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Improved monitoring and forecasting of ecological status of European INland waters by combining Future earth ObseRvation data and Models (INFORM)

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and the INFORM consortium

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Why focus on inland waters?

- Fishing, recreation, water supply, transport, waste disposal, irrigation,…

  increased **pressures** on EU inland waters

  asks for sustainable water management

- **Monitoring** of inland water quality required by
  - EU Water Framework Directive (2000/60/EC)
  - EU Habitats Directive (92/43/EEC)
  - EU Shellfish Waters Directive (2006/113/EC)
  - EU Drinking Water Directive (98/83/EC)
  - EU Bathing Water Directive (2006/7/EC)
  - EU Nitrates Directive (91/676/EEC)
  - EU Urban Waste Water
  - ...
- Environmental Impact Assessments (e.g. by dredging companies)
- **BUT** less resources are available for in-situ monitoring

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Blueprint to Safeguard Europe's Water Resources (COM/2012/673) mentions Copernicus

“THE STATUS OF EU WATERS IS NOT DOING WELL ENOUGH! “

“The Water Information System (WISE) … will benefit from the development of INSPIRE, SEIS and Copernicus and from current water research works under FP7 and those to be conducted under H2020”

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Earth Observation for monitoring inland waters?

- Today: underutilized
  - complexity and variability of these inland waters
  - lack of adequate analysis methods
  - lack of adequate low-cost EO data

Report GEO inland and coastal Water Quality Algorithm Workshop, Washington DC, May 2009:

"There is a lack of appropriate/dedicated satellite sensors for nearshore coastal and inland water quality applications".

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Earth Observation & biogeochemical models?

Assimilation of EO products into biogeochemical models allows for analysis of the cause-effect relationships governing a status change, forecast the response to pressures and evaluate different management actions.

"the future lies in the combined utilization of in situ data, remote sensing, and modeling."

Tiffany A.H. Moisan, Shubha Sathyendranath and Heather A. Bouman (2012). Ocean Color Remote Sensing of Phytoplankton Functional Types, Remote Sensing of Biomass - Principles and Applications, Temilola Fatoyinbo (Ed.), ISBN: 978-953-51-0313-4, InTech, Available from: http://www.intechopen.com/books/remote-sensing-of-biomass-principles-and-applications/remote-sensing-of-marine-phytoplankton-biomass

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EU FP7-SPACE project INFORM

- Collaborative project - THEME [SPA.2013.1.1-07] [Remote sensing methods]
- Start date: 1/1/2014
- Duration: 48 months
- 9 beneficiaries from 7 EU Member States
- Requested EU contribution: € 1 991 902. 97
- Grant agreement n° 606865

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Main concept

The main concept is to develop novel **user-driven products** for **inland water quality** monitoring by using new **innovative methods integrated into models** which fully exploit the capabilities of **upcoming Earth Observation missions (Sentinel-2, Sentinel-3, EnMAP and PRISMA)**

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Main objectives

- INFORM will explore and demonstrate how the new capabilities of **upcoming sensors**, combined with **innovative analysis techniques** and the coupling with **biogeochemical models** can be exploited to deliver new and improved products for inland water quality monitoring addressing better the end-user needs
- INFORM will develop methodologies to improve existing Copernicus services and will provide a basis for new Copernicus service products
- INFORM will provide **recommendations for future EO missions** taking into account requirements for inland water quality monitoring

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Outlook

- **Improvement of existing products and development of new products** for the Copernicus Land Monitoring Core Service (LMCS). In turn this could lead to the **development of new downstream services**
- It is our goal to trigger the end-users and make them aware of the new possibilities of upcoming missions in order to increase the opportunities of take up by the LMCS or generate a downstream service

