

Scientists have just returned from a groundbreaking research campaign to understand the Indian monsoon. Andy Turner reports back.

Solving the mysteries of the monsoon

The Indian monsoon is among the most dramatic examples of the annual cycle. As winds change from winter to summer, they bring much-needed moisture from across the ocean and supply India with 80 per cent of its annual rainfall between June and September.

But there is a problem: we can't make good monsoon forecasts more than a day or so ahead. Farmers, industry and policymakers want predictions weeks, seasons or years ahead, but it's difficult to offer reliable information.

The models we use for monsoon forecasts often don't represent the physical processes controlling the timing, intensity and duration of rainfall. Perhaps they are not at high enough resolution – the grid on which physical equations are solved is too coarse – and we don't have enough observations of the real tropical environment to properly design our models in the first place.

We hope to go some way to solving the monsoon problem with results from our recent field campaign for the INCOMPASS project. We used the FAAM research aircraft from before the onset of monsoon rains in early June into mid-July to fly over coastlines, deserts and mountains in northern and southern India. Together with our partners we also installed several instrument towers to measure the moisture and heat passed between the surface and atmosphere, and also launched several radiosondes (weather balloons).

We hope the information we gathered will help answer vital questions about the monsoon in India and its relationship with Earth's surface:

- How does the temperature and humidity of the atmosphere change moving across from the Indian Ocean, across the coastline of India and across mountains?
- How do the transitions between sparse desert regions and moist agricultural landscapes affect the development of monsoon storms?
- Do small showers before the monsoon provide moisture that helps prepare the atmosphere for more violent storms later?

This was the aircraft's first visit to India, and the first time foreign airborne research has been performed there for such a long period. INCOMPASS is part of the most ambitious atmospheric observational campaign yet by NERC scientists.

Such unique fieldwork brought its own hurdles. How would we get permission to fly for research in a nation more familiar with commercial air traffic? How would scientists and engineers cope with working in the extreme heat and humidity of monsoon India? All of this required months of planning and negotiation.

Once in India, flights had to be planned meticulously: flight-plans had to be filed with the authorities around two days in advance. This made accurate forecasting of the weather vital since we had to know in advance where we could find the most interesting data. Using a specially developed Met Office model, each day we worked with our Indian colleagues to forecast the monsoon and plan the best routes.

By consulting air traffic control during flights, the pilots could then choose a variety of altitudes to get the data we wanted. Sometimes we spent an hour or more only a few hundred feet above mountains and fields! We measured variables including temperature, humidity, and atmospheric radiation. Other on-board instruments such as the lidar, which works like radar except with lasers instead of radio waves, looked at the layers of cloud and dust towards the ground.

The fieldwork was exciting and at the same time exhausting – it represents a fantastic effort from many across India and in the UK. Now it is over, the rest of the science begins: we'll spend the next few years analysing data and solving some of the problems of the monsoon.

The Drivers of Variability in the South Asian Monsoon programme

INCOMPASS (Interaction of Convective Organisation with Monsoon Precipitation, Atmosphere, Surface and Sea) is one of three projects jointly funded by NERC and India's Ministry of Earth Sciences from 2015-2018. It is led jointly by University of Reading and the Indian Institute of Science, including researchers at the University of Leeds, Met Office, Centre for Ecology & Hydrology and a host of other Indian partners. Other projects under the programme are SWAAMI and BoBBLE. The INCOMPASS field campaign was recently completed between May and July 2016, involving airborne and ground measurements.

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