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POTENTIAL COMMERCIAL USES OF EOS REMOTE SENSING PRODUCTS

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ABSTRACT

The instrument complement of the EOS satellite system will generate data sets with potential interest to a variety of users who are, for instance, now just beginning to develop geographic information systems tailored to their special applications and/or jurisdictions. Other users may be looking for a unique product that enhances competitive position. The generally distributed products from EOS will require additional value added processing to derive the unique products desired by specific users. Entrepreneurs have an opportunity to create these proprietary level 4 products from the EOS data sets. Specific instruments or collections of instruments could provide information for crop futures trading, mineral exploration, television and printed medium news products, regional and local government land management and planning, digital map directories, products for third world users, ocean fishing fleet probability of harvest forecasts, and other areas not even imagined at this time. This paper looks at the projected level 3 products that will be available at launch from EOS instruments and speculates about commercial uses of the data after value added processing.

BACKGROUND

The Earth Observing System is planned to the primary NASA system that supports the national and international Global Change Program. The first satellite platform will be launched in calendar year 1998. This platform will carry a payload of between 8 to 12 sensor systems. The selection of the instruments has not been made at this time. It may be by the time of the meeting at which this paper is being presented. The payload will be determined based on contributions to global science observations and financial constraints. The financial constraint depends on congressional action on the FY91 budget and total program authorization. Since the FY91 budget is still in negotiation between the President and Congress the payload cannot be selected at this time.

Over the past year an Investigators Working Group (IWG) has been meeting. The IWG has been active in providing recommendations to NASA management on the EOS Science Plan, establishing a preliminary list of data products to be available at launch, and recommending an instrument payload for the first EOS platform. It is the list of initial data products that this paper wants to make the end user community aware. At this time the number of at launch products approaches 3000 in number. This list will probably undergo evolution to be reduced to a set of products numbering in the 100's in order to be more manageable.

The data products of course depend on the instrument payload of the first EOS platform. The next section provides a short description for the candidate instruments. These instruments are considered to be Facility Instruments that support a large science team or Principle Investigator Instruments that support science in specific research areas. If you do not want to read the instrument descriptions skip over the next two sections.

The Proposed USA Facility Instruments for EOS-A

The following list contains those instruments that are currently considered the Facility instruments for EOS-A:

1) The Moderate Resolution Imaging Spectrometers-Nadir or Tilt (MODIS-N, MODIS-T)

   The Nadir MODIS provides 24 hour day and night global coverage of the Earth by scanning through the nadir with a +- 55 degree field-of-regard. This instrument provides a nominal 1000m GIFOV from a 705km altitude in 38 narrow spectral bands from 413nm to 14.3um. Selected spectral bands will have improved ground sample distance to provide 8 bands with 500m GIFOV and 2 bands with 250m GIFOV. MODIS-N has removed the polarization sensing bands from its complement of capabilities. This instrument delivers 1.7 x 10^{12} bits per day to the Data and Information System.

The Tilt MODIS provides a visible spectral region spectrometer with a slightly narrower field-of-regard, +/- 45 degrees, and has a 1.1km GIFOV. The minimum spectral interval provides 15nm bandwidths over 32 contiguous bands starting at 410nm wavelength. The field-of-regard is tilted to positions fore and aft of the orbital track to avoid specular glint off of the oceans and to perform bidirectional reflectance studies. The ocean science for this instrument requires that polarization sensitivity be less than 2.5% over the field-of-regard for pointing angles less than 20 degrees fore or aft. The primary mission for MODIS-T is to support world bioproductivity (ocean color) research, thus bidirectional reflectance studies occur on a scheduled basis rather than all the time.

2) Atmospheric Infrared Sounder (AIRS)

AIRS is a scanning radiometer with a +/- 49 degree field-of-regard and provides continuous soundings of the atmosphere in up to 4280 contiguous spectral intervals (wavenumber interval between 0.5 cm-1 to 2.0 cm-1 in bandwidth) in the 3.7um-17um spectral region. AIRS will provide important atmospheric correction data for the MODIS in addition to its sounding products. The GIFOV equals 50km in most of the channels and selected channels with 15km GIFOV'S. This instrument has the potential to provide pressure and temperature profiles of the atmosphere with a vertical resolution of 1km. The current AIRS approach uses a grating spectrometer and requires a cryogenic refrigerator for the large infrared focal plane.

