
Holocene forest decline and its climatic feedback

Hongyan Liu, Yi Yin, Guo Liu

College of Urban and Environmental Sciences,
Peking University, Beijing, 100871, China

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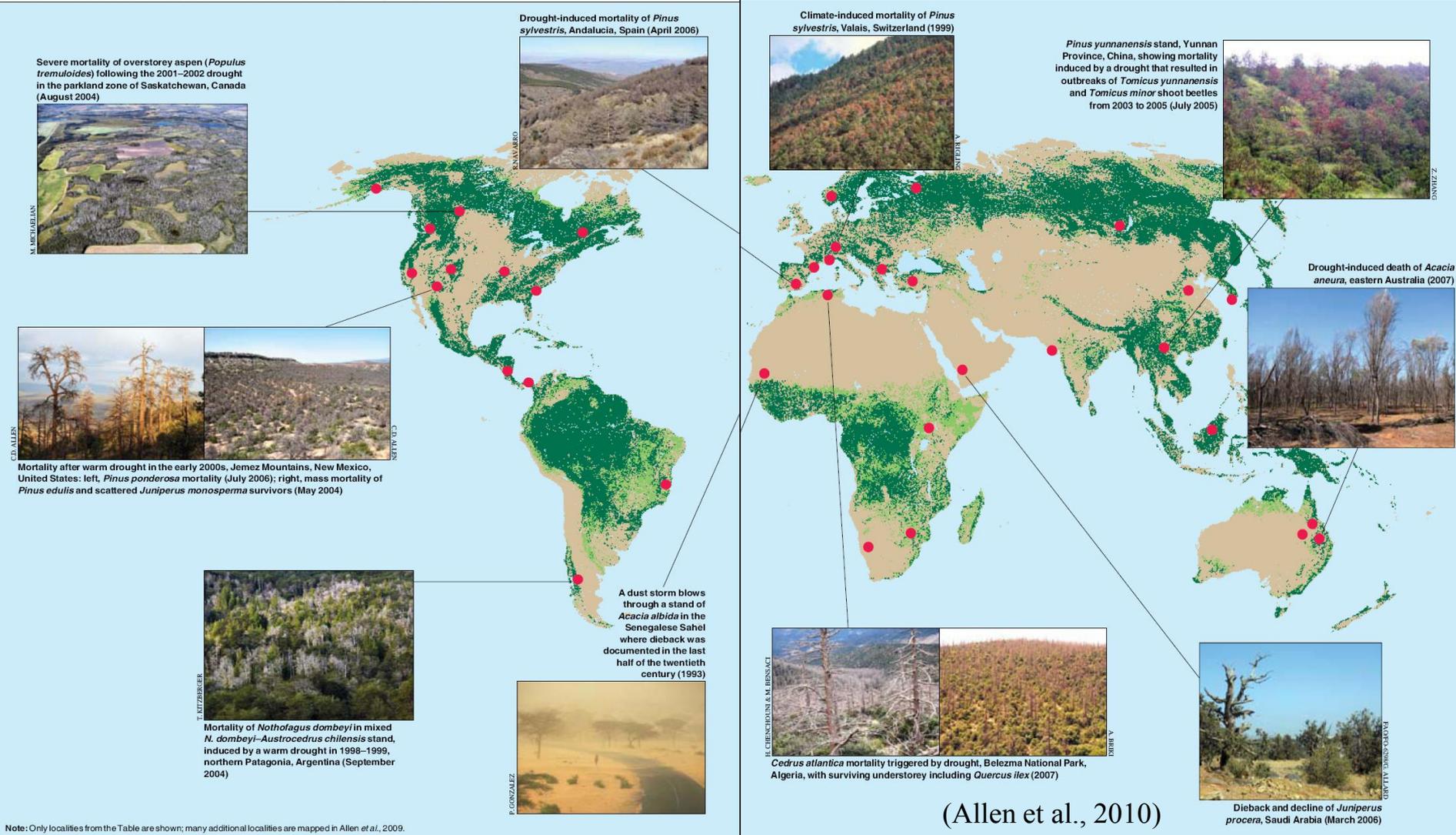
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Observed forest mortality over the world

