Extrapolated Imagery (EXIM) – the product

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EumeTrain Wind Event Week, 2 March 2022

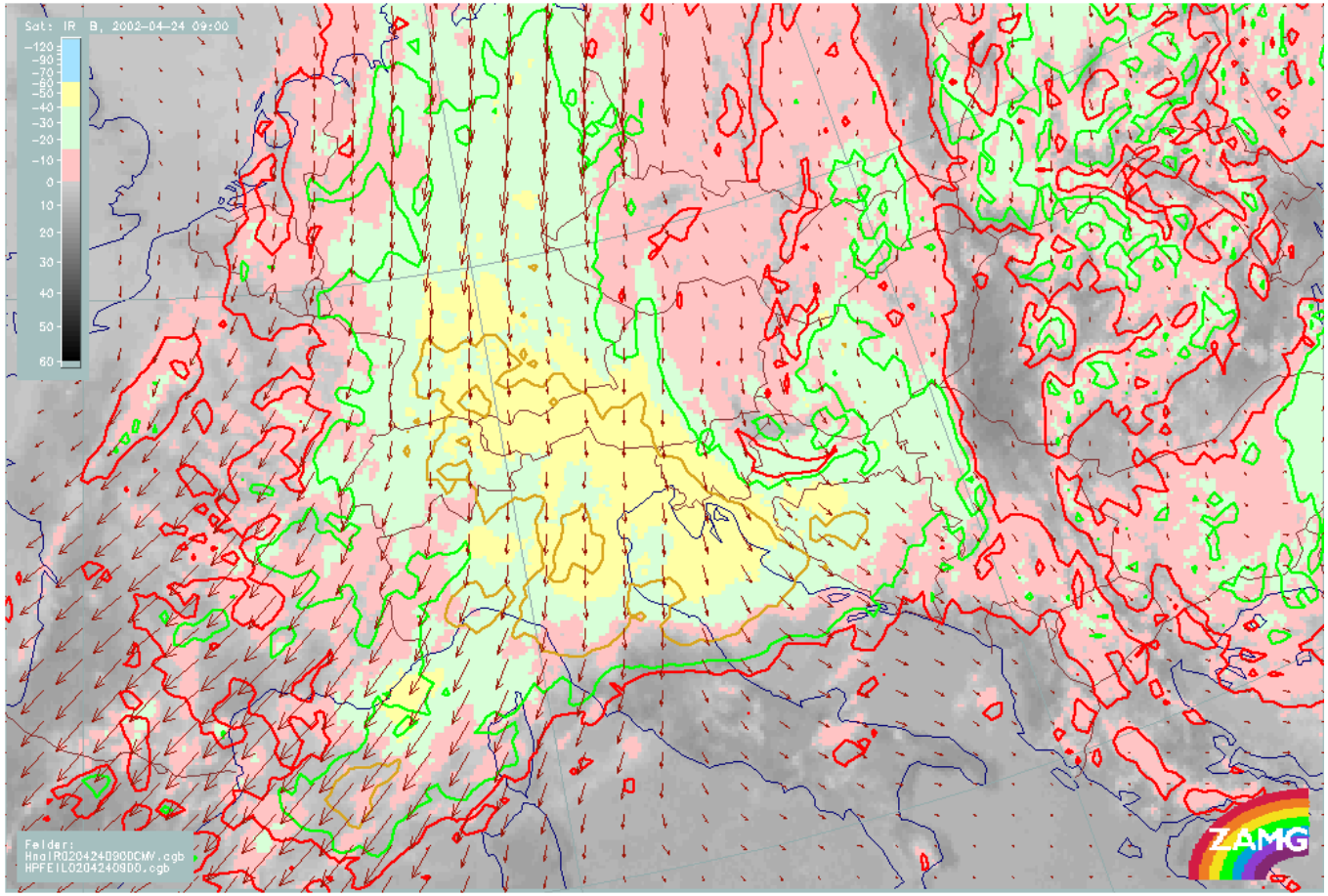
Goal of EXIM

It is a product offered in the Nowcasting-SAF package dealing with geostationary satellites, and provides

- **forecast satellite images**
- **forecast Nowcasting-SAF products**

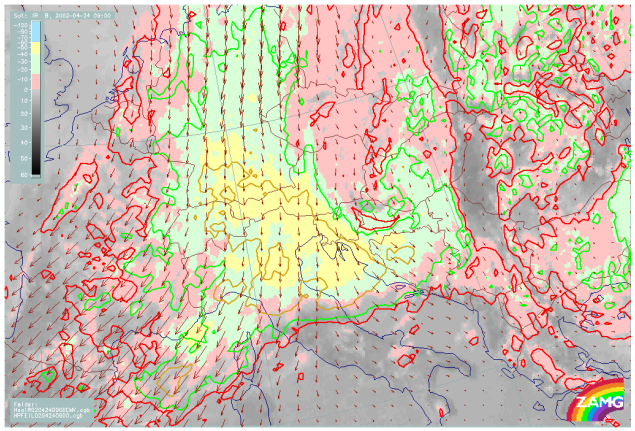
- **through kinematic extrapolation**
- **for lead times ≤ 1 hour**

Heritage (MFG IR, +2h)



Isolines show how far the cloud field advances in the next two hours

Disclaimer

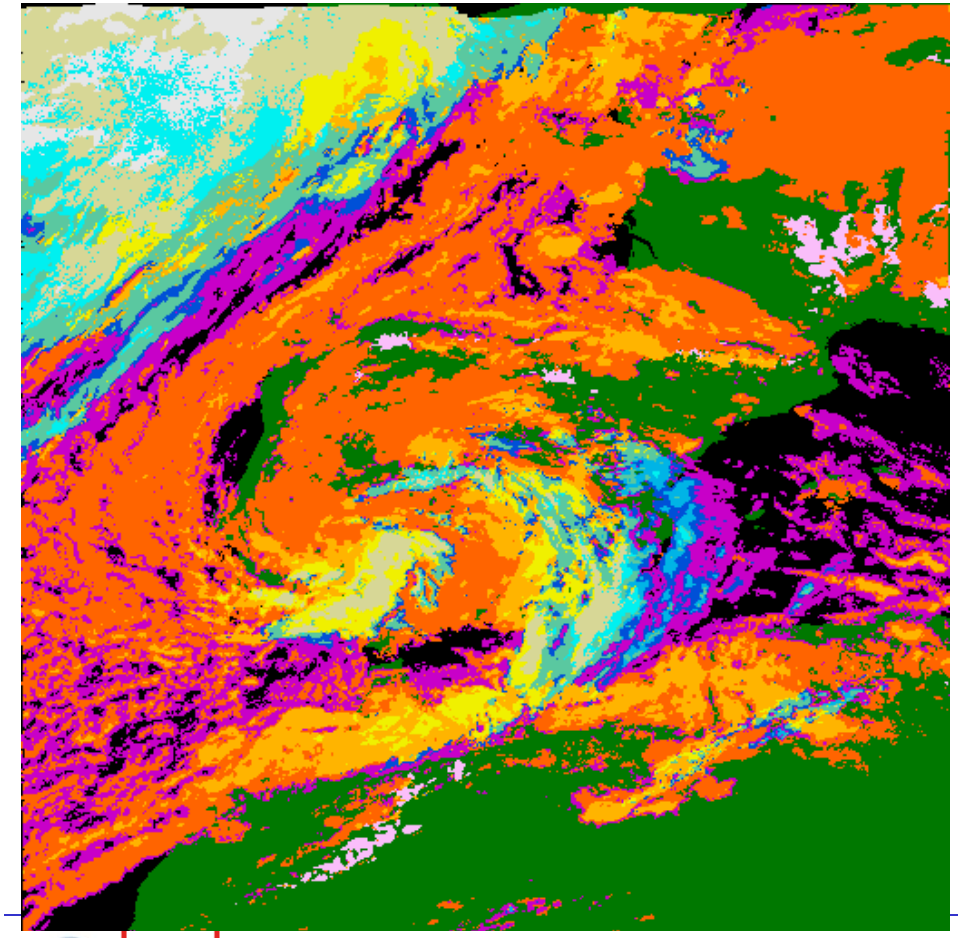


Of course, there are a growing number of competitors from the AI/ML scene trying to accomplish the same thing. However, as their algorithms/diagrams generally do not feature any displacement vectors, a discussion of such methods is not within the scope of a **Wind** Event Week.

