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WATER RESOURCE APPLICATIONS –

Terrestrial Water Cycle from a Climate Perspective

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With contributions from:

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ITC FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

What is the problem?

Water is essential to all life, but at what time scale do we see a tipping point ?

Learning Objectives

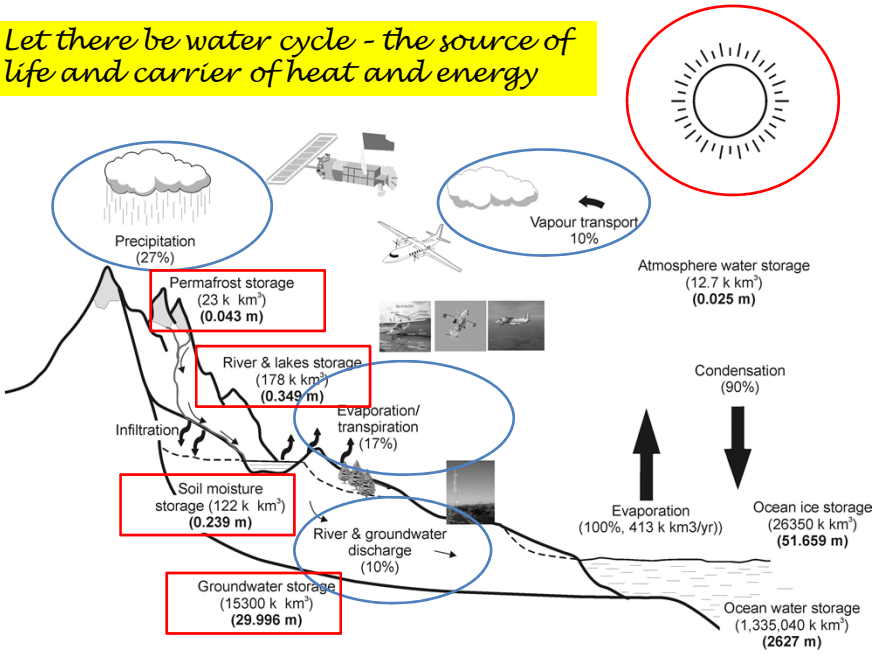
1. To understand basic ideas of the estimation of water availability

2. To familiarize with the data and data products for the derivation of different water availability terms

3. To understand the possibilities, limitations and for estimation of water availability using different approaches

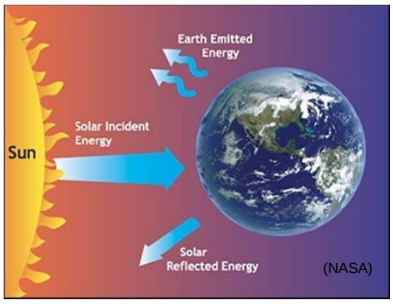
4. To familiarize with the applications

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

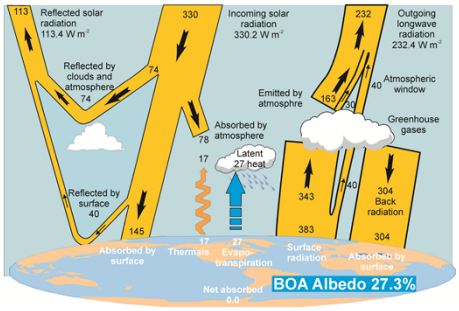


(Su et al., 2010)

Let there be light - the external solar driver

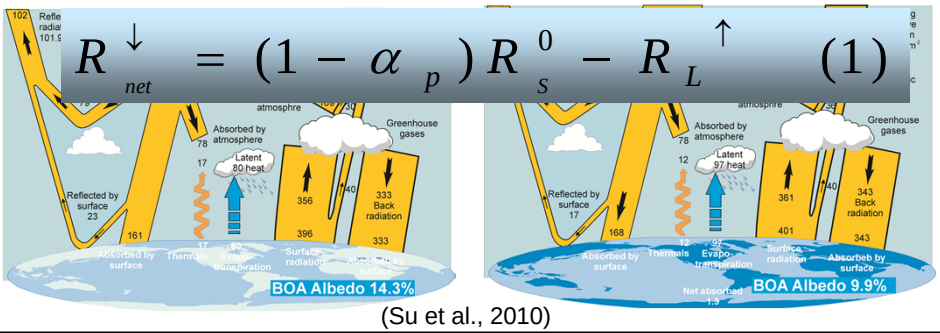


Land energy budget,TOA Albedo 34.4%



Global energy budget, TOA Albedo 29.8%

Ocean energy budget, TOA Albedo 28.3%



$$R_{net}^{\downarrow} = (1 - \alpha_p) R_s^0 - R_L^{\uparrow} \quad (1)$$

(Su et al., 2010)

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Part I

Basic principles –
Energy and mass conservation

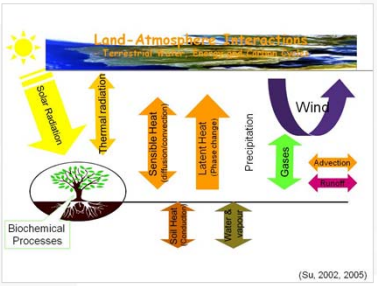
(a) Land Energy & Water budgets

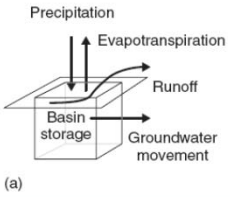
Change of the energy (S_E) stored at the **land surface**, largely expressed as a change in **land surface temperature**

$$\frac{dS_E}{dt} = R_n^{\downarrow} - H - \lambda E - G_0 - A \quad (2)$$

$$R_n^{\downarrow} = (1-\alpha)R_s^{\downarrow} + R_l^{\downarrow} - R_l^{\uparrow} \quad (3)$$

