16th International TOVS Study Conference

Experiment of the Use of Satellite Microwave Data Affected by Cloud in Numerical Prediction

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Our talk includes:

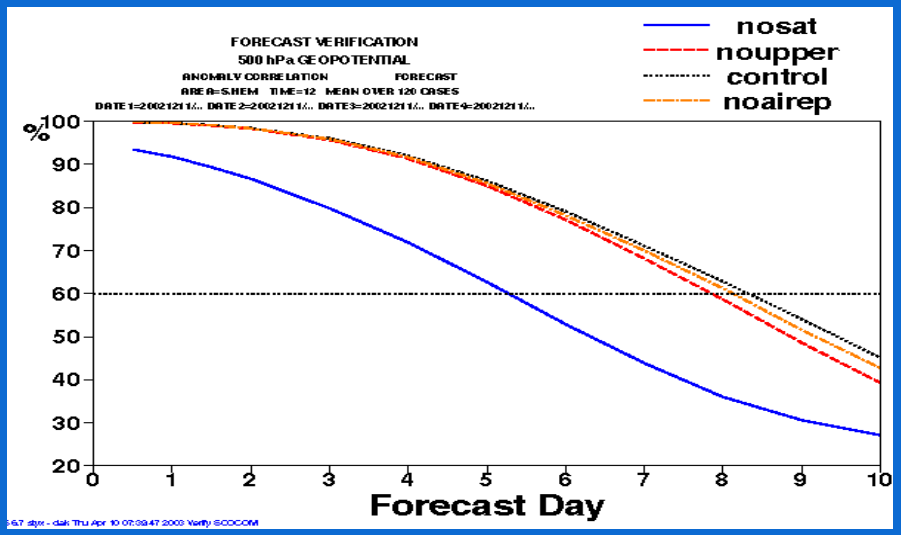
1 **Introduction**

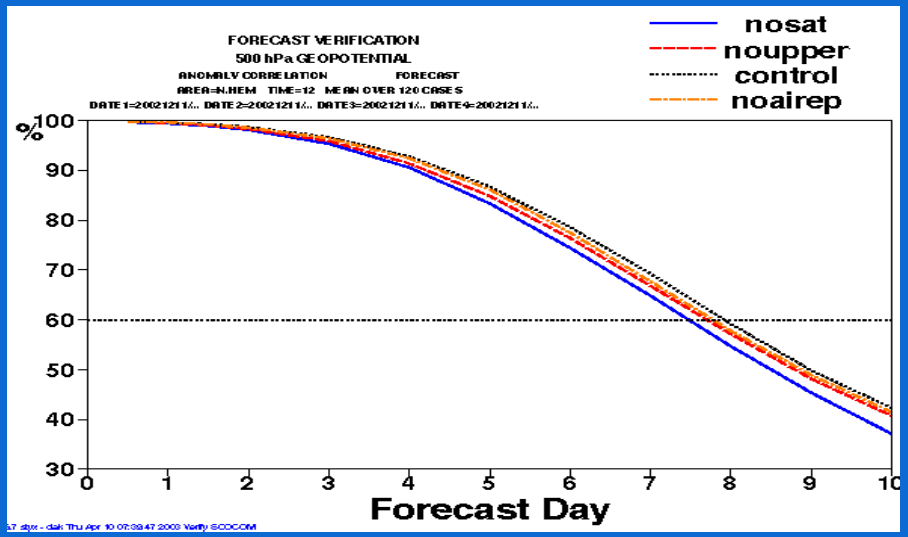
2 **The experiment of cloud examination**

3 **Verification of simulation of satellite microwave data in cloudy and rainy area**

4 **Conclusion and discussion**

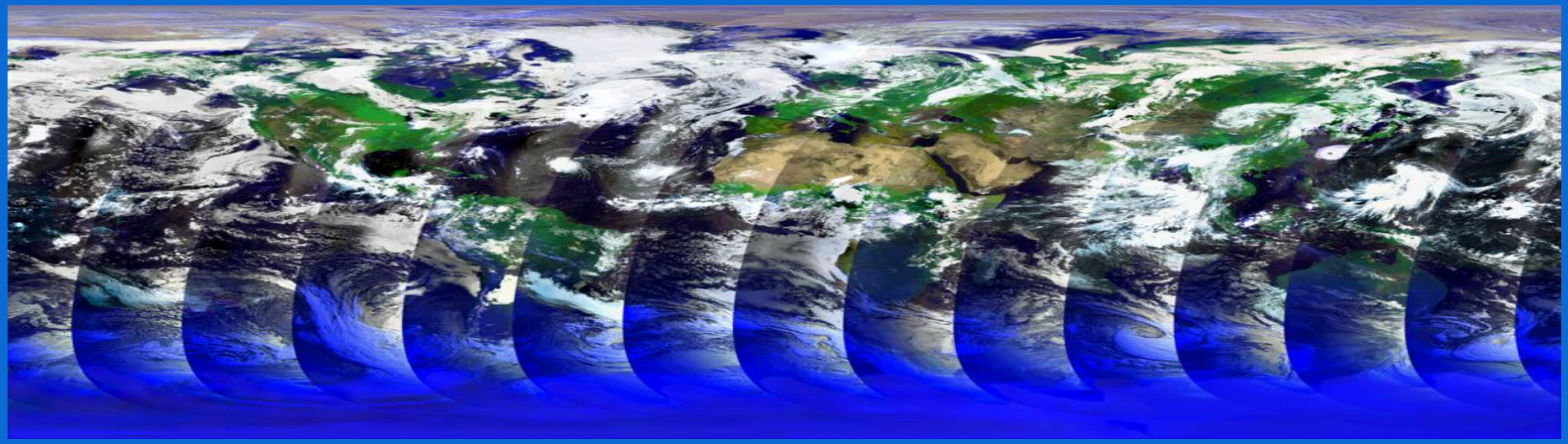
1 Introduction





Satellite date have been using in numerical weather prediction and already took up the role of main data source among the observations used.

It improves greatly the quality of initial condition and the accuracy of numerical weather forecast.



However, more than 97% satellite data passed the pre-process are discarded before they enter into the data assimilation system. Among them, it is showed that the satellite data affected by cloud held more than 75% in the ECMWF statistical report. Only cloud-cleared satellite data are used in most current data assimilation systems.

At present, the satellite data affected by cloud is examined through the cloud examination method.

Météo-France: the bias between the simulated bright temperature and observation of AMSU-A channel 4, Δ>1.5 K.

MetOffice UK: the total perciptible water for AMSU-A channel 4, 5 and AMSU-B channel 5;
precipitation examination for AMSU-A channel 4-8 and AMSU-B all channel.

Canadian Meteorological Centre: Bennartz Scattering Index is used for AMSU-B. The thresholds are 0, 15 and 40 for land, sea and sea ice, respectively

AAPP: Scattering Index, precipitation probability, precipitation examination and so on.

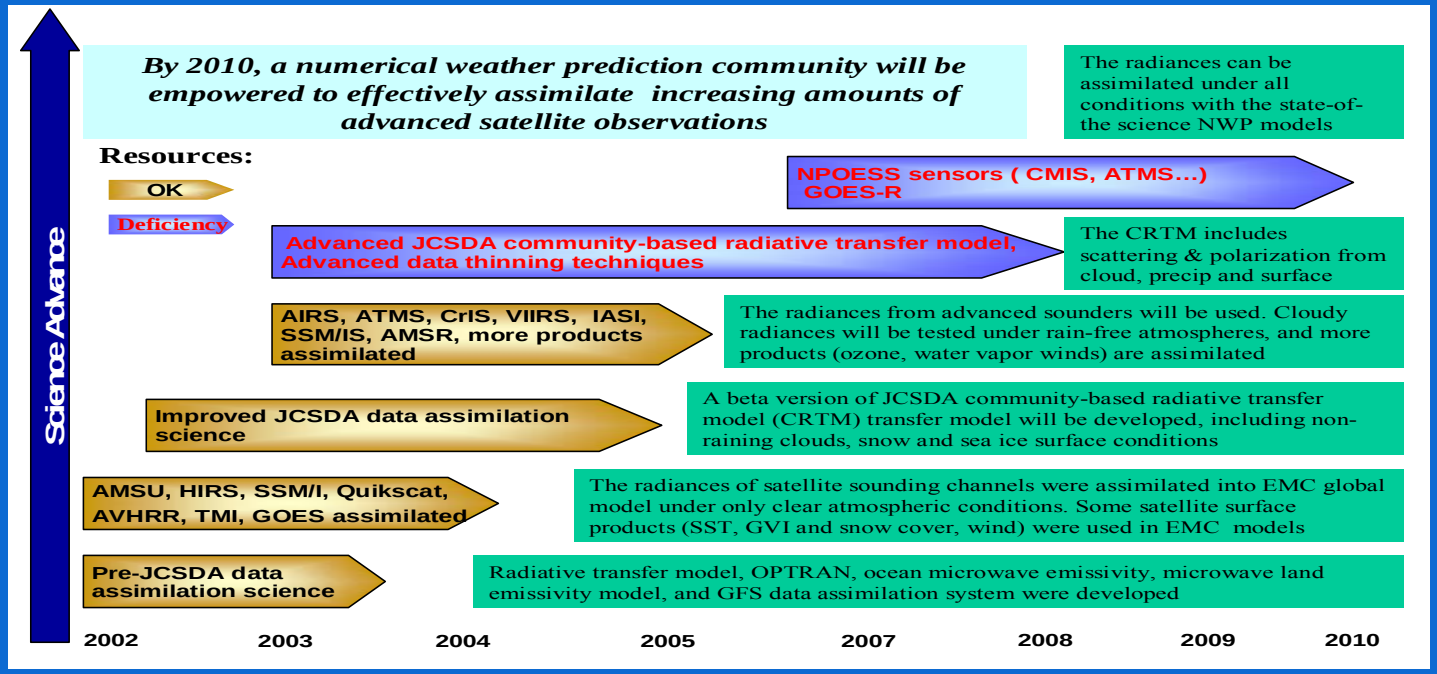
At the same time, the code for simulation of cloud-affected radiance is being developed in the fast radiative transfer model.

ECMWF RTTOV 9.1:

the cloud radiant effects for the infrared are parameterized rather than treated explicitly, while a slower, explicit approach is applied to the microwave in an individual module RTTOV-SCATT.

JCSDA CRTM :

is designed to make use of satellite data under all weather conditions.