Outline of the EXIM algorithm

- Interpolate (irregularly distributed) HrW product down to pixel level
- Apply the vector field on every pixel *n* times (i.e. a trajectory for every pixel in nominal resolution)
- Construct the predicted image / NWCSAF product by putting pixels at their predicted positions
- (Optionally) fill gaps through nearest-neighbour or average interpolation
- Other post-processing, e.g. applying land-sea mask or writing an outage code at the edge of the image

Forecast Cloud Type 12/12/2008, 11.00 + 15min



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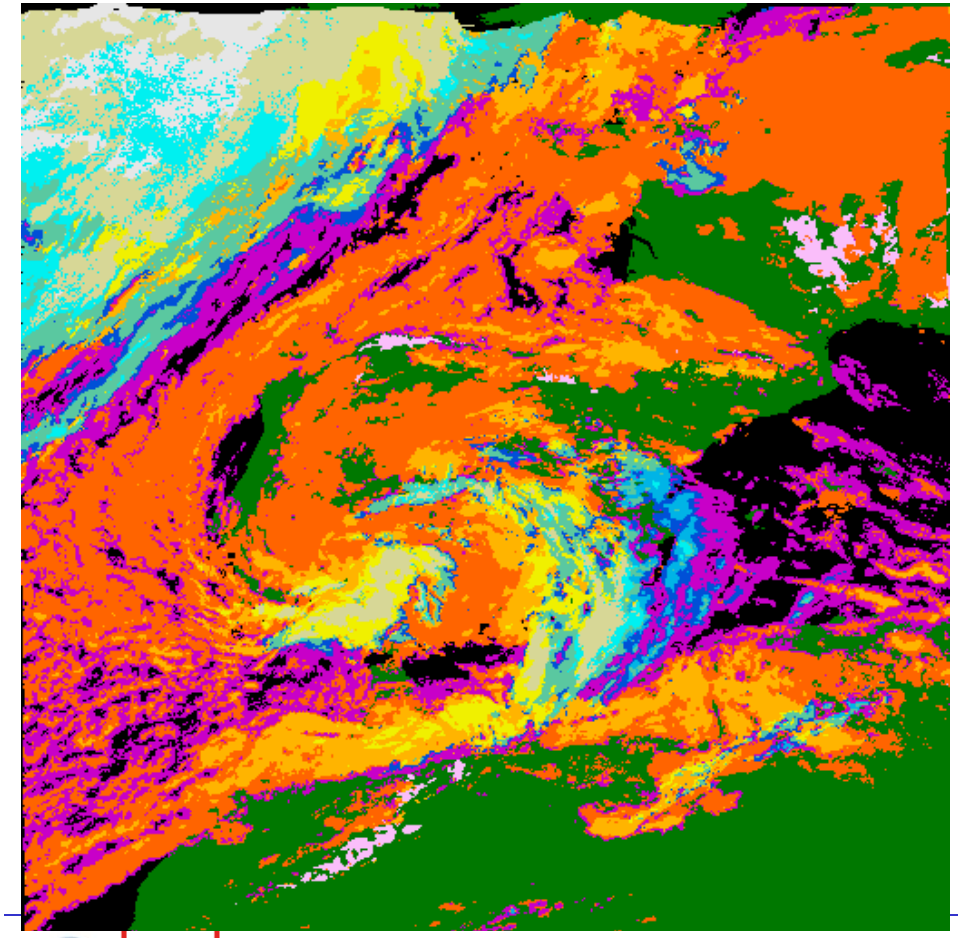
Forecast Cloud Type 12/12/2008, 11.00 + 30min



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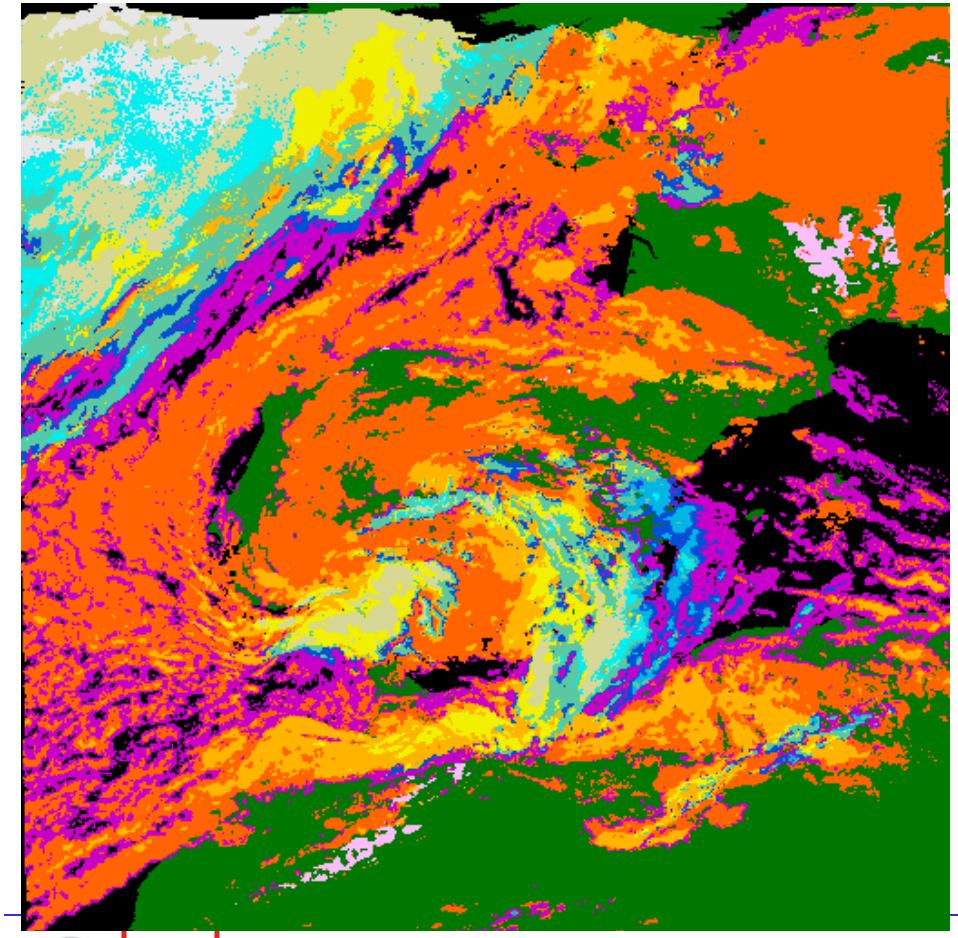
Forecast Cloud Type 12/12/2008, 11.00 + 45min



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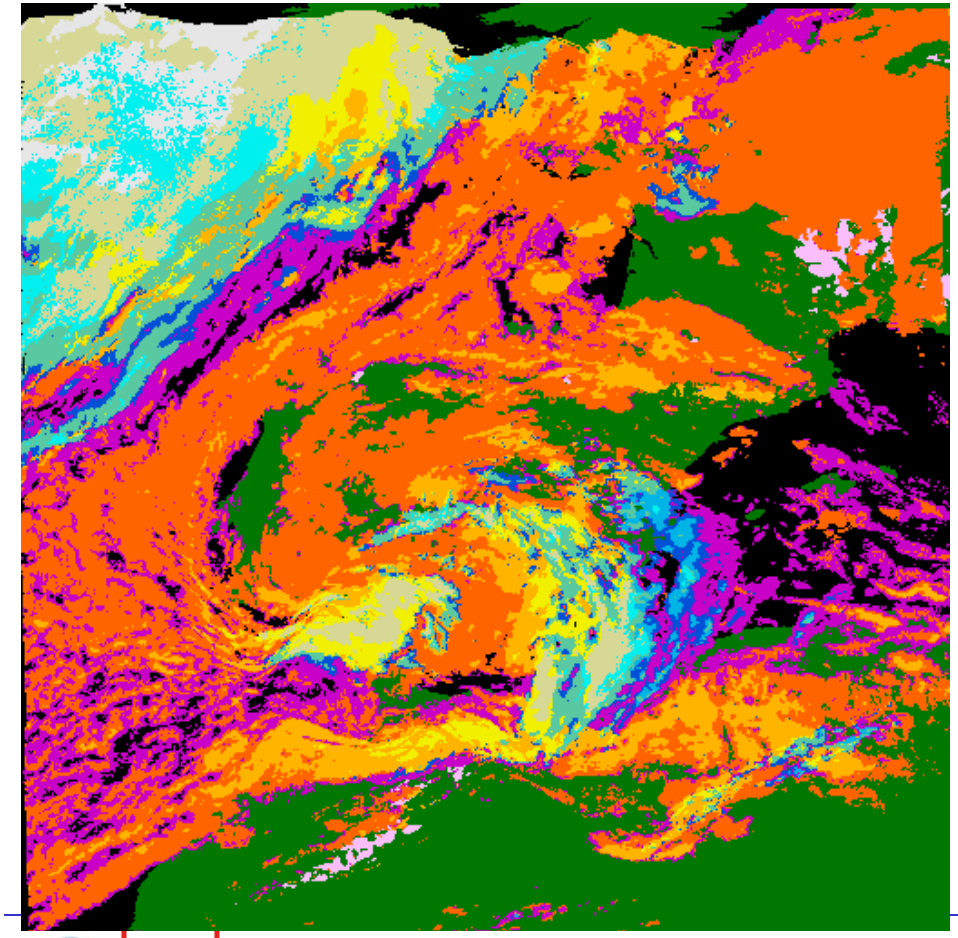
Forecast Cloud Type 12/12/2008, 11.00 + 60min



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very low cum.
sea ice
land snow
sea
land
no proc.

