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Rooting satellite observations in land-atmosphere exchange processes

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with contributions from
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J. Wen+ (CUIST), Y. Ma+ (ITP/CAS)

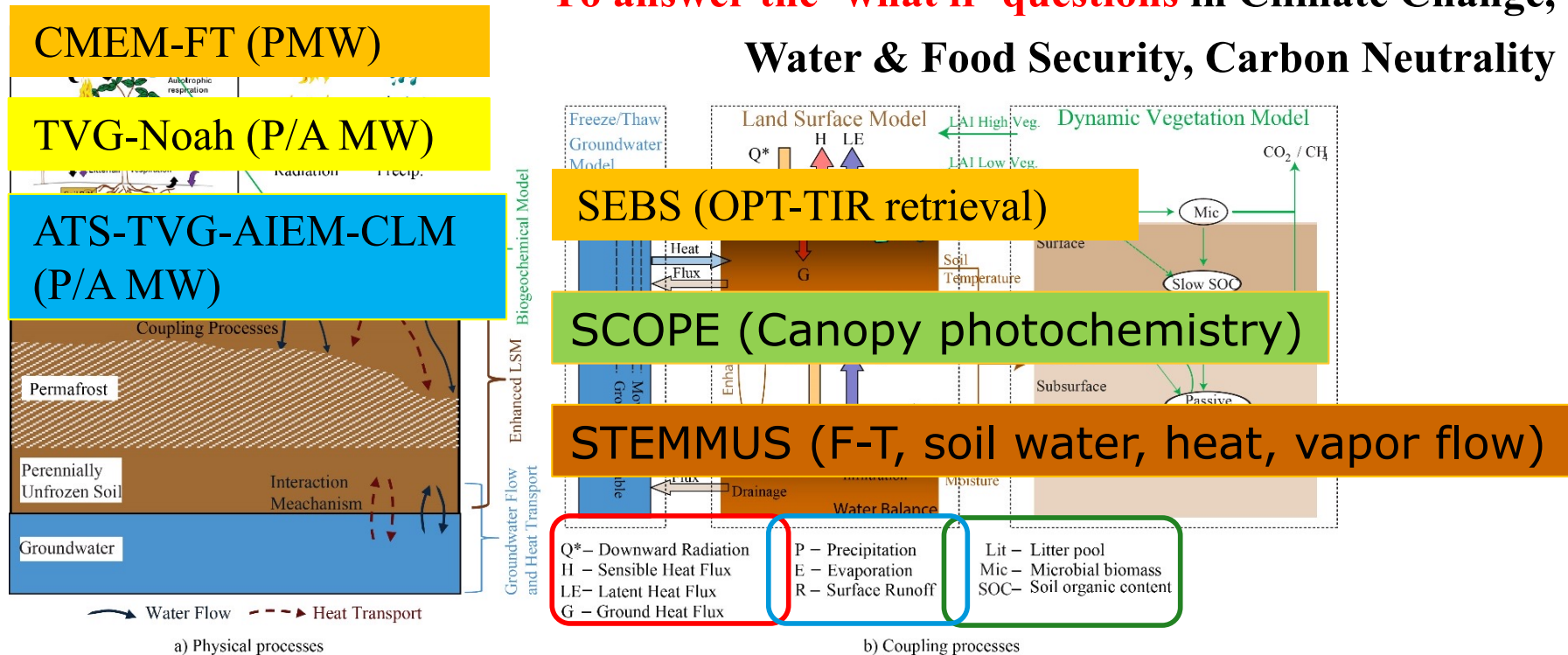
in collaboration with
P. de Rosnay, G. Balsamo (ECMWF), M. Ek (NCAR),
P. Ferrazzoli (UR), M. Schwank (ETH), Y. Kerr (CESBIO), A. Cilliander (JPL)



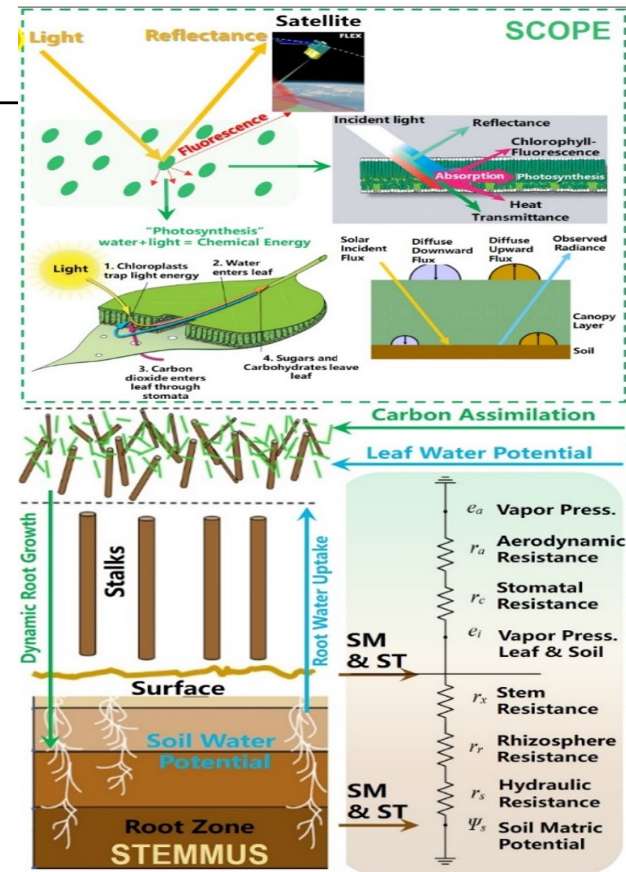
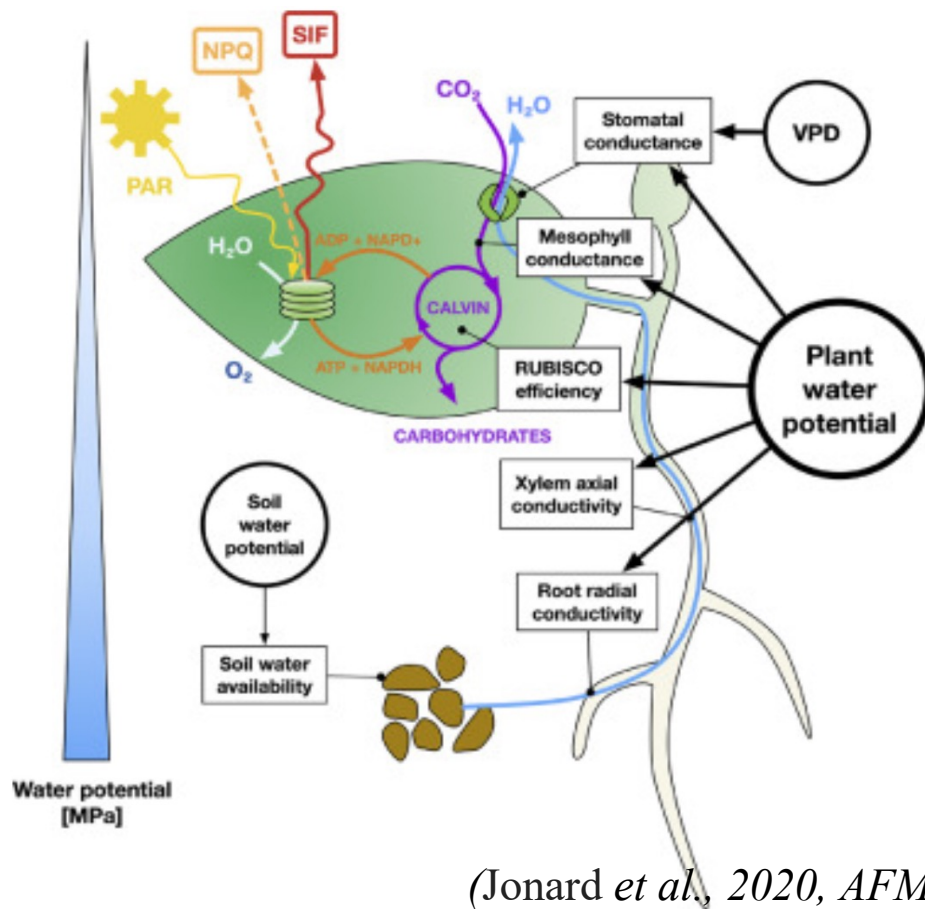
FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

