INTERNATIONAL SPACE SCIENCE INSTITUTE

Prediction skill and predictability of Eurasian snow cover in the NCEP Climate Forecast System version 2 (CFSv2)

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layout

- Introduction for NCEP Climate Forecast System version 2 (CFSv2) and verification datasets
- General prediction for the Eurasian snow seasonal cycle
- Prediction of snow cover fraction (SCF) during snow melt and snowfall season
- Prediction of spring snow water equivalent (SWE)
- Prediction of Asian monsoon and its relation to Eurasian snow

Part I

- Introduction for NCEP Climate Forecast System version 2 (CFSv2) and verification datasets

NCEP CFSv2

Atmosphere	GFS2009(T126/64)
land	NOAH-4-L
Ocean	MOM4
Sea ice	Predicted
Initial conditions (ICs)	CFS Reanalysis(CFSR)
Hindcast	~24/month(4 runs/5 days)

i.e. **LM0**-Ensemble mean reforecasts initialed from its previous month

Verification data

Snow cover fraction (SCF)	**Rutgers**
Snow water equivalent (SWE)	**Globsnow**
Precipitation	**GPCP**
2-metre temperature(T2m)	**GHCN**
850hPa temperature(T850)	**ECMWF**

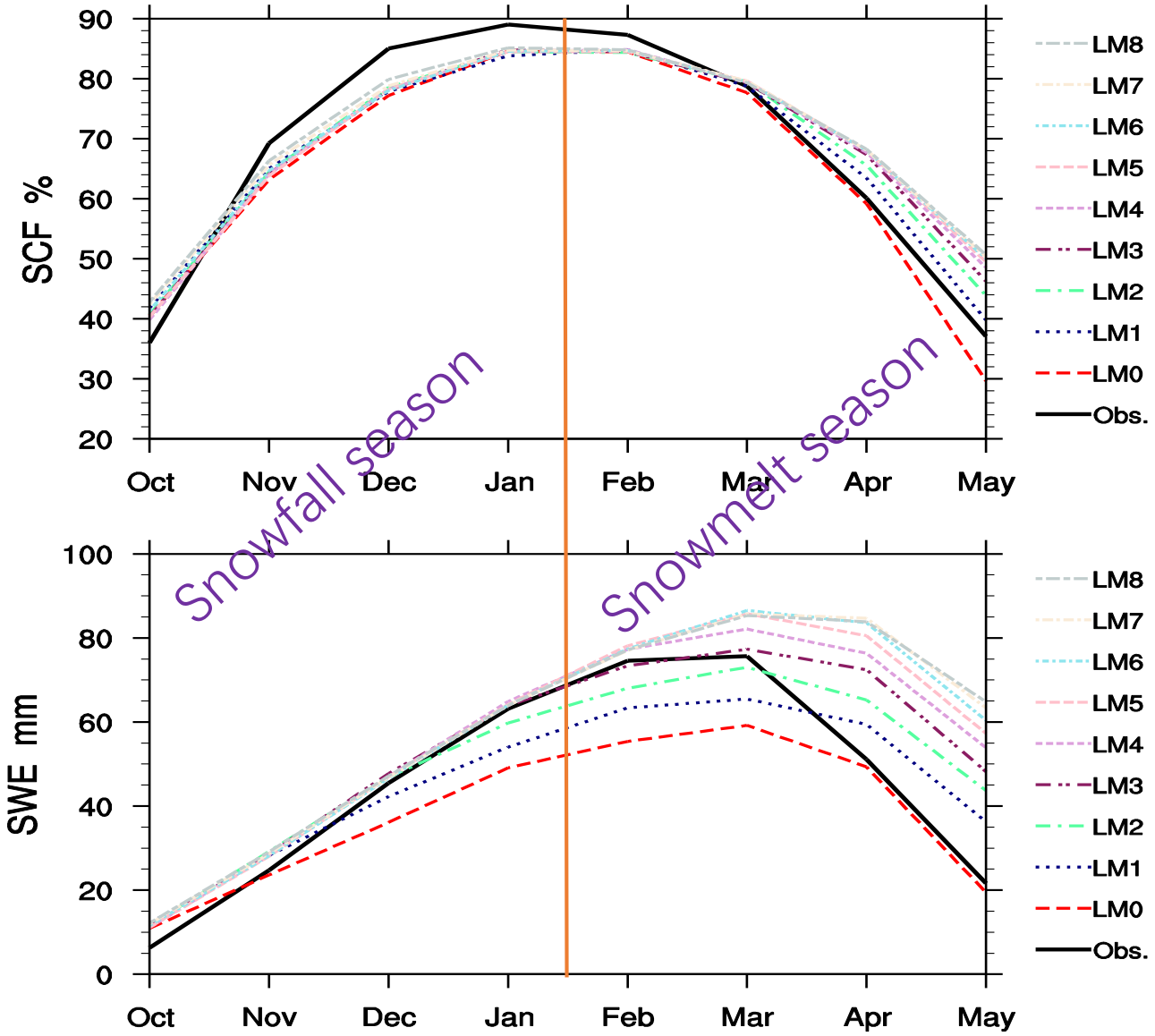
Part II

- General prediction for the Eurasian snow seasonal cycle

Prediction for seasonal cycle of Eurasian snow

SCF

SWE

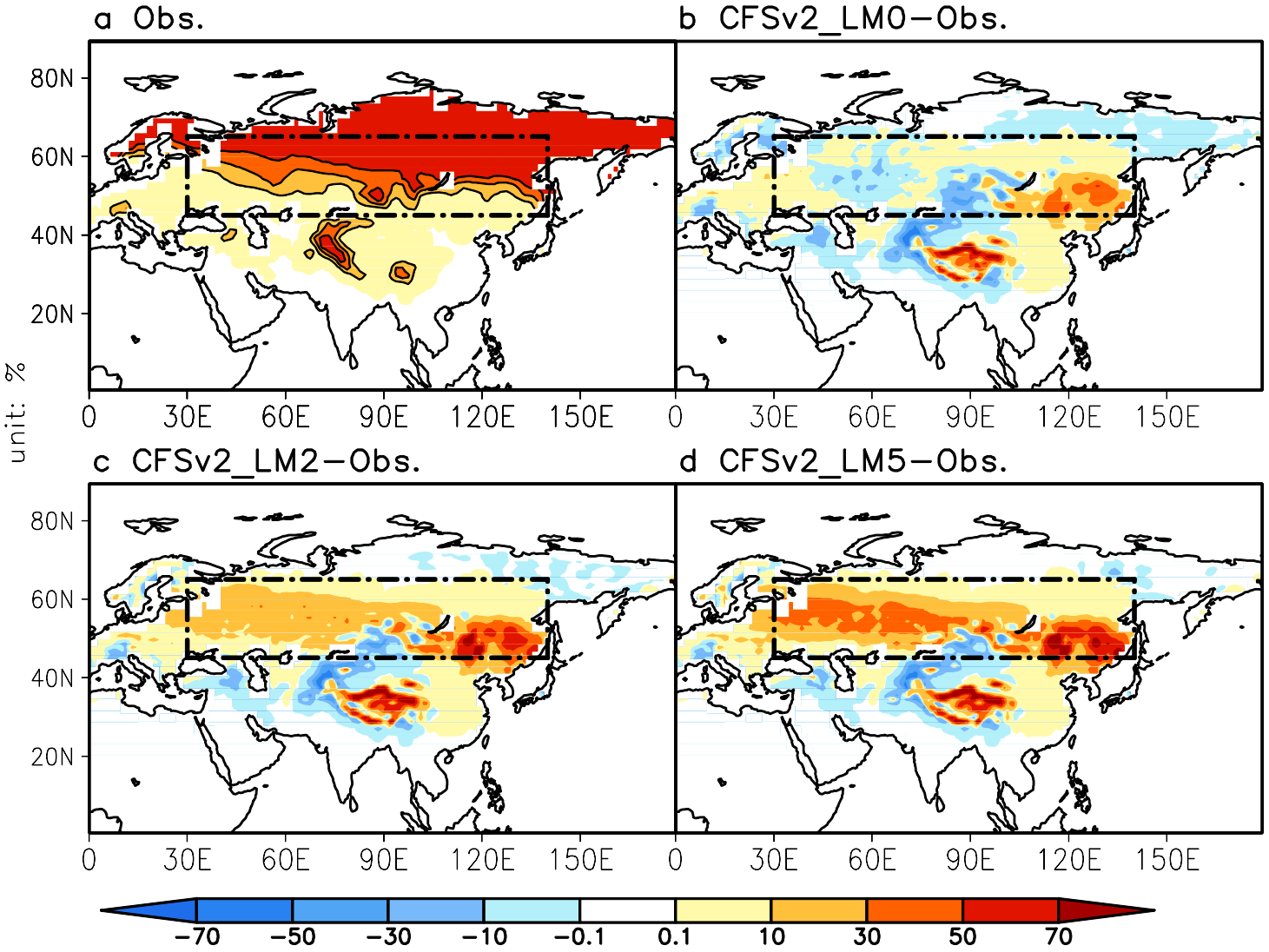


- Generally less in snowfall season and larger in April and May.
- Spread is greater in snowmelt season than in snowfall season

