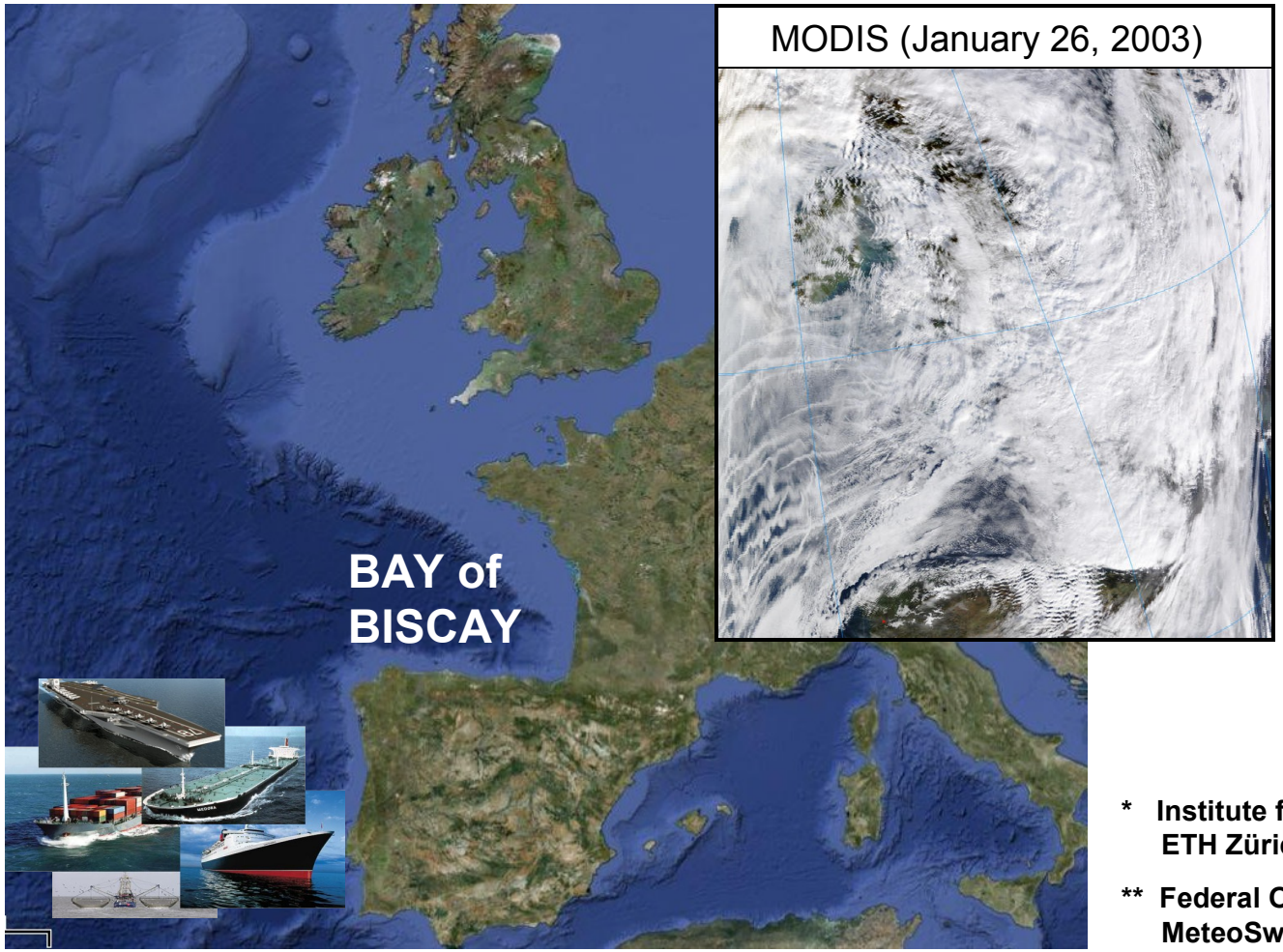
A Case Study on Ship Tracks in the Bay of Biscay



MODIS (January 26, 2003)

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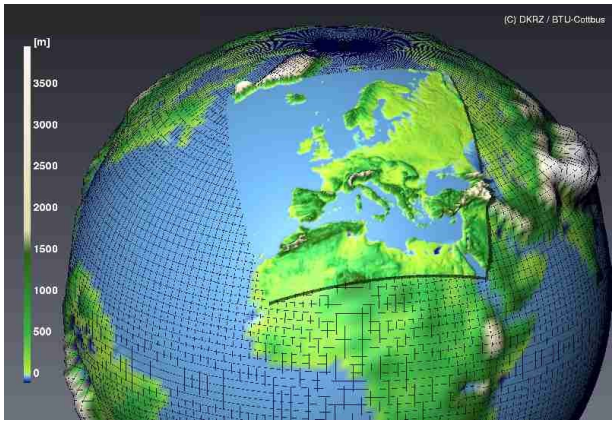
Modeling Approach



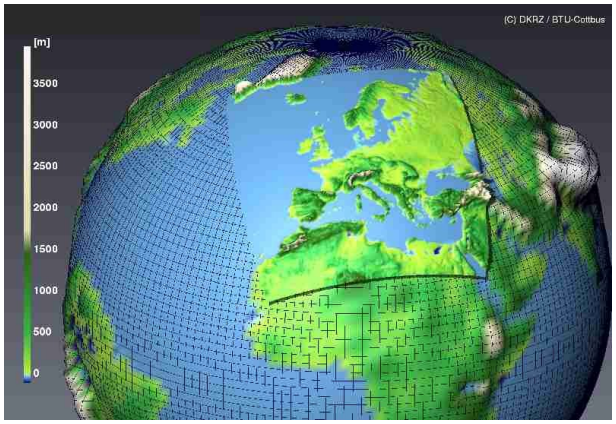
COSMO 4.14

Cloud Microphysics: **Seifert and Beheng 2006**
(2-moment scheme)

Aerosol Microphysics: **Vignati at al 2007**
(7 modes for SU,BC, OC, SS, DU)

Satellite Simulator: **Bodas-Salcedo et al 2011**
(COSP Simulator Package)

Modeling Approach



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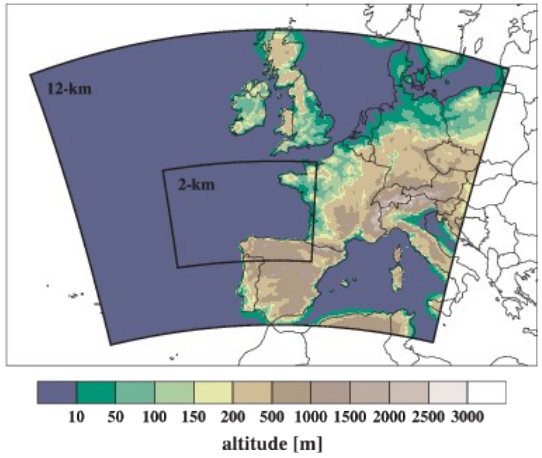
Resolutions: 12 km x 12 km x 50 - 150 m (in PBL)
nested: 2 km x 2 km x 50 - 150 m (in PBL)

Initialisation Time: 26.01.2003 at 00 UTC

BC & IC (dyn): Era-interim (Simmons et al. 2007)

BC & IC (aerosol): ECHAM5-HAM (Folini et al. 2011)

Emissions (no ships): AEROCOM (Dentener et al. 2006)



