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Impact of snow cover data assimilation over the High Tibetan Plateau (HTP) on ECMWF NWP

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Team “Snow reanalyses over the Himalaya-Tibetan Plateau region and the monsoons”

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS

Snow assimilation at ECMWF

Snow Model: Component of H-TESSEL **(Dutra et al., JHM 2010, Balsamo et al JHM 2009)**

Single layer snowpack

- Snow water equivalent SWE (m)
- Snow Density ρ_s

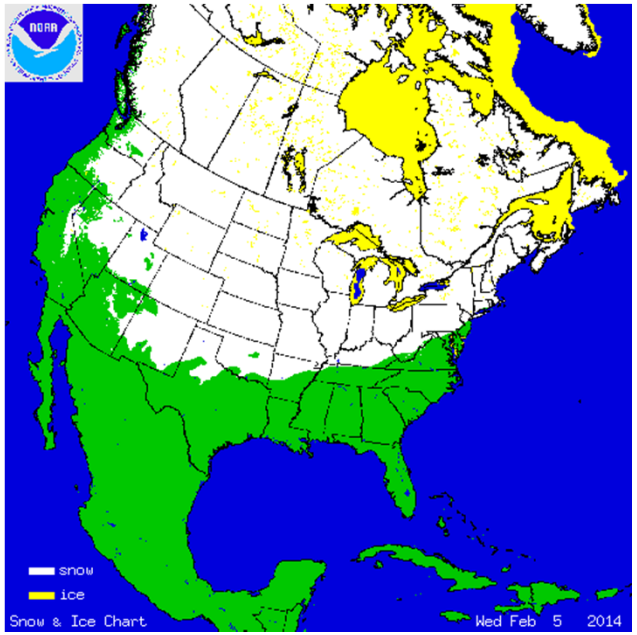
} **Prognostic variables**

Observations: **de Rosnay et al ECMWF Newsletter 2015**

- Conventional snow depth data: SYNOP and National networks
- Snow cover extent: NOAA NESDIS/IMS daily product (4km)

Data Assimilation: **de Rosnay et al SG 2014**

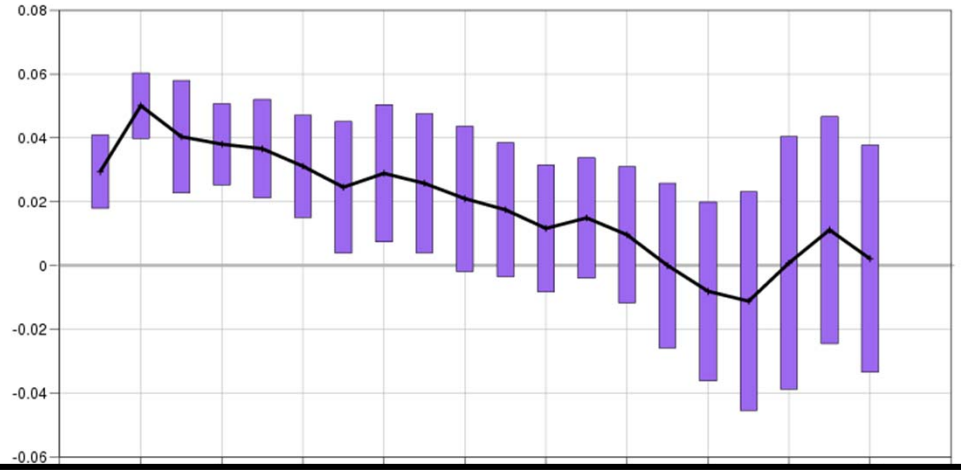
- Optimal Interpolation (OI) is used to optimally combine the model first guess, in situ snow depth and IMS snow cover



9 years ago: IMS data assimilation impact study in the IFS

Impact of blacklisting IMS above 1500m

DJF 2009-2010, NH
500 hPa Geopot RMSE
[with IMS]-[without IMS] in mountains above 1500m



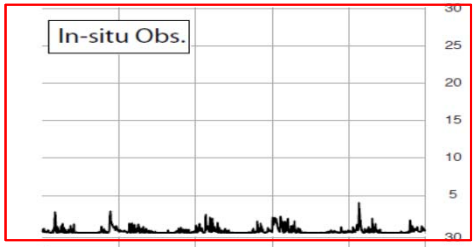
- IMS DA over the HTP degrades NWP performances
- Unknown quality of IMS over the HTP

→ Stopped using IMS for NWP at high altitude from IFS cycle 36r4 (2010)

- ERA-Interim: IFS cycle 31r1 (2006) → assimilates IMS (24km) including mountains
- ERA5: IFS cycle 41r2 (2016)→ assimilate IMS (4km) only below 1500m altitude
- Current oper NWP: IFS cycle 46r1 (2019) → assimilate IMS (4km) only below 1500m altitude

Comparison of reanalysis products over the HTP

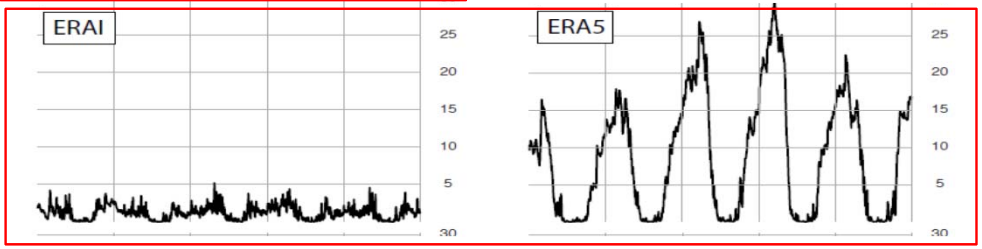
Observations:
In-situ



2009-2013
average over 33 stations
Unit : cm

Observations:
Microwave satellite

ERA-Interim
ECMWF



ERA5
ECMWF

ERA5: overestimates SD over the HTP
ERA-Interim: SD in better agreement with in situ stations

Orsolini et al.
(presentation yesterday)

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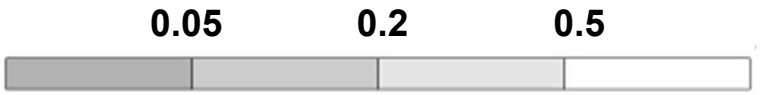
Numerical weather prediction experiments

