




Environnement et
Changement climatique Canada

Environment and
Climate Change Canada

Canada



**«Современные проблемы физики»:
atmospheric / ocean measurements,
modelling &
data assimilation for
NWP / operational / climate applications**

Sergey Skachko

distant.msu.ru, December 7th 2021

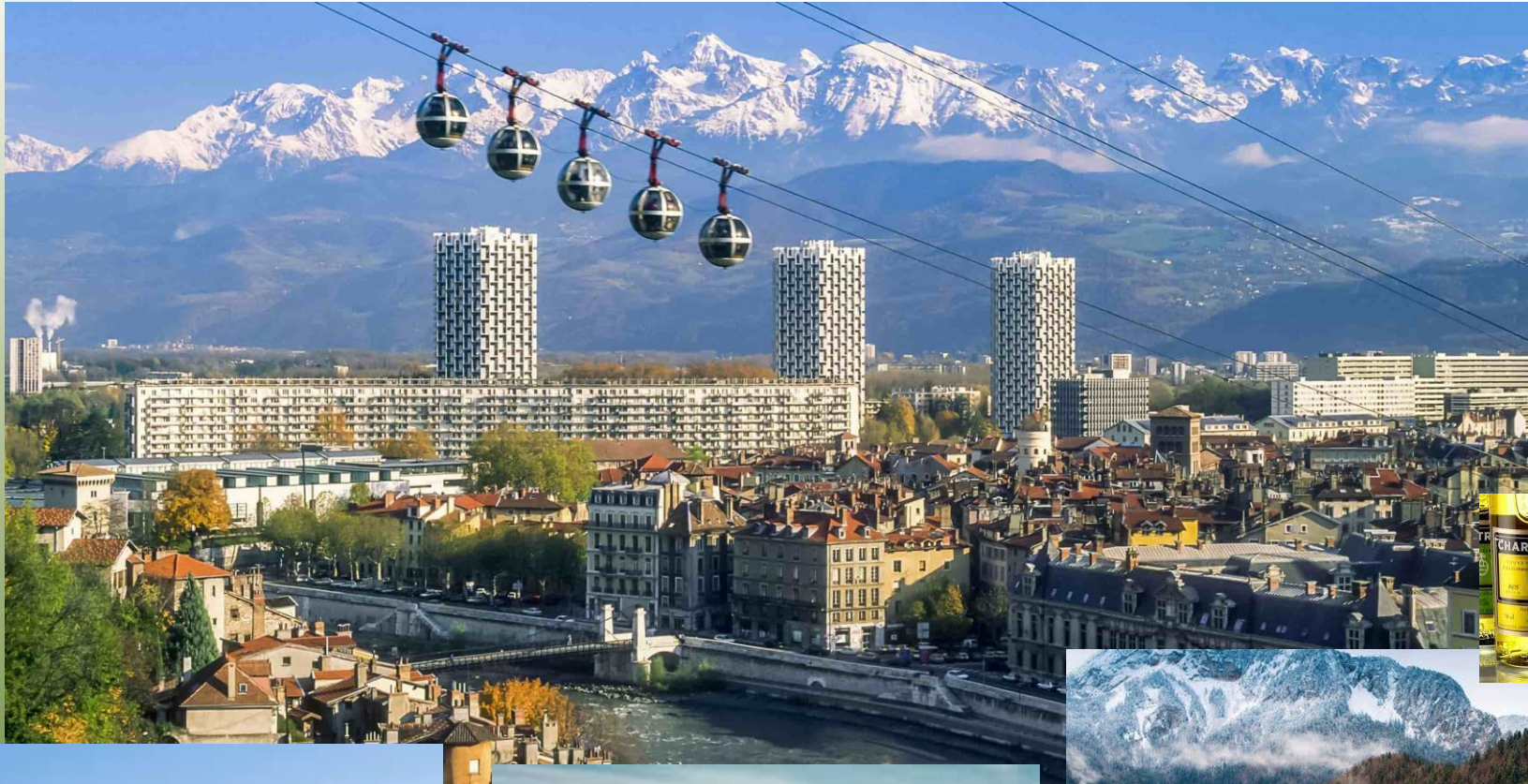
Résumé

- **Физфак МГУ, кафедра физики моря 1997-2003**
 - динамические процессы в очаге цунами
- Laboratoire des Écoulements Géophysiques et Industriels, CNRS, Grenoble, France, postdoc 2004-2006
 - ocean data assimilation
- Alfred Wegener Institut für Meereskunde, Bremerhaven, Deutschland, research scientist 2006-2008
 - ocean data assimilation
- Université du Québec à Montréal, Montréal (Québec), research scientist 2008-2011
 - coupled data assimilation
 - ocean / atmospheric modelling
- Koninklijk Belgisch Instituut voor Ruimte-Aeronomie / Institut royal de l'Aéronomie spatiale de Belgique, Brussel / Bruxelles, België / Belgique 2011-2016
 - CTM
 - stratospheric chemistry data assimilation
- Environnement et Changement climatique Canada / Environment and Climate Change Canada, Montréal, Québec, research scientist 2016-present time
 - coupled atmospheric-ocean-ice data assimilation





Laboratoire des Écoulements Géophysiques et Industriels, CNRS, Grenoble, France, postdoc 2004-2006



matique

 Alfred Wegener Institut für Meereskunde, Bremerhaven, Deutschland, research scientist 2006-2008







Koninklijk Belgisch Instituut voor Ruimte-Aeronomie / Institut royal de l'Aéronomie spatiale de Belgique, Brussel / Bruxelles, België / Belgique 2011-2016



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Environnement et Changement climatique Canada / Environment and Climate Change Canada, Montréal, Québec, research scientist 2016-present time



Environnement et
Changement climatique Canada

Environment and
Climate Change Canada

Canada

Outline

- **Intro**
- **Observation systems**
- **Modelling**
- **Data assimilation methods**
- **NWP / operational / climate applications**
- **Skills**



Intro: области интересов

- hydrology
- ocean ecosystem numerical modelling
- atmospheric chemistry
- waves
- renewable energy
- (coupled) ocean-atmosphere-ice systems for NWP and climate applications



Intro: перспективы карьеры

- research scientist:
 - applied research (government, NWP centres / operations)
 - fundamental research (universities), professorship
 - teaching
- scientific engineer
- scientific programmer
- R&D, operations
- management



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Monitoring the oceans

ocean measurements:

- insitu (T, S, p, bio & geophys.)
 - drifters
 - gliders
 - ships / buoys
 - bottom gages
 - sea mammals
- satellite
 - altimetry & geoid
 - (ocean) surface
 - biology / chemistry

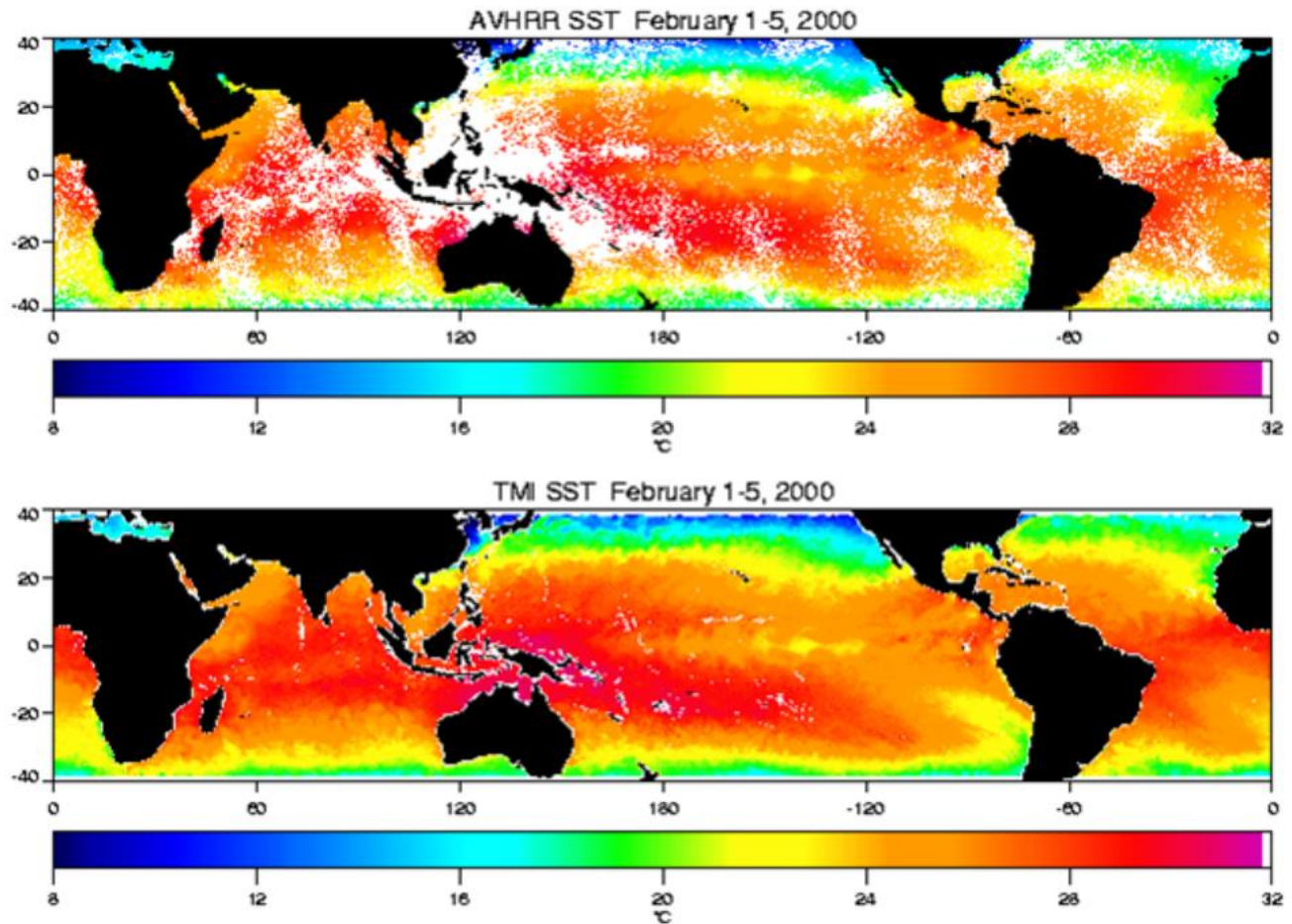


Page 12 – 7 décembre 2021



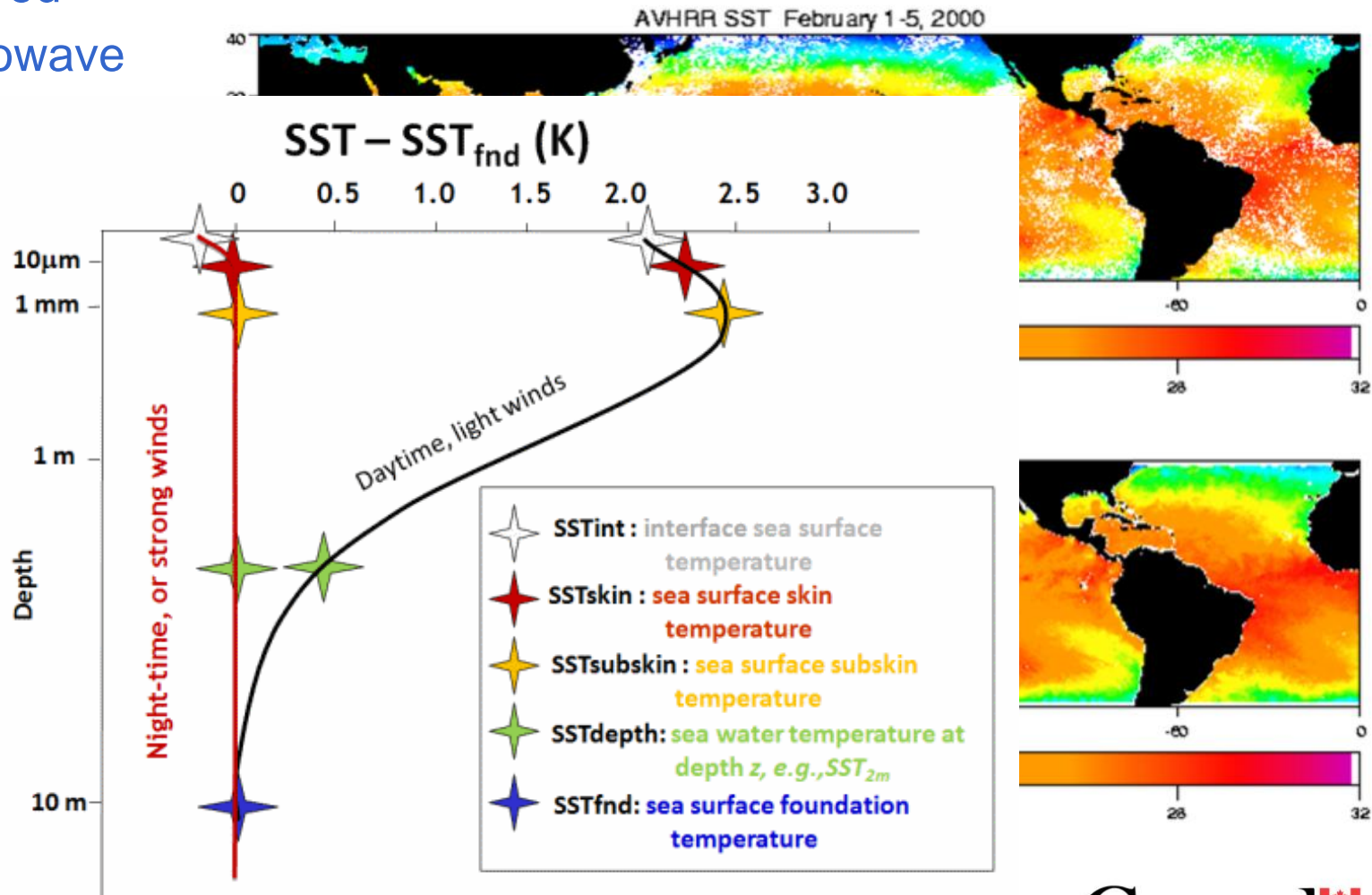
Satellite measurements

- Infrared
- Microwave



Satellite measurements

- Infrared
- Microwave



Monitoring the oceans: SENTINELLE

OceanOPS - Static Maps x Remote Sensing for Ocean- x

https://eumetsat.zoom.us/j/92780582943?join?track_id=8jmf_code=&meeting_result=&tk=PFYoE6uo8zuuVXqTtVwTz1GFV53rEkXQkMzK1WXs6pg.DQMAAAVmidYHxZaaJiraEkxQJRdVRpeXJSX01N...

REC

You are viewing EUMETSAT_Federico_Fierli's screen View Options

Greenhouse gases – preparing for CO2M – Sentinel7

copernicus.eumetsat.int

The image displays a satellite in space on the left, emitting a beam of light towards a map of the Earth. On the right, there are two maps: a global map showing atmospheric CO2 concentration with a color scale from 1 to 3, and a regional map of Europe showing CO2 concentration with a color scale from 404.0 to 407.0 ppm.

