

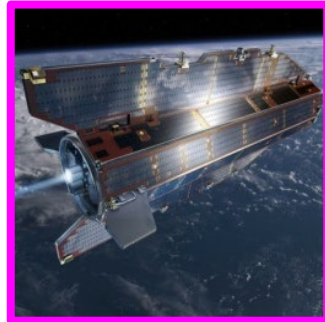
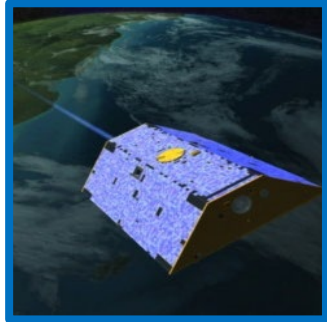
# Mass change And Geosciences International Constellation (MAGIC)

Roland Pail

Chair of Astronomical and Physical Geodesy  
Technical University of Munich, Germany



# Temporal gravity: Sustained observation of mass transport from space

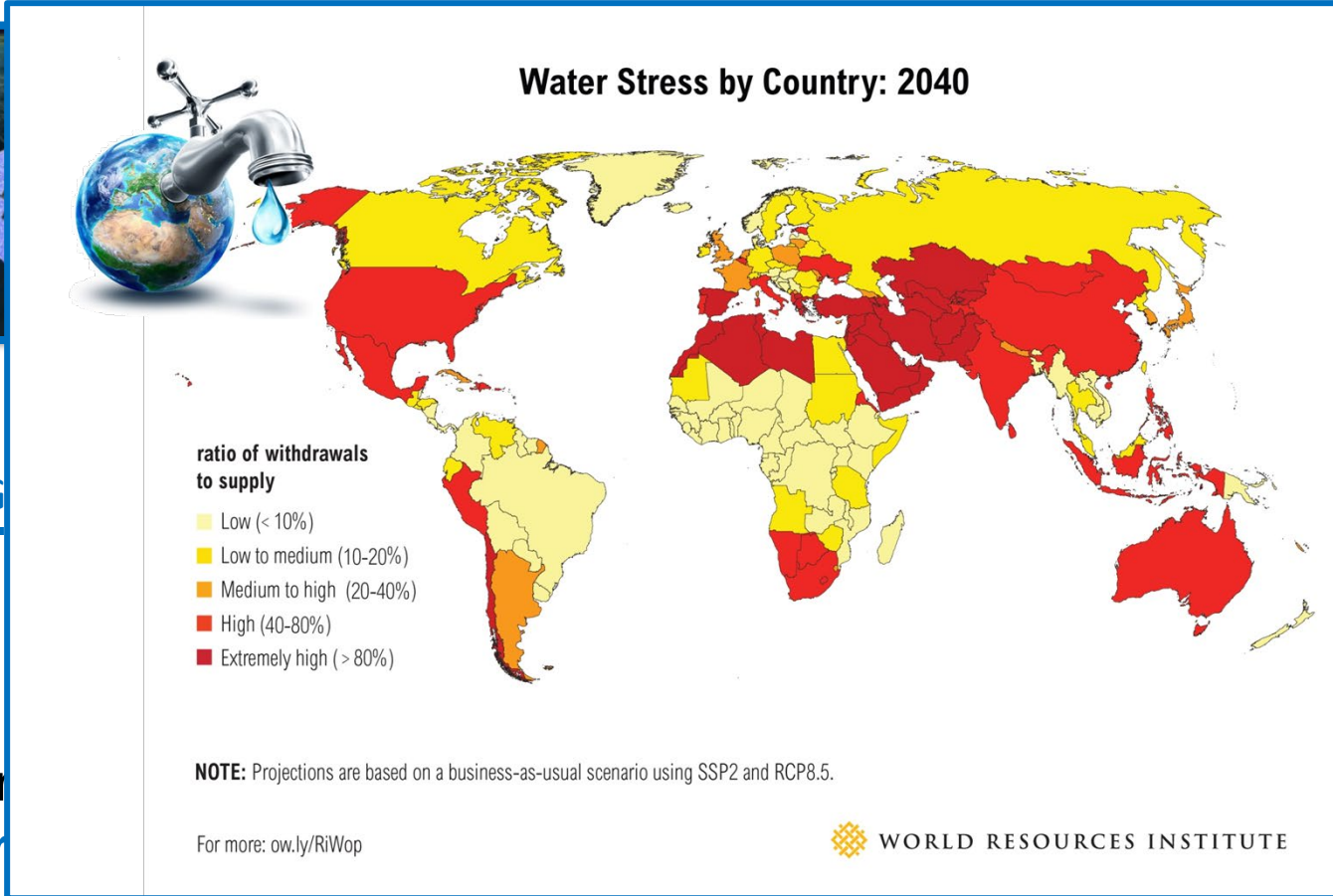


CHAMP (GFZ, 2000-2010)

GRACE (NASA/DLR, 2002-2017)

GRACE-FO (NASA/G

GOCE (ESA, 2009-2013)



- Gravity field observations are a **unique** measure to observe and monitor mass and **mass transport**

- Water** will be one of the most **critical** and geopolitically most important **resources of the future**.

- Sustained gravity field observation from space contributes significantly to a number of **Essential Climate Variables** (ECVs) as defined by GCOS.



