World Weather Research Programme (SSC 2022)

Updates from
Data Assimilation and Observing Systems (DAOS)

Co chairs: Sarah L. Dance and Ulrich Löhnert

WEATHER CLIMATE WATER
TEMPS CLIMAT EAU

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World Meteorological Organization
Organisation météorologique mondiale

Working Group Membership

- **Sarah Dance** (Univ. Reading) – DA for convection permitting NWP, hydrology, obs. uncertainty, methodology
- **Ulrich Löhnert** (Univ. of Cologne) – remote sensing, boundary layer, observation network design
- Tom Auligne (JCSDA USA) – satellite assimilation, methodology
- Nadia Fourrié (Météo France) – satellite assimilation, mesoscale DA
- Sean Healy (ECMWF) – GPSRO, operational NWP
- Lili Lei (Nanjing Univ.) – methodology, ensembles, tropical cyclones
- Andy Moore (Univ. of Calif.-Santa Cruz) – regional ocean/marine, methodology
- New: Takemasa Myoshi (RIKEN) – high-res. DA, big data & super-computing
- Juan Ruiz (CIMA-UBA Argentina) – methodology, mesoscale DA
- New: Rossella Arcucci (Imperial College London) – deep learning and DA

WG calls on: 11.2., 18.3., & 22.6.2022

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DAOS Overview 2022

- 2022 biggest accomplishments
- Outlook to the end of 2023
- Innovative science and technology
- DAOS potential contribution to new WWRP projects

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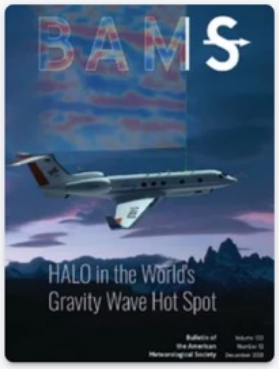
2022 DAOS accomplishments & contributions

Summary: WCRP-WWRP Symposium on Data Assimilation and Reanalysis and 2021 ECMWF Annual Seminar on Observations
...New observations, Error characterization Machine Learning in DA, Coupled DA...

Current challenges and future directions in data assimilation and reanalysis

Arianna Valmassoi[1,2], Jan D. Keller[3], Daryl T. Kleist[4], Stephen English[5], Bodo Ahrens[6], Ivan Bašták Ďurán[6], Elisabeth Bauernschubert[3], Michael G. Bosilovich[7], Masatomo Fujiwara[8], Hans Hersbach[5], Lili Lei[9], Ulrich Löhnert[10], Nabir Mamnun[11], Cory R. Martin[4], Andrew Moore[12], Deborah Niermann[3], Juan José Ruiz[13], and Leonhard Scheck[1,3]



Bulletin of the American Meteorological Society

https://doi.org/10.1175/BAMS-D-21-0331.1

Further Symposium Outcomes

QJRMS special collection on **Coupled Earth System data assimilation** (open through the end of 2022):
https://rmets.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1477-870X.coupled-assimilation

QJRMS special collection: **Combined machine learning and data assimilation for the atmosphere and ocean sciences** (open through July 2024):
https://rmets.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1477-870.machine-learning-data-assimilation

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2022 DAOS accomplishments & contributions

Collaborative research on **Ensemble Sensitivity Analysis** (ESA) to characterize the impact of a network of Doppler lidars (DL) – (University of Cologne, University of Vienna, RIKEN)

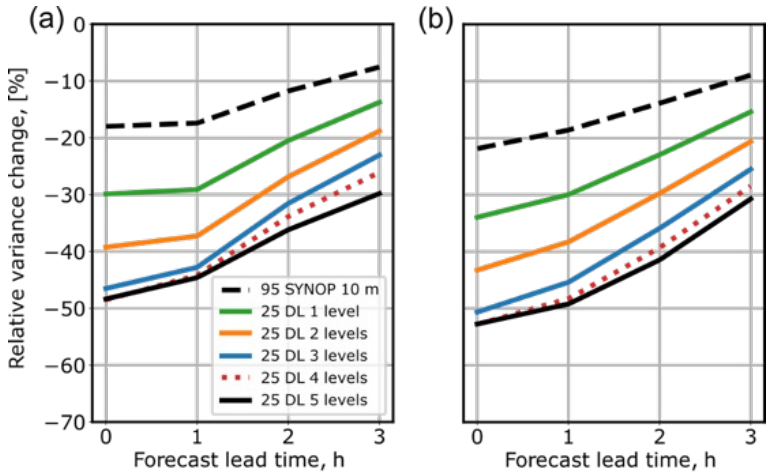

Figure adopted from Nomokonova et al., (2022)

WMO UAS Demonstration Campaign 2024 SPO Committee: prepare data use and assimilation in 2024; initiate dedicated projects

Linking WWRP/DAOS with GAW: WMO urban workshop in June

DAOS Feedback to: JET-EOSDE Working Group document on "High-level guidance on evolution of global observing system"

