



ESA-ECMWF Data Exchange for Earth System Insight

A (very) short story of symbiosis in science

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Steve English & Philippe Goryl

ECMWF & ESA

21 Years of Co-operation



APPLICATIONS

ESA and ECMWF sign agreement to exchange information and expertise

01/06/2005 1405 VIEWS 0 LIKES

ECMWF
Council
60th session
Item 7.6

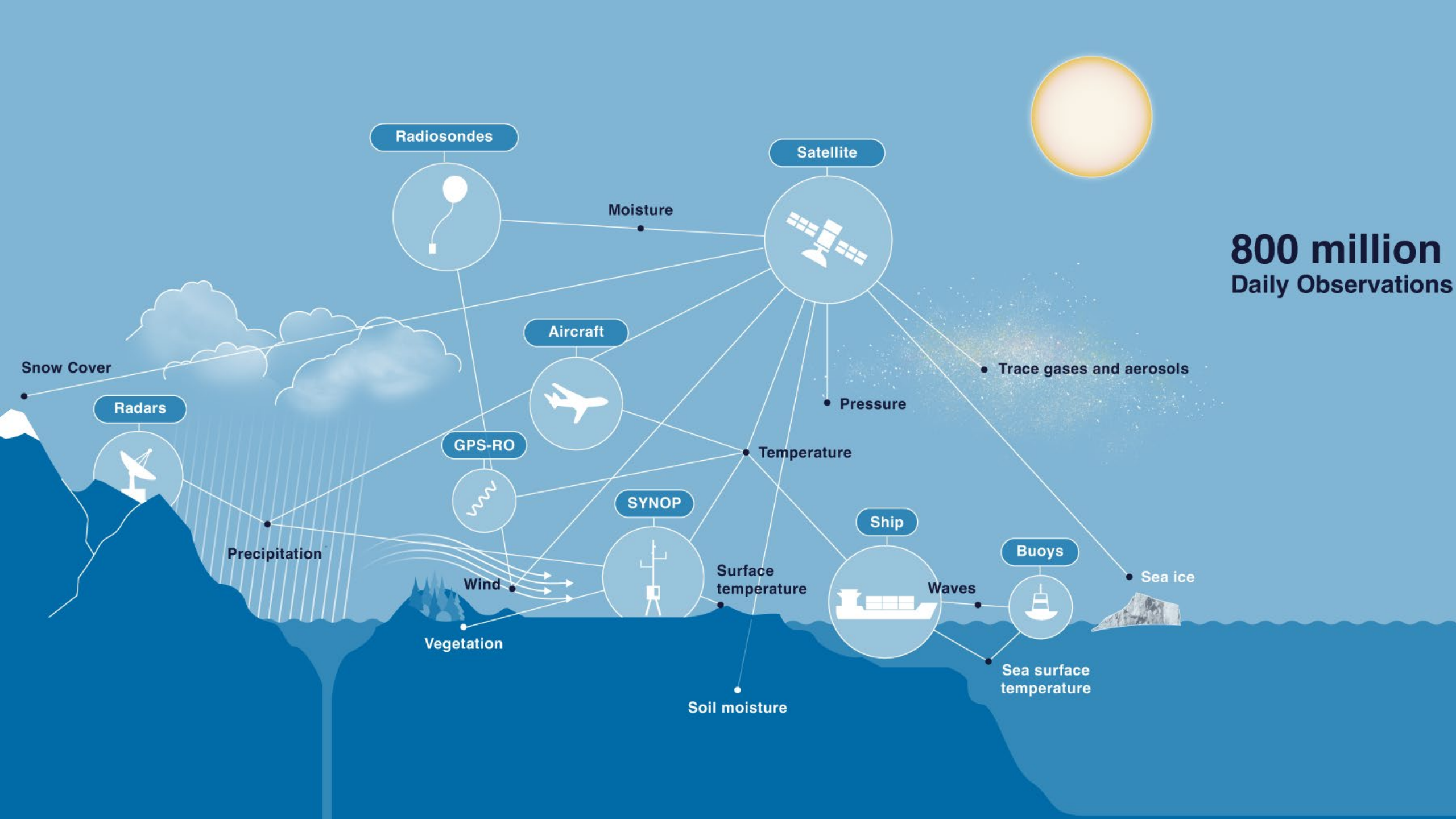


ECMWF/C/60(04)15
Reading, 6 May 2004
Original: English

Subject:	Matters concerning States and international organisations <i>7.6 Consideration of a co-operation agreement with the European Space Agency (ESA)</i>
Action required:	The Council authorise the Director to negotiate a co-operation agreement with ESA
Majority required:	Two-thirds majority: Article 6(3)(k) of the Convention
Views of Committees:	-
Budgetary implications:	-

Co-operation Agreement signed between ECMWF and ESA in June 2004.

The agreement was later extended indefinitely in December 2009.

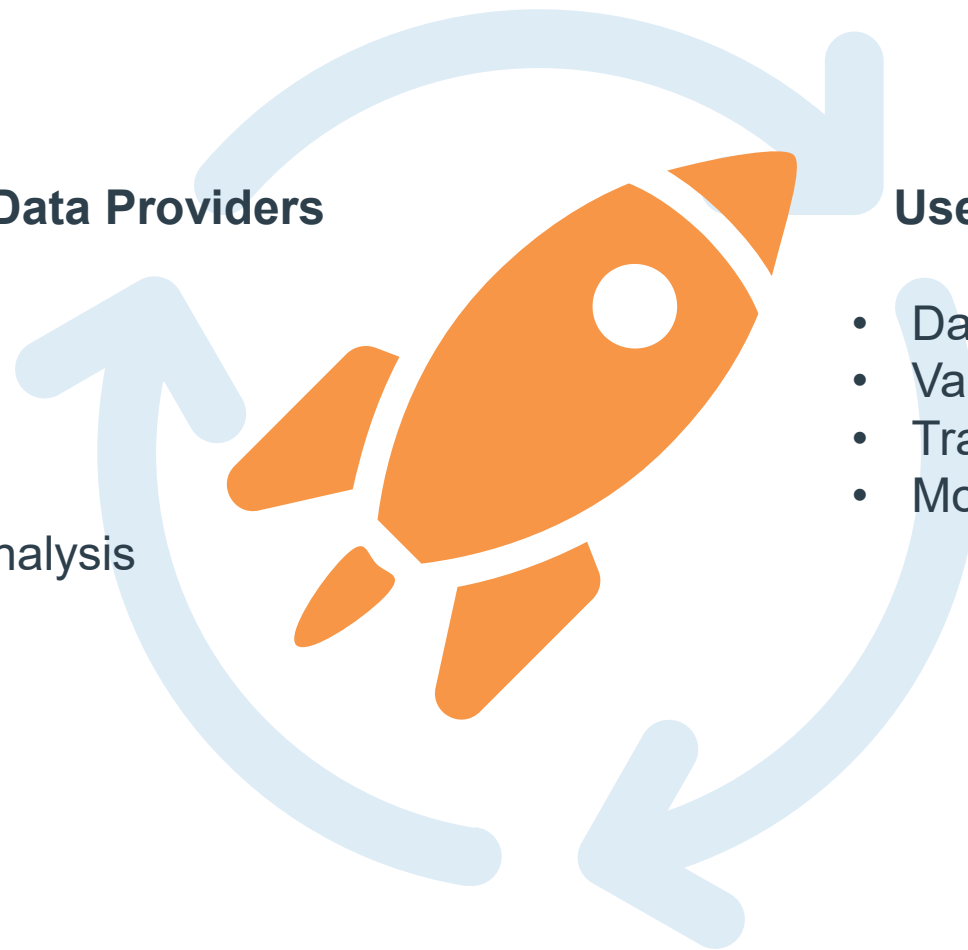


800 million
Daily Observations

A beneficial symbiotic relationship

Use of NWP by Satellite Data Providers

- Calibration & validation
- Enhancing algorithms
- System development
- Error characterisation
- Atmospheric profiling and analysis



