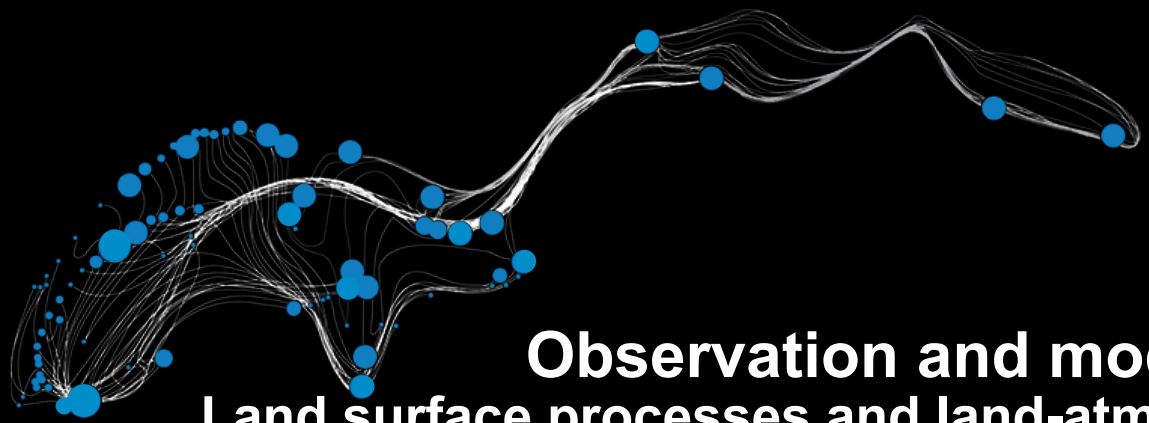
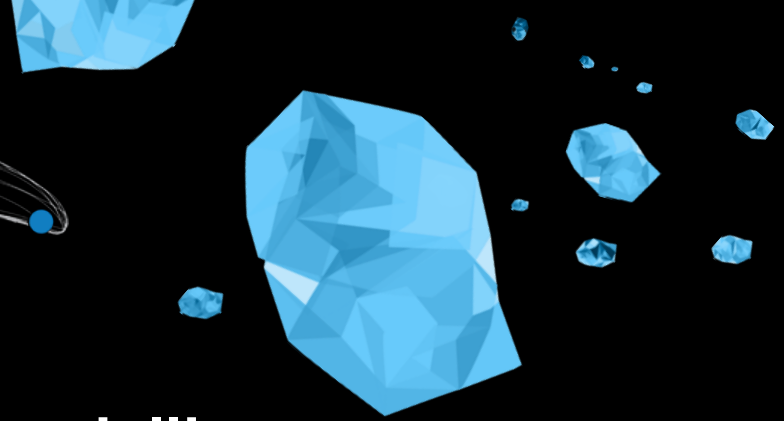


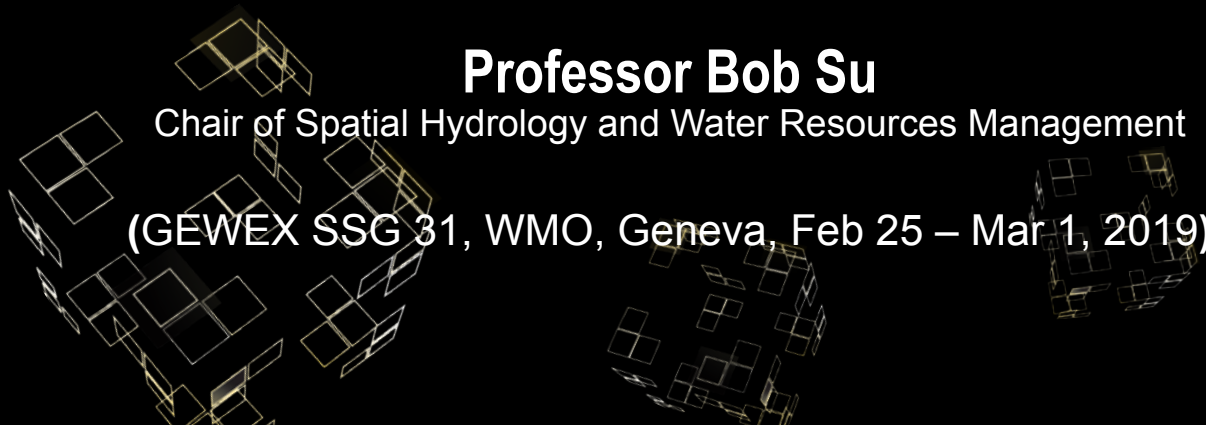


Observation and modelling:
Land surface processes and land-atmosphere interactions,
Earth observation of water cycle and applications

Professor Bob Su

Chair of Spatial Hydrology and Water Resources Management

(GEWEX SSG 31, WMO, Geneva, Feb 25 – Mar 1, 2019)



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OF TWENTE.

Department of Water Resources

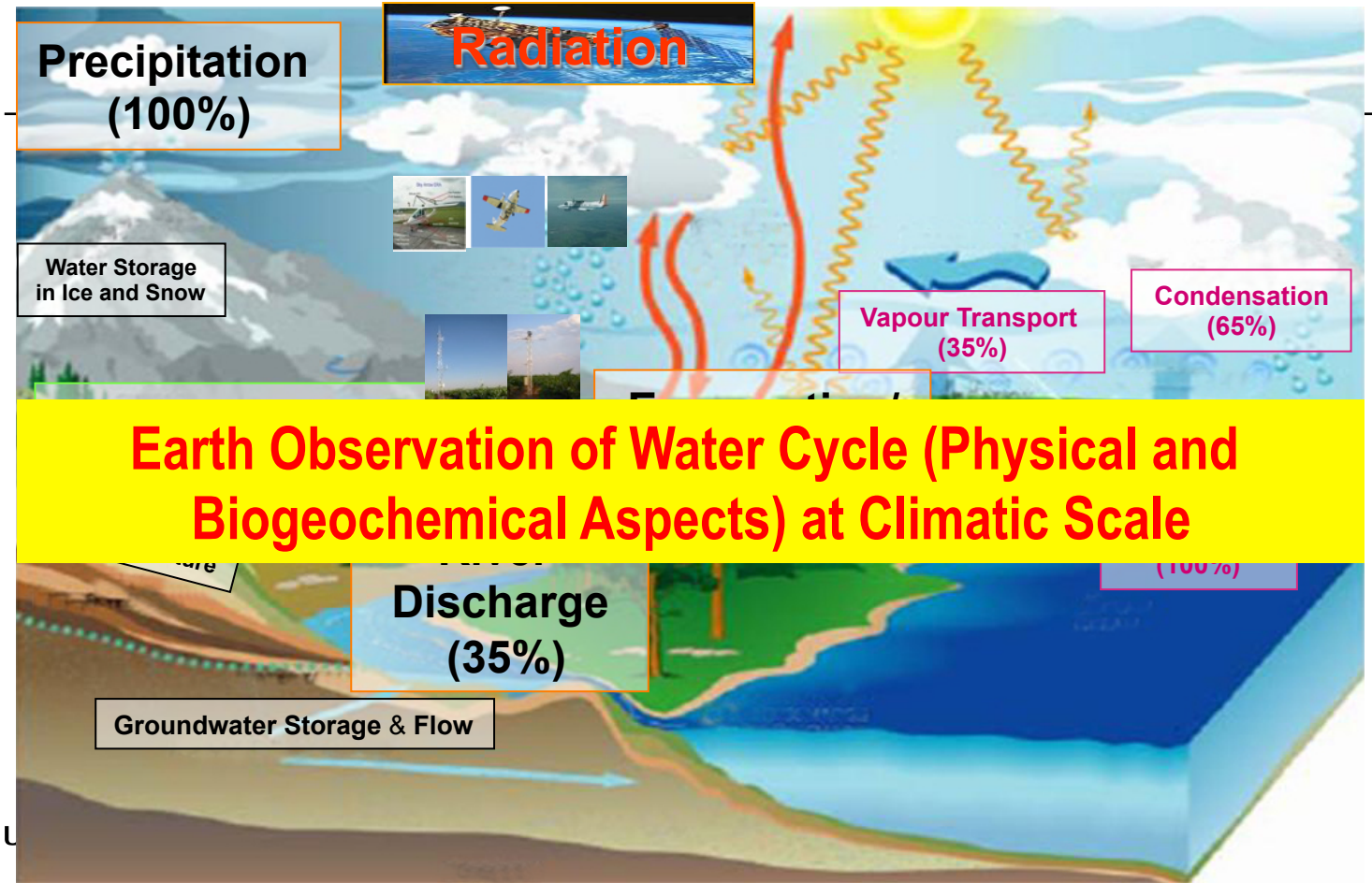
our vision

“Safe water resources for all”

our mission

“Creating and transferring knowledge in earth observation of water cycle for solving society’s problems in water resources and environment”

