ALMIP AMMA Land Surface Model Intercomparison Project Phase 2

Land Surface model Scaling issues over West Africa: Perspectives from the AMMA Land surface Model Inter-comparison Project (ALMIP)

Boone A., Peugeot C., Cappelaere B, Demarty J, Grippa M, Kergoat L, Benarrosh N, Brender P, Chaffard V, Charvet G., Chazarin J-P, Cloché S, Cohard J-M, Ducharne A, Fleury L, Galle S, Getirana, A., Gosset M, Guichard F, Hiernaux P, Kaptué A., Lebel T, Maignan F, Mougin E, Ottlé C, Polcher J, Quantin G., Ramage K, Robert D, Roujean, J.-L., Séguis, L., Timouk F, Velluet C., Viarre J, and Vischel T.

AND the International Working Group

Context: why is the land surface important for the WAM?

- Surface conditions modulate PBL development, convective initiation and subsequent lifecycle
- Surface albedo and meridional gradient influence radiative feedback, and surface humidity and roughness influence flux of aerosols
- Long term surface memory effects from deep soil moisture reserves and vegetation extraction ➔ long term prediction?
- Vegetation feedbacks and Carbon fluxes, impacts on hydrological cycle…
- Surface gradients of MSE ➔ postion/intensity of AEJ
- LULCC ➔ water resource management: population expansion/Society
- Soil moisture/surface water influence on viruses/disease vectors (malaria…)

ALMIP

ALMIP2 Science Questions:

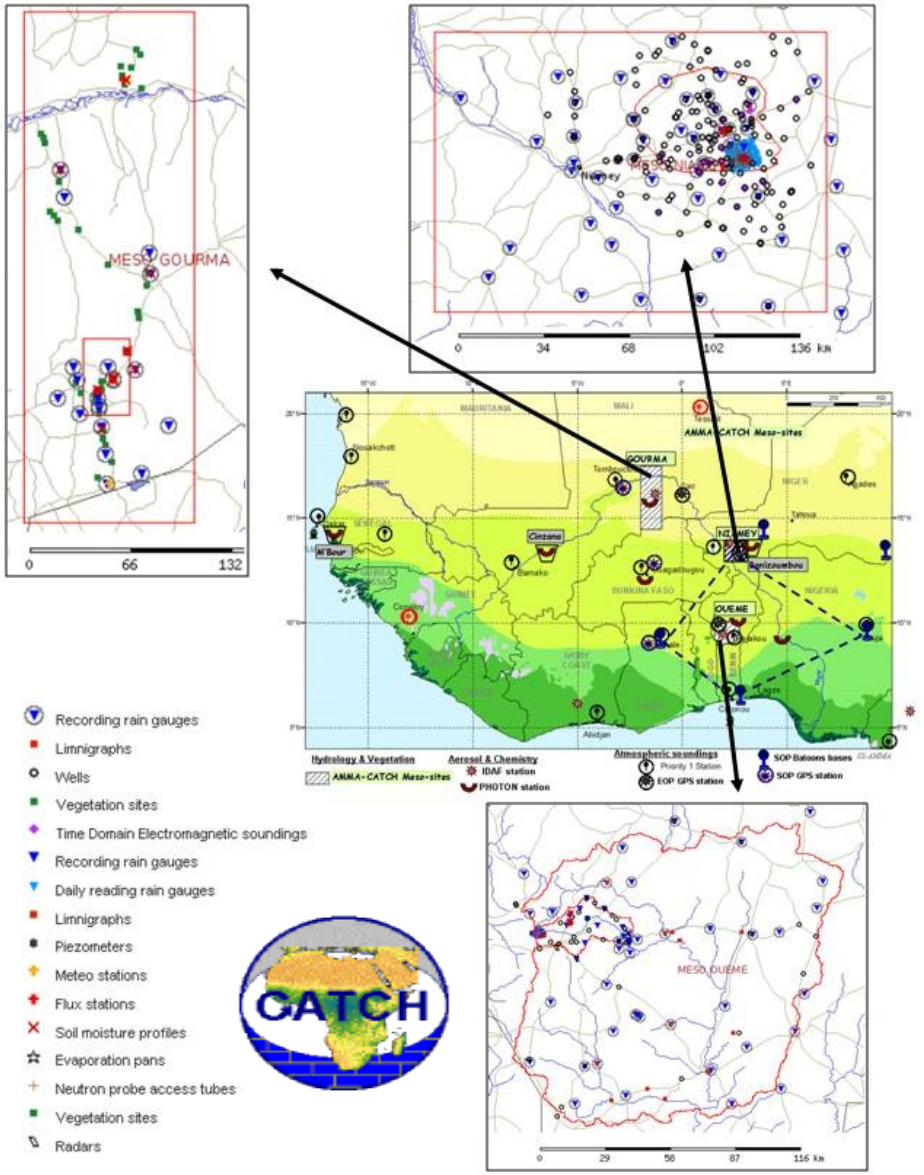
1. Which **processes are missing or not adequately modeled** by the current generation of LSMs over this region (infiltration over crusted soils, plants with defensive water strategies, endorheic hydrology...)?

2. How do the various LSM respond to **changing the spatial scale** (three scales will be analyzed: the local, meso and regional scales)? The relation between meso and regional scales will be made using ALMIP Phase 1 results.

3. Can relatively simple LSMs **simulate the vegetation** response to the atmospheric forcing on seasonal time scale (for several annual cycles) for the diverse climates/vegetation covers?

4. How can LSM simulate **mesoscale hydrology** given their relatively simple representation of such processes?

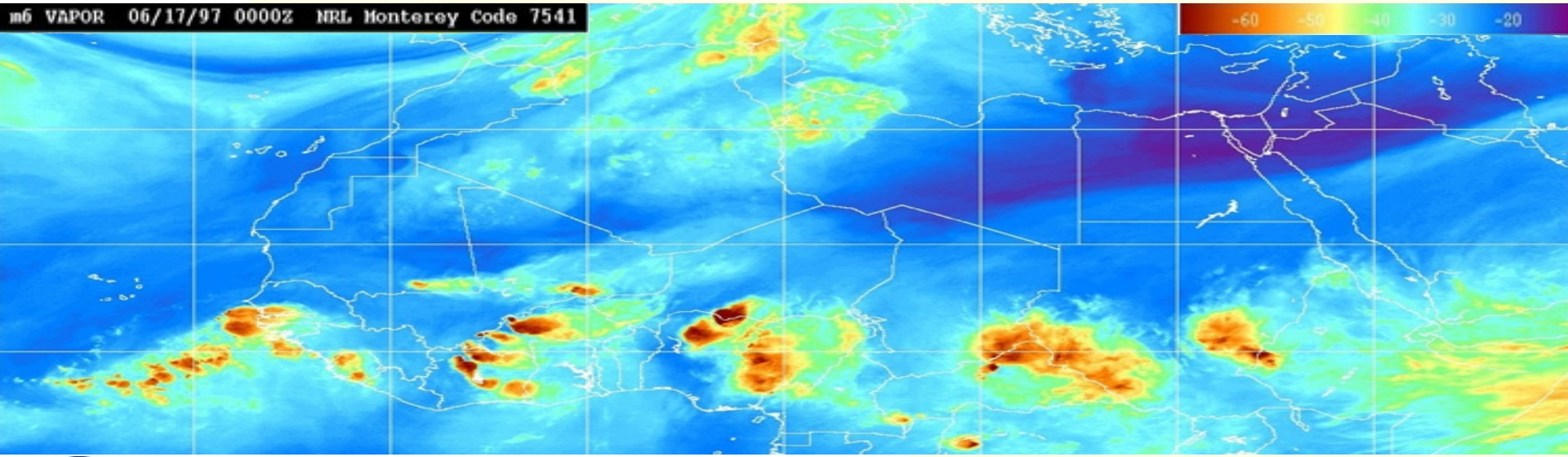
*5. What are the impacts of **uncertainties/differences in the precipitation** on the surface fluxes and hydrological responses of the LSM models?



MCSs explain 80% of the total rainfall in the Sahel

Locally 1 rainy season ~ 40 to 50 MCSs

From T. Vischel, LTHE



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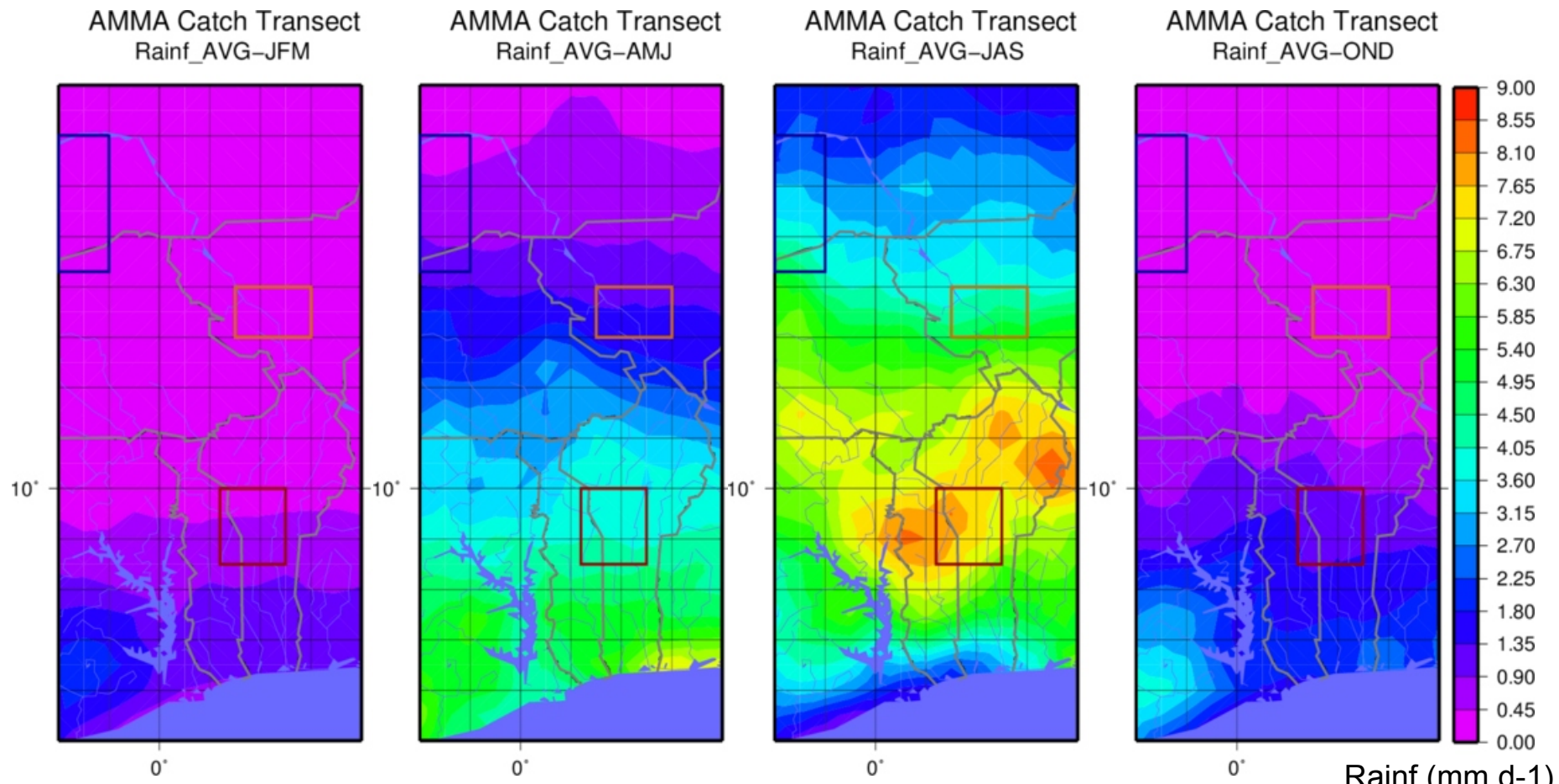
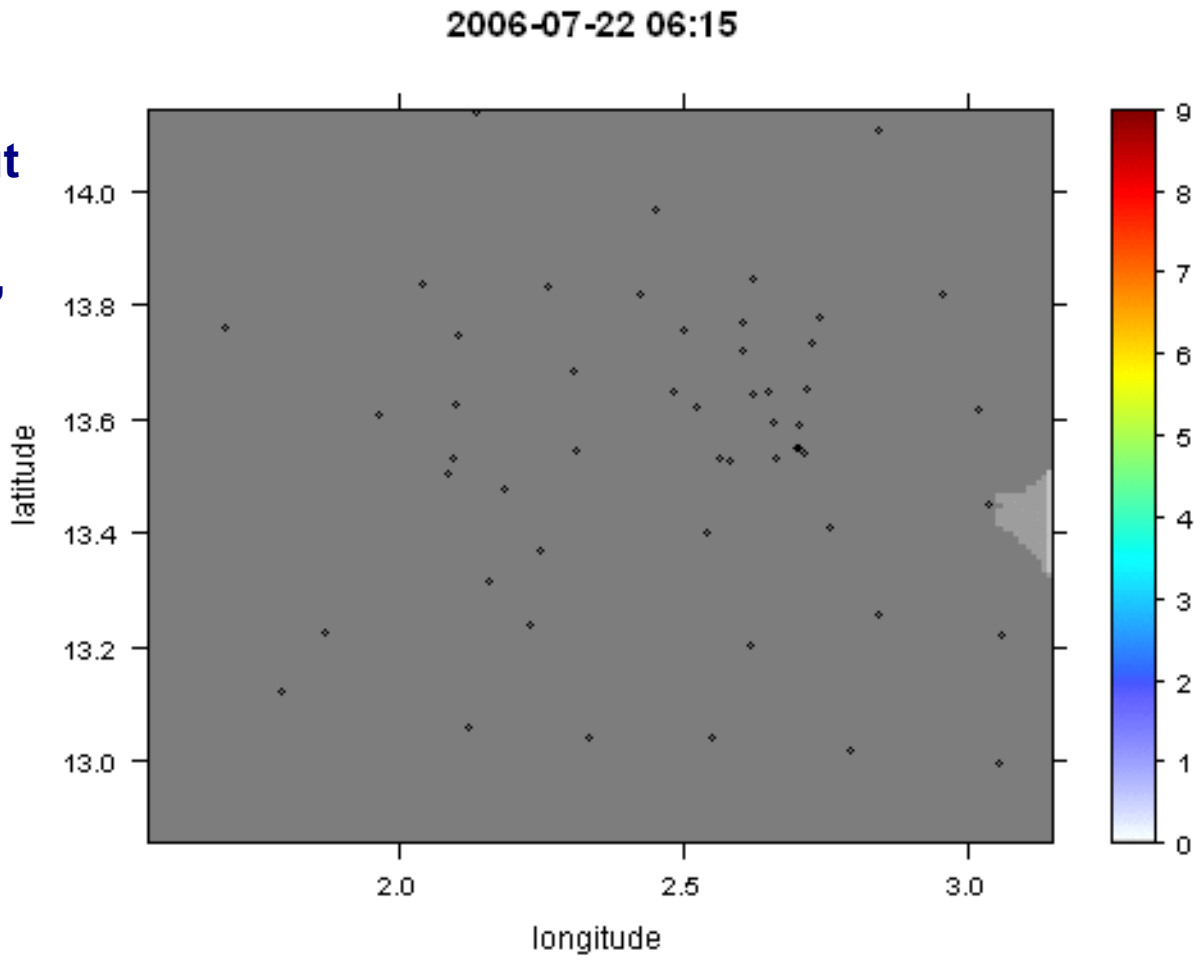


