Lateral Exchanges Control ET Seasonality in a Tropical Watershed: Analysis with PAWS+CLM

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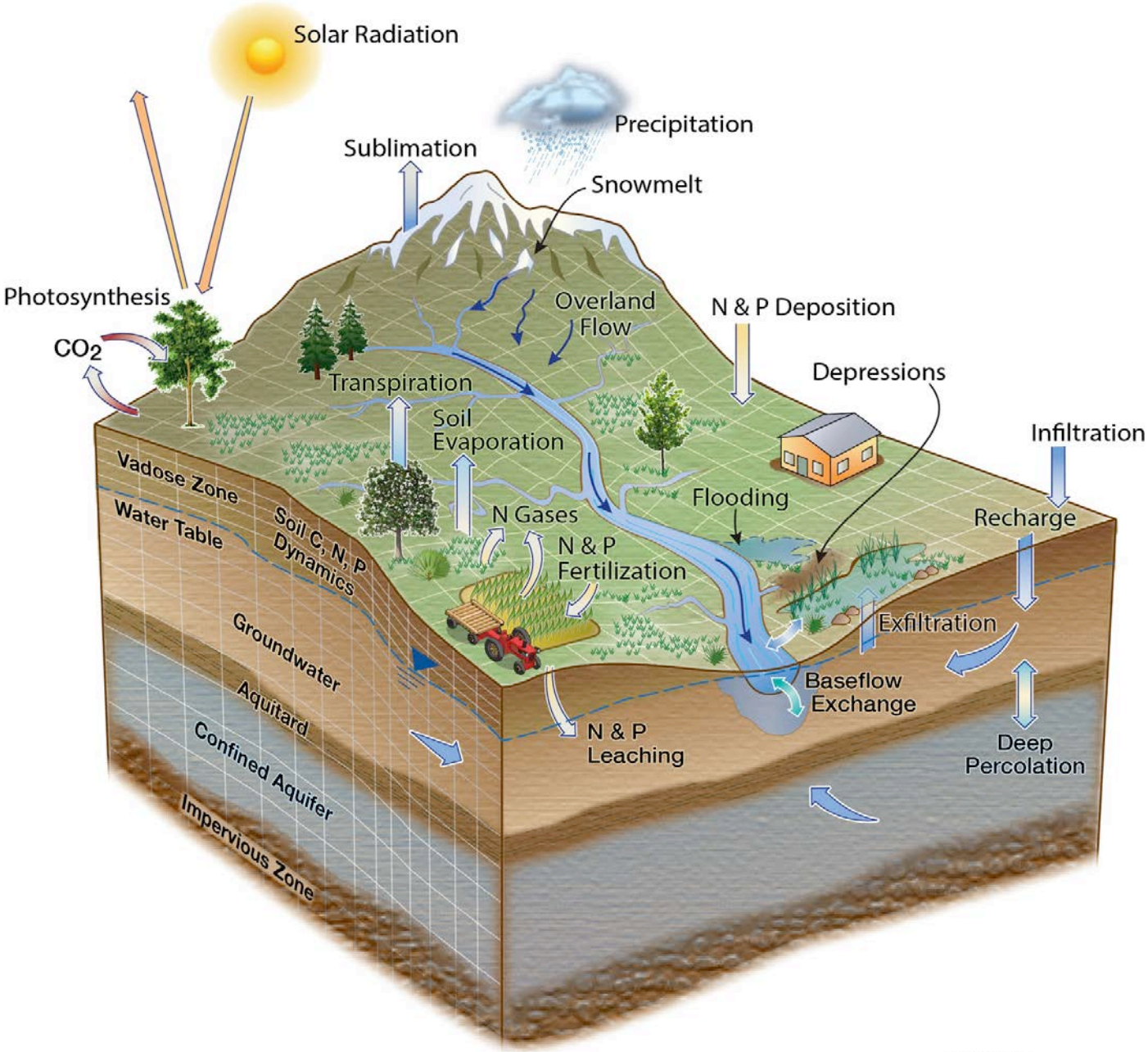
Goals

- Develop 3D hydrological and biogeochemical model for an upland tropical watershed
- Investigate spatial structure, dynamics, and controls on exchanges with the atmosphere
- Inform requirements for ESM scale land models

PAWS+CLM Description

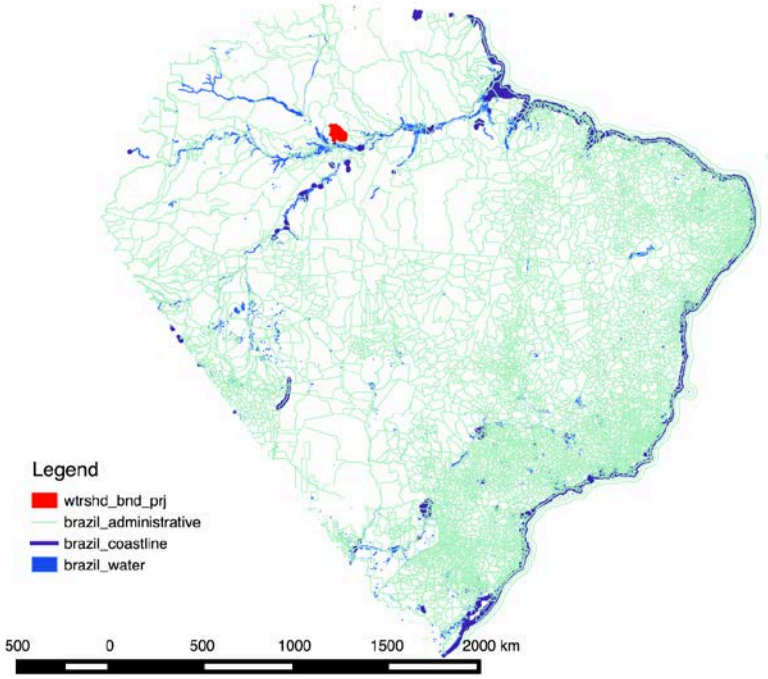
- 3D surface, vadose zone, and GW hydrological and BGC model
- Tested and applied in several temperate watersheds

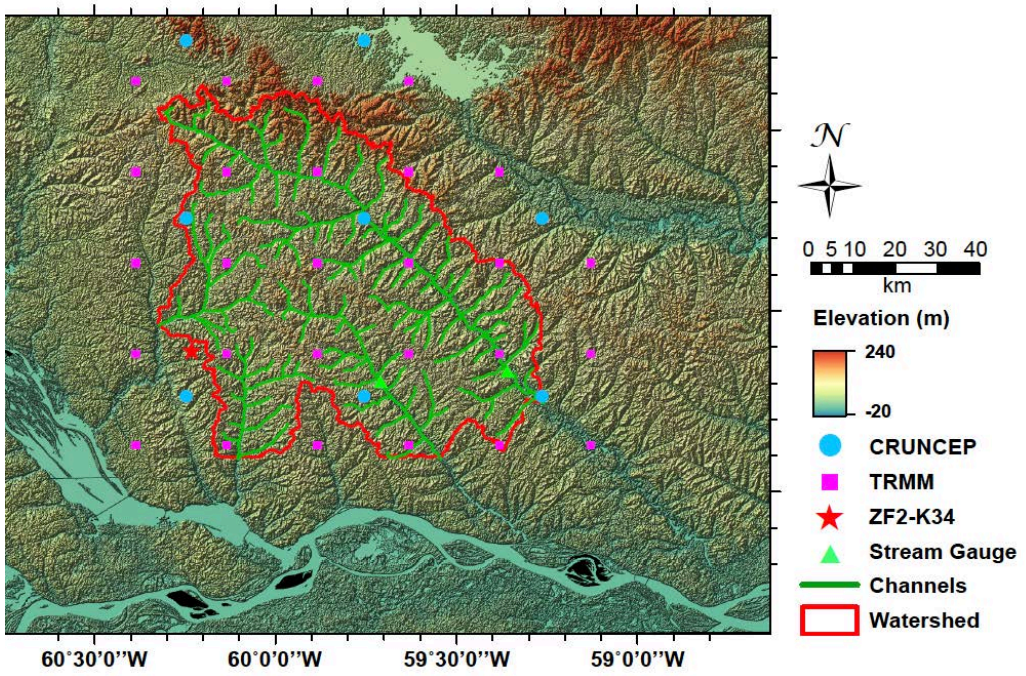


Shen and Phanikumar (2010); Riley and Shen (2014); Shen et al. (2015)