➤ Mostly in the semi-arid forest boundary

Localities with increased forest mortality related to climatic stress from drought and high temperatures



(Allen et al., 2010)

Observed climatic feedback of deforestation

- Deforestation and its climatic effect is becoming a new hotspot

Contribution of Semi-Arid Forests to the Climate System **Science**

Eyal Rotenberg and Dan Yakir*

are required to balance the twofold $S + L$ effect. Desertification over the past several decades, however, contributed negative forcing at Earth's surface equivalent to ~20% of the global anthropogenic CO_2 effect over the same period, moderating warming trends.

LETTER

doi: 10.1038/nature10588

Observed increase in local cooling effect of deforestation at higher latitudes

Xuhui Lee¹, Michael L. Goulden², David V. Hollinger³, Alan Barr⁴, T. Andrew Black⁵, GIL Bohrer⁶, Rosvel Bracho⁷, Bert Drake⁸, Allen Goldstein⁹, Lianhong Gu¹⁰, Gabriel Katul¹¹, Thomas Kolb¹², Beverly E. Law¹³, Hank Margolis¹⁴, Tilden Meyers¹⁵, Russell Monson¹⁶, William Munger¹⁷, Ram Oren¹¹, Kyaw Tha Paw U¹⁸, Andrew D. Richardson¹⁹, Hans Peter Schmid²⁰, Ralf Staebler²¹, Steven Wofsy¹⁷ & Lei Zhao¹

Scientific questions

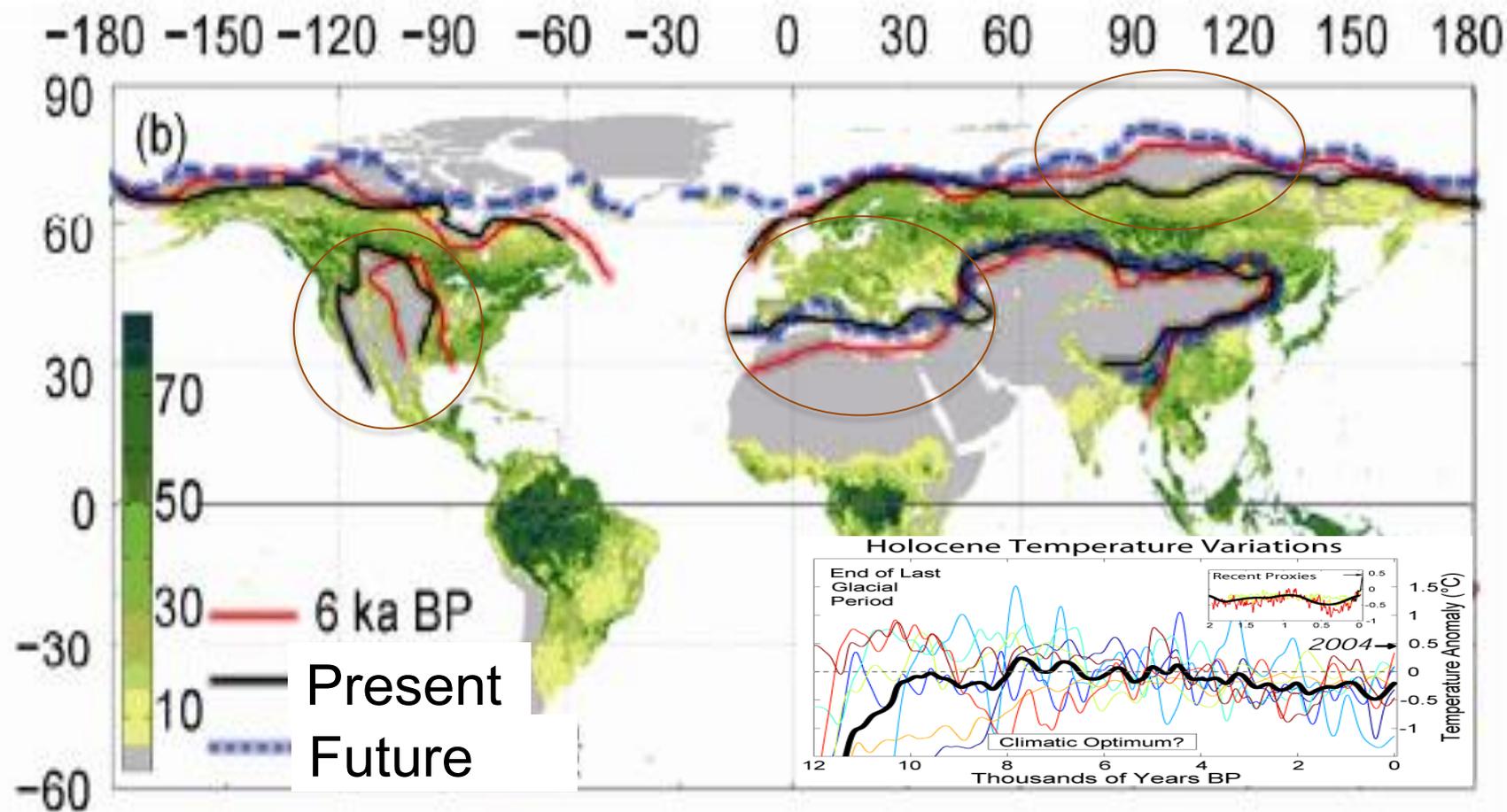
- As a centennial ecosystem process due to a long life-span of trees, natural forest decline, however, is inappropriate to link to climatic processes on annual and decadal scales
- Can we find evidence of forest decline at centennial and millennial time scale and how to link forest decline to climatic feedback ?

