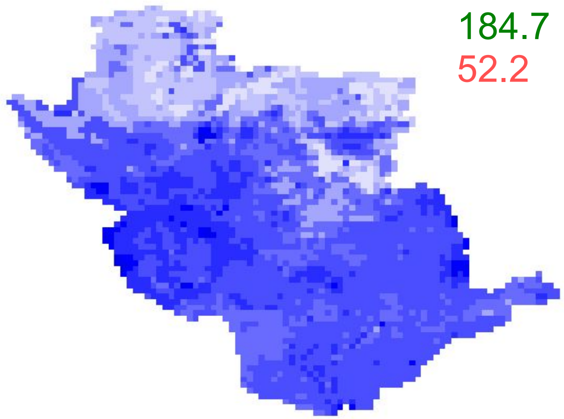
Application of GPM-TRMM in Studies of Hydrologic Extremes – Droughts and Floods

Venkat Lakshmi

Layer 3: 40-140cm

UPPER MISSISSIPPI RIVER BASIN

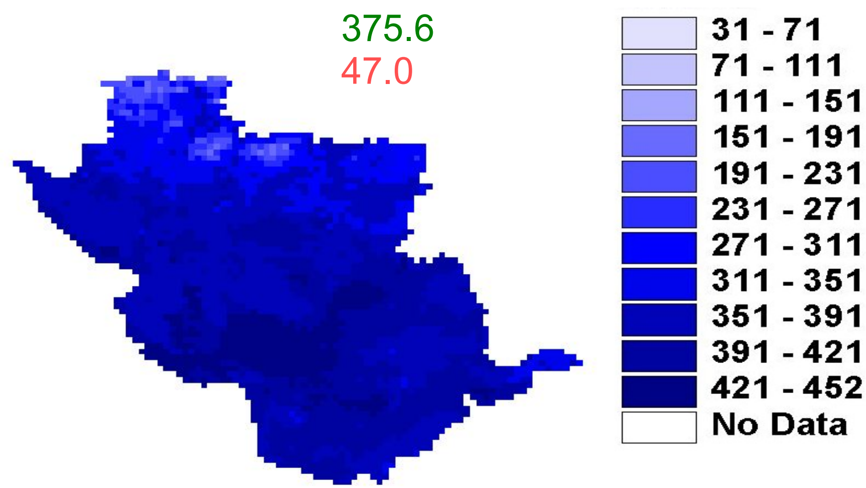
July 1988



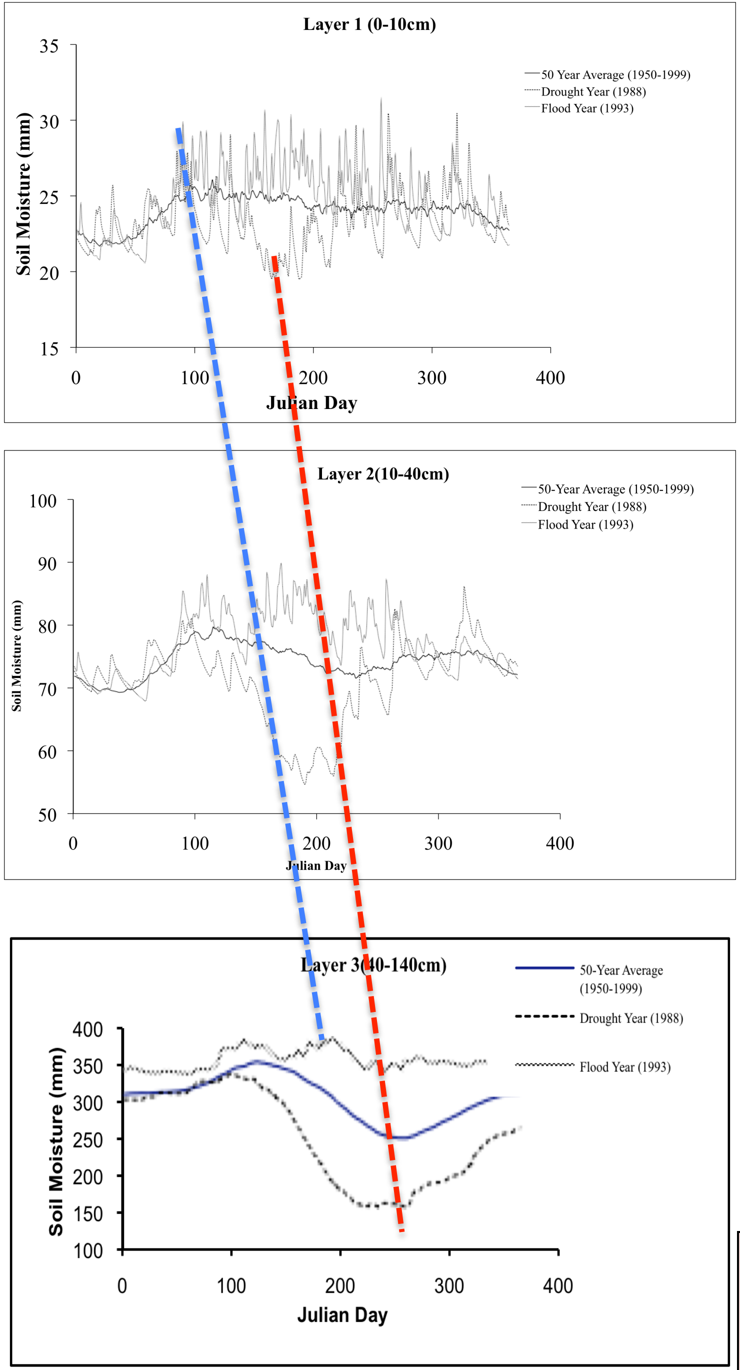
It can be seen that in the drought year (1988) by the end of the summer, the third layer also dries out to a maximum of 270mm soil moisture and a minimum of 40mm

July 1993

The flood year (1993) on the other hand, the moisture infiltrates to the third layer by July making it range from 250mmto 450mm. This is almost a 200mm change from 1988



Srinivasan, R., and ***V. Lakshmi****, Water and Energy Budgets using a macroscale hydrological model for the Upper Mississippi River Basin, Chapter 5 in Watershed Models, edited by Vijay Pal Singh and Donald K. Fevert. September 19, 2005. Copyright year 2006, Taylor and Francis Books*



Whereas the first peak wetness occurs around Julian Day 100 in the 0-10cm layer, the same is seen in the 40-140cm layer around day 200. In the case of the drought the difference between the first dry peak is around day 180 in the 0-10cm layer and day 250 in the 40-140cm layer.

This demonstrates the lag between the surface and the deeper layers – the time it takes for the signal to propagate.

Examination of the 40-140cm layer shows that during the drought year 1988, the deep layer soil moisture was already dry with respect to the 50 year average and the converse is true for the flood year 1993

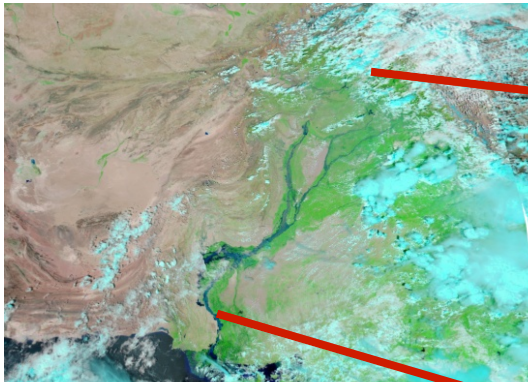
This corroborates previous studies of amplification of initial conditions…dry conditions preceding low rainfall results in large droughts and wet conditions preceding rains results in a flood. This is also seen from satellite images for the weeks during the 1993 flood.