Simulations Setup

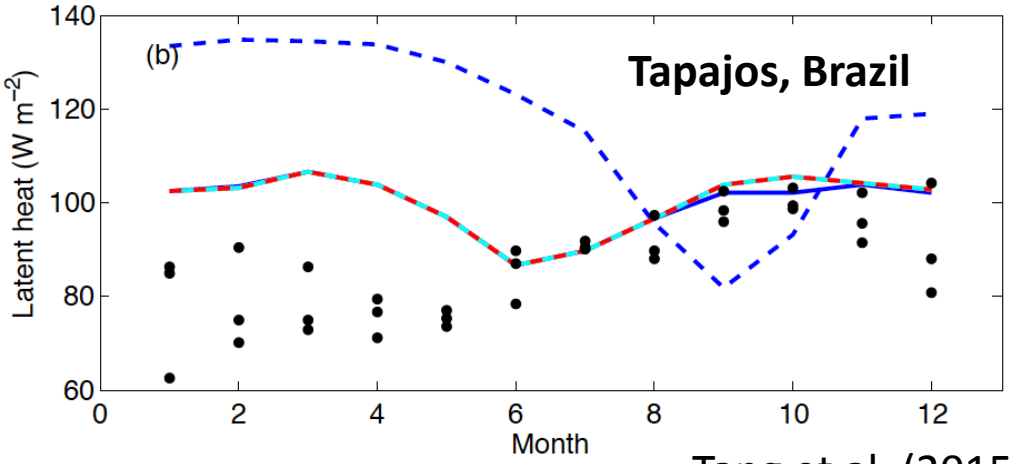
- We applied PAWS+CLM to a 9000 km^2 watershed near Manaus, Brazil (NGEE-Tropics)
  - Niu et al. (submitted J. Hydrology)
  - 1 km^2 discretization
  - Channels delineated with 30 m NASA SRTM
  - Several climate forcings (CRUNCEP, TRMM, tower)
  - Calibration
    - Hydraulic conductivities, van Genuchten parameters, riverbed leakance





Simulations

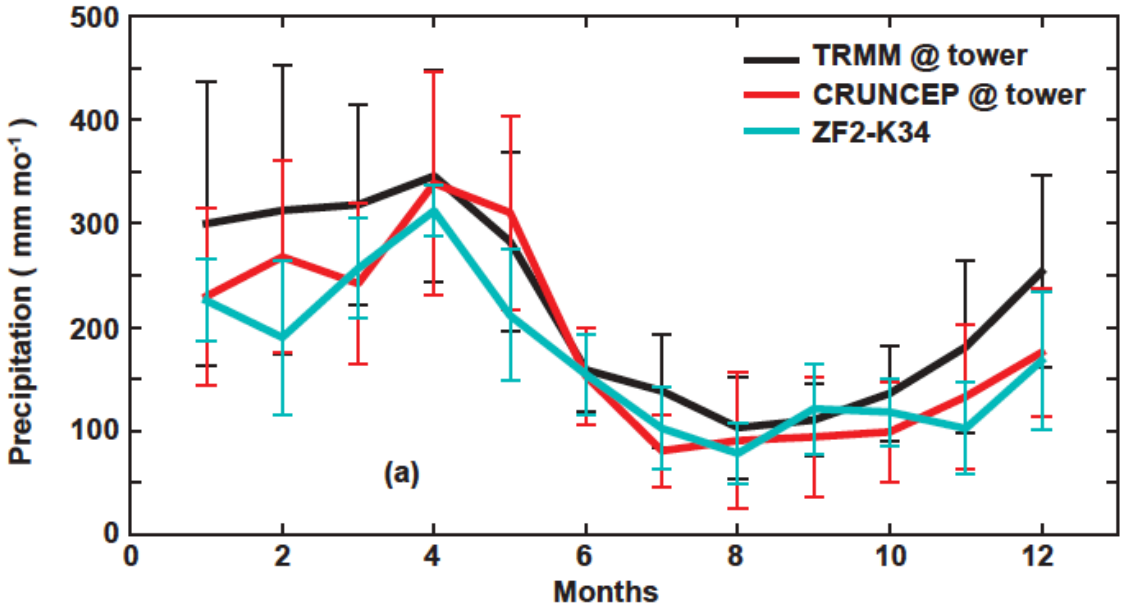
- Temporal and spatial correlation analyses
  - Characterize factors influencing hydrological and carbon budgets
  - Explain spatial variability of hydrological components
- Model experiments to investigate controls on ET seasonality
  - Full 3D model
  - No GW lateral flow
  - No overland flow
  - No channel flow
- Wavelet analysis to characterize phase relationships

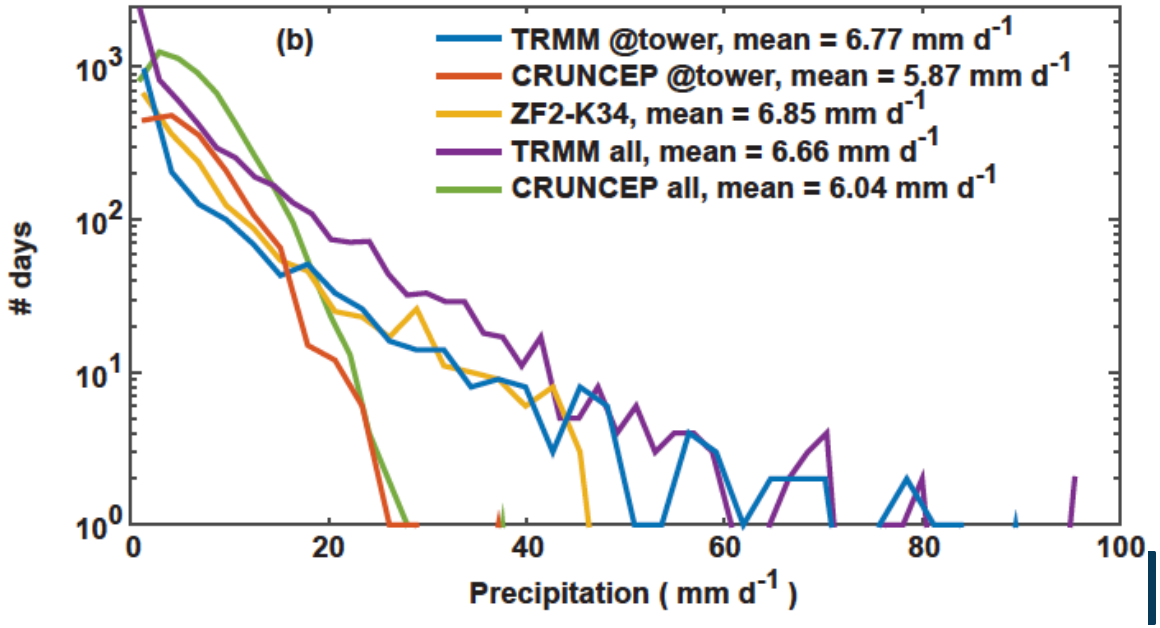


Tang et al. (2015)

Model Testing

- Precipitation
- Streamflow
- Tower data (NEE, ET)
- MODIS LAI and ET
- FLUXNET-MTE
- GRACE





