



A projection of future changes in summer precipitation and monsoon in East Asia

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Outline

- 1. Description of IPCC-AR4 Models and Multi-model ensemble**
- 2. Projection of future changes in summer precipitation and monsoon in East Asia**
- 3. Conclusions**





1. Description of IPCC-AR4 Models and Multi-model ensemble





19 climate models in the study

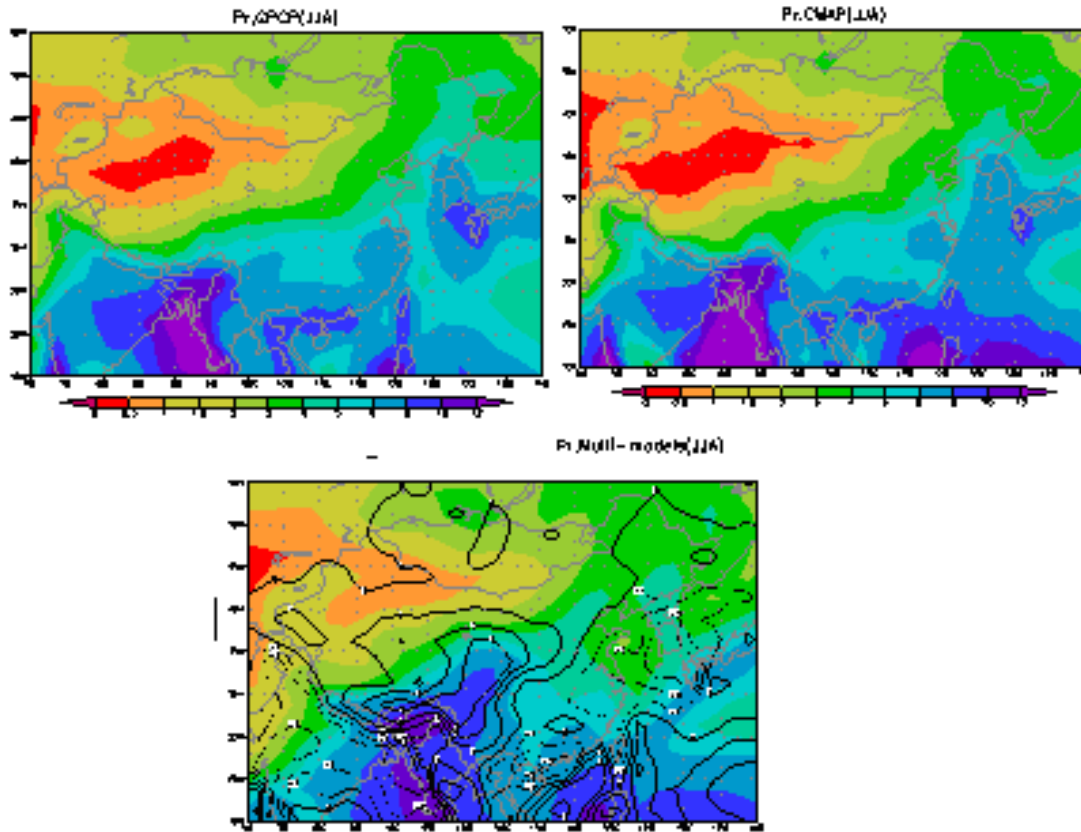
Information of 19 climate models examined in the study

