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Interannual Variations of Summer Precipitation in Southwest China: Anomalies in the Moisture Transport and Roles of the Tropical Atlantic

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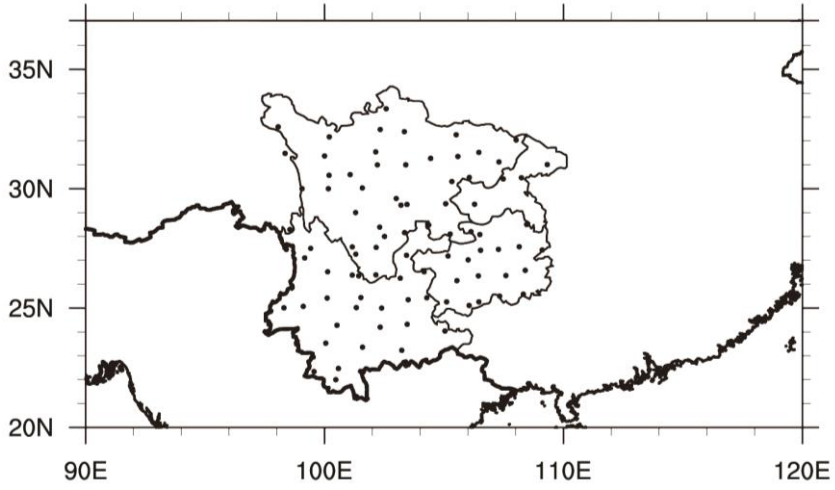
Content

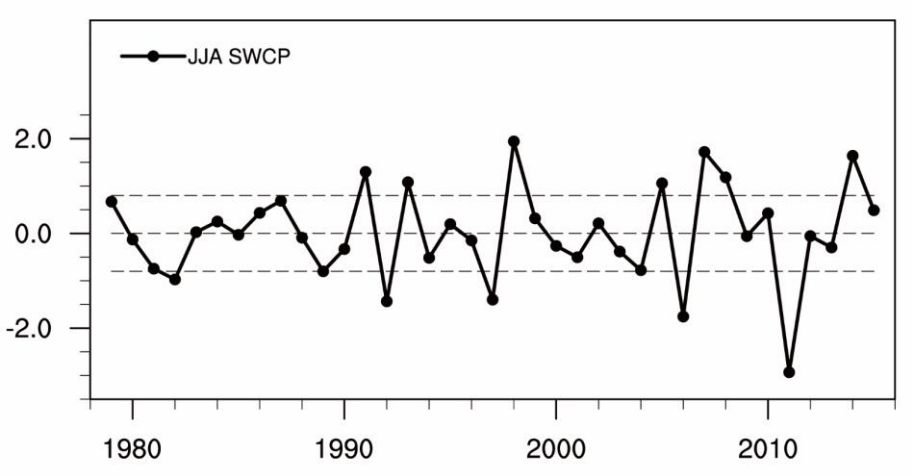
- Objects
- Data and methods
- Main conclusions
- Discussion

Precipitation in Southwest China (SWCP)

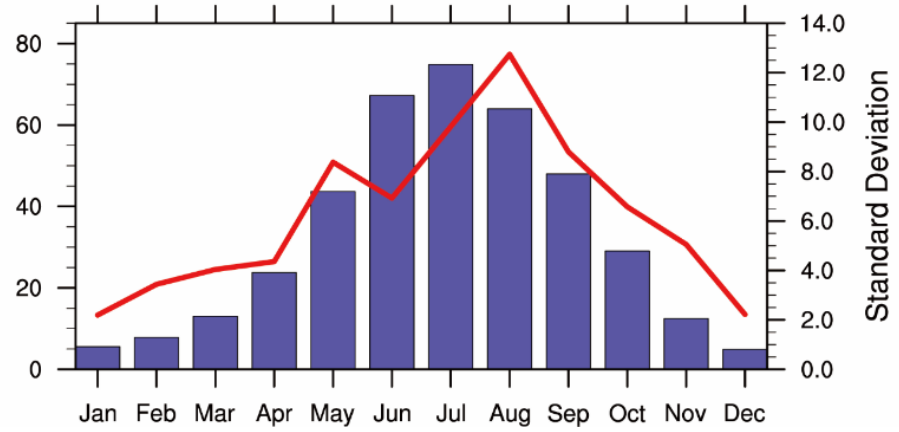
geographical location of SWC and observation stations



Time Series of summer SWCP



Monthly Mean and SD of SWCP

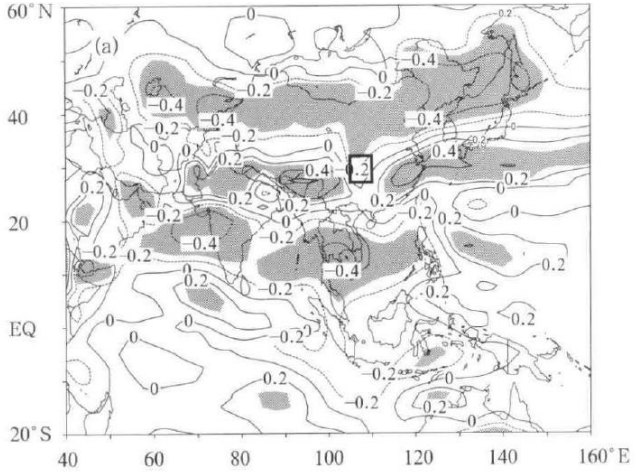


- The precipitation in SWC is concentrated in summer (accounting for 52.3%)
- Significant interannual variances

This study helps improve our understanding of the SWC summer precipitation variations and may also provide a possible source of seasonal predictability.

