ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

EUMETSAT

INTERNATIONAL ATOVS WORKING GROUP

ITSC-25 | Goa, India

EXPANDING THE USE OF GEOSTATIONARY SATELLITE RADIANCES AT ECMWF

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ORAL PRESENTATION 9.02

MONDAY 12 MAY 2025

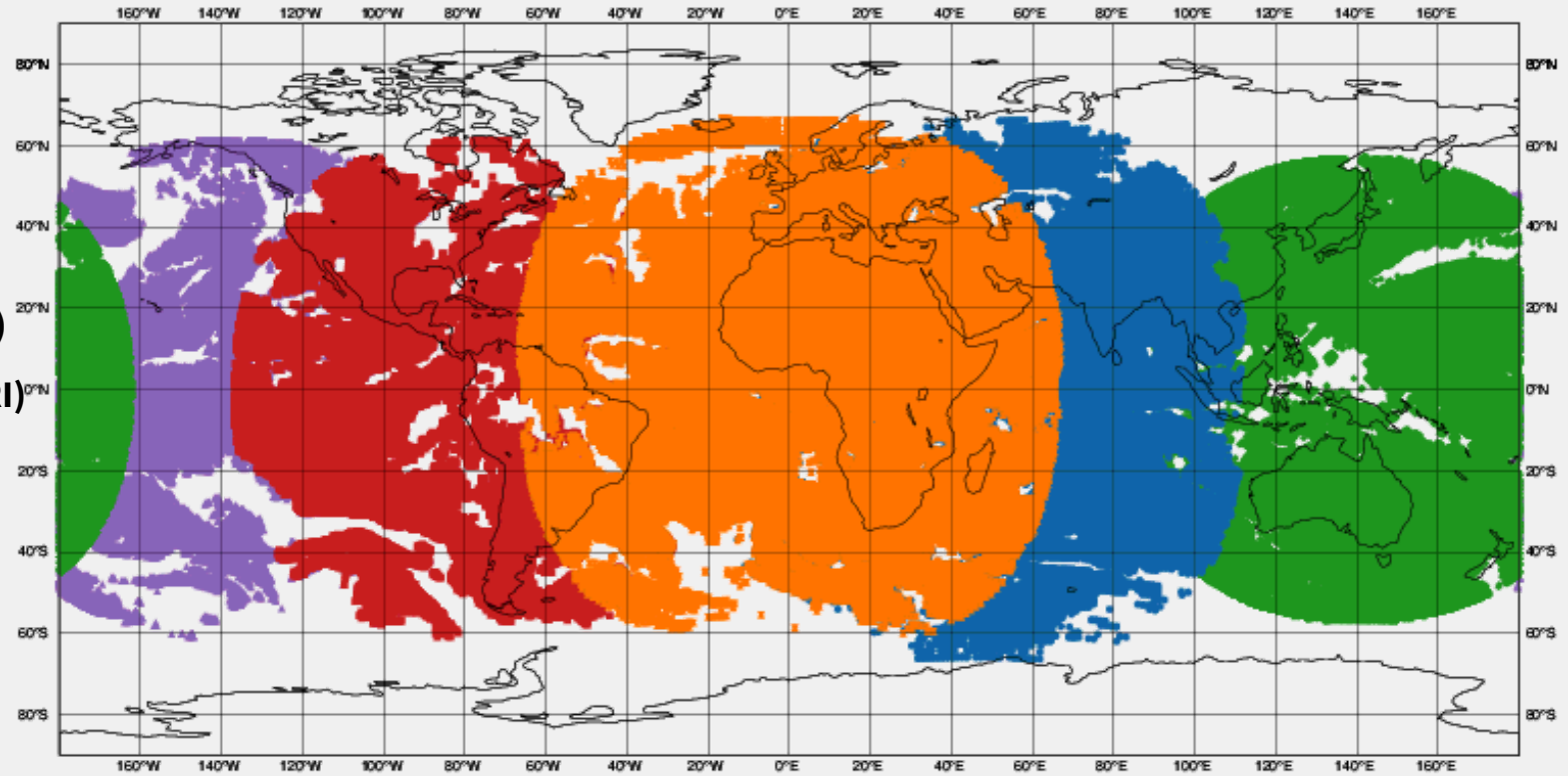
https://www.eumetsat.int/our-satellites/meteosat-series

THE CURRENT USE OF GEOSTATIONARY SATELLITES AT ECMWF

Clear-sky assimilation only.

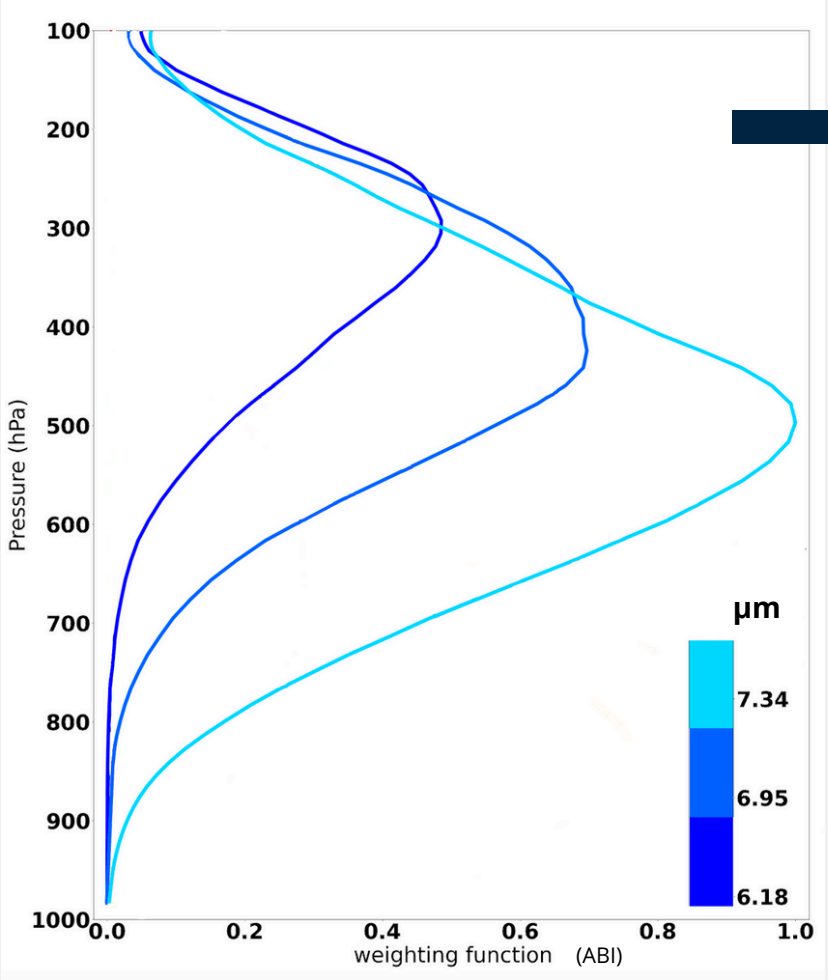
Infrared **water vapour** (WV) sensitive channels.

- **GOES-19 (ABI)**
- **GOES-18 (ABI)**
- **Meteosat-9 (SEVIRI)**
- **Meteosat-10 (SEVIRI)**
- **Himawari-9 (AHI)**



