UNESCO-IHE
Institute for Water Education

Towards improving hydrological model capabilities for drought risk monitoring and prediction

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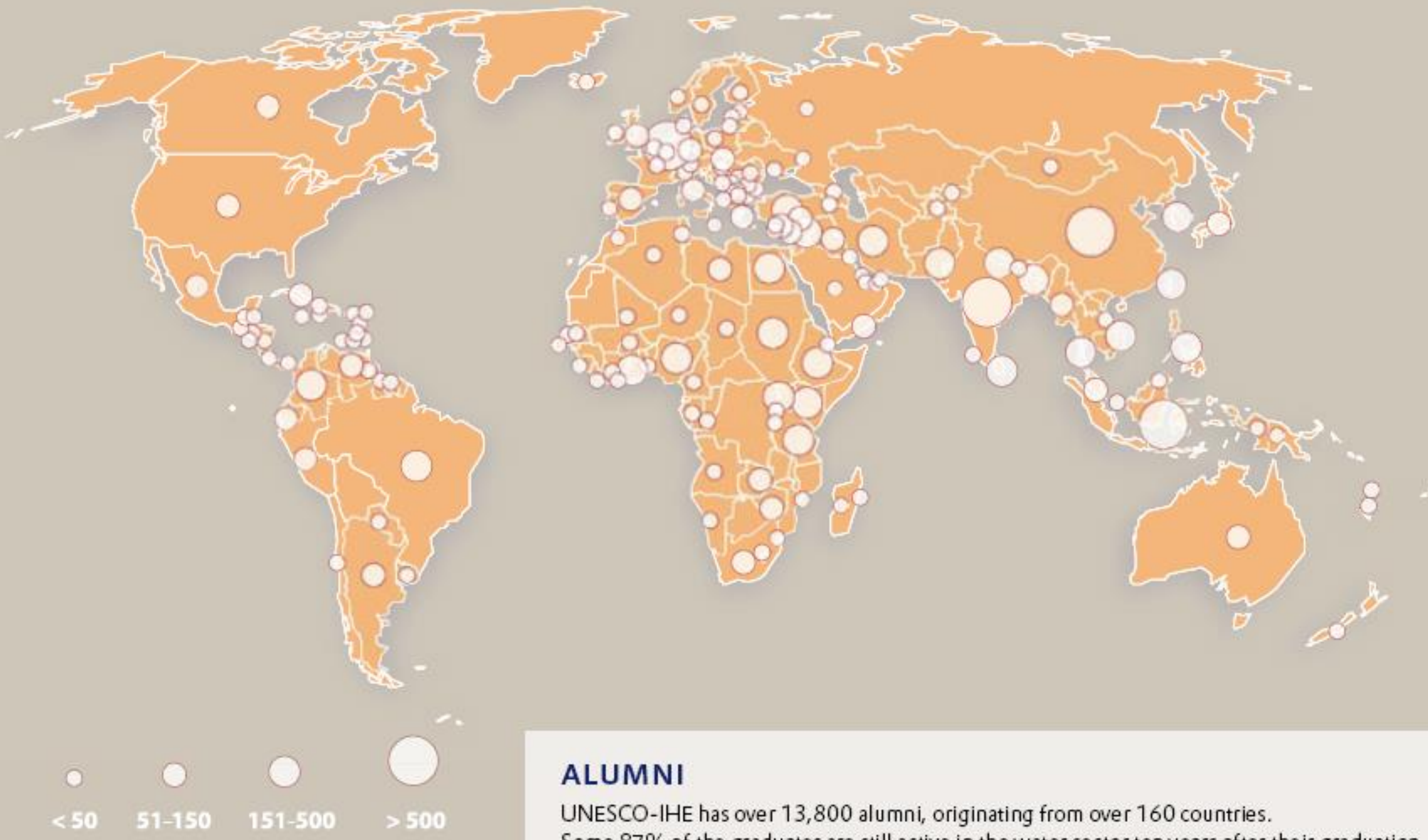
UNESCO-IHE Delft

Picture Showing drying water point

www.unesco-ihe.org

UNESCO-IHE
Institute for Water Education

- Established in 1957 (as IHE)
- 2003 as UNESCO-IHE Institute for Water Education
- 4 MSc programs (19 specializations) and PhD programs
  - -*Water Science and Engineering*
  - - *Water Management*
  - - *Environmental Science*
  - - *Urban Water and Sanitation*
- 200 staff, 250 guest staff
- 200+ MSc students/year
- 135+ PhD fellows at the moment
- Large number of short courses
- Total >14.000 alumni (world wide)