Objects

Correlation coefficient between SWCP and moisture flux



Moisture flux when SWC is wet/dry

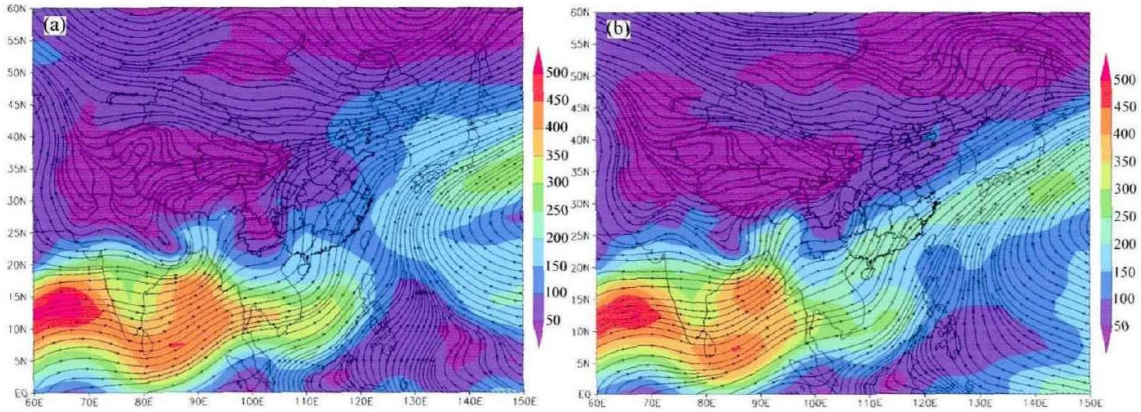


图 4-6 西南地区夏旱（a）、夏涝（b）时水汽输送通量（单位：$kg \cdot m^{-1} \cdot s^{-1}$）

- Many studies on moisture transport use the Eulerian method to diagnose sources of moisture, however, they cannot get the quantitative results.
  (e.g., Simmonds et al. 1999; Zhou and Yu 2005; Zhu et al. 2014).
- Lagrangian method is a better alternative. (Sun and Wang 2014a, b)

Objects

- Quantify the contributions of different moisture sources to summer precipitation in SWC by using the Lagrangian model of HYSPLIT.

- Examine the underlying mechanisms responsible for the moisture source changes in the wet/dry summers.

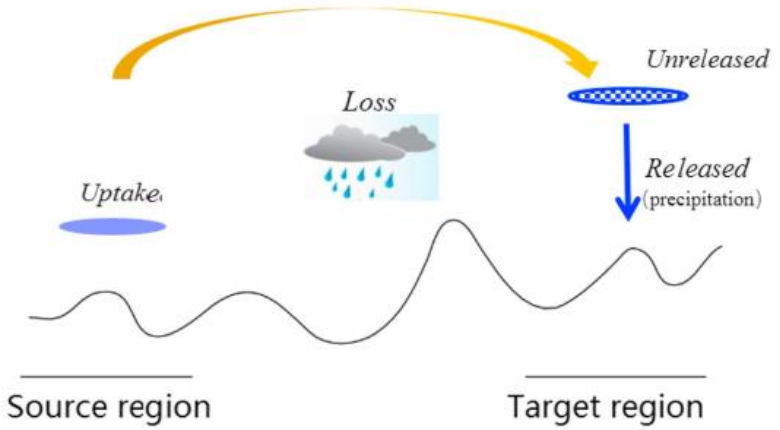
Data and Methods

- Observed monthly precip by CMA, 1979-2015
- NOAA SST, 1979-2015
- NCEP/NCAR, 1979-2015

- Correlation coefficient, Composite etc.
- HYSPLIT Lagrangian model
- The areal source-receptor attribution method
- AGCM experiment (CAM 5.3)

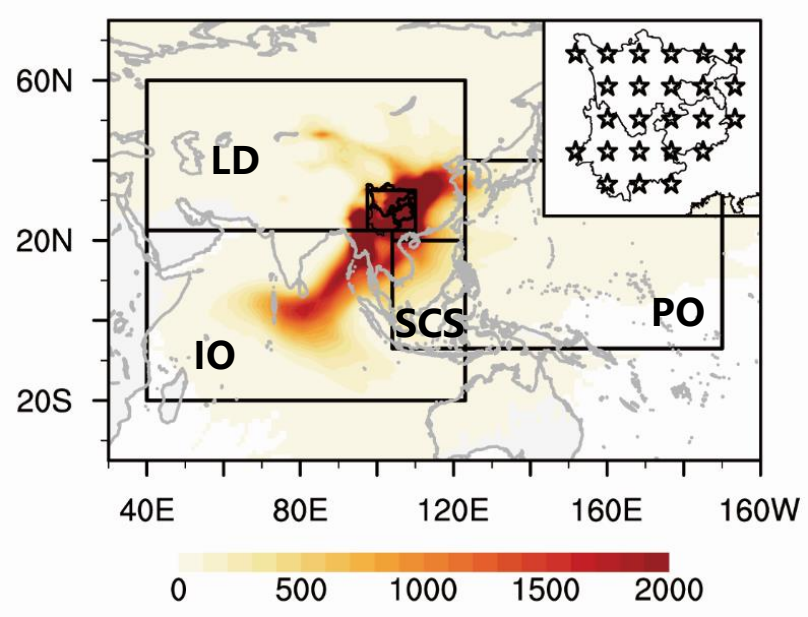
The areal source-receptor attribution method

