Role of snow depth in the influence of El Niño on summer climate anomalies over East Asia

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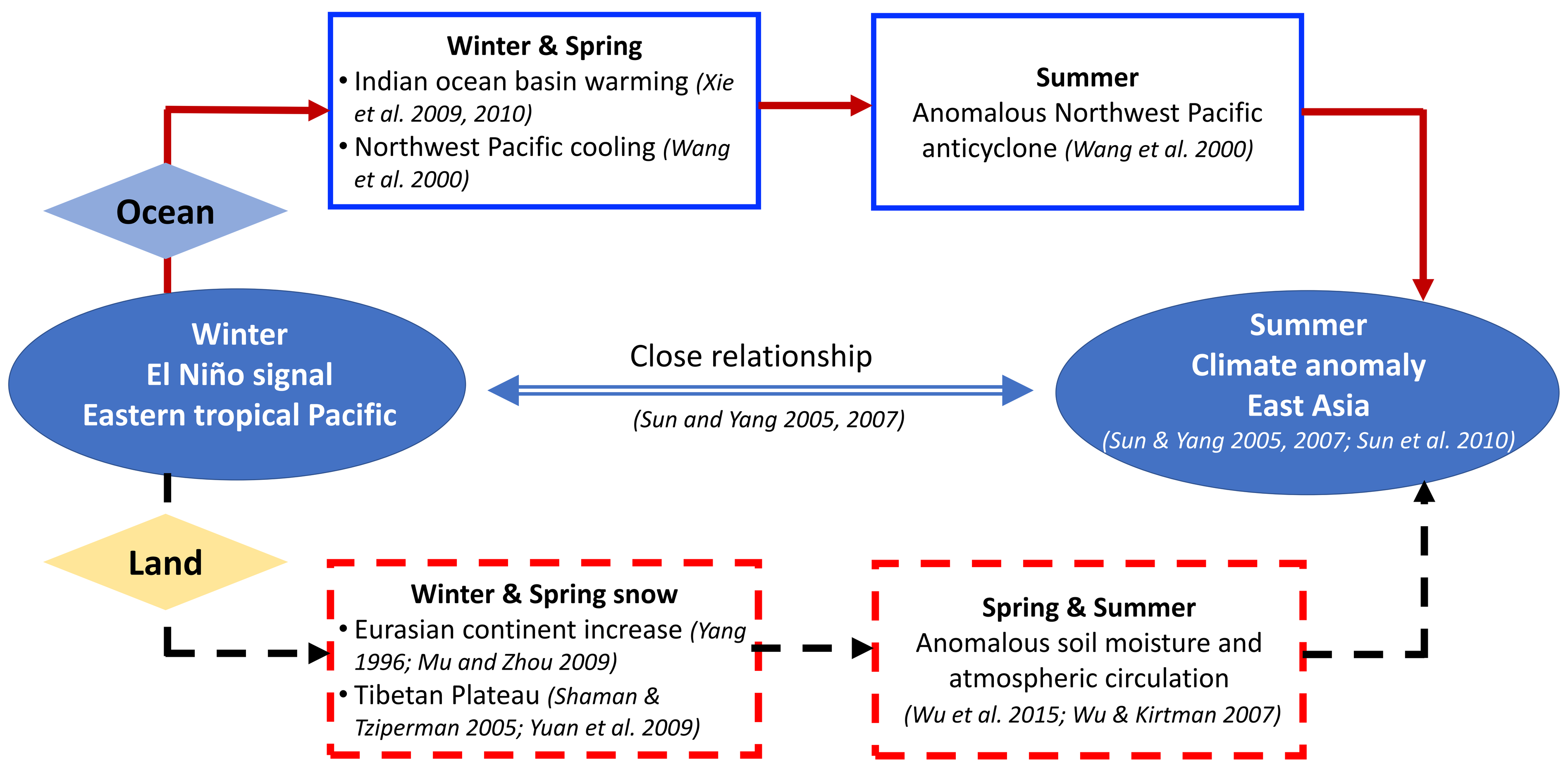
1. Motivation



Questions:

- What are the key regions of snow depth anomalies in response to the winter El Niño forcing?
- How do the El Niño-related winter snow depth anomalies in key regions influence the East Asian summer climate anomalies?

