→ 6th ESA ADVANCED TRAINING COURSE ON LAND REMOTE SENSING

Earth observation of water resources

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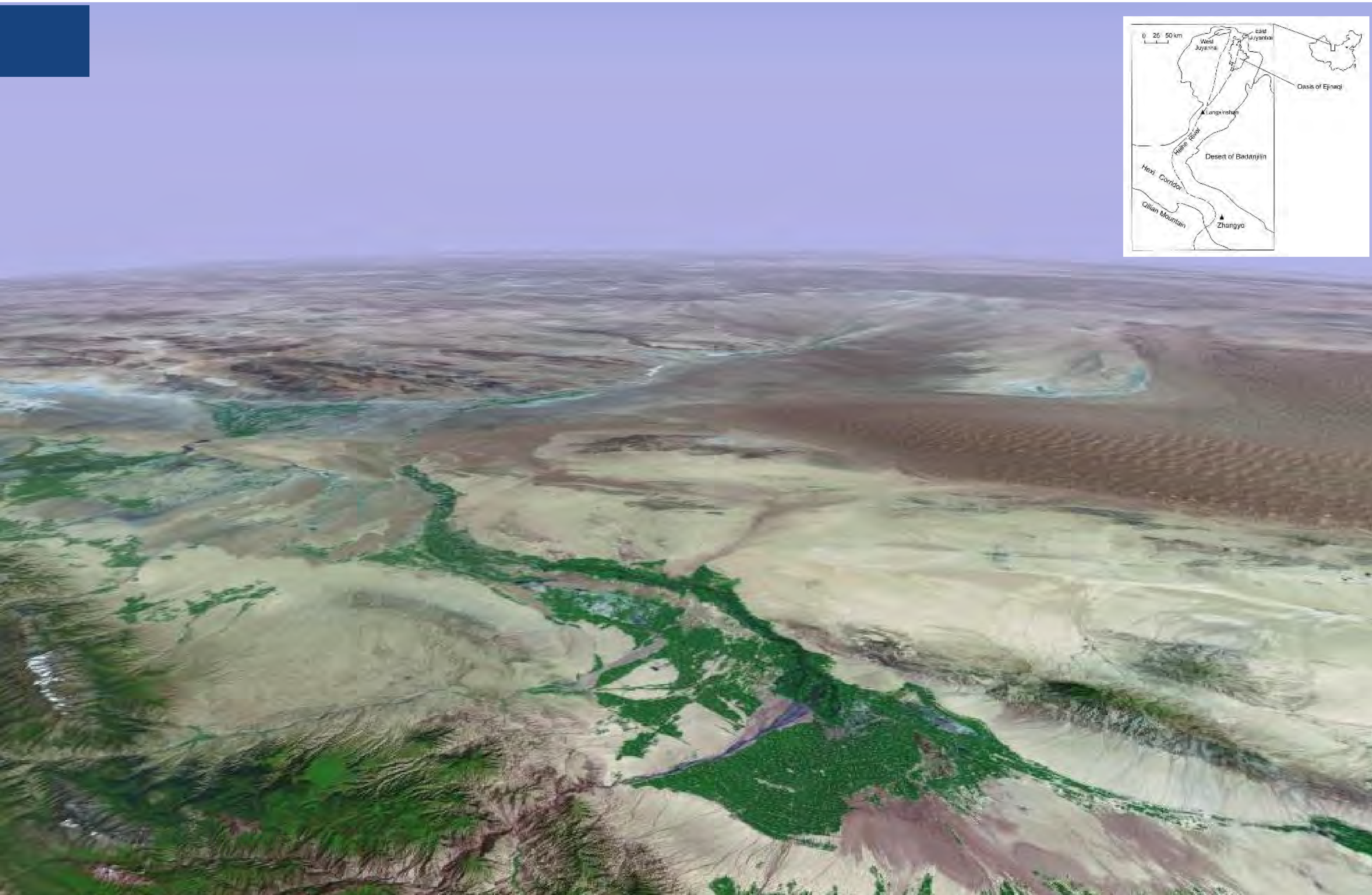
Heihe River Expedition 2006



What is the problem?

What had gone astray?

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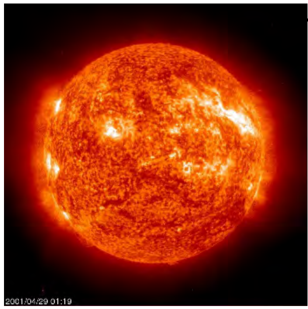
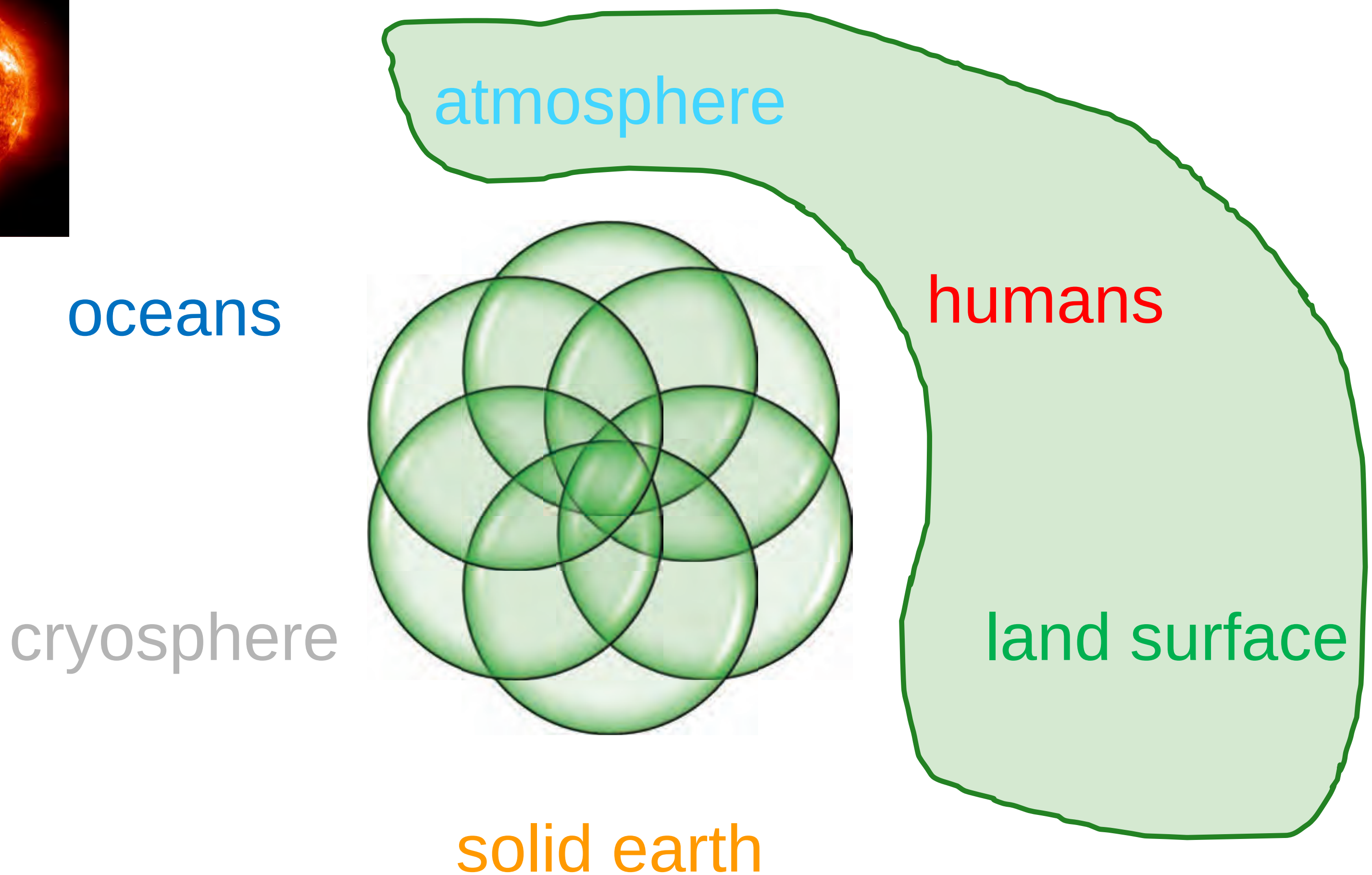
WATER DISASTERS

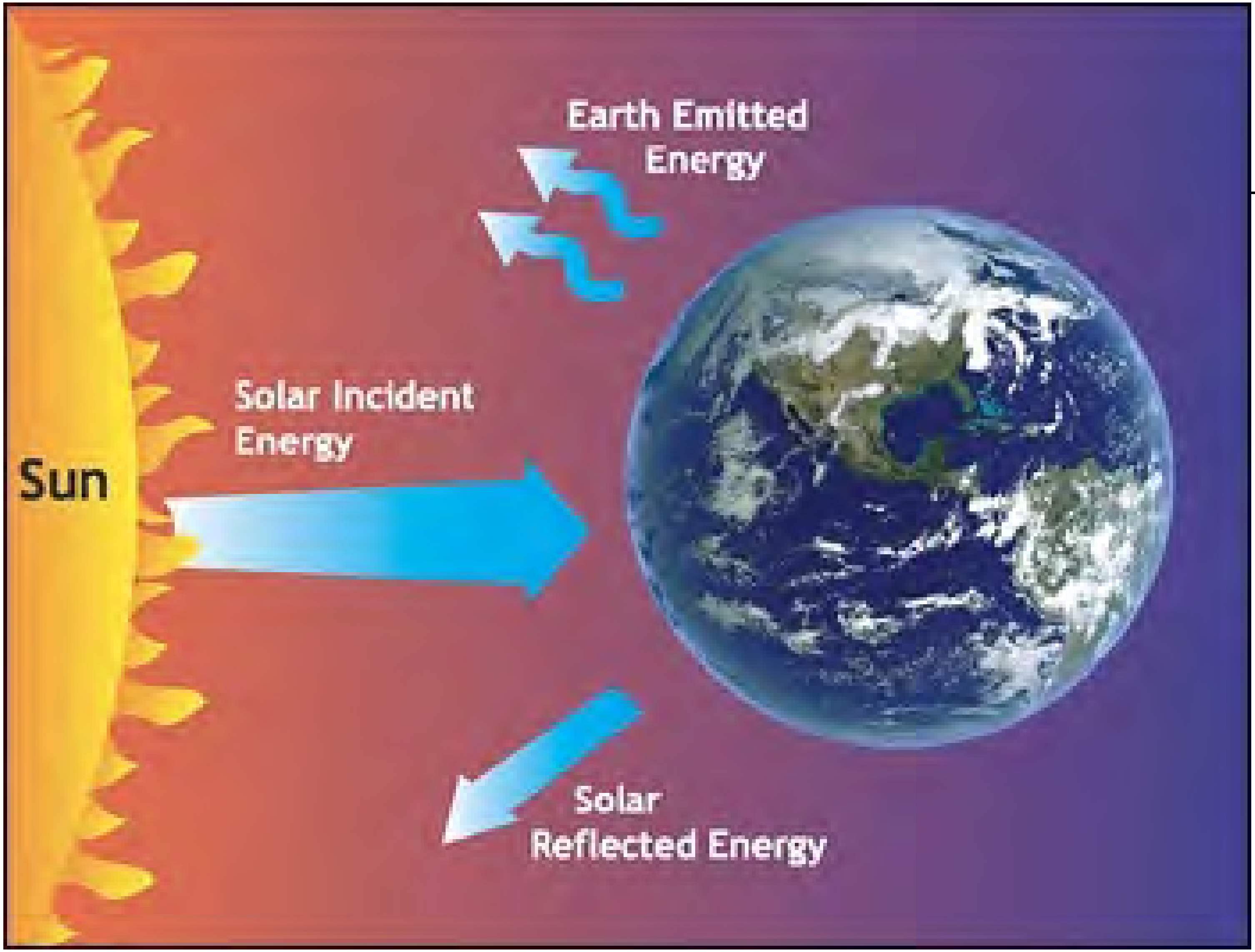
The Earth system
- Hydrosphere, Atmosphere, Anthroposphere, Biosphere, Cryosphere and Geosphere

(oceans, atmosphere, humans, land surface, cryosphere, solid earth)



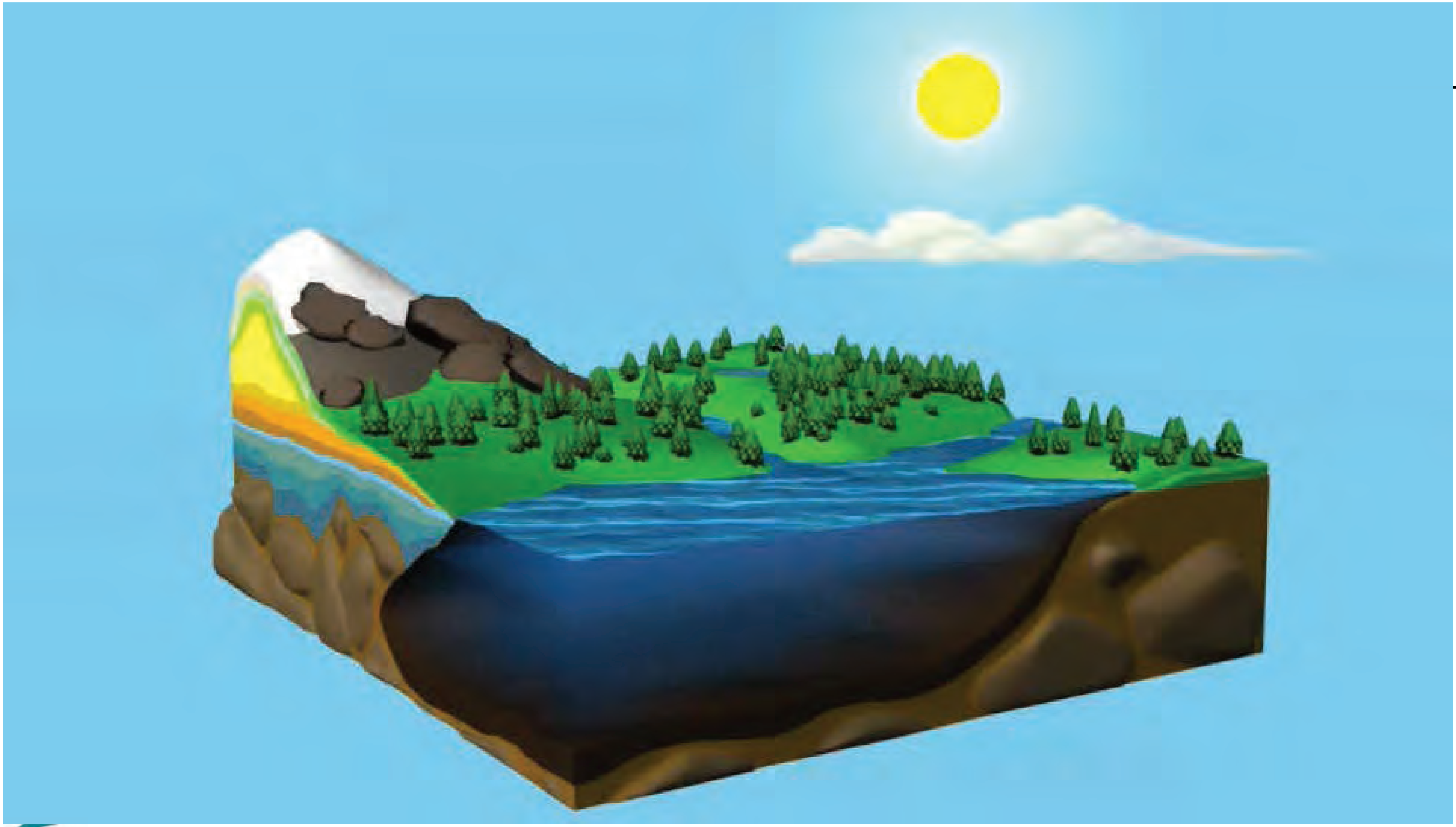


Let there be light - the external solar driver

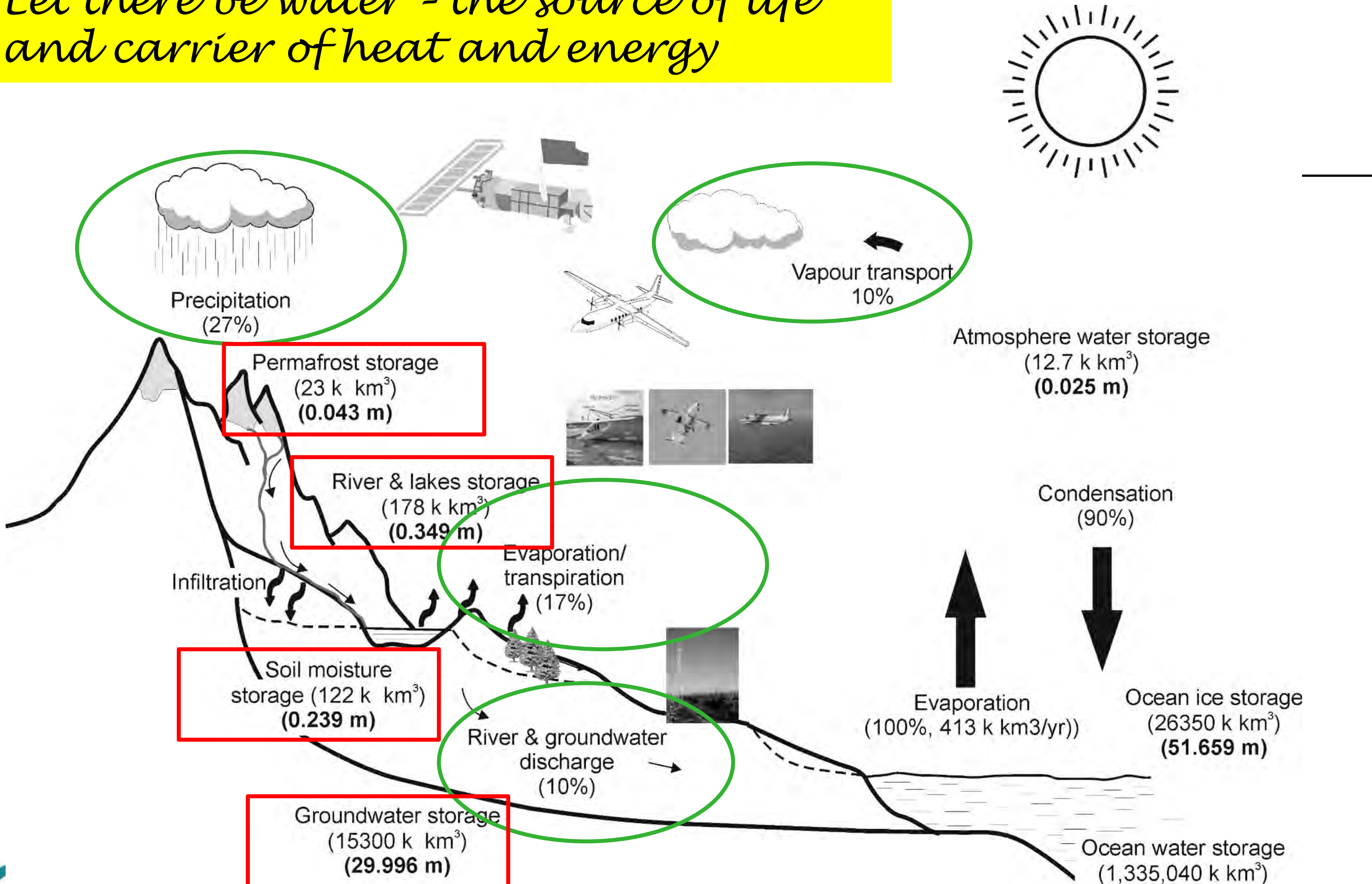


(NASA)

Let there be water cycle



Let there be water - the source of life and carrier of heat and energy



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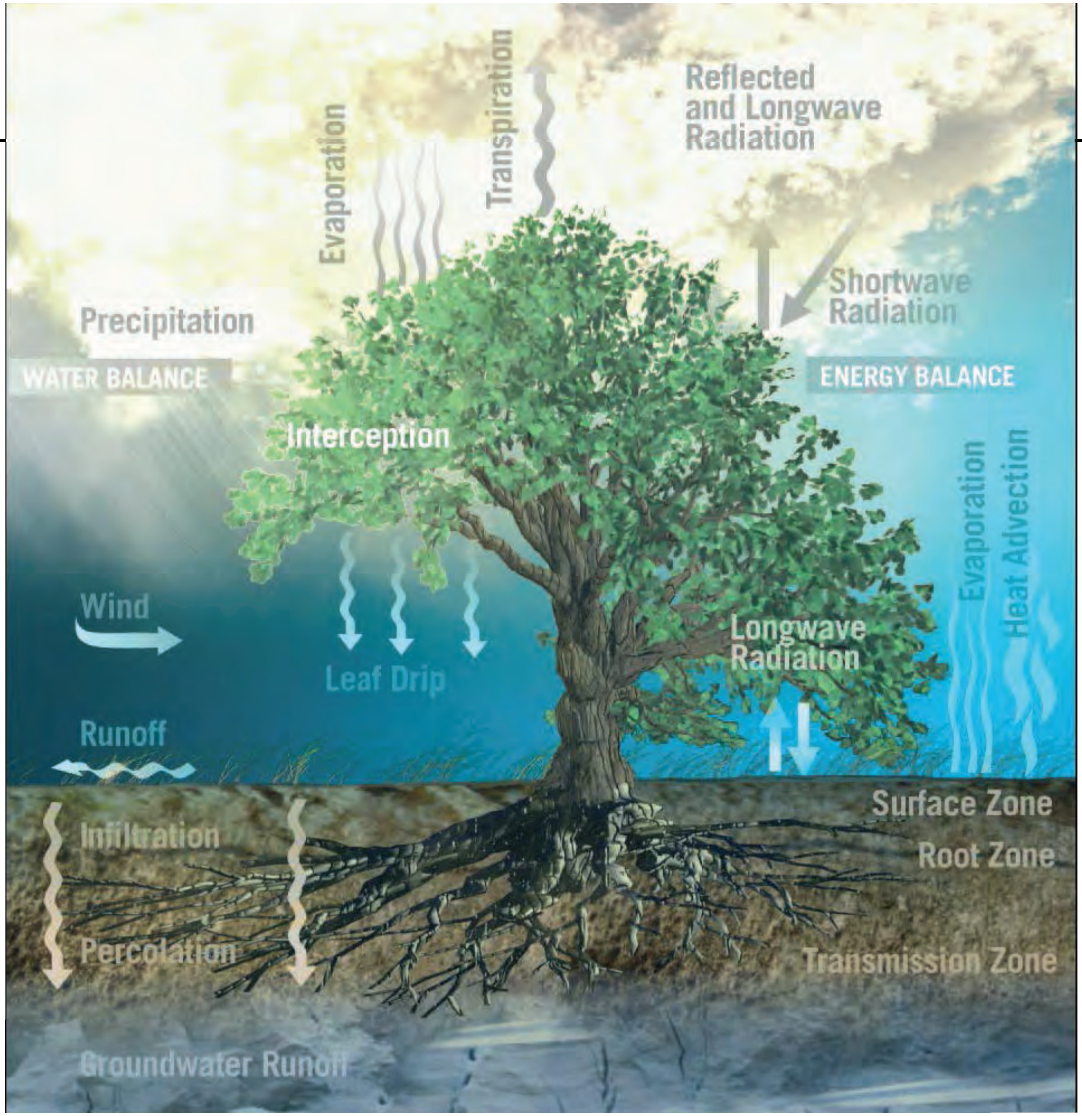
Water Cycle (Su, et al., 2010)

