

Contributions of different water storage compartments to total storage change from multi-sensor analysis

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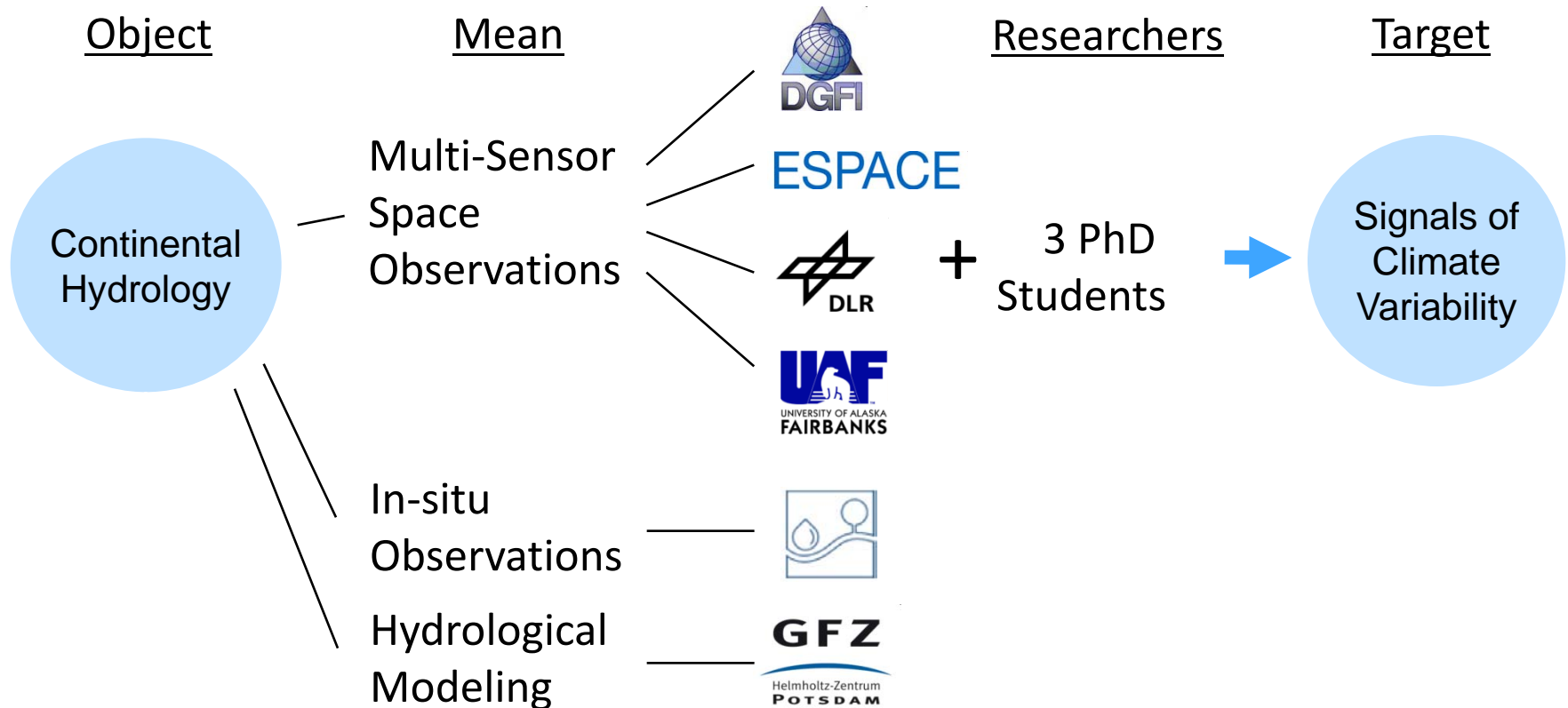
Geodätische Woche 2010



Introduction

CLIVAR-Hydro

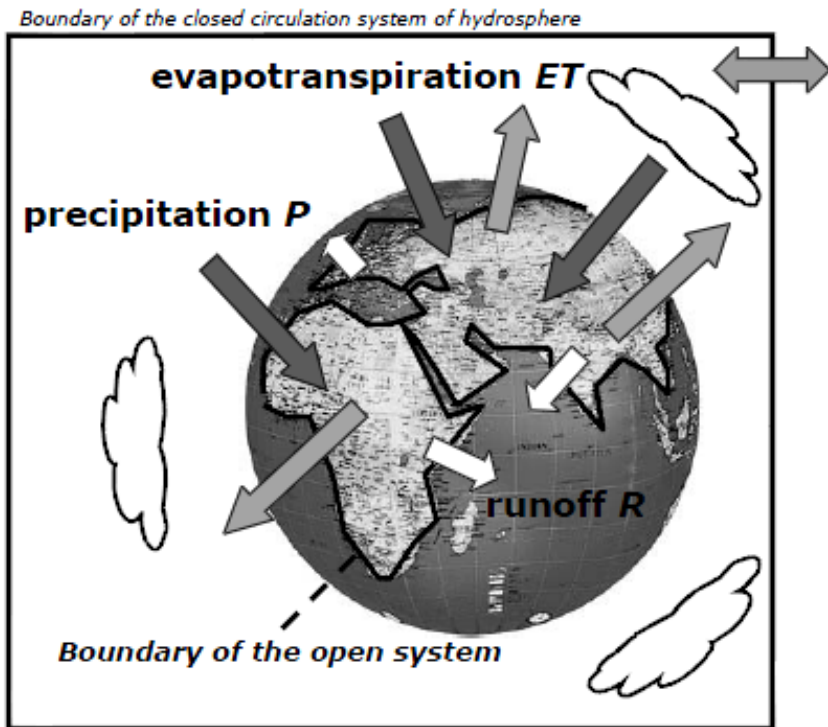
- Signals of Climate Variability in Continental Hydrology from Multi-Sensor Space and In-situ Observations and Hydrological Modeling



