Remote Sensing and *in situ* terrestrial water cycle observation capabilities

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Report of **Committee on Earth Observation Satellites**

- Priority research areas in 2004 for CEOS
- Concerning terrestrial water cycle and water resources
- Case Studies- Remote Sensing Applications
- Conclusions

Integrated Global Observing Strategy (IGOS)

Geohazards Theme

Ocean Theme

Coral Reef Sub-Theme

IGOS Themes

Global Carbon Theme

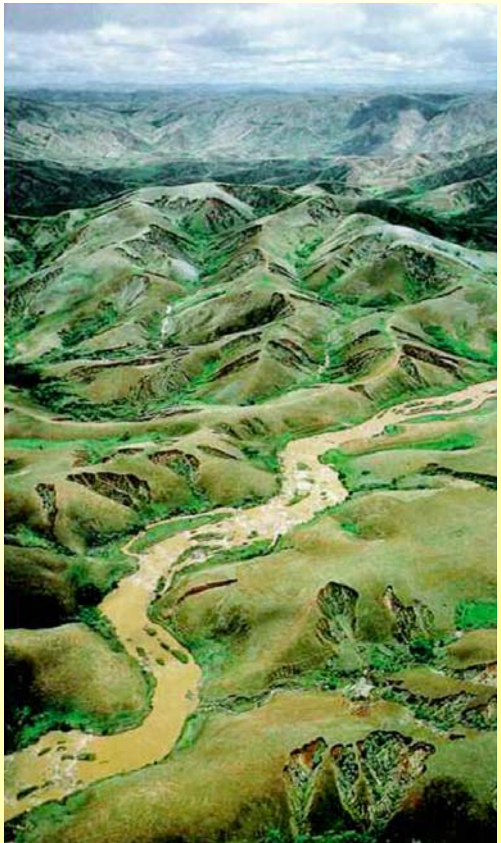
Water Cycle Theme

Atmospheric Chemistry Theme

Committee on Earth Observation Satellites

The priority areas of the Committee in 2004

- Global change (i.e. global environmental monitoring and protection),
- Disaster management
- Water resource management
- Data utilization and popularization
- Education and training



WATER: A GIFT TO MANKIND

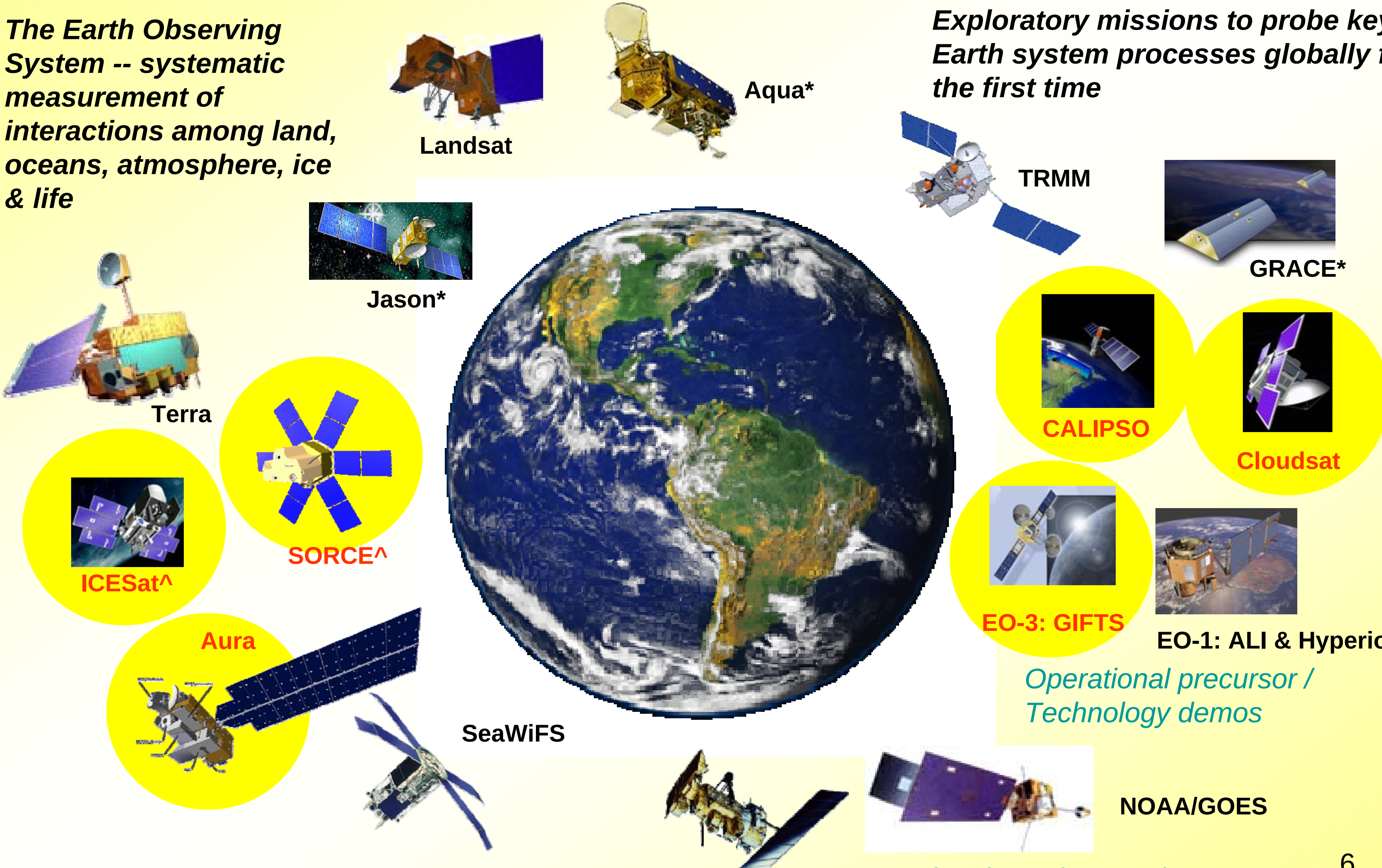
- **IT IS ESSENITAL FOR LIFE:** WHEN WATER WAS NOT AVAILABLE NOMADIC PEOPLE MOVED TO ANOTHER LOCATION
- **IT IS ESSENTIAL FOR PROSPERITY:** DAMS AND RESERVOIRS THAT COULD STABILIZE THE MONTH TO MONTH AND YEAR TO YEAR VARIABILITY IN SUPPLY.
- **IT IS ESSENTIAL FOR HEALTH:** NOT ALL WATER IS SAFE OR USEABLE



