



CSIRO



Australian Government
Australian Centre for
International Agricultural Research



Regionalization of water balance model in the Loess Plateau, China

Xiaoping Zhang, Lu Zhang, Tim McVicar, Tom Van Niel,
Lingtao Li, Rui Li, Qinke Yang

October 2006





Estimating the impacts of afforestation on mean annual streamflow





Principal controls on evapotranspiration



Australian Government
Australian Centre for
International Agricultural Research



Dry

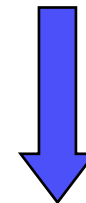
- Rainfall interception
- Plant available water
- Canopy resistance



Available Water

Wet

- Net radiation
- Advection
- Turbulent transport



Atmospheric Demand



Mean annual water balance model



$$\frac{ET}{P} \rightarrow 1 \quad \text{when} \quad \frac{E_o}{P} \rightarrow \infty \quad \text{(very dry conditions)}$$

$$ET \rightarrow E_o \quad \text{when} \quad \frac{E_o}{P} \rightarrow 0 \quad \text{(very wet conditions)}$$

$$\frac{ET}{P} = \Phi\left(\frac{E_o}{P}\right) \quad \text{(Budyko, 1974)}$$





Mean annual water balance model



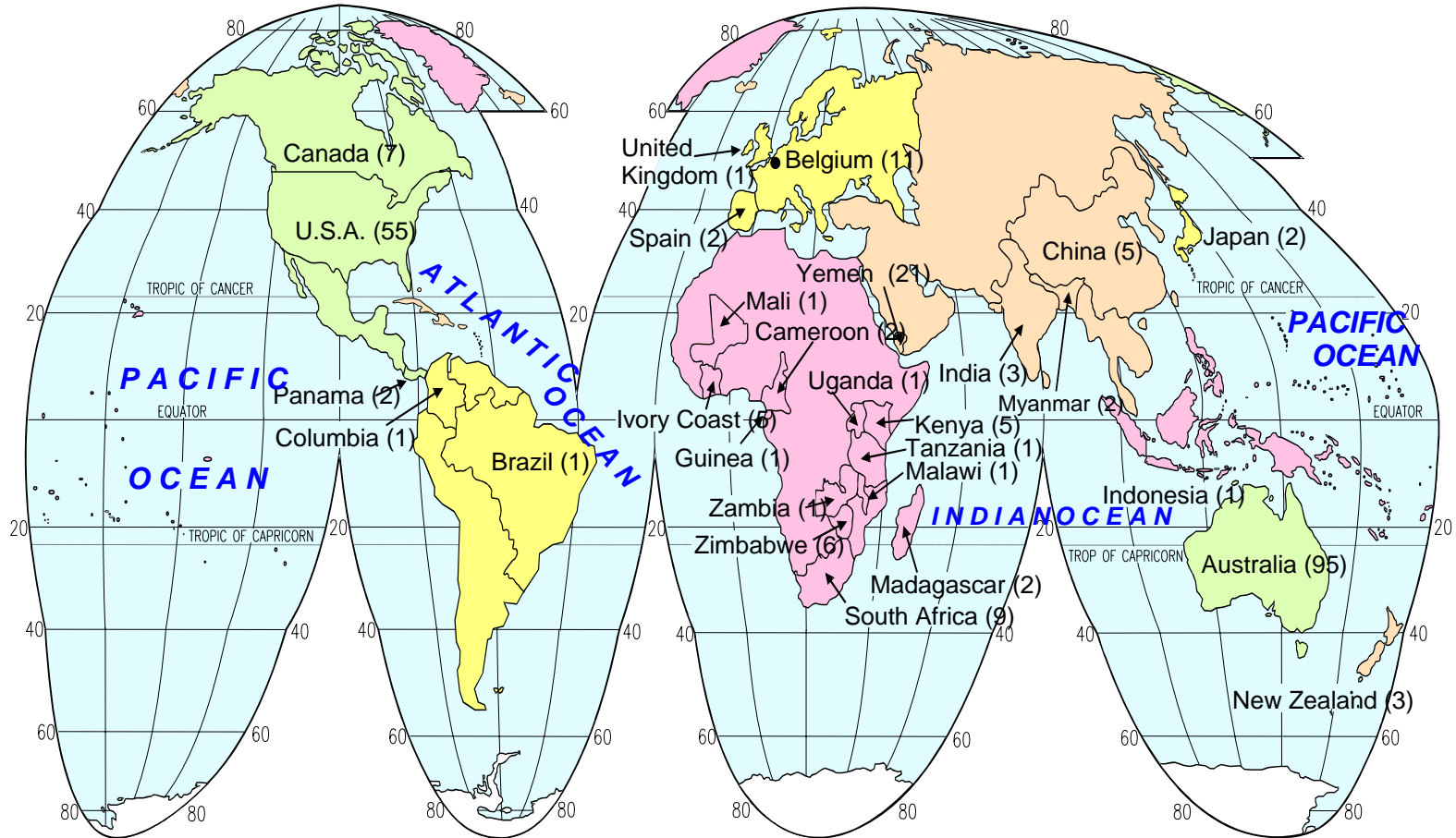
$$\frac{ET}{P} = \frac{1 + w \left(\frac{E_o}{P} \right)}{1 + w \left(\frac{E_o}{P} \right) + \left(\frac{E_o}{P} \right)^{-1}}$$