Part III

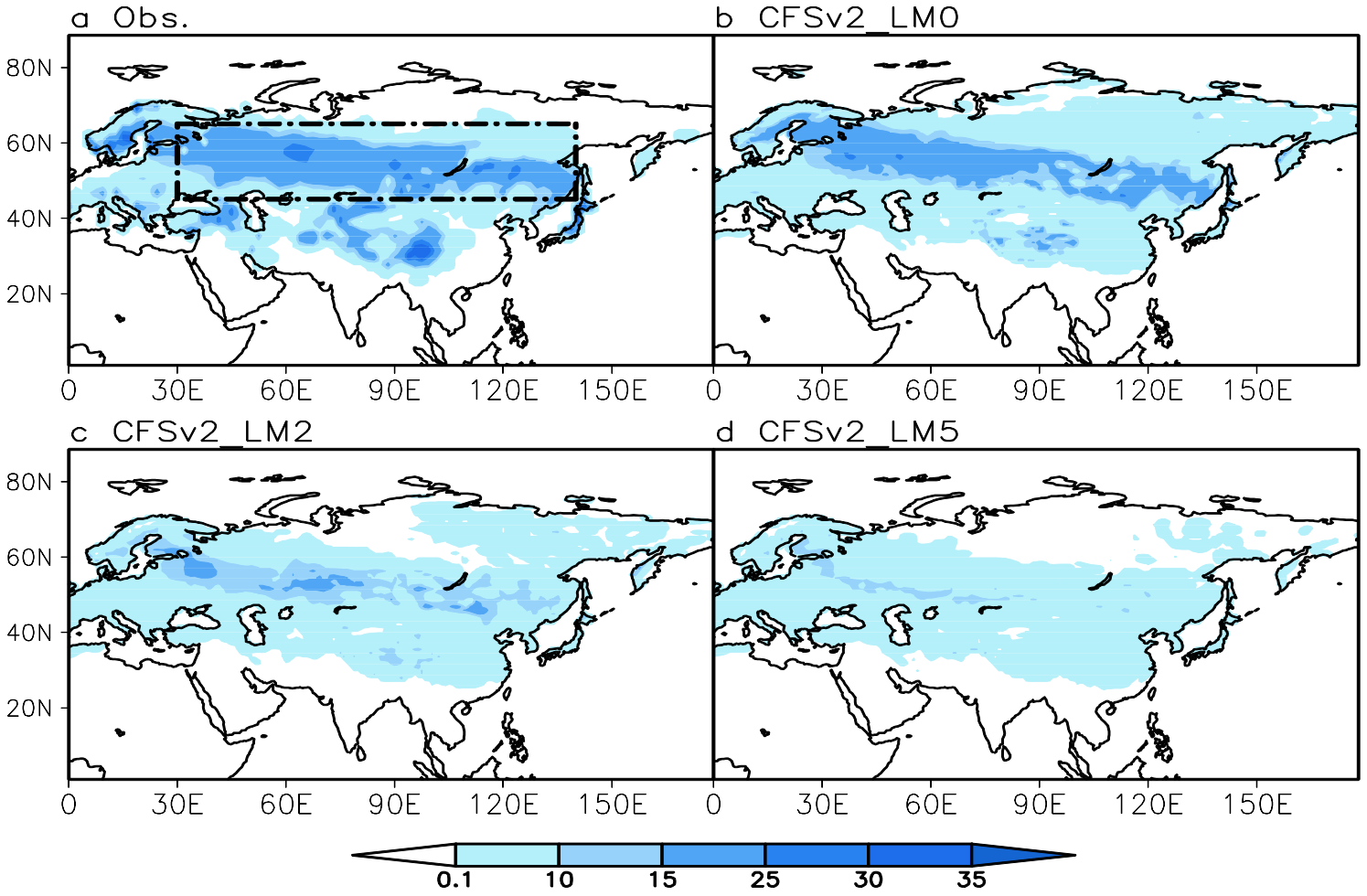
- Prediction of snow cover fraction (SCF) during snowmelt and snowfall season

Prediction for SCF Climatology in snowmelt season-April



- Positive biases in northeastern China, Tibetan Plateau.
- Negative biases in north, west and south of Tibetan Plateau

Prediction for SCF variability in snowmelt season-April



LM0 shows similar pattern but a little smaller magnitude.

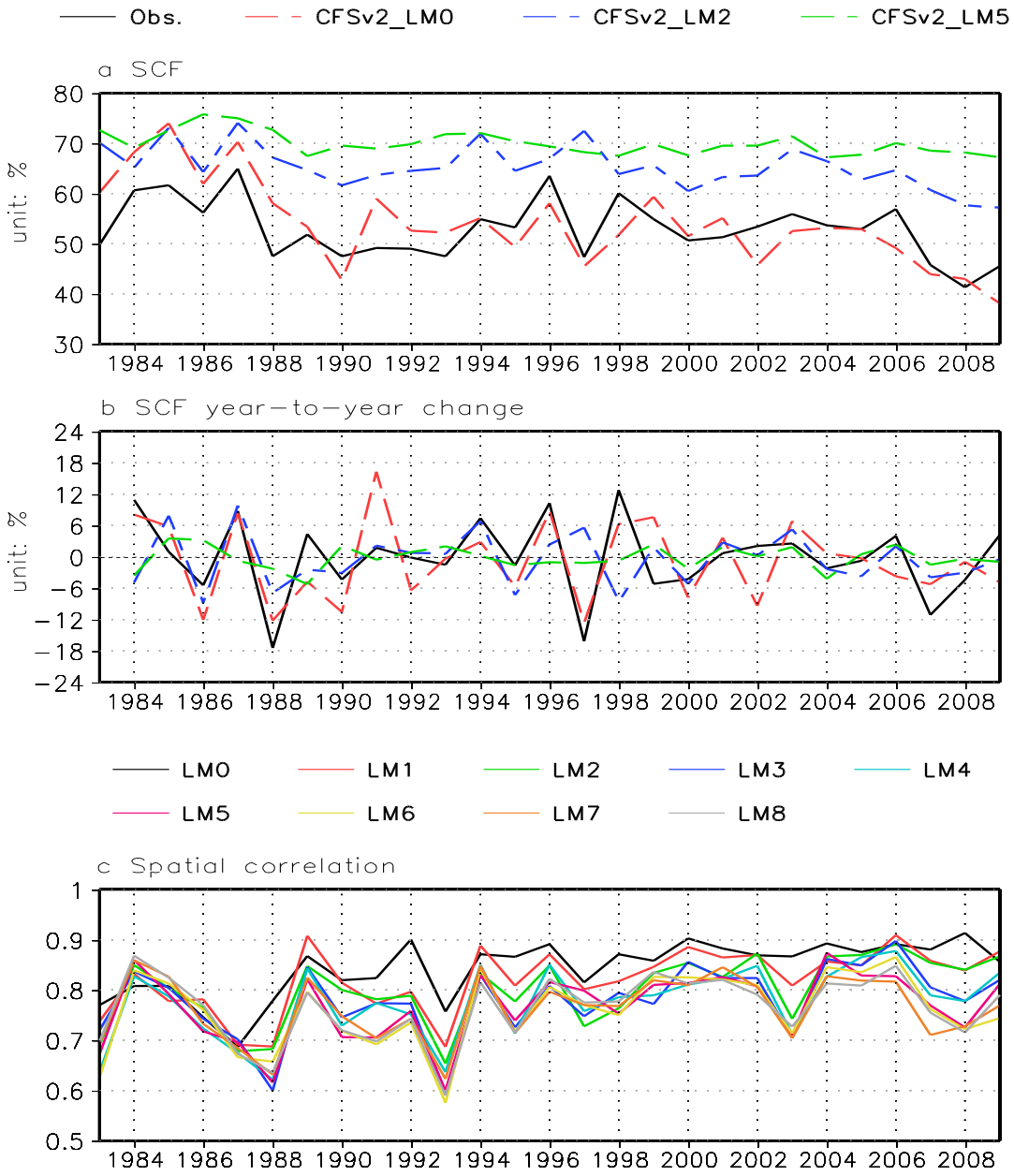
Most intensive snowmelt

Large model bias

Located over **30°-140°E, 45°-65°N** (black dashed rectangles).

Define this area as snowmelt key area (SMKA).

Prediction for SCF interannual variations in snowmelt season-April

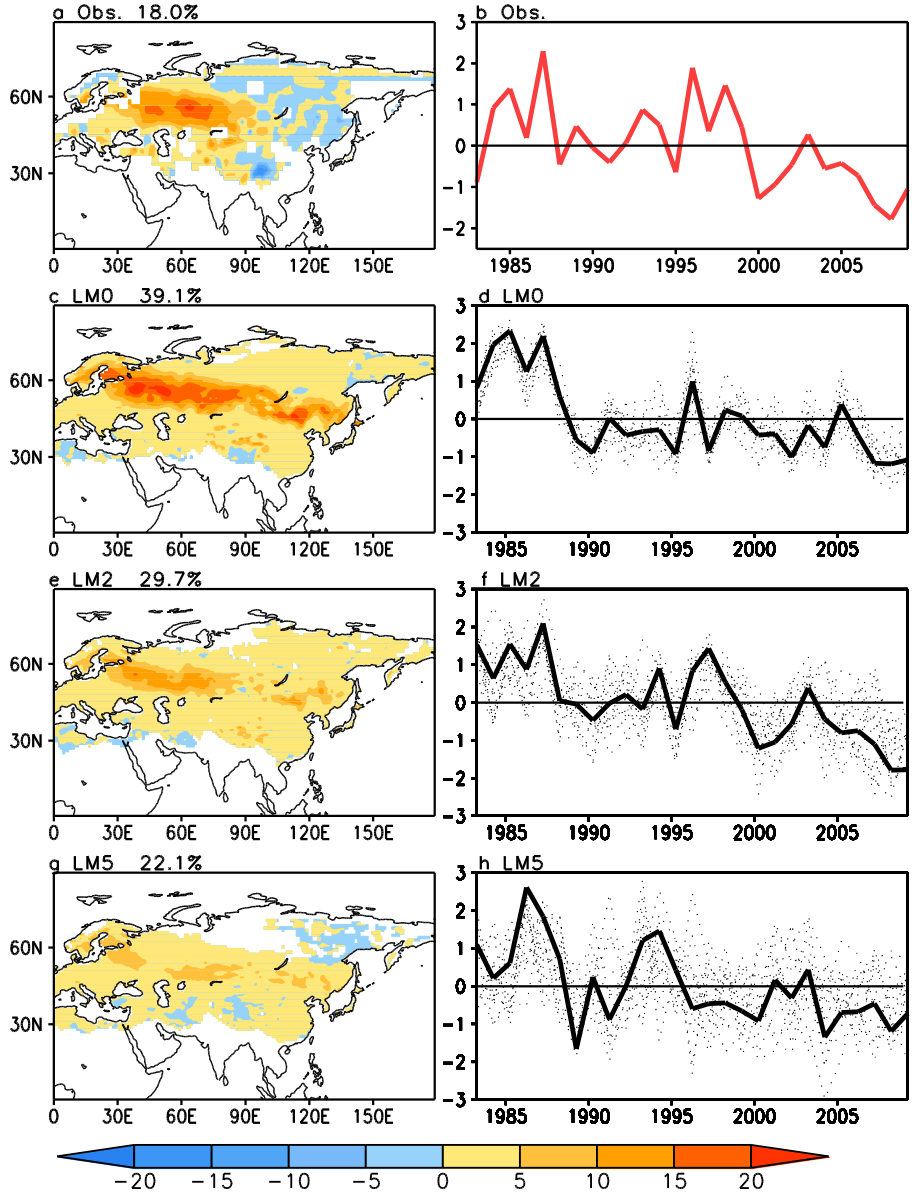


R	LM0	LM1	LM2	LM3	LM4	LM5	LM6	LM7	LM8
Original	**0.67**	**0.54**	**0.62**	**0.44**	**0.51**	0.3	0.18	0.21	0.18
Year-to-year	**0.59**	**0.4**	0.29	-0.1	0.18	-0.1	-0.05	-0.24	0.13

