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CLIMATE AS RELATED TO THE JET STREAM IN THE ORIENT

Glenn Trewartha

With 9 figures.

Das Klima des Orients in seinem Verhältnis zum jet stream

Zusammenfassung: Es bestehen ziemlich überzeugende Beweisgründe dafür, daß viele charakteristische Eigenschaften des Klimas von Ost- und Südasiens sich aus bedeutenden Veränderungen der Windsysteme, die im Zusammenhang mit Verlagerungen der jet streams stehen, ergeben. Für diese jahreszeitlichen Verlagerungen der jet streams spielen die Hochländer von Zentralasien eine bedeutende Rolle. Die Zerteilung der zonalen Westwinde während des Winters, wodurch ein jet stream von hoher Geschwindigkeit an der Südflanke des Himalaja fixiert wird, hat wichtige klimatische Wirkungen zur Folge. Durch den regenerierenden und steuernden Einfluß des jet auf atmosphärische Störungen werden die Winterniederschläge auf Nordindien-Pakistan und Südchina lokalisiert. Auf der äquatorialen Seite des Himalaja-jet rufen kräftige Abwinde die Trockenzeiten des Winters und Frühlings, besonders im Subkontinent, hervor. Der schwächere und örtlich weniger fixierte nördliche Arm des Winter-jet, nördlich der zentralen Hochländer gelegen, hat keine derartigen, die Winterniederschläge regionalisierenden Auswirkungen wie der mehr festgelegte südliche Arm. In der tibetanischen, leeseitigen Konvergenzzone zwischen den beiden Winter-jets liegt eine der kontinentalen Hauptregionen starker Zyklogenese, wobei die dort entstandenen Störungen die Winterregen betont auf Südchina konzentrieren. Die ozeanischen Zentren der Zyklogenese fallen mit den Winterlagen der beiden jets in der Nähe von Japan zusammen.

Gleichzeitig mit der Anfang Juni stattfindenden Verlagerung des südlichen jet von seiner Winterlage südlich des Himalaja zu einer, die nördlich der zentralen Hochländer verläuft, folgt ein schneller Vorstoß äquatorialer Luft über Süd- und Ostasien nach Norden, der seinerseits die Sommerregenzeit mit dem „Burst of Monsoon“ in Indien und dem Einsetzen der „Baiu Rains“ in Ostasien einleitet.

To an overwhelming degree regional climatology has been descriptive in character, while genesis or explanation has been neglected. This is a highly regrettable situation. A second disappointing feature is that climatic description has been based very largely upon averages of the climatic elements, while the dynamic weather element,

either in the form of the atmospheric disturbance as portrayed on the synoptic chart, or the more durable "grosswetter" situation, has been seriously neglected.

At no time, however, has climatology been so richly provided with the tools and methods required for climatic explanation as at present. Since a climate has its origin in physical processes of the atmosphere, it follows that the genetic climatologist is dependent upon atmospheric physics for insight into climatic qualities and distributions. As a consequence of the phenomenal strides made by meteorological science over the last two decades, a similar accelerated development in genetic climatology is capable of achievement. This paper is meant to provide a sample of how this new meteorological material can be made to function climatically.

One of the relatively new discoveries concerning the atmosphere and its circulation is the existence at high altitudes in the lower middle latitudes of the jet stream, or streams. Since its discovery less than 15 years ago, the jet stream and its effects upon weather have been the object of very intensive research. The effects are expressed in a variety of ways but chiefly through, (1) the jet's regenerative and steering effects upon cyclonic disturbances and (2) the strong subsidence which develops to the north and south of the jet axis. It has not been proven that the jet actually originates the atmospheric perturbations, but certainly they intensify and concentrate underneath the jet stream and their trajectories tend to follow its course, so that they are steered by it. The function served by the jet appears to be that of removing the air aloft which is rising in the convergent cyclonic system at lower levels. Since the jet stream represents a strong convergence of air

streams aloft, it is logical to expect that this convergence at high altitudes will be reflected in subsidence on the margins of the jet at lower levels, especially the equatorial flanks. It becomes obvious that the jet stream, especially where it is locationally stable, should express itself in weather and in climatic conditions at the earth's surface, both temperature and precipitation. The region here selected in which certain coincidences be-

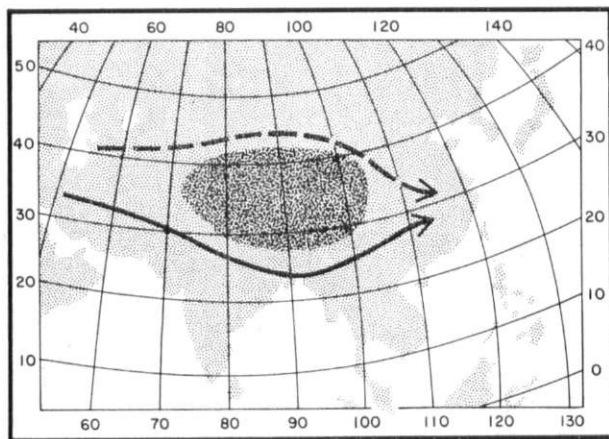


Fig. 1

Representation of the westerly flow in the high troposphere around the Central Asiatic Highlands in the cooler months (After Yin).

tween jet stream and climate will be pointed out, is southern and eastern Asia.

In summer the zonal westerlies and their widely fluctuating jet stream lie north of the central Asian highlands. Since this jet is not confined by terrain barriers it fluctuates widely in latitudinal position, so that its climatic effects are less concentrated latitudinally, and hence less obvious. As the zonal westerlies and the jet follow the sun southward in winter they are increasingly obstructed by the Tibetan Highland and its still higher flanking mountains, which act in such a way as to bifurcate the high-velocity westerly air stream in winter, causing a southern branch of the westerlies and its jet to wrap themselves around the southern flanks of the Himalayas, while the other jet flows around the terrain barrier on the north side (Fig. 1)¹). The southern winter jet, lo-

cationally confined as it is by the high mountain wall of the Himalayas, is relatively fixed in position and has very high velocities, features that are less well developed in the branch flowing eastward on the northern side of the highlands. The two branches of the winter jet, one to the north and the other to the south of the Tibetan barrier, tend to converge again east of the obstructing highlands, the lee confluence being most marked along the Pacific margins of the continent and in the longitude of Japan, where there is located a fixed high-level trough of great latitudinal dimensions. In this area of confluence in the vicinity of Japan the average latitude of the southern jet is about 33° N. and that of the northern one about 41° N.

