

衛星観測から見た 大気－陸面相互作用

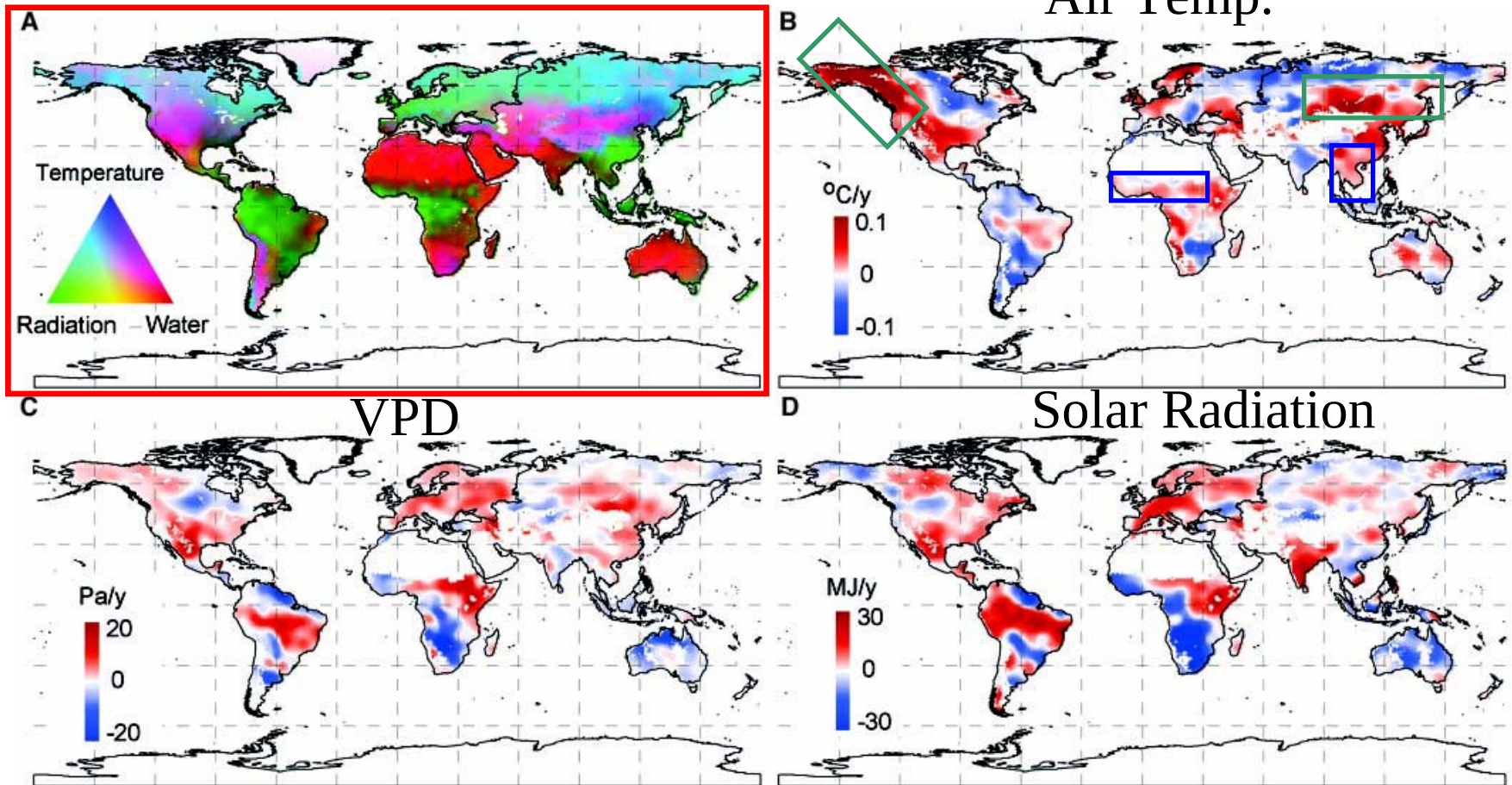
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研究センター

第二回沼口敦さん記念シンポ「水循環環境科学のアプローチ」,
セッション2: 大気から陸面, 陸面から大気へのインパクト,
3/29-30, 2006; 東大生産研

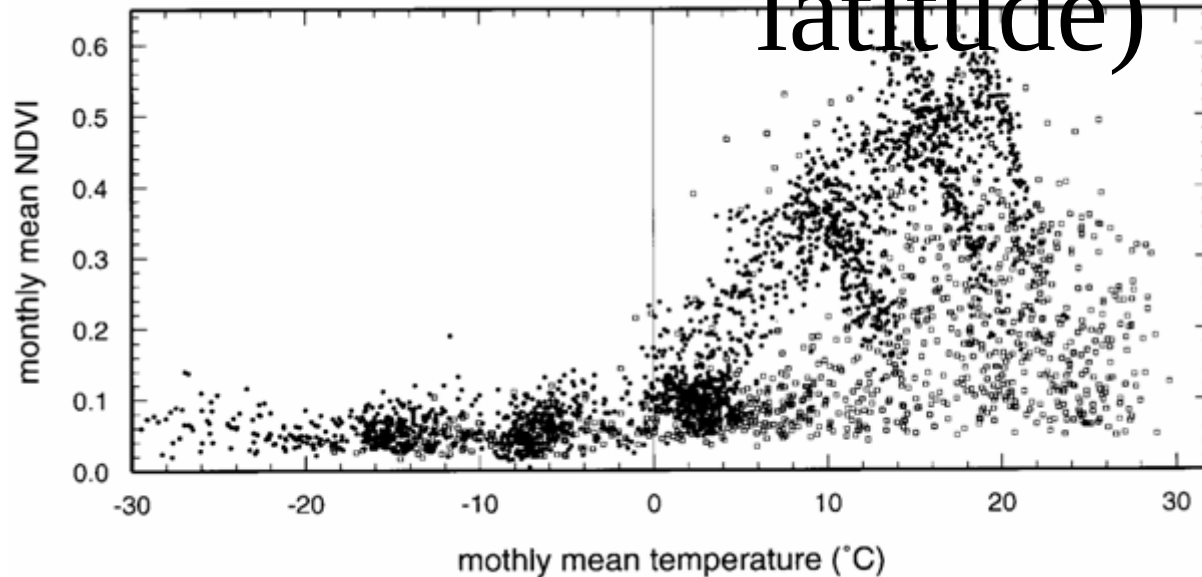


Nemani et al., 2003, Science



陸面過程(ここでは単純に植生と考える)に影響を与える要素
温度(energy)・水(利用可能な水, 土壤水分, 灌漑)・日射(PAR)

Temperature dependent (high latitude)

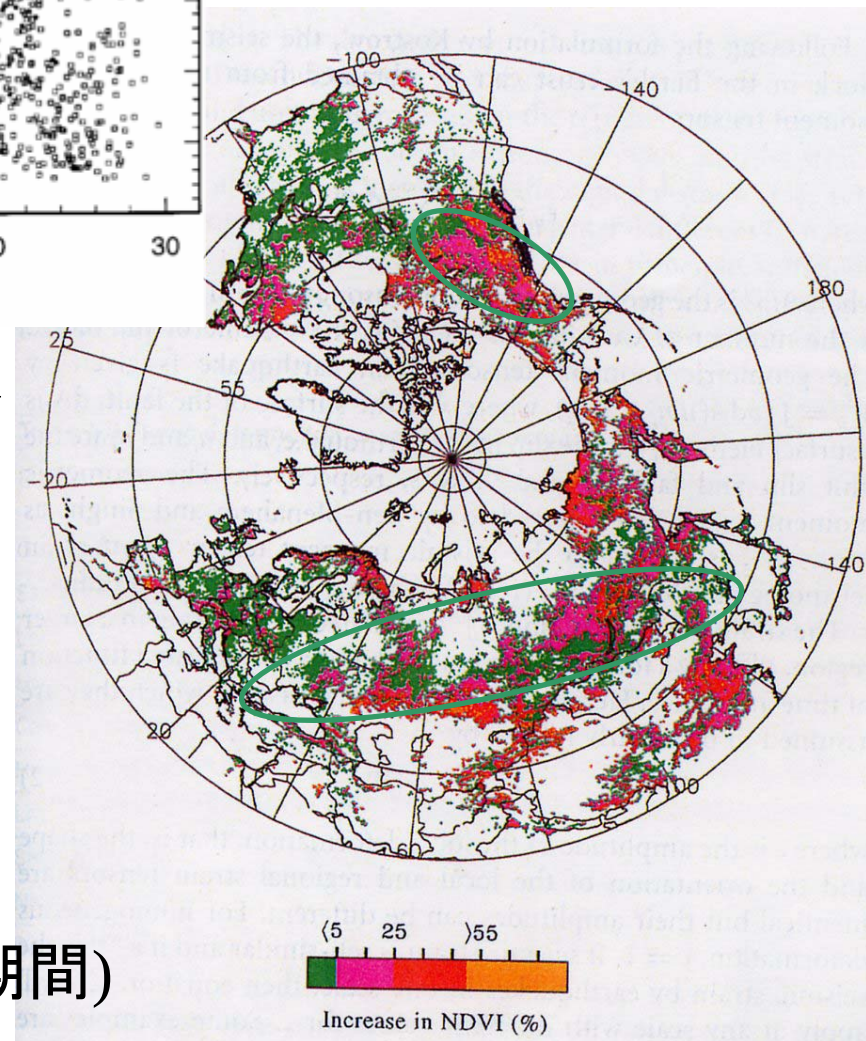


Suzuki et al., 2000, Int. J. Climatology
(over Siberia)

