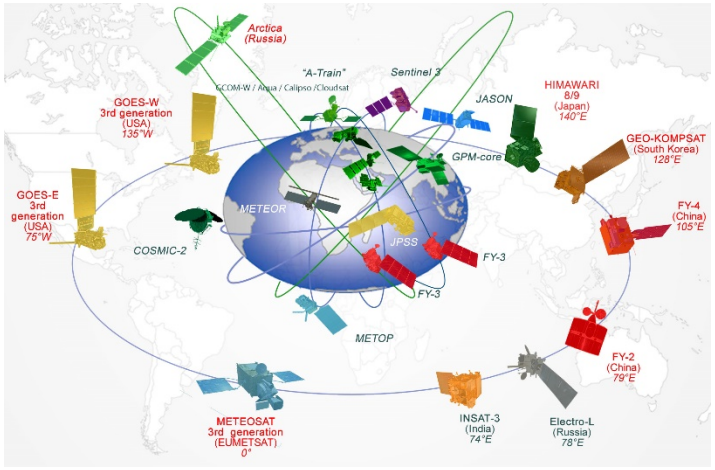

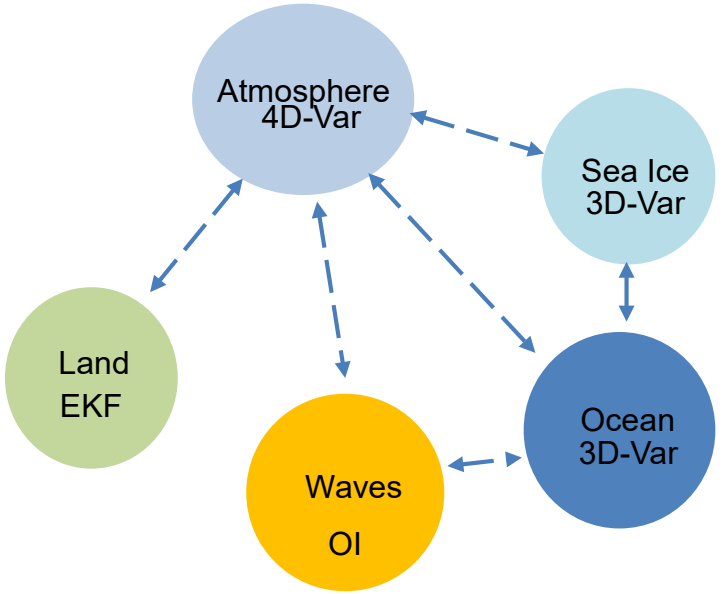

Future evolution of the data assimilation system

S. English, ECMWF

CGMS-49 plenary, agenda item 5

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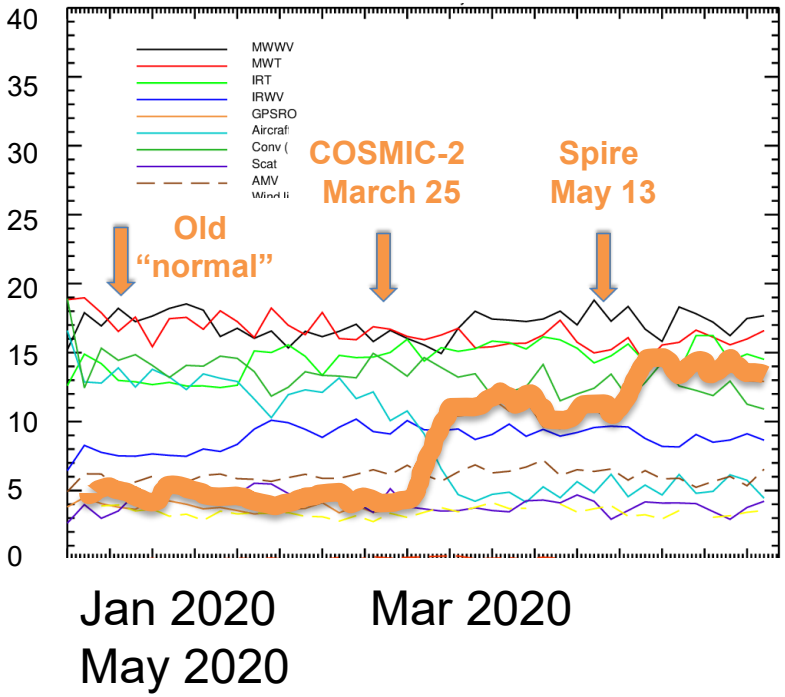
Earth System Assimilation requirement for Observations

