

Exercise Part 1

- Producing Guidance and Verification -

TCC Training Seminar on Seasonal Prediction Products

11-15 November 2013

Objectives

- To understand how to produce guidance for seasonal temperature and precipitation.
- To think rationally and find possible predictors.
- To find more effective predictors.
- To verify the guidance based on deterministic and probabilistic methods.

Contents

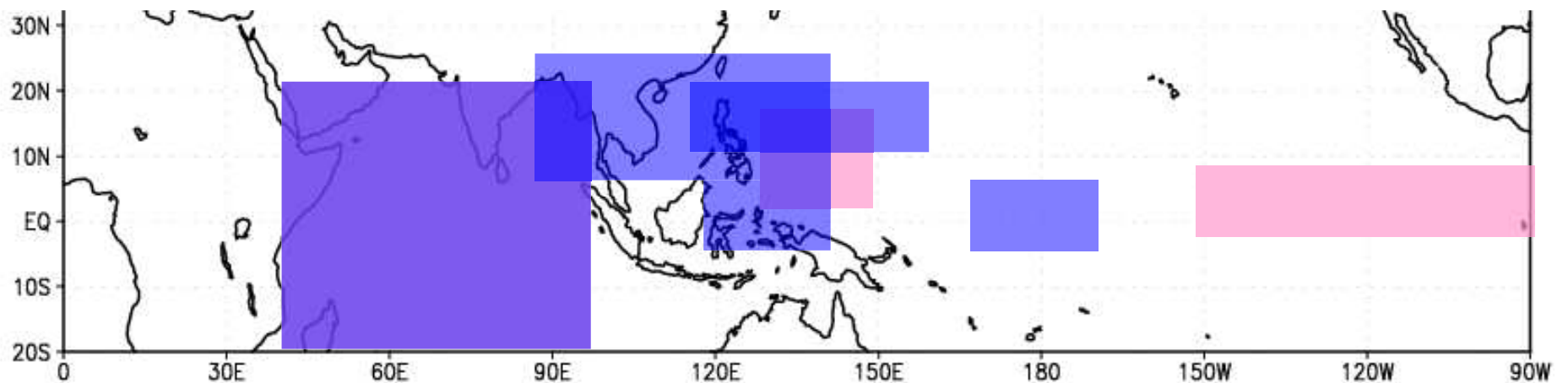
1. Single Regression Model
2. Multiple Regression Model
3. Probabilistic Forecast
4. Verification
 - 4.1 Deterministic Verification
 - 4.2 Probabilistic Verification

Preparations

- Observation data (You have prepared.)
- Predictors (init. 28th Sep. for DJF)
 - GPV data over your stations “*GPVdata.xls*”
 - Indices such as NINO3SST, Asia Monsoon, etc.
“*indices.xls*”
- Excel software for making guidance
“*ProducingGuidance.xls*”
- Excel software for verification
“*Verification.xls*”

Indices

	indices	variables	areas
SST	NINO3 SST	SST	(150W-90W, 5S-5N)
	NINOWEST SST	SST	(130E-150E, EQ-15N)
	IOBW SST	SST	(40E-100E, 20S-20N)
	WIO SST	SST	(40E-70E, 0-20N)
	EIO SST	SST	(70E-100E, 0-20N)
RAIN	IOBW RAIN	RAIN	(40E-100E, 20S-20N)
	WIO RAIN	RAIN	(40E-70E, 0-20N)
	EIO RAIN	RAIN	(70E-100E, 0-20N)
	SAMOI RAIN	RAIN	(80E-140E, 5N-25N)
	WNP RAIN	RAIN	(110E-160E, 10N-20N)
	SEAsia RAIN	RAIN	(115E-140E, 10N-20N)
	MC RAIN	RAIN	(110E-135E, 5S-5N)
	DL RAIN	RAIN	(170E-170W, 5S-5N)
Z500	Z2030	500hPa Height	(0-360, 20N-30N)
	Z3040	500hPa Height	(0-360, 30N-40N)
	Z4050	500hPa Height	(0-360, 40N-50N)
	Z5060	500hPa Height	(0-360, 50N-60N)
Thickness	THMD	Thickness Middle	(0-360, 30N-50N, 300hPa-850hPa)
	THEX	Thickness extratropic	(0-360, 30N-90N, 300hPa-850hPa)
	THTR	Thickness tropic	(0-360, 25S-25N, 100hPa-850hPa)



1. Single Regression Model

- Open the ProducingGuidance.xls.
- Paste observation data into the Temperature/Precipitation worksheet.

“1981 DJF” means
DJF of 1980/1981.

Observation	Year	Target	Mean Temp.	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast N(σ, σ _n)	Probabilistic Forecast N(σ, σ _n)	Probabilistic Forecast N(σ, σ _n)
	JJA/DJF		deg C					%		Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
5.8	1981 DJF											
6.3	1982 DJF											
7.3	1983 DJF											
4.6	1984 DJF											
6.1	1985 DJF											
5.4	1986 DJF											
7	1987 DJF											
6.9	1988 DJF											
8	1989 DJF											
7.3	1990 DJF											
7.6	1991 DJF											
7.6	1992 DJF											
7.8	1993 DJF											
6.9	1994 DJF											
7.3	1995 DJF											
6.6	1996 DJF											
7.7	1997 DJF											
7.2	1998 DJF											
7.4	1999 DJF											
7.5	2000 DJF											
6.8	2001 DJF											
7.9	2002 DJF											
6.4	2003 DJF											
8	2004 DJF											
7.4	2005 DJF											
6.1	2006 DJF											
8.6	2007 DJF											
0.8	2008 DJF											
8.1	2009 DJF											
7.5	2010 DJF											

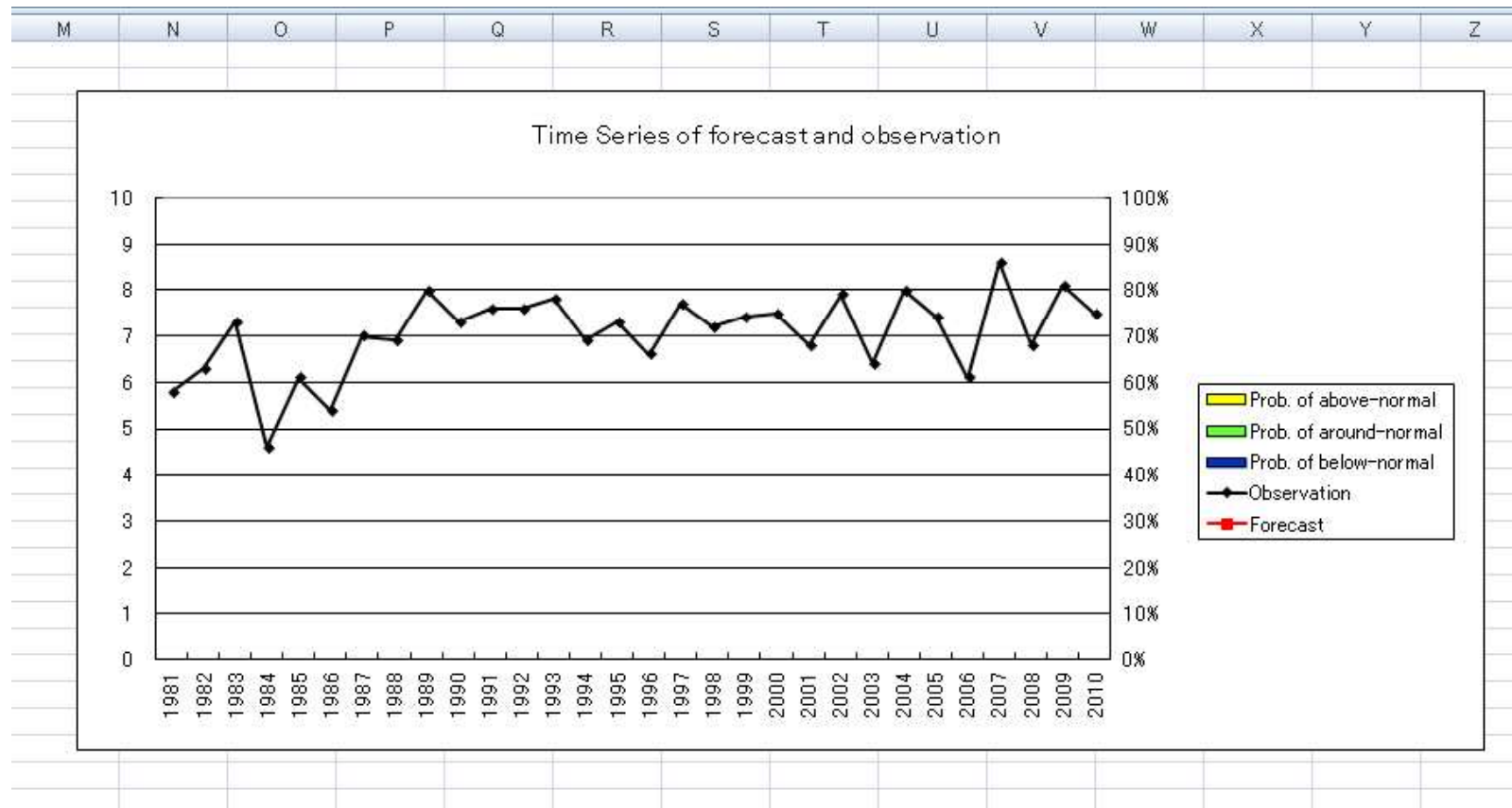
Paste observation data.

In this case, the predictand is temperature and the station is Tokyo.

Temperature worksheet

1. Single Regression Model

A graph of time series of the observation data has been automatically produced.



1. Single Regression Model

- Calculate the normal from 1981 to 2010.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast N(μ , σ)	Probabilistic Forecast N(μ , σ)	Probabilistic Forecast N(μ , σ)
1981	JJA/DJF	deg C	5.8							Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1982	DJF		6.3									
1983	DJF		7.3									
1984	DJF		4.6									
1985	DJF		6.1									
1986	DJF		5.4									
1987	DJF		7									
1988	DJF		6.9									
1989	DJF		8									
1990	DJF		7.3									
1991	DJF		7.6									
1992	DJF		7.6									
1993	DJF		7.8									
1994	DJF		6.9									
1995	DJF		7.3									
1996	DJF		6.6									
1997	DJF		7.7									
1998	DJF		7.2									
1999	DJF		7.4									
2000	DJF		7.5									
2001	DJF		6.8									
2002	DJF		7.9									
2003	DJF		6.4									
2004	DJF		8									
2005	DJF		7.4									
2006	DJF		6.1									
2007	DJF		8.6									
2008	DJF		6.8									
2009	DJF		8.1									
2010	DJF		7.5									
Normal			7.1									
The lower limit of around normal												
The upper limit of around normal												
Single Regression	slope		#DIV/0!	#DIV/0!	#DIV/0!							
	intercept		#DIV/0!	#DIV/0!	#DIV/0!							
	Correlation		#DIV/0!	#DIV/0!	#DIV/0!							
Multiple Regression	slope		#VALUE!	#VALUE!	#VALUE!							
	intercept		#VALUE!	#VALUE!	#VALUE!							
	Correlation		#DIV/0!									

Input “=AVERAGE(C4:C33)” at C34.

1. Single Regression Model

- Rank the data from 1981 to 2010 in descending order (preparation for probabilistic forecast).

The screenshot shows a Microsoft Excel spreadsheet with the following data table:

Year	Target	Mean Temp. deg C	Rank	Predictor 1	Predictor 2	Predictor 3	%s	Regression Error	Probabilistic Forecast N(s, σn)	Probabilistic Forecast N(s, σn)	Probabilistic Forecast N(s, σn)
1981	DJF	5.8	25								
1982	DJF	6.9									
1983	DJF	7.3									
1984	DJF	4.6									
1985	DJF	6.1									
1986	DJF	5.4									
1987	DJF	7									
1988	DJF	6.9									
1989	DJF	8									
1990	DJF	7.3									
1991	DJF	7.6									
1992	DJF	7.6									
1993	DJF	7.8									
1994	DJF	6.9									
1995	DJF	7.3									
1996	DJF	6.6									
1997	DJF	7.7									
1998	DJF	7.2									
1999	DJF	7.4									
2000	DJF	7.5									
2001	DJF	6.8									
2002	DJF	7.9									
2003	DJF	6.4									
2004	DJF	8									
2005	DJF	7.4									
2006	DJF	6.1									
2007	DJF	8.6									
2008	DJF	6.8									
2009	DJF	8.1									
2010	DJF	7.5									

Normal

		7.1									
The lower limit of around normal											
The upper limit of around normal											
slope			#DIV/0!	#DIV/0!	#DIV/0!						
intercept			#DIV/0!	#DIV/0!	#DIV/0!						
Correlation			#DIV/0!	#DIV/0!	#DIV/0!						
slope			#VALUE!	#VALUE!	#VALUE!						
intercept			#VALUE!	#VALUE!	#VALUE!						
Correlation			#DIV/0!								

Time Series of predictor and predictand

1. Single Regression Model

- Rank the data from 1981 to 2010 (preparation for probabilistic forecast).

The screenshot shows an Excel spreadsheet with the following data table:

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	%s	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg C									N(s, σ_n)	N(s, σ_n)	N(s, σ_n)
1981	DJF	5.8	28									
1982	DJF	6.9	25									
1983	DJF	7.3	14									
1984	DJF	4.6	30									
1985	DJF	6.1	26									
1986	DJF	5.4	29									
1987	DJF	7	18									
1988	DJF	6.9	19									
1989	DJF	8	3									
1990	DJF	7.3	14									
1991	DJF	7.6	8									
1992	DJF	7.0	8									
1993	DJF	7.8	6									
1994	DJF	6.9	19									
1995	DJF	7.3	14									
1996	DJF	6.6	23									
1997	DJF	7.7	7									
1998	DJF	7.2	17									
1999	DJF	7.4	12									
2000	DJF	7.5	10									
2001	DJF	6.8	21									
2002	DJF	7.9	5									
2003	DJF	6.4	24									
2004	DJF	8	3									
2005	DJF	7.4	12									
2006	DJF	6.1	26									
2007	DJF	8.6	1									
2008	DJF	0.8	21									
2009	DJF	8.1	2									
2010	DJF	7.5	10									
Normal		7.1										
The lower limit of around normal												
The upper limit of around normal												
Single Regression	slope		#DIV/0!	#DIV/0!	#DIV/0!							
	intercept		#DIV/0!	#DIV/0!	#DIV/0!							
	Correlation		#DIV/0!	#DIV/0!	#DIV/0!							
Multiple Regression	slope		#VALUE!	#VALUE!	#VALUE!							
	intercept		#VALUE!	#VALUE!	#VALUE!							
	Correlation		#DIV/0!									

Copy D4 and paste it into D5:D33.

1. Single Regression Model

- Calculate the upper and lower limits of around normal (preparation for probabilistic forecast).

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast N(μ, σ)	Probabilistic Forecast N(μ, σ)	Probabilistic Forecast N(μ, σ)
1981	DJF	5.8	28									
1982	DJF	6.3	25									
1983	DJF	7.3	14									
1984	DJF	4.6	30									
1985	DJF	6.1	26									
1986	DJF	5.4	29									
1987	DJF	7	18									
1988	DJF	6.9	19									
1989	DJF	8	3									
1990	DJF	7.3	14									
1991	DJF	7.6	8									
1992	DJF	7.6	8									
1993	DJF	7.8	6									
1994	DJF	6.9	19									
1995	DJF	7.3	14									
1996	DJF	6.6	23									
1997	DJF	7.7	7									
1998	DJF	7.2	17									
1999	DJF	7.4	12									
2000	DJF	7.5	10									
2001	DJF	6.8	21									
2002	DJF	7.9	5									
2003	DJF	6.4	24									
2004	DJF	8	3									
2005	DJF	7.4	12									
2006	DJF	6.1	26									
2007	DJF	8.6	1									
2008	DJF	6.8	21									
2009	DJF	8.1	2									
2010	DJF	7.5	10									
Normal		7.1										
The lower limit of around normal		6.9										
The upper limit of around normal		7.5										
Single Regression	slope				#DIV/0!							
Single Regression	intercept				#DIV/0!							
Single Regression	Correlation				#DIV/0!							
Multiple Regression	slope				#VALUE!	#VALUE!	#VALUE!					
Multiple Regression	intercept				#VALUE!							
Multiple Regression	Correlation				#DIV/0!							

Calculate the mean value of the rank 20th and 21st data (C35)

Calculate the mean value of the rank 10th and 11th data (C36)

1. Single Regression Model

Original line number	Year	Mean Temp	Rank
30	2007	8.6	1
32	2009	8.1	2
12	1989	8	3
27	2004	8	3
25	2002	7.9	5
16	1993	7.8	6
20	1997	7.7	7
14	1991	7.6	8
15	1992	7.6	8
23	2000	7.5	10
33	2010	7.5	10
22	1999	7.4	12
28	2005	7.4	12
6	1983	7.3	14
13	1990	7.3	14
18	1995	7.3	14
21	1998	7.2	17
10	1987	7	18
11	1988	6.9	19
17	1994	6.9	19
24	2001	6.8	21
31	2008	6.8	21
19	1996	6.6	23
26	2003	6.4	24
5	1982	6.3	25
8	1985	6.1	26
29	2006	6.1	26
4	1981	5.8	28
9	1986	5.4	29
7	1984	4.6	30

} The upper limit of around normal can be calculated as the average of "C23" and "C33".

} The lower limit of around normal can be calculated as the average of "C17" ("C11") and "C24" ("C31").

1. Single Regression Model

- Open GPVdata.xls and indices.xls. ← Predictors
- Select a predictor and paste the data into E column.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
	JJA/DJF	deg C			Tokyo			%		N(0, σ _n)	N(0, σ _n)	N(0, σ _n)
1981	DJF	5.8	28	-0.03								
1982	DJF	6.3	25	-0.20								
1983	DJF	7.3	14	0.21								
1984	DJF	4.6	30	-0.34								
1985	DJF	6.1	26	-0.80								
1986	DJF	5.4	29	-1.07								
1987	DJF	7	18	-0.07								
1988	DJF	6.9	19	0.18								
1989	DJF	8	3	-0.44								
1990	DJF	7.3	14	-0.44								
1991	DJF	7.6	8	-0.11								
1992	DJF	7.6	8	-0.37								
1993	DJF	7.8	6	-0.37								
1994	DJF	6.9	19	0.08								
1995	DJF	7.3	14	0.37								
1996	DJF	6.6	23	0.03								
1997	DJF	7.7	7	-0.29								
1998	DJF	7.2	17	1.25								
1999	DJF	7.4	12	-0.06								
2000	DJF	7.5	10	-0.16								
2001	DJF	6.8	21	-0.16								
2002	DJF	7.9	5	0.54								
2003	DJF	6.4	24	0.36								
2004	DJF	8	3	0.46								
2005	DJF	7.4	12	0.15								
2006	DJF	6.1	26	0.24								
2007	DJF	8.6	1	0.22								
2008	DJF	6.8	21	-0.31								
2009	DJF	8.1	2	-0.07								
2010	DJF	7.5	10	0.68								
Normal		7.1								σ _n		
The lower limit of around normal		6.9										
The upper limit of around normal		7.5										
slope					0.62	#DIV/0!	#DIV/0!					
intercept					7.07	#DIV/0!	#DIV/0!					
Correlation					0.32	#DIV/0!	#DIV/0!					
slope					#VALUE!	#VALUE!	#VALUE!					
intercept					#VALUE!	#VALUE!	#VALUE!					
Correlation					#DIV/0!							

In case of Tokyo, the anomaly correlation is 0.32 (not so large). I will try other predictors.

