

A Roadmap for Future Satellite Gravity Missions

- The “Graz Workshop”
(- The Roadmap)
- Why time-variable gravity?
- The Declaration
- Hope and Long-Term Perspective

Hans-Peter Plag¹, Roland Pail², Michael Watkins³, Roger Haagmans⁴

1) Nevada Bureau of Mines and Geology, University of Nevada, Reno, NV, USA

2) Graz University of Technology, Graz, Austria

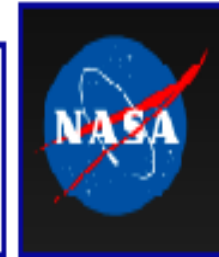
3) Jet Propulsion Laboratory, Pasadena, CA, USA

4) ESA, Noordwijk, The Netherlands

The Workshop



***Towards a Roadmap for Future
Satellite Gravity Missions***
**September 30 - October 2,
2009, Graz, Austria**



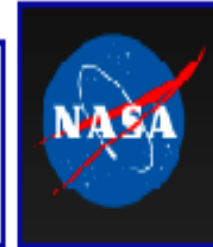
Objectives of the workshop: The workshop aimed at bringing together stakeholders in satellite gravity missions in order to establish a roadmap for future gravity satellite missions that would outline the sensor developments, mission concept developments, and mission implementation, and that would be consistent with anticipations of the main users of the data, and with the needs of key user groups (such as

In 2007, an international workshop on *The Future of Satellite Gravimetry* was held (see the [Workshop Report](#)) and attended by about 50 leading scientists representing relevant fields of science and technology. The participants agreed on a set of [recommendations](#), which provided the starting point for the roadmap.

The Workshop



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Output: The workshop will produce a roadmap document that could be submitted to the IUGS for endorsement and also to the CEOS Plenary and SIT for further consideration. The anticipated output of the Workshop included:

- Roadmap for future satellite gravity missions;
- Workshop report on the Workshop Web page;
- Summary report in *Episodes*;
- A thematic issue of *Physics and Chemistry of the Earth*.

The Workshop

- 55 participants from eleven countries and three continents
- Outputs produced:
 - roadmap (*)
 - declaration (*)
 - draft recommendations
 - one-page stories (**)

(*) Input to GEO Plenary

(**) GGOS Booth

Experimental aspects of the Workshop:

- bring GEO and GEOSS to a science&technology community;
- create a forum for the discussion of user groups with data providers;
- produce output of value for GEO
- create channels for S&T communities to make their results better known to decision makers

Roadmap: Towards Future Satellite Gravity Missions

Contents:

STRATEGIC TARGET

PREAMBLE: Why? For Whom?

ORIGIN OF THE ROADMAP

INTRODUCTION

- *Why gravity? A unique quantity related to mass redistribution in the Earth system*
- *Where we want to go: The goal*
- *Where do we stand?*
- *What is needed in order to get from here to there?*