| | Model | Center, Country | Atmospheric Resolution (long. × lat.) |
|----|-------------------|---|--|
| 1 | CGCM3.1 (T47) | Canadian Centre for Climate Modeling & Analysis, Canada | 3.75°×~3.75° |
| 2 | CGCM3.1 (T63) | Canadian Centre for Climate Modeling & Analysis, Canada | 2.8°×~2.8° |
| 3 | CNRM-CM3 | Météo-France/Centre National de Recherches Météorologiques, France | 2.8°×~2.8° |
| 4 | CSIRO | CSIRO Atmospheric Research, Australia | 1.88°×~1.88° |
| 5 | GFDL-CM2.0 | US Dept. of Commerce/NOAA/Geophysical Fluid Dynamics Laboratory, United States | 2.5°×2.0° |
| 6 | GFDL-CM2.1 | US Dept. of Commerce/NOAA/Geophysical Fluid Dynamics Laboratory, United States | 2.5°×2.0° |
| 7 | GISS-EH | NASA/Goddard Institute for Space Studies, United States | 5°×4° |
| 8 | GISS-ER | NASA/Goddard Institute for Space Studies, United States | 5°×4° |
| 9 | FGOALS-g1.0 | LASG/Institute of Atmospheric Physics, China | 2.8°×~2.8° |
| 10 | INM-CM3.0 | Institute for Numerical Mathematics, Russia | 5°×4° |
| 11 | IPSL-CM4 | Institut Pierre Simon Laplace, France | 3.75°×2.5° |
| 12 | MIROC3.2 (medres) | Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC), Japan | 2.8°×~2.8° |
| 13 | MIROC3.2 (hires) | Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC), Japan | 1.125°×~1.12° |
| 14 | ECHAM5/MPI-OM | Max Planck Institute for Meteorology, Germany | 1.88°×~1.88° |
| 15 | MRI-CGCM2.3.2 | Meteorological Research Institute, Japan | 2.8°×~2.8° |
| 16 | CCSM3 | National Center for Atmospheric Research, United States | 1.4°×~1.4° |
| 17 | PCM | National Center for Atmospheric Research, United States | 2.8°×~2.8° |
| 18 | UKMO-HadCM3 | Hadley Centre for Climate Prediction and Research/Met Office, United Kingdom | 1.25°×1.25° |
| 19 | UKMO_hadgem1 | Hadley Centre for Climate Prediction and Research/Met Office, United Kingdom | 1.875°×1.25° |



Validations of IPCC model performance

| | 模式名称 | 模式和CMAP 1979-99夏季平均 降水的相关 | 模式和GPCP 1979-99夏季平 均降水的相关 | 模式和中国站点降水资 料1979-99减去1958- 78降水变化的相关 | 分类情况 |
|----|------------------|---------------------------------|---------------------------------|--|------|
| 1 | CGCM3.1(T47) | 0.51 | 0.39 | -0.52 | 3类 |
| 2 | CGCM3.1(T63) | 0.59 | 0.49 | 0.31 | 3类 |
| 3 | CNRM-CM3 | 0.84 | 0.85 | -0.45 | 2类 |
| 4 | CSIRO | 0.75 | 0.76 | -0.10 | 2类 |
| 5 | GFDL-CM2.0 | 0.83 | 0.83 | 0.46 | 1类 |
| 6 | GFDL-CM2.1 | 0.82 | 0.80 | -0.22 | 2类 |
| 7 | GISS-EH | 0.33 | 0.36 | -0.50 | 3类 |
| 8 | GISS-ER | 0.40 | 0.44 | -0.60 | 3类 |
| 9 | FGOALS-g1.0 | 0.24 | 0.28 | -0.50 | 3类 |
| 10 | INM-CM3.0 | 0.76 | 0.70 | 0.15 | 2类 |
| 11 | IPSL-CM4 | 0.68 | 0.68 | -0.42 | 3类 |
| 12 | MIROC3.2(hires) | 0.80 | 0.82 | 0.38 | 1类 |
| 13 | MIROC3.2(medres) | 0.81 | 0.76 | 0.23 | 1类 |
| 14 | ECHAM5 | 0.71 | 0.60 | -0.43 | 3类 |
| 15 | MRI-CGCM2.3.2 | 0.60 | 0.61 | 0.43 | 3类 |
| 16 | CCSM3 | 0.57 | 0.48 | -0.09 | 3类 |
| 17 | PCM | 0.28 | 0.11 | 0.46 | 3类 |
| 18 | UKMO-HadCM3 | 0.89 | 0.84 | -0.76 | 2类 |
| 19 | UKMO_hadgem1 | 0.80 | 0.73 | 0.16 | 2类 |



observation

Simulation

1979–1999 June-July-August (JJA) mean precipitation (mm d⁻¹) based on GPCP (a) and 19-model ensemble mean (b). Shaded areas in (b) indicate the model ensemble mean and contours are the difference between the model ensemble and GPCP. From Sun and Ding .