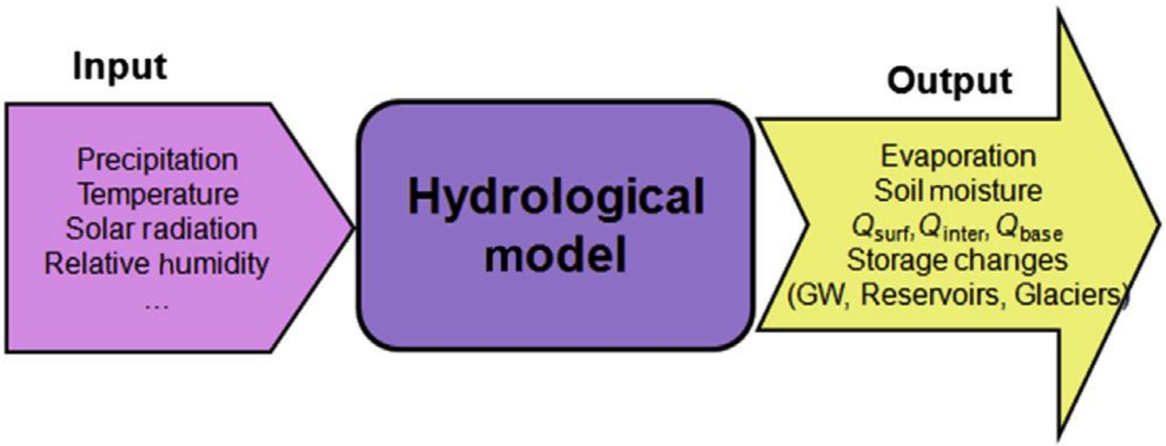


ALUMNI

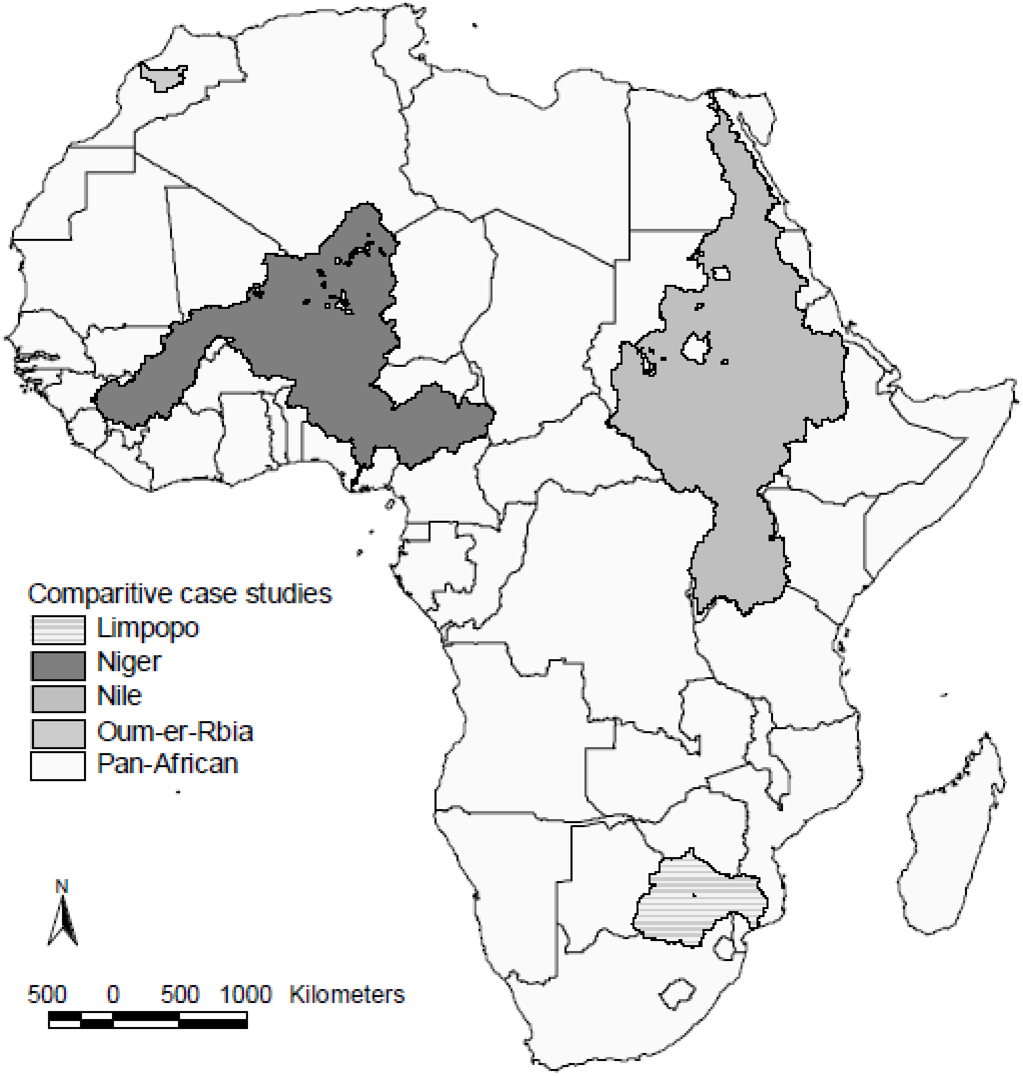
UNESCO-IHE has over 13,800 alumni, originating from over 160 countries.
Some 87% of the graduates are still active in the water sector ten years after their graduation.
Today, several Ministers and Deputy Ministers, heads of international organisations, and top professors and scientists around the globe are UNESCO-IHE graduates.

