This text, for consideration to San Diego Union Tribune consists of 3 parts: (a) „A Story About Delayed Monsoon" written by A. Holdys for the polish newspaper „Gazeta Wyborcza", translated by Piotr Flatau; (b) Maria Flatau comments on basics tropical circulation, (c) Interview with Dr Roland Madden who discovered Madden-Julian Oscillations in 1971. Additional illustration can be provided upon request.

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A Story About Delayed Monsoon

By Andrzej Holdys

(Translated and modified by Piotr J. Flatau from the text which will appear in the „Gazeta Wyborcza", www.wyborcza.pl on March 3, 2002)

Bad monsoon forecast costs India billions of dollars. Perhaps new research will lead to smaller loses.

Weather forecasting is not particularly rewarding unless one forecasts for San Diego. But in Denver, for example, there is no weather forecaster with a perfect record; small pressure oscillations or a barely visible temperature fluctuation and all calculations can go wrong.

In the deep tropics a weatherman deals with extremes such as tropical cyclones or monsoon floods. Tropical meteorology is a science for people with strong nerves. When the sun is overhead the emotions run high.

In the last year Maria and Piotr Flatau from the Scripps Institution of Oceanography in La Jolla, California, and the Naval Research Laboratory in Monterey found themselves in the middle of the most important discussion to more than a billion of Hindus – the onset of the summer monsoon.

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- This story begins from a buoy tossed to the Arabian Sea close to the shores of Africa - describes Maria Flatau. In the tropics the air and sea are constantly interacting with each other. Atmospheric winds, rains, clouds, and countless weather events influence the oceans, and the oceans in turn influence the weather. This interaction between the two elements is particularly close and complicated, and to decipher them, computer models, chewing zillions of data each day, often leave no clues for the scientist.

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We are all accustomed to weather vagaries, but in San Diego it may rain on occasion, which makes at worst the weekend mildly unpleasant.

In the deep tropics the weather extremes often decide about life or death. The weather there likes extremes, but it can also be surprisingly benign. The problem appears when the weather turns out to be unpredictable.

Summer monsoons have for thousand of years set the rhythm of life for the people of India and South-East Asia. Similar winds blow in Africa, Australia, and Indonesia, but only in India is it so well defined. Here, the vastness of the Indian Ocean borders with the huge Indian sub-continent. There is no such other place on Earth.

The air over India warms quickly in summer. When it rises over the warm land, the colder air blowing from the ocean replaces it. This is the monsoon – the strong and vast wind system, which brings rain and floods. These may be devastating. But it is even worse if the rains do not come. The calm weather and the sun overhead are destructive.

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The monsoon comes to India from the south. People, animals, and plants wait for the water. The weather is dry and hot. The sun gets higher and higher with each passing day, and the temperatures become unbearable. One hopes for shade and water.

The relief comes with the monsoon rains. This gigantic sea breeze begins to blow towards the scorched land sometimes between May and June. Officially, the monsoon season starts in India around June 1. People are counting the days and waiting for information from the Southern-most tip of India – the Kerala province - where the monsoon starts.

But sometimes, May comes and goes and there is no news about the rains. It becomes hot and dry. In this country of more than a billion people, the longer the monsoon delay, the stronger chance for the commodities market to become destabilized.

This is why the Indian government would give large rewards to a person who could forecast the monsoon onset and its subsequent progress months in advance. But this is a difficult task, perhaps impossible. The monsoon onset depends on many conditions, sometimes far from India, in the equatorial Indian and Pacific oceans. In this huge sauna, composed of the ocean and the atmosphere, everything can be the cause and effect.

Researchers shake their heads watching such dynamical systems. Many give up. But the monsoon vagaries are too important to ignore. And the scientists are persistent. They don't believe in chaos and try to find out what governs nature. The monsoon is a perfect challenge for them.

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Maria Flatau got interested in the monsoon onset problem in 1999 when her husband came back to San Diego from a research cruise in the Indian Ocean. He studied air pollution at that time, but when the ship crossed the Equator on meridian 60E, the seas were eerily calm. This is the place in the Indian Ocean where powerful cloud systems and storms, of the size of half of the United States, generate.