Concept

Water Balance Continental Surface

- open system -



only energy

long-term average

$$\bar{P} = \bar{ET} + \bar{R}$$

short-term balance

$$P = ET + R + \Delta S \rightarrow \text{Gravimetry}$$

Surface Water

Soil Moisture

Ground Water

Snow Water and Ice

Schönheinz D., BTU-Cottbus

Soil Moisture

Theory

- Basic Principle:

Fresnel reflection equation

$$r^H = \left| \frac{\cos\theta - \sqrt{k - \sin^2\theta}}{\cos\theta + \sqrt{k - \sin^2\theta}} \right|^2 \quad r^V = \left| \frac{k \cos\theta - \sqrt{k - \sin^2\theta}}{k \cos\theta + \sqrt{k - \sin^2\theta}} \right|^2$$

Reflectivity of the ground (r) for a certain polarization (H or V) depends on:

- the viewing angle of the sensor (θ)
- the dielectric constant (k) → depends on the constituents of the ground (air, soil, water)

Example: dry soil: $k = 5$

 water: $k = 80$

Jackson 2005
Jackson 2002

Passive vs. Active Sensors

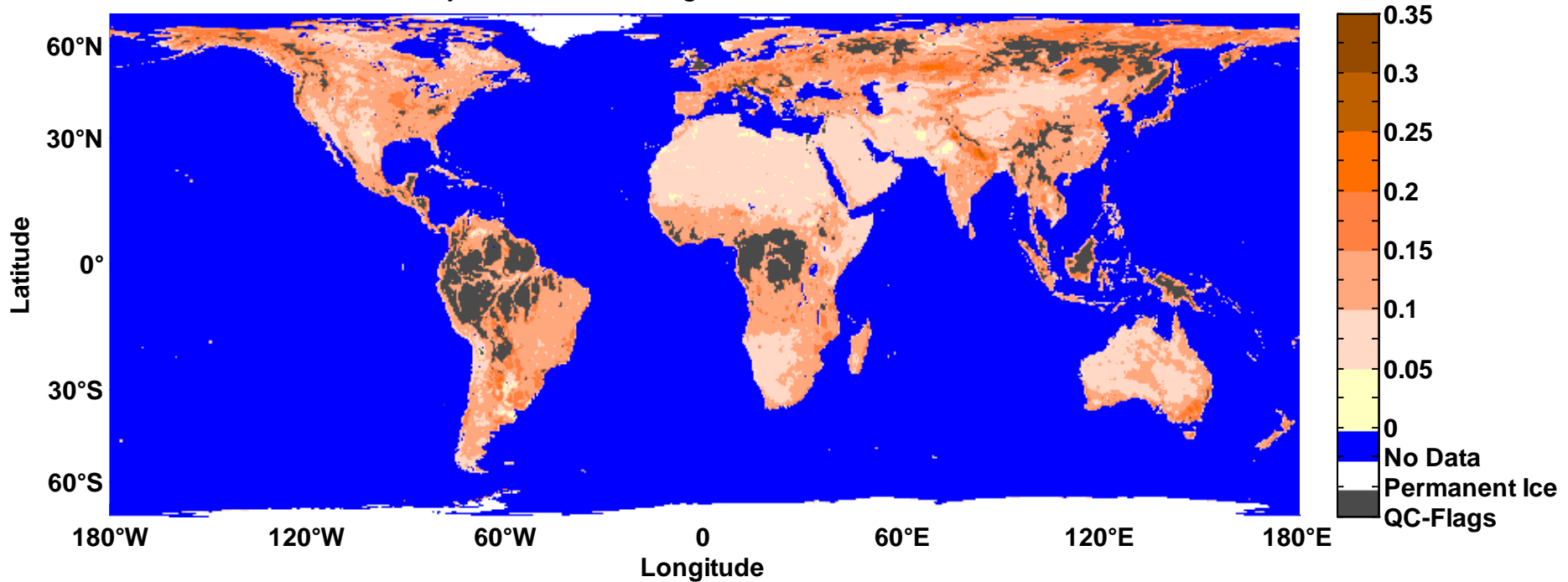
Sensor Type	Passive	Active
Measured Quantity	brightness temperature	backscattering coefficient
Connection to Reflectivity	emissivity = $1 - \text{reflectivity}$	requires k and the surface height std to solve for SM
Problems	vegetation	geometric properties of the soil surface and vegetation
Data Products	AMSR-E (Aqua), MIRAS (SMOS)	ASCAT (MetOp)