INFRARED WATER VAPOUR CHANNELS SENSITIVITY

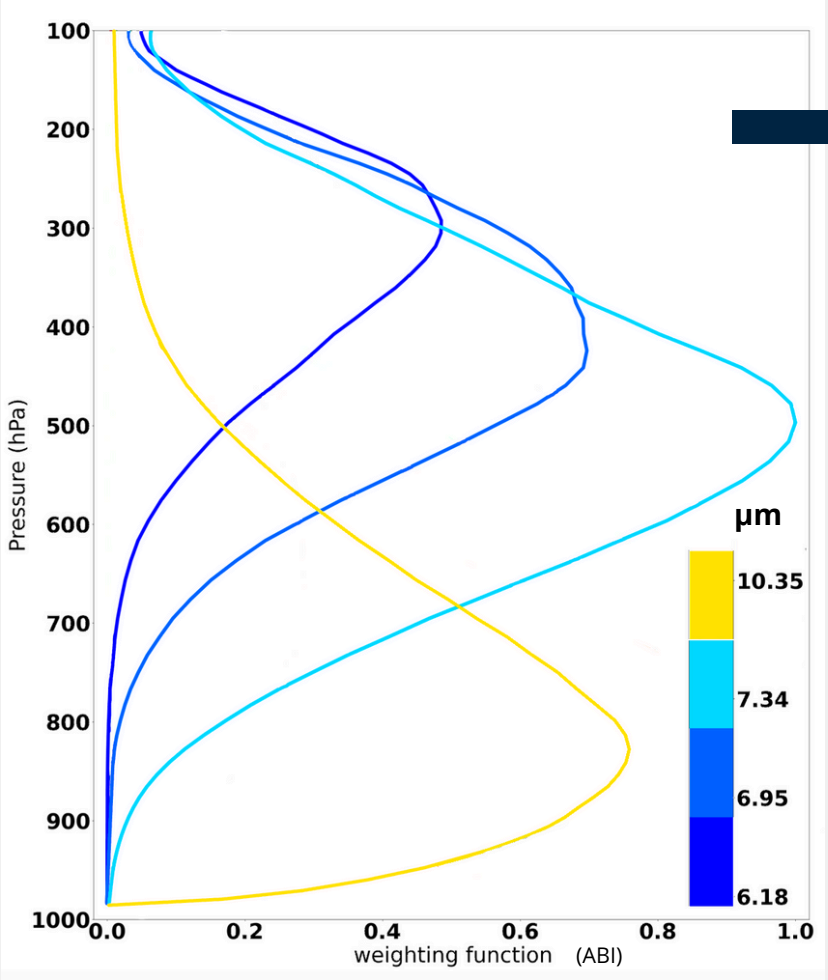
Weighting function of the water vapour channels (GOES-16 ABI)



- 2 (SEVIRI) to 3 (ABI & AHI) channels sensitive to water vapour, sensitivity to **upper to mid troposphere**.
- Other channels available on GEOS imagers (e.g. window channels).

INFRARED WV AND WINDOW CHANNELS SENSITIVITY

Weighting function of the water vapour channels + window channel (GOES-16 ABI)



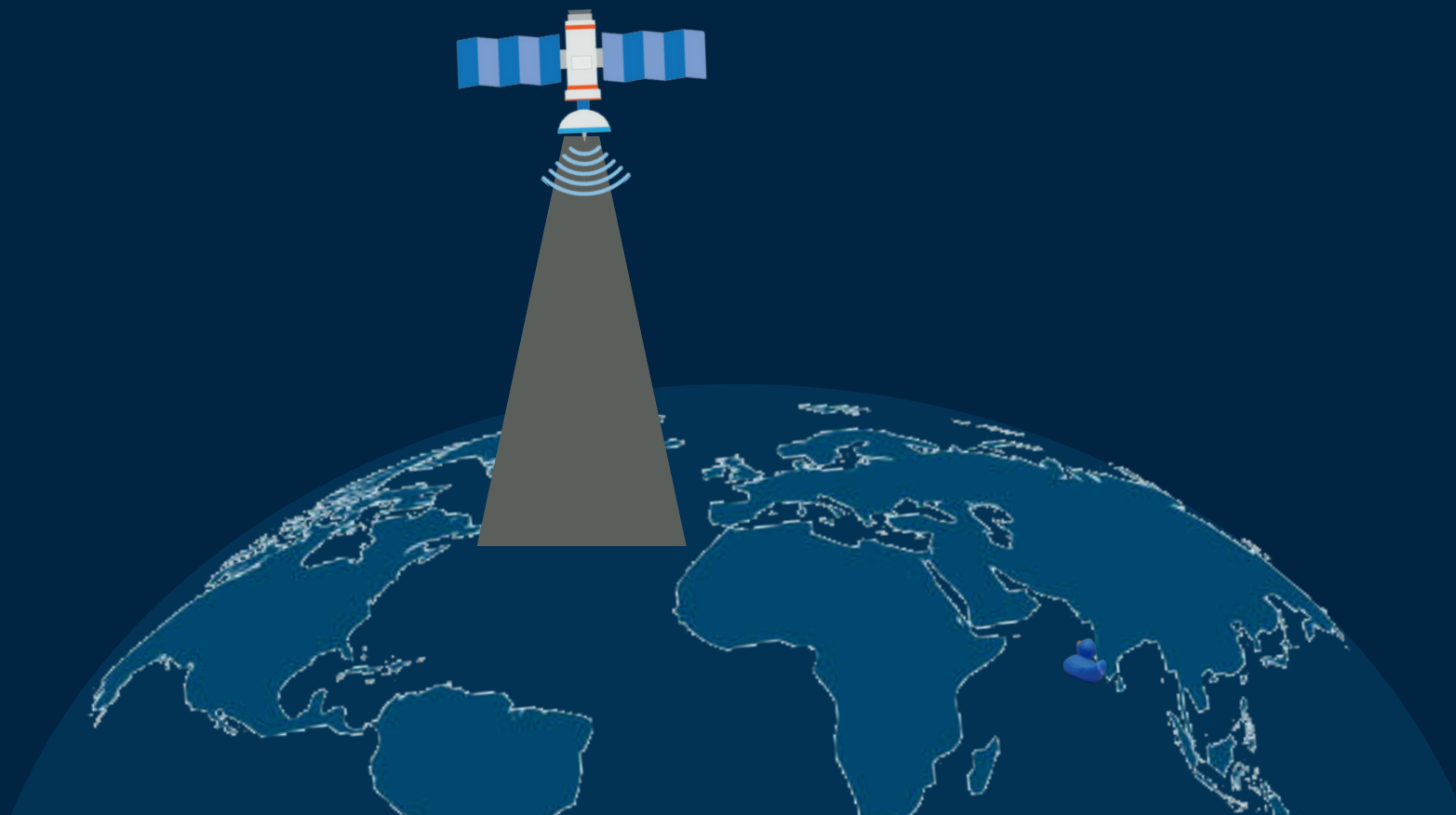
- 2 (SEVIRI) to 3 (ABI & AHI) channels sensitive to water vapour, sensitivity to **upper to mid troposphere**.
- Other channels available on GEOS imagers (e.g. window channels).
- **Window channel** sensitive to low troposphere. Would be sensitive to the surface in clear-sky condition.

Adds valuable new information over ocean...

ASSIMILATING IR GEOS WINDOW CHANNEL - CHALLENGES

Ensure clear-sky all the way down to the surface:

Ensure that we observe the ocean:



ASSIMILATING IR GEOS WINDOW CHANNEL - CHALLENGES

Ensure clear-sky all the way down to the surface:
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ASSIMILATING IR GEOS WINDOW CHANNEL - CHALLENGES

Ensure clear-sky all the way down to the surface:
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2) no dust contamination.

