Challenge for land surface modelling

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LSMs for what?

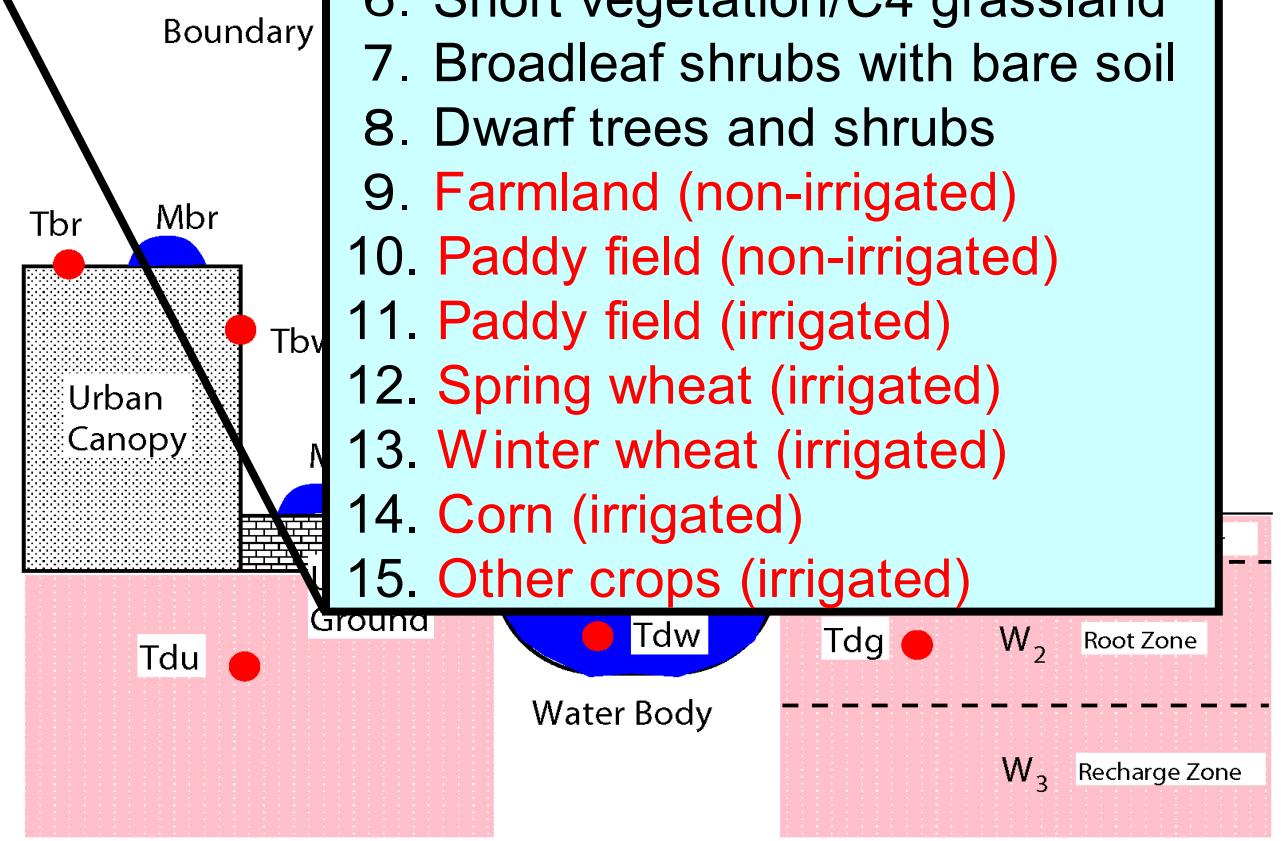
- BC of atmospheric model
  (energy & radiation balance, friction)
- BC of hydrological model
  (surface runoff, baseflow)
- IWRM
  (evaporation, soil moisture, IWR, snow, WQ,..)
- Analysis/Prediction
  time varying parameters for past/future
  seasonal variation + inter-annual variation+
  human impact

Land surface model (SiBUC)

Grid box is divided into three landuse categories

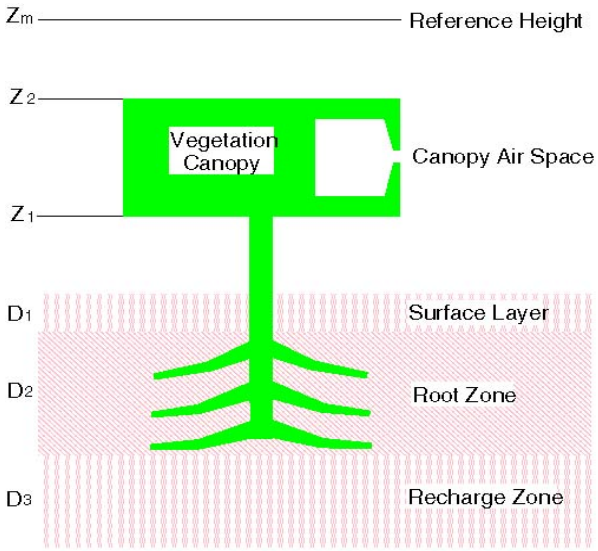
1. Green Area
2. Urban Area
3. Water Body

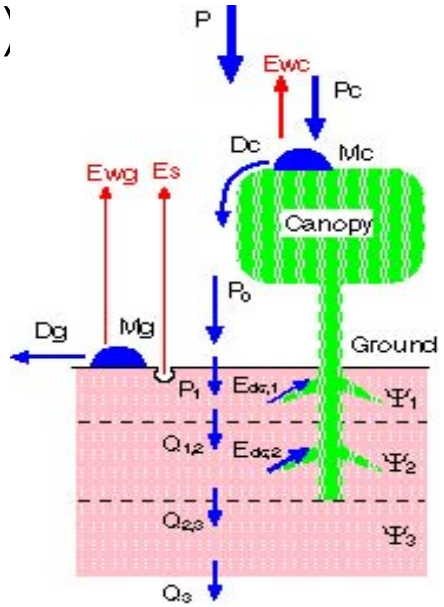
1. Broadleaf-evergreen trees
2. Broadleaf-deciduous trees
3. Broadleaf and needle leaf trees
4. Needle leaf-evergreen trees
5. Needle leaf-deciduous trees
6. Short vegetation/C4 grassland
7. Broadleaf shrubs with bare soil
8. Dwarf trees and shrubs
9. Farmland (non-irrigated)
10. Paddy field (non-irrigated)
11. Paddy field (irrigated)
12. Spring wheat (irrigated)
13. Winter wheat (irrigated)
14. Corn (irrigated)
15. Other crops (irrigated)

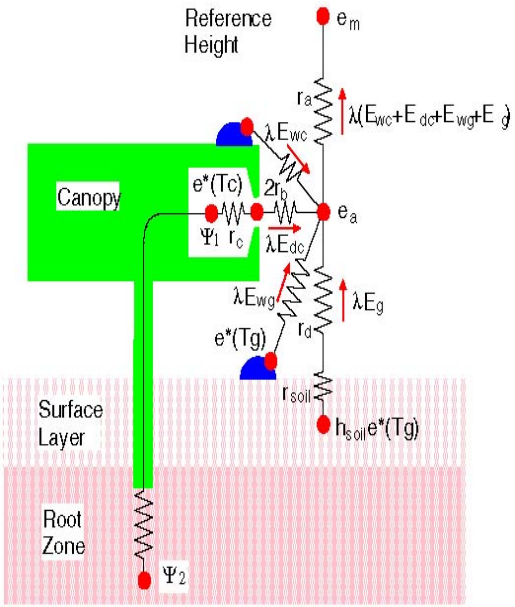


Green area model (SiB)

- Prognostic variables
  temperature (canopy, ground, deep soil)
  interception water (canopy, ground)
  soil wetness (surface, root zone, recharge)
- Time invariant parameter
  geometrical parameter
  optical parameter
  physiological parameter
  soil physical properties
- Time varying parameter (LAI etc.)
  estimate from satellite data
- Physical processes
  radiative transfer
  interception loss
  soil hydrology
  canopy resistance
  transpiration
  turbulent transfer,
  snow, freezing/melting,… etc.







