ECMWF-Met Office land surface data assimilation meeting
5 June 2023, University of Reading

Recent snow DA development at ECMWF

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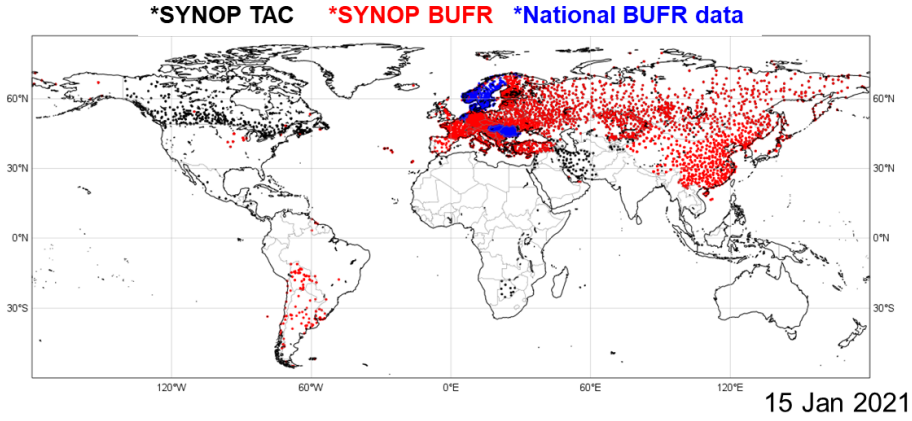
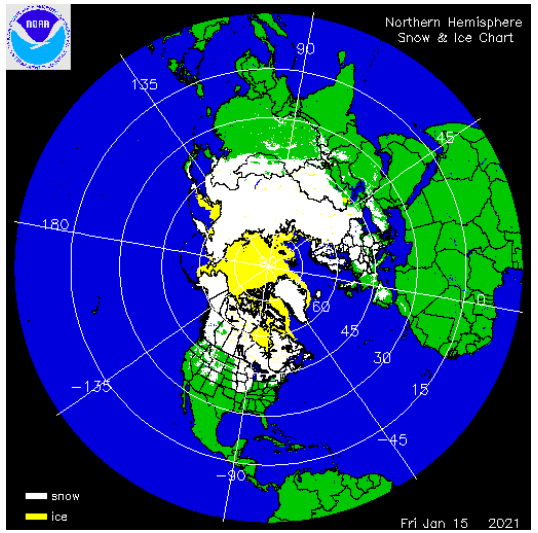
Snow data assimilation at ECMWF



- **Observations:**
  - Conventional snow depth data: **SYNOP and National networks**
  - Snow cover extent: **NOAA NESDIS/IMS daily product** (4km)
    - Available daily at 23 UTC, assimilated in the next analysis at 00UTC



- **Data assimilation:**
  - **Optimal Interpolation (OI)**
    - Based on horizontal and vertical structure function in Brasnett (1999)
  - The result of the data assimilation is used to initialize NWP

- **One of current issues:**
  - IMS assimilation below 1500m only, leading to excess snow depth on high mountains
  - Especially on the Tibetan Plateau (Orsolini et al, 2019)

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Snow DA and related model changes proposed for CY49R1