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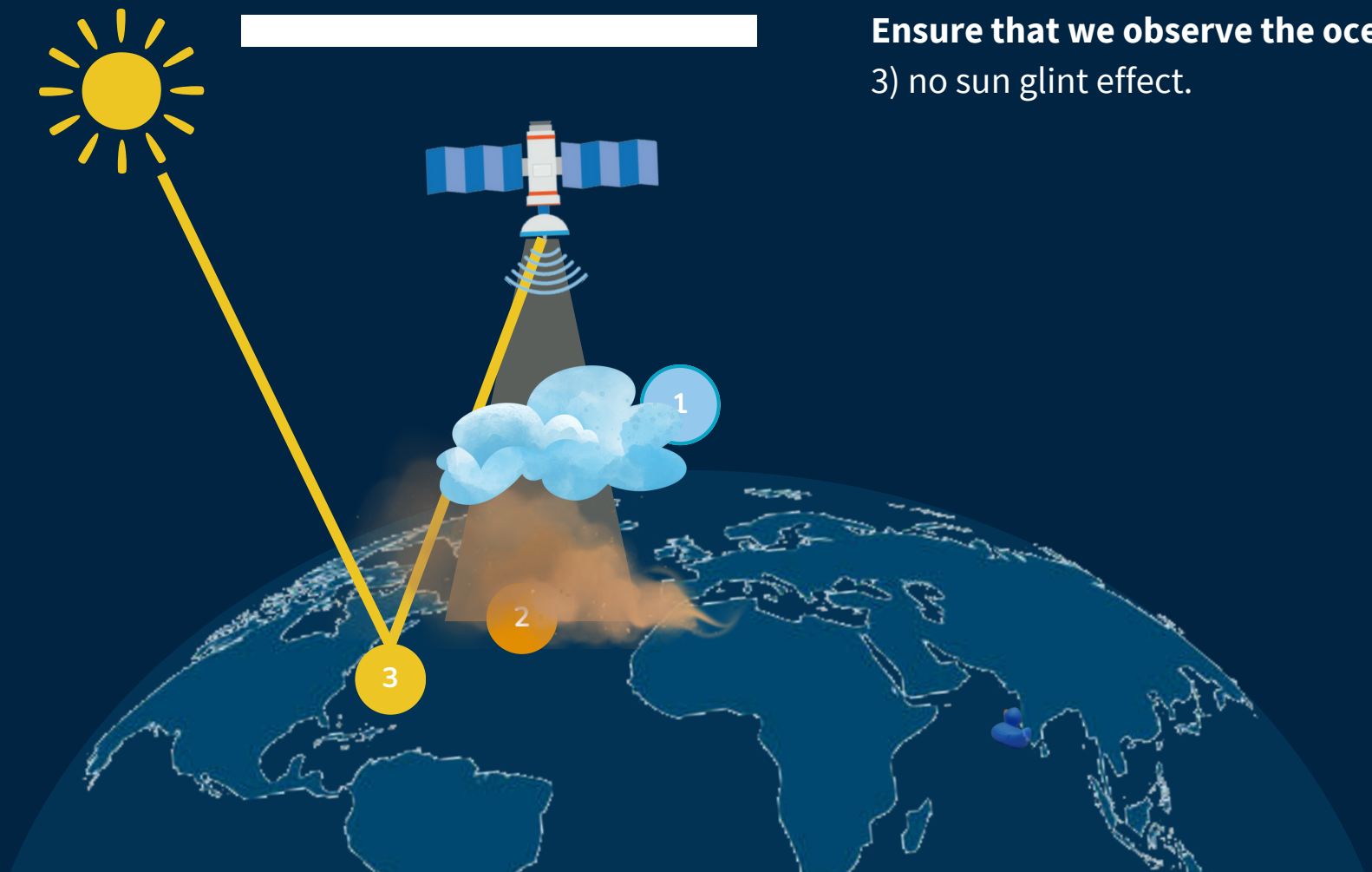
Ensure that we observe the ocean:
3) no sun glint effect.



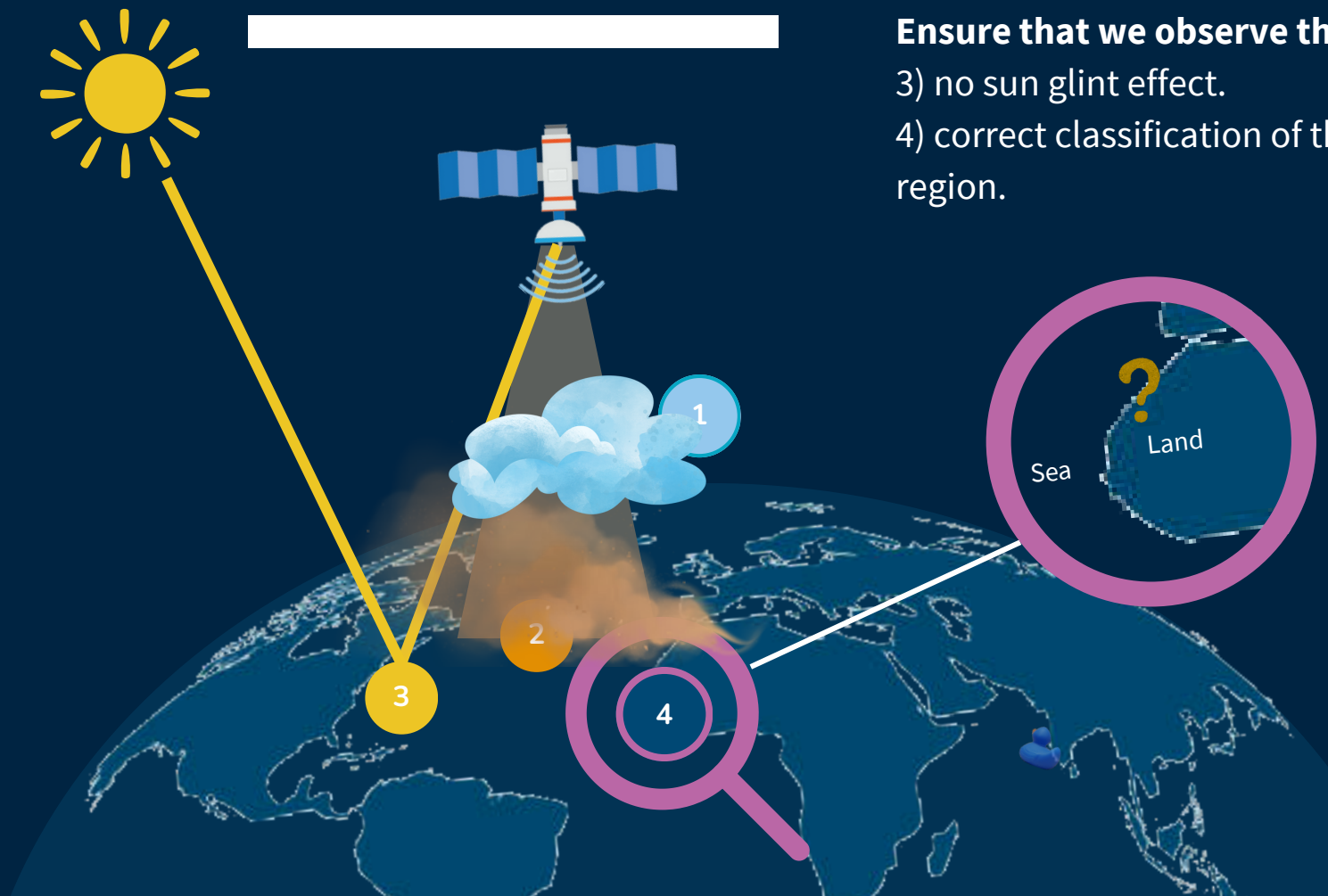
ASSIMILATING IR GEOS WINDOW CHANNEL - CHALLENGES

Ensure clear-sky all the way down to the surface:

1) no cloud contamination.
2) no dust contamination.

Ensure that we observe the ocean:

3) no sun glint effect.
4) correct classification of the coastline region.



SEEING CLEARLY THROUGH THE SKY:

DEALING WITH CLOUDS AND DUST

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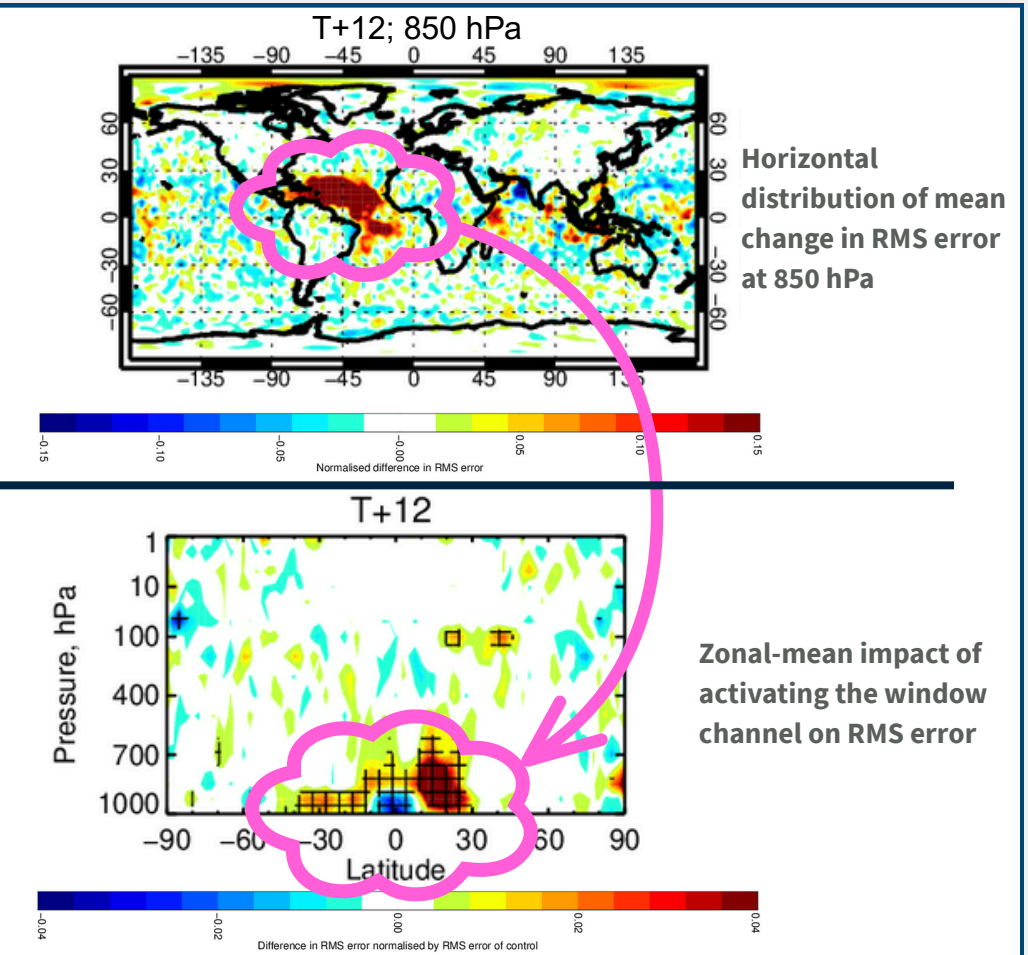
CLOUD AND DUST: A SOURCE OF ERRORS