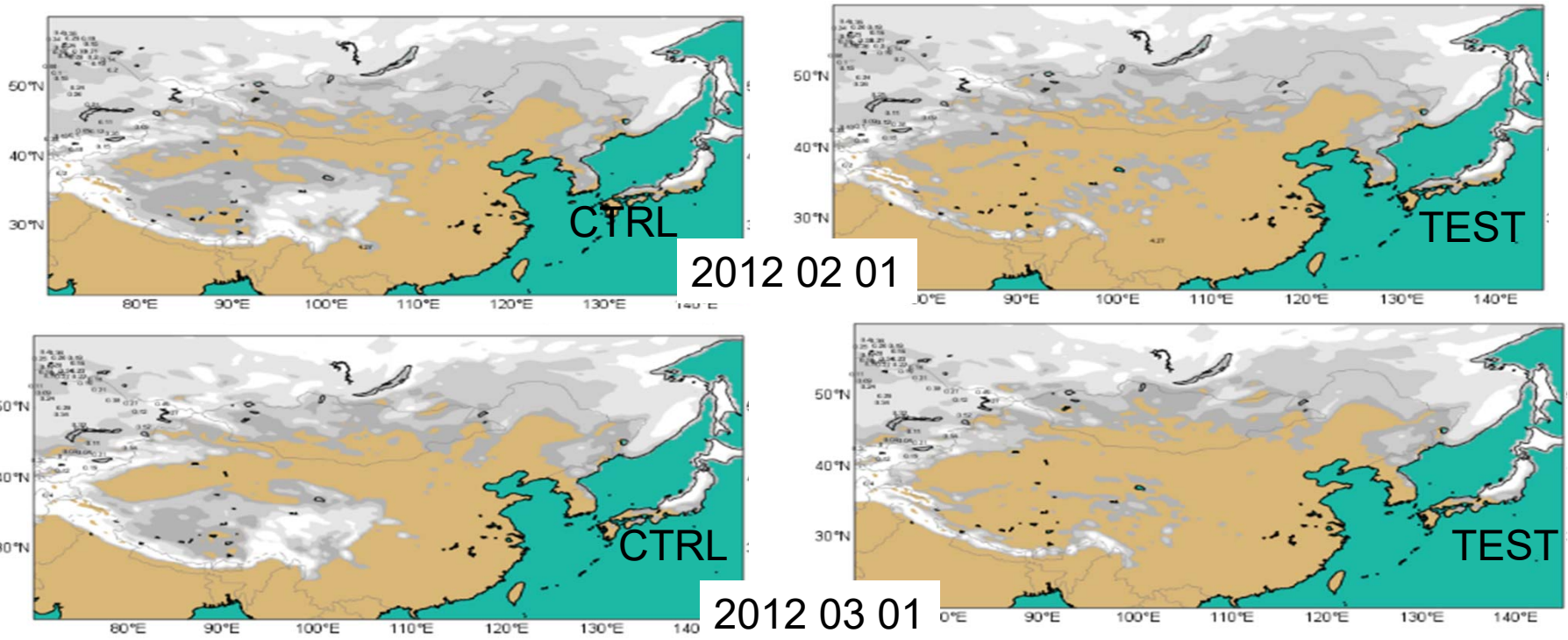
- NWP experiments, Sept 2011 – Dec 2012 (matching the ISSI-BJ period)
- Two 10-day FC per day (976 forecasts)
- Resolution: Tco399 (~25 km)
- IFS cycle: 43r3

CTRL : blacklist IMS above1500m altitude (like in NWP and ERA5)

TEST : no blacklist for IMS (use IMS everywhere)

Snow depth (m)





CTRL (no IMS DA over the HTP)

TEST (IMS DA over the HTP)

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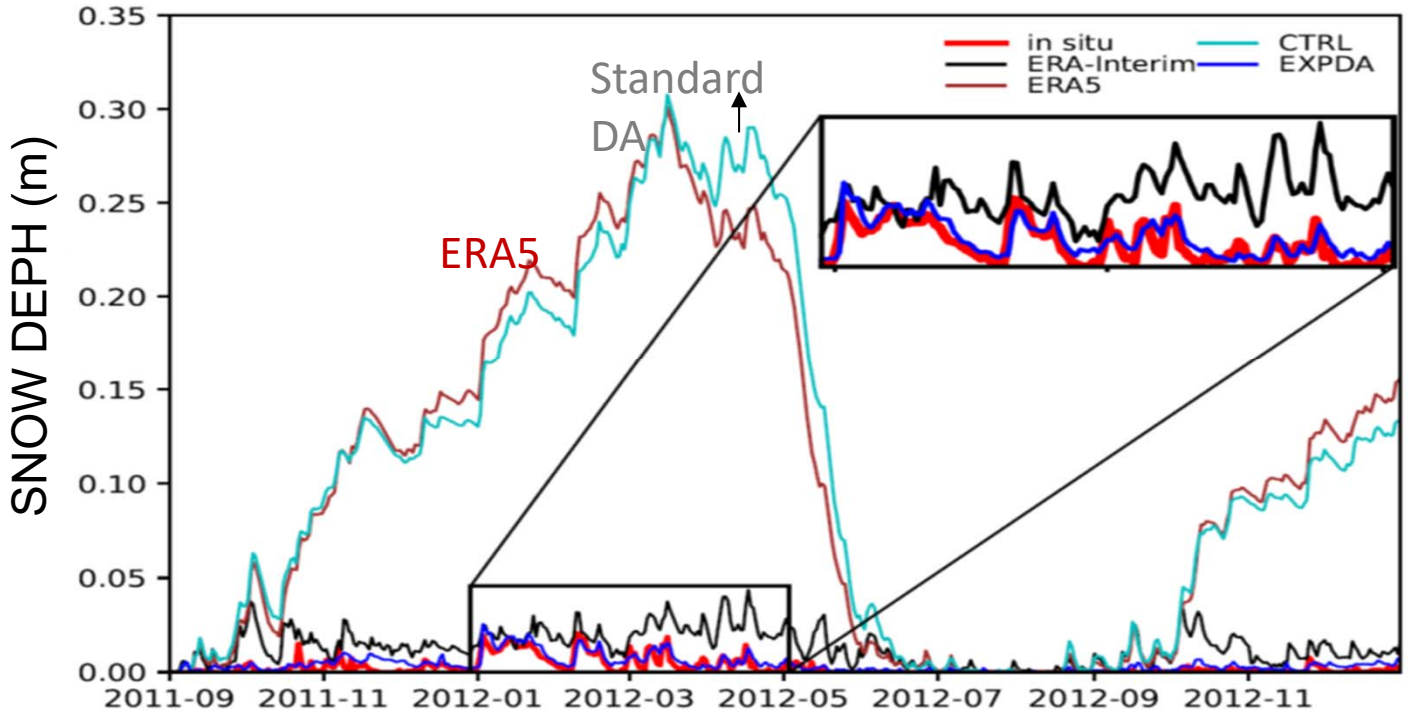
Snow cover data assimilation over the Tibetan Plateau
Evaluation against in situ snow depth stations (33)



CTRL(no IMS DA)

ERA5 (no IMS DA)

