

GLOBAL RESEARCH ALLIANCE

ON AGRICULTURAL GREENHOUSE GASES

CROPLANDS RESEARCH GROUP:

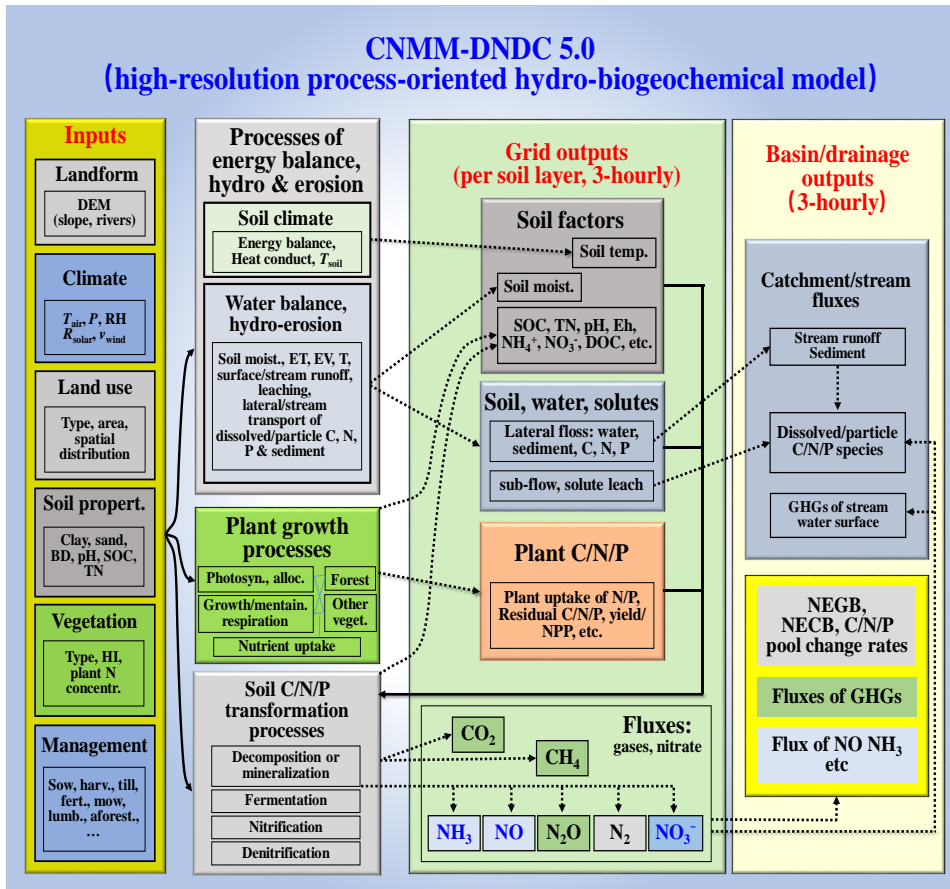
Landscape Management of Agricultural System Network (LMAS)

Leader: Xunhua Zheng

Membership: 5 Countries (CN, GE, ES, FR, US)

Activities/Accomplishment since last meeting: **LMAS**

CNMM-DNDC was updated to version 5.0



CNMM-DNDC is:

- ❑ a hydro-biogeochemical model;
- ❑ a DNDC family member with special features, such as space distribution (three dimensions), designs to facilitate universal applicability for ecosystems of all terrestrial land types (croplands, forests, grasslands, wetlands, aquatic ecosystems), soil hydro-erosion, customized soil layers and resolutions;
- ❑ capable of revealing the effects of lateral water flows on GHG fluxes and other processes; and,
- ❑ a core working model for the LMAS of GRA.

(Zhang *et al.*, 2021, BG; Li *et al.*, 2022, BG; Li *et al.*, 2023, BG, submitted ;
Li *et al.*, 2023, in preparation; Zhang *et al.*, 2023, in preparation)

■ **CNMM-DNDC updates**

- **Revised the model** (version 3.0 to 5.0) **to better facilitate catchment landscape simulation** through
 - validating the newly added soil erosion processes,
 - modifying and validating the processes of forest growth, so as to improve simulations of forest biogeochemistry and GHG fluxes,
 - designing a new module to enable CNMM-DNDC to calculate off-farm GHG emissions and thus yield-based GHG footprints of crop production.
- **Published the model modification with improved NH₃ volatilization mechanisms** (Li et al., 2022, BG).
- **Adapted the model to both MPI and MPI-GA modes, to enable fast high-resolution 3D simulations at large-scales** (river basins, national, continental or global scales).

■ **CNMM-DNDC application**

- CNMM-DNDC was applied by the local governmental project for **water quality management** of a subtropical river drainage in Sichuan province, southwest China;
- CNMM-DNDC was applied to evaluate **GHG footprints of maize** production in tropical (Kenya), subtropical and temperate climate;
- CNMM-DNDC is involved as single indispensable tool in three lately granted multi-year **research projects** to implement
 - ◆ study of net ecosystem carbon balance (NECB) of croplands in Fujian province (granted by National Natural Science Foundation of China),
 - ◆ investigation of carbon, nitrogen and phosphorous cycling and interactions of ecosystems in Tibet Plateau (granted by Ministry Sci. Tech., China), and
 - ◆ **identification of best management strategies to mitigate non-CO₂ emissions from croplands toward carbon neutrality** (granted by Ministry Sci. Tech., China; an **international cooperation** project).

