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My tryst with the monsoon

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Pune where I was born and brought up has for a century and a half been in the forefront of the struggle for the liberation of women. My grandfather, a physician, was a freedom fighter, and many of his fellow participants in the struggle against the colonial rule were regular guests at our house. My father, a physician with an M.D. in allopathy, had also studied the Indian systems of medicine, Ayurveda and Yoga, in depth. My mother was one of the members of a thriving group of women writers in Marathi.

I am the third of four daughters. My parents encouraged us all to study and take to learned professions; two of my sisters are physicians. I also did well in school and college, so I was destined to become a professional!

I studied in a primary school in Pune, before moving to Rishi Valley for my high school education. At Rishi Valley, we were encouraged to study what we wished, as we wished, without any pressure to score good grades. I adopted the same carefree approach for my undergraduate studies at Fergusson College, back in Pune. Madhav, the fellow student whom I eventually married, claims that I caught his attention when jumping out of a high French window of a lecture hall to escape from a boring class! I had enjoyed mathematics from a young age and decided to

continue in the science stream rather than joining an engineering college. I went on to do a master's degree in Applied Mathematics at Pune University. At this juncture, I became engaged to Madhav who comes from an academic family. From the outset he was keen on both of us actively pursuing a career in science.

Madhav and I felt that a sound foundation for such a career might be laid in a good university abroad and luckily we were both admitted with scholarships to Harvard. I was a graduate student of applied mathematics, and with my interest in the natural world, decided to work in physical oceanography with Prof. A R Robinson. The course work equipped me with an excellent grounding in applied mathematics and physics. Because of Madhav, I also developed an interest in mathematical ecology and evolutionary biology and began some work in that field. Amongst the many advanced courses I took, one was on planetary fluid dynamics, taught by Prof. Jules Charney, who has made fundamental contributions to tropical meteorology. After my Ph.D. I decided to focus on the monsoons, surely the most challenging problem in tropical meteorology and of such vital concern to us. So I did a year's post doctoral work with Prof. Charney at MIT. During my graduation days, there was an outstanding group of geophysical fluid dynamicists between Harvard, MIT and Woods Hole Oceanographic Institute. Perhaps the most important part of my education at Harvard and MIT was learning the art and science of modeling of complex systems from stalwarts in the field. This gave me the confidence to undertake modeling studies of not only the monsoon, but also of crops and to develop simple models for the impact of pests and diseases on crops in a variable climate.

In 1971, Madhav and I came back to India and for two years I worked as a CSIR pool officer at the Indian Institute of Tropical Meteorology. This gave me an opportunity to learn from the great tropical meteorologists like R. Ananthakrishnan and to work with the distinguished monsoon meteorologist D R Sikka. Thus began my lifelong passionate involvement with the monsoon. Fortunately for me, Satish Dhawan, then director of the Indian Institute of Science in Bangalore, was fascinated by the monsoon as a challenging problem in fluid dynamics. So he

recruited me as one of the members of the newly founded Centre for Theoretical Studies (CTS) comprising an interdisciplinary group of scientists engaged in modeling complex systems, including biological systems, the atmosphere and the oceans. Madhav was also hired as a mathematical ecologist at CTS. Out of these beginnings grew the Centre for Atmospheric and Oceanic Sciences (CAOS). CAOS has made very important research contributions and played a major role in the formulation and implementation of the Indian Climate Research Programme, providing leadership for major observational experiments over the surrounding seas in the raging monsoon.

Over the years, in collaboration with many scientists at IISc and other institutions in the country, I have studied the 'How and Why' of monsoon variability, with analysis of conventional and satellite data and investigations of models of varying levels of complexity to understand the mechanisms responsible for important phenomena. I have worked on the formulation of the methodology for application of the knowledge and prediction of rainfall variability for farming strategies and also on modeling ecological and evolutionary phenomena. One of the most satisfying pieces of work involved a study of the daily satellite imagery of the Indian region and the surrounding seas which led to the discovery of a basic feature of the sub-seasonal variation in the monsoon cloud bands. We showed that in each monsoon season, cloud bands are generated over the equatorial Indian Ocean and move northward to the Indian region at intervals of a few weeks. This demonstrated that the variability of the monsoon is inexorably linked to that of the cloud systems over the surrounding ocean. Our endeavour to understand what leads to the variation of cloud systems over the tropical oceans led to another important discovery: the presence of a threshold for sea surface temperature above which there is a high propensity for occurrence of cloud systems. The validity of both these results obtained from analysis of the first satellite datasets has been confirmed with the better quality datasets now available. From these studies we have also demonstrated that the monsoon is not a gigantic land-sea breeze (as we are taught in schools) but instead is a manifestation of the seasonal migration of

a planetary scale system which is seen over non-monsoonal regions as well. I am particularly excited about the recent work in which we showed that the variability of the monsoon is linked to that of cloud systems over the equatorial Indian Ocean. It may be possible to use this link to enhance the skill of monsoon predictions. Since we meteorologists always stress the importance of studying the monsoon in an agricultural country such as ours, I tried to learn from farmers in the semi-arid tracts of Karnataka whether information and prediction of rainfall variability could, in fact, lead to enhancing production in the rainfed tracts. In collaboration with the farmers we have derived farming strategies which are tailored to the rainfall variability of the region.

I have thoroughly enjoyed trying to develop a comprehensive understanding of the monsoon, a tantalizing mixture of order and chaos. I have never participated in the scientific rat race. Yet my contributions have more often than not, received the recognition they deserved. I believe that active encouragement from Madhav, who always had more faith in my abilities than I did, has played a crucial role in whatever I have achieved. I have been fortunate in having a wonderful family. We have a vivacious daughter, a journalist who also teaches Spanish. She is married to an innovative and enterprising mechanical engineer. They have two lively daughters who are a source of unmitigated joy. My son is a dedicated mathematician with wide ranging interests, and has made critical contributions to two of my recent papers. He has married the daughter of another meteorologist. She is currently doing a Ph. D in management sciences. As a family we share love for nature and I have spent many a happy hours with them watching birds, butterflies and elephants as well as clouds, stars and comets.

I have always been treated as a capable scientist who happens to be a woman rather than as a woman scientist, and never experienced any gender discrimination. Over the last three decades, as a working scientist in India, I have never witnessed any discrimination against women whether in selection of students or for jobs, or in assessment for promotion. In this congenial atmosphere, I believe that women have every opportunity to achieve their potential as scientists.