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Correcting EO-1 Hyperion Data for Atmospheric Attenuation

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Abstract: ***The process, which transforms the data from spectral radiance to spectral reflectance, is knownasatmosphericcorrection,compensation,orremoval.Hyperionimagesaretherich sourceofinformation containedinhundredsnarrowcontiguous spectralbands.Thereare numberofatmosphericagentswhichcontaminatethecontentofvariousbandsinformation. TogetthecompleteadvantageofHyperiondataitisrequiredtoapplyatmosphericcorrection sothattheinfluenceofatmosphereontheEarthobservationdatacanberemoved.Primary typeincludescenebasedandradiationtransmissionmodelbased algorithms.Majorscene basedalgorithmsareIARandELM.MODTRANisverypopularandeffectiveatmospheric transmissionmodelfor correctingmutispectralandhyperspectraldata.MODTRANbased FLAASH algorithmsavailable inENVIareveryeffective forHyperion dataatmospheric correction.InthispaperIAR,ELMandFLAASHavailablein ENVIhasbeenappliedfor atmospherecorrectionofHyperiondataandcomparativeanalysiscarriedout.***

KeyWords:IAR-InternalAverageReflectance,ELM-EmpiricalLineMethod,MODTRAN-MODerateresolutionatmosphericTRANsmission,FLAASH-Fast Line-of-sightAtmospheric Analysisof SpectralHypercube.

1.Introduction

Hyperionsensorisahyperspectralimageron-boardofEarthObservatio-1(EO-1)satellite.

The process, which transforms the data from spectral radiance to spectral reflectance, is knownasatmosphericcorrection,compensation,orremoval.

1.1HyperspectralData-Hyperion

The data of EO-1arearchivedanddistributedbytheUSGSCenterforEarthResources ObservationandScience(EROS)andplacedinthepublicdomain. Thereare242spectral bandsrangingfrom356to2577nm.Outofwhichonly198bandsarecalibratedandhence canbeusedforfurtherprocessing. Thespatialresolution of Hyperionis30 meter.Each Hyperionsceneiscollectedasanarrowstrip,coveringagroundarea approximately7.7 km in the across-trackdirection,and42kmor 185kmin thealong-trackdirection(dependingonthe originaldataacquisitionrequest). TheproductisdistributedbyUSGS,andthelevelone product,whichisonlyradiometricallycorrected,isavailable(Pearlman,etal.,2003;USGS, 2004a).

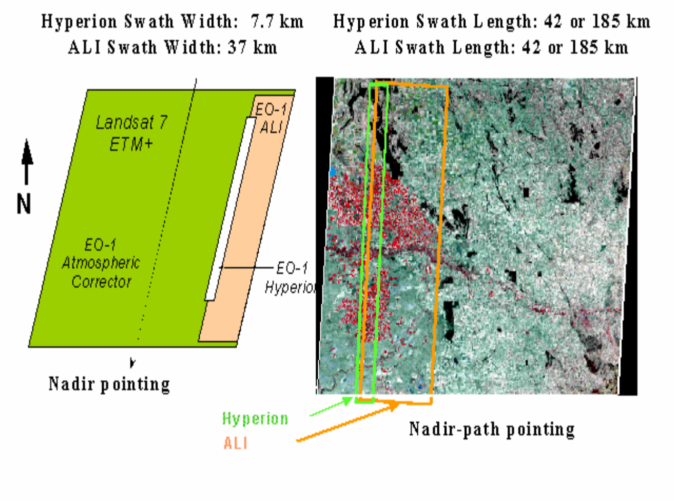


Fig.1 Hyperion'sSwathWidthandLength, (USGS,2004b)

1.2ConceptsofAtmosphericCorrection

RadiationenteringasensorisclassifiedasinFig.2.Atmosphericcorrectionistheprocessing to eliminateS2,S3 andcloudsandGaseousabsorptionwhichare contaminatingtheobserved pixels.