Zhang *et al.*, 2001, Water Resources Research



Location map of the catchments



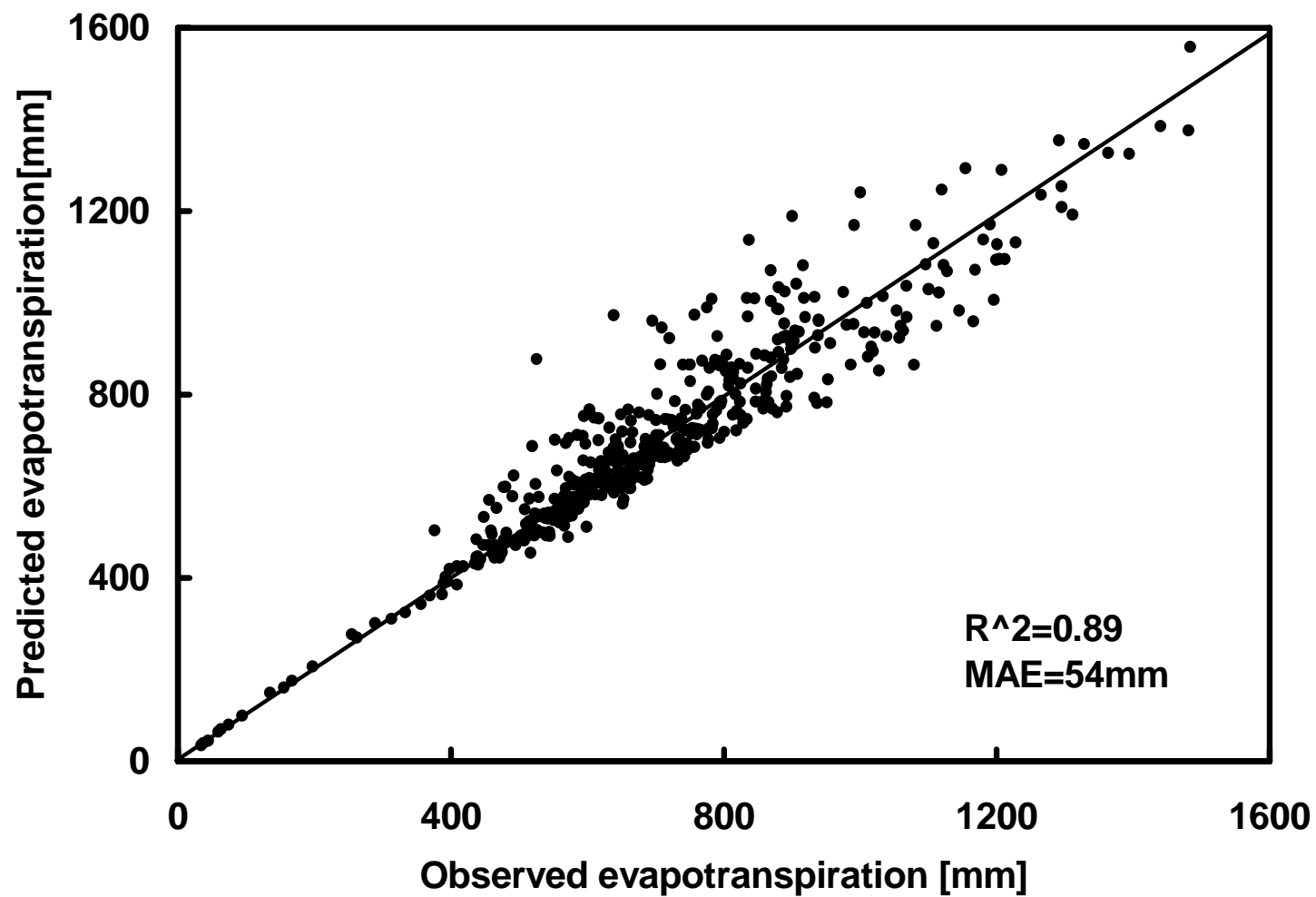
Total: 257 catchments



Comparison against observed data

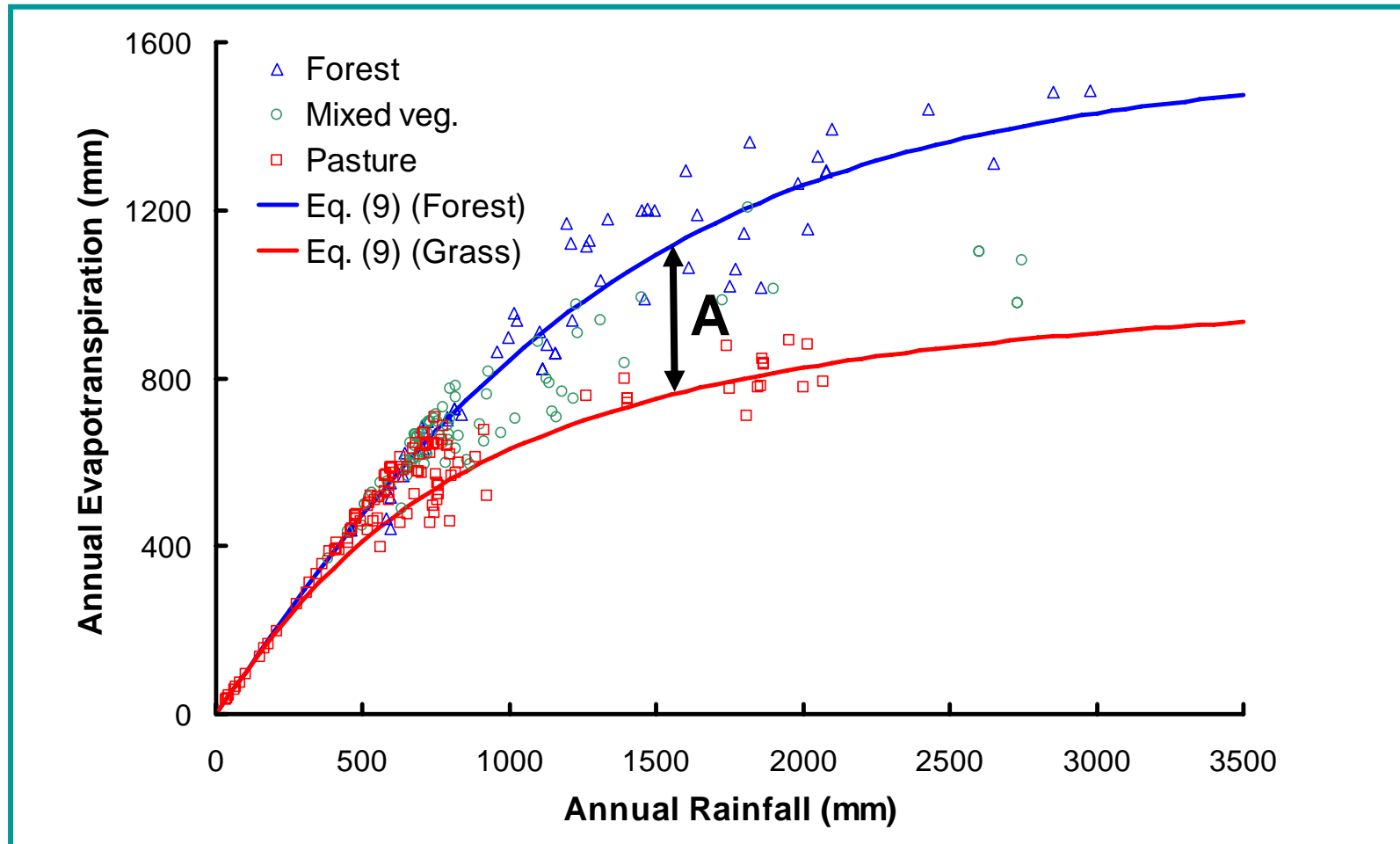


Australian Government
Australian Centre for
International Agricultural Research



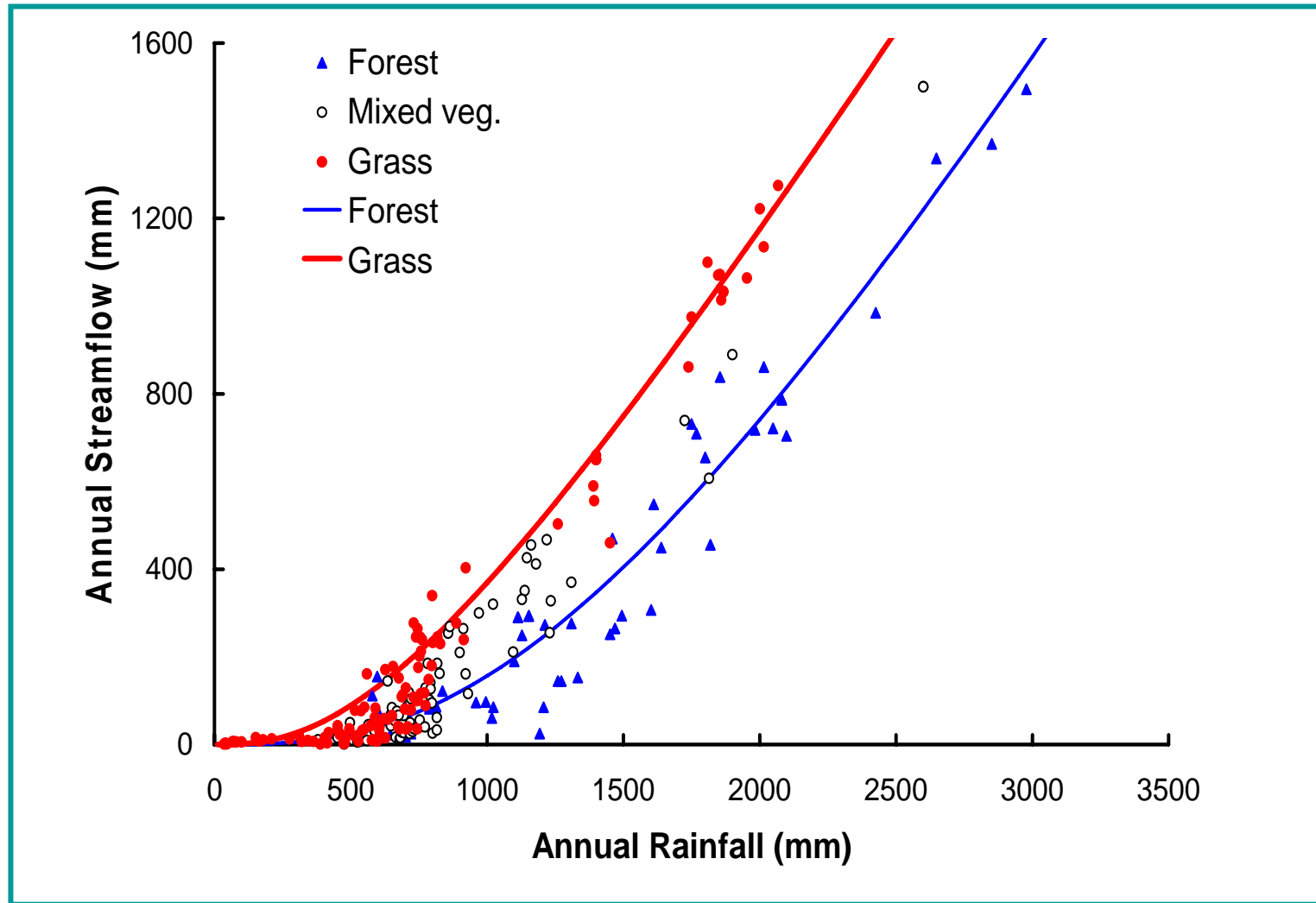


Mean annual water balance model – Zhang's model





Mean annual Water Yield

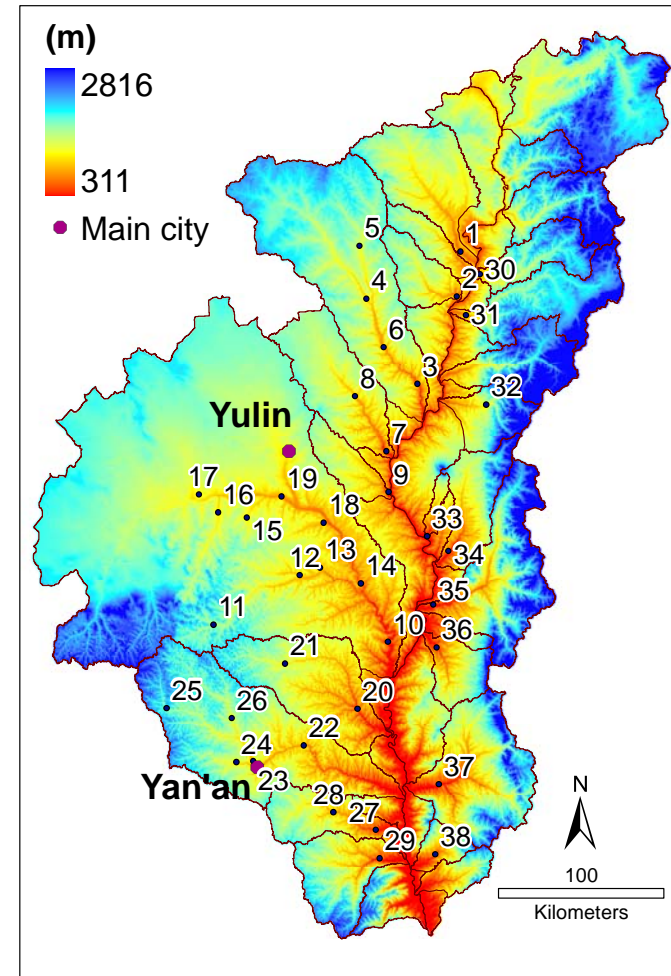




Study area



Australian Government
Australian Centre for
International Agricultural Research



Area: $113 \times 10^3 \text{ km}^2$;

Precipitation: 456mm

60-70% from June to September





Complex soil conservation measures





Local data



Australian Government
Australian Centre for
International Agricultural Research

Average annual streamflow:

38 nested catchments, 1980-2000;

Average annual precipitation, 1980-2000,

Pan evaporation: 1980-2000

(McVicar *et al.*, 2005);

Quality control performed (Li *et al.*, 2005)

