Establishment (Farnborough) under an agreement between ESA and NASA.

The performance of a satellite's sensors must be assessed against reliable surface observations and the question now being asked of the SEASAT mission is whether sufficiently diverse surface data were obtained last summer to satisfy the main 'proof-of-concept' objective. A special data-gathering cruise was organised by the US National Oceanographic and Atmospheric Administration (NOAA) in the Gulf of Alaska during a 4-week period in August-September 1978. Observations of wind, waves, temperature and other parameters were made by two ships, four aircraft and an array of surface buoys. A detailed comparison between these observations and the signals from SEASAT's sensors was made recently during two workshops held at the Jet Propulsion Laboratory, Pasadena. More than 60 scientists and engineers from several oceanographic and space research centres were involved and the preliminary results for each sensor have been reported in *Science* (**204**, 1405-1424; 1979).

The scatterometer task group had evolved three candidate algorithms which made slightly different assumptions in relating the measured scattering coefficient to the wind vector as a function of incidence angle, azimuth angle and polarisation. Since these were largely constructed from a limited set of aircraft measurements it is not surprising that the satellite models required some modifications especially with regard to determining wind direction unambiguously. An analysis of some 30 comparisons showed the scatterometer winds to be biased high by 1.9 m s^{-1} with a standard deviation about this bias of 1.8 m s^{-1}. When the scatterometer values were compared with wind fields produced by kinematic analysis techniques (as opposed to spot measurements) wind speed differences were in the range 1.1–5.2 m s^{-1} (scatterometer higher) and for direction the means were less than 10° with standard deviations of approximately 20°. Wind speeds were generally low throughout the experiment and part of the observed differences may be attributed to errors in the surface spot observations.

The scanning microwave multi-channel radiometer (SMMR) measured Earth's radiation at five microwave frequencies at both vertical and horizontal polarisation. The algorithms to extract sea surface temperature and wind speed are correspondingly complex since they involve ten values of brightness temperature with different weightings according to frequency, to the antenna pattern, and to the amount of cloud and rain present. Over open ocean the best wind speed determinations gave a standard deviation of 3 m s^{-1} about a bias of 1.5 m s^{-1}. Sea surface temperature estimates were disappointing with a standard deviation of 1.5 °C about a bias of 3-5 °C. However, further analysis may determine the cause of the bias and suitable correction can be made. The SST value is averaged over a footprint approximately 120 km on the side.

In validating the performance of the radar altimeter the GOASEX data were used to calibrate only significant wave height and radar backscatter; the calibration of the altimeter's height determination was made over a range in Bermuda. During its last few weeks of operation SEASAT was manoeuvred into a frozen orbit pattern which allowed it to pass over Bermuda every 3 days. The calibration range included high precision tide gauges and a laser tracking system. For four overhead passes where laser tracking was possible the weighted mean bias in the altimeter-derived height was -50 ± 11 cm (over a height of 800 km). During the engineering assessment of the altimeter the noise in the height measurements for a 4-m significant wave height was 5-8 cm. If relative changes of this order can be detected in sea surface topography than valuable information can be obtained on ocean circulation patterns, eddies, tides, and the marine geoid. For this reason, the altimeter represents perhaps the greatest loss to the oceanographic community.

There was some lively discussion before the synthetic aperture radar was flown on SEASAT as to its ability to image surface waves. SAR sweeps out a 100 km swathe centred about a point 250 km to the right of the satellite's sub-orbital point. Each target remains in the radar beam for about 2 seconds and it was argued that in this time the movement of the shorter capillary waves which scatter the L-band energy could be more than enough to blur the return image. And since the detection of the larger gravity waves was seen to depend on their modulation of the shorter waves, it seemed doubtful if they could be detected. In the event, SAR produced several images of swell waves not only in the Gulf of Alaska but in other ocean areas including those covered by the Oakhanger station. Wave directions can be estimated to a few degrees and wave length greater than about 100 m appear to show clearly, given a certain minimum significant wave height (apparently around 2 m), certain minimum wind conditions and, up to the present, a wave direction predominantly across the satellite track. Apart from imagery of surface swell the SAR record analysed to date has shown remarkable examples of internal wave trains, surface pollutants, ice features in the Arctic, and details of shallow sand banks in the Channel and other shallow water areas around the UK. Its fine resolution (25 m against Landsat's 80 m) and its independence from adverse weather conditions have now aroused the interest of land surveyors and geologists.

Before the launch of the spacecraft the SEASAT Users Research Group of Europe (SURGE) had submitted a list of proposed experiments to NASA and as a result SAR was activated over a number of European sites. The most important of these was JASIN — a Joint Air-Sea Interaction experiment in a comparatively small area close to Rockall in which up to 14 research vessels, 3 aircraft and 35 buoys took measurements in the period mid-July to mid-September. Although SEASAT's early demise is proving inceasingly regrettable as its results become available, it was a piece of extremely good fortune that one of the most intensive research programmes of sea-surface observations took place during its short life. Now that the sensor algorithms have been refined and modified following GOASEX, the JASIN data should allow a comprehensive assessment of the performance of each microwave sensor. It may still be possible to go a long way towards reaching SEASAT's first objective — to prove the concept of reliable remote sensing of the seas from satellites. □

100 years ago

It may interest our readers to know the elevations which at present are reached by lines of railway in different parts of the world. The Apennine Railway reaches its highest point at an elevation of 617 metres above sea-level; the Black Forest Railway ascends to 850 metres, the Semmering line to 890, the Caucasus line to 975 metres. The St. Gothard tunnel is 1,154 metres above sea-level; the railway across the Brenner reaches 1,367 metres; the Mont Cenis Railway ascends to 1,338 metres, the North-Pacific line to 1,652, the Central-Pacific to 2,140, and the Union-Pacific to 2,513 metres. The highest of all is the line across the Andes, which reaches an elevation of 4,769 metres.

We have on our table the following works: — "The Spiders of Dorset," Rev. O. Pickard Cambridge; "Chemical and Geological Essays," by T. Sterry Hunt (Trübner); "Deaths in Childbed," Dr. Æneas Munro (Smith, Elder, and Co.); "The Silk Goods of America," W.C. Wyckoff; "Structural Botany," Dr. Asa Gray (Trübner); "Luxurious Bathing," A. W. Tuer (Field and Tuer); "Phrepology Vindicated," A. L. Vago (Simpkins); "On the Diffusion of Liquids," J. H. Long (H. Laupp); "Reform Essays on Incentive Religion and Warfare;" "Farming for Pleasure and Profit" (Poultry Keeping), Arthur Roland (Chapman and Hall); "Manual of Practical Anatomy," J. Cossar-Ewart (Smith, Elder, and Co.); "Rays from the Realms of Nature," Rev. James Neil (Cassell); "Jack's Education; or, How He Learnt Farming," Prof. Henry Tanner (Chapman and Hall); "Vocal Physiology and Hygiene," Gordon Holmes (Churchill); "Fauna der Gaskohle und der Kalksteine der Perm Formation Böhmens," Dr. Ant. Fritsch.

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