Satellite Observations for Advancing Global Earth Surface Modelling

How satellite-based information can support Earth surface model development?

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Outline

- Comparison of ECMWF model output with a range of Satellite Dataset enable to highlight model error and can support model development
- 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 Lake Surface Temperature EUMETSAT/OSI-SAF
  - Improvement in the representation of water bodies
- Surface soil moisture and ESA/CCI product
  - Assess the value of increased soil vertical discretisation

Land surface model status at ECMWF and evolution since ERA-Interim

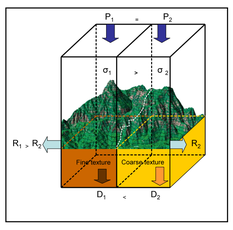
Hydrology-TESSEL

Balsamo et al. (2009)
van den Hurk and Viterbo (2003)

Global Soil Texture (FAO)

New hydraulic properties

Variable Infiltration capacity & surface runoff revision



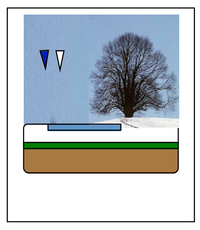
NEW SNOW

Dutra et al. (2010)

Revised snow density

Liquid water reservoir

Revision of Albedo and sub-grid snow cover

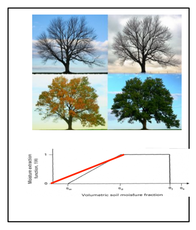


NEW LAI

Boussetta et al. (2013)
New satellite-based Leaf-Area-Index

SOIL Evaporation

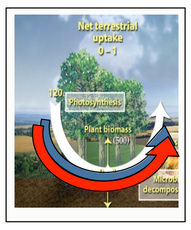
Balsamo et al. (2011), Albergel et al. (2012)



H_2O / E / CO_2

Integration of Carbon/Energy/Water Boussetta et al. 2013

Agusti-Panareda et al. 2015



Flake

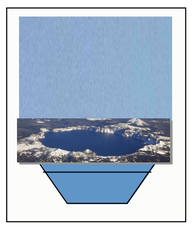
Mironov et al (2010),

Dutra et al. (2010),

Balsamo et al. (2012, 2010)

Extra tile (9) to for sub-grid lakes and ice

LW tiling (Dutra)



Satellite Land Surface Temperature (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 latent and sensible heat fluxes at surface partition
- Its diurnal cycle is associated to the degree of coupling between the land and the atmosphere that is shown to vary greatly across models.
- LST is informative also for water bodies thermodynamics and freezing condition

Satellite Land Surface Soil Moisture (SSM)

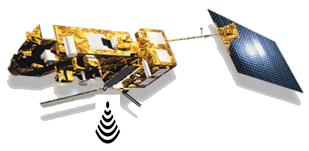
As a model diagnostic tool

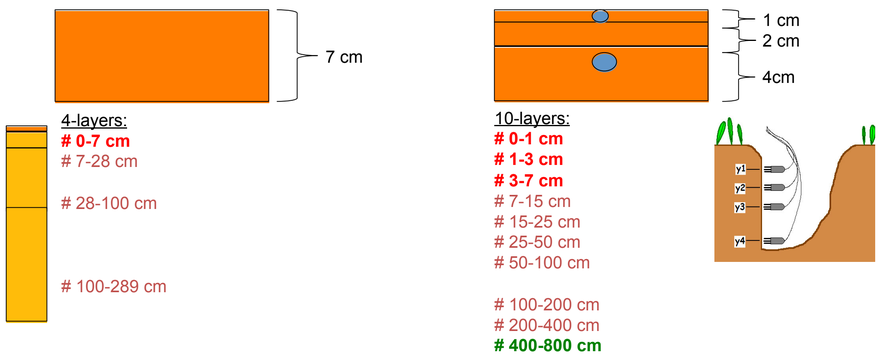
ECMWF Surface soil moisture (0-7 cm):

- The temporal correlation with satellite based soil moisture indicates wetting drying trends are realistically represented.