New task challenges palynologist

- Palynological studies has focused on biomilization, e.g. replacement of forests by other biomes.
- How to reconstruct the history of forest decline, including deforestation and savannification?



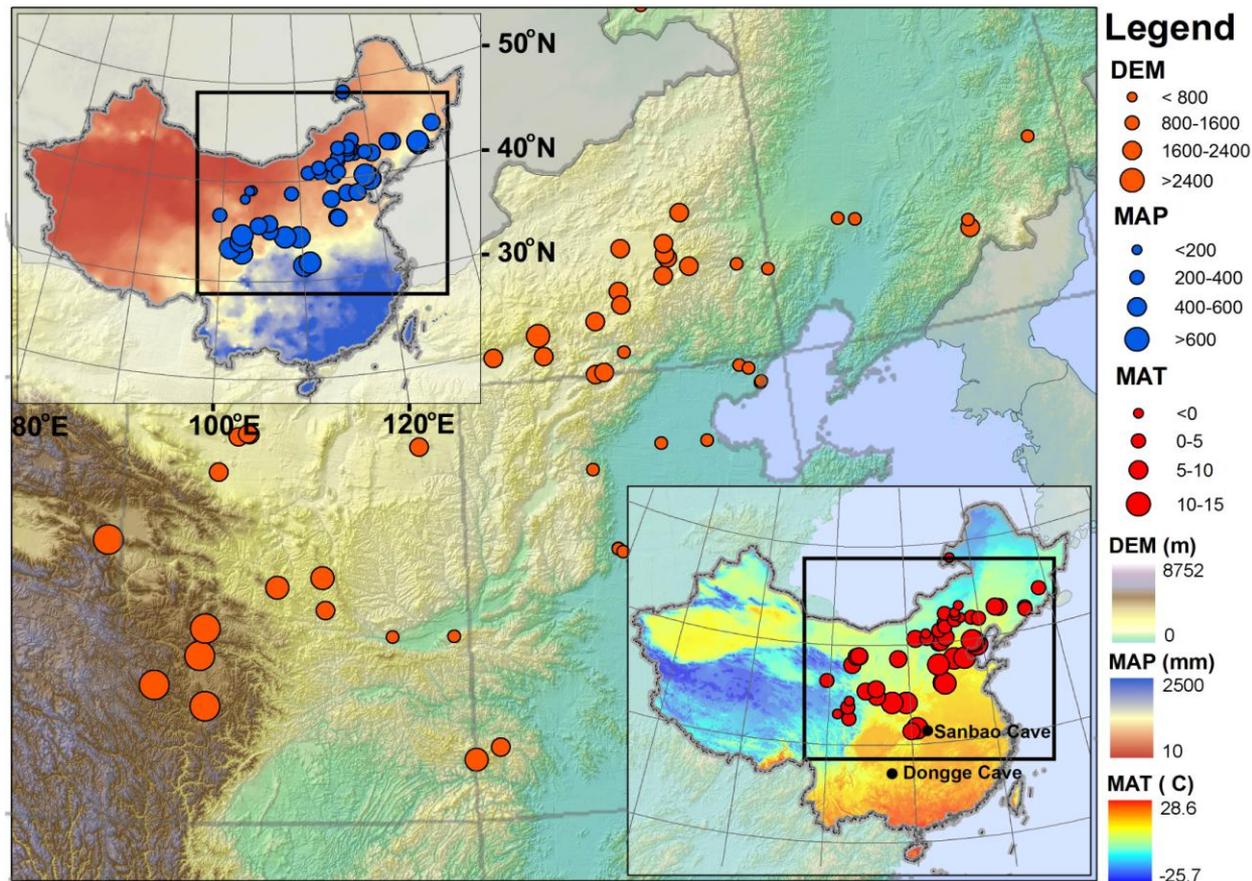
Global forest decline and climate cooling during the last 6000 years



