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Calibration and Validation Methodologies for SMOS/SMAP

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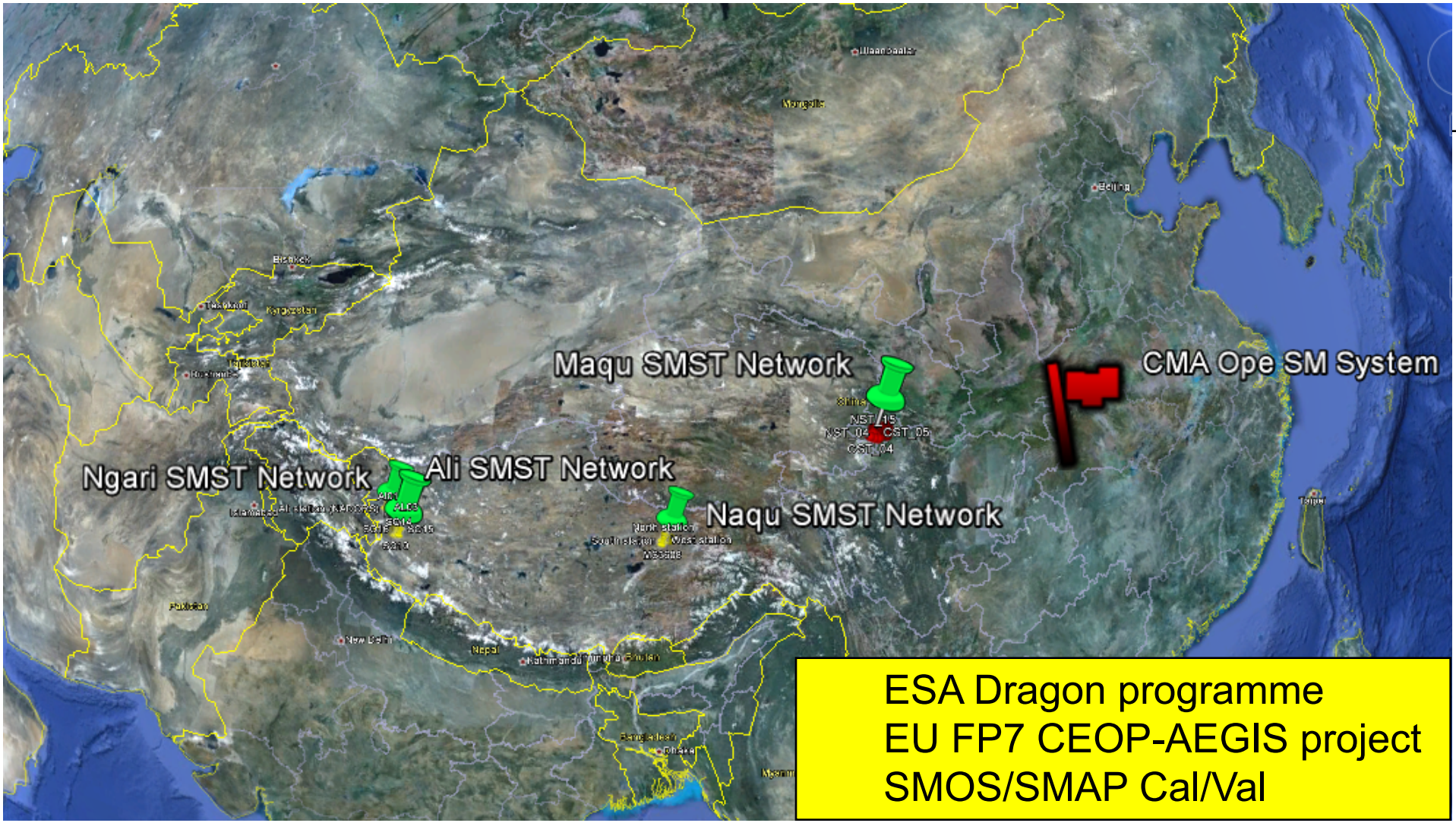
ITC GEO Soil Moisture Soil Temperature Networks

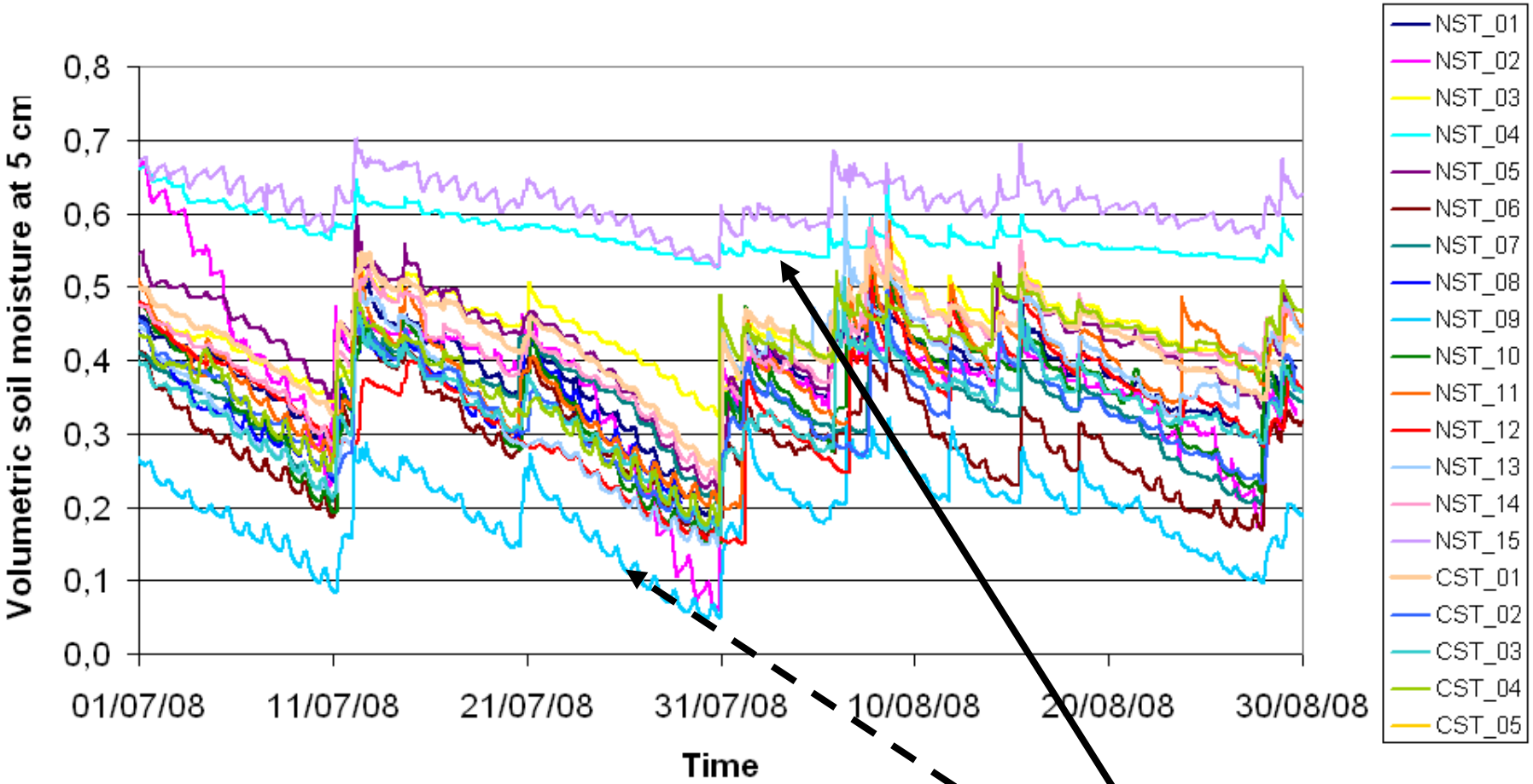
Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs)



