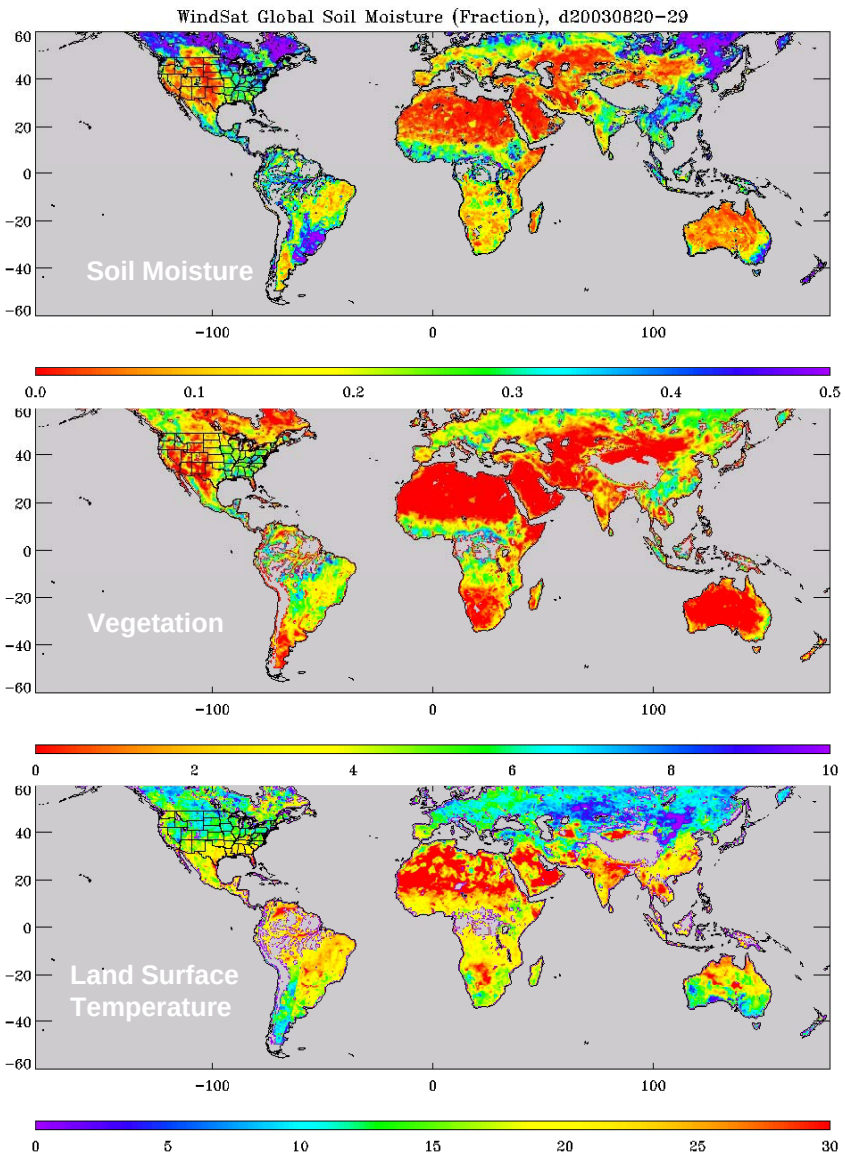
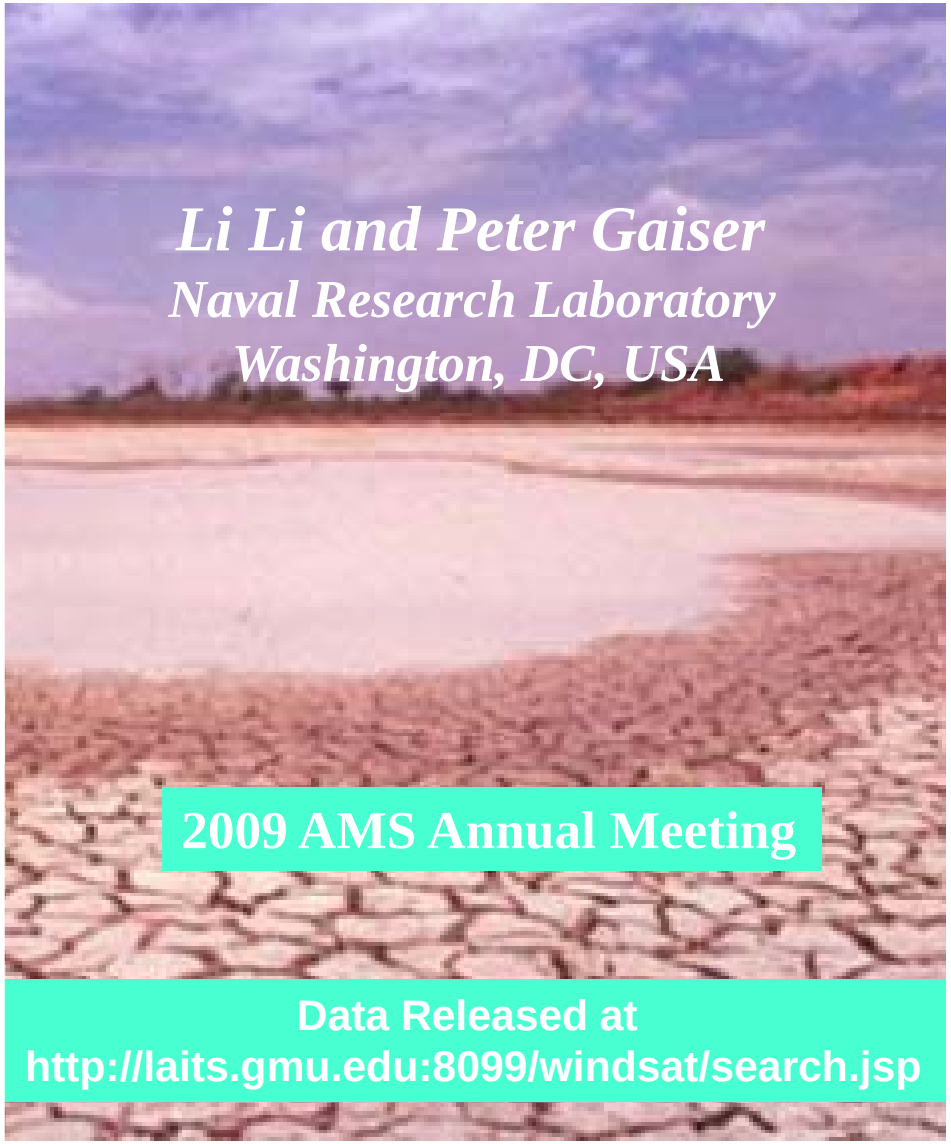
WindSat Land Surface Products as a Tool for the Analysis of 2003 European Heat Wave