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Addressing product specificalities makes a difference

From the „Abstract Brochure of the 3rd European Nowcasting Conference“, Madrid, April 2019:

P15. Assessment of satellite rainfall nowcasting based on extrapolation technique

Seon-Young Jeong; Ki-Hong Park; Geun-Hyeok Ryu; Jae-Dong Jang
KMA – Korea Meteorological Agency, Republic of Korea

The National Meteorological Satellite Center (NMSC)/Korea Meteorological Agency (KMA) produce extrapolated images based on satellite data for nowcasting. THE MAPLE (McGill Algorithm for Precipitation Nowcasting and Lagrangian Extrapolation) algorithm is a technique to predict echo after several hours by Lagrangian extrapolation using motion vectors generated by VET. It is used for radar - based precipitation prediction, but it is also applied to satellite images. However, the VET technique used in MAPLE has the problem of moving the coastline or the land because it generates vectors in the clear regions and predicts them based on images. To solve these problems, the NMSC uses the EXIM (Extrapolated Imagery) algorithm to produce a prediction image. The EXIM algorithm is an algorithm developed by NWCSAF, which uses an atmospheric motion vector containing altitude information. The EXIM technique solves the previously mentioned problem by applying cloud detection and land / sea mask.

The portfolio of EXIM products

(driven by validation results)

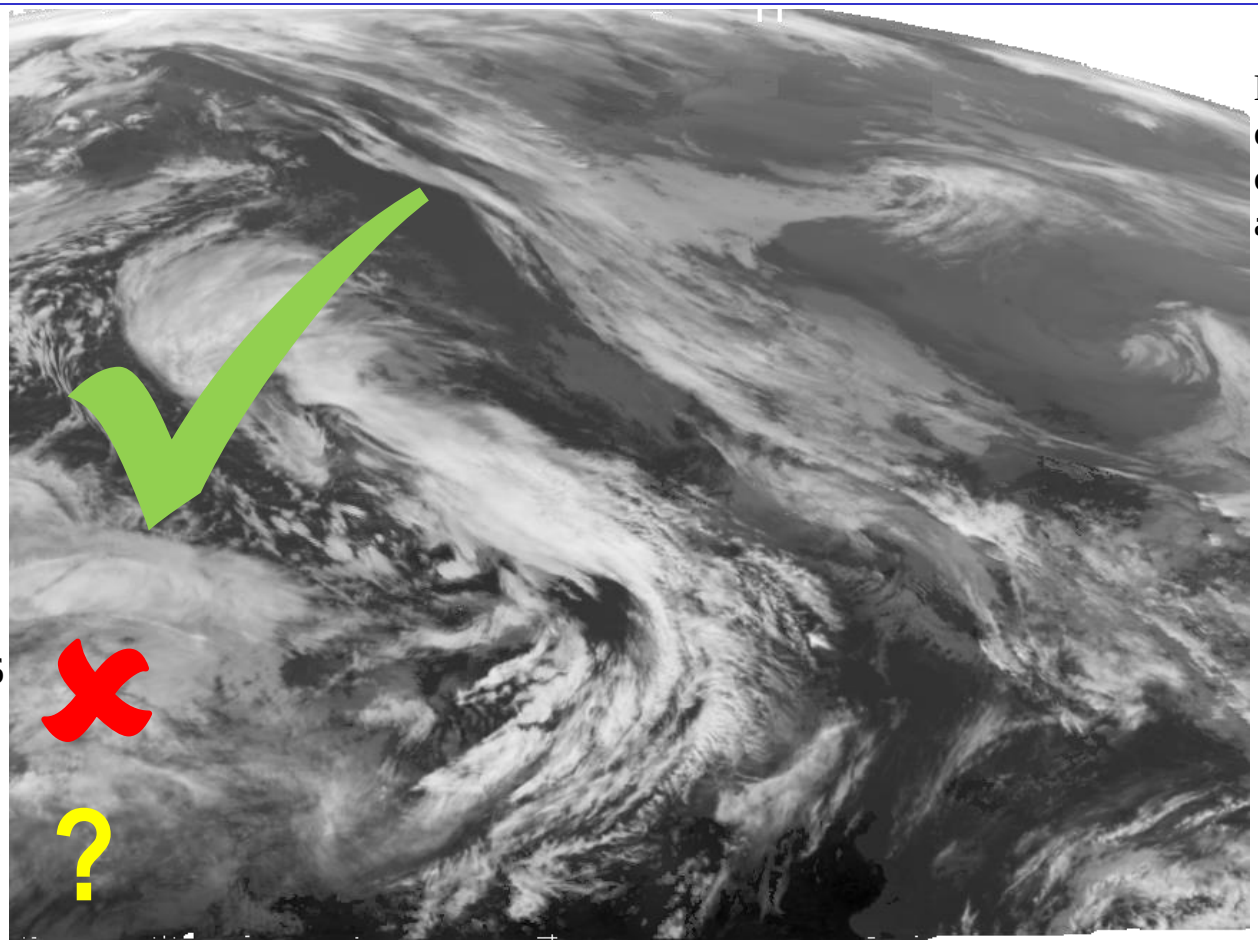
MSG, Himawari, GOES images

MSG:

VIS0.6
VIS0.8
IR3.9
WV6.2
WV7.3
IR8.7
IR9.7
IR10.8
IR12.0
IR13.4

NIR1.6

HRVIS



HIMAWARI, GOES: corresponding channels, where available

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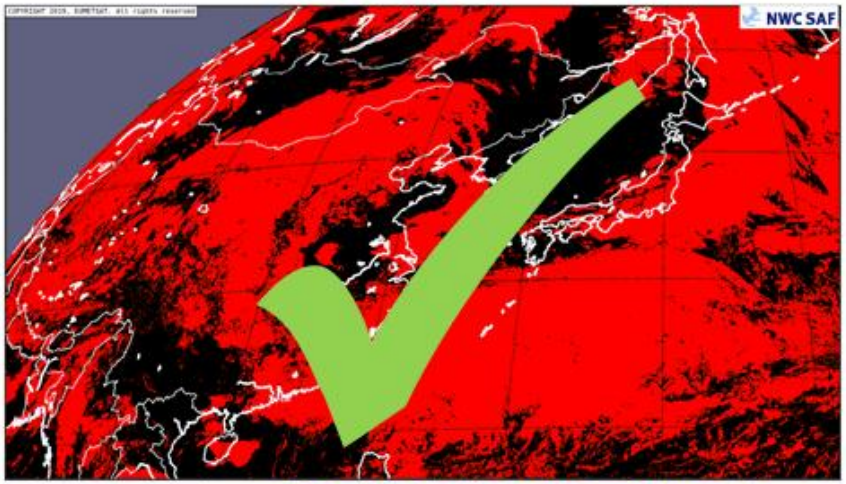
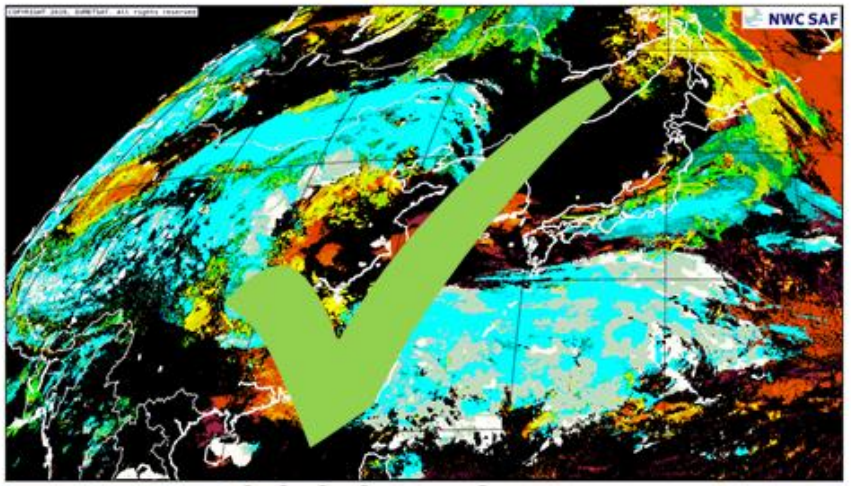
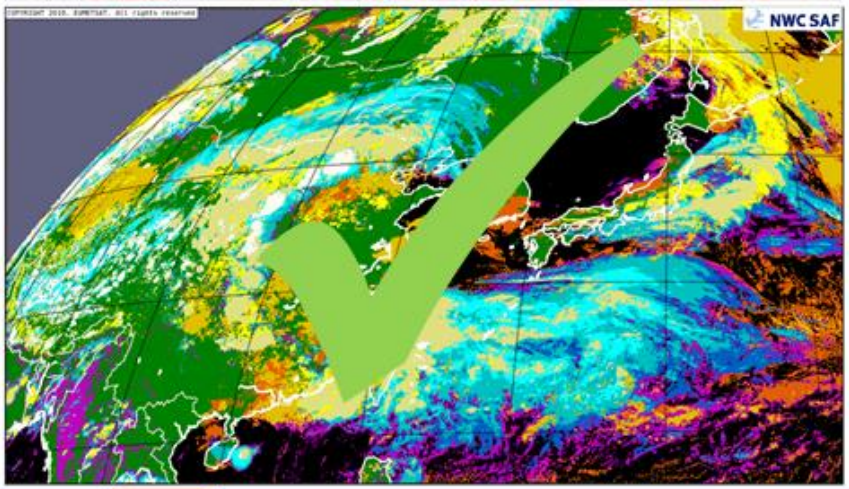
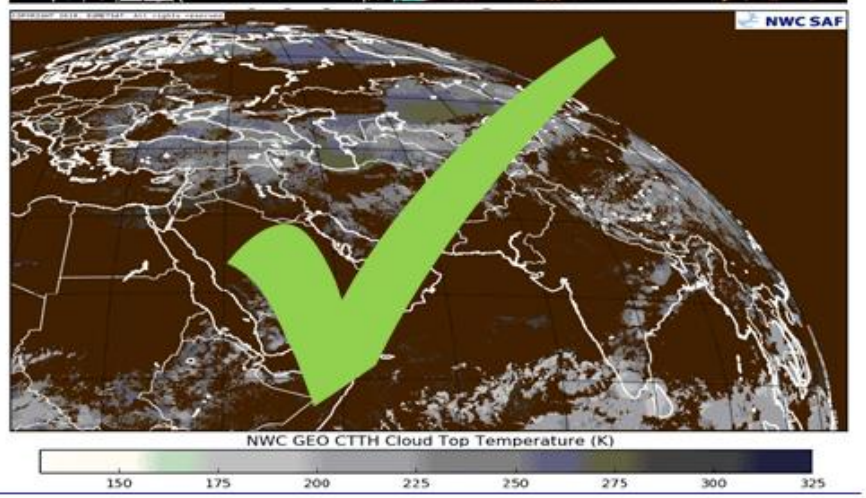
Cloud mask, cloud type, cloud top temperature & pressure & height









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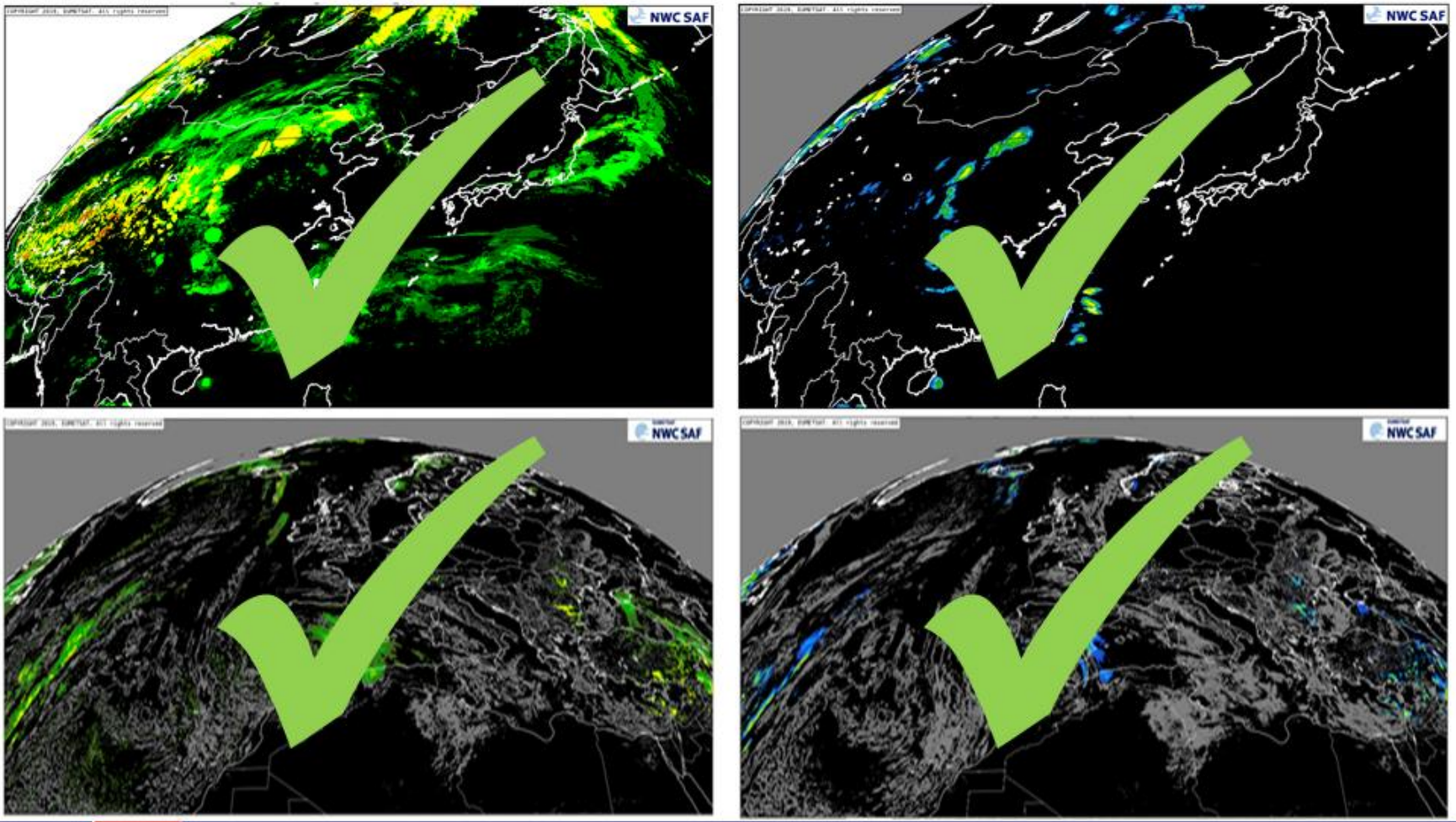
Precipitation products



