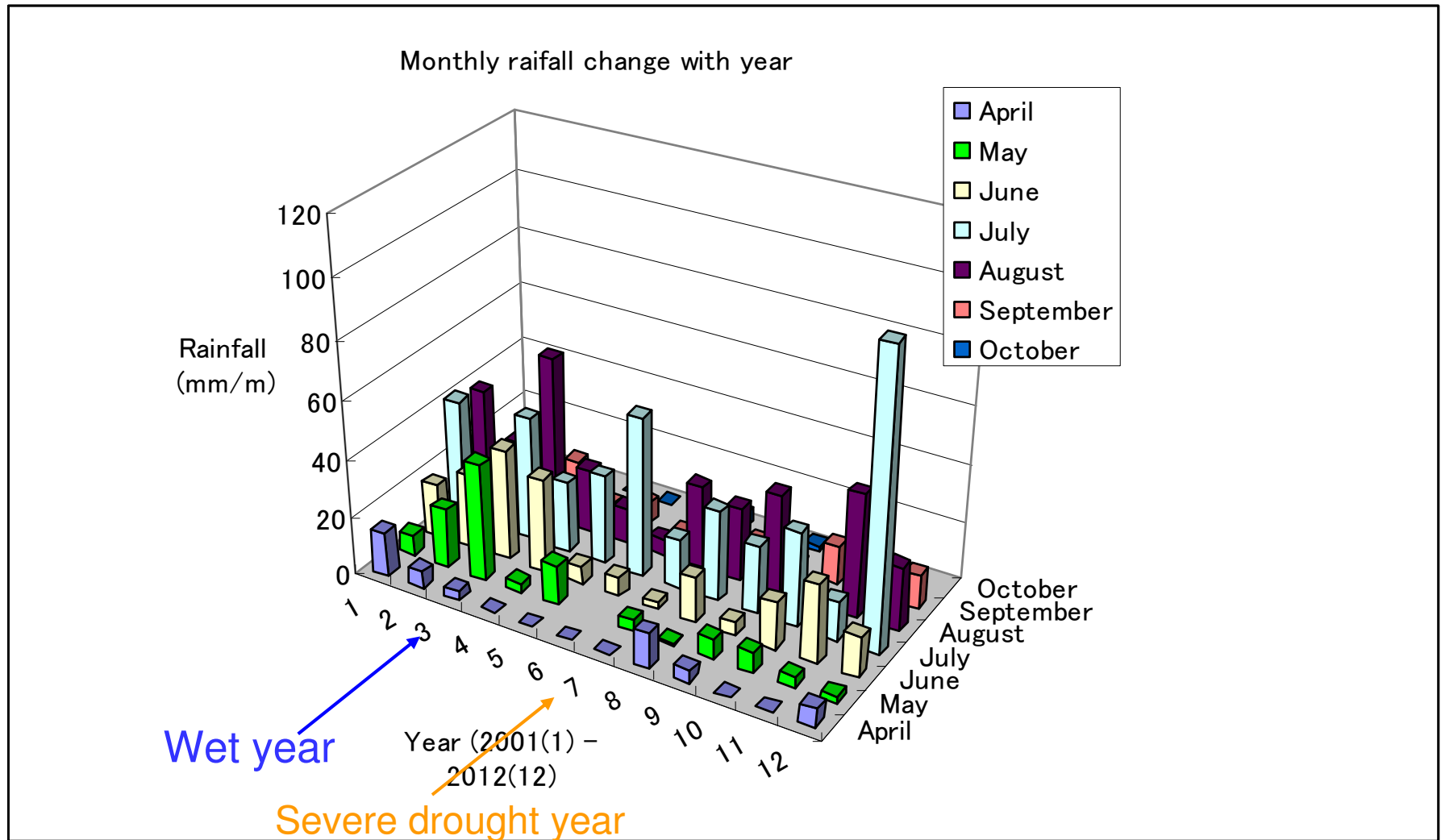
ASSH: In situ soil moisture measurement by TDR (Time Domain Reflectometry)

