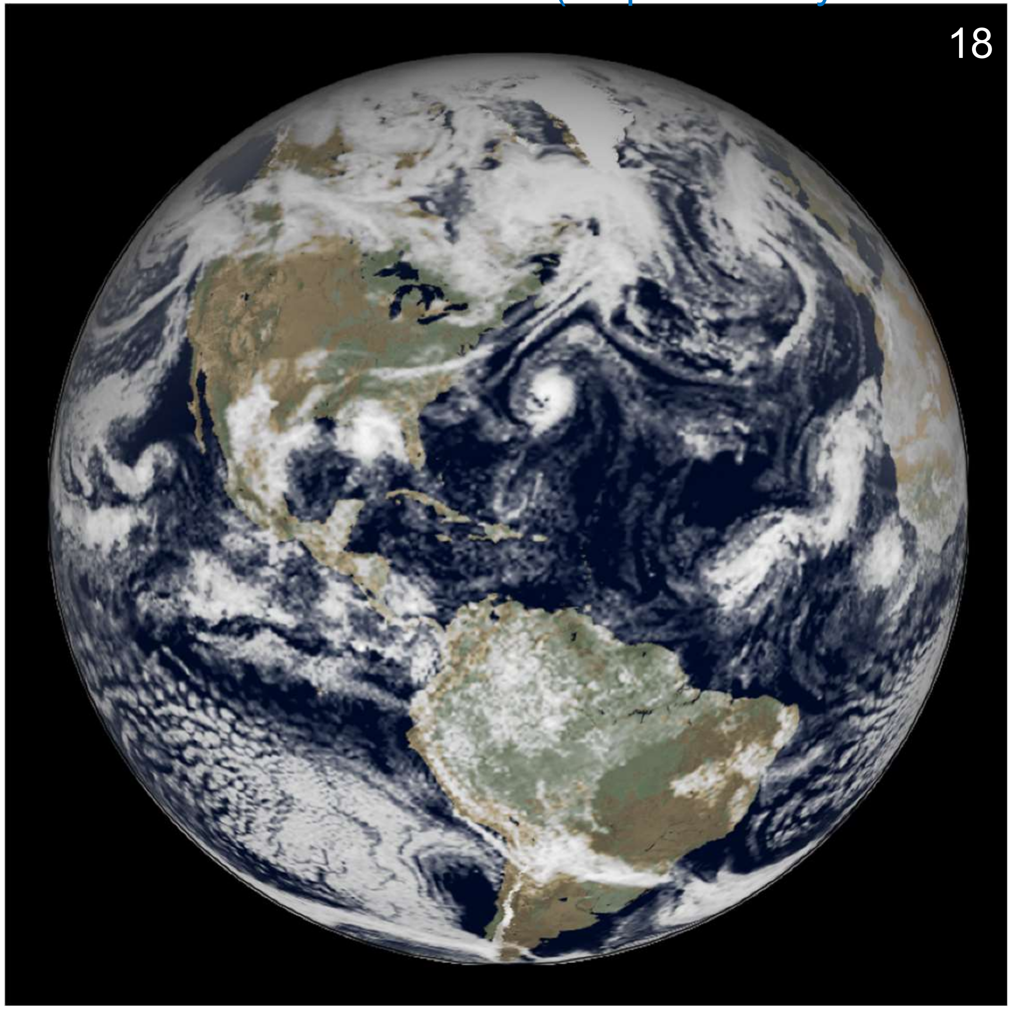
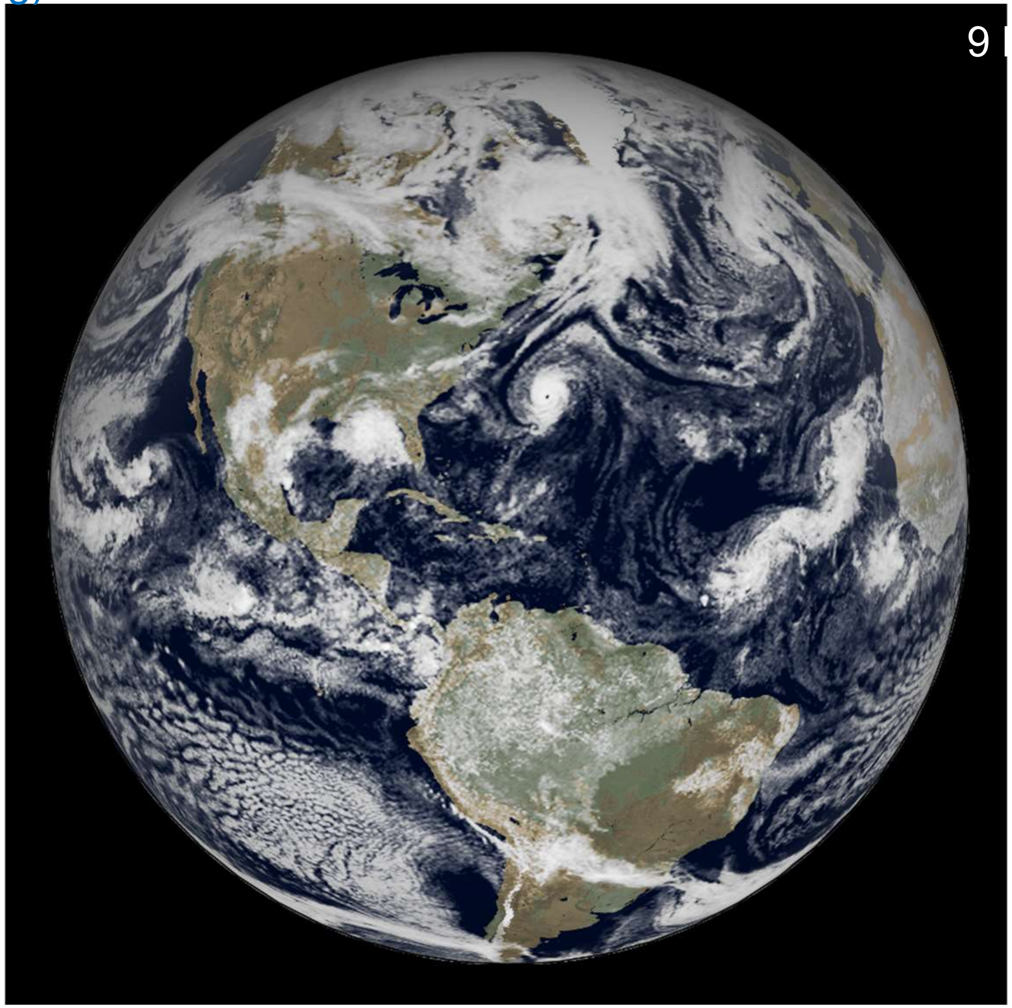
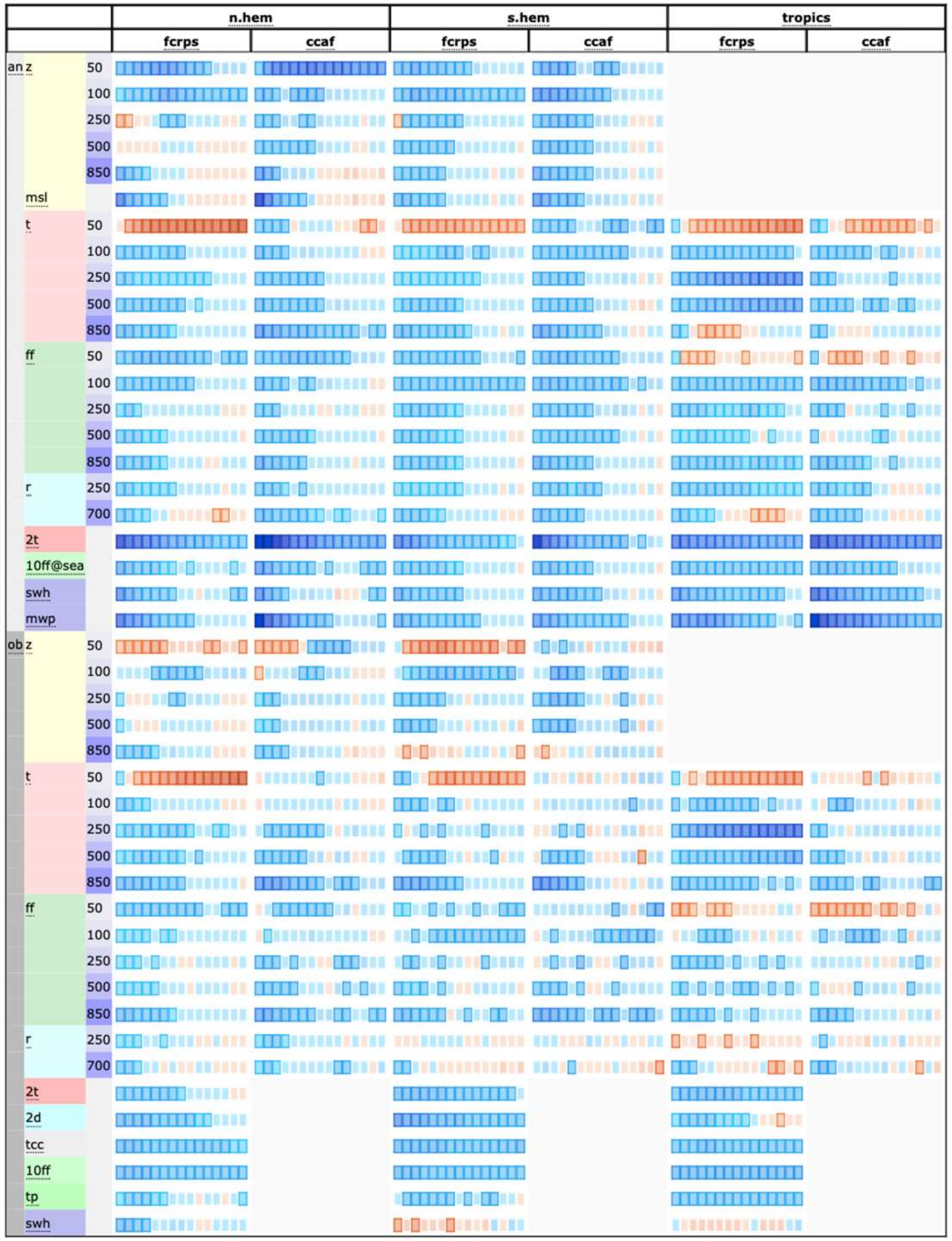
Horizontal resolution upgrade ENS : 18 km -> 9 km (same as HRES)

(responsible cycle Simon Lang)





ENS impact from resolution upgrade only -> does not include all model and da contributions

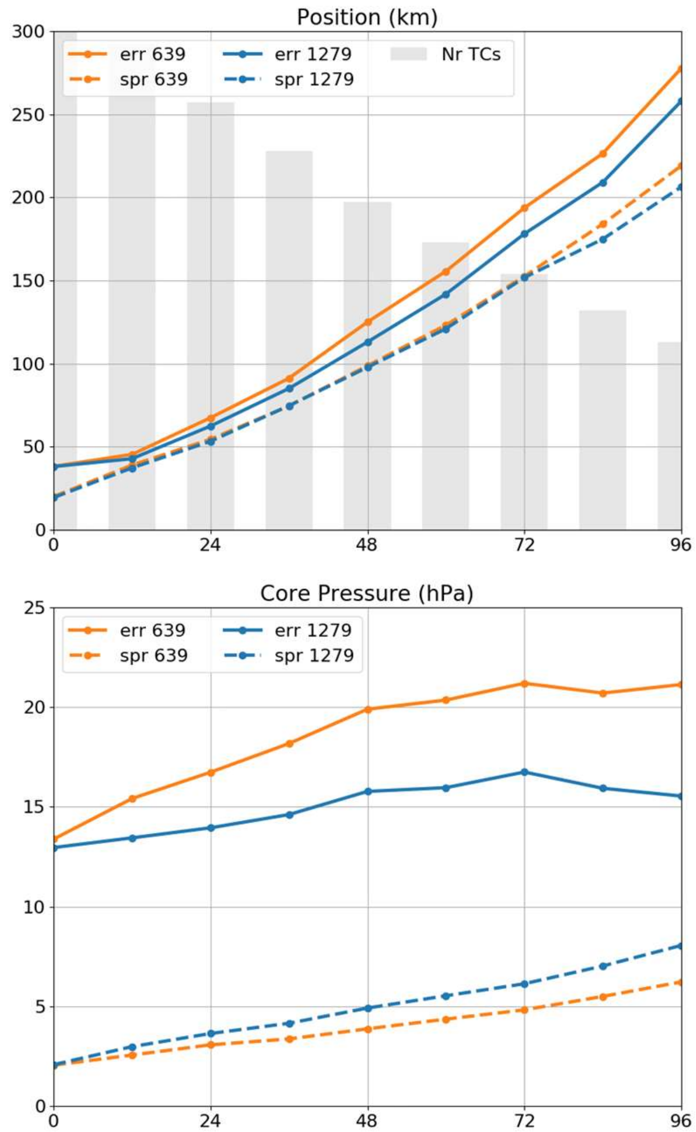


8 pert members,
00, 12 UTC
20200602 - 20200812,
20210901 - 20211031,
20201202 – 20210201

