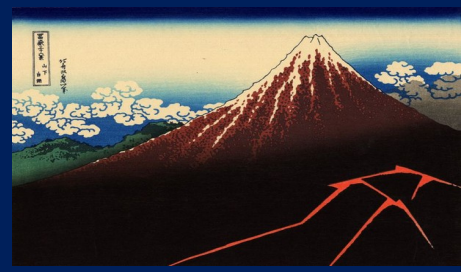


Determination of Convection Dynamics using MSG-SEVIRI/MTG-FCI and ASCAT wind measurements



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Francisco Lozano (UCM), Javier Garcia-Pereda (AEMET), Amelia Arribas (AEMET), Marcos Portabella (ICM), Pao Wang (UW), Martin Setvak (CHMI)

EUMETSAT Conference
17 September 2025

Czech Hydrometeorological Institute

Institut de Ciències del Mar

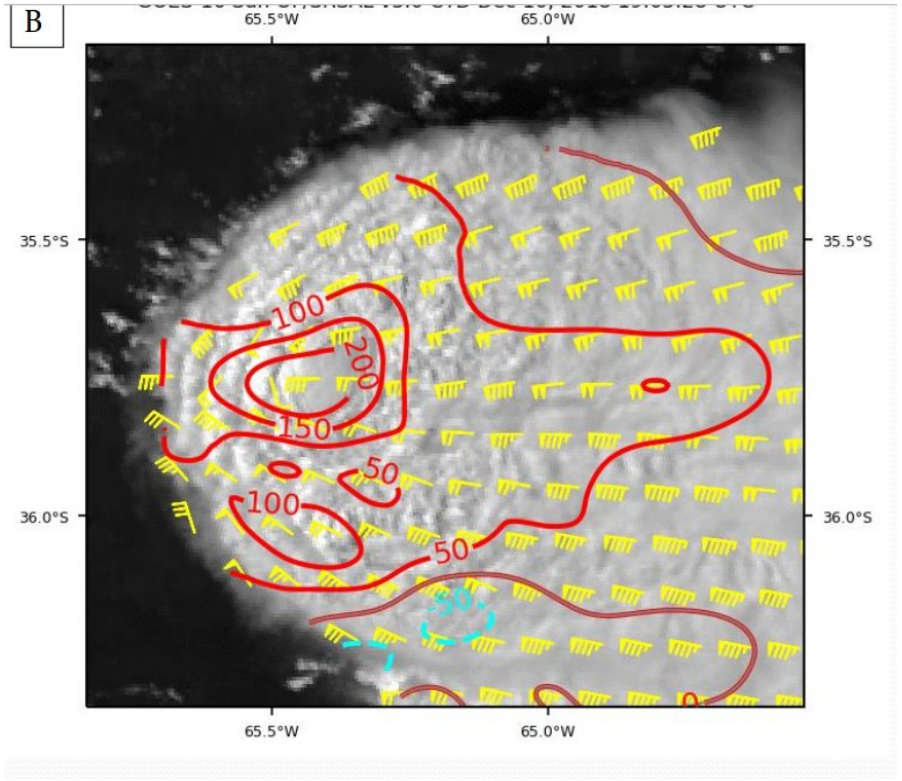
EUMETSAT OSI SAF

aemet

EUMETSAT NWC SAF

Can we derive Convection Dynamics from Satellite Data?

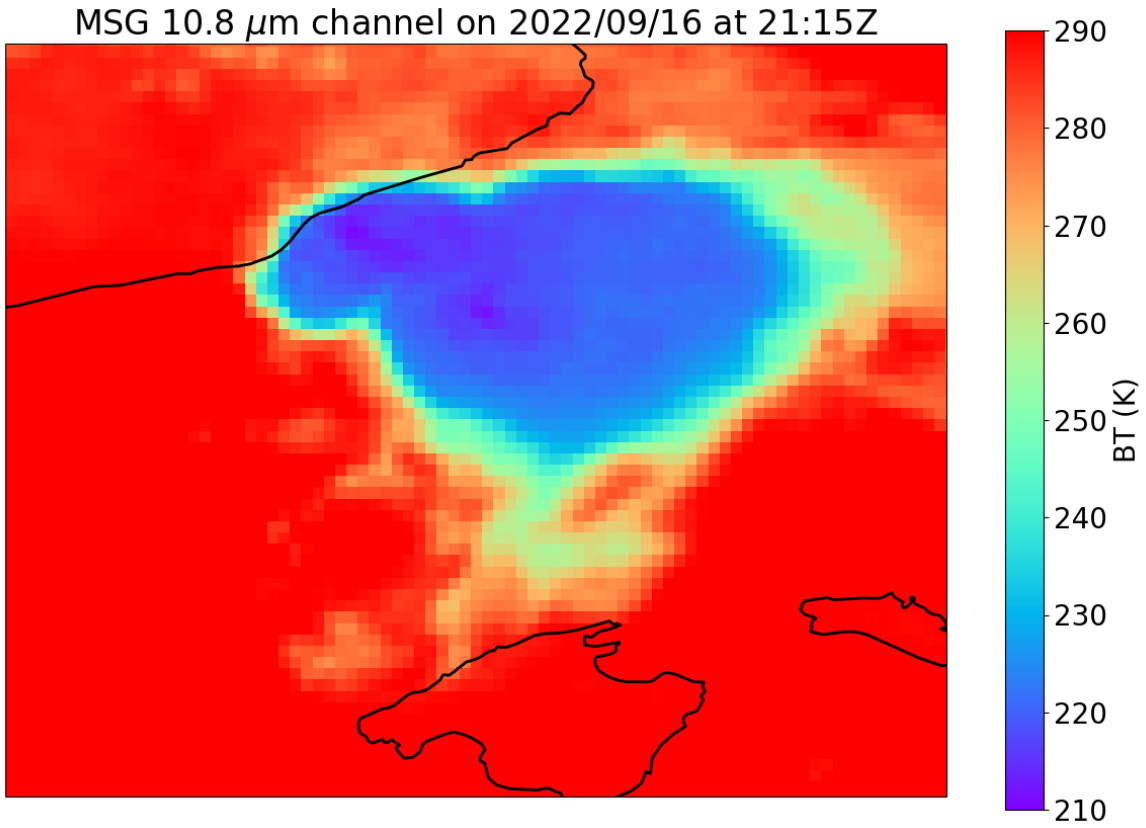
- ✓ Jason Apke and colleagues have shown that cloud top divergence in convective clouds is now possible with new meteorological geoestationary satellites improved spatial and temporal resolutions
- ✓ Can an operational algo be developed within the NWC SAF?



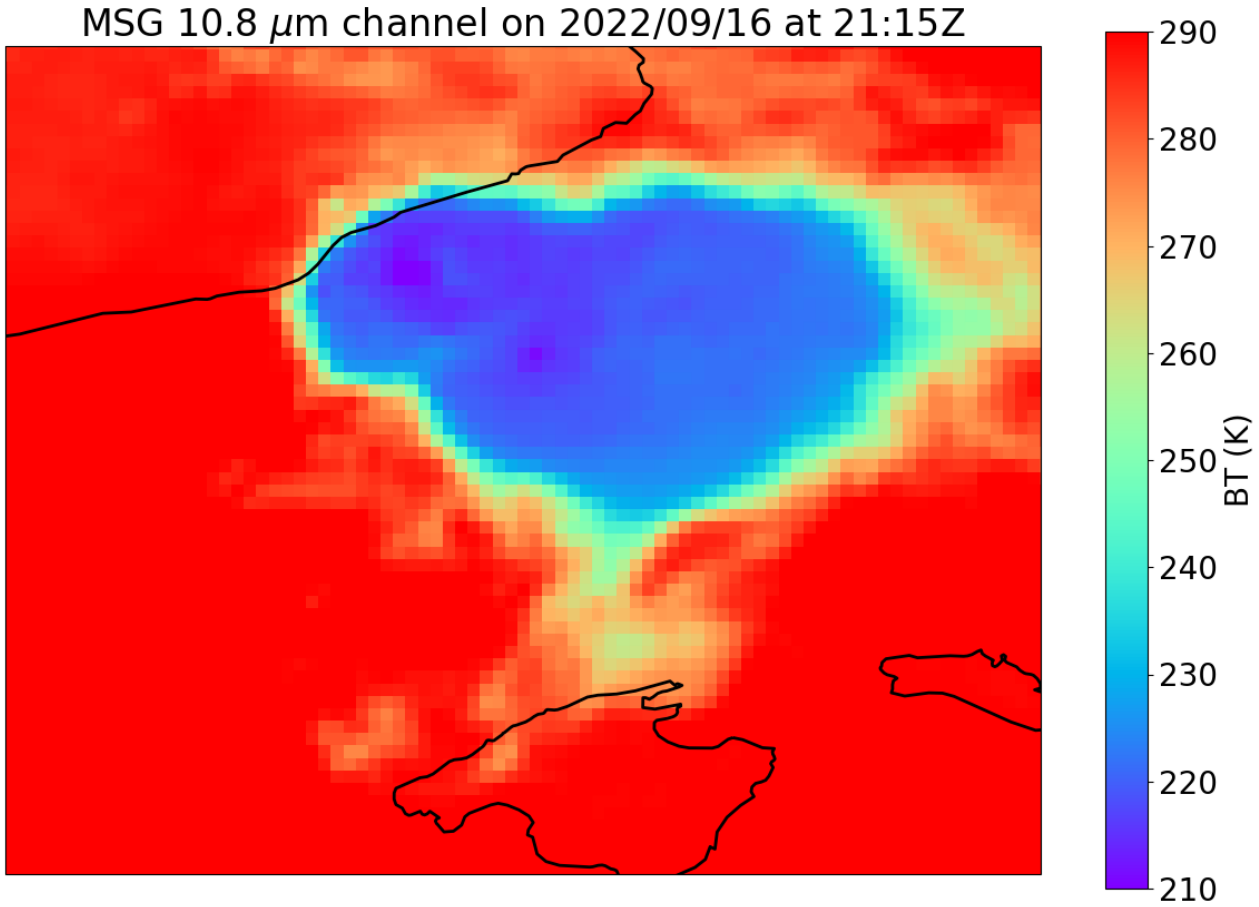
https://www.star.nesdis.noaa.gov/star/documents/seminardocs/2020/20201106_Apke.pdf

Can we derive Convection Dynamics from Satellite Data?

