



Remote sensing for disaster prediction, detection, response, and relief

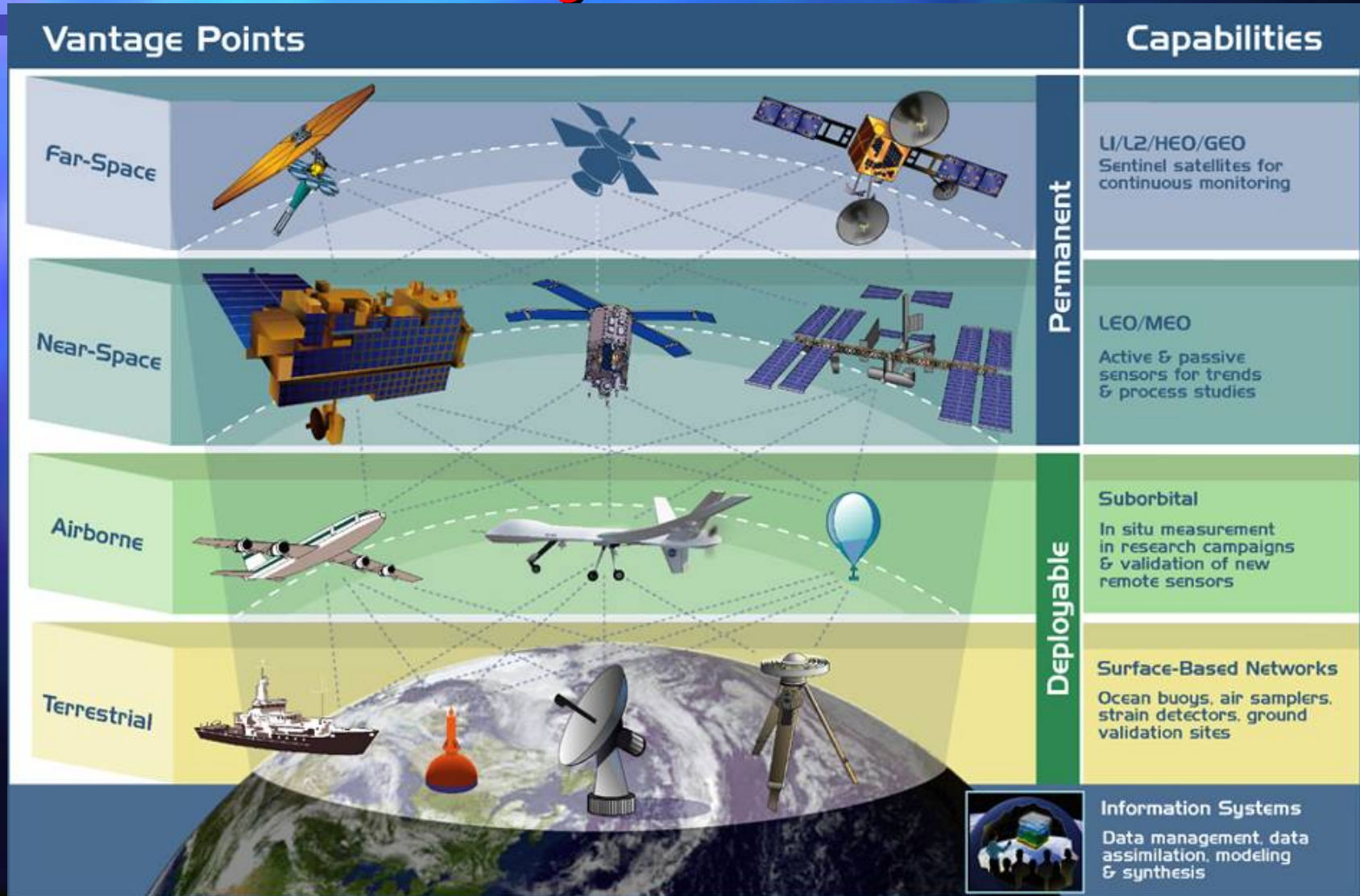
Thomas vonDeak

NASA HQ Spectrum Management Office

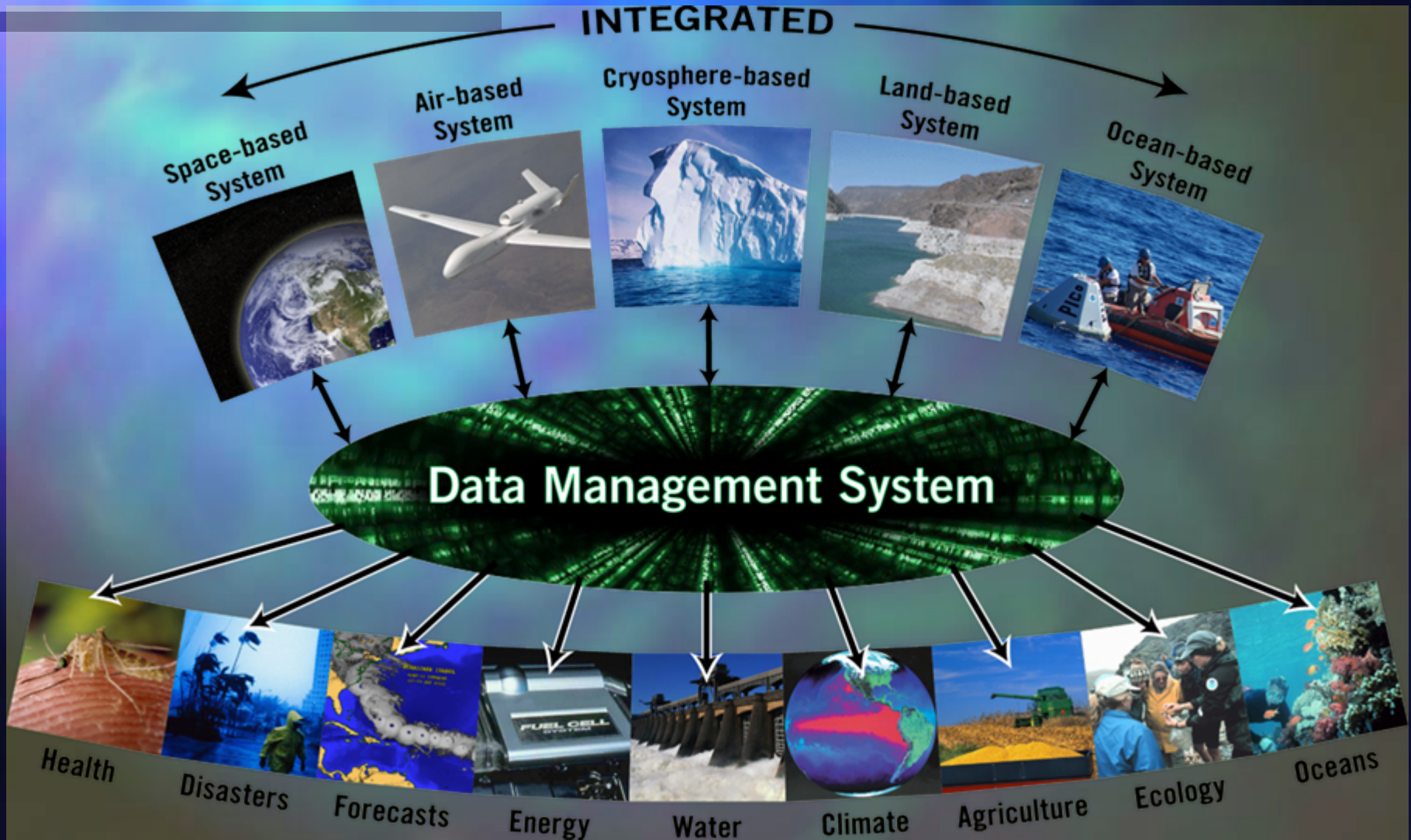
Three fundamental types of Remote Sensing

- **Optical, Infra-red**
 - Images
- **Submillimeter**
 - Images
- **Microwave (active or passive)**
 - Some images, data overlays