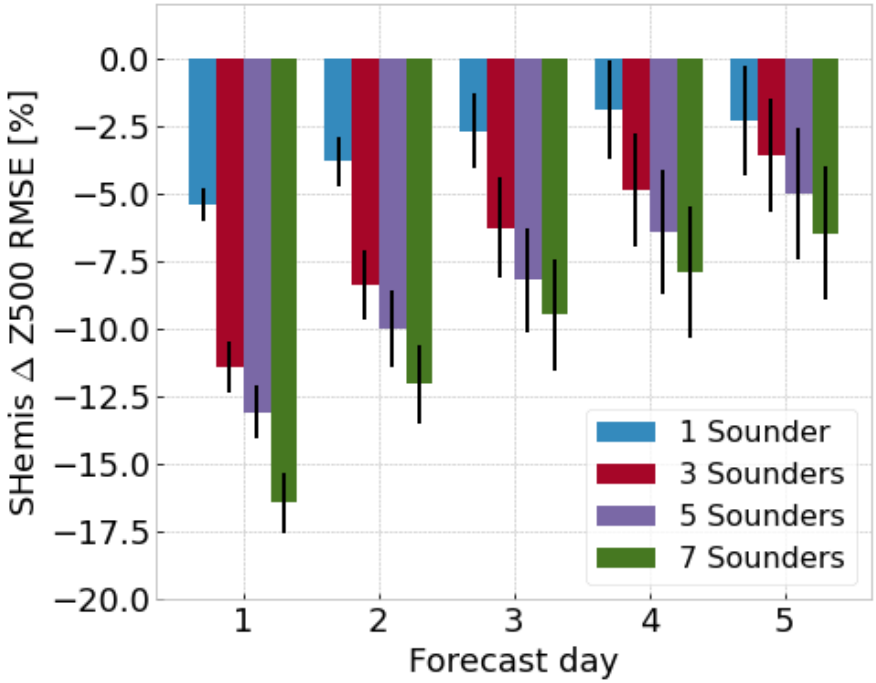
- Many requirements for global Earth System NWP could be met by the commitments and aspirations in the CGMS baseline, the CGMS HLPP and the Vision 2040 of WMO
  - Recognising they need constant review to align with the evolving Earth System approach

- Regarding atmospheric observations we recognise the need for:
  - The 3 orbit "reference" LEO satellites is the backbone of the observing system for global NWP;
  - Addition of other orbits (e.g. with small satellites) to achieve higher temporal resolution;
  - The GNSS constellation evolution towards 20,000 obs per day (CGMS HLPP);
  - Additional wind observations, drawing on Aeolus (Doppler wind lidar) experience;
  - Hyperspectral sounding and advanced VIS/IR imaging from Geo.

Atmosphere: GNSS and orbit configuration for radiances



COSMIC-2 and Spire obs in 2020 confirm need for more GNSS data



Duncan (2020) demonstrated value of MW data from additional LEO orbits

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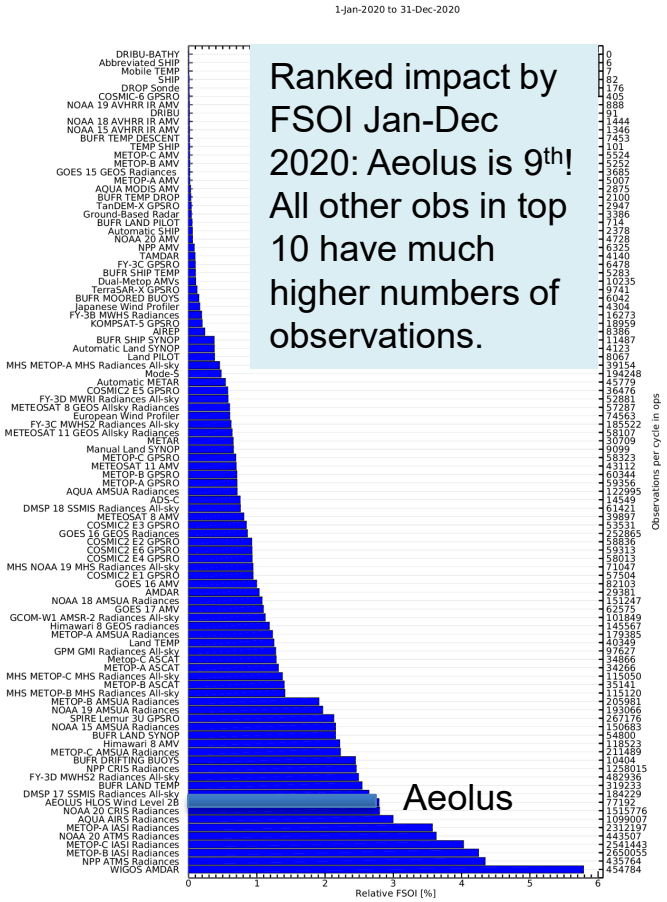
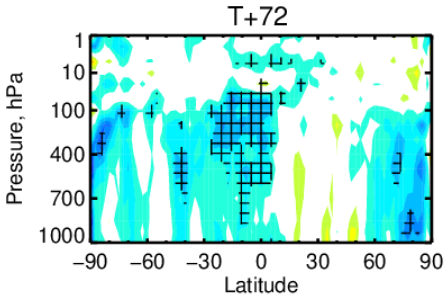
Atmosphere: Aeolus

