The EUMETSAT Network of Satellite Application Facilities

LSA SAF
Land Surface Analysis

Comparison of ECMWF model skin Temperature with SEVIRI LST

Isabel F. Trigo, Souhail Boussetta, Pedro Viterbo, Gianpaolo Balsamo, Anton Beljaars, and Irina Sandu

ipma
instituto português do mar e da atmosfera

ECMWF

Outline

- Comparison of ECMWF Skin Temperature and SEVIRI/Land-SAF Land Surface Temperature estimates to assess changes in:
  - Model representation of vegetation - LAI
  - Model Surface roughness – Aerodynamic Resistance
  - Parameter controlling ground flux – skin conductivity

Satellite LST

As a model diagnostic tool

ECMWF Skin Temperature:

- Corresponds to a thickness-less surface, close to the radiometric temperature that is obtained from thermal infra-red channels
- Plays a role in the partitioning between latent and sensible heat fluxes at surface;
- Its diurnal cycle is associated to the degree of coupling between the land and the atmosphere that is shown to vary greatly across models.

Model deficiencies in skin temperature

- provide an indication of problems in surface energy fluxes and soil moisture …
- with impact on predictability of NWP / Earth System Models at medium and monthly-range.

ECMWF Tskin and SEVIRI LST

The EUMETSAT Network of Satellite Application Facilities

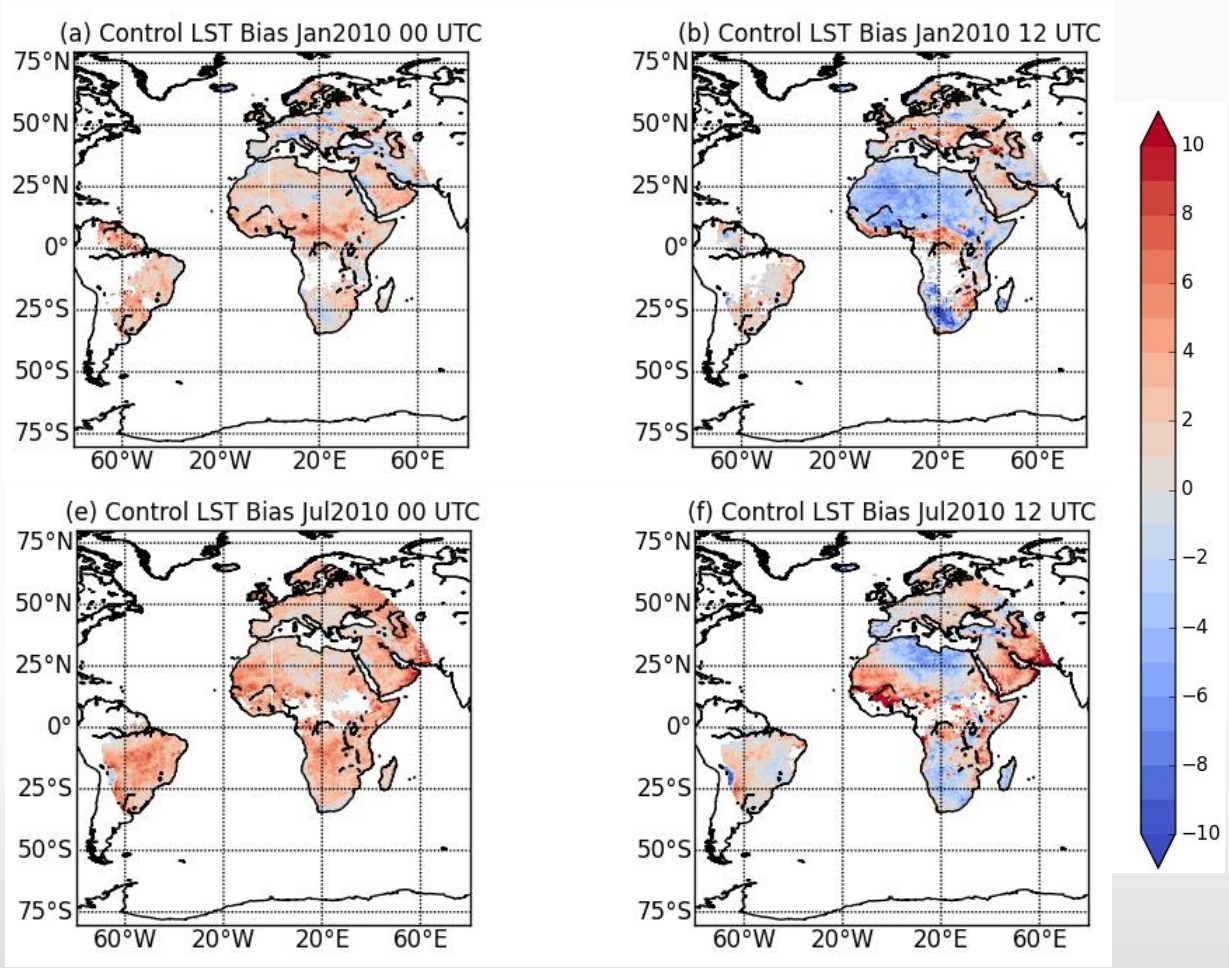
LSA SAF Land Surface Analysis

Tskin (ECMWF) – LST (SEVIRI)

Clear sky cases only: ECMWF TCC < 10% always!