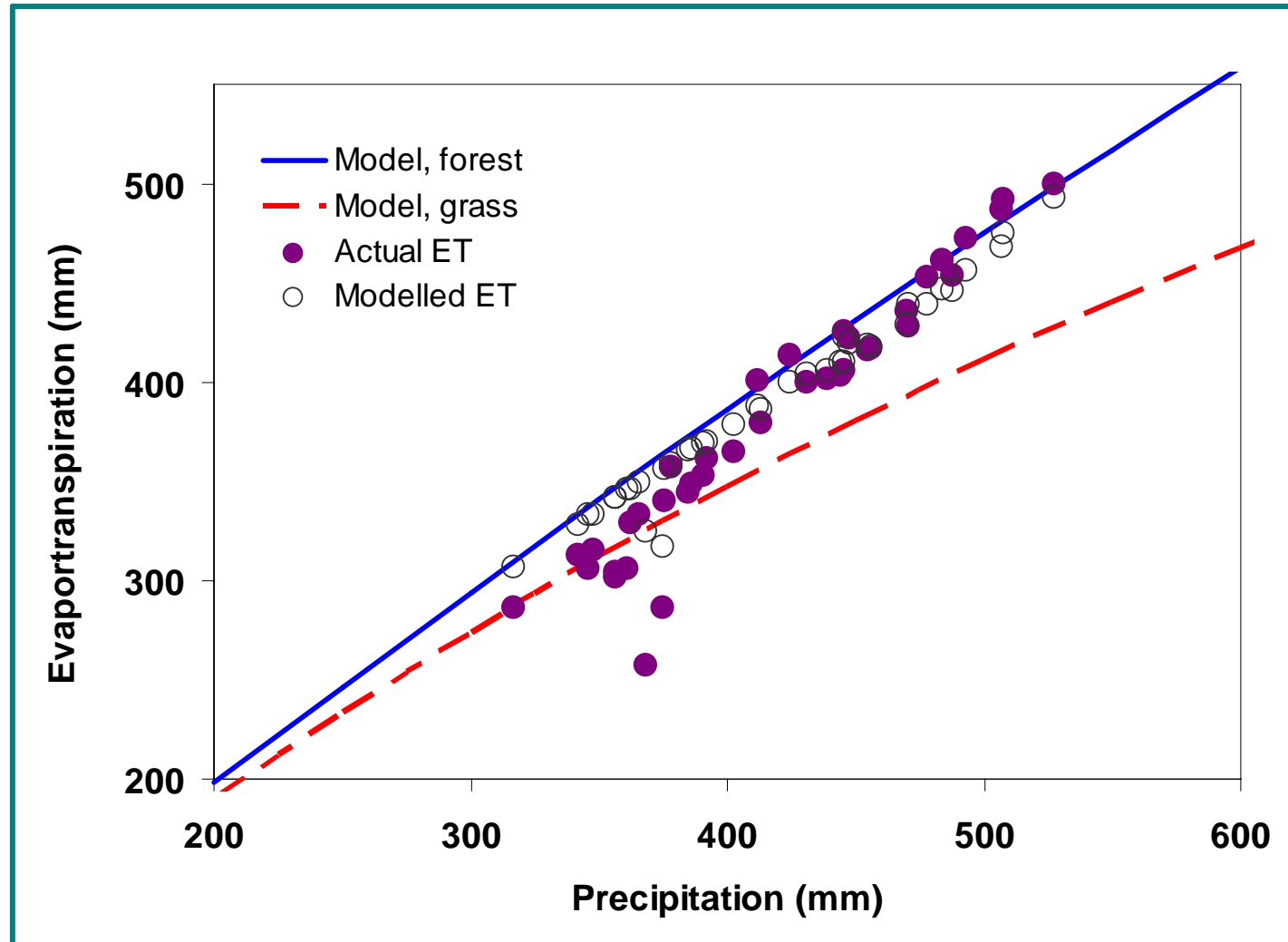




Testing Zhang's model

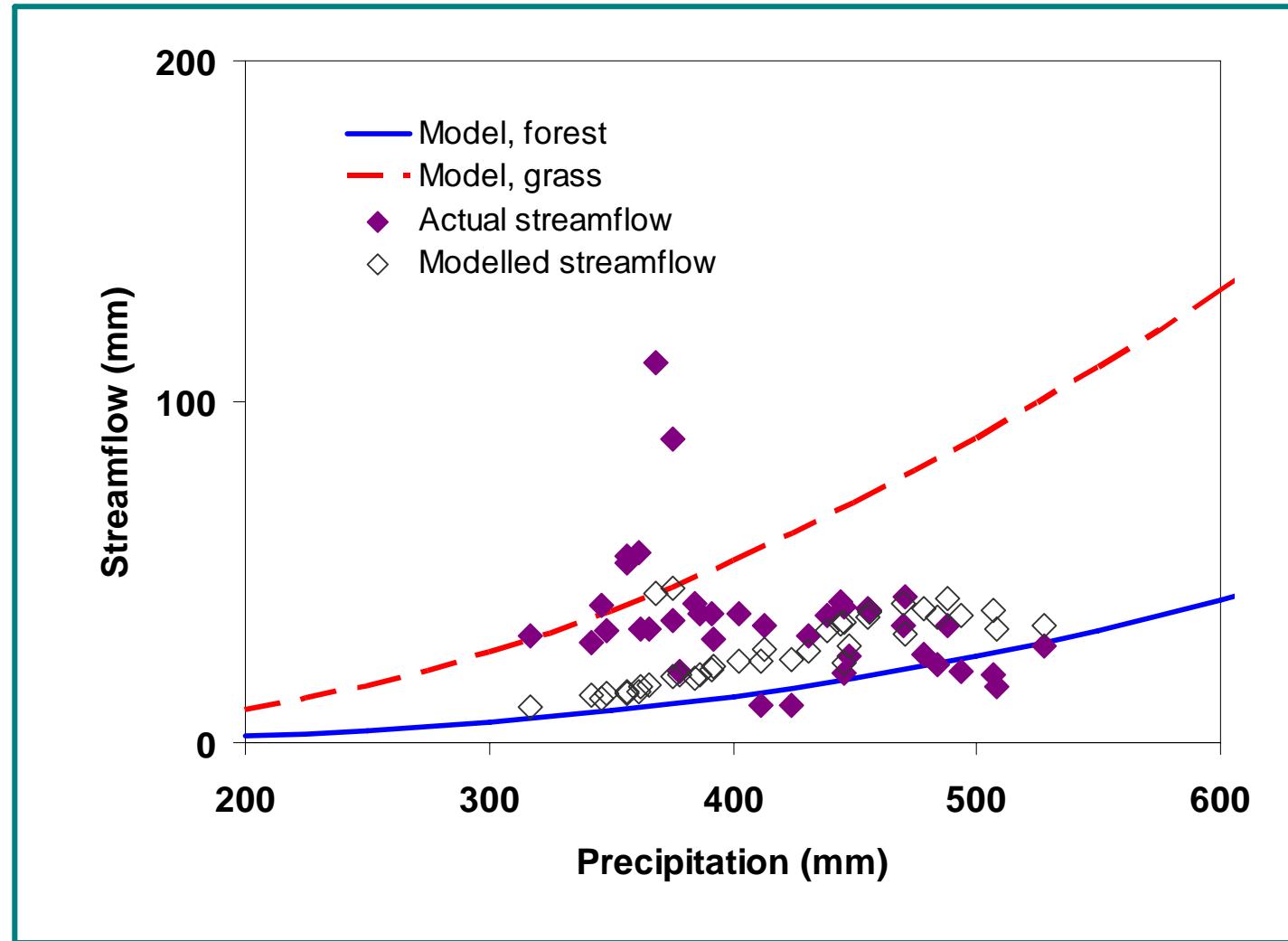


Australian Government
Australian Centre for
International Agricultural Research





Testing Zhang's model

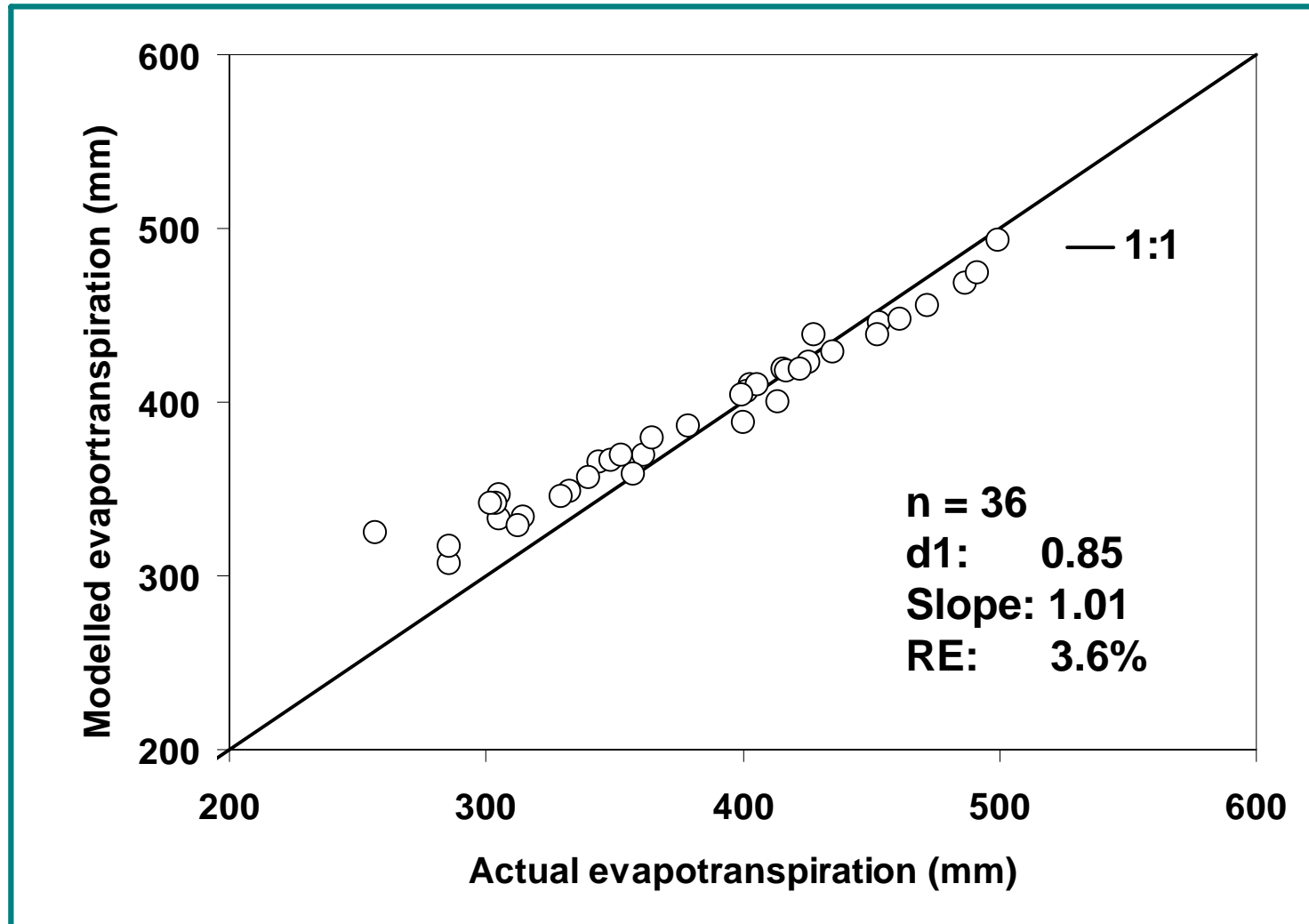




Testing Zhang's model

