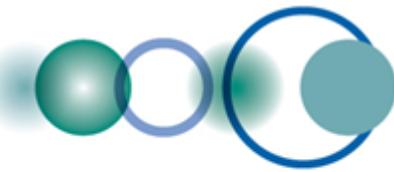


INTOGENER: Integrated Water flow monitoring and prediction system aimed at hydropower production

Erwan Motte, Laura Moreno

Starlab®
Living Science





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Project Concept and Background

- Objectives
- System Overview
- Project Background
- Feasibility study

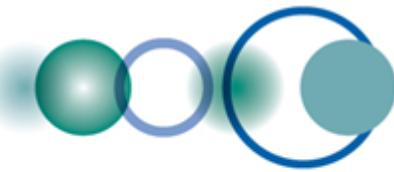
Current Activities and system Description

- Description of the demonstration phase
- Overview of the Pilot service
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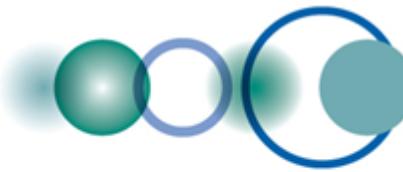
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PROJECT CONCEPT AND BACKGROUND





Objectives

The most important contribution to hydroelectric power generation comes from the spring melting of accumulated snow

The challenge:

To deliver an operational and accurate forecast service of water flow during the melting season aimed at hydropower industry.

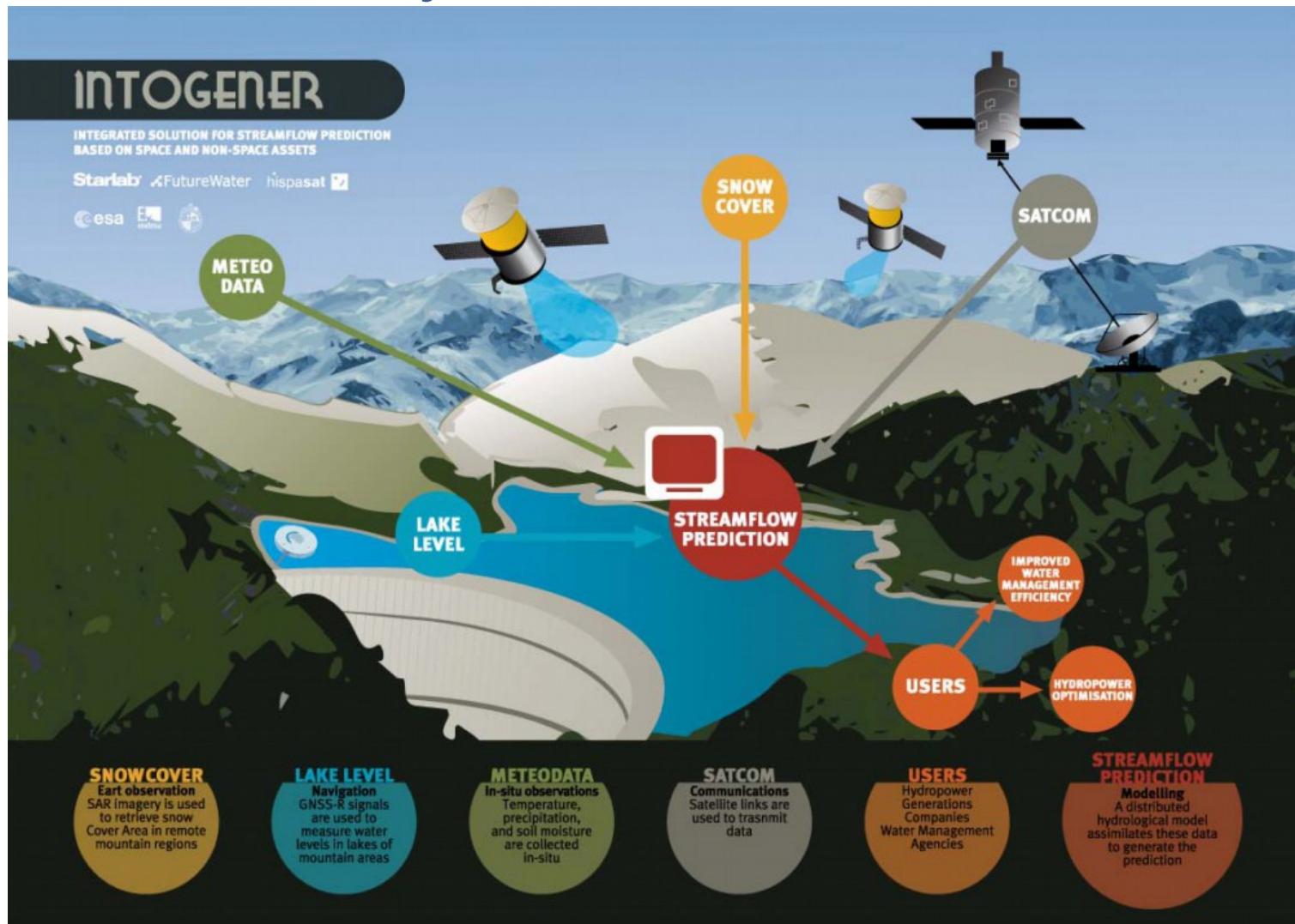
- Large areas (<10 000 km²)
- Difficult Access (remote mountainous regions)
- Short (weekly) and medium (monthly) scales
- Forecast points depending on operational needs