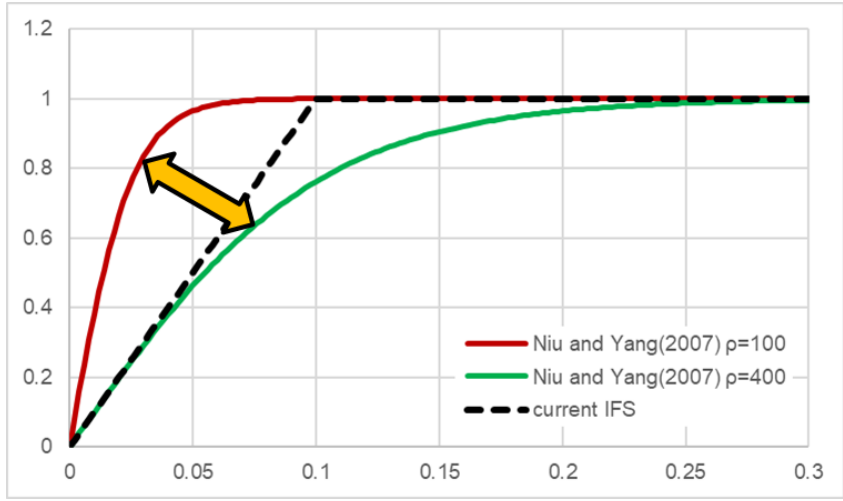
	Current system	Proposed for CY49R1
IMS mask	based on altitude (>1500m)	based on SDFOR* (>250m)
IMS thinning	select 1 from every 36	select closest 1 to a gaussian grid of 40km
IMS snow depth (SD_{IMS})	5cm	3cm
Condition to assimilate SD_{IMS}	IMS=1 & $SD_{model} < 10^{-9}$cm	IMS=1 & $SD_{model} < 1$cm
Capping value for snow depth	1.4m	3.0m
Vertical correlation length in OI	800m	500m

* Standard deviation of filtered subgrid orography

- To improve snow cover fraction for shallow snow, the SCF parameterization is changed to Niu and Yang (2007)

$$f_{sno} = \tanh\left(\frac{h_{sno}}{2.5 z_{0g} \left(\rho_{sno}/\rho_{new}\right)^{m}}\right)$$

- $z_{0g} = 0.1, \rho_{new} = 100, m = 1$ as with CLM4, CLM4.5



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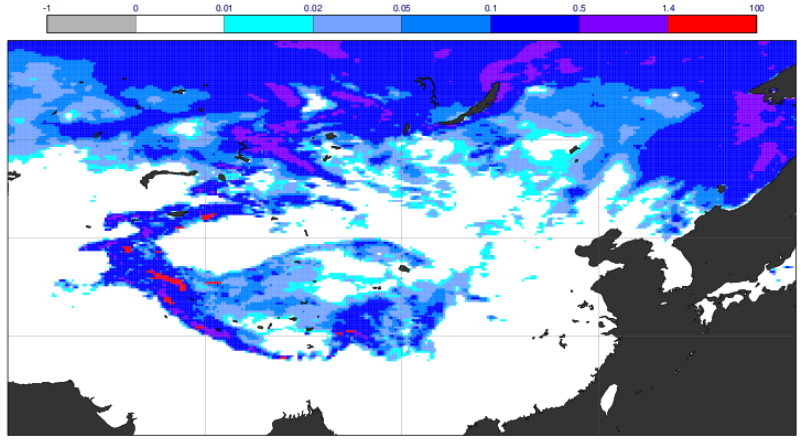
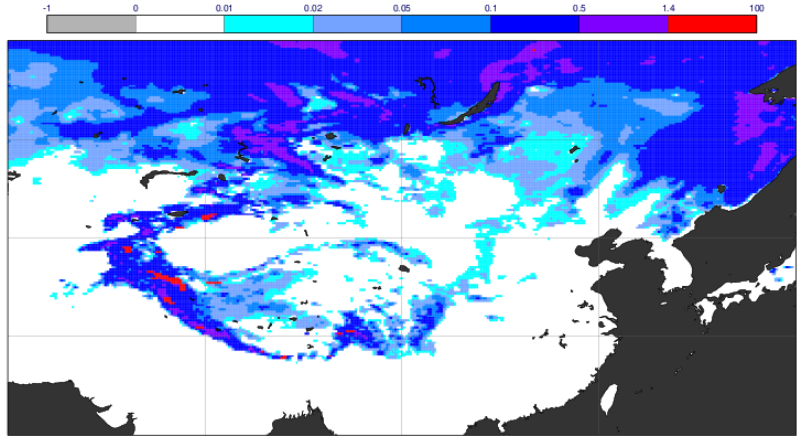
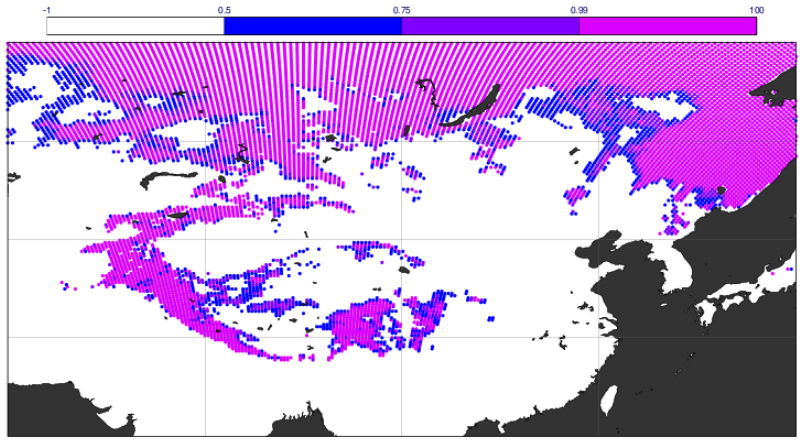
Impact on snow depth and snow cover fraction

