Determination of water vapour column using IRS-P3 MOS data

The column water vapour content over ocean can presently be derived from space-borne microwave sensor data.\(^1\)\(^2\) Over land surfaces microwave sensors fail due to highly varying microwave emissivity and water vapour amounts can be determined from radiosonde measurements, infrared space-borne data and back-scattered measurements of solar radiation. The radiosonde measurements have the problem of being only point measurements, whereas, the back-scattered solar radiation measurements do not reach a high accuracy.\(^3\) Various methods have been used to determine column water vapour from back-scattered solar radiation using the highly resolved spectral data of imaging spectrometers.\(^1\)\(^3\)\(^4\)\(^5\)

Atmospheric water vapour is given in centimeter precipitable water which is the height of the liquid water column that would emerge when condensing all water vapour in the zenith direction on to one unit area. One cm corresponds to 1 g/cm\(^2\) of column water vapour. The method to deduce atmospheric water vapour is discussed in detail by Tahl and Schonermark.\(^6\) which is given by the Continuum Interpolated Band Ratio (CIBR):

\[
\text{CIBR} = \frac{L(\lambda_2) c_1 L(\lambda_2) c_2 L(\lambda_2)}{L(\lambda_2) c_1 L(\lambda_2) c_2 L(\lambda_2)}
\]  

where \(L\) is the radiance at the top of atmosphere and \(\lambda\) is wavelength. The index \(v\) indicates the water vapour channel and \(w1\), \(w2\) are the two neighbouring window channels. The coefficients \(c_1\) and \(c_2\) are defined as:

\[
c_1 = \frac{(\lambda_2 - \lambda_1)}{(\lambda_2 - \lambda_1)}
\]

\[
c_2 = \frac{(\lambda_2 - \lambda_1)}{(\lambda_2 - \lambda_1)}
\]

The 940 nm absorption band is the most sensitive to variations in atmospheric water vapour content.\(^5\) The channel 12 (940 nm) of the MOS-B spectrometer has been selected for the water vapour channel and correspondingly channel 11 (867 nm) and channel 13 (1009 nm) have been used as the window channels.

The water vapour path values are converted to column water vapour \((V_c)\) by using the zenith angles of the sun and sensor according to

\[
V_c = V_p \left( \frac{1}{\cos \theta_1 + 1/\cos \theta_2} \right)
\]  

where \(V_c\) is column water vapour (cm) and \(\theta\) is the viewing angle equal to 0° for MOS-B and \(\theta\) is the solar zenith angle, \(\theta_1\) is taken for the center pixel of the scene. These information are available with the MOS data from the Data Center, National Remote Sensing Agency, Hyderabad.

The water vapour path is the amount of the gas, which is penetrated by the radiation on its sun surface-sensor path. Tahl and Schonermark have found that for non-vegetation and vegetation cover the water vapour path values \((V_p)\) are different. So there is a need to distinguish between non-vegetation and vegetation cover. In order to determine the surface cover of a pixel NDVI has been used as the criteria. The NDVI has been computed using following formula:

\[
\text{NDVI} = \frac{L(\lambda_2) - L(\lambda_1)}{L(\lambda_2) + L(\lambda_1)},
\]

where \(L(\lambda_2)\) corresponds to channel 11 and \(L(\lambda_1)\) corresponds to channel 8 of IRS-P3 MOS-B sensor.

The threshold between non-vegetation and vegetation cover has been set to 0.5. Tahl and Schonermark have given the following equations for water vapour path values in the case of both non-vegetation and vegetation cover.

\[
V_p = (\ln(\text{CIBR})/0.592)^{1.0568},
\]

and

\[
V_p = (\ln(\text{CIBR})/0.599)^{1.0575}.
\]

Taking radiation at the top of the atmosphere, the portion of the path radianc compared to ground is reflected.