Paddy field model

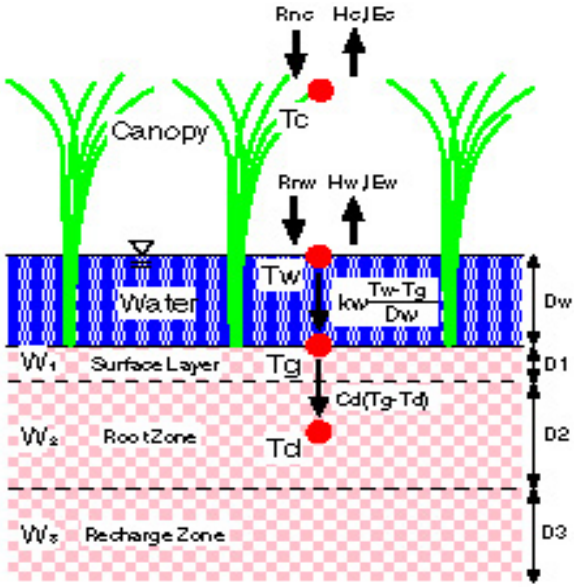
- Water depth and water temperature are added

$$C_c \frac{\partial T_c}{\partial t} = Rn_c - H_c - lE_c$$

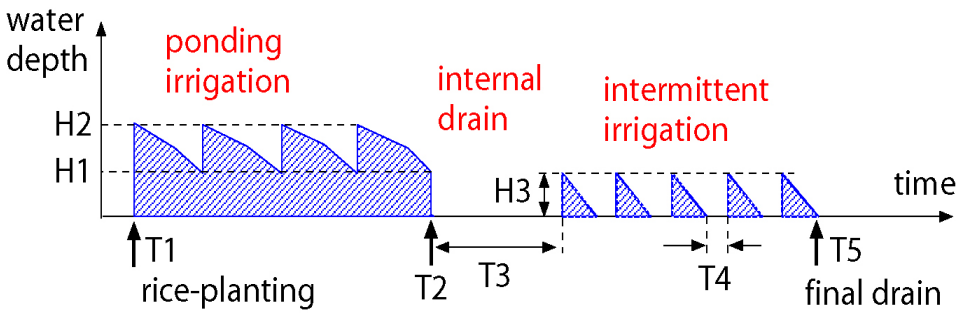
$$C_w D_w \frac{\partial T_w}{\partial t} = Rn_w - H_w - lE_w - k_w \frac{T_w - T_g}{D_w}$$

$$C_g \frac{\partial T_g}{\partial t} = k_w \frac{T_w - T_g}{D_w} - \omega C_d (T_g - T_d)$$

$$C_d \frac{\partial T_d}{\partial t} = \omega C_d (T_g - T_d)$$

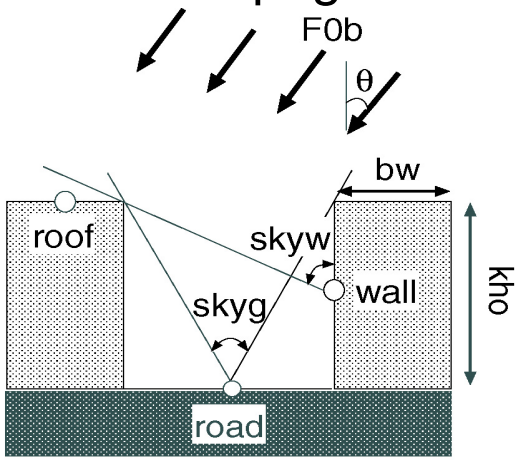


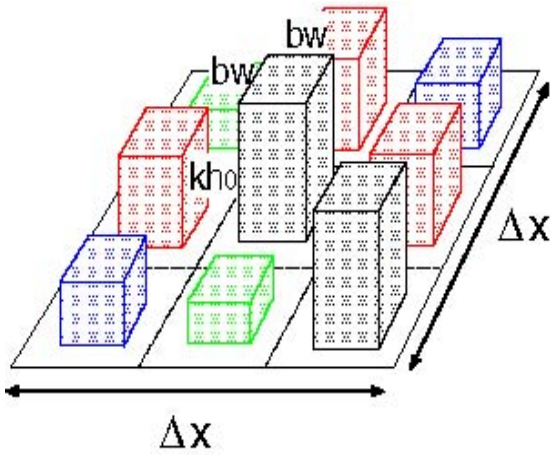
- Water depth control (irrigation / drainage) according to the growing stage optimal / minimum water depth specified
  - Ponding irrigation
  - Internal drain
  - Intermittent irrigation

