NPOESS – Global Data for the Global Observation System

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The Aerospace Corporation

Direct Readout Conference
9 December 2004
NPOESS MISSION

NPOESS provides high quality, timely observations of the Earth’s environment. Not just a “Weather” satellite, also provides climate quality data.

Evolutionary move from today to support emerging science (NWP, etc)
Serves as a compliment to new hardware and computer modeling

NPOESS uses a variety of sensors to observe the Earth’s environment:
- Routinely measure from ultra violet to far Infrared and microwave
- Three evenly spaced orbits to provide global coverage
- 15 geographically separated ground sites to improve data timeliness

Time from photon to product less than 28 minutes 95% of the time
Time from photon to product less than 15 minutes 75% of the time
NPOESS Requirements

Integrated Operational Requirements Document (IORD-I)
- 59 Data Products
- 9 Enhancement Products
- 1 System Characteristic KPP
Validated by JARC 1996

IORD-II
- 55 Data Products
- 21 Enhancement Products
- 2 System Characteristic KPPs
Validated by JARC Dec 2001

Converged Requirements Provide Foundation for Combined Program
NPOESS Program Overview

NPOESS EDR-to-Sensor Mapping

**MISSION AREAS**
- Atmosphere
- Climate
- Land
- Ocean
- Space

**CMIS** (19)
- CLOUD BASE HEIGHT
- Ice Surface Temperature
- VISABLE / IR IMAGERY
- LAND SURFACE TEMP
- Sea Ice Characterization
- Snow Cover/Depth
- Surface Type
- SEA SURFACE TEMPERATURE
- SOIL MOISTURE

**SESS** (13)
- Aurora Boundary
- Auroral Energy Deposition
- Electric Fields
- Electron Density Profile
- Auroral Imagery
- Energetic Ions
- Geomagnetic Field
- In-situ Plasma Fluctuation
- In-situ Plasma Temp
- Ionospheric Scintillation
- Med Energy Chgd Parts
- Neutral Density Profile
- Supra-Them-Aura Prop

**CrIS/ATMS** (3)
- ATM VERT MOIST PROFILE
- ATM VERT TEMP PROFILE
- PRESSURE (SURFACE/PROFILE)

**VIIRS** (22)
- AEROSOL OPTICAL THICKNESS
- AEROSOL PARTICLE SIZE

**APS** (4)
- Aerosol Refractive Index
- Cloud Particle Size/Distrib

**ERBS** (4)
- Down LW Radiance (Sfc)
- Down SW Radiance (Sfc)
- Net Solar Radiation (Sfc)
- Outgoing LW Rad (TOA)

**ALTIMETRY** (2)
- OCEAN WAVE CHARACTERISTICS
- Sea Surface Height

**OMPS** (1)
- $O_2$ Total Column & Profile

**TSIS** (1)
- Solar Irradiance

**Underlined** = NPP EDRs (25)

**KEY**
- = NPOESS Key Performance Parameters
- BOLD CAPS = LDR Environmental Data Records
* = not yet on contract

16 Nov 2004
DOC, NOAA, NESDIS, Integrated Program Office
D. Pierce, J. Whitcomb, J. Schaeffer

NPOESS Program Overview
Integrated Operational Requirements Document (IORD) Example

Sea Surface Temperature (SST)
Highly precise measurement of the temperature of the surface layer (upper 1 meter) of ocean water

<table>
<thead>
<tr>
<th>Systems Capabilities</th>
<th>Thresholds</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Horizontal Cell Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nadir, clear</td>
<td>1 km</td>
<td>0.25 km</td>
</tr>
<tr>
<td>Worst case, clear</td>
<td>1.3 km</td>
<td></td>
</tr>
<tr>
<td>All Weather</td>
<td>40 km</td>
<td>20 km</td>
</tr>
<tr>
<td>b. Mapping Accuracy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nadir, clear</td>
<td>1 km</td>
<td>0.1 km</td>
</tr>
<tr>
<td>Worst case, clear</td>
<td>1.3 km</td>
<td></td>
</tr>
<tr>
<td>All Weather</td>
<td>5 km</td>
<td>3 km</td>
</tr>
<tr>
<td>c. Measurement Range</td>
<td>-2° to 40° C</td>
<td>-2° to 40° C</td>
</tr>
<tr>
<td>d. Measurement Precision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear</td>
<td>0.2° C</td>
<td>0.1° C</td>
</tr>
<tr>
<td>All Weather</td>
<td>0.3° C</td>
<td>0.1° C</td>
</tr>
<tr>
<td>e. Measurement Uncertainty</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clear</td>
<td>0.5° C</td>
<td>0.1° C</td>
</tr>
<tr>
<td>All Weather</td>
<td>1.0° C</td>
<td>0.5° C</td>
</tr>
<tr>
<td>f. Refresh</td>
<td>6 hours</td>
<td>3 hours</td>
</tr>
<tr>
<td>g. Long-Term Stability</td>
<td>0.1° C</td>
<td>0.05° C</td>
</tr>
<tr>
<td>h. Latency</td>
<td>90 minutes</td>
<td>15 minutes</td>
</tr>
<tr>
<td>i. Geographic Coverage</td>
<td>Global Ocean</td>
<td>Global Ocean</td>
</tr>
</tbody>
</table>

