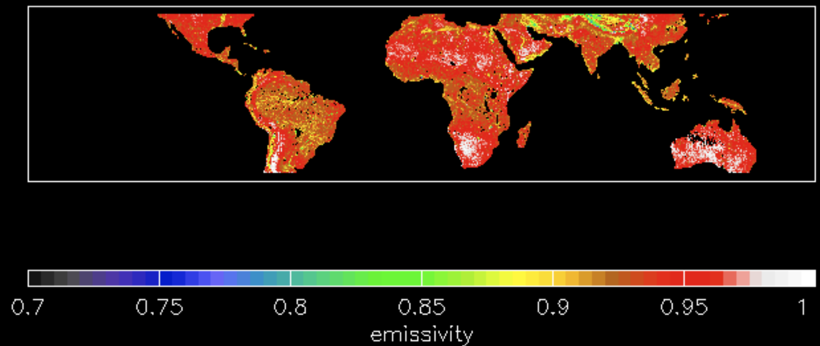
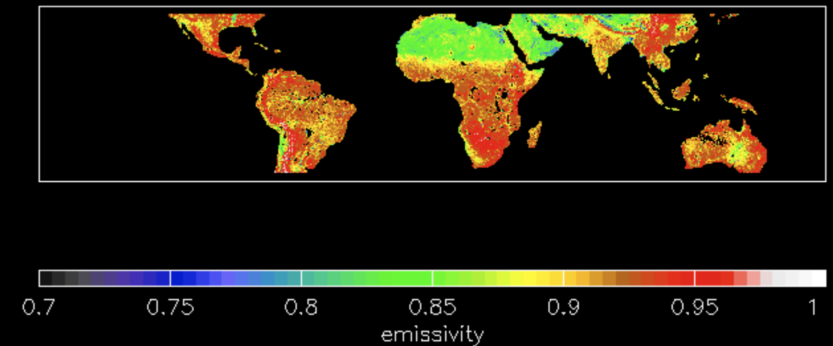
1998 Seasonal variation 37 GHz V and H




# Land Emissivity Map obtained from TRMM PR, TMI and JRA-25 data

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20090611 12 : 05-12 : 20 ( 15 min. )
Session 5: Monitoring Land Surface (ex. Heat Fluxes, Rain)
2nd Workshop on Remote Sensing and Modeling of Surface Properties, Toulouse, June 2009

## Project : one of GPM/JAXA projects

「 Examination and trial product of DPR/GMI rain retrieval combined algorithm 」

Objectives of the project

- Rain estimate from combined utilization of GPM core satellite sensors; DPR and GMI
- Contribution for improvement of rain estimate from constellation satellites

## Importance of land rain retrieval algorithm for GPM microwave radiometers

- Observation region extends to high latitude and wide land area is covered & observation sampling is frequently done by microwave radiometers launched with constellation satellites→ contribution for hydrology or preventing of natural hazard, etc will be expected.

Therefore, reliable land rain products must be provided

# Objective

- For rain estimation from passive microwave radiometer
  - ocean: emission of low freq. 10,19GHz is used.
  - land : scattering of high freq. 37,85GHz is used.

    ∵ land emission >> rain emission &

    large variation of land emissivity
  - Assuming that land emissivity is constant, the case which f ts with scatting signal from the look up table made from cloud resolving model

    ← objective-1 : assumed emissivity check
- Objective-2 : rain estimation from brightness temperature of all frequencies by using characteristics of variation of land emissivity.
- Therefore, development of ε estimation is necessary. I investigated spatial/time variation of ε and will try to estimate rain rate by using

# Data for $\varepsilon$ estimation
# TRMM Satellite data

- PR (2A23V6) rain identif cation
- TMI (1B11V6) brightness temperature TB (10GV/H, 19GH/V ,21GV, 37GV/H, 85GV/H)
- TMI (2A12V6) land def nition

# JRA-25 data (JMA reanalysis data)

- 6 hourly data (00,06,12,18 Z)
- geopotential height, air temperature, specif c humidity, cloud water content at each altitude : 23 levels (1000-0.4h Pa) (1.25 deg-resolution) are selected from ±3hrs.
- Ground temperature (1.125 deg-resolution) (if no, surface 2 m air temperature) is estimated by f tting during ±9hrs.
- Lfegtopo (1.125 deg-resolution)

# Estimation of ε

a. When all data within one grid show PR(2A23) rain flag of "no-rain" / "no-rain+possible", and TMI (2A12) indicates "over land", the map of instantaneous TMI(1B11) 0.2 deg x 0.2 deg brightness temperature $T_B$ is made for each local time and for each frequency(5freq.9ch). (← advantage: use of PR rain identification)

a. Absorption coefficient (cloud water, water vapor, O2) and optical depth τ for above PR-no-rain land pixel are calculated from JRA-25 data within ±3 hrs, assuming that no cloud ice exists.

   a. Ground temperature is calculated from three JRA-25 data within ±9 hrs by fitting with quadratic function.

   b. Step function of altitude assumed for calculation

# Estimation of ε

Used equation (Prigent et al. 2006, etc.)

$$\tau(z_0, z_1) = \int_{z_0}^{z_1} \alpha(z) dz$$

$$T_{\mathrm{atm}}^{\downarrow} = \int_{H}^{0} T(z)[\alpha(z)/\mu] e^{-\tau(z,0)/\mu} dz + T_{\mathrm{cosm}} e^{-\tau(0,H)/\mu}$$

$$T_{\mathrm{atm}}^{\uparrow} = \int_{0}^{H} T(z)[\alpha(z)/\mu] e^{-\tau(z,H)/\mu} dz.$$

$$\varepsilon_p = \frac{\mathrm{Tb}_p - T_{\mathrm{atm}}^{\uparrow} - T_{\mathrm{atm}}^{\downarrow} e^{-\tau(0,H)/\mu}}{e^{-\tau(0,H)/\mu} (T_{\mathrm{surf}} - T_{\mathrm{atm}}^{\downarrow})}$$

(From integrated transfer equation for a nonscattering plane-parallel atmosphere over a f at surface)

Used values:
zenith angle:52.8(before boost), 53.4(after boost)
satellite altitude:350km(before boost), 402.5km (after boost)

# Estimation of ε

a. Emissivity is calculated from results of ① (TMI $T_B$) and ② (τ ,α ).

(1) Step function of altitude assumed for calculation of Tatm↑ and Tatm↓ is a linear function .

(2) Lfegtopo value (geopotential) divided by 9.80665 is used for surface altitude and calculation is done over the surface altitude.