- **Two User Community Workshops**

- Noordwijk, NL, 2007
- Graz, AUT, 2009



- **IUGG Resolution 2011** and letter to Space Agencies (ESA, NASA) 2012



- **International Science and User Community Team under the umbrella of IUGG** (2014-2015)

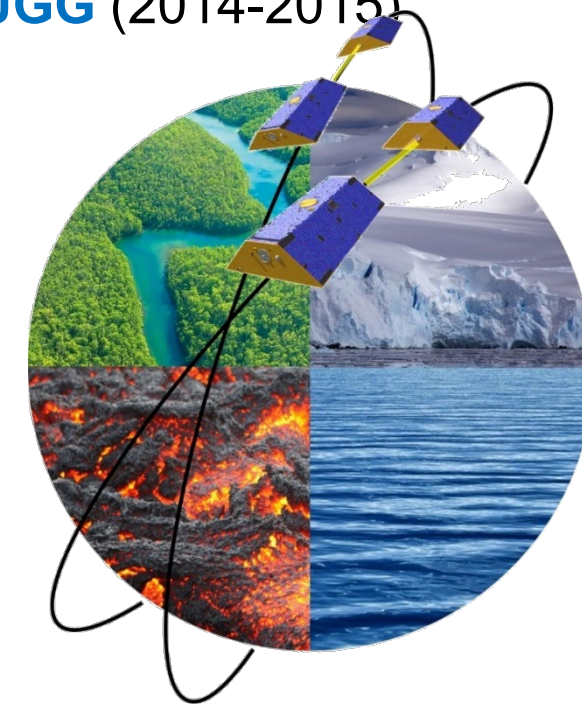
- Contribution by >80 international experts in the fields of
  - Hydrology
  - Cryosphere
  - Oceans
  - Solid Earth

- **Objectives**

1. Consolidation of science and user needs among the communities
2. Expression of need for mass transport observations from space



International Union of Geodesy and Geophysics (IUGG)



## Users' priorities ...

- Extension of observation time series → separation of natural and anthropogenic forcing
- Improved spatial resolution
- Improved temporal resolution → operational applications

## ... expressed in numbers

Target

Spatial resolution	Equivalent Water Height		Geoid	
	Monthly field	Long-term trend	Monthly field	Long-term trend
400 km	0.5 mm	0.05 mm/yr	5 μm	0.5 μm/yr
200 km	1 cm	0.1 cm/yr	0.05 mm	5 μm/yr
150 km	5 cm	0.5 cm/yr	0.1 mm	0.01 mm/yr
100 km	0.5 m	0.05 m/yr	1 mm	0.1 mm/yr

- Significant leap forward
- Significantly increased spatial and temporal resolution
- New applications (science, societal benefit)

Surv Geophys (2015) 36:743–772  
DOI 10.1007/s10712-015-9348-9

**Science and User Needs for Observing Global Mass Transport to Understand Global Change and to Benefit Society**

Roland Pail<sup>1</sup> · Rory Bingham<sup>2</sup> · Carla Braitenberg<sup>3</sup> · Henryk Dobslaw<sup>4</sup> · Annette Eicker<sup>5</sup> · Andreas Güntner<sup>4</sup> · Martin Horwath<sup>6</sup> · Eric Ivins<sup>7</sup> · Laurent Longuevergne<sup>8</sup> · Isabelle Panet<sup>9</sup> · Bert Wouters<sup>2,10</sup> · IUGG Expert Panel