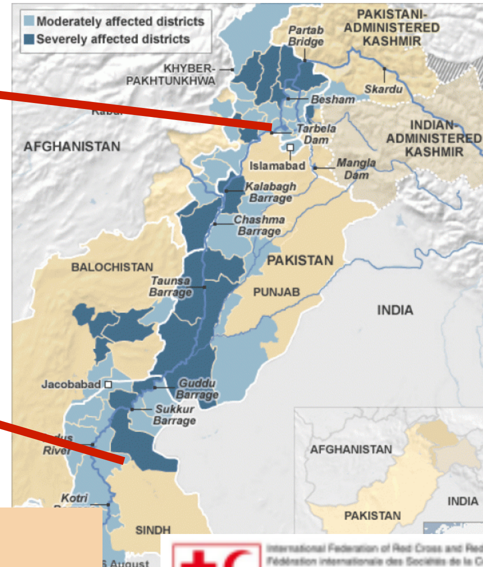
Lakshmi, V.*, T. Piechota, U. Narayan, C. Tang, Soil moisture as an indicator of weather extremes, Geophysical Research Letters, Vol. 31, L11401, doi: 10.1029/2004GL019930, 2004*

Current and Past Sensors

Sensor/Satellite/Data	Variables
AMSR-E/AQUA, GLDAS	Soil moisture
TOPEX/Poseidon, Jason-1, Jason-2	Surface Elevation
AVHRR, MODIS	Vegetation/ET
GPCP	Precipitation
GRACE	Total Water

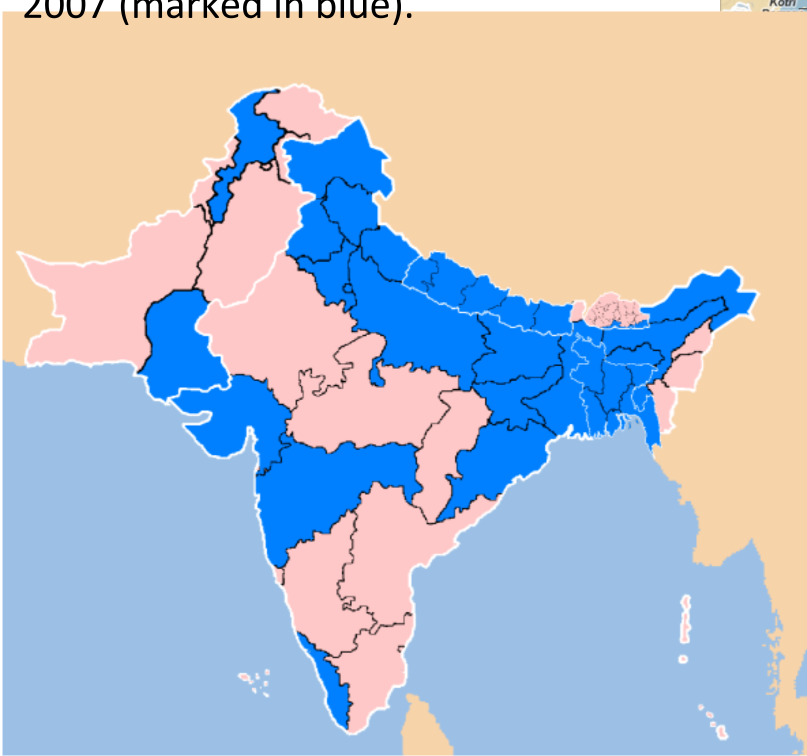
Major flood events since 2007



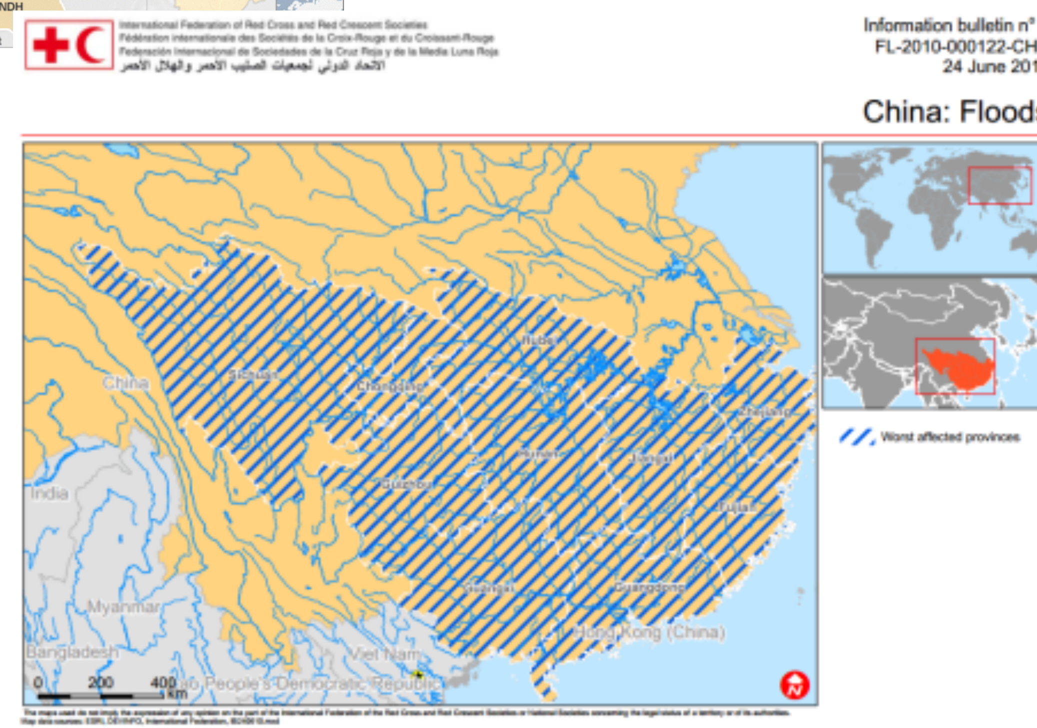


2010 Pakistan Floods Indus River
A NASA satellite image (left)

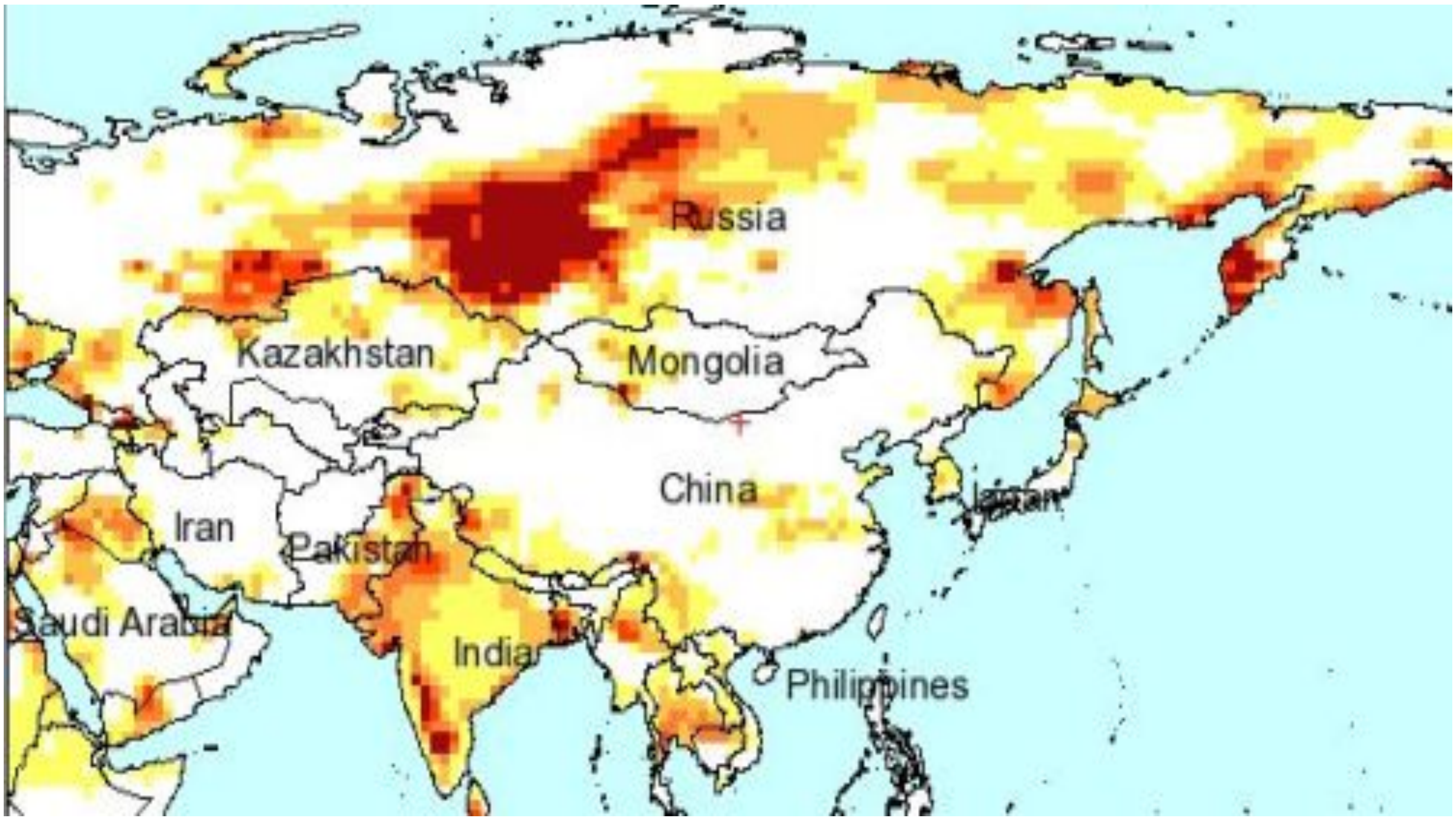
South Asia subdivisions affected by flooding between July 3 and August 15, 2007 (marked in blue).



