TERENO International Conference 2014
September 29th - October 2nd 2014
Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany

Changes in water storage and water quality in the largest freshwater lake (Poyang Lake) in China and effects of the Three Gorges Dam

Prof Qi Zhang
qzhang@niglas.ac.cn

Nanjing Institute of Geography and Limnology
Chinese Academy of Sciences

In the last decade, unusual droughts encountered in the middle reaches of the Yangzte River;

Potential impacts on the ecosystem of the two lakes attached to the River;

Debates about possible influence of TGD (started impoundment in 2003) on dryness;

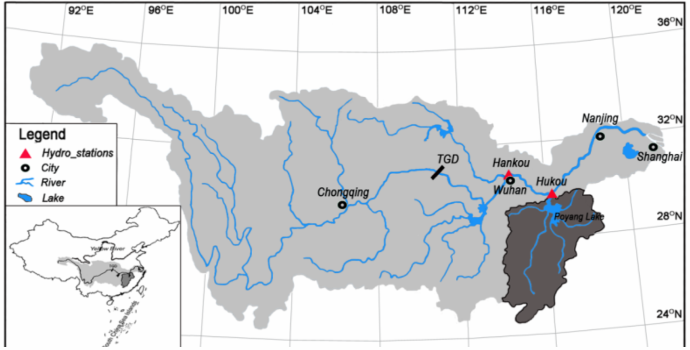
Length 2335m, Height 185m, WL175m
Capacity $393X10^8$ m^3

The Yangzte River basin
1,800,000 km^2

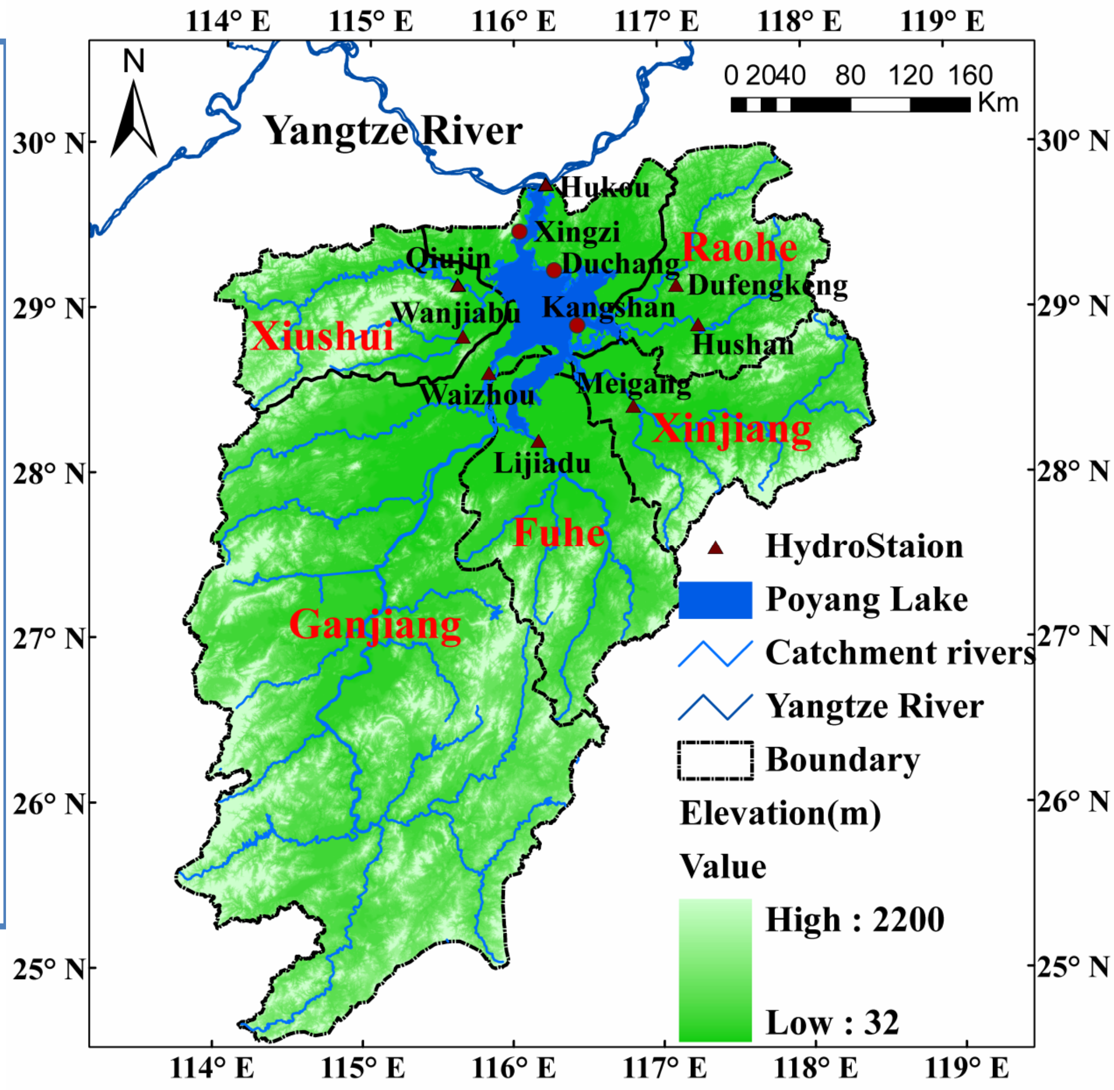
Dongting Lake
262,800 km^2

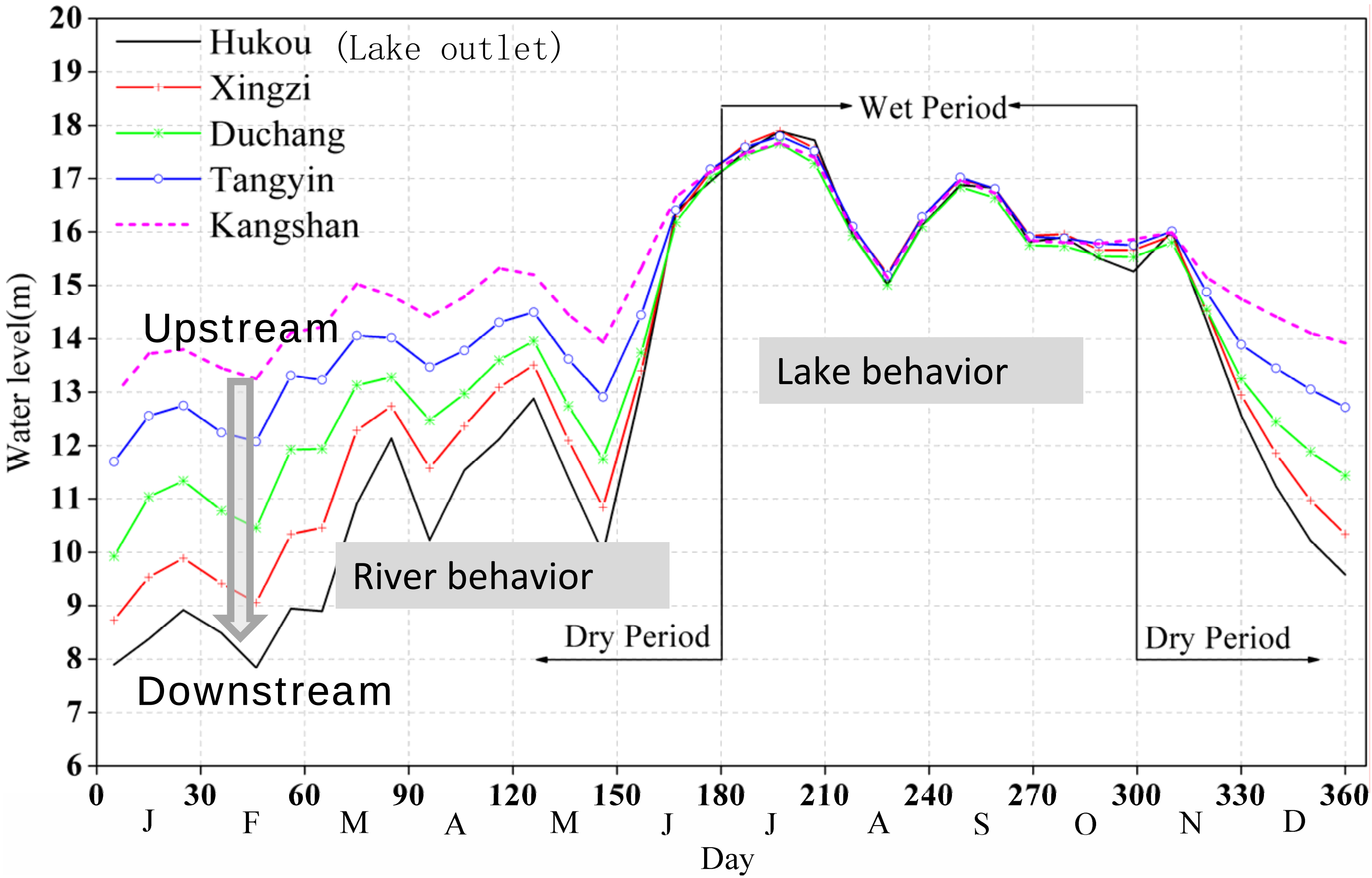
Poyang Lake
162,000 km^2

The Poyang Lake



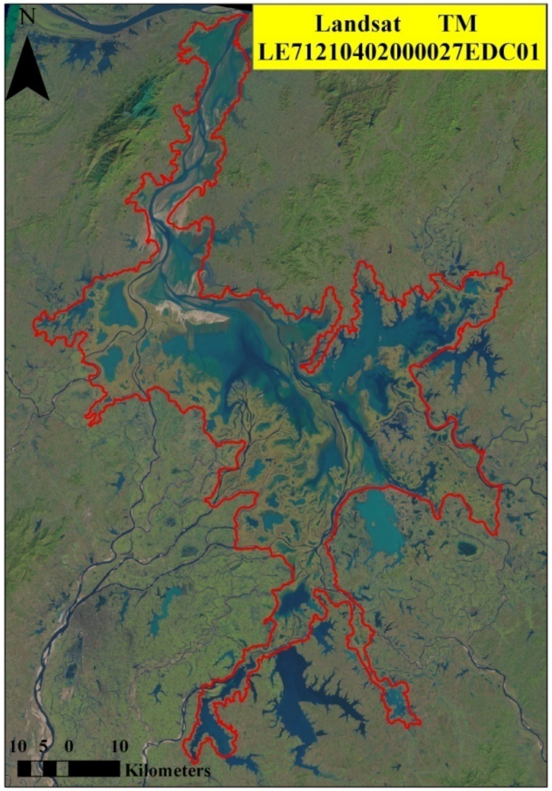
- Average depth 8.4m, with max. 25m;
- Direct hydraulic connection with Yangtze river;
- Good quality freshwater resource – the largest freshwater lake in China;
- Globally important wetland – rich biological species;
- Mitigating Yangtze floods;



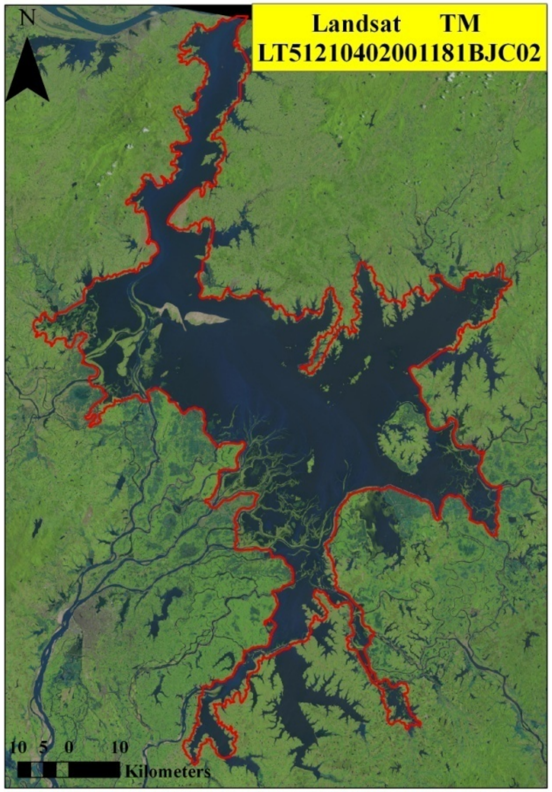


Seasonal changes in lake water level at gauging stations from downstream to upstream (Hukou, Xingzi, Duchang, Tangyin, Kangshan)