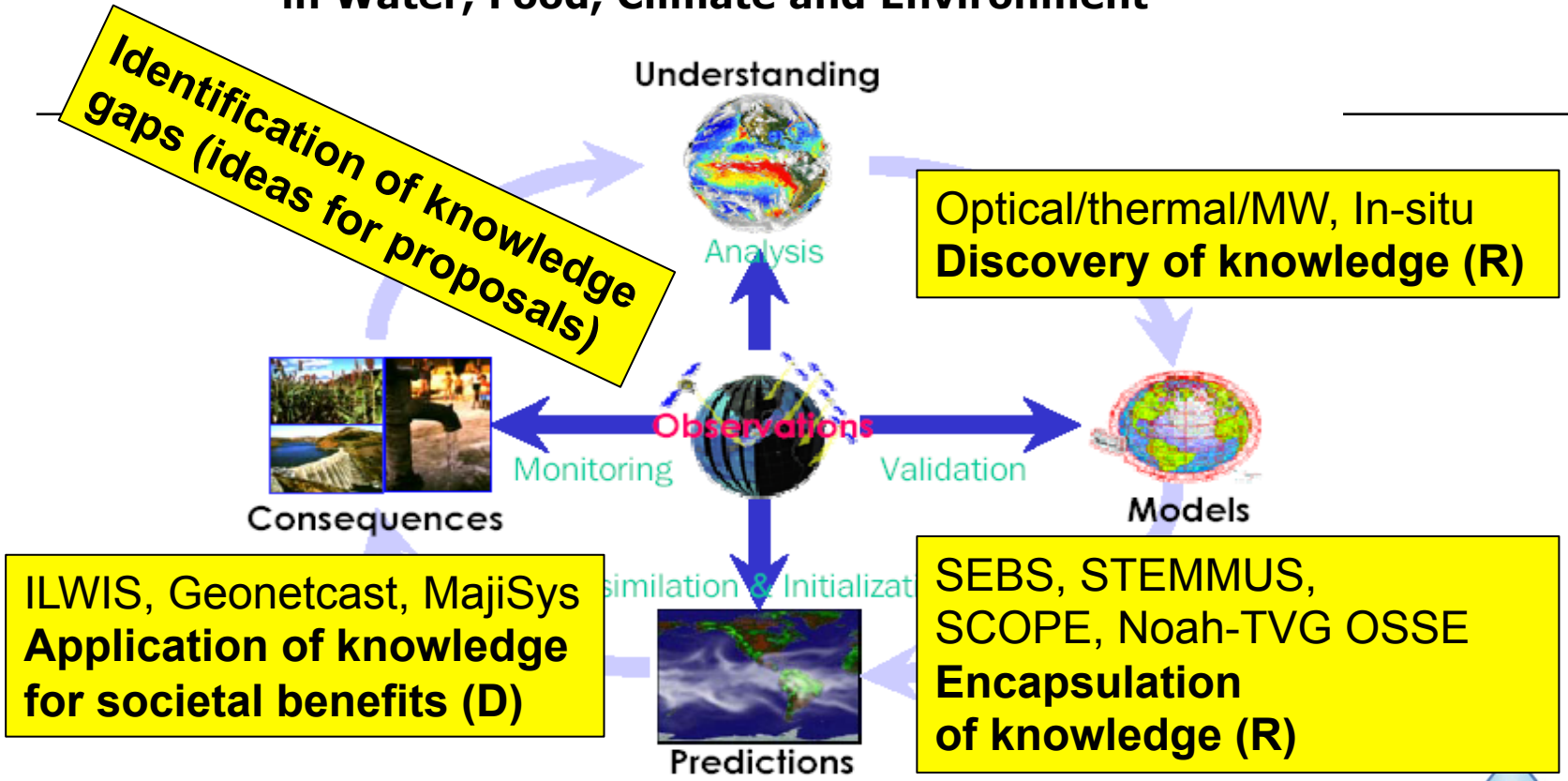
Earth Observation of Water Cycle at Climatic Scale



The organizing principle of WRS activities

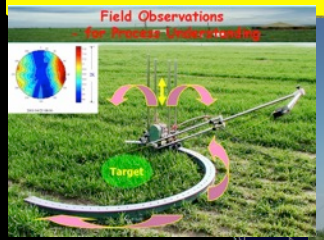
Water Cycle and Climate		
Science (to systematically study, understand and predict)	**Physical aspects of water cycle** (storage, variability and changes of water quantity)	**Biogeochemical aspects of water cycle** (variability and changes in biogeochemistry and water quality)
Technology (to use, develop and apply)	- **Observation (in- situ and satellite observations)** - **Numerical modelling** - **Data assimilation**	
Applications (to assess, quantify, project and predict)	**Water resources and food security (floods, droughts, water use, impacts of climate and land use changes on water quantity)**	**Environmental security (water pollution, impacts of climate and land use changes on water quality)**
Education and capacity building	- **MSC Water resources and environmental management (WREM, water resources track & environmental security track)** - **JEPs in line with WREM** - **Tailor-made short courses**	

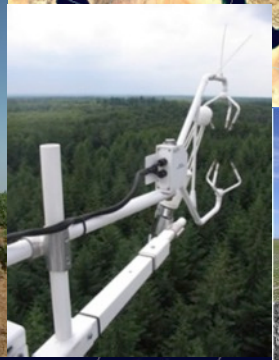
Observation, Modelling and Data Assimilation in Water, Food, Climate and Environment

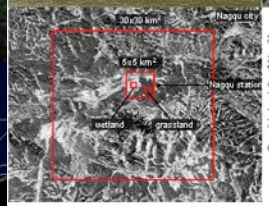


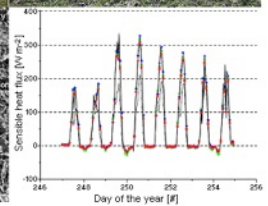
ITC GEO Earth Observation Research & Education Sites

1. Basic Water Cycle and Earth Observation Process Studies
2. Cal/Val sites for EO data/Instruments (e.g. SMOS, SMAP)
3. PhD/MSc research sites
4. Testbed for major projects (e.g. ESA, EU)
5. Long-term hydro-climate studies