Jan 2010

Jul 2010



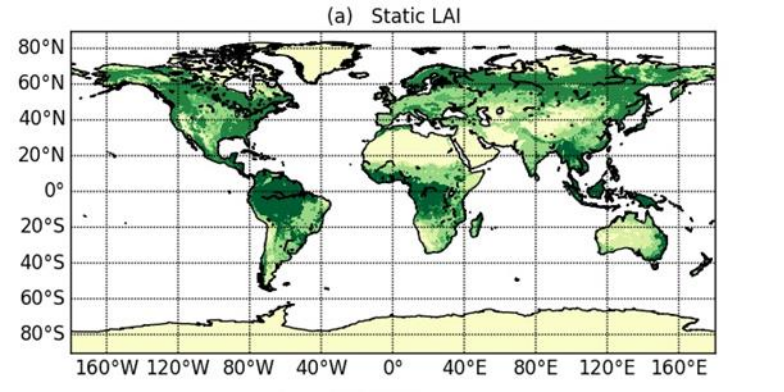
- Cool bias during daytime (12 UTC panels) over most of Africa and Europe
- Warm bias, although generally less pronounced, during night-time, i.e., ….
- Underestimation of daily amplitude of Tskin, particularly in semi-aird regions
- Different pattern over subtropical regions (during the wet season)

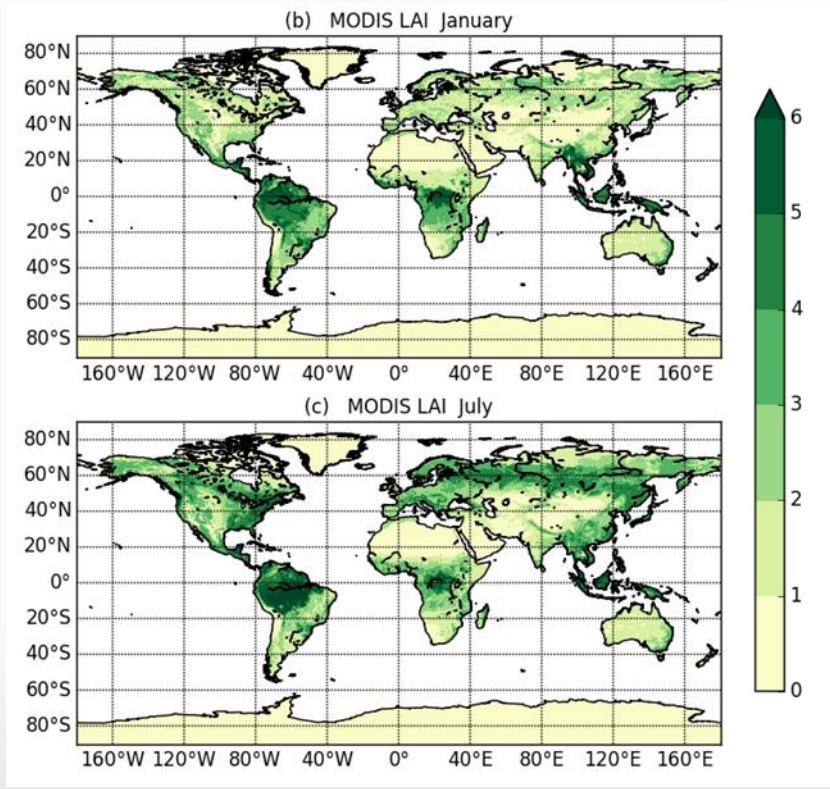
ipma instituto português do mar e da atmosfera

ECMWF

ECMWF: Moving towards more realistic LAI

Results shown in previous slide: run (**control**) with the prescription of a single static LAI (used in ECMWF IFS until November 2010)





- LAI set to MODIS monthly means
- Revised (decrease) minimum stomatal resistance: crops, short grass, needle-leaf forest
- Initial conditions:

  Off-line runs driven by ERA-Interim (Jan 2009 – Dec 2010) + LAI / stomata changes

ECMWF: Montly LAI

Impact on Tskin:

$$|Tskin\_CTL - LST\_SEVIRI| - |Tskin\_exp - LST\_SEVIRI|$$

Sensitivity of variable Y:

$$\Delta = (Y\_EXP - Y\_CTL)$$

ECMWF: Montly LAI

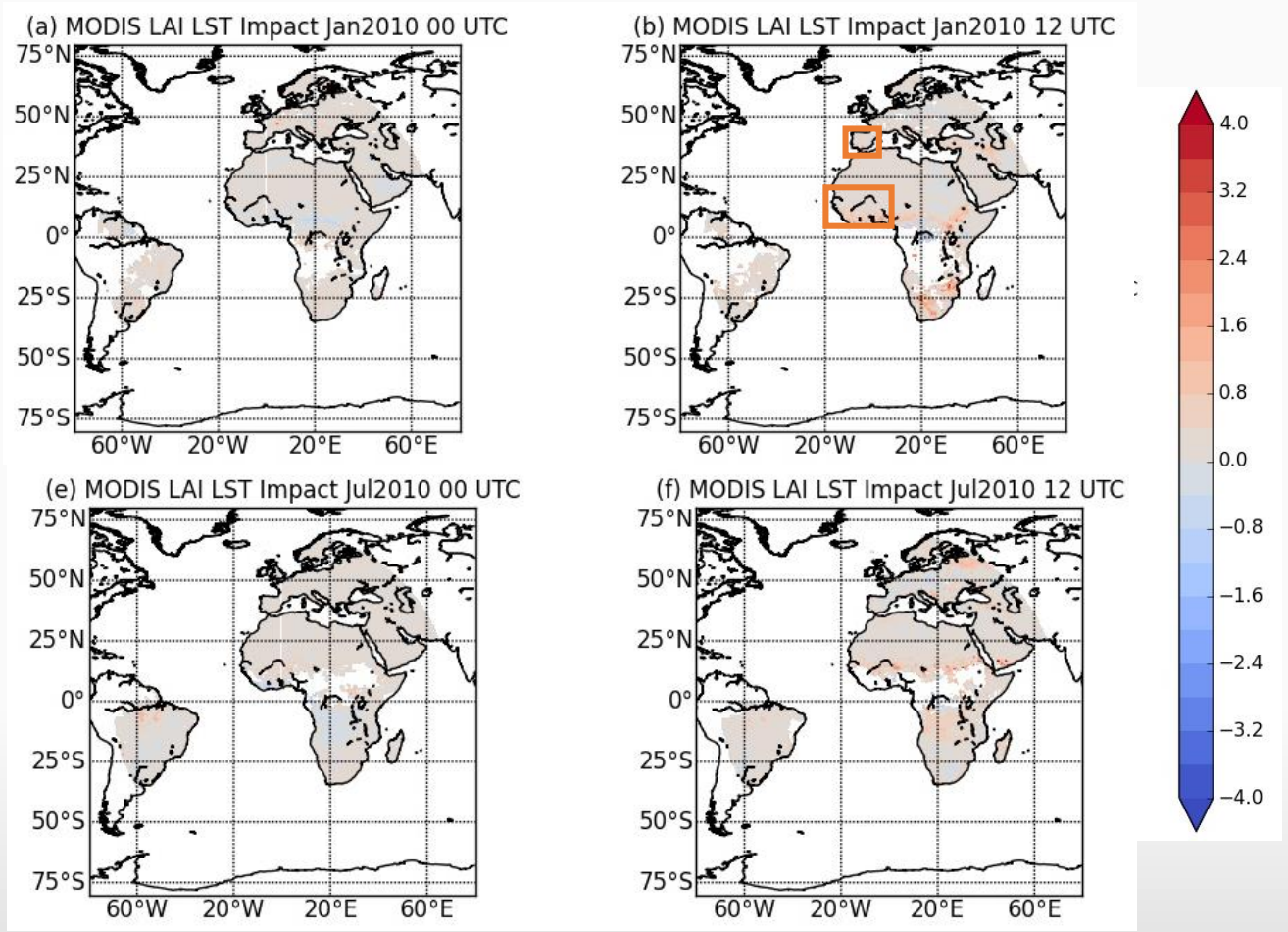
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Impact on LST

Jan 2010

Jul 2010



Reduced LAI + seasonal variability

- 00 UTC: neutral impact.
- 12 UTC shows positive impact over limited areas: Sahel in January and July; Europe and Middle East in April (not shown)