-TRMM 3B42-v6

« AVG Meteorological conditions » computed from ALMIP1 forcings 2002-7

METEO FRANCE
Toujours un temps d'avance

Example of input rainfall forcing (from T. Vischel, LTHE)



Some results….

- Inter-model scatter slightly LARGER than in ALMIP1 (0.5 deg)

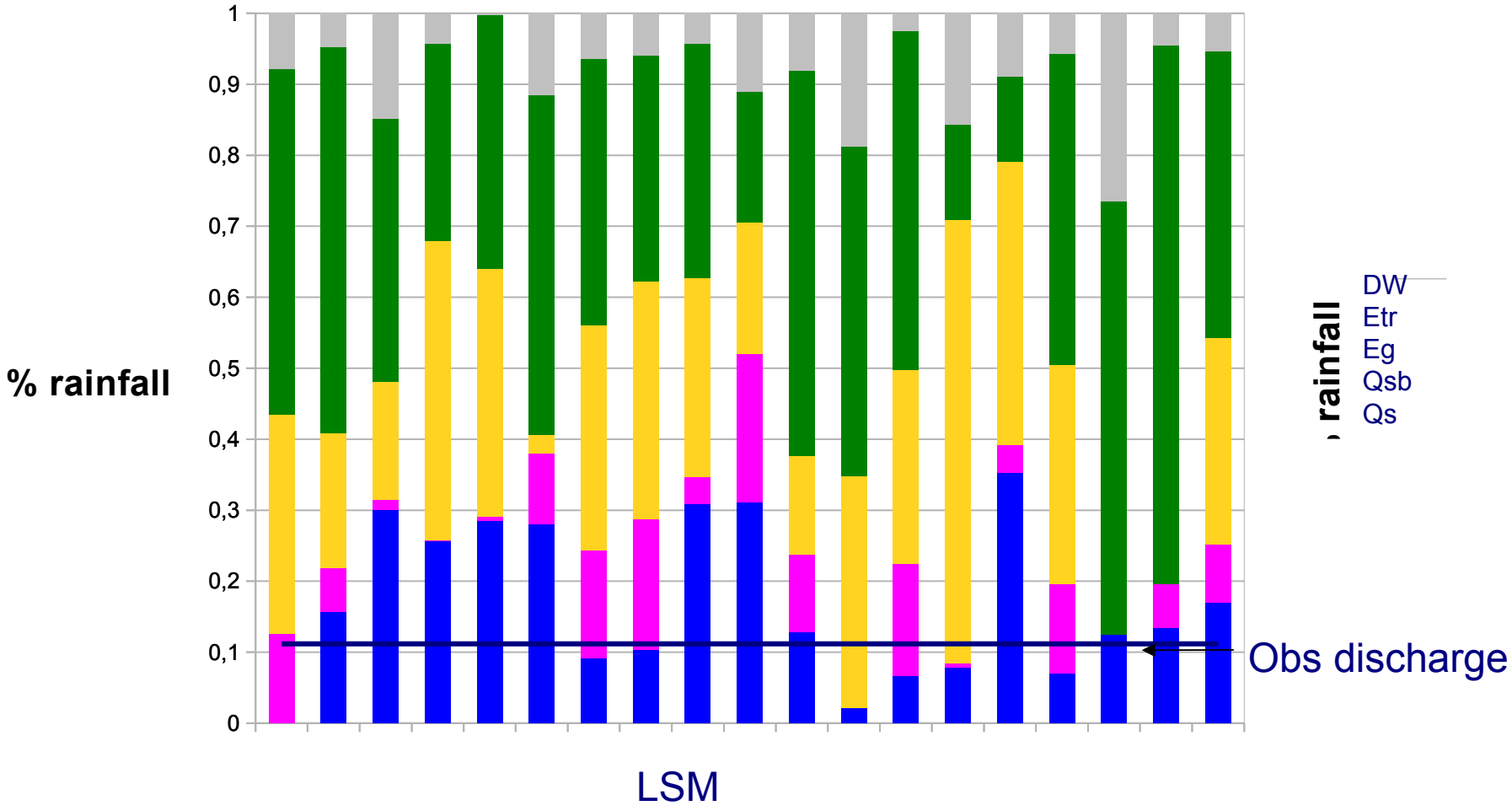
- Scaling ALMIP1 ➔ ALMIP2 ➔ local (not covered here: ongoing)

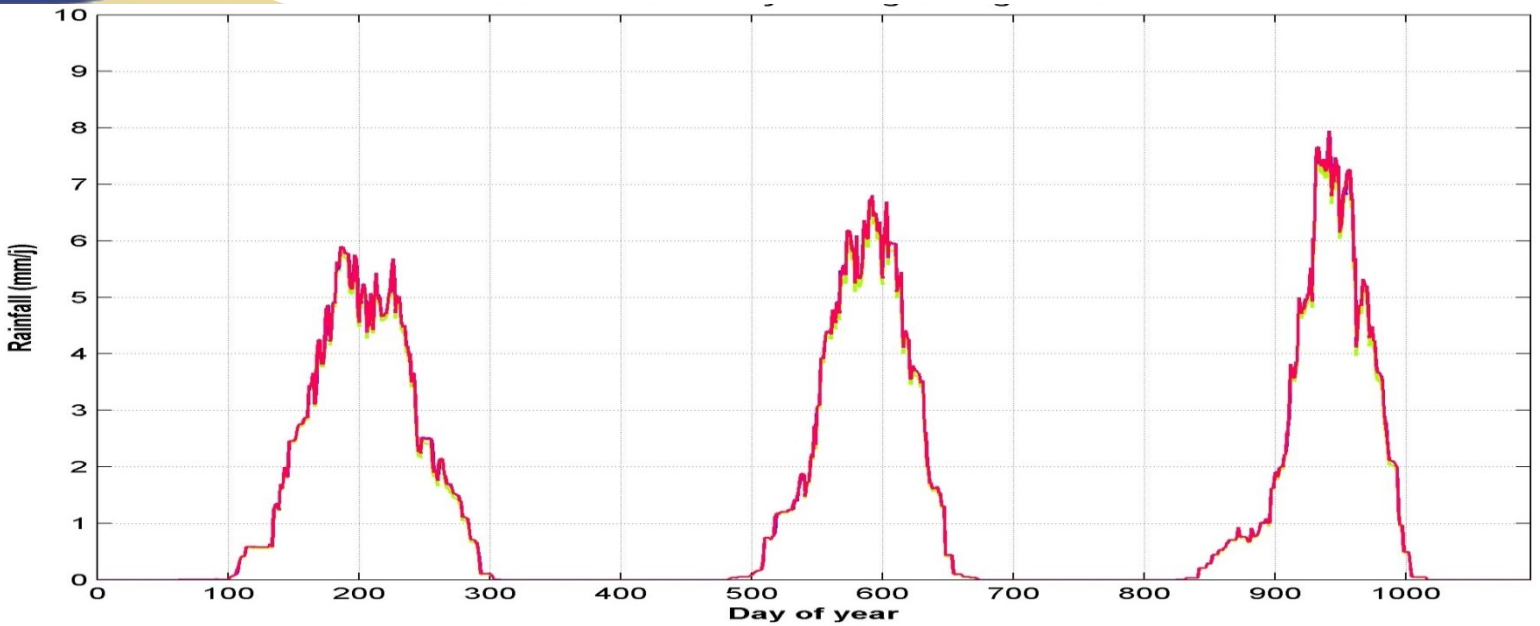
  - (ALMIP1-10 LSMs, ALMIP2-17 LSMs currently, 8 used herein for consistency)

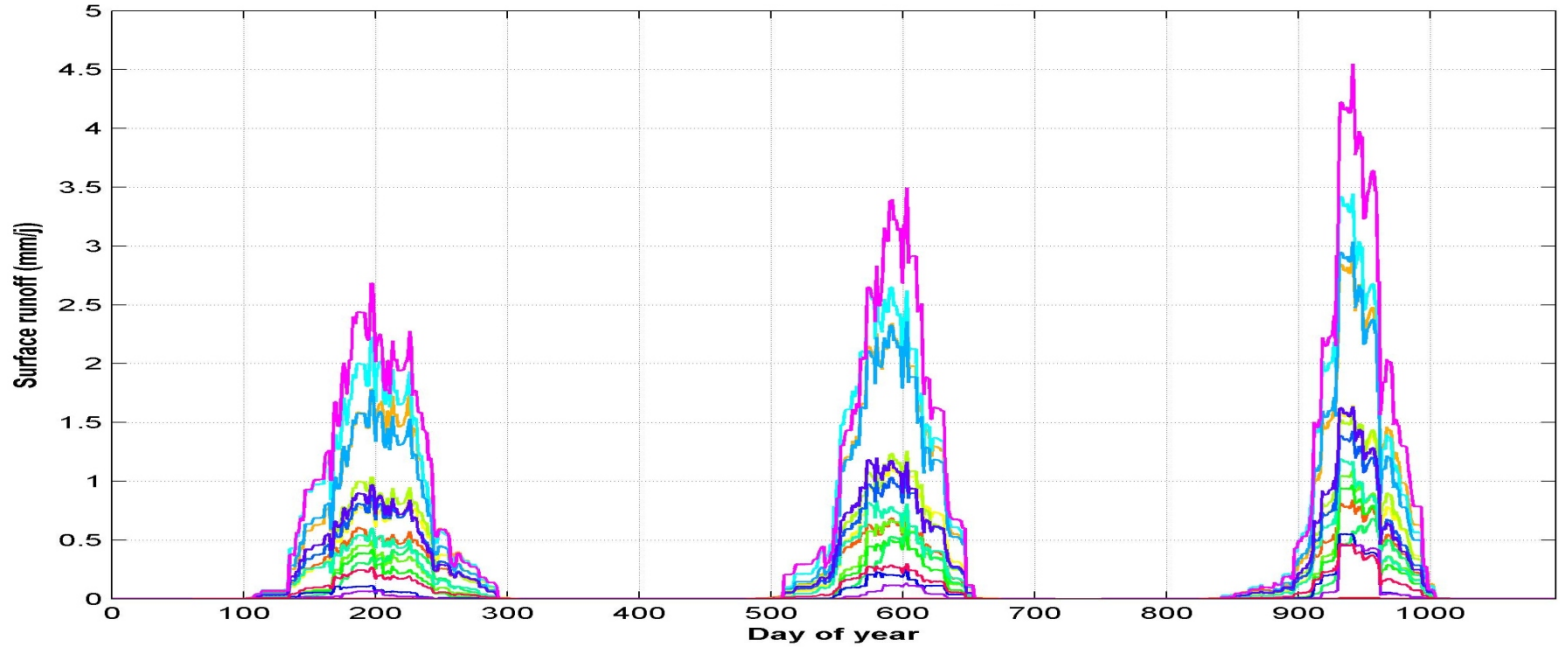
  - significant source of het ➔ precipitation