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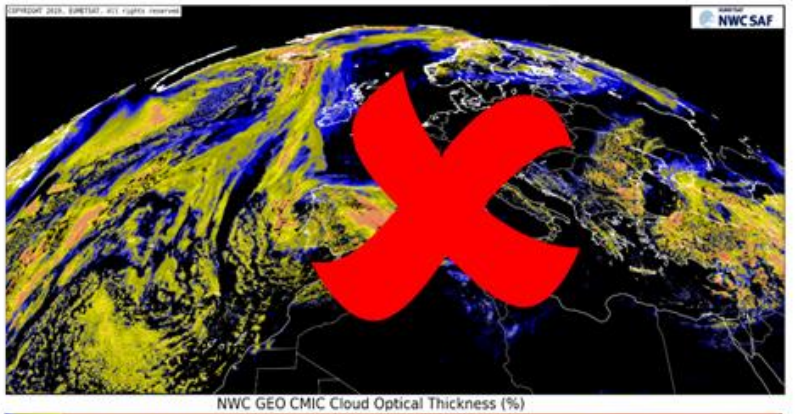
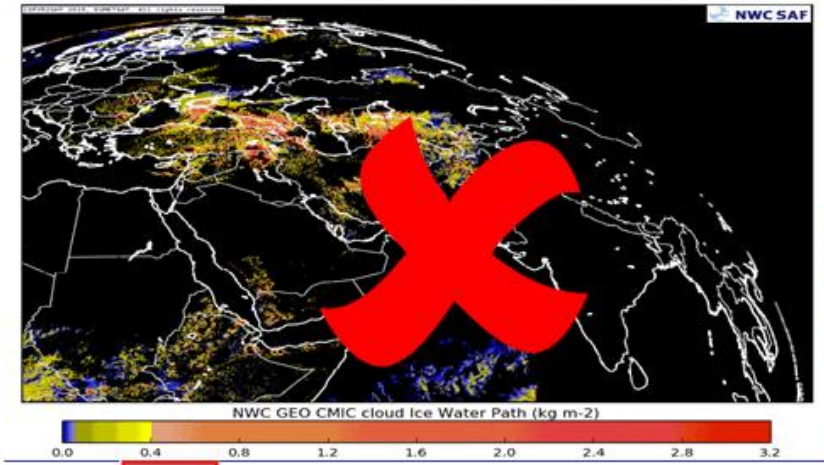
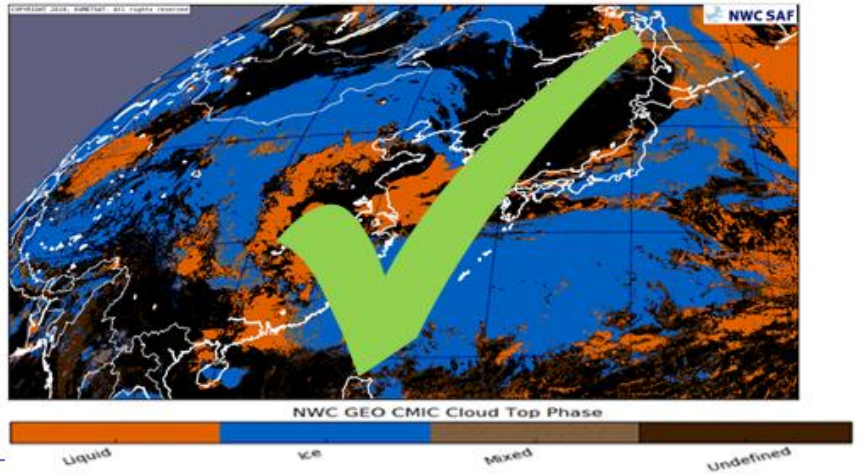
Cloud microphysics (only cloud phase amenable to the EXIM approach)







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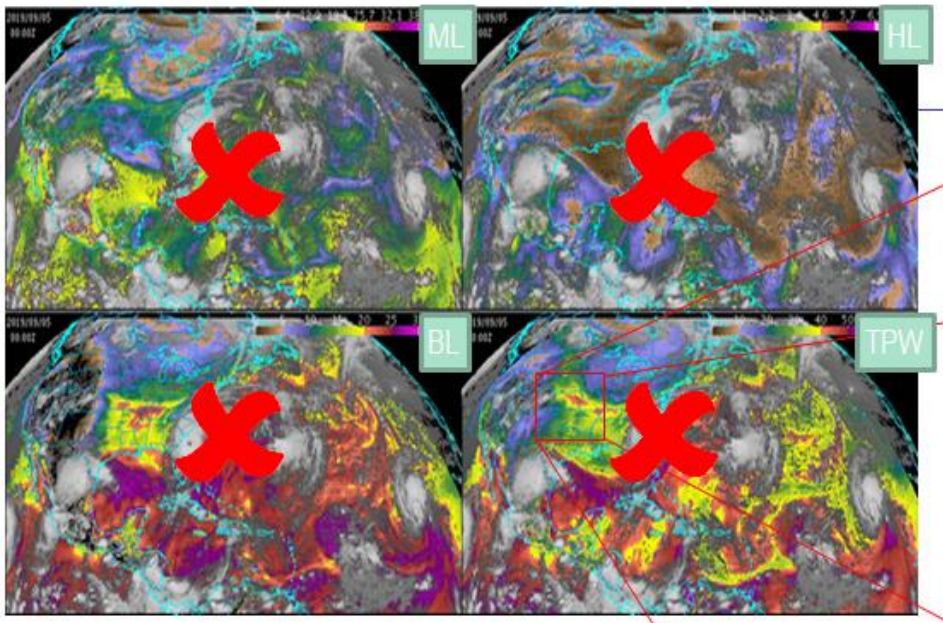
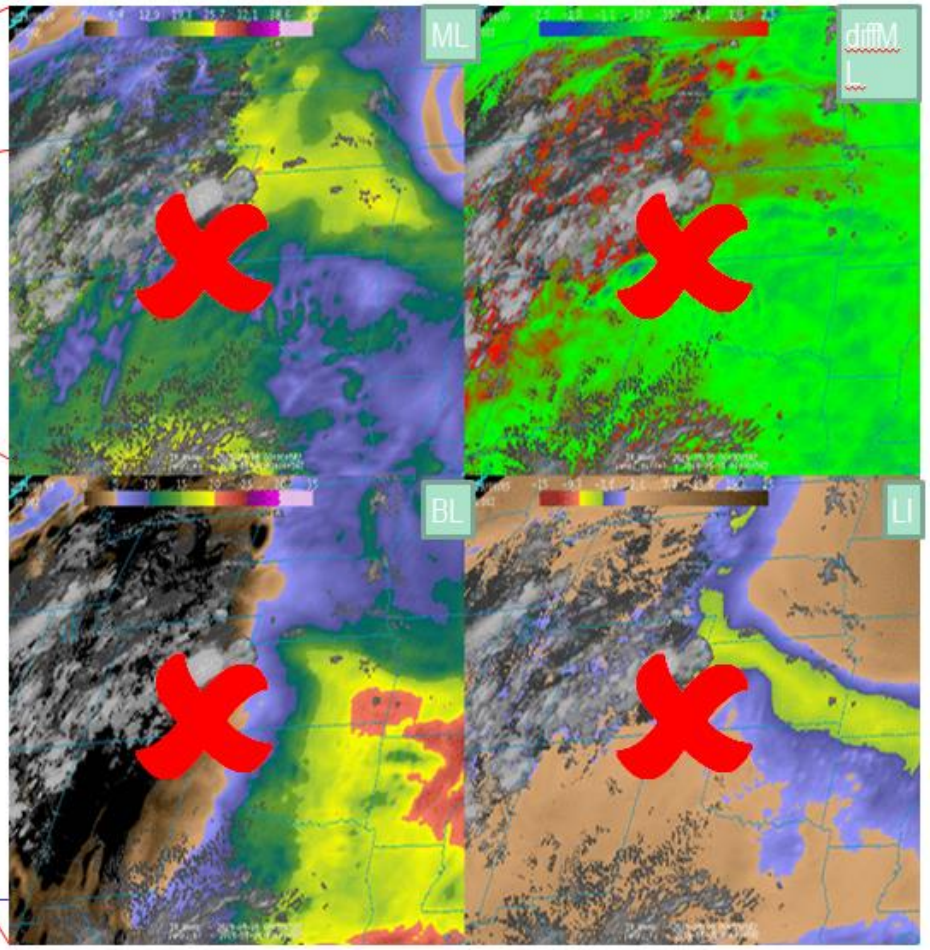
iSHAI – imaging Satellite Humidity and Instability

