Earth Observations and Targeted Water Security Needs

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What is Water Security?

Water security describes a condition where an adequate secure supply of clean water is available to meet all of the needs of humans and ecosystems on a continuous basis within each basin of the world. Some countries have abundant rainfall and infrastructure that facilitates water security. However, a number of the world's communities live in countries and basins that are water insecure because the climate is arid or highly variable, water supplies are very limited, and the infrastructure is inadequate. Water insecurity is often the main cause of food insecurity and in some nations, a cause of energy insecurity and transboundary issues.

Examples of Threats to Water Security

Climate Change: The changing climate is expected to produce more extreme events, expand drought areas, intensify floods, shift precipitation patterns, and lead to rising sea levels,.

Industrial Expansion and Land Use Change: Uncontrolled industrial expansion, agricultural practices, and deforestation can lead to stress on hydrologic systems, overuse of the scarce water resources, and water pollution.

Inadequate Infrastructure: Infrastructure is needed for protection from floods and rising water levels, the movement of waste water, and the efficiency of water treatment services. In many basins water infrastructure is either old or non-existent.

Growth in consumer numbers and consumer demand: Population growth, urbanization, economic prosperity, changing diets, and increasing expectations lead to increases in water demand.

Water Pollution: The lack of adequate water treatment to return water to the standards for potable water, the expanded emission of industrial pollutants, the release of novel chemicals and pharmaceuticals into water sources, and the inadequate use of water recycling.

Water Inequity: Social stresses arising from inefficient practices (e.g., water intensive agriculture in water-poor countries for export); easier access to water for favoured communities, inadequate services for indigenous groups, unregulated upstream use and pollution, all cause inequities leading to social tensions.

Applications of Data for maintaining Water Security

In general, data (and data driven models) are used to support:

Planning: Data and models support the scoping and evaluation of options, risk assessment and the assessment of benefits of infrastructure development under different management scenarios. Planning is needed for risk reduction, market development, effective management of water resources, and reducing the impacts of short-term extreme events and long-term environmental trends.

Evaluation: Information enables governments to assess proposals for increasing water security and to select those worth funding.

Management: Information supporting operational decisions is needed on different time scales by basin managers to ensure that quality water continues to be available under every threat and contingency.

Monitoring: Data for analysis to determine if government policies and regulations are achieving the goals set for water security if specific controls need to be put in place.

Enforcement: Data for use by governments, insurance companies and others to evaluate where regulations and standards have been violated and where penalties should be levied or claims need to be denied.

An optimum Water Security Monitoring Strategy requires both In-situ and Satellite Earth Observations.

Advantages of each type of Earth observation data:

1) Satellite data provide impartial global coverage with standardized data for every pixel.
2) Satellite data production is sponsored by developed countries. Often users need only to download and analyze the data.
3) Satellite data are not limited by national boundaries so they are useful for informing international and transboundary water issues.
4) In-situ data are essential for calibrating satellite data and assessing similarities and differences in historic extreme events.
5) Satellite data are especially useful where in-situ data are not available and interpolation is needed to estimate fields.
6) In-situ data are critical for assessing trends and changes to event return periods.

Challenges in using satellite data:

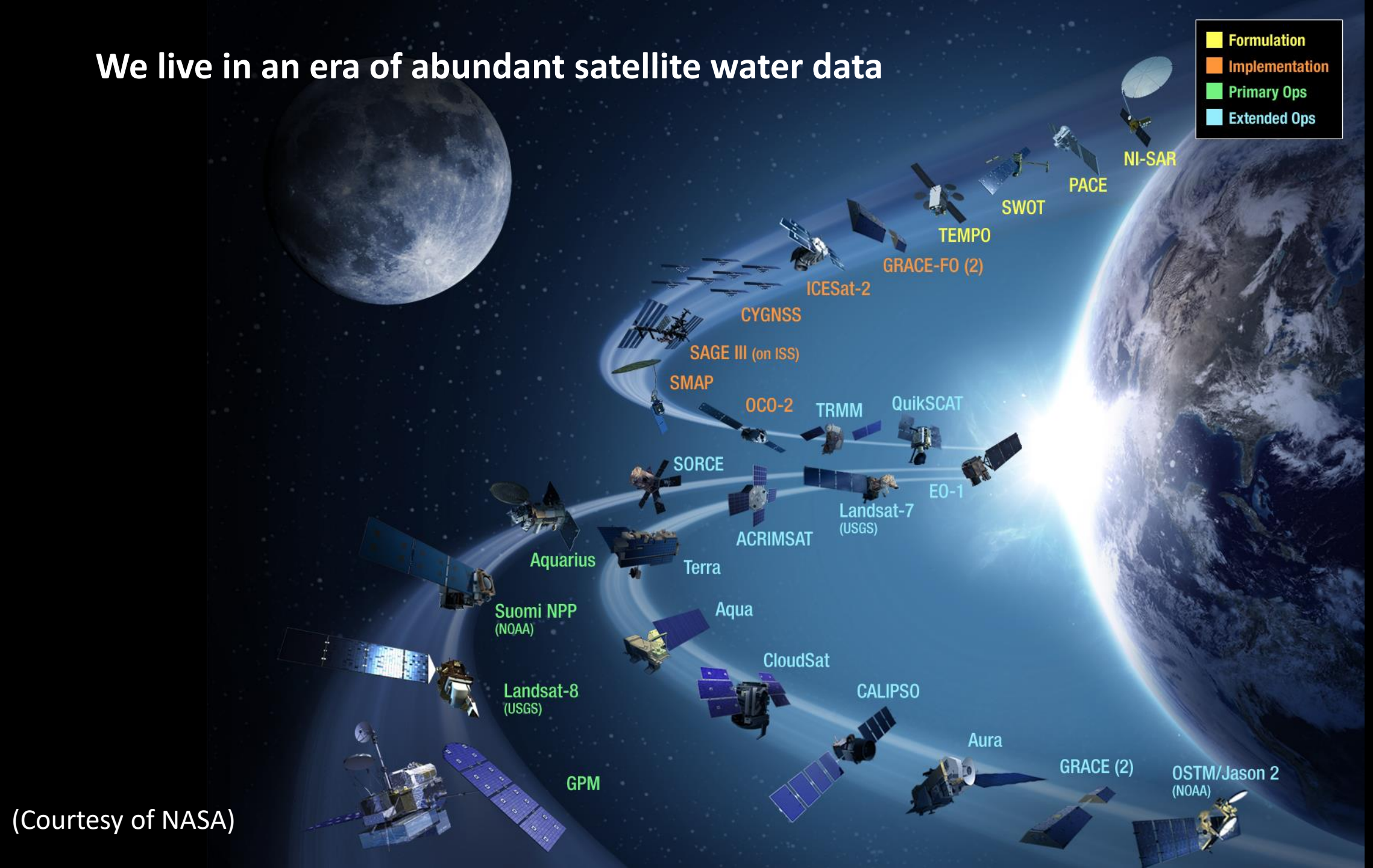
1) Algorithms are needed to calculate reliable water data and information from satellite radiance measurements. These algorithms are usually most accurate for the location where they were developed but may be less reliable for other locations.

2) In the case of optical satellite data, clouds sometimes block the target being observed and night-time data are very limited.

3) Operational applications rely on stable satellite platforms. Some satellites in orbit support operations (e.g., NOAA, EUMETSAT) while others support research programs (NASA, ESA, JAXA). Ideally, research satellite technologies are placed on operational satellites once their utility is proven (and budgets are available).