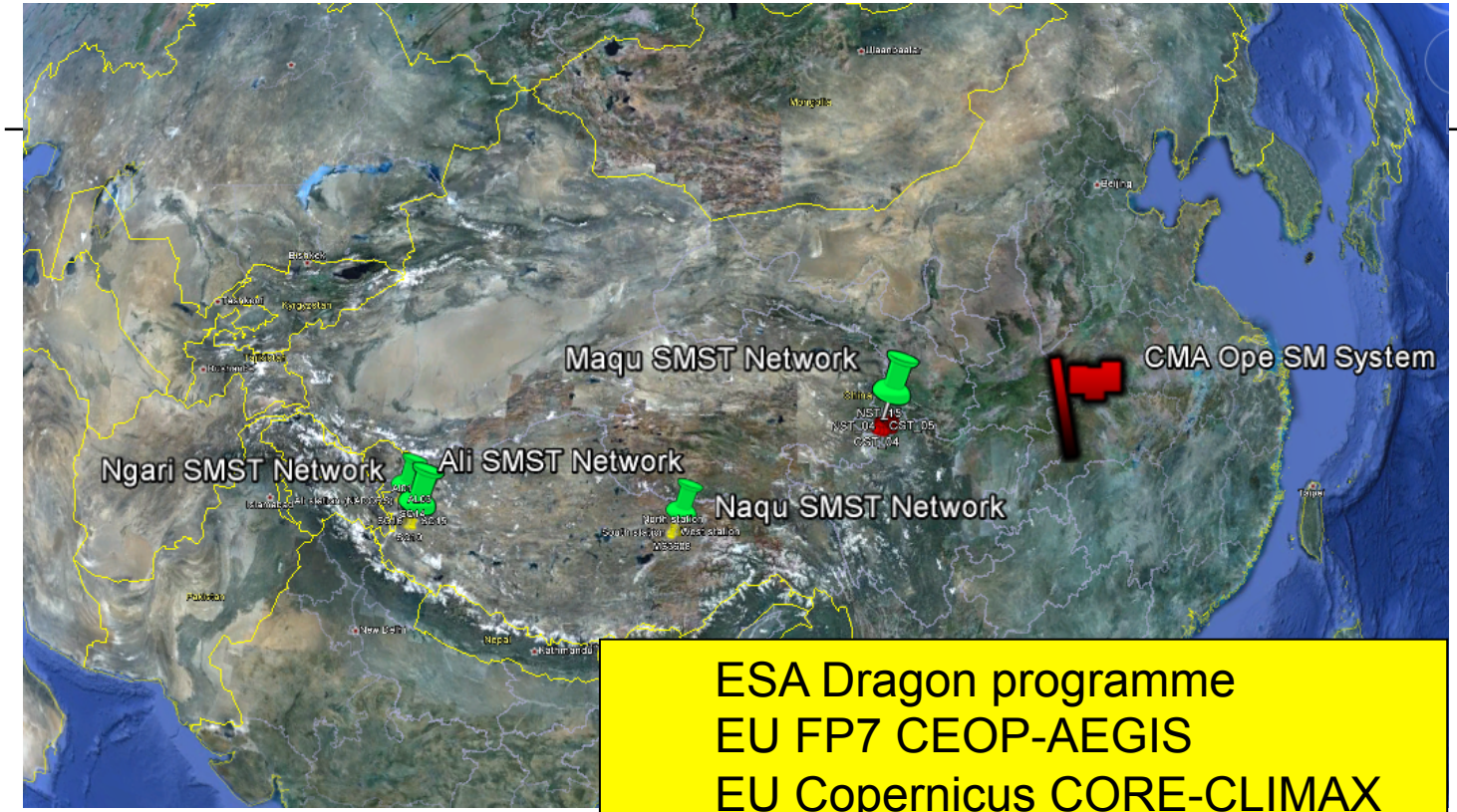




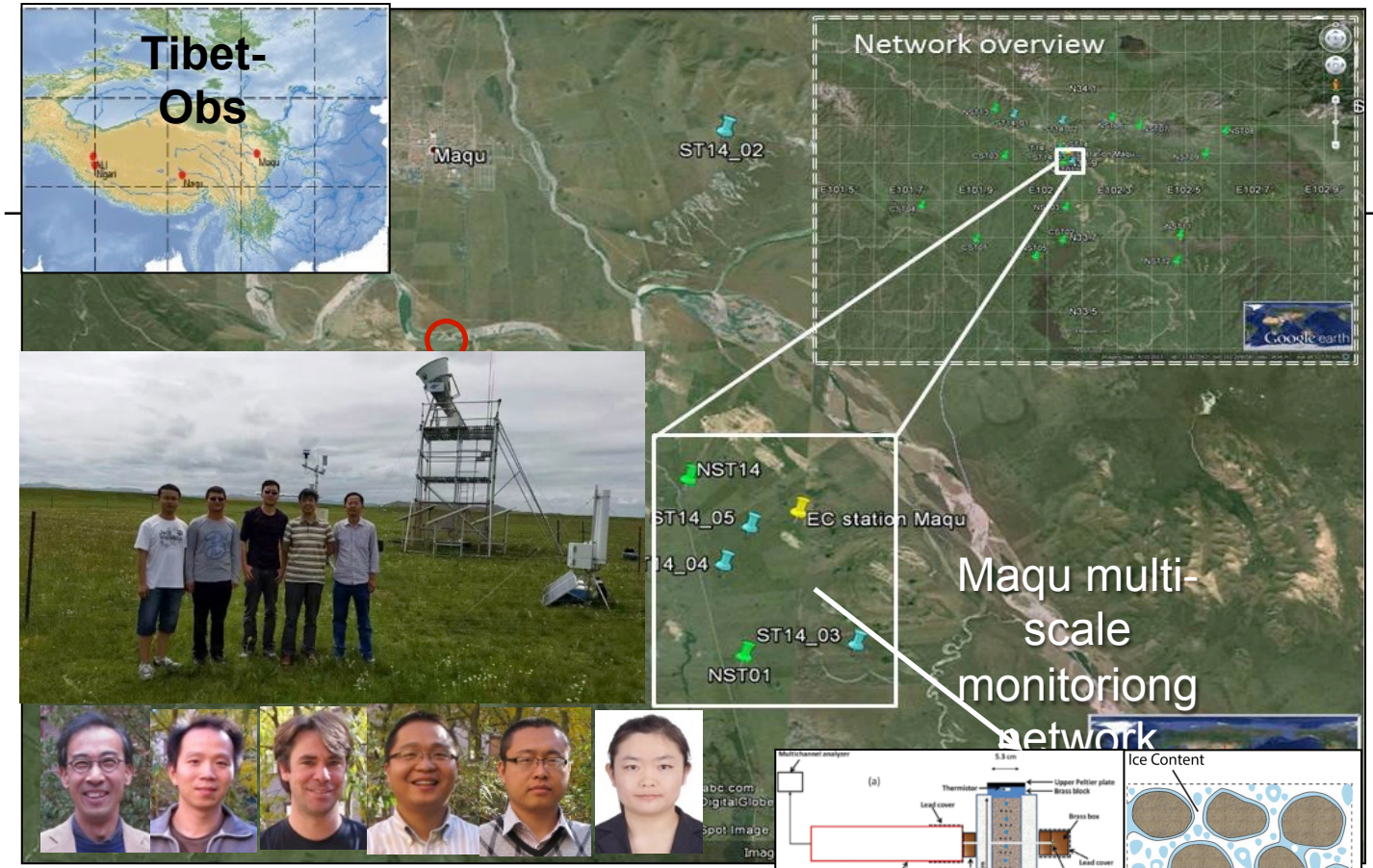




Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs)



ESA Dragon programme
EU FP7 CEOP-AEGIS
EU Copernicus CORE-CLIMAX
SMOS/SMAP Cal/Val
NWO SMAP F/T



- Tibet-Obs (Su et al. 2011) serves as one of the SMOS/SMAP Cal/Val sites

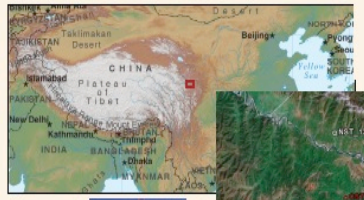
ITC Earth Observation Research and Education Sites

The Role of Soil Moisture in Global Climate

(Collaboration with Chinese Academy of Sciences)

MAQU SITE

Location:	South of Maqu city (Gansu province, China)
Coordinates:	33°30′ – 34°15′N, 101°38′ – 102°45′E
Elevation:	3430 – 3750 m
Date of installation:	June 2008
Climate (Koeppen Clas. Syst.):	Cold (Dw, winter dry season)



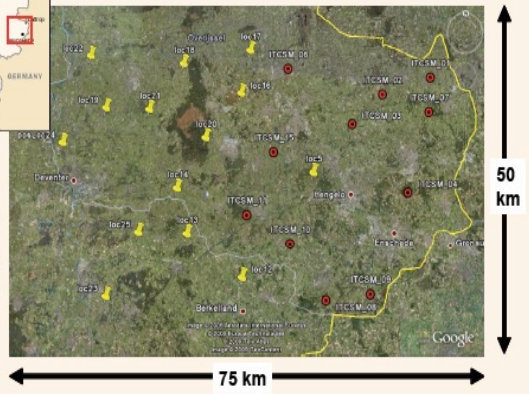
20 soil moisture & soil temperature stations

CAS climate station

TWENTE SITE

Location:	Twente region, The Netherlands
Coordinates:	52°05′ – 52°27′N, 6°05′ – 7°00′E
Elevation:	-3 – 50 m
Date of installation:	November 2008 – present
Climate (Koeppen Clas. Syst.):	Temperate (Cf)

25 soil moisture & soil temperature stations



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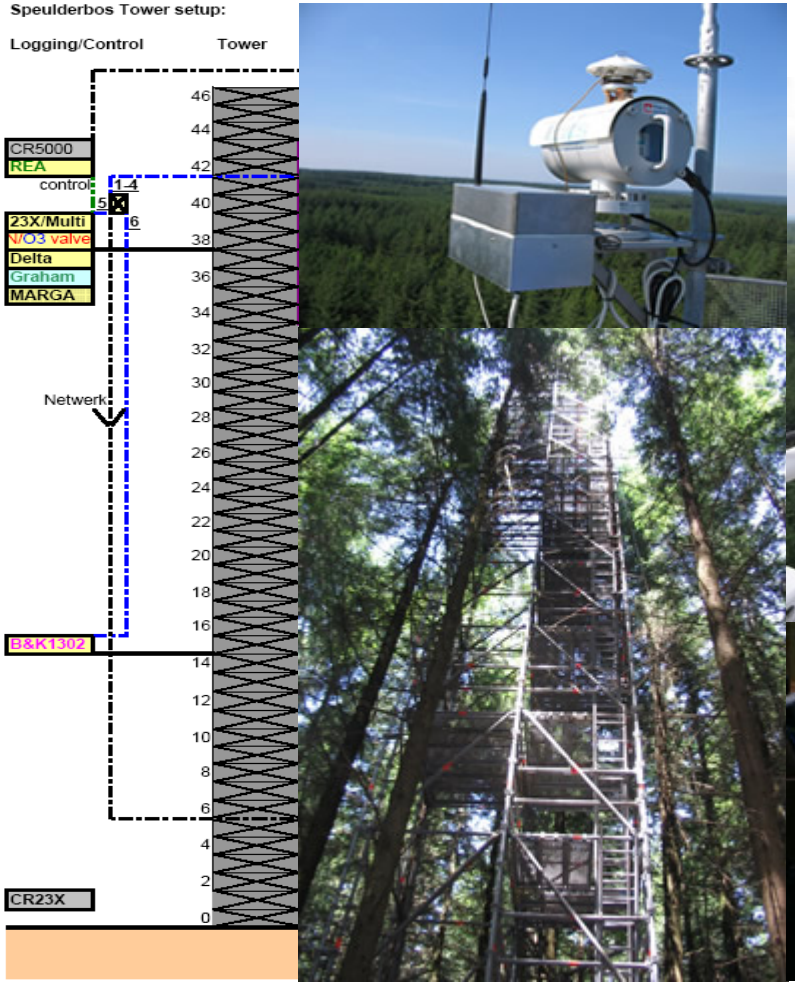
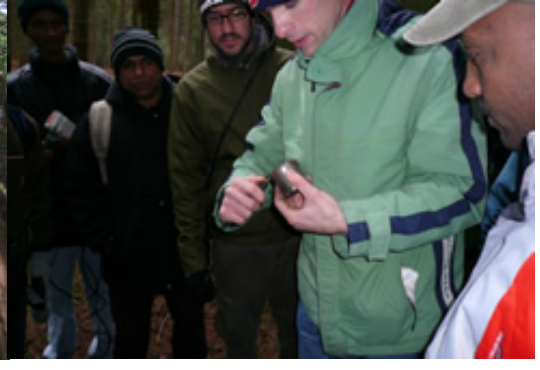
ESA Dragon programme
EU FP7 CEOP-AEGIS project

ITC EO Res/Edu Site - Speulderbos



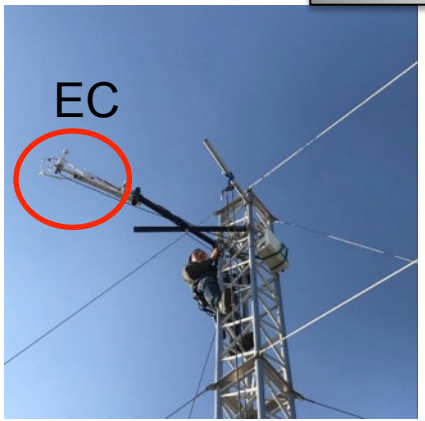


UNIVER

X/MW LAS Transmitter at Esmarke

X/MW LAS Receiver at Horst

Instruments at ITC Hotel



Disdrometer

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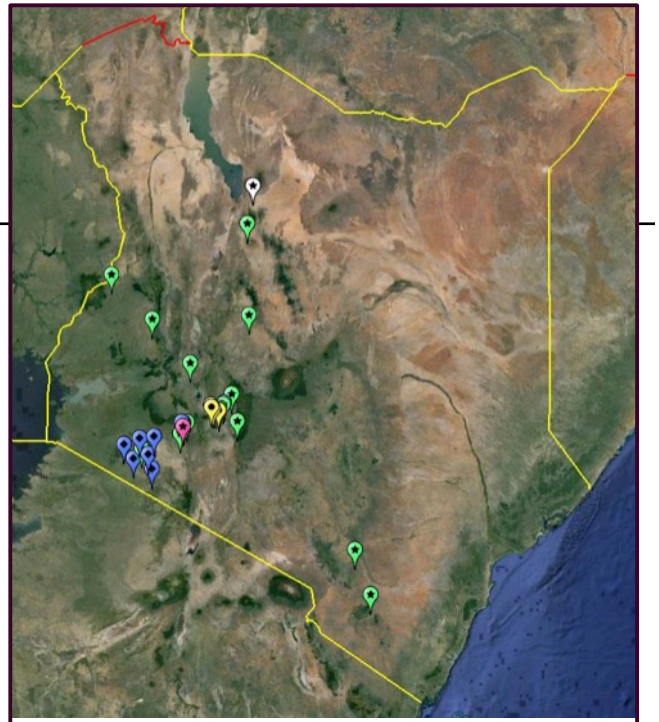
Enschede Hydroclimate Observatory