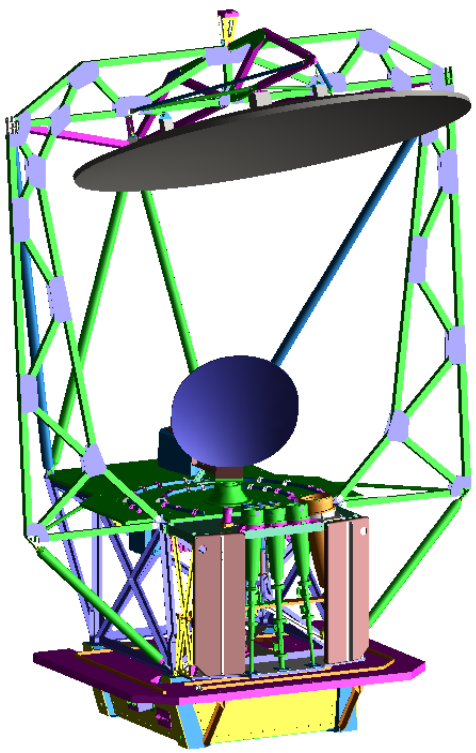




Outline

- Passive Microwave Land Remote Sensing
  - Algorithm Summary
  - Retrieval Performance Evaluations
    - Soil moisture/vegetation climatology
    - In-situ validations
- Examples of Soil Moisture Observations
  - Drought and Rain Events at Synoptic Scale
  - Hurricane Katrina Impact
  - The 2003 European Killer Heat Wave

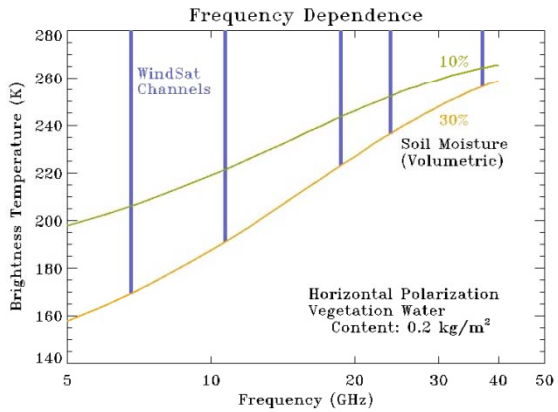
WindSat Description

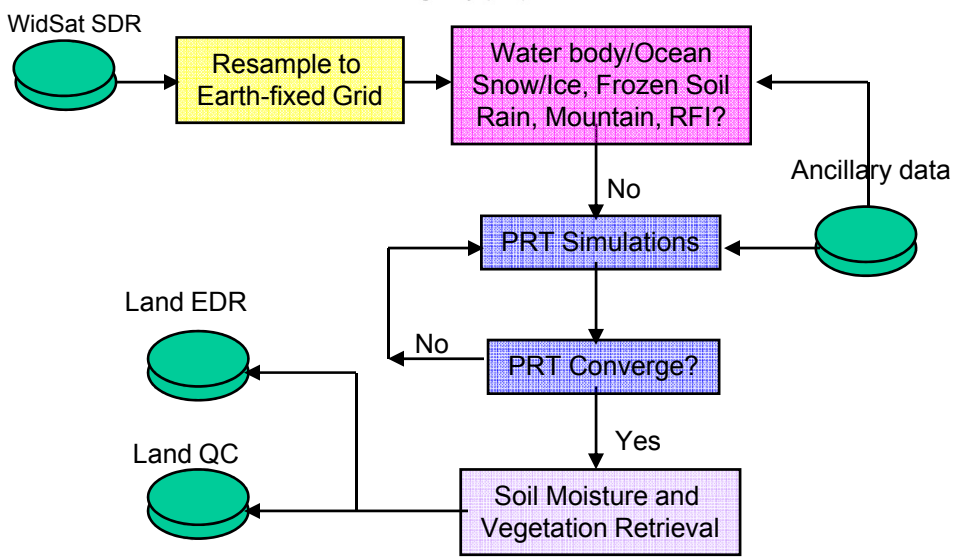


	SSM/I	AMSR-E	WindSat	MIS
85/91 GHz	x	x		x
37 GHz	x	x	x	x
22/23 GHz	x	x	x	x
19 GHz	x	x	x	x
10.8 GHz		x	x	x
6.8 GHz		x	x	x
Spatial Resolution	27 x 38	8 x 14	8 x 13	TBD

- Instrument is stable and well calibrated
- Sun-synchronous circular orbit at 840 km
- 1000 km Swath Width
- Repeat coverage each 8 days

Land Algorithm & Validation



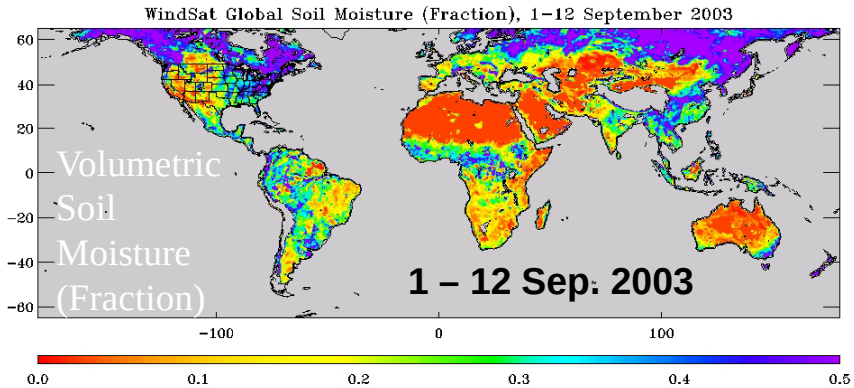


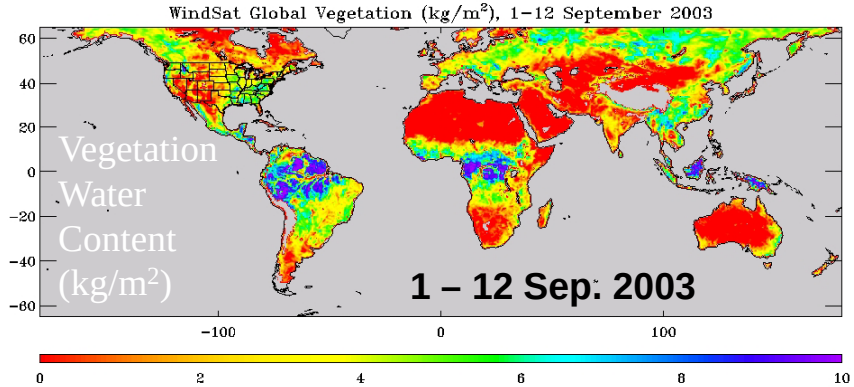
$$LH(x) = -\frac{1}{2}\sum_j \log(2\pi\sigma_j^2) - \sum_j \frac{\{y_{mj} - y_{sj}(x)\}^2}{2\sigma_j^2}$$

