WP5 - DATA INTEGRATION AND MANAGEMENT

Tasks 5.4-5.5: Implementing the WP6 showcase applications in collaboration with WP6 tasks

INTAROS 4th Year General Assembly

Remote meeting
15.50-16.00
January 12th 2021

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Agenda

- **Implementing iAOS Showcase Applications**
  - For T6.1 with SMHI: Pan-Arctic Hydrological Modelling
  - For T6.2 with IMR: Barents Sea Multi-depth Temperature & Salinity Maps
  - For T6.4 with FMI: Maps for Svalbard Avalanche Forecast Modelling
  - For T6.8 with Aarhus: Baffin Bay Bottom Temperature Maps
- **Promoting iAOS Showcase Applications**
  - Communications
  - Reusable tools

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WP5 / WP6 coordination for the definition of iAOS Showcases

"WP6 will integrate **remote sensing data** and **in situ observations delivered through WP5**, from a variety of platforms and geographical scales and locations. *Incorporation of these data into analysis and modelling systems, including physical and* ***ecological process models****,* ***climate models*** *and* ***forecast methods****, will provide support for better products to key societal areas*."

-- from WP6 Description of work

Helsinki, 2018 - Joint WP5-6 Workshop (but WP6 starting later)

Bremen, 2019 - RGeostats Workshop

Sopot, 2020 - Interviews with WP6 task leaders for their work plan analysis, and identification of best 'showcase' opportunities to be supported by the iAOS (WP5)

- As return of experience (INTAROS internal) on how the WPs interact in order to illustrate the iAOS added value
- As a set of results-oriented data collections and services, which can support the INTAROS outreach activities in 2020-2021

Remote, 2020 - Intermediate results reviews and definition of final objectives for each Showcase

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Implementing
iAOS Showcase Applications

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Pan-Arctic Hydrological Modelling (1/3)
T6.1 SMHI

Objectives

- Have the "observational" data available for search and download from the iAOS Portal
- Have the Arctic-HYPE produced at SMHI and provide the data as open data from SMHI repositories:
  - Daily analyses of last 60 days
  - Medium range forecast of coming 10 days
- Improve predictions of spring floods, river ice breakup and freshwater flow to Arctic Ocean, cf.INTAROS D6.1 Climate model initialization v1.4

Data exploitation

- Implement HYCOS pre-processing (both archive of quality controlled data with 4months/2years lag, or provisional datasets)
  - In-house server at SMHI
  - Cloud-based, using Ellip, to compare
- Schedule HYCOS pre-processing operations to be made daily at a certain time
- Setup OpenDAP server for publishing the Arctic-HYPE model results

Data sources

- River discharge data from the Arctic Hydrological Cycle Observing system (Arctic-HYCOS) - assessed and enhanced in INTAROS WP2 https://catalog-intaros.nersc.no/dataset/arctic-hycos-hydrological-data/
- HydroGFD v3 temperature and precipitation data
- ECMWF deterministic medium range weather forecasts

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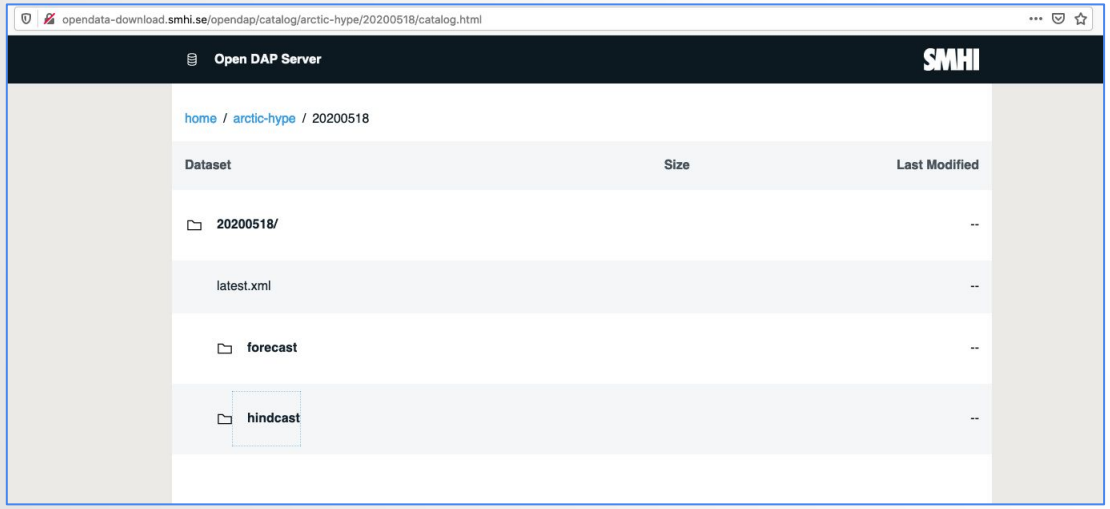
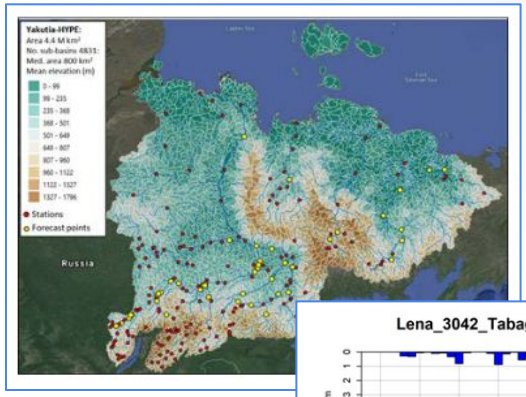
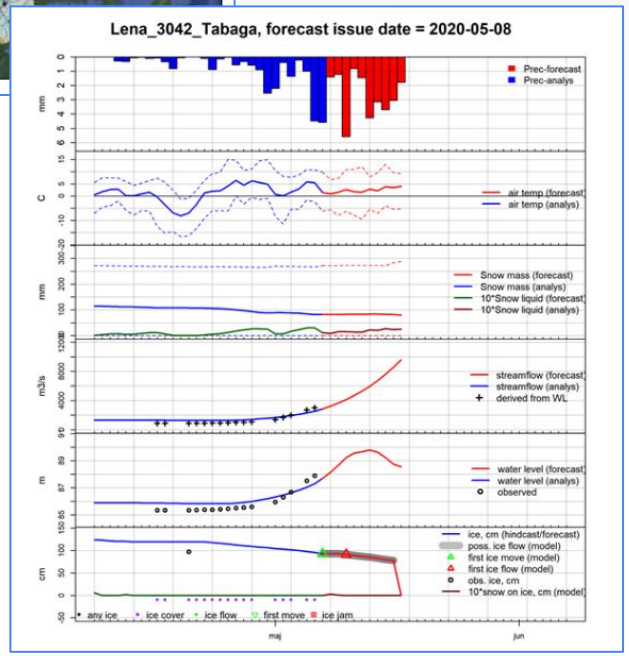
Pan-Arctic Hydrological Modelling (2/3)
T6.1 SMHI

Current results

- OpenDAP server publishing Pan-arctic hydrological model Arctic-HYPE results provided by SMHI http://opendata-download.smhi.se/opendap/catalog/catalog.html







Pan-Arctic Hydrological Modelling (3/3)
T6.1 SMHI

Perspectives

iAOS Showcase (demo)	**Use of Arctic-HYCOS sources (multi-provider)**	**Use of Arctic-HYPE (SMHI) outputs (per station ID, with 1 dimension time)**
Flood forecasting use cases Select a point, or some AOI (in Russia MPI in Yakutsk - L. Lebedeva)	For checking the initial conditions	For checking the model analysis of current condition and the model forecast
Entire freshwater inflow to the ocean (in collaboration with IMR - R.Hordoir)	To integrate discharge into the ocean from observations (only represent 60% draining land, see WP2 deliverables).	To integrate model analysis/predictions on river discharge into the ocean on user defined resolution

Barents Sea Multi-depth Temperature & Salinity Maps (1/3)
T6.2 IMR

Objectives

- Use the **Geostatistical Library** (RIntaros / RGeostats) and build the R software for interpolating maps from **CTD datasets**
- Generate temperature and salinity fields for:
  - modelling of Arctic Ocean biogeochemistry
  - validation of climate model projections (NorCMP)
- Build a **Web Processing Service** for iAOS

Data exploitation

- Use of the iAOS OpenDAP server at NODC
- Explanatory data analysis and variography
- Modelisation of **spatial behavior** for Temperature and Salinity