(Liu & Yin, 2013)

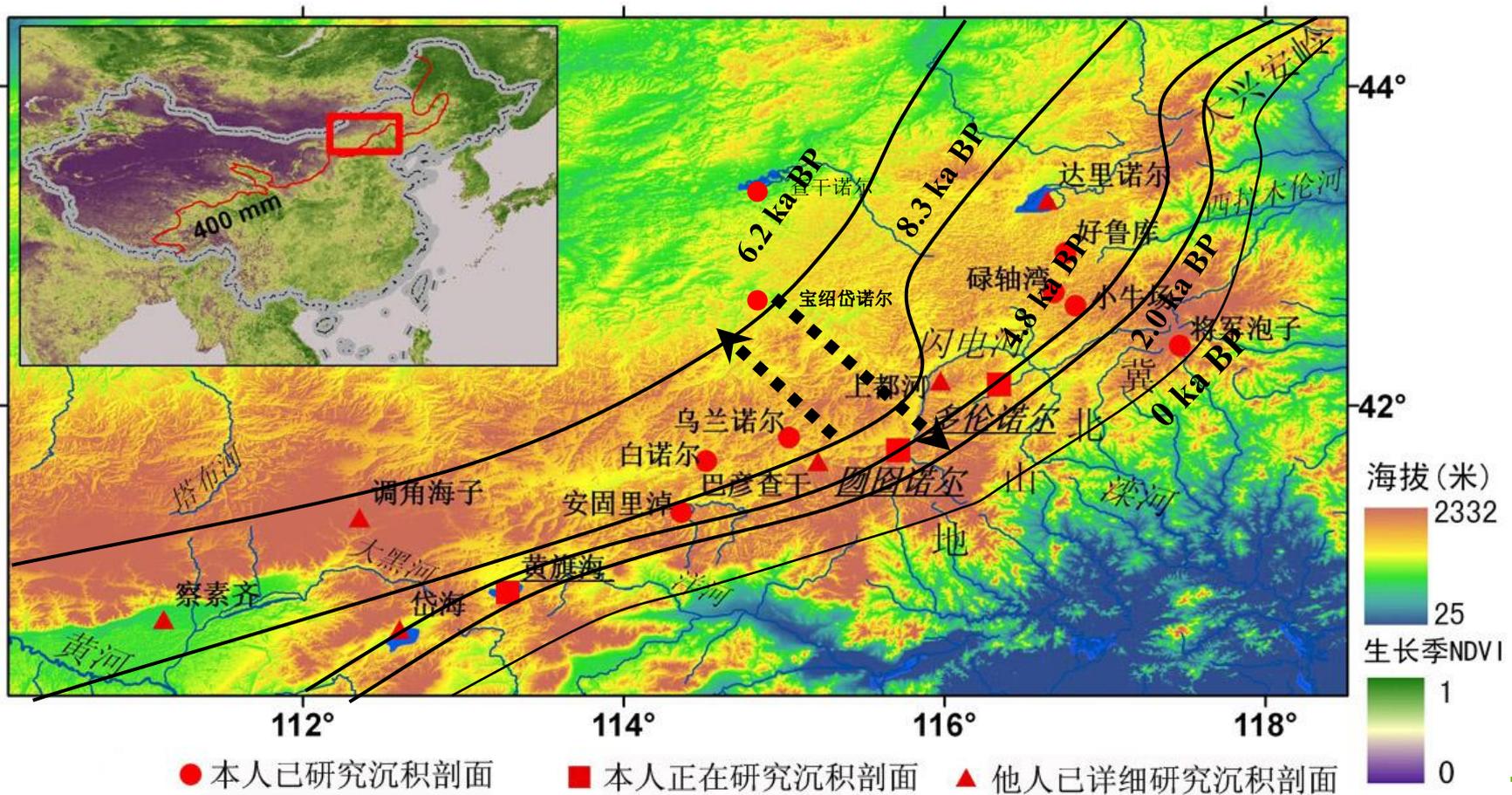
Regional scale reconstruction of forest decline