↓

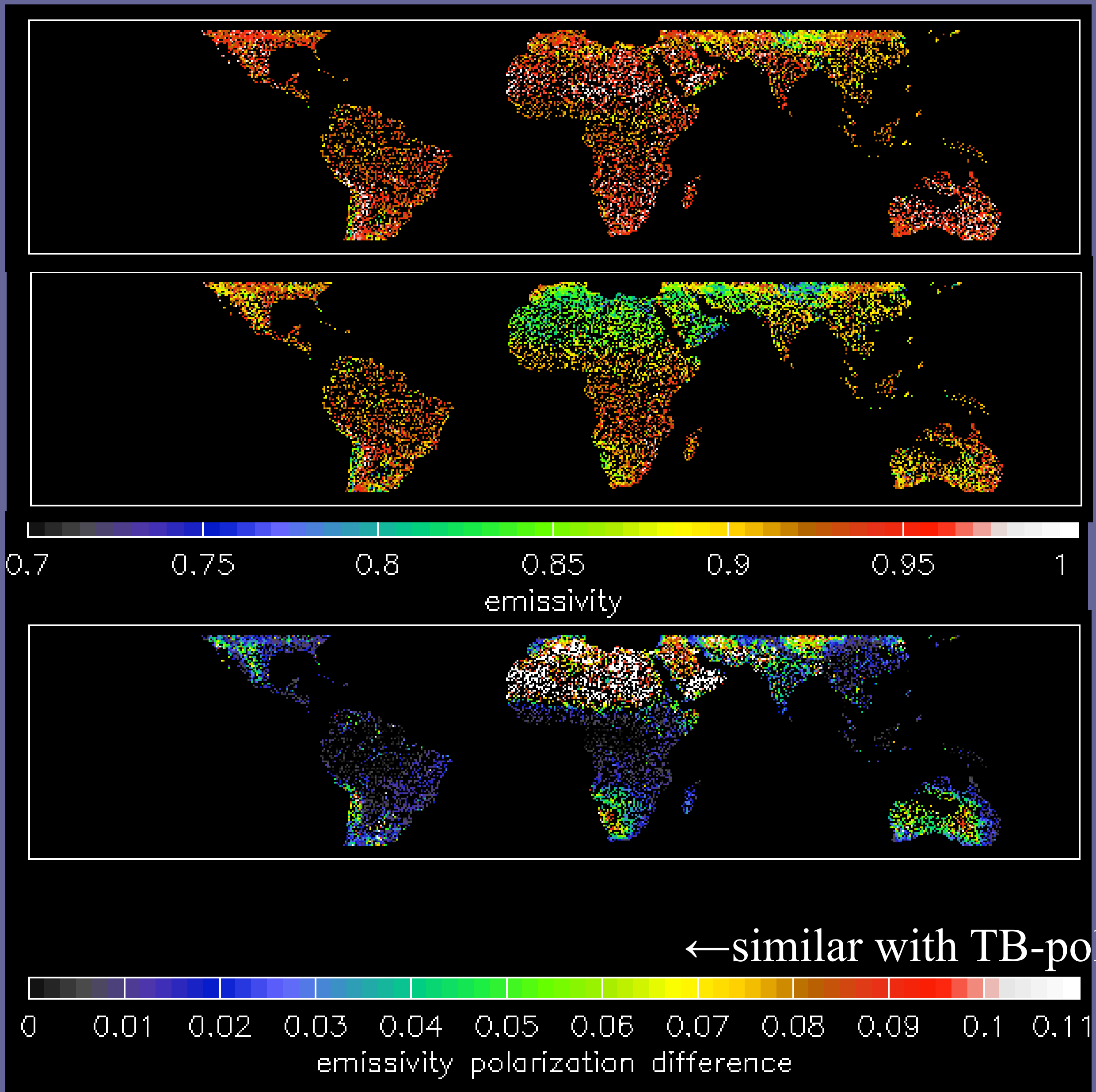
11yrs, 5freq./9ch, 0.2 deg x 0.2 deg instantaneous
emissivity map for each local time for each TRMM pass

↓

Monthly averaged emissivity map for each yrs and
11yrs averaged Monthly emissivity map

Results example

# 37GHz : 1998-June monthly ε



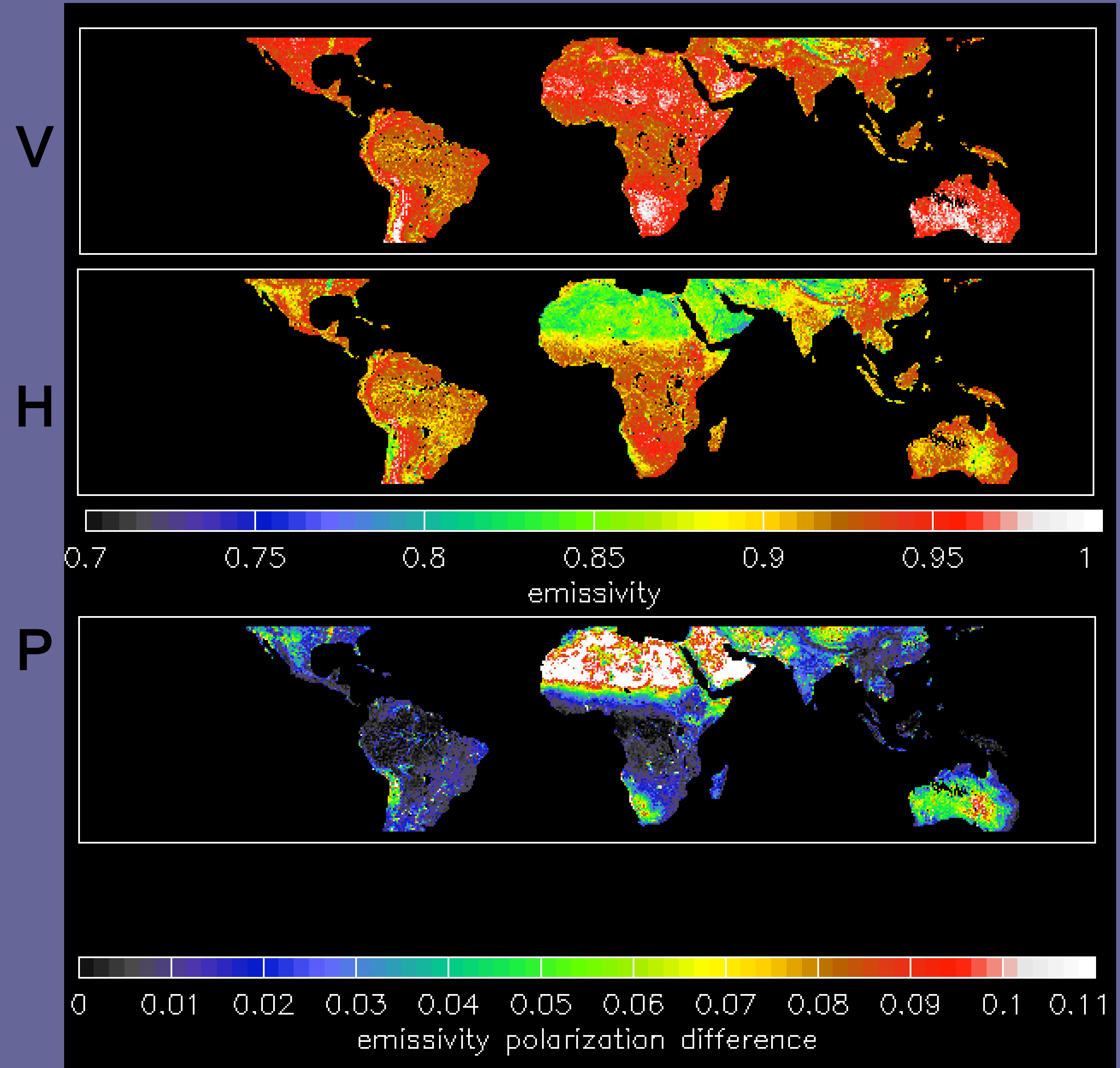

199806

0.2 deg x 0.2 deg

←similar with TB-polarization map .