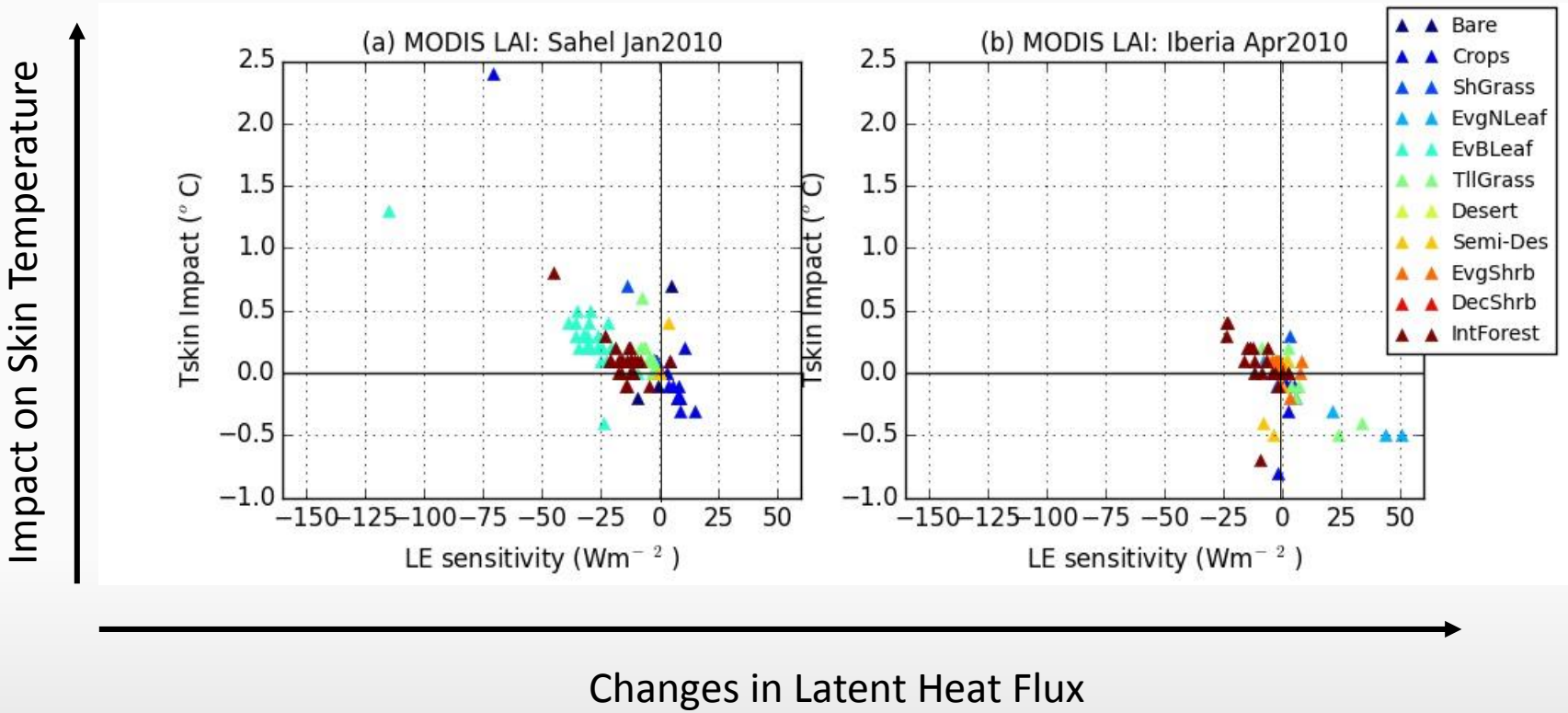
ipma instituto português do mar e da atmosfera

ECMWF

ECMWF: Montly LAI

Sahel, January

Iberia, April



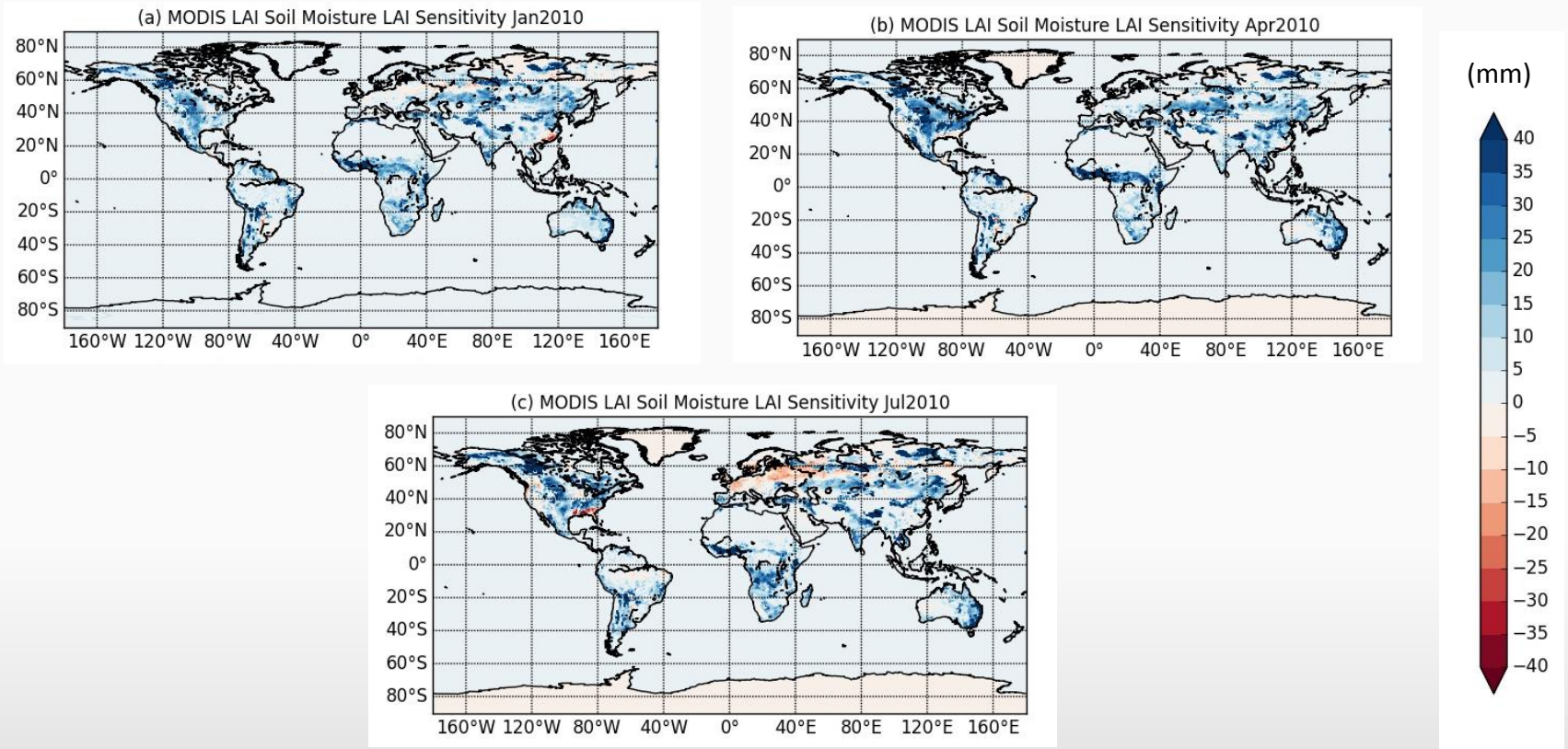
- Positive impact for land-cover types where LE decreases:
  - Tall grass;
  - Interrupted Forest;
  - Evergreen Broad-leaf Forest
- Why not more widespread?