The **INTOGENER** project aim at overcoming these obstacles by the integrated use of:

- Satellite-based EO measurements of Snow
- Real-time In situ measurements sent by communication satellites
- Assimilation of these data into a distributed hydrological model



System Overview





Project Background...

- 2008-2009: Project started financed by Endesa R&D Department, as a preliminary investigation of the concept
- 2010-2011: Consolidation through a Feasibility Study financed by **ESA IAP ARTES 20 Program**
- 2012-2014: Demonstration phase financed by **ESA IAP ARTES 20**

... and Actors

- Starlab (Operational service design and management)
- Future Water (Hydrological Modelling)
- Hispasat (Satellite communications)
- Universidad Católica de Chile (Consultants in Hydrology)
- ENDESA Chile (User)
- European Space Agency

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FutureWater

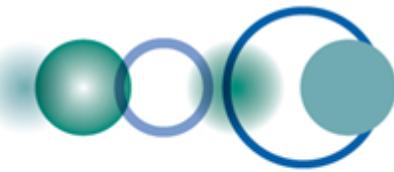
hispasat



Pontificia Universidad Católica de Chile
Escuela de Ingeniería

endesa chile
EM

e esa



Feasibility Study 2010-2011

t_0 May 2010

**User Requirements
Consolidation**

Proof of Concept

**State-of-the-art
Technologies**

Service Definition

**Implementation
Roadmap**

Viability Analysis

July 2010

October 2010

April 2011

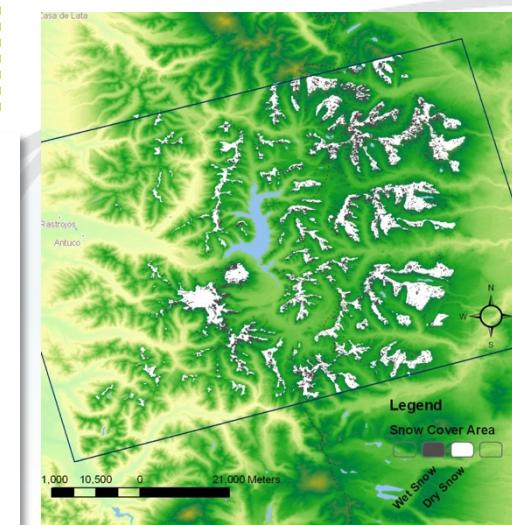
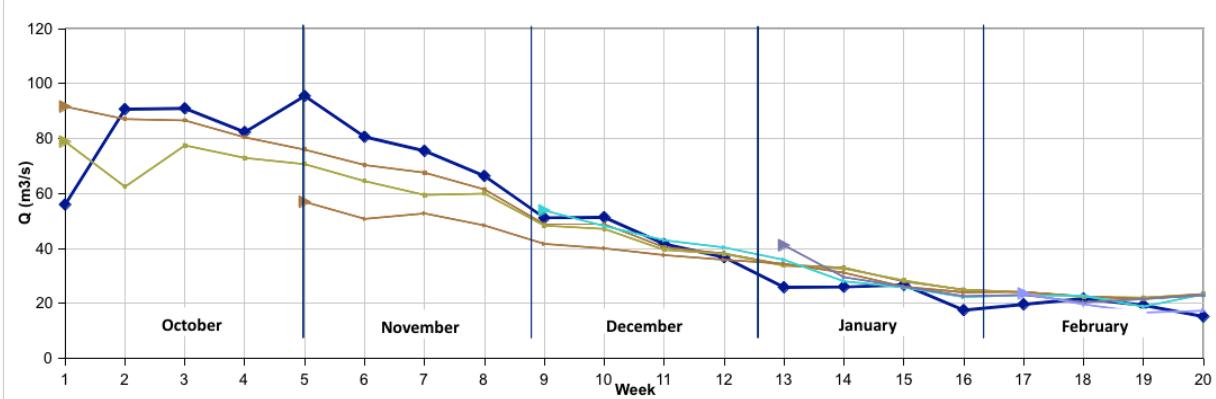
t_f June 2011