1. Single Regression Model

- Try other predictors.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg C	deg C			IOBW SST			%		N(0, σ _n)	N(0, σ _n)	N(0, σ _n)
1981	DJF	5.8	28		-0.13							
1982	DJF	6.3	25		-0.11							
1983	DJF	7.3	14		0.23							
1984	DJF	4.6	30		-0.33							
1985	DJF	6.1	26		-0.23							
1986	DJF	5.4	29		-0.28							
1987	DJF	7	18		-0.04							
1988	DJF	6.9	19		0.19							
1989	DJF	8	3		-0.26							
1990	DJF	7.3	14		-0.16							
1991	DJF	7.6	8		0.06							
1992	DJF	7.6	8		-0.02							
1993	DJF	7.8	6		-0.26							
1994	DJF	6.9	19		-0.12							
1995	DJF	7.3	14		0.06							
1996	DJF	6.6	23		-0.15							
1997	DJF	7.7	7		-0.10							
1998	DJF	7.2	17		0.53							
1999	DJF	7.4	12		-0.15							
2000	DJF	7.5	10		-0.15							
2001	DJF	6.8	21		0.04							
2002	DJF	7.9	5		0.11							
2003	DJF	6.4	24		0.23							
2004	DJF	8	3		0.06							
2005	DJF	7.4	12		0.05							
2006	DJF	6.1	26		0.11							
2007	DJF	8.6	1		0.32							
2008	DJF	6.8	21		-0.03							
2009	DJF	8.1	2		-0.05							
2010	DJF	7.5	10		0.41							

Normal 7.1
The lower limit of around normal 6.9
The upper limit of around normal 7.5

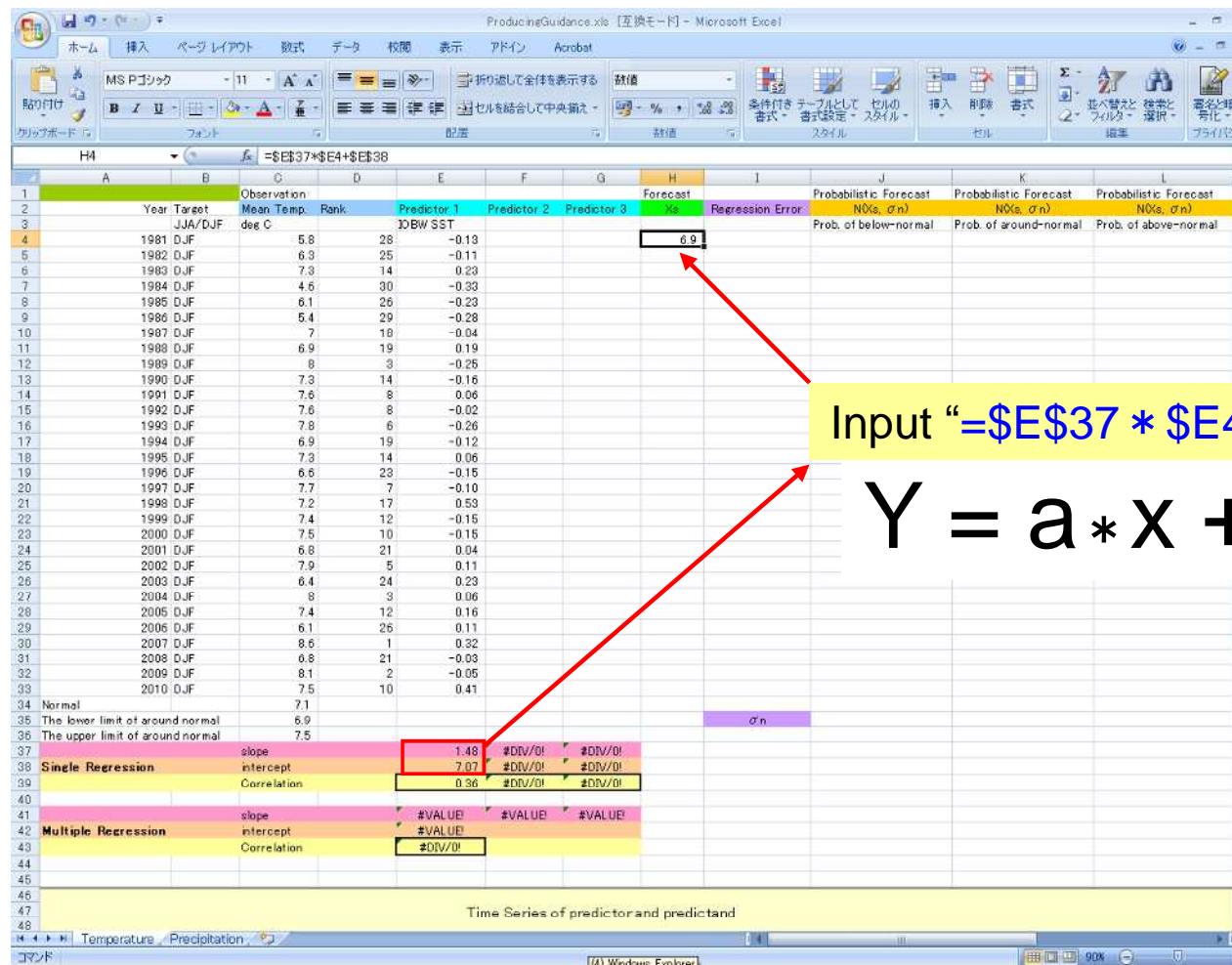
Single Regression	slope	1.48	#DIV/0!	#DIV/0!
	intercept	7.07	#DIV/0!	#DIV/0!
	Correlation	0.36		

Multiple Regression	slope	#VALUE!	#VALUE!	#VALUE!
	intercept	#VALUE!	#VALUE!	#VALUE!
	Correlation	#DIV/0!		

Please try to look for the most effective predictor.

1. Single Regression Model

- Calculate the forecasts using single regression equation.



1. Single Regression Model

- Calculate the forecasts using single regression equation.

The screenshot shows an Excel spreadsheet titled "ProducingGuidance.xls" with the following data and formulas:

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF		deg C			JOBW SST			%		N(μ, σ)	N(μ, σ)	N(μ, σ)
										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981 DJF	5.8	28	-0.13					6.9				
1982 DJF	6.3	25	-0.11					6.9				
1983 DJF	7.3	14	0.23					7.4				
1984 DJF	4.6	30	-0.33					6.6				
1985 DJF	6.1	26	-0.23					6.7				
1986 DJF	5.4	29	-0.28					6.7				
1987 DJF	7	18	-0.04					7.0				
1988 DJF	6.9	19	0.19					7.4				
1989 DJF	8	3	-0.25					6.7				
1990 DJF	7.3	14	-0.16					6.8				
1991 DJF	7.6	8	0.06					7.2				
1992 DJF	7.6	8	-0.02					7.0				
1993 DJF	7.8	6	-0.26					6.7				
1994 DJF	6.9	19	-0.12					6.9				
1995 DJF	7.3	14	0.06					7.2				
1996 DJF	6.6	23	-0.15					6.8				
1997 DJF	7.7	7	-0.10					6.9				
1998 DJF	7.2	17	0.53					7.9				
1999 DJF	7.4	12	-0.15					6.8				
2000 DJF	7.5	10	-0.15					6.8				
2001 DJF	6.8	21	0.04					7.1				
2002 DJF	7.9	5	0.11					7.2				
2003 DJF	6.4	24	0.23					7.4				
2004 DJF	8	3	0.06					7.2				
2005 DJF	7.4	12	0.16					7.3				
2006 DJF	6.1	26	0.11					7.2				
2007 DJF	8.6	1	0.32					7.5				
2008 DJF	6.8	21	-0.03					7.0				
2009 DJF	8.1	2	-0.05					7.0				
2010 DJF	7.5	10	0.41					7.7				
Normal		7.1										
The lower limit of around normal		6.9										
The upper limit of around normal		7.5										
slope			1.48	#DIV/0!	#DIV/0!							
intercept			7.07	#DIV/0!	#DIV/0!							
Correlation			0.36	#DIV/0!	#DIV/0!							
slope			#VALUE!	#VALUE!	#VALUE!							
intercept			#VALUE!	#VALUE!	#VALUE!							
Correlation			0.36									

Regression Statistics:

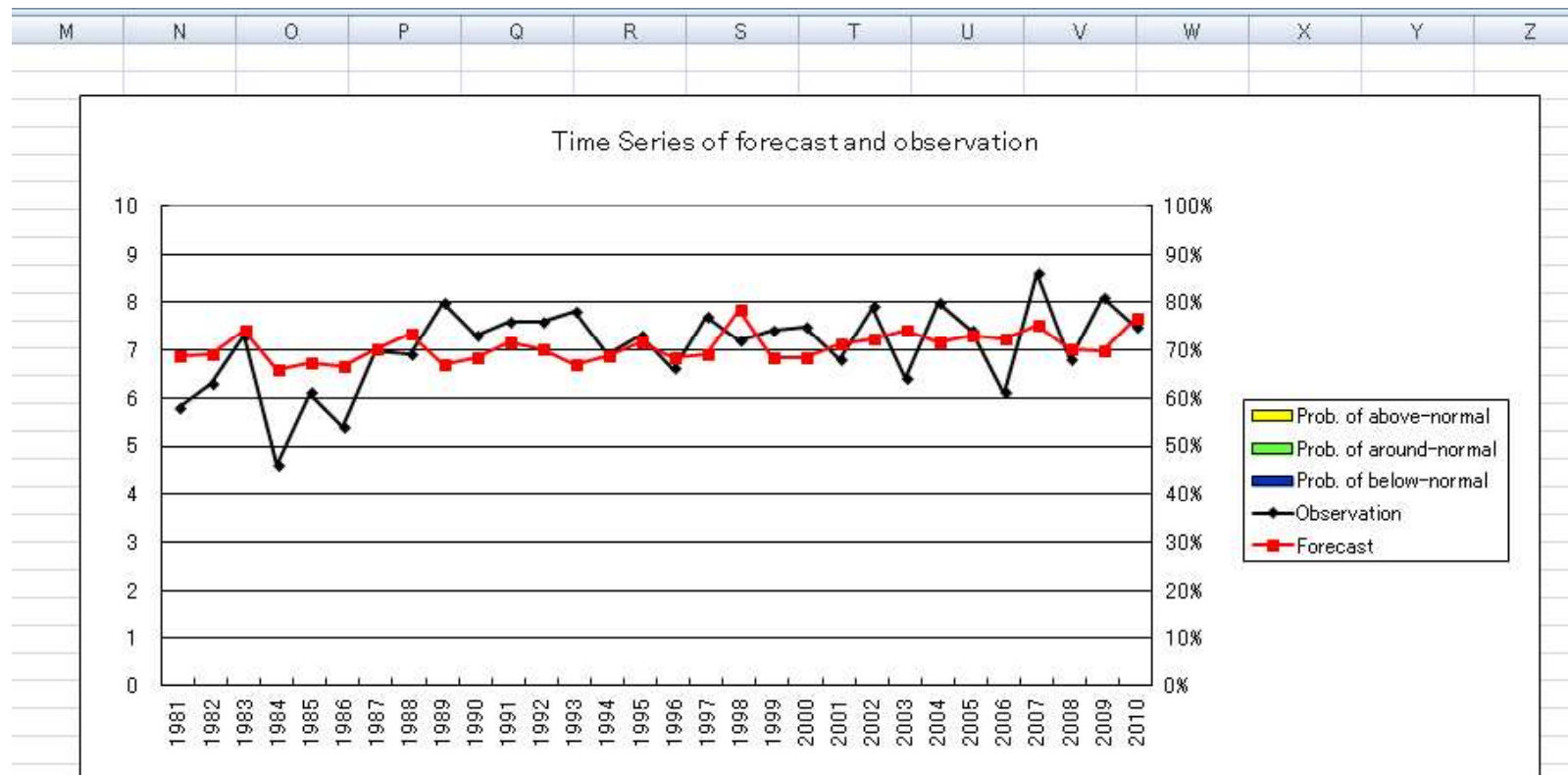
- Single Regression: slope = 1.48, intercept = 7.07, Correlation = 0.36
- Multiple Regression: slope = #VALUE!, intercept = #VALUE!, Correlation = 0.36

Time Series of predictor and predictand: Temperature, Precipitation

Copy H4 and paste it into H5:H33.

1. Single Regression Model

The time series of the forecast data has been automatically added to the graph.



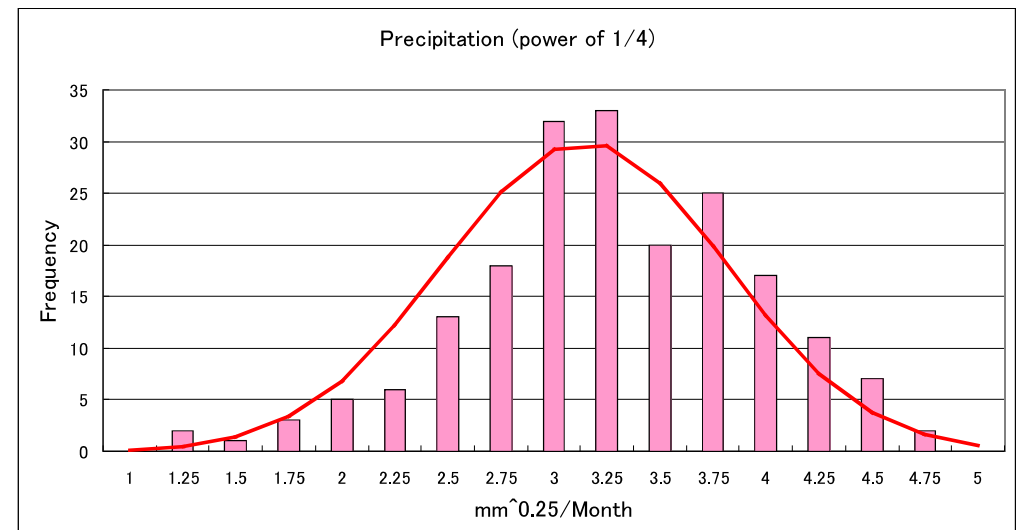
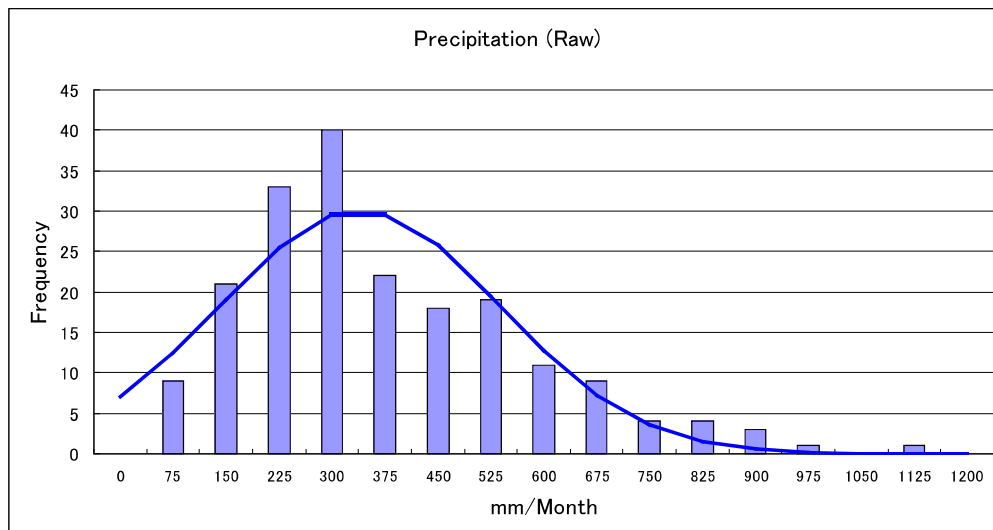
I will ask you the following questions at the end of this session:

1. "What predictor did you select?"
2. "Could you get an accurate guidance?"

1. Single Regression Model

How about precipitation?

The histogram of temperature is generally normal (Gaussian) distribution, but that of precipitation is usually Gamma distribution and has gaps from Gaussian distribution. The error distribution of regression model is assumed normal distribution, so normalization is necessary for precipitation. JMA seasonal forecast guidance uses the 1/4-power transformation as the simplest method.



The histogram of raw precipitation data has gaps from Gaussian distribution (left).
The histogram of the power of 1/4 of precipitation values is similar to Gaussian distribution (right).

1. Single Regression Model

How about precipitation?

Temperature worksheet

Year	Target	Observation	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
Year	Target	Observation	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981	5.9	29	-0.12				6.9				
1982	6.9	26	-0.11				6.9				
1983	7.3	14	0.23				7.4				
1984	4.6	29	-0.22				6.6				
1985	6.1	26	-0.22				6.7				
1986	5.4	29	-0.28				6.7				
1987	7	18	-0.04				7.4				
1988	6.9	19	-0.19				6.7				
1989	8	3	-0.25				6.7				
1990	7.3	14	-0.16				6.8				
1991	7.6	8	0.06				7.2				
1992	7.5	8	-0.02				7.0				
1993	7.8	6	-0.26				6.7				
1994	6.9	19	0.12				6.9				
1995	7.9	14	0.06				7.2				
1996	6.5	23	-0.15				6.6				
1997	7.7	7	-0.10				6.9				
1998	7.2	17	0.03				7.9				
1999	7.4	12	-0.15				6.8				
2000	7.5	10	-0.15				6.8				
2001	6.8	21	0.04				7.1				
2002	7.9	5	0.11				7.2				
2003	6.4	24	-0.23				7.4				
2004	8	3	0.05				7.2				
2005	7.4	12	0.16				7.5				
2006	6.1	26	-0.11				7.2				
2007	6.6	1	0.32				7.6				
2008	6.0	21	-0.03				7.0				
2009	6.1	2	-0.05				7.0				
2010	7.5	10	0.41				7.7				

Temperature worksheet

Precipitation worksheet

Year	Target	Observation	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
Year	Target	Observation	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981	753	226	28	-0.13			331	1205			
1982	915	308	24	-0.11			336	1313			
1983	96	93	25	0.03			344	1761			
1984	1085	323	19	-0.33			322	1079			
1985	2145	383	6	-0.23			330	1184			
1986	67	279	29	-0.20			329	1124			
1987	180	358	12	-0.04			344	1304			
1988	106	321	20	0.19			361	1698			
1989	300	377	10	-0.25			329	1167			
1990	179	345	13	-0.16			326	1255			
1991	160	357	14	0.05			351	1522			
1992	100	332	18	-0.02			340	1418			
1993	2379	390	5	-0.26			329	1186			
1994	2004	279	9	-0.12			326	1299			
1995	94	306	36	0.06			341	1604			
1996	56	276	30	-0.15			334	1269			
1997	964	315	22	-0.10			338	1323			
1998	273	406	2	0.03			386	2014			
1999	100	319	21	-0.15			336	1268			
2000	773	297	26	-0.15			338	1269			
2001	189	259	15	0.04			340	1409			
2002	1530	352	16	0.11			352	1562			
2003	249	397	4	0.03			360	1744			
2004	765	296	27	0.06			351	1523			
2005	2045	379	8	0.16			348	1845			
2006	1835	368	11	0.11			356	1888			
2007	2595	416	1	0.32			370	1872			
2008	1465	346	17	-0.03			345	1412			
2009	295	409	3	-0.06			343	1303			
2010	3065	379	7	0.41			371	2013			

Precipitation worksheet

the 1/4-power transformation

the 4th-power transformation

Precipitation worksheet has two additional columns related with "normalization". Please see the appendix slides to know the detail.

2. Multiple Regression Model

- Try to look for most effective combination of predictors.

“1981 DJF” means
DJF of 1980/1981.

Observation	Year	Target	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
Mean Temp.	JJA/DJF	deg C	EIO RAIN	THEX	MO RAIN	%		N(0, σ _n)	N(0, σ _n)	N(0, σ _n)
Rank								Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1	1981	5.8	-0.16	-0.18	0.29					
2	1982	6.3	-0.41	-0.20	0.52					
3	1983	7.3	-0.06	-0.16	-1.19					
4	1984	4.6	0.55	-0.14	0.25					
5	1985	6.1	-0.27	-0.32	0.06					
6	1986	5.4	0.08	-0.26	0.46					
7	1987	7	-0.41	-0.21	-0.47					
8	1988	6.9	0.35	-0.11	-0.21					
9	1989	8	0.30	-0.28	-0.03					
10	1990	7.3	-0.19	-0.11	0.77					
11	1991	7.6	0.11	0.02	0.04					
12	1992	7.6	-0.07	-0.01	-0.34					
13	1993	7.8	-0.33	-0.26	0.14					
14	1994	6.9	0.27	-0.23	-0.14					
15	1995	7.3	-0.08	-0.16	-0.62					
16	1996	6.6	-0.45	-0.02	0.12					
17	1997	7.7	-0.70	-0.02	0.12					
18	1998	7.2	0.05	0.33	-0.94					
19	1999	7.4	0.52	0.19	0.20					
20	2000	7.5	0.42	-0.11	0.27					
21	2001	6.8	0.33	0.12	0.31					
22	2002	7.9	-0.39	0.25	0.04					
23	2003	6.4	0.19	0.36	-0.31					
24	2004	8	0.39	0.18	0.53					
25	2005	7.4	-0.14	0.23	-0.06					
26	2006	6.1	-0.03	0.24	0.77					
27	2007	8.6	-0.04	0.31	-0.80					
28	2008	6.8	0.17	0.08	0.22					
29	2009	8.1	0.13	0.05	0.37					
30	2010	7.5	-0.16	0.41	-0.37					

Normal	slope	intercept	Correlation
7.1	-0.32	1.24	-0.54
The lower limit of around normal 6.9	7.06	7.06	7.06
The upper limit of around normal 7.5	0.12	0.31	0.30

Single Regression	slope	intercept	Correlation
	-0.35	1.15	-0.44
	7.06		
	#DIV/0!		

Select the most effective combination of predictors after trial and error.

Correlation coefficients
(the absolute values)

The ITACS will help you find them.

2. Multiple Regression Model

The screenshot shows the ITACS v4.0 web interface. The browser window title is "ITACS v4.0 - Windows Internet Explorer". The address bar shows the URL: http://intra.cpd.naps.kishou.go.jp/~climatex/itacs4/index1.php?dataset=SAT&element=olr&element_edit=&dtype=ANOM&area=30%2C190%2C-10%2C85%2CASI. The interface is divided into several sections:

- data1**: A table with columns: dataset (SAT), element (OLR [W/m²]), data type (ANOM), area (ASIA), level (1000hPa), average period (Year average), and show period (RANGE). There are also input fields for latitude (10-85) and longitude (30-190).
- analysis method**: A dropdown menu set to "REGRESSION_COEFFICIENT".
- data2**: A table with columns: dataset (USER INPUT), element (LAST_USED 2013/10/23 18:00:48), input txt (a list of observation data), average period (Year average), tag (0), and significance (90%(two side)).