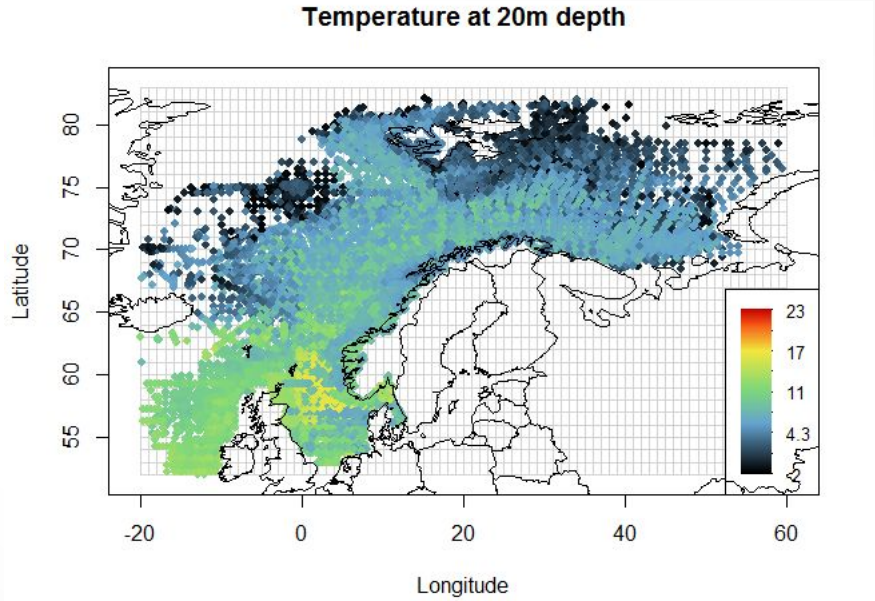
Data sources

Institute of Marine Research (**IMR**) center of Norway, 7 research vessels collecting conductivity, temperature, depth (CTD) data in the North Sea.

- Acquisitions between 7th January 1995 and 29th November 2016.
- 5.5 billion of samples measured over 63 500 positions (vertical profiles).

All files are freely available on an OpenDAP server:
http://opendap1.nodc.no/opendap/physics/point/yearly/contents.html

NetCDF files (one file by year and per vessel). Coordinates are in degrees (Long/Lat) and the timestamp is the number of minutes since the 1st January 1950. The whole dataset volume is 880 GB.

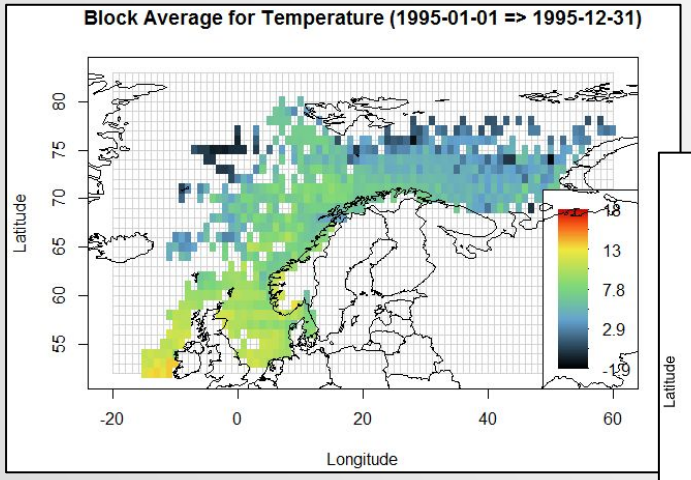


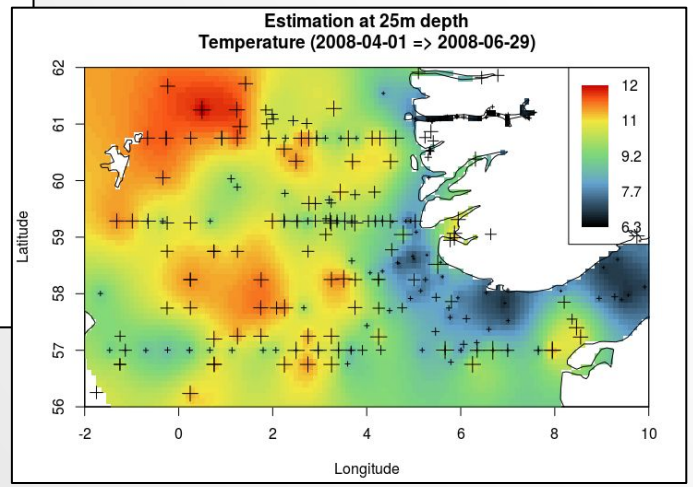
Barents Sea Multi-depth Temperature & Salinity Maps (2/3)
T6.2 IMR

Current results

Standalone solution (R software)

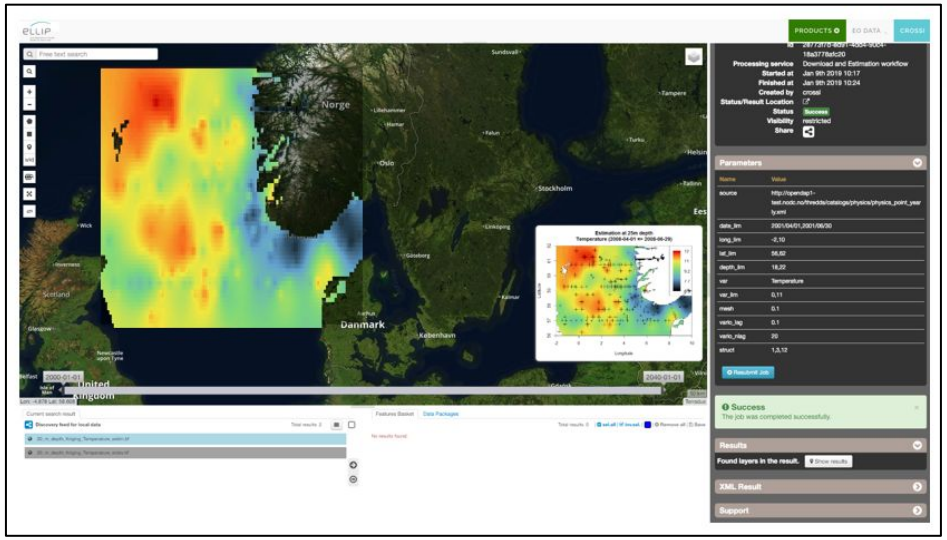
- Map productions per run:
  - Base maps
  - Average per cell
  - Cross-validation (blind test) maps
  - **Estimation** (Temperature / Salinity) and corresponding **uncertainty maps**





Solution as-a-Service (Cloud software)

- Map productions per WPS run:
  - On-demand, self performed by each user from the **Portal**
  - Split tiles for large areas

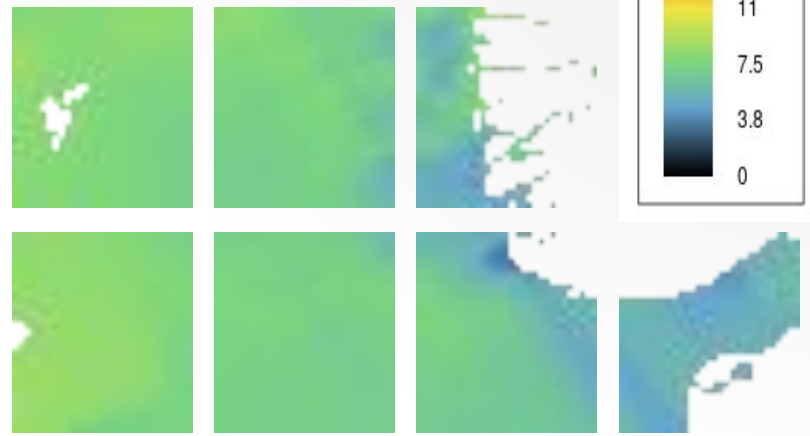


Barents Sea Multi-depth Temperature & Salinity Maps (3/3)
T6.2 IMR

Perspectives

Methodology

- **Improve** the initial geostatistical spatial analysis performed in 2018 by:
  - building a unique spatio-temporal variogram model for Temperature
  - taking into account co-variables like (salinity, bathymetry...)
  - handling currents non stationarities and distance to coastline



Standalone solution (R software)

- **Promote** the Jupyter Notebook and Rmarkdown scripts on iAOS and their documentation on GitHub
- Build a flyer for addressing the reusability of the solution

Solution as-a-Service (Cloud software)

- **Promote** the use of the Ellip Solutions for parallel processing
  https://gitlab.com/ec-intaros/dcs-imr-estim
- Consider the use of a single global variogram model for each computing node in charge of each kriging tile

RGeostats

ELLIP TERRADUE

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Maps for Svalbard Avalanche Forecast Modelling (1/3)
T6.4 FMI

