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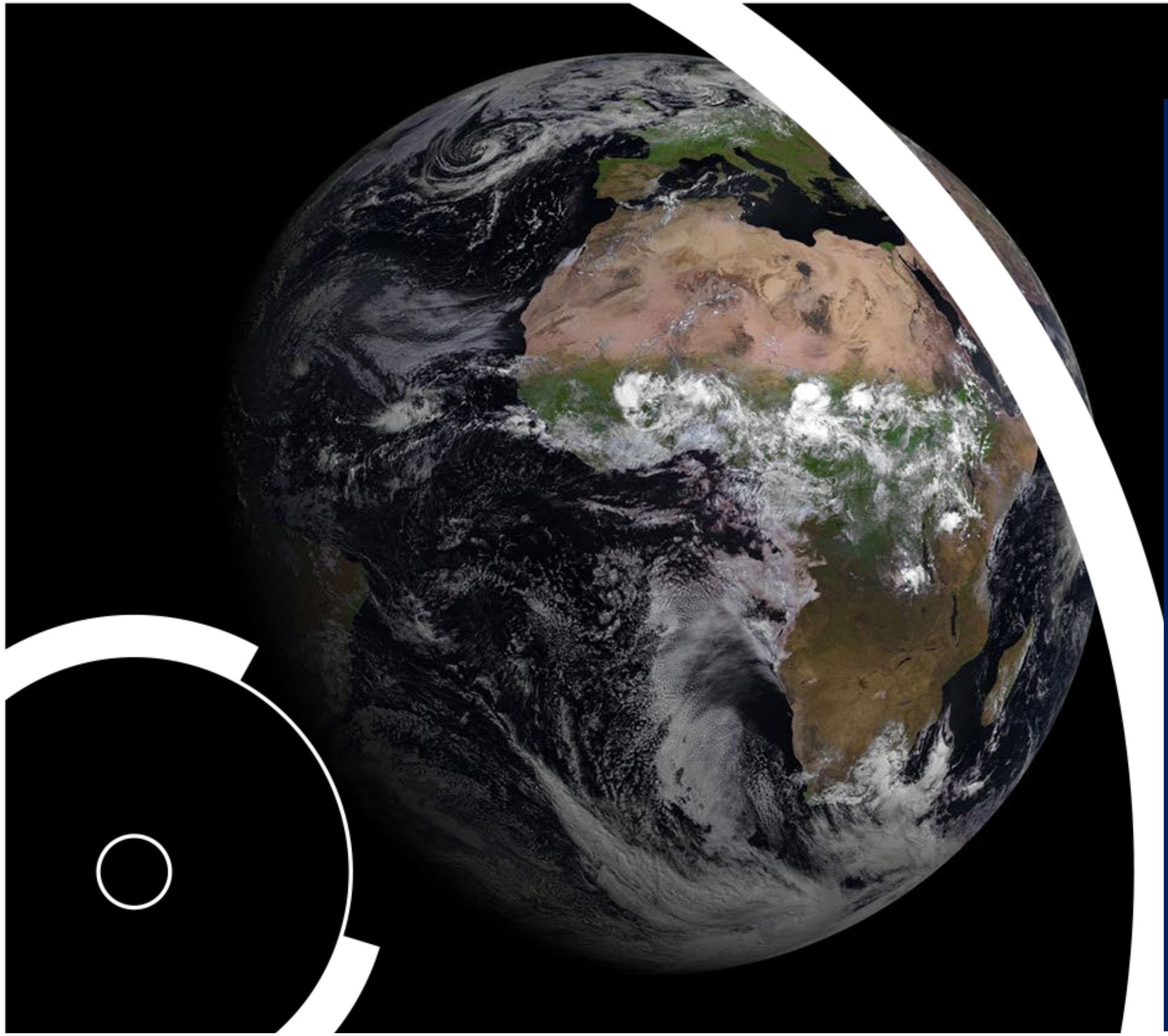

Overview and status of EUMETSAT-supported scientific studies on NWP impact assessments of possible AWS constellation scenarios