Yellow callout boxes provide instructions:

- "Select REGRESSION_COEFFICIENT" points to the analysis method dropdown.
- "Select UPLOAD_TXT" points to the "LAST_USED" element in the data2 table.
- "Upload the observation data (In this case, TokyoDJFTemp.csv)" points to the "input txt" column in the data2 table.

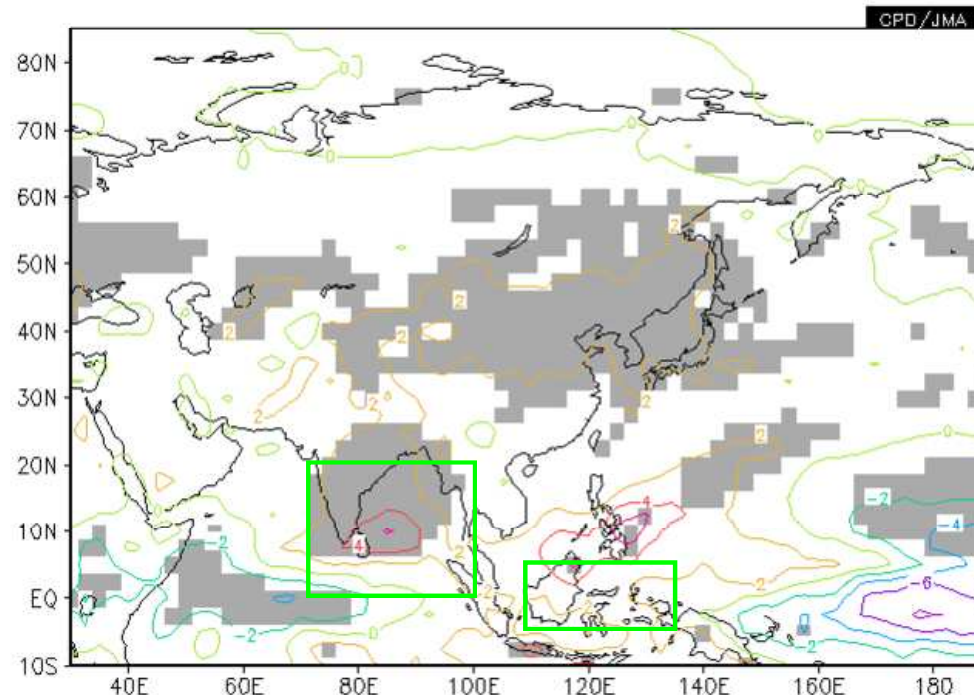
Graphic Option

Drawing: CONTOUR

ITACS

2. Multiple Regression Model

```
DATA1 SAT_olr ANOM lat = -10:85 lon = 30:190 level = 1:1  
time = 1980120100:2010020100 ave = 1YR(3+1MD)  
DATA2 INPUT_lastused HIST lat = -90:90 lon = 0:360 level = 1:1  
time = 1980120100:2010020100 ave = 1YR(3+1MD) analysis method = REGRESSION_COEFFICI
```

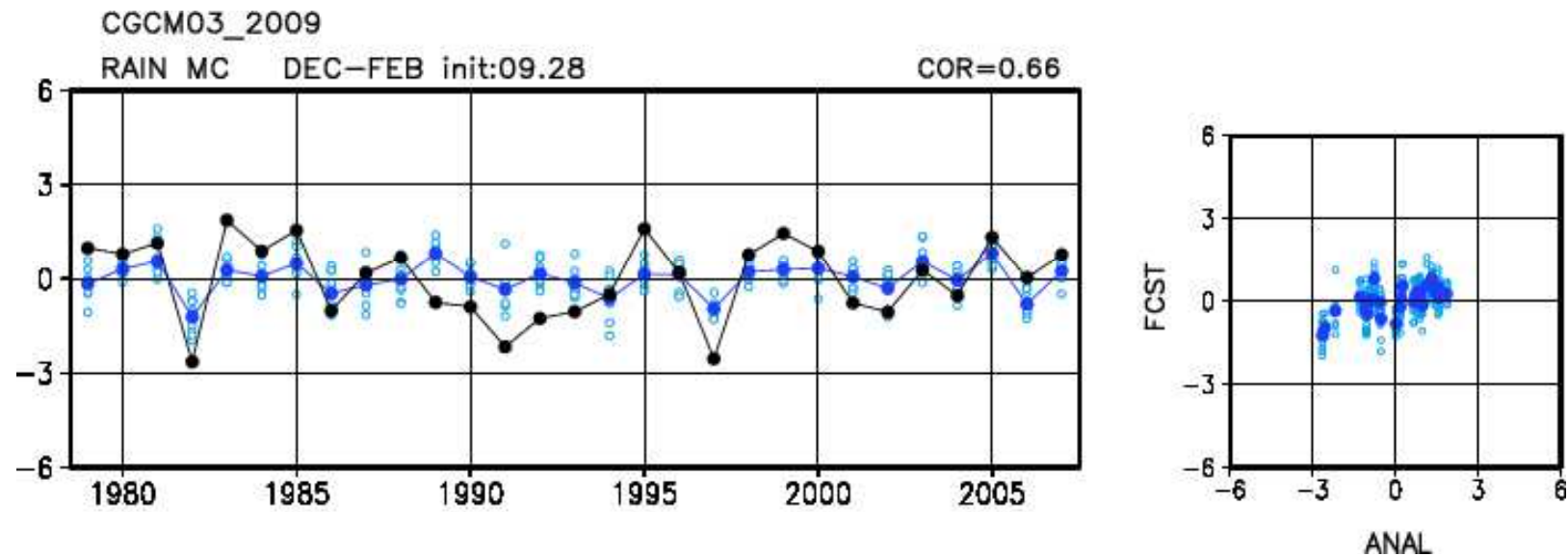


This is the relationship between OLR and DJF temperature in Tokyo. The OLR (convective activity) in Maritime Continent and that in the eastern Indian Ocean look possible predictors.

However, it is necessary to confirm the seasonal forecast model's skill about them.

2. Multiple Regression Model

Prediction skill evaluated by 30 years hindcast

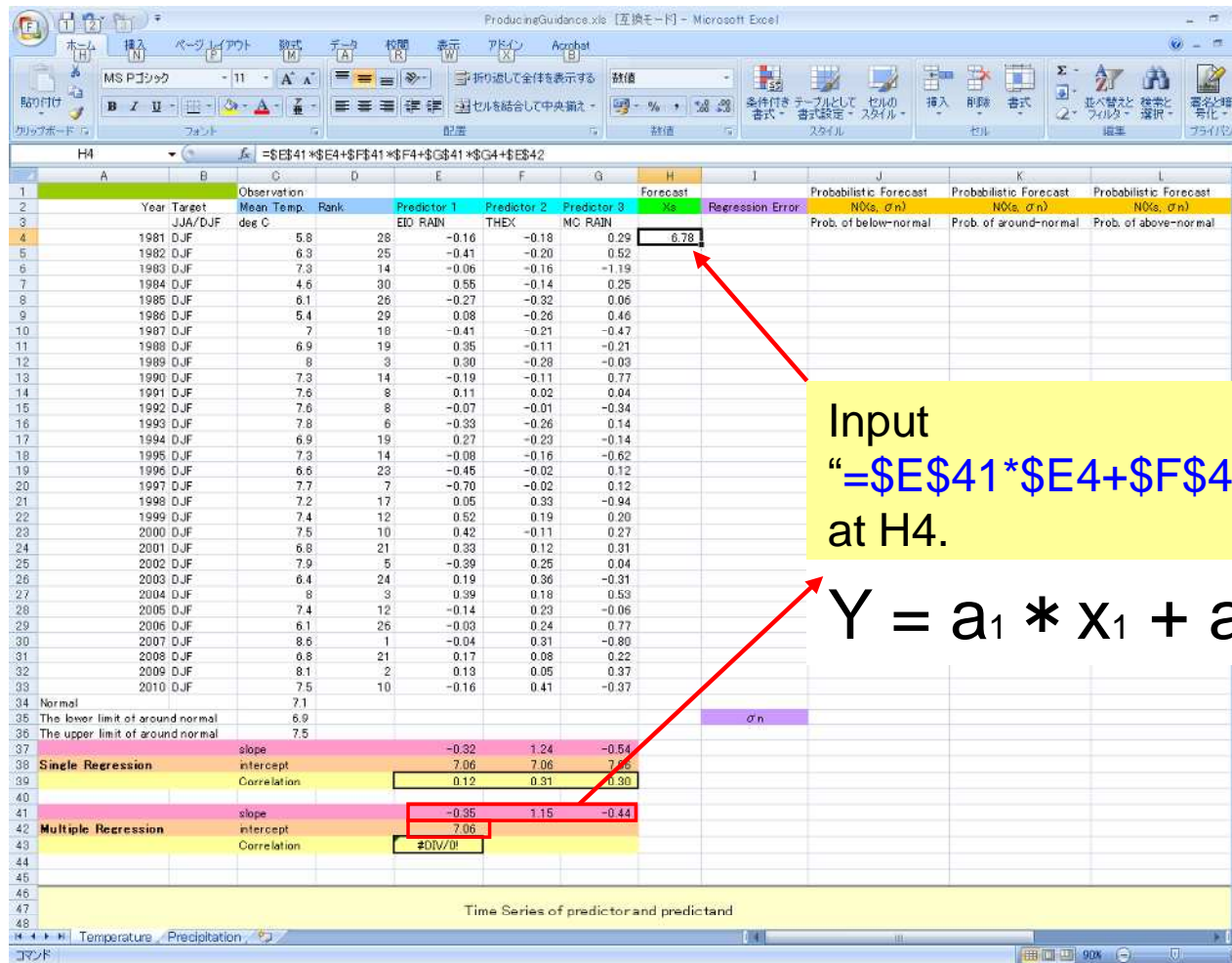


Anomaly correlation between the observed and forecasted DJF rainfall amounts in Maritime Continent is more than 0.6. Prediction skill is good.

http://ds.data.jma.go.jp/tcc/tcc/products/model/hindcast/cgcm03_vrf/shisuu_10mem12mon_tcc.html

2. Multiple Regression Model

- Calculate the forecasts using multiple regression equation.



Input
 “=SE\$41*\$E4+\$F\$41*\$F4+\$G\$41*\$G4+\$E\$42”
 at H4.

$$Y = a_1 * x_1 + a_2 * x_2 + a_3 * x_3 + b$$

2. Multiple Regression Model

- Calculate the forecasts using multiple regression equation.

The screenshot displays an Excel spreadsheet titled "ProducingGuidance.xls" with the following data and analysis:

Year	Target JJA/DJF	Mean Temp deg C	Rank	Predictor 1 EID RAIN	Predictor 2 THEX	Predictor 3 MC RAIN	Forecast %	Regression Error	Probabilistic Forecast N(0, σ _n)	Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981 DJF	5.8	28	-0.16	-0.18	0.29	-0.18	6.78					
1982 DJF	6.3	25	-0.41	-0.20	0.52	-0.16	7.42					
1983 DJF	7.3	14	-0.06	-0.16	-1.19	0.25	6.60					
1984 DJF	4.6	30	0.55	-0.14	0.06	0.46	6.76					
1985 DJF	6.1	26	-0.27	-0.32	0.06	0.46	6.53					
1986 DJF	5.4	29	0.08	-0.26	-0.21	-0.47	7.18					
1987 DJF	7	18	-0.41	-0.21	-0.21	-0.21	6.91					
1988 DJF	6.9	19	0.35	-0.11	-0.21	-0.21	6.66					
1989 DJF	8	3	0.30	-0.28	-0.03	0.04	7.03					
1990 DJF	7.3	14	-0.19	-0.11	0.77	0.04	6.66					
1991 DJF	7.6	8	0.11	-0.02	0.02	-0.34	7.23					
1992 DJF	7.6	8	-0.07	-0.01	-0.34	0.14	6.82					
1993 DJF	7.8	6	-0.33	-0.26	0.14	0.14	6.82					
1994 DJF	6.9	19	0.27	-0.23	-0.14	0.57	6.77					
1995 DJF	7.3	14	-0.08	-0.16	-0.62	7.18						
1996 DJF	6.6	23	-0.45	-0.02	0.12	7.15						
1997 DJF	7.7	7	-0.70	-0.02	0.12	7.23						
1998 DJF	7.2	17	0.05	0.33	-0.94	7.84						
1999 DJF	7.4	12	0.52	0.19	0.20	7.01						
2000 DJF	7.5	10	0.42	-0.11	0.27	6.67						
2001 DJF	6.8	21	0.33	0.12	0.31	6.95						
2002 DJF	7.9	5	-0.39	0.25	0.04	7.47						
2003 DJF	6.4	24	0.19	0.36	-0.31	7.55						
2004 DJF	8	3	0.39	0.18	0.53	6.90						
2005 DJF	7.4	12	-0.14	0.23	-0.06	7.41						
2006 DJF	6.1	26	-0.03	0.24	0.77	7.01						
2007 DJF	8.6	1	-0.04	0.31	-0.80	7.78						
2008 DJF	6.8	21	0.17	0.08	0.22	7.00						
2009 DJF	8.1	2	0.13	0.05	0.37	6.92						
2010 DJF	7.5	10	-0.16	0.41	-0.37	7.25						

Summary Statistics:

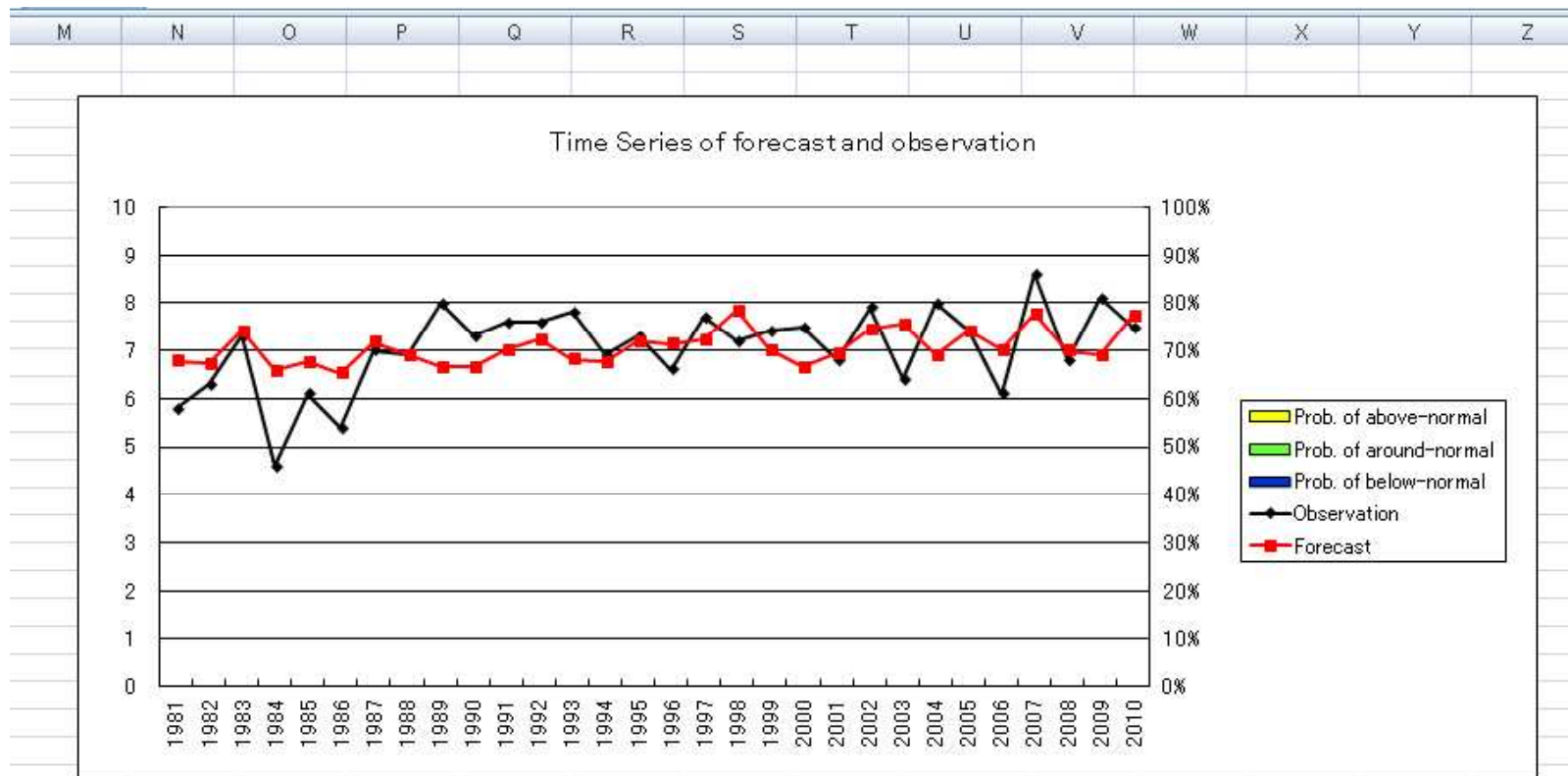
Regression Type	slope	intercept	Correlation
Single Regression	-0.32	7.06	0.12
Multiple Regression	-0.35	7.06	0.42

Annotations:

- Yellow callout: Copy H4 and paste it into H5:H33.
- Pink callout: Multiple Anomaly Correlation Coefficient (0.42).

2. Multiple Regression Model

The time series of the forecast data has been automatically updated.



I will ask you the following questions at the end of this session:

1. "What predictors did you select?"
2. "Is the multiple regression model guidance more accurate than the single regression model guidance?"

3. Probabilistic Forecast

- Calculate squares of regression errors.
- Calculate the root mean square error.

“1981 DJF” means
DJF of 1980/1981.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Year	Target	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast		
JJA/DJF	deg C			EIO RAIN	THEX	MO RAIN	%		N(σ, σn)	N(σ, σn)	N(σ, σn)		
									Prob. of below-normal	Prob. of around-normal	Prob. of above-normal		
1981 DJF	5.8	28	-0.16	-0.18	0.29	6.78		0.966					
1982 DJF	6.3	25	-0.41	-0.20	0.52	6.74							
1983 DJF	7.3	14	-0.06	-0.16	-1.19	7.42							
1984 DJF	4.6	30	0.55	-0.14	0.25	6.60							
1985 DJF	6.1	26	-0.27	-0.32	0.06	6.76							
1986 DJF	5.4	29	0.08	-0.26	0.46	6.53							
1987 DJF	7	18	-0.41	-0.21	-0.47	7.18							
1988 DJF	6.9	19	0.35	-0.11	-0.21	6.91							
1989 DJF	8	3	0.30	-0.28	-0.03	6.66							
1990 DJF	7.3	14	-0.19	-0.11	0.77	6.86							
1991 DJF	7.6	8	0.11	0.02	0.04	7.03							
1992 DJF	7.6	8	-0.07	-0.01	-0.34	7.23							
1993 DJF	7.8	6	-0.33	-0.26	0.14	6.82							
1994 DJF	6.9	19	0.27	-0.23	-0.14	6.77							
1995 DJF	7.3	14	-0.08	-0.16	-0.62	7.18							
1996 DJF	6.6	23	-0.45	-0.02	0.12	7.15							
1997 DJF	7.7	7	-0.70	-0.02	0.12	7.23							
1998 DJF	7.2	17	0.05	0.33	-0.94	7.84							
1999 DJF	7.4	12	0.52	0.19	0.20	7.01							
2000 DJF	7.5	10	0.42	-0.11	0.27	6.67							
2001 DJF	6.8	21	0.33	0.12	0.31	6.95							
2002 DJF	7.9	5	-0.39	0.25	0.04	7.47							
2003 DJF	6.4	24	0.19	0.36	-0.31	7.55							
2004 DJF	8	3	0.39	0.18	0.53	6.90							
2005 DJF	7.4	12	-0.14	0.23	-0.06	7.41							
2006 DJF	6.1	26	-0.03	0.24	0.77	7.01							
2007 DJF	8.6	1	-0.04	0.31	-0.80	7.78							
2008 DJF	6.8	21	0.17	0.08	0.22	7.00							
2009 DJF	8.1	2	0.13	0.05	0.37	6.92							
2010 DJF	7.5	10	-0.16	0.41	-0.37	7.75							
Normal		7.1											
The lower limit of around normal		6.9											
The upper limit of around normal		7.5											
slope				-0.32	1.24	-0.54							
intercept				7.06	7.06	7.06							
Correlation				0.12	0.31	0.30							
slope				-0.35	1.15	-0.44							
intercept				7.06									
Correlation				0.42									

Input “ $=($H4-$C4)^2$ ” at I4 to calculate square error.

3. Probabilistic Forecast

- Calculate squares of regression errors.
- Calculate the root mean square error.