Use of Satellite Data by NWP Providers

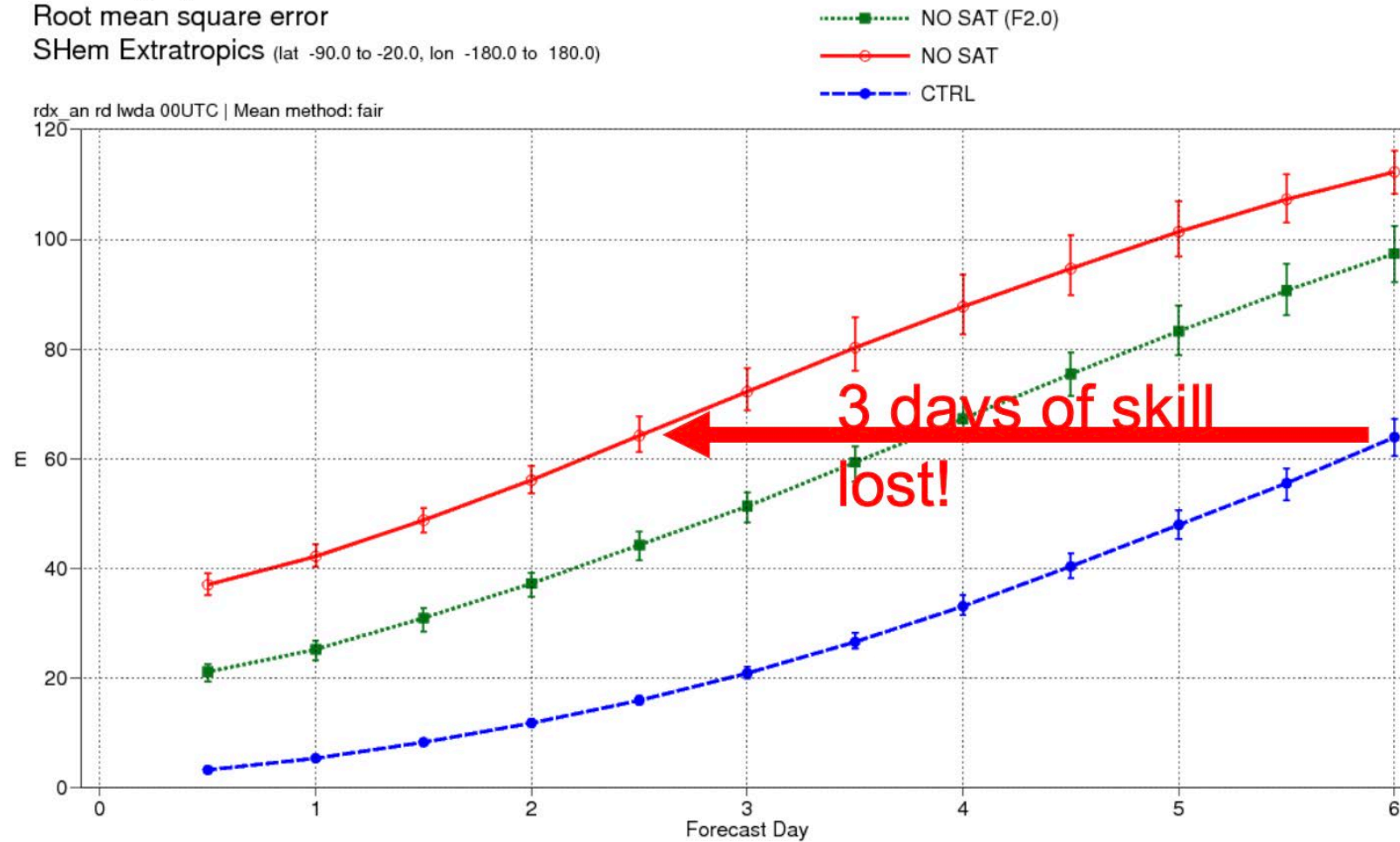
- Data assimilation
- Validation
- Tracking via imagery
- Model improvement

Impact of Satellites on Weather Forecasts

500hPa geopotential
Root mean square error

SHem Extratropics (lat -90.0 to -20.0, lon -180.0 to 180.0)

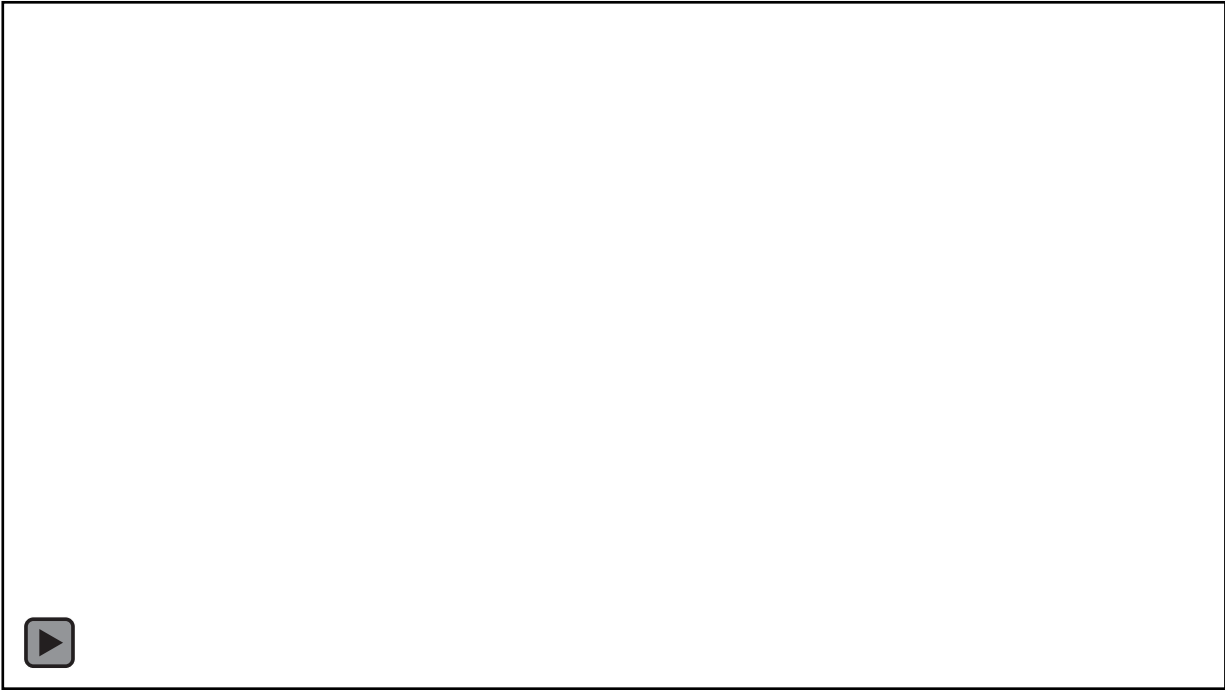
rdx_an rd lwda 00UTC | Mean method: fair