PROBE COST ACTION

Probing the atmospheric boundary layer on European scale

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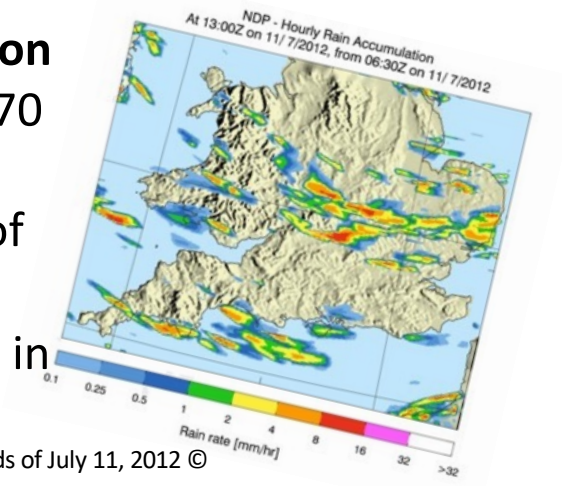
2022 DAOS accomplishments & contributions

Convection-permitting (km-scale) DA for hazardous weather prediction

- Online virtual workshop held in November 2021 attended by over 70 scientists from 17 countries
- Goal: discuss recent developments and the continuing challenges of improving convection-permitting DA
- Initial outcome: Meeting report (with research recommendations) in press in Atmospheric Science Letters



NDP forecast from the floods of July 11, 2012 © Met Office 2012

Numerical Weather Prediction and Warning Communication System for Densely Populated and Vulnerable Cities

Principal Investigator (Affiliation)	Chief Scientist MIYOSHI Takemasa (Cluster for Pioneering Research, RIKEN) researchmap
Research Institutions in Japan	RIKEN
Research Institutions in Peru	-
Adoption fiscal year	FY 2021
Research Period	5 Years
ODA Recipient Country	Argentine Republic

- PREVENIR: new 5-year project
- Aims at advancing technological tools for an integrated hydro-meteorological forecasting system for predicting urban flash-floods
- Collaboration between Japan and Argentina

Publications exploring opportunistic observations for NWP inc. vehicle – based temperature measurements

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2022 DAOS accomplishments & contributions

Training and Development of Early Career Researchers

Technical DA training course held in Reading, UK (face to face) with online participants from India – May 2022

School workshops

Sci-Art Collaboration

Art exhibition in Care homes on DA for flood prediction

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Outlook to end of 2023

- Co-lead coordination of informal working group involving members of WGNE, OMDP, S2S, OceanPredict, and other interested parties, on **identifying strategies** for initializing the ocean component of coupled models for **predicting the MJO**

- Active contributions to UAS Demo campaign

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Outlook to end of 2023

- Review paper on observation impact in DA for convection-permitting NWP (collab with NMR, PDEF & HiWeather)

- Leading roles workshop/conference planning
  - Major conference (EMS, AGU, EGU?) session on observation system design
  - next “Adjoint workshop” (expected to be held in 2024)
  - MLDADS (Machine learning & DA)

- Launch of new (non-technical) MOOC “Dare to discover data assimilation”

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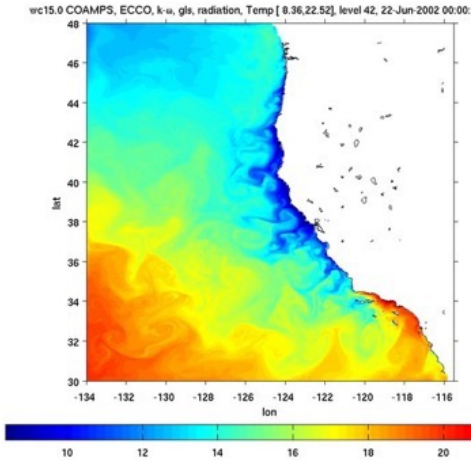
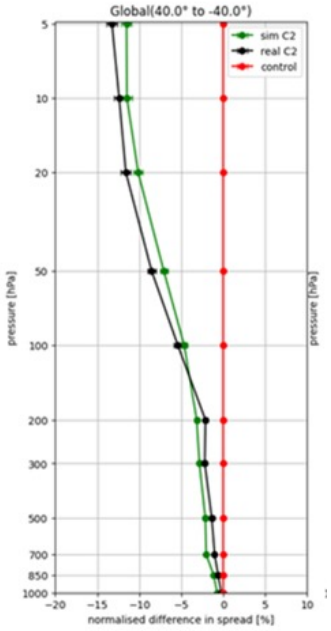
DAOS innovative science & technology

Regional Ocean Modeling System (ROMS)

- Interfacing with JEDI
- FSOI capability
- Development of a nested 4D-Var capability





EDA (Ensemble of Data Assimilation) / ESA (Ensemble Sensitivity Analysis)

- Methodologies for quantifying observation impact from ensembles (no classical OSE, OSSE necessary)
- Currently applied to specific RO satellites (EDA) and ground-based Doppler lidars (ESA)
- Expandable to arbitrary observation system configurations
- Potentially valuable for NWS