3) High Resolution Imaging Spectrometer (HIRIS)

HIRIS compliments MODIS operation by providing higher spatial resolution with a narrower swath. At nadir the GIFOV is 30m with a swath width of 30km. This instrument operates as a system to sample selected data about the spacecraft subtrack. The FOV can be directed to targets within a field-of-regard 60 degrees up track, 30 degrees down track, and +/-24 degrees acrosstrack. The HIRIS is an imaging grating spectrometer with spectral ranges in the visible to near IR and the SWIR. As with AIRS the infrared focal plane is cryogenically cooled with a refrigerator.

4) Advanced Microwave Sounding Unit (AMSU)

AMSU is a microwave radiometer providing measurements of atmospheric temperature and humidity. This complements the infrared measurements of AIRS. It is a 20-channel instrument divided into AMSU-A and AMSU-B subsystems. AMSU-A primarily provides atmospheric temperature from the surface to 40km altitude in 15 channels, i.e., 23.8 GHz, 31.4 GHz, 12 channels between 50.3 to 57.3 GHz, and 89 GHz. Coverage is approximately 50 degrees on both sides of nadir, with a GIFOV of 50km. AMSU-B provides atmospheric water vapor in 5 channels at 89 GHz, 166 GHz, and 183 GHz. Coverage is the same as AMSU-A, but the GIFOV is 15km.

Currently, AMSU-A is the only AMSU subsystem planned for EOS-A, although the accommodation of AMSU-B is being studied.

Potential Principle Investigator Instruments for EOS-A

The following Principal Investigator instruments may be included in the EOS-A payload:

1) Cloud and the Earth's Radiant Energy System (CERES)

The CERES are a pair of scanning radiometers similar to the Earth Radiation Budget instruments flown on previous missions. They are broadband radiometers with three channels: total radiance (.0.2um to 100um), shortwave (0.2um to 3.5um), and longwave (6um to 25um). One radiometer scans crosstrack, and the second scans in a constant angle rotating plane. The GIFOV is 2.3 degrees by 3.4 degrees.

2) High Resolution Microwave Spectrometer Sounder (HIMSS)

HIMSS is a dual band scanning microwave radiometer. It scans in a constant angle rotating plane with a GIFOV of 5km at 90 GHz and a 50km GIFOV at 6.6 GHz. HIMSS is used to derive parameters for precipitation rate, cloud water, water vapor, sea surface roughness, ice, and snow. HIMSS has a 2m parabolic antenna with a scanning feed subsystem.

The following PI instruments are new capabilities with characteristics that compliment the facility instruments:

3) Multi-angle Imaging Spectroradiometer (MISR)

MISR provides data on bidirectional reflectance properties using fixed field-of-view pushbroom sensors operating in the visible to near infrared. There are four sensors looking forward and four looking aft with a separate nadir viewing pushbroom sensors. The viewing angles are 28.5°, 45.6°, 60°, and 72.5°. Four narrow spectral bands are used in each of the sensors in the spectral region between 440nm and 860nm. The spatial resolution is 1.73km in normal mode and 216m in local mode. The field-of-view is 27° for the sensors observing at an angle of 28.5°. This swath width is matched by the other sensors with the FOV corrected for the angle off the nadir. All FOV's are centered on the orbital track.

4) GPS Geoscience Instrument (GGI)

The GGI uses 18 dual frequency Global Positioning System (GPS) receiver-processor units and 3 distributed GPS antennas to provide centimeter level global geodesy, atmospheric temperature profiling, ionospheric gravity wave detection and tomographic mapping, and precise attitude determination in support of other instruments.

5) Lightning Imaging Sensor (LIS)

The Lightning Imaging Sensor observes the distribution and variation of lightning over the Earth. This sensor uses a solid-state staring army with a very narrow band filter in the visible spectrum and special signal processing electronics to threshold and detect lightning events and the time of their occurrence.

6) Earth Observing Scanning Polarimeter (EOSP)

The EOSP simultaneously measures radiance and degree of polarization in 12 spectral bands from 410nm to 2250nm. The GIFOV is 10km over a swath of +/- 55 degrees acrosstrack. This is the only polarimeter proposed for EOS.

7) High Resolution Dynamic Limb Sounder (HIRDLS)

HIRDLS is a synergistic combination of two PI instruments to provide a single capability to observe atmospheric constituents in the upper troposphere, mesosphere and stratosphere. This radiometer scans in azimuth and elevation while observing the atmosphere above the limb of the earth. 3km vertical steps are observed over a 70km range in altitude above the limb. 12 spectral bands are used from 6.1um to 17.3um.

8) Measurements of Pollution I in the Troposhere (MOPIT or Tropospheric Radiometer for

Atmospheric Chemistry and Environmental Research (TRACER)

These instruments measure the upwelling radiation from carbon monoxide and potentially methane and ammonia in the troposhere. Both use gas correlation radiometers and differential detection processing. One or the other of these sensors are candidates for EOS-A.