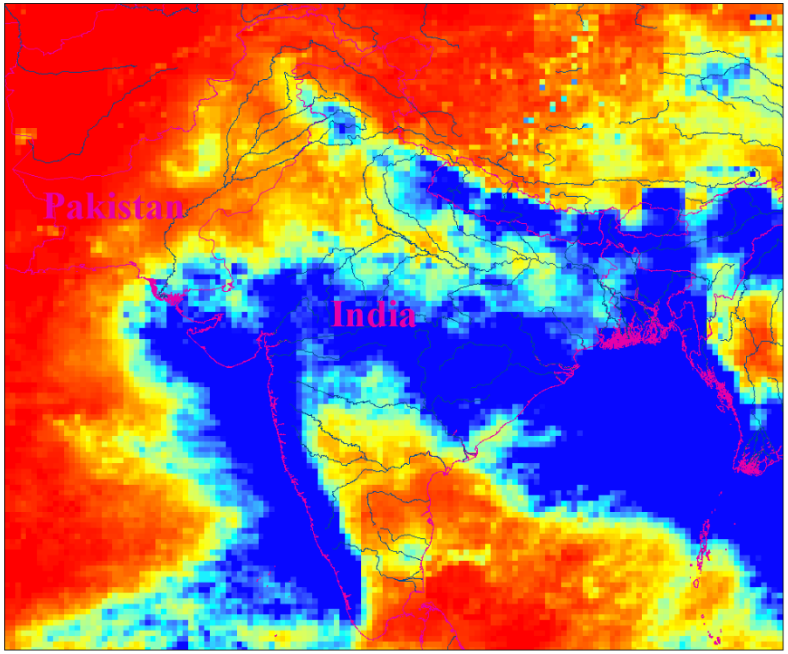
2010 China Floods (24 Jun 2010) (below)



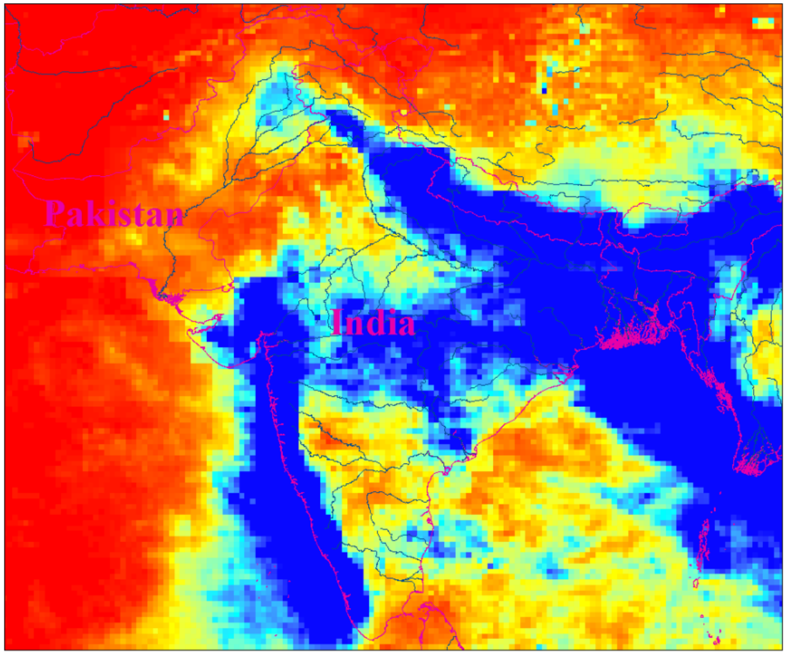
Drought areas in August 2012



TRMM Product 3B43 (monthly, 0.25^{o} resolution)

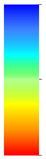


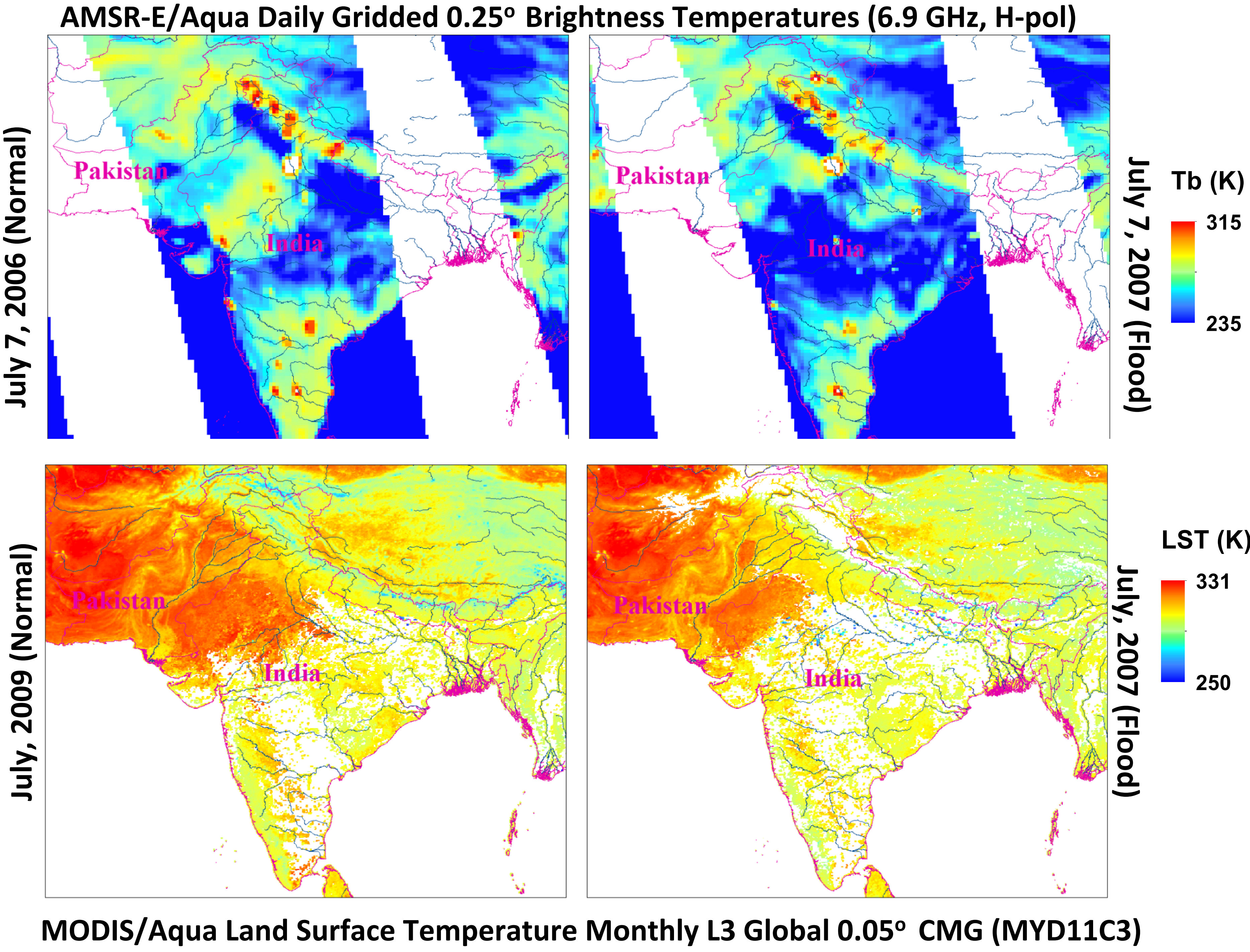
July, 2009 (Normal)