Mean change in RMS error in R by activating the window channel

Summer 2022 + Winter 2022-2023 (6 months)



Horizontal distribution of mean change in RMS error at 850 hPa

Zonal-mean impact of activating the window channel on RMS error

Localised errors in Humidity field over Atlantic Ocean in lower layers of the atmosphere

→ cloud- and dust-affected areas.

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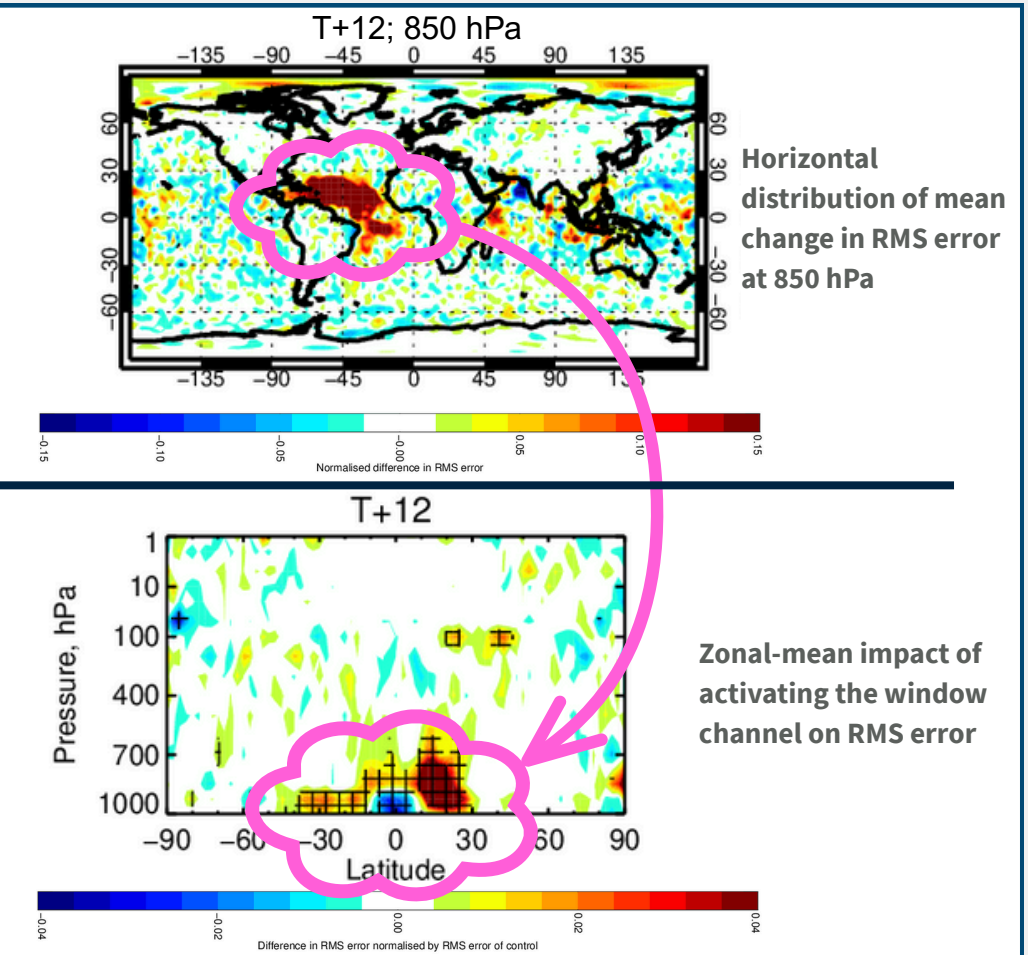

Horizontal distribution of mean change in RMS error at 850 hPa

Zonal-mean impact of activating the window channel on RMS error

Localised errors in Humidity field over Atlantic Ocean in lower layers of the atmosphere
→ cloud- and dust-affected areas.

How to make sure we assimilate clear-sky scenes only?

i) decrease the tolerance threshold to **clouds**
→ reject even slightly-cloudy scenes.

ii) apply a filtering of the **dust**:

FG_departures [10 μm] – FG_departures [12 μm] < 0

When positive, the difference between the two window channels indicates the presence of dust.

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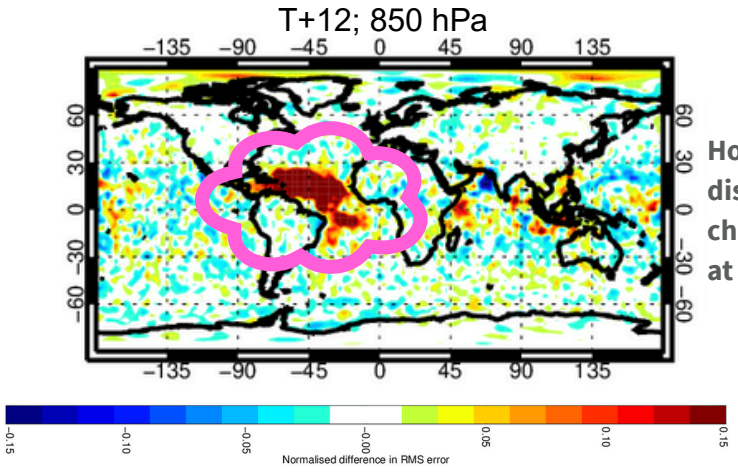

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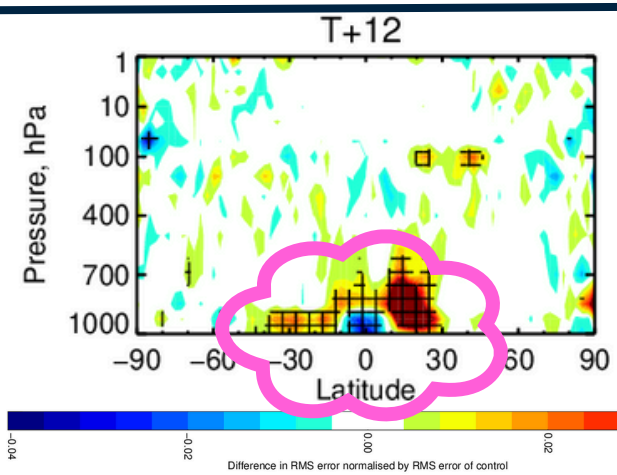
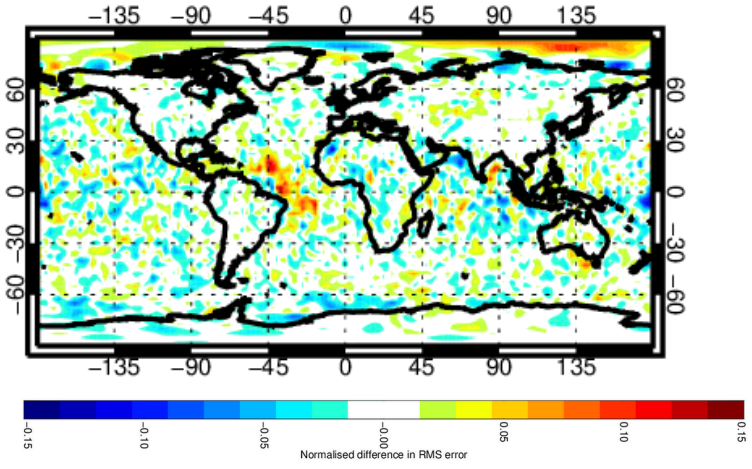


Zonal-mean impact of activating the window channel on RMS error

Remove most of the systematic errors near the surface.
Need to refine more to improve the impact of this channel on forecasts.