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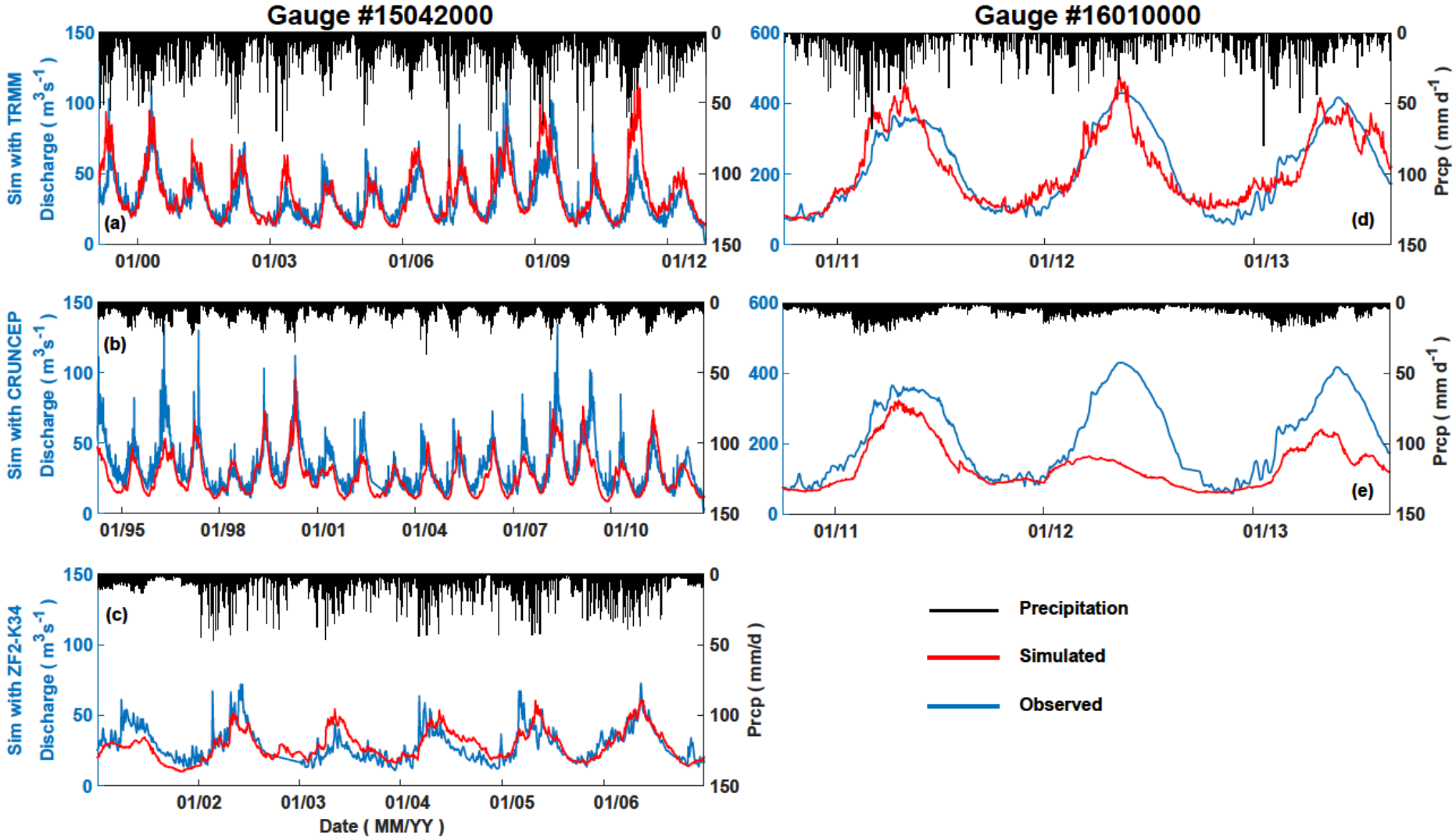
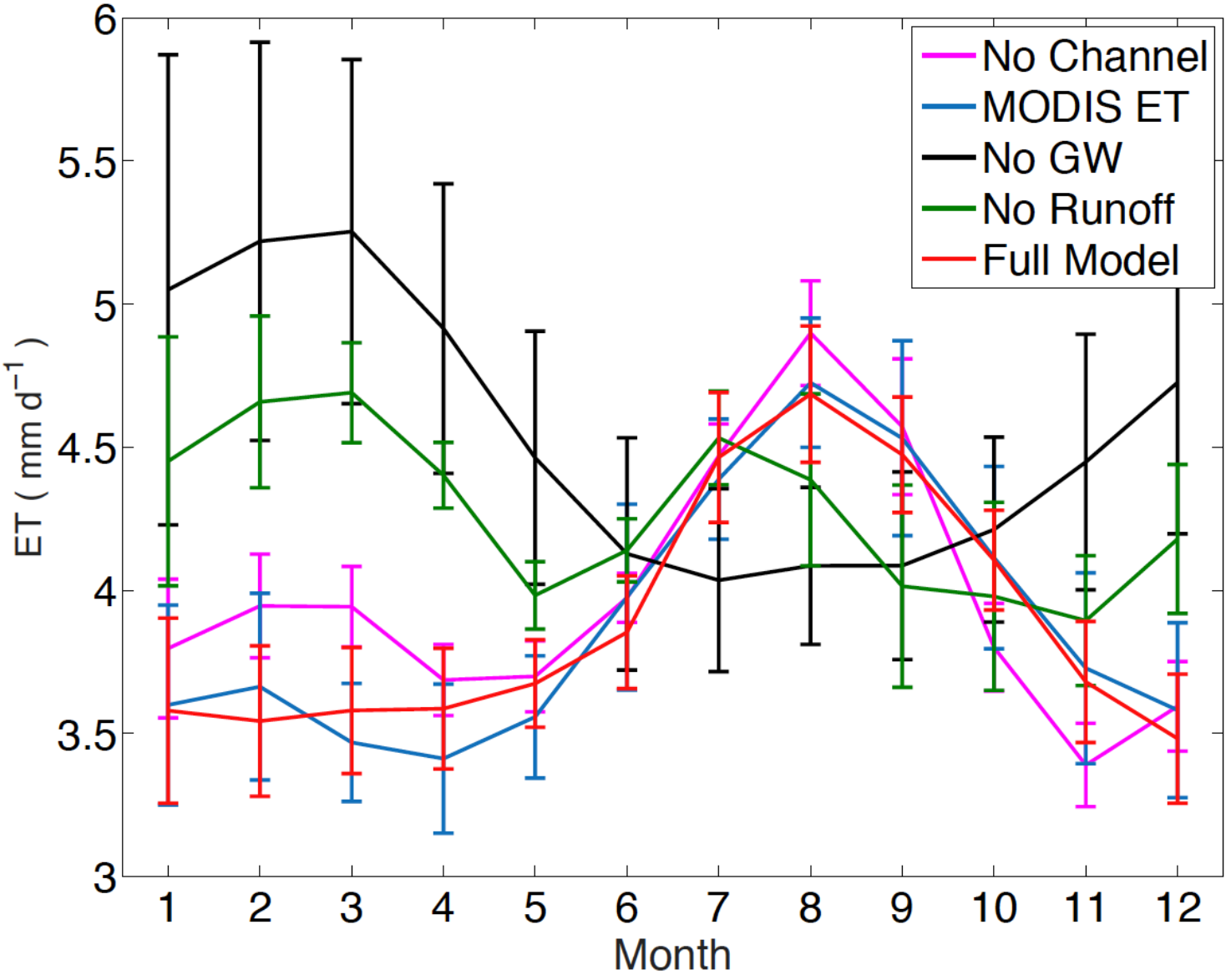
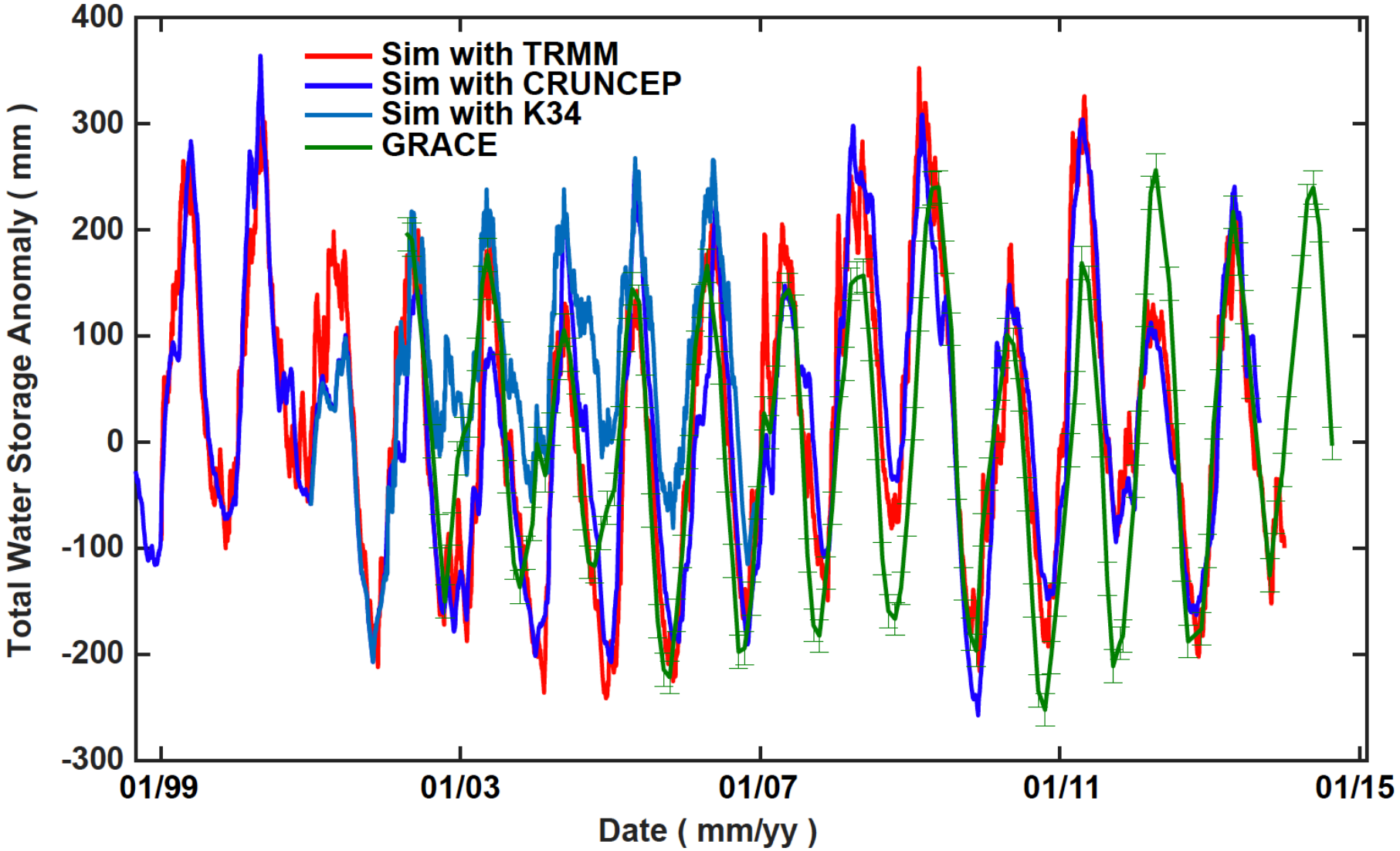
Model Testing: Streamflow



