Space Systems Observation/Monitoring of Climate Change

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IAF Symposium
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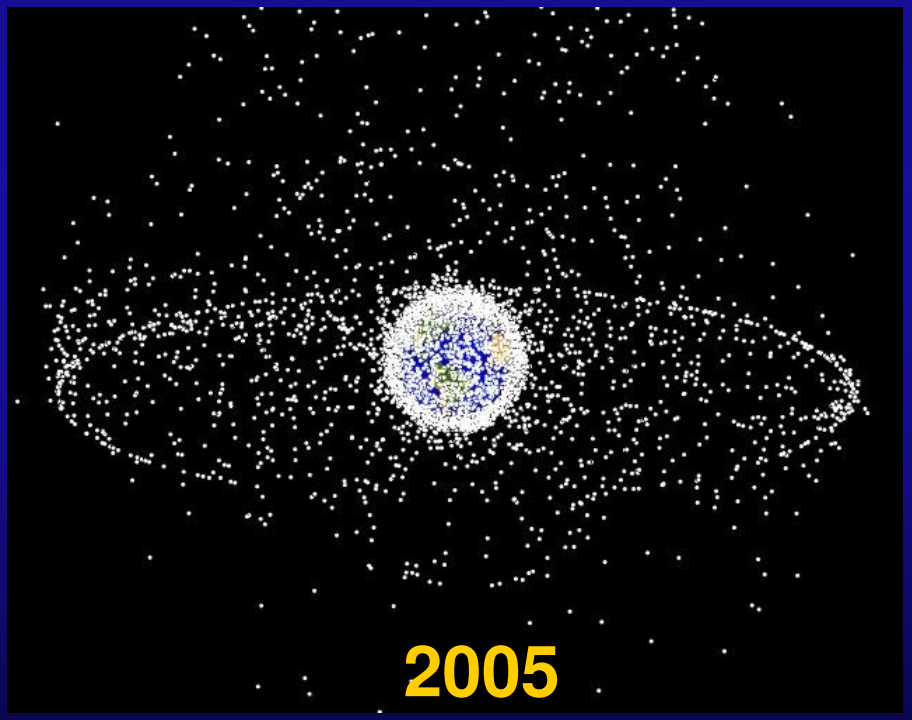
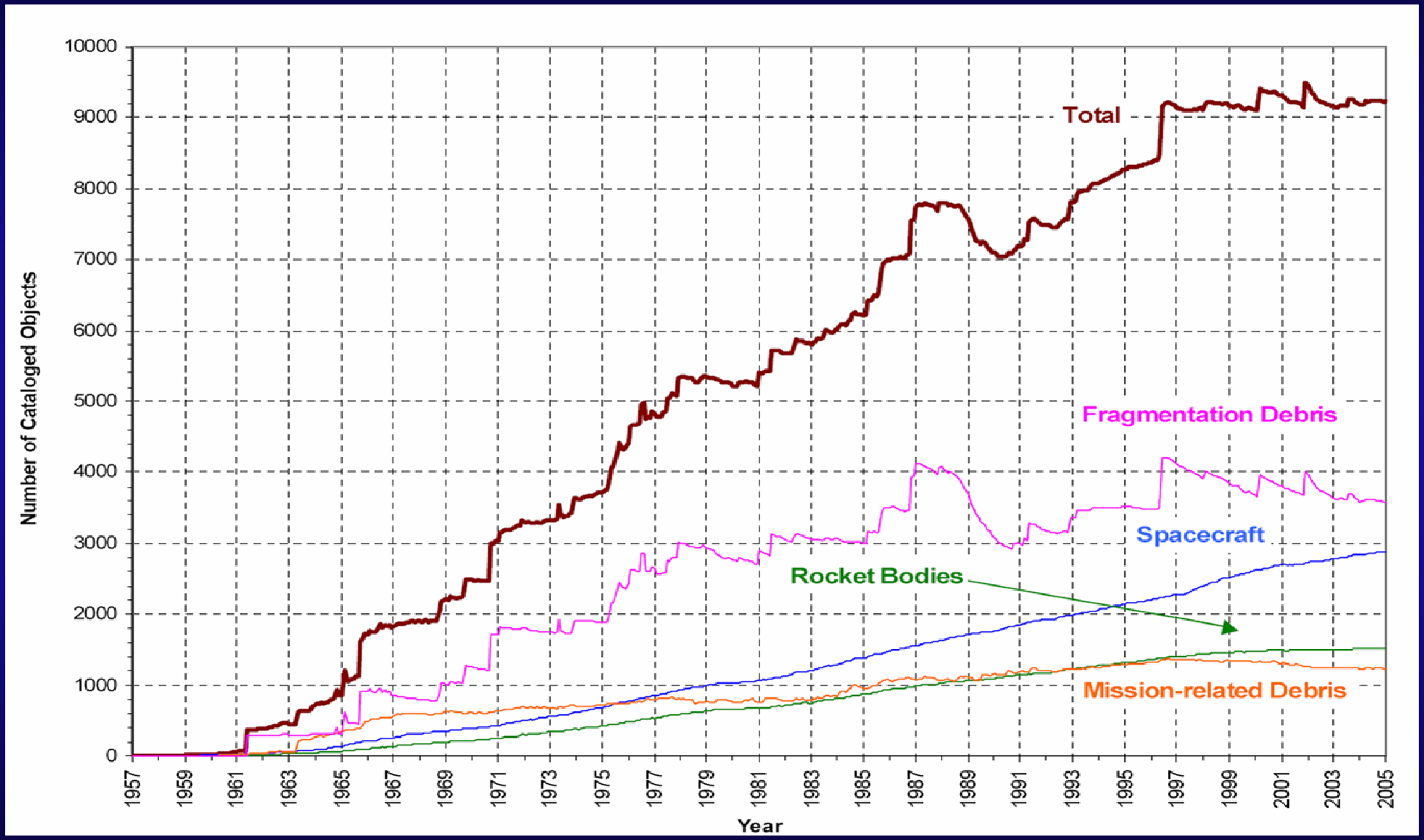
Overview

- Historical perspective
- International collaboration needed to address global change
- The Way Forward

