An Earth System View of Observations

Stephen English, ECMWF

With thanks to many colleagues notably Niels Bormann, Tony McNally, Alan Geer, Michael Rennie, Lars Isaksen, Patricia de Rosnay, Giovanna De Chiara, Phil Browne, Adrian Simmons, Andy Brown (all ECMWF), Heather Lawrence (Met Office), Tim Palmer (Oxford University)

And special thanks to all speakers and sessions chairs at AS2021 and to Karen Clarke, Regina Mansor, Simon Witter, Hilda Carr, the science committee and the ECMWF leadership team for the organisation of the event

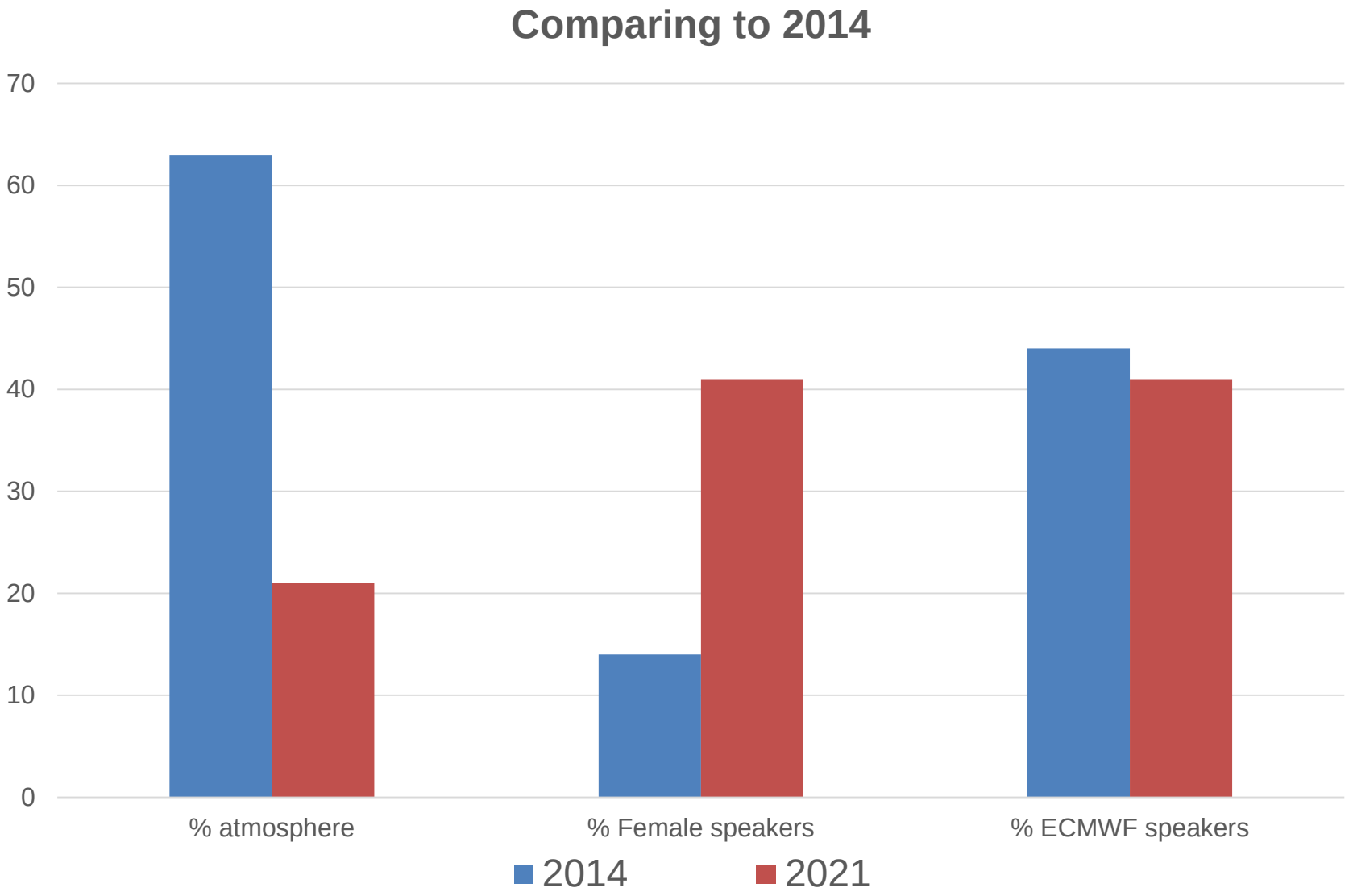
And finally also to our friends from the WMO Data Assimilation and Reanalysis symposium for the joint organisation, especially Jan Keller, Daryl Kleist, Wenchao Chen, Nico Caltabiano, Estelle De Coning, Michael Rixen and Catherine Michaut