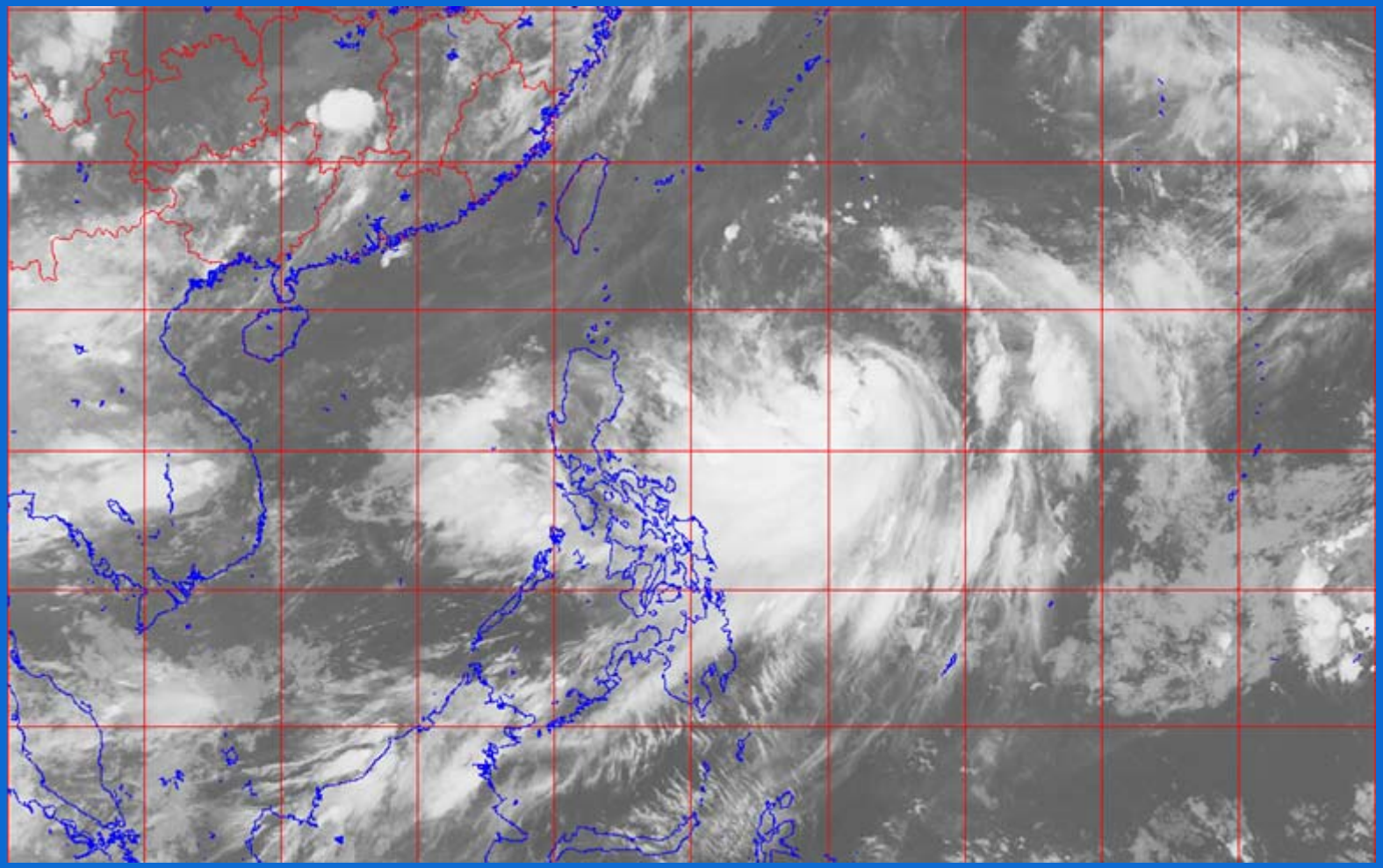


2 The experiment of cloud examination

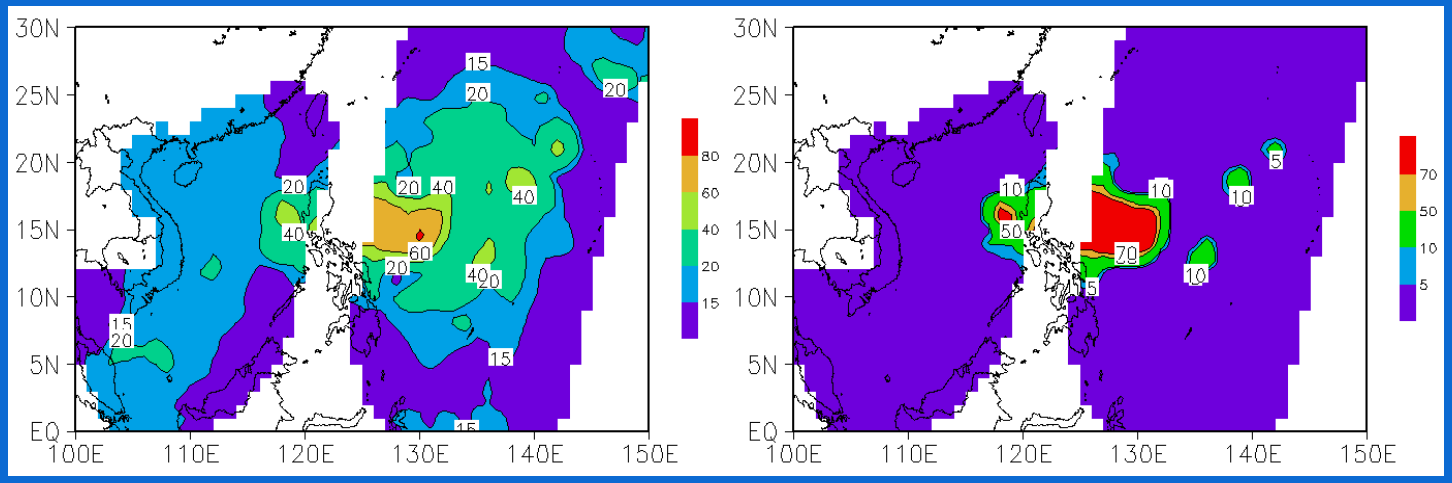
1) Cloud examination method

Table 1: The cloud examination method for AMSU data

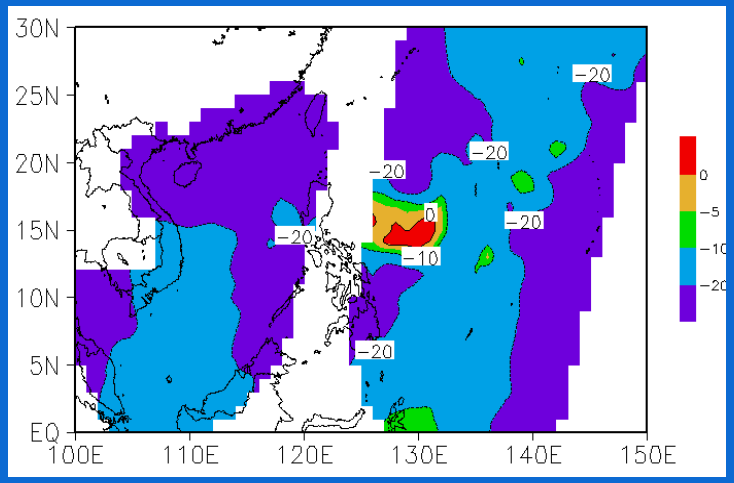
Data	Examination method	Formula
AMSU-A	Scattering Index	SI=ETB15-TB15 ETB15=a+b×TB1+c×TB2+d×TB3 Where, a□ b□ c and d are tri-polynomial for tangent of scanning angle.
	Precipitation probability	P=1/□ 1+e^{-f}□ ×100 Where, f=10.5+0.184×TB1-0.221×TB15
	Precipitation examination	R=ETB1-TB1 Where, ETB1=38+0.88× TB2
AMSU-B	Bias between simulated bright temperature and observation for Channel 2	$\Delta=\|obs-fg\|_{ch2}$ Where, ob and fg are simulated bright temperature and observation, respectively.
	Bennartz Scattering Index	SI=□ TB1-TB2□ -(-39.2010+0.1104Θ) Where, Θ is the local zenith angle of scanning field.



0604 Bilis at 1800 UTC 10 July, 2006

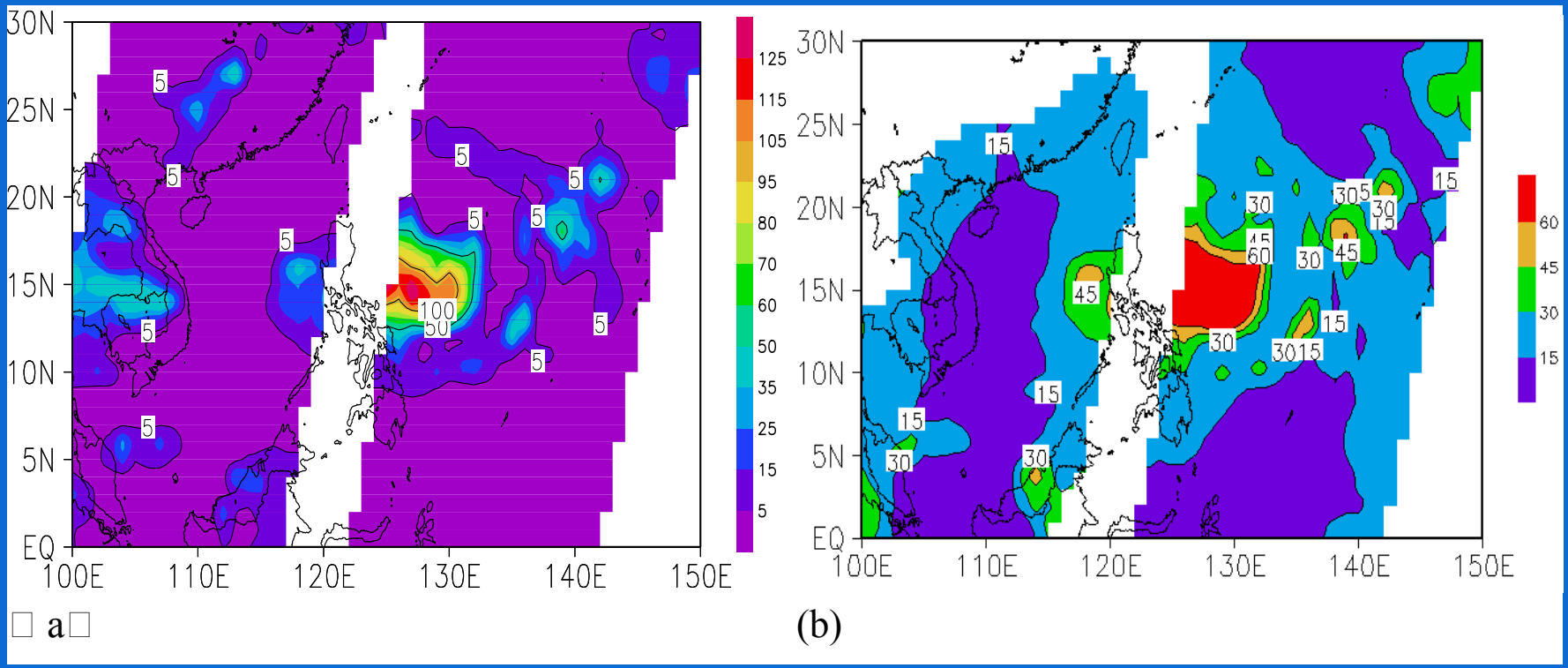


□ a□ (b)



□ c□

The value of cloud examination methods for AMSU-A. (a) Scattering Index; (b) precipitation probability; (c) precipitation examination



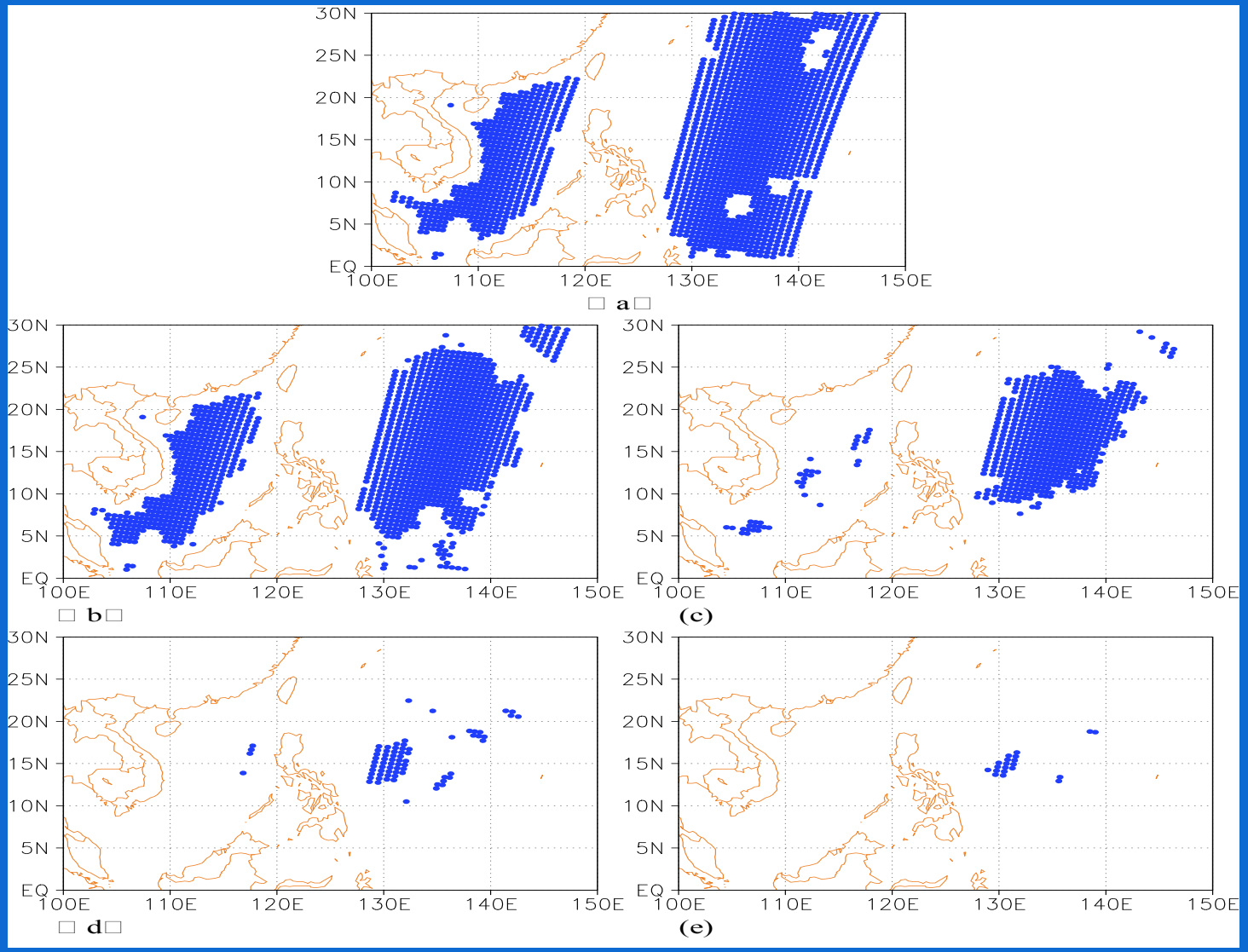
The value of cloud examination methods for AMSU-B. (a) Bias between simulated bright temperature and observation for Channel 2; (b) Bennartz Scattering Index

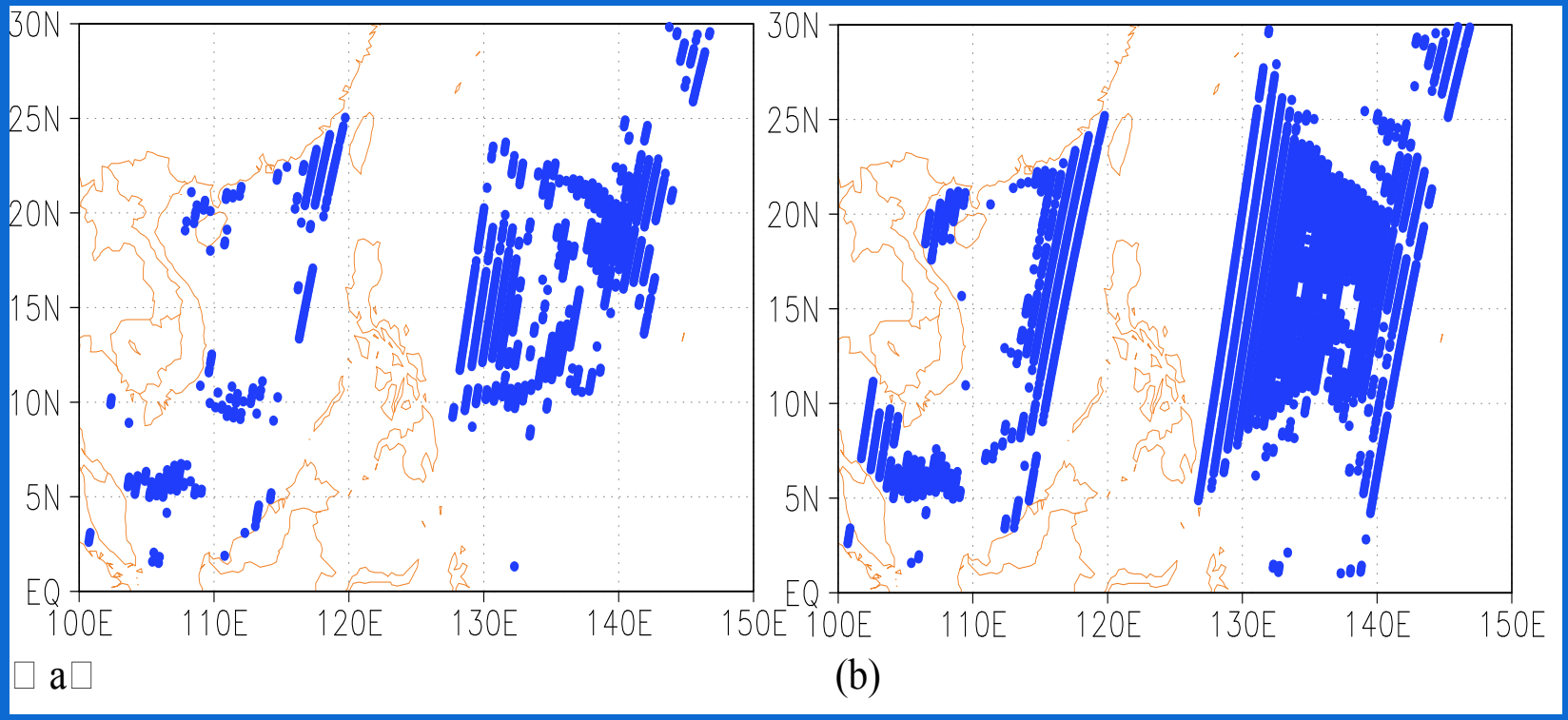
2) Experiment design

Table 2: List of numerical experiment design

Experiment design			
Control experiment	The initial backgound without data assimilation is used for numerical simulation		
Assimilation experiment	The initial condition with the correction by satellite data is used		
	Data	Criterion	Channel selection
Experiment 1	AMSU-A	SI>10	5□ 7
Experiment 2		SI>10	5□ 10
Experiment 3		SI>15	5□ 7
Experiment 4		SI>20	5□ 7
Experiment 5		P>5	5□ 7
Experiment 6		R>0	5□ 7
Experiment 7	AMSU-B	**Δ ≥ 5K**	3□ 5
Experiment 8		Bennartz SI>15	3□ 5

3) Screen of data affected by cloud

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□ a□
(b)

Table 3: The number of cloudy satellite and the root mean square error of the bias between background simulated bright temperature and observation for AMSU-A channel 5□ 10

Cloud examination and threshold	The number of cloudy satellite observation	Channel / RMSE	5	6	7	8	9	10
SI>10	1827		0.89	0.34	0.43	0.53	0.32	0.28
SI>15	1399		1.00	0.35	0.44	0.53	0.32	0.28
SI>20	646		1.38	0.41	0.52	0.57	0.33	0.30
P>5	73		3.47	0.61	0.67	0.61	0.49	0.43
R>0	20		4.54	0.59	0.77	0.60	0.63	0.51
Threshold of the bias between simulated bright temperature and observation			1.14	0.54	0.51	1.02	0.66	0.63