Year	Target	Observation	Mean Temp.	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg C	deg C			EID RAIN	THEX	MC RAIN	%		N(0, σ _n)	N(0, σ _n)	N(0, σ _n)
										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981	DJF	5.8	28	-0.16	-0.18	0.29	6.78	0.066				
1982	DJF	6.3	25	-0.41	-0.20	0.52	6.74	0.197				
1983	DJF	7.3	14	-0.06	-0.16	-1.19	7.42	0.014				
1984	DJF	4.6	30	0.55	-0.14	0.25	6.60	3.985				
1985	DJF	6.1	26	-0.27	-0.32	0.06	6.76	0.438				
1986	DJF	5.4	29	0.08	-0.26	0.46	6.53	1.280				
1987	DJF	7	18	-0.41	-0.21	-0.47	7.18	0.032				
1988	DJF	6.9	19	0.35	-0.11	-0.21	6.91	0.000				
1989	DJF	8	3	0.30	-0.28	-0.03	6.66	1.807				
1990	DJF	7.3	14	-0.19	-0.11	0.77	6.66	0.411				
1991	DJF	7.6	8	0.11	0.02	0.04	7.03	0.325				
1992	DJF	7.6	8	-0.07	-0.01	-0.34	7.23	0.140				
1993	DJF	7.8	6	-0.33	-0.26	0.14	6.82	0.964				
1994	DJF	6.9	19	0.27	-0.23	-0.14	6.77	0.017				
1995	DJF	7.3	14	-0.08	-0.16	-0.62	7.18	0.014				
1996	DJF	6.6	23	-0.45	-0.02	0.12	7.15	0.297				
1997	DJF	7.7	7	-0.70	-0.02	0.12	7.23	0.222				
1998	DJF	7.2	17	0.05	0.33	-0.94	7.84	0.415				
1999	DJF	7.4	12	0.52	0.19	0.20	7.01	0.148				
2000	DJF	7.5	10	0.42	-0.11	0.27	6.67	0.691				
2001	DJF	6.8	21	0.33	0.12	0.31	6.95	0.022				
2002	DJF	7.9	5	-0.39	0.25	0.04	7.47	0.189				
2003	DJF	6.4	24	0.19	0.36	-0.31	7.55	1.328				
2004	DJF	8	3	0.39	0.18	0.53	6.90	1.201				
2005	DJF	7.4	12	-0.14	0.23	-0.06	7.41	0.000				
2006	DJF	6.1	26	-0.03	0.24	0.77	7.01	0.820				
2007	DJF	8.6	1	-0.04	0.31	-0.80	7.78	0.664				
2008	DJF	6.8	21	0.17	0.08	0.22	7.00	0.039				
2009	DJF	8.1	2	0.13	0.05	0.37	6.92	1.403				
2010	DJF	7.5	10	-0.16	0.41	-0.37	7.75	0.063				
Normal		7.1										
The lower limit of around normal		6.9						σ _n				
The upper limit of around normal		7.5										
Single Regression	slope			-0.32	1.24	-0.54						
intercept				7.06	7.06	7.06						
Correlation				0.12	0.31	0.30						
Multiple Regression	slope			-0.35	1.15	-0.44						
intercept				7.06								
Correlation				0.42								

Copy I4 and paste it into I5:I33.

3. Probabilistic Forecast

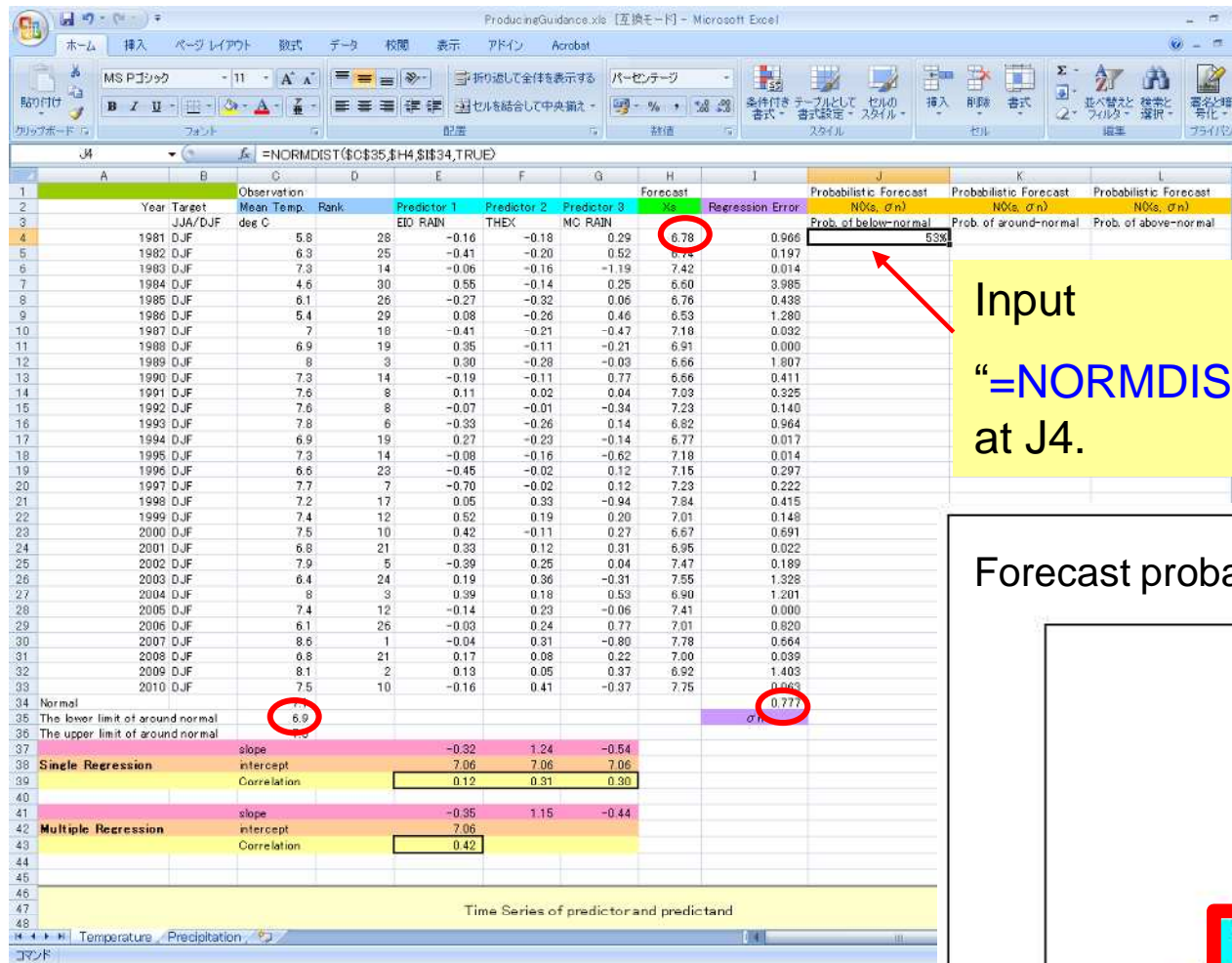
- Calculate squares of regression errors.
- Calculate the root mean square error.

Input “=SQRT(AVERAGE(I4:I33))” at I34 to calculate root mean square error.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg C	deg C			EID RAIN	THEX	MO RAIN	%		NO(a, σ_n)	NO(a, σ_n)	NO(a, σ_n)
										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981	DJF	5.8	28	-0.16	-0.18	0.29	6.78	0.966				
1982	DJF	6.3	25	-0.41	-0.20	0.52	6.74	0.197				
1983	DJF	7.3	14	-0.06	-0.16	-1.19	7.42	0.014				
1984	DJF	4.6	30	0.55	-0.14	0.25	6.60	3.985				
1985	DJF	6.1	26	-0.27	-0.32	0.06	6.76	0.438				
1986	DJF	5.4	29	0.08	-0.26	0.46	6.53	1.280				
1987	DJF	7	18	-0.41	-0.21	-0.47	7.18	0.032				
1988	DJF	6.9	19	0.35	-0.11	-0.21	6.91	0.000				
1989	DJF	8	3	0.30	-0.28	-0.03	6.66	1.807				
1990	DJF	7.3	14	-0.19	-0.11	0.77	6.66	0.411				
1991	DJF	7.6	8	0.11	0.02	0.04	7.03	0.325				
1992	DJF	7.6	8	-0.07	-0.01	-0.34	7.23	0.140				
1993	DJF	7.8	6	-0.33	-0.26	0.14	6.82	0.964				
1994	DJF	6.9	19	0.27	-0.23	-0.14	6.77	0.017				
1995	DJF	7.3	14	-0.08	-0.16	-0.62	7.18	0.014				
1996	DJF	6.6	23	-0.45	-0.02	0.12	7.15	0.297				
1997	DJF	7.7	7	-0.70	-0.02	0.12	7.23	0.222				
1998	DJF	7.2	17	0.05	0.33	-0.94	7.84	0.415				
1999	DJF	7.4	12	0.52	0.19	0.20	7.01	0.148				
2000	DJF	7.5	10	0.42	-0.11	0.27	6.67	0.691				
2001	DJF	6.8	21	0.33	0.12	0.31	6.95	0.022				
2002	DJF	7.9	5	-0.39	0.25	0.04	7.47	0.189				
2003	DJF	6.4	24	0.19	0.36	-0.31	7.55	1.328				
2004	DJF	8	3	0.39	0.18	0.53	6.90	1.201				
2005	DJF	7.4	12	-0.14	0.23	-0.06	7.41	0.000				
2006	DJF	6.1	26	-0.03	0.24	0.77	7.01	0.820				
2007	DJF	8.6	1	-0.04	0.31	-0.80	7.78	0.664				
2008	DJF	6.8	21	0.17	0.08	0.22	7.00	0.039				
2009	DJF	8.1	2	0.13	0.05	0.37	6.92	1.403				
2010	DJF	7.5	10	-0.16	0.41	-0.37	7.75	0.06				
Normal		7.1						0.777				
The lower limit of around normal		6.9						σ_n				
The upper limit of around normal		7.5										
Single Regression	slope				-0.32	1.24	-0.54					
intercept					7.06	7.06	7.06					
Correlation					0.12	0.31	0.30					
Multiple Regression	slope				-0.35	1.15	-0.44					
intercept					7.06							
Correlation					0.42							

3. Probabilistic Forecast

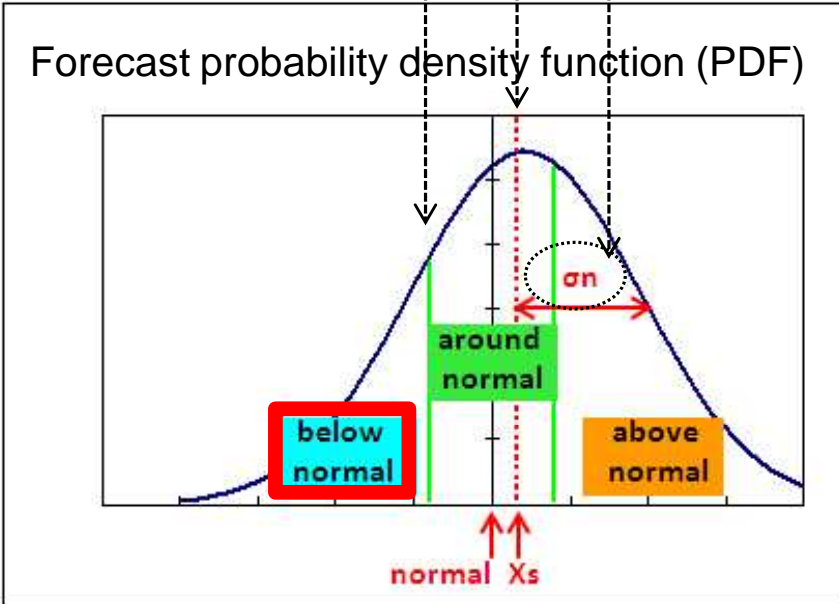
- Calculate probability of below-normal.



TRUE:
Value of cumulative distribution function for the first argument (i.e. \$C\$35).

FALSE:
Value of probability density function for the first argument (i.e. \$C\$35).

Input
"=NORMDIST(\$C\$35,\$H4,\$I\$34,TRUE)"
at J4.



3. Probabilistic Forecast

- Calculate probability of below-normal.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg C	deg C			EID RAIN	THEX	MC RAIN	%		N(σ, σ _n)	N(σ, σ _n)	N(σ, σ _n)
										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981	DJF	5.8	28	-0.16	-0.18	0.29	6.78	0.966	0.066	53%		
1982	DJF	6.3	25	-0.41	-0.20	0.52	6.74	0.197	0.763	55%		
1983	DJF	7.3	14	-0.06	-0.16	-1.19	7.42	0.014	0.986	23%		
1984	DJF	4.6	30	0.55	-0.14	0.25	6.60	3.985	-0.385	63%		
1985	DJF	6.1	26	-0.27	-0.32	0.06	6.76	0.438	0.562	55%		
1986	DJF	5.4	29	0.08	-0.26	0.46	6.53	1.280	-0.280	66%		
1987	DJF	7	18	-0.41	-0.21	-0.47	7.18	0.032	0.968	34%		
1988	DJF	6.9	19	0.35	-0.11	-0.21	6.91	0.000	1.000	47%		
1989	DJF	8	3	0.30	-0.28	-0.03	6.66	1.807	-0.807	60%		
1990	DJF	7.3	14	-0.19	-0.11	0.77	6.66	0.411	0.589	60%		
1991	DJF	7.6	8	0.11	0.02	0.04	7.03	0.325	0.675	41%		
1992	DJF	7.6	8	-0.07	-0.01	-0.34	7.23	0.140	0.860	31%		
1993	DJF	7.8	6	-0.33	-0.26	0.14	6.82	0.964	-0.164	52%		
1994	DJF	6.9	19	0.27	-0.23	-0.14	6.77	0.017	0.983	54%		
1995	DJF	7.3	14	-0.08	-0.16	-0.62	7.18	0.014	0.986	33%		
1996	DJF	6.6	23	-0.45	-0.02	0.12	7.15	0.297	0.703	35%		
1997	DJF	7.7	7	-0.70	-0.02	0.12	7.23	0.222	0.778	31%		
1998	DJF	7.2	17	0.05	0.33	-0.94	7.84	0.415	0.585	10%		
1999	DJF	7.4	12	0.52	0.19	0.20	7.01	0.148	0.852	42%		
2000	DJF	7.5	10	0.42	-0.11	0.27	6.67	0.691	-0.291	59%		
2001	DJF	6.8	21	0.33	0.12	0.31	6.95	0.022	0.978	45%		
2002	DJF	7.9	5	-0.39	0.25	0.04	7.47	0.189	0.811	21%		
2003	DJF	6.4	24	0.19	0.36	-0.31	7.55	1.328	-0.328	18%		
2004	DJF	8	3	0.39	0.18	0.53	6.90	1.201	-0.201	47%		
2005	DJF	7.4	12	-0.14	0.23	-0.06	7.41	0.000	1.000	24%		
2006	DJF	6.1	26	-0.03	0.24	0.77	7.01	0.820	-0.220	42%		
2007	DJF	8.6	1	-0.04	0.31	-0.80	7.78	0.664	-0.164	11%		
2008	DJF	6.8	21	0.17	0.08	0.22	7.00	0.039	0.961	42%		
2009	DJF	8.1	2	0.13	0.05	0.37	6.92	1.403	-0.403	47%		
2010	DJF	7.5	10	-0.16	0.41	-0.37	7.75	0.069	0.931	12%		
Normal		7.1						0.777				
The lower limit of around normal		6.9						σ _n				
The upper limit of around normal		7.5										
Single Regression	slope				-0.32	1.24	-0.54					
	intercept				7.06	7.06	7.06					
	Correlation				0.12	0.31	0.30					
Multiple Regression	slope				-0.35	1.15	-0.44					
	intercept				7.06							
	Correlation				0.42							

Copy J4 and paste it into J5:J33.

3. Probabilistic Forecast

- Calculate probability of above-normal.

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ホーム 挿入 ページレイアウト 数式 データ 校閲 表示 アドイン Acrobat

MS Pゴシック 11 A A

=NORMDIST(\$C\$36,\$H4,\$I\$34,TRUE)

Observation	Mean Temp. deg C	Rank	Predictor 1 EID RAIN	Predictor 2 THEX	Predictor 3 MC RAIN	Forecast %	Regression Error	Probabilistic Forecast NO(a, σn)	Probabilistic Forecast NO(a, σn)	Probabilistic Forecast NO(a, σn)
Year	Target JJA/DJF							Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981 DJF	5.8	28	-0.16	-0.18	0.29	6.78	0.966	53%		
1982 DJF	6.3	25	-0.41	-0.20	0.52	6.44	0.197	55%		
1983 DJF	7.3	14	-0.06	-0.16	-1.19	7.42	0.014	23%		
1984 DJF	4.6	30	0.55	-0.14	0.25	6.60	3.985	63%		
1985 DJF	6.1	26	-0.27	-0.32	0.06	6.76	0.438	55%		
1986 DJF	5.4	29	0.08	-0.26	0.46	6.53	1.280	66%		
1987 DJF	7	18	-0.41	-0.21	-0.47	7.18	0.032	34%		
1988 DJF	6.9	19	0.35	-0.11	-0.21	6.91	0.000	47%		
1989 DJF	8	3	0.30	-0.28	-0.03	6.66	1.807	60%		
1990 DJF	7.3	14	-0.19	-0.11	0.77	6.66	0.411	60%		
1991 DJF	7.6	8	0.11	0.02	0.04	7.03	0.325	41%		
1992 DJF	7.6	8	-0.07	-0.01	-0.34	7.23	0.140	31%		
1993 DJF	7.8	6	-0.33	-0.26	0.14	6.82	0.964	52%		
1994 DJF	6.9	19	0.27	-0.23	-0.14	6.77	0.017	54%		
1995 DJF	7.3	14	-0.08	-0.16	-0.62	7.18	0.014	33%		
1996 DJF	6.6	23	-0.45	-0.02	0.12	7.15	0.297	35%		
1997 DJF	7.7	7	-0.70	-0.02	0.12	7.23	0.222	31%		
1998 DJF	7.2	17	0.05	0.33	-0.94	7.84	0.415	10%		
1999 DJF	7.4	12	0.52	0.19	0.20	7.01	0.148	42%		
2000 DJF	7.5	10	0.42	-0.11	0.27	6.67	0.691	55%		
2001 DJF	6.8	21	0.33	0.12	0.31	6.95	0.022	48%		
2002 DJF	7.9	5	-0.39	0.25	0.04	7.47	0.189	21%		
2003 DJF	6.4	24	0.19	0.36	-0.31	7.55	1.328	16%		
2004 DJF	8	3	0.39	0.18	0.53	6.90	1.201	47%		
2005 DJF	7.4	12	-0.14	0.23	-0.06	7.41	0.000	24%		
2006 DJF	6.1	26	-0.03	0.24	0.77	7.01	0.820	42%		
2007 DJF	8.6	1	-0.04	0.31	-0.80	7.78	0.664	11%		
2008 DJF	6.8	21	0.17	0.08	0.22	7.00	0.039	42%		
2009 DJF	8.1	2	0.13	0.05	0.37	6.92	1.403	47%		
2010 DJF	7.5	10	-0.16	0.41	-0.37	7.75	0.063	12%		
Normal	7.1						0.77%			
The lower limit of around normal	6.9									
The upper limit of around normal	7.5									
Single Regression	slope		-0.32	1.24	-0.54					
	intercept		7.06	7.06	7.06					
	Correlation		0.12	0.31	0.30					
Multiple Regression	slope		-0.35	1.15	-0.44					
	intercept		7.06							
	Correlation		0.42							

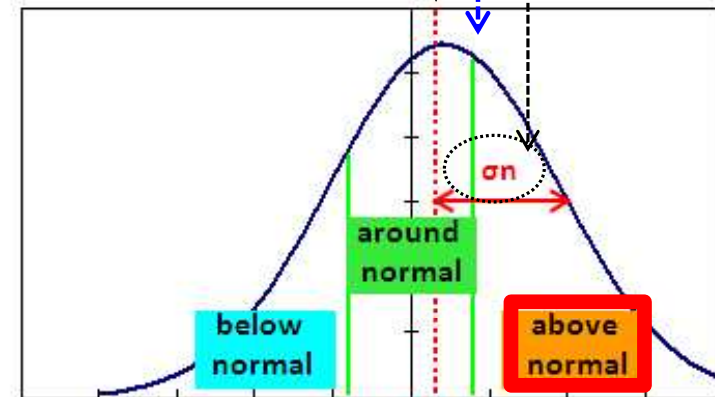
Very important!

TRUE:
Value of cumulative distribution function for the first argument (i.e. \$C\$36).
FALSE:
Value of probability density function for the first argument (i.e. \$C\$36).

Input

"=NORMDIST(\$C\$36,\$H4,\$I\$34,TRUE)"
at L4.

