The Global Ocean Observing System

Why the ocean matters: WMO observations impact workshop

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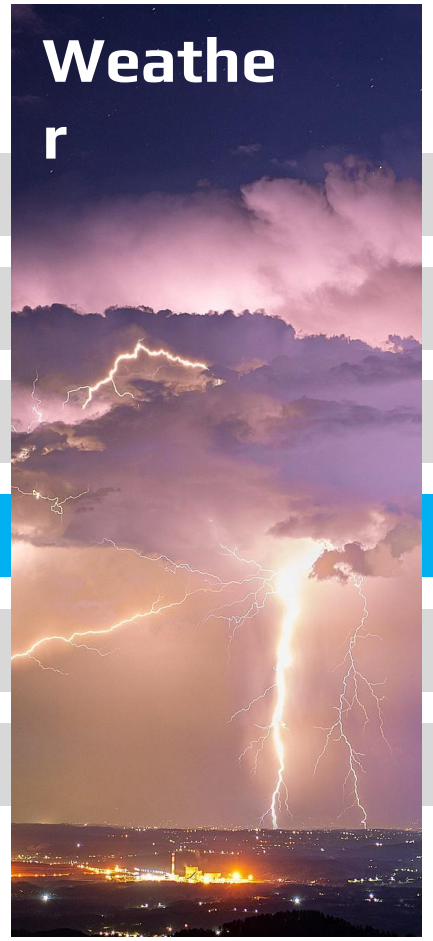
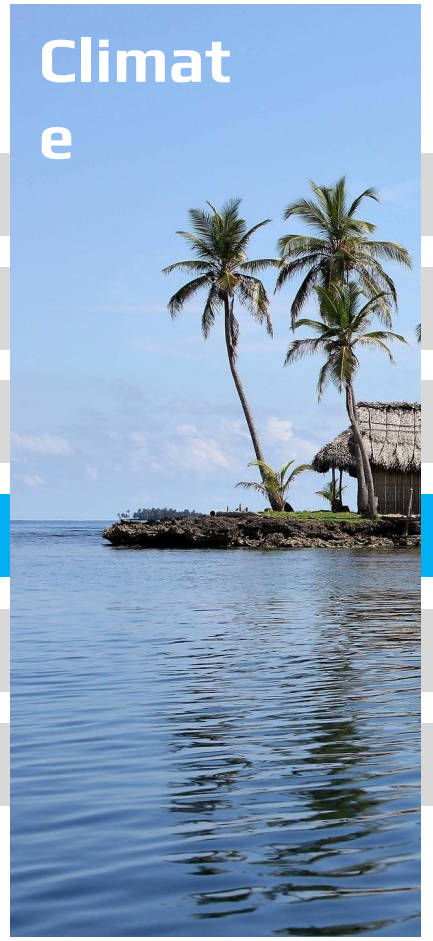
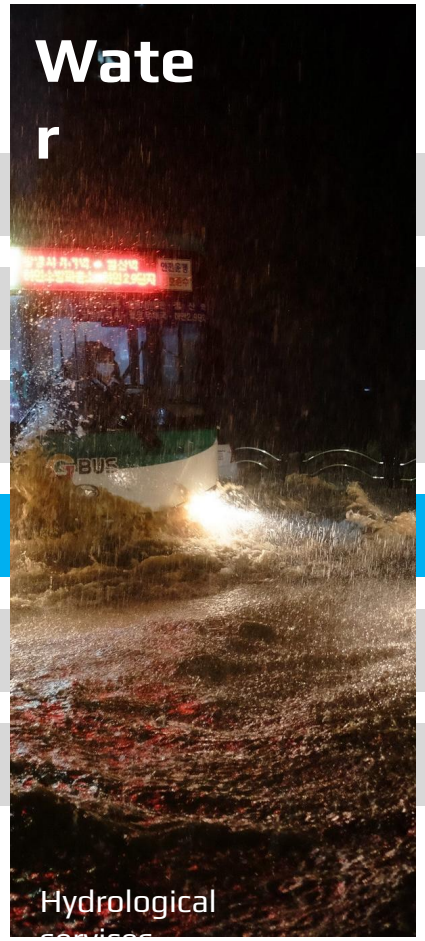
Infrastructure = observations, data exchange and policy, prediction systems