Objectives

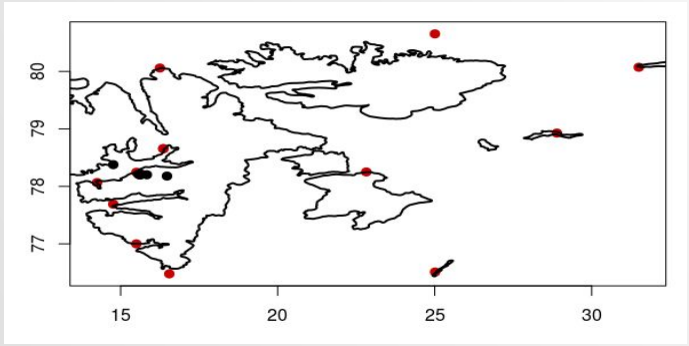
- Use the **Geostatistical Library** (RIntaros / RGeostats) and build the R software for interpolating maps from snow stations, arome model output and terrain model
- Generate **snow depth maps** at regular time intervals as input for avalanche forecast model

Data exploitation

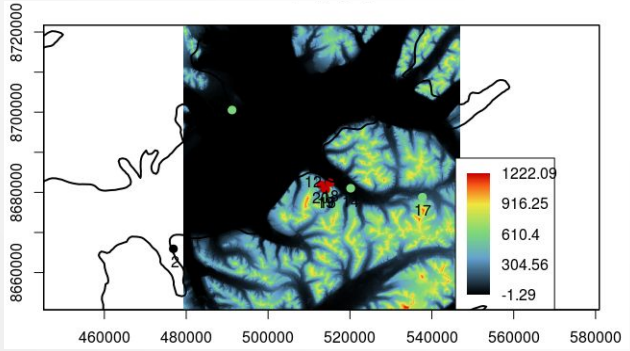
- Explanatory data analysis and variography
- Handle the different spatial distributions and resolutions of the data ("support")
- Modelisation of **spatial and temporal behavior** for **snow depth** through co-variables (temperature, wind speed by class of wind direction)

Data sources

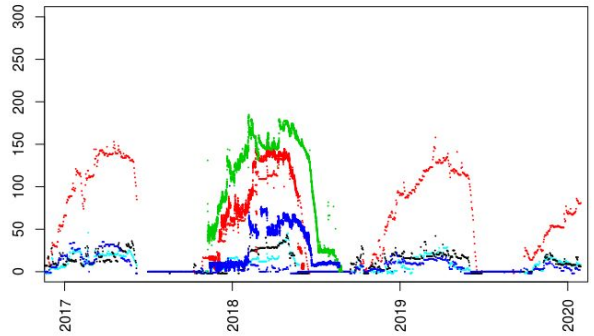
- NMI Frost API historical weather and climate data stations (selected files on shared Drive)
- NMI arome model: https://thredds.met.no/thredds/catalog/aromearcticarchive/catalog.html
- Norwegian Polar Institute Svalbard Terrain Model: https://doi.org/10.21334/npolar.2014.dce53a47



Location of Stations



Terrain Model



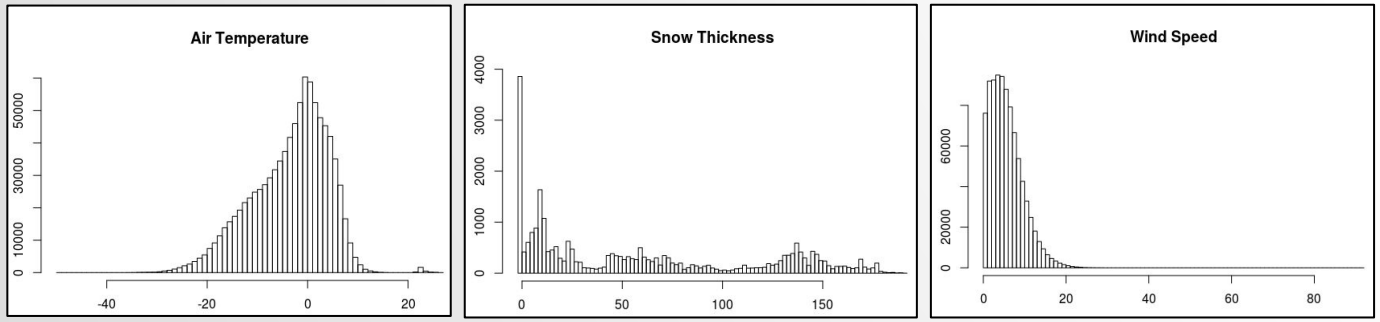
Snow Time Series at Stations

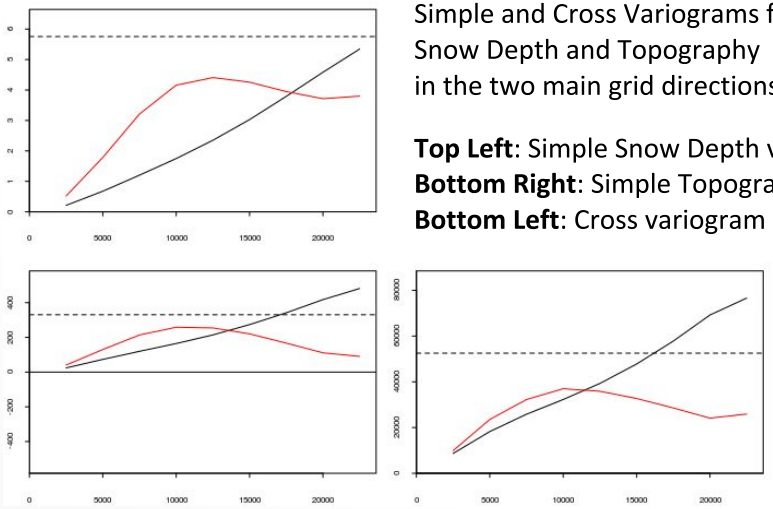
Maps for Svalbard Avalanche Forecast Modelling (2/3)
T6.4 FMI

Current results

- **Pre-analysis** of the data :
  - Few stations: temporal series of snow thickness measured at short time steps
  - Arome models: various maps covering the whole area, every 6 hours, on large scale grid (incl. snow thickness derived from model)
  - Several co-variables
- Processing :
  - Regularization of the station time series by averaging over 6 hours
  - **Correlation** (space-time) of snow depth variable with arome model output
  - Estimation using both informations (with relevant co-variables) over a small scale grid, at regular 6 hours intervals.

Stations histograms





Simple and Cross Variograms for Snow Depth and Topography in the two main grid directions.

Top Left: Simple Snow Depth variogram
Bottom Right: Simple Topography variogram
Bottom Left: Cross variogram

Maps for Svalbard Avalanche Forecast Modelling (3/3)
T6.4 FMI

Perspectives

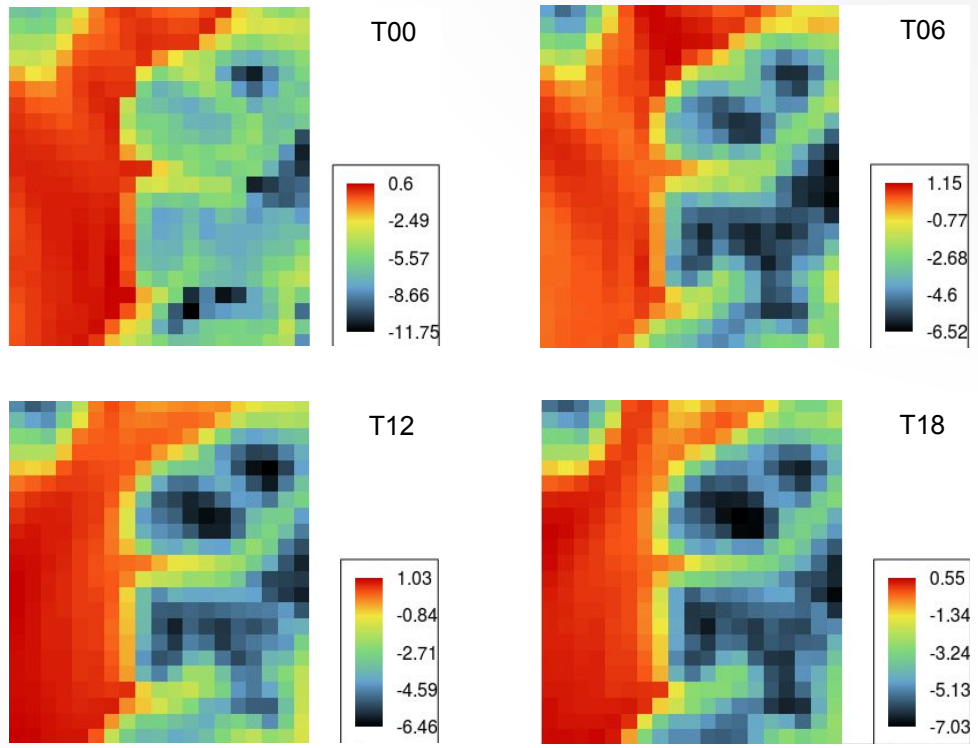
Methodology

- **Finalize** the showcase with a proof-of-concept:
  - Create snow depth variogram models (with relevant co-variables) for each class of wind orientation
  - Generate snow depth map for:
    - a given date and time interval (6 hours)
    - accounting for a global wind orientation