ERA-I

TEST with IMS DA

In situ data

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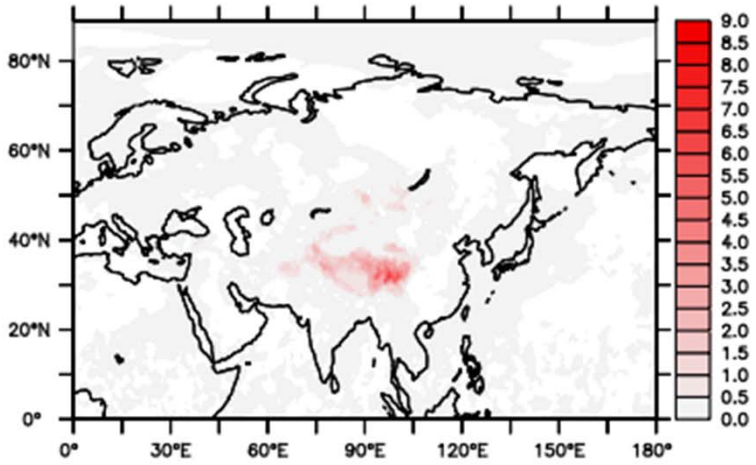
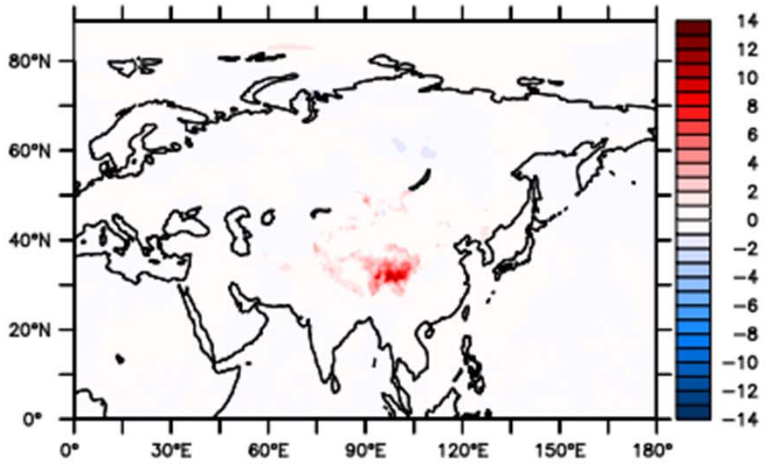
Snow cover data assimilation over the Tibetan Plateau

Impact on air temperature

IMS removes snow
→ Warmer surface conditions



T2m impact 10-day forecasts
Oct 2011-Sept 2012



T2m impact 10-day forecasts
Dec 2011-Feb 2012

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Snow cover data assimilation in mountainous areas

1 Year
(Oct 2011-Sep 2012)

Mean change in near surface air temperature (T2m) and 500 hPa humidity forecasts

IMS DA:
Remove snow
T2m increases
Humidity decreases

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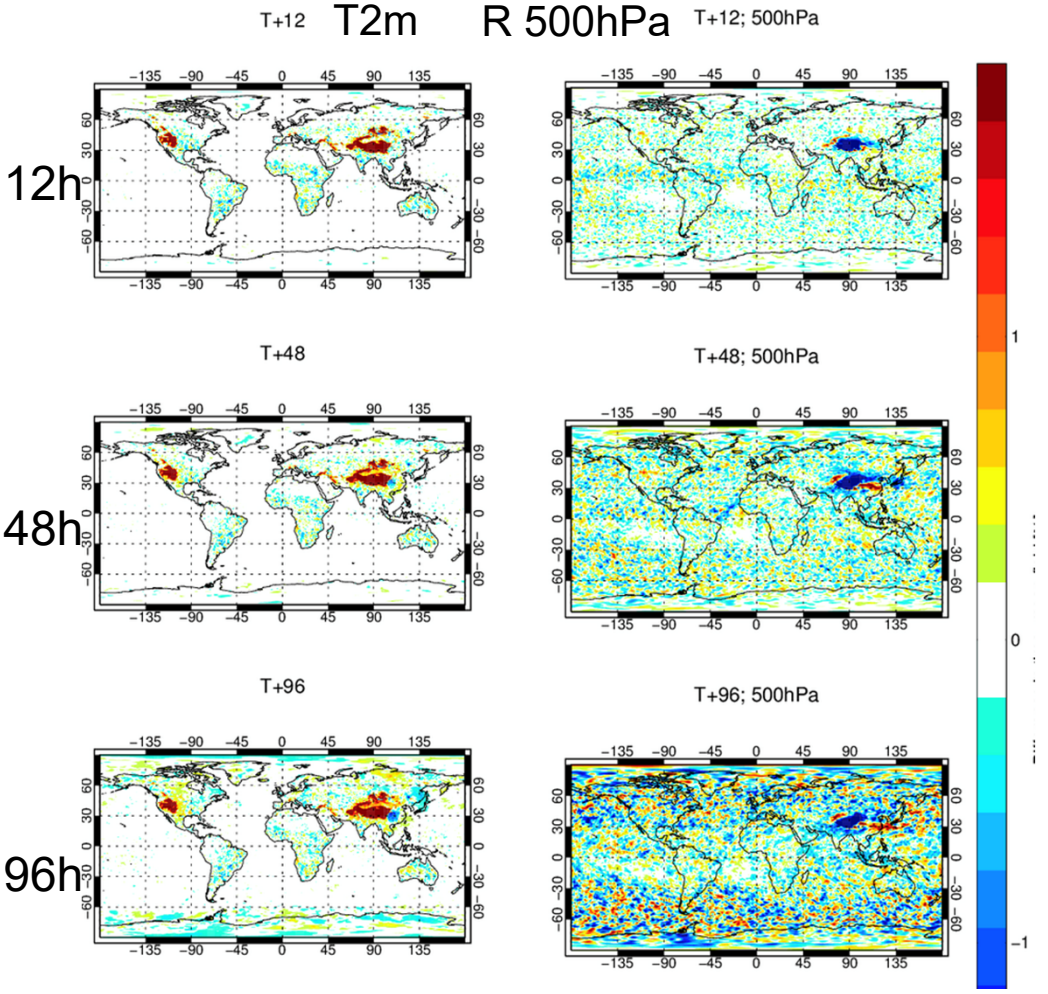
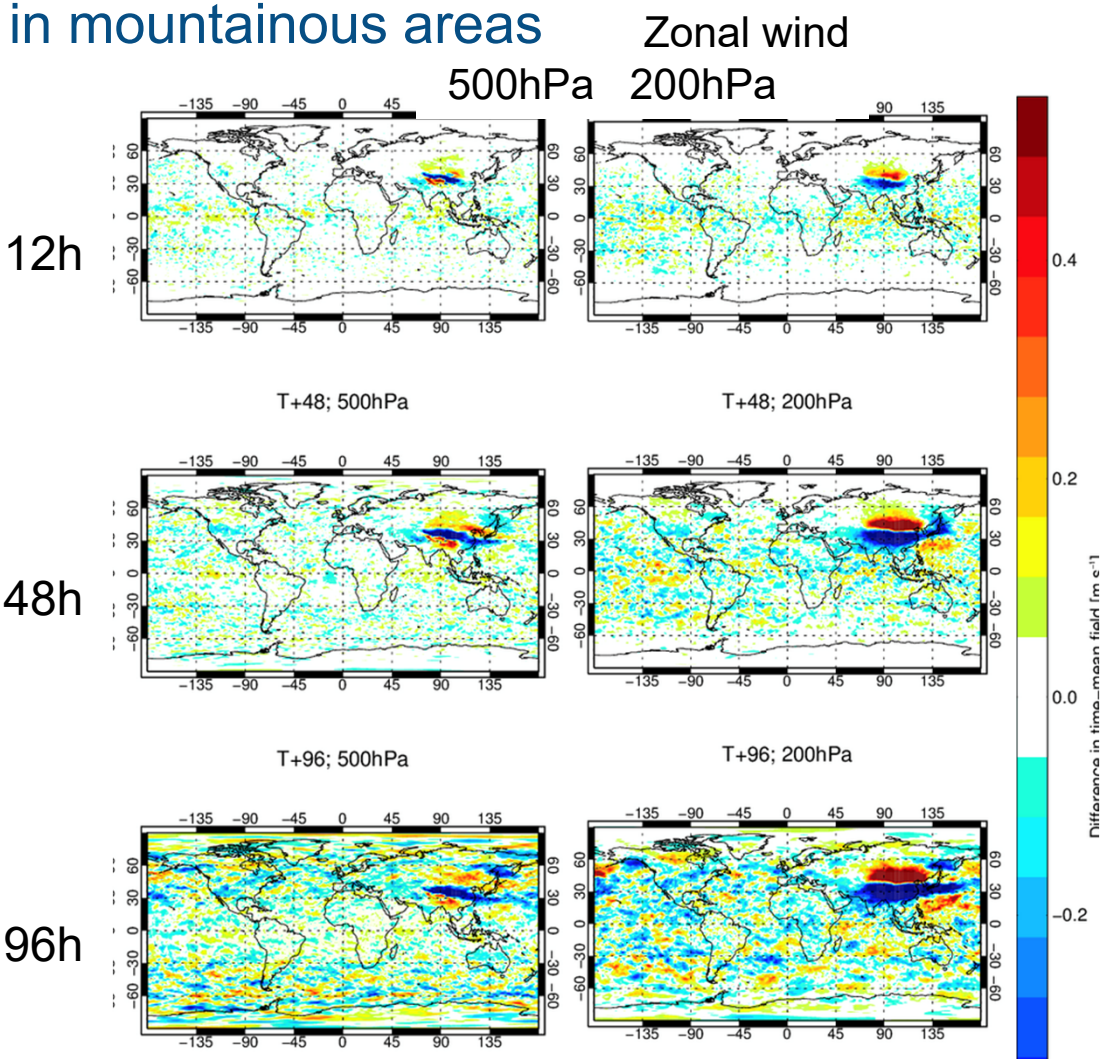