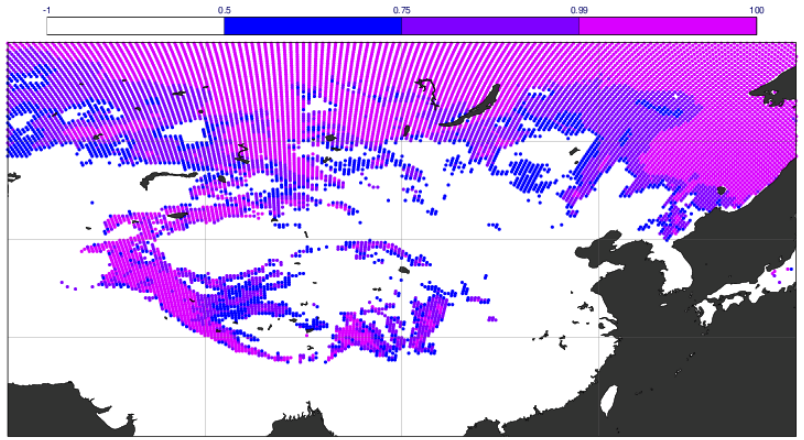
CNTL



TEST



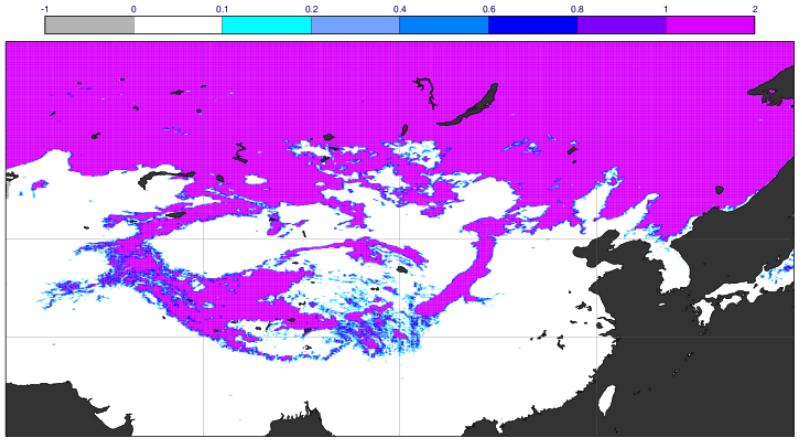




Top: snow depth
Bottom: snow cover fraction

on 12th Dec 2021

IMS (SCF>0.5 if IMS=1)