Results example

# 37GHz : 12yrs Jan. monthly ε




**199801~ 200901**

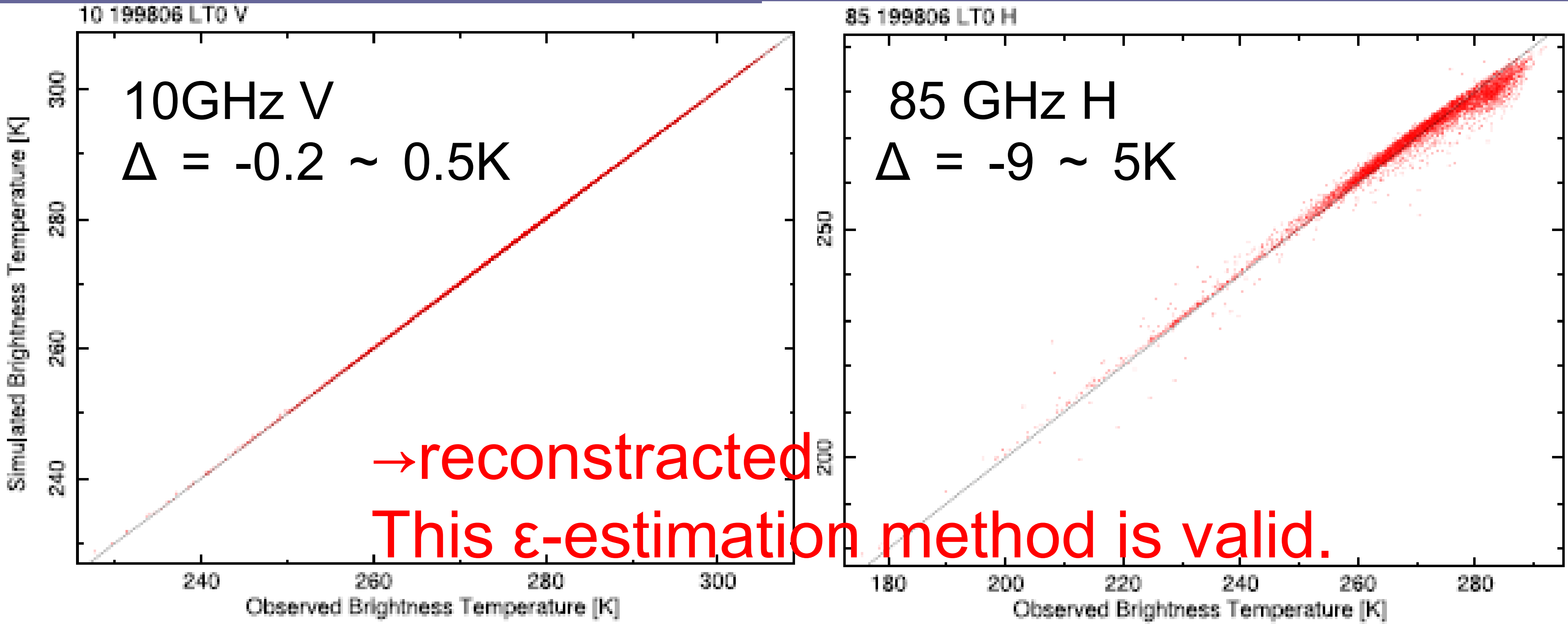
0.2 deg x 0.2 deg

# Check

# Simulation of TB

- RTM : Aonashi & Liu (2000) code
- Assuming that JRA25 air profile and cloud water content follows a 10-linear interpolated function and there is no ice cloud, TB is simulated from our land emissivity dataset.
- X axis is TRMM TMI 2A12 TB.