Unmute Start Video

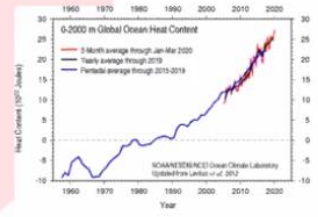
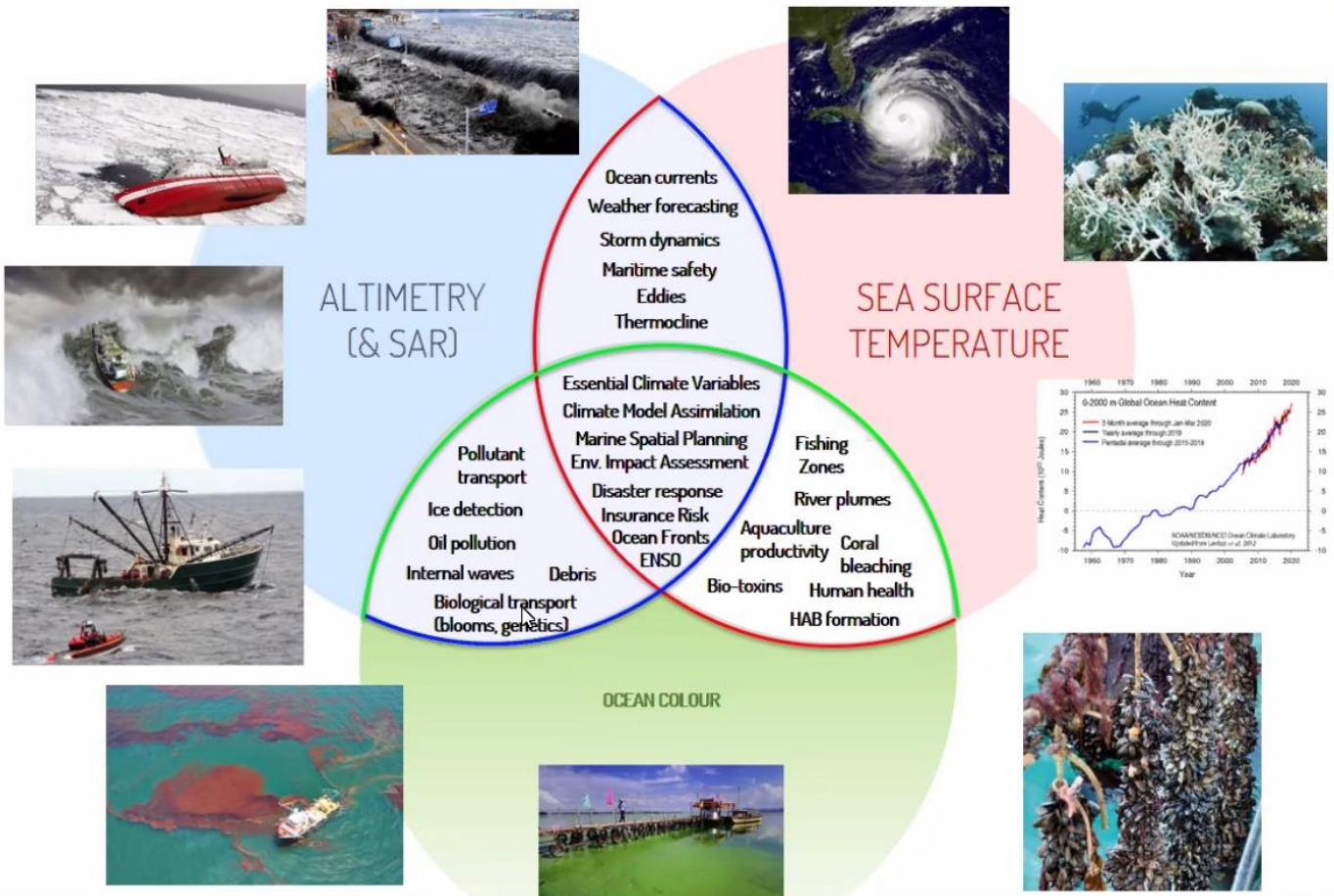
Participants 115 Share Screen Chat Reactions Settings More

Leave

Monitoring the oceans: SENTINELLE

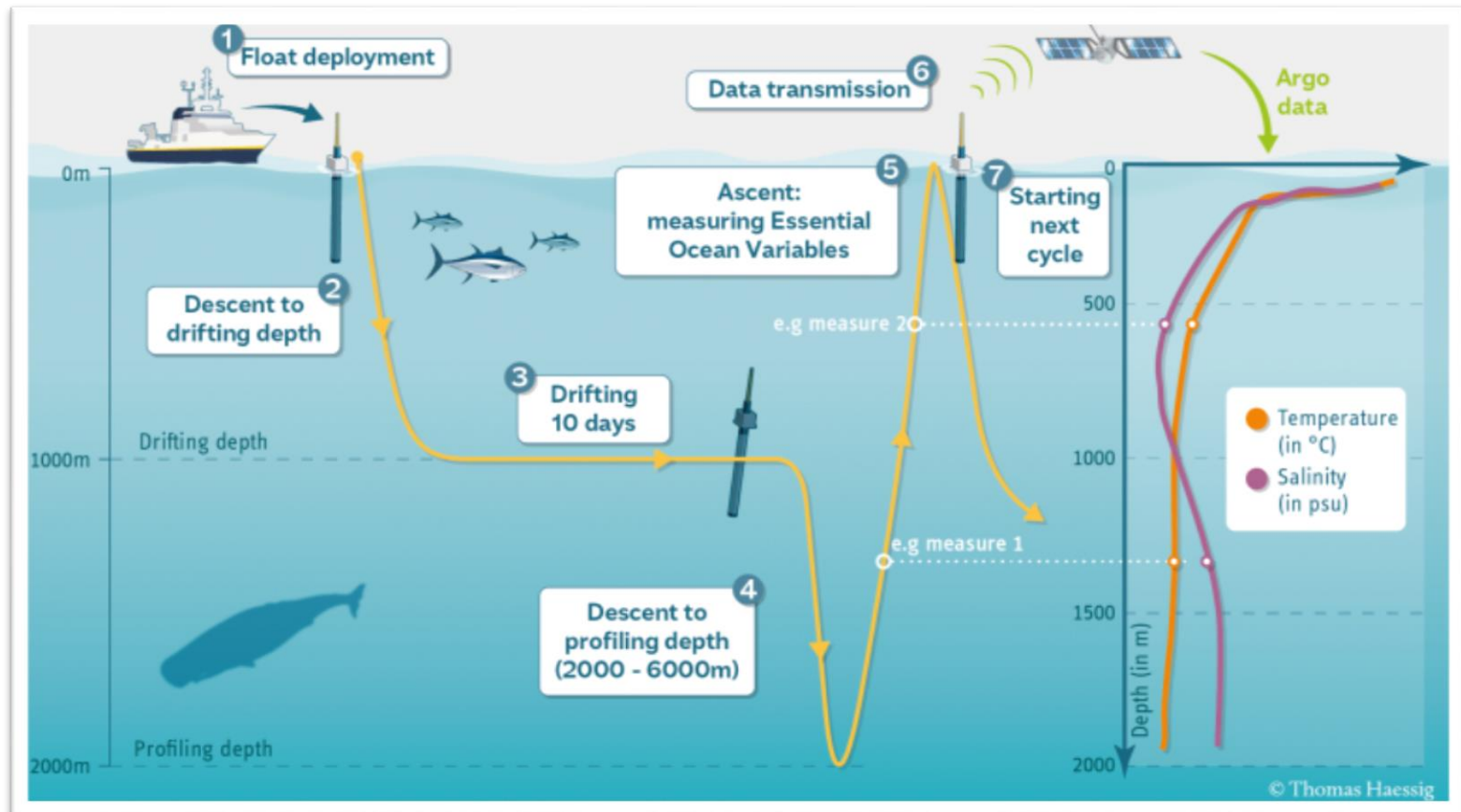
Sentinel-3 for ocean-atmosphere applications

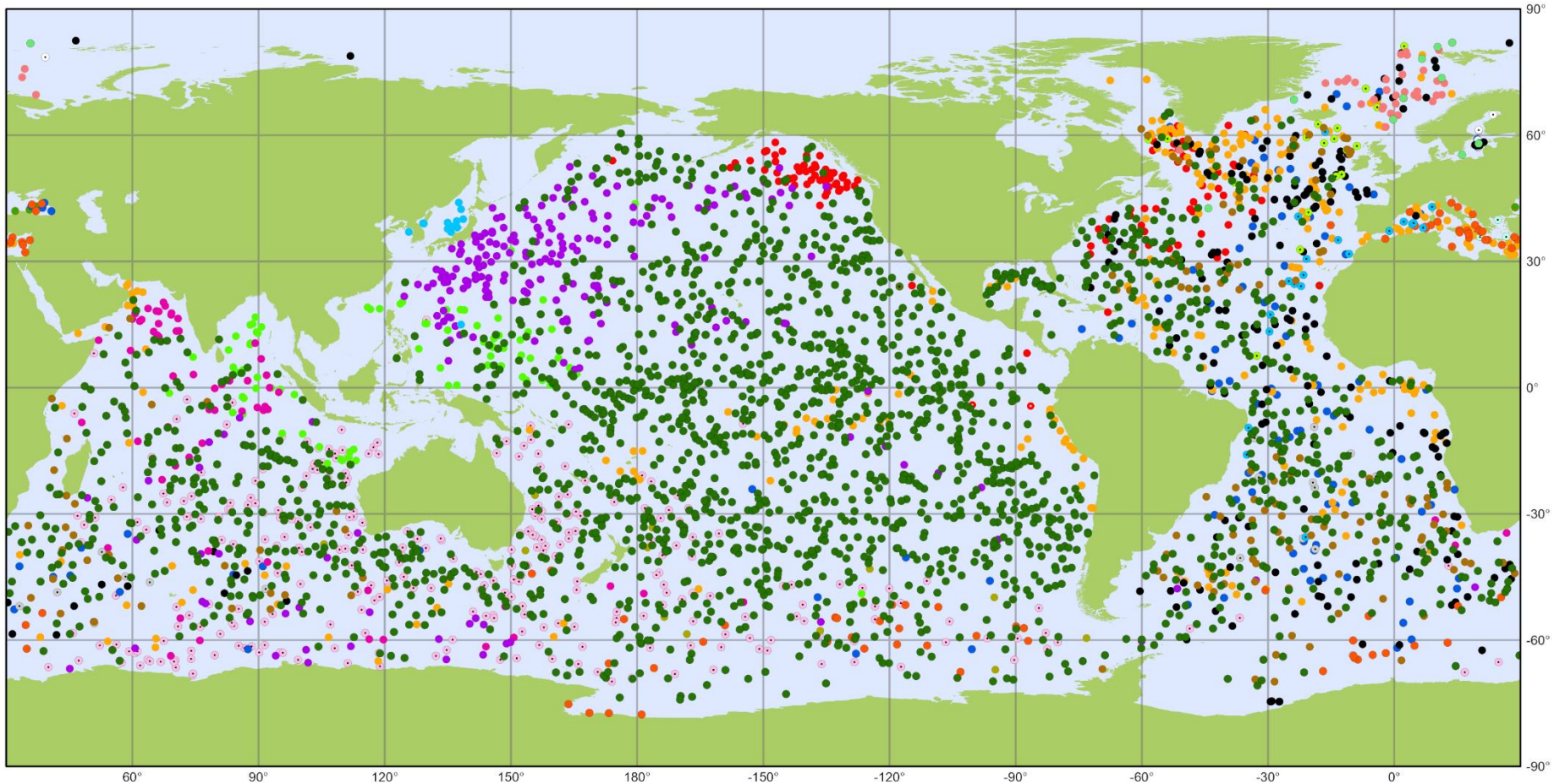
copernicus.eumetsat.int



Argo international program

- collects information from inside the ocean
- using a fleet of robotic instruments:
 - drift with the ocean currents
 - move up and down between the surface and a mid-water level





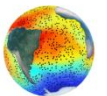
Argo

National contributions - 3870 operational floats

October 2021

Latest location of operational floats (data distributed within the last 30 days)

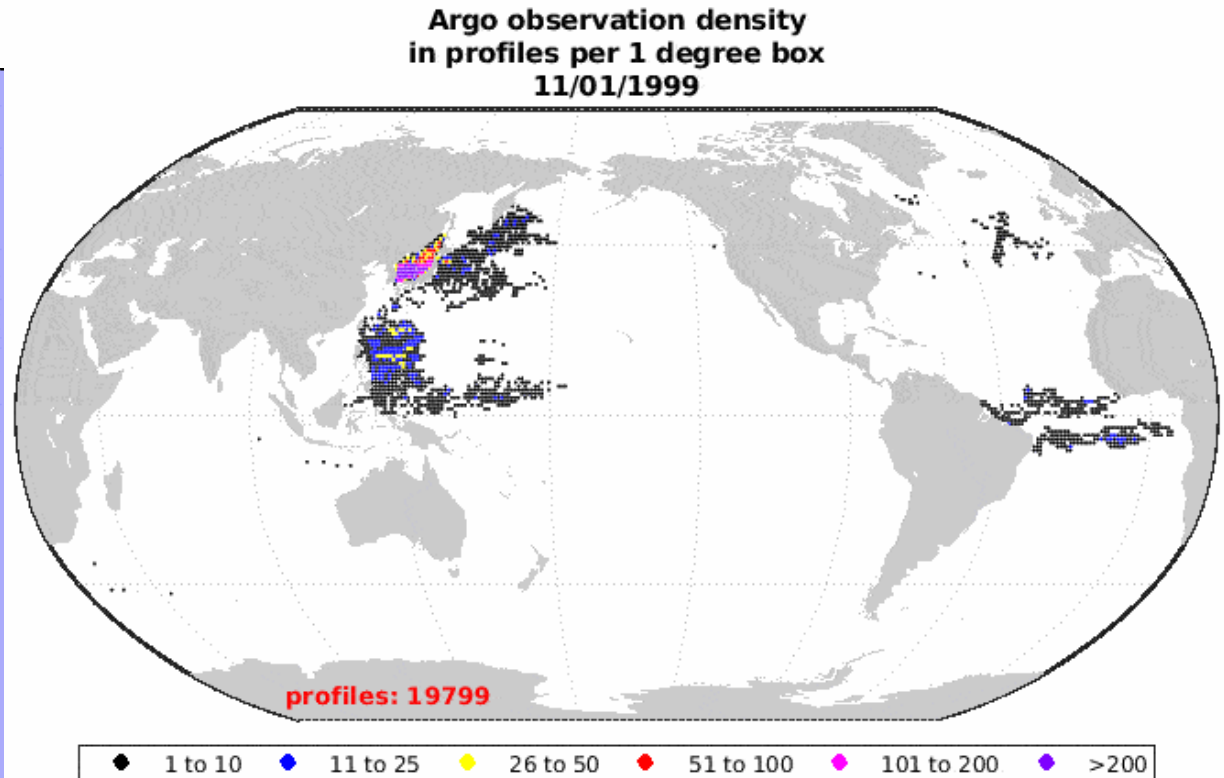
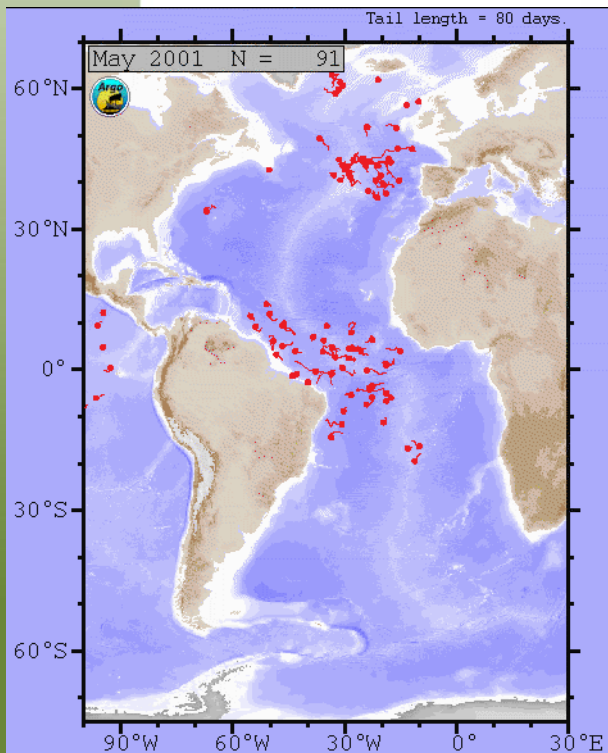
- | | | | | |
|-------------------|-----------------|----------------|--------------------|---------------------------|
| ● AUSTRALIA (307) | ● FINLAND (5) | ● IRELAND (19) | ● NETHERLANDS (19) | ● KOREA, REPUBLIC OF (13) |
| ● BULGARIA (6) | ● FRANCE (272) | ● ITALY (82) | ● NEW ZEALAND (14) | ● SPAIN (21) |
| ● CANADA (113) | ● GERMANY (201) | ● JAPAN (228) | ● NORWAY (36) | ● UK (150) |
| ● CHINA (77) | ● GREECE (3) | ● MEXICO (1) | ● PERU (2) | ● USA (2117) |
| ● EUROPE (109) | ● INDIA (63) | ● MOROCCO (1) | ● POLAND (11) | |