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List of beneficiaries

	Participant organisation name	Participant short name	Country
vito vision on technology	VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V.	VITO - Coordinator	BELGIUM
istituto per il rilevamento elettromagnetico dell'ambiente	CONSIGLIO NAZIONALE DELLE RICERCHE	CNR	ITALY
EOMAP	EOMAP GmbH & Co.KG	EOMAP	GERMANY
UNIVERSITY OF STIRLING	THE UNIVERSITY OF STIRLING	U STIRLING	UK
	INSTITUT ROYAL DES SCIENCES NATURELLES DE BELGIQUE	RBINS	BELGIUM
Deltares	STICHTING DELTARES	Deltares	THE NETHERLANDS
PML Plymouth Marine Laboratory	PLYMOUTH MARINE LABORATORY	PML	UK
MTA ÖKOLÓGIAI KUTATÓKÖZPONT Centre for Ecological Research	MAGYAR TUDOMANYOS AKADEMIA OKOLOGIAI KUTATOKOZPONT	MTA OK	HUNGARY
	KLAIPEDOS UNIVERSITETAS	KLAIPEDOS UNIVERSITETAS	LITHUANIA

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Steering Advisory Board (SAB)

- Members
  - Dr. Tiit Kutser, Remote Sensing and Marine Optics Department, Estonian Marine Institute, University of Tartu, Estonia
  - Dr. Stewart Bernard, CSIR-NRE (Centre of High Performance Computing), South-Africa
  - Dr. Vittorio Brando, CNR-IREA
- Tasks
  - To provide recommendations at the SAB01 meeting (January 2014)
  - To formulate scientific comments on the INFORM progress and to provide recommendations at SAB02 meeting (Mid-term, January 2016)

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End-User Advisory Board (EUAB)

- Members
  - Marc Sas/Boudewijn Decrop, International Marine and Dredging Consultants (IMDC), Belgium
  - Marco Bartoli, Expert ecologist, University of Parma, Life Sciences Department
  - Ute Menke, advisor Network Water, Rijkswaterstaat, the Netherlands
  - István Kóbor head of laboratory, Central-Transdanubian Water Directorate, Hungary
  - Dr. Geoff Phillips, Research, Monitoring and Innovation. Environmental Agency (EA) for England & Wales
  - Alfred Johny Wüest, EAWAG, aquatic research institute, Switzerland
  - Dr. Algirdas Stankevičius, Head of the Marine Research Department of the Ministry of Environment, Lithuania
- Tasks
  - To provide user requirements for INFORM developments at the EUAB01 (March 2014) and EUAB02 (Mid-term, January 2016)
  - To attend the INFORM EUAB03 results uptake workshop (December 2017)

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European approach

Site	Country	Characteristic
Lake Balaton Kis Balaton	Hungary	Largest shallow lake in Central Europe, mezo-oligotrophic Water Protection System, hypereutrophic
Curonian lagoon	Lithuania	Hypereutrophic coastal lagoon
Lakes Mantua	Italy	Small and shallow artificial eutrophic basins
Lagoon of Venice	Italy	Turbid coastal lagoon
Lake Constance	Germany, Switzerland, Austria	Eutrophic lake
Gironde river	France	Highly turbid river
Scheldt river	Belgium	Highly turbid river
Lake Windermere	UK	Mesotrophic lake
Loch Lomond	UK	Warm, monomictic basin. Oligotrophic northern basin, mesotrophic southern basin
Loch Leven	UK	polymictic, nonstratifying and eutrophic shallow lake
Ijsselmeer	The Netherlands	Eutrophic lake, largest freshwater lake area in Northwestern Europe Markermeer is a turbid lake.