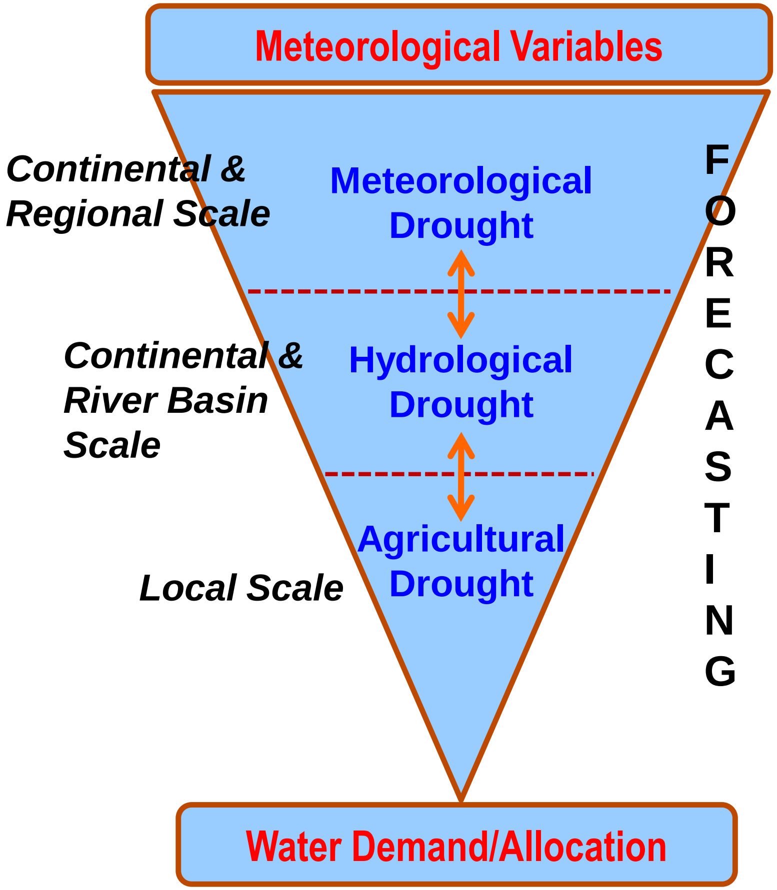
Hydrological models for drought assessment and monitoring

- Hydrological model offers a great potential for drought assessment and monitoring
- The Palmer method (PDSI, PDHI) is one of the earliest to use a (simple) hydrological model in drought assessment
- Indices such as SRI, ETDI, SMDI, etc. are usually based on hydrological model outputs
- Hydrological model capabilities may be improved in several ways for better monitoring and prediction of droughts



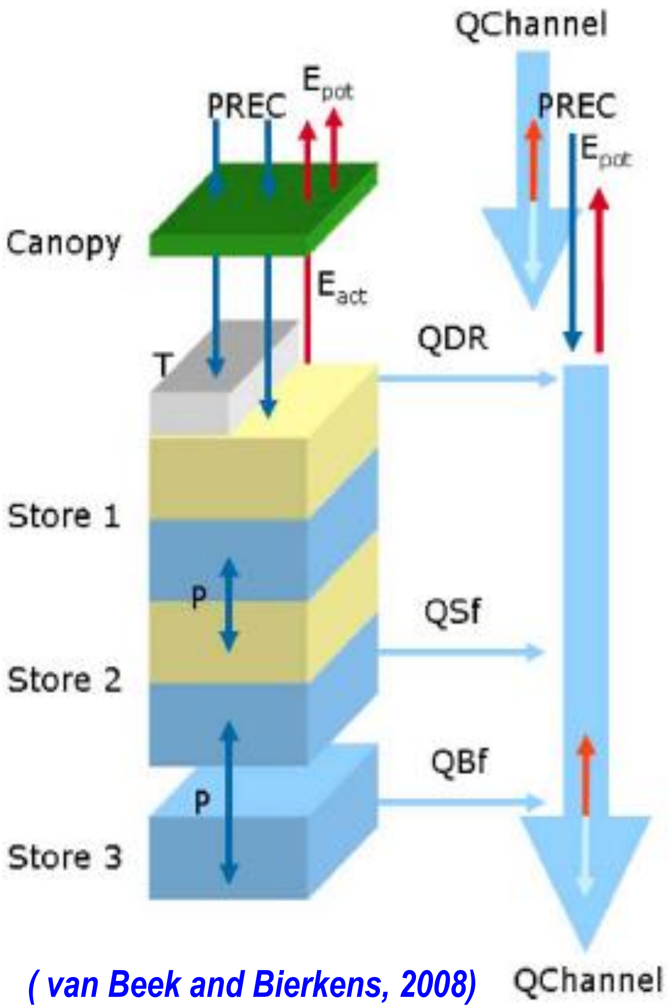
DEWFORA (www.dewfora.net)
WP4: Drought forecasting on different scales





The PCR-GLOBWB hydrological model

- **PCR-GLOBWB model originally developed at Utrecht Univ. (*van Beek and Bierkens, 2008*)**
- **Spatially distributed: Global/continental version 0.5° x 0.5°, Limpopo version 0.05° x 0.05°**
- **ET from vegetation (tall and short), canopy and soil**
- **Two soil layers (storage) and one groundwater storage**
- **Three runoff components: direct runoff, subsurface flow and baseflow**
- **Forcings based on ERAInterim-GPCP corrected (*ECMWF, 2012*)**



(van Beek and Bierkens, 2008)