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

(Su et al. 2011, HESS)

Maqu: Soil moisture at 5 cm depth

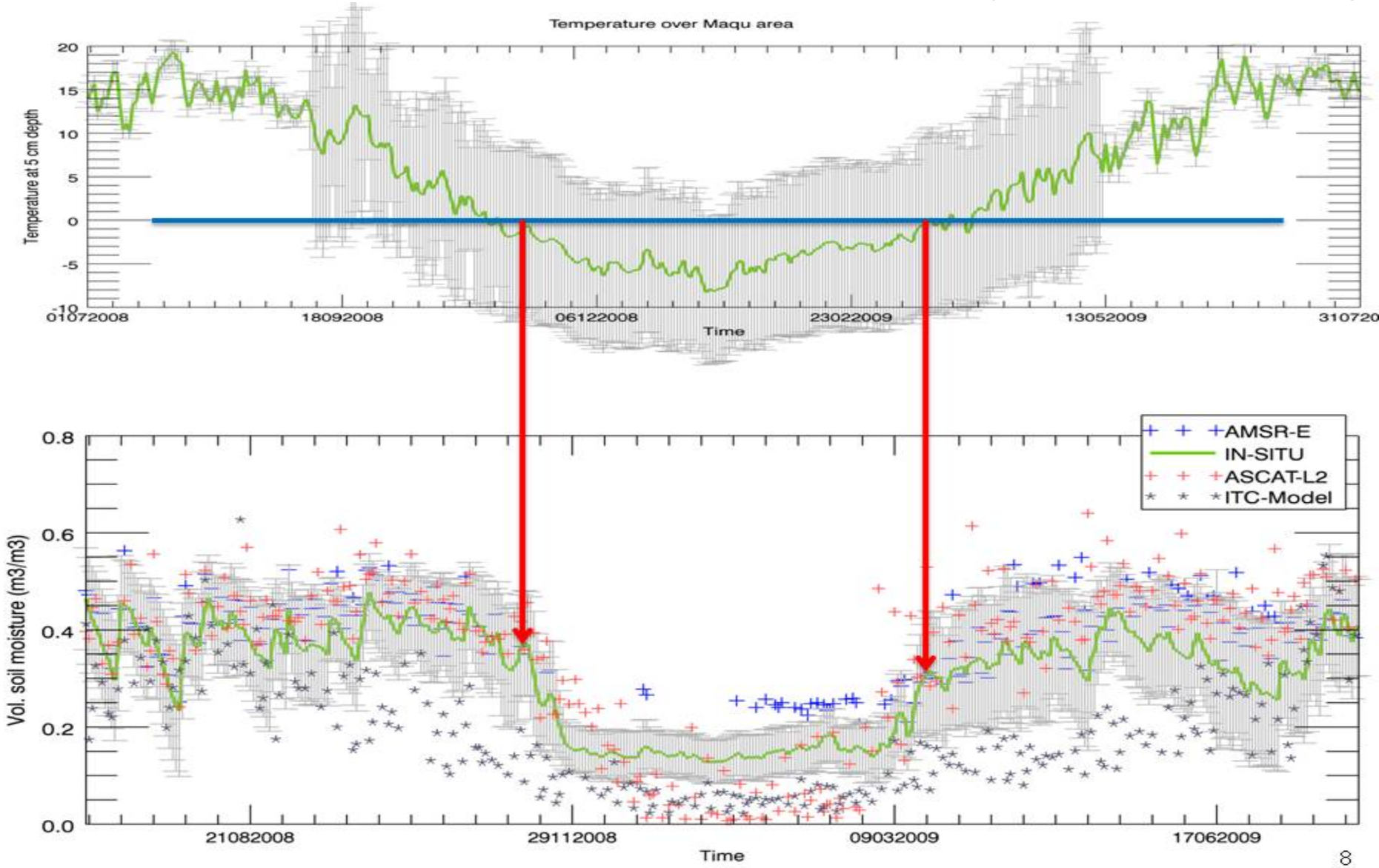


Organic soils

Sandy loam soil

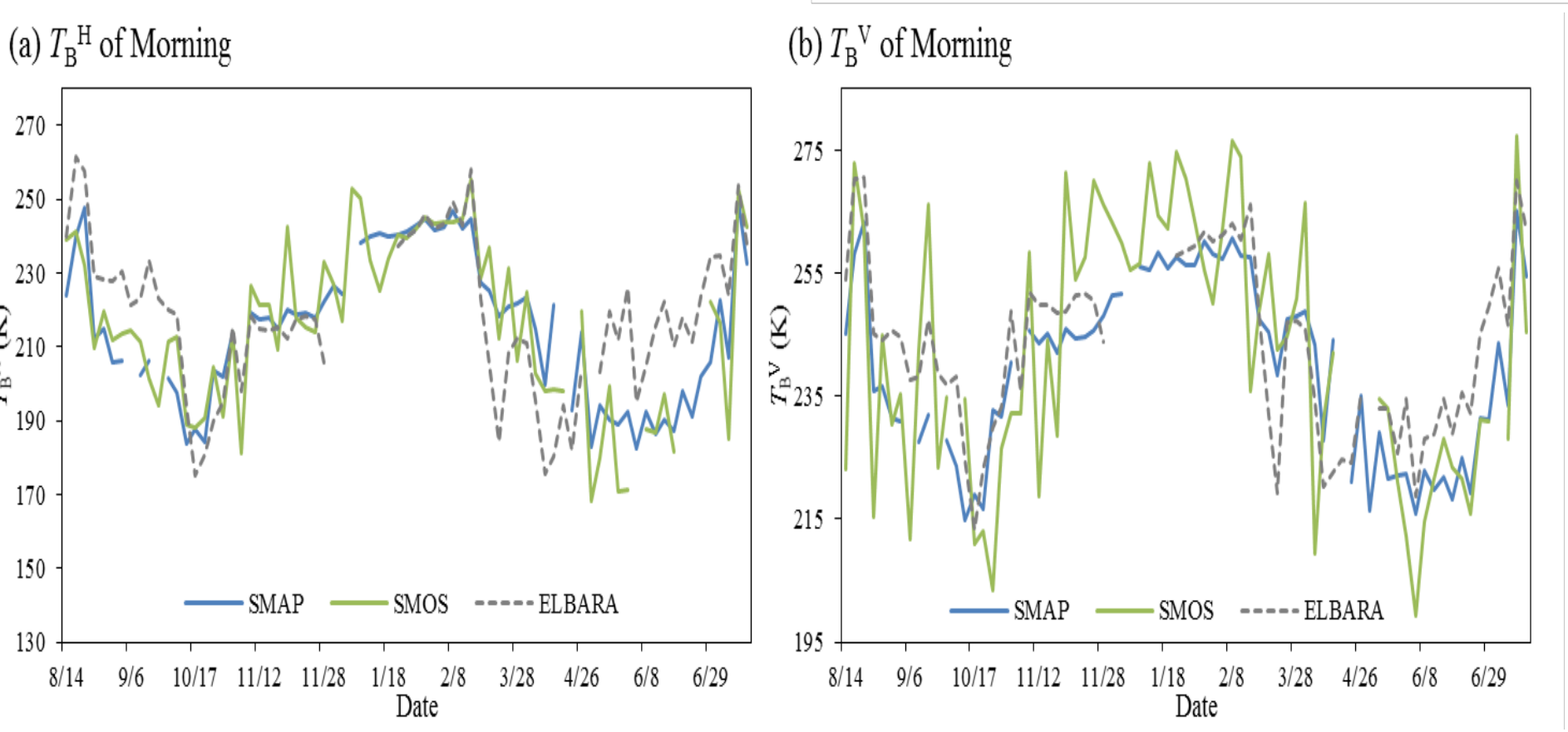
Validation - Quantification of uncertainties

(Su, et al., 2011, HESS)



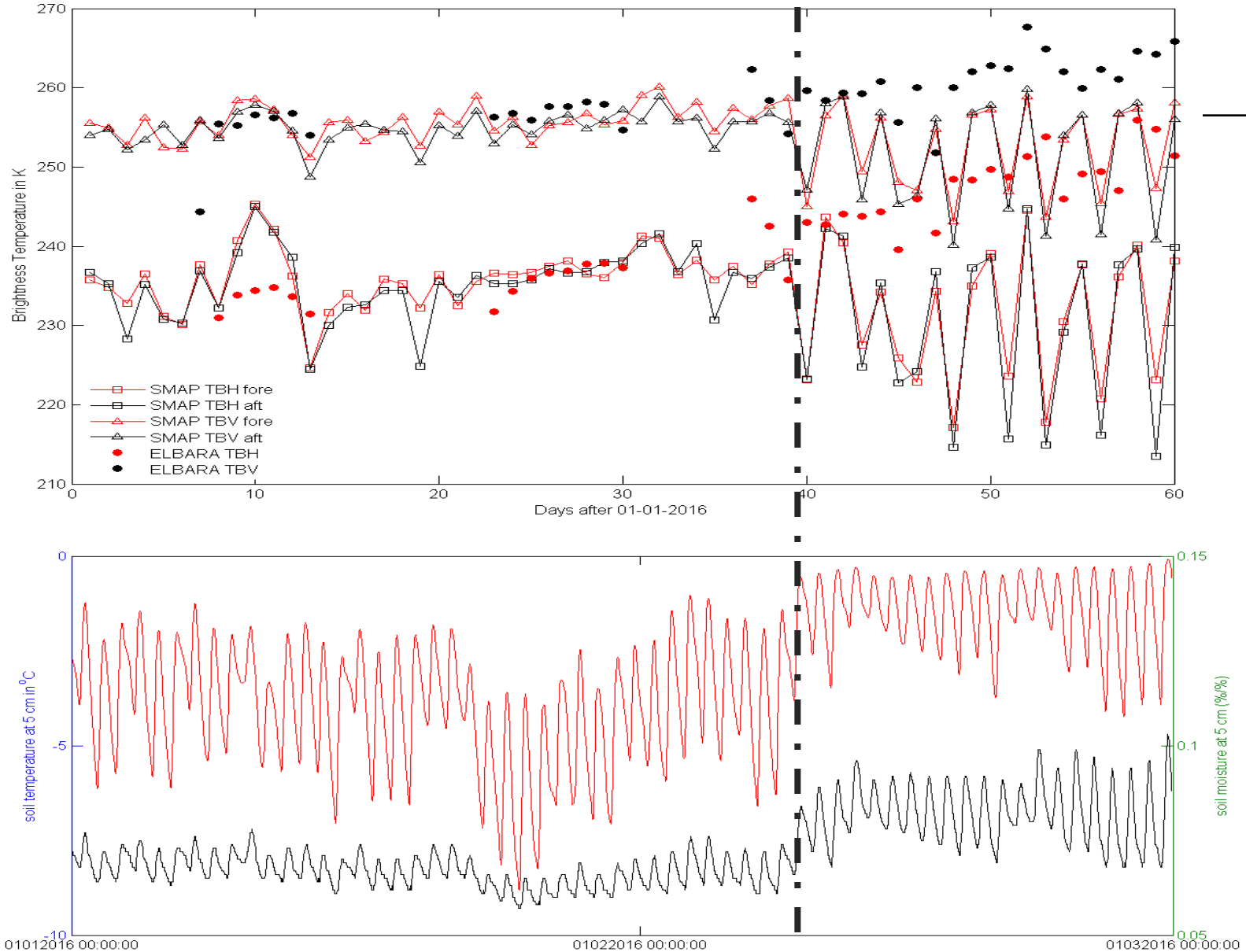
How good is the satellite signal? (Tb)
How good is the satellite retrieval? (SM)
What is the spatial-temporal representativeness? (Pixel scale?)