Parameters considering the entire tropospheric column →





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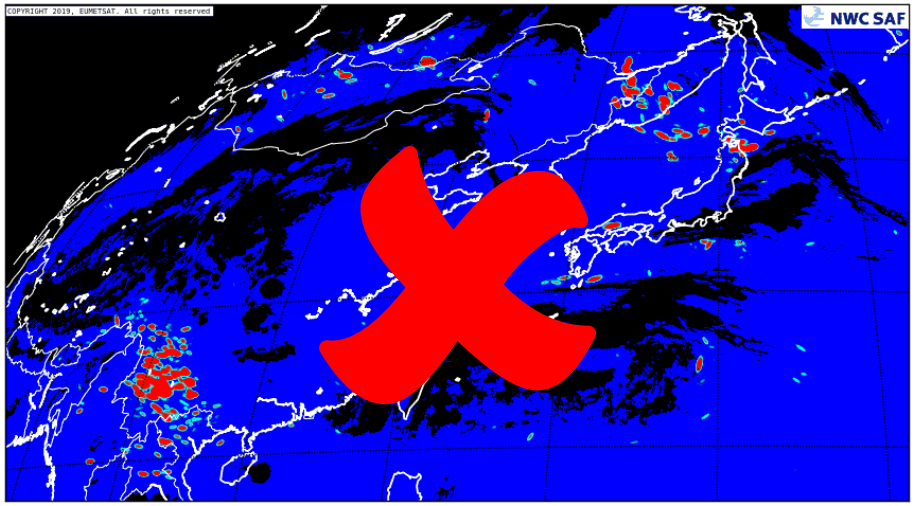
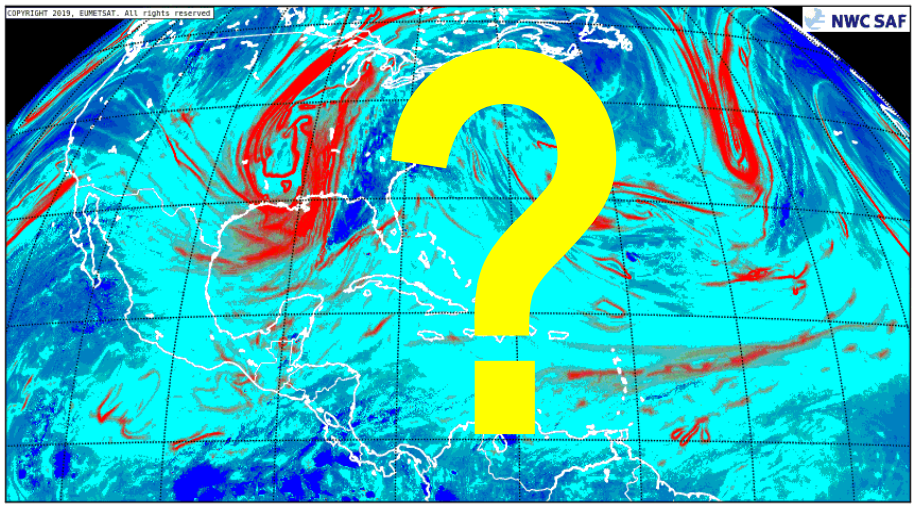
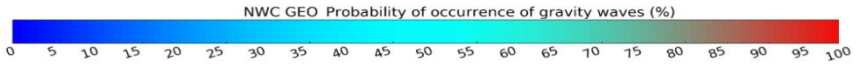
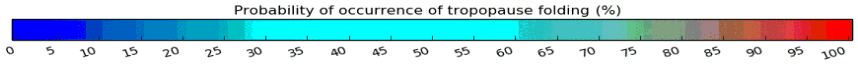
Automatic Satellite Image Interpretation: Gravity wave & tropopause folding probabilities









Gravity waves not expected to move with the Atmospheric Motion Vector

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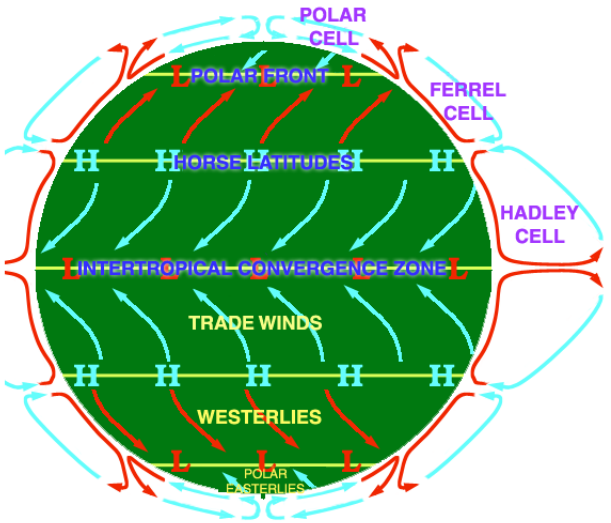
Convection products

- "CI – Convection Initiation": not considered a candidate for EXIM: "Probability of a cloudy pixel to become a thunderstorm in 15-60 minutes" does not move with the Atmospheric Motion Vector!
- "RDT – Rapidly Developing Thunderstorms" likewise not considered a candidate because the cells follow their own rules concerning movement
  !! Actually not needed since RDT offers its own object-oriented forecast of the convective cell position!!

A subject of debate: How to deal with vectors in different layers?

- Creating the displacement field from every available atmospheric motion vector normally yields the extrapolation with the highest skill scores

- However, the critics of this statistical view score a point when referring to atmospheric circulation:



Source: https://en.wikipedia.org/wiki/Atmospheric_circulation

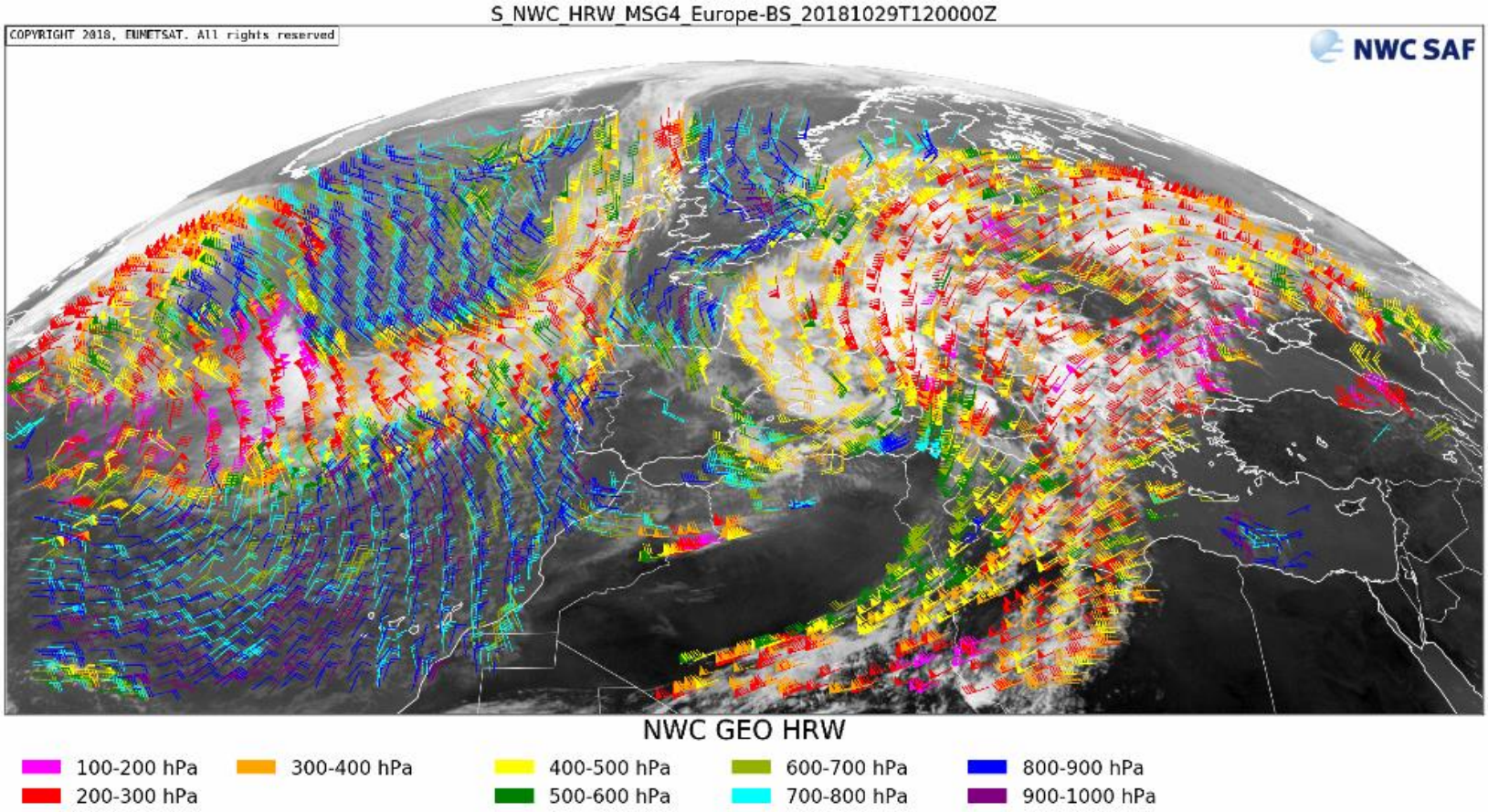
„Solution“: User-configurable handling of vectors in different layers!