<table>
<thead>
<tr>
<th>Table 1. Modular Opto Electronic Scanner(^2) (MOS)</th>
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<tr>
<td>Parameter</td>
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<td>(I_{max}) (W cm(^{-1}) nm(^{-1}) sr(^{-1}))</td>
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<td>Quantization (bit)</td>
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<td>In-flight calibration</td>
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radiance is larger over dark surfaces compared to bright ones. As the path radiance does not reach the earth's surface, it has a shorter way through the atmosphere other than the surface reflected radiance and therefore, it has less penetration through water vapour. Therefore, to correct for the underestimation of water vapour content for low
The non-vegetation covered areas are shown with dark red colour and areas with highest amount of vegetation cover are shown in light green colour. In the 11 January 1998 image, low NDVI values are seen in areas where cloud cover is present. The vegetated areas generally yield high NDVI values because of their relatively high reflectance in infrared and low visible reflectance. In the composite images of Figure 2a and b, the areas with red colour reflect vegetated areas. In band 11 (867 nm, infrared region), vegetated areas have high reflectance values and appear red. In this region there are moist tropical evergreen forests, which show high NDVI values (green colour) both in the 11 January 1998 and 11 May 1998 images. The spatial features in the NDVI map match very well with the spatial features of the these colour composite images.

Spectral reflectance plots at points marked on the colour composite images of 11 January 1998 and 11 May 1998 are shown in Figure 3a and b, respectively. In Figure 2b, we have selected points 1 to 6 which are lying over vegetated region, point 7 lying over inland water body and point 8 lying over the sea intruding into land. The spectral reflectance plots (Figure 3b) for points 1 to 6 manifest the 'peak and valley' configuration of green healthy vegetation. The valleys in the visible portion of the spectrum are attributed to the pigments in the plant leaves. Chlorophyll strongly absorbs energy in the wavelength band centered at 670 nm, which can be seen as an absorption peak at band 7 (650 nm) and band 8 (685 nm). The reflectance increases dramatically from the visible to infrared portion of the spectrum at about 700 nm. Plant reflectance in the range 700 nm to 1200 nm is primarily due to the internal structure of the plant leaves. Near infrared reflectance increases with the number of layers of leaves in a canopy. A minor absorption peak at band 10 (814 nm) and a major absorption peak at band 12 (942 nm) are seen (Figure 3b). These absorption peaks are attributed to the strong absorption at these wavelengths (water absorption bands) due to the presence of water in the leaves. Reflectance peaks can be seen at bands 9 (750 nm), 11 (867 nm) and 13 (1010 nm). Vegetation curves
also have an absorption peak at 1400 nm and a small reflection peak at 1600 nm. However, as MOS has no band at 1400 nm this feature cannot be seen in the reflectance curves. From Figures 2b and 3b, it can be seen that in the infrared region (700 nm to 1200 nm) points lying on regions which have darker shades of red (highly vegetated areas) in the colour composite image have high reflectance values and those lying on regions with lighter shades of red (less vegetated areas) have low reflectance values. The reflectance values are found to be highest in band 11 and lowest in band 8 (Figure 3b). Due to this high contrast, these bands are used for NDVI calculation. In Figure 2a, points 5 and 6 lie over cloud-covered regions, so at these points high reflectance (Figure 3a) values for all bands are seen. The reflectance plots confirm the presence of vegetated and non-vegetated regions.

Figure 4a and b show the column water vapour (cm) images of 11 January 1998 and 11 May 1998, respectively. The column water vapour values range from 0.22 to 0.60 cm in Figure 4a and b. We have found that the column water vapour is higher in 11 January 1998 than 11 May 1998. This observation is also consistent with the presence of clouds found at various places in the 11 January 1998 image. This seems to be plausible due to contrast in the surface temperature of ocean and land as a result of which water evaporates from the ocean and moves in to the atmosphere over the land. The dark values are those with smaller amounts of water vapour and high values are marked white. Water surfaces have been masked and are painted black. Due to the very low reflectance of water in the spectral region of MOS bands 11 (868 nm), 12 (942 nm) and 13 (1011 nm), the signal received over water surfaces mainly consists of path radiance; therefore the estimate of water vapour column cannot be made. As the algorithm used is based upon the surface reflected radiance, which is attenuated by water vapour on its way through the atmosphere, it cannot be applied over water surfaces.

In the water vapour image of 11 January 1998 and especially of 11 May 1998, the Western Ghats are clearly visible running parallel to the coastline. The Western Ghats have higher amounts of water vapour compared to the adjoining coastal plains. The white patches in the image of 11 January 1998 are due to cloud cover. In the corresponding water vapour image, higher amount of water vapour represents the clouds which obviously contain a lot of water vapour. When compared with the NDVI images (Figure 1a and b) of the same area it is seen that lower water vapour amounts are found over highly vegetated regions surrounded by higher amounts of water vapour over less-vegetated areas. In the absence of ground truth data, it is difficult to validate the present results. However, the present results show a great potentiality of IRS-P3 MOS data in the determination of water vapour over land region.