9 km (TCo1279)
vs 18 km (TCo639)

Scores:
Fair CRPS and
Anomaly correlation

Impact on TC forecasts:



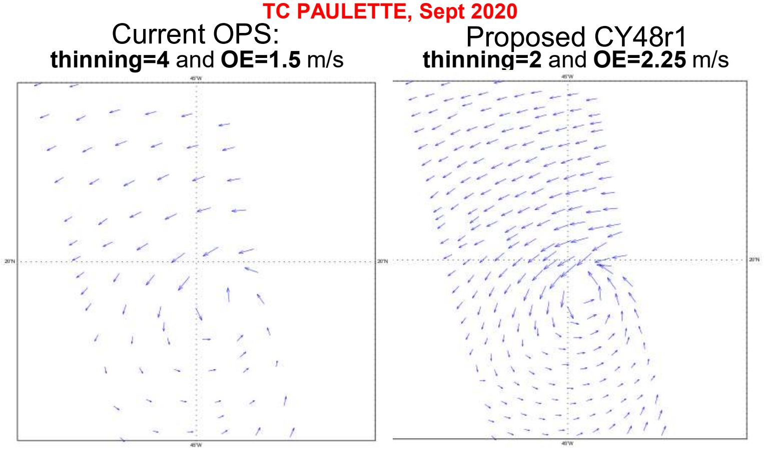
CY48r1: selection of model contributions

- Multi level snow scheme
- Revised climate fields
- Improved drag representation
- Revised computation of SL advection departure points
- Changes to dynamics and physics to improve water conservation
- New model top sponge layer formulation
- Consistent physics-dynamics interface across NL/TL/AD
- Radiatively interactive prognostic ozone using new HLO scheme
- Semi-Lagrangian vertical filter
- Readiness of wave model for high-resolution experimentation (IO, better modularity, code optimisation)
- Moist physics changes (saturation adjustment, ice fall speed, freezing drizzle)
- Exclude cloud saturation adjustment tendency from SPPT

CY48r1: Improvements in data assimilation (I)
(responsible cycle D. Schepers)

- Soft-recentred EDA and EDA horizontal resolution upgrade (same as ENS)
- TL511 inner loop resolution in CTL 4DVar (pert members are at TL399)
- OOPS

- Reduced thinning of ASCAT L2 products
  - High resolution tests indicate reduced position error for tropical cyclones as well as reduced bias in intensity

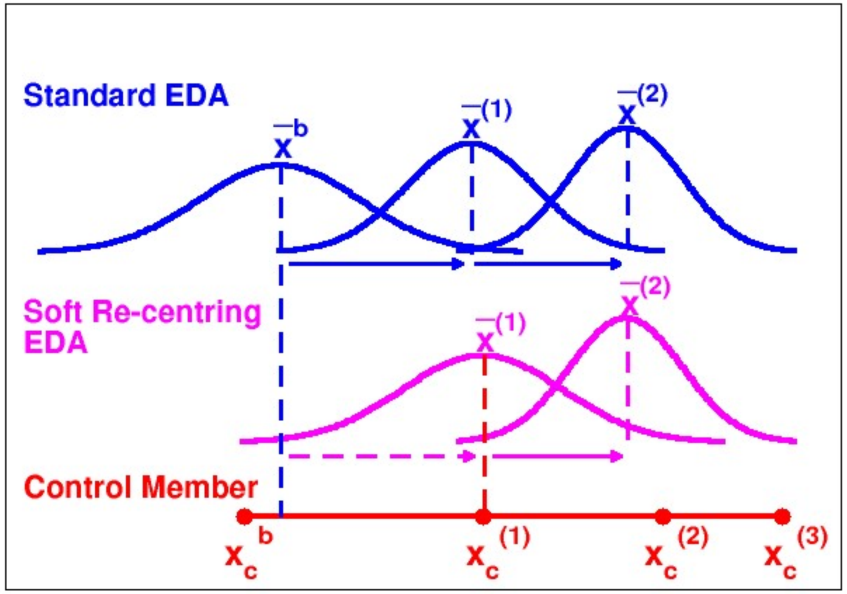


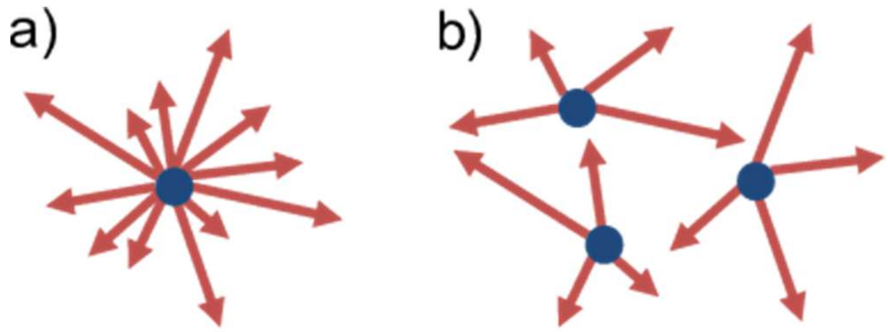
- Various optimisations for hyperspectral IR sounders
  - Unified VarBC setup for IR sounders
  - Allow usage of all pixels from IASI
  - Aerosol type classification in IR data
  - Update on the IR trace gas detection

EDA and ENS Developments… (Elias Holm).

Soft Re-centring EDA: Re-centring the EDA starting position on more accurate control analysis saves one EDA minimization, enabling higher resolution EDA

Distributed Observation Multi-analysis: Re-centre ENS on multiple high-resolution analyses that use different sub-sets of the observations.





CY48r1: Improvements in data assimilation (II)

- Upgrade RTTOV to v13
  - Latest version of RTTOV: technical upgrade + additional capabilities to prepare for future
  - Microwave gas optical depth coefficient file upgrade, using new predictors (v13)
  - Major scientific upgrade of cloud and precipitation microphysics in RTTOV-SCATT

- ATMS snow, Lambertian, slant-path
  - Activate ATMS humidity channels over snow
  - ATMS Lambertian surface reflection over snow and sea-ice
  - Slant-path interpolation for selected MW sensors assimilated in the all-sky system

- Improved treatment of surface-sensitive channels in all-sky
  - Assimilate polewards of 60 degrees over land and ocean; relying on new sea-ice detection
  - Improved treatment of mixed land-water and water-sea-ice scenes

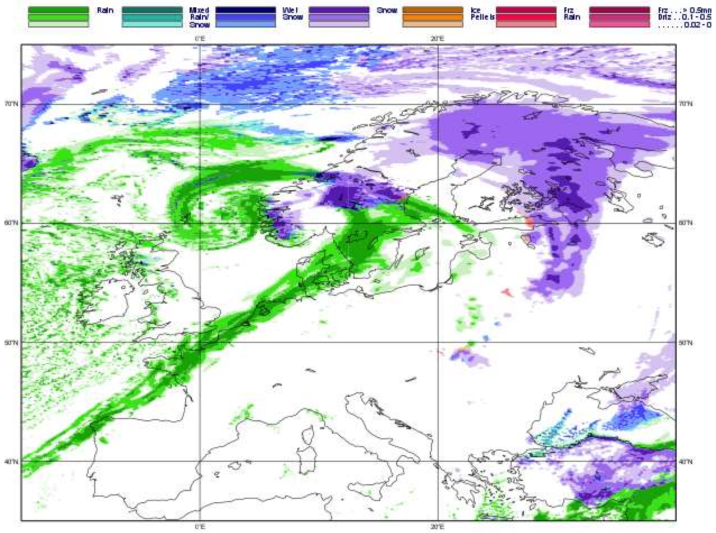
- Assimilation of microwave imagers over land surfaces
  - 89 GHz, 150/166 GHz channels of GMI, SSMIS + GMI 183 GHz over land
  - Add 37 GHz channels, Add AMSR2; improved bias correction, QC and error models

Example: Freezing drizzle

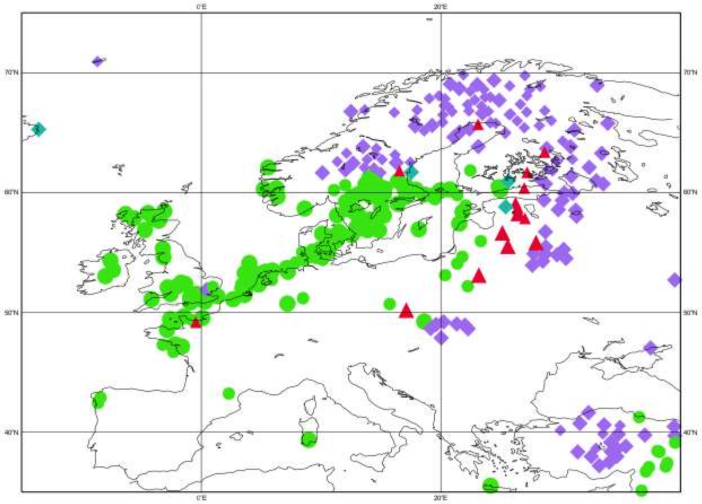
Case study: Europe 24 Jan 2018

Freezing drizzle= "warm-rain" process at supercooled temperatures
vs freezing rain= snow melts to rain in >0degC layer aloft then doesn't refreeze in <0degC near-surface layer

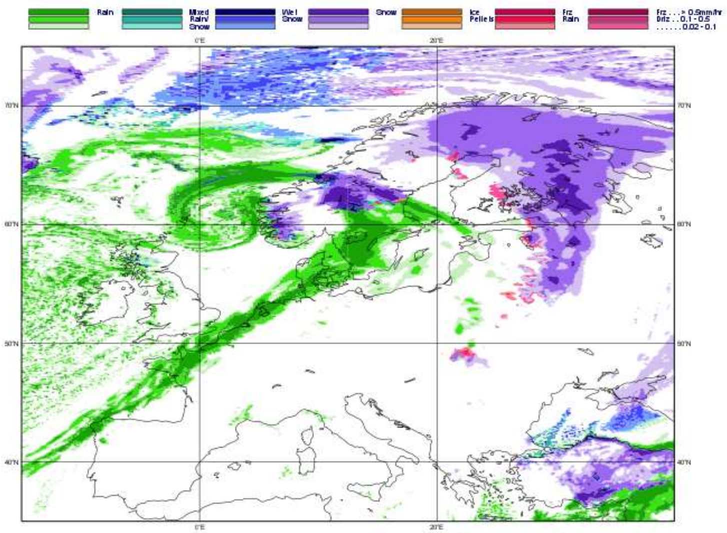
47r3 TCo1279
20180124 00Z T+18



Observed precipitation type
20180124 18Z



47r3 TCo1279 mergecloudfor48r1 frzdrz0.5
20180124 00Z T+18



rain / mix rain-snow / wet snow / snow / ice pellets / freezing rain / freezing drizzle

Extended-range configuration in 48R1

(responsible cycle Frédéric Vitart)

ECMWF

Current configuration of the ECMWF extended-range forecasts and re-forecasts

Extended-range forecasts:

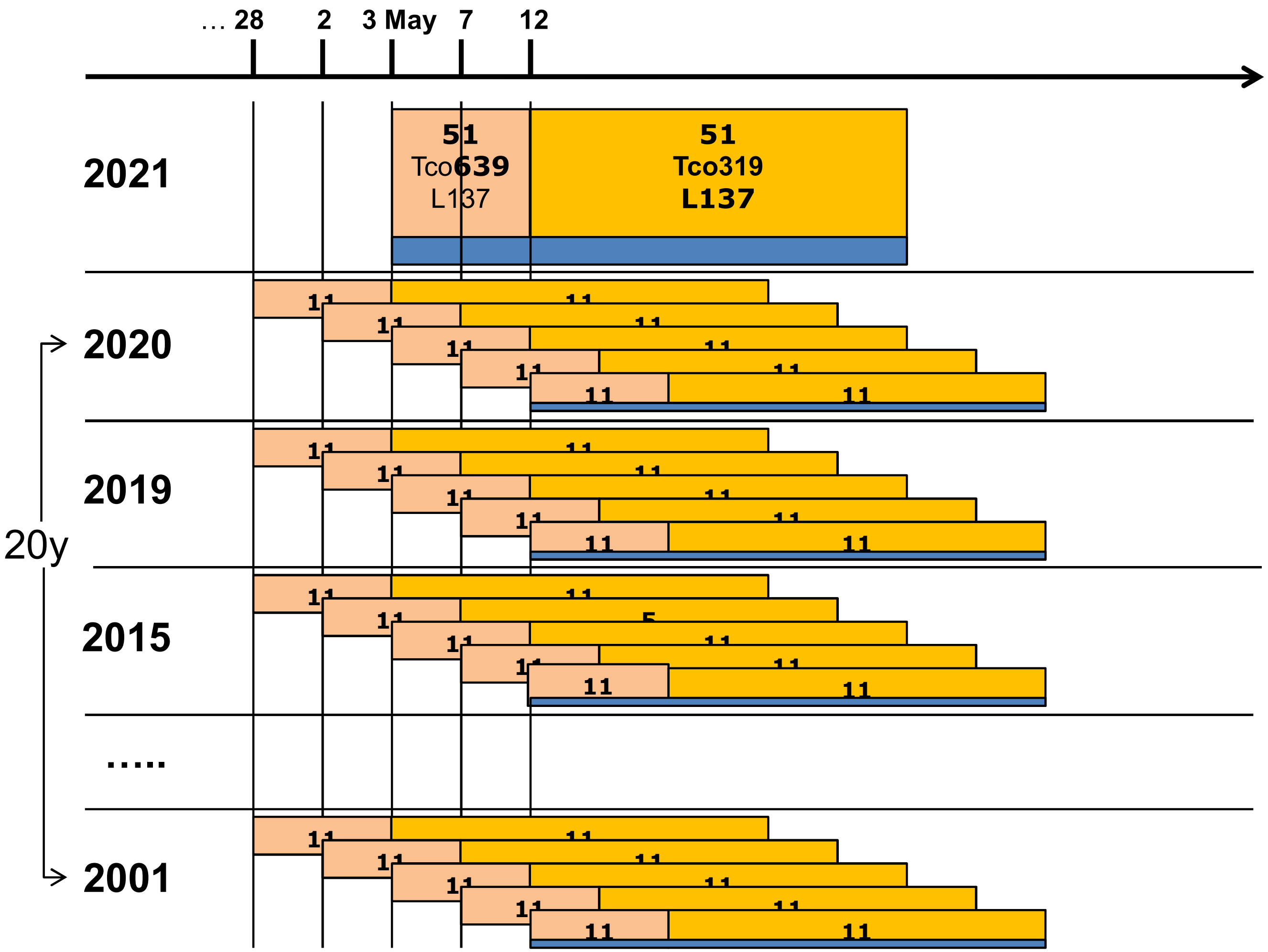
Twice a week (Mondays and Thursdays 00z), the 51-member ensemble forecasts are extended to 46 days.

The resolution between day 15 and 46 is Tco319L137

Reforecasts:

11-members starting the same day and month as the real-time forecasts over the past 20 years.

- Same resolution as real-time forecasts (Tco639/Tco319L137)
- Initialized from ERA5 and ORAS5



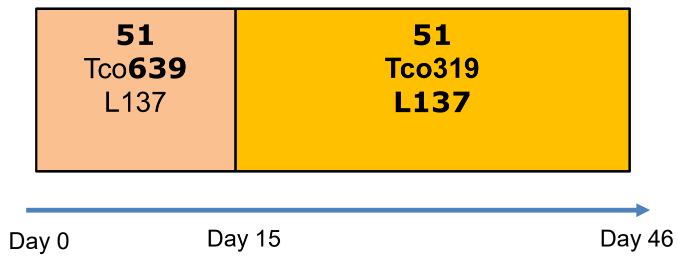
Extended-range forecast configuration 48r1 and beyond

1. Same horizontal resolution as now (Tco319L137)
2. Daily real-time forecasts (00Z) instead of twice weekly
3. 101 members instead of 51
4. Extended-range ensemble (lower resolution) starting at step 0, separately from the 15-day medium-range ensemble (higher resolution)
5. Re-forecasts are run daily (instead of twice weekly) but with lower ensemble size

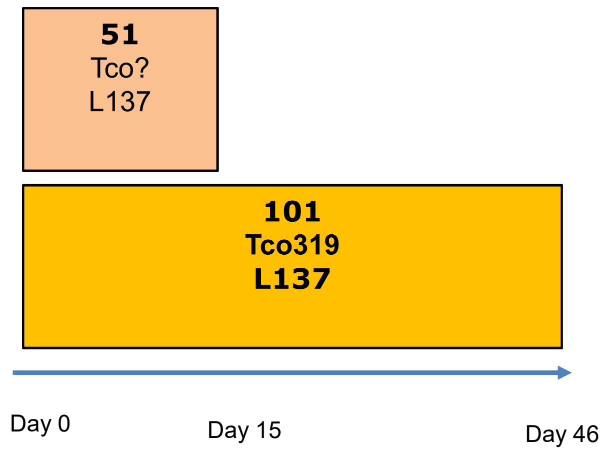
1-2-3-4 to be introduced in 48R1

5 will be introduced in a later cycle (49R1?). So no change in re-forecast configuration (twice a week, 11 members). However there will be 2 different sets of re-forecasts for medium-range (high resolution up to day 15) and extended-range (low resolution up to day 46).

Current configuration



Next configuration



Computing cost

Hres	Vres	Time Step	RT Ens per week	RFC Ens per week	Fct length	Precision	Cost
Tco319	137	1200s	102	440	Day 14-46	Single	1
Tco319	137	1200s	700	440	Day 0-46	Single	3.2

Motivations: Running daily instead of twice weekly

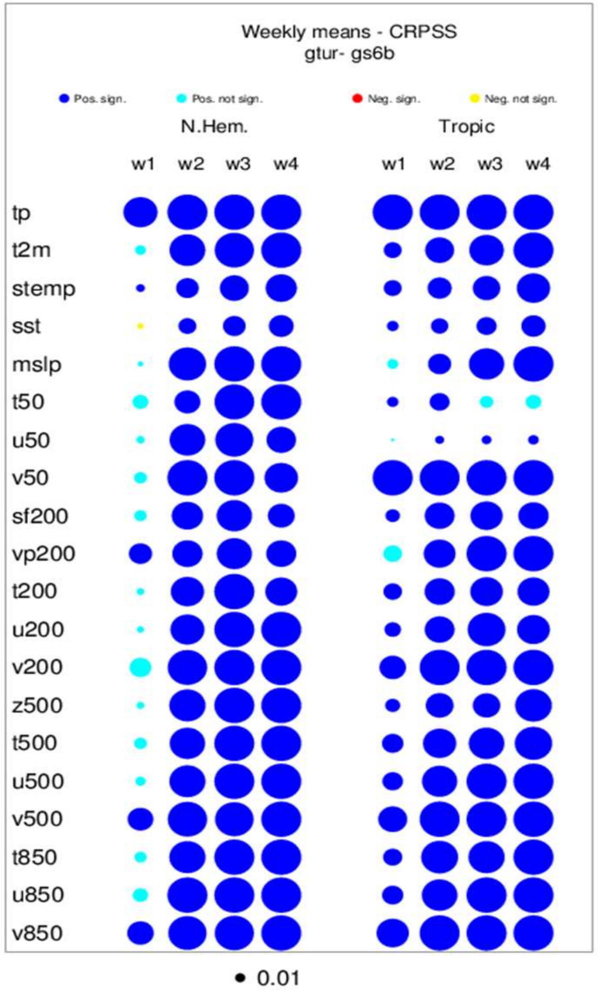
- Produces better forecasts for other days of the week than Monday and Thursday

- Gives the possibility of creating lagged ensembles.

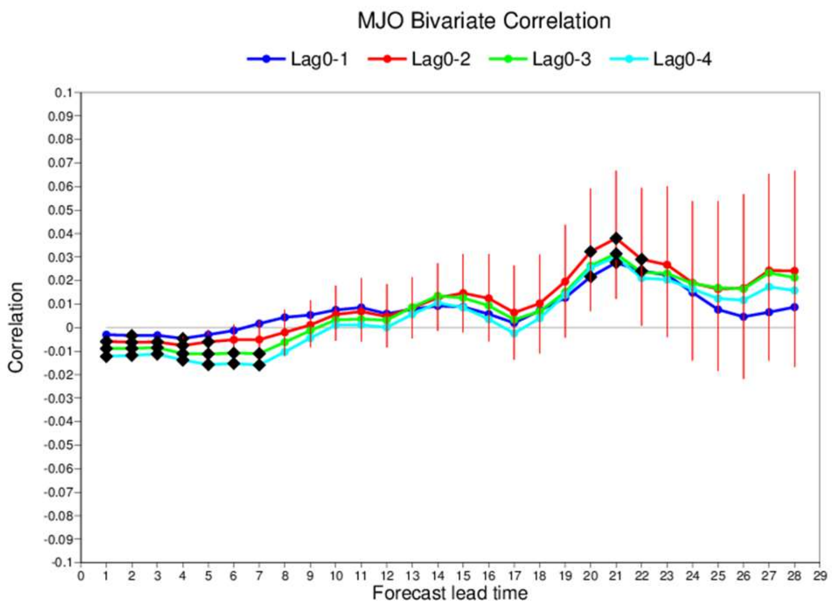
Lagged ensemble can help improve forecast skill in weeks 3 and 4 because of the larger ensemble size and provides smoother evolution of the forecasts (less flip-flop)

Lagged-Ensemble Approach

3d 15m lag (45m) vs 15m burst



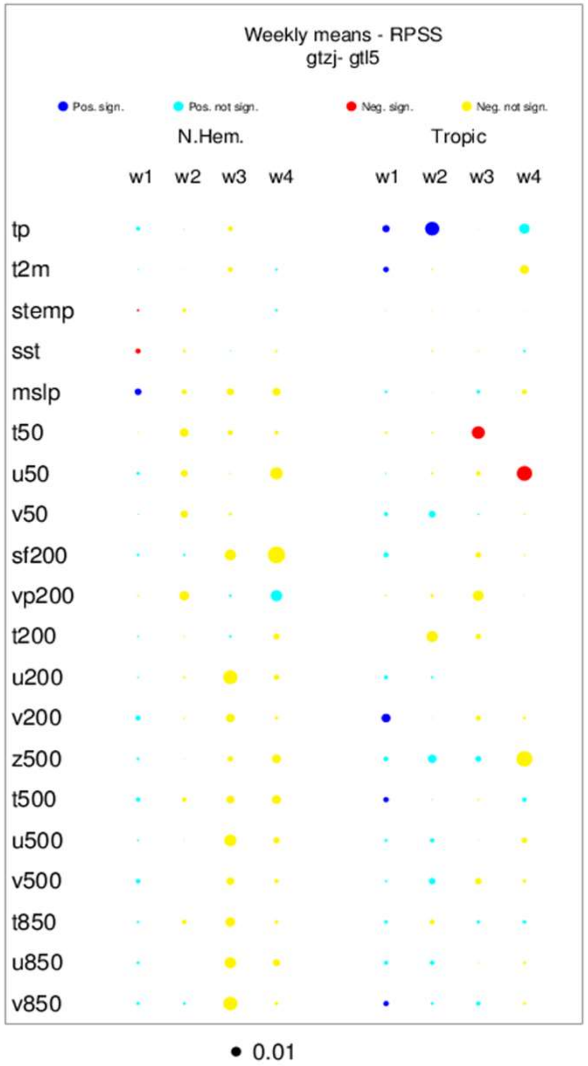
Madden-Julian Oscillation



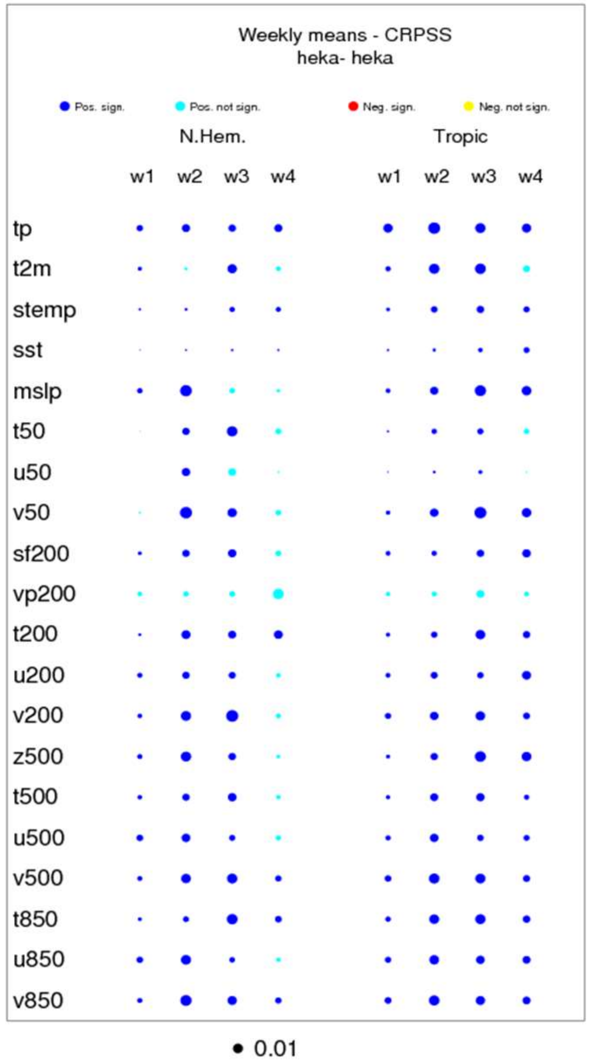
Motivations: Not increasing horizontal resolution