- Snow depth is reduced by assimilating IMS on the Tibetan Plateau
- SCF is improved (increased) on the Tibetan Plateau and around snow lines by the SCF change

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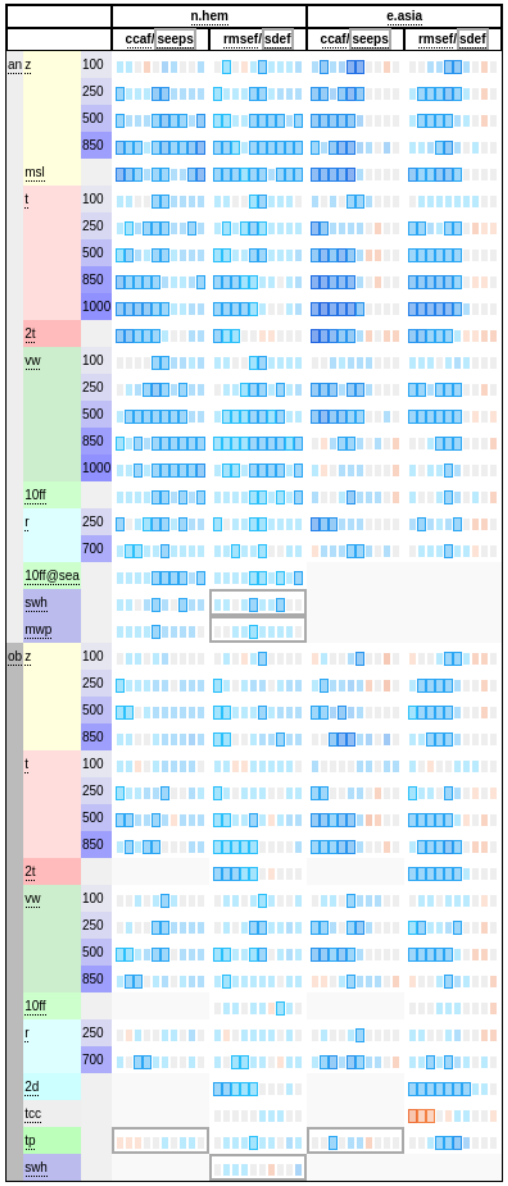
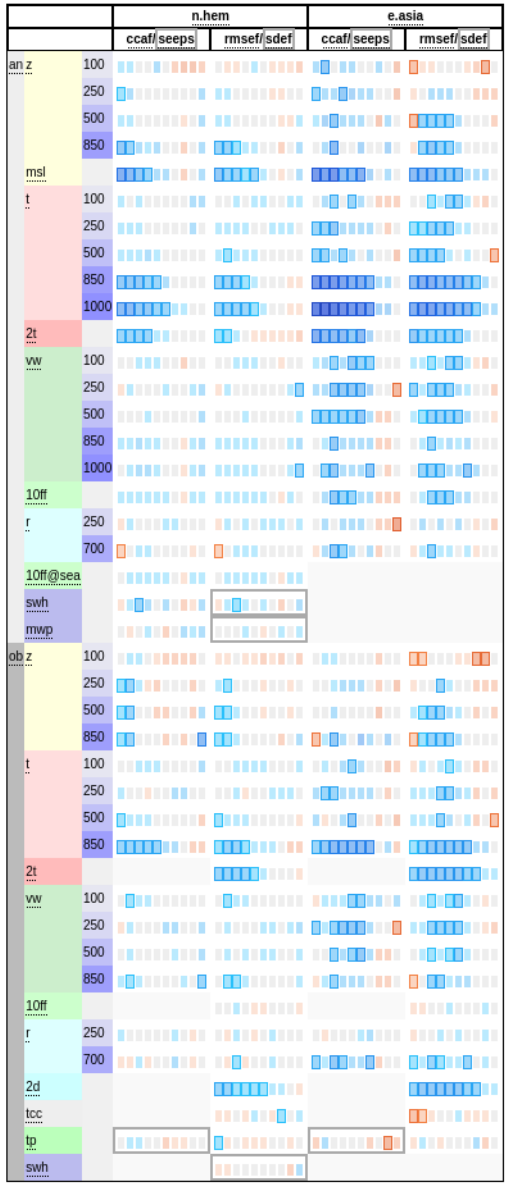
Impact on forecast skill in 2 winter seasons