Digital Twin Earth – Observation Operator & Dynamic Model components

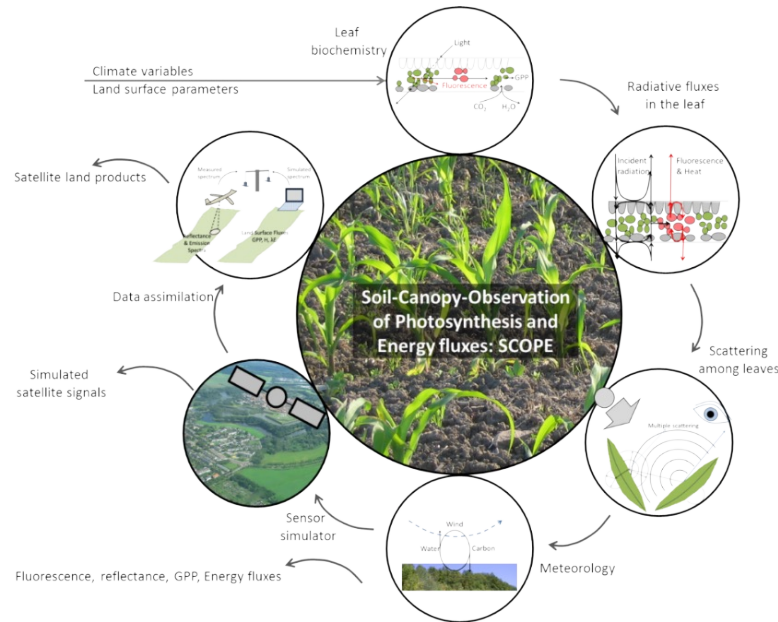
To answer the ‘what if’ questions in Climate Change, Water & Food Security, Carbon Neutrality



STEMMUS-SCOPE: Modeling integrated Photochemistry, Biochemistry and Transfer of Energy, Mass and Momentum in the Soil-Vegetation System

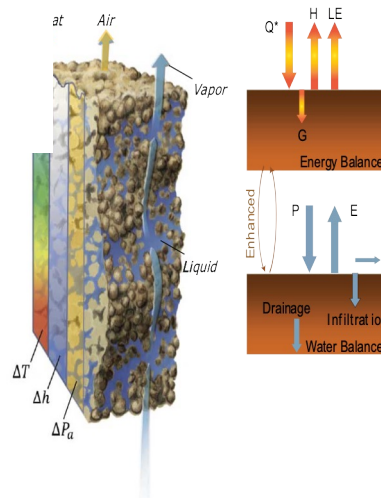


Water, Heat and Carbon fluxes and Optical-Thermal RT + Canopy Photochemistry



SAIL4 (*Verhoef et al., 2007, TGRS*)

SCOPE (*Van der Tol et al., 2009, Biogeos.*)



Three driving forces:
 - Temperature Gradient,
 - Matric Potential Gradient,
 - Soil Air Pressure Gradient.