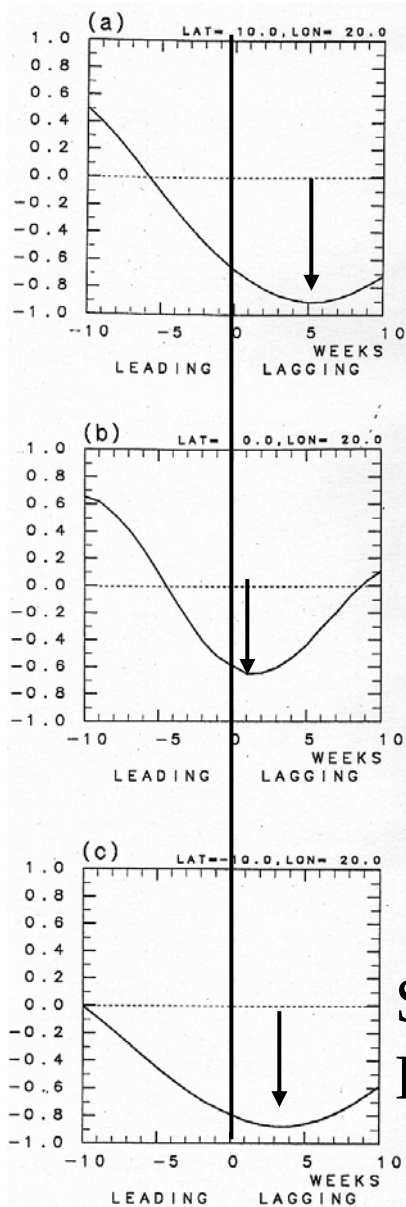
→ NDVI(植生)の温度依存性

Myneni et al., 1997, Nature →
Increasing GSL over zonal 60 N
due to warming in spring

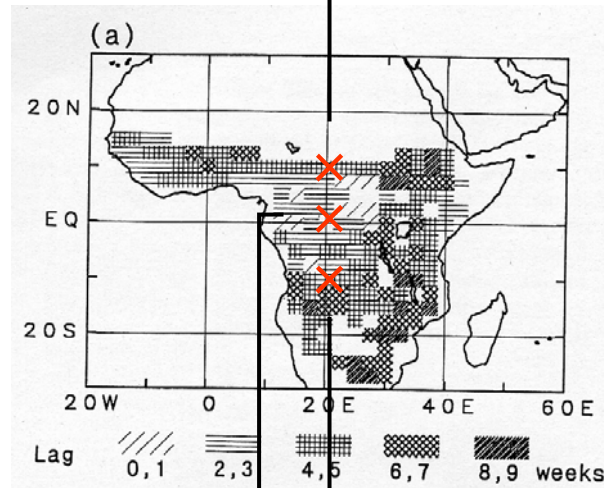
GSL: Growing Season Length (生育期間)



Water dependent (arid & semi-arid)

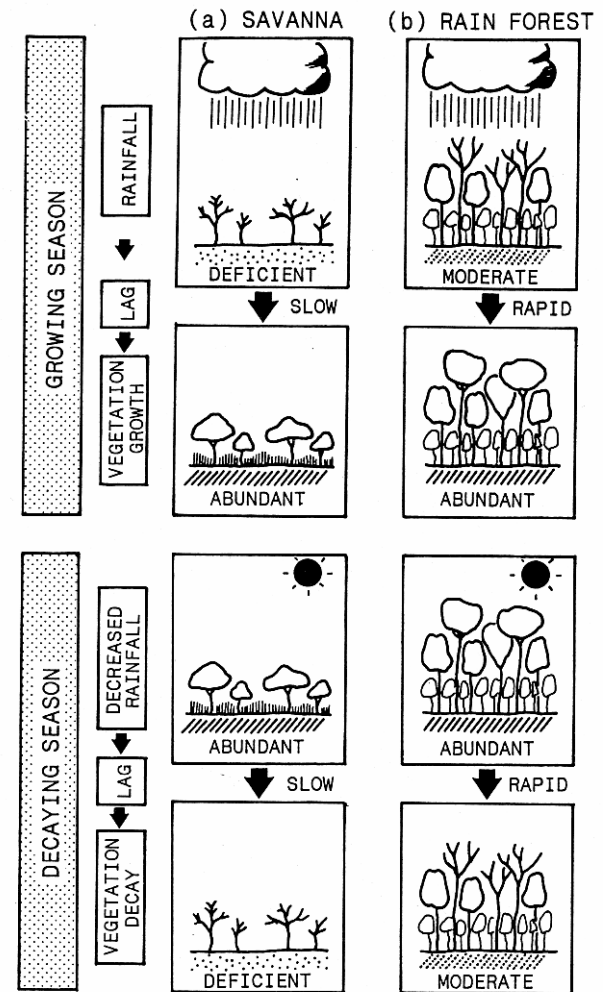


Savanna
Lat. 10N



Rain Forest
EQ

Savanna
Lat. 10S



Shinoda, 1995

Int. J. Climatology

Lag analysis OLR vs NDVI

Over Sahel with surface temperature (Ts)

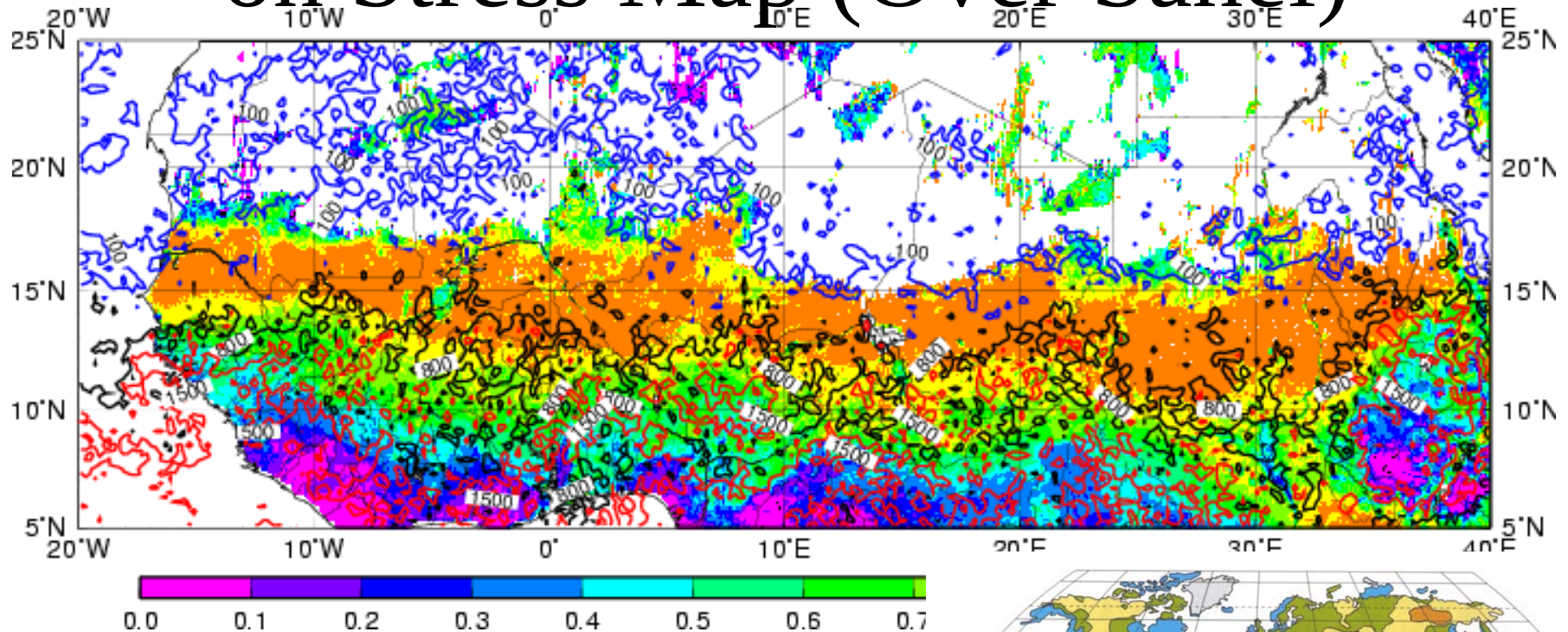
- **PAL** (pathfinder AVHRR land): Original dataset period was: 1981-2001, *but to avoid the systematic trend due to sensors changes, use: 1995-1999 (5 years, NOAA-14). NDVI, ch.4 & 5 (thermal-IR) used. Surface temperature (Ts) was estimated by Price's classical split window.

– **Ts stress index** (defined here):

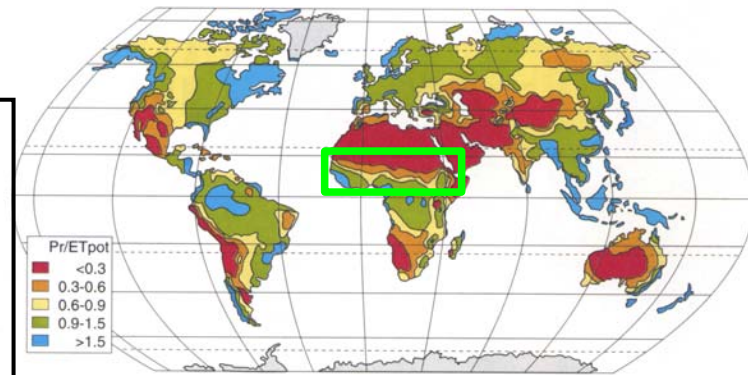
$$\text{Ts stress index} = \frac{\text{NDVI} > 0.1 \text{ (vegetated or not) \& } Ts > 35 \text{ degC* (heat stessed)}}{\text{NDVI} > 0.1 \text{ (vegetated or not) \& } Ts > 5 \text{ degC* (Kira's warm index)}}$$

*35 degC in Ts is threshold to classify forest or grass/crops
(Nemani and Running, 1997)

Overlay TRMM-PRrainfall (contour) on Stress Map (Over Sahel)