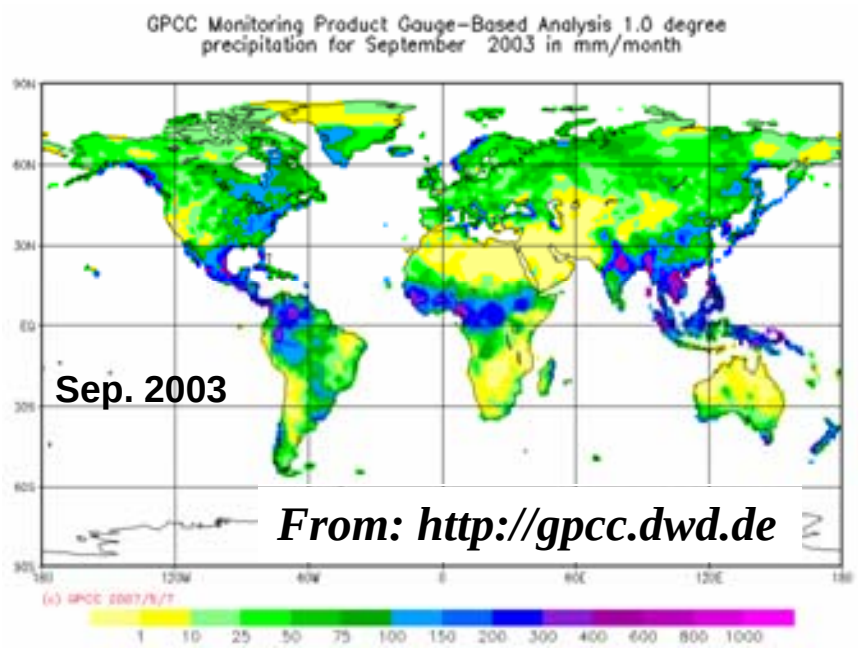
Validation Strategy: Comparisons of multiple data sources

- Soil Moisture Climatology
  - Climate Regime
  - Correlation with vegetation
  - Global precipitation climatology
- Ground In-Situ
  - Micronet/SMEX
  - SCAN
  - JAXA, NAFE
- Precipitation
  - NEXRAD
  - Land climate Monitoring Data
- Vegetation Dynamics
  - GVF/AVHRR
  - NDVI/MODIS

Soil Moisture and Precipitation Climatology

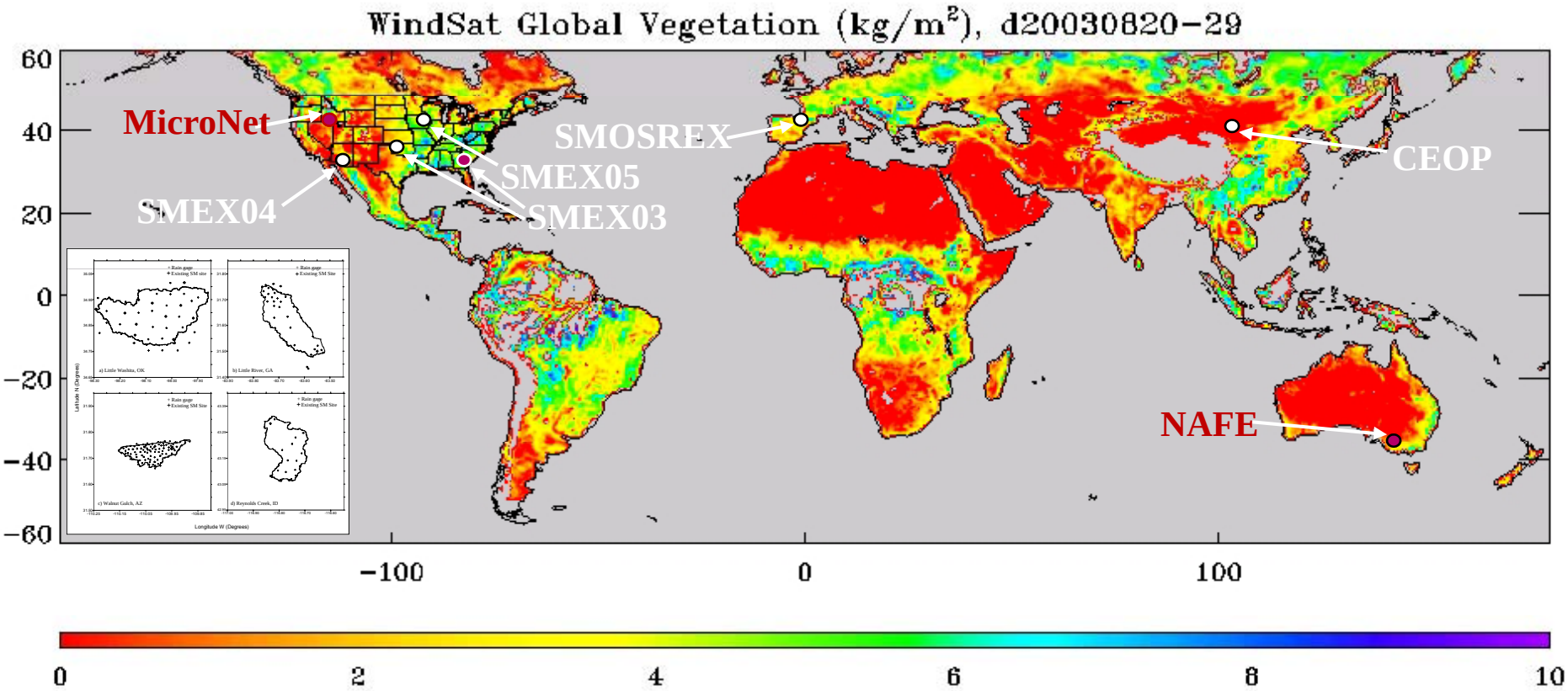




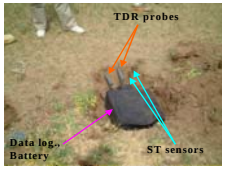


- *Indirect comparisons*
- *Global soil moisture patterns are consistent with dry/wet patterns of climate regimes.*
  - *Sahara, Arabian, Gobi, Australia, South Africa*
  - *US, high lat. wet regions*
- *Soil moisture is roughly correlated with vegetation with some exceptions*
  - *India, Canada*
- *Capture high moisture in the subarctic regions*
  - *Canada, Europe, Asia*
- *Show consistent features with Monsoon patterns.*
  - *Africa, India, China, North America*