The Cool Months; Double Jet, One North and the Other South of Tibet

There is a rather sudden reappearance of the jet stream to the south of the Himalaya in October and November and once it arrives in this southerly position it is likely to remain there, and is less subject to disappearance and reappearance than it is in spring, so that fall weather on the subcontinent is less fickle than that of late spring.

With the reappearance in October-November of the zonal westerlies and the subtropical jet to the south of the Himalaya, and the nearly simultaneous establishment of a discontinuity between easterly and westerly air streams in the northern part of the subcontinent and Burma-Indochina, there is initiated a set of large-scale weather changes that have important climatic repercussions over much of tropical eastern, as well as southern, Asia, for the winter jet stream which appears over northern India, continues eastward to southern China and Japan.

It needs reemphasis that, to a remarkable degree, this southern jet is stable in its location as determined by the highland barrier to the north. Therefore its climatic effects are likely to be more apparent than where a jet is permitted to wander over a wide latitudinal range.

Of unusual climatic consequence are the cool-season perturbations, designated by the Indian meteorologists as "western disturbances", which follow the course of the jet stream across northern India-Pakistan and also southern China²). The

¹B. W. Thompson, An Essay on the General Circulation of the Atmosphere over South-East Asia and the West Pacific. Quar. Jour. Royal Met. Soc., Vol., 77, 1951, 571—574. — A. M. Chaudbury, On the Vertical Distribution of Winds and Temperature over India-Pakistan along the Meridian 76°E. in Winter, Tellus, Vol. 2, 1950, 56—62. C. S. Ramage, Relationship of General Circulation to Normal Weather over Southern Asia and the Western Pacific During the cool Season. Jour. of Meteorology, Vol. 9, 1952, 405—406.

²D. A. Mooley, The Role of Western Disturbances in the Production of Weather over India During Different Seasons. Indian Jour. of Meteorology and Geophysics. Vol. 8, 1957, 254—260. — A Brief Report on Western Disturbances Held at New Delhi. Indian Jour. of Meteorology and Geophysics. Vol. 7, 1956, 1—6. — P. R. Pisharaty and B. N. Desai, „Western Disturbances“ and Indian Weather. Indian Journ. of Meteorology and Geophysics. Vol. 7, 1956. 333—338.

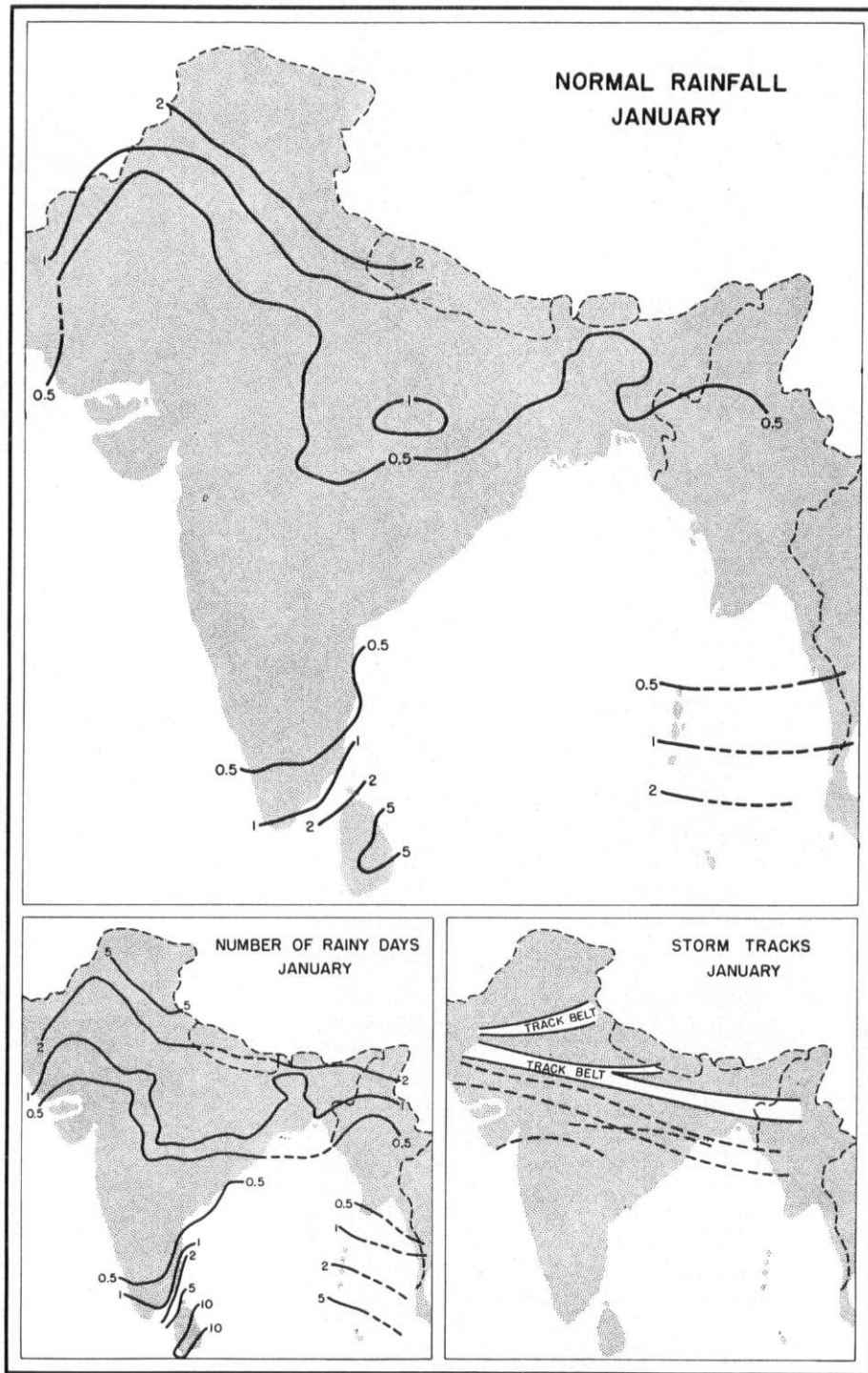


Fig. 2

Winter rainfall in the Indian subcontinent is principally concentrated in the north and is caused by western depressions which follow underneath the jet stream, one branch of which lies south of the Himalayas. (Rainfall in inches.)