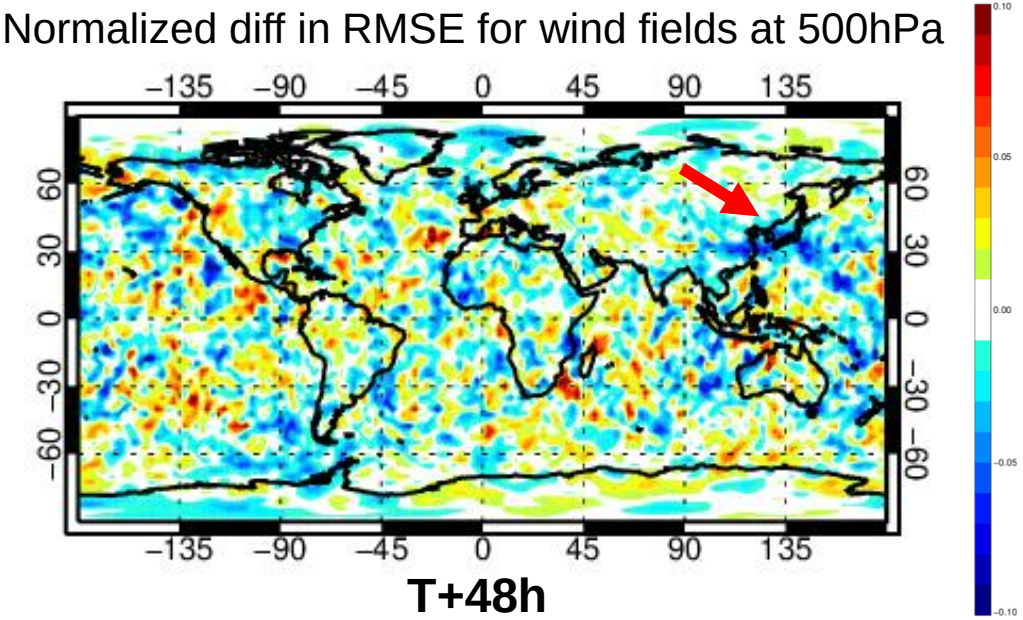
Winter 2020/21



Winter 2021/22



Normalized diff in RMSE for wind fields at 500hPa



T+48h

- Significant improvements in the NH, especially in East Asia
- Large impact of snow on forecast skill

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Summary and ongoing works

- Snow DA and related model changes have been tested for the next cycle

- The snow changes have large impact on forecast skill in the NH
  - Not only near surface temperature, but also in the mid-to-upper troposphere

- Ongoing works:
  - Implement snow DA in the offline LDAS for SEAS6 and ERA6-Land
  - ESA CCI Snow assimilation in ERA6
  - Snow DA in a unified multivariate ensemble-based LDAS (de Rosnay et al, 2022)

