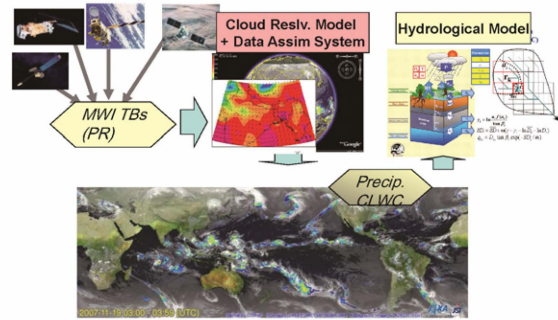


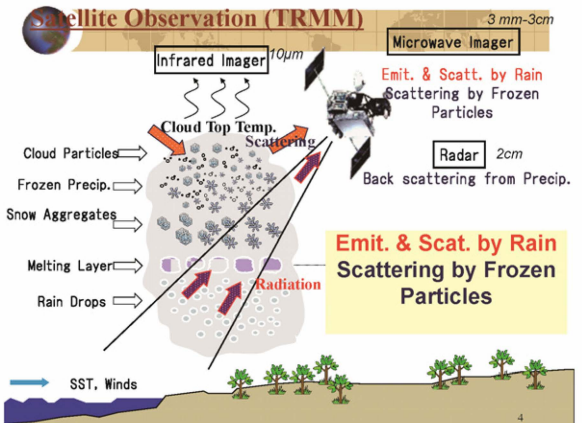
多波長マイクロ波放射計データを用いた  
水物質リトリーバルの研究:  
高周波TBの前方計算バイアスの補正

青梨和正(気象研)  
担当教官 高村民雄

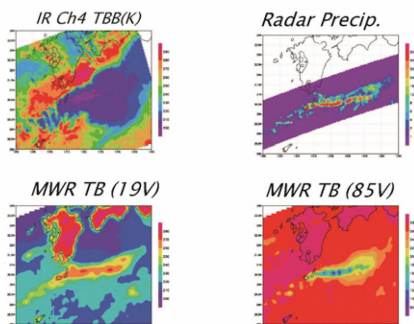


OUTLINE

- ✦ はじめに
  - ❑ 今までの研究: EnVAを用いた低周波TB同化法
  - ❑ 目標: 高周波のTBの同化
- ✦ 高周波TBのバイアスのチェック法
  - ❑ GSMaPアルゴリズムの利用
  - ❑ TMI と PRの比較
- ✦ バイアスの補正法
  - ❑ MWI指標
  - ❑ バイアスのMWI指標への依存性
  - ❑ バイアス補正法と適用例
- ✦ まとめ

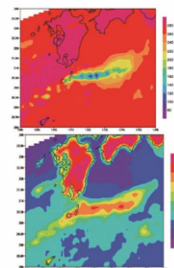


Heavy Precipitation observed with TRMM sensors  
(MCS near Southern Kyushu, Jun. 13, 1998)



Physical Basis of Microwave Precip. Retrieval

- ✦ Over Land:  
Scattering by frozen particles (Higher Freq.)
- ✦ Over Ocean:  
Scattering (Higher Freq.) + Emission from Rain (Lower Freq.)



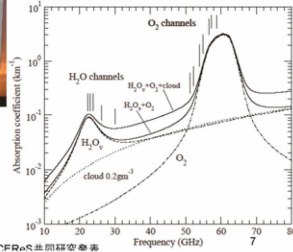
## 地上型MWR



観測周波数 (GHz)  
22.235, 230.35, 23.835,  
26.235, 30.0,

51.250, 52.280, 53.850,  
54.940, 56.660, 57.290,  
58.800

2012年度CEReS共同研究発表



## EnVA: min. cost function in the Ensemble forecast error subspace

- Minimize the cost function with non-linear Obs. term.