- The global scale data do not have a time series with high temporal resolution



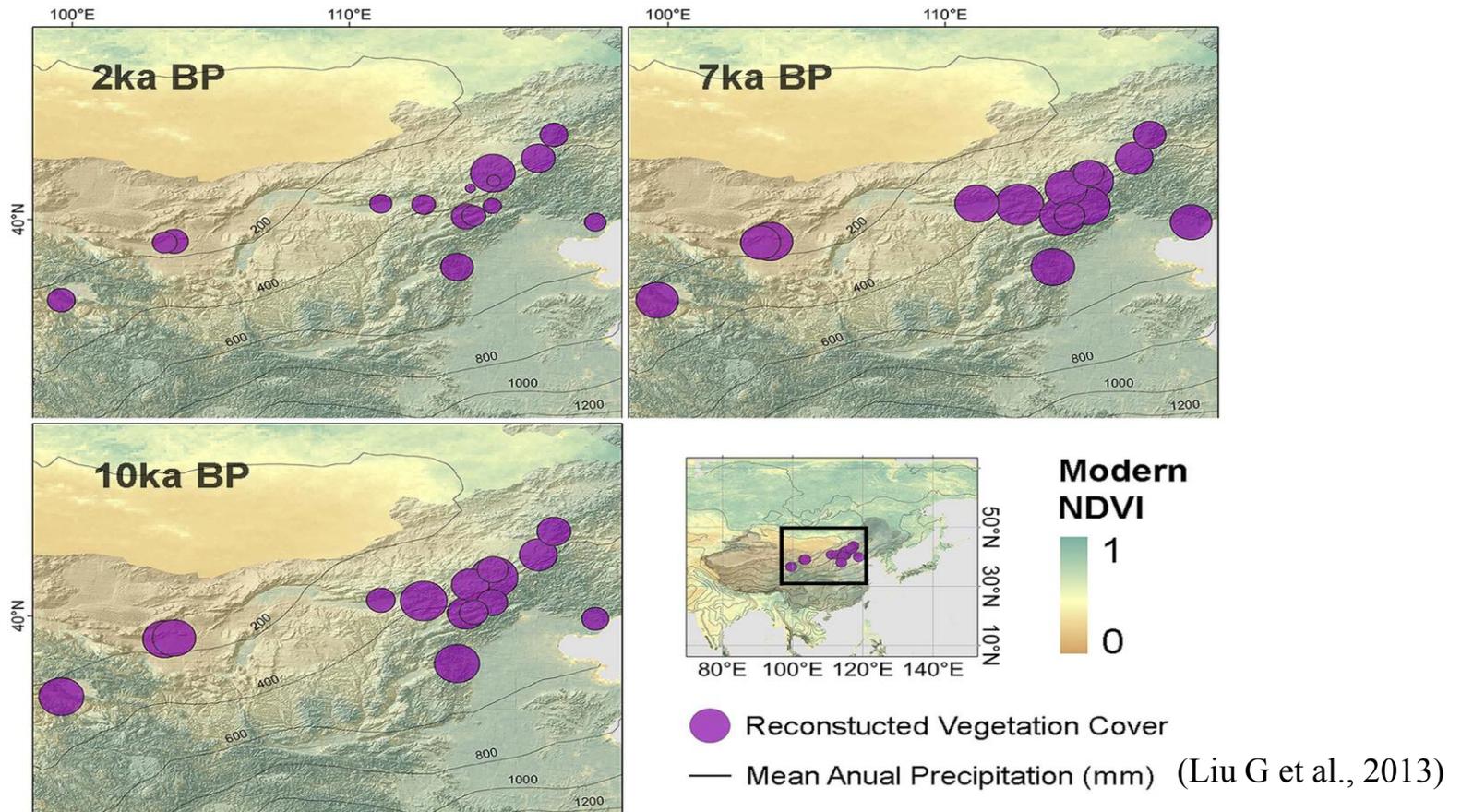
Holocene forest border shifting in N China