Forecast probability density function (PDF)



normal Xs

3. Probabilistic Forecast

- Calculate probability of above-normal.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	JJA/DJF	deg C			EID RAIN	THEX	MO RAIN	%		NO(a, σ_n)	NO(a, σ_n)	NO(a, σ_n)
										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981 DJF		5.8	28	-0.16	-0.18	0.29	6.78	0.966		53%		18%
1982 DJF		6.3	25	-0.41	-0.20	0.52	6.74	0.197		55%		17%
1983 DJF		7.3	14	-0.06	-0.16	-1.19	7.42	0.014		23%		46%
1984 DJF		4.6	30	0.55	-0.14	0.25	6.60	3.985		63%		12%
1985 DJF		6.1	26	-0.27	-0.32	0.06	6.76	0.438		55%		17%
1986 DJF		5.4	29	0.08	-0.26	0.46	6.53	1.280		66%		11%
1987 DJF		7	18	-0.41	-0.21	-0.47	7.18	0.032		34%		34%
1988 DJF		6.9	19	0.35	-0.11	-0.21	6.91	0.000		47%		22%
1989 DJF		8	3	0.30	-0.28	-0.03	6.66	1.807		60%		14%
1990 DJF		7.3	14	-0.19	-0.11	0.77	6.66	0.411		60%		14%
1991 DJF		7.6	8	0.11	0.02	0.04	7.03	0.325		41%		27%
1992 DJF		7.6	8	-0.07	-0.01	-0.34	7.23	0.140		31%		36%
1993 DJF		7.8	6	-0.33	-0.26	0.14	6.82	0.964		52%		19%
1994 DJF		6.9	19	0.27	-0.23	-0.14	6.77	0.017		54%		17%
1995 DJF		7.3	14	-0.08	-0.16	-0.62	7.18	0.014		33%		34%
1996 DJF		6.6	23	-0.45	-0.02	0.12	7.15	0.297		35%		32%
1997 DJF		7.7	7	-0.70	-0.02	0.12	7.23	0.222		31%		36%
1998 DJF		7.2	17	0.05	0.33	-0.94	7.84	0.415		10%		67%
1999 DJF		7.4	12	0.52	0.19	0.20	7.01	0.148		42%		27%
2000 DJF		7.5	10	0.42	-0.11	0.27	6.67	0.691		59%		14%
2001 DJF		6.8	21	0.33	0.12	0.31	6.95	0.022		45%		24%
2002 DJF		7.9	5	-0.39	0.25	0.04	7.47	0.189		21%		48%
2003 DJF		6.4	24	0.19	0.36	-0.31	7.55	1.328		18%		53%
2004 DJF		8	3	0.39	0.18	0.53	6.90	1.201		47%		22%
2005 DJF		7.4	12	-0.14	0.23	-0.06	7.41	0.000		24%		45%
2006 DJF		6.1	26	-0.03	0.24	0.77	7.01	0.820		42%		26%
2007 DJF		8.6	1	-0.04	0.31	-0.80	7.78	0.564		11%		64%
2008 DJF		6.8	21	0.17	0.08	0.22	7.00	0.039		42%		26%
2009 DJF		8.1	2	0.13	0.05	0.37	6.92	1.403		47%		23%
2010 DJF		7.5	10	-0.16	0.41	-0.37	7.75	0.063		12%		63%
Normal		7.1						0.777				
The lower limit of around normal		6.9						σ_n				
The upper limit of around normal		7.5										
Single Regression		slope			-0.32	1.24	-0.54					
		intercept			7.06	7.06	7.06					
		Correlation			0.12	0.31	0.30					
Multiple Regression		slope			-0.35	1.15	-0.44					
		intercept			7.06							
		Correlation			0.42							

Copy L4 and paste it into L5:L33.

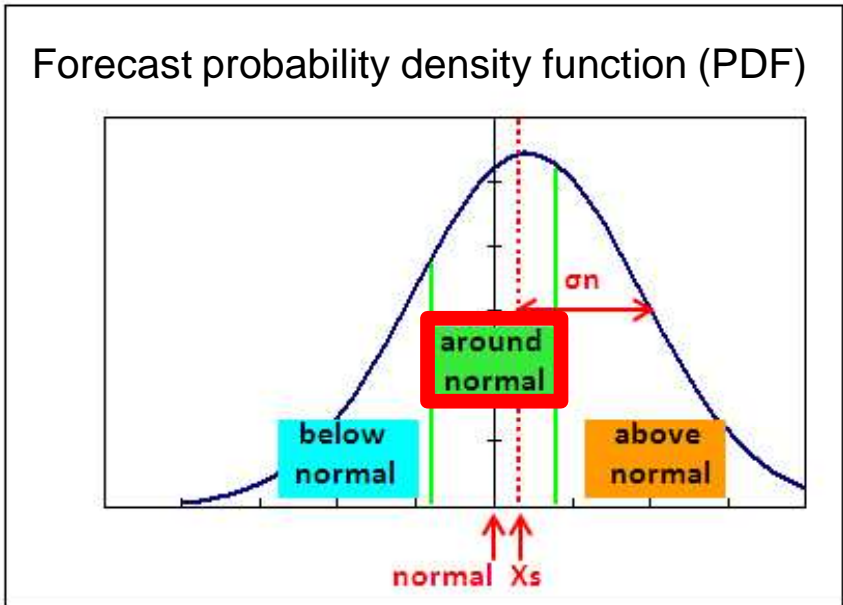
3. Probabilistic Forecast

- Calculate probability of around-normal.

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1	A	B	C	D	E	F	G	H	I	J	K	L
2	Year	Target	Observation		Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
3	JJA/DJF	deg C	Mean Temp.	Rank	EIO RAIN	THEX	MO RAIN	%		N(μ, σ)	N(μ, σ)	N(μ, σ)
4										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
4	1981 DJF	5.8	28	-0.16	-0.18	0.29	6.78	0.966		53%	29%	18%
5	1982 DJF	6.3	25	-0.41	-0.20	0.52	6.74	0.197		55%		17%
6	1983 DJF	7.3	14	-0.06	-0.16	-1.19	7.42	0.014		23%		46%
7	1984 DJF	4.6	30	0.55	-0.14	0.25	6.60	3.985		63%		12%
8	1985 DJF	6.1	26	-0.27	-0.32	0.06	6.76	0.438		55%		17%
9	1986 DJF	5.4	29	0.08	-0.26	0.46	6.53	1.280		66%		11%
10	1987 DJF	7	18	-0.41	-0.21	-0.47	7.18	0.032		34%		44%
11	1988 DJF	6.9	19	0.35	-0.11	-0.21	6.91	0.000		47%		47%
12	1989 DJF	8	3	0.30	-0.28	-0.03	6.66	1.807		60%		41%
13	1990 DJF	7.3	14	-0.19	-0.11	0.77	6.66	0.411		60%		41%
14	1991 DJF	7.6	8	0.11	0.02	0.04	7.03	0.325		31%		36%
15	1992 DJF	7.6	8	-0.07	-0.01	-0.34	7.23	0.140		52%		19%
16	1993 DJF	7.8	6	-0.33	-0.26	0.14	6.82	0.964		54%		17%
17	1994 DJF	6.9	19	0.27	-0.23	-0.14	6.77	0.017		33%		34%
18	1995 DJF	7.3	14	-0.08	-0.16	-0.62	7.18	0.014		35%		32%
19	1996 DJF	6.6	23	-0.45	-0.02	0.12	7.15	0.297		31%		35%
20	1997 DJF	7.7	7	-0.70	-0.02	0.12	7.23	0.222		10%		47%
21	1998 DJF	7.2	17	0.05	0.33	-0.94	7.84	0.415		42		42
22	1999 DJF	7.4	12	0.52	0.19	0.20	7.01	0.148		55		48
23	2000 DJF	7.5	10	0.42	-0.11	0.27	6.67	0.691		21		21
24	2001 DJF	6.8	21	0.33	0.12	0.31	6.95	0.022		16		16
25	2002 DJF	7.9	5	-0.39	0.25	0.04	7.47	0.189		47		47
26	2003 DJF	6.4	24	0.19	0.36	-0.31	7.55	1.328		24		24
27	2004 DJF	8	3	0.39	0.18	0.53	6.90	1.201		42		42
28	2005 DJF	7.4	12	-0.14	0.23	-0.06	7.41	0.000		11		11
29	2006 DJF	6.1	26	-0.03	0.24	0.77	7.01	0.820		47		47
30	2007 DJF	8.6	1	-0.04	0.31	-0.80	7.78	0.664		42		42
31	2008 DJF	6.8	21	0.17	0.08	0.22	7.00	0.039		47		47
32	2009 DJF	8.1	2	0.13	0.05	0.37	6.92	1.403		42		42
33	2010 DJF	7.5	10	-0.16	0.41	-0.37	7.75	0.063		42		42
34	Normal	7.1						0.777				
35	The lower limit of around normal	6.9						σn				
36	The upper limit of around normal	7.5										
37	Single Regression	slope		-0.32	1.24	-0.54						
38		intercept		7.06	7.06	7.06						
39		Correlation		0.12	0.31	0.30						
40	Multiple Regression	slope		-0.35	1.15	-0.44						
41		intercept		7.06								
42		Correlation		0.42								

Input "=1-J4-L4" at K4.



3. Probabilistic Forecast

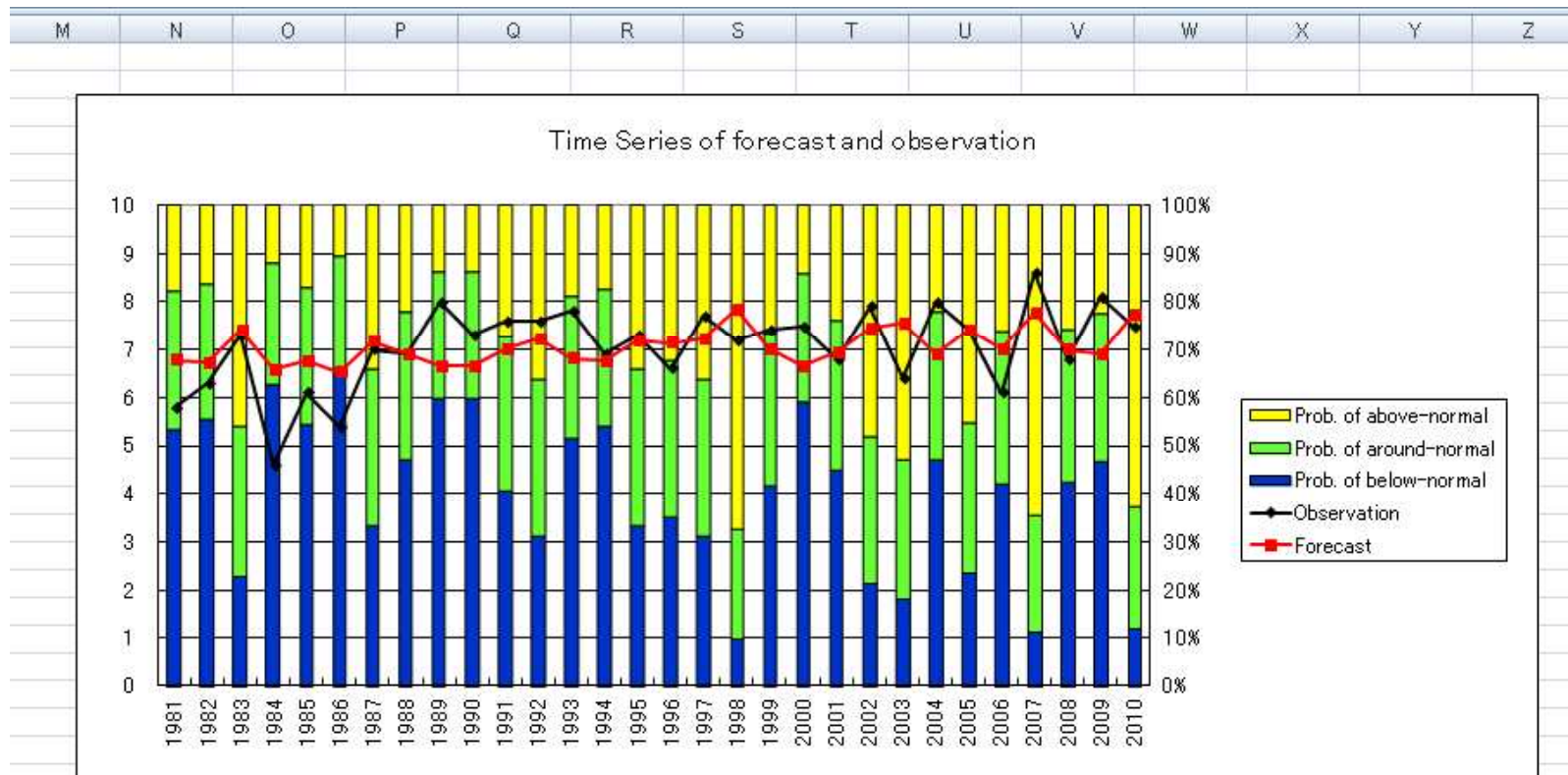
- Calculate probability of around-normal.

Year	Target	Observation	Mean Temp	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	Regression Error	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg C	deg C			EID RAIN	THEX	MO RAIN	%		NO(a, σ_n)	NO(a, σ_n)	NO(a, σ_n)
										Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
1981 DJF	5.8	28	-0.16	-0.18	0.29	6.78	0.966			53%	29%	18%
1982 DJF	6.3	25	-0.41	-0.20	0.52	6.74	0.197			55%	28%	17%
1983 DJF	7.3	14	-0.06	-0.16	-1.19	7.42	0.014			23%	31%	46%
1984 DJF	4.6	30	0.55	-0.14	0.25	6.60	3.985			63%	25%	12%
1985 DJF	6.1	26	-0.27	-0.32	0.06	6.76	0.438			55%	28%	17%
1986 DJF	5.4	29	0.08	-0.26	0.46	6.53	1.280			66%	23%	11%
1987 DJF	7	18	-0.41	-0.21	-0.47	7.18	0.032			34%	32%	34%
1988 DJF	6.9	19	0.35	-0.11	-0.21	6.91	0.000			47%	31%	22%
1989 DJF	8	3	0.30	-0.28	-0.03	6.66	1.807			60%	26%	14%
1990 DJF	7.3	14	-0.19	-0.11	0.77	6.66	0.411			60%	26%	14%
1991 DJF	7.6	8	0.11	0.02	0.04	7.03	0.325			41%	32%	27%
1992 DJF	7.6	8	-0.07	-0.01	-0.34	7.23	0.140			31%	32%	36%
1993 DJF	7.8	6	-0.33	-0.26	0.14	6.82	0.964			52%	29%	19%
1994 DJF	6.9	19	0.27	-0.23	-0.14	6.77	0.017			54%	29%	17%
1995 DJF	7.3	14	-0.08	-0.16	-0.62	7.18	0.014			33%	32%	35%
1996 DJF	6.6	23	-0.45	-0.02	0.12	7.15	0.297			35%	32%	33%
1997 DJF	7.7	7	-0.70	-0.02	0.12	7.23	0.222			31%	32%	37%
1998 DJF	7.2	17	0.05	0.33	-0.94	7.84	0.415			10%	23%	67%
1999 DJF	7.4	12	0.52	0.19	0.20	7.01	0.148			42%	32%	26%
2000 DJF	7.5	10	0.42	-0.11	0.27	6.67	0.691			59%	27%	14%
2001 DJF	6.8	21	0.33	0.12	0.31	6.95	0.022			45%	31%	24%
2002 DJF	7.9	5	-0.39	0.25	0.04	7.47	0.189			21%	30%	48%
2003 DJF	6.4	24	0.19	0.36	-0.31	7.55	1.328			18%	29%	53%
2004 DJF	8	3	0.39	0.18	0.53	6.90	1.201			47%	31%	22%
2005 DJF	7.4	12	-0.14	0.23	-0.06	7.41	0.000			24%	31%	45%
2006 DJF	6.1	26	-0.03	0.24	0.77	7.01	0.820			42%	32%	26%
2007 DJF	8.6	1	-0.04	0.31	-0.80	7.78	0.664			11%	24%	64%
2008 DJF	6.8	21	0.17	0.08	0.22	7.00	0.039			42%	32%	26%
2009 DJF	8.1	2	0.13	0.05	0.37	6.92	1.403			47%	31%	23%
2010 DJF	7.5	10	-0.16	0.41	-0.37	7.75	0.063			12%	25%	63%
Normal		7.1					0.777					
The lower limit of around normal		6.9					σ_n					
The upper limit of around normal		7.5										
Single Regression	slope		-0.32	1.24	-0.54							
	intercept		7.06	7.06	7.06							
	Correlation		0.12	0.31	0.30							
Multiple Regression	slope		-0.35	1.15	-0.44							
	intercept		7.06									
	Correlation		0.42									

Copy K4 and paste it into K5:K33.

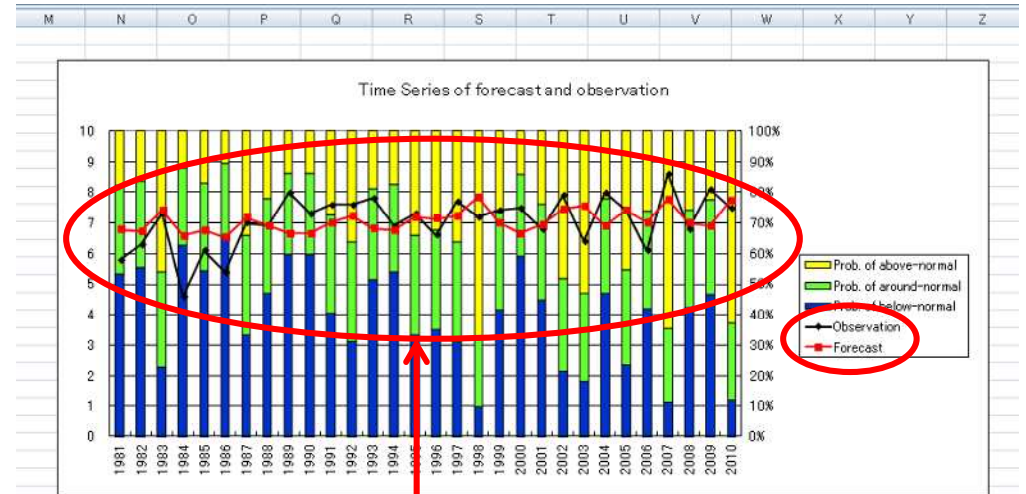
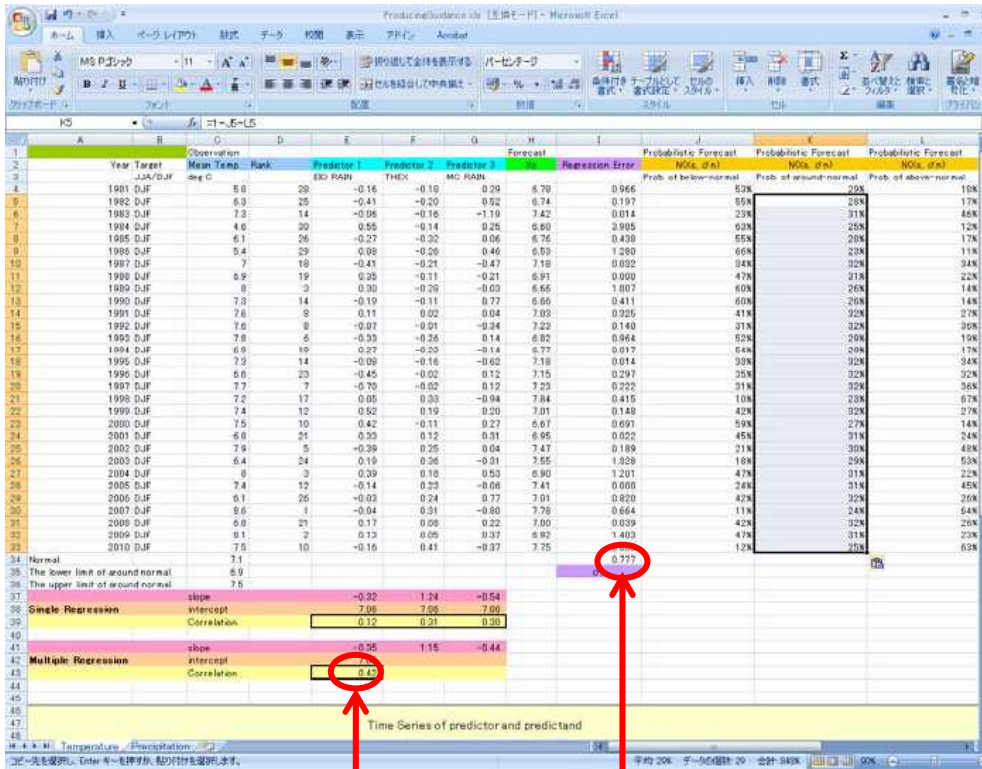
3. Probabilistic Forecast

The time series of the probabilistic forecast data has been automatically added.