Global In-Situ Soil Moisture Validations



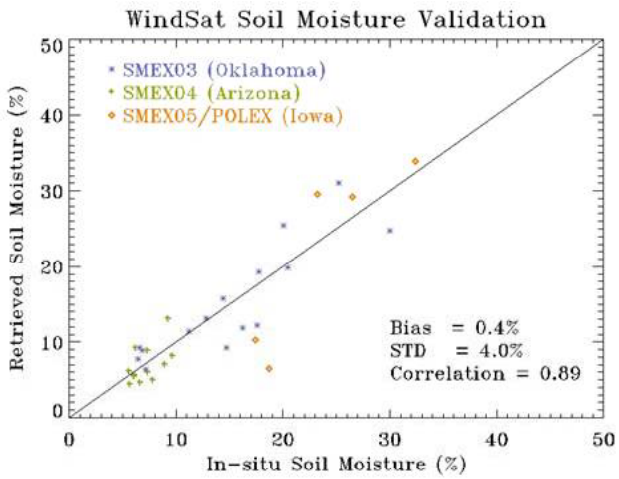
AWS in BTS



ASSH

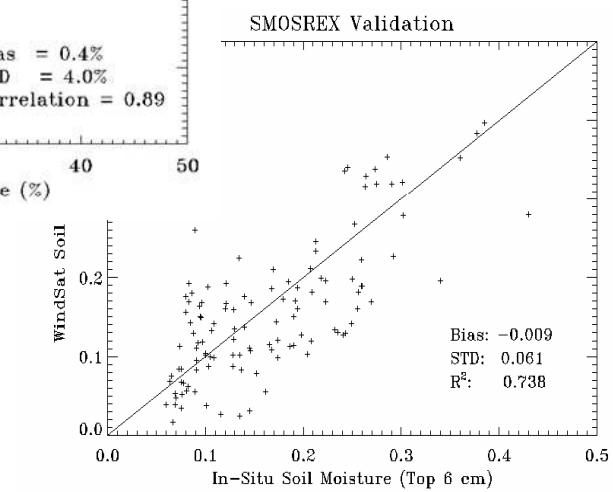
Soil Moisture In-Situ Validation

United States

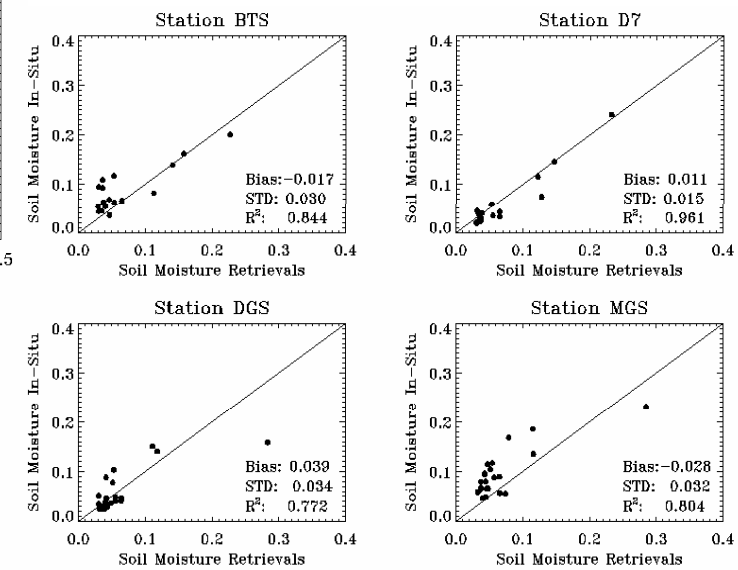


These validation data provide diverse land/vegetation covers and extreme wet/dry soil conditions

France



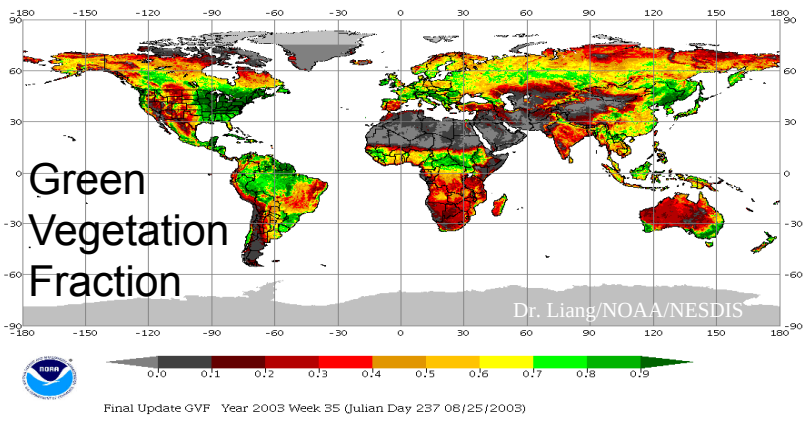
Mongolia

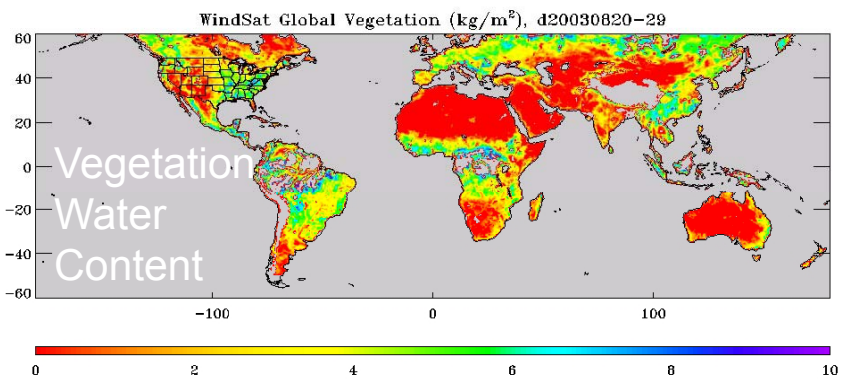


The ground in-situ validation meets science requirements for low to moderate vegetation land

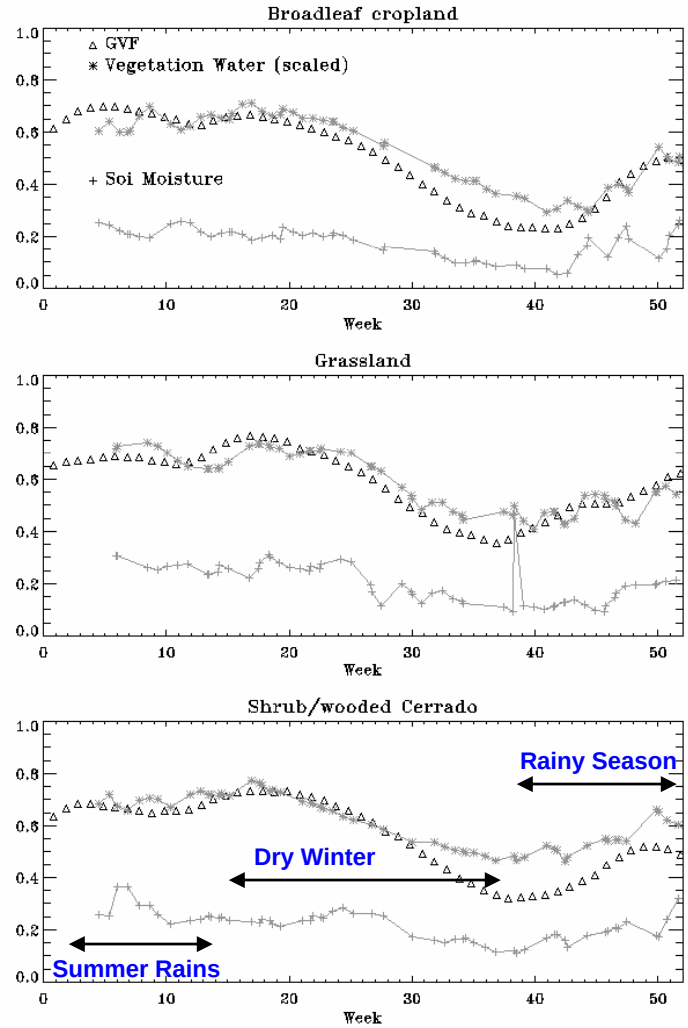
WindSat Vegetation Data Validation

The WindSat vegetation water content is consistent with the Green Vegetation Fraction derived from AVHRR data.