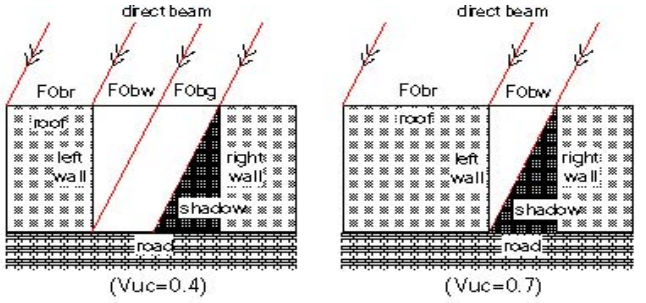


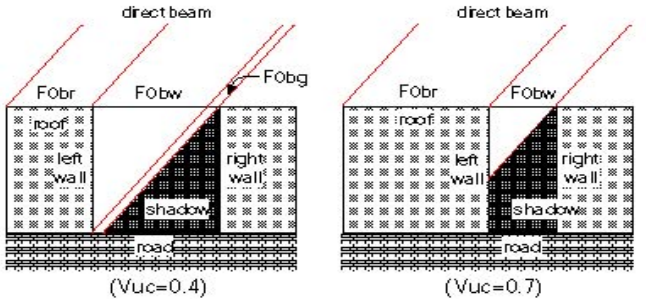
Urban Canopy model

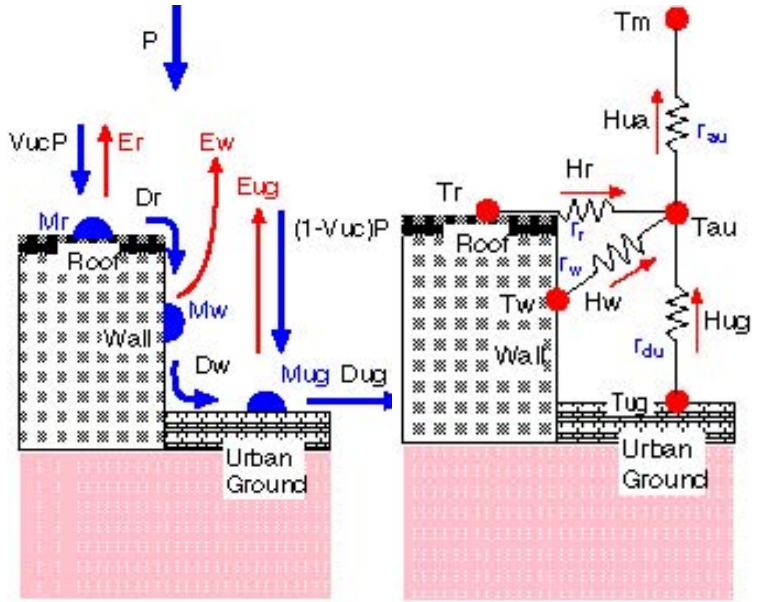
- Urban canyon concept
  sky-view factor (road: skyg wall: skyw)
- Prognostic variables
  temperature (roof, wall, road, deep soil)
  interception water (roof, wall, road)
- Roughness elements
  (same width but different roof height)
- Spatial distribution of roof height and anthropogenic heat











Challenges

- In modeling itself

  better representation of physical processes in various landuse / landcover condition
  + human activity (city, cropland, reservoir)
  + vegetation in semi-arid region (physiology)
  + deep soil moisture (ground water table)
  + soil moisture re-distribution by micro topography

- In parameter setting

  realistic spatial/temporal distribution of parameters
  + landcover / landuse (past, present, future)
  + anthropogenic heat in mega-city
  + crop type / farming calendar
  + soil properties (physical → effective / apparent)
  + underground structure (physical → conceptual)

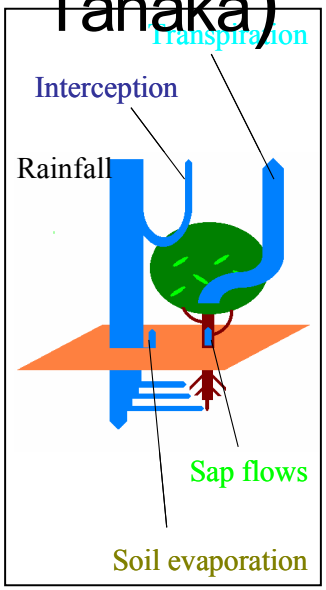
Challenges (2)

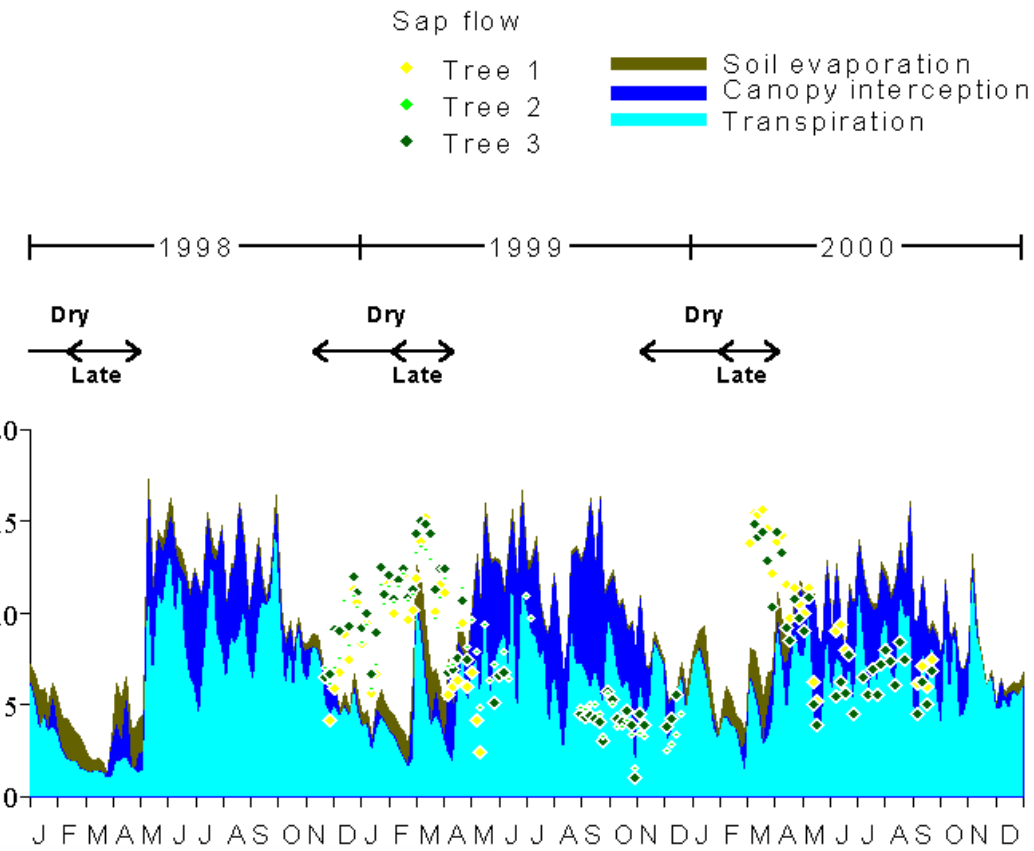
- In data assimilation
  + updating state variables
    (temperature, soil moisture, snow)
  + calibrating model parameters
  + correcting forcing data (precipitation)

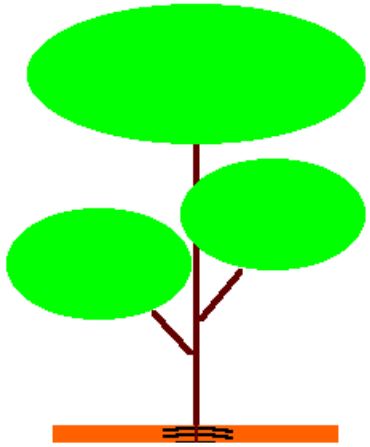
  Prediction error is brought from
  1. Insufficiency of model physics (bad parameterization)
  2. Insufficiency of parameters used
  3. Insufficiency of forcing data

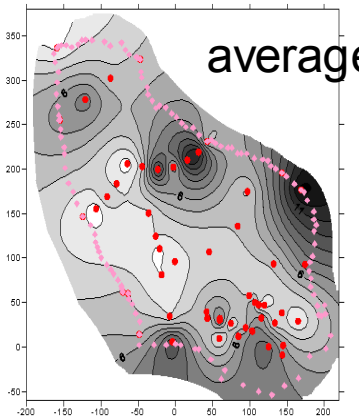
- For seasonal prediction
  + seasonal evolution of vegetation
    (deciduous forest, grassland, cropland,…)

Numerical Simulation (by Dr.Katsunori Tanaka)

