SEASONAL AND INTERANNUAL VARIABILITIES OF ATMOSPHERIC WATER BALANCE IN GEWEX STUDY REGIONS

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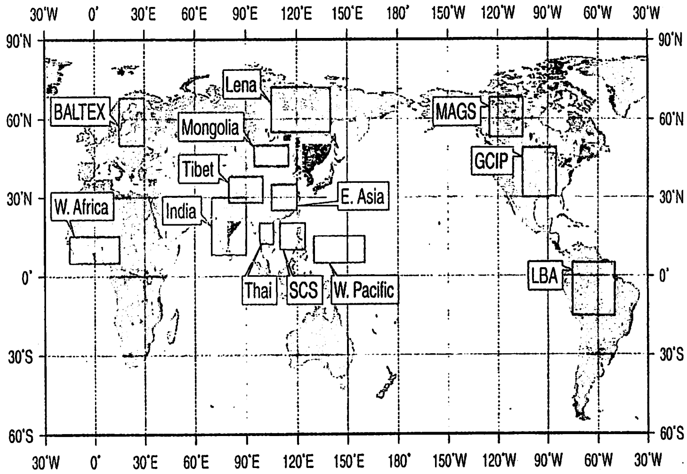
Precipitation depends upon moisture transport and convergence, and evapotranspiration from the surface. Seasonal and interannual variability of precipitation (P) is determined by the characteristic of water vapor transport and convergence (C) and evapotranspiration (E), and their mutual dependencies. The C in the atmosphere is basically controlled by large-scale atmospheric circulation, whereas E is strongly controlled by surface conditions (e.g., SST, soil moisture and vegetation) and near-surface atmospheric conditions. The interactions among P, C, and E should differ from region to region, and season to season, depending upon climatological and geographical conditions.

Yasunari et al. (1999) surveyed seasonal and interannual variabilities of P, C and E over the Continental-Scale Experiment (CSE) regions under the GEWEX Hydrometeorology Panel (GHP). They sought to understand seasonal and regional dependencies of P variability on C and E, and their relative importance, which involves specific feedbacks of each region. The 15 year (1979–1993) reanalysis data from the European Centre for Medium Range Weather Forecasts (ECMWF), i.e., ERA data, are a basic data source for computing atmospheric water vapor convergence (C) for some regions of the world. The vertically integrated atmospheric water vapor convergence is computed from the surface to 10 hPa for each specified region based on four-times-daily relative humidity, temperature, geopotential height and wind (u, v) field for the 15 years (Yatagai and Yasunari, 1998), and is converted to monthly mean data. P is adopted from CMAP analysis (Xie and Arkin, 1997), which is a merged product of in situ rain-gauge data and satellite-derived rainfall data (from OLR and SSM/I). E is evaluated as a residual of the atmospheric column mean water vapor budget, i.e., $E = P - C$, where the local time change of the column water vapor content (precipitable water) is neglected.



Selected Regions for Atmospheric Water Balance

Before we examined the nature of the interannual variablility, we compared the 15-year mean atmospheric water balance. The regions selected (see figure above) are eight GAME-related subregions—the Indian subcontinent (IND), the Tibetan Plateau (TBT), Thailand (TH), the South China Sea (SCS), the tropical Western Pacific (WP), the Yantze-Huaihe river basin in China (HBX), Mongolia (MN), and Lena River Basin in Siberia (LE); the Amazon River Basin of LBA (LBA); the Mississippi River Basin of GCIP (GCP); the Mackenzie River Basin of MAGS (MGS); the BALTEX region (BTX); and the forthcoming CATCH-related Western African monsoon region. On the first page, the seasonal changes of P, C and E in the regions of IND, HBX, GCP and LBA are shown. In most of the regions, the seasonal cycle of P corresponds well to that of C. In the HBX region, however, E maintains a nearly comparable order to C through the season cycle.