■ Research articles on CNMM-DNDC development

- **Li *et al.*, 2022, *BG***
- **Li *et al.*, 2023, *BG* (submitted)**

Li S, Zhang W, Zheng X, Li Y, Han S, Wang R, Wang K, Yao Z, Liu C, Zhang C, 2022. Update of a biogeochemical model with process-based algorithms to predict ammonia volatilization from fertilized cultivated uplands and rice paddy fields. *Biogeosciences* 19, 3001–3019.

Li S, Zhu B, Zheng X, Hu P, Han S, Fan J, Wang T, Wang R, Wang K, Yao Z, Liu C, Zhang W, Li Y, 2023. Enabling a process-oriented hydro-biogeochemical model to simulate soil erosion and nutrient losses. *Biogeosciences* (lately submitted).

■ Research priorities

□ Priority 1: To test/validate CNMM-DNDC applicability

- ◆ Validation of the model with field observations in different terrestrial ecosystems, landscapes or catchments by using worldwide observations subject to different natural conditions or management.
- ◆ Needs of GRA members and other countries/organizations to join the validation and application of this core model developed by the LMAS network **to develop carbon neutrality strategies of crop production and landscape management.**

□ Priority 2: To further improve CNMM-DNDC functions

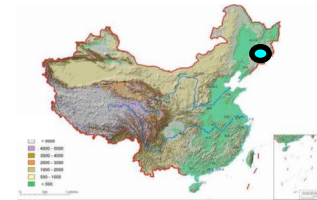
- ◆ To modify the model source codes to enable process-oriented simulations for complex cropping systems or agroforests with intercropping features (this plan of model development is still delayed due to failures in applying for project funds).
- ◆ To add a groundwater module to improve dynamical water balance simulation.
- ◆ To couple CNMM-DNDC with an atmospheric model to enable simulations on synergy and trade-off between GHG mitigation and erosion/pollution control.

■ Capability priorities

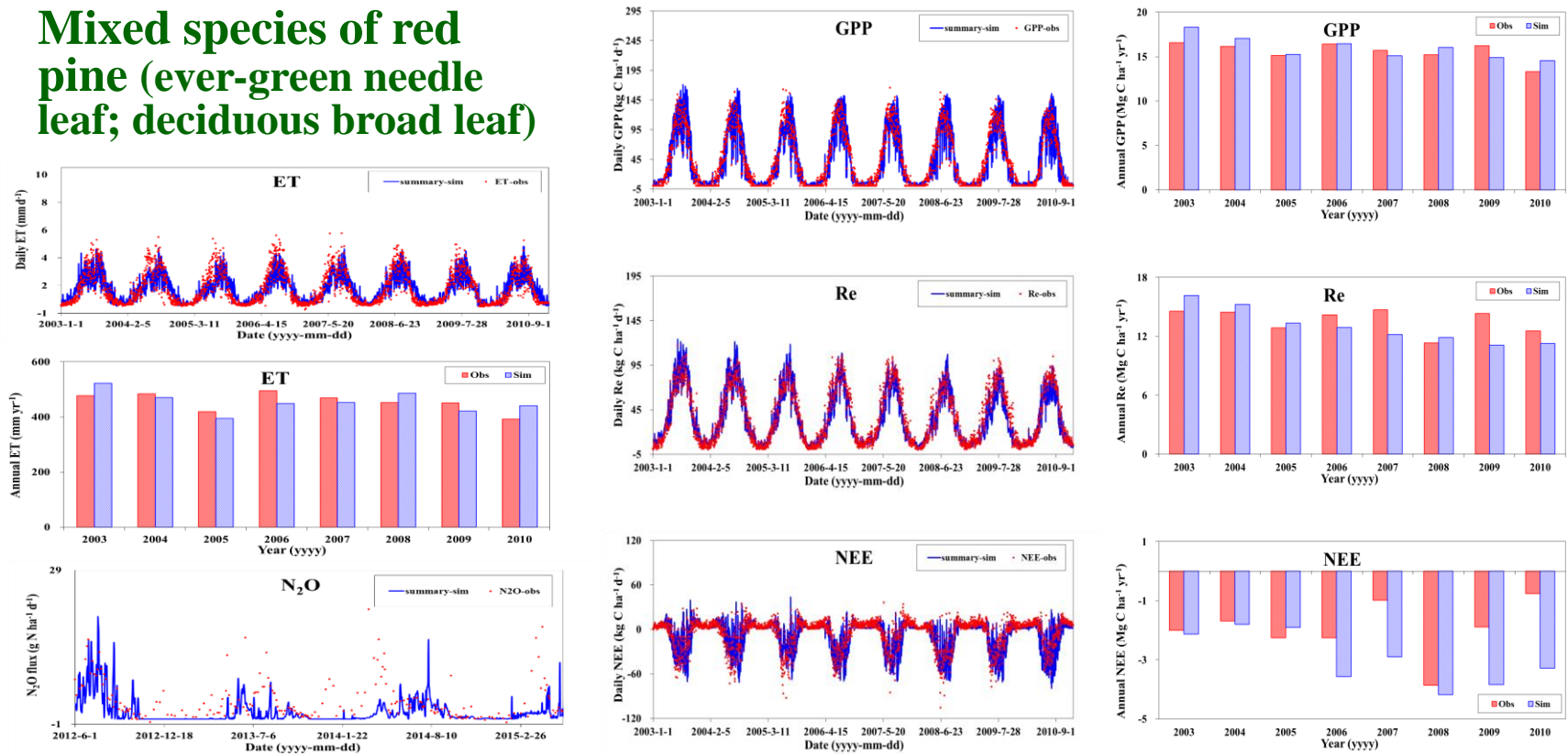
- **Priority 1: To apply for cooperation research projects** (bilateral or multi-lateral cooperation projects with GRA members of countries or international organizations)
- **Priority 2: To identify opportunities of cooperation with other GRA research groups** (Integrative Research Group or Rice Research Group of GRA, to use CNMM-DNDC as a research tool)
- **Priority 3: To apply for scholarships for international students** (i.e., student program of the University of Chinese Academy of Sciences).
- **Priority 4: to apply for international postdoc positions in universities or the institutes of CAS** (by using fellowships from CAS or the National Post-Doctor Regulatory Commission of China).