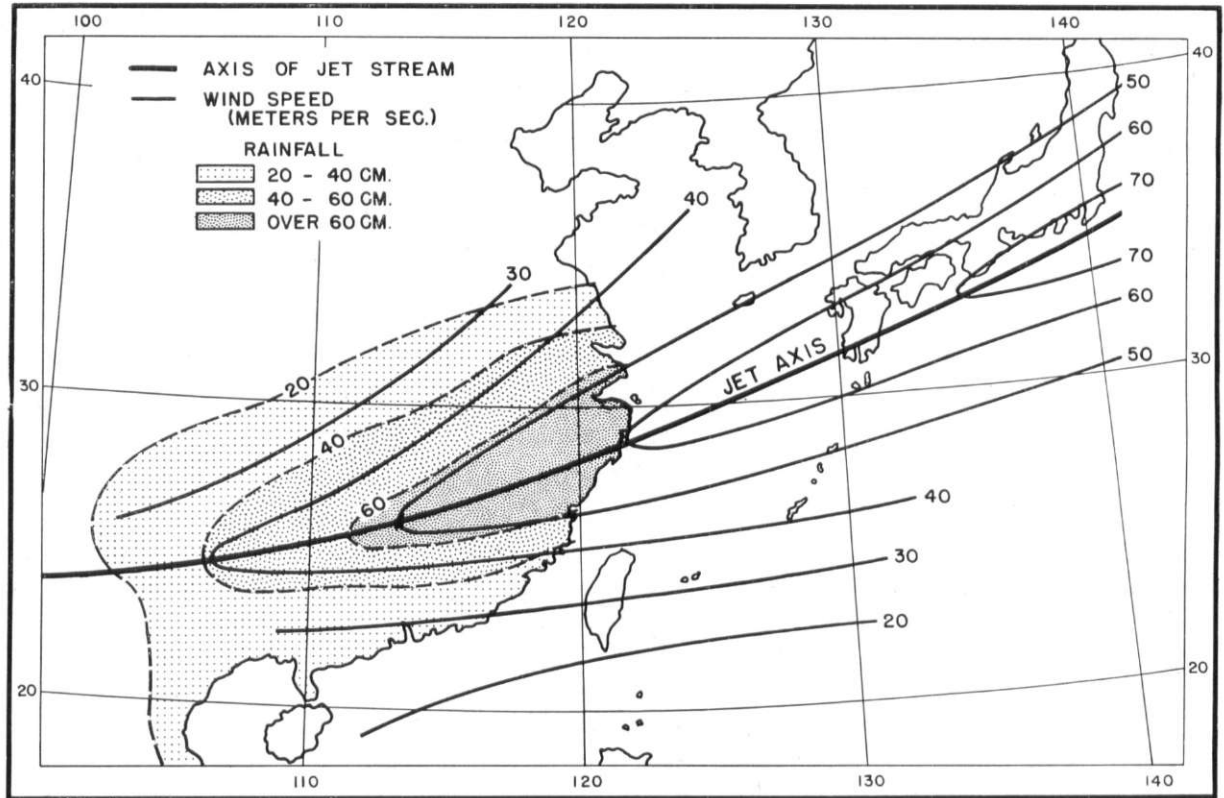


Fig. 3

Distribution of mean west-wind speed (m/sec) at 12 km over the Far East in winter (solid lines) and mean precipitation pattern in centimeters in winter over China (dashed lines). The heavy line shows the mean position of the jet stream (After *Mobri and Yeh*).

origin of these western disturbances is not so clear. Some may have arrived from farther west, probably the Mediterranean Basin or Western Europe. Other appear to originate along the polar front in West Pakistan. Most of them are relatively weak disturbances, and not very conspicuous on the surface synoptic charts. Some exist only in the form of above-surface waves. It is significant that since upper-air soundings began in 1920, and their detection was made more possible, a larger number of western disturbances has been reported. In northwestern India about five a month are reported from January through April. Their tracks are pretty much confined to the north where they follow underneath the jet to the south of the Himalayas.

The significant climatic consequence of the jet-steered western disturbances across northern India is the light to moderate rainfall which they generate, amounting to 1 to 3 inches during the three winter months alone, and considerably more than this in the pre-monsoon spring months. It is still heavier in the highlands to the north where the deep snowfall provides abundant meltwater

in spring and summer for irrigation on the Indus-Ganges lowlands. The November rainfall map of India, for example, shows an appreciably greater amount of precipitation in the northern than in the central parts (Fig. 2). Over most of the northwestern part of the subcontinent there is a modest secondary rainfall maximum in the cooler months. Quantitatively it appears somewhat feeble compared with the stronger summer maximum, but small as it is, it is highly effective for winter crops because of the greatly reduced evaporation in winter. In the extreme northwest, as for example at Peshawar, winter rainfall may equal that of summer, and in Kashmir, cool-season precipitation, much of it from western disturbances, predominates.