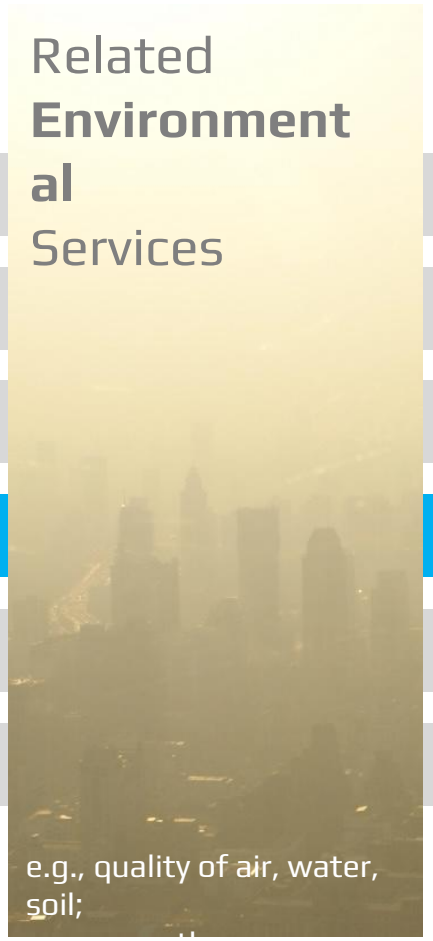
GOOS Steering Committee, 19 February 2025, Paris, France

Why WMO thinks anything matters:
Weather, climate, water service delivery









space-based

Atmosphere

Hydrology

Cryosphere

Ocean

Terrestrial

Space weather

surface-based

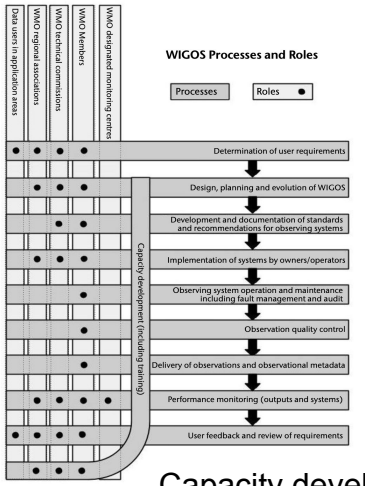
Photos: Various authors, WMO Calendar Competition

WMO's USPs, WIGOS processes, Impacts workshops

WMO USPs

How can engaging WMO lift GOOS implementation?

- operational service delivery focus
- *"shall"* in Technical Regulations
- Complementary WIGOS processes
- Compliance tracking and linked financing through SOFF



Requirements
Design
Standards / best practice

Implementation

Quality
Delivery
Monitoring
Feedback/review

Capacity development

Impact Workshops

- 4-year cycle
- May 2024 edition enlarged focus beyond Numerical Weather Prediction (NWP) to Earth System prediction

WORLD METEOROLOGICAL ORGANIZATION

1950-2025 SCIENCE for ACTION

WEATHER CLIMATE WATER

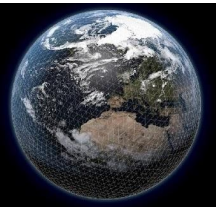
WORLD METEOROLOGICAL ORGANIZATION

8th WMO Workshop

on the Impact of Various Observing Systems on Numerical Weather Prediction and Earth System Prediction