2. Data and Method

SST dataset: NOAA ERSSTv3 2°×2° 1948-2010

Definition of an El Niño event:

niño3 index is greater than or equal to 0.5 °C for any five months during the period from September to the next May

List of 18 El Niño events:

1951-1952, 1953-1954, 1957-1958, 1963-1964, 1965-1966, 1968-1969, 1969-1970, 1972-1973, 1976-1977, 1982-1983, 1986-1987, 1987-1988, 1991-1992, 1997-1998, 2002-2003, 2004-2005, 2006-2007, 2009-2010

Land dataset: GLDAS_NOAH025 0.25°×0.25° 1948-2010

GLADS (Global Land Data Assimilation System) data is a product of data assimilation of satellite data, land surface model and ground observational data *(Zhu and Shi, 2014)*, including 4 soil layers: 0-10 cm, 10-40 cm, 40 cm-1m and 1m-2m.

Variables: soil moisture, soil temperature, snow depth, snow melting, sensible heat flux, latent heat flux

Precipitation dataset: GPCCv7 0.5°×0.5° 1948-2010

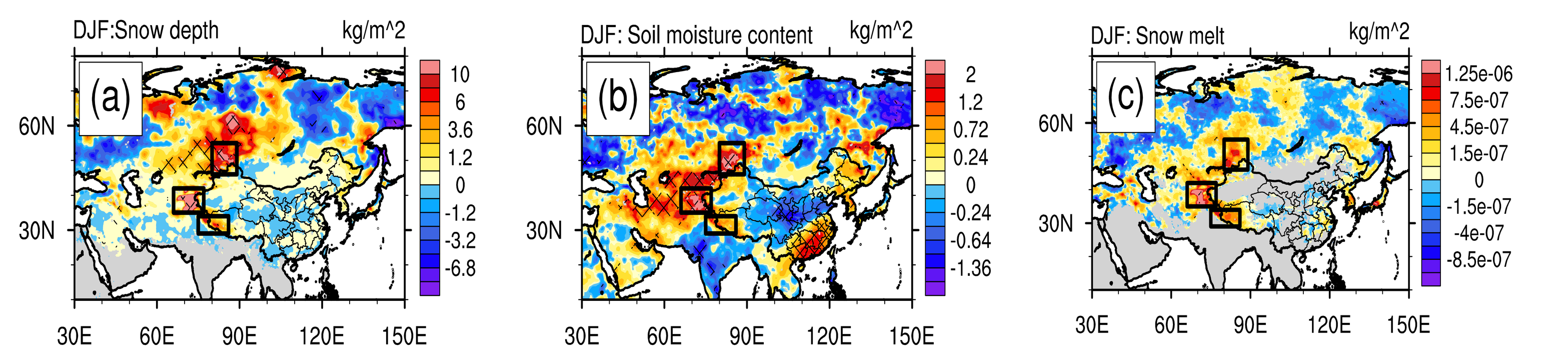
Atmosphere Reanalysis dataset: NCEP/NCAR reanalysis 2.5°×2.5° 1948-2010

Methodology:

band-pass filtering at interannual time scale (13-month to 8-year)