Let there be interactions - energy, water and carbon

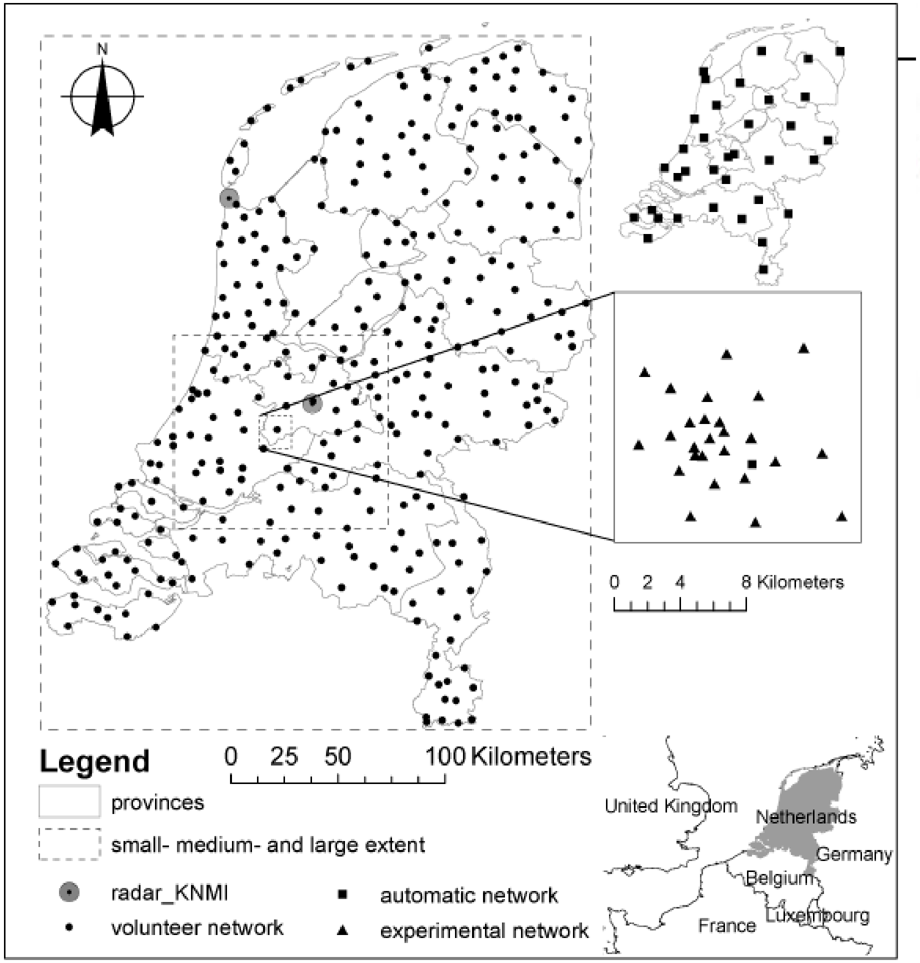


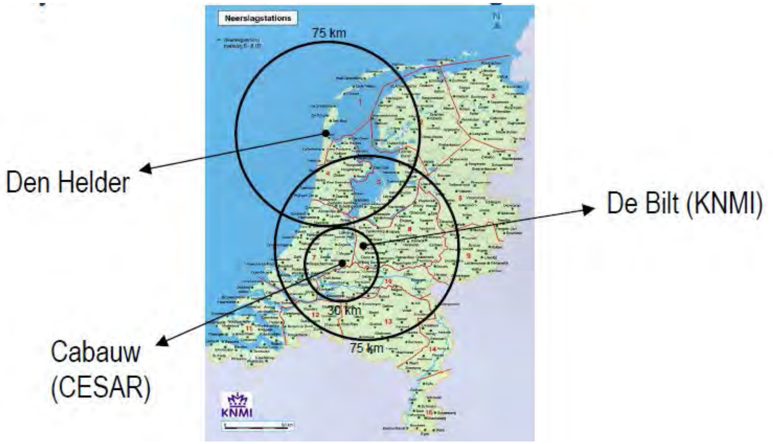
(ESA)

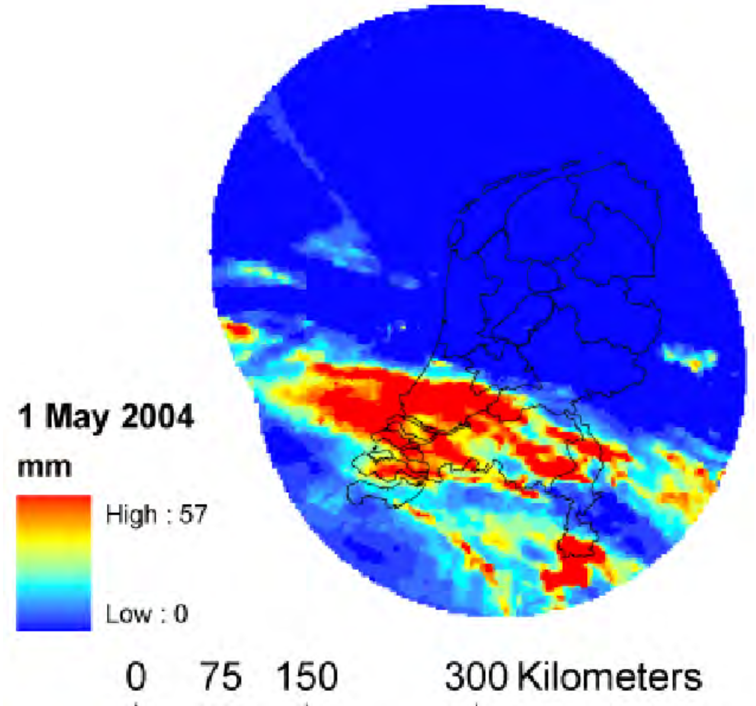
Precipitation - measurements and estimates

Part I - In-situ measurements
Part II - Radar measurements
Part III - Satellite estimates

I. Operational rainfall data (KNMI) in the Netherlands

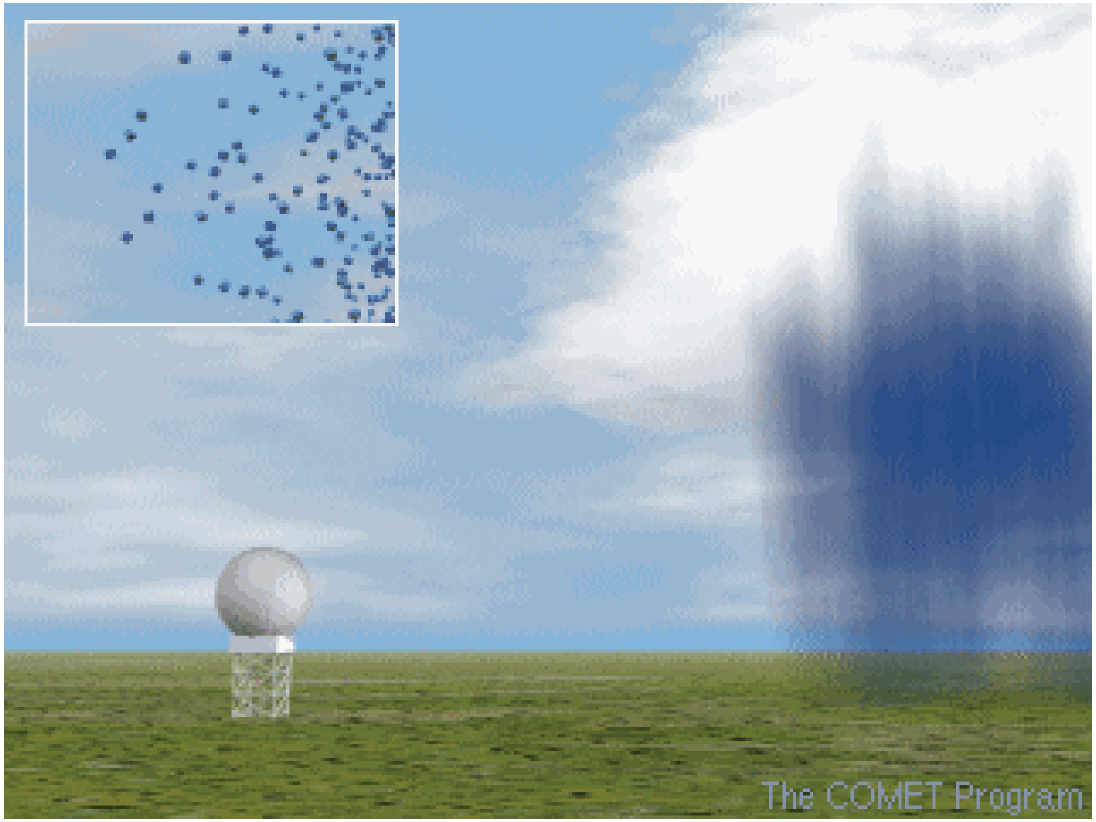




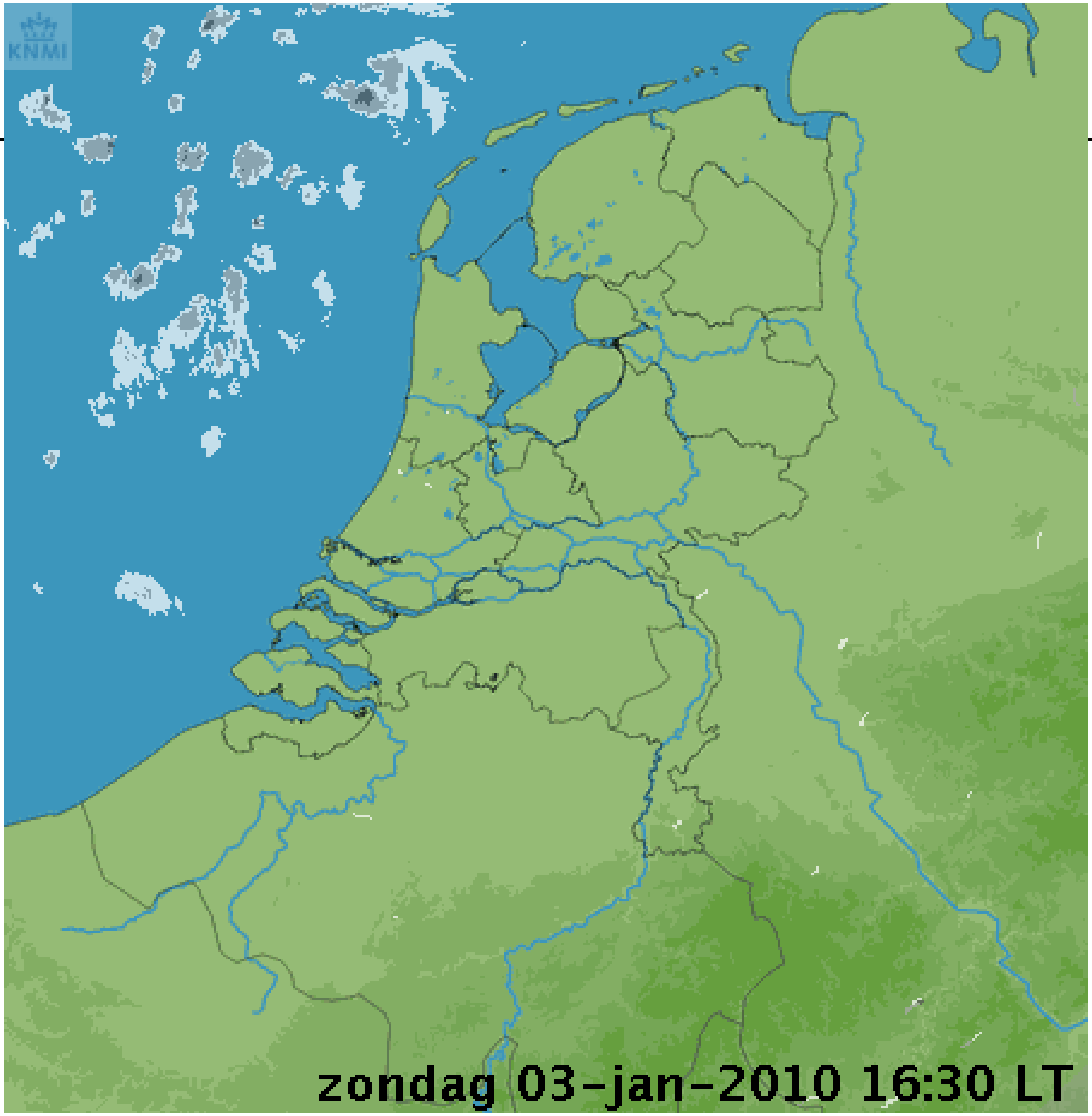


II: Radar—radio detection and ranging

- An electronic instrument used for the detection and ranging of distant objects of such composition that they scatter or reflect radio energy.