An Historical Comparison



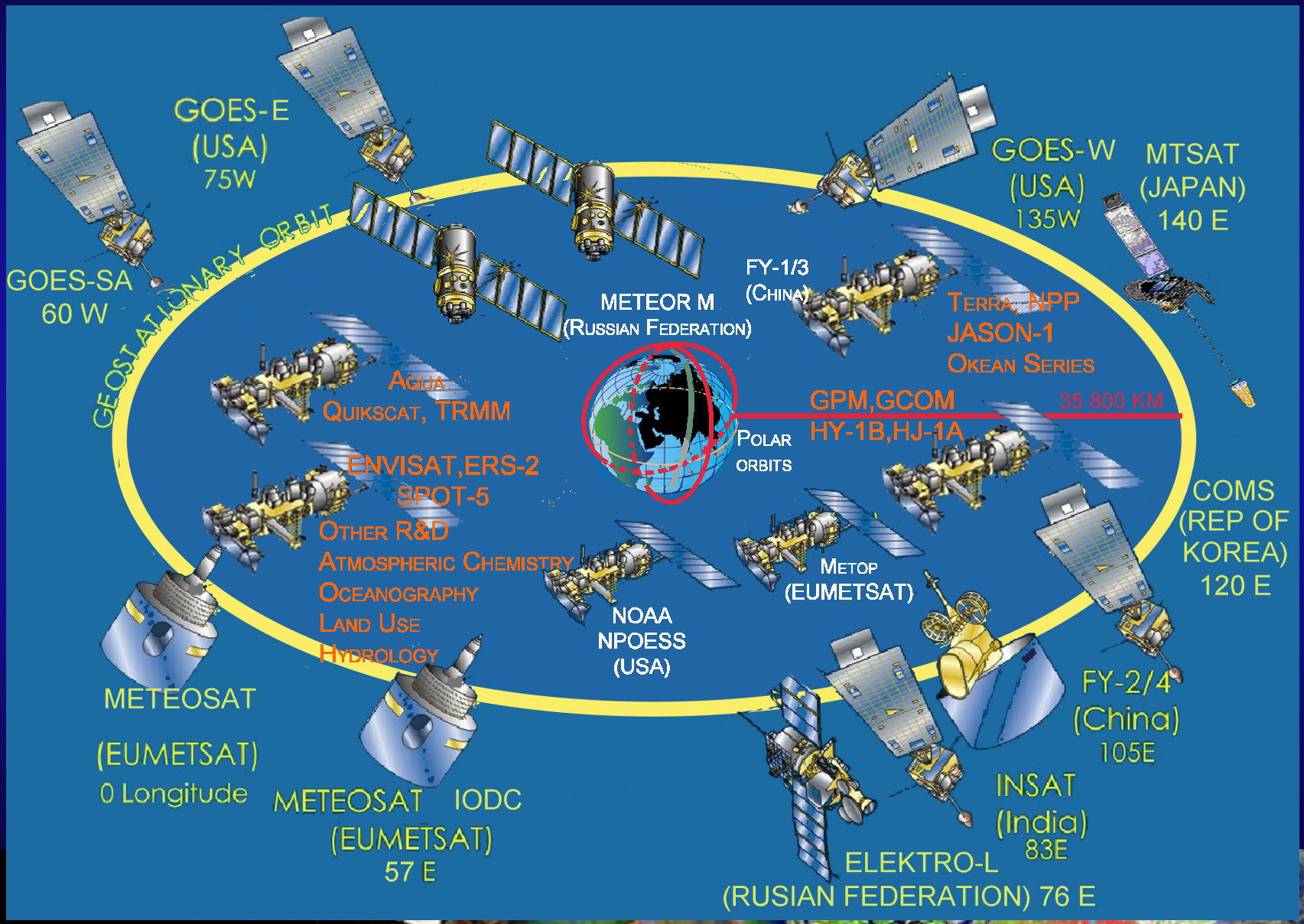
Cataloged Objects in Earth Orbit



Connecting Satellite Observation Systems to GEOSS

- Integrate observing systems, nationally and internationally, to benefit from the increased number and distribution of observations of any given event
- Identify measures to minimize data gaps – to move toward a comprehensive, coordinated, and sustained Global Earth Observation "System of Systems"

Space-based Component of WMO's Global Observing System (GOS)



Agencies Contributing to WMO's GOS

EUMETSAT

NOAA

JMA

CMA

ROSHYDROMET

IMD

KMA

NASA

esa

JAXA

cnes

INPE

ISRO

USGS

DLR

UN Framework Convention on Climate Change (UNFCCC)

- Actions from COP - 10, 11, and 12
- "Satellite Observation of the Climate System: The CEOS Response to the GCOS Implementation Plan"
- Response covers atmospheric, oceanic and terrestrial domains, as well as cross-cutting issues
- 59 actions identify where additional resources are needed to fill gaps
- Calls for a major, sustained satellite component

GCOS 26 Essential Climate Variables (ECVs)

A.	**Atmosphere**
A.1	Surface Wind Speed and Direction
A.2	Upper-air Temperature
A.3	Water A Vapour
A.4	Cloud properties
A.5	Precipitation
A.6	Earth Radiation Budget
A.7	Ozone
A.8	Atmospheric reanalysis (multiple ECVs)
A.9	Aerosols
A.10	Carbon Dioxide, Methane and other Greenhouse Gases
A.11	Upper-air Wind

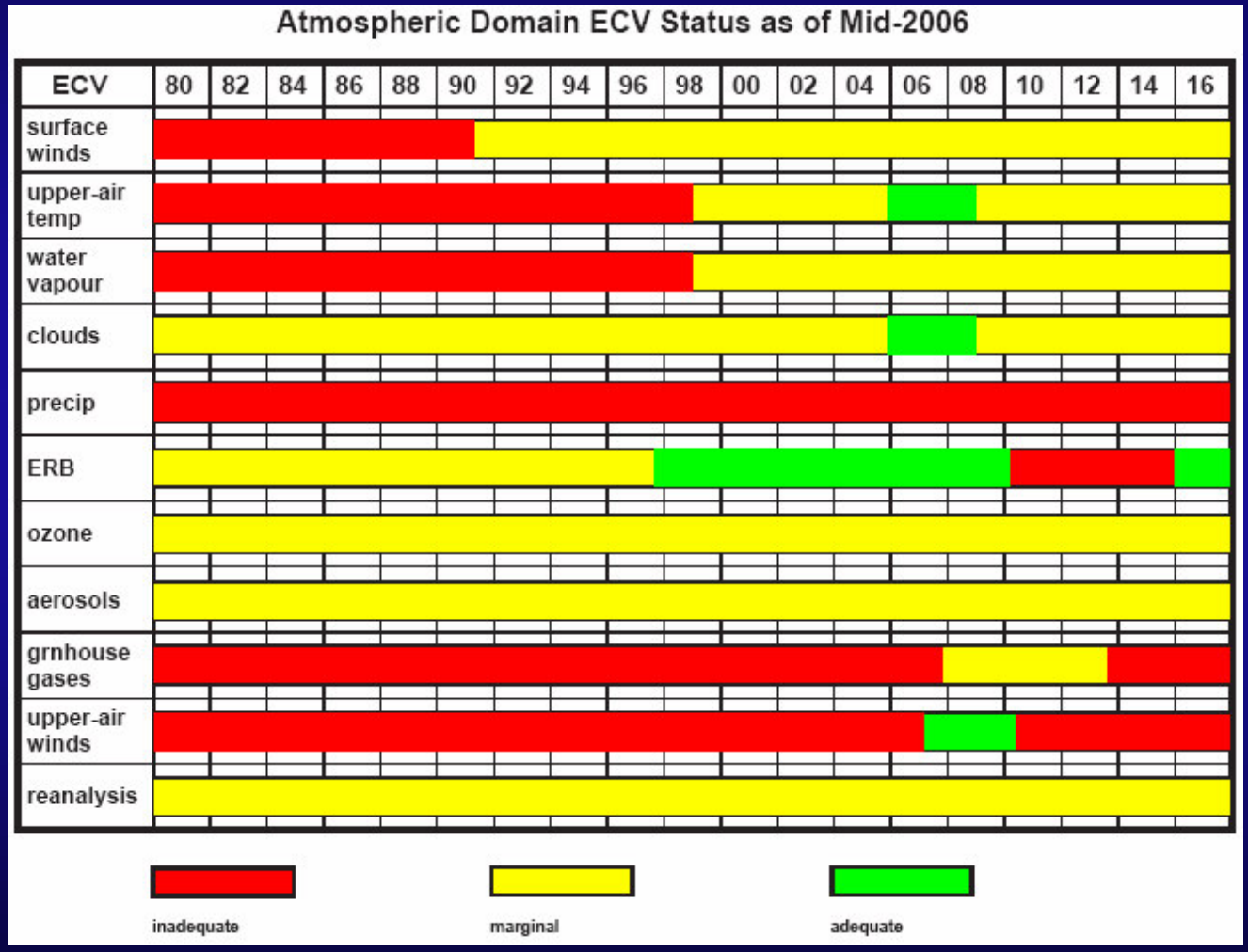
O.	**Oceans**
O.1	Sea Ice
O.2	Sea Level
O.3	Sea Surface Temperature
O.4	Ocean Colour
O.5	Sea State
O.6	Ocean Reanalysis
O.7	Ocean Salinity