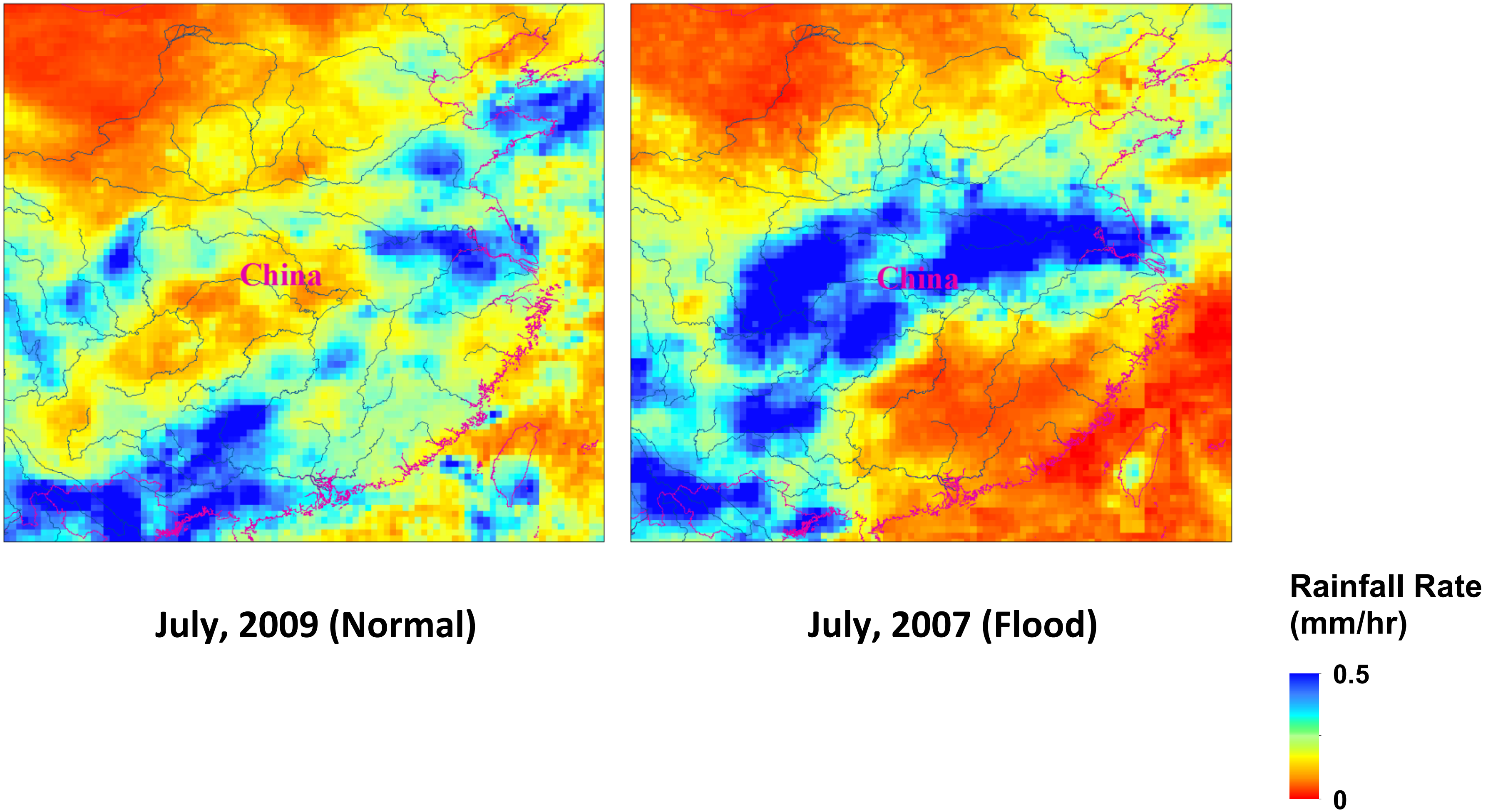
July, 2007 (Flood)

Rainfall Rate (mm/hr)




AMSR-E/Aqua Daily Gridded 0.25° Brightness Temperatures (6.9 GHz, H-pol)
July 7, 2006 (Normal)
July 7, 2007 (Flood)
Pakistan
India
Pakistan
India
Tb (K)
315
235
July, 2009 (Normal)
July, 2007 (Flood)
Pakistan
India
Pakistan
India
LST (K)
331
250
MODIS/Aqua Land Surface Temperature Monthly L3 Global 0.05° CMG (MYD11C3)

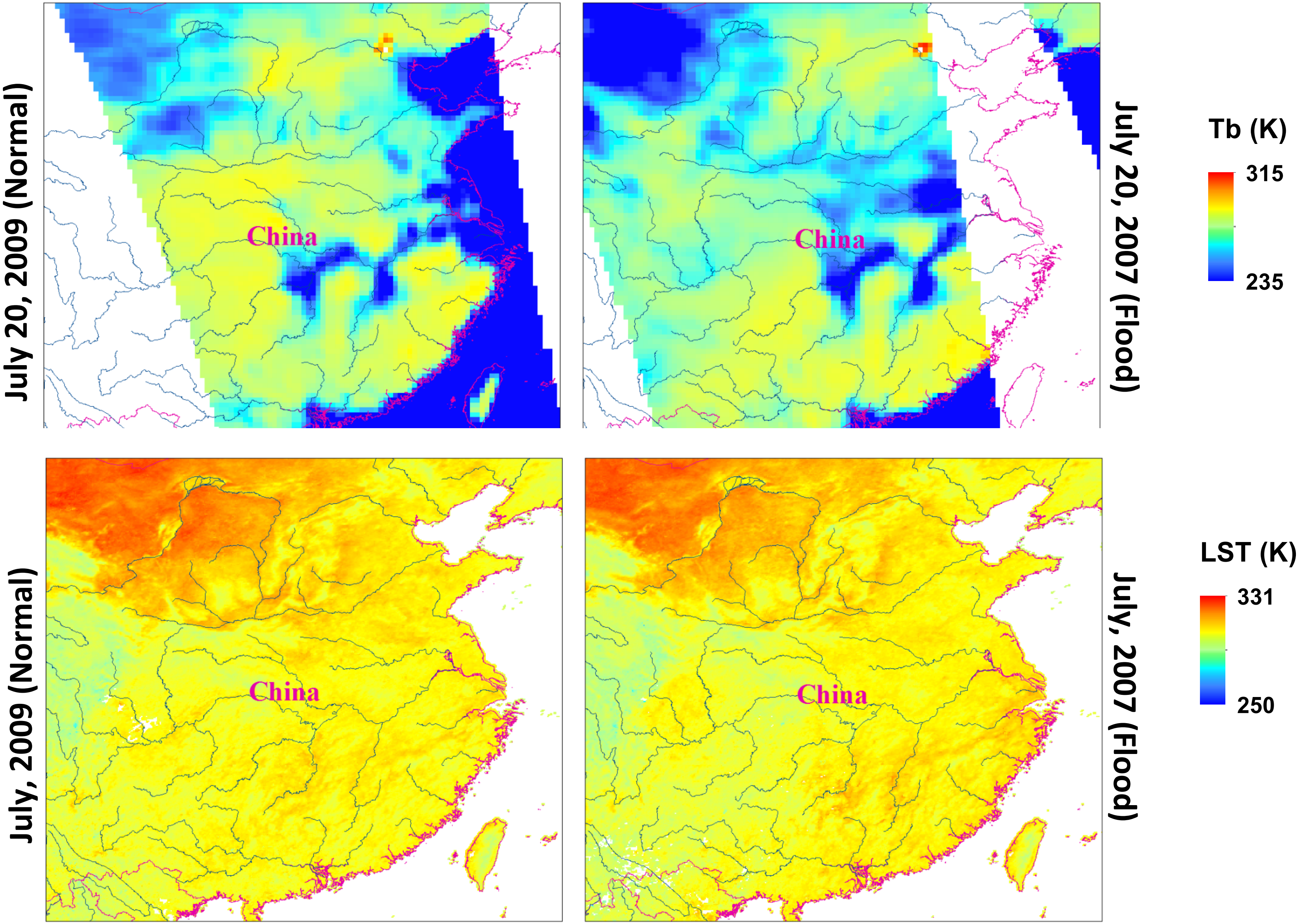
TRMM Product 3B43 (monthly, 0.25° resolution)



July, 2009 (Normal)