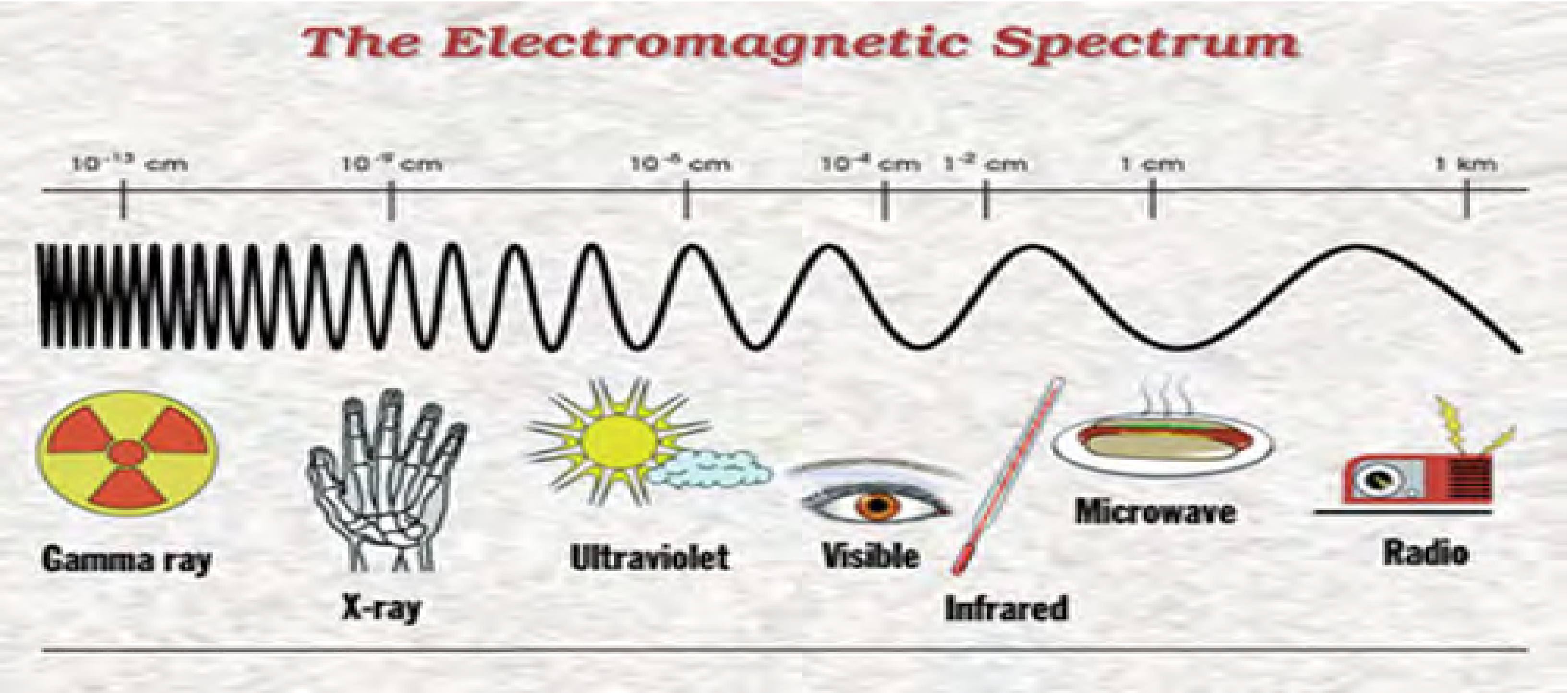


II: Radar - Operational rainfall data (KNMI) in the Netherlands

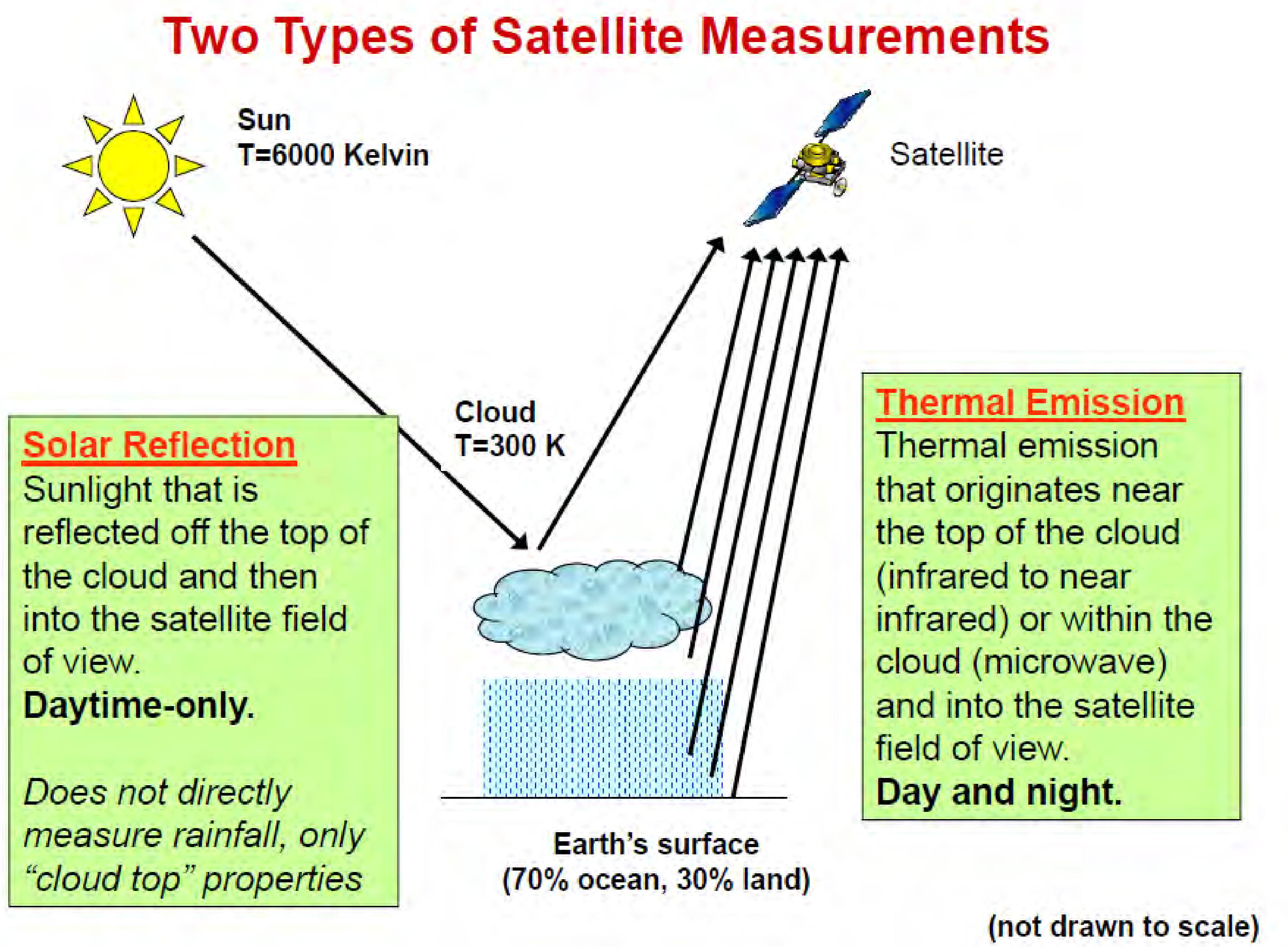


III: Satellite observations

Basic measurement principles



Passive satellite measurements



Global Precipitation Measurement

Core Observatory

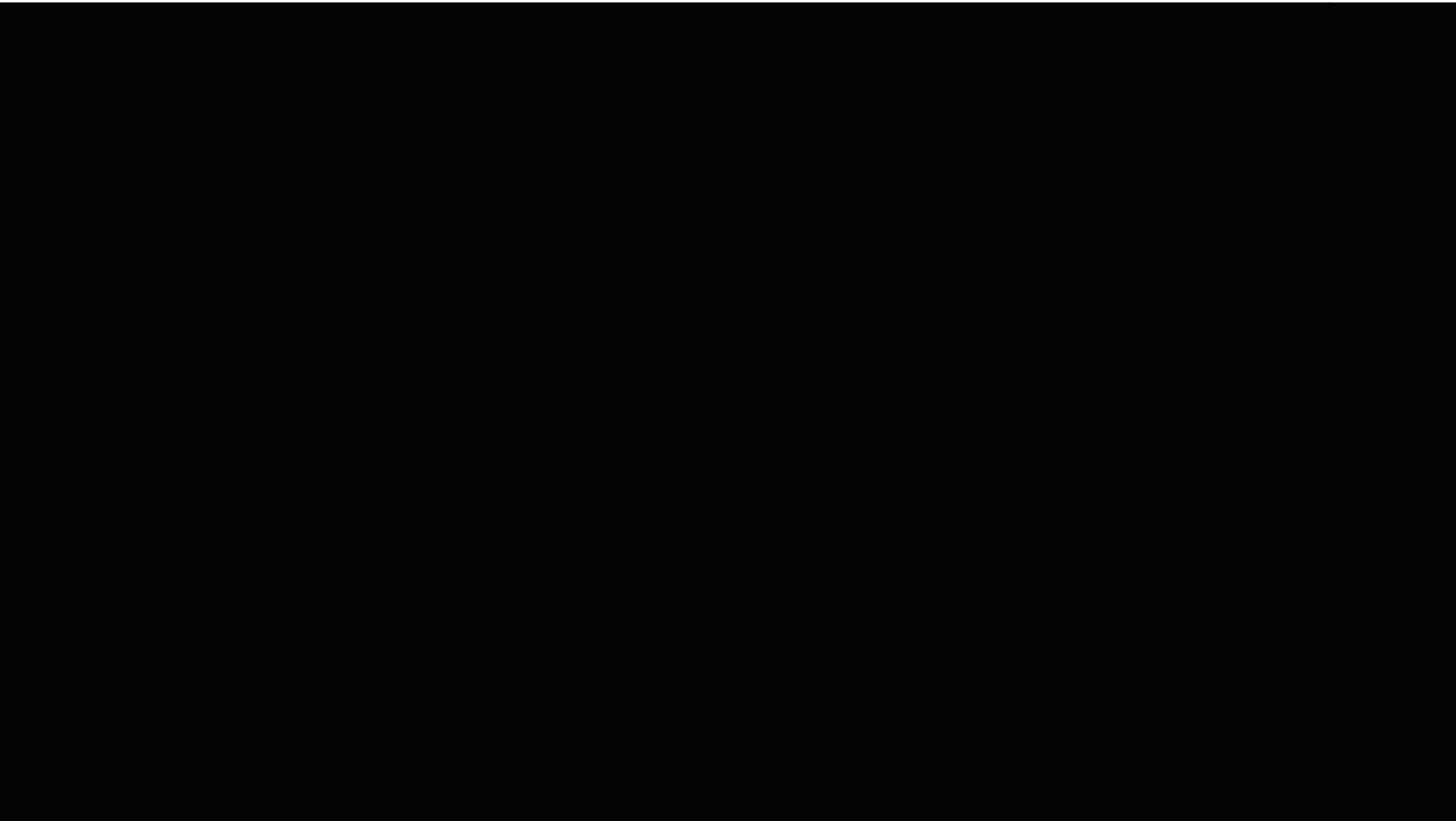
A SNOW OBSERVED BY GLOBAL PRECIPITATION MEASUREMENT (GPM)

(NASA)

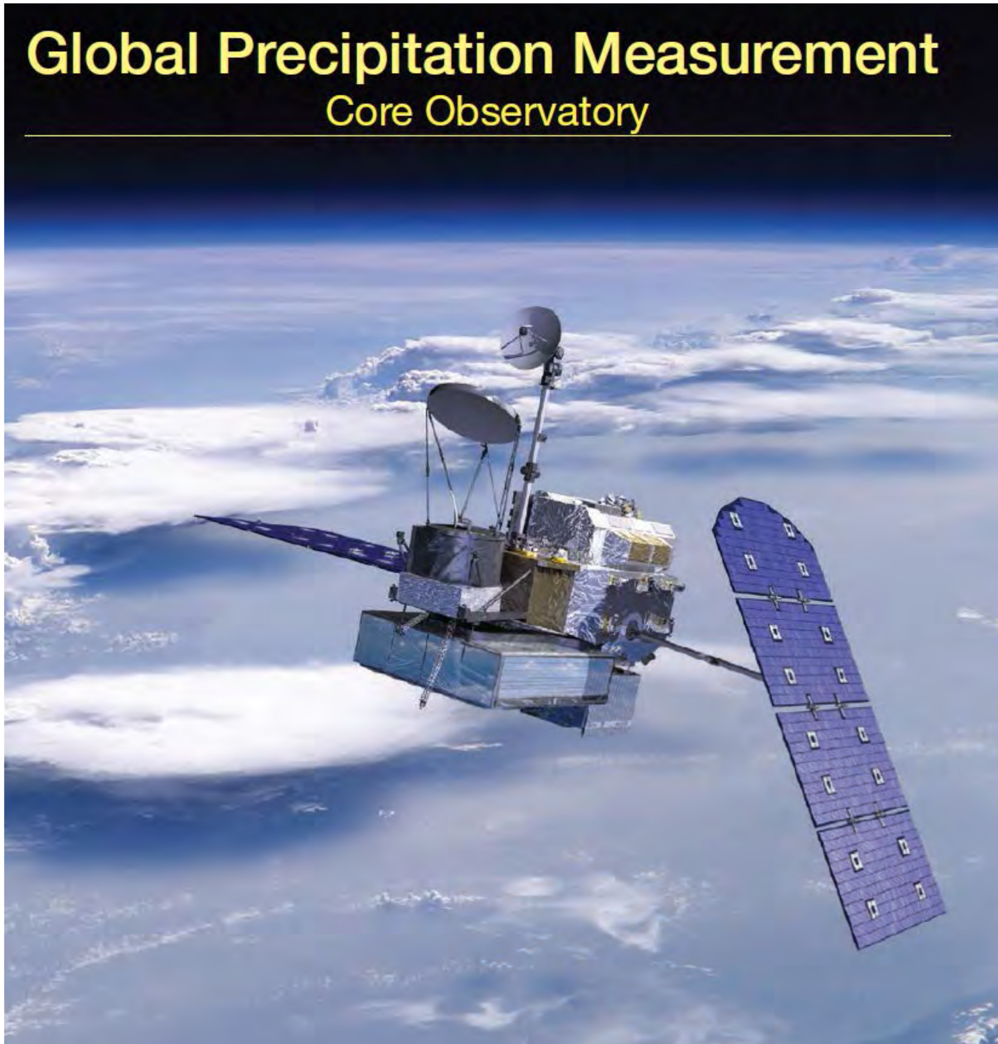
GPM INSTRUMENTS

(NASA)

FLOODS & DROUGHTS



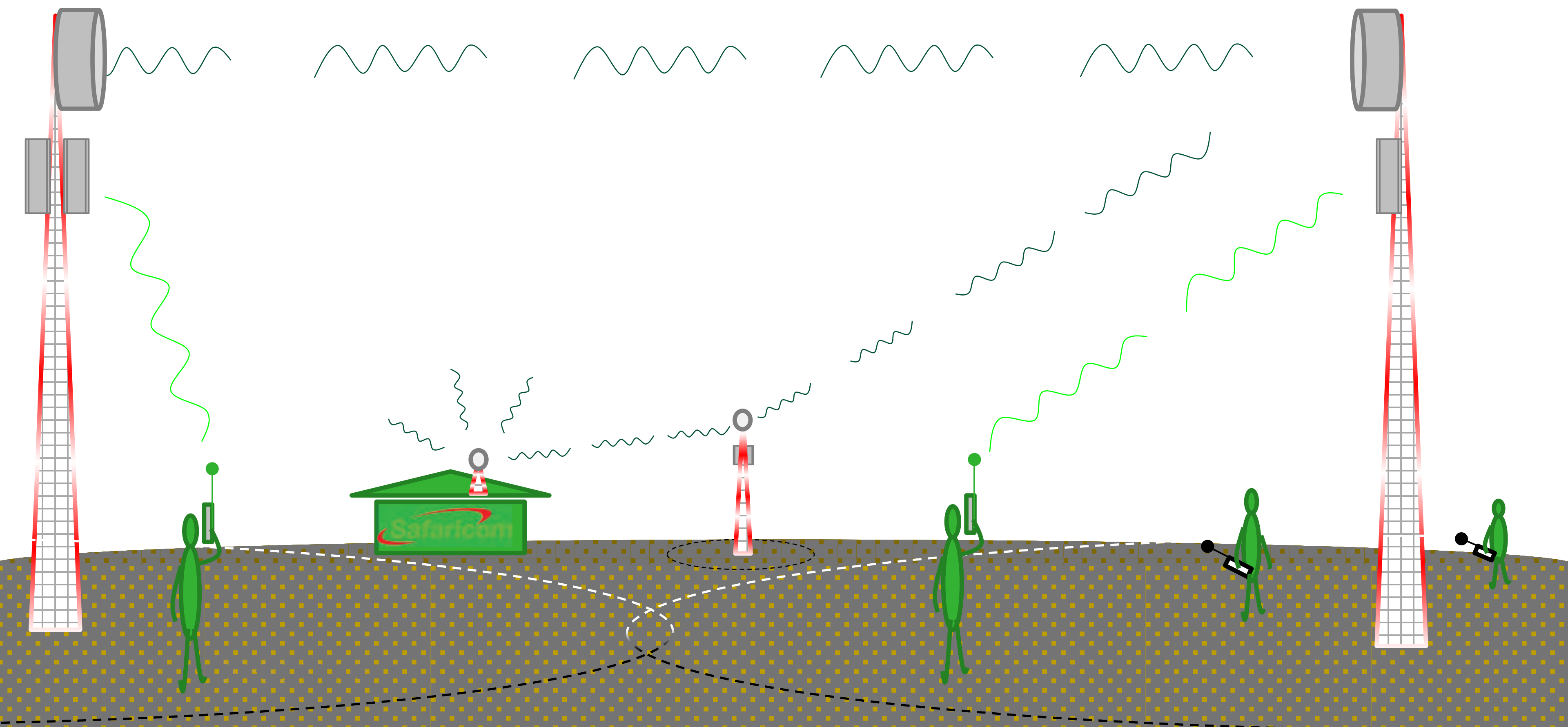
(NASA)



What if we link these techniques ?

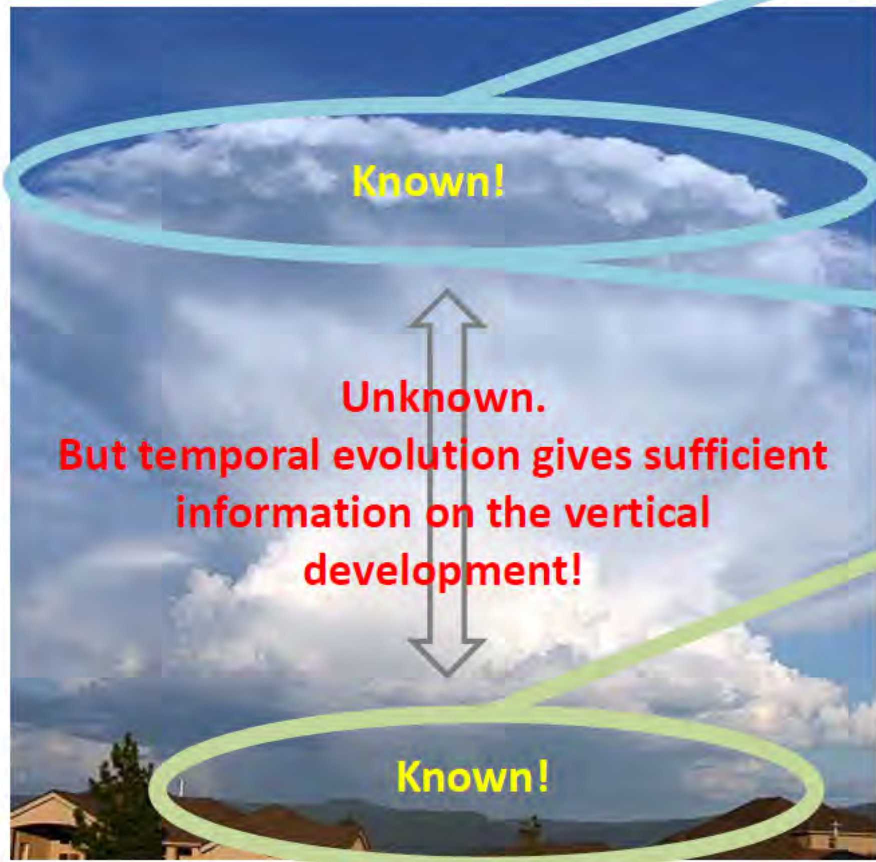
Mobile telephone networks

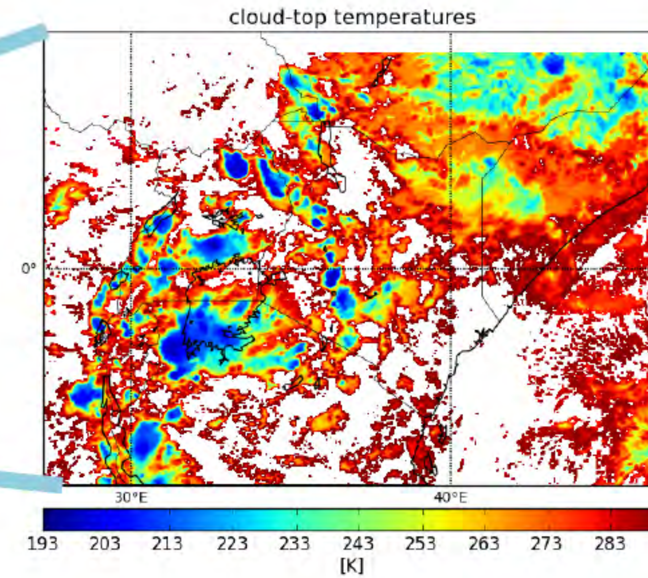
-Terrestrial microwave links (and/or fibre optic cables) link up all network cells;
-One GSM tower in the middle of one network cell;
-Provider knows how many of their subscribers in each cell at any time;
-Calls are routed through the provider’s (central) NMS to specific cell;
-Network Managment System monitors network performance (centrally).

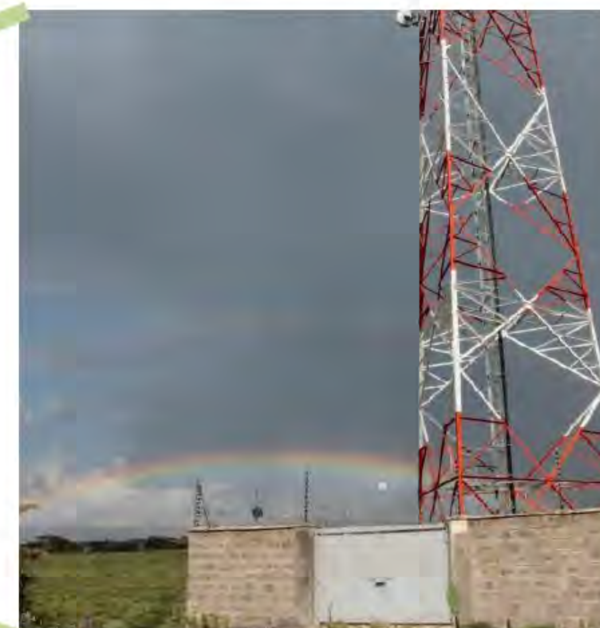


Combining Observations

Matching scales of Observation

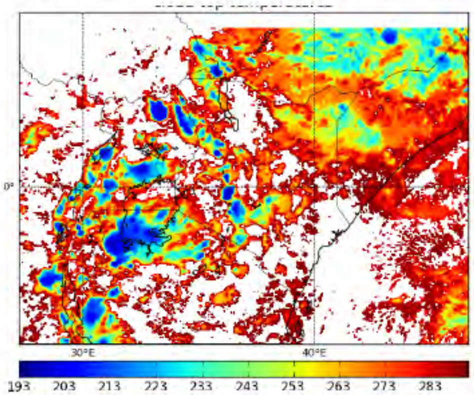




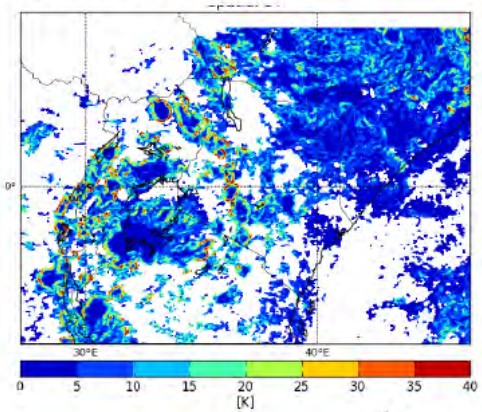


Rainfall Observations

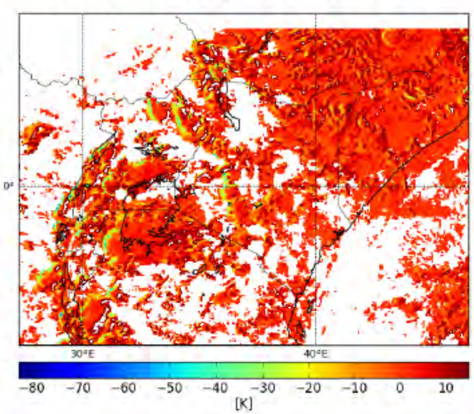
Cloud Top Temperature



Spatial gradient CTT



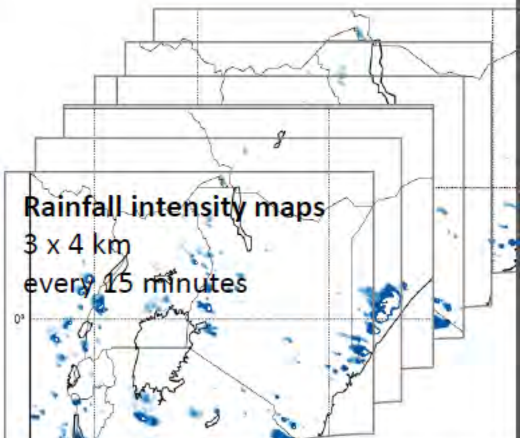
Temporal gradient CTT



hh:00, hh:15, hh:30, hh:45
x 8 infrared channels

hh:00, hh:15, hh:30, hh:45
n Microwave links

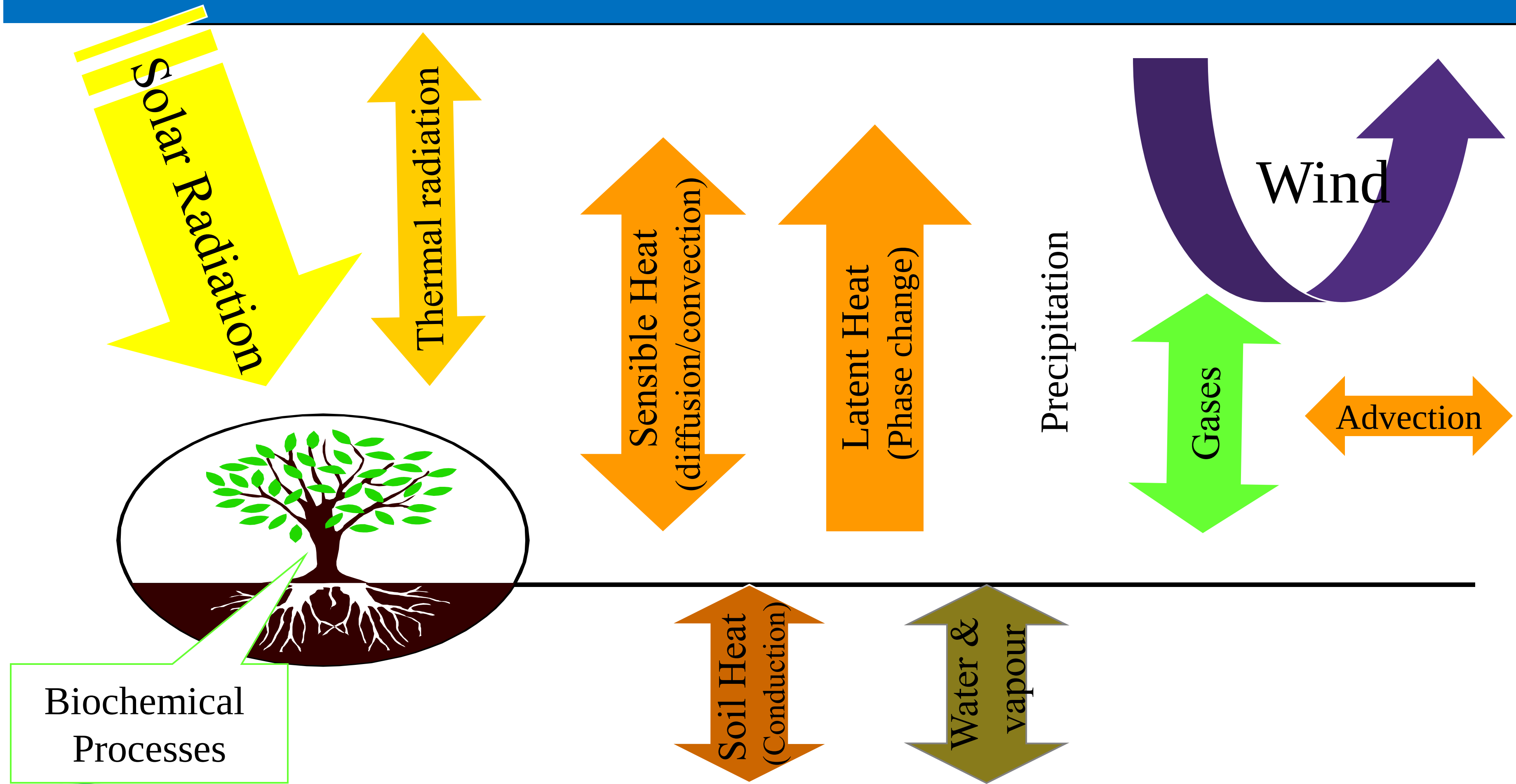
Empirical Grey Box



Calibration and Validation of algorithm to start during 2013 long rains. Experimental measurements to take place during each rainy season after that.