THE WAY FORWARD: THE MAP

Activity 1: Science developments

Activity 2: Technological developments

Activity 3: Mission implementation

Activity 4: Processing, modeling and applications

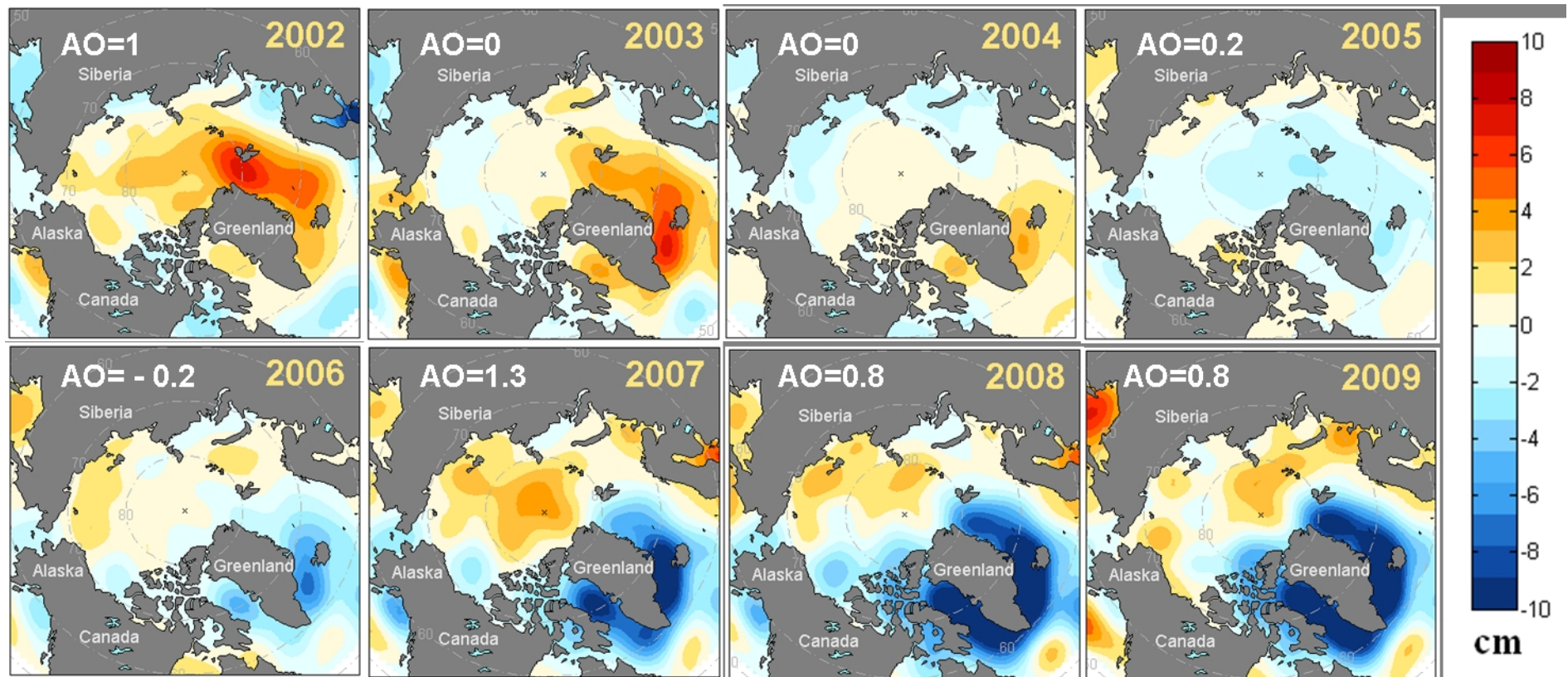
Why time-variable gravity?

Satellite gravity missions are a unique observational system for monitoring mass redistribution in the complete Earth system – no other sensors could do the same.

GRACE Reveals Changes in Arctic Ocean Circulation Patterns

Variations in the Arctic Ocean circulation are associated with clockwise and counterclockwise shifts in the front between salty Atlantic-derived and less salty Pacific-derived upper ocean waters.

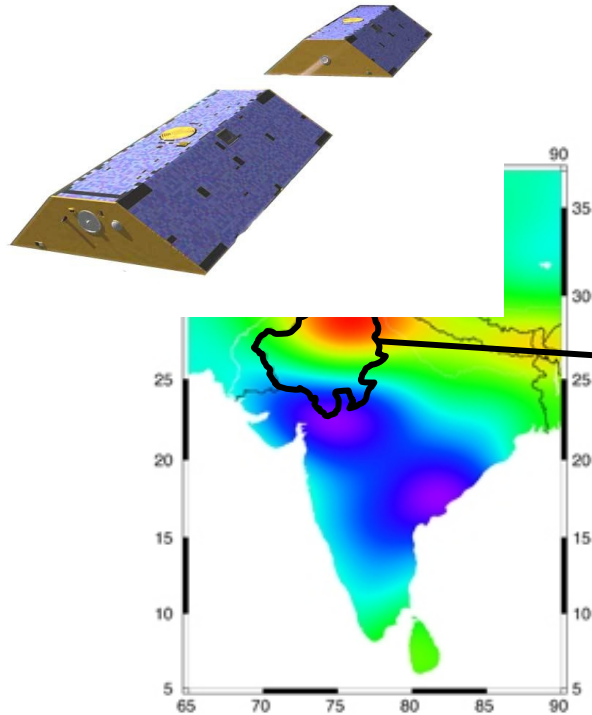
Orientation of the front is climatically important because it impacts sea ice transport.