Specified Ship Emissions – Cargo Ships

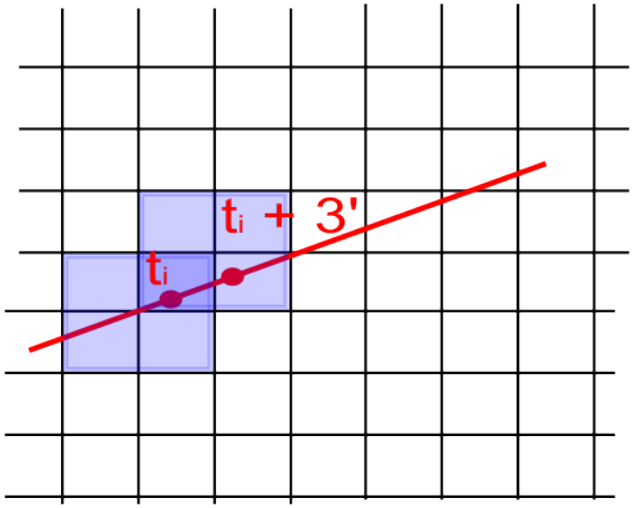
Mass fluxes (Hobbs et al 2000, Petzold et al 2008)

BC [g/s]	OC [g/s]	SO2(g) [g/s]	SO4 [g/s]
0.9	2.7	40.0	2.3 + (2.5% x [SO2])

Scaled Emission Mass fluxes from Literature by Factor 10

Ship Speed: 10 ms^{-1}

Grid Distribution

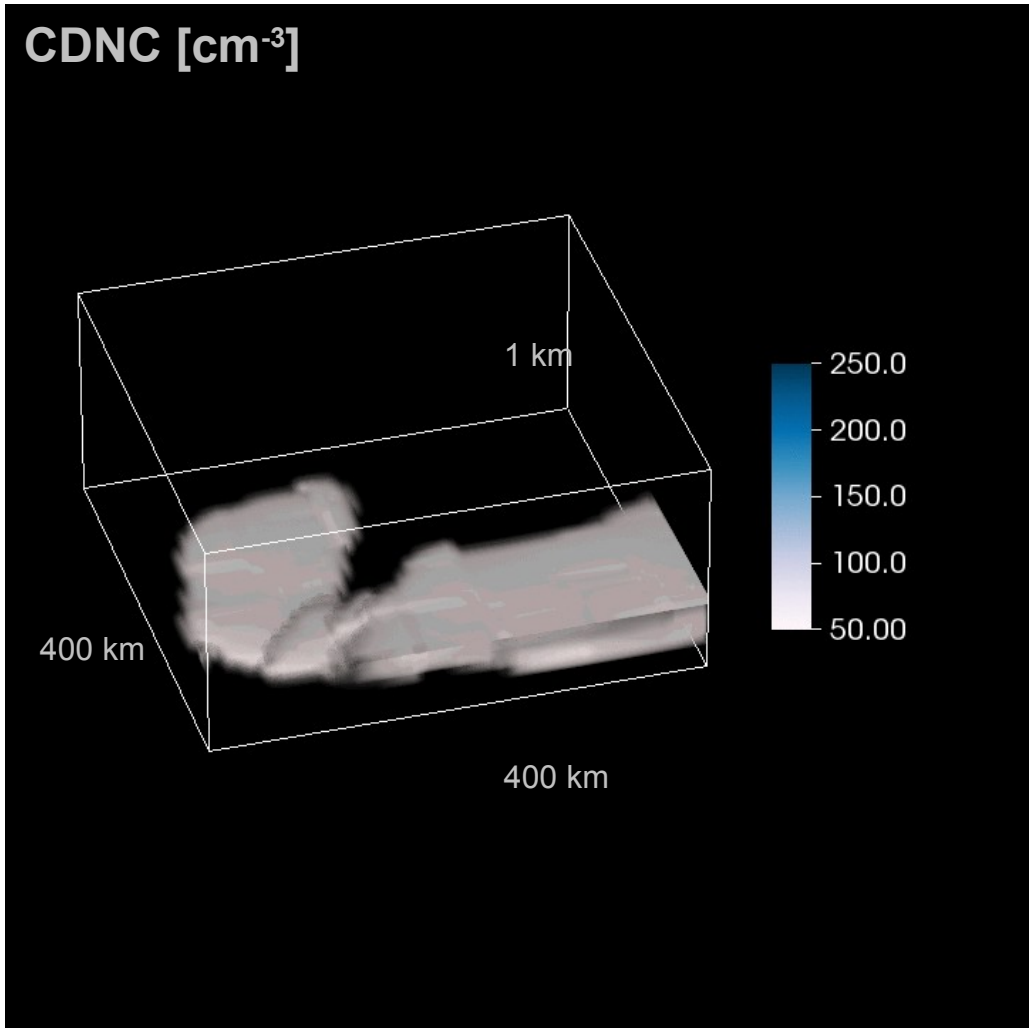


Size Distributions (Righi et al 2011)

	Fresh	Aged
D [µm] AIT/ACC	0.03/-	0.058/0.31
% AIT/ACC	100/0	96/4

Emission height: 150 m ASL

Results



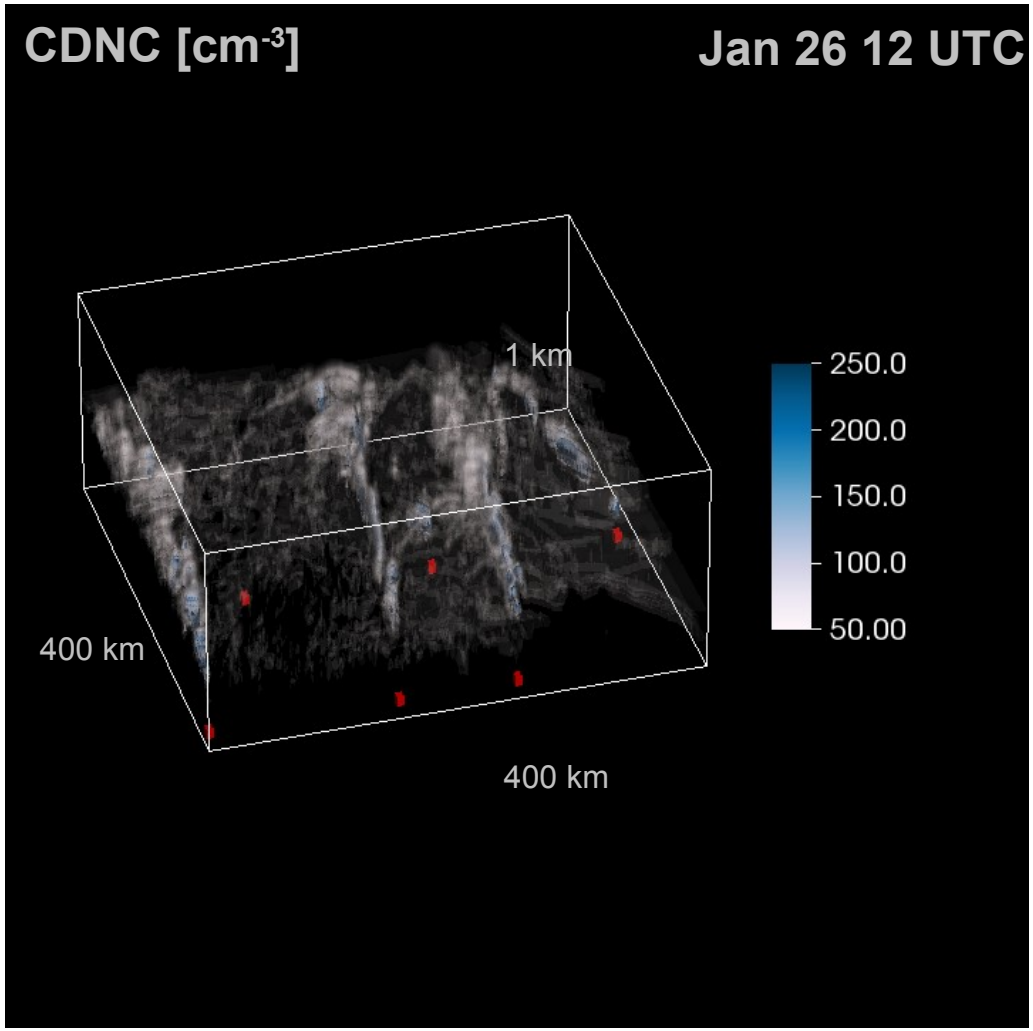
Animation from Jan 26 00 UTC until 12 UTC