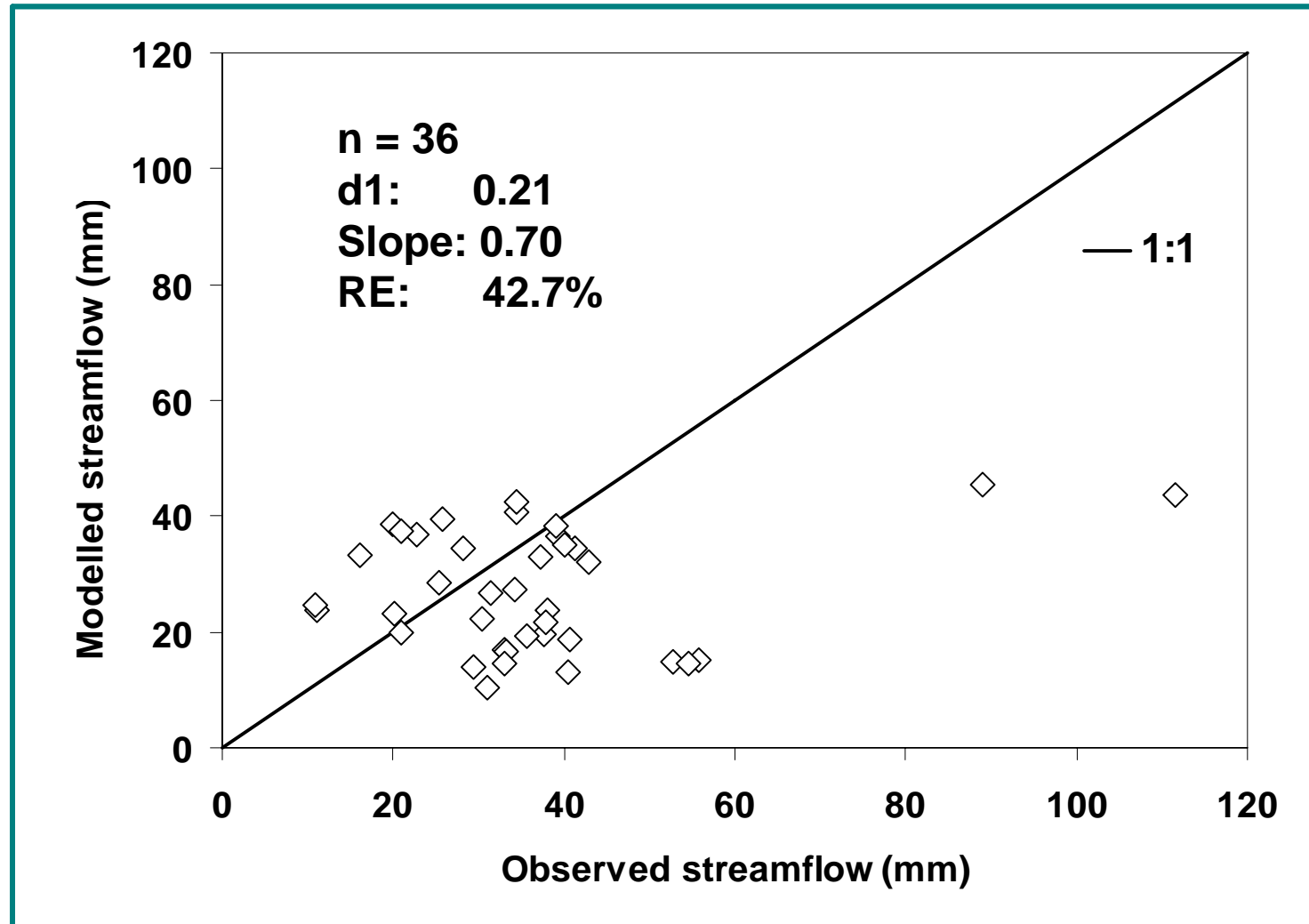


Australian Government
Australian Centre for
International Agricultural Research





Testing Zhang's model

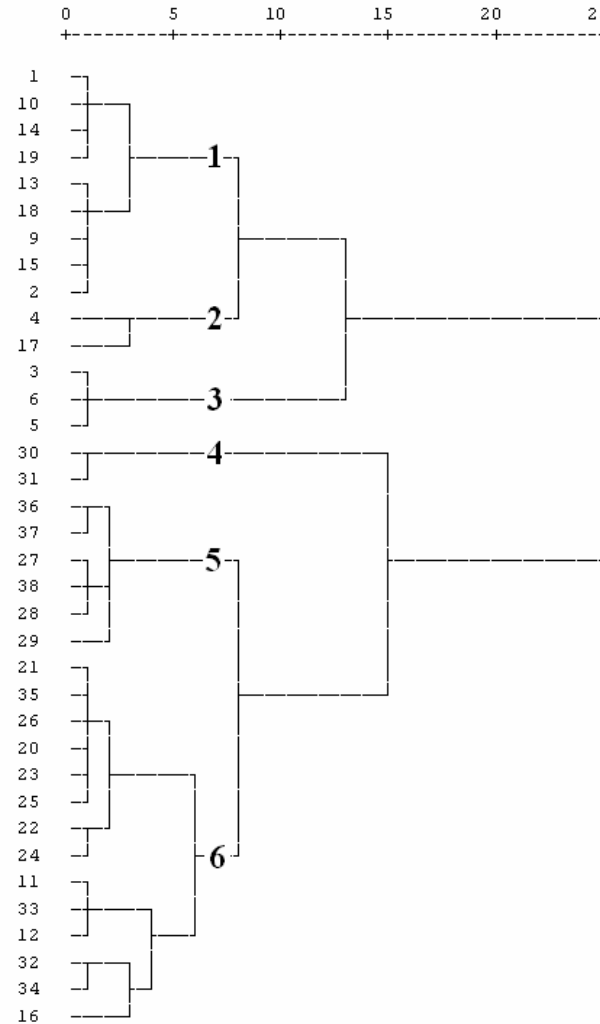




Regionalization of water balance model



Hierarchical cluster analysis



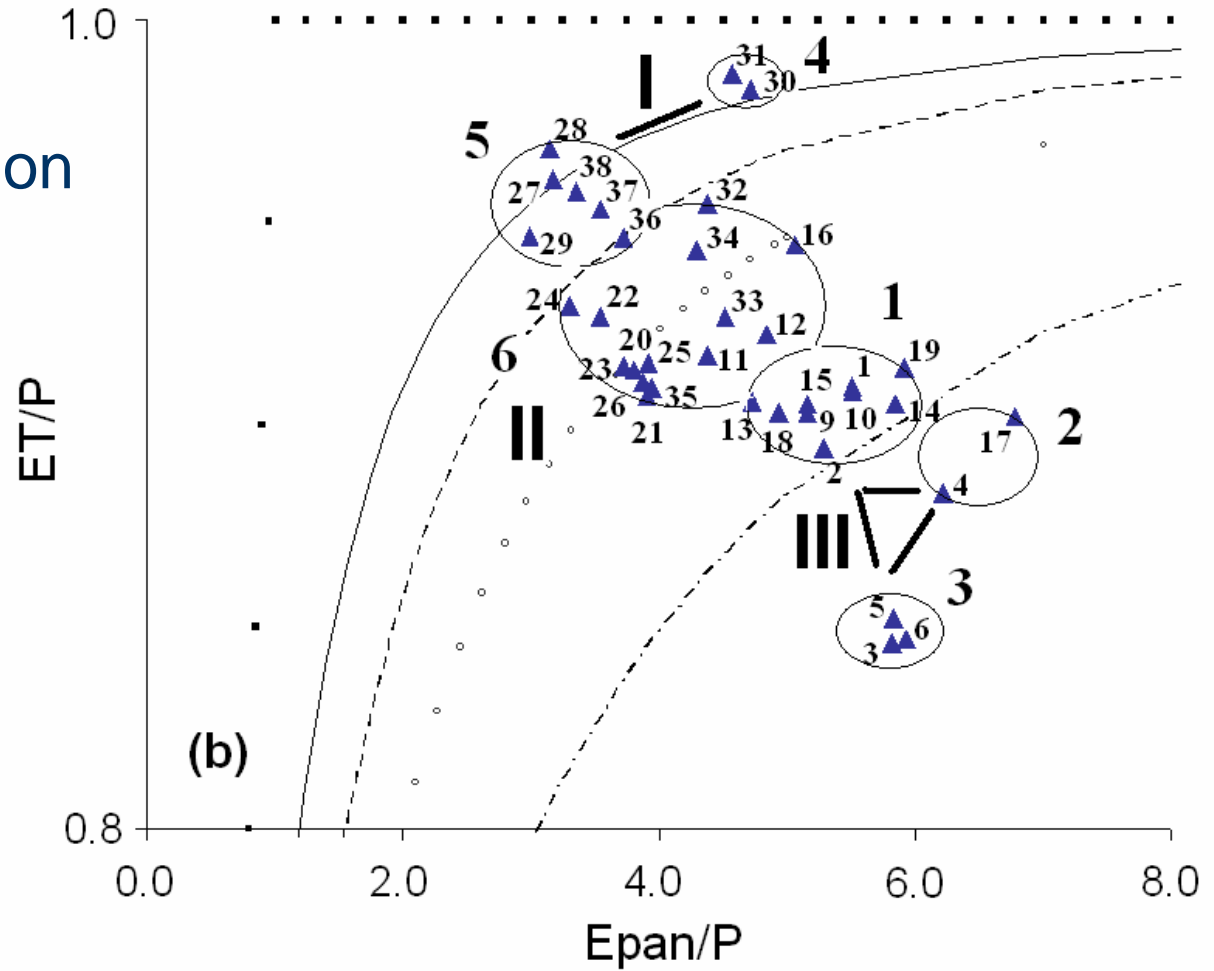


