SURFACE RADIATION AND THERMODYNAMIC COUPLINGS IN WEST-AFRICA: CONTRASTING RE-ANALYSES, CMIP5 CLIMATE SIMULATIONS AND IN-SITU AMMA OBSERVATIONS

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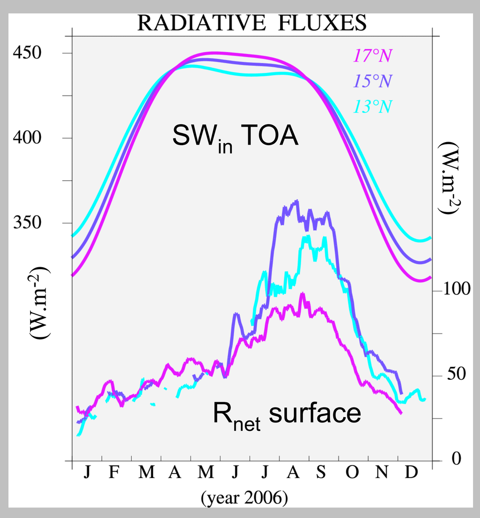
FIGURE 1 annual cycle of radiation in the Sahel



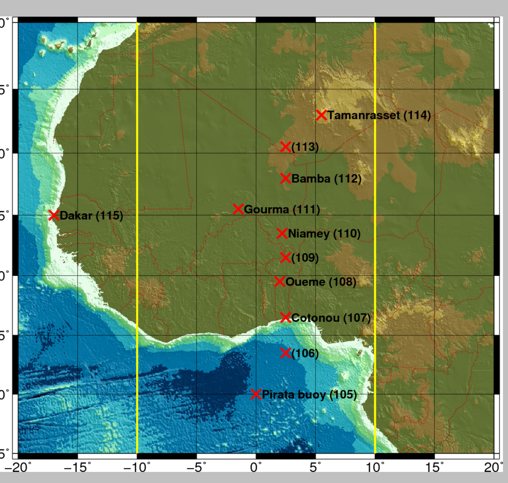
For TOA incoming shortwave flux and surface net radiation at 3 Sahelian sites

a lag is observed between the TOA solar energy input and the surface energy budget (Fig from Guichard et al. 2012)

CONTEXT

- Surface radiation and thermodynamics display strong couplings across West Africa and play an important role on the monsoon dynamics (Charney QJRMS 1975, Eltahir & Gong J. Climate 1996).
- These couplings change along the year and with the contrasted climates encountered from the southern wet cloudy Guinean zone to the Sahara (Meynadier et al. JGR 2010, Gounou et al. BLM 2012). A **pronounced and complex annual cycle of the surface radiative budget** is observed there (Guichard et al. Hydrology 2009, Slingo et al. 2009), e.g. example of **[Fig 1]**.
- The data acquired - and observational studies carried out- within the AMMA project allow for the first time to evaluate in a comprehensive way the modelling of these key features of the West African climate at a time when dedicated CMIP5 model outputs become available **[Fig 2]**.

FIGURE 2 AMMA TRANSECT and CMIP5 cfSites



✔ yellow lines delineate the climatic transect [10°W,10°E]

✔ CMIP5 cfSites (red crosses) coincide with location where ground-data are available (AMMA Catch, ARM Niamey) and where high-frequency (~30min) output from CMIP5 runs have been made available.

OBJECTIVE & METHOD

This study explores the simulation of the annual cycle by (i) reanalyses (ERA-Interim, MERRA and NCEPCFSR) and (ii) CMIP5 climate simulations (amip,historical,piControl runs). We use of data acquired from several automatic weather stations installed along the climatic transect. Additional information is presented at the conference by Bouniol et al (2012) and Guichard et al. (2012)

Reanalyses provide a reasonable depiction of the annual cycle of the surface thermodynamics but a much more approximative estimates of surface radiation. Monthly-mean biases reach several tens of W.m-2 in both LW and SW **[Fig 3]**.

