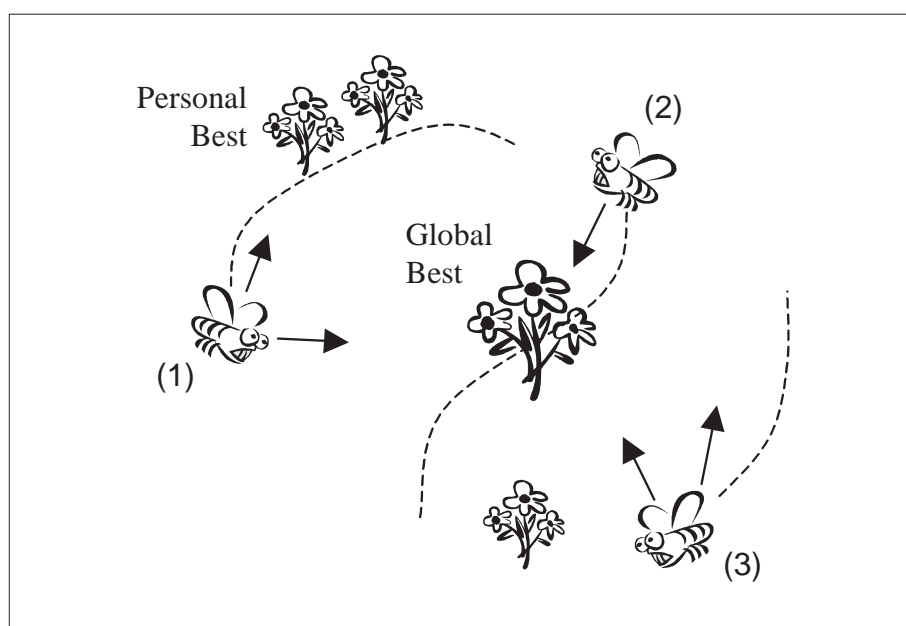
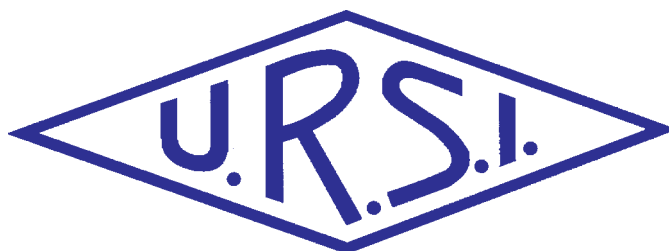


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# TENTH INTERNATIONAL WORKSHOP ON TECHNICAL AND SCIENTIFIC ASPECTS OF MST RADAR - MST10

Universidad de Piura, Northern Peru, 13 - 20 May 2003

Tenth International Workshop on Technical and Scientific Aspects of MST Radar - MST10 - was held 13-20 May 2003 at the campus of the Universidad de Piura in northern Peru. These international workshops are held every 2-3 years and comprise major events gathering together experts from all over the world, engaged in research and development of radar techniques to study the mesosphere, stratosphere and troposphere (MST). It includes also ionospheric coherent scatter radars and planetary boundary layer radars. It offers excellent opportunities to young scientists, research students and also new entrants to the field for close interactions with the well-known experts on all technical and scientific aspects of MST radar methods.

As a new approach, the workshop consisted of two major parts: (Section I) standard workshop papers presented orally or as posters, and (Section II) a brain-storming session with the aim to highlight open questions and potential solutions, to produce proposals for innovative approaches, define new programs and prepare recommendations and resolutions.

The Universidad de Piura (UDEP) is known in radar circles due to its operation of ST and boundary layer radars, which are part of the activities of the Instituto Geofísico del Perú (IGP), operating the Jicamarca Radio Observatory (JRO), in collaboration with institutions like the University of Colorado (via CIRES) and NOAA (via the Aeronomy Laboratory).

Sponsors of MST10 were the Scientific Committee on Solar Terrestrial Physics (SCOSTEP), the International Union of Radio Science (URSI), the National Science Foundation (NSF) of USA, Consejo Nacional de Ciencia y Tecnología (CONCYTEC) of Peru and various research and development companies.