Snow cover data assimilation in mountainous areas

1 Year
(Oct 2011-Sep 2012)

Mean change in zonal wind atmospheric forecasts

IMS DA:
Jet circulation shifted to the north



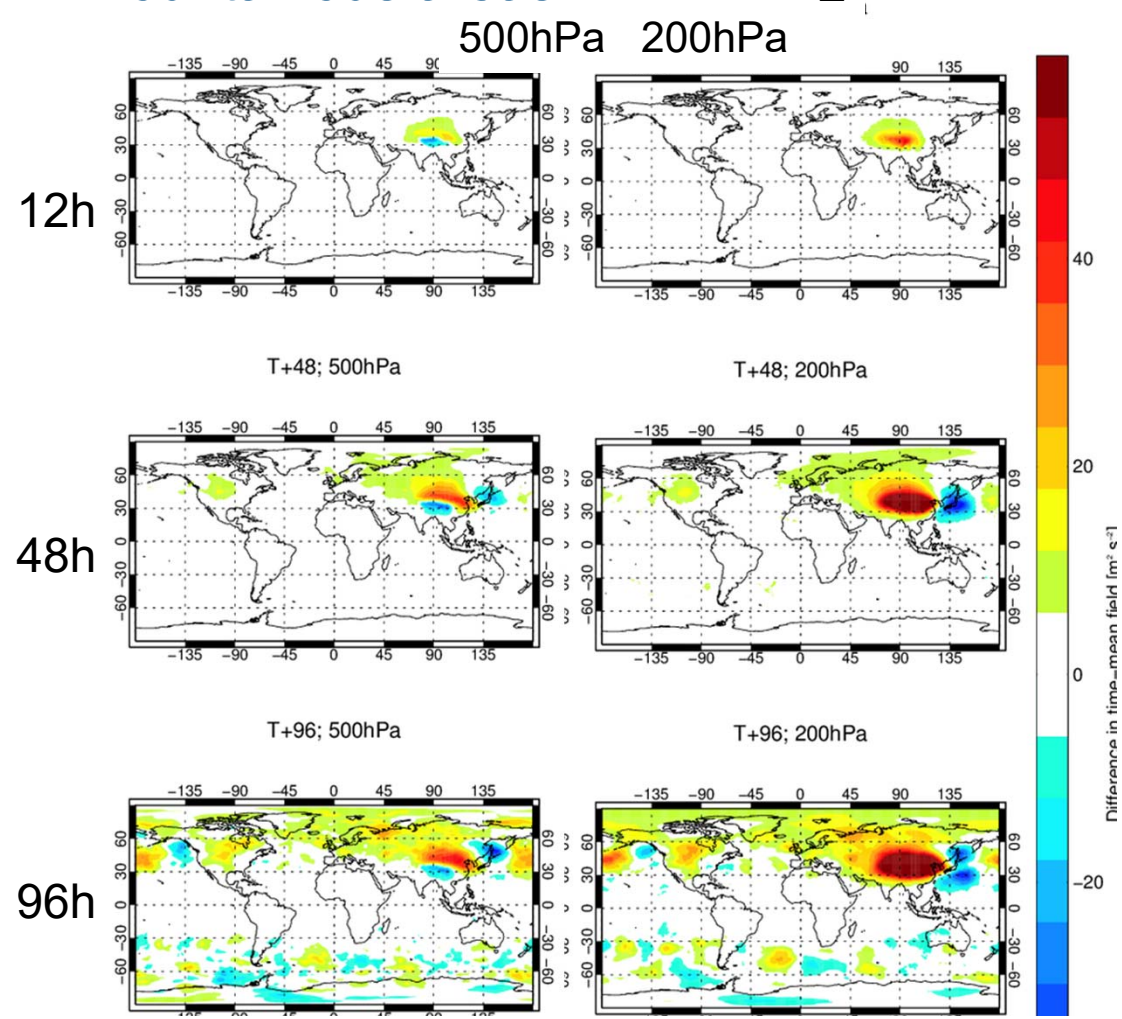
ECMWF

Snow cover data assimilation in mountainous areas

Z

1 Year
(Oct 2011-Sep 2012)

Mean change in
geopotential height forecasts



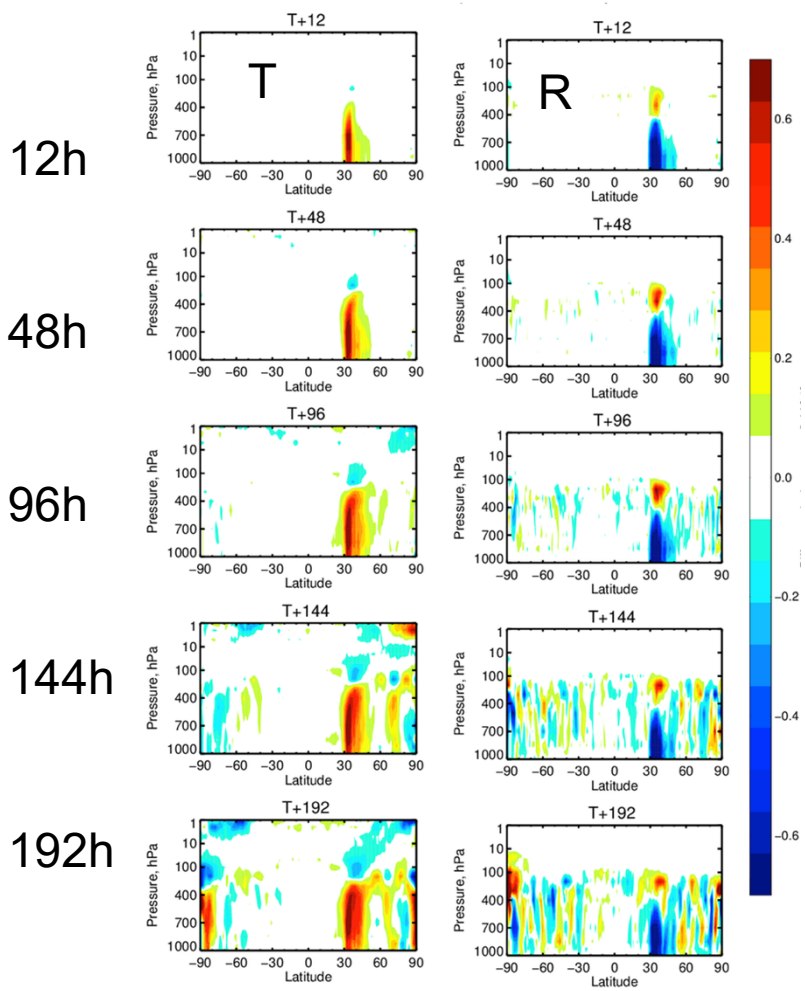
ECMWF