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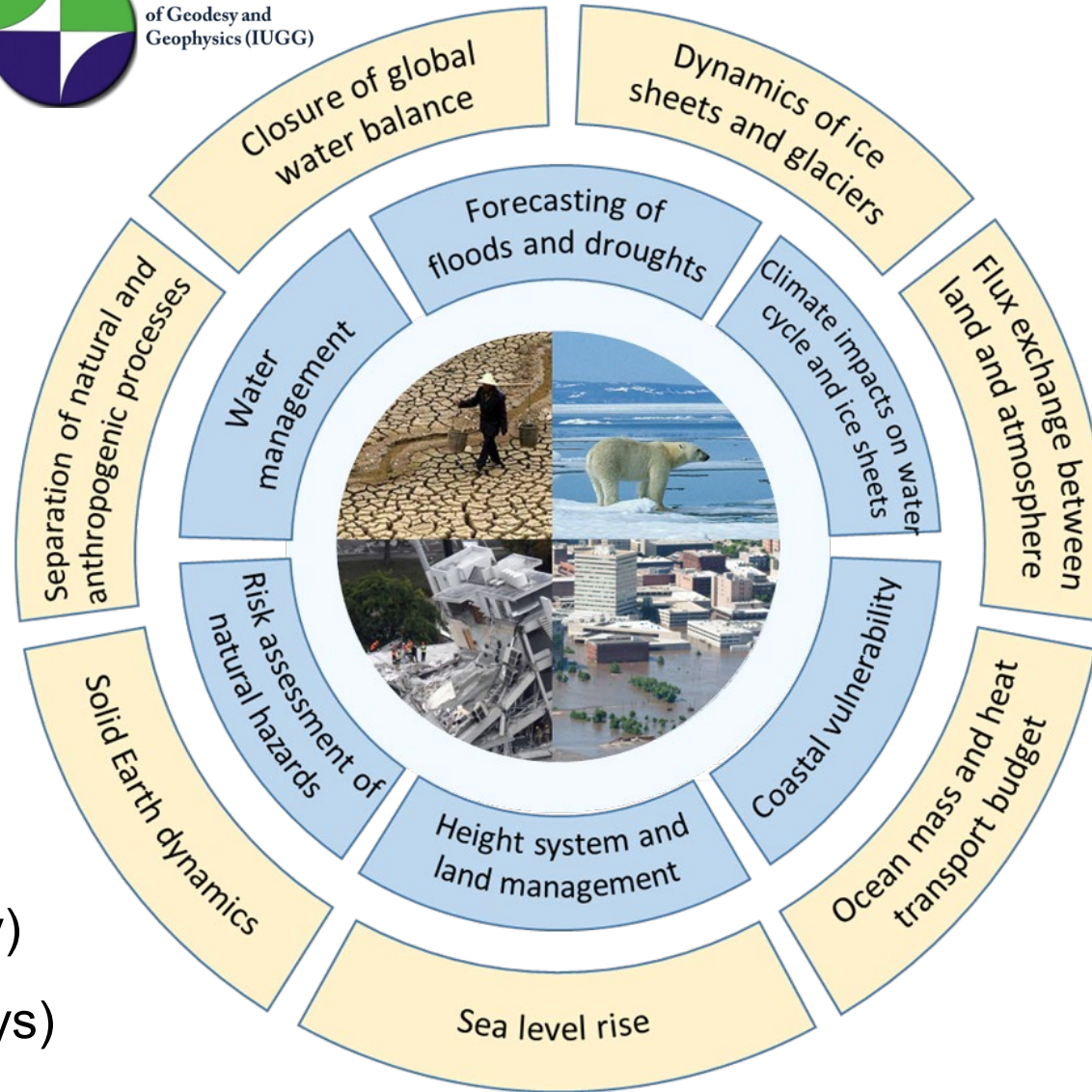
**International Union of Geodesy and Geophysics**

**Resolutions**

From science ...  
... to societal need

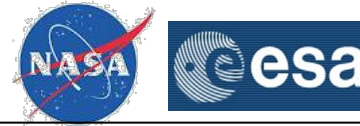


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Needs for service applications:

- High **temporal resolution** (daily)
- **Short latencies** (max. a few days)



## Science and User Needs

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### Science and User Needs for Observing Global Mass Transport to Understand Global Change and to Benefit Society

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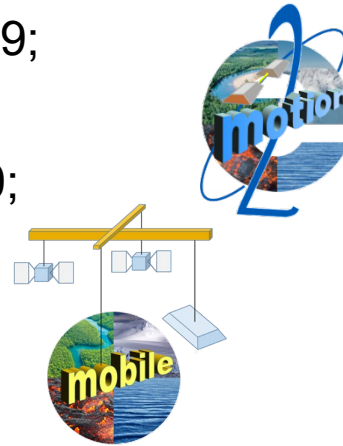
## Resolutions

## NASA/ESA Interagency Gravity Science Working Group



## Mission proposals

- **e-motion<sup>2</sup>** (ESA EE9; double pair)
- **MOBILE** (ESA EE10; high-low tracking)

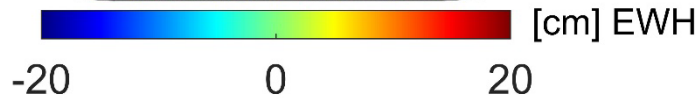
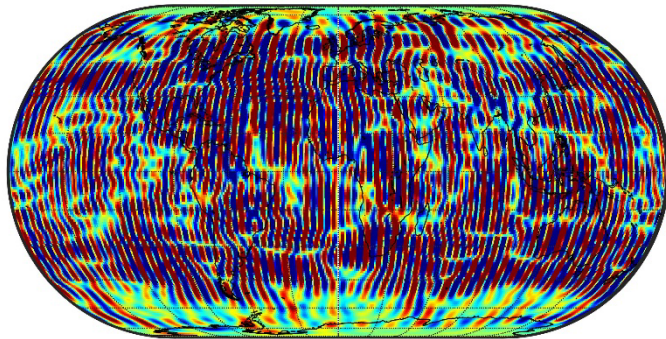


## NASA/ESA joint activities

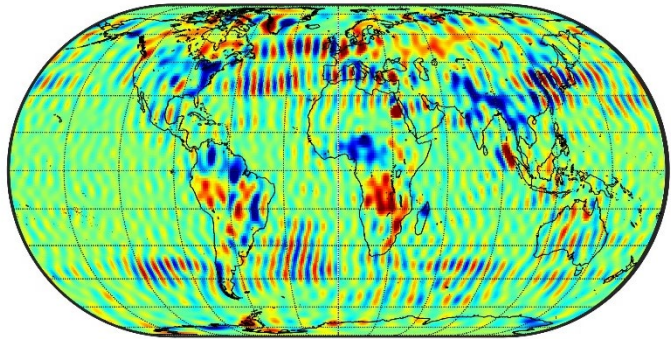
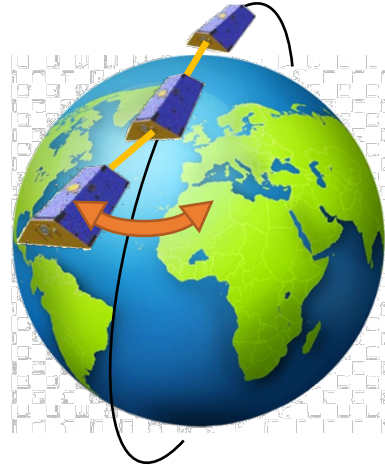
- NASA Mass Change Designated Observable (*MCDO*) study
- ESA Next-Generation Gravity Mission (NGGM) study, *MAGIC* Phase A  
→ joint Mission Requirement Document

