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Land-Atmosphere Interactions on the Tibetan Plateau - In-situ Observation, Remote Sensing and Modeling

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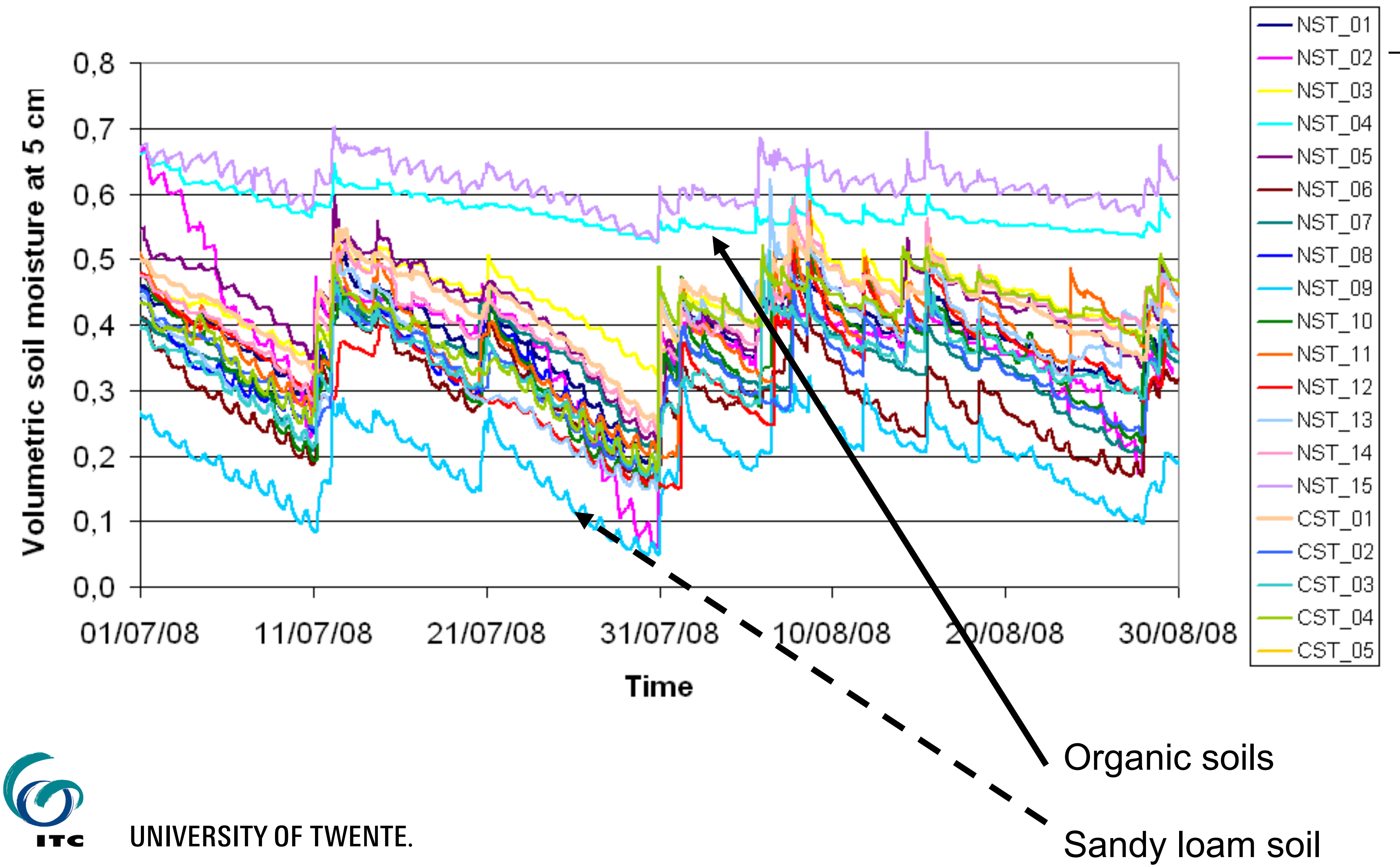
ITC GEO Soil Moisture Soil Temperature Networks

Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs)

ESA Dragon programme
EU FP7 CEOP-AEGIS project
SMOS/SMAP Cal/Val

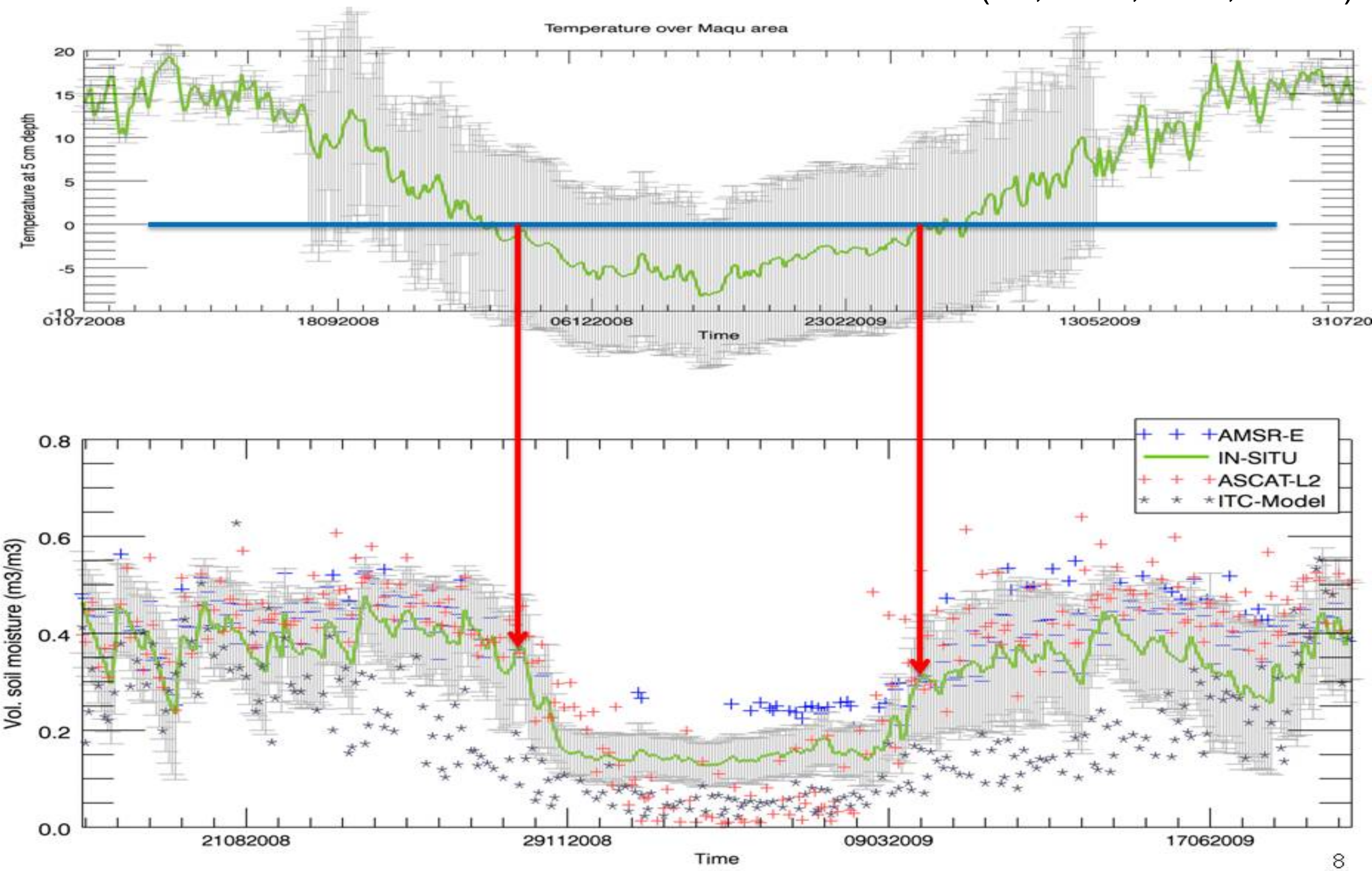
(Su et al. 2011, HESS)