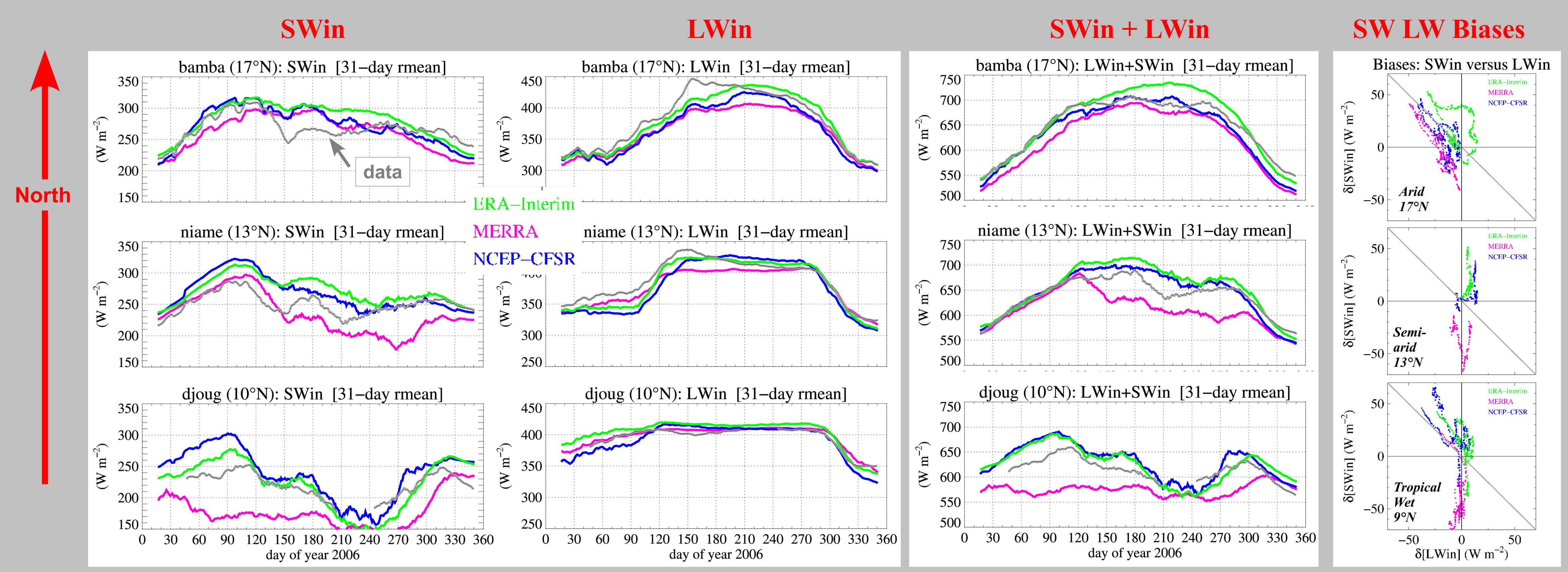
These limitations can be traced back to the modelling of physical processes involving surface properties, but also clouds and aerosols (e.g. Guichard 2009).

Biases varies according to the reanalyse, the climate and the time in year.

In the LW, they are larger in the Sahel than further south, and smaller during the moist season.
In the SW, they can be large at all time of the year, but are especially large at the wetter cloudier southern site.

Bias in SW and LW do not compensate each other at all time (even if partly) [righ panel].

FIGURE 3 Evaluation of surface incoming radiation in reanalyses



Surface radiation in CMIP5 models

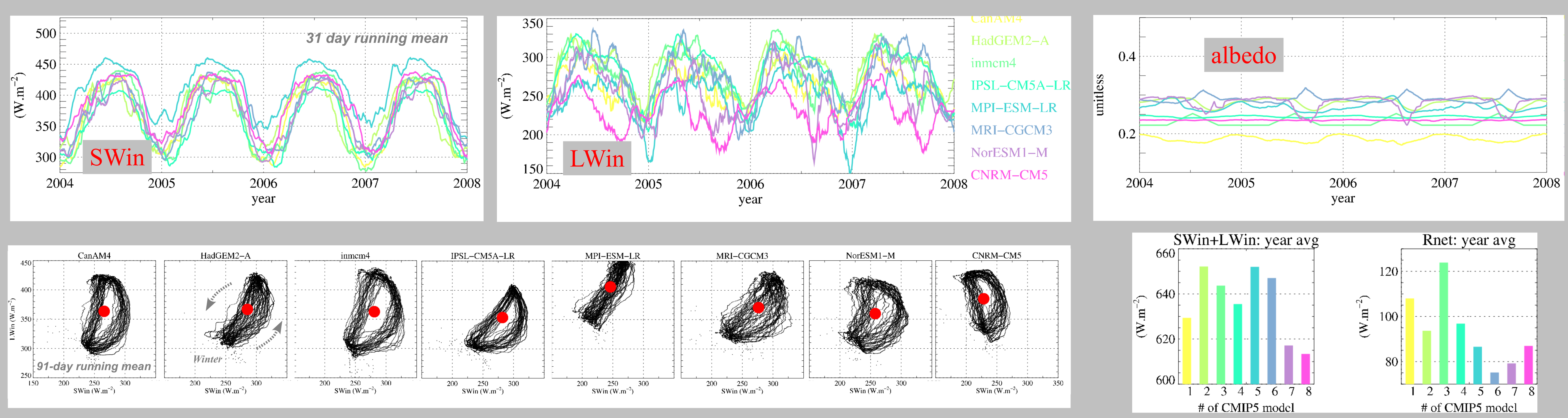
The depiction of the annual cycle by climate models is more diverse **[Fig 4]**. and it varies more from one model to the other than from one type of run to another (amip, historical or piControl runs).