The International Steering Committee of MST10 consisted of J. Röttger (Chair, Germany), J. Chau (Peru), S. Fukao (Japan), E. Kudeki (USA), and R. Woodman (Peru). Adherent to the International Steering Committee were the Chairpersons of the MST Radar Permanent Working Groups P. Chilson (USA), D. Holdsworth (Australia), G. Nastrom (USA), P.B. Rao (India), and M. Yamamoto (Japan). Honorary Members of the Steering Committee were M.F. Larsen (USA), C.H. Liu (Taiwan), A.P. Mitra (India). The National Organizing Committee of MST10 consisted of: R. Woodman (Chair, IGP), J. Chau (JRO-IGP), Antonio Mabres (UDEP) and M. Sarango (Ciencia Internacional). The Local Organizing Committee consisted of Rodolfo Rodríguez (Chair), William Ipanaque, and Sergio Balarezo. Session conveners and session chair persons were drawn from the international scientific community.

The workshop was opened on Tuesday morning, 13 May 2003, in the presence of the President of the Piura region, Dr. César Trelles, the President of UDEP, Dr. Antonio Abruña, the Dean of the Faculty of Engineering of



*Figure 1: Group Picture*



*Figure 2: Informal discussions during a coffee break (Dr. Roettger from Germany, Dr. D.N. Rao from India, and Dr. Y.H. Chu from Taiwan)*

UDEP, Dr. Sergio Balarezo, the President of the Instituto Geofísico del Perú, Dr. R.F. Woodman and the Chairman of the German Embassy and the Consulate in Piura were represented by R. Niemann and J. M. Irazola.

Participants were from 17 countries from all continents. A total of 175 abstracts had been submitted, and 109 oral papers (24 thereof invited) and 66 poster papers were presented. A tour of the university institutes and facilities as well as the radar systems took place on Thursday afternoon, which was followed by an outing to a nearby horse farm.

During the get-together on Monday evening and the workshop dinner on Thursday evening the workshop participants enjoyed north Peruvian-style folklore, and an extended tour took place on Sunday to visit the famous historical site of Sipan in the northern Peru region.

Public lectures at the university were given by R.F. Woodman on "Space exploration from the ground: Peruvian contributions to human knowledge", and by B.B. Balsley on "A half century of cooperation with my Peruvian colleagues". During the workshop dinner D.T. Farley spoke about his long-lasting experience with Jicamarca and corresponding episodes and adventures.

The hotel facilities were excellent, in short-walking distance to the university campus, and the local organizing committee, supported by Jicamarca personnel and university students, kept track of the very pleasant and highly functional workshop performance.

**Session I.1** was on radar scattering processes in the neutral atmosphere (convened by H. Luce and A. Muschinski). This session dealt with observational and theoretical investigations (1) on how to separate the effects of different scattering mechanisms in the same data set, and on (2) radar echo characteristics in different radar

configurations and their interpretations are presented. Emphasis of the papers was placed on contributions that discuss new observations (e.g., multi-beam, multi-frequency, multi-receiver, and/or multi-regime radar observations, also inter-comparisons with in situ measurements) on the basis of innovative, first-principle theoretical analysis. Invited talks were given by D. Fritts on direct numerical simulations of turbulence and radar backscatter, and by F. Dalaudier on combined radar and balloon observations. B. Balsley's kite observations, which show very thin structures in the lower troposphere point into the direction of understanding the highly specular radar returns as well.

**Session I.2** was on D-, E-, and F-region coherent scattering (convened by D. Hysell and R.D. Palmer). It was devoted to the theory and observation of coherent scatter from ionospheric irregularities at all latitudes. Papers were presented, pertaining to such mature fields of study as the auroral and equatorial electrojets, PMSE, sporadic E-layers, and equatorial spread-F. Recent and planned campaigns like SEEK II, C/NOFS, and CIELO attest to the fact that numerous problems remain unsolved in these areas. In addition, papers on emerging areas of research were given, including long-lived meteor trails, 150 km echoes, daytime spread-F, and mid-latitude spread-F. Novel experimental techniques such as passive radar, networked radar, radar imaging, and coherent scatter Faraday rotation may promote rapid progress in the areas outlined above. Reports describing new experimental radar techniques were given also in section II. Invited papers were given by E. Kudeki on 150-km echoes, J. Chau on E region studies at low-latitudes,

W. Singer et al. on PMSE, F. Lind on E region irregularities at high latitudes, and S. Fukao on the SEEK-2 campaign. Due to short-notice travel cancellation P. Chilson could not give his invited talk on PMSE.