Schematic of moisture change in particle



Chu et al. 2017

Trajectories of particles to SWC



Before reaching SWC:

Evaporation: $\Delta q_i = \Delta q_i + \Delta e_i$

Precipitation: $\Delta q_i = \Delta q_i - \Delta q_i \frac{\Delta p_i}{pw_i}$

After reaching SWC:

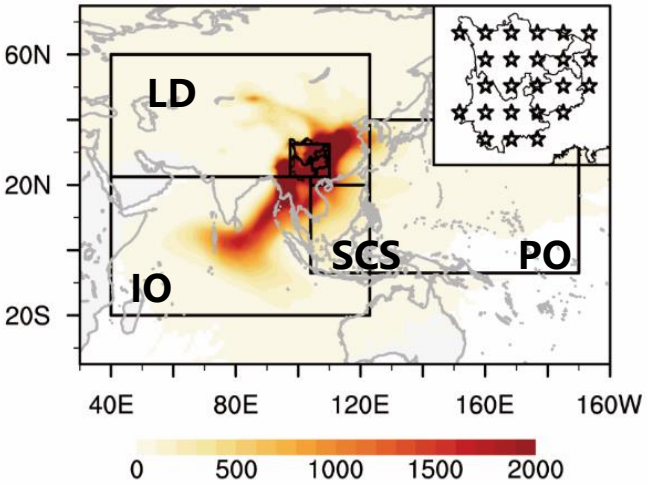
$$v_i = v_i + \Delta q_i \qquad r_i = r_i + \Delta q_i \frac{\Delta p_i}{pw_i}$$