Since we focus on the contribution of C and E to P, particularly, in the rainy (or monsoon) season, these three parameters of the peak rainy month for each region are plotted (circles) in the P-C-E diagram in the figure on the back page. As is clearly shown, P of the ocean regions is around 400 mm/month, with C contributing more than 50% of the total amount. Over all the land-based regions in the tropics, P ranges from 200 to 300 mm/month, but the C-E ratio differs considerably from region to region. In the India and Tibet regions, C accounts for most of P (more than 70%), but in the West African monsoon region, E accounts for about 60% of P. In the Amazon and Thailand regions, C and E account for nearly equal amounts. In the HBX region, where the Meiyu (or Baiu) frontal rain dominates in the peak rainfall month (June or July), E contributes most of P (about 150 mm/month). It is noteworthy that in all the high latitude regions (MN, LE, GCP, MGS and BTX), P is nearly balanced by E, though the amount of P (about 50 mm/month) is very small compared to the other subtropical and tropical regions.

Using the 15-year monthly values of P, C and E, we computed the linear correlations between P, and C and E for each region. In most of the regions, P and C exhibit a high linear correlation at a significance level exceeding 1% significant level, but the correlation between P and E is weaker even when the mean contribution of E to P is large. In addition, some regional characteristic tendencies of the gradient (C *vs.* E) of the linear regression were noticed, suggesting different physical processes or feedbacks involved in the P-C-E relations. In the same P-C-E diagram (back page), the interannual ranges of the three components are drawn for each region, based on the linear regressions between P and C. Interestingly, the C vs. E gradients for the tropical warm water pool region (SCS, WP) are positive, implying that some positive feedback processes, e.g., wind-evaporation feedback (Emanuel, 1986), dominated between C and E over these regions, presumably based upon the strong association between wind speed and low-level convergence.

In most of the land-based regions, C vs. E gradients are negative, implying negative feedbacks, e.g., cloudiness-insolation-surface flux feedback between C and E. The range (variance) of C is considerably large in the tropical Asian monsoon region (THI), but relatively small in the Amazon and West Africa. In the East Asian monsoon region (HBX), the C-E gradient is nearly flat or slightly positive, suggesting some positive or "thermostat" feedback controlling the nearly constant E. The water-fed rice paddy fields that dominate this region may be responsible for this feedback. In the high latitude regions, although P varies year to year depending upon C, it is most likely that E primarily determines the basic mean value of P for each region. This suggests that, in the high latitudes, soil moisture, vegetation, surface energy, and water balance may be more important in precipitation climatology than in the lower latitudes.

This study has preliminarily unraveled the relative contribution of C and E on P for various regions, specifically focusing on the major CSE regions. This approach will offer an effective tool for evaluating and modeling the variability of water cycling processes in the climate system. Independent estimations of P, C and E as a closure of the water cycle are being coordinated in each region of the Earth as part of GHP activity.

References

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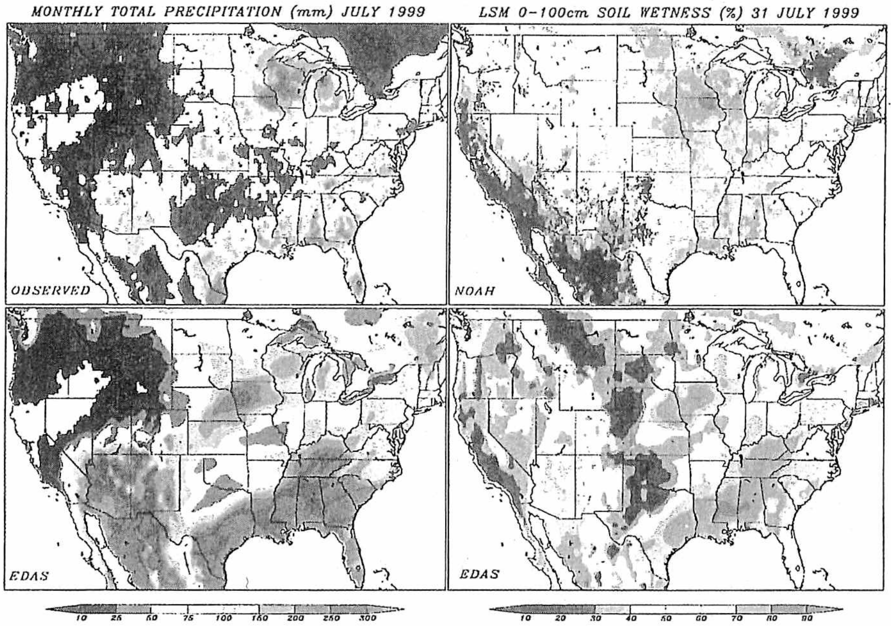
GEWEX PROJECTS MOVE FORWARD