- In these large cloud complexes twin cyclones are born. One twin moves towards the South and the second towards the North. Off the equator they turn towards the west. Between them, the westerly winds blow. But this time the clouds and the winds were gone – Piotr Flatau reminisces. He was intrigued but did not pursue the topic. But his wife, Maria did.

- Why is the monsoon late? Perhaps something is delaying its course? But what is it? We looked with Piotr for the answers. At the end we decided that the unusual rainfall pattern in the beginning of May is the culprit. After that, a long lasting draught sets in India. We called this pattern the bogus monsoon onset – Maria Flatau comments.

The researchers went through 40 years of the data. They found several cases of bogus onset, which convinced them that they were following a good lead. They had to answer two more questions. How were these rainfalls in the beginning of May occurring and how do they prevent the monsoon onset? After many months of analysis, checks of satellite data, tests of different scenarios they formed the model describing the phenomena of monsoon delay. Together with Scripps' physical oceanographer Professor Daniel Rudnick they published a paper in the Journal of Climate at the end of 2001.

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Why are the monsoons delayed? – Partly, it depends on the break in harmony of the atmospheric circulation over the Indian Ocean and the Pacific. These are pressure and wind waves which circle around the globe. They are called intra-seasonal oscillations or Madden-Julian Oscillations (MJO) – Maria Flatau comments.

Madden-Julian Oscillations move about 5 to 10 meters per second. During one day they travel several hundreds of kilometres. They form in the deep tropics every 30-60 days. It is largely unknown when they form. More and more research indicates that MJOs trigger the summer monsoon. There is also some evidence that MJOs help trigger the El Nino. These disturbances do not cause the monsoon, but when the system is ready, the MJO comes and provides the decisive kick to begin the monsoon.

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- Since MJOs appear irregularly and their propagation speed varies, nobody has deciphered the rhythm yet. All goes to hell when the disturbance shows up in the

Equatorial Indian Ocean in the beginning of May when the monsoon is still not ready to move north. It is maturing – says Maria.

Such premature oscillations generate twin cyclones, one of them moves towards the North in the direction of India. Several weeks latter it would have been a forerunner of the monsoon. But now it is just a lost soul hovering over vast expanses of the warm ocean waters. This is the cyclone, which often brings early May precipitation to India and it is followed rather quickly by a drought.

But even more profound is that the “lost cyclone" cools the ocean surface thanks to its strong winds. In several days the temperature in the Bay of Bengal decreases by several degrees Fahrenheit. Not much? Maybe be so, but not for the monsoon. It cannot begin on time. It waits several weeks before the ocean warms up and is ready for the next MJO oscillation.

-As you can see, in the beginning of May one can predict if the monsoon will come on time, or if it will be delayed. The ocean and the atmosphere send us signals in advance – says Maria Flatau.

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Neither she nor her husband were aware that the hypothesis put forward in their distant offices at Scripps, would be tested by mother nature rather quickly. Well, they observed the Indian weather with some interest after they published their paper. But, their idea was supposed to work once every several years. Yet, ….

-In the beginning of May 2002 I received an email from the science correspondent of “The Hindu" asking me to comment about the monsoon onset. I looked at the maps and I noticed that the MJO just crossed the Equatorial Indian Ocean. I realized that the monsoon might be delayed. And I wrote back to him about it – says Maria Flatau.

Meanwhile, in India, the worst drought in many years was about to happen. On May 22, 2002 the Associated Press informed that the death toll from a heat wave that has gripped southeastern India rose to 1,030. "There seems to be no end to our suffering," said P. Venkateshwara Rao, a fish farmer in the town of Kaikalur. "We are totally helpless in the face of relentless heat. It is the highest one-week toll on record for any Indian heat wave, meteorologists said. "Everyday we are looking toward the sky with the hope of some cloud cover and rain," said Sai Ramesh, a trader in Rajahmundry town. "But after some relief, things are even worse." In the hardest-hit districts, mostly on the Bay of Bengal, the heat was so intense that tin-roofed shanties turned into ovens, ponds and rivers dried up, birds fell from the sky and animals collapsed.