Fully coupled transport of
 - water,
 - vapor,
 - air,
 - heat

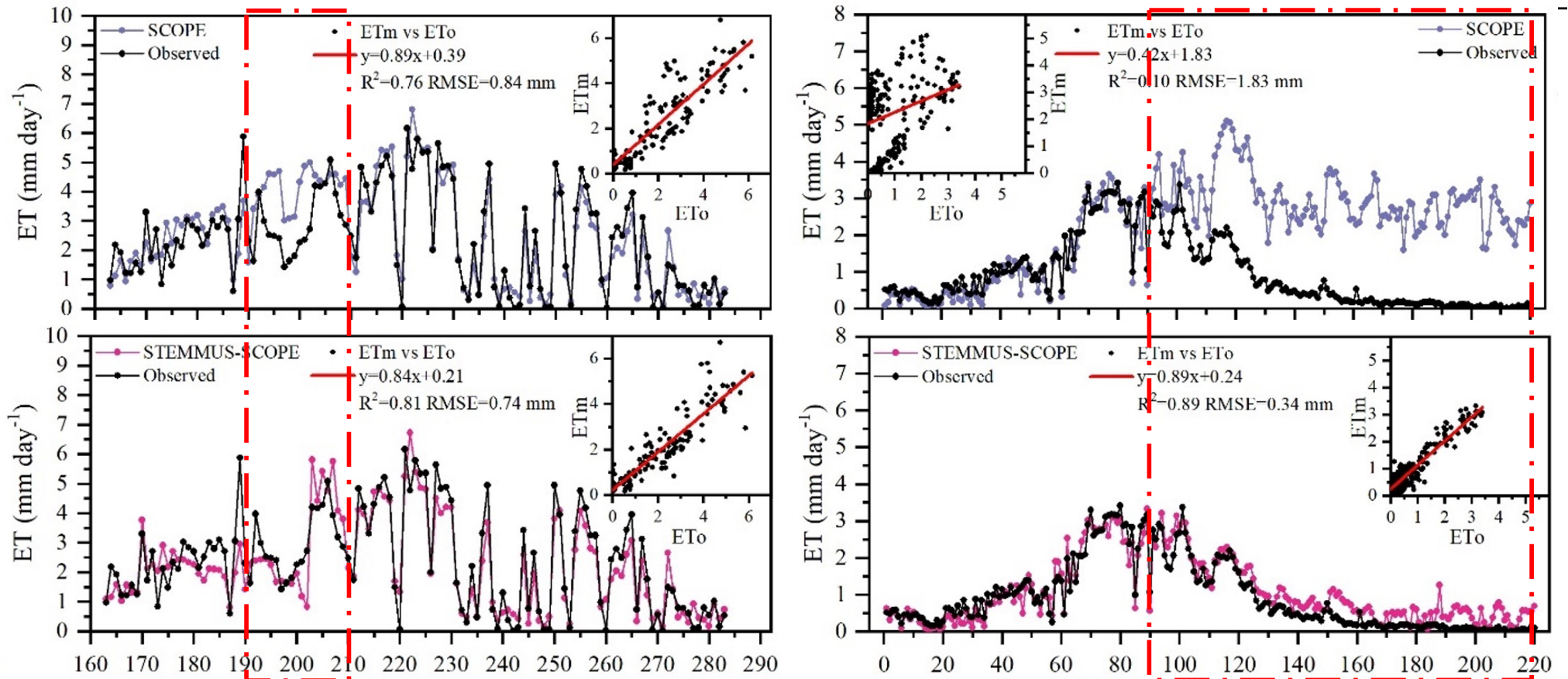


STEMMUS
 Simultaneous Transfer of Energy, Mass and Momentum in Unsaturated Soil

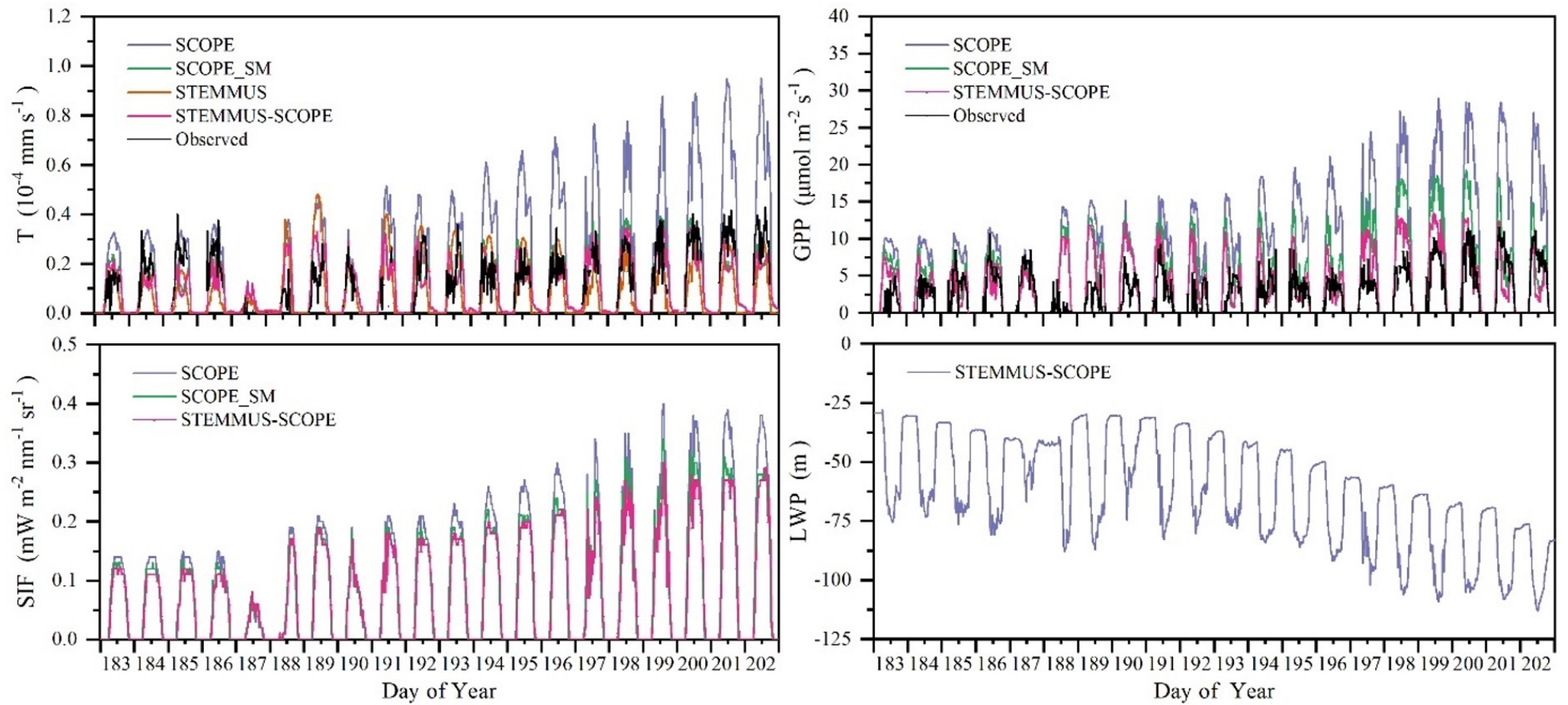
(Zeng, et al. 2011a WRR)
 (Zeng, et al. 2011b JGR)
 (Zeng & Su, 2013 WRR)
 (Yu, Zeng, et al. 2016 HESS)
 (Yu, Zeng, et al. 2018 JGR)
 (Yu, Zeng, et al. 2020 HESS)
 (Yu, Zeng, et al. 2020 TC)
 (Wang, Zeng, et al. 2021 GMD)

Simulation of Evapotranspiration

(Daily ET: (L) Maize at Yangling station; (R) Grassland at Vaira Ranch Fluxnet site)

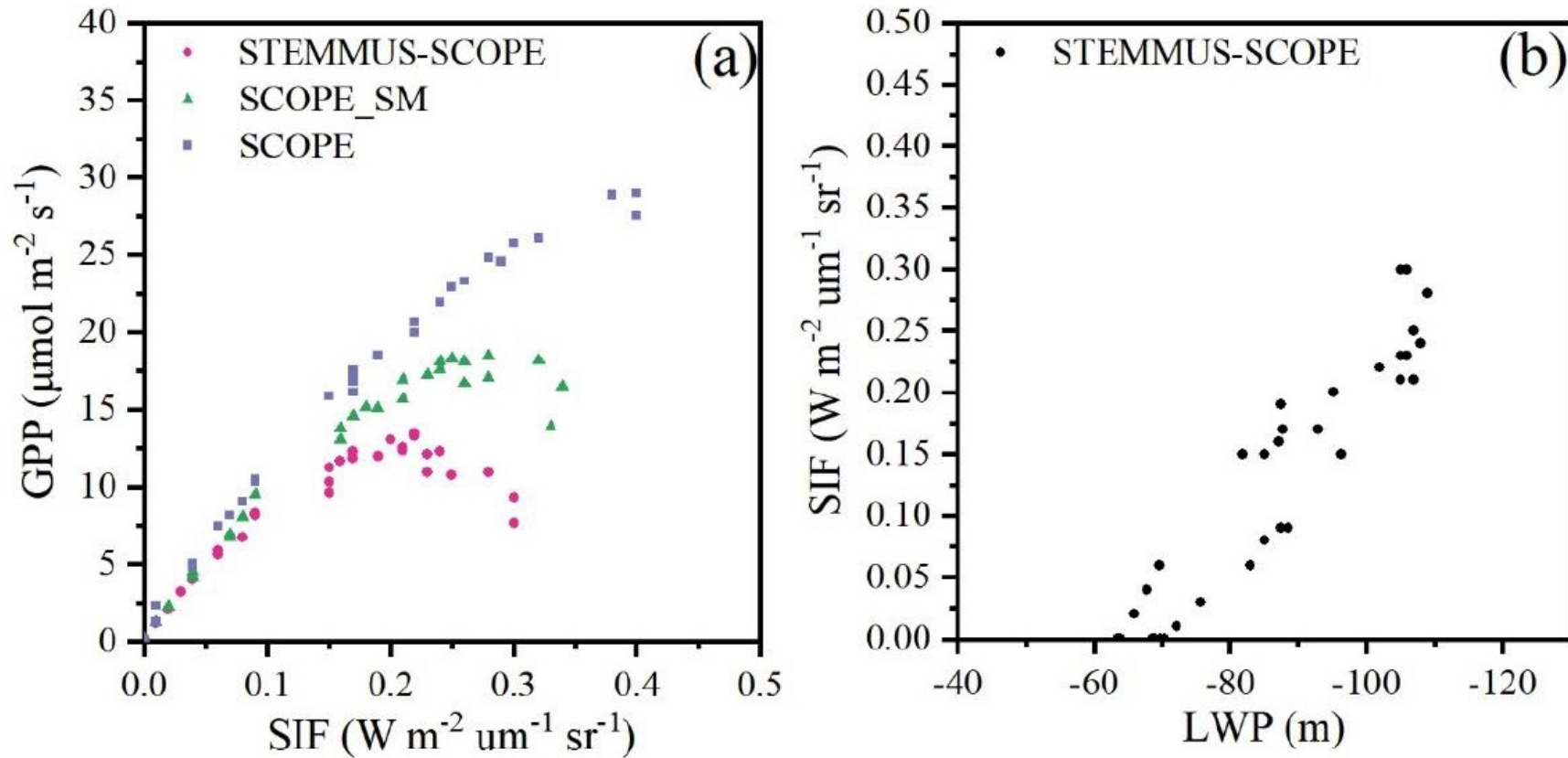


Half-hourly transpiration (T), gross primary production (GPP), top of canopy solar-induced fluorescence (SIF) and leaf water potential (LWP) at Yangling station