best case worst case 19980600

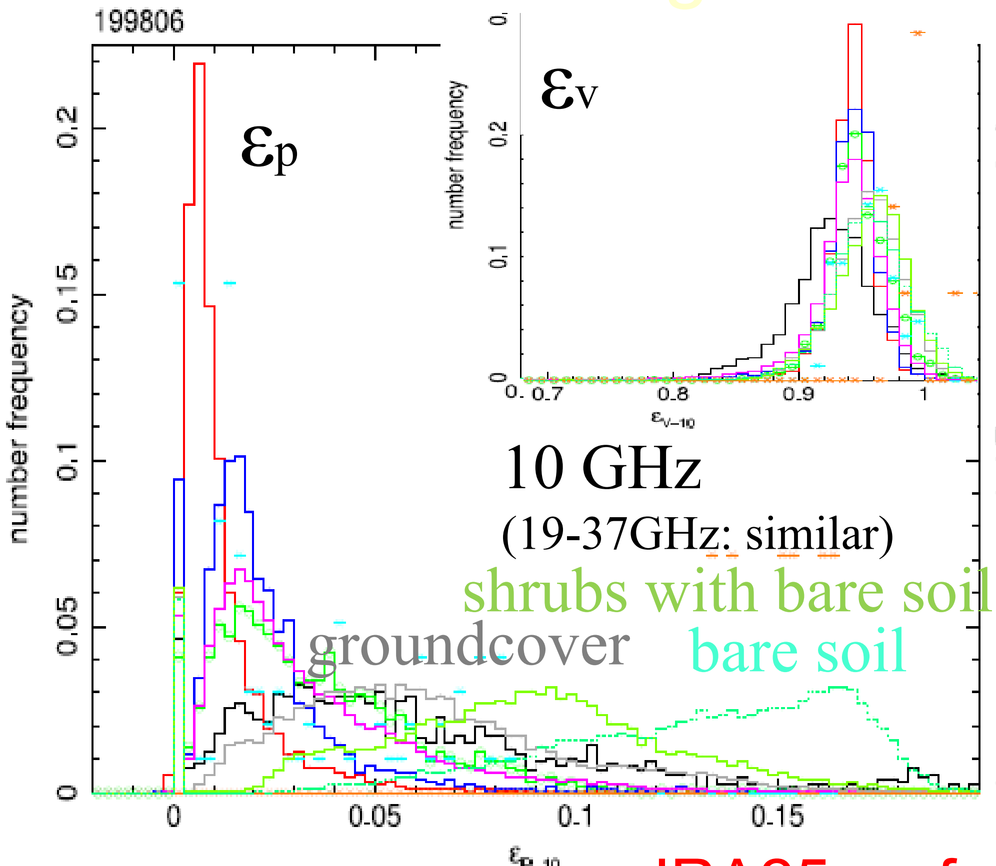


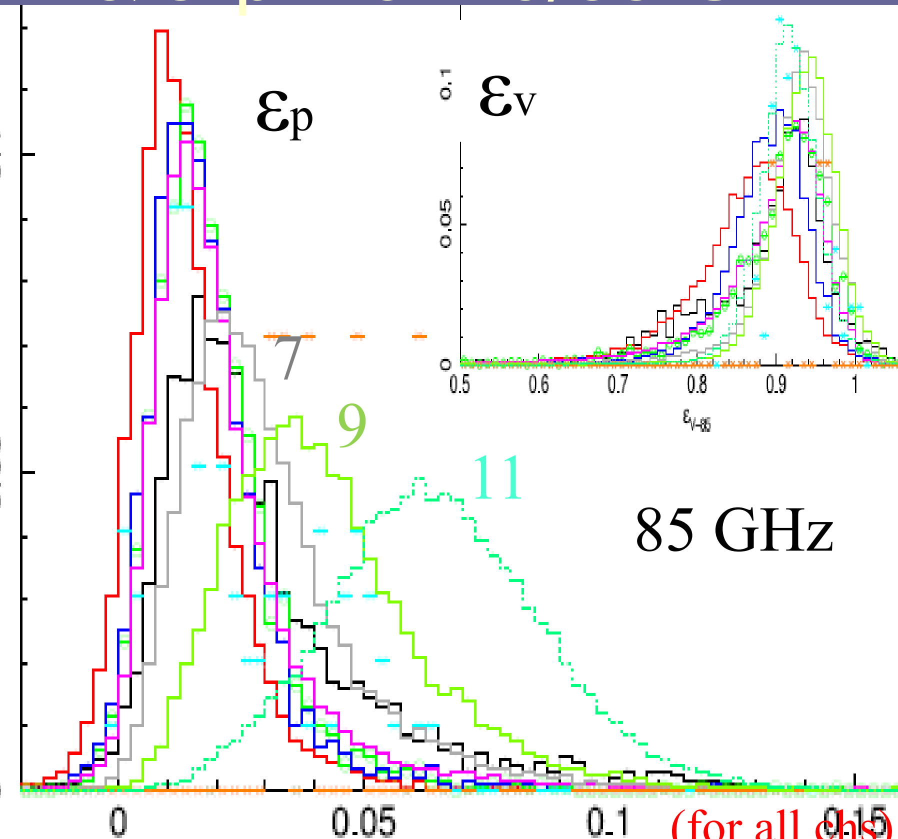

→reconstracted

This ε-estimation method is valid.

# Correlation between surface type index and ε

## Normalized Histogram of ε v & ε p for 10/85 GHz

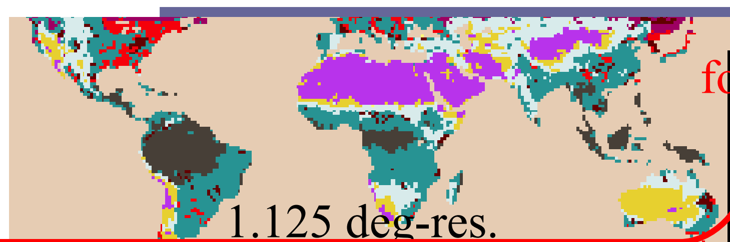


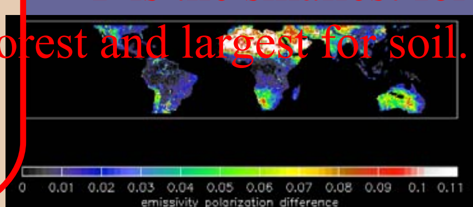




(for all chs)
εv:small difference.but forest:small,soil:large.
εH is invert.
∴P is the smallest for forest and largest for soil.

## JRA25 surface type index

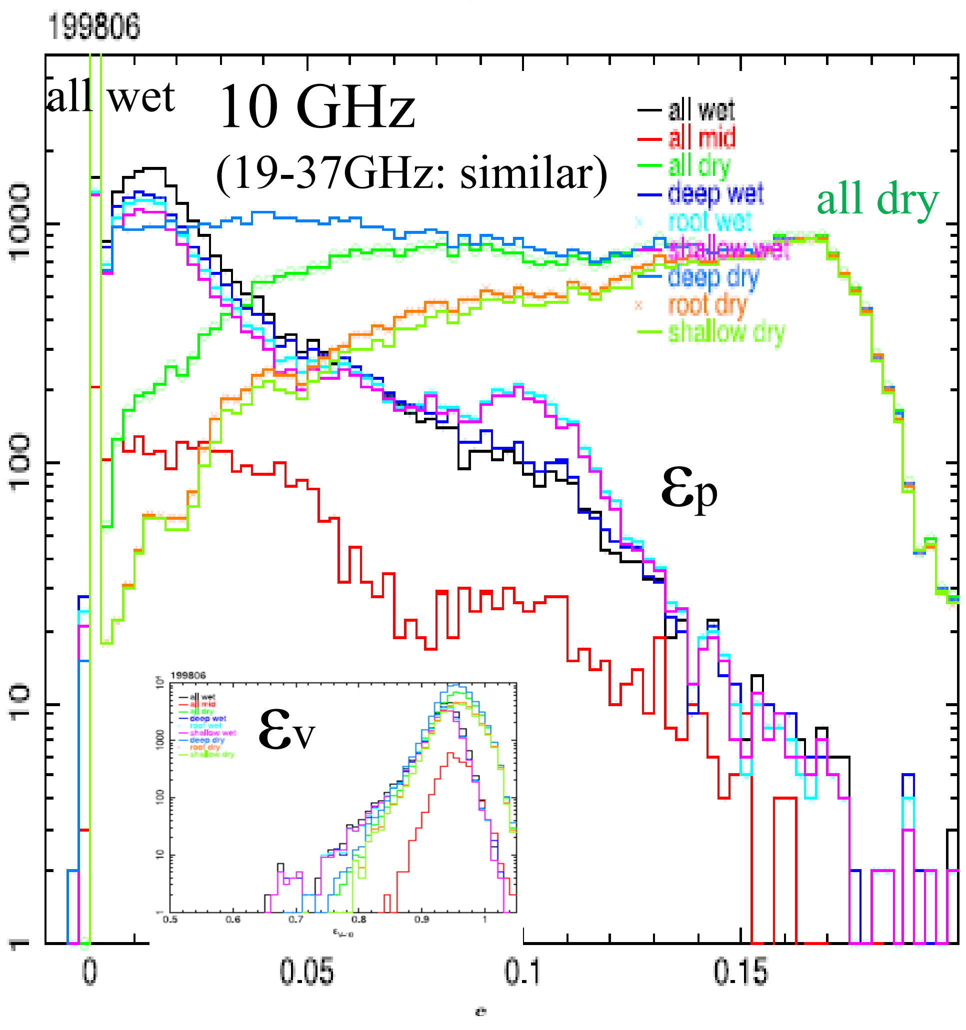
1 evergreen broadleaf trees
2 broadleaf deciduous trees
3 broadleaf and needle leaf trees
4 evergreen needle leaf trees
6 broadleaf trees with groundcover
7 groundcover
1 broadleaf shrubs with groundcover
9 broadleaf shrubs with bare soil
11 bare soil