- ✓ Can an operational algo be developed within the NWC SAF? Final objective is to use MTG-FCI data ONLY
- ✓ Analyse a case study where we have NWC SAF HRW cloud top winds, ASCAT surface winds and AEMET Radar data
- ✓ Convective system between Mallorca and mainland Spain on 2022/09/16 around 21:00Z

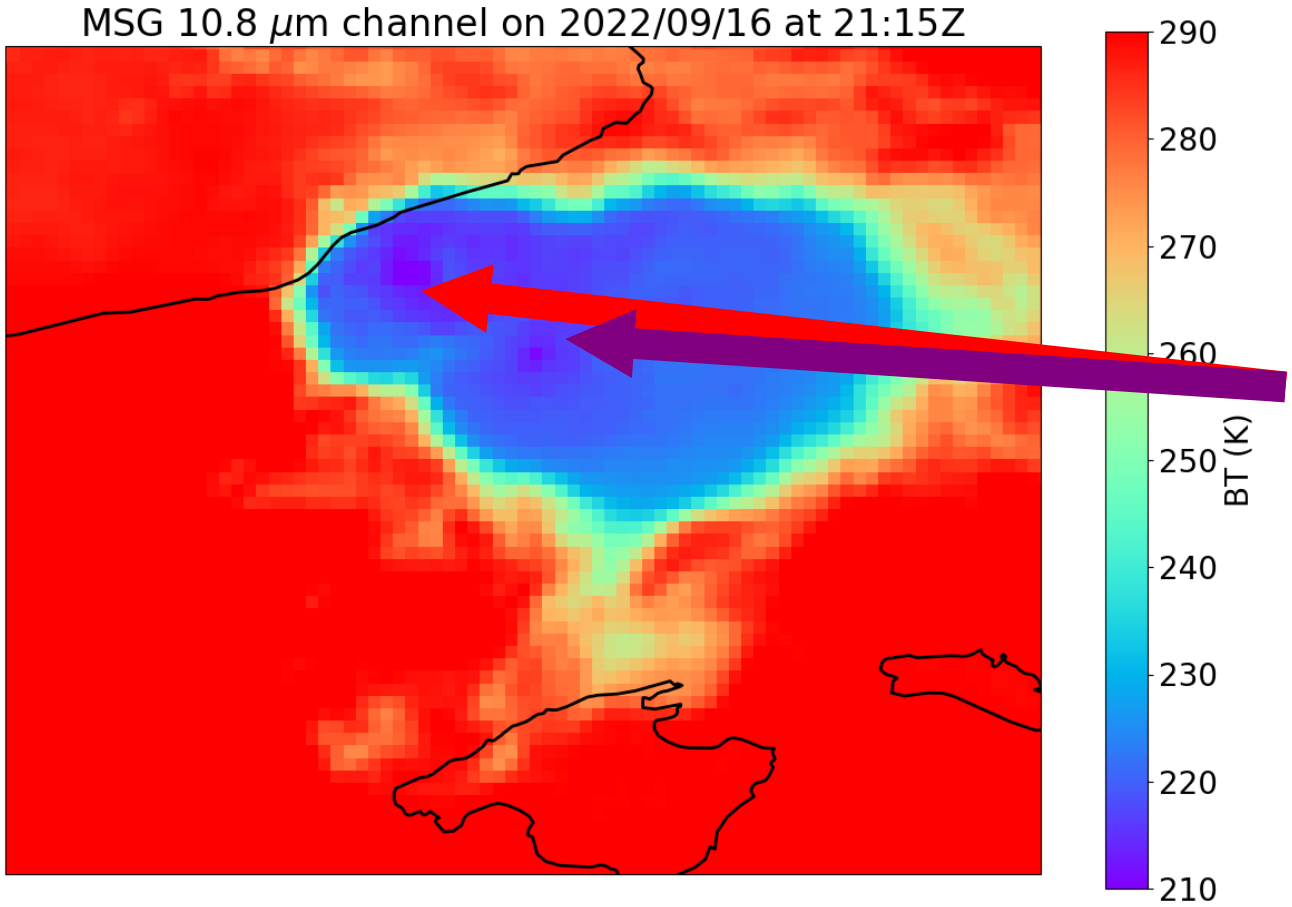


✓ Convective system between Mallorca and mainland Spain on 2022/09/16 around 21:00Z



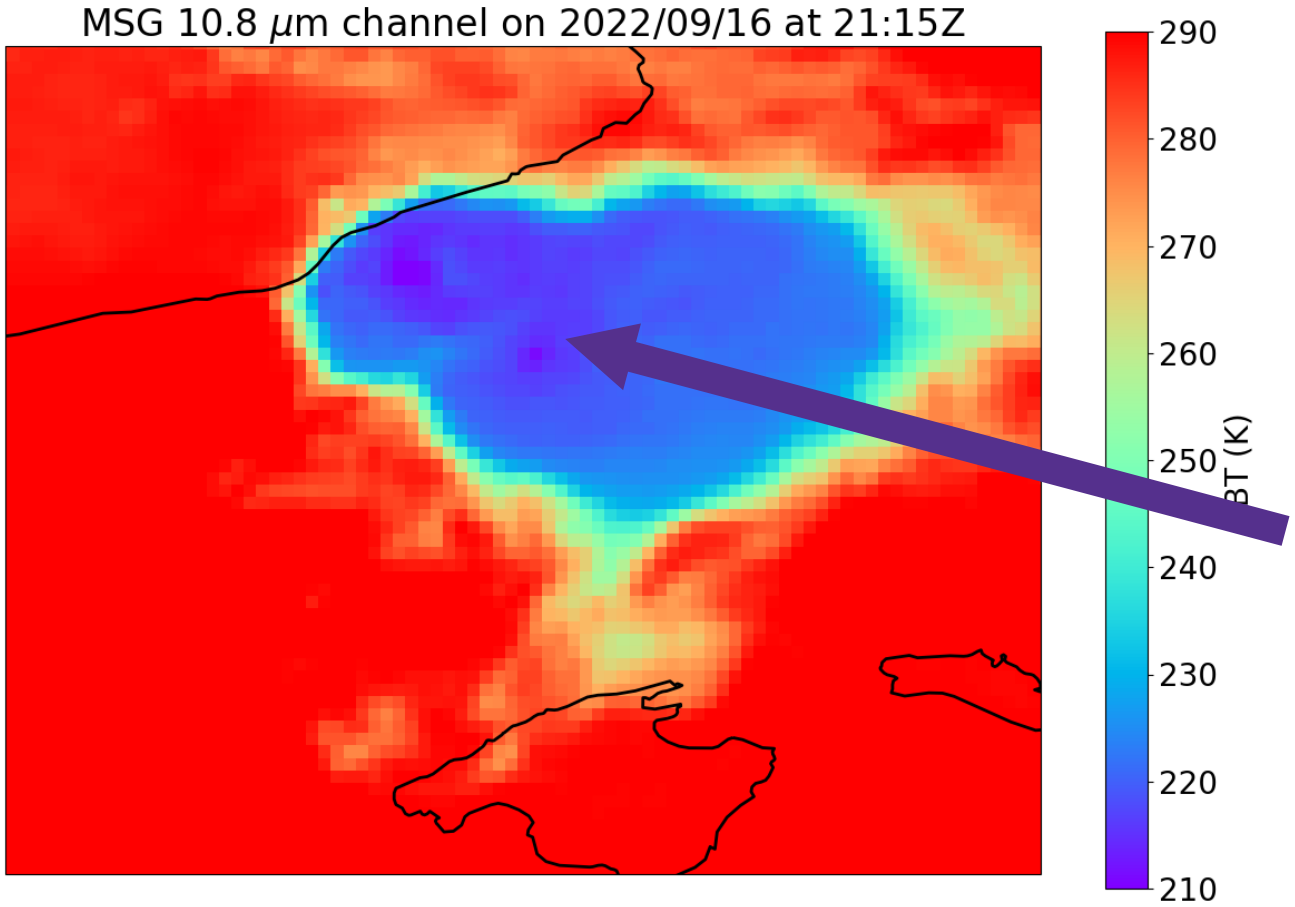
- MSG 10.8 micron channel image
- Overshooting tops are visible
- Cold ring is also visible

✓ Convective system between Mallorca and mainland Spain on 2022/09/16 around 21:00Z