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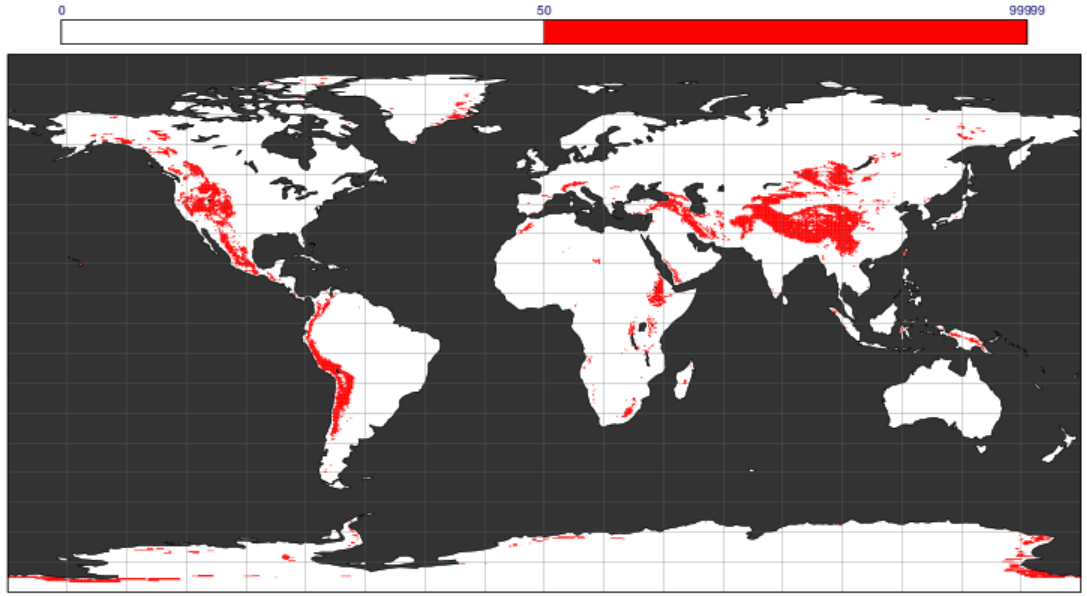
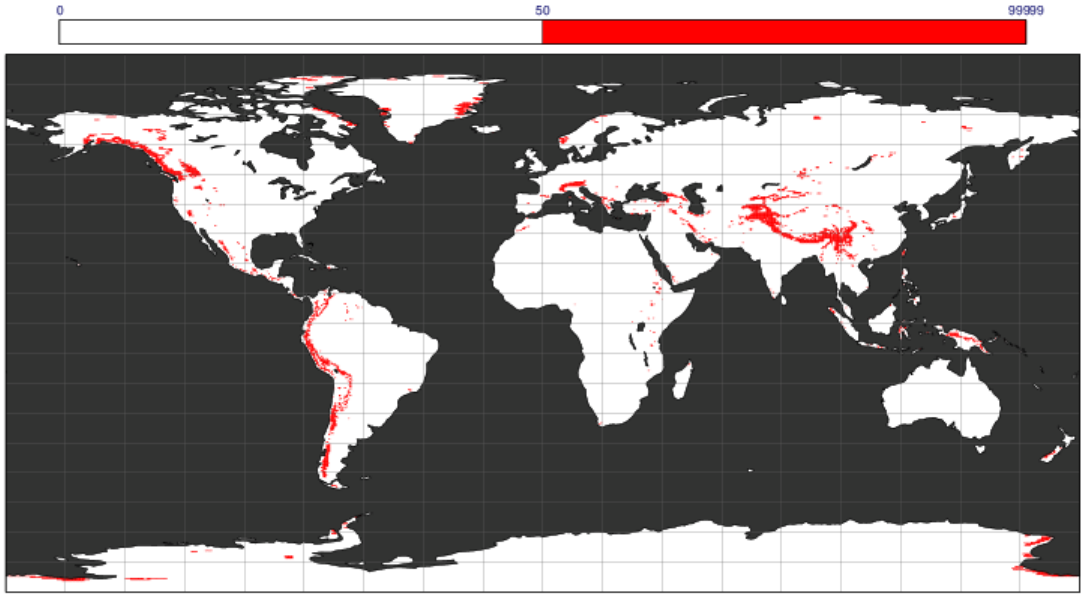
IMS mask

CNTL (altitude > 1500m)



TEST (SDFOR > 250m)