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.

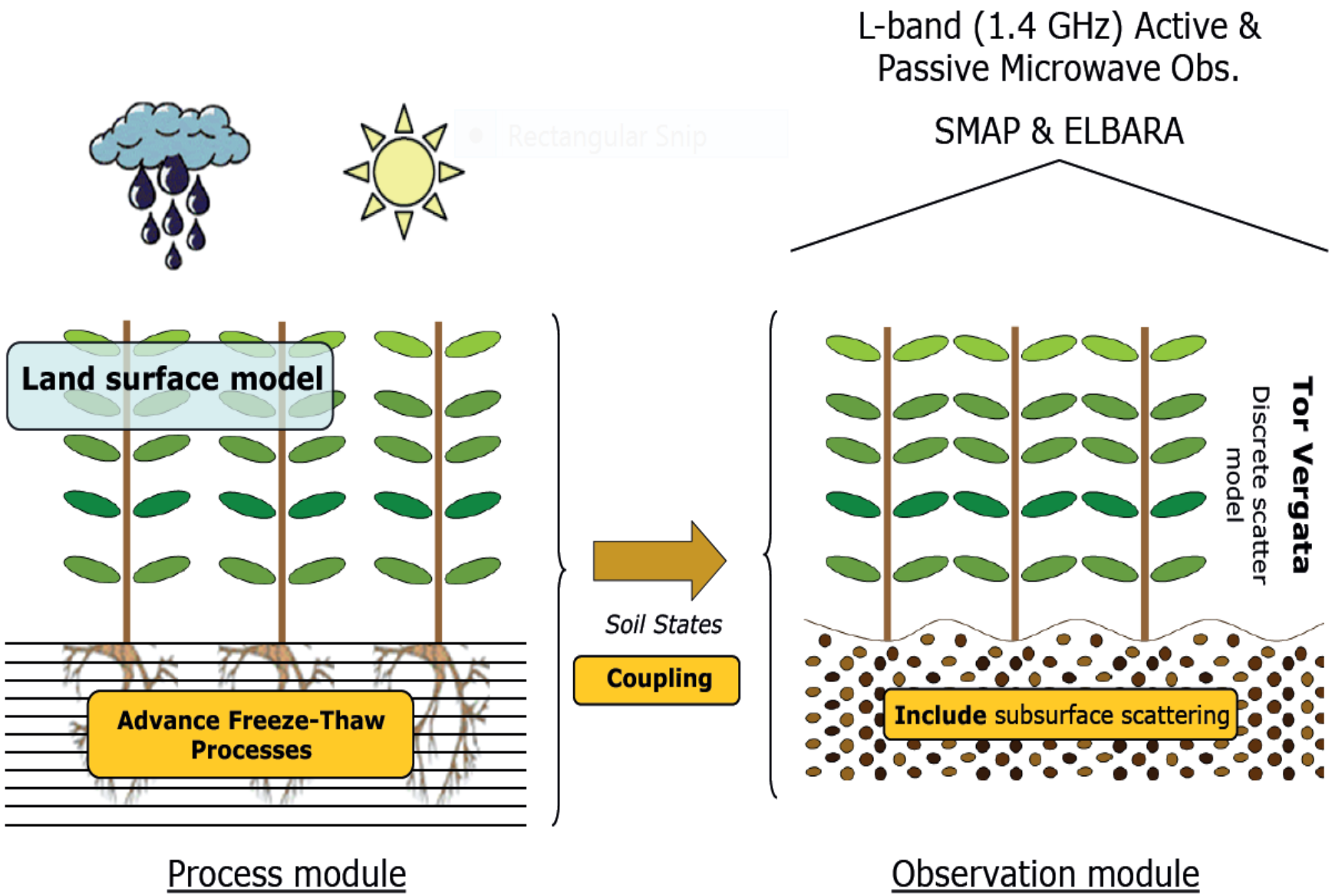
Why does SMAP underestimate ELBARA Tb?



DOY 1:
01-01-2016

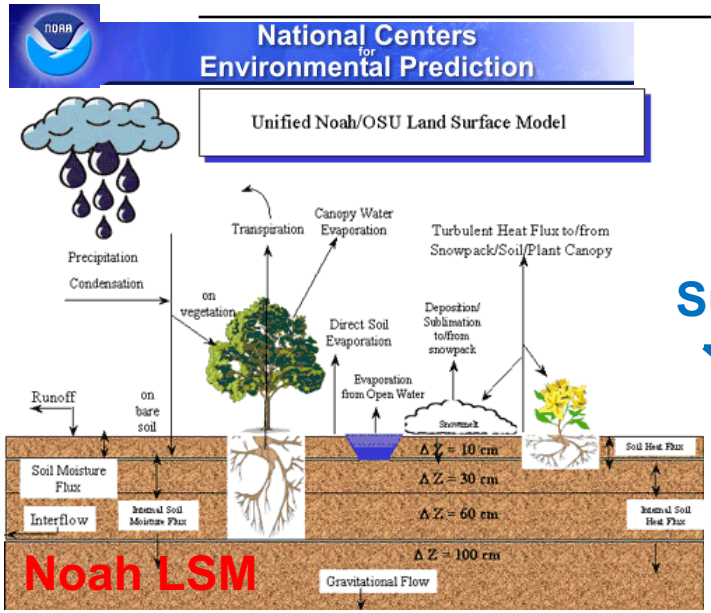
DOY 40:
10-02-2016

DOY 60:
29-02-2016



5. Coherent process modeling and radiative transfer modelling

Noah-Tor Vergata OSSE (Observation Opearator)