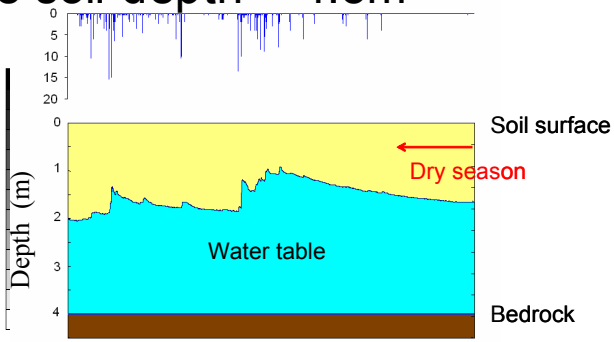






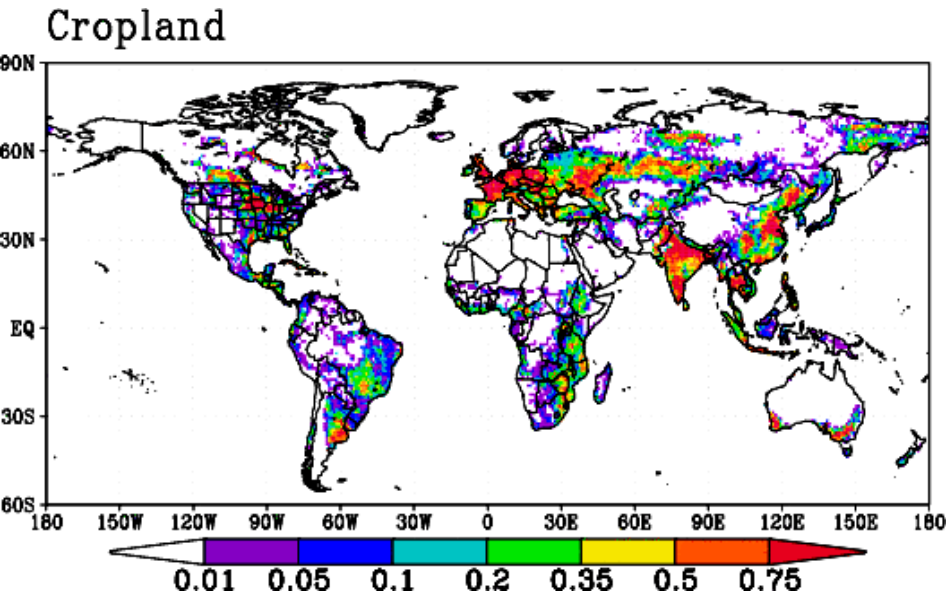


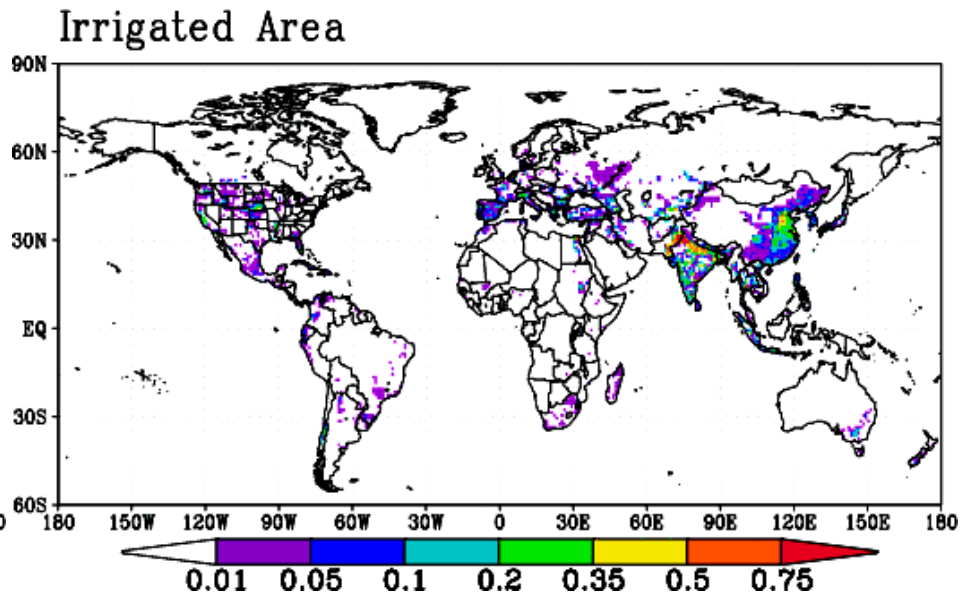
average soil depth = 4.5m



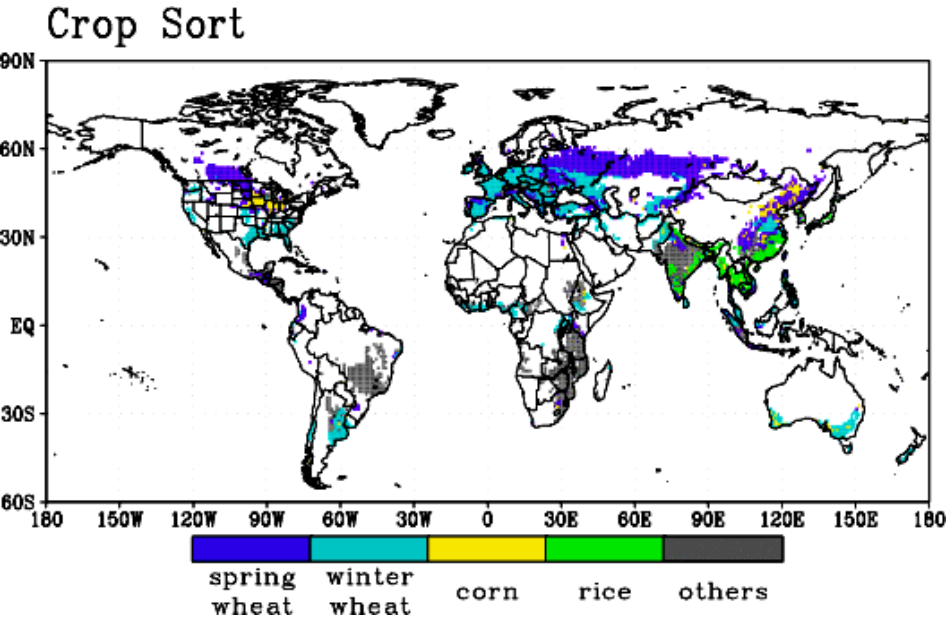
Rooting depth= 1 m

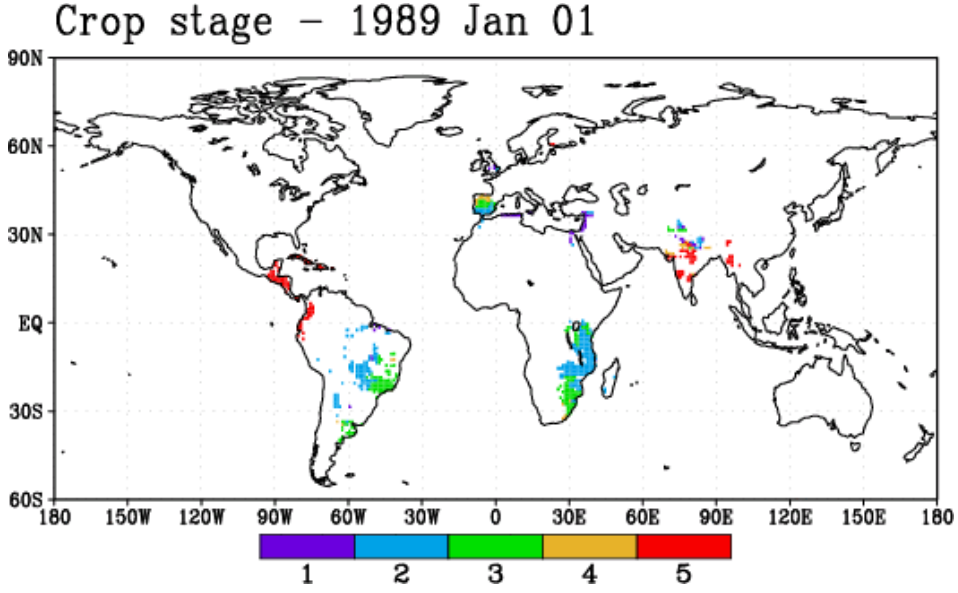