- No statistically significant positive signal beyond week 1
- No impact on the prediction of sources of extended-range predictability such as the MJO.
- Experiments with Tco1279 46-day forecasts (METIS project) also indicate a lack of impact of the higher horizontal resolution on week 3 and 4 forecasts

Scorecard Tco639L137 – Tco319L137

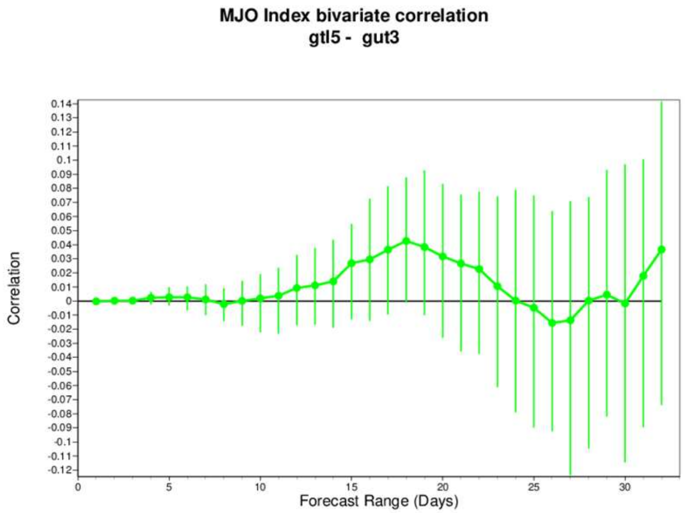


100m vs 50m

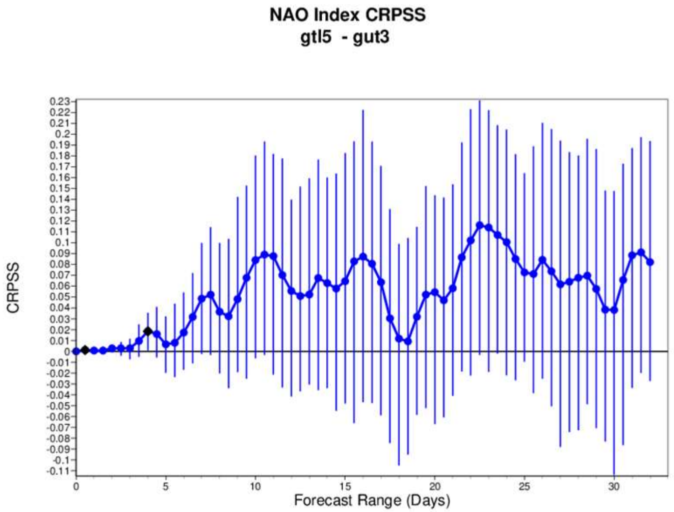


Impact on MJO and via teleconnection on NAO

MJO: 20m Tco319 vs 10m Tco639/Tco319

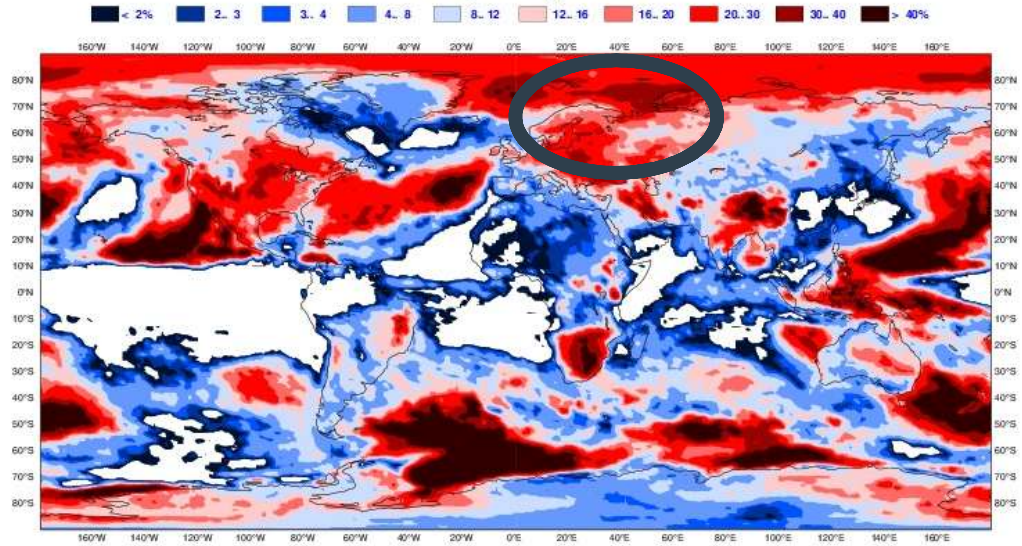


NAO: 20m Tco319 vs 10m Tco639/Tco319

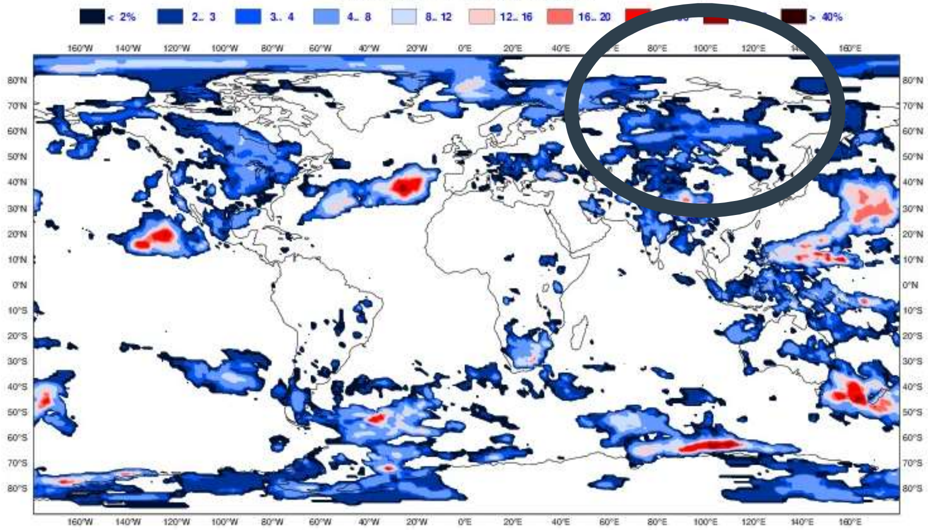


50m

Probability 2T in upper decile

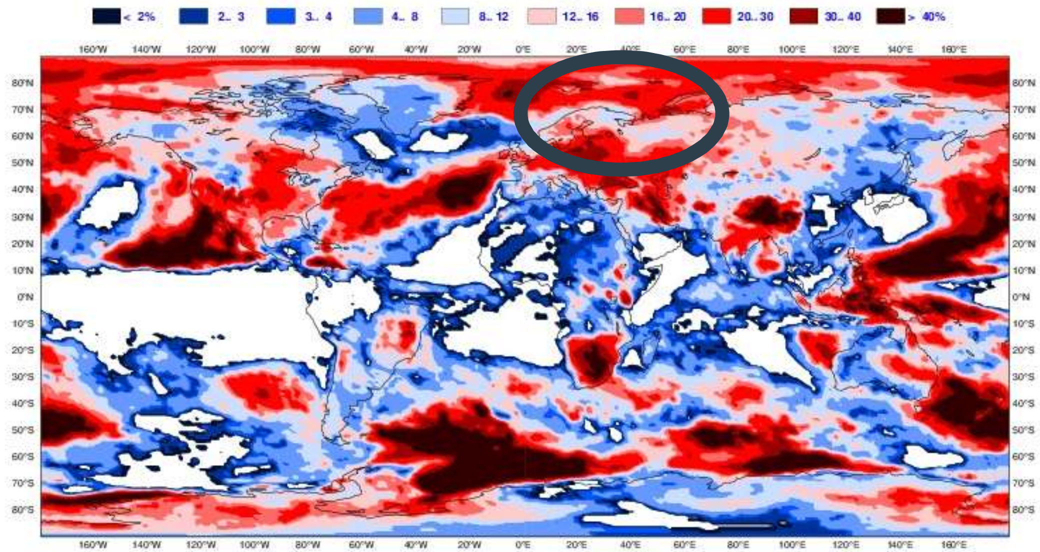


Probability 2T in top percentile

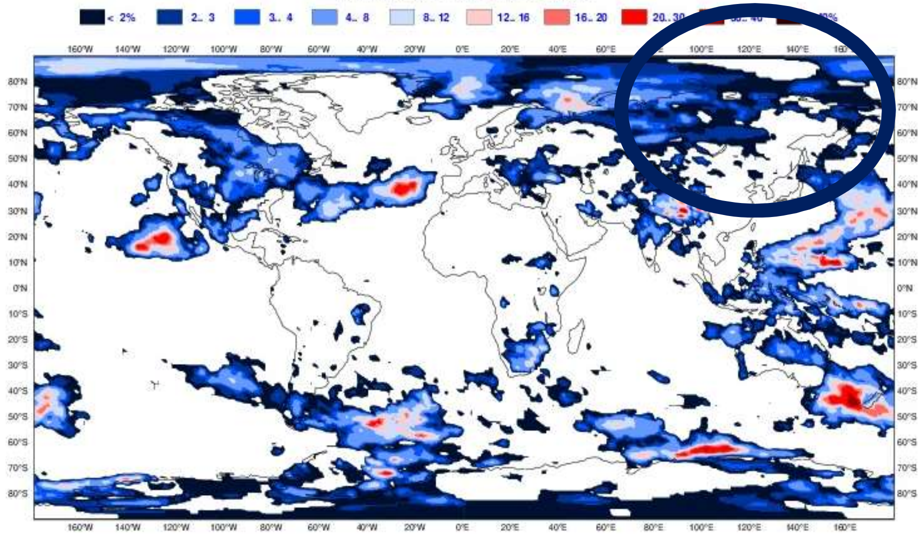


100m

Probability 2T in upper decile



Probability 2T in top percentile



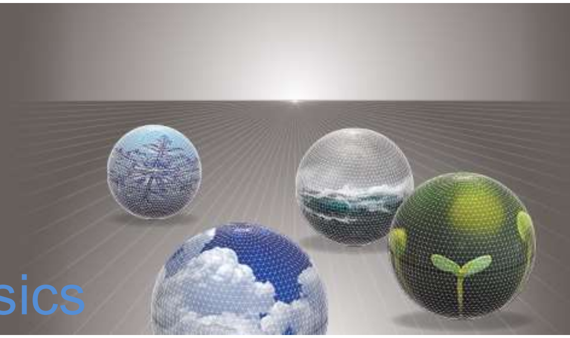
New Streams for 48R1

Extended ensemble forecast hindcast:	**eefh**
Extended ensemble forecast hindcast statistics:	**eehs**
Extended ensemble prediction system:	**eefo**
Wave extended ensemble forecasts:	**weef**
Wave extended ensemble hindcasts:	**weeh**
Wave extended ensemble hindcasts statistics:	**wees**

12–16 September 2022

Annual Seminar 2022

#AS2022



some results from our ECMWF Annual Seminar on physics

https://events.ecmwf.int/event/300/timetable/

some degree of convective mixing needed even down to 1 km in global models (tropics). For tropical cyclones/medicanes (polar lows?) 4 km resolution sufficient

Orography (drag): ”resolved-subgrid” filtering 3-5 dx from very high resolution (<1 km) dataset, Himalayas during winter subtropical jet still problem

Prognostic turbulence approaches still challenging –horizontal gradients at high-resolutions