Remote sensing is a layered system

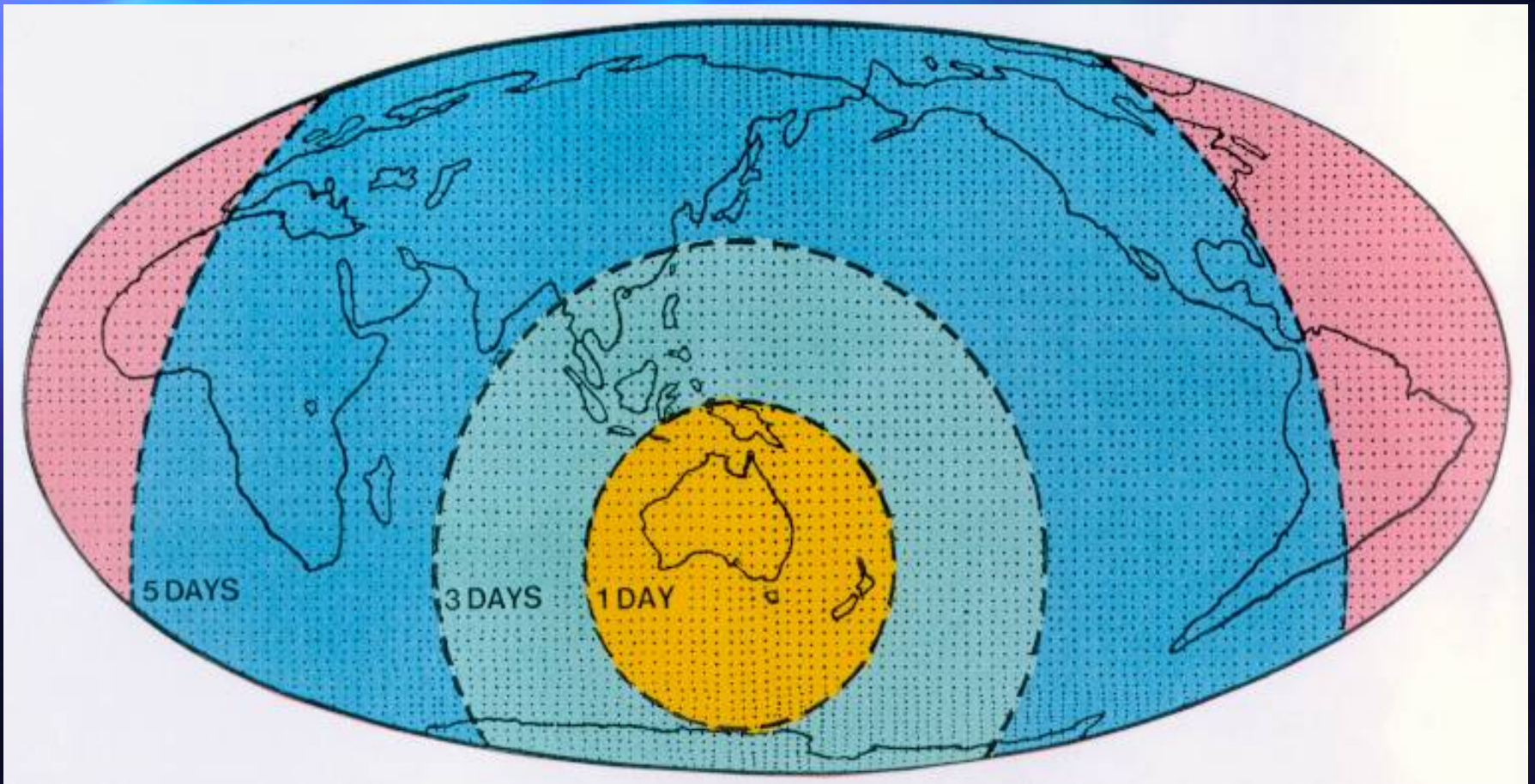


The complete system addresses societal concerns



Long range weather forecasts require global measurements

Space-based sensors provide this capability.



Remote Sensing Application Areas



**Agricultural
Efficiency**



Air Quality



Aviation



**Carbon
Management**



**Coastal
Management**



**Disaster
Management**



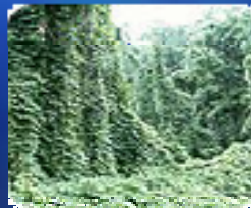
**Ecological
Forecasting**



**Energy
Management**



**Homeland
Security**



Invasive Species



Public Health



**Water
Management**

Disaster Management

EARTH SYSTEM MODELS

- Earthquake: *MMI, Quakesim*
- Hurricane: *HURRSIM*
- Flood: *SLOSH, WAVEwatch, STWAVE, HURSURGE*
- Land: *GPS Network, SBEACH*
- Building Cost Models: *ATC-13*
- Building Structure Models: *EPEDAT*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Land:** *Landsat, SRTM, GPS, SCIGN, Terra, Aqua*
- **Ocean:** *QuickSCAT, Seawinds, IceSAT, GOES, POES, SSMI, JASON, TOPEX/POSEIDON*
- **Atmosphere:** *TRMM, GOES, POES, GPM, NPP, NPOESS*

**Future Mission*

Predictions

- Earthquake prediction
- Floods
- Hurricane & Typhoons

- Land Surface Topography
- Global Precipitation
- Ocean Surface Winds
- Surface Deformation
- Motions of the Earth's Interior

Observations

DECISION SUPPORT TOOLS

- HAZUS-MH (Hazards U.S. - Multi Hazard)
- Disaster Recovery/ Mitigation
- Land use decision
- Potential economic loss
- Estimation of direct damage, induced damage, direct losses, and indirect losses
- Accurate risk prediction to communities
- Loss estimates of buildings, essential facilities, transportation & utility lifelines, and population
- Social impacts



VALUE & BENEFITS

- Identify/ Prioritize high-risk communities
- Reduction in lives lost
- Reduction in damage cost
- Anticipate the scope of disaster-related damage
- Improve disaster response
- Community Planning

Disaster Related Remote Sensing Applications

- Weather Prediction: a key input to numerical weather prediction models used globally for weather forecasting. (MW(passive))
- Global Warming: concentrations and distributions of atmospheric gases, sea and land ice thickness and change, and ozone measurements are key components to studying and prediction of global warming. (Microwave(passive), IR)
- Severe Weather Events: the prediction of severe weather events requires accurate measurements of rain rates in storms over the oceans which is only possible with remote sensing satellites. (MW(passive))
- Forest Fires: detection of fires through smoke by their microwave radiation. (IR)

Key Applications (continued)