Hoedjes et al., 2015

Evaporation
Land-Atmosphere Interactions
- Terrestrial Water, Energy and Carbon Cycles



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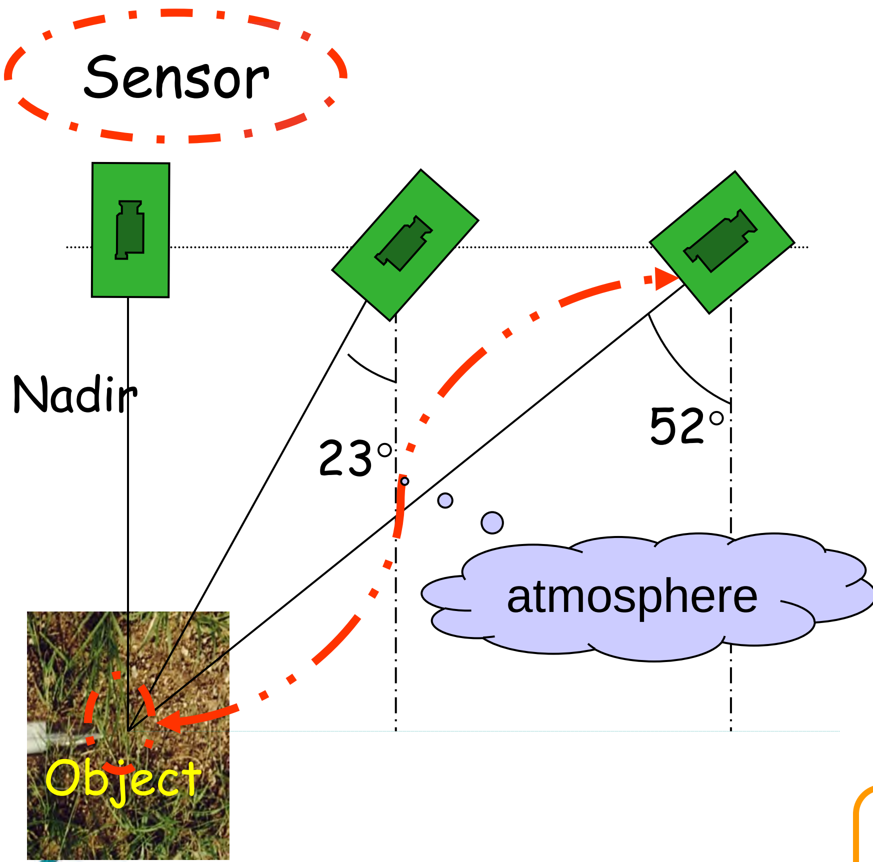


Sensor Response

A. How much radiation is detected?

B. When does it arrive?

Object Properties:

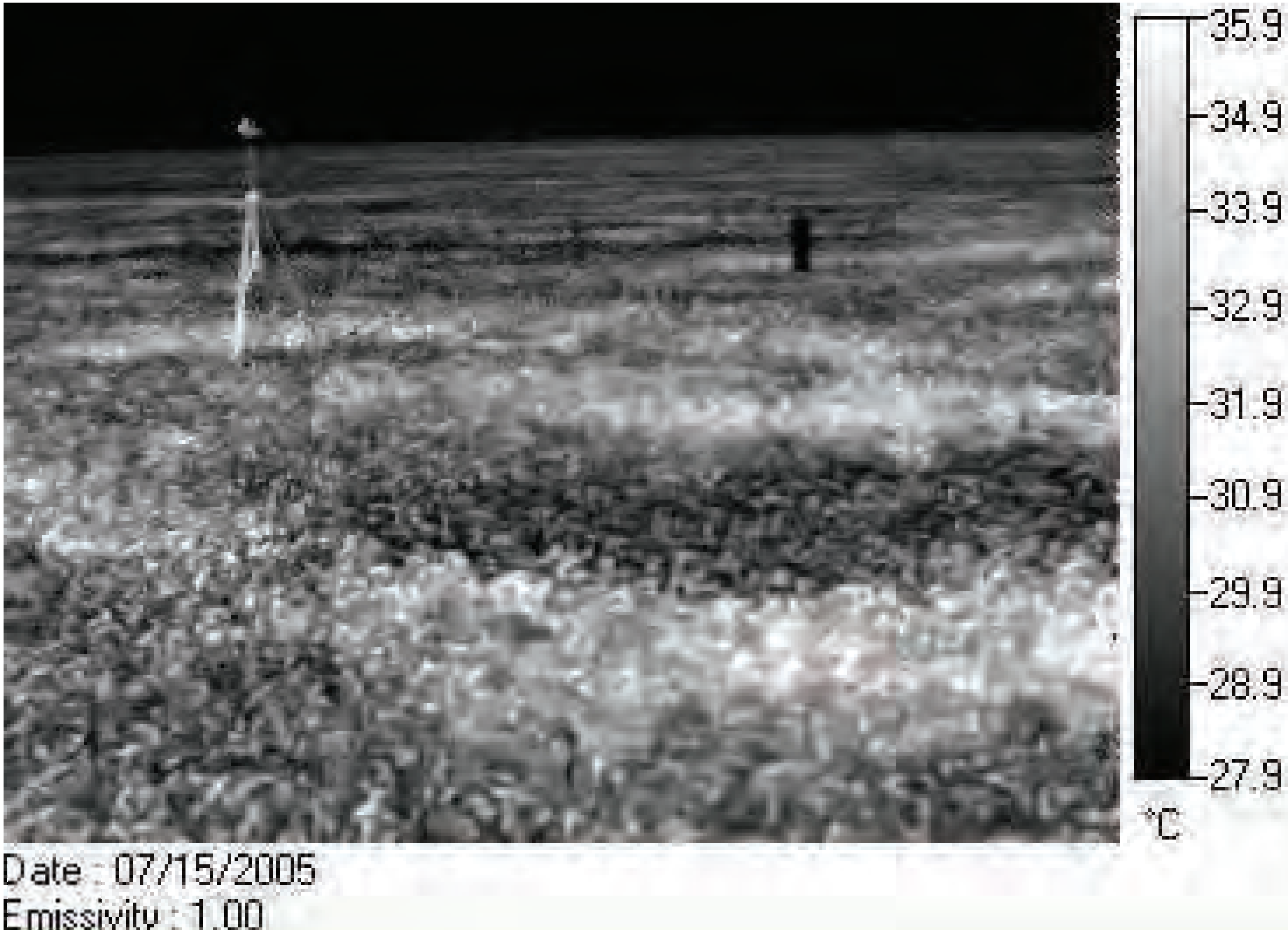
Its range, its combined temperature & emissivity (or reflectivity) at different times, at different spatial resolution, at different wavelengths, at different direction, at different polarization

A: A Passive Sensor System

A+B: An Active Sensor System

The Fundamental of Earth Observation

(from radiometric observations to quantification of processes in turbulence, thermodynamics and fluid dynamics at different scales in space and time)



Credits:

Editors:
Lee Balick &
Chris Jeffery

Camera:
Alan Gillespie

Director:
Lee Balick

Actors:
the wheat field et al. in Barrax, Castilla - la Mancha, Spain

Producer:
University of Valencia (Spain) & ESA

(Su et al., 2008, IJRS)

Schematic representation of SEBS

(Radiometric observables) (r_0, T_0),

(RS observables or estimates) (f_c, LAI, h_c),

(Surface observation, radiosonds, NWP fields) (T_{PBL}, V_{PBL}, P_{PBL}, q_{PBL}, R_s, R_{ld})

↓

Preprocessing to derive radiation balance terms

↓

Submodel to derive roughness length for heat transfer
(Su, Schmugge, Kustas, Massman, 2001)

↓

Submodel to derive stability parameters
(ASL scaling or PBL scaling, Brutsaert, 1999)

↓

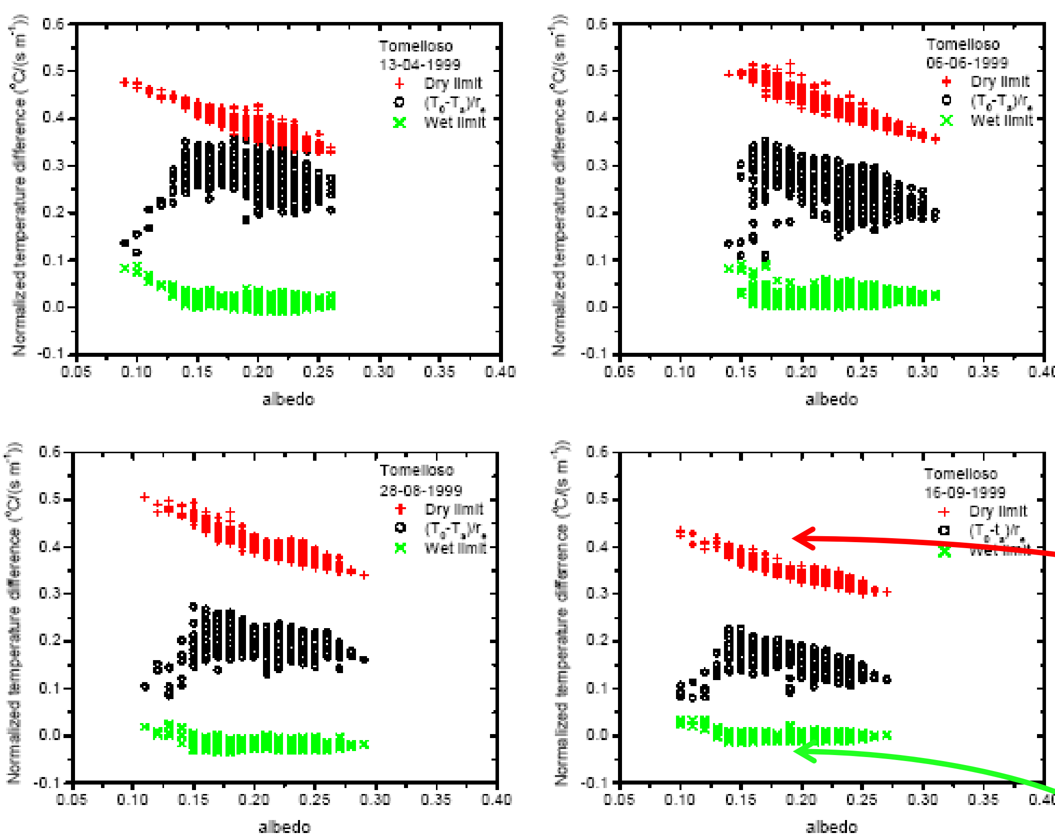
Energy balance at limiting cases
(Menenti, Choudhury,1993)

↓

Energy balance terms
(R_n, G_0, H, λE, Λ)

(Su., 2002, HESS)

Graphical representation of the SEBS equations

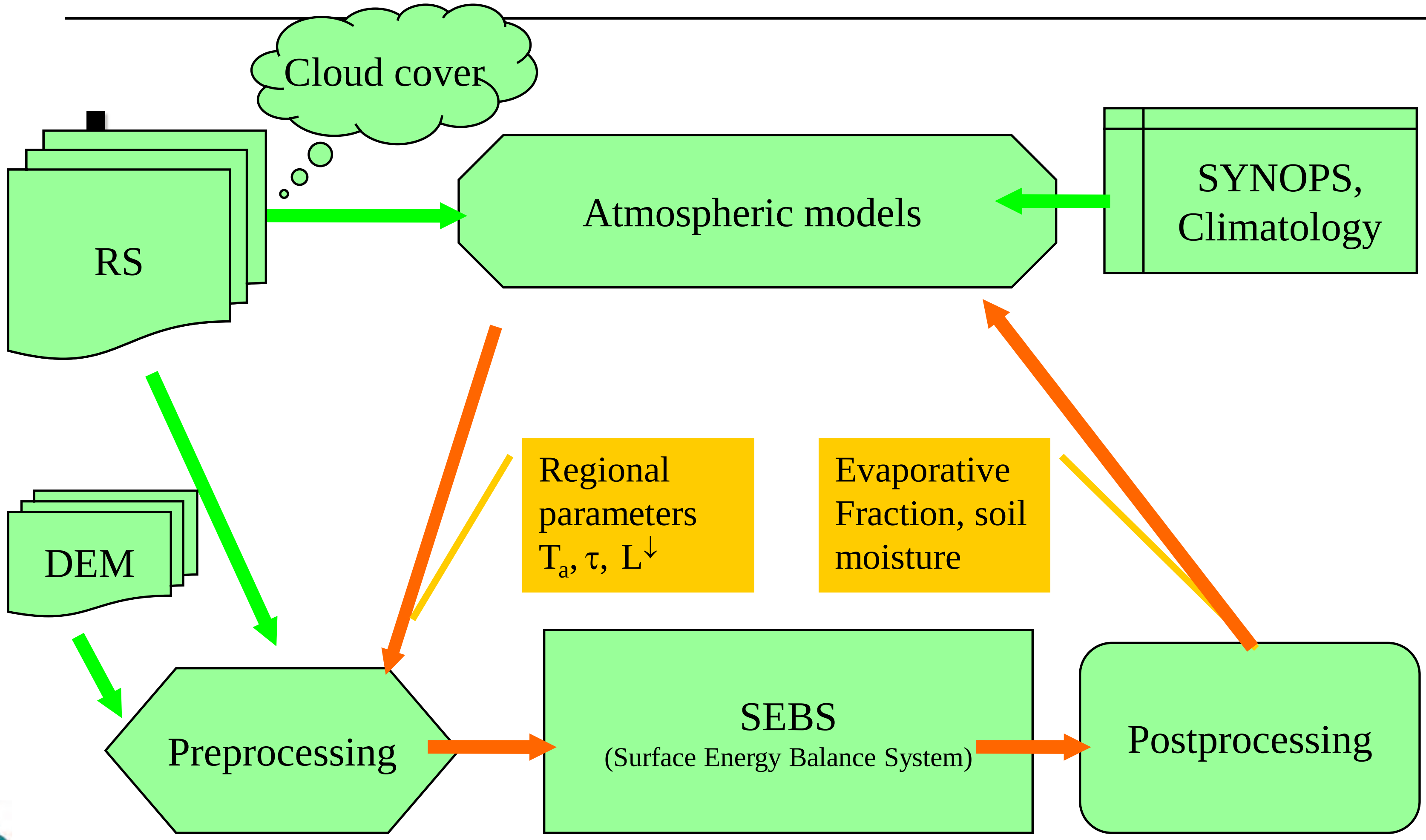


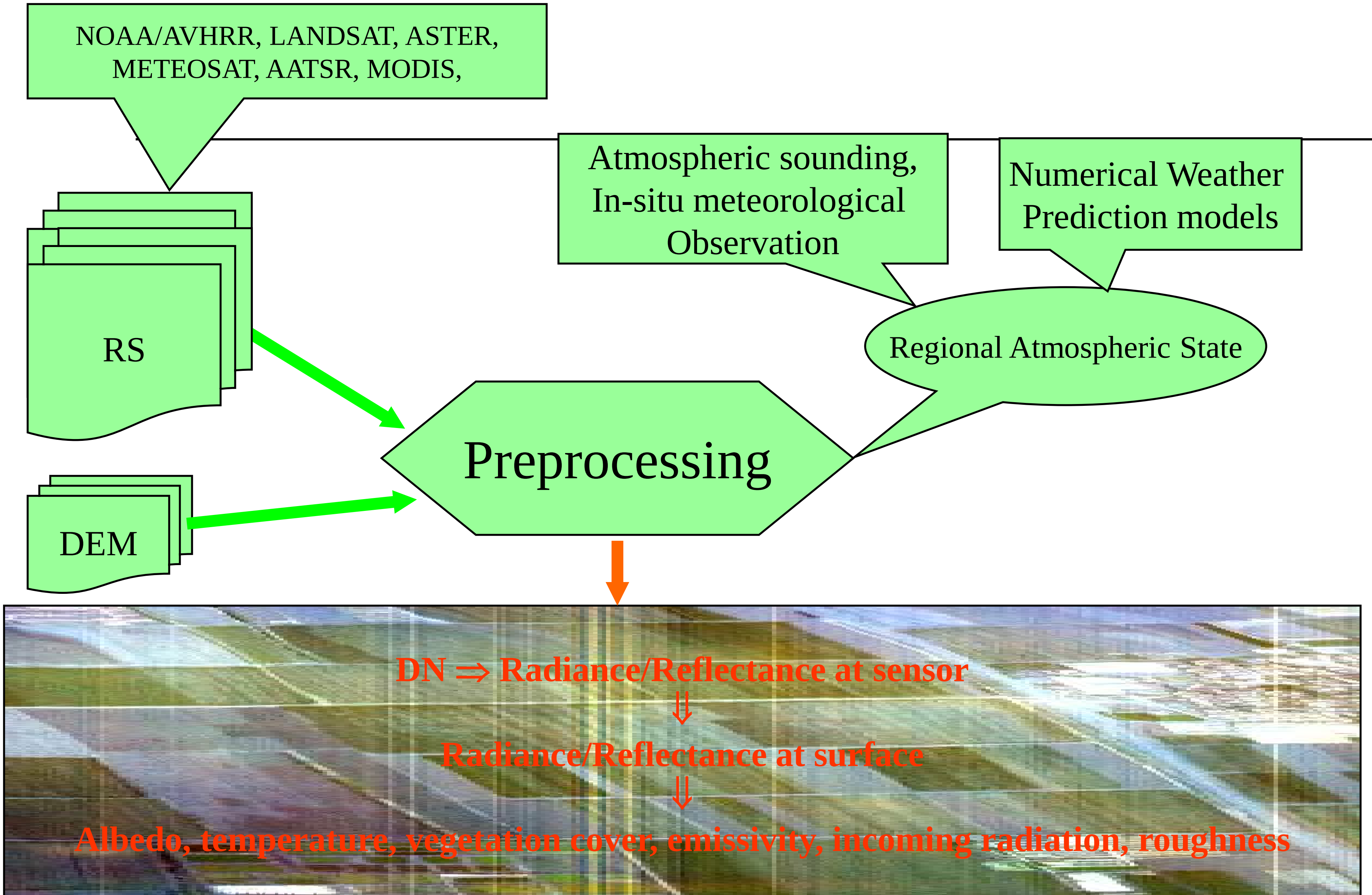
$$\Lambda_r = 1 - \frac{H - H_{wet}}{H_{dry} - H_{wet}}$$

Dry limits

Wet limits

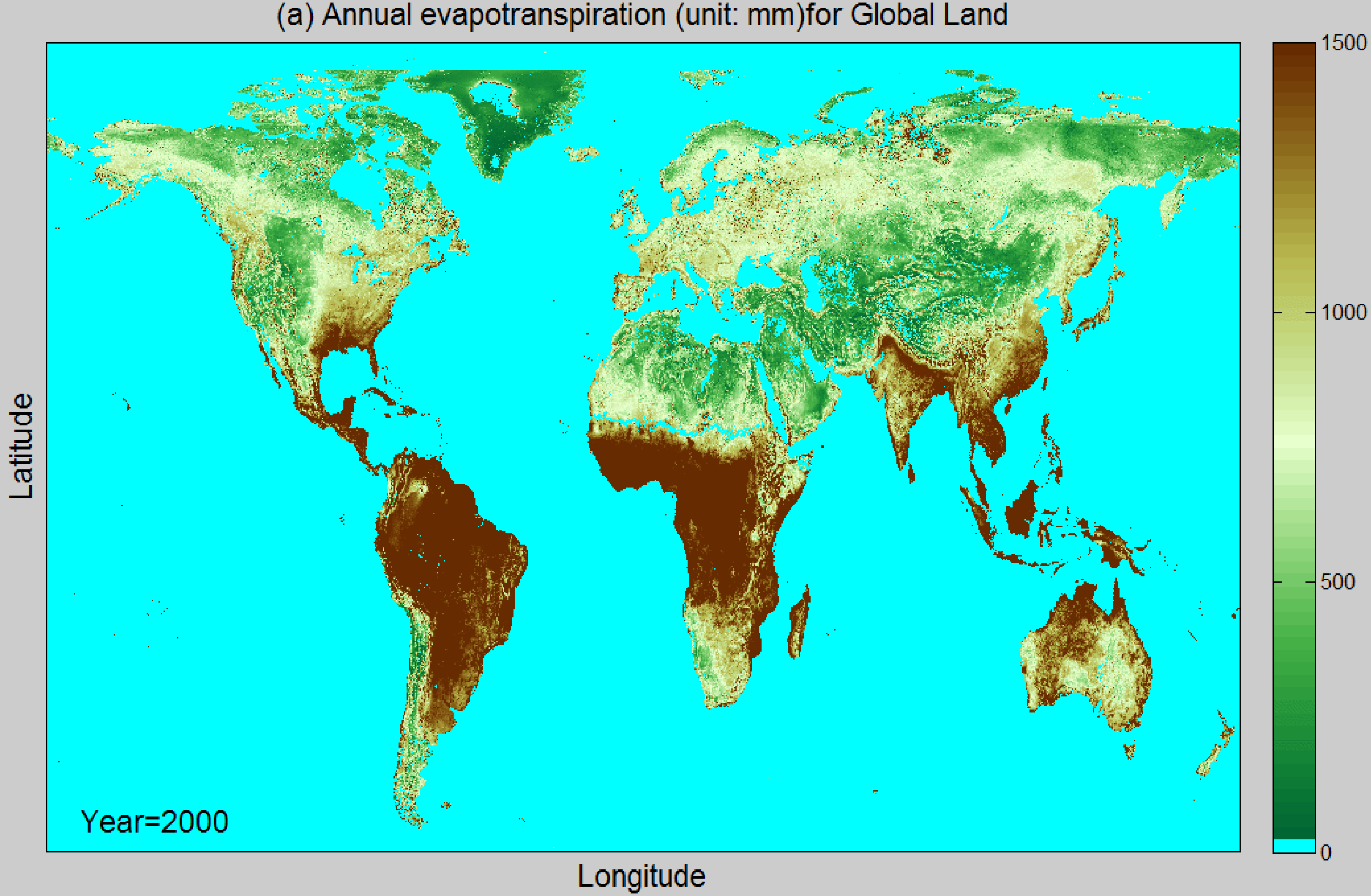
General Methodology




NOAA/AVHRR, LANDSAT, ASTER,
METEOSAT, AATSR, MODIS,
Atmospheric sounding,
In-situ meteorological
Observation
Numerical Weather
Prediction models
Regional Atmospheric State
RS
Preprocessing
DEM
DN ⇒ Radiance/Reflectance at sensor
⇓
Radiance/Reflectance at surface
⇓
Albedo, temperature, vegetation cover, emissivity, incoming radiation, roughness