Njoku et al. 2003

AMSR-E Data

Monthly Soil Moisture

Monthly Soil Moisture in g/cm^3 of AMSR-E Jul 2008



Selection of the Test-Site

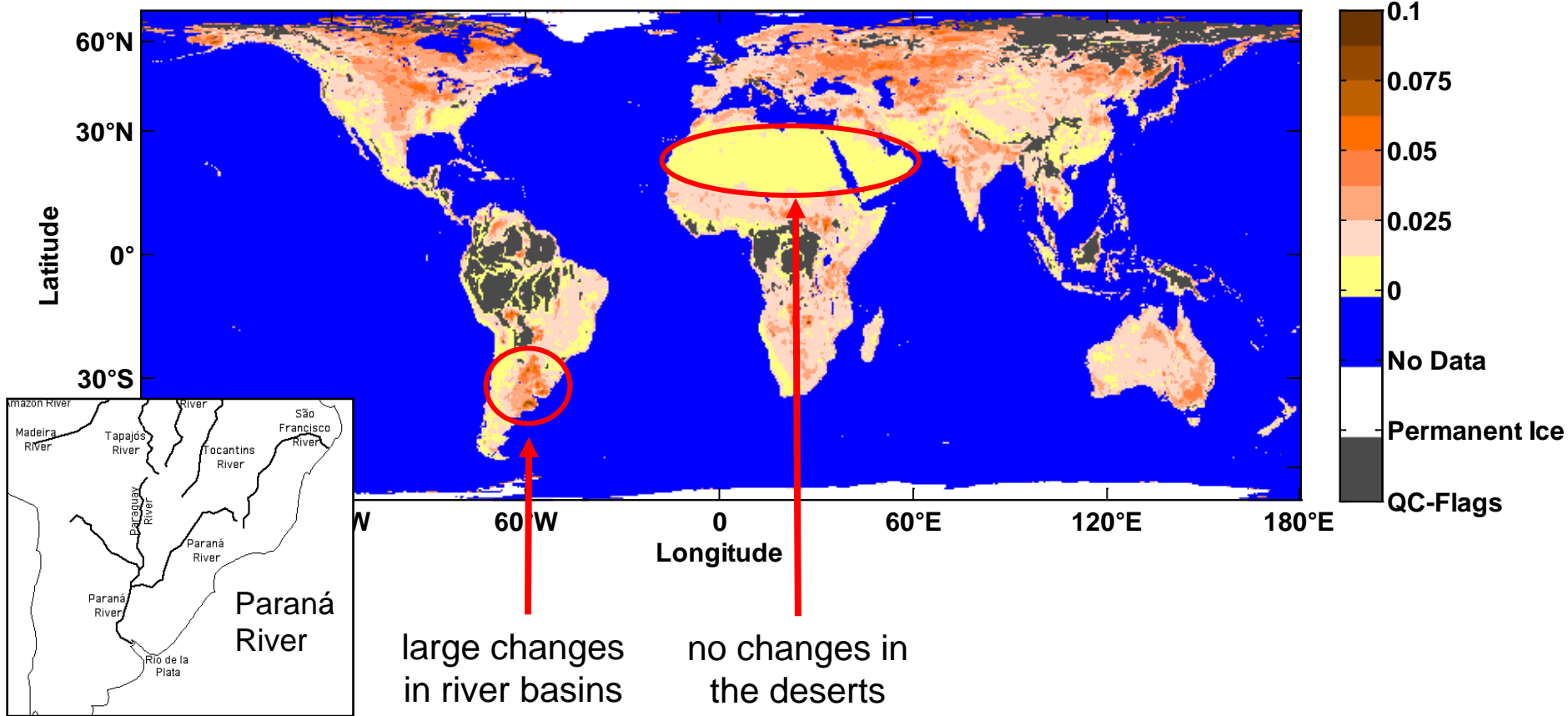
Limitations

- Gravimetric changes (GRACE) can be identified in regions with:
 1. High soil moisture ($\geq 20 \text{ kg/m}^2$)
Example: $20 \text{ kg/m}^2 = 0.2 \text{ g/cm}^2$ and 10 cm depth
 2. Strong variation in soil moisture
 3. Large spatial extend ($> 300 \text{ km} \times 300 \text{ km}$)

- Soil moisture (AMSR-E) can be acquired in regions with:
 4. Low vegetation water content ($< 1.5 \text{ kg/m}^2$)

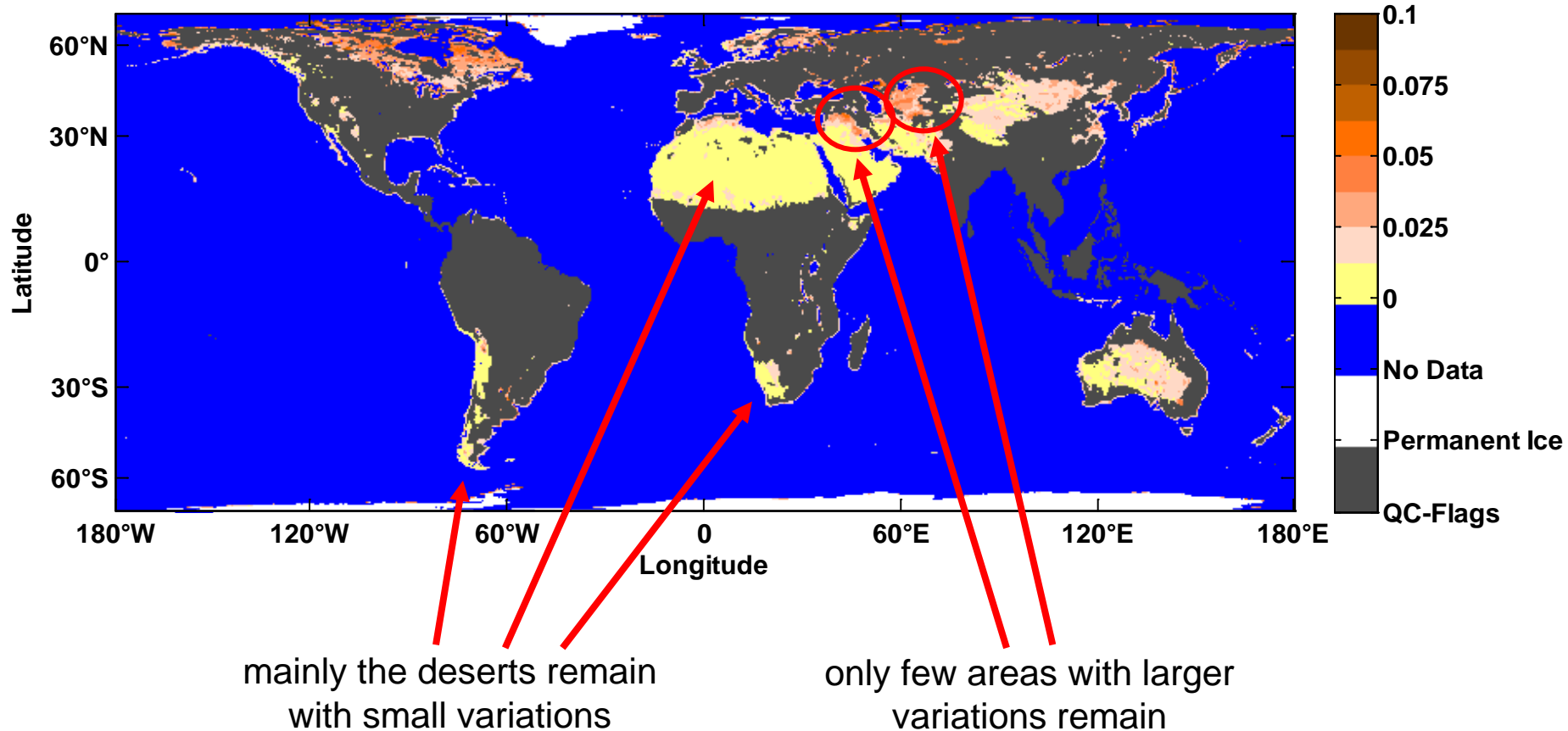
Variation of Soil Moisture

Standard Deviation for Daily Soil Moisture in g/cm^3 of AMSR-E (Jan 2003 - Dec 2009)