Maqu: Soil moisture at 5 cm depth



Validation - Quantification of uncertainties

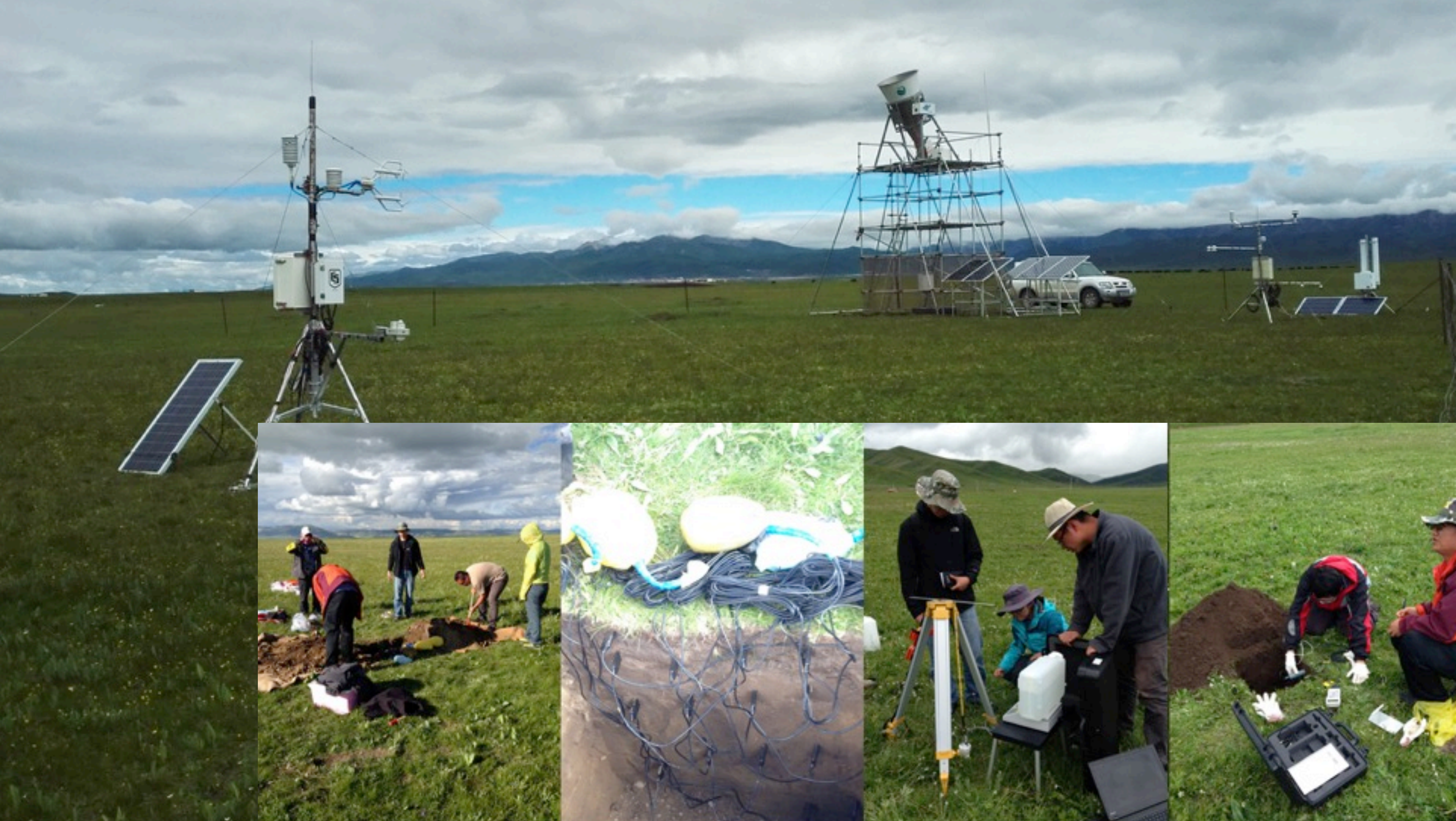
(Su, et al., 2011, HESS)