Standalone solution (R software)

- **Promote** the Jupyter Notebook and Rmarkdown scripts on iAOS and their documentation on GitHub
- Build a flyer for addressing the reusability of the solution

Coarse Grid – Time slices (T°C)



RGeostats

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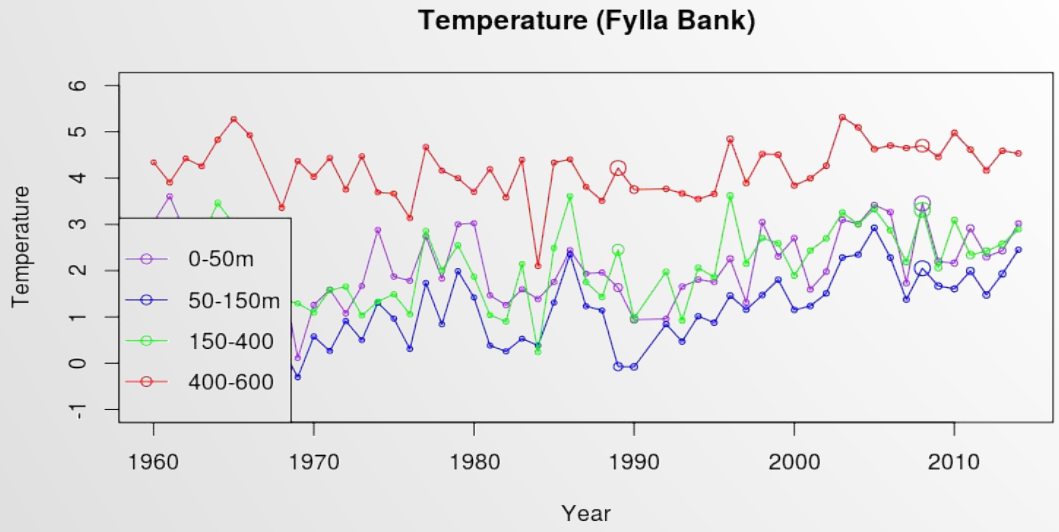
Baffin Bay Bottom Temperature Maps (1/4)
T6.8 Aarhus

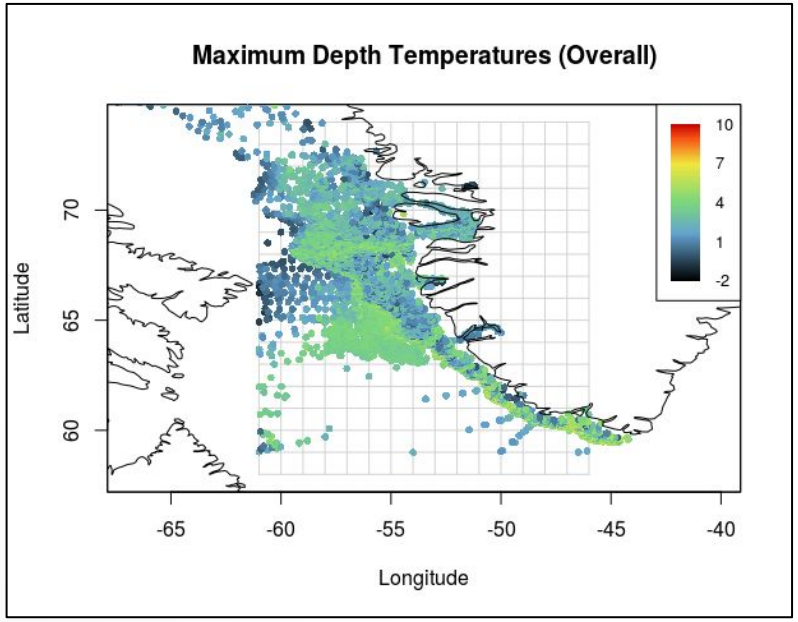
Objectives

- Use the **Geostatistical Library** (RIntaros / RGeostats) and build the R software for interpolating ocean floor temperature maps from CTD and Trawl datasets
- Generate temperature fields at bottom of the ocean in support of:
  - Analysis of **long term global warming** influence
  - Analysis of the **fish stock correlation** to bottom temperature



Data Exploitation

- Explanatory data analysis and variography
- Local and global temperature evolution analysis
- Modelisation of **spatial and temporal behavior** for **ocean floor temperature** through Bathymetry co-variable



Baffin Bay Bottom Temperature Maps (2/4)
T6.8 Aarhus

CTDs (ICES)
- 1977 to 2017
- 3700 vertical profiles
- 1.34M samples
- 1 CSV file (95Mo)

Bottles (ICES)
- 1960 to 2017
- 7800 vertical profiles
- 167K samples
- 1 CSV file (11Mo)

Trawls (GINR)
- 1988 to 2016
- Catches near sea floor only
- 51K samples
- 1 CSV file (11Mo)

Greenland Institute of Natural Resources

Bathymetry (Gebco)
- Grid lag = 1/250 degree
- Grid size = 10320x4560 nodes
- 47M samples
- 1 NetCDF file (94Mo)

New data (M. Sejr, Nov. 2020):

Better quality of arctic bathymetry: https://www.nature.com/articles/s41597-020-0520-9

World ocean database (Temp fields): https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html

Global temperature and salinity profile program (data?): https://www.nodc.noaa.gov/GTSPP

NASA project in Greenland (new CTD): https://omg.jpl.nasa.gov/portal/browse/OMGEV-AXCTD/

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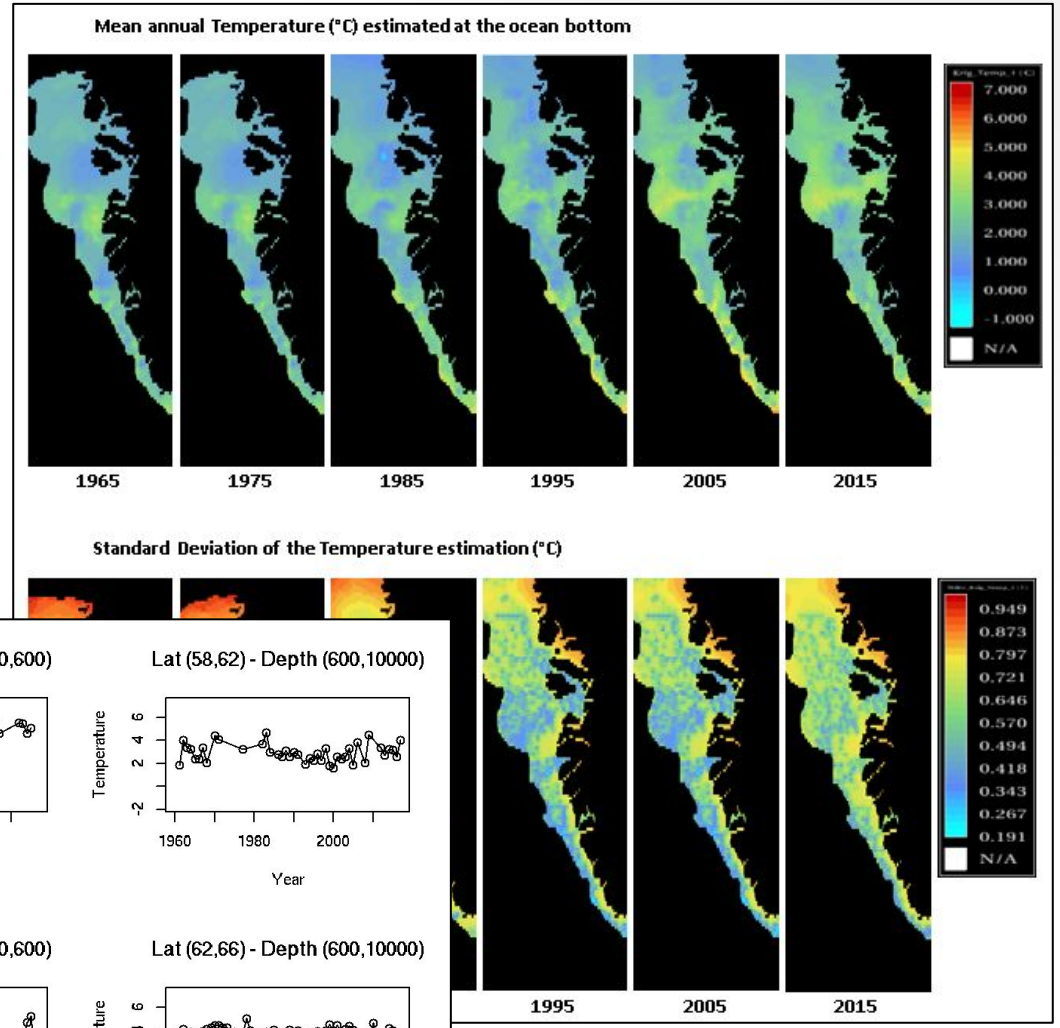
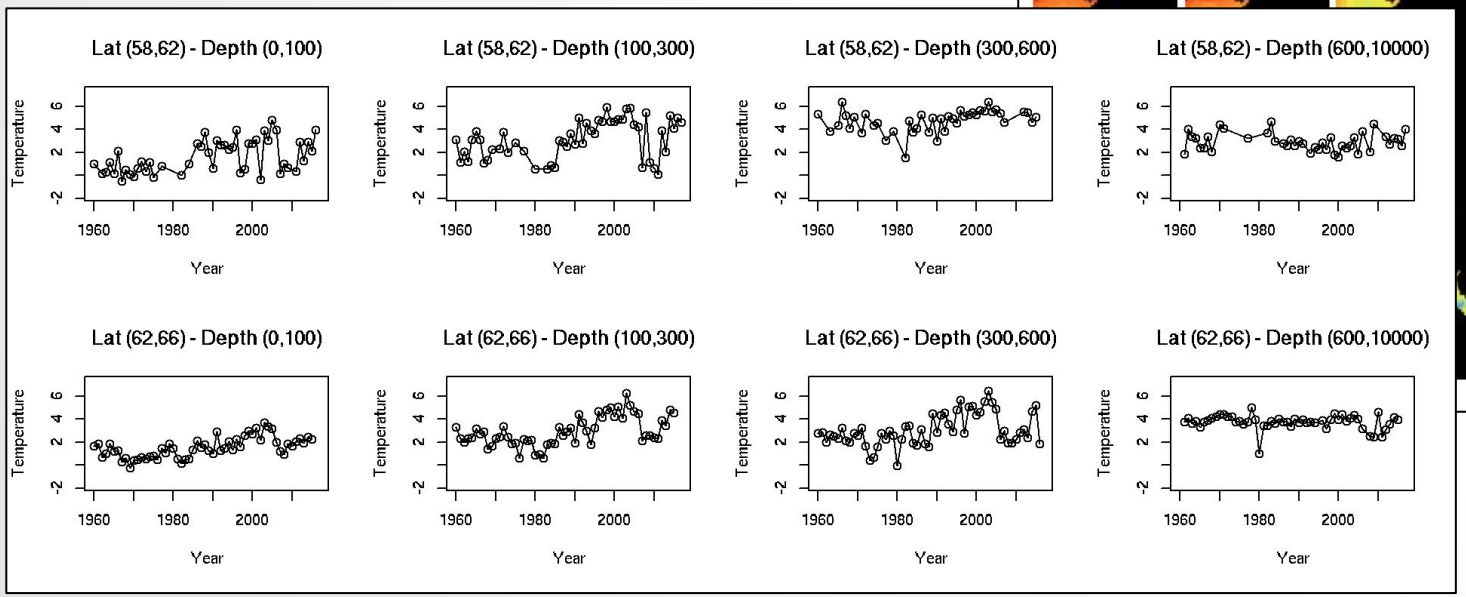
Baffin Bay Bottom Temperature Maps (3/4)
T6.8 Aarhus