#RFI2022

https://events.ecmwf.int/event/258/

ECMWF

The ECMWF Annual Seminar 2021: talks



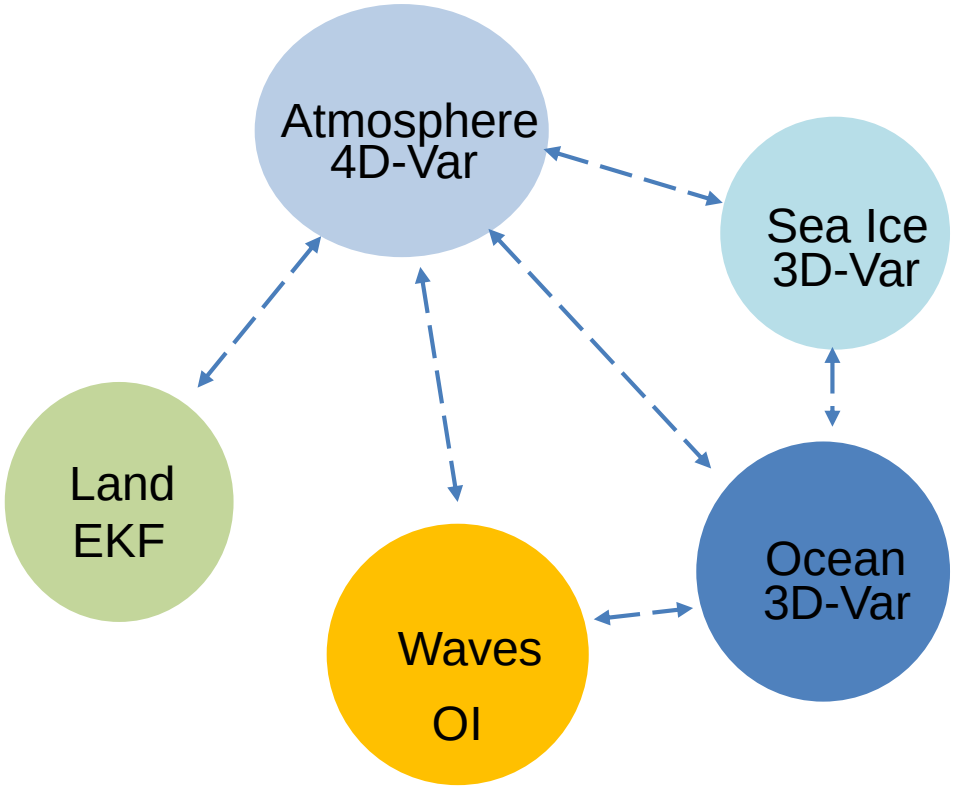
2014
Only satellite

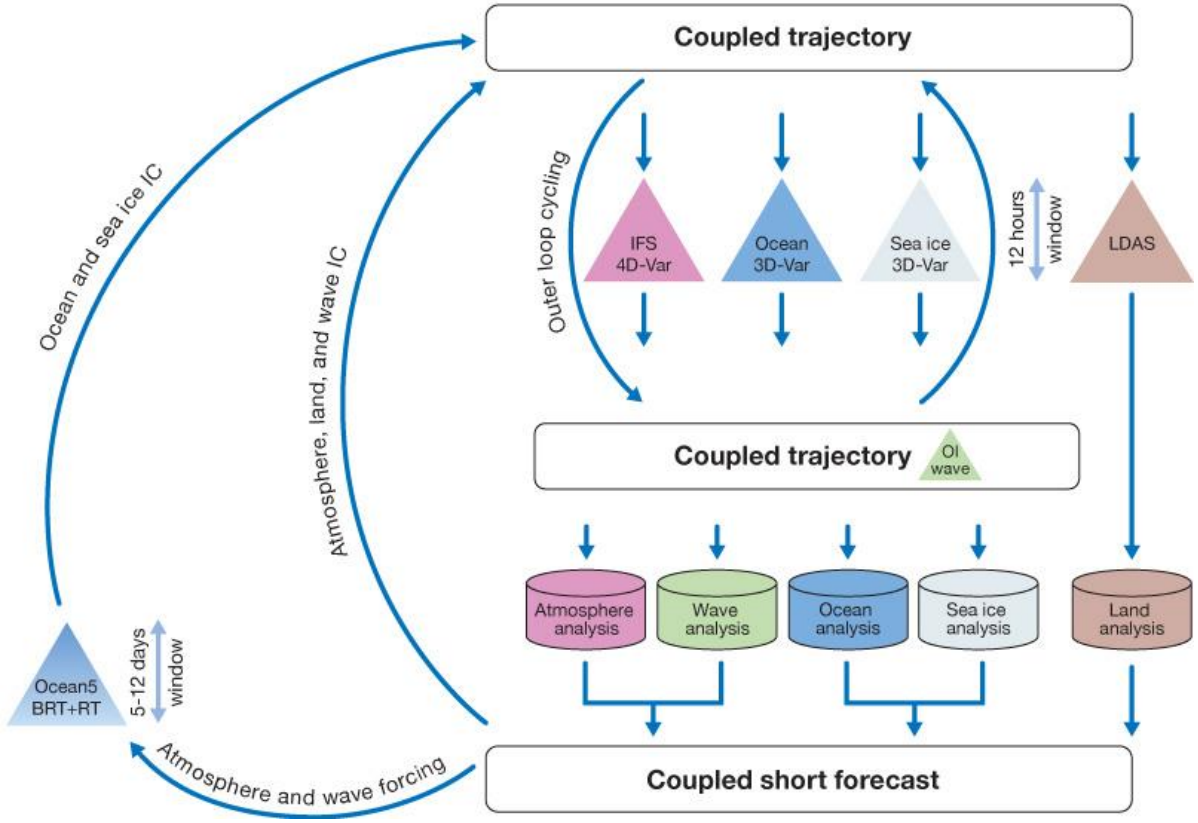
2021
All observations

2014
Atmosphere

2021
Earth System

Earth System Approach



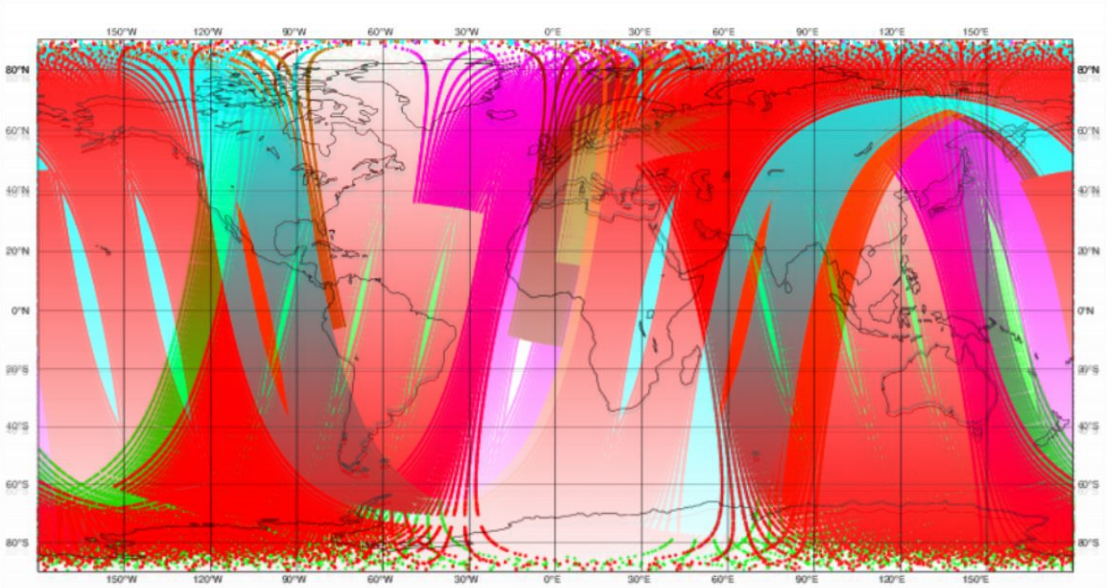


Patricia de Rosnay
ECMWF

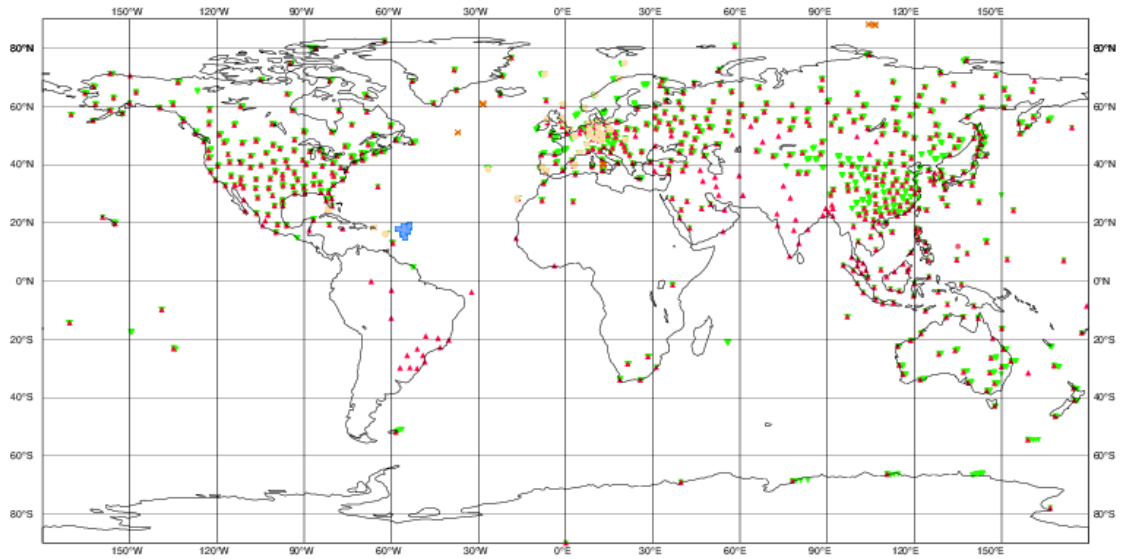
Annual Seminar structure

Mon	**Session 1: Current observations: do they meet requirement (e.g. for NWP)?**	Stephen English, Christina Köpken-Watts, Bruce Ingleby, John Siddorn, Gunnar Spreen, Antje Inness, Angela Benedetti, Cristina Charlton-Perez, Melody Sandells	Overview then atmosphere-weather, atmosphere-composition, ocean, land, snow, sea ice