9) Stick Scatterometer (STIK SCAT)

This is an active microwave radar that uses 6 fixed fan beam antennas and operates in the 13.995 GHz regime with dual polarization. This instrument uses a doppler processor and provides 1200km swaths with 25/50 km resolution.

Potential Japanese Facility Instrument for EOS-A

The Intermediate Thermal Infrared Radiometer (ITIR) is a candidate to be supplied by the Japanese Space Agency (NASDA). The ITIR is a 14 band pushbroom scan radiometer with 60km a crosstrack swath. There are 3 visible bands at 15m GIFOV, 6 SWIR bands at 30m GIFOV, and 5 thermal infrared bands at 90m GIFOV. The field-of-view is pointable both fore and aft and in the crosstrack.

PROPOSED DATA PRODUCTS

This paper will not try to give an detailed preview of EOS data products that are planned to be available at launch and then in the time frame a year post launch. However, the nature of the data base is shown.

The proposed list of data products for the EOS program now numbers around 3300 for both the at launch and post launch time frames. The at launch products will be comprised mostly of Level 1 radiometrically corrected digital data and Level 2 radiometric data that has been gridded to one of several Earth located map projections. Of more interest will be Level 3 products that begin to derive geophysical parameters. Many Level 3 products will be available at launch. These Level 3 products will encompass ocean chlorophyll, sea surface temperature, land surface temperature, fire locations, cloud cover, vegetation index, vegetation type, biomass, atmospheric temperature and humidity profiles, net energy balance, total ozone, precipitation rate, snow cover and water content, and many others. It is the Level 3 products which can provide an information source that receives value added processing that leads to products for end users. EOS participating scientists will be generating algorithms for a large range of Level 4 products, but an expanding end user community may need the Level 4 product tailored to their specific situation or may need a unique product developed from Level 2 and 3 data. It is in the area of value added processing that commercial opportunities exist to develop and distribute proprietary products to different public and private users.

In order to provide a flavor the data product data base that is being created for EOS by Dr. Al Fleig of NASA Goddard Space Flight Center, Tables 1 and 2 are shown as examples of what is currently collected into the books. At some time in the future after decisions are made to reduce the overlap and redundancy between various investigators, a more compact list of products will be available for consideration.

Table 1 illustrates the data as collected by common data product area. The first column just list the sequential number of the product in the data base. The second column (CAT) identifies category of earth science research; in this example the "AR" is for Atmospheric Radiation. The third column (Parameter) is self explanatory. The fourth column (Type) indicates that the investigator is Interdisciplinary (II), Facility (FI), or Principal (PI). The fifth column (Investigator) is the name of the scientist involved. The sixth column (Instr.) is the related EOS instrument. The seventh column (Units) provides the relevant measurement parameters. The eighth column (Accuracy) is self explanatory, but perhaps a little cryptic with respect to percentages of what. The next three columns provide the anticipated temporal, horizontal, and vertical resolutions for the data product (note: N/A is not applicable). The last column (Time Frame) shows that the product will be available At Launch, Post Launch, or not known at this time.