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Two weeks later Indian climatologist Dr P. V. Joseph, former director of the India Meteorological Department, issued a forecast that the 2002 monsoon would be delayed by two weeks. Joseph is a well-known tropical meteorologist who established himself as an expert on monsoon research. In the beginning of 90s he wrote paper on the climatology of monsoon onsets, but he never predicted them in the past.

Joseph emailed his forecast to researchers in India and throughout the world including Maria and Piotr Flatau. The next day the information about the forecast appeared in "The Hindu." The text included comments from Maria who predicted the delay. This way we began a bit of competition with the Indian Meteorological Department (IMD). When Joseph put his neck on the line, and I supported him, we were both on the same wagon – mentions Maria.

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The night of 29 of May 2002 was stormy. The southern Kerala was covered with heavy clouds. The information went to the rest of India that the monsoon came in on time, even three days in advance. The IMD declared the monsoon onset, and the prediction of the Indian scientist and the US-Polish researchers turned out to be wrong. But did they?

The next day the sky over India was clear again, and tourists in Goa were basking in the sun. The rains trickled here and there but the torrential rains of the mighty monsoon did not materialize. Both Joseph and the Flataus maintained that the monsoon was delayed contrary to the IMD statement.

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Recently, Maria Flatau and Jerry Schmidt of NRL Monterey analysed events of the last summer. They looked at the satellite data from the Tropical Rainfall Mission (TRMM), which collects information about the rain in the tropics. The researchers checked ocean temperature, wind speed, cloudiness, relative humidity, and, of course, rainfall. They used a numerical weather model.

- I don't have any doubts that last year's monsoon in India was delayed till June 13th. The early rains were associated with local thunderstorms and the big wave of moisture carried by the Findlater Jet came to India in the mid-June – says Piotr Flatau. They and J. Schmidt prepared manuscript, which they submitted to Geophysical Research Letters. Dr Joseph prepared also his own publication where he showed that the monsoon was delayed.

- Our work shows that one can forecast the monsoon delay with one-month lead-time. Clearly, we cannot show this precisely yet. But perhaps in the years to come we will be able to provide more definitive forecasts – summarizes Maria Flatau.

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The monsoon of 2002 captured the attention of many researchers. Peter Webster, one of the most outstanding monsoon researchers, has been developing a monsoon rainfall forecast in India during the last year. With his students at the Georgia Institute of Technology, he tested the scheme on forecasting the intraseasonal precipitation in the Ganges and Bangladesh regions. There are hundreds of millions of Hindus in these regions and their existence depends on farming and consequently on the timing of the monsoon rainfalls.

In hindsight, Webster also forecasted that the monsoon of 2002 was delayed. His dream is to develop monsoonal rainfall prediction for one month in advance. He claims that his model - based on similar physical principles to that developed by the Flataus - allows for a good forecasts 20-25 days in advance.

If we learn how to properly forecast the intraseasonal monsoon rainfall, it will be an achievement on the scale of a second "green revolution" - says Webster.

Untill now, bad forecasts have caused gigantic losses. The 2002 monsoon was so important to so many not only because it was delayed, but also because the overall precipitation was much below average.

According to independent scientists, the Indian Meteorological Department (IMD) completely missed the forecast for July 2002 - the month when almost ½ of all the rain falls on average in India. IMD forecasted a normal amount but the rain just trickled. According to Webster in the Ganges region alone the losses averaged $6 billion.

This shows that good forecasts are priceless.

Oscillations, Monsoons, and Cyclones

By Maria Flatau

Around 1735 British physicist George Hadley (1685-1768) described the tropical circulation model in which warm and moist equatorial air of the Northern Hemisphere moves upwards, travels North and descends in the subtropical regions.