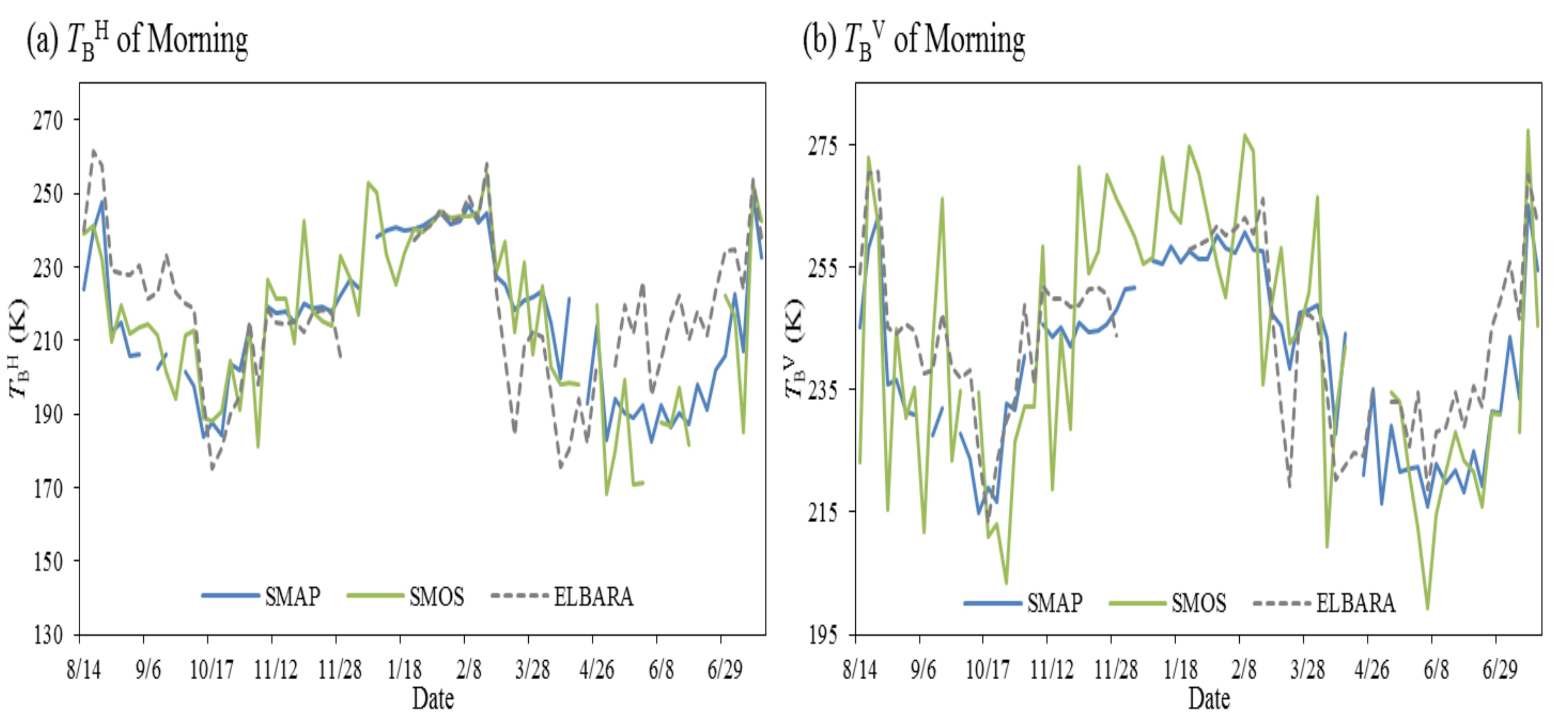
Nederlandse Organisatie voor Wetenschappelijk Onderzoek

European Space Agency

How good is the satellite signal? (Tb)
How good is the satellite retrieval? (SM)
What is the spatial-temporal representativeness? (Pixel scale?)

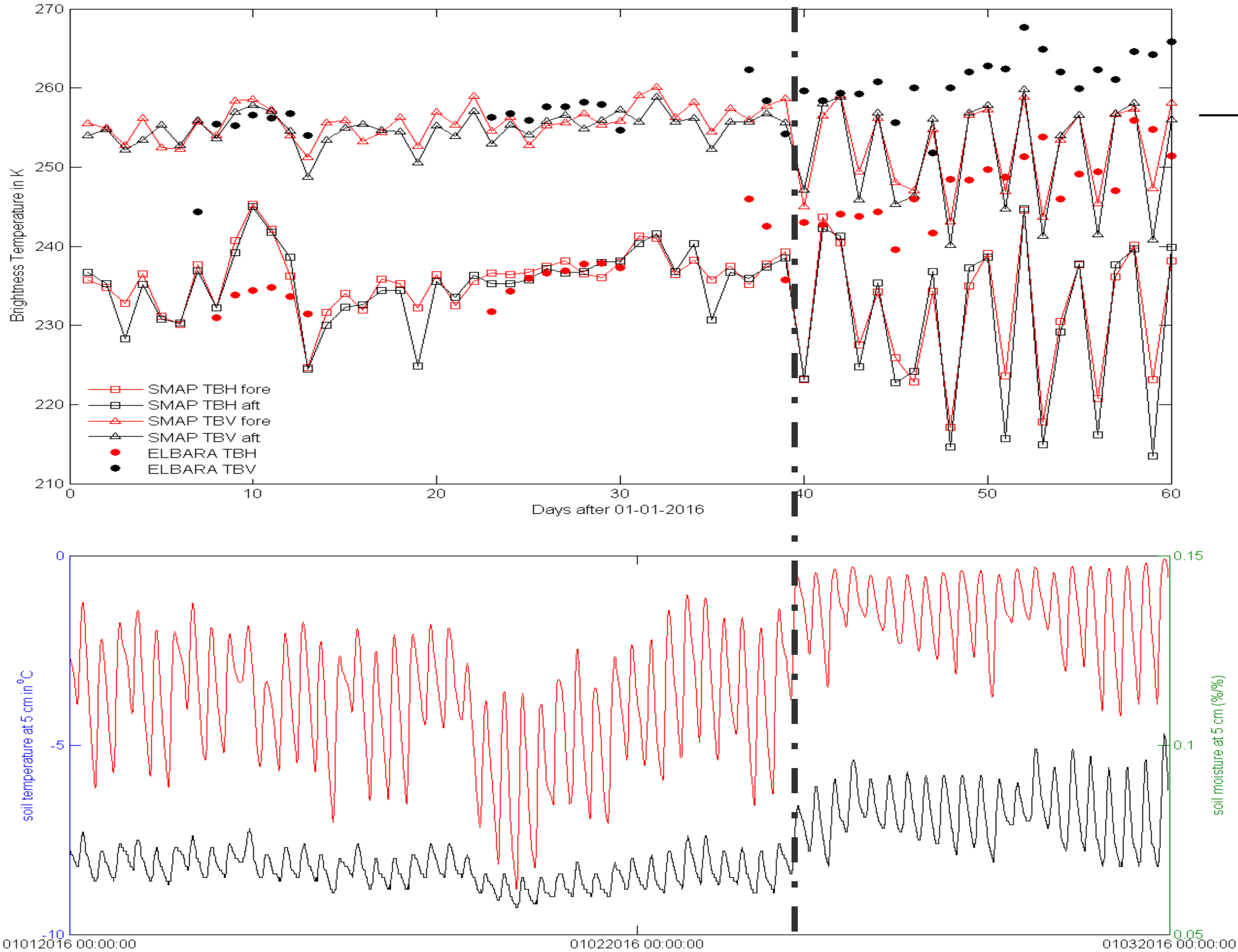


HOW GOOD IS THE SATELLITE SIGNAL? (TB)



Comparisons of SMAP, SMOS and ELBARA-III measured T_B^H and T_B^V during morning overpasses - Aug. 2016 and July 2017.