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Agenda

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Introduction and Objectives

- ESA **Arctic Weather Satellite** (AWS) is a small (120 kg) satellite with microwave sounding capabilities (19 channels between 54 and 325 GHz) operated in a polar orbit (sun-sychronous).
- An AWS prototype currently planned for launch in 2024 could be a pathfinder mission in expanding the support of the EUMETSAT Polar System Second Generation (EPS-SG) MicroWave Sounder (MWS) mission to global and regional **numerical weather prediction (NWP)** applications.
- ESA and EUMETSAT are cooperating on the preparatory activities that could possibly lead to a constellation of flying AWS recurrent models, providing sounding information on global humidity and temperature profiles to the users in near real time. → See **A. Canestri's Presentation** in **session B5.01.4** Future Meteorological Missions
- The Phase A activities for the constellation definition are currently ongoing at EUMETSAT, and include various complementary NWP impact assessment studies by:
    1. **Météo France, Centre Nationale de Recherches Météorologiques (CNRS);**
    2. **European Centre for Medium-range Weather Forecasts (ECMWF);**
    3. Consortium led by **Met Norway,** including the **Swedish Meteorological and Hydrological Institute (SMHI)** and the **Finnish Meteorological Institute (FMI).**
- Outcome of these studies will serve as input for cost-benefit assessment (socio-economic impact) of the AWS Constellation.
- This presentation provides an overview of the objectives, methods and status of the scientific studies in support to the definition of the AWS Constellation.

AWS Constellation in a nutshell

- The AWS Constellation will focus on:
  - Water vapor sounding
  - Temperature sounding
  - Cloud & precipitation detection

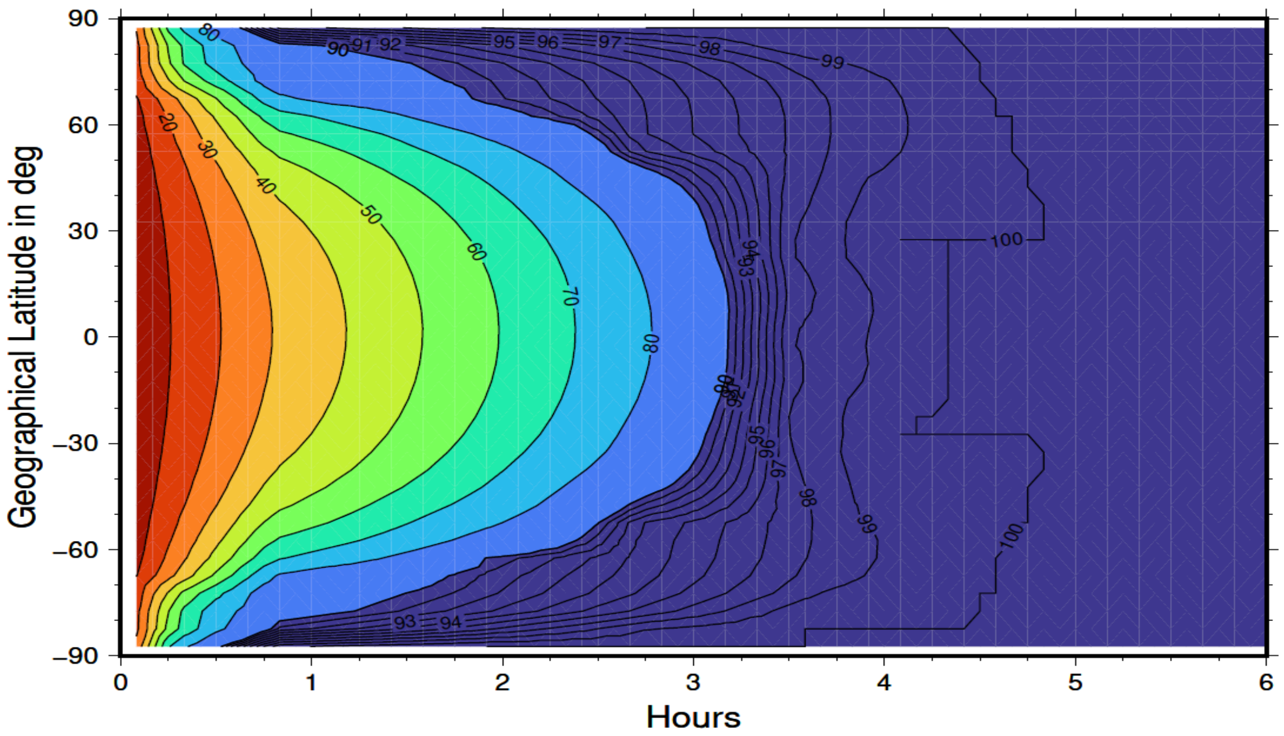
- The primary objectives of the AWS Constellation would be to:
  - Contribute to improved global and regional NWP accuracy
  - Complement the microwave observations from the Metop/Metop-SG and NOAA JPSS (Joint Polar Satellite System) polar-orbiting meteorological satellites