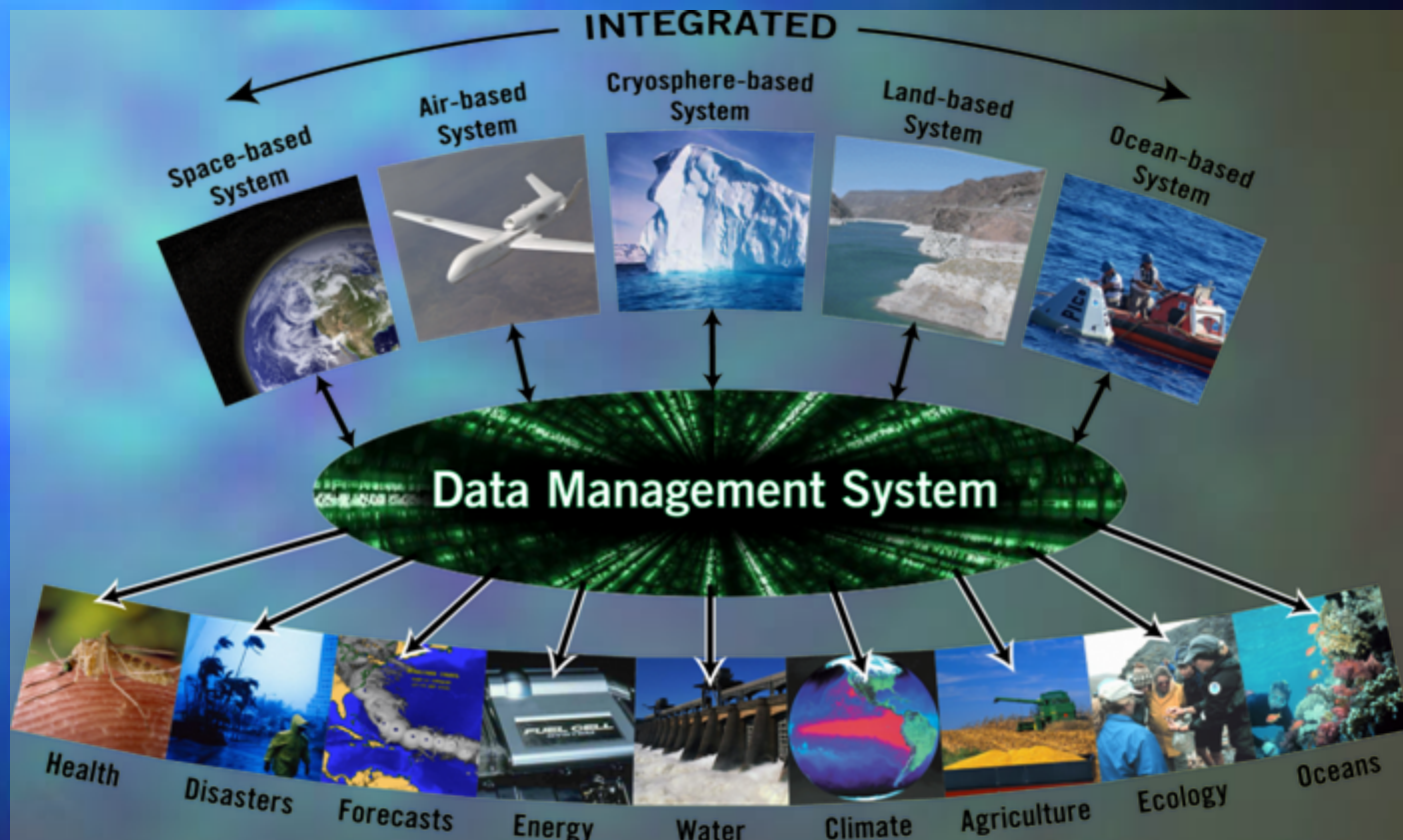
- Management of Natural Resources: measurements of biomass, deforestation, and water resources through systematic environmental monitoring. (MW (passive), IR, Optical)
- Volcanoes: used to detect volcanic activity even before eruptions and to track and predict the volcanic fallout effects. (Optical, MW(active), IR, SubM)
- Shipping: used to track sea ice, ice floes, and ocean storms to steer ships out of harm's way. (Optical, MW(active))
- Long Range Climate Forecasts: study of global atmospheric and oceanic events such as El Niño requires sea surface temperature, ocean winds, ocean wave height, and many other components used in the prediction of long range weather forecasting and climatic trends. (MW(active/passive))

Data Distribution and Access

Sensing

Processing

Distribution



The Bowtie

Data Distribution and Access

- **Two Current Efforts (of many)**
 - GEONETCast
 - Will support SPIDER
 - The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (SPIDER)

Group on Earth Observing

http://www.earthobservations.org/about/about_GEO.html

“The intergovernmental *Group on Earth Observations* (GEO) is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years.”