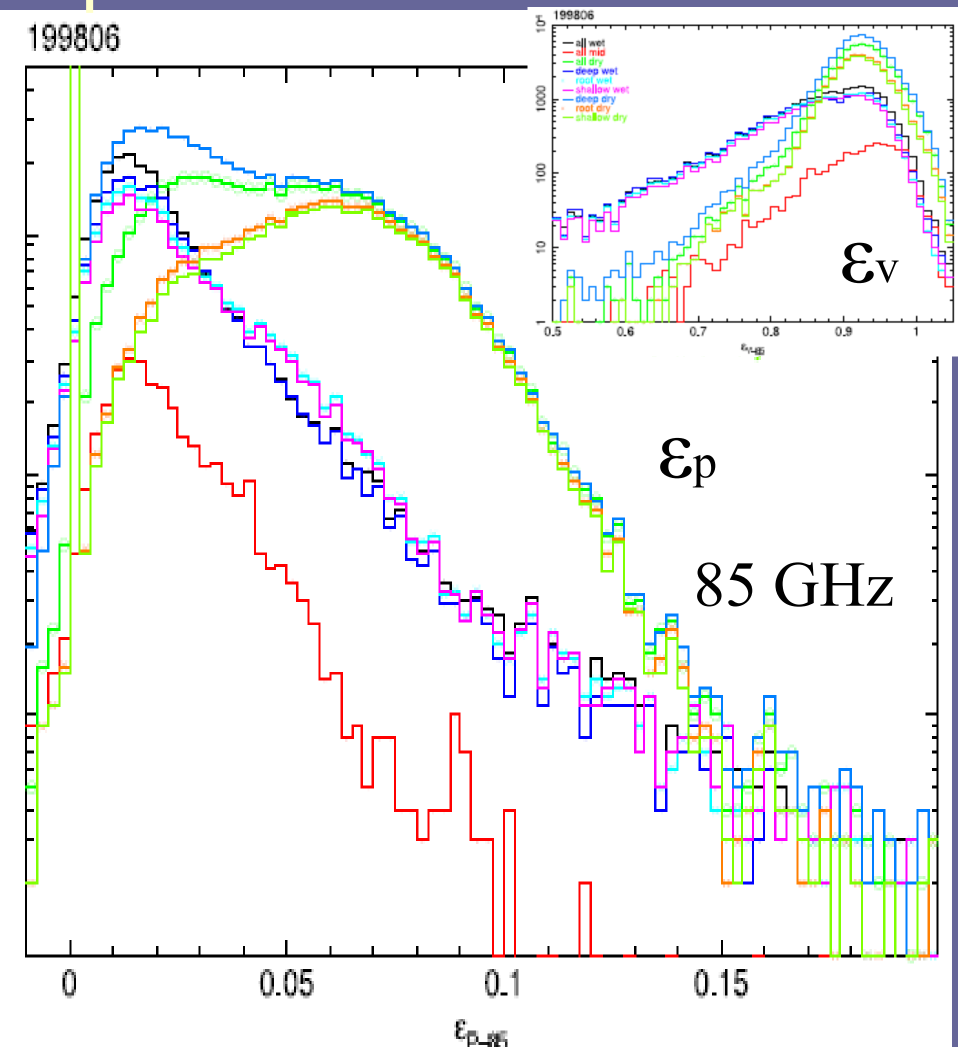


# Correlation between Soil-wetness and ε

## Histogram of $\varepsilon_v$ & $\varepsilon_p$ for 10/85 GHz




All: wet, mid, dry (0.4,0.6)

Deep: wet, dry (0.3,0.7)

Surface: wet, dry

(all chs)

εv:wet:small, dry:large. and

εH is invert.

∴P is small for wet, large for dry.

dry deep + wet surf.→mid-P

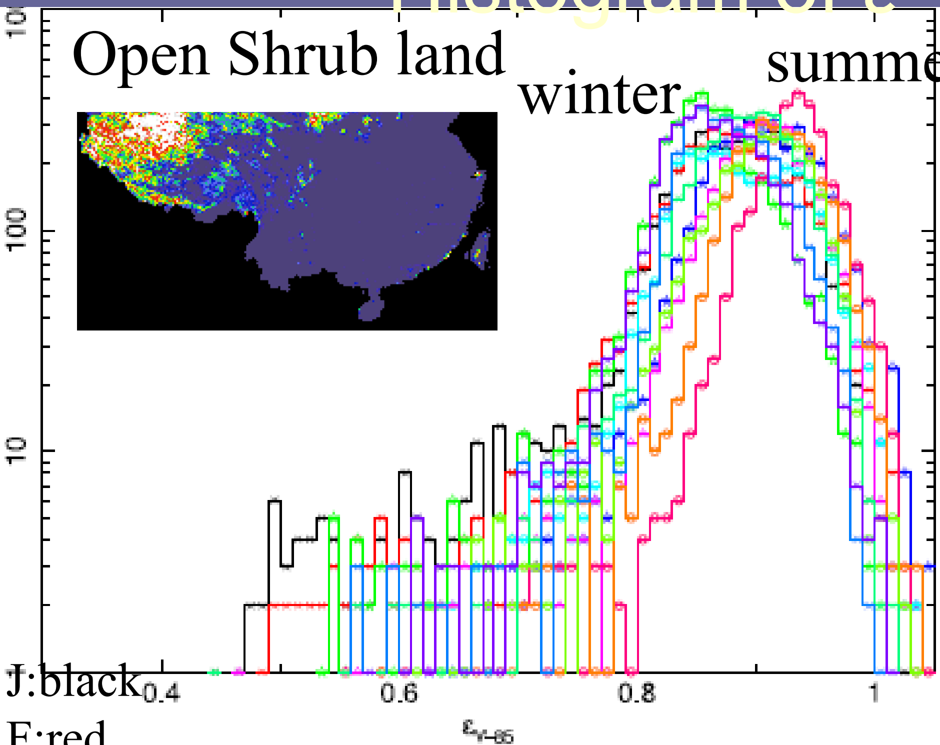
(0.1@10GHz)

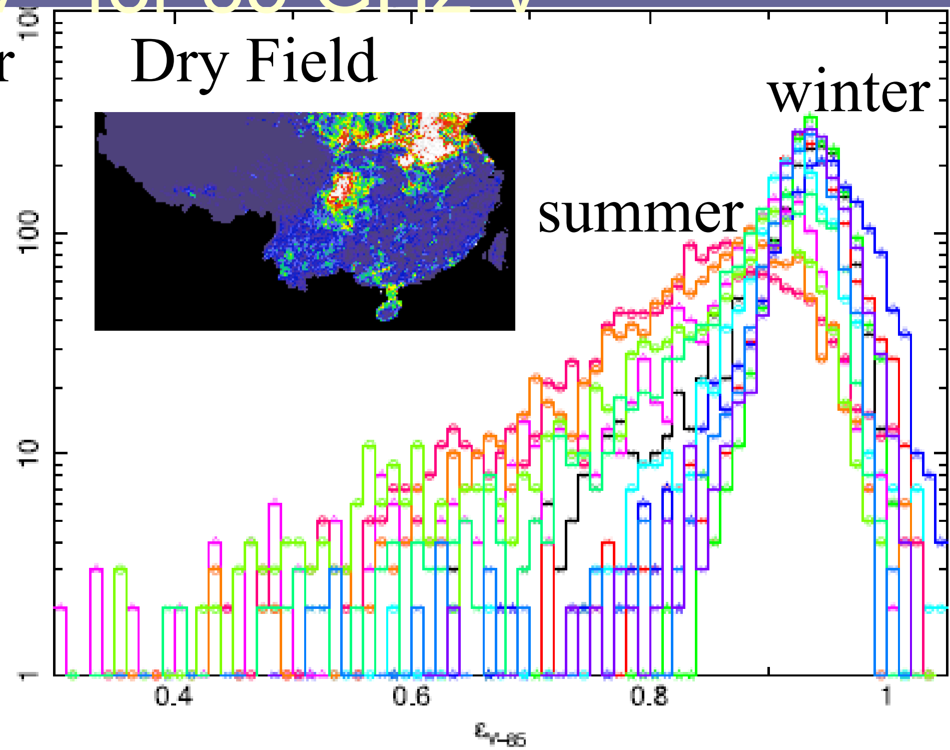
wet deep+dry surf→mid-P

(0.03-0.13@10GHz)