SATELLITES COULD PROVIDE A NEW GLOBAL PERSPECTIVE ON THE WATER CYCLE

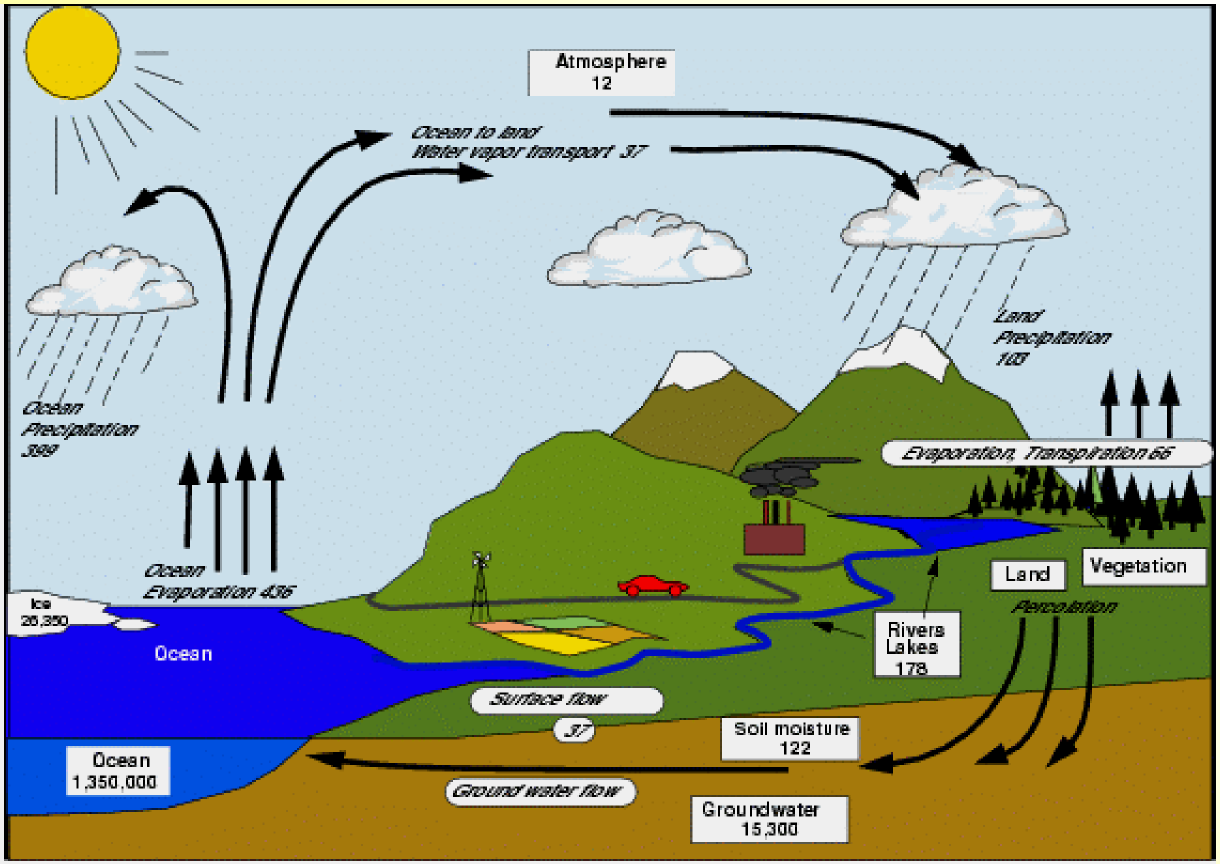
The Earth Observing System -- systematic measurement of interactions among land, oceans, atmosphere, ice & life

Exploratory missions to probe key Earth system processes globally for the first time

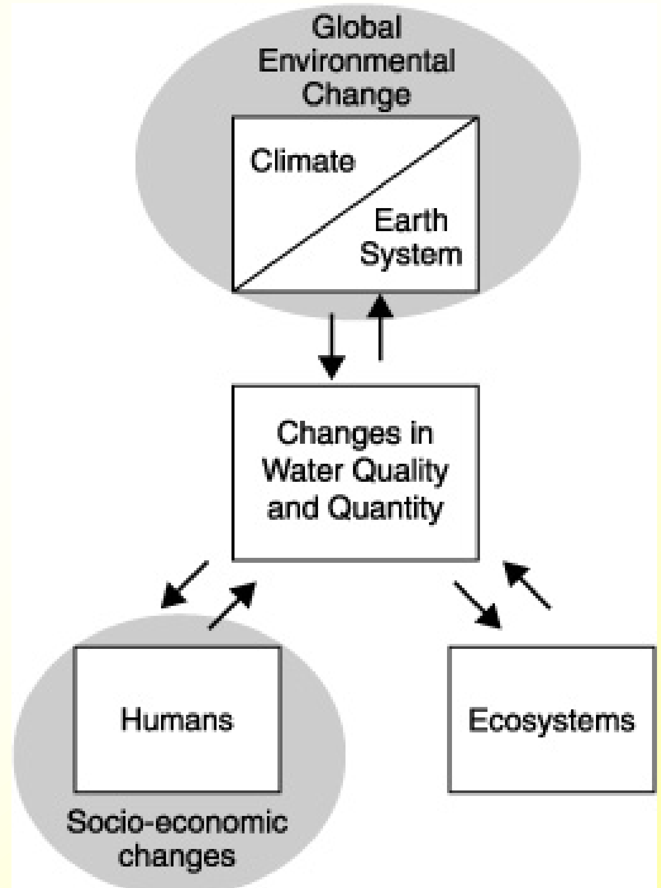


*FY02 launch (+ SAGE III)
^FY03 launch (+SeaWinds)

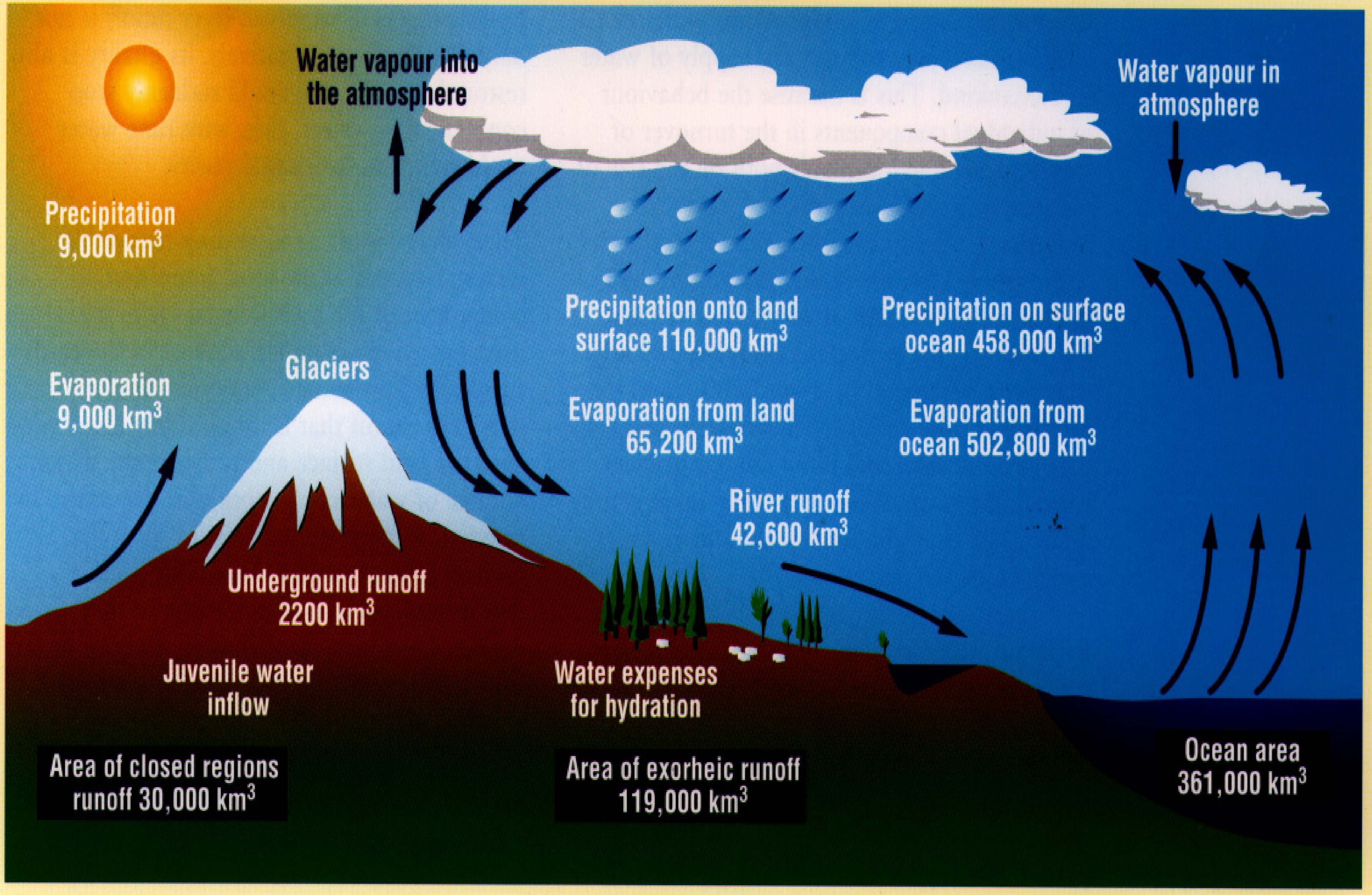
Concerning terrestrial water cycle and water resources