Generated by ocean-ops.org, 2021-11-01
Projection: Plate Carree (-150.0000)

Argo international program

Evolution of the program: Atlantic ocean (left), globally (right)



Monitoring the oceans: Copernicus Marine Service

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Copernicus Marine Portfolio

Temperature Salinity

Temperature bottomT
Salinity
Sea surface density
Mixed Layer Depth

Sea Surface Elevation

Sea surface height ab. geoid
Sea surface height ab. sea level
Mean Dynamic Topography

Primary Production

Chlorophyll-a
Primary production
Phytoplankton
Phytoplankton Functional Types
Phytoplankton Sizes

Low & mid-trophic levels

Zooplankton
Micronekton

Currents

Geostrophic velocity
Barotropic velocity
Stokes drift
Tidal velocity (current tides)
Vertical velocity

Surface Wind

Wind speed
Stress

Transparency Turbidity Reflectance

RRS: Reflectance
Transparency Turbidity
Absorption coefficient
Back scattering coefficient
Light attenuation
Secchi depth
Suspended matter

Carbonate system

Potential Hydrogen
Surface partial pressure of CO2
Surface flux of CO2
fugacity of CO2
Dissolved Inorganic Carbon
Alkalinity

Waves

Significant wave height
Mean wave period
Mean wave direction
Stokes drift
Wind wave (period, height, direction)
Primary swell wave (p., h., d.)

Sea Ice

Sea ice concentration
Sea ice thickness
Sea ice velocity
Sea ice drift
Sea ice edge
Sea ice surface temperature

Nutrients

Nitrate
Phosphate
Silicate
Iron
Ammonium

Dissolved oxygen


eurometsat.zoom.us partage votre écran.

Arrêter le partage

Masquer

Dissolved oxygen

Monitoring the planet: Copernicus Climate

You are viewing Samantha Burgess's screen   View Options 

Climate data records of Essential Climate Variables (ECVs)

C3S supports 22 ECV services grouped in 5 thematic areas:

Atmospheric physics

Precipitation
Surface radiation budget
Water vapour
Cloud properties
Earth radiation budget

Atmospheric composition

Carbon dioxide
Methane
Ozone
Aerosol

Ocean

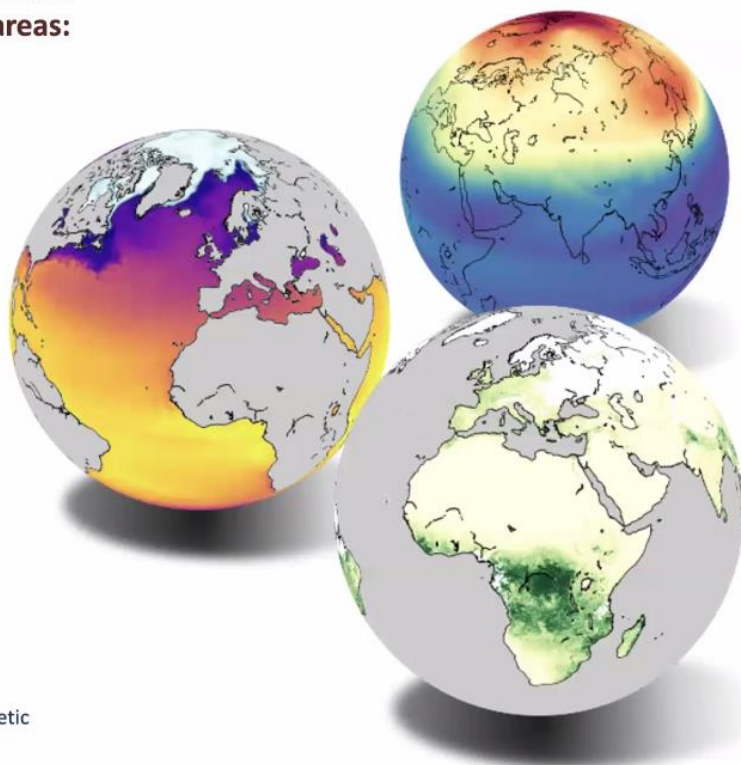
Sea surface temperature
Sea level
Sea ice
Ocean colour

Land hydrology & cryosphere

Lakes
Glaciers
Ice sheets & ice shelves
Soil moisture

Land biosphere




Albedo
Land cover
Fraction of absorbed photosynthetic
Leaf area index
Fire



ECV products that are

- State-of-the-art
 - *Coordination with ESA CCI, EUMETSAT/SAFs & other Copernicus Services*
- Long-term, consistent, complete (CDR)
 - **Single/Multi sensor approach**
- Regularly extended in time (ICDR)
 - **Frequent updates of data records**
- Gridded, aggregated
 - **Meeting user requirements**
- *Accessible & Traceable*
 - *Access through the Climate Data Store*
 - *Documentation*
 - *Quality Assurance*
 - *User support*

Monitoring the planet: Copernicus Sea Level & Ocean Color

You are viewing Samantha Burgess's screen   View Options 

C3S OCEAN ECVs: SEA LEVEL & OCEAN COLOUR

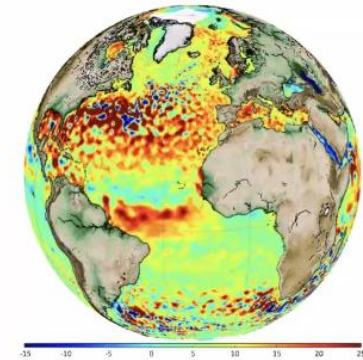
Sea Level

- Daily global estimates of **sea level anomaly**, **absolute dynamic topography**, and **geostrophic velocities**
- Available from Jan 1993 onward
- Based on altimetry measurements from a 2-satellite constellation:
 - **Reference mission** (T/P, Jason-1, Jason-2, Jason-3)
 - **Complementary mission** (ERS-1/2, Envisat, SARAL/Altika, Sentinel-3A)
- Products optimised for climate monitoring → focus on homogeneity and stability
- Resolution: 0.25° lat-lon
- Data updated 3x/year with 5-month latency behind real time
- Latest version: **vDT2021** (released in Oct 2021)

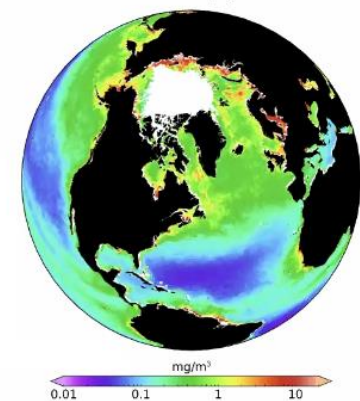
Ocean Colour

- Daily global estimates of ocean surface **chlorophyll-a concentration** and **remote sensing reflectance**
- Based on multiple sensors: SeaWiFS, MERIS, MODIS Aqua, VIIRS, and (from v5.0 onward) OLCI
- Processing chain software developed as part of **ESA OC CCI**
- Resolution: 0.042° lat-lon (4 km at Equator)
- Quarterly updates with 9-12 month latency behind real time
- Latest version: **v5.0** (released in Nov 2020)

Sea Level Anomaly (cm) for 01/09/2020 from CDR vDT2021



2018 annual mean chlorophyll-a concentration



Monitoring the planet: Copernicus Sea Ice

You are viewing Samantha Burgess's screen View Options



Climate
Change

C3S OCEAN ECVs: SEA ICE

Sea Ice Thickness

- Monthly product for the Northern Hemisphere
- Based on radar altimetry measurements from **Envisat** (10/2002 – 10/2020) and **CryoSat-2** (11/2010 – present)
- Resolution: 25 km
- Daily data available with 16-day latency behind real time
- Latest version: **v2.0** (released in Oct 2021)

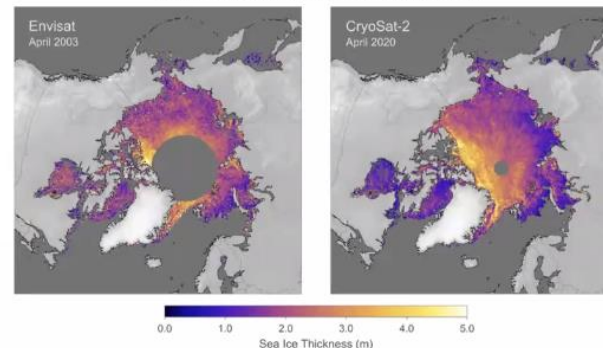
Sea Ice Type

- Daily classification of sea ice as **first-year ice** or **multiyear ice**
- Based on PMW measurements from SMMR-SSM/I-SSMIS
- Available for N. Hemisphere from October through April
- Resolution: 25 km
- Daily data available with 16-day latency behind real time
- Latest version: **v2.0** (released in Sept 2021)

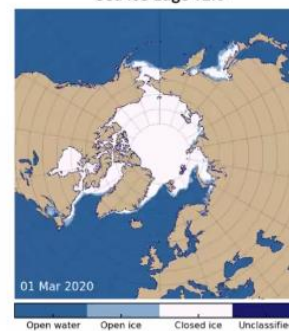
Sea Ice Edge

- Daily classification of sea surface as **open water**, **open ice**, or **closed ice**
- Based on PMW measurements from SMMR-SSM/I-SSMIS
- Available for N. and S. Hemispheres
- Resolution: 12.5 km
- Daily data available with 16-day latency behind real time
- Latest version: **v2.0** (released in Sept 2021)

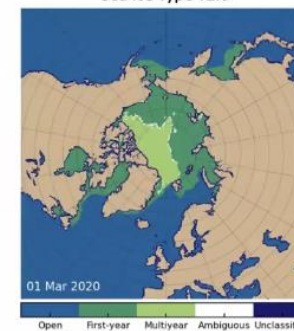
Sea Ice Thickness Climate Data Record v2.0



Sea Ice Edge v2.0



Sea Ice Type v2.0



Forschungseisbrecher Polarstern

Wahrzeichen deutscher Polarforschung

Das Forschungsschiff Polarstern ist wichtigstes Werkzeug der deutschen Polarforschung und das Flaggschiff des Alfred-Wegener-Instituts.





À PROPOS D'AMUNDSEN SCIENCE

Amundsen Science est l'organisme à but non-lucratif responsable du mandat scientifique du brise-glace de recherche NGCC *Amundsen*. Fonctionnant en grande partie grâce au financement octroyé par la Fondation canadienne pour l'innovation à l'Université Laval, Amundsen Science gère et entretient le parc d'équipements scientifiques du navire, coordonne les expéditions scientifiques en collaboration avec la garde côtière canadienne et fournit un support technique aux usagers du programme scientifique lorsque le navire est en mer.

Outline

- Intro
- Observation systems
- **Modelling**
- Data assimilation methods
- NWP / operational / climate applications
- Skills



High Performance Computer (HPC)



HPC Upgrade #1: Supercomputers

XC40	XC50
2 x 18 core, 2.1 Ghz	2 x 20 core, 2.4Ghz
Broadwell	Skylake
792 compute nodes	1,266 compute nodes
28,512 compute cores	50,640 compute cores
128 GB 4 channel DDR4-2400	192 GB 6 channel DDR4-2666

- Essentially, a bigger version of a machine we already know well.
- Increase of ~1.6x increase in number of nodes, and ~1.8x increase in total number of compute cores.



HPC Upgrade #1: PPP Clusters

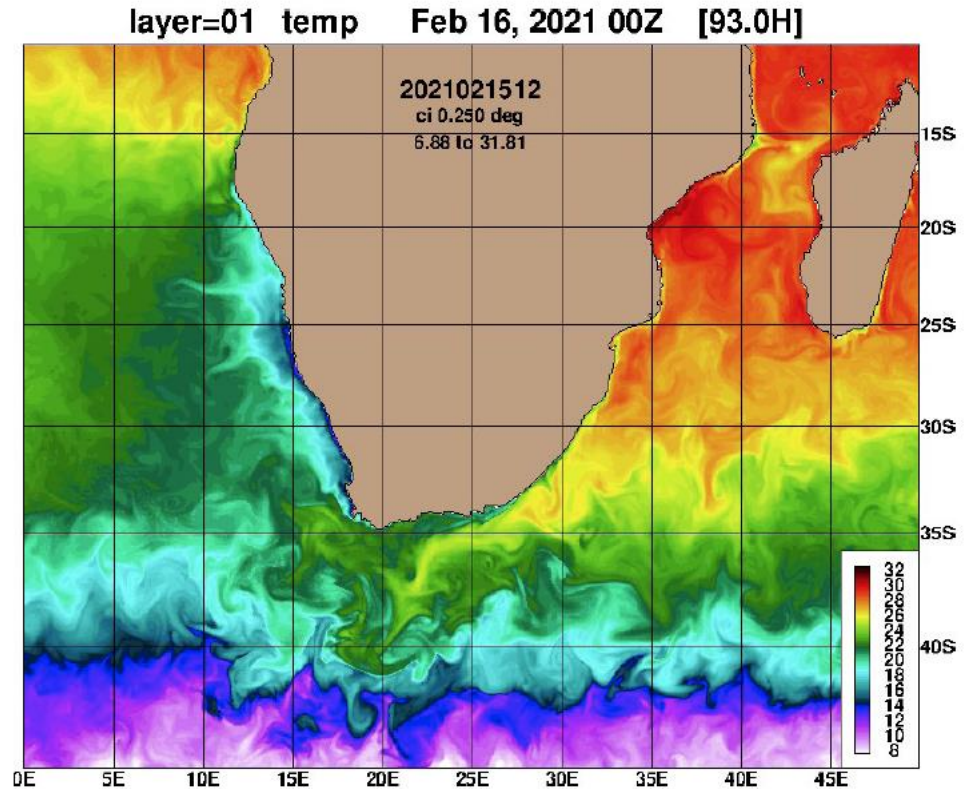
CS-400	CS-500
2 x 22 core, 2.1 Ghz	2 x 20 core, 2.4Ghz
Broadwell	Skylake
158 compute nodes	248 compute nodes
6,952 compute cores	9,920 compute cores
225 GB 4 channel DDR4-2400	192 GB 6 channel DDR4-2666

- Compute nodes have same processor as the XC50.
- Increase of ~1.6x increase in number of nodes, and ~1.4x increase in total number of compute cores.