Simulation with 6 sea-going cargo ships:

3 ships started at Jan 26 03 UTC

3 ships started at Jan 26 09 UTC

Results



Animation from Jan 26 00 UTC until 12 UTC

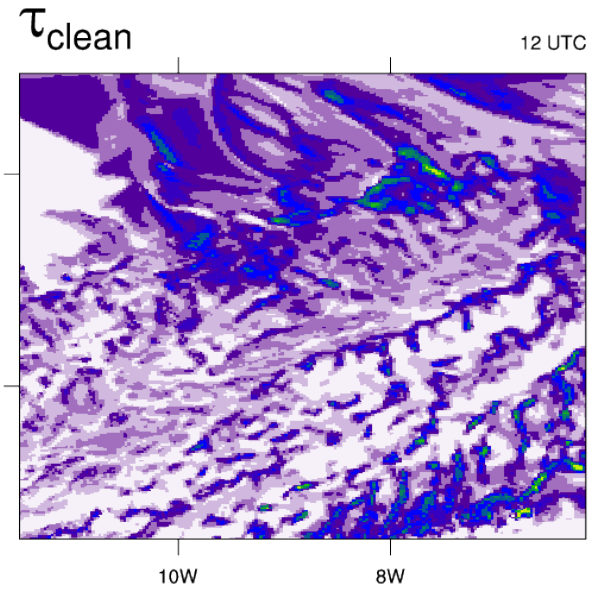
Simulation with 6 sea-going cargo ships:

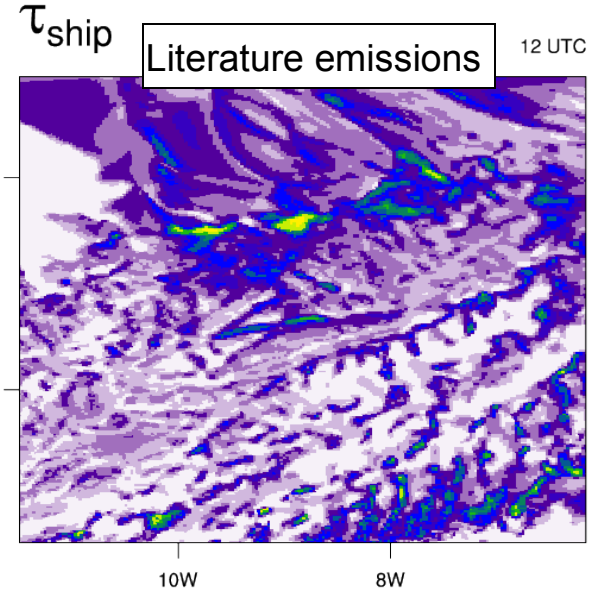
3 ships started at Jan 26 03 UTC

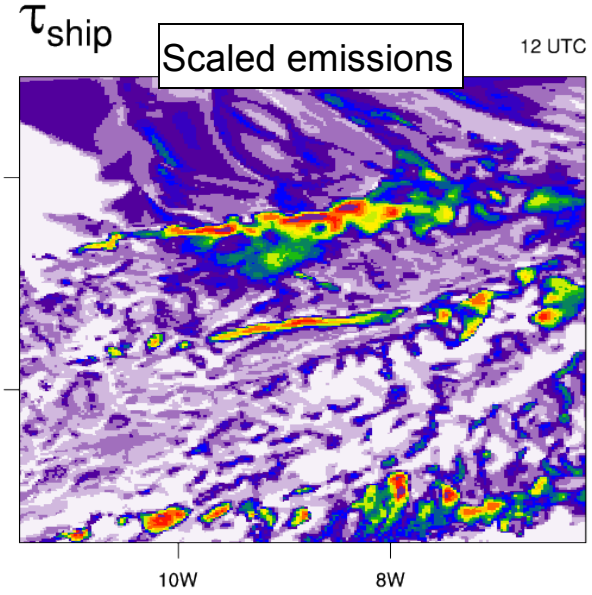
3 ships started at Jan 26 09 UTC

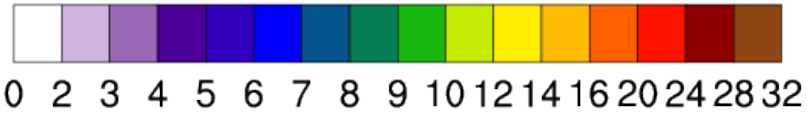
Observe increased CDNC along ship's routes that started at 03 UTC