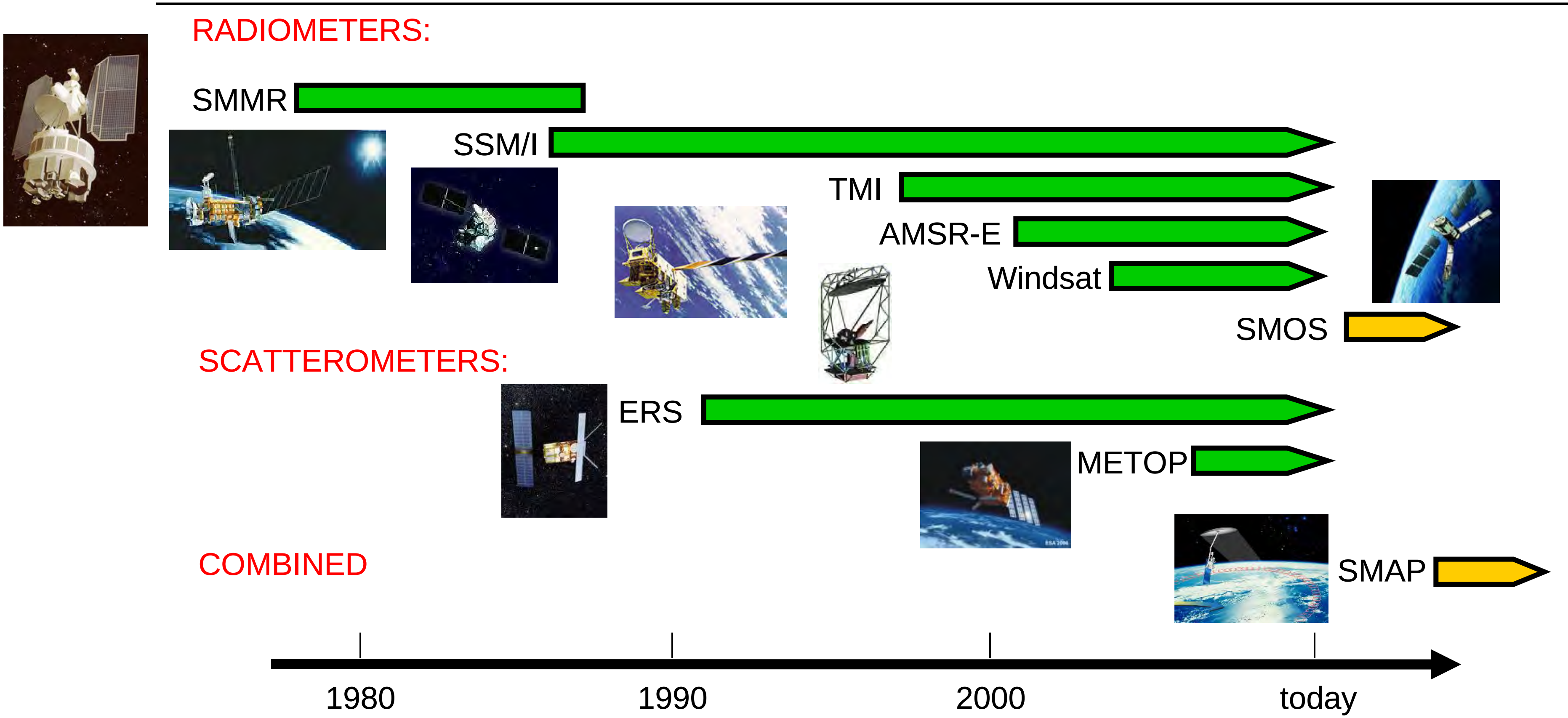
ITC SEBS derived GLOBAL Energy & ET FLUXES

(2000 to near present at 5 km*5 km spatial resolution), data access: linkendin SEBS group



(Chen et al., 2014, ACP)

Soil moisture: Microwave Sensors



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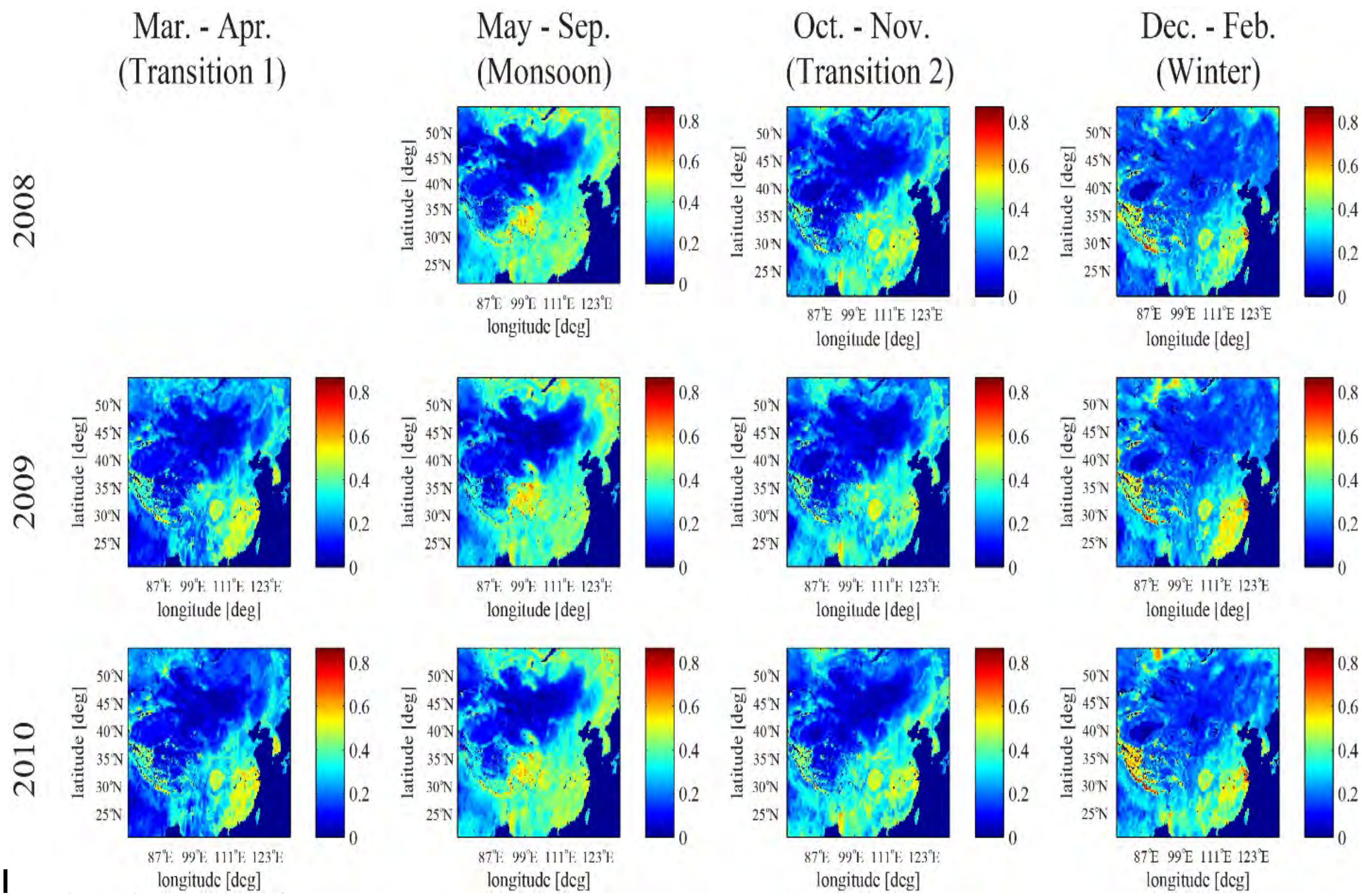
(Source: W. Wagner, R. de Jeu)

NEW: A Combined Soil Moisture Product over China Using Different Sensors (AMSR-E & ASCAT)

(Y. Zeng, L. Dente, L. Wang, J, Wen, Z. Su)

A simple Bayesian based method is used (bias correction & variational method)



The WACMOS global soil moisture product

http://www.esa-soilmoisture-cci.org/node/127

Global monthly averages of soil moisture in the early 1980s in litres per m3, followed by changes in global soil moisture to present. Major anomalies are highlighted, such as the 1992 flooding in Afghanistan, the 2005 drought in the central US, Russia’s heatwave in 2010 and Australia’s floods in Queensland in January 2011.

ITC GEO Soil Moisture Soil Temperature Networks

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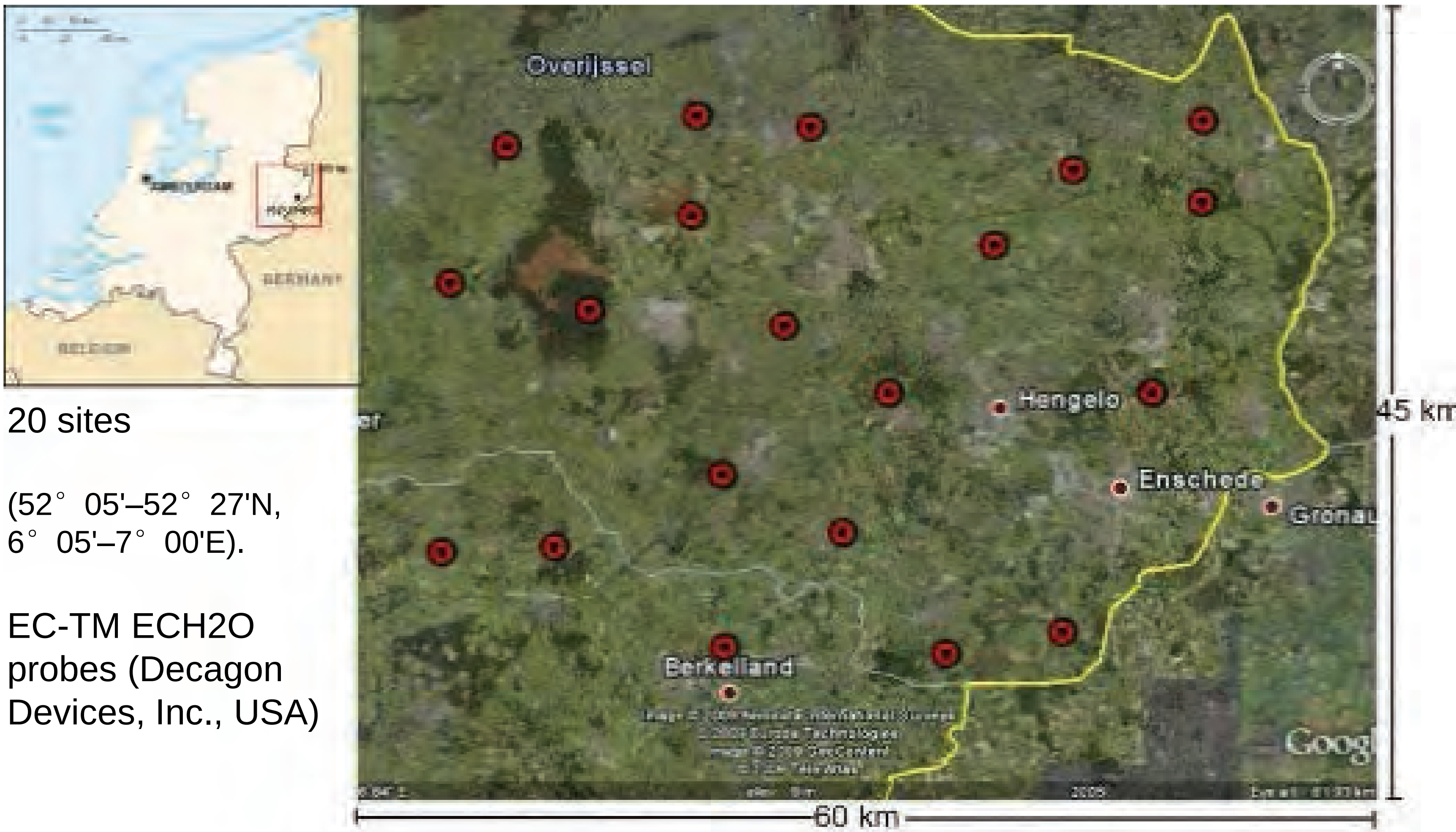
(Su et al., 2011, HESS)

Twente SMST Network – technical details

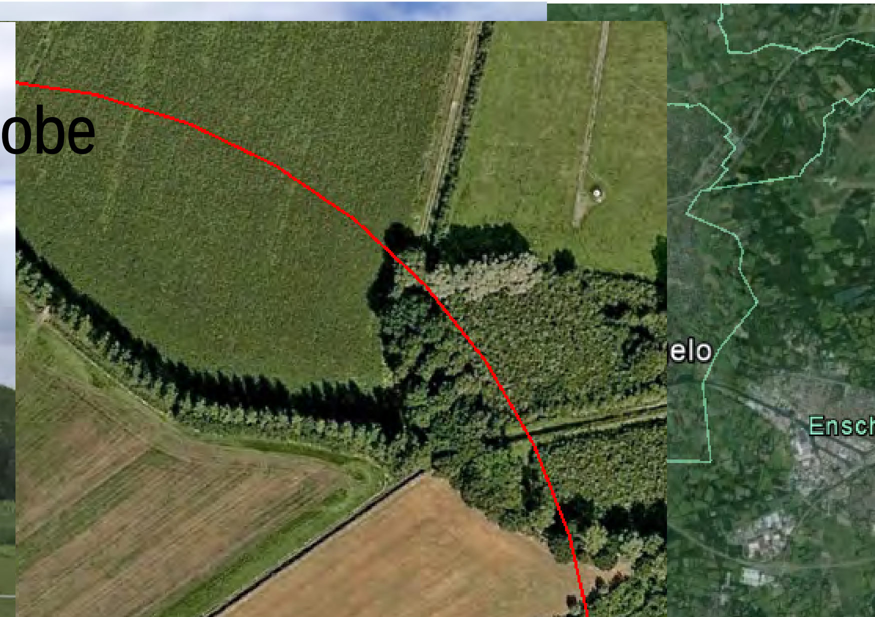


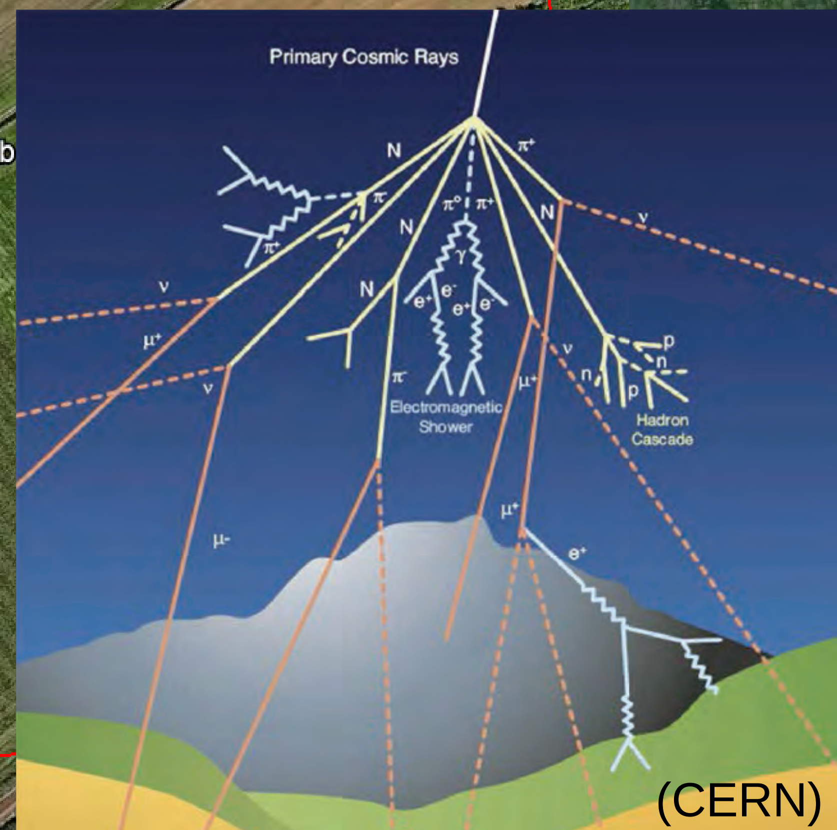
20 sites

(52° 05'–52° 27'N, 6° 05'–7° 00'E).

EC-TM ECH2O probes (Decagon Devices, Inc., USA)

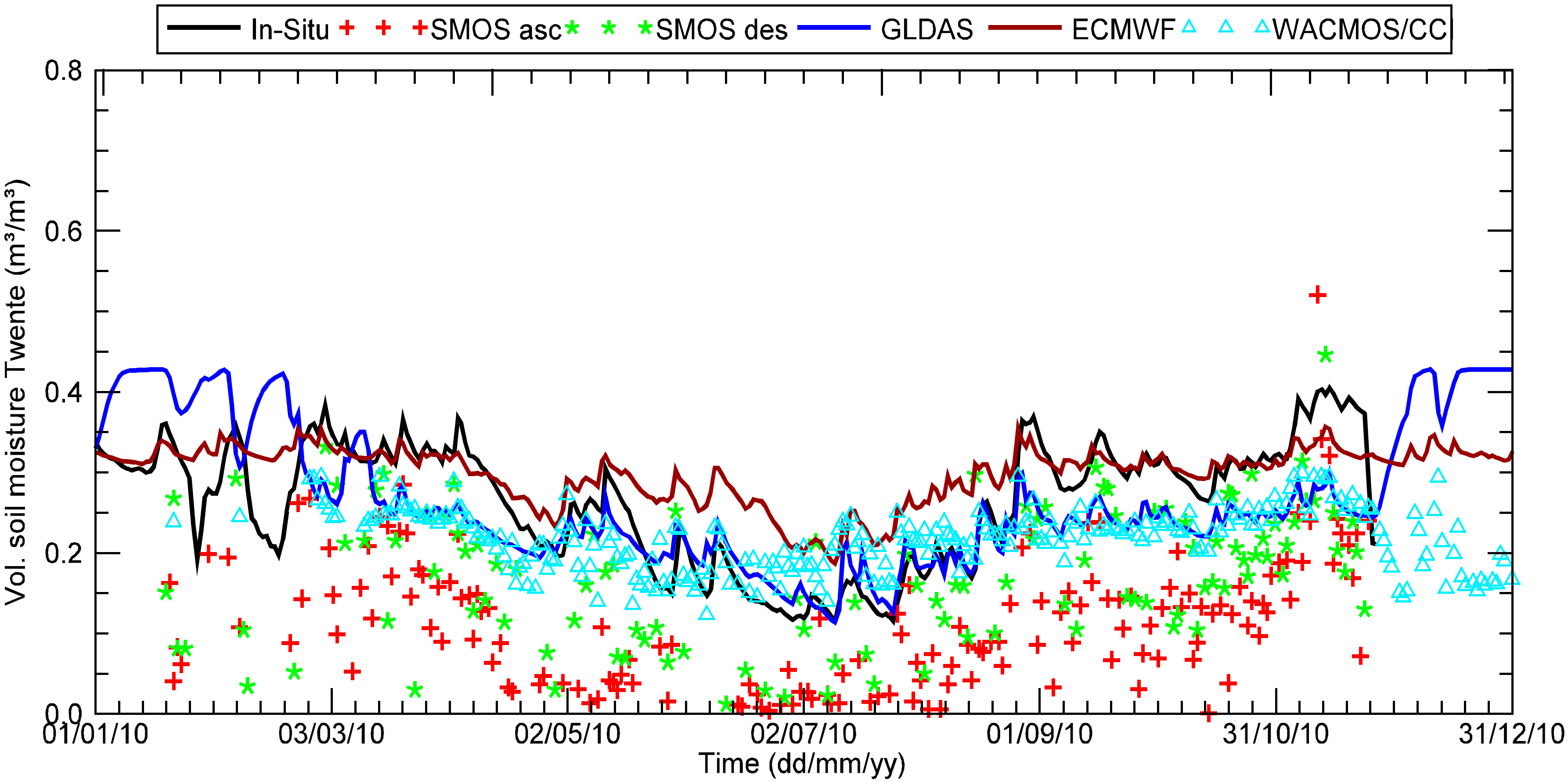
Twente SMST Network – Cosmic Ray Probe



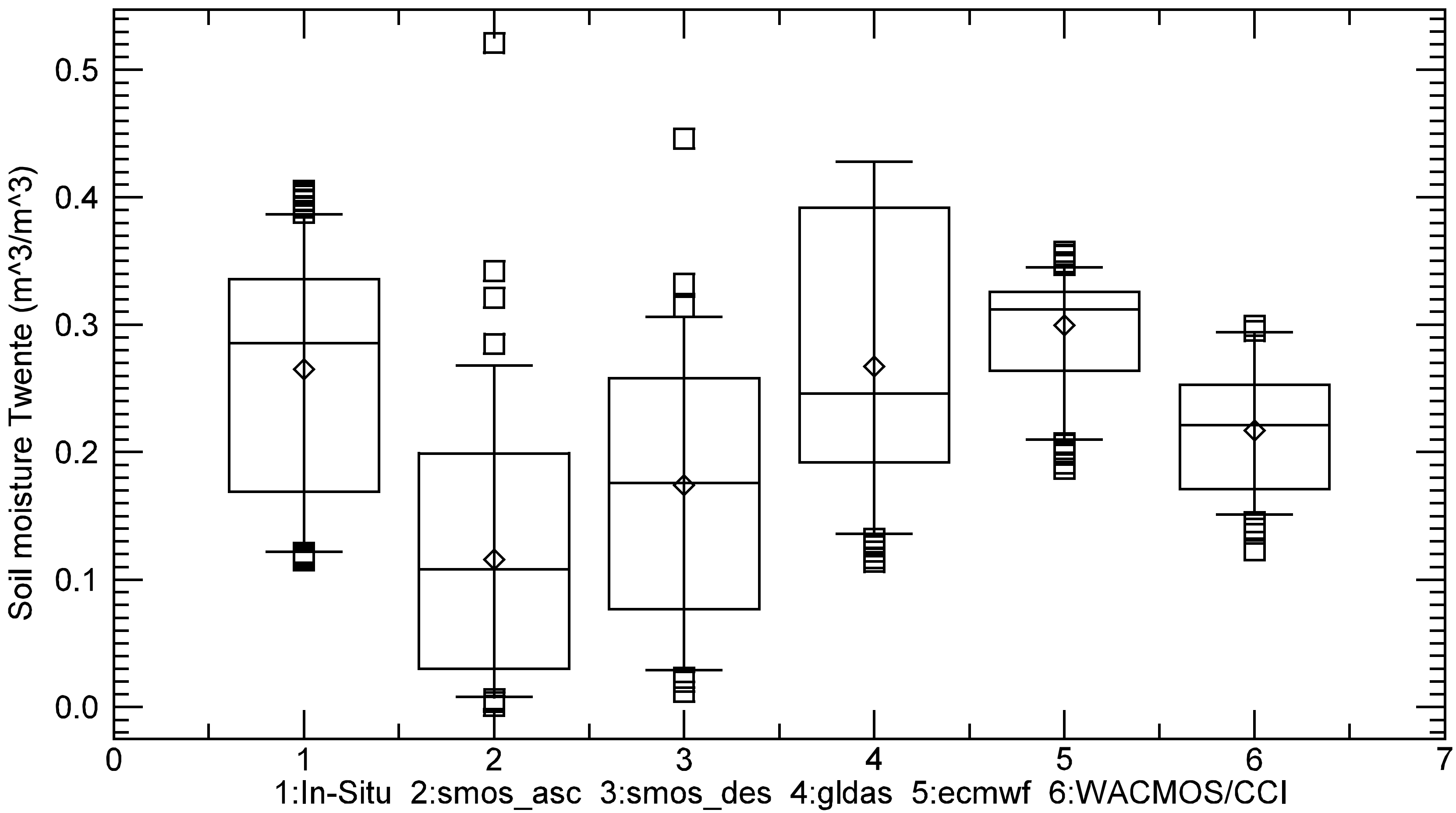


(CERN)