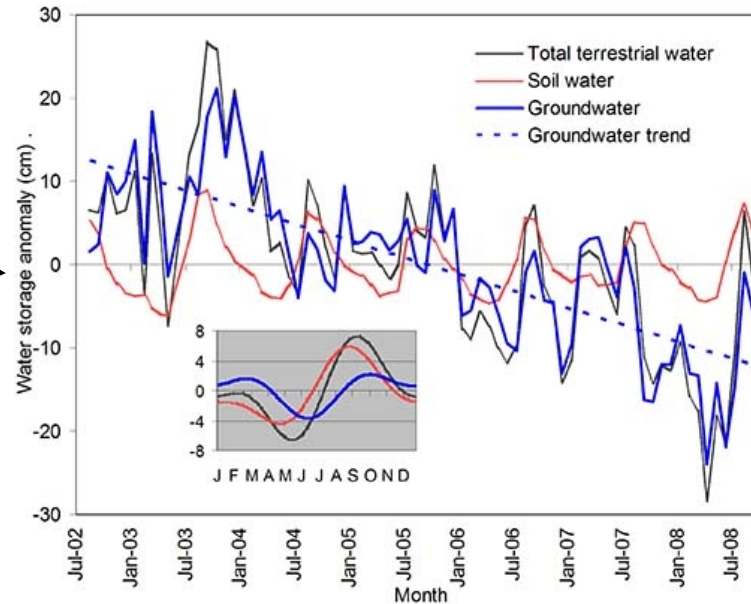
GRACE Quantifies Massive Depletion of Groundwater in NW India

The water table is declining at an average rate of 33 cm/yr

GRACE is unique among Earth observing missions in its ability to monitor variations in all water stored on land, down to the deepest aquifers.



Trends in groundwater storage during 2002-08, with increases in blue and decreases in red. The study region is outlined.



Time series of total water from GRACE, simulated soil water, and estimated groundwater, as equivalent layers of water (cm) averaged over the region. The mean rate of groundwater depletion is 4 cm/yr. Inset: Seasonal cycle.

During the study period, 2002-08, 109 km³ of groundwater was lost from the states of Rajasthan, Punjab, and Haryana; triple the capacity of Lake Mead

GRACE Detects Accelerated Ice Mass Loss in Greenland and Antarctica

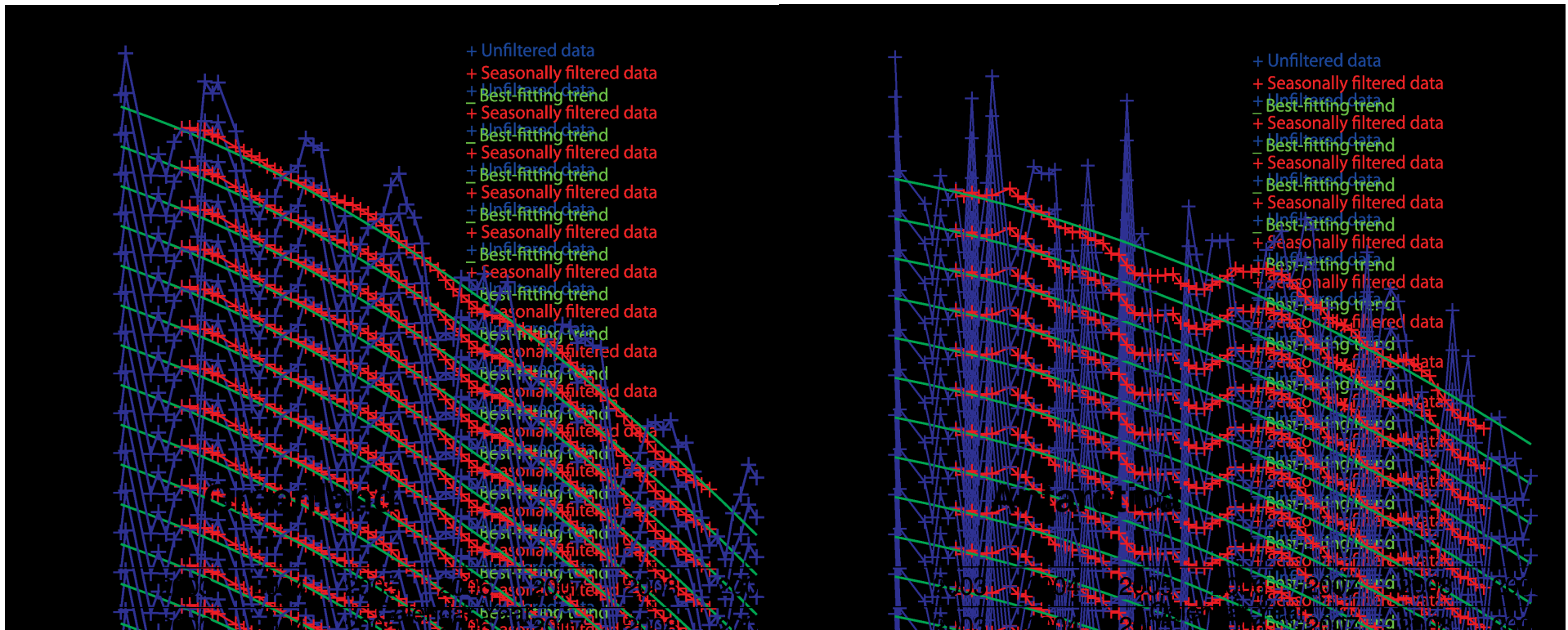
During the period of April 2002 to February 2009 the mass loss of the polar ice sheets was not constant but increased with time, implying that the ice sheets' contribution to sea level rise was increasing.