Current results

- Temporal evolution (global and local):
  - Between 1960 and 2015, T°C has gained 1°C (around 1995)
  - Lower T°C values around 2008 have been recorded
- Map productions:
  - Basemap of data
  - **Bottom temperature estimation** by year and its standard deviation
- Time series of average temperature by region (Lat/Depth)





Baffin Bay Bottom Temperature Maps (4/4)
T6.8 Aarhus

Perspectives

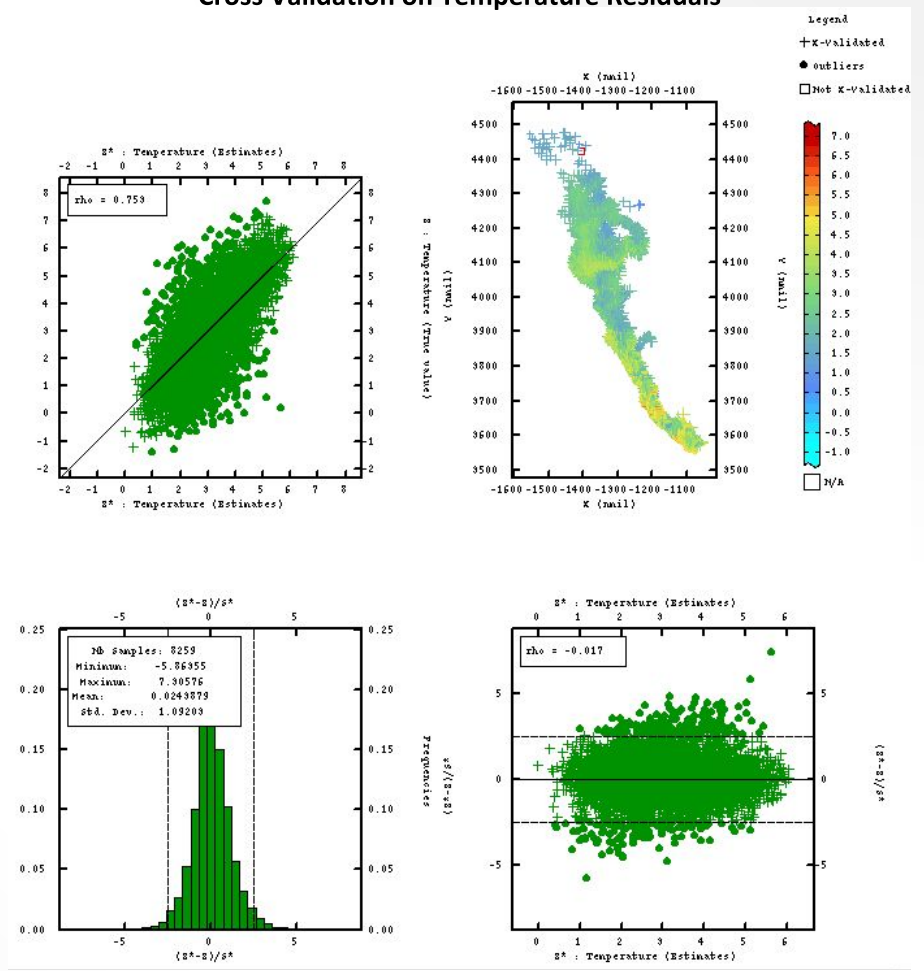
Methodology

- **Improve** first kriging estimation:
  - Reduce the estimation error (currently around 0.7°C)
  - Reduce estimation smoothing
- Next improvements:
  - Multi-directional variography and zonal anisotropies
  - Local cross-validation with additional abyssal (or new) data
  - **Bathymetry** as external drift using non linear regression
  - **Salinity** as co-variable to be studied

Standalone solution (R software)

- **Promote** the Jupyter Notebook and Rmarkdown scripts on iAOS and their documentation on GitHub
- Build a flyer for addressing the reusability of the solution

Cross Validation on Temperature Residuals



Promoting
iAOS Showcase Applications

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Communications

For each of the four WP6 Showcased applications, the communications will emphasize the driving domain aspects such as listed hereafter, as well as the reusable tools:

Pan-Arctic Hydrological Modelling (T6.1 SMHI)

- Understanding of climate impact on fine-scale hydrology in the Arctic
- Predictions of river discharge into the ocean for present and future climate

Barents Sea Multi-depth Temperature & Salinity Maps (T6.2 IMR)

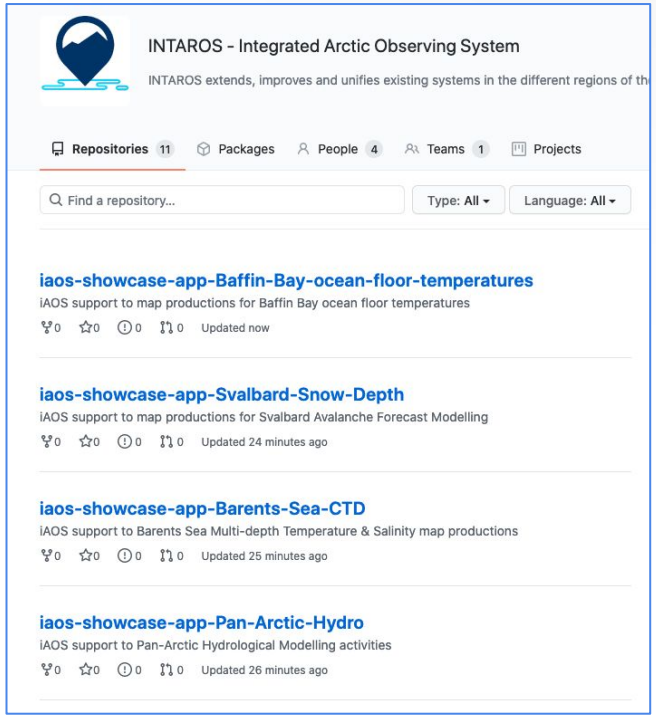
- Inputs for Ecosystem models (e.g. NORWECOM, ATLANTIS, FLEXEM)
- Arctic Ocean biogeochemistry / Climate model projections