Seasonal change of lake area



January

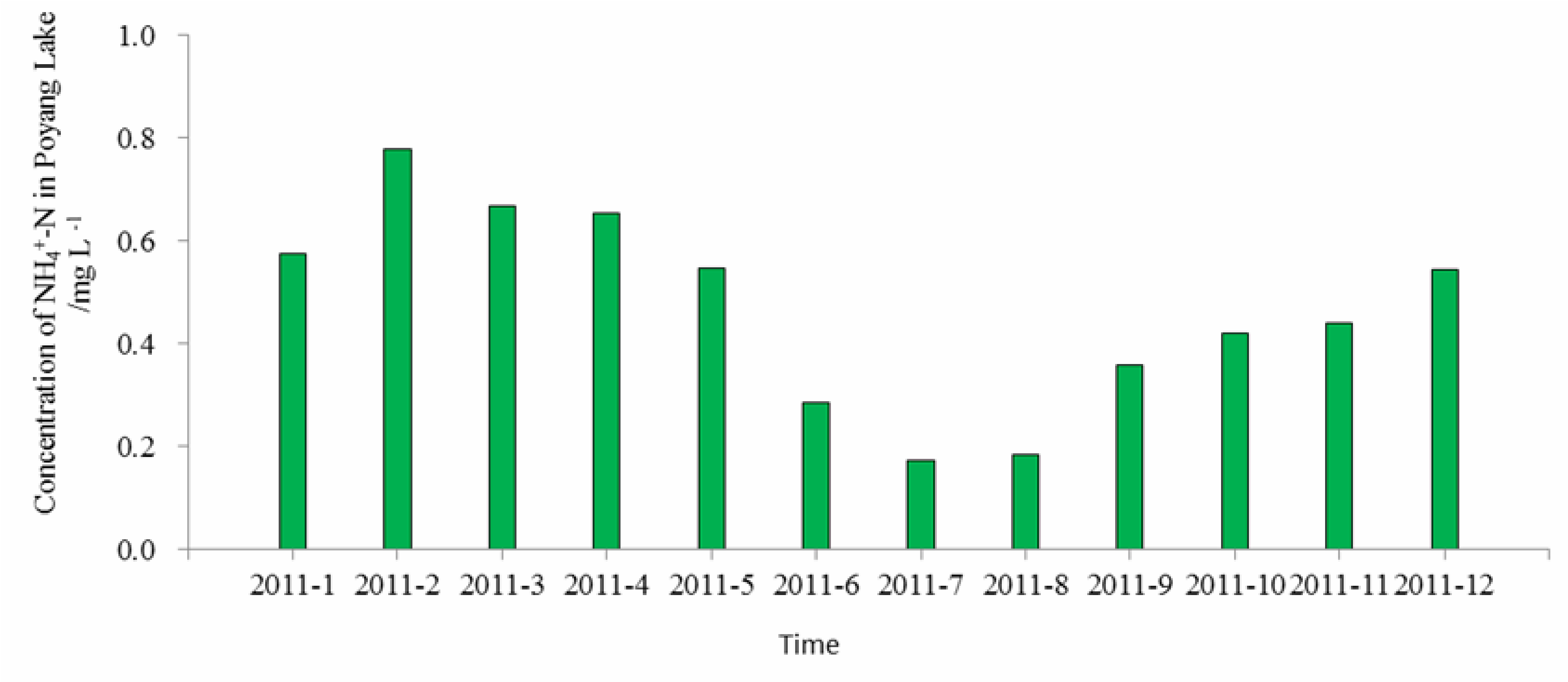


July

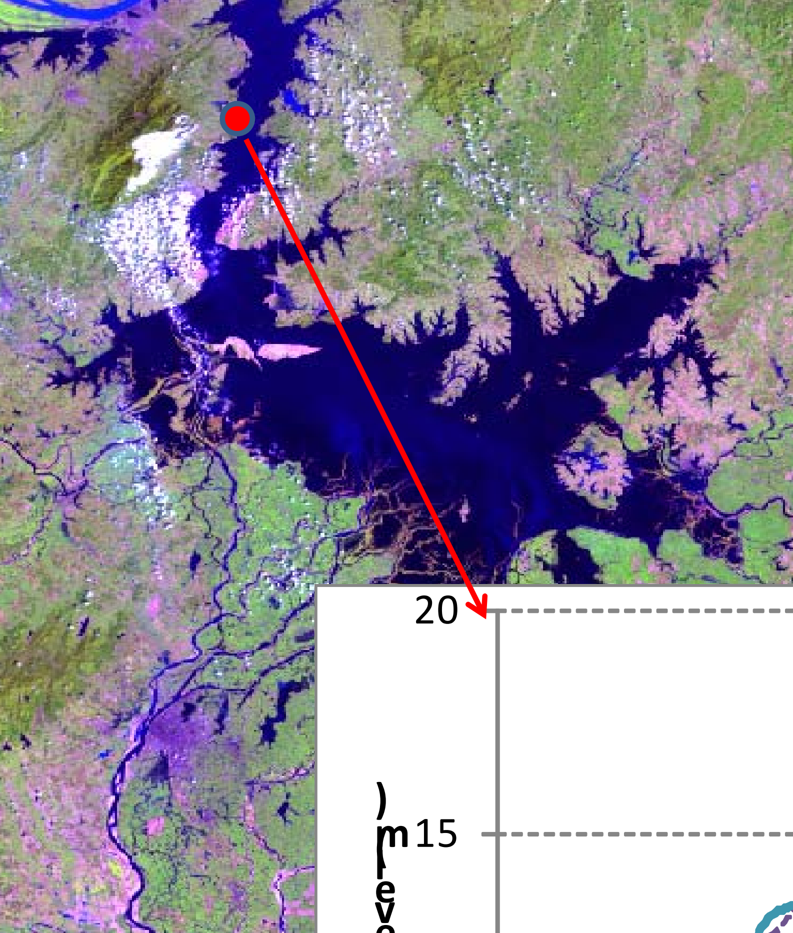
~ 900 km^2 at low water level (9m)

~ 4000 km^2 at high water level (18m)

Seasonal variation of water quality in the Lake

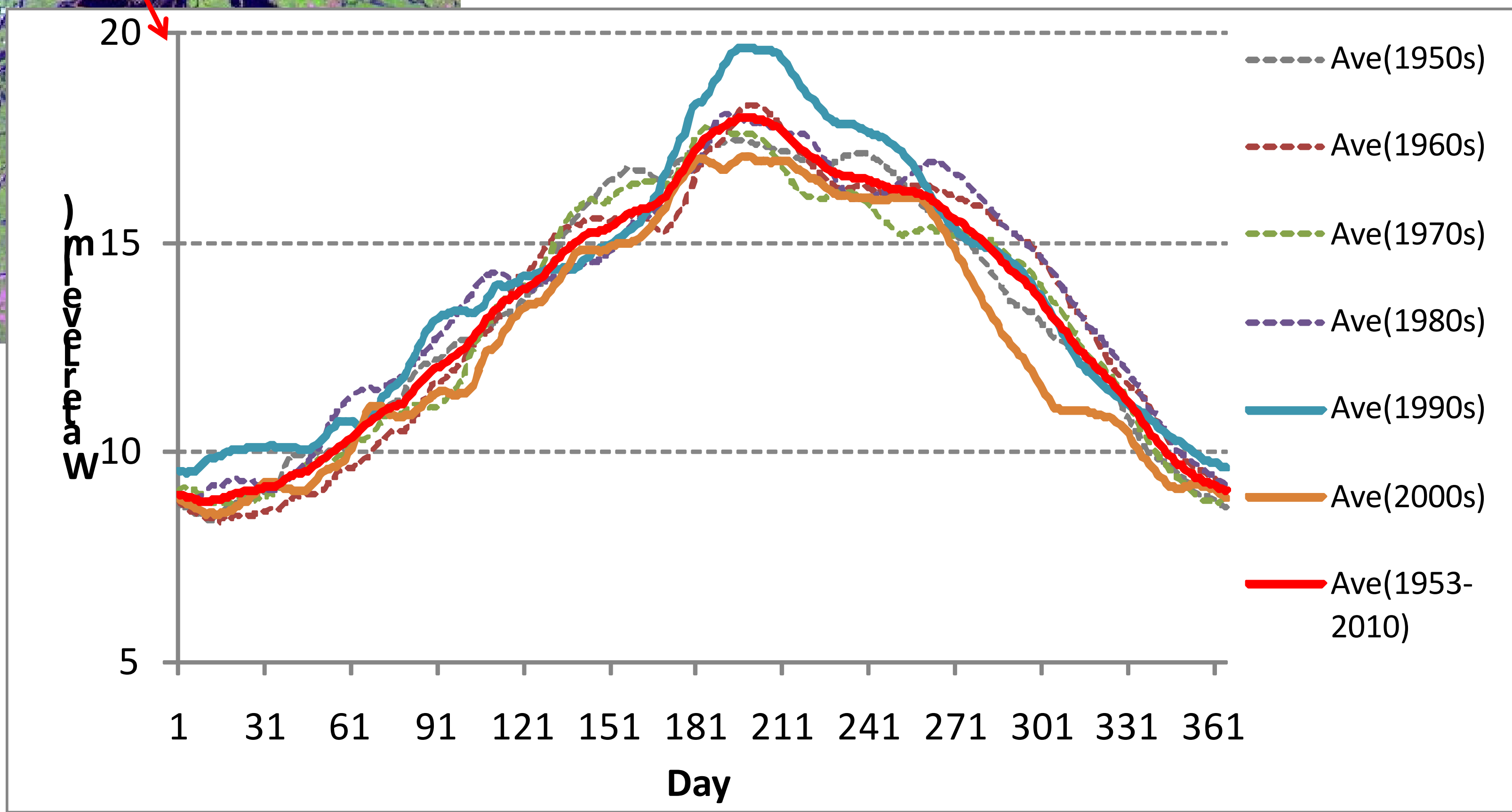


Ecologically rich wetland, habitats of many birds (crane, swan)