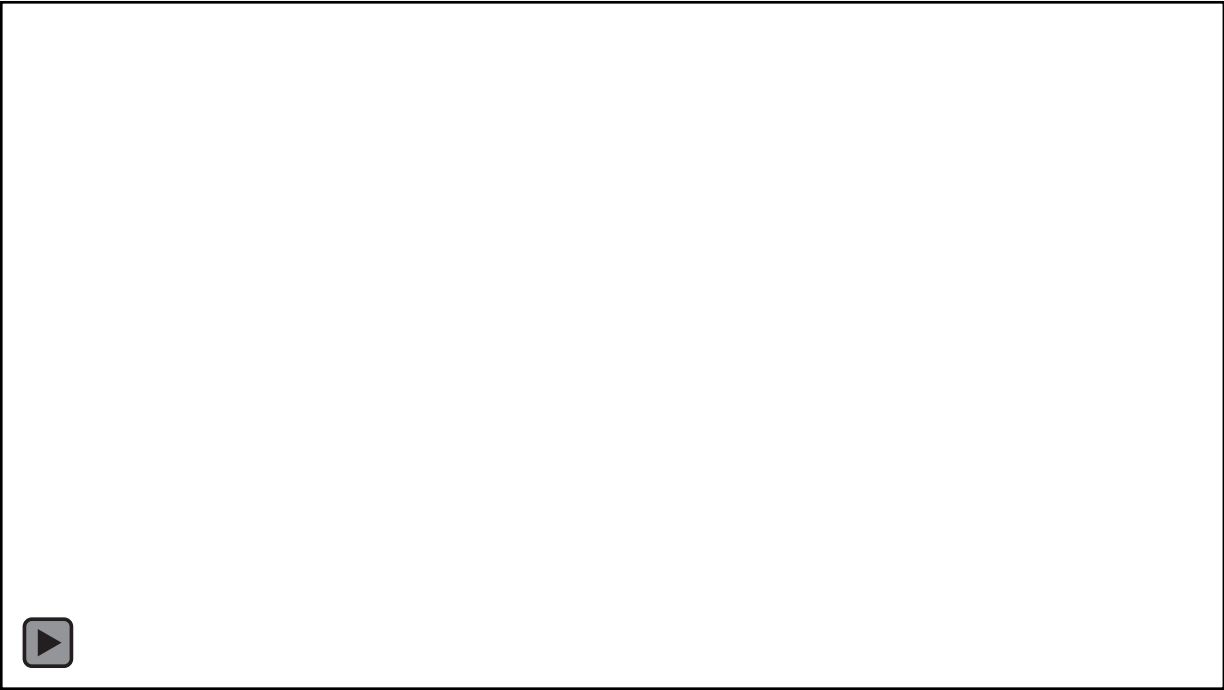
S. Healy

Impact of Satellites on Weather Forecasts

Hurricane Irma with Satellite Data



Hurricane Irma without Satellite Data

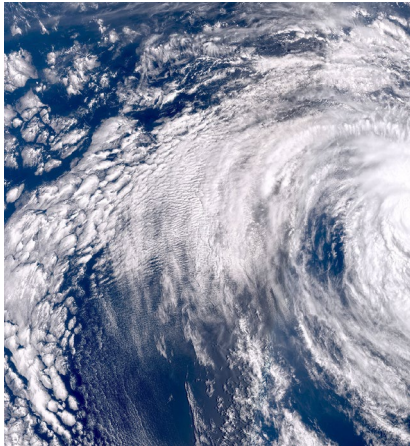


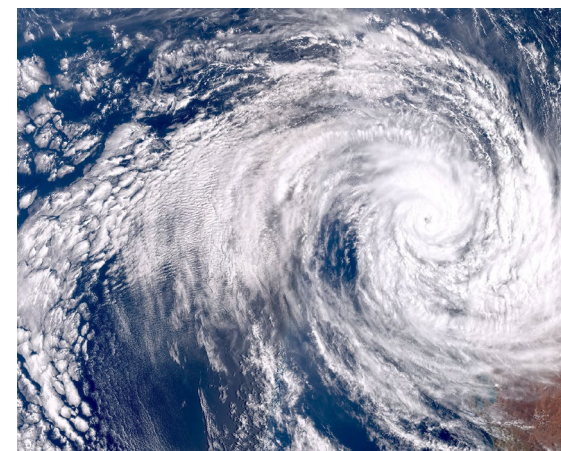
Irma caused an estimated **\$77 billion in damages** and more than **130 fatalities in 2017**, in Barbuda (50% people became homeless), other Caribbean islands and the USA.

Data Transfer ECMWF → ESA

- **1.87 TB** per day **produced** for ESA operations (or subcontractors where applicable)
- **13 destinations** and **61 feeds**
- Data flows managed by Interface Control Documents (ICDs) and reviewed annually in the "Science & Tech" meetings

First workshop on visible radiance assimilation for NWP

- Held at ESRIN on March 4-6, 2025, hosted by Philippe Goryl and his team
 - Co-organized by Ben Johnson (JCSDA) and Angela Benedetti (ECMWF) and supported by colleagues involved in the ISSI team on VIS and near IR radiance assimilation (<https://teams.issibern.ch/frameworkdataassimilation/>)
 - 20 in-person + 8 online participants from various NWP centres (NOAA, NCAR, JCSDA, JMA, IMD, CMA, DWD, MetOffice, ECMWF)
 - Presentations from ESA and EUMETSAT on current and future optical missions
 - Presentations from radiative transfer experts on current and future observation operator capabilities
 - Presentations from NWP centres on current status and future plans for visible radiance assimilation
 - Lots of stimulating discussions including on role of AI in this context
 - Next in-person workshop planned for 2027
- 
- A satellite image of a tropical cyclone, showing a well-defined eye and spiral cloud bands over a dark blue ocean. The image is positioned on the right side of the slide, partially overlapping the bottom right corner of the text area.



Sentinel-3 OLCI on Jan 20, 2025
<https://www.eumetsat.int/image-week-cyclone-sean>

Mission Examples

SMOS Mission

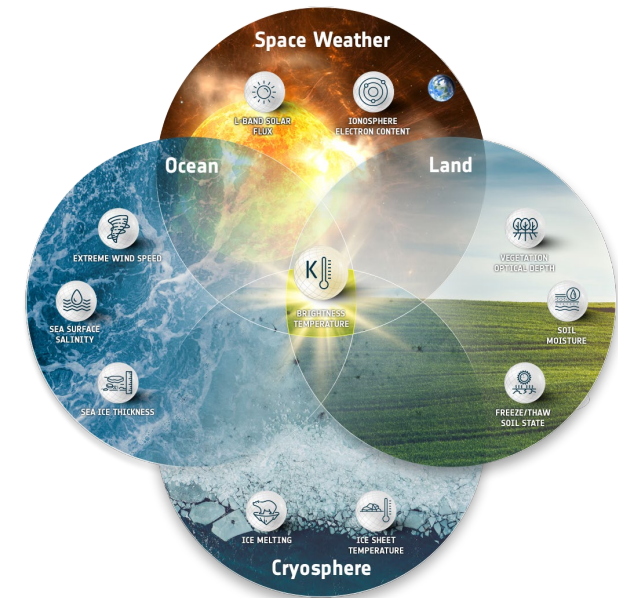


Launched on 2 Nov 2009 by ESA, in operation from +15 years!

Soil Moisture and Ocean Ssalinity (SMOS) mission provides L-band measurements relevant for:

- soil moisture
- sea surface salinity
- thin sea ice thickness
- vegetation optical depth
- high winds
- freeze/thaw soil state
- Relevant contribution for RFI management

SMOS has been extended up to 2028.



