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River Discharge, in State of the Climate in 2008

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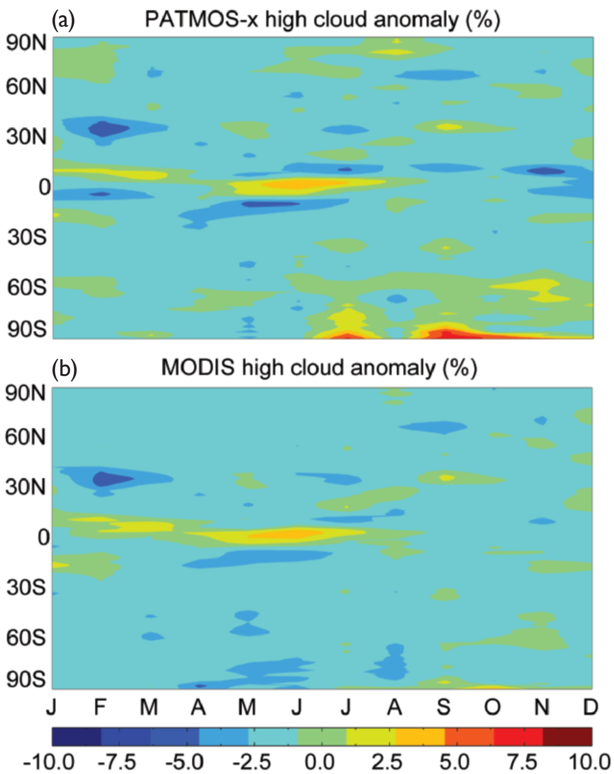

Fig. 2.19. (a) Monthly zonal average PATMOS-x anomalies of high cloud cover (cloud top pressure < 440 hPa) in 2008, relative to 2003–08 climatology based on retrievals from the NOAA-16 and NOAA-18 satellites. The 2003–08 reference period is chosen to match that of MODIS (b) to facilitate comparison. (b) Same as (a) but for MODIS (cloud top pressure < 440 hPa) based on retrievals from the *Aqua* and *Terra* satellites.

In 2007 increased temperatures and decreased tropospheric humidity associated with an anticyclonic atmospheric circulation pattern caused noticeable decreases in Arctic summer cloudiness (Kay et al. 2008). In 2008 this anticyclonic atmospheric circulation pattern persisted through boreal spring but weakened during the Arctic summer, resulting in an increase in cloudiness over northern Greenland and much of the Arctic Ocean of 15% to 20%. None of these increases is statistically significant.

Figure 2.20 shows global mean monthly cloud amount anomalies since January 1971 from four sources: SOBS for 1971–96, infrared sounder instruments on the NOAA polar orbiting weather satellites (HIRS-W) for 1979–2002, imaging radiometers on operational weather satellites (ISCCP) for 1983–2007 (and continuing), and the PATMOS-x data. The records appear to disagree on the long-term variation of cloudiness, but the variations and their differences are smaller than the estimated uncertainties and are much smaller than the annual cycle. We conclude that the global monthly mean cloud cover did not vary by more than a few percent over more than two decades. This upper limit is significant in light of other, simultaneous variations of the climate: the lack of change needs to be explained as much as would a significant change.

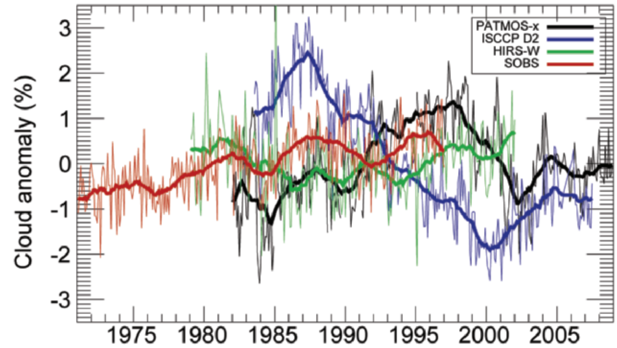

Fig. 2.20. Anomalies of monthly cloud amount between Jan 1971 and Dec 2008 taken from four datasets. The thick solid lines represent smoothing with a boxcar filter with a 2-yr window. There are 6 months missing from the PATMOS-x time series between Jan 1985 and Feb 1991, as well as a gap from Jan 1994 to Feb 1995.

PATMOS-x is the only record shown that currently extends throughout 2008. Its 2008 annual mean globally averaged cloud amount is 65%, very close to its 27-yr mean of 65.2; all months were within 1% of the long-term mean cloudiness.

