Precipitation regime classification by local meteorological state

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Introduction

- Appropriate microphysical models of rainfall systems are essential for accurate precipitation retrievals from satellite measurements
- In GSMaP (Aonashi et al. 2009), a PR and LIS-based, 3-monthly maps of dominant rainfall systems (Takayabu 2008) are used as hydrometeor profiles in the retrieval algorithm
- But in the GPM era…
  - Need information on precipitation systems over the extratropics and higher latitudes
  - Need to get the estimates with finer spatial/temporal resolution
  - GPM satellites don't carry lightning observing instruments
- It is worthwhile if we can classify different type of rainfall systems not from satellite rainfall data themselves, but from the environmental meteorological states
- In this study, a precipitation regime classification is performed, by constructing look-up-table (LUT) for estimating precipitation types in terms of local meteorological state

Data

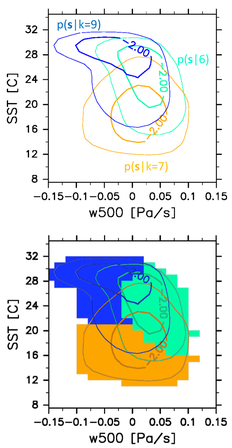
- ERA-interim; monthly and 6-hourly, 1.5° in lon/lat
- OISST; monthly, 1° in lon/lat
- Gridded precipitation type data by T08; trimonthly, 2.5° in lon/lat
- Objective analyses and SST data have been regridded onto 2.5°-deg of T08 data
- Analysis domain/period: 60S-60N, 1998-2006
  - T08 data (35°S-35°N) during 1998-2004 are used as training data for constructing LUT

Construction of Look-up Table

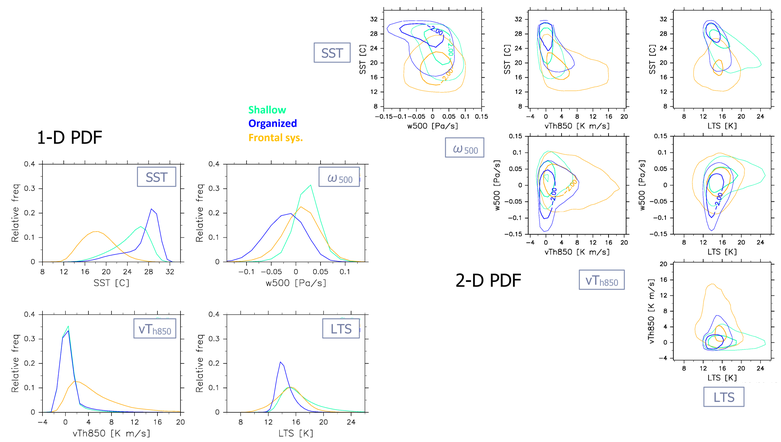
1. Choosing meteorological variables as input variables to LUT
   - Variable set should be chosen so as to describe the seasonal/regional characteristics in prec. regime
2. Calculating probability densities in phase space
   - For each of T08 prec. types, the PDF of meteorological state (**s**) in N-dimensional phase space $P(s|k)$ (k: T08 prec. type, 0≤k≤9), is calculated
3. Constructing LUT
   - Estimate of prec. type for an observed state **s** is defined as the T08 type that have the maximum probability density:

$$\mathrm{Prtype}(s) = \arg\max_k \mathrm{P}(k|s) = \arg\max_k \mathrm{P}(s|k)\mathrm{P}(k)/\mathrm{P}(s)$$

- The input variables to the LUT are from objective analyses, and are not (explicitly) dependent of TRMM/GPM observations
  Prtype(lon, lat, season) → Prtype(**s**(t))

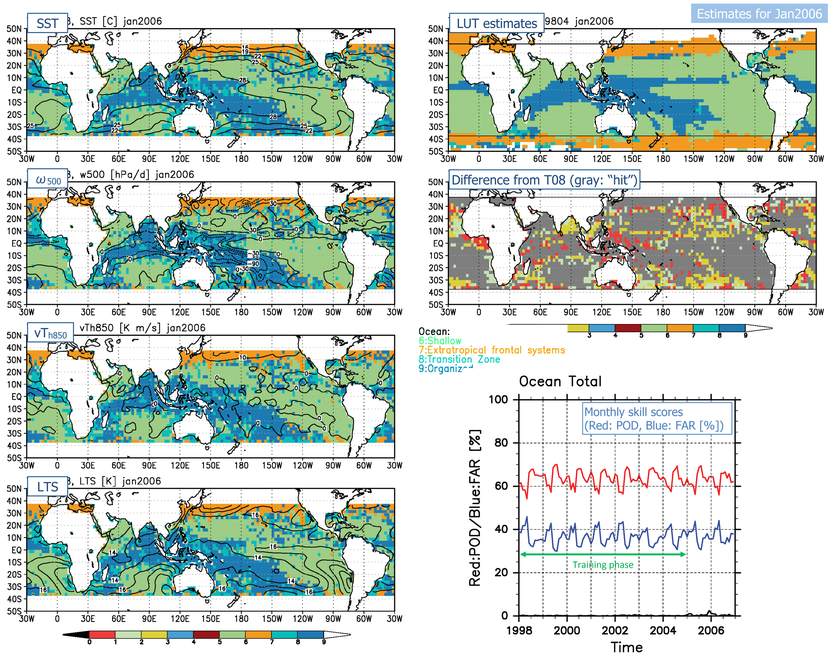


Probability densities of state variables for each T08 precipitation type



Reconstructed precipitation regimes

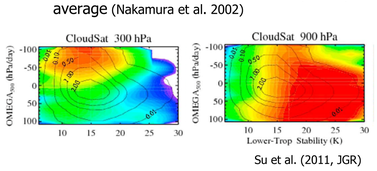
- Estimates from 4D-LUT are well matched with those from T08
- Prec. types in the tropics are almost determined by ω_{500}, and are less sensitive to SST
- Shallow type is well characterized by the high values of LTS in the midlatitude eastern ocean, and determined by relatively warmer SST and downflow in the subtropics