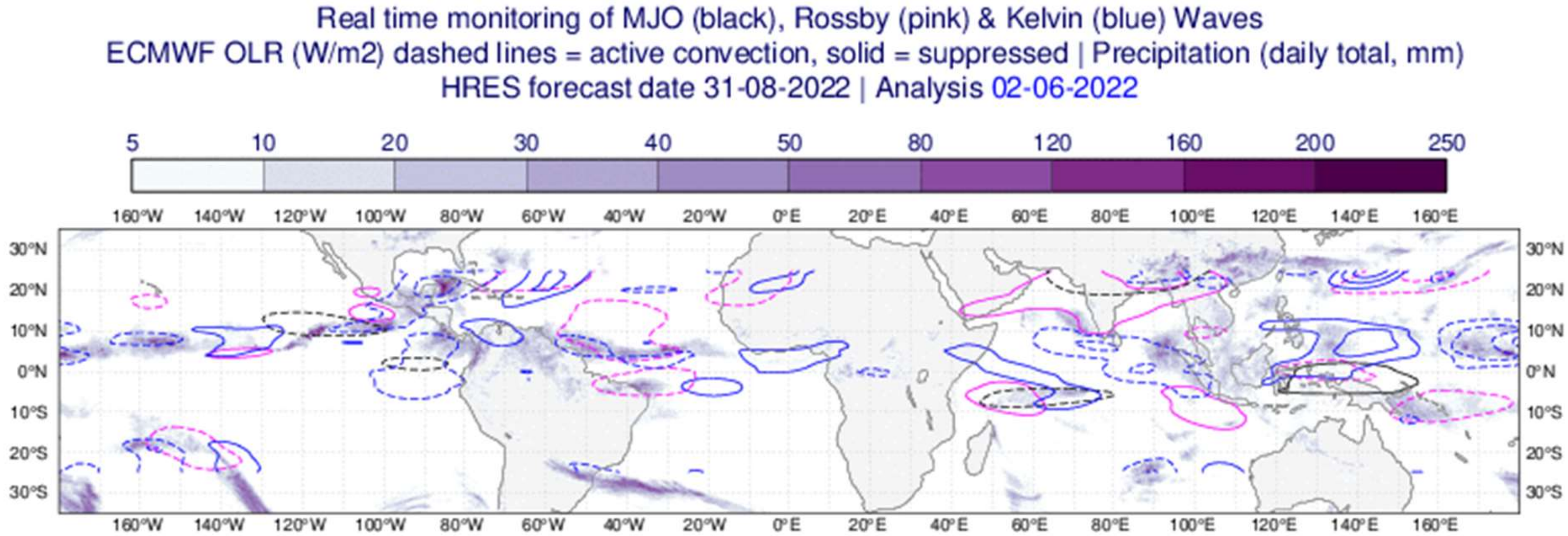
Advantages of two-moment microphysics at high resolutions

New surface fields, evolving LAI (monthly or prognostic), more surface layers (1 cm), surface drag at high wind speeds

SPP vs SPPT, stochastic shallow convective mass flux

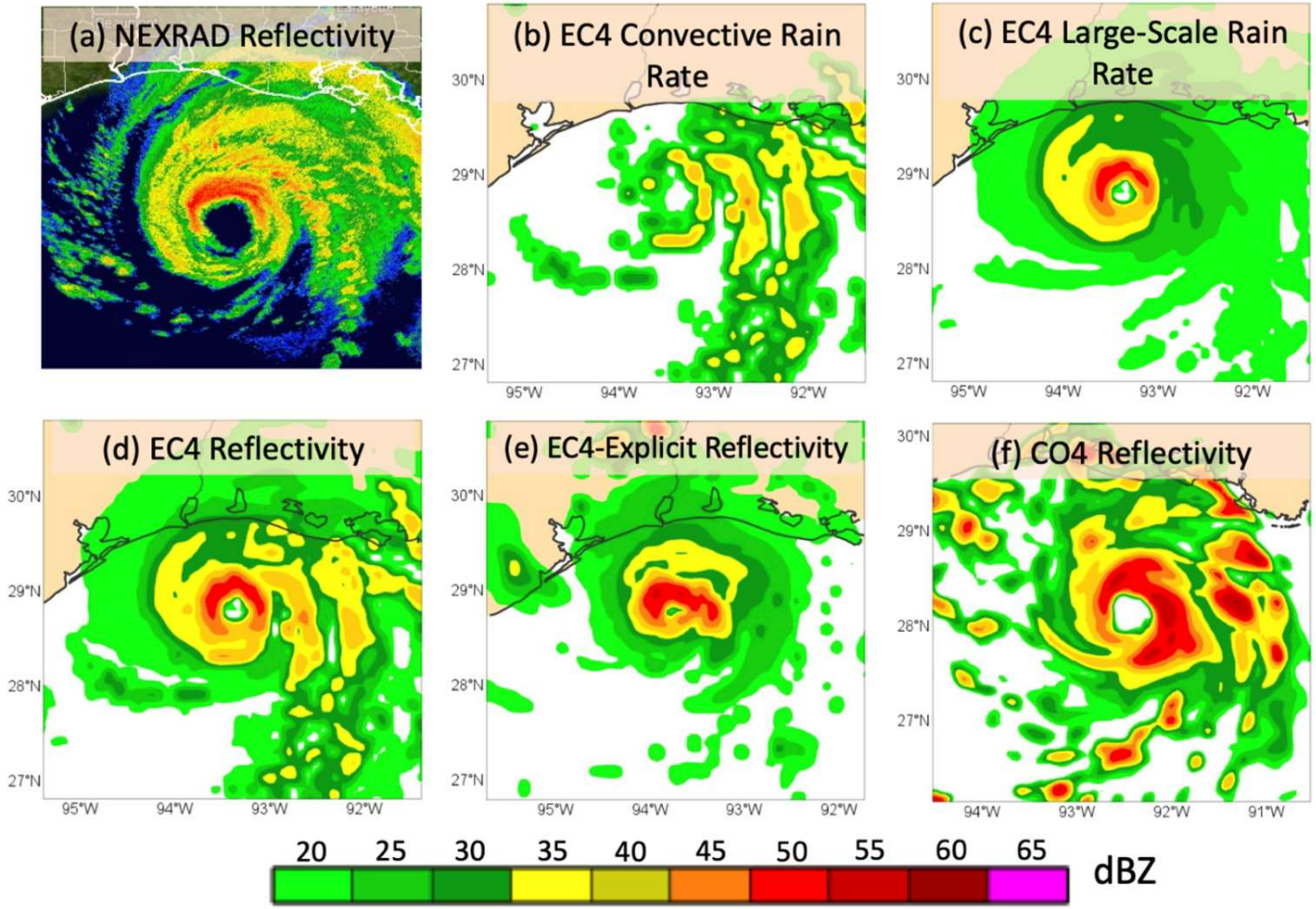
Enjoy some convective structures, dicussions towards high-resolution and why convection/tropical forecasting so sensitive/difficult but gratifying

Tropical Waves: MJO, Rossby, Kelvin. (from our Forecast department R. Emerton)

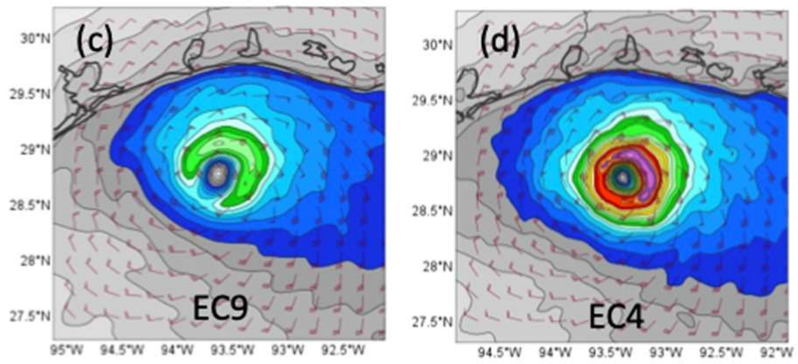


- Real-time monitoring of tropical waves in analysis & forecasts, using wave identification software developed by Peter Bechtold et al.
- Animation shows MJO, Kelvin & Rossby waves in analysis data over JJA 2022, with daily total precipitation
- Tropical waves are an important source of predictability and linked to high-impact weather in the tropics, and teleconnections to the mid-latitudes – how well do we represent them & their impacts?
- More info: https://confluence.ecmwf.int/display/~more/Real-Time+Monitoring+of+Tropical+Waves

Convection and tropical cyclones (e.g. Laura 27 August 2020)



4 km resolution/scaling generally good (see also INCITE project Inna, DestinE experimentation), 9 km still too weak. Effect of convective heating in eyewall and strong low-level and weak mid-level inflow(spiraling arms) of θ_e and angular momentum



Majumdar S., L. Magnusson, P. Bechtold, J.-R. Bidlot, J. Doyle, MWR 2022 (submitted)

Vortex sensitivity to convective heating/stabilisation

Large+weaker vortex vs smaller+stronger vortex

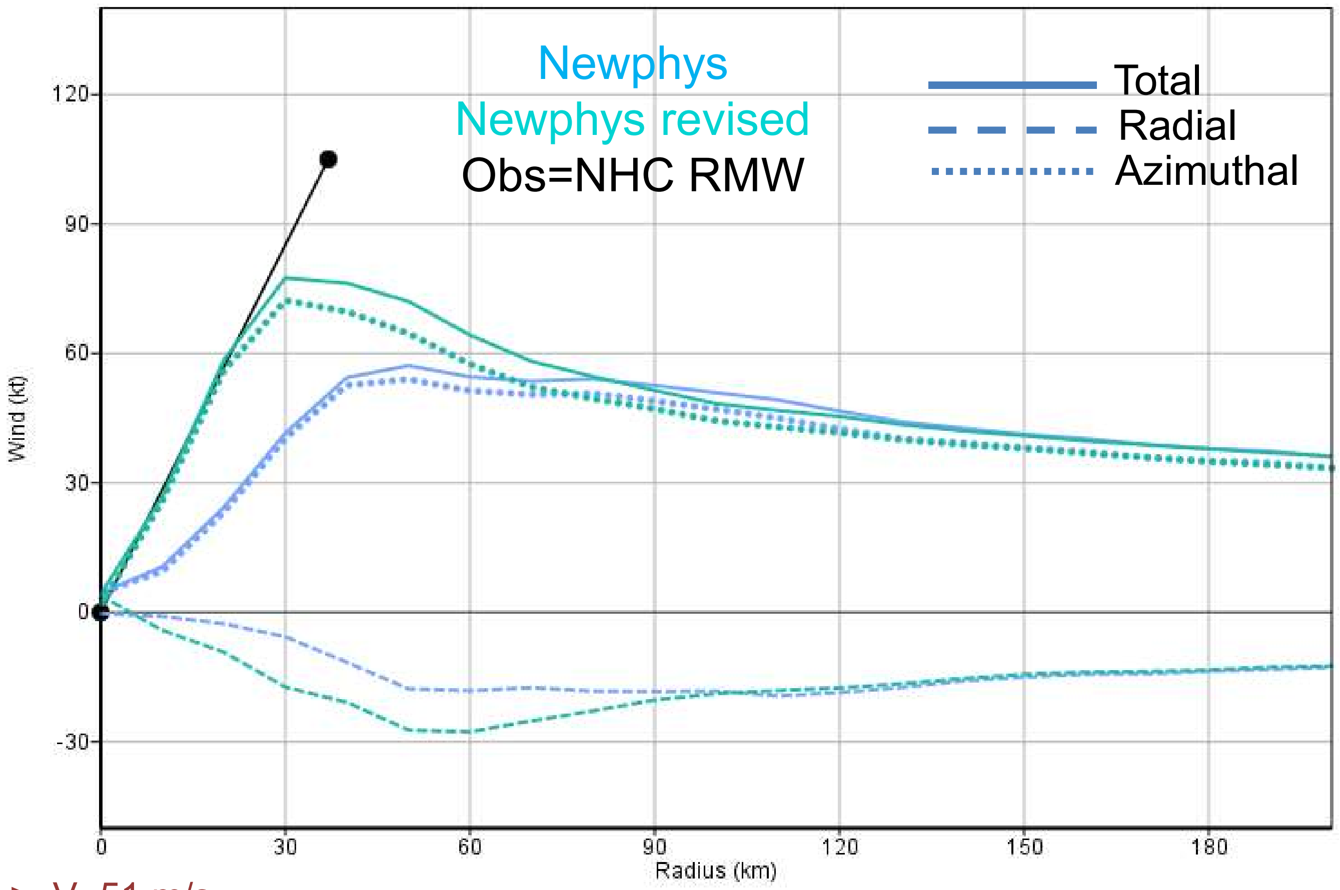
For Vortex dynamics= perturbation buoyancy force (pushing inward) vs pressure force (pushing outward) in thermal/gradient wind balance

maximum intensity just above PBL, see Emanuel&Rotunno 2011, Montgomery&Smith 2016, Makarieva&Nefiodov 2021

$$\left(T_{pbl} - T_0\right) C_p \frac{1}{\theta_e} \frac{\partial \theta_e}{\partial r} = -\frac{V^2}{r}$$

28.5C -83C 345K 8K/150 km (9 km) => V=51 m/s
12K/150 km (4.5 km) => V=62 m/s @850 hPa

