Integrated modelling for assessment the influence of aerosol feedbacks on a regional scale as a result of accidental wildfires and land cover changes in Ukraine

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INTRODUCTION

Two HPC-Europa3 studies

IMA-WFires "Integrated Modelling for Assessment of Potential Pollution Regional Atmospheric Transport as Result of Accidental Wildfires"

+ 1.5 km spatial resolution

Temporal sensitivity tests

MALAWE "Integrated Modelling and Analysis of Influence of Land Cover Changes on Regional Weather Conditions/ Patterns"

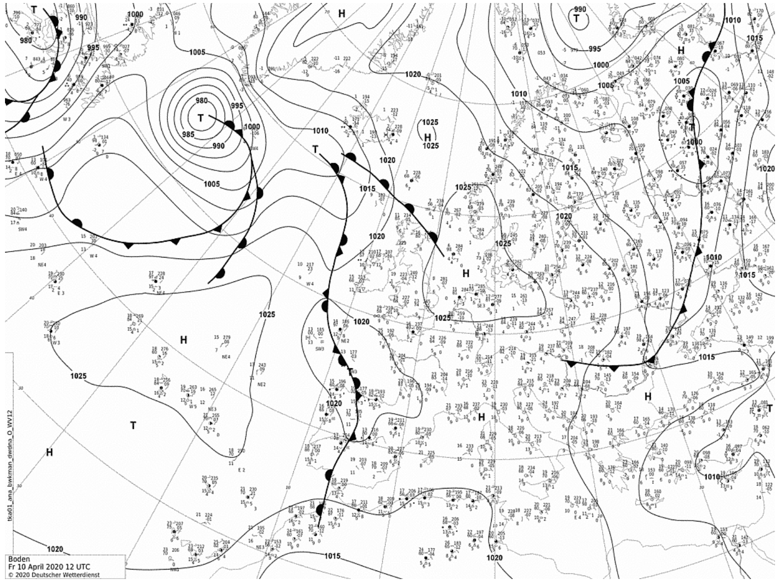
+ 1.5 km spatial resolution for Kyiv metropolitan area

Land cover changes scenarios:

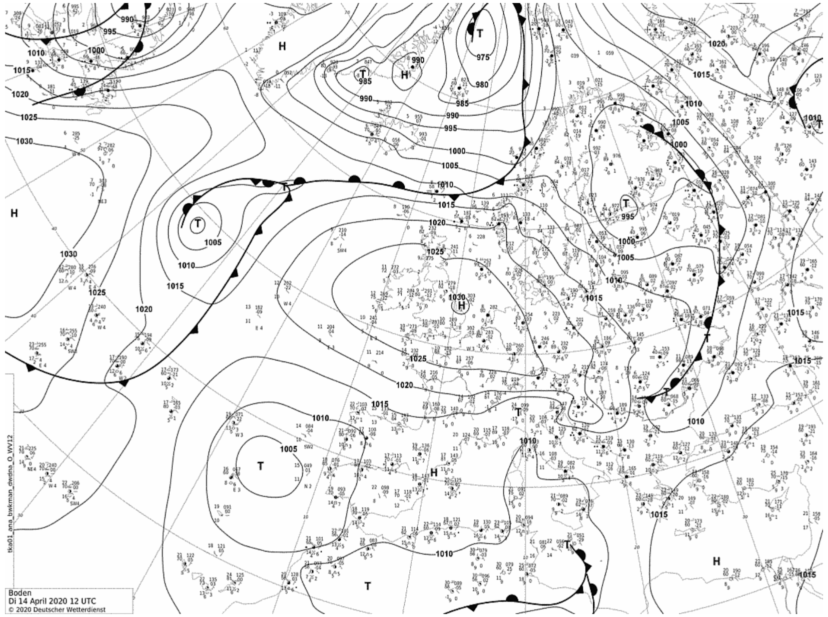
- total afforestation;
- half afforestation;
- total deforestation;
- half deforestation.

Model: Enviro-HIRLAM
Input data: ECMWF IFS, IFS-MOZART + emission inventories
Spatial resolution: 15 km, 5 km, 2 km
Model modes: reference (***REF***), direct (***DAE***), indirect (***IDAE***) and both (***DAE+IDAE***) aerosol effects included
Model output: 3 hours