Modified CNMM-DNDC validation cases: Temperate forest (China)

■ Forest ecosystems: Fluxes of ET (water vapor), CO₂ fluxes of NEE, GPP & ER



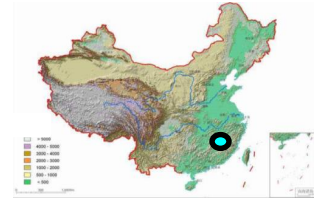
Mixed species of red
pine (ever-green needle
leaf; deciduous broad leaf)



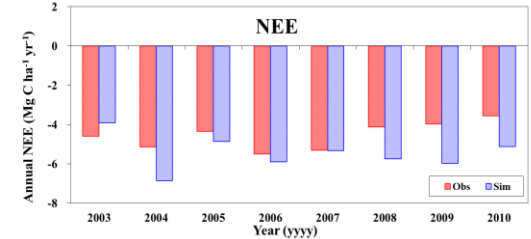
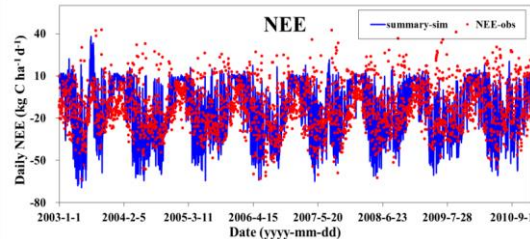
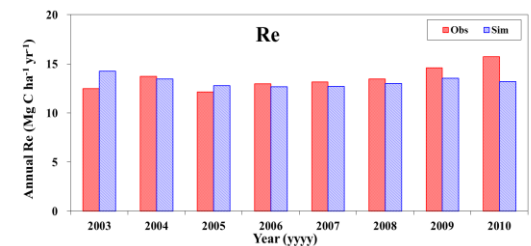
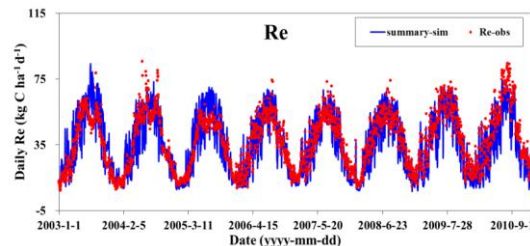
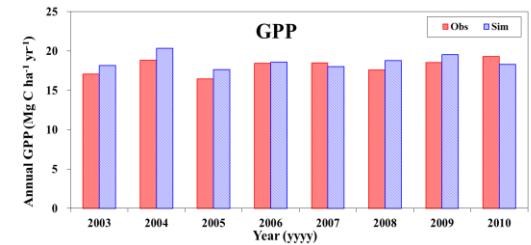
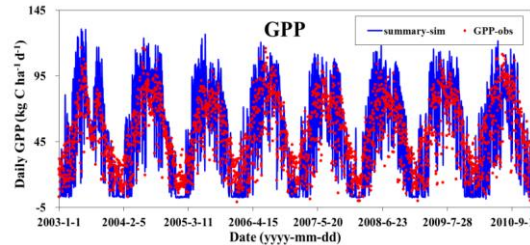
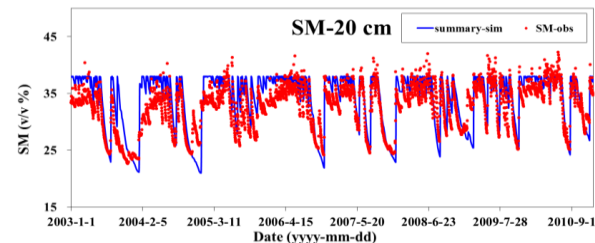
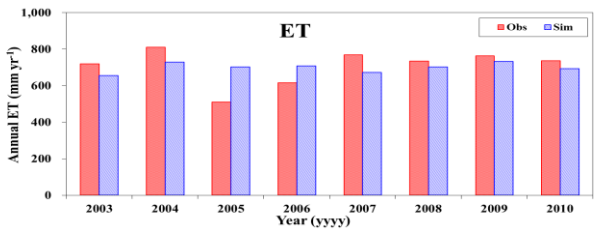
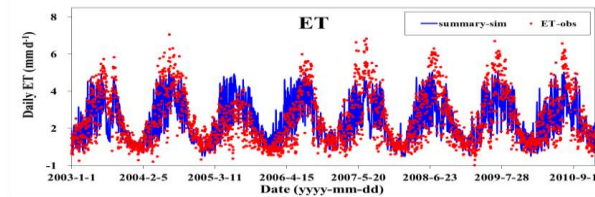
(Zhang *et al.*, 2023, in preparation)