Tue	**Session 2: How are observations processed and assimilated?**	Peng Zhang, Nigel Atkinson, Peter Lean, Patrick Eriksson, Mark Buehner	Observation handling, preprocessing, calibration, radiative transfer, data assimilation
Wed	**Session 3: Current challenges**	Jo Waller, Patrick Laloyaux, Catherine Prigent, Patricia de Rosnay, Kristen Bathmann	Observation error (random, systematic), improved operators, new applications, coupled data assimilation, quality control and data screening
Thu	**Session 4: Assessing the impact of observations**	Mohamed Dahoui, Philippe Chambon, Niels Bormann, Elizabeth Remy, Jana Kolassa. Plus Joint Reanalysis Session: Shinya Kobayashi, Hans Hersbach, Bill Bell, Joaquin Munoz-Sabater, Amal EL Akkraou, Deep Sankar Banerjee	Observation monitoring and diagnostics, model validation (atmosphere, ocean, land), impact studies (atmosphere, ocean), use in reanalysis,
Fri	**Session 5: New science and future directions**	Tony McNally, Dorothee Coppens, Craig Donlon, Natalia Donoho, Roger Randriamampianina, Alan Geer	The value of observations in an Earth System approach, the evolving GOS and its challenges (EUMETSAT, ESA, NOAA and global perspectives), new types of observation, “all surface” strategy

What do we mean by observation data gaps?



Darker shades: AMSU-A
Lighter shades: ATMS



Upper Air Data
(sondes and pilots)

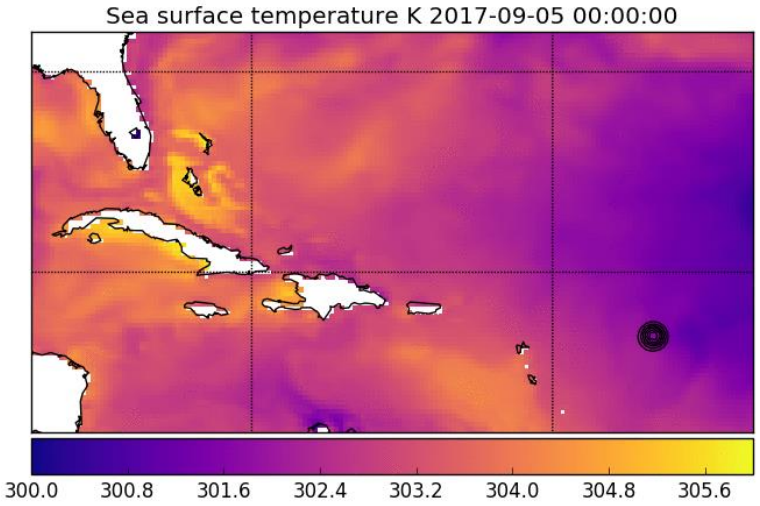
Easy to spot data voids on a map: do they matter?
And is satellite data coverage really as complete as this looks?

How does this look for “Earth System”?

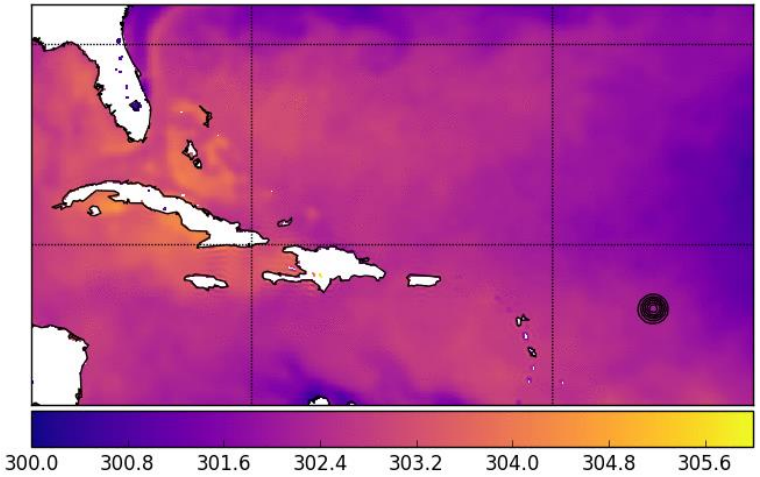
ECMWF

Changing impact of observations complicates “gap analysis”

With ASCAT



Without ASCAT



What maturity will we have in 5, 10, 20 years in the future?

Many other examples:

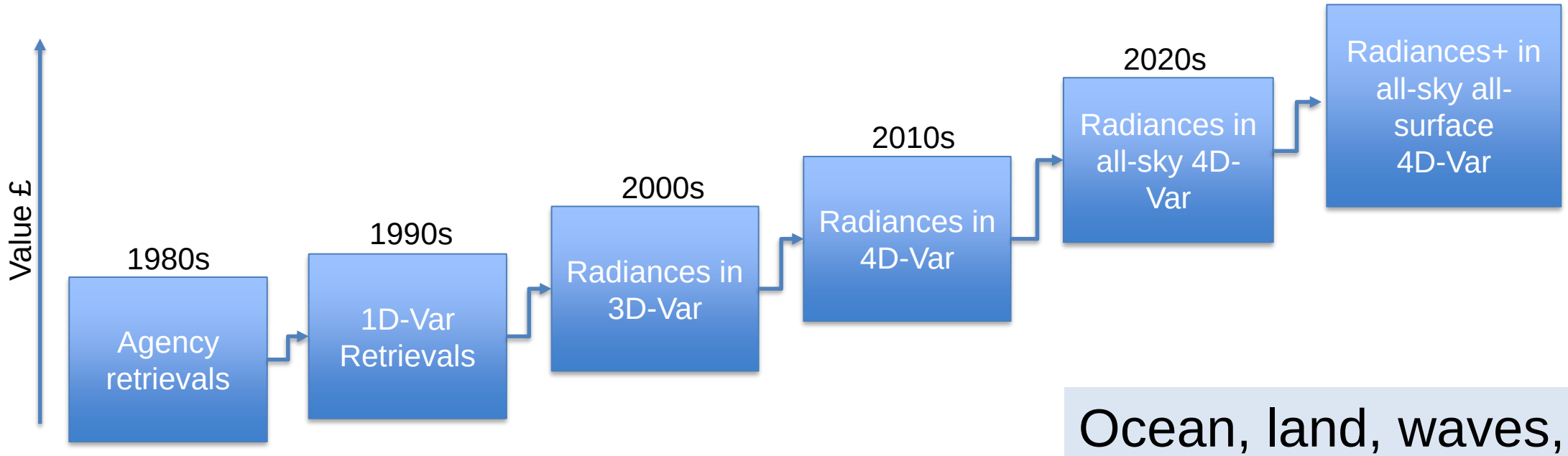
- Winds from assimilating atmospheric composition observations as tracers
- Atmospheric composition from “weather” instruments e.g. IASI
- MW imagers coupling surface and atmosphere
- …

Tony McNally, Phil Browne and Giovanna De Chiara, ECMWF

Gaps may simply reflect immature use of existing observations

Did we anticipate the rise and rise in value of MW humidity sensitive radiances 20 years ago?

Science has matured and transformed their impact from minor to major

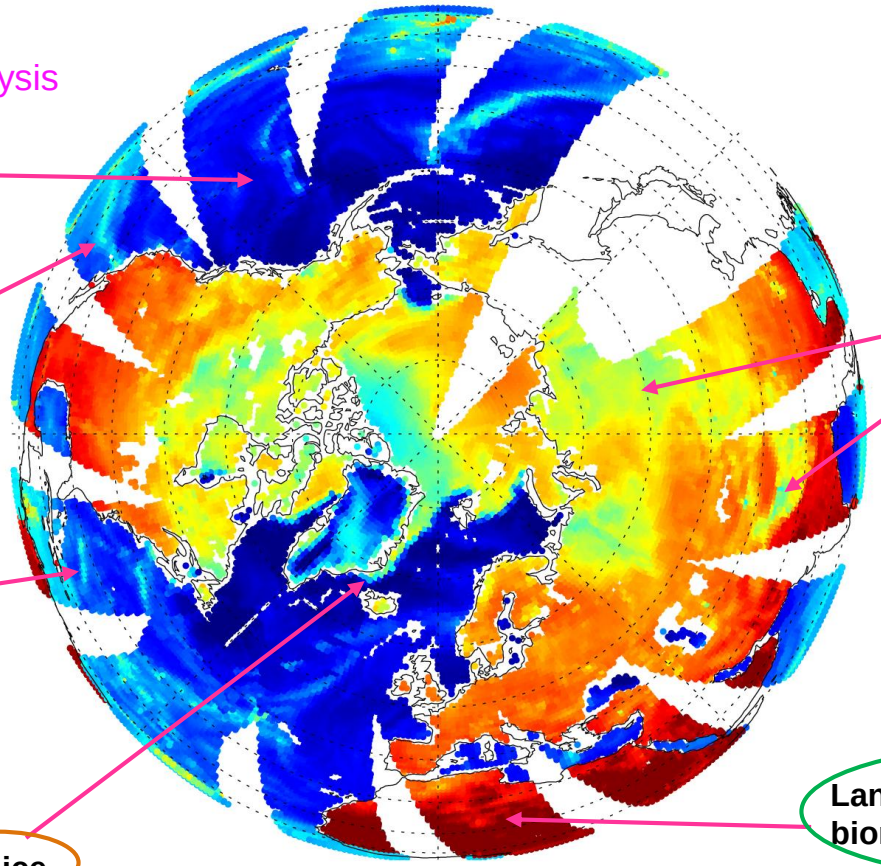


Ocean, land, waves, sea ice tend to lag behind atmosphere

ECMWF

Interface Observations: under exploited without coupled DA

SSMIS F-17 channel 13 (19 GHz, v)
Microwave brightness temperatures
3rd December 2014