Time series of measurement results of in situ soil moisture (area averaged soil moisture) and area averaged precipitation (rainfall) from 2001 to 2012 in the MAVEX study area on the Mongolian Plateau
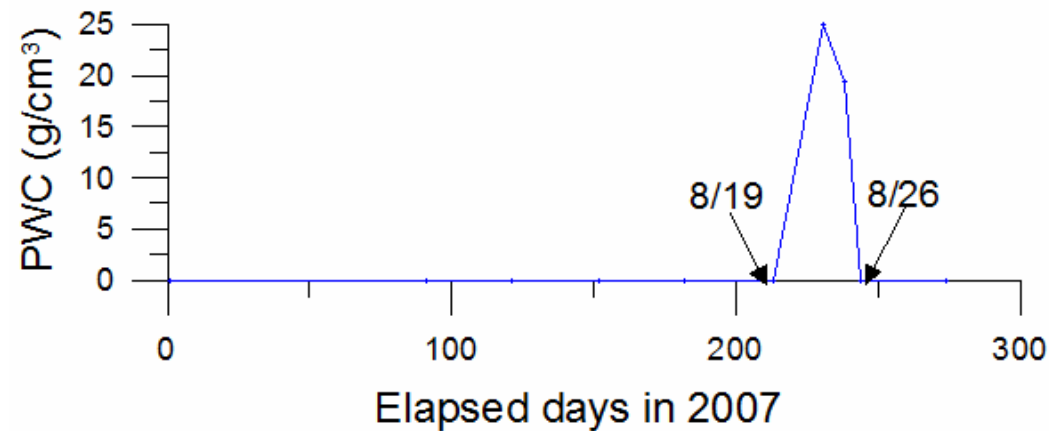
Annual precipitation change in the MAVEX study area from 2001 to 2012