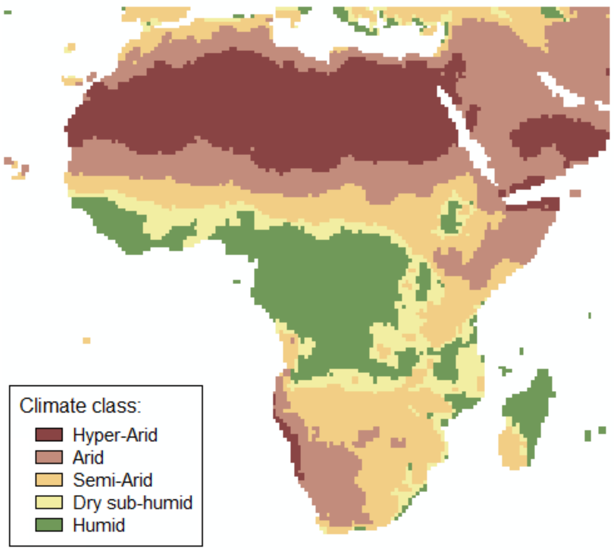
Evaporation comparison for Africa

Evaporation Product	Provider	Input precipitation data	Potential Evaporation – Method	Spatial resolution	Temporal coverage
PCR-GLOBWB	This study(*)	ERAI+GPCP	Hargreaves	0.5°	1 Jan 1979 -31 Dec 2010
PCR_PM	This study(*)	ERAI+GPCP	Penman Monteith	0.5°	1 Jan 1979 -31 Dec 2010
PCR_TRMM	This study(*)	TRMM 3B42 v6	Hargreaves	0.5°	Since 1 Jan 1998
PCR_Irrig	This study(*)	ERAI+GPCP	Hargreaves	0.5°	1 Jan 1979 -31 Dec 2010
ERAL	ECMWF	ERAI+GPCP	No PE input	~ 0.7°	1 Jan 1979 -31 Dec 2010
ERAI	ECMWF	ERAI	No PE input	~ 0.7°	1 Jan 1979 -near real-time
MOD16	University of Montana	NASA's GMAO	Penman Monteith	1 km	Since 1 Jan 2000
GLEAM	VU Amsterdam	PERSIANN	Priestley and Taylor	0.25°	Since 1 Jan 1998

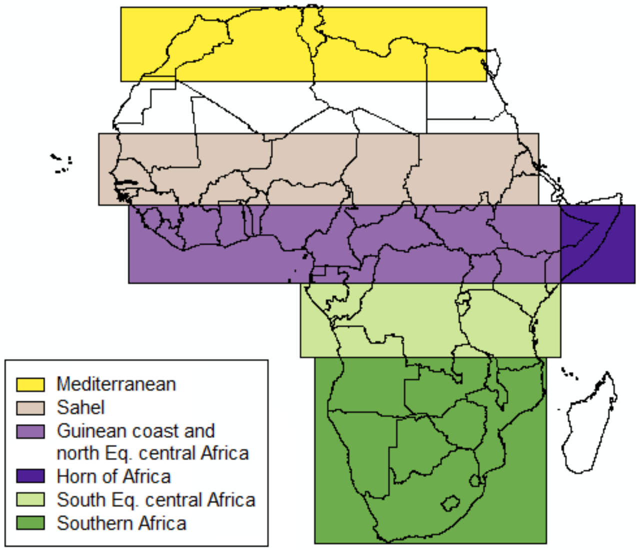
(*) The evaporation product resulted from the PCR-GLOBWB hydrological model forced with different input data and conditions.

- **PCR-GLOBWB – continental version set up for this project.**
- **ERAL and ERAI (*ECMWF products*). ERAL uses the updated version of land surface model HTESSEL.**
- **MOD16 ET (*MODIS product, Mu et al. 2011*). Based on Penman-Monteith equation but several of the parameters derived from MODIS satellite data.**
- **GLEAM – largely based on remote sensing products.**

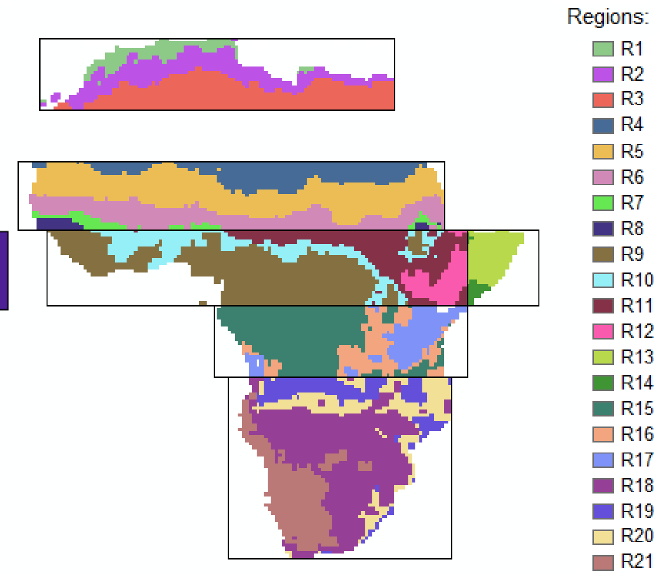
Regions and sub-regions for ET comparison



Climate classes (based on aridity)