Surface SMST

Four Phase Dielectric Mixing Model

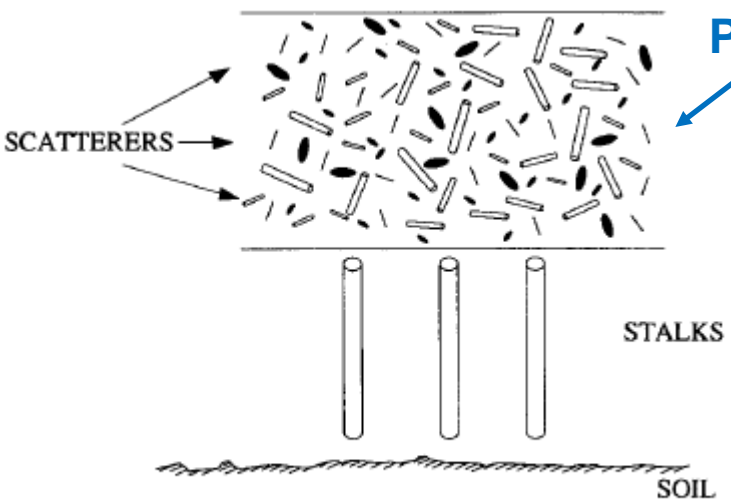
$$\varepsilon^{\eta} = (\theta_s - \theta)\varepsilon^{\eta}_{air} + \theta_{liq}\varepsilon^{\eta}_{w} + (\theta - \theta_{liq})\varepsilon^{\eta}_{ice} + (1-\theta_s)\varepsilon^{\eta}_{matrix}$$

SMST Profiles

Effective Temperature

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

Permittivity



Emissivity

Brightness Temperature

(Zheng et al., 2017, TGRS)