An enhanced soil vertical resolution

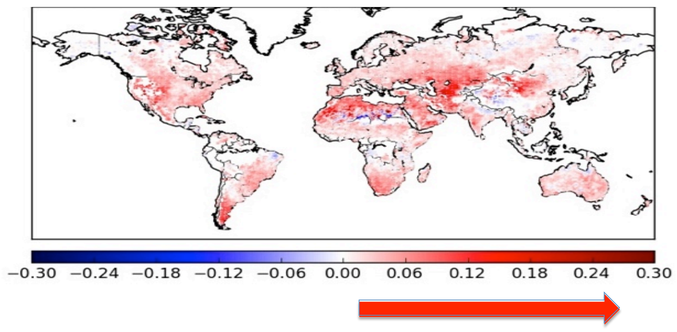
The model bias in Tskin amplitude shown by *Trigo et al. (2015)* motivated the development of an enhanced soil vertical discretisation to improve the match with satellite products.

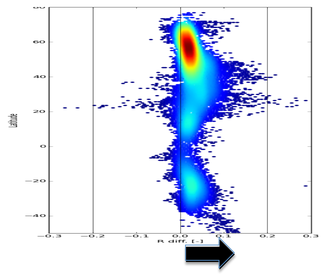




Impact of soil vertical resolution using ESA CCI SSM

Impact on Anomaly Correlation with ESA-CCI satellite soil moisture (courtesy of C. Albergel)





Globally Improved match to satellite soil moisture (shown is ΔACC calculate on 1-month running mean)

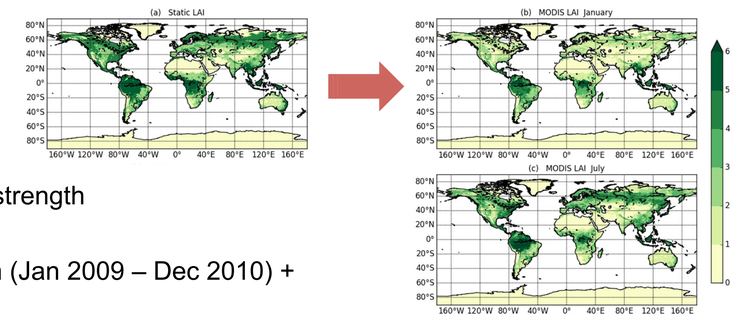
Anomaly correlation (1988-2014) measured with ESA-CCI soil moisture remote sensing (multi-sensor) product. This provide a global validation of the usefulness of increase soil vertical resolution.

Vegetation modelling impact using EUMETSAT LSA-SAF LST

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
- Revised roughness and Coupling strength
- Initial conditions:

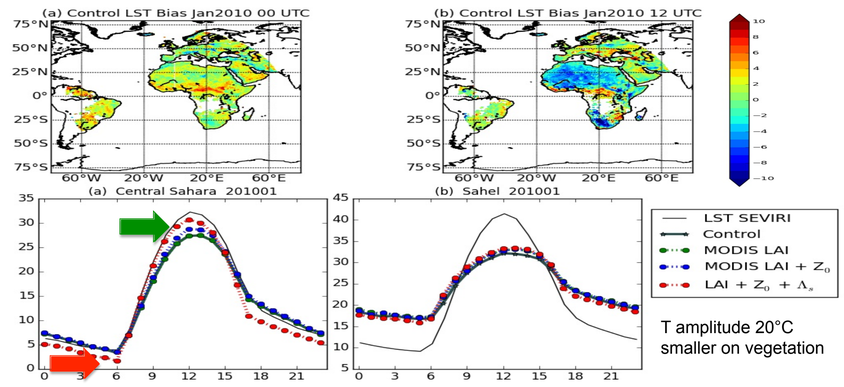
  Off-line runs driven by ERA-Interim (Jan 2009 – Dec 2010) + LAI / stomata changes