East African Monsoon Observation Network



Three main sites:

- **Lake Naivasha Catchment**
  - 1 Eddy Covariance System
    - CSAT3 Sonic Anemometer
    - LiCor 7500 open path IRGA
    - Energy balance and other (e.g. IRT) measurements
  - 1 Large Aperture Scintillometer (Scintec)
  - 9 ARG-100 rain gauges
  - 2 low-cost Bowen ratio systems *(planned)*

- **Mara/Narok (FlashCall and MaMaSe projects)**
  - 5 Soil moisture profile stations
  - 3 low-cost Bowen ratio systems *(planned)*
  - 6 additional soil moisture profile stations *(planned)*
  - 1 Cosmic Ray Soil Moisture Observing System (COSMOS) *(planned)*

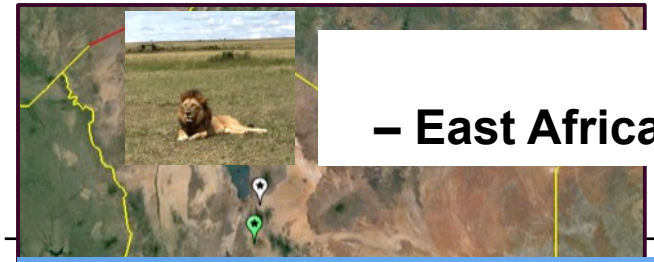
- **Lake Turkana Wind Power**
  - 1 Eddy Covariance System *(planned)*

One cost effective automatic weather station network:

- **15 low cost AWS**
  - Low power requirements, small solar panels to reduce risk of theft
  - double aspirated THP's for Bowen ratio calculations
  - Mountable on GSM towers

Real-time, cloud based time series management:

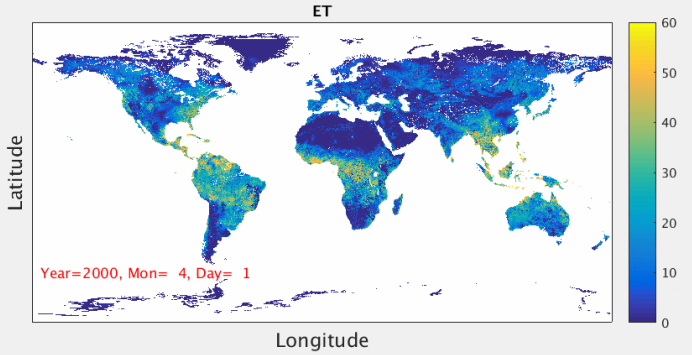
- **Maji-Sys**
  - Developed by ITC

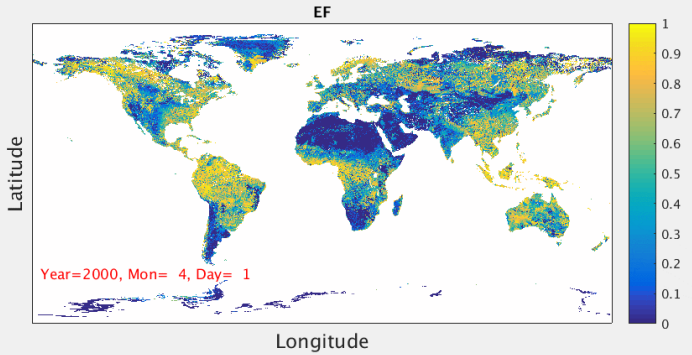


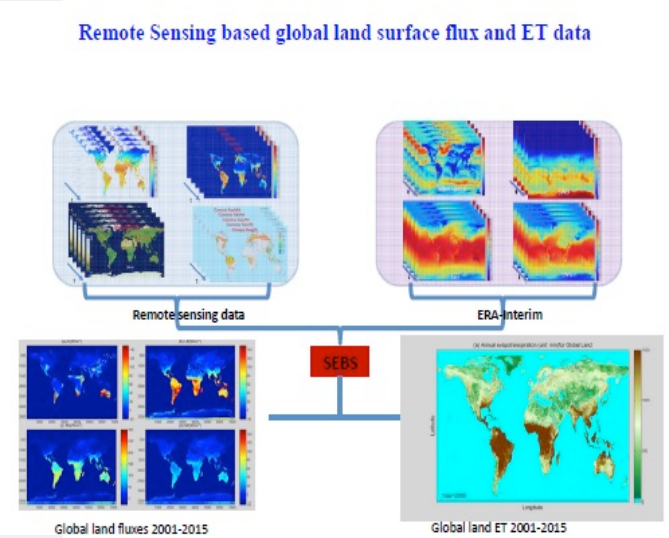
ITC EAMON
– East Africa Monsoon Observation Network

High Resolution Hydrologic and Ecosystem Fluxes

2000 – Near Present at 5km x 5km Daily Evaporation and Heat Fluxes



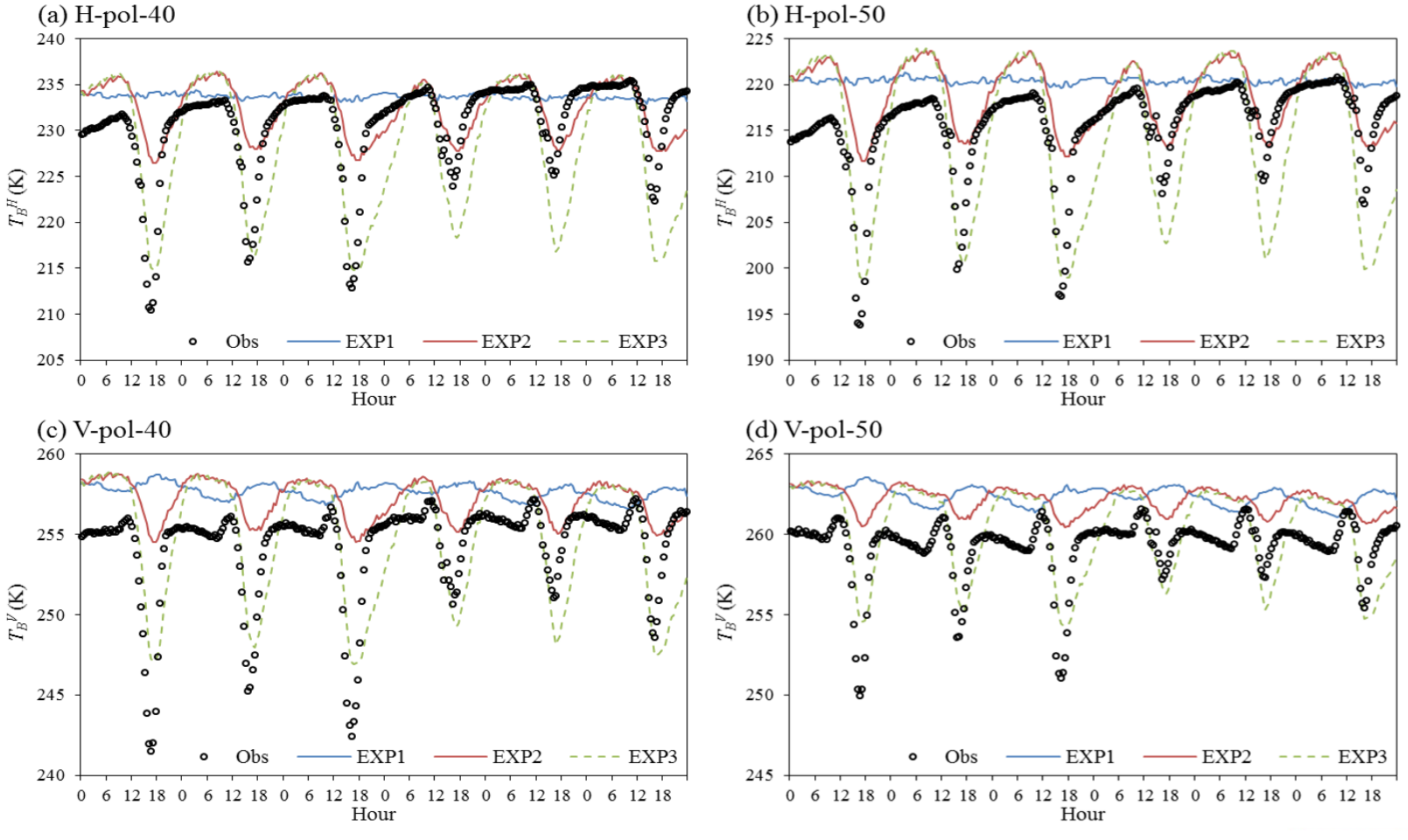




(Su, 2002, HESS; Chen et al., 2013, JAMC; Chen et al., 2014, ACP)