Group on
Earth Observations



GEOSS Concepts

GEOSS Societal Benefits

Improve Weather Forecasting

Reduce Loss of Life and Property From Disasters

Protect and Monitor Our Ocean Resource

Understand, Assess, Predict, Mitigate and Adapt of Climate Variability and Change

Support Sustainable Agriculture and Combat Land Degradation

Understand the Effects of Environmental Factors on Human Health and Well-Being

Develop the Capacity to Make Ecological Forecasts

Protect and Monitor Water Resources

Monitor and Manage Energy Resources

Information-Sharing During Disasters

- Agreement by all countries, governments and industry partners to share timely *in situ* and satellite information during disasters.

“GEONETCast”

- Global broadcast system for the delivery of data, products and services in support of all nine GEOSS societal benefit areas, including reducing loss of life and property from disasters.

Web-based Portal System

- Common web-based portal system for access to all Earth observation data, with specific links designed to increase use, quality and accessibility of existing information tools and networks – could serve as the data base link to GEONETCast.

The United Nations Platform for Space-based Information for Disaster Management and Emergency Response (SPIDER)

- **General Assembly A/RES/61/110; Adopted 14 December 2006**
 - Mission statement: “Ensure that all countries have access to and [develop the capacity to] use all types of space-based information to support the full disaster management cycle”.
 - A programme of the United Nations Office for Outer Space Affairs.
- **UN SPIDER expected to be a**
 - Gateway to Space-based Information for Disaster Management Support
 - Bridge to Connect the Disaster Management and Space Communities
 - Facilitator of Capacity Building and Institutional Network of Regional Support Offices and National Focal
- **Announced that SPIDER will have offices in Beijing and Bonn, Germany.**
- **Proposed Platform Programme 2007 – 2009 and Plan of Work for 2007 considered by the COPUOS Scientific and**

THANK YOU!

Thomas vonDeak

NASA HQ Spectrum Management Office

(VIEWS EXPRESSED ARE THOSE OF THE PRESENTER
AND DO NOT NECESSARILY REFLECT THOSE OF NASA.)

Backup Slides

- Complete set of Remote Sensing Application block diagrams.

Remote Sensing Application Areas



**Agricultural
Efficiency**



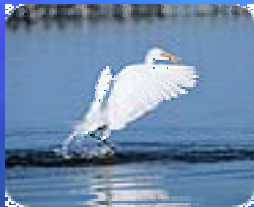
Air Quality



Aviation



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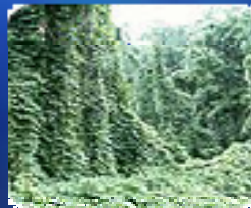
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VALUE & BENEFITS

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Air Quality



EARTH SYSTEM MODELS

- **Aerosol Transport:** *DAO GoCART*
- **Global-Regional Assimiliations:** *RAQMS*
- **Atmopsheric Chemistry:** *GEOS-CHEM*
- **Emissions:** *SMOKE*
- **Meteorology:** *MM5*
- **Air Trajectories:** *NOAA-Hysplit4*

Data

EARTH observatories

- **Aerosols:** *Terra, Aqua, TOMS, Aura, Aeronet, AIRNow, INTEX, Calipso Glory-APS*
- **Ozone & Precursors:** *TOMS, Aura, SAGE III, AIRNow, INTEX*
- **Trace Gases:** *Terra, Aqua, OCO*
- **Clouds:** *Terra, Aqua, CloudSAT, Calipso*
- **Land Use/Cover:** *Terra, Aqua, Landsat*
- **Atmospheric Parameters:** *GOES, POES, GITFS, NPP, NPOES*

Predictions

- **Atmospheric state parameters**
- **Global-to-regional concentrations**
- **Emissions inventories**
- **Regional-Global transport**
- **Trace Gas Sources**
- **Aerosol properties**
- **Ozone profiles & columns**
- **Global-regional boundary conditions**
- **Data fusion techniques**
- **Ground-satellite data comparison techniques**

Observations

DECISION SUPPORT TOOLS

- **CMAQ** (Community Multi-Scale Air Quality modeling system)
- **Assess emissions control strategies**
- **Develop achievable SIPs** (State Implementation Plan)
- **Assess compliance**
- **Waivers to air standards**
- **Quantify voluntary stationary emission reductions**

Inputs: Urban heat island reduction, emissions inventories

AQI (Air Quality Index)

- **Forecast transport of dust/pollutants**
- **Actions to reduce source emissions**
- **PM_{2.5} forecasts**

International Treaties

VALUE & BENEFITS

- **Reduce lung-related diseases & premature death**
- **Reduce hospital admissions & use of medicines**
- **Reduce lost workdays and schooldays**
- **Improve visibility and reduce haze for tourism**
- **Improve resiliency of crops; increase yields**
- **Increase confidence in government**
- **Improve crop estimates**
- **Sensitive populations can change activities**