$$L_i = R_i + V_i$$

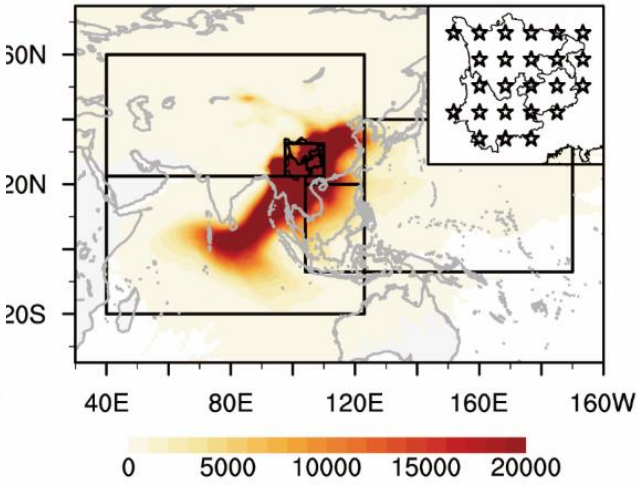
Main Conclusions

Moisture sources of summer SWCP

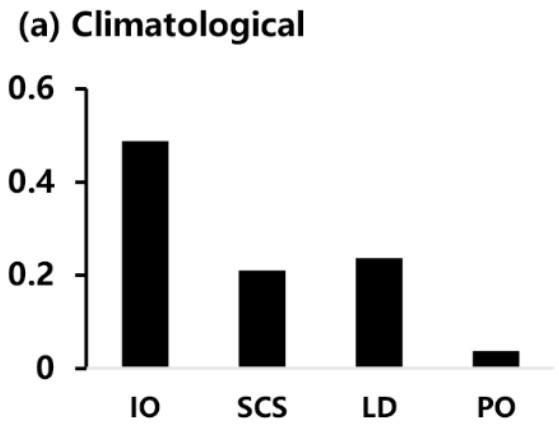
Particle frequency



Accumulate moisture carried by particles



Moisture contribution by differences source regions

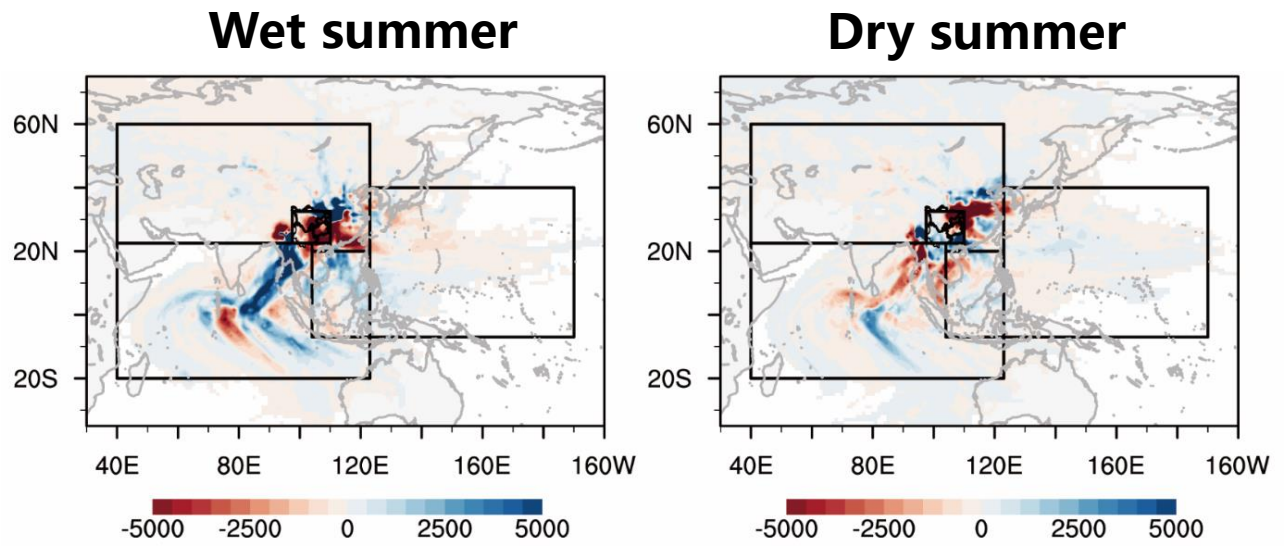


IO : Indian Ocean SCS: South China Sea
LD: Land region PO: Pacific Ocean

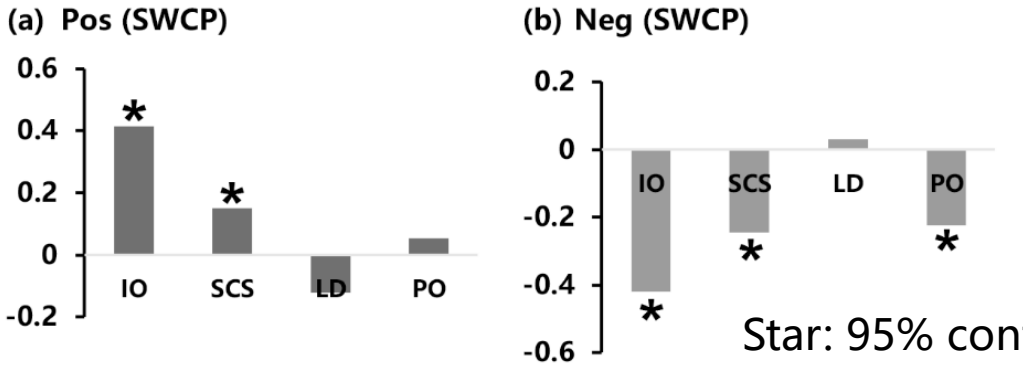
- **The Indian Ocean is the main source of moisture.**
- **IO/SCS/LD/PO contributed 48.8%/22.1%/23.6%/3.7% of precipitation.**