T.	**Terrestrial**
T.1	Lakes
T.2	Glaciers and Ice Caps, and Ice Sheets
T.3	Snow Cover
T.4	Albedo
T.5	Land Cover
T.6	fAPAR
T.7	LAI
T.8	Biomass
T.9	Fire Disturbance
T.10	Soil moisture

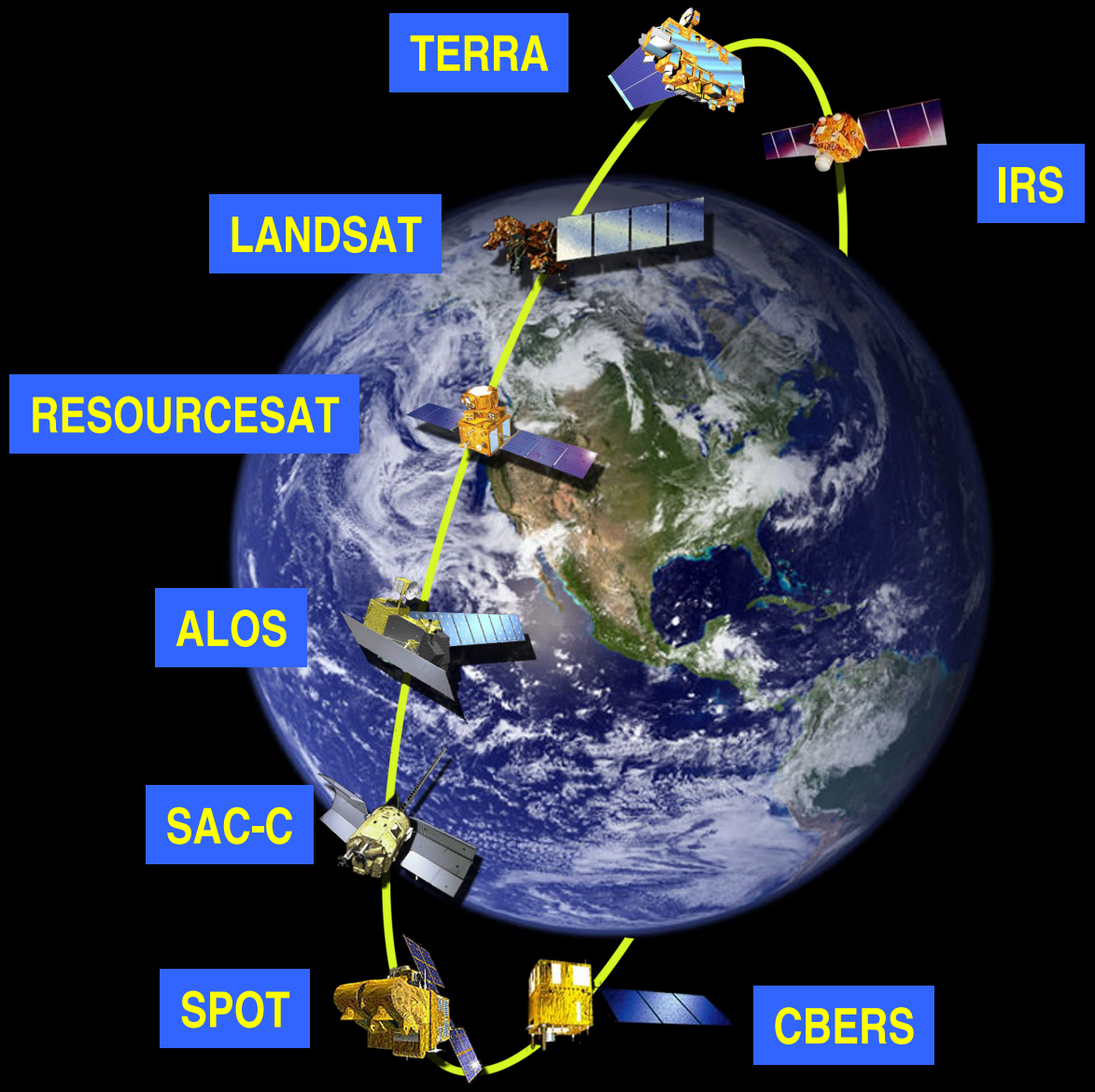
CEOS Virtual Constellations

- Synergies among national and regional satellite programs and focus dialogue and resources
  - Atmospheric composition
  - Global precipitation
  - Land surface imaging
  - Ocean surface topography
  - Ocean color radiometry
  - Ocean surface vector winds
- Common guidelines
- Optimal end-to-end capabilities
- Coordinated user requirements for future systems

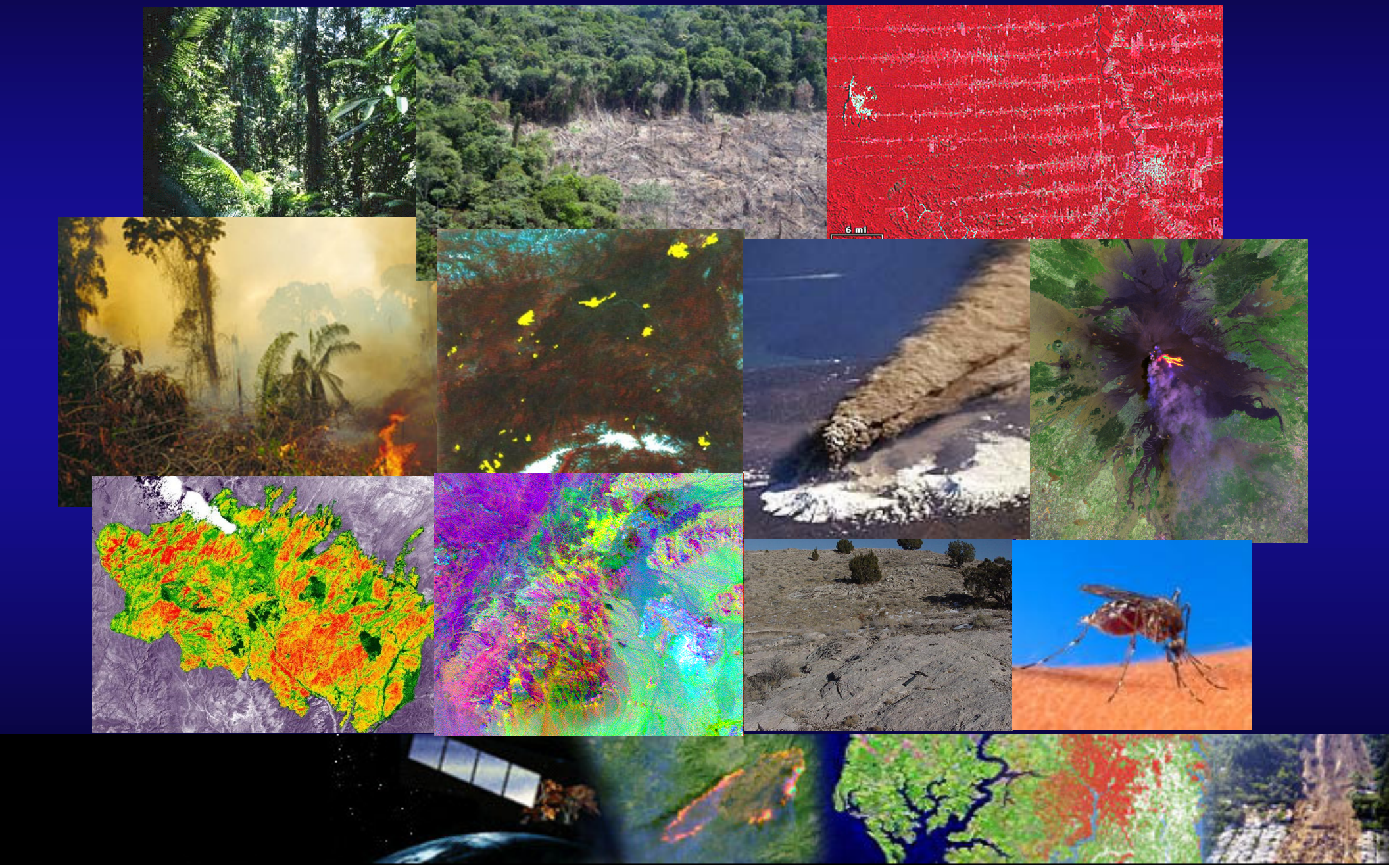
Satellite Observations for Climate – Example of Domain ECV Status