- The mission will also to contribute to nowcasting applications over the Arctic region through the increase the frequency and availability of microwave observations.

- Climate monitoring is not a primary objective of the mission, however AWS is expected to contribute through the provision of long-term data records and implementation of the necessary capabilities.

- Illustration of the **Time-to-Coverage requirement**:

Total Number of AWS Satellites 6
Total Number of AWS Planes 3
without EPS-SG and JPSS
=> Total Number of Satellites 6



This 2D representation can be translated in a global requirement resuming in a single figure the setting of a possible constellation system: e.g. achieving 90% global coverage in X hours.

- *The AWS constellation shall achieve 90% of **global** coverage in 5 hrs (Threshold); 4 hrs (Breakthrough); 3 hrs (Objective);*

Constellation scenarios

		Nr. of satellites	Nr. of planes and satellites over planes	Local Time of Descending Node
Baseline scenario (OP3-6SAT)		6	3 orbital planes, 2 satellites *per* plane, relative phasing 180 degrees	Plane 1 (P1) – 3:30 LTDN Plane 2 (P2) – 11:30 LTDN Plane 3 (P3) – 7:30 LTDN
Degraded case #1 (OP3-4SAT)		4	3 orbital planes, 1 satellite *per* plane	Plane 1 (P1) – 3:30 LTDN Plane 2 (P2) – 11:30 LTDN Plane 3 (P3) – 7:30 LTDN
Degraded case #2 (OP2-4SAT)		4	2 orbital planes, 2 satellites *per* plane, relative phasing 180 degrees	Plane 1 (P1) – 3:30 LTDN Plane 2 (P2) – 11:30 LTDN
Baseline – minimum (OP3-4SAT)		4	3 orbital planes, 1 or 2 satellites *per* plane	Plane 1 (P1) – 3:30 LTDN Plane 2 (P2) – 11:30 LTDN Plane 3 (P3) – 7:30 LTDN
Augmented baseline (OP4-8SAT)		8	4 orbital planes, 2 satellites *per* plane, relative phasing 180 degrees	Plane 1 (P1) – 3:30 LTDN Plane 2 (P2) – 11:30 LTDN Plane 3 (P3) – 7:30 LTDN Plane 4 (P4) – 5:30 LTDN

These scenarios have been selected to explore various possible Time-to-Coverage configurations