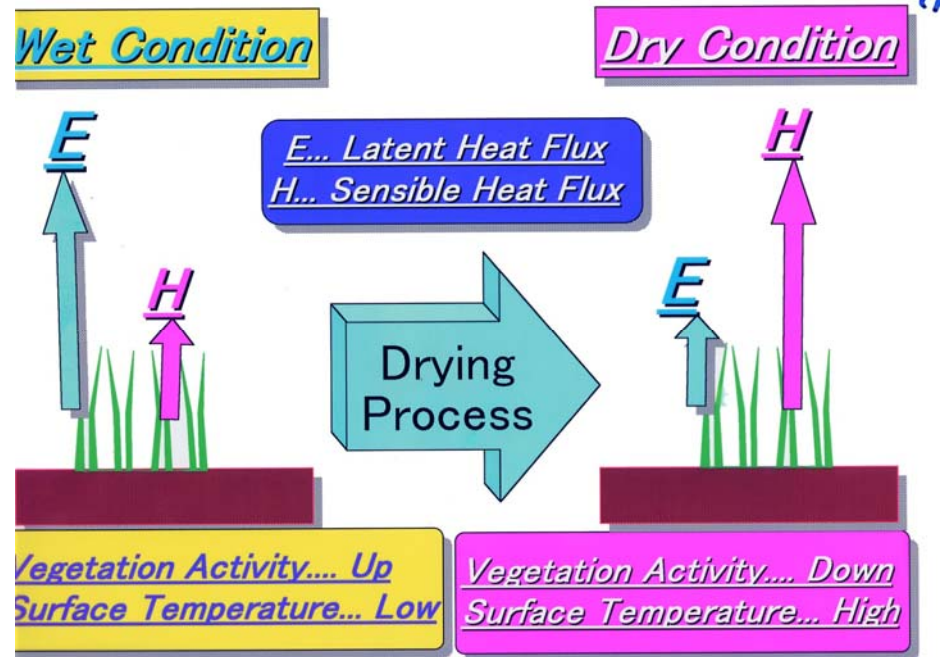
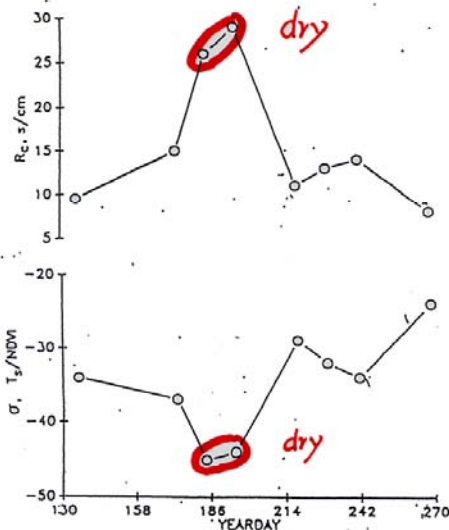
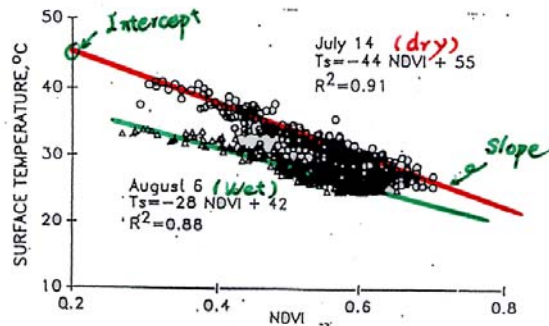


- 100mm/year is the boarder of desert or savanna
- 800mm/year is the boarder of vegetation “always” stressed or not
- 1500 mm/year is maybe forest or not



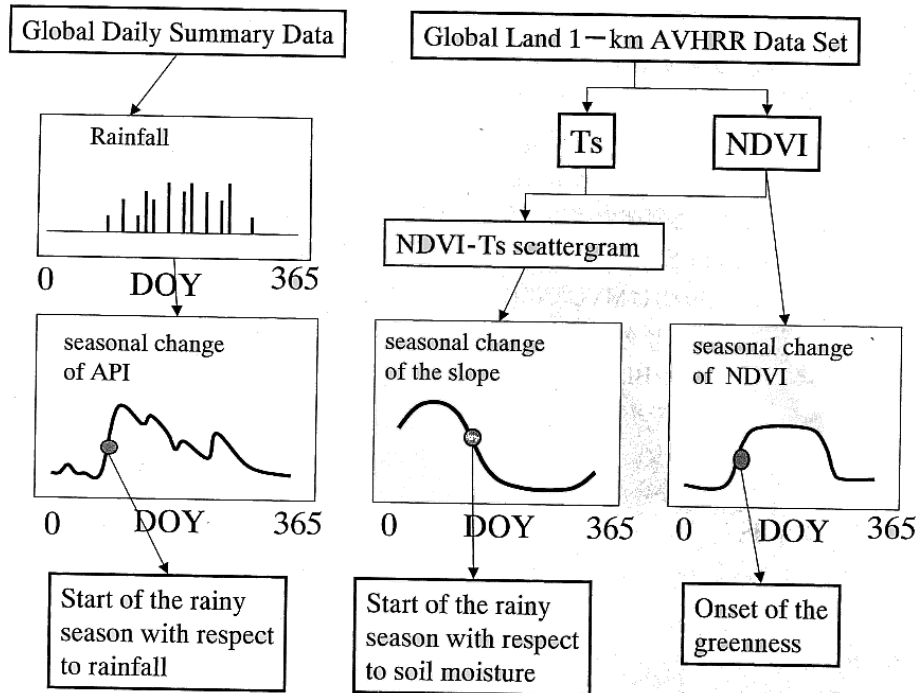
Color chart IVb (cf. page 401): Dry regions and regions with precipitation surplus on earth. The classification is based on the ratio of annual precipitation and potential regional evapotranspiration (Pr/ET_{pot}). Arid climate below 0.3; semiarid climate 0.3–0.6; subhumid climate 0.6–0.9; humid climate 0.9–1.5; perhumid climate above 1.5. (After UNESCO 1979; Box and Meentemeyer 1991). For insights on aridity indices based on meteorological information, see Thornthwaite (1948); Grigorjev and Budyko (1956); Lauer et al. (1996)

Through surface moisture status (SMS; as proxy of soil moisture)

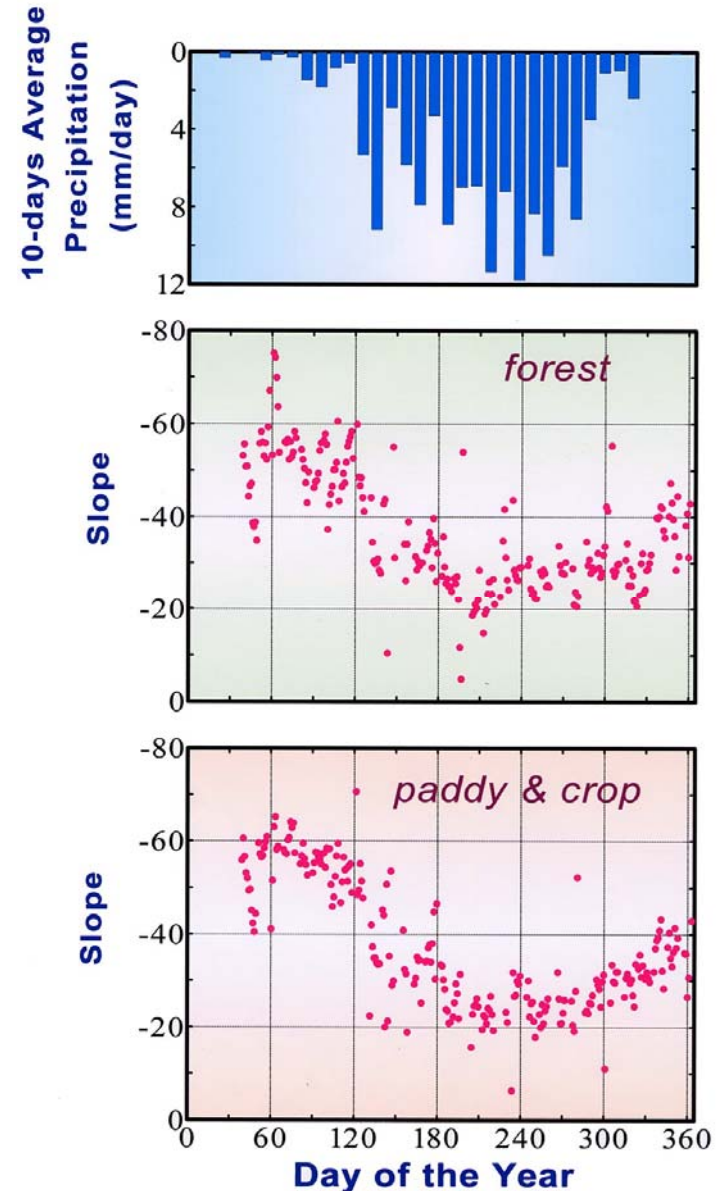


Combination usage of vegetation index & surface temperature (TVX)