Cloud and dust screening



ASSIMILATING OCEAN OBSERVATIONS

i) Sunglint effect
ii) Classification ocean/land

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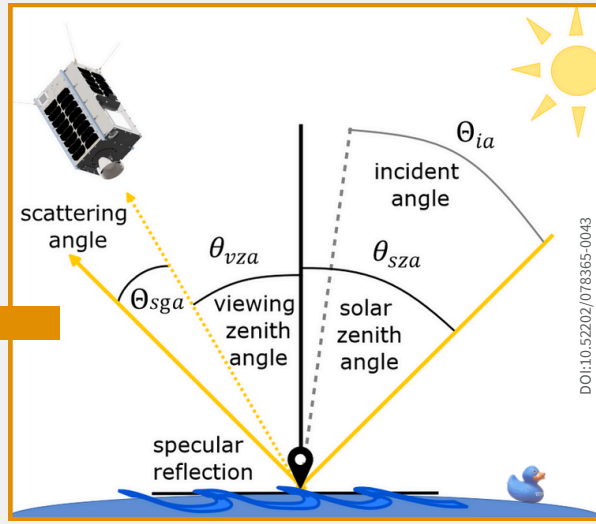
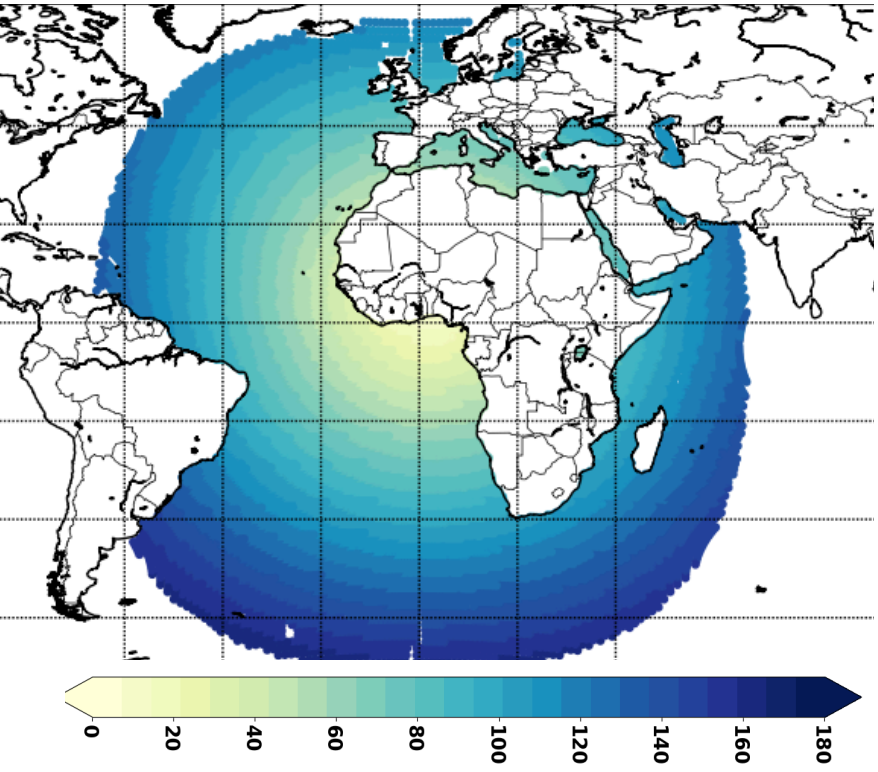
IMPACT OF THE SUN GLINT ON SATELLITE OBSERVATIONS



Representation of viewing and sun angles to illustrate the sunglint angle

Map of the sunglint angle (Meteosat-11) at 1145UTC



Over ocean, sunlight can be reflected off the surface at the same angle that the sensor observes it.
This can affect the quality of the data.

Sun glint angle:

$$\cos\alpha = \cos(\theta_{vza})\cos(\theta_{sza}) - \sin(\theta_{vza})\sin(\theta_{sza})\cos(\phi_{vza} - \phi_{sza})$$

Data may be degraded when α is small (< 30°)

CLASSIFICATION SEA / LAND

Aim: Assimilation of the window channel data strictly over ocean

- Misclassifications of coastal areas as sea can introduce anomalies.

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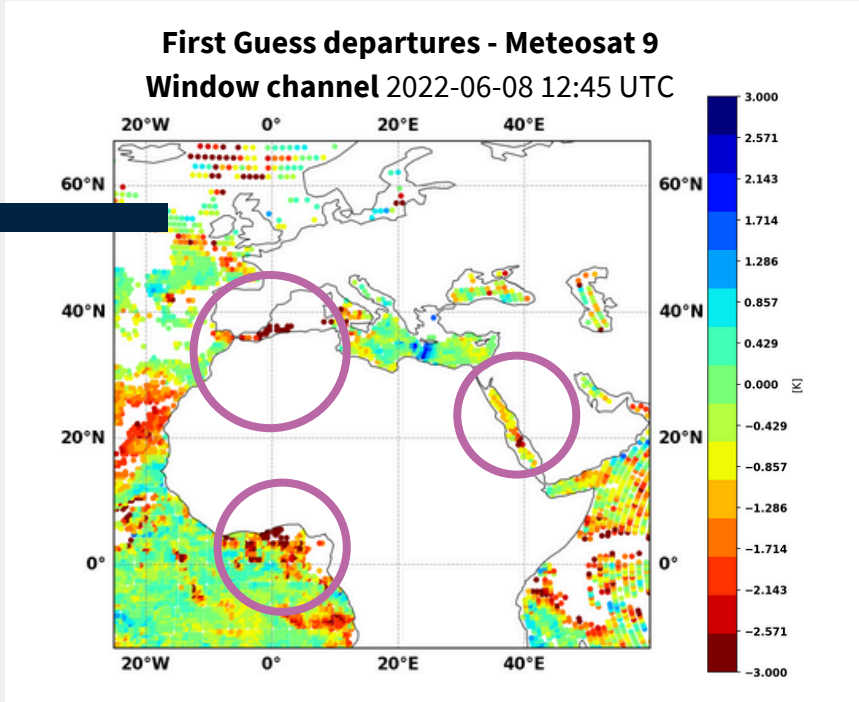
- Narrow sea regions (straits, gulfs) are influenced by land on both sides, leading to increased FG departures.



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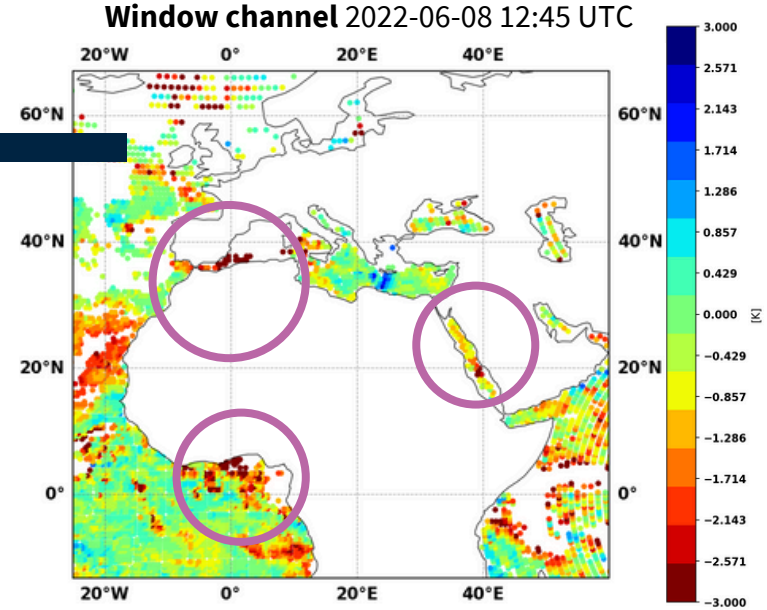
Aim: Assimilation of the window channel data strictly over ocean