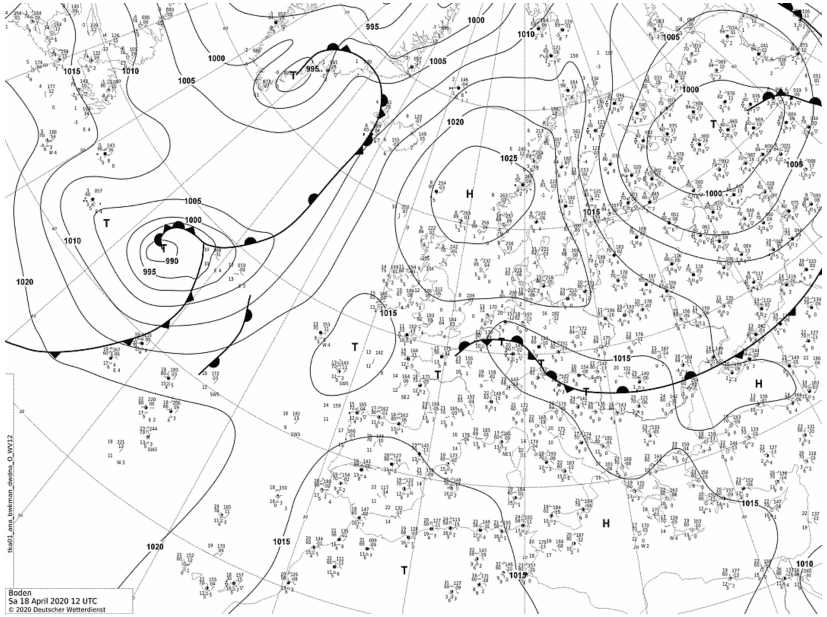
IMA-WFires: Synoptic situation



12UTC, 10 April 2020



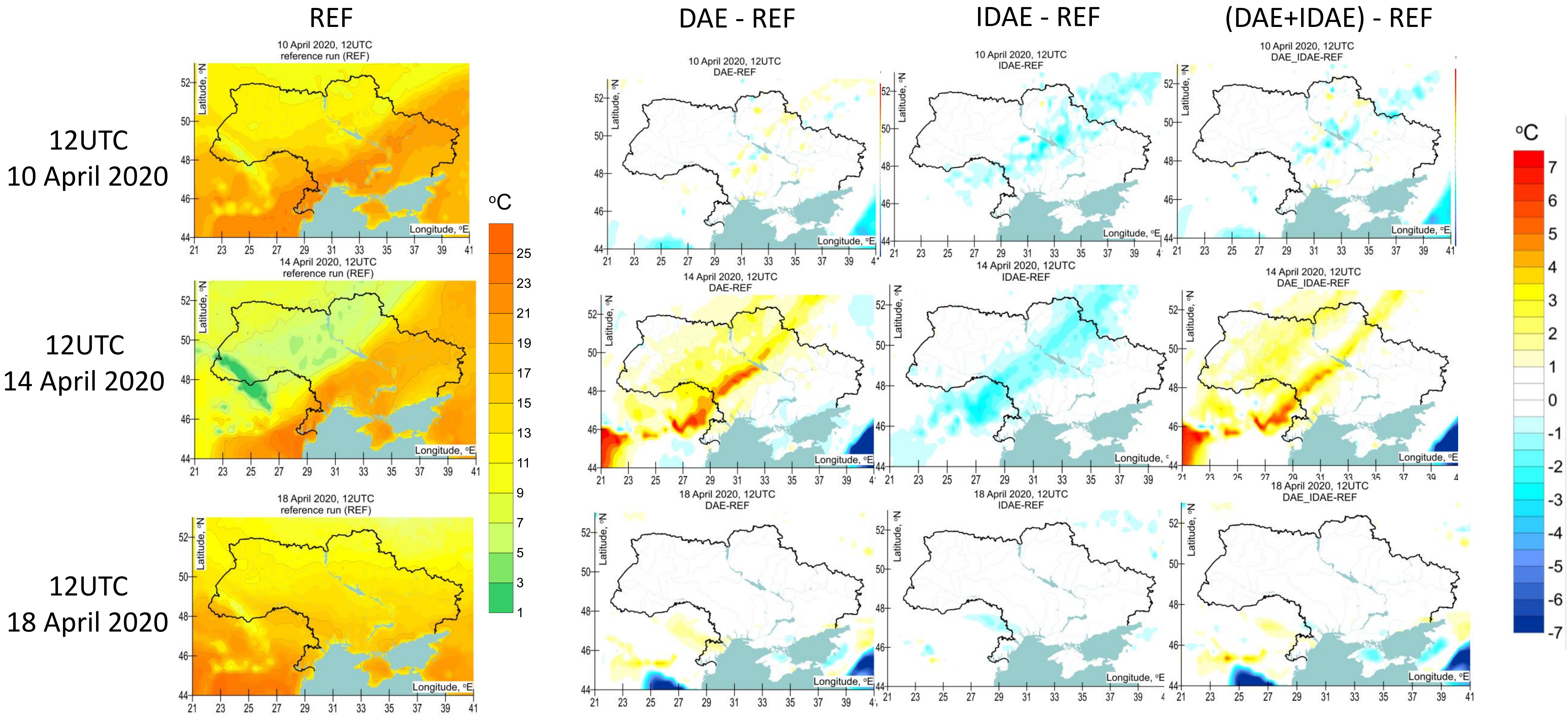
12UTC, 14 April 2020



12UTC, 18 April 2020

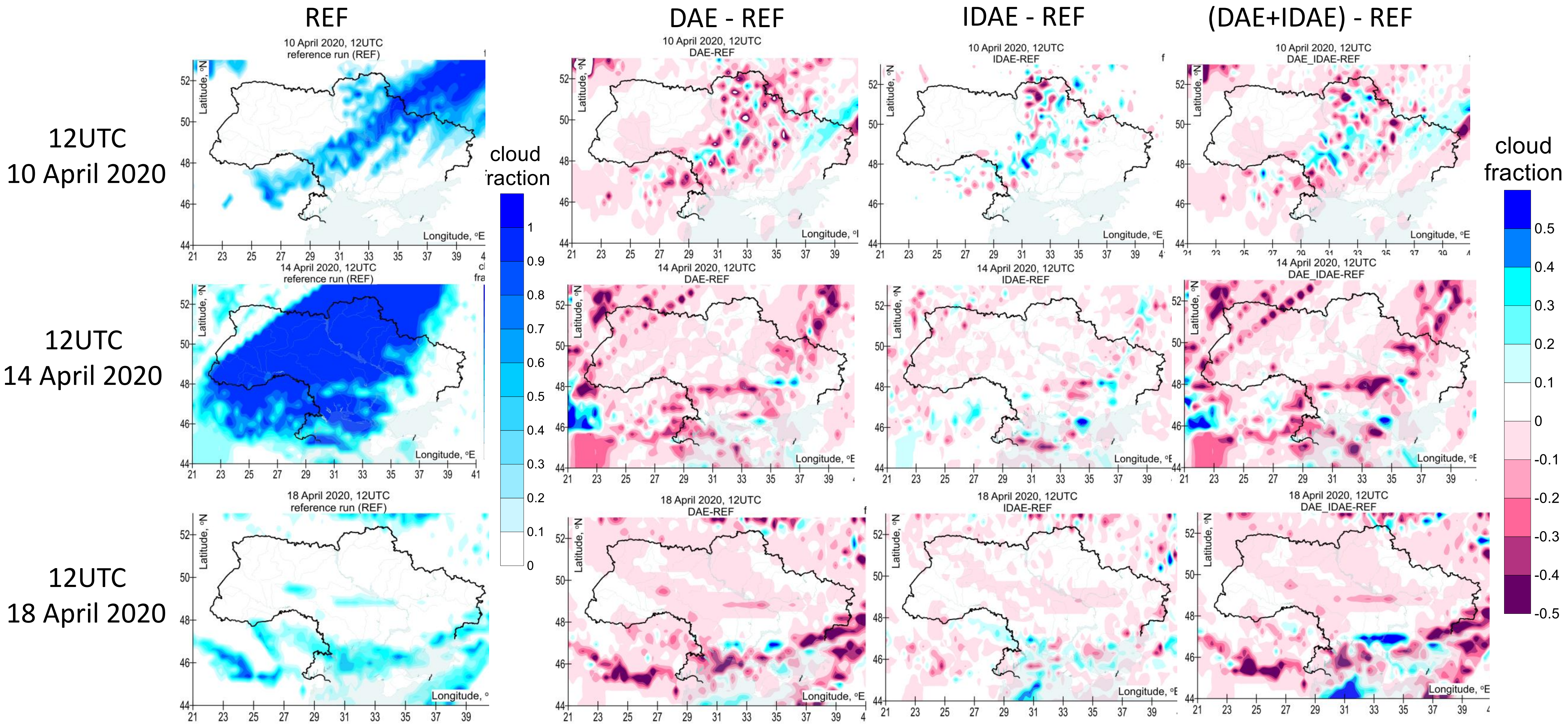
Source: https://www.wetter3.de/archiv_dwd_dt.html

IMA-WFires: 2-m Air Temperature



Aerosol effects were observed in areas with high temperature gradients (e.g., atmospheric front, etc.). IDAE effects caused 2-m air temperature decrease up to -2°C, whereas DAE and DAE+IDAE effects showed 2-m air temperature increase up to 6°C near the front line. There were no aerosol effects observed in the areas with small baric and temperature gradients.