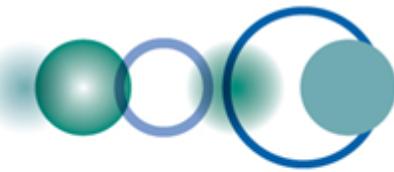


Feasibility Study Results

- Consolidation of user requirements
- Identification of suitable technologies
- Definition of the service and system architecture
- Proof of concept trial over the melting season 2010-2011

INTOGENER service is technically and commercially viable in response to a set of user needs already expressed by key stakeholders





CURRENT ACTIVITIES AND SYSTEM DESCRIPTION



2012-1014: Demonstration Phase

Goal: To demonstrate the readiness of the operational service before commercialization





Overview of the Pilot Service

- **User:** Endesa Chile
- **Area:** Laja and Maule Basins, Chile ($\sim 50\,000 \text{ km}^2$)
- **Period:** October 2013 to March 2014
- **In situ measurements:**
 - Deployment of 2 weather stations
 - GNSS-R instrument for lake water level
 - Satellite communications links for real time data transfer
- **Processing of satellite EO data**
 - Daily Optical images
 - Monthly SAR images
- **Distributed Hydrological Modelling**
 - Weekly runs
 - Assimilation of all available data
- **Water flow reports**
 - Weekly periodicity
 - Custom tailored for the user



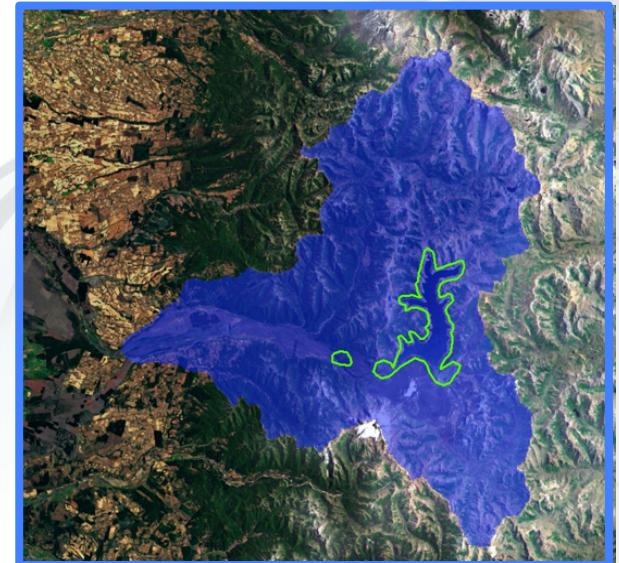
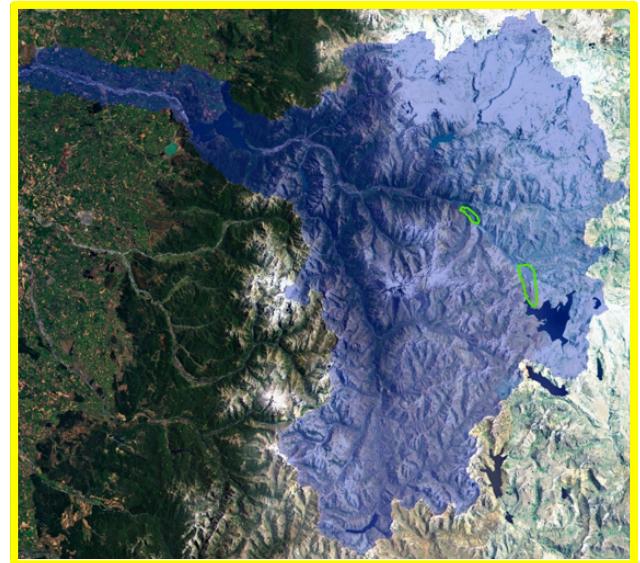
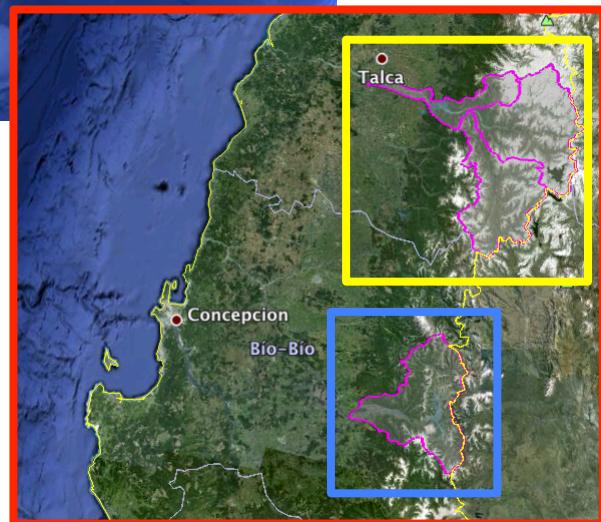
Sites of Interest