Anomalies in moisture contribution

Moisture anomaly



Moisture contribution anomaly

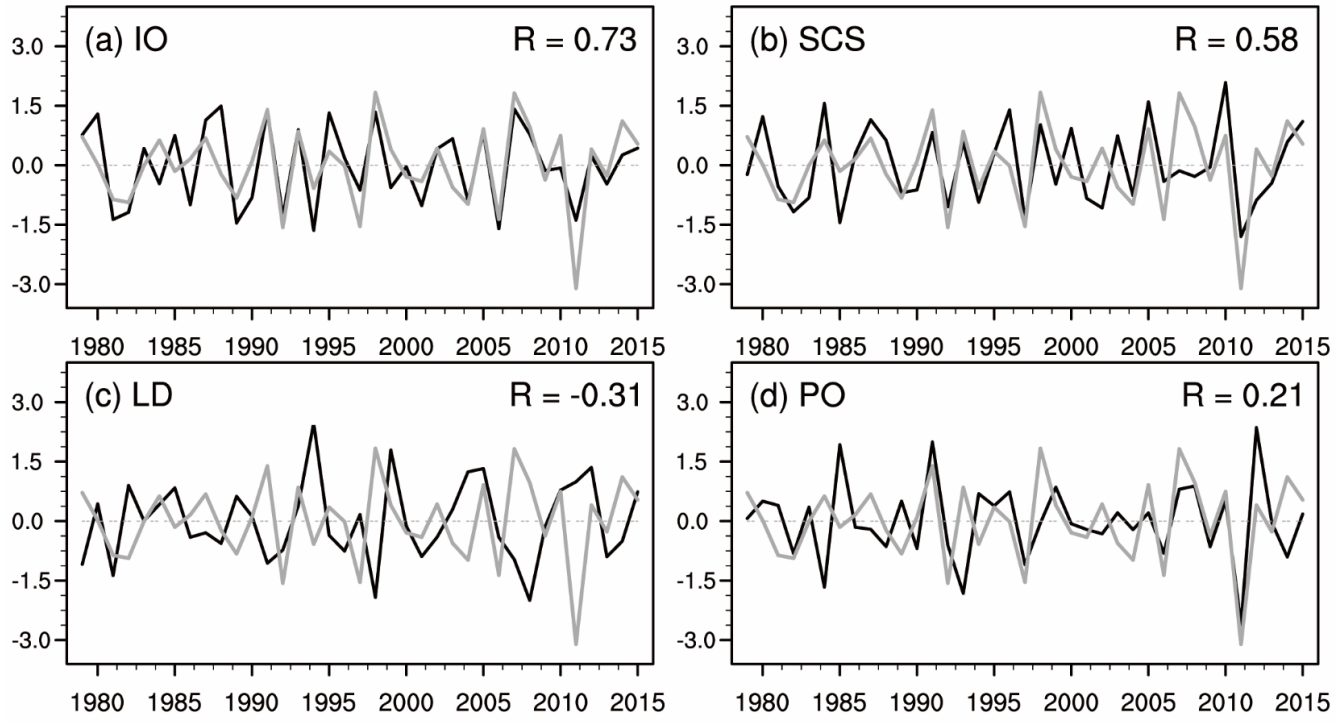


Star: 95% confidence

- In summers with the above-normal precipitation, moisture release from the IO/SCS increases significantly by 41.4%/15.1%
- In summers with the below-normal precipitation, moisture release from IO/SCS/PO decrease significantly by 44.0%/24.6%/22.3%

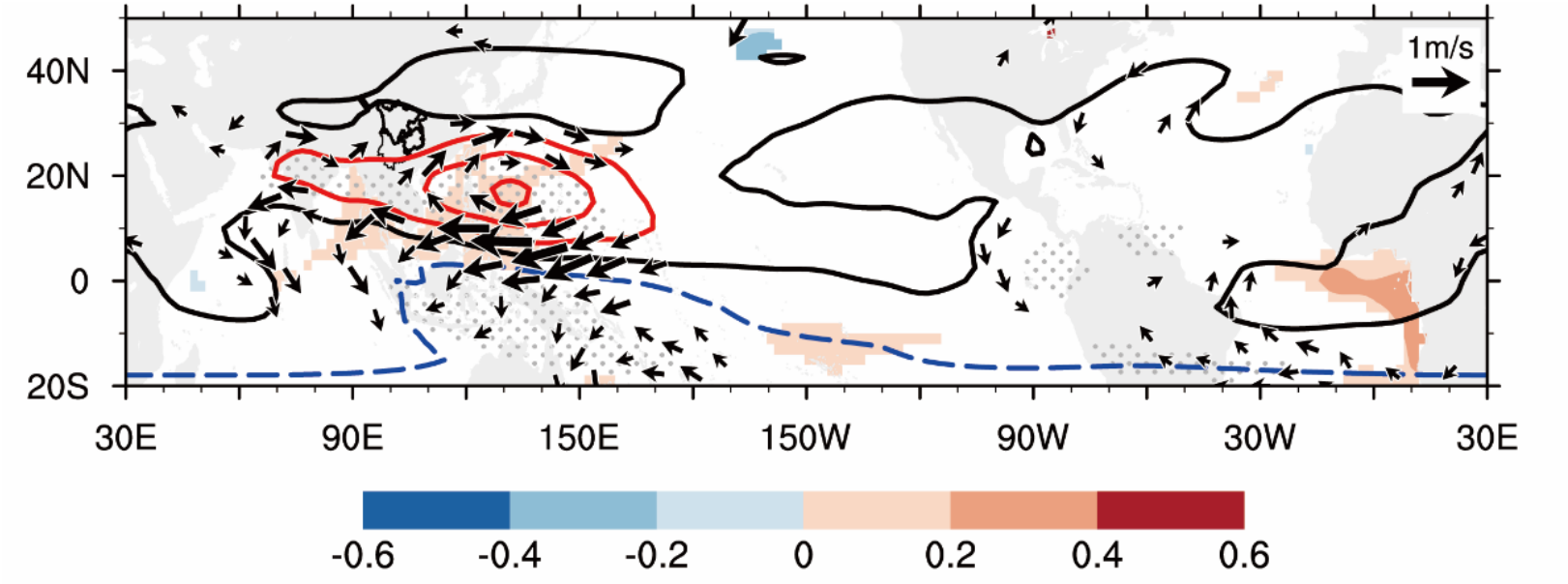
The long-term series of contribution from each moisture source

The long-term series of contribution from each moisture source and its correlation coefficient with SWCP



- The moisture anomalies from the four source regions together explain 86.5% of the total interannual variances of SWC summer precipitation.
- The IO and SCS only can explain 75.7%
- The anomalous moisture contribution from IO and SCS is the main reason