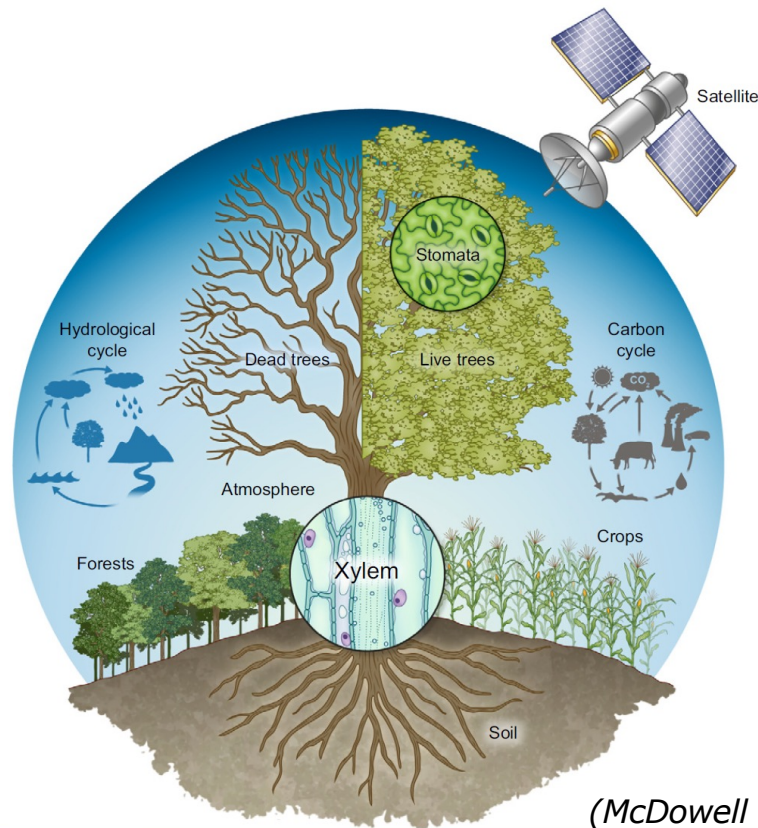


What information does SIF carry on GPP and LWP?

SIF: top of canopy solar induced fluorescence, GPP: Gross Primary Production, LWP: leaf water potential (**DOY 199, Yangling station**)



Rooting satellite observations in land-atmosphere exchange processes
by considering **plant hydraulics** in water-soil-roots-leaves-atmosphere system



(McDowell et al., 2019, *New Phyt.*)

STEMMUS-SCOPE
links energy, water
& carbon processes to
EO OPT/SIF/TIR observables
(Wang et al., 2021, *GMD*)

Simulate/Retrieve
States/Parameters/Fluxes with
S-2, S-3, LSTM, CHIME, FLEX
+ MSG/MTG

Rooting satellite observations in land-atmosphere exchange processes by considering the interface of Air-To-Soil transition



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scientific **data**

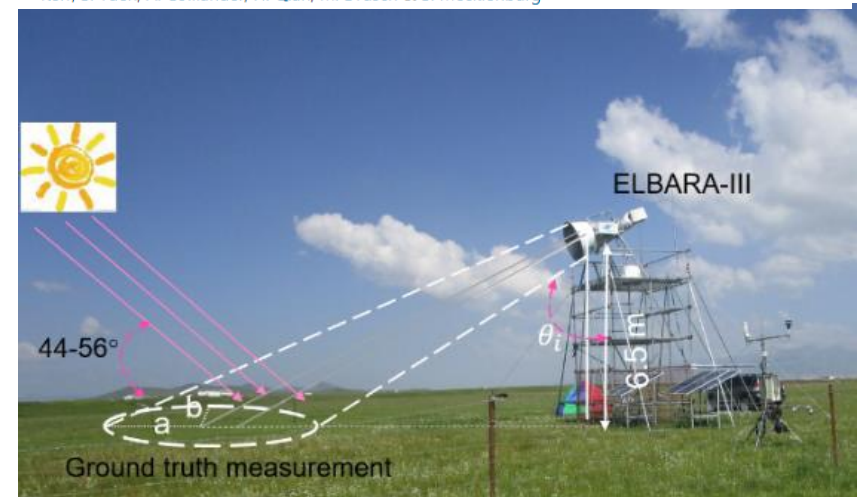
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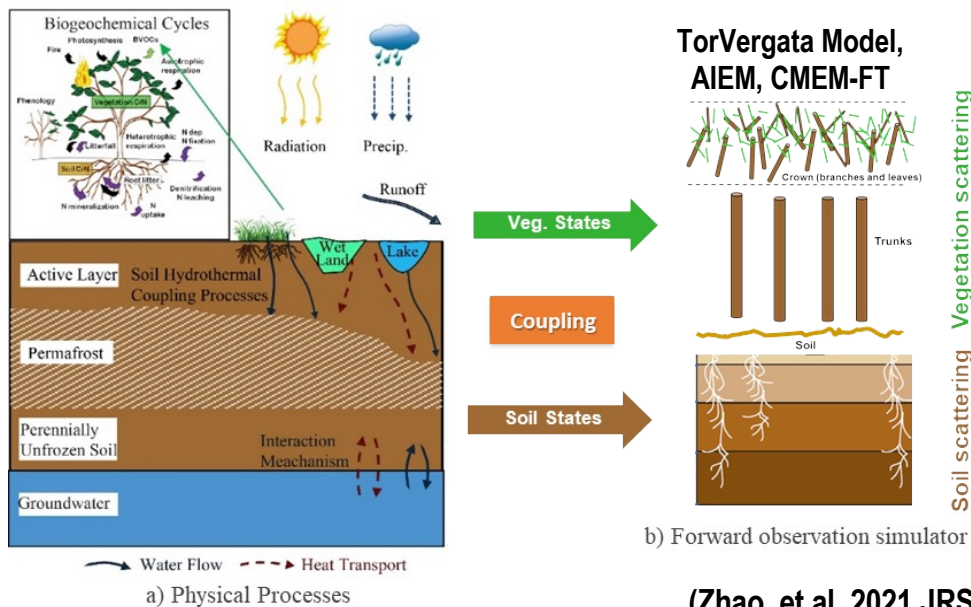
Data Descriptor | [Open Access](#) | Published: 30 September 2020

Multiyear in-situ L-band microwave radiometry of land surface processes on the Tibetan Plateau