- Missing processes (also linked with scale: sub-grid parameterizations)

Ouémé (annual water cycle 2007)

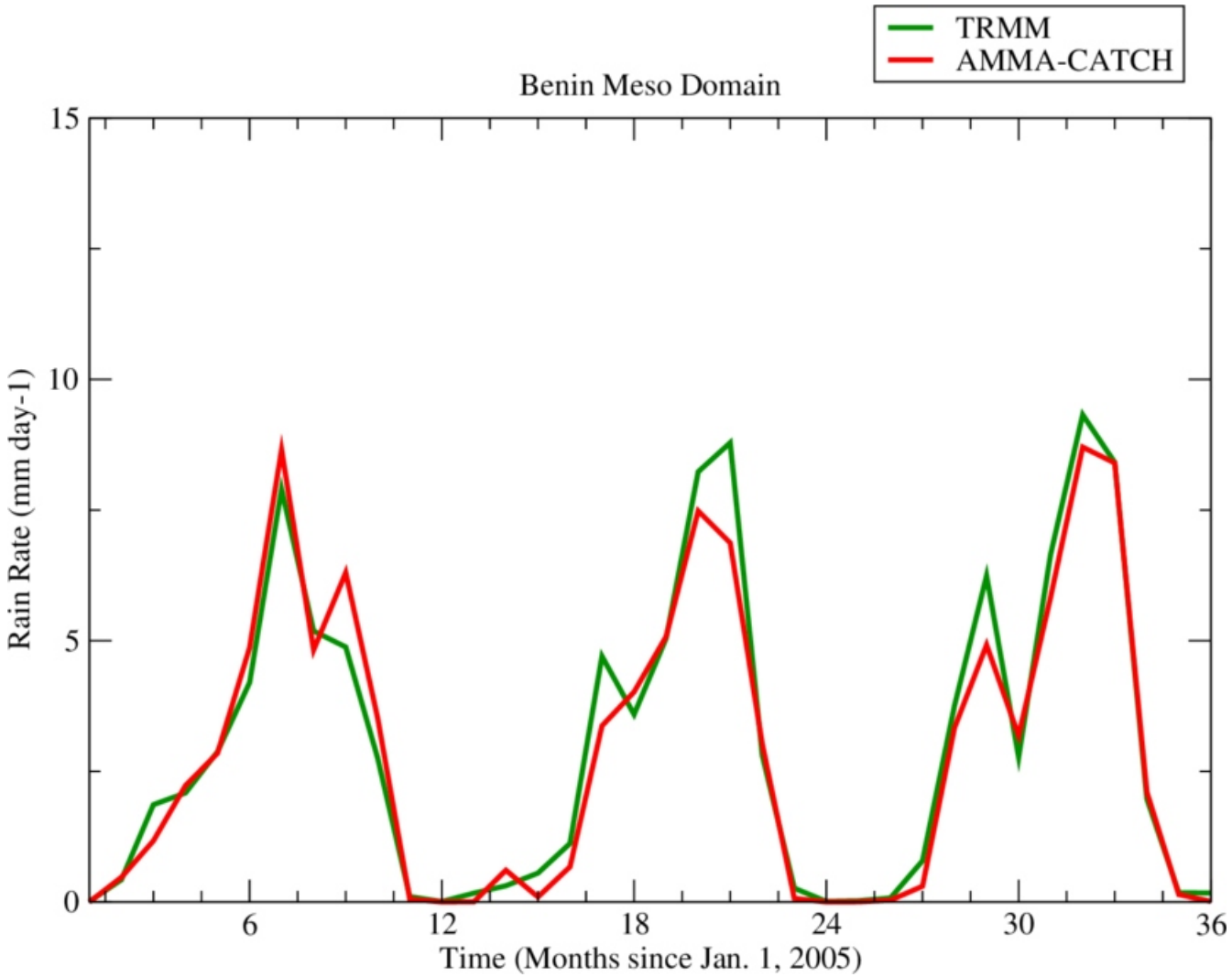






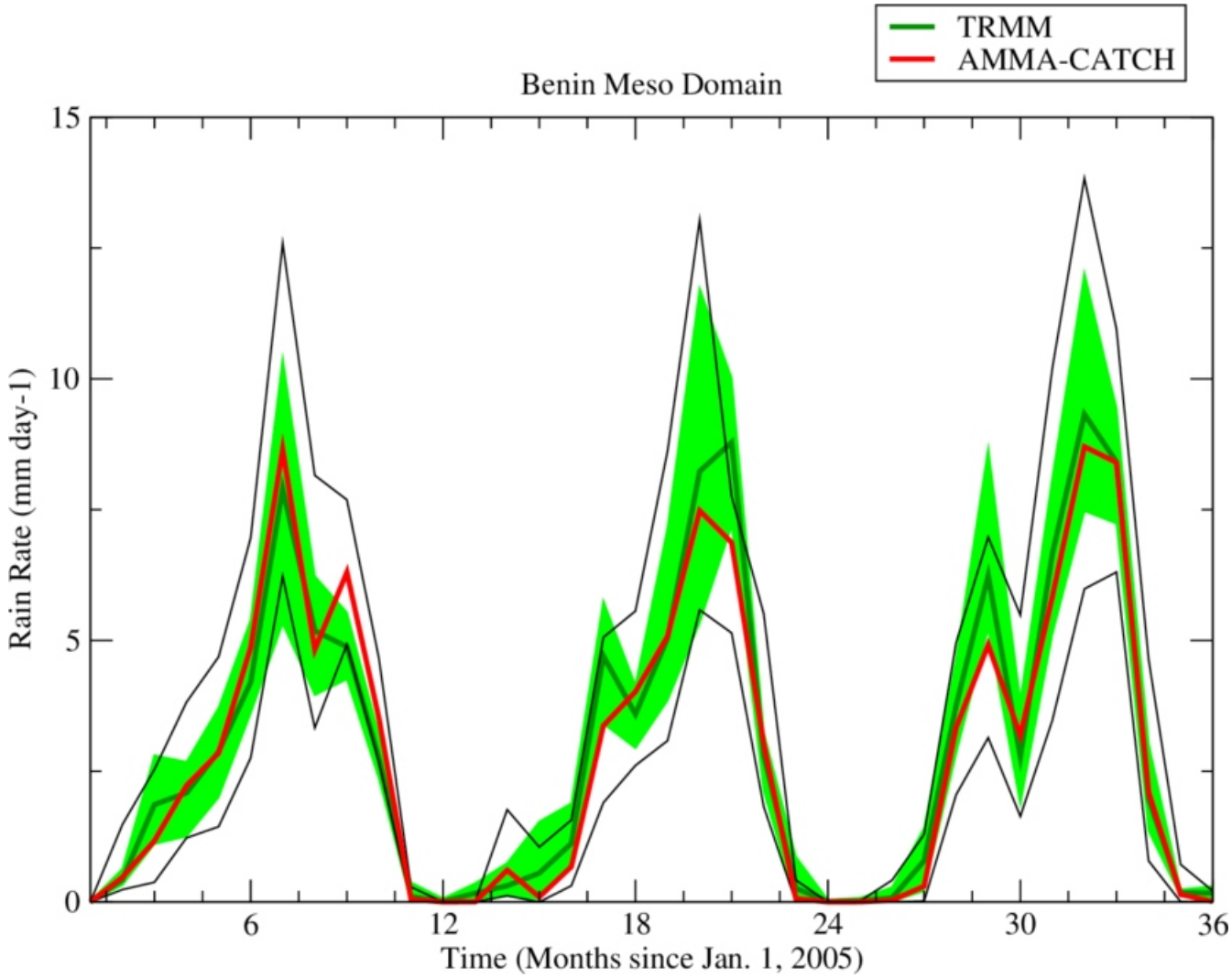
Niger (mesoscale AVG)

Domain AVGd rainfall forcing comparison



Agreement with TRMM is reasonable on a monthly to decad timescale….averaged over the domain