Wind and streamfunction@850hPa and SST anomalies regressed on summer SWCP



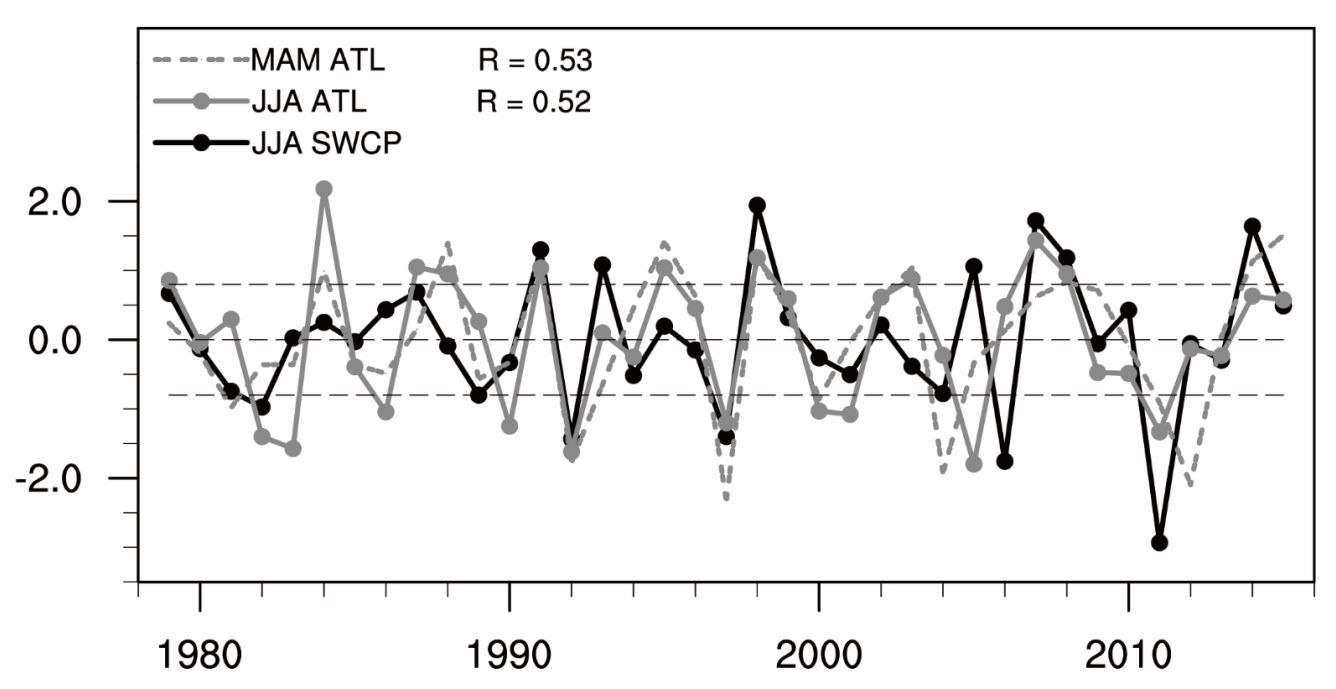
Stipple: 95% confidence
Shading: 95% confidence

- More moisture from both the IO and SCS is transported to SWC by anomalous southwesterlies over the northwestern quadrant of the anomalous anticyclone.
- Tropical Atlantic warming may cause the anomalous anticyclone.

Tropical Atlantic SST Index

$$ATL = \mathrm{C}(5^{\circ}\mathrm{S} - 5^{\circ}\mathrm{N}, 10\mathrm{W}^{\circ} - 15^{\circ}\mathrm{E})$$

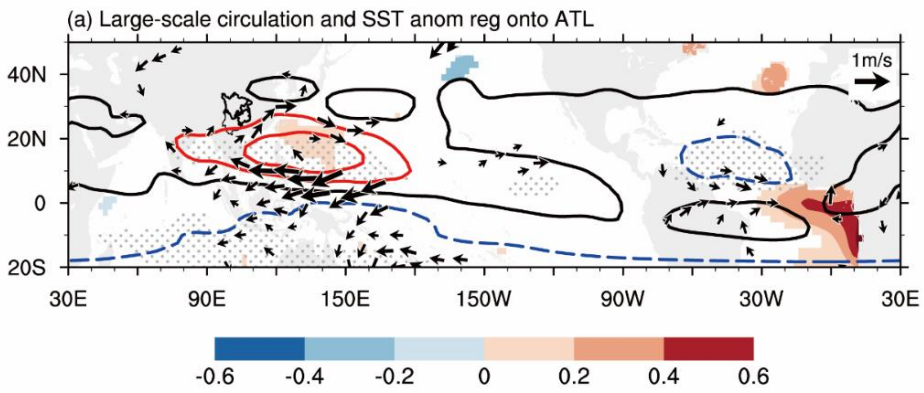
Normalized time series of (MAM/JJA) ATL and CC with (JJA) SWCP



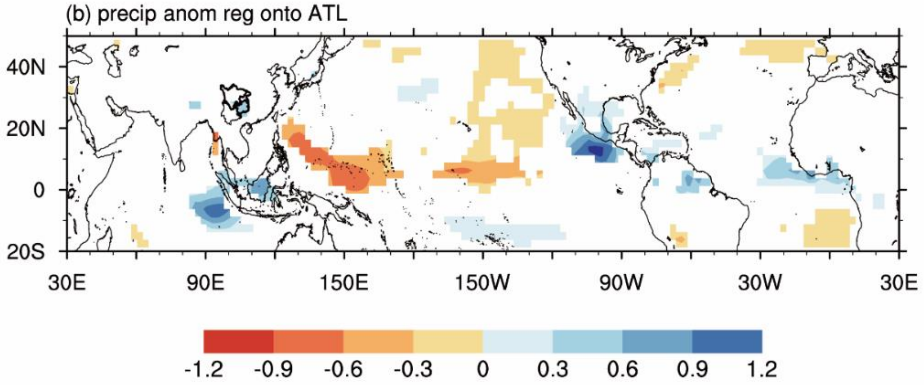
The Tropical Atlantic SST is an indicator of SWCP and has strong statistical relationship