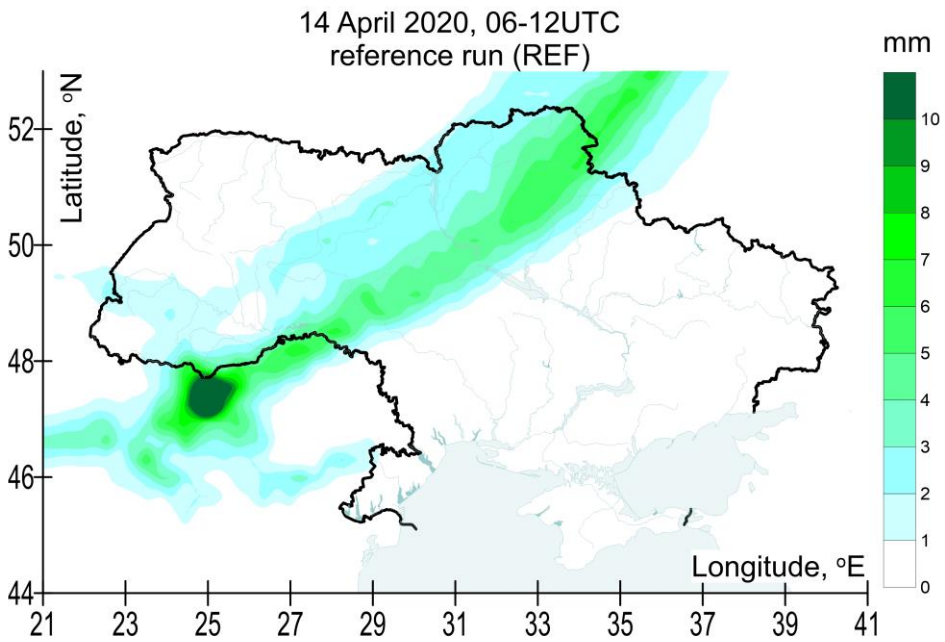
IMA-WFires: Total Cloud Cover



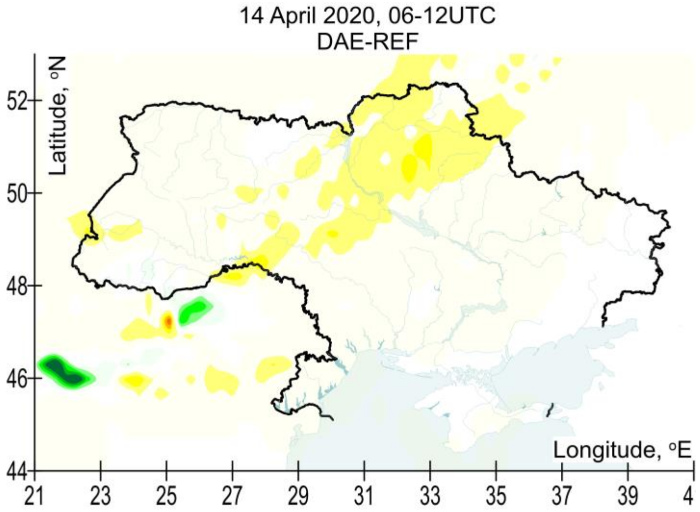
Aerosol effects mainly resulted in the decreasing of total cloudiness on 5-50% depending on the synoptic conditions. Cloudiness formation was observed before the atmospheric front line (especially for IDAE), and in the areas with smaller ratio of carbonaceous aerosols emitted by the wildfires (for example, near the sea or over the regions which was not affected by the transportation of wildfire emissions)

IMA-WFires: Total Precipitation

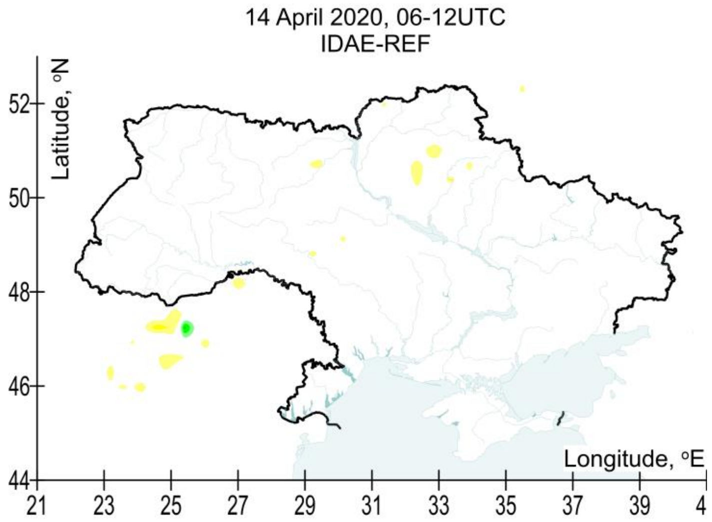
Total precipitation for 06-12UTC
14 April 2020