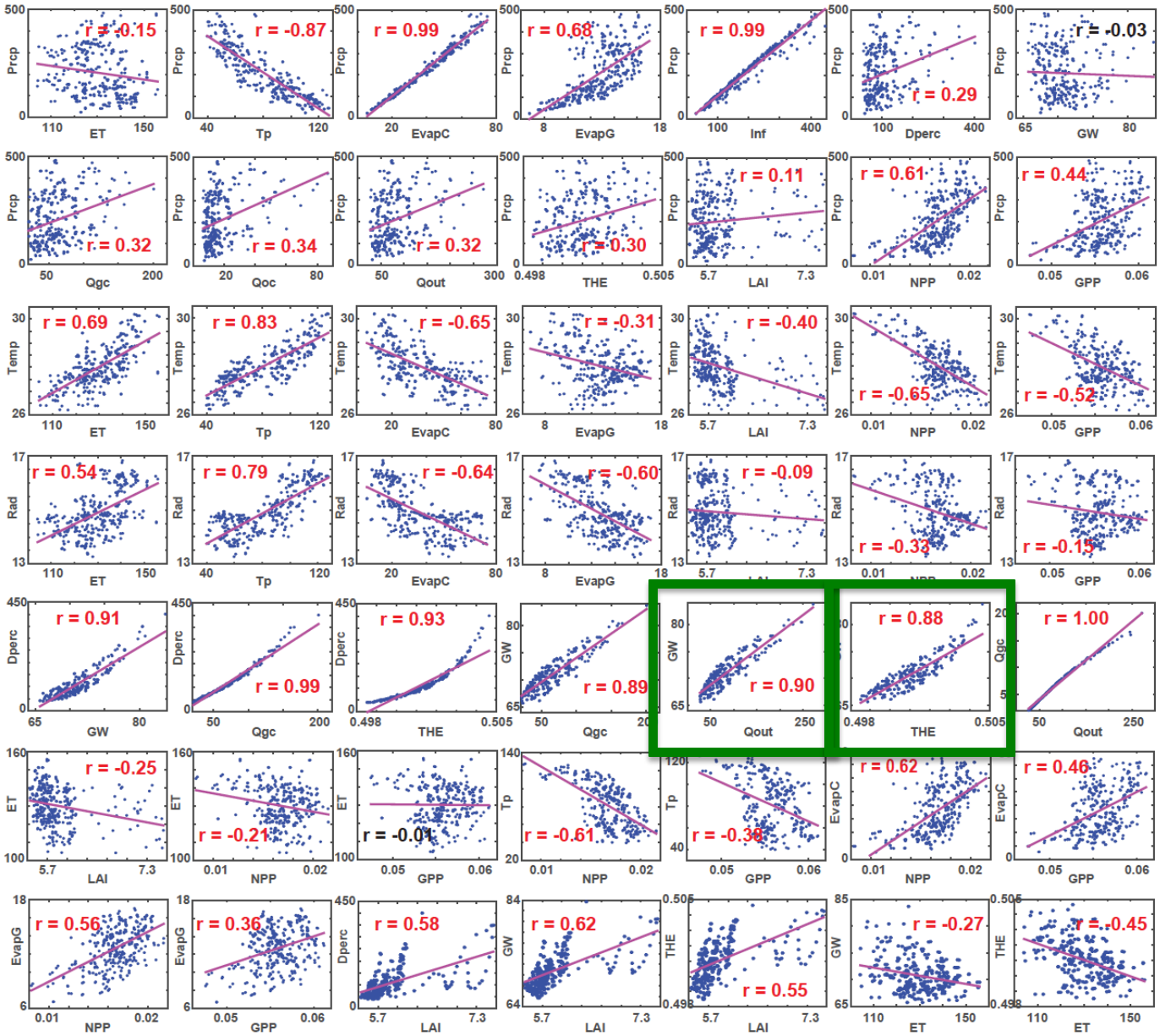
Model Testing: ET



Model Testing: GRACE



Temporal Relationships (Watershed Average)



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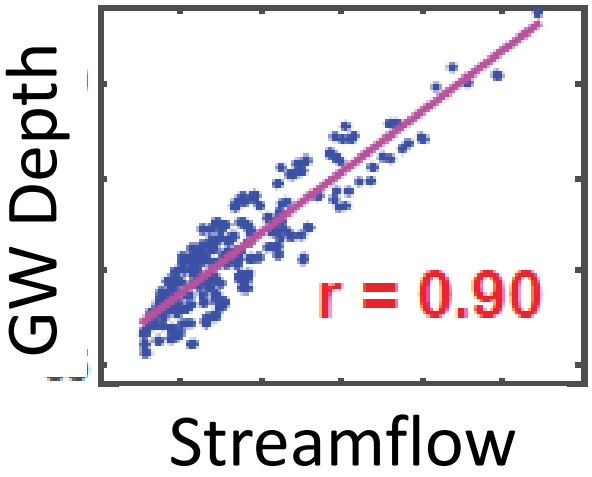
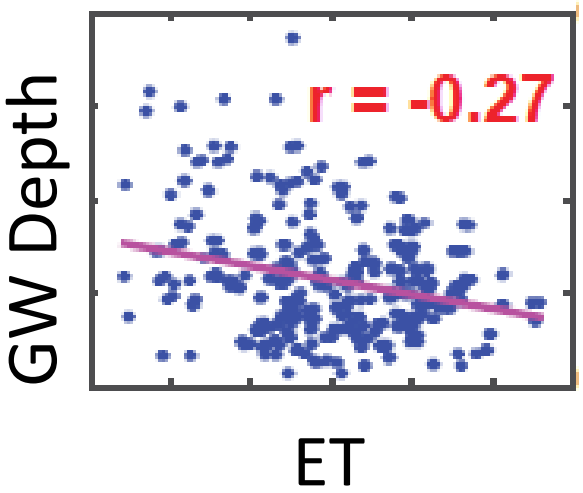
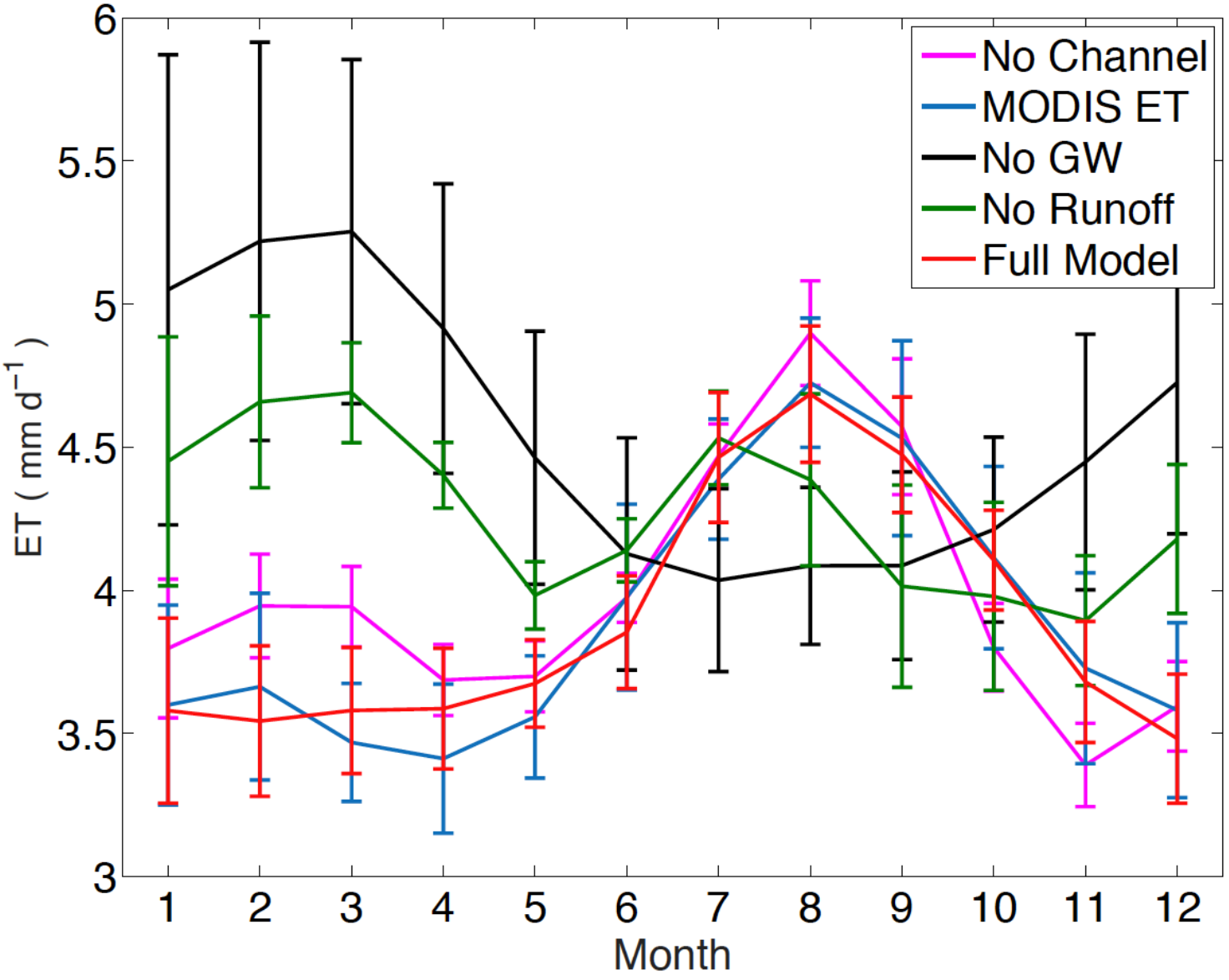
Temporal Relationships (Watershed Average)