Greenland:

- mass loss increased from 137 Gt/yr in 2002–2003 to 286 Gt/yr in 2007–2009
- acceleration of -30 ± 11 Gt/yr² in 2002–2009.

Antarctica:

- mass loss increased from 104 Gt/yr in 2002–2006 to 246 Gt/yr in 2006–2009
- acceleration of -26 ± 14 Gt/yr² in 2002–2009.



Roadmap: Towards Future Satellite Gravity Missions

STRATEGIC TARGET

A multi-decade, continuous series of space-based observations of changes in the Earth's gravity field begun with the GRACE mission, and leading, before 2020, to satellite systems capable of global determination of changes in the Earth's gravity field from global down to regional spatial scales and on time scales of two weeks or shorter, as a contribution to an integrated, sustained operational observing system for mass redistribution, global change, and natural hazards, and in support of global water management, the understanding of climate variations, and the characterization and early detection of natural hazards.

Roadmap: Towards Future Satellite Gravity Missions

THE WAY FORWARD: THE MAP

Activity 1: Science developments

- 1.1 Identifying the guiding science questions and application
- 1.2 Consolidating and reviewing user and mission requirements
- 1.3 Meeting the scientific challenges on the road to future gravity missions

Activity 2: Technological developments

- 2.1 Short-term developments
- 2.2 Medium-term developments
- 2.3 Long-term developments

Activity 3: Mission implementation

- 3.1 Facilitate the international co-ordination of science and technology activities
- 3.2 Develop a proposal for a virtual constellation for mass redistribution
- 3.3 Inter-agency coordination
- 3.4 Agency plans including operation

Activity 4: Processing, modeling and applications

- 4.1 Processing
- 4.2 Geophysical modeling
- 4.3 Supporting science and societal applications through a dedicated service

Declaration



■ Little or no water scarcity

■ Not estimated

■ Approaching physical water scarcity

■ Physical water scarcity

■ Economic water scarcity

Source: International Water Management Institute

Declaration

Towards a Service for the Water Cycle

Noticing that

one billion people are currently without sufficient access to clean drinking water;

*according to the 2nd UN Water Assessment Report, this deficit is a result of **governance problems** and poorly informed decision-making; **demand for water resources is rising** due to increased water usage for potable consumption, energy production, irrigation for agriculture purposes, industrial and urban uses, while climate change is locally to regionally impacting water resources through increased frequencies and magnitudes of droughts and floods; a better understanding of the water cycle on regional to global scales is critical for managing water resources in a sustainable manner;*