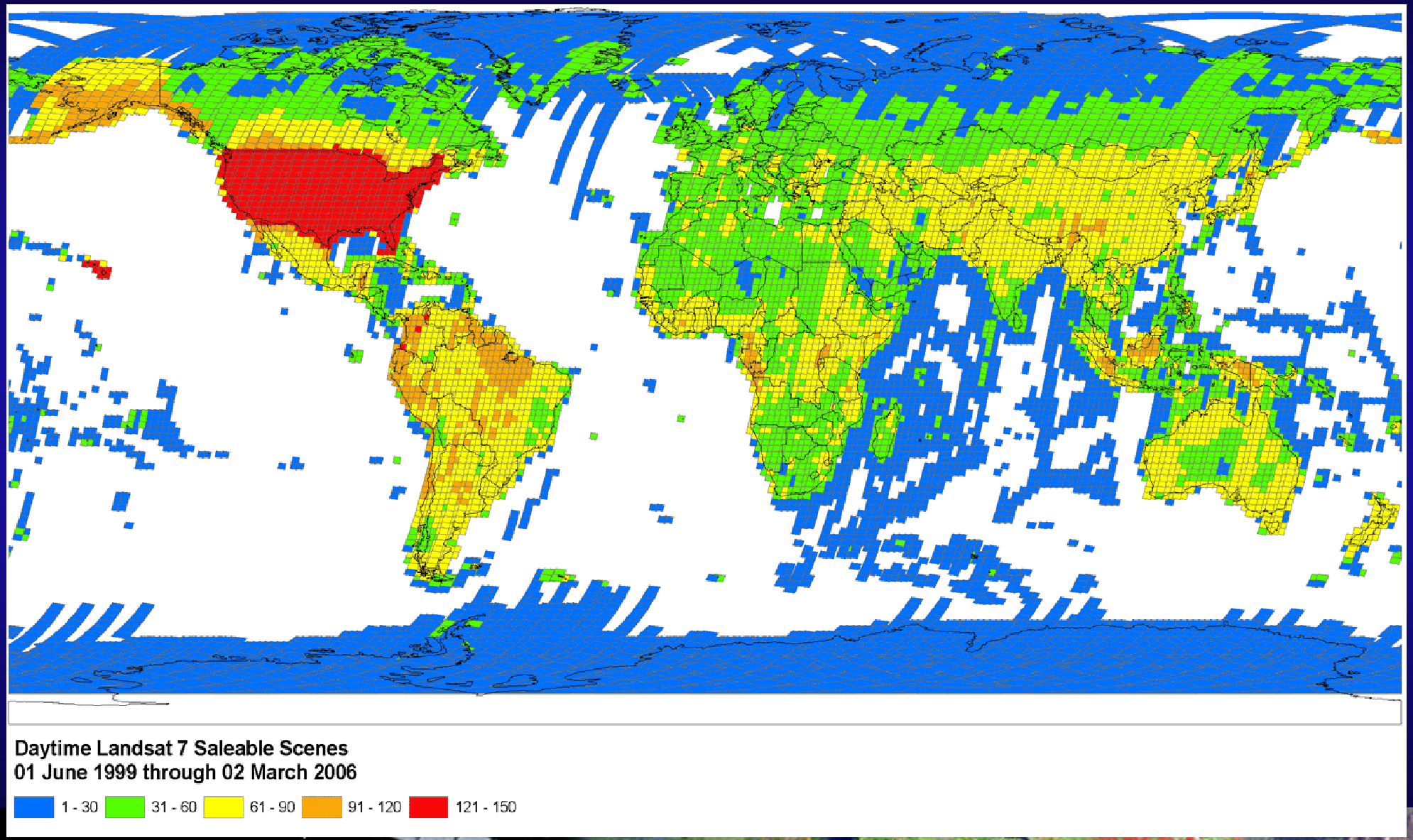
Land Surface Imaging Constellation



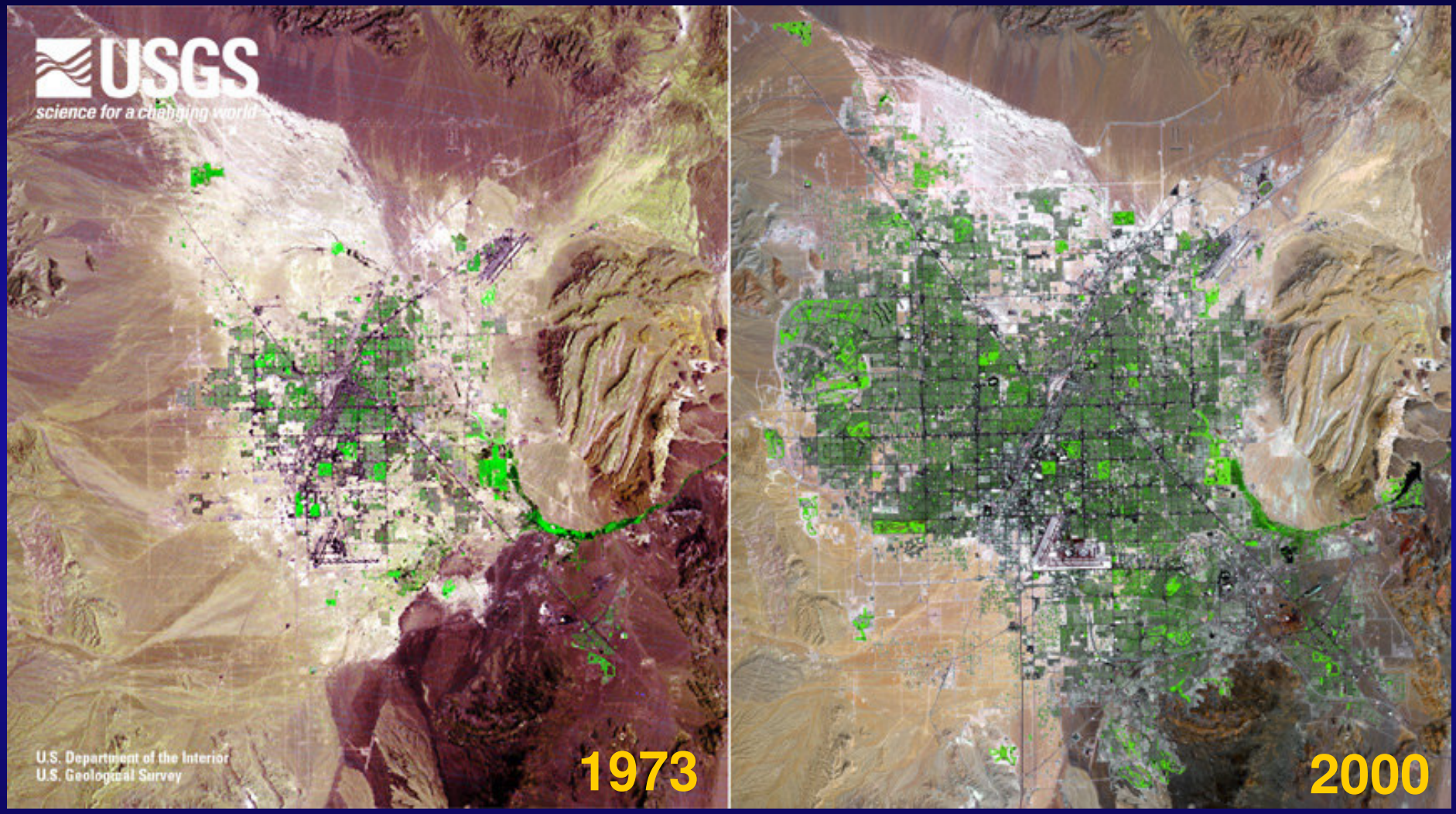
Working Across Spatial, Spectral and Temporal Resolutions