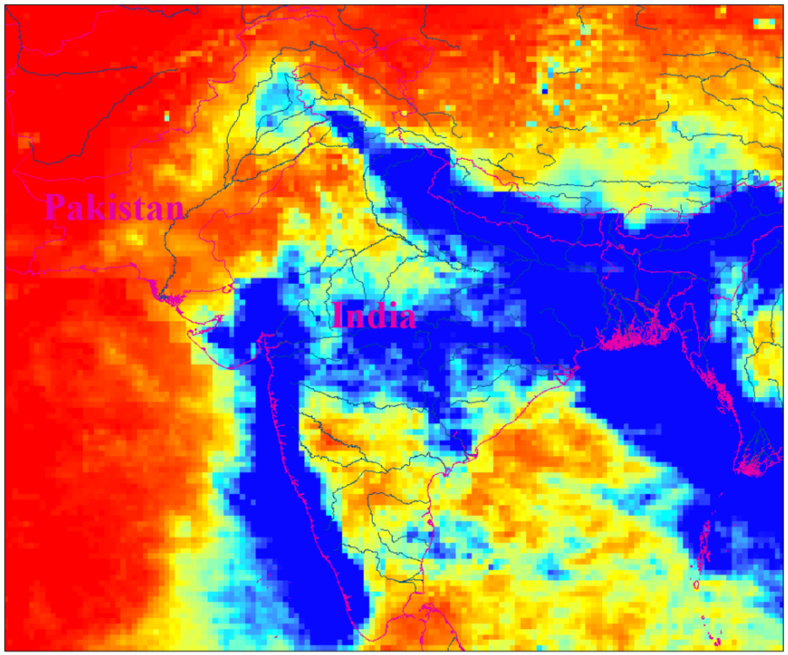
July, 2007 (Flood)

AMSR-E/Aqua Daily Gridded 0.25° Brightness Temperatures (6.9 GHz, H-pol)

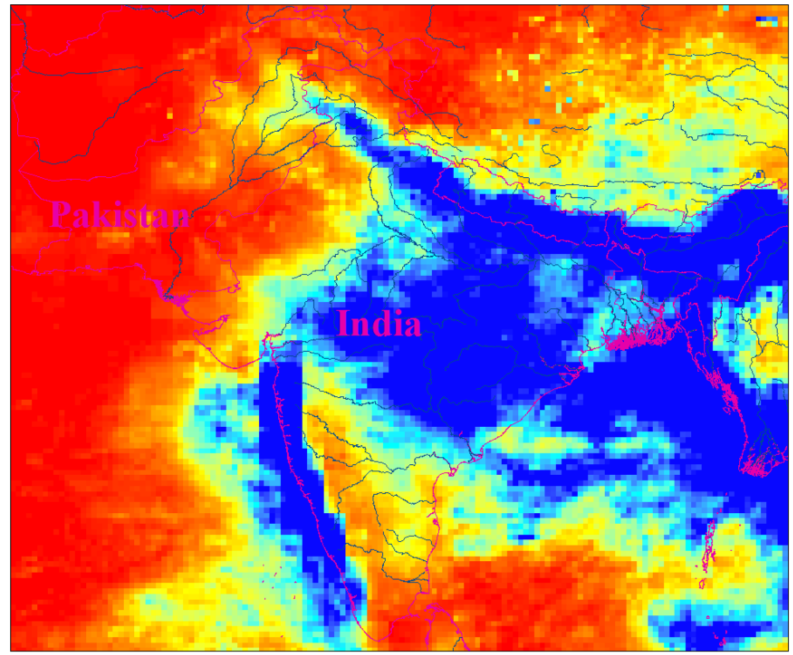


MODIS/Aqua Land Surface Temperature Monthly L3 Global 0.05° CMG (MYD11C3)

TRMM Product 3B43 (monthly, 0.25° resolution)

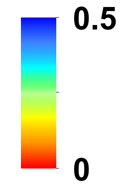


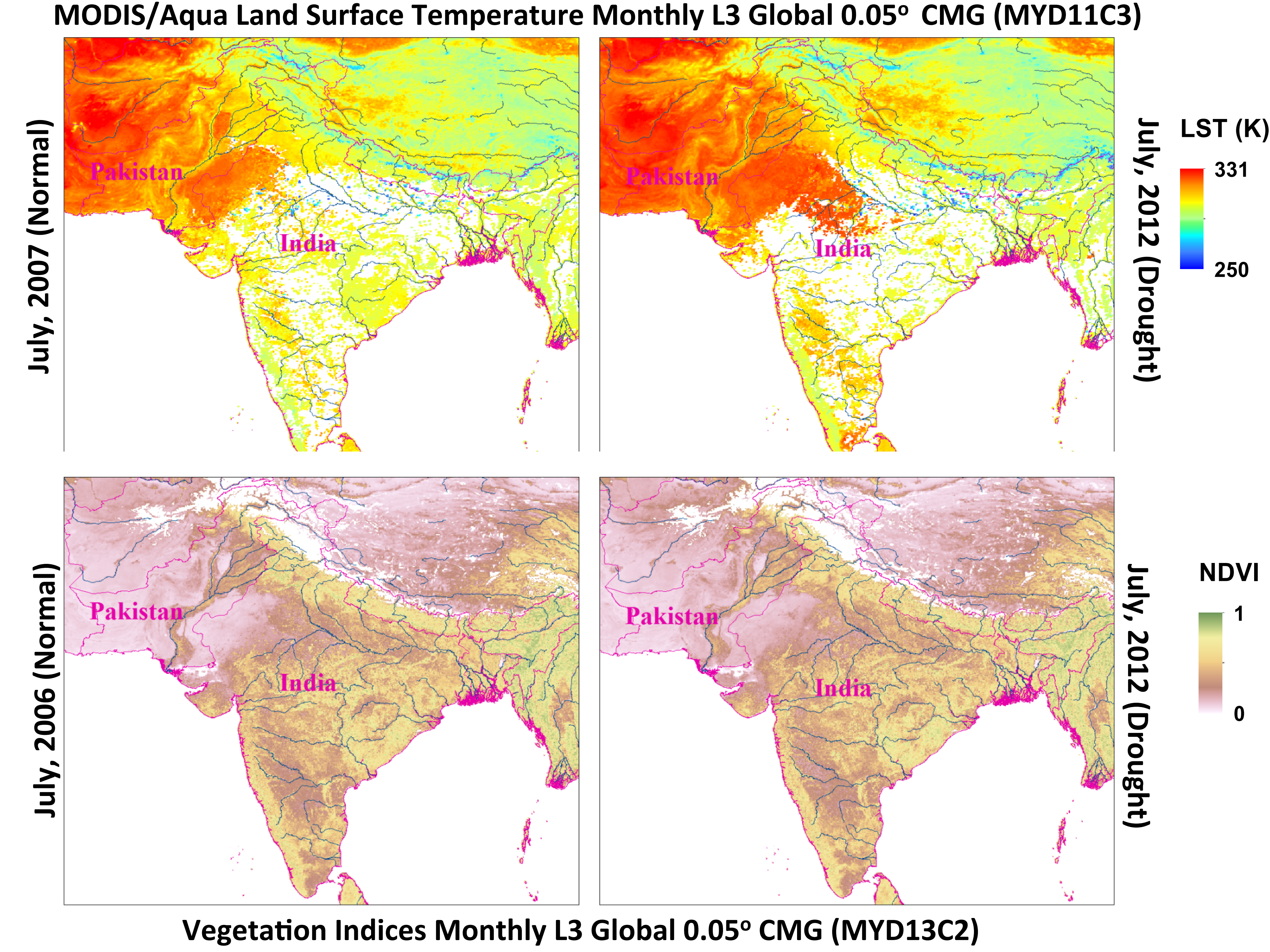
July, 2007 (Normal)



July, 2012 (Drought)

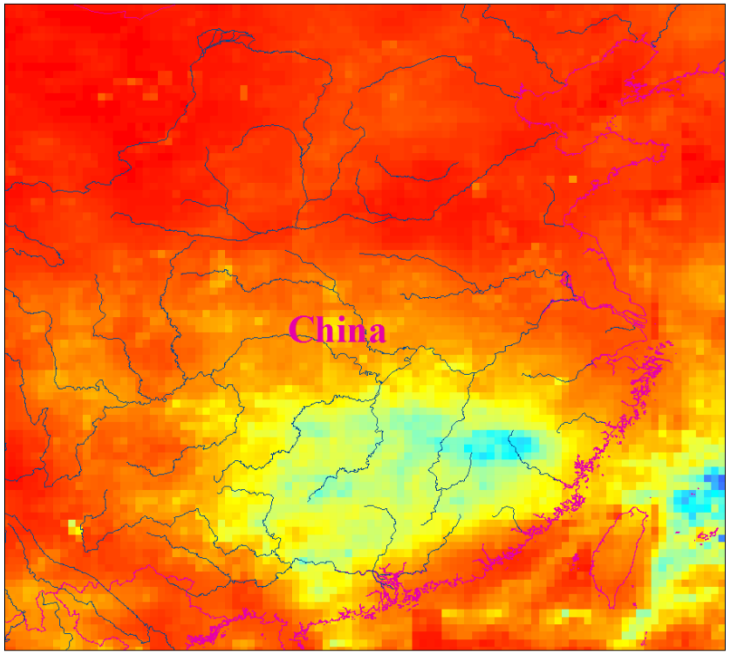
Rainfall Rate (mm/hr)