Prod #	Cat	Parameter :: Qualifier	Type	Investigator	Instr.	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Domain	Vertical Resol. :: Domain	Time frame
2051	AR	Cloud cover ::	I :: II	Barron		%	5 :: 5	1 dy	30 m :: Local	N/A :: Cloud	
2052	AR	Cloud cover ::	I :: II	Hansen			3% ::	1-wk avg	500 km :: Global	:: Cloud	
2053	AR	Cloud cover ::	I :: II	Isacks		%		1/wk avg	5 km :: Land/R	N/A :: Cloud	
2054	AR	Cloud cover ::	I :: II	Lau		%	5% :: 5%	12 hr	50 km :: Regional	N/A :: Atmos	
2055	AR	Cloud cover ::	I :: II	Liu					:: Ocean	N/A :: Cloud	
2056	AR	Cloud cover ::	I :: II	McNutt			5% ::		:: Canada/R	N/A :: Cloud	
2057	AR	Cloud cover ::	I :: II	Moore		% cover	10% :: 10%	wk	1 km :: Global		
2058	AR	Cloud cover ::	I :: II	Murakami		% cover	10% ::			N/A :: Cloud	
2059	AR	Cloud cover ::	I :: II	Sellers				4/dy	100 km ::	0.5 km :: Trop	
2060	AR	Cloud cover ::	I :: II	Srokosz		%	5% :: 1%	2/dy	10 km :: Ocean/S.A	N/A :: Cloud	
2061	AR	Cloud cover ::	I :: II	Wielicki			2% :: 2%	6/dy(d,n)	25-100 km :: Global	N/A :: Atmos	
2062	AR	Cloud cover ::	O :: FI	Chahine,Smith	AIRS/AMSU	dimensionless	0.05 :: 0.025	2/dy(d,n)	15 x 45 km :: Global	N/A :: Cloud	AL
2063	AR	Cloud cover ::	O :: FI	Smith	AIRS/AMSU	dimensionless	0.05 :: 0.025	2/dy (d,n)	15 x 45 km :: Global	N/A :: Cloud	AL
2064	AR	Cloud cover ::	O :: II	Barron		%		1 dy	10 km :: Regional		
2065	AR	Cloud cover ::	O :: II	Barron		%		5 min	30 km :: East.U.S		
2066	AR	Cloud cover ::	O :: II	Barron		%		5 min	2 km :: East.U.S		
2067	AR	Cloud cover ::	O :: II	Wielicki		fraction	5% :: 1%	18/dy(d,n)	25 km :: Regional	:: Atmos	
2068	AR	Cloud cover :: Areal extent	O :: FI	Kaufman	MODIS-N	km^2		mo	1 dg :: Global	N/A :: Sfc	PL
2069	AR	Cloud cover :: Cirrus	I :: II	Bates		/m/sr		1 dy-avg	100 km :: Global	0.5 km :: Trop	
2070	AR	Cloud cover :: Cirrus	I :: II	Lau		%	5% :: 5%	1 dy	100 km :: Global	N/A ::	
2071	AR	Cloud cover :: Cirrus	O :: FI	Hardesty	LAWS	/m/sr		1 dy-avg	100 km :: Global	0.5 km :: Trop	AL
2072	AR	Cloud cover :: Fraction	I :: II	Bates		dimensionless	0.05 :: 0.025	2/dy(d,n)	15 x 45 km :: Global	N/A :: Cloud	
2073	AR	Cloud cover :: Fraction	I :: II	Bates			:: 10%	6 hr	1 x 1 dg :: Global	N/A :: Cloud	
2074	AR	Cloud cover :: Fraction	I :: II	Bates		%	10% :: 5%	dy,mo	1 dg :: Global	N/A :: Cloud	
2075	AR	Cloud cover :: Fraction	I :: II	Kerr,Sorooshian		%	5% :: 5%	1 dy	10 km :: Land/R	N/A :: Cloud	
2076	AR	Cloud cover :: Fraction	I :: II	Rothrock		dimensionless	0.1 :: 0.1	1 dy	100 km :: Polar	N/A :: Cloud	
2077	AR	Cloud cover :: Fraction	I :: II	Wielicki			2% :: 2%	16 dy	30 m :: Regional	N/A :: Atmos	
2078	AR	Cloud Cover :: Fraction	O :: FI	Spinhirne	GLRS	%	1% ::	2-16 dy	10-200 km :: Global	N/A ::	AL
2079	AR	Cloud cover :: Fraction	O :: FI	Welch	HIRIS	dimensionless	1% :: 0.5%	1-3 min,2-16 dy	30 m :: Local	:: Cloud	AL
2080	AR	Cloud cover :: Fraction	O :: FI	Welch	ITIR	dimensionless	3% :: 3%	16 dy	15-30 m :: Local	N/A :: Cloud	AL
2081	AR	Cloud cover :: Fraction	O :: FI	King	MODIS-N	%	10% :: 5%	2/dy(d,n), mo	5 km :: Global	N/A :: Cloud	AL
2082	AR	Cloud cover :: Fraction	O :: FI	King	MODIS-N	%	10% :: 5%	1 dy,mo	1 x 1 dg :: Global	N/A :: Cloud	AL
2083	AR	Cloud cover :: Fraction	O :: II	Bates		dimensionless		20 min	50 km :: Global	N/A :: High cloud	
2084	AR	Cloud cover :: Fraction	O :: II	Bates		dimensionless		20 min	50 km :: Global	N/A :: Mid clouds	
2085	AR	Cloud cover :: Fraction	O :: II	Bates		dimensionless		20 min	50 km :: Global	N/A :: Low clouds	
2086	AR	Cloud cover :: Fraction	O :: PI	Barkstrom	CERES	dimensionless	5% :: 2%	6/dy (d,n)	25 km :: Global	N/A :: Atmos	AL
2087	AR	Cloud cover :: Fraction	O :: PI	Barkstrom	CERES	dimensionless	5% :: 2%	6 hr	1.25 x 1.25 dg :: Global	N/A :: Atmos	AL
2088	AR	Cloud cover :: Fraction	O :: PI	Barkstrom	CERES	dimensionless	5% :: 2%	dy-,mo-avg	1.25 x 1.25 dg :: Global	N/A :: Atmos	AL
2089	AR	Cloud cover :: Fractional	O :: II	Barron		fraction		12 hr	4.5 x 7.5 dg :: Global		
2090	AR	Cloud cover :: Fractional	O :: II	Barron		fraction		12 hr	2.8 x 2.8 dg :: Global		
2091	AR	Cloud cover :: OH	I :: II	Hansen			3% ::	1-wk avg	500 km :: Global	:: Trop	
2092	AR	Cloud cover :: Perimeter	O :: FI	Kaufman	MODIS-N	km		mo	1 dg :: Global	N/A :: Sfc	PL
2093	AR	Cloud cover :: Size distribution	O :: FI	Welch	ITIR	dimensionless		16 dy	15-90 m :: Local	N/A :: Cloud	AL
2094	AR	Cloud JPDF ::	O :: FI	King,Menzel	MODIS-N&T	dimensionless		1 dy , mo	1 dg :: Global	N/A :: N/A	PL
2095	AR	Color index :: Soil	O :: FI	Huete	MODIS-N&T	class	10% :: 5%	mo	1 km :: Land/R	N/A :: Sfc	AL
2096	AR	Cross section :: Altimeter	I :: II	Srokosz		dB	0.2dB :: 0.1dB	10 dy	10 km :: Ocean/S.A	N/A :: Sfc	
2097	AR	Cross section :: Backscatter	I :: II	Brewer		dB	10% :: TBD	dy,seas	25 km :: Ocean	N/A :: Sfc	
2098	AR	Cross section :: Backscatter	I :: II	Cihlar			2 dB :: 1 dB	3 mo	25 m :: Canada/R	N/A :: Sfc	
2099	AR	Cross section :: Backscatter	I :: II	Cihlar			2 dB :: 1 dB	3 mo	25 m :: Canada/R	N/A :: Sfc	
2100	AR	Cross section :: Backscatter	I :: II	Cihlar			2 dB :: 1 dB	6 mo	10 m :: Canada/R	N/A :: Sfc	