Data Access: <https://earth.esa.int/eogateway/missions/smos/data>

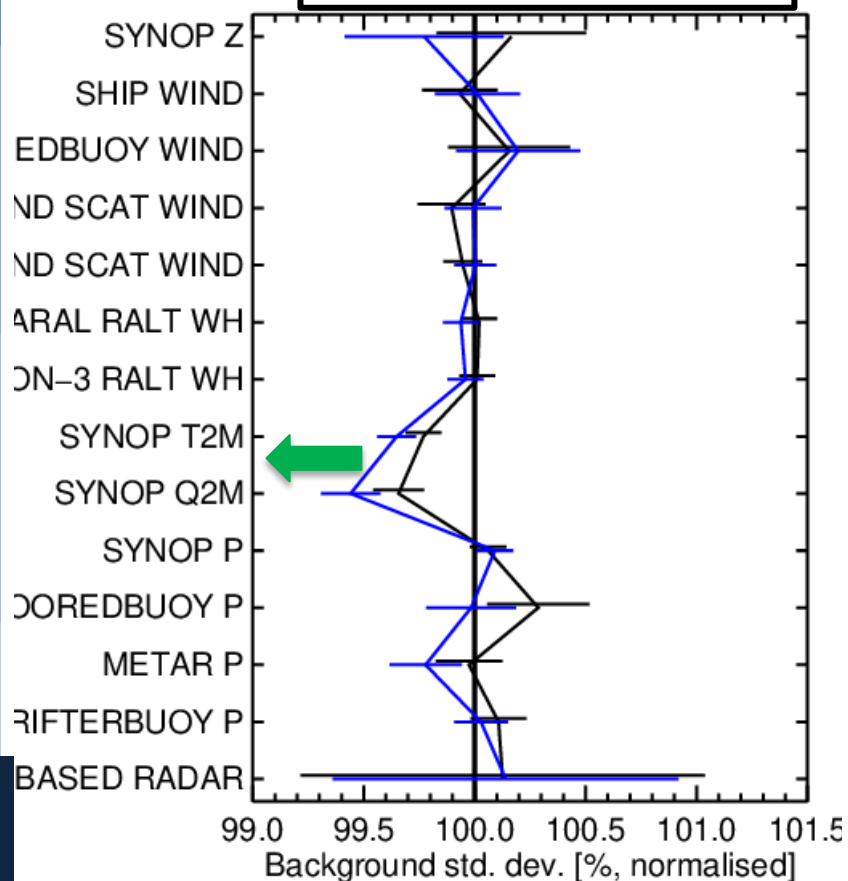


More info: <https://earth.esa.int/eogateway/missions/smos>

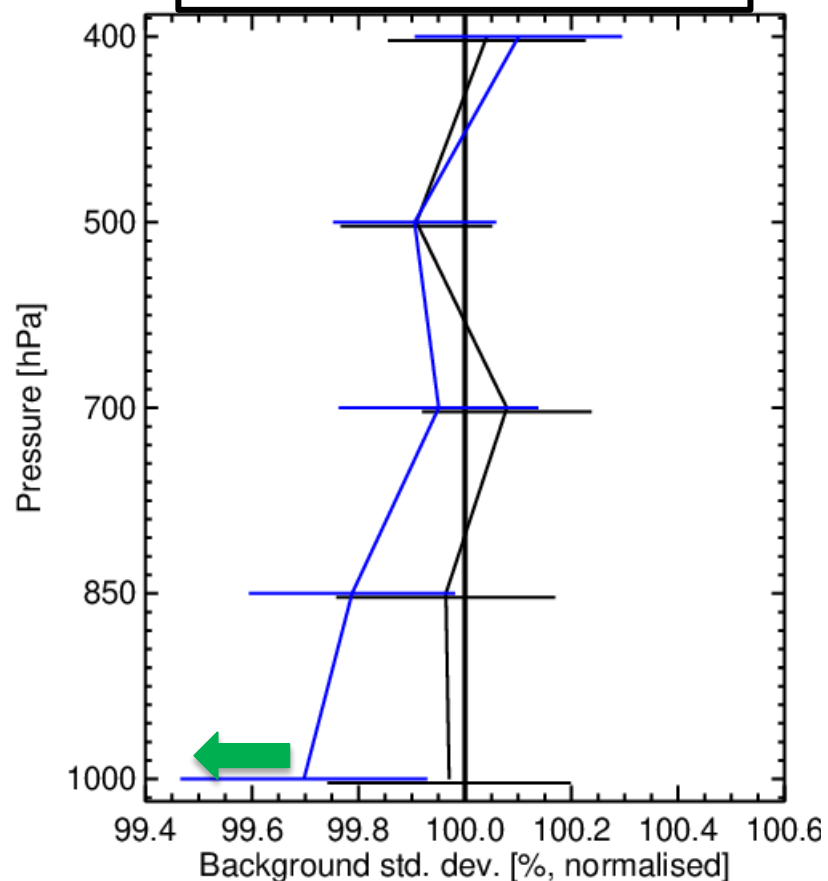
SMOS data assimilation impact

- Assimilation of **XB** or **NN** based SMOS soil moisture has positive impact near surface when compared to **no SMOS** experiment (100% line).
- The positive impact of assimilation of **XB** based soil moisture is stronger than of **NN** in 49r1.