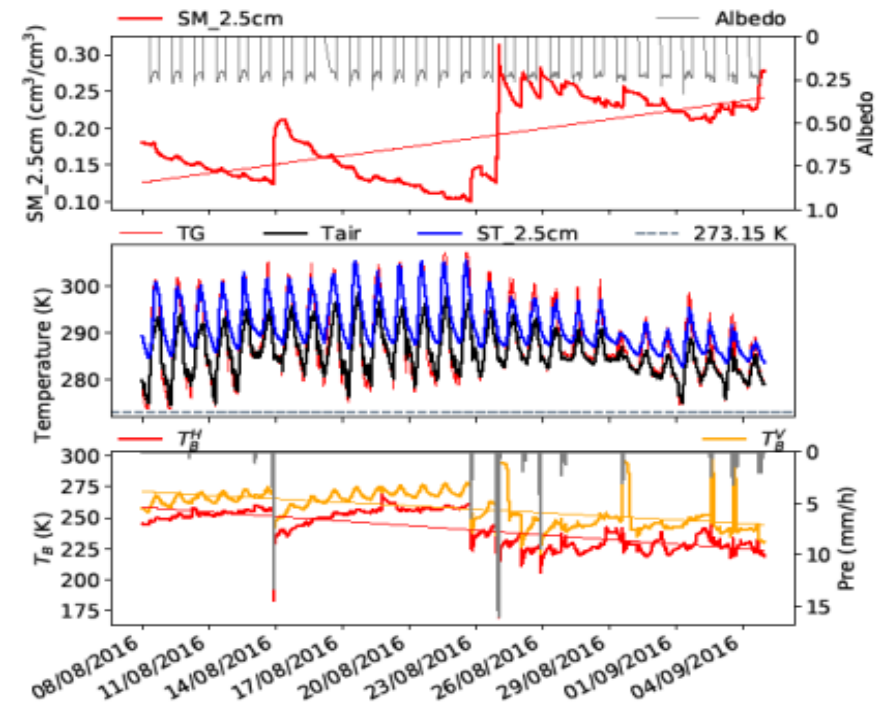
Z. Su [✉](#), J. Wen [✉](#), Y. Zeng, H. Zhao, S. Lv, R. van der Velde, D. Zheng, X. Wang, Z. Wang, M. Schwank, Y. Kerr, S. Yueh, A. Colliander, H. Qian, M. Drusch & S. Mecklenburg



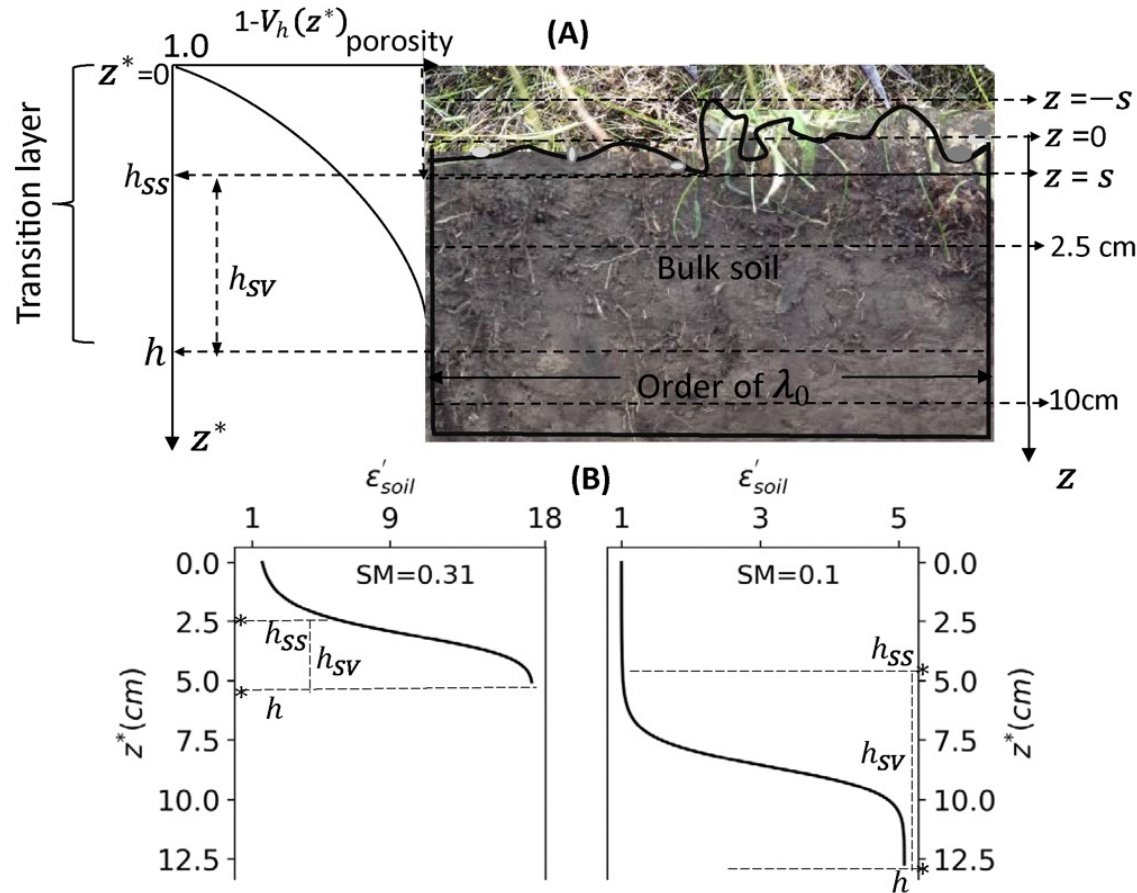
CLAP μ w - Microwave observations of land-atmosphere exchange processes (Community Land Active Passive Microwave Simulator)



(Zhao, et al. 2021 JRS, Lv et al., 2021, in review)



An Integrated Air-Plant-Soil Process Model for Modelling MW Scattering-Emission



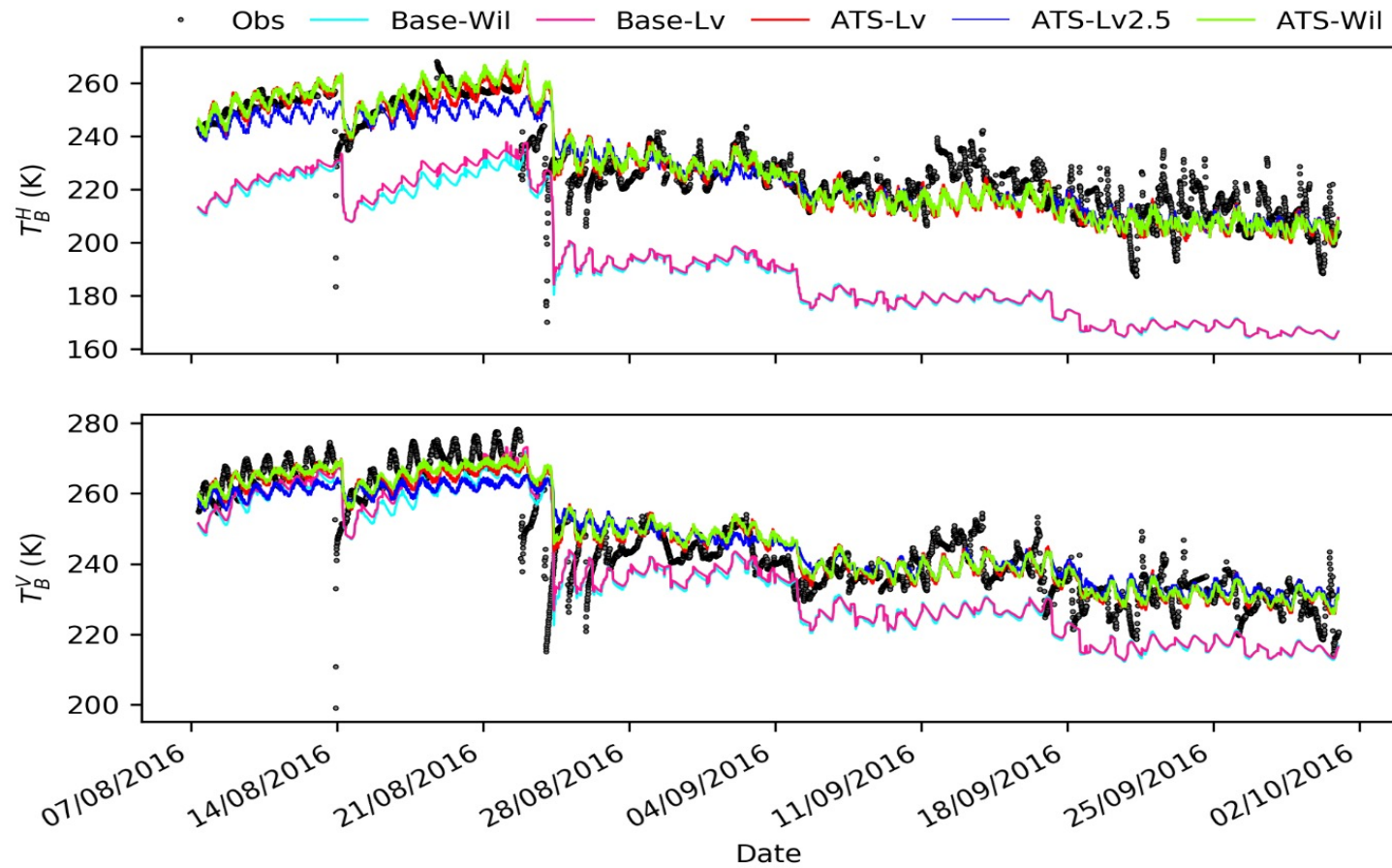
ATS-TVG-AIEM-CLM
links energy, water
& carbon processes to
EO MW P/A observables