Maps for Svalbard Avalanche Forecast Modelling (T6.4 FMI)

- Snow depth interpolation at regular time intervals

Baffin Bay Bottom Temperature Maps (T6.8 Aarhus)

- Analysis of long term global warming influence
- Analysis of the fish stock correlation to bottom temperature



https://github.com/ec-intaros

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Reusable tools

Out of the four WP6 Showcased applications, the tools made available on the iAOS to support the implementation of user applications are listed hereafter:

Data Servers

- Arctic-HYPE pan-Arctic hydro model
  http://opendata-download.smhi.se/opendap/catalog/catalog.html
- NODC's CTD 1995-2016
  http://opendap1.nodc.no/opendap/physics/point/yearly/contents.html

R code and Jupyter Notebooks

- RGeostats Bremen Workshop (2019)
  https://github.com/ec-intaros/RGeostats-workshop
- RGeostats resources per showcase
  https://github.com/ec-intaros?q=iaos-showcase

Software libraries

- RGeostats Conda package
  https://anaconda.org/Terradue/r-rgeostats
- RIntaros Conda package
  https://anaconda.org/Terradue/r-rintaros

Cloud services

- Ellip Notebooks solution
  https://ellip.terradue.com/#!notebooks
- Ellip Workflows solution
  https://ellip.terradue.com/#!workflows

End of presentation

Back-up slides

TASK 5.4 - DEVELOPMENT OF GEO-STATISTICAL METHODS FOR DATA INTEGRATION

Partners : ARMINES, NERSC, DTU

- Deployment of RGeostats package with anaconda for iAOS developers: https://anaconda.org/Terradue/r-rgeostats
- Creation and deployment of RIntaros Geostatistical package for iAOS developers: https://anaconda.org/Terradue/r-rintaros
- Dissemination material produced to outreach the iAOS users community (Bremen Workshop, Terradue Seminar at Fontainebleau, XIVème Journées de Géostatistique)
- Overall, the task activities are progressing according to the schedule.

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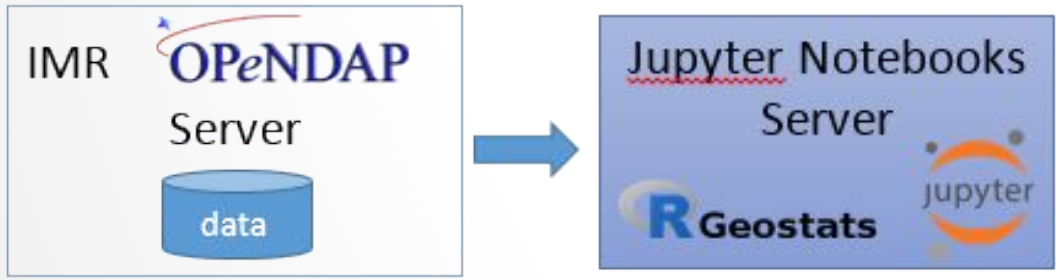
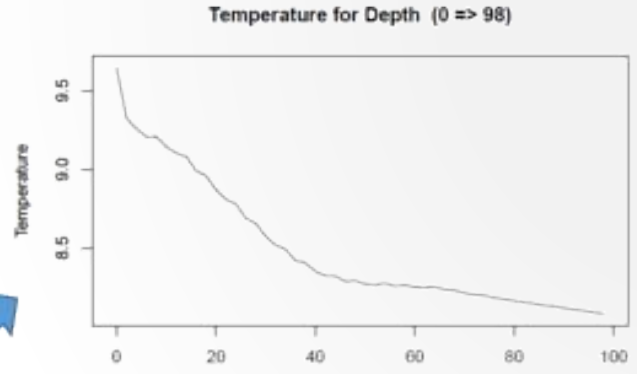
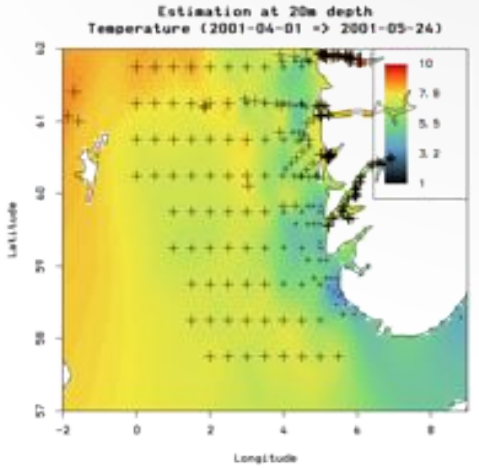
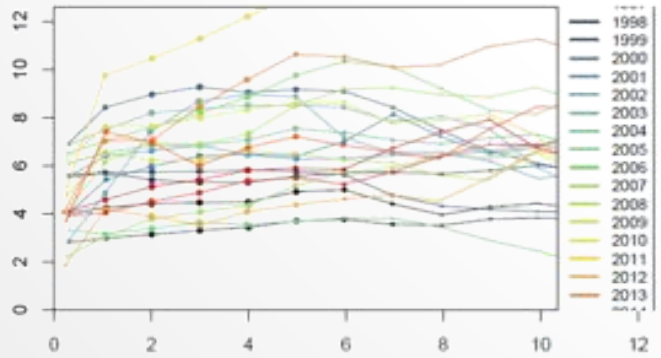
iAOS Platform
IMR Dataset Analysis

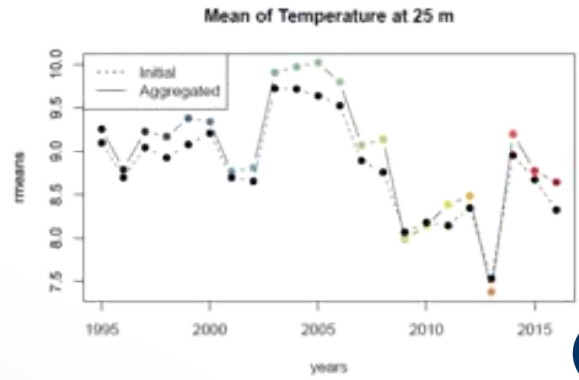
- Use of Jupyter Notebooks Terradue solution
- Access to IMR dataset (OPeNDAP)
- Geostatistical analysis of IMR dataset using RGeostats