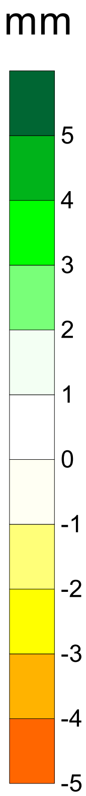


DAE - REF

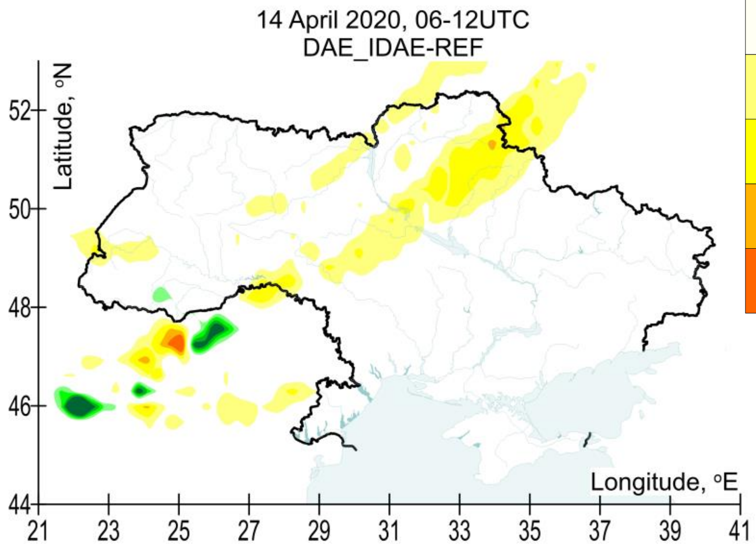


IDAE - REF



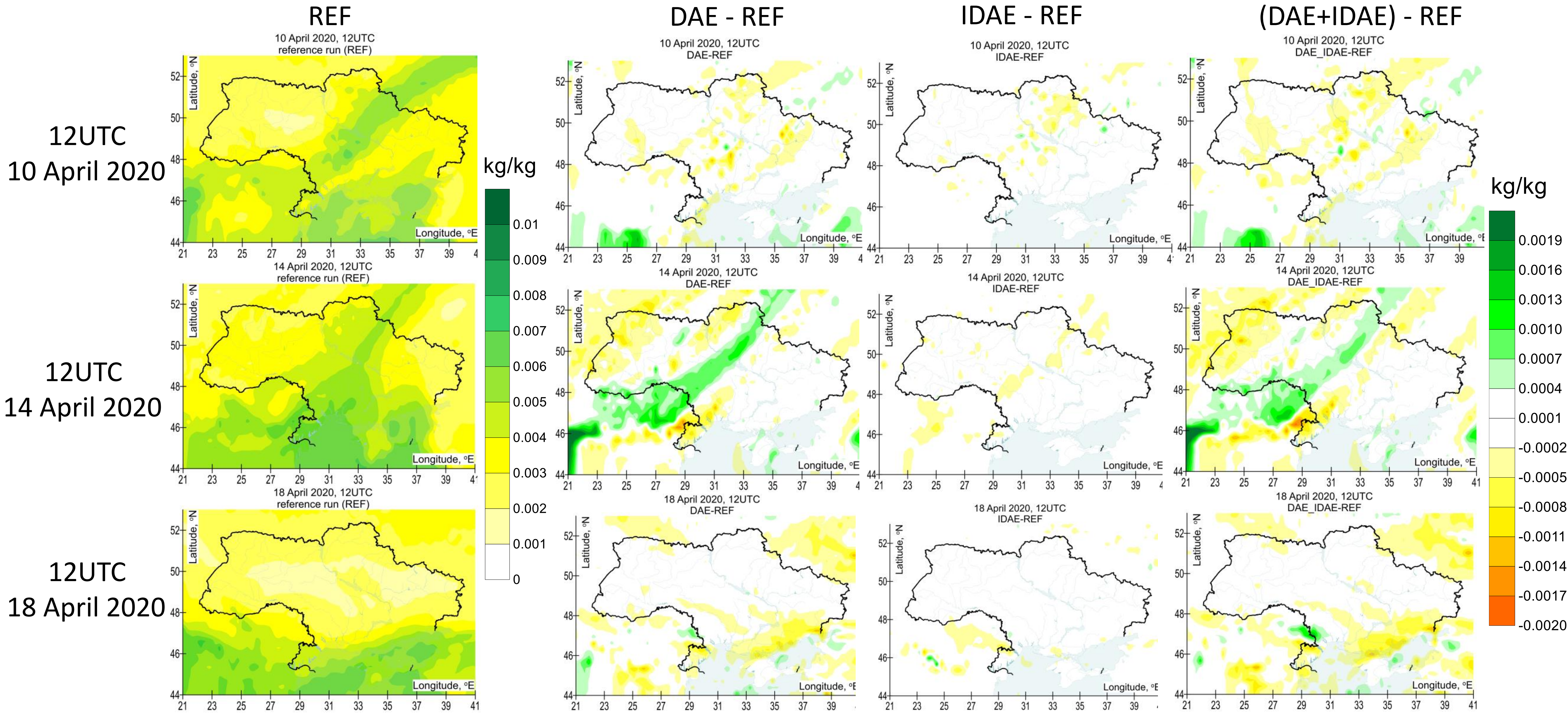


(DAE+IDAE) - REF



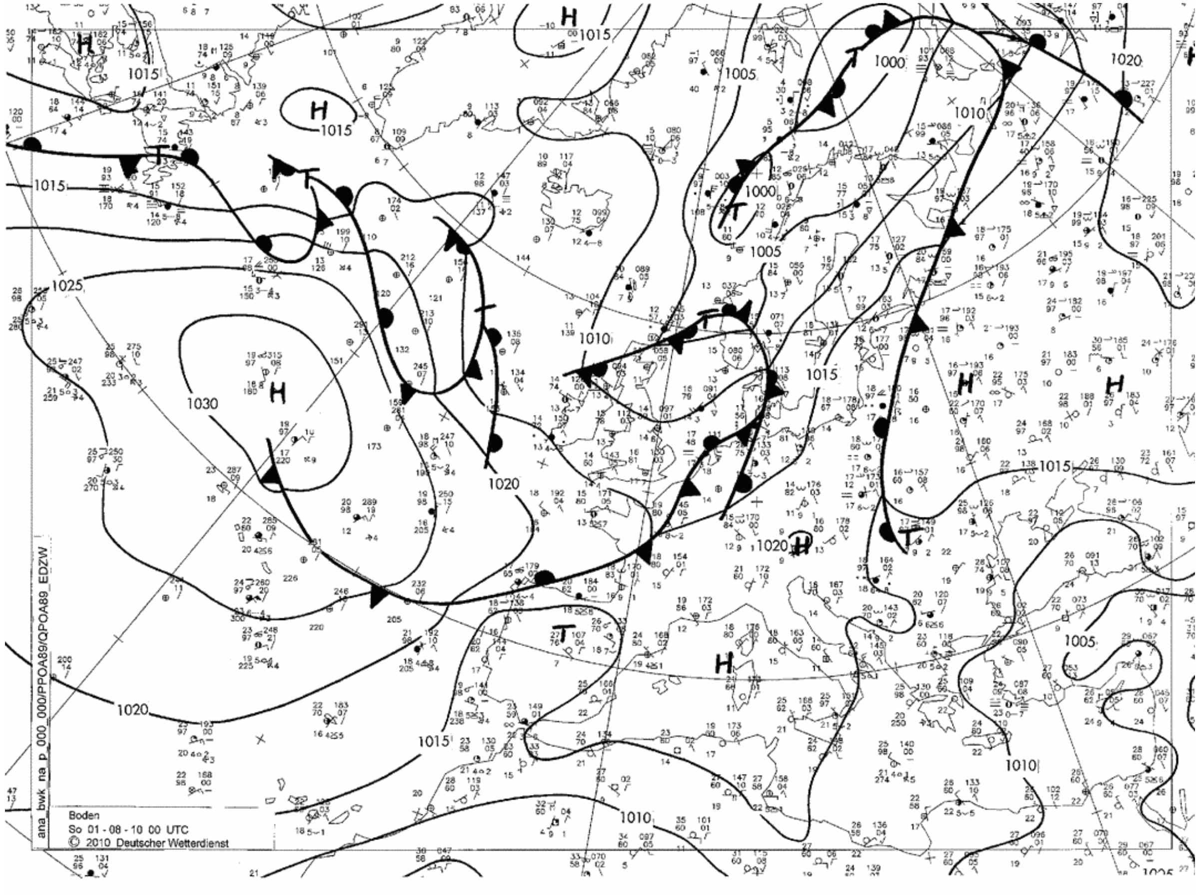
DAE and both DAE+IDAE effects caused the decreasing of total precipitation over the region of interest. Over the territory influenced by wildfire emissions, total precipitation decreased up to -3 mm/ 6 hours during the episode with atmospheric front movement.

IMA-WFires: 2-m Specific Humidity

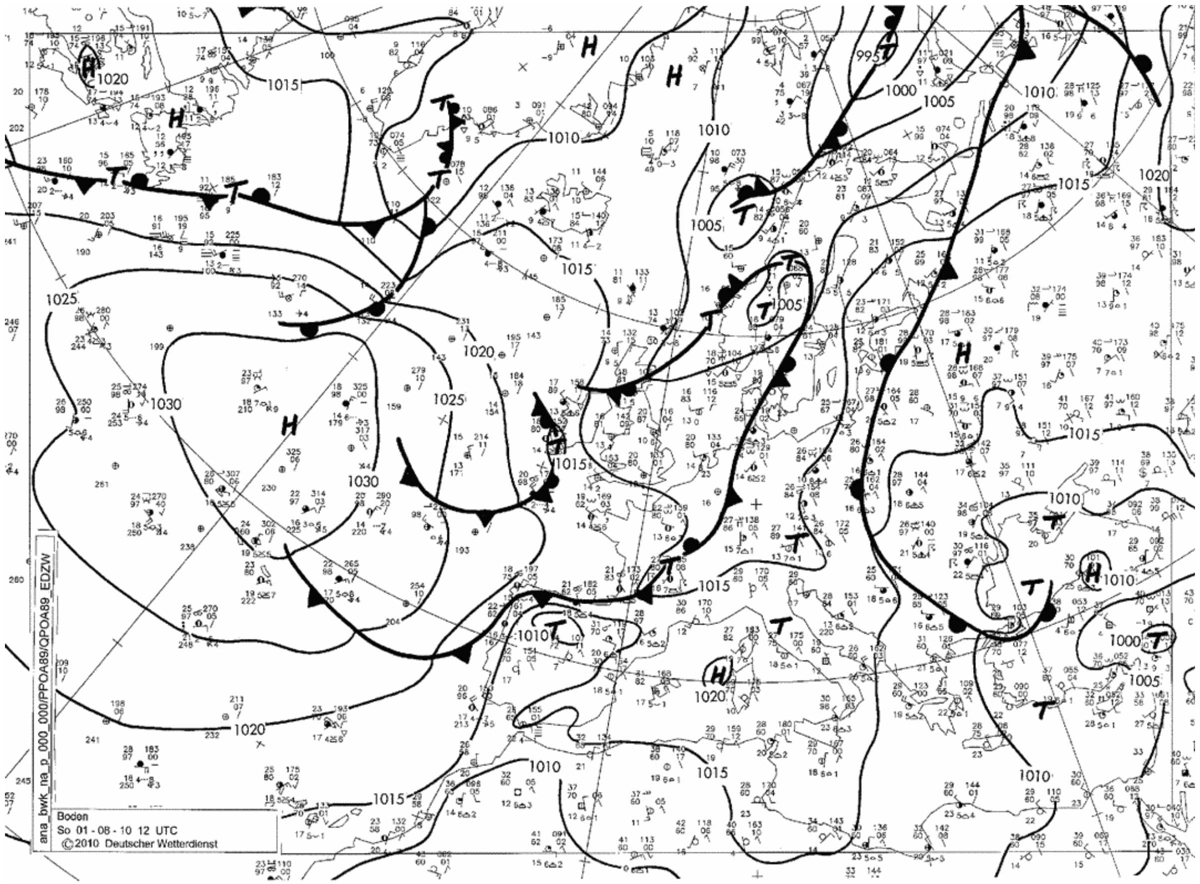


Aerosol effects on 2-m specific humidity observed mostly in areas with high baric and temperature gradients. Despite DAE and DAE+IDAE caused 2-m air temperature increase and total precipitation decrease, specific humidity was higher for DAE and DAE+IDAE effects during the episode of atmospheric front movement (14.04.2020). Aerosol effects showed the decrease of specific humidity on other days