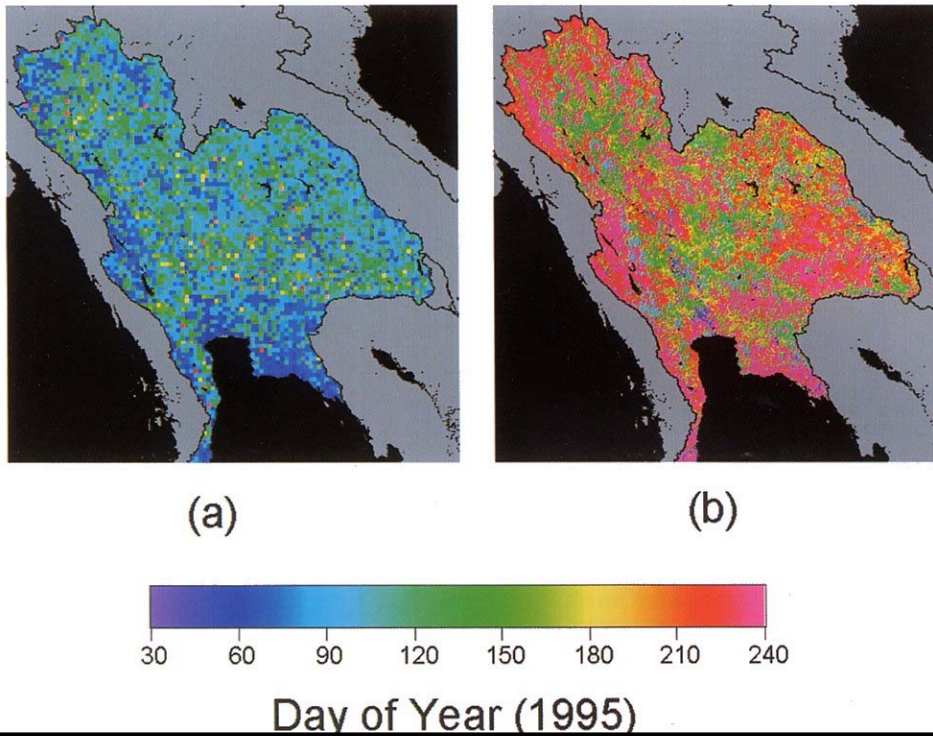
Application TVX over Thailand



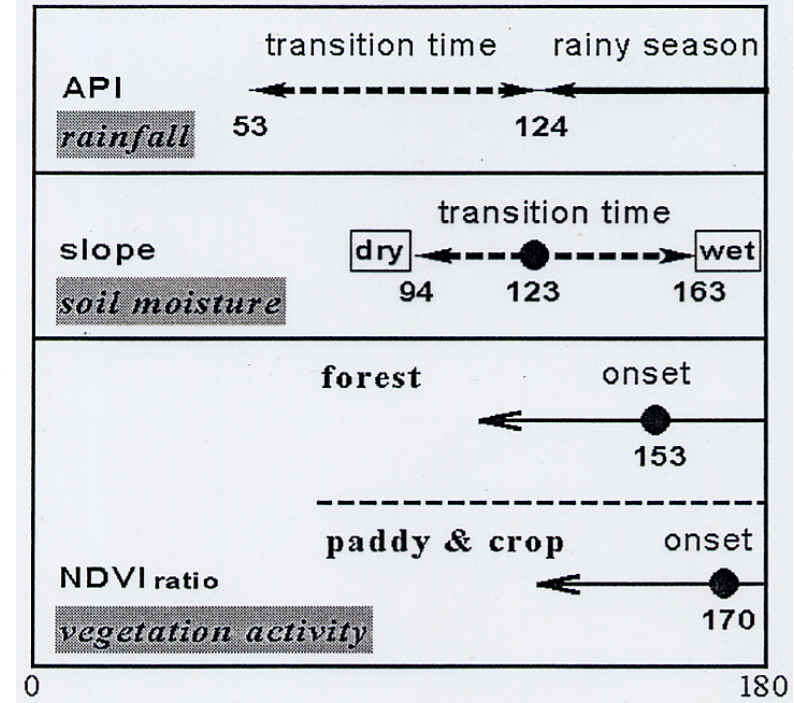
Flow chart of analysis



Apply TVX over Thailand [2]



(a) A date from “dry” to “wet” by TVX
(b) A date “onset” of vegetation

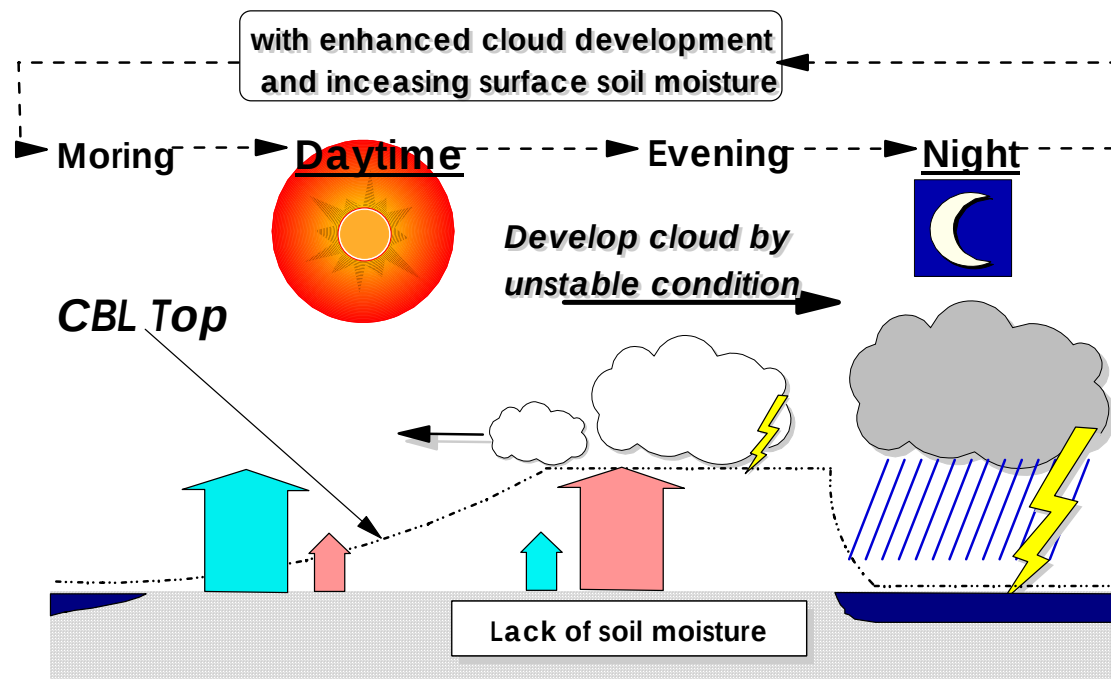


Date of changing land condition changing (rain, TVX, NDVI)

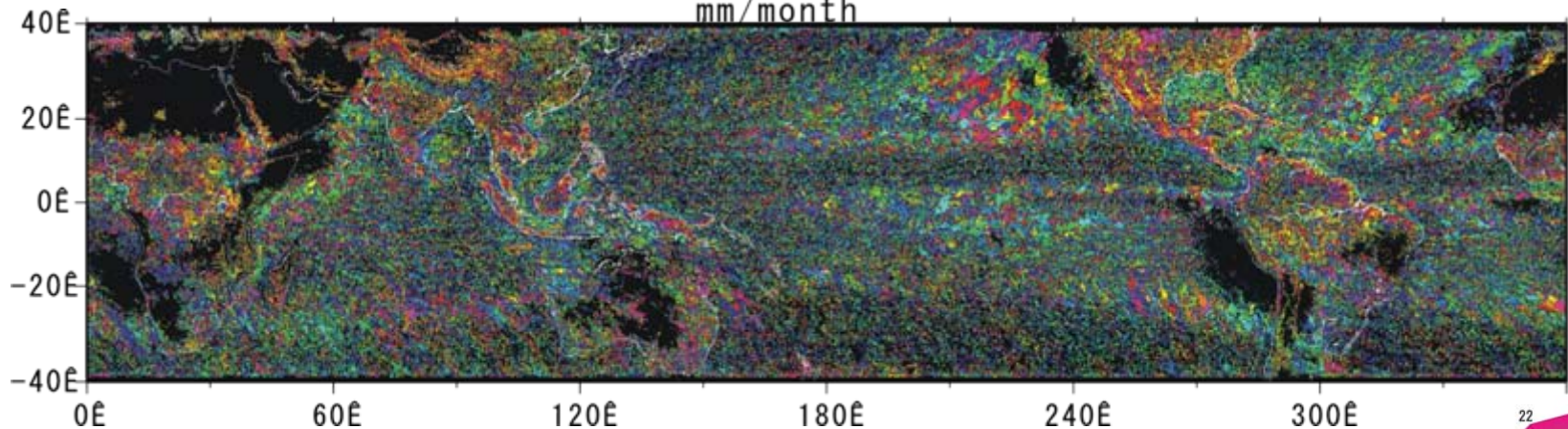
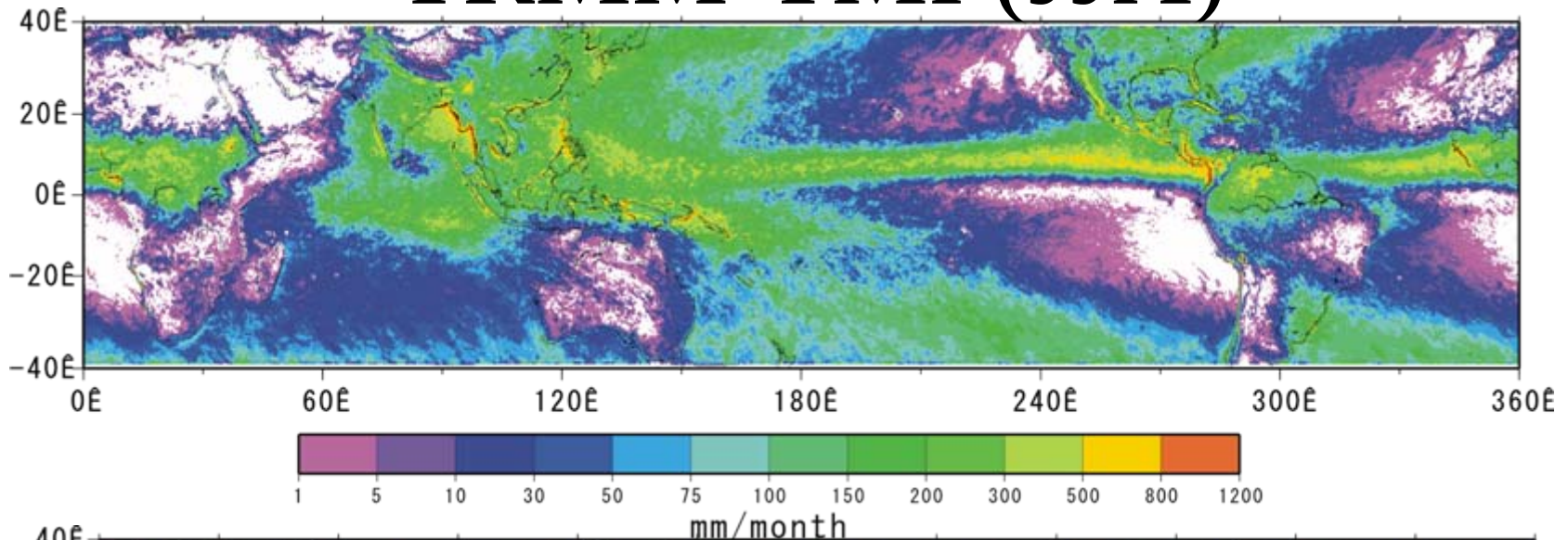
雨季の開始 → SMS 変化(湿潤化; 土地利用に無関係)
→ 植生の出芽, 植え付け(土地利用・土地被覆に綿密に関係)