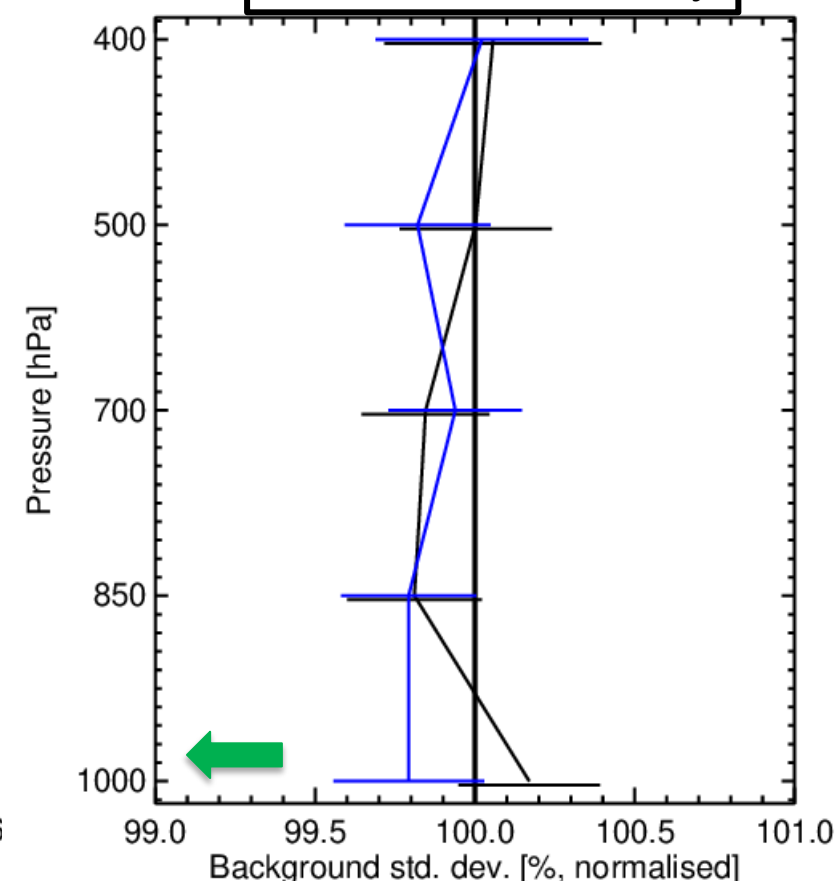
Surface observations



Radiosonde temperature

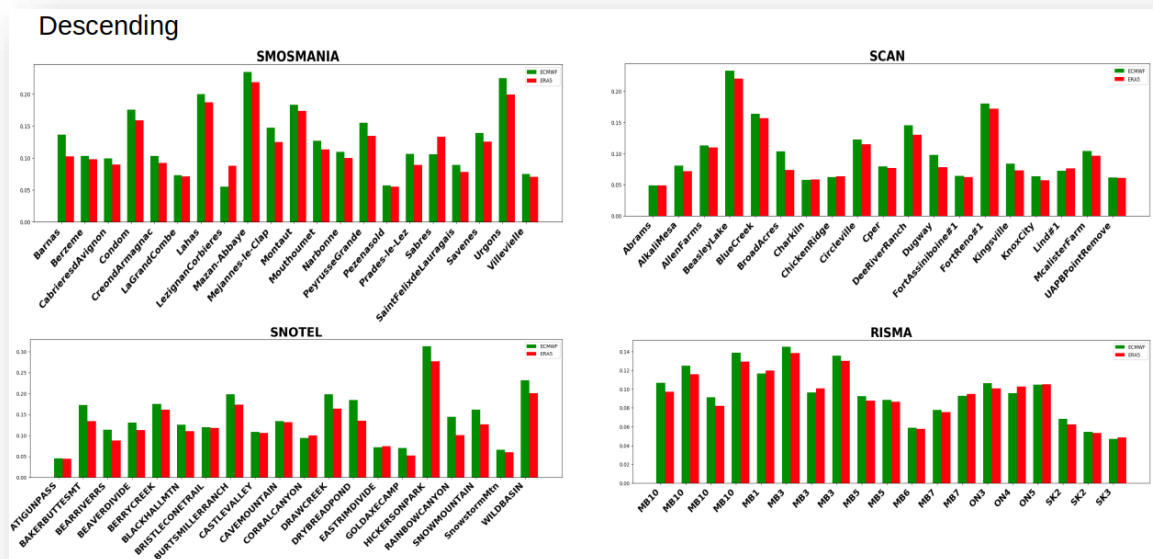


Radiosonde humidity



SMOS: Data quality evolution

Operational perspective: SM DQ improvment



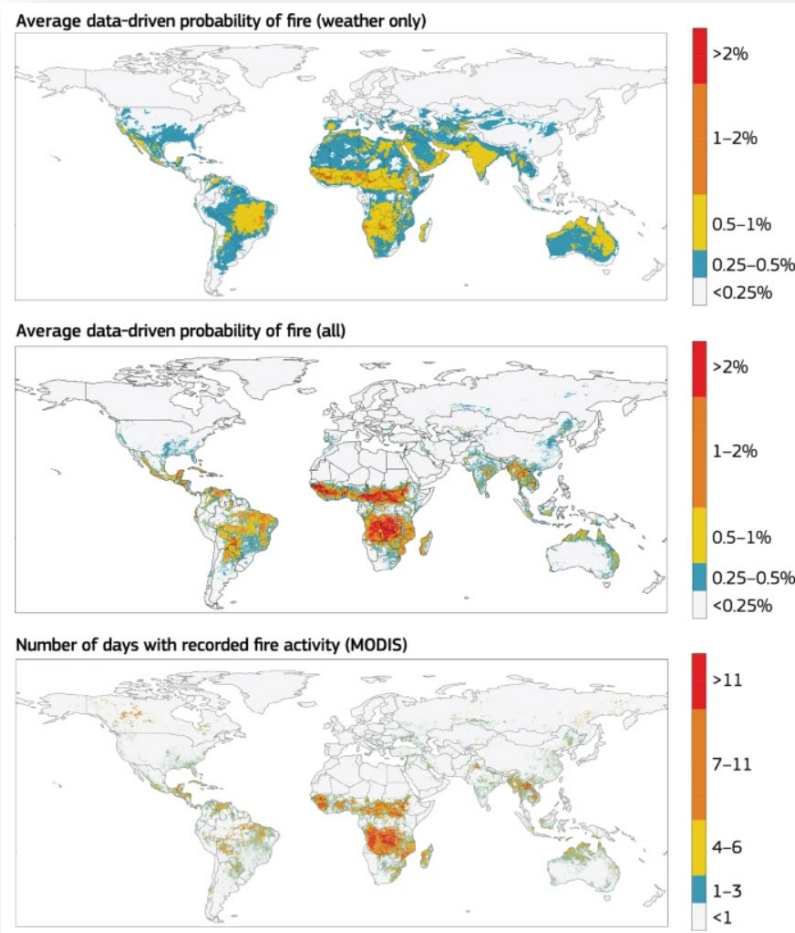
Soil moisture: SMOS – ISMN, Y 2014

TDS1: SMOS SM processed using ECMWF c40r1 as auxiliary

TDS2: SMOS SM processed using ERA5 as auxiliary

Reanalysis data from ERA5 provides more stable time series. For the ascending passes, RMSD for both products were found to be very similar across the different sites.

Application perspective: Improving fire probabilities with SMOS

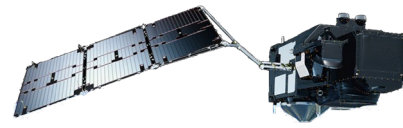


**nature
communications**

Di Giuseppe, F., *et al.* Global data-driven prediction of fire activity. *Nat Commun* 16, 2918 (2025)

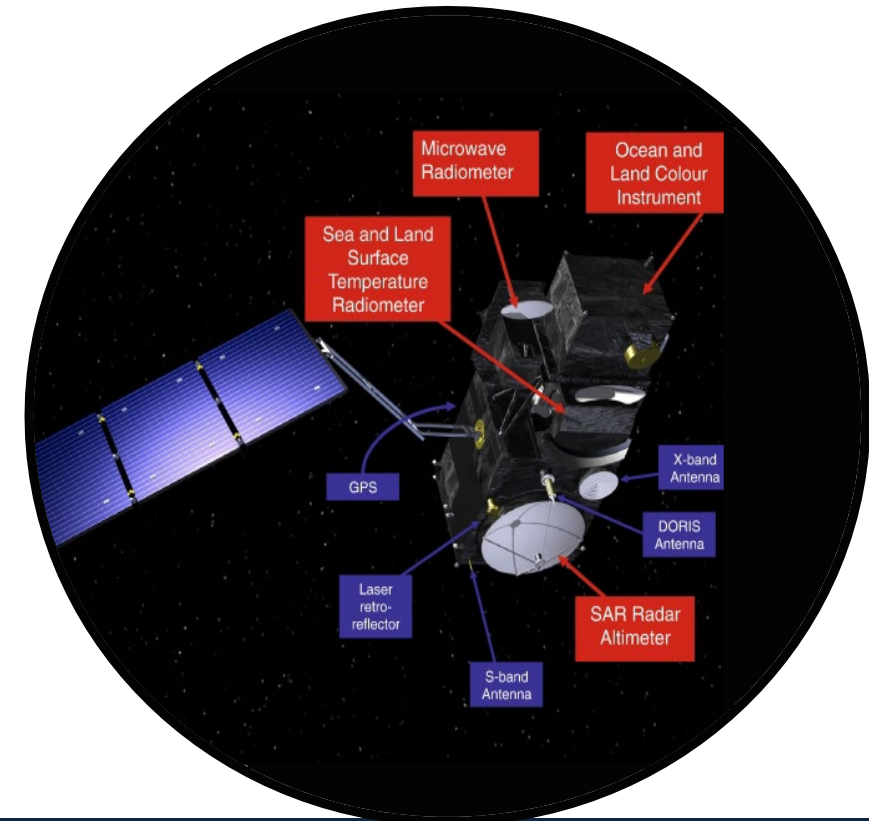
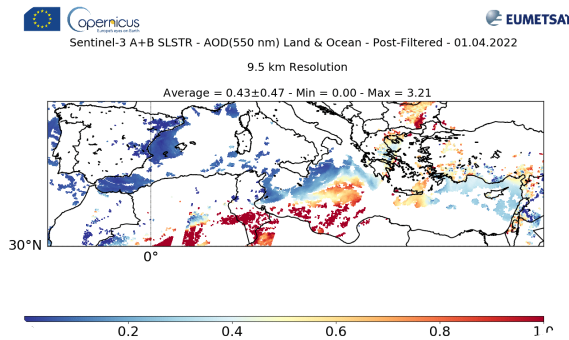
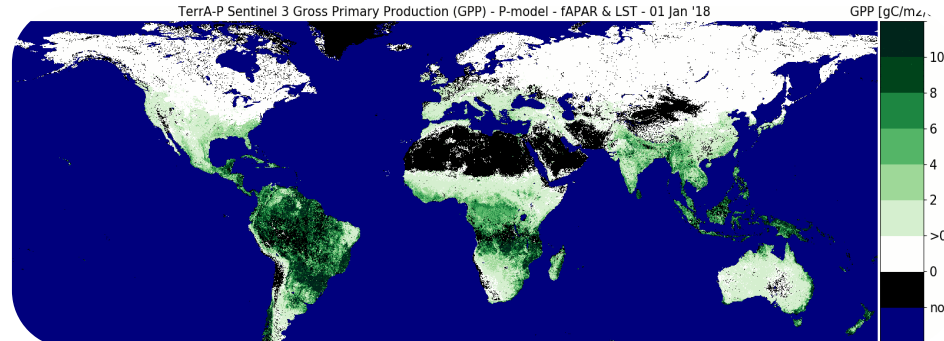
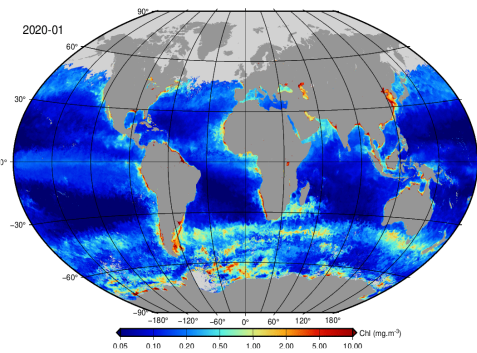
FOPI included
VOD SMOS data
since 2023.