# Performance simulation of different constellations

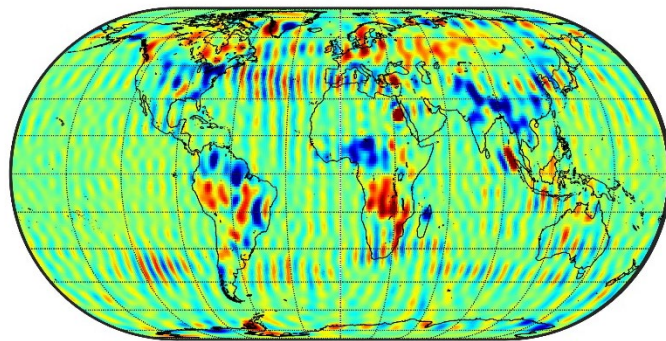
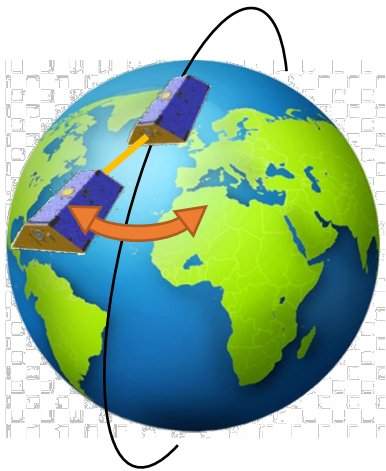
In-line single-pair



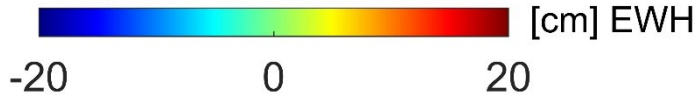
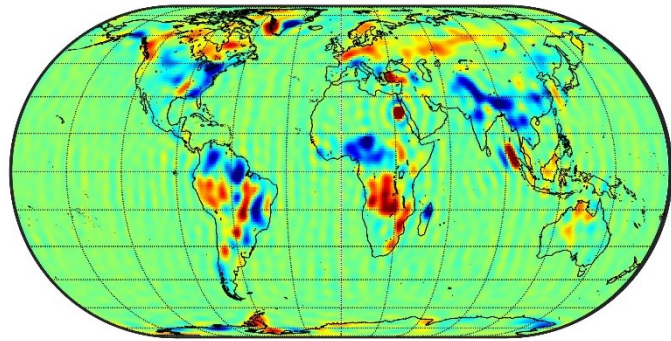
MARVEL 3 sats.