Brazil Cerrado



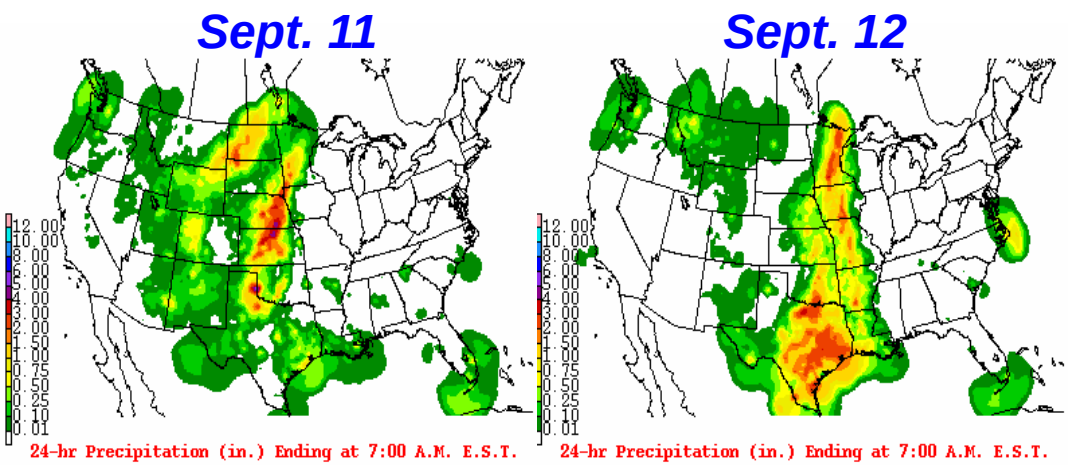
Drought and Rain Events at Synoptic Scale

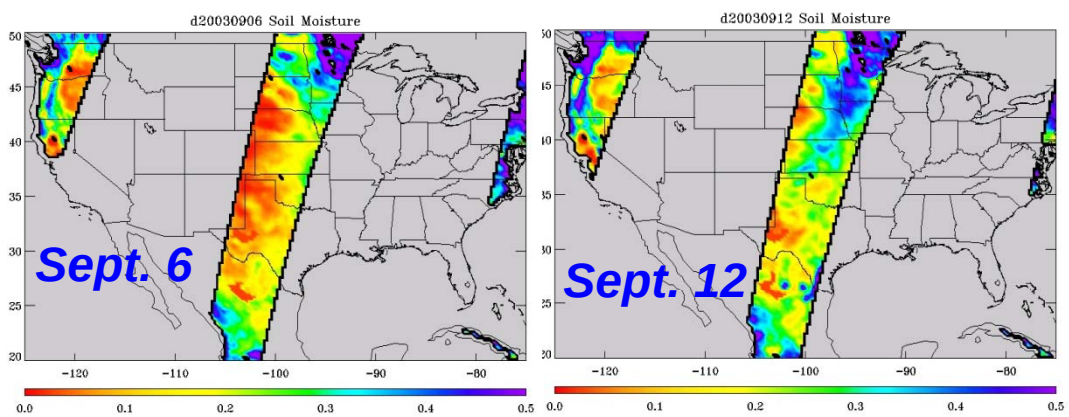
Major Drought & Rain Event Observed by WindSat at Synoptic scale

Extreme short-term drought conditions were recorded in July and August 2003 from western Great Lakes to northern Rockies and Great Plains. **The drought was captured by WindSat soil moisture data on 6 September.**

A major rain event created saturated ground following the extreme drought, which was observed by the AVHRR precipitation on 11 September. The rain moved to the east of Mississippi river then diminished on 12 September.

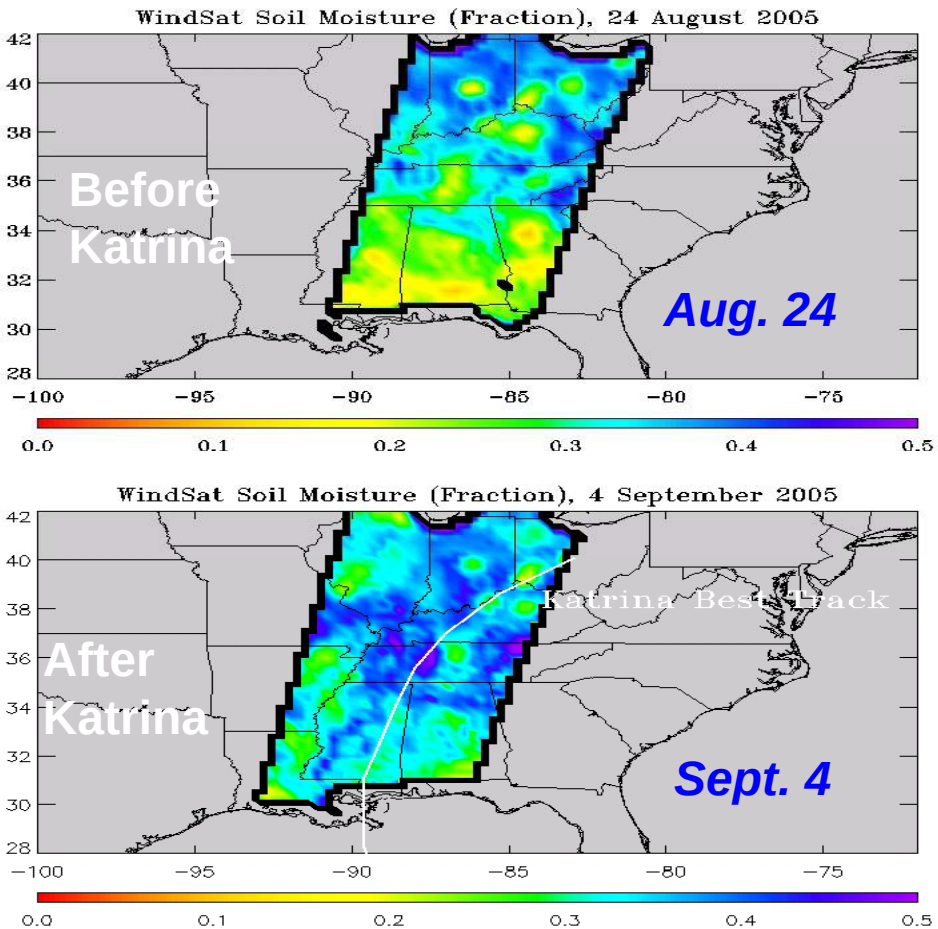
The WindSat soil moisture retrievals captured the large precipitation pattern on 12 September.



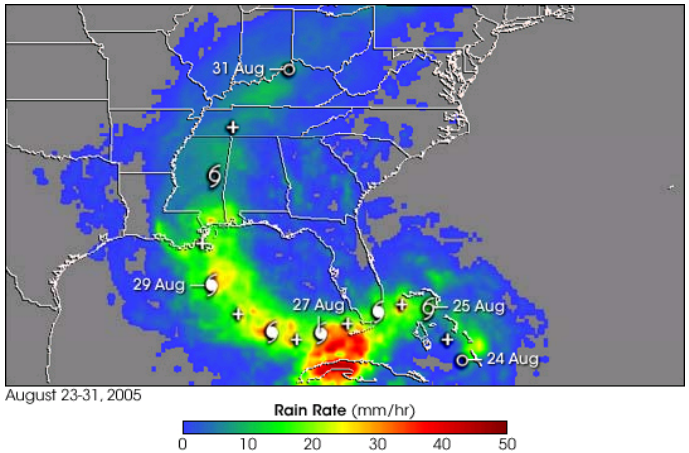


Hurricane Katrina

***The WindSat soil moisture data capture the dramatic wetting-up event along the best track of hurricane Katrina*.**



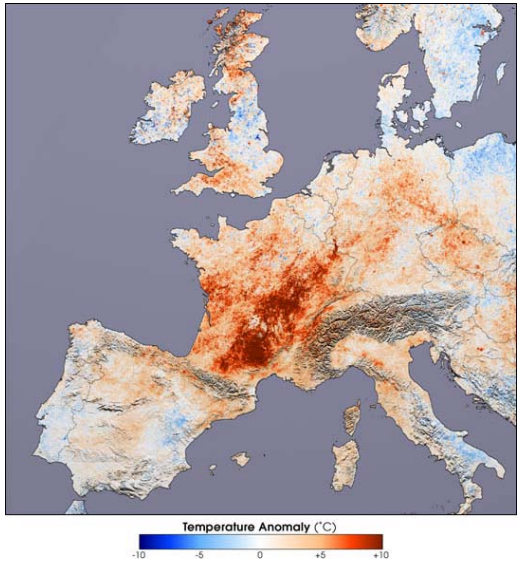
The top left panel shows soil moisture retrievals four days before Katrina made landfall on 29 August, and bottom left panel shows soil moisture retrievals four days after the end of Katrina on 4 September.