Composite, linear regression/correlation

3. Results

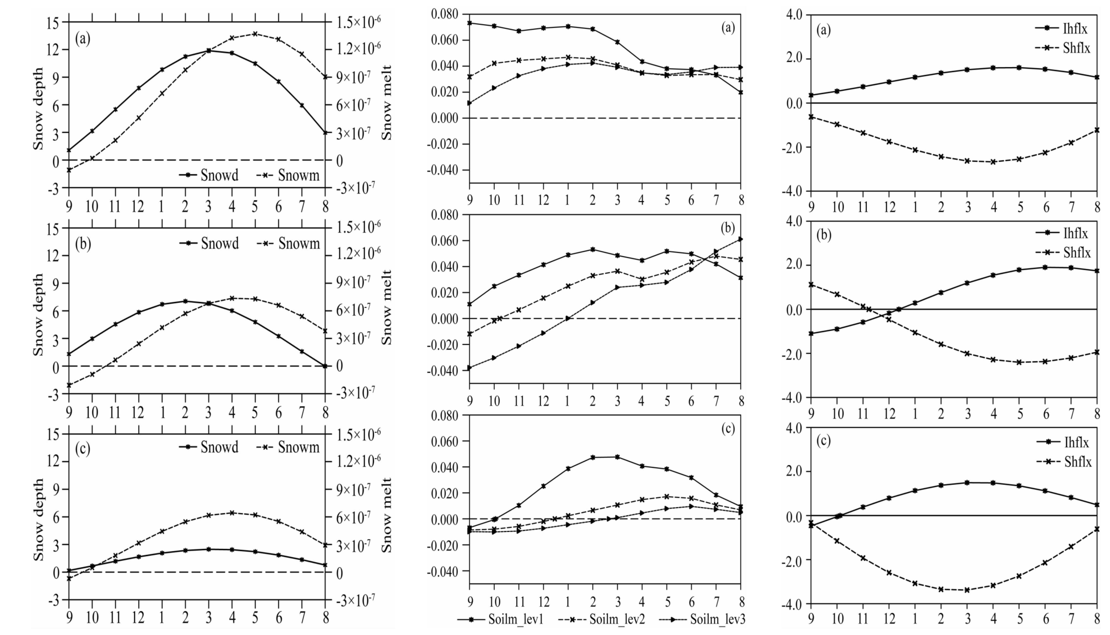


snow depth   snow melting   subsurface soil moisture (0-10 cm)

Fig.1: Composites anomalies in El Niño mature winter (DJF) based on the 18 El Niño events. The crossed areas indicate significant correlation at 0.1 significance level. Black boxes indicate the three key regions, i.e.**, Iranian Plateau**, **northeast of Lake Balkhash** and **southern Tibetan Plateau.**