Table 4: The number of cloudy satellite and the root mean square error of the bias between background simulated bright temperature and observation for AMSU-B channel 3□ 5

Cloud examination and threshold	The number of cloudy satellite observation	Channel / RMSE	3	4	5
$\|obs-fg\|_{ch2} \geq 5K$	1160		9.17	16.54	28.44
Bennartz SI >20	2843		6.73	10.99	18.33
Threshold of the bias between simulated bright temperature and observation			7.98	7.14	7.38

4) Effect on the numerical forecast

Table 5: The error between simulated and observation trace for Bilis

Time	Control	Exp1	Exp2	Exp3	Exp4	Exp5	Exp6	Exp8
Second Period								
1018	144.81	144.81	144.81	144.81	144.81	144.81	144.81	144.81
1100	208.05	208.05	208.05	200.85	208.05	208.05	208.05	200.85
1106	163.61	163.61	163.61	163.61	163.61	163.61	163.61	163.61
1112	177.93	177.93	177.93	173.15	173.15	177.93	177.93	177.93
1118	203.69	151.65	203.69	155.49	155.49	151.65	203.69	151.65
1200	186.33	126.76	179.02	136.92	126.76	179.02	179.02	126.76
1206	194.50	127.25	178.38	125.14	127.25	178.38	178.38	178.38
1212	212.77	141.08	186.51	70.89	186.51	212.77	257.11	186.51
1218	291.46	178.75	292.26	104.97	252.37	292.26	335.00	219.74
1300	339.96	191.28	278.91	155.96	155.96	344.53	377.78	191.28
1306	403.84	272.11	346.57	168.26	382.28	403.84	451.30	272.11

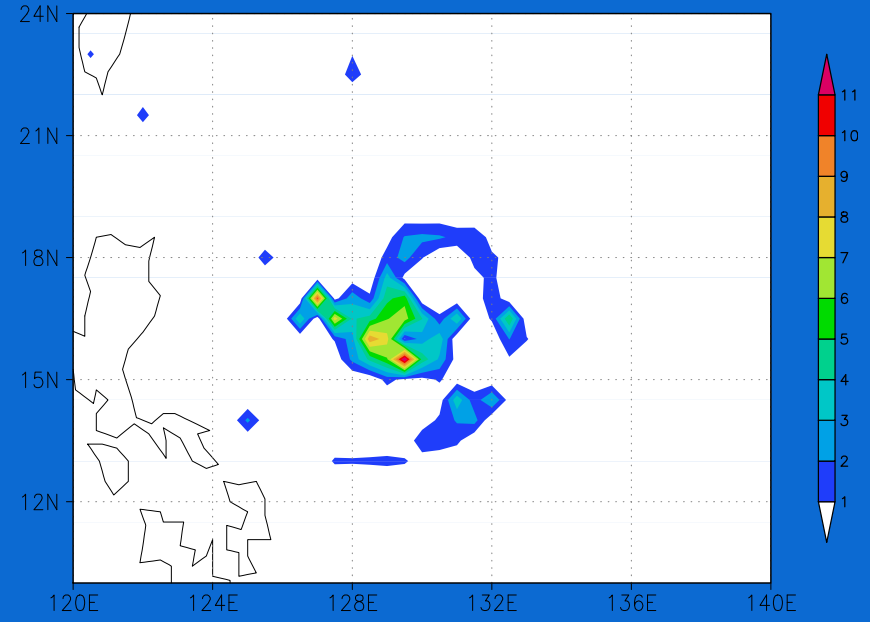
Generally speaking:

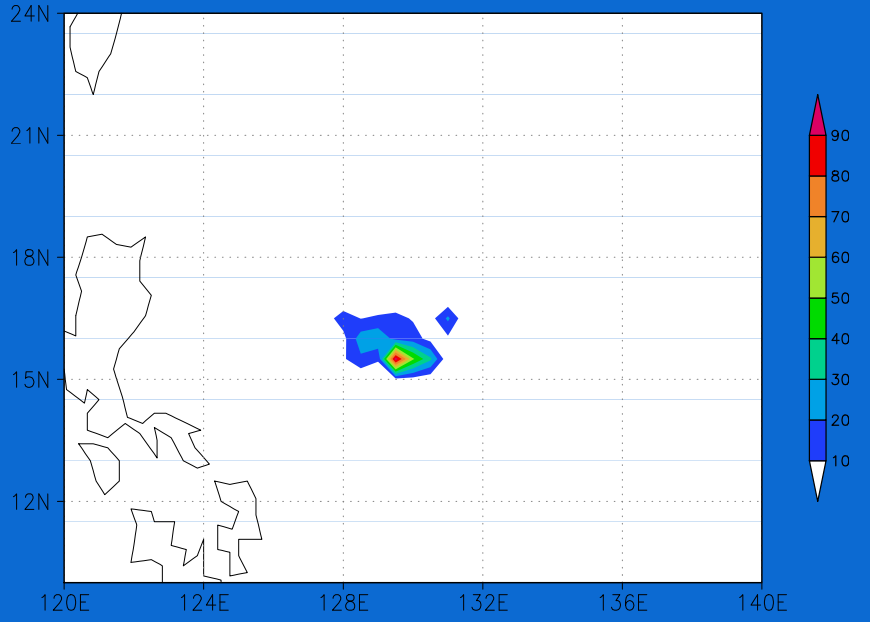
The introduction of AMSU-A data by Scattering Index with threshold 15 has positive effect on the regional numerical forecast.

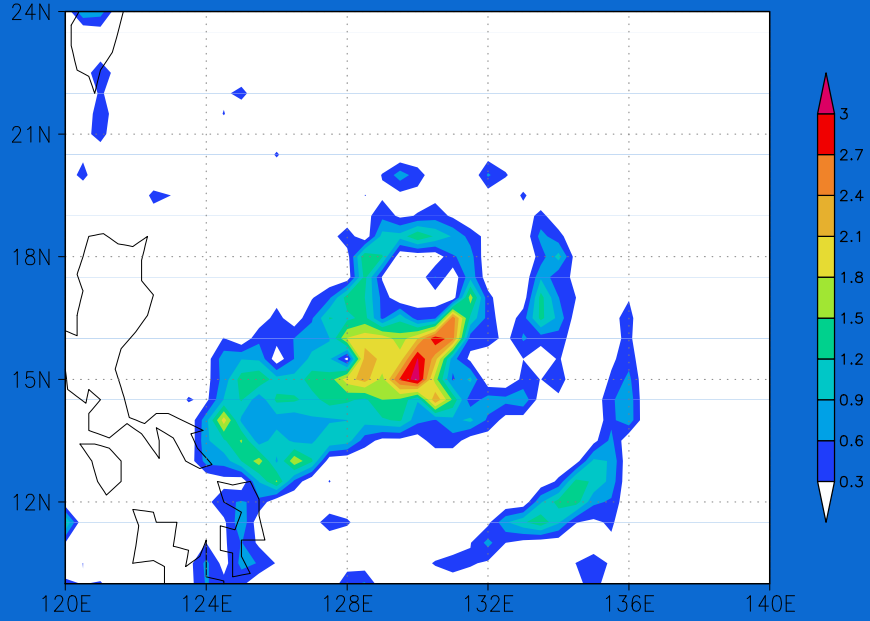
While with the number of satellite data used increasing by using Scattering Index with threshold 20, precipitation probability and precipitation examination, the forecast is degraded.

For AMSU-B, the bias between simulated bright temperature and observation of AMSU-B channel 2 performs well than Bennartz Scattering Index.

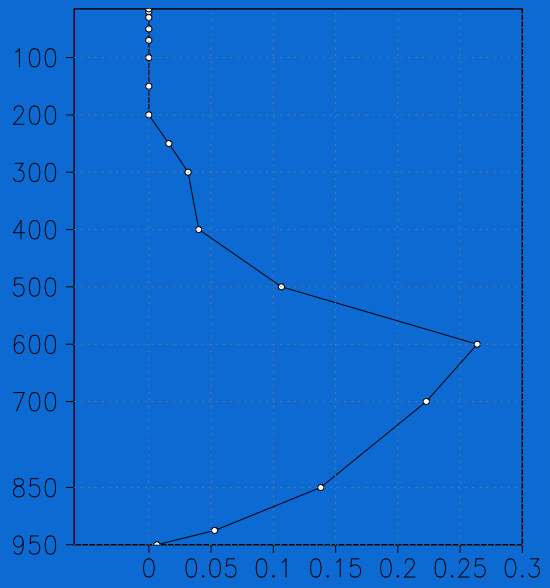
3 Verification of simulation of satellite microwave data in cloudy and rainy area

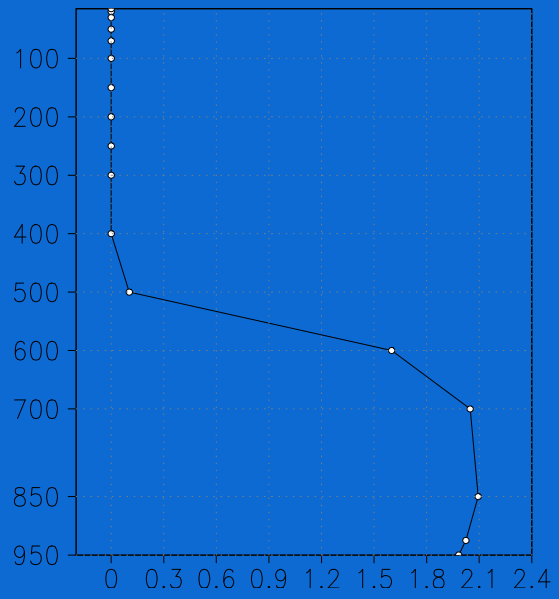


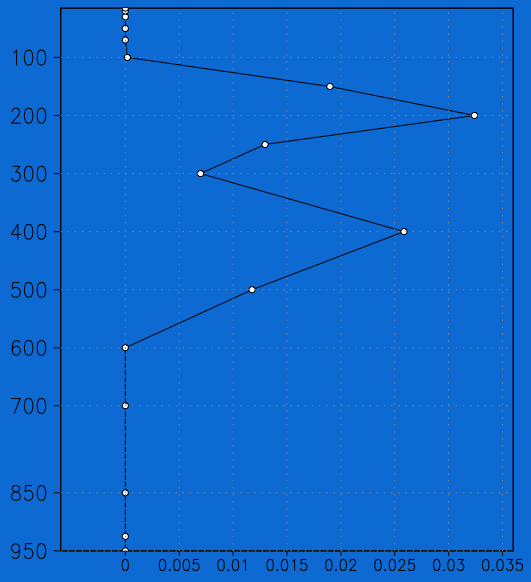




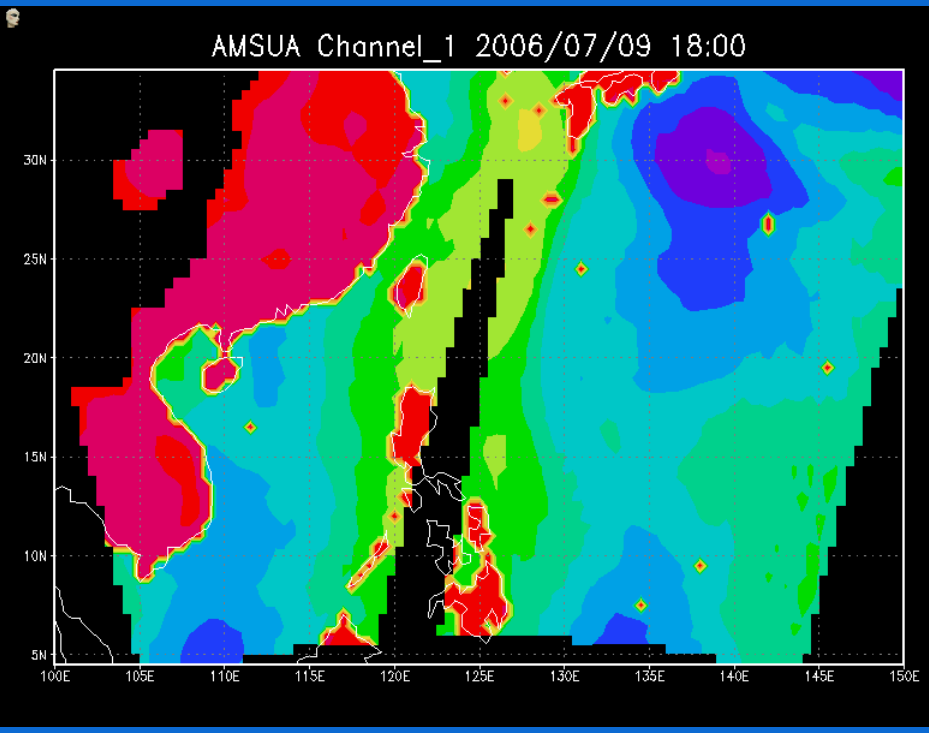
The total cloud water, rain water and ice water contents.