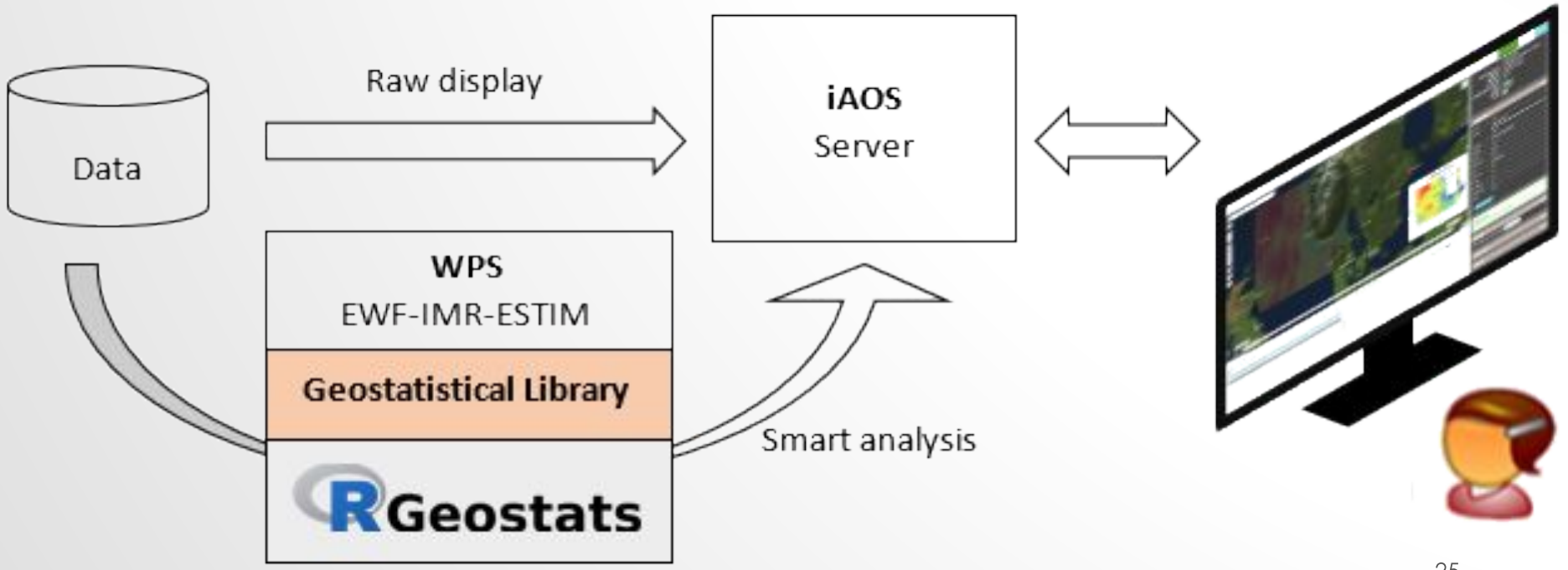






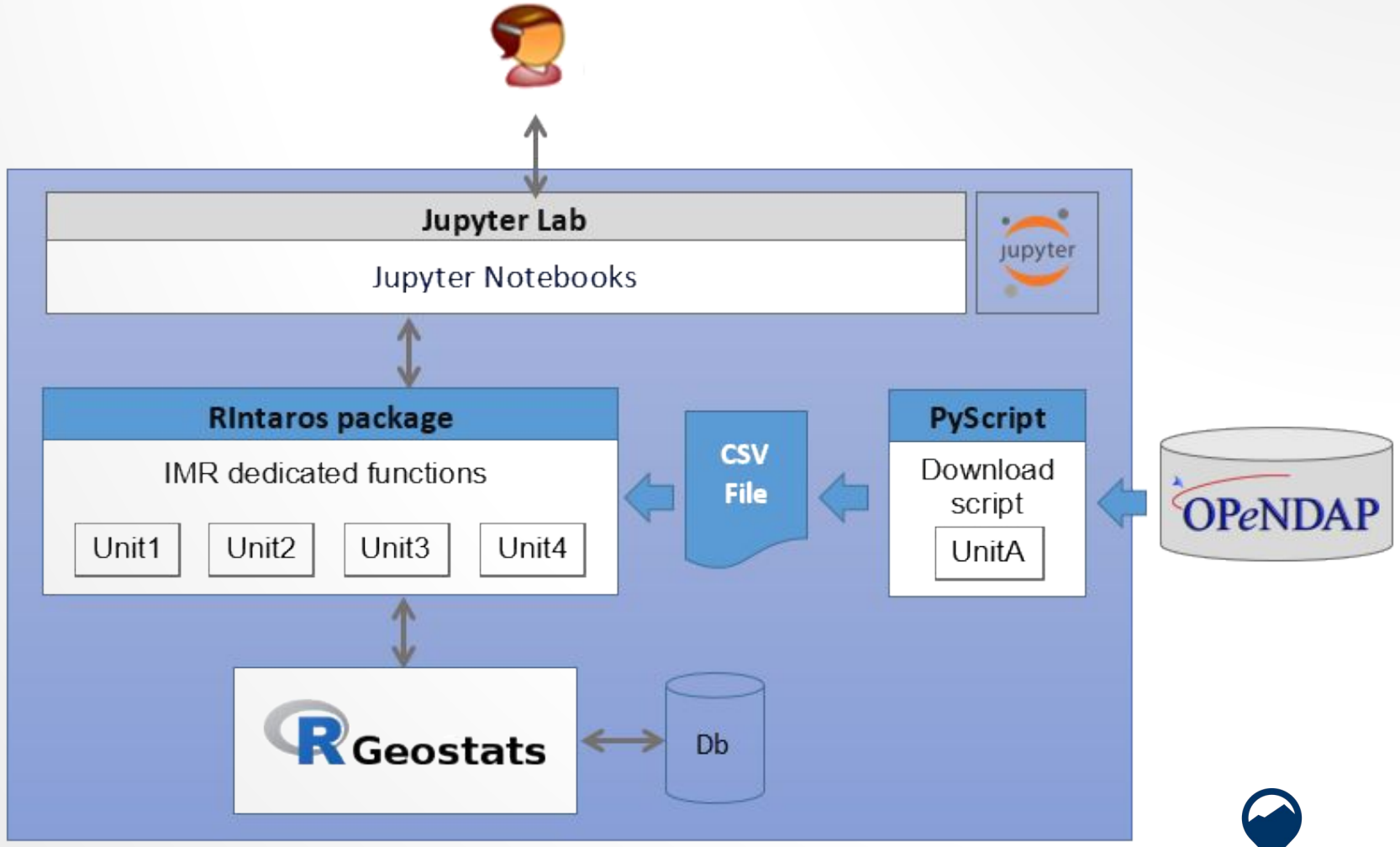
iAOS Platform
Geostatistical Library Creation

- Creation of the Geostatistical Library (**RIntaros**) as a wrapper of RGeostats package for smarter analysis of IMR dataset (to be extended later to another INTAROS datasets)



iAOS Platform
Unitary Scripts using RIntaros

- New Python script for downloading IMR data
- Design of unitary R scripts using RIntaros package for each Geostatistical operation



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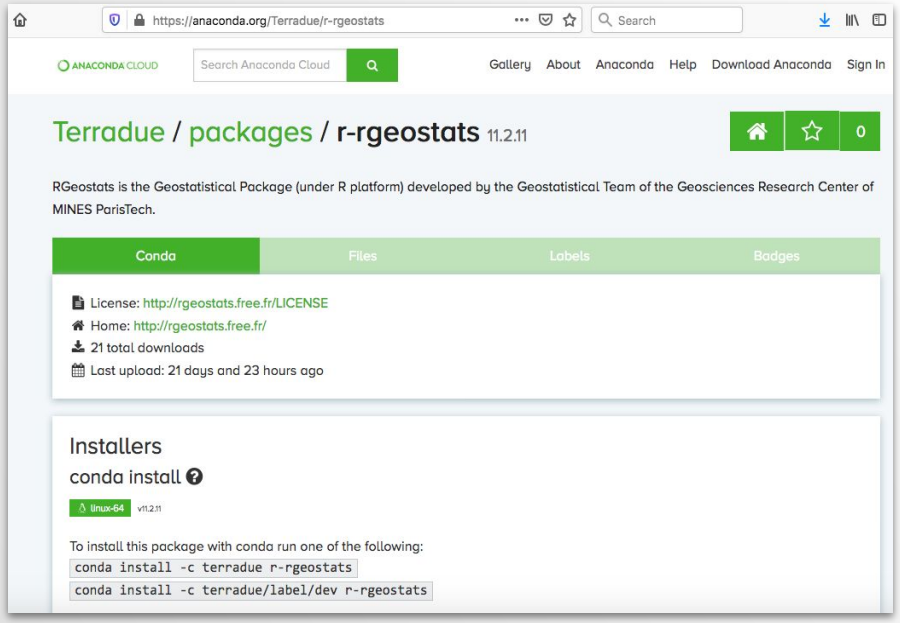
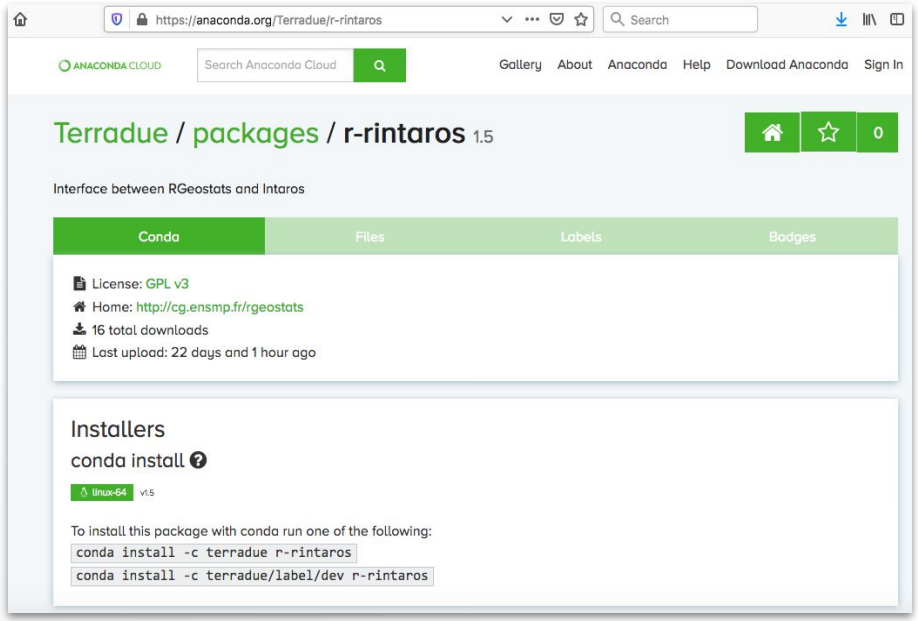
iAOS Platform
RGeostats and RIntaros Deployment