Chile:

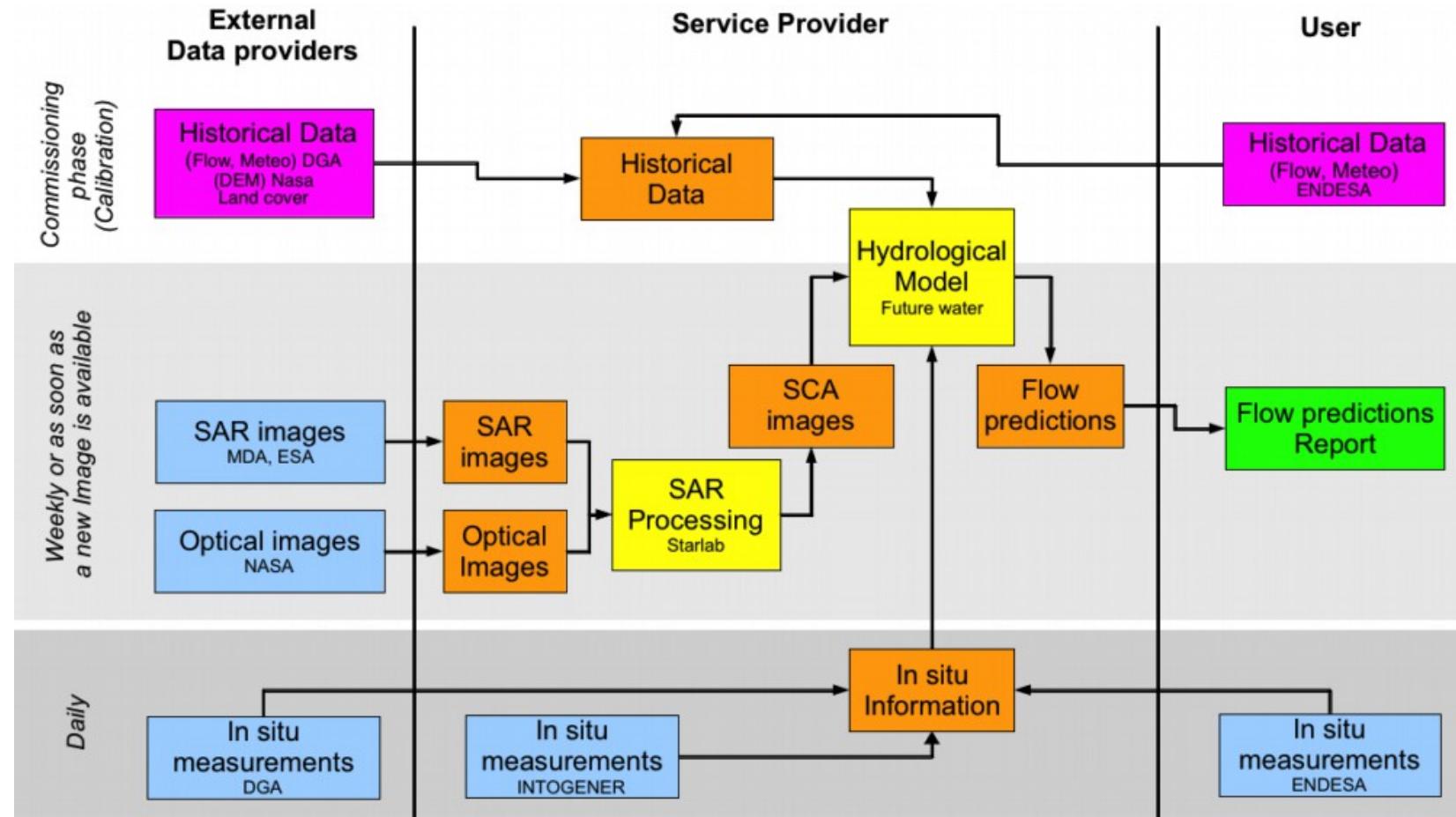
- Maule Basin
- Laja Basin

71°W, 36°S



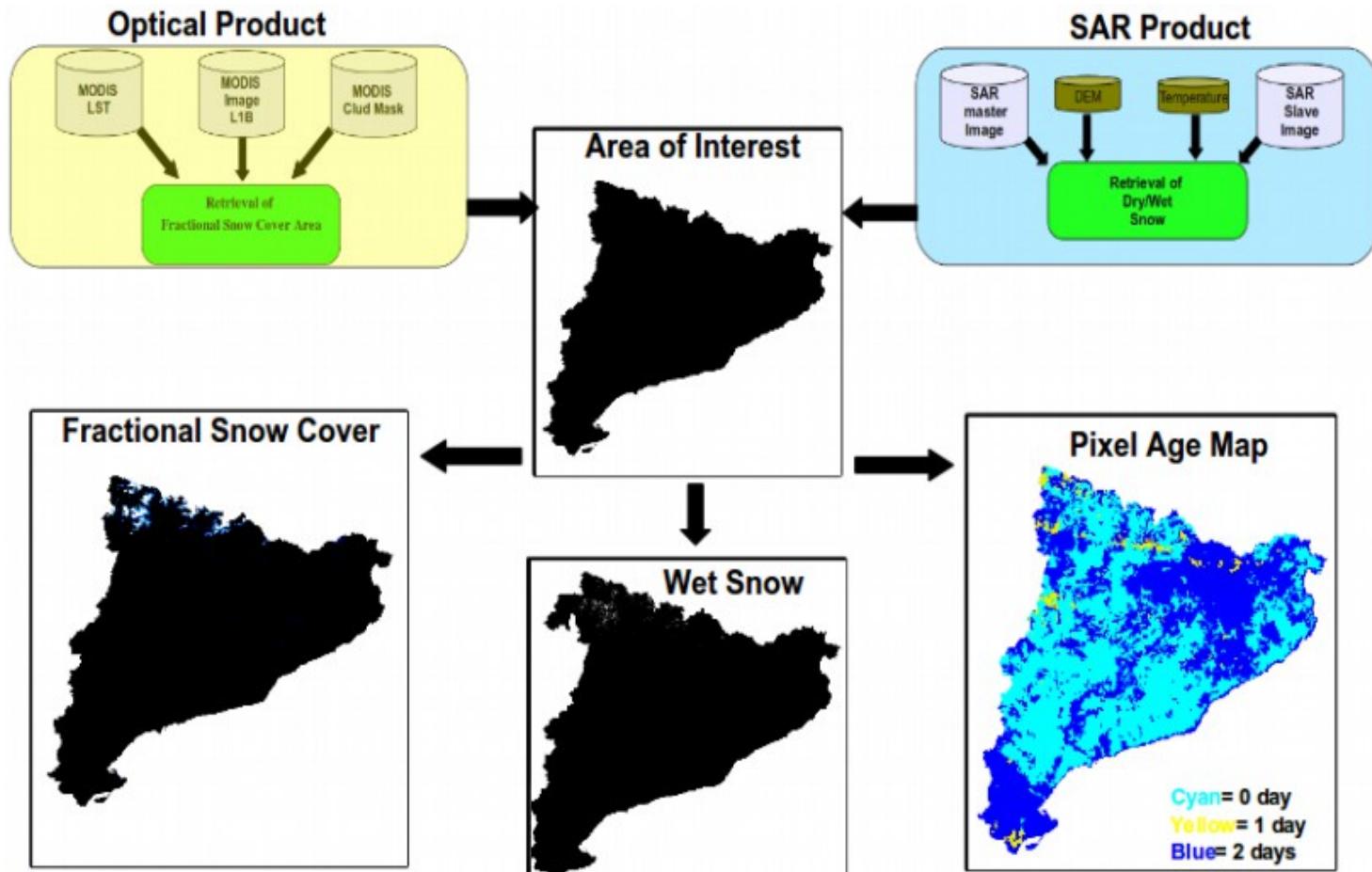


Operational chain Overview