# Seasonal variation of ε over China region 2000

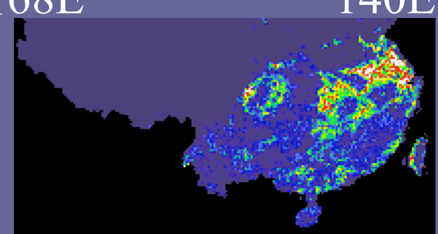
## Histogram of ε_v for 85 GHz V

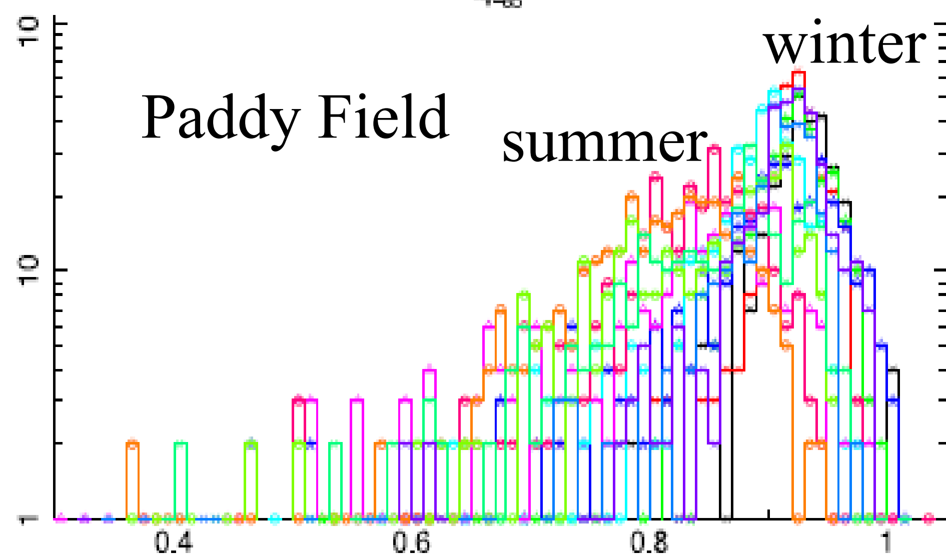



J:black
F:red
M:green
A:blue
M:lightblue
J:magenta
J:red+magenta
A: orange
S:green+cyan
N:blue+cyan
D:blue+magenta

LUCC: Land-Use and Land-Cover Change
Land type >50 %



# Interpolation of land emissivity

- Land emissivity over rainy region can not be obtained. Therefore, interpolation of land emissivity obtained over clear-air-condition is done. Wide instantaneous ε dataset is obtained.
- Assuming Gaussian distribution and weighting with the distance, interpolation is done within the radius of 0.4 deg.

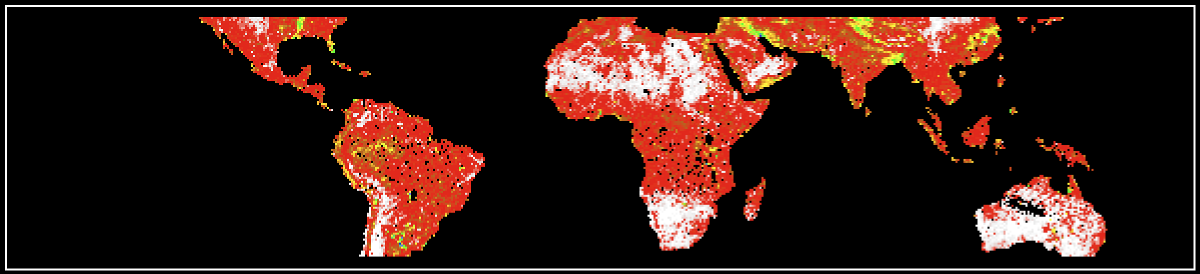
$$\varepsilon_i = \frac{\sum_j \varepsilon_j \exp(-d_{ij}^2 / \sigma^2)}{\sum_j \exp(-d_{ij}^2 / \sigma^2)}$$

$d_{ij}$ : distance between $\mathrm{FOV_i}$ and $\mathrm{FOV_j}$

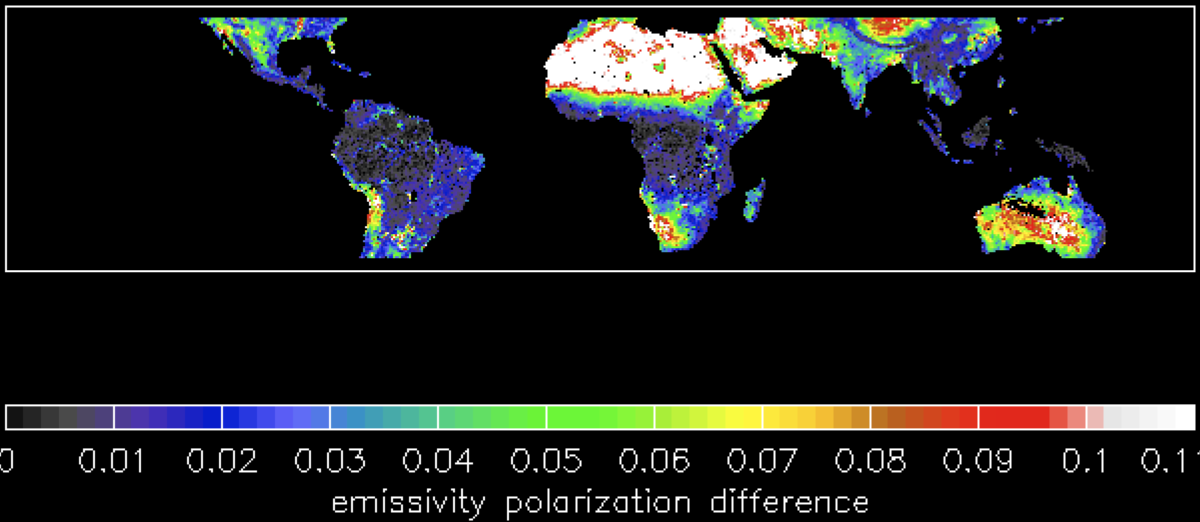
$\sigma$ : correlation length (= 0.1 deg)

- 10yrs' 5freq/9ch monthly ave. map is obtained from the instantaneous interpolated emissivity.