■ PHYSICAL WATER SCARCITY

■ ECONOMIC WATER SCARCITY

Source: International Water Management Institute

Declaration

Towards a Service for the Water Cycle

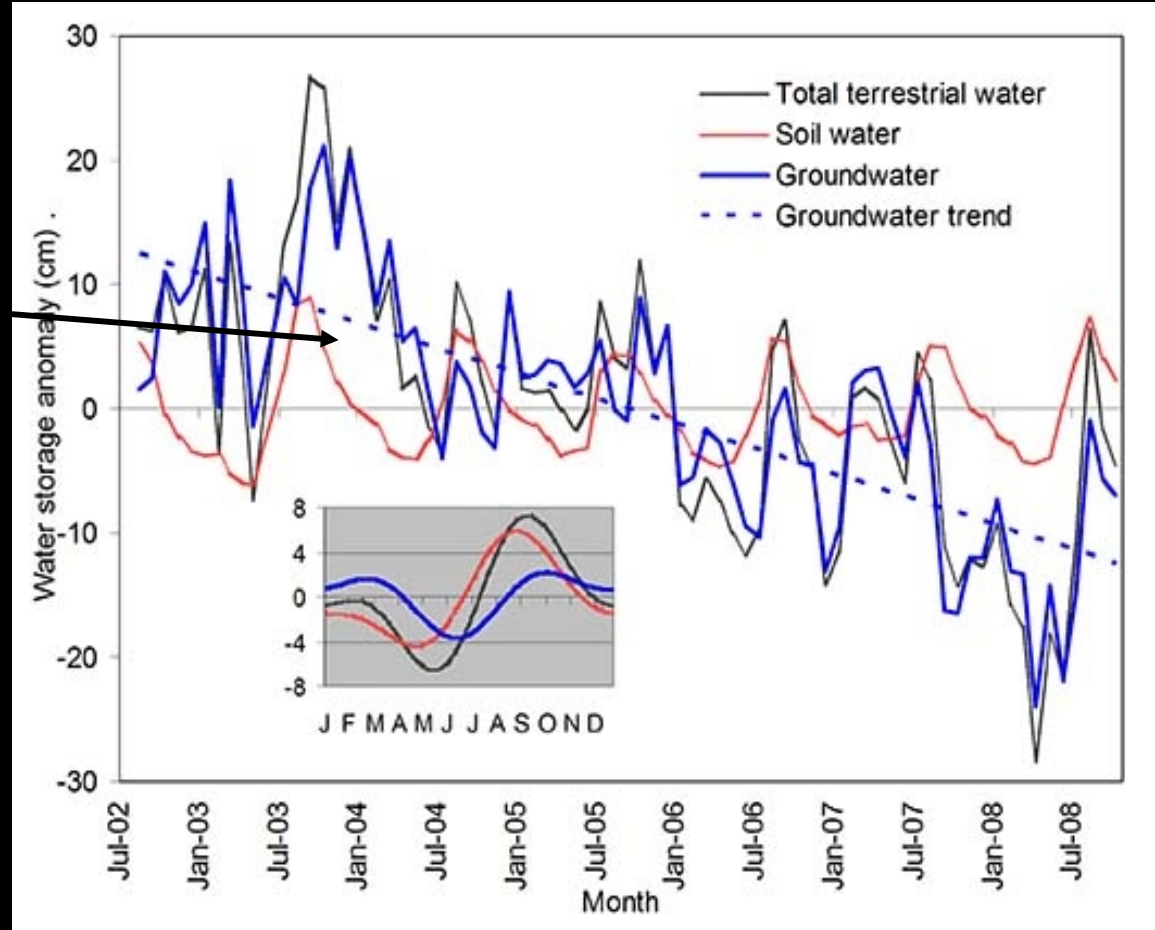