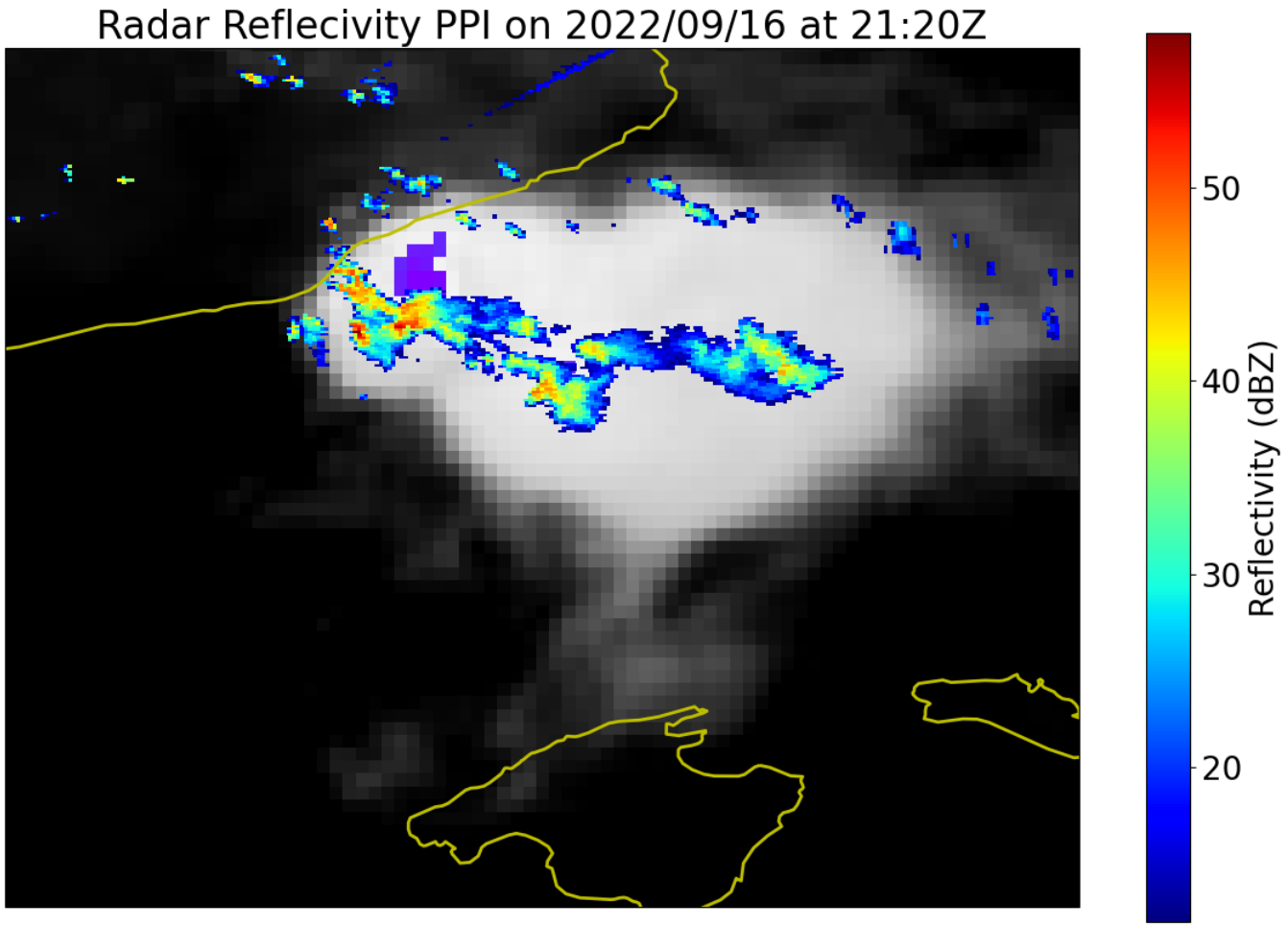
- ✓ MSG 10.8 micron channel image
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✓Convective system between Mallorca and mainland Spain on 2022/09/16 around 21:00Z



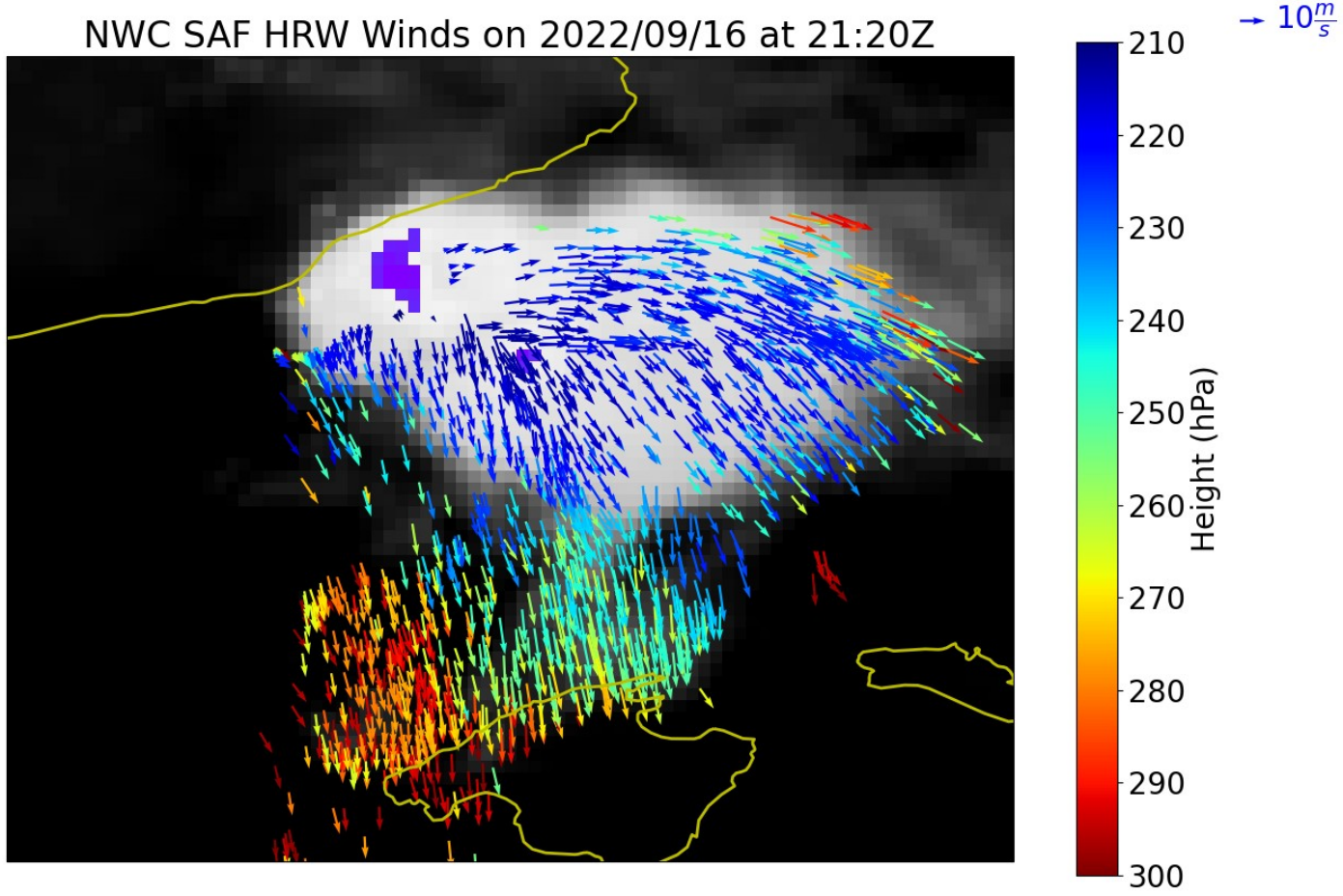
- MSG 10.8 micron channel image
- Overshooting tops are visible
- We will study this system because of availability of ASCAT winds

✓ Convective system between Mallorca and mainland Spain on 2022/09/16 around 21:00Z



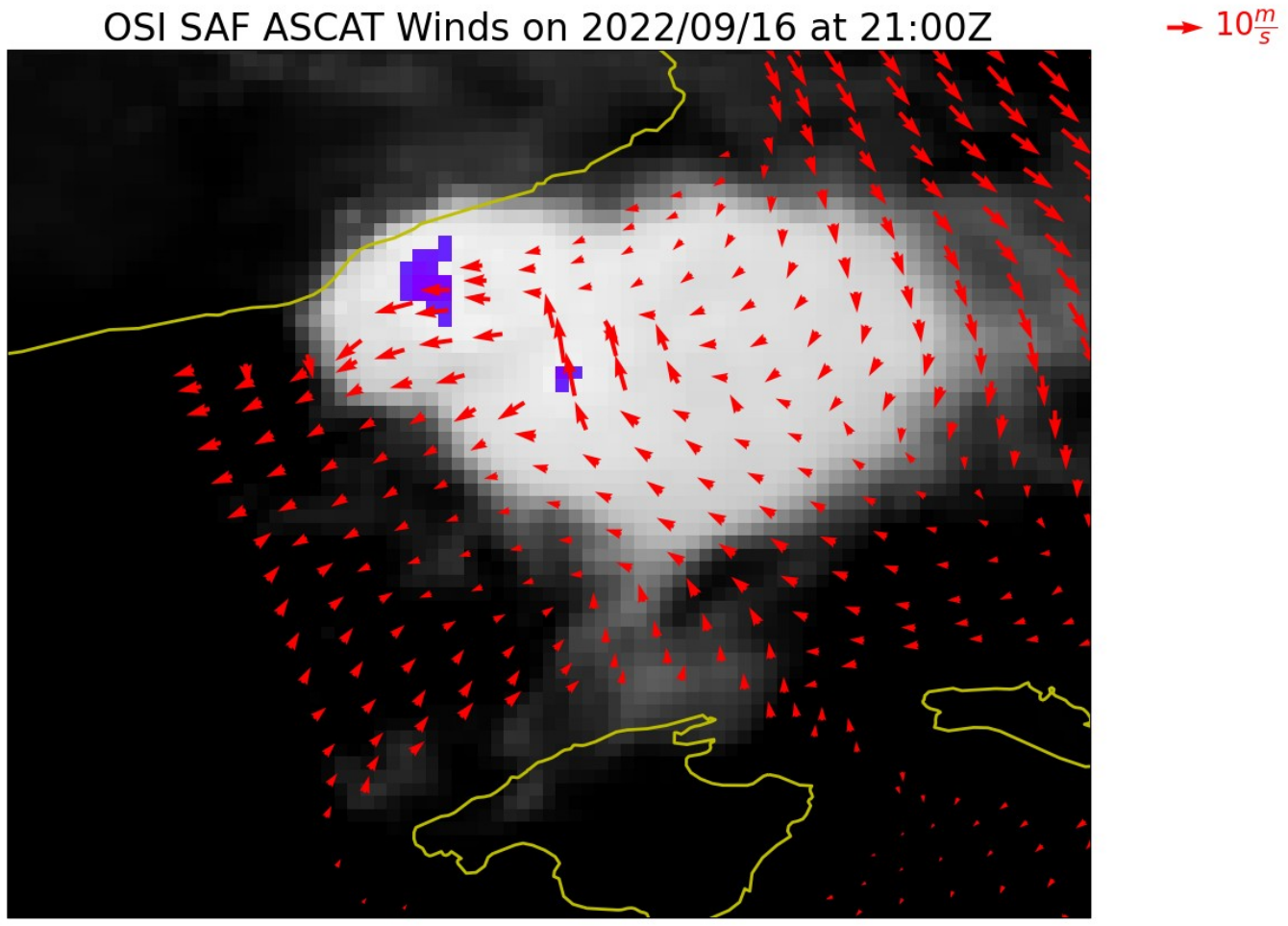
- ✓ Radar data also available → PPI at 21:00Z