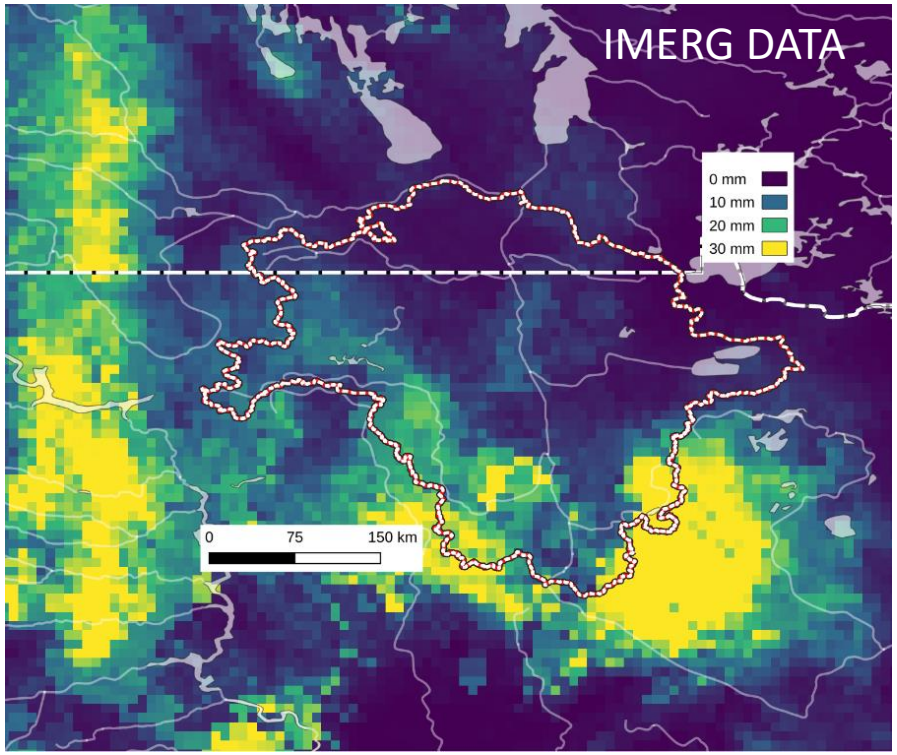
4) The growth of the private sector involvement in providing Earth Observations may lead to new polices regarding making data available at no cost.

We live in an era of abundant satellite water data



(Courtesy of NASA)

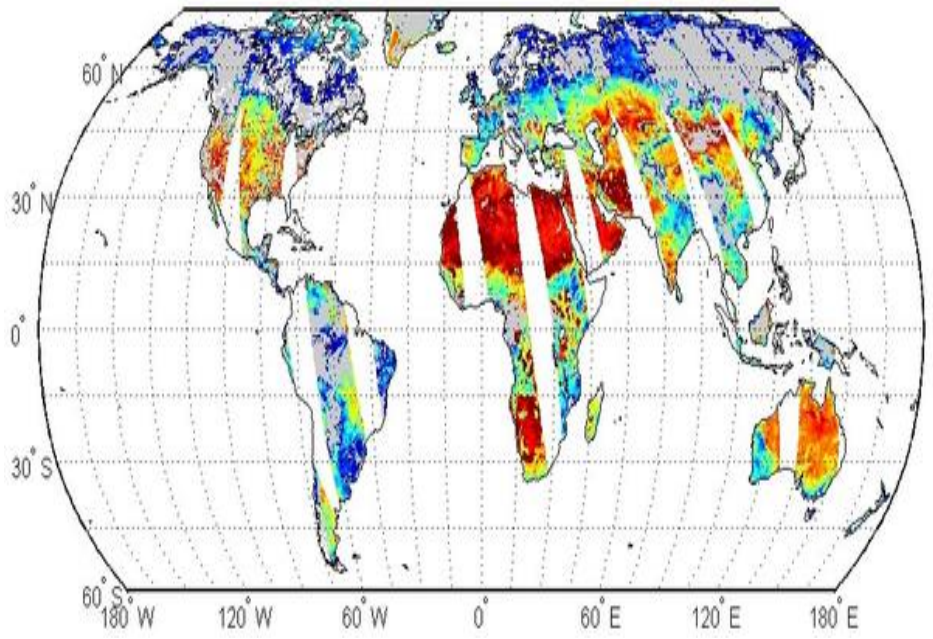
Satellite Data for Water Security



Variable: Precipitation (Amount and Rate)