TABLE 1: EXAMPLE OF EOS DATA PRODUCTS IN THE SCIENCE OF CLOUDS

It is evident from Table 1 that significant overlap does exist between investigators and their proposed products. It is probable that each instrument team will have one person responsible for a single product. Products common between instruments will provide cross correlation and verification of each others product. The Interdisciplinary Investigators may come to depend on the instrument learns for many of these overlap products. Thus, there is the expectation that the number of products can be seduced as indicated earlier.

Table 2 is an illustration of products anticipated for the MODIS instrument. MODIS has a very broad range of utility and will be a primary source of data for many products related to global change.

Having provided these examples of the data base, it is now time to speculate regarding potential commercial uses.

SPECULATIONS ON THE COMMERCIAL USES OF EOS DATA

Several years ago the book Megatrends projected that we would increasing depend on information technology. Judging by the large number of articles on geographic information systems now appearing in the journal Photogrammetric Engineering & Remote Sensing, both hardware and software have progressed to be able to support multidimensional data overlays. It is in this environment that it seems likely that EOS Level 3&4 data will find potential commercial application. Government data policy will impact this potential to some extent. With 8 years to launch, data access policy and pricing can be worked between the government and the science and end user communities.

The business community that will supply the value added processing to tailor EOS data products to the needs of their customers will supply much of the insight and imagination required to provide the commercial products. ne next set of paragraphs suggest some areas that have already been in consideration. Cost to the user and lack of timeliness have limited the success of these endeavors in the current time frame.

Commodity Futures Trading

Global information on crop type, estimates of acreage undercultivation, and crop vigor may be a data set that can be derived from EOS data. Data on vegetation index, crop cover type, areal extent of cultivation, precipitation, soil water content, and long term climate trends are expected to be products provided on a global scale by EOS passive electro-optical sensors (MODIS, AIRS, & CERES), and passive microwave sensors (AMSU & HIMSS). Some clever individuals may find a way to combine the essential elements in a unique approach that is beneficial to futures trading in commodities or to farming interests that want to optimally compete in the global market. The Goddard Space Flight Center work by Dr. Jim Tucker in deriving global vegetation index by season from AVHRR archived data is a precursor technology in this area.