<u>MALAWE</u>: Synoptic situation



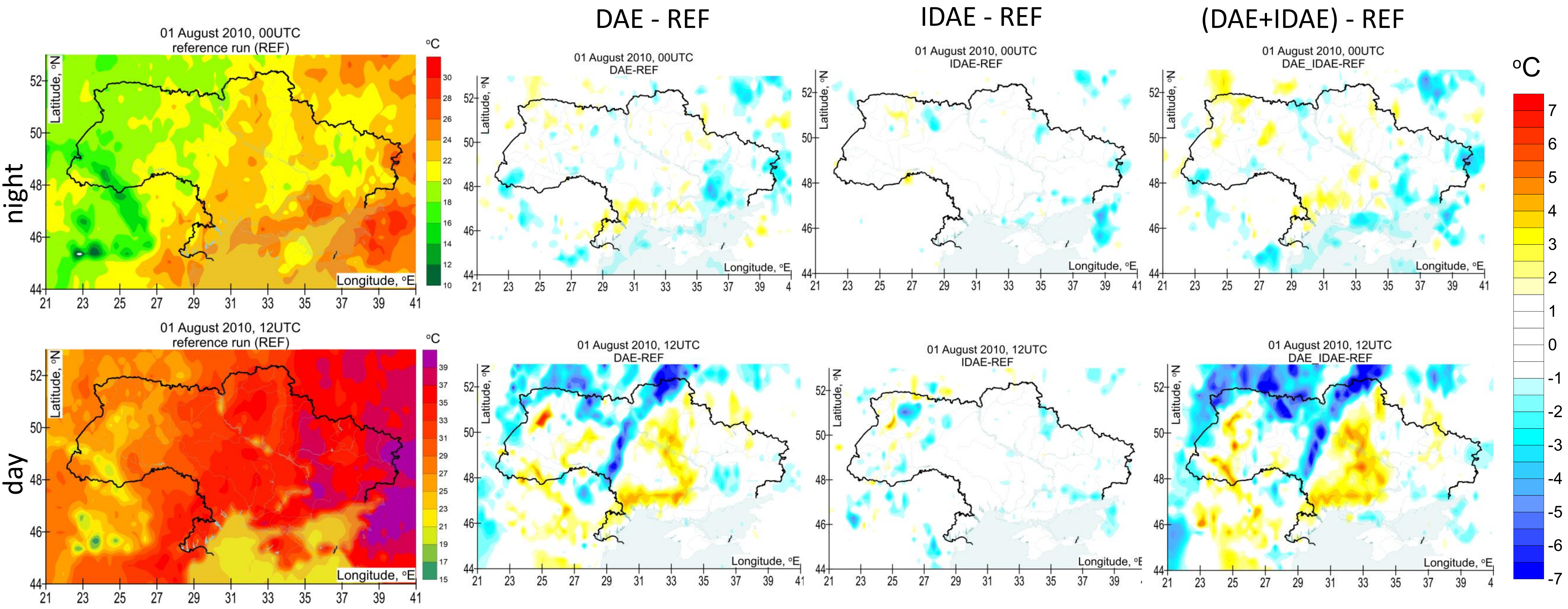
00UTC, 1 August 2010



12UTC, 1 August 2010

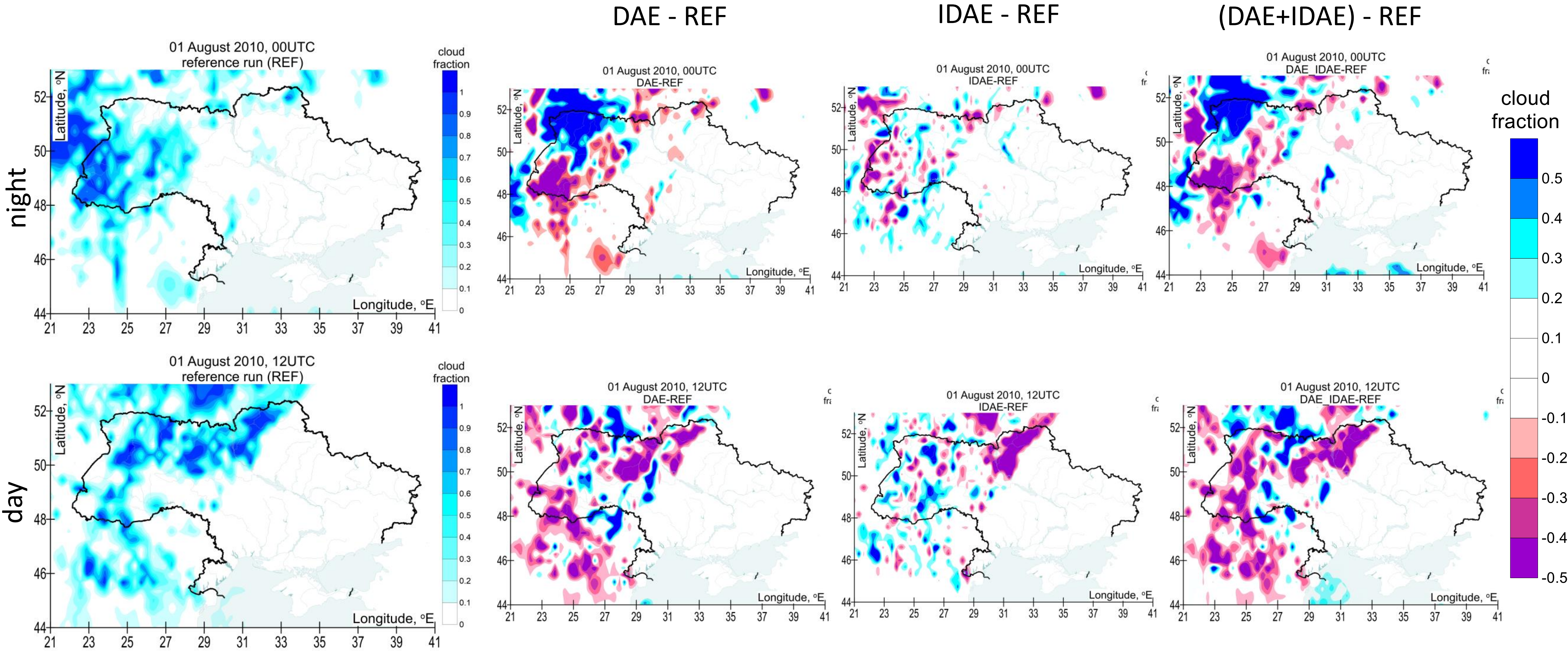
Source: https://www.wetter3.de/archiv_dwd_dt.html