Regionalization of water balance model



Regionalization

Australian Government
Australian Centre for
International Agricultural Research





Regionalization of water balance model



Optimization



Australian Government
Australian Centre for
International Agricultural Research



Group	Optimized w
I (8)	1.61
II (14)	0.45
III (14)	0.10



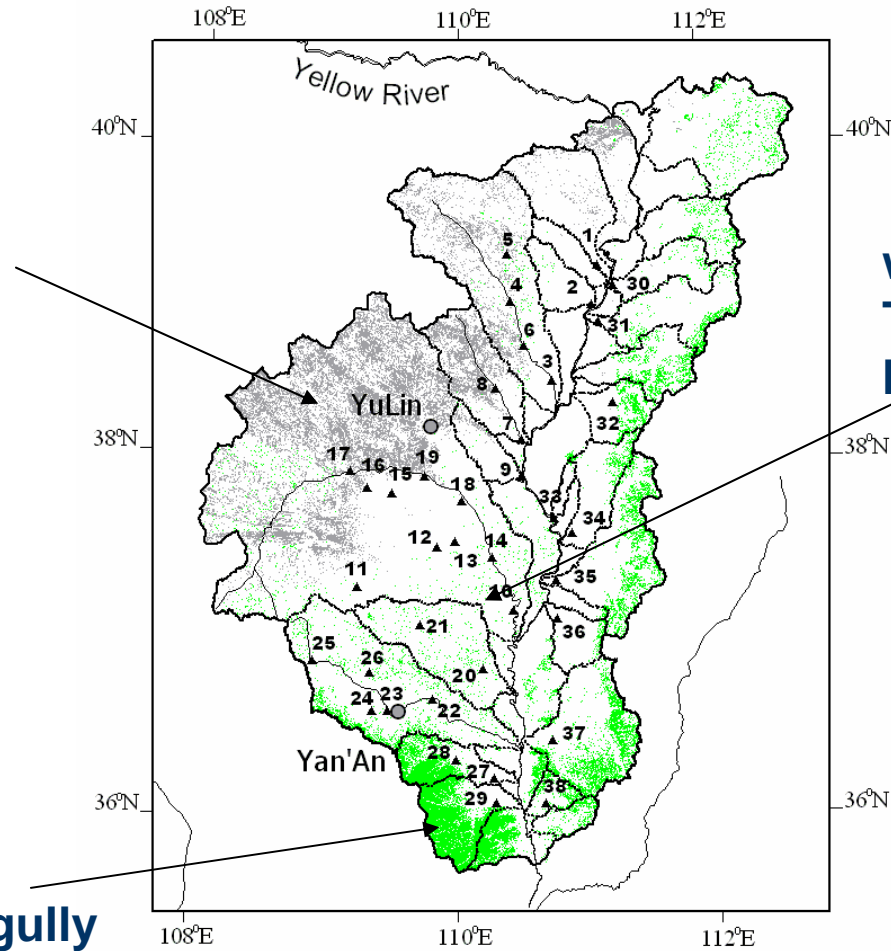
Regionalization of water balance model



w = 0.1
Sandy area



w = 1.61
Forested hill gully
loess plateau



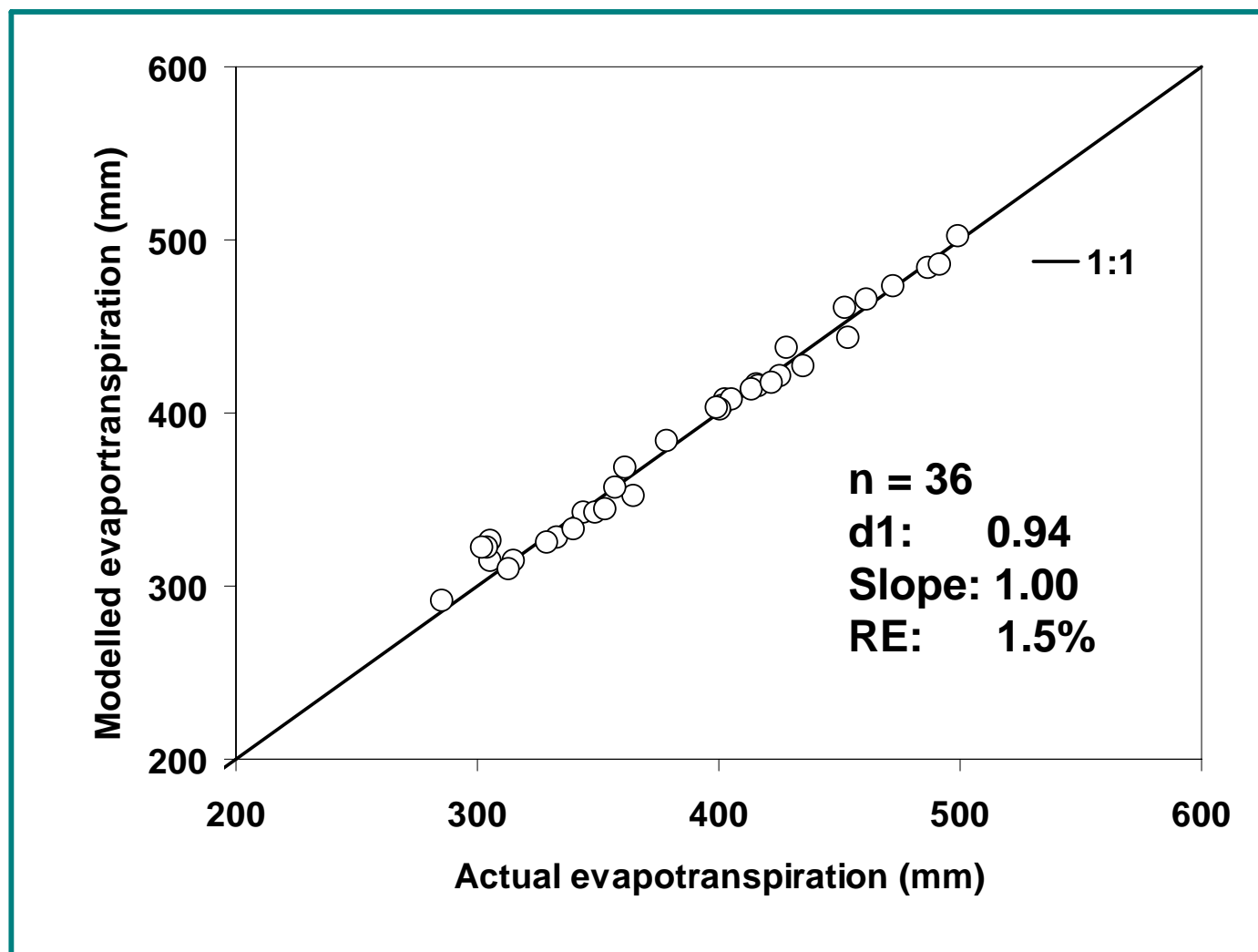
w = 0.45
Typical hill gully
loess plateau