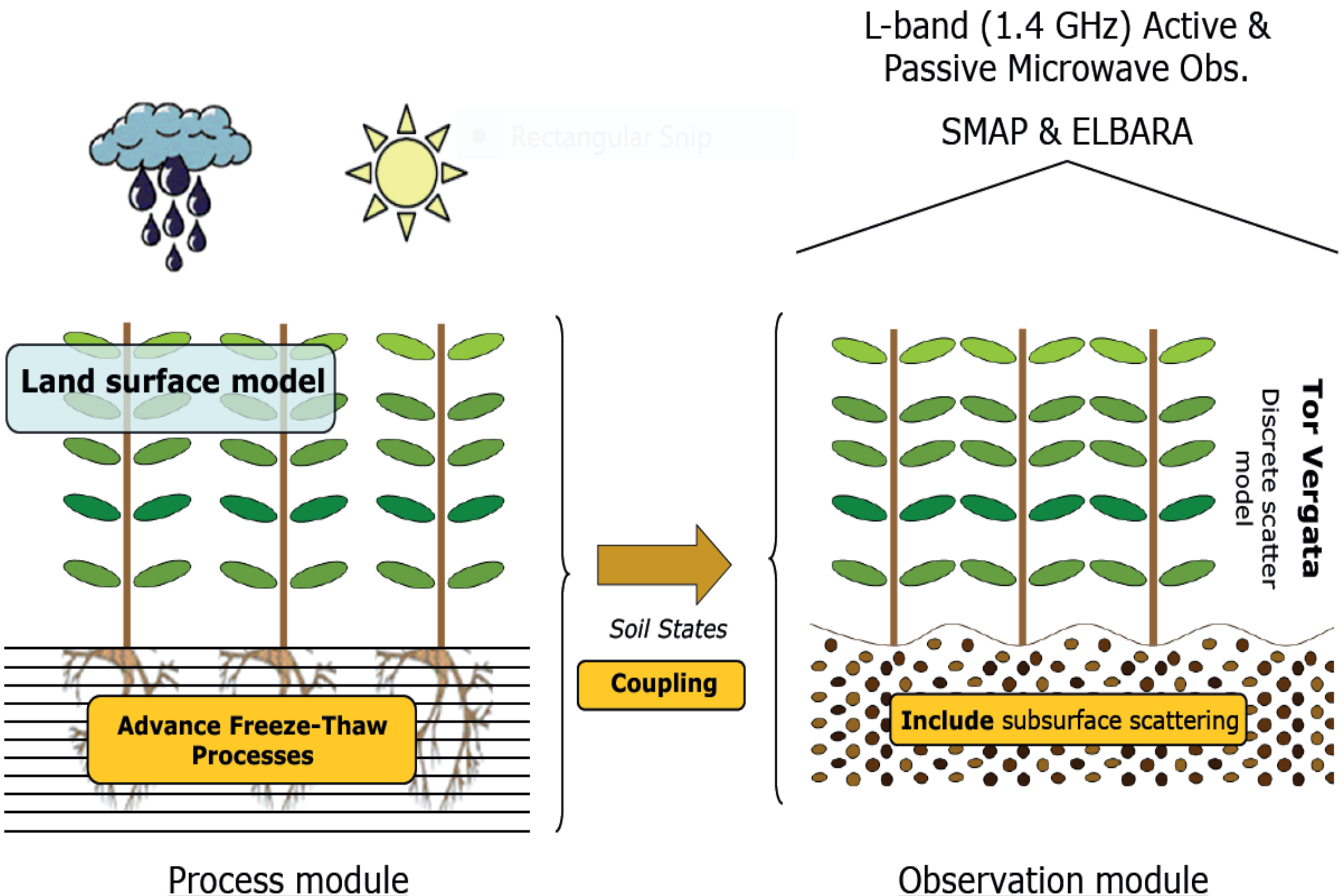
Why does SMAP underestimate ELBARA Tb?