Deeper root can get water from the deeper soil layers



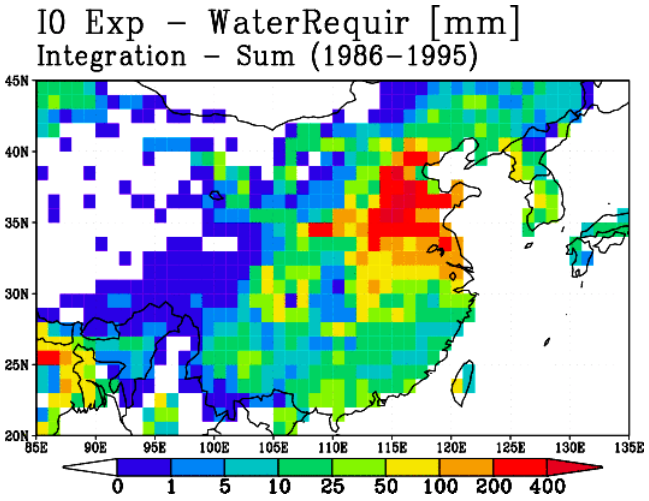


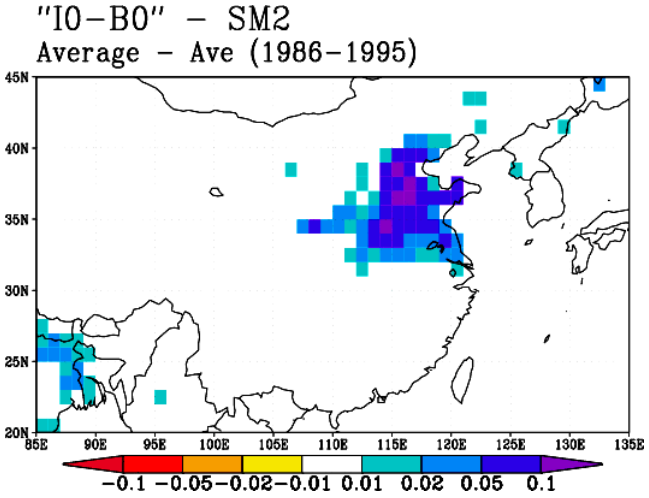
Agricultural sector accounts 85 percent of the world's water consumption
40 percent of the world's food is produced in irrigated agricultural land.