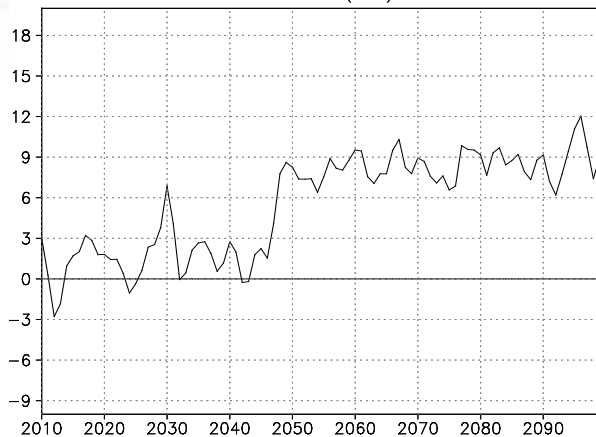
2. Projection of future changes in summer precipitation and monsoon in East Asia





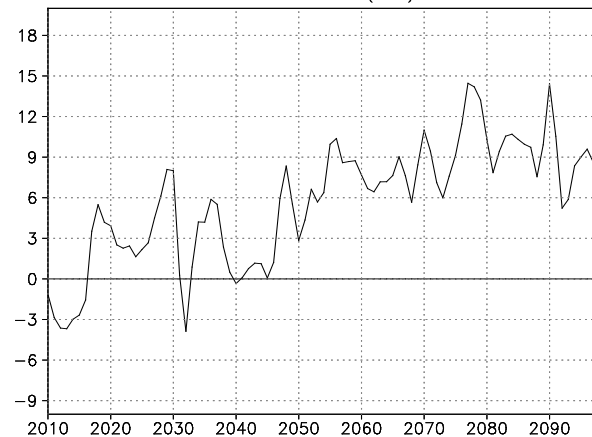
East Asia

East Asia(JJA)

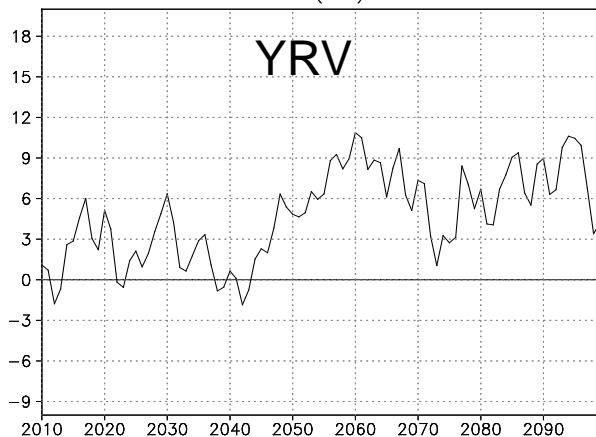


S. China

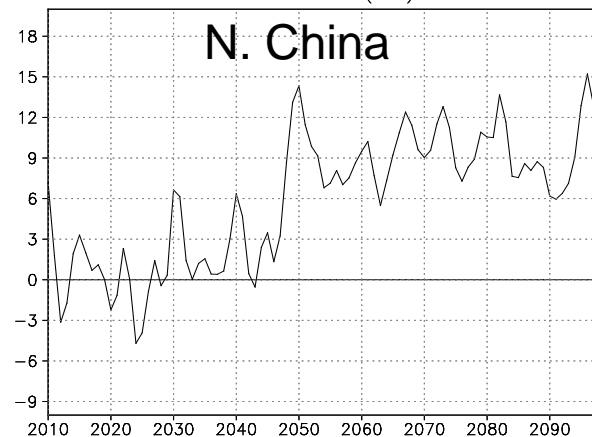
South China(JJA)



YRV(JJA)