The western disturbances and their rainfall continue into the spring months as well, so that the rainfall map of the subcontinent in April somewhat resembles that of winter. They are not able to produce as much rainfall in the dry, hot air over the northwest at this season, but there they are accompanied by severe line squalls. In the more humid air of the northeast, however,

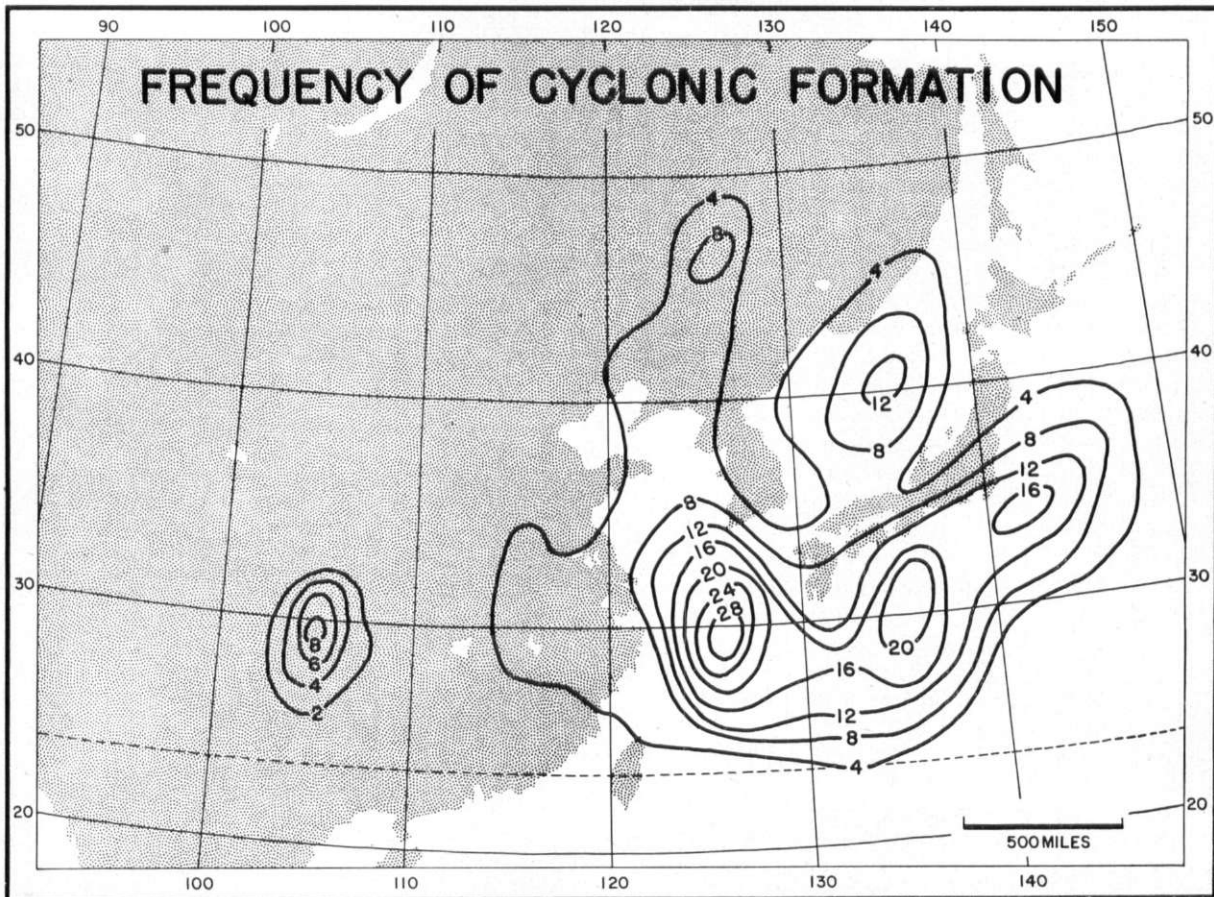


Fig. 4

The principal region of cyclogenesis in the Far East is over the waters just to the east of the continent with major centers over the East China Sea, the waters south and east of Japan, and the Sea of Japan. Continental centers are to be found in the lee-convergence zone to the east of Tibet and over Manchuria. The value of an isoline at any point represents the number of cyclones that formed within a radius of 2.5 latitude degrees from that point in months October through April, 1932-1937. (After Miller and Mantis, and Yeh.)

they yield relatively more abundant rainfall (in the Ganges Delta, 2 to 5 inches in April and 5 to 10 in May) than in winter, some of it associated with violent and destructive thundersqualls.

Lack of observations make it impossible to trace the winter jet and its disturbances across northern Burma, but again over southern China and Japan its climatic effects, expressed through cyclonic concentration and associated rainfall, are noteworthy. While it is still impossible to state that the jet creates atmospheric disturbances, certainly surface cyclonic activity is concentrated underneath the jet which appears to provide a favorable environment for the development and intensification of these disturbances through its action in removing aloft the rising air in the cyclone. Thus the position of the southern winter jet at about latitudes 25 to 30° N. over southern China, and 33° N. over Japan, is coincident with

the principal regions of winter cyclogenesis and of storm tracks in those areas (Fig. 3). Some of the disturbances in South China arrive from northern India by way of Burma, and they intensify underneath the jet over China. Others appear to originate in the lee-convergence zone east of Tibet between the two branches of the jet stream. Lee eddies of small diameter develop in the stagnation point east of Tibet, and under the influence of the frontal zone and the strong jet adjacent, move eastward intensifying as they proceed. Ramage³⁾ shows a strong maximum of cyclogenesis over interior China just to the lee of Tibet, while the map of Miller and Mantis⁴⁾ reveals an oceanic center of winter cyclogenesis in the vic-

³⁾ C. S. Ramage, op. cit., 407.

⁴⁾ James E. Miller and Homer T. Mantis, Extratropical Cyclogenesis in the Pacific Coastal Regions of Asia, *Jour. of. Met.*, Vol. 4, 1947, 29-34.

nity of the jet just south of Japan (Fig. 4). Disturbances originating in the latter center move in an east and northeast direction paralleling the long axis of the Japanese archipelago, thereby producing a maximum affect upon its climate⁵. The relatively permanent East Asian upper-air trough has the effect of intensifying storms arriving from farther west and of creating conditions favoring cyclogenesis.