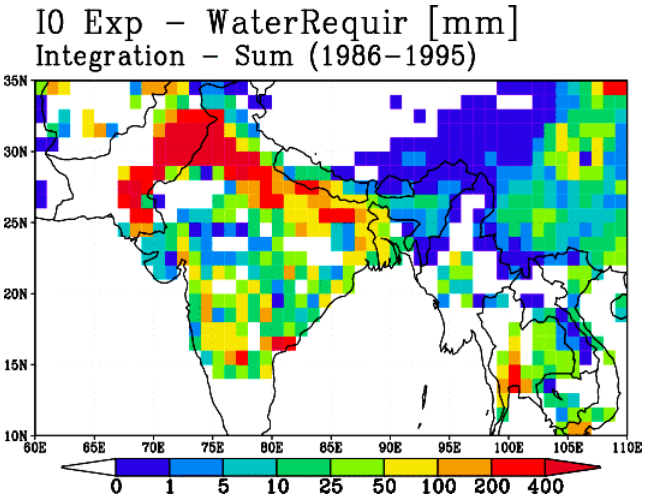


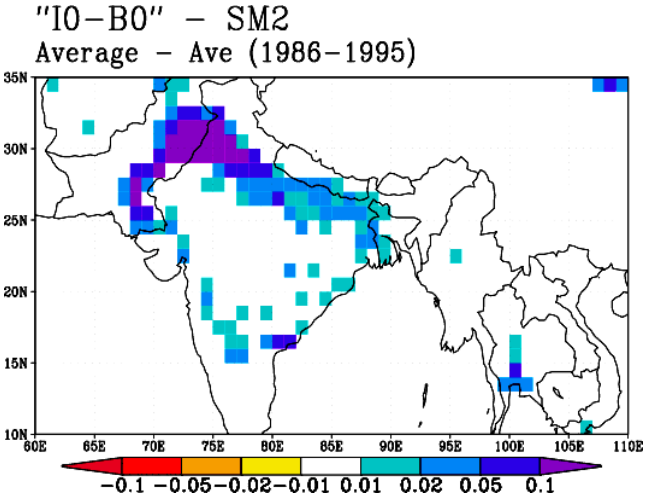


Effects of irrigation



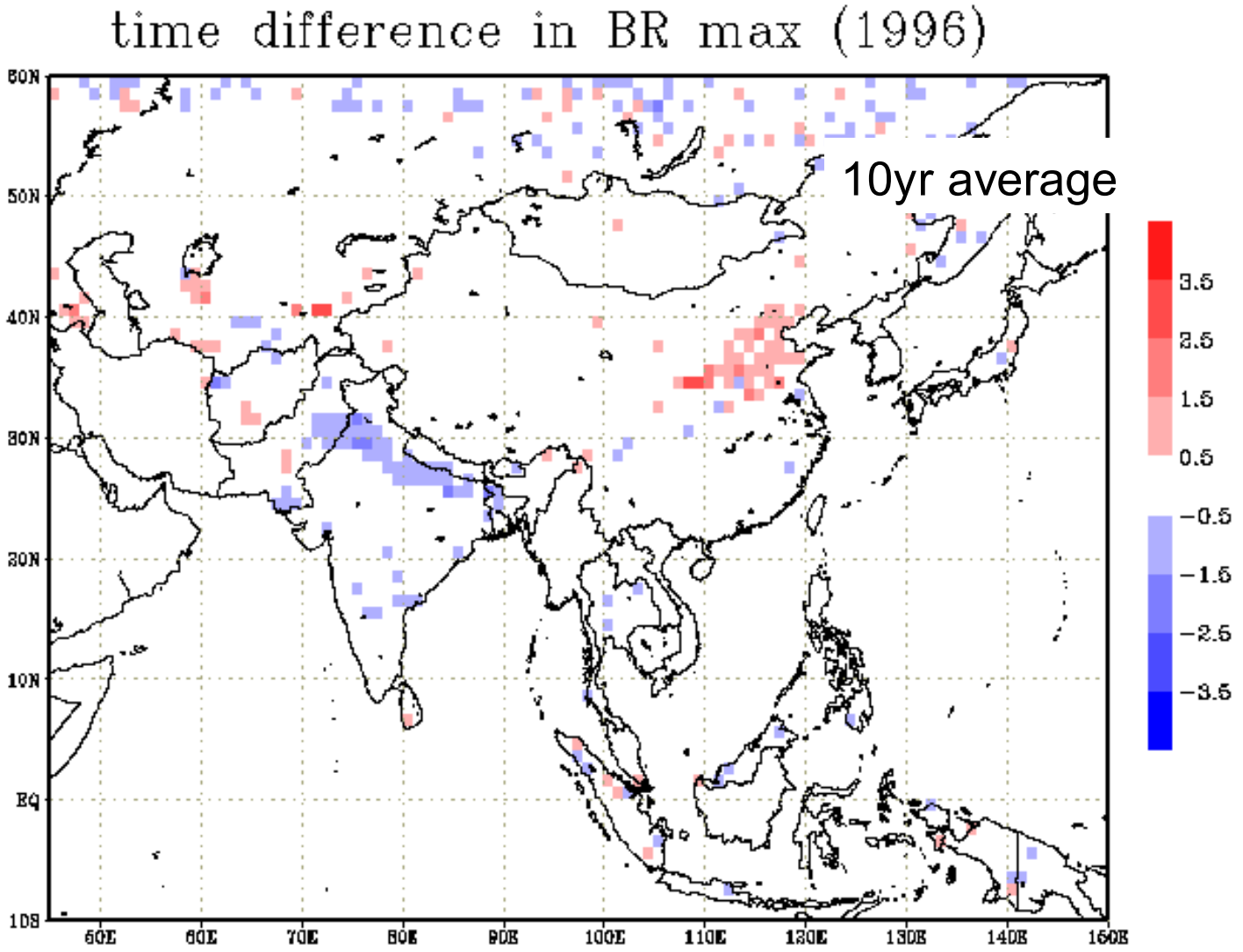






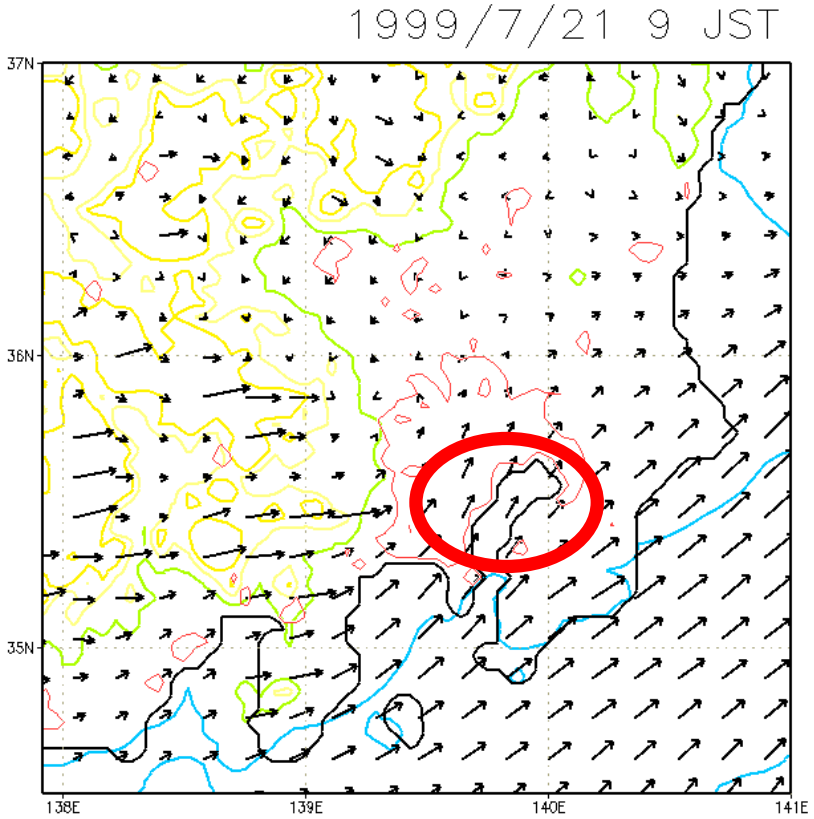
Irrigation Water Requirement

Soil Wetness



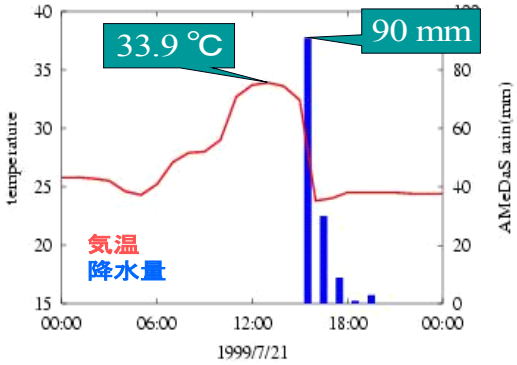
Irrigation can change the phase of seasonal cycle of surface energy balance

Does urban heat island affect heavy rainfall?