Modified CNMM-DNDC validation cases: Subtropical forest (China)

Forest ecosystems: Fluxes of ET (water vapor), CO₂ fluxes of NEE, GPP & ER



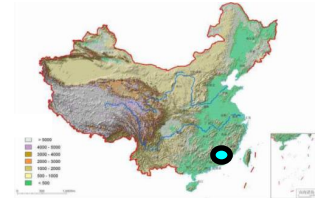
Afforested masson pine forest (ever-green needle leaf)



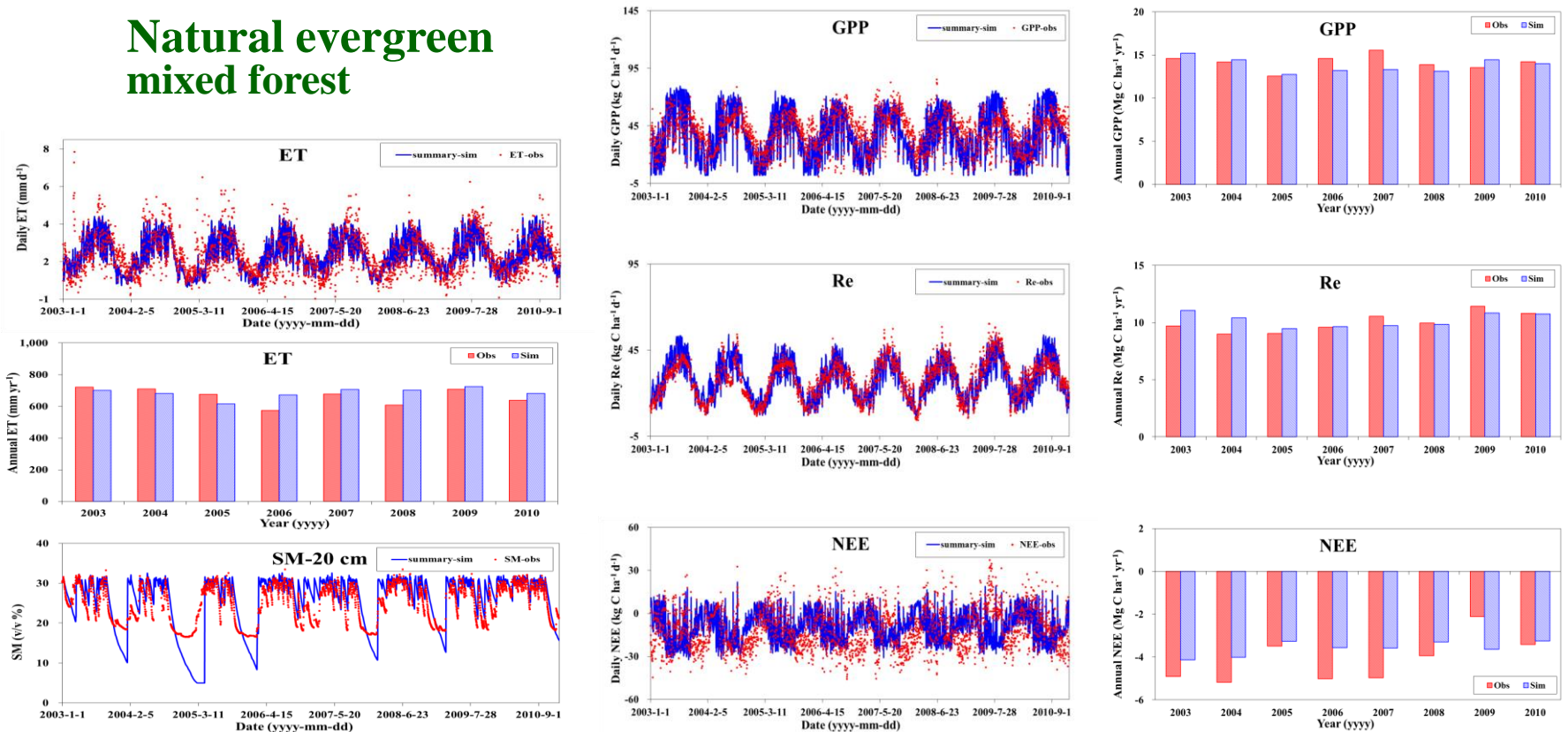
(Zhang *et al.*, 2023, in preparation)

Modified CNMM-DNDC validation cases: Subtropical forest (China)