The climatic effects of the winter jet and its perturbations in East Asia are striking. South China with its steady and strong subtropical jet is a region of relatively abundant cool-season precipitation, while North China where the northern branch of the jet is weak, diffuse, and fluctuating, is a region of cool-season drought. A steep winter-rainfall gradient exists at about latitudes 30 to 34° where the east-west isohyets are packed close together⁶. North of latitude 34° the precipitation is only about one-half of what it is south of latitude 30°. *Mobri*⁷ attributes this to the fact that the cold anticyclones advancing southward, are, after reaching about 30° N., steered eastward by the jet stream rather than allowed to progress farther southward. Thus the dry cold continental air is confined largely to the northern latitudes. A second effect of the cold anticyclones being halted at about 30° N. and steered abruptly eastward by the jet, is to conspicuously steepen the winter temperature gradients over central China. Isotherms like isohyets are closely spaced over Middle China. The generally steep temperature gradients over eastern Asia in winter are also believed to be associated with the fact that this is a region of jet confluence. Here the subtropical jet from south of the Himalayas is moving northward, while that branch of the jet flowing around the northern flanks of the highlands is moving southward (Fig. 5). The effects of this convergence of jets and associated air streams from different latitudes is to pack the isotherms together.

Within South China where winter rainfall is relatively abundant there is a marked zone of concentration extending in a southwest-to-northeast direction, which coincides with the axis of the locationally-stable jet (Figs. 3, 5). Rainfall drops off to the north and to the south of this axis of maximum, but more sharply to the south where subsidence associated with the jet is more marked. Not only is the maximum amount of

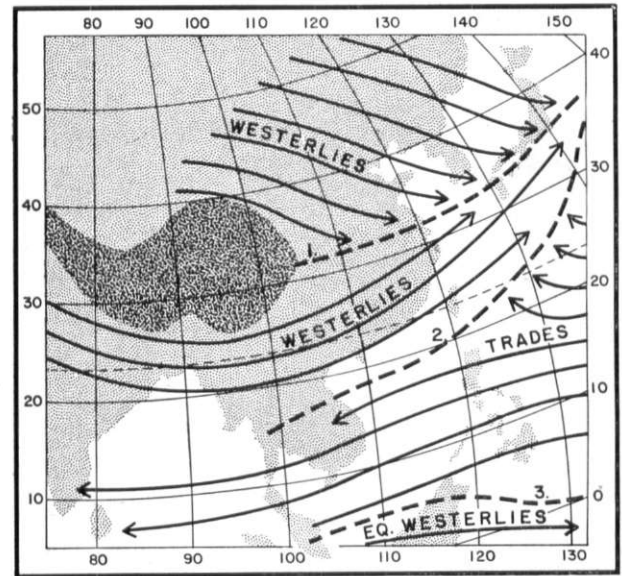


Fig. 5

Characteristic air flow at about 10,000 feet, November to March. 1. Tibet lee-convergence zone; 2. polar front; 3. I. T. C. (After Thompson.)

winter precipitation concentrated underneath the jet, but also the zone of maximum days with precipitation, as well as the zone of least rainfall variability.

The weaker and locationally more variable branch of the winter jet that operates over northern Asia north of the central highlands has no such striking effects on the winter climates of that region. Here the winter perturbations are by no means few, but their tracks are not concentrated, and over the continent at least, they are poor generators of precipitation, the strong thermal anticyclone providing an unsatisfactory environment for abundant condensation. As these northern disturbances approach the Pacific coast, however, the more humid atmosphere plus the effects of jet confluence and the upper-level East Asian trough, cause their intensification, if not actual cyclogenesis. Japan, as a consequence of its location within the jet confluence and close to the upper-level trough, is strongly cyclonic throughout all latitudes, with abundant cool-season precipitation. *Miller and Mantis*⁸ show a second region of strong winter cyclogenesis over the Japan Sea at about latitude 40° N. which approximately coincides with the mean location of the northern branch of the jet stream in these longitudes.

But if the jet has the positive effect of concentrating cyclones and their precipitation along its axis, it likewise has a marked negative effect

⁵) C. S. Yao, The Origin of the Depressions of Southern China. Bull. Amer. Met. Soc., Vol. 21, 1940, 351—355.

⁶) Tu-Cheng Yeh, The Circulation of the High Troposphere over China in the winter of 1945—46. Tellus, Vol. 2, 1950, 173—183.

⁷) Keitaro Mobri, On the Fields of Wind and Temperature over Japan and Adjacent Waters During the Winter of 1950—51. Tellus, Vol. 5, 1953, 340.

⁸) Op. cit., 32.

upon precipitation distribution through the subsidence which prevails to the north and to the south of the jet axis, but more emphatically to the south over southern Asia. Due to the very active convergence of high-level air flow into the jet, there must be a compensating subsidence on its margins. This subsidence and its aridifying effects will be especially noticeable where the jet is relatively stable in its location, as is the winter jet of southern Asia where terrain barriers limit its latitudinal fluctuations.

Most of central peninsular India and also peninsular southeast Asia, south of the tracks of the western disturbances, experience a drought in the cooler months (Fig. 2). The usual textbook explanation is that the dry season in southern Asia is caused by a land monsoon which prevails at the low-sun period. Actually, however, the drought in India continues on beyond the cool period of northerly winds and into the intensely hot period of April and May when northerly air flow is not so conspicuous. Moreover, if a monsoon system is defined as having its origin in the differential heating of land and water, then this northerly flow is scarcely a monsoon. It is, nevertheless, strongly subsident air with a westerly component in the north and an easterly component in central India. It appears now that much of this drought-generating winter subsidence is associated with the orographically located and very stable jet to the south of the Himalayas⁹. Thus the same jet which influences the course of the winter perturbations and the distribution of their rainfall over northernmost India-Pakistan, also acts to produce the drought which prevails over central peninsular India, and which persists there in spite of the heat of April and May until the jet finally disappears to the north of Tibet in June. There is also a sharp falling off in the amounts of winter rainfall in China south of the belt of maximum lying beneath the jet. That the winter drought in China south of the jet is not so marked as it is in India may be associated with the much greater cyclonic activity and totally heavier rainfall in the former area. However, the actual amount of decline in rainfall over a distance of several hundred miles south of the zone of winter maximum is far greater in the case of China than of India.