Regionalization of water balance model



Australian Government
Australian Centre for
International Agricultural Research

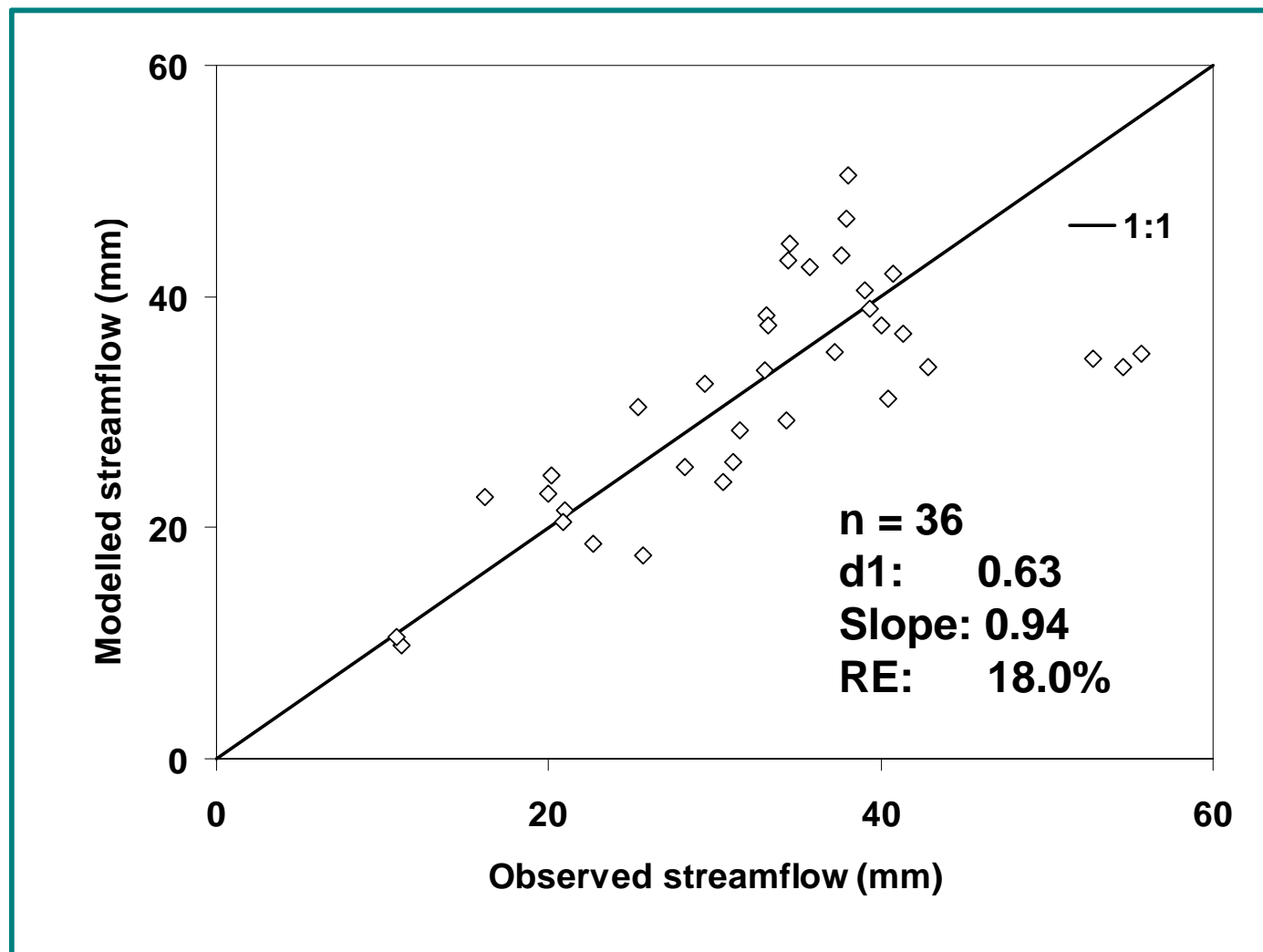




Regionalization of water balance model



Australian Government
Australian Centre for
International Agricultural Research





Generalization



$$w = 2.4136 - 1.75685(1 - f) - 0.01659(DI)^2$$

f : forest coverage in catchment;

DI : dryness index

r^2 : 0.75





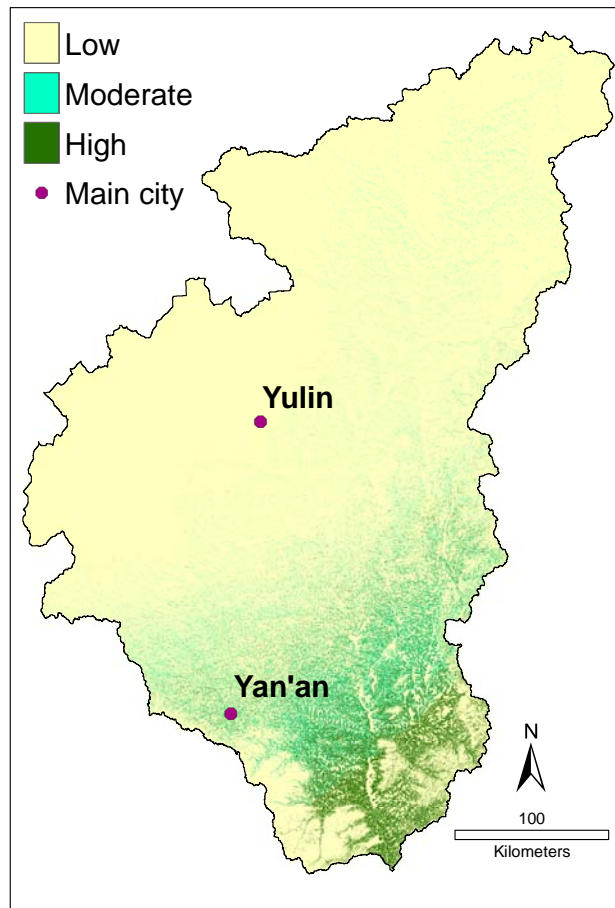
Application – scenario modelling



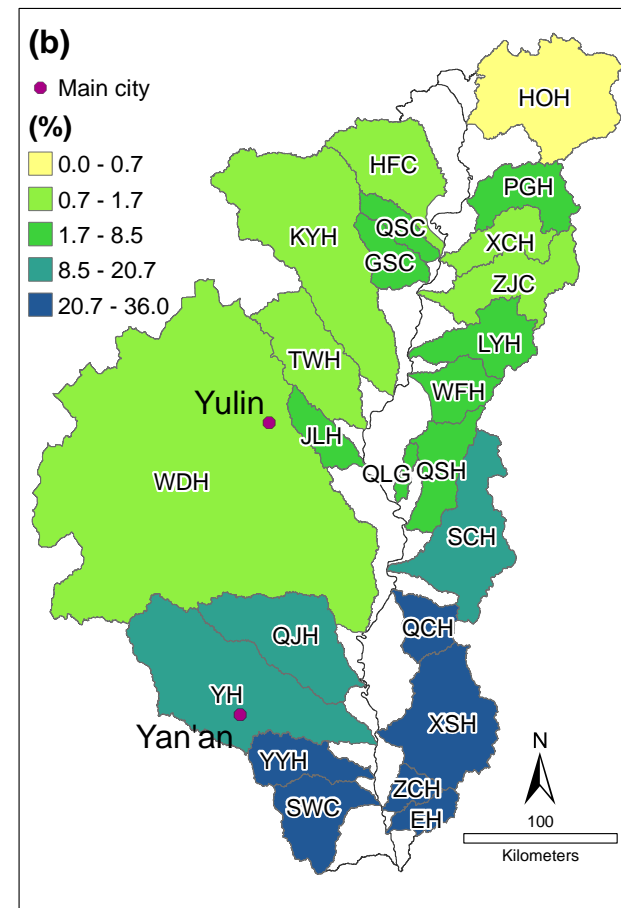
Australian Government
Australian Centre for
International Agricultural Research



Plantation suitability



Scenario





Conclusions



In the Loess Plateau, Zhang's model could accurately simulate the mean annual evapotranspiration very well, but not mean annual streamflow.

After calibration, the index of streamflow agreement increased from 0.21 to 0.63, RE decreased from 42.7% to 18.0%.

Hierarchical cluster analysis could be used in the regionalization of hydrology study.

Zhang's model can be used to evaluate the impact of potential afforestation on mean annual streamflow for catchments in the Loess Plateau.





Australian Government
Australian Centre for
International Agricultural Research

谢谢

Thank You