Coupling and diurnal cycle on vegetation and soil

Trigo et al. (2015, JGR in rev.), Boussetta et al. (2015, RSE)

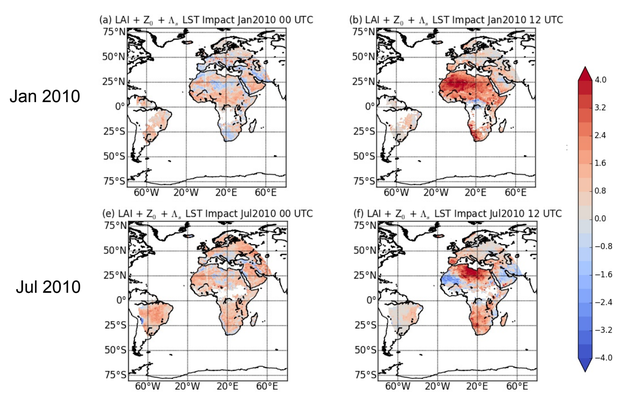
Findings of large biases in the diurnal temperature reposed on the use of MSG Skin Temperature. However with the current model version we are limited (both over bare soil and vegetation)



T amplitude 20°C smaller on vegetation

Forecast impact of revised LAI + Zo + Λskin

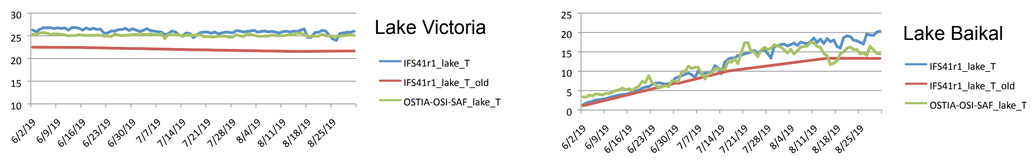
Impact on LST



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

Impact on Tskin is measured as Mean Absolute Error (MAE) reduction:
|Tskin_CTL – LST_SEVIRI| - |Tskin_exp – LST_SEVIRI|

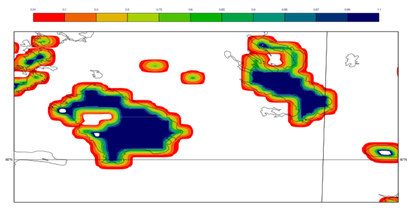
Lake surface temperature diagnostics using EUMETSAT OSI-SAF LST



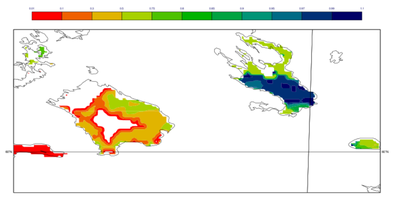
Improved representation of lake ice melting: Lakes Ladoga and Onega

Case Study of 18 April 2016:
The Largest European Lakes: Lake Lagoda & Lake Onega started to melt lake ice, with faster melting occurring in Ladoga

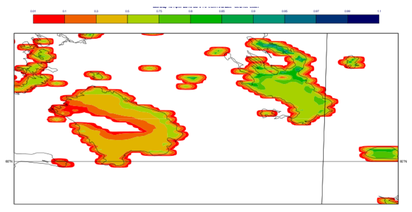
ECMWF Old model climatology (no difference in melting)



OSI-SAF Satellite Ice cover 18 April 2016:



ECMWF IFS Lake Ice Cover (Ladoga melting faster)



Summary

- Satellite LST and SSM information is extremely valuable to Earth surface modelling
- Impact of surface parameters and improved model versions on model skin temperature and surface moisture can be verified using satellite-based datasets (e.g. ESA/CCI soil moisture, EUMETSAT OSI-SAF and LSA-SAF)

Perspective

- Satellite LST and SSM exist at very high resolution thanks to geostationary/polar coverage and SAR technologies and can support the development of kilometric scale Earth surface modelling