Radiation dependent (Tropics)

- 日射量(PAR)が効く？
 - 日周期が強化されると植生活動も活発化か？
 - Nemani et al., 2003 Science, Hashimoto et al., 2004 JGRでの(アマゾンでのNPP増加の原因)主張は↑.
- 日周期や降水に関してはTRMM が計測(1998～)



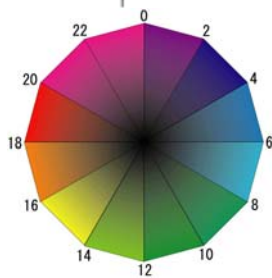
TRMM-TMI (JJA)



Nakamura, 2005, GEWEX News (modified)

陸地で色が付く → 日周期成分が多い

→ PRは鉛直プロファイルも直接計測できる



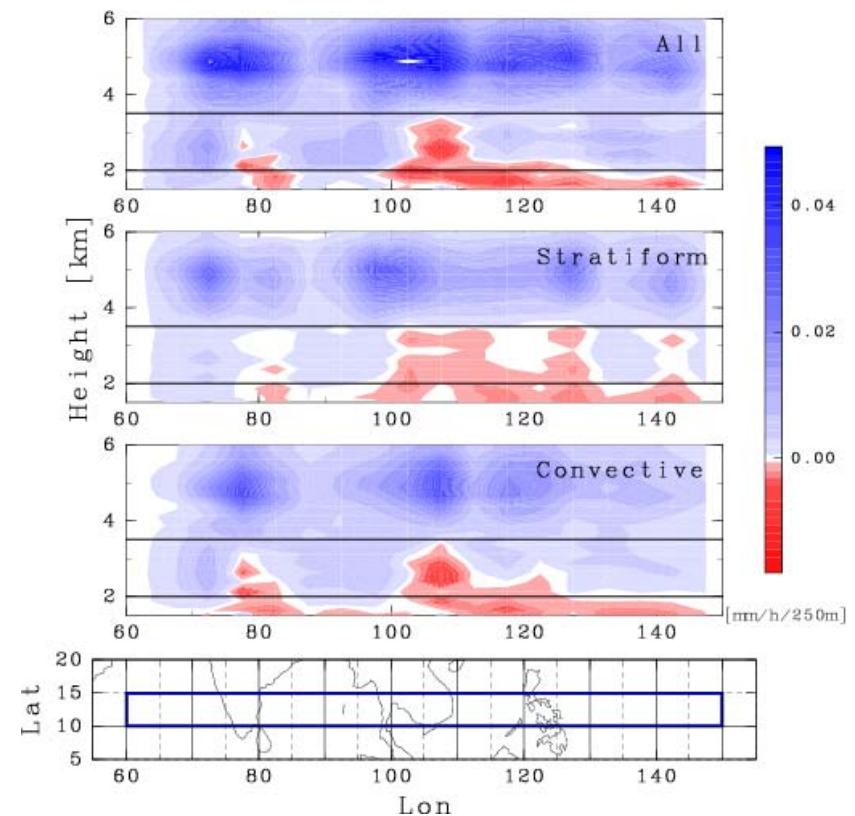
$$IVG = \frac{\Delta R}{\Delta Z} = \frac{R_{2\text{ km}} - R_{3.5\text{ km}}}{1.5\text{ km}}$$

