The impacts of land use land cover change on climate in the Vu Gia – Thu Bon river basin in Central Vietnam

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Introduction

Future changes in climate and land use (LU) are likely to have significant impacts on the regional climate system. To increase the accuracy of the climate models and the resulting predictions, the use of high resolution and updated LU data is analyzed. In the framework of LUCCi, the impacts of land use land cover change (LULCC) for Vu Gia - Thu Bon river basin (VGTB) are investigated, by:

- Comparing WRF simulations based on WRF default LU and observed LU;
- Artificial LU conversion experiments around Da Nang station;
- Long-term transient regional climate simulations using observed and WRF default LULC data.

Comparison of WRF simulations using observed LU vs. WRF default LU map

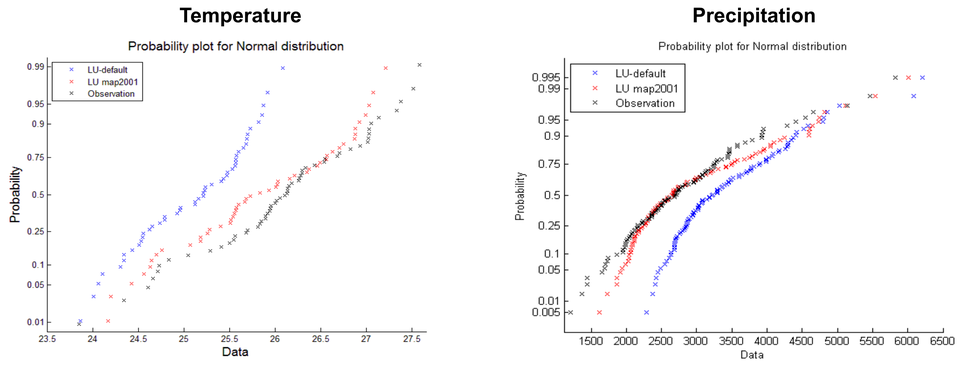

Fig.1 Probability of surface temperature (left) and precipitation (right) for stations from 2001 to 2010 with default LU map (blue), observed map 2001 (red), and observations (black).

- In case of using WRF with observed LU data provided from LUCCi project, the surface temperature and rainfall are found to correspond better with observations compared to the results of the WRF default LU run (Fig.1).
- The results give evidence to the necessity to use true LULC data for climate modelling.

LULCC sensitivity: artificial LU data conversion experiments

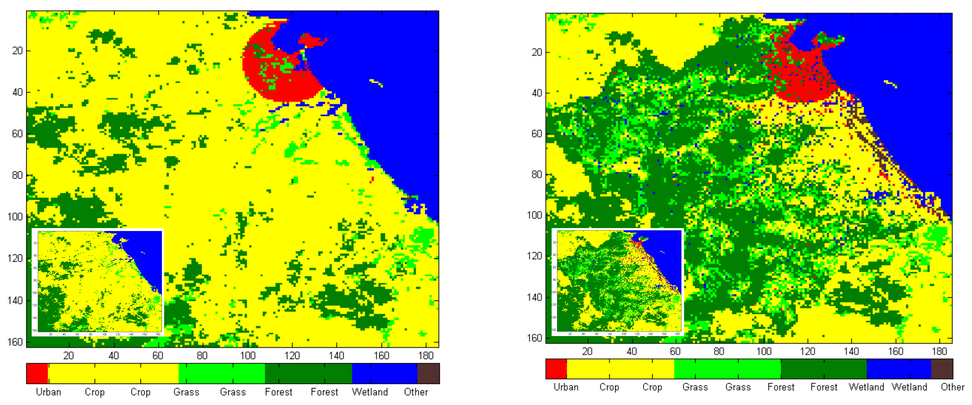

Fig.2 Converted LULC at 20km surrounding Da Nang station: based on default LU map (left), observed LU map 2010 (right)

- To investigate the sensitivity of LULC change, we artificially converted LU in a radius of 20 km around Da Nang station: Cropland (yellow) was converted to urban (red) (Fig.2). 15 runs with different initial conditions (perturbation runs) with both artificial LU and default LU were performed using WRF.
- A t-test is applied to test the differences of the mean values of WRF default LU and WRF artificial LU for statistical significance.
- We also use the signal-to-noise ratio (SNR) and bootstrapping test to highlight regions, which exhibit a clear signal:

$$SNR = \frac{|\mu_A - \mu_B|}{\sigma_A + \sigma_B}$$

A: WRF - default LU
B: WRF - artificial LUC

Temperature based on observed LU map 2010

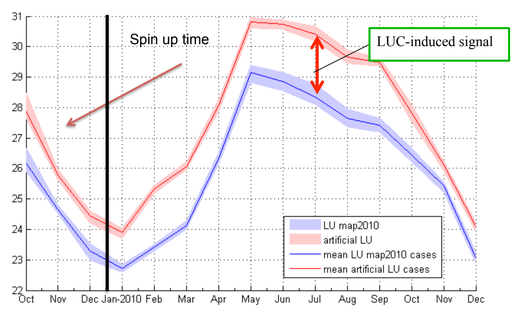

Fig.3a Surface temperature of 15 perturbation runs with LU map 2010 (blue) and artificial LU (red) at Da Nang station