2003 European Killer Heat Wave

Heat waves are the most lethal type of weather phenomenon

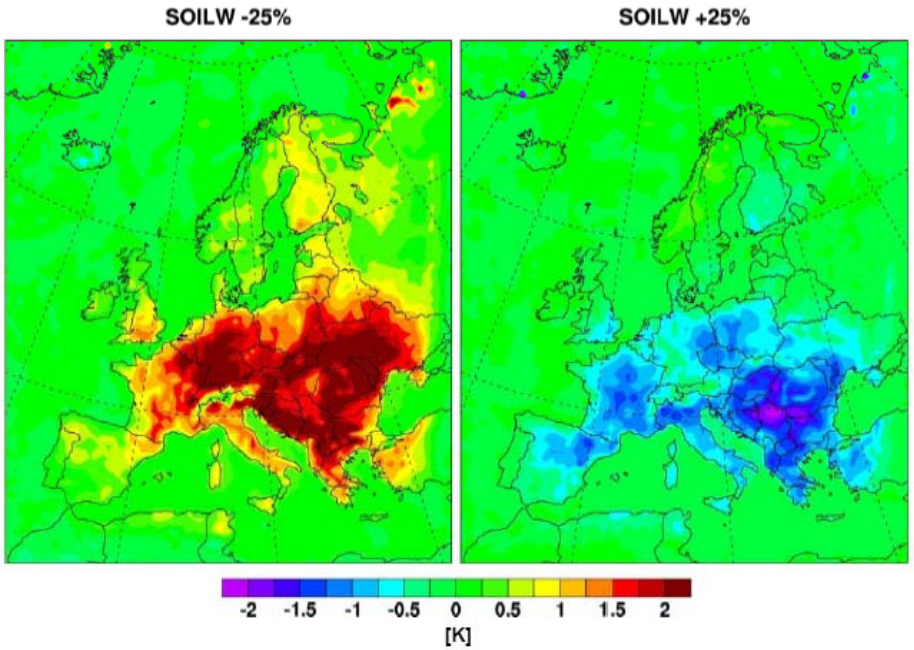
- One of the hottest summers on record in Europe.
- 35,000 people died as a result of the heat wave.
- Uninsured crop loss totaling $12.3 Billions



2003 European Heat wave: Land-Atmosphere Interaction Modeling

- Initiated by anticyclonic atmospheric circulations
- Low soil moisture induced a positive feedback mechanism between surface conditions and atmospheric circulation.
  - Strong positive radiative anomalies and a large precipitation deficit in the months preceding the extreme event contributed to a rapid loss of soil moisture
  - Low soil moisture resulted in strongly reduced evapotranspiration and latent cooling

Climate High-Resolution Model (CHRM) Simulations



Temperature anomaly due to soil water perturbation.

Left panel: Dry run vs. control run.

Right panel: Wet run vs. control run.

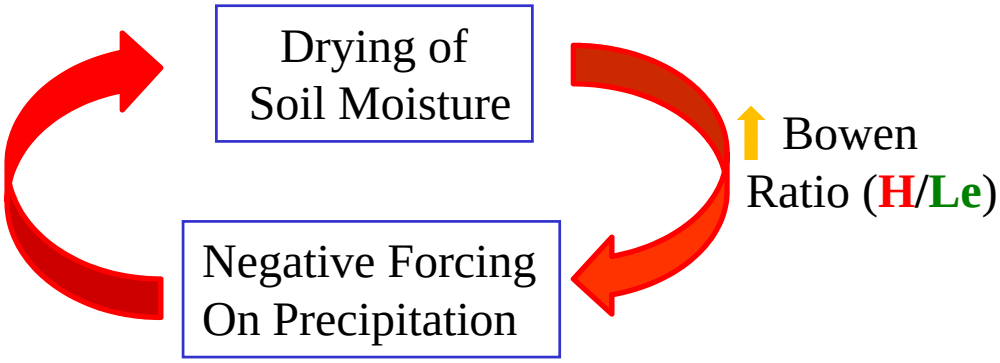
Courtesy of Drs. E. Fischer and S. Seneviratne
Institute of Atmospheric and Climate Science ETH
Zurich, Switzerland

Extreme Heat Wave Mechanisms

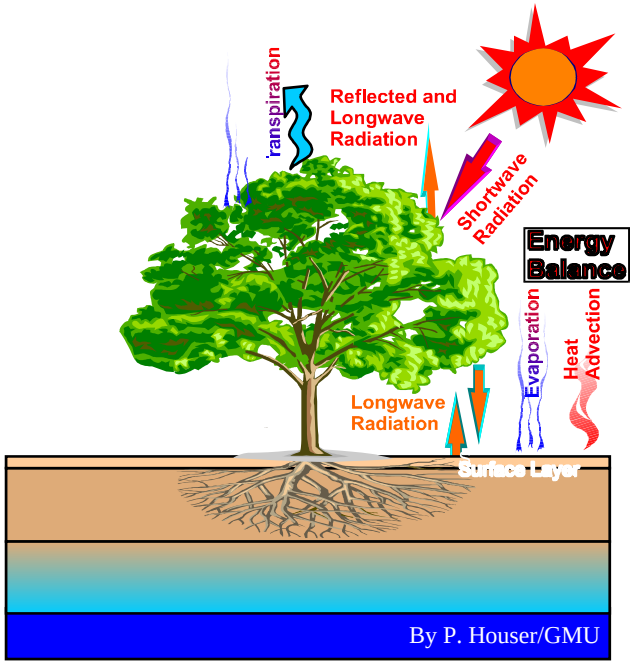
Roles of Soil Moisture, Vegetation, and LST

Soil Moisture – Precipitation Feedback

(By Dr. B.F. Zaithik)



- Reduction in Precipitation Recycling
- Deepening of daytime of PBL (Planetary boundary layer) with increased entrainment of hot/dry air
- Reduction in net radiation (R_n) and Q_t



Energy Balance.