Sentinel-3 Mission



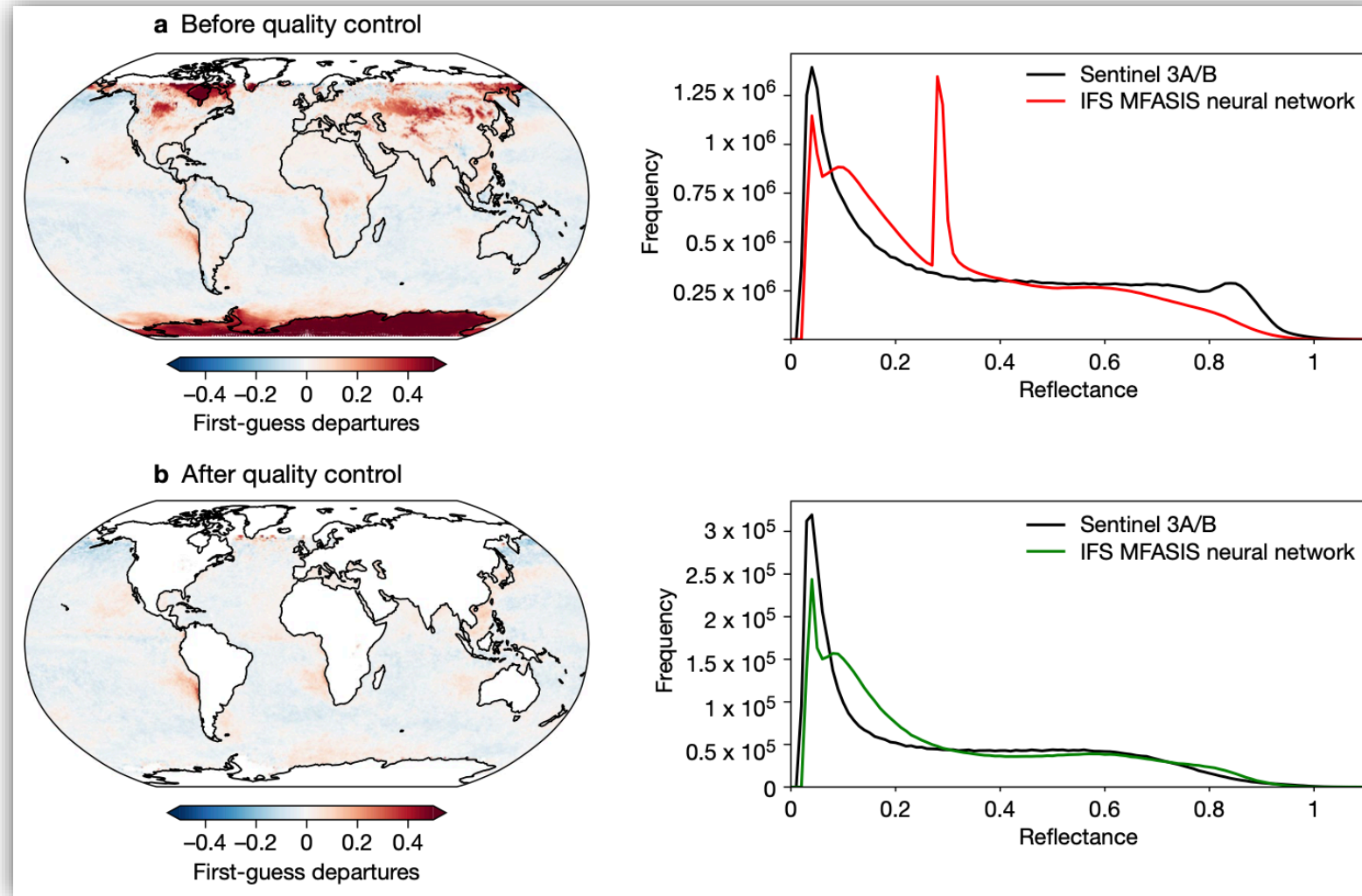
- ✓ **Operational mission:** constellation of 2 satellites (S3A + S3B) jointly operated by ESA and EUMETSAT and flying on same orbital plane separated by 140°
- ✓ **Orbit:** polar, sun-synchronous at altitude of 815 km
- ✓ **Payload :** Optical: (OLCI and SLSTR) and Topography (SRAL, MWR, POD)

- ✓ **Heritage:** Continues multi-instrument, thematic EO data from ESA's ERS, ENVISAT, and CNES's SPOT missions.
- ✓ **Objectives:** Provide high-accuracy measurements of ocean topography, surface temperature, and colour over ocean and land—supporting applications in vegetation, atmosphere, inland water, and cryosphere



On February 14, 2025 (April 25, 2025), S3-A(-B) celebrated 9 (7) years in space

Visible Radiances in ECMWF's analysis

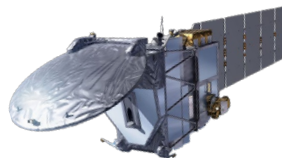


Evaluation of OLCI 655 nm visible reflectance observations and first-guess model equivalents (a) before and (b) after quality control.

The left-hand maps of first-guess departures show 3-month averages of observations minus model and the right-hand reflectance frequency histograms provide the number of observed and forecast reflectances.

Angela Benedetti & CLOVIS Team

EarthCARE Mission



Cloud Profiling Radar CPR (JAXA)

High Power 94GHz Doppler Radar

- Cloud profiles, rain estimates, particle vertical velocity



Multi Spectral Imager (SSTL)

- Context information
- Creating 3D cloud-aerosol scenes
- VIS, Near IR, SWIR Camera (VNS)
- Thermal IR Camera (TIR)
- 4 solar and 3 TIR channels



Atmospheric LIDAR ATLID (Airbus TLS)

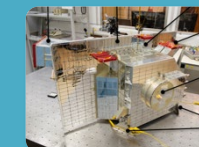
High spectral resolution 355nm LIDAR

- Vertical profiles of aerosol and (thin) clouds

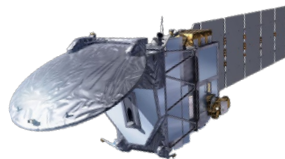


BroadBand Radiometer BBR (TAS-UK)

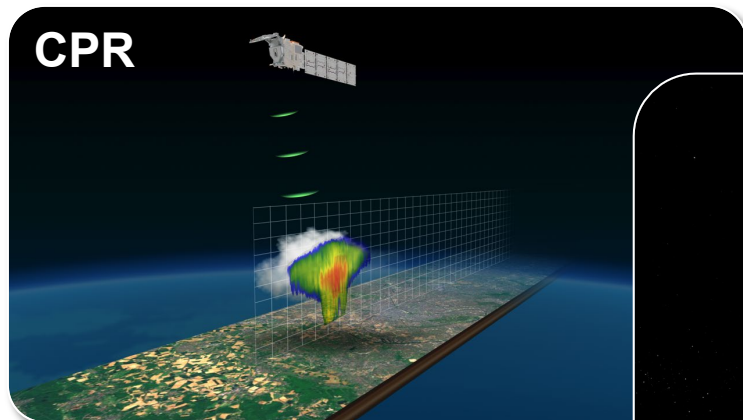
- Measurements of reflected solar and emitted thermal radiation