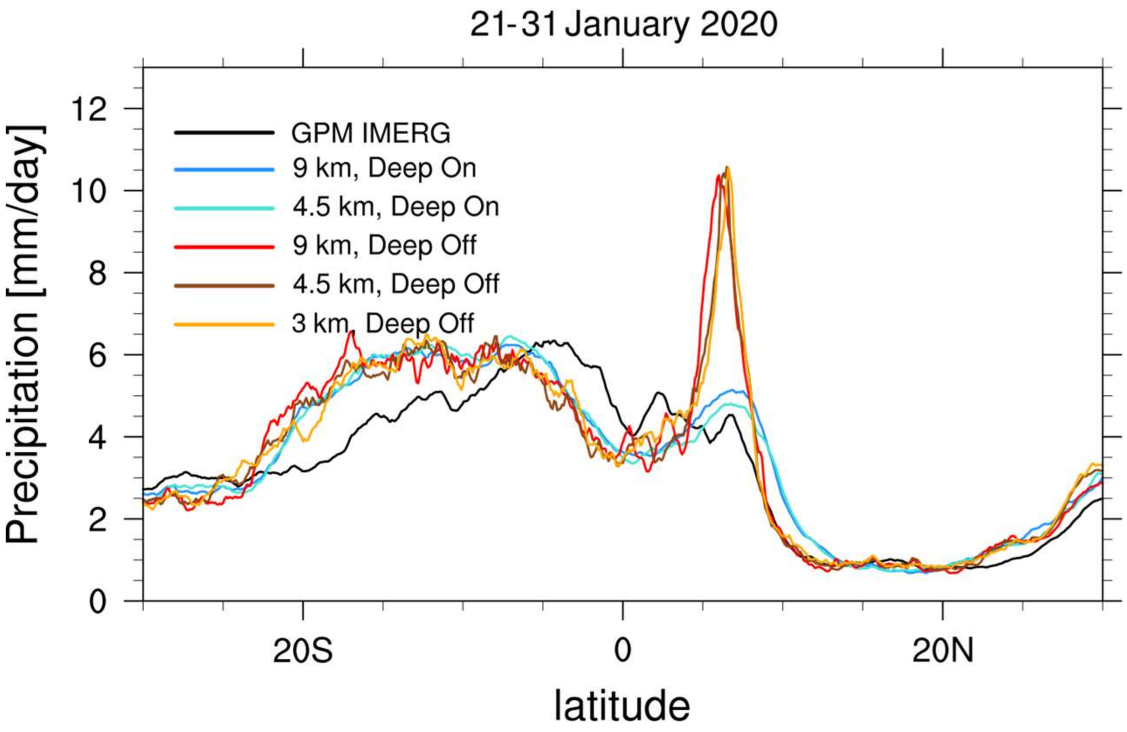
Azimuthally averaged radial profiles of 10 m wind



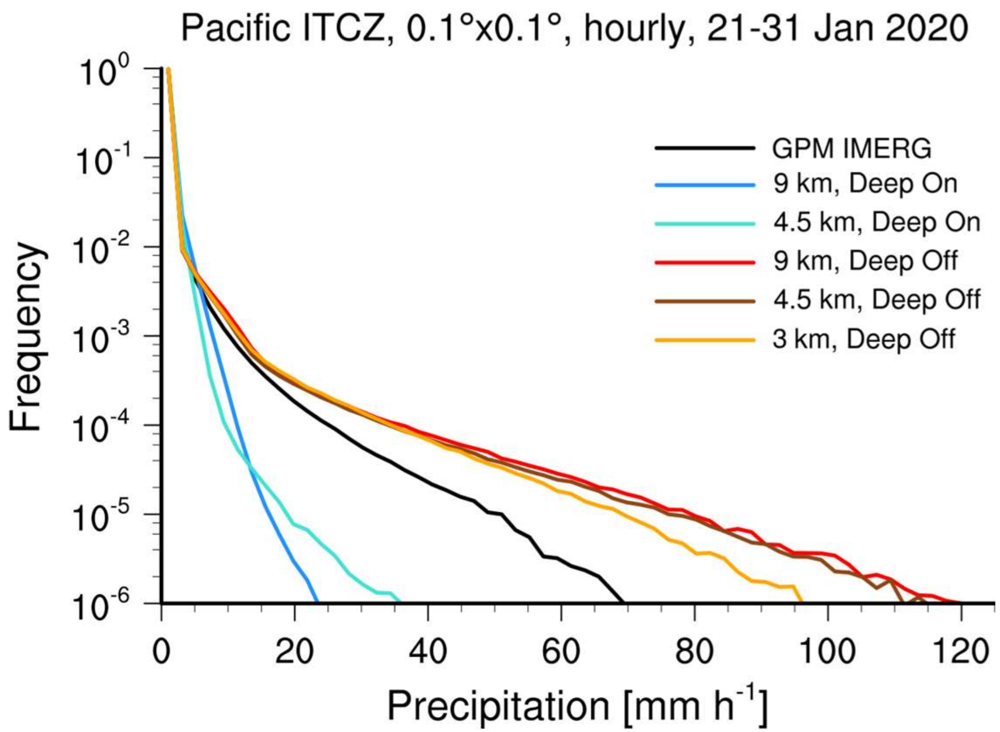
courtesy: Sharan Majumdar

Precipitation statistics tropics deep on/off (T. Becker)

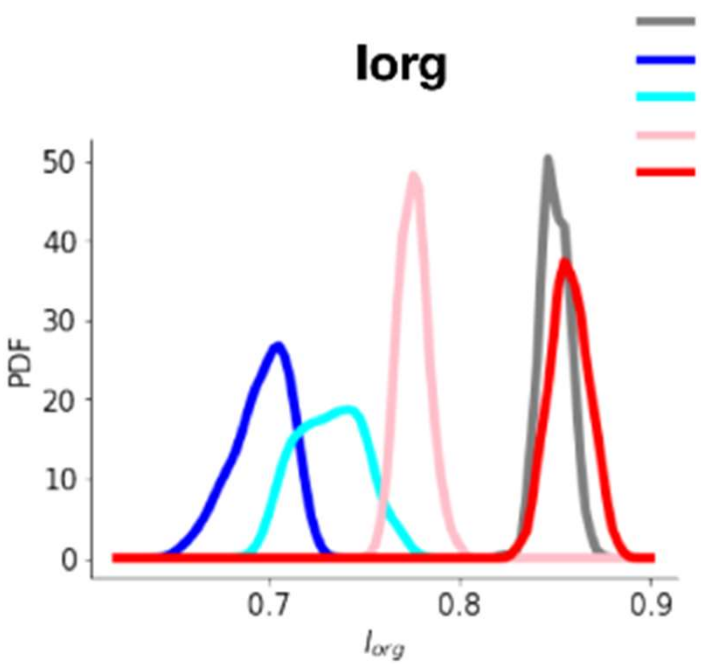
zonal mean precipitation strongly overestimated over NH Pacific ITCZ with Deep Off



precipitation too intense with Deep Off and not intense enough with Deep On

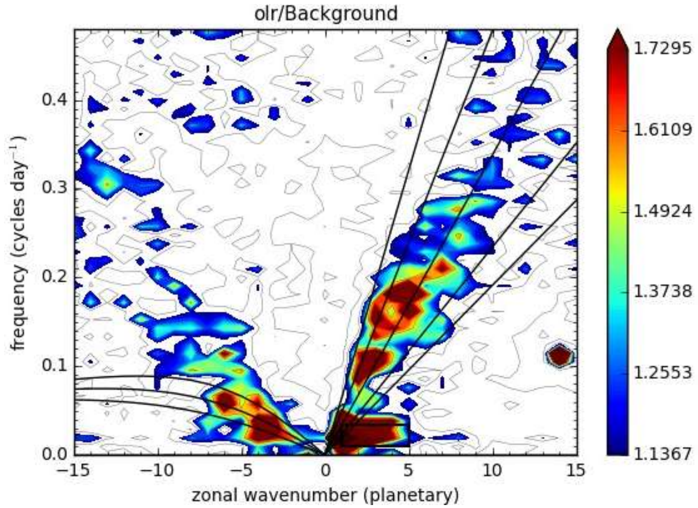


Organisation and waves always good?, what can happen? and why tendency to smaller scales when going to more “resolved”

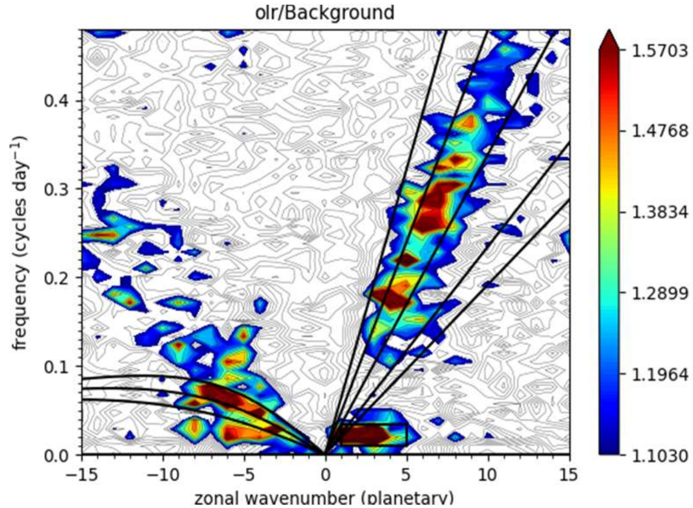


no deep

from NEXTGEMS by Jiawei Bao (MPI Hamburg)