$$J_x = 1/2(\bar{X} - \bar{X}_f)P_f^{-1}(\bar{X} - \bar{X}_f) + 1/2(Y - H(\bar{X}))R^{-1}(Y - H(\bar{X}))$$

- Assume the analysis error belongs to the Ensemble forecast error subspace (Lorenz, 2003):

$$\bar{X} - \bar{X}^f = P_e^{f/2} \circ \Omega \quad \Omega = [\bar{w}_1, \bar{w}_2, \dots, \bar{w}_N]$$

$$P_e^{f/2} = [\bar{X}_1^f - \bar{X}^f, \bar{X}_2^f - \bar{X}^f, \dots, \bar{X}_N^f - \bar{X}^f]$$

- Forecast error covariance is determined by localizer

$$P^f = P_e^f \circ S$$

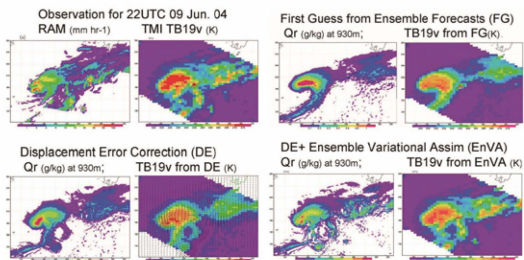
- Cost function in the Ensemble forecast error subspace:

$$J(\Omega) = 1/2 \text{trace}\{\Omega^T S^{-1} \Omega\} + 1/2 \{H(\bar{X}(\Omega)) - Y\}^T R^{-1} \{H(\bar{X}(\Omega)) - Y\}$$

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## これまでの研究: EnVAを用いた低周波TBの変分法的同化法: 台風200404への適用結果



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## MWI TBの前方計算

- マイクロ波放射伝達モデルでMWIの観測に相当するTBを計算する

- 本研究では、Liu (1998)を使用している

- 水物質を含む大気モデルを使う

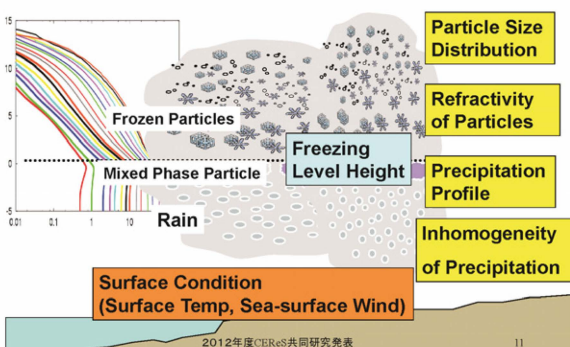
- 降水物理量の特性(固体降水)についての情報が不足

> 固体降水の効果が大きくなる高周波TBの前方計算にバイアスが見られる

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## Parameters for RTM calculation



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## Fast Radiative Transfer Code (Liu, 1998)

$$\mu \frac{dT(\tau, \mu, \varphi)}{d\tau} = TB - (1 - \omega_0)T(\tau) -$$

$$\frac{\omega_0}{4\pi} \iint P(\tau, \mu, \varphi, \mu', \varphi') TB(\tau, \mu', \varphi') d\mu' d\varphi'$$

$$\text{where } \mu = \cos\theta, \tau = \int K_{ab} + K_{sc} dz, \omega_0 = K_{sc} / (K_{ab} + K_{sc}),$$

P is phase function

- One-dimensional model (Plane-parallel)
- 4 stream approximation
- Mie Scattering (Sphere)
- Assuming constant effective density for frozen precipitation particles

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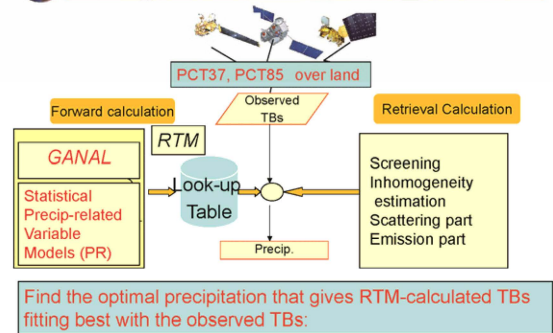
## 高周波TBのバイアスのチェック法