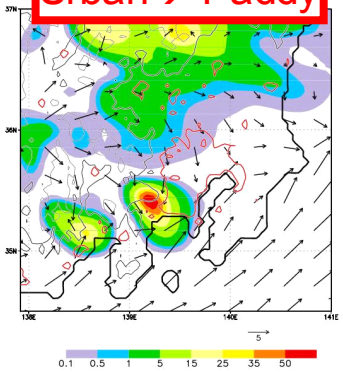


Cloud resolving model (CReSS)
+
Land surface model (SiBUC)
||
CReSiBUC

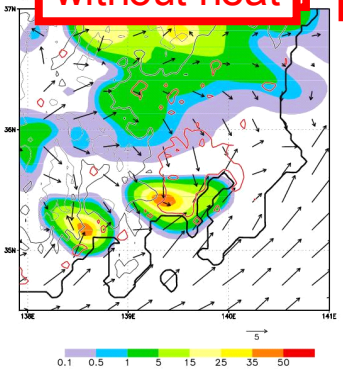
1999/7/21



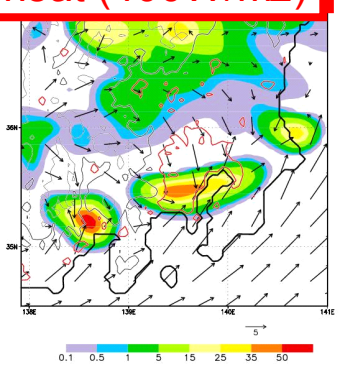
Urban→ Paddy



without heat



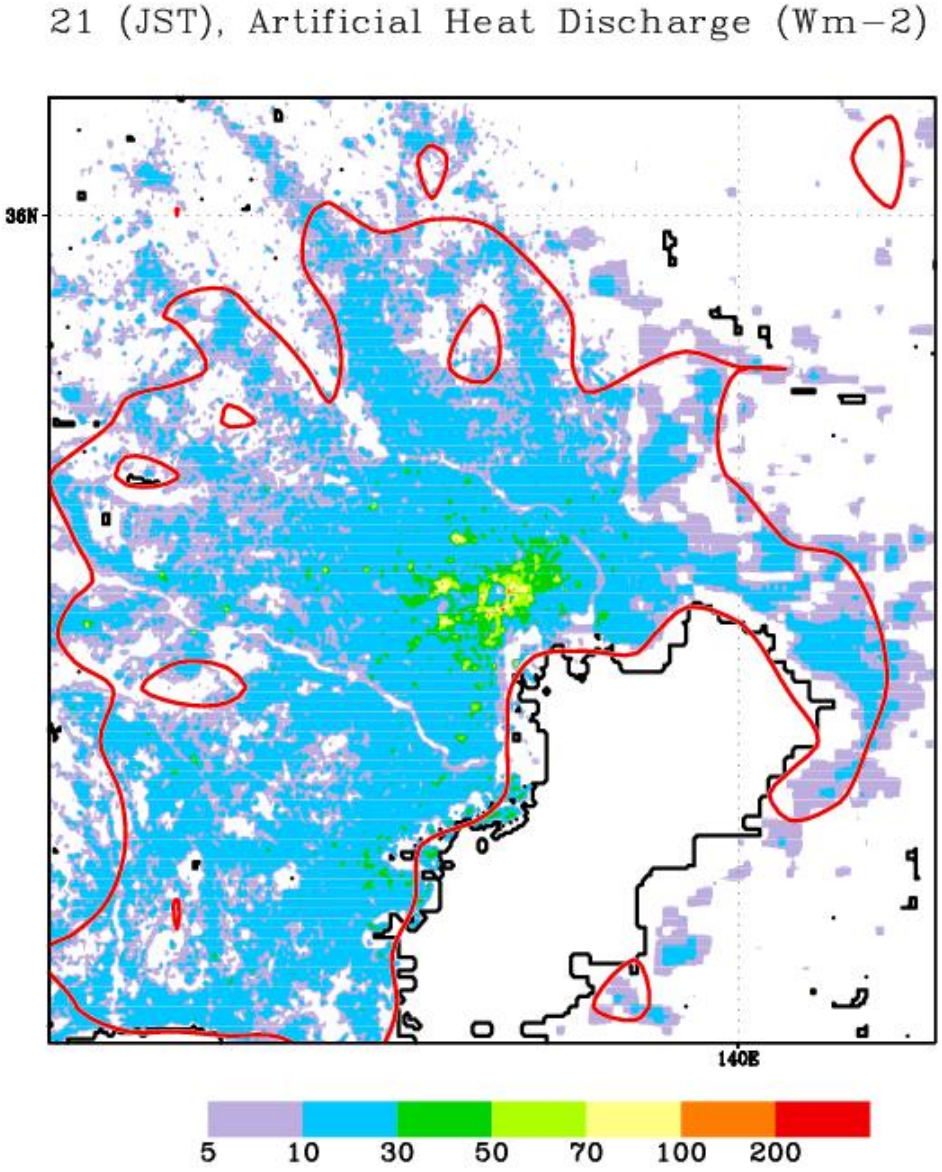
heat (400W/m2)



Effect of existence of Urban Area
shift the position of rainfall
Effect of anthropogenic heat
enlarge the rainfall area

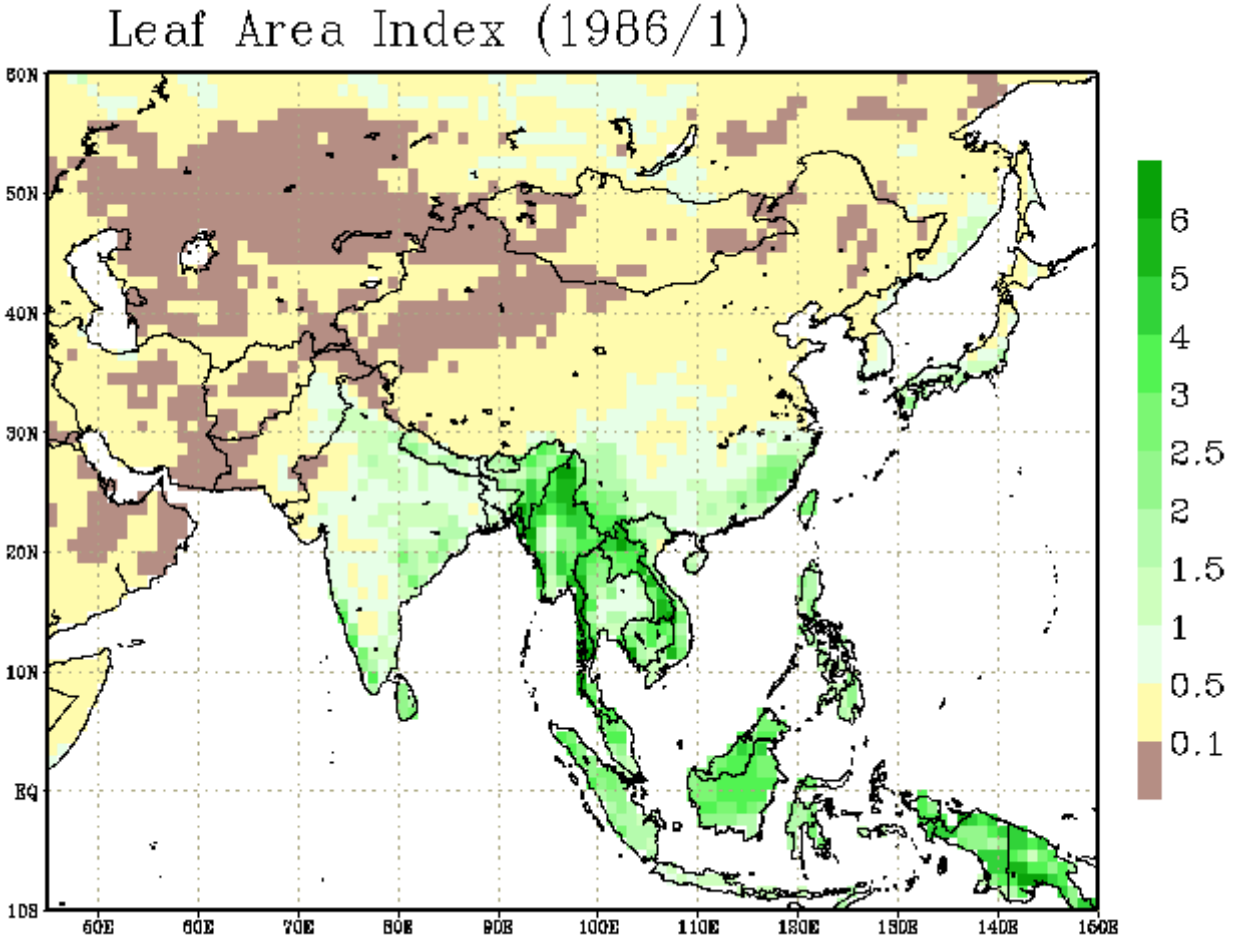
Importance of the representation of urban area in short range NWP

