Source apportionment of atmospheric water over East Asia – a source tracer study in CAM5.1

Chen Pan, Bin Zhu, Jinhui Gao, Hanqing Kang

Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disaster, Nanjing University of Information Science and Technology, Nanjing, China, 210044

1. Introduction

In summer, the Asian summer monsoon (ASM) brings large amounts of water vapour to the East Asian (EA) continent, leading to a wet season and abundant precipitation. However, the water vapour transport mechanisms for precipitation over EA during the ASM are still unquantified. In this study, the Eulerian atmospheric water tracer (AWT) method is incorporated into the CAM5.1 model to identify the dominant moisture source regions to precipitation and water vapour over EA.

2. Model and method

2.1 CAM5.1 Model setup:

- The finite volume dynamical core
- Driven by MERRA meteorological fields
- Horizontal resolution 1.9° (latitude) ×2.5° (longitude)
- Chemistry mechanism: MOZART-4
- Run time: 1997 – 2007, the first year is taken as spin-up.

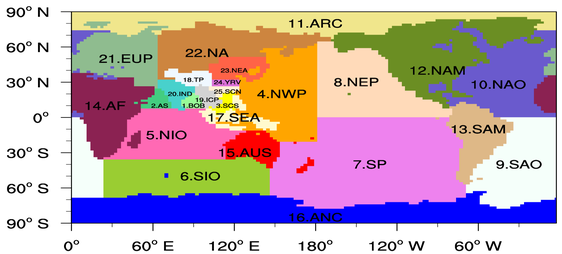

Fig. 1 Definition of moisture source regions.

2.2 AWT method:

a) The global surface is divided into 25 source regions as shown in Fig. 1. Within source region k, the surface flux of the tagged water vapour tracer E^k is equal to the surface evaporation flux of water vapour E; otherwise $E^k = 0$.

b) The tagged atmospheric water tracers experience same physical processes (deep convection, shallow convection, cloud macrophysics, cloud microphysics, advection, and vertical diffusion) as original water in CAM5.1.

c) From the simulation results, the contribution to the contents of atmospheric water substances over arbitrary spatial grid-point from one source region can be quantified.

3. Model assessment

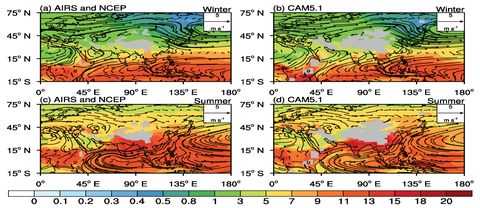

Fig. 2 Water vapour content from AIRS and horizontal wind fields from NCEP vs. CAM5.1 results.

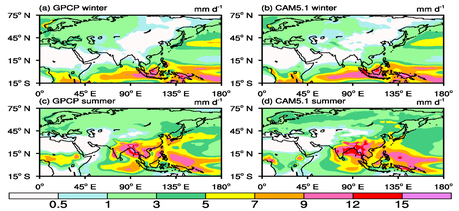

Fig. 3 Comparison between GPCP data and CAM5.1 precipitation.

☆ CAM5.1 has the capability to represent water vapour, precipitation, and large-scale circulation.

4. Results and discussion

4.1 Contributions over the Yangtze River Valley (YRV)

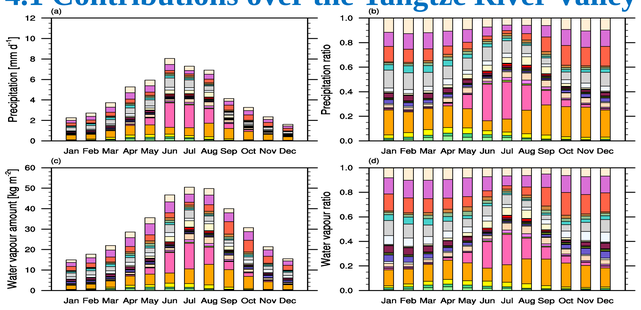

Fig. 4 (a) Precipitation contribution, (b) precipitation percentage contribution, (c) water vapour contribution, and (d) water vapour percentage contribution over the Yangtze River Valley from 25 source regions.