*Summer or Warm Months;
Single Jet North of Highlands*

During late May and early June revolutionary changes occur in the general circulation patterns

⁹) Ramage, op. cit. 403. H. Riehl, M. A. Alaka, C. L. Jordan and R. J. Renard, *The Jet Stream*. Meteorological Monograph, Vol. 2, No. 7, Amer. Met. Soc., Aug., 1954, 91.

over India and likewise over eastern Asia whose repercussions are felt in the regional climates. As long as the zonal westerlies and their jet stream are located south of the Himalaya, the strong subsidence south of the jet prevents the northward advance of moisture-bearing winds and their rain-generating perturbations from the south. Thus drought prevails over much of the subcontinent in April and May in spite of the superheating of the land at that time. Characteristically the shift from the dry weatherless spring period to the cloudy, rainy, season of the so-called summer monsoon with its numerous perturbations, is abrupt and accompanied by relatively violent weather in the form of thunderstorms and squall winds. This rapid northward surge of the southerly currents and their atmospheric disturbances has been called the "Burst of the Monsoon". Its occurrence in June is synchronized with basic changes in the jet stream and with longitudinal shifts in the location of the South Asian upper-air trough (Fig. 6). As the subcontinent begins to heat intensively in April and May the zonal westerlies move northward, but the movement is resisted by the high mountain barrier. This results in that branch of the jet which has been south of the high-

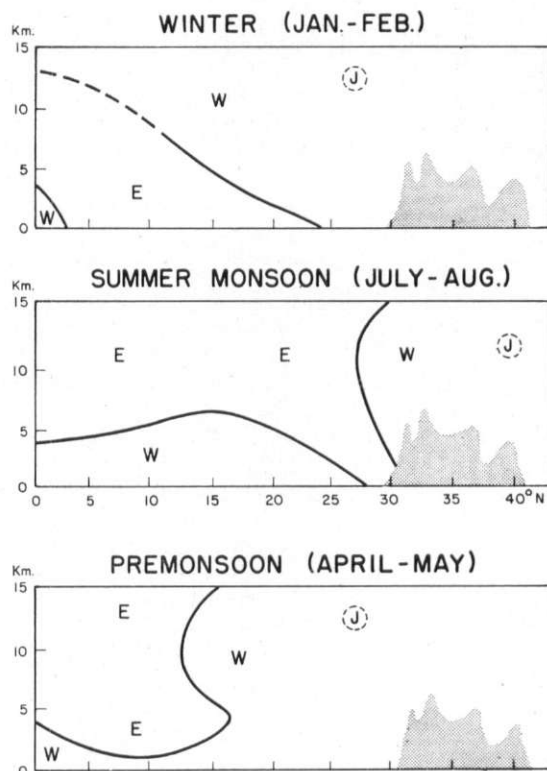


Fig. 6
Schematic profile of the planetary wind belts along 78° E. in the different seasons. J, jet stream. (After Flohn.)

lands during winter and spring to become somewhat fickle, so that it alternately disappears and then reappears south of the mountains. Finally the jet disappears completely from south of the highlands and flows as a single jet to the north of the mountains. Simultaneously there occurs a longitudinal shift in the low-latitude trough and ridge positions, and the high-level meridional trough that previously was located around 85° E., abruptly shifts westward some 10° so that it takes up a position over western India at about 75° E. With the disappearance of the southerly jet and the westward shift of the high-level trough, the equatorial southwesterlies (so-called summer monsoon) surge northward with their accompanying unsettled weather (Fig. 7)¹⁰. This is scarcely a monsoon in the usual meaning of that term for it is not the result of the differential heating of land and water. Such a northward advance of southerly air would occur in summer even if the tropical-equatorial area south of Asia were entirely land. What is here called a monsoon is only the normal seasonal migration of the planetary winds following the sun. But apparently the heating of the land is unable to produce a northward advance of the equatorial southwesterlies over India until the dynamic features of the circulation aloft become favorable. It is a well-known fact that the onset of the summer monsoon is retarded over India more than it is over Burma. Yin suggests this may be due to the fact that as long as the meridional trough is located at about 85° E., as it is in spring, it acts to accelerate the southwesterly monsoon over Burma, lying east of the trough, while at the same time retarding it over India to the west. When the jet reappears south of the highlands again in fall the southwesterlies and their perturbations are forced to retreat as the subsidence zone south of the jet is reestablished. What becomes clear is that the seasonal climates of India are intimately associated with jet stream locations.

But the shift of westerlies and jet to the north of the central Asian Highlands during the warmer season has important climatic repercussions in eastern Asia as well. When the Indian jet of

¹⁰ Maung Tun Yin, A Synoptic-Aerologic Study of the Onset of the Summer Monsoon over India and Burma. *Jour. of Met.*, 6, 1949, 393—400. The following authors have expressed some doubts concerning Yin's explanation of the „Burst of the Monsoon“.

R. Frost, Upper Air Circulation in Low Latitudes in Relation to Certain Climatological Discontinuities. British Meteorological Office, Professional Notes No. 107, 1953, 1—25.

P. R. Pisharaty and B. N. Desai. *Op. Cit.*, 333—338. Frost has been able to correlate the Burst of the Monsoon with a rapid raising of the lower tropopause level at Habaniya in Arabia.

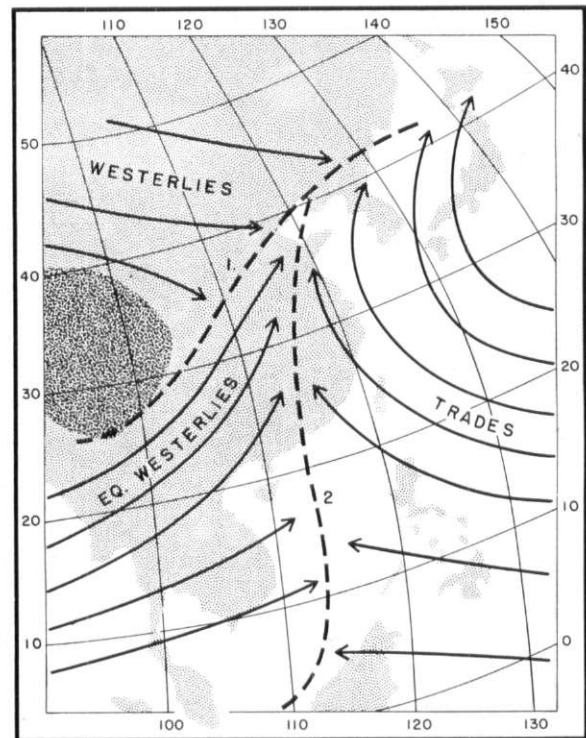


Fig. 7

Schematic flow pattern during July at 10,000 feet and also 2000 feet. 1. polar front; 2. convergence zone between southwesterly and southeasterly air streams.