Bold numbers are above the 95% confidence level (Student T-test)

- **Capable of forecasting the interannual variation five months in advance.**
- **prediction skill has been improved after late-1990s**

Prediction for SCF EOF1 in snowmelt season-April



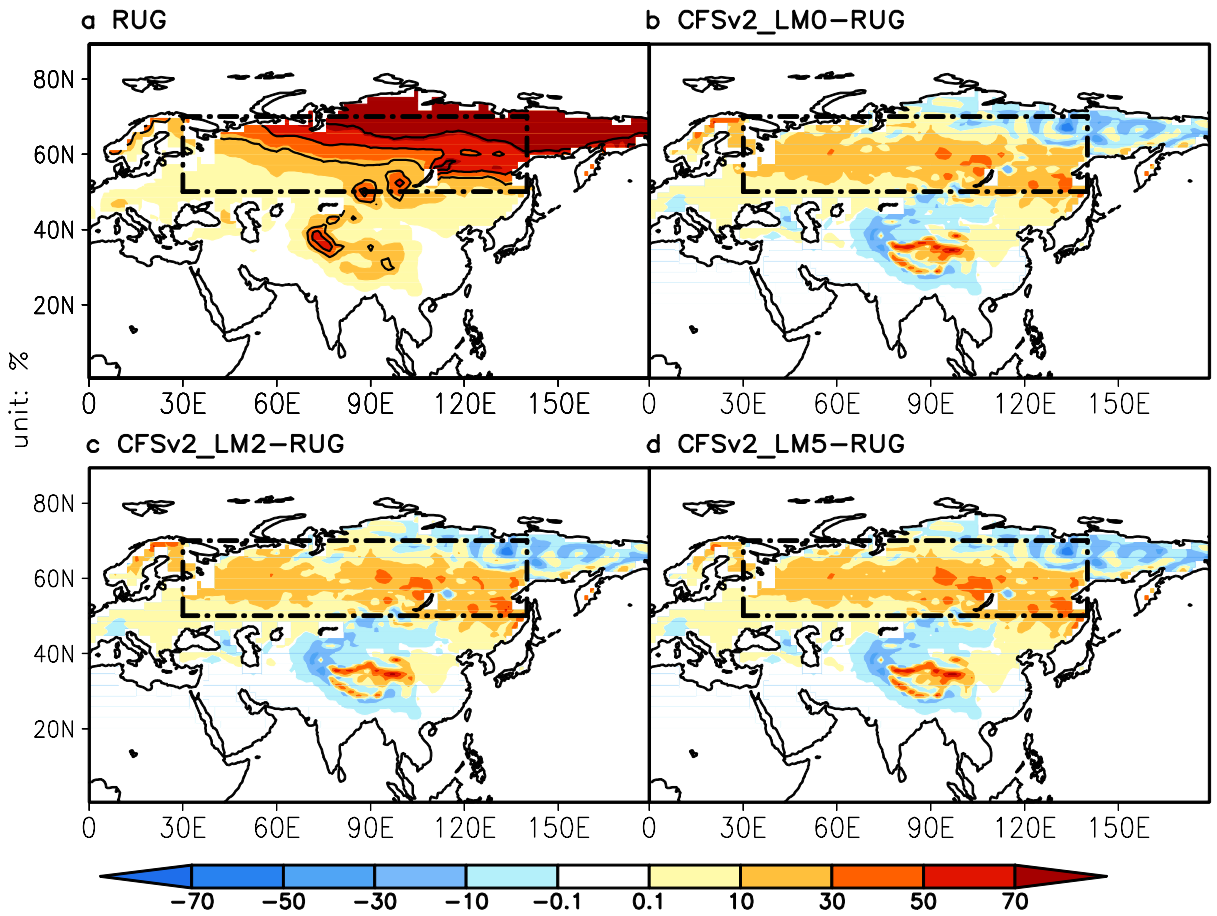
PC Correlation

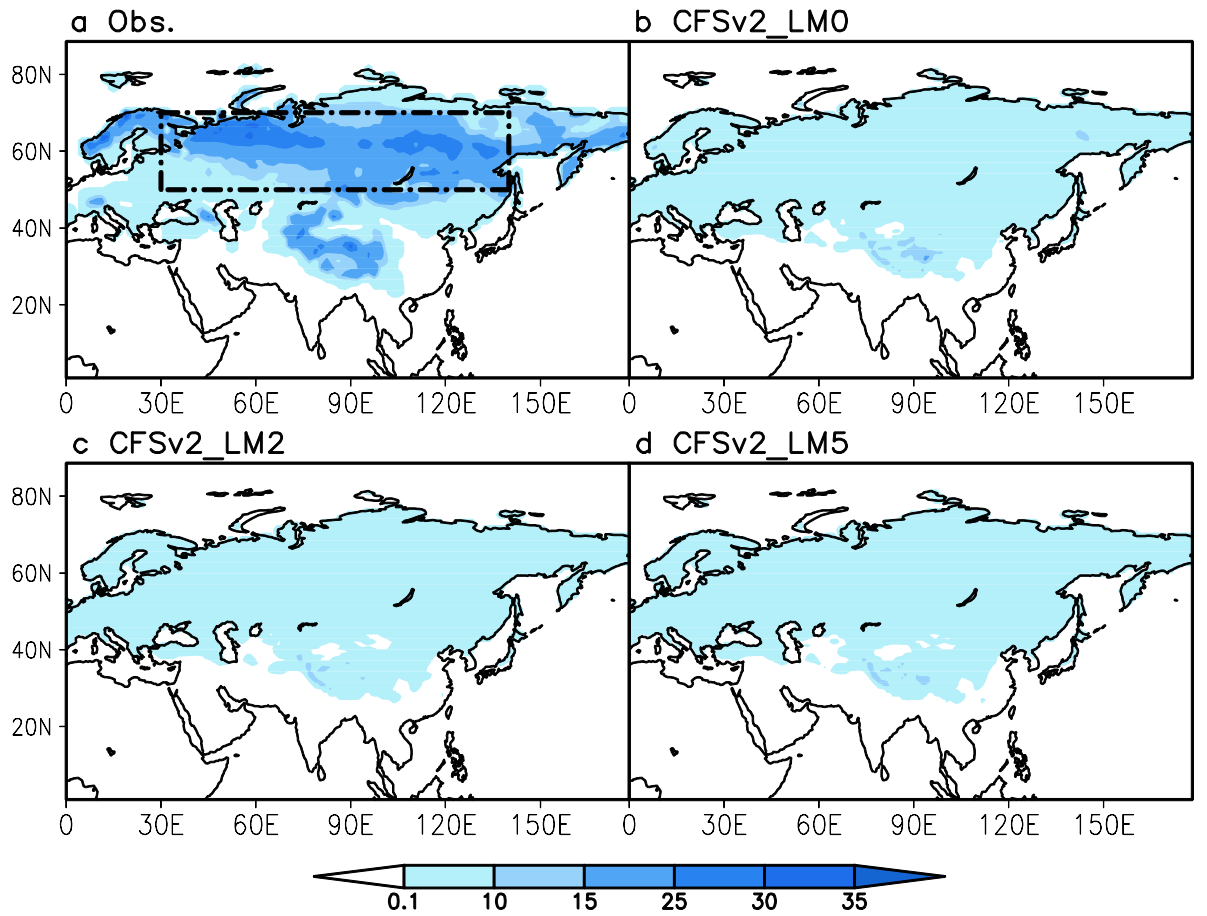
LM	LM0	LM2	LM5
Ensemble mean	0.67	0.76	**0.36**
16 members	**0.65**	**0.7**	0.3
	0.67	**0.51**	-0.01
	0.67	**0.5**	0.22
	0.72	**0.57**	0.06
	0.55	**0.62**	0.08
	0.59	**0.49**	0.11
	0.57	0.37	0.12
	0.56	**0.7**	0.01
	0.62	0.35	0.1
	0.63	0.69	0.13
	0.49	**0.47**	0.17
	0.48	**0.66**	0.4
	0.75	**0.48**	0.15
	0.65	**0.64**	0.43
	0.58	**0.53**	0.34
	0.56	**0.65**	0.4

Bold numbers are above the 95% confidence level (Student T-test)

Predict the EOF1 of Eurasian SCF about 3 months in advance

Prediction for SCF Climatology & variability in snowfall season-October





Positive biases over 30-140°E, 50-70°N; biases vary little as the LM increases.