Scaling of Emission Flux

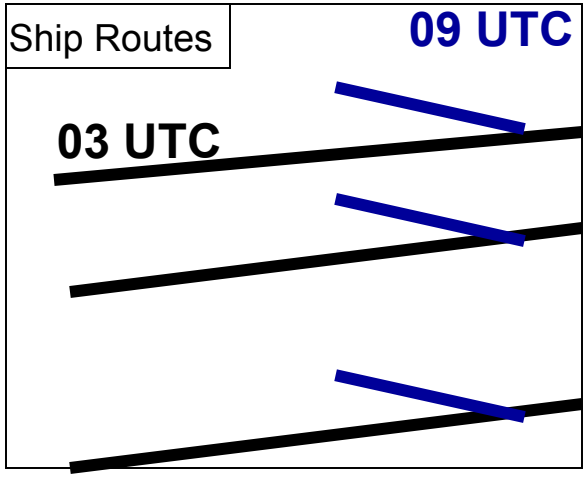




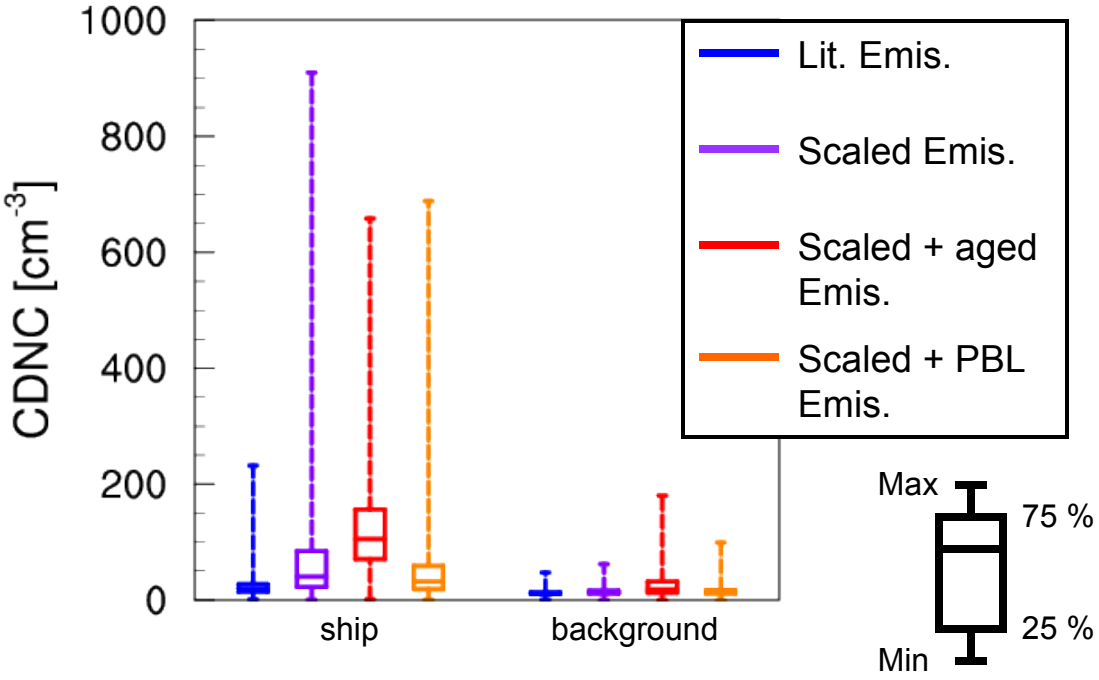


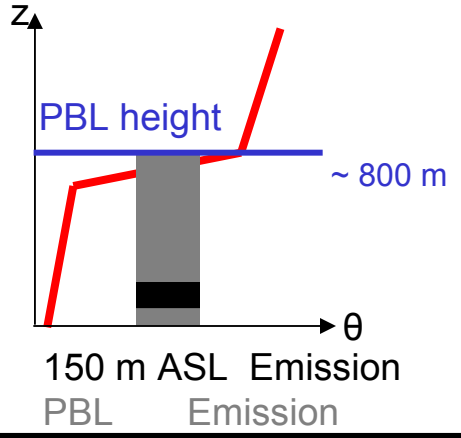


We simulate a clear ship track signal in optical thickness only when scaling up the emission flux



Aerosol Number Concentration and Emission Size





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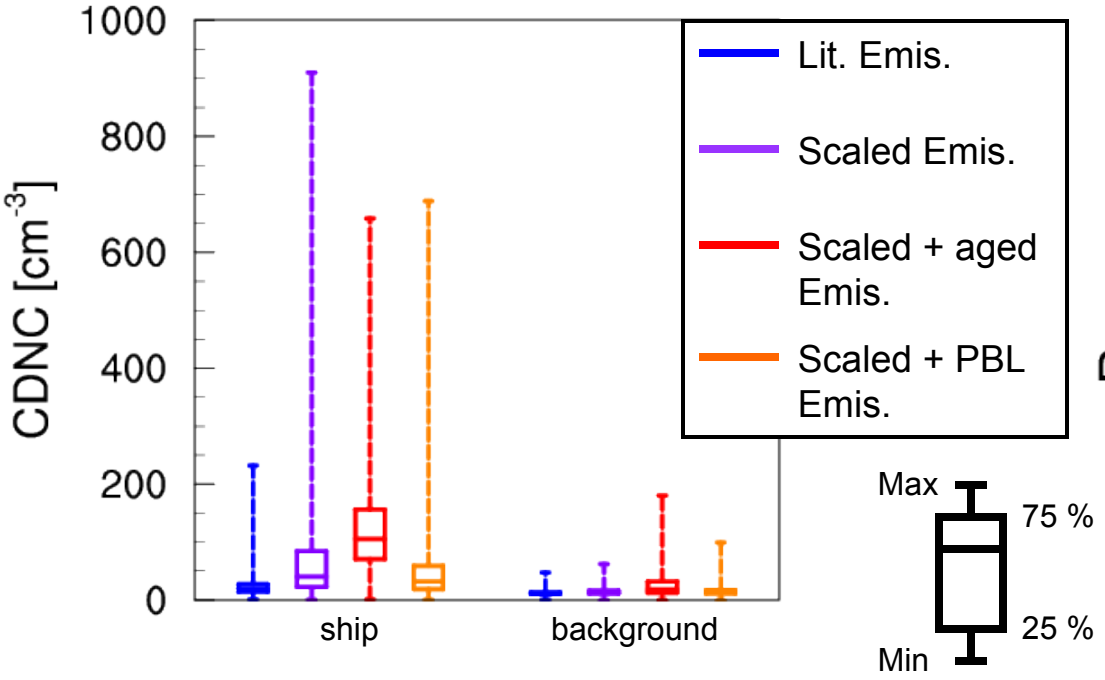