Twente SMST Network – validation results



Twente SMST Network – validation results



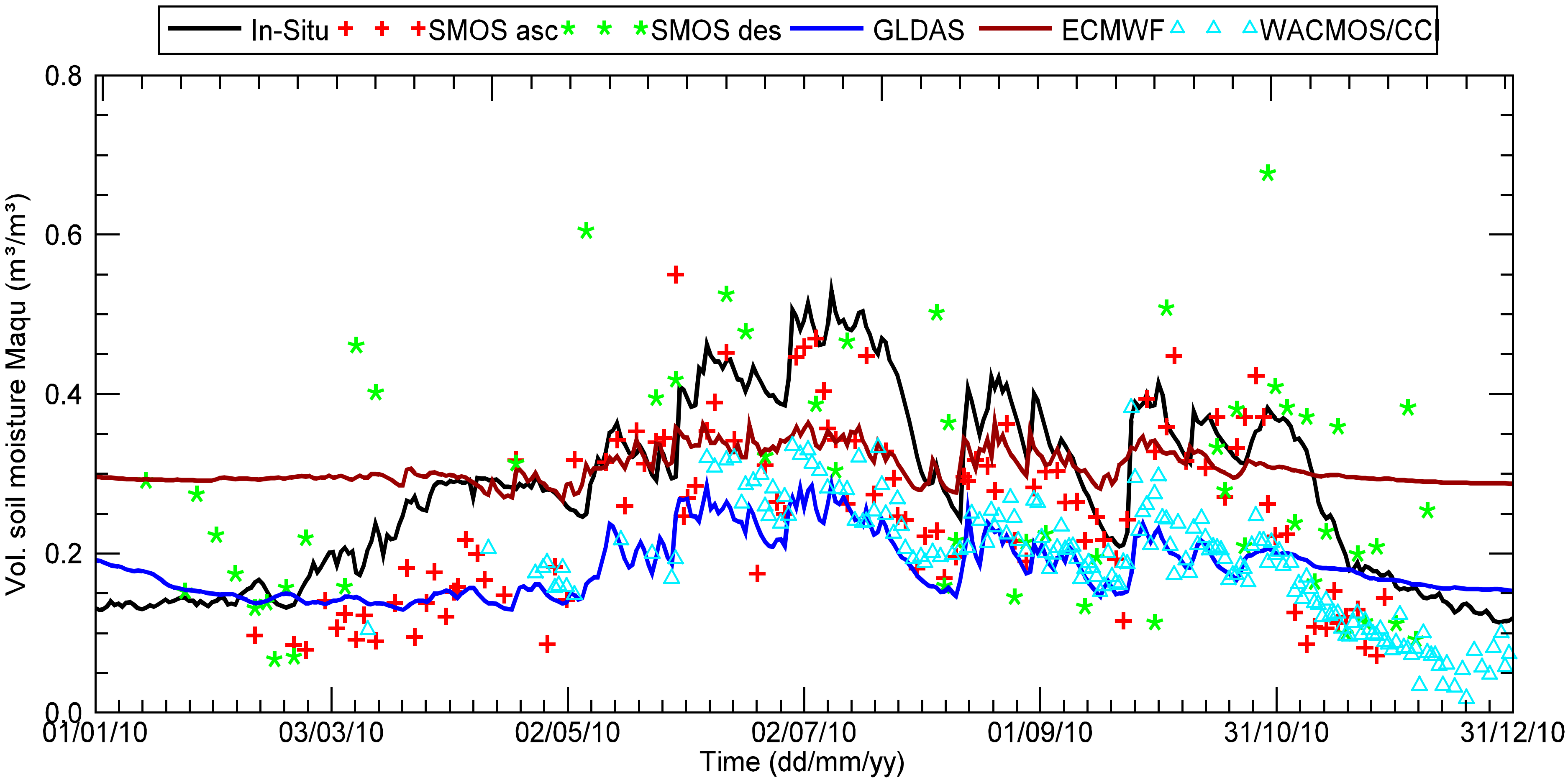
Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs)

Su et al. 2011, Hydrol. Earth Syst. Sci., 15, 2303–2316,
www.hydrol-earth-syst-sci.net/15/2303/2011/

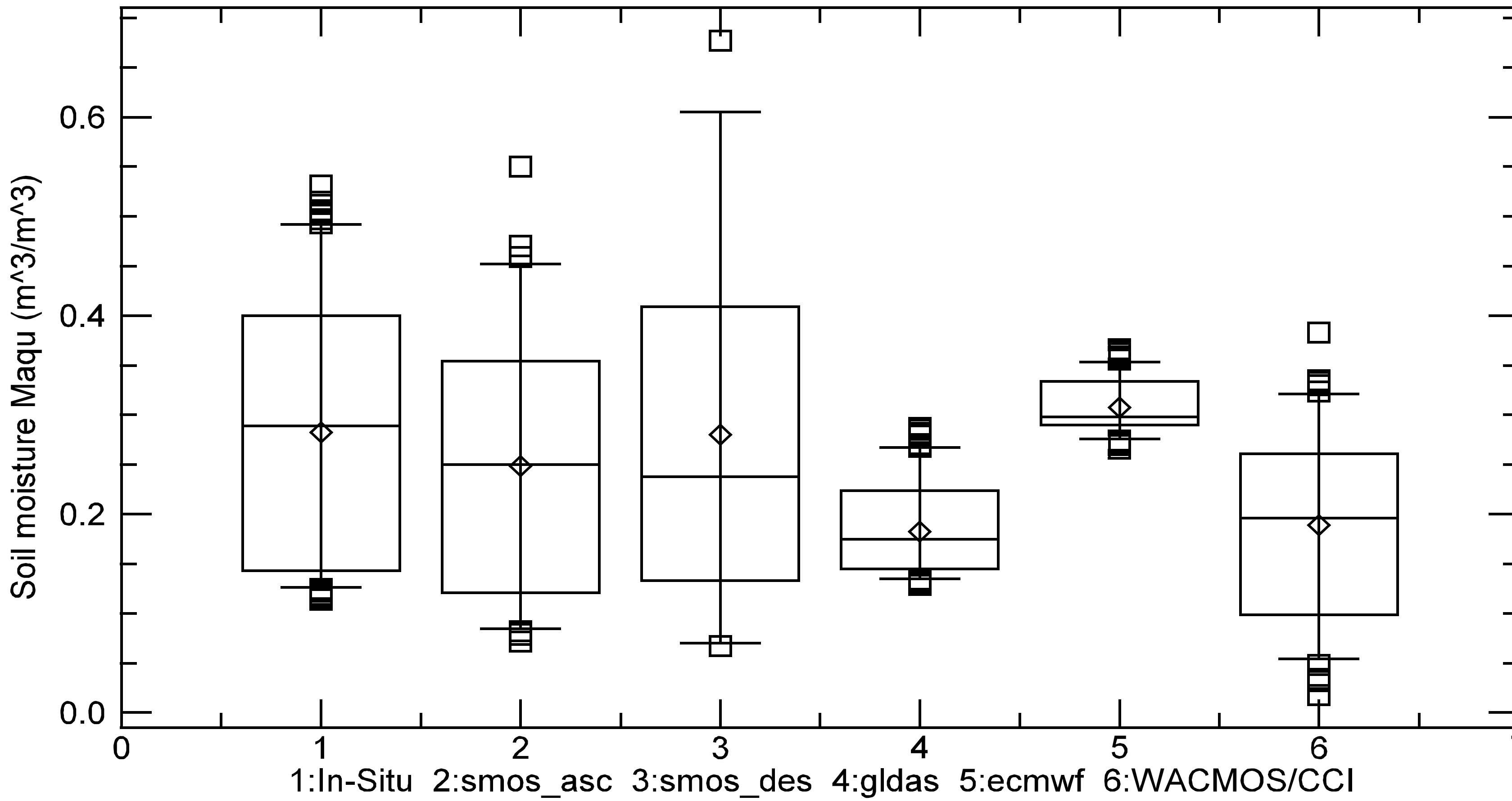
Maqu: station description

- 2/3 soil moisture & temperature probes
- 5, 10 & 20 cm deep (few profiles deep 80 cm)
- 1 datalogger
- data collected every 15 min
- memory capacity of 1 year
- completely buried
- site revisit to download data:
  - beginning and end of monsoon season in Maqu

Maqu SMST Network – validation results

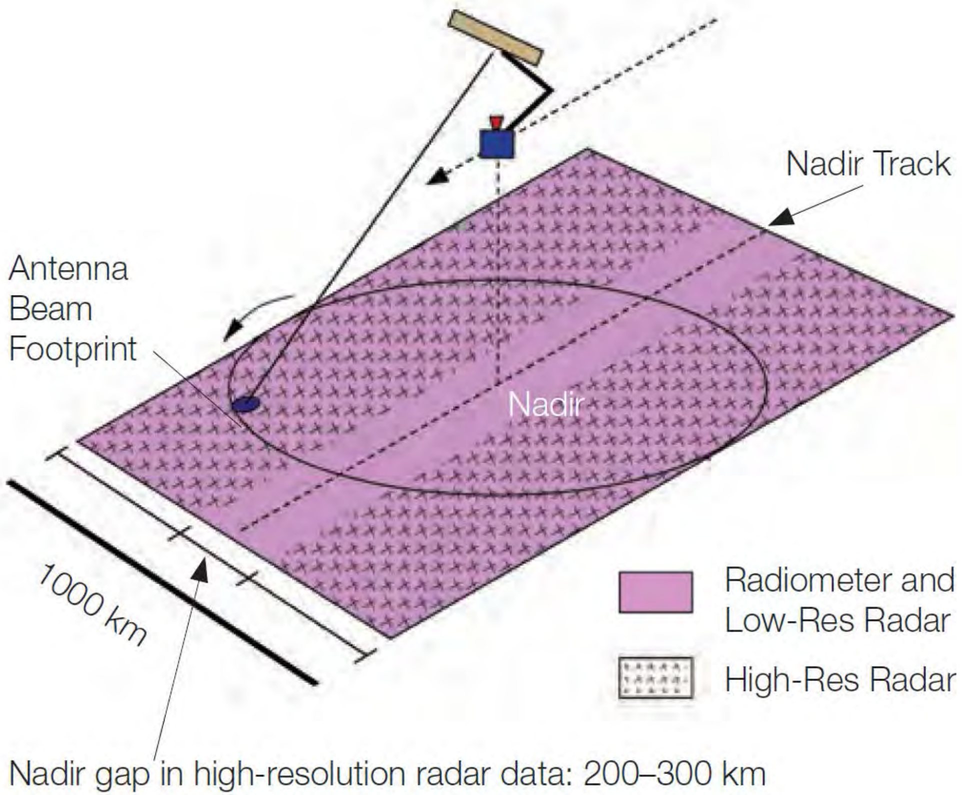


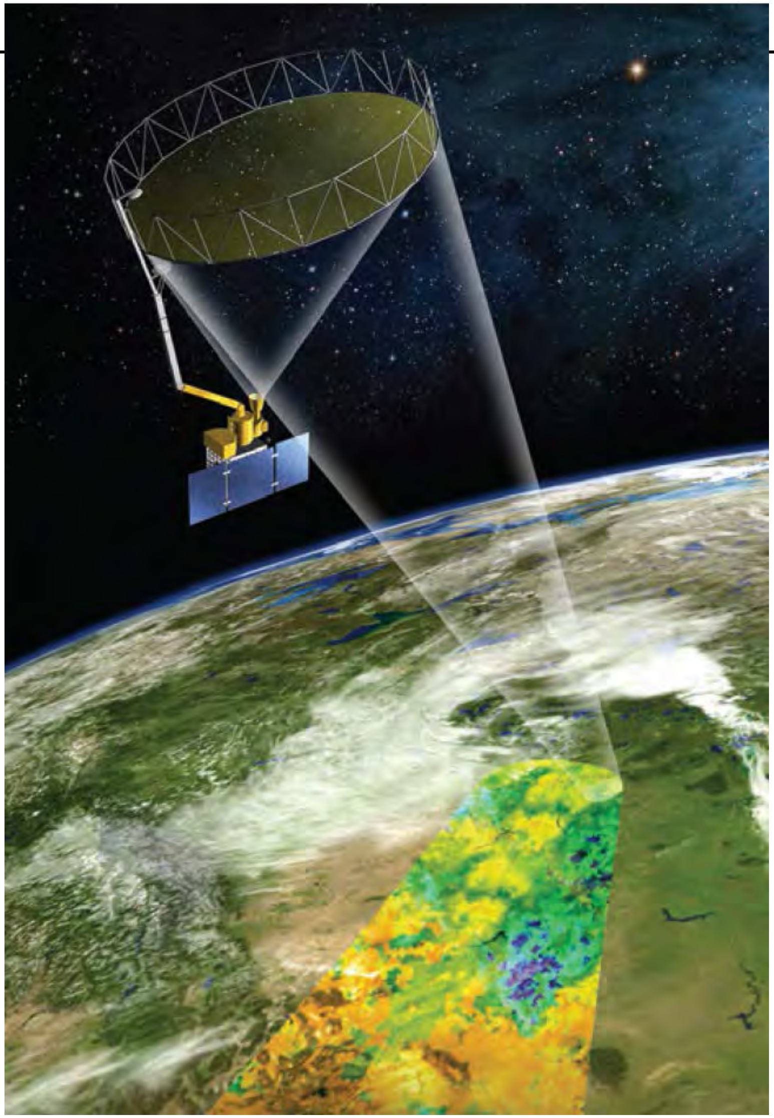
Maqu SMST Network – validation results



SMOS (Soil Moisture and Ocean Salinity) - a joint ESA / CNES / CDTI Earth Observation program

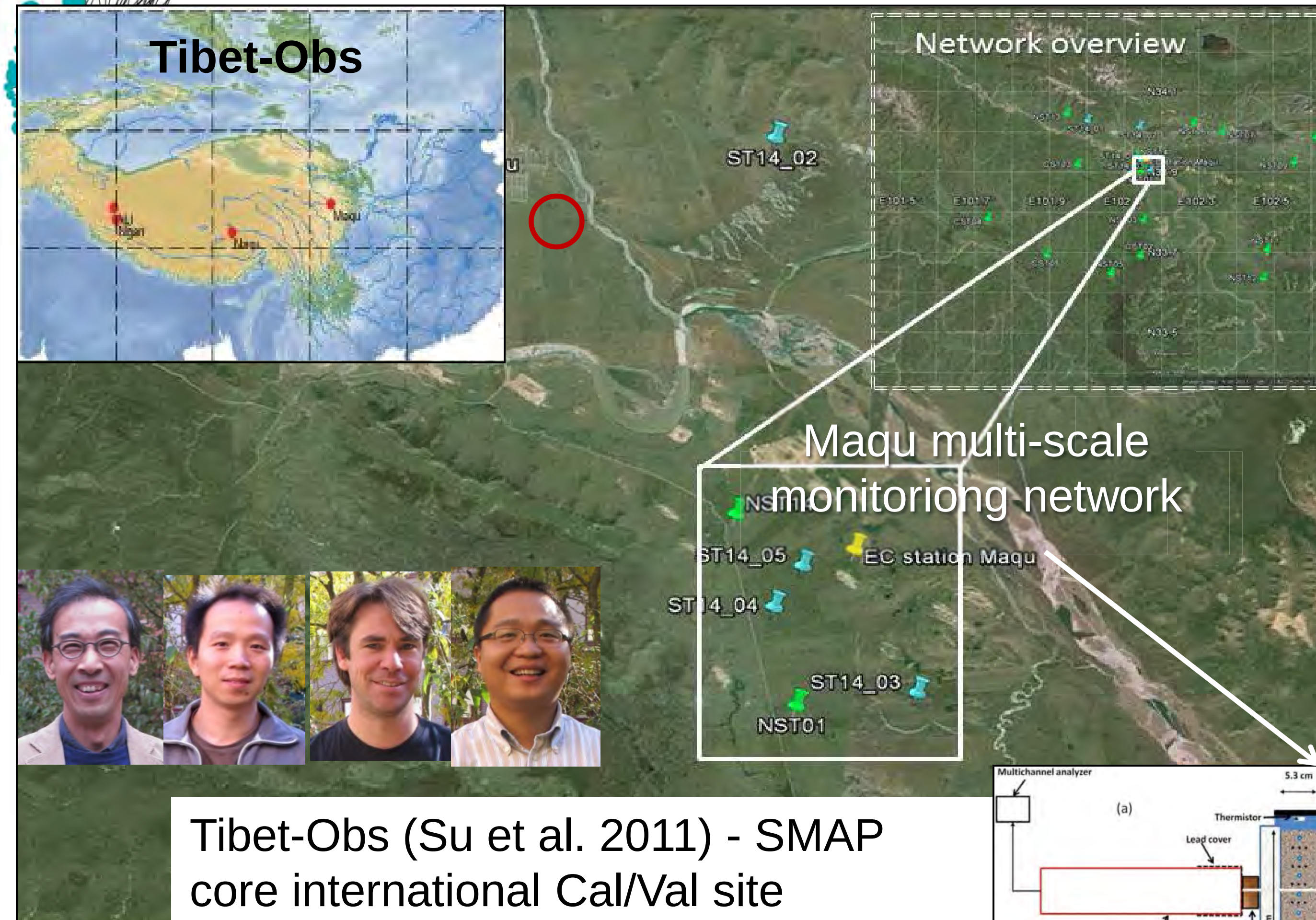
NASA SMAP – SOIL MOISTURE ACTIVE PASSIVE
LAUNCHED JAN 31 2015