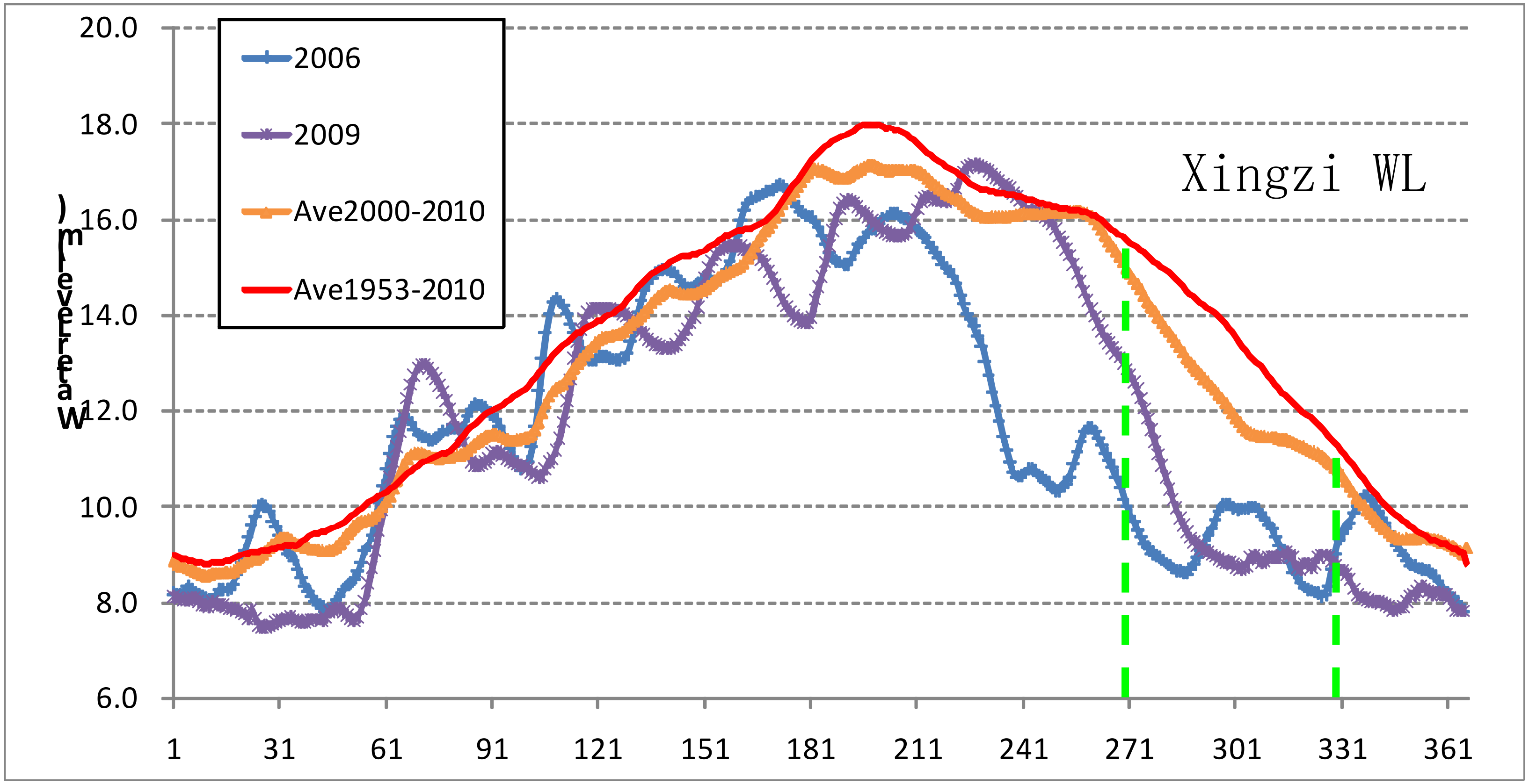


Evidence of recent dryness

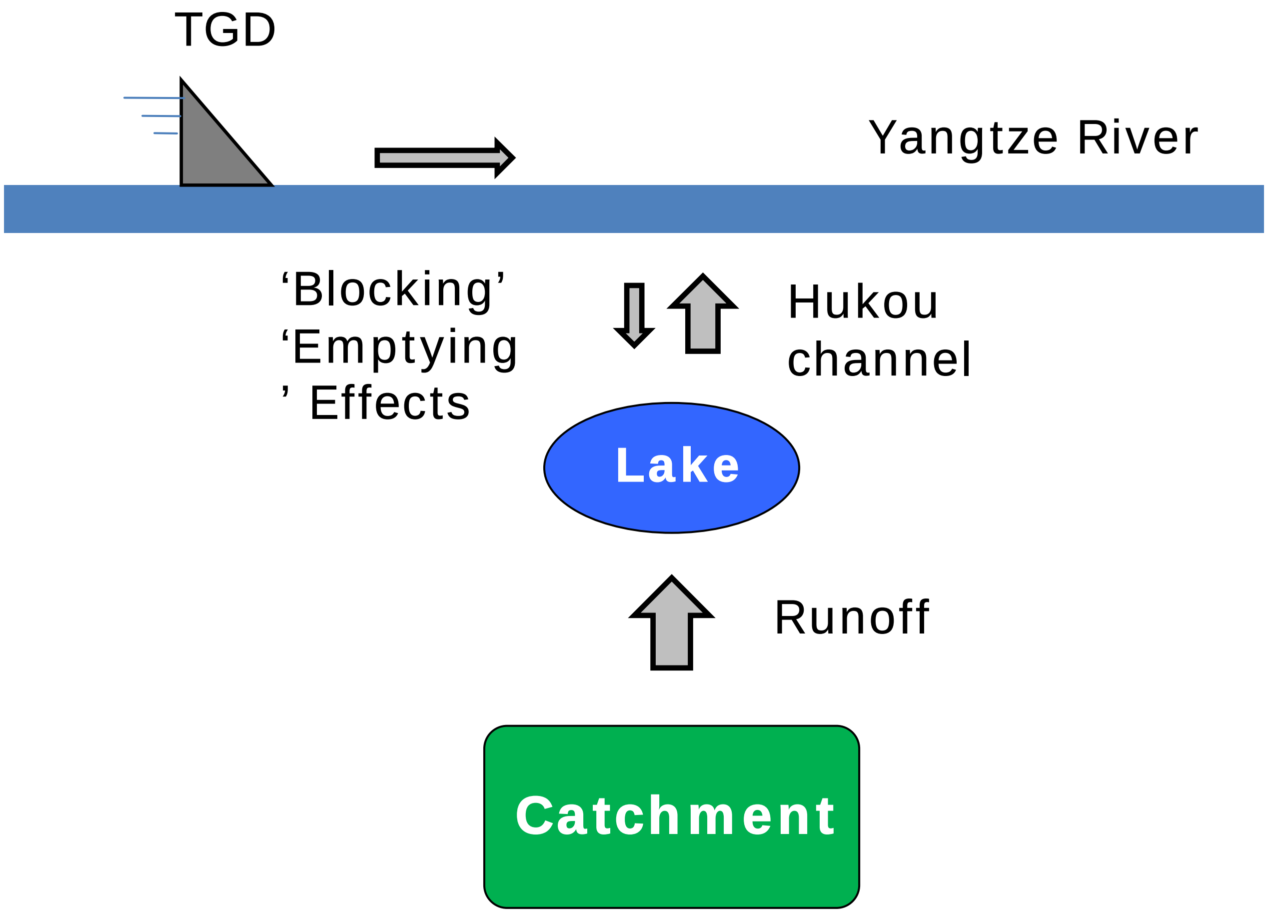
Lower water level for 2000-2010

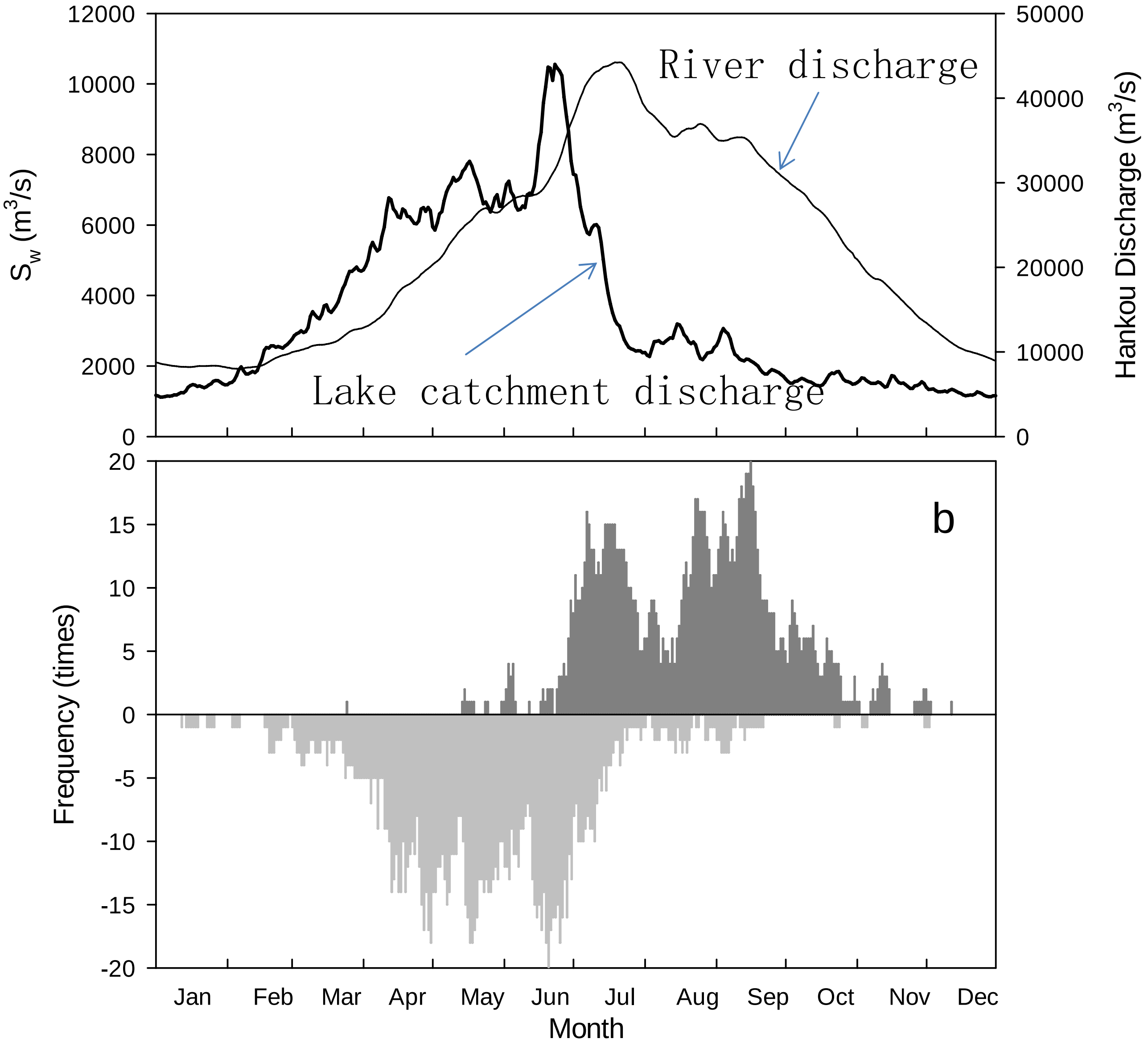


Particularly dry autumn in 2006 and 2009

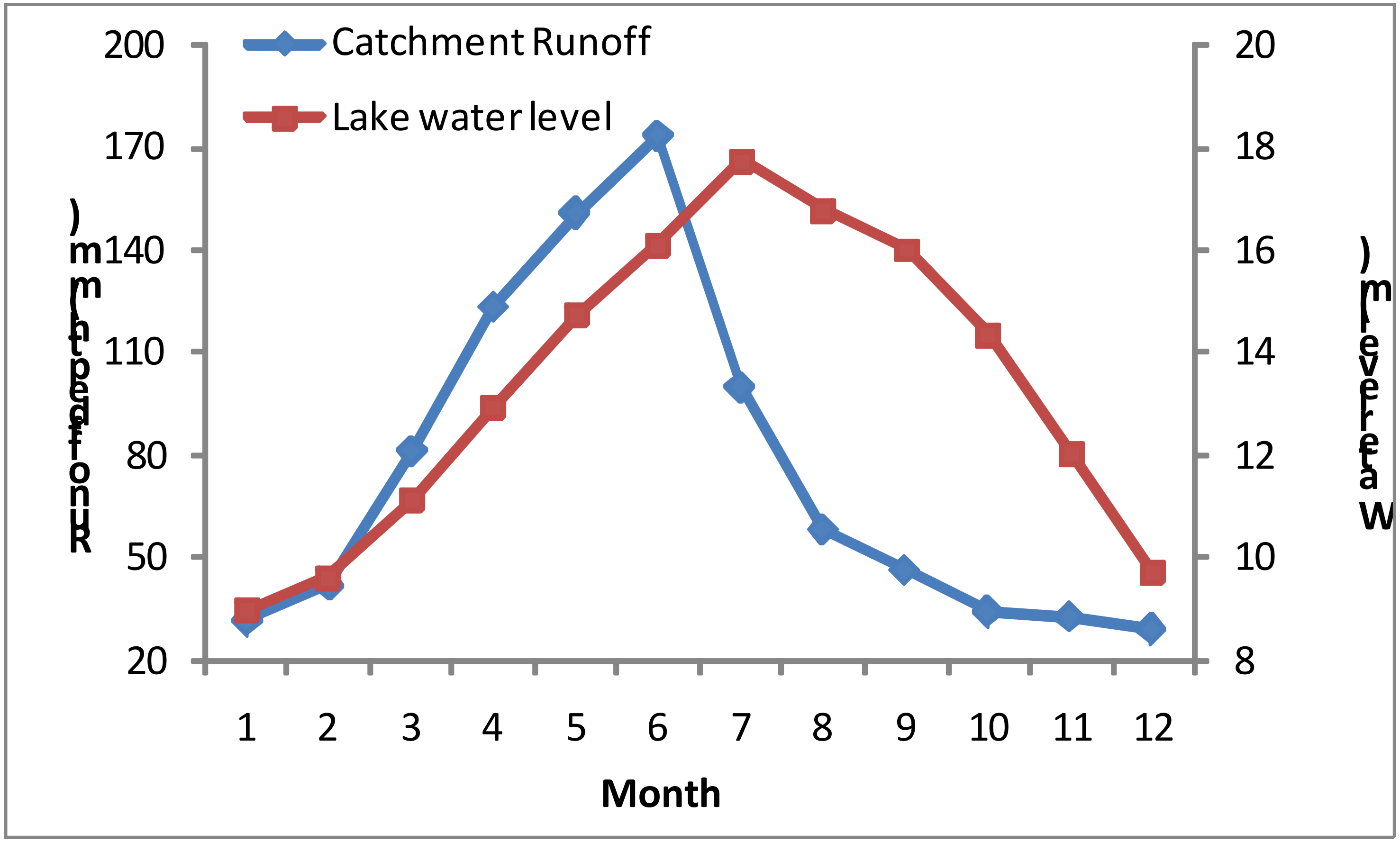


Conceptulisation of the Lake-Catchment-River system



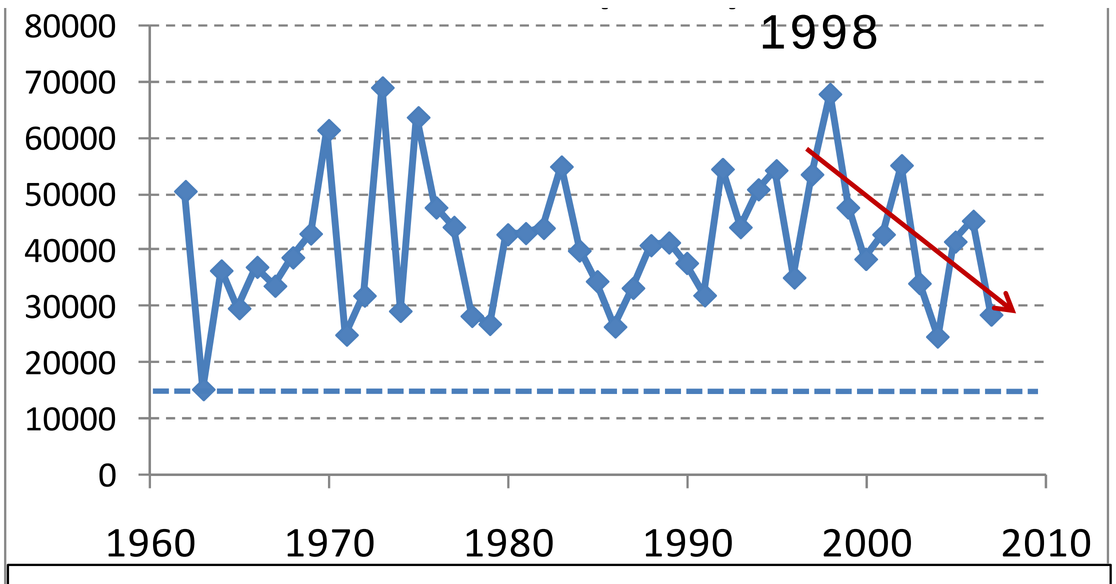


12000
10000
8000
6000
4000
2000
0
50000
40000
30000
20000
10000
0
S_w (m^3/s)
Hankou Discharge (m^3/s)
River discharge
Lake catchment discharge
20
15
10
5
0
-5
-10
-15
-20
Frequency (times)
b
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

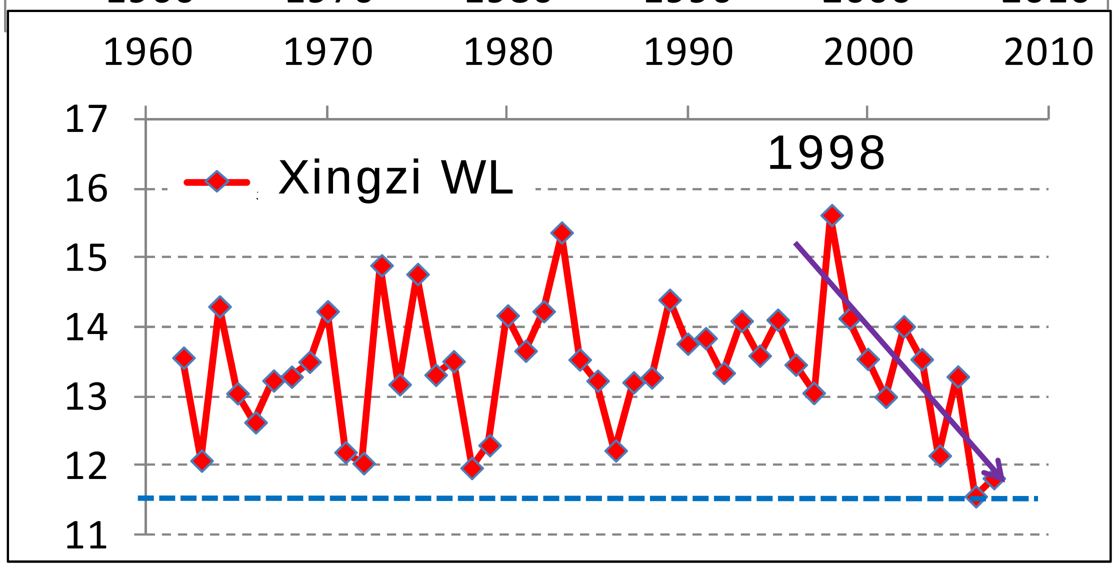


Variation of catchment runoff and lake water level

Annual average catchment discharge (m³/s)



Decrease in catchment discharge cannot fully explain the low WL, especially the unusual dryness in autumn