Tor Vergata RT

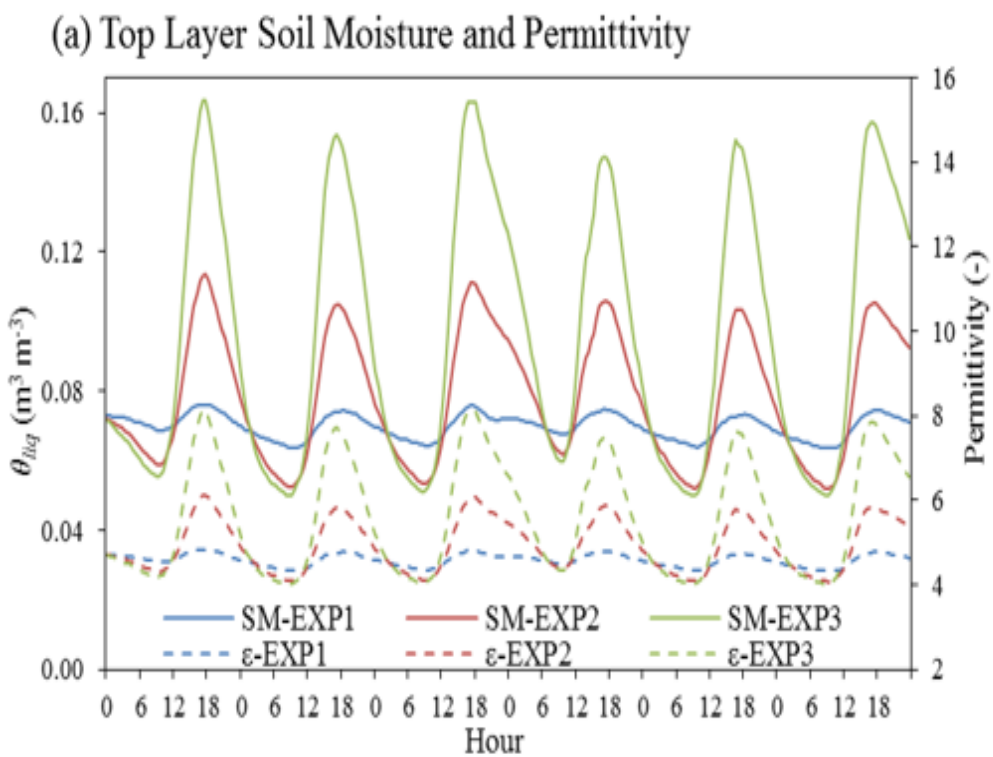
Noah-Tor Vergata Simulations

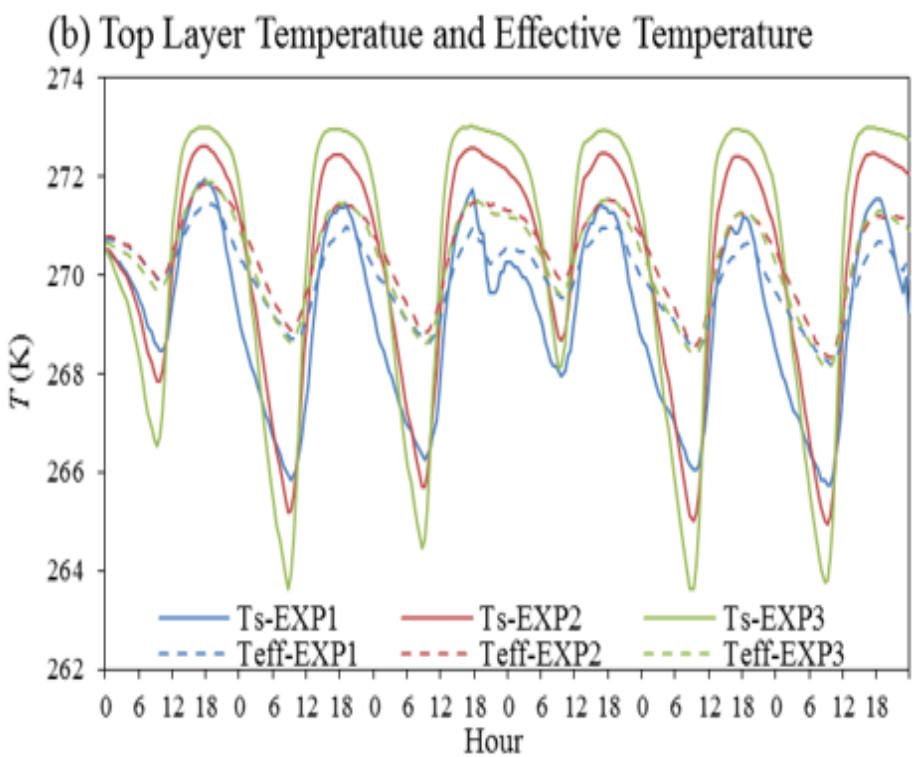
Frozen Period: DOY 1-6

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