# Annual variation




1998 ~ 2009 January animation
19GHz V and P

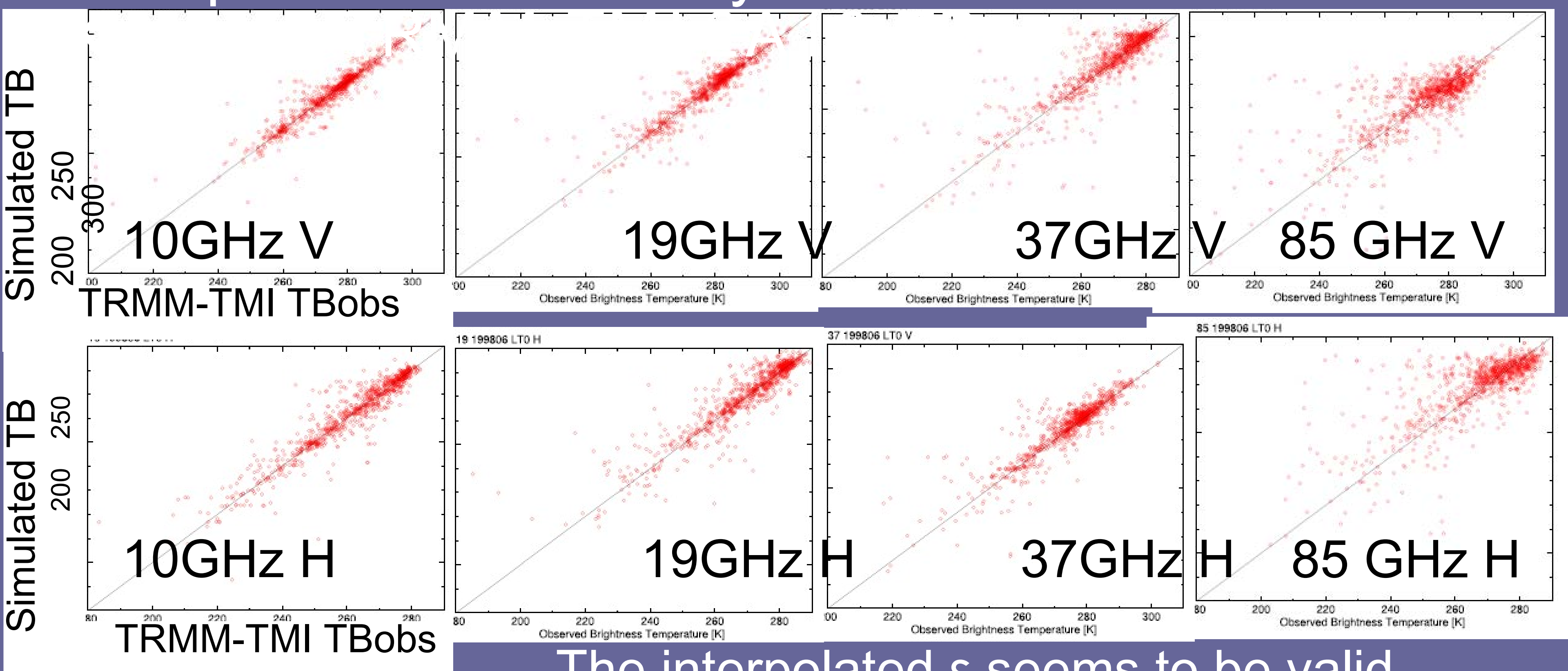


# Check

# Simulation of TB

- RTM : Aonashi & Liu (2000) code
- Assuming that JRA25 air prof le and cloud water content follows a 10-linear interpolated function, there is no ice cloud, and PR rain-prof le, TB is simulated from our land interpolated emissivity dataset.

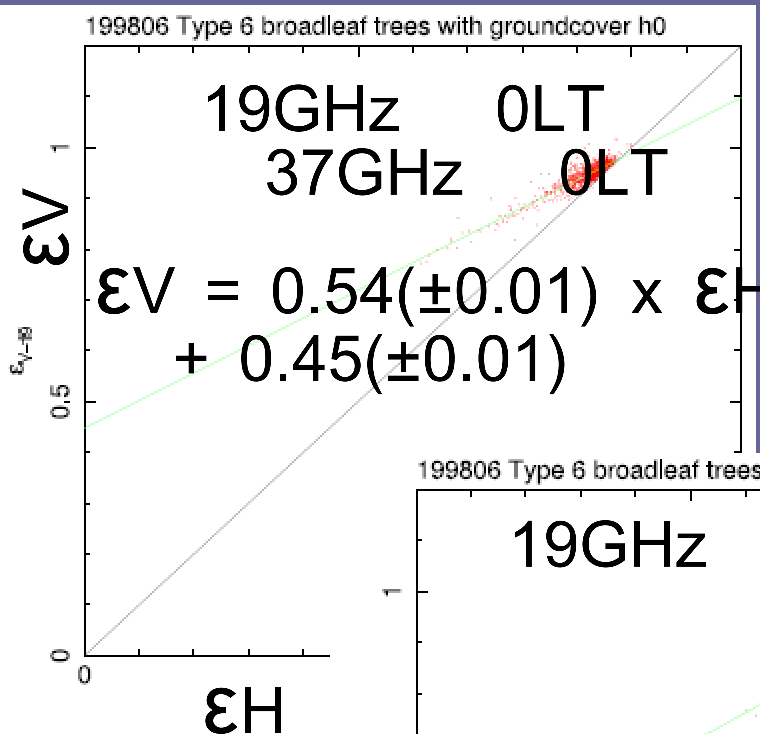
19980600

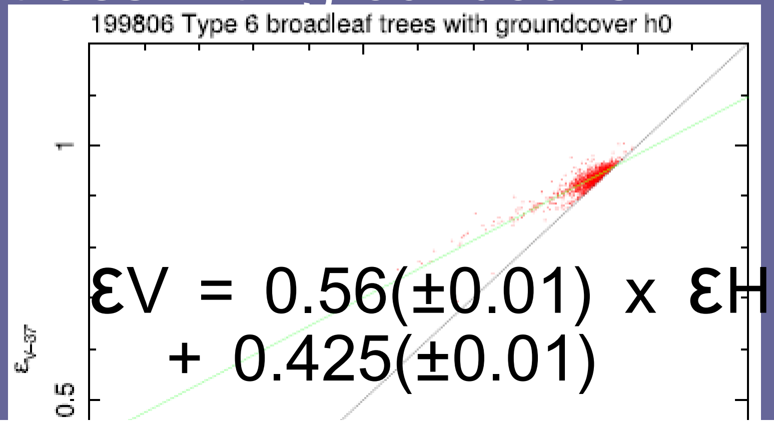


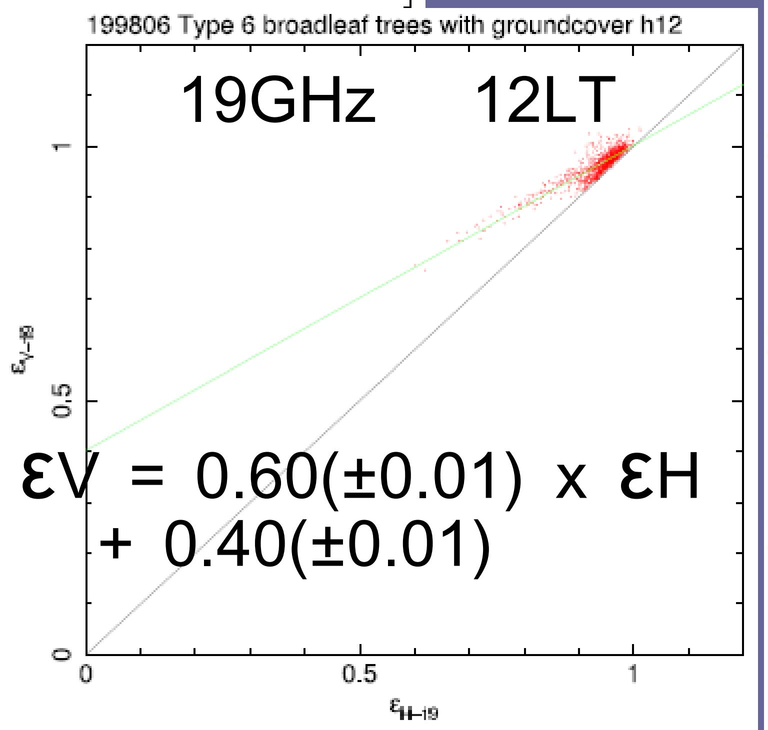

The interpolated ε seems to be valid.