Global NWP assessment - CNRS/Météo France

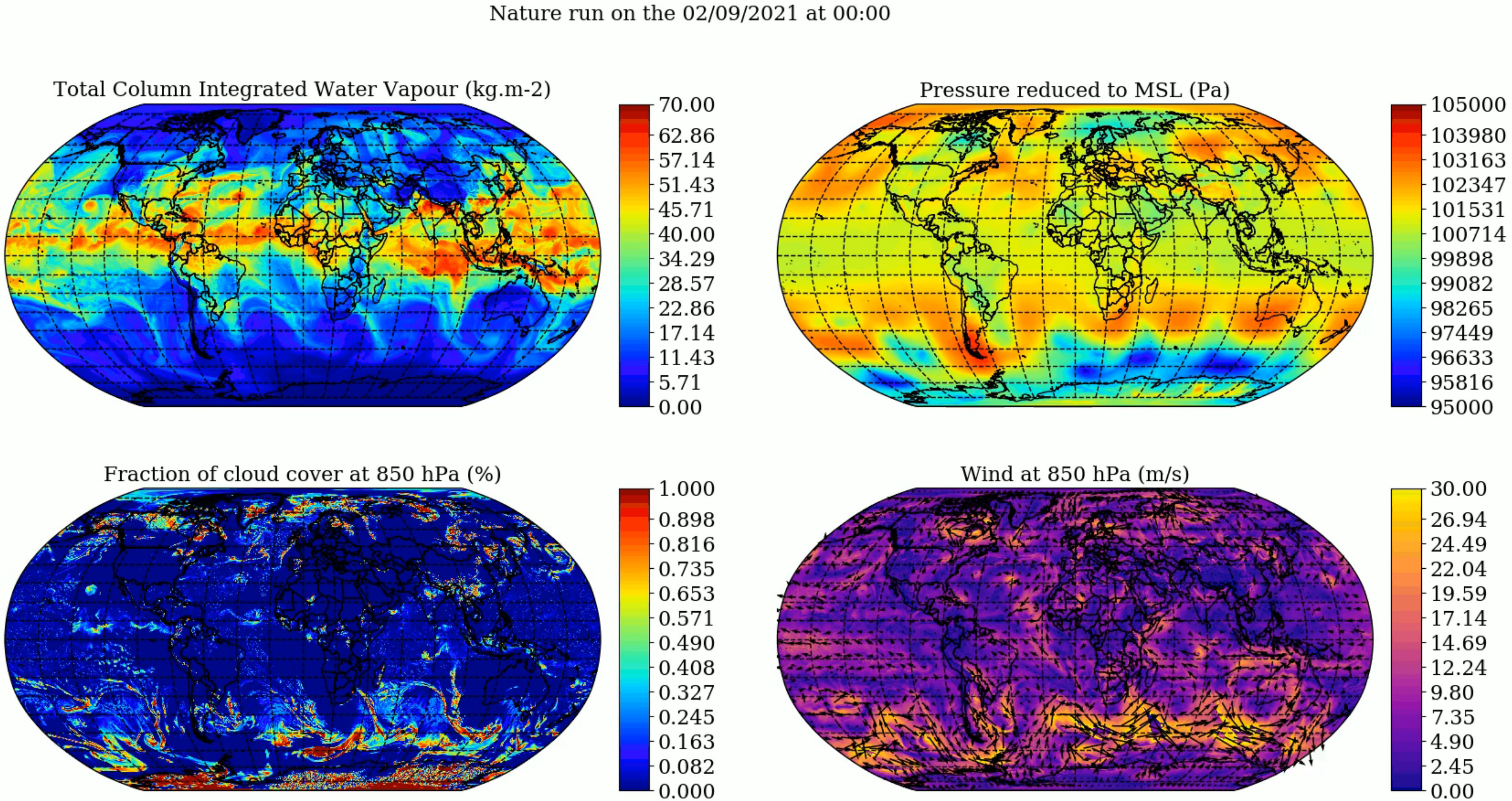
- **CNRS/Météo France** uses the **Observing System Simulation Experiment** (OSSE) approach by simulating all observations from a reference forecast - the nature run – taken as truth.

- Simulated AWS observations are assimilated (all-sky approach) in the ARPEGE (Action de Recherche Petite Echelle Grande Echelle) 4D-Var system, and the day-to-day analysis/forecast errors are collected

- The statistics of the analysis/forecast errors are computed by averaging over the selected time interval

- “Calibration” of the system is a critical step: all the simulated observations in the reference system shall have statistics comparable with the statistics from the equivalent real observations - necessary to provide realistic impact evaluation