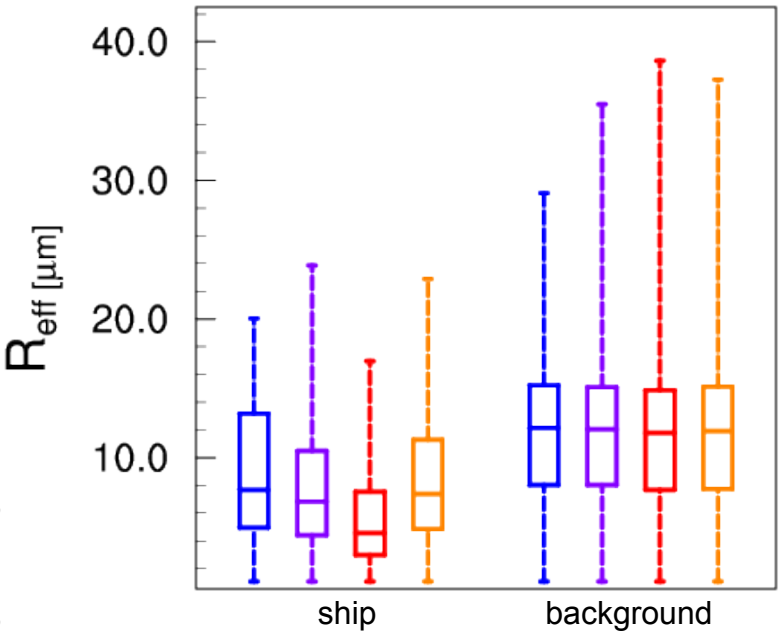

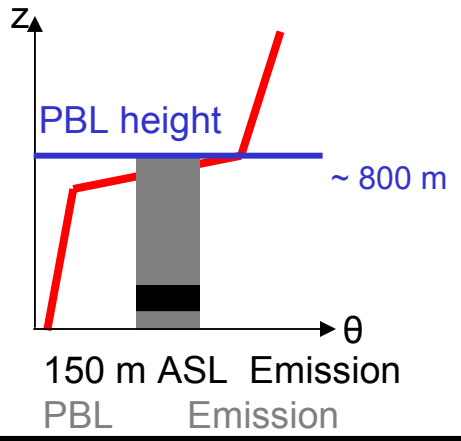

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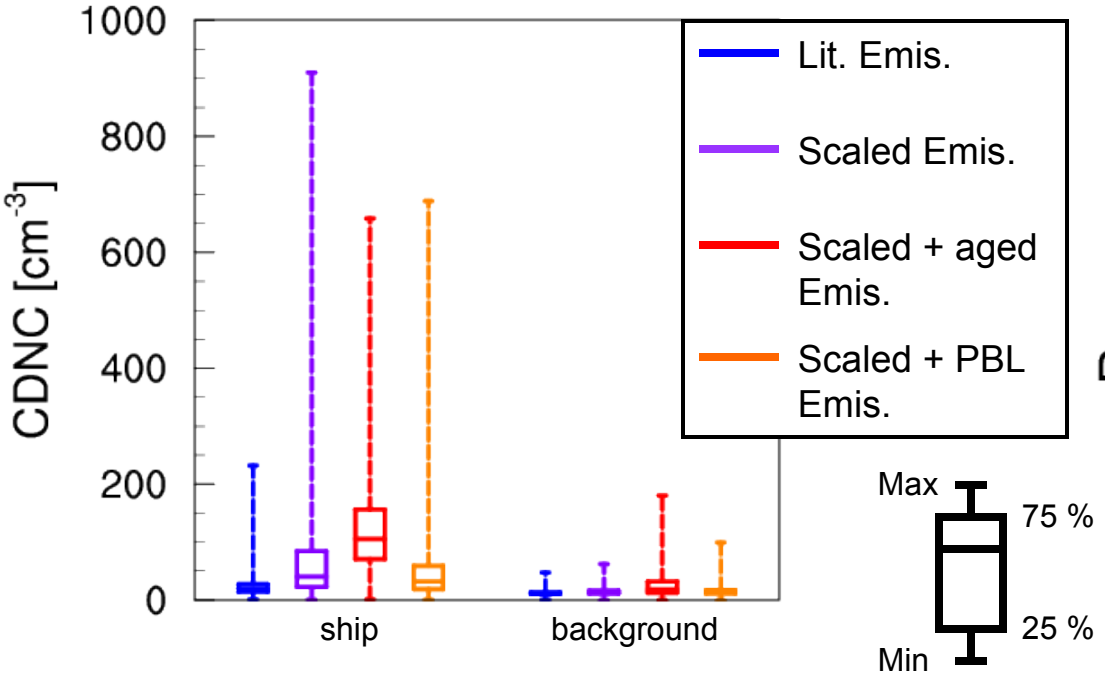
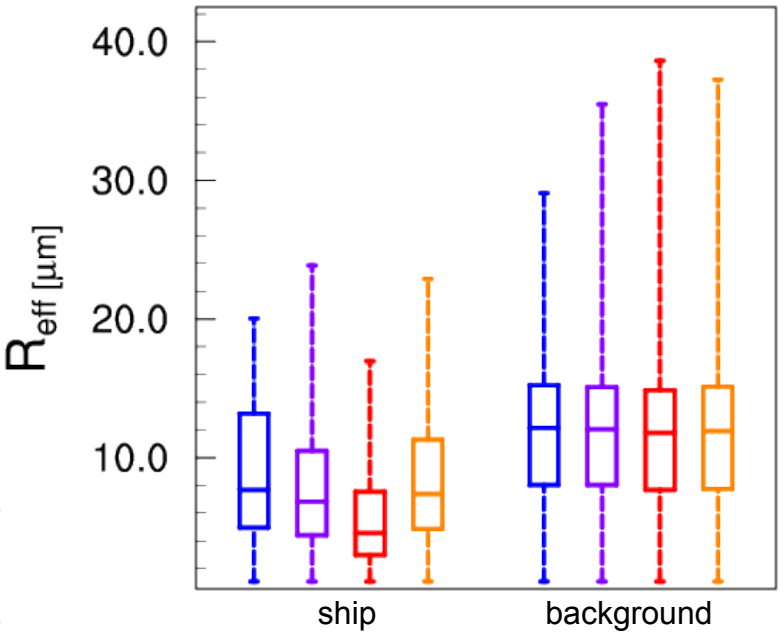
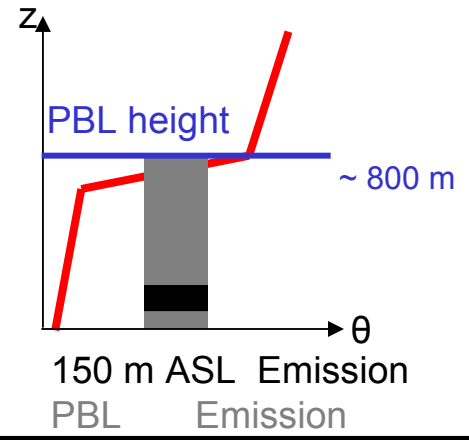
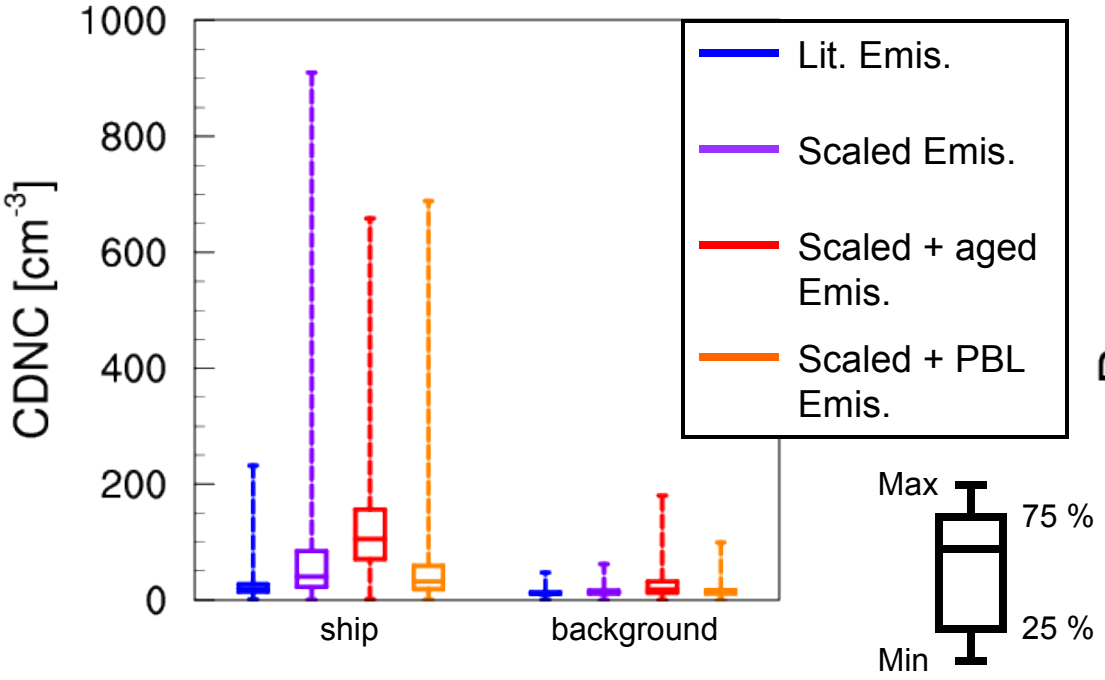