Use: Determine water inputs to river systems and soils, raise flood potential, and increase erosion rates.
Useful scales and frequencies Δx ~1km; hourly
The security issues:
Precipitation: too much (floods);
too little (low flows, no water recharge,)
High rain rates: cause flash floods and high erosion rates.

Data Sources:
Satellite: Global Precipitation Mission Constellation
Merged products: IMERG,
Predictive Capability: Predicted by meteorological models
Use in hydrologic forecasting: Precipitation is a critical input to hydrologic models and streamflow prediction

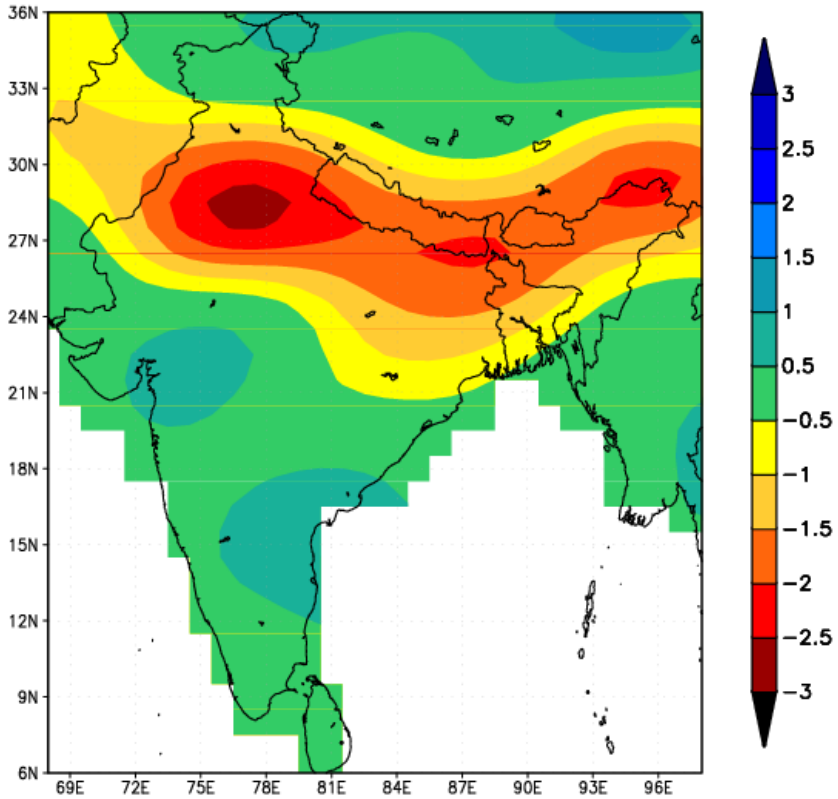


Variable: Soil Moisture

Use: Determine the water in the soil for plant growth.
Useful scales and frequencies Δx ~20 km; weekly
The security issues:
Soil moisture too low: crop failure, higher LST
too high: increased flood risk

Data Sources:
Satellite: SMOS, SMAP, AMSER/E, Sentinel

Predictive Capability: Predicted by Land Surface models using meteorological inputs
Used in hydrologic and meteorological forecasting through inputs to models.