MALAWE: 2-m Air Temperature

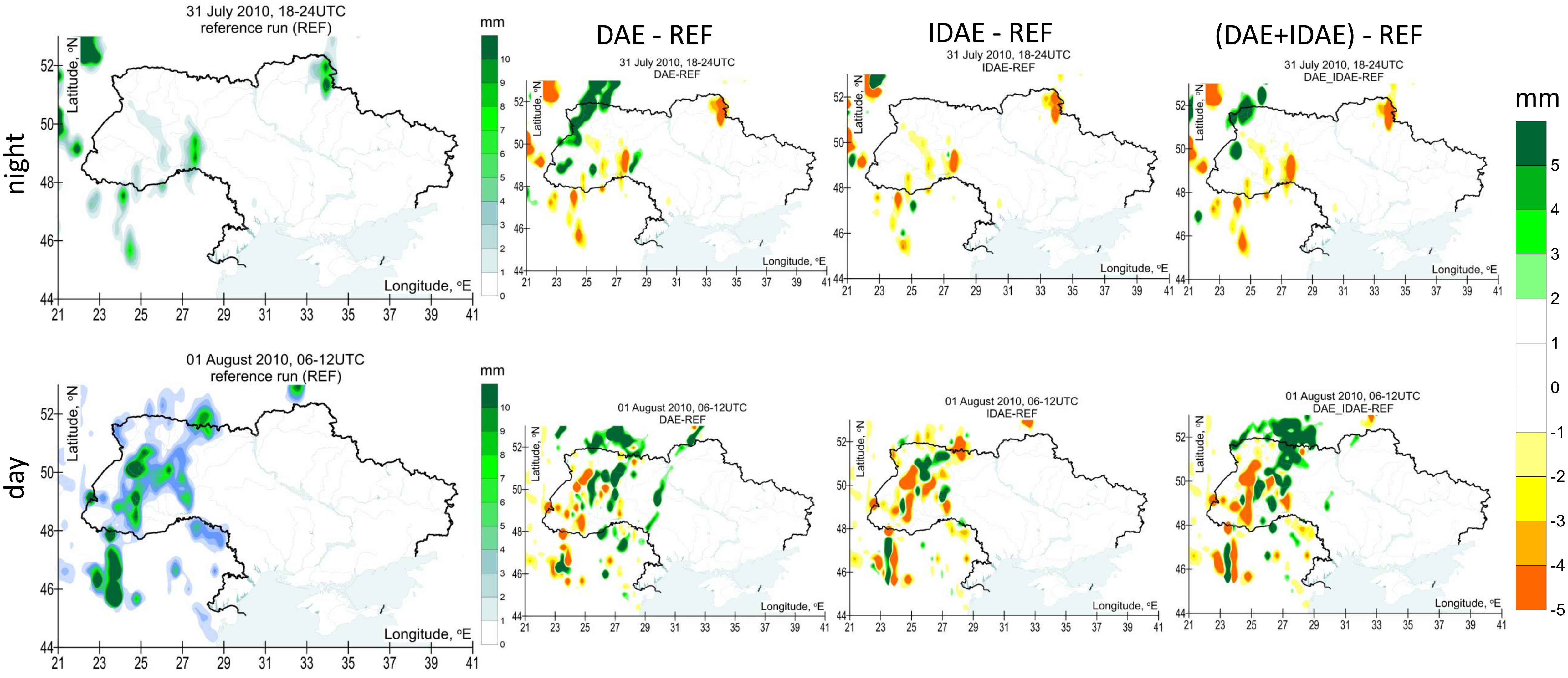


Aerosol effects during the extreme heat-wave episode showed as 2-m air temperature increase (for DAE and DAE+IDAE) up to 4°C, so also decrease up to -5°C. IDAE effects are not so evident. In future analyses, results are going to be validated and linked to aerosol species ratio for considering the nature of observed effects.