Assimilated in atmospheric analysis

Ocean waves, wind, skin temperature

Atmospheric water vapour and temperature

Cloud and precipitation

Not used yet but could be in snow DA

Snow cover

Not yet used, but could be in land DA

Land surface temperature, biomass, soil moisture

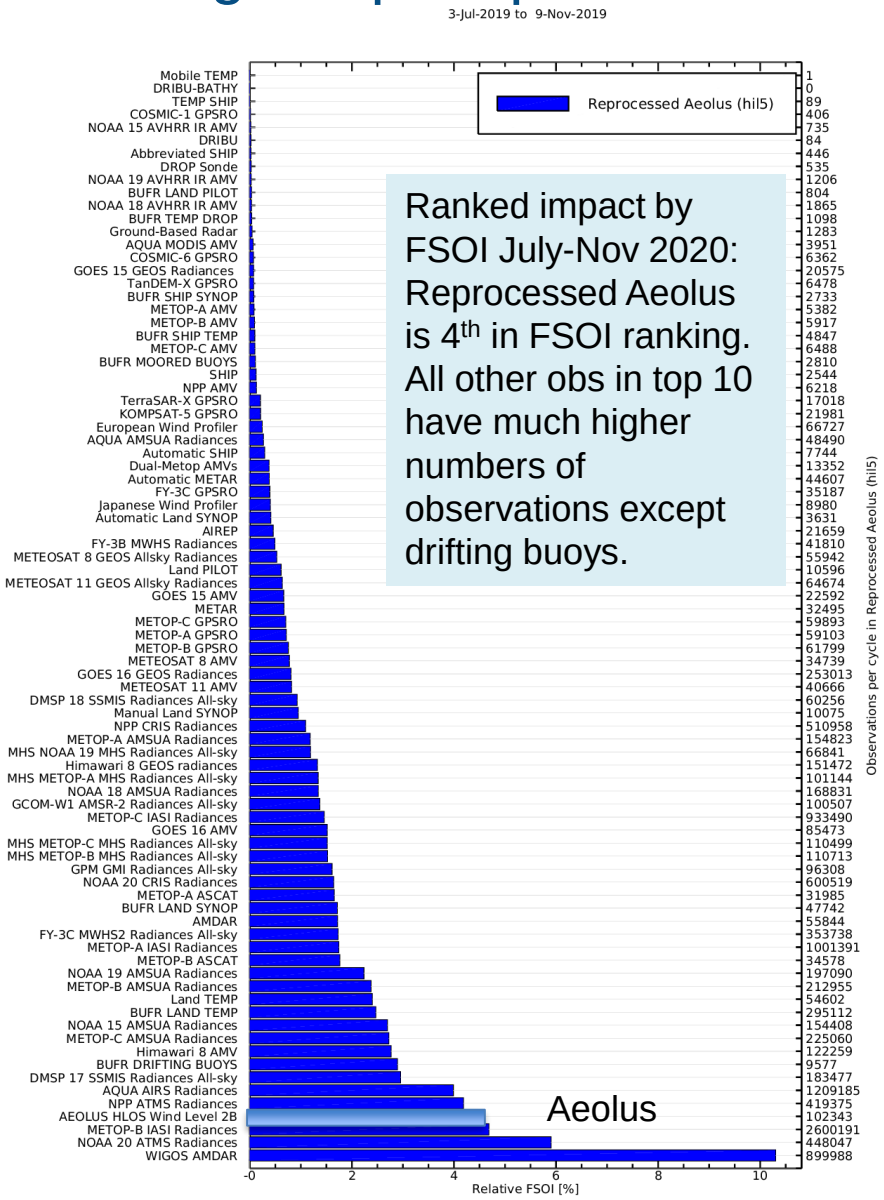
At ECMWF used via third party L4 (OSTIA)

Sea-ice

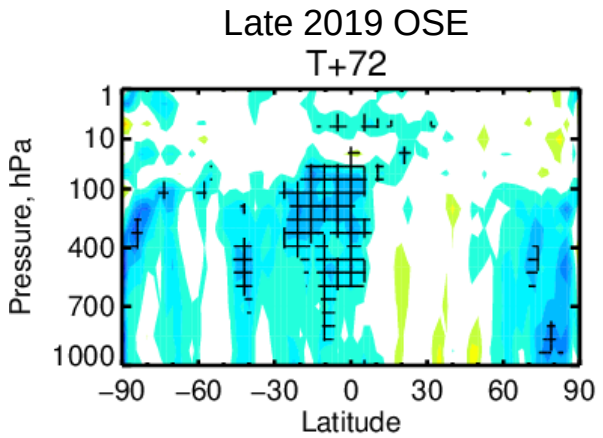
ECMWF

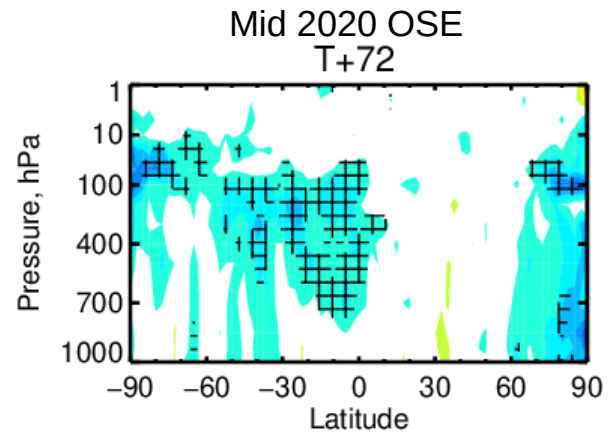
Alan Geer

Some good past predictions: wind gap matters



Ranked impact by FSOI July-Nov 2020: Reprocessed Aeolus is 4th in FSOI ranking. All other obs in top 10 have much higher numbers of observations except drifting buoys.