Forest ecosystems: Fluxes of ET (water vapor), CO₂ fluxes of NEE, GPP & ER

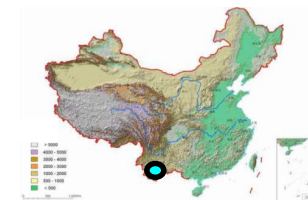


Natural evergreen mixed forest

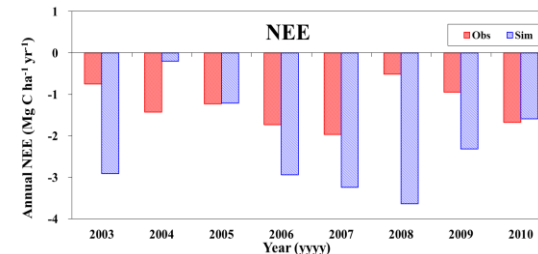
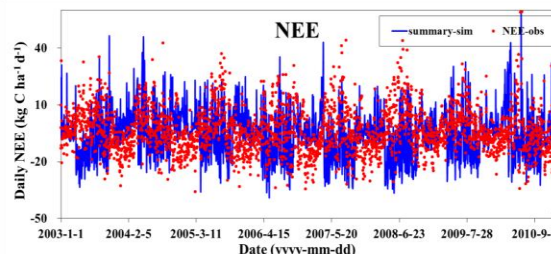
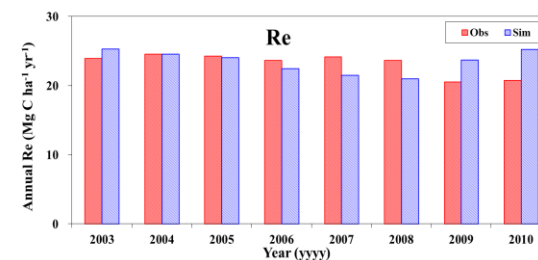
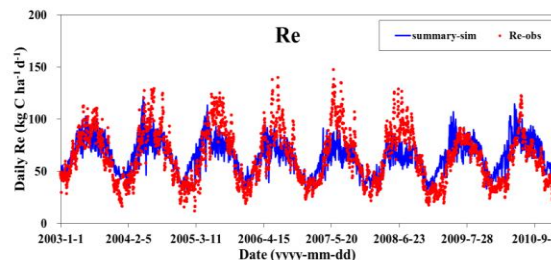
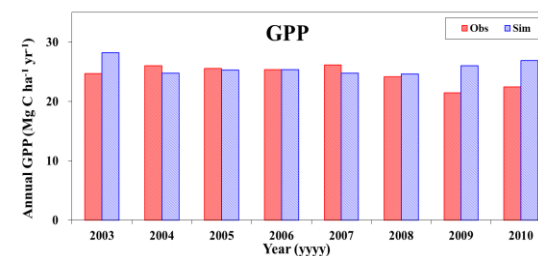
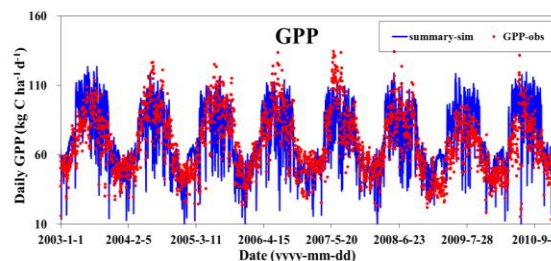
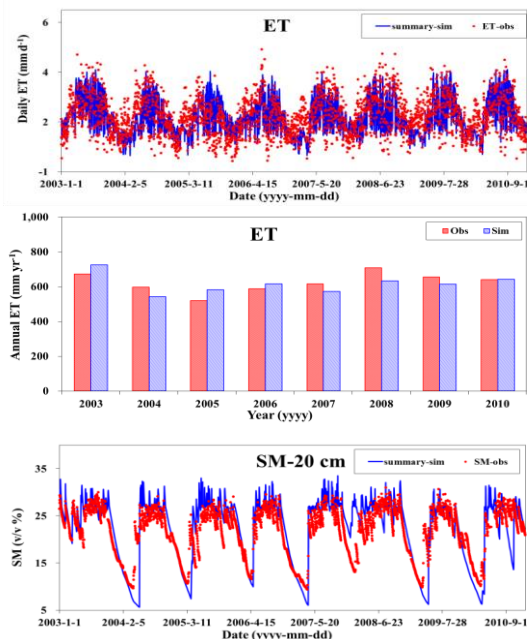


Modified CNMM-DNDC validation cases: Tropical rain forest (China)