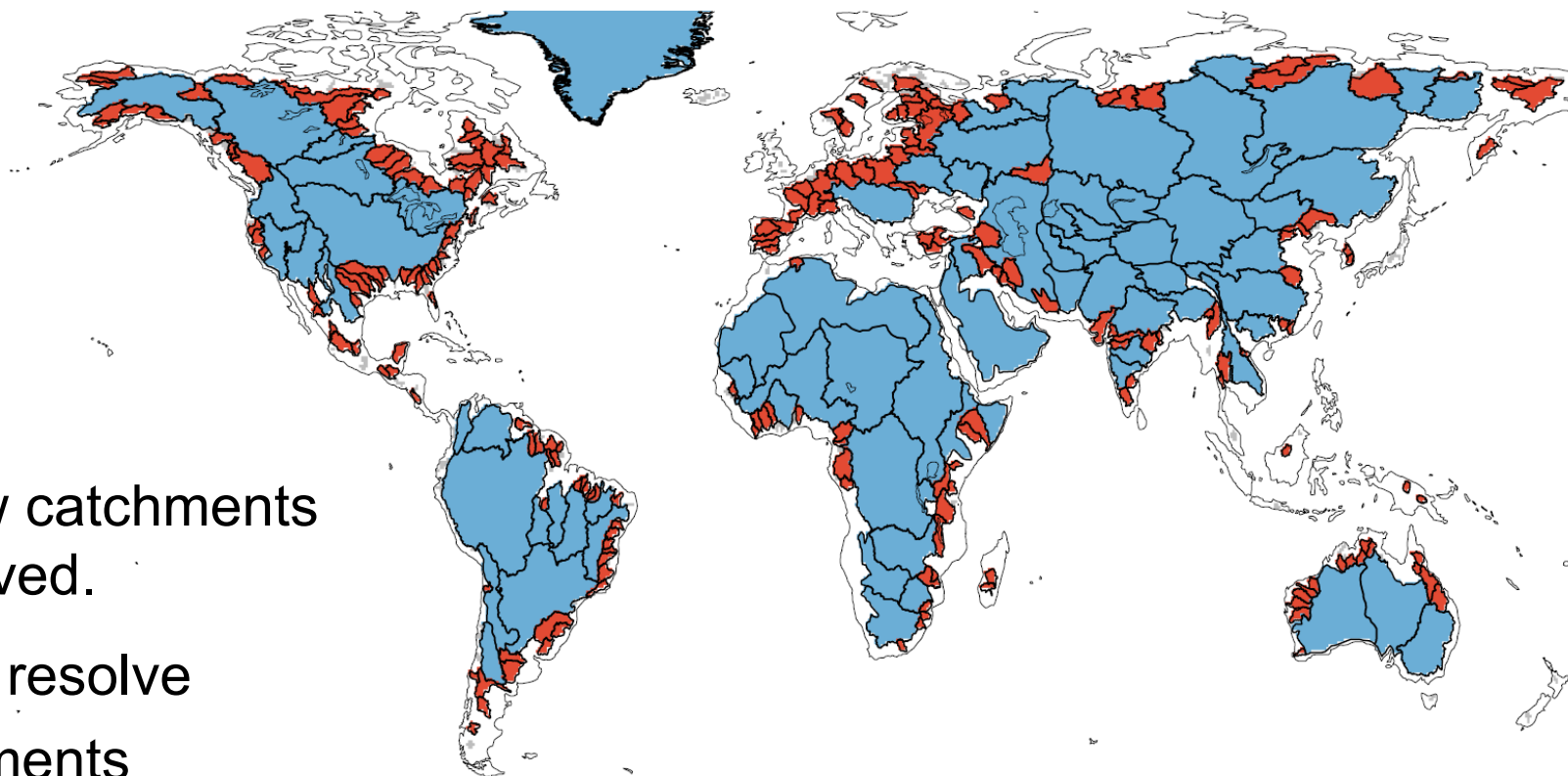
Pendulum single-pair 30°



Bender double-pair



## Observable catchments

 GRACE / GRACE-FO NGGM/MAGIC

- Currently, only very few catchments in Europe can be resolved.
- With MAGIC, we could resolve
  - many more catchments worldwide
  - sub-catchments inside the large catchments (given in blue)





# Application: continental hydrology

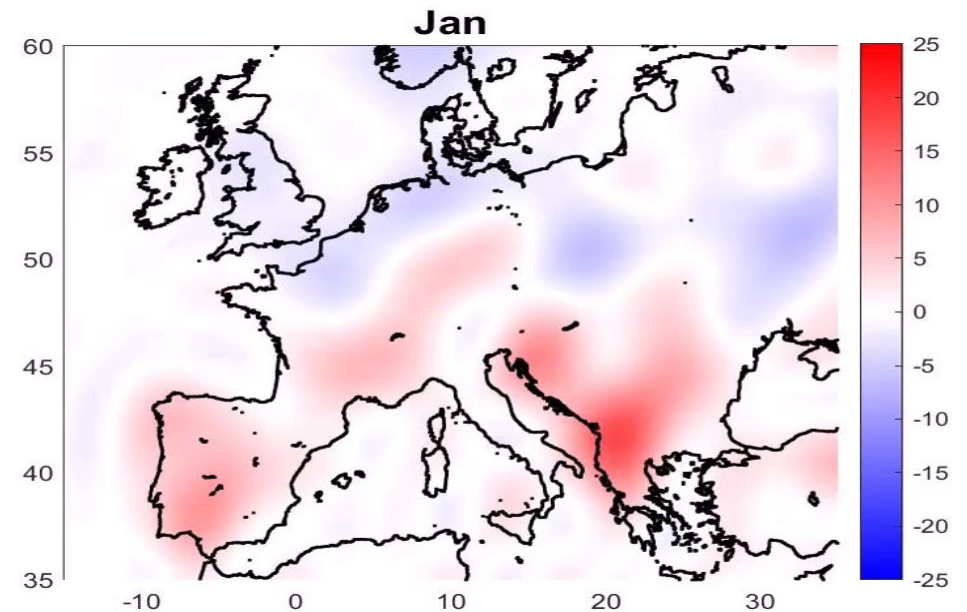
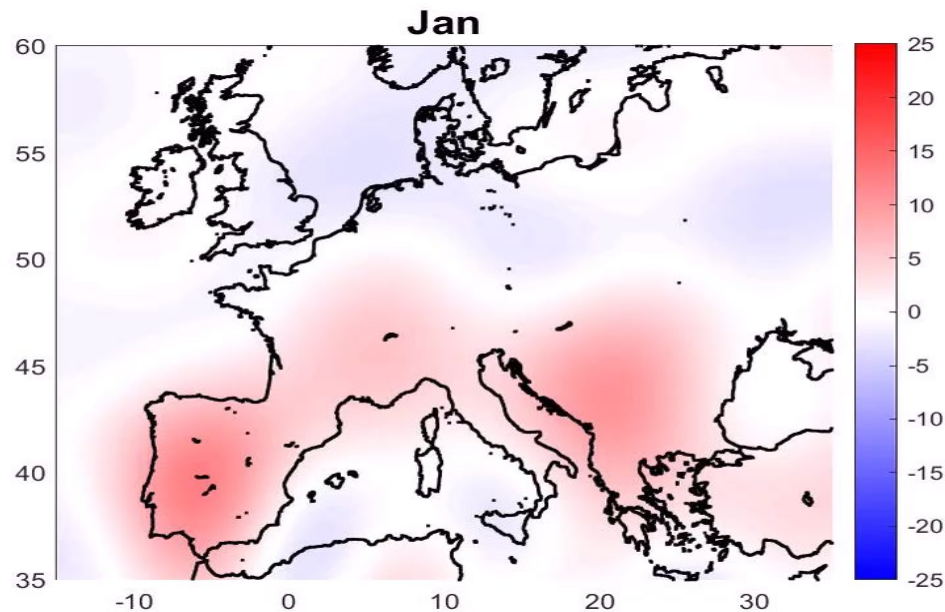


- With MAGIC, a significantly **improved spatial and temporal resolution** will be achieved, and thus
- **new products** (weekly, sub-weekly) will be available.