1.3NeedofAtmosphericCorrectionforEO-1HyperionImages

EO-1 Hyperion hyperspectral images are the rich source of information contained in hundreadsnarrowcontiguousspectralbands.Therearenumberof atmosphericagentswhich contaminate thecontent of various bands information. To getthe complete advantage of Hyperiondataitisrequiredtoapplyatmosphericcorrectionsothat some bandswhichcontain usefulinformationandcontaminatedbyatmosphericagentsthatcanberetrieved.

Theatmosphericcorrectionisoftenconsideredasa criticalpre-processingsteptoachievefull spectralinformation fromeverypixelespecially with hyperspectral data.Inhyperspectral imageanalysissomeapproacheshasbeenimplementedusingspectrallibraryorfieldspactra. If atmosphericcorrectionis notappliedthenthereis markedlydifferencebetweenobserved spectral radianceand spectral library orfield spectra. These differences may negatively influence the accuracy to which the image analysis has been carried out based on an independentspectrallibraryorfieldspectra(PerryE.Metal.,2000).

Chauhan, 2008, has studied several hyperspectral atmospheric correction approaches developedduringthelasttwo decades,outofthatsomeapproachesareappliedtocorrecting Hyperiondatainthisresearchwork.

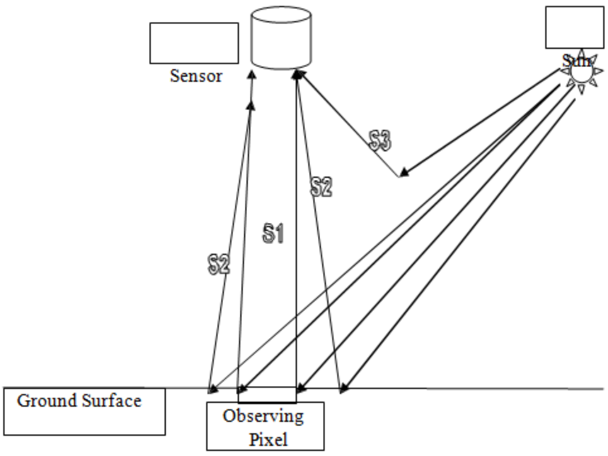


Fig.2: RadiationEnteringaSensor
Where,S1:Radiancetobeobserved,
S2:Radiancefromatmosphericdispersion(Neighboringeffect)
S3:PathRadiance

2AtmosphericCorrectionApproaches

Atmosphericcorrection maybeappliedbycollectinginformationfromscene(image)orby modelingradiationtransmissionthroughatmosphere.

2.1SceneBasedEmpiricalApproaches

These approaches are based on the radiance values at present in the image (i.e. scene) therefore they are known as scene based empirical approaches. IAR, FFC and ELM approachesarecommonlyusedbyvariousresearchers.

2.1.1InternalAverageRelative(IAR)Reflectance

TheInternalAverageRelative(IAR)Reflectance approach(Kruse,F.A.,1988)calculatesthe averagespectrumofascene.Thespectrum ofanypixelinthesceneisthendividedbythe averagespectrumtoestimatetherelativereflectance spectrum forthepixel. This approach doesnotneedanyfieldmeasurementsofreflectancespectraofsurfacetargets.Thisapproach ismostlyapplicableforimagingdataacquiredoveraridareaswithoutvegetation.

2.1.2EmpiricalLineMethod(ELM)

Theempiricallineapproach(KarpouzliE.andMalthus,T, 2003)calculatesthesurface reflectancebasedonthefieldmeasurementof referencepixelsandregressionanalysis.This methodassumesthattheradianceandreflectedvaluesforeachwavelengthchannelofthe sensorarelinearly related.Therefore theimagingspectrometer dataarelinearlyregressed againstthe field-measuredradiancespectratoderivethegainandoffsetcurves.Thegainand offsetcurvesarethenapplied tothewholeimageforthederivationofsurfacereflectance valuesfortheentirescene.