Larger range ➔ higher spatial resolution



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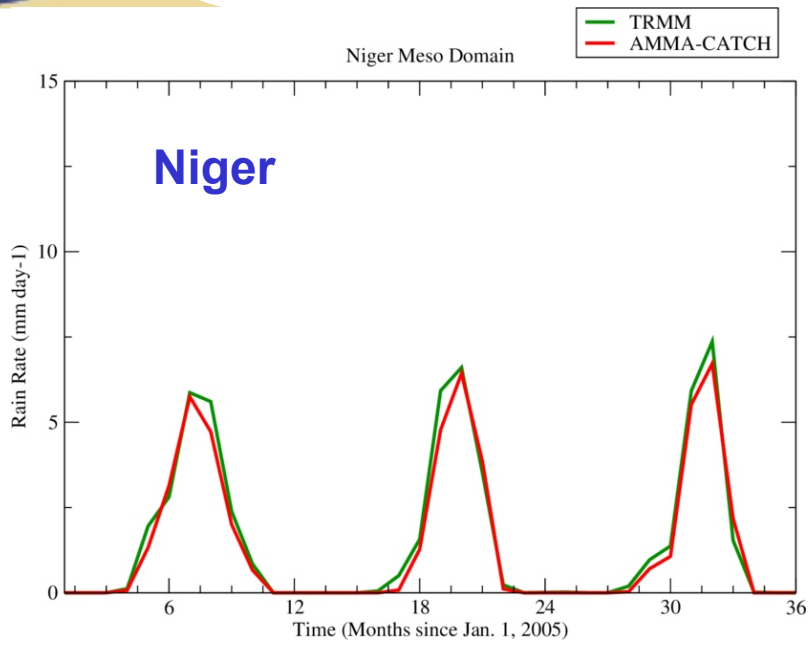
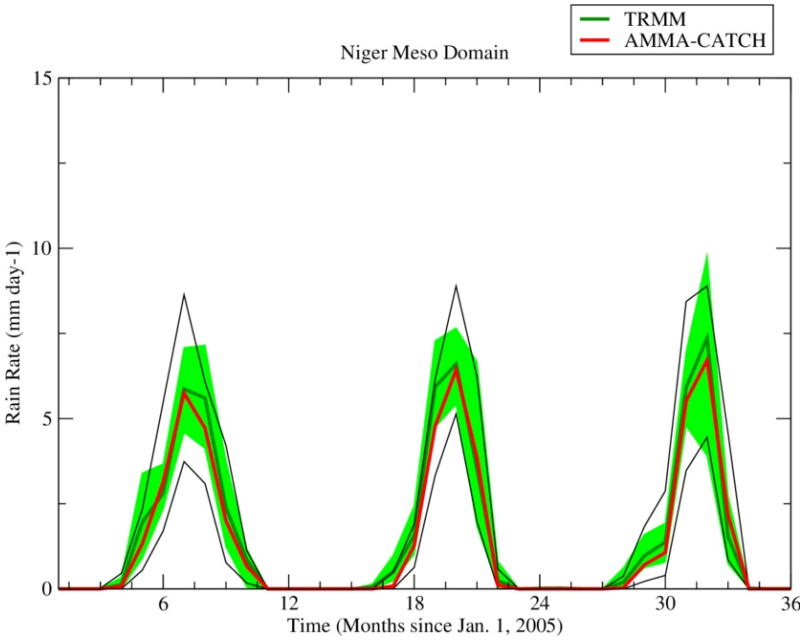
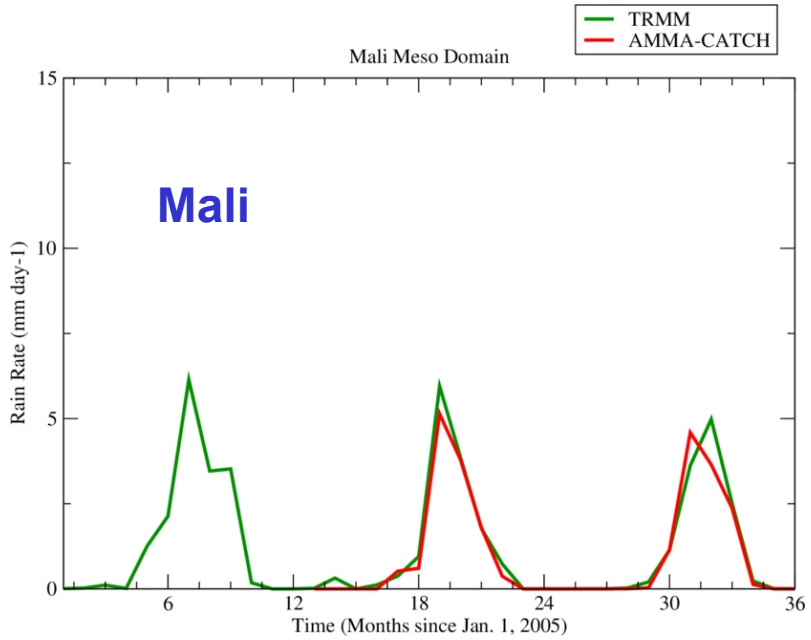
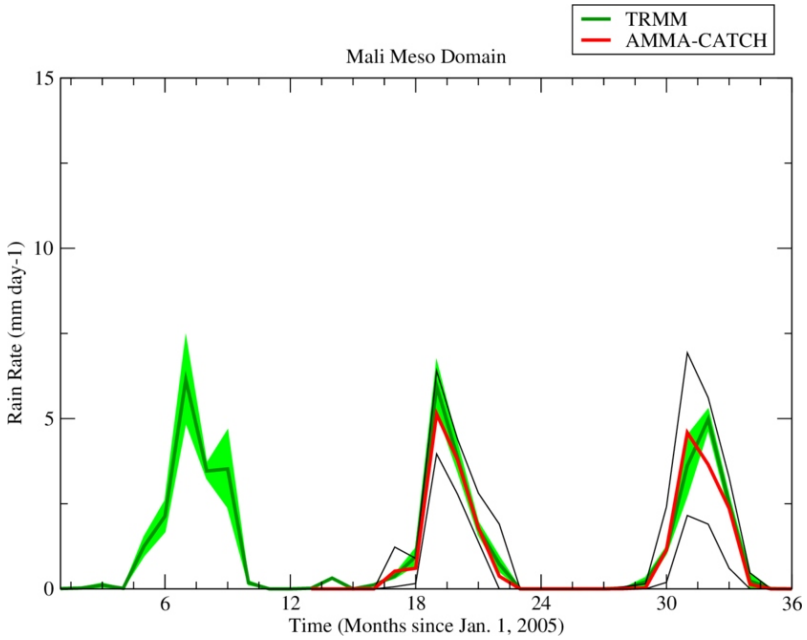
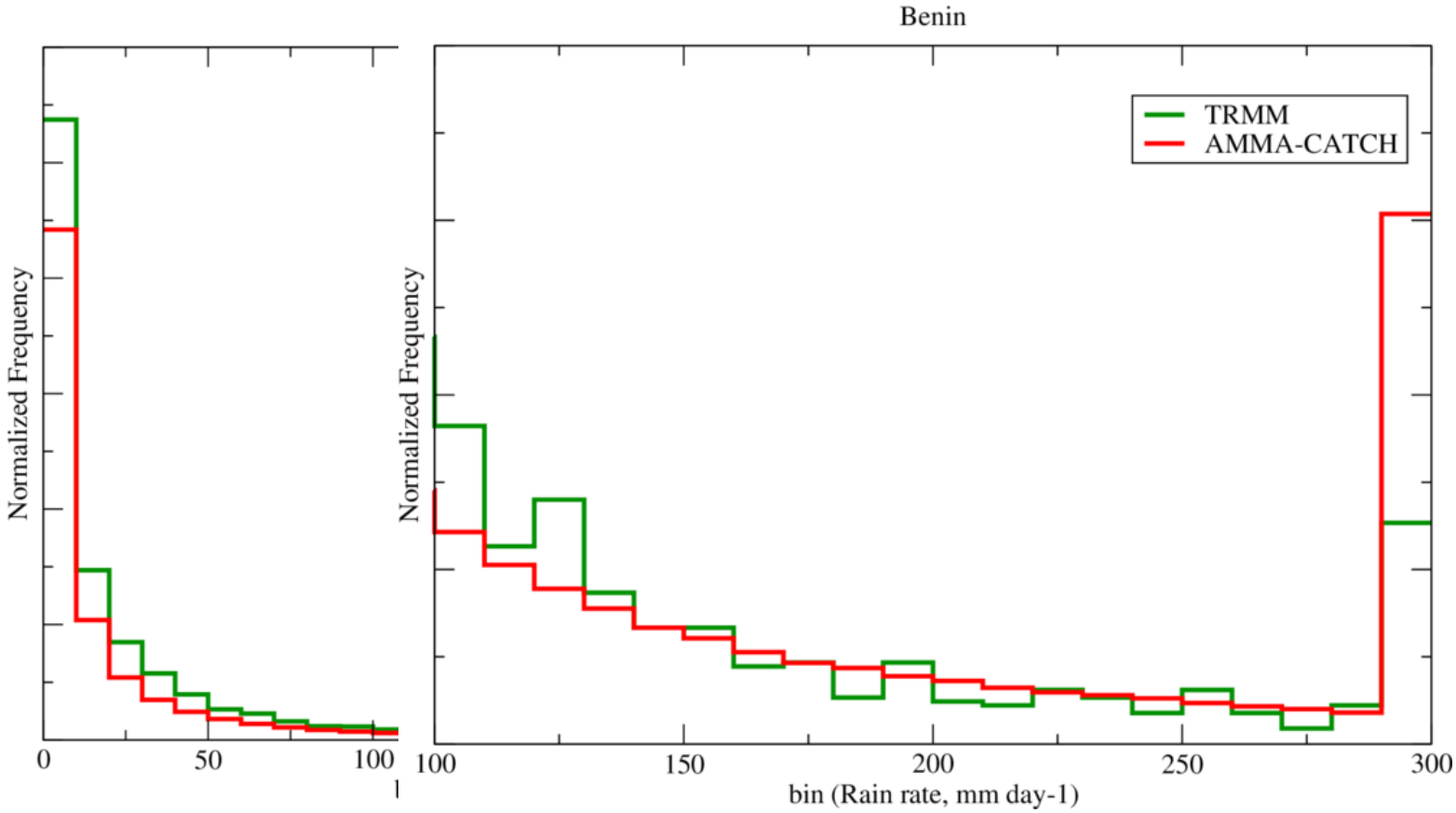