- IMS is **not** assimilated on the areas with red shading

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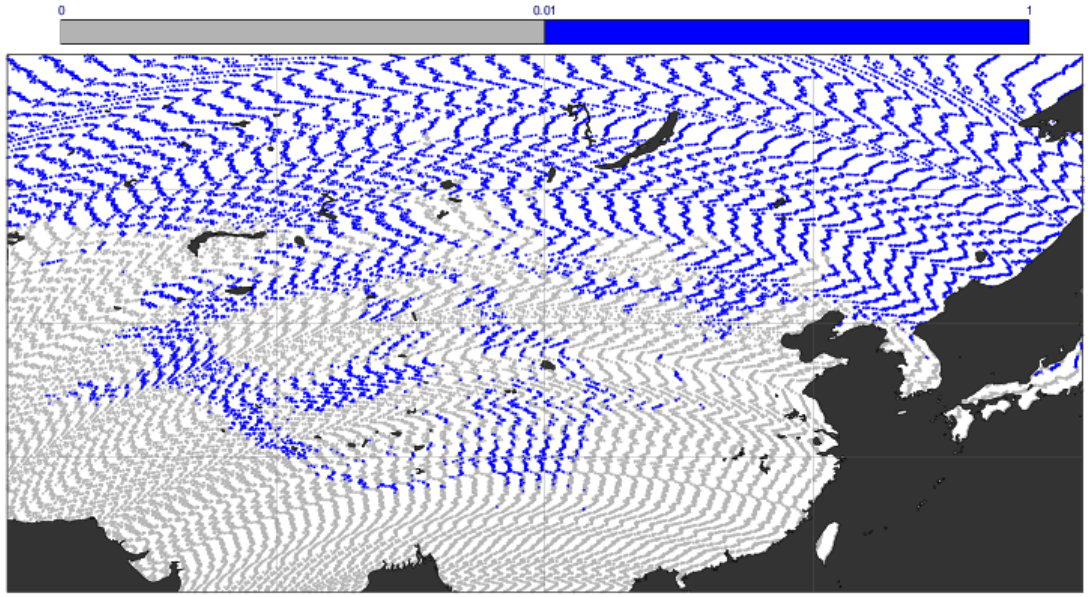
Thinning for IMS

CNTL



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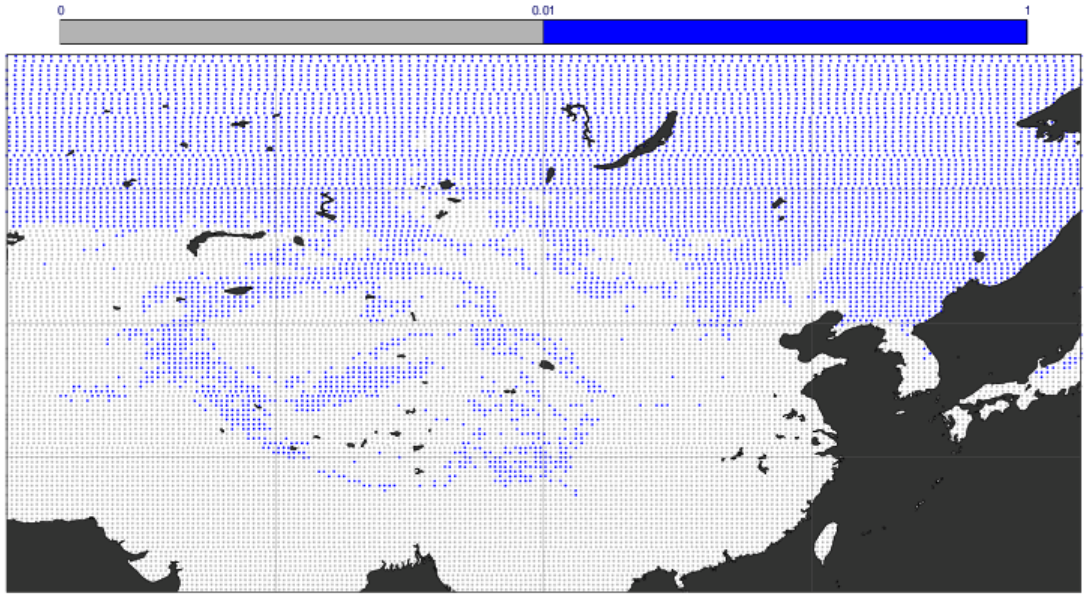

