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En route to sustainable aviation: from climate science to mitigation policies

Abstract

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Progress in numerical weather prediction of ice-supersaturated regions at Météo-France, verification and improvement pathways

Emissions from the aviation sector contribute to climate change, with contrails being one of the main factors. Contrails can persist and have a significant climate effect as long as they are emitted and remain within an ice super saturated region (ISSR) - that is, a mass of atmospheric air characterized by a low temperature and a level of humidity that is over the saturation with respect to ice. Therefore, reliable weather forecasts of ISSRs are essential for effective planning of contrail avoidance operations aimed at reducing aviation climate impact.

For several years now, through various contributions, Météo-France has been participating in a global research effort aimed at evaluating and improving the representation of humidity at cruising altitudes in numerical weather prediction (NWP) models. This effort has notably taken shape within the SESAR CICONIA project, where a modified cloud scheme derived from Météo-France's operational NWP model ARPEGE was implemented to enable the representation of ISSRs at cruising altitude (Arriolabengao et al. 2026 – ACP). The verification of this new model against IAGOS airborne observations shows fairly good spatial agreement between the observations and the forecasts, as well as a reduction in biases when benchmarked against the ECMWFS's IFS model. These modifications are currently being integrated into the next operational cycle of ARPEGE.

Future improvements can be achieved through different strategies which are currently being topics of active or upcoming research. One major axis is to improve the initial state of the forecast by enhancing moisture assimilation into the UTLS, particularly through the integration of new aviation or remote-sensing observations (e.g. hyperspectral microwave radiometer). This topic will be addressed in the SESAR CICONIA-MET project which is just getting started. Using ensemble forecasts is also an important way to overcome predictability limitations associated with ISSRs and provide forecast uncertainties which can be useful to optimize daily operations. Finally, artificial intelligence techniques also offer very promising prospects for improving ISSR forecasts (e.g. for nowcasting applications), and certain avenues will be explored.