Anomalies regressed on ATL

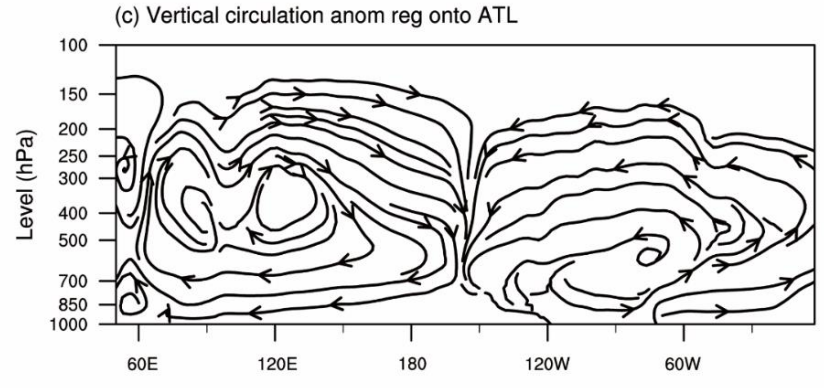
850hPa



Precipitation

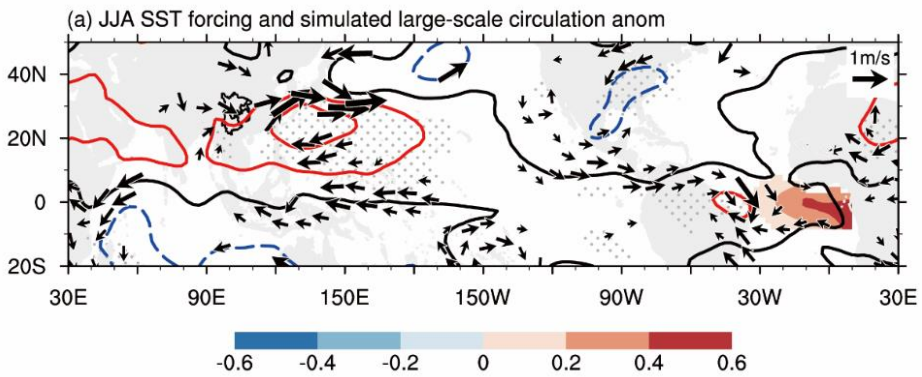


Zonal-Vertical circulation

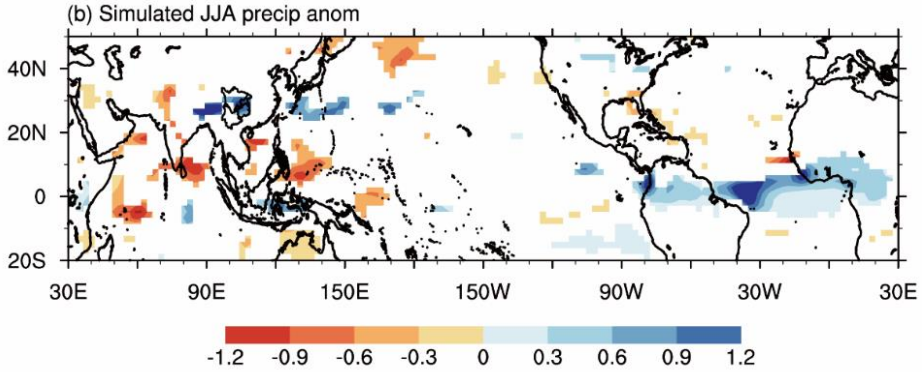


AGCM experiment (CAM5.3)

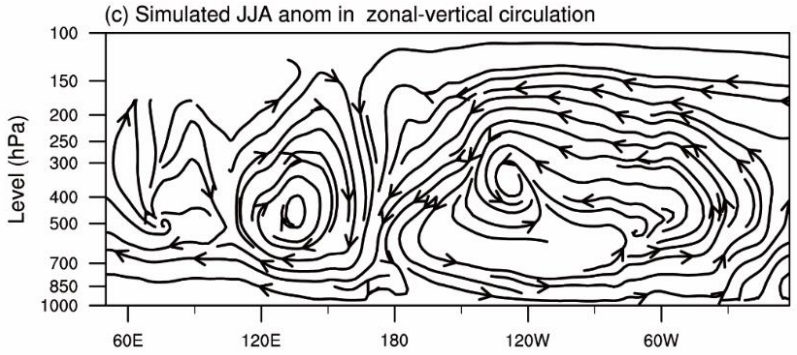
ATL SST forcing & Anomalies response @850hPa