ECMWF: Montly LAI

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Changes in Soil Moisture – top 1m of soil



- "LAI MODIS" simulations present higher soil moisture.

⇑

- Lower LAI in the offline run (which sets up initial conditions) leads indeed to less evaporation in most places, and therefore to higher SM.

- A wetter soil compensates for lower of evaporation and limits the impact on skin temperature.

ipma instituto português do mar e da atmosfera

ECMWF

ECMWF: Aerodynamic Resistance

Roughness Length for Momentum (ZoM)

Roughness Length for Heat (ZoH)

Control sensible heat flux: directly or via the near surface wind profile

- ✓ **ZoM**: revised in Nov 2011 to compensate an overestimation of 10m wind over a wide range of landcover types (increase in ZoM in grass, semi-desert, shrubs, crops, ...)
- ✓ **ZoH**: were revised to balance the increase in ZoM, and

$Z_{oM} / Z_{oH} = 10$ is set to $Z_{oM} / Z_{oH} = 100$ for (nearly) all surface types …

… leading to an increased resistance to heat transfer almost everywhere.

ECMWF: Revised LAI + ZoM and ZoH

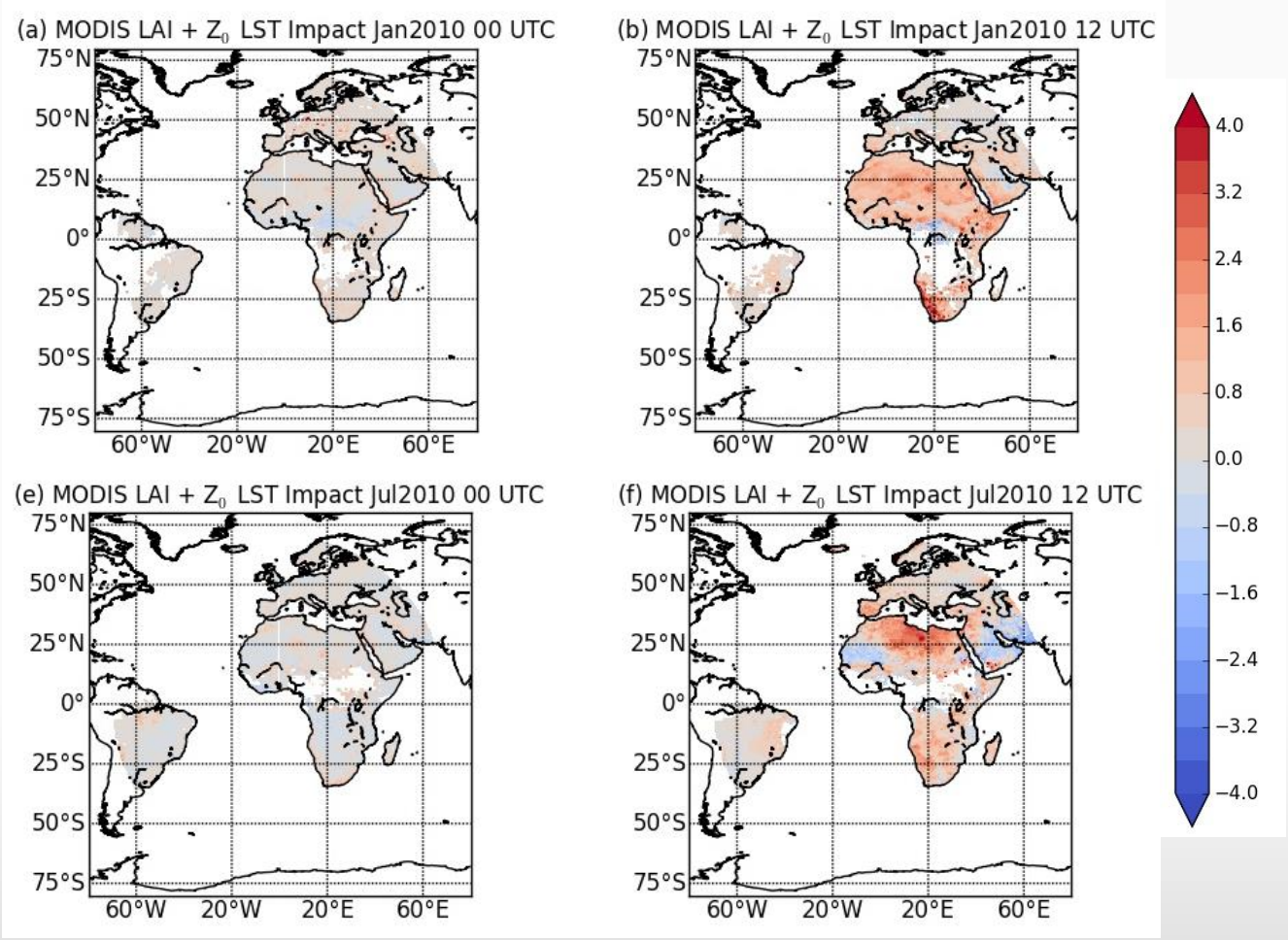
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Impact on LST