Mineral and Oil Exploration

For many years the GEOSAT group has lobbied for space technology that supports the oil and mineral exploration industry. Several EOS sensors may be a step in this direction. HIRIS with its high spatial (30m) footprint and high spectral resolution shortwave infrared capability and pointable field-of-view (24km swath width) is well suited to potential mineral exploration capability. The Japanese ITIR will provide same orbit stereo observations at 15m resolution. This capability could benefit observation of geologic formations of interest to the oil industry. The MISR instrument provides a potential for stereo observations, but with a larger footprint over a wider swath. Again, the potential exists to develop commercial products tailored to a user in need of data in. poorly explored regions of the globe.

Products for the News Media

With multispectral capability and high resolution that is capable of observing interesting cultural features, the ITIR instrument may find potential users of its data to provide the nightly news or the printed media with color photography that might even show the deployment of opposing military confrontations, the extent of

Prod #	Cat	Parameter :: Qualifier	Type	Investigator	Instr.	Units	Accuracy Abs :: Rel	Temporal Resolution	Horizontal Resol. :: Domain	Vertical Resol. :: Domain	Time frame
2417	AR	Radiance :: Water_leaving	O :: FI	Gordon et al	MODIS-N&T	mW/cm^2/sr/um	10% :: 5%	1 dy,wk,mo	20 km :: Ocean/GR	N/A :: Sfc	AL
2577	BM	Coccolith :: Detached	O :: FI	Gordon,Clark	MODIS-N&T	mg-CaCO3/m^3	30% :: 10%	1 dy,wk,mo	20 km :: Ocean/GR	N/A :: TOO	AL
2578	BM	Coccolith :: Detached	O :: FI	Gordon,Clark	MODIS-N&T	mg-CaCO3/m^3	30% :: 10%	1 dy,wk,mo	1 km :: Ocean/L	N/A :: TOO	AL
2591	BM	Pigment ::	O :: FI	Gordon,Clark	MODIS-N&T	mg/m^3	30% :: 10%	1 dy,wk,mo	20 km :: Ocean/GR	N/A :: TOO	AL
2592	BM	Pigment ::	O :: FI	Gordon,Clark	MODIS-N&T	mg/m^3	30% :: 10%	1 dy,wk,mo	1 km :: Ocean/RL	N/A :: TOO	AL
3199	OR	Attenuation_coef :: @490nm	O :: FI	Gordon,Clark	MODIS-N&T	/m	25% :: 10%	1 dy,wk,mo	20 km :: Ocean/I, RL	N/A :: TOO	AL
3200	OR	Attenuation_coef :: @490nm	O :: FI	Gordon,Clark	MODIS-N&T	/m	25% :: 10%	1 dy,wk,mo	1 km :: Ocean/I, RL	N/A :: TOO	AL
2573	BM	Chlorophyll :: Fluor_line_curv	O :: FI	Hoge	MODIS-N	mW/cm^2/sr/um	25% :: 8%	1 dy,wk	1 km :: Ocean/R	N/A :: TOO	AL
2574	BM	Chlorophyll :: Fluor_line_curv	O :: FI	Hoge	MODIS-N	mW/cm^2/sr/um	25% :: 8%	1 dy,wk	20 km :: Ocean	N/A :: TOO	AL
2593	BM	Pigment :: Curv	O :: FI	Hoge	MODIS-N&T	mg/m^3	35% :: 15%	1 dy, 1 wk	1 km :: Ocean/R	N/A :: TOO	PL
2594	BM	Pigment :: Curv	O :: FI	Hoge	MODIS-N&T	mg/m^3	35% :: 15%	1 dy, 1 wk	20 km :: Ocean/R	N/A :: TOO	PL
2585	BM	Phycoerythrin ::	O :: FI	Hoge	MODIS-T	mg/m^3	200% :: 50%	1 dy,wk,mo	1 km :: Ocean/RL	N/A :: TOO	AL
2586	BM	Phycoerythrin ::	O :: FI	Hoge	MODIS-T	mg/m^3	200% :: 50%	1 dy,wk,mo	20 km :: Ocean	N/A :: TOO	AL
2537	AR	Temperature_diff :: Day-night	O :: FI	Huete	MODIS-N	K	1 K :: 1 K	1 dy	856 m :: Regional	N/A :: Sfc	PL
2047	AR	Brightness_index :: Soil	O :: FI	Huete	MODIS-N&T	%	5% :: 5%	mo	1 km :: Land/R	N/A :: Sfc	AL
2095	AR	Color_index :: Soil	O :: FI	Huete	MODIS-N&T	class	10% :: 5%	mo	1 km :: Land/R	N/A :: Sfc	AL
2286	AR	Mixture_model :: Spectral-Spatial	O :: FI	Huete	MODIS-N&T	dimensionless	5-10% :: 0.05	1 dy	Pixel size :: Global	N/A :: Sfc	PL
2724	BT	Vegetation_index :: Soil&BRDF_adjusted	O :: FI	Huete	MODIS-N&T	dimensionless	0.01 :: 0.01	1 dy,wk,mo	1 km :: Land/R	N/A :: Sfc	PL
2748	BT	Vegetation_index :: Soil_adjusted	O :: FI	Huete	MODIS-N&T	dimensionless	0.01 :: 0.01	dy,wk,mo	1 km :: Land/R	N/A :: Sfc	AL