Isolation, biochemical characterization and in vitro tests of pathogenicity of Yersinia enterocolitica isolated from pork

Yersinia enterocolitica, an important food- and water-borne gastrointestinal agent is regarded as an emerging pathogen worldwide. It causes acute gastroenteritis, enterocolitis and mesenteric lymphadenitis, as well as a variety of extra-intestinal problems. In several temperate or cold regions, Y. enterocolitica is frequently responsible for diarrhoeal diseases and its incidence almost rivals those of Salmonella and Campylobacter. Recently, a food-borne outbreak of gastroenteritis involving 25 persons in North Arcot district of Tamil Nadu was attributed to Y. enterocolitica. In India, Y. enterocolitica has earlier been isolated from stools of diarrhoeic patients, milk, pig intestinal contents and rectal swabs. Recently, in our laboratory, Y. enterocolitica was isolated from sewage effluents in Delhi (unpublished). Although pigs represent the single most important reservoir of this organism and pork has been implicated in a number of outbreaks in several parts of the world, there has been no report on the isolation of Y. enterocolitica from pork in India. The present study reports isolation, biochemical characterization and in vitro tests of pathogenicity of Y. enterocolitica from pork collected from a local slaughterhouse.

Twelve samples of pork, each from a separate animal, were collected over a period of two weeks from a local slaughterhouse-cum-piggery farm. Samples were collected in sterile petri plates from inside the thigh muscle to avoid surface contamination. These were transported to the laboratory within 20 min and refrigerated immediately. All pork samples were processed for isolation of Y. enterocolitica within 1 h of collection. 25 g of sample was homogenized in a blender and added to 225 ml of phosphate-buffered saline containing sorbitol (1%) and bile salts (1.5%), and kept at 4°C up to 3 weeks. After 2 and 3 weeks, the cold-enriched samples were subjected to alkali treatment by adding 0.5 ml of 0.5% KOH into 4.5 ml of cold-enriched samples for 5, 15 and 30 s (ref. 11). The cold-enriched and alkali-treated, and also non-alkali-treated samples were streaked on to ceftiolodin-irgasan-novobiocin (CIN) and MacConkey agars (Hi Media) and incubated at 25°C. After 18–24 h of incubation, presumptive Y. enterocolitica colonies were identified by studying these both by the naked eye as well as under a stereomicroscope (10 x) (Leica). The colonies showing characteristic bulls-eye morphology with deep red center and clear colourless periphery on CIN agar and non-lactose-fermenting (NLF) on MacConkey agar were selected for detailed biochemical characterization. Suspected Y. enterocolitica isolates were maintained as both slant and stab cultures in nutrient agar and stored at 4°C.

Colonies conforming to the above cultural criteria were initially subjected to four biochemical tests, viz. urease, Kliger's iron agar (KIA), differential motility and Voges-Proskauer (VP). Based on these results, the suspected isolates were subjected to detailed biochemical characterization. Species identification was done by fermentation of rhamnose, melibiose, a-methyl-D-glucoside, sucrose and raffinose. Isolates identified as Y. enterocolitica were biotyped according to Wauter's biotyping scheme. Samples were sent to Institut Pasteur, Paris for confirmation and serotyping.

In vitro tests for pathogenicity, viz. pyrazinamidase activity, CR–MOX (Congo red–magnesium oxalate) agar, autoagglutination, salicin, esculin, d-xylose fermentation and crystal violet binding were carried out as recommended. A virulence plasmid-bearing Y. enterocolitica reference strain (W22703, serotype O:9) was used concurrently as control for these tests.

Thirty isolates were picked up from CIN agar and MacConkey agar plates based on their colony morphology. Cold enrichment of the samples for 3 weeks was found to be better in yielding colonies of suspected Y. enterocolitica (24 isolates) compared to enrichment for 2 weeks (6 isolates). Also most of these isolates were obtained after the cold-enriched samples were treated with alkali for 15–30 s. Lack of alkali treatment or treatment of samples for 5 s was unsatisfactory as the presence of the background micro-flora masked the isolation of Y. enterocolitica.

The results of biochemical characterization of the isolates are summarized in Table 1. Biochemical tests identified 14 of the isolates from six pork samples as Y. enterocolitica while two isolates from two samples were found to be Morganella morganii subsp. morganii (biotype C). All isolates of Y. enterocolitica belonged to biotype 1A.