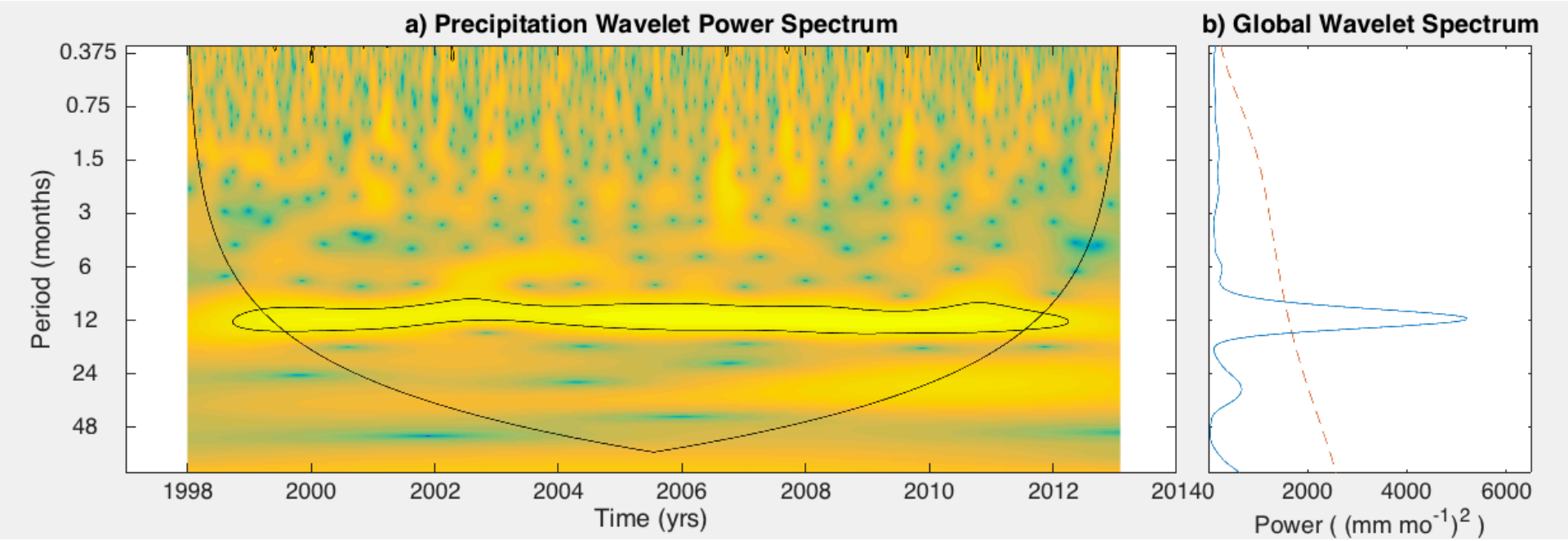


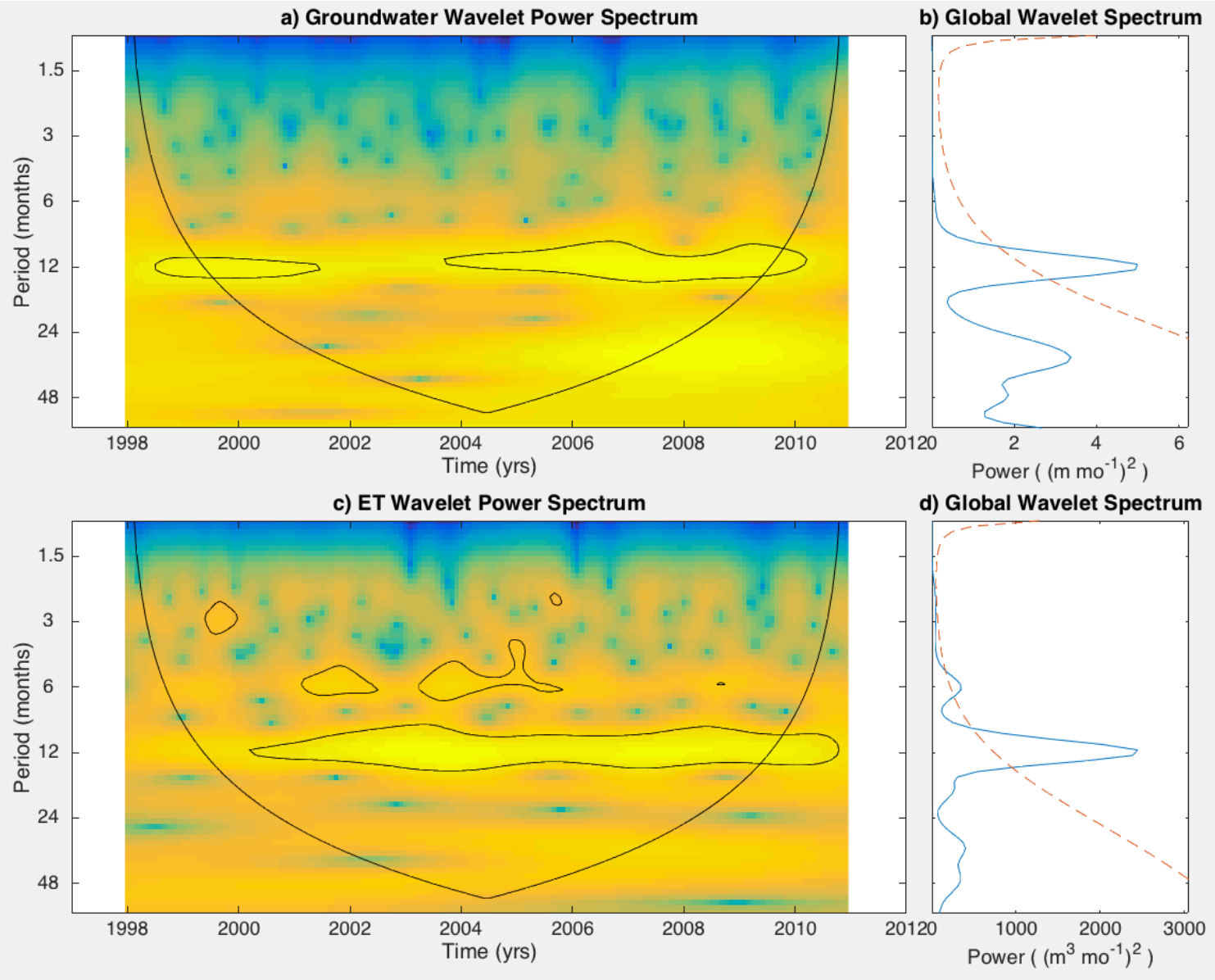


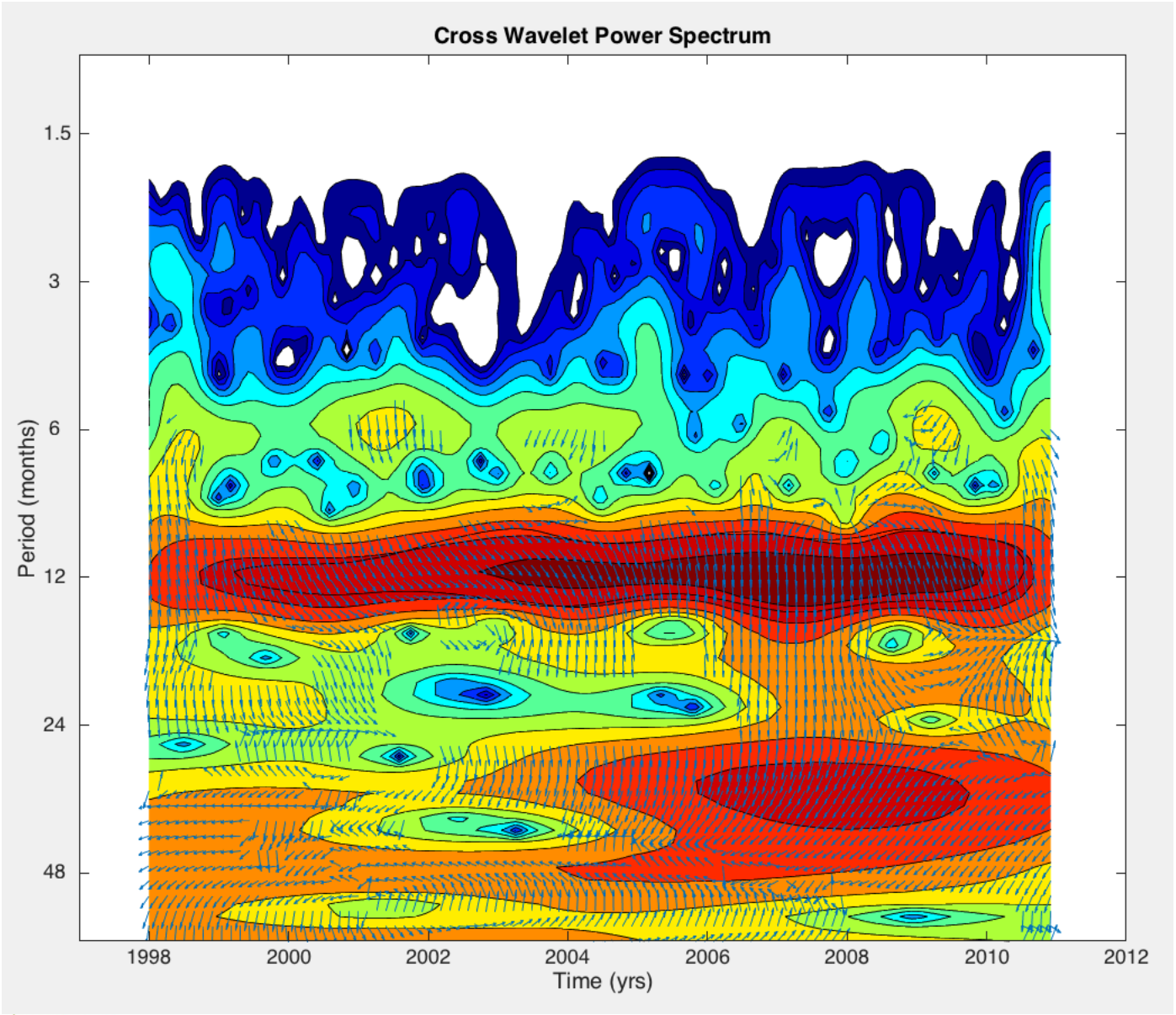
Effects of Lateral Hydrological Exchanges

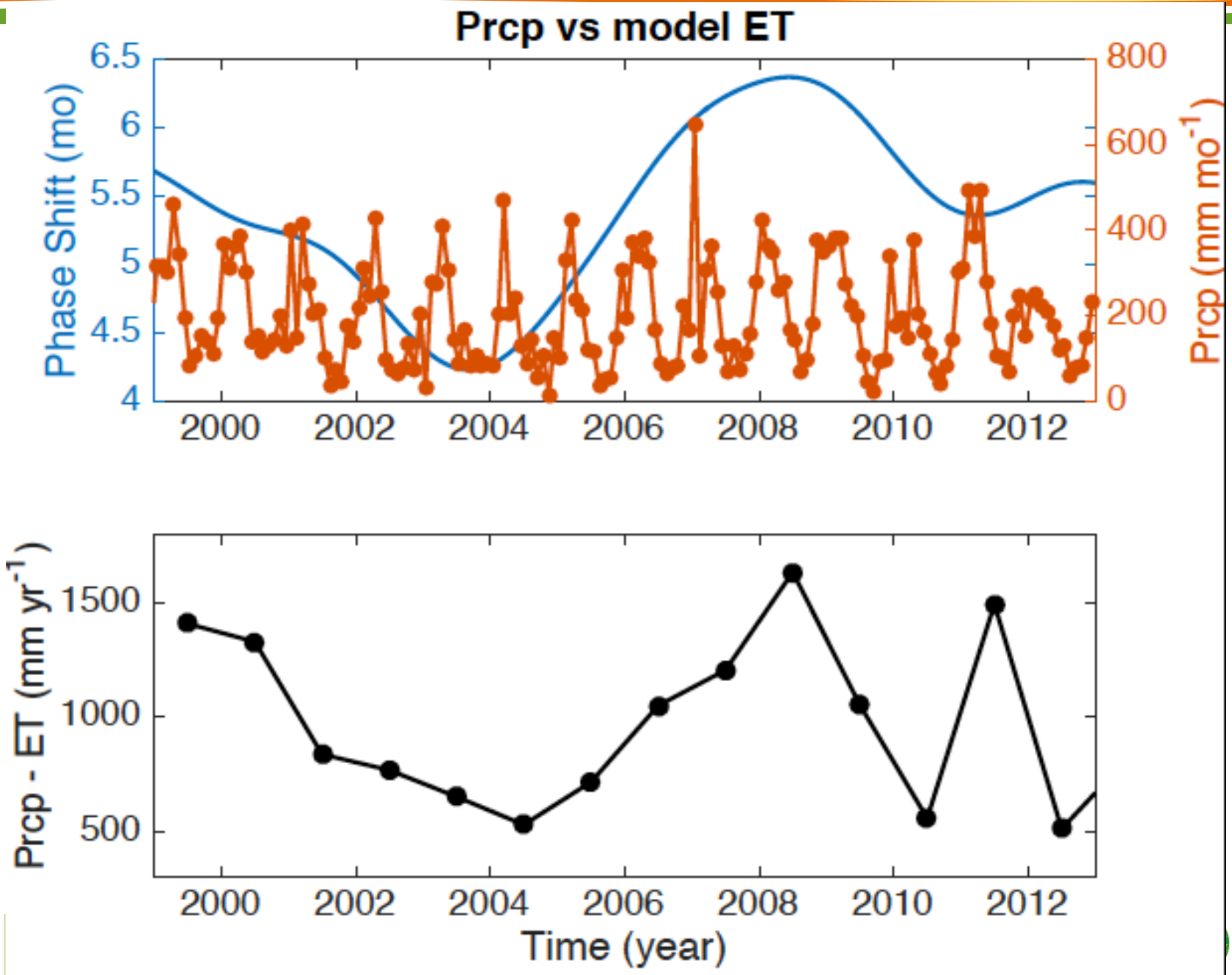


Wavelet Analysis




a) Groundwater Wavelet Power Spectrum
b) Global Wavelet Spectrum
Period (months)
1.5
3
6
12
24
48
1998
2000
2002
2004
2006
2008
2010
2012
Time (yrs)
0
2
4
6
Power ((m mo-1)2)
c) ET Wavelet Power Spectrum
d) Global Wavelet Spectrum
Period (months)
1.5
3
6
12
24
48
1998
2000
2002
2004
2006
2008
2010
2012
Time (yrs)
0
1000
2000
3000
Power ((m3 mo-1)2)