Landsat 7 Archive



Urban Growth -- Las Vegas, Nevada

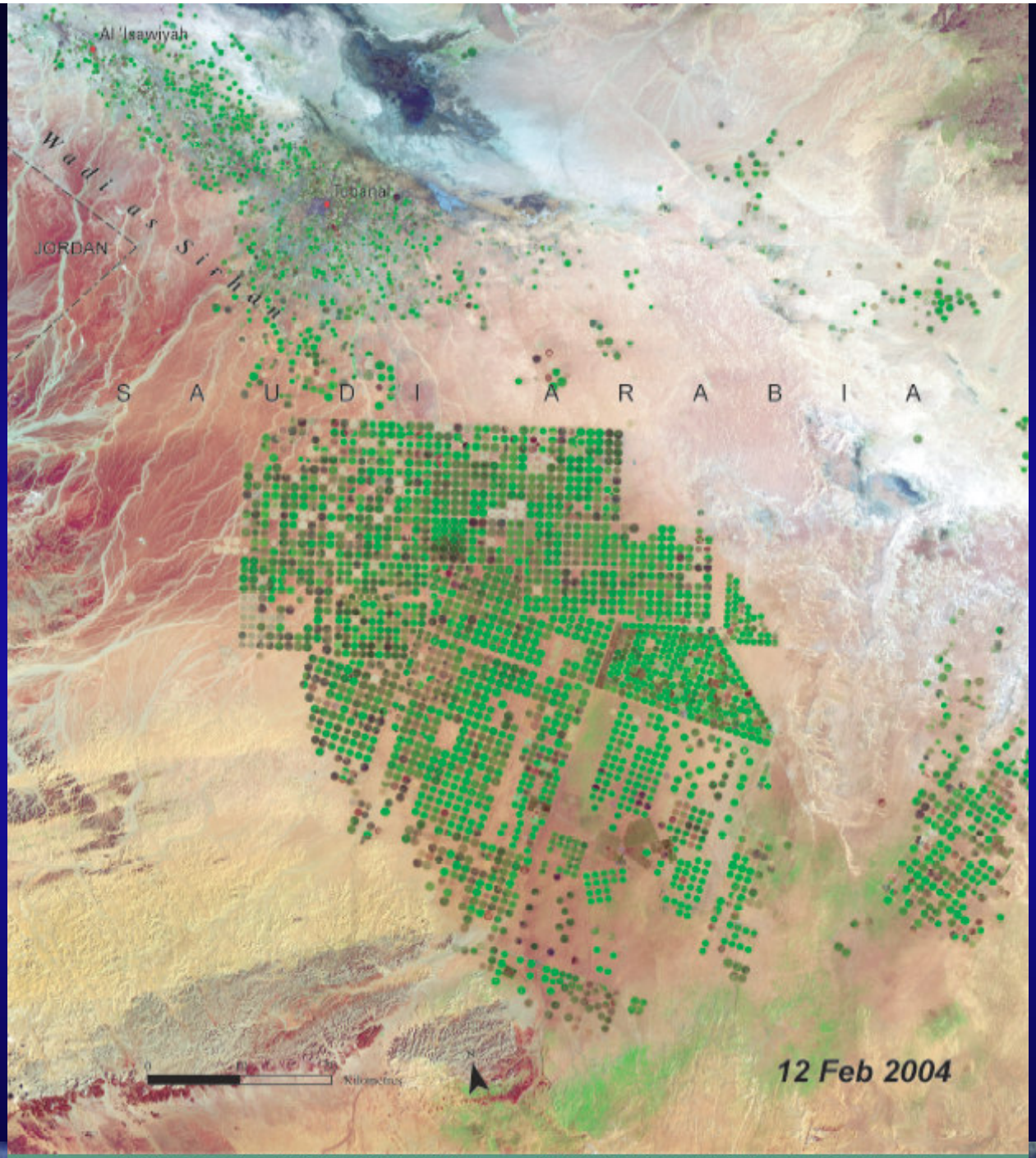


Population: 358,000 1,560,000

UNEP's Atlas of our Changing Environment

"One Planet, Many People"

Al'Isawiyah
Saudi Arabia



These three images, from 1986, 1991, and 2004, reveal the effects of this irrigation strategy in a vast desert region in Saudi Arabia known as Wadi As-Sirhan. This region was once so barren that it could barely support the towns Al'Isawiyah and Tubarjal that can be seen in the upper left of each image. Following the introduction of center-pivot irrigation, however, barren desert was gradually transformed into a greener, food-producing landscape.

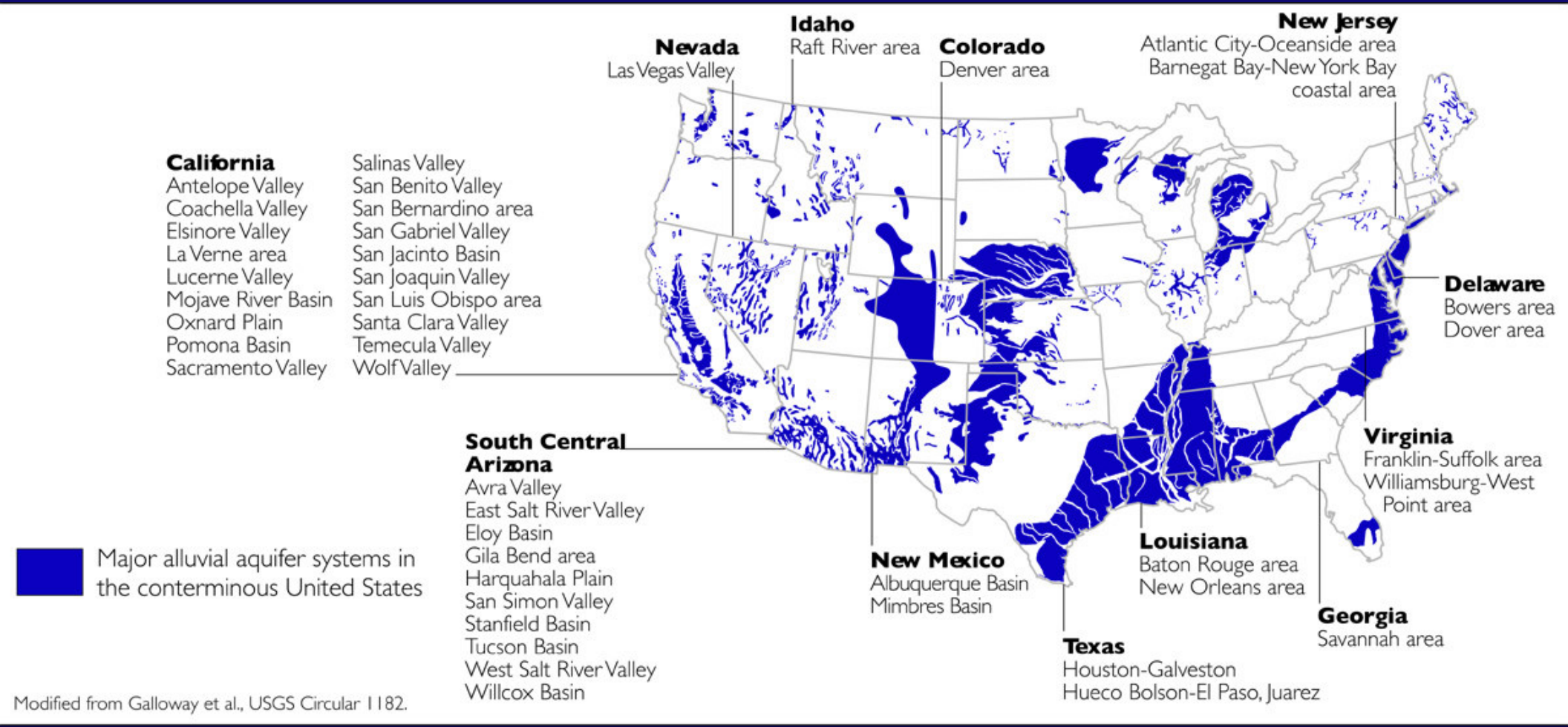
The irrigation system draws water from an ancient aquifer—some of the water it contains may be as much as 20 000 years old. Judicious use of water resources, and climate-appropriate technology, has in this situation helped improve food production without being detrimental to the environment.