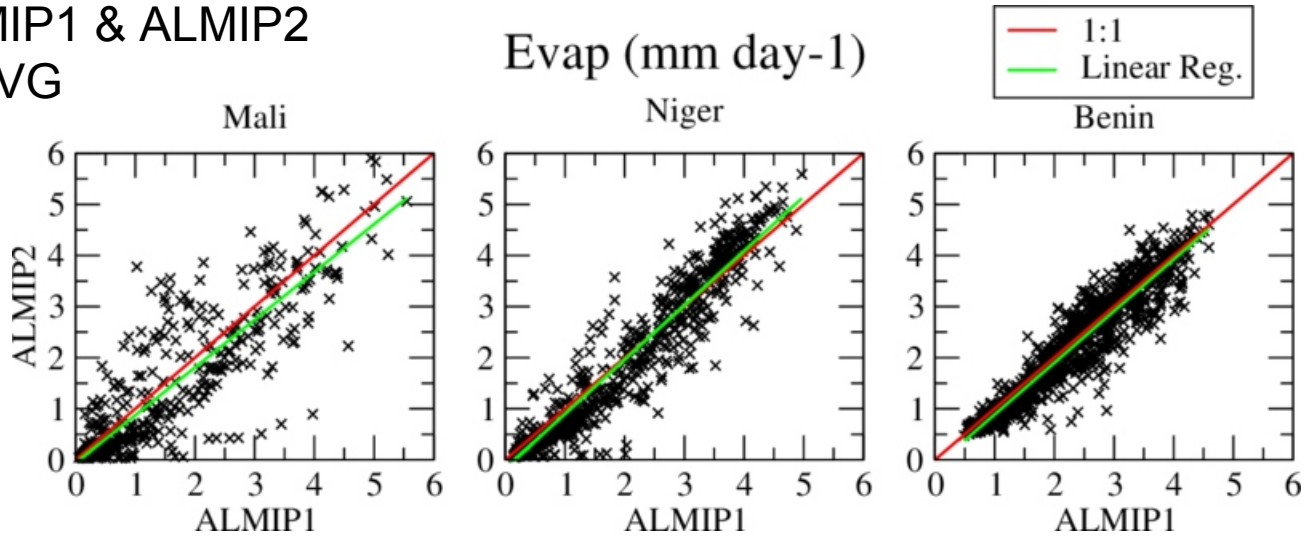




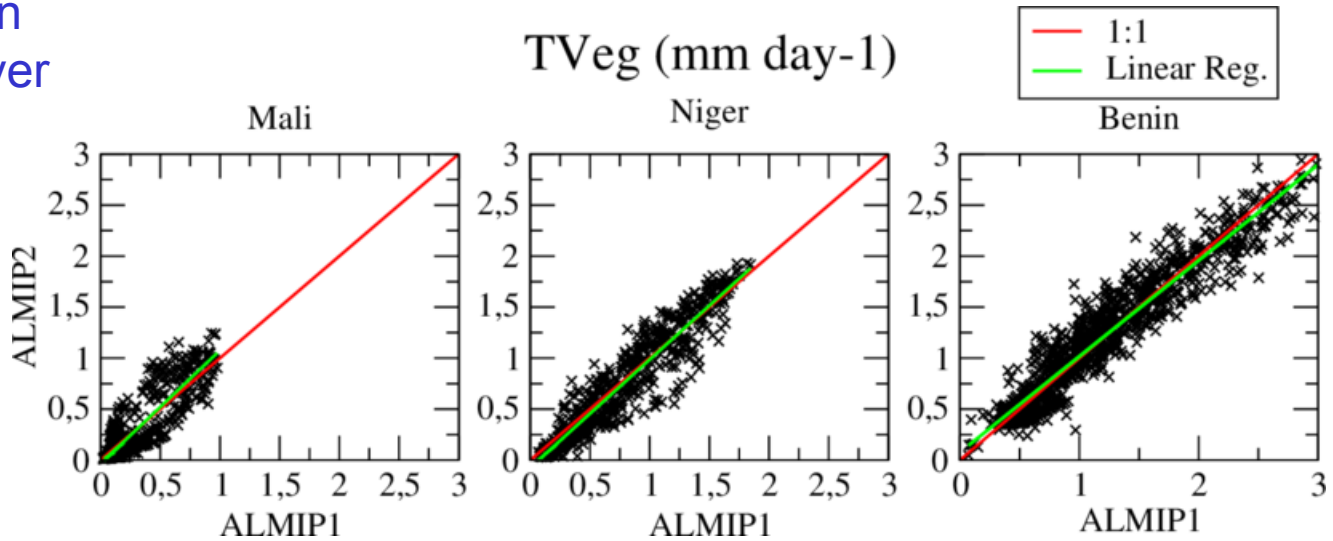


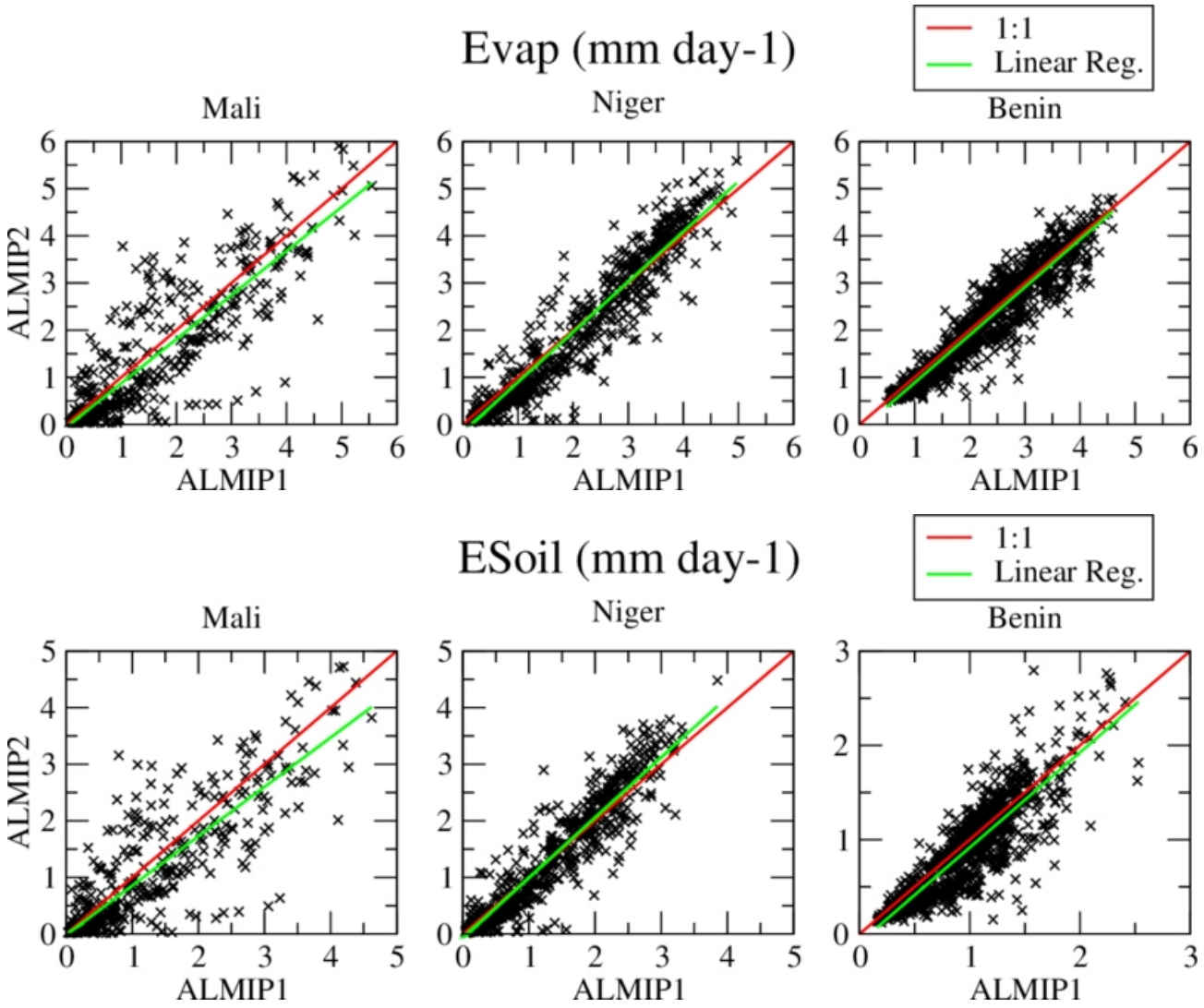
Time step values: **3h** vs **30 min**

Compare ALMIP1 & ALMIP2 multi-model AVG

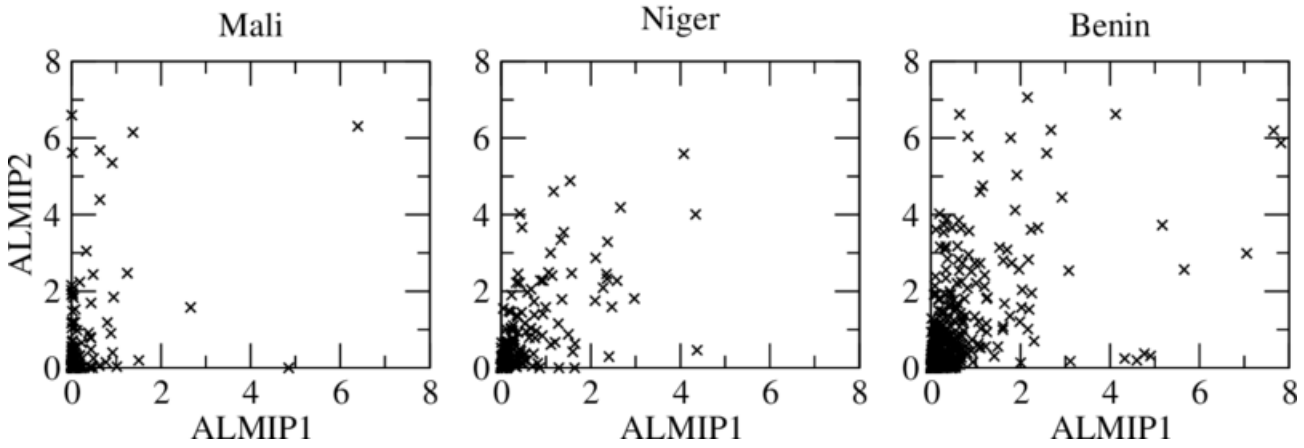


Daily domain averages over 2-3 years

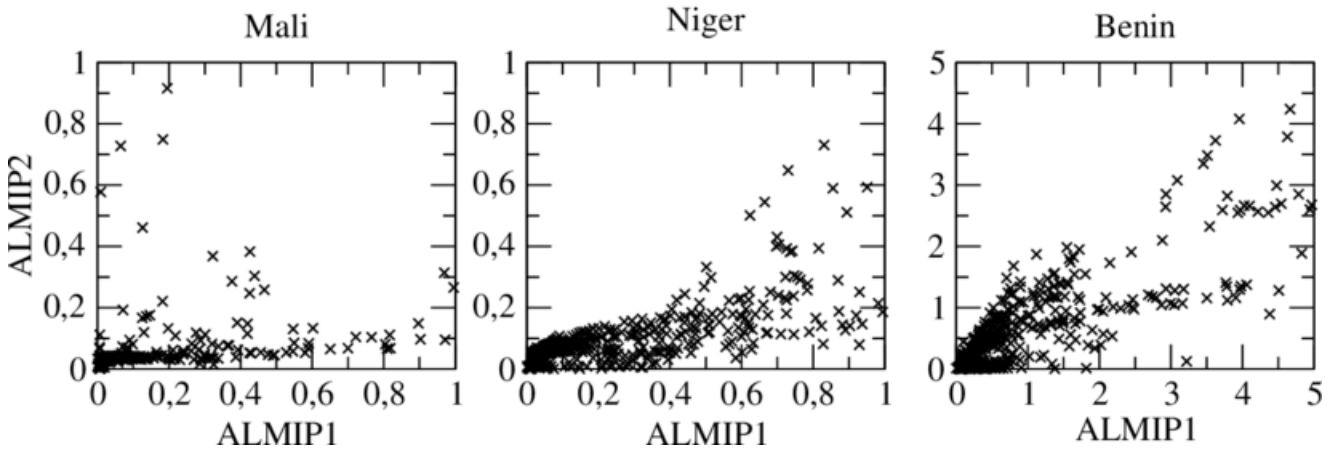



Evap (mm day-1)
1:1
Linear Reg.
Mali
Niger
Benin
ALMIP2
ALMIP1
ESoil (mm day-1)
1:1
Linear Reg.
Mali
Niger
Benin
ALMIP2
ALMIP1

Surface Runoff (Qs: mm day-1)



Drainage Runoff (Qsb: mm day-1)