Snow cover data assimilation in mountainous areas

1 Year
(Oct 2011-Sep 2012)

Pressure-latitude

Mean change in forecasts



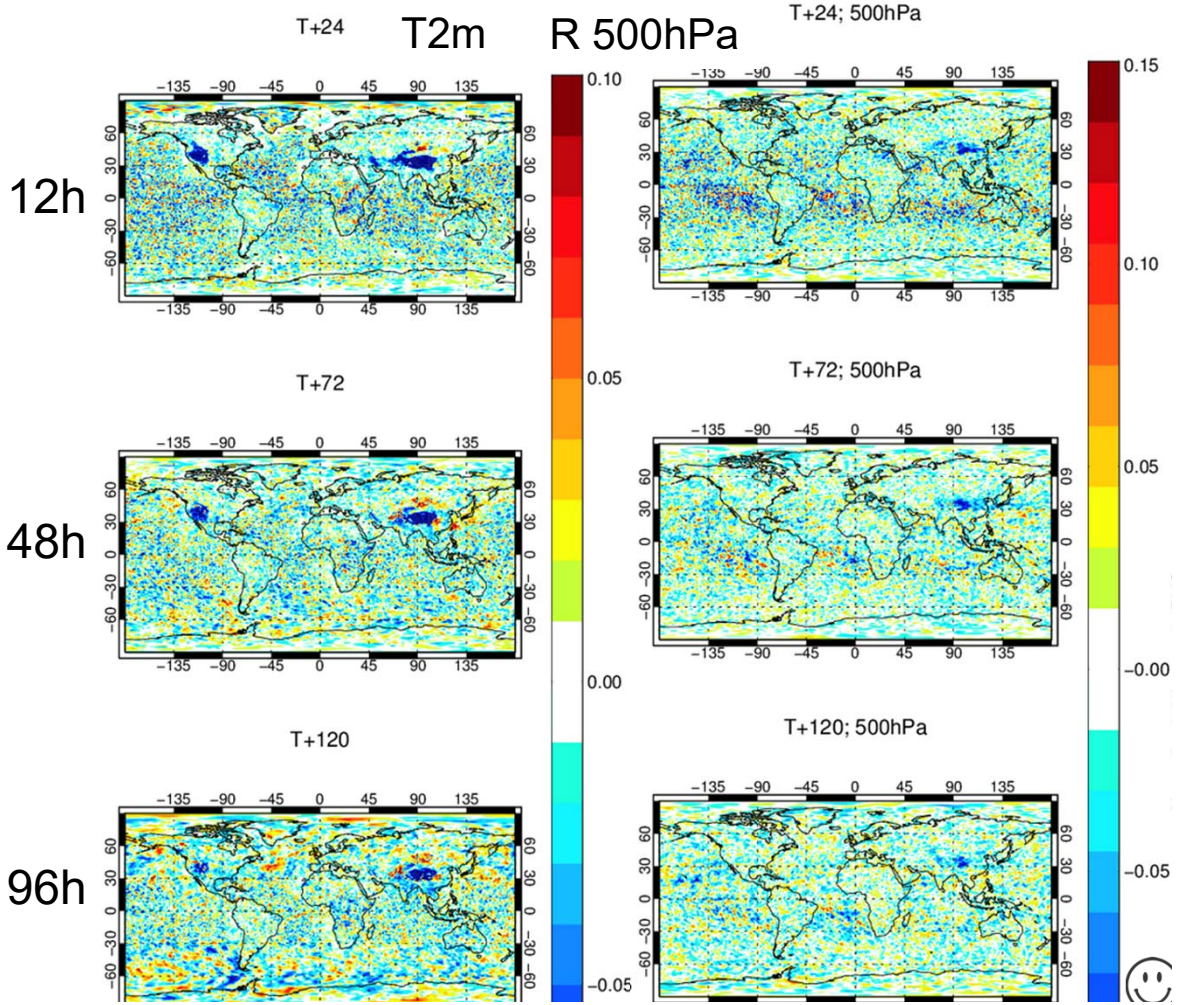
ECMWF

Snow cover data assimilation in mountainous areas

1 Year
(Oct 2011-Sep 2012)

<u>Impact on forecasts error (RMSE normalised difference)</u>

air temperature (T2m) and 500 hPa humidity forecasts



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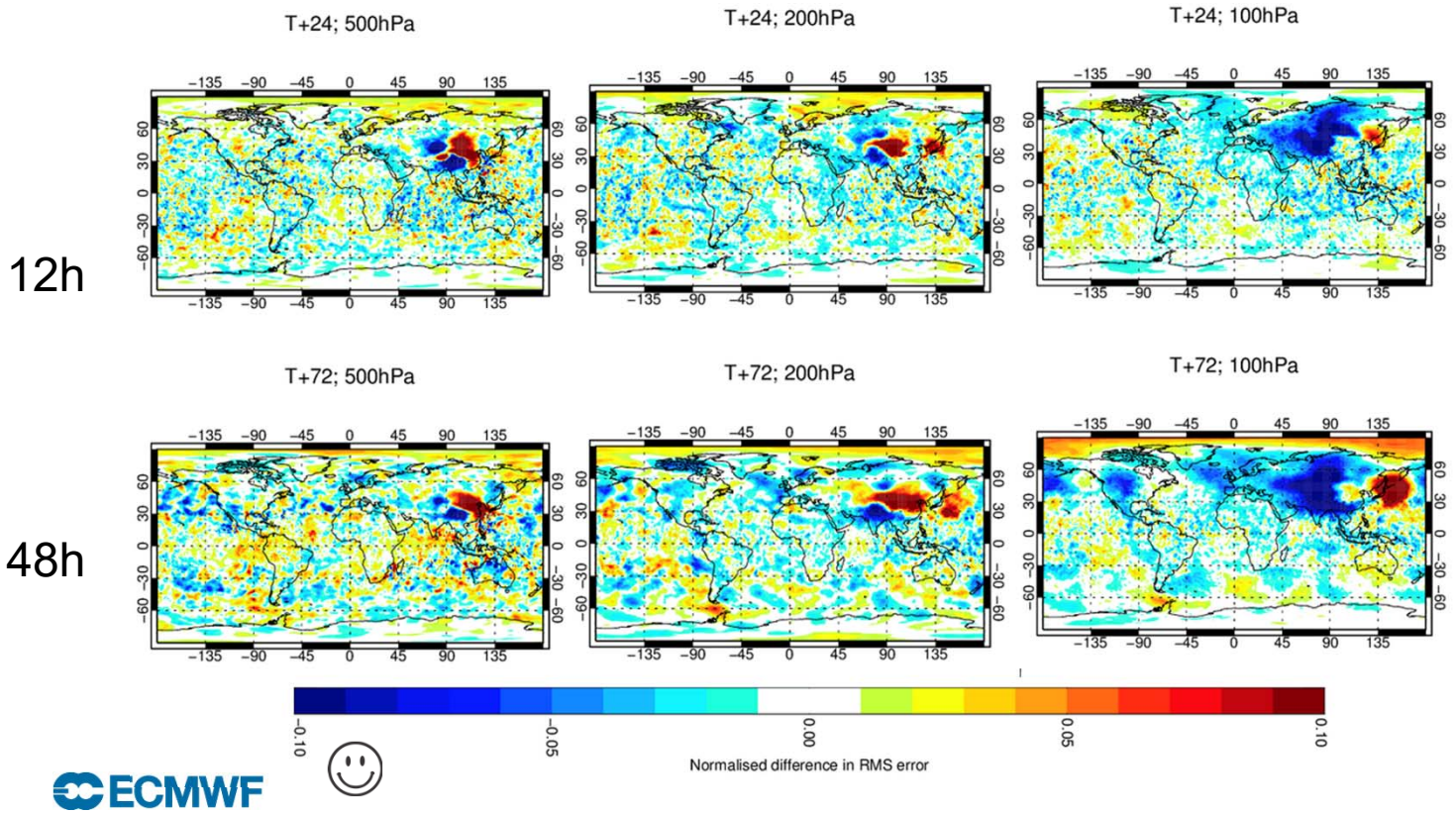