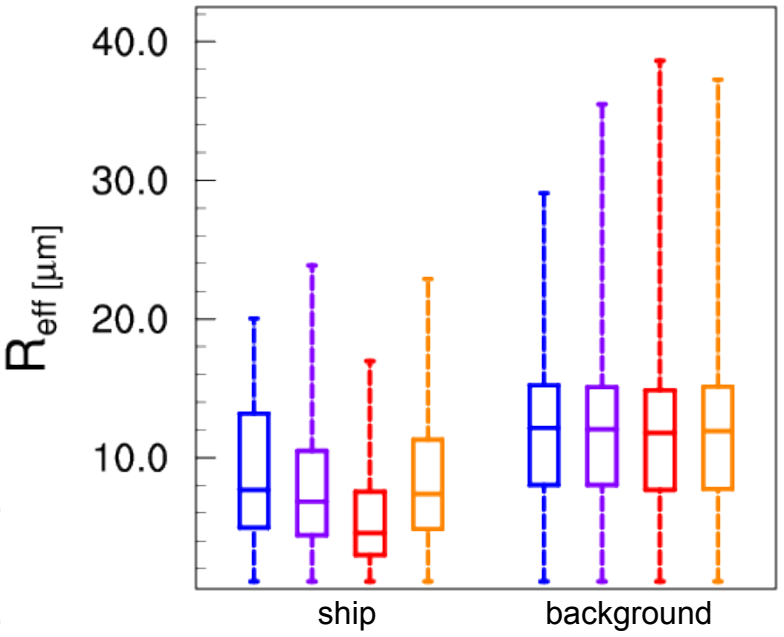


- Larger Emission particles (aged category) lead to stronger increase of CDNC and decrease of R_{eff}.

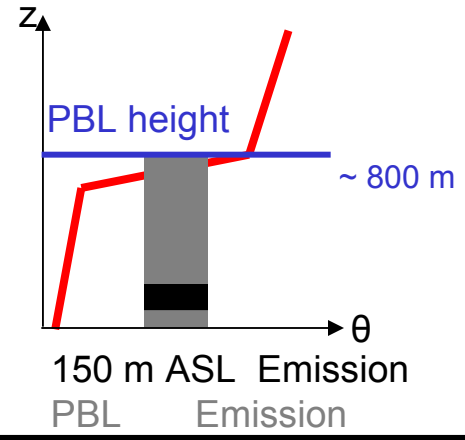


Aerosol Number Concentration and Emission Size

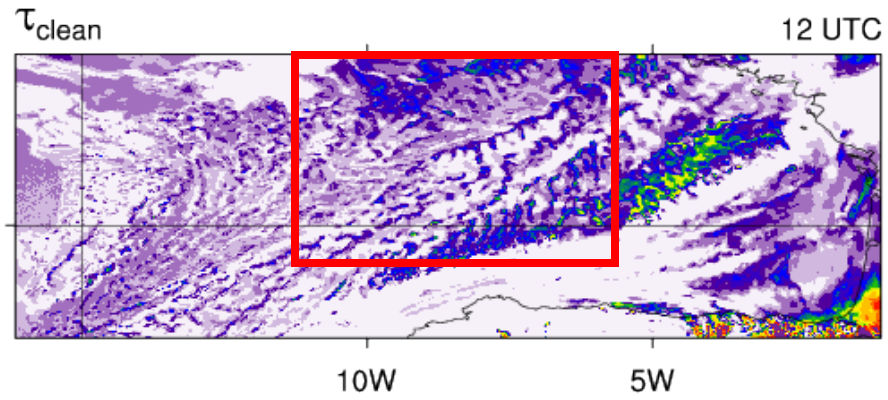


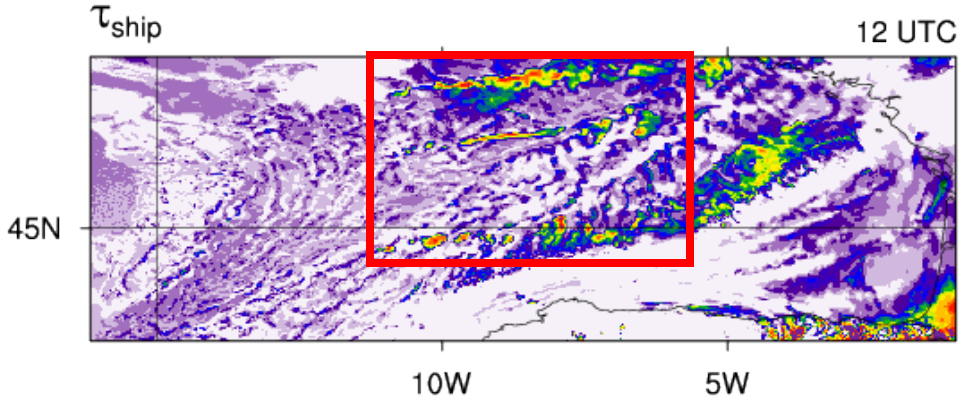


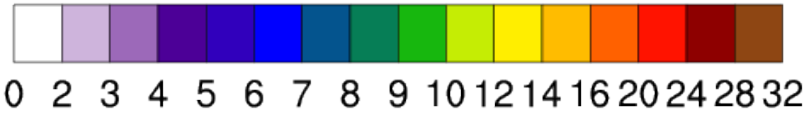
- Larger Emission particles (aged category) lead to stronger increase of CDNC and decrease of R_{eff}.
- Diluting the ship emissions over the PBL weakens the cloud response.



Comparison to Observation







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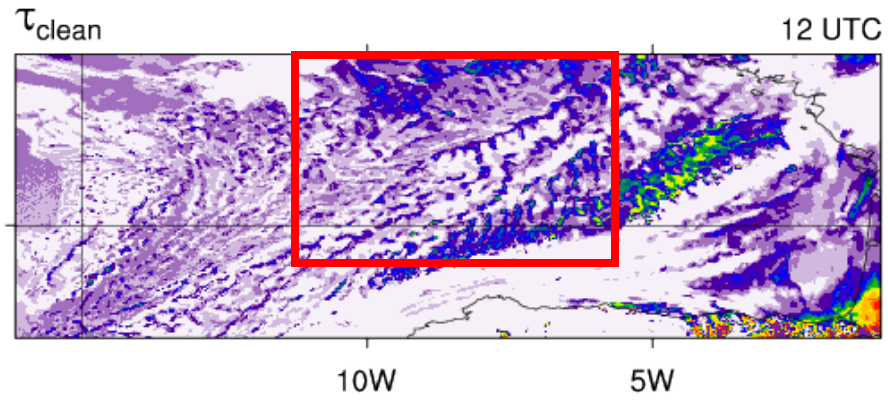