http://en.tpedatabase.cn/

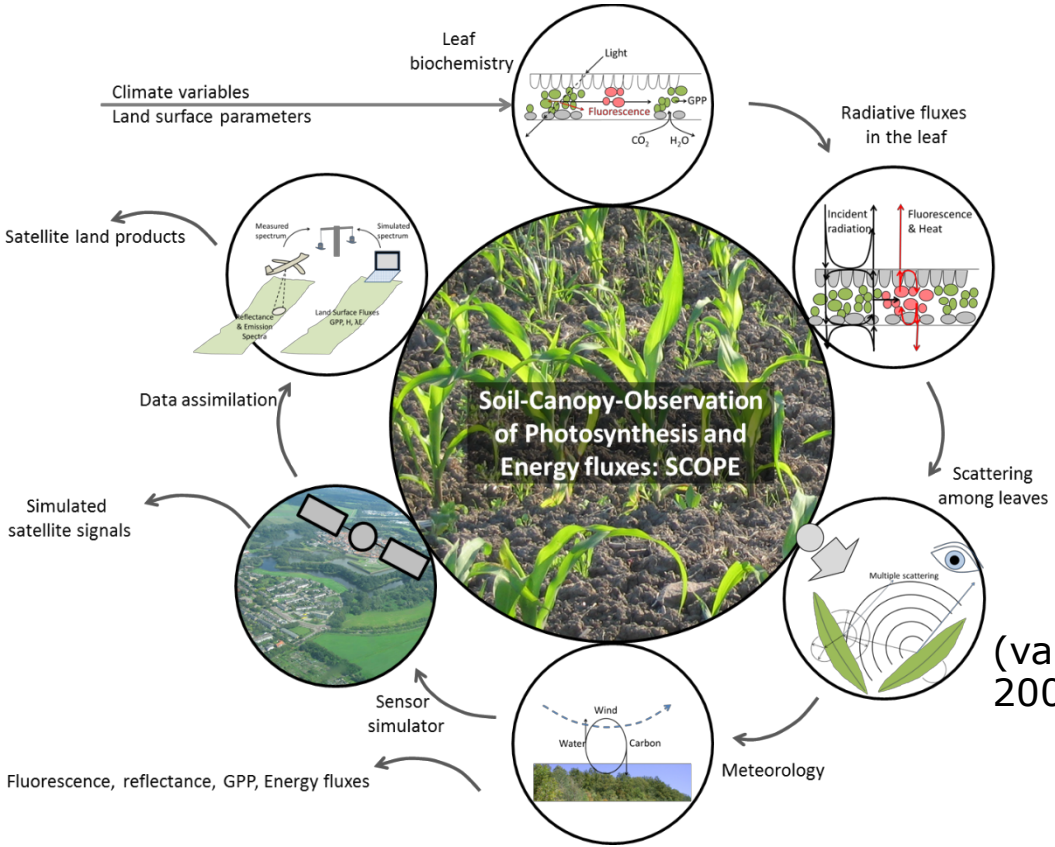
Noah-Tor Vergata OSSE (Observation Opearator)



Soil-**C**anopy-**O**bservation of **P**hotosynthesis and **E**nergy Fluxes (SCOPE)

- Computer simulation model
- Bridges eco- hydro-meteorology with proximal and remote sensing

Christiaan van der Tol



(van der Tol et al., 2009, Biogeosci.)

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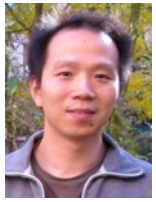
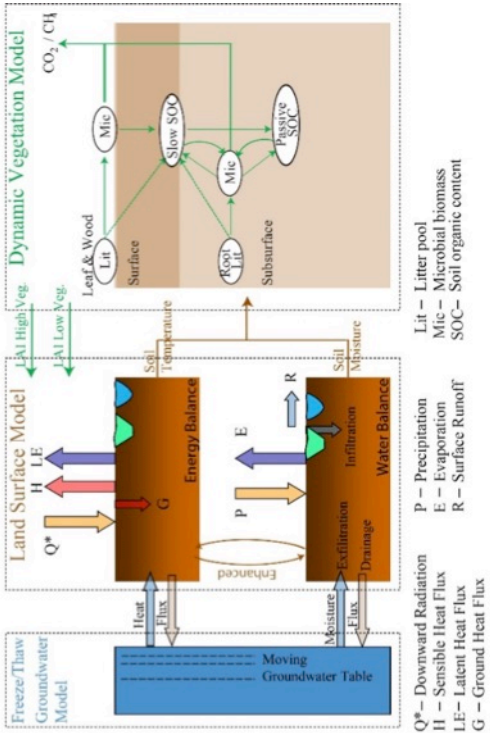
water & Climate

Water-Energy-Plant Interactions in Cold Regions: Tools

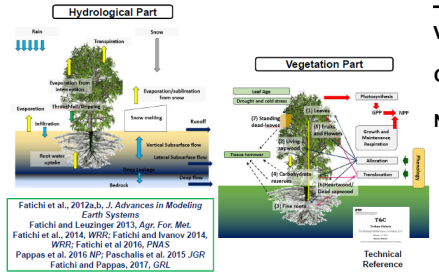


Yijian Zeng



b) Coupling processes

Tethys-Chloris (T&C) MODEL



Fatichi et al., 2012a,b, *J. Advances in Modeling Earth Systems*
Fatichi and Leuzinger 2013, *Agr. For. Met.*
Fatichi et al., 2014, *WRR*; Fatichi and Ivanov 2014, *WRR*; Fatichi et al 2016, *PNAS*
Pappas et al. 2016 *NP*; Paschalis et al. 2015 *JGR*
Fatichi and Pappas, 2017, *GRL*

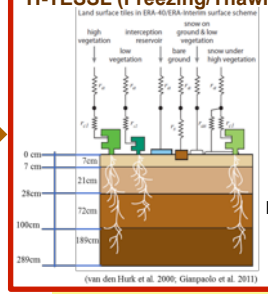
Vegetation Dynamics

Carbon Cycle

Nutrient Cycle

(Zeng et al., 2011, WRR)

H-TESSL (Freezing/Thawing)

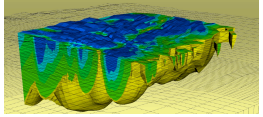


STEMMUS

Simultaneous Transfer of Energy, Momentum and Mass in Unsaturated Soil

SUTRA

A Model for Saturated-Unsaturated Variable-Density Ground-Water Flow with Solute or Energy Transport



PFLOTRAN

A Massively Parallel Reactive Flow and Transport Model for describing Surface and Subsurface Processes

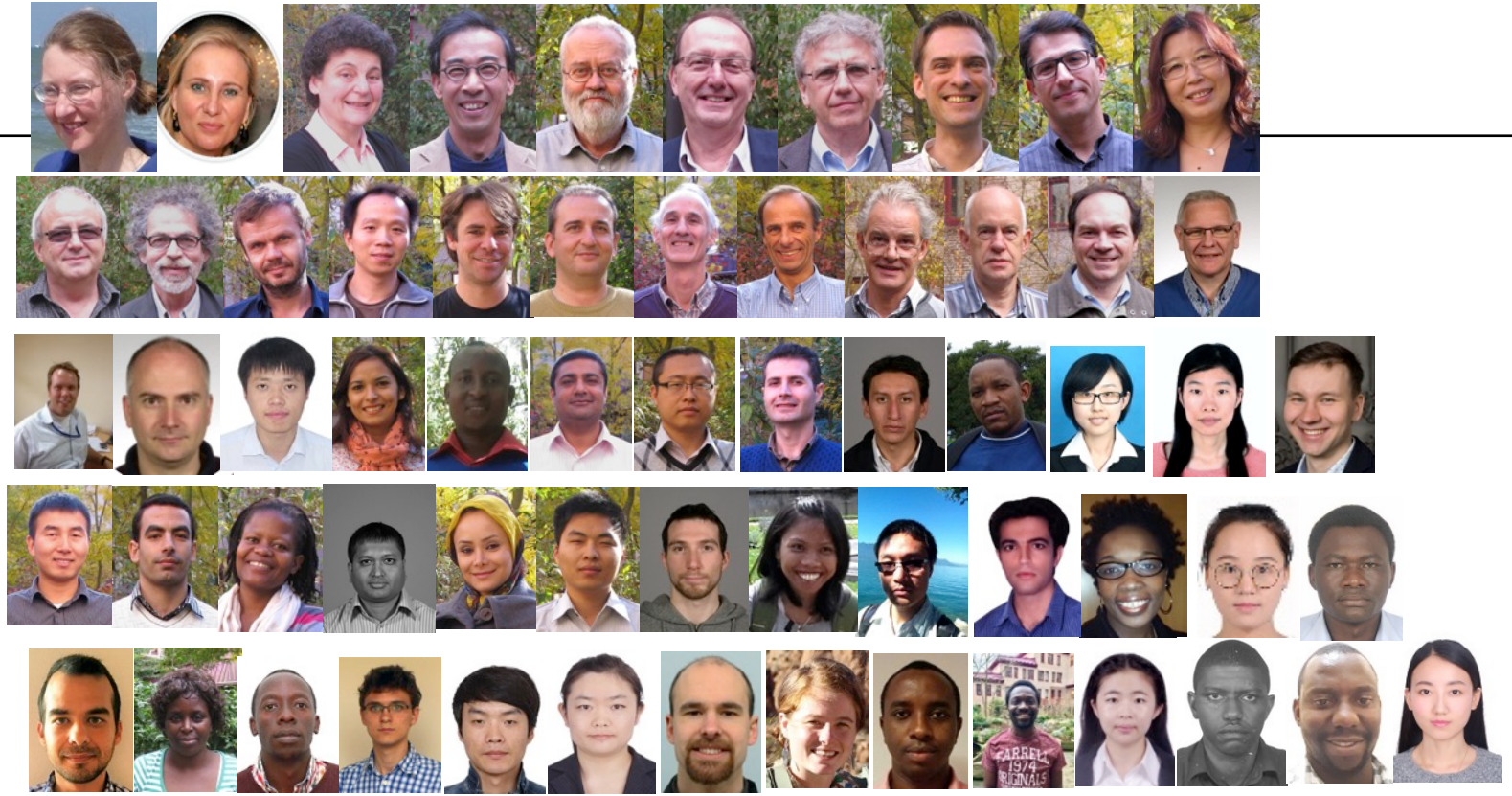
ITC

UNIVERSITY OF TWENTE.