In-line single-pair

Bender double-pair



# Basin-scale estimates of hydrological catchments

RMS differences (estimated vs. truth) of basin averages based on post-processed 7-day solutions (including filter omission error)

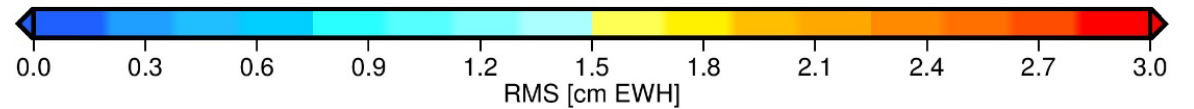
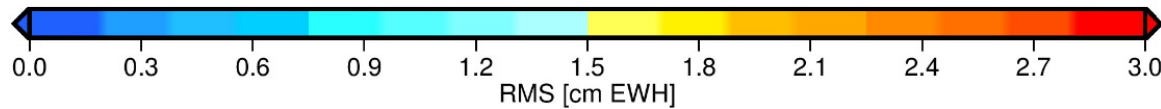
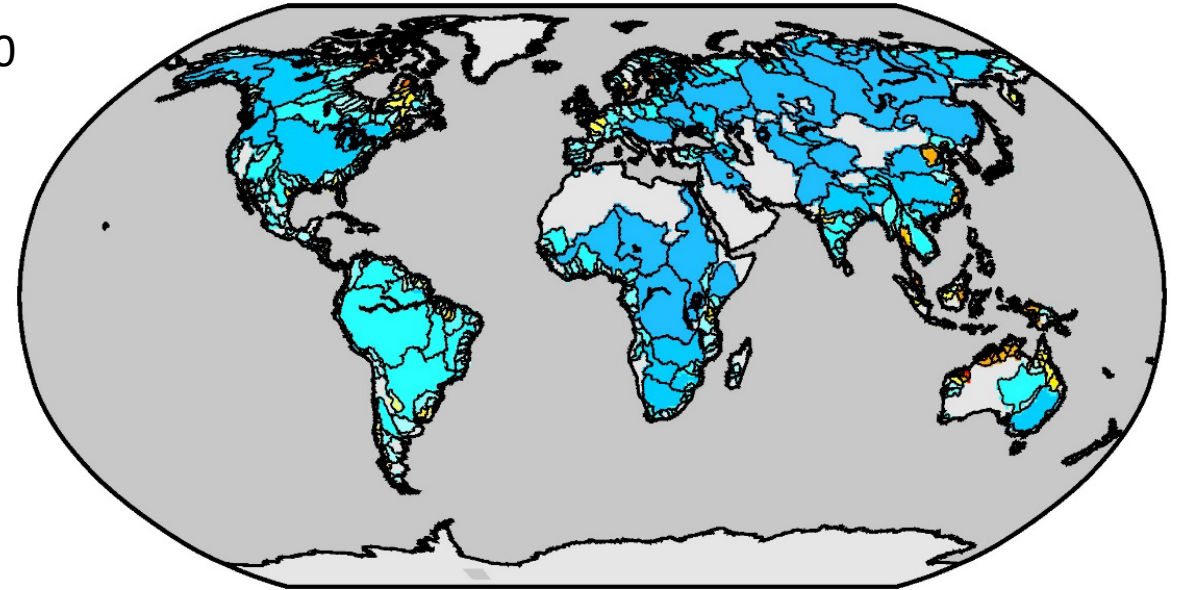
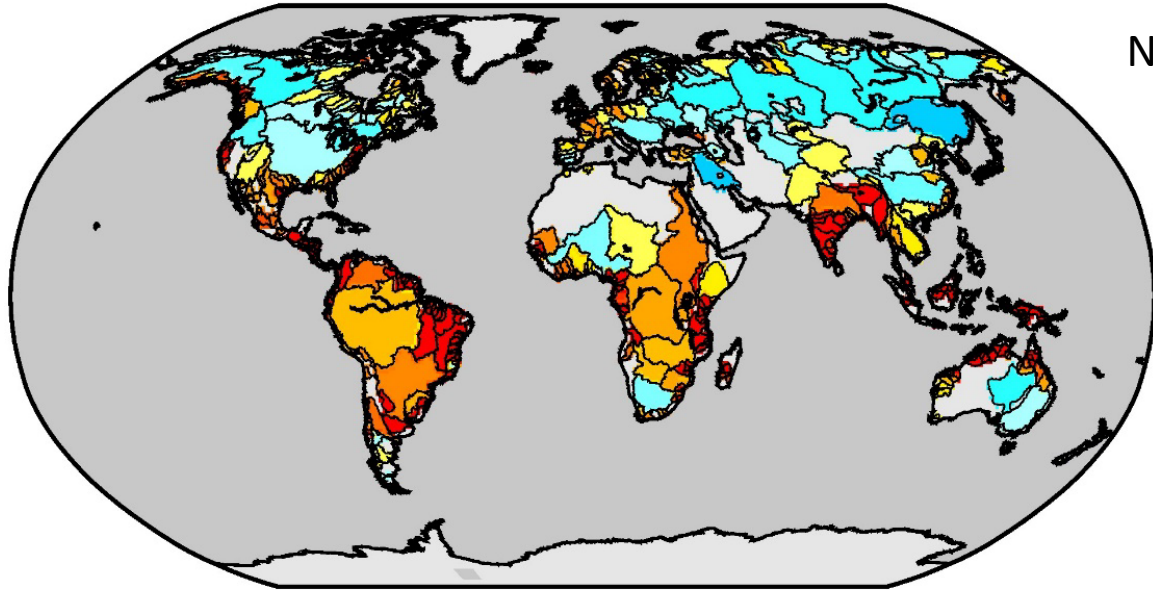
In-line single-pair