**Session I.3** on winds, waves and turbulence in the lower and middle atmosphere and the lower thermosphere

was convened by W.K. Hocking and M.F. Larsen. This session examined recent developments of studies and observations of dynamics in the middle atmosphere and lower thermosphere. Topics of particular interest included wave-wave interaction, wave sources and generation mechanisms, wave deposition processes, non-linear interactions, wave propagation studies, turbulence anisotropy and turbulent transport processes. Correlations of wave events as a function of height, and multi-instrument studies were presented, and inter-comparisons of different techniques were considered to be important. One area of special interest was studies of wave velocity amplitudes and variability in the region above 90 km altitude, with particular interest in determining the frequency of occurrence of large amplitude events and large wind velocities (up to 100 m/s and higher) in this region. D. Fritts gave the invited presentation of P. Franke, who could not attend. This talk expanded the direct numerical simulation of turbulent structures. Investigations on gravity wave break down and the different kind of instabilities done by G. Klaassen were presented by W. Hocking. The invited review on turbulent diffusivity was presented by R. Wilson, and N. Gavrilov gave an invited talk on gravity wave and turbulence studies and drew attention on the possible relation of middle atmosphere gravity wave activity to El Nino.

K. Gage and D. Riggin convened **Session I.4** on meteorological phenomena and applications. It was concerned with recent developments in Doppler radar profiling in the lower neutral atmosphere, especially studies of lower atmospheric phenomena made with profilers in combination with other instruments during field campaigns. Topics of interest included the assimilation of profiler data in meteorological models, quality control of profiler data, operational networks of profilers and the impact of profiler data on forecasting. Of special interest were studies that demonstrate the utility of profiling for quantifying the vertical structure of turbulence, humidity, cloud and precipitation fields including drop size distributions and their variability. The invited talks were given by K. Gage (on behalf of S. Koch) on mesoscale analysis and prediction using wind profiler data and by C. Williams and K. Gage on rain drop size distributions deduced from profiler observations.

The operational aspects and recent system developments were handled in **Session I.5**, which was convened by I. Reid and D. Thorsen. The focus was on aspects related to the technical performance of radar systems and multi-instrument measurements. Papers pertaining to all aspects of technical performance of current and/or proposed facilities, including the unique problems associated with operation of remote stations were included. These aspects related as well to pros and cons of system configurations and measurement methods. It was addressed how multi-instruments can be used together to augment

scientific research as well as how measurements from diverse instruments (including models) may be appropriately compared.

Short reports and summary presentations on the **Permanent Working Groups (PWGs)** activities were presented at the beginning of the second workshop week. These PWGs deal with (1) system calibration and definitions, (2) data analysis, validation, and parameter reduction methods, (3) accuracies and requirements for meteorological applications, and (4) international collaborations and education.

This was followed by **Section II on "Novel perspectives and unsolved issues"**. To stimulate brainstorming in this section, several invited talks were presented. T. Sato and K. Kamino introduced an adaptive clutter rejection scheme for MST radars, W. Hocking evaluated diagnostic capabilities of measurements of backscatter anisotropy, H. Luce reviewed the future of the multi-frequency techniques, J. Röttger asked what is turbulence seen by VHF radars, W. Hocking et al. reported about potential applications of a world-wide network of mesospheric radars with special emphasis on the Columbia space shuttle disaster, A. and E. Praskovsky presented a structure-function-based approach to data analysis for spaced antenna radars, and J. Sahr proposed VHF parasitic radar interferometry for MST zenith sounding. These presentations lead to distinct lively discussions. These were summarized in the final plenary session together with reports on the oral poster sessions prepared by the chairpersons.

The **Plenary and Closing Session** was held on Tuesday afternoon and chaired by J. Röttger. It included discussions of the highlights presented in the oral and poster workshop papers of Section I and in particular important issues and questions raised in the presentations of Section II.