Snow Cover Maps Processing





Dedicated In situ instruments

Lake Level

- Starlab GNSS-R Sensor Oceanpal



Weather Station

- Temperature
- Precipitations (rain and snow)
- Solar radiation
- Soil Moisture



Satellite communications

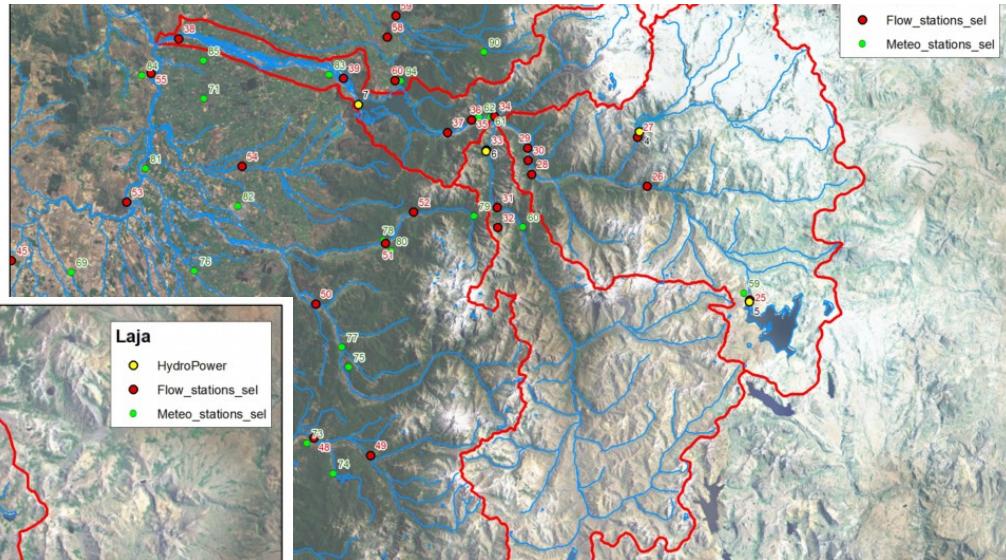
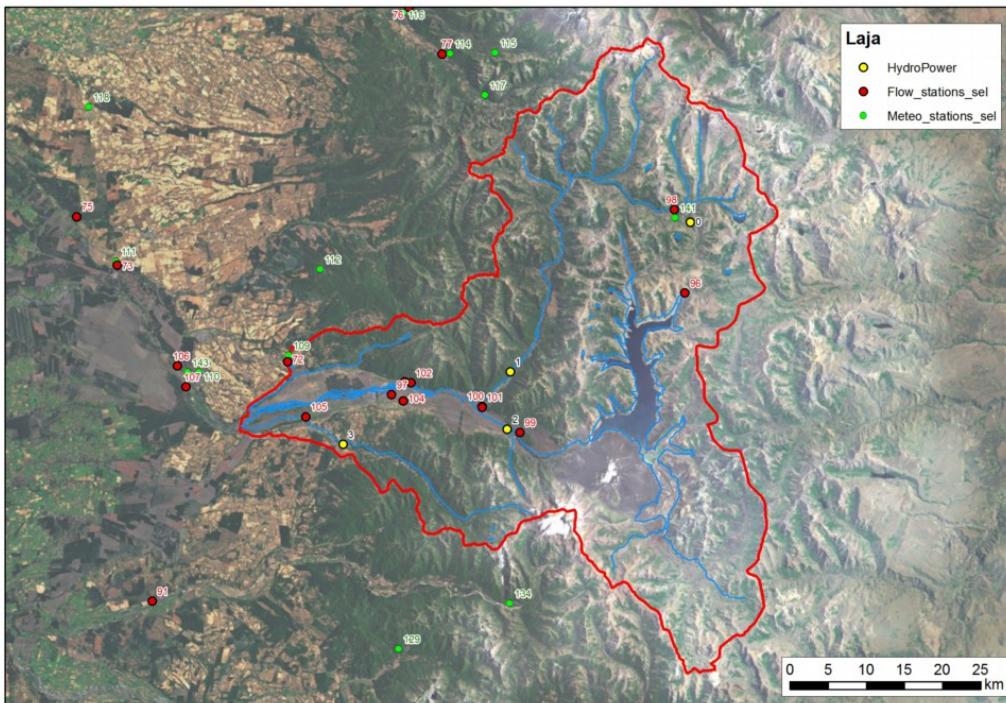
- Hispasat DVB-RCS Platform
- Bi-directional