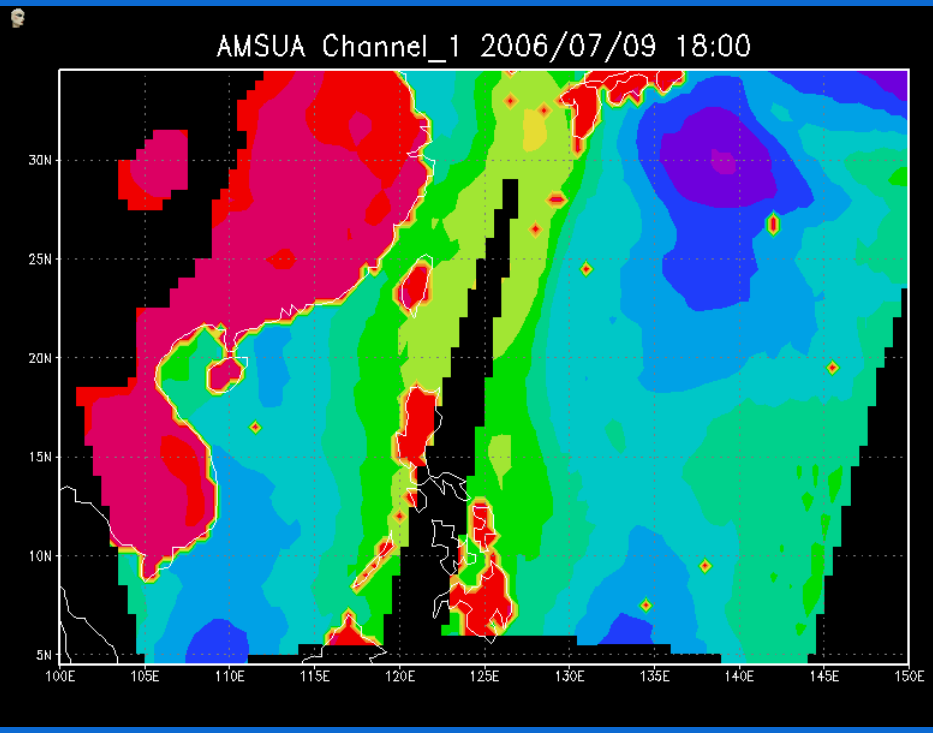




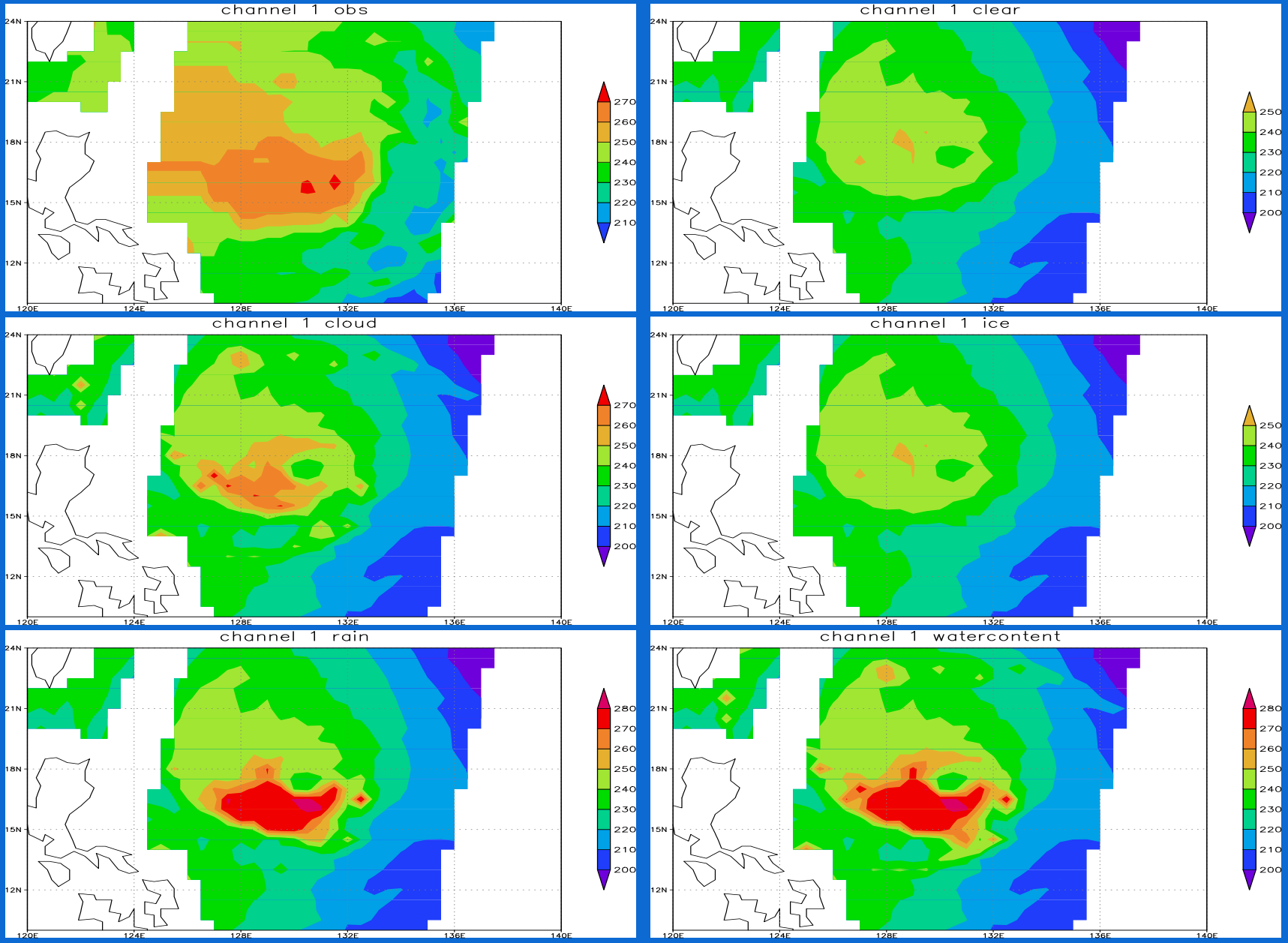
The vertical profile of cloud water, rain water and ice water contents.