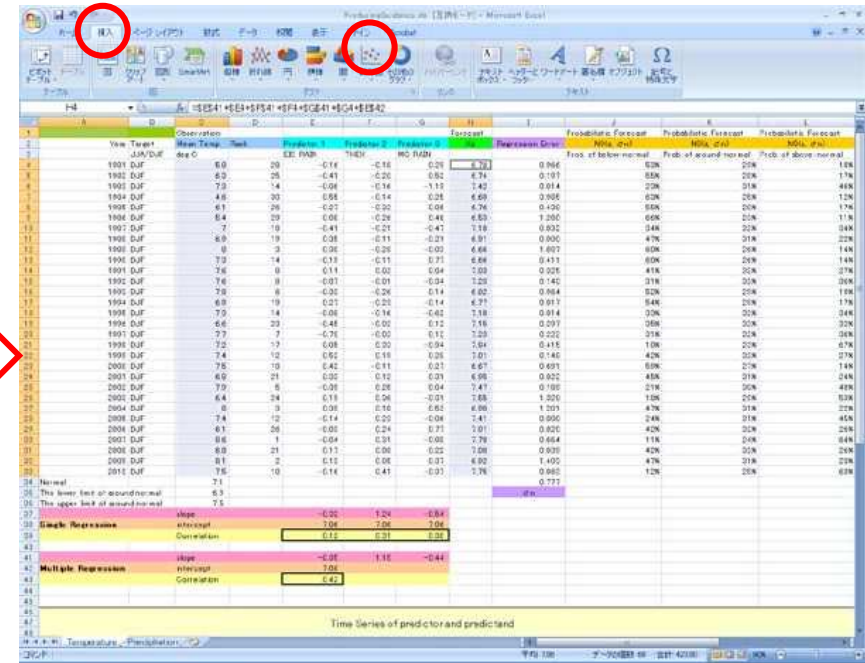
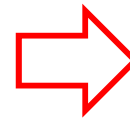
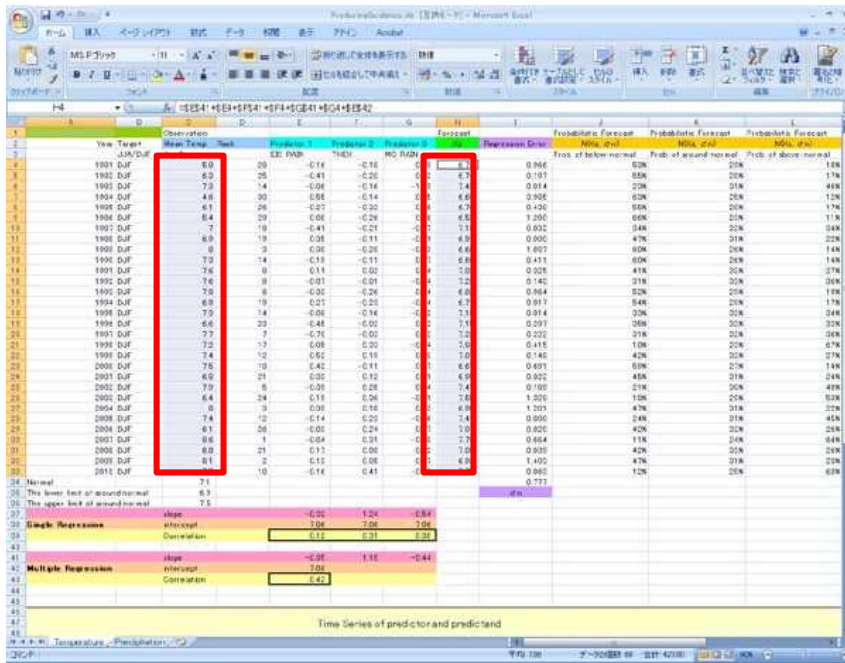
- I will ask you the following questions at the end of this session:
1. “How did the guidance predict the hottest/coldest/wettest/driest year in your country?”
 2. “Are there any essential differences of the probability between the temperature and precipitation?”

4-1. Deterministic Verification



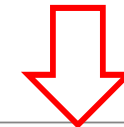
- Anomaly Correlation
- Root Mean Square Error (RMSE)
- Time Series Chart
- Scatter Plot

4-1. Deterministic Verification

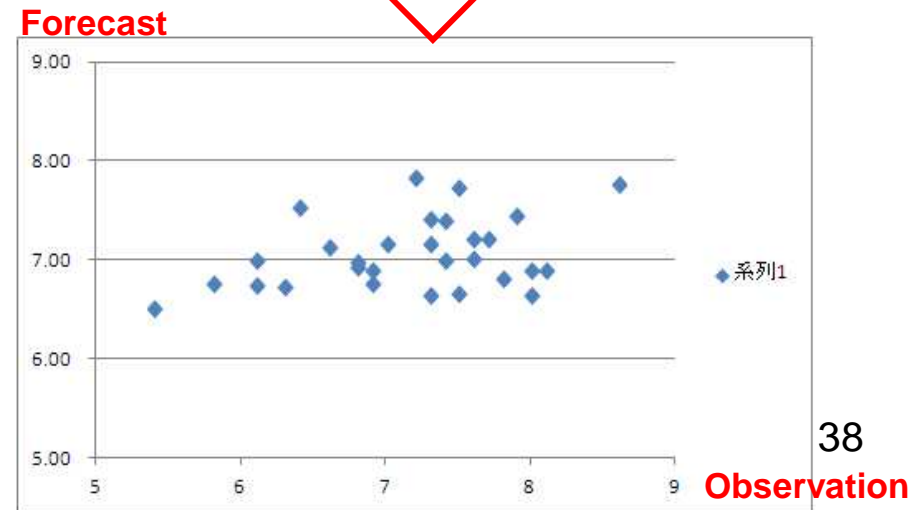


Select C4:C33 → Select H4:H33
(with pushing “ctrl” key)

Select “Insert” → Select “Scatter plot”



- Anomaly Correlation
- Root Mean Square Error (RMSE)
- Time Series Chart
- Scatter Plot



4-2. Probabilistic Verification

Brier skill score (3-category forecast)

- **Brier score** measures mean squared error of the probability forecasts.

$$BS = \frac{1}{2N} \sum_{i=1}^N \sum_{m=1}^3 (p_i^m - o_i^m)^2$$

p_i^m : forecast probability

o_i^m : observed occurrence (0 or 1)

N : forecast frequency

m : category

Range: 0 to 1. Perfect score: 0

- **Brier skill score** measures **skill** relative to a reference forecast (usually climatology).

$$BSS = 1 - \frac{BS}{BS_{reference}}$$

Range: minus infinity to 1. BSS=0 indicates no skill when compared to the reference forecast. Perfect score: 1.

4-2. Probabilistic Verification

Brier skill score (3-category forecast)

□ Brier skill score

= the relative skill of the probabilistic forecast to the climatology

$$BSS = \frac{BS - BS_{clim}}{0 - BS_{clim}} = 1 - \frac{BS}{BS_{clim}}$$

$$Skill\ score = \frac{score_{forecast} - score_{reference}}{score_{perfect\ forecast} - score_{reference}}$$

$$BS_{clim} = 1/3$$

Perfect score: 1

BSS>0 : better than the climatology.

BSS=0 indicates no skill when compared to the climatology.

BSS<0 : worse than the climatology.

4-2. Probabilistic Verification

Brier skill score (3-category forecast)

- Open the Verification.xls. * If you are busy, please use BriefVerification.xls in place of Verification.xls.

“1981 DJF” means
DJF of 1980/1981.

	A	B	C	D	E	F	G	H
1			observation	Prob	$(P_i - V_i)^2$	round off	Hit : 1	1
2	1981 DJF	below nor	5.8					
3	1982 DJF		6.3					
4	1983 DJF		7.3					
...								
32	1981 DJF	around nc	5.8					
33	1982 DJF		6.3					
34	1983 DJF		7.3					
...								
62	1981 DJF	above no	5.8					
63	1982 DJF		6.3					
64	1983 DJF		7.3					
...								
92					Brier Score	climate Brier Score	Brier Skill Score (BSS)	
93	The lower limit of around normal							
94	The upper limit of around normal							
95								
96								
97								
98								

In this case, the predictand is temperature and the station is Tokyo.

* These values should be copied from C4:C33 in the temperature sheet of the ProducingGuidance.xls.

4-2. Probabilistic Verification

Brier skill score (3-category forecast)

	A	B	C	D	E	F	G	H
1			observation	Prob	$(P_i - V_i)^2$	round off	Hit : 1	1
2	1981 DJF	below nor	5.8					
3	1982 DJF		6.3					
4	1983 DJF		7.3					
	...							
32	1981 DJF	around nc	5.8					
33	1982 DJF		6.3					
34	1983 DJF		7.3					
	...							
62	1981 DJF	above nor	5.8					
63	1982 DJF		6.3					
64	1983 DJF		7.3					
	...							
92								
93		The lower limit of around	6.85		Brier Score	climate Brier Score	Brier Skill Score (BSS)	
94		The upper limit of around	7.5					
95								
96								
97								
98								

Paste the values of the lower and upper limits of around normal (*) into C93 and C94, respectively.

* These values should be copied from the C35 and C36 cells in the temperature sheet of the ProducingGuidance.xls

4-2. Probabilistic Verification

Brier skill score (3-category forecast)

	A	B	C	D	E	F	G	H
1			observation	Prob	$(P_i - V_i)^2$	round off	Hit : 1	1
2	1981 DJF	below nor	5.8	53%				
3	1982 DJF		6.3	55%				
4	1983 DJF		7.3	23%				
				
32	1981 DJF	around nc	5.8	29%				
33	1982 DJF		6.3	28%				
34	1983 DJF		7.3	31%				
				
62	1981 DJF	above nor	5.8	18%				
63	1982 DJF		6.3	17%				
64	1983 DJF		7.3	46%				
				
92					Brier Score	climate Brier Score	Brier Skill Score (BSS)	
93	The lower limit of around		6.85					
94	The upper limit of around		7.5					

Paste the values of the probabilities of below normal (*) into D2:D31.

* J4:J33 in the temperature sheet of the ProducingGuidance.xls

Paste the values of the probabilities of around normal (**) into D32:D61.

** K4:K33 in the temperature sheet of the ProducingGuidance.xls

Paste the values of the probabilities of above normal (***) into D62:D91.

*** L4:L33 in the temperature sheet of the ProducingGuidance.xls

4-2. Probabilistic Verification

Brier skill score (3-category forecast)

* If you use BriefVerification.xls in place of Verification.xls, the procedure in this slide is unnecessary.

	A	B	C	D	E	F
			observation	Prob.	(Pi-Vi)^2	round off
1						
2	1981 DJF	below nor	5.8	53%	0.2168	
3	1982 DJF		6.3	55%	0.1986	
4	1983 DJF		7.3	23%	0.0536	
	
32	1981 DJF	around nc	5.8	29%	0.0828	
33	1982 DJF		6.3	28%	0.0787	
34	1983 DJF		7.3	31%	0.4767	
	
62	1981 DJF	above nor	5.8	18%	0.0317	
63	1982 DJF		6.3	17%	0.0273	
64	1983 DJF		7.3	46%	0.2107	
	
92						
93		The lower limit of around	6.85		Brier Score	climate Brier Score
94		The upper limit of around	7.5			
95						
96						
97						
98						

Input “=IF(C2<=\$C\$93,(D2-1)^2,D2^2)” at E2 (*) and paste it into E3:E31.

* If the observed value is below normal, $E2 = (p_i^m - 1)^2$
 If not so (around or above normal), $E2 = (p_i^m - 0)^2$

Input “=IF(C32<=\$C\$93,D32^2,IF(C32>\$C\$94,D32^2,(D32-1)^2))” at E32 (***) and paste it into E33:E61.

*** If the observed value is below or above normal, $E32 = (p_i^m - 0)^2$
 If not so (around normal), $E32 = (p_i^m - 1)^2$

Input “=IF(C62>\$C\$94,(D62-1)^2,D62^2)” at E62 (***) and paste it into E63:E91.

*** If the observed value is above normal, $E62 = (p_i^m - 1)^2$
 If not so (below or around normal), $E62 = (p_i^m - 0)^2$

4-2. Probabilistic Verification

Brier skill score (3-category forecast)

* If you use BriefVerification.xls in place of Verification.xls, the procedure in this slide is unnecessary.

	A	B	C	D	E	F
1			observation	Prob	(Pi-Vi)^2	round off
2	1981 DJF	below nor	5.8	53%	0.2168	
3	1982 DJF		6.3	55%	0.1986	
4	1983 DJF		7.3	23%	0.0836	
	
32	1981 DJF	around nc	5.8	29%	0.0828	
33	1982 DJF		6.3	28%	0.0787	
34	1983 DJF		7.3	31%	0.4167	
	
62	1981 DJF	above nor	5.8	18%	0.0317	
63	1982 DJF		6.3	17%	0.0273	
64	1983 DJF		7.3	46%	0.2107	
	
92					0.3350	0.33333333
93	The lower limit of around		6.85		Brier Score	climate Brier Score
94	The upper limit of around		7.5			Brier Skill Score (BSS)
95						
96						
97						
98						

Input “=AVERAGE(E2:E91)*(3/2)” at E92 (*).

$$* BS = \frac{1}{2N} \sum_{i=1}^N \sum_{m=1}^3 (p_i^m - o_i^m)^2$$

Input “=((1-1/3)^2+(0-1/3)^2+(0-1/3)^2)/2” at F92 (**).

** BS_{clim}

Input “=(F92-E92)/F92” at G92 (***)

$$*** BSS = \frac{BS - BS_{clim}}{0 - BS_{clim}}$$

4-2. Probabilistic Verification

Reliability Diagram

• Continue using the Verification.xls.

* If you use BriefVerification.xls in place of Verification.xls, the procedure in this slide is unnecessary.

	A	B	C	D	E	F	G
			observation	Prob	(Pi-Vi) ²	round off	Hit
1							Hit : 1
2	1981 DJF	below nor	5.8	53%	0.2168	50%	
3	1982 DJF		6.3	55%	0.1986	60%	
4	1983 DJF		7.3	23%	0.0536	20%	
	...						
32	1981 DJF	around nc	5.8	29%	0.0828	30%	
33	1982 DJF		6.3	28%	0.0787	30%	
34	1983 DJF		7.3	31%	0.4767	30%	
	...						
62	1981 DJF	above nor	5.8	18%	0.0317	20%	
63	1982 DJF		6.3	17%	0.0273	20%	
64	1983 DJF		7.3	46%	0.2107	50%	
	...						
92					0.3350	0.333333333	-0.005
93	The lower limit of around		6.85		Brier Score	climate Brier Score	Brier Skill Score (BSS)
94	The upper limit of around		7.5				

Input “=ROUND(D2,1)” at F2.

* 10%→10%, 7% →10%, 24% →20%, and so on.

Copy F2 and paste it into F3:F91.

4-2. Probabilistic Verification

Reliability Diagram

* If you use BriefVerification.xls in place of Verification.xls, the procedure in this slide is unnecessary.

	A	B	C	D	E	F	G
			observation	Prob.	(Pi-Vi)^2	round off	Hit : 1
1							
2	1981 DJF	below nor	5.8	53%	0.2168		50% 1
3	1982 DJF		6.3	55%	0.1986		60% 1
4	1983 DJF		7.3	23%	0.0536		20% 0
	...						
32	1981 DJF	around nc	5.8	29%	0.0828		30% 0
33	1982 DJF		6.3	28%	0.0787		30% 0
34	1983 DJF		7.3	31%	0.4767		30% 1
	...						
62	1981 DJF	above nor	5.8	18%	0.0317		20% 0
63	1982 DJF		6.3	17%	0.0273		20% 0
64	1983 DJF		7.3	46%	0.2107		50% 0
	...						
92					0.3350	0.333333333	-0.005
93	The lower limit of around		6.85		Brier Score	climate Brier Score	Brier Skill Score (BSS)
94	The upper limit of around		7.5				

Input `"=IF($C2<=$C$93,"1","0")"` at G2 (*) and paste it into G3:G31.

* If the observed value is below normal, G2=1.
If not so (around or above normal), G2=0.

Input `"=IF(C32<=C93,"0",IF(C32>C94,"0","1"))"` at G32 (**) and paste it into G33:E61.

** If the observed value is below or above normal, G32=0.
If not so (around normal), G32=1.

Input `"=IF(C62>C94,"1","0")"` at G62 (***) and paste it into G63:G91.

*** If the observed value is above normal, G62=1.
If not so (below or around normal), G62=0.

4-2. Probabilistic Verification

Reliability Diagram

	A	B	C	D	E	F	G	H
1			observation	Prob	(Pi-Vi) ²	round off	Hit : 1	
2	1981 DJF below nor		5.8	53%	0.2168		50% 1	1
3	1982 DJF		6.3	55%	0.1986		60% 1	1
4	1983 DJF		7.3	23%	0.0536		20% 0	0
				
32	1981 DJF around nc		5.8	29%	0.0828		30% 0	0
33	1982 DJF		6.3	28%	0.0787		30% 0	0
34	1983 DJF		7.3	31%	0.4767		30% 1	1
				
62	1981 DJF above nor		5.8	18%	0.0317		20% 0	0
63	1982 DJF		6.3	17%	0.0273		20% 0	0
64	1983 DJF		7.3	46%	0.2107		50% 0	0
				
92					0.3350	0.333333333		-0.005
93	The lower limit of around		6.85		Brier Score	climate Brier Score		Brier Skill Score (BSS)
94	The upper limit of around		7.5					

Copy G2:G91, and paste their values into H2:H91 (functions → values).

4-2. Probabilistic Verification

Reliability Diagram

(2) Hit frequency of forecast XXX%

`=SUMPRODUCT((F2:F91=J$2)*($H$2:$H$91=$H$1))`

(1) Frequency of forecast XXX%

`=COUNTIF(F2:F91,"XXX%")`

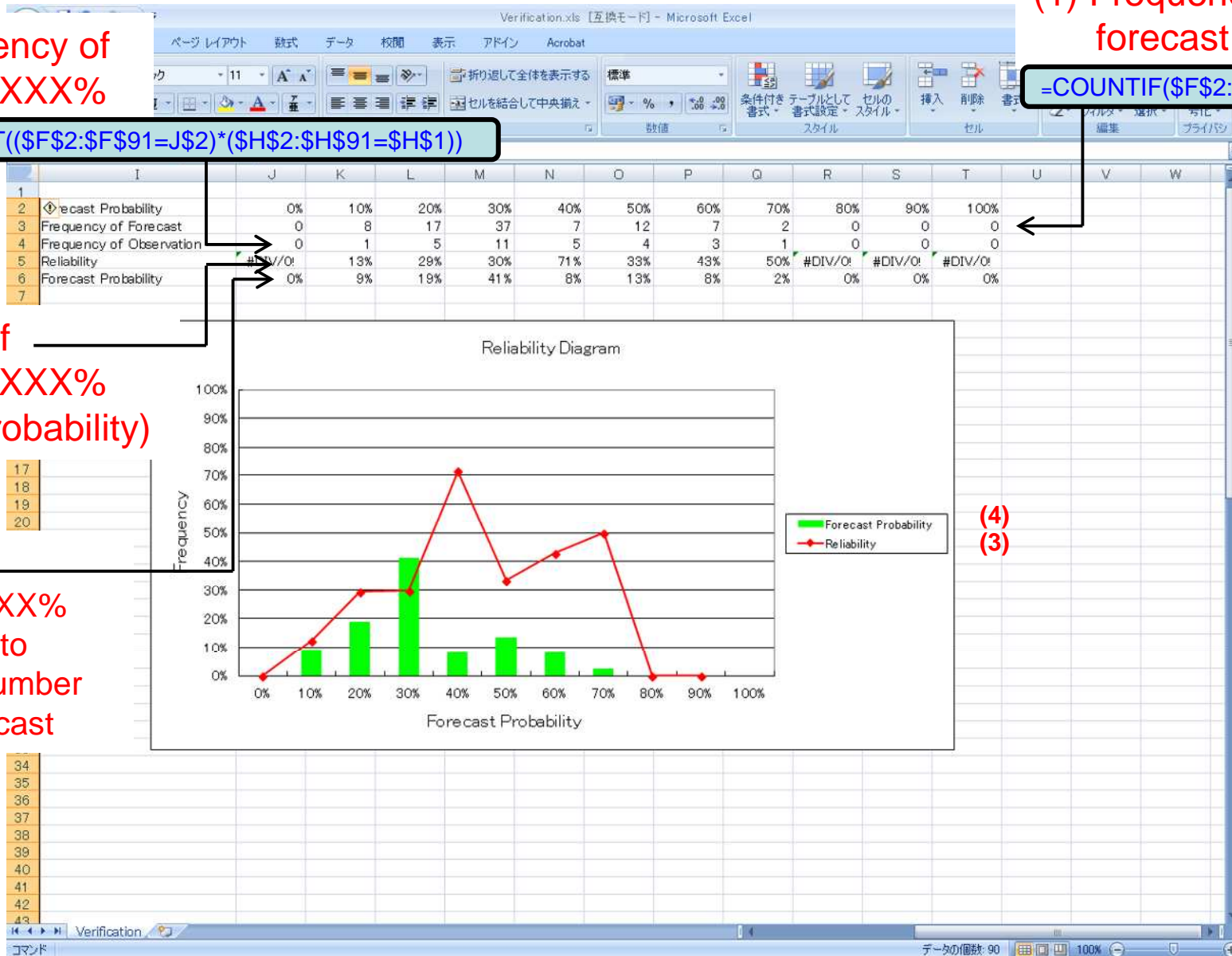
* XXX: 0,10, ...,100

(3) Hit rate of forecast XXX% (observed probability)