$$\frac{\partial S_w}{\partial t} = P - E - R_0 - R_u \quad (4)$$

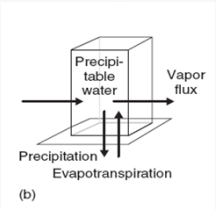




(b) Atmospheric water budget

$$\frac{\partial \rho q}{\partial t} = -\nabla \cdot (\rho v q) + \rho (E - P)$$

$$\overline{\nabla \cdot (vq)} = \overline{E} - \overline{P}$$



Part II

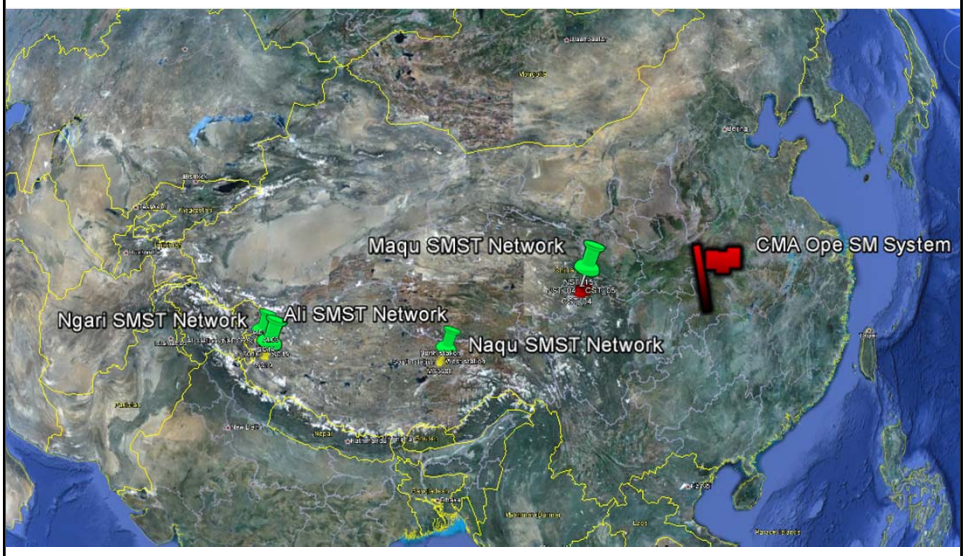
Observations – Process understanding in energy and mass conservation

– In-situ observations

– Satellite observations

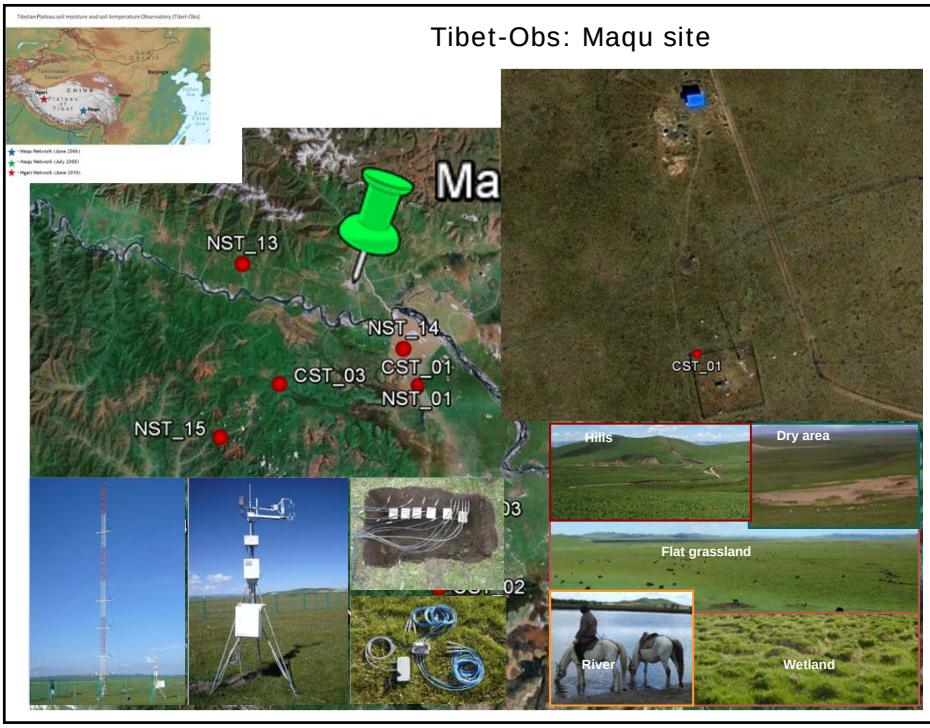
ITC GEO Soil Moisture Soil Temperature Networks

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



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

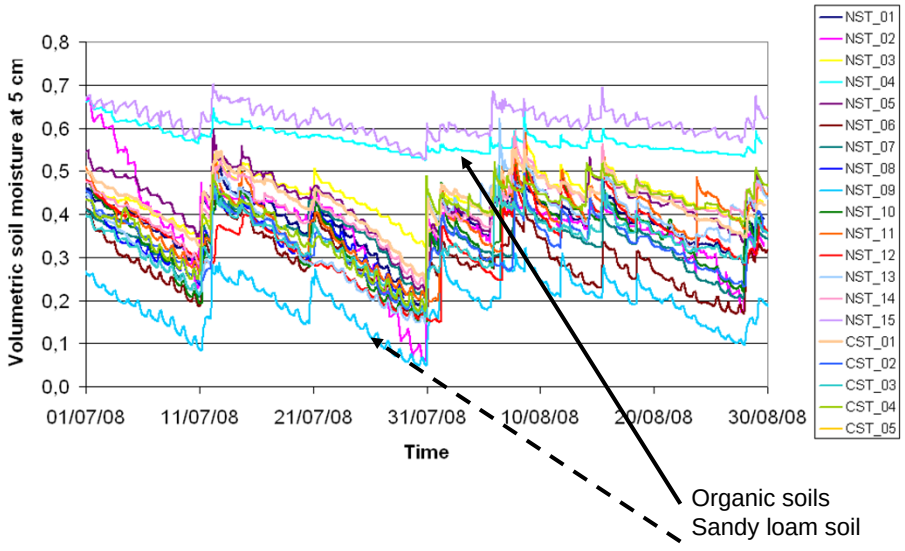
Tibet-Obs: Maqu site



Station description (Maqu)