The Hadley circulations would result in a perfect symmetric circulation all over the globe but such is not the case. “It is a natural supposition that there should be in weather free oscillations with fixed natural periods, and that these oscillations should persist except when some external disturbance produces discontinuous changes in phase or amplitude” — wrote Sir Gilbert T. Walker. He discovered so called Walker Circulation, a large-scale circulation consisting of sinking and rising air between the eastern and western Pacific. Walker was appointed the Director General of Observatories of India's meteorological department in 1904, just after the catastrophically dry 1899 monsoon season. He was one of the first who tried to understand the Indian monsoon.

In 1971 Roland Madden and Paul Julian observed in the tropical atmosphere pressure oscillations propagating with 40-50 days. These oscillations travel around the globe like waves but are confined to the Equatorial regions. Later, the wave was named intra-seasonal oscillation or Madden-Julian Oscillation (MJO). The MJO cause all kinds of havoc, or order, depending on your point of view. There is even “burst" hypothesis of the El Nino onset, which is based on the MJOs ability to push warm water towards the Eastern Pacific in a sequence of bursts.

The onset of monsoon is sometimes, but not always, associated with the MJO propagation. On occasion MJO spawns tropical cyclones, which propagate towards the West, against the main phase speed of the MJO. At the last month's general meeting of the American Meteorological Society, Professor Peter Webster (Georgia Tech) described a forecasting model of floods in Bangladesh tied to the MJO propagation and other predictors. Coupled ocean-atmosphere predictions of the MJO are one of the hottest topics of tropical meteorology.

Interview with Dr Roland Madden

by A. Holdys, scientific correspondent of the „Gazeta Wyborcza".

Dr. Roland Madden retired from the National Center for Atmospheric Research in Bolulder, Colorado this year. He moved to the suburbs of San Diego and plans to continue his research, on occasions, at the Scripps Institution of Oceanography.

[Holdys] You published your seminal paper with Julian in 1971. Could you tell how you discovered this phenomenon? What were the meteorological fields you analysed? How the subsequent advances in technology (satellites, etc) influenced the understanding of the MJO?

[Madden] We were looking at tropical weather phenomena that had time scales of roughly 3-10 days. We had some very long time records of pressure and wind from Canton Island (2S, 177W) and they allowed us to look at longer time scales too. We

noticed some "extra" variability occurring on 45-day time scales. No one had previously mentioned that. We looked then at data from other stations in the tropics and found that whatever caused the "extra" variability seemed to be moving from west to east. This too seemed new since most tropical activity was thought to move to the west with the trade winds. Based on wind and pressure data we built a picture of the disturbance which suggested that there must be convection, or storminess associated with it. In those early days we had no cloud data to confirm this. Satellite data was becoming available and by the early eighties it confirmed our prediction of a large-scale eastward propagating near-equatorial stormy area. It is now known, because of newer data, that the MJO affects ocean temperatures, weather in the tropics, hurricanes and even the rotation rate of the earth.

[Holdys] What was the initial reaction to your findings? What was the role of the FGGE experiment in understanding of intraseasonal interactions in tropics?

[Madden] The initial reaction was a mild interest but there were no other data sets available to check or confirm or expand on our results. There may have been half a dozen papers referencing our work during the seventies. During the northern summer phase of FGGE there were at least three strong MJOs. This began what is now a very big interest in MJOs

[Holdys] The research on MJO seems to be one of the most active fields in equatorial dynamics. Do you try to follow all of the new developments? Is there a room for new discoveries in the tropical meteorology?

[Madden] I really can't keep up with all the research. I am happy to note that although a great deal has been learned in the past 20 years about the MJO, much of it was contained to a lesser extent in our paper 30 years ago. With respect to new discoveries - we were lucky because we were the first to look at long, daily data records from the tropics. There are other new data sets that I think will yield similarly interesting surprises. One is the scatterometer winds measured over the world oceans by satellite. There are many new data and variables that are being measured in the tropical oceans and they too will yield important findings in the not distant future.