Ocean / atmospheric modelling

- global
- regional
- nested



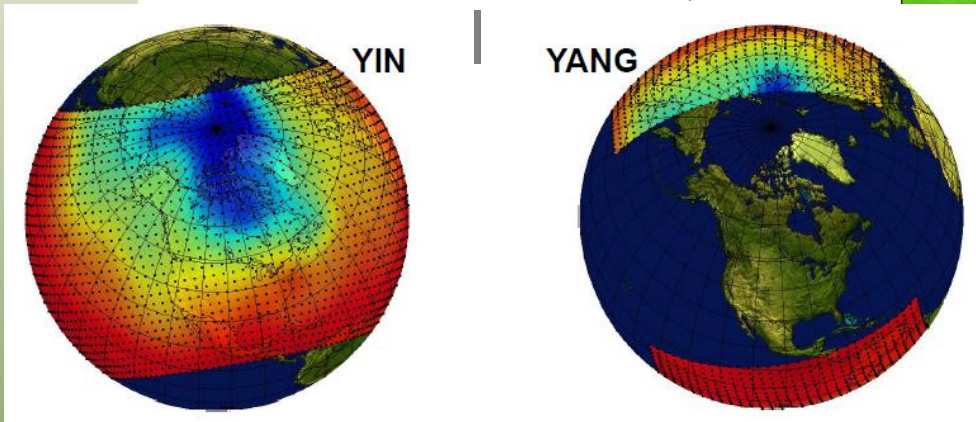
*GOFS forecast sea surface temperature, Day 7-1/2
(Source: U.S. Naval Research Laboratory)*



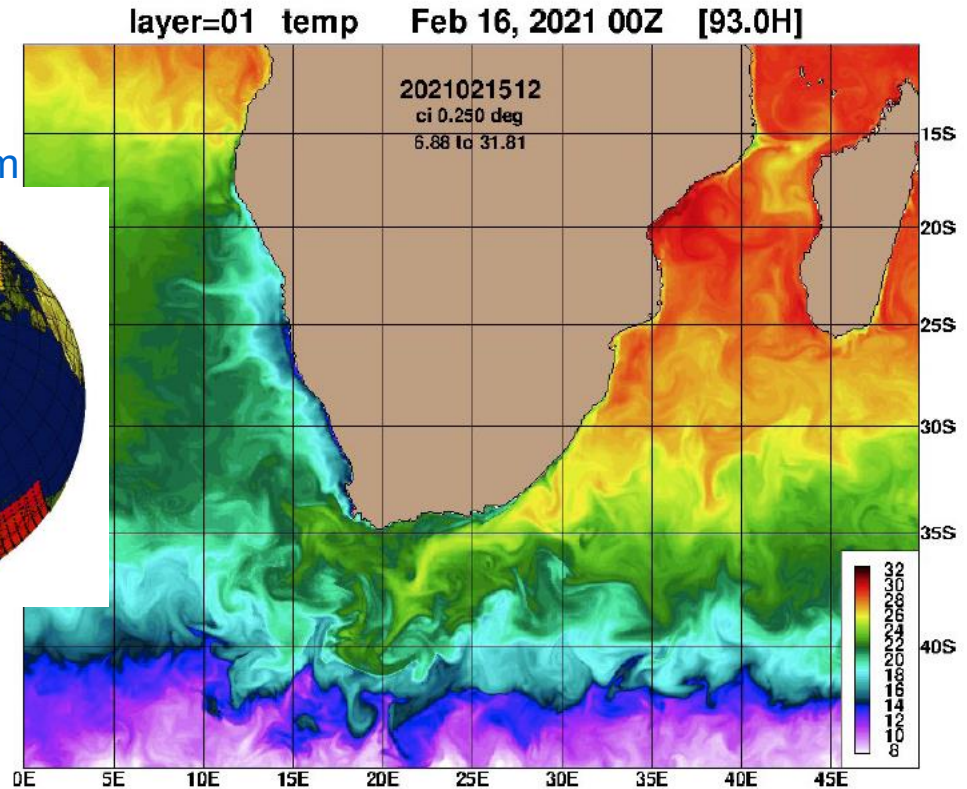
Ocean / atmospheric modelling

- global

Global, $\Delta x = 25\text{km}$



Canadian atmospheric model GEM

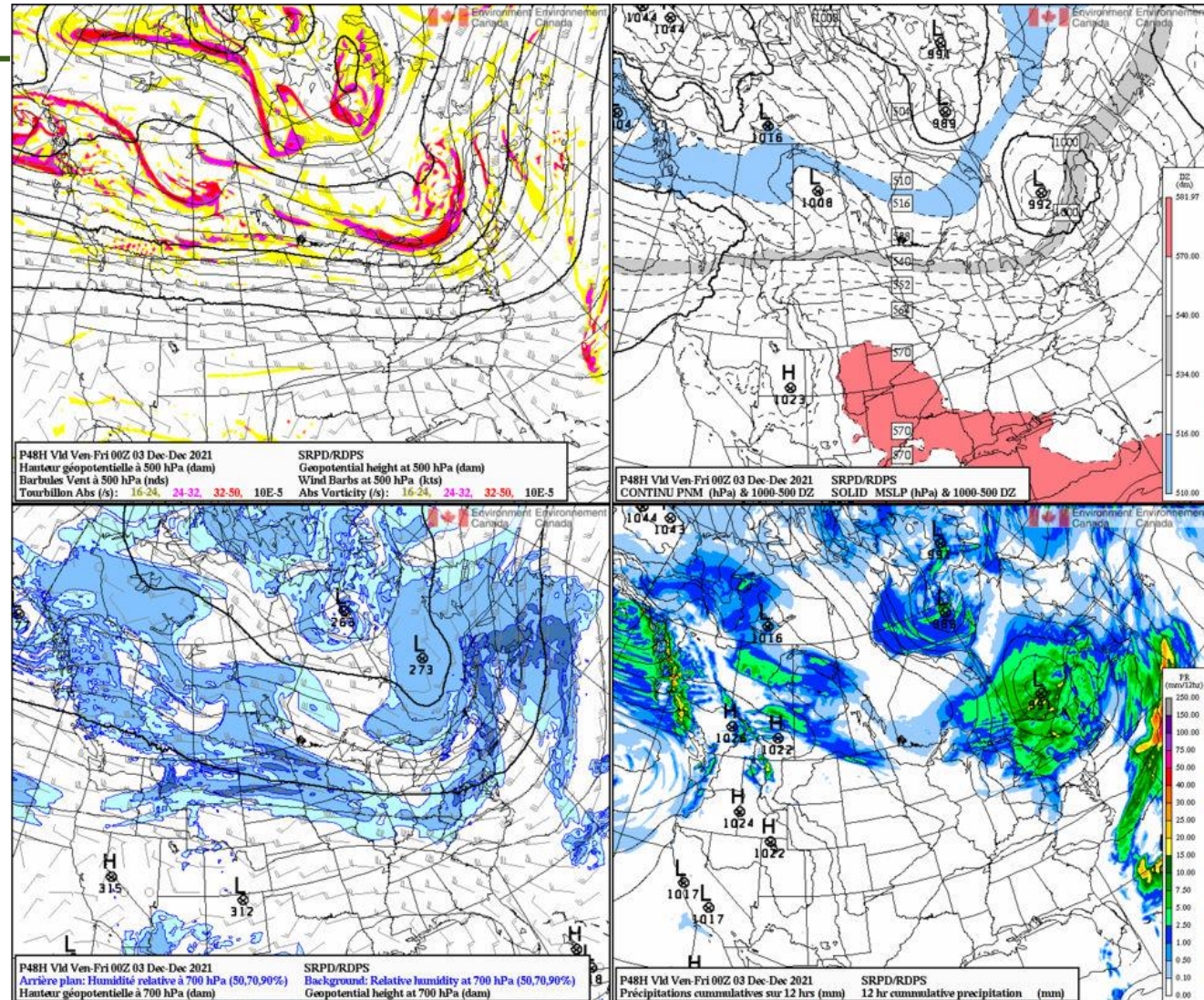


*GOFS forecast sea surface temperature, Day 7-1/2
(Source: U.S. Naval Research Laboratory)*



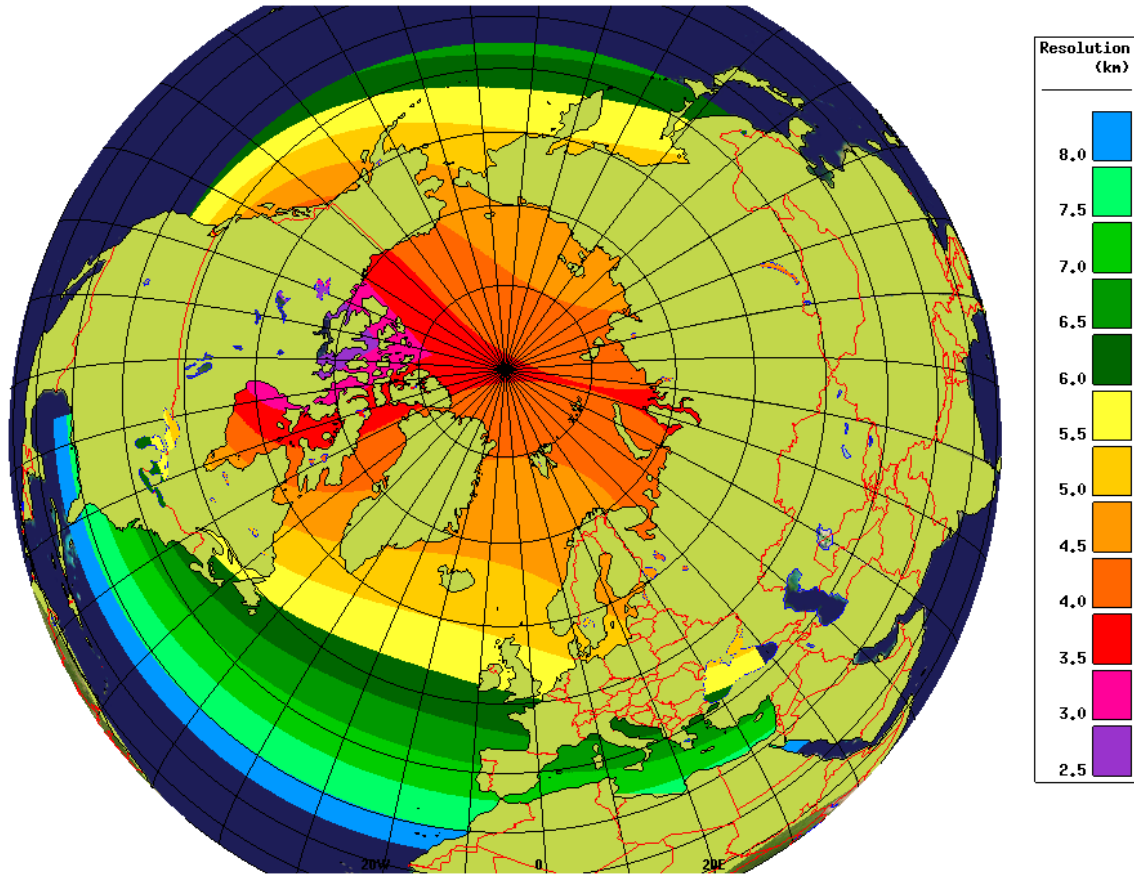
Ocean / atmospheric modelling

- global
- regional
- nested



Canadian Ice-Ocean Prediction System

- global
- regional
- nested



The coverage of the Canadian ice-ocean prediction system showing the model grid resolution (km). The domain extends from 26° N in the Atlantic Ocean over the Arctic Ocean to 44° N in the Pacific Ocean. (source: Smith et al 2021)



AGRIF nested grids

- nested



- HOME
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- DOCUMENTATION
- CONTACTS
- HOW TO CITE ?

ROMS_AGRIF PROJECT

SUMMARY

Source code

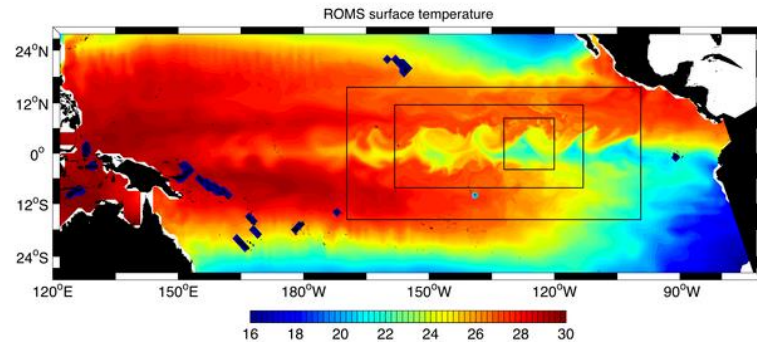
- Roms_Agrif v3.1.1 : Latest stable version, 07 July 2014
- Roms_Agrif v3.1 : 03 February 2014
- Roms_Agrif v3.0 :
- Roms_Agrif v2.2 :
- Roms_Agrif v2.1 :

Sources Change Log

- 2014
- 2012
- 2010

Roms tools

- ROMSTOOLS V3.1.1 : Latest stable version, 07 July 2014.
- ROMSTOOLS V3.1 : 03 February 2014.
- ROMSTOOLS V3.0 : 21 December 2012.
- ROMSTOOLS V2.2 : 16



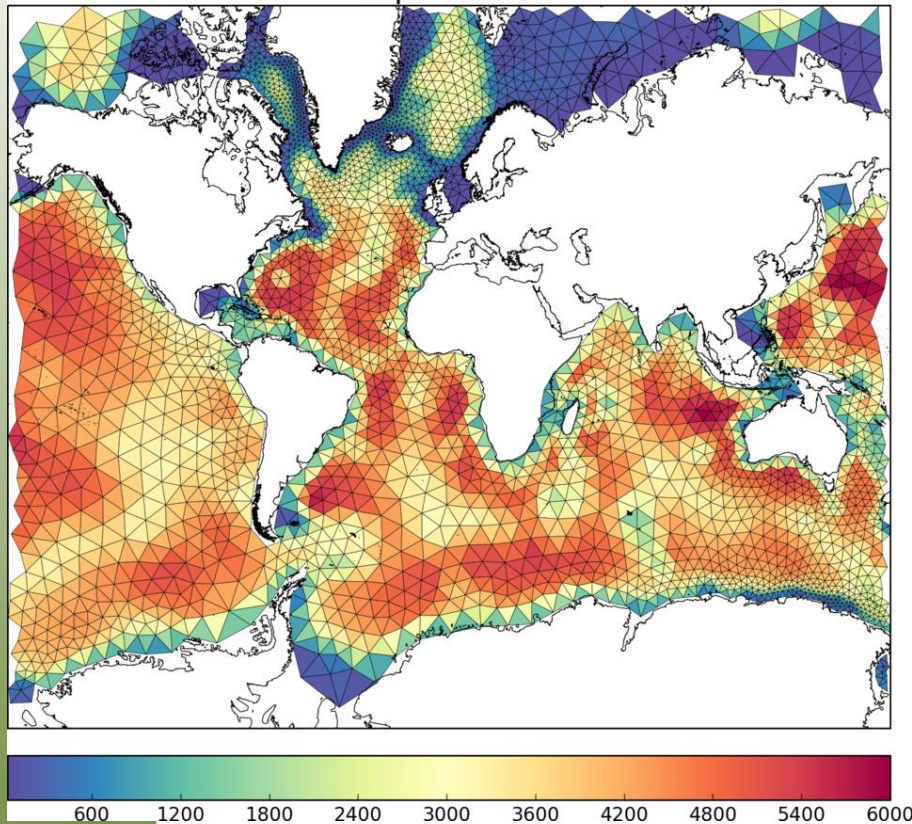
ROMS_AGRIF is based on the Regional Ocean Modeling System (ROMS) and has benefited from developments made by the ROMS community. If not done yet, we encourage you to also register at the [official ROMS website](#).