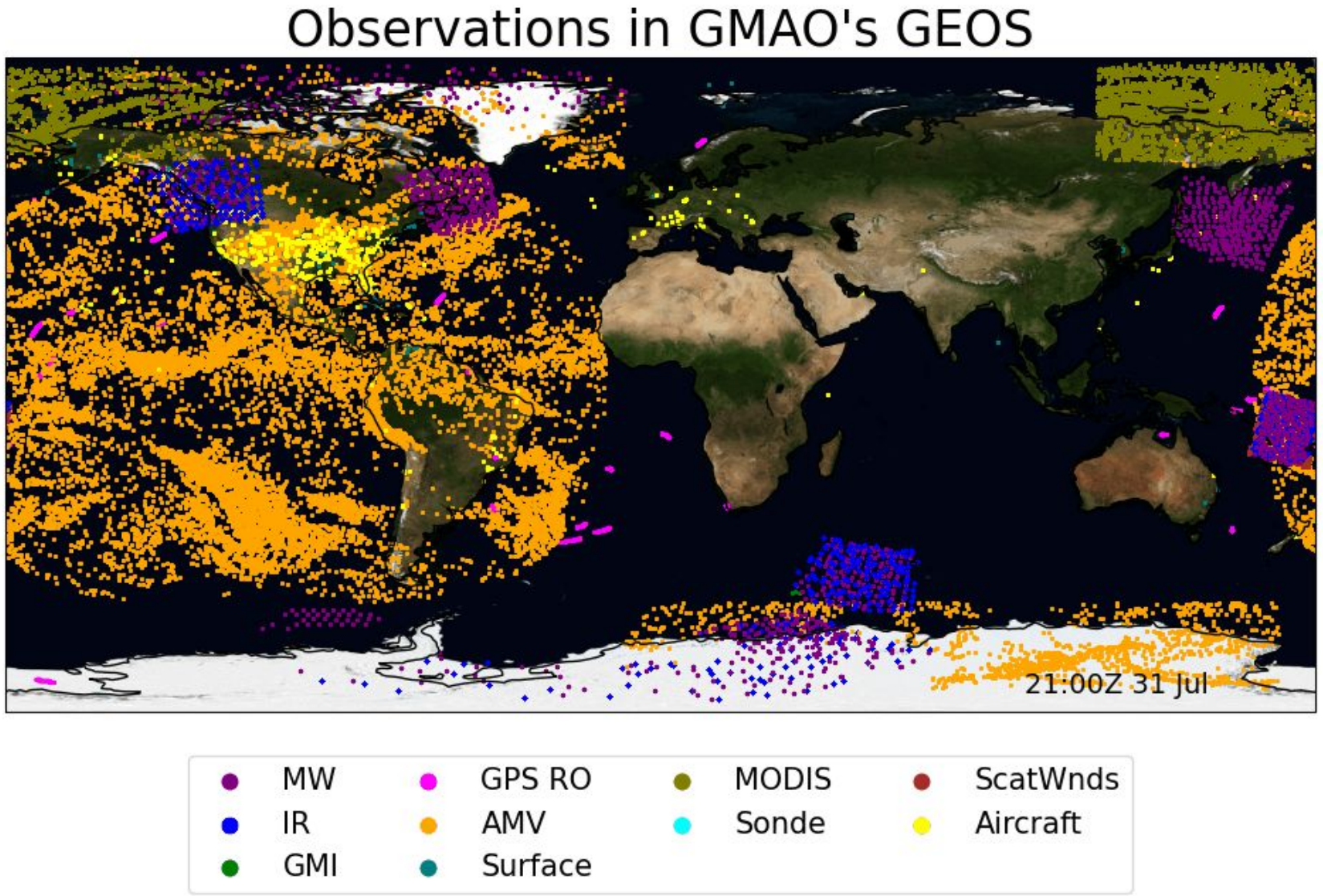
27 - 30 May 2024
Norrköping, Sweden

SMHI



Snapshot of observations going into NWP

5-minute windows, large volume of satellite data



NASA GMAO Erica

Big 5 for skill

Satellite data provide **70-80%** of prediction skill

- Passive microwave radiometers *(sat)*
- Hyperspectral infrared sounders *(sat)*
- Radio occultation sounders *(sat)*
- Radiosondes *(surface)*
- Aircraft-based sensors *(surface)*