Water contents



No water contents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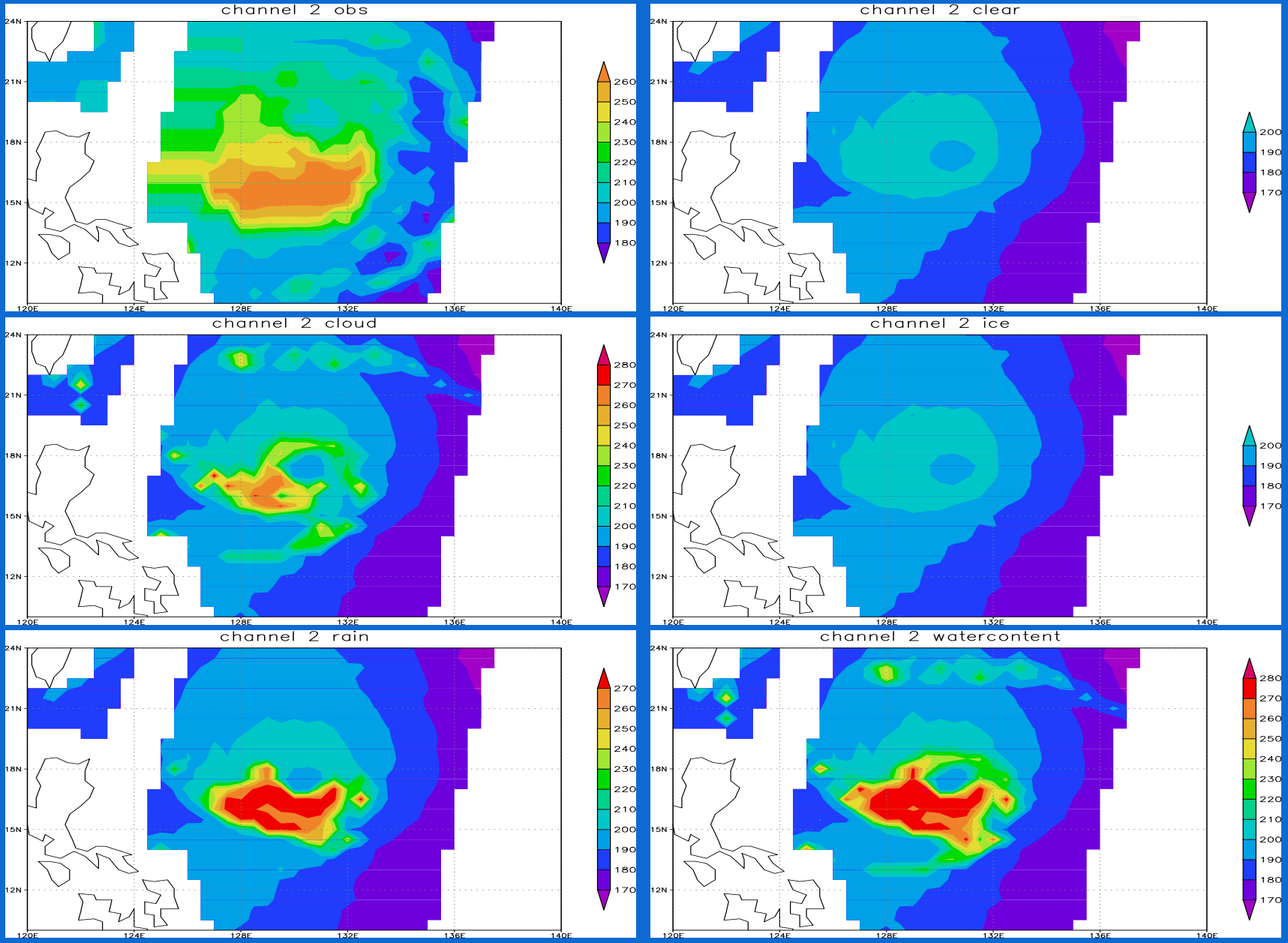
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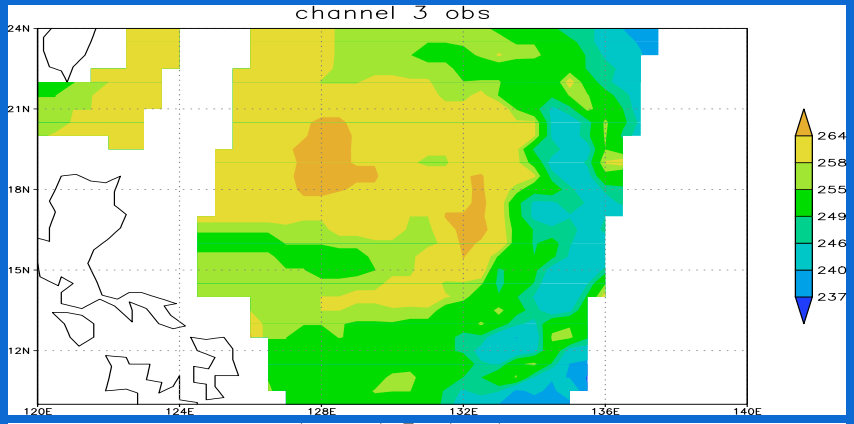
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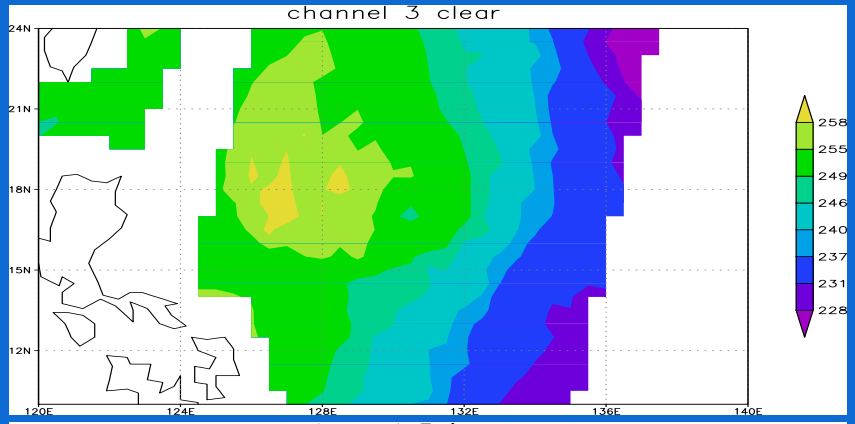
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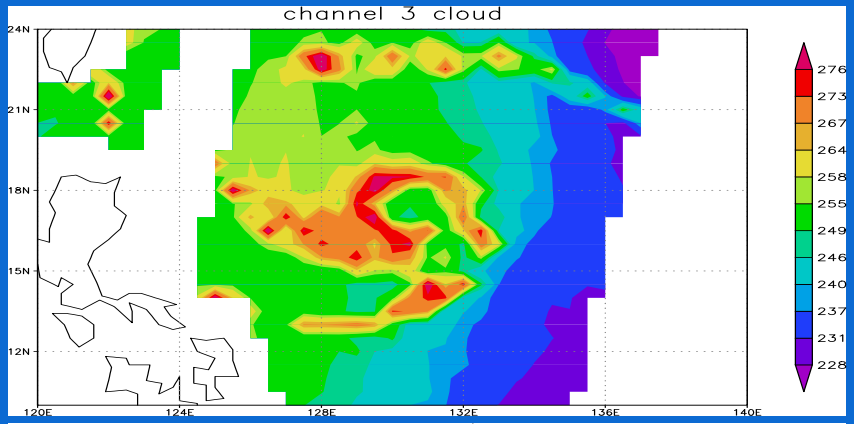
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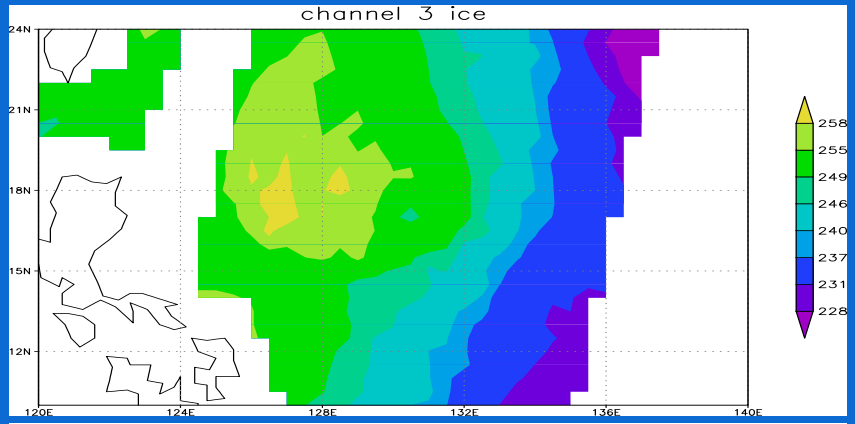
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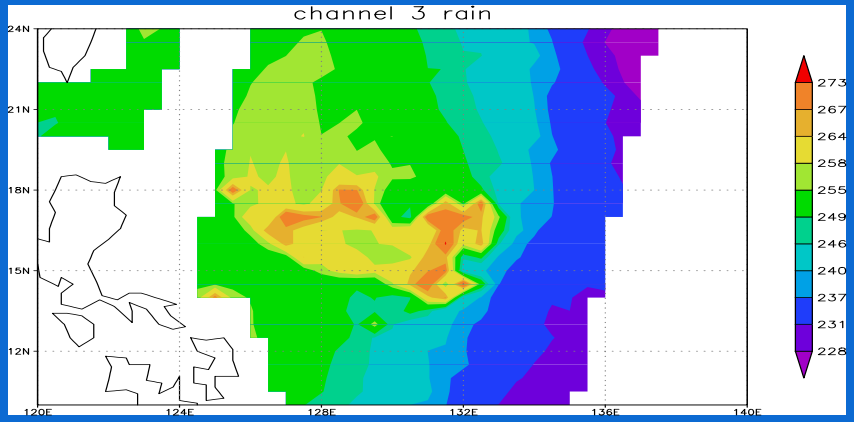
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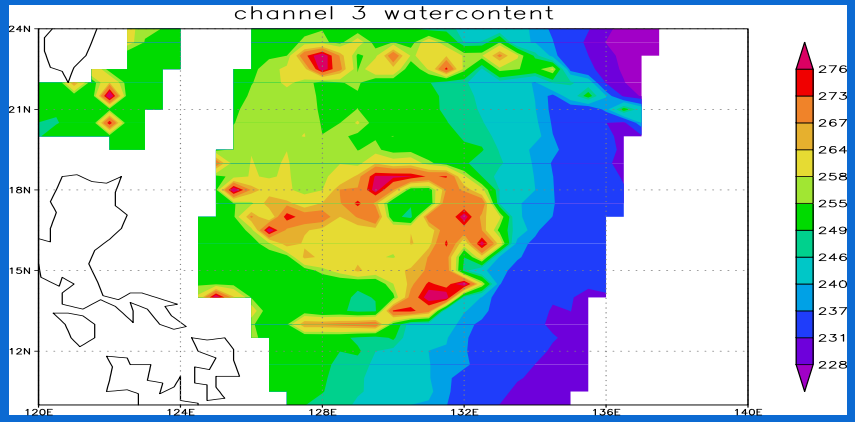
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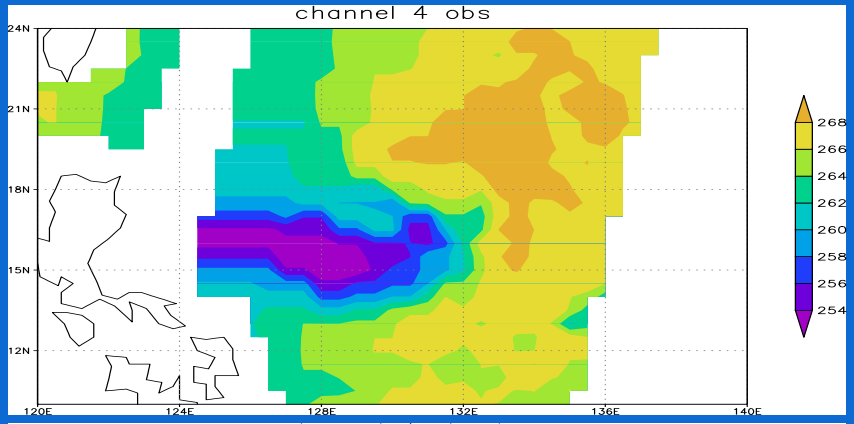
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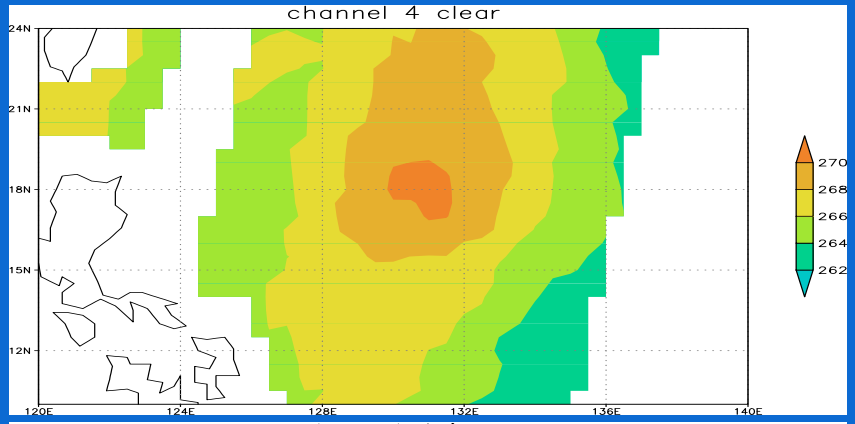
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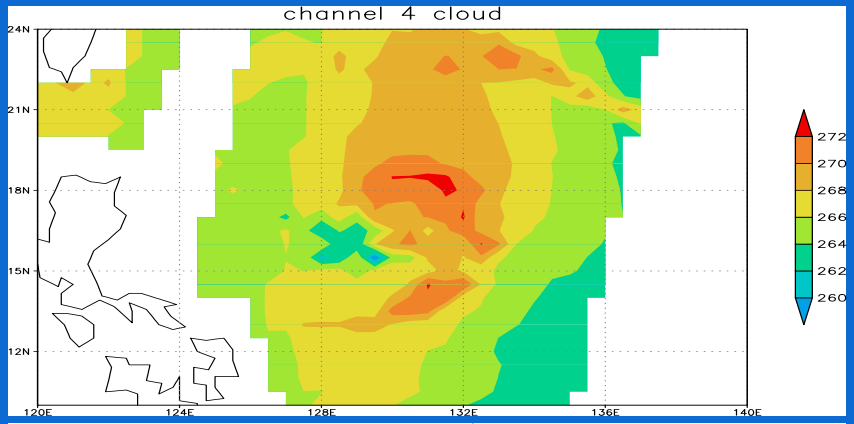
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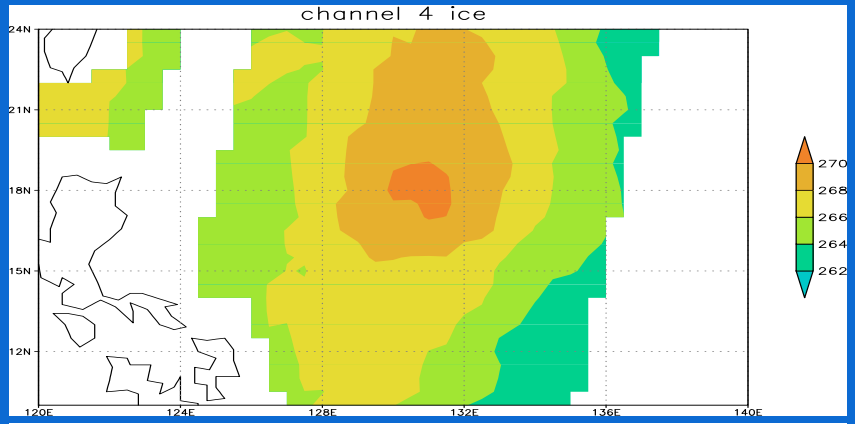
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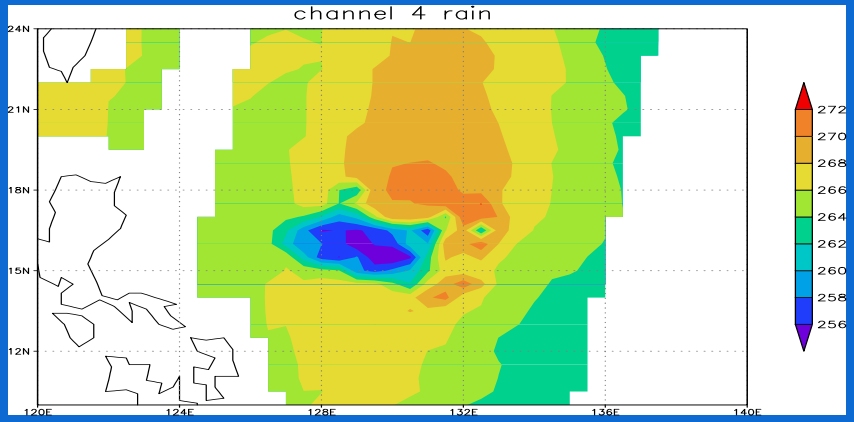
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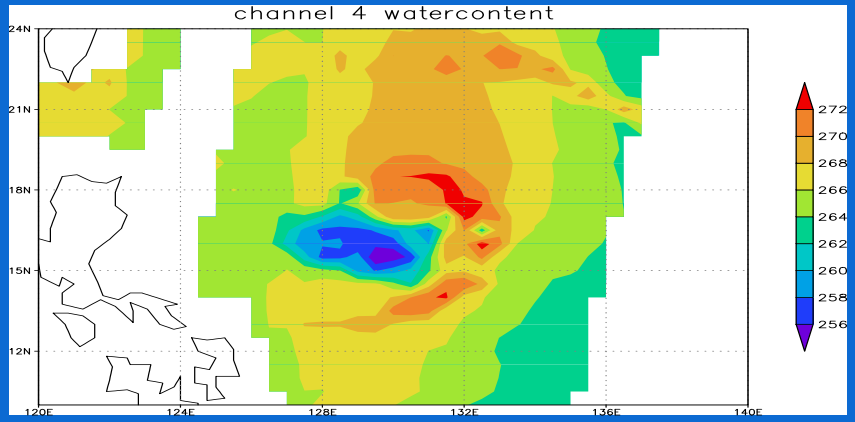
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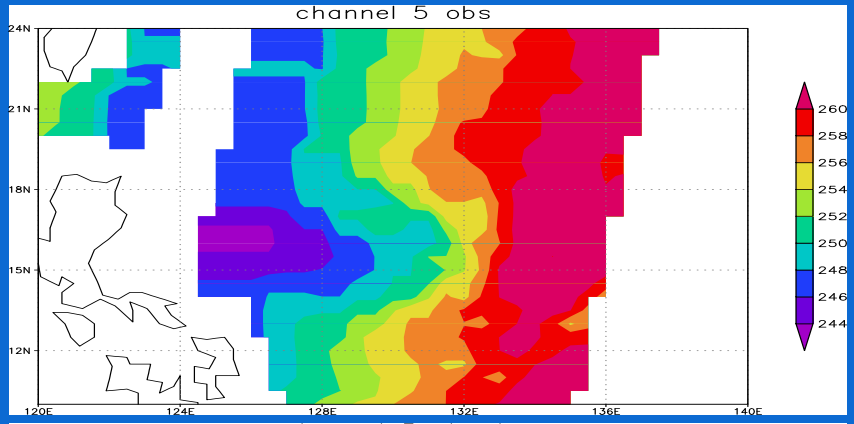
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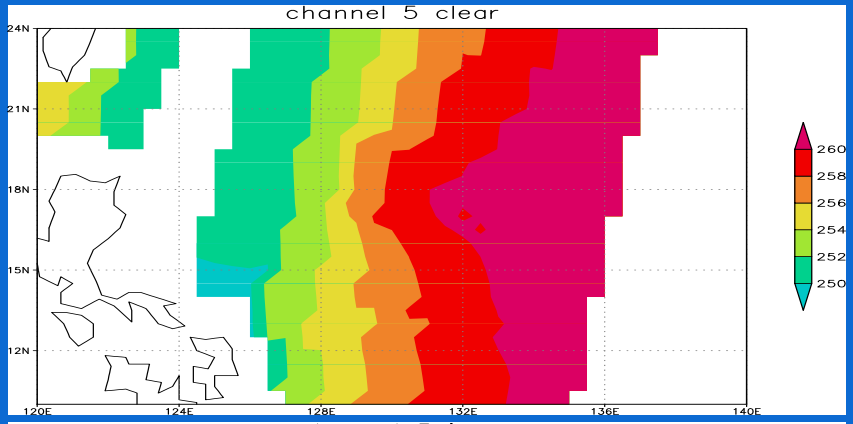
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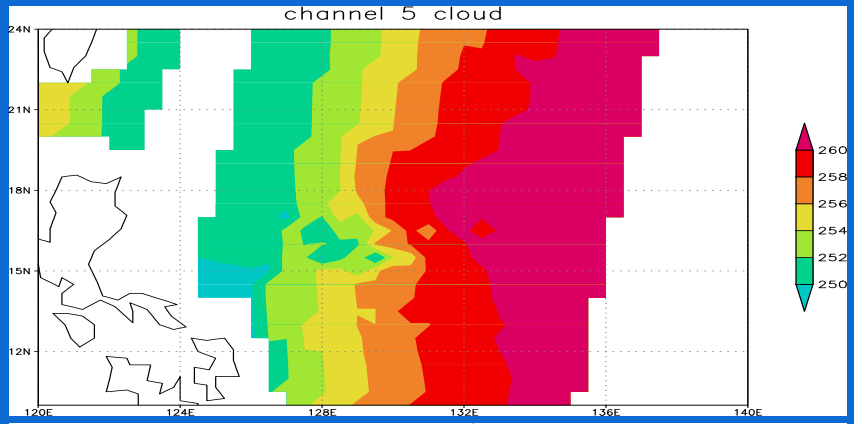
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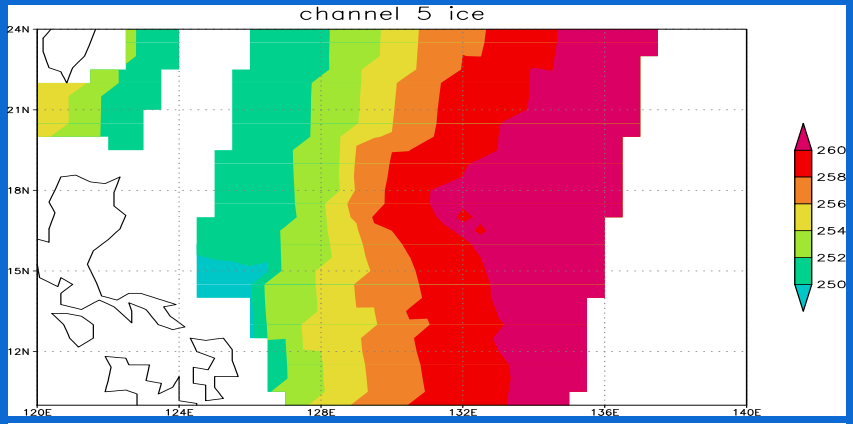