Hydrological cycle.
Units are thousand cubic km for storage and thousand cubic km/year for exchanges



Estimation of Water Cycle Globally

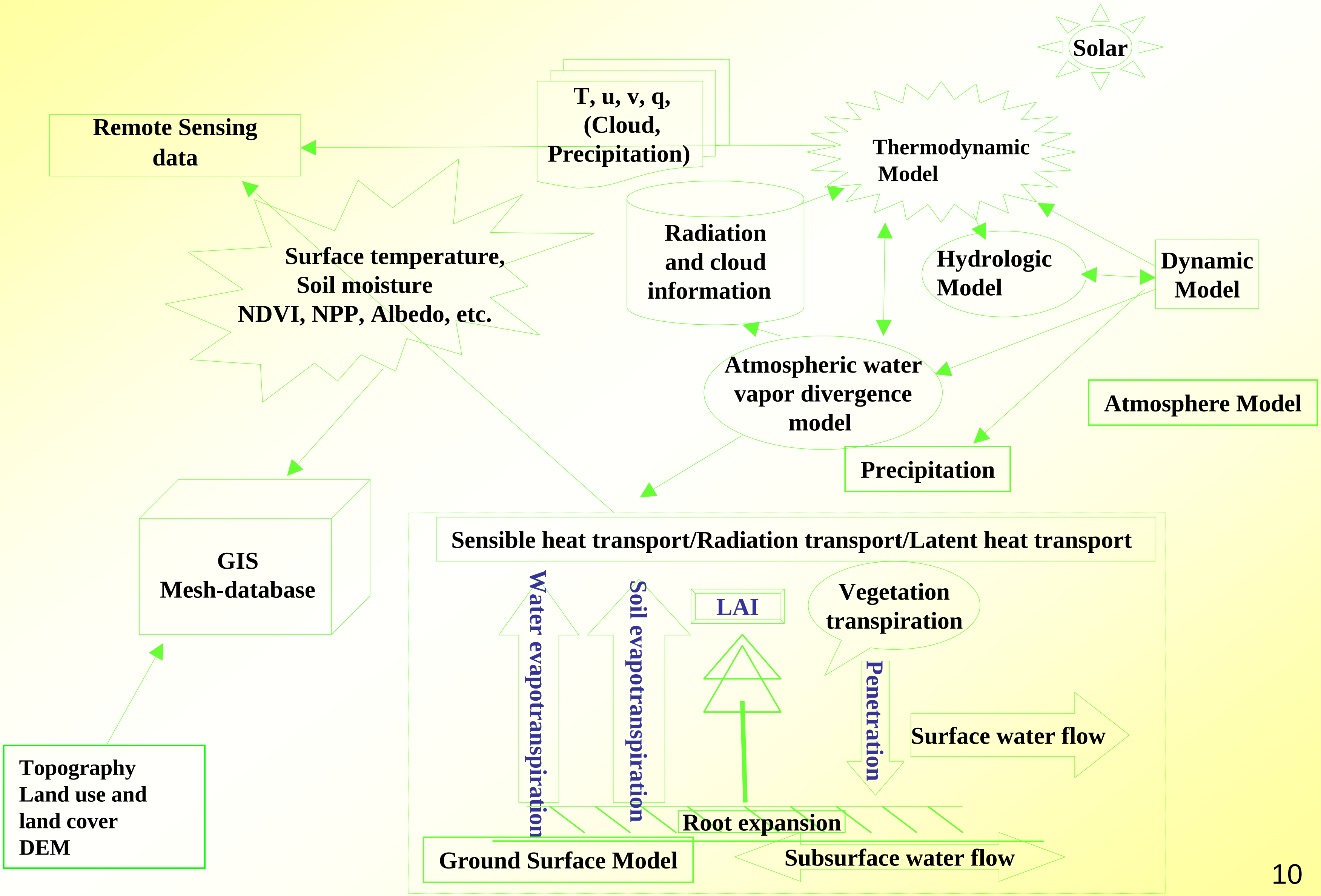


Concerning terrestrial water cycle and water resources

Theory of water cycle and water balance is one of the basic scientific issues for the studies on hydrology and water resources sciences

- **Simulating the mechanism of water cycle dynamics**
- **maintaining of water resources renewable ability**
- **multi-dimension critical adjustment and control**
- **revealing the relationship between the functions of river system and reformation structures of water management**
- **developing the analyzing model for water resources evolvement**
- **presenting adjustment and control measures for the sustainable development of the water resources in the terrestrial regions**