Nature run – example CNRS/Météo France



Courtesy Météo France – Louis Rivoire

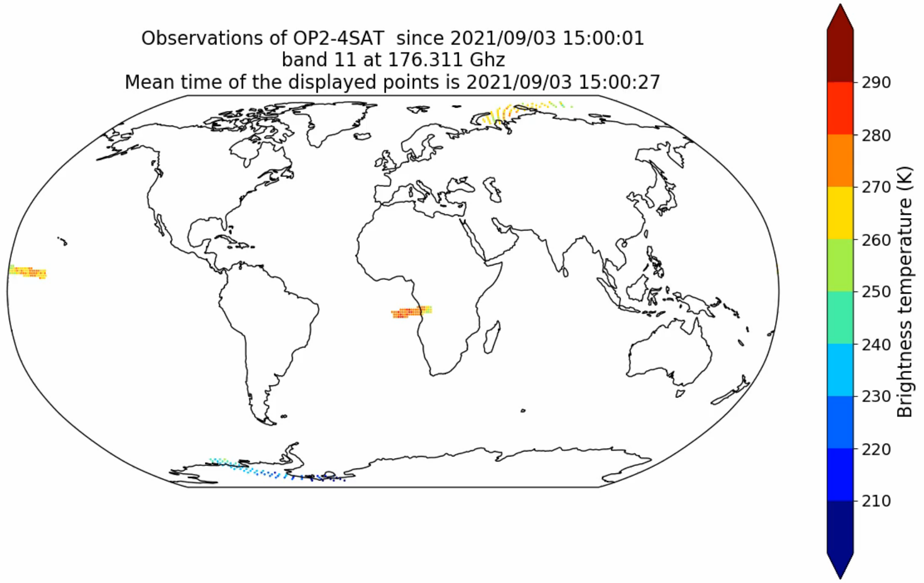
Status – CNRS/Météo France

- Computation of the Nature Run completed (both summer 2021 and winter 2021/22)

Ongoing:

- OSSE calibration (adjustment of the Nature Run) using real observations
- Integration of AWS Constellation within the assimilation system
- Initial focus on temperature and water vapour sounding channels

- First results expected by the end of 2022, study to be completed by summer 2023



Courtesy Météo France – Louis Rivoire

Global NWP assessment - ECMWF

- ECMWF uses the Ensemble of Data Assimilations (EDA) method by simulating the new AWS observations on top of real observations.

- Based on the assumed observation/forecast model error statistics, the EDA method estimates the analysis and forecast error covariance matrices (rather than the actual forecast errors).

- The Spread (variance) of ensemble members for EDA experiments for each analysis/forecast time provides information on the impact of the new observations (less spread => analysis closer to real observations => less uncertainty in forecasts => positive impact).

- EDA spread is assessed when simulated AWS data are added to the operational global observing system → AWS observations impact. This approach has been already explored during a previous ESA-funded study.

Global NWP assessment - ECMWF

- 4-week study period of 1-28 July 2019 will be used for all EDA experimentation
- EDA experimentation will use a standard 10-member configuration
- All spread analyses will be based on 12-hour forecasts, as this maximises the signal to be analysed
- Assimilation of the new AWS observations based on ECMWF's all-sky approach, covering clear, cloudy, and precipitating scenes