(After Thompson and Flohn.)

winter suddenly shifts to the north of the central Asiatic highlands in June, and the equatorial southwesterlies begin to pour northward, conditions become ripe for the beginning of the first, or early-summer, rainy season in both China and Japan, the Baiu (Fig. 8). The two events are so concurrent in time that it suggests a cause-and-effect relationship (Fig. 9)¹¹. As the continental jet takes up its summer position exclusively to the north of Tibet, the jet stream east of the continent over Japan bifurcates, one branch swinging south and flowing with cyclonic curvature off the south coast of Japan and the other maintaining a more northerly position. Simultaneously there is a sweeping northward of the equatorial southwesterlies (summer monsoon) over China and Japan, partially induced by the increasing broad, thermal low over the continent. The branching of the summer jet over East Asia and Japan

¹¹ K. Suda and T. Asakura, A Study of the Unusual „Baiu“ Season in 1954 by means of Northern Hemisphere Upper Air Charts. *Jour. Met. Soc. of Japan*, Vol. 33, 1955, 233—244.

C. S. Ramage, Analysis and Forecasting of Summer Weather over and in the Neighborhood of South China. *Jour. of Met.*, Vol. 8, 1951, 296.

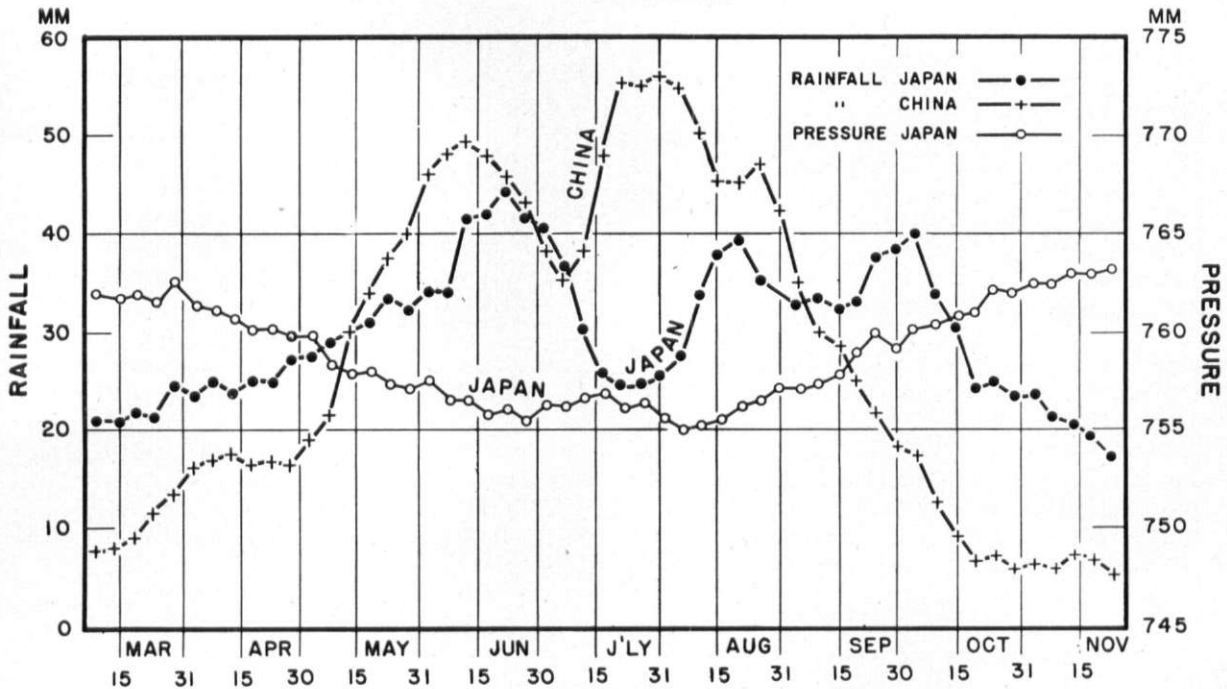


Fig. 8

Composite profiles of 5-day mean rainfall and pressure for 5 stations in southern Japan, and composite profile of 5-day mean rainfall for 9 stations in southern China and Formosa. (After Ramage.)

and the northward surge and intensification of the southwesterlies in eastern Asia, are fairly concurrent with the development of the Okhotsk High to the north of Japan. Upper-level pressure troughs develop in the southwesterly current over

bances in the form of velocity convergences in the monsoonal southwesterly currents¹²).

It has been suggested that the Baiu rains are heavier over Japan when a single jet prevails and less when there is a double jet¹³. In other words, when the confluence of the summer East-Asian jets occurs to the west of Japan, usually over the margins of the continent, Baiu rains are abnormally heavy, and when the confluence occurs farther to the east, over the western Pacific, the rains are less abundant. This summer bifurcation and confluence of the jet over East Asia should not be confused with the winter bifurcation which occurs west of Tibet, and the confluence which occurs to the lee of that highland barrier. A mid-summer secondary minimum of rainfall in Japan and southern China occurs when a strengthening of the Pacific Anticyclone temporarily weakens the southwesterly flow and its perturbations. But as the high retreats again in late summer, and the Baiu stream is again temporarily reestablished, the second summer maximum results¹⁴).