Land Subsidence

- More than 80% of the identified 17,000 square miles of land affected by subsidence in the Nation is a consequence of our exploitation of ground water -- *National Research Council, 1991*
- Most of the ground-water related subsidence is caused by the compaction of susceptible alluvial aquifer systems that typically accompanies overdraft of these systems

California's Central Valley

Major U.S. aquifers and locations where subsidence has been attributed to groundwater pumping



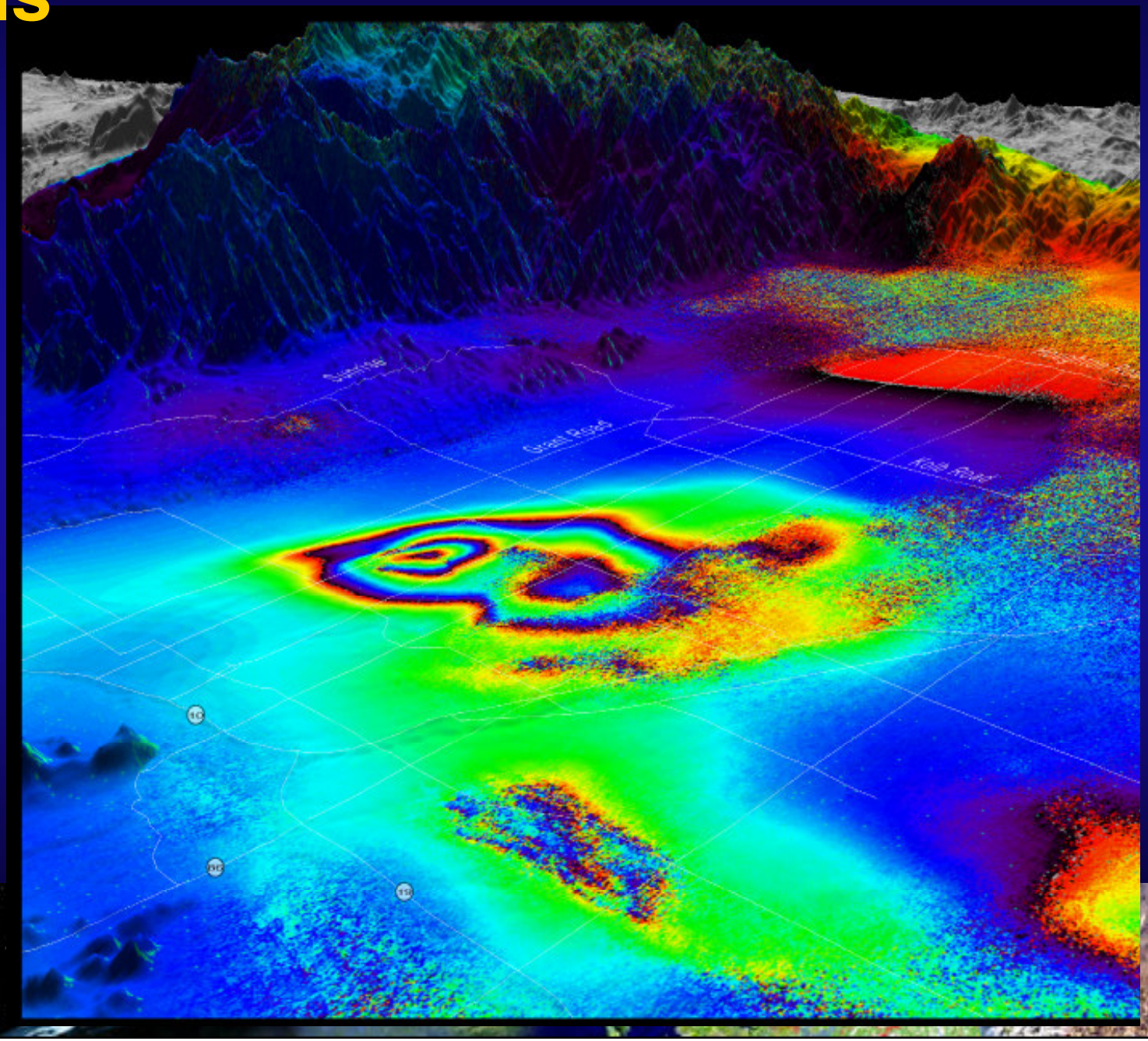
Subsidence due to Ground-Water Withdrawals