Jan 2010

Jul 2010

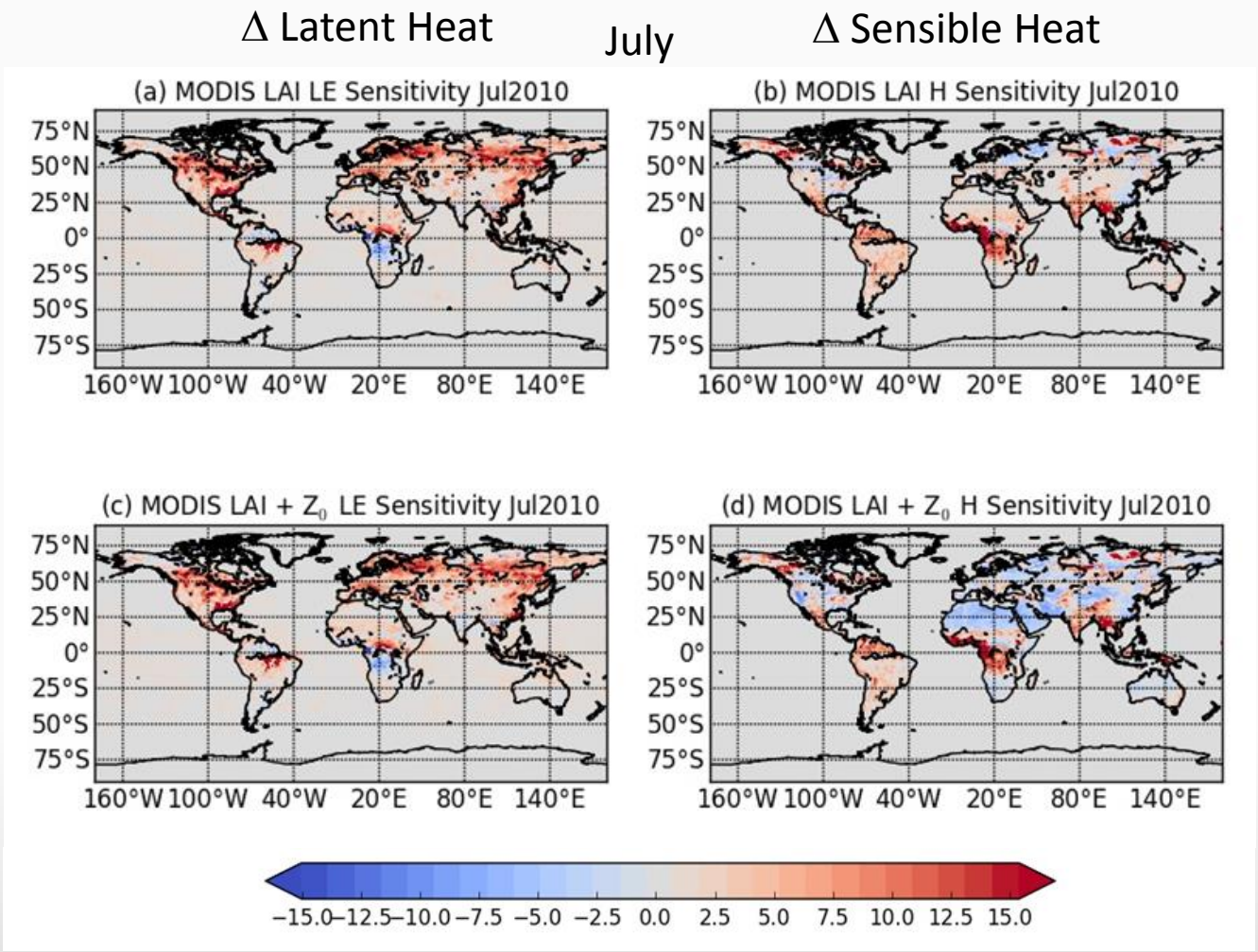


- 00 UTC: neutral impact.
- 12 UTC shows wider areas of positive impact over limited areas: Most of northern Africa, southern Europe
- The impact also complements the (smaller) impact induced by the revised LAI