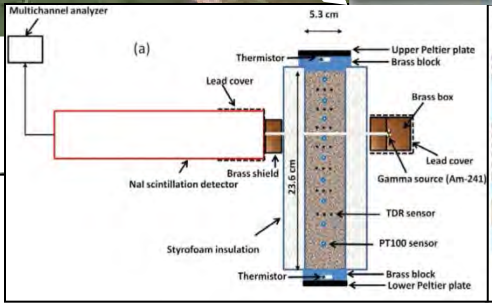


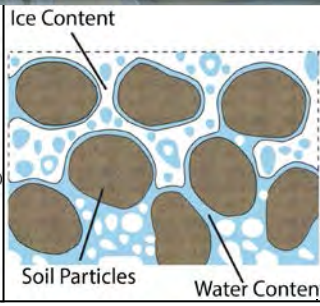
https://youtu.be/RLw3veKBqo0

NWO-GO: SMAP FREEZE-THAW

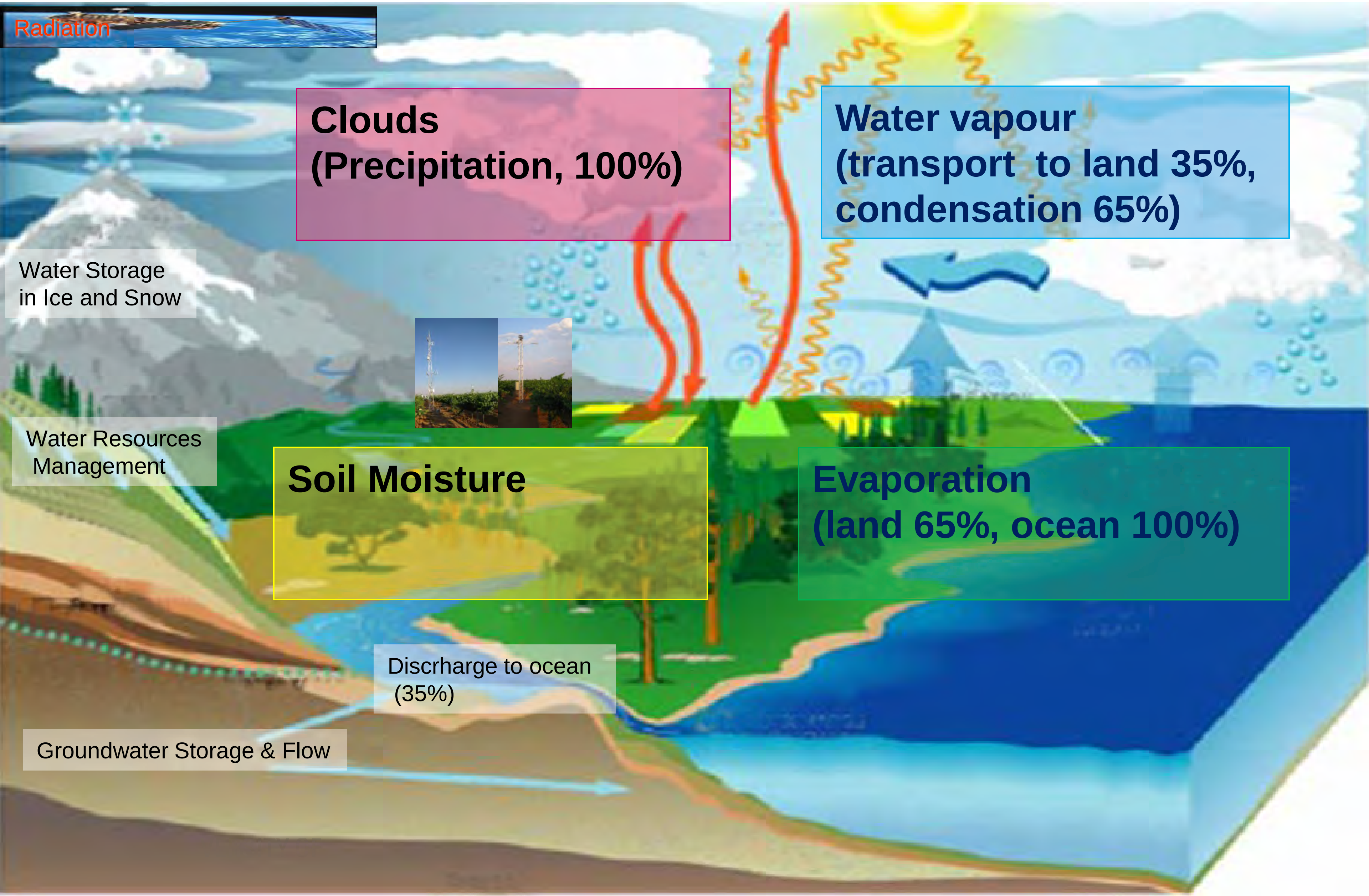


Tibet-Obs (Su et al. 2011) - SMAP core international Cal/Val site

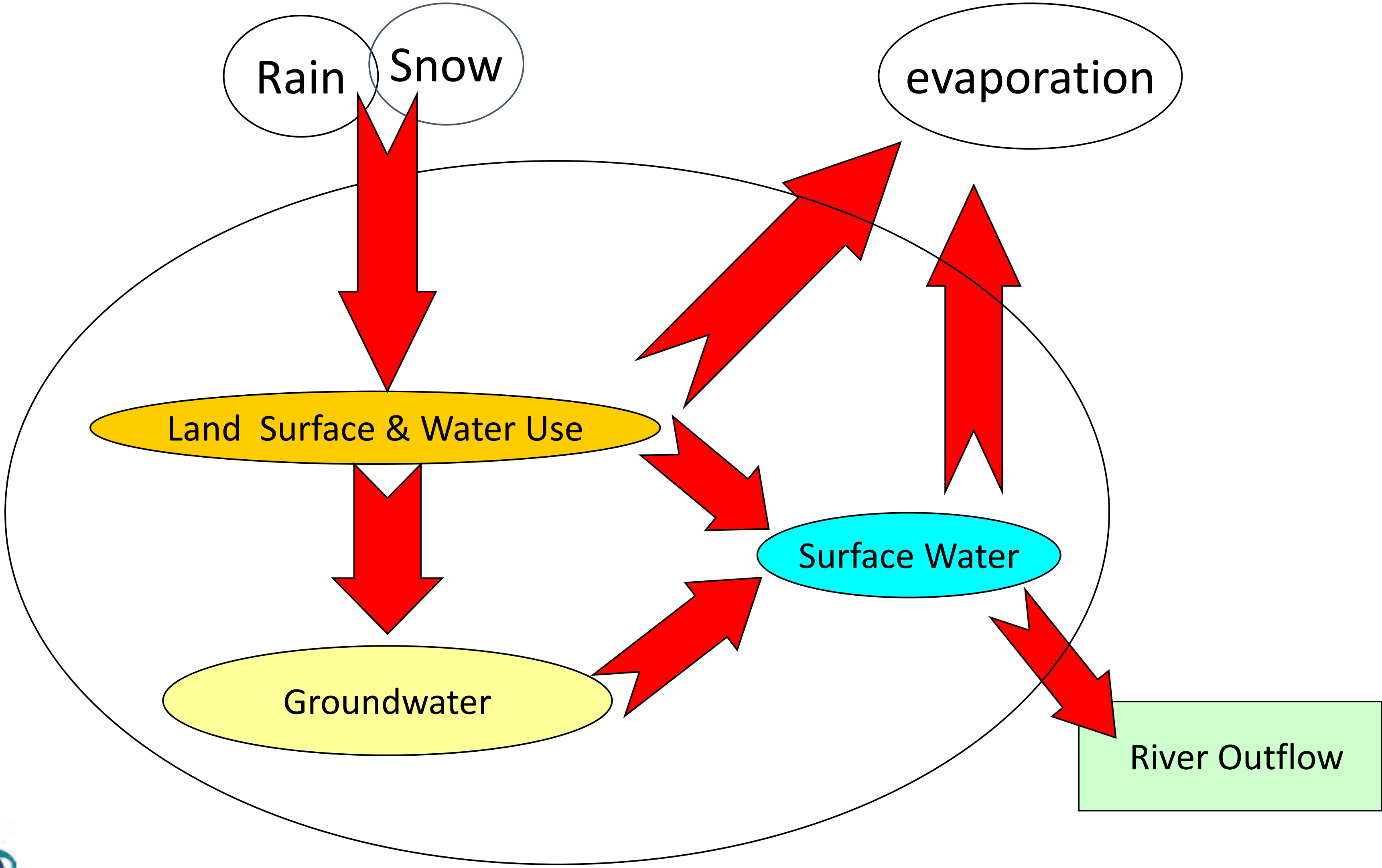




Earth Observation of Water Cycle



Changes in Water Budget



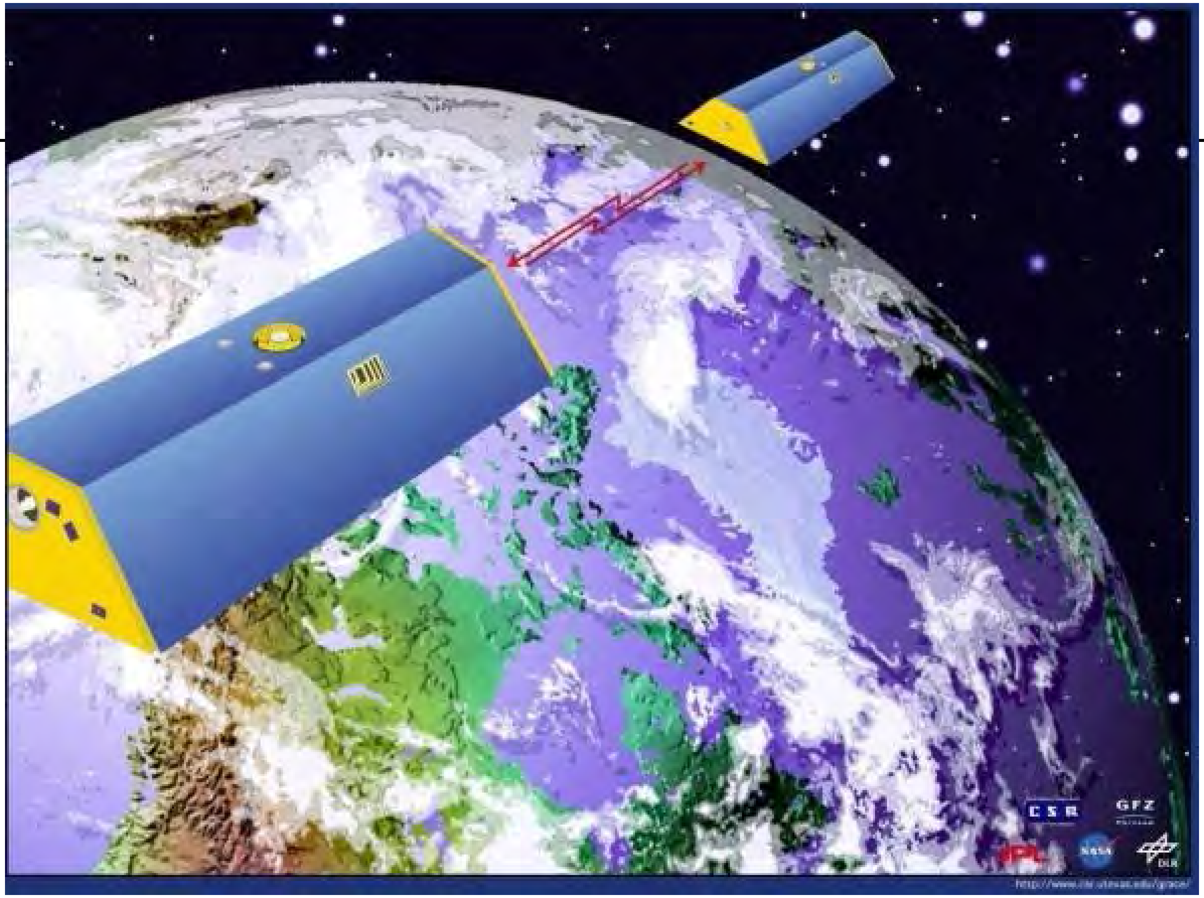
Never ending human activities


NEWSFOCUS

Trouble on The Yangtze

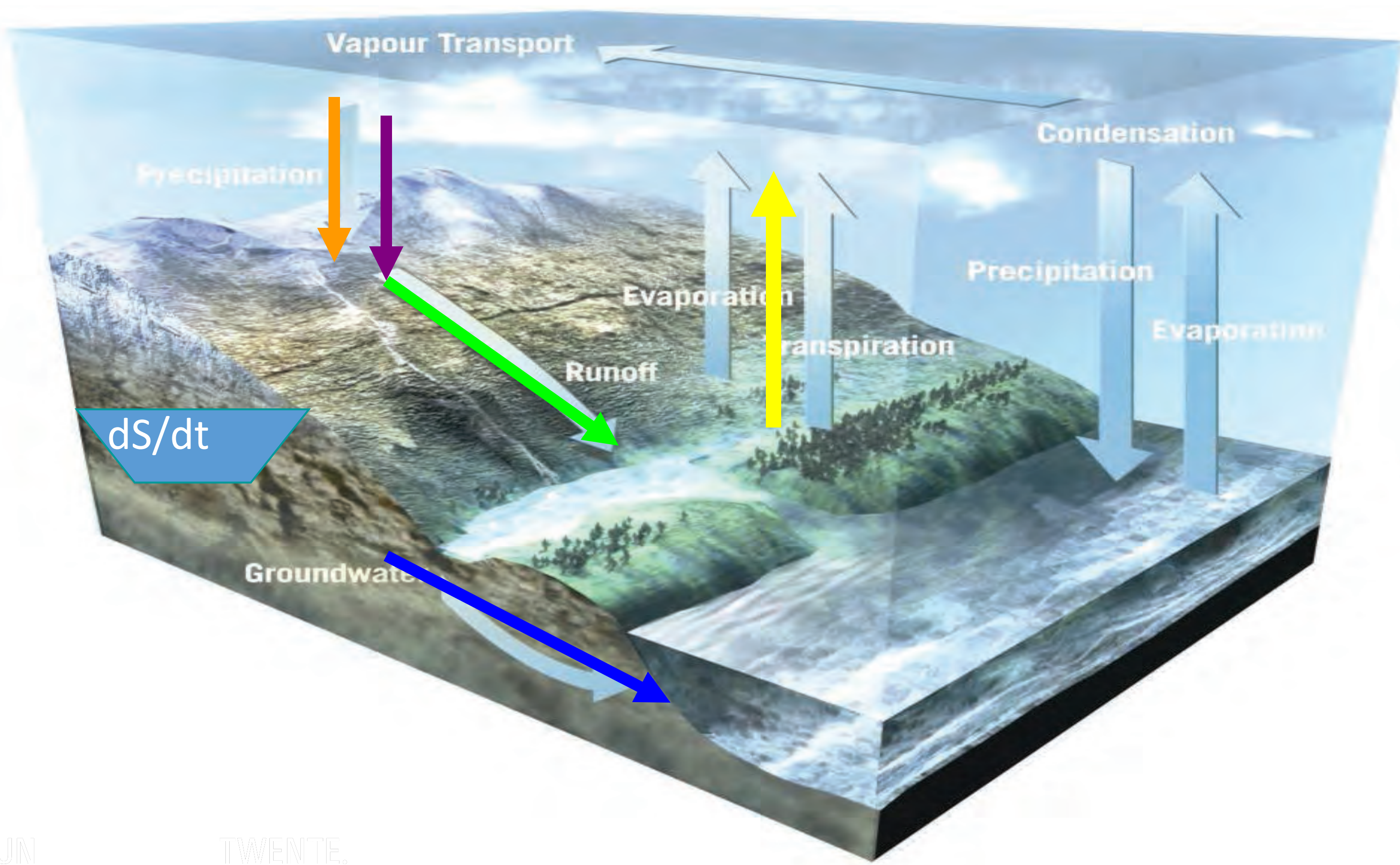
Upriver habitats—including a critical refuge created when construction began on the Three Gorges Dam—are now at risk from a series of new projects

The Gravity Recovery and Climate Experiment (GRACE) observations

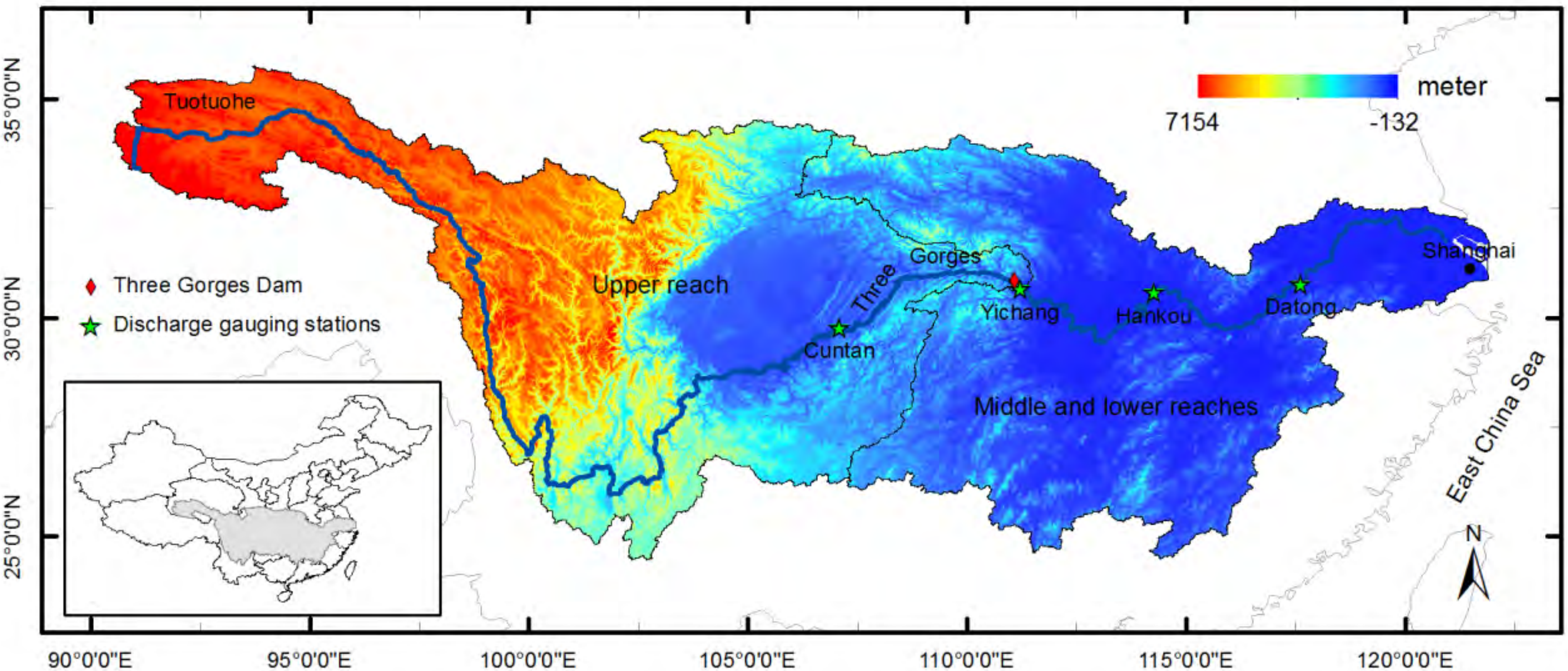


GRACE twin satellites orbiting the earth at altitude of 500 km and at 220 km distance apart each other.

Consistency among different physically interrelated variables (Spatial Water budget of the Yangtze River Basin)



Yangtze River Basin



- Upper Yangtze reach, from Tuotuohe, to Yichang.
- Middle reach from Yichang to Hukou.
- Lower reach extends from Hukou to the river mouth near Shanghai.
- Cuntan, Yichang, Hankou, and Datong are four gauging stations located along the mainstream of the Yangtze.

Closure of Water Cycle over a river basin

Total water Storage(TWS)

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

For this study we used the following datasets.