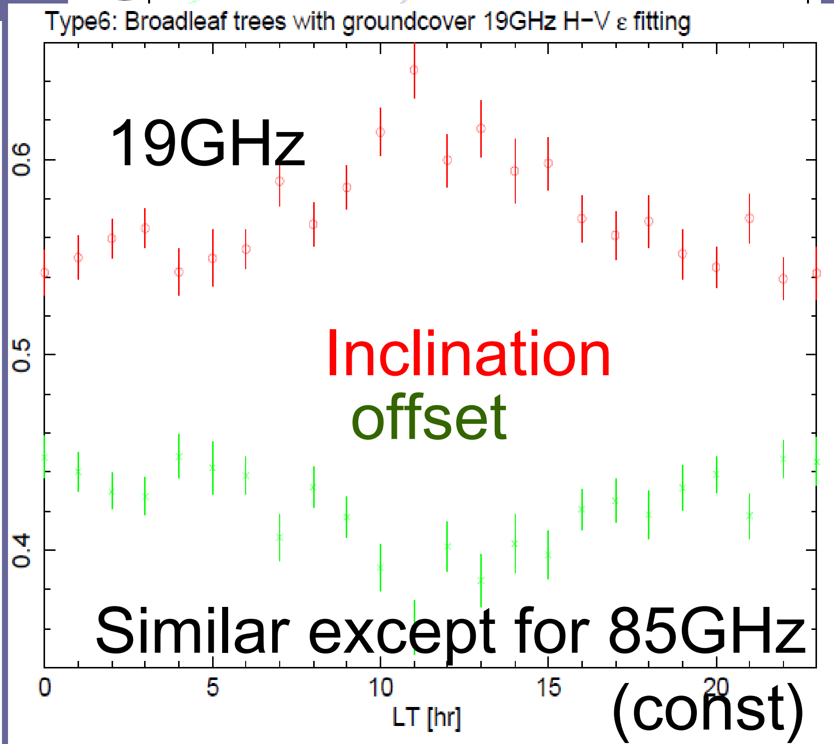
# Determination of surface temperature
# Correlation of ε

Example: 199806
Broadleaf trees with groundcover

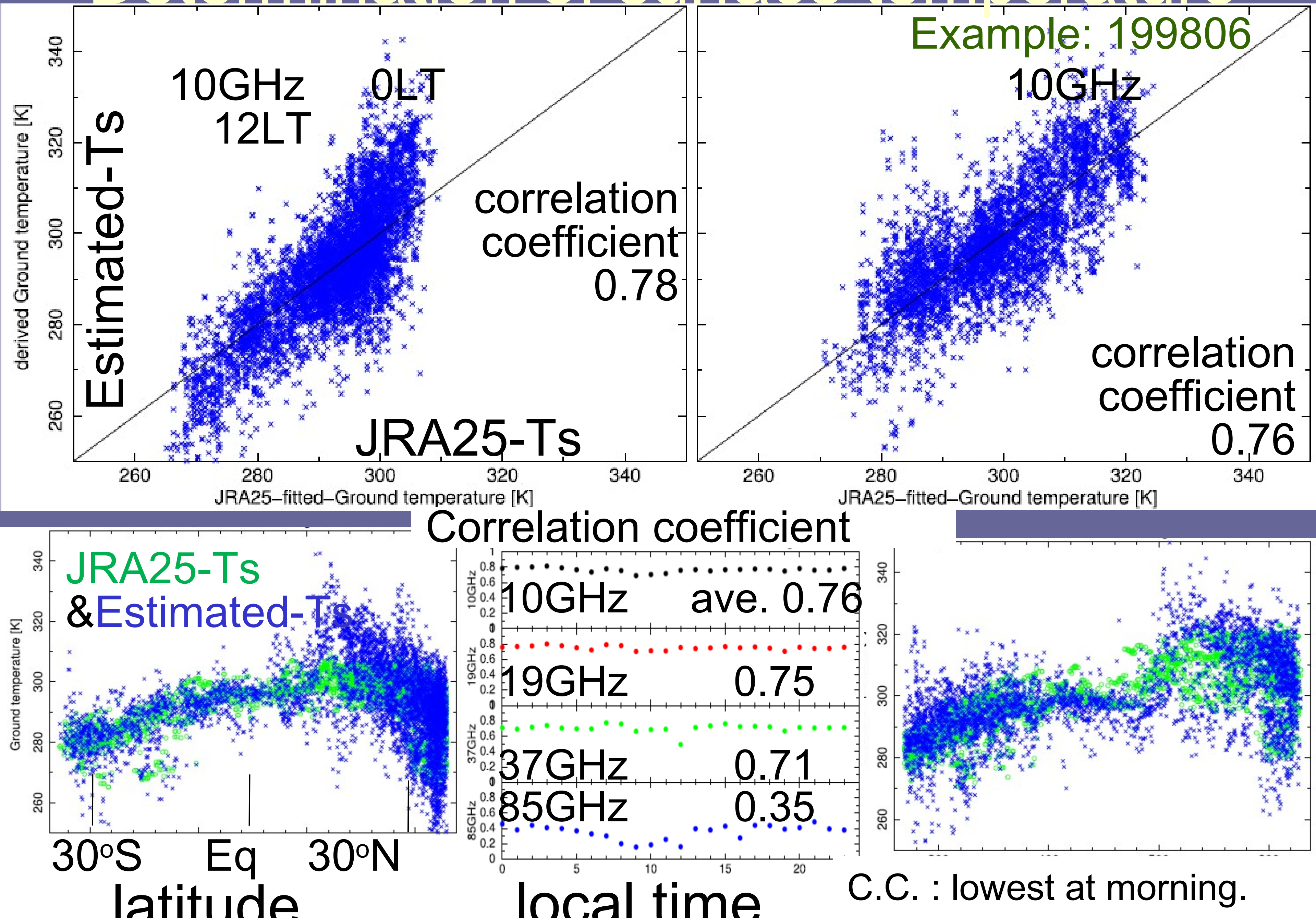


# Determination of surface temperature



# Conclusions

- Over no-rain land TRMM PR observation area, 11(+α ) yrs instantaneous ε dataset and monthly ε map for each yrs and over-11yrs climatology were made for TMI-5freq/9ch. Assumption : the CLW over 0-deg level is 0 [kg/kg]. Validity of this dataset is conf rmed by simulation using LIU radiation code and comparing with TMI TB, and moreover, comparison with results of Dr. Uesawa @EORC and Dr. Prigent.
- Obtained monthly averaged map shows regional seasonal, annual variations, and dif erent dependencies on surface type (JRA25, landsat, LUCC) and soil-wetness for 5-freq/9-ch.
- Interpolated ε data over rainy area was made. Simulation using LIU code and the interpolated ε was done and compared with TMI TB, assuming JRA25 cloud water content +

# Future Plan

- By including the ε dataset into our GPM/GMI combined algorithm which Nagoya Univ,. has been developing, and some other algorithms, I will check whether the rain estimation is improved or not.
- I will change the limitation of “no-rain only” into “no-rain only + rain possible” and compare with the interpolated ε dataset.
- I will improve the method to estimate surface temperature.