`=J4/J3`

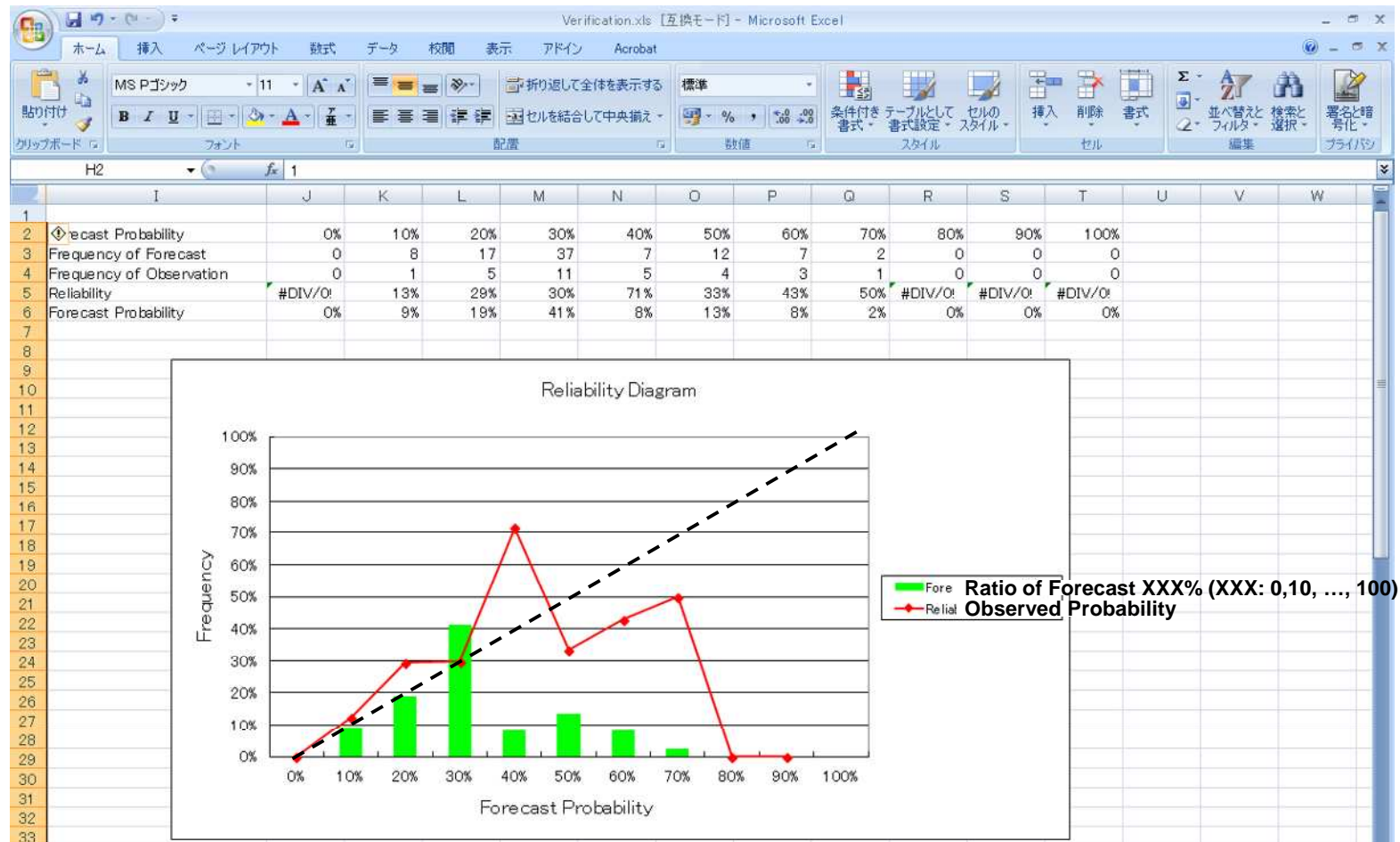
(4) Ratio of forecast XXX% compared to the total number of the forecast

`=J3/90`



4-2. Probabilistic Verification

Reliability Diagram



- The reliability diagram plots the observed probability(Y-axis) against the forecast probability(X-axis).
- The diagonal broken line indicates perfect reliability (observed probability equal to forecast probability).
- Points below (above) the diagonal line indicate overforecasting (underforecasting).



Questions

Single Regression Model

1. “What predictor did you select?”
2. “Could you get an accurate guidance?”

Multiple Regression Model

1. “What predictors did you select?”
2. “Is the multiple regression model guidance more accurate than the single regression model guidance?”

Probabilistic Forecast

1. “How did the guidance predict the hottest/coldest/wettest/driest year in your country?”
2. “Are there any essential differences of the probability between the temperature and precipitation?”

Verification

1. Is your guidance skillful from the viewpoint of deterministic forecast?
(Anomaly Correlation, Root Mean Square Error, Time Series Chart, and Scatter Plot)
2. Is your guidance skillful from the viewpoint of probabilistic forecast?
(Brier skill score and Reliability Diagram)

Please answer these questions as many as possible in your presentation time (17 minutes) after the Exercise Part 2.

Appendix

1. Single Regression Model

- Open the ProducingGuidance.xls.
- Paste observation data, calculate the normal from 1981 to 2010, and calculate the power of 1/4 of precipitation values.

“1981 DJF” means DJF of 1980/1981.

(1) Paste observation data.

(2) Input “=AVERAGE(C4:C33)” at C34.

(3) Input “=C4^0.25” at D4.

(4) Copy D4 and paste it into D5:D34.

Year	Target	Observation	power of 1/4	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	power of 4	σn	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	JJA/DJF	deg mm	deg mm					%			NOs, σn	NOs, σn	NOs, σn
1981	DJF	75	295										
1982	DJF	91.5	309										
1983	DJF	95	312										
1984	DJF	108.5	323										
1985	DJF	214.5	383										
1986	DJF	61	279										
1987	DJF	183	368										
1988	DJF	106	321										
1989	DJF	202	377										
1990	DJF	178	365										
1991	DJF	162	357										
1992	DJF	122	332										
1993	DJF	237.5	393										
1994	DJF	203.5	378										
1995	DJF	86	305										
1996	DJF	68	276										
1997	DJF	98.5	315										
1998	DJF	273	406										
1999	DJF	103	319										
2000	DJF	77.5	297										
2001	DJF	156	353										
2002	DJF	153.5	352										
2003	DJF	249	397										
2004	DJF	76.5	296										
2005	DJF	204.5	378										
2006	DJF	183.5	368										
2007	DJF	299.5	416										
2008	DJF	146.5	349										
2009	DJF	259	401										
2010	DJF	205.5	379										
Normal		159.7	353										
The lower limit of around normal													
The upper limit of around normal													
slope					#DIV/0!	#DIV/0!	#DIV/0!						
intercept					#DIV/0!	#DIV/0!	#DIV/0!						
Correlation					#DIV/0!	#DIV/0!	#DIV/0!						
slope					#VALUE!	#VALUE!	#VALUE!						
intercept					#VALUE!	#VALUE!	#VALUE!						
Correlation					#DIV/0!								

Precipitation worksheet

In this case, the predictand is precipitation and the station is Tokyo.

1. Single Regression Model

- Rank the data from 1981 to 2010 in descending order and calculate the lower and upper limits of around normal (preparation for probabilistic forecast).

(1) Input “=RANK(C4,\$C\$4:\$C\$33,0)” at E4.

(2) Copy E4 and paste it into E5:E33.

(3) Calculate the mean value of the rank 20th and 21st data (C35).

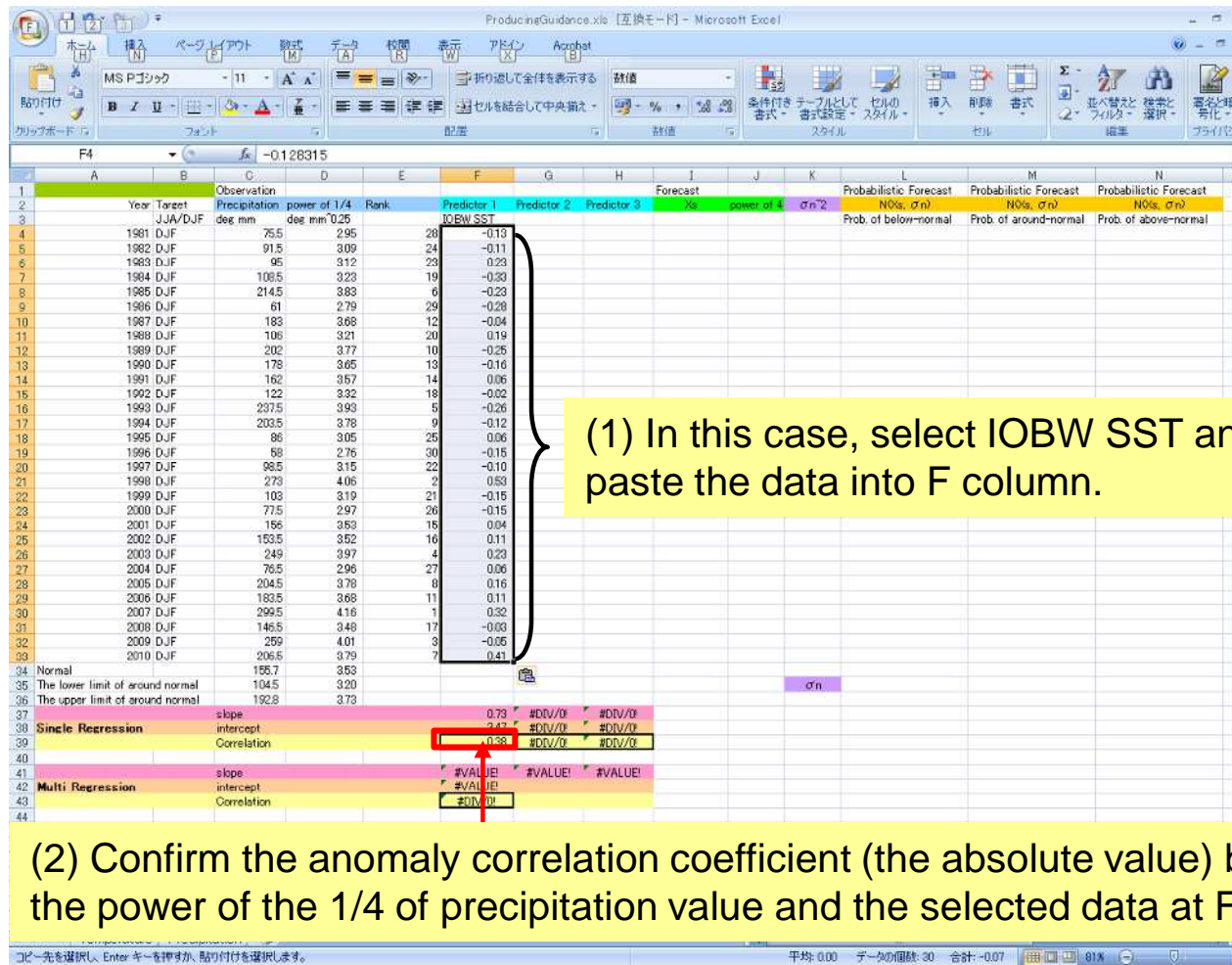
(4) Calculate the mean value of the rank 10th and 11th data (C36).

(5) Copy D34 and paste it into D35:E36.

Year	Target	Observation	power of 1/4	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	power of 4	σn ²	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
JJA/DJF	deg mm	deg mm	deg mm ^{0.25}					%			NOs, σn	NOs, σn	NOs, σn
1981	DJF	75.5	2.95	28									
1982	DJF	91.5	3.09	24									
1983	DJF	95	3.12	23									
1984	DJF	108.5	3.23	19									
1985	DJF	214.5	3.83	6									
1986	DJF	61	2.79	29									
1987	DJF	183	3.68	12									
1988	DJF	106	3.21	20									
1989	DJF	202	3.77	10									
1990	DJF	178	3.65	13									
1991	DJF	162	3.57	14									
1992	DJF	122	3.32	18									
1993	DJF	237.5	3.93	5									
1994	DJF	203.5	3.78	9									
1995	DJF	86	3.05	25									
1996	DJF	68	2.76	30									
		315	3.22	22									
		406	3.44	2									
		319	3.19	21									
		297	3.08	26									
		353	3.53	15									
		352	3.52	16									
		397	3.97	4									
		296	2.96	27									
		378	3.78	8									
		368	3.68	11									
		416	4.16	1									
		349	3.49	17									
		401	4.01	3									
		379	3.79	7									
2009	DJF	259	3.53										
2010	DJF	206.5	3.79										
Normal		196.7	3.53										
The lower limit of around normal		104.5	3.20										
The upper limit of around normal		192.8	3.73										

1. Single Regression Model

- Open GPVdata.xls and indices.xls.
- Select a predictor and paste the data into F column



(1) In this case, select IOBW SST and paste the data into F column.

Year	Target JJA/DJF deg mm	Observation precipitation deg mm	power of 1/4 deg mm ^{0.25}	Rank	Predictor 1 IOBW SST	Predictor 2	Predictor 3	Forecast %	power of 4	σn^2	Probabilistic Forecast NOs, σn	Probabilistic Forecast NOs, σn	Probabilistic Forecast NOs, σn
1981 DJF	75.5	75.5	2.95	28	-0.13								
1982 DJF	91.5	91.5	3.09	24	-0.11								
1983 DJF	95	95	3.12	23	0.23								
1984 DJF	108.5	108.5	3.23	19	-0.30								
1985 DJF	214.5	214.5	3.83	6	-0.23								
1986 DJF	61	61	2.79	29	-0.28								
1987 DJF	183	183	3.68	12	-0.04								
1988 DJF	106	106	3.21	20	0.19								
1989 DJF	202	202	3.77	10	-0.25								
1990 DJF	178	178	3.65	13	-0.16								
1991 DJF	162	162	3.57	14	0.06								
1992 DJF	122	122	3.32	18	-0.02								
1993 DJF	237.5	237.5	3.93	5	-0.26								
1994 DJF	203.5	203.5	3.78	9	-0.12								
1995 DJF	86	86	3.05	25	0.06								
1996 DJF	68	68	2.76	30	-0.15								
1997 DJF	98.5	98.5	3.15	22	-0.10								
1998 DJF	273	273	4.06	2	0.63								
1999 DJF	103	103	3.19	21	-0.15								
2000 DJF	77.5	77.5	2.97	26	-0.15								
2001 DJF	156	156	3.53	15	0.04								
2002 DJF	153.5	153.5	3.52	16	0.11								
2003 DJF	249	249	3.97	4	0.23								
2004 DJF	76.5	76.5	2.96	27	0.06								
2005 DJF	204.5	204.5	3.78	8	0.15								
2006 DJF	183.5	183.5	3.68	11	0.11								
2007 DJF	299.5	299.5	4.16	1	0.32								
2008 DJF	146.5	146.5	3.48	17	-0.03								
2009 DJF	259	259	4.01	3	-0.05								
2010 DJF	206.5	206.5	3.79	7	0.41								
Normal		155.7	3.53								σn		
The lower limit of around normal		104.5	3.20										
The upper limit of around normal		192.8	3.73										
Single Regression	slope				0.73	#DIV/0!	#DIV/0!						
	intercept				2.42	#DIV/0!	#DIV/0!						
	Correlation				0.88	#DIV/0!	#DIV/0!						
Multi Regression	slope				#VALUE!	#VALUE!	#VALUE!						
	intercept				#VALUE!	#VALUE!	#VALUE!						
	Correlation				#DIV/0!	#DIV/0!	#DIV/0!						

(2) Confirm the anomaly correlation coefficient (the absolute value) between the power of the 1/4 of precipitation value and the selected data at F39.

Please try to look for the most effective predictor.

1. Single Regression Model

- Calculate the power of 1/4 of the precipitation value using single regression equation.
- Calculate the 4th powers of them. (That is to say, forecasted precipitation values.)

(1) Input “ $=\$F\$37 * \$F4 + \$F\$38$ ” at I4.

(2) Copy I4 and paste it into J5:J33.

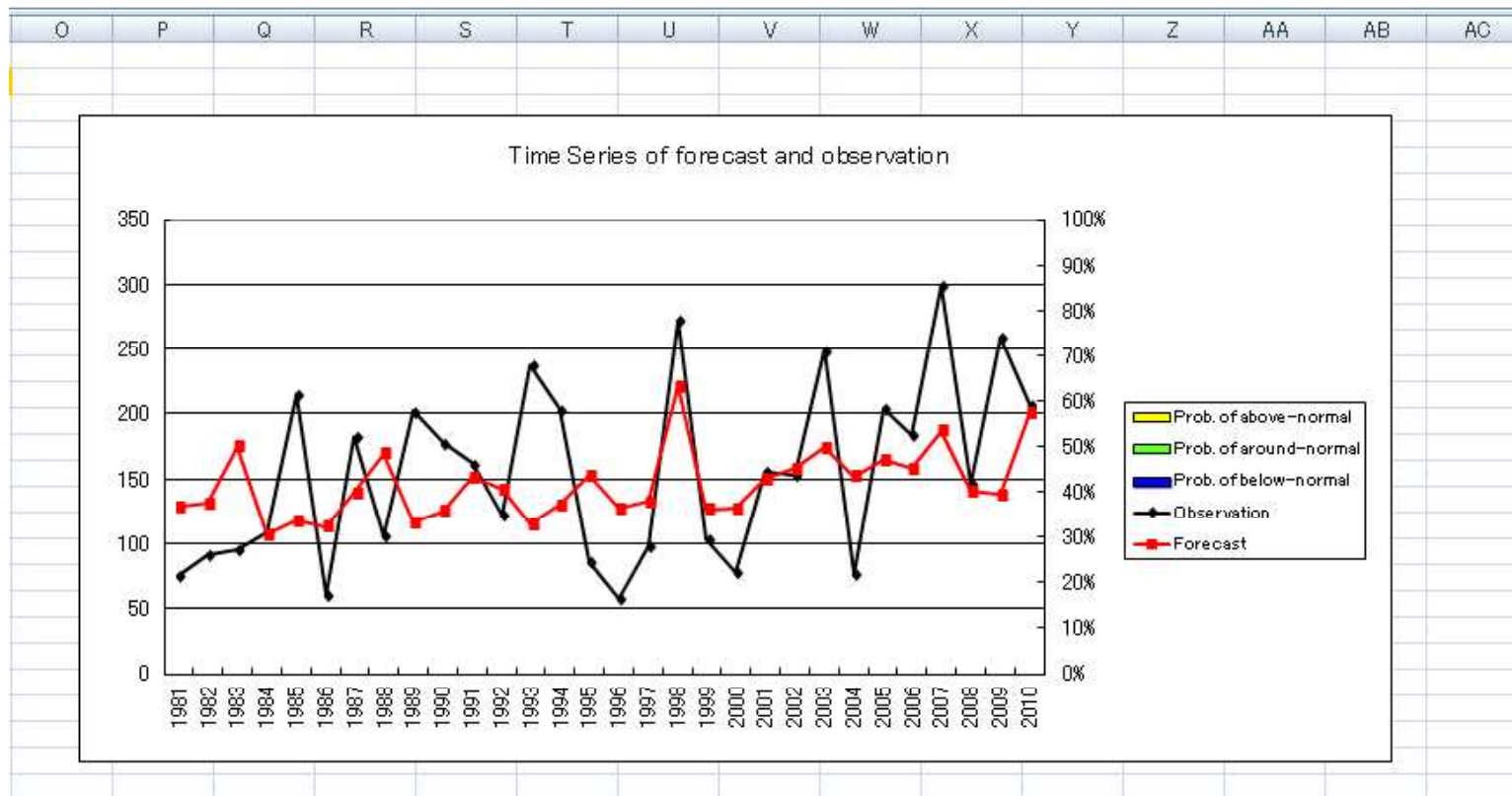
(3) Input “ $=I4^4$ ” at J4.

(4) Copy J4 and paste it into J5:J33.