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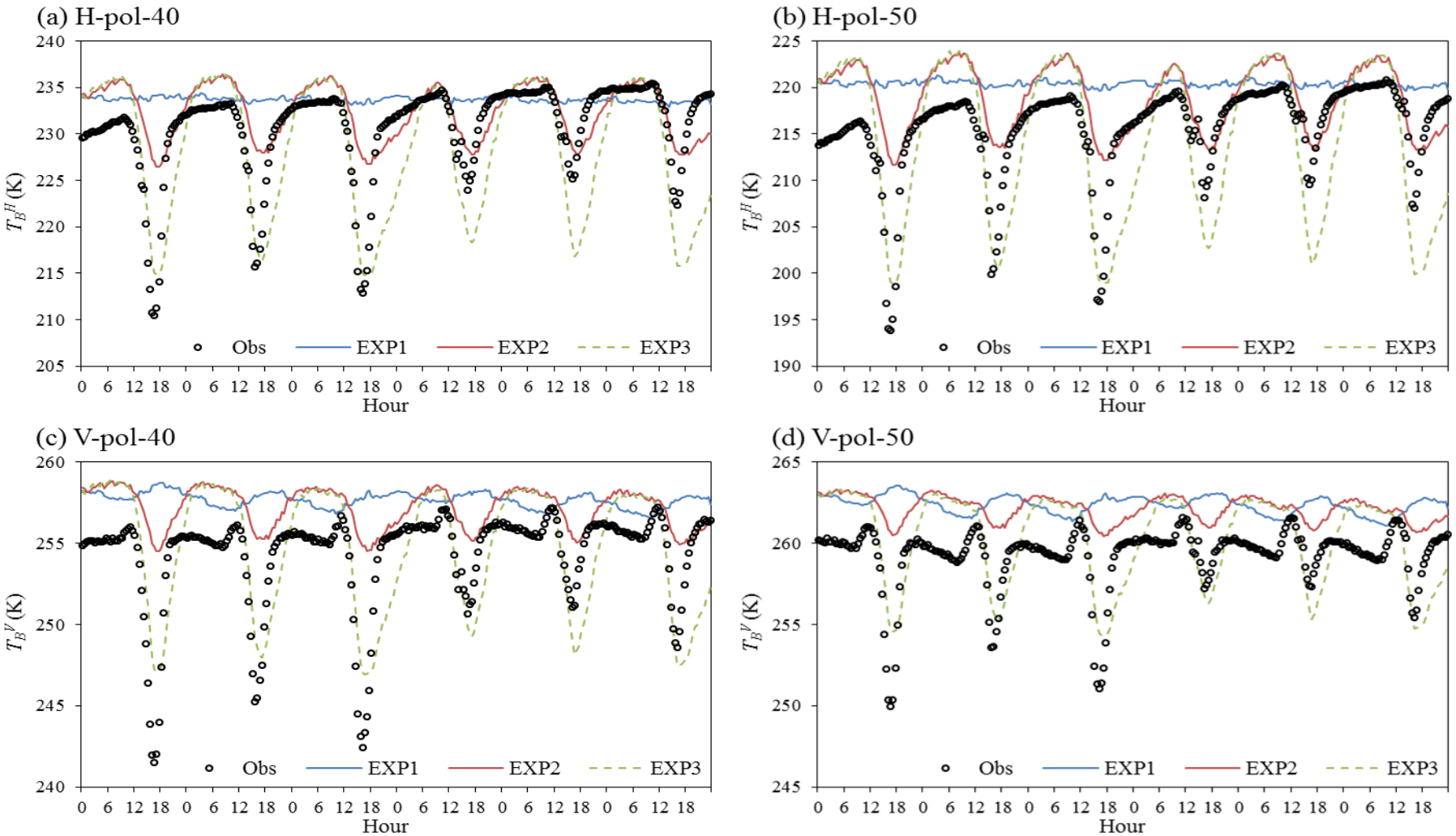
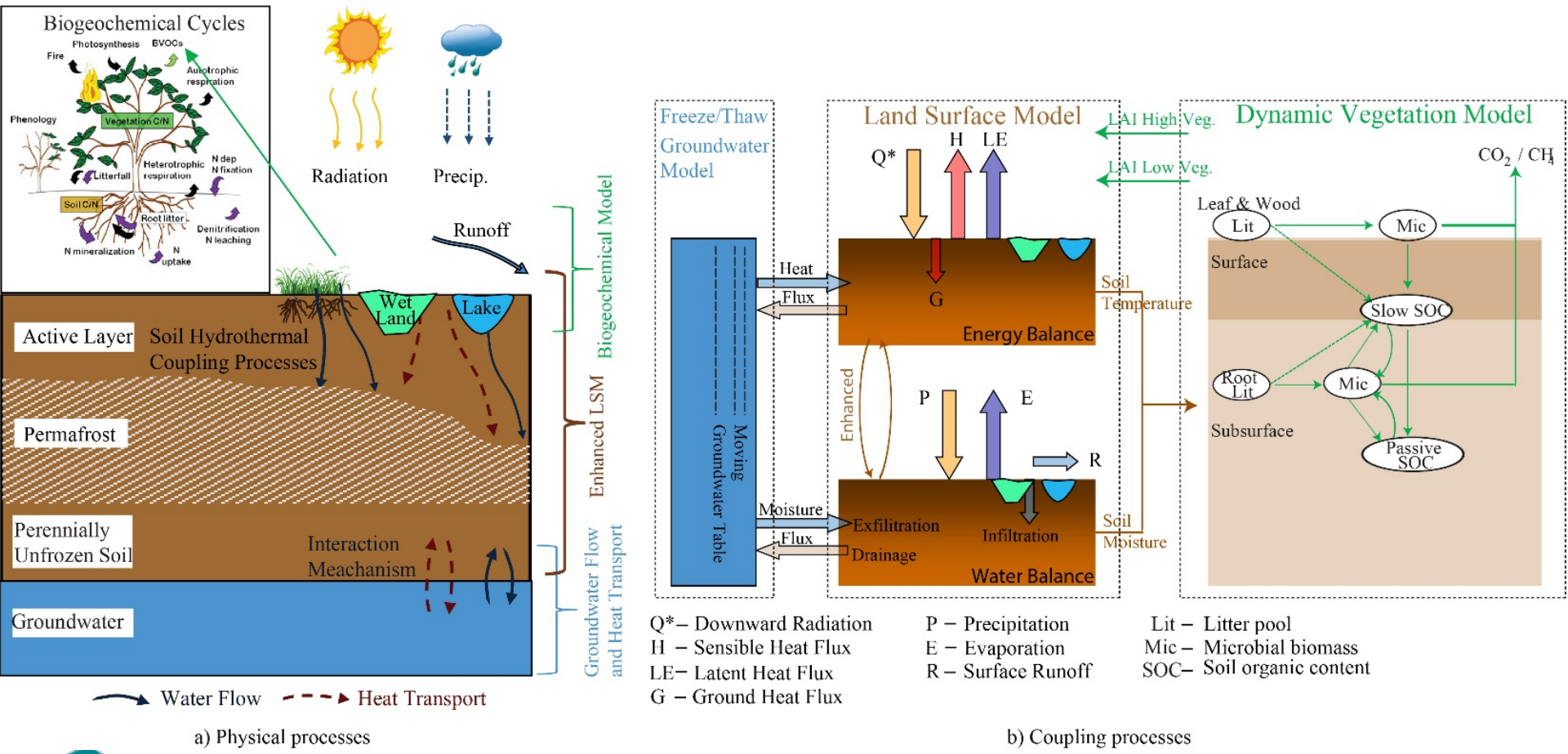
(Zheng et al., 2017, TGRS)