Bias in SW and LW do not compensate each other and their joint annual dynamics differ significantly among models (lower left panel, for 30 year AMIP runs).

Apart from the issue of the reprensentation of the annual dynamics of the monsoon and of rainfall, the surface albedo is very different from one model to another (upper right panel) and annual surface net radiation varies by tens of W.m^2.

FIGURE 4 Spread in surface radiation of CMIP5 simulations

(AMIP runs at 15°N, Agoufou cfSite)



2m temperature in CMIP5 models

differs by several K in the Sahel (and differs more than further South) **[Fig 5]**. The large spread in T2m observed outside of the monsoon (JJAS) and the differences in the diurnal cycles suggests an important role of night-time processes in shaping the low-level temperature and of LW exchanges between the surface and the atmosphere.

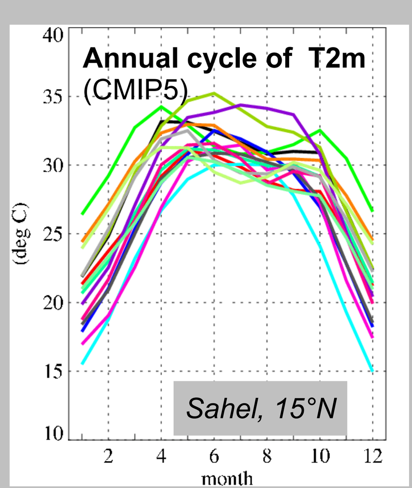
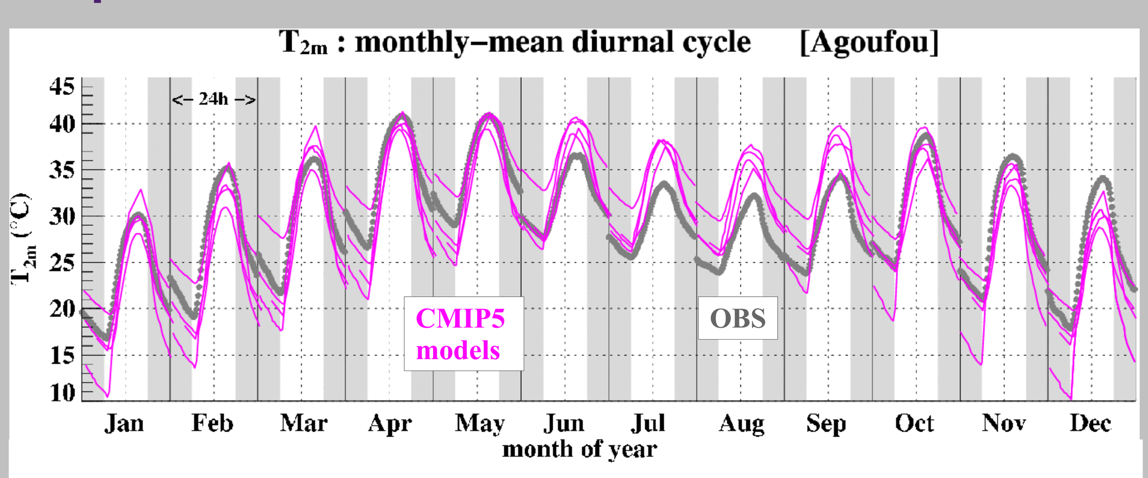


FIGURE 5 Annual cycle of 2m temperature in CMIP5 models



JFMA: cold bias at night, JJAS: warm bias during the day

PERSPECTIVES

The differences in the annual cycle and monsoon dynamics among models suggests the interest of synthetic integral diagnostics **[Fig 6]**. They illustrate basic couplings between water vapour, clouds and LW fluxes (see e.g. Betts BAMS 2004, Guichard et al. J. Hydrology 2009, Stephens J. Climate 2012).

Such couplings are present in both data and models, but the differences in the structure of the couplings is informative of the regimes which are the most critical.