- 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 Network: Soil moisture at 5 cm depth of all the stations

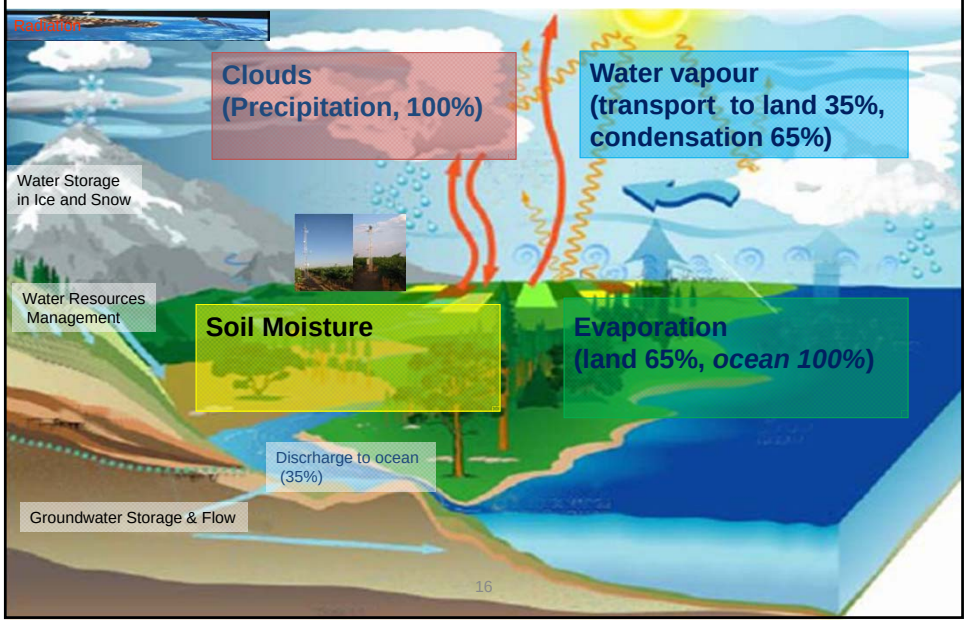


Part III

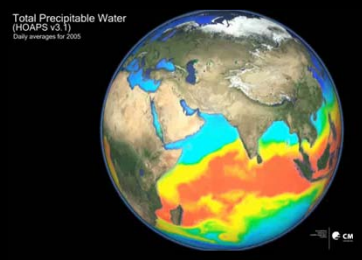
- Reliability of global data products

ESA STSE programme:

Water Cycle Multimission Observation Strategy (WACMOS)

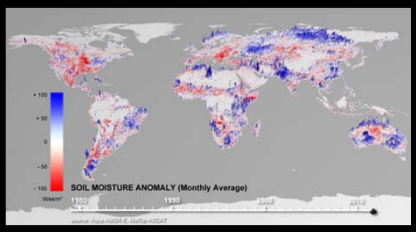


Future R&D needs – consistency of ECVs (essential Climate Variables)
(Closing the Water Cycle with Earth Observation)



The WACMOS global soil moisture product

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



Hydrol. Earth Syst. Sci., 15, 2303–2316, 2011
www.hydrol-earth-syst-sci.net/15/2303/2011/
doi:10.5194/hess-15-2303-2011

Hydrology and Earth System Sciences

The Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs) for quantifying uncertainties in coarse resolution satellite and model products

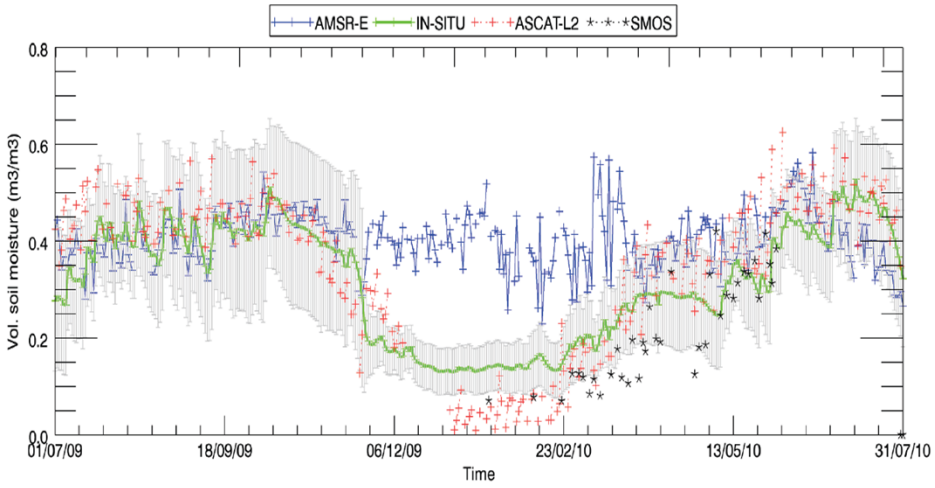
Z. Su[1], J. Wen[2], L. Dente[1], R. van der Velde[1], L. Wang[1], Y. Ma[3], K. Yang[3], and Z. Hu[2]

JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES, VOL. 118, 1–15, doi:10.1002/jgrd.50468, 2013

Evaluation of ECMWF's soil moisture analyses using observations on the Tibetan Plateau