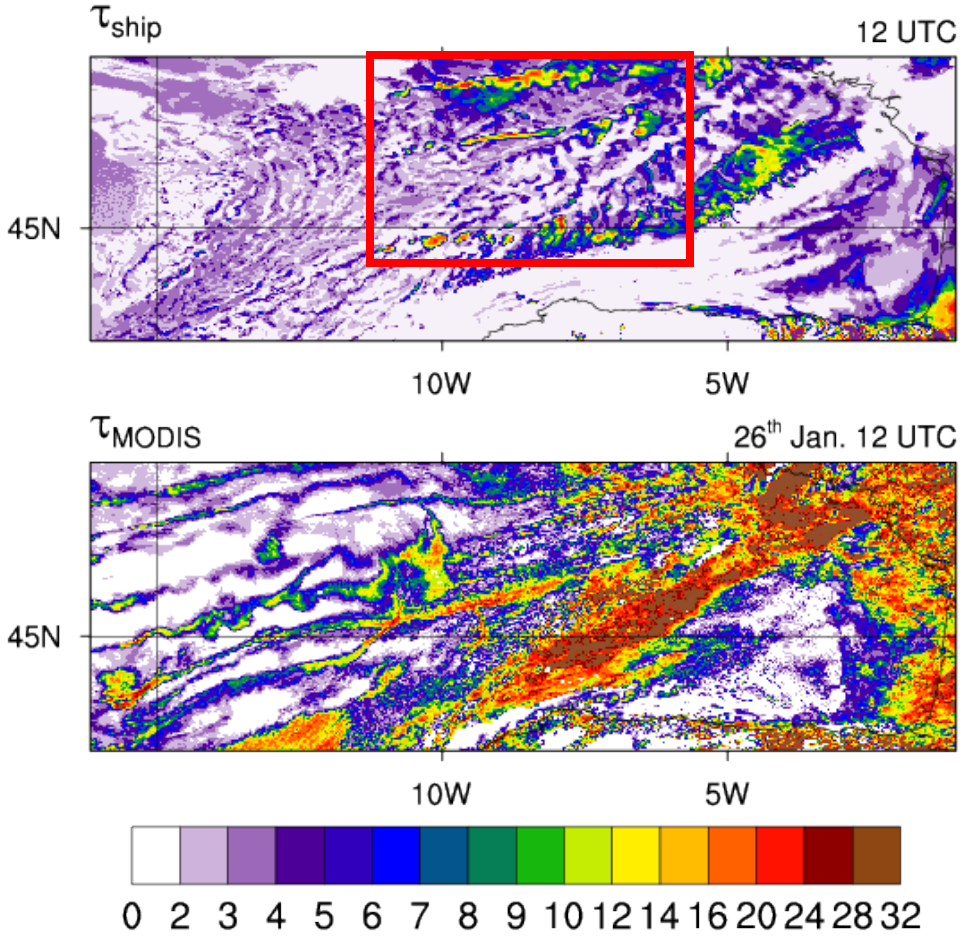

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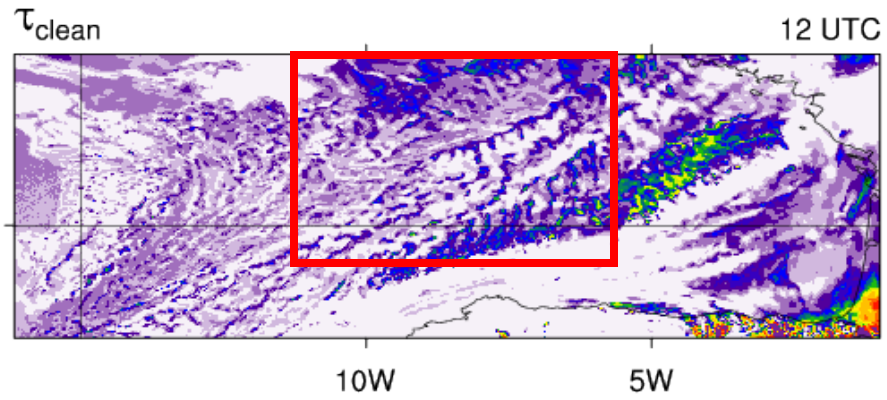
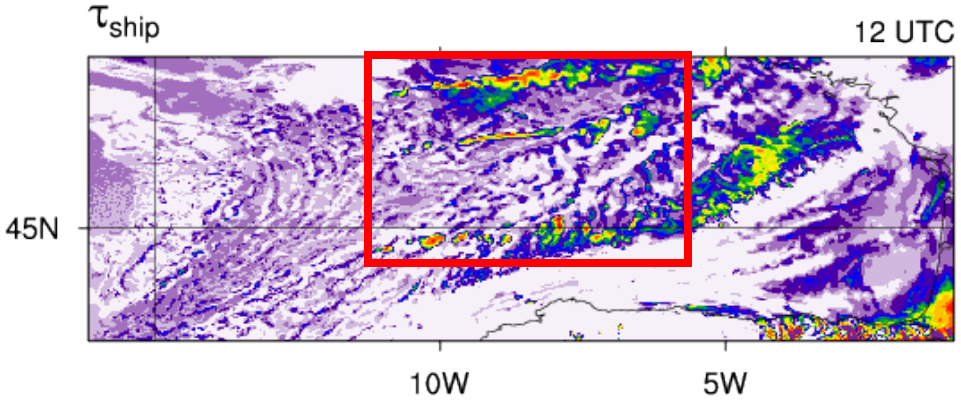
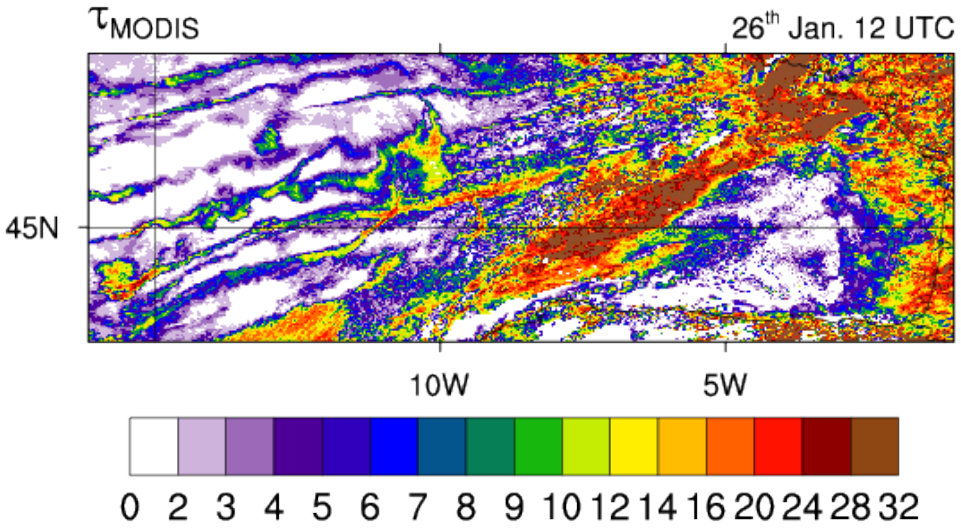




- Horizontal extent (length and width) of ship tracks realistic



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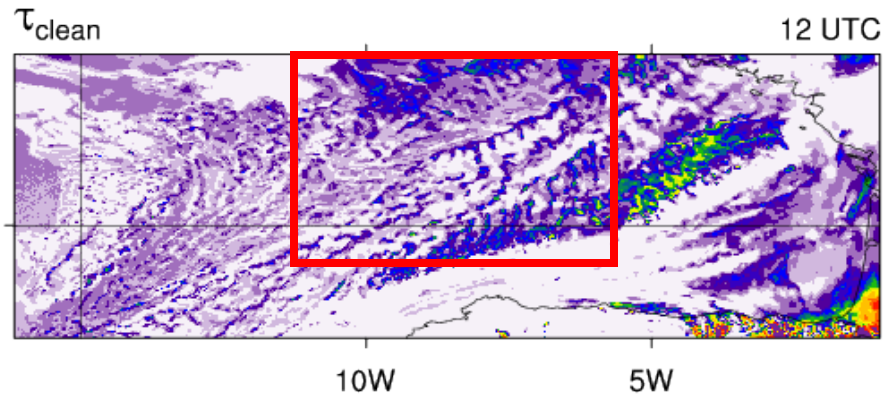