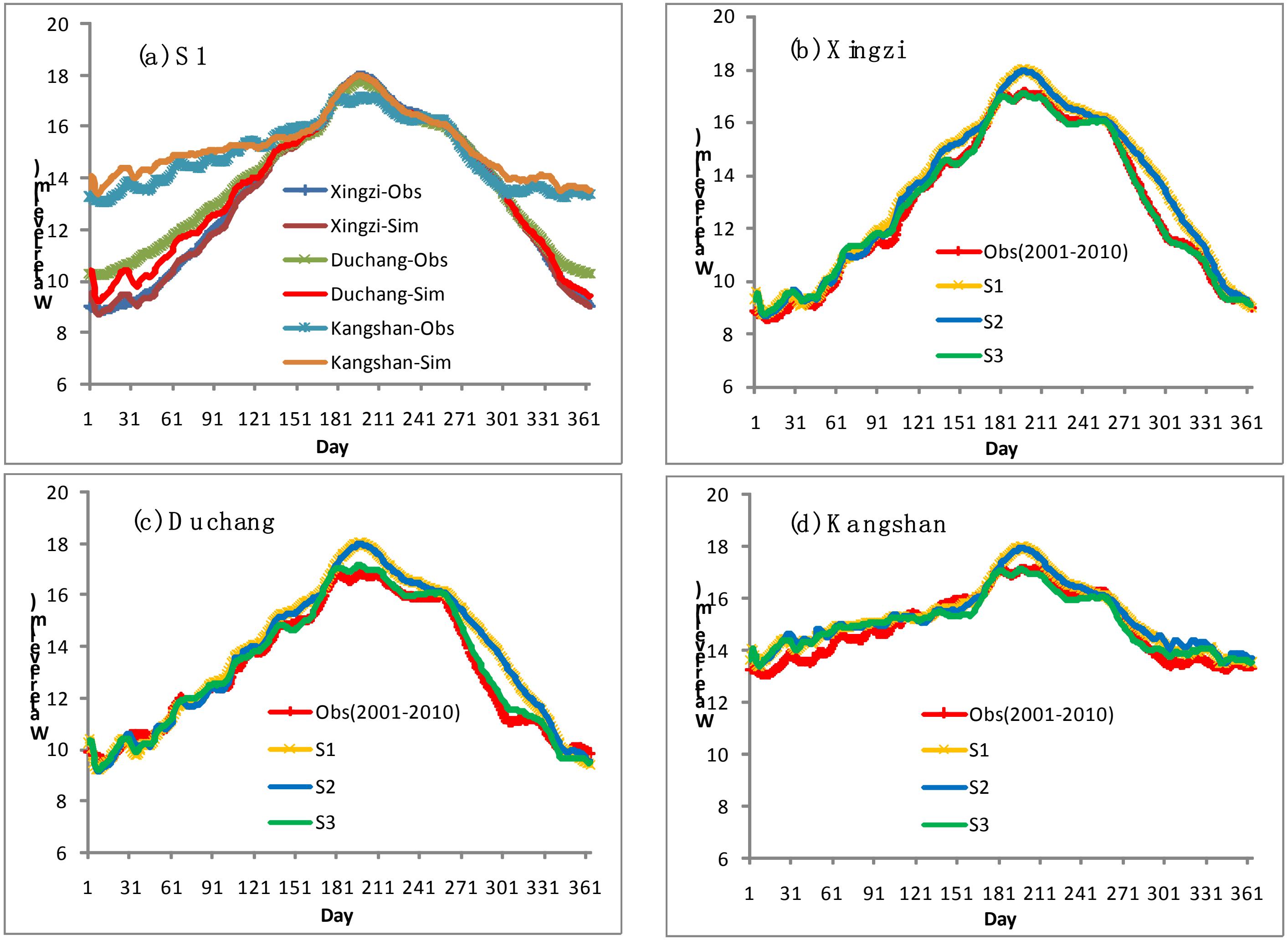
After 1998 flood, WL at Xingzi reached the lowest of records

Averaged water balance components for different periods ($10^8 m^3$/year)

Period	Gauged outlfow Q	Gauged inflow R_1	lake storage change R_X	R_X/R_1 (%)	Water level at Xingzi (m)
1953-1960	1533	1242	291	23.4	13.31
1961-1970	1369	1164	205	17.6	13.33
1971-1980	1417	1212	205	16.9	13.22
1981-1990	1429	1172	257	21.9	13.67
1991-2000	1769	1431	338	23.6	13.87
2001-2010	1428	1151	277	24.1	12.74
1953-2010	1489	1228	261	21.3	13.36

Hydrodynamic modelling using MIKE 21

S1 - average condition for 1953-2010, and as a reference case
S2 - evaluation of the effects of catchment inflows (inflow for 2001-2010)
S3 - assess the effects of the Yangtze River (river stage for 2001-2010)

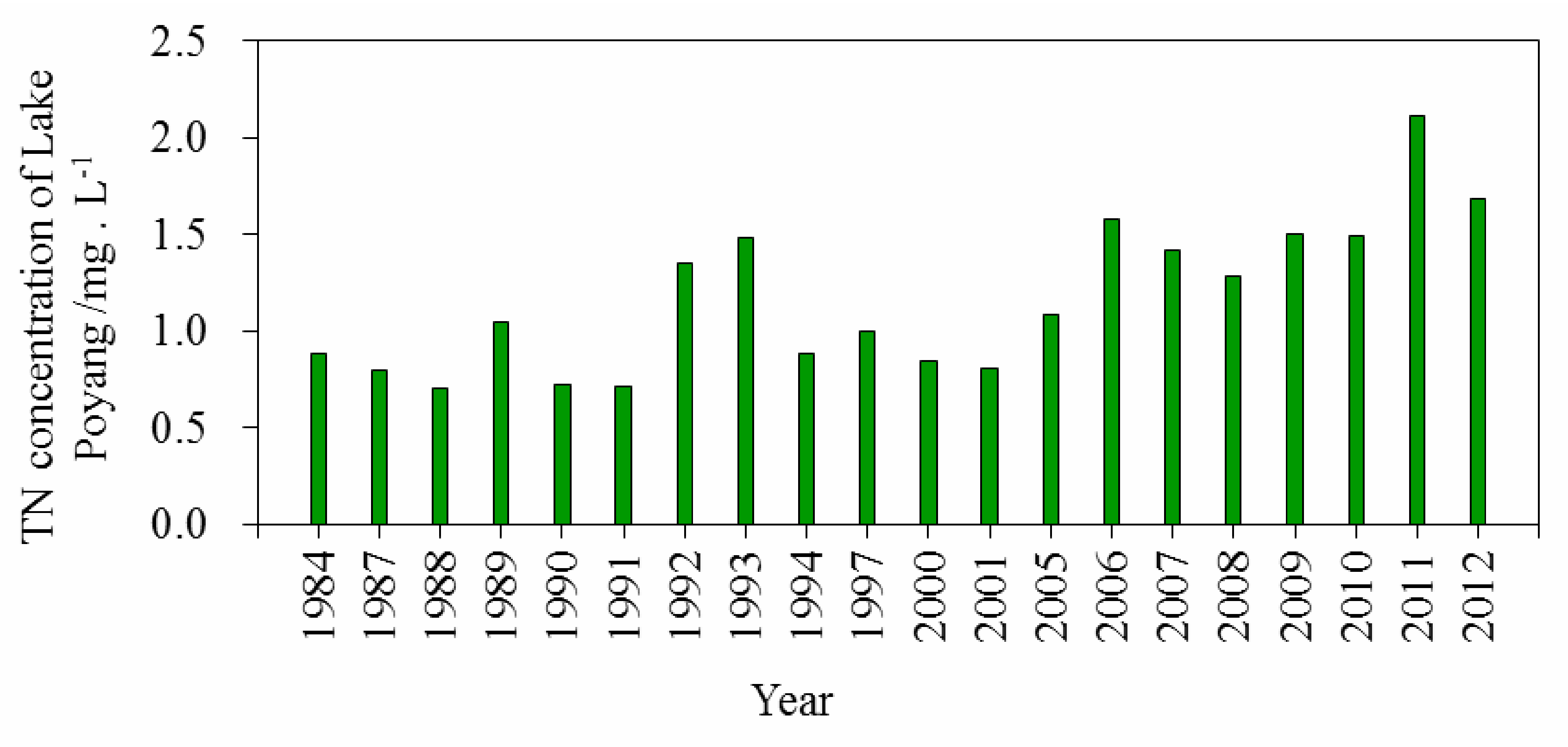


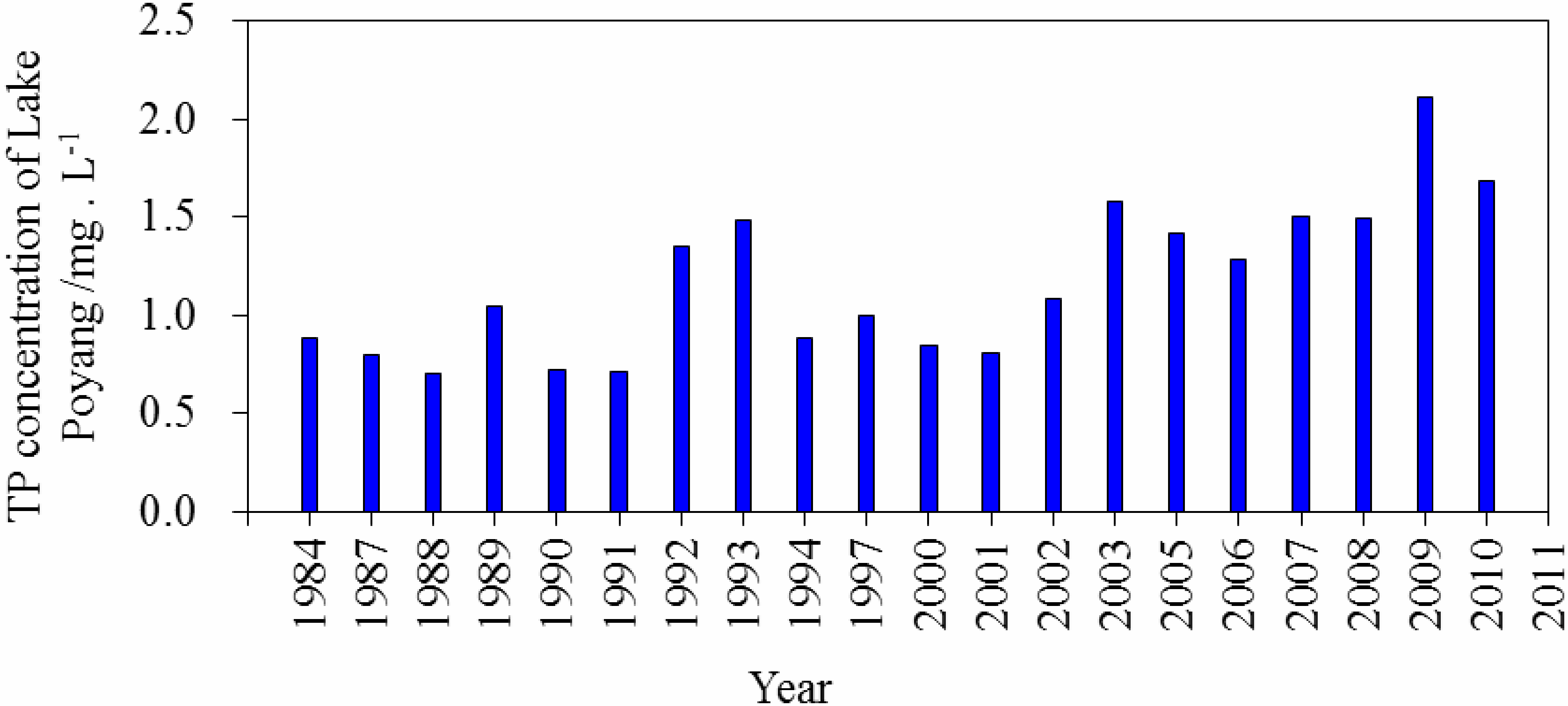
(Zhang et al 2014 JOH)

Change of Lake storage

- Lake water level fell to the lowest during 2001-2010 relative to previous decades;
- The average Lake size and volume reduced by 154 km^2 and 11×10^8 m^3 for 2001-2010, compared to those for the preceding period (1970-2000).