90 mm Subsidence

Tucson Arizona

November 1992 to January 1997

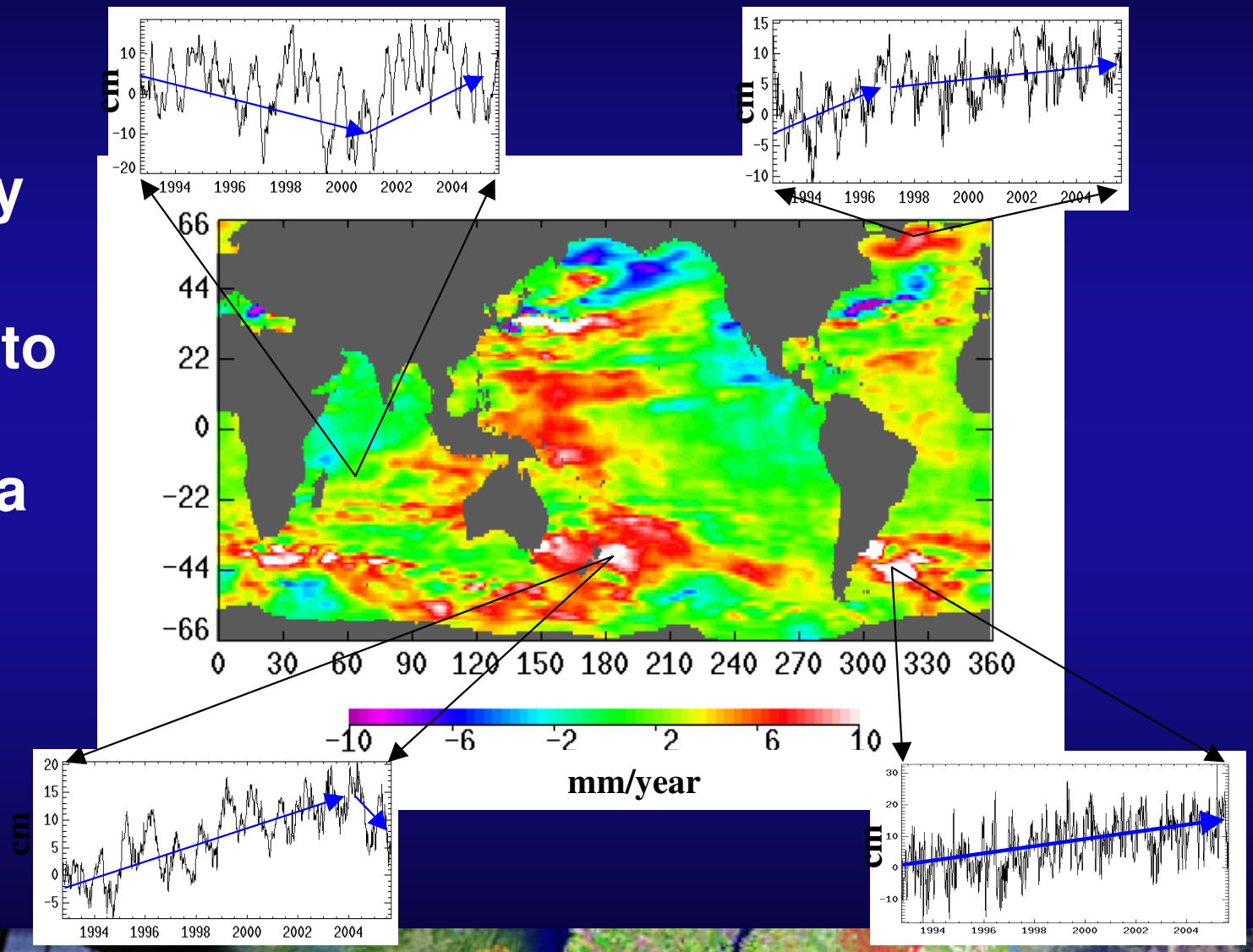
InSAR data from Envisat



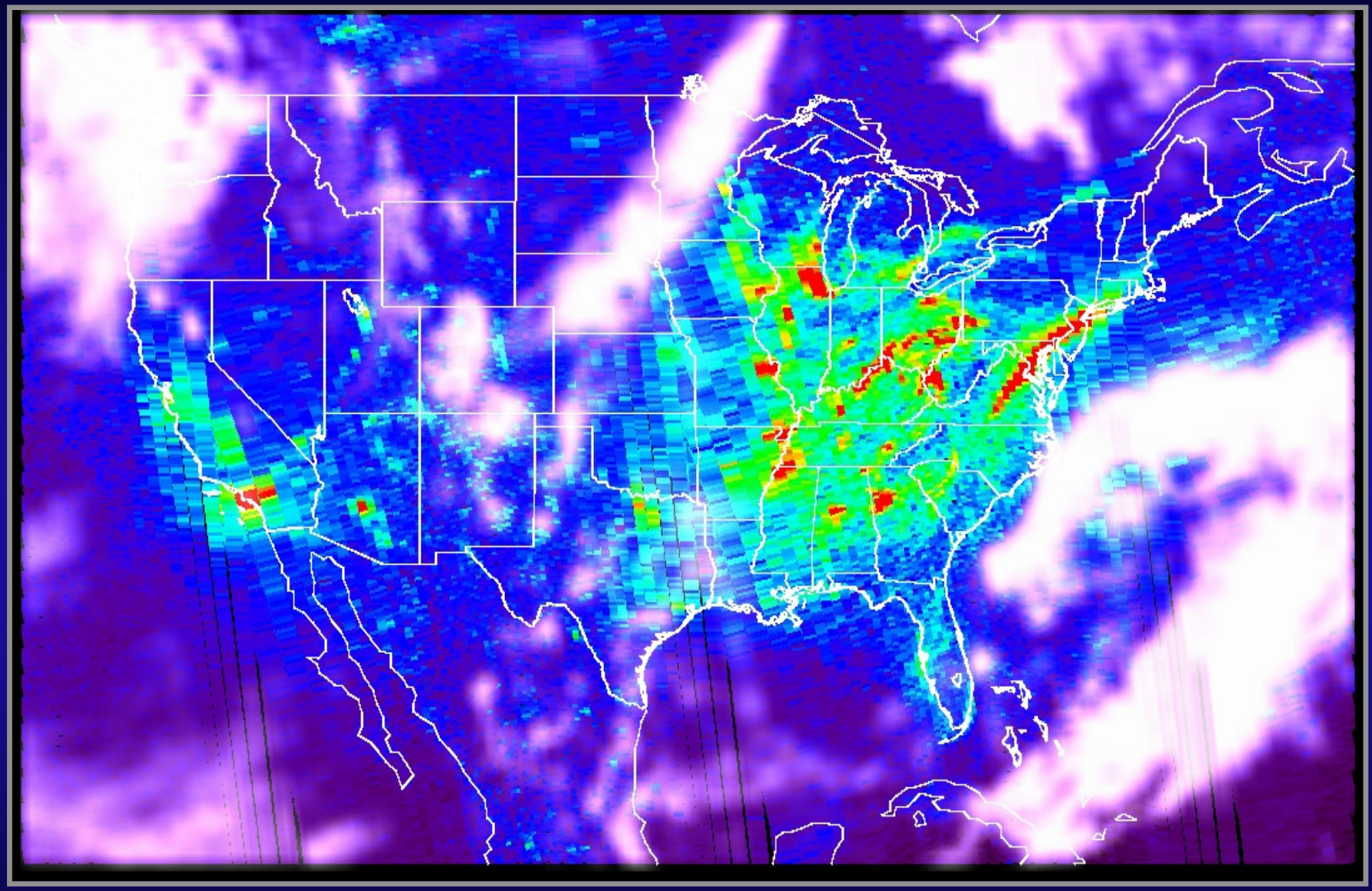
Global Sea Level Rise

Satellite Altimetry

- Unique system to observe **global variations** in sea level rise



NO_2 Images for April 15, 2004



NASA

Importance of the Value Chain

Societal Need

Volcanic Eruption Ash

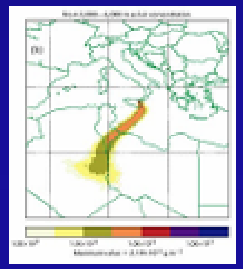
Societal Benefit

Disaster Warning System

Decision Makers

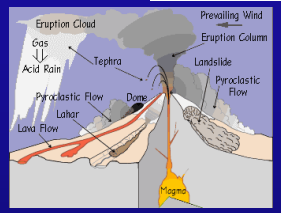
Information

Improved Indexes and Forecast Products



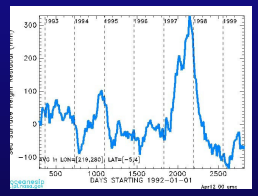
Science

Improved knowledge and models

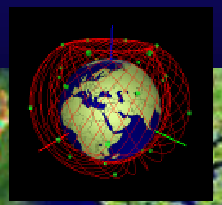


Measurements

Improved technology



Mission



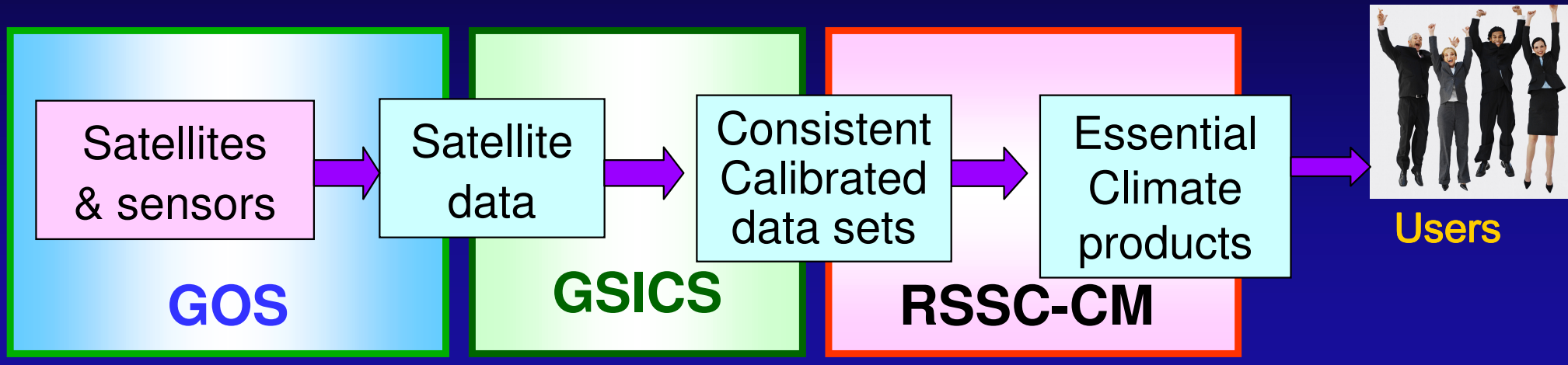
Needs and Requirements

AC individual missions provide limited continuity and coverage

Results and Products

AC Constellation provides improved continuity and coverage

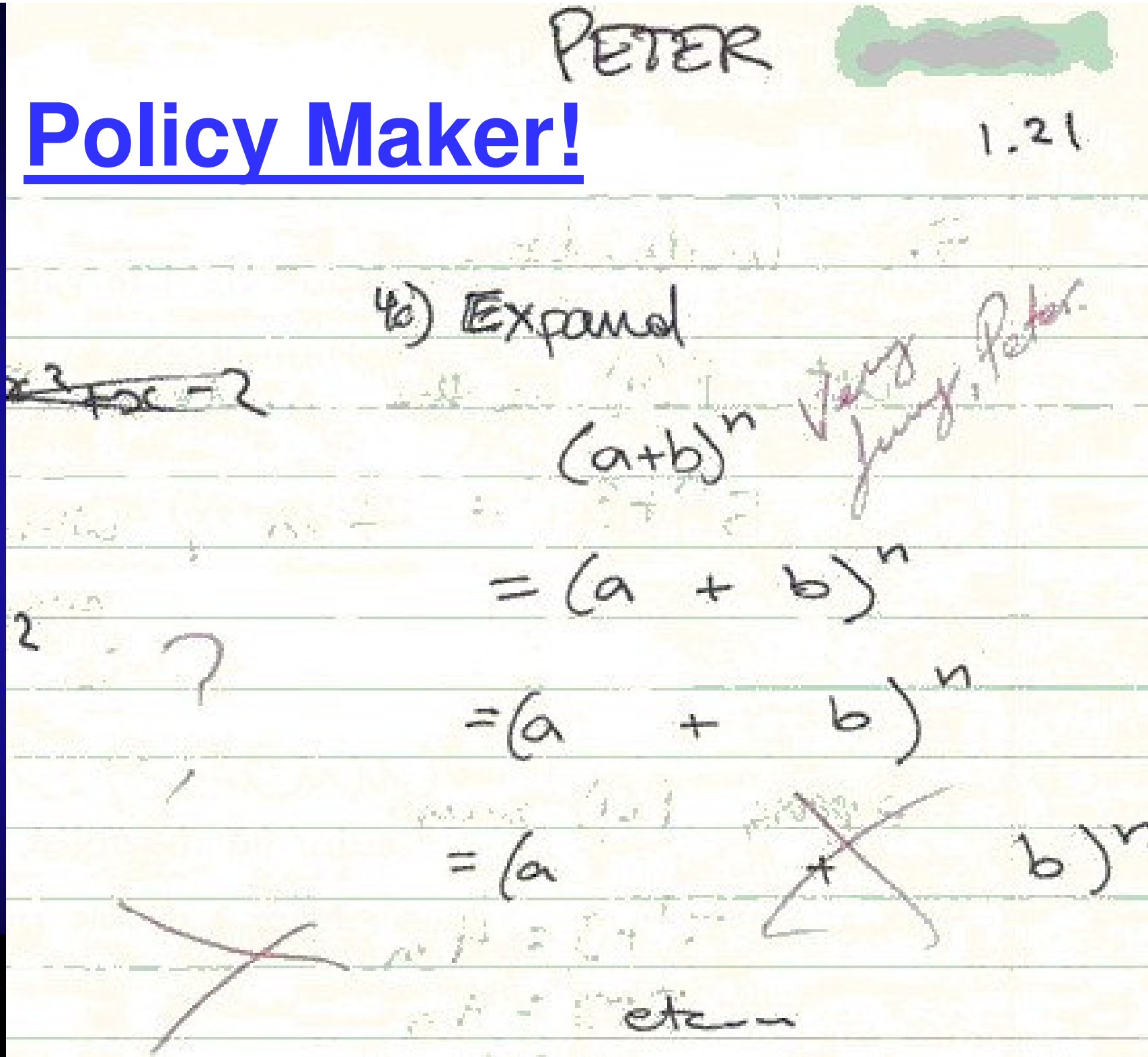
Maximizing Data Quality and Usability



- **Regional/Specialized Satellite Centres for Climate Monitoring (RSSC-CM)**
  - **Concept agreed following CM-7 guidance**
  - **Implementation Plan developed**