✓NWC SAF HRW Cloud Top Winds



- Fine tuned NWC SAF HRW processed over cloud tops on MSG Rapid Scan Service (5 min intervals)
- The NWC SAF HRW product satisfactorily shows winds over cloud tops
- NWC SAF HRW is based on tracking tracers (not optical flow)
- Divergence is clearly visible
- Winds at different levels available
- Overshooting tops are shown in purple

OSI SAF ASCAT Ocean Surface Winds



OSI SAF ASCAT surface winds show convergence

Nice complement to NWC SAF HRW winds

Overshooting tops are shown in purple

Can we Derive Updraft Velocities and Fluxes?

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \mathbf{j} = \sigma$$



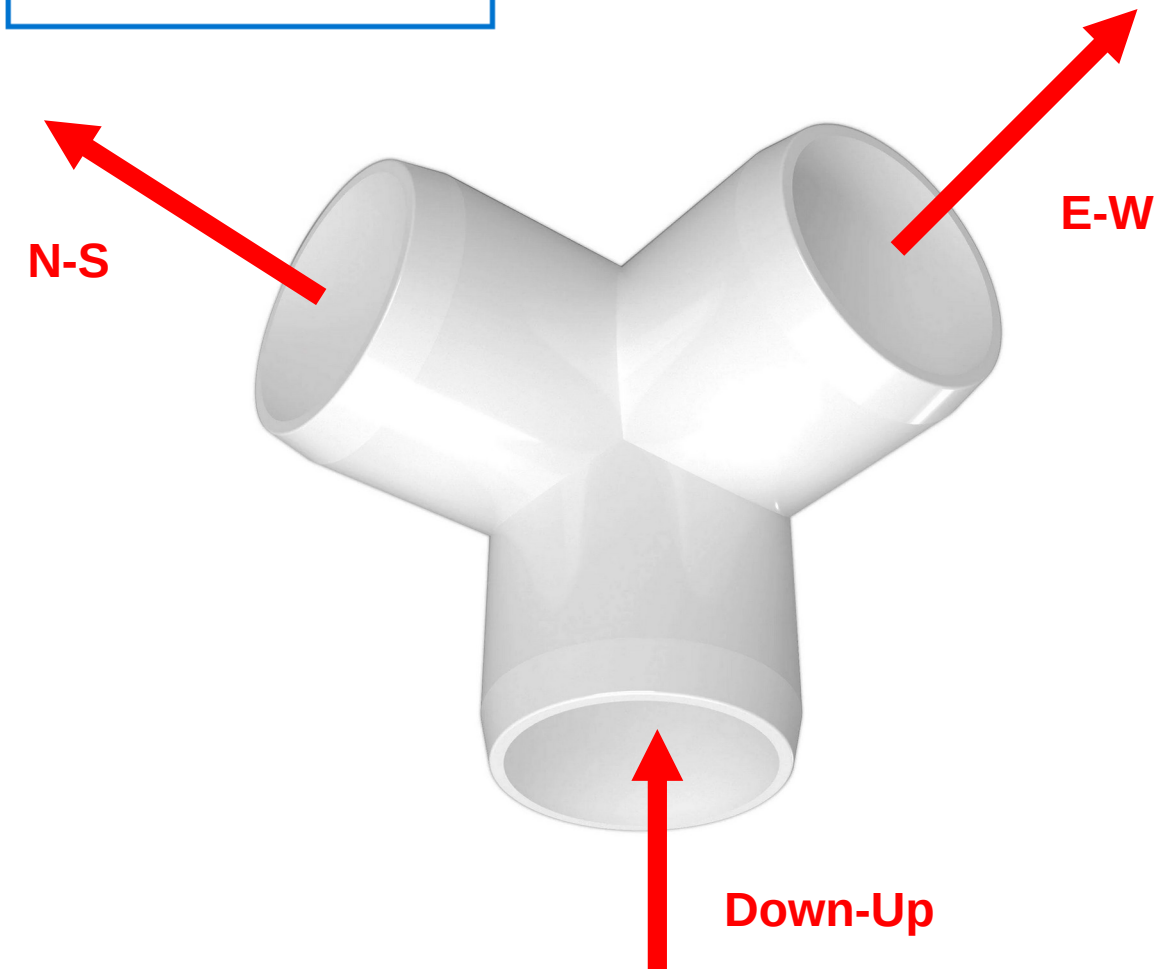
$$\frac{\partial q}{\partial t} + \oint_S \mathbf{j} \cdot d\mathbf{S} = \Sigma$$



- We can use continuity equation in
  - Integral form
  - Differential form
- Differences with real data are usually very noisy → Integral form is preferred
- $\mathbf{j} = \rho \mathbf{v}$

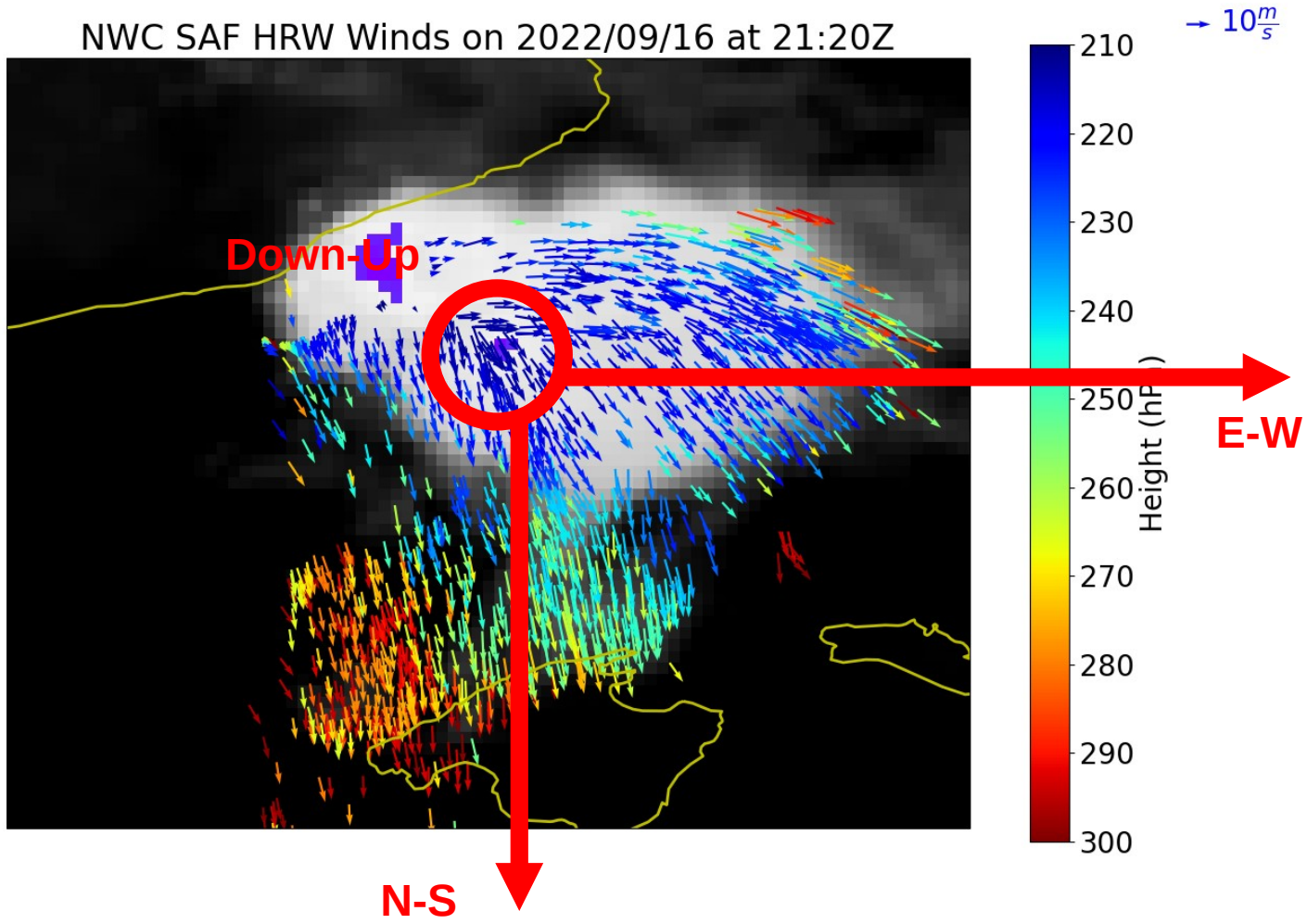
Can we Derive Updraft Velocities and Fluxes? Upper Level Analysis

$$\frac{\partial q}{\partial t} + \oint_S \mathbf{j} \cdot d\mathbf{S} = \Sigma$$