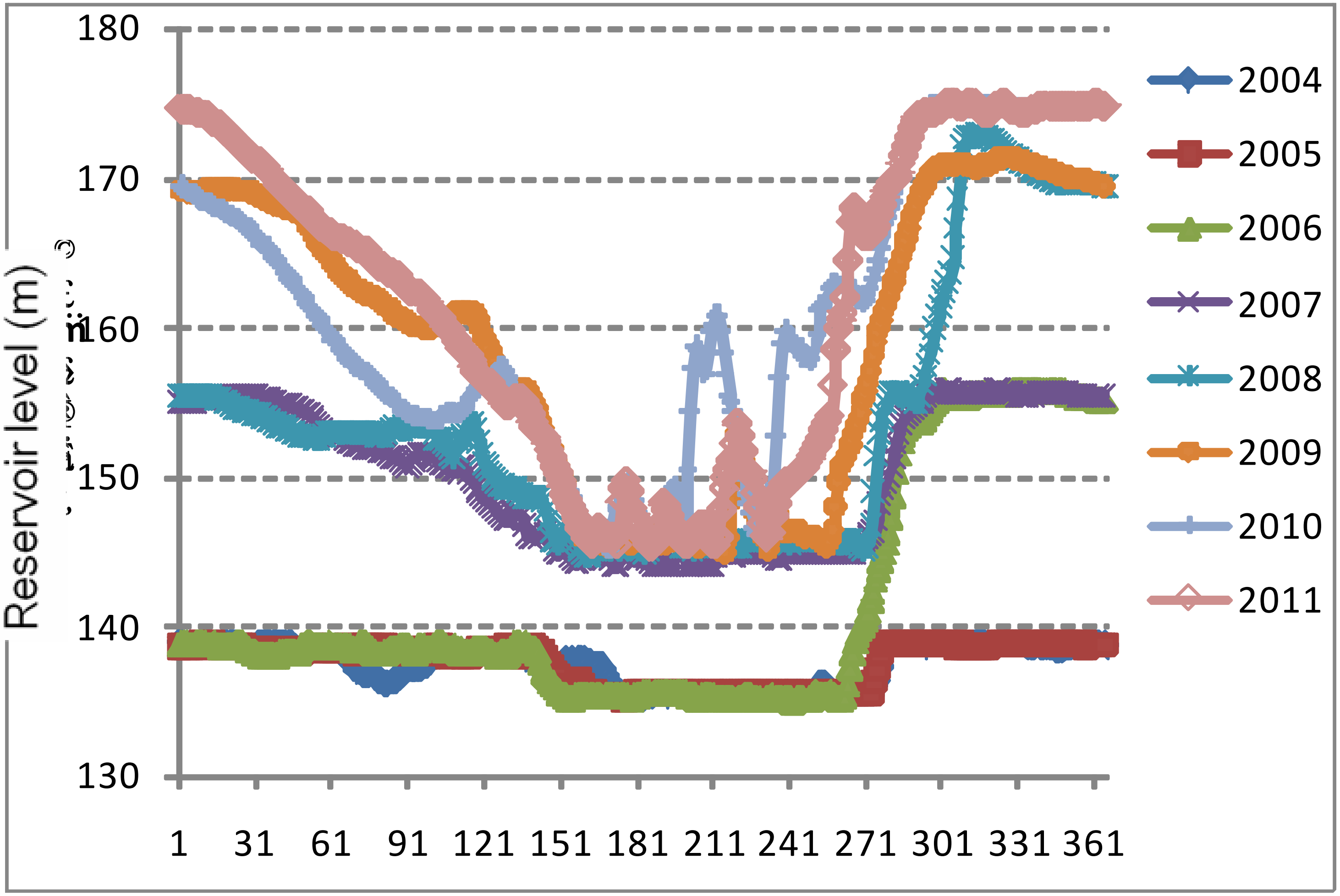
Water quality changes in the Lake



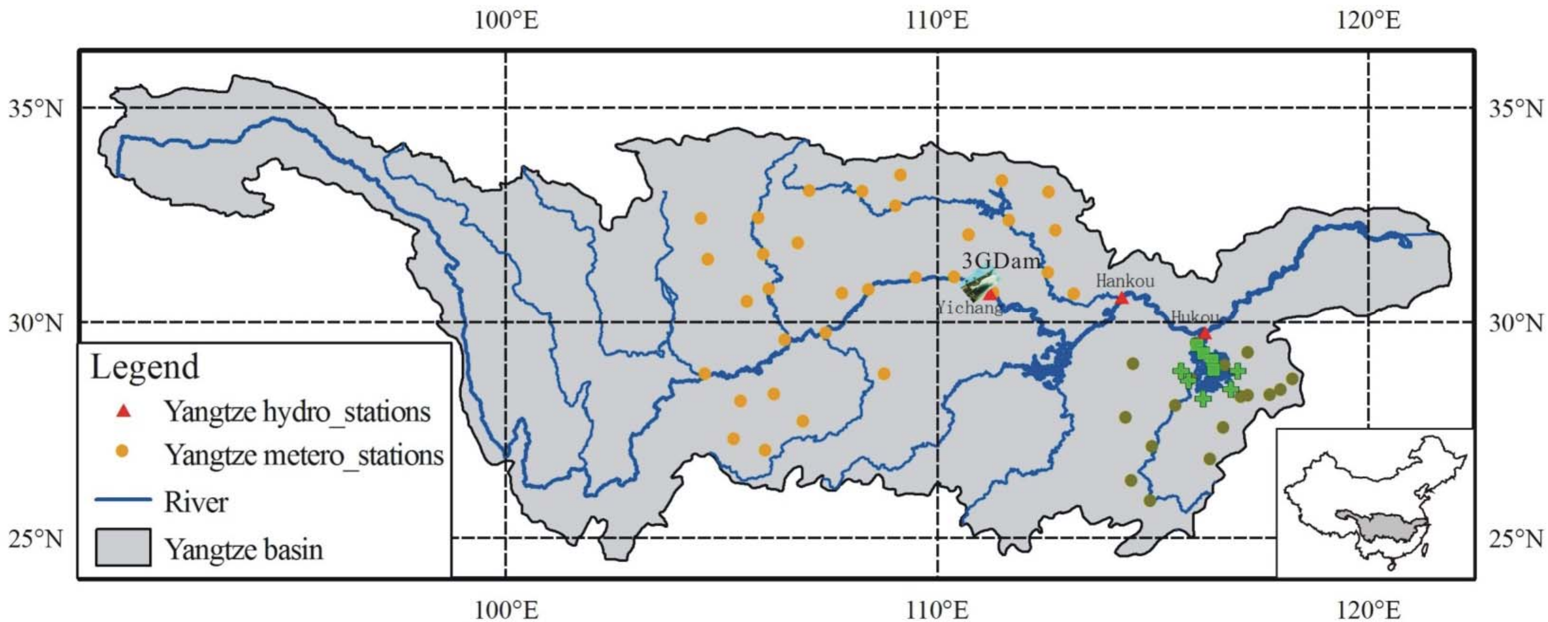


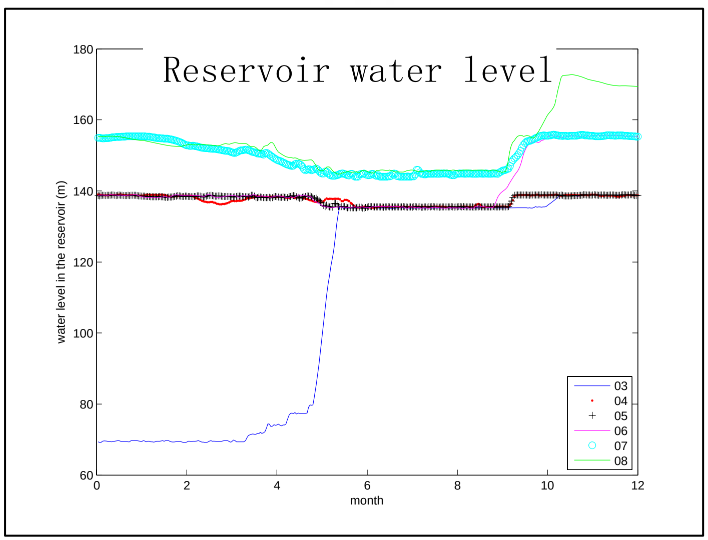
TP concentration of Lake Poyang /mg . L-1
2.5
2.0
1.5
1.0
0.5
0.0
1984
1987
1988
1989
1990
1991
1992
1993
1994
1997
2000
2001
2002
2003
2005
2006
2007
2008
2009
2010
2011
Year

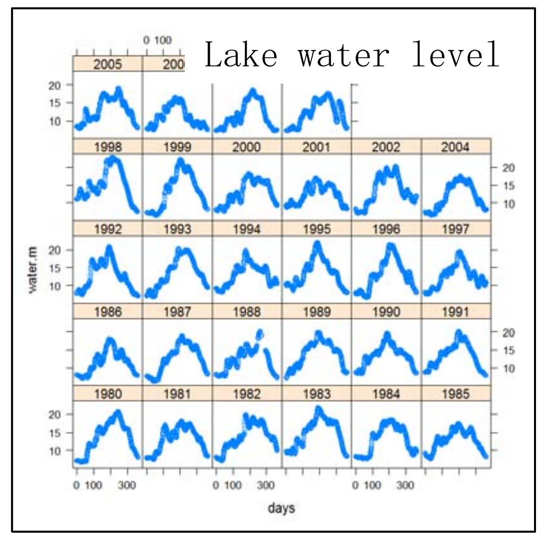
The Three Gorges Dam Effect



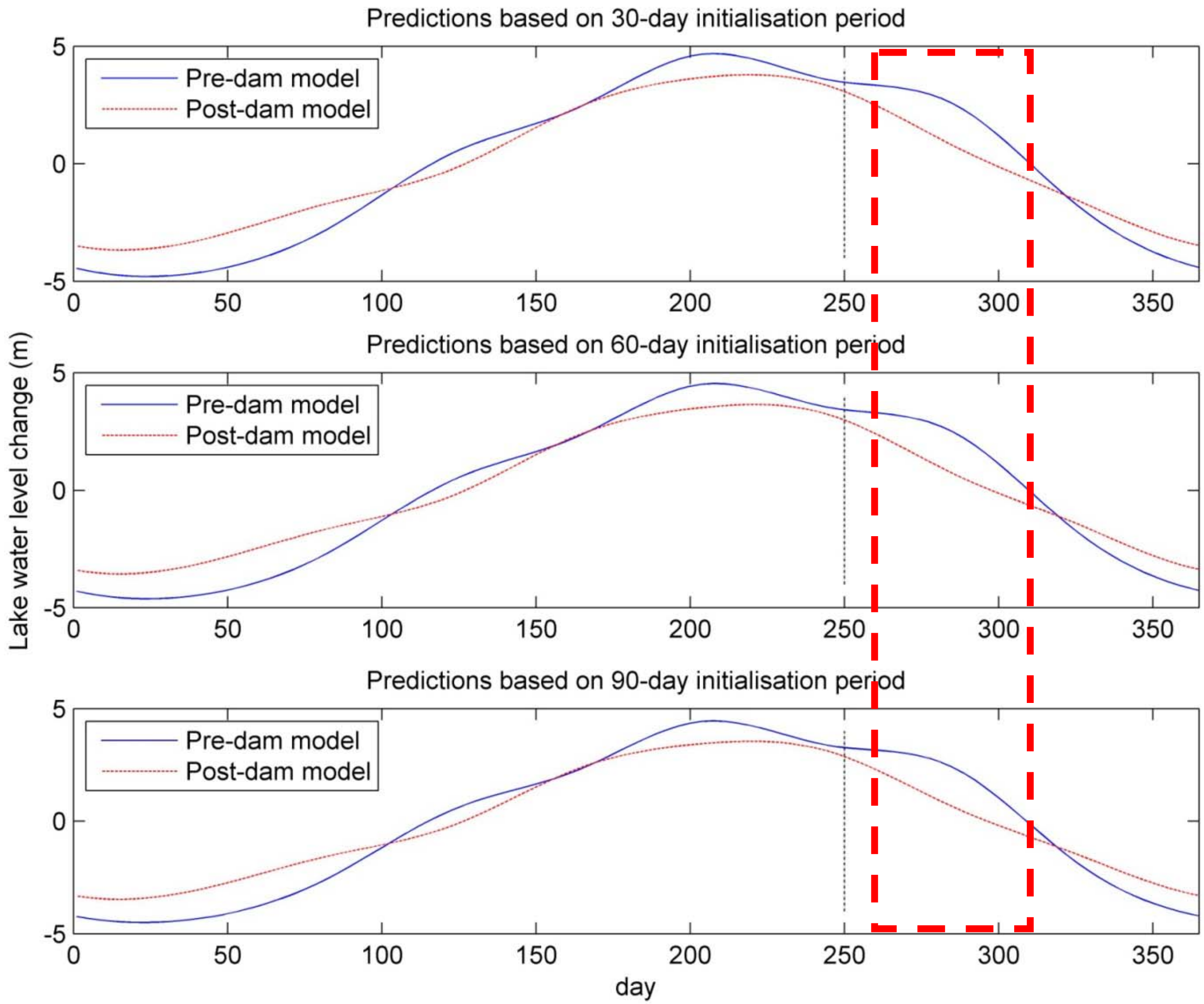
Water level changes in the Three Gorges Reservoir







A modeling assessment of effects of TGD using Generalized Additive Model

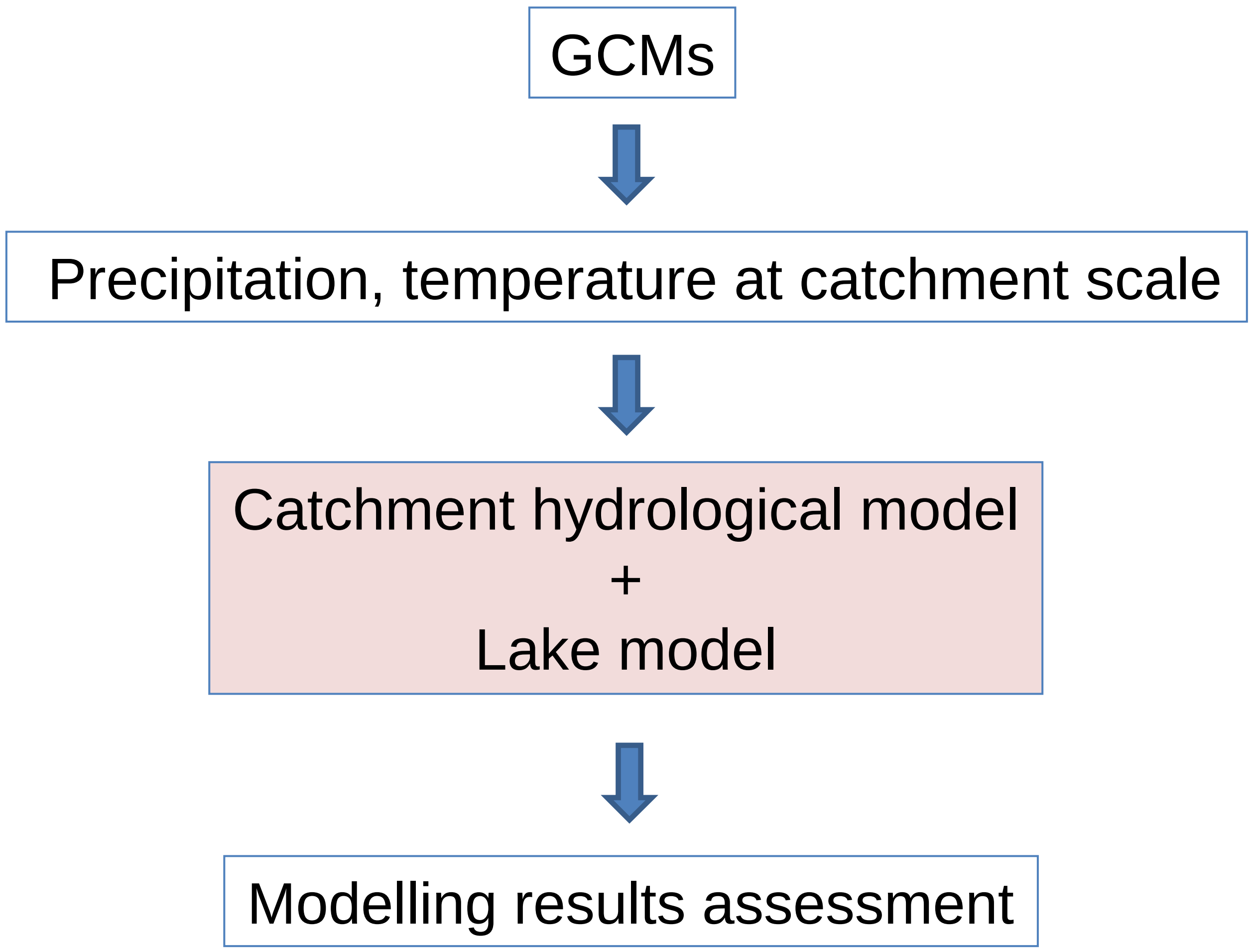


A max. 2m drop in water level at junction of River and Lake in Sep.-Oct. caused by operation of reservoir