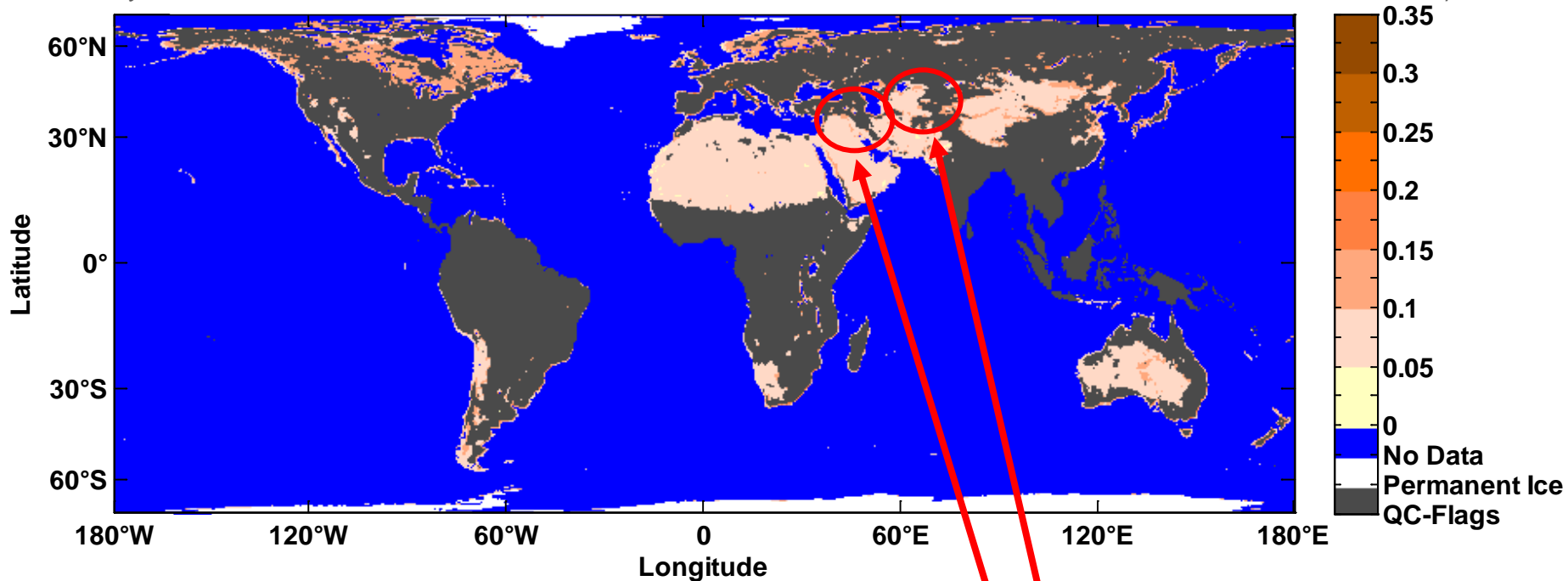
Variation of Soil Moisture with Quality Mask

Std for Daily Soil Moisture in g/cm^3 of AMSR-E for Vegetation-Water-Content $< 1.5 \text{ kg/m}^2$ (Jan 2003 - Dec 2009)



Mean of Soil Moisture with Quality Mask

Mean for Daily Soil Moisture in g/cm^3 of AMSR-E for Vegetation-Water-Content $< 1.5 \text{ kg/m}^2$ (Jan 2003 - Dec 2009)



variation is high but the mean value is low

Summary and Outlook

Summary and Outlook

References

- Jackson, T., 2002. Remote sensing of soil moisture: implications for groundwater recharge. *Hydrogeology Journal*, 10(1), 40-51.
- Jackson, T., 2005. Soil Moisture. In *Encyclopedia of soils in the environment*. Elsevier, pp. 392-398.
- Njoku, E. et al., 2003. Soil moisture retrieval from AMSR-E. *Geoscience and Remote Sensing, IEEE Transactions on*, 41(2), 215-229.
- Njoku, E. 2004, updated daily. AMSR-E/Aqua L3 Surface Soil Moisture, *Interpretive Parameters, & QC EASE-Grids V002*, 01.07.2002 - 31.07.2010. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

AMSR-E

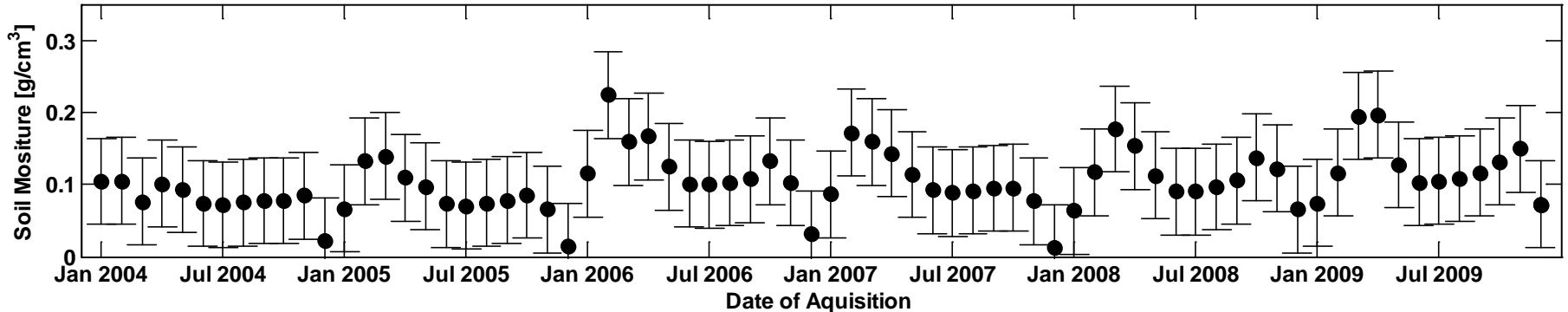
- AMSR-E = Advanced Microwave Scanning Radiometer for EOS (AMSR-E)
- Space Agency: NASA
- Satellite: Aqua (precipitation, evaporation, water cycle)
- Data products:
 - Soil Moisture
 - Vegetation Water content
 - Land-cover (10 types)
- Time span: 2002 – present
- Spatial resolution: 25 km² (of data products)
- Largest Wavelength: 4.3 cm = 6.9 GHz (C-Band)