Forest ecosystems: Fluxes of ET (water vapor), CO₂ fluxes of NEE, GPP & ER



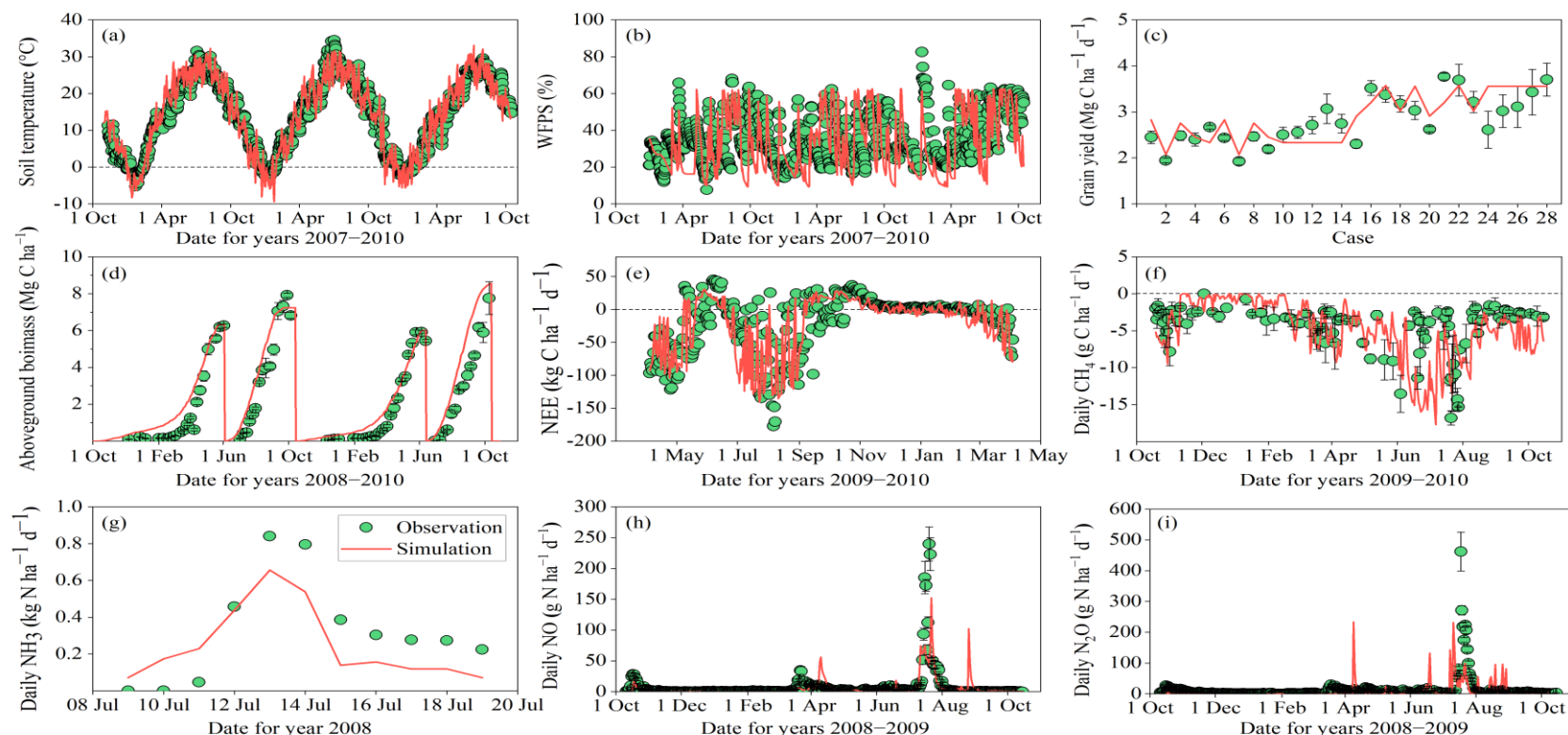
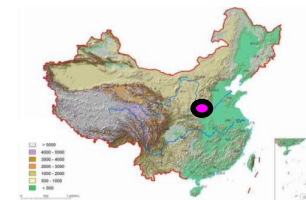
Natural evergreen broad leaf forest



(Zhang *et al.*, 2023, in preparation)

Modified CNMM-DNDC validation cases: Warm temperate cropland (China)