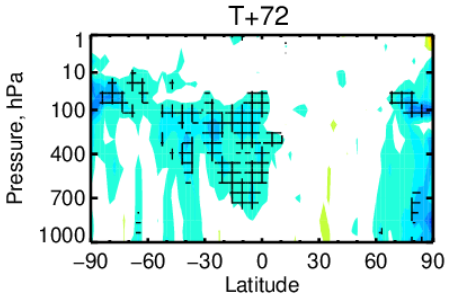
Michael Rennie, Lars Isaksen



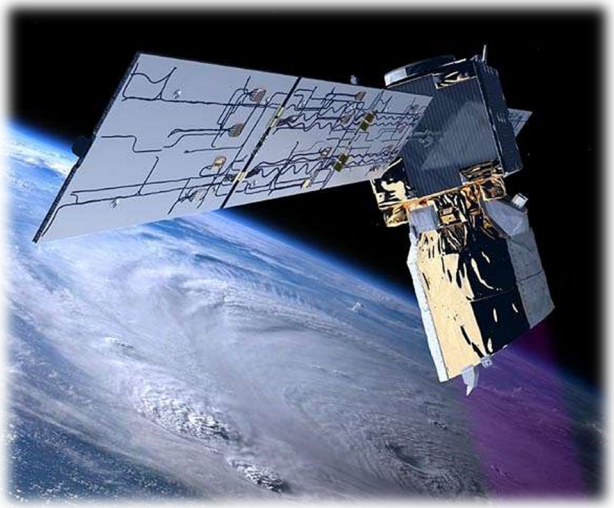
Ranked impact by FSOI Jan-Dec 2020: Aeolus is 9th! All other obs in top 10 have much higher numbers of observations.



Late 2019 OSE



Mid 2020 OSE



Aeolus demonstrated value of wind profile data from lidar

aeolus

DISC

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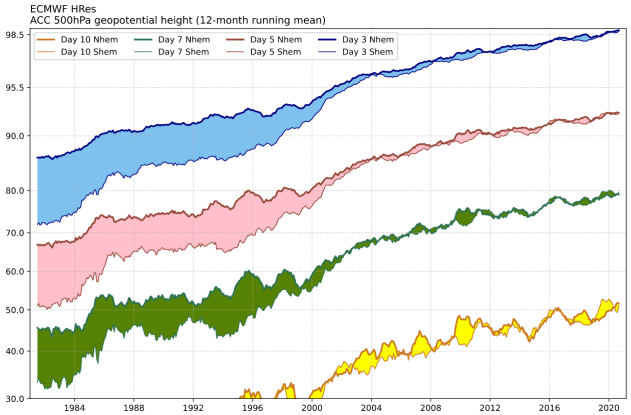
Long history of skill gains from improved atmospheric model, DA and observations



NWP worksh ops

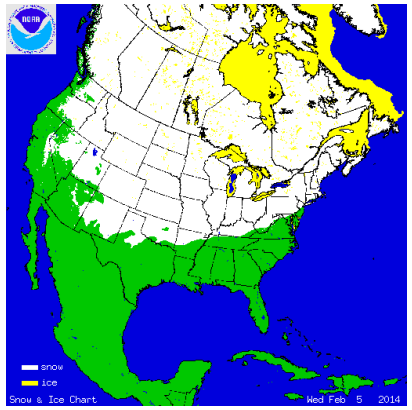
To maintain this rate of advance we need an Earth System approach and hence land, ocean, snow, sea ice observations.