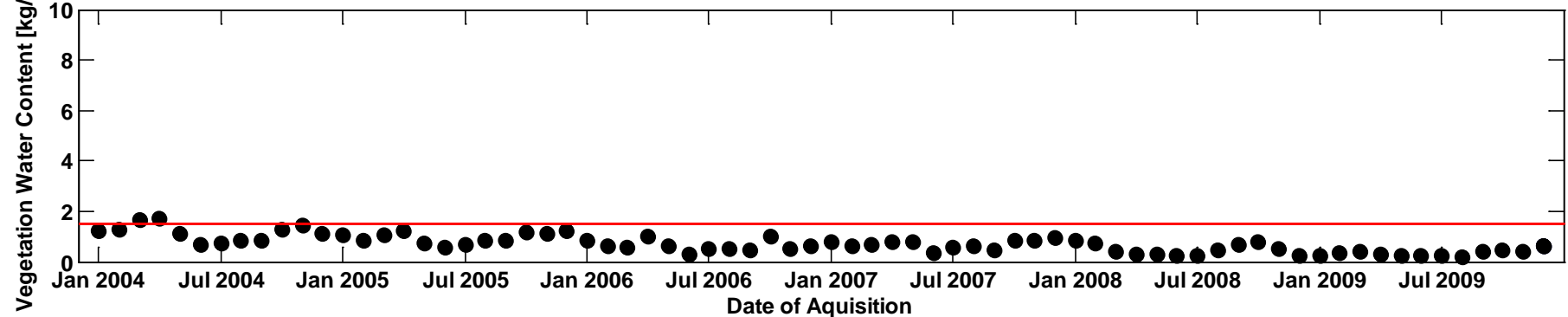
http://en.wikipedia.org/wiki/File:Aqua_satellite_simulation.jpg

Variation of Valid Soil Moisture

Monthly Soil Moisture [g/cm^3] of AMSR-E at Latitude = 35° and Longitude = 44°

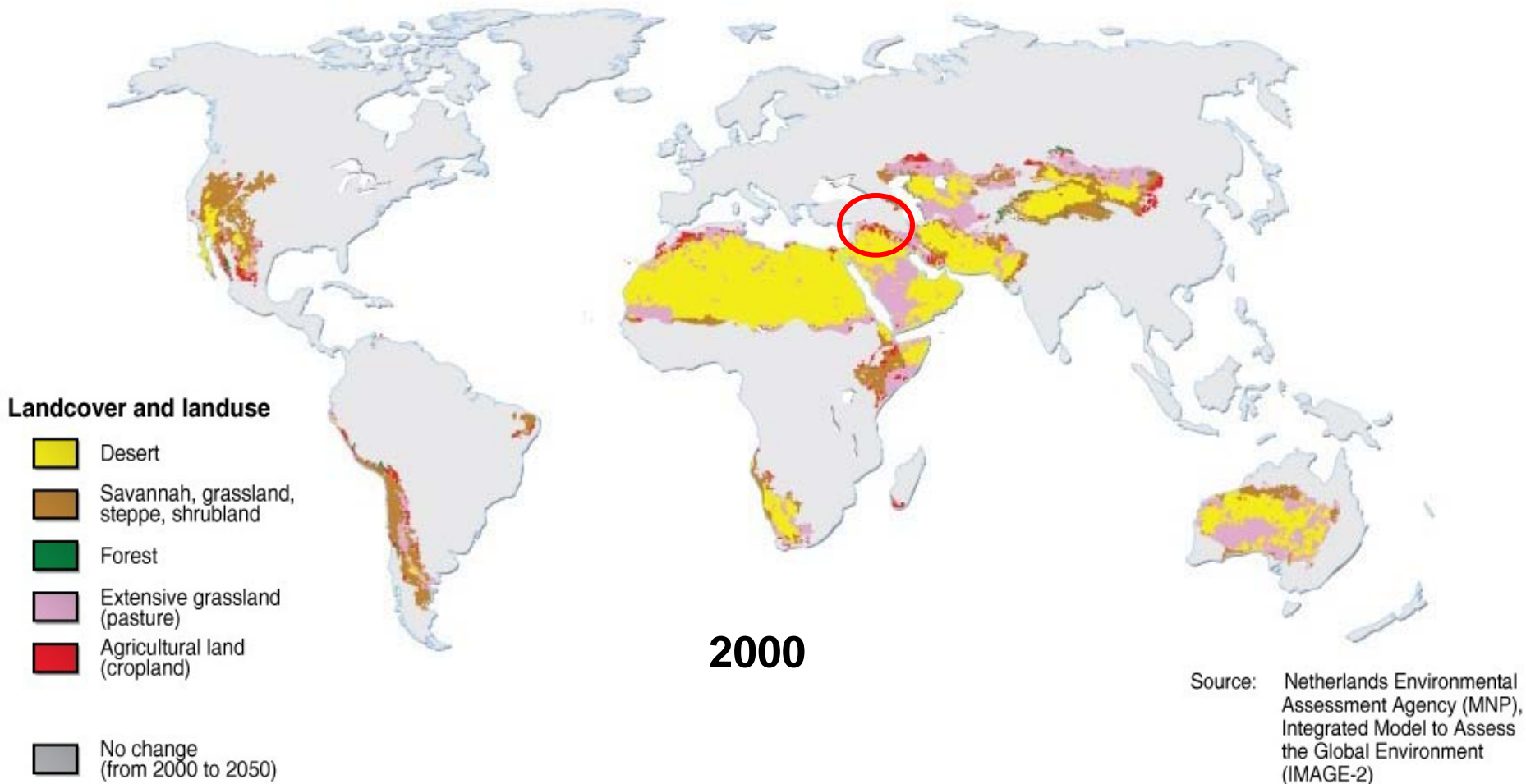


Monthly Vegetation Water Content [kg/m^2] of AMSR-E at Latitude = 35° and Longitude = 44°