- ~200 km retreat of forest border since 6 ka BP in N China



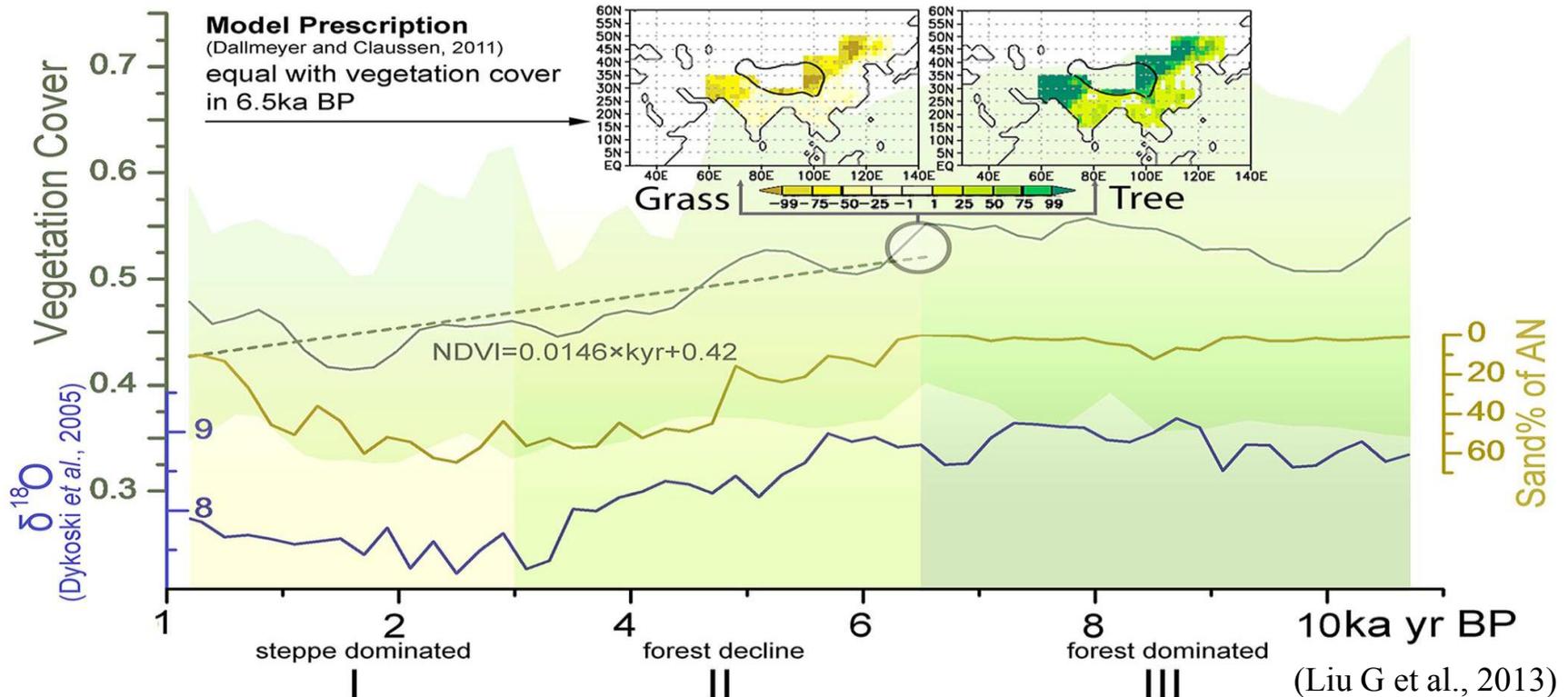
Reconstructed vegetation cover in N China