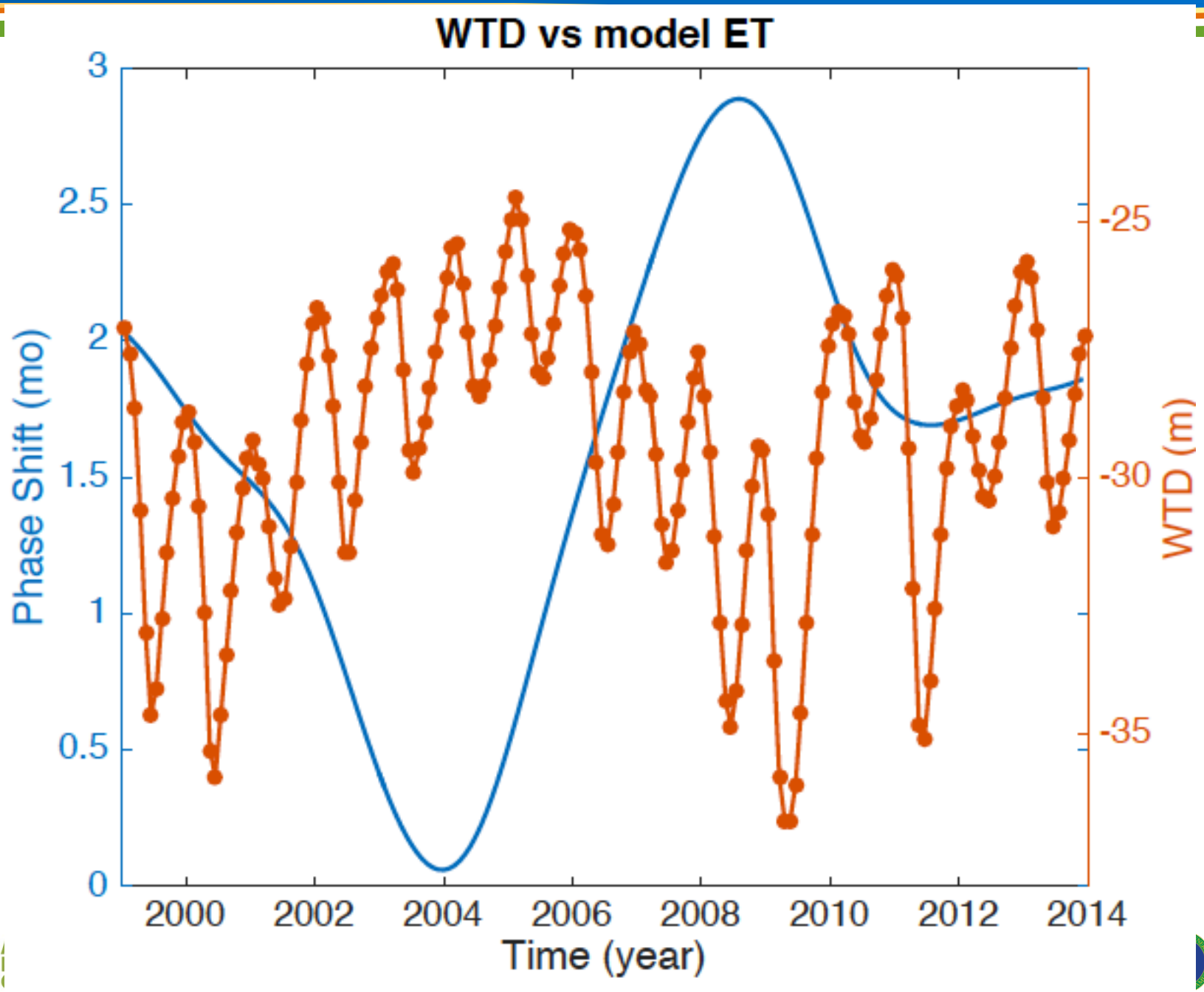

Cross Wavelet Power Spectrum
Period (months)
1.5
3
6
12
24
48
1998
2000
2002
2004
2006
2008
2010
2012
Time (yrs)


Prcp vs model ET
Phase Shift (mo)
Prcp (mm mo-1)
6.5
6
5.5
5
4.5
4
800
600
400
200
0
2000
2002
2004
2006
2008
2010
2012
Prcp - ET (mm yr-1)
1500
1000
500
Time (year)

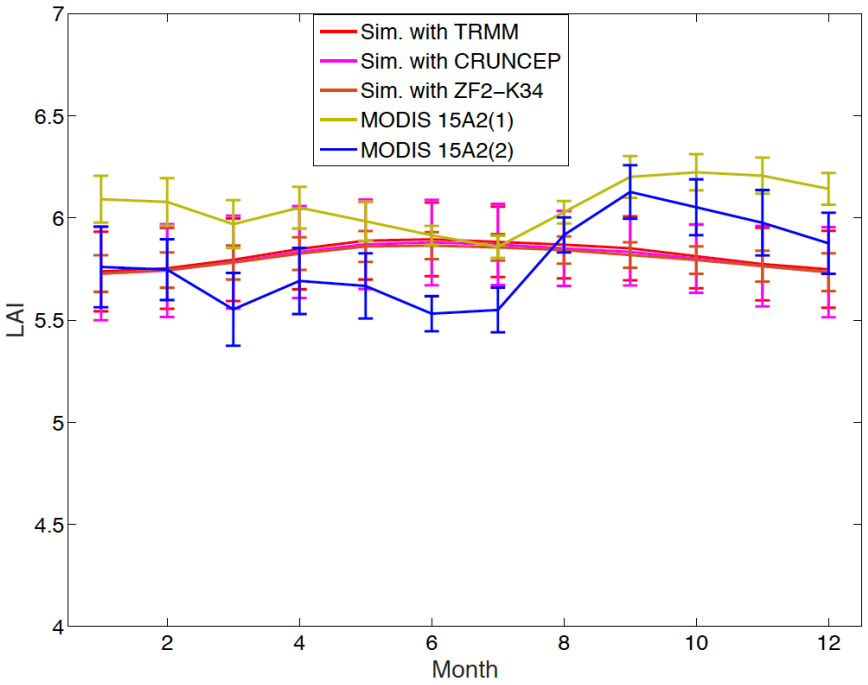
Summary

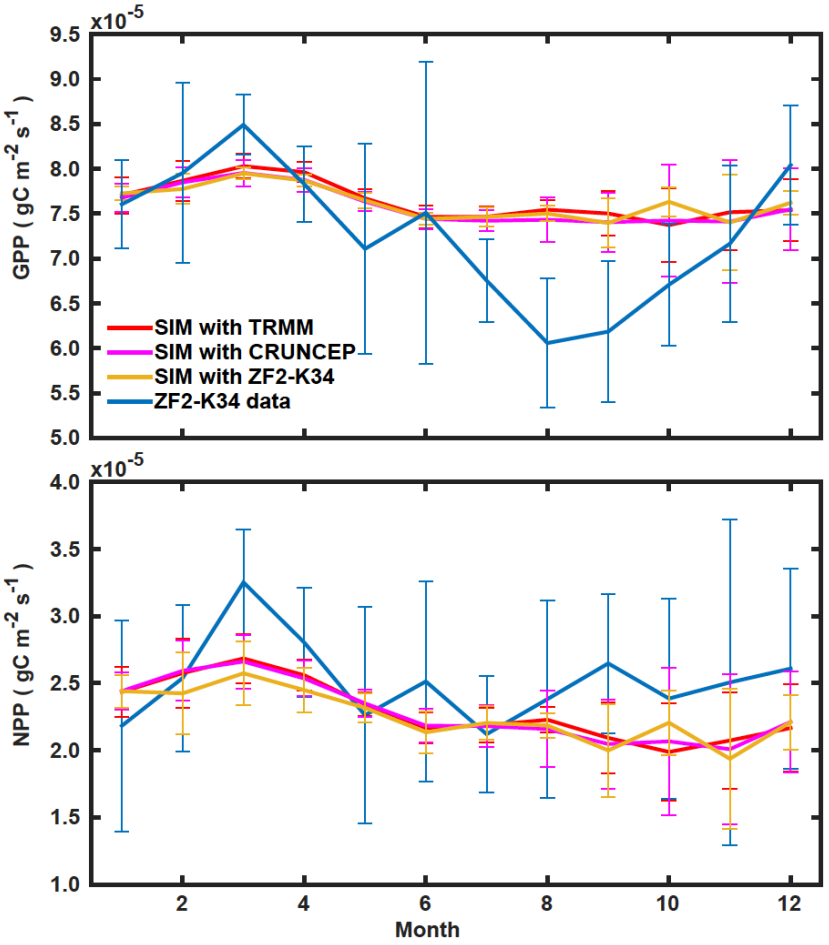
- Used a quasi-3D GW, surface water, and channel model (PAWS) coupled to CLM to investigate controls on ET seasonality
  - Lateral subsurface flows are critical
    - Runoff may play a secondary role
  - Column mode predicts phase 6 months earlier than observed and predicted by the full model
- Results (if confirmed elsewhere) argue for representation of 3D watershed hydrology in ESMs