GPCP: Global Precipitation Climatology Project (P),

SEBS: SEBS derived land evaporation (E),

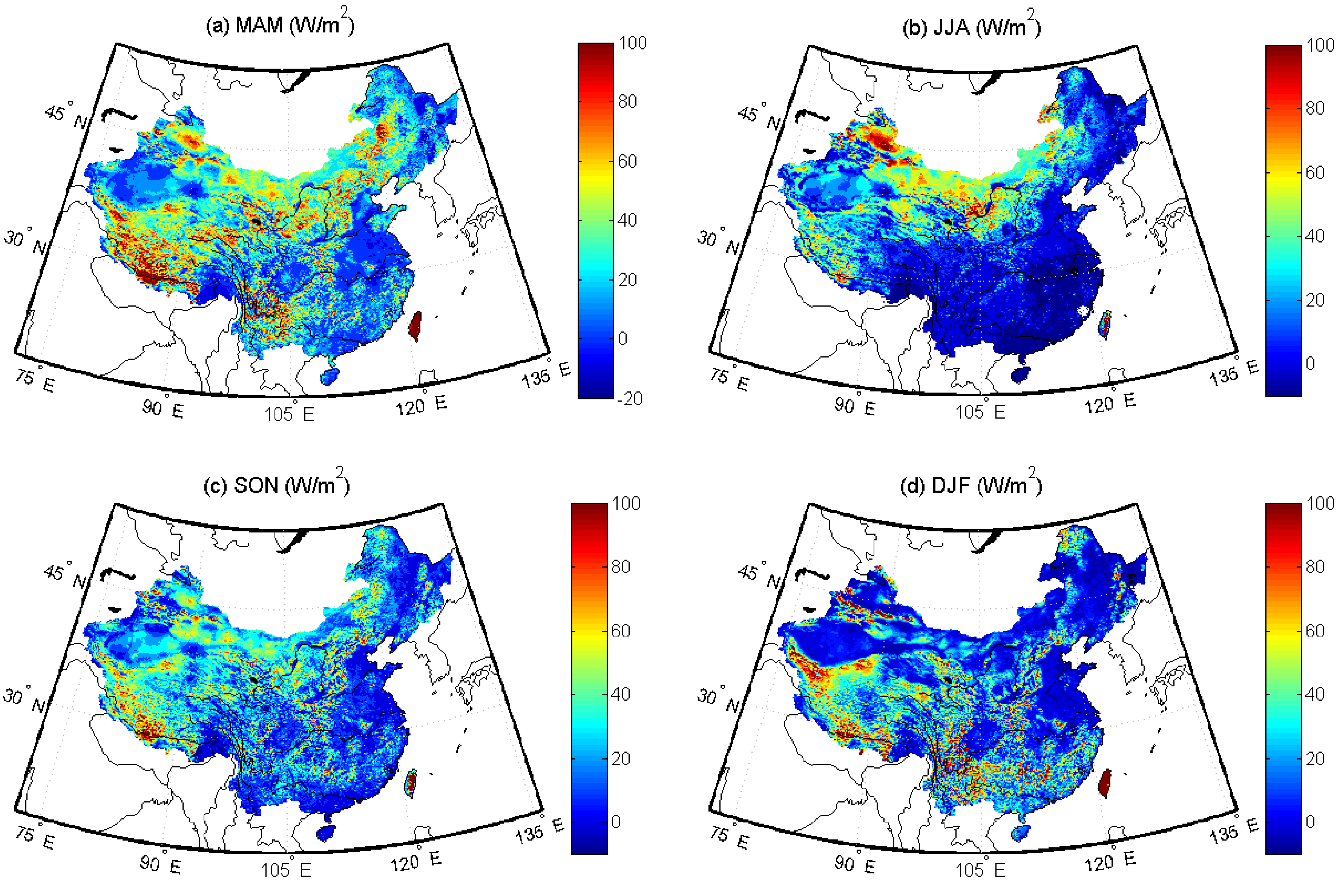
In-situ: River discharges (R),

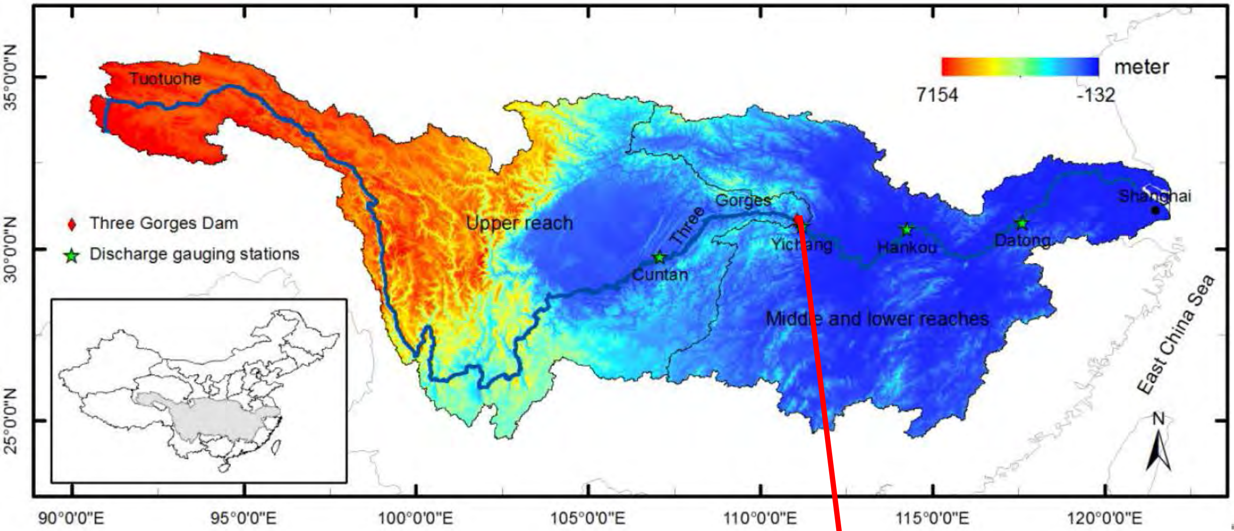
→ In-situ & satellite Observations

REA-Interim: ECMWF reanalysis (P, E, R), → Reanalysis

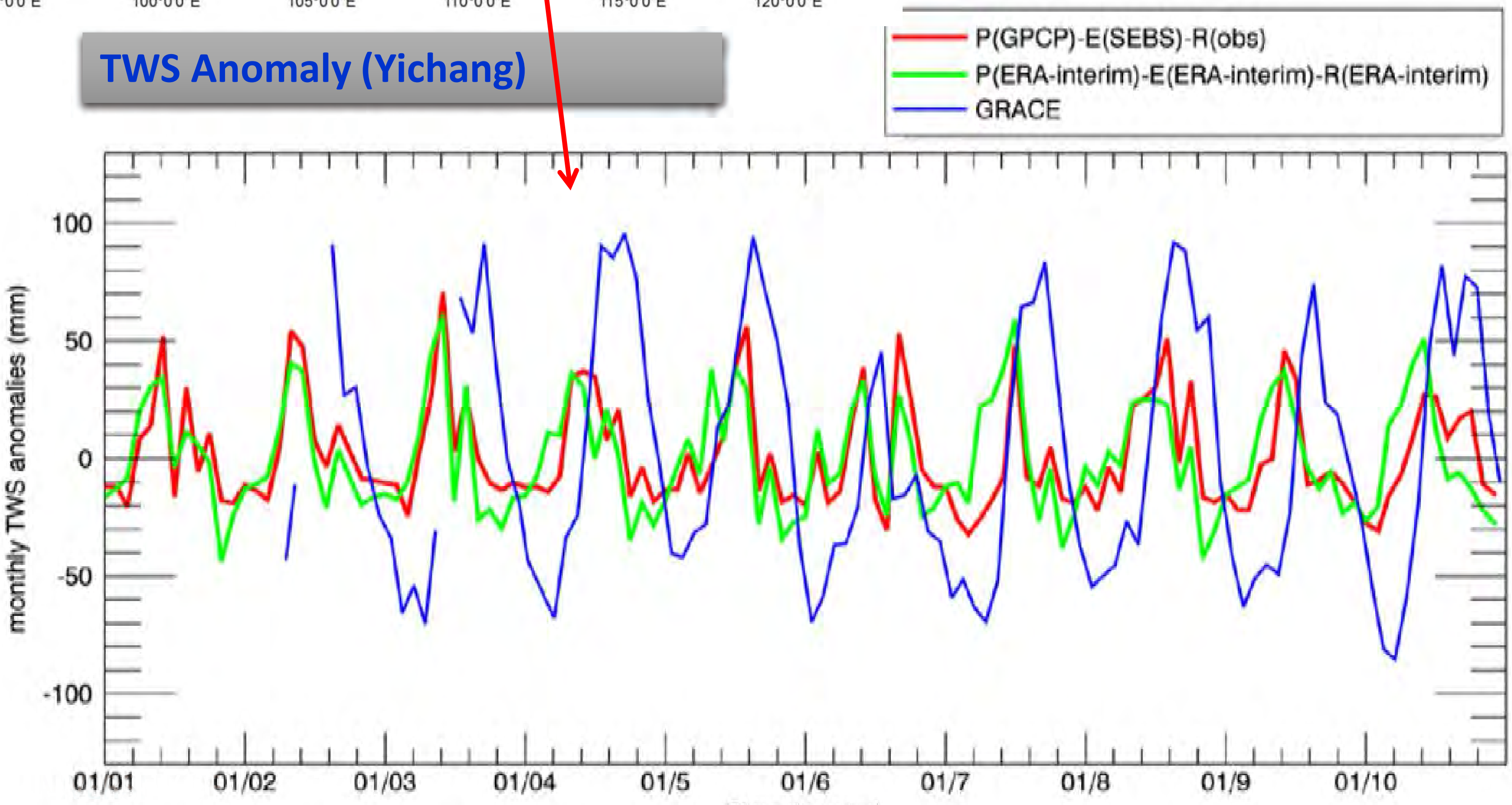
Storage change: The Gravity Recovery and Climate Experiment (GRACE) observations (dS/dt). → Satellite Observations

Seasonal average maps of sensible heat flux (H)
(a) Mar-May, (b) Jun-Aug,(c) Sep-Nov, (d) Dec-Feb

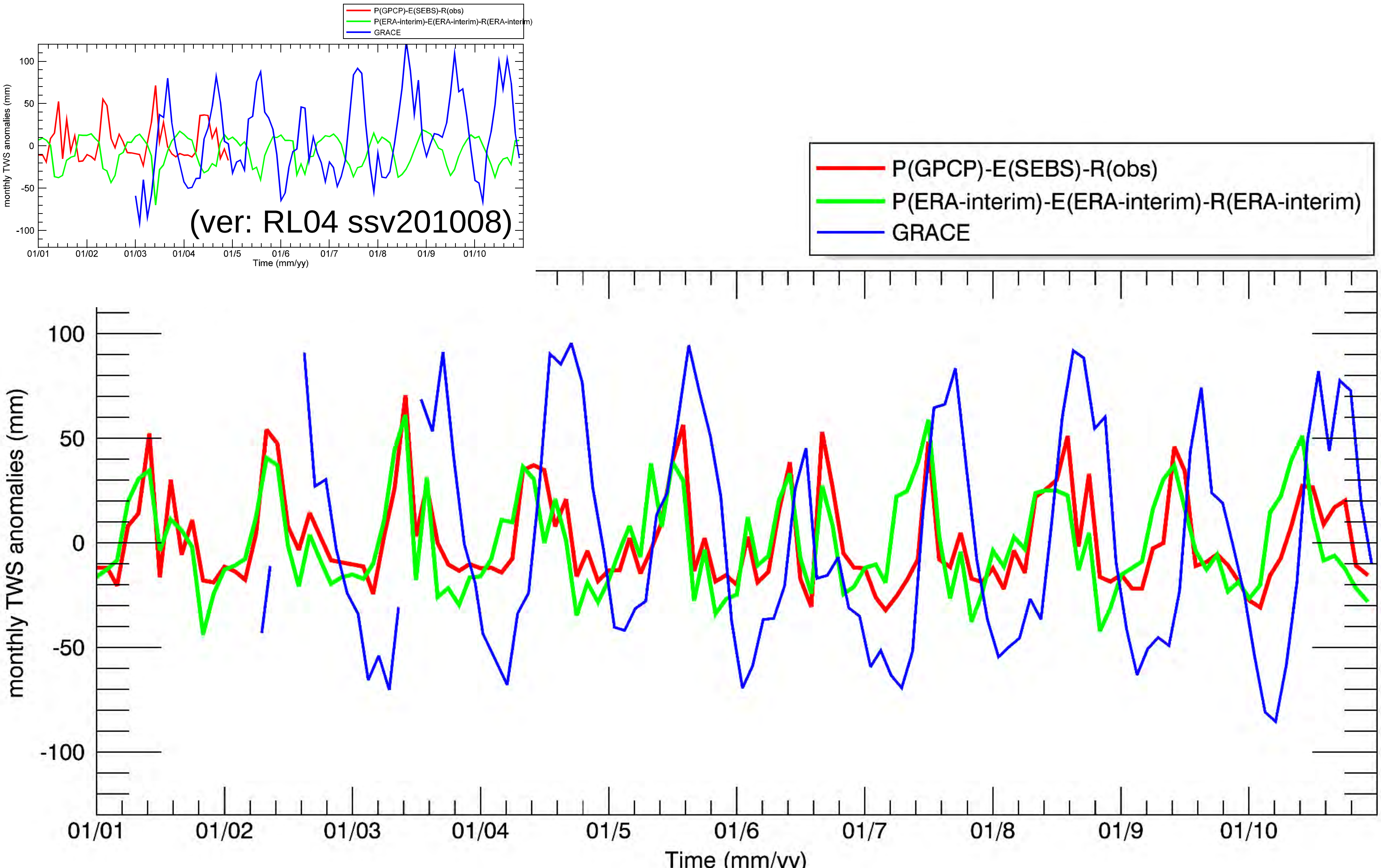




TWS Anomaly (Yichang)

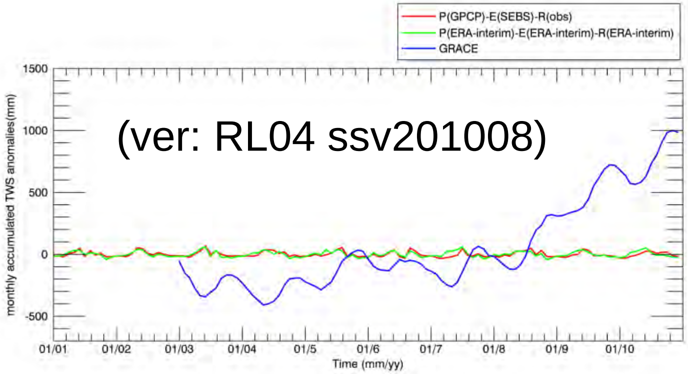


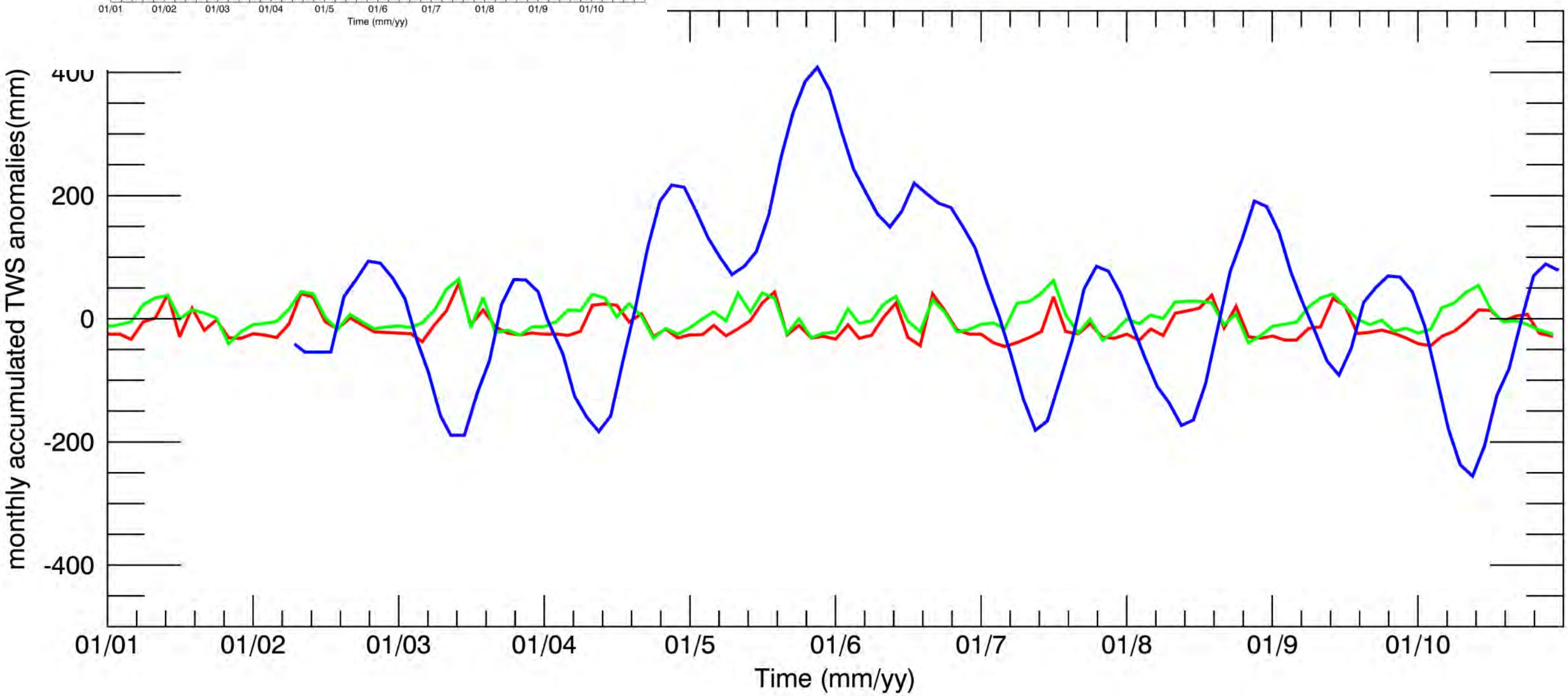
Upper reach TWS anomaly



GRACE data
(ver: RL05.DSTvSCS1401)

Cumulative TWS anomaly at Upper Reach (Yichang station)



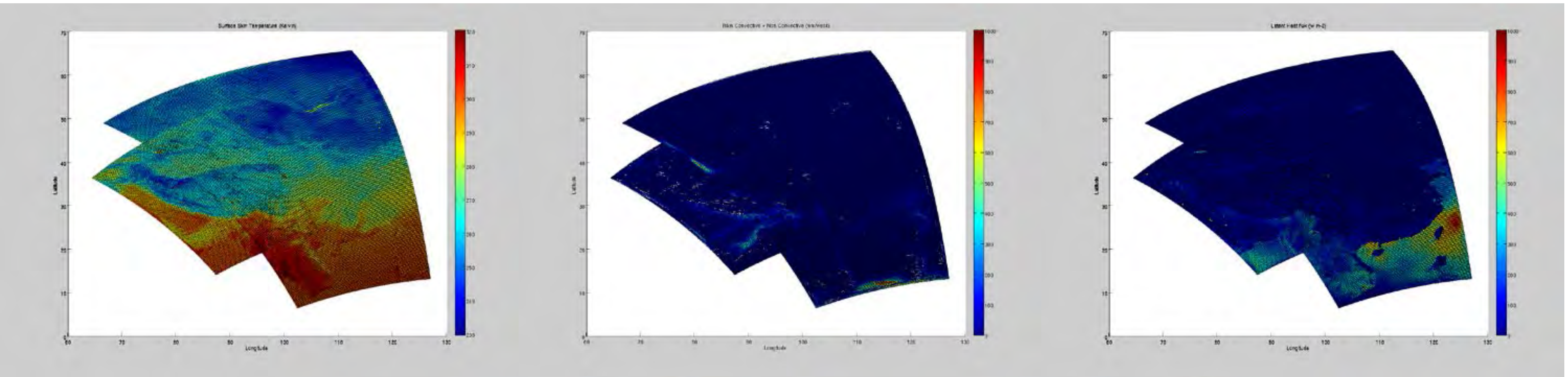


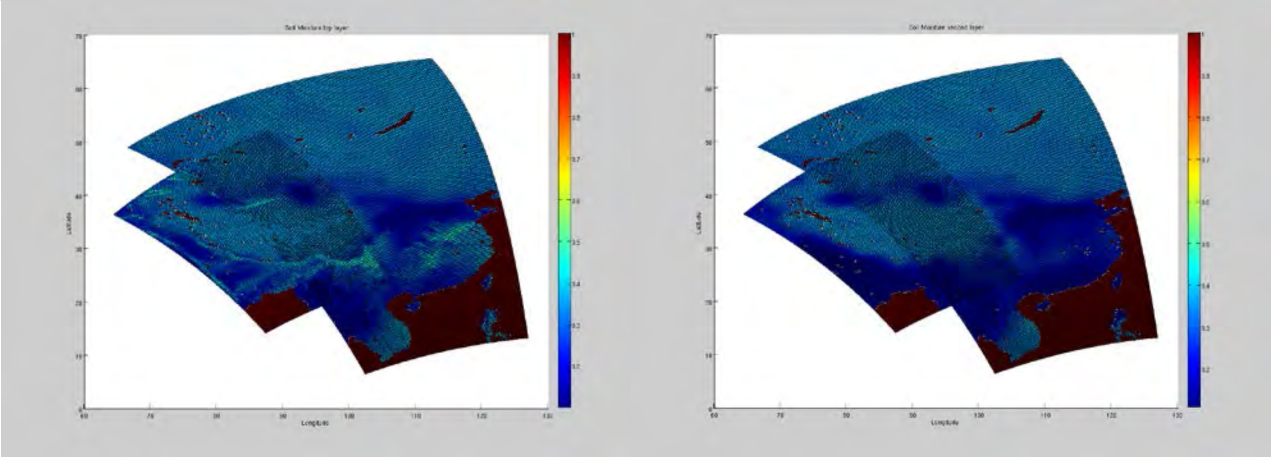
GRACE data
(ver: RL05.DSTvSCS1401)

Continental scale simulations

1 Jan – 9 Dec 2009, grid resolution 25 KM

Skin temperature	Precipitation (convective + non-convective)	Latent heat flux (Evaporation/transpiration)
Soil moisture of top layer	Soil moisture of second layer	



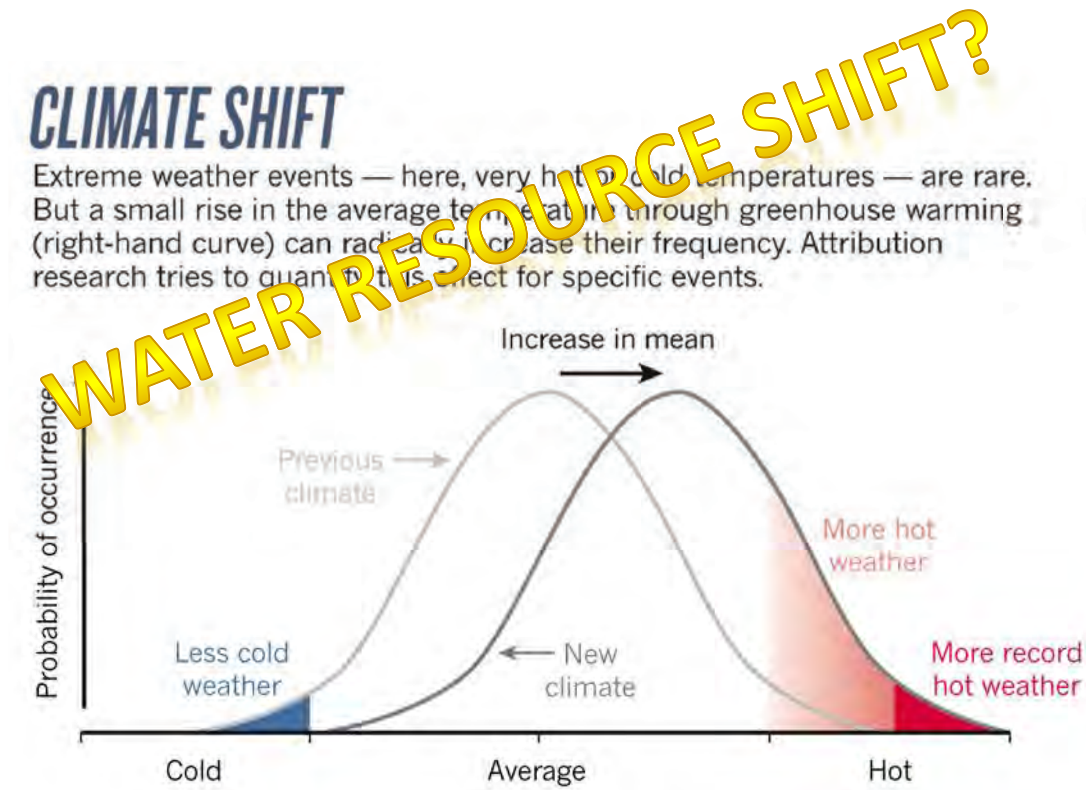


Impacts and projections in water resources

- *Q1: What are observed impacts to water resources in Yangtze due to climate and human changes ?*

- *Q2: Will the changes in the Yangtze River Basin influence the East Asian monsoon patterns?*

- *Q3: What will be the spatial/temporal distribution of water (sediment) resources in 21st century ?*



What is the difference?

Challenges to Land – atmosphere interactions

Climate change?
Anthropogenic change?
What can we attribute past changes to?
Can we predict future changes?
Can we adapt to changes?

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