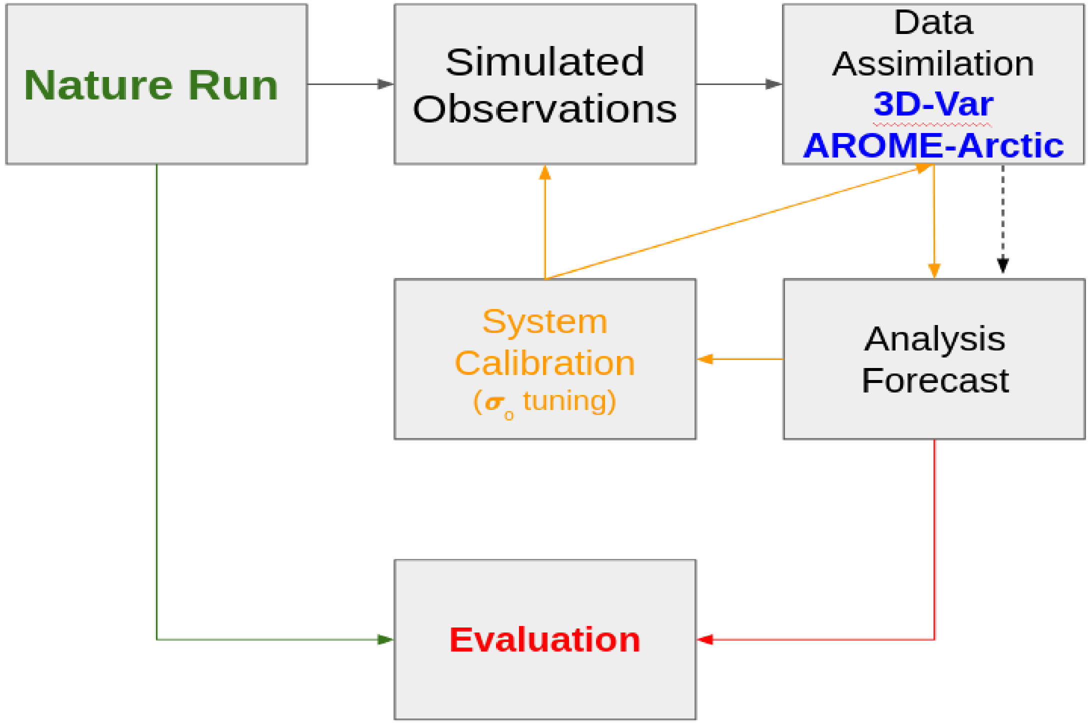
Status - ECMWF

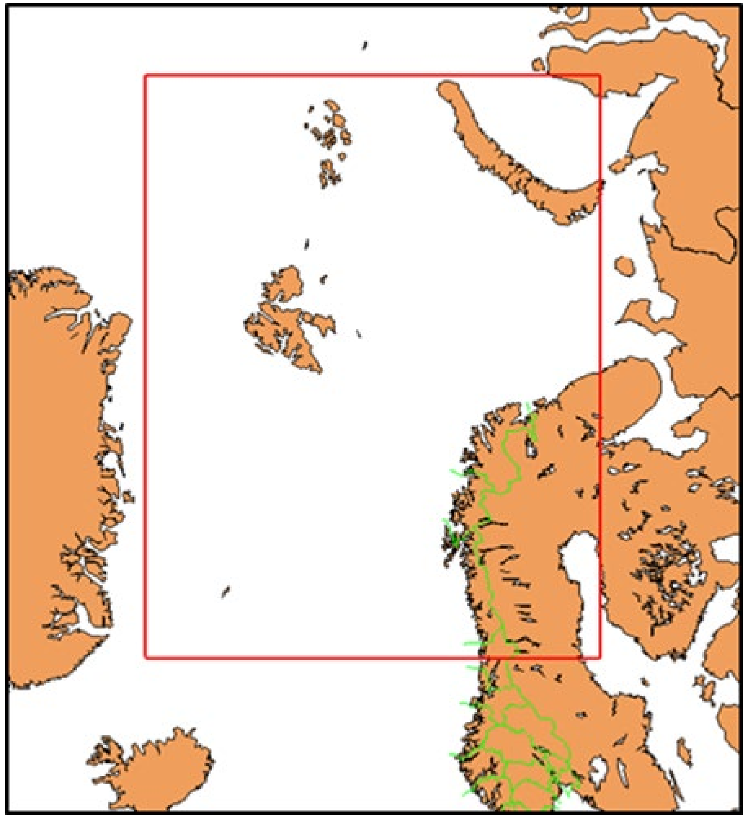
- Kick-off of activities on 25 April 2022 – initial scenarios agreed and consistent with the ones used in the Météo France study.
- Ongoing:
  - Integration of AWS observations into the ECMWF assimilation system
  - Initial focus on T and Q sounding channels, use of 325 GHz at a later stage
- Some results expected by the end 2022, study to be completed by summer 2023.
- Also Doppler Wind Lidar assessment performed (as separate activity).

Regional NWP high latitudes – Met Norway, SMHI, FMI

- OSSE assessment using the AROME-Arctic regional NWP model (under Met Norway lead)
- Considering nowcasting applications (SMHI lead)
- Downstream socio-economic impact (FMI lead)
- Kick-off planned on 30 May 2022

- Regional OSSE (3D-Var, clear sky microwave sensor data assimilation)





AROME (Applications de la Recherche l'Opérationnel à Méso-Echelle)-Arctic domain

- Nature Run provided by Météo France

Summary and Outlook

- Three different and complementary NWP impact studies:

1. **CNRS/Météo France** (global OSSE)
2. **ECMWF** (global EDA)
3. **Met Norway, SMHI** and **FMI (regional OSSE + Nowcasting assessment + socio-economic impact at high latitudes)**