Aviation

EARTH SYSTEM MODELS

- Weather: *WRF, RUC*
- Icing: *FAA CIP, FAA FIP*
- Convective Weather: *CIMSS Convective Cloud Mask, FAA NCWF*
- Ceiling/ Visibility: *FAA NCVP*
- Turbulence: *FAA GTG, ITFA*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

Atmosphere: *GOES, METEOSAT, GMS, TOMS, TRMM, QuikScat (SeaWinds), GIFTS Imager and Sounder Terra, Aqua*

- *MODIS, AIRS, NPP, NPOESS, etc.*
- *CrIS, IASI, NOAA-series, PIREPS, TAMDAR, THORPEX, AIRS, IHOP, CRYSTAL, IPO*
- *NAST, CPL, MAS, Wind Lidars, DOD Assets – GPS, DMSP, IAEA sats*

**Future Mission*

Predictions

- Convective Weather
- Turbulence
- Icing
- Ceiling and Visibility
- Volcanic Transport
- Oceanic Winds
- Winter Storms
- Tropical Cyclones

Observations

- Atmospheric Temperature
- Atmospheric Water Vapor
- Atmospheric Winds
- Storm Cell Properties
- Volcanic Gas & Ash
- Cloud Properties
- Global Precipitation

DECISION SUPPORT TOOLS

- **NAS-AWRP (National Airspace System- Aviation Weather Research Program)**
- Key weather observations
- Nowcasting Products
- 24 Hour precise continuous atmosphere
- Weather warnings and predictions
- Accurate and easily accessible weather forecasts
- Increase in understanding of atmospheric conditions
- Real time interest fields
- Comprehensive image library

Management Decisions

- Routing of Flights
- Turbulence/convective weather avoidance
- Fuel/Landing loads



VALUE & BENEFITS

- Improved Safety
- Improved Airline Efficiency
- Earlier warnings of hazardous weather
- Reduction in the cost of flying

Coastal Management

EARTH SYSTEM MODELS

- **Global Ocean Circulation Models:** LANL POP, LANL HYPOP
- **Coastal Ocean Circulation Models:** MITgcm, GFDL MOM4, ADCIRC, SHORECIRC
- **Wind & Wave Models:** COAMPS, SWAN
- **Ocean Pattern Models:** MITgcm, GFDL, HIM
- **Chlorophyll Models (regional)**
- **Sea Surface Temperature:** NSIPP Ocean, ECCO OSE

Data

EARTH OBSERVATORIES

- **SST & Salinity:** Terra, Aqua, Aquarius, GOES, NPP, NPOESS
- **Ocean Winds:** QuikScat, ADEOS-II, GCOM
- **Coastal/Land Use:** Terra, Aqua
- **Ocean Color:** Terra, Aqua, NPP, NPOESS
- **Ocean Topography:** Topex, Jason 1, OSTM
- **Precipitation:** TRMM, Aqua
- **Ocean Circulation:** Jason, Aqua

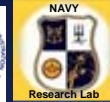
Predictions

- **Nearshore upwelling**
- **Speed and direction of ocean currents**
- **Ecological Forecasts**
- **Runoff Change**
- **Seasonal Forecasts**
- **Aerosol Properties**
- **Salinity predictions**
- **Ocean Surface Currents/ Winds/ Topography**
- **Sea Surface Salinity/Temperature**
- **Land Use**
- **Phytoplankton concentrations**

Observations

DECISION SUPPORT TOOLS

- **HAB (Harmful Algal Bloom) Bulletin & Mapping System**



VALUE & BENEFITS

- Reduce public health risks, hospital admissions, lost work-school days
- Reduce impacts to regional coastal economies & tourism
- Raise quotas for shellfish harvesting prior to HABs; improve siting and design of shellfish beds
- Preserve ecological diversity and tourism economies
- Reduced threats to human and natural environments
- Rapid response to emergencies to reduce effects on human safety and economies
- Public health and reduce preventable costs

Ecological Forecasting

EARTH SYSTEM MODELS

- Ecological Niche (GARP)
- Scalable spatio-temporal models a la CSU's NREL
- Regional Ocean Models & Empirical Atmospheric Models coupled with ecosystem trophic models
- Ecosystem (ED, CASA)
- Population & Habitat Viability Assessment (VORTEX, RAMAS GIS)
- Biogeography (MAPSS, BIOME3, DOLY)
- Biogeochemistry (BIOME-BGC, CENTURY, TEM) **Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Land cover:** MODIS, AVHRR, Landsat, ASTER, ALI, Hyperion, IKONOS/QuickBird
- **Topography/Vegetation Structure:** SRTM, ASTER, IKONOS, LVIS, SLICER, Radars
- **Primary Productivity/Phenology:** AVHRR, SeaWiFS, MODIS, Landsat, ASTER, ALI, Hyperion, IKONOS, QuickBird, AVIRIS
- **Atmosphere/Climate:** AIRS/AMSU/HSB, TRMM (PR, LIS, TMI), AVHRR, MODIS, MISR, CERES, QuikScat
- **Ocean:** AVHRR, SeaWiFS, MODIS, TOPEX/Poseidon, JASON, **AQUARIUS**
- **Soils:** AMSR-E, AIRSAR **Future Mission*