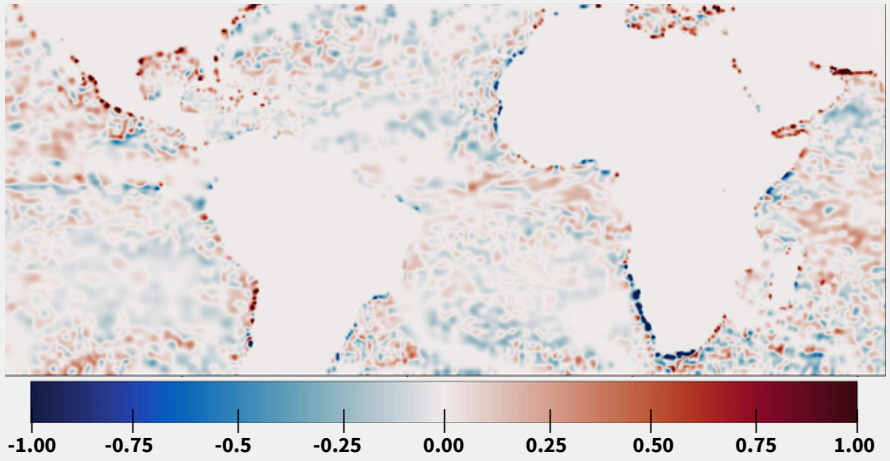
- Misclassifications of coastal areas as sea can introduce anomalies.
- Narrow sea regions (straits, gulfs) are influenced by land on both sides, leading to increased FG departures.

- Use of window channel in coupled system: large SKT increments along the coasts.

First Guess departures - Meteosat 9
Window channel 2022-06-08 12:45 UTC



Skin temperature increments with GEOS window channel assimilated in the coupled-system
2023-01-01:12:00:00 window

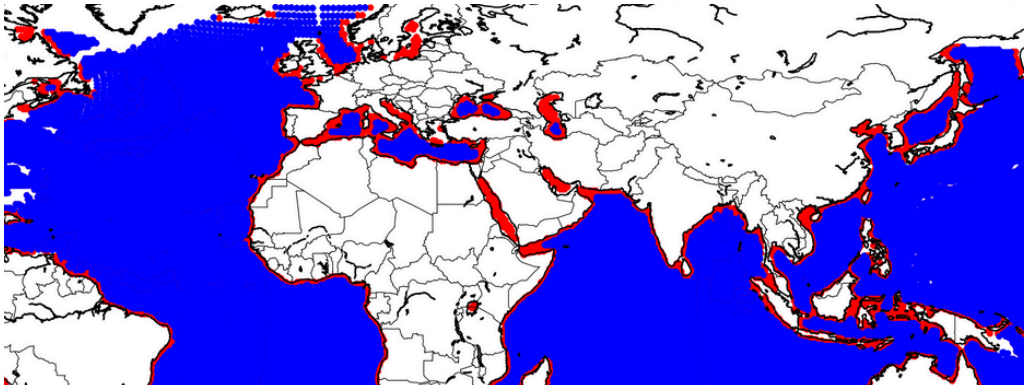


CLASSIFICATION SEA / LAND

Aim: Assimilation of the window channel data strictly over ocean

- Misclassifications of coastal areas as sea can introduce anomalies.
- Expand the land sea mask 100km away from the coast

New Land/Sea mask applied
in red: rejected areas



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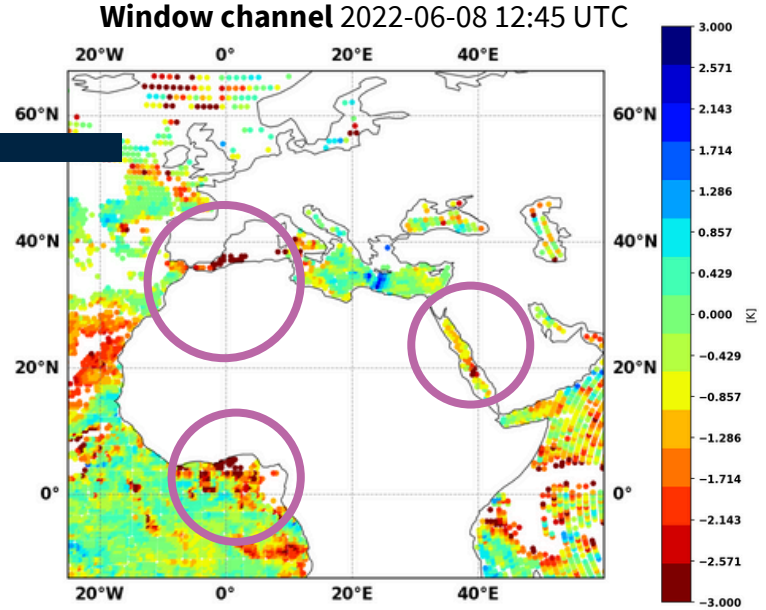
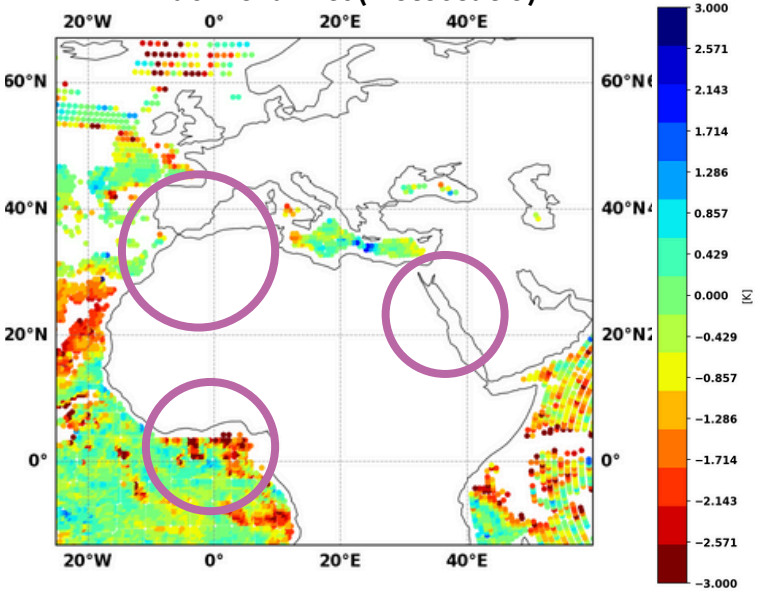


New Land/Sea mask applied to the window channel (Meteosat-9)



IMPACT OF ASSIMILATING IR GEOS WINDOW CHANNEL IN THE IFS

- Improved fit to observations.
- Will be assimilation in operations in the IFS later this year.

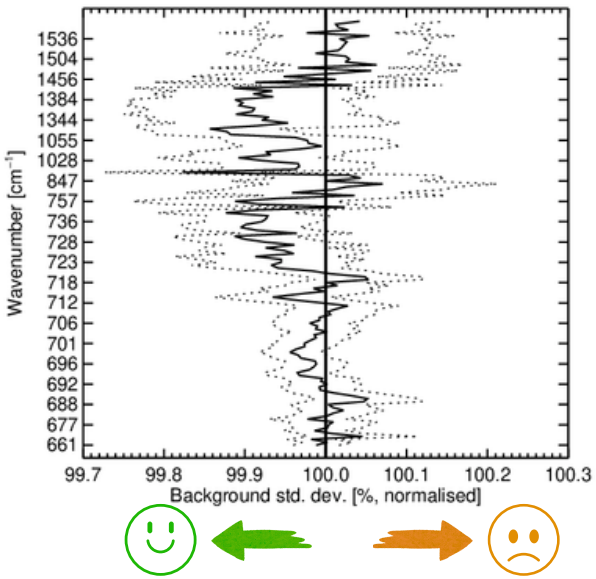
Further use:

- Assimilation in the **coupled system** to assess the Sea Surface Temperature

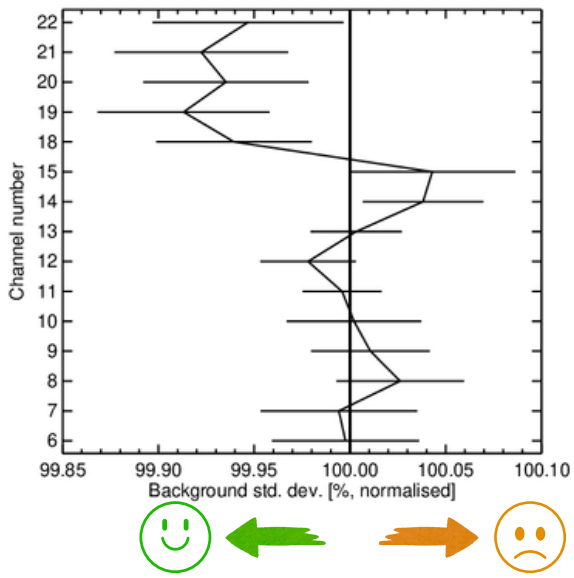
Fit to observations – against operational configuration (i.e. no IR GEOS window channel assimilated)