NOAA

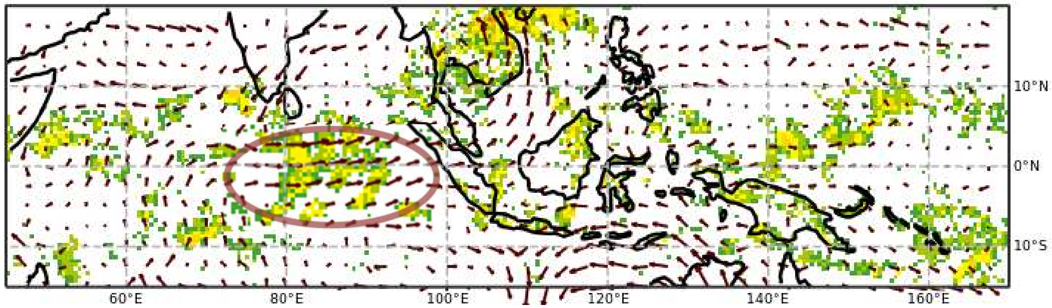


IFS climate

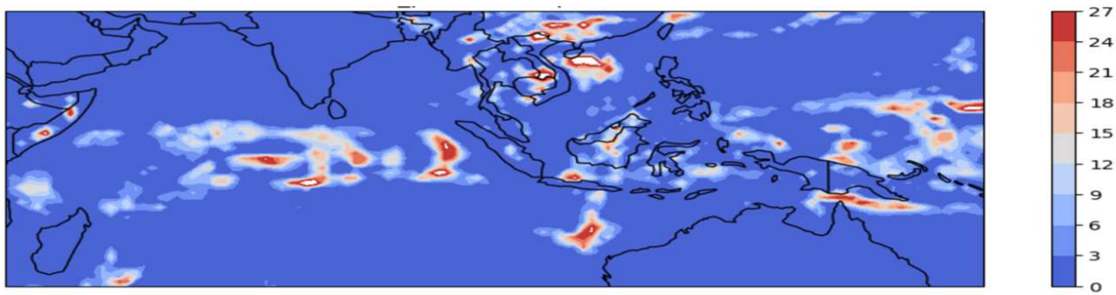
1-day filtered

Inertia-gravity waves vs convergence forcing/response

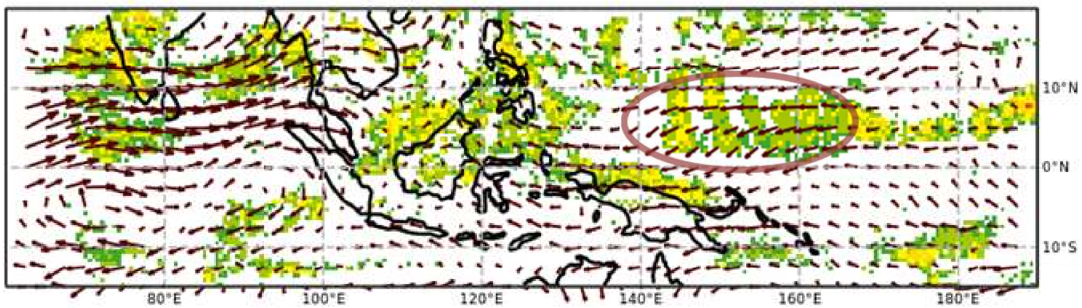
IFS 20220428 12+72h TP 3h uv 700 hPa

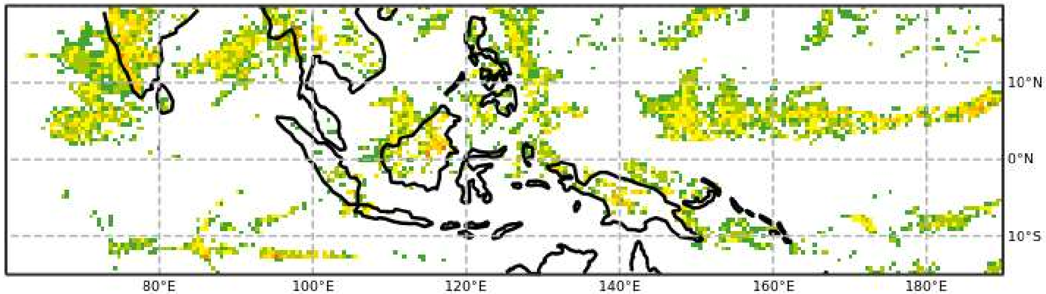


ICON/DWD Maike Ahlgrimm



IFS 20220803 00+748hTP 3h uv 700 hPa





$N = 0.02 - 0.04\ s^{-1}$ ϖ~2π/10800 s

U=10-20 m s^{-1} ;v=0; Lx~600 km k= 2π/ Lx; m= 2π/ Lz

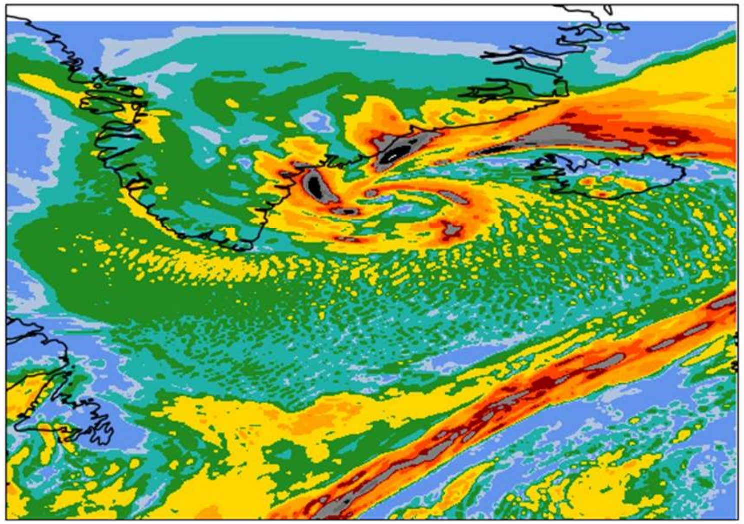
=> $\tilde{c}$**=c-U=55 m s^{-1} ; Lz~10 km**

wave limit on how fast but not on how slow

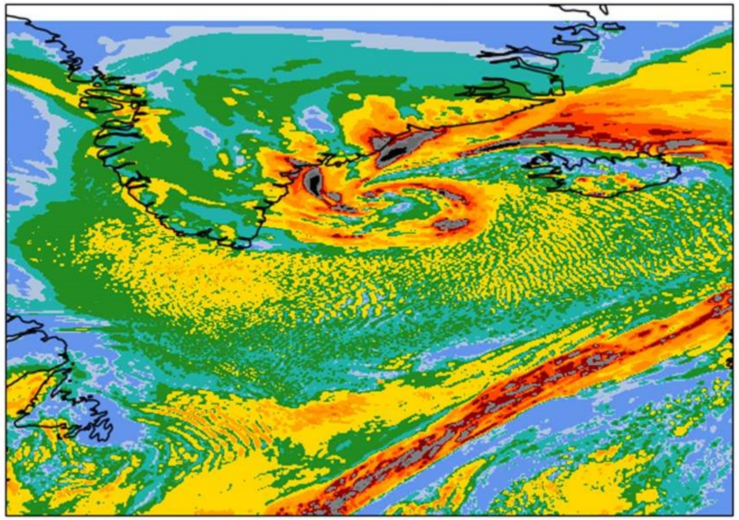
$$f^2 < \tilde{\omega}^2 < N^2 \qquad m^2 = \frac{k^2 N^2}{\tilde{\omega}^2} = \frac{N^2}{\tilde{c}^2}$$

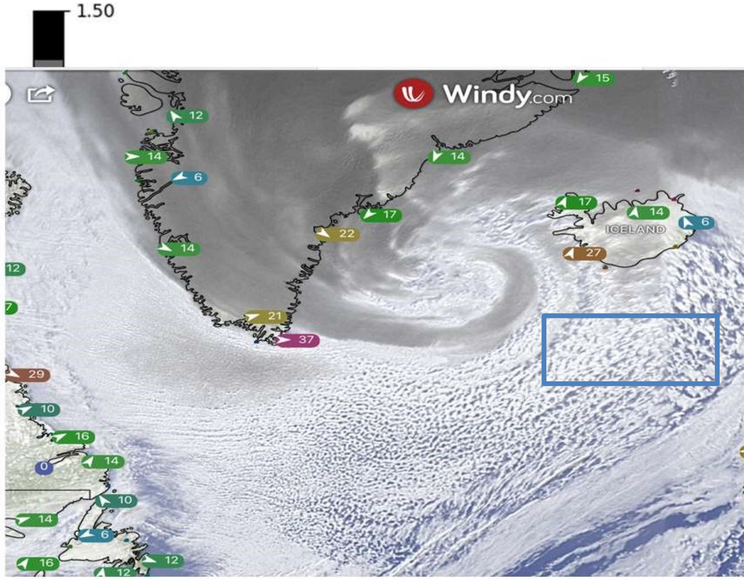
Convective organisation in cold air outflow 20220207 15 UTC mit Maike Ahlgrimm