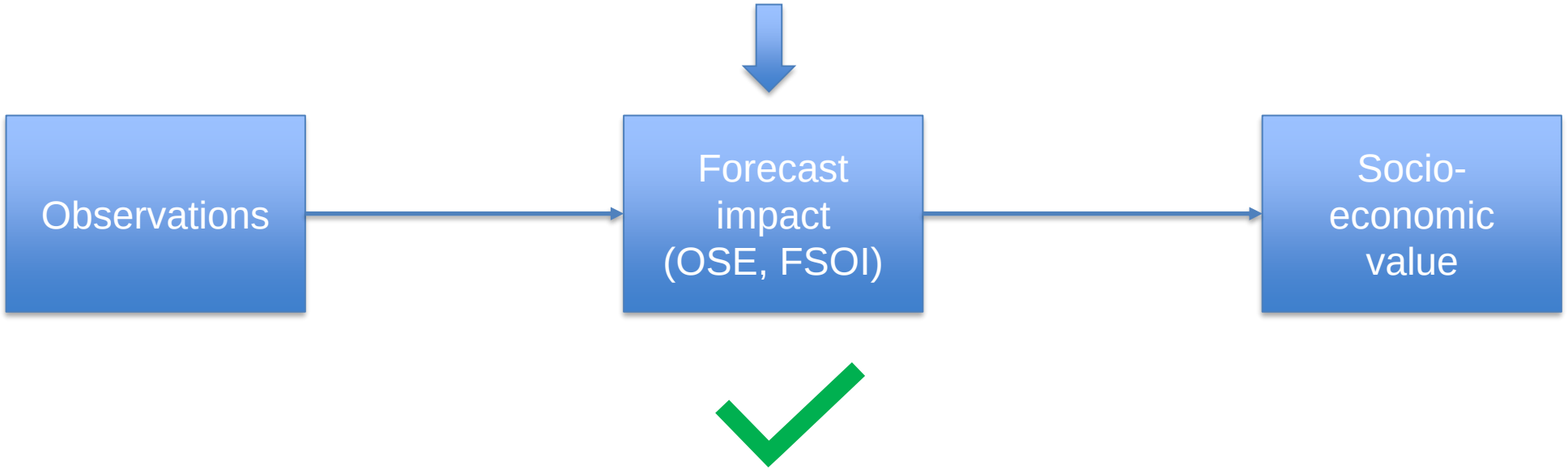
Aeolus demonstrated value of wind profile data from lidar

aeolus

DISC

Michael Rennie and Lars Isaksen ECMWF

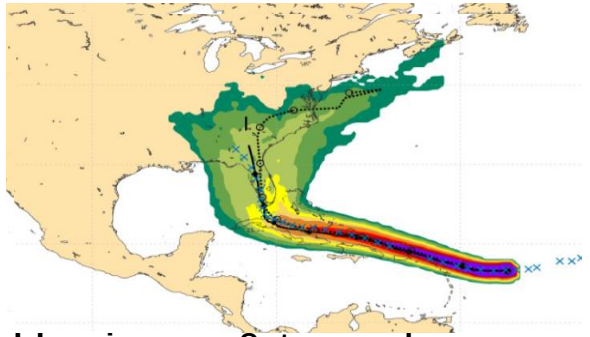
NWP centres can measure the impact of observations on skill of forecasts and (re-)analysis



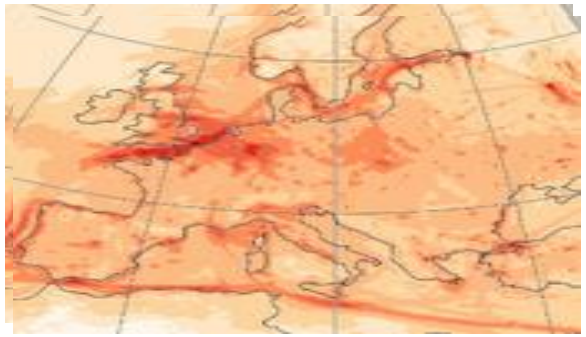
Global and regional NWP underpins many socioeconomic sectors

Weather advice

Snow, flood & fire



Hurricane & tornado



Air quality

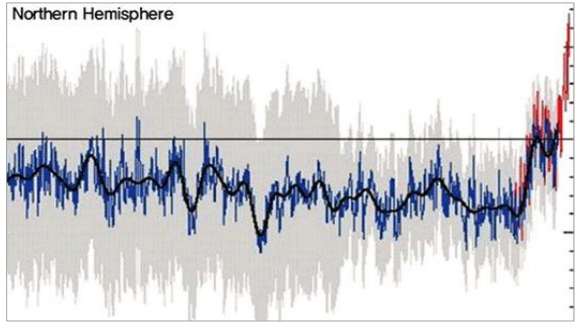
Warnings, public safety, protection of life and property

Transport

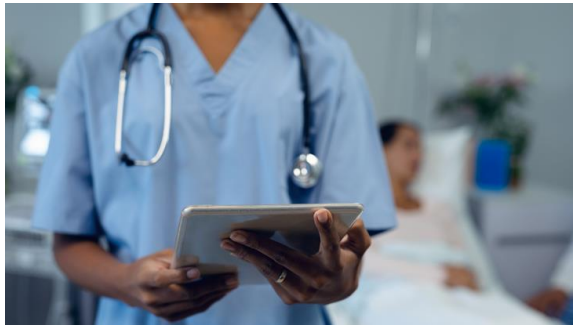
Energy

Agriculture

Tourism



Climate change Monitor



Public health and famine

Business and commerce

Defence

How to measure medium range skill changes from observations?