2km: Sampling number,
statistical problems at low level

3.5km: echo peak concentration
To avoid the trace of BB

Downward Decreasing DD
IVG < 0

Downward Increasing DI
IVG > 0



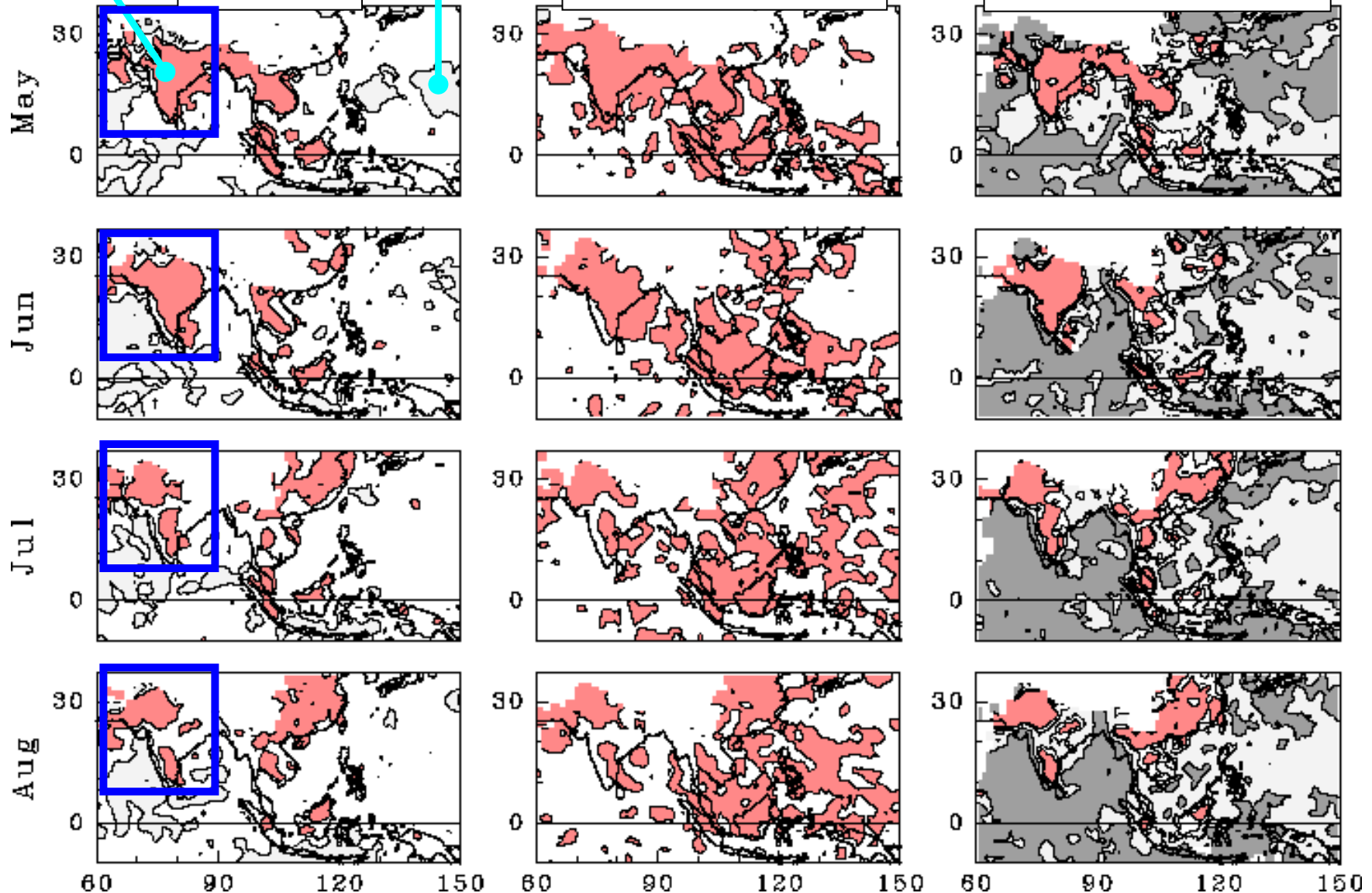
DD

DI

All rain

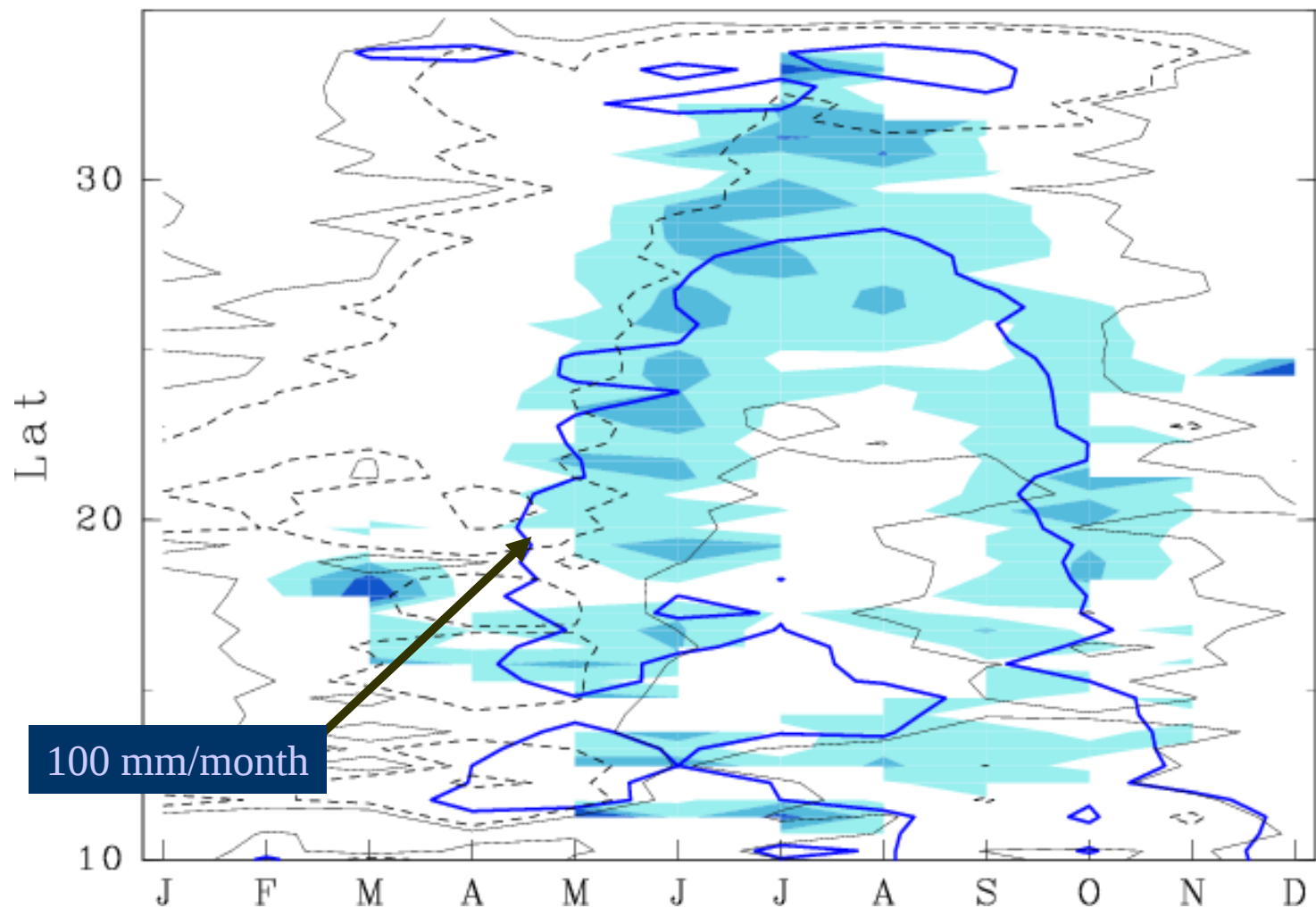
Stratiform rain

Convective rain



Frequency of DD occurrence for convective rain over India

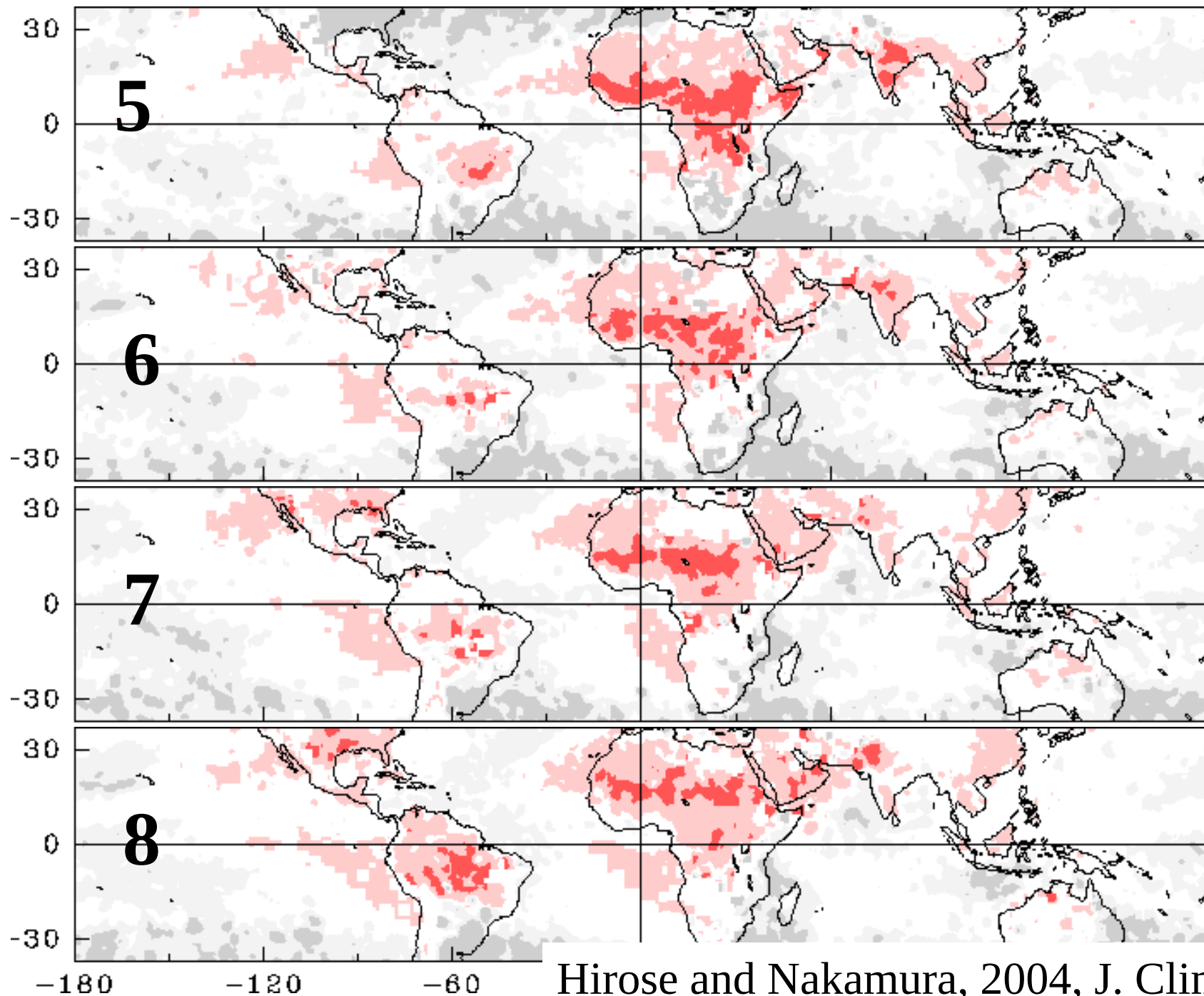
$$\text{Nos_DD/Nos_rain} \times 100 \quad [\%]$$



Latitudinal time-section illustrating the relationship between maximum total rainfall (100 mm/month, thick line), strong conditional rainfall rate (5 and 3 mm/h, dashed and thin line) and clear DD occurrence (IVG<-0.5, light (>20%) and dark (>40%) shadings) over India.

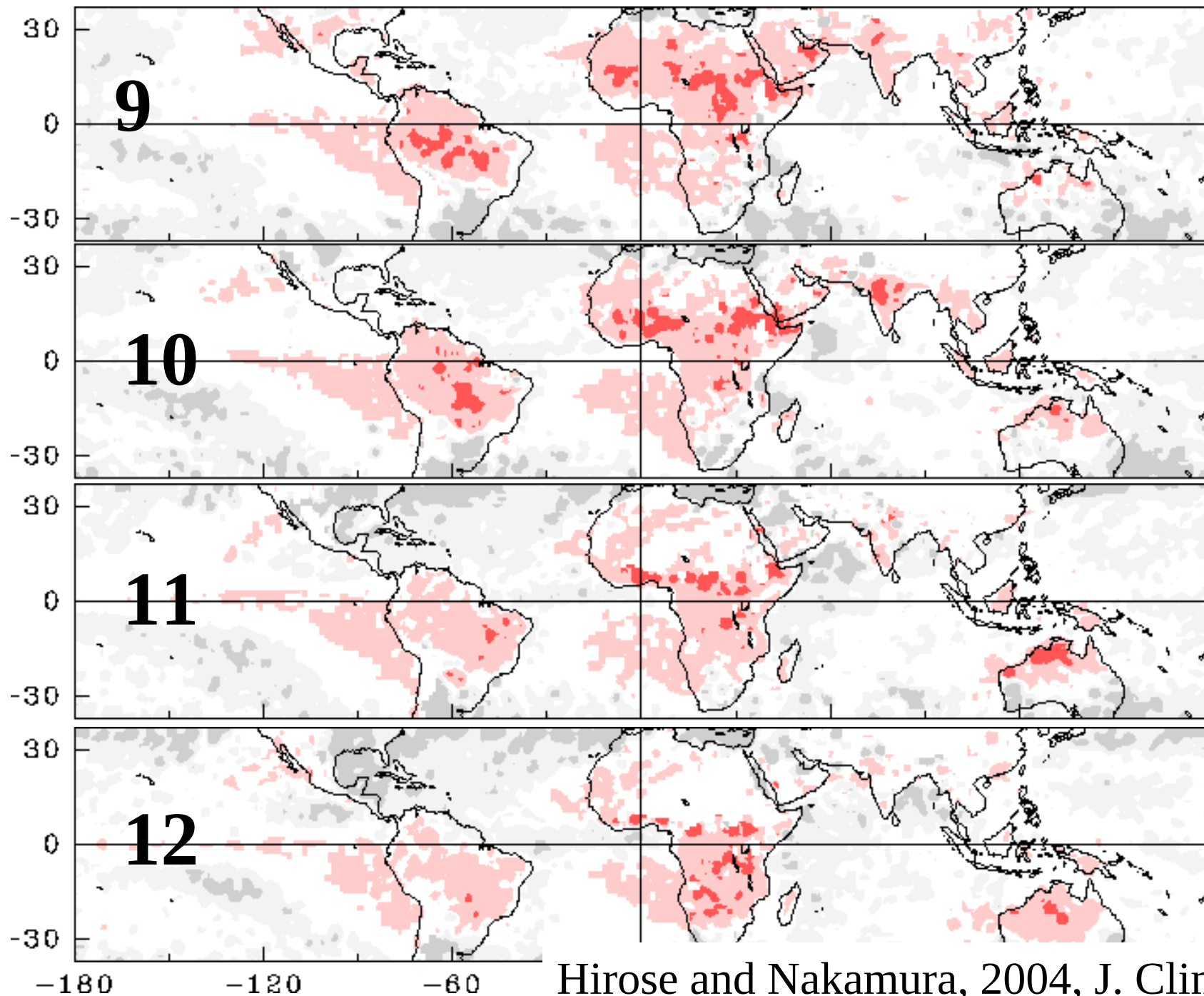
Hirose and Nakamura, 2002, J. Climate

IVG map during 1998-2000 (red: DD)