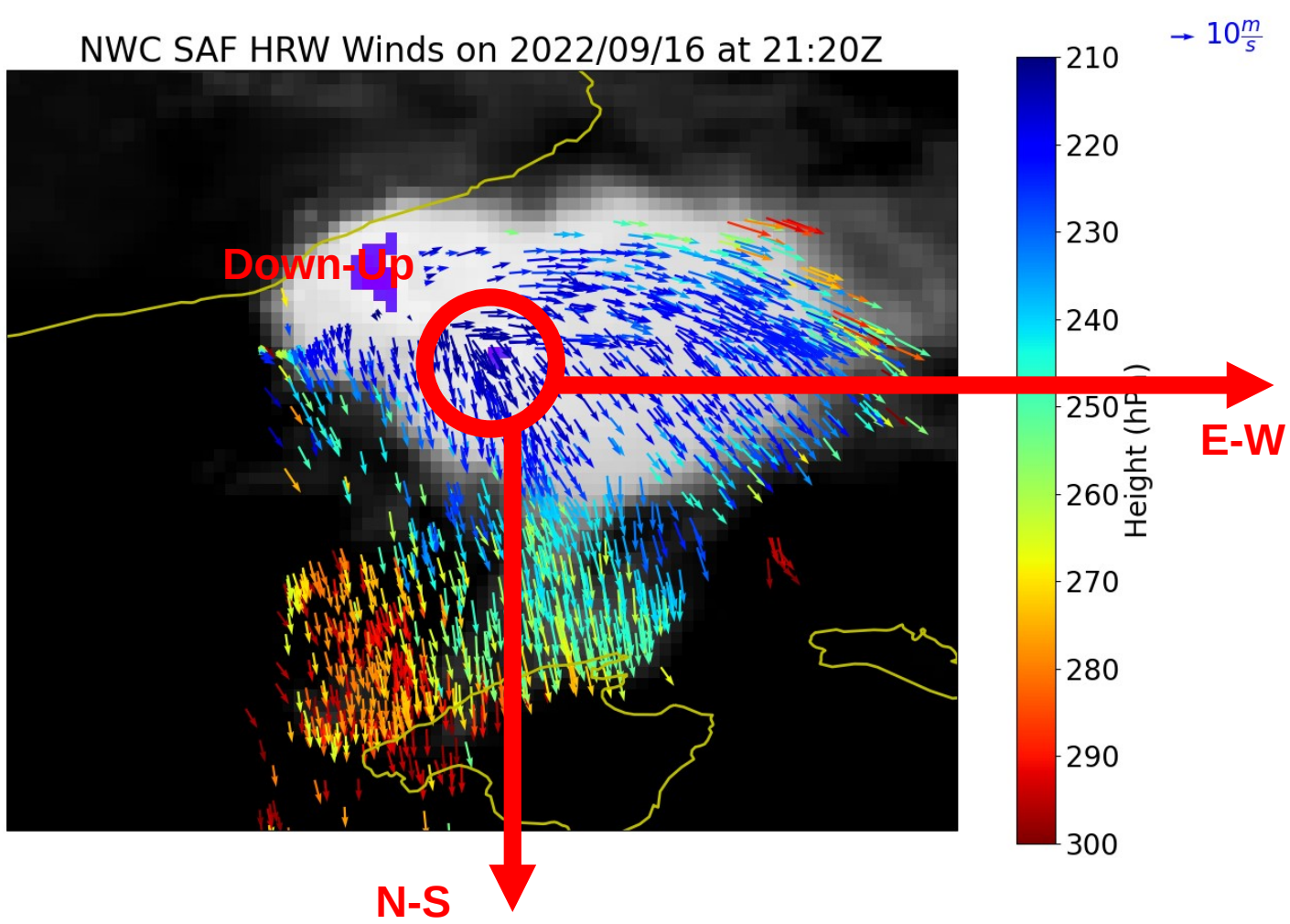
- Continuity Equation in Integral Form
- Three main fluxes:
  - East-West
  - North-South
  - Down-Up
- Constant ρ density for upper levels

Can we Derive Updraft Velocities and Fluxes? Upper Level Analysis



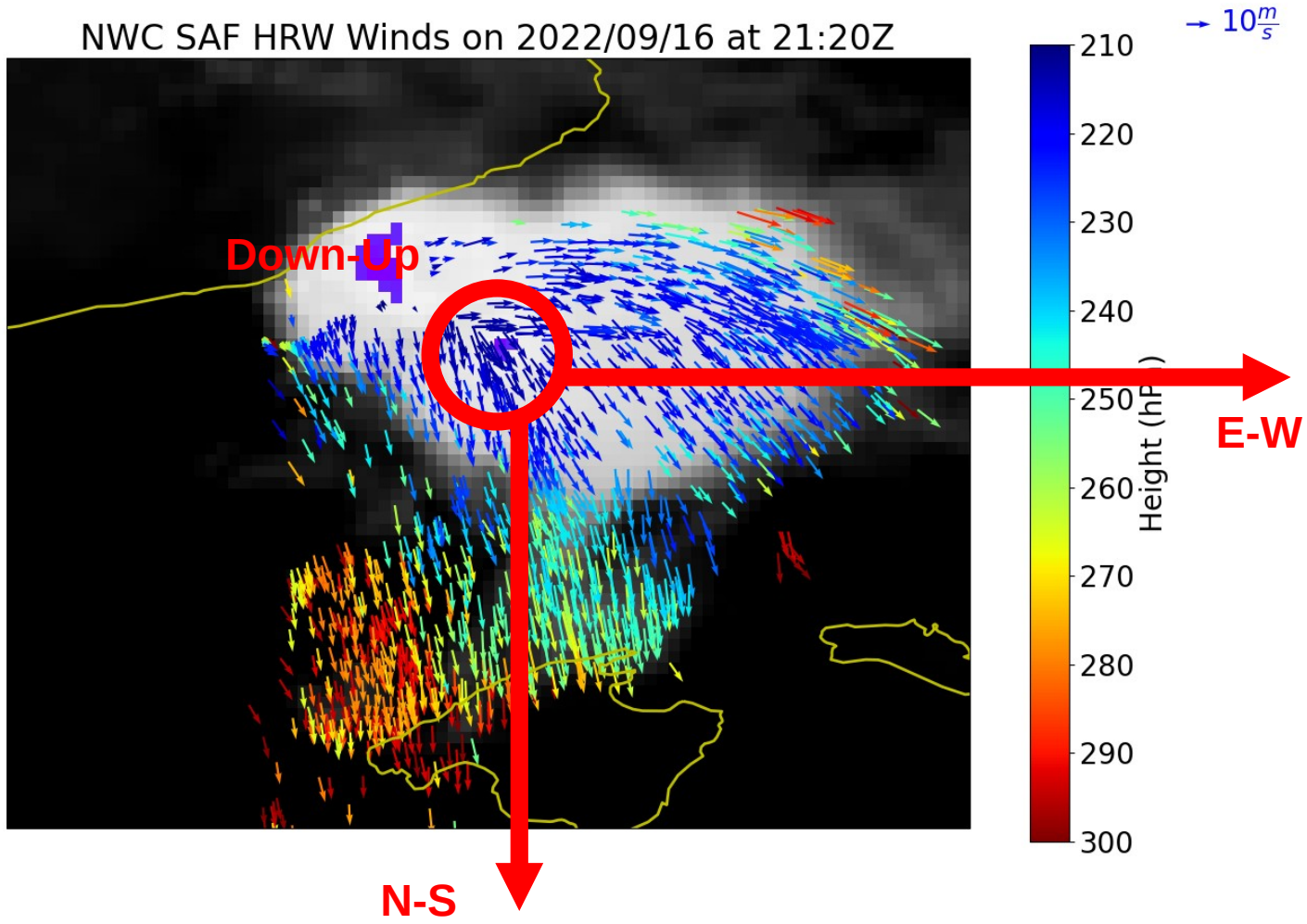
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Can we Derive Updraft Velocities and Fluxes? Upper Level Analysis