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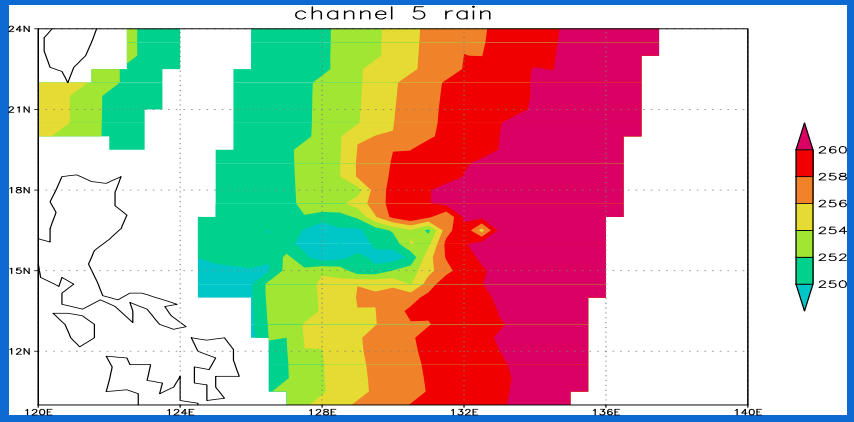
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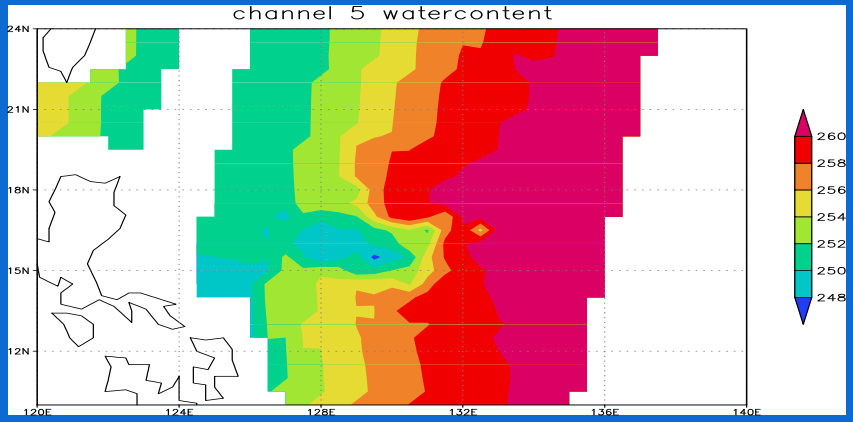
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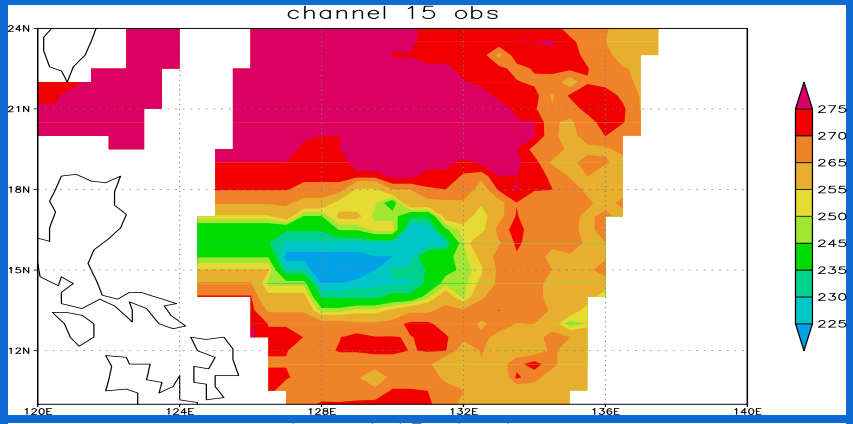
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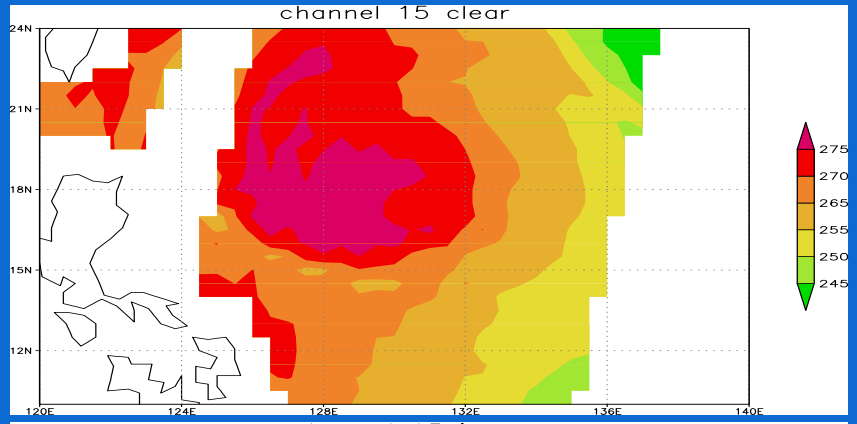
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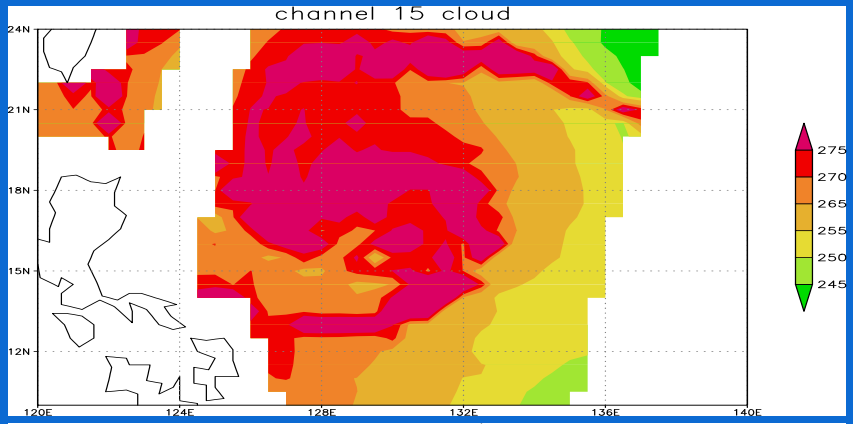
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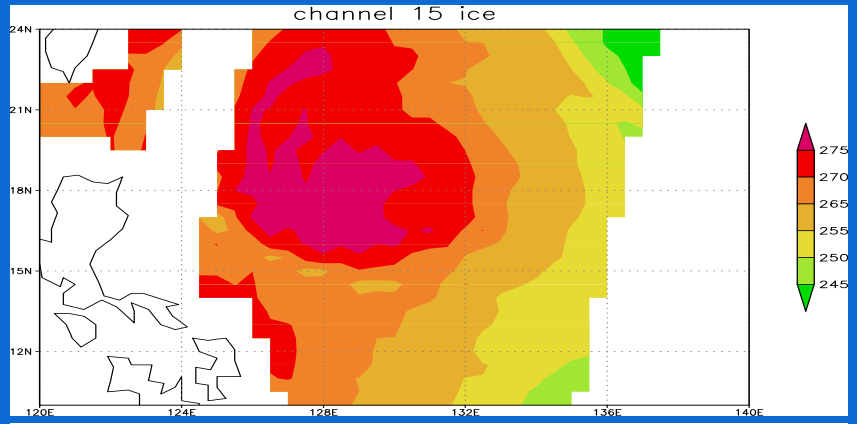
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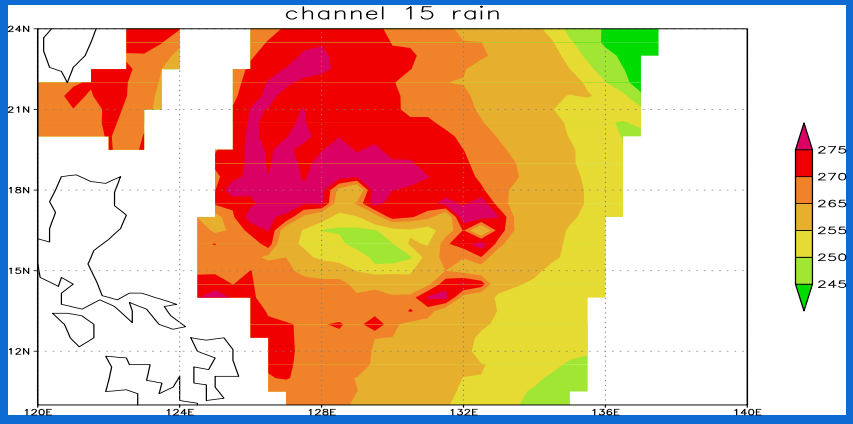
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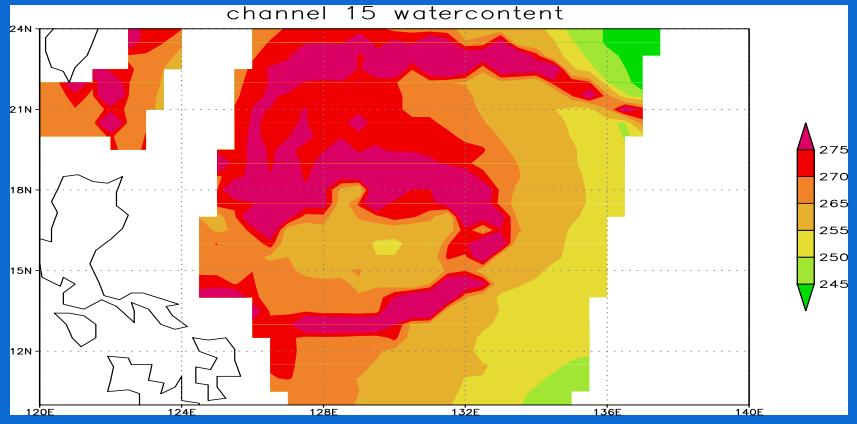
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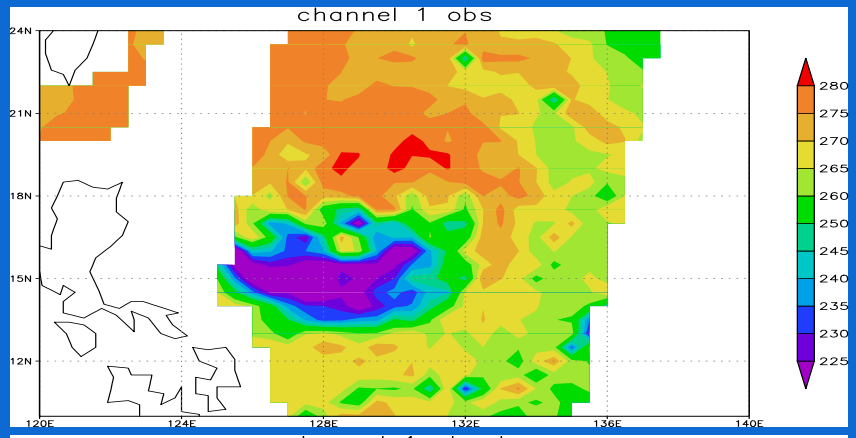
AMSU-B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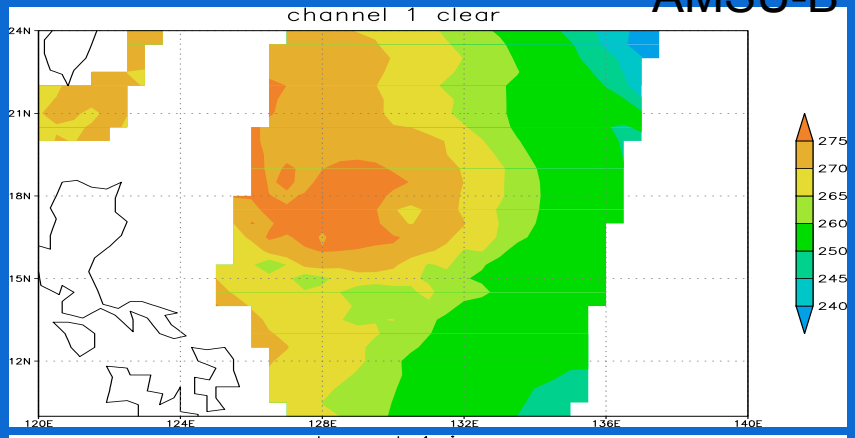
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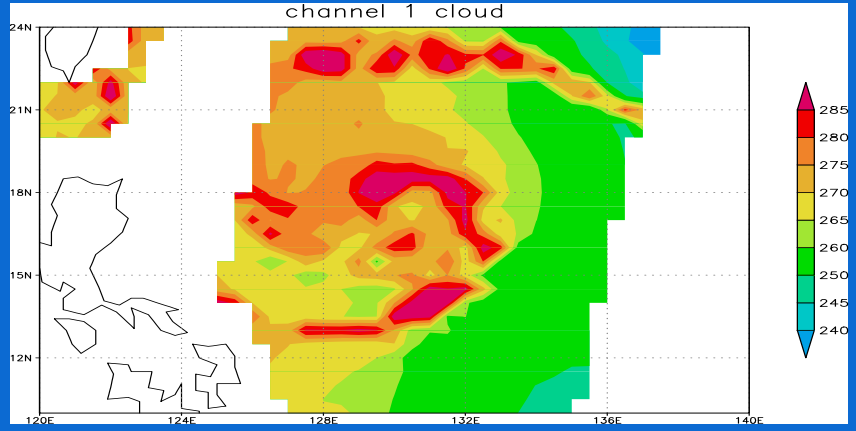
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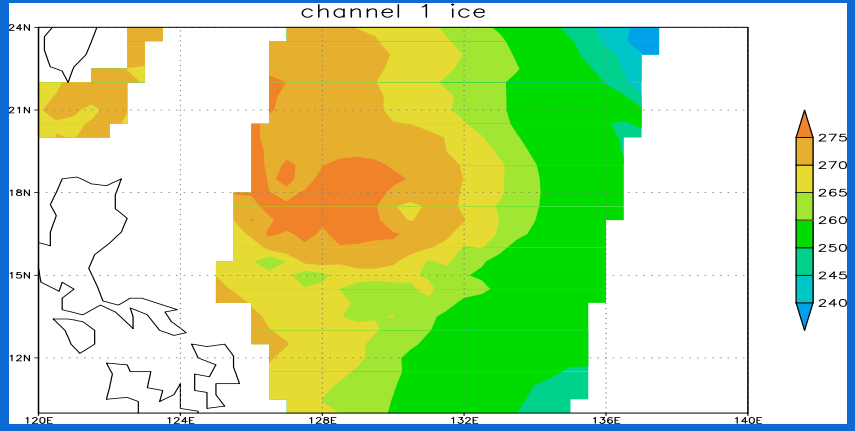
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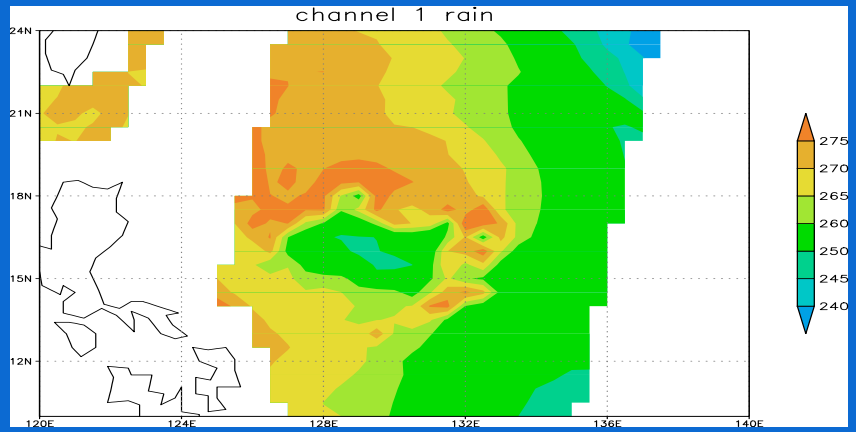
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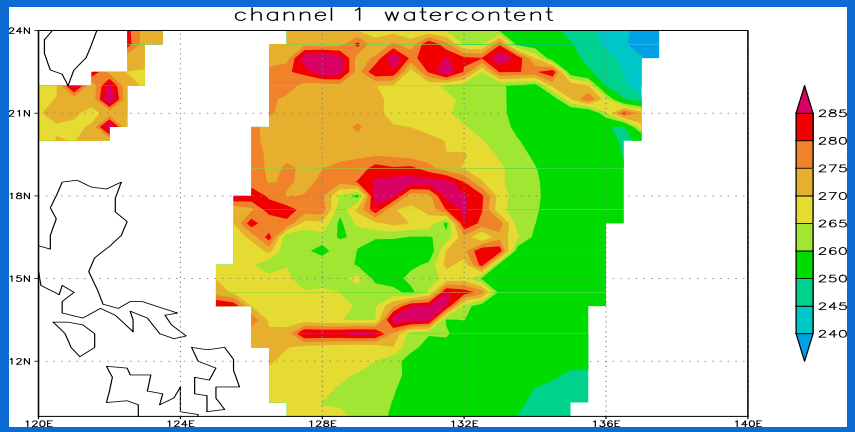
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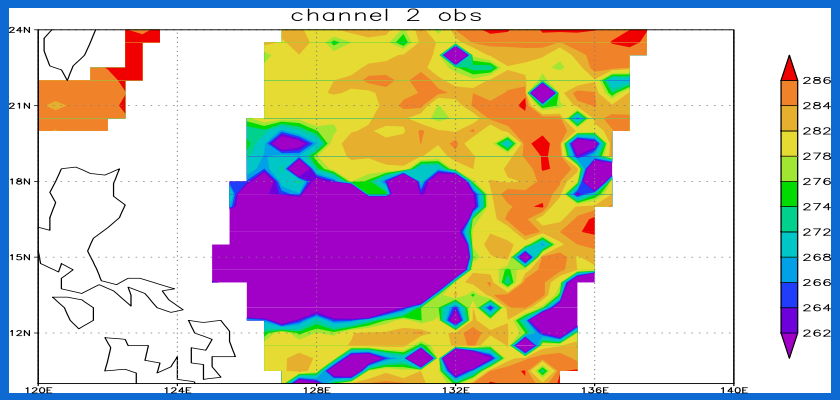
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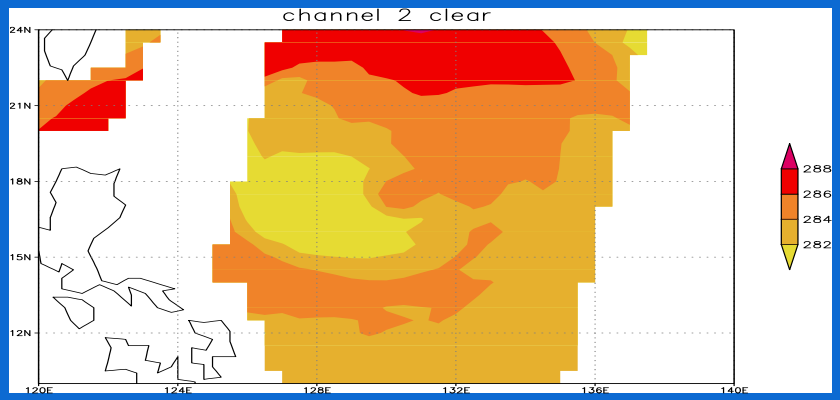
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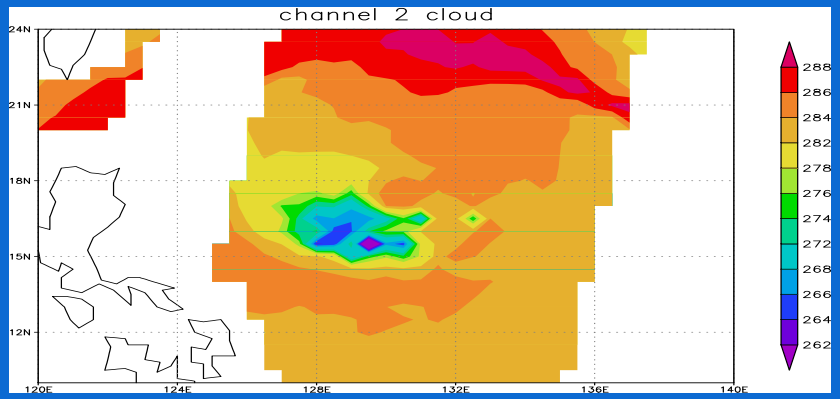
channel 2 cloud