Can not predict the observed large variation

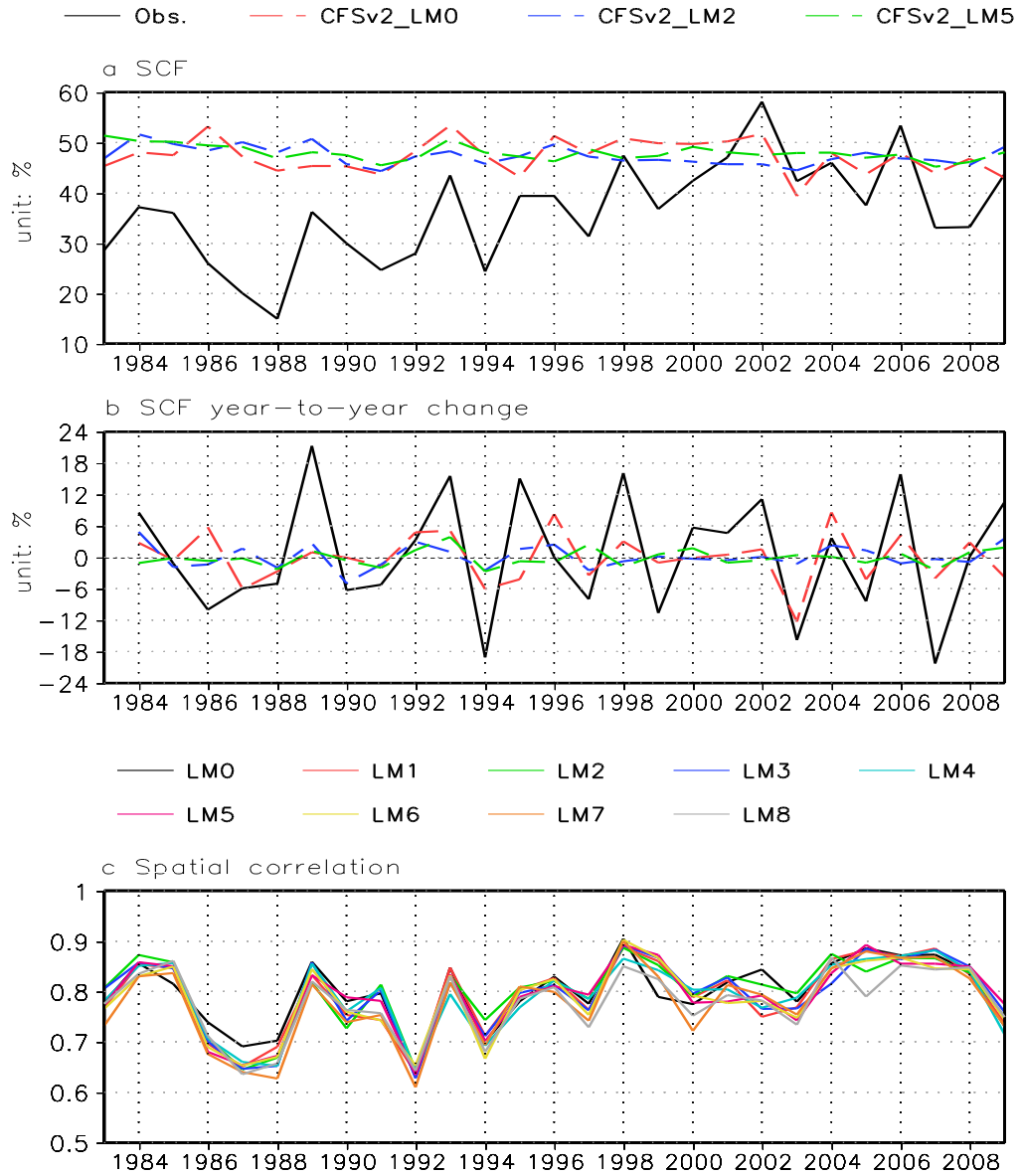
Most intensive snowfall

Large model bias

Located over **30°-140°E, 50°-70°N** (black dashed rectangles).

Define this area as snowfall key area (SFKA).

Prediction for SCF interannual variations in snowfall season-October

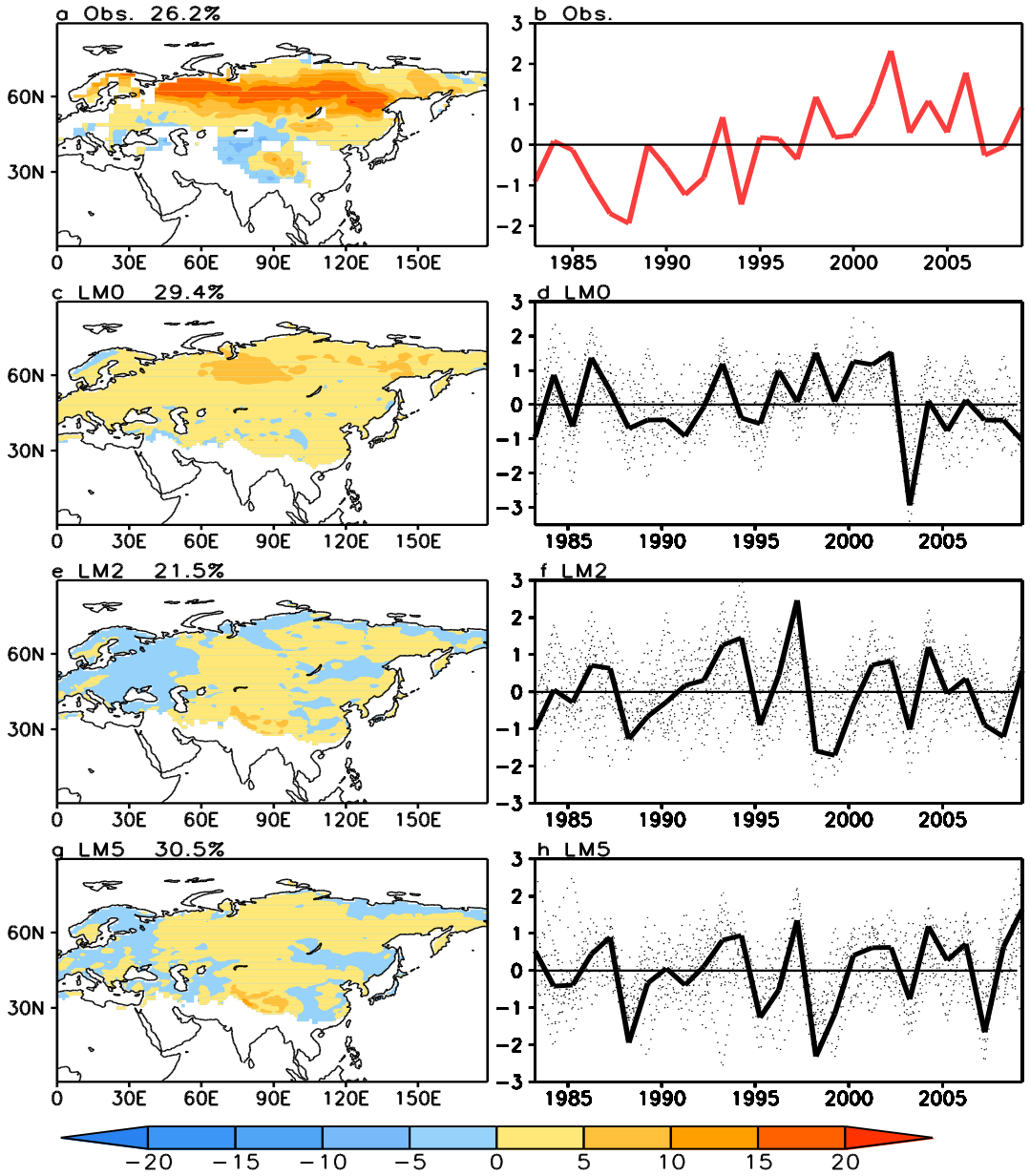


R	LM0	LM1	LM2	LM3	LM4	LM5	LM6	LM7	LM8
Original	0.3	-0.07	-0.1	-0.3	-0.01	0.03	-0.23	-0.13	-0.1
Year-to-year	**0.58**	0.21	0.4	-0.2	0.08	0.29	-0.03	0.2	0.07

Bold numbers are above the 95% confidence level (Student T-test)

- **Insignificant relationship with the observation.**
- **Higher prediction skill after late-1990s**

Prediction for SCF EOF1 in snowfall season-October

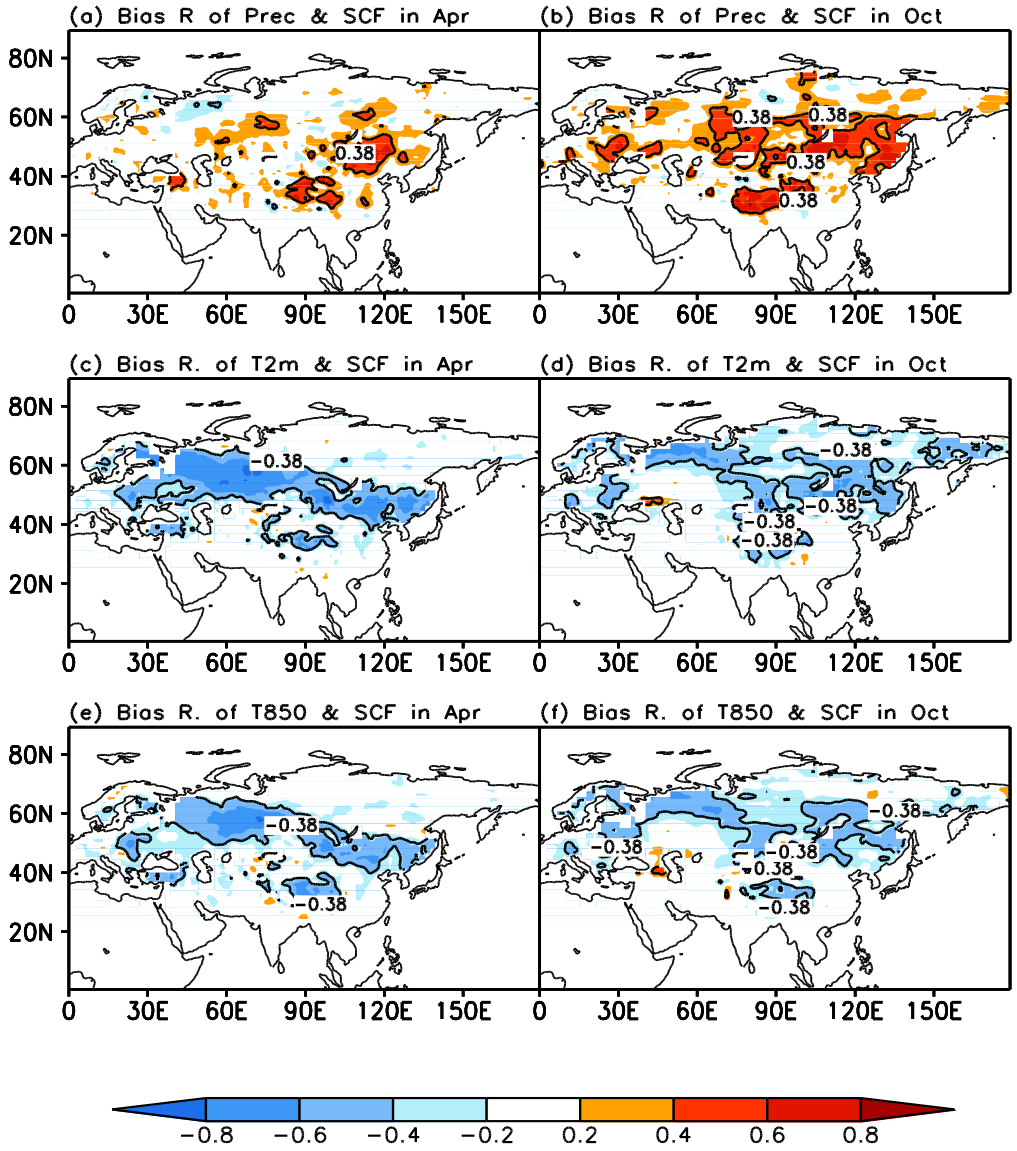


- Similar pattern to the observation but with much weaker magnitude.
- None of the PC1s in CFSv2 reproduce the observed upward trend.
- Insignificant correlation.