- GSMaPアルゴリズムの利用
- TMI と PRの比較

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## Basic Idea of the Retrieval Algorithm



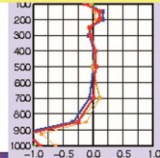
2012年度CERES共同研究発表

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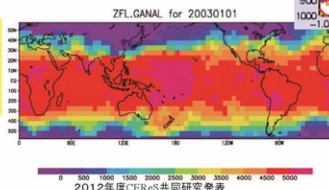
## Parameters used in the Algorithm: Atmospheric & surface variables

- Atmospheric variables (Temp, FLH), surface variables (Ts, SSW, SST) are derived from the Global Analysis data of JMA

Temperature bias of GANAL against sonde



Freezing Level Height for Jan. 1, 2003



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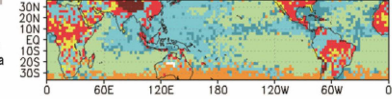
## Statistical precip-related var. models from TRMM observation

Precip type classifier

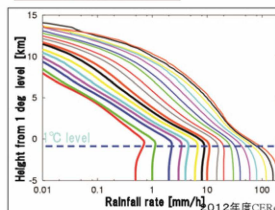
Data base

10 types (land 6, sea 4) are classified from TRMM PR data (2.5 deg, 3 monthly)

Precipitation-type Classification: SUMMER2000



Precip Profile



(land) 0: thunderstorm, 1: shower, 2: shallow, 3: frontal rain, 4: organized rain 5: highland (sea) 6: shallow 7: frontal rain, 8: transit, 9: organized rain

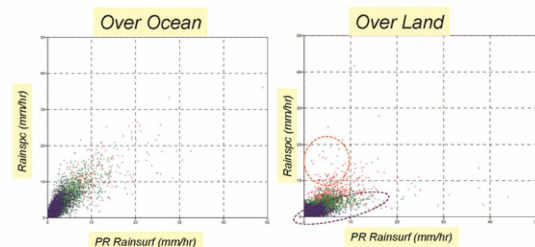
Precip profile data base

Example: TRMM PR averaged precipitation profiles for each type, surface precip, conv/stra

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## PR Rainsurf vs conventional GSMaP retrievals for July '98

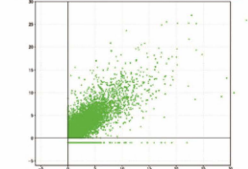


2012年度CERES共同研究発表

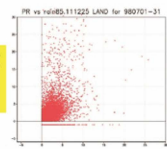
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## PR Rainsurf vs TMI retrievals for Jul '98

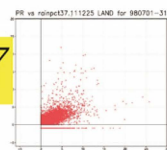
海上の低周波TBからのリトリバル



PCT85 (陸上)



PCT37 (陸上)



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## バイアスの補正法

- ❖ MWI指標
  - ❖ 統計的な降水雲モデルと実況の違いを考慮
- ❖ バイアスのMWI指標への依存性
- ❖ バイアス補正法と適用例

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## Summary of forward calculation experiments

- Sensitivities of TB depressions to precip variables

Freq (GHz)	Depth of frozen precip	PSD of frozen particles	Non-spherical Particles	Freezing level height (FLH)	DSD of rain
85	◎	◎	◎	○	×
37	○	○	×	◎	○

- TB85 depression was very sensitive to frozen precip properties (Dtop, PSD, shapes)
- TB37 depression was sensitive to FLH and Rain DSD in addition to frozen precip properties.