Existing stations

Belong to the Chilean
Governemental Water Agency
(DGA)



Access to:

- Historical Records
- Real Time data

Water flow, precipitations,
lakes level

Output



Weekly report

- Similar to former forecast format
- Wednesday 7am
- Excel + Web Graphical report

Weekly Report Flow Prediction HYDROFLOW October [WK40]

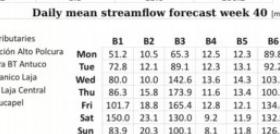
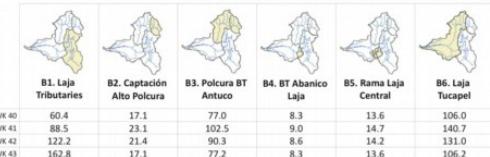
Area

Laja Basin, Chile
[365.71W - 395.74W]
Basin maximum altitude: 3030 m

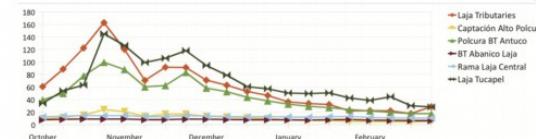
Forecast Info

Variable to Forecast: Streamflow at points of interest
Forecast Dimension: DAY, WEEK, MONTH
Forecast Method: HydroFlow_SAT Model
Mean absolute percent error: 5%

Weekly mean streamflow forecast / weeks 40-43 [m³/s]



Snowmelt seasonal streamflow forecast [m³/s]

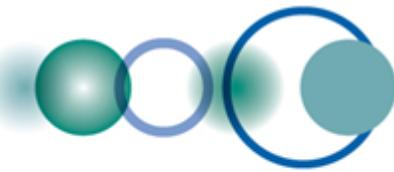


Input data available for weekly update [Sept28 TO Oct4]

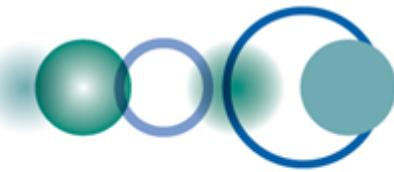
EO Data Services	Precipitation SAT	Temperature SAT	Field flow meter	Field precipitation	Field temperature
Snow	Metop	GOES	DGA	DGA	DGA
Albedo	GOES	WGT	Others	Others	Others
Others	NOAA	MSG			

Meteo stations: Abancio, 60 m
Mean Altitude of basin: 0.1159 m
Importance of remote data: Low Medium High Very High