3304	XX	XXX :: Data_char	O :: FI	Justc,Strahlr	MODIS-N&T	dimensionless	30,10, 5% ::	1 dy	1 km :: Global	N/A :: Sfc	PL
3305	XX	XXX :: Data_char	O :: FI	Justc,Strahlr	MODIS-N&T	dimensionless	30,10, 5% ::	1 dy	10 km :: Global	N/A :: Sfc	PL
3306	XX	XXX :: Data_char	O :: FI	Justc,Strahlr	MODIS-N&T	dimensionless	30,10, 5% ::	1 dy	50 km :: Global	N/A :: Sfc	PL
2659	BT	Duration :: Growing_season	O :: FI	Justice	MODIS-N&T	dy	10 dy ::	1 yr	1 km :: Land	N/A :: Sfc	PL
2660	BT	Duration :: Growing_season	O :: FI	Justice	MODIS-N&T	dy	10 dy ::	1 yr	10 km :: Land	N/A :: Sfc	PL
2749	BT	Vegetation_index ::	O :: FI	Justice,Huete,et al	MODIS-N&T	dimensionless	0.01 :: 0.01	dy,wk,mo	10 km :: Land	N/A :: Sfc	AL
2750	BT	Vegetation_index ::	O :: FI	Justice,Huete,et al	MODIS-N&T	dimensionless	0.01 :: 0.01	dy,wk,mo	0.5 km :: Land/R	N/A :: Sfc	AL
2751	BT	Vegetation_index ::	O :: FI	Justice,Huete,et al	MODIS-N&T	dimensionless	0.01 :: 0.01	dy,wk,mo	1 km :: Land/R	N/A :: Sfc	AL
2259	AR	Heterogeneity :: Spatial	O :: FI	Justice,Strahler	MODIS-N	W/m^2/sr/um	50% ::	1 dy	428 m :: Global	N/A :: Sfc	AL
2260	AR	Heterogeneity :: Spatial	O :: FI	Justice,Strahler	MODIS-N	W/m^2/sr/um	20% ::	1 dy	856 m :: Global	N/A :: Sfc	AL
2262	AR	Heterogeneity :: Spatial	O :: FI	Justice,Strahler	MODIS-T	W/m^2/sr/um	30% ::	1 dy	1.1 km :: Global	N/A :: Sfc	AL
2068	AR	Cloud_cover :: Areal_extent	O :: FI	Kaufman	MODIS-N	km^2		mo	1 dg :: Global	N/A :: Sfc	PL
2092	AR	Cloud_cover :: Perimeter	O :: FI	Kaufman	MODIS-N	km		mo	1 dg :: Global	N/A :: Sfc	PL
2429	AR	Reflectance :: Directional	O :: FI	Kaufman et al	MODIS-N	dimensionless	0.01 :: 0.005	1 dy	856 m :: Global	N/A :: Sfc	AL
2430	AR	Reflectance :: Directional	O :: FI	Kaufman et al	MODIS-N	dimensionless	0.01 :: 0.005	1 dy	428 m :: Global	N/A :: Sfc	AL
2431	AR	Reflectance :: Directional	O :: FI	Kaufman et al	MODIS-N	dimensionless	0.01 :: 0.005	1 dy	214 m :: Global	N/A :: Sfc	AL
2471	AR	Temperature :: Fires	O :: FI	Kaufman, Justice	MODIS-N	C (K)	10 C (K) :: 5 C (K)	1 dy,wk	1 km :: Land/R	N/A :: Sfc	AL
2663	BT	Fires :: Count	O :: FI	Kaufman, Justice	MODIS-N			1 dy,wk	1 km :: Land/R	N/A :: Sfc	AL
2664	BT	Fires :: Count	O :: FI	Kaufman, Justice	MODIS-N			1 dy,wk	10 km :: Land	N/A :: Sfc	AL
2665	BT	Fires :: Extent	O :: FI	Kaufman, Justice	MODIS-N			1 dy,wk	1 km :: Land/R	N/A :: Sfc	AL
2666	BT	Fires :: Extent	O :: FI	Kaufman, Justice	MODIS-N			1 dy,wk	10 km :: Land	N/A :: Sfc	AL
2711	AR	Temperature :: Fires	O :: FI	Kaufman, Justice	MODIS-N	C (K)	10 C (K) :: 5 C (K)	1 dy,wk	10 km :: Land	N/A :: Sfc	AL
1017	AC	Aerosol_mass ::	O :: FI	Kaufman,Tanre	MODIS-N	g/m^2	30% :: 10%	dy,mo	0.5 dg :: Global/R	N/A :: Atmos	AL
1874	AH	H2O :: Integrated	O :: FI	Kaufman,Tanre	MODIS-N	mm	5 mm :: 3 mm	1 dy	5 km :: Global	N/A :: Atmos	AL
2293	AR	Optical_depth :: Aerosol	O :: FI	Kaufman,Tanre	MODIS-N	dimensionless	0.1 :: 0.05	dy,mo	0.5 dg :: Land	N/A :: Atmos	AL
2379	AR	Radiance :: Land_leaving	O :: FI	Kaufman,Tanre	MODIS-N	W/m^2/sr/um	10% :: 5%	1 dy	1 km :: Land/R	N/A :: Sfc	AL
2380	AR	Radiance :: Land_leaving	O :: FI	Kaufman,Tanre	MODIS-N	W/m^2/sr/um	10% :: 5%	1 dy	10 km :: Land	N/A :: Sfc	AL
2381	AR	Radiance :: Land_leaving	O :: FI	Kaufman,Tanre	MODIS-N	W/m^2/sr/um	10% :: 5%	1 dy	0.5 km :: Land/R	N/A :: Sfc	AL
1764	AH	Cloud_drop_phase ::	O :: FI	King	MODIS-N	water/ice	90% Conf :: 90% Conf	1/dy	5 km :: Global	N/A :: Cloud	AL
1765	AH	Cloud_drop_phase ::	O :: FI	King	MODIS-N	water/ice	90% Conf :: 90% Conf	1 dy,mo	1 dg :: Global	N/A :: Cloud	AL
2081	AR	Cloud_cover :: Fraction	O :: FI	King	MODIS-N	%	10% :: 5%	2/dy(d,n), mo	5 km :: Global	N/A :: Cloud	AL