Water & Climate

Department of Water Resources

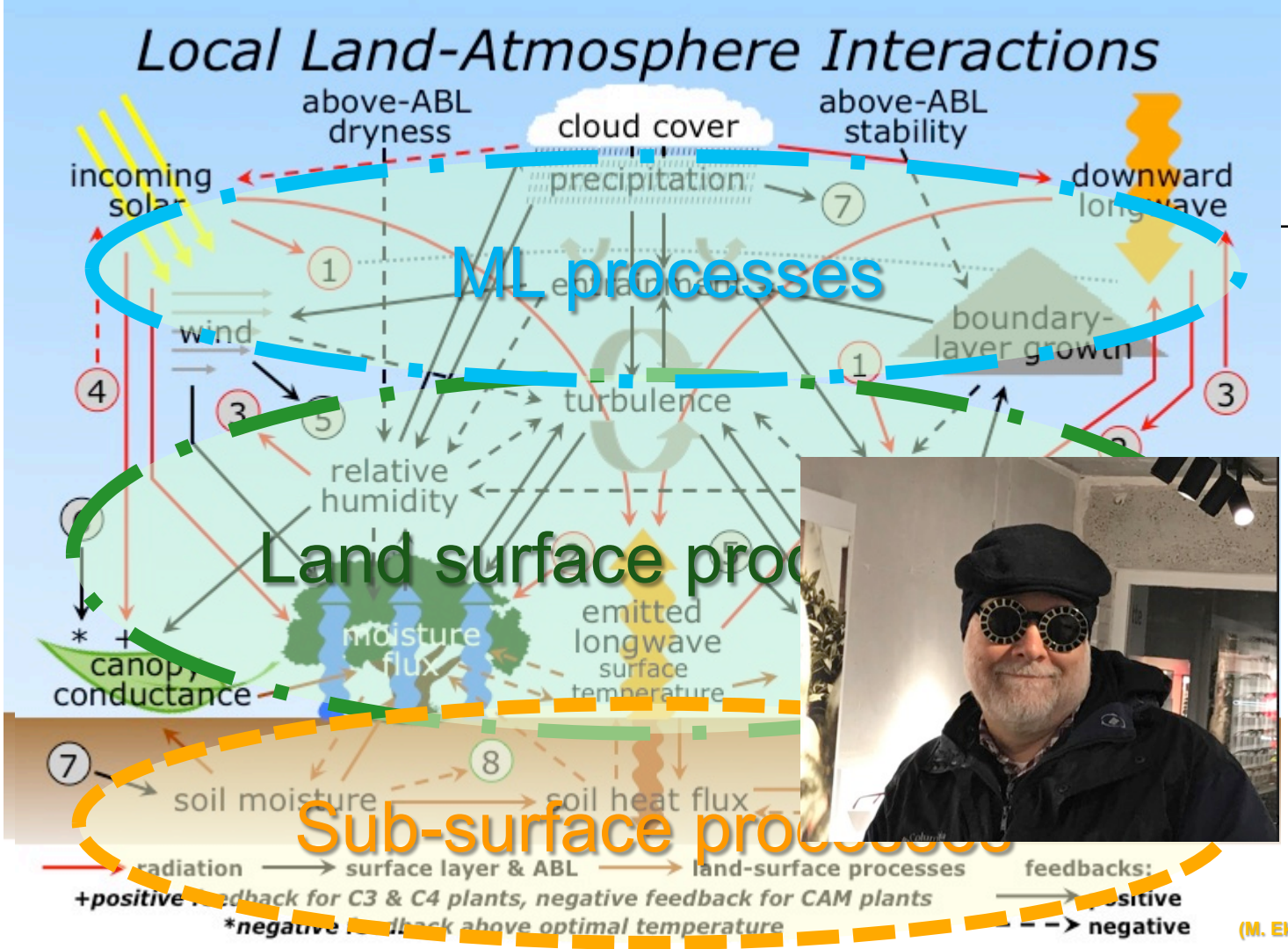
24 staff, 39 PhDs (Oct. 2018), + ca. 30 MSc Students



Observation and modelling of radiative and heat-water transfer processes on the Tibetan Plateau

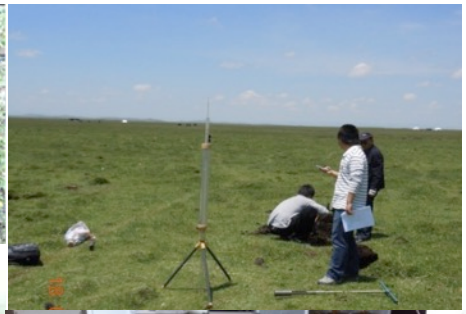
Bob Su
z.su@utwente.nl
www.itc.nl/wrs
with contributions from
R. van der Velde, Y. Zeng, D. Zheng, X. Chen
S. Lv, Q. Wang, L. Yu, H. Zhao
J. Wen, X. Wang (NIEER/CAS), Y. Ma (ITP/CAS)

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


Local Land-Atmosphere Interactions
above-ABL dryness
cloud cover
above-ABL stability
incoming solar
precipitation
downward longwave
ML processes
wind
boundary-layer growth
turbulence
relative humidity
Land surface proc
emitted longwave
surface temperature
moisture flux
canopy conductance
soil moisture
soil heat flux
Sub-surface processes
radiation
surface layer & ABL
land-surface processes
feedbacks:
+positive feedback for C3 & C4 plants, negative feedback for CAM plants
*negative feedback above optimal temperature
negative
(M. Ek)

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

http://en.tpedatabase.cn/ *(Su et al. 2011, HESS)*

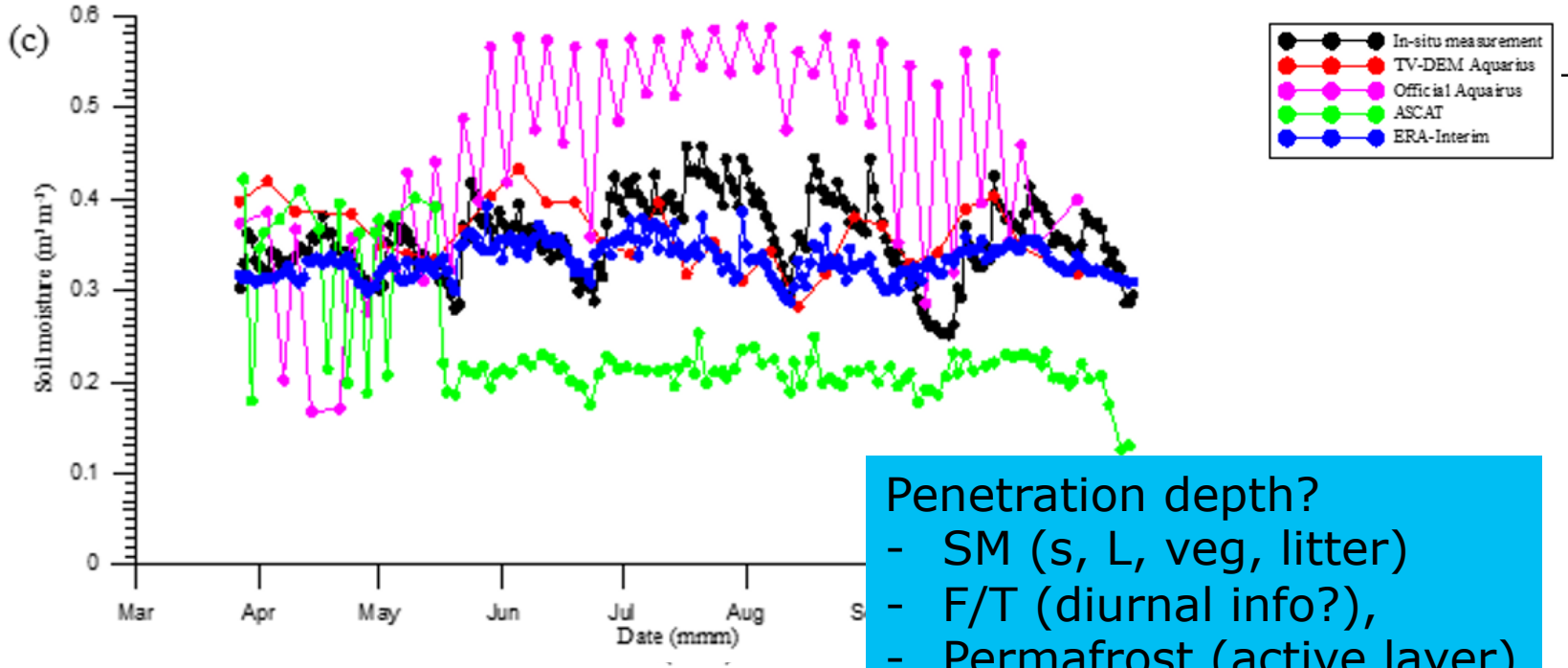


Dataset: **Soil Hydraulic and Thermal Properties for Land Surface Modelling over the Tibetan Plateau**

https://data.4tu.nl/ *(Zhao et al. 2018, ESSD)*

How good are some soil moisture products?