EXTRAS


WTD vs model ET
Phase Shift (mo)
WTD (m)
Time (year)
3
2.5
2
1.5
1
0.5
0
-25
-30
-35
2000
2002
2004
2006
2008
2010
2012
2014

Model Testing: Carbon

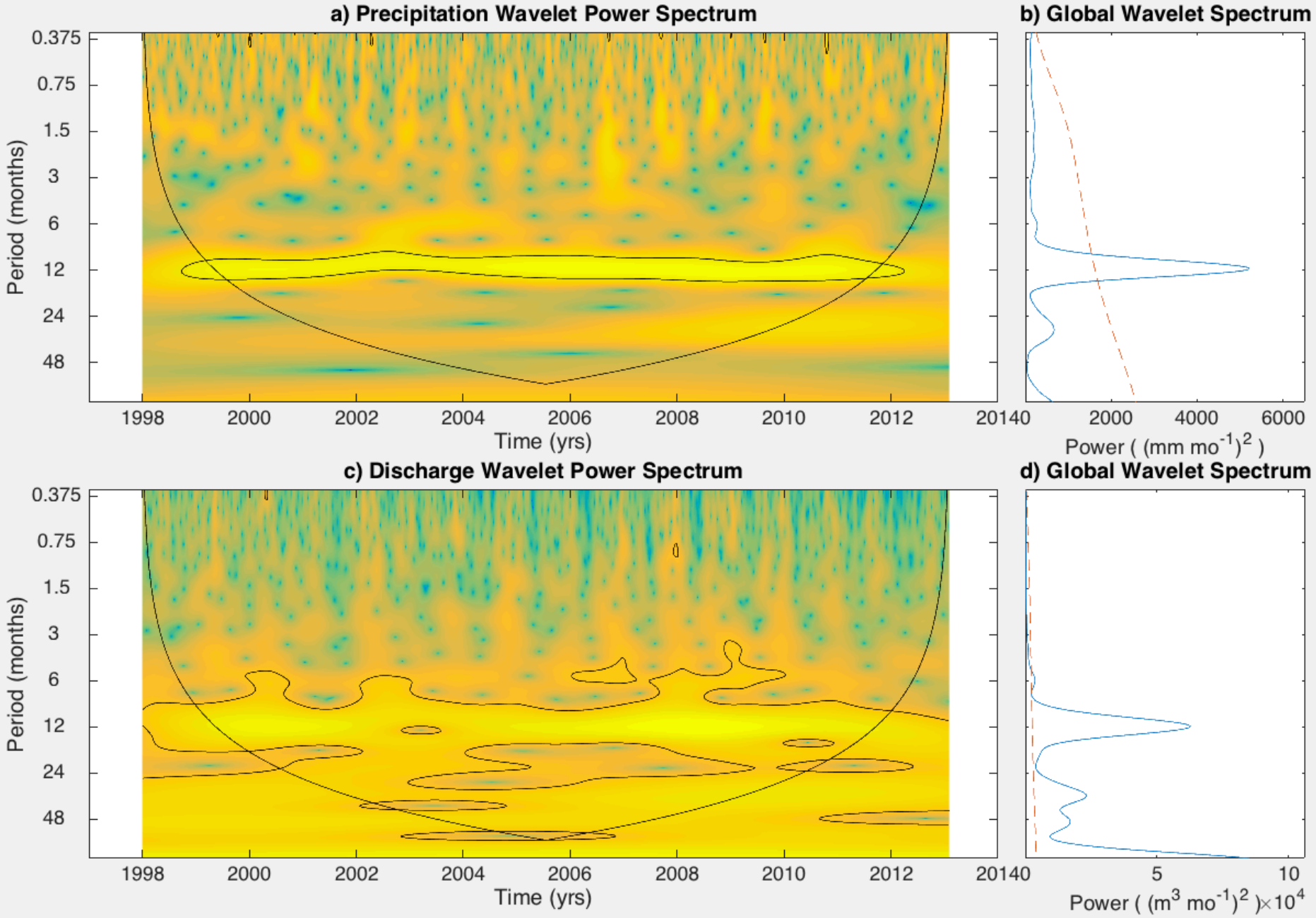


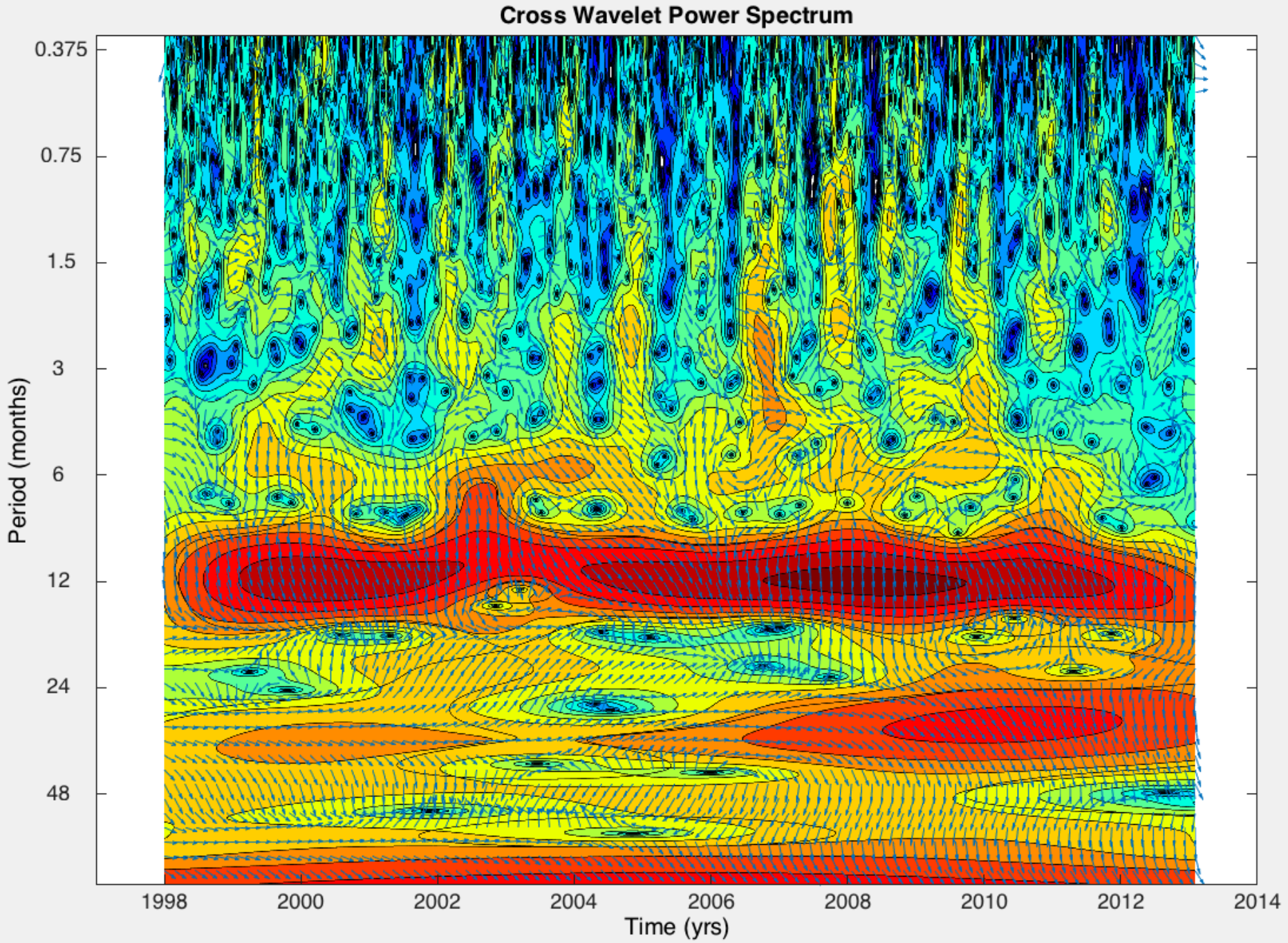


EXTRAS

- 2) Ground evaporation is 9.7% of ET, canopy evaporation is 27.9%, and transpiration is 62.4% of ET.
- Ground evaporation is 6.1% of P, canopy evaporation is 17.6%, transpiration is 39.3% of P, and ET is 63% of P.

Model Testing: GRACE




Cross Wavelet Power Spectrum
0.375
0.75
1.5
3
6
12
24
48
Period (months)
1998
2000
2002
2004
2006
2008
2010
2012
2014
Time (yrs)