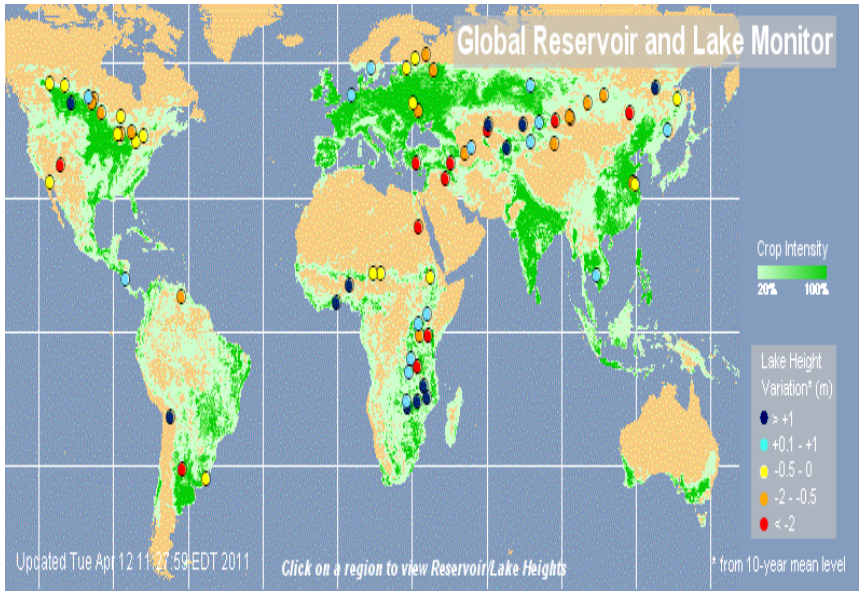


Rate of change in TWS (cm/mo.) (after Rodell)

Variable: Groundwater

Use: Determine location of groundwater aquifers and their rates of recharge or depletion (from overuse). Infer potential contamination threats (e.g., salinization).
Useful scales and Frequencies: Δ~30km; bi-weekly
The security issues: Ground water depletion or contamination leads to the inability to use this source to meet water needs.

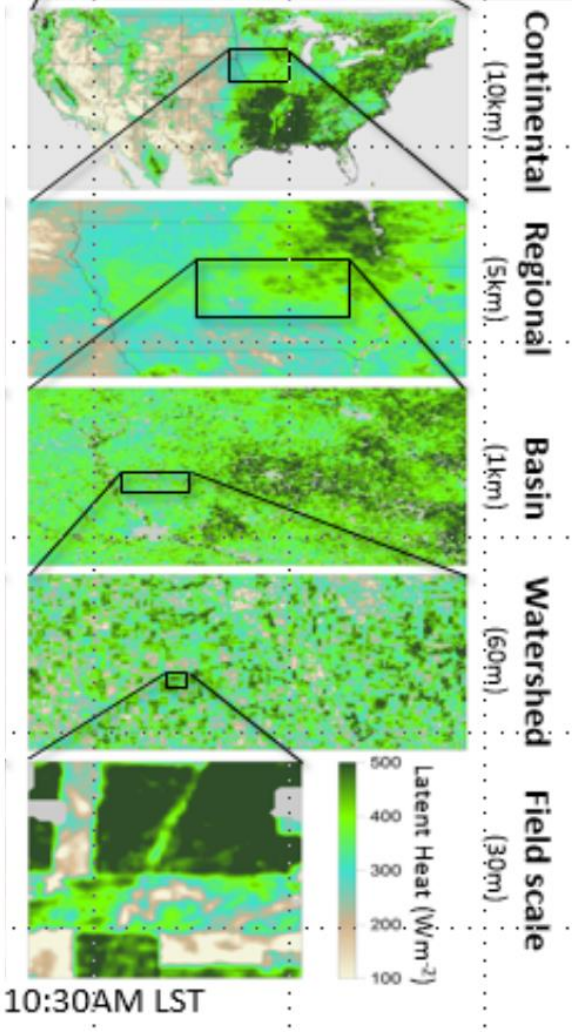
Data Sources:
Satellite: GRACE II, Sentinel
Predictive Capability: Quantity predicted by hydrological models tracking recharge rates. Quality is predicted by models that track the flow paths for individual contaminants (e.g., gasoline)



Variable: Reservoir and Lake Storages
(assessed by lake level measurements)
Use: Lake levels are used to calculate storage volumes in reservoirs or as proxies for storage volumes.
Useful scales and frequencies: Δx~10 km; bi-weekly
Security issues:
Water Quantity: too high (flood); too low (drought).
These levels affect water availability for hydropower, irrigation, and recreation.