- First impact assessments expected by Q3/Q4 2022

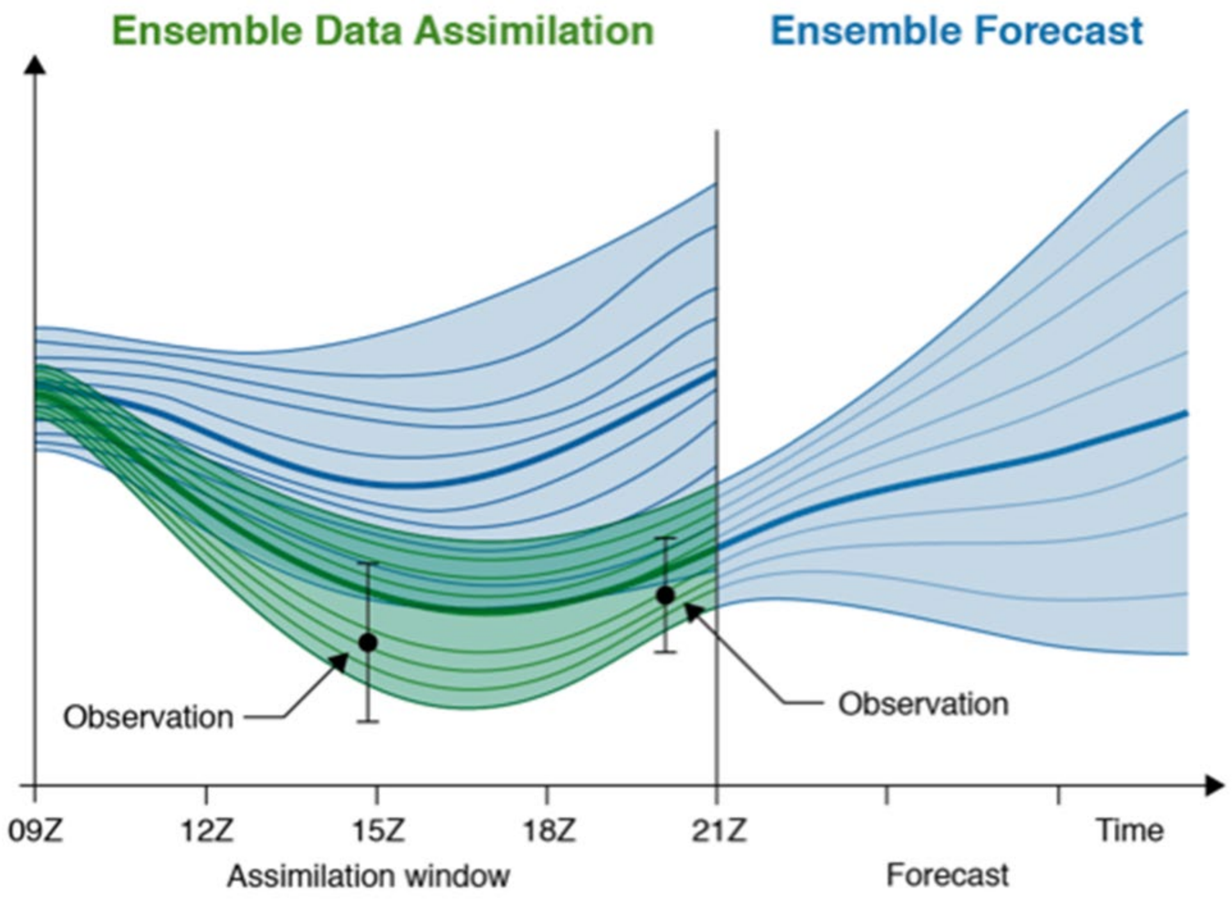
Thank you!