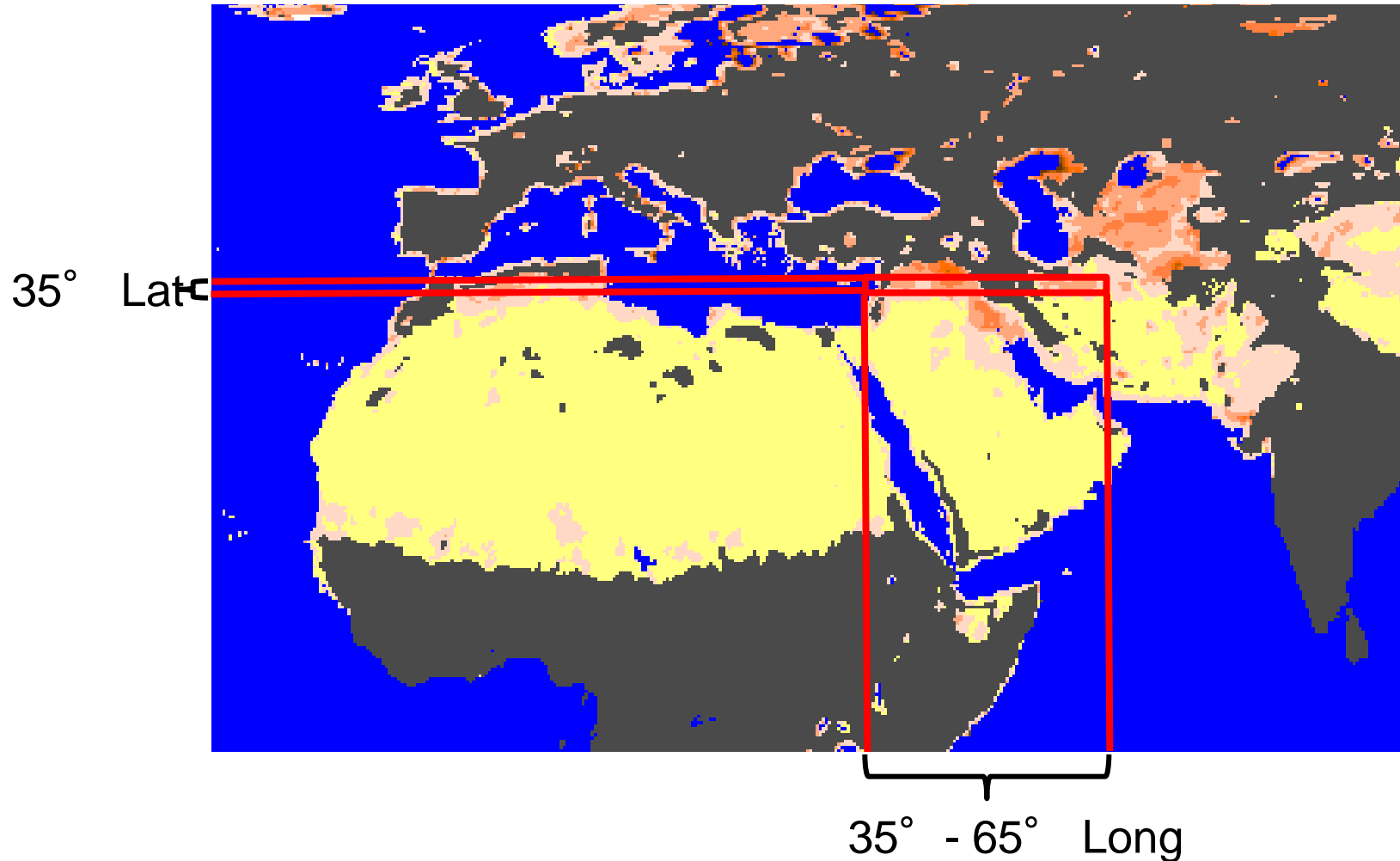


- ➔ No pronounced temporal variation
- ➔ Vegetation Water Content is mostly below $1.5 \text{ kg}/\text{m}^2$