ROMSTOOLS is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version. ROMSTOOLS is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details. You should have received a copy of the GNU General Public License along with this program; if not, write to the Free Software Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA

ROMSTOOLS uses several Matlab [Utilities](#), and [Datasets](#) available for download.

See **Change Log** section for **Known problems and Fixes**.

topo at 0.0

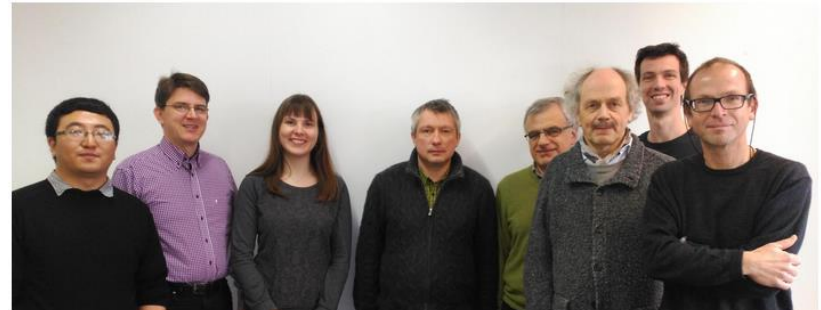


Roelof Rietbroek

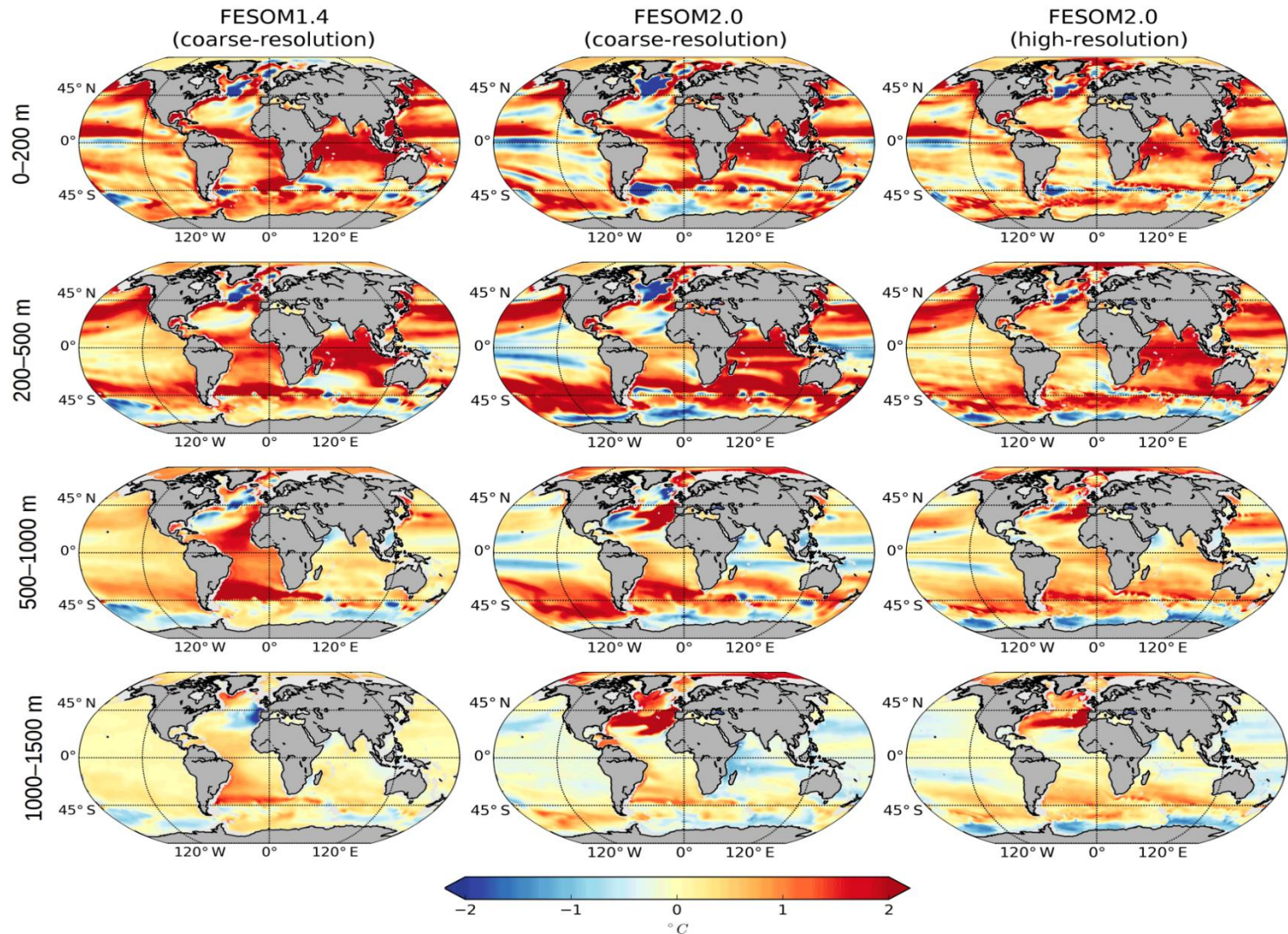
Mar 1, 2018

Tags: Ocean mass, Sea level, Low Earth Orbiters, Orbit Determination, CONTIM

The DFG funded project CONTIM (Consistent Ocean Mass Time Series from LEO Potential Field Missions), is part of the Priority Program [Dynamic Earth](#), and started in 2015 (initially for 3 years). It's primary goal is to estimate and study ocean mass variations using numerical ocean modelling, precise orbit determination of low earth orbiters (LEO's), and data combination approaches. The project is expected to yield results which are highly relevant for closing the sea level budget, indirectly providing constraints on the ocean warming and the related energy budget of the Earth. Three institutes are directly involved in the project: Institut für Erdmessung (IfE) Leibniz Universität Hannover, Institut für Geodäsie und Geoinformation (IGG) in Bonn, and the Alfred Wegener Institut (AWI) in Bremerhaven.

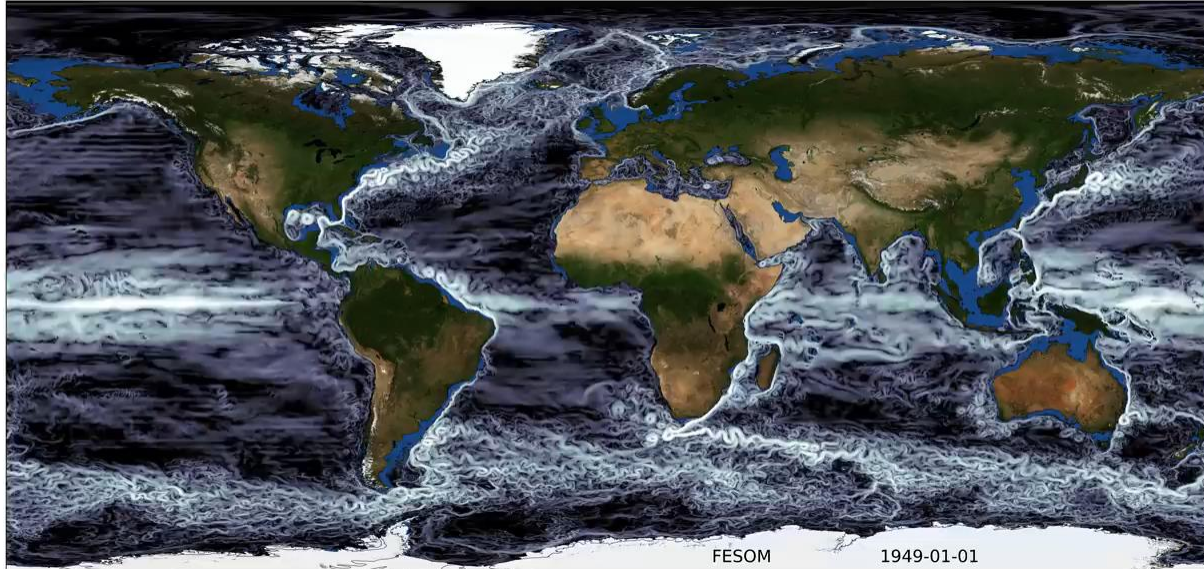


Team members of the CONTIM team. From left to right: Le Ren, Steffen Schön, Christina Lück, Alexey Androsov, Sergey Danilov, Jens Schröter, Roelof Rietbroek, Jürgen Kusche



The departure of simulated potential temperature averaged over 1998–2007 from WOA2005 climatology, averaged over depth ranges. The left and middle columns correspond to the simulations performed with FESOM1.4 and FESOM2, respectively, on the coarse resolution reference mesh. The right column corresponds to FESOM2.0 on the global mesh with a resolution of 15 km

High resolution simulations



FESOM2 20-year run. 5^E6 node grid.
computation, D. Sidorenko;
graphics, N. Koldunov

Может ли современная модель глобального океана предсказать изменчивость гидродинамических полей?

Outline

- Intro
- Observation systems
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Data assimilation

- sparse data w.errors
- numerical model w.errors
- DA: how to combine info from data and model to improve model forecasts
- DA methods:
 - variational (3D-Var, 4D-Var)
 - sequential (derived from Kalman filter: EKF, SEEK, EnKF, LETKF...)
 - use of machine learning



based on simulation results from the global cloud-resolving model NICAM and NASA satellite imagery. Courtesy of Ryuji Yoshida.



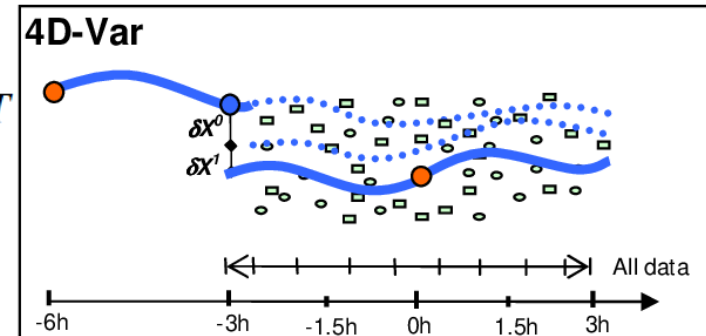
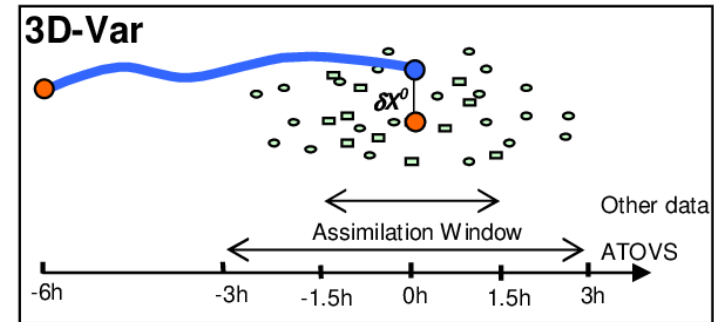
Variational DA

numerical model:

$$\mathbf{x}(t_k) = M_{k-1,k}(\mathbf{x}(t_{k-1})), \quad k \in [0, K], \quad (\text{S. Laroche 2005})$$

minimize a cost function:

$$J = \frac{1}{2} [\mathbf{x}(t_0) - \mathbf{x}^b(t_0)]^T \mathbf{B}_0^{-1} [\mathbf{x}(t_0) - \mathbf{x}^b(t_0)] + \frac{1}{2} \sum_{k=0}^K \left(\mathbf{H}_k M_{0,k}(\mathbf{x}(t_0) - \mathbf{x}^b(t_0)) - \mathbf{d}_k \right)^T \mathbf{R}_k^{-1} \left(\mathbf{H}_k M_{0,k}(\mathbf{x}(t_0) - \mathbf{x}^b(t_0)) - \mathbf{d}_k \right),$$



- Analysis
- Trial field
- ATOVS
- Other data
- Full-resolution trajectory of the final analysis.
- ⋯ Updated trajectories for the calculation of innovations at the appropriate time.