North China(JJA)



Future percentage changes(%) in summer precipitation for East Asia and its three sub-regions (South China, Yangtze River Valley(YRV) and North China), relative to climatological mean of 1980-1999. Projections are based on 19 IPCC AR4 climate models.(Sun and Ding,2009)





Time of abrupt increase of precipitation in East China and 3 key areas based on the running-*t* test with 95% significance level^a

| | Model | South China | YRV | North China | East China |
|----|-------------------|-------------|------------|-------------|------------|
| 1 | CGCM3.1 (T47) | – | 2072 | – | – |
| 2 | CGCM3.1 (T63) | 2070 | 2054 | 2040 | – |
| 3 | CNRM-CM3 | 2078 | – | – | – |
| 4 | CSIRO | – | – | – | – |
| 5 | GFDL-CM2.0 | – | 2054 | – | 2054 |
| 6 | GFDL-CM2.1 | – | 2031, 2070 | – | 2069 |
| 7 | GISS-EH | – | – | 2046, 2066 | 2044, 2074 |
| 8 | GISS-ER | 2032 | 2063 | 2048 | 2066 |
| 9 | FGOALS-g1.0 | 2056 | – | – | – |
| 10 | INM-CM3.0 | 2058 | 2058 | – | 2058 |
| 11 | IPSL-CM4 | 2051 | – | – | – |
| 12 | MIROC3.2 (medres) | – | – | 2071 | 2049 |
| 13 | MIROC3.2 (hires) | – | 2081 | 2057 | 2051 |
| 14 | ECHAM5/MPI-OM | 2046 | – | – | 2046 |
| 15 | MRI-CGCM2.3.2 | 2029, 2049 | 2050 | – | 2052 |
| 16 | CCSM3 | 2042 | 2043 | 2046 | 2046 |
| 17 | PCM | 2065 | 2046 | 2083 | 2046 |
| 18 | UKMO-HadCM3 | – | – | 2051 | 2050 |
| 19 | UKMO_hadgem1 | – | – | 2047 | 2024, 2047 |

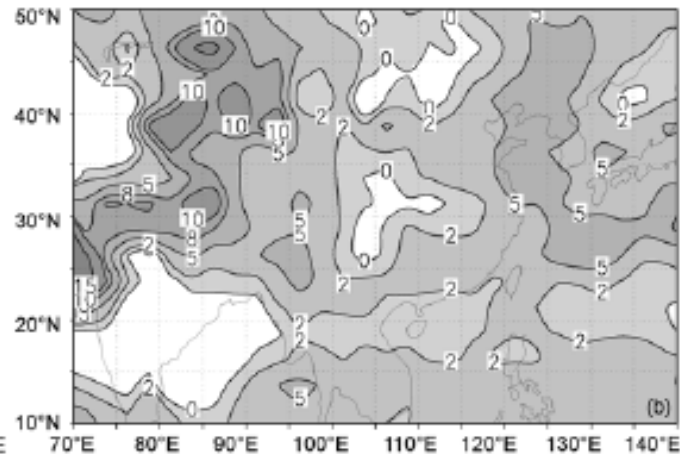
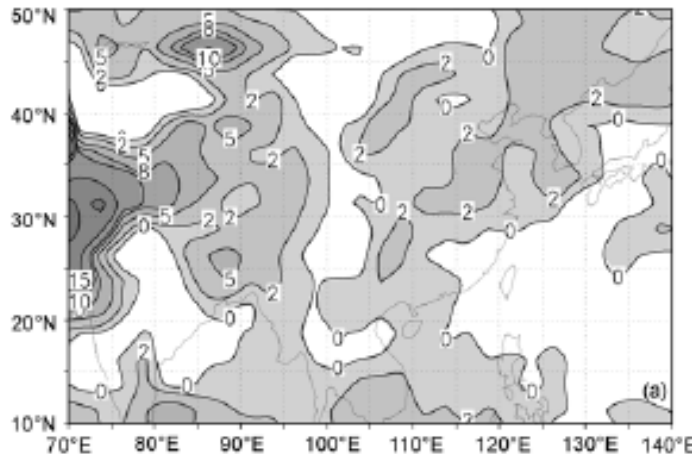
a) The hyphen “–” indicates the inexistence of abrupt increase or insignificant increase.