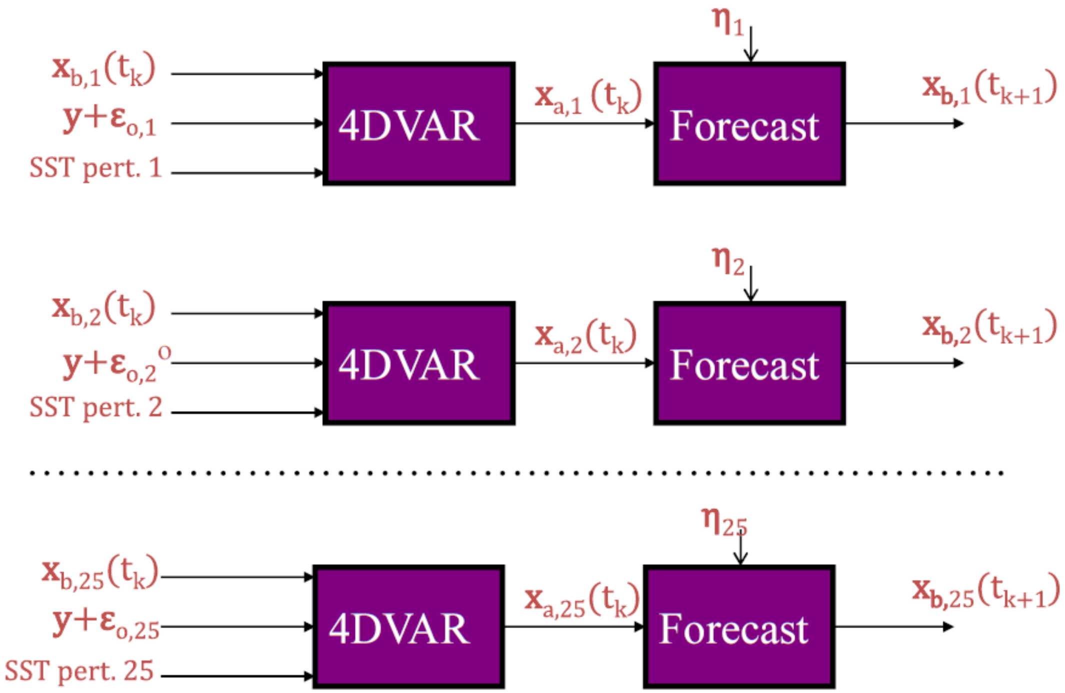
Questions are welcome.

Back up slides

AWS payload channels and performance requirements

Channel	Frequency (GHz)	Bandwidth (MHz)	NEΔT (K)	Footprint (km)	Utilisation
AWS-11	50.3	180	<0.6	≤ 40 km	Temperature sounding
AWS-12	52.8	400	<0.4	≤ 40 km	Temperature sounding
AWS-13	53.246	300	<0.4	≤ 40 km	Temperature sounding
AWS-14	53.596	370	<0.4	≤ 40 km	Temperature sounding
AWS-15	54.4	400	<0.4	≤ 40 km	Temperature sounding
AWS-16	54.94	400	<0.4	≤ 40 km	Temperature sounding
AWS-17	55.5	330	<0.5	≤ 40 km	Temperature sounding
AWS-18	57.290344	330	<0.6	≤ 40 km	Temperature sounding
AWS-21	89	4000	<0.3	≤ 20 km	Window and Cloud detection
AWS-31	165.5	2800	<0.6	≤ 10 km	Window/humidity sounding
AWS-32	176.311	2000	<0.7	≤ 10 km	Humidity sounding
AWS-33	178.811	2000	<0.7	≤ 10 km	Humidity sounding
AWS-34	180.311	1000	<1	≤ 10 km	Humidity sounding
AWS-35	181.511	1000	<1	≤ 10 km	Humidity sounding
AWS-36	182.311	500	<1.3	≤ 10 km	Humidity sounding
AWS-41	325.15±1.2	800	<1.7	≤ 10 km	Humidity sounding/cloud detection
AWS-42	325.15±2.4	1200	<1.4	≤ 10 km	Humidity sounding/cloud detection
AWS-43	325.15±4.1	1800	<1.2	≤ 10 km	Humidity sounding/cloud detection
AWS-44	325.15±6.6	2800	<1	≤ 10 km	Humidity sounding/cloud detection





$$s = \sqrt{\mathbb{E}\left[\sigma_d^2\right]} = \sqrt{\frac{1}{D}\sum_{d=1}^{D}\left(\frac{1}{N-1}\sum_{n=1}^{N}\left(x^n-\overline{x}\right)^2\right)}$$