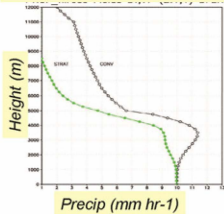
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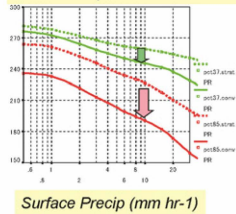


## Forward calculation for deep and shallow precip Over Land (ON,20E) Jul. 1<sup>st</sup>, 1998

Precip profiles for deep (blk) & shallow (green)



TB37 (green) & TB85 (red) Solid: deep, Dashed: shallow



Relation between TB depressions and precip is dependent on Dtop  
Hence, information on Dtop is required for retrieval.

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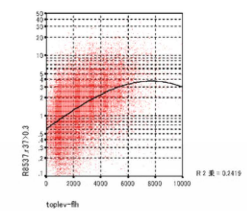
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## Index of Dtop, R8537

- ❖ R8537 expressed as ratio of precipitation retrieved from TB85 (Rain85) to TB37 (Rain37) using the conventional GSMaP algorithm.

Retrain.v4.10.20080417 match-up data (Land '98)



- ❖ TMI R8537 increases with Dtop estimated from PR.

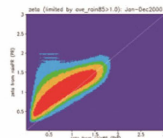
2012年度CERES共同研究発表

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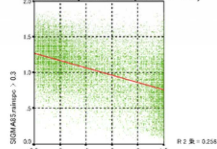


## Index of SRR, Sigma85

- ❖ Precip inhomogeneity estimated from variability of Rain85 within the TB10v FOVs (Kubota et al. 2009).



Retrain.v4.10.20080417 match-up data (Land '98)



- ❖ Sigma85 tends to decrease with SRR.

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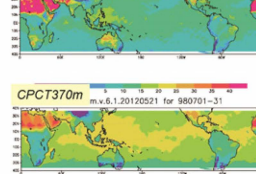
23



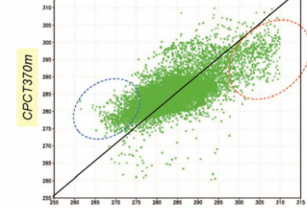
## Index of FLH: PCT37 with no rain

- ❖ For each rainy pixel, PCT37 with no rain (PCT37nr) is derived from surrounding no rain pixels.
- ❖ GANAL tends to over (under)estimate PCT37nr over cold (hot) regions.

PCT37nr 370m.v.6.1.20120521 for 980701-31



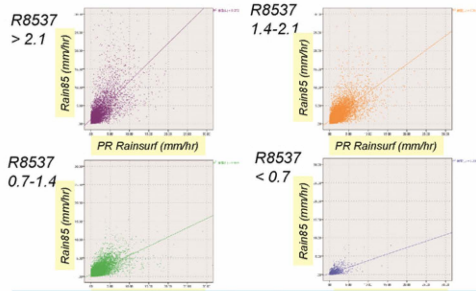
pct137nr vs pct1370m.120521 LAND for 980701-31 Pr>0.



2012年度CERES共同研究発表

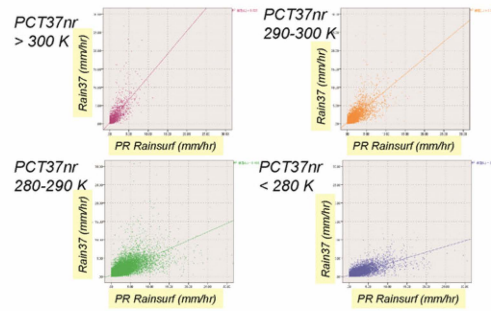
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### Rain85 vs PR rainsurf depending on R8537 (1998, over Land)