2.2RadiationTransportModelsbasedapproach

Thescenebasedapproachesdiscussedabovearenotgenerallyproducingverygoodresults,as the linearityassumption,whichpresumesuniformatmospherictransmission,scatteringand adjacencyeffectsthroughoutthescene,maynotbeaccurate.Inradiationtransportmodeling effortsaremadeto understandandremovetheeffectsof majoratmosphericprocesseswith radiationsuchas absorptionandscattering.Veryeffectiveand latestatmospherictransmission modelis MODerateresolutionatmosphericTRANsmission(MODTRAN).MODTRANisan algorithmandcomputermodel,whichisdevelopedbythe, Air Force Research Laboratory(AFRL) in collaboration with Spectral Sciences, Inc.(SSI).MODTRAN calculates atmospherictransmittanceandradianceforfrequenciesfrom0to50,000 cm^{-1} atmoderatespectralresolutionof1cm^{-1}.MODTRAN'sinternalminimumspectralresolutionof1cm^{-1}whichcorresponds toaspectralresolutionofabout0.625nmattheuppermostwavelength(Ientiluccietal., 2008). The latestmodelis MODTRAN 4whichis the newlyreleased radiativetransfermodelwhichprovidesaccuracyrequiredfortheprocessingof hyperspectral imagery.ThereforeFLAASHaMODTRAN4basedapproach isdiscussedinfurthersections.

2.2.1FastLine-of-SightAtmosphericAnalysisofSpectralHypercubes(FLAASH)

FLAASHisanefficientcorrectioncodebasedonMODTRAN 4thathasbeendeveloped collaboratively bySpectralSciences, Inc. and the Air Force Research Laboratory; with assistance from the Spectral Information Technical Applications Center (SITAC) (Adler-Goldenetal.,2008).FLAASHisavailable intheResearchSystemsInc.ENVIsoftware package.FLAASHoperatesinthe0.4–2.5 μ mspectralrange(KruseF.A.,2008).

3.ImplementationofAtmosphericCorrectionAlgorithms

Hyperiondataiscorrectedusingvariousalgorithmsavailableindifferentsoftware's.

3.1 SceneBasedEmpiricalApproaches

Itisveryeasytoapplyscenebasedempiricalapproachesastheyrequireeithernilorverylessinputparameters.

3.1.1IAR

Thisis particularlyeffectiveforreducinghyperspectraldatato relativereflectancein anarea wherenogroundmeasurementsexistandlittleis knownaboutthescene.It worksbestforarid areaswithnovegetation.IARReflectancecalibrationisusedtonormalizeimagestoascene averagespectrum.Anaveragespectrumis calculatedfromtheentiresceneandis usedas the referencespectrum,whichis thendividedintothespectrumat eachpixelof theimage.IAR algorithmavailablewithRSI-ENVIisimplementedonHyperiondataandresultsareanalyzed.

3.1.2ELM

EmpiricalLine calibration isusedtoforcespectraldatatomatchselectedfieldreflectance spectra.AlinearregressionisusedforeachbandtoequateDNandreflectance. Thisis equivalentto removingthesolarirradianceandtheatmosphericpathradiance.Thefollowing equationshowshowtheempiricallinegainandoffsetvaluesarecalculated.

Reflectance(fieldspectrum)=gainxradiance(inputdata)+offset

ENVI'sempirical linecalibrationrequiresatleastonefield,laboratory,orotherreference spectrum;thesecancomefromspectralprofilesorplots,spectrallibraries,ROIs,statisticsor fromASCIIfiles.Inputspectrawillautomaticallyberesampledtomatchtheselected data wavelengths.If morethanonespectrumis used,thentheregressionforeachbandwillbe calculatedbyfittingtheregressionlinethroughallof thespectra.If onlyonespectrumis used, thentheregressionlinewillbeassumedtopassthroughtheorigin(zeroreflectanceequals zeroDN).Thecalibrationcanalsobeperformedonadatasetusingexistingfactors. For atmosphericcorrectionfieldspectracollectedduringfieldstudyis usedandrelativeimage spectrahasbeenfindoutbygeoreferencingthelocationsoffielddata collected.