ipma instituto português do mar e da atmosfera

ECMWF

ECMWF: Revised LAI + ZoM and ZoH



- **LAI:**
  - Generalized increase in Latent Heat Flux (coinciding with the wetter soil);
- **LAI + Zo:**
  - Lower Sensible Heat: compatible with revised ZoH, complementing the changes induced by LAI alone.

ECMWF: Skin Conductivity

- For completeness we assess the sensitivity of model skin temperature to surface conductivity, Λ_{skin}.

$$\Lambda_{skin} \Rightarrow \Lambda_{skin} / 2$$

- Λ_{skin} controls the heat transfer to the ground by diffusion
- A first approach to test the use of remotely sensed LST to estimate surface parameters, otherwise difficult to prescribe.

ECMWF: Revised LAI + Zo + Λskin

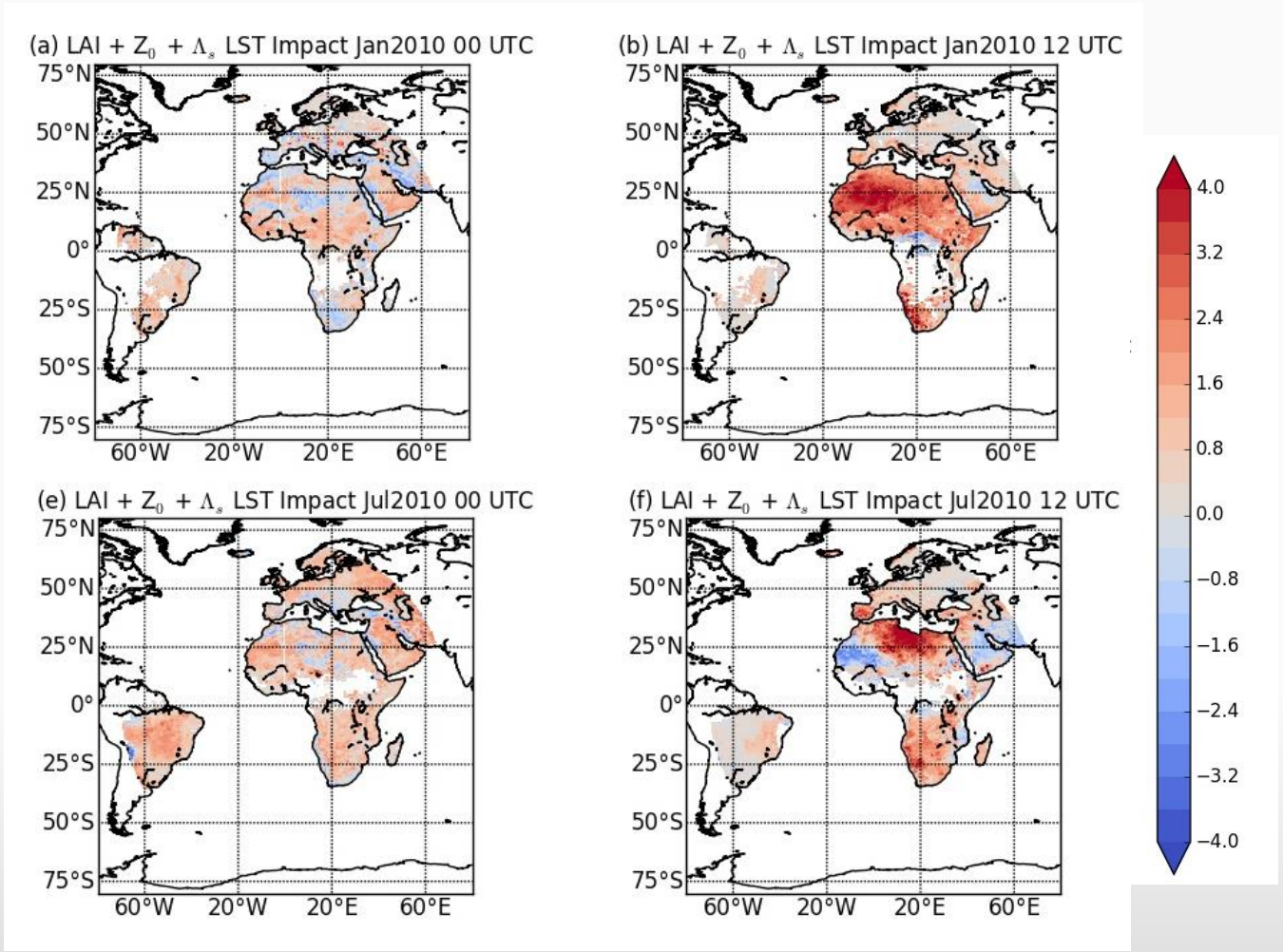
The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Impact on LST