TABLE 2: EXAMPLE OF SELECTED DATA PRODUCTS FOR THE MODIS FACILITY INSTRUMENT

earthquake damage, the details of an ash cloud from a volcanic explosion, or the acreage destroyed by fires in the tropical rain forest. Of course, mother nature has to cooperate with reasonable clear observing conditions, but given the opportunity the potential is there to service the news organizations.

Land Management

Geographic information systems are beginning to be a practical tool for local, regional, and national governments to use in land management. Documentation on utility and transportation infrastructure and zoning are already being incorporated. Remote sensing products will be increasingly beneficial to the monitoring of land use, of changes with time, and of natural resources. Several EOS instruments can benefit customers concerned with these issues. The value of the data from a given instrument depends on the scale of the observation, the field-of-view, and the temporal coverage. Third world customers could be a significant user of these kinds of data sets if the benefit to price ratio is within the scope of their resources. Value added services will have to work with these customers to develop the data needs of the land managers.

Ocean Fishing Fleet Harvest Forecasts

The MODIS instrument is specifically tailored to extend the present Coastal Zone Color Scanner capability to a higher precision product. Knowledge of seasonal trends in bioproductivity and potentially weekly knowledge of fishing area conditions conducive or destructive to commercial fish populations could be products derived from EOS data. With a FAX machine in everybody's floating office the data could be provided to the user in situ. The trick will be to develop enough experience to know what information is useful to be able to develop a commercial information product from the EOS data sets.

SUMMARY

Combinations of the data from selected instruments in the EOS payload has the potential to meet the needs of public and private customers. The development of commercial data products from these data requires value added services. The people that provide these value added services will have to understand the needs of their customers, the nature of the EOS data sets, and the proper combination of EOS data to meet the needs of their customers. Most of the initiative and imagination needed to create these products will come from the private sector. Data policy and pricing are issues to be worked over the next half decade.

SESSION D - HUMAN FACTORS ENGINEERING AND LIFE SCIENCES (PART 2)

Wednesday November 28, 1990

- Simulation Of Blood Flow Through An Artificial Heart
- Three-Dimensional Structure Of Human Serum Albumin
- A Noninvasive Measure Of Minerals And Electrolytes In Tissue
- Oxygen Production Using Solid-State Zirconia Electrolyte Technology
- Monitoring And Control Technologies For Bioregenerative Life Support Systems