Zuo et al., ECMWF, 2024

1. Ocean prediction skill largely from in situ data (65%)

Impact of ocean obs on ECMWF operational system – ORAS5

~65% of the total RMSE reduction comes from assimilating in-situ data

MRB: moored buoy
OSD: CTD sonde
XBT: Expendable bathythermograph
PFL: Argo float

Temperature RMSE: 0-1000m

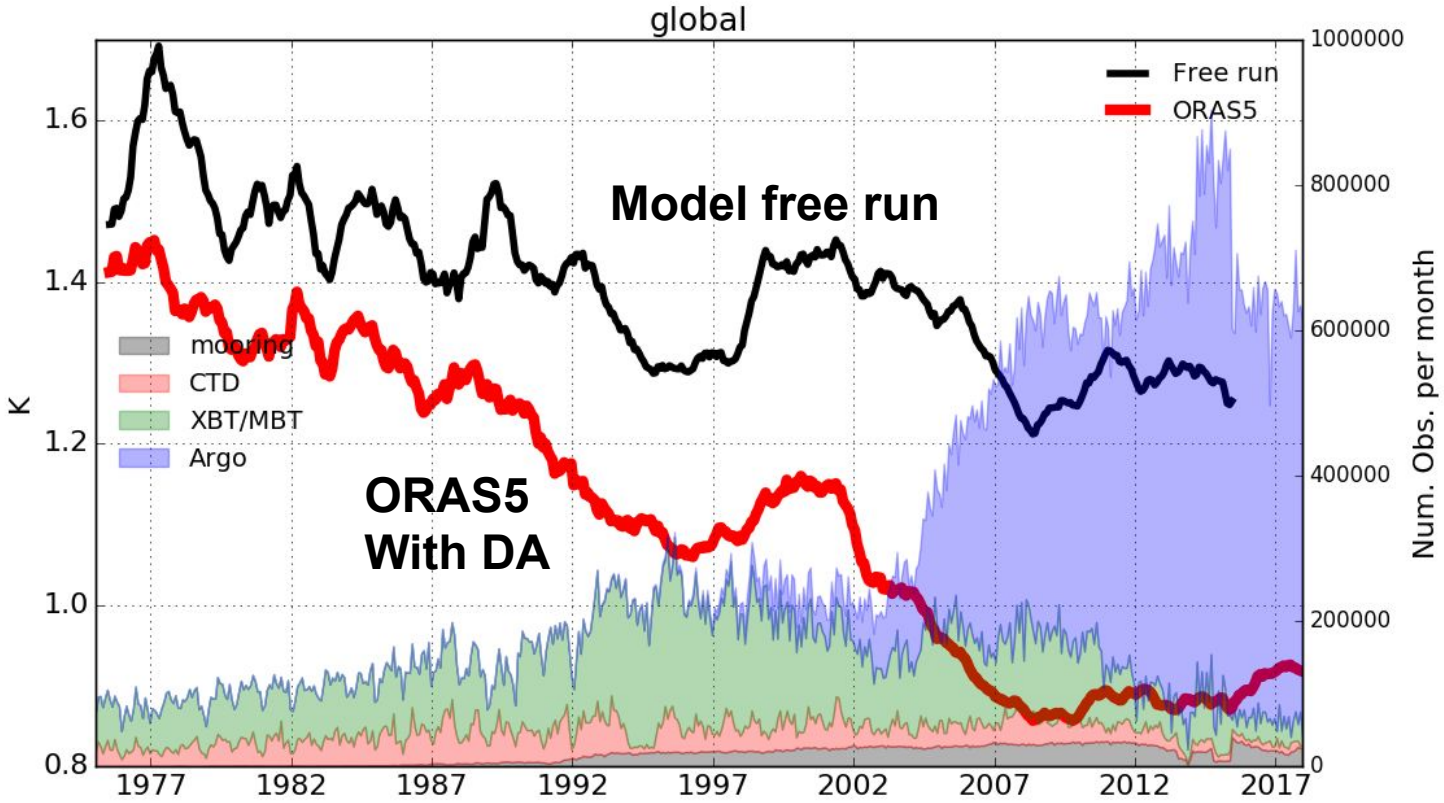


Figure adapted from Zuo et al., 2019

ECMWF

Assimilation of ocean observations helps to constrain the ocean, therefore providing better estimation of the ocean initial condition for the coupled forecasting system

Zuo et al., ECMWF, 2024

2. Ocean data are critical in monthly to seasonal prediction

Impact of ocean obs on ECMWF operational system – SEAS5

ORAS5 provides ocean and sea-ice initial conditions for all ECMWF coupled forecasting systems since 2017, including ENS, HRES and SEAS5.