$R_n - G = Le + H = Q_t$

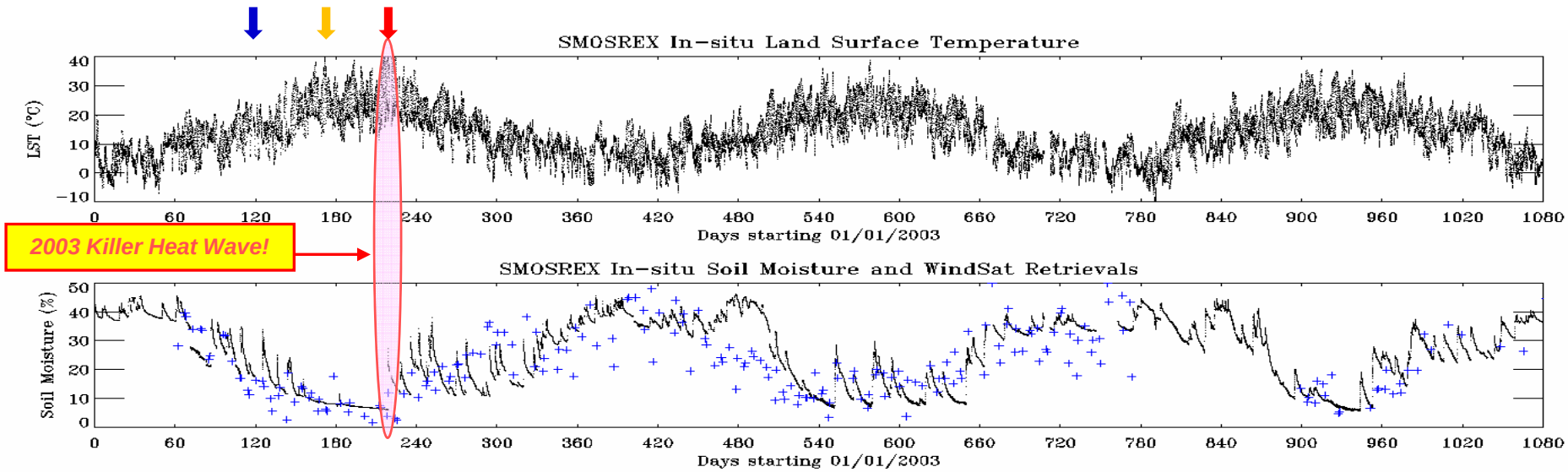
R_n : net radiation available at surface
G : heat flux into the soil
Le : latent heat flux
H : sensible heat flux
Q_t : total turbulent energy flux into the PBL

WindSat Soil Moisture Data Capture the 2003 European Killer Heat Wave

Heat waves are the most lethal type of weather phenomenon.

The soil moisture level has a major contribution to the strength and spatial and temporal extent of the heat waves.

WindSat data captured the extremely low soil moisture at the peak of 2003 Killer Heat wave



WindSat retrievals and anomalies associated with 2003 European heat wave

During early Spring

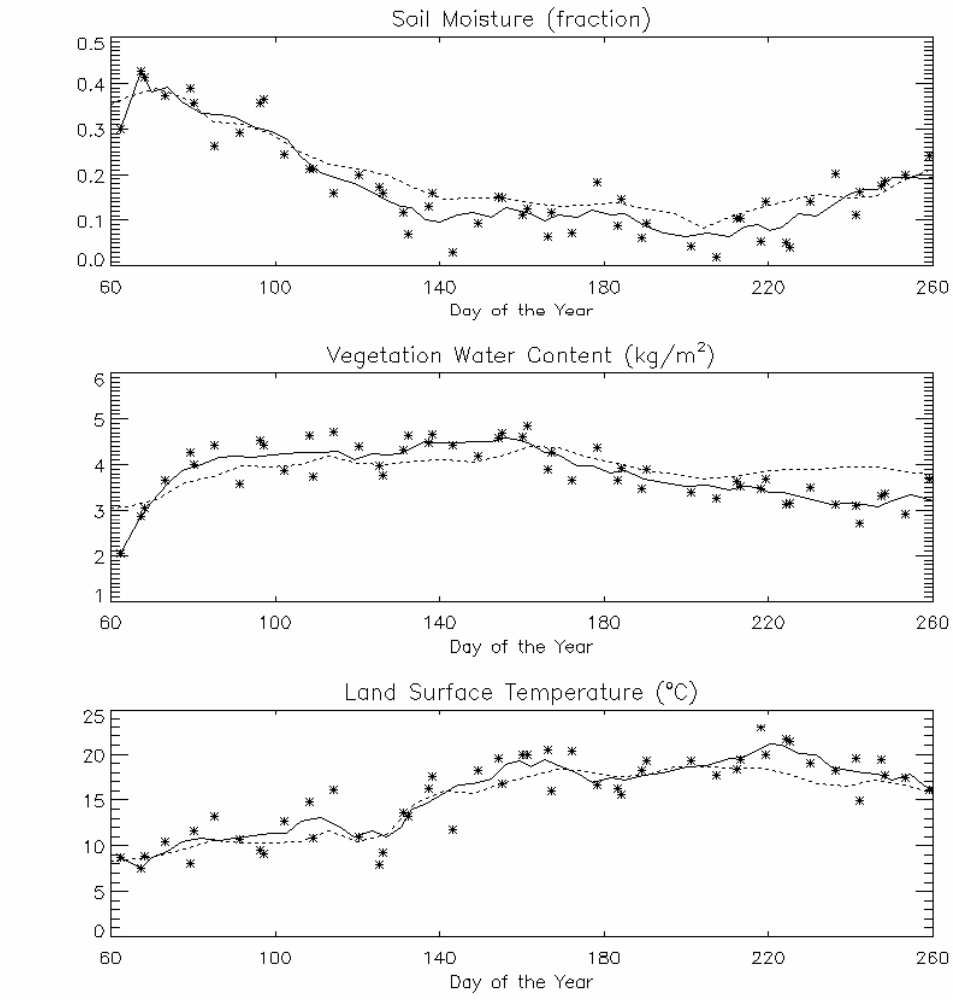
- Warmer spring temperature
- Normal soil moisture level
- Rapid vegetation green-up

During Spring

- Soil moisture was below average
- VWC was above the average until around day 150-160, depleting soil moisture

During the Summer

- When the heat wave hits near day 220, both soil moisture and VWC were low.