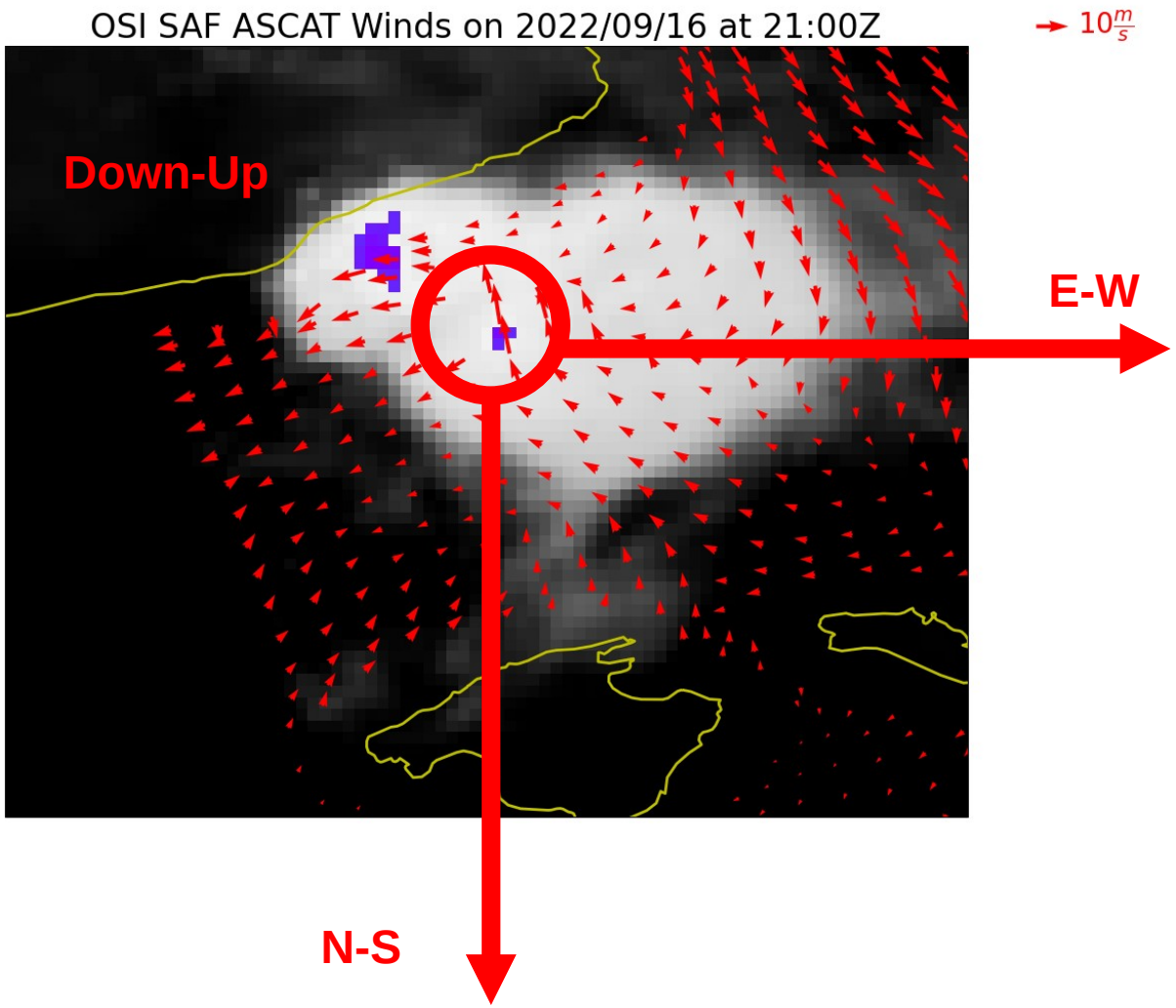
- Continuity Equation in Integral Form
- Three main Integrated Fluxes :
  - East-West: 55 km * 2680 m * 12 m/s
  - North-South: 40 km * 2680 m * 12 m/s
  - Down-Up: ρ w A
- Vertical Depth collected from existing HRW levels: 300 to 200 hPa = 2680 m
- Updraft Area, A, equal to overshooting top area = 9.2 km * 8.9 km
- Constant ρ density for upper levels = 0.38 kg/m^3
- Integrated Flux: E-W + N-S = Down-Up

Can we Derive Updraft Velocities and Fluxes? Upper Level Analysis



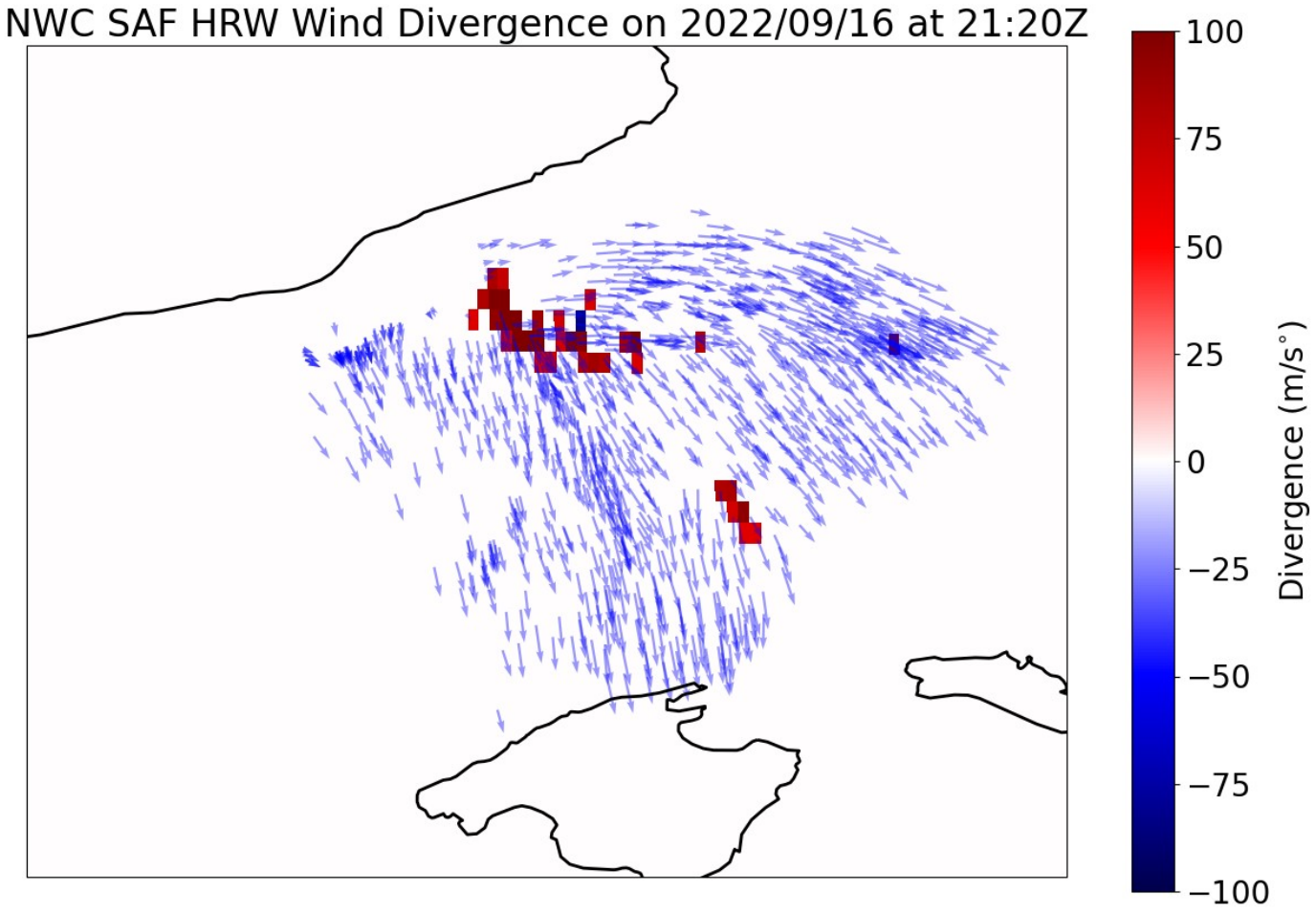
- Continuity Equation in Integral Form
- Three main Integrated Fluxes :
  - East-West: 55 km * 2680 m * 12 m/s
  - North-South: 40 km * 2680 m * 12 m/s
  - Down-Up: ρ w A
- Integrated Flux: E-W + N-S = Down-Up
- Vertical Velocity, w = 37.5 m/s
- Upward Integrated Flux = 1,163 M kg/s
- Reasonable values!