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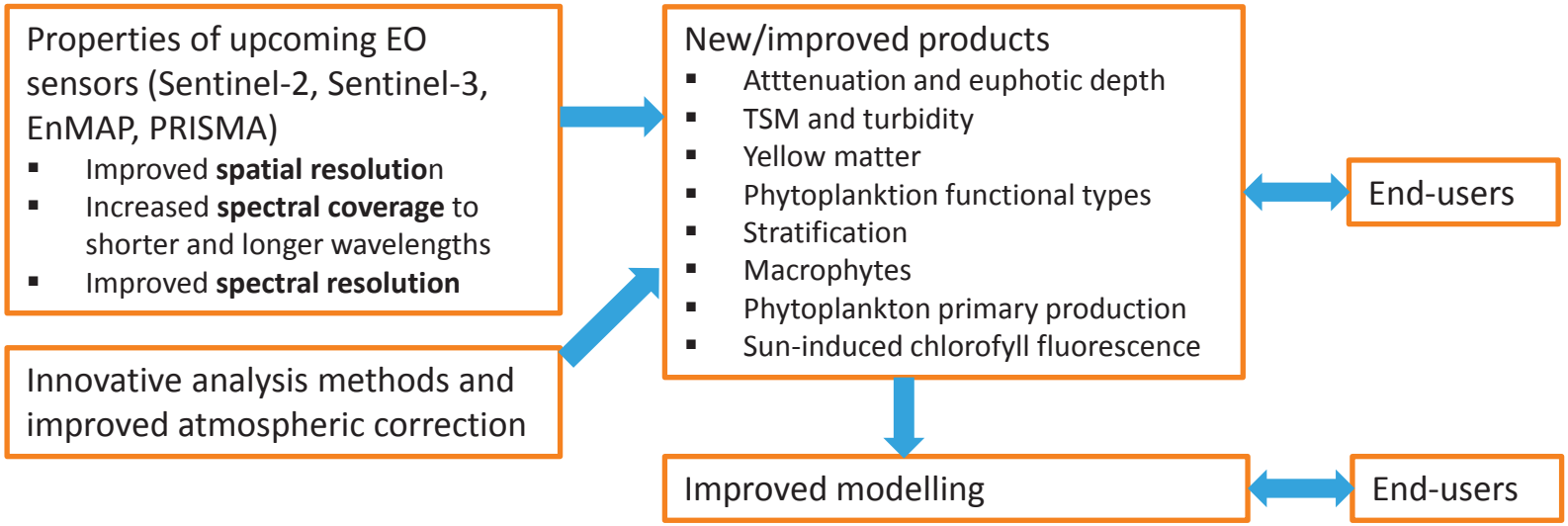
INFORM concept (detail)



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Progress beyond state-of-the-art

- Which upcoming EO missions do we envisage?
- What are the improvements and what are the expected new products?

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Upcoming Earth Observation instruments for water quality monitoring

SeaWiFS, MODIS, MERIS -> requirements driven by oceanographic community, product limitations

Look at other missions, maybe not Ocean Colour (OC) mission

Sentinel-2 , Sentinel-3, EnMAP, PRISMA

Spatial resolution! Increase in number of spectral bands!

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WP objectives (1/3)

- WP1 Management
  - Legal management
  - Financial management and distribution of funds between participants
  - Administrative management
- WP2 Scientific coordination
  - Scientific coordination of the project
- WP3 End-user interaction
  - To explore the end-user requirements in terms of water quality products
  - To stimulate project results' uptake by the end-users and industry
- WP4 Data gathering
  - To inventory existing data, identify data gaps and acquire new (in-situ, APEX hyperspectral and satellite) data for development and validation

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WP objectives (2/3)

- WP5 Algorithm development and validation
  - Development and validation of EO products, and estimation of their uncertainty for WP6
    - Atmospheric correction
    - Attenuation and euphotic depth
    - TSM and turbidity
    - Yellow matter
    - Phytoplankton functional types
    - Stratification
    - Macrophytes
    - Phytoplankton primary production
    - Sun-induced chlorophyll fluorescence

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WP objectives (3/3)

- WP6 EO-model integration
  - Integration of Earth Observation (EO) & In-Situ (IS) data and Water Quality (WQ) modelling
- WP7 Demonstration
  - To demonstrate to end-users
    - the INFORM prototype algorithms applied to new satellite sensors and
    - the added value of INFORM EO products for WQ model validation and forecasting
  - To test the compliance of INFORM EO products (including quality information) with end-user requirements
- WP8 Dissemination
  - To disseminate the project objectives, progress and results
  - To raise the awareness of the INFORM project
  - To give recommendations for future satellite missions
  - To organise a results uptake workshop