  - **Executive Panel to meet on 25-26 February**

Working toward an integrated space-based observing system – Mt. Etna InSAR

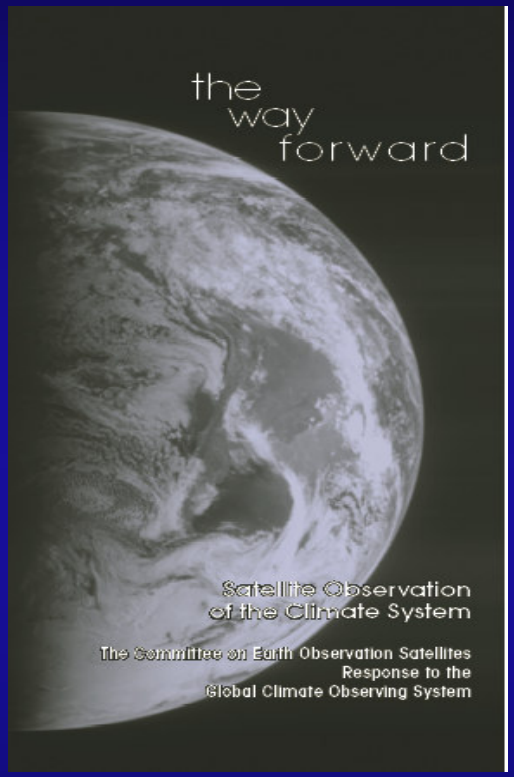
Policy Maker!



Challenges Facing the Community

- Different approaches/terminology among different sectors and/or organizations – confusing to many
- Research to Operations Transition (R2O) -- Remarkable record of satellite observations derived from instruments largely designed for weather forecasting
- Data Sharing Principles -- WMO Resolutions 40 (met) and 25 (hydro)

The Way Forward



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. . . . . both satellite and *in situ* data are required to better monitor, characterize, and predict changes in the Earth system. While *in situ* measurements will remain essential and largely measure what cannot be measured from satellites, Earth-observation satellites are the only realistic means to obtain the necessary global coverage, and with well-calibrated measurements will become the single most important contribution to global observations for climate.

Summary

- Historical perspective
- International collaboration needed to address global change
- The Way Forward – Working together with academia, industry, and policy makers