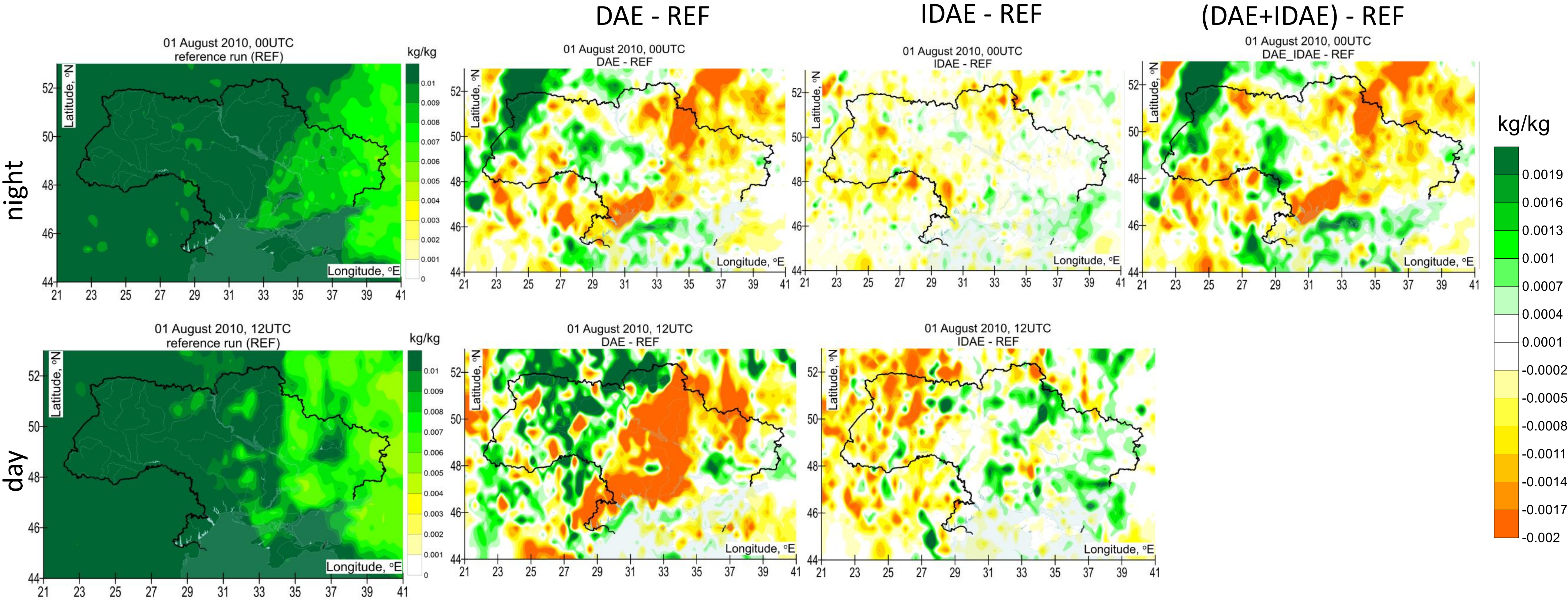
MALAWE: Total Cloud Cover



MALAWE: Total Precipitation

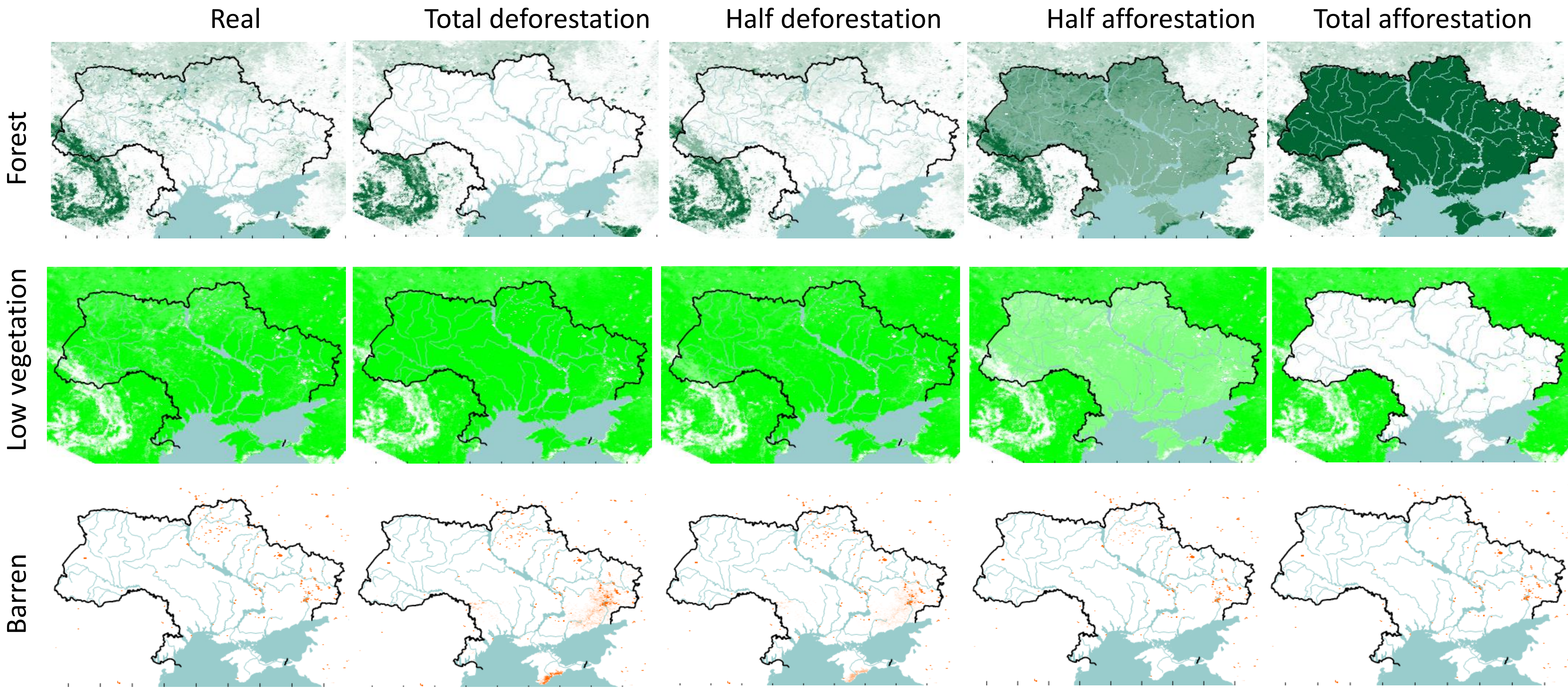


<u>MALAWE</u>: 2-m Specific Humidity

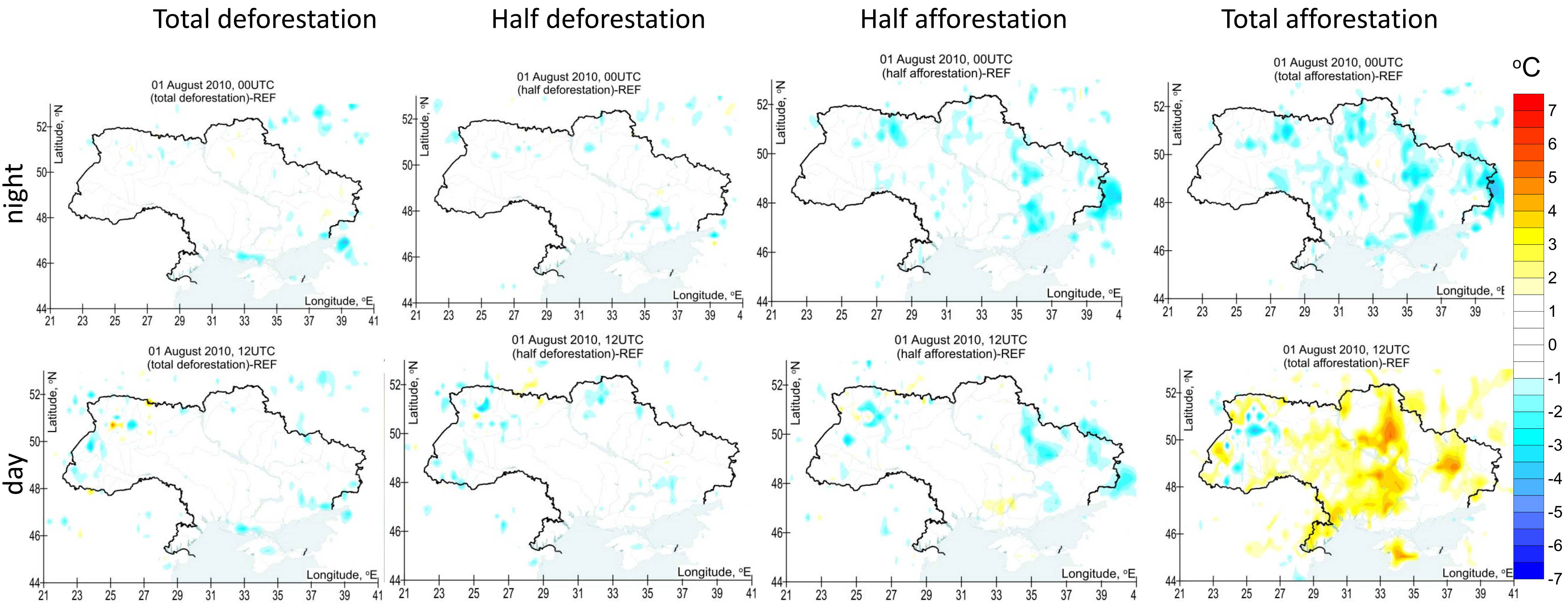


Aerosol effects during the extreme heat-wave episode showed 2-m specific humidity decrease up to -0.02 kg/kg over warmer regions with clear-sky conditions (DAE and DAE+IDAE); and increase up to 0.019 kg/kg over colder regions with cloudiness. IDAE effects are opposite during the midday hours.