Plausible causes for the prediction and predictability

- Temperature
- precipitation

Bias correlation in Precipitation, T2m, T850 for LM0



Correlation coefficients between the CFSv2 and obs.

		LM0	LM1	LM2	LM3	LM4	LM5	LM6	LM7	LM8
Apr	Prc	0.03	0.20	0.07	0.11	0.16	0.19	0.12	0.03	-0.01
	T2m	**0.58**	**0.50**	0.23	0.27	0.34	0.23	0.21	0.14	0.09
	T850	**0.57**	**0.44**	0.14	0.24	0.30	0.17	0.17	0.09	0.09
Oct	Prc	-0.02	-0.06	0.10	-0.20	0.25	0.25	0.22	-0.32	0.42
	T2m	**0.63**	**0.38**	0.20	0.18	0.23	0.36	0.19	0.24	0.27
	T850	**0.60**	0.34	0.20	0.15	0.29	**0.43**	0.15	0.26	0.05

Bold numbers are above the 95% confidence level (Student T-test)

- Prediction skill for temperature is greater than that for precipitation.
- Poor prediction skill for precipitation and its close relationship with October SCF may interpret the worse prediction skill in the SCF in October than in April.

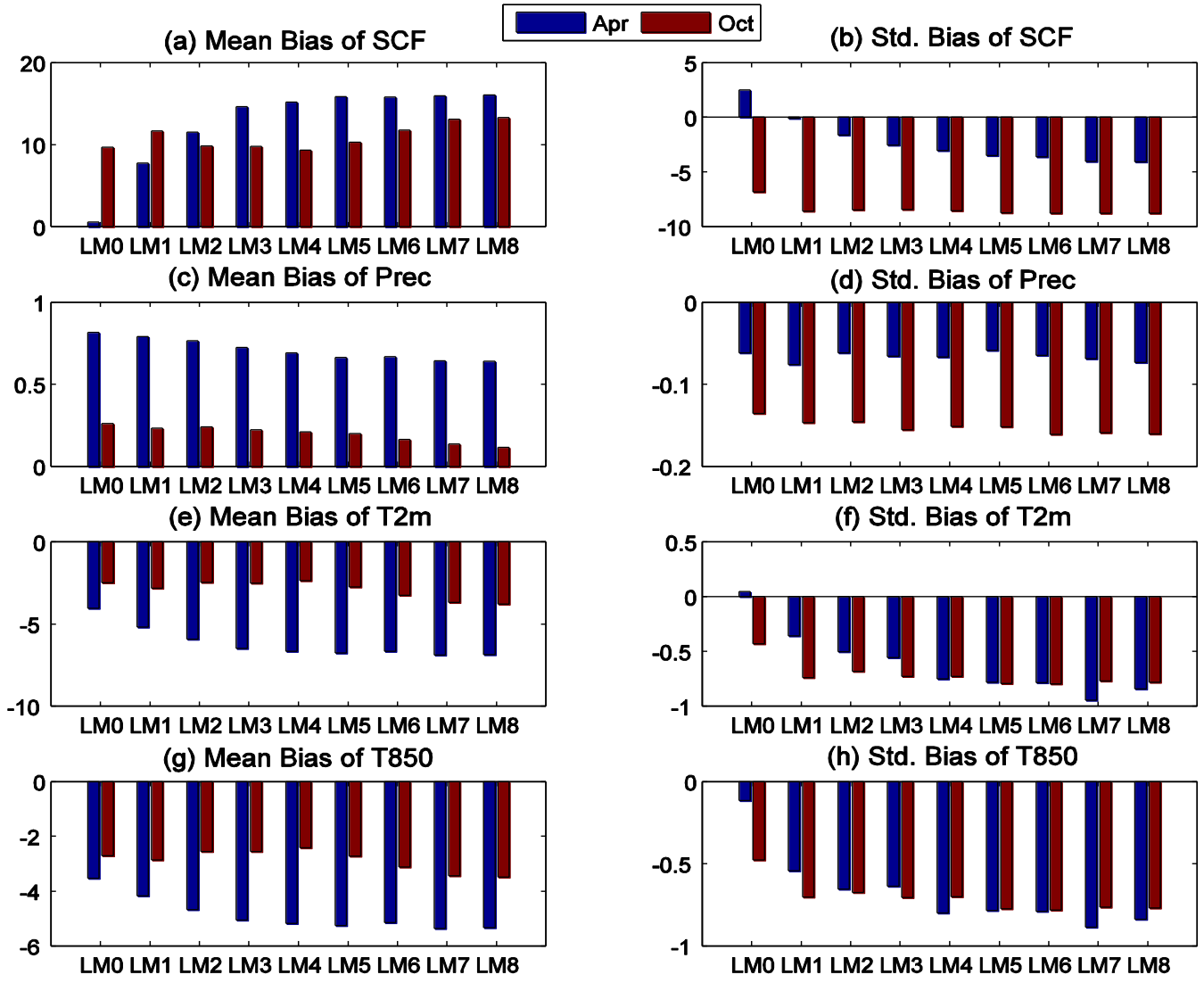
Mean and Std. Bias in SCF, Precipitation, T2m and T850

SCF

Prec.

T2m

T850



Mean value

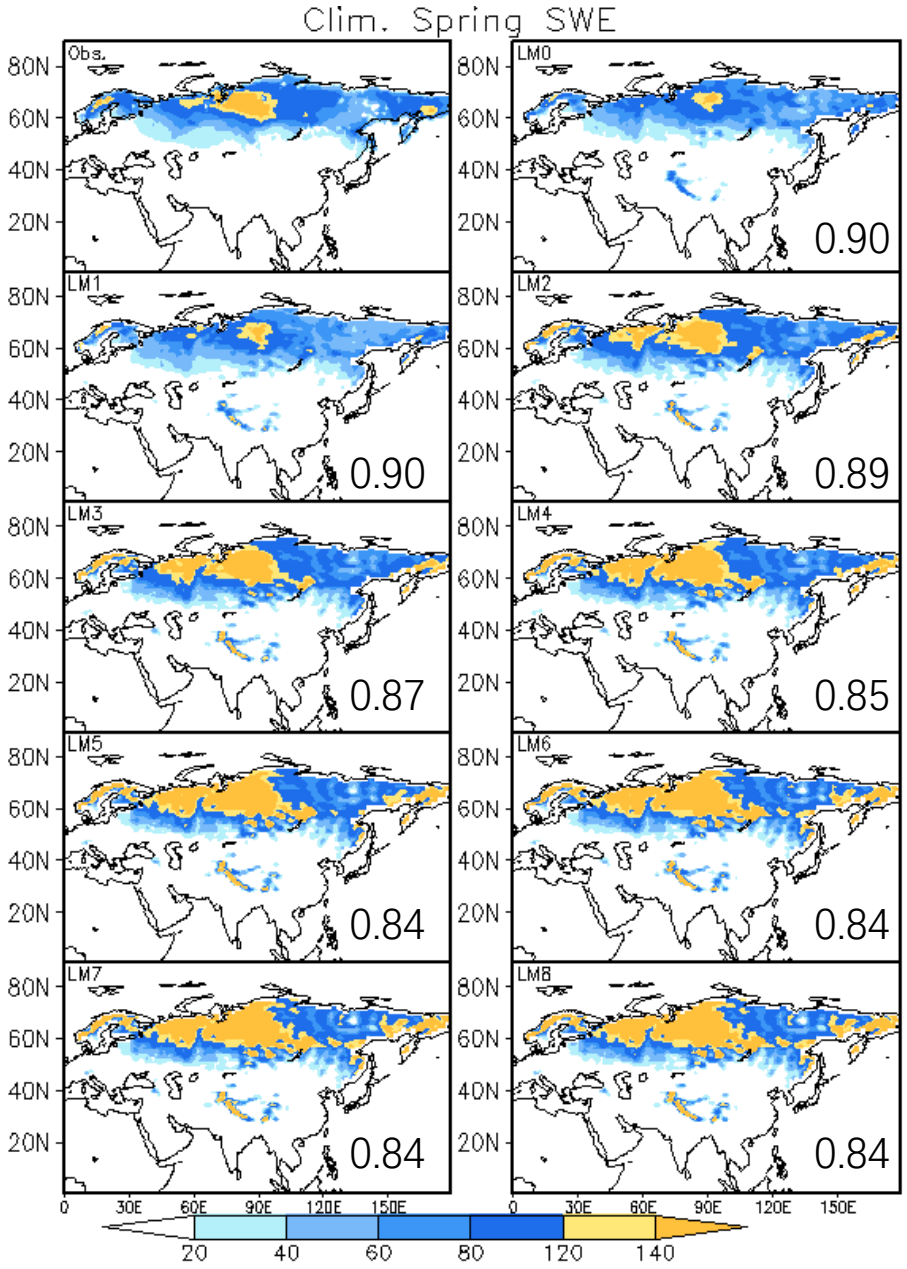
Std.

- Cooler and wetter atmosphere, preventing from snowmelt but conduces to snow accumulation.
- Underestimated SCF variability.
- Precipitation variability in October is worse than in April.