- 200-year intervals
- Validated by modern NDVI values



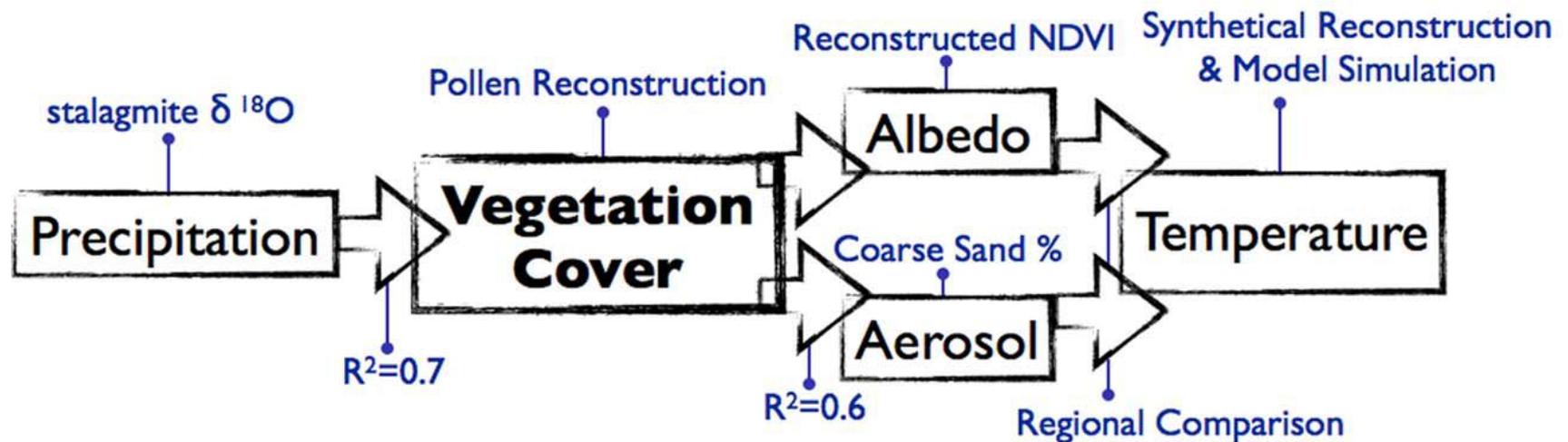
Forest decline and climatic feedback in N China