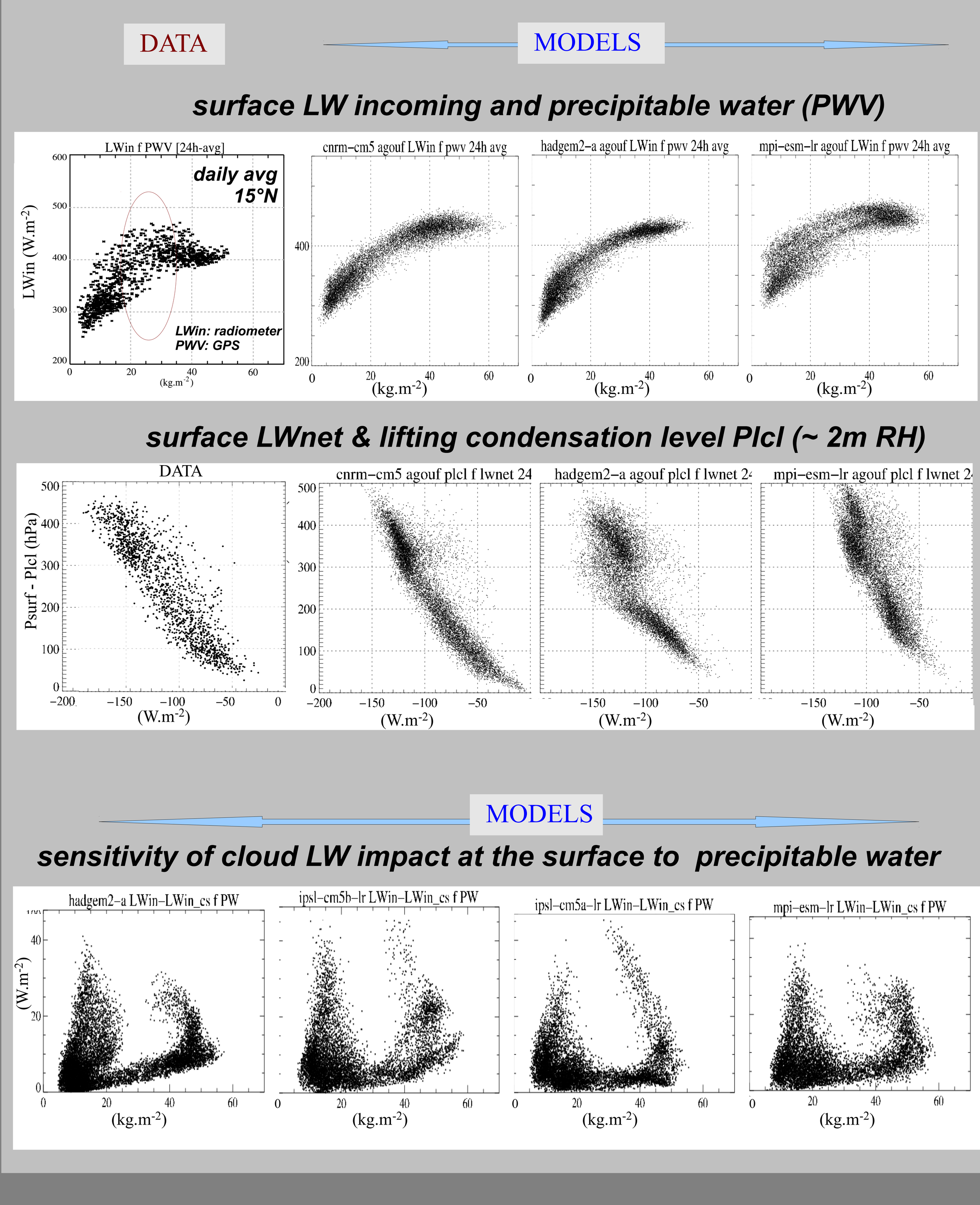
The lower panel points to the subtle cloud-radiative impact, which deserves further studies, in particular observational ones following Bouniol et al. (2012).

AMMA data show that the simulation of the surface radiative and energy budgets is both difficult and critical over West Africa for climate models but also reanalyses.

More CMIP5 cfSites outputs, not included here, are becoming available, they will be integrated in this study.

Not only rainfall but also water vapour, cloud and aerosols radiative impact, surface properties, notably albedo and vegetation phenology, nocturnal turbulence, all need to be considered for process-oriented evaluations of the West African climate in models.

FIGURE 6 THERMODYNAMIC-RADIATIVE COUPLINGS *LW fluxes, water vapour and clouds*



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