Bender double-pair

RMSD of basin averages (grdc), grace, 7days, vader, N50

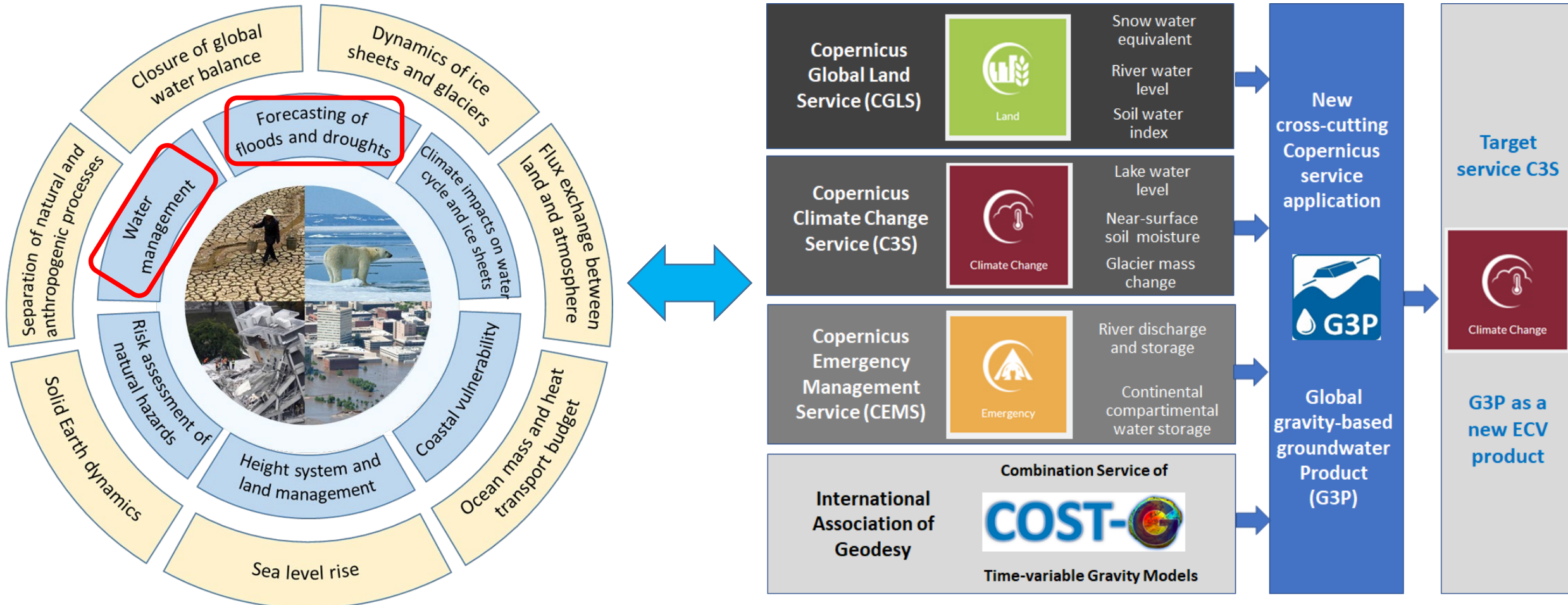
RMSD of basin averages (grdc), bender, 7days, vader, N50

N=50



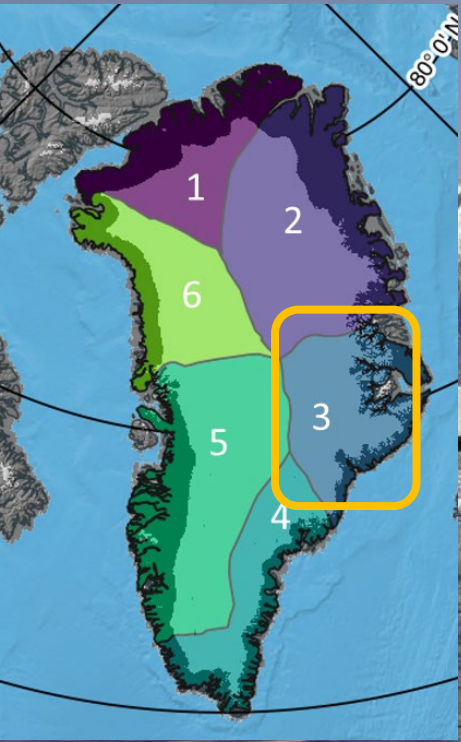
# Towards operational service applications ...