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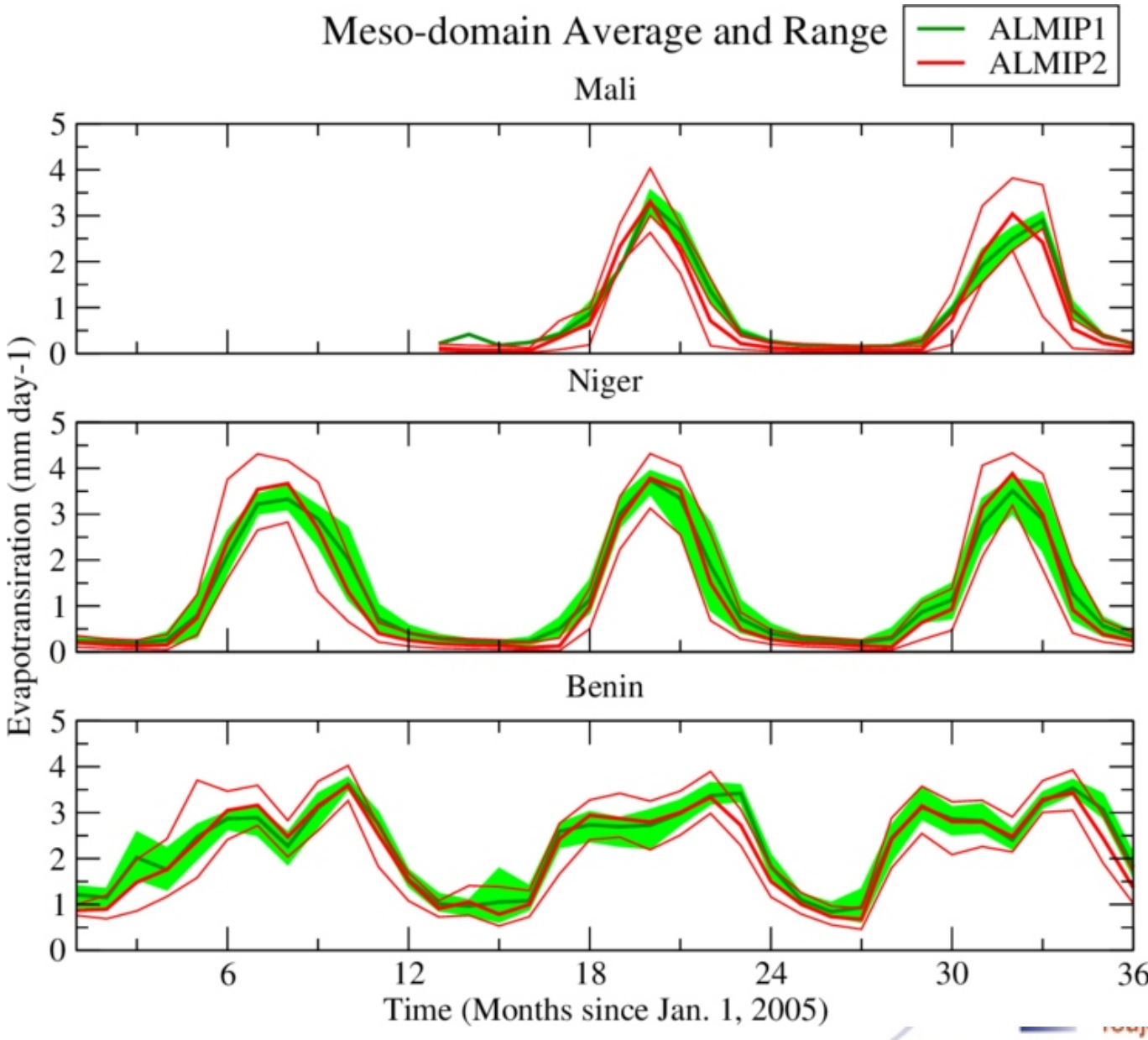
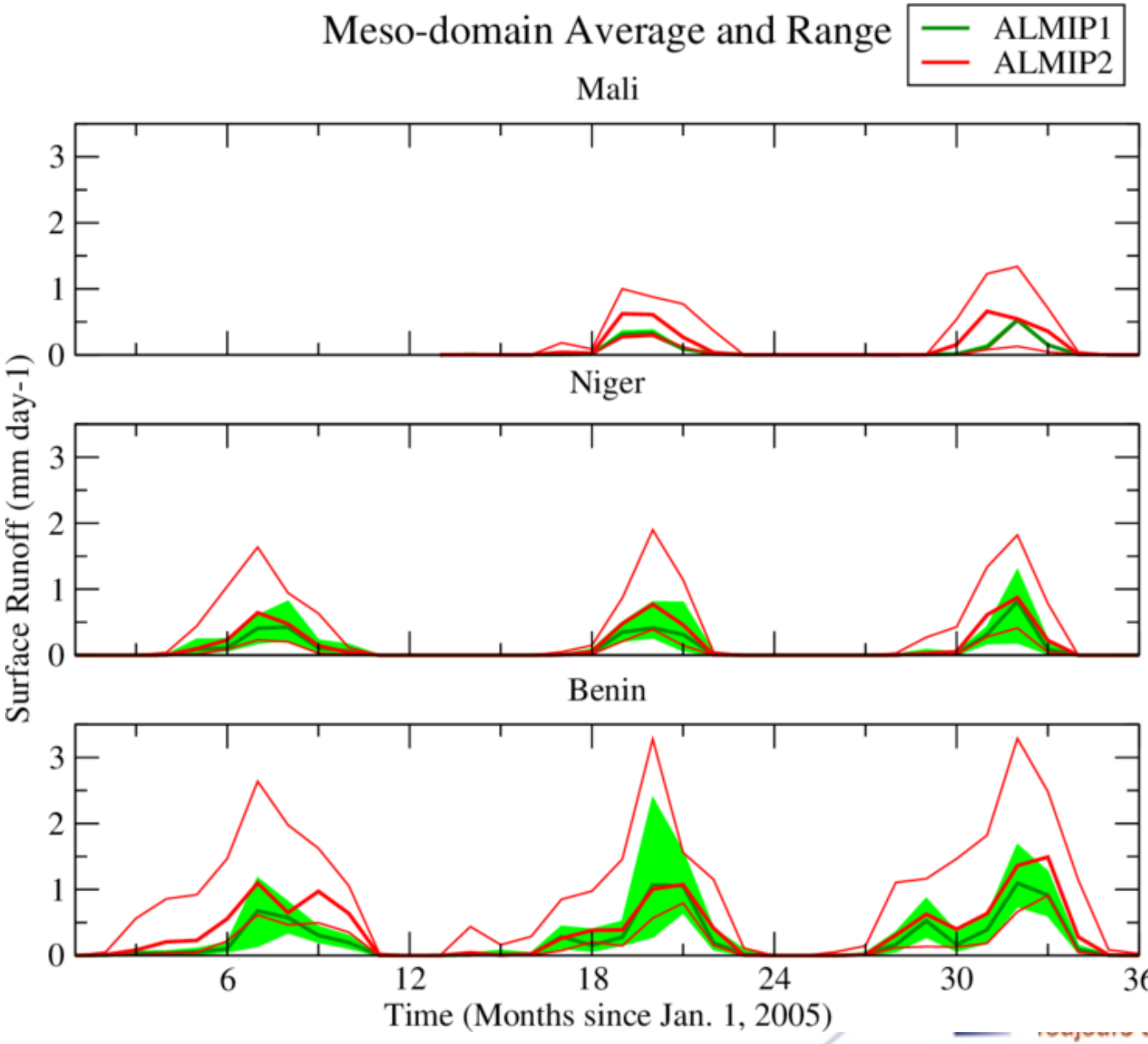
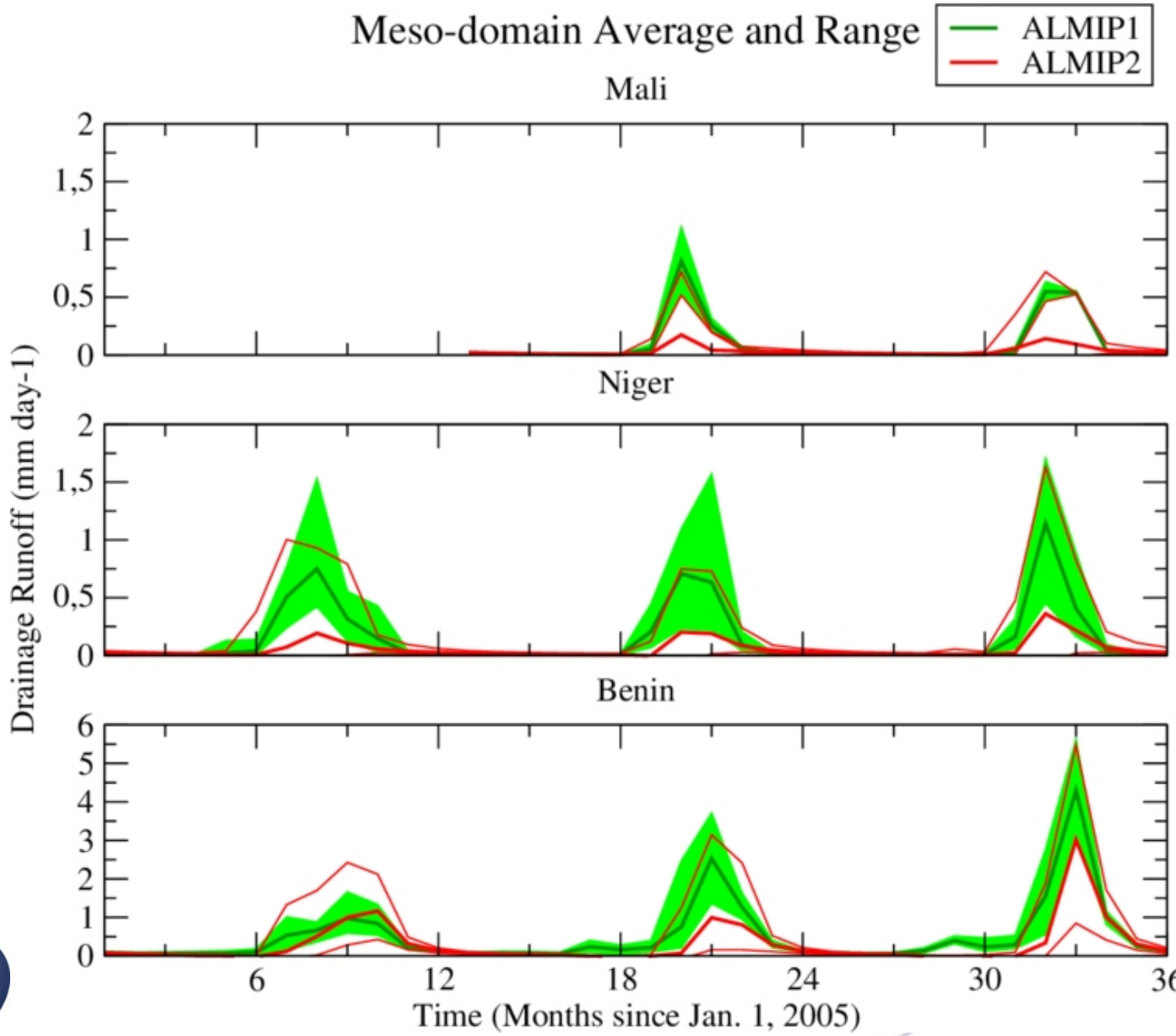
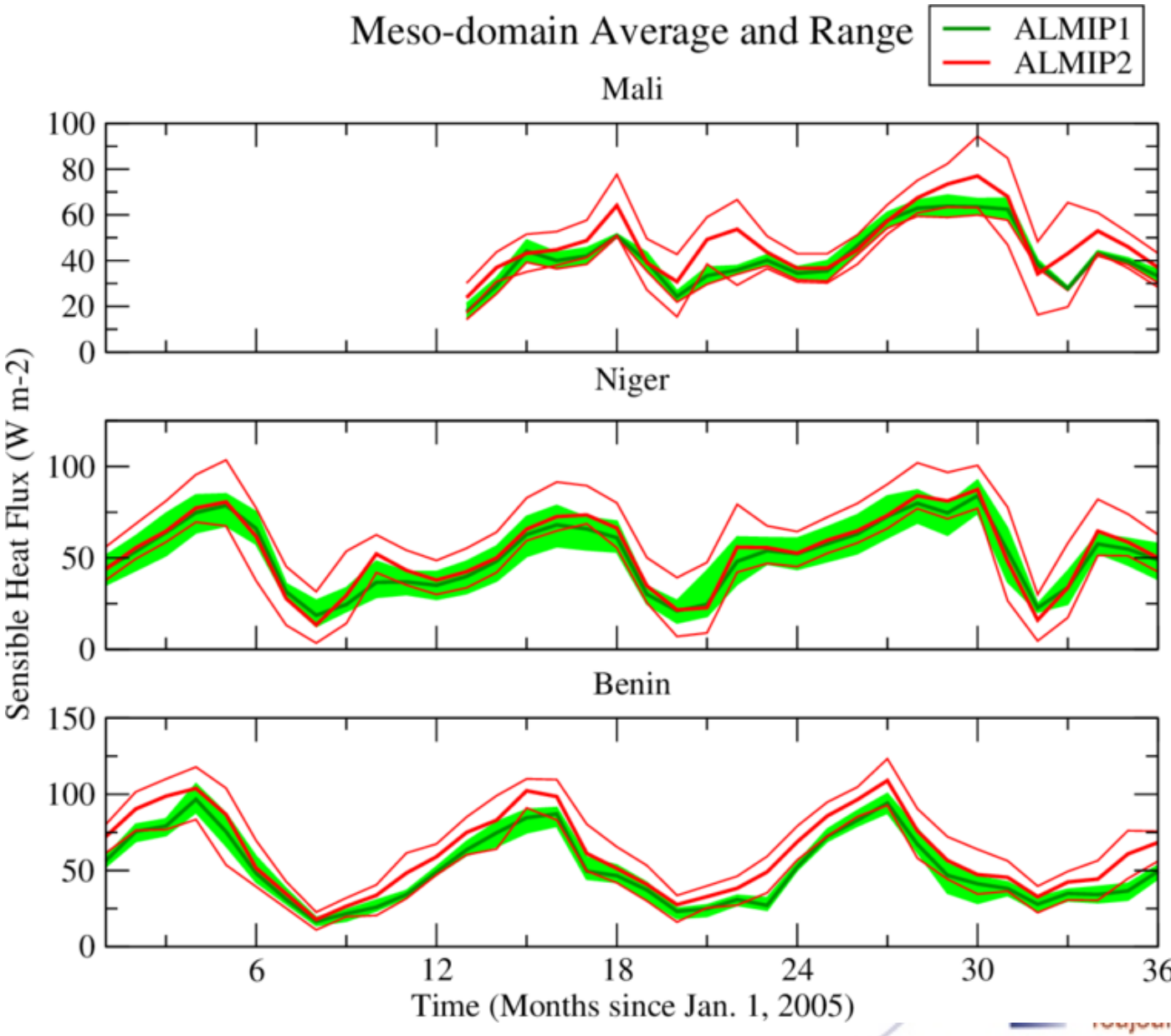


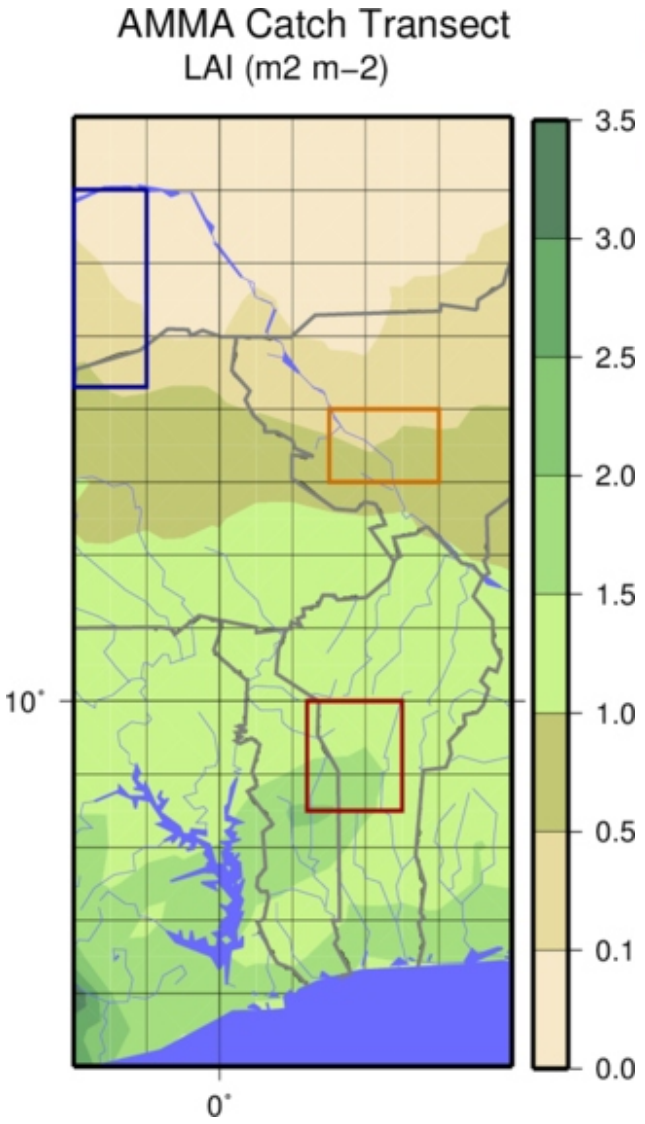

Meso-domain Average and Range
ALMIP1
ALMIP2
Mali
Niger
Benin
Surface Runoff (mm day-1)
0
1
2
3
6
12
18
24
30
36
Time (Months since Jan. 1, 2005)


Meso-domain Average and Range
ALMIP1
ALMIP2
Mali
Niger
Benin
Drainage Runoff (mm day-1)
Time (Months since Jan. 1, 2005)
0
0,5
1
1,5
2
3
4
5
6
12
18
24
30
36