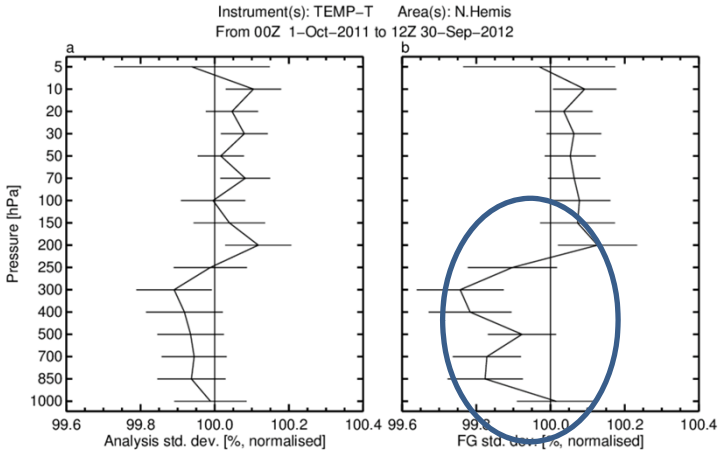
Snow cover data assimilation in mountainous areas

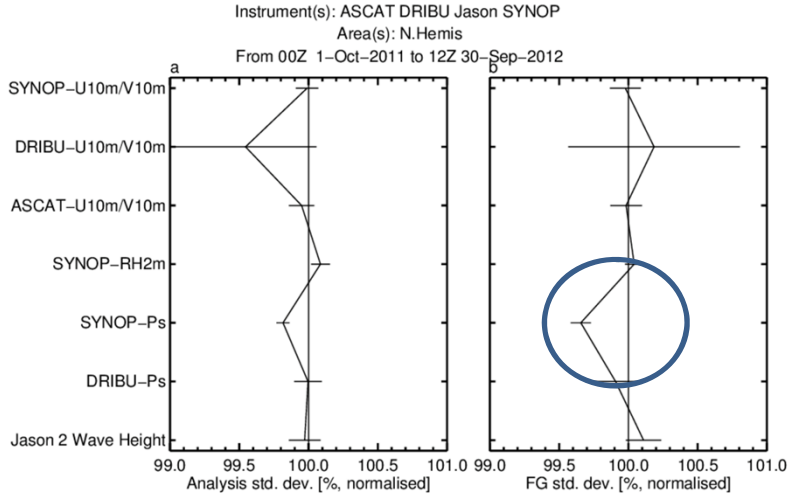
Geopotential height forecats RMSE difference (normalised)



Snow cover data assimilation in mountainous areas

Fit of first guess departure to observations





-> better match of FG (3h to 15h FC) with Ps and Temp
(and slightly more obs used)