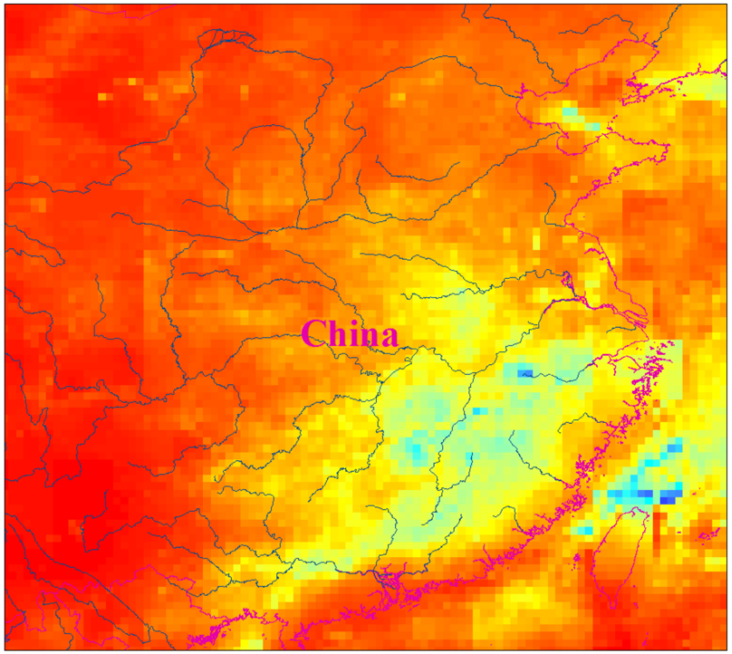


MODIS/Aqua Land Surface Temperature Monthly L3 Global 0.05° CMG (MYD11C3)
July, 2007 (Normal)
July, 2012 (Drought)
LST (K)
331
250
Pakistan
India
Pakistan
India
July, 2006 (Normal)
July, 2012 (Drought)
NDVI
1
0
Pakistan
India
Pakistan
India
Vegetation Indices Monthly L3 Global 0.05° CMG (MYD13C2)

TRMM Product 3B43 (monthly, 0.25° resolution)

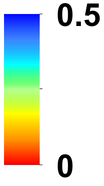


March, 2008 (Normal)

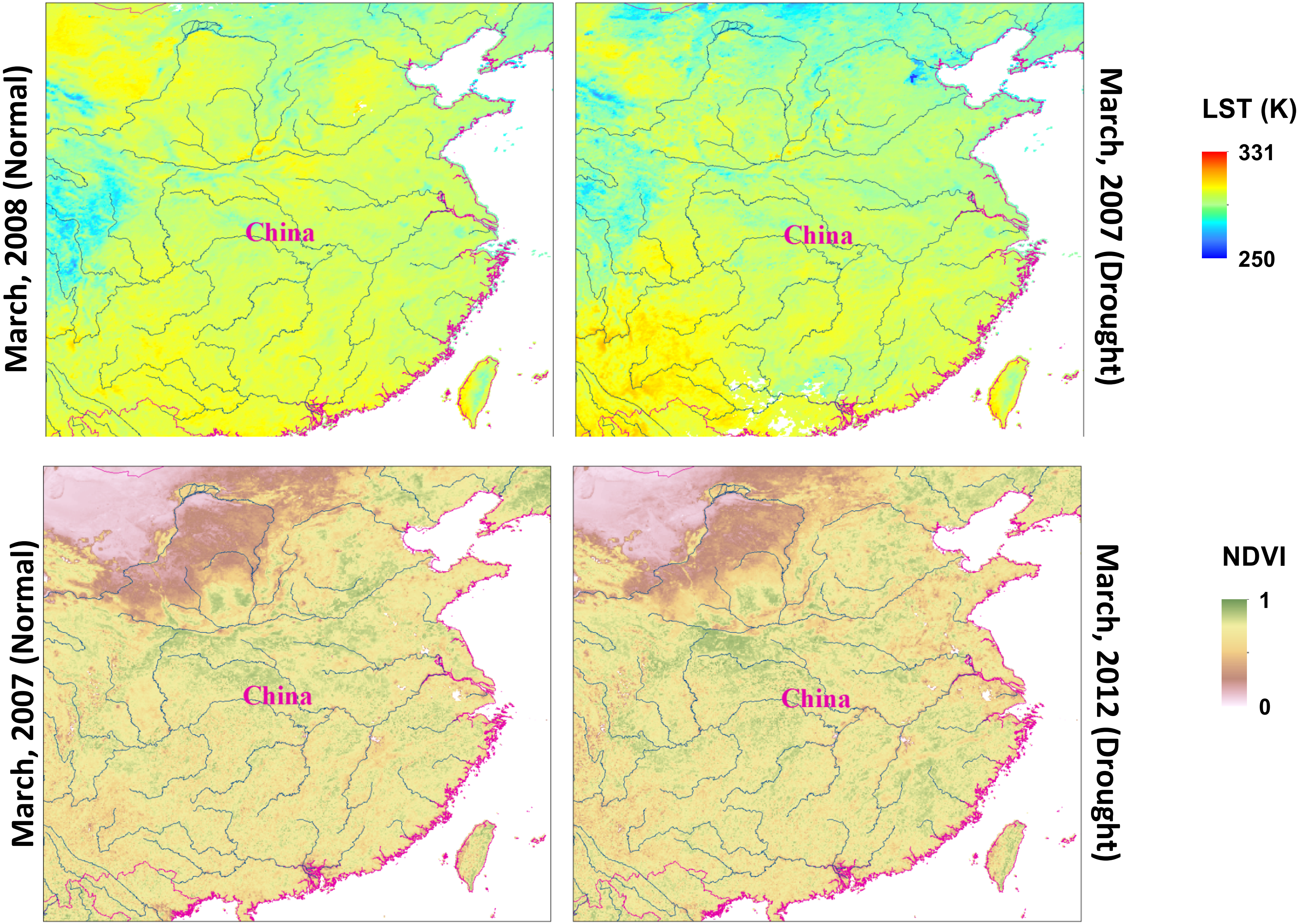


March, 2007 (Drought)

Rainfall Rate (mm/hr)



MODIS/Aqua Land Surface Temperature Monthly L3 Global 0.05° CMG (MYD11C3)



Vegetation Indices Monthly L3 Global 0.05° CMG (MYD13C2)

ESTIMATING AVAILABLE WATER CAPACITY IN THE LOWER MEKONG RIVER BASIN BY INTEGRATING GRACE OBSERVATIONS INTO A LAND SURFACE MODEL

Background

The Gravity Recovery and Climate Experiment (GRACE) data has provided global monthly time series data on water storage change at one-degree resolution over the past decade (2003-2012). Available Water Capacity (AWC) of the soil in watersheds is useful for estimating potential groundwater recharge. The dynamics of Terrestrial Water Storage (TWS) are constrained by the Available Water Capacity, related to field capacity and wilting point, and reflect regional water dynamics. In the Lower Mekong River Basin, the Available Water Capacity map being applied by the Mekong River Commission (MRC) is in need of update. The goal of this study is to assimilate TWS from GRACE data using an Ensemble Kalman Smoother and the NASA Catchment Land Surface Model (CLSM) over a sub-basin of the Lower Mekong River Basin. In this way, the water holding capacity of the sub-basin is constrained.