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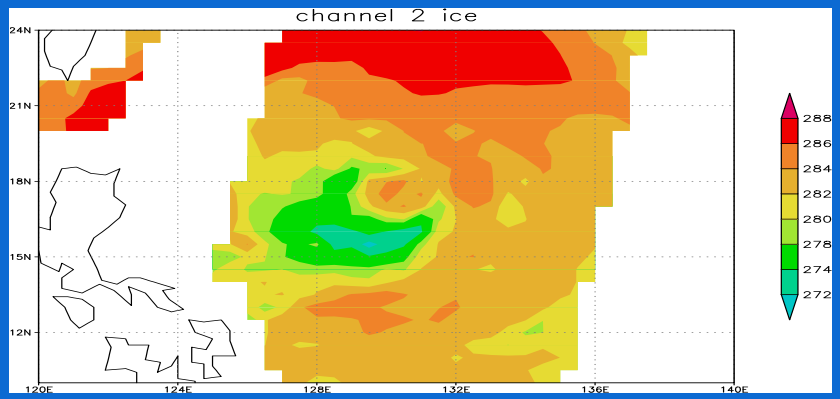
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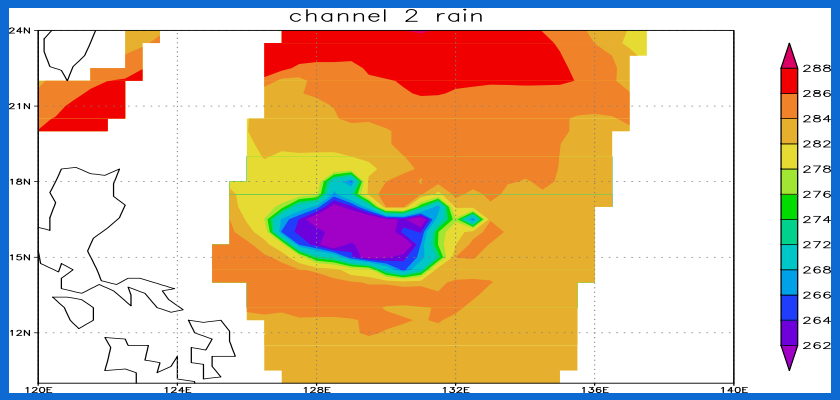
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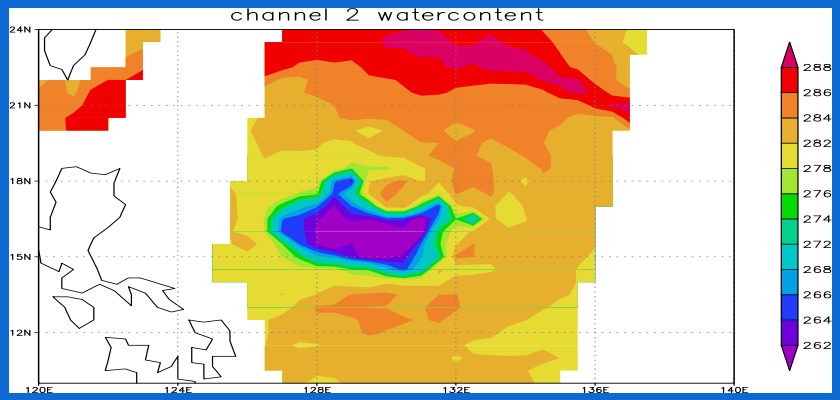
channel 2 watercontent
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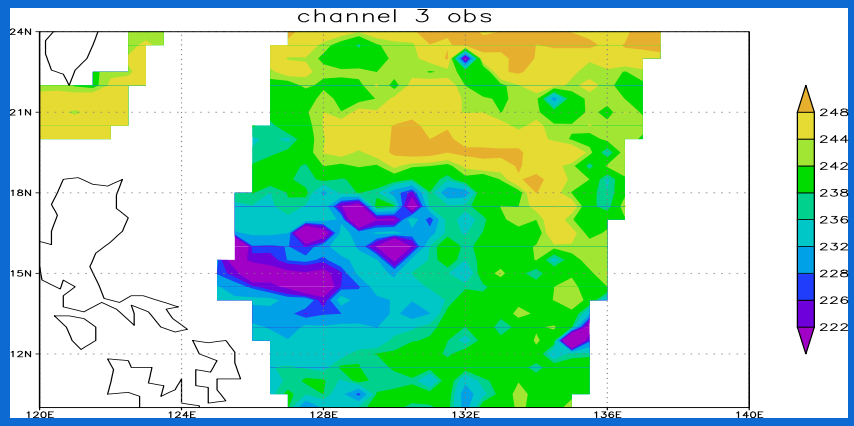
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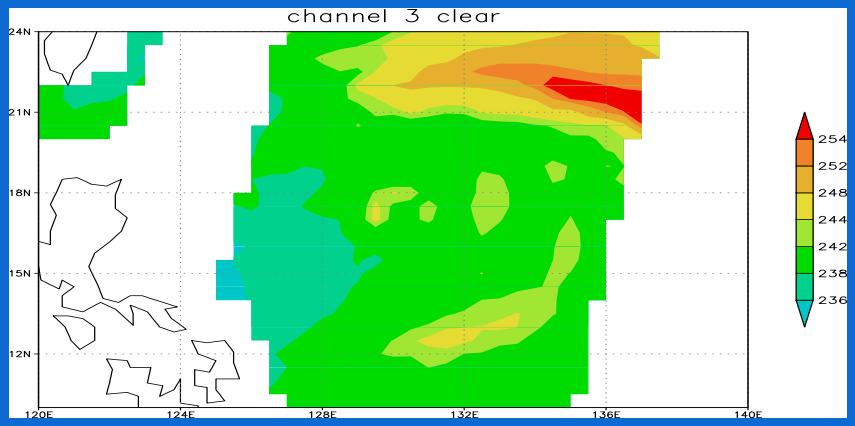
channel 3 clear
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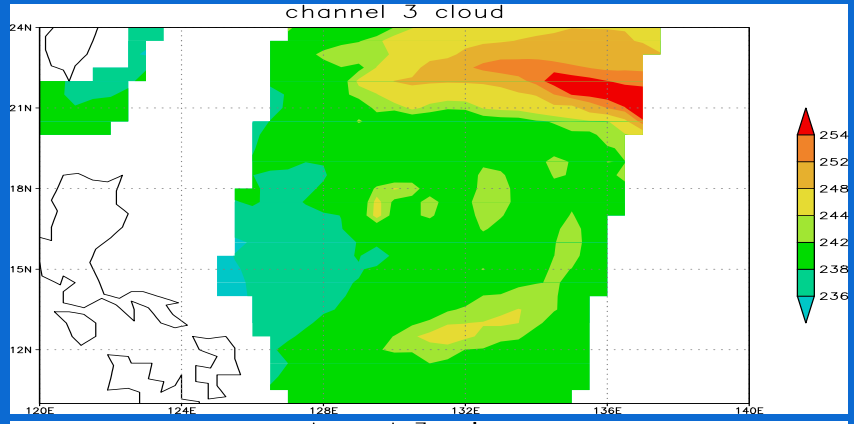
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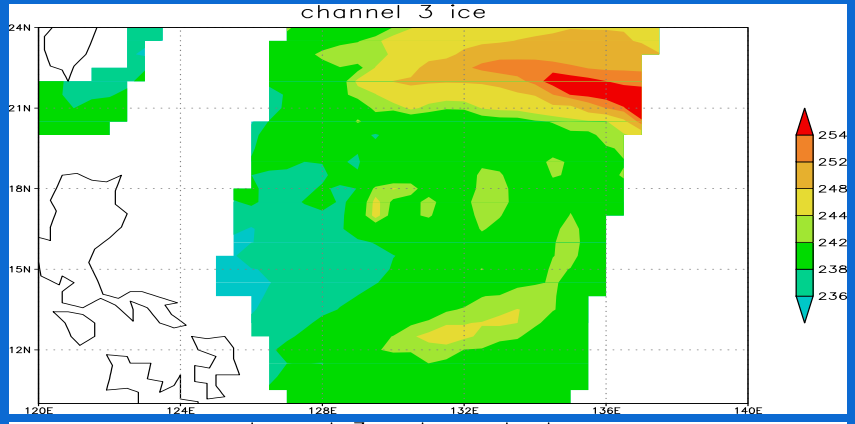
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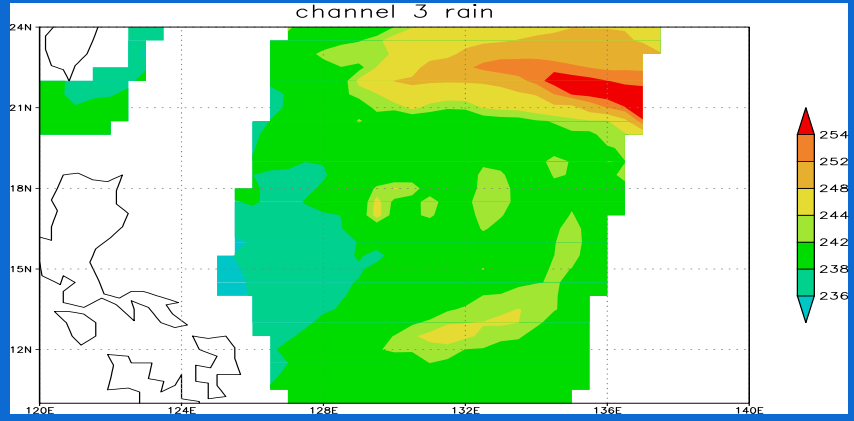
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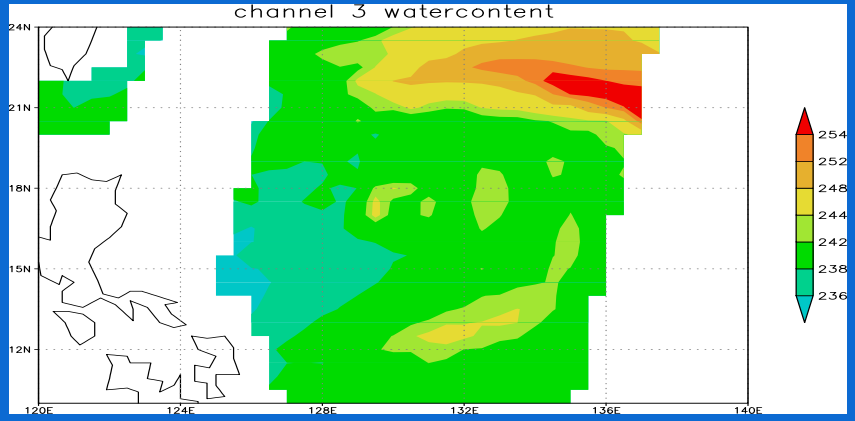
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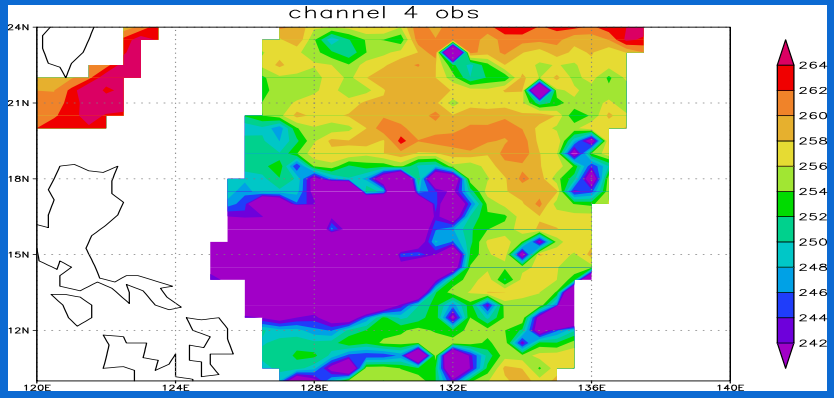
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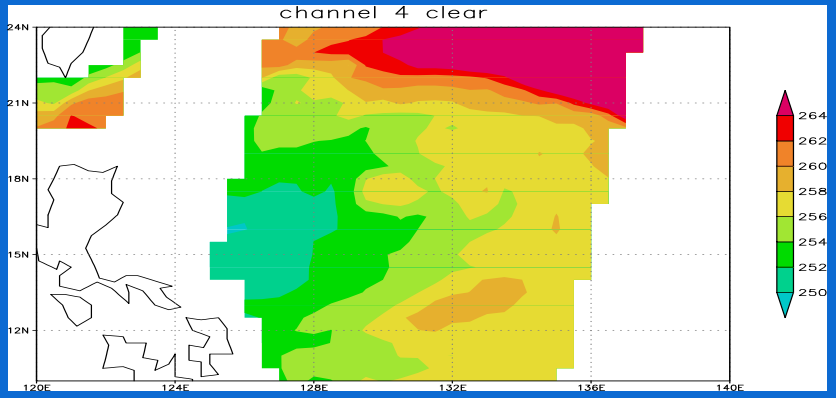
channel 4 clear
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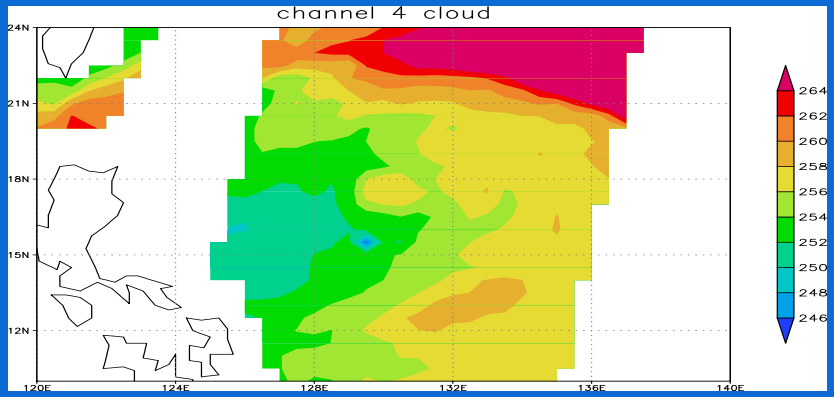
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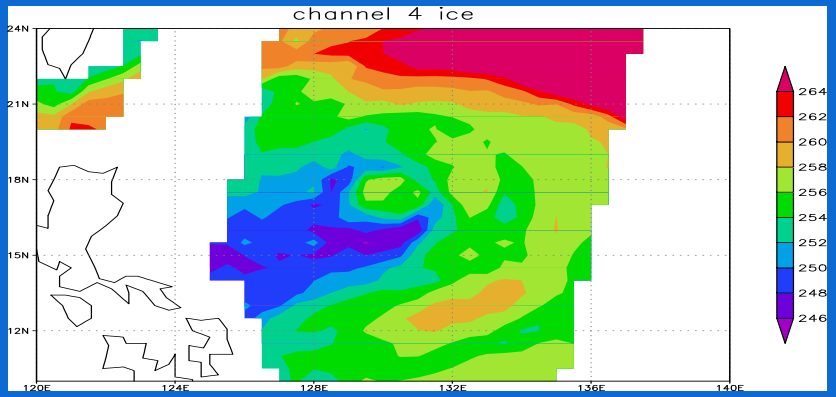
channel 4 ice
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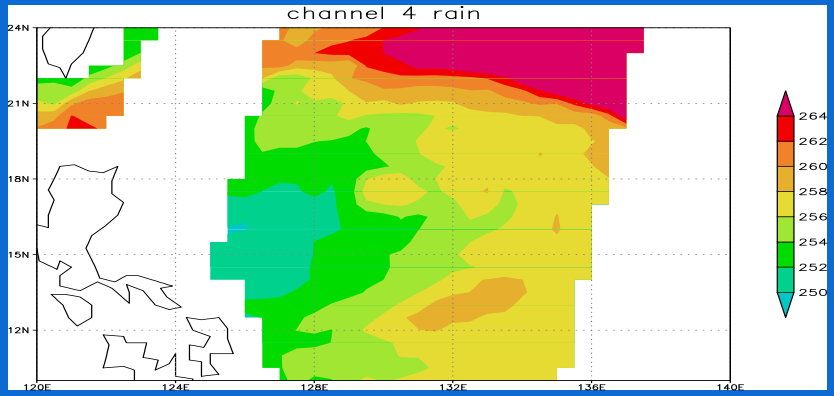
channel 4 rain
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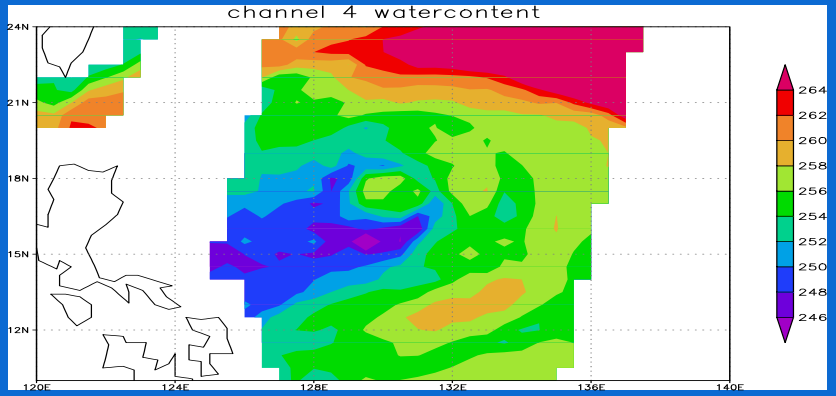
channel 4 watercontent
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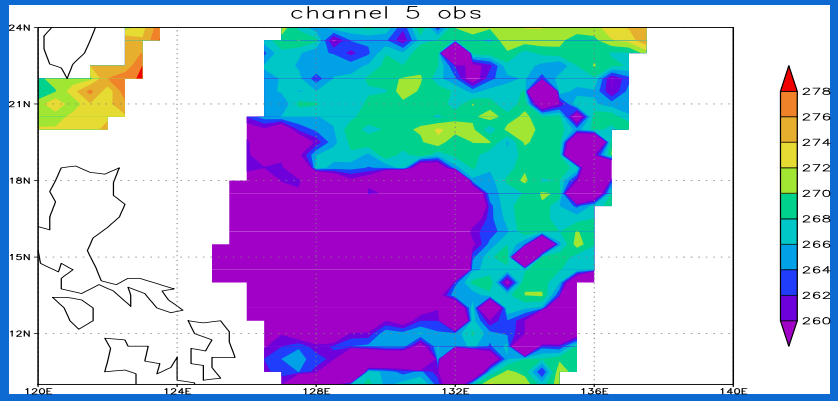
channel 5 obs