Predictions

- Species Distributions
- Ecosystem Fluxes
- Ecosystem Productivity
- Population Ecology
- Land Cover Change
- Land Cover/Land Use & Disturbances (e.g., fire)
- Species Composition
- Biomass/Productivity
- Phenology
- Vegetation Structure
- Elevation
- Surface Temperature
- SST, SSH, Circulation, & Salinity
- Atmospheric Temp.
- Soil Moisture
- Precipitation
- Winds

Observations

DECISION SUPPORT TOOLS

SERVIR (Spanish acronym for Regional Visualization & Monitoring System)

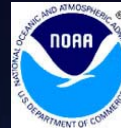
- Monitor changes in land cover, weather, & fires to assist the sustainable management of the Mesoamerican Biological Corridor

Protected Area Monitoring System with ALDO & TOPS

- Coordinate multi-NGO effort to pool resources for monitoring protected areas
- Link to President's logging initiative & CBFP

Impact of ENSO & PDO Events on Fisheries

- Combine physical ocean & ecosystem trophic-level models to predict how climatological changes driven by ENSO & PDO events will affect regional fisheries



VALUE & BENEFITS

- Management of a global hotspot of biodiversity, i.e. Mesoamerica, at a regional scale through the coordination of the activities of 7 countries - a model for other regions.
- Predict the impacts of changing land use patterns & climate on the ecosystem services that support all human enterprises.
- Develop ecological forecasts with reliable assessments of error.

Homeland Security

EARTH SYSTEM MODELS

- Air Plume/deposition Models: *ALOHA, HYSPLIT*
 - Hydrologic and Hydraulic Models: *FLDWAVE*
 - Weather: *ETA, Aviation (NCEP)*
 - Agriculture/Biology: *Vegetation NDVI, Vector Models*
- *Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- Land: *Landsat, SRTM, GPS-SCIGN, Terra, Aqua, GRACE*
- Ocean: *QuickSCAT, Seawinds, IceSAT, GOES, POES, SSMI, JASON, TOPEX/POSEIDON*
- Atmosphere: *TRMM, GOES, POES, GPM, NPP, NPOESS*

**Future Mission*

Predictions

- Nuclear, Chemical, Biological, & Radiological Concentrations
- Precipitation Distribution
- Wind Velocity/ Direction
- Surface Topography

Observations

DECISION SUPPORT TOOLS

IOF – Integrated Operations Facility

- Integrated Operations and Coordinated Response
- Disaster Recovery/ Mitigation
- Loss estimates of buildings, essential facilities, transportation & utility lifelines, and population
- Social impacts



VALUE & BENEFITS

- Identify/ Prioritize high-risk communities
- Reduction in lives lost
- Reduction in damage cost and time to recovery
- Anticipate the scope of disaster-related damage
- Improve disaster response

Agriculture Efficiency

EARTH SYSTEM MODELS

- Agricultural Meteorological Model: **AGRMET**
- 2 Layer Soil Moisture Models:
- Crop Models: **CERES, AGRISTARS, Mass, URCROP, Sinclair**

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- Land: **Aqua, Terra, Landsat 7, SRTM, NPP, NPOESS, Aquarius**
- Atmosphere: **TRMM, GPM**
- Ocean: **SeaWIFS, Quikscat, Aqua**

**Future Mission*

Predictions

- **12 Month Global Seasonal Surface Temperature/ Soil Moisture/ Precipitation Forecast**

- **Biomass**
- **Land Cover/ Use**
- **Land Surface Topography**
- **Ocean Surface Currents**
- **Global Precipitation**
- **Soil Moisture**

Observations

DECISION SUPPORT TOOLS

- **CADRE (Crop Assessment Data Retrieval & Evaluation)**
- **Generated time series graphs for rainfall, temperature , and soil moisture**
- **Multi-year time series/ crop comparisons**
- **Automated web products**



VALUE & BENEFITS

- **Early warning of problems in major agricultural commodities**
- **Reduction in production costs.**
- **Better seasonal yield estimates**
- **Early warning of food shortages**

Carbon Management

EARTH SYSTEM MODELS

Net Ecosystem Production Model:

CASA

- Carbon assimilation in above and below ground biomass,
- Assessment of land and ocean carbon sink strength,
- Soil moisture,
- Land-atmosphere-ocean carbon exchange.