Major Applications
1) sea surface phenomenology
2) infrared cloud / no cloud decision for processed cloud data

apply only under clear conditions (unless specified otherwise)
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Evolutionary Roadmap

1960 - 2010

DMSP
(Defense Meteorological Satellite Program)
Sensor data rate: 1.5 Mbps
Data latency: 100-150 min.
1.7 GigaBytes per day (DMSP)
6.3 GigaBytes per day (POES)

POES
(Polar Orbiting Operational Environmental Satellites)

2000 - 2010

NPP
(NPOESS Preparatory Project)
15 Mbps sensor data rate
Data latency: 100-180 min.
Data availability: 98%
Ground revisit time: 12 hrs.
2.6 TeraBytes per day (EOS)
2.4 TeraBytes per day (NPP)

EOS
(Earth Observing System)

2010 – 2020+

NPOESS
(National Polar-orbiting Operational Environmental Satellite System)
20 Mbps sensor data rate
Data latency: 28 min.
Data availability: 99.98%
Autonomous capability: 60 days
Selective encryption/deniability
Ground revisit time: 4-6 hrs.
8.1 TeraBytes per day

NPOESS Satisfies Evolutionary Program Needs with Enhanced Capabilities
5-Order Magnitude Increase in Satellite Data Over 10 Years

Daily Upper Air Observation Count

Satellite Instruments by Platform

<table>
<thead>
<tr>
<th>Year</th>
<th>Count (Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>1</td>
</tr>
<tr>
<td>2000</td>
<td>10</td>
</tr>
<tr>
<td>2002</td>
<td>20</td>
</tr>
<tr>
<td>2003</td>
<td>50</td>
</tr>
<tr>
<td>2010</td>
<td>100</td>
</tr>
<tr>
<td>2010-250ch</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Count

Year

NPOESS
METOP
NOAA
Windsat
GOES
DMSP
Use of Advanced Sounder Data for Improved Weather Forecasting/Numerical Weather Prediction

NOAA Real-Time Data Delivery Timeline
Ground Station Scenario

C3S → IDPS → NOAA Real-time User

Joint Center for Satellite Data Assimilation

NWS/NCEP
GSFC/DAO
ECMWF
UKMO
FNMOC
Meteo-France
BMRC-Australia
Met Serv Canada

NWP Forecasts
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Development Sensor Highlights

Visible/Infrared Imager Radiometer Suite (VIIRS) (Supports 22 EDRs)
- Raytheon Santa Barbara: Prototype in assembly/qual, flight unit in production
  - 0.4 km imaging and 0.8 km radiometer resolution
  - 22 spectral bands covering 0.4 to 12.5 µm
  - Automatic dual VNIR and triple DNB gains
  - Spectrally and radiometrically calibrated
  - EDR-dependent swath widths of 1700, 2000, and 3000 km

Crosstrack InfraRed Sounder (CrIS) (Supports 3 EDRs)
- ITT Ft Wayne: Prototype in qualification, flight unit in production
  - 158 SWIR (3.92 to 4.64 µm) channels
  - 432 MWIR (5.71 to 8.26 µm) channels
  - 711 LWIR (9.14 to 15.38 µm) channels
  - 3x3 detector array with 15 km ground center-to-center
  - 2200 km swath width

Advanced Technology Microwave Sounder (ATMS) - NASA (Supports 3 EDRs)
- Northrop Grumman Electronics: Flight unit in protoqual
  - CrIS companion cross track scan
  - Profiling at 23, 50 to 57, 183 GHz
  - Surface measurements at 31.4, 88, 165 GHz
  - 1.1, 3.3, and 5.2 deg (SDRs resampled)
  - 2300 km swath width