Z. Su,[1] P. de Rosnay,[2] J. Wen,[3] L. Wang,[1] and Y. Zeng[1]

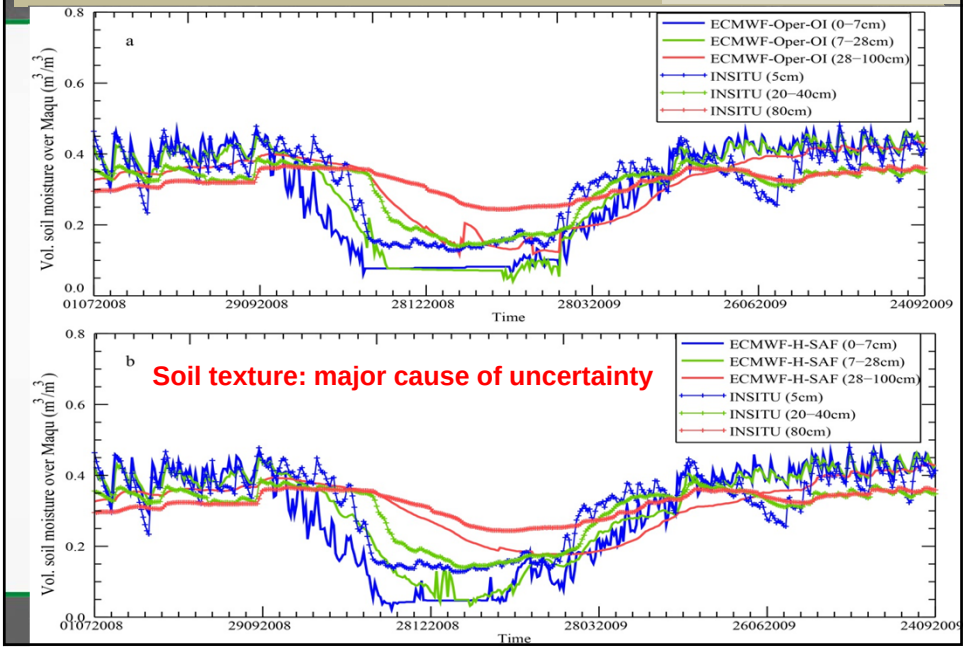
Quantification of uncertainties in global products (Su et al., 2011, HESS)



The AMSR-E, ASCAT-L2 and SMOS soil moisture retrieval the Maqu area vs observations at 5 cm soil depth (20 stations)

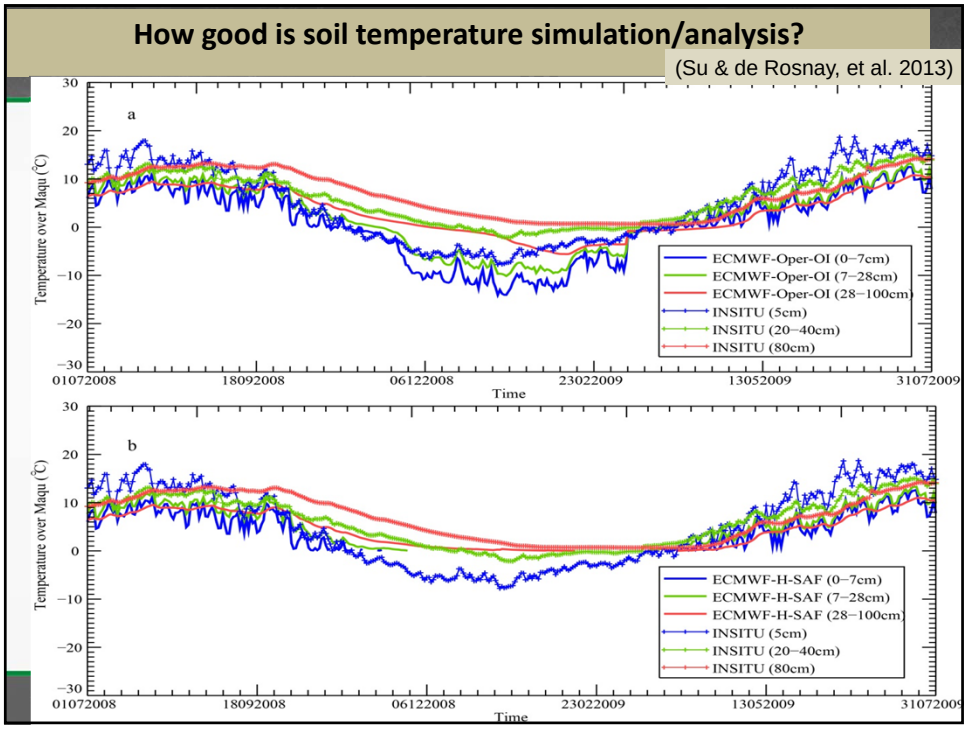
How good is soil moisture analysis/assimilation?

(Su & de Rosnay, et al. 2013)

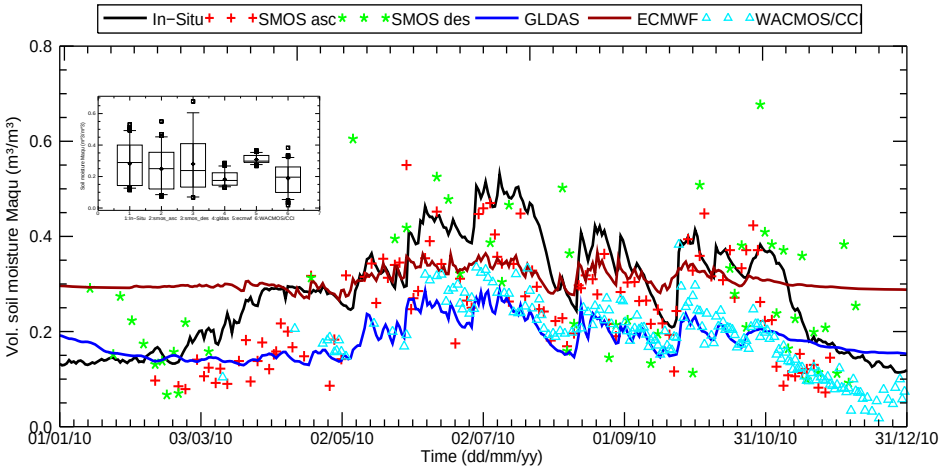


How good is soil temperature simulation/analysis?