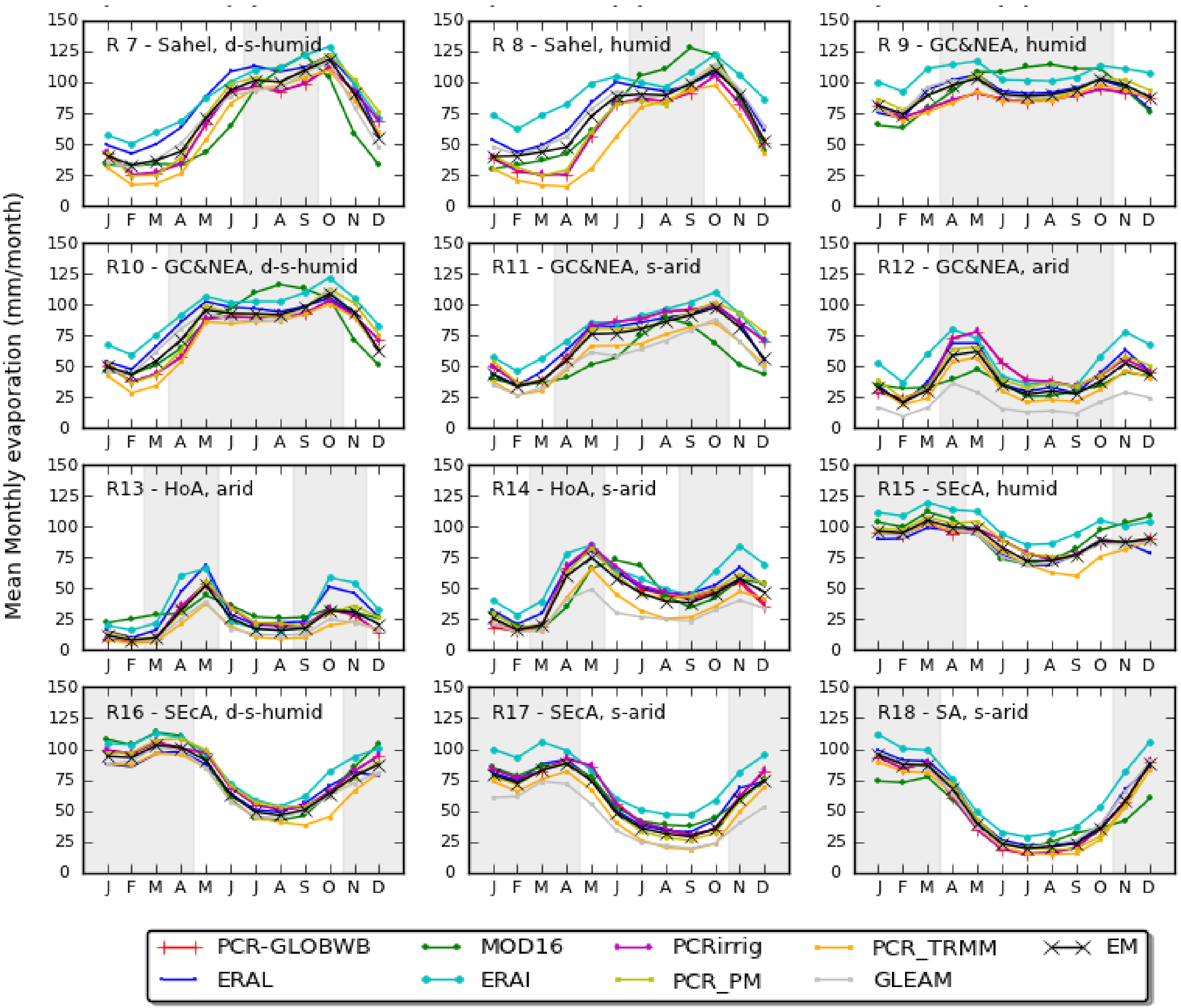
Regions (modified Sylla et al. 2010)



Sub-regions (for this study)

- **Climatic classes are based on aridity index (MAP/MAE) (Zomer et al. 2008) and UNEP (1997) definition.**