The written reports of the session conveners and chairpersons formed a suitable input for the final discussions, which concentrated on topics such as (to mention just a few): Identification of backscattering mechanism by statistical analysis and the Direct Numerical Simulation. Here the questions were how DNS can model turbulence decay and how one can expand the modeling for multiple gravity waves and their breaking. The question on the realistic meaning of the effective diffusivity and turbulence energy dissipation rate remains to be studied. A dominant item seems to be the contributions of ST radars for the studies of stratosphere-troposphere exchange. Interesting and not yet solved topics are the scattering mechanism of polar mesosphere summer echoes, their structure and inter-hemispheric difference. The creation and propagation of gravity waves from low altitudes to higher altitudes in the mesosphere and lower thermosphere, and their momentum and energy dissipation. Also the E- and F-region





*Other participants at lunch: D. Hysell (US), E. Kudeki (Turkey), J. Roettger (Germany), G. Lehmacher (Germany), H. Bahcivan (Turkey), J. Chau (Peru), C. Haldoupis (Greece), G. Hussey (Canada), G. Hassenpflug (South Africa)*

irregularities, leading to coherent scatter, are still a relevant item and open questions were summarized, such as their generation mechanisms and their relation to coupling with above (electric fields) and below (gravity waves and tides).

Several approaches are in use to analyze and interpret spaced antenna and interferometer observations and the pros and cons are disputed. Imaging techniques are highlights of the recent developments to understand the structure and dynamics of the atmosphere. A promising idea is to apply the parasitic radar method for lower atmosphere studies. Combination with other techniques, such as the application aspects of the wind profilers, providing data for improving forecasting and modeling, are a most recognized spin-off of the MST radar technique.

The activities of the Permanent Working Groups were evaluated and it was resolved that these groups, which are mostly dormant between workshops, should become part of a discussion group on topical issues, which should be introduced and handled via the internet. The present workshop homepage <http://jro.igp.gob.pe/mst10> forms a suitable forum for this purpose.

The normal abstracts of all papers were published by the local organizers in the abstract proceedings. Extended abstracts will be published on CD-ROM and as hardcopy, as usual, in the final workshop proceedings. An editorial team at the Jicamarca Radar Observatory takes care of this duty, supported by the steering committee. Full manuscripts can be submitted for potential publication in a special MST radar issue of the journal *Annales Geophysicae*. These manuscripts undergo the standard refereeing procedure,

where the guest editors are D. Hooper and D.N. Rao. A call for papers has been distributed to all, who had submitted abstracts for MST10.

Several proposals for resolutions were discussed. The one on educational issues aims towards continuing and expanding the international radar schools, such as ISAR, but also supporting the tendencies for establishing regular schools on national levels as well as forming permanent departments on atmospheric radar at universities and other institutions. Concentrated efforts should be undertaken, supported by a resolution, to understand the hemispheric difference and frequency dependence of PMSE using calibrated radar systems. To improve the understanding of dynamical processes in low latitudes, special campaigns and in particular a tropical network of radars on a global scale was proposed and is laid down in a resolution. In general it was felt that the MST radar technique, although basically mature, still expects further and deeper understanding of the atmosphere by introducing new techniques, establishing new observation sites and upgrading existing facilities. Another resolution covers research requirements to understand mid-latitude E-region irregularities. These resolutions will be published in the final proceedings and submitted to the sponsoring organizations as well as other governing agencies.

The character of the workshop was discussed and it was felt that the addition of a brain storming section to foster new directions has raised the quality of the MST radar workshop. It was decided to continue with these workshops, and also keep the time frame of 8 days, not starting on Monday and including one weekend. Invitations to hold the next workshop - MST11 - were received from Australia, Germany and India. It was noted that Australia had twice been candidate before, but the final decision was postponed to allow more information of the community about the possible venue.

The workshop was closed on Tuesday afternoon leaving in the minds of the participants proper updates on scientific research and technical developments, potential approaches of open questions, views into a promising future and most delightful impressions on the University of Piura and the appreciation of the whole-hearted contributions by the members of the local organizing committee.

Those, who were still present after the workshop had the chance to see the tropical sunset at the nearby ocean front of Colan, - an ultimate finale of a successful workshop on atmospheric research. Our sincere particular thanks for the most efficient performance of MST10 are directed to the sponsors, the University of Piura and the staff of the local organizing committee.

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