Simulate/Retrieve
States/Parameters/Fluxes with
S-1, ROSE-L, CIMR,
SMOS/SMAP
+ASCAT

(Zheng et al., 2017, TGRS)

(Zhao et al., 2021, JRS)

Simulated T_B^p vs ELBARA-III observed T_B^p during the late-monsoon period (Base-: AIEM+TVG; ATS-: ATS+AIEM+TVG)

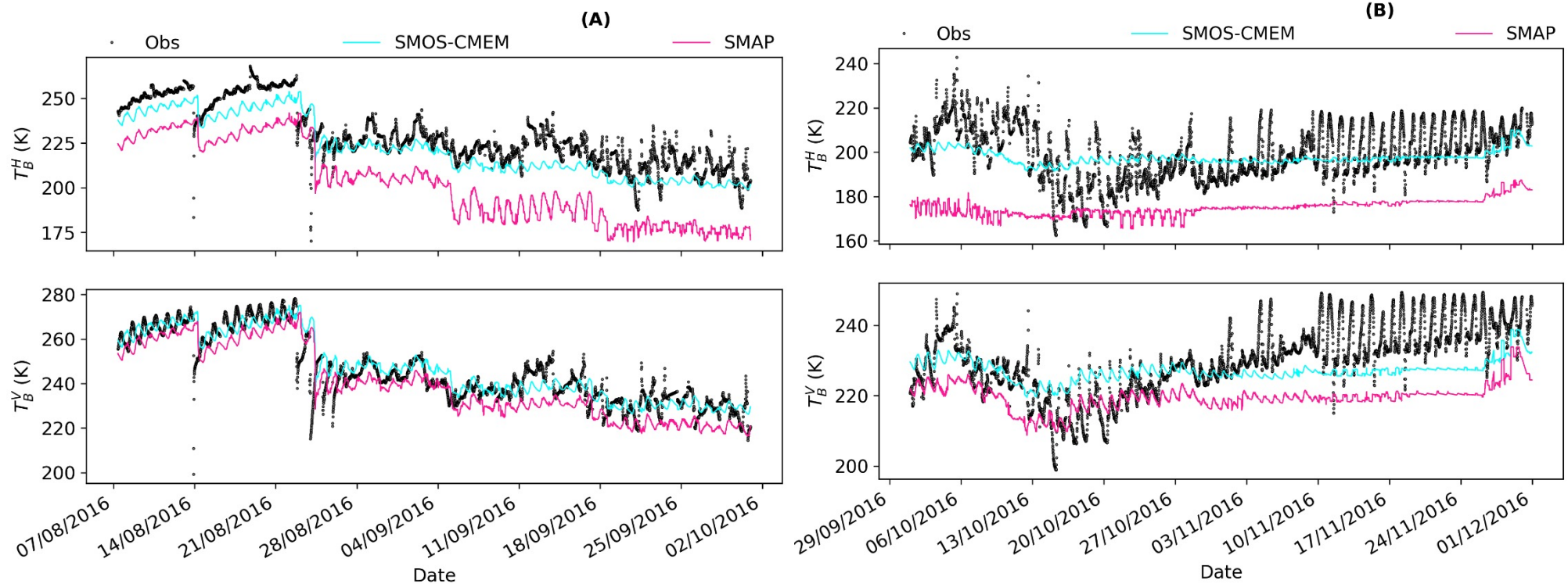


(Zhao et al., 2021, JRS)

Simulated T_B^p by the ATS-based models with fixed roughness parameters

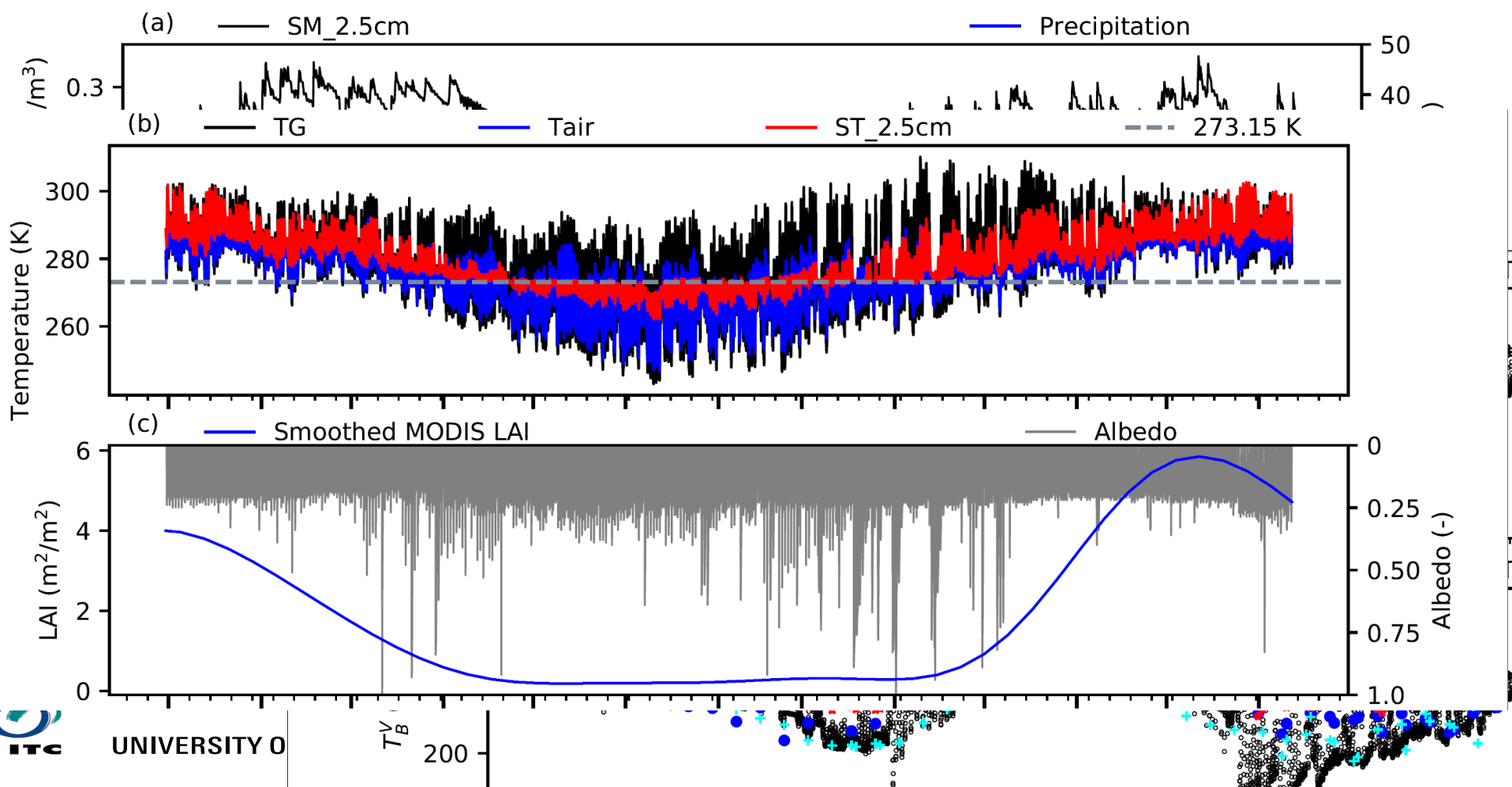
(A) late-monsoon period, (B) post-monsoon period