METHODOLOGY

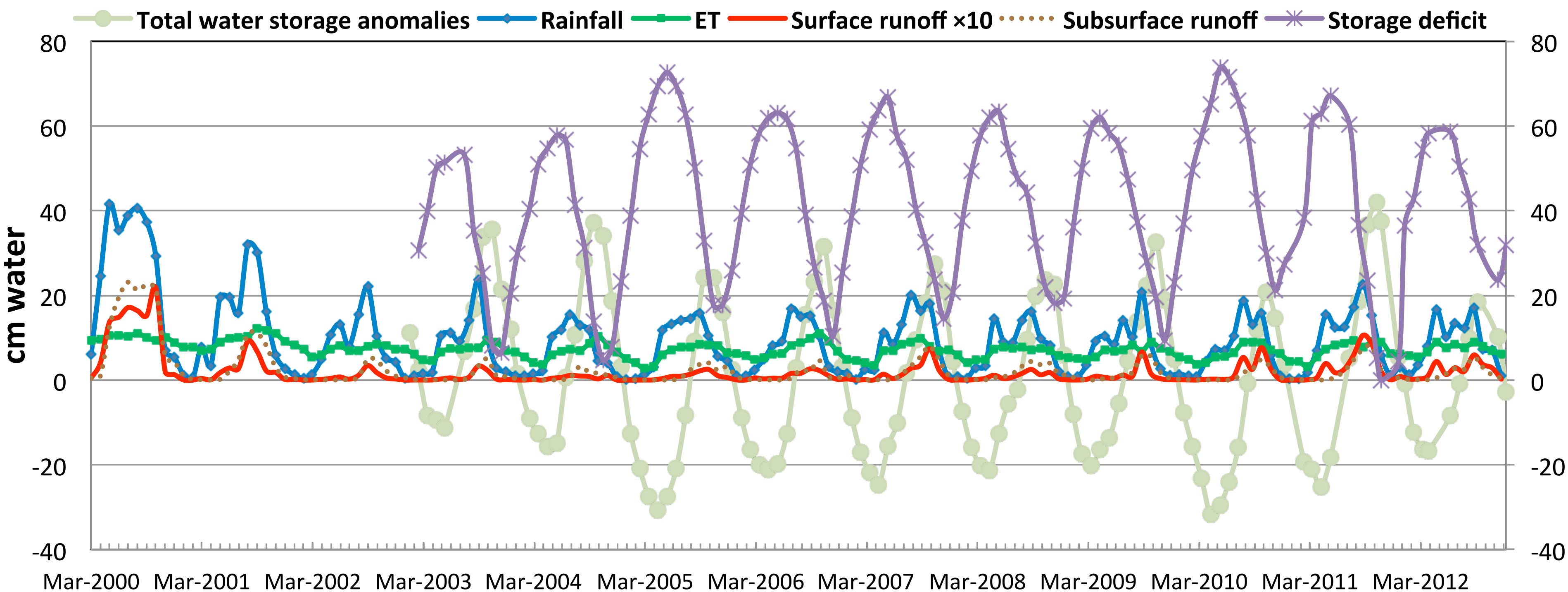
GRACE captures Terrestrial Water Storage (TWS) anomalies, including groundwater, soil moisture, surface water, snow and ice

Assimilate TWS data from GRACE data: integrate the GRACE data with other meteorological observations within the Catchment Land Surface Model, using Ensemble Kalman smoother type data assimilation

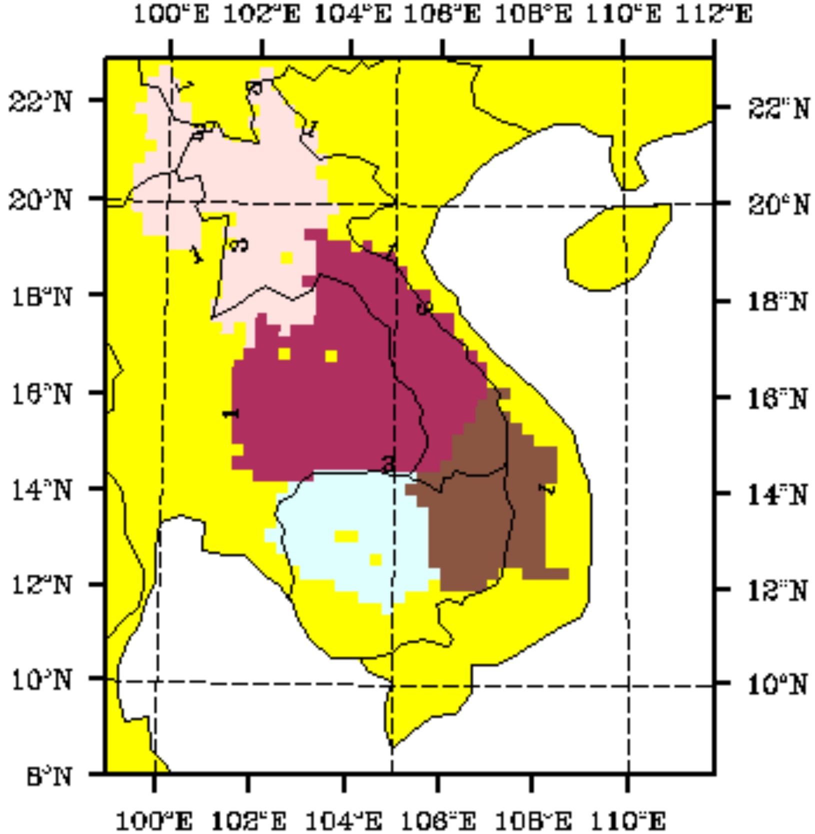
Determine available water capacity (AWC) of the soil: field capacity (can be approximated by the historic record maximum of the repeated peaks in GRACE storage anomaly **soil moisture** time series) **– wilting point** (from Catchment model)

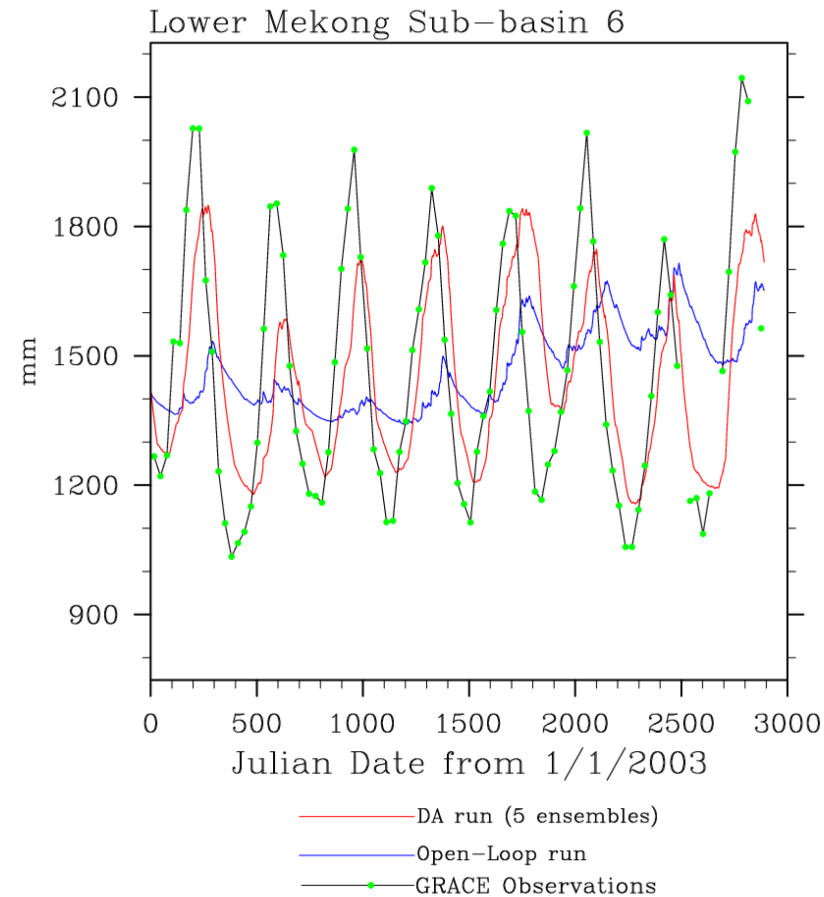
Compare GRACE-AWC with AWC from Catchment model

GRACE and GLDAS Data and Storage Deficit for Sub-Basin 6 of Lower Mekong River Basin