Total column water, Oper 9 km

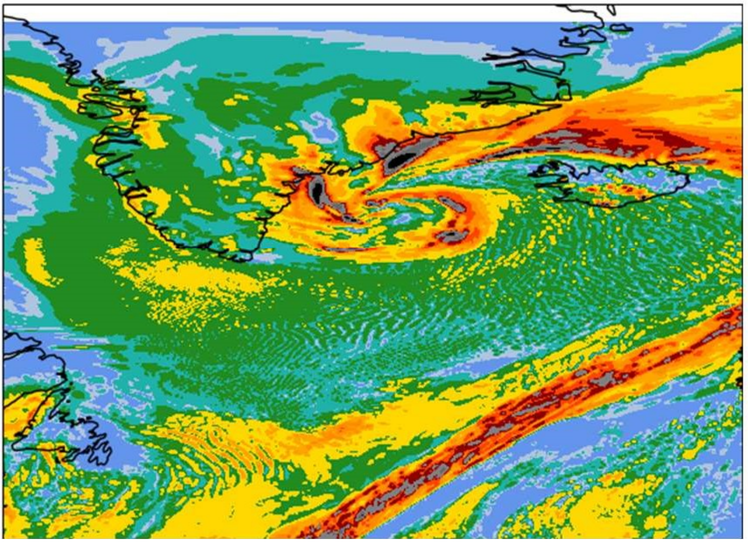


Total column water, 4 km

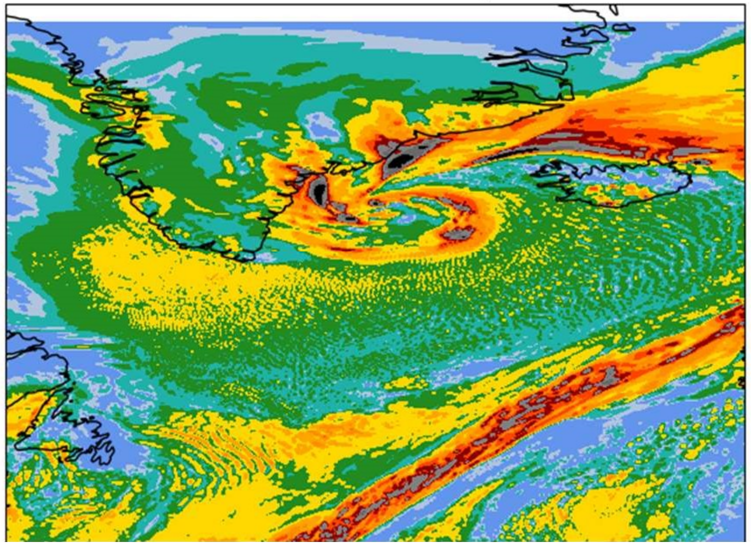




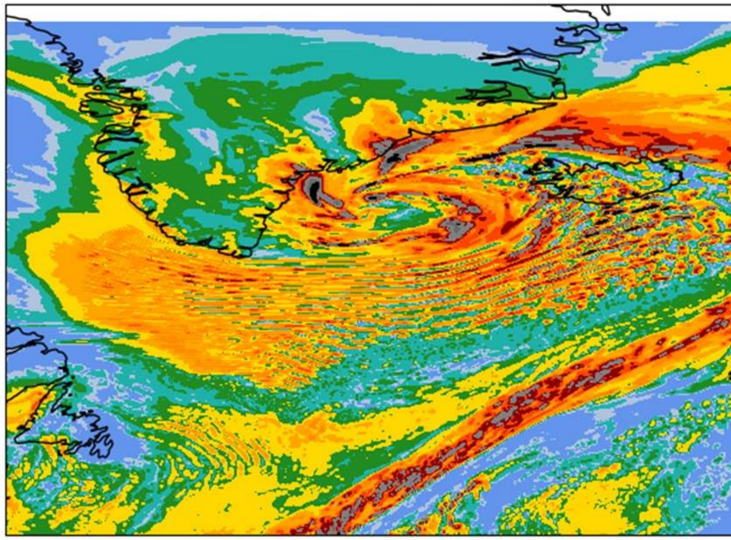
Total column water, CFL=1

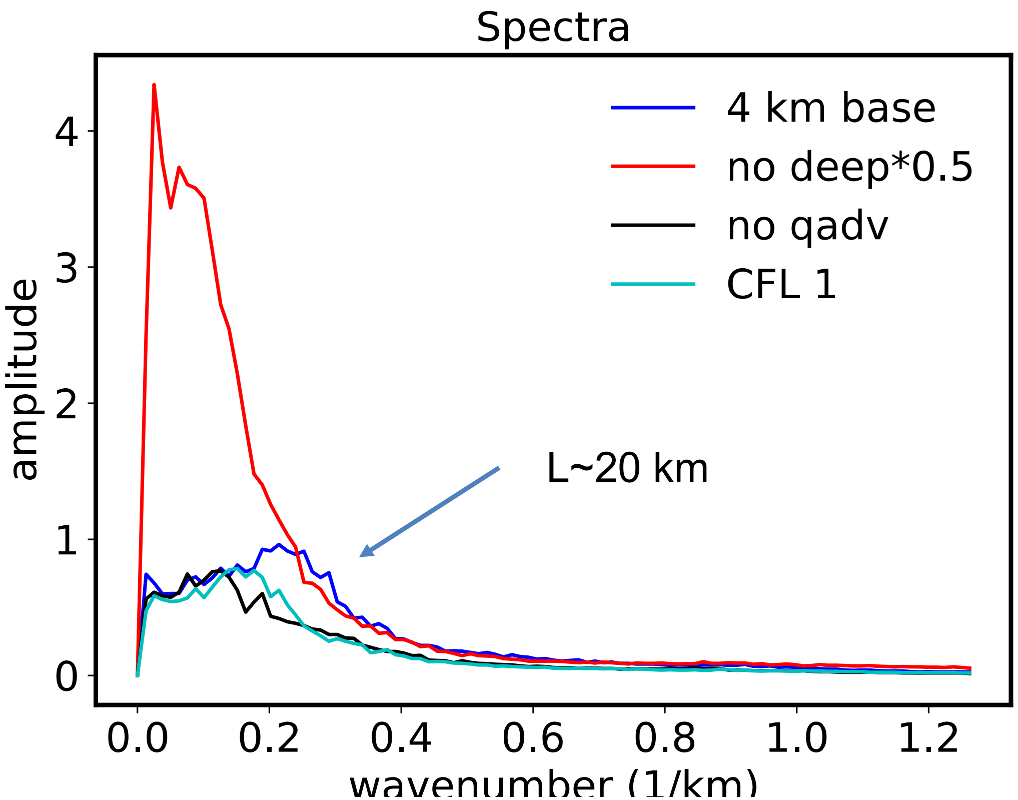


Total column water, no qadv



Total column water, no deep

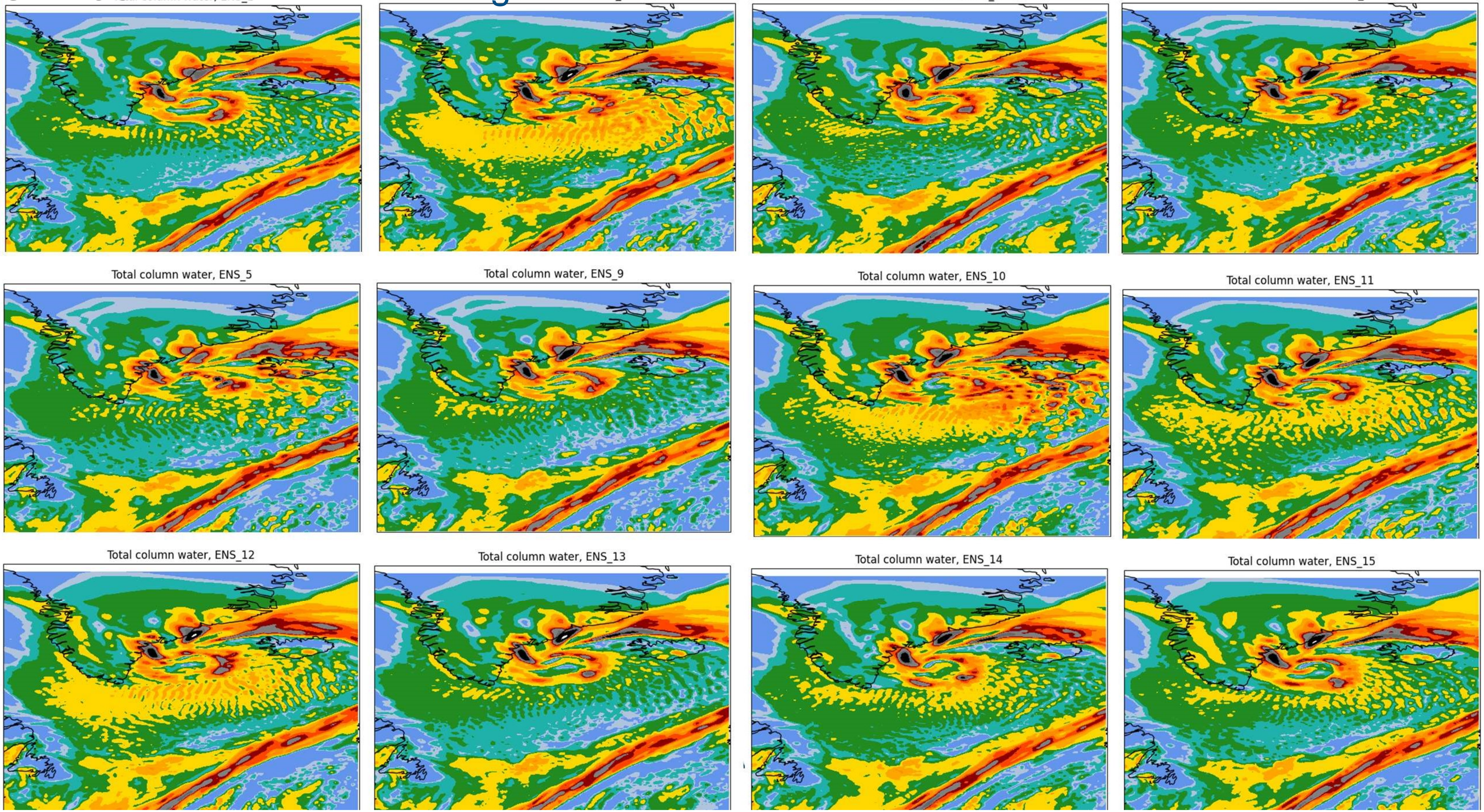


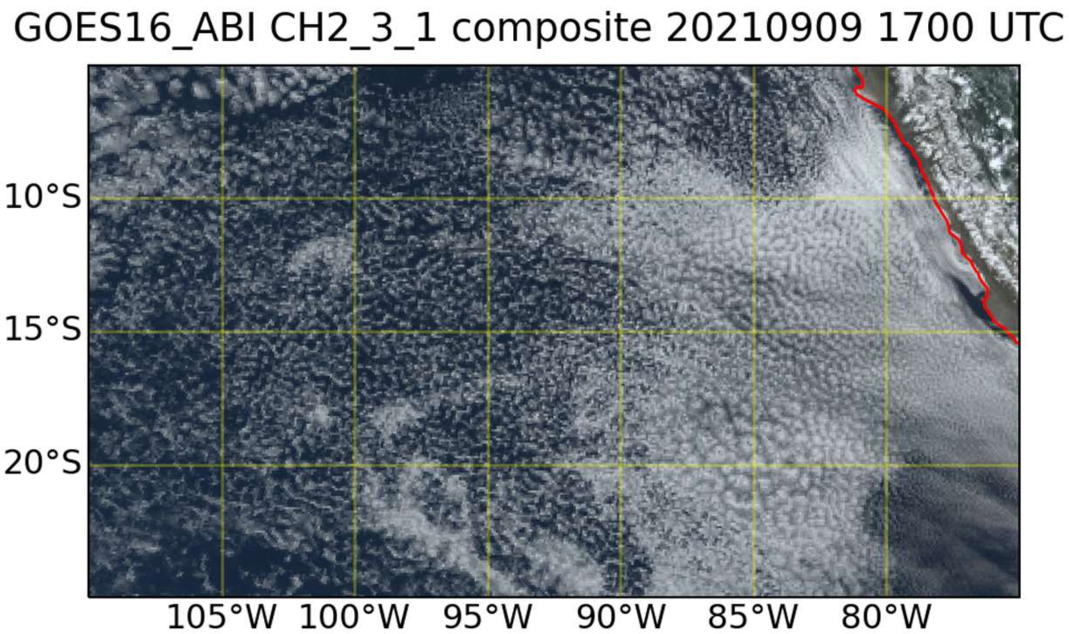


Making convection more intense-> smaller scales

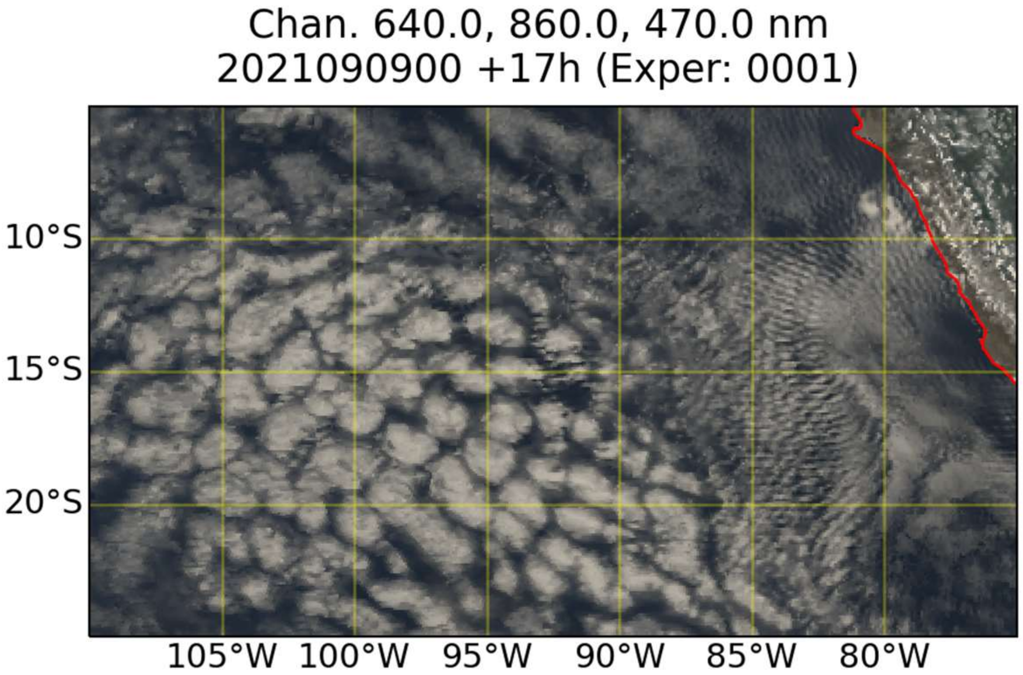
Switching off -> too intense, also larger scales affected

SPP Conv Convective organisation in cold air outflow 20220207 15 UTC



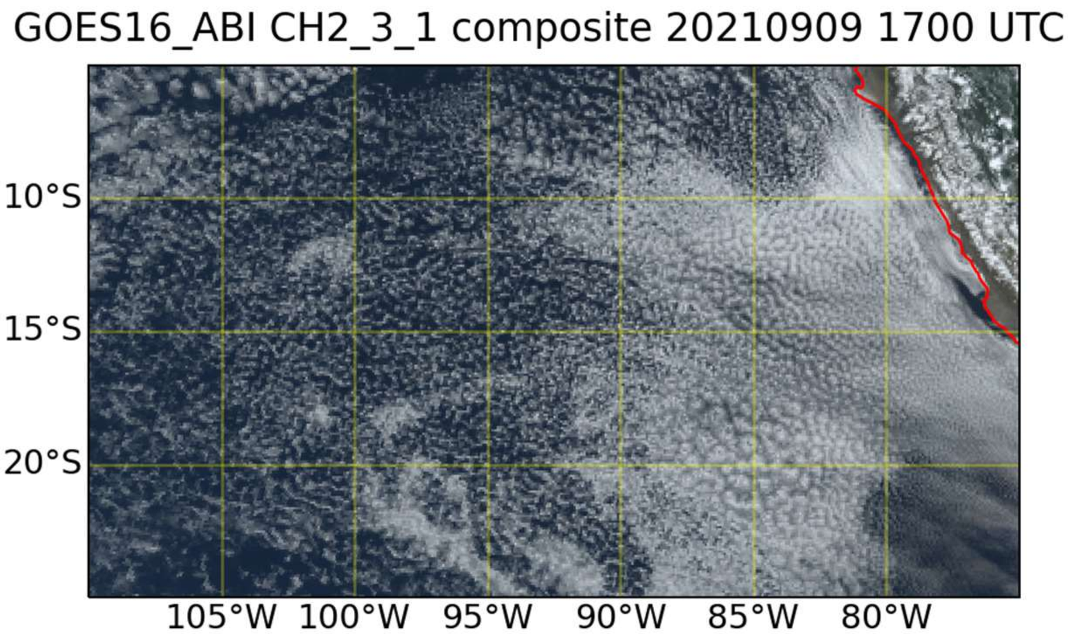


GOES-16 ABI (0.47, 0.64 & 0.86 μm)

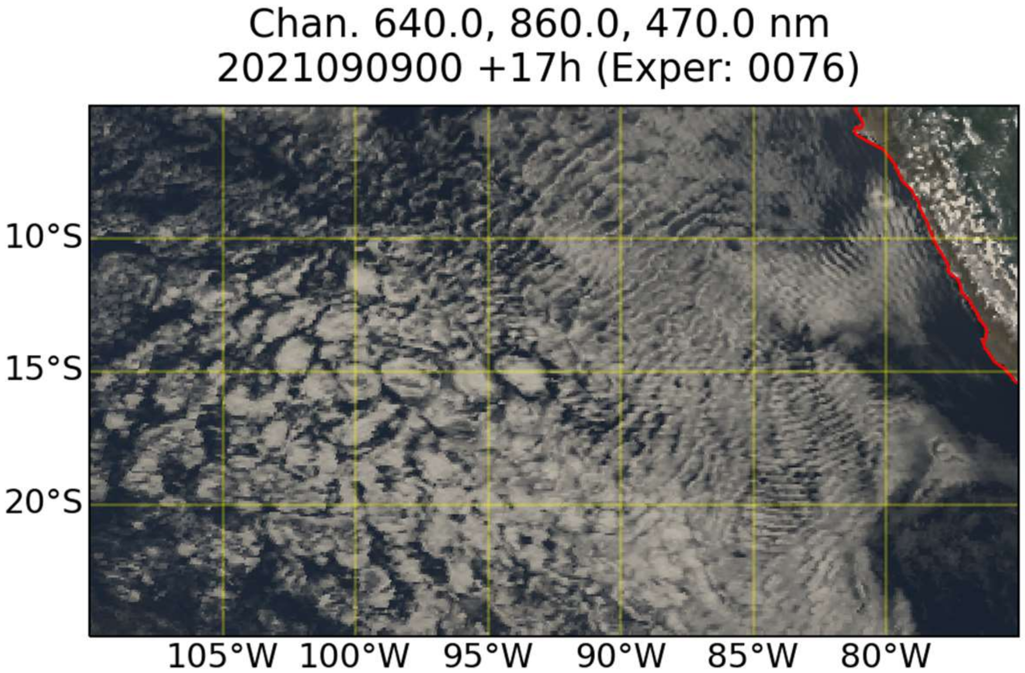


CY47R1

- With CY47r1, IFS produced far too large low-level trade-wind cloud clusters compared to GOES-16 obs.
- Closed-cells in the IFS, but open-cells in satellite obs.



GOES-16 ABI (0.47, 0.64 & 0.86 μm)



CY47R3

- With CY47r3, trade-wind low-level cloud clusters tend to be smaller, thus closer to GOES-16 obs.

- However, most cloud clusters are still too large.