Hi CGMS! We need Earth System Observations

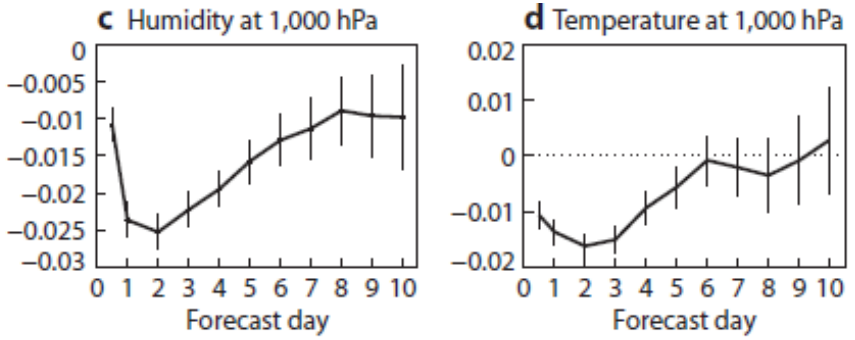
NWP scientist

Examples of existing Earth System observation impacts

- Snow pack analysis: significant impacts on NWP (IMS product)
- MW imager observations validation of multi-layer snow model
- Sea ice thickness impacting seasonal prediction of 2m temperature in polar regions
- Soil moisture impact on low level temperature and humidity
- SST (direct and indirect)



Impact on atmospheric forecasts
October 2012 to April 2013 (RMSE new-old)



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Patricia de Rosnay and Yoichi Hirahara

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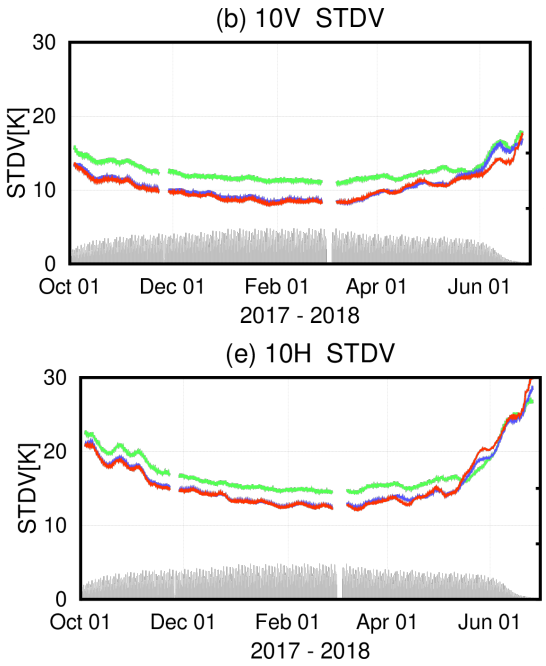

--- Single Layer
--- Multi-layer model and RT
--- Multi-layer model only

Examples of existing Earth System observation impacts

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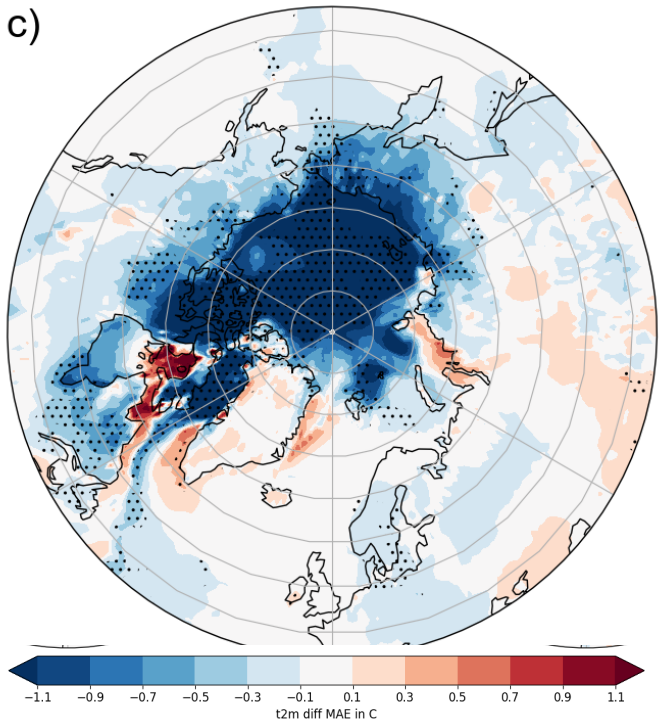
June forecast for Sept/Oct/Nov