- Three curves (vegetation cover, sand percentage in sediment, monsoon intensity) well matched
- Our results validated the scenario simulation of deforestation-induced cooling by Dallymeyer et al. (2011)



Suggested climate-vegetation interactions

- Precipitation brought by the monsoon determined changes in vegetation cover (deforestation, savannification, grassland degradation)
- Decline in vegetation cover contributed to climate cooling through: (1) increasing albedo; (2) increasing aerosol caused by windy erosion of soil

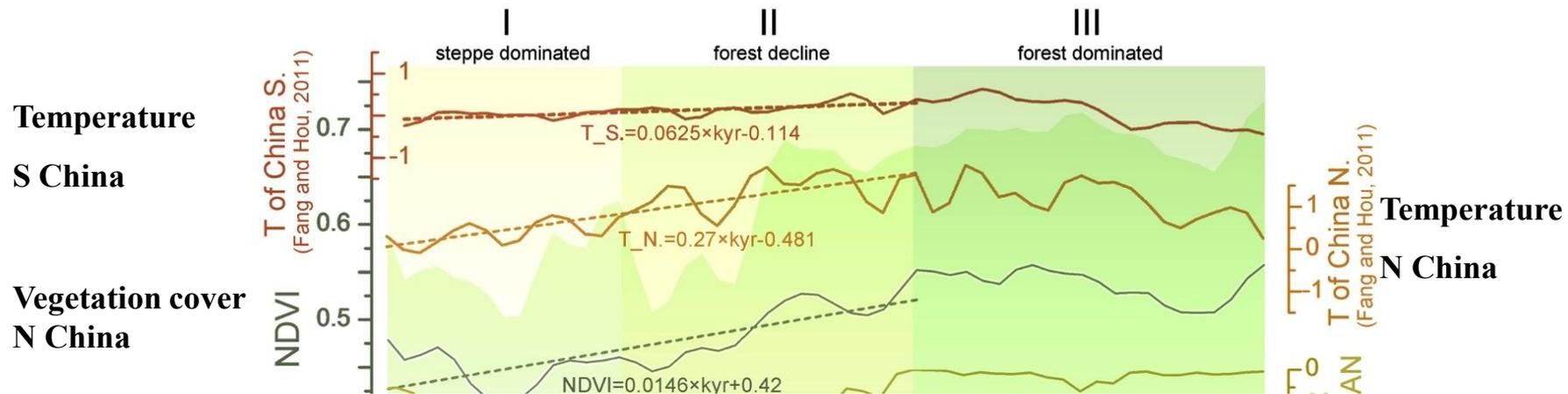


(Liu G et al., 2013)

What to do:

Vegetation-climate interaction in China

- The higher cooling rate in N China than in S China is hypothesized to be caused by the substantial decline of vegetation cover in N China
- Dynamic model simulation is required
- More reliable temperature sequences independent of pollen evidence are required



What to do:

Global forest decline and contribution to cooling

- Build a global database of the Holocene forest cover with a meta-analysis of palynological literatures

Yes, We are working on it

- Reliable regional curves of the Holocene temperature change with corresponding time resolution with pollen data

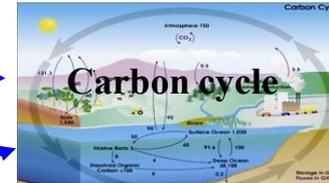
Yes, there are such curves in Europe and North America

- Incorporate soil erosion and aerosol processes into model simulation

I have no idea

Summary

- The estimated forest decline in the semi-arid regions potentially reverse the warming trend
- Our regional scale vegetation reconstruction validated a simulation of the mid-Holocene climatic cooling caused by deforestation in N China, but reliable temperature curve and simulation with dynamic vegetation model are required
- Future work should be focused on reconstructing global vegetation cover dynamics during the Holocene as well as incorporating soil erosion into the current models



Carbon fixation

Vegetation cover

Species composition

Thank you very much for your attention!