Ngari (a), Naqu (b) and Maqu (c) for year 2012



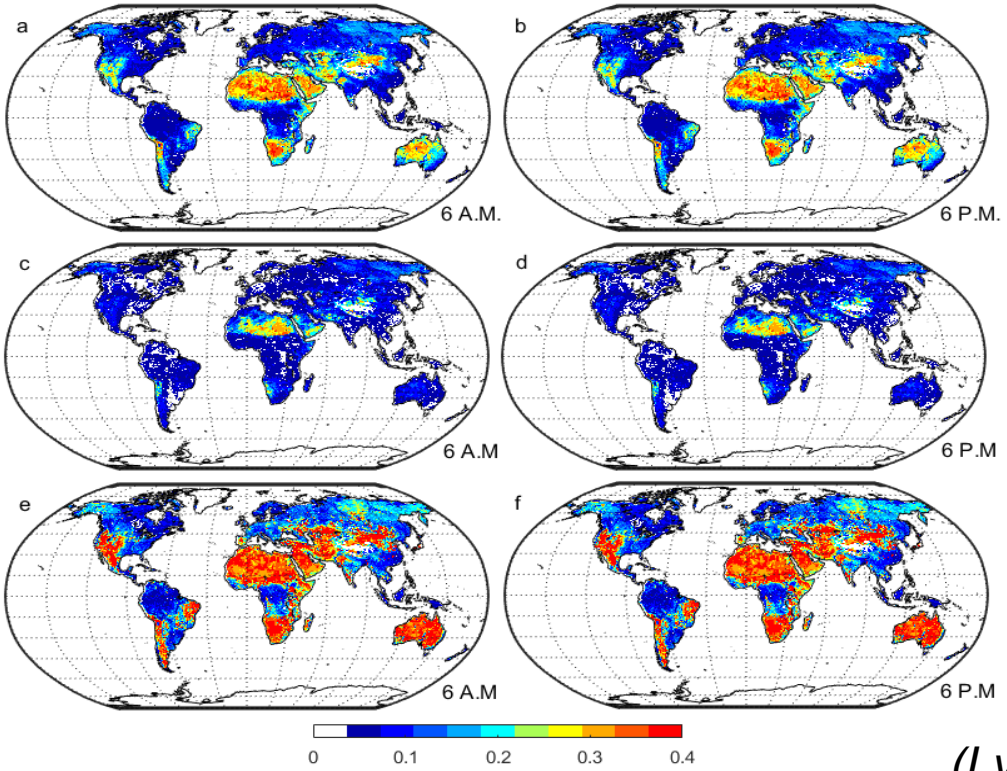
Penetration depth?

- SM (s, L, veg, litter)
- F/T (diurnal info?),
- Permafrost (active layer)

(Wang et al., 2019, JAG)

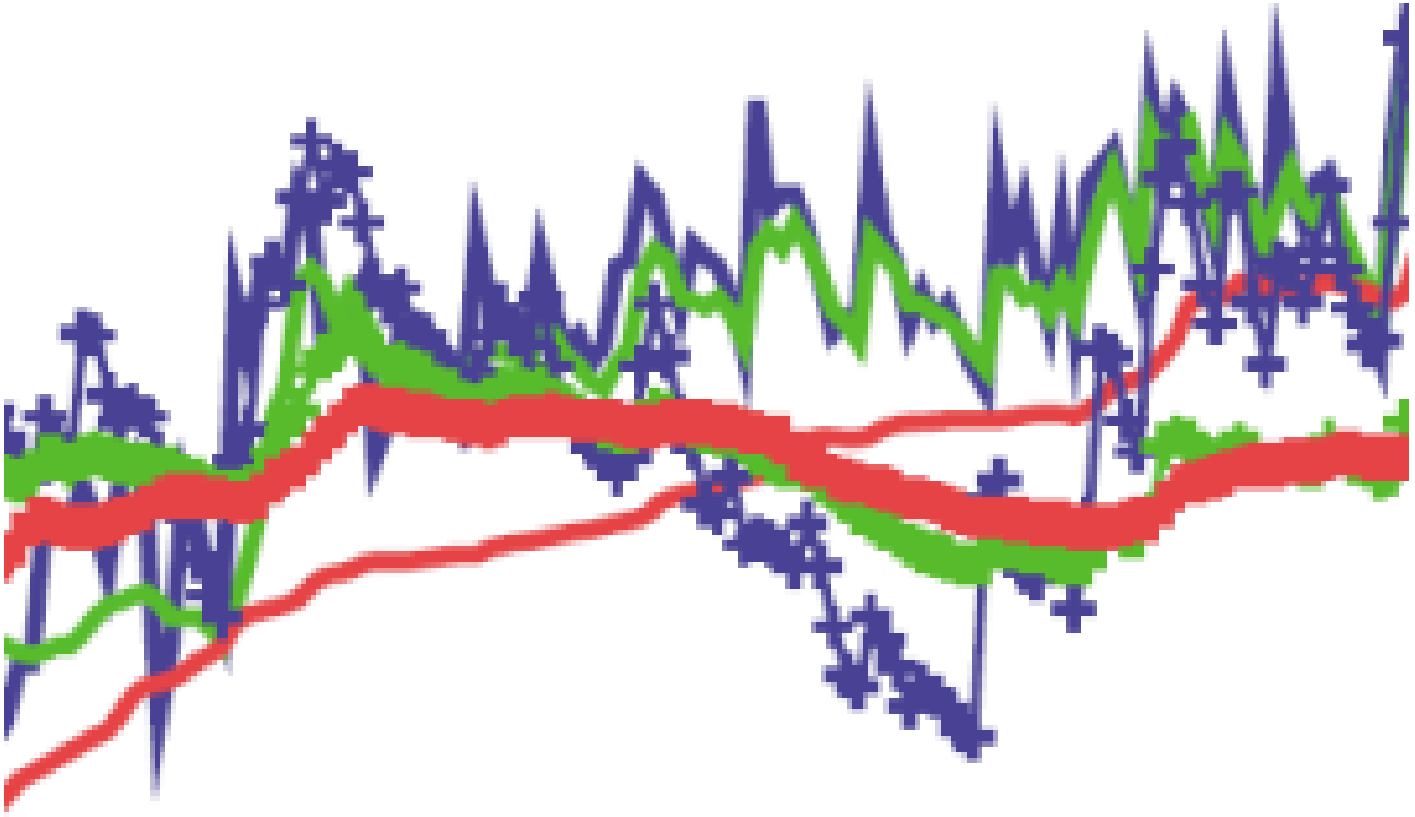
Global soil temperature sensing depth

a, b) mean; c, d) minimum; e, f) maximum at 6 am/pm local time, resp.