Beena Balan Sarojini

https://doi.org/10.5194/tc-15-325-2021

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Patricia de Rosnay

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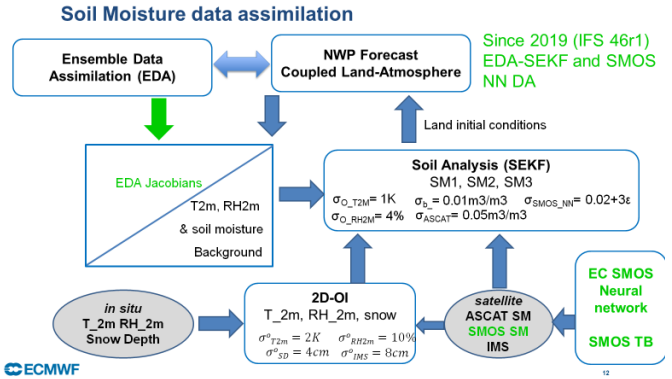

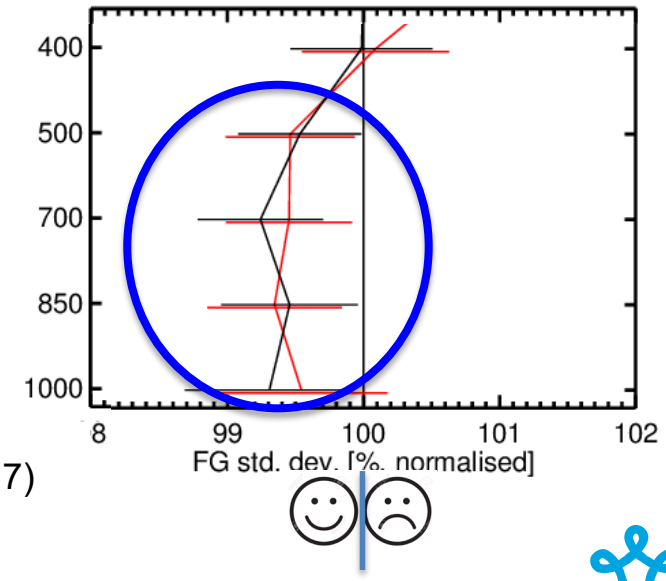

Atmospheric impact of SMOS DA

Fit to aircraft humidity (JJA 2017)

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Tony McNally

Examples of existing Earth System observation impacts

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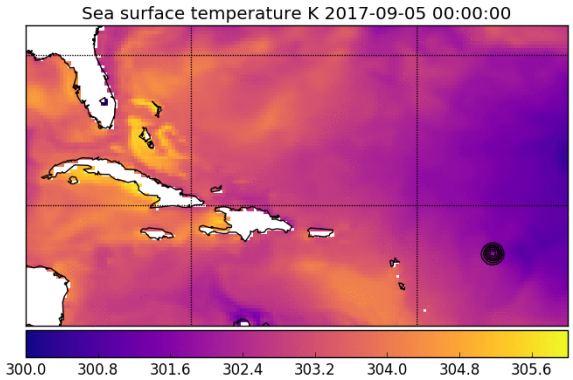
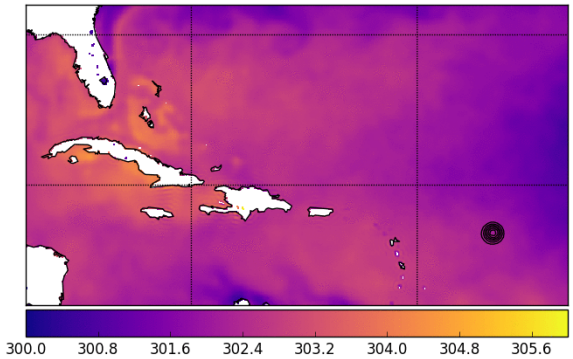
With ASCAT