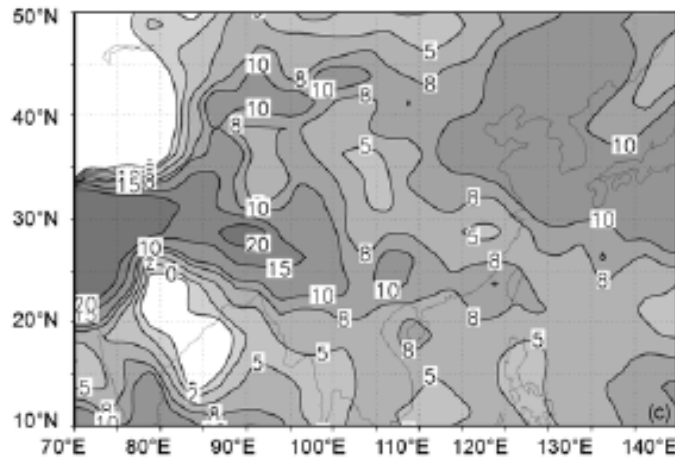


2010-2019

2030-2039



**JJA
precipitation**



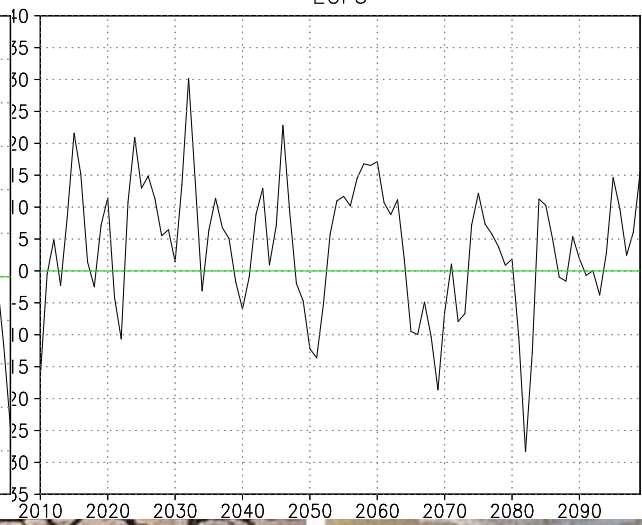
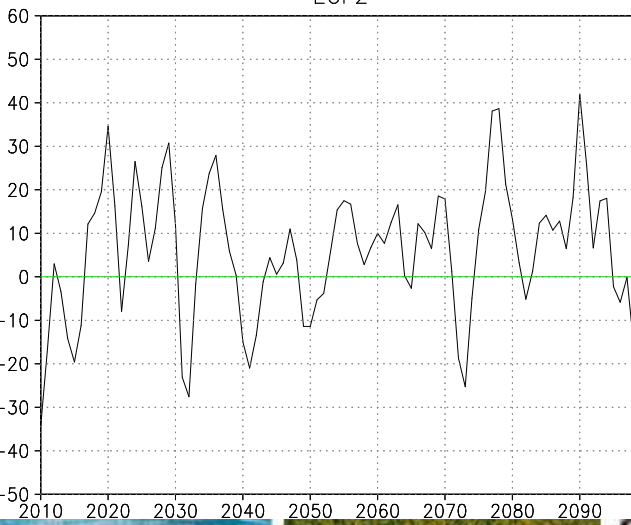
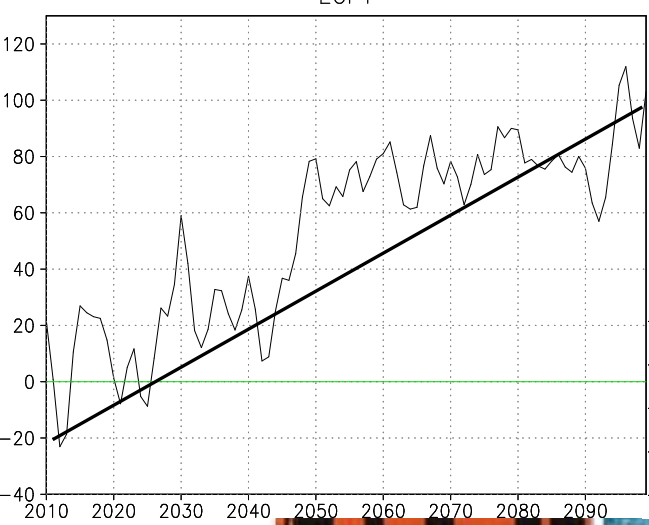
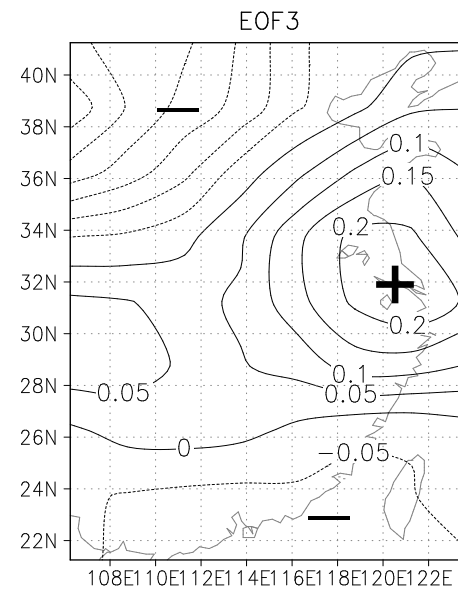