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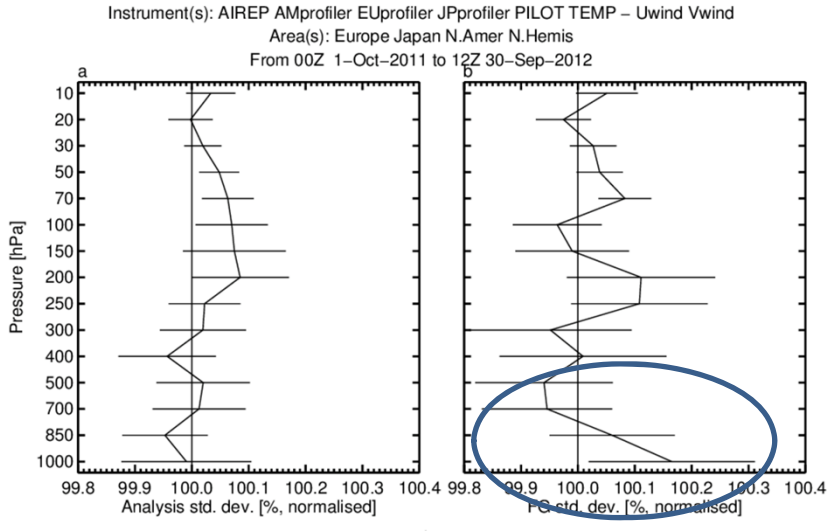
Snow cover data assimilation in mountainous areas

Fit of first guess departure to observations



Degraded match with wind obs

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Snow data assimilation score card: Impact of IMS DA in mountains

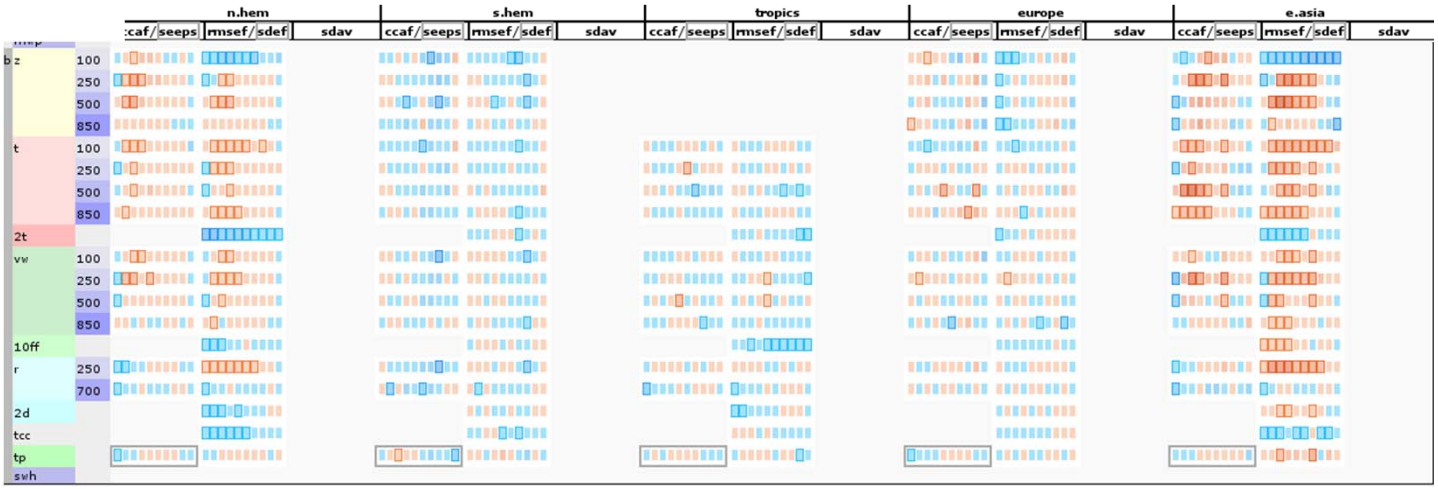
2018-2019 (NDJF)

Test repeated for more recent winters 2017-2018 and 2018-2019, with IFS cycles 45r1, 46r1, and refined QC approach (stdev slope instead of 1500m threshold)

IMS snow DA in the Himalaya

- Improves T2m
- Degrades FC in East Asia

→ Model issue to solve before activating IMS DA in the IFS



10-day forecasts verified against observations

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Summary

- IMS snow cover provides relevant snow information over the HTP, whereas the model overestimates snow over the HTP

- DA tests for Sept 2011- Dec 2012 with IMS DA activated in mountainous areas

- IMS removes snow over the HTP and improves snow (compared to in situ data)

- Very strong impact on T2m (warmer) and reduced T2m forecasts errors

- Shift the jet position and impact Z500 hPa to Z50 hPa significantly

  → Degradations of the medium range NH forecasts (verified against observations)

  → Model inconsistencies between surface and jet circulation over the HTP

  → To be solved before we can activate IMS DA over the HTP

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Special Issue "Remote Sensing of Land Surface and Earth System Modelling"

- Special Issue Editors
- Special Issue Information
- Keywords
- Published Papers

https://www.mdpi.com/journal/remotesensing/special_issues/Land_Surface_Earth_System_Modeling

A special issue of *Remote Sensing* (ISSN 2072-4292). This special issue belongs to the section "Biogeosciences Remote Sensing".

Deadline for manuscript submissions: **30 June 2020**.

- Land surface data assimilation
- Land surface re-analysis
- Land surface forward modelling (VIS/IR/MW),
- Inverse modelling and machine learning

Special Issue Editors

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European Center For Medium-Range Weather Forecasts, UK
Website | E-Mail
Interests: Land surface data assimilation; coupled assimilation; Earth system modelling; Land surface observations; Forward modelling