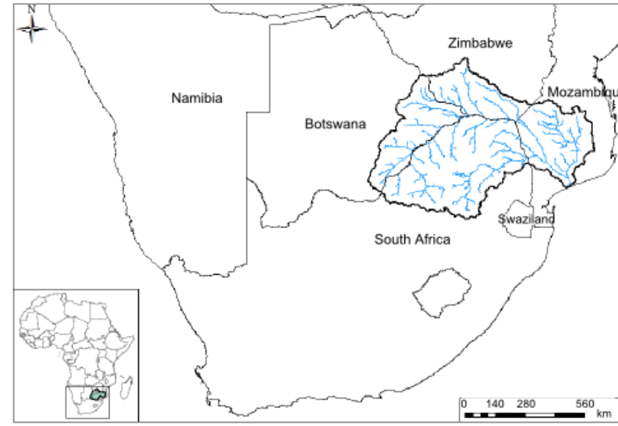
Comparison of different ET products

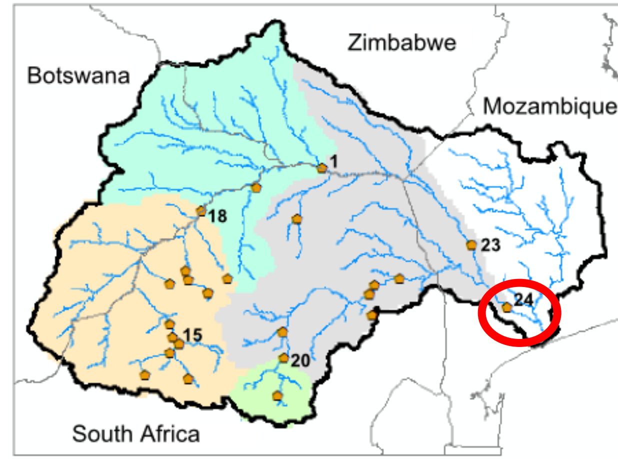


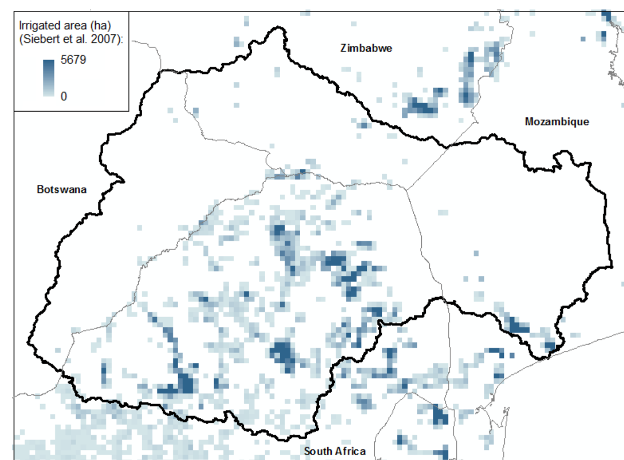
Trambauer et al. (2014), HESS

Limpopo river basin

- Drainage area: aprox. 415,000 km^2
- Annual rainfall: 530 mm (200 – 1200 mm) mainly in the summer months (Oct – Apr)
- Highly modified basin
  - Major user of water: Irrigation
- Challenging basin for hydrological modeling – very low runoff coefficient (RC = Q/P)
  - Station # 24
    - RC naturalized discharge = 3.1%
    - RC observed discharge = 0.4 %