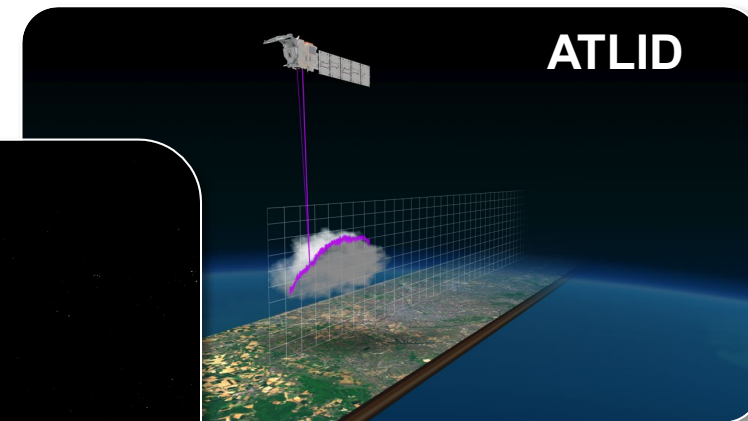
EarthCARE Mission



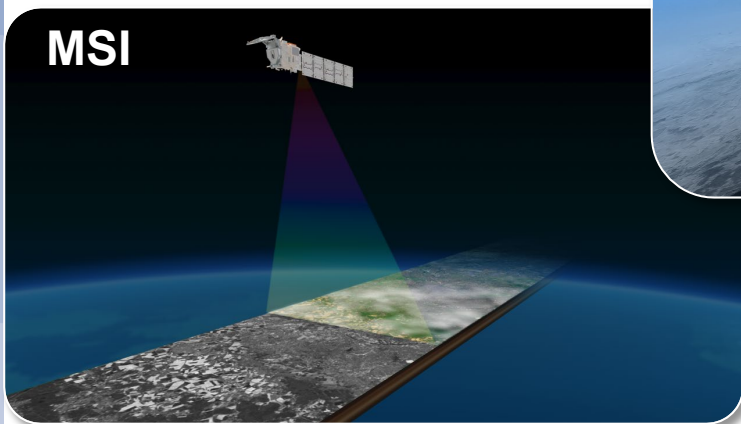
CPR



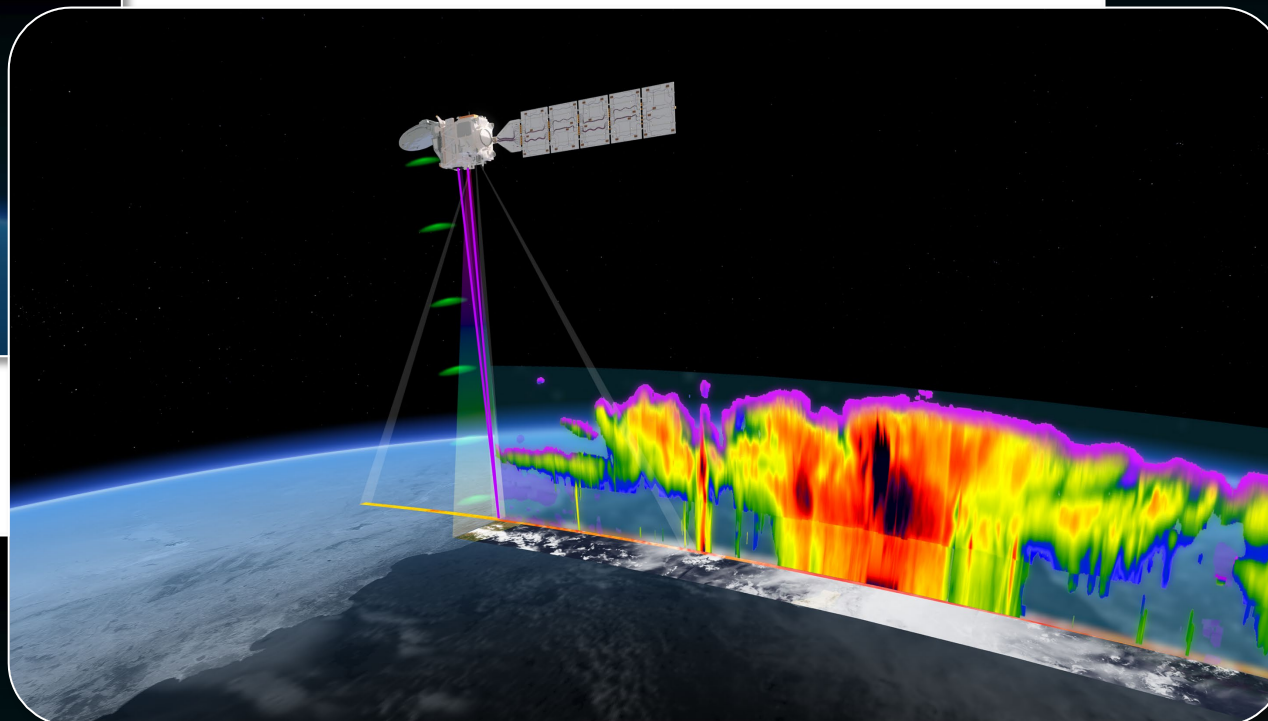
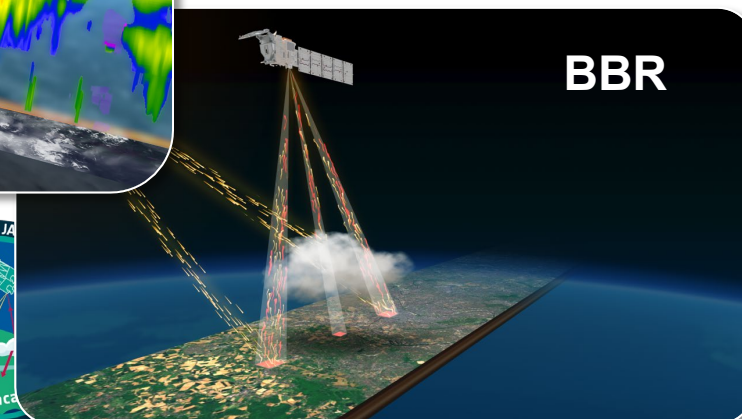
ATLID



MSI



BBR



**3&4 sensors synergy products
will be released on 1 Dec 2025 !**

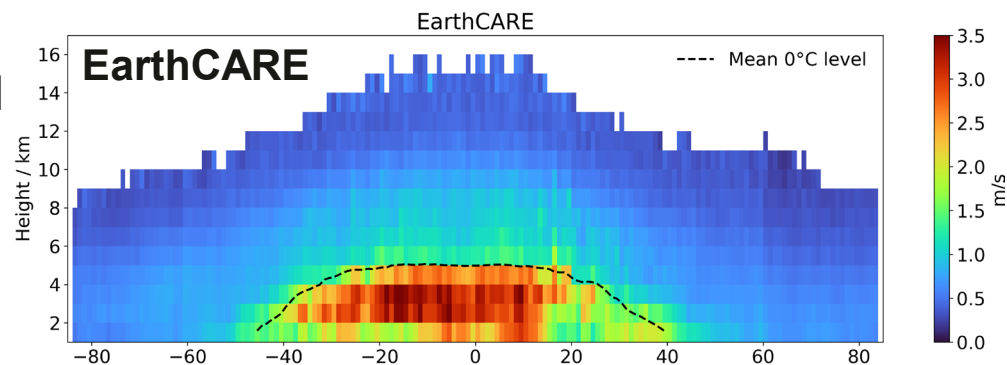
<https://earth.esa.int/eogateway/missions/earthcare/data>



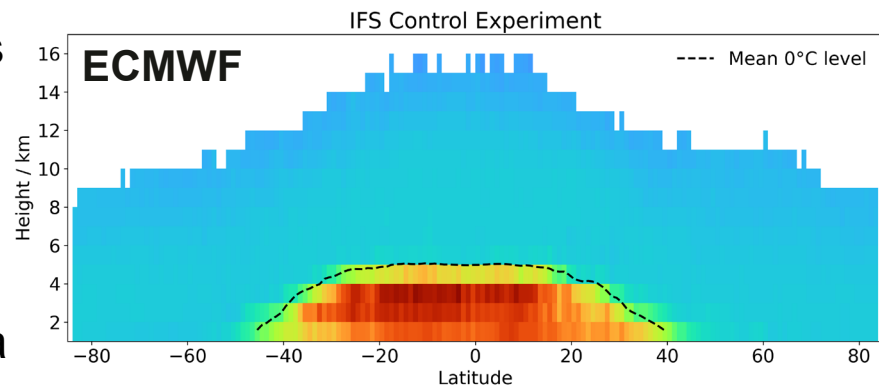
Impact of EarthCARE Mission on Research & Modelling