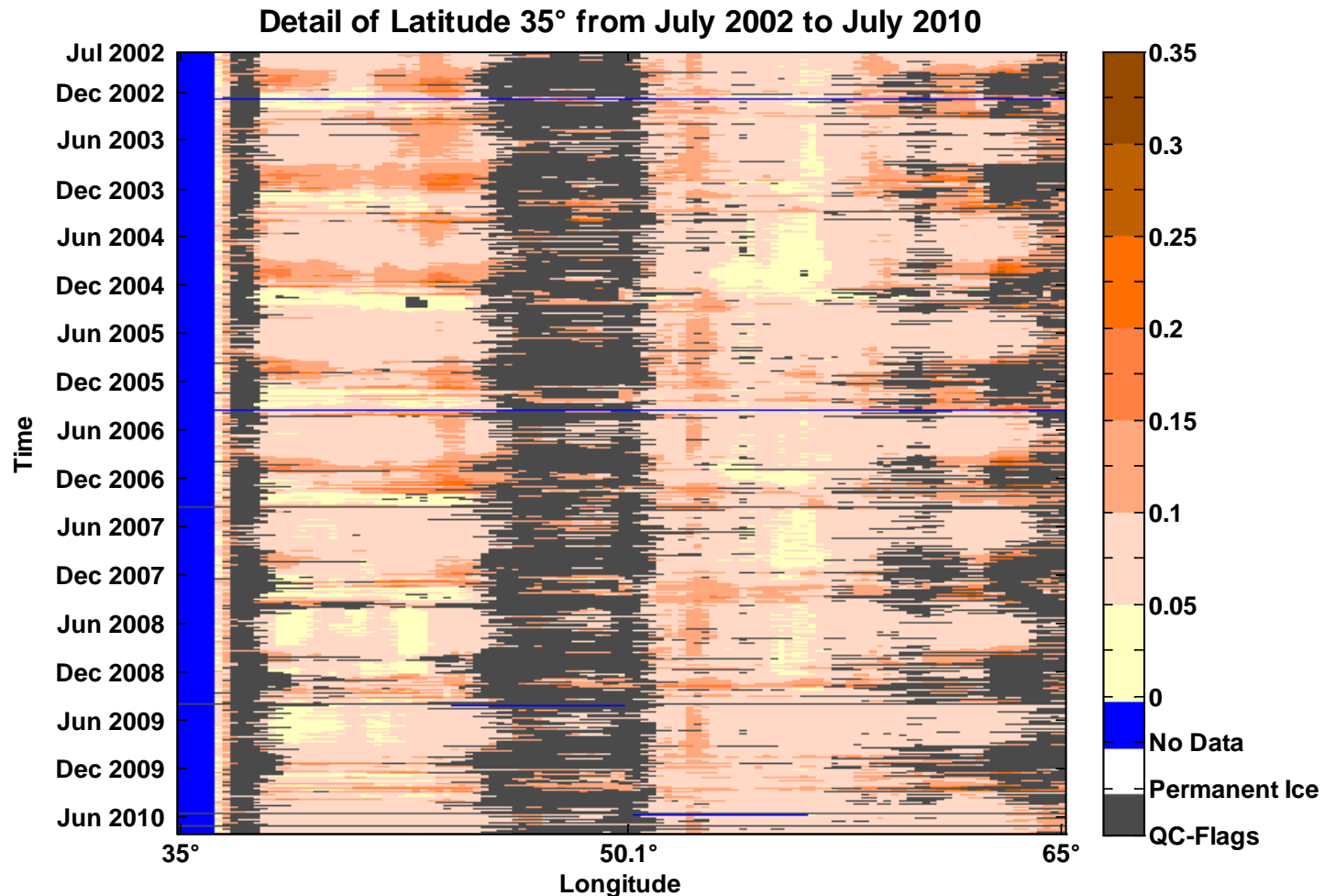
Integration of Other Data Sources



Test-Site Proposal

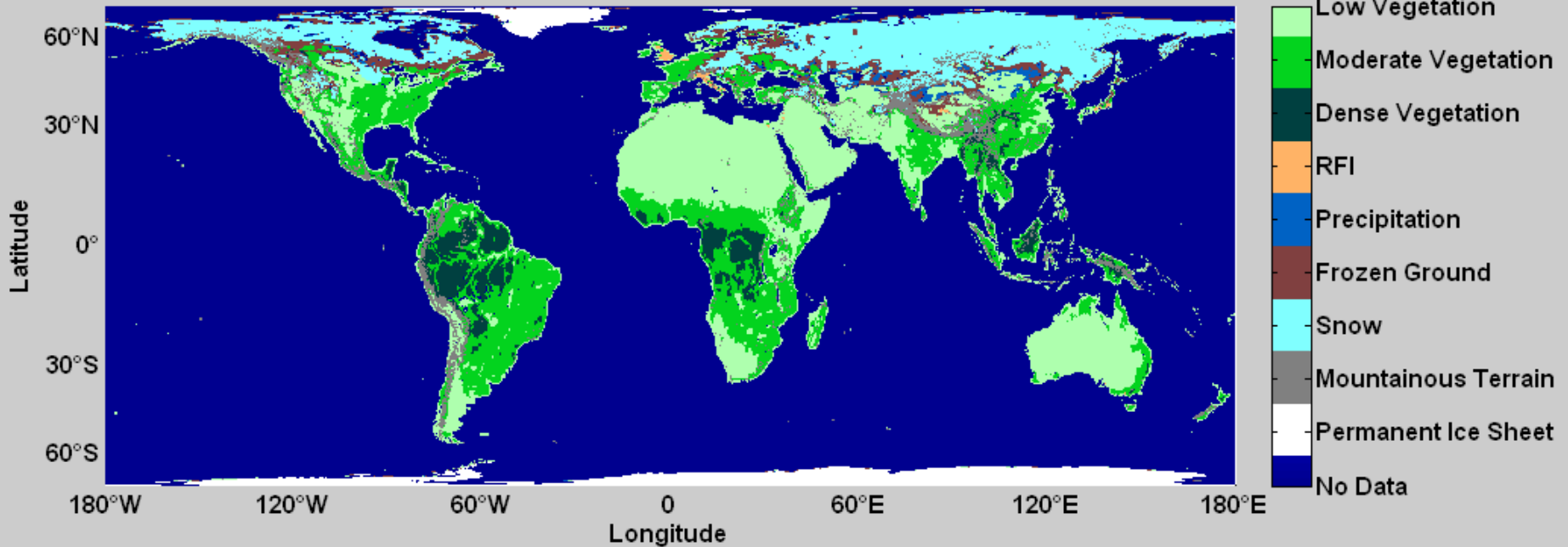


Annual Cycle



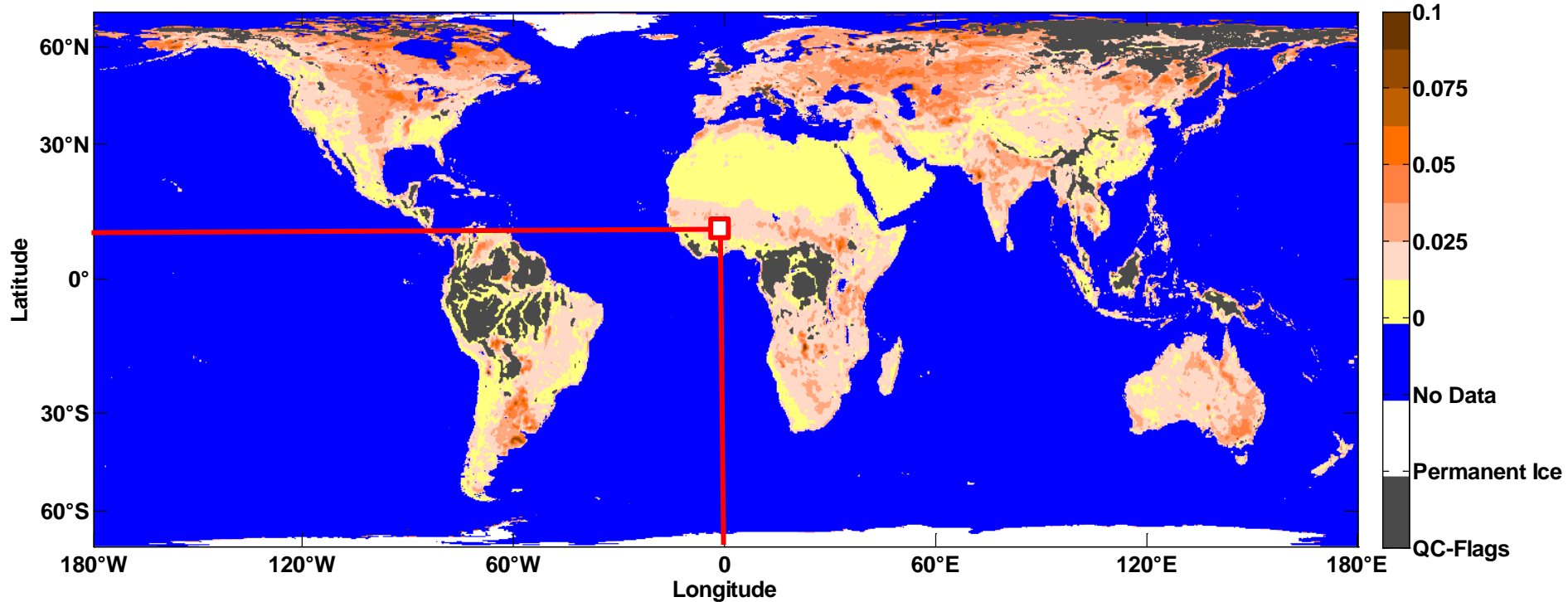
Ancillary Data: Quality Control Flags

Monthly Quality Control Flags of AMSR-E Jan 2006



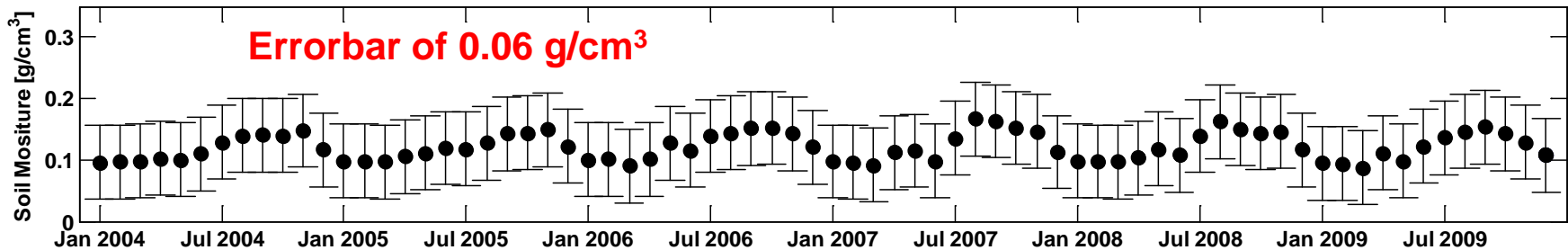
Selection of one Grid Cell

Standard Deviation for Daily Soil Moisture in g/cm^3 of AMSR-E (Jan 2003 - Dec 2009)