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Atmosphere:** Terra, Aqua, Terrestrial Networks, NPP, NPOESS, OCO
- **Land:** Terra, Aura, Landsat,, Terrestrial Networks
- **Ocean:** SeaWIFS, Aqua, Terra, NPP, NPOESS

**Future Mission*

Predictions

- Ecological Forecast
- CO₂ Atmospheric Concentration Projection
- Net Ecosystem Production Forecast

- Trace Gas Source
- CO₂ and Methane
- Fire Occurrence and Extent
- Land Cover/Use
- Marine Primary Productivity in coastal regions
- Terrestrial Primary Productivity
- Trace Gas Source

Observations

DECISION SUPPORT TOOLS

1605b of the 1992 Energy Act

- Indication for potential soil carbon sequestration
- Indication for Farmers to comply with 1605b
- Purchase of carbon credits



VALUE & BENEFITS

- Climate change mitigation
- Improved efficiency in energy production
- Improved efficiency in crop production through enhancements in soil carbon
- Improved economy in marginal rural agricultural areas
- Climate change mitigation

Energy Management

EARTH SYSTEM MODELS

- Earth System & Climate Change: *DAO Analysis, NCEP Analysis*
- Seasonal Prediction Models: *NSIPP Analysis, NCEP Analysis*
- Aerosol Transport Models: *RAQMS, DAO fvCAM, NCAR WRF, GFDL FMS Atmosphere*
- Climate Models: *GISS Model II, GFDL FMS B-Grid Atmosphere*
- Atmospheric Analysis Models: *ISCCP, SRB, CERES-SARB, GVAP, GPCP*
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Data

EARTH OBSERVATORIES

- **Atmosphere:** *GOES, POES, TRMM, Terra, Aqua, TOMS, Aeronet, AIRNow, INTEX, Aura, Calipso APS, CloudSat, GPM, NPP*
- **Land :** *Terra, Aqua, Landsat, Terrestrial Networks, BSRN, ARM, SURFRAD, GIFTS*
- **Ocean:** *SeaWinds*

*Future Mission

Predictions

- Severe Local Storms
- Weather Forecasts
- 12 Month Global Seasonal Precipitation Forecast
- Seasonal Forecast
- Land Use Projections

- Cloud System Structure
- Land Cover/Use
- Land Surface Temperature
- Soil Moisture
- Ocean Surface Winds
- Global Precipitation
- Total Aerosol Amount
- Land Surface Topography

Observations

DECISION SUPPORT TOOLS

NREL

- National Solar Radiation Database
- Provides data sets for numerous energy management decisions

EPRI

- Neural Net Load Forecast Tools
- Forecasting tool for Energy industry

RETScreen

- Provides common platform for evaluating project proposals while significantly reducing the costs and uncertainties of preliminary studies
- Reduces the time and errors of a preliminary study



VALUE & BENEFITS

- Optimize renewable energy systems for power production
- Optimal integration of traditional and renewable energy supply systems into electric power grid
- Improved prediction of electric power need and supply – mitigate power shortages, prevent price increase
- Reduction in greenhouse emissions from energy production

Water Management

EARTH SYSTEM MODELS

- **Mesoscale Models:** *MM5, CSU RAMS*
- **General Circulation models:** *GMAO (DAO & NSIPP), NCEP ETA*
- **LSMs:** *MOSAIC, Noah, VIC, Catchment, CLM2*
- **In Stream Water Quality Model:** *QUAL2E*
- **Non-Point source annual loading model:** *PLOAD*
- **Watershed loading and transport models:** *HSPF*

**Supported Non-NASA Model*

Predictions

Soil Moisture

- **Evapotranspiration**
- **Precipitation**
- **Snow cover, accumulation, and water equivalent:**
- **Groundwater storage change**
- **Vegetation type**
- **River discharge height**
- **Flood and Drought Assessment and Prediction**
- **Seasonal Forecasts**

Observations

EARTH OBSERVATORIES

- **Surface Temperature:** *Terra, Aqua, GOES*
- **Precipitation:** *TRMM, Aqua, GOES*
- **Soil Moisture:** *Aqua, TRMM, NPOES*
- **Snow Cover:** *Aqua, Terra*
- **Snow Quantity:** *Aqua*
- **Groundwater:** *Grace*
- **Land Use/Cover:** *Terra, Aqua, Landsat*
- **Surface Radiation:** *GOES, Terra, Aqua, Aster*

Data

DECISION SUPPORT TOOLS

- **BASINS (Better Assessment Science Integrating Point and Non-point Sources)**
- **Facilitate examination of environmental information**
- **Provides an integrated watershed and modeling framework**
- **Support analysis of point and non-point source management alternatives**
- **Urban/Rural land use evaluations**
- **AWARDS (Agricultural Water Resources Decision Support)**
- **Estimates of water consumption by crops**
- **Crop suitability assessment**
- **Irrigation requirements**
- **RiverWare**
- **Estimates of river flow and water loss to vegetation**
- **River sustainability assessment**



VALUE & BENEFITS

- **Improvements in identifying:**
 - impaired surface waters
 - storm water management issues
 - drinking water source protection
- **Improvement in habitat management practices**
- **Improved efficiency of water use**
- **Increased Agricultural productivity**