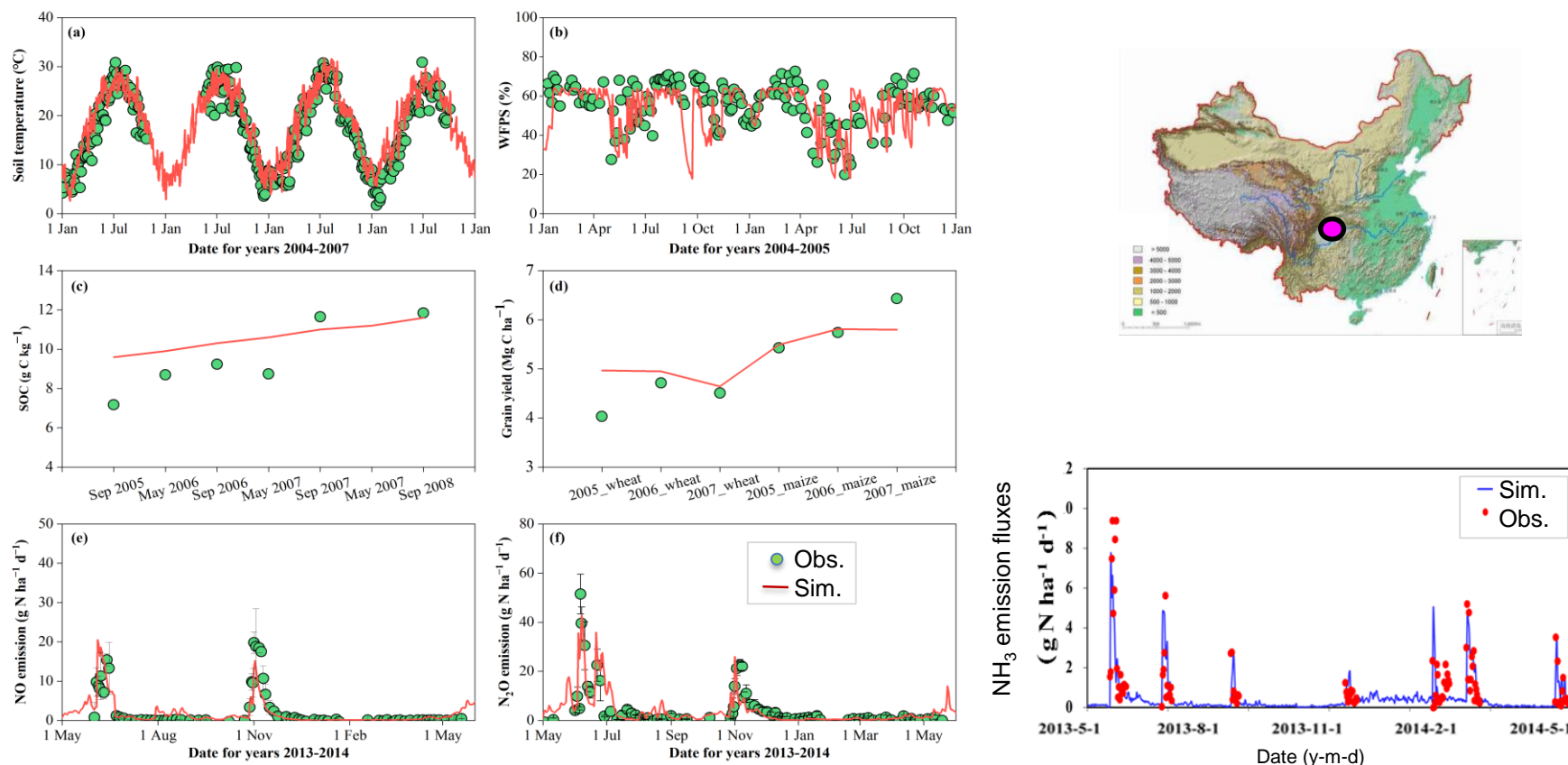
■ Summer maize-winter wheat rotation (YJ): soil temp./moist., yields/biomass, fluxes of NEE, CH₄, N₂O, NO and NH₃



(Li *et al.*, 2023, in preparation)

Modified CNMM-DNDC validation cases: Subtropical cropland (China)

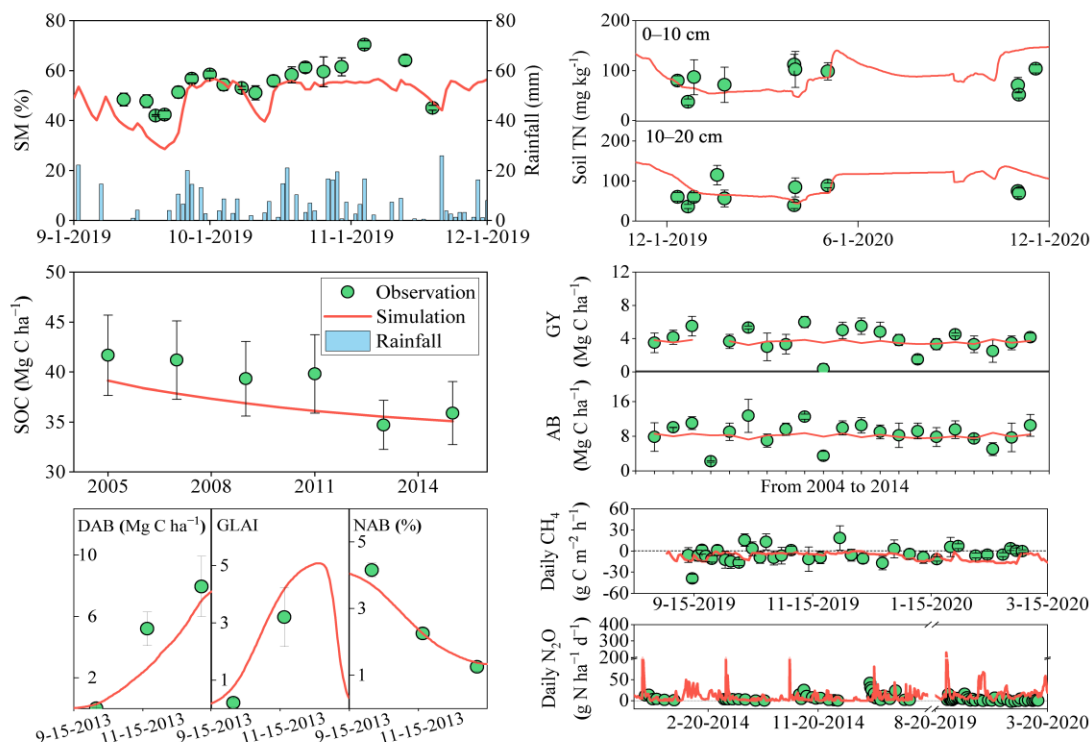
■ Summer maize-winter wheat rotation (YT): soil temp./moist., SOC, yields, fluxes of N₂O, NO and NH₃