Ensemble Kalman filter

numerical model:

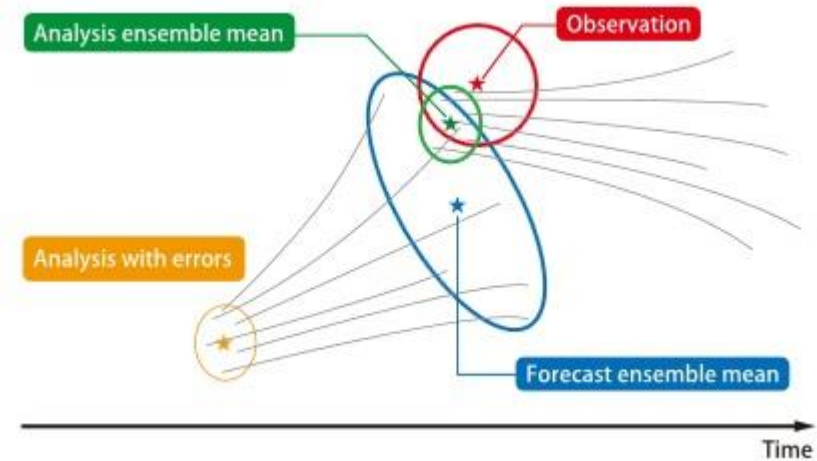
$$\mathbf{x}_i^f(t_k) = M_{k-1,k}(\mathbf{x}_i^a(t_{k-1})) + \boldsymbol{\eta}_i(t_k), \quad i \in [1, N],$$

ensemble covariance matrix:

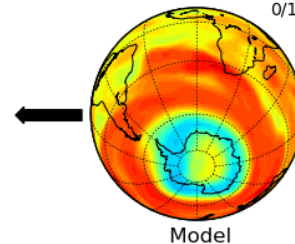
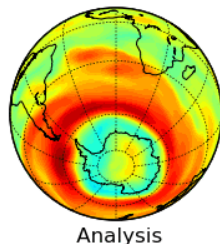
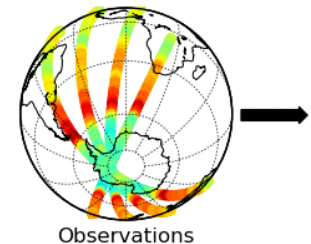
$$\mathbf{B}_e = \frac{1}{N-1} \sum_{i,j} \tilde{\mathbf{x}}_i \tilde{\mathbf{x}}_j^T.$$

ensemble Kalman filter equation:

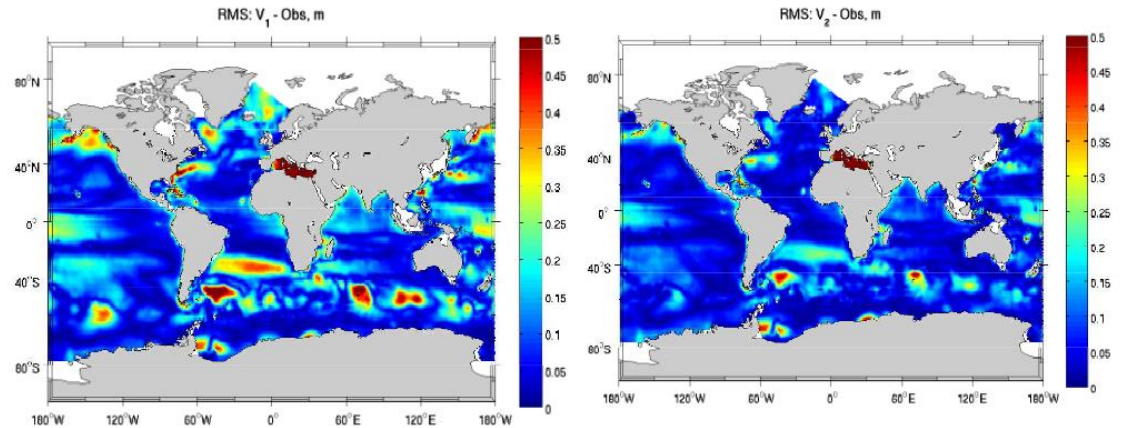
$$\mathbf{X}^a(t_k) = \mathbf{X}^f(t_k) + \mathbf{B}_e(t_k) \mathbf{H}_k^T \left[\mathbf{H}_k \mathbf{B}_e(t_k) \mathbf{H}_k^T + \mathbf{R}_k \right]^{-1} \mathbf{D}_k,$$



$$\mathbf{D}_k = \mathbf{Y}_k - \mathbf{H}_k \mathbf{X}^f(t_k)$$



Example: how DA corrects model initial conditions



S. Skachko et al.: Sequential assimilation of dynamical topography

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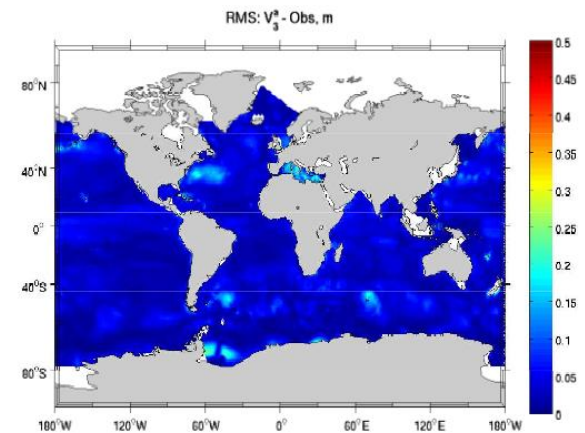
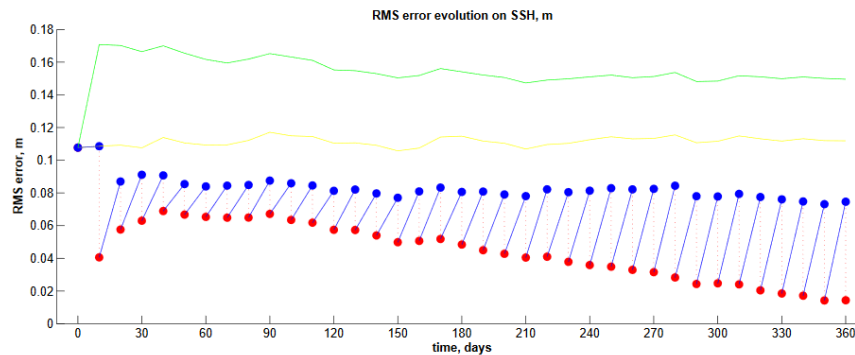


Fig. 3. Evolution of RMS error of SSH for the world ocean (except zones corresponding to RIO05 MDT location in the data see Fig. 1). The green and yellow solid lines show the errors corresponding to the V_1 and V_2 free simulations (without assimilation), respectively. The blue lines with bullets represent the V_3^f 10-day model forecasts, while the dotted red lines V_3^a correspond to the V_3^a analysis. V_1 model which was spun up was re-initialized at the initial time with the initial condition of V_2 .

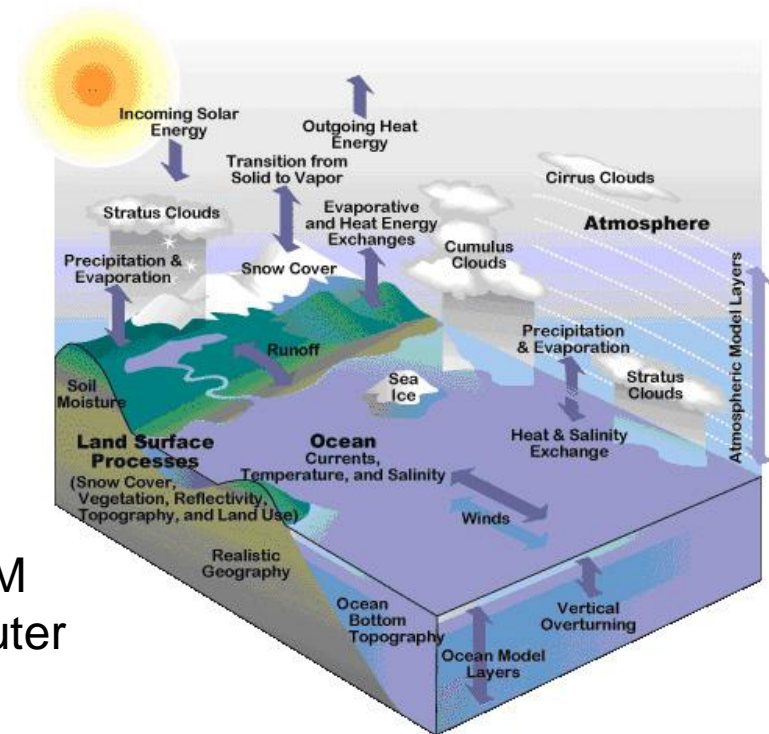
Outline

- Intro
- Observation systems
- Modelling
- Data assimilation methods
- **NWP / operational / climate applications**
- Skills



Climate coupled models

- ocean and atmosphere models talk to each other: 2-way coupling



What's in a global climate model? The Community Climate System Model (CCSM version 3) that is run with the supercomputer at the National Center for Atmospheric Research incorporates data about all of the natural processes shown in this diagram to simulate Earth's complex climate system.

UCAR



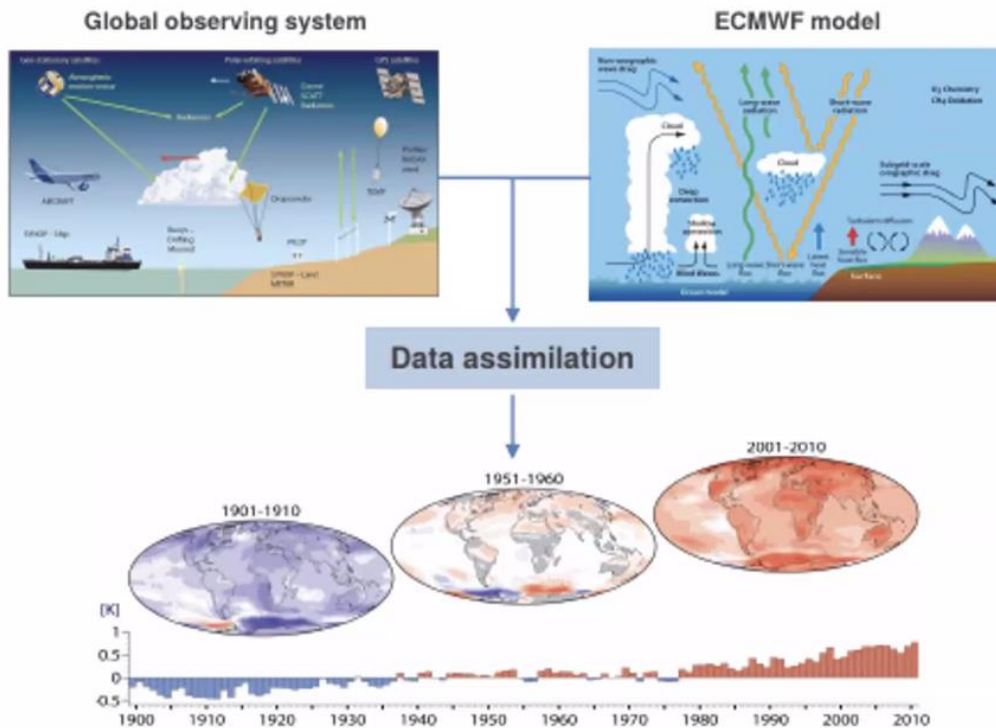
Monitoring the planet: Copernicus Reanalysis

You are viewing Samantha Burgess's screen View Options

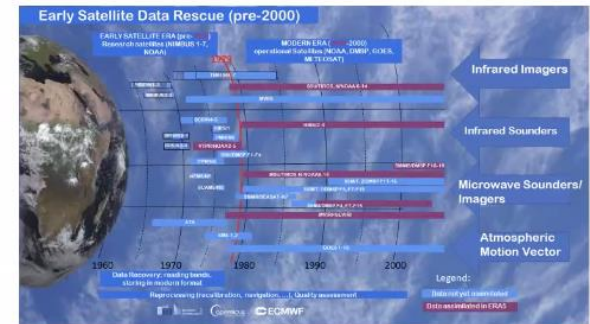
Reanalysis uses past observations with today's weather forecast model



Climate Change



- ✓ **Complete:** combining vast amounts of observations into (global) fields
“reanalysis is a smart machine”
- ✓ **Consistent:** use the same physical model and data assimilation system throughout
- ✓ **Convenient:** “maps without gaps”, always available in the same way
- provide an uncertainty estimate



Monitoring the planet: Copernicus

REC

You are viewing Samantha Burgess's screen View Options



Climate Change

Future of reanalysis



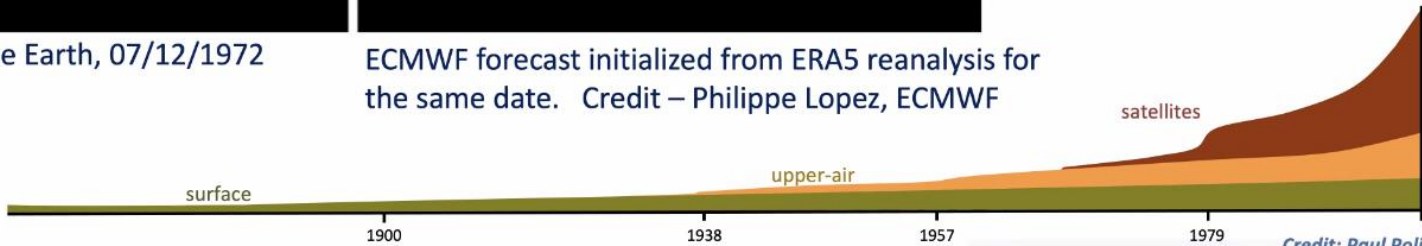
Apollo 17 image of the Earth, 07/12/1972
Credit - NASA



ECMWF forecast initialized from ERA5 reanalysis for the same date. Credit – Philippe Lopez, ECMWF

ERA6:

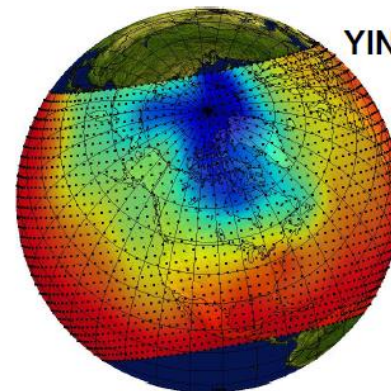
- Coupled ocean-atmosphere
- Better representation of key atmosphere-ocean processes and feedbacks
- C3S satellite data rescue
- ERA6L with enhanced land data assimilation



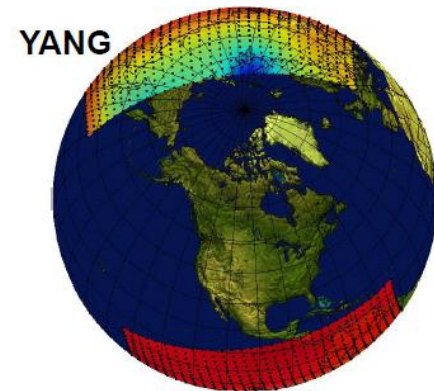
Credit: Paul Poli

ECCEC's Global Deterministic Prediction System (GDPS)

- **GEM atmospheric model**
 - Current ECCEC's NWP system
 - Coupled GDPS 10 day forecasts: atmosphere-ocean-ice
- **4D-EnVar data assimilation:**
 - Variational approach using 4D ensemble covariances from EnKF
 - Hybrid covariances by averaging the ensemble covariances with the static NMC-method covariances
- **Data assimilated by the GDPS:**
 - radiosondes, aircraft
 - Surface report (SYNOP, SHIP, BUOYs)
 - ATOVS
 - ATMS
 - SSMIS
 - AIRS/IASI/CrIS
 - GeoRad
 - ASCAT
 - AMVs
 - GPS-RO



Global, $\Delta x = 25\text{km}$



Ice-ocean modelling and data assimilation with



- Global Ice-Ocean Prediction System (GIOPS), NEMO-CICE coupled model

- Seasonal forecasting
- Coupled GDPS 10 day forecasts: atmosphere-ocean-ice

- Mercator Ocean Assimilation System SAM2 (SEEK):

- Sea surface temperature **daily**
- Temperature and salinity profiles weekly
- Sea level anomaly from satellite altimeters weekly