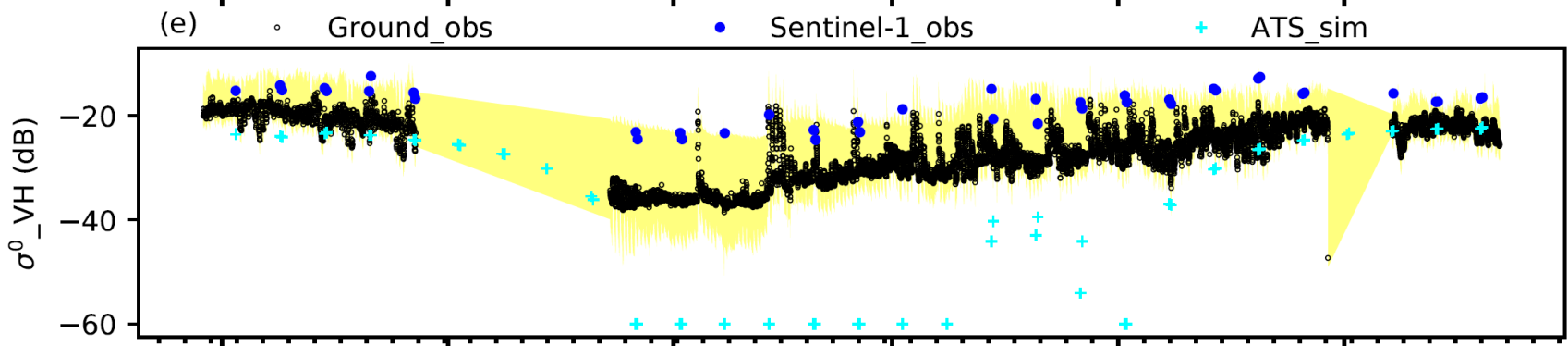
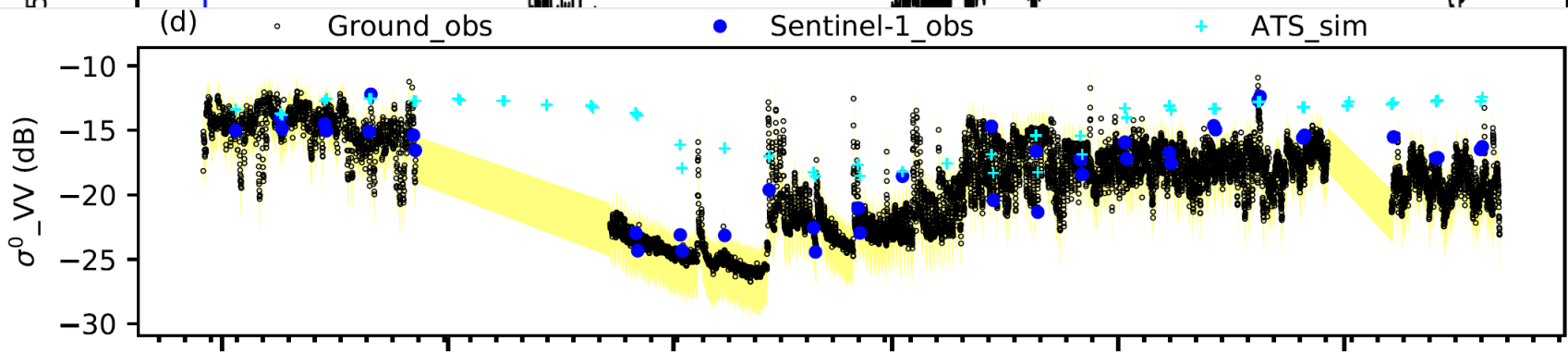
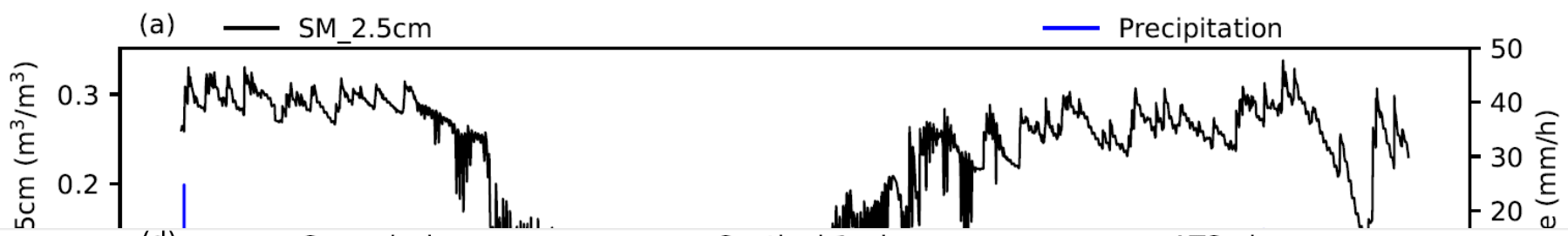
(SMOS-CMEM with $h_{SS}/h = 0.77$ and SMAP with $h_{SS}/h = 0.58$)



(Zhao et al., 2021, JRS)