Part IV

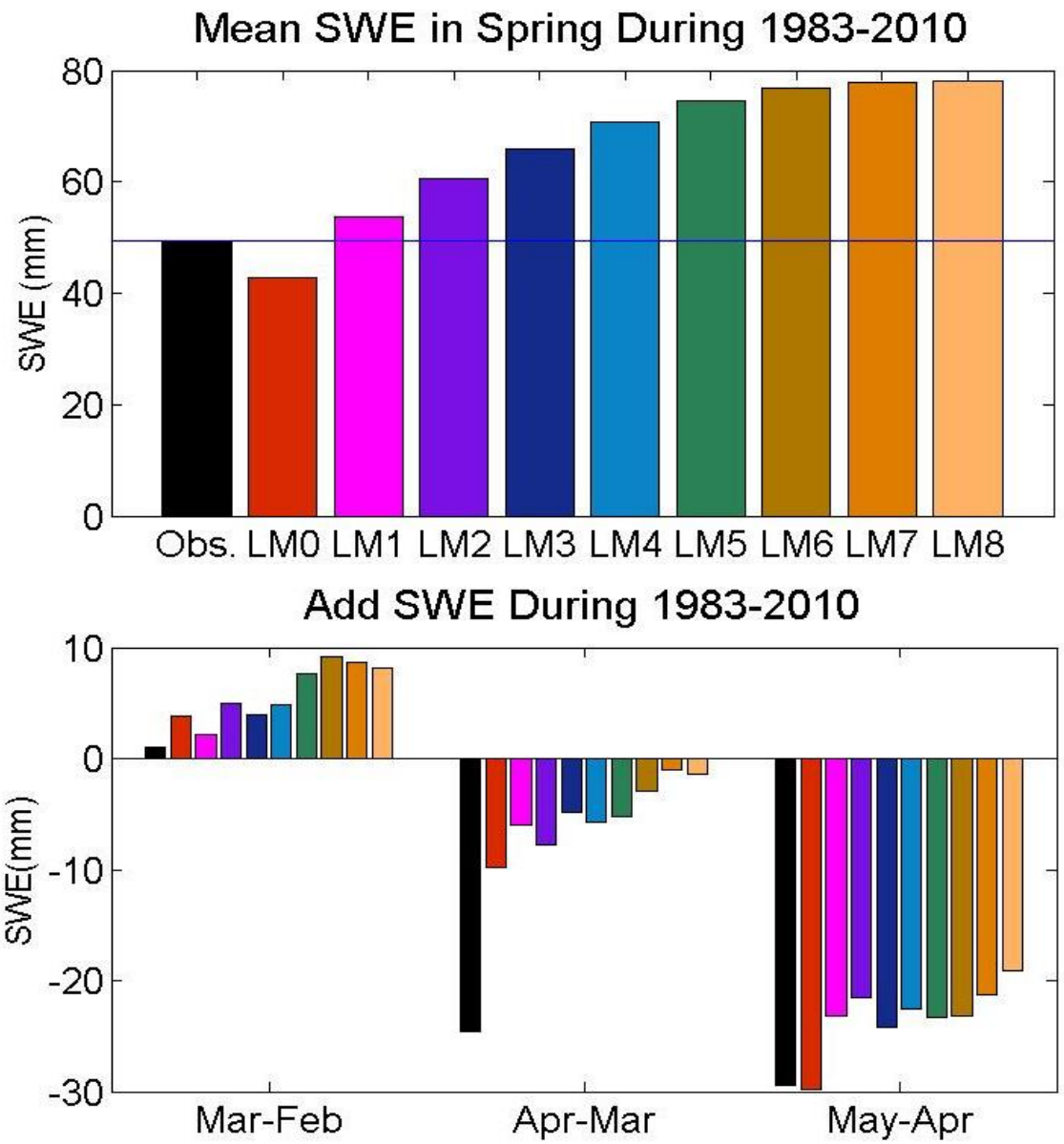
- Prediction of spring snow water equivalent (SWE)

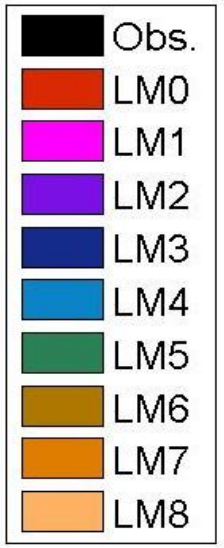
Prediction for Spring SWE Climatology

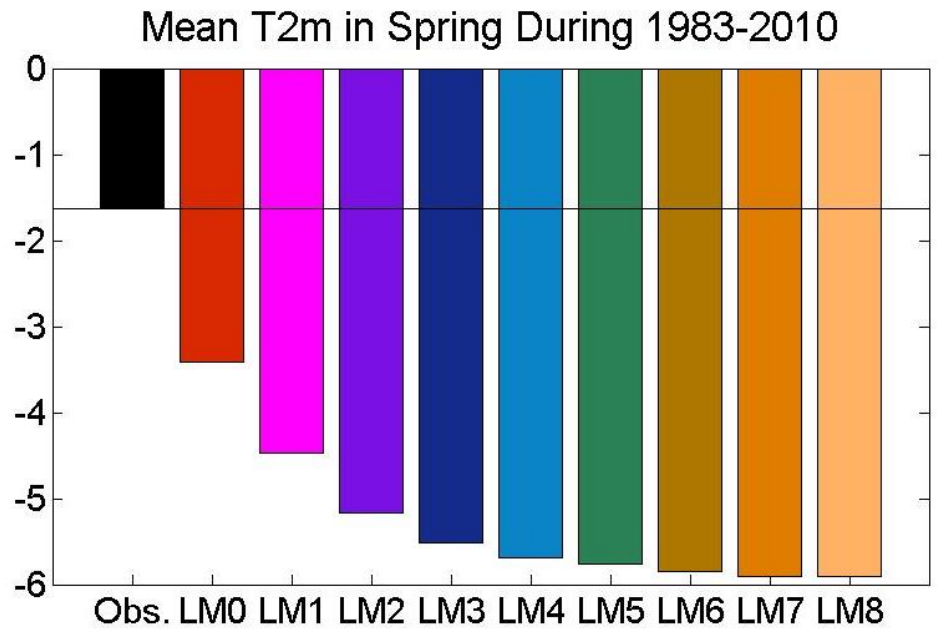


A similar distribution to that of the observation with pattern correlation coefficients all above 0.84.

Prediction for Spring climatological mean SWE

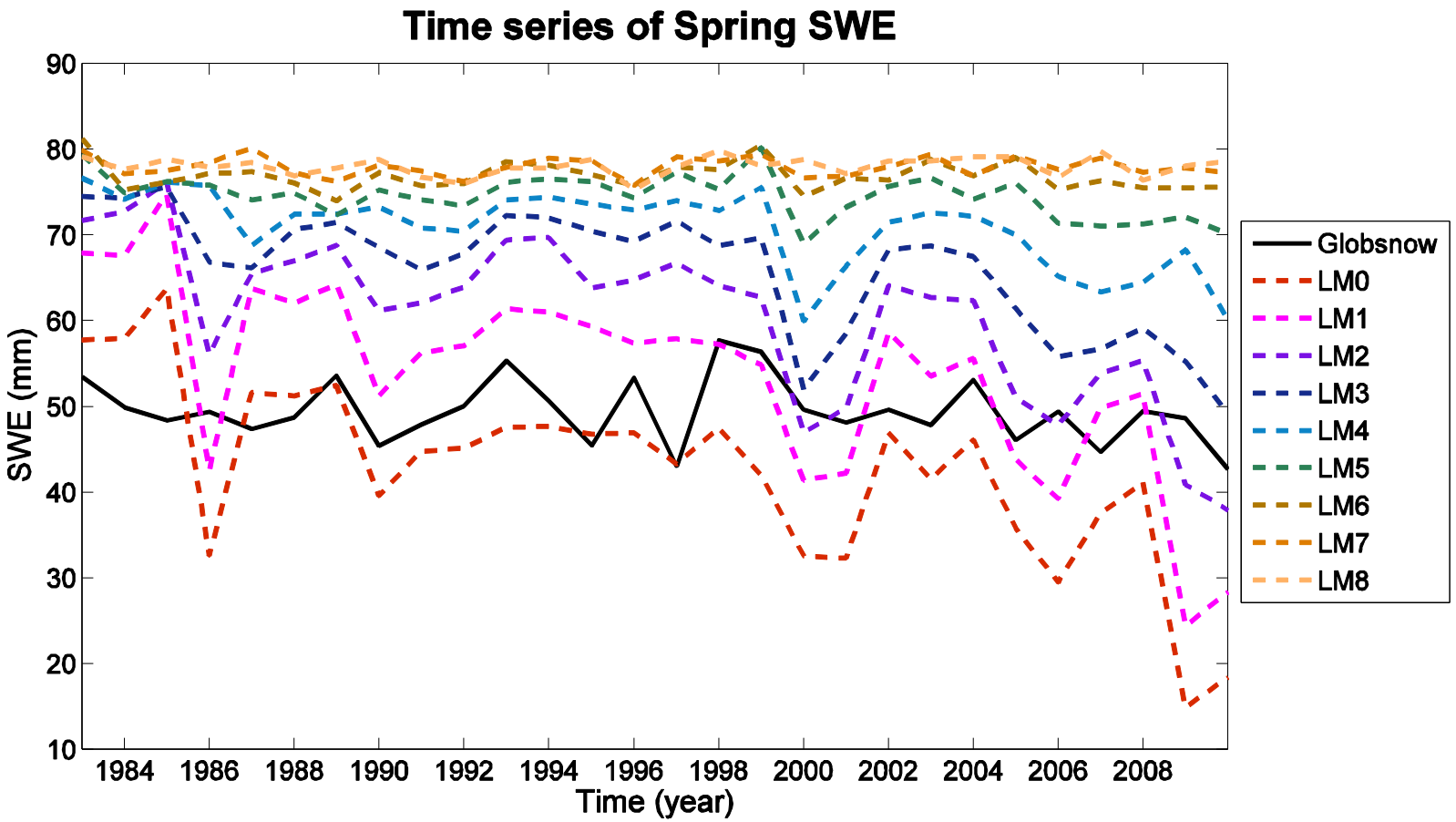






Later start of snowmelt and a smaller snowmelt rate than the observation.