6-month period (Jun-Jul-Aug 2022, Dec 2022- Jan-Feb 2023)

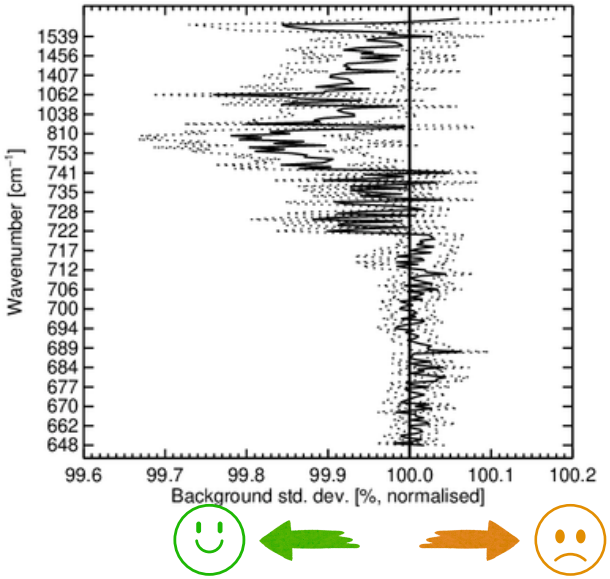
CrIS



ATMS

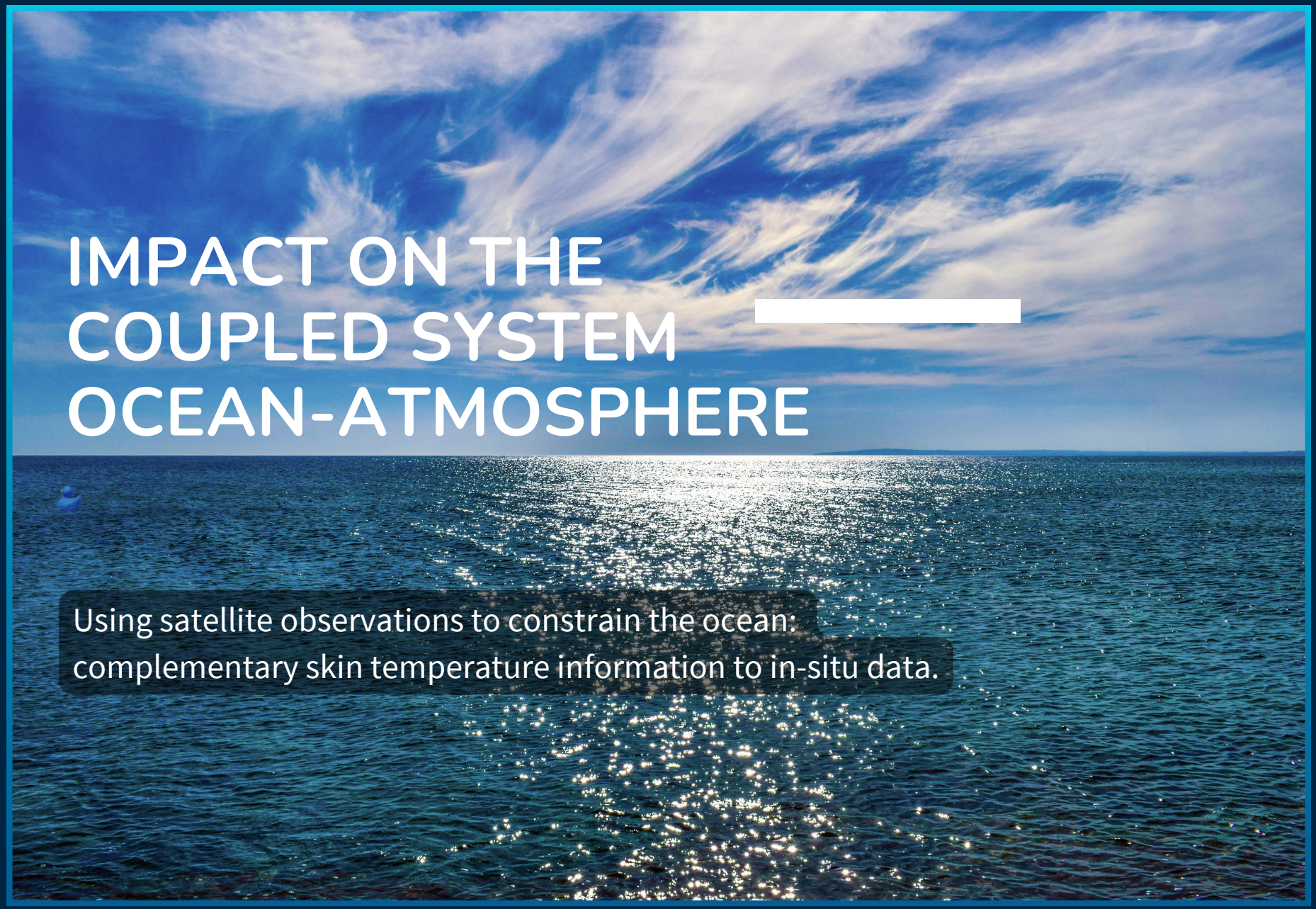


IASI



——— = IR GEOS Window channel assimilated

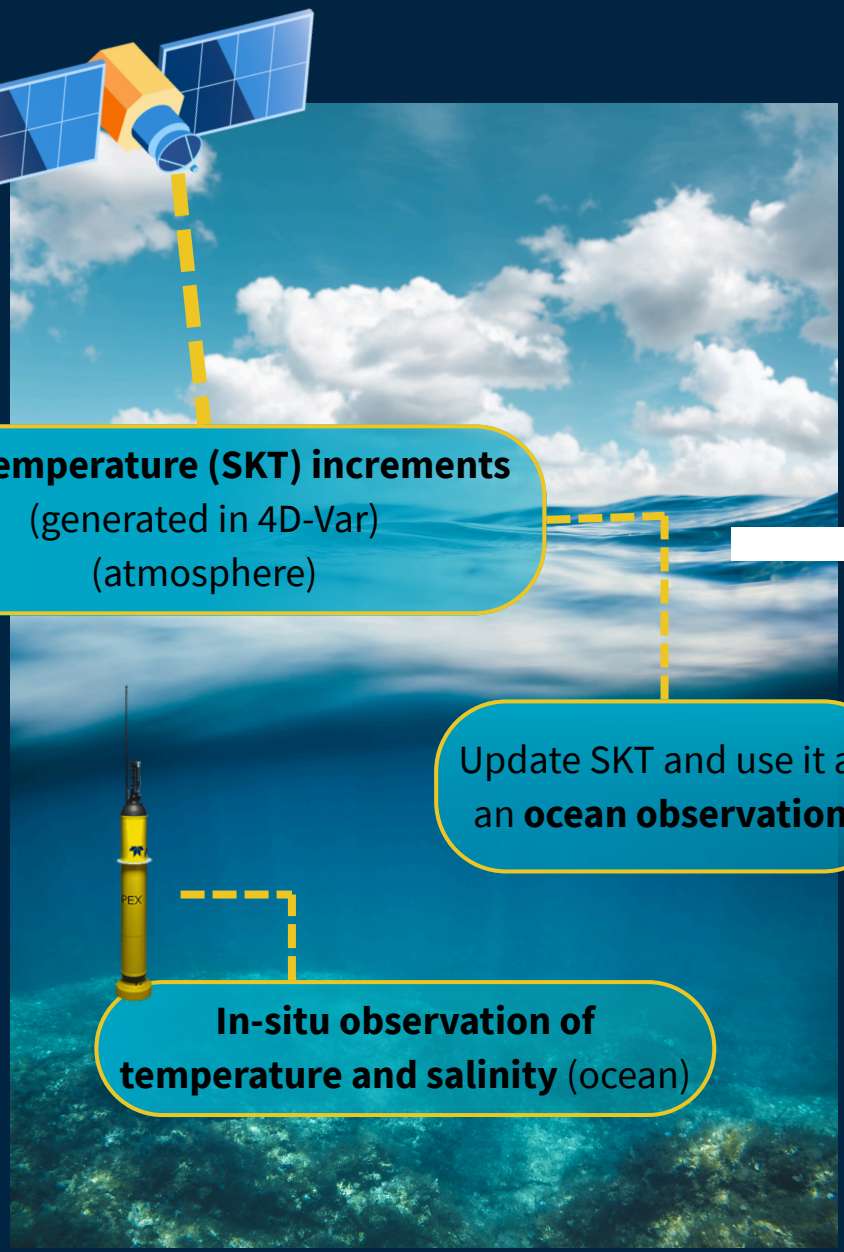
100% = CTRL, no window channel



IMPACT ON THE COUPLED SYSTEM OCEAN-ATMOSPHERE

Using satellite observations to constrain the ocean: complementary skin temperature information to in-situ data.