Monthly rainfall change with year at MGS
from 2001 to 2012
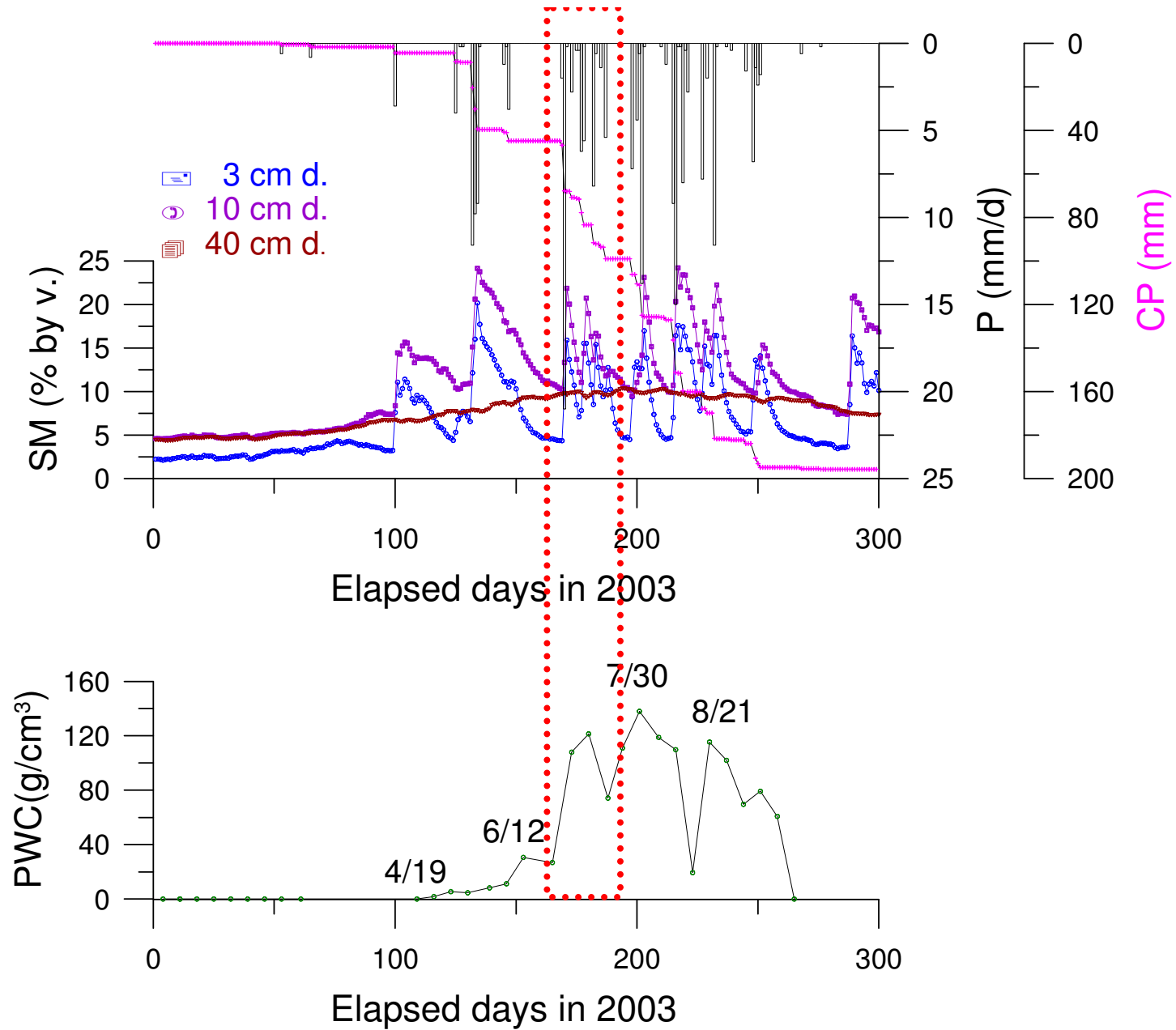
Change of soil moisture (SM), and plant water content (PWC), rainfall (P), and cumulative rainfall (CP) in 2003
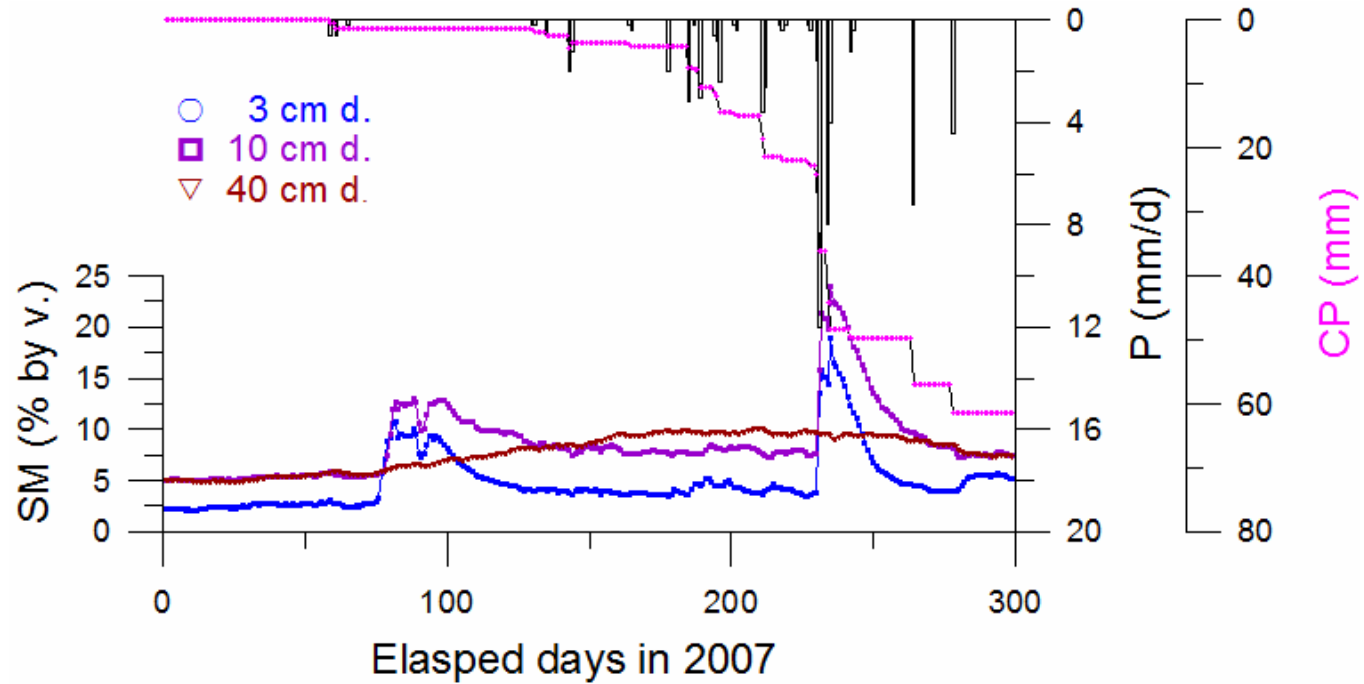
Change of soil moisture (SM), and plant water content (PWC), Rainfall (P), and cumulative rainfall (CP) in 2007