International Satellite Land-Surface Climatology Program

The ISLSCP Initiative II 10-year data set kick-off meeting was held at NASA/GSFC on October 27–29. Over 50 scientists participated in reviewing potential data sets and defining the parameters for the 1x1 degree co-registered land-surface, near-land surface and atmospheric data sets to be made available online and on CD-ROM in 2002. As of September 30th, 8,921 Initiative I CD-ROMs have been distributed. An ISLSCP Science Panel meeting is being planned in conjunction with the BAHC Science Steering Committee in April 2000 in Caracus, Venezuela.

Baltic Sea Experiment

The Baltic Sea Experiment (BALTEX) enhanced observational period, named BRIDGE, started October 1999, and may be extended in several components to the end of the year 2002 to provide a complete overlap with the Coordinated Enhanced Observational Period (CEOP) of the other GEWEX Continental Scale Experiments.



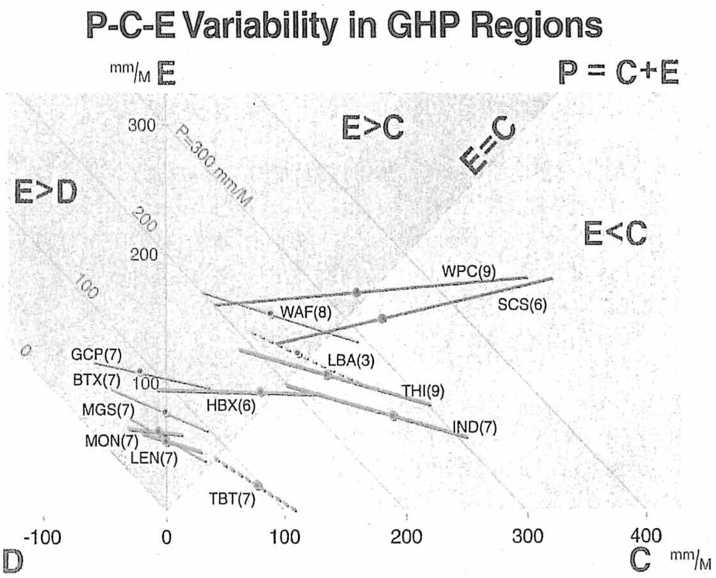
LDAS PROJECT UNDERWAY

Nine groups collaborate to derive a new Land Data Assimilation System (LDAS)—results for July 1999 are shown here (see page 3).

The top upper left is the monthly total precipitation (mm) from LDAS gauge observations, bottom left from the Eta-based 4-D Data Assimilation System (EDAS). The top upper right is a representation of end-of-month soil wetness (percent saturation) for LDAS with EDAS on the bottom.

ATMOSPHERIC WATER BALANCE OVER GEWEX CONTINENTAL-SCALE EXPERIMENT REGIONS

Seasonal and Interannual Variabilities of Precipitation (P), Convergence (C) and and Evapotranspiration (E) show differences and feedbacks (see page 7).



P-C-E diagram with interannual ranges of atmospheric water balances in six CSE regions. Fifteen-year mean values are shown by circles. Green lines indicate GAME regions; yellow lines, the other CSE regions; and red lines, the two tropical oceanic regions.

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