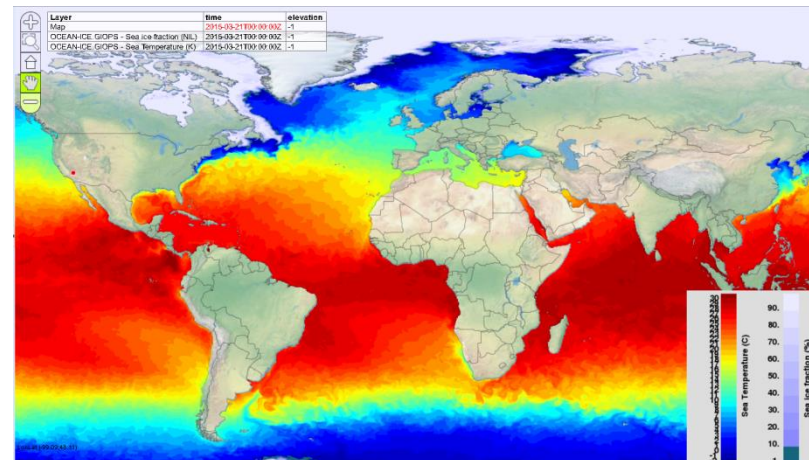
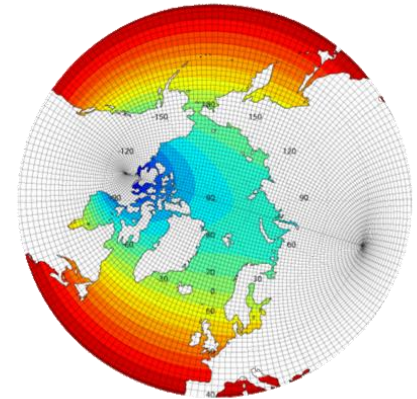
- 3DVar Ice analysis:

- SSM/I, SSM/IS, ASCAT, AVHRR
- CIS charts and image analyses

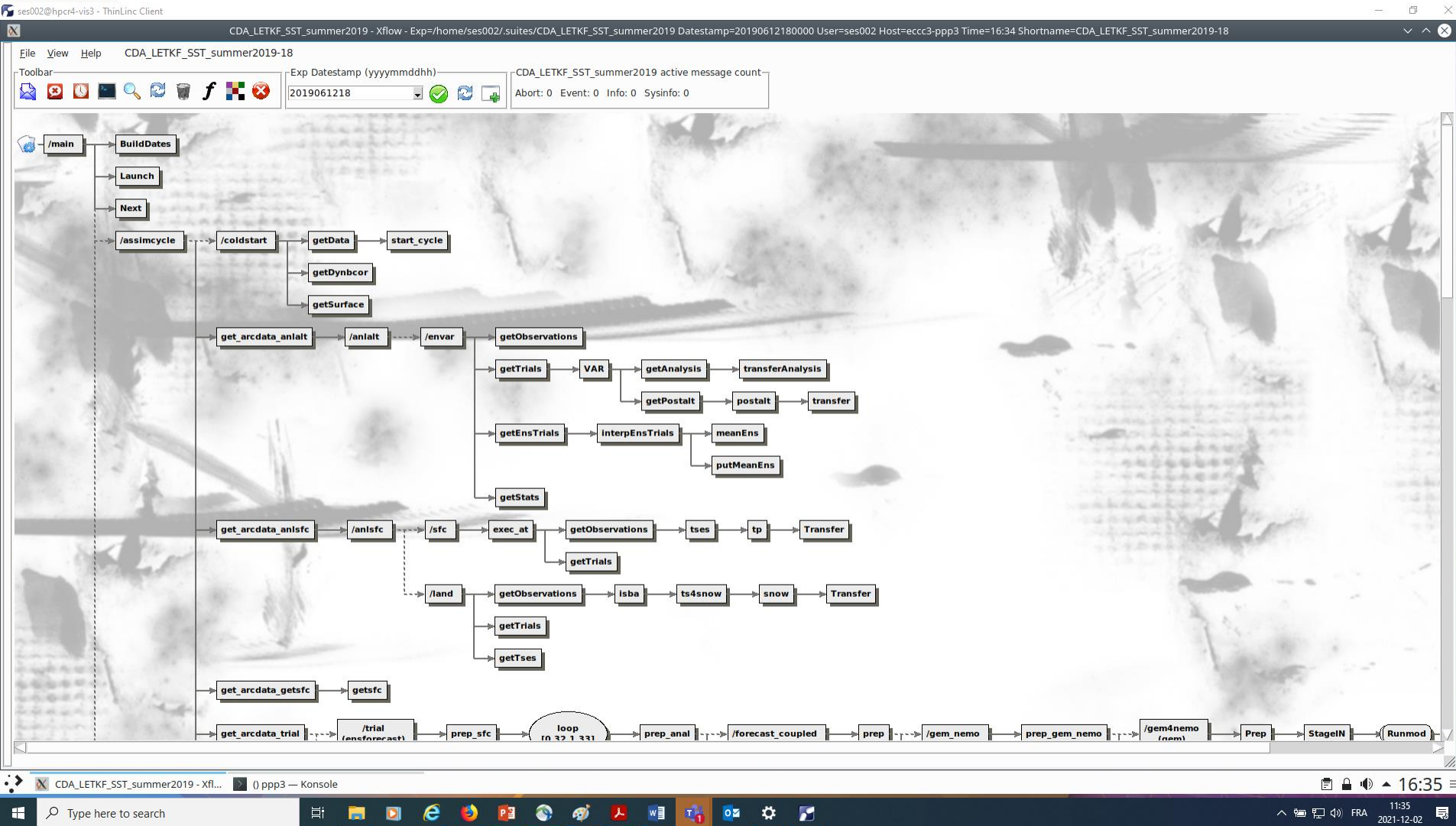
- SST OI analysis:

- in situ data, AVHRR, AMSR-E, ATSR
- foundation SST
- background: previous day analysis

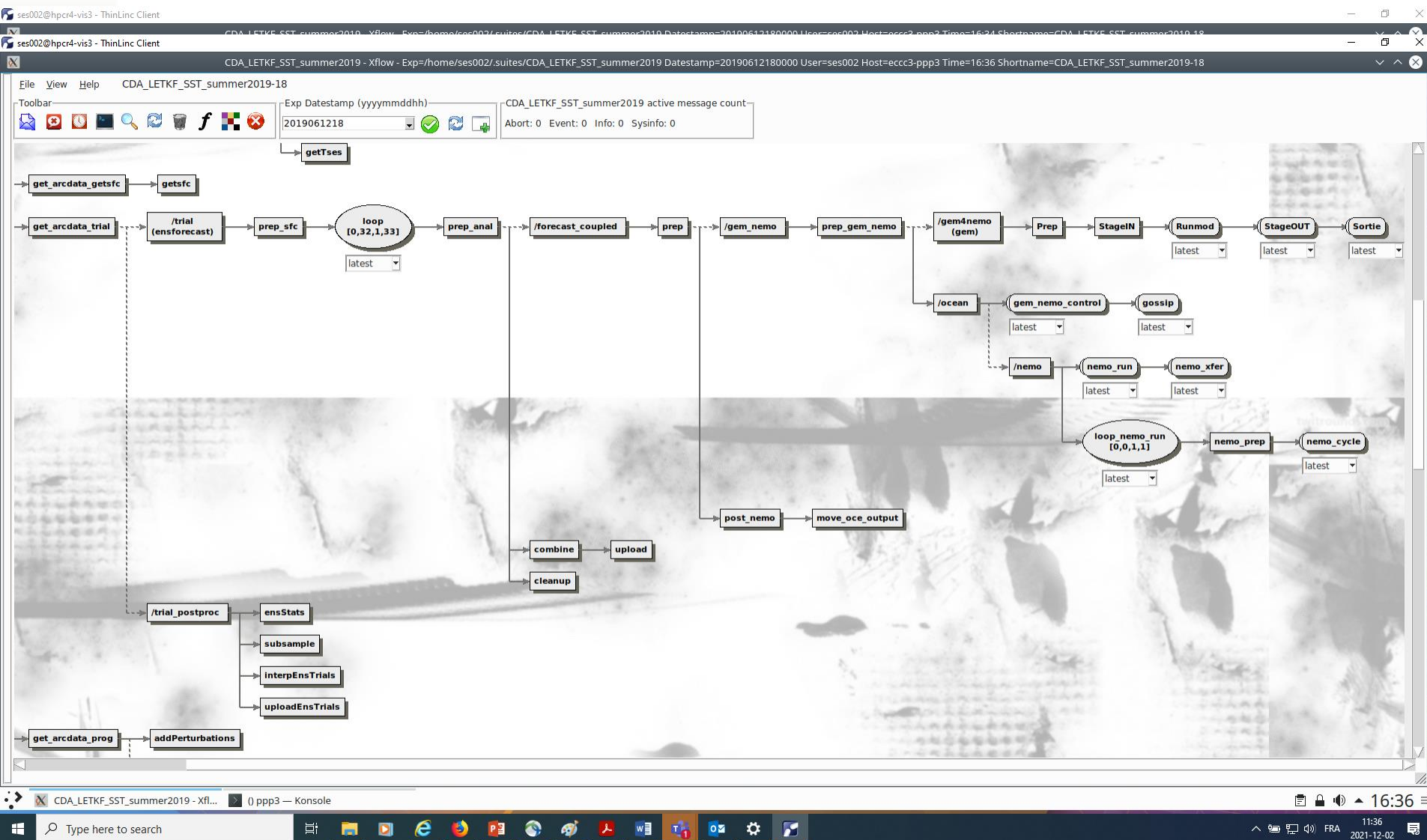
1/4° (ORCAS025)



Cycle launcher: coupled ensemble data assimilation system



Cycle launcher: coupled ensemble data assimilation system



Motivation: Impact of Coupling on Forecasts for Typhoon Neoguri

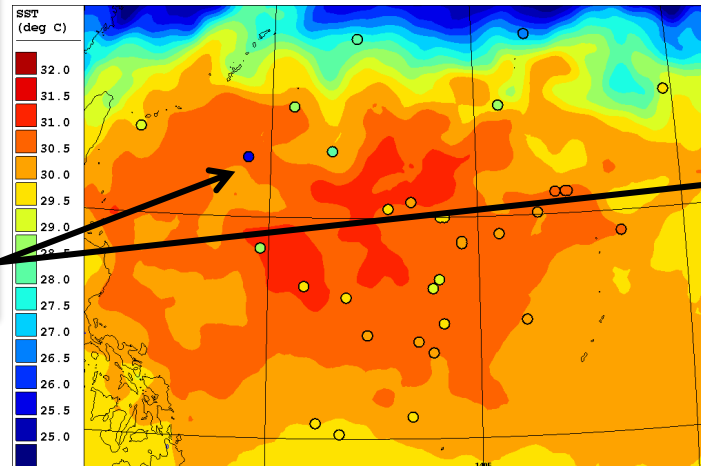
96h forecasts, valid 00Z, July 10, 2014

Smith et al., MWR, 2018

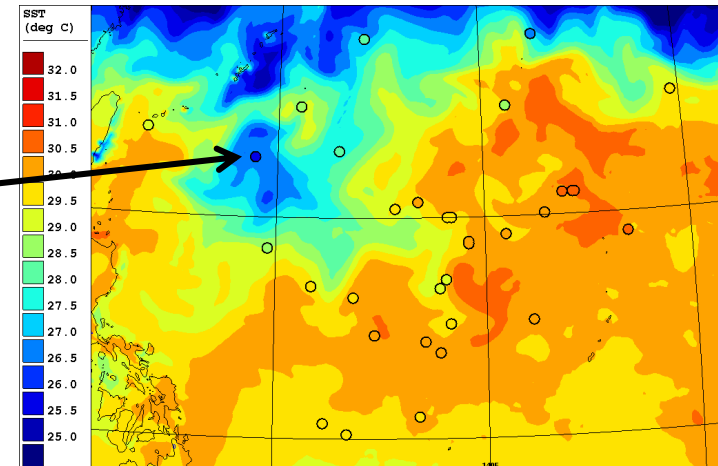
SST from drifter obs.

Much better agreement of cold wake in Coupled forecasts

a) Forced (uncoupled) SST

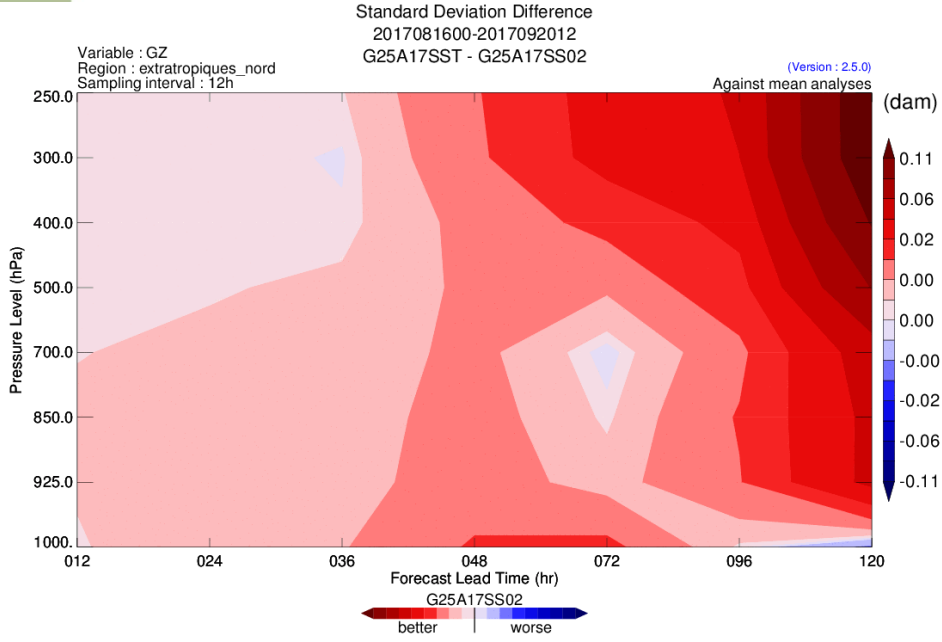
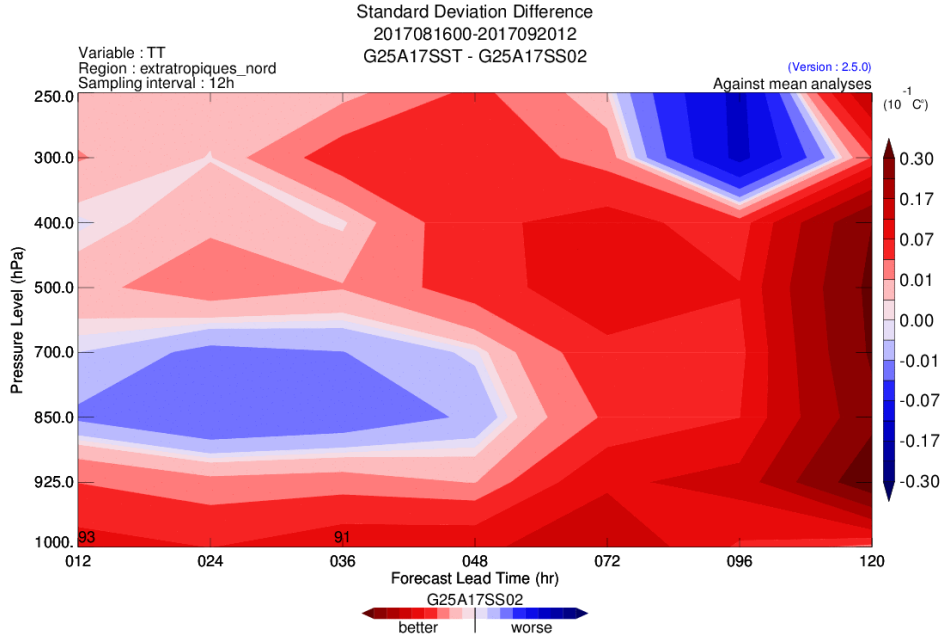


b) Coupled SST



STD difference on atmospheric T and GZ with respect to own analyses as a function of forecast lead time.