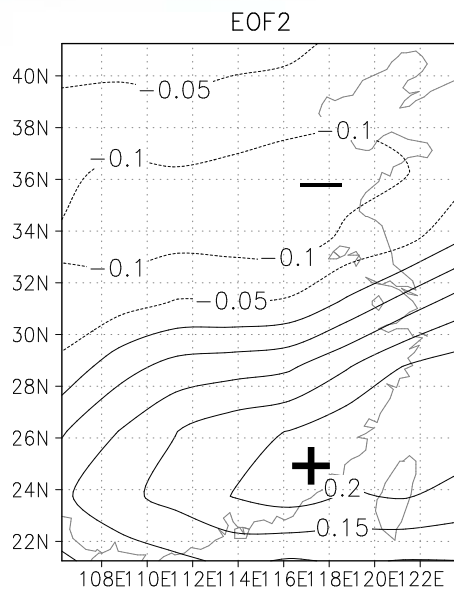
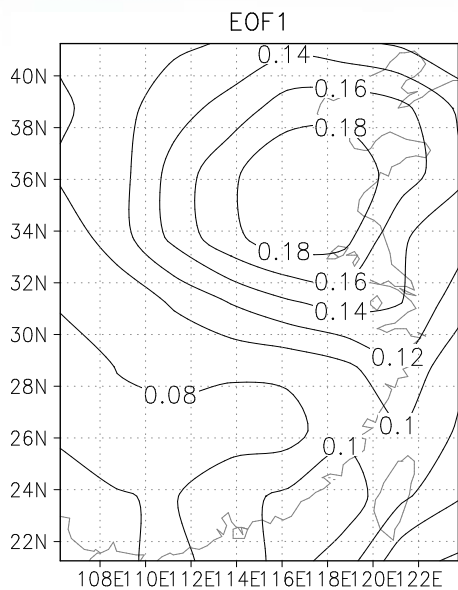
2080-2099

Percentage changes (%) of JJA precipitation (relative to 1980–1999 average) for 2010–2019 (a), 2030–2039 (b) and 2080–2099 (c).