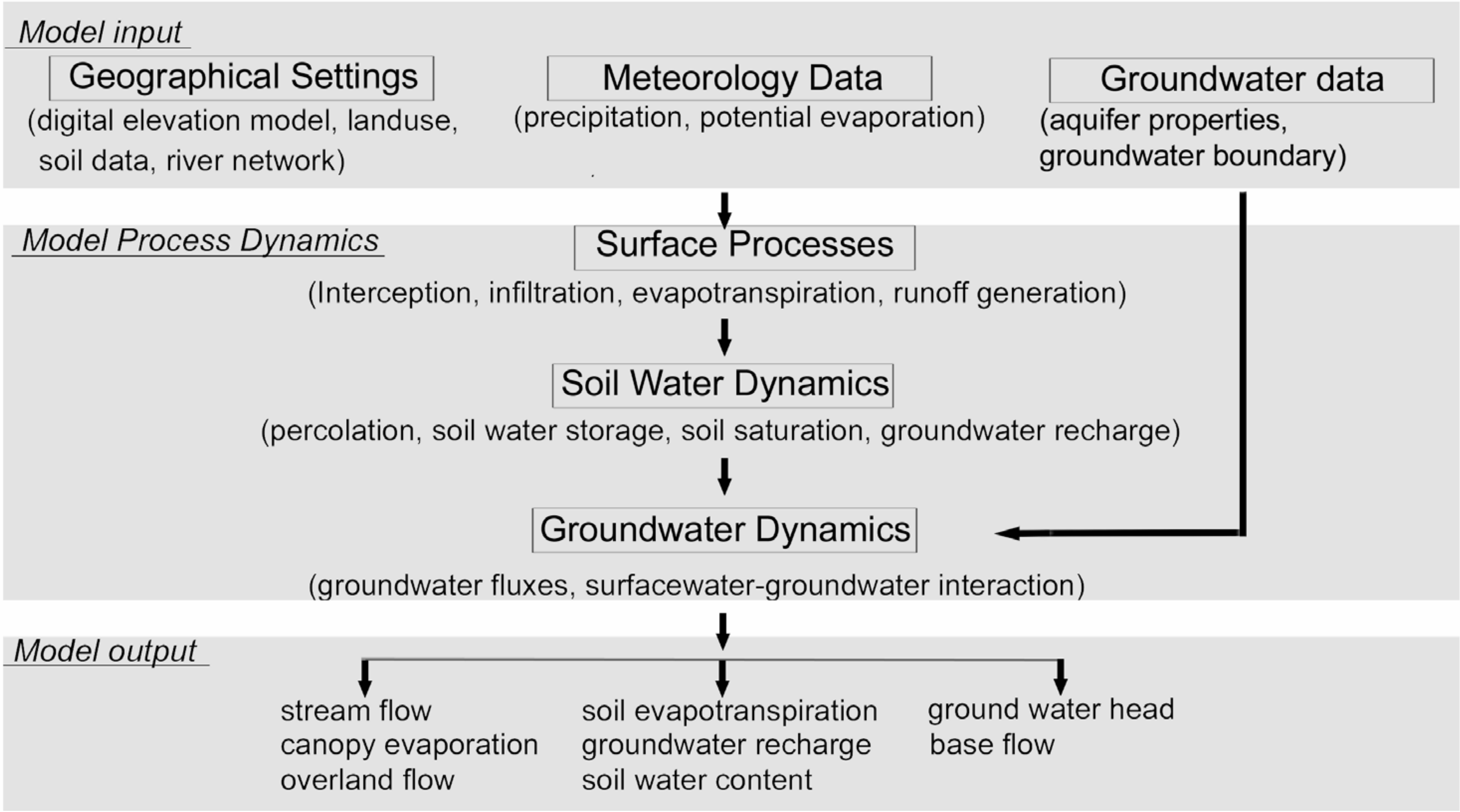
(Zhang et al 2012 GRL)

Impact of Future Climate Changes

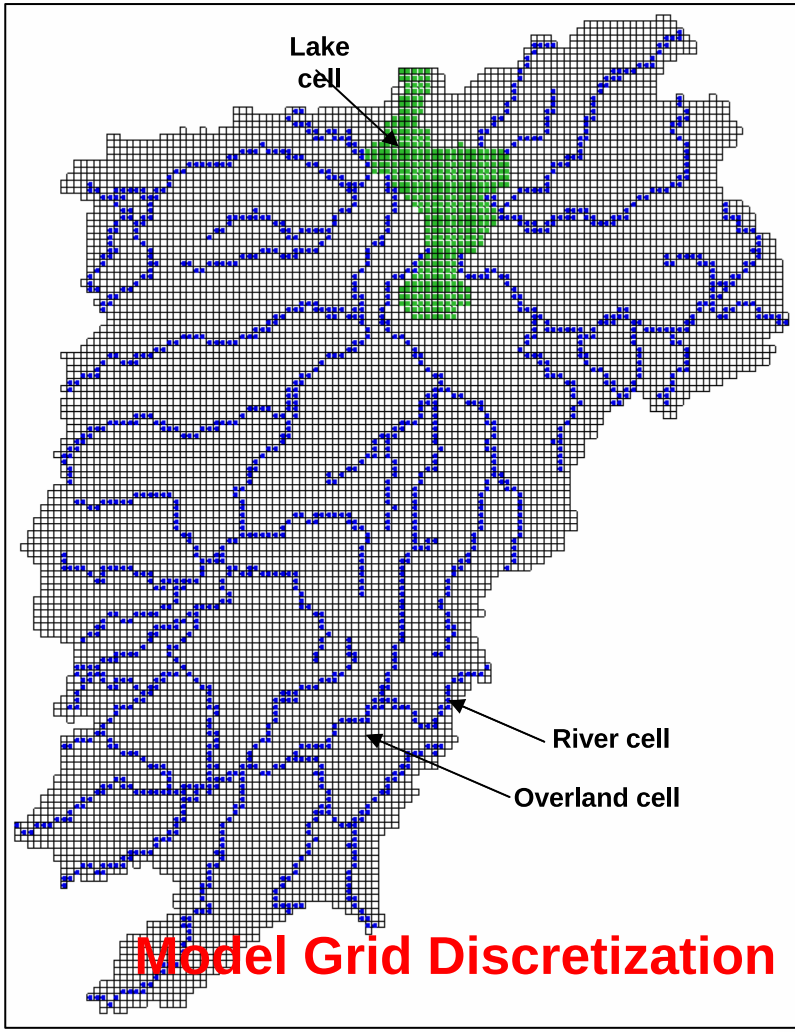
Modelling Framework

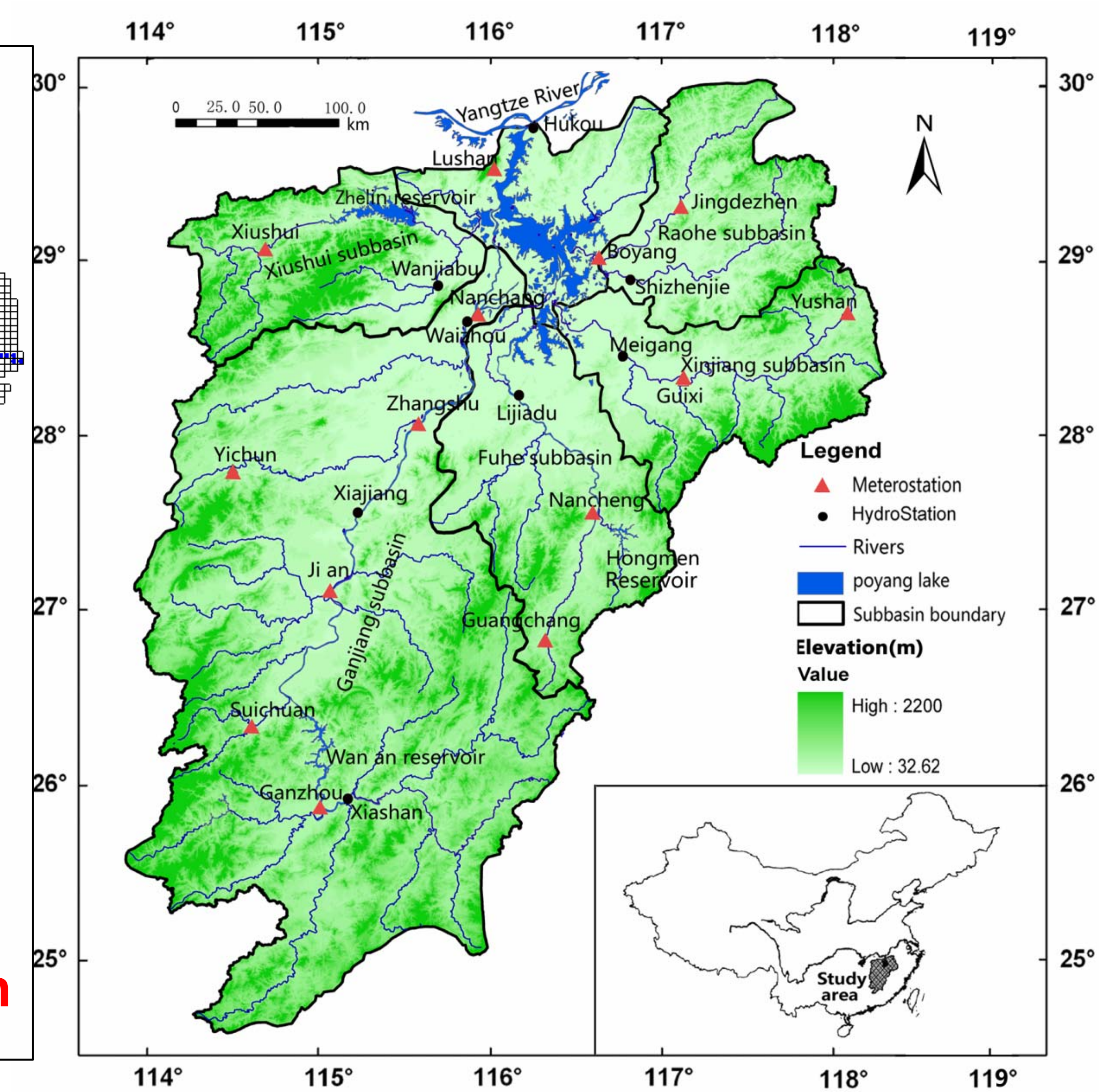


rid-based fully coupled surface runoff-groundwater flow mode (WATLAC)