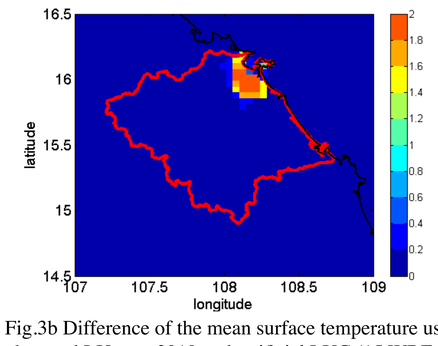

Fig.3b Difference of the mean surface temperature using observed LU map 2010 and artificial LUC (15 WRF runs respectively)

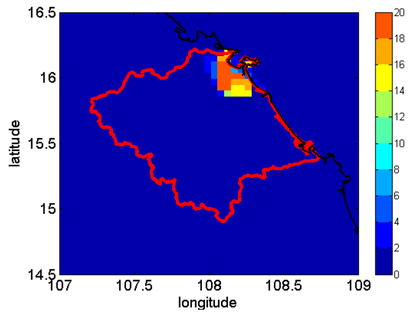

Fig.3c Signal-to-noise ratio for surface temperature based on 15 perturbation runs

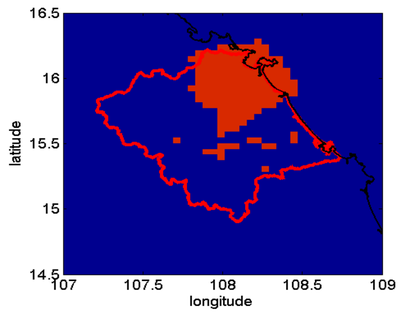

Fig.3d t-test for temperature based on 15 perturbation runs (h=1: reject, h=0: failure to reject)

- The converted land cover data from cropland to urban land strongly impacts on surface temperature (increases up to 2°C) at the converted area (Fig.3).

Precipitation based on observed LU map 2010

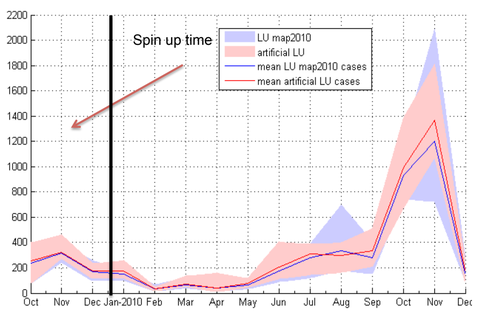

Fig.4a Precipitation of 15 perturbation runs with LU map 2010 (blue) and artificial LU (red) at Da Nang station

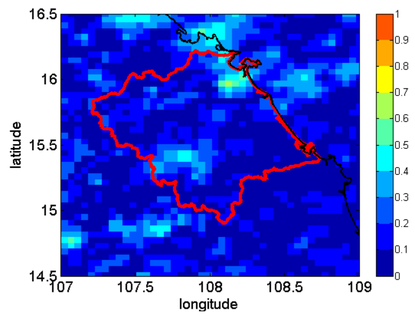

Fig.4b Signal-to-noise ratio for precipitation based on 15 perturbation runs

Precipitation based on default LU map

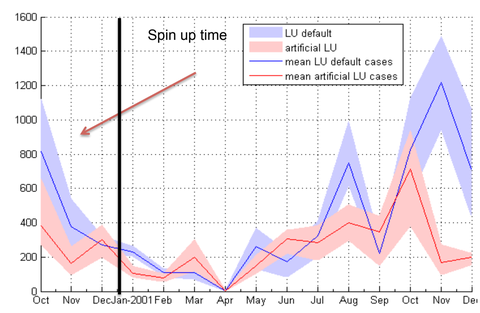

Fig.5a Precipitation of 15 perturbation runs with WRF default LU map (blue) and artificial LU (red) at Da Nang

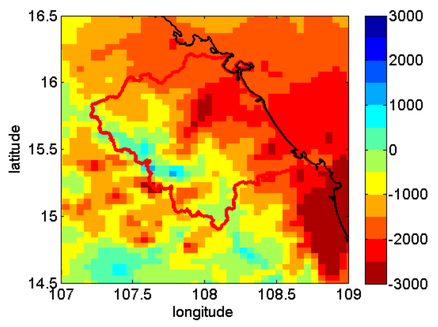

Fig.5b Difference of mean precipitation values of 15 perturbation runs with LU default and artificial LU (LUC *minus* default)