Jan 2010

Jul 2010



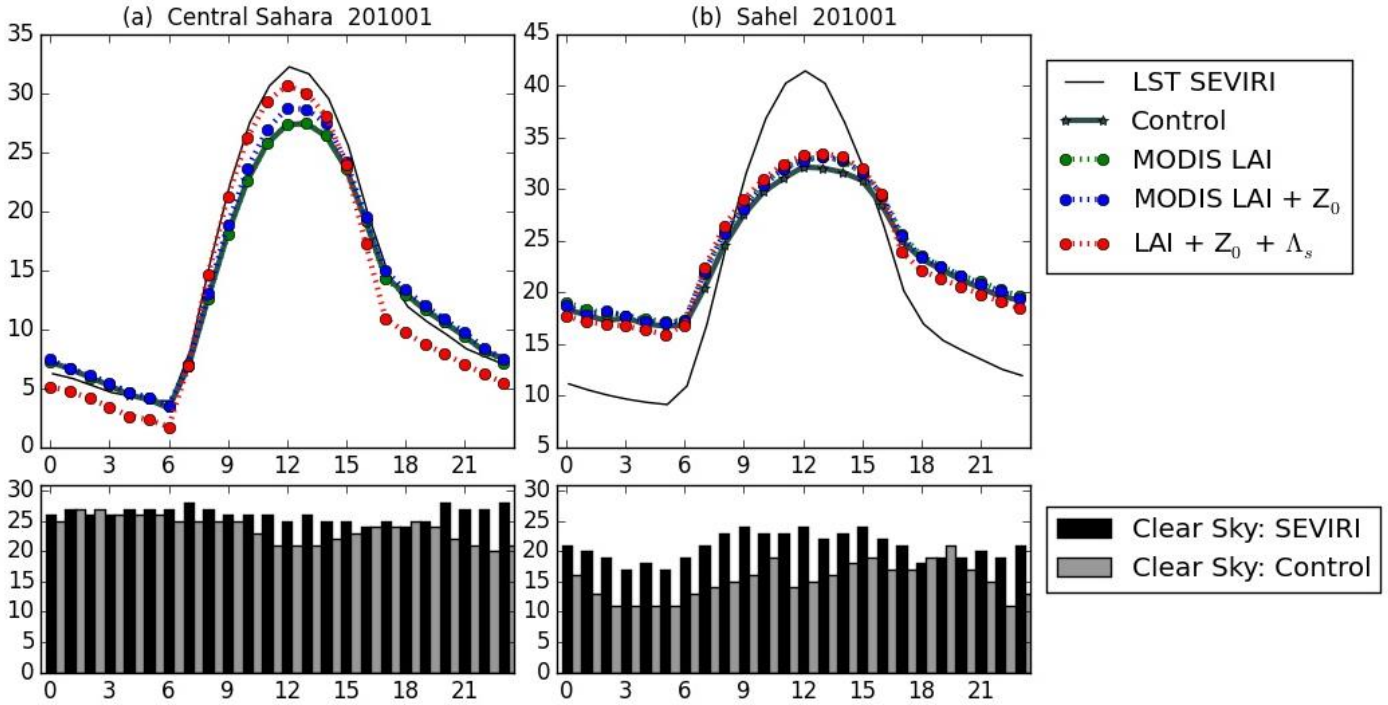
- 00 UTC: less neutral than in previous experiments
- 12 UTC shows stronger positive impact on Tskin over a large part of the disk.

ipma instituto português do mar e da atmosfera

ECMWF

ECMWF: Revised LAI + Zo + Λskin

Daily cycles of LST / Tskin averaged over January 2010



- Figure illustrates well the impact of the various changes introduced in ECMWF surface scheme.
- Points out discrepancies in the phase between model and satellite (besides daily amplitude), which also need to be addressed.

Final Remarks

- Several studies reported **cold biases** in **model surface temperatures** when compared to **satellite LST's** - particularly daytime over arid regions, when compared either to satellite estimates.
- Biases of this type also identified in the ECMWF model. **LST** was then used to assess the **impact of sfc parameters on mode skin temp & sfc fluxes**.
- Changing **static to monthly LAI**: showed **a limited impact on the model Tskin**, with a **slight improvement over semi-arid / sparsely vegetated regions** (e.g., Sahel, Iberian Peninsula). The new (mostly lower LAI) leads **higher soil moisture**; this is the result of a new equilibrium reached by the model during the long integration with lower Evapotranspiration.
- The **adjustment of ZoM and ZoH** leads to an overall **positive impact on daytime skin temperature**, generally associated to a **reduction of sensible heat flux** (lower values of Z_{oH}). The impact is particularly relevant in non-vegetated areas that remained unaffected by the changes in the vegetation representation.
- The **reduction of skin conductivity** is shown to **further strengthen the positive impact on model Tskin**. A complete analysis of changes/ tuning of this parameter in other surface fluxes and other surface variables is still needed.