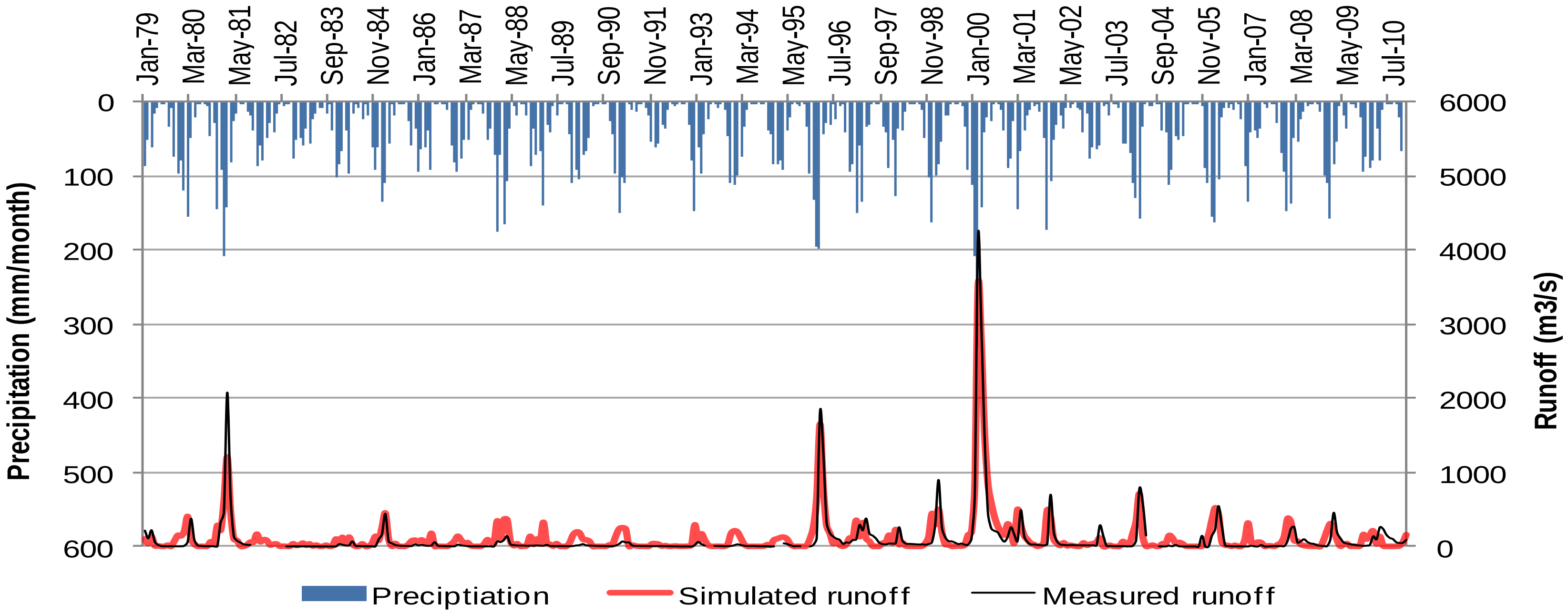


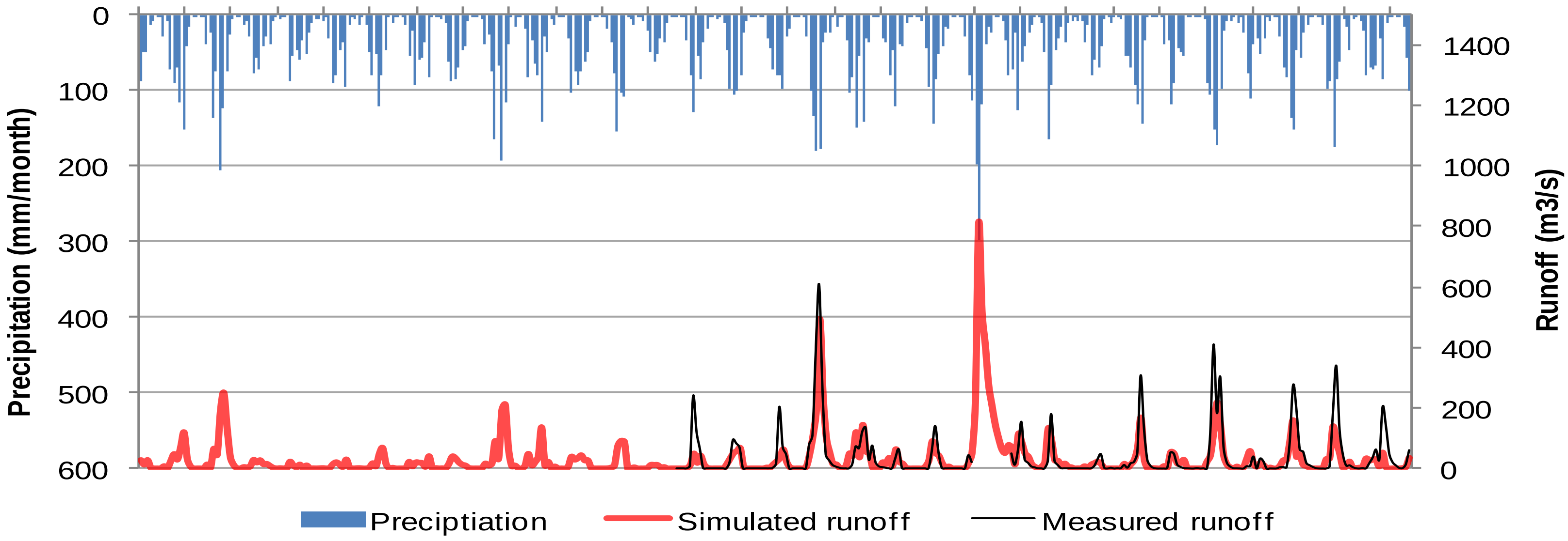




Global Map of Irrigation Areas (Siebert et al. 2007)

Limpopo river basin – runoff simulation



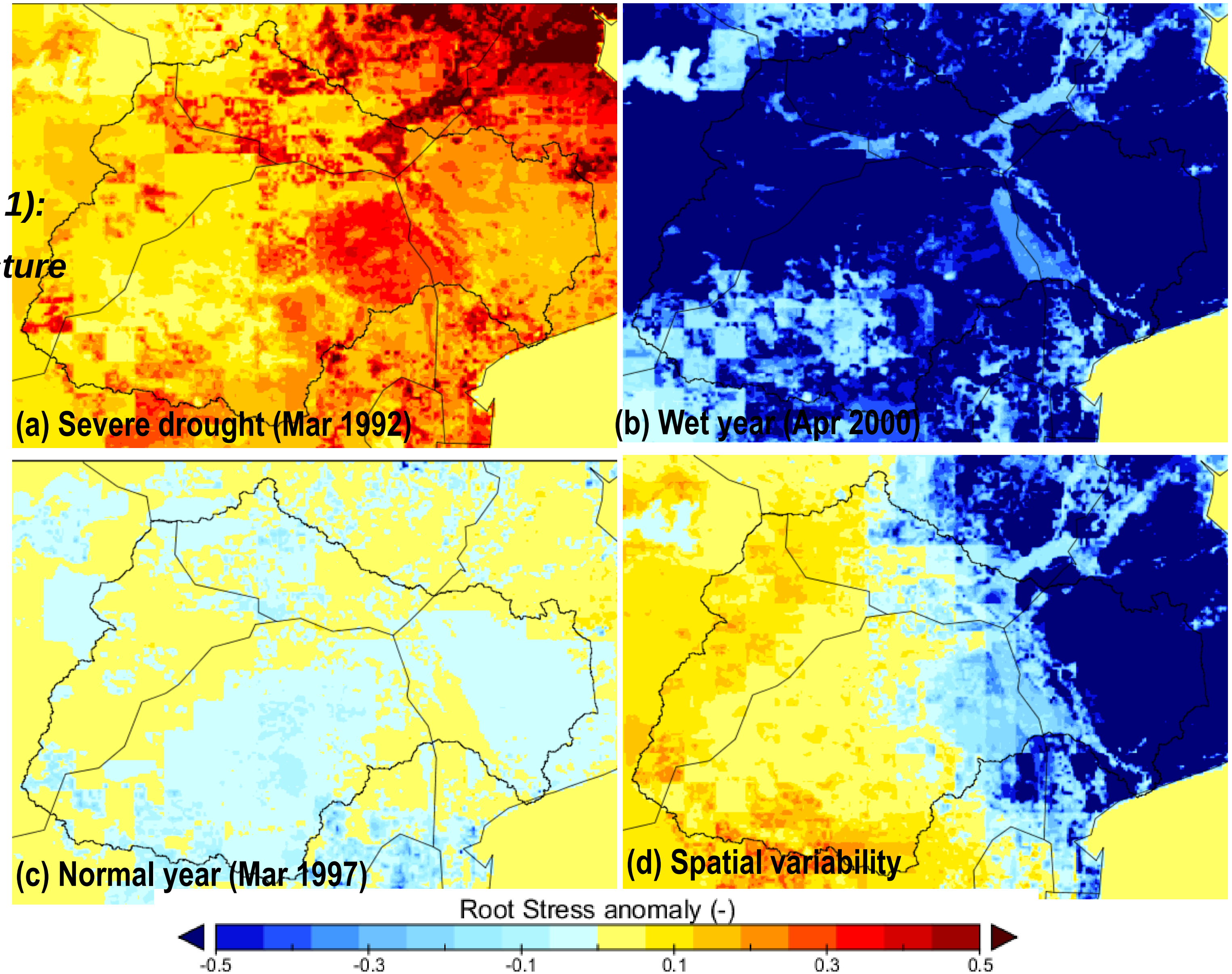


Maskey and Trambauer , EWRA 2013

Root stress anomaly (simulated)

Root stress (0 to 1):

Lack of soil moisture



Do hydrological drought indices bring additional information?