Johnson et al., 2019 GMD
Tietsche et al., 2020 Climate Dynamics

- **Gain about 2 months in ENSO prediction**
- **Without Ocean observations and DA, we would lose about 15 years of progress (from S1 to S5).**

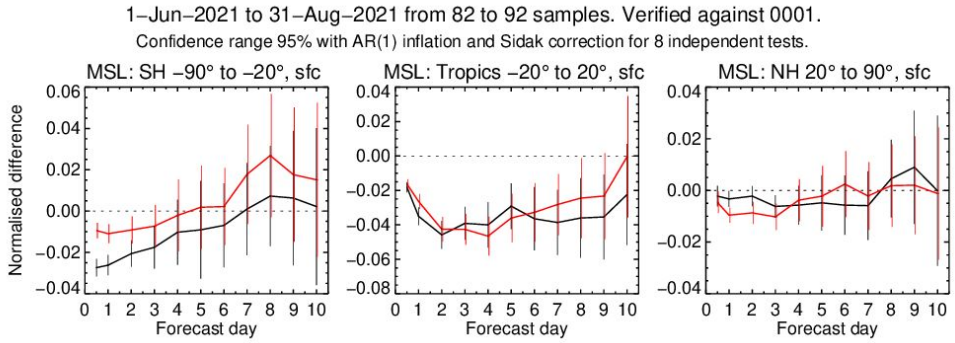
ECMWF

Zuo et al., ECMWF, 2024

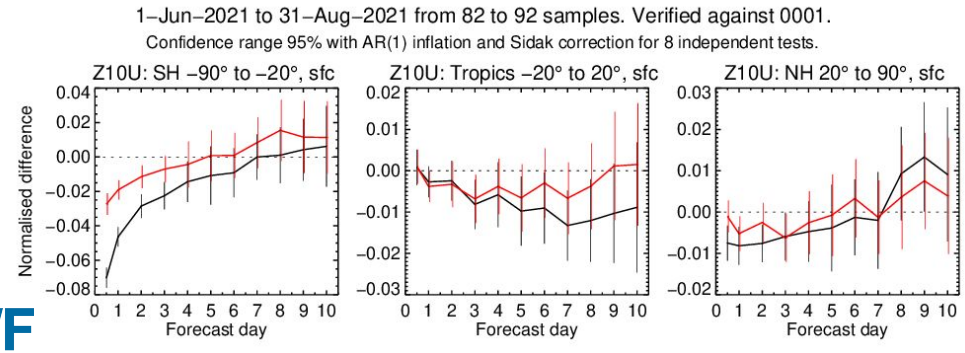
3. Ocean subsurface data increase medium-range (3-10 day) forecast skill, particularly in the tropics

- **Assimilation of In-situ and altimeter observations has sizable impact (positive) on forecasting atmospheric variables in the medium-range**
- **Impact from ocean observations lasts longer in the tropics**

MSL



Zonal wind at 10m



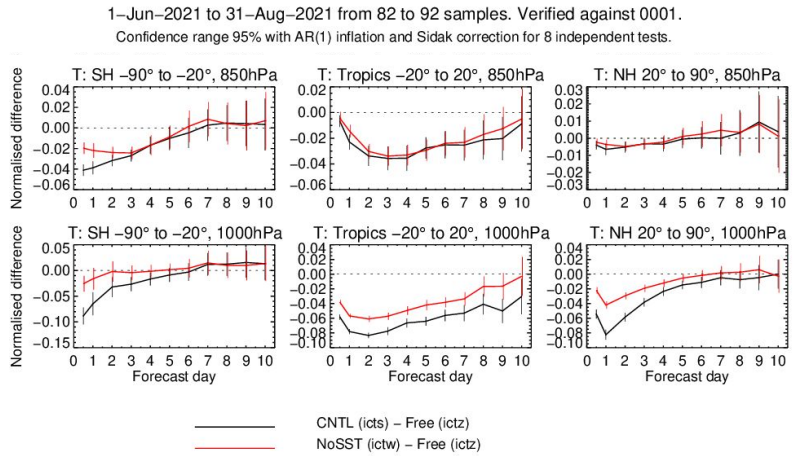
Changes in normalized RMS errors

Reference is Free run without data assimilation

+ in-situ, Alti and SST

+ in-situ and Alti

Temperature
(Lower troposphere and surface)



Conclusions

All 10 of WMO's Global Meteorological (prediction) Centres assimilate ocean surface and subsurface physical data

- The majority of predictive skill in the ocean comes from in situ data, in contrast to the atmosphere
- Ocean data are critical to monthly to seasonal prediction
- In the latest tightly-coupled prediction systems, subsurface ocean data significantly improves atmospheric skill in the medium-range (3-10 days), particularly in the tropics

WMO's NMHSs increasingly depend on ocean surface / subsurface data to deliver weather and climate services, but studies on the impact of in situ observations are rare

AI / ML techniques are very quickly changing how data are used in prediction