DOY 1:
01-01-2016

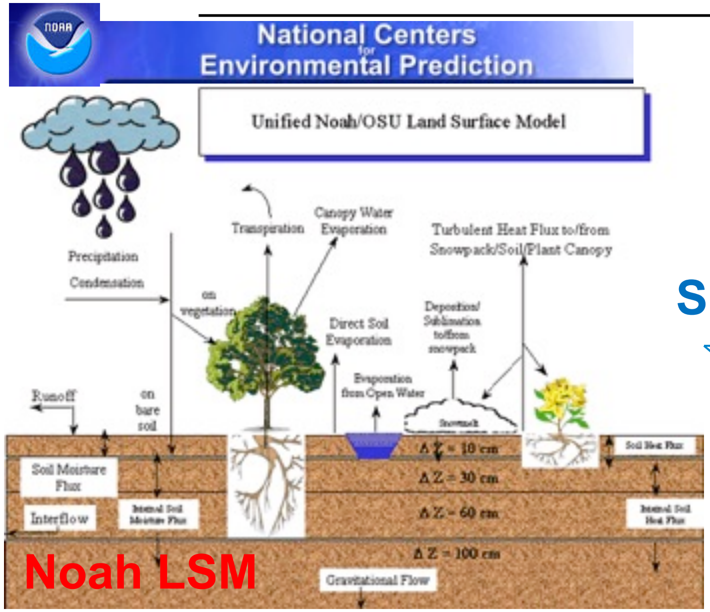
DOY 40:
10-02-2016

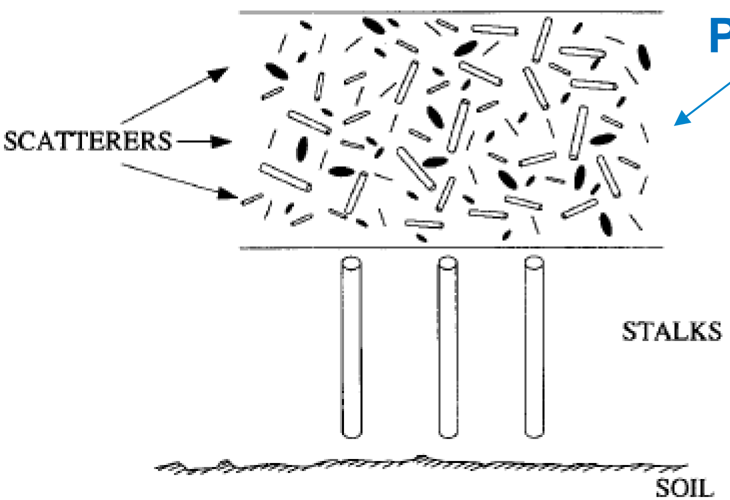
DOY 60:
29-02-2016



5. Coherent process modeling and radiative transfer modelling

Noah-Tor Vergata OSSE (Observation Opearator)





Tor Vergata RT

Surface SMST

SMST Profiles

Permittivity

Four Phase Dielectric Mixing Model

$$\varepsilon^{\eta} = (\theta_s - \theta)\varepsilon_{air}^{\eta} + \theta_{liq}\varepsilon_{w}^{\eta} + (\theta - \theta_{liq})\varepsilon_{ice}^{\eta} + (1 - \theta_s)\varepsilon_{matrix}^{\eta}$$

Effective Temperature

$$T_{eff} = \int_0^{\infty} T_s(z)\alpha(z)\exp\left[-\int_0^{z}\alpha(z')dz'\right]dz$$

Emissivity

Brightness Temperature

(Zheng et al., 2017, TGRS)
(Lv et al., 2014, 2016, RSE, 2016, 2018, RS)