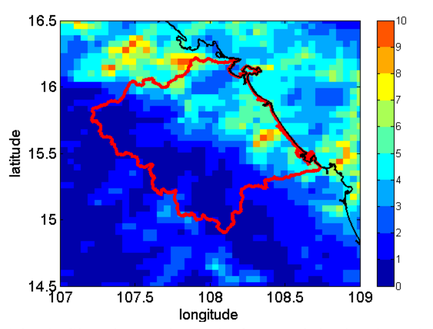

Fig.5c Signal-to-noise ratio for precipitation based on 15 perturbation runs

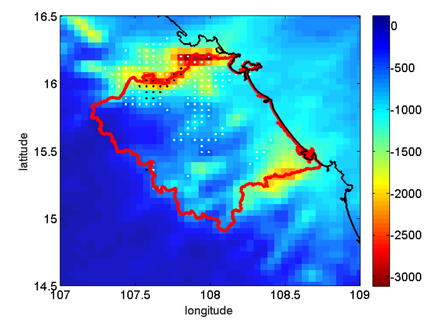

Fig.5d Difference of mean precipitation values of 15 perturbation runs with LU default and artificial LU in November 2001 (LUC *minus* default). Dots indicate a significant (alpha = 90 (black) and alpha = 80 (white)) signal-to-noise ratios based on bootstrapping test

- Large noise of precipitation with and without artificial LU based on observed LU map 2010 (Fig. 4); thus, the separation of signal from noise is difficult
- However, we can find the signal induced by LULCC in the artificial LU conversion experiments based on default LU map. (Fig. 5)

Effects of LUC on regional climate using emission scenario A1B of ECHAM5 (2001 – 2020)

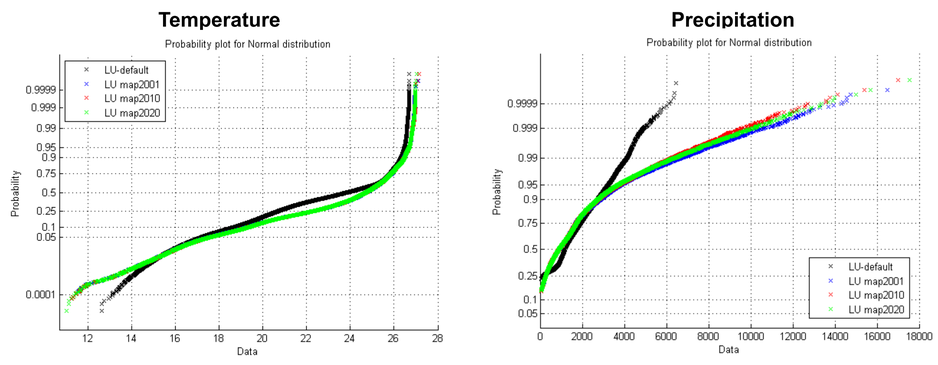

Fig.6 Probability of surface temperature (left) and precipitation (right) for domain 3 for the period 2011 to 2020 with WRF default LU map, observed maps 2001 and 2010, and projected map 2020

- Small differences between temperature and precipitation found for WRF simulations using LU maps obtained from LUCCi project.
- These results show a slight increase in surface temperature, 90% rainfall amount is remain similar and potentially high amount of rainfall compared with simulations is obtained by the default LU map (Fig.6).

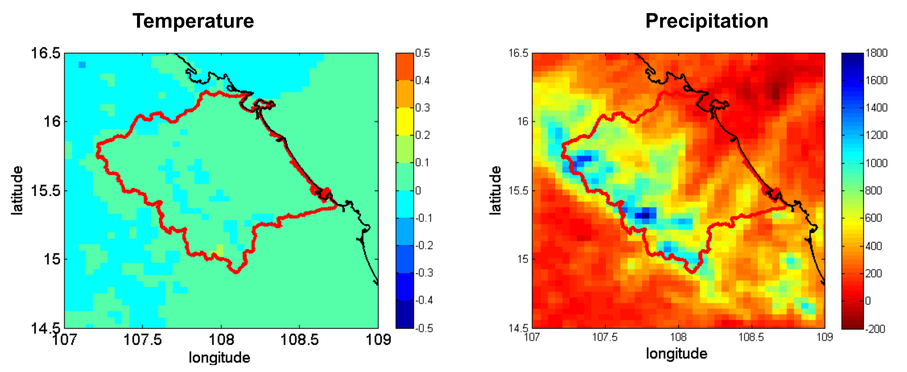

Fig.7 Difference of mean annual surface temperature (left) and mean annual precipitation (right) using observed LU map 2001 between the period 2001-2010 and period 2011-2020 (2011-2020 minus 2001-2010)

- The surface temperature is expected to remain similar.
- The annual precipitation is expected to be greatly changed. The amount of rainfall is slightly increased in the lowland area around the coast and greatly increased in the highland area up to 1800 mm (Fig.7).

Conclusions

The results demonstrate that using the observed LULC maps improves the results of regional climate simulations. It also shows that LULC change may remarkably impact on hydrometeorological variables, as shown for Da Nang region. For this decade, the surface temperature is expected to remain similar compared to the previous one. Rainfall amount is expected to be significantly increased in the highland areas and slightly increased in the lowlands.

Future work

- Besides the sensitivity of converted LU from cropland to urban land, it is necessary to analyze the sensitivity of other potential conversions, and also study gradual LU changes.
- It is also important to further analyze the differences obtained by the different observed LU maps and the projected LU map.
- Extending our analysis until 2050.

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