Multivariate analysis (Multivariate regression analysis)

Regression model

$$y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots + b_n x_n$$

y : dependant variable (→ plant water content → coverage → NDVI

by MODIS (Aqua and Terra))

a : constant

b : weighted coefficient (unknown parameters)

x : independent variables (air temperature, soil moisture, ‥)

n : 1, 2, 3‥

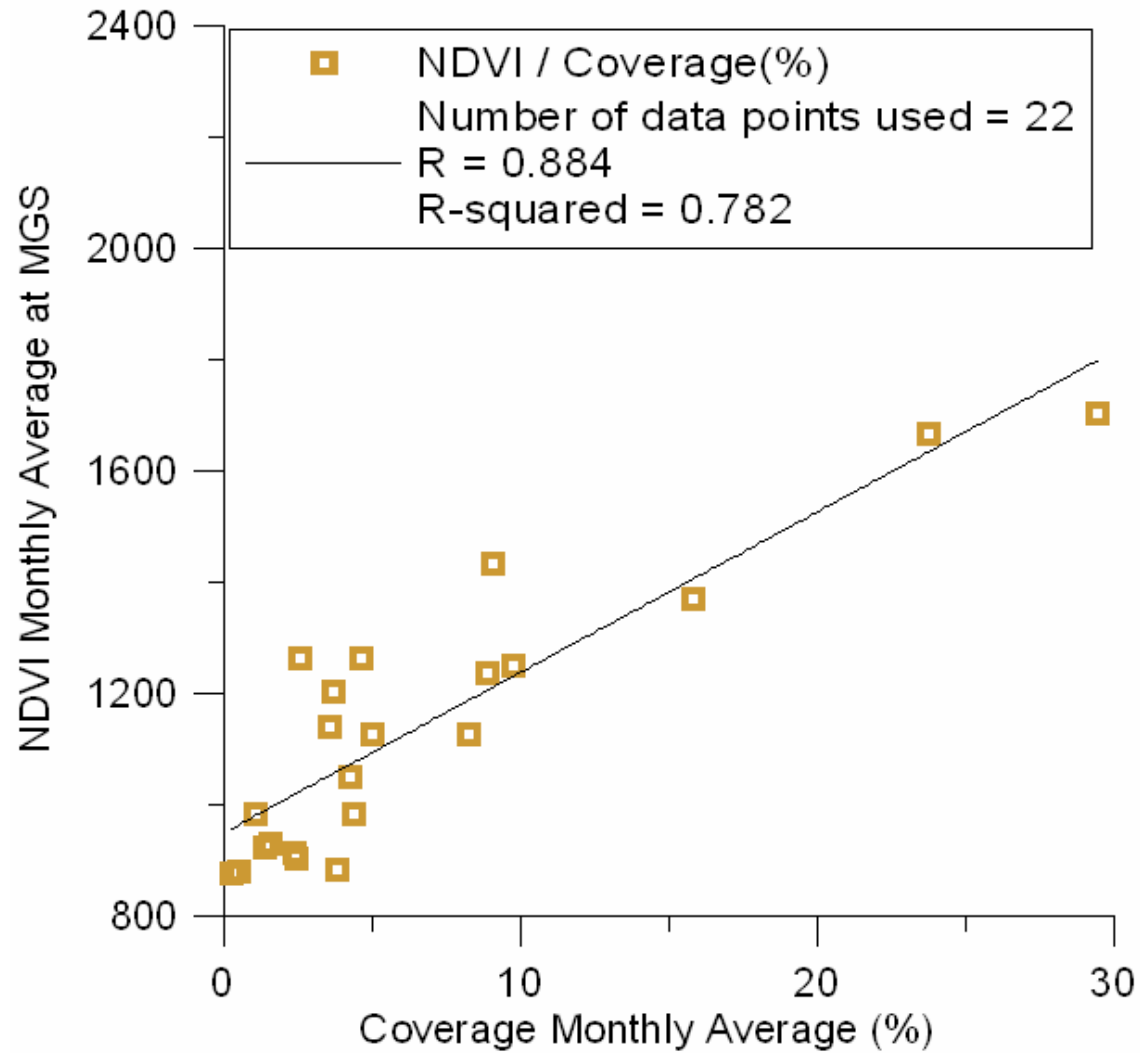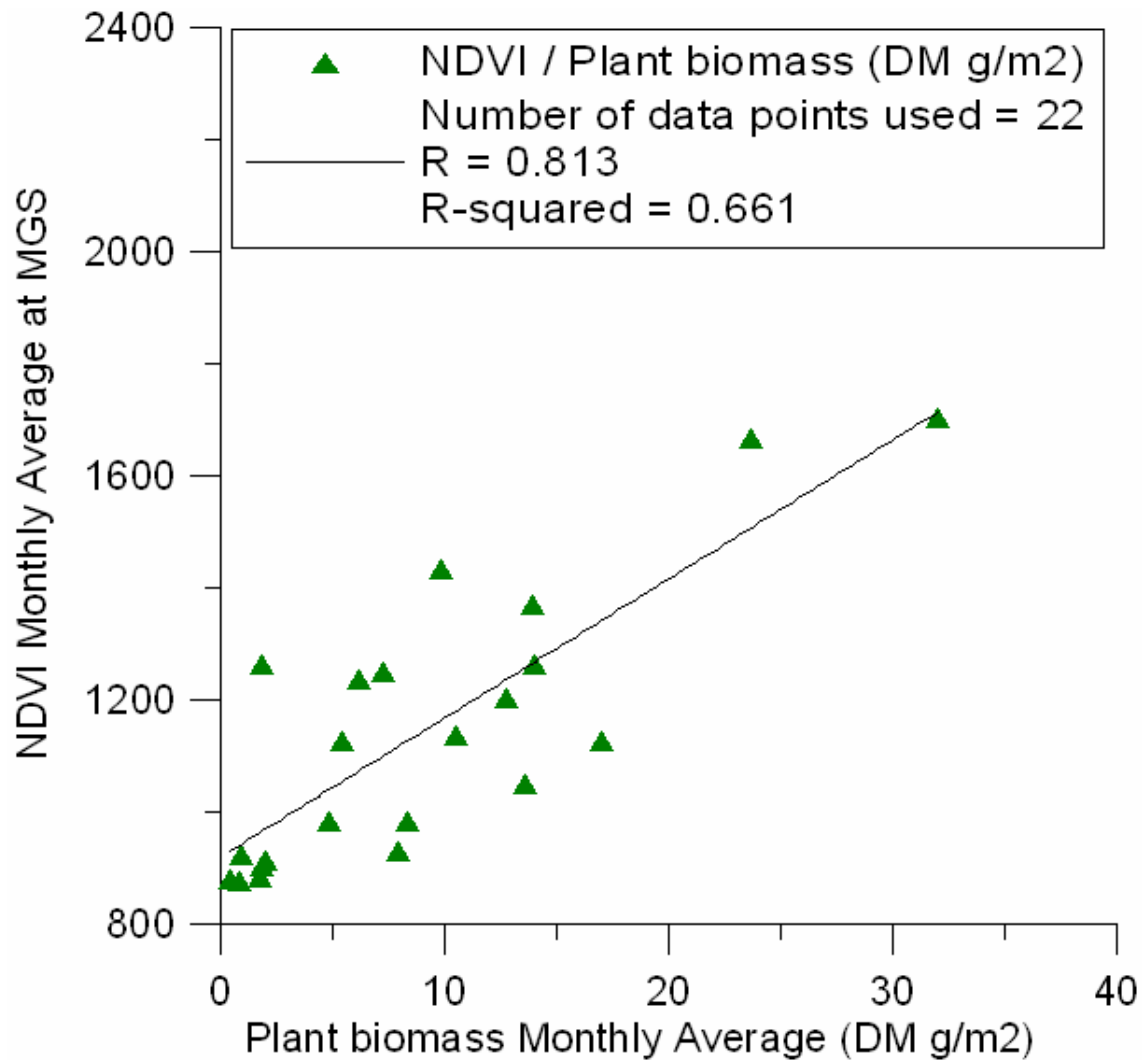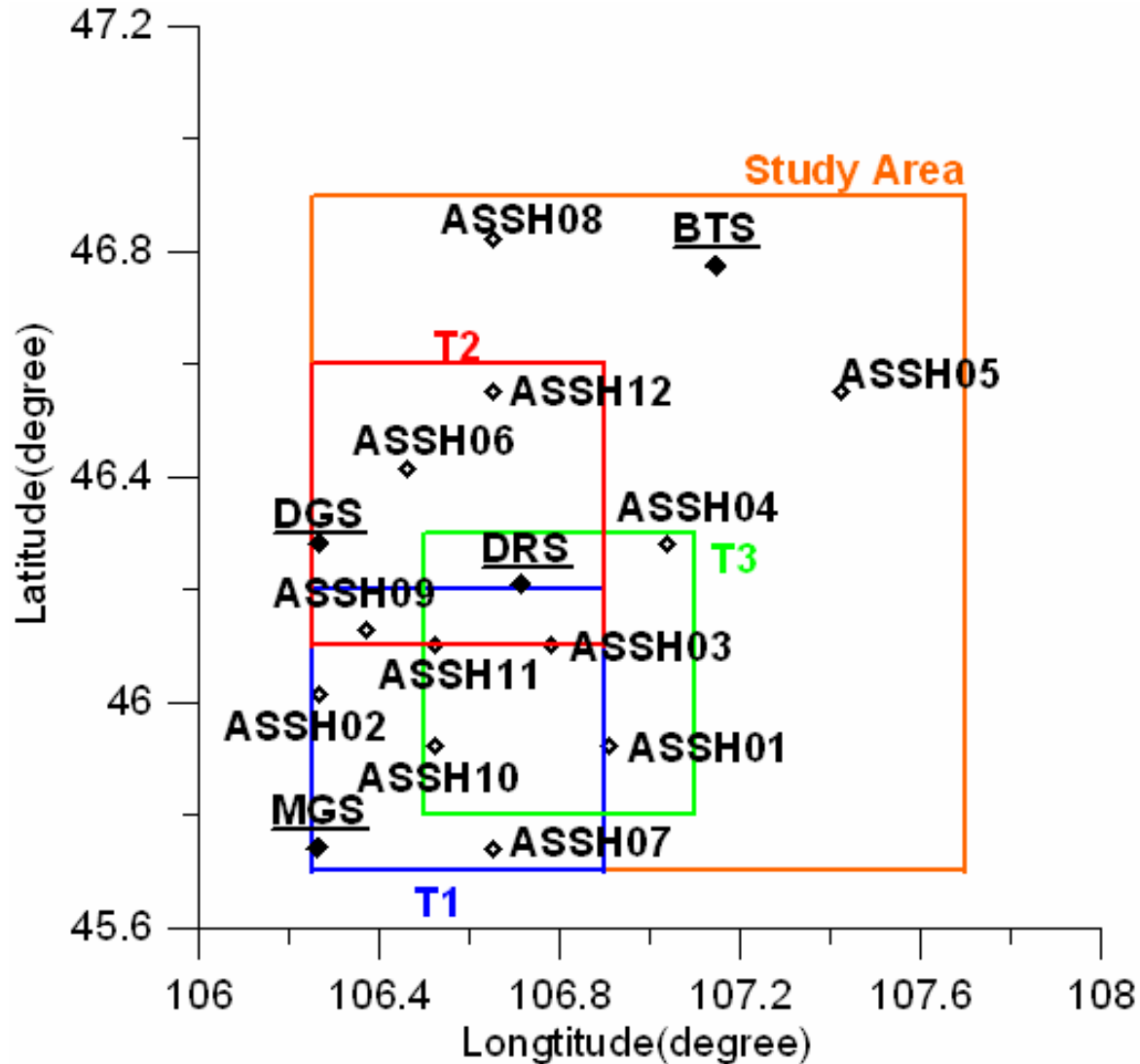Relationship between NDVI and coverage at MGS