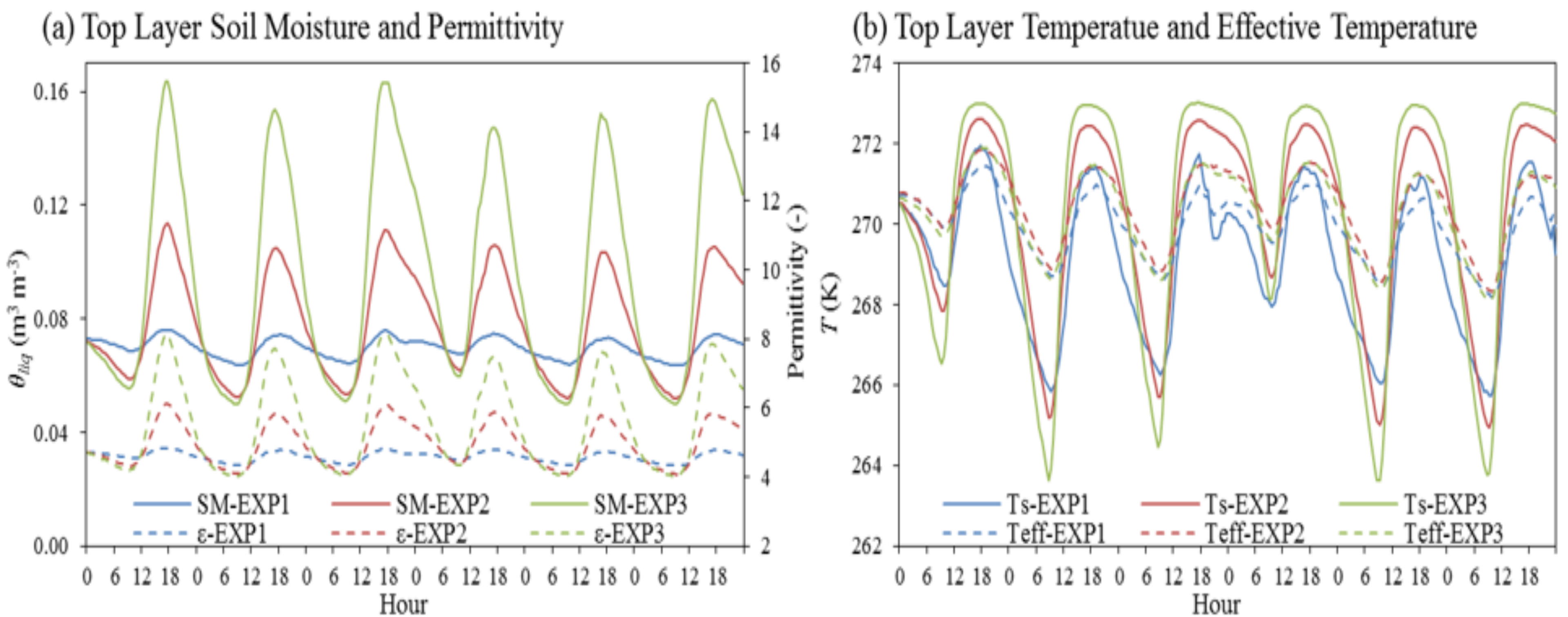
Noah-Tor Vergata Simulations

Frozen Period: DOY 1-6

EXP1: SMST in situ measurements at 5 cm

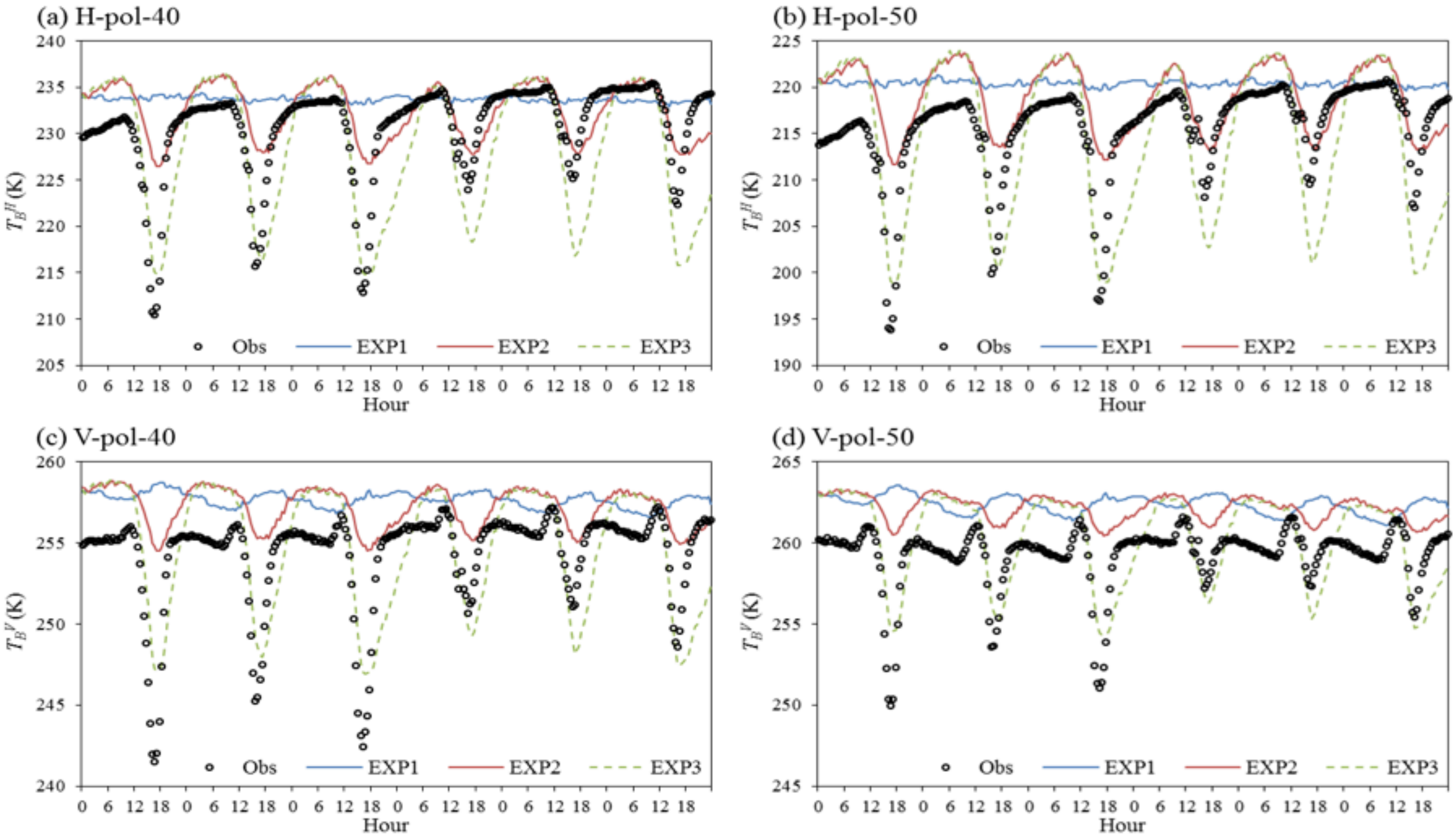
EXP2: SMST Noah 4-layer (0.1, 0.4, 1.0, 2.0) midpoint of top layer at 5 cm

EXP3: SMST Noah 5-layer (0.05, 0.1, 0.4, 1.0, 2.0) midpoint of top layer at 2.5 cm



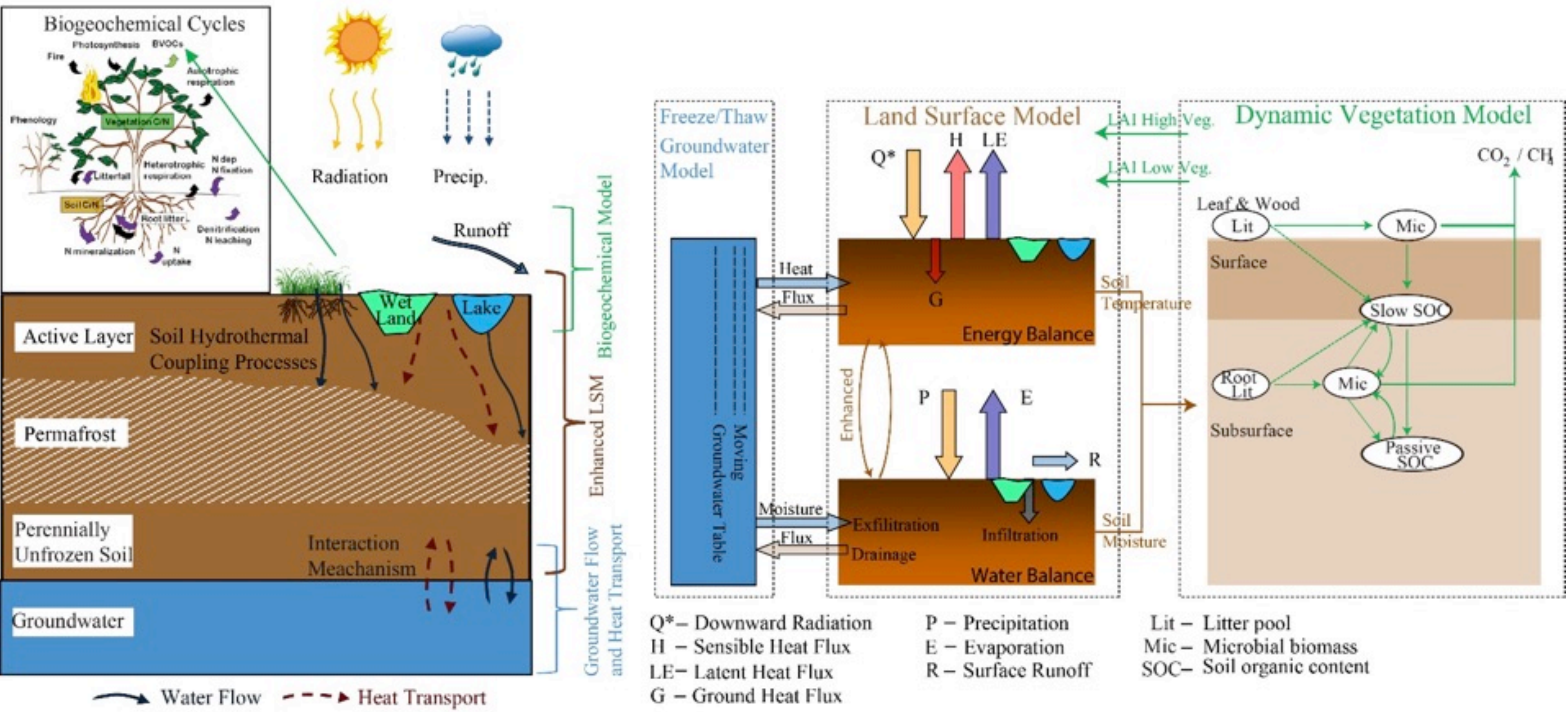
(Zheng et al., 2017, TGRS)