Spatial distribution of Anthropogenic heat in Tokyo

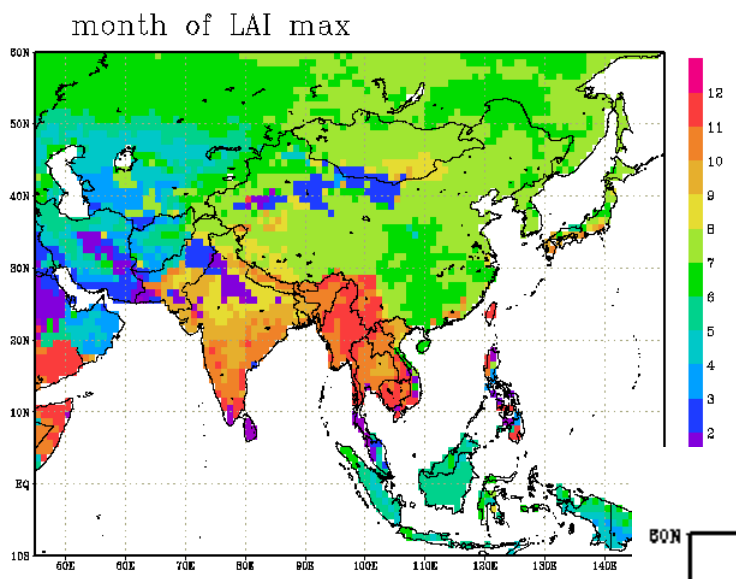


Is there a good dataset for Time/space distribution of anthropogenic heat in Asian mega cities?

LAI (Leaf Area Index)

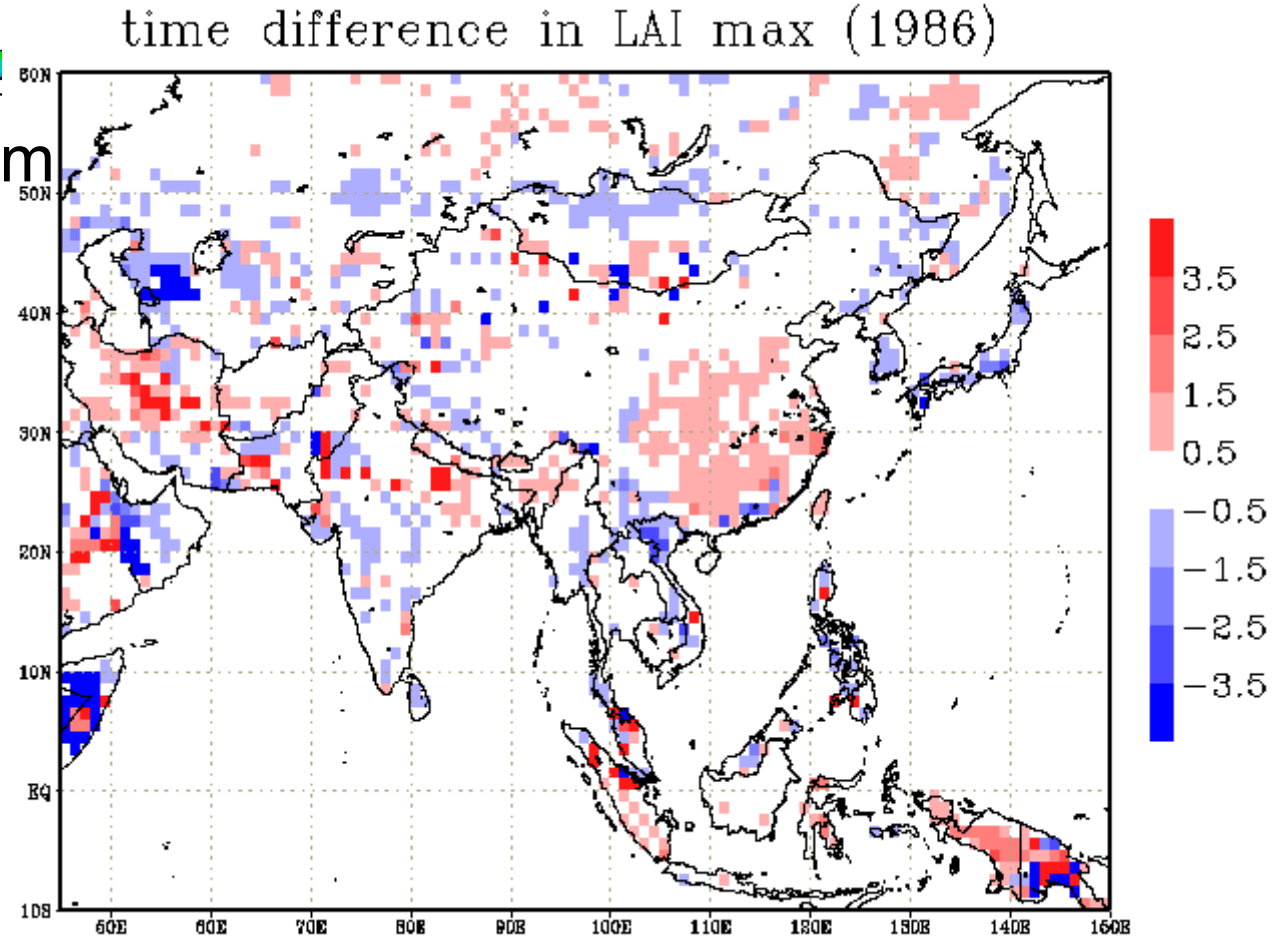


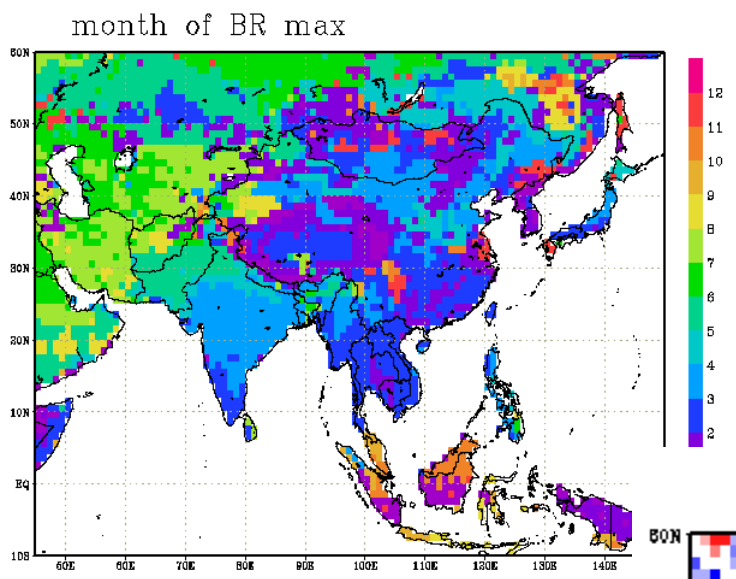
How vegetation is affected from Monsoon variation?
How Monsoon is affected from vegetation dynamics?



Month of LAI maximum

Deviation of LAI-max month





Month of BR maximum

Deviation of BR-max month