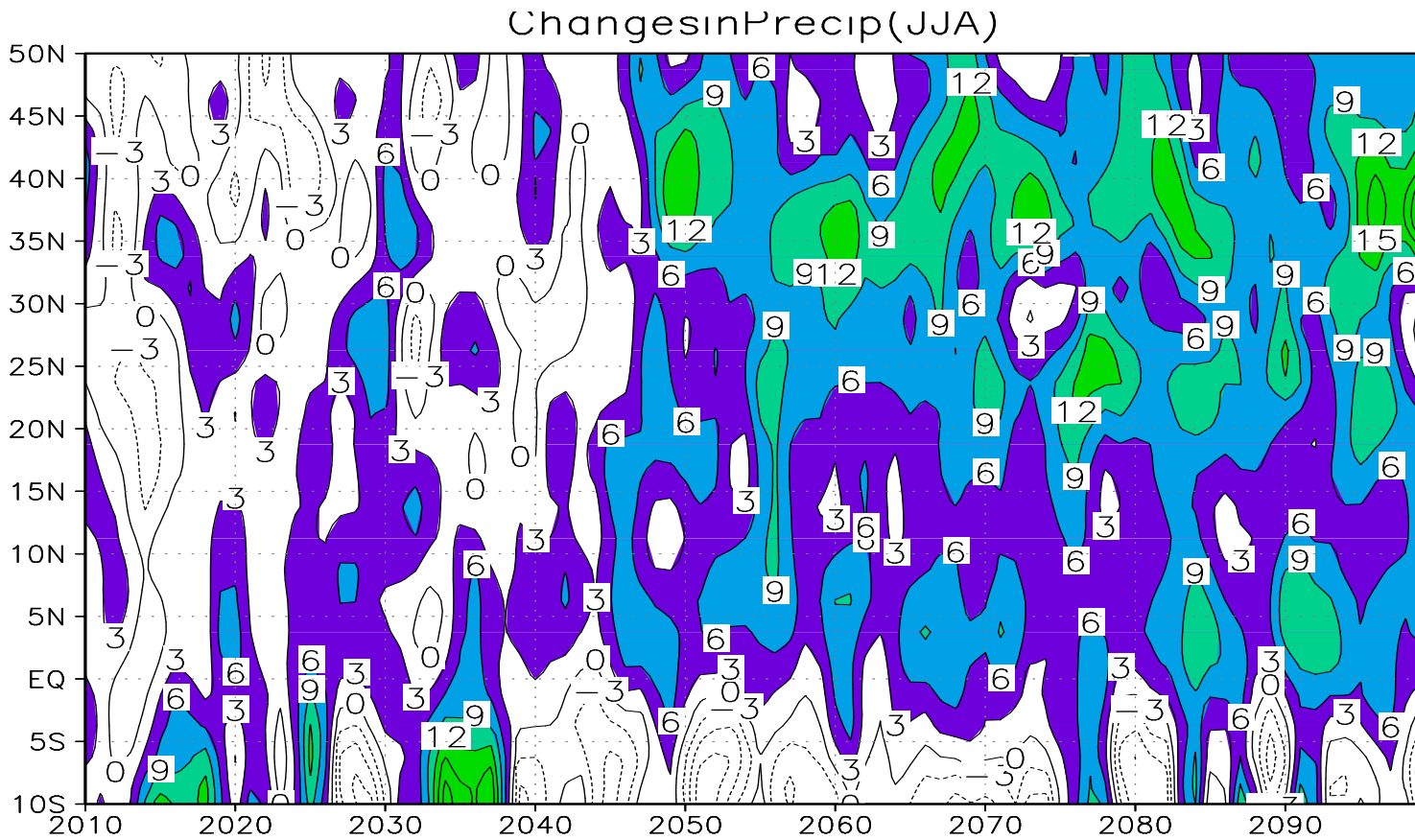


EOF analysis of summer precipitation in East China for 2010-2099



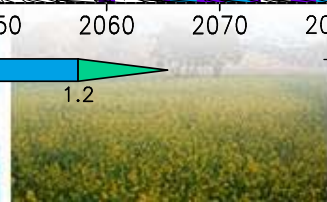
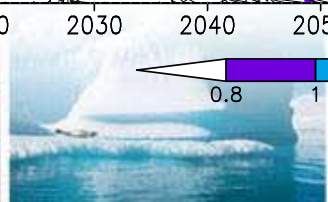
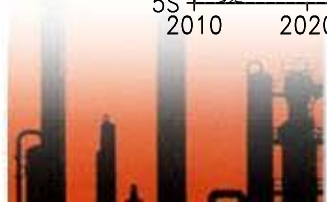
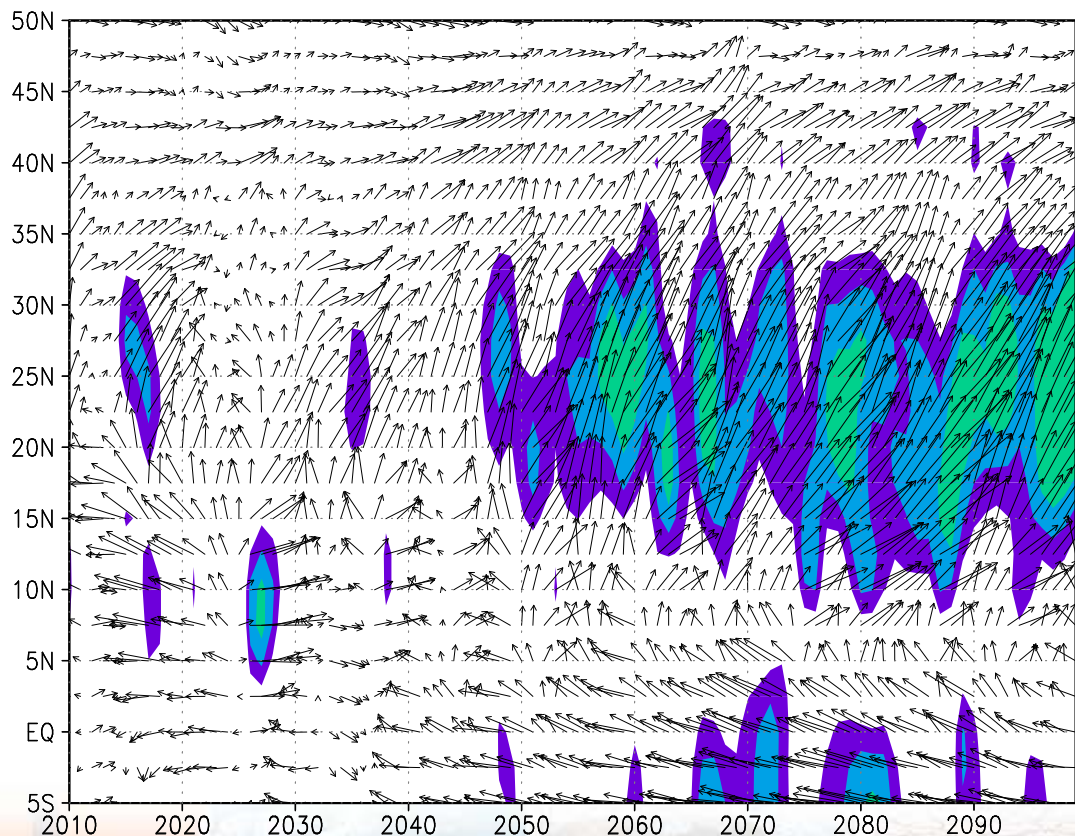


Latitude-time cross-section of East Asian summer precipitation for 2010-2099





Latitude –time cross-section of 850hpa moisture transport in East Asia for 2010-2099





Future change of the East Asian summer index for next 100 years



(based on the definition of monsoon index by Lu and Chan, with estimate of the V-component of wind).





3. Conclusions





It seems that the major rainfall belts would move northward by about 2040, but unstable. Afterwards, the summer precipitation in North China would increase considerably and stably. Furthermore, this anthropogenically-driven precipitation shift would appear to be consistent with the occurrence of rainfall peak period caused by the natural near-80-yr cycle. But this coincidence will be reliable?





谢谢!