- As the perception of “how far apart in the vertical direction is too far?” varies, the software allows individual settings of upper and lower boundaries of the layer(s) from which motion vectors are taken
- Two-layer approach implemented, working with two displacement fields, one in an upper layer and one below

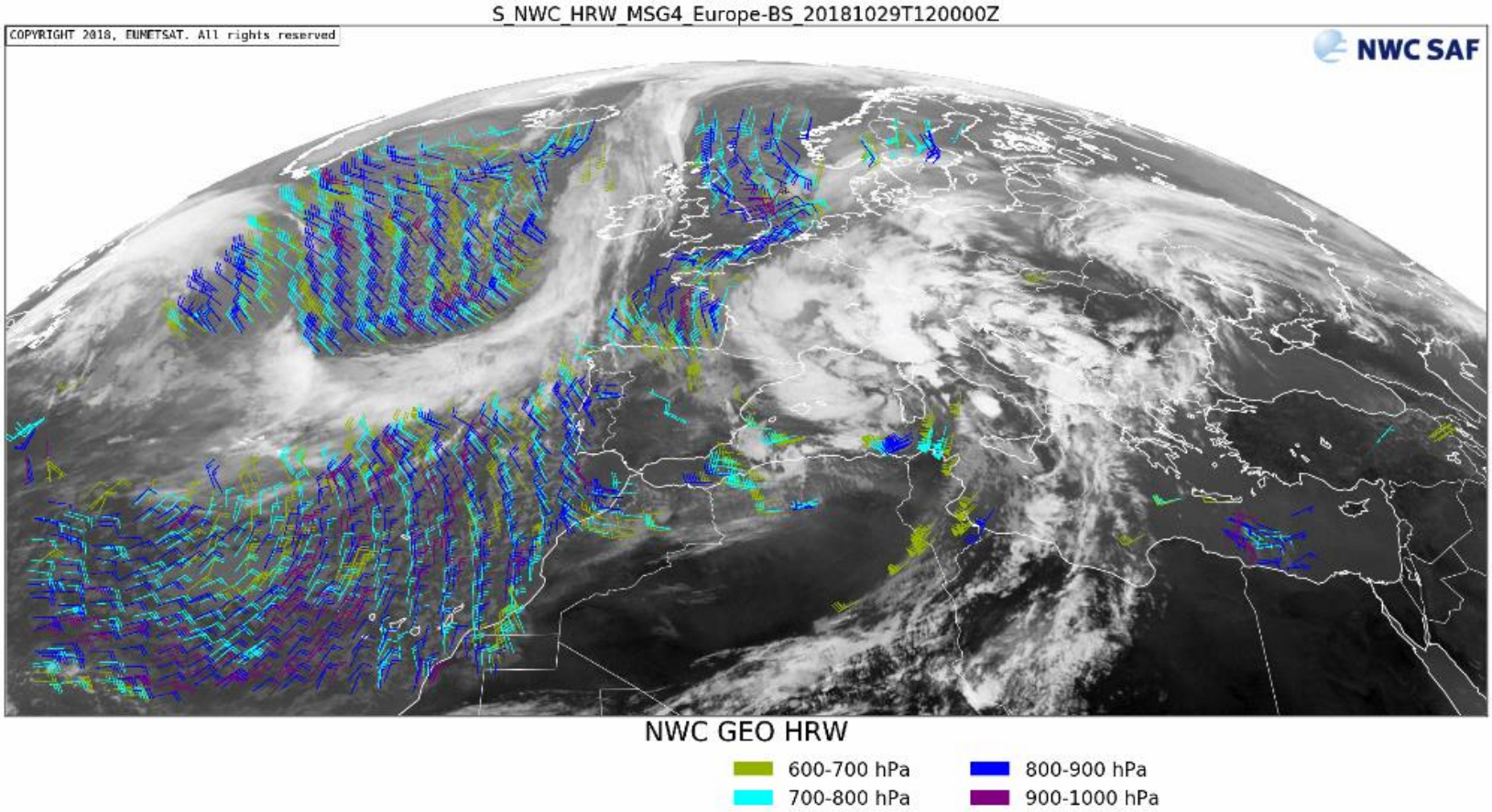
How to handle pixels in the “wrong layer”?

- We first employed a “better-than-nothing” approach, still displacing them along the trajectory suggested by the selected AMVs (in the two-layer approach taking the displacement fields with the nearest atmospheric motion vectors).
- When being strict on physical principles, one has to reject the displacement of high-layer pixels with low-layer winds (and vice versa)
- Inevitable drawback: many pixels for which it becomes unjustifiable to apply any displacement → gaps in the product

An example HrW field, colours indicating assigned heights



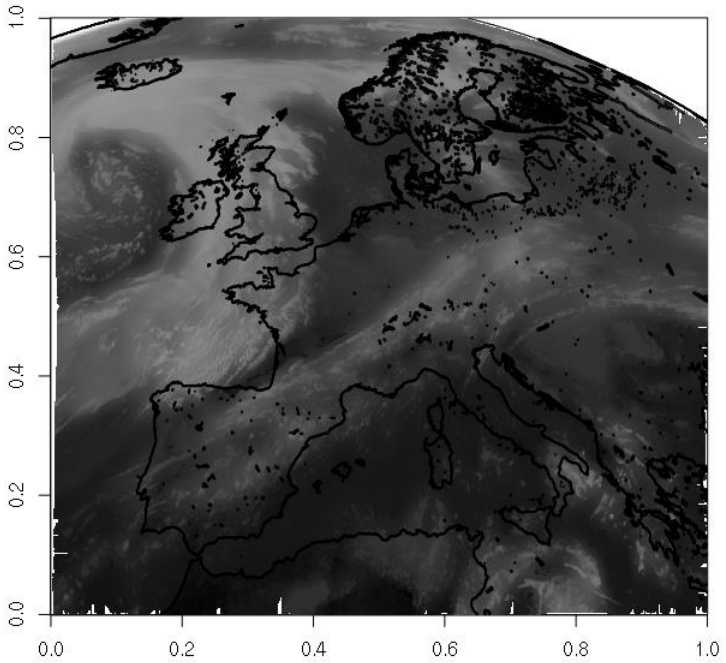
Situation at the lower level

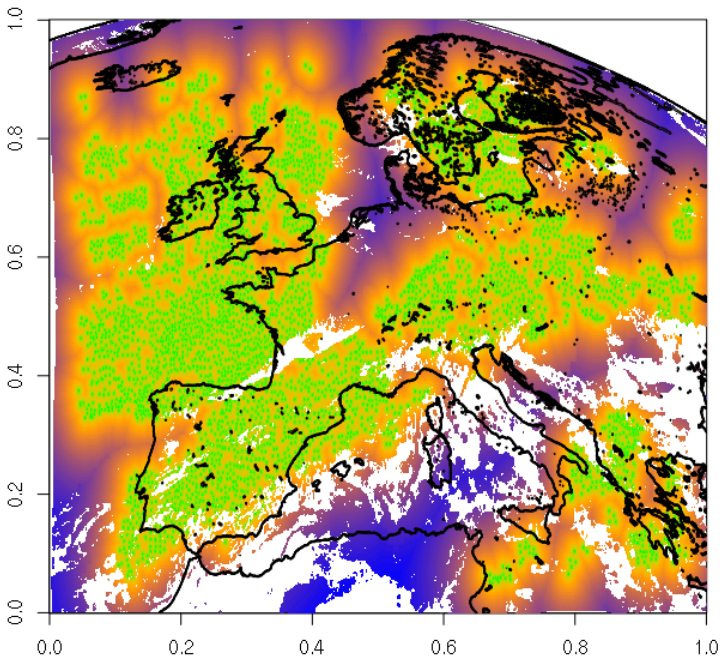


Consequences for the „v2021“ release (coming in a few weeks)

- Option to include the cloud top height product
  - to mask pixels from layers not covered by the wind input
  - to strictly displace high-layer (low-layer) pixels with the high-layer (low-layer) motion
- Include in the quality flag information about the distance to the closest vector (enabling the user to mask even more pixels deemed questionable)