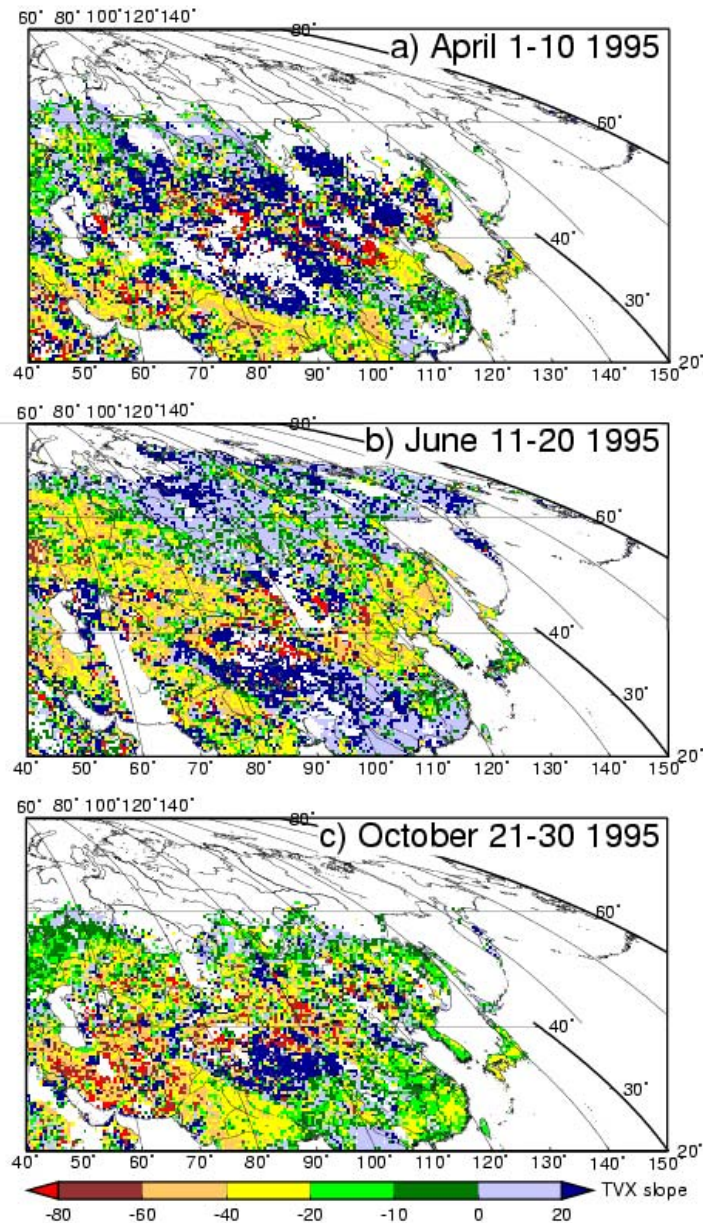
Hirose and Nakamura, 2004, J. Climate

IVG map during 1998-2000 (red: DD)

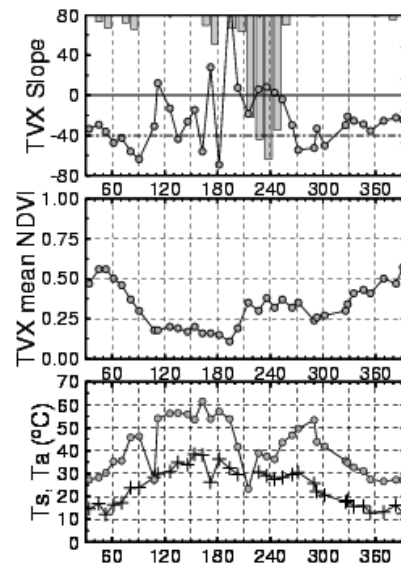


Hirose and Nakamura, 2004, J. Climate

TVX response over monsoon Asia (Higuchi et al., 2006 Hydrol. Process)

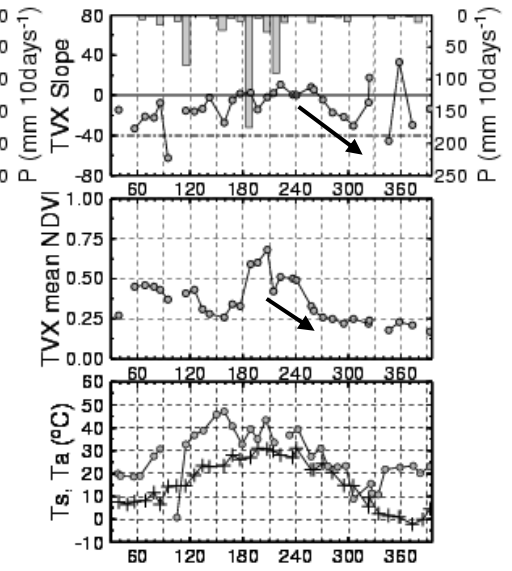


a) Delhi (India, Tropic)



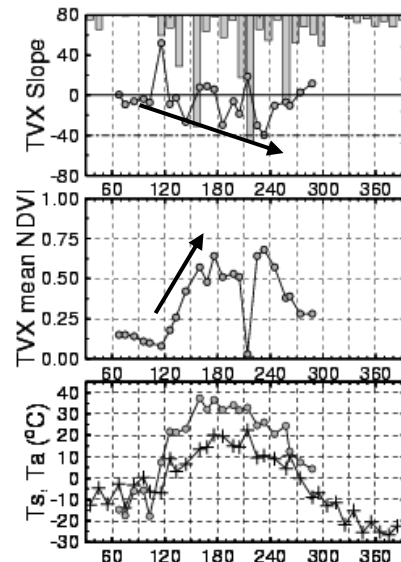
Day of Year (Feb 1995 - Jan 1996)

b) Shouxian (China, Temperate)



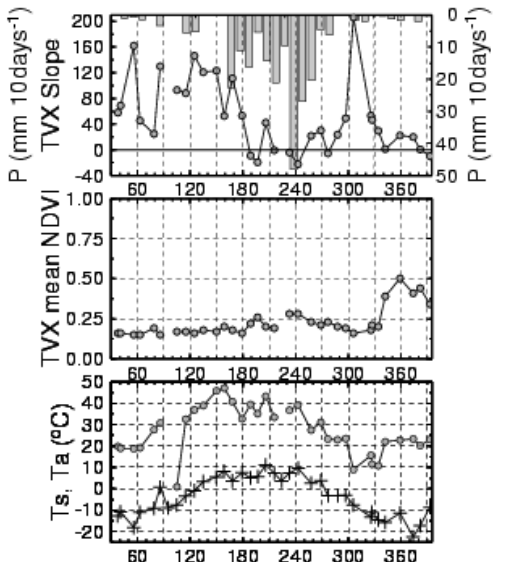
Day of Year (Feb 1995 - Jan 1996)

c) Yakutsk (Russia, East Siberia)



Day of Year (Feb 1995 - Jan 1996)

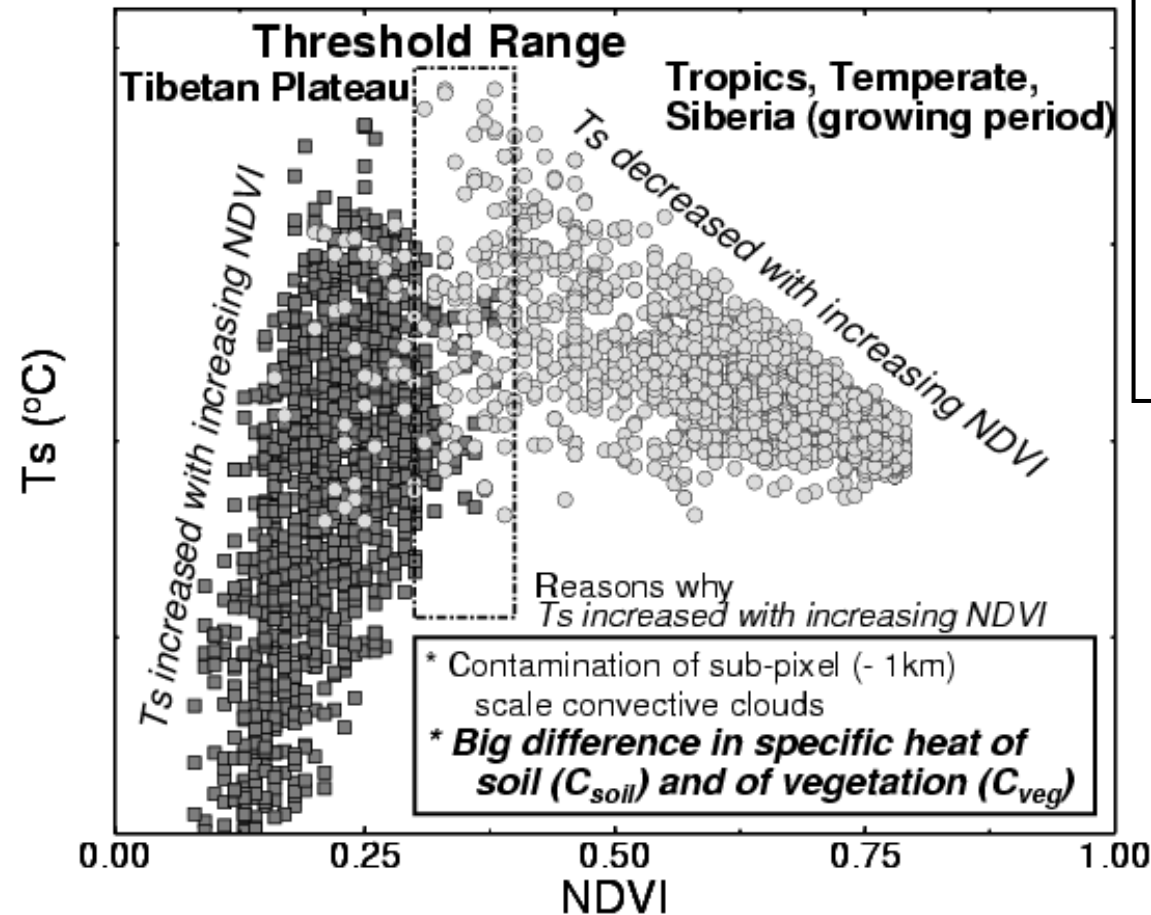
d) Toutouhe (China, Tibetan Plateau)