Region: Northern Extratropics



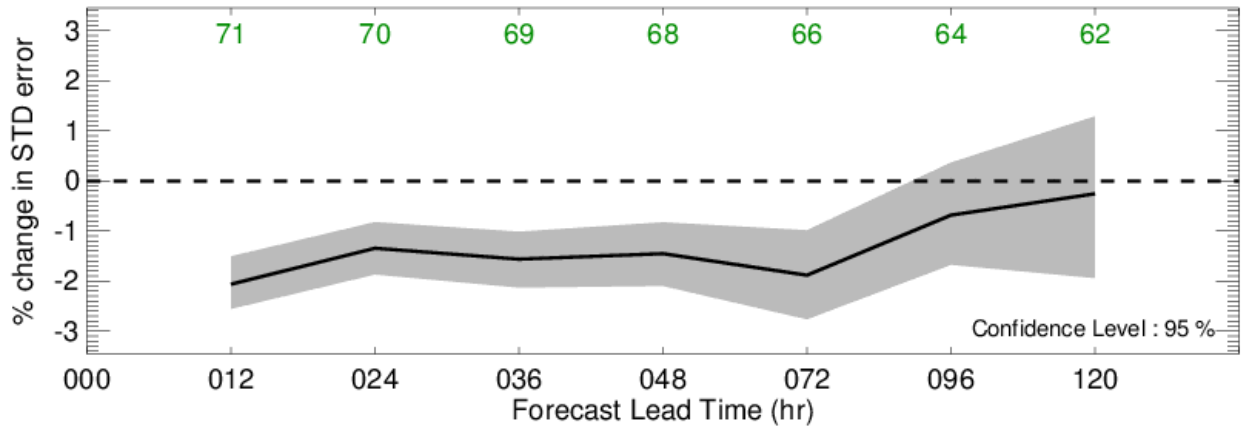
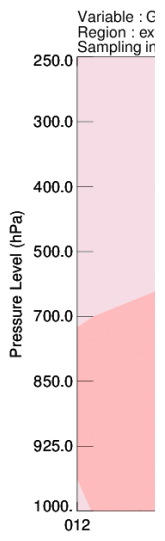
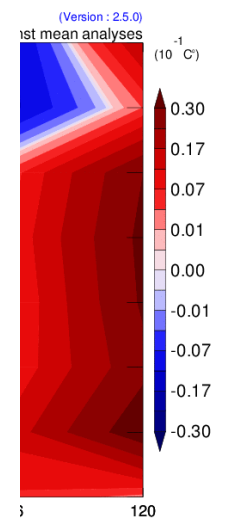
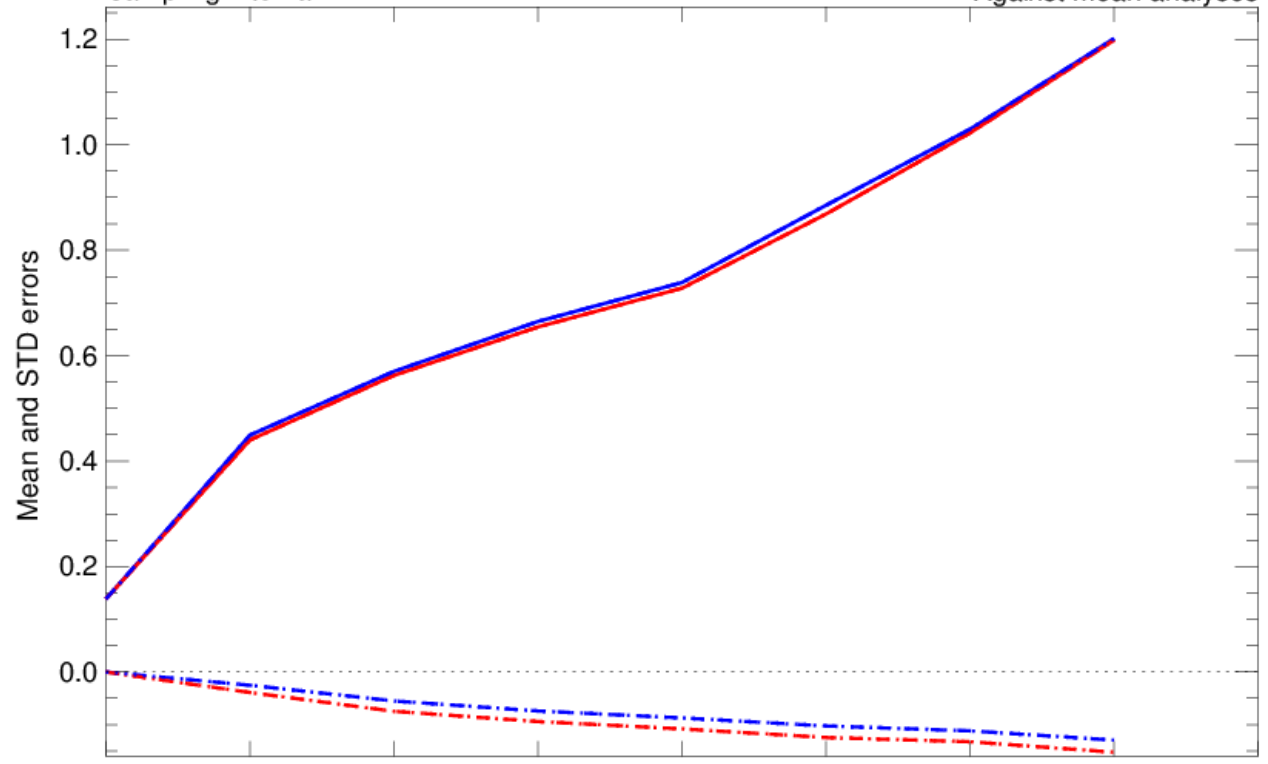
STD dif analyse Region: |

STD and Mean errors against analyses

(Version : 2.5.0)

Variable : TT
Level : 1000 hPa
Region : extratropiques_nord
Sampling interval : 12h

G25A17SS02 —
G25A17SST —
Against mean analyses



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- **Skills**

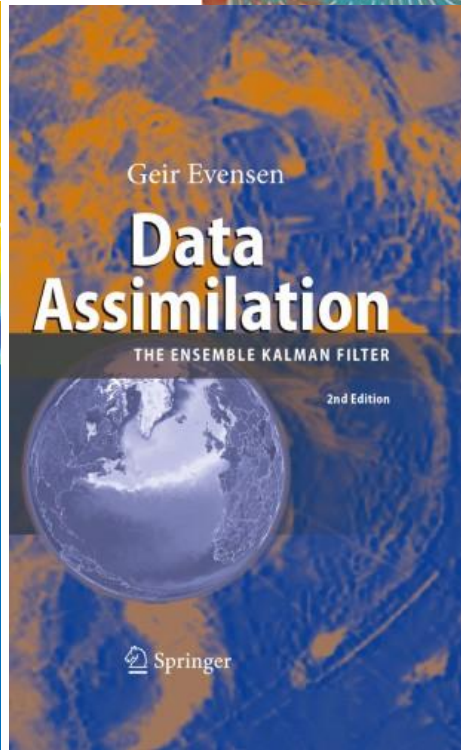
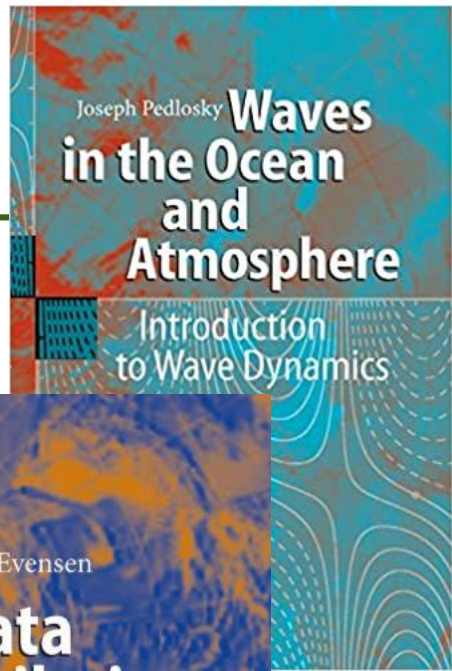
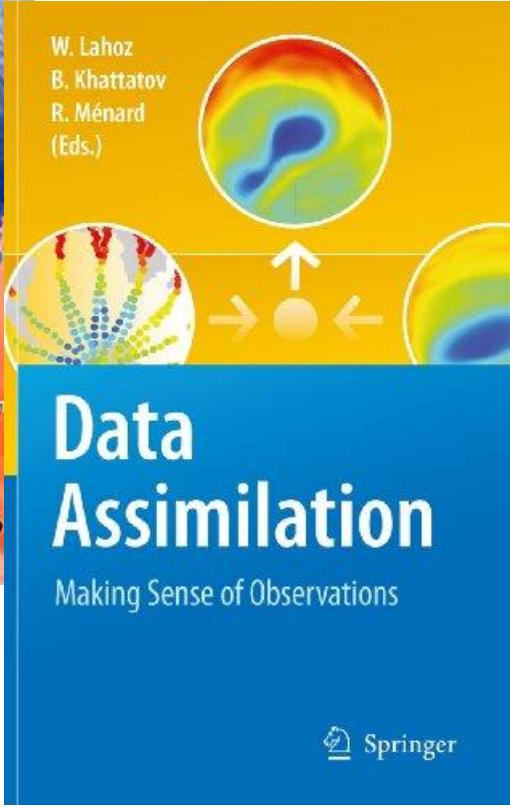
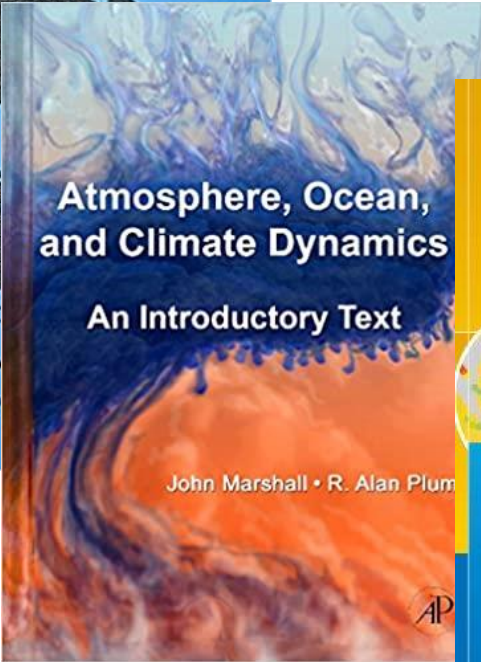
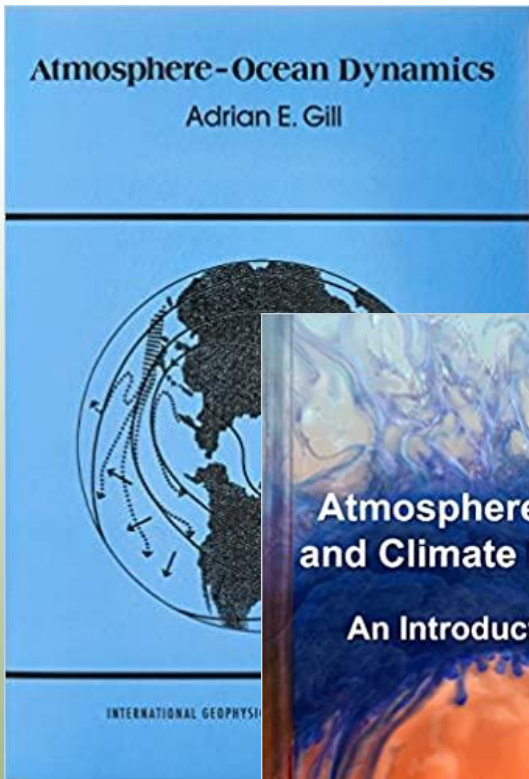


Полезные навыки в нашей работе

- bash / ksh scripting, linux environment
- Fortran
- python
- matrix and variational analysis, numerical modelling methods
- error statistics
- satellite retrieval algorithms
- ocean-ice-atmosphere-waves thermodynamics, interactions
- global ocean/atmosphere circulation
- ЯЗЫКИ



Хорошие книги



Интересные ресурсы

The screenshot shows a Zoom meeting in progress. The main content is a presentation slide titled "Massive On-line Courses - most recent ones" from copernicus.eumetsat.int. The slide features four overlapping browser window screenshots:

- Top Left:** A slide titled "AI FOR EARTH MONITORING" with logos for Copernicus, WEKEO, and EUMETSAT. It lists topics: Water Monitoring, Atmosphere Monitoring, Land Monitoring, and Climate Change.
- Top Right:** A browser window showing the ESA climate office website with a "Massive Open Online Course" banner.
- Bottom Left:** A browser window showing a chapter titled "Chapter: Impact of COVID-19 measures on Atmospheric Composition" by ESA.
- Bottom Right:** A browser window showing a slide titled "Monitoring Atmospheric Composition" with logos for Copernicus, EUMETSAT, and ECMWF.

At the bottom of the Zoom window, there is a control bar with icons for Unmute, Start Video, Participants (116), Share Screen, Chat, Reactions, Settings, and More. A red "Leave" button is visible in the bottom right corner.



ECMWF online courses & trainings

The screenshot shows the ECMWF website's Learning section. The browser address bar displays "European Centre for Medium-... (GB) https://www.ecmwf.int/en/learning". The ECMWF logo is in the top left, and navigation links for Home, About, Forecasts, Computing, Research, Learning, and Publications are in the top right. Below the navigation bar, there are sub-links for Training, Workshops, Seminars, and Education material. The main content area features four columns, each with a representative image and a text description:

- Training:** Image of people at computers. Text: "Our training courses are broken down into modules so that you can take each one separately over a timescale that suits you." Link: "Guidelines for training course applications".
- Workshops and Annual Seminar:** Image of a speaker at a seminar. Text: "We run workshops throughout the year and a week-long Annual Seminar on a specific topic every September." Link: "Past workshops and Annual Seminars".
- Informal seminars:** Image of a meeting. Text: "We regularly organise informal seminars given by internal or external speakers on a range of topics." Link: "Past informal seminars".
- Resources:** Image of hands on a laptop. Text: "We provide learning materials related to our courses and workshops, NWP lecture notes, and eLearning modules." Link: "eLearning - online resources".

At the bottom of the page, there is a row of flags representing various countries and a navigation bar with links for About, Forecasts, Computing, Research, Learning, and Publications.



Спасибо!

Sergey.Skachko@canada.ca

+1 438 391 9750