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



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

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

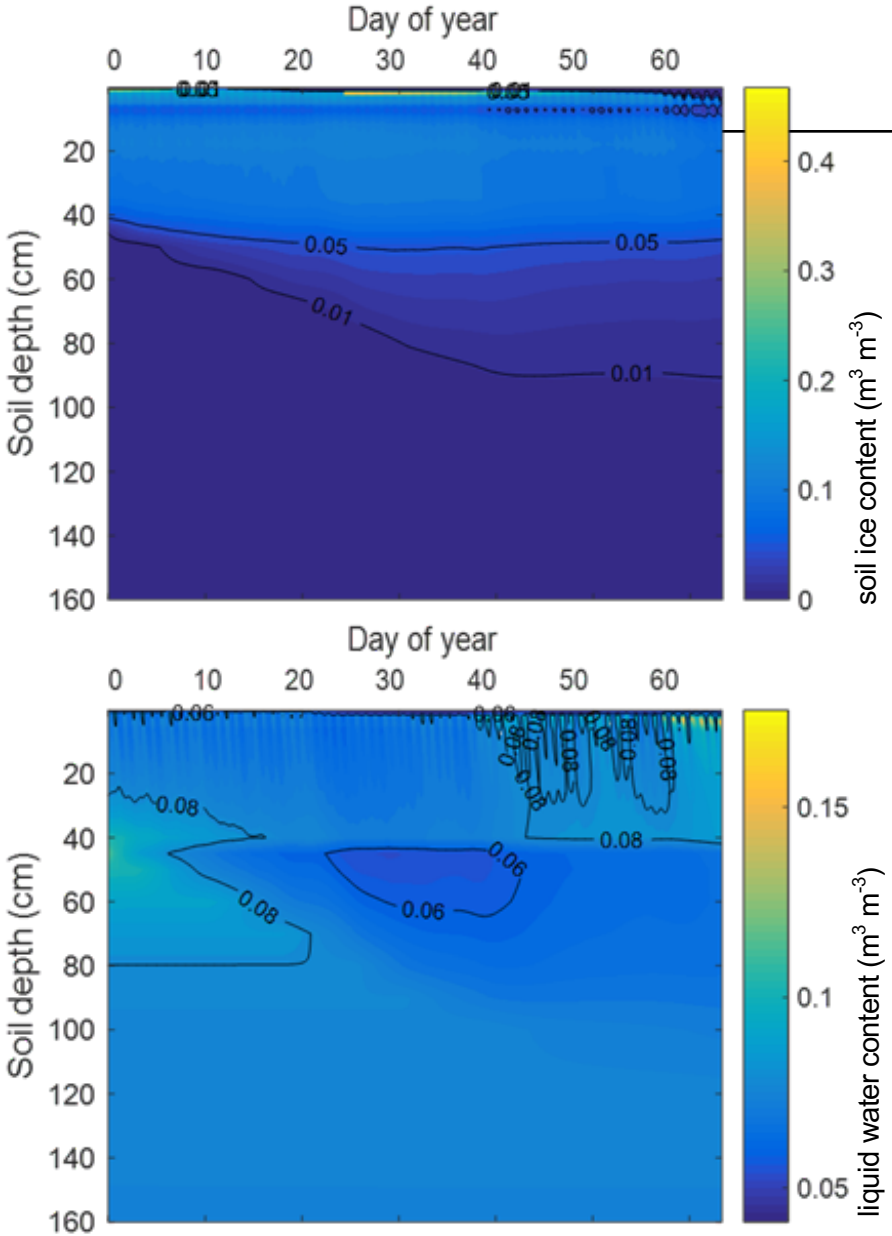
$$= \frac{\partial}{\partial z}(\lambda_{eff}\frac{\partial T}{\partial z}) - \frac{\partial q_L}{\partial z}C_L(T-T_r) - \frac{\partial q_V}{\partial z}[L_0 + C_V(T-T_r)] - C_L S(T-T_r)$$