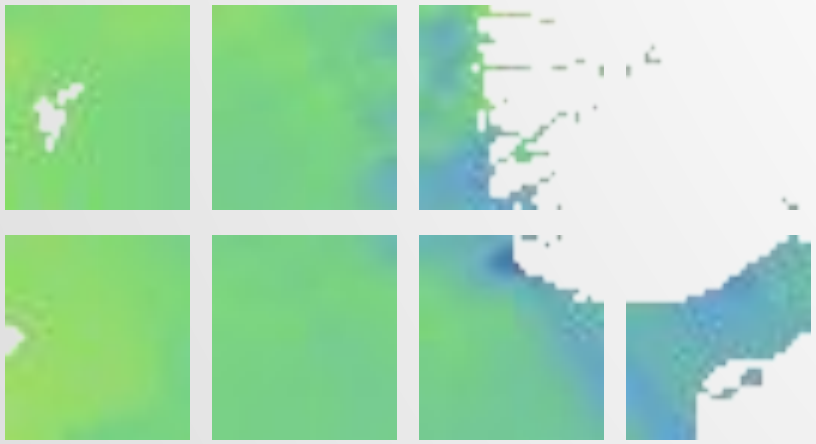
- Deployment of RGeostats and RIntaros packages as anaconda package for iAOS developers

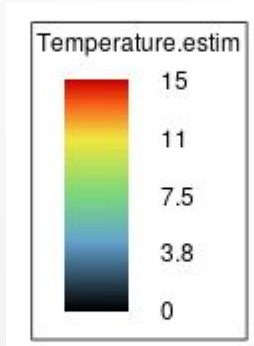


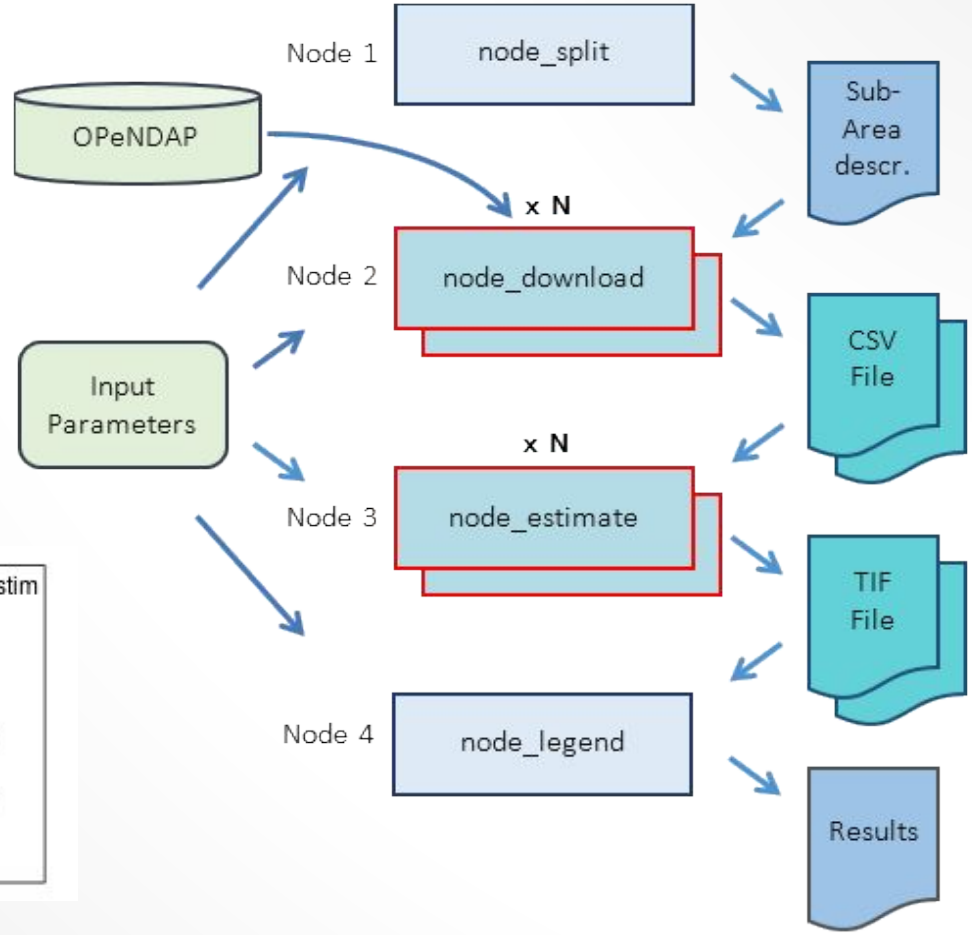


iAOS Platform
Workflow Parallelization

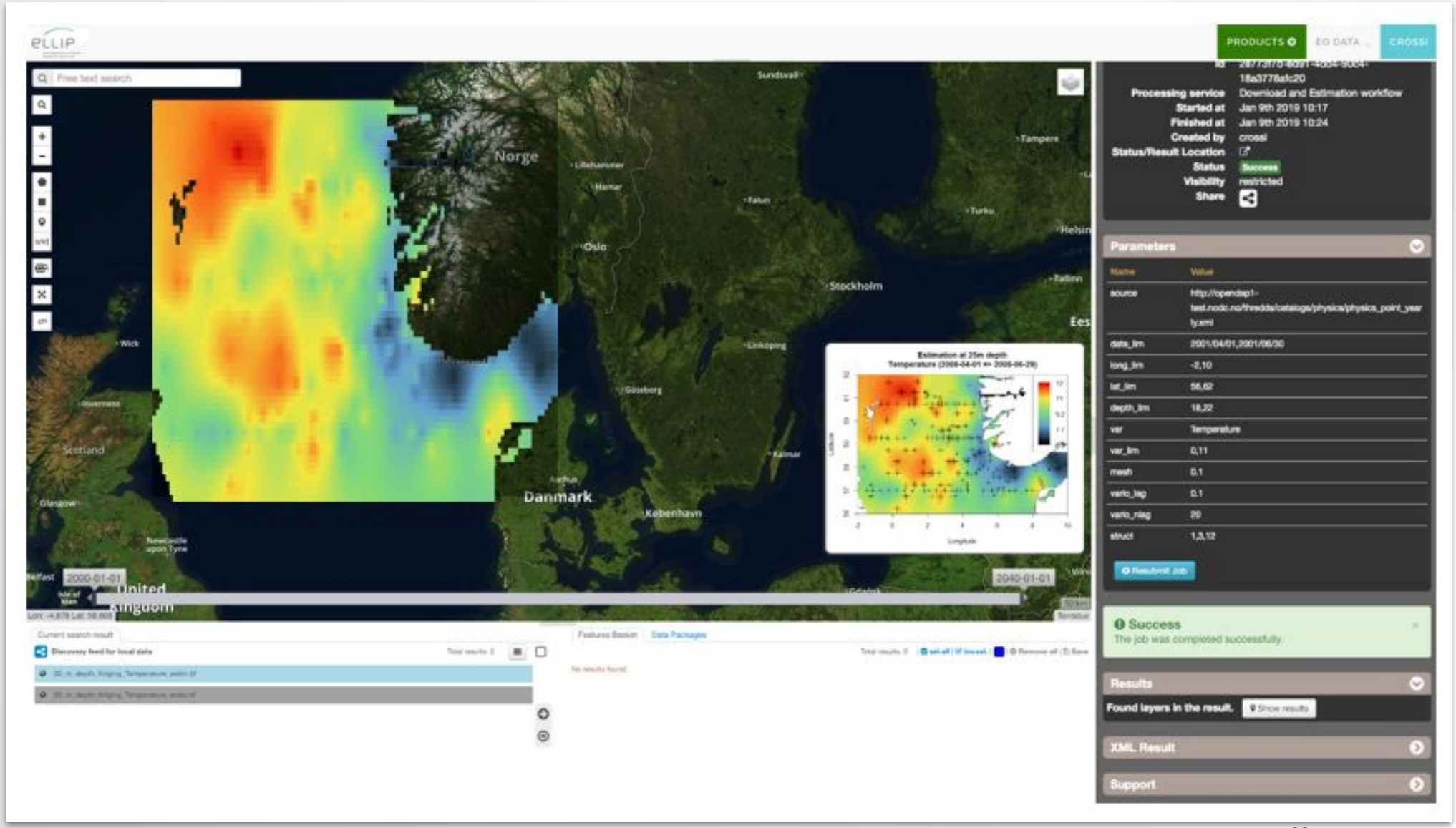
- Improving efficiency:
  - Duplication of downloading node
  - Estimation by tile







iAOS Platform with new **ewf-imr-estim**



TASK 5.5 - INTEGRATION OF NEW PROCESSING SERVICES

Partners : Terradue, NERSC, ARMINES

- User support on the use of Terradue's Ellip solutions to the partners NERSC and ARMINES for their service integration activities.
- New version of dcs-imr-estim Web Processing Service dedicated to IMR dataset analysis for iAOS users: https://gitlab.com/ec-intaros/dcs-imr-estim (Ellip Workflows app)
- Description of the applications integration work into the deliverable D5.7 Processing services for iAOS v1.
- Overall, the task activities are progressing according to the schedule.

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