Year	Target	Observation	power of 1/4	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast	%	power of 4	σn^2
1985 DJF	214.5	383	6	-0.23				337		1295	
1986 DJF	61	279	29	-0.28				338		131.3	
1987 DJF	183	368	12	-0.04				364		175.1	
1988 DJF	106	321	20	0.19				322		107.9	
1989 DJF	202	377	10	-0.25				330		118.4	
1990 DJF	178	365	13	-0.16				326		113.4	
1991 DJF	162	357	14	0.06				344		139.6	
1992 DJF	122	332	18	-0.02				361		169.8	
1993 DJF	237.5	393	5	-0.26				329		116.7	
1994 DJF								335		125.5	
1995 DJF								351		152.2	
1996 DJF								345		141.8	
1997 DJF								328		115.6	
1998 DJF								338		129.9	
1999 DJF	103	319	21	-0.15				351		152.4	
2000 DJF	77.5	297	26	-0.15				336		126.8	
2001 DJF	156	353	15	0.04				336		126.9	
2002 DJF	153.5	352	16	0.11				350		149.9	
2003 DJF	249	397	4	0.23				355		158.2	
2004 DJF	76.5	296	27	0.06				363		174.4	
2005 DJF	204.5	378	8	0.16				351		152.3	
2006 DJF	193.5	369	11	0.11				358		164.6	
2007 DJF	299.5	416	1	0.32				355		156.6	
2008 DJF	146.5	349	17	-0.03				370		187.2	
2009 DJF	259	401	3	-0.05				345		141.2	
2010 DJF	206.5	379	7	0.41				343		138.3	
Normal		155.7	353					377		201.0	
The lower limit of around normal		104.5	320								
The upper limit of around normal		192.8	373								

Single Regression	slope	0.73	#DIV/0!	#DIV/0!
	intercept	3.47	#DIV/0!	#DIV/0!
	Correlation	0.38	#DIV/0!	#DIV/0!
Multi Regression	slope	#VALUE!	#VALUE!	#VALUE!
	intercept	#VALUE!	#VALUE!	#VALUE!
	Correlation	0.42		

1. Single Regression Model



2. Multiple Regression Model

- Try to look for most effective combination of predictors. after trial and error. The ITACS will help you find them (see the slides 21-23).

“1981 DJF” means
DJF of 1980/1981.

Year	Target	power of 1/4	Rank	Predictor 1	Predictor 2	Predictor 3	Forecast
JJA/DJF	deg mm	deg mm ^{0.25}		WNP RAIN	THEX	MC RAIN	%
1981 DJF	75.5	2.95	28	0.55	-0.18	0.29	
1982 DJF	91.5	3.09	24	0.13	-0.20	0.82	
1983 DJF	95	3.12	23	-1.04	-0.16	-1.19	
1984 DJF	108.5	3.23	19	0.75	-0.14	0.25	
1985 DJF	214.5	3.83	6	0.69	-0.32	0.66	
1986 DJF	61	2.79	29	0.30	-0.26	0.46	
1987 DJF	183	3.68	12	-0.81	-0.21	-0.47	
1988 DJF	106	3.21	20	-0.01	-0.11	-0.21	
1989 DJF	202	3.77	10	0.92	-0.28	-0.63	
1990 DJF	178	3.65	13	-0.23	-0.11	0.77	
1991 DJF	162	3.57	14	-0.42	0.02	0.04	
1992 DJF	122	3.32	18	-0.54	-0.01	-0.34	
1993 DJF	237.5	3.93	5	0.33	-0.26	0.14	
1994 DJF	203.5	3.78	9	0.04	-0.23	-0.14	
1995 DJF	86	3.05	25	-0.54	-0.16	-0.62	
1996 DJF	68	2.76	30	0.57	-0.02	0.12	
1997 DJF	98.5	3.15	22	0.10	-0.02	0.12	
1998 DJF	273	4.06	2	-1.42	0.33	-0.94	
1999 DJF	103	3.19	21	0.71	0.19	0.20	
2000 DJF	77.5	2.97	26	0.13	-0.11	0.27	
2001 DJF	156	3.83	15	0.03	0.12	0.31	
2002 DJF	153.5	3.82	16	0.18	0.25	0.04	
2003 DJF	249	3.97	4	-0.78	0.36	-0.31	
2004 DJF	76.5	2.96	27	0.19	0.18	0.53	
2005 DJF	204.5	3.78	8	-0.93	0.23	-0.95	
2006 DJF	193.5	3.69	11	0.23	0.24	0.77	
2007 DJF	299.5	4.16	1	-0.22	0.31	-0.60	
2008 DJF	146.5	3.49	17	0.55	0.08	0.22	
2009 DJF	259	4.01	3	0.08	0.05	0.37	
2010 DJF	206.5	3.79	7	-0.44	0.41	-0.32	

(1) In this case, select IOBW, Z2030, and NINOWEST SST. Paste them to F4:F33, G4:G33, and H4:H33, respectively.

(2) Check the correlation coefficients (the absolute values).

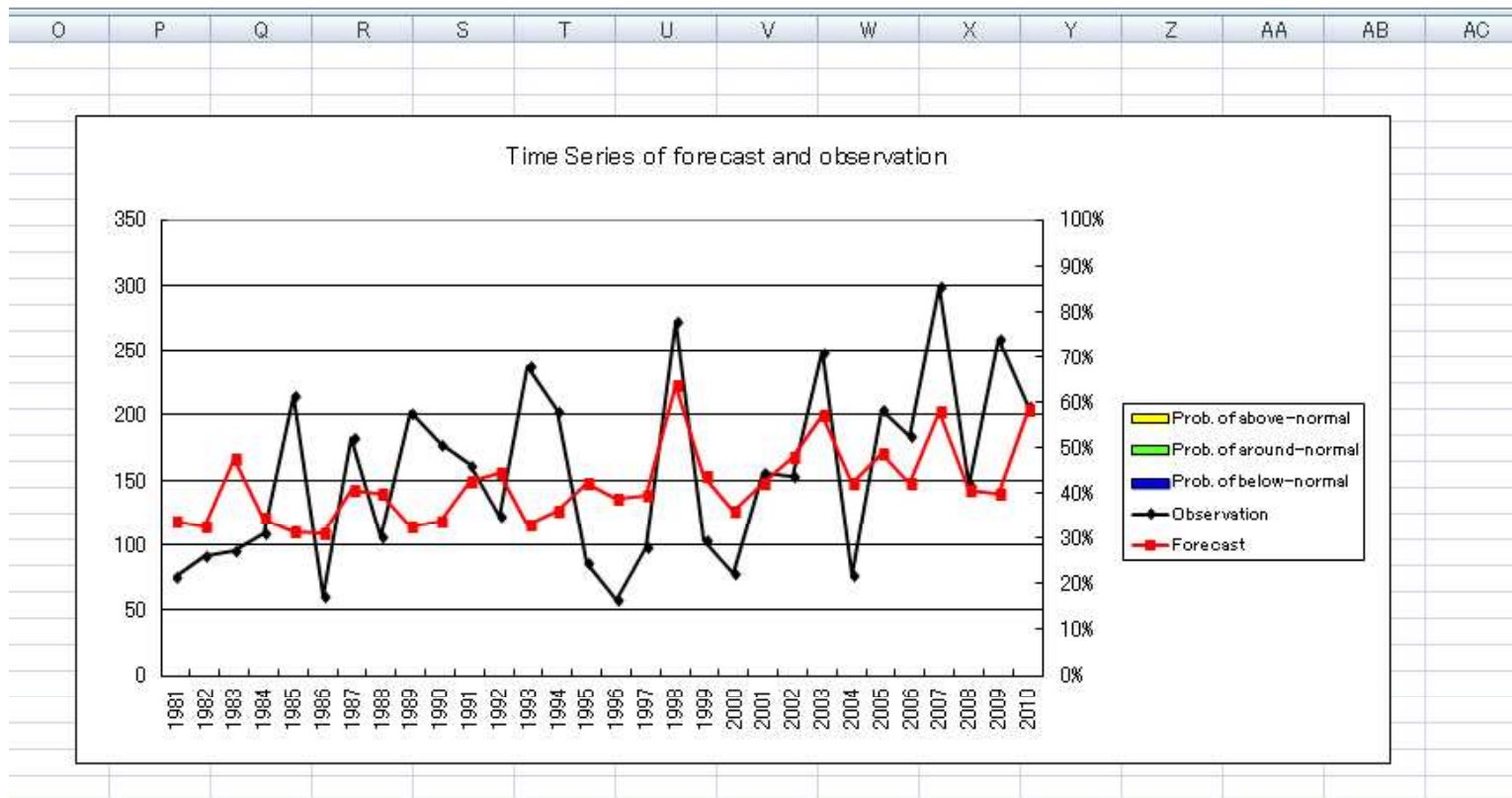
Regression Type	Parameter	Value
Single Regression	slope	-0.20
	intercept	3.47
	Correlation	0.28
Multi Regression	slope	-0.05
	intercept	3.47
	Correlation	#DIV/0!

2. Multiple Regression Model

- Calculate the power of 1/4 of the precipitation value using multiple regression equation.
- Calculate the 4th powers of them. (That is to say, forecasted precipitation values.)

Year	Target	Observation	power of 1/4	Rank	Predictor 1	Predictor 2	Predictor 3	%	Forecast	power of 4	σn ²	Probabilistic Forecast	Probabilistic Forecast	Probabilistic Forecast
					RAIN	TEMP	MOI	RAIN				NOs, σn ²	NOs, σn ²	NOs, σn ²
15	1992 DJF	122	332	18	-0.54	-0.01	0.90	0.329	117.6					
16	1993 DJF	297.5	393	5	0.33	-0.26	0.82	327	114.1					
22	1999 DJF	103	319	21	0.71	0.19	0.20	351	152.6					
23	2000 DJF	77.5	297	26	0.13	-0.11	0.27	335	126.7					
24	2001 DJF	156	353	15	0.03	0.12	0.31	349	148.1					
25	2002 DJF	153.5	352	16	0.18	0.25	0.04	360	167.4					
26	2003 DJF	249	397	4	-0.78	0.36	-0.31	376	199.7					
27	2004 DJF	76.5	296	27	0.19	0.18	0.53	349	147.8					
28	2005 DJF	204.5	378	8	-0.93	0.23	-0.95	361	170.3					
29	2006 DJF	193.5	369	11	0.23	0.24	0.77	348	147.1					
30	2007 DJF	299.5	416	1	-0.22	0.31	-0.60	377	202.5					
31	2008 DJF	146.5	349	17	0.55	0.08	0.22	345	142.4					
32	2009 DJF	259	401	3	0.08	0.05	0.37	344	140.1					
33	2010 DJF	206.5	379	7	-0.44	0.41	-0.37	370	203.8					
34	Normal	155.7	353											
35	The lower limit of around normal	104.5	320											
36	The upper limit of around normal	192.8	373											
37	Single Regression	slope			-0.20	0.67	-0.22							
38		intercept			3.47	3.47	3.47							
39		Correlation			0.28	0.26	0.26							
40														
41	Multi Regression	slope			-0.05	0.88	-0.14							
42		intercept			3.47									
43		Correlation			0.47									

2. Multiple Regression Model



3. Probabilistic Forecast

- Calculate squares of regression errors of the powers of 1/4 of precipitation values .
- Calculate the root mean square error.

“1981 DJF” means DJF of 1980/1981.

(1) Input “ $= (I4 - D4)^2$ ” at K4 to calculate the square error.

(2) Copy K4 and paste it into K5:K33.

(3) Input “ $= \text{SQRT}(\text{AVERAGE}(K4:K33))$ ” at K34 to calculate root mean square error.

Year	Year	Year	Forecast	power of 1/4	sigma n ²
1981 DJF	75.5	295	329	0.25	0.119
1982 DJF	91.5	309	327	0.25	0.031
1983 DJF	95	312	359	0.25	0.220
1984 DJF	108.5	323	331	0.25	0.007
1985 DJF	214.5	383	324	0.25	0.348
1986 DJF	61	279	323	0.25	0.191
1987 DJF	183	368	345	0.25	0.051
1988 DJF	106	321	343	0.25	0.051
1989 DJF	202	377	327	0.25	0.254
1990 DJF	178	365	330	0.25	0.124
1991 DJF	162	357	349	0.25	0.006
1992 DJF	122	332	353	0.25	0.044
1993 DJF	237.5	393	328	0.25	0.418
1994 DJF	203.5	378	335	0.25	0.182
1995 DJF	86	305	349	0.25	0.197
1996 DJF	68	276	341	0.25	0.424
1997 DJF	98.5	315	343	0.25	0.079
1998 DJF	273	406	386	0.25	0.041
1999 DJF	103	319	351	0.25	0.108
2000 DJF	77.5	297	335	0.25	0.150
2001 DJF	156	353	349	0.25	0.002
2002 DJF	153.5	352	360	0.25	0.006
2003 DJF	249	397	376	0.25	0.045
2004 DJF	76.5	296	349	0.25	0.280
2005 DJF	204.5	378	361	0.25	0.029
2006 DJF	193.5	368	348	0.25	0.039
2007 DJF	299.5	416	377	0.25	0.150
2008 DJF	146.5	349	345	0.25	0.001
2009 DJF	259	401	344	0.25	0.327
2010 DJF	206.5	379	378	0.25	0.000
Normal	155.7	353			0.382
The lower limit of around normal	104.5	320			
The upper limit of around normal	192.8	373			
Single Regression		slope	-0.20	0.67	-0.22
		intercept	3.47	3.47	3.47
		Correlation	0.28	0.26	0.26
Multi Regression		slope	-0.05	0.58	-0.14
		intercept	3.47		
		Correlation	0.47		

3. Probabilistic Forecast

- Calculate probability of below-normal.

TRUE:
Value of **cumulative distribution function** for the first argument (i.e. \$C\$35).

FALSE:
Value of **probability density function** for the first argument (i.e. \$C\$35).

(1) Input
"=NORMDIST(\$D\$35,\$I4,\$K\$34,TRUE)"
at L4.

σn	Prob. of below-normal	Prob. of around-normal	Prob. of above-normal
0.119	40%		
0.031	42%		
0.220	14%		
0.007	38%		
0.348	46%		
0.191	46%		
0.051	24%		
0.054	26%		
0.124	42%		
0.124	38%		
0.006	21%		
0.044	18%		
0.418	41%		
0.182	34%		
0.197	21%		
0.424	28%		
0.079	26%		
0.041	36%		
0.108	19%		
6.7	15%		
8.1	0.002	21%	
7.4	0.006	13%	
9.7	0.045	6%	
7.8	0.280	21%	
0.3	0.029	13%	
7.1	0.039	21%	
2.5	0.150	6%	
2.4	0.001	24%	
0.1	0.327	25%	
3.8	0.000	5%	
0.362			
σn			

(2) Copy L4 and paste it into L5:L33.

Forecast probability density function (PDF)

3. Probabilistic Forecast

- Calculate probability of above-normal.

Very important!

TRUE:
Value of cumulative distribution function for the first argument (i.e. \$C\$36).

FALSE:
Value of probability density function for the first argument (i.e. \$C\$36).

(1) Input
"=1-NORMDIST(\$D\$36,\$I4,\$K\$34,TRUE)"
at L4.

Forecast probability density function (PDF)

below normal, around normal, above normal

normal Xs

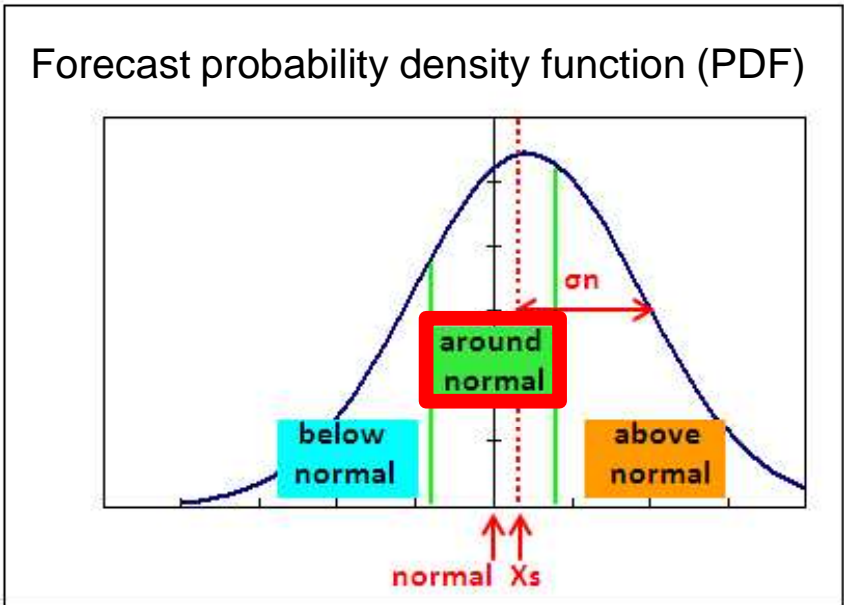
(2) Copy N4 and paste it into N5:N33.

3. Probabilistic Forecast

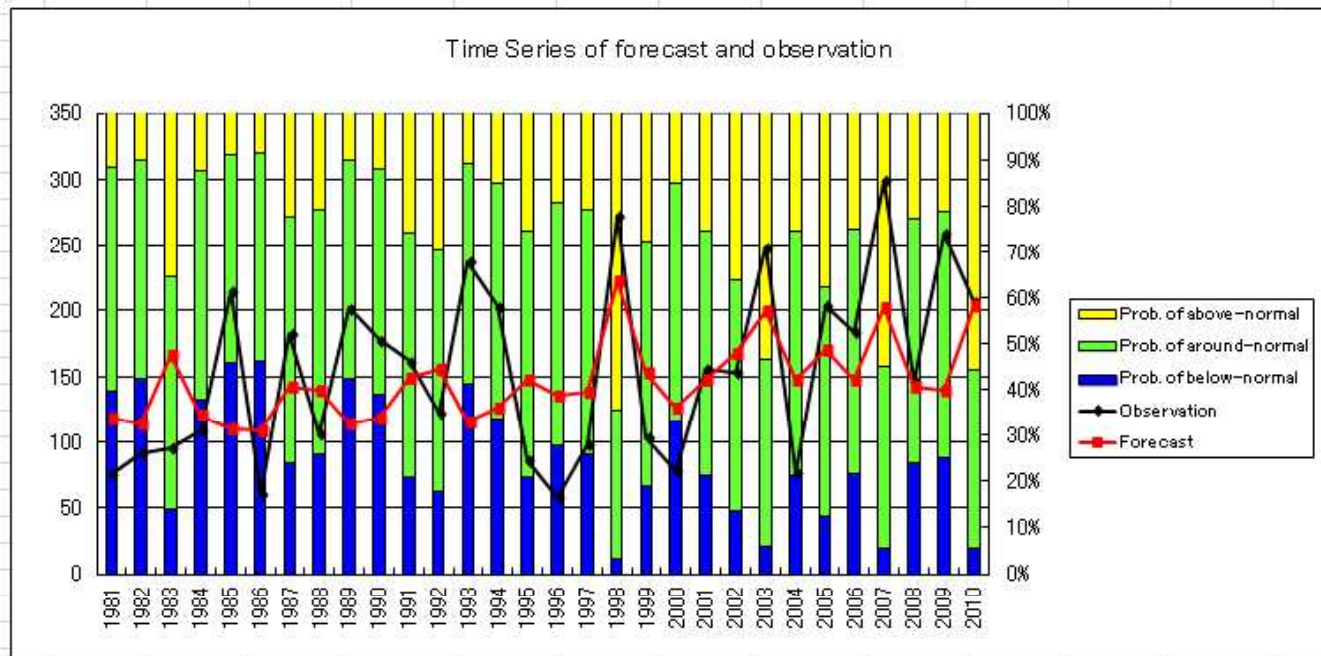
- Calculate probability of around-normal.

(1) Input "`=1-L4-N4`" at M4.

(2) Copy M4 and paste it into M5:M33.



3. Probabilistic Forecast



Anomaly Correlation (AC)

$$AC = \frac{\sum_{i=1}^N (F_i - C_i)(O_i - C_i)}{\sqrt{\sum_{i=1}^N (F_i - C_i)^2} \sqrt{\sum_{i=1}^N (O_i - C_i)^2}}$$

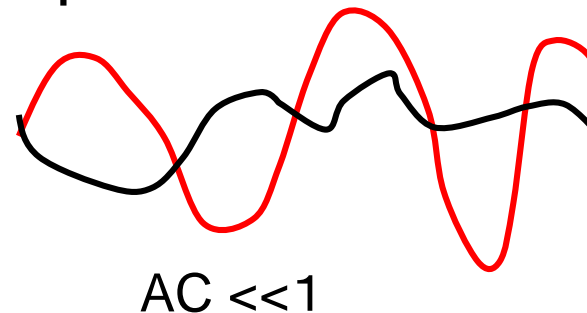
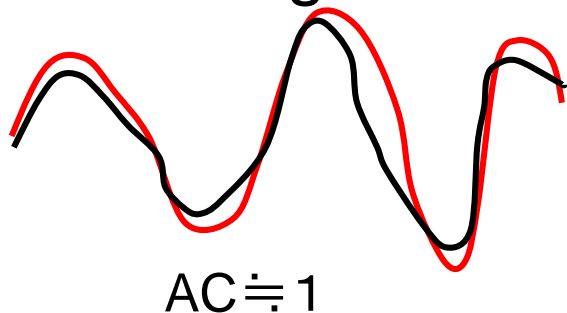
F : forecast

O : observation

C : climatology

Range: -1 to 1. Perfect score: 1.

- AC measures correspondence or phase difference between forecast and observation, subtracting out the climatological mean at each point.



Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (F_i - O_i)^2}$$

F : forecast

O : observation

N : sample size

Range: 0 to infinity, Perfect score: 0.

- RMSE measures absolute magnitude of the forecast error.
- It does not indicate the direction the error.