Ozone Mapping and Profiler Suite (OMPS) (Supports 1 EDR)
- Ball Aerospace: Flight unit in production
  - Total ozone column 300 to 380 nm with 1.0 nm resolution
  - Nadir ozone profile 250 to 310 nm with 1.0 nm resolution
  - Limb ozone profile 290 to 1000 nm with 2.4 to 54 nm resolution
  - Swath width of 2800 km for total column
Conical Scanning Microwave Imager/Sounder (CMIS) (Supports 19 EDRs)

Boeing Space Systems  Delta PDR complete

- 2.2 m antenna
- RF imaging at 6, 10, 18, 36, 90, and 166 GHz
- Profiling at 23, 50 to 60, 183 GHz
- Polarimetry at 10, 18, 36 GHz
- 1700 km swath width
- Radio Interference (RFI) ECP complete, negotiations being wrapped up
Leverage Sensor Highlights

Radar Altimeter (ALT)  (Supports 3 EDRs)
Alcatel
- Measures range to ocean surface with a radar at 13.5 GHz
- Corrects for ionosphere with 5.3 GHz radar
- Corrects for atmosphere with CMIS water vapor measurements
- Precise orbit determination with GPS

Earth’s Radiation Budget Suite (ERBS)  (Supports 4 EDRs)
Northrop Grumman Space Technology
- Three spectral channels
- Total radiation measurement 0.3 to 50 \( \mu \text{m} \)
- Shortwave Vis and IR measurement 0.3 to 5 \( \mu \text{m} \)
- Longwave IR measurement 8 to 12 \( \mu \text{m} \)

Total Solar Irradiance Sensor (TSIS)  (Supports 1 EDR)
University of Colorado  Agreements in place, design underway
- Two sensors for total irradiance (TIM) & spectral irradiance (SIM)
  - TIM measures total solar irradiance
  - SIM measures spectral irradiance 200 to 2000 nm
- Pointing platform and sensor suite to be provided by CU LASP

Survivability Sensor (SS)
Highlights of Other Sensors

Space Environment Sensor Suite (SESS) (Supports 13 EDRs)

Ball Aerospace  Final instrument suite being selected, ECP in negotiations
- Sensor suite collecting data on particles, fields, aurora, and ionosphere
- Suite includes a UV disk imager (BATC), charged particle detectors (Amptek/U. of Chicago), thermal plasma sensors (UTD)
- Will distribute suite on all 3 orbital planes

Advanced Data Collection System (ADCS) and Search and Rescue Satellite-Aided Tracking (SARSAT)

ITAR approved licenses in place, first integration TIMs underway
- “GFE” to NPOESS from France and Canada
- ADCS supports global environmental applications
- SARSAT collects distress beacon signals

Aerosol Polarimetry Sensor (APS) (Supports 4 EDRs)

Raytheon Santa Barbara Research Center  Full development on hold pending NASA satellite “Glory” plans
- Aerosol characterizations of size, single scattering albedo, aerosol refractive index, aerosol phase function
- Multispectral (broad, 0.4 to 2.25 µm)
- Multiangular (175 angles)
- Polarization (all states)
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### NPOESS Top Level Architecture

#### Data Quality
- **SMD/HRD**
- **LRD**

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<tr>
<th>Data Quality</th>
<th>Threshold</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>128 attributes above, 724 at, 7 below threshold</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>305 attributes above, 180 at, 0 below threshold</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Data Latency
- **SMD**
- **HRD/LRD**

#### Data Availability

#### Operational Availability

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**NPOESS Program Overview**
Average Data Latency

![Map of Average Data Latency](image)

Latency (minutes)

- > 63
- 58
- 53
- 48
- 43
- 38
- 33
- 28
- 23
- 18
- 13
- 8
- 3
A sample of NPOESS data will be available in late 2006 from NPP
NPOESS launches in late 2009
Operational after 12-18 month cal/val (varies by sensor)
Expect all three orbits filled by 2013
Data will be available to all
Real time data from direct downlink sent in the clear
Processing software will be available to all
No cost other than media and shipping
No cost if downloaded from the net
NPOESS will provide higher quality data in a more timely manner

For more information see www.npoess.noaa.gov