(Li *et al.*, 2023, in preparation)

Modified CNMM-DNDC validation cases: Tropical cropland (western Kenya)

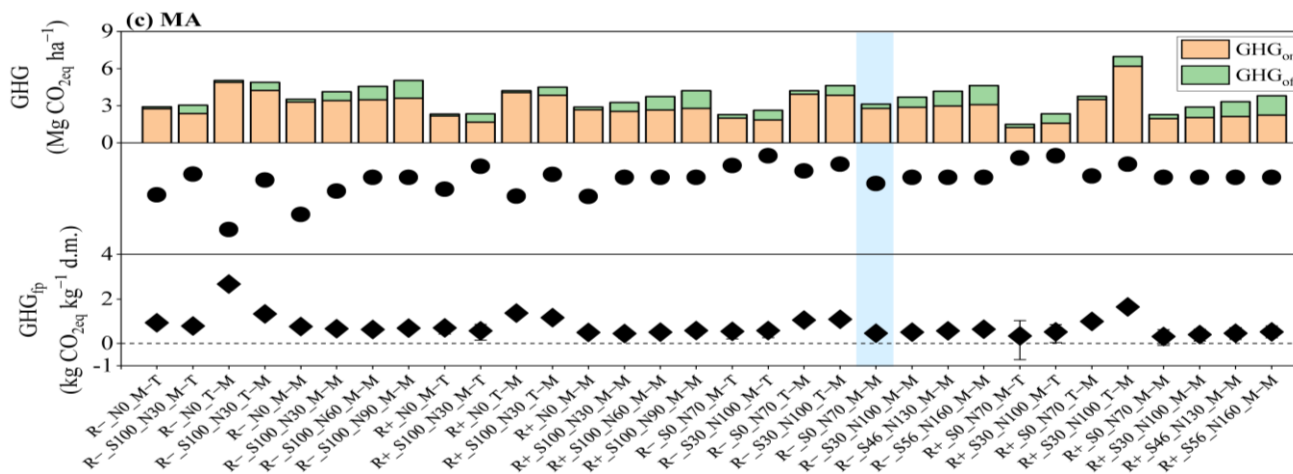
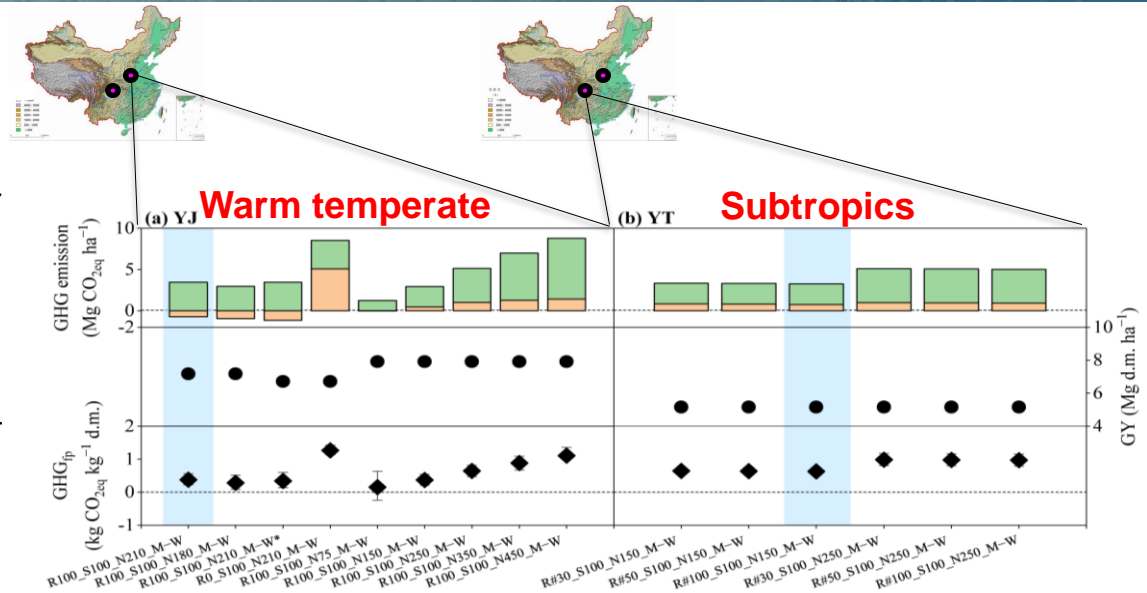
- **Double cropping system (MA):** soil moist., SOC, TN, Gain yield (GY), aboveground biomass at harvest (AB) or dynamically (DAB), green-leaf LAI (GLAI), tissue N (AB), and fluxes of CH₄ and N₂O



(Li *et al.*, 2023, in preparation)

Modified CNMM-DNDC application cases: Yield-based GHG footprints in maize production

GHG footprints: Different management scenarios of cultivation in warm temperate, subtropical and tropical climates



A scenic view of a park with a river, a red bridge, and a tall tower in the background. The text is overlaid on the image.

*Thanks very much
for your attention!*

Corresponding to
Prof. Dr. Xunhua Zheng (xunhua.zheng@post.iap.ac.cn)
from Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China