- MAGIC will enable **new near-real time (NRT) applications**, such as monitoring and forecasting of **floods and droughts**, to be implemented in **operational Copernicus services**.

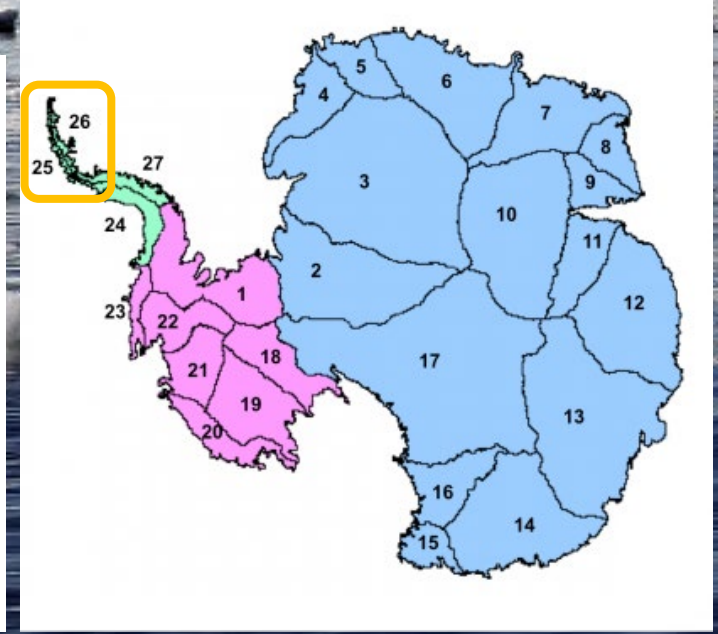
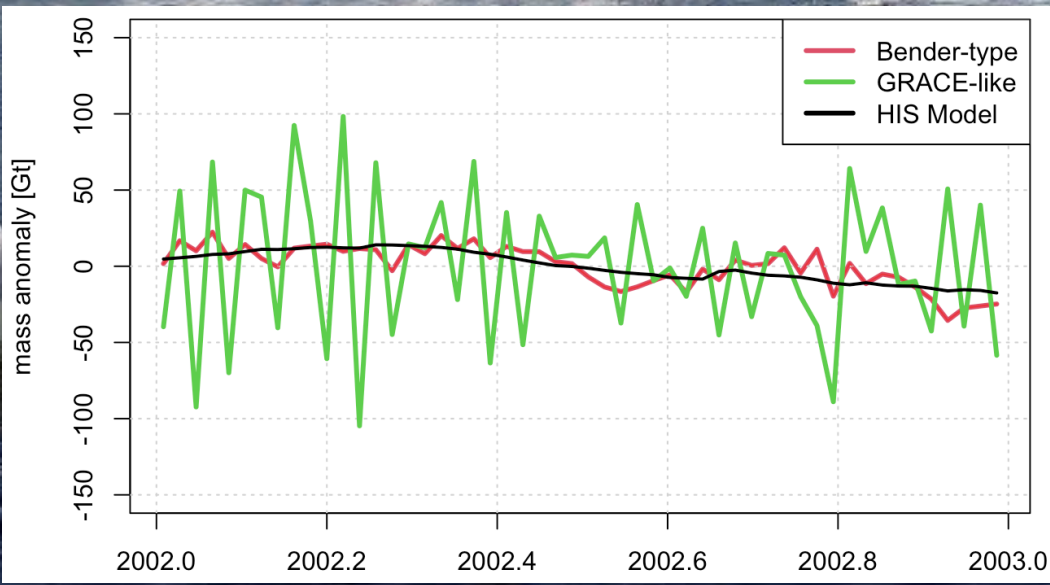


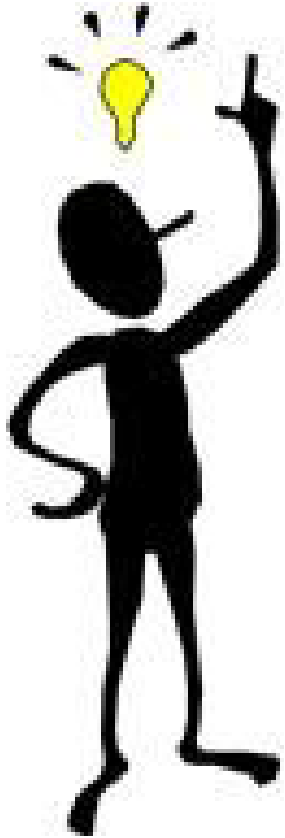
# Application: Basic-scale estimates of ice mass balance

Greenland: Basin 3 – high elevations



Northern Antarctic Peninsula





- There are strong user needs for future gravity missions with higher spatial and temporal resolution.
- Especially operation service applications request high temporal resolution and short latencies.
- The joint ESA/NASA mission constellation MAGIC double-pair constellation can meet these ambitious goals.
- For more details, please visit [B2.04](#) and [A10.2](#).