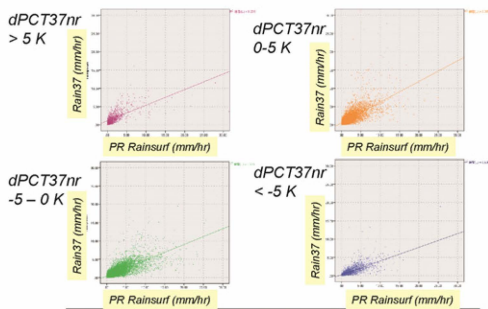


Retrieval bias of Rain85 is mainly due to Dtop error

### Rain37 vs PR rainsurf depending on PCT37nr (1998, over Land)

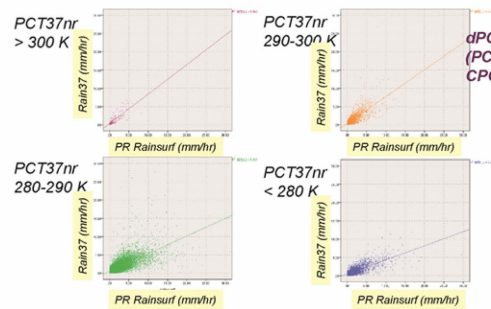


### Rain37 vs PR rainsurf depending on dPCT37nr (PCT37nr ~ (280-290 K) (1998, over Land)



$dPCT37nr = (PCT37nr - CPCT370m)$

### Rain37 vs PR rainsurf depending on PCT37nr dPCT37nr = (-3 ~ +3 K) (1998, over Land)



Forward calculation error is main cause of Rain37 biases

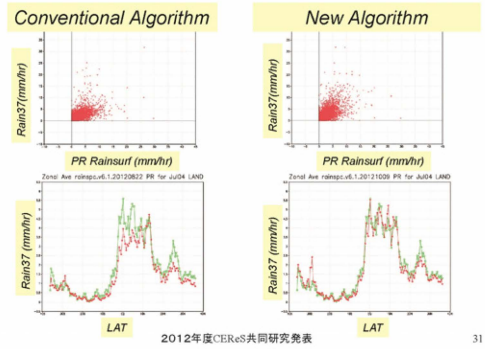
### Statistical correction of LUTs using (PCT37nr, R8537)

- TRMM data sets for 1998 are classified by (R8537, PCT37nr).
- Linear fitting coefficients between Rain37, Rain85 and PR surface precipitation rates.

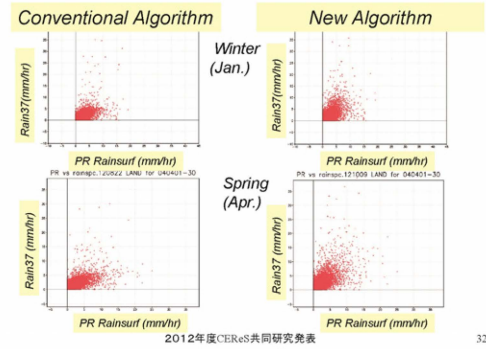
### Validation Results

Over-land retrieval for 2004

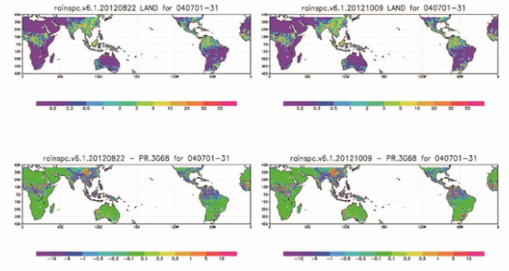
## Comparison of over-land retrievals Rainsurf vs. Rain37 over Land (Jul. '04)



## Comparison of over-land retrievals Rainsurf vs. Rain37 over Land (2004)



## Daily precip (mm/day) of rainspc and their difference from PR rainsurf: over land for Jul. '03



## 今後の方向性

- ✦ バイアスの物理的な原因の調査
- ✦ EnVAへの導入法
  - ☑ MWI TB から求めた降水リターン値の同化
  - ☑ CRMのモデルバイアスの調査

## Summary

高周波TBのバイアスのチェック法  
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