SATELLITE OBSERVATION IN THE COUPLED SYSTEM



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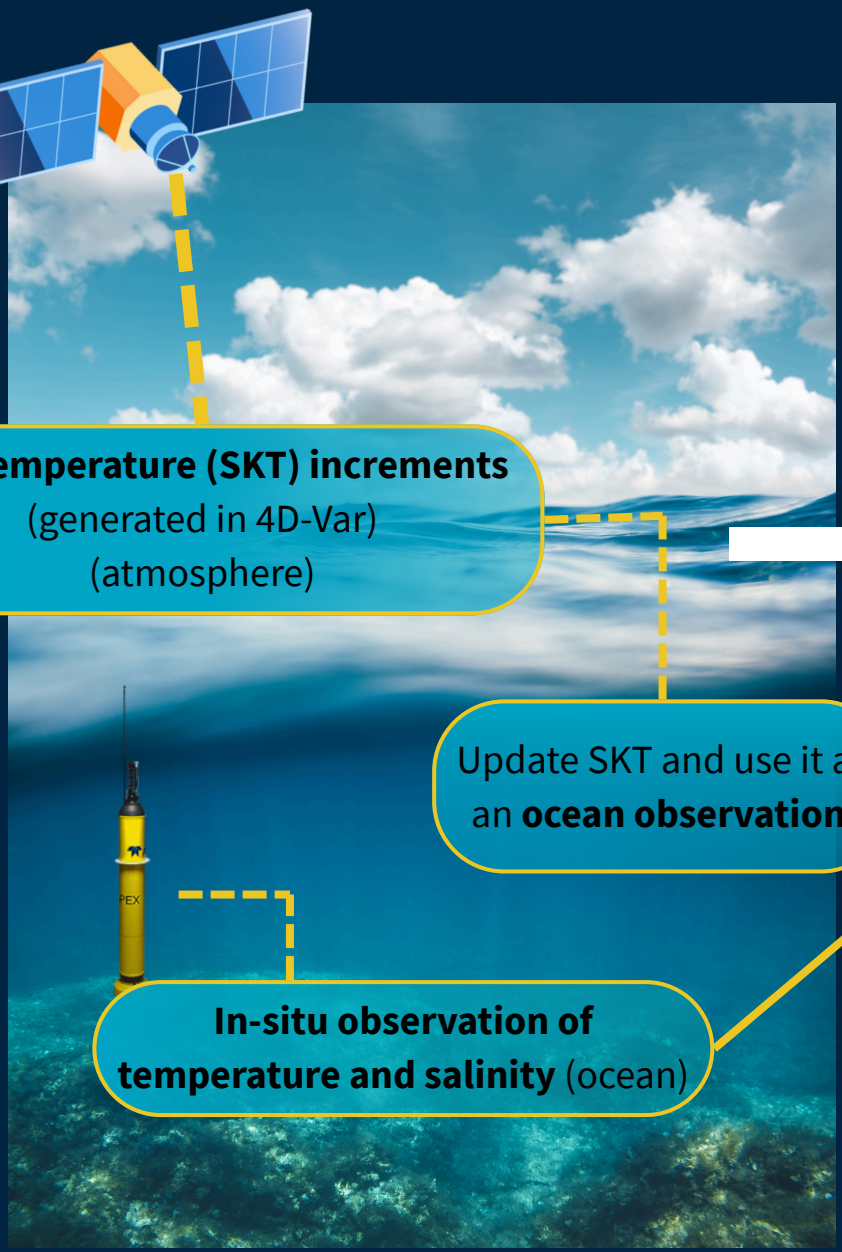


Skin temperature (SKT) increments (generated in 4D-Var) (atmosphere)

Update SKT and use it as an **ocean observation**

In-situ observation of temperature and salinity (ocean)

3D-VAR (NEMOVAR)

4D-VAR

Coupled trajectory

Analysis (atmosphere, wave, ocean, sea ice)

ASSIMILATION OF SATELLITE DATA IN THE COUPLED SYSTEM

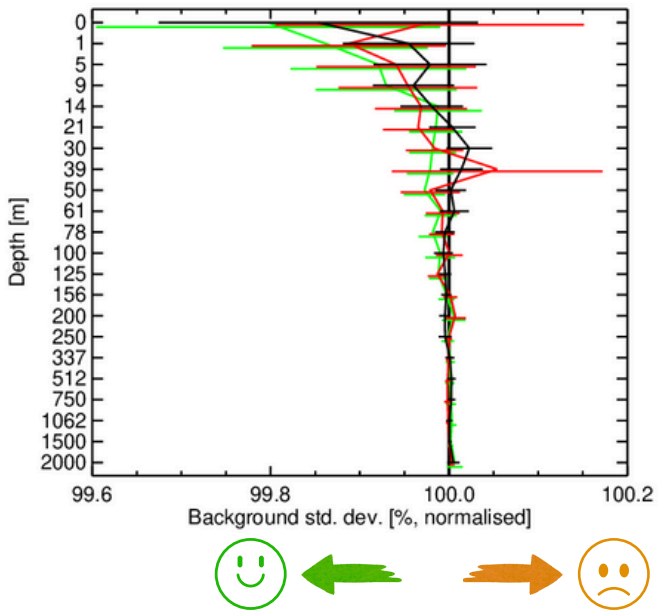
Aim:

- Better quality of initial conditions for coupled forecasts.
- Use the maximum of information from observations.

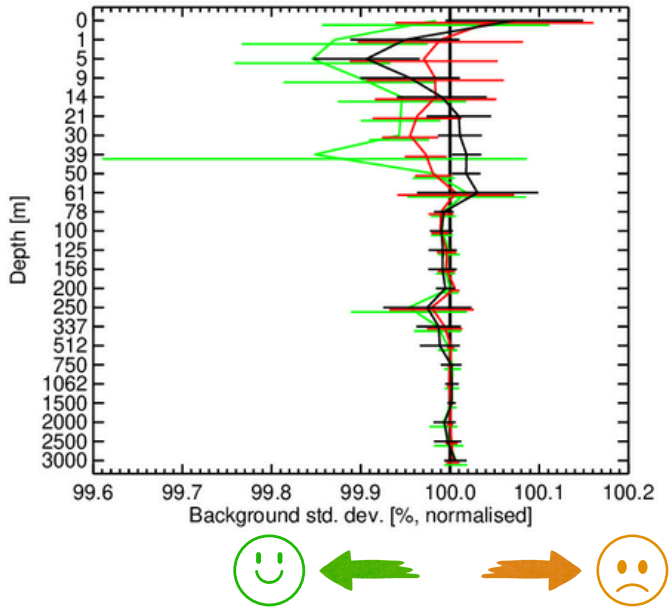
Significant improvements in the first layers of the ocean

Fit to ARGO floats temperatures in-situ observations

Summer period Jun-Jul-Aug 2022



Winter period Dec 2022, Jan-Feb 2023



Impact of adding:

- IR GEOS Window channel (10 µm)
- MW AMSR2 (6 and 10 GHz)
- Both

100% = Control

CONCLUSION

Infrared GEOS window channels provide new surface-sensitive information in clear-sky conditions

- Strict screening for clouds, dust, sunglint and coastal contamination is essential.
- Positive impact on atmospheric forecasts.
- Synergetic improvement in the fit to in-situ ocean observations when adding IR GEOS and MW satellite observations in the ocean-atmosphere coupled system.

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