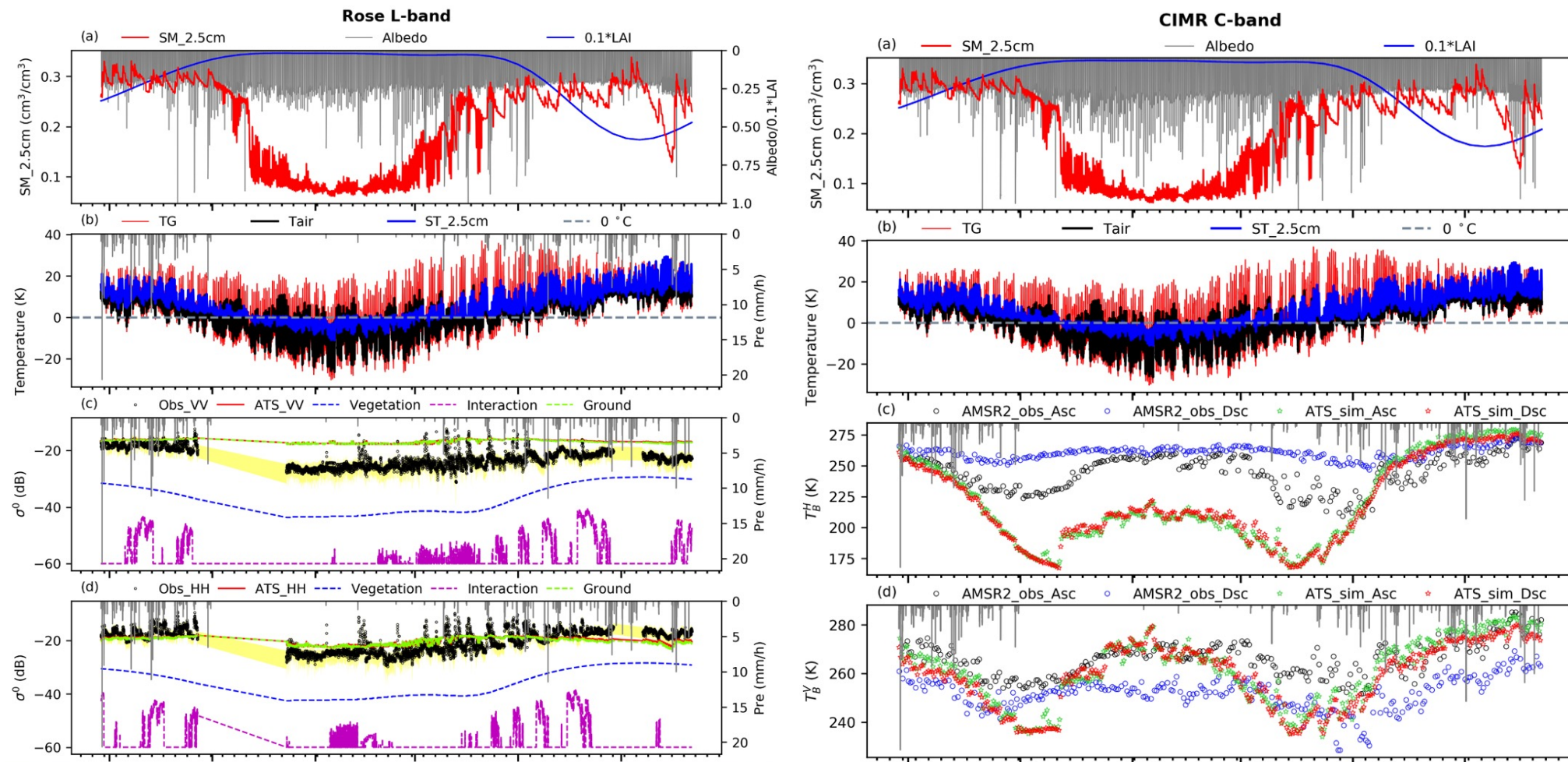
Seasonal variations of the Maqu ELBARA-III radiometry dataset (01/08/2017 - 01/08/2018)



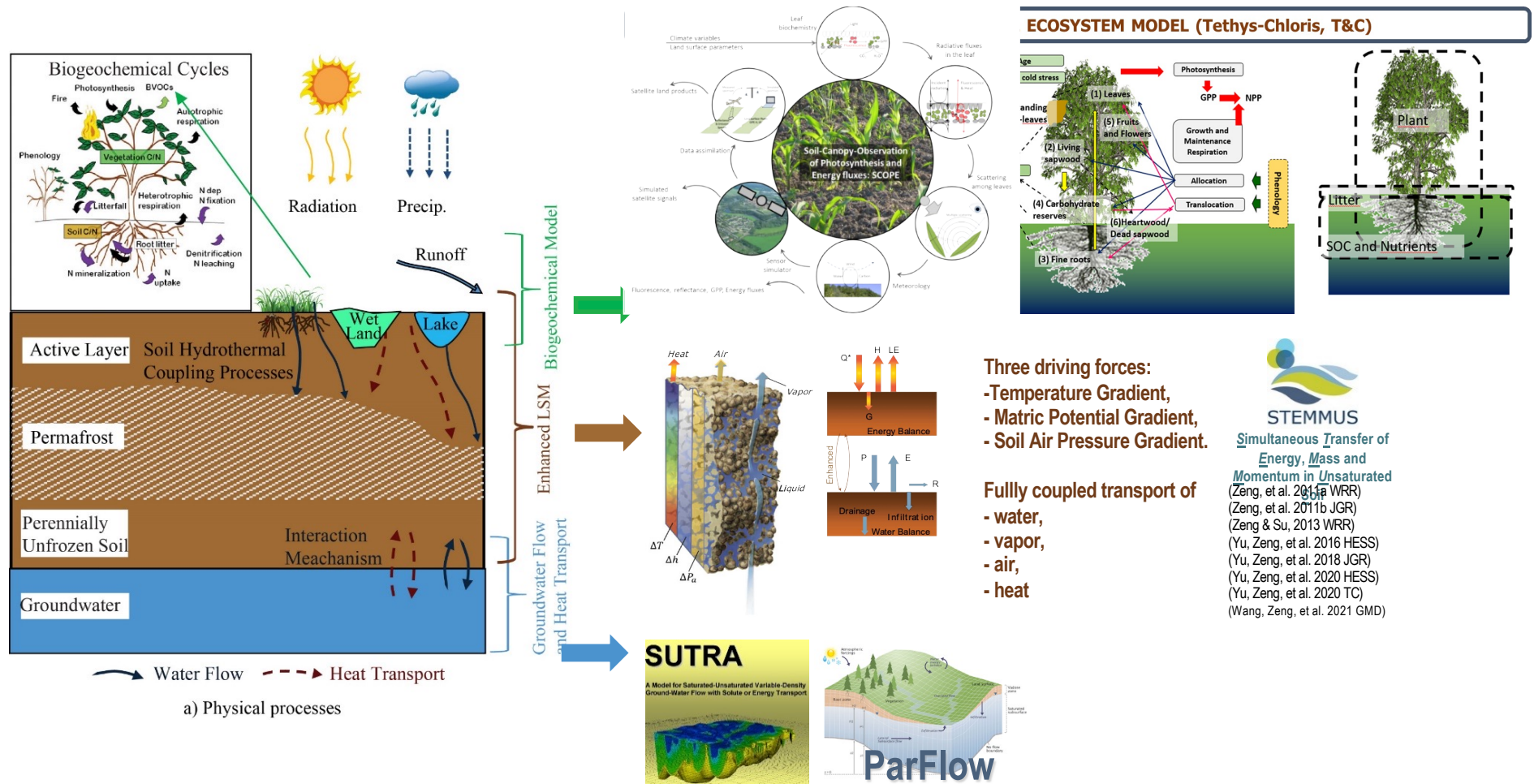


01/09/2017 01/11/2017 01/01/2018 01/03/2018 01/05/2018 01/07/2018

Observation simulation of future microwave systems



Towards a Digital Twin Earth – Water-Soil-Plant-Energy Interaction





CONCLUSIONS & OUTLOOK

- Process understanding based on measurements is of primary importance in modeling land-atmosphere exchanges
- Rooting satellite observations in land-atmosphere exchange processes by considering plant hydraulics in water-soil-plant-atmosphere system enables links of energy, water and carbon processes
- Our ability to directly use EO observables is fundamental to explore full potential of EO data
- Success of **Digital Twin Earth** must consider **Observation Operator & Dynamic Process Exchanges**
- **These are all of essential importance for climate change, water and food security and achieving carbon neutrality**