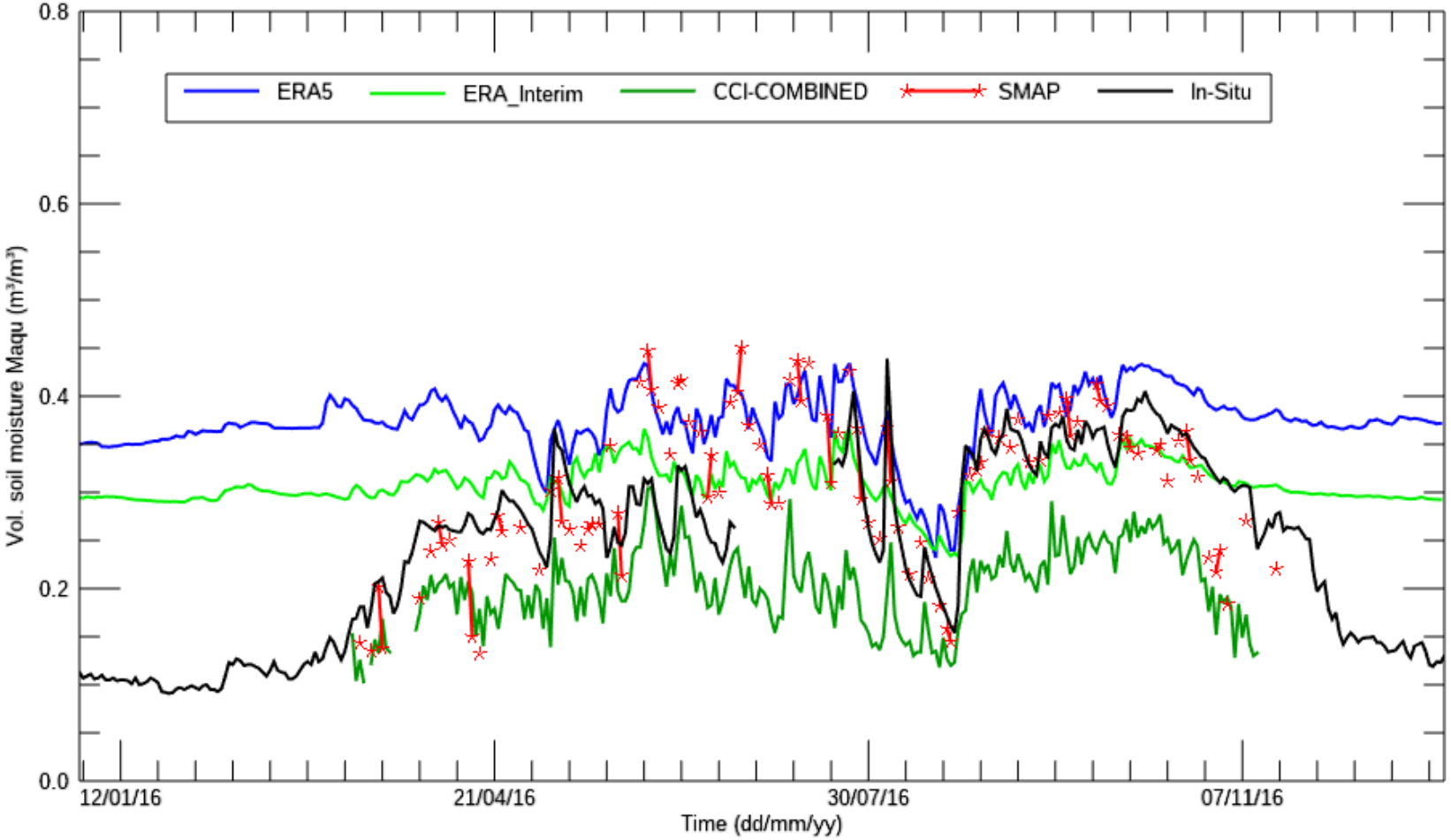


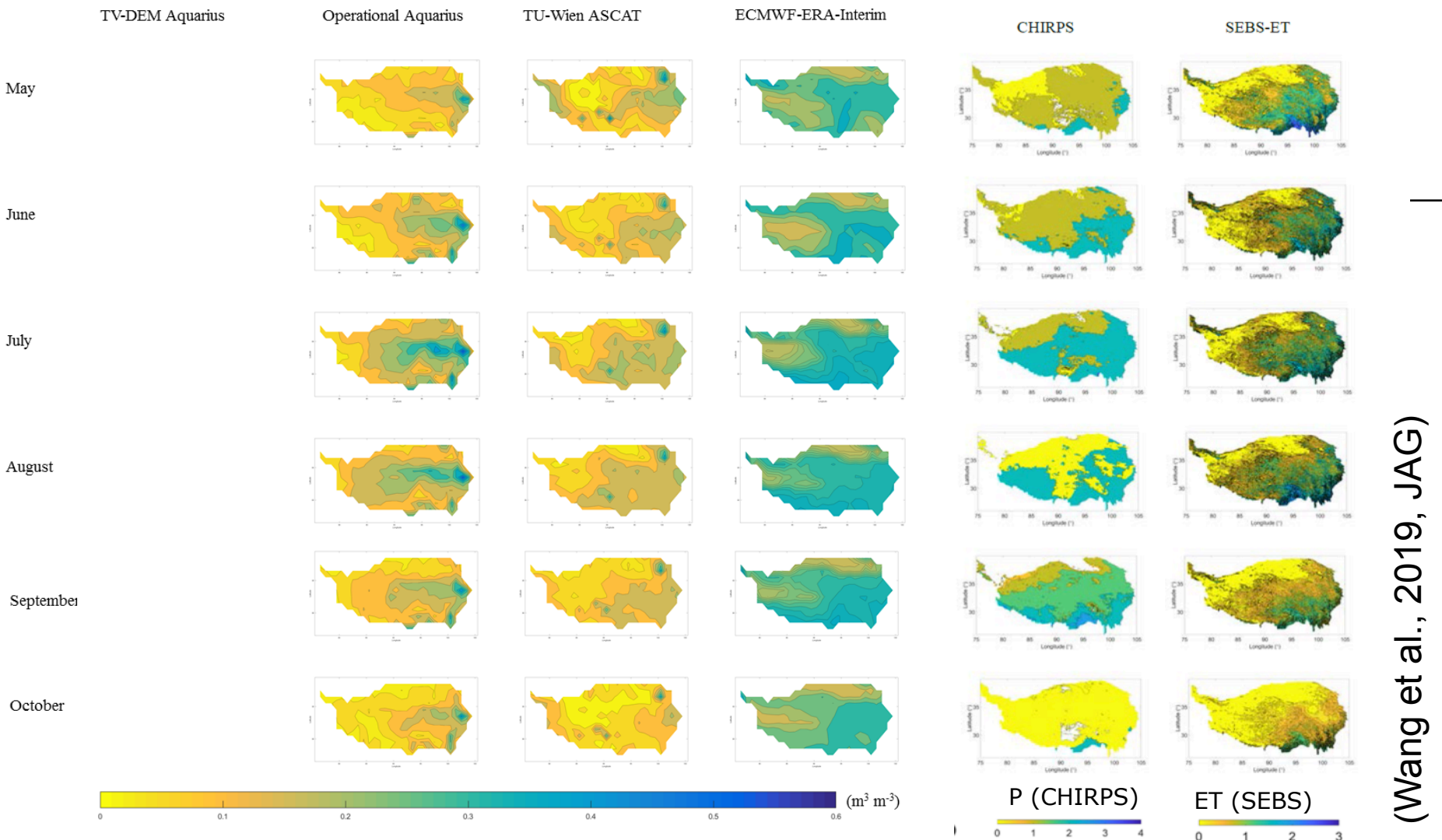
(Lv et al. 2018, RS)

How good is soil moisture assimilation?



(Su & de Rosnay, et al. 2013, JGR)


ERA5
ERA_Interim
CCI-COMBINED
SMAP
In-Situ
0.8
0.6
0.4
0.2
0.0
Vol. soil moisture Maqu (m³/m³)
12/01/16
21/04/16
30/07/16
07/11/16
Time (dd/mm/yy)


TV-DEM Aquarius
Operational Aquarius
TU-Wien ASCAT
ECMWF-ERA-Interim
CHIRPS
SEBS-ET
May
June
July
August
September
October
(m³ m⁻³)
0
0.1
0.2
0.3
0.4
0.5
0.6
P (CHIRPS)
0
1
2
3
4
ET (SEBS)
0
1
2
3
(Wang et al., 2019, JAG)

Regional Water Budget Yangtze River

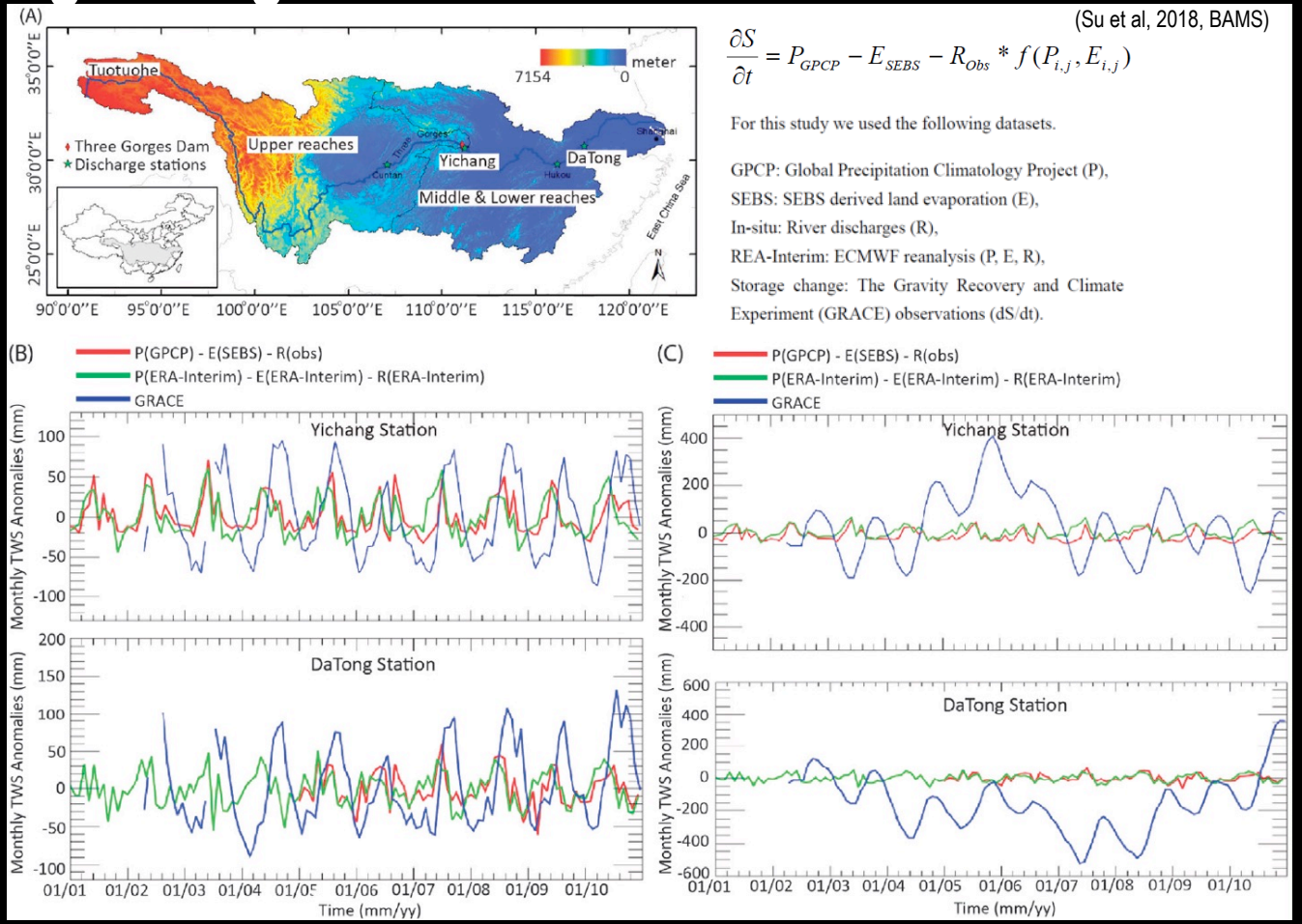
- The TWS results derived from the observation data and from ERA-Interim data are consistent with each other, indicating both datasets capture the surface dynamics of the water cycle fluxes.
- However, the TWS derived from GRACE has somewhat larger amplitudes than those from the observations and the reanalysis data, indicating deep groundwater contributions.

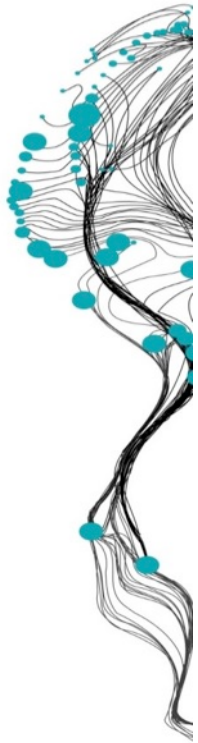
(Su et al, 2018, BAMS)

$$\frac{\partial S}{\partial t} = P_{GPCP} - E_{SEBS} - R_{Obs} * f(P_{i,j}, E_{i,j})$$

For this study we used the following datasets.

GPCP: Global Precipitation Climatology Project (P),
SEBS: SEBS derived land evaporation (E),
In-situ: River discharges (R),
REA-Interim: ECMWF reanalysis (P, E, R),
Storage change: The Gravity Recovery and Climate Experiment (GRACE) observations (dS/dt).





OUTLOOK

- Process understanding based on measurements and modeling is of primary importance in land-atmosphere interactions:
  - Cal/Val needed to assure the stability and truthiness of satellite observations, retrievals and reanalysis
  - Spatial scaling remains a challenge – what is the scale of interest? Is there a scaling law across scales?
  - Modeling and DA remains indispensable in understanding and efficient use of (satellite) observations and retrievals
  - ESM needs to consider the land-atmosphere interactions in a dynamic manner instead of the current focus in parameterization