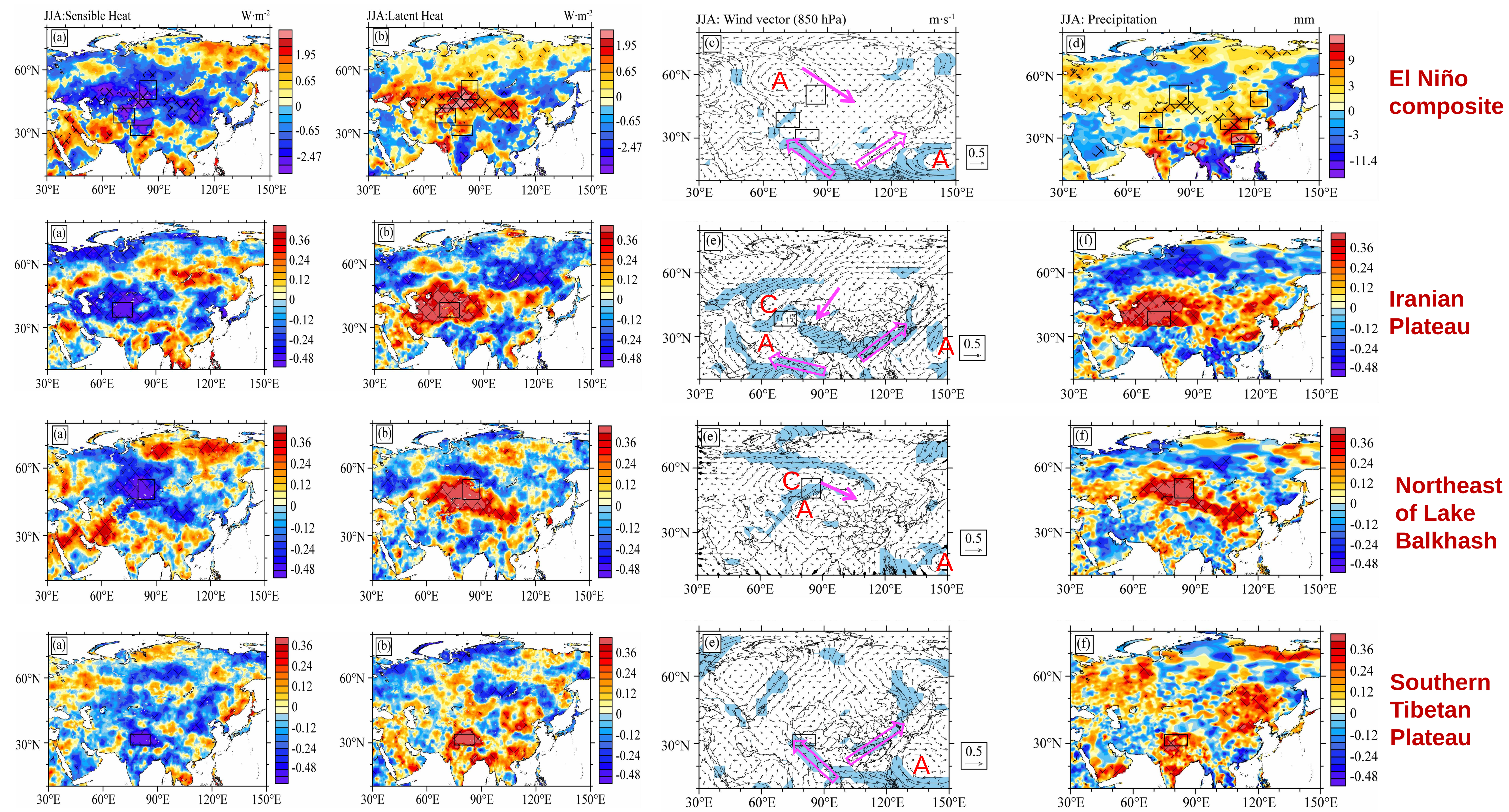
Three key regions of snow depth anomalies in El Nino mature winter (DJF)

Key regions	Correlation with niño3	Cases in El Niño events
Iranian Plateau	0.42	9/18 (50%)
Northeast of Lake Balkhash	0.38	7/18 (39%)
Southern Tibetan Plateau	0.37	5/18 (28%)



snow depth & snow melting   Soil moisture   Surface heat flux

Fig.2: Evolutions of composite area-averaged anomalies of snow depth (snowd, unit: kg/m^2), snow melting (snowm, unit: kg/m^2), soil moisture (unit: kg/m^2), sensible heat flux (shflx, unit: Wm^2) and latent heat flux (lhflx, unit: Wm^2) for Iranian plateau (a), northeast of Lake Balkhash (b) and southern Tibetan plateau regions in El Niño life time.



sensible heat flux   latent heat flux   850 hPa wind   precipitation

Fig.3: El Niño composite and regressed anomalies of summer atmospheric variables on the standardized time series of simultaneous area-averaged second-layer soil moisture anomalies in the three key regions.

4. Summary

- Three key regions, i.e., Iranian Plateau, northeast of Lake Balkhash and southern Tibetan Plateau, of snow depth anomalies are identified associated with El Niño events.
- Major processes: El Niño → increased snow depth (DJF) → increased soil moisture due to snow melting (DJF-to-JJA) → increased local precipitation due to positive feedback between soil moisture and rainfall *(Pal and Eltahir 2003)* → atmospheric circulation and precipitation anomalies over East Asia due to the key-region rainfall-induced diabatic heating forcing.

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