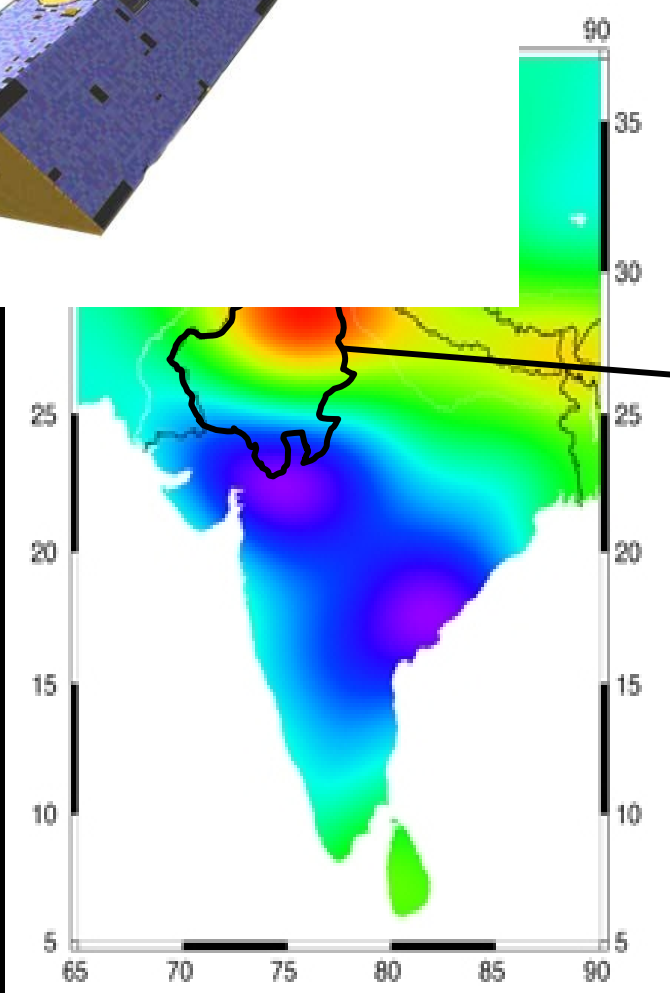
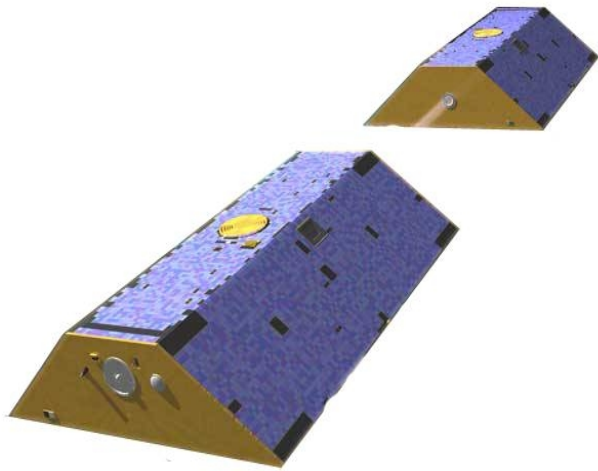
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and recognizing that