Ed Lorenz, 1982:
Cutting the one-day root-mean-square error in half should add another two days to the range of predictability
https://doi.org/10.3402/tellusa.v34i6.10836

Adrian Simmons, 2002:
…significantly reduced analysis and short-range forecast errors, have led to substantially lower medium-range forecast errors.
https://doi.org/10.1256/003590002321042135

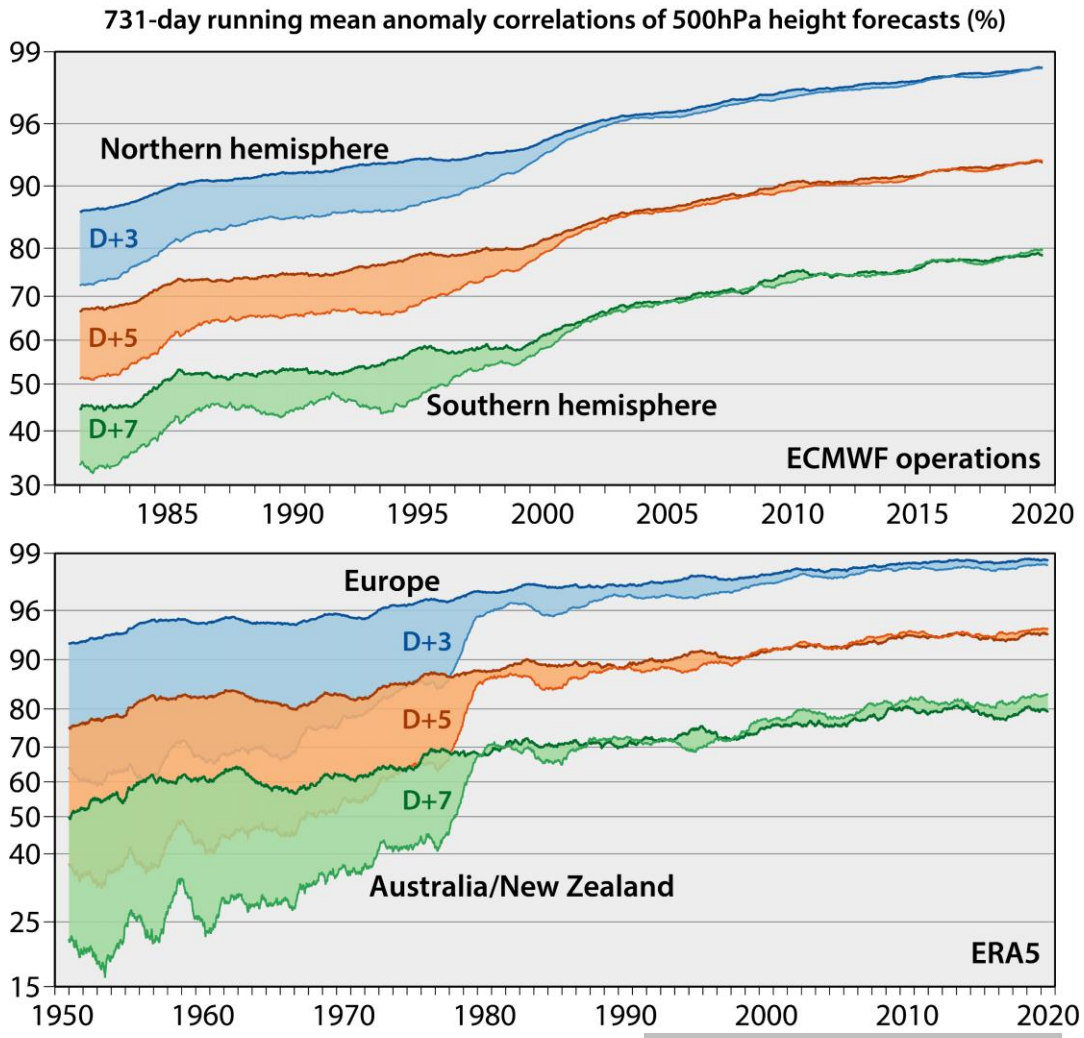
Recent discussions with Tim Palmer, Niels Bormann and Adrian Simmons:

Tim Palmer on Lorenz 1982: On-going need for Singular Vectors shows short range skill is only a partial predictor for medium range skill;

Niels Bormann: Some obs tend to do better at short range (AMVs, humidity observations) and others comparatively well at medium range (microwave temperature). Maybe this links to how well they project onto fast growing modes?

Adrian Simmons: Link from short to medium range may not hold locally (e.g. errors at short range in the Arctic may become important only in the medium range in middle latitudes);

Adrian Simmons: SST, sea-ice, some aspects of the land surface - not improving these would eventually limit the potential for improving the medium range.



From Adrian Simmons

ECMWF

Summary

Science	Share	Measure
Earth System approach, coupling, interface obs	WDQMS, GBON, Res-42, WMO satellite position paper	Space agencies, SOFF, Commercial
L1 MW imagery for land and snow in coupled DA L1 visible for cloud and aerosol L1 for atmospheric chemistry (e.g UV) L1 for ocean (SST, waves)	Commercial with global license Share hydrology in situ Share all regional snow observations Faster dissemination	High temporal resolution MW Doppler wind lidar follow-on Operational high vertical resolution e.g. radar, lidar, limb sounders

Enjoy the seminar!