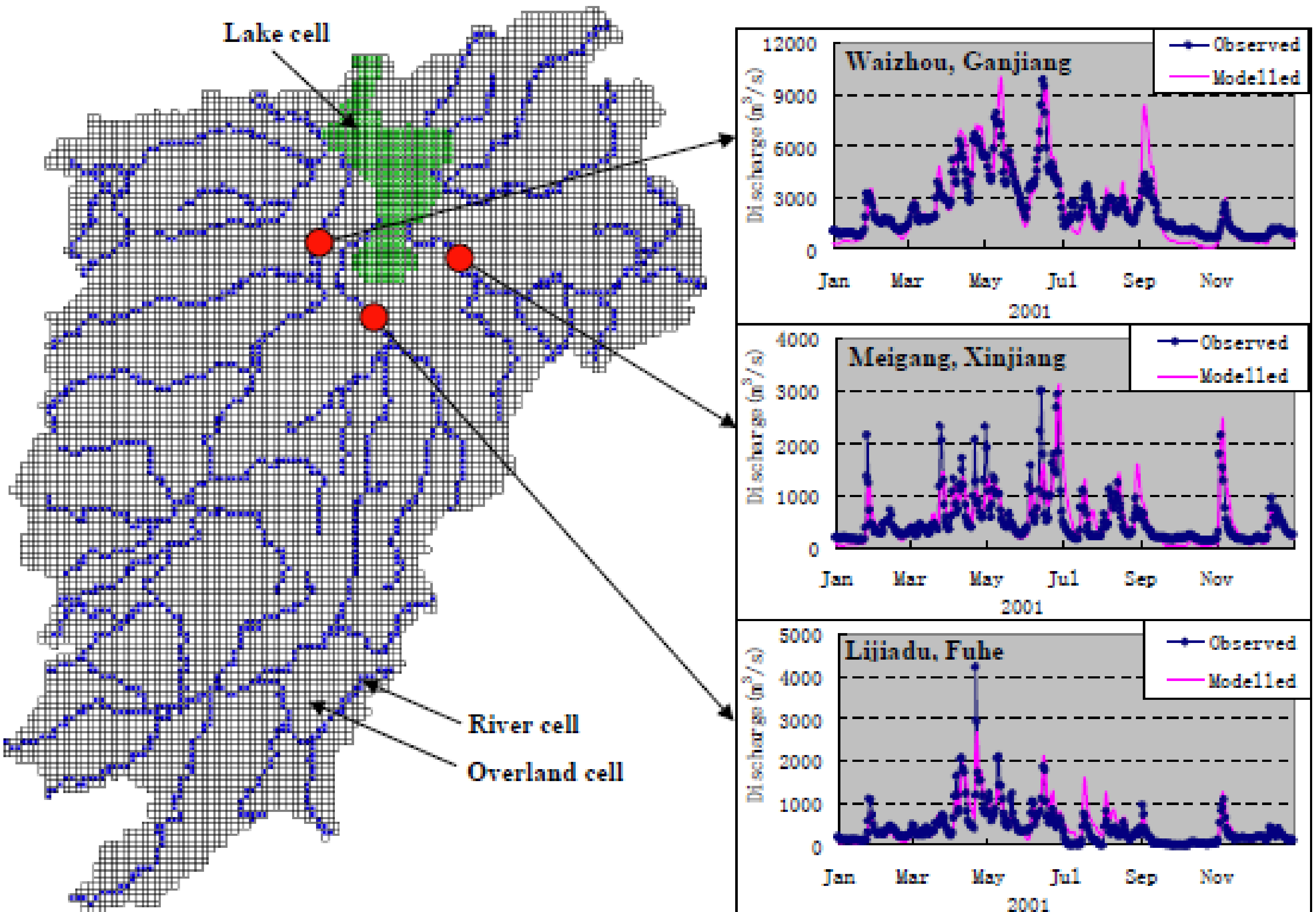


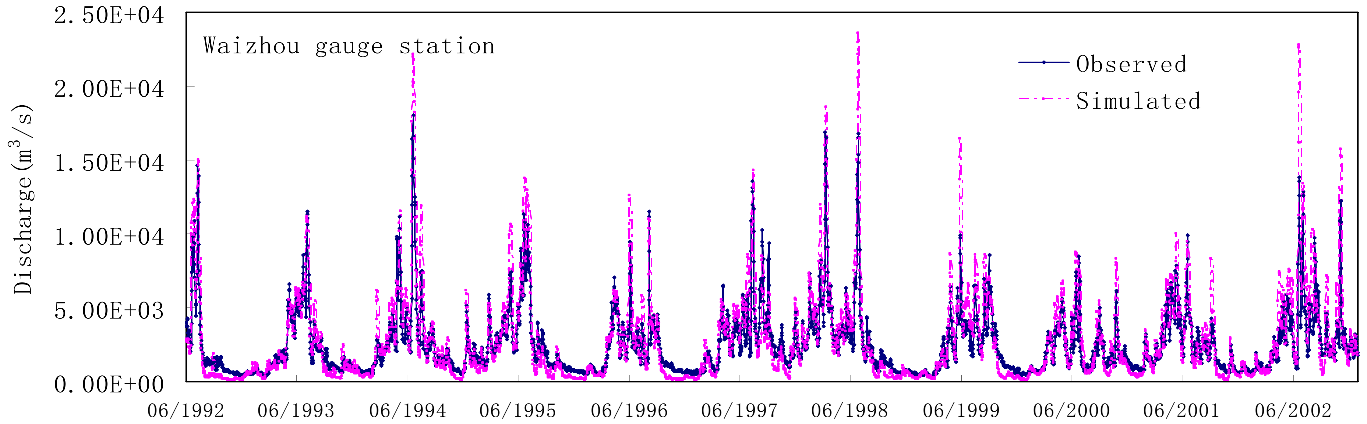
Poyang Lake Catchment Model

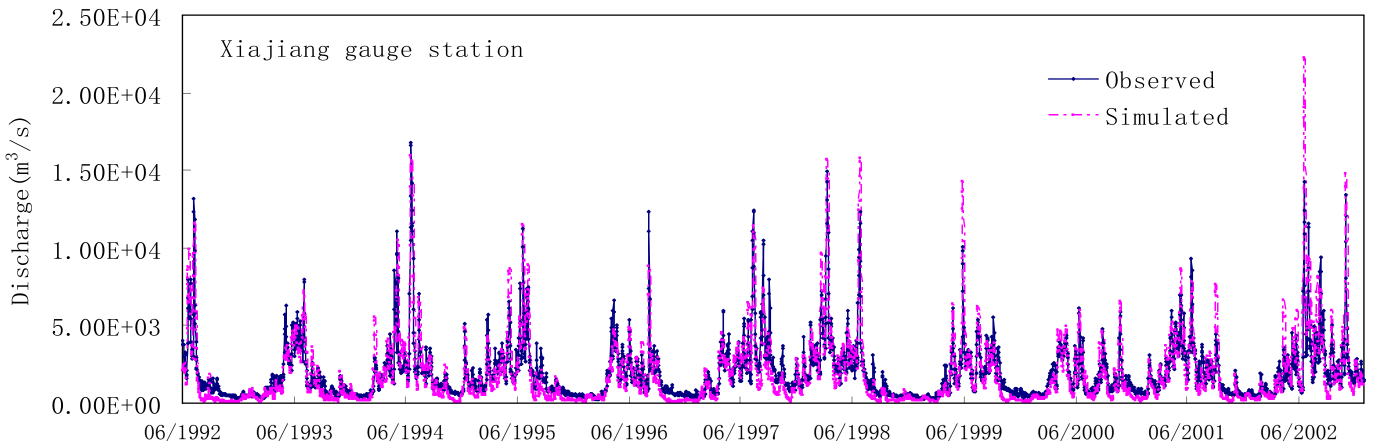


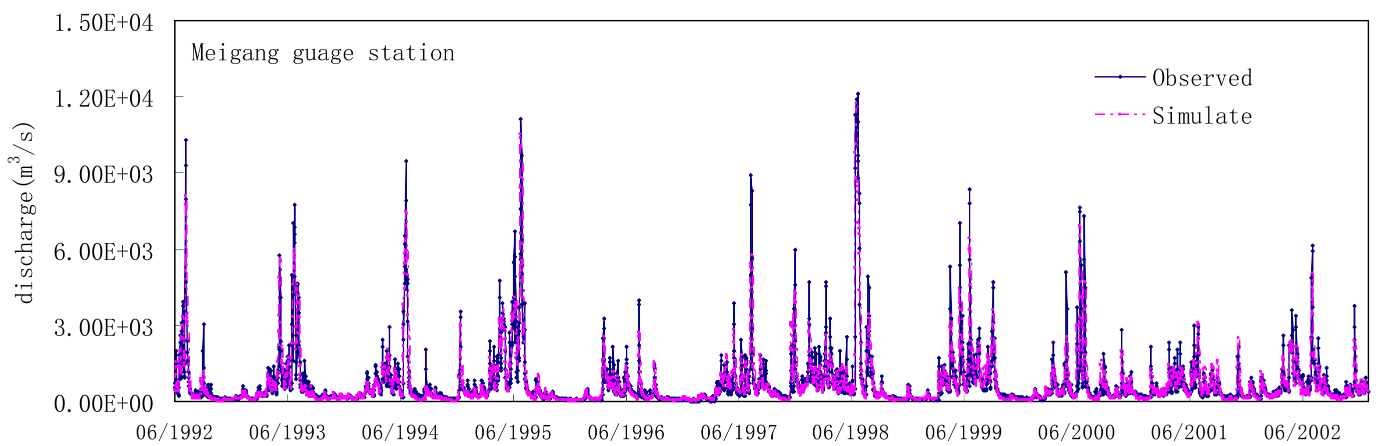


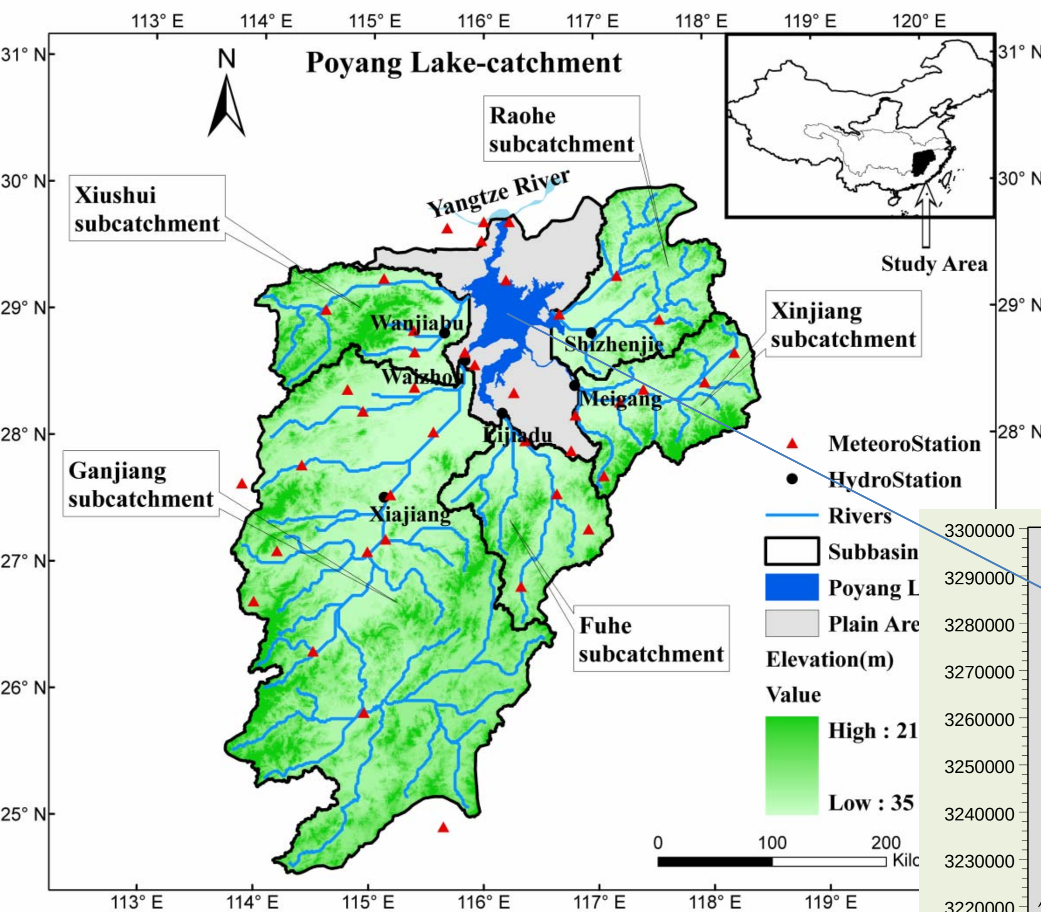
Model calibration and verification



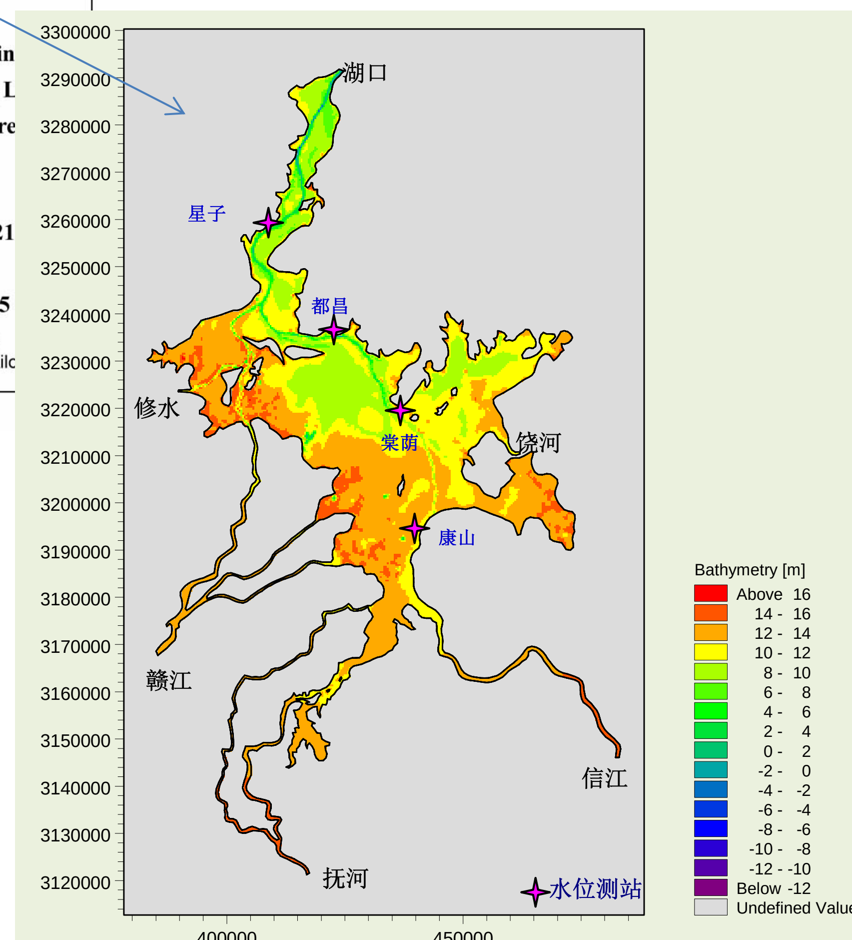

Waizhou gauge station
Observed
Simulated
Discharge(m3/s)
2.50E+04
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
06/1992
06/1993
06/1994
06/1995
06/1996
06/1997
06/1998
06/1999
06/2000
06/2001
06/2002


Xiajiang gauge station
Observed
Simulated
Discharge(m3/s)
2.50E+04
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
06/1992
06/1993
06/1994
06/1995
06/1996
06/1997
06/1998
06/1999
06/2000
06/2001
06/2002

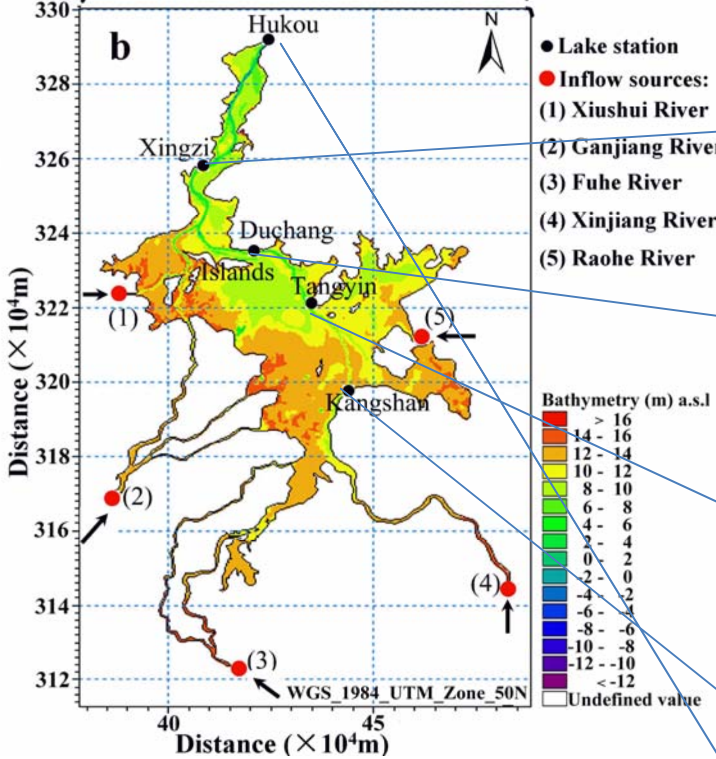

Meigang guage station
Observed
Simulate
discharge(m3/s)
1.50E+04
1.20E+04
9.00E+03
6.00E+03
3.00E+03
0.00E+00
06/1992
06/1993
06/1994
06/1995
06/1996
06/1997
06/1998
06/1999
06/2000
06/2001
06/2002