Noah-Tor Vergata Simulations



TB signature of diurnal soil freeze/thaw cycle is more sensitive to the liquid water content of soil surface layer than in situ measurements at 5 cm depth

STEMMUS - Simultaneous Transfer of Energy, Momentum and Mass In Unsaturated Soil



a) Physical processes

b) Coupling processes

http://blogs.itc.nl/stemmus/

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STEMMUS-FT (Freezing/Thawing) model

Soil Water Phase Change

Soil Water Transport

$$\frac{\partial}{\partial t}(\rho_L\theta_L + \rho_V\theta_V + \rho_i\theta_i) =$$

$$\rho_L \frac{\partial}{\partial z}[K(\frac{\partial h}{\partial z} + 1) + D_{TD}\frac{\partial T}{\partial z} + \frac{K}{\gamma_w}\frac{\partial P_g}{\partial z}] + \frac{\partial}{\partial z}[D_{vh}\frac{\partial h}{\partial z} + D_{vT}\frac{\partial T}{\partial z} + D_{va}\frac{\partial P_g}{\partial z}] - S$$

Soil Heat Transport

$$\frac{\partial}{\partial t}[(\rho_s\theta_s C_s + \rho_L\theta_L C_L + \rho_V\theta_V C_V)(T - T_r) + \rho_V\theta_V L_0 - \rho_i\theta_i L_f] - \rho_L W\frac{\partial \theta_L}{\partial t}$$

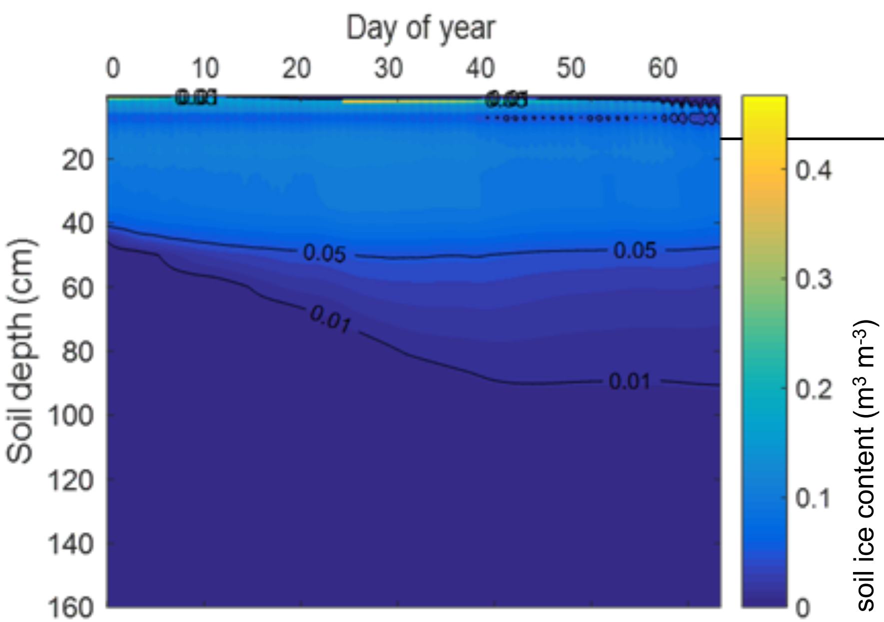
$$= \frac{\partial}{\partial z}(\lambda_{eff}\frac{\partial T}{\partial z}) - \frac{\partial q_L}{\partial z}C_L(T - T_r) - \frac{\partial q_V}{\partial z}[L_0 + C_V(T - T_r)] - C_L S(T - T_r)$$