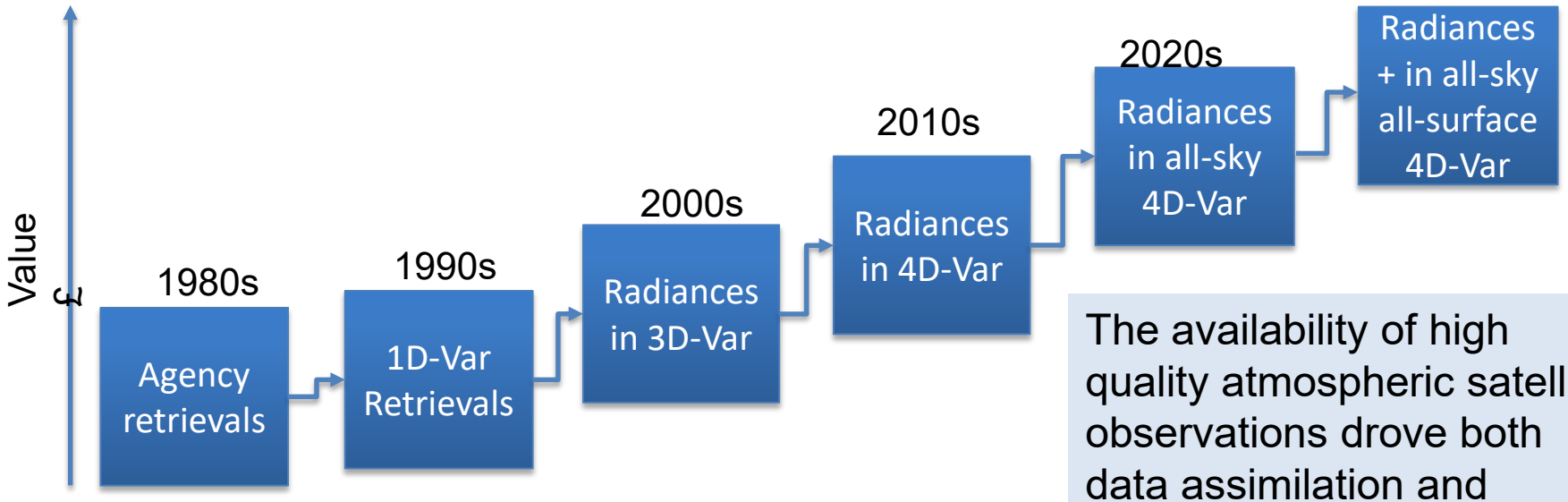
Without ASCAT



Hurricanes Irma and Jose in 2017

Requirements evolve as models and data assimilation improve

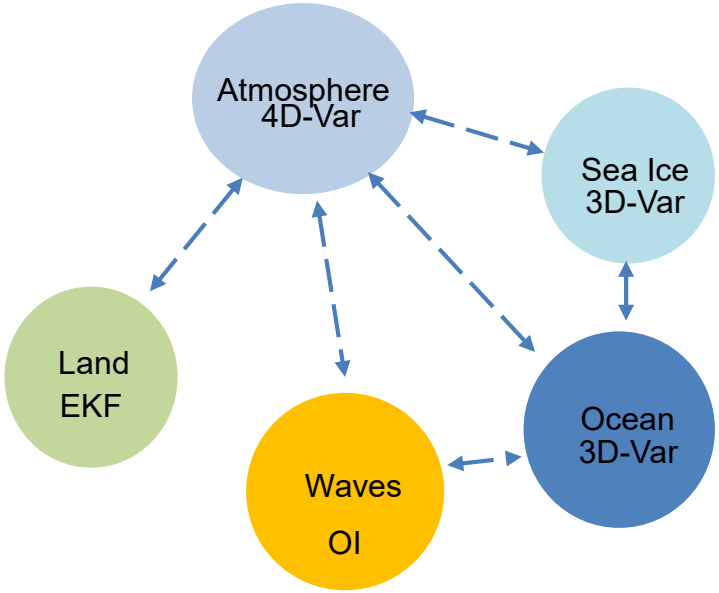
- Moving from “weather”, “ocean”, “land” etc. to Earth System changes fundamentally the value of and hence requirement for observations
- Mature systems use sparse and incomplete observations better than less mature systems, are increasingly coupled and at higher resolution **e.g. recall satellite radiances for atmosphere:**



The availability of high quality atmospheric satellite observations drove both data assimilation and model developments to make effective use of them.