Relationship between NDVI and biomass
(plant water content) at MGS

Target areas for Multivariate analysis
(Multivariate regression analysis)

Results 1
(Analysis 1 using the daily mean values of short radiation, air temperature, rainfall, soil temperature at 3cm depth, soil temperature at 10cm depth, soil moisture at 3cm depth, soil moisture at 10cm depth)

T2	切片	Rn(W/m2)	AT(℃)	P(mm)	ST1(℃)	ST2(℃)	SM1(%)	SM2(%)	重相関 R	重決定 R²	補正 R²	観測数
					t値							
2001年	1.9	−0.8	−0.2	1.9	1.0	−0.9	1.1	−1.1	0.95	0.90	0.77	13
2002年	0.0	−1.3	0.9	−0.7	0.1	0.4	−1.3	2.3	0.90	0.80	0.70	21
2003年	3.6	−0.1	2.7	0.5	0.3	0.2	0.8	−2.9	0.94	0.89	0.85	26
2004年	4.5	−0.8	1.2	1.1	−0.1	1.2	2.6	−2.2	0.96	0.92	0.88	26
2005年	1.2	1.5	1.3	0.9	−3.2	3.9	−0.1	0.5	0.93	0.86	0.81	26
2006年	1.3	−2.4	−2.6	−2.2	0.4	1.8	2.7	−0.2	0.96	0.92	0.89	26
2007年	6.2	−	−	−0.5	−2.3	2.4	−0.5	2.7	0.84	0.70	0.62	26
2008年	3.9	−	−	0.0	−3.9	4.1	−0.5	0.4	0.89	0.79	0.74	26
2009年	3.4	2.2	0.1	0.1	−1.2	1.1	2.2	−2.2	0.92	0.85	0.79	26
2010年	2.5	0.6	1.5	−0.6	−0.9	1.0	1.2	−1.5	0.88	0.77	0.68	26

t値 : t value of the t test

Results 2

(Analysis 2 using the maximum values of short radiation, air temperature, rainfall, soil temperature at 3cm depth, soil temperature at 10cm depth, soil moisture at 3cm depth, soil moisture at 10cm depth)

T2	切片	Rn(W/m2)	AT(℃)	P(mm)	ST1(℃)	ST2(℃)	SM1 (%)	SM2 (%)	重相関 R	重決定 R²	補正 R²	観測数
					t値							
2001 年	0.8	−1.1	0.7	−0.2	0.7	0.4	1.2	−0.6	0.94	0.88	0.71	13
2002年	2.4	−2.2	−1.3	−0.3	1.8	0.2	1.1	0.5	0.87	0.76	0.63	21
2003年	0.5	−1.9	0.7	0.3	0.7	1.2	0.1	−0.6	0.90	0.81	0.74	26
2004年	0.5	−1.6	0.9	1.6	0.2	2.6	0.7	−0.1	0.94	0.89	0.85	26
2005年	0.8	−0.2	−2.4	−0.9	−1.5	3.4	2.6	1.6	0.93	0.87	0.81	26
2006年	2.2	−0.8	−0.2	−0.6	0.3	0.8	5.1	−2.4	0.94	0.88	0.83	26
2007年	7.1	−	−	−	−0.7	0.7	6.1	0.2	0.89	0.79	0.71	26
2008年	2.4	0.9	−0.9	−2.3	−5.0	5.5	0.3	0.3	0.92	0.85	0.79	26
2009年	−1.2	−0.3	−0.3	1.2	0.0	0.7	0.1	0.9	0.93	0.87	0.82	26
2010年	−1.0	−0.5	−0.1	−3.0	−1.1	1.9	3.3	−0.2	0.94	0.88	0.83	26

t値 : t value of the t test

Summary

❒ Indispensable to monitor hourly in situ soil moisture with meteorological elements

❒ Remarkable influence of soil moisture change on plant growth on the Mongolian Plateau