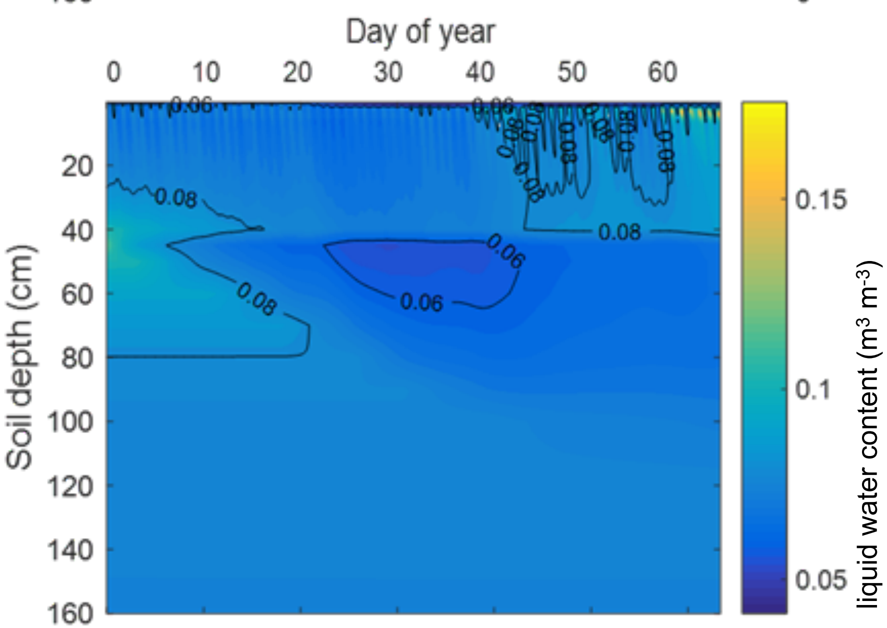
Soil Dry air Transport

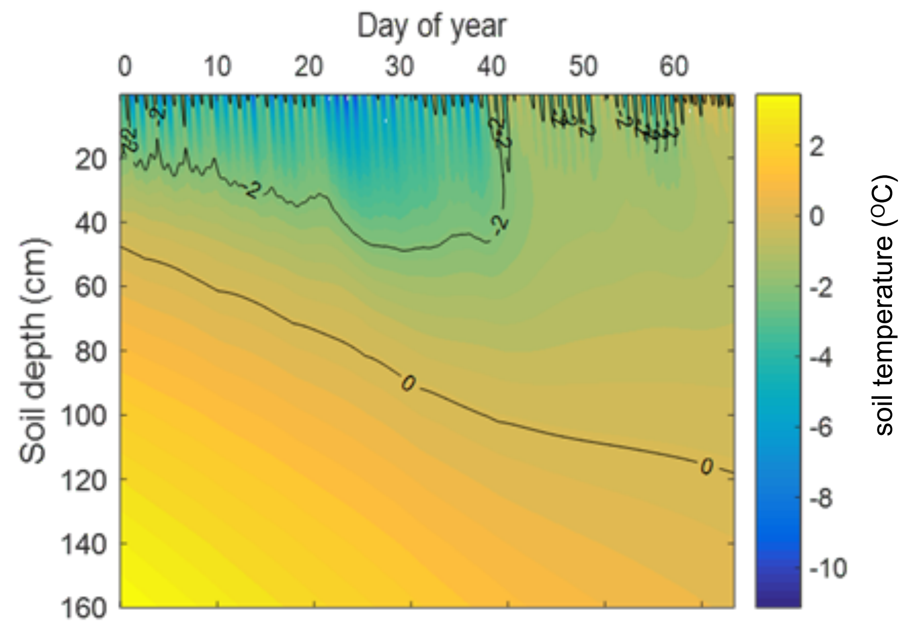
$$\frac{\partial}{\partial t}[\varepsilon\rho_{da}(S_a + H_c S_L)] = \frac{\partial}{\partial t}[D_e\frac{\partial \rho_{da}}{\partial z} + \rho_{da}\frac{S_a K_g}{\mu_a}\frac{\partial P_g}{\partial z} - H_c\rho_{da}\frac{q_L}{\rho_L} + (\theta_a D_{Vg})\frac{\partial \rho_{da}}{\partial z}]$$

(Zeng et al., 2011 JGR,
Zeng et al., 2011 WRR,
Yu et al., 2016, HESS, 2018, JGR)

STEMMUS-FT
Profile of ice, liquid water and temperature

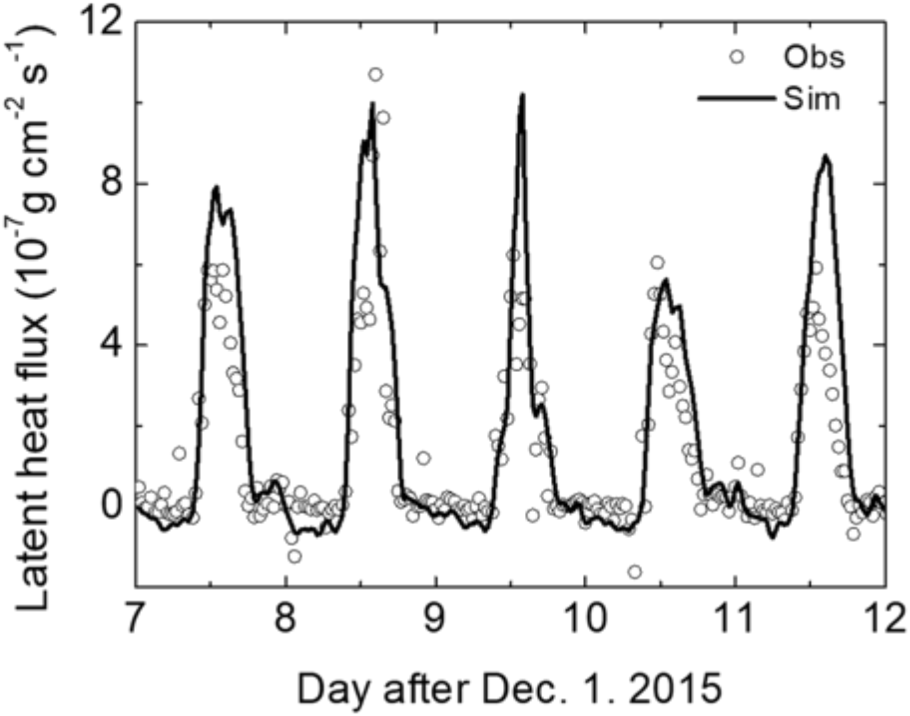




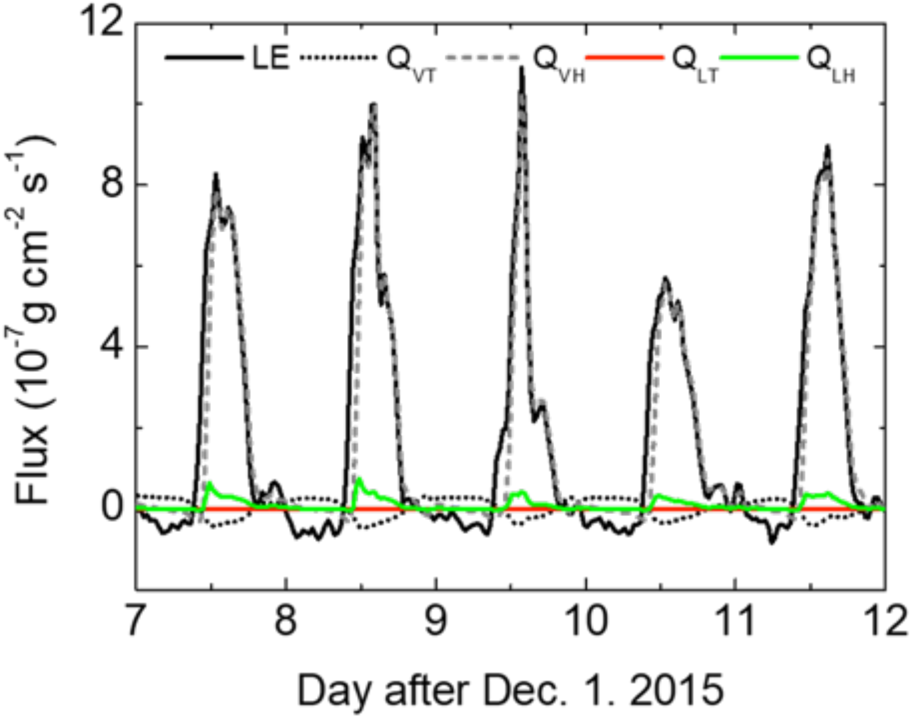


Freezing front increase along with the zero isotherm

Soil liquid water content behave differently



(a)Latent heat flux



(b) Surface (0.1cm) thermal/isothermal liquid and vapor flux

CONCLUSIONS

- Process understanding based on measurements and modeling is of primary importance:
  - ➢ Cal/Val needed to assure the stability and truthiness of observations and retrievals
  - ➢ Spatial scaling remains a challenge – could Sentinel data help?
  - ➢ Modeling and DA remains indispensable in understanding and efficient use of observations and retrievals