BASIN	DAILY MEAN STREAMFLOW (m³/s)							WEEKLY MEAN STREAMFLOW (m³/s)				SNOWMELT SEASONAL STREAMFLOW FORECAST (m³/s)				
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	WK 40	WK 41	WK 42	WK 43	OCT	NOV	DEC	JAN	FEB
Laja basin																
Laja Tributaries	4.5	8.2	10.6	10.1	8.6	4.5	8.2	10.6	10.1	8.6	4.5	8.2	10.6	10.1	8.6	8.6
Captación Alto Polcura	4.5	10.0	12.5	10.1	7.9	4.5	10.0	12.5	10.1	7.9	4.5	10.0	12.5	10.1	7.9	7.9
Polcura BT Antuco	6.6	11.6	9.5	7.3	5.6	6.6	11.6	9.5	7.3	5.6	6.6	11.6	9.5	7.3	5.6	5.6
BT Abanico Laja	4.5	8.2	10.6	10.1	8.6	4.5	8.2	10.6	10.1	8.6	4.5	8.2	10.6	10.1	8.6	8.6
Rama Laja Central	4.5	10.0	12.5	10.1	7.9	4.5	10.0	12.5	10.1	7.9	4.5	10.0	12.5	10.1	7.9	7.9
Baja Tucapel	6.6	11.6	9.5	7.3	5.6	6.6	11.6	9.5	7.3	5.6	6.6	11.6	9.5	7.3	5.6	5.6
Maule Alto basin																
Afluentes Laguna Maule	10.0	15	11.3	8.9	8.3	10.0	15	11.3	8.9	8.3	8.3	10.0	15	11.3	8.9	8.3
C1.BT.C1.e - desagüe L.Maule	46.2	57	29.6	13.1	8.8	46.2	57	29.6	13.1	8.8	8.8	46.2	57	29.6	13.1	8.8
Afluentes Laguna Invernada	30.9	46	35.9	24.9	20.7	30.9	46	35.9	24.9	20.7	20.7	30.9	46	35.9	24.9	20.7
Maule en BT.C.Frehuenche (RN)	107.3	136	88.9	61.7	51.8	107.3	136	88.9	61.7	51.8	51.8	107.3	136	88.9	61.7	51.8
C1.BT.Maule.C.Frehuenche-L.Invernada-L.Maule	66.4	74	41.7	27.9	22.8	66.4	74	41.7	27.9	22.8	22.8	66.4	74	41.7	27.9	22.8
Afluentes E.Melado (RN)	124.5	114	69.2	36.6	29.5	124.5	114	69.2	36.6	29.5	29.5	124.5	114	69.2	36.6	29.5
e7. Caro en S.Carlos + E.Las Garzas	31.3	23	15.7	11.6	11.4	31.3	23	15.7	11.6	11.4	11.4	31.3	23	15.7	11.6	11.4
Afluentes E.Cobún	270.3	283	190.1	120.0	99.7	270.3	283	190.1	120.0	99.7	99.7	270.3	283	190.1	120.0	99.7
C.I.E.Cobún-Desagué L.Invernada-L.Maule	229.4	222	142.9	86.2	70.7	229.4	222	142.9	86.2	70.7	70.7	229.4	222	142.9	86.2	70.7
e10. C.I. E.C.Cobún-Maule en Armerillo	7.2	11	16.2	10.2	6.9	7.2	11	16.2	10.2	6.9	6.9	7.2	11	16.2	10.2	6.9



TOWARDS A COMMERCIAL SERVICE



Roadmap towards the end of the Demo

Deployment and commissioning (May-Sept 2013)

- On site deployment and validation
- System tuning
- Service commissioning

Service Demonstration (Sept 2013- Feb 2014)

Business Plan Consolidation (Sept 2013- Feb 2014)

Final Service assessment (March 2014)

- System Performance
- Service quality



Conclusions

- The service is being implemented, from a concept to operational product by following a sound and thorough process thanks to the ESA IAP ARTES 20 framework
- Strong interactions with the user in the definition, operation and validation of the service
- Final step (Pilot execution) to occur during the melting season 2013-2014 will demonstrate the operational readiness
- Starlab getting prepared for commercial roll-out.
- **Commercial Availability for 2014-2015?**



Thank you for your attention
erwan.motte@starlab.es

More info on

<http://iap.esa.int/projects/energy/intogener>

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