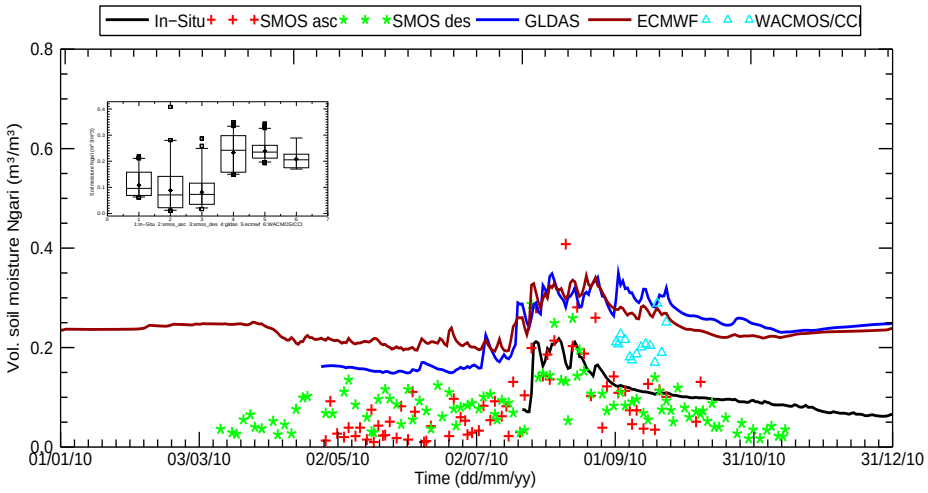
(Su & de Rosnay, et al. 2013)



Maqu SMST Network – validation



Ngari SMST Network – validation



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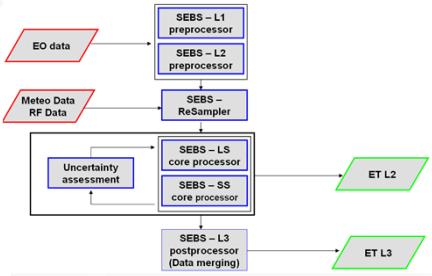
- **SEBS algorithm updated/validated for different land covers (forest, cold/arid regions, glaciers/snow and water surface, & low vegetations)**
- **A processing chain developed in the ESA WACMOS project (wacmos.itc.nl)**
- **A high performance SEBS GPU implementation open source code : http://code.google.com/p/sebs-gpu/**

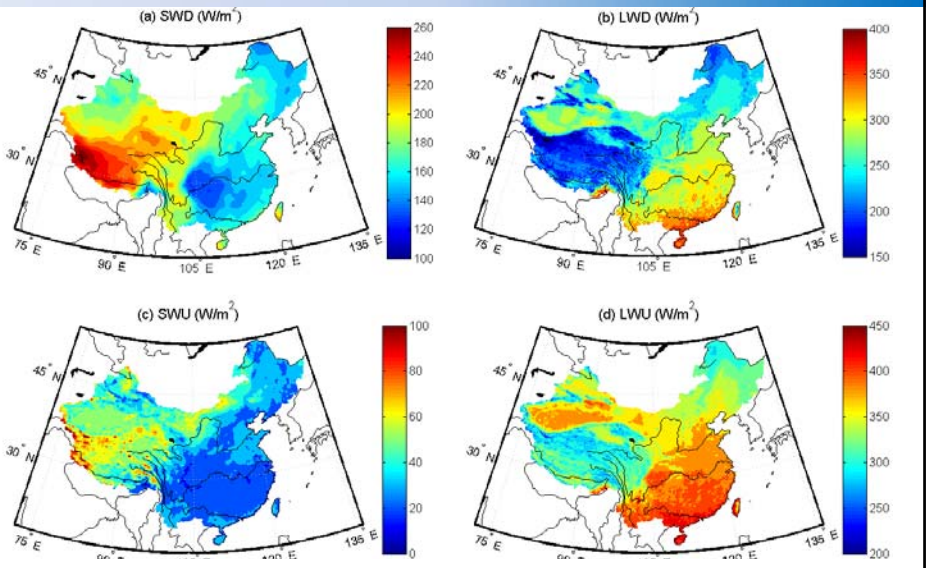


References:

•Chen et al., 2013, An improvement of roughness height parameterization of the surface energy balance system (SEBS) over the Tibetan Plateau. J. Appl. Meteorol. Clim., 52 (2013)3, 607-622.

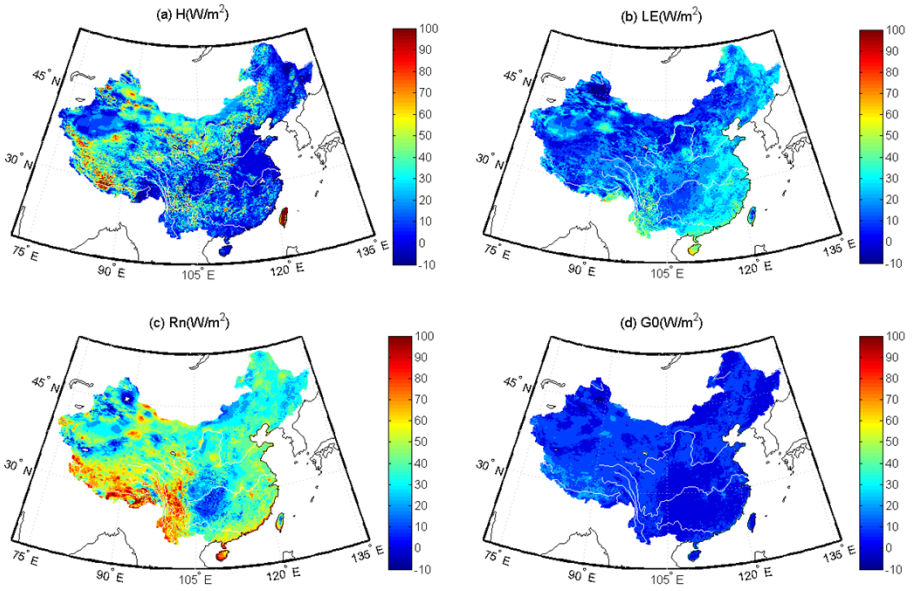
•Abouali, et al., 2013, A high performance GPU implementation of Surface Energy Balance System (SEBS) based on CUDA-C, Environ. Mod. & Software, 41, 134-138.

Yearly average of (a) downward shortwave radiation (SWD), (b) downward longwave radiation (LWD), (c) upward shortwave radiation (SWU), (d) upward longwave radiation (LWU) from 2000 to 2010.

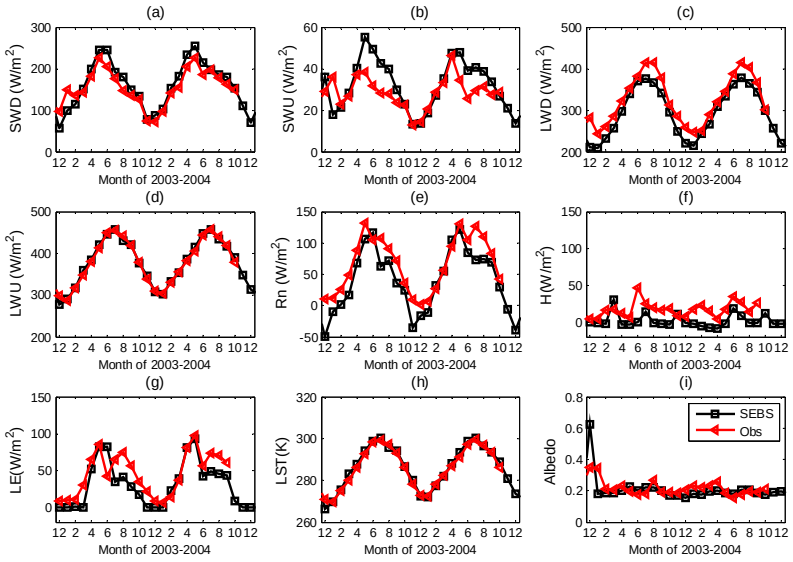


(Chen et al. 2013, Development of an 11 years (2000-2010) land surface energy balance product in China (in review)

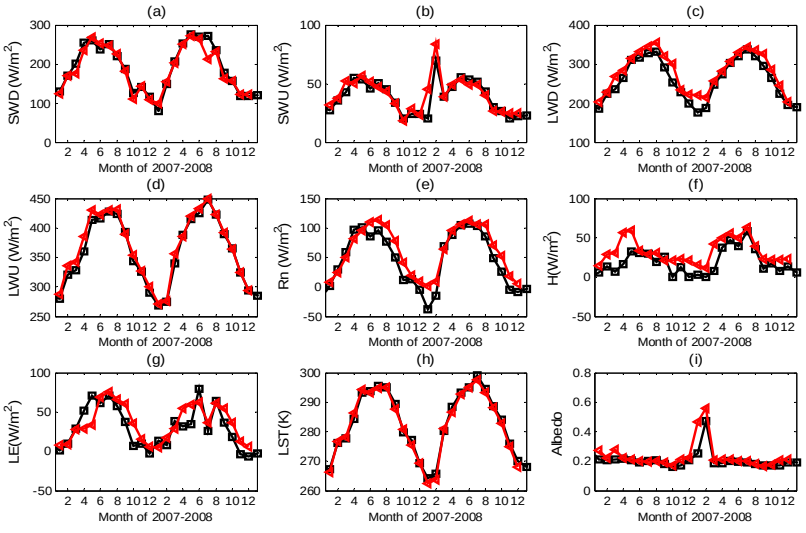
Multiyear mean of the retrieved fluxes (2000-2010), (a) sensible heat flux (H), (b) latent heat flux (LE), (c) net radiation (Rn), (d) ground heat flux (G0).



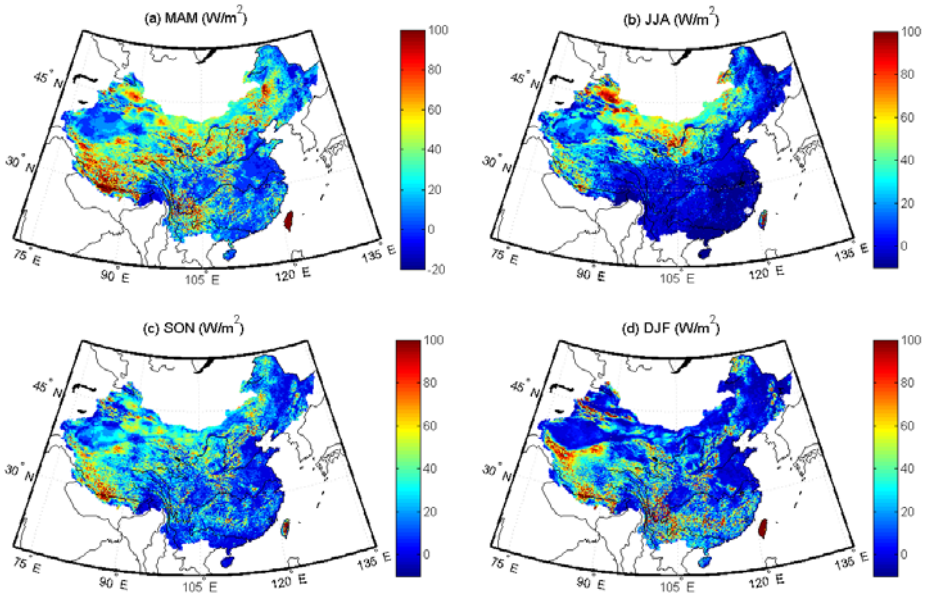
SEBS input and output variables vs measurement at Yucheng station



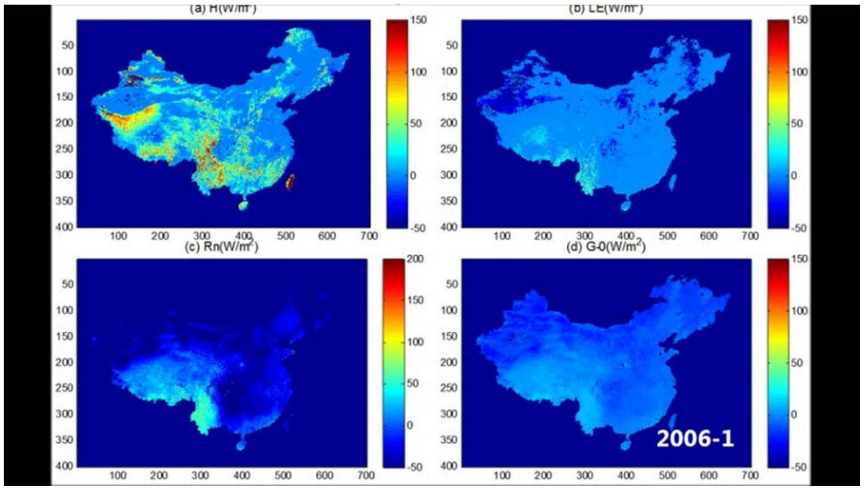
SEBS input and output variables vs measurement at SACOL station
(Semi-Arid Climate and Environment Observatory of Lanzhou University)



Average sensible heat flux (a) March-May (MAM), (b) June-August (JJA), (c) September-November (SON), (d) December- February (DJF) from 2000-2010.



A 10-year heat fluxes dataset for



Climate change impacts and adaptation in River Basins

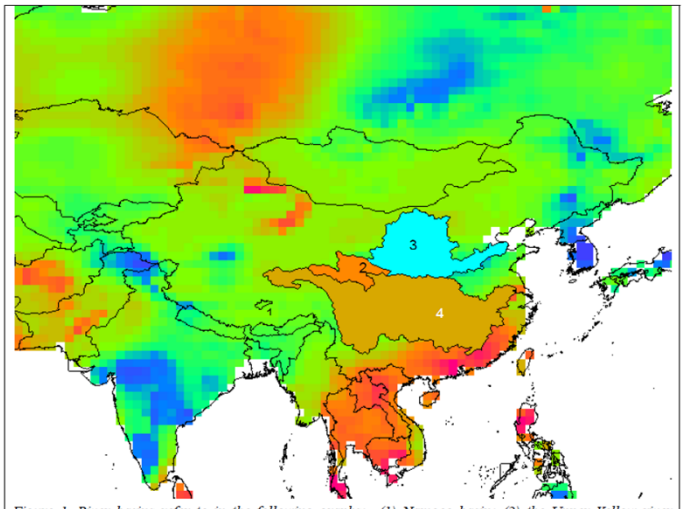


Figure 1. River basins refer to in the following graphs: (1) Namoco basin; (2) the Upper Yellow river basin;(3) the whole Yellow river basin (including the upper part (2) ;(4) Yangteze river basin.

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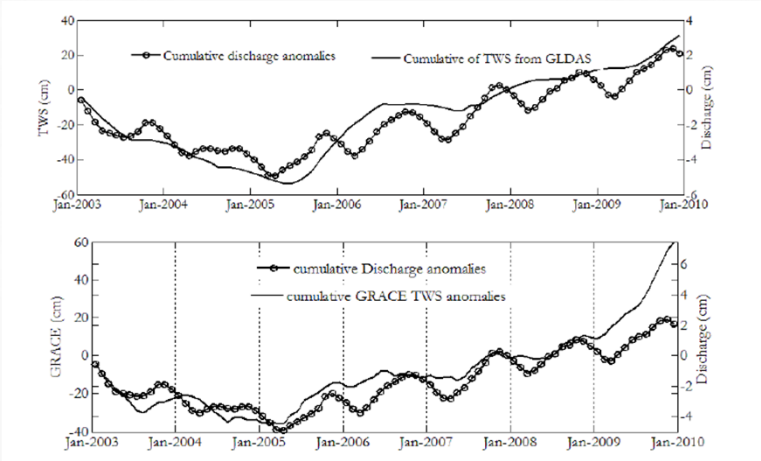
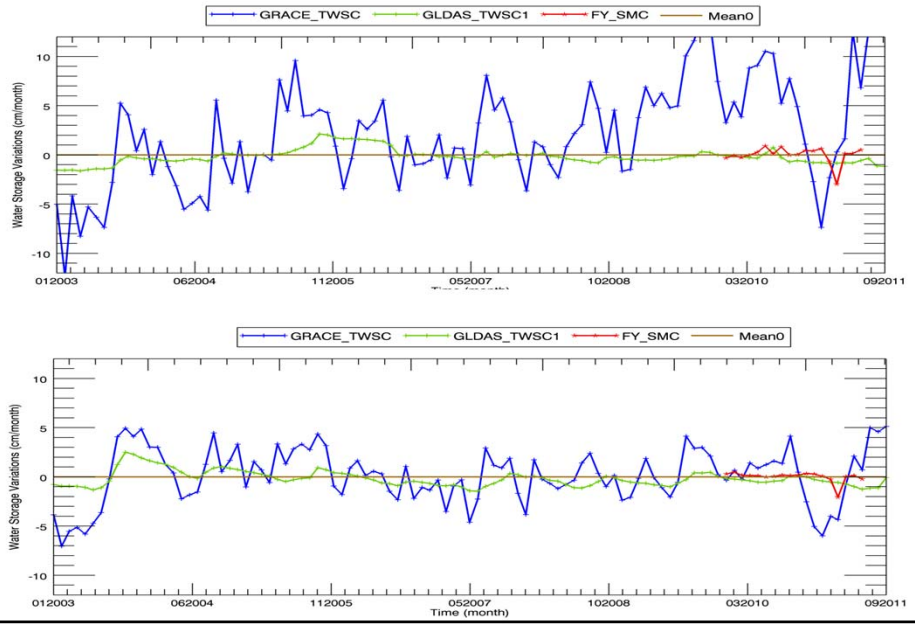
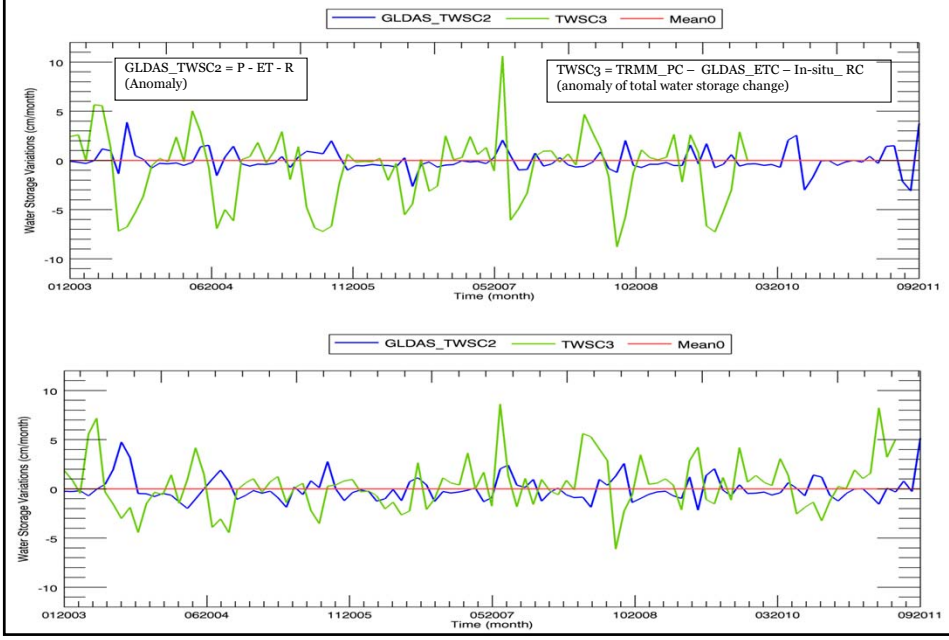
Cumulative discharge anomalies (right axis) and TWS estimated from GRACE observations and GLDAS state variables (measured discharge at Lanzhou station)



Example of the Yellow River Basin (upper basin vs whole basin)



Example of the Yellow River Basin (upper basin vs whole basin)



A Roadmap From Process Understanding To Adaptation

Climate Change Adaptation In Water Resources

Describe
- Trends (change)
- Variability (natural cycle)
- Outliers

Understand
- Attribution (variability vs. error)
- Consistency Process (e.g. Volcanic eruption, fire/aerosol)
- Feedback links (e.g. ENSO teleconnection)

Detect
- Hot Spot
- Quality issue
- Outside Envelope

Predict
- Impacts

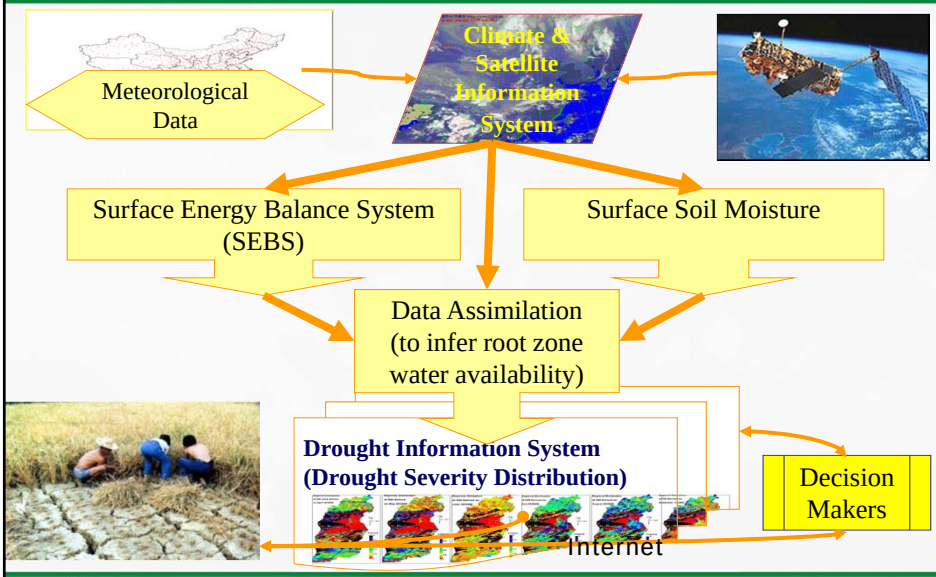
Adapt
- Consequences

What is Drought ?

Dry Condition: No transpiration

→ 4th ADVANCED TRAINING COURSE IN LAND REMOTE SENSING
1–5 July 2013 | Harokopio University | Athens, Greece

Drought Monitoring & Prediction



Practical - Part 1 – Energy balance and evaporation

Objectives

1. To derive land surface biophysical parameters using MODIS and AATSR data
2. To apply SEBS to derive surface energy balance terms (net radiation, soil heat flux, sensible heat flux, latent heat flux and evaporation)

Materials (Prepared by Lichun Wang, ITC)

- Practical SEBS exercise (MODIS part) – Exercise 1 & 2
- Practical SEBS exercise (AATSR part) – Exercise 3

Software

- ILWIS, ModisSwathTool, HDFView
- BEAM

Referances/Further Readings

- Su, Z., Wen, J., Dente, L., van der Velde, R., Wang, L., Ma, Y., Yang, K., and Hu, Z. 2011, The Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs) for quantifying uncertainties in coarse resolution satellite and model products, Hydrol. Earth Syst. Sci., 15, 2303–2316, 2011, www.hydrol-earth-syst-sci.net/15/2303/2011/.
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