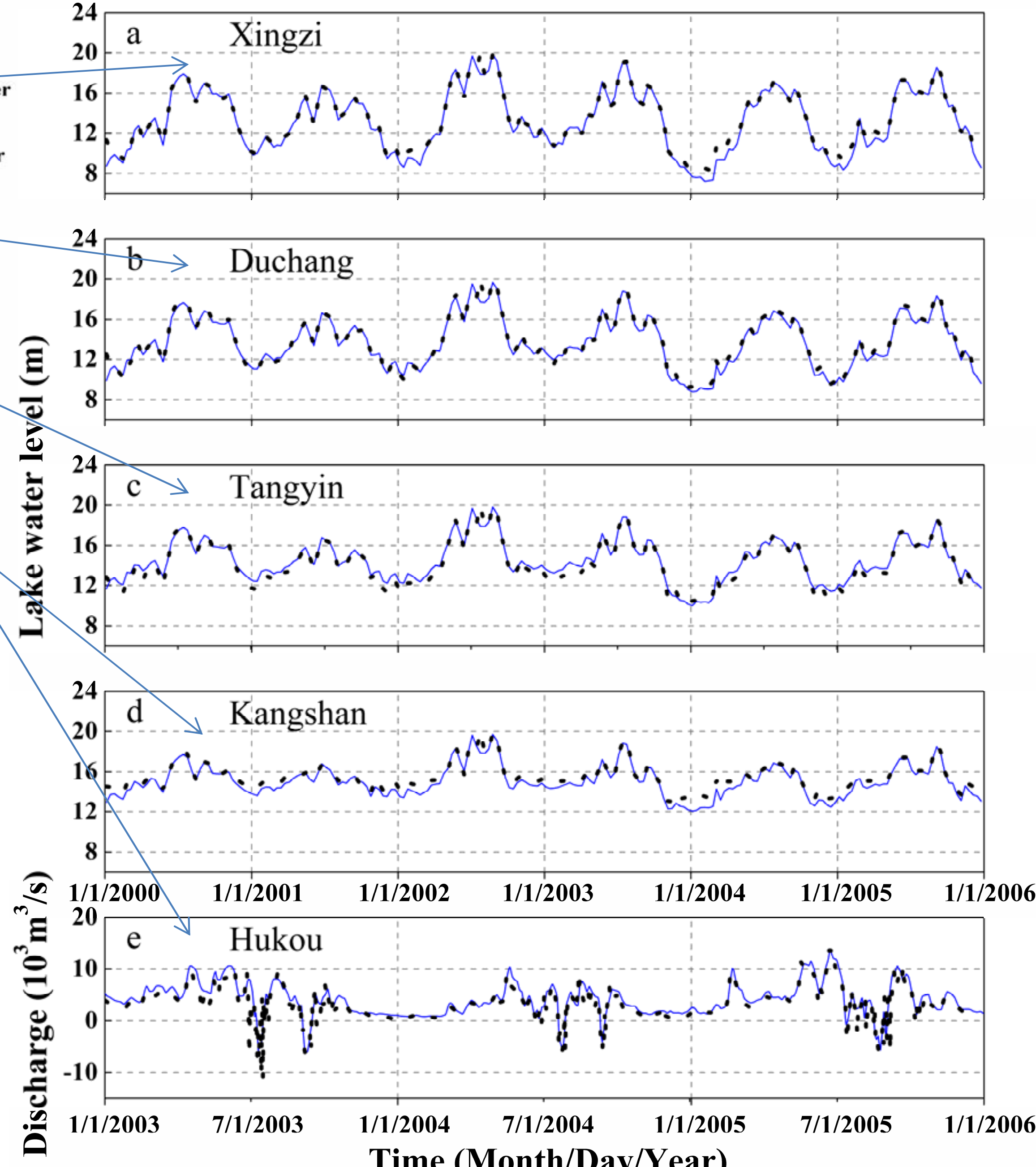


Catchment discharge prediction using WATLAC



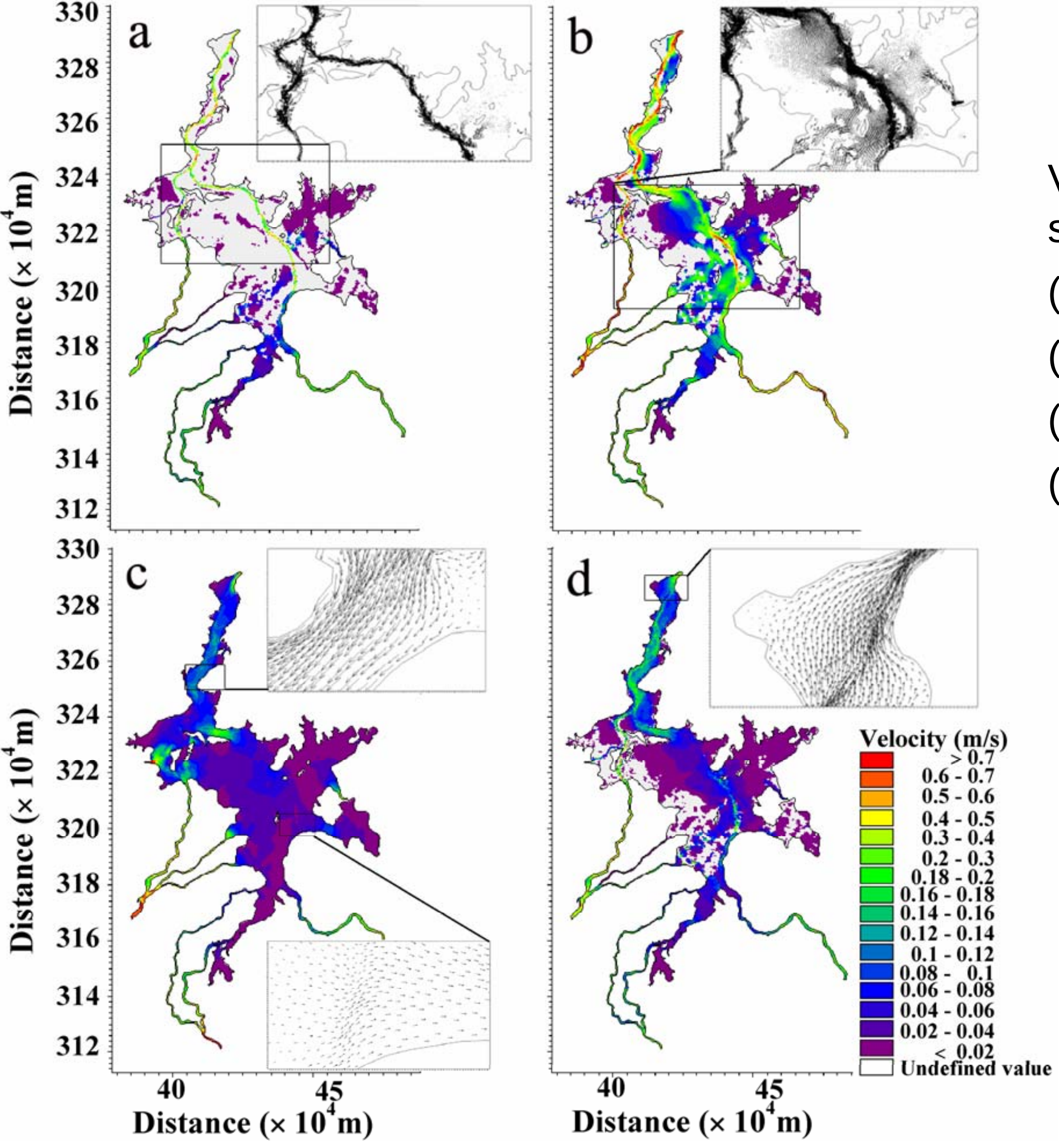
Lake hydrodynamics modeling using MIKE 21





Comparison of simulated water level and flow rate with the observed ones

(Li et al 2014 JHE)



Velocity magnitude (in m/s) at selected time slices:

(a) January 15 (WL=10.8 m)

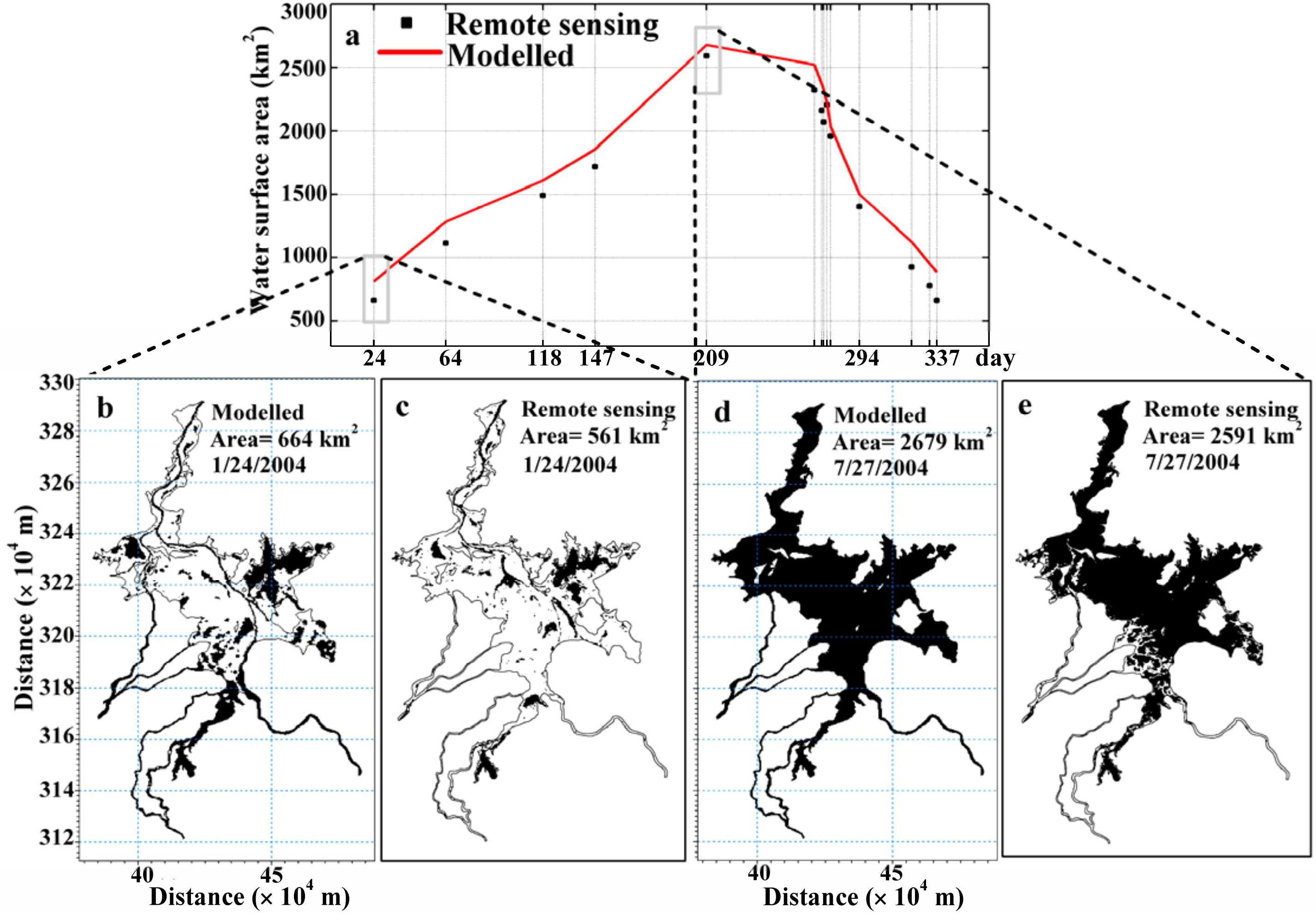
(b) April 15 (WL=12.8 m)

(c) September 2 (WL=17.8 m)

(d) October 15 (WL=14.8 m)

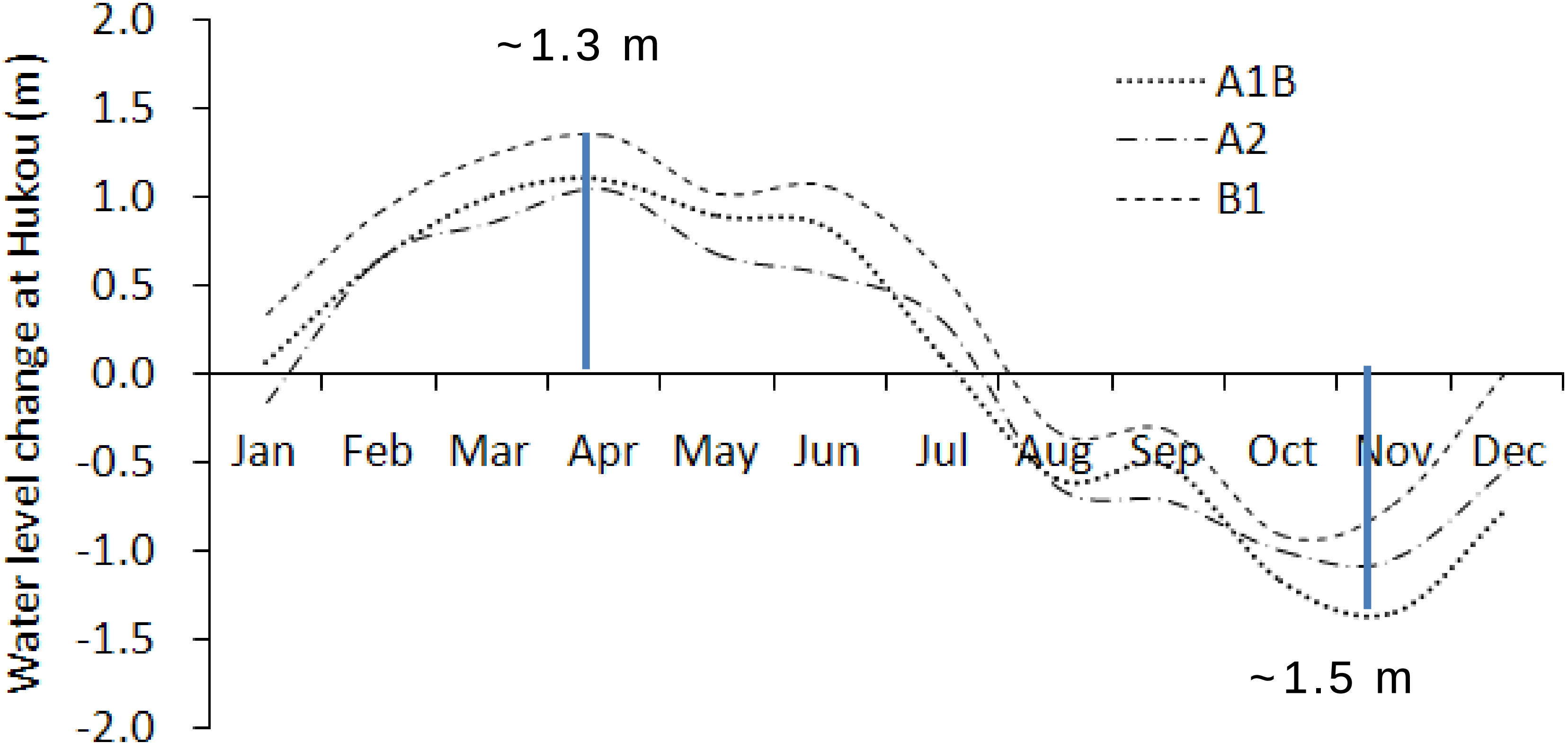
Assessment of simulated flow pattern and lake water area for different water levels in 2005

Simulation of seasonal variation of lake water surface



Future climate change predictions

- Model: ECHAM5
- Scenarios: SRES - A2 (high emission), A1B (mid-range emission) and B1 (low emission)
- Statistical downscaling model (SDSM) was adopted to establish statistical relationships between the ECHAM5 output and local weather station variables;
- Period: to 2050



The lake may get wetter in wet season and drier in dry season

(Ye et al 2011 QI)

Conclusions

- In the last decade, Poyang Lake was generally drier than the long-term average condition. The reduction in Lake storage may influence the Lake water quality resulting in an increase in TP and TN concentrations.
- The dominant influencing factor was the lowered stage of the Yangtze River, resulted from a combined effect of climate changing and the operation of the Three Gorges Dam;
- The draining effect of the Yangtze River on the Lake was greater than we thought. Management strategies should be more focused on manipulating the seasonal flow of the Yangtze River and the lake-river interactions;
- Under future climate changing, the Lake may become wetter in wet season and even drier in dry season. With the high demand in energy and the rapid development in hydraulic engineering in China, more dams are to be built in the Yangtze River, putting significant pressure on the management of water resources in the downstream;

Poyang Lake catchment

Acknowledgements

- Research funding from Ministry of Science and Technology of China, and National Natural Science Foundation of China;
- Contributions from team members Dr X.-H. Li, Dr Y.-L., Li, Dr Y. Jin, Dr X.-C. Ye, Dr D. Zhang, and postgraduate students;

Thank You for Attention!

qzhang@niglas.ac.cn (Qi Zhang)