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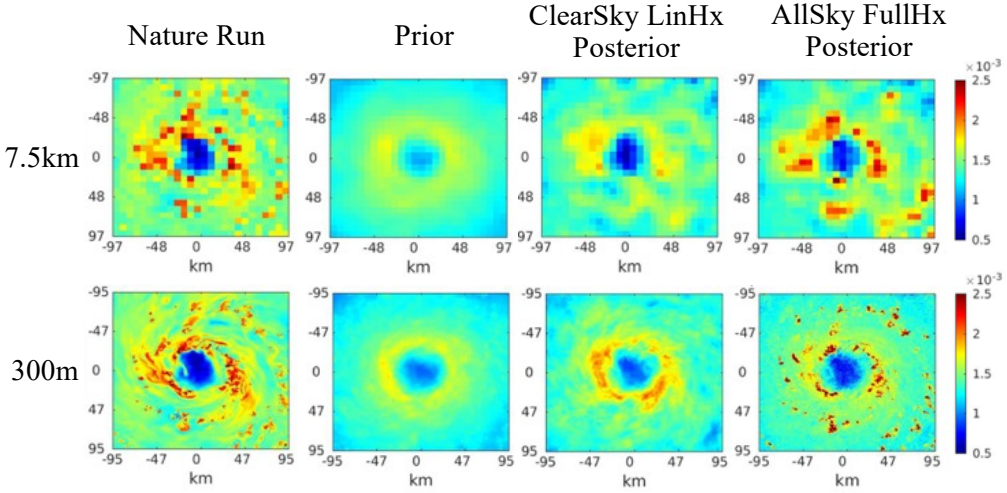
DAOS innovative science & technology

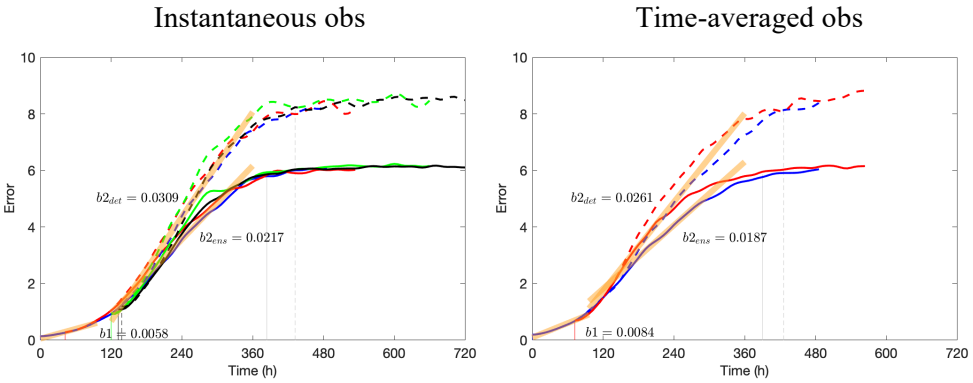
Sub-kilometer ensemble data assimilation

- As the spatial resolutions of observations and models will keep increasing, the potential issues of assimilating high spatial-resolution observations given fine model resolutions need be examined
- With model resolution increasing from 7.5 km to 300 m, linearized observation operator has advantages over full operator for assimilating clear-sky radiances, but the opposite is true for assimilating all-sky radiances



Cross-scale data assimilation and forecast

- To capture the complex and cross-scale features of the Earth system, seamless prediction is required, thus the DA strategy with different importance of DA components for cross scales need be understood
- Instantaneous observations are preferred than time-averaged observations
- Cycling assimilation and flow-dependent **B** are superior to offline assimilation and static **B**, while the superiority decreases with longer window and less frequent obs



DAOS: contribution to existing WWRP projects

- **HIWeather**
  - Convection-permitting data assimilation observation impact measures (review paper, conference session, research projects)
  - Input to citizen science guide
  - Crowdsourced observations (ongoing research work dependent on successful bid to UK national research council)
- **JWGFVR (joint VC)**
  - Potential collaboration: observation uncertainties / representativeness issue / data assimilation techniques for verification practices
- **Paris RDP**
  - ICON-LES evaluation over Paris domain
- **WGNE**
  - Joint paper on TC initialization paper ist being iterated amongst authors
- **TC-PFP**
  - New research project National Natural Science Foundation of China, “Theory of typhoon genesis and development, and techniques of fine prediction”, 01/2022-12/2026

DAOS: contribution to new WWRP projects

Contribute to new projects requiring

- DA methodological developments (coupling, multi-scale,...)
- Input on observation network design
- Machine learning / new data science

IHAPP

- Convection-permitting DA methodology; multi-scale data assimilation
- Polarimetric radar and new satellite QPE, QPF, WV observations
- Land surface, soil moisture, snow coupling

SAGE

- Ocean Predict → ocean initialization, coupled DA & ML
- UN Ocean Decade

PCAP

- Ocean-ice-atmosphere coupled DA
- Assess reference data for polar region
- Destination Earth → high-res. ensembles

URBAN

- Make use of high-resolution observations through machine learning rather than explicit DA/modelling?
- Tiered observation network approach: from crowd sourcing to novel expert obs. networks

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Thank you
Merci

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