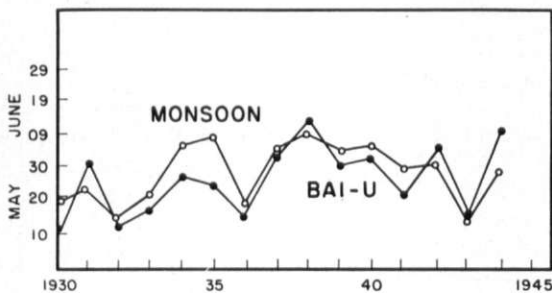


Fig. 9

The date of the first appearance of the southwest monsoon in India and of the Baiu in the Far East. (After Suda and Asakura.)

China and move slowly eastward toward Japan, intensifying under the southerly branch of the jet and along the front formed by the cooler air moving southward from the Okhotsk High. It is these perturbations, taking a northward course across southern Japan, that bring the Baiu or early summer rains to that region. A similar wet season in southern China is associated with distur-

¹² C. S. Ramage, Variations of Rainfall Over South China. Through the Wet Season. Bull. Amer. Met. Soc., Vol. 33, 1952, 308-311.

¹³ S. Matsumoto, H. Ito and Akio Arakawa, An Aerological Study of the Pre-Summer Rainy Season in Japan. Jour. Met. Soc. of Japan, Vol. 32, 1954, 85-95.

¹⁴ Ramage, Bull. Amer. Met. Soc. Vol. 33, op. cit., 309.

Summary and Conclusions

One may doubt whether bona fide monsoon circulations are an adequate explanation of the seasonal climatic phenomena of southern and eastern Asia. The evidence is fairly strong that many of the region's distinctive climatic features result from large-scale changes in atmospheric circulation patterns associated with locational shifts of the jet streams. In these seasonal shifts in the jet the highlands of central Asia, with their excessive altitude but short latitudinal extent, play an important role. The splitting of the zonal westerlies in winter so that a high-velocity and positionally-stable jet is anchored along the southern slopes of the Himalayas, carries in its train important climatic consequences. Through the jet's regenerating and steering effects upon perturbations it localizes the winter precipitation of northern India-Pakistan and of South China. On the equatorial side of the Himalayan jet

strong subsidence acts to create the dry seasons of winter and spring, especially on the subcontinent. The weaker and locationally less stable northern branch of the winter jet, to the north of the Central Highlands, has no such regionalizing effects on winter precipitation as does its more stable southern counterpart. In the Tibetan lee-convergence zone between the two winter jets, is a region of strong cyclogenesis, the perturbations which originate there markedly influencing the winter rainfall of South China.

Concurrent with the disappearance in early June of the Himalayan jet from its southern winter position to one north of the Central Highlands, there is a rapid northward surge of equatorial air over southern and eastern Asia, which in turn ushers in the summer rainy season with the "Burst of Monsoon" in India and the beginnings of the Baiu rains in southern China and Japan.

BERICHTE UND KLEINE MITTEILUNGEN

GEOGRAPHIC RESEARCH AND TEACHING INSTITUTIONS IN THE SOVIET UNION

Notes on a Trip to the USSR in May-June, 1957

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1. *Academy of Sciences of the USSR*
 - a. Division of Geology and Geography
 - b. Institute of Geography
 - c. Geographic Section, Institute of Scientific Information
2. *Geographical Faculties of Universities*
 - a. University of Moscow
 - b. University of Leningrad
 - c. University of Kiev
3. *Pedagogical Institutes*
 - a. Herzen Pedagogical Institute, Leningrad
 - b. Lenin Pedagogical Institute, Moscow
4. *Economics Institute of GOSPLAN, Moscow*
5. *All-Union Geographical Society, Leningrad*

Although I have long been interested in the geography of the Soviet Union my first trip to this country was in the summer of 1957. Travel at this time was made possible by the opening of the USSR to foreigners for 30-day tourist visits.

The main value of my trip was not research on some geographical topic or area in the Soviet Union but the meeting of many Soviet geographers and the visiting of several geographic institutions¹).

I was deeply impressed by (1) the friendliness of Soviet geographers and their sincere desire for international contacts, for learning about geographic work in other countries, and for the international recogni-

tion of Soviet work, and (2) the tremendous scale of geographic training and research programs in the Soviet Union.

A warm reception was extended to me. In particular, the Soviet geographers who had participated in the 18th International Geographical Congress in Rio de Janeiro in 1956 helped to establish contacts with other Soviet geographers and with research and training institutions. Altogether I was able to talk in small groups with about 140 geographers.

I was asked to talk about the organization of American research in geography at the Institute of Geography of the Academy of Sciences of the USSR and this talk was later published²). I was also invited to lecture on American agriculture at the All-Union Geographical Society in Leningrad and before the

¹) For general accounts of geography in the universities and the Academy of Sciences of the USSR see:

Dresch, Jean: „L'Enseignement de la Géographie et la Recherche en Union Soviétique“, *Annales de Géographie*, No. 345, Vol. 64 (September-October 1955), pp. 378—386.

Ryabchikov, A. M.: „Geographical Education in State Universities of the Soviet Union“, paper presented to International Geographical Seminar in Aligarh, India, Moscow, 1955, 18pp. and map (processed).

Kalesnik, S. V.: „Podgotovka Issledovatel'ia i Prepodavatel'ia Geografii v Universitetakh SSSR“, in *Voprosy Geografii, Sbornik dlia XVIIIgo Mezhdunarodnogo Geograficheskogo Kongressa (Akademii Nauk SSSR, Geograficheskoe Obshchestvo Soiuza SSR)*. Moscow-Leningrad: Izdatel'stvo Akademii Nauk SSSR, 1956, pp. 18—23; also available in French as *S. V. Kalesnik*, „La formation des explorateurs et des professeurs de géographie dans les universités de l'URSS“, *Essais de Géographie, Recueil des Articles pour le XVIIIe Congrès International Géographique*. Moscow-Leningrad: Izdatel'stvo Akademii Nauk SSSR, 1956, pp. 18—23.

²) *Vestnik Akademii Nauk*, 1958, no. 2. pp. 23—30.