3.2RadiationTransportModelsbasedapproach

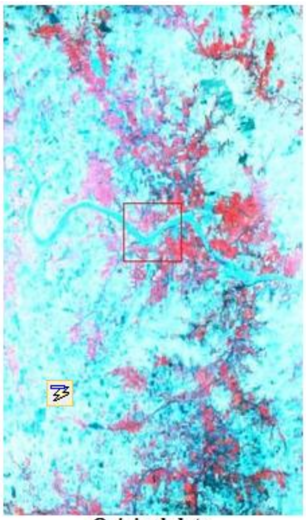
3.2.1AtmosphericCorrectionusingFLAASHinENVI

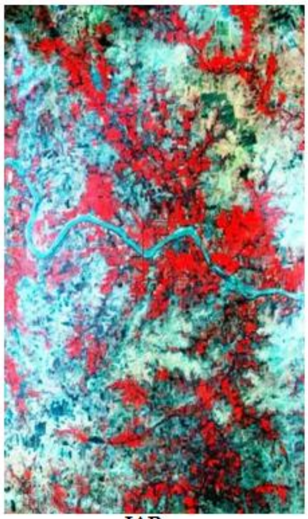
FLAASHsoftwareisaMODTRANbasedpackage.Withseveraldefinedatmospheremodels andaerosolmodels,theuserinterfaceissimplified.Theinputsrequiredarerequiredare Input radiance image, Atmospheric parameters, Sensor and Ground parametersand Scene parameters.InputradianceimageisENVIstandardimageandcontains196calibratedbands only outof 224 bandswithoriginal Hyperion dataasnoncalibrated bands settozero. Atmospheric parametersinclude Atmospheric model, Aerosol model and Initial visibility (km).SensorandGround parameterinput includes sensortype, flying height andground elevationwhichistheaverageelevationofthestudyareacanbeobtainedfromtopographical map.SceneparametersincludeSceneCenterLocation,FlightDate andFlightTime(GMT) whichcanbeobtainedfrom".met"file. Theatmosphericallycorrectedimageisgenerated andinadditiontoitcloudmaskandcolumnwaterimagehasbeengenerated.

4.ResultsandDiscussion

Hyperionscene includingtheLonarcraterandsomeotherpartsofMahekarandBuldana districtof Maharashtrastateis appliedforatmosphericcorrection.Theimageusedis EO1H1450462008007110KF. "EO1" standsfor the satellite EO1 and "H" stands for Hyperion.Thenumbers,145and046,aretheWRSpathandrowrespectively.2008istheyear of imageacquisitionwhile007istheJuliandayofacquisition.Thefirst "1"following"007" indicatesthattheHyperionsensorison.Thesecond"1"indicatesthattheALIsensorison. Thefollowing"0",indicatesthattheACsensorisoff."K"isacodefor thepointingmode, and"F"isthecodeforthescenelength.Therearethreefilesreceived withthedistributed scene,themetadata(.met),theimage(.L1R),andtheheaderfile(.hdr).Theimagefileis storedinBILorder.

Scenebasedandradiationtransportmodelbasedapproachesare appliedfor atmospheric correctionandportionof theimagewhereatmosphericattenuationis appreciablethatis shown inthefig.3andcomparativeanalysisiscarriedout.