Rebecca Murray-Watson, Mark Fielding, Richard Forbes

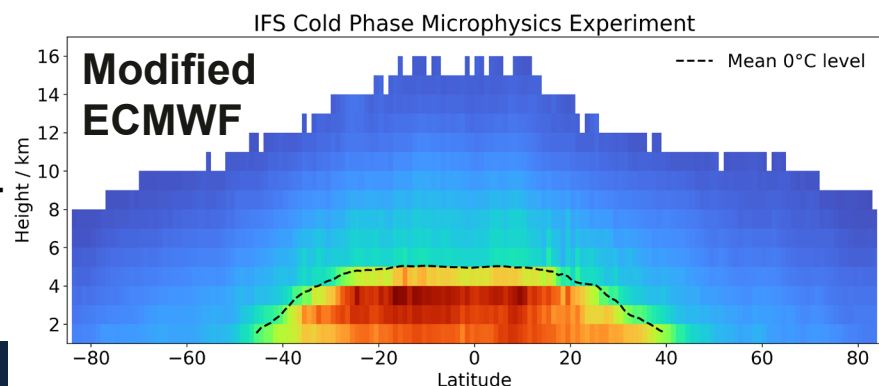
CPR mean fall speed



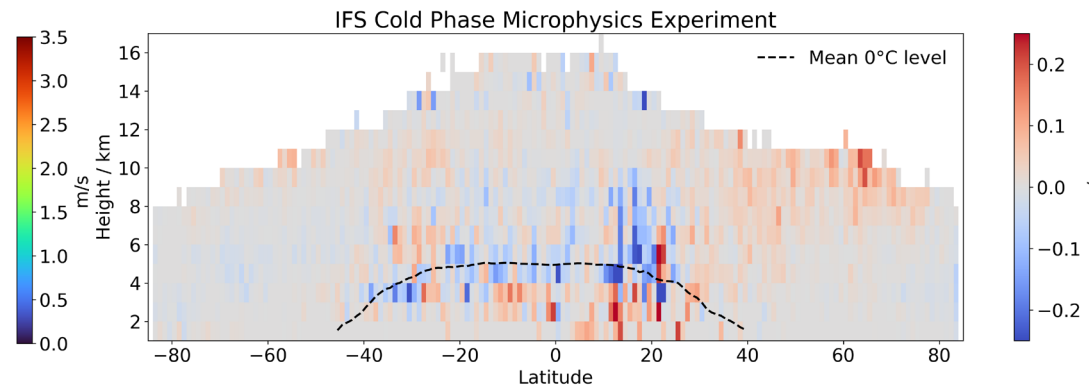
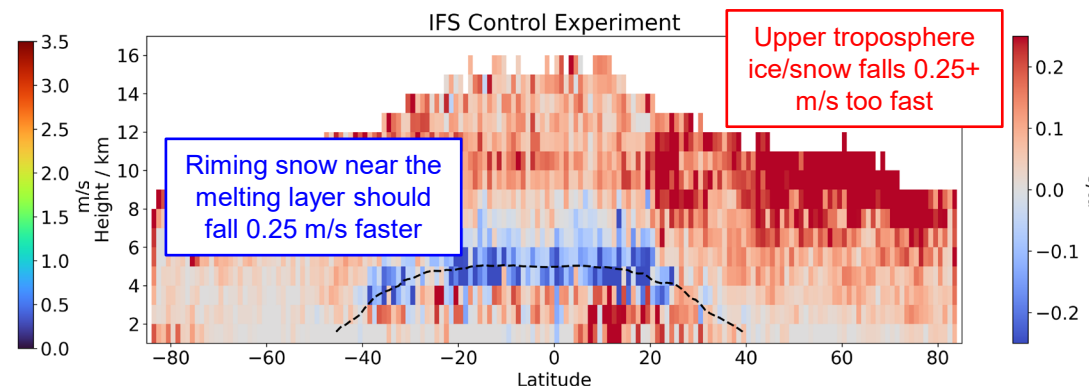
ECMWF model is very simple! ice falls at 0.13 m/s, snow at 1 m/s



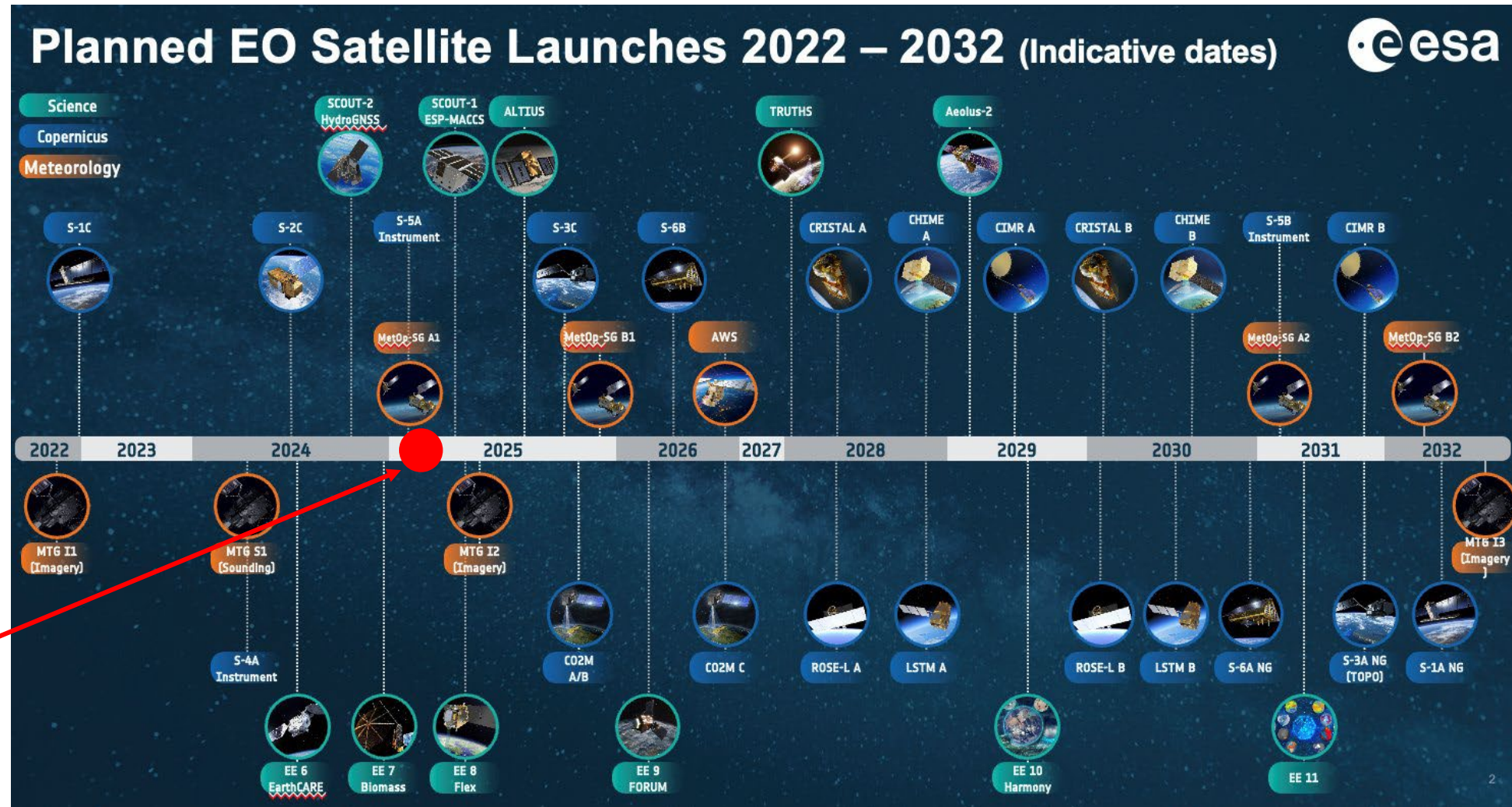
Modifications: use a mass-weighted fall speed; add rimed snow, temperature-dependent size & air-density effect



Ice & snow fall speeds affect model climate and forecast skill: this is first time we have been able to evaluate it globally!



And many more to come!





Thanks for your attention!



...and we also had fun!