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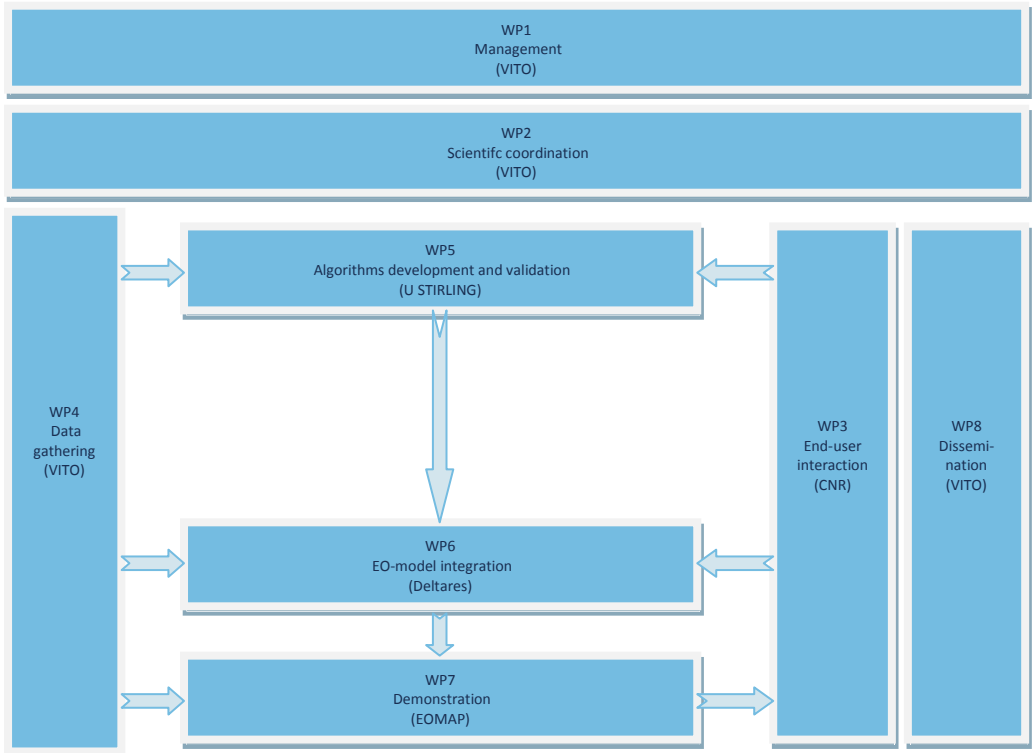
Interdependency of Work Packages



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Time line

		M1	M7	M13	M19	M25	M31	M37	M43
WP 1	**Management (MGT)**								
WP 2	**Scientific coordination (RTD)**	♦		♦		♦	♦		♦
WP 3	**End-user interaction (RTD)**								
Task 31	End-user requirements	♦•			♦	•			
Task 32	Preparation of results uptake								•
WP 4	**Data gathering (RTD)**								
Task 41	Existing data and data gaps	•							
Task 42	Data acquisition development campaign		•						
Task 43	Data acquisition testing campaign						•		
WP 5	**Algorithms development and validation (RTD)**				•				
Task 51	Atmospheric correction								
Task 52	Attenuation and euphotic depth								
Task 53	TSM and turbidity								
Task 54	Yellow matter								
Task 55	Phytoplankton functional types								
Task 56	Stratification								
Task 57	Macrophytes								
Task 58	Phytoplankton primary production								
Task 59	Sun-induced chlorofyll fluorescence								
WP 6	**EO-model integration (RTD)**						•		
Task 61	WQ modelling					••			
Task 62	EO as WQ model input						•		
Task 63	Integration EO&IS and WQ modelling								
WP 7	**Demonstration (DEM)**								
Task 71	INFORM algorithms application								
Task 72	Quality information of INFORM satellite products							•	
Task 73	INFORM products as input and validation for models								
Task 74	Model application and WQ forecasting								•
WP 8	**Dissemination (OTHER)**								
Task 81	INFORM website								
Task 82	Conferences and meetings								
Task 83	Papers								
Task 84	Recommendations for future missions								•
Task 85	Results uptake workshop								♦

Milestones	•	
Meetings	♦	progress meetings PM01 (Month 1), PM02 (Month 13), PM03 (Month 25), PM04 (Month 36), PM05 (Month 48)
		scientific advisory board meetings SAB01 (Month 1), SAB02 (Month 25)
		end-user advisory board meetings EUAB01 (Month 3), EUAB02 (Month 25), EUAB03 (Month 48)
		review meetings RV01 (Month 13), RV02 (Month 25), RV03 (Month 48)

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