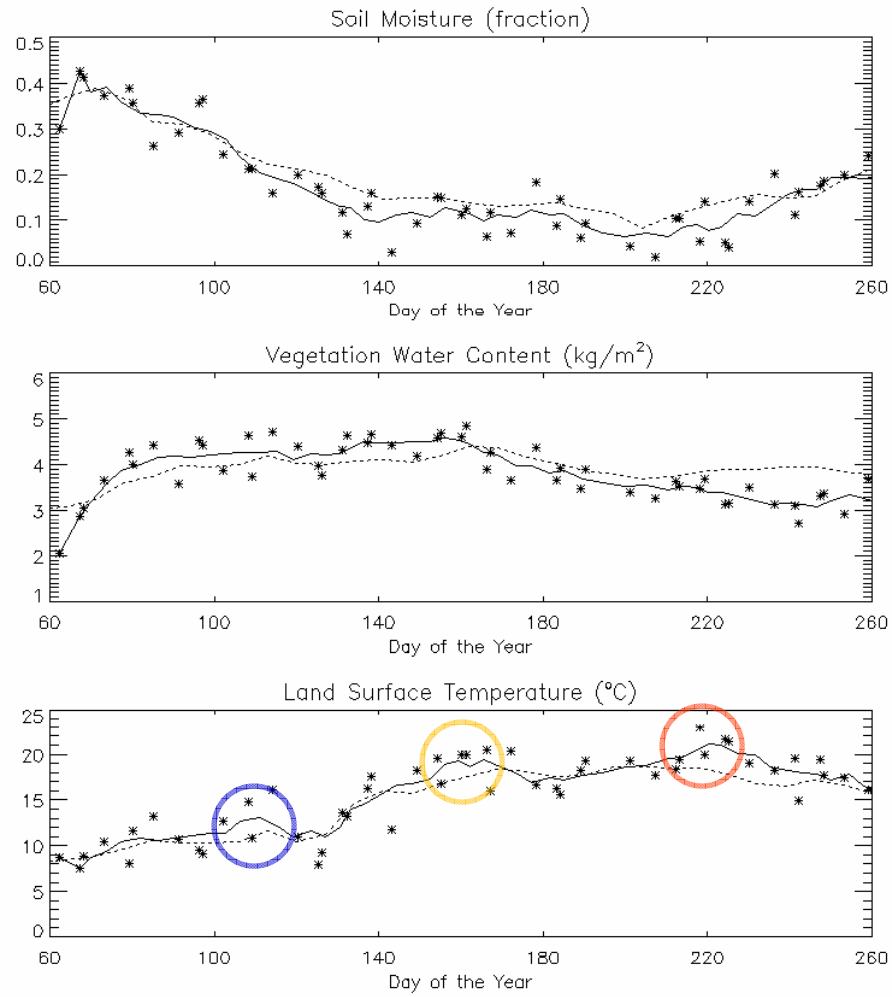
WindSat Land Data Capture the 2003 European Killer Heat Wave

Captured three recorded LST anomalies

April Anomaly
- Normal soil moisture level
- High vegetation water content
- Warmer spring temperature

June Anomaly
- Low soil moisture level
- High vegetation water content
- Synoptic-scale weather pattern

July-August Anomaly
- Drought
- Low vegetation water content
- Positive feedback and a Killer heat wave!



Conclusions

- The WindSat land data products were validated globally against multiple data sources.
- WindSat land observations corroborate the climate model simulations suggesting an important role of drought in the deadly 2003 heat wave.

Acknowledgments:

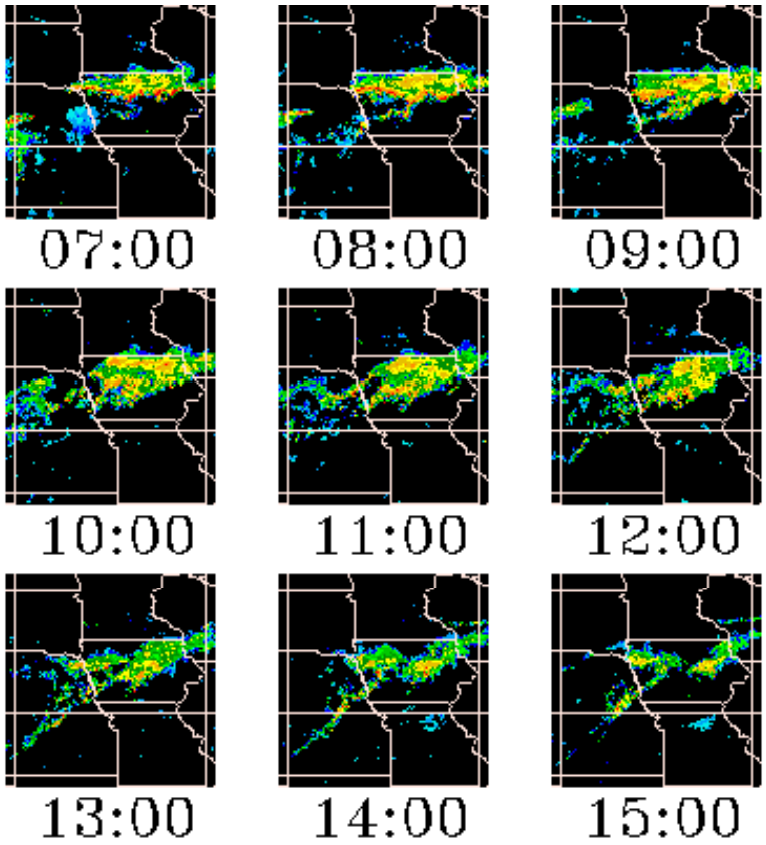
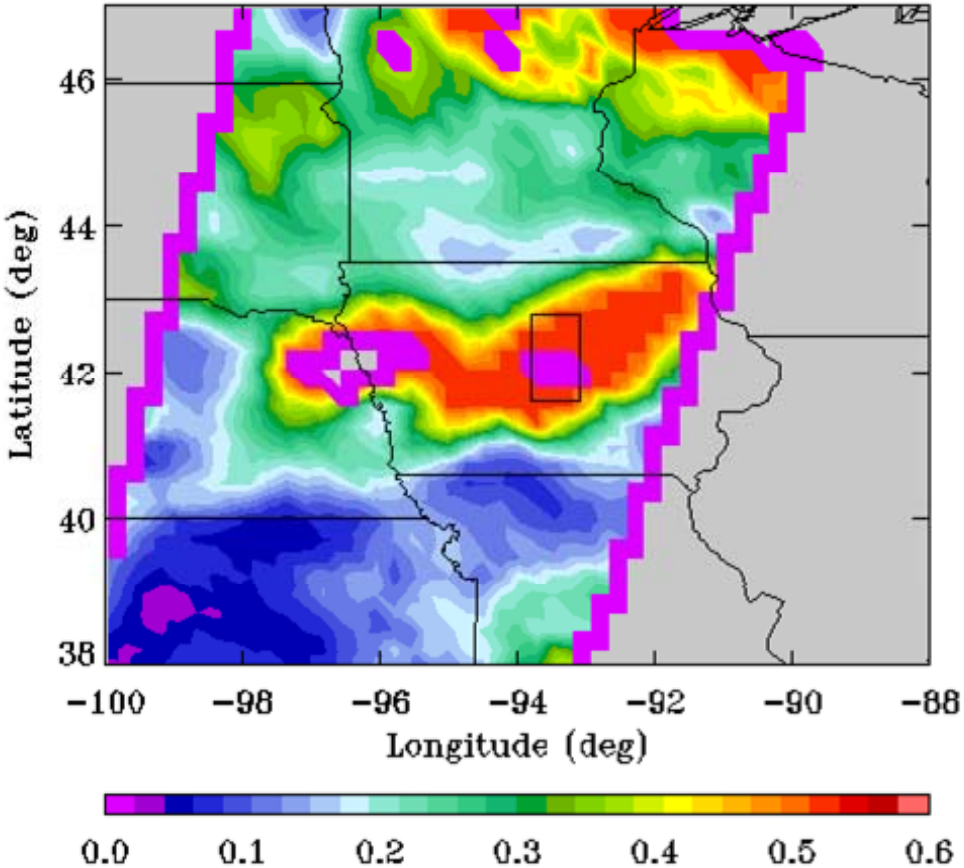
Thanks Dr. Sonia I. Seneviratne
for very helpful discussions.

Version 1 data were released at:

www.nrl.navy.mil/windsat
laits.gmu.edu:8099/windsat/search.jsp

6/25/2005

NEXRAD



WindSat,12:44 UTC