Prediction for Spring SWE interannual variations



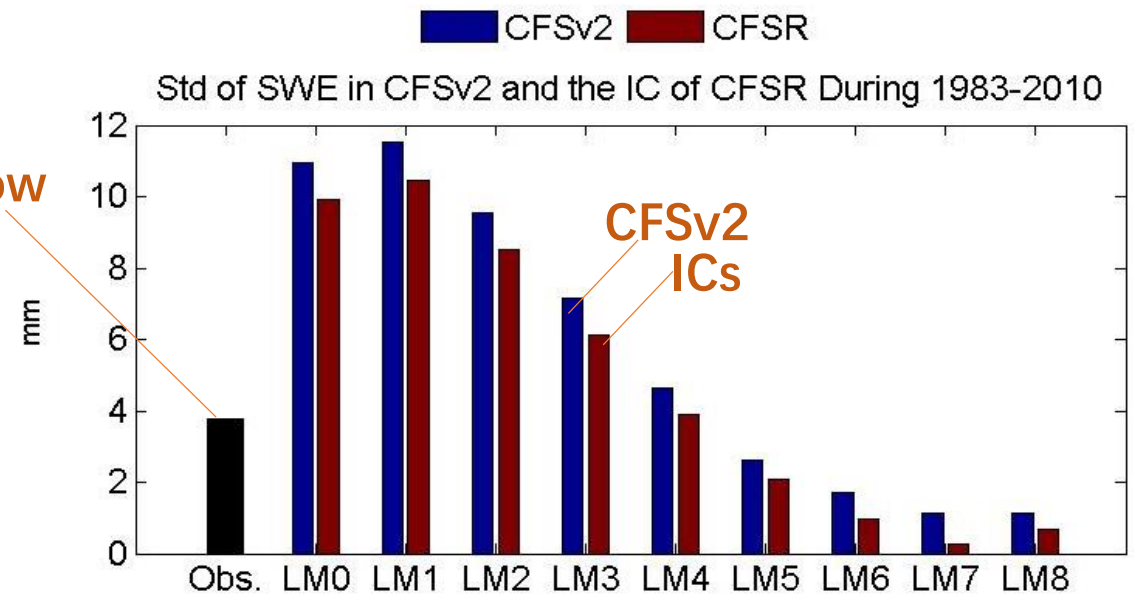
A level of predictive capability for the Eurasian spring SWE one to five months ahead.

	LM0	LM1	LM2	LM3	LM4	LM5	LM6	LM7	LM8
R	**0.36**	**0.33**	**0.38**	**0.38**	**0.4**	0.29	0.22	-0.1	-0.1
RMSE	0.92	0.93	0.91	0.92	0.99	1.47	2.19	3.5	3.53

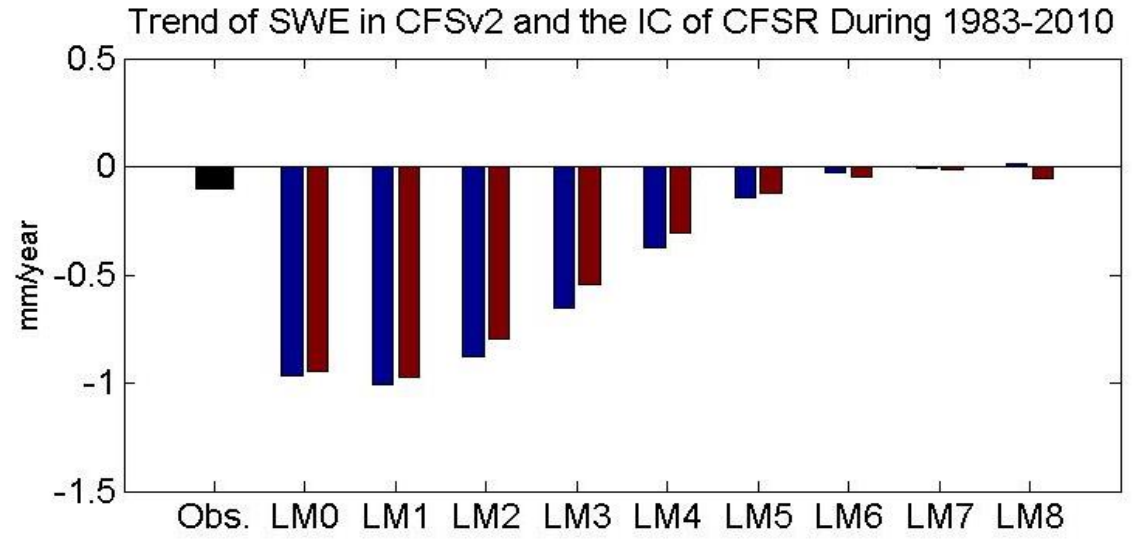
Bold numbers are above the 95% confidence level (Student T-test)

Std. and Trend in obs., CFSv2 and its ICs.

Std



Trend



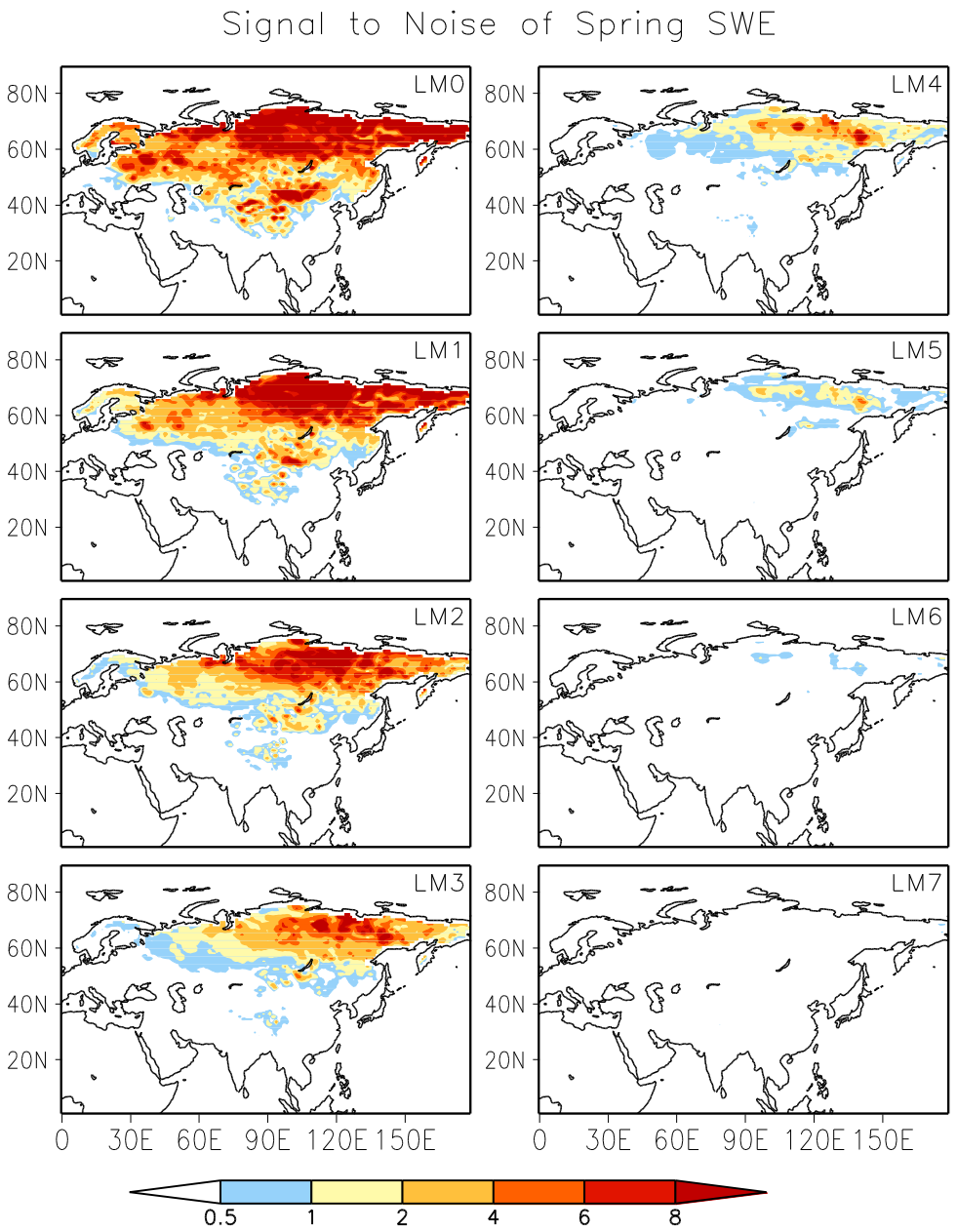
Lead time	R
LM0	**0.99**
LM1	**0.98**
LM2	**0.98**
LM3	**0.97**
LM4	**0.96**
LM5	**0.89**
LM6	**0.68**
LM7	0.33
LM8	-0.02

Overestimated std. and downtrend in CFSv2 for LM0–4 are primarily driven by the corresponding ICs.

$$\textbf{Signal to Noise Ratio (SNR)} = \frac{\boldsymbol{ensemble\ mean\ variance\ (EMV)}}{\boldsymbol{forecast\ spread}}$$

- To analyze the potential model predictability.
- A greater SNR indicates a higher potential.