☆ The northern Indian Ocean is the dominant source for precipitation over the YRV in June and July, with a percentage contribution of ~30 %.

☆ The northwest Pacific serves as the dominant oceanic source region in other months, which supplies 15.8–24.6 % of precipitation.

The Indo-China Peninsula is an important terrestrial source region in the whole year (~10 %).

4.2 Contributions over South China (SCN)

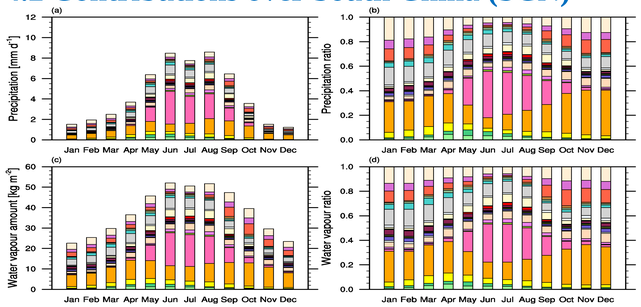

Fig. 5 (a) Precipitation contribution, (b) precipitation percentage contribution, (c) water vapour contribution, and (d) water vapour percentage contribution over South China from 25 source regions.

☆ Similar to the situation over the YRV, the northern Indian Ocean is the dominant source region in boreal summer (28.4–37.8 %), while the northwest Pacific dominates precipitation over SCN during other seasons (15.3–37.2 %).

The overall relative contribution from each source region to the water vapour amount is similar to the corresponding contribution to precipitation over the YRV and SCN.

4.3 Contributions over South China Sea (SCS)

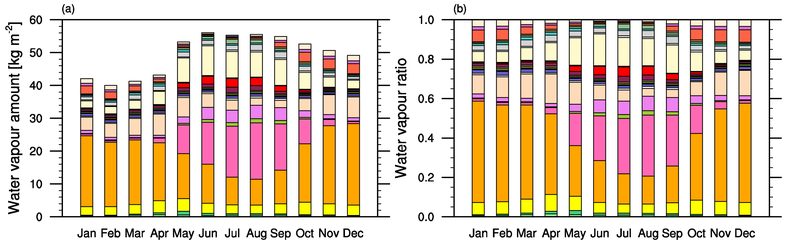

Fig. 6 (a) Water vapour contribution, and (b) water vapour percentage contribution over the South China Sea from 25 source regions.

The local contribution of the SCS is small (~4.7–5.5 %) in summer, and the mean contribution in other months is ~6.8 %.

Similar to the results for water vapour over the YRV and SCN, the northern Indian Ocean is the dominant source region from June to September, with a contribution of 22.7–31 %. The northwest Pacific dominates the water vapour over the SCS in the remaining months, with contributions of 25.7–51.3 %.

From the SCS to SCN and further to the YRV (from south to north), the SCS generally represents a small (≤ 5.5 %) contribution to the water vapour amount over the three target areas in summer. In contrast, much more water vapour is supplied by evaporation from the northwest Pacific and northern Indian Ocean.

☆ **This indicates that the SCS is a water vapour transport pathway where moisture from the northern Indian Ocean and northwest Pacific meet in summer.**

5. Conclusions

- **The dominant oceanic moisture source region during summer is the northern Indian Ocean (20.5–30.3 % of precipitation over the YRV; 28.4–37.8 % of precipitation over SCN), whereas during other seasons, the northwest Pacific is the dominant source region (15.8–24.6 % of precipitation over the YRV; 15.3–37.1 % of precipitation over SCN).**
- **The overall relative contribution from each source region to the water vapour amount is similar to the corresponding contribution to precipitation over the YRV and SCN.**
- **Evaporation over the SCS represents a small contribution to water vapour amounts over the SCS, SCN, and the YRV in summer, implying that the SCS acts as a water vapour transport pathway rather than a dominant source region.**