MALAWE: Land Cover Change Scenarios

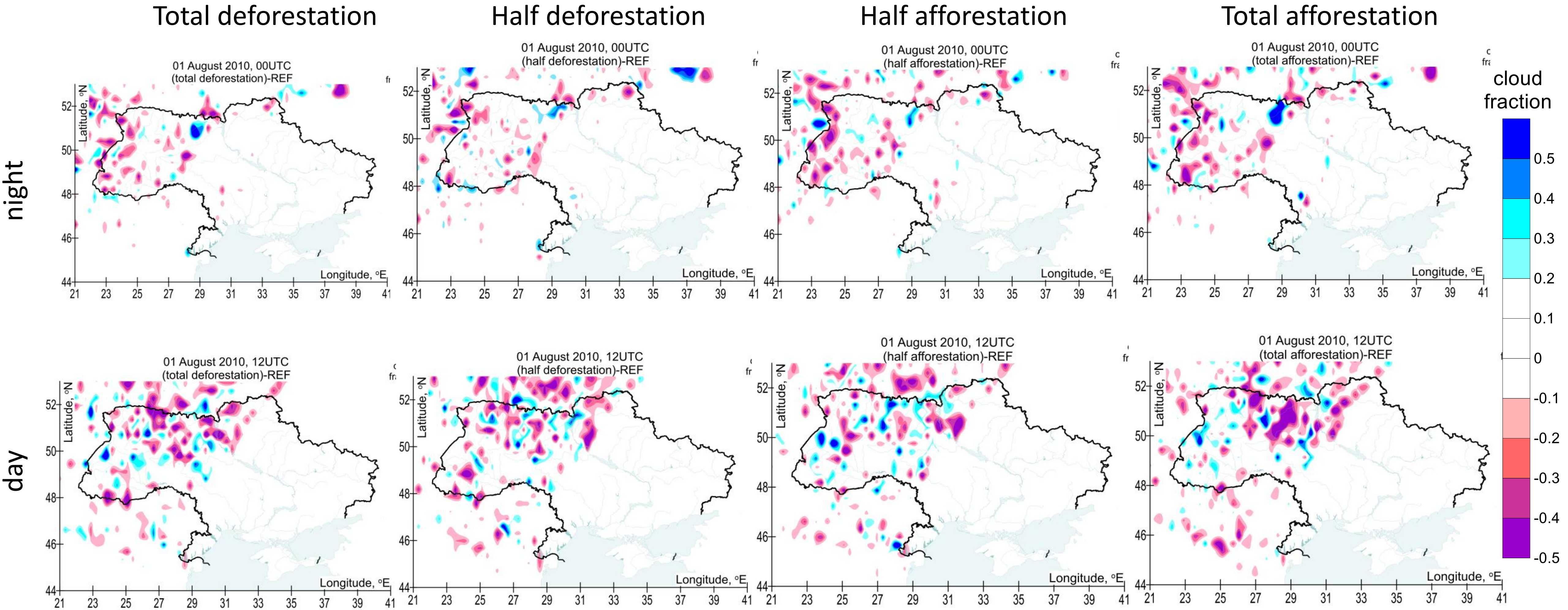


MALAWE: 2-m Air Temperature



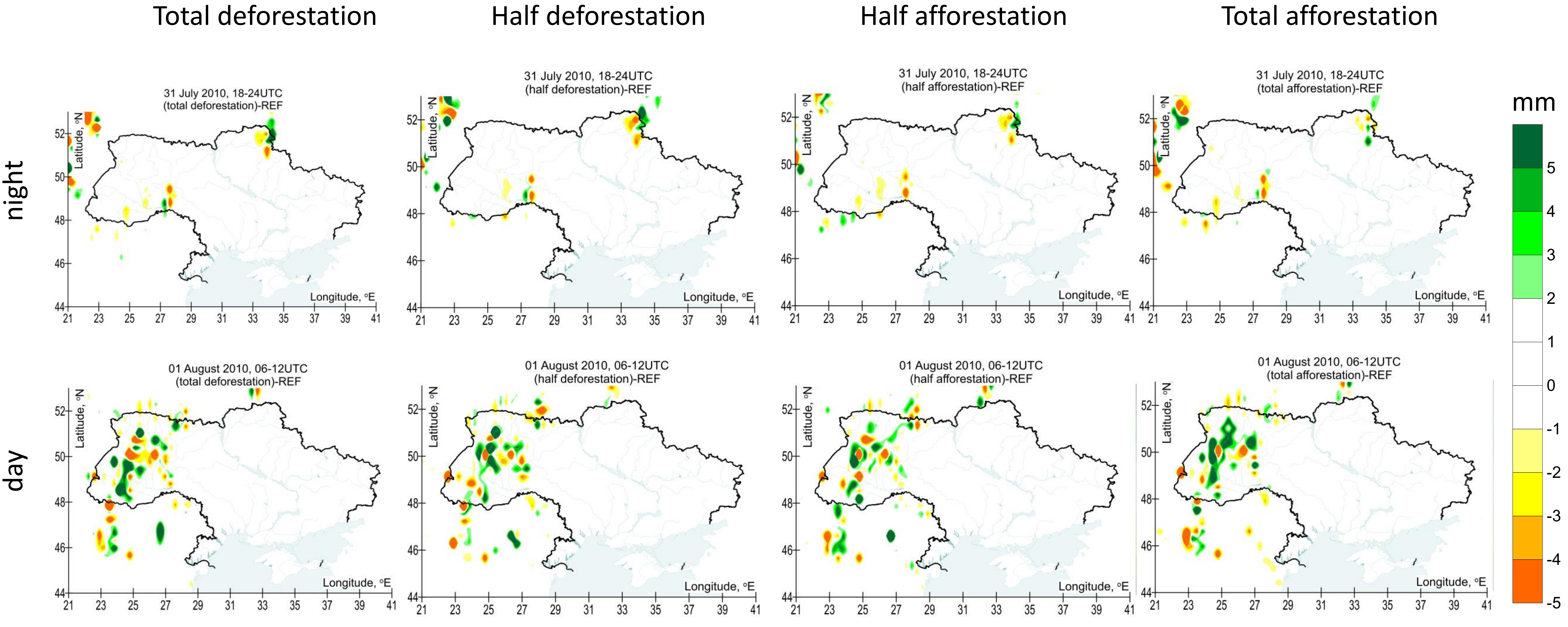
The most significant changes were observed for total afforestation scenario, which showed 2-m air temperature decrease up to -3°C at night and increase up to +4°C at midday. Afforestation has higher impact on 2-m air temperature than deforestation process.

MALAWE: Total Cloud Cover



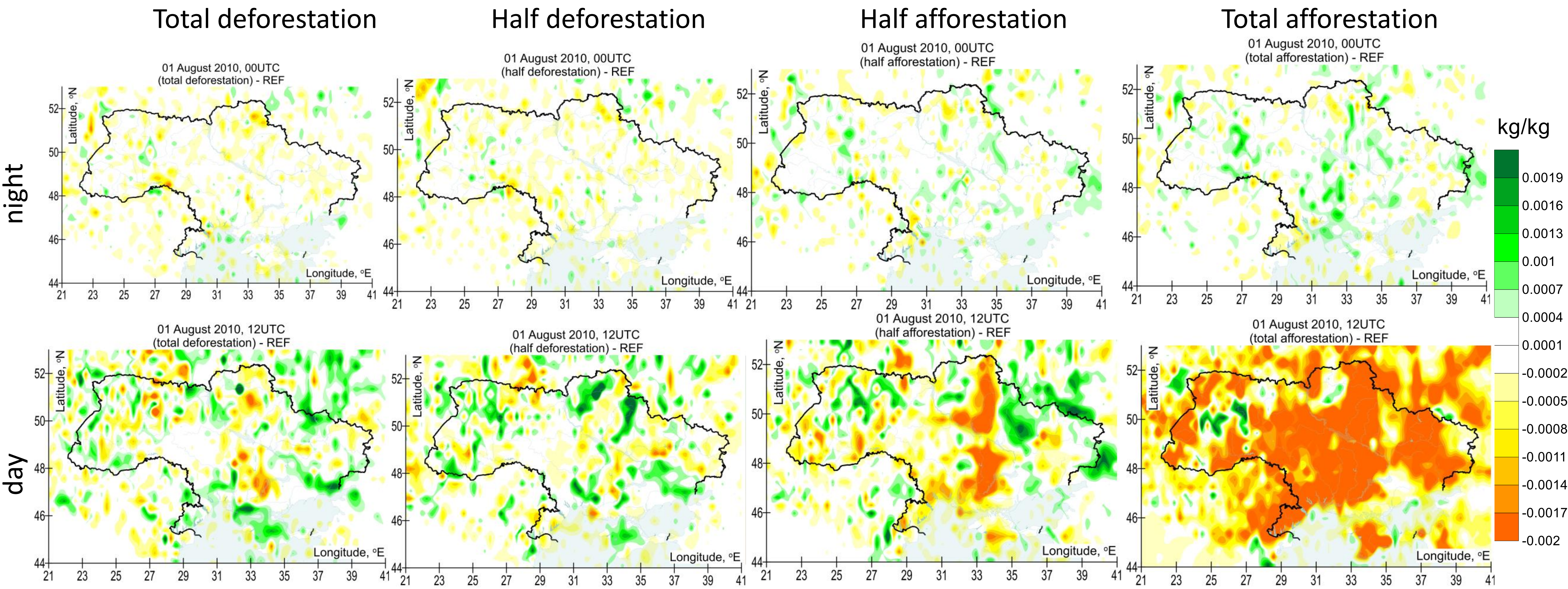
Preliminary analysis does not show clear effects of afforestation and deforestation on cloudiness. Detected changes significantly differ and need consideration complex feedbacks in the atmosphere together with atmosphere-land interactions.

MALAWE: Total Cloud Cover



Preliminary analysis does not show clear effects of afforestation and deforestation on total precipitation. Detected changes significantly differ and need consideration complex feedbacks in the atmosphere together with atmosphere-land interactions.

MALAWE: 2-m Specific Humidity



Preliminary analysis showed rather unexpected results for specific humidity changes under deforestation/afforestation. For example, specific humidity decrease during the midday hours in case of total afforestation. In fact, it might be the reaction on air temperature increase, however, future studies need deep analysis with consideration the model uncertainties, complexity of feedbacks and land-atmosphere interactions.

CONCLUSIONS

The study presents the preliminary results of ongoing projects IMA-WFires "Integrated Modelling for Assessment of Potential Pollution Regional Atmospheric Transport as Result of Accidental Wildfires" and MALAWE "Integrated Modelling and Analysis of Influence of Land Cover Changes on Regional Weather Conditions/ Patterns"

Observed aerosol effects caused temperature changes from -5^{o}C to 6^{o}C which is especially important to consider during the extreme meteorological conditions. All aerosol effects depends on synoptic conditions and may significantly vary in space and time.

Changes of total cloud cover and total precipitation which are driven by direct and indirect aerosol effects are rather complex. They are tending to decrease in case the influence of wildfire emissions. Strong dependence of aerosol effects from synoptic conditions was found which need further investigation.

DAE and DAE+IDEA effects caused 2-m specific humidity increase near the atmospheric front lines; and significant decrease on more than -0.002 kg/kg under extreme hot and clear-sky weather conditions.

Deforestation and afforestation processes influenced the temperature and moisture regimes. The most significant changes were observed for the afforestation scenario. Results showed the complexity of the atmosphere response to land cover changes that on a regional scale could have different effects than on microscale.

In the future the modelling results need validation and estimation of model sensitivity and uncertainties. The prospects of the studies are:
- analysis the regional influence of wildfire emissions occurred in the exclusion zone (abandon area) of the Chernobyl nuclear power plant (Ukraine); and identification the affected territories and impact on chemical composition and weather patterns ;
- analysis the influence of land cover changes and its consequences on meteorology for cases of extreme meteorological situations and air quality/ atmospheric composition.

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