Can we Derive Updraft Velocities and Fluxes? Surface Level Analysis



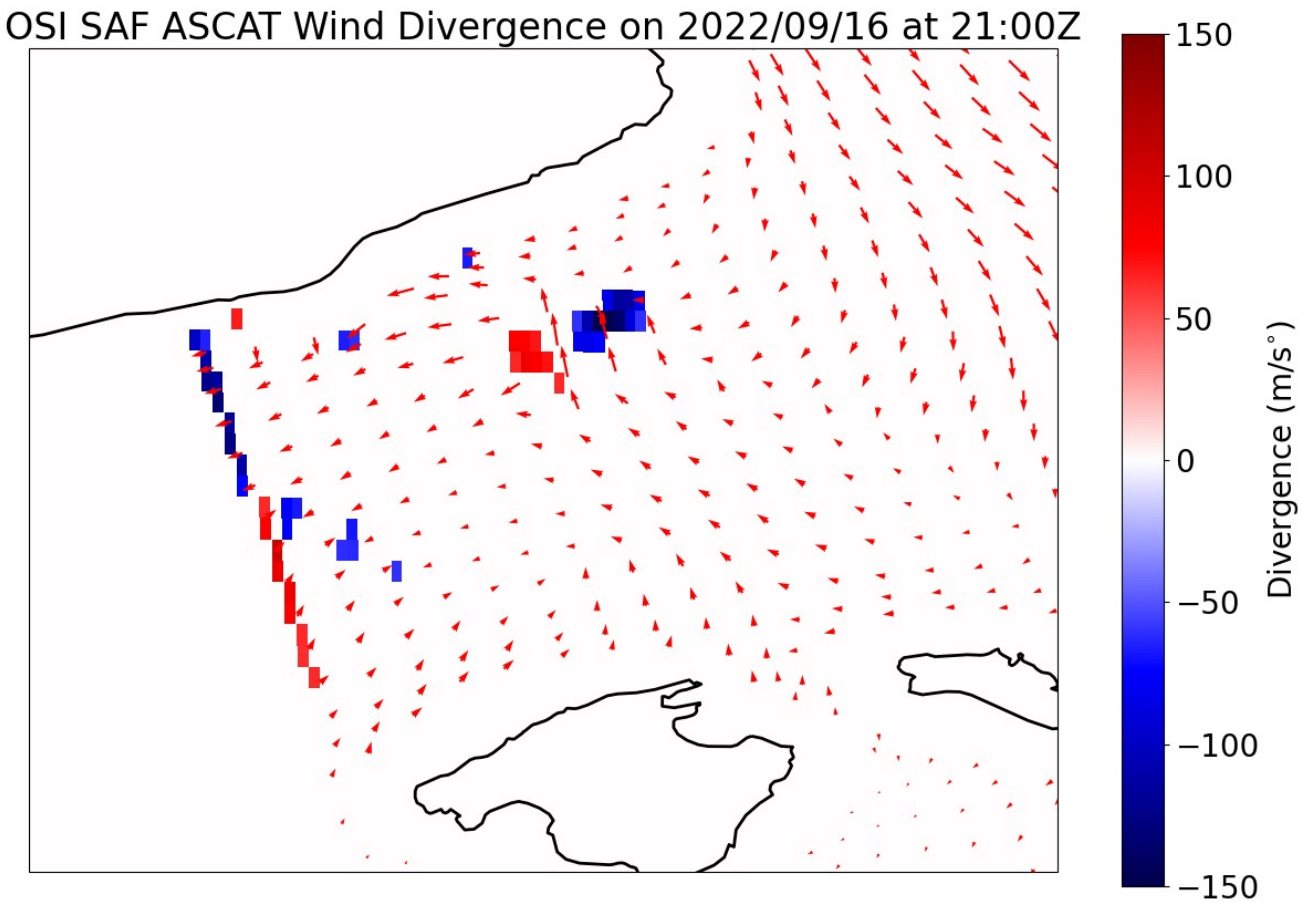
- Continuity Equation in Integral Form
- Three main Fluxes:
  - East-West
  - North-South
  - Down-Up
- Vertical velocity, w = 33.8 m/s
- Upward Integrated Flux = 1,522 M kg/s
- Consistent values with Upper Levels!

✓NWC SAF HRW Cloud Top Wind Divergence



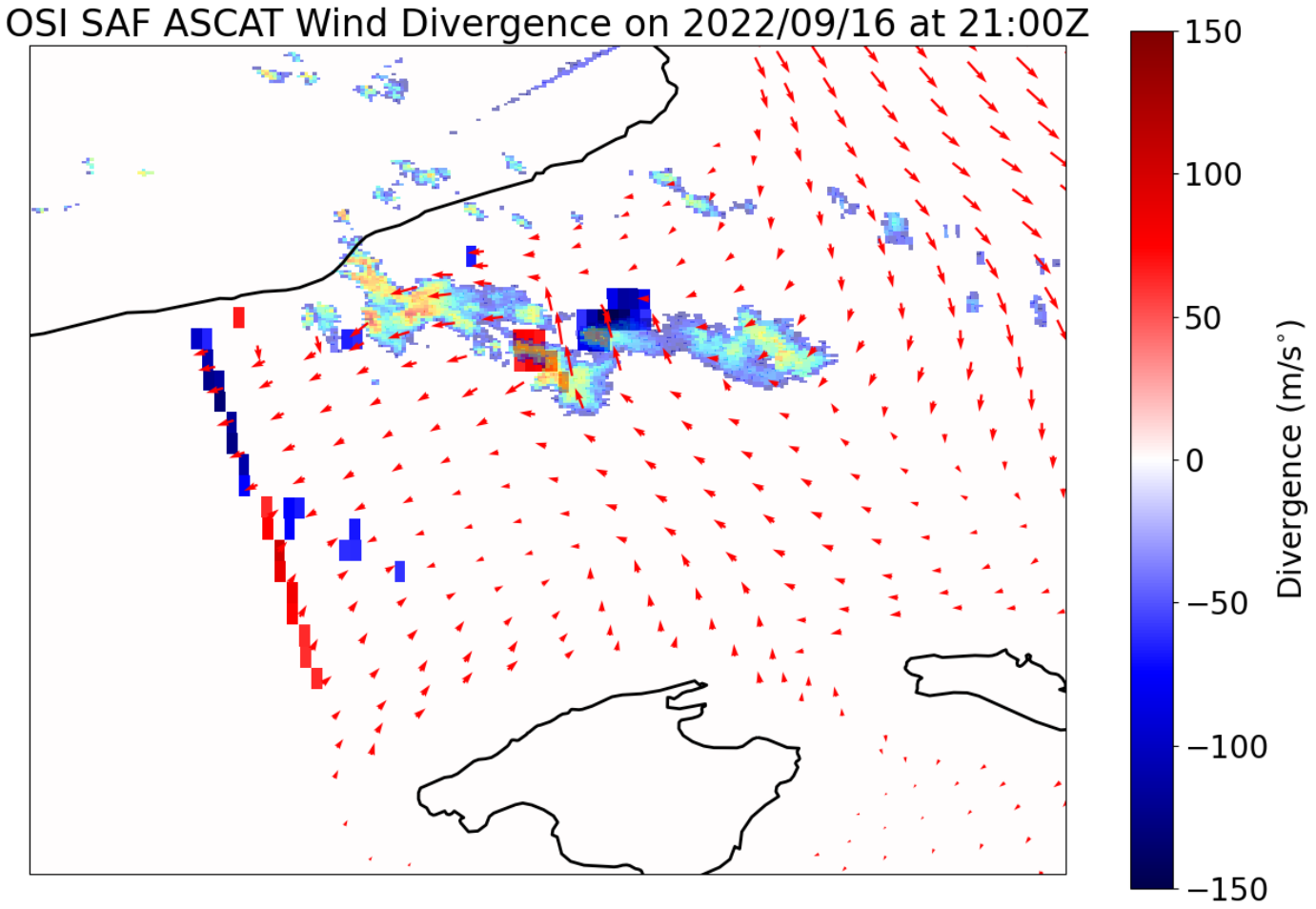
- Divergence is noisy → Only high values plotted
- Divergence field seems reasonable

✓OSI SAF ASCAT Ocean Surface Wind Divergence



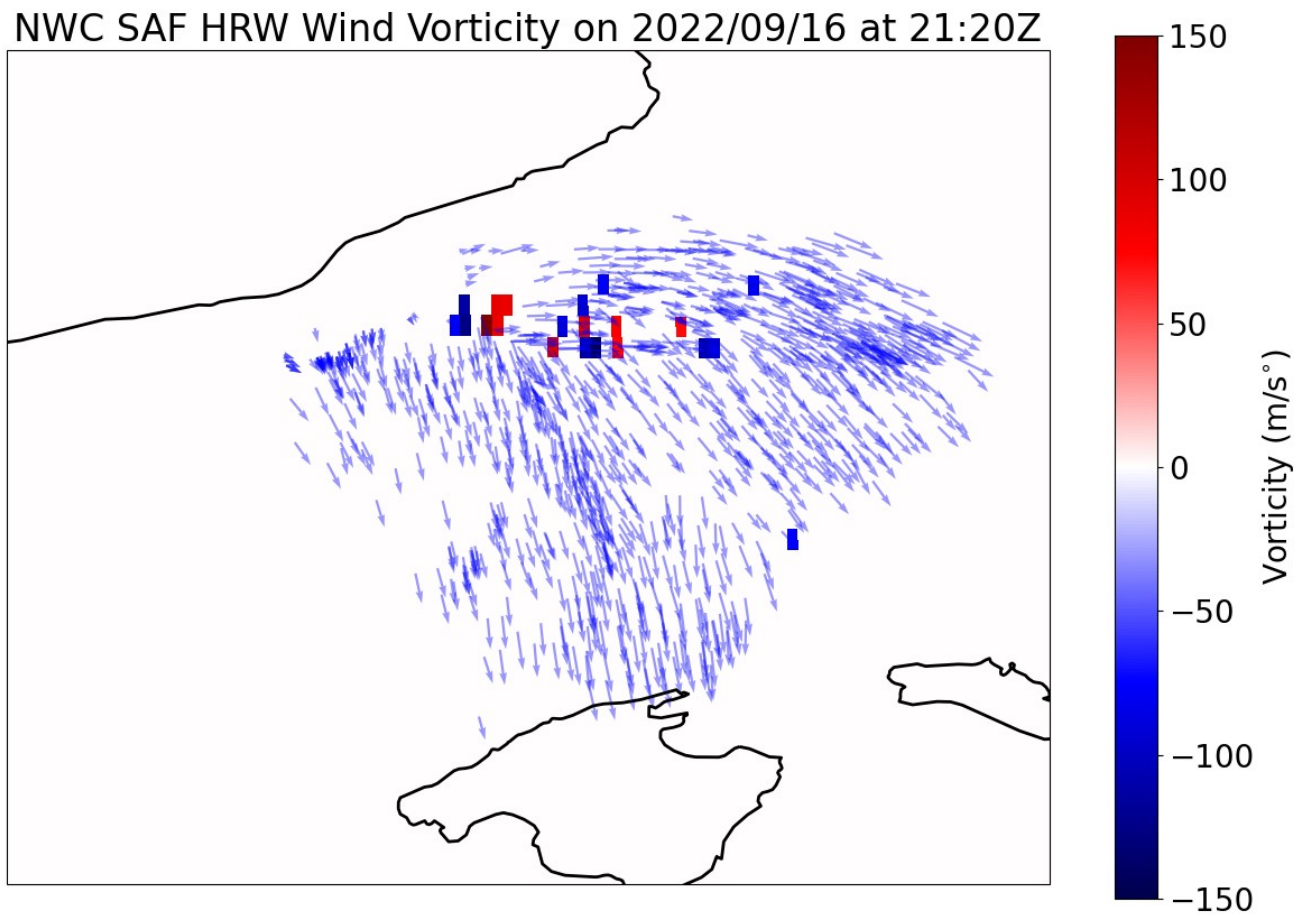
- Divergence is noisy → Only high values plotted
- Divergence and convergence fields seems reasonable