Day of Year (Feb 1995 - Jan 1996)

+ + + Air temperature (Station) — — — TVX mean surface temperature (AVHRR)

Regional response difference via NDVI-Ts space

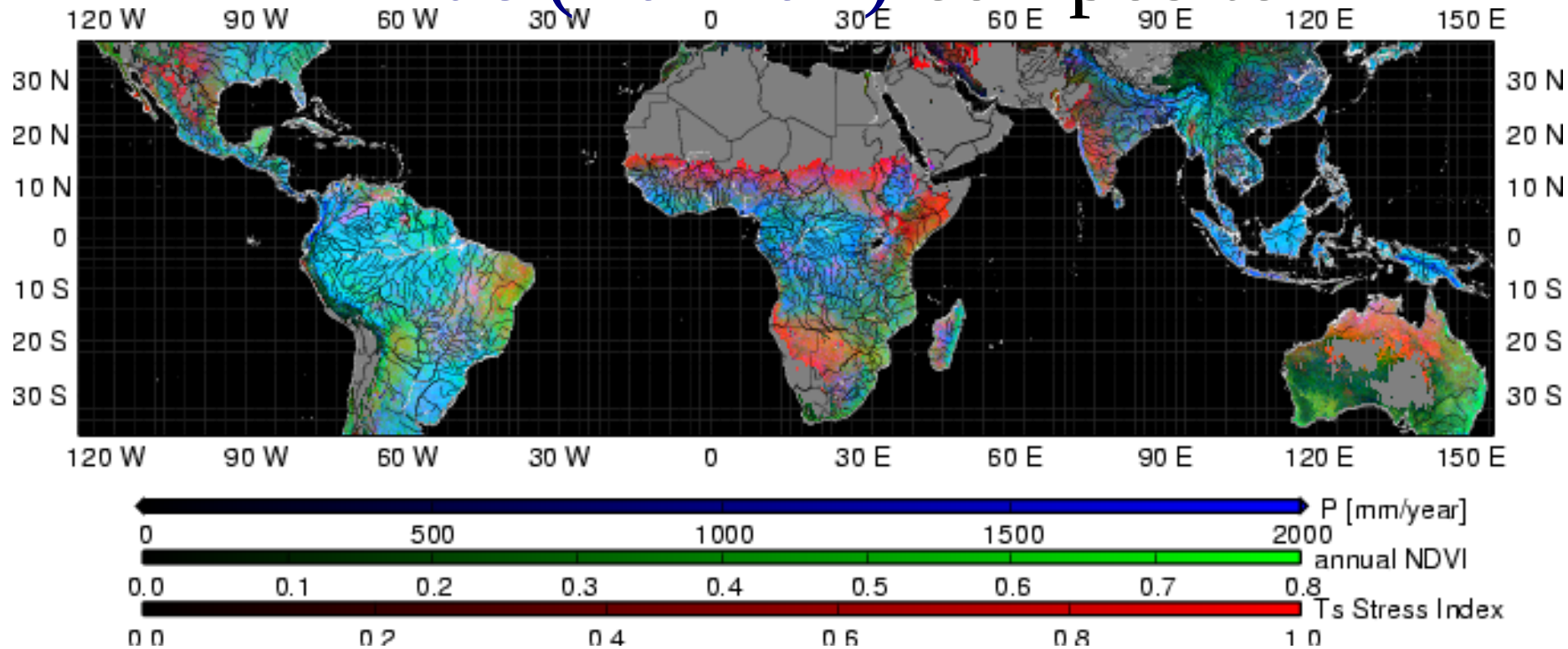


- チベット高原の応答特性
 - Ts up & NDVI up
 - 比熱の違い？
 - 一律の解釈では説明不可

↓

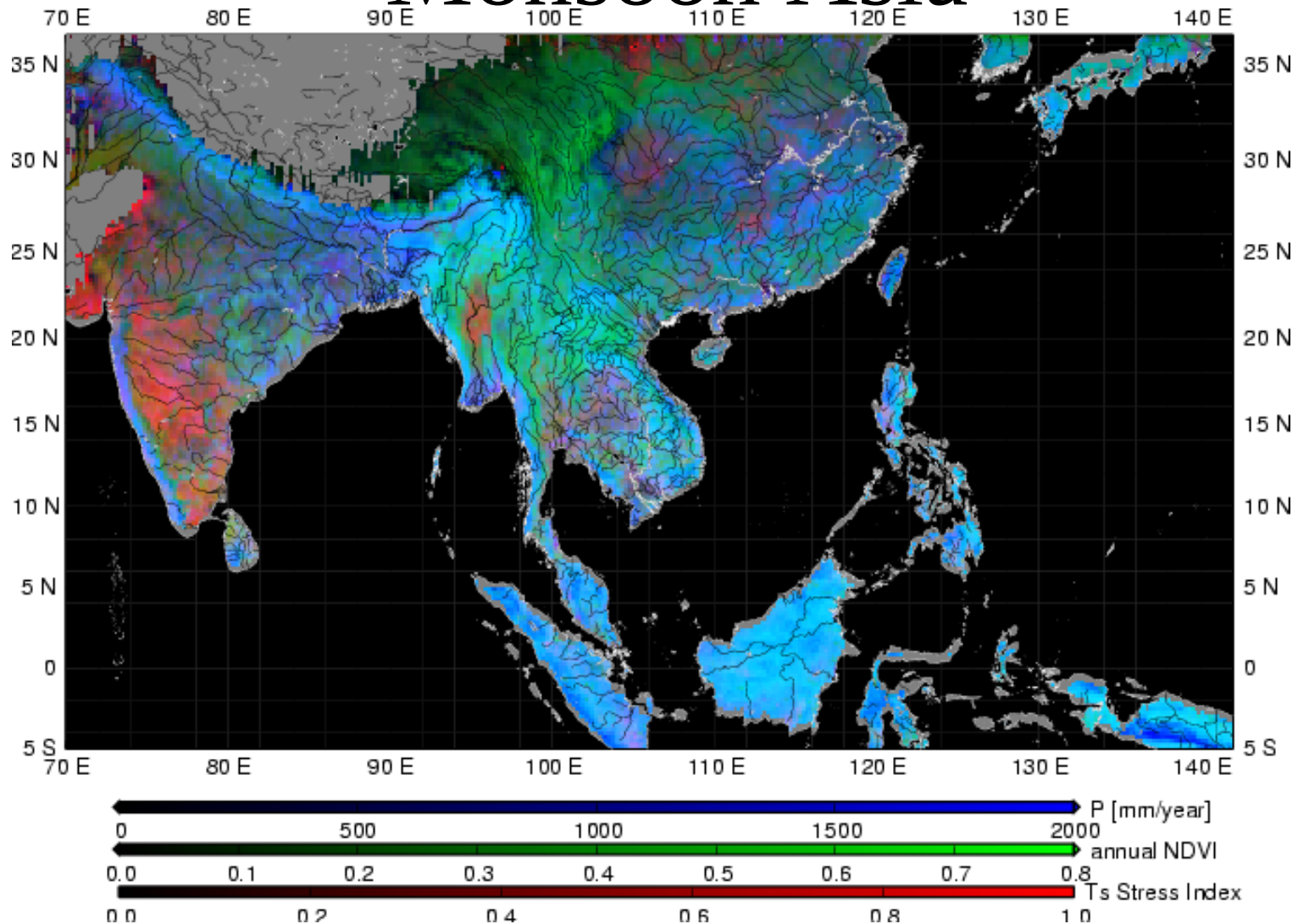
地域応答特性把握
のための衛星計測
(その中の一般性,
普遍性の探究)

Red (Stress Index) – Green (annual NDVI) – Blue (Rainfall) composite



見方: 十分な降水量(+blue) + で植生が活発(+green) + で熱ストレスは無い(-red)
= 青 or light blue → 熱帯雨林や地形性降雨で雨が落とされる地域(山岳域)
逆に: 雨が降らず(-blue) + 植物も育ちににくく(-green) + 育っても常に熱ストレス(+red)
= 赤 or 紫 (青 + 赤) → サバンナ(サヘル)・半乾燥域, 紫は都市域, 森林伐採域
緑は温帯で見られる(温度依存性. 気温の四季がハッキリしているところ)

(cont.) RGB composite over Monsoon Asia



最後に

- 衛星データの持つアドバンテージとして...
 - 地域性と一般性の両方を議論できうる可能性がある.
 - 複数の衛星データ(プロダクト, アルゴリズム)を組み合わせてることにより, より面的な相互作用が浮き彫りになる.
- これらのアドバンテージを最大限享受するためには...
 - 粛々と(回りも巻き込んで)アーカイブ, よってたかって処理をするという集団形成が必要.
 - 平均場と“空間分散”的な場を衛星データで生成させて時空間不均質を表現させる努力(モデルとのコラボ)