- Number of IMS is reduced from 251926 to 70125
- More effective and efficient use of IMS
  - Considering the current horizontal correlation in the OI

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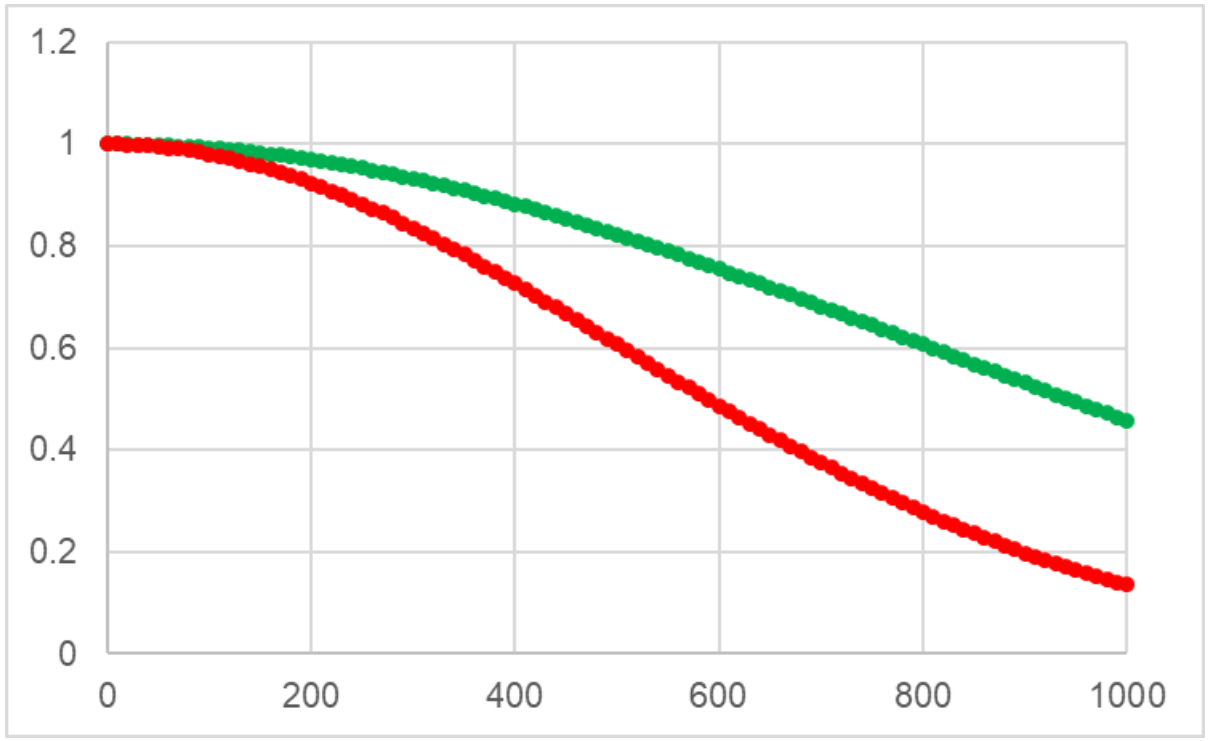
Vertical correlation function



$$\beta(\Delta z_{ij}) = \exp\left(-\left[\frac{\Delta z_{ij}}{h}\right]^2\right)$$

⇐ *h* is changed from **800m** to **500m**

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