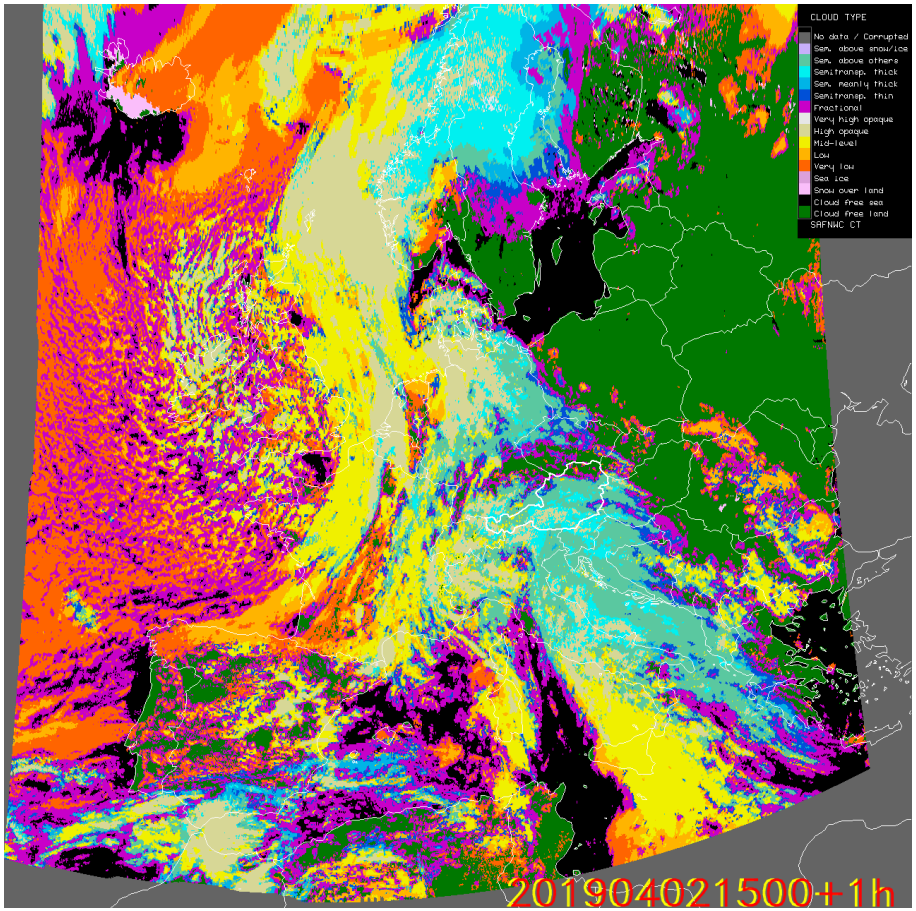
Forecast IR image + „nearest vector flag“

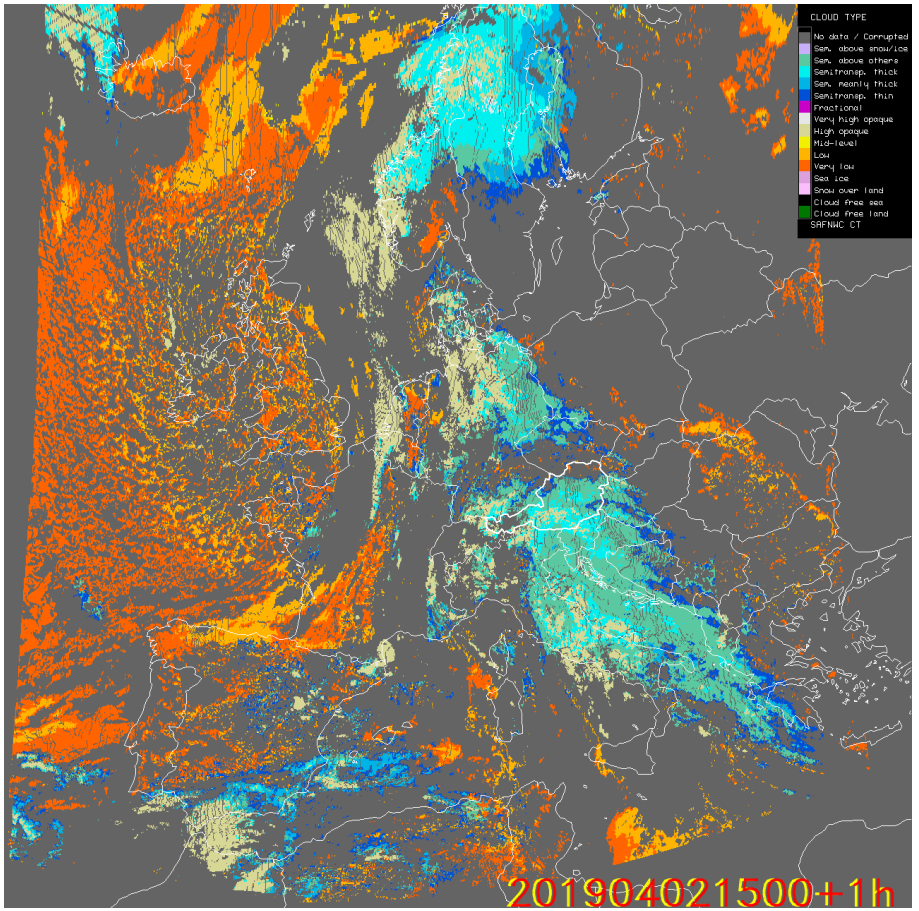




Example: Cloud type forecast, two-layer approach, 0-400 hPa + 700-1000 hPa

„Classical“ „Physical“





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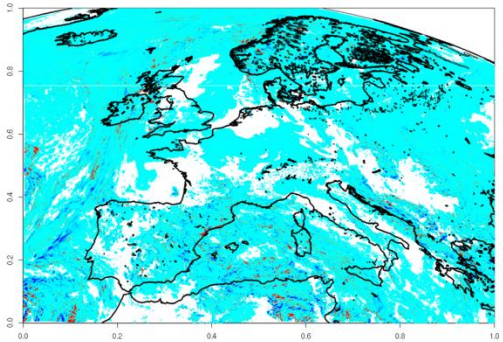
Status today

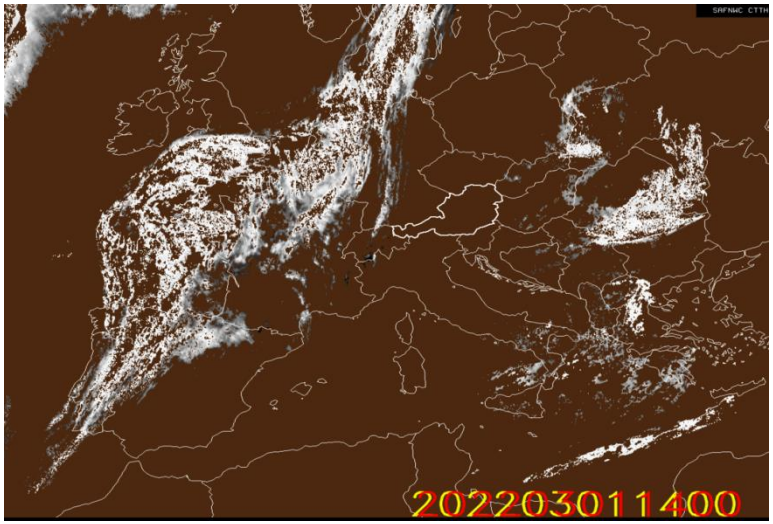
- **„Extrapolated Imagery“ by default delivers forecasts of the cloud products, but users can select any arbitrary set of the indicated EXIM portfolio**
- **Scientifically validated for MSG, technically capable of handling Himawari and GOES-N/-R input**
- **Allows the setting of the preferred HrW layer(s)**
- **Allows the CTTH-based filtering of pixels outside the selected HrW layer(s)** *[don‘t get distracted by my ugly image on the last slide – your application may not need (nice) images or be perfectly happy with information from a narrow layer]*

Status today

- Offers a difference image for quick visual judgement on the current extrapolation quality



- Latest addition in the expanding portfolio: ctth_effective (defined as fraction of the field of view covered by clouds (cloud amount) multiplied by the cloud emissivity in the 10.8 µm window channel).



Anticipated status at vMTG 2023+

- Technically capable of handling MTG
- Even faster code desired (10-minute interval and higher number of pixels)
- VIS „corrected“ for sun zenith angle
- Extrapolated satellite channels (again this generally concerns VIS) have their „native (i.e. higher) resolution“ (requires more trajectory computations; once more even faster code desired)

THANK YOU FOR YOUR ATTENTION!

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