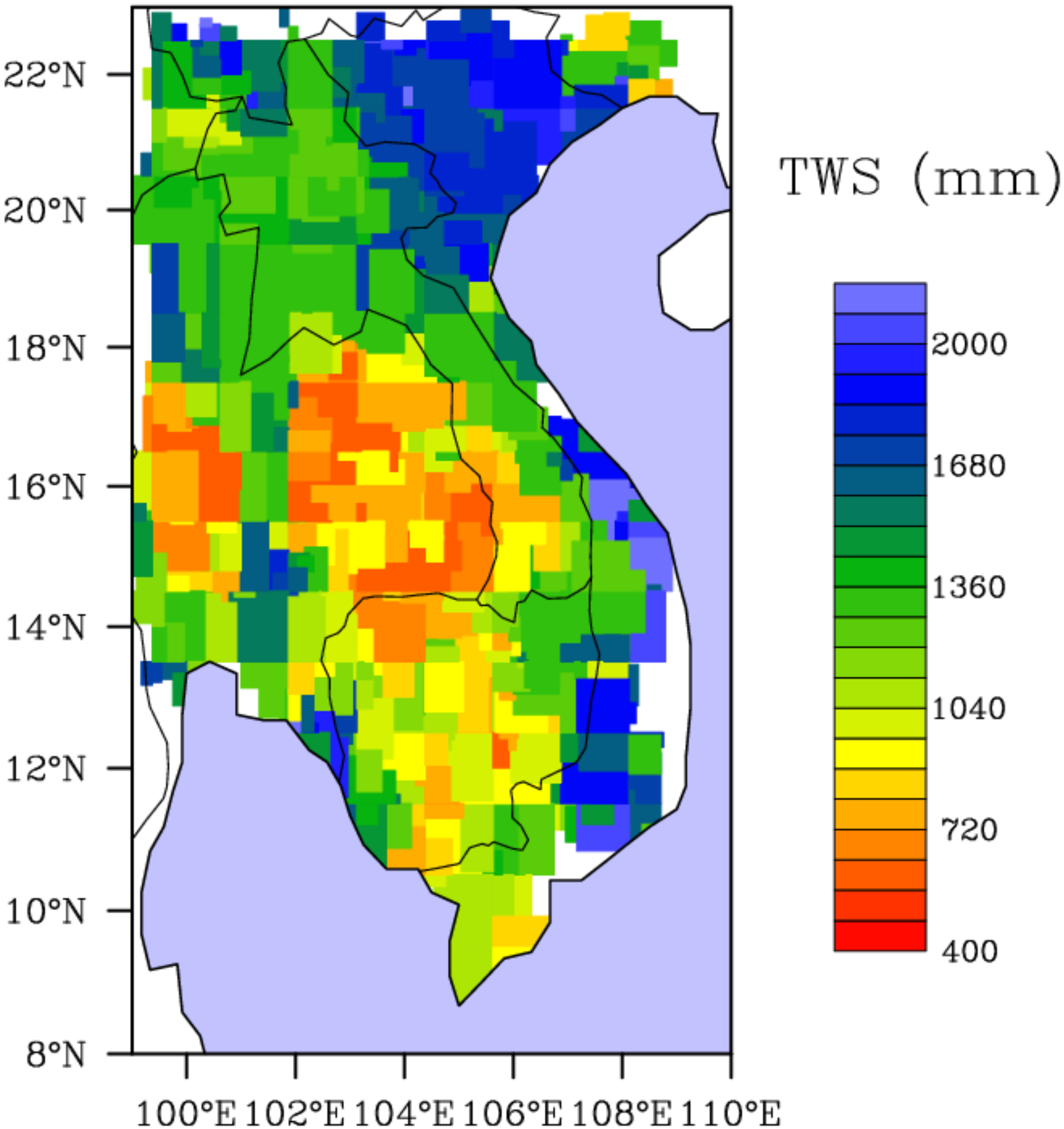


Time series of Total Water Storage Anomaly (TWSA) from GRACE, rainfall, ET, surface runoff and subsurface runoff from GLDAS and Storage Deficit (SD) over the GRACE record length for Sub-basin 6 (at 105°-109° longitude and 12°-16° latitude) of the Lower Mekong River Basin.

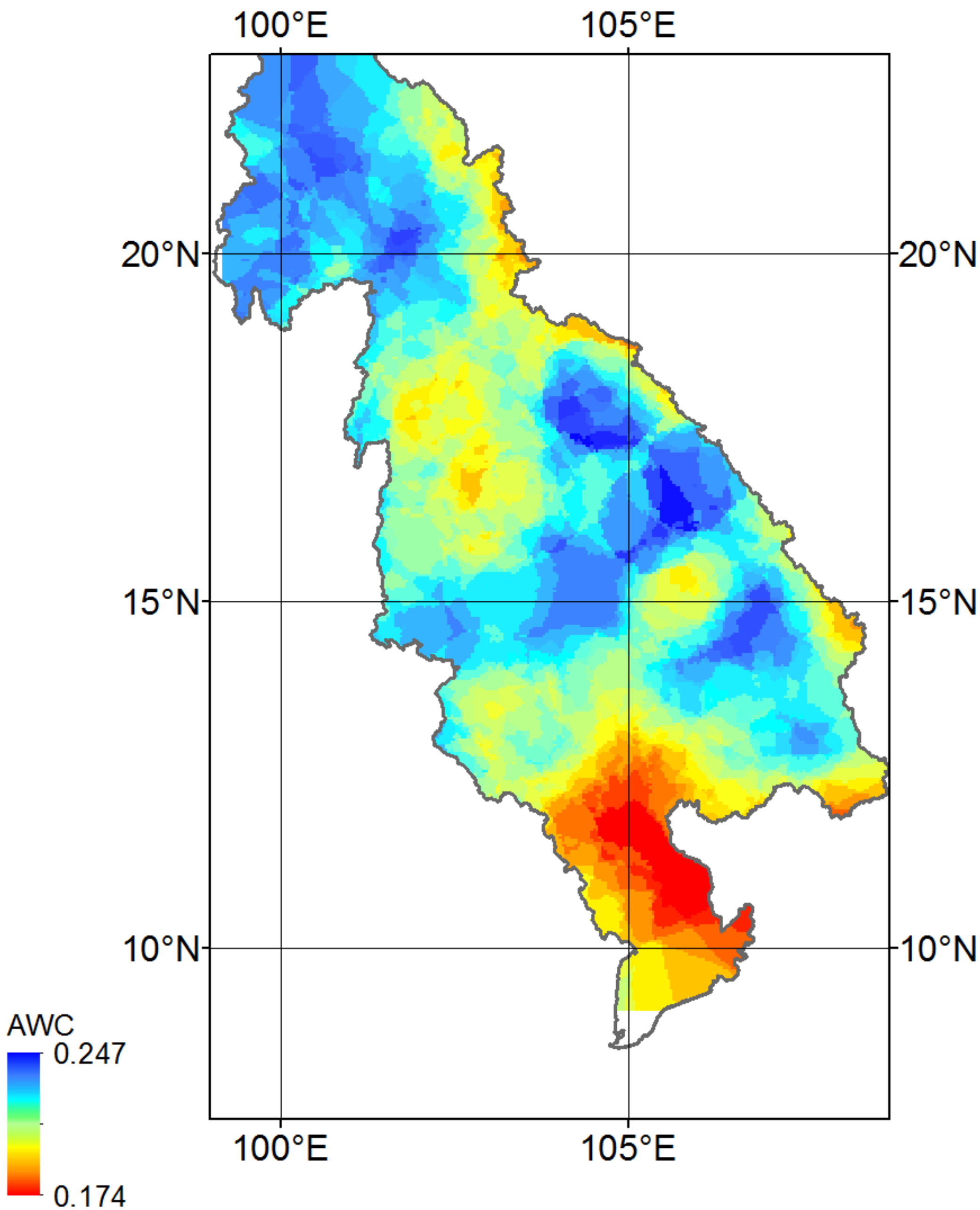




The U.S./German Gravity Recovery and Climate Experiment (GRACE) satellite mission provides large scale (>200,000 km^2) estimates of changes in total terrestrial water storage (green dots) on a monthly basis. We apply a modified Ensemble Kalman Smoother (EnKS) for assimilating the GRACE data into the Catchment Land Surface Model (CLSM) for Sub-basin 6 of the Lower Mekong River Basin, producing estimates of variations in the components of terrestrial water storage (TWS).



Average TWS from 2003 to 2010 of the Lower Mekong River Basin (at 99 -109 deg longitude and 8.5-23 deg latitude) from GRACE DA



AWC of the Lower Mekong River Basin from CLSM

The available water capacity will be estimated by GRACE DA. The calculated AWC will be validated using the Soil and Water Assessment Tool (SWAT), which requires AWC as an adjusted parameter on discharge calibration. AWC is important on watershed management, especially in flood prediction for the Lower Mekong River Basin.

Conclusions

- The mapping of flooded and drought areas is important for society
- We have used rainfall and water storage data derived from a combination of model and satellite observations to understand inter-annual water resources variability in the Lower Mekong River Basin
- We will continue to analyze other catchments in Southeast Asia for drought and flood events