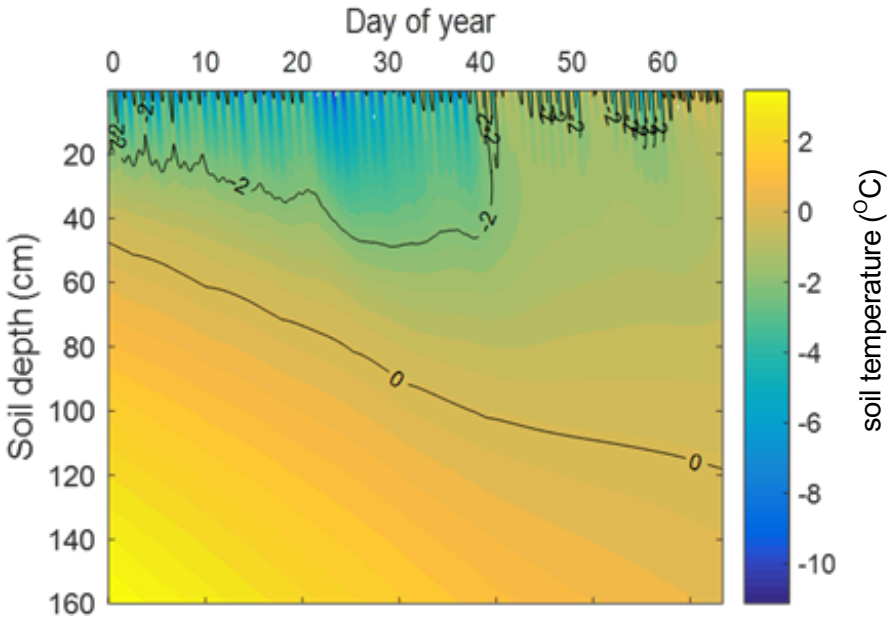
Soil Dry air Transport

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

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

STEMMUS-FT
Profile of ice, liquid water and temperature

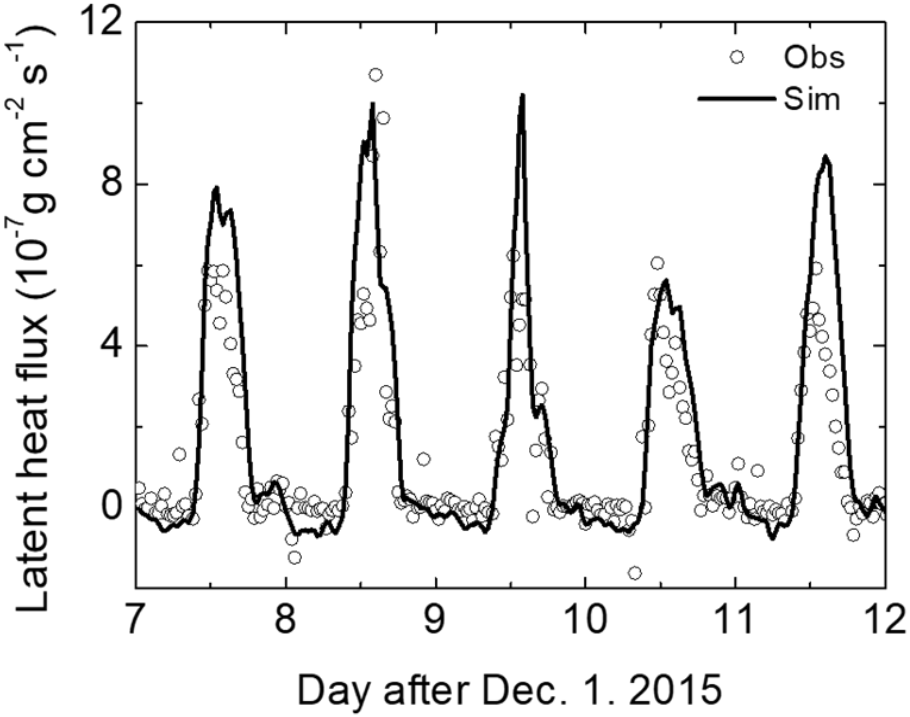




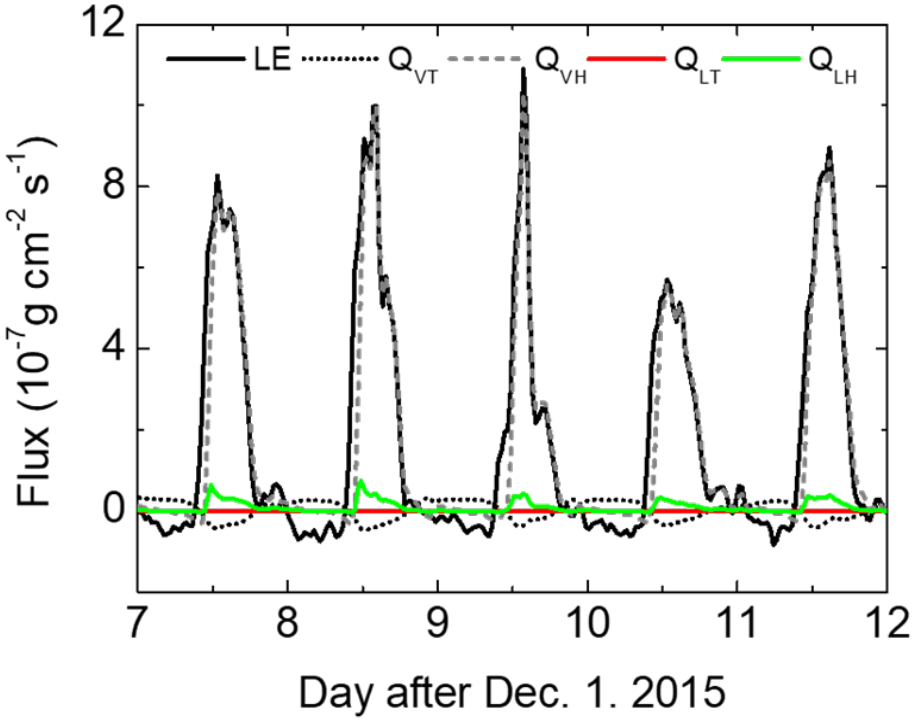
Freezing front increase along with the zero isotherm

Soil liquid water content behave differently

STEMMUS-FT results
Surface fluxes



(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 UAS help?
  - Modeling and DA remains indispensable in understanding and efficient use of observations and retrievals