Data Sources:
Satellite: SWOT (Future), OSTM/Jason 2 , Sentinel, GRACE II

Predictive Capability: Based on precipitation amounts and hydrometric inputs (inflows, outflows) to basin scale hydrologic models

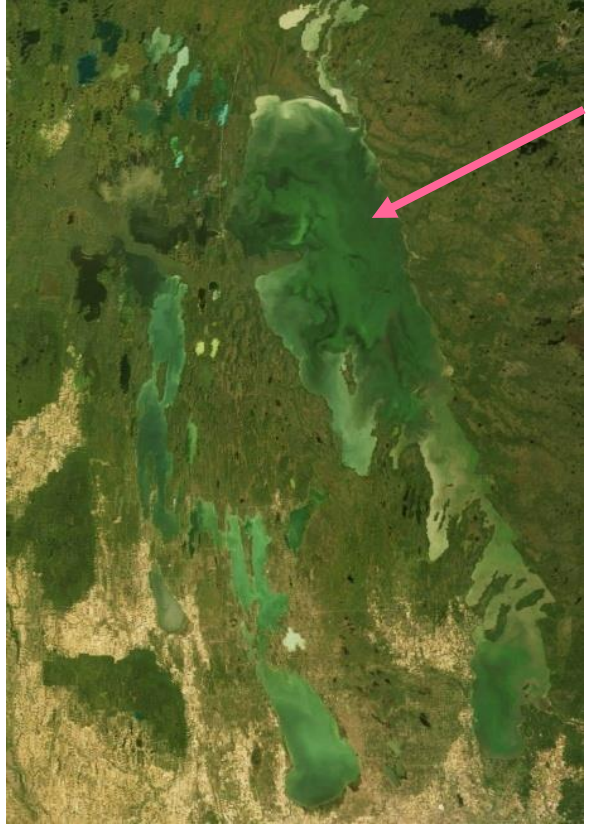


Variable: Evapotranspiration (ET)

Use: Determine the need for irrigation and evaluate the irrigation water use.
Useful scales and frequencies Δx~0.1 km, 30 minutes
The security issues:
Too little: not enough crop growth, enhances heat waves
“Too much”: possible ineffective irrigation practices.

Data Sources:
Satellite: LANDSAT, MODIS, Sentinel, ECOSTRESS

Predictive Capability: ET derived from satellite land surface temperature measurements (LSTs) and LST forecasts.



Algal bloom on Lk. Winnipeg

Variable: Water Quality

Use: Identification of areas with potential water quality problems (Phytoplankton blooms, suspended solids, thermal pollution)

Useful scales and frequencies: $\Delta x \sim 0.1$ km; daily

The security issues: Use of water affected if blue-green algae or other pollutants are present.

Data Sources:

Satellite: LANDSAT, MODIS, Sentinel

Predictive Capability: Generally limited. Hydrological models used with WQ parameterizations in some situations.

Conclusions

Satellites continue to provide very useful sources of data for supporting water security initiatives and services. Satellite data is a freely available resource which are most effective for informing water security when used in an integrated In-situ data, satellite data, and model environment.

Space agencies, CEOS, and GEO, welcome “needs” statements from countries and agencies concerned with public policy issues such as water security for climate change, disaster risk reduction, sustainable development, etc.

A study should be undertaken to assess the emerging needs of developing countries for satellite data to improve water security, to enable these countries to develop strategies and actions to achieve the SDG6 targets, and to promote ways to increase private and public sectors’ joint actions and collaboration in addressing water resources issues.

Thank you for listening