SNR of the SWE in CFSv2

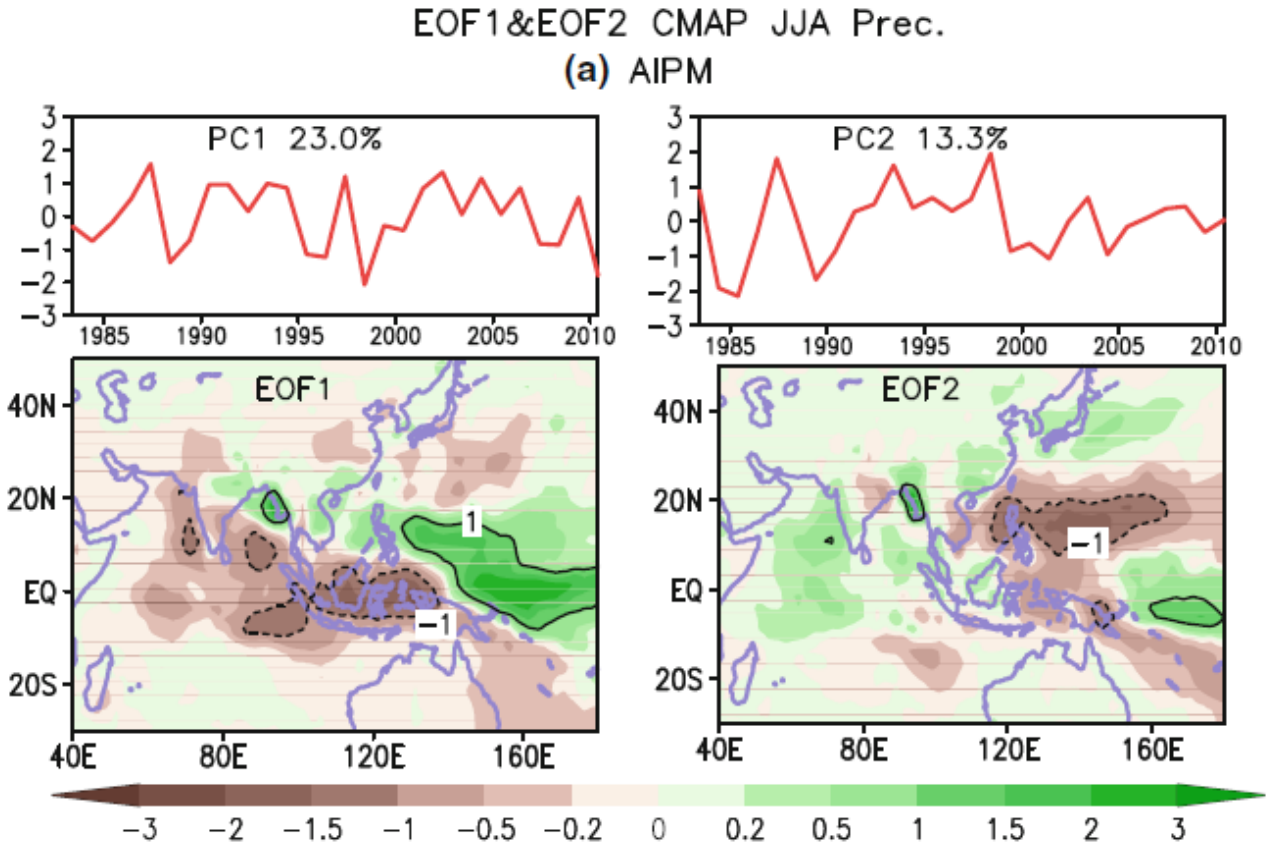


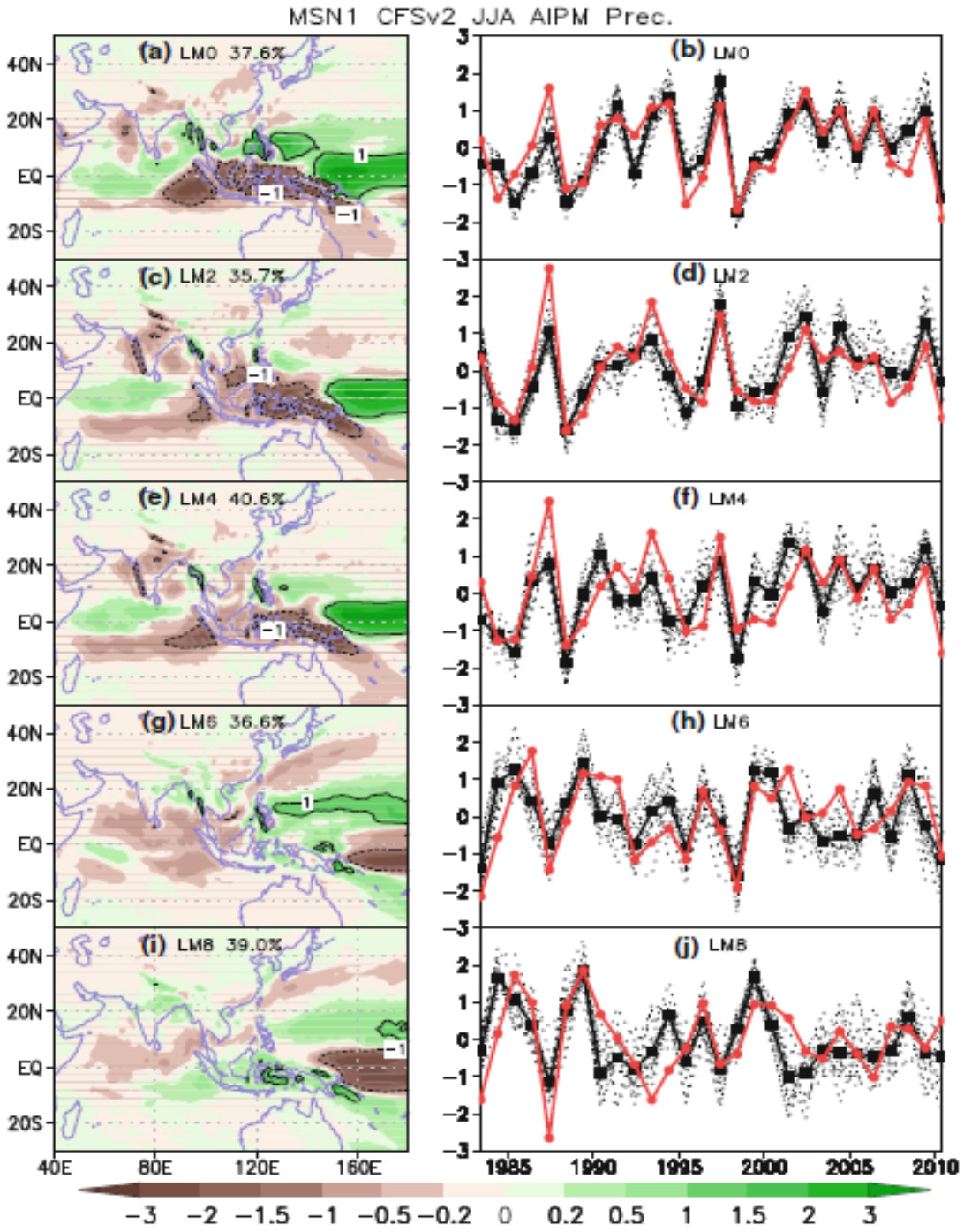
CFSv2 has potential predictability for spring SWE ahead of 1-5 months

Part V

- Prediction of Asian monsoon and its relation to Eurasian snow

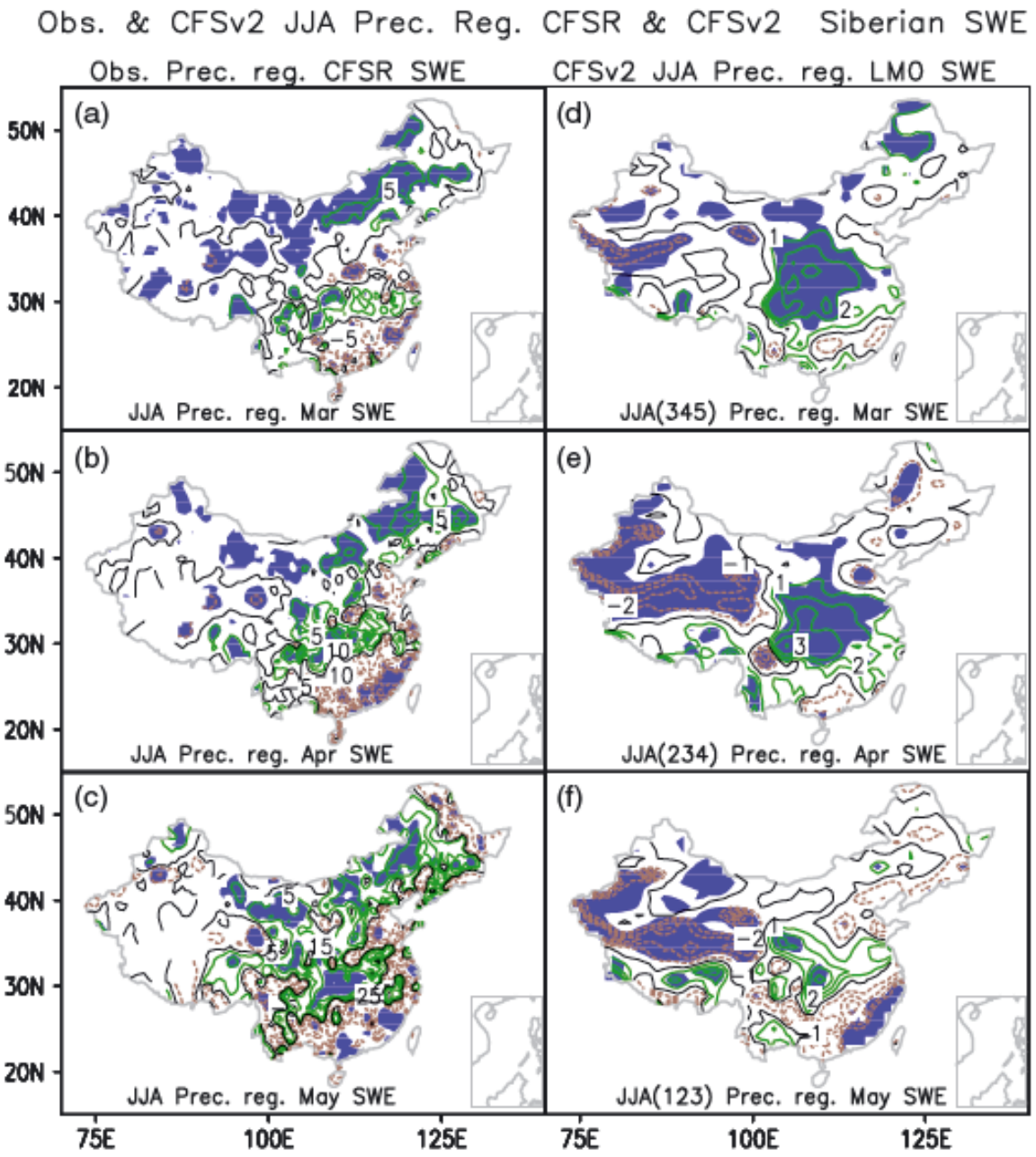
Prediction of Asian and Indo-Pacific monsoon





The equatorial dipole pattern is captured by the CFSv2

Response of Summer China rainfall to spring Siberian snow



Using the initial condition in April, the CFSv2 can predict the SWE over Siberia in May and the corresponding summer rainfall pattern over China.

Thank you!