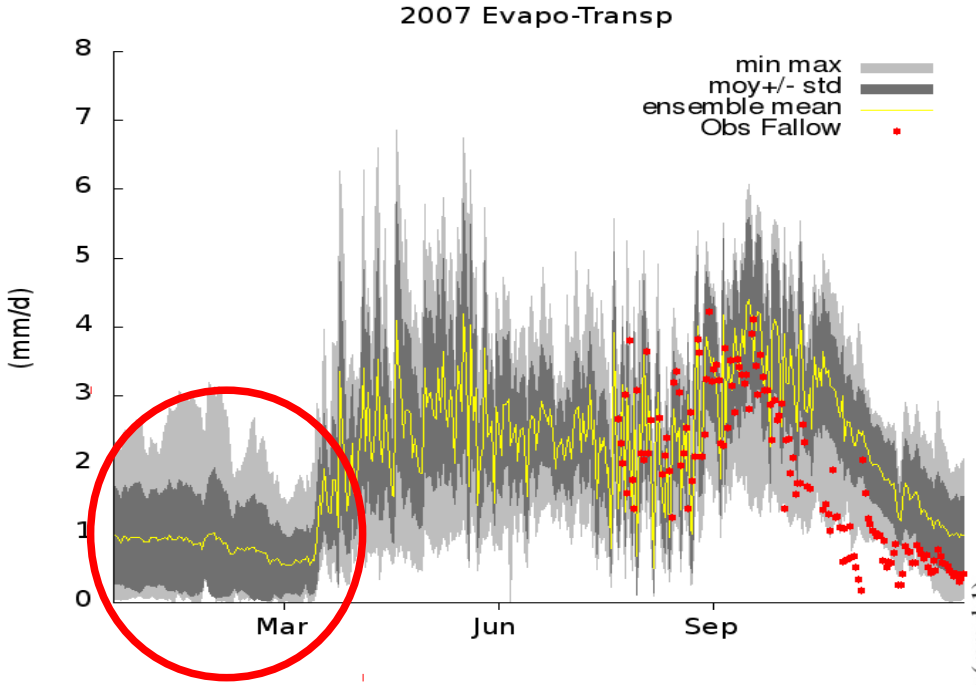
Bias➔

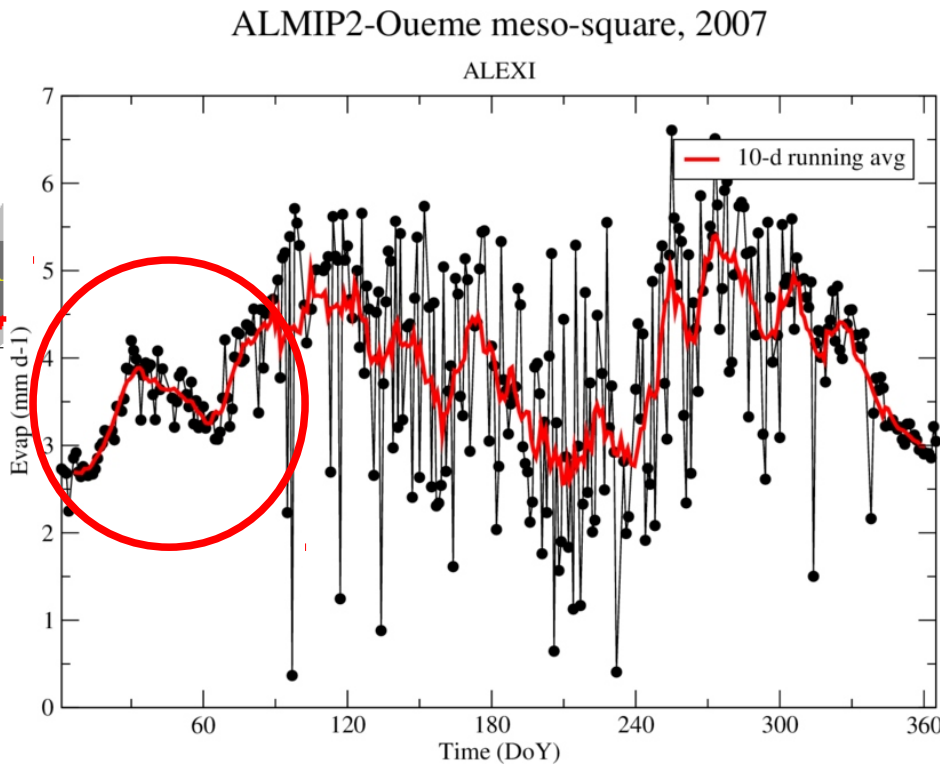
aerosols



M. Grippa, L/ Kergoat, C. Pierre, E. Mougin, P. Hiernaux, F. Timouk (GET, Toulouse)

Ouémé 2007





Significant Evap occurs during the dry season : deep rooting plants tap into the saturated zone : missed by MOST models owing to physics

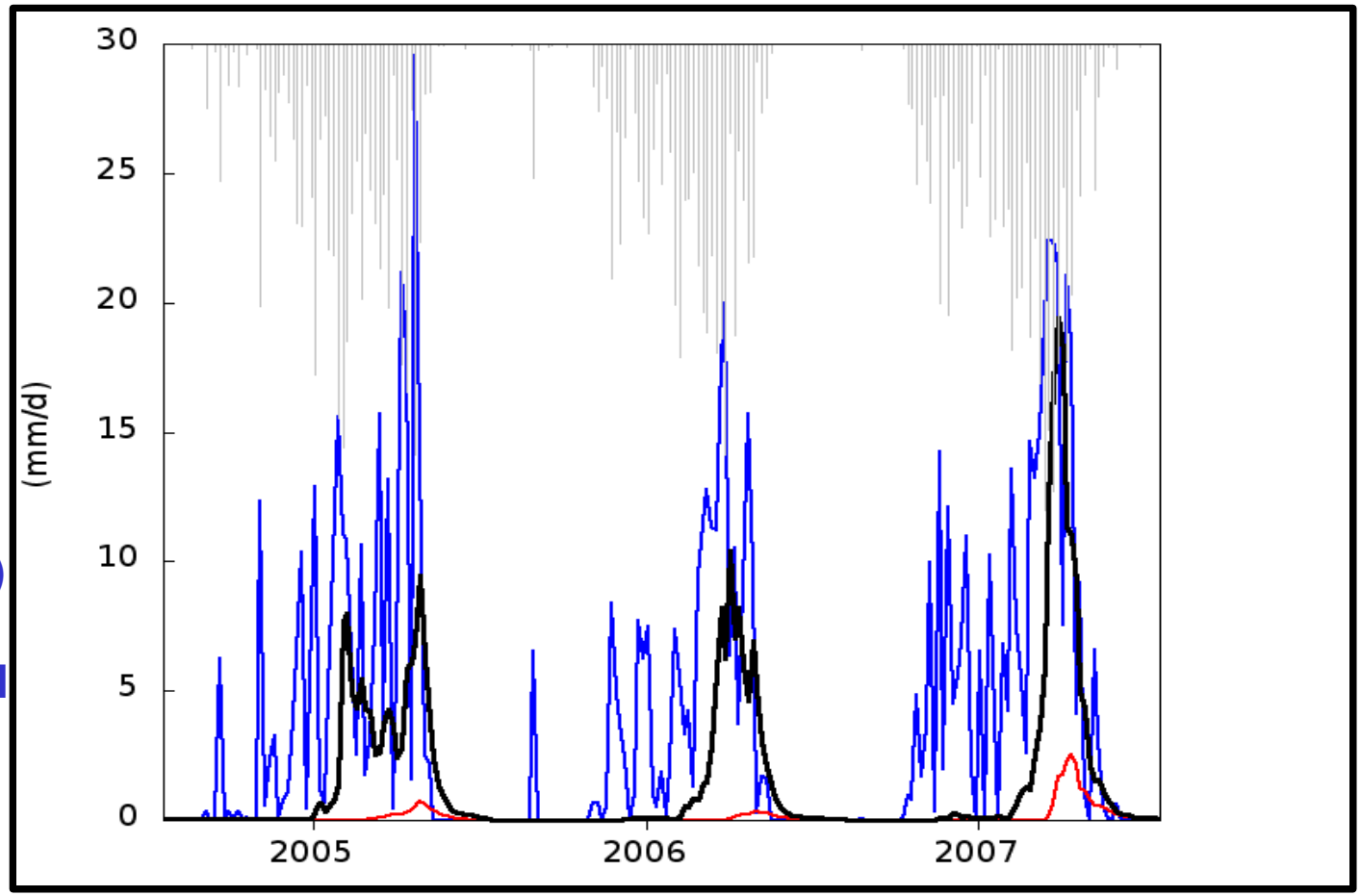
Benin: Oueme basin

Qs

Qsb

Obs Discharge

Obs Rainf



There is (in reality!) a significant lag between runoff and discharge

➔ **Ground water?**

C. Peugeot, HSM

Summary:

- inter-model var > inter-annual var

- Qh-Qle scatter large (but comparable to ALMIP1)

- E/P vs R/P changes little across sites

- Evap (and main components) scale well on daily-monthly timescales (LSM average, but generally the case for LSMs)

- Runoff does not scale well ➔ sub-grid runoff not scale dependent (enough?)

- Missing processes (could impact land atmosphere coupling)

  - **Significant Interactions with ground water**
  - **Endoric processes**
  - **Lateral fluxes (also extensive seasonal ponding)**
  - **Deep rooting plants**
  - **hydrophobic (f(t)) soils ➔ crusting……**

ALMIP AMMA Land Surface Model Intercomparison Project Phase 2

Participants (as of 2013): 28 research groups

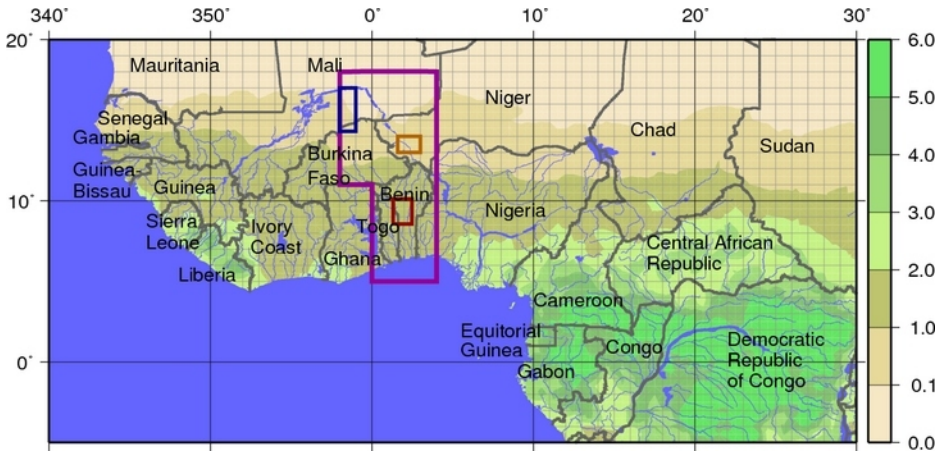
- CNRM-GAME
- HSM
- GET
- SYSYPHE
- CESBIO
- LSCE
- LTHE
- LMD

- Department of Geography, University of Bonn
- International Centre for Water Hazard and Risk Management-UNESCO, Japan