(a)

Hydrological drought (SRI-3 < −0.5)	Meteorolgical drought (SPI-3 < −0.5): Yes	Meteorolgical drought (SPI-3 < −0.5): No
Yes	69	47
No	30	215

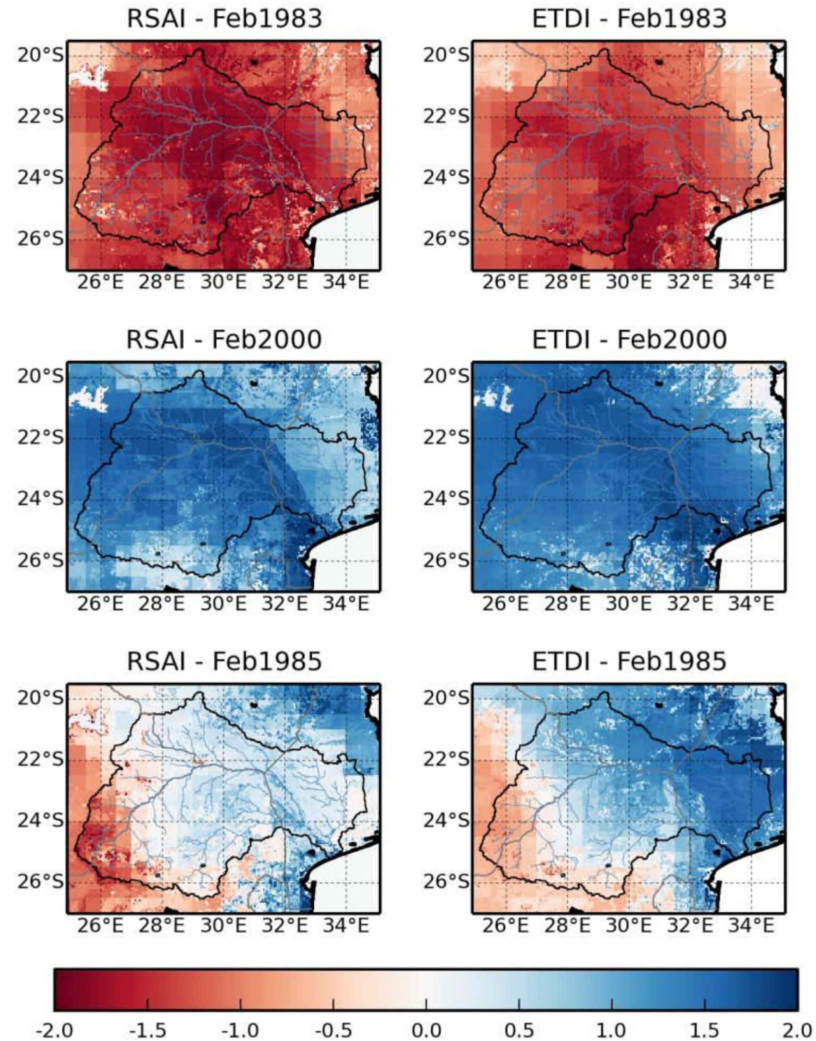
PC = 0.79, HR = 0.70, FAR = 0.18

(b)

Hydrological drought (SRI-6 < −0.5)	Meteorolgical drought (SPI-6 < −0.5): Yes	Meteorolgical drought (SPI-6 < −0.5): No
Yes	74	42
No	25	220

PC = 0.80, HR = 0.72, FAR = 0.18

Maskey and Trambauer (2014)



Towards improving hydrological model capability on

- **Representation of relevant processes**
  - How good is my ET model?
  - How good is the surface water – GW connection?
- **Spatial calibration using RS data**
  - How can we best use RS based spatial data (ET, LAI, NDVI)?
  - Can we do spatial calibration on ET?
  - Can we use LAI as a dynamic input?

Towards improving hydrological model capability on

- **Prediction in response to change**
  - **Is my model capable of simulating under climate change?**
  - **Is my model capable of simulating in response to human intervention?**

CHINA DAILY, 5 Dec 2014

NACHO DOCE / REUTERS

Brazilian artist and activist Mundano places a cactus plant in the cracked ground on Tuesday to work on a drought-related cactus installation called *Desert of Cantareira* at Atibainha dam, part of the Cantareira reservoir, during a drought in Nazare Paulista, Sao Paulo.

Rain forest's destruction blamed for long drought

Taps run dry as Brazil suffers worst water shortage in eight decades

Brazilian climate scientist Antonio Nobre of the Center for Earth System Science. The study draws together

impact was quick: Destruction in 2012 was one-sixth of what was recorded eight years earlier. Researchers at the Univer-

Thank you for your attention!