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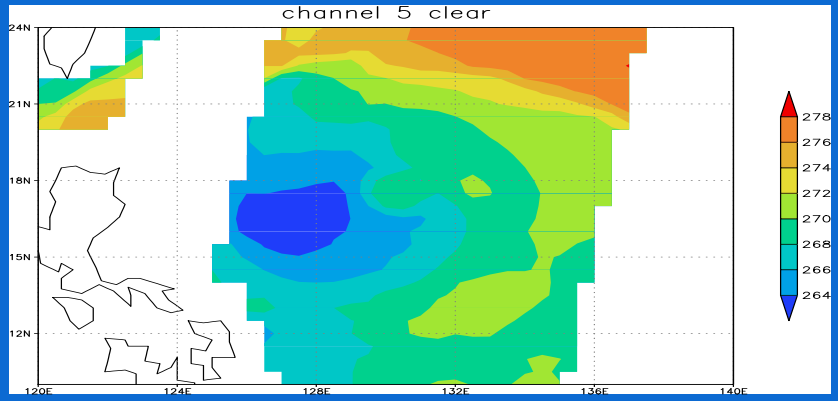
channel 5 clear
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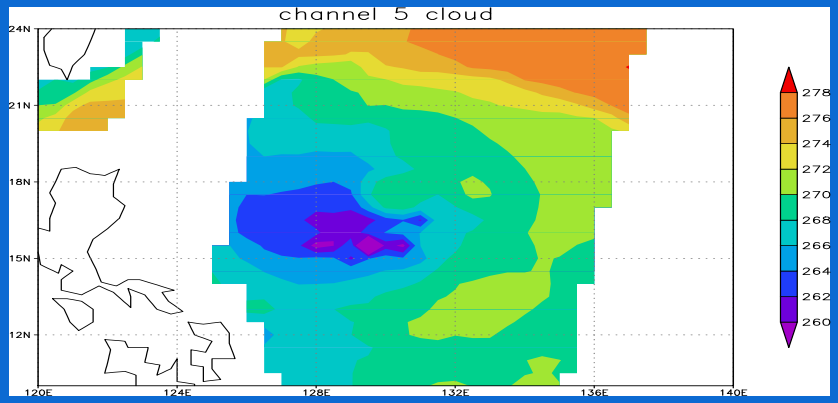
channel 5 cloud
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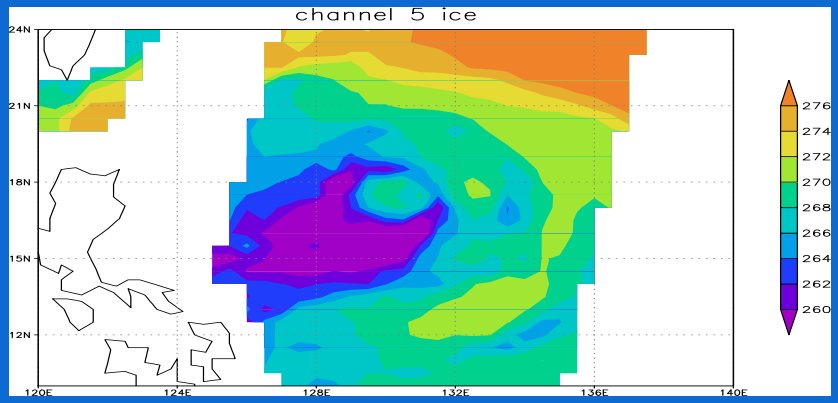
channel 5 ice
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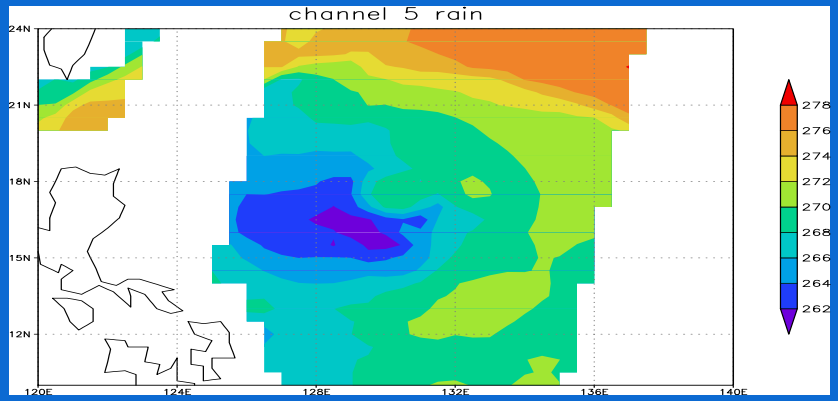
channel 5 rain
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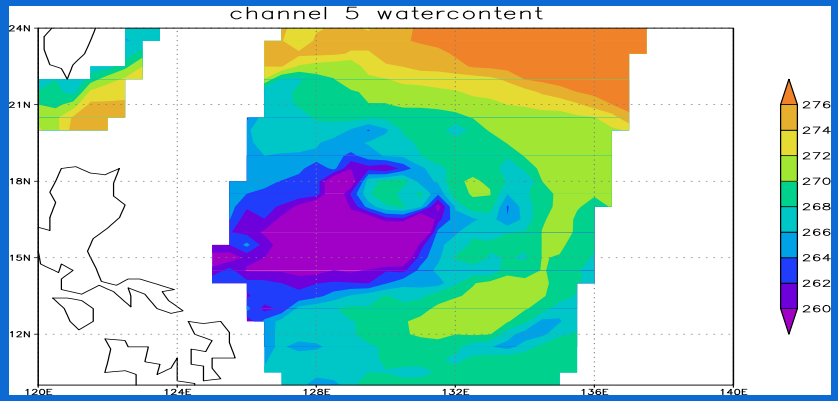
channel 5 watercontent
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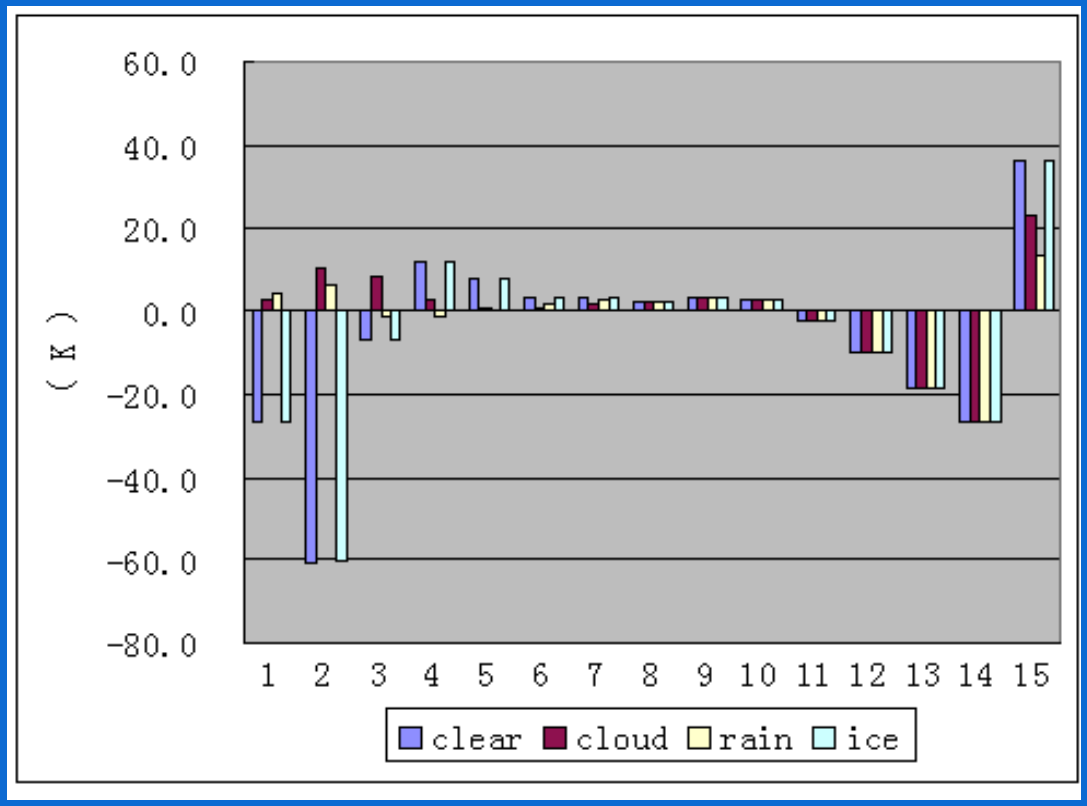
60.0
40.0
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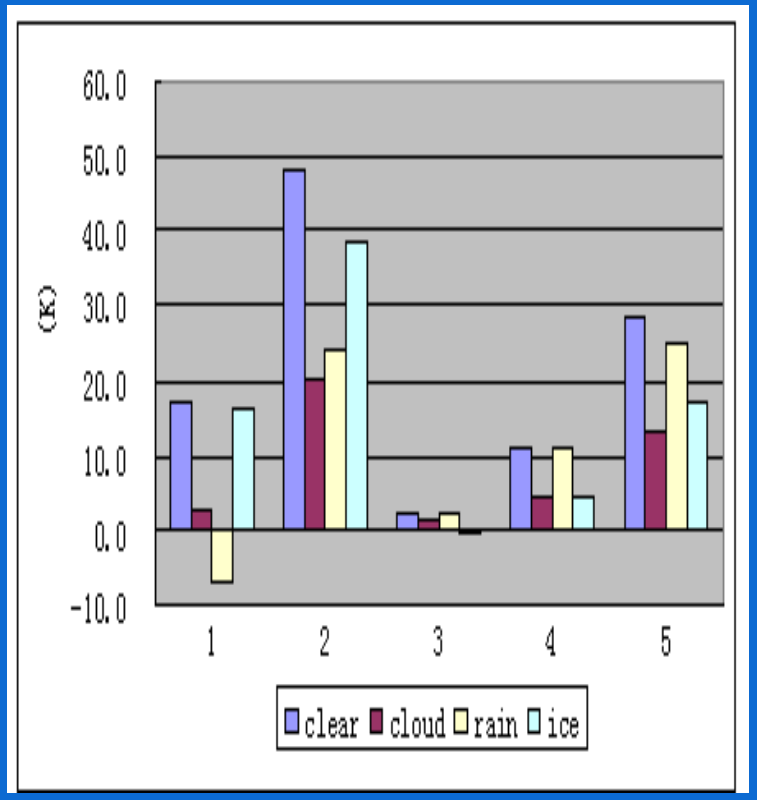
-60.0
-80.0
(K)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
clear cloud rain ice


60.0
50.0
40.0
30.0
20.0
10.0
0.0
-10.0
(K)
1 2 3 4 5
clear cloud rain ice

4 Conclusion and discussion

a) For AMSU-A, the inclusion of satellite date introduced by the Scattering Index with threshold 15 has positive effect on the numerical forecast of regional model;
For AMSU-B, the bias between simulated bright temperature and observation of AMSU-B channel 2 performs well than Bennartz Scattering Index.

b) The inclusion of radiant effect of water contents in radiative transfer model makes the simulation match the observation closely.

c) There is still a little large bias between simulated and observation satellite data. Some issues will be discussed further. For example, is the cloud and rain information from numerical forecast competent for the background information…

Thanks for your attention