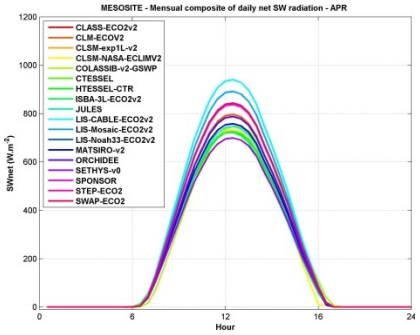
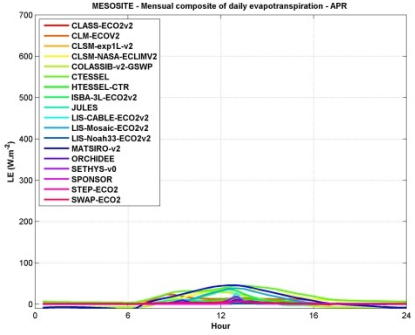
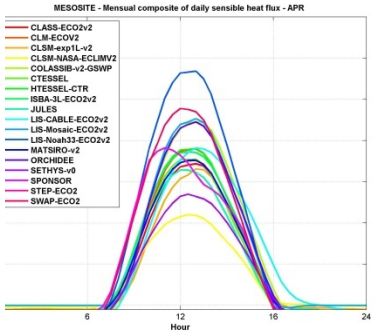
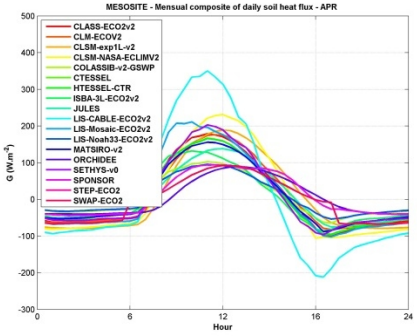
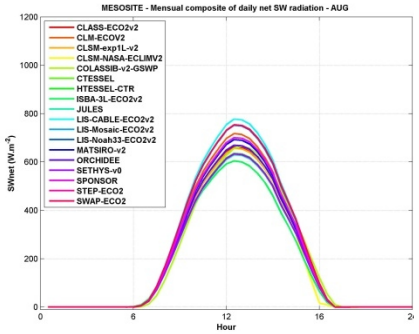
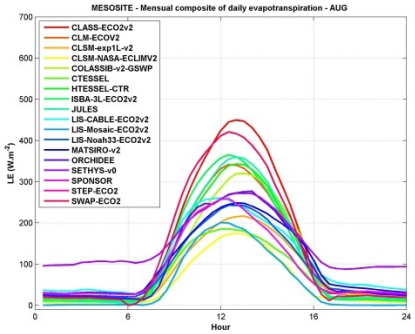
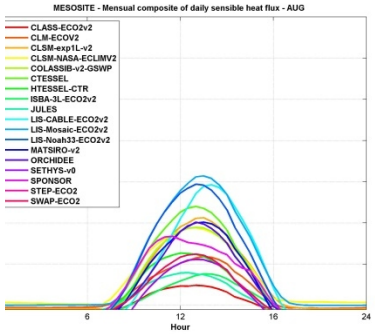
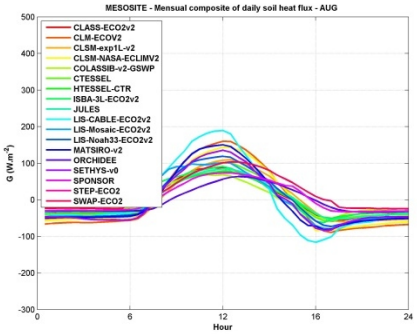
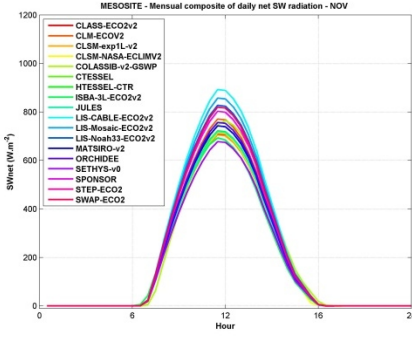
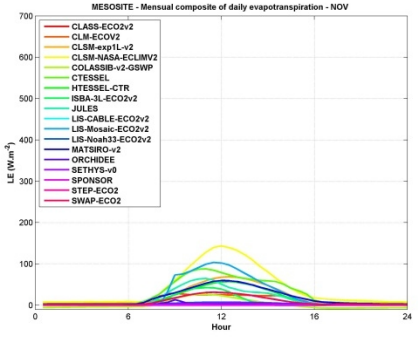
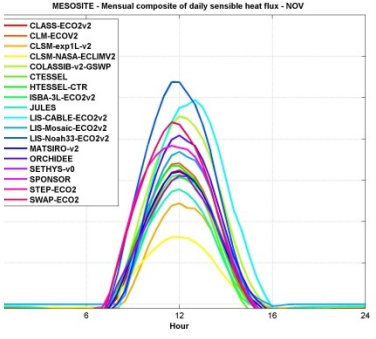
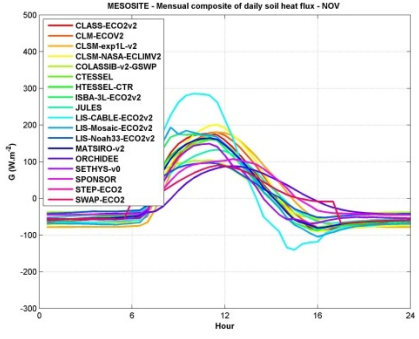
- University of Copenhagen, Denmark
- Columbia University, NY, US
- USDA, Beltsville, MD, USA

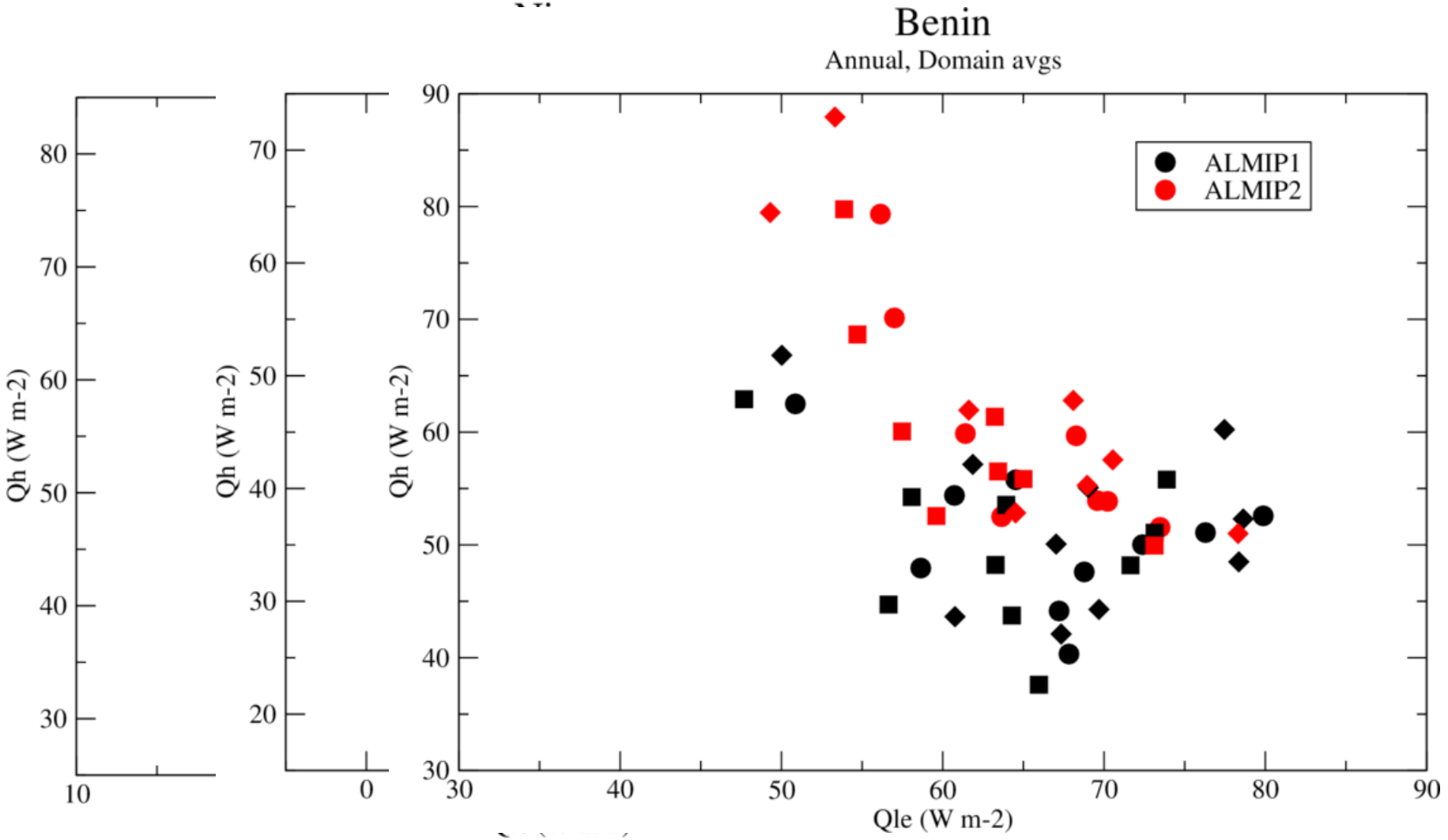
- CEH, (& UKMO) Wallingford, UK
- ECMWF, Reading, UK
- NOAA-NCEP, Camp Springs, MD, US
- NASA-GSFC, Greenbelt, MD, US
- NASA-MSPC, Huntsville, AL, US
- COLA, Calverton, MD, US
- Institute of Water Problems, Russia
- Institute of Geography, Moscow, Russia
- Environment Canada
- KIT, Germany
- Water Resources Research Center, Gokasho, Japan
- Institute of Industrial Science, Tokyo, Japan
- Hydrology and Water Resources Research Laboratory, Kyoto, Japan
- Department of Atmospheric Sciences at National Taiwan University
- TERG, Sydney, Australia

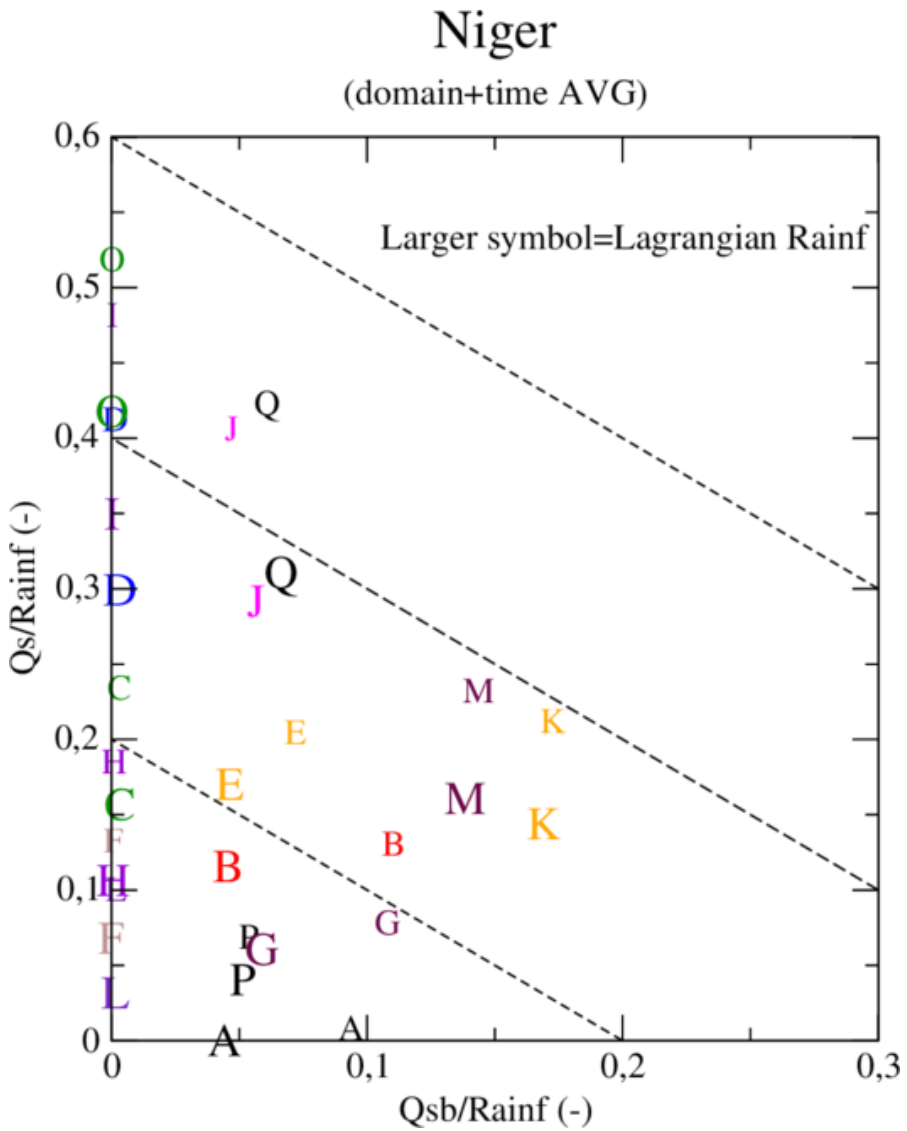
22 LSMs, 5 Hydrological Models, 1 ET model


340°
350°
0°
10°
20°
30°
20°
10°
0°
Mauritania
Mali
Niger
Senegal
Gambia
Guinea-Bissau
Guinea
Burkina Faso
Benin
Chad
Sudan
Nigeria
Sierra Leone
Liberia
Ivory Coast
Ghana
Togo
Central African Republic
Cameroon
Equitorial Guinea
Gabon
Congo
Democratic Republic of Congo
6.0
5.0
4.0
3.0
2.0
1.0
0.1
0.0

Niger...average daily cycles

Rnet	LE	H	G	
				Apr
				Aug
				Nov


Benin
Annual, Domain avgs
ALMIP1
ALMIP2
Qh (W m-2)
Qle (W m-2)
10
20
30
40
50
60
70
80
90
0



Impact of different Rainf on runoff partitioning:

-lines of constant total runoff ratio (dashed)

- larger Thiessen: diff is fairly consistent among models, but Qs-dominant models remain Qs-dominant (and vice versa for Qsb dominant)