5) River discharge—A. M. Macdonald, B. M. Fekete, L. C. Bowling, R. B. Lammers, R. Lawford

Discharge is a uniquely useful climate indicator among water cycle components as hydrograph observations integrate both in space and time. Runoff varies in response to natural and anthropogenic forcing (e.g., land-use change, reservoirs, dams) (Milliman et al. 2008; IPCC 2007; Gedney et al. 2006). Variations that affect the water available in local watersheds contribute to changes in ocean freshwater budgets (Talley 2008; Peterson et al. 2006), and play a significant role in the temporal variability and trends of the global water cycle (Oki and Kanae 2006). Modern estimates of global runoff vary by less than 10% (Table 2.2). Regional year-to-year discharge is dominated by variations in precipitation but is also nonlinearly dependent on groundwater contributions, regional runoff fractions, and surface water withdrawals.

Most discharge records have temporal gaps and/or infrequent or spatially inhomogeneous sampling. Divergent methods of data collection and apparent political disincentives to report accurately com-

TABLE 2.2. Estimates of long-term mean annual global runoff ($km^3 yr^{-1}$) into major ocean basins. Percent variation is a measure of the variation among the different estimates and is equal to the std dev divided by the mean times 100. Rows 1–3, 5, and 7 are adapted from Dai and Trenberth's (2002) Table 4, which states that the values exclude the Antarctic runoff into the Southern Ocean that they estimate at ~2614 $km^3 yr^{-1}$ after Jacobs et al. (1992) (see their references). Rows 4, 6, and 8 are estimated from GRDC (2004). Including only those estimates made in the last decade reduces the percent variation among the estimates to 16%, 6%, 8%, 42%, 10%, and 4% for columns 1 to 6, respectively

	Arctic	*Atlantic*	*Indian*	*Mediterranean & Black Seas*	*Pacific*	*Total*
Baumgartner and Reichel (1975)	2,600	19,300	5,600	0	12,000	37,713
Korzun et al. (1977)	5,220	20,760	6,150	0	14,800	46,930
Oki (1999)	4,500	21,500	4,000	0	10,000	40,000
Shiklomanov (1999)	4,281	19,799	4,858	0	12,211	41,149
Fekete et al. (2000)	2,947	18,357	4,802	1,169	11,127	38,402
Fekete et al. (2002)	3,268	18,506	4,858	475	10,476	37,583
Dai and Trenberth (2002)	3,658	19,168	4,532	838	9,092	37,288 ±662
GRDC (2004)	3,863	20,373	5,051	0	11,245	40,533
Average, Std Dev and % Variation of above Values	3,792 ±863 23%	19,720 ±1,102 6%	4,981 ±653 13%	827 ±347 42%	11,369 ±1724 15%	39,950 ±3176 8%

pound the issue. Although satellite measurements may improve global coverage, orbit tracks present issues for spatial and temporal resolution (Alsdorf et al. 2007).

The primary archive for global in-situ river discharge data is the GRDC. As of December 2007, it held 3.3 million monthly discharge estimates from 7,332 stations in 156 countries worldwide, representing some 276,000 station years of data. The shortest records are for a single year, the longest 197 years. However, the most recent data available (GRDC 2009) are for 2004.

Planned discharge data products will combine discharge observations with rainfall runoff simulation based on meteorological observations to provide spatially distributed estimates (Fekete et al. 2001). Alsdorf and Lettenmeier (2003) also recommend incorporation of satellite estimates. As a precursor to such merged products, the Global Terrestrial Network for Hydrology publishes runoff and river discharge estimates based on climate and precipitation data forcing. There is strong spatial variability of 2007 runoff and anomalies (Fig. 2.21), reflecting the integral quality of discharge. Such products offer the potential for global monitoring, even where primary data are not readily accessible.

d. Atmospheric circulation

1) MEAN SEA LEVEL PRESSURE—R. Allan

The major feature of the 2008 annual global MSLP field was the influence of the moderate La Niña event. Annual MSLP anomalies were 1 to 2.5 hPa above average across the bulk of the Pacific Ocean and up to 1 hPa below average across the Indian Ocean and the "maritime continent" of Indonesia (Plate 2.1, panel 7). El Niño and La Niña events can be monitored by the SOI, the normalized MSLP difference between Tahiti and Darwin (Allan et al. 1996). El Niños (negative SOI) and La Niñas (positive SOI) vary in magnitude, duration, and evolution, and no two events or episodes are exactly the same. Major events can be near global in their influence on weather patterns, due