What are the data needs and requirements to move to a seamless Earth System Monitoring and Prediction?

In operational systems, ocean, land, waves, sea ice tend to lag behind atmosphere



Less mature systems struggle to demonstrate value of observations

High quality observations drive increased maturity

Radiative transfer models and other key components of analysis system also need to be developed to a mature level

Earth System Assimilation requirement for Observations

- In considering Earth System assimilation we note,
  - Continuity and enhancement / gap-filling of critically important atmospheric observations!
    - Small satellite constellations for high temporal resolution
    - Lidar (for cloud, aerosol, wind) and radar (cloud and precipitation)
    - Visible assimilation (for aerosol and clouds)
    - SAR winds for km scale surface winds
  - Snow and sea ice
  - Surface temperature (ocean, land, sea ice)
  - Soil moisture
  - Atmospheric composition (ozone, aerosol primarily for NWP)
    - On going need for better vertical resolution e.g. limb sounders

Interface observations

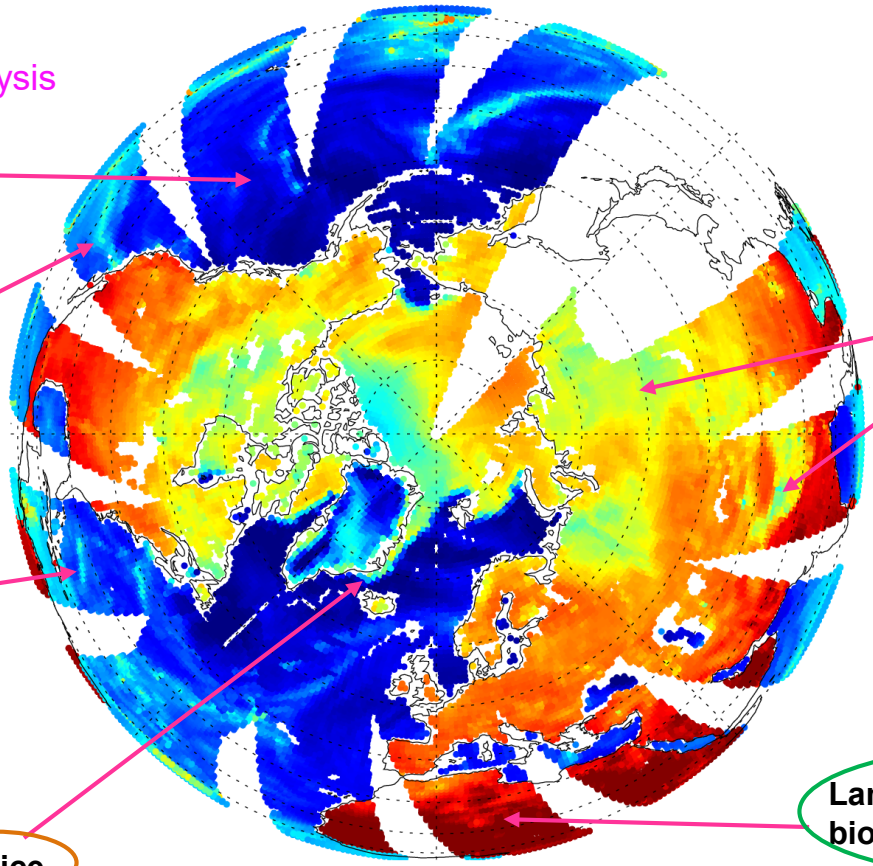
Atmospheric missions that are sensitive to other Earth System components e.g. MW imager e.g. CIMR, infrared imager, scatterometer, infrared sounder.

They have very high potential in coupled data assimilation for Earth System prediction systems

Alan Geer

Interface Observations

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

Sea-ice

At ECMWF used via third party L4 (OSTIA)

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

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Priorities

- **Science: In less mature systems effort is needed to assess full potential of existing "interface" observations before need for new observations can be fully assessed**
  - **In particular Enhanced MW imagers and active sensing instruments** have potential to be key current and future missions for coupled Earth System data assimilation
- **Sharing** of research observations to be encouraged to accelerate path to demonstration and maturity
- **New observations:** When science has matured, we may find some gaps can only be addressed with **new observations** (including for atmospheric analysis!)

Science	Share	Measure
Top priority: increase maturity of use of current obs	Ensure sharing of all obs, esp. current research obs	Where proves necessary acquire new obs to fill gaps

Questions