Original data


IAR

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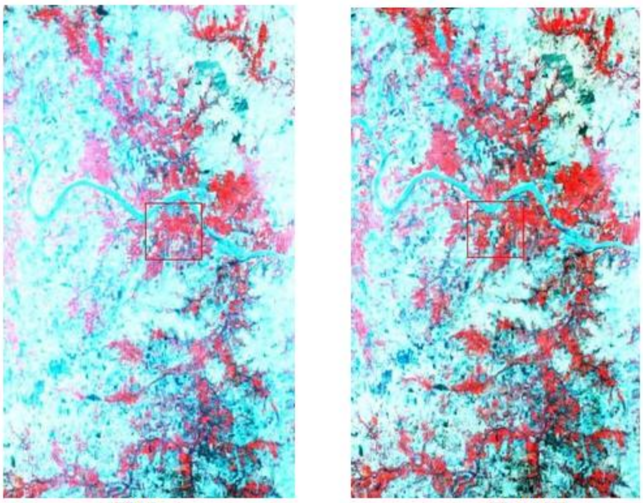

ELM FLAASH

Fig.3: AtmosphericcorrectionofHyperiondatausingscene&modelbasedapproaches

Imageinfig.3showsthatoriginal datahasmuchmoreatmospheric attenuation overthis portionoftheimage.IAR approachaverageoutthe reflectance valuesoverthescene,therefore imageappearsassmoothimage. ELMresultisnotgood maybeduetospectrausedfor calibrationis spectracollectedforvariouscropsandit is suggestedtousedarkandbright regions for calibration. Result of FLAASH appears very good and it corrects data for atmosphericscattering,atmosphericabsorptionandadjacencyeffect.

References

i. *Adler-GoldenS.,Berk,A,,Bernstein,L.S.,Richtsmeier,S.,Acharya,P.K.,andMatthew, M.W.,Anderson,G.P, Allred,C. L., Jeong,L.S.,andChetwynd,J.H.,(2008),"FLAASH,A MODTRAN4AtmosphericCorrectionPackagefor HyperspectralData Retrievaland Simulations",downloadedin September,2008from, ftp://popo.jpl.nasa.gov/pub/docs/workshops/98_docs/2.pdf*

ii. *Chauhan,2008,UnpublishedSeminarreportforpartialfulfillmentofDoctorofPhilosophy,atCSRE,IITBombay.*

iii. *IentilucciE. J., (2008),UsingMODTRANPredictingSensor-ReachingRadiance,ChesterF. CarlsonCenterfor ImagingScience,RochesterInstituteof Technology, www.cis.rit.edu/~ejipci/Reports/Modtran_lab.pdf,downloadedonAugust,2008.*

iv. *KarpouzliE. and Malthus, T., (2003). The empirical line method for the atmospheric correctionofIKONOSimagery,InternationalJournalofRemoteSensing, vol:24, no:5, pp.1143-1150.*

v. *Kruse,F.A.,(1988),Useofairborneimagingspectrometerdatatomapmineralsassociated with hydrothermally altered rocks in the northern Grapevine Mountains, Nevada and California,RemoteSensingofEnvironment,vol.24, pp.31-51.*

vi. *Kruse F. A., (2008), Comparison of ATREM, ACORN, And FLAASH Atmospheric CorrectionsusinglowaltitudeAVIRISdataof Boulder,Co,USA, http://www.hgimaging.com/FAK_Pubs.htm,downloadedonSeptember, 2008.*

vii. *Pearlman,J.S.,Barry,P.S.,Segal,C.C.,Shepanski,J., Beiso,D.,Carman,S.L.,(2003). Hyperion, a Space Borne Imaging Spectrometer, IEEE Transactions on Geosciences and RemoteSensing,vol.41,no.6,pp.1160-1173.*

viii. *PerryE.M.,WarnerT. andFooteP.,(2000),Comparisonof atmosphericmodelingversus empirical line fitting for mosaicking HYDICE imagery, International Journal of Remote Sensing,vol:21,no.4,pp.799-803.*

ix. *USGS,2004a.EarthObserving1,downloadedonMay,2009,from,url:http://eo1.usgs.gov/*

x. *USGS, 2004b, EO-1, User Guide version 2.3, downloaded on May, 2009, from,* ***eo1****.usgs.gov/documents/****EO1userguide****v2pt320030715UC.pdf.*