✓OSI SAF ASCAT Ocean Surface Wind Divergence + Radar PPI



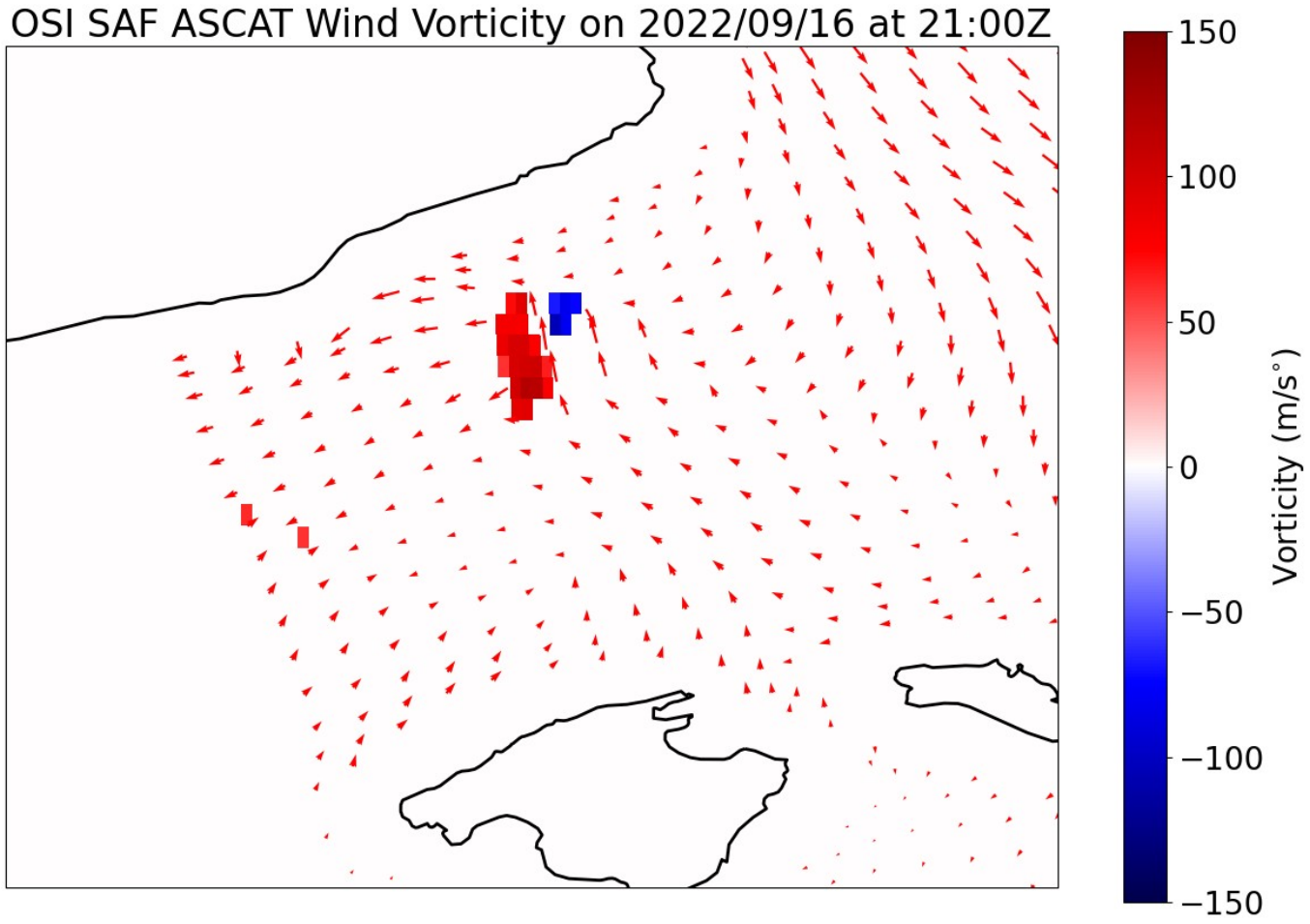
- Divergence is noisy → Only high values plotted
- Divergence plotted over radar PPI data → Divergence and convergence fields seems to match radar precipitation

✓NWC SAF HRW Cloud Top Wind Vorticity



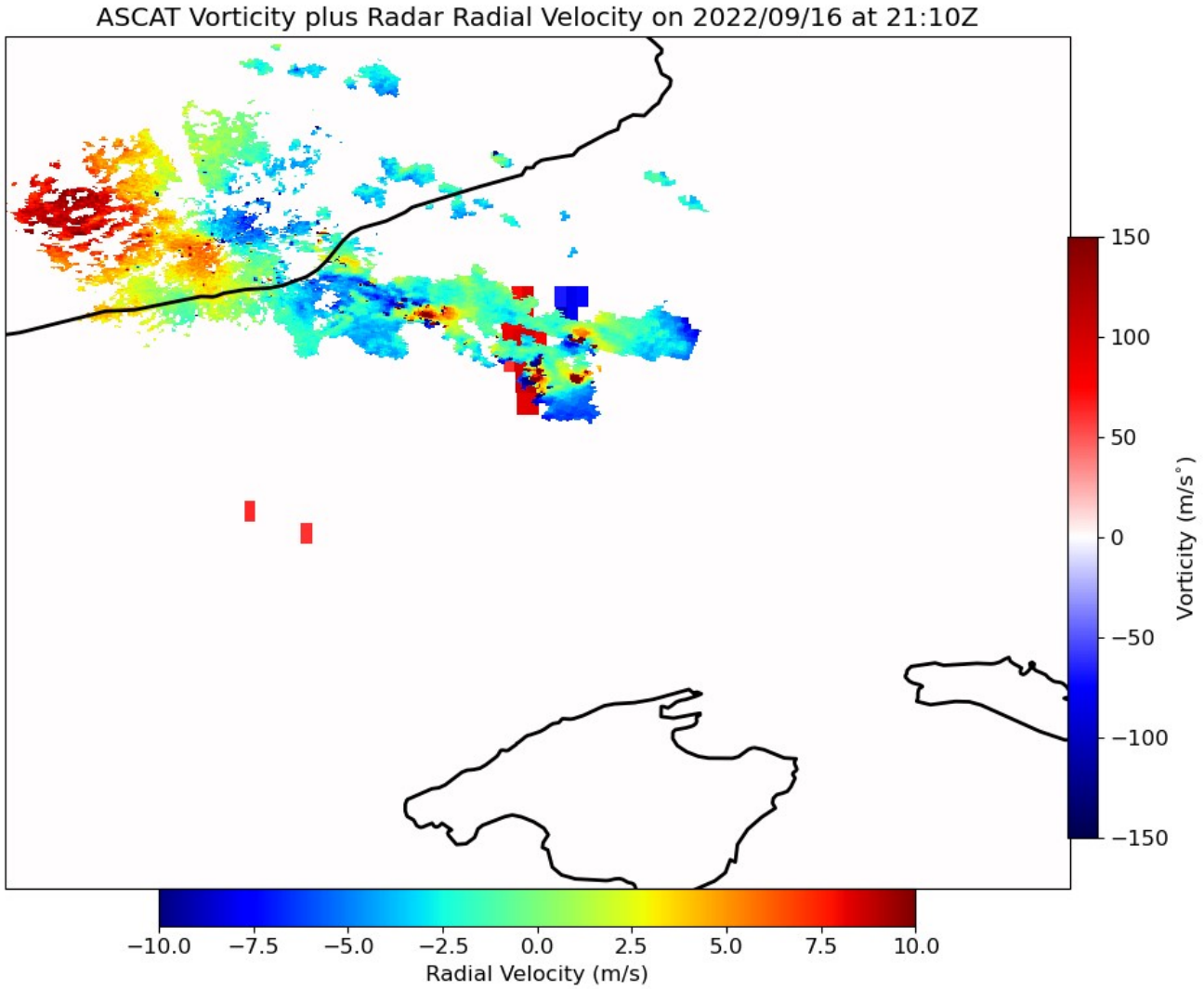
- Vorticity is noisy → Only high values plotted
- Noise??

✓OSI SAF ASCAT Ocean Surface Wind Vorticity



- Vorticity is noisy → Only high values plotted
- Vorticity real or noise?
- If real → Supercell?

✓OSI SAF ASCAT Ocean Surface Wind Vorticity + Radar Wind PPIW



- Vorticity is noisy → Only high values plotted
- Vorticity real or noise?
- If real → Supercell?

Can we derive Convection Dynamics from Satellite Data?

- Winds from NWC SAF HRW MSG Rapid Scan seem to be useful to determine cloud convection dynamics, like updraft velocities and fluxes
- OSI SAF ASCAT surface winds could be exploited further for convection analyses
- A “Cloud Top Wind” product that could become operational seems plausible
- Further studies needed → If you want to participate please contact xcalbeta@aemet.es or safnwchd@aemet.es