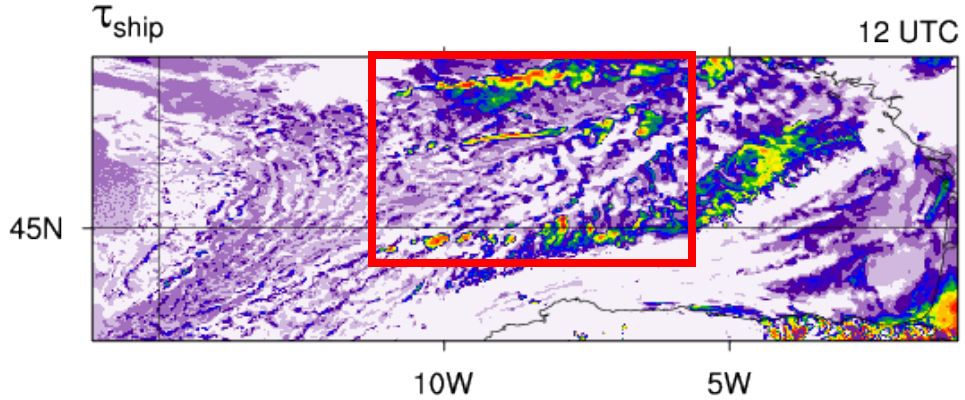

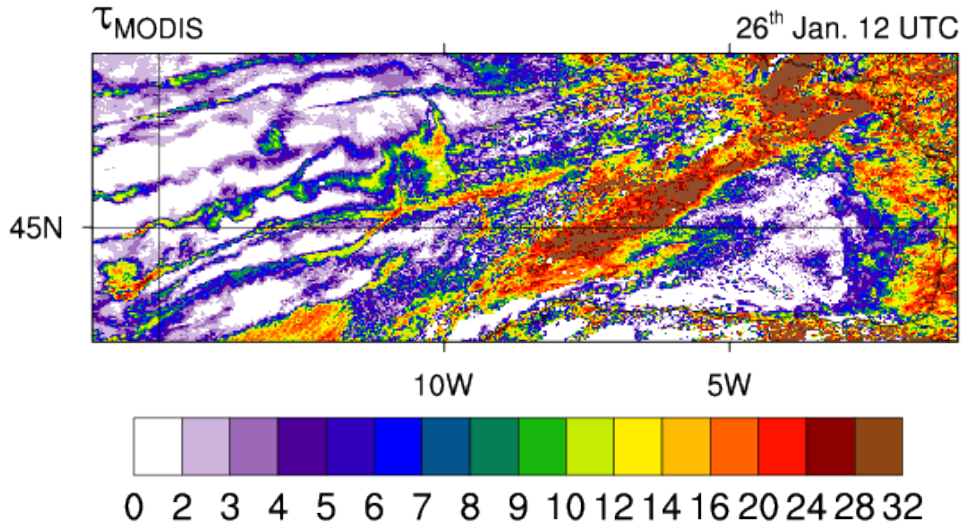

- Horizontal extent (length and width) of ship tracks realistic
- Increase of optical thickness along ship tracks agrees with observation

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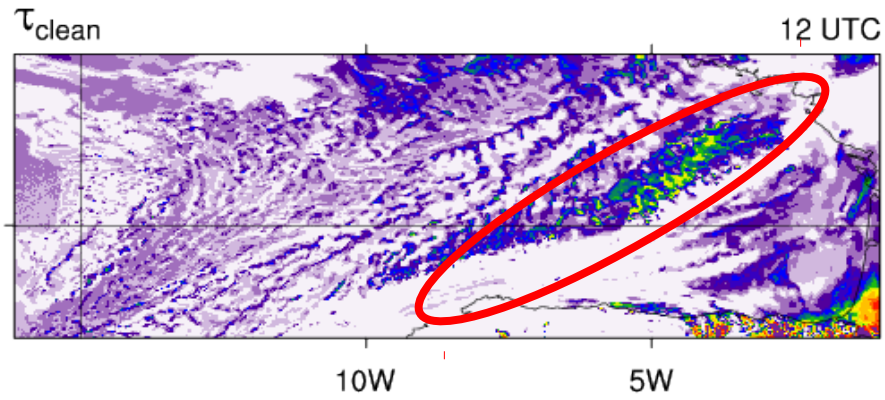

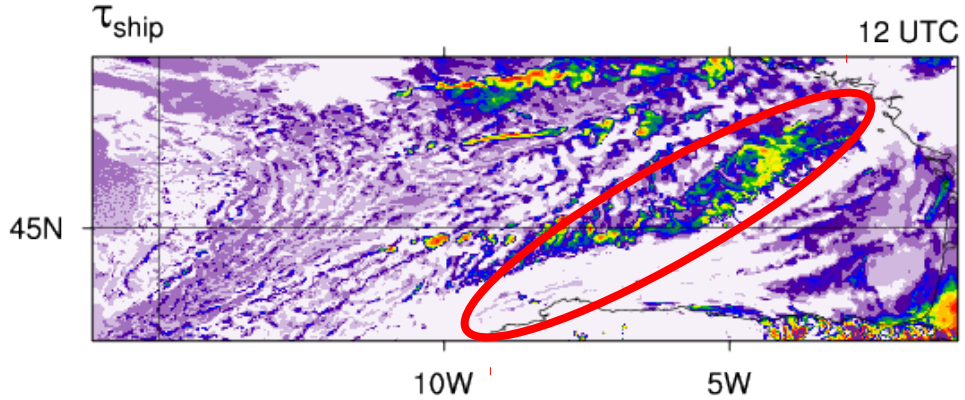

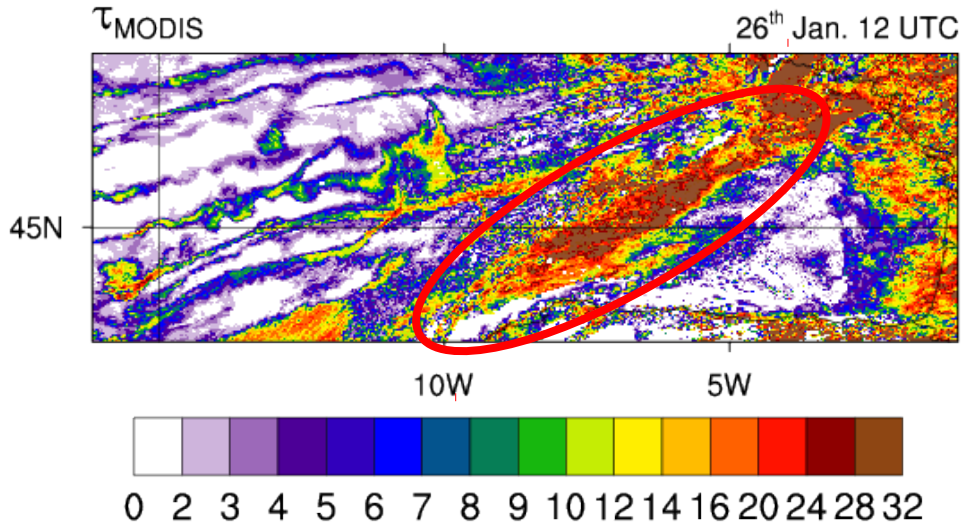

- Horizontal extent (length and width) of ship tracks realistic
- Increase of optical thickness along ship tracks agrees with observation
- Underestimation of cloud optical thickness along cloud band forming downwind of emission zone

Preliminary Conclusions

- We simulate track-like structures of increased cloud optical thickness of realistic magnitude using a scaling of the ship emission mass flux by a factor 10.

- We observe a thickening of the cloud band found downwind from the emission zone, although the effect appears underestimated in comparison to the MODIS observation.

- We find a clear dependency of the simulated cloud optical thickness on the aerosol size and number concentration at the point of emission.