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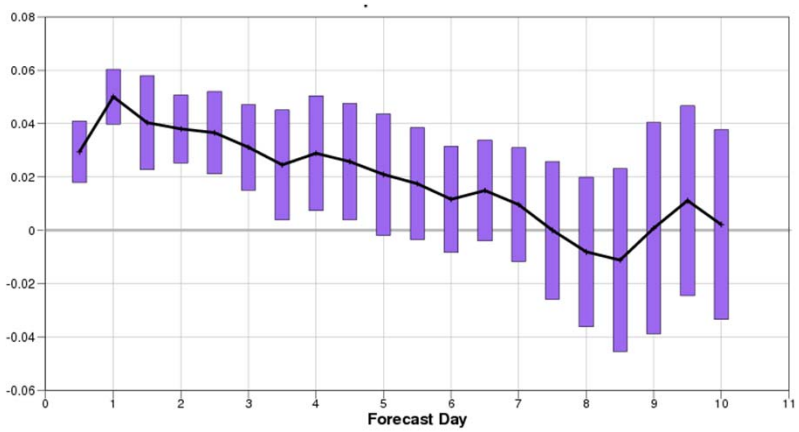
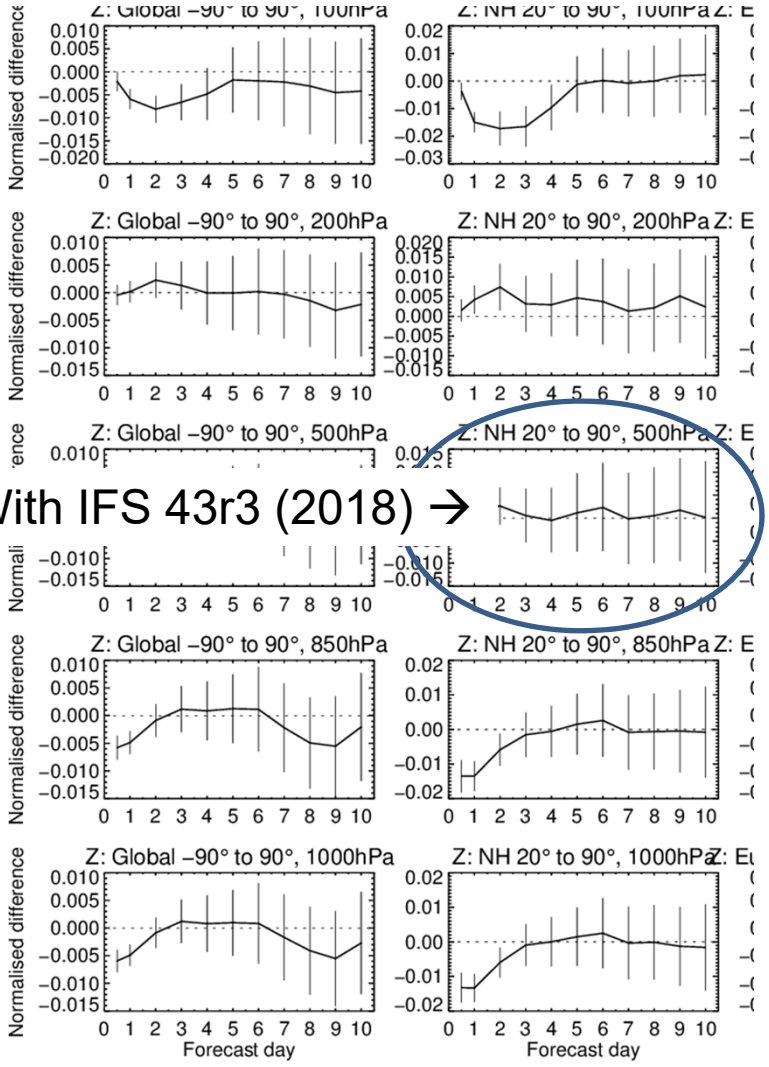
Hydrological Sciences Lab, NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD, 21042, USA
Website | E-Mail
Interests: land surface modelling; hydrology; data assimilation; remote sensing; Optimization

IMS above 1500m DA impact

With IFS 36r4 (2010)



With IFS 43r3 (2018) →



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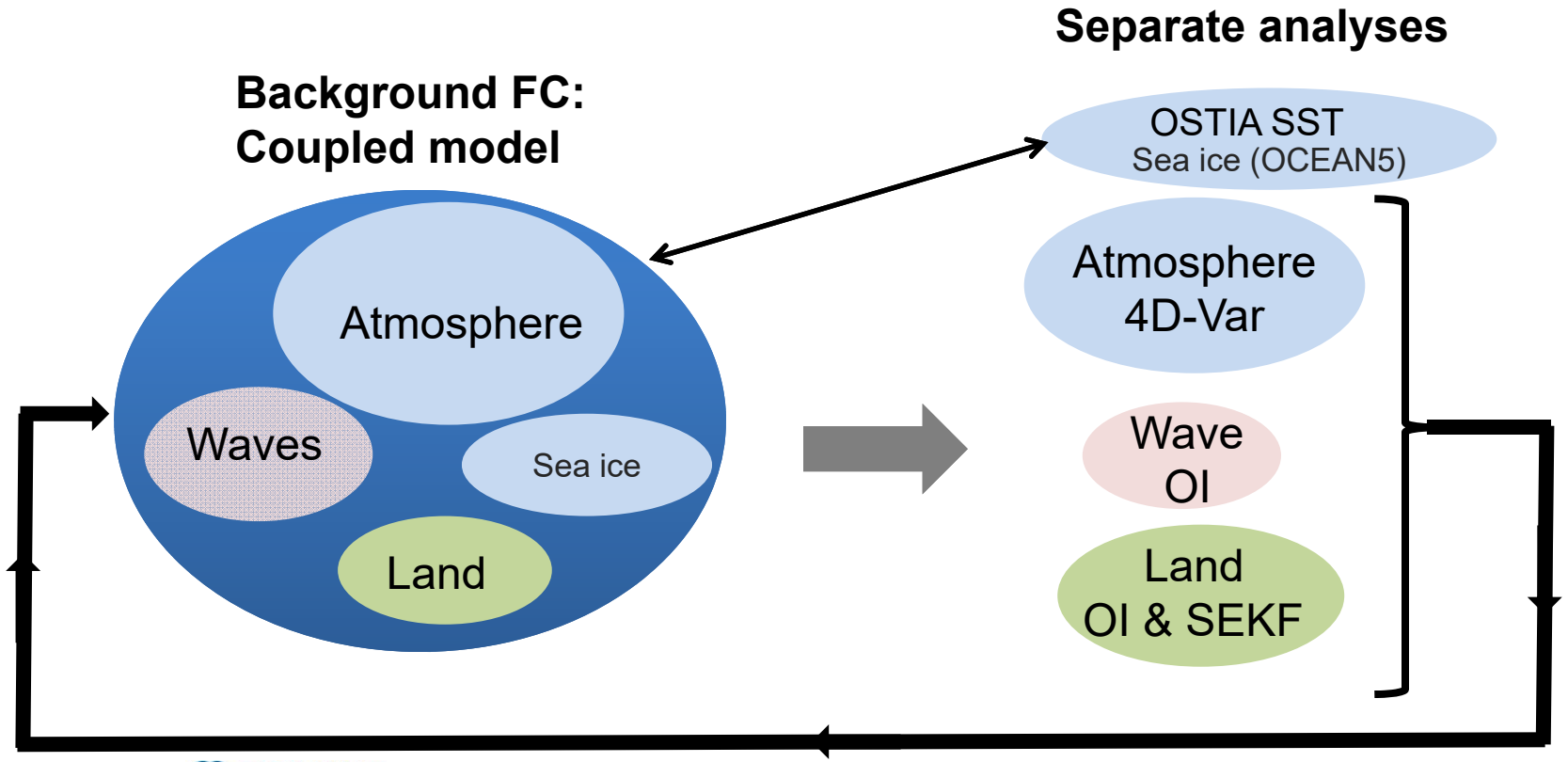
Current operational NWP DA system at ECMWF:

weakly coupled land-atmosphere and ocean-atmosphere assimilation



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(IFS cycle 46r1, since June 2019)