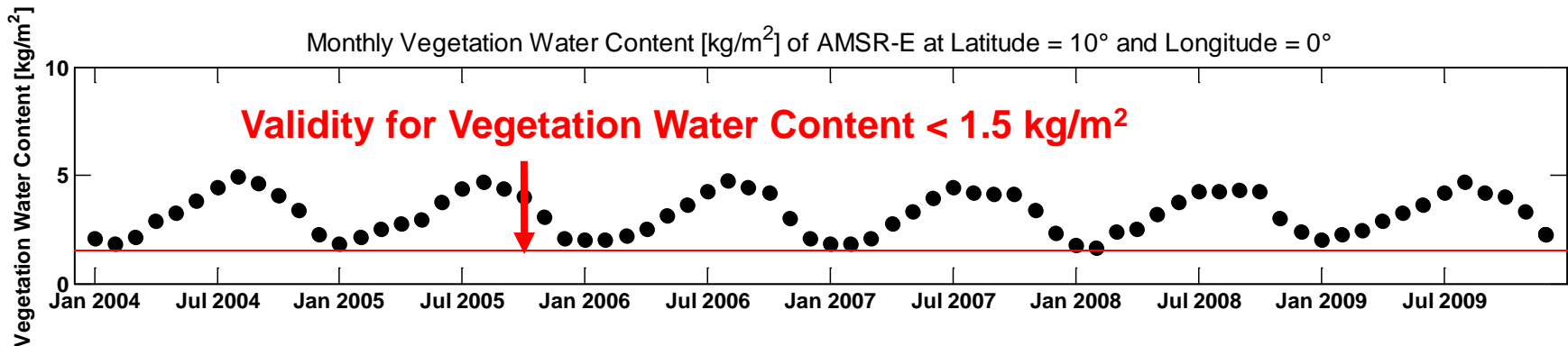


Soil Moisture: Time Variation

Monthly Soil Moisture [g/cm^3] of AMSR-E at Latitude = 10° and Longitude = 0°



Monthly Vegetation Water Content [kg/m^2] of AMSR-E at Latitude = 10° and Longitude = 0°



- ➔ Soil Moisture goes up to $0.2 \text{ g}/\text{cm}^2$
- ➔ Errorbar is relatively high
- ➔ Limitation is the Vegetation Water Content

Njoku et al. 2003