*the **GRACE** satellite gravity mission has **demonstrated the ability to measure mass redistribution in the water cycle**, exemplified most recently by the detection of a decline in the water table in northwestern India between 2002 and 2008 of about 33 cm/yr due to groundwater withdrawals for irrigation; also exemplified by measurement of net decreases in the masses of ice stored in Greenland, certain regions of Antarctica, and Alaskan glaciers over the same time period;*

...

Declaration



Declaration

Towards a Service for the Water Cycle

...

the Participants of the Workshop on a Roadmap for Future Satellite Gravity Missions declare that

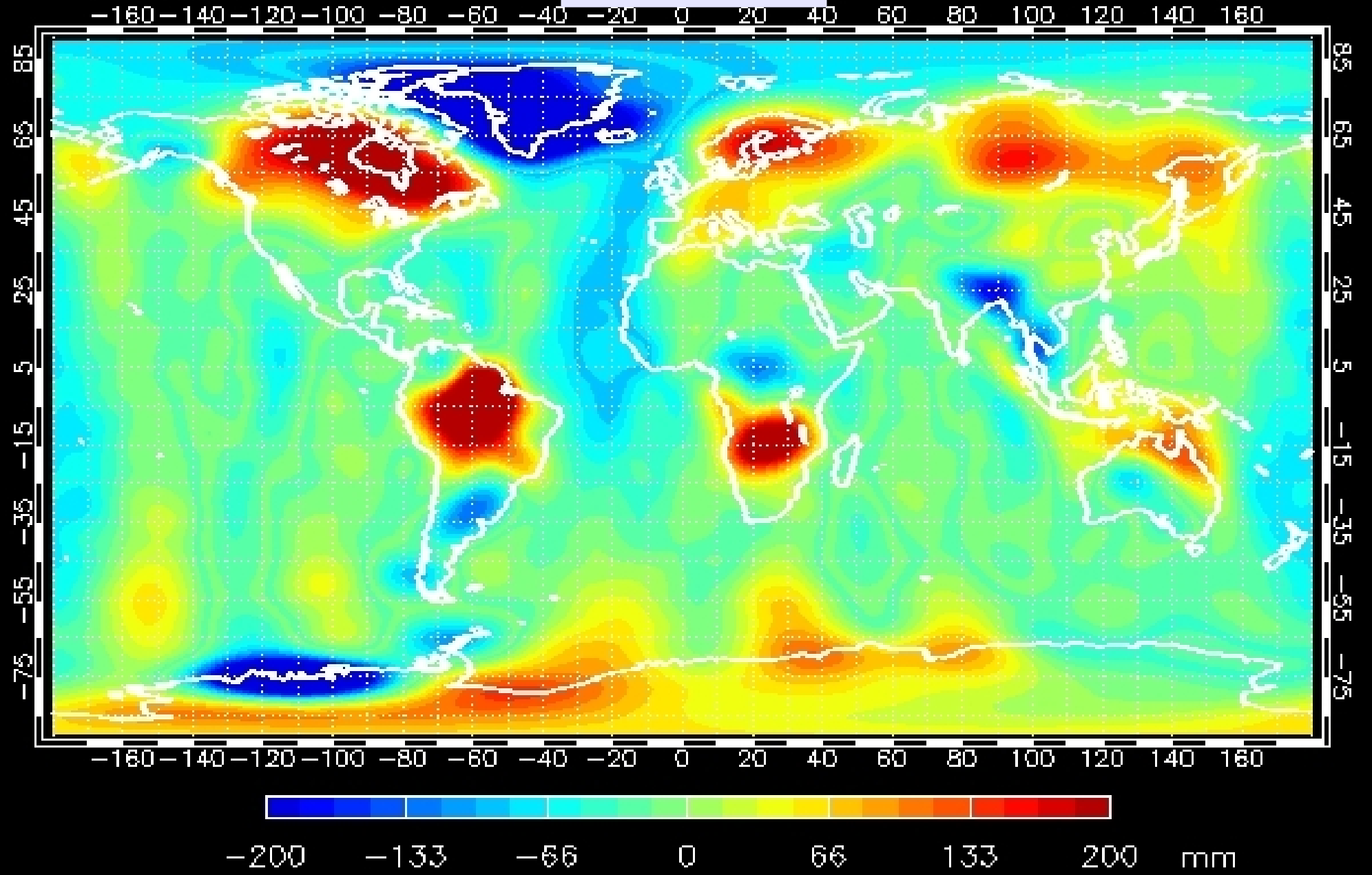
*a long and uninterrupted series of satellite gravity missions with accuracies and resolutions at least as good as GRACE's is a **crucial element** of an observation system to adequately monitor the global water cycle and to improve our understanding of the processes and consequences of change;*

*such a series of satellite gravity missions would provide the **basis for a global service to inform decision makers** in a timely manner about ongoing and forecasted changes in the water cycle related to droughts, groundwater depletion, sea level changes, and other potential impacts of climate change.*

...

Tin Declaration 21

500 km



Towards a Service for the Water Cycle

...

Furthermore, the Participants of the Workshop have agreed on a roadmap towards future satellite gravity missions and, with this declaration, bring this roadmap to the attention of the GEO Plenary, the governments of the GEO Member Countries, and the Participating Organizations in GEO in an effort to initiate international action for the implementation of this roadmap, for the benefit of science and society in support of a sustainable and peaceful development. The participants declare their support for this action.

The Hope and Longer-Term Perspective

Immediate Goals:

- Bring the roadmap to the attention of the GEO Plenary;
- A major international effort to implement the roadmap, i.e.
 - * facilitate the science and technology development;
 - * realize the missions.

Further outreach to

- other disciplines to increase usage/benefits (STC, UIC);
- CEOS and GEO Water and Climate Tasks to increase support for roadmap;
- UNFCCC: gravity/mass redistribution as a key climate variable.