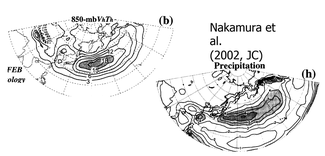
Results over the ocean

Selection of meteorological variables for the classification

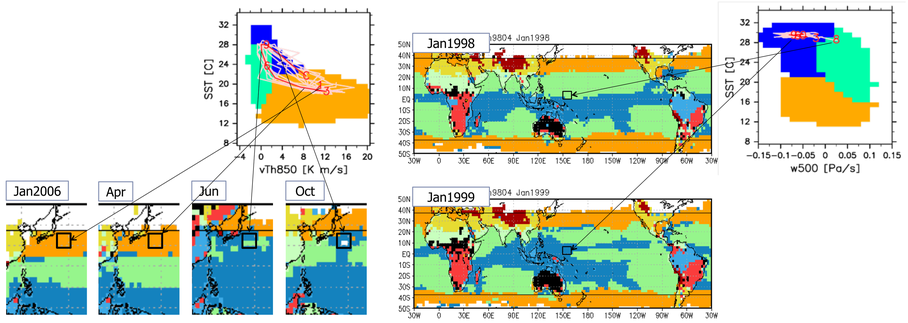
- Four variables are chosen for the input variables to the LUT
  - SST (2-metre temperature over land)
  - ω_{500}: Vertical p-velocity at 500hPa
  - LTS: Lower-tropospheric stability (:= θ_{700} - θ_{sfc})
  - vT_{h850}: High-pass filtered meridional sensible heat flux at 850hPa (:=sgn(lat)*v_hT_h)
    - v_hT_h: Product of 8-day high-pass (Lanczos) filtered meridional velocity and temperature at 850hPa, smoothed by 8-day low-pass filter and 31-day running average (Nakamura et al. 2002)



Su et al. (2011, JGR)



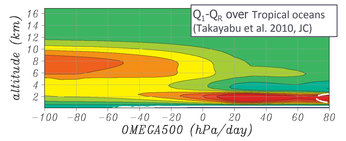
Seasonal/interannual variations are successfully expressed as a (closed) trajectory in the phase space

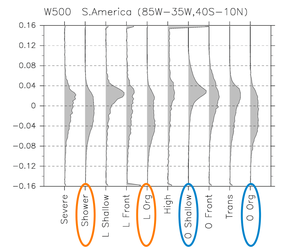


Preliminary results over land

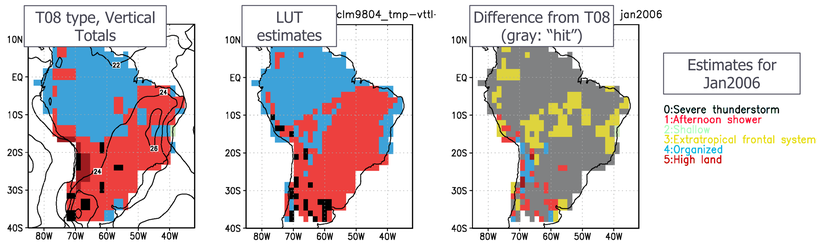
Selection of meteorological variables for the classification

- Primary precipitation regimes:
  - Ocean: Shallow and Organized → "Shallow" and "deep"
  - Land: Afternoon shower and Organized → Both are "deep"
- "Shallow" and "deep" regimes are also well separated by ω_{500} over land, but none of four variables works well to further classify "deep" regimes
- We tried using the following three variables:
  - Vertical Totals: $T_{850} - T_{500}$; alternative to CAPE
  - DTTD: $T_{850} - Td_{sfc}$; alt. to CIN (Myoung et al. 2010)
  - vT_{h850}





Reconstructed precipitation regimes



- Organized (blue) and Afternoon shower (red) are well separated
- Convective intensity (in terms of RPF; red and black) are not well represented
- LUT are substantially different over different land regions (e.g., Africa)
  → The environments favorable to organized systems are completely different, or we were just lucky to get good results by over-training…?

Summary and future works

- A precipitation regime classification is performed by constructing a look-up-table (LUT) for estimating precipitation types in terms of local meteorological state
- The LUT is constructed experimentally, and not (explicitly) dependent of spaceborne radar measurements
- Oceanic regimes are well reconstructed by four-dimensional LUT with SST, ω_{500}, LTS, and vT_{h850}. Seasonal/interannual variations are also well described
- Land types are modestly reconstructed by 3-D LUT with VT, DTTD, and vT_{h850}, but LUTs are highly dependent on the region

Future works in progress:

- Further classification in the midlatitudes – e.g., winter precipitation from frontal systems and cold outbreaks associated with Monsoon
- Classification at the higher latitudes – how many kinds of precipitation?
- Improvement of temporal resolution – can be applied to near-real time classification?