Anomalies response in Precipitation

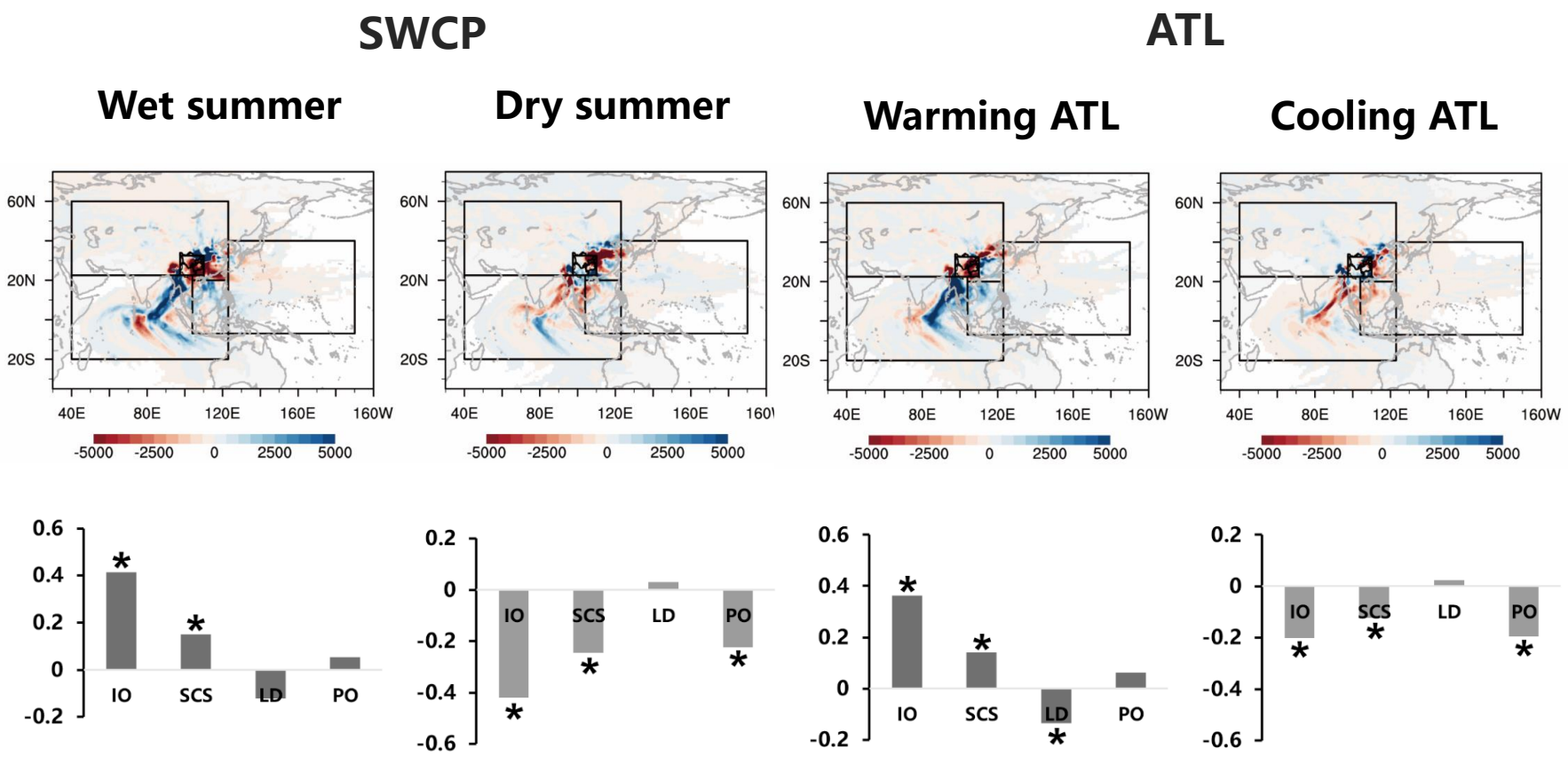


Anomalies response in Zonal-Vertical circulation



- 25 Ensemble member
- Significant at the 95% confidence level

The effect of tropical Atlantic



- In tropical Atlantic warming/cooling summer, moisture contribution from four source regions is similar to that from SWCP wet/dry summer.
- Warm tropical Atlantic has strong connection with anomalous anticyclone in the western North Pacific and thus influence moisture transport.

Summary

- The main moisture sources of SWCP are IO and SCS. The contribution from IO/SCS/LD/PO is 48.8%/22.1%/23.6%/3.7%. In summers with the above-normal precipitation, moisture release from the IO/SCS increases significantly by 41.4%/15.1%. In summers with the below-normal precipitation, moisture release from the IO/SCS decreases significantly by 44.2%/24.6%.
- The anomalous moisture transport is mainly caused by the anomalous anticyclone in the western North Pacific, which enhances the moisture transport from the IO and SCS by the anomalous southwesterlies over its northwestern quadrant but reduces that from the LD east of SWC by the anomalous westerlies along its northern frame.
- Anomalous warming in the tropical Atlantic can modify the Walker circulation, induce anomalous descending motion over the central tropical Pacific and excite the anomalous anticyclone in the western North Pacific as the classic Matsuno-Gill response. The observed impacts of the tropical Atlantic warming on the anomalous anticyclone and summer precipitation in SWC can be well reproduced in an atmospheric general circulation model.

Thanks

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