The frame of water cycle research based on RS / GIS

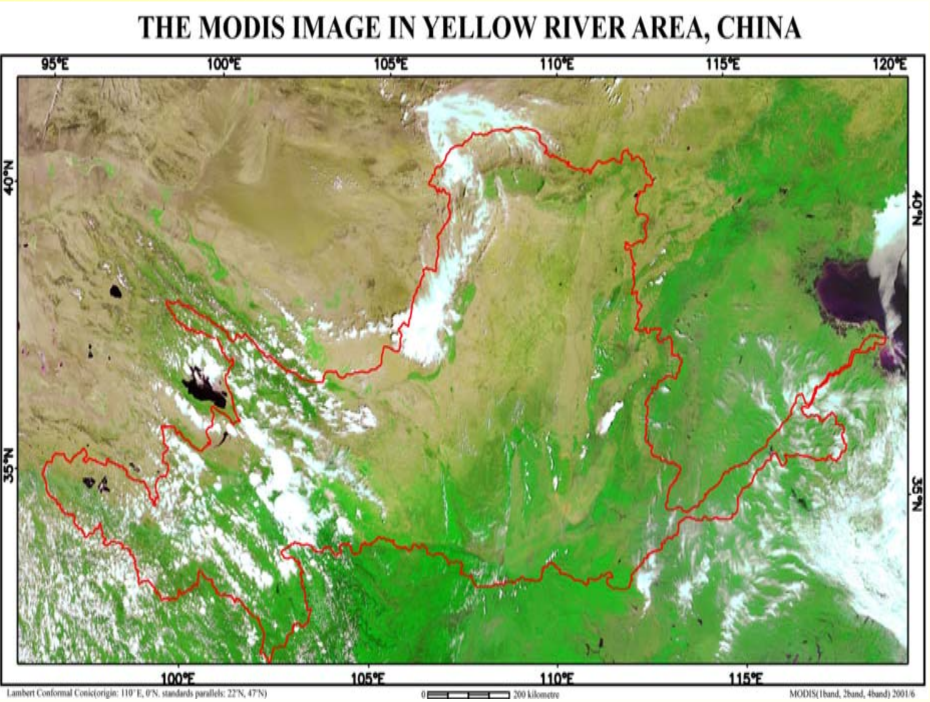


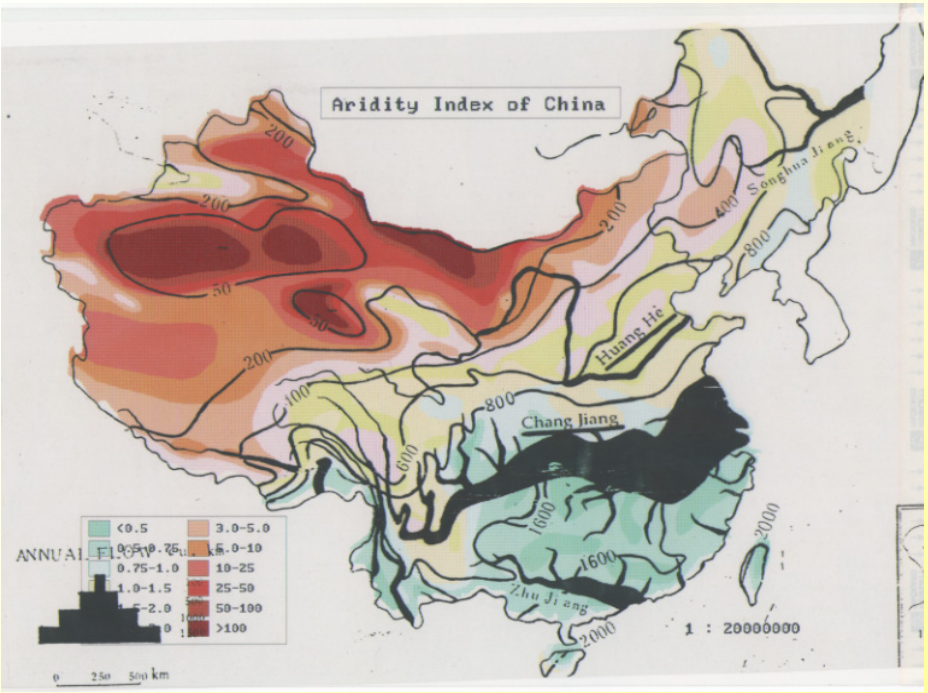
Concerning terrestrial water cycle and water resources

towards an ***integrated water cycle observational system*** that integrates data from different sources (e.g., ***satellite systems***, in-situ networks, field experiments, new data platforms) together with **emerging data assimilation and modeling capabilities**

Case Studies- Remote Sensing Applications

Yellow river basin covers a vast area. Now it is facing a harsh situation mixing with the problems in water resources shortage, water flood intensification, and the deterioration of the ecology and environment in the basin.





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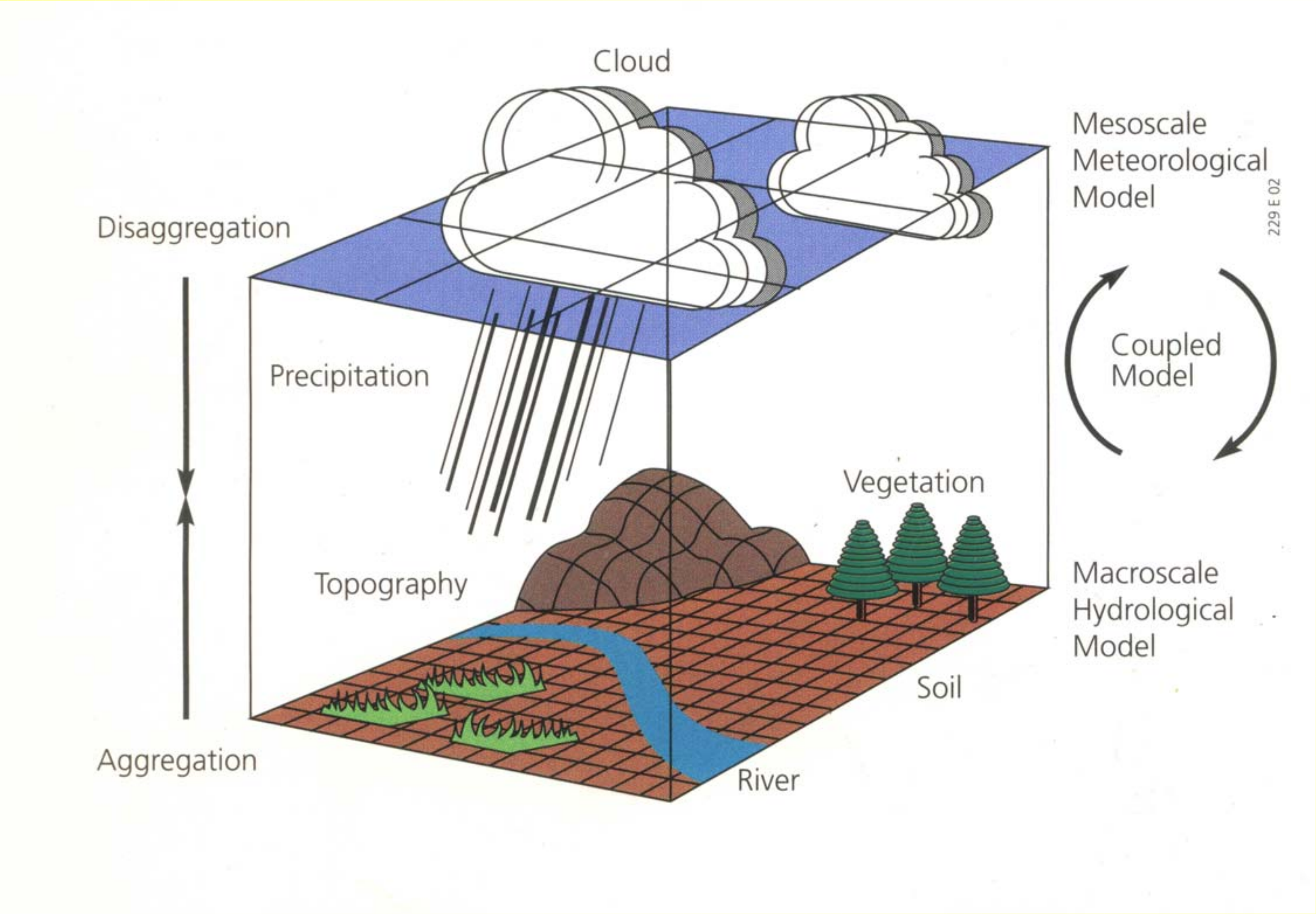
Case Studies- Remote Sensing Applications

Case Studies- Remote Sensing Applications

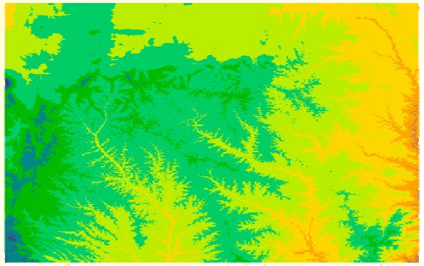
Water cycle at different scale

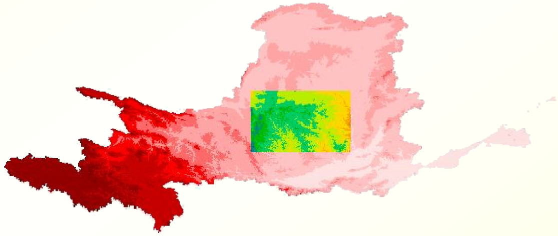


Case Studies- Remote Sensing Applications

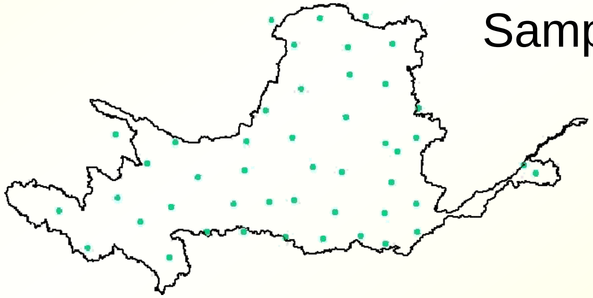
Water cycle at different scale

Study area

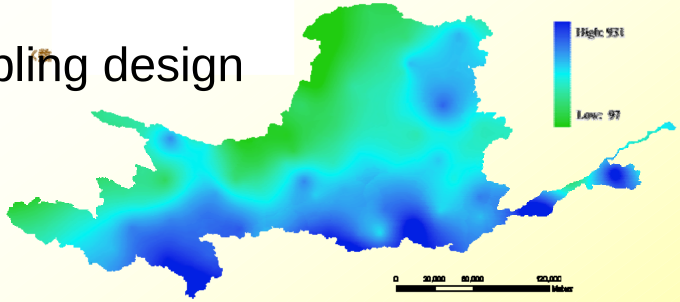




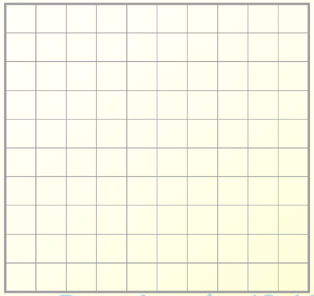
Land cover



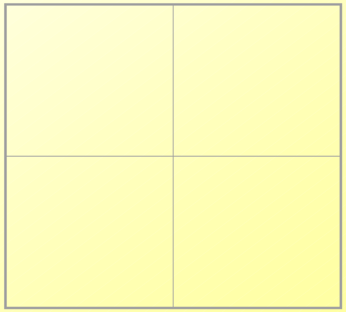
Sampling design



Grid data



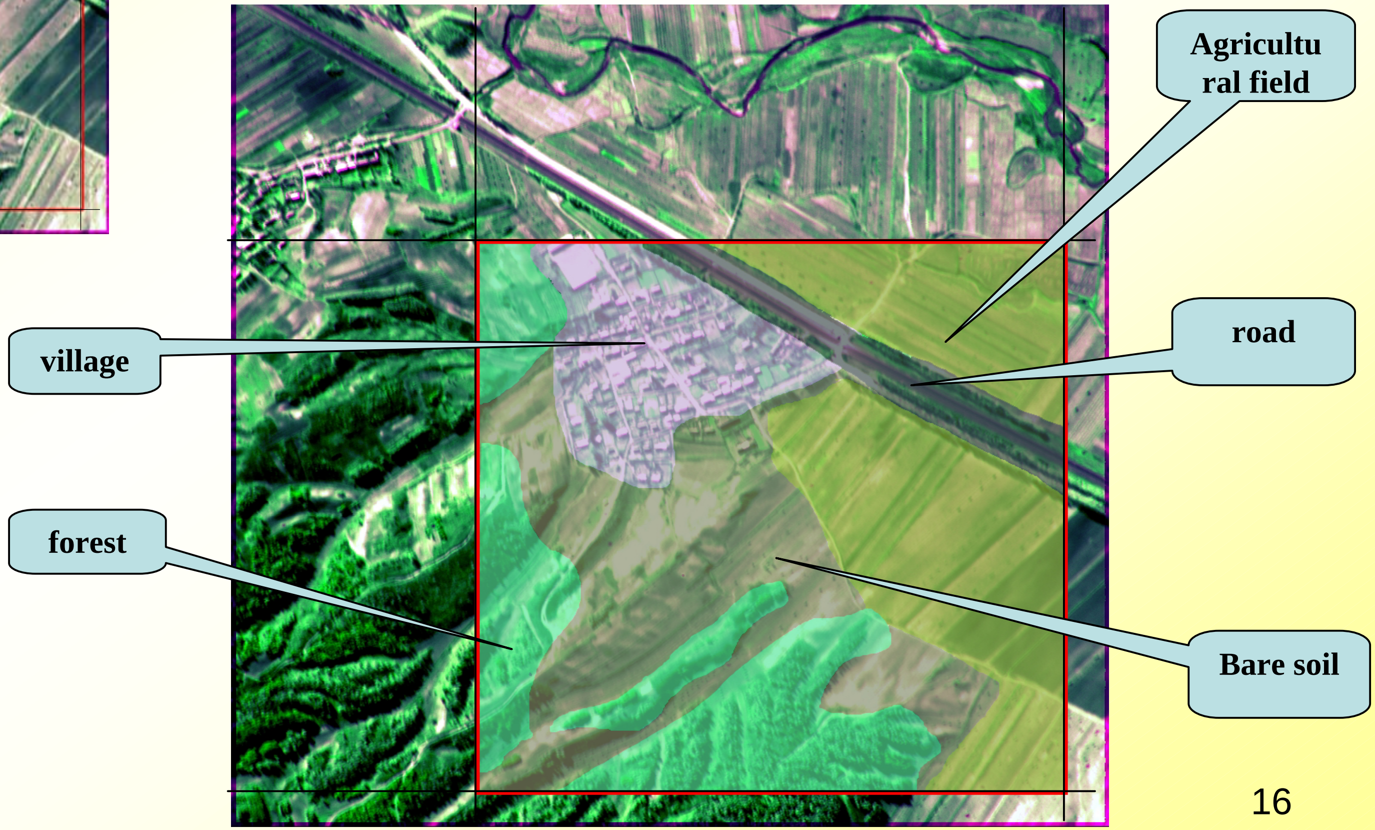
Scaling up



Case Studies- Remote Sensing Applications

A typical test site

In large scale model: classification



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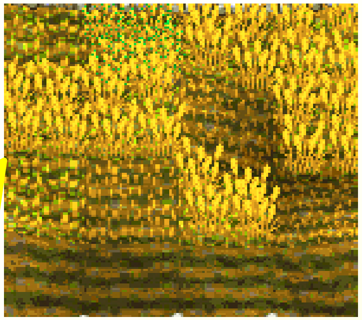
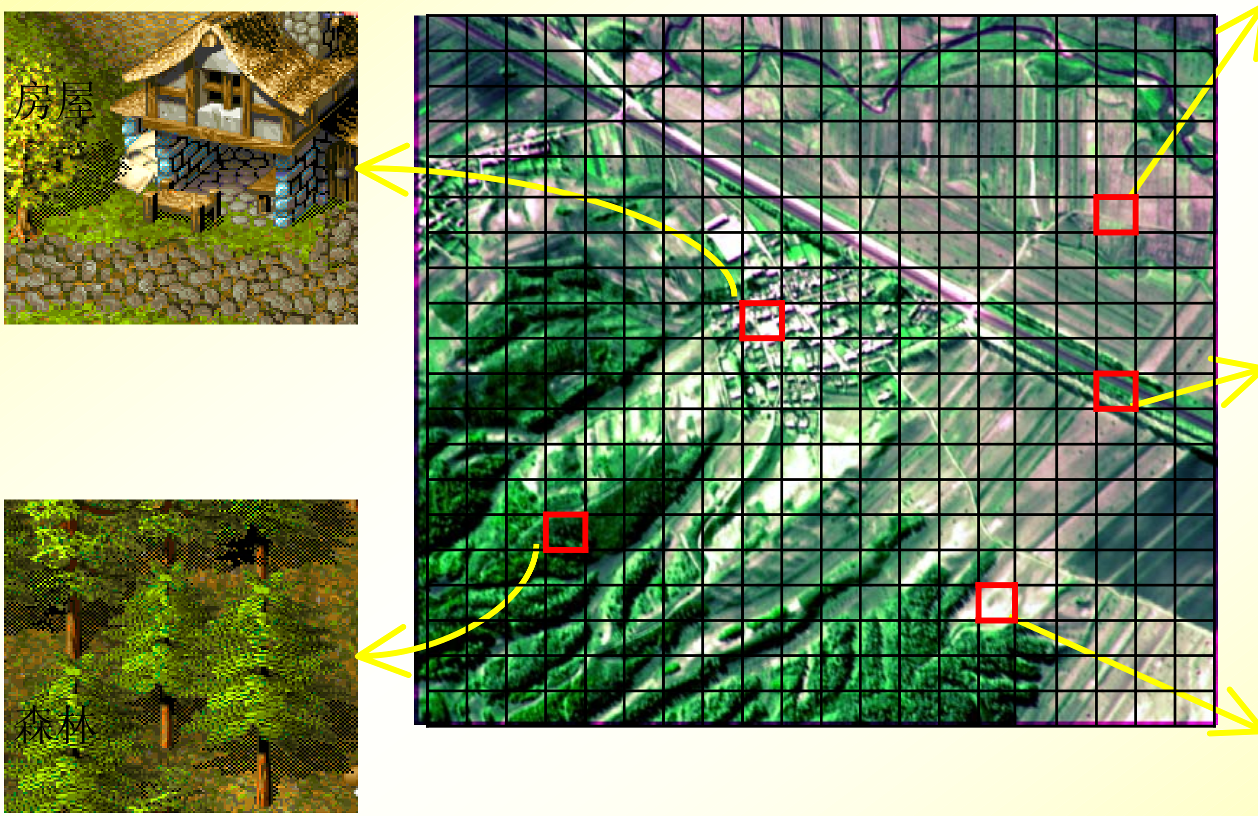
Case Studies- Remote Sensing Applications

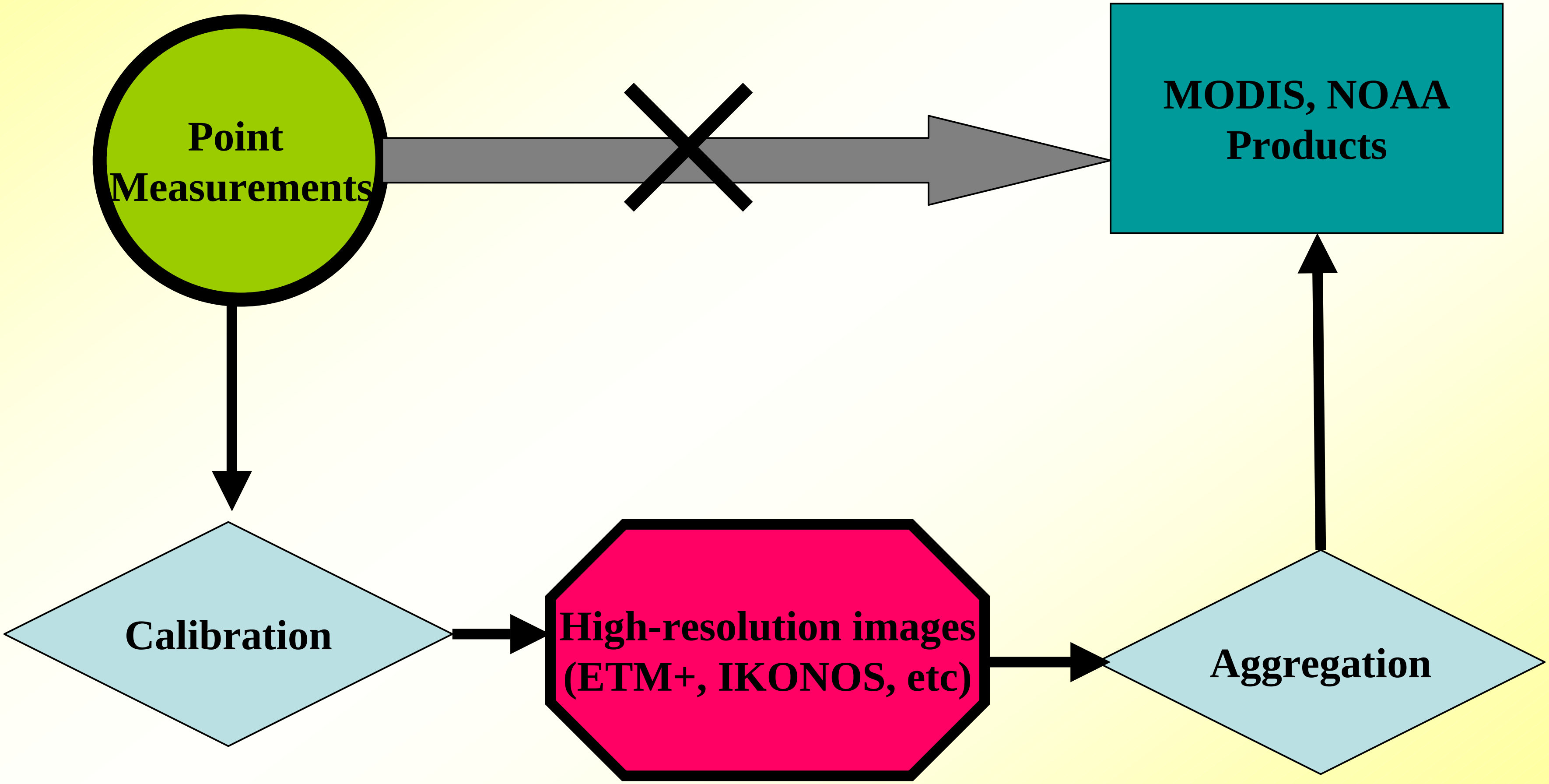
In small scale model: 3D simulation needed





Case Studies- Remote Sensing Applications

Up-scaling



Case Studies- Remote Sensing Applications

latent heat flux Model

$$LE = Rn - G - H$$

Instantaneous evaporation rate (i.e. latent heat flux *LE*) can be estimated as the residual term of energy balance formulation

Rn: net radiation

G: soil heat flux

H: sensible heat flux

Rn Model

$$Rn = RL + Rs$$

RL: long wave radiation

Rs: short wave radiation

Sensible heat flux Model

$$H = \rho\, Cp(T0-Ta)/raa \rightarrow H = \rho\, Cp(T0-Ta)/(raa+r)$$

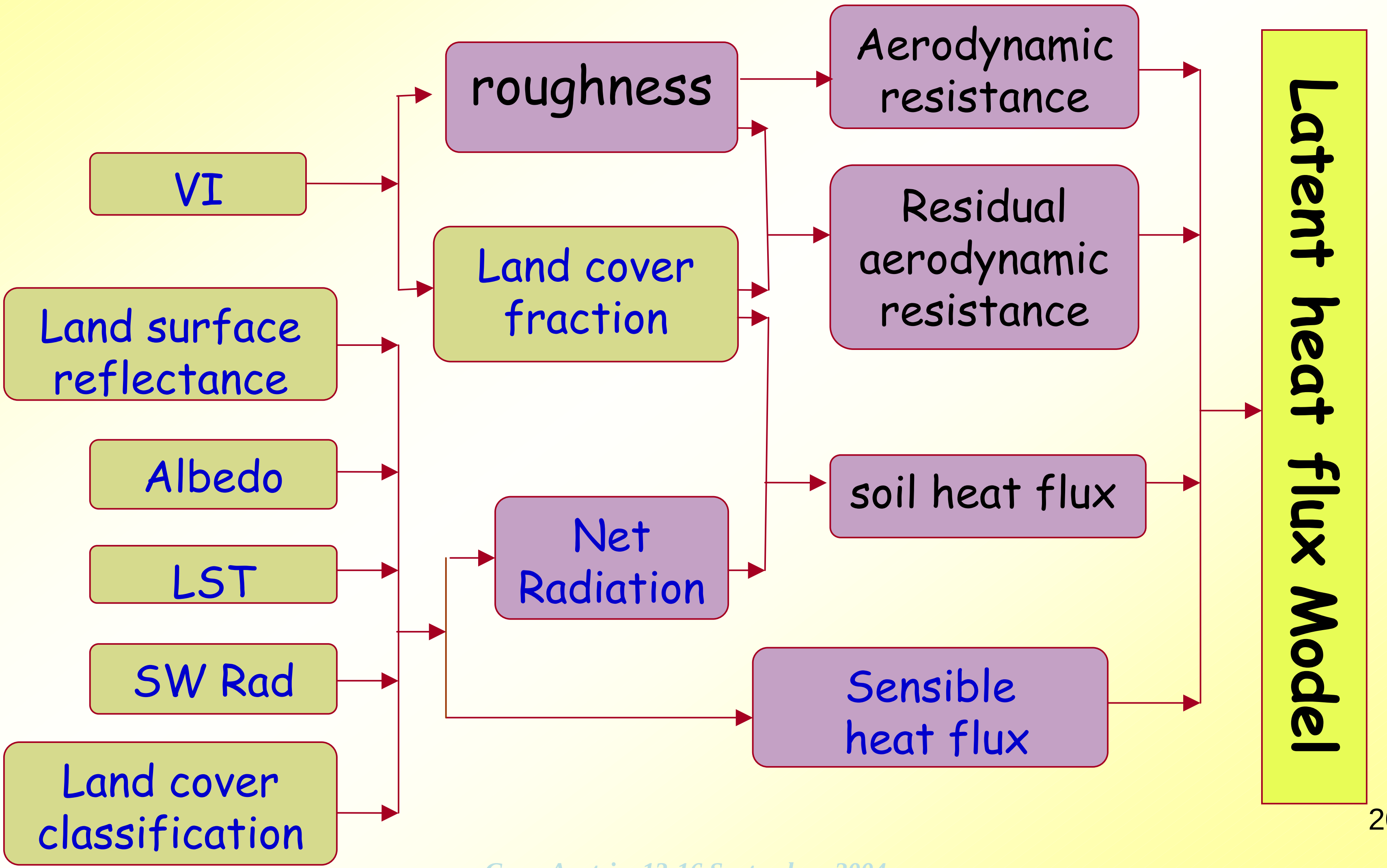
T0 :aerodynamic temperature

Ta :air temperature at reference height

Tr :radiometric surface temperature

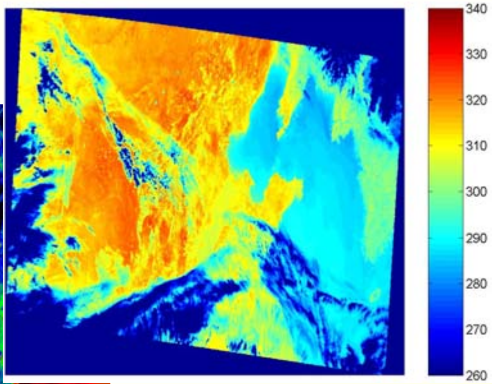
Case Studies- Remote Sensing Applications

The procedural sketch of ET estimated by remote sensed data

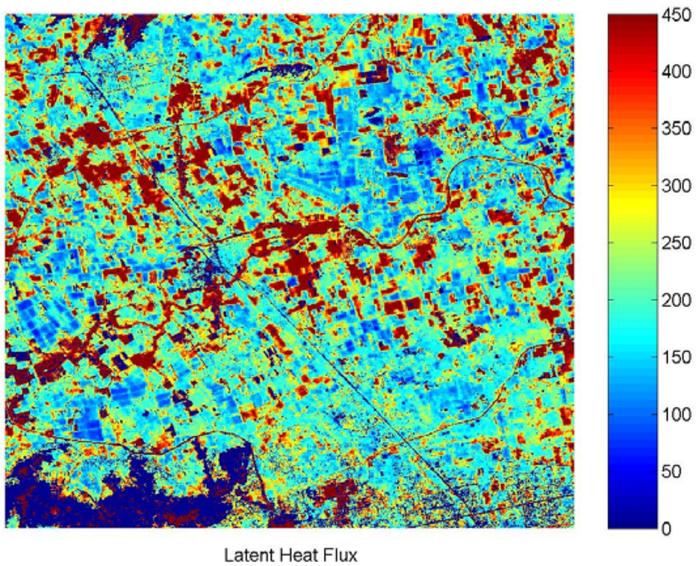


Case Studies- Remote Sensing Applications

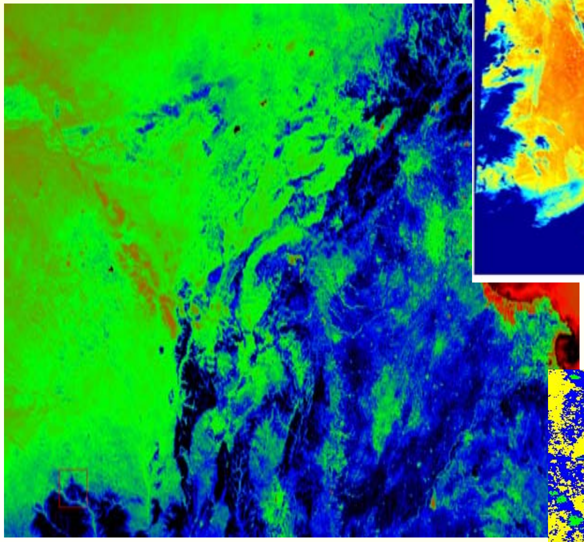
LST



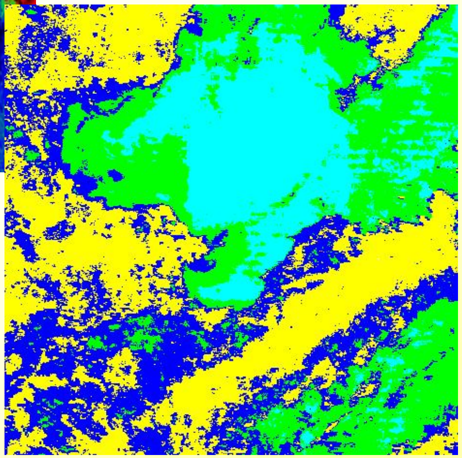
Evapotranspiration



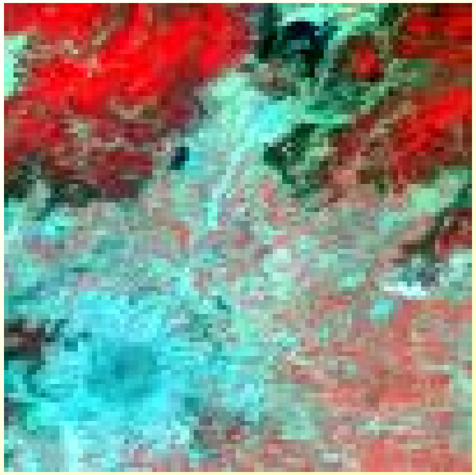
NDVI 5/19/2002



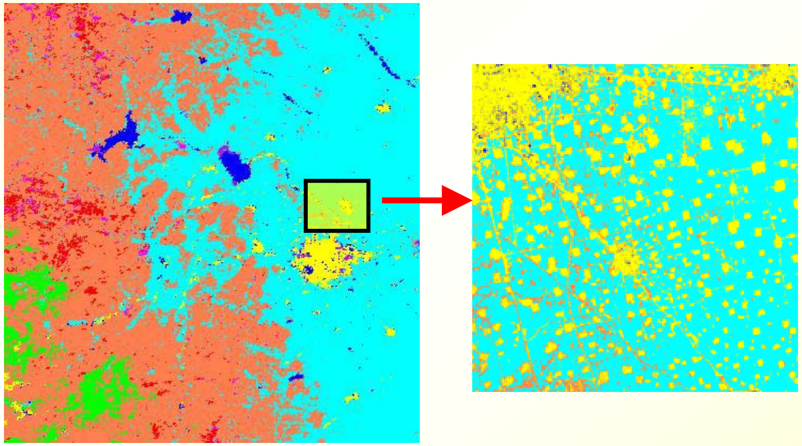
Albedo 5/19/2002



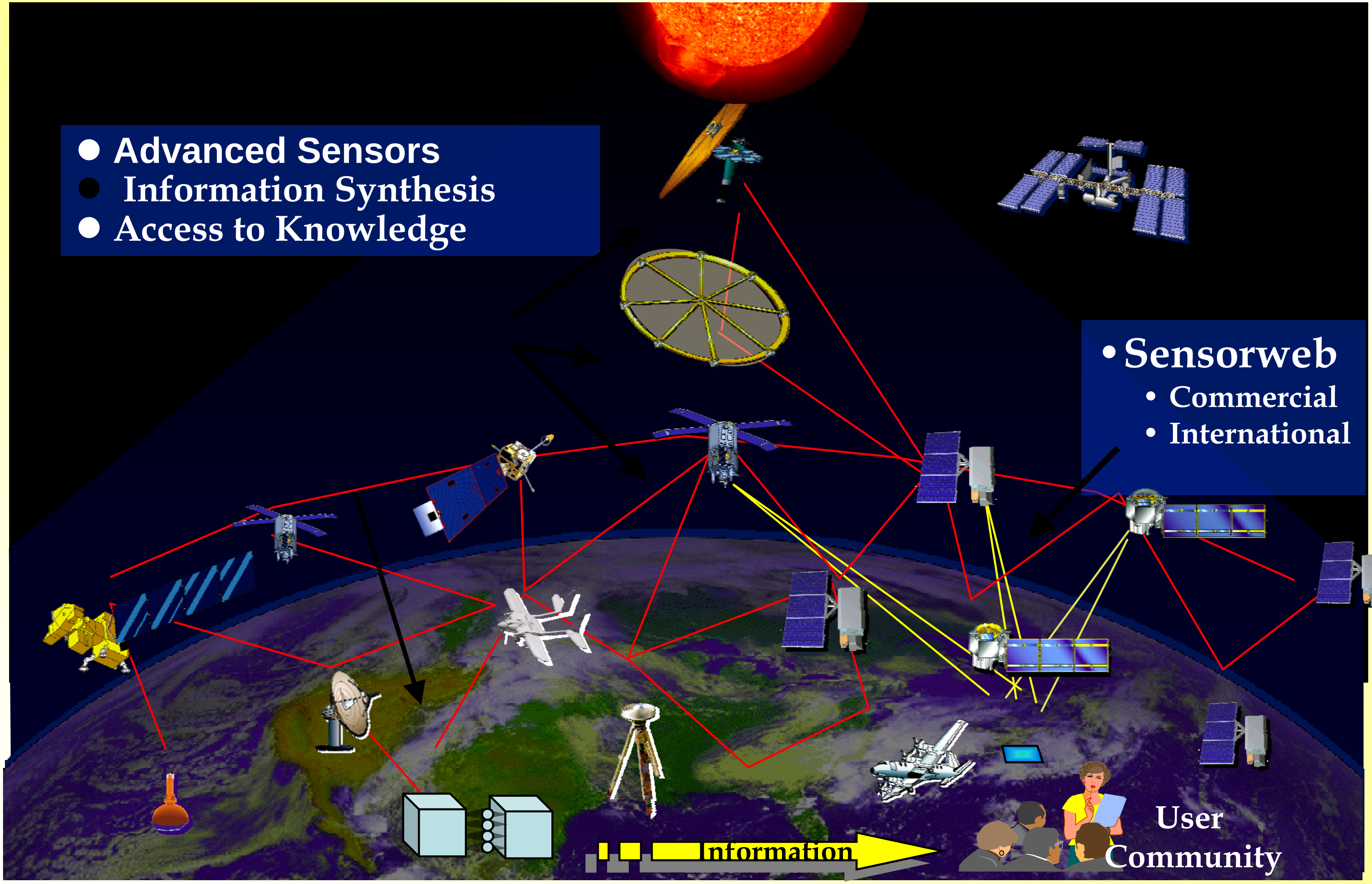
LAI 5/19/2002



Land cover



Observing System of the Future



Conclusions

- Observing the Global Water Cycle is not possible without observations from satellites

- Satellite observations are limited as well, but are well-suited to partner with 4-dimensional data assimilation